HST Phase II Proposal Instructions for Cycle 19
Revision History

<table>
<thead>
<tr>
<th>Version</th>
<th>Type</th>
<th>Date</th>
<th>Editor</th>
</tr>
</thead>
</table>
| 19.0    | GO   | June 2011 | J. Younger and S. Rose  
See Changes Since the Previous Cycle |
| 18.1    | GO   | Feb 2011 | J. Younger                                      |
| 18.0    | GO   | June 2010 | J Younger and S Rose: Cycle 18 Initial release |

This version is issued in coordination with the APT release and should be fully compliant with Cycle 19 APT.

This is the General Observer version. If you would like some hints on how to read and use this document, see: Some Pointers in PDF and APT JavaHelp

How to get help

1. Visit STScI’s Web site: http://www.stsci.edu/ where you will find resources for observing with HST and working with HST data.

2. Contact your Program Coordinator (PC) or Contact Scientist (CS) you have been assigned. These individuals were identified in the notification letter from STScI.

3. Send e-mail to help@stsci.edu, or call 1-800-544-8125. From outside the United States, call 1-410-338-1082.
Table of Contents

HST Phase II Proposal Instructions for Cycle 19

Part I: Phase II Proposal Writing ................................. 1

Chapter 1: About This Document .................... 3
  1.1 Document Design and Structure ...................... 4
  1.2 Changes Since the Previous Cycle .................. 4
  1.3 Document Presentation .............................. 5
  1.4 Technical Content ....................................... 5
  1.5 Where to Find Additional Information ............... 6
  1.6 Some Pointers in PDF and APT JavaHelp .......... 6

Chapter 2: The Basics of Phase II Proposals ......................................................... 9
  2.1 How to Prepare and Submit Phase II Information 9
    2.1.1 Astronomer's Proposal Tool (APT) .................. 9
    2.1.2 Entering Information: The APT Graphical User Interface (GUI) versus the Text Proposal File ........................................... 10
    2.1.3 APT Tools .............................................. 11
    2.1.4 Submitting Your Program ............................ 11
  2.2 What to Submit .......................................... 12
  2.3 General Instructions .................................... 13
    2.3.1 Proposal Information [Proposal_Information] ...... 13
    2.3.2 Proposal Description .................................. 15
    2.3.3 Investigators ........................................... 16
    2.3.4 Target Information [Fixed_Targets, Solar_System_Targets, Generic_Targets] .............................................. 16
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3.5 Visit Information [Visits]</td>
<td>16</td>
</tr>
<tr>
<td><strong>2.4 Examples and General Advice</strong></td>
<td>17</td>
</tr>
<tr>
<td>2.4.1 Acquisitions and Pointings</td>
<td>17</td>
</tr>
<tr>
<td>2.4.2 Examples</td>
<td>18</td>
</tr>
<tr>
<td>2.4.3 Common Problems</td>
<td>18</td>
</tr>
<tr>
<td>2.4.4 Consideration of Limited Resources</td>
<td>19</td>
</tr>
<tr>
<td><strong>2.5 Text Proposal File</strong></td>
<td>20</td>
</tr>
<tr>
<td>2.5.1 Basic Syntax Rules</td>
<td>20</td>
</tr>
<tr>
<td>2.5.2 Sample Text Proposal File Template</td>
<td>21</td>
</tr>
</tbody>
</table>

**Chapter 3: Fixed and Generic Targets** .................................. 25

3.1 **Target Number [Target_Number]** ...................................... 27

3.2 **Target Name [Target_Name and Alternate_Names]** .................... 27
3.2.1 Catalog Name                                                   | 28   |
3.2.2 Uncataloged Targets                                            | 29   |
3.2.3 Common Names                                                   | 30   |
3.2.4 Special Targets                                                | 30   |

3.3 **Target Category and Target Description [Description]** .......... 31

3.4 **Target Position Type [Position]** .................................... 36
3.4.1 Required Accuracies of Target Positions                        | 36   |
3.4.2 Equatorial Coordinates                                         | 38   |
3.4.3 Positional Offsets                                             | 39   |
3.4.4 Region of Sky (Extended Targets)                               | 41   |
3.4.5 Determining Coordinates in the Guide Star Selection System (GSSS) Reference Frame | 42   |
3.4.6 A Caution on Astrometry Prepared from STScI Plate Scans         | 44   |
3.4.7 Early Acquisitions                                             | 44   |

3.5 **Equinox for Coordinates [Equinox]** .................................. 44

3.6 Coordinate Reference Frame [Reference_Frame] ........................ 45

3.7 **Radial Velocity or Redshift [RV_or_Z]** ................................ 45

3.8 **Is Proper Motion or Parallax Relevant?** ................................ 45
3.8.1 Proper Motion and Parallax Data                                 | 46   |

3.9 **Flux Data [Flux and Other Fluxes]** .................................... 47
3.9.1 General Guidelines on What Flux Data to Include                  | 47   |

3.10 **Bright-Object Constraints** ............................................ 51

3.11 **Comments [Comments]** .................................................. 53
3.12 Generic Targets List [Generic_Targets] ............ 53
3.12.1 Target Number(s) [Target_Number] .......... 54
3.12.2 Target Name [Target_Name] ................. 54
3.12.3 Target Description [Description] ............. 54
3.12.4 Flux Data [Flux] ...................................... 54
3.12.5 Comments [Comments] .......................... 55
3.12.6 Generic Target Specifications [Criteria] ....... 55
3.13 Getting Coordinates Coordinated .................. 57

Chapter 4: Solar System Targets ......................... 59
4.1 Target Number [Target_Number] .................. 61
4.2 Target Name [Target_Name] ....................... 62
4.3 Target Description [Description] ................. 64
4.4 Target Position ............................................. 65
  4.4.1 Target Position Level 1 [Level_1] .......... 67
  4.4.2 Target Position Level 2 [Level_2] .......... 69
  4.4.3 Target Position Level 3 [Level_3] .......... 76
4.5 Ephemeris Center [Ephem_Center] ............... 76
4.6 Ephemeris Uncertainty [Ephem_Uncert] ....... 76
4.7 Acquisition Uncertainty [Acq_Uncert] ......... 77
4.8 Observing Windows [Windows] .................. 77
  4.8.1 Default Target Windows .................... 82
4.9 Flux Data [Flux and Other_Fluxes] ............. 83
4.10 Comments [Comments] ............................ 85
4.11 Illustrations of Orbital Longitude ............... 85
4.12 Examples of Target List Blocks .................. 86

Chapter 5: Visits, Exposures and Exposure Groups ........................................ 89
5.1 Visit Number and Status .......................... 91
5.2 Visit-level Special Requirements
  [Visit_Requirements] ................................. 92
5.3 On Hold Comments [On_Hold_Comments] ...... 93
5.4 Visit Comments [Visit_Comments] ............... 93
5.5 Exposure Number [Exposure_Number] .......... 93
5.6 Exposure Label [Exposure_Label] ............... 93
5.7 Target Name [Target_Name] ........................................... 94
  5.7.1 Astronomical Targets........................................... 94
  5.7.2 Special Targets................................................. 94
5.8 Instrument Configuration [Config] .............................. 95
5.9 Operating Mode [Opmode] .......................................... 96
5.10 Aperture or Field of View [Aperture] ............................ 96
5.11 Spectral Element [Sp_Element] .................................... 97
5.12 Central Wavelength or Range if Grating or Prism Used [Wavelength] ......................................................... 98
5.13 Number of Times to Iterate the Exposure
  [Number_of_Iterations].............................................. 98
5.14 Time per Exposure [Time_Per_Exposure] ............. 98
5.15 Exposure-level Comments [Comments] ...................... 99
5.16 Optional Parameters [Optional_Parameters]... 100
5.17 Exposure-level Special Requirements
  [Special_Requirements]................................................ 100
5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns ........................................ 101
5.19 Subexposures............................................................ 102
  5.19.1 Actual_Duration .................................................. 102
  5.19.2 Orbit_Number ...................................................... 102

Chapter 6: Parallel Science Exposures 103
  6.1 Parallel Science Limitations.................................... 104
  6.2 Pure Parallels......................................................... 105
  6.3 Coordinated Parallel Containers ......................... 105
     6.3.1 Instrument Configuration ..................................... 106
     6.3.2 Targets.......................................................... 107
     6.3.3 Special Requirements........................................ 108
     6.3.4 Optional Parameters......................................... 109
     6.3.5 Ordering Restrictions and Interpretations............ 110
     6.3.6 Efficiency Considerations ................................. 110

Chapter 7: Special Requirements
  [Visit and Exposure
Special_Requirements]............................................ 111
  7.1 Introduction to Special Requirements:
    Syntax and Rules..................................................... 113
### 7.2 Visit-level Special Requirements
- 7.2.1 Guiding ................................................................. 116
- 7.2.2 Target Orientation ................................................ 118
- 7.2.3 Special Observation Requirements ....................... 128
- 7.2.4 Timing Requirements ............................................. 130
- 7.2.5 Conditional Requirements ..................................... 133

### 7.3 Exposure-level Special Requirements ................. 133
- 7.3.1 Target Acquisition ................................................ 133
- 7.3.2 Target Position ..................................................... 134
- 7.3.3 Special Observation Requirements ....................... 135
- 7.3.4 Special Communications Requirements ................. 139
- 7.3.5 Timing Requirements ............................................. 141

### Chapter 8: Pointings and Patterns ................. 145
- 8.1 Pointing the Telescope ................................................ 145
- 8.2 Introduction to Patterns ............................................. 145
  - 8.2.1 APT User Interface ............................................. 146
  - 8.2.2 Text Proposal File ............................................. 147
- 8.3 How to Fill Out the Pattern Parameters Form .... 148
  - 8.3.1 Pattern Parameters ............................................. 149
- 8.4 Convenience Patterns ............................................. 152
  - 8.4.1 STIS Patterns ................................................... 152
  - 8.4.2 ACS Patterns ................................................... 156
  - 8.4.3 NICMOS Patterns ............................................. 160
  - 8.4.4 WFC3 Patterns ................................................ 167
  - 8.4.5 COS Patterns .................................................. 172

### Part II: Supported Science Instruments .......... 173

### Chapter 9: Space Telescope Imaging Spectrograph (STIS) ........................................... 175
- 9.1 Introduction to STIS ................................................. 176
  - ACQUISITION MODES .............................................. 178
- 9.2 Mode = ACQ
  - Config = STIS/CCD ................................................. 178
  - 9.2.1 Aperture or FOV ............................................. 179
  - 9.2.2 Spectral Element ............................................. 179
9.2.3 Optional Parameters .................................................. 179
9.2.4 Number of Iterations .................................................. 180
9.2.5 Time Per Exposure ...................................................... 180
9.2.6 Special Requirements .................................................. 180

9.3 Mode = ACQ/PEAK
Config = STIS/CCD ............................................................ 181
9.3.1 Aperture or FOV .......................................................... 181
9.3.2 Spectral Element .......................................................... 181
9.3.3 Optional Parameters ....................................................... 182
9.3.4 Number of Iterations ...................................................... 182
9.3.5 Time Per Exposure ...................................................... 182
9.3.6 Special Requirements ..................................................... 182

IMAGING AND SPECTROSCOPIC MODES ............................................. 183

9.4 Mode = ACCUM
Config = STIS/CCD ............................................................ 183
9.4.1 Aperture or FOV .......................................................... 183
9.4.2 Spectral Element .......................................................... 183
9.4.3 Wavelength ................................................................. 183
9.4.4 Optional Parameters ....................................................... 183
9.4.5 Number of Iterations and Time Per Exposure .................. 185

9.5 Mode = ACCUM
Config = STIS/FUV–MAMA,
Config = STIS/NUV–MAMA .................................................. 186
9.5.1 Aperture or FOV .......................................................... 186
9.5.2 Supported Spectral Elements ............................................ 186
9.5.3 Wavelength ................................................................. 186
9.5.4 Optional Parameters ....................................................... 187
9.5.5 Number of Iterations and Time Per Exposure .................. 187

9.6 Mode = TIME–TAG
Config = STIS/FUV–MAMA,
Config = STIS/NUV–MAMA .................................................. 188
9.6.1 Aperture or FOV .......................................................... 188
9.6.2 Spectral Element .......................................................... 188
9.6.3 Wavelength ................................................................. 188
9.6.4 Optional Parameters ....................................................... 189
9.6.5 Number of Iterations and Time Per Exposure .................. 189
9.6.6 Special Requirements ..................................................... 190
### REFERENCE INFORMATION

9.7 STIS Central Wavelengths ........................................ 190
9.8 STIS Internal Calibration Targets .......................... 191
  9.8.1 Target_Name = WAVE ........................................... 191
  9.8.2 Target_Name = CCDFLAT .................................... 193
9.9 STIS Coordinate System ......................................... 196
The Official STIS Aperture List for Cycle 19 .............. 197

### Chapter 10: Fine Guidance Sensors (FGS)

209
10.1 Introduction to the FGS ........................................... 210
10.2 Mode = POS  
  Config = FGS ................................................................. 211  
  10.2.1 Aperture or FOV ................................................... 211  
  10.2.2 Spectral Element .................................................. 212  
  10.2.3 Optional Parameters ............................................. 212  
  10.2.4 Special Requirements ........................................... 213  
  10.2.5 Time Per Exposure ............................................... 214
10.3 Mode = TRANS  
  Config = FGS ................................................................. 214  
  10.3.1 Aperture or FOV ................................................... 214  
  10.3.2 Spectral Element .................................................. 214  
  10.3.3 Optional Parameters ............................................. 215  
  10.3.4 Time Per Exposure ............................................... 215  
  10.3.5 Special Requirements ........................................... 215
10.4 Tables and Illustrations ......................................... 216

### Chapter 11: Advanced Camera for Surveys (ACS)

219
11.1 Introduction to the ACS ........................................... 220
11.2 Mode = ACCUM  
  Config = ACS/WFC ..................................................... 221  
  11.2.1 Aperture or FOV ................................................... 221  
  11.2.2 Spectral Element .................................................. 222  
  11.2.3 Wavelength ........................................................... 222  
  11.2.4 Optional Parameters ............................................ 223  
  11.2.5 Number of Iterations ............................................. 224  
  11.2.6 Time Per Exposure ............................................... 224
11.3 Mode = ACCUM
Config = ACS/SBC ...................................................... 224
11.3.1 Aperture or FOV ......................................................... 224
11.3.2 Spectral Element ........................................................ 225
11.3.3 Wavelength ................................................................. 225
11.3.4 Optional Parameters .................................................... 225
11.3.5 Number of Iterations ................................................... 225
11.3.6 Time Per Exposure ...................................................... 225

11.4 Tabular Reference Data .................................................... 226
11.4.1 Spectral Elements for WFC ......................................... 226
11.4.2 Permitted Filter Combinations ..................................... 228
11.4.3 Ramp Filter Wavelength Ranges ................................. 229
11.4.4 Spectral Elements for ACS/SBC ................................. 229
11.4.5 Allowed Combinations of Aperture, Spectral Element & Readout ................................................... 230

11.5 ACS Aperture Coordinate System ...................................... 231

Chapter 12: Near Infrared Camera and Multi-Object Spectrometer (NICMOS) ...................................................... 233

12.1 Introduction to NICMOS ................................................... 234

12.2 Mode = ACCUM
Config = NIC1 or NIC2 or NIC3 ........................................... 235
12.2.1 Aperture or FOV ........................................................ 236
12.2.2 Spectral Elements ....................................................... 236
12.2.3 Wavelength ............................................................... 236
12.2.4 Optional Parameters .................................................... 236
12.2.5 Number of Iterations ................................................... 237
12.2.6 Time Per Exposure ...................................................... 237
12.2.7 Special Requirements .................................................. 238

12.3 Mode = MULTIACCUM
Config = NIC1 or NIC2 or NIC3 ........................................... 238
12.3.1 Aperture or FOV ........................................................ 238
12.3.2 Spectral Elements ....................................................... 238
12.3.3 Wavelength ............................................................... 238
12.3.4 Optional Parameters .................................................... 238
12.3.5 Number of Iterations ................................................... 240
12.3.6 Time Per Exposure ...................................................... 240
12.3.7 Special Requirements .................................................. 240
12.4 Mode = ACQ
 Config = NIC2 .......................................................... 243
 12.4.1 Aperture or FOV ............................................... 243
 12.4.2 Spectral Elements .............................................. 243
 12.4.3 Wavelength ...................................................... 243
 12.4.4 Optional Parameters ........................................... 243
 12.4.5 Number of Iterations .......................................... 243
 12.4.6 Time Per Exposure ............................................. 243
 12.4.7 Special Requirements ......................................... 244

12.5 Tabular Data ....................................................... 244
 12.5.1 TPG_TIME Values ............................................... 244
 12.5.2 NICMOS Apertures .............................................. 245
 12.5.3 NICMOS Spectral Elements .................................... 246

12.6 Illustrations ........................................................ 249

Chapter 13: Cosmic Origins Spectrograph (COS) ......................... 253
 13.1 Introduction to the COS ......................................... 254

ACQUISITION MODES .................................................. 256

13.2 Mode = ACQ/SEARCH
 Config = COS/FUV ..................................................... 256
 13.2.1 Aperture or FOV ................................................ 256
 13.2.2 Spectral Element ................................................. 257
 13.2.3 Wavelength ....................................................... 257
 13.2.4 Optional Parameters ............................................ 257
 13.2.5 Number of Iterations .......................................... 258
 13.2.6 Time Per Exposure ............................................. 258
 13.2.7 Special Requirements ......................................... 259

13.3 Mode = ACQ/PEAKXD
 Config = COS/FUV ..................................................... 259
 13.3.1 Aperture or FOV ................................................. 260
 13.3.2 Spectral Element ................................................. 260
 13.3.3 Wavelength ....................................................... 260
 13.3.4 Optional Parameters ............................................ 260
 13.3.5 Number of Iterations .......................................... 260
 13.3.6 Time Per Exposure ............................................. 260
 13.3.7 Special Requirements ......................................... 261

13.4 Mode = ACQ/PEAKD
13.4 Mode = ACQ/FUV
Config = COS/FUV ...................................................... 261
13.4.1 Aperture or FOV ................................................... 261
13.4.2 Spectral Element .................................................. 261
13.4.3 Wavelength ........................................................... 262
13.4.4 Optional Parameters ............................................. 262
13.4.5 Number of Iterations ............................................. 263
13.4.6 Time Per Exposure .............................................. 263
13.4.7 Special Requirements ........................................... 263

13.5 Mode = ACQ/SEARCH
Config = COS/NUV ...................................................... 263
13.5.1 Aperture or FOV ................................................... 264
13.5.2 Spectral Element .................................................. 264
13.5.3 Wavelength ........................................................... 264
13.5.4 Optional Parameters ............................................. 265
13.5.5 Number of Iterations ............................................. 266
13.5.6 Time Per Exposure .............................................. 266
13.5.7 Special Requirements ........................................... 266

13.6 Mode = ACQ/IMAGE
Config = COS/NUV ...................................................... 266
13.6.1 Aperture or FOV ................................................... 267
13.6.2 Spectral Element .................................................. 267
13.6.3 Wavelength ........................................................... 267
13.6.4 Optional Parameters ............................................. 267
13.6.5 Number of Iterations ............................................. 267
13.6.6 Time Per Exposure .............................................. 267
13.6.7 Special Requirements ........................................... 268

13.7 Mode = ACQ/PEAKXD
Config = COS/NUV ...................................................... 268
13.7.1 Aperture or FOV ................................................... 269
13.7.2 Spectral Element .................................................. 269
13.7.3 Wavelength ........................................................... 269
13.7.4 Optional Parameters ............................................. 269
13.7.5 Number of Iterations ............................................. 270
13.7.6 Time Per Exposure .............................................. 270
13.7.7 Special Requirements ........................................... 270

13.8 Mode = ACQ/PEAKD
Config = COS/NUV ...................................................... 270
13.8.1 Aperture or FOV ................................................... 271
13.8.2 Spectral Element .................................................. 271
13.8.3 Wavelength ........................................................... 271
13.8.4 Optional Parameters ............................................. 271
13.8.5 Number of Iterations ............................................. 272
13.8.6 Time Per Exposure ............................................... 272
13.8.7 Special Requirements ........................................... 273

OBSERVING MODES .................................................. 274

13.9 Mode = TIME-TAG
Config = COS/FUV ...................................................... 274
13.9.1 Aperture or FOV ................................................... 274
13.9.2 Spectral Element .................................................. 274
13.9.3 Wavelength ........................................................... 274
13.9.4 Optional Parameters ............................................. 275
13.9.5 Number_of_Iterations ......................................... 277
13.9.6 Time Per Exposure ............................................... 277
13.9.7 Special Requirements ........................................... 277

13.10 Mode = ACCUM
Config = COS/FUV ...................................................... 278
13.10.1 Aperture or FOV ................................................. 278
13.10.2 Spectral Element ................................................ 278
13.10.3 Wavelength ......................................................... 278
13.10.4 Optional Parameters ........................................... 278
13.10.5 Number_of_Iterations .......................................... 279
13.10.6 Time Per Exposure ............................................. 279

13.11 Mode = TIME-TAG
Config = COS/NUV ...................................................... 280
13.11.1 Aperture or FOV ................................................. 280
13.11.2 Spectral Element ................................................ 280
13.11.3 Wavelength ......................................................... 280
13.11.4 Optional Parameters ........................................... 280
13.11.5 Number_of_Iterations ......................................... 282
13.11.6 Time Per Exposure ............................................... 282
13.11.7 Special Requirements ........................................... 283

13.12 Mode = ACCUM
Config = COS/NUV ...................................................... 283
13.12.1 Aperture or FOV ................................................. 283
13.12.2 Spectral Element ................................................ 283
13.12.3 Wavelength ......................................................... 283
13.12.4 Optional Parameters ........................................... 283
13.12.5 Number_of_Iterations ......................................... 284
13.12.6 Time Per Exposure ............................................. 284

REFERENCE INFORMATION ................................. 285

13.13 COS Apertures .................................................. 285
13.14 COS Spectral Elements and Central Wavelengths .................................................. 285
13.15 COS Internal Calibration Targets ...................... 286
13.16 WAVECAL Exposure Parameters ................. 287
13.17 COS Coordinate System ................................. 288

Chapter 14: Wide Field Camera 3
(WFC3) ............................................................. 291

14.1 Introduction to WFC3 ....................................... 292
14.2 Mode = ACCUM
   Config = WFC3/UVIS ............................................ 293
   14.2.1 Aperture or FOV ........................................... 293
   14.2.2 Spectral Elements ......................................... 295
   14.2.3 Wavelength .................................................. 295
   14.2.4 Optional Parameters ...................................... 296
   14.2.5 Number of Iterations and Time Per Exposure ...... 296
   14.2.6 Special Requirements .................................... 297
14.3 Mode = MULTIACCUM
   Config = WFC3/IR .................................................. 297
   14.3.1 Aperture or FOV ........................................... 298
   14.3.2 Spectral Elements ......................................... 300
   14.3.3 Wavelength .................................................. 300
   14.3.4 Optional Parameters ...................................... 300
   14.3.5 Number of Iterations ...................................... 301
   14.3.6 Time Per Exposure ......................................... 302
   14.3.7 Special Requirements .................................... 308
14.4 Tabular Reference Data ..................................... 308
   14.4.1 Spectral Elements for WFC3/UVIS .................... 308
   14.4.2 Spectral Elements for WFC3/IR ...................... 310
14.5 WFC3 Aperture Coordinate System .................... 312

Index ........................................................................ 315
PART I: Phase II Proposal Writing

The chapters in this section explain how to use the Phase II Instructions, how to fill out your Phase II information file and submit it to STScI. It also explains where to go for help and describes the information that must be submitted to STScI by GOs and GTOs during Phase II.

Chapter 1: About This Document / 3
Chapter 2: The Basics of Phase II Proposals / 9
Chapter 3: Fixed and Generic Targets / 25
Chapter 4: Solar System Targets / 59
Chapter 5: Visits, Exposures and Exposure Groups / 89
Chapter 6: Parallel Science Exposures / 103
Chapter 7: Special Requirements [Visit and Exposure Special_Requirements] / 111
Chapter 8: Pointings and Patterns / 145
Proposals to observe with Hubble Space Telescope (HST) are reviewed in two phases managed by the Space Telescope Science Institute (STScI). In **Phase I**, proposers submitted an Observation Summary for review by the Telescope Allocation Committee (TAC). The Observation Summary provides only general descriptions of the targets and of the proposed observations. The TAC review results in a list of accepted proposals.

During **Phase II**, General Observers (GOs) with accepted proposals, as well as Guaranteed Time Observers (GTOs), must provide complete details of their proposed observations so that STScI can conduct a full technical feasibility review. The Phase II information will then be used to schedule the actual observations and obtain data.

This document, the *Phase II Proposal Instructions*, has the following purposes:

- To describe the information that must be submitted to STScI by GOs and GTOs during Phase II.
- To describe what you have to provide in APT (*Astronomer’s Proposal Tool*).
- To show how to submit the information to STScI.

Readers of this document should be familiar with the Cycle 19 *Call for Proposals*, issued in December 2010, and with the *Instrument Handbooks*.

---

## Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Document Design and Structure</td>
<td>4</td>
</tr>
<tr>
<td>1.2 Changes Since the Previous Cycle</td>
<td>4</td>
</tr>
<tr>
<td>1.3 Document Presentation</td>
<td>5</td>
</tr>
<tr>
<td>1.4 Technical Content</td>
<td>5</td>
</tr>
<tr>
<td>1.5 Where to Find Additional Information</td>
<td>6</td>
</tr>
<tr>
<td>1.6 Some Pointers in PDF and APT JavaHelp</td>
<td>6</td>
</tr>
</tbody>
</table>
1.1 Document Design and Structure

These Instructions are meant to be read on-line, although many readers may wish to print selected portions. Many cross-references have been added to make navigation easy and convenient. A comprehensive table of contents allows you to go directly to chapters, sections and subsections.

Each chapter starts with a listing of sections and subsections, each linked to its page. Near the beginning of most chapters, a list of figures and tables is provided; this list is cross-referenced for convenient navigation to a particular item you may wish to examine.

Also, an index has been provided.

1.2 Changes Since the Previous Cycle

This is the initial Release for Cycle 19. Significant changes include:

- Spatial Scans have been reimplemented in a limited fashion for WFC3/IR MULTIACCUM and WFC3/UVIS ACCUM (Table 7.2, Table 7.6, and Section 7.3.3).
- WFC3: Grism aperture changes and additions (Section 14.3.1 and Table 14.3); New and revised patterns (Section 8.4.4).
- COS: New G130M central wavelengths (Table 13.3 and Table 13.5; FP-POS updates (Sections 13.3.4, 13.9.4, 13.10.4, 13.11.4 and 13.12.4)
- New DARK-EARTH-CALIB special target (Table 3.1 and Table 5.1)
1.3 Document Presentation

Navigation
Cross-references and external references highlighted in blue can be accessed by clicking on the item.

Text Proposal File Instructions
Sections and text in brown have been added for those proposers who elect to export, and then edit their proposal in a Text Proposal File. For guidelines on when you might use this template, see “Using the Text Proposal File” in Chapter 2.

Available Formats
Proposers can access this information in two formats: PDF via the Web and Sun JavaHelp via the Astronomer’s Proposal Tool (APT).

- The PDF version available on the Web will be the only one that you can be certain is up-to-date. It can be downloaded and printed if you wish, and when used on-line provides “instant” access to internal and external cross-references.

- The JavaHelp version available in APT should not be printed due to the limitations of printing in JavaHelp. Both internal and external references are now active.

Reader Feedback
We strive to present this critical, detailed, and complex information in a form that allows it to be used accurately and effectively. Your comments on its good and bad qualities will help us in the future; please send e-mail to help@stsci.edu.

1.4 Technical Content

Available Science Instruments for Cycle 19
ACS/WFC, ACS/SBC, COS, WFC3, NICMOS (tentative), STIS and FGS are available for this cycle.

Instrument Modes, Special Requirements, etc.
Some changes have been made to these Instructions since the previous version to correct errors and omissions, and to document new modes or options. There are too many to list, but as long as you use the most recent
version the information provided should reflect our current state of knowledge.

1.5 Where to Find Additional Information

As you write your Phase II proposal, you will probably need to consult the Instrument Handbooks for additional information on one or more Science Instruments. These handbooks are available on the Web in both PDF and HTML versions at http://www.stsci.edu/hst/HST_overview/documents

There are some policies that were delineated in the Call for Proposals, which asked for Phase I proposals. You may wish to review those, particularly the sections discussing limited resources.

1.6 Some Pointers in PDF and APT JavaHelp

PDF Online and Print

Adobe’s Portable Document Format (PDF) is the standard for the commercial sector because it is easily produced with modern documentation software and has many excellent features. If you’re new to PDF here are some hints that you may find useful:

- PDF has links, just like HTML. Anything in blue in this document is a link you can click on to go somewhere else.
- PDF can print selected pages. Note that the page numbers you enter are PDF’s sequential numbers (look at the bottom of the Acrobat window to see where you are).
- PDF is searchable with most viewing software such as Adobe’s Reader and Apple’s Preview.
- You can move up or down page by page using the scroll bar on the right of your Acrobat window; just click above or under the indicator that shows your relative position. You can also click and hold on this indicator to speed through the document.
- If you wish to save this document as a PDF file on your local machine, click with your right mouse button on the Institute’s Web page that has the Phase II information at the spot where you link to the PDF file. In other words, your left button opens the file in Acrobat, but the right button lets you save the file if you pull down to “Save Link as.”
• Look at Acrobat’s help facility (the help button is in the upper right corner of the Acrobat window) for more pointers.

**APT JavaHelp**

The Astronomer’s Proposal Tool (APT) user interface provides access to this document via Sun JavaHelp -- a help format specifically designed for Java-based applications.

• Internal and external cross-references are linked (in blue).

• The JavaHelp viewer provides access to a table of contents and an index; all the listed items are linked to the referenced sections. Once you are in a document, you can use the table of contents, the index, or the cross-references in the text to navigate to other parts of the document as you would in html.

• JavaHelp has a very useful search utility.

• Some of the sections in the Phase II Instructions are used for “context-sensitive” help in APT. At the top of the APT user interface, click on the “Help” menu item for access to this document and instructions on how to use the context-sensitive help.

We welcome your comments and thoughts for improving how we provide information to you.
CHAPTER 2: The Basics of Phase II Proposals

In this chapter . . .

2.1 How to Prepare and Submit Phase II Information / 9
2.2 What to Submit / 12
2.3 General Instructions / 13
2.4 Examples and General Advice / 17
2.5 Text Proposal File / 20

2.1 How to Prepare and Submit Phase II Information

The computer software used to schedule and execute HST observations can interpret the proposal information only if it is in the proper format. Therefore, proposals must be filled out accurately, completely, and in strict accordance with the instructions in this document. Observers now have the capability and responsibility, with the help of their Program Coordinator (PC) and/or Contact Scientist (CS) for creating and submitting proposals that are not only syntactically correct but also feasible and schedulable. The Astronomer’s Proposal Tool (APT) will help you achieve this.

2.1.1 Astronomer’s Proposal Tool (APT)

With APT you can prepare your Phase II program on your computer and then submit it electronically to STScI. You will use a copy of your Phase I proposal (marked up in XML), which contains all the information from your Phase I submission. If you haven’t done so already, please consult the APT Web Page for detailed instructions on how to install and use APT on your computer. Observers without access to a suitable computer platform to run APT for Phase II should contact their PC.
2.1.2 Entering Information: The APT Graphical User Interface (GUI) versus the Text Proposal File

In the previous proposal entry system, RPS2, you could enter and edit information as text (usually in the form `<keyword>=<value>`) using a template and your favorite text editor. Also, you could use the Proposal Editor (PED), a graphical editor in RPS2 designed for editing your Phase II program.

In APT you can enter proposal information by using either the APT Form/Spreadsheet Editors via a GUI or a Text Proposal File that employs a "simplified" RPS2 syntax. This text file has been developed for APT as an alternative method for editing proposals outside of the APT GUI; you use a flat ASCII file format that is similar to the RPS2.prop file that was used in HST cycles 5-11. Small changes to the original RPS2 format were necessary to accommodate enhancements that came with APT, and some of the syntax has been made stricter in order to make reading of the file more robust. You create this file in APT by exporting your proposal into a text proposal file format (for details please see the APT Web Page).

Using the APT GUI

In most of the fields in the APT graphical interface, you choose a keyword or parameter `<value>` in a list from a pull-down menu, or check a box. In a few other fields (e.g., Other Fluxes, Observing Windows and Criteria in the Targets forms) you enter free text in the field using the formats specified in this document. Required items are marked with a red “x” if you haven’t selected or entered a `<value>`. Also, for many of the keywords, a tooltips message will appear when you place your pointer on the keyword: `<value>` area.

Using the Text Proposal File

When creating or editing large repetitive proposals, editing with APT’s graphical interface can be inefficient and prone to error. We present two examples where you may want to use a text proposal file.

1. You are building a large repetitive program with many targets and visits in order to create a mosaic. Initially, you would use APT to build a proposal that has one or two targets and one of each of the unique visits. You would then run the Orbit Planner and Visit Planner to make sure that the visits fill the right number of orbits and schedule. Then, you would export this small template proposal to the Text Proposal File format, and use scripts or your favorite editor to build your program into a larger version. You would then import the resulting file back into APT for checking and processing.

2. You have already built a fairly large program in APT by creating unique exposures and visits, and then used the duplicate and multiple duplicate features in APT. Then, you discover that you need to make a small change to a large number of exposures (such as removing or
adding an optional parameter). This would be tedious to do in the APT GUI, but straightforward in the Text Proposal File. Simply export your program to the Text Proposal File format, make your changes in an editor, and then import the Text Proposal File back into APT for new processing.

Table 2.1 summarizes some of the differences between the APT GUI and the Text Proposal File.

<table>
<thead>
<tr>
<th>Data Entry Method</th>
<th>Syntax</th>
<th>Help Features and Error Checking</th>
</tr>
</thead>
<tbody>
<tr>
<td>APT</td>
<td>For most of the fields (exceptions noted below), choose a keyword=value from a pull-down list, or check a checkbox, or enter a text=value in the field provided.</td>
<td>1) Required data marked with a red x 2) Tooltips (e.g., a message noting a required item and its format) provided during data entry 3) Context-sensitive help available</td>
</tr>
<tr>
<td>Text Proposal File</td>
<td>Enter free text in the file in the form keyword=value. You must conform to the proper syntax described in this document.</td>
<td>None while editing. After editing your proposal, you must import it back into APT (see the APT Web page for instructions). Once you have imported your program back into APT you can run the diagnostics tool.</td>
</tr>
</tbody>
</table>

1. The exceptions are:
   - Other Fluxes field for all types of Targets
   - Criteria field for Generic Targets
   In these fields you must enter text (=keyword>, =value> and any separators) exactly as described in the relevant sections of this document.

2.1.3 APT Tools

APT also provides tools to help you plan your observations, such as an Aladin based visualization tool, an Orbit Planner and a Visit Planner (see the Using APT web page). If you have any problems using APT, or have any questions about your proposal, please feel free to contact your assigned Program Coordinator (PC) and/or Contact Scientist (CS). Programs without an assigned CS may also contact help@stsci.edu for help with APT.

2.1.4 Submitting Your Program

After you submit your Phase II program, the APT system will give you an automatic electronic acknowledgment. This should be followed in a few
days by an acknowledgment from your PC. If, at the time of submission, the proposal contains errors, the APT submission system will give a warning, but will allow the proposal to be submitted. However, the proposal will be flagged, and your PC will contact you within a few days to discuss how to proceed.

The resolution of errors in the Phase II Program is the responsibility of the Principal Investigator. The fact that APT may allow you to submit a program that contains errors does not mean that your program can or will be scheduled.

We strive to make APT a useful aid for preparing and checking your Phase II program, but it is nevertheless imperfect. On rare occasions syntax errors are not detected. Also, APT does not check for guide stars.

### 2.2 What to Submit

Observers must submit their Phase II proposal to STScI by the Phase II deadline. It should contain the following:

- **Updated Proposal Information**: This section includes the title, the abstract, a Phase II ID, a proposal description, PI and CoI information. Please note that some general information is very useful for a thorough and helpful technical review of your proposal. You may wish to include parts of your Phase I science discussion, but please note that all the Phase II information you provide will be freely available via the Web.

- **Target Information**: The information for one or more of the Fixed, Solar System, or Generic Targets must be completed. If necessary, proper motion and parallax information should be supplied for fixed targets. Detailed instructions for filling out the target data, as well as the proper motion and parallax information, are provided in Chapter 3: Fixed and Generic Targets on page 25 and Chapter 4: Solar System Targets on page 59 of this document.

- **Visit, Exposure Group, and Exposure Specifications**: These specifications include orientation information, scheduling requirements, SI information, exposure special requirements and so on. Required items will be clearly noted as you complete the specifications. Gen-
eral instructions for completing this section are provided in Chapter 5: Visits, Exposures and Exposure Groups on page 89 of this document.

2.3 General Instructions

When you first bring up APT, you will have to convert the information in your Phase I proposal, which is an XML file, into a Phase II program format using the “Phase I->Phase II” conversion button on the APT User Interface.

Note the following general instructions and conventions when entering your Phase II information:

- After converting your Phase I Proposal into Phase II information, please verify that all the general information is correct and readable.

- Entries in text must precisely conform to the formats specified in this document. If you have decided to use the Text Proposal File, the order of the entries must be correct as well (see Section 2.5 on page 20).

- Proposal data text may contain only standard ASCII characters. All other symbols must be spelled out. Greek letters must be spelled out (e.g. BETA-LYR, H-ALPHA). The degree sign should be replaced with “D” (e.g. BD+16D516). Subscripts and superscripts are not allowed.

- Additional information not covered by the keywords and values already provided may be entered in the “Additional Comments” or “Comments” boxes.

- When providing a Target “Description” please use the target keywords and syntax presented in Tables 3.2 to 3.10 and Table 4.2.

If you are unable to use the APT software, please contact your PC (listed in your notification letter) to make other arrangements.

2.3.1 Proposal Information [Proposal_Information]

This block contains basic information about the proposal including the Title, Abstract, Category, and Cycle. After converting your proposal from Phase I to Phase II, your Phase II program will have the program information filled out based on your Phase I submission.
Chapter 2: The Basics of Phase II Proposals

Proposal Title

Abstract
The Abstract from your Phase I submission has been included in your Phase II information. Please check this since you may need to update this text based on your final TAC allocation.

If a Phase II submission is not based on a Phase I proposal, please fill in missing information.

Phase II ID
This ID will be provided to you by your Program Coordinator.

STScI Edit Number
This field holds a counter for an operational version number of the proposal and cannot be edited by the user. If you are connected to the internet, the version number in your proposal file is compared to the one in the STScI proposal database when a proposal is opened or submitted. In either case, if your file’s version number is less than the database’s number for that proposal, you will get a pop up warning that a more recent version is available (via APT’s Retrieve from STScI). This prevents you from doing an update with an old copy of the proposal, or making edits to a version that does not include changes your PC has made to the proposal. The STScI software increments this number whenever the Phase II file is edited by STScI staff.

Proposal Cycle
Unless you have been told otherwise, the Cycle should be 19. Multiple values of Cycle are not permitted.

Proposal Category
For those Phase II submissions that are not based on a Phase I proposal, the Category should be selected from one of the following:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GO (General Observer)</td>
<td>GO/DD (Director’s Discretionary time)</td>
</tr>
<tr>
<td>GO/SURVEY (GO Survey Programs)</td>
<td></td>
</tr>
<tr>
<td>SNAP (snapshot proposals)</td>
<td>GTO (Guaranteed Time Observer)</td>
</tr>
</tbody>
</table>

A Category of SNAP is used for “snapshot” programs. By their nature these programs take advantage of otherwise-unused blocks of telescope time for relatively short exposures. SNAP exposures therefore must carry as few restrictions as possible. In particular, Special Requirements should not ordinarily be used with SNAP programs (consult with your Program Coordinator if you feel you need to do so). Some special policies apply to
SNAP programs: in particular, STScI will not repeat failed SNAP exposures.

For pure parallel proposals (see Section 6.2), check the “Parallel” checkbox next to the Proposal Category in the Proposal Information form. Please note that SNAP/PAR is not a valid proposal type.

Availability
You must choose supported. If the observing modes normally offered by STScI to GOs do not meet the needs of your program, please contact your Program Coordinator.

2.3.2 Proposal Description

Proposal Text Sections
These four sections are needed for STScI to execute your program properly. Not all questions will need to be answered by every observer, and note that the answers to these questions will be made public. As with the Abstract, please review this text to make certain the information is correct.

Description of Observations [Observing_Description]
Provide a detailed description of your observing plans. Text from your Phase I proposal will need updating based on your final TAC allocation and on details to be worked out in Phase II.

Justification of Real-time observations and Special Scheduling Requirements [Realtime_Justification]
Provide an explanation for any real-time or special scheduling requirements, if they have been requested. Information from your Phase I proposal has been inserted, but it is possible that the text will need updating based on your final TAC allocation, to include the details worked out in Phase II, and to remove any special calibration requirements (see below).

Justification of Special Calibration Requirements [Calibration_Justification]
Provide a justification for any special calibrations required for your program, if requested.
Additional Comments [Additional_Comments]
Provide any additional comments that you feel STScI needs to know in order to properly implement your program.

2.3.3 Investigators
These sections contain the names of the Principal Investigator (PI), all Co-Investigators¹ (CoI), and their institute affiliations. This information comes from your Phase I proposal submission. If a Co-Investigator (or another individual) is to serve as the contact for a program, then the Contact keyword box should be checked. More than one CoI may be designated as a Contact. The Contact(s) and PI will receive all (non-budgetary) questions/information on the program.

If any of the Investigators have changed addresses between the Phase I and Phase II submissions (or any time after the Phase I submission), please contact your Program Coordinator with the updated address. You cannot use the Phase II submission to implement address changes.

For Phase II submissions that are not based on a Phase I proposal, please fill in the information accordingly.

2.3.4 Target Information [Fixed_Targets, Solar_System_Targets, Generic_Targets]
Chapter 3: Fixed and Generic Targets on page 25 and Chapter 4: Solar System Targets on page 59 describe how to fill out the Target Lists.

2.3.5 Visit Information [Visits]
Chapter 5: Visits, Exposures and Exposure Groups on page 89 of this document describes how to fill out the Visit and Exposure Specifications. Instructions for submitting parallel observations are given in Chapter 6: Parallel Science Exposures on page 103, and the detailed, instrument-specific parameters are described in Part II: Supported Science Instruments on page 173.

¹. The number of CoIs is limited to 99.
2.4 Examples and General Advice

2.4.1 Acquisitions and Pointings

Getting HST located and oriented properly lies at the heart of successful observations, especially when a small aperture is being used, and there are a number of ways to do that. The remarks here apply specifically to fixed targets, and mostly apply to the use of small apertures, although many of them can be applied to moving targets as well. For more information, see Section 3.4 on page 36.

First, you have to acquire an object successfully that is at or near the position at which the science observation will be made. The object to be acquired should meet these conditions:

1. It should be a point source or nearly enough to point-like that the centering algorithms can determine a precise centroid.

2. The object’s coordinates must be both precise and accurate and any proper motion must be known. This requirement boils down to the need for the object to fall within the search region at the time of the acquisition. For this to happen the coordinates must also be consistent with the Guide Star Catalog or they must fall within another system that can be related to the GSC. This is why the source of the acquired object’s coordinates are required.

3. The object must be neither too bright nor too faint for the instrument mode used. These conditions are described in the various Instrument Handbooks.

The coordinates for the acquired object can be specified in several ways:

- As explicit absolute celestial coordinates, i.e., RA and DEC. See Section 3.4.2 on page 38.
- As celestial coordinates relative to another nearby object, using offsets in RA and DEC. See Section 3.4.3 on page 39.
- As a REGION; see Section 3.4.4 on page 41.

Second, once the acquisition has been made, the telescope must be repositioned to the precise point desired. This step is unnecessary, of course, if the object acquired in the first instance is the object to be observed. Repositioning can be implicit or explicit.

An offset is implicit when a target such as “XX-OFFSET” is acquired with some ACQ mode, and then “XX” is observed via a science exposure. This often leads to confusion because no specific motion of the telescope has been provided, but that motion is implied by specifying the separate targets with different coordinates. “XX-OFFSET” is specified for the acquisition
because it is bright enough and point-like enough to be acquired successfully, but the coordinates specified by “XX” are what is to be observed.

An offset is explicit when you use a Special Requirement such as POS TARG (see POSition TARGet <X-value>,<Y-value>) to move the telescope away from the position acquired. In this scheme, the position specified in the acquisition is placed at the fiducial point for the aperture requested (in general the geometric center of the aperture). The POS TARG then moves the telescope relative to that nominal position. Thus POS TARGs are not cumulative, and always refer back to the original acquired position.

### 2.4.2 Examples

People who are looking for examples of APT files are encouraged to go to [http://archive.stsci.edu/hst/abstract.html](http://archive.stsci.edu/hst/abstract.html) and do a search for a selection of proposals from the most recent cycle. For any program that appears as though it could serve as a useful example, the APT file can be obtained by typing the proposal ID number into the search form at [http://www.stsci.edu/hst/scheduling/program_information](http://www.stsci.edu/hst/scheduling/program_information).

Additionally, several examples of ACS dither patterns using POS TARGs which may be used in an APT proposal can be found on the ACS Web site at:

[http://www.stsci.edu/hst/acs/proposing/dither](http://www.stsci.edu/hst/acs/proposing/dither)

### 2.4.3 Common Problems

**Incorrect Proposal Format**

When you are entering text in a field the formats described in this document must be followed exactly, since the information in the forms is interpreted by computer software. Some items that warrant repetition are:

- Visit numbers must be unique.
- Target names must be spelled exactly the same throughout the proposal.
- The format for target positions must be followed to the letter. For more information on coordinates, see Section 3.13 on page 57.
- The format for flux data must be followed. Only those defined in these Instructions are acceptable.
The format for Optional Parameters and Special Requirements must be followed to the letter.

Observations which cannot be defined using the syntax in these Instructions may be described in Comments fields, but such comments should be used very sparingly, if at all, and their use may impede execution of a program.

**Imprecise Target Positions**

See the discussion of required position accuracies in Table 3.11: Required Coordinate Accuracies. The requirements are much more stringent than is typically the case for ground-based observations.

**Lack of Acquisition Exposures with Small Apertures**

When exposures are requested in very small apertures or fields of view, a separate acquisition exposure is generally required. Please consult the Instrument Handbooks for the instrument you are using.

### 2.4.4 Consideration of Limited Resources

Proposers should be aware that several of the Special Requirements impose serious constraints on the scheduling system because they require the use of limited resources; for example, **RT ANALYSIS** requires real-time use of the TDRSS that is only available some of the time. Hence these Special Requirements should be requested only if they are absolutely necessary to achieve the scientific goals of a project. It is quite possible that some proposals will be impossible to schedule because of their resource requirements, rather than a lack of scientific merit. The limited-resource Special Requirements can force the planning system to schedule the observations at a less than optimal time. The use of limited-resource Special Requirements by many observers can reduce the overall efficiency with which the planning system can schedule the science program. For these reasons, these Special Requirements should only be used when necessary to achieve the science objectives of the program. The STScI will review the necessity for the Special Requirements and in some cases may suggest removing them, or using alternate methods to obtain the same goal.

The following table summarizes the Special Requirements that involve seriously limited resources.

The need for many of these Special Requirements must be justified in the **Proposal Description**. Note that several of these Special Requirements must have been justified in the Phase I Proposal in order to be used.
legitimately in Phase II; those are **CVZ, SHADOW, LOW-SKY, and ON HOLD** for Targets of Opportunity.

Table 2.2: Limited-Resource Special Requirements

<table>
<thead>
<tr>
<th>Limited Resource</th>
<th>Reason for constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON HOLD [FOR &lt;visit-list&gt;]</td>
<td>Requires special handling (e.g., Targets of Opportunity).</td>
</tr>
<tr>
<td>RT ANALYSIS, REQuires UPLINK</td>
<td>Requires real-time TDRSS links, which are difficult to schedule and may be withdrawn at last moment.</td>
</tr>
<tr>
<td>ORIENTation &lt;angle1&gt; TO &lt;angle2&gt;, SAME ORIENTation AS &lt;visit&gt;</td>
<td>A specific orientation can be available for as little as a one-week period every six months.</td>
</tr>
<tr>
<td>SHADOW, LOW-SKY, CVZ</td>
<td>Available for only a fraction of orbits.</td>
</tr>
<tr>
<td>AFTER &lt;date&gt;, BETWEEN &lt;date1&gt; AND &lt;date2&gt;, BEFORE &lt;date&gt;, SEQuence &lt;visits-checked&gt; WITHIN &lt;time&gt;, SEQuence &lt;exposure-list&gt; NON-INterruptible (replaced by Exposure Group Containers in the APT User Interface); see Section 5.18, “Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns,” on page 101, PHASE &lt;number1&gt; TO &lt;number2&gt;,</td>
<td>Constrain scheduling opportunities. Can be mutually incompatible.</td>
</tr>
</tbody>
</table>

---

### 2.5 Text Proposal File

#### 2.5.1 Basic Syntax Rules

Users (particularly RPS2 old-timers) should be aware that some changes to the original RPS2 format were necessary to accommodate enhancements that came with APT; also, some of the syntax has been made stricter in order to make parsing of the file more robust (e.g., for special requirements).

Here are a few basic rules that must be followed:

- Commas or semicolons must be used to delimit items in a list (see specific rules in the following bullets). New lines for each item **will not** be sufficient delimiters.
- Semicolons **must** be used to delimit Special Requirements items.
• Commas must be used to delimit items in all other lists including target descriptions, target position, fluxes, optional parameters, and spectral elements.

• Only the shortest forms of the special requirements will be accepted (e.g., POSition TARGet must be POS TARG). For more information on special requirements see Chapter 7.

• Exposure lists in Special Requirements must be specified as a single range. No commas are allowed in an exposure list (e.g., use 1-5 instead of 1,2,3-5). As before, visit lists can have comma delimiters.

• The Time_Per_Exposure must be specified in seconds.

• Dates should be in the form 01-Jan-2005:00:00:00 (as an example) with the hours:minutes:seconds being optional. Other formats will not be supported except for JD, which is used for ZERO-PHASE.

2.5.2 Sample Text Proposal File Template

Your Text Proposal File should include the following and in the order given. Optional blocks are in square brackets ([ ]). The use of colons is required in the form given. Note that at least one of the three target types (Fixed, Solar System, or Generic) must be present. You can make your own template in APT from your Phase I proposal by opening it in APT and changing it to Phase II. Then enter your Phase II ID number, add a visit, and then export to a text proposal file (If you have already retrieved your proposal from STScI using the Phase II ID given to you by your PC, then the Phase II ID number will have already been filled in).

Proposal Information
Title:
Proposal_ID:
Proposal_Category:
Cycle:
[Avail_Ok:]
[StScI_Edit_Number:]

Investigators
PI_Honorific:
PI_First_Name:
PI_Middle_Initial:
Chapter 2: The Basics of Phase II Proposals

PI_Last_Name:
PI_Institution:
[CoI_Name:
CoI_Honorific:
CoI_Middle_Initial:
CoI_First_Name:
CoI_Last_Name:
CoI_Institution:
[Contact:]]

Abstract

Questions
Observing_Description:
[Real_Time_Justification:] [Calibration_Justification:] [Additional_Comments:]

[Fixed_Targets]
Target_Number:
Target_Name:
[Alternate_Names:] Description:
Position:
Equinox:J2000 Coordinate_Source:
[RV_or_Z:] [RA_PM:] [Dec_PM:] [Epoch:]
[Annual_Parallax:] Flux:
[Other_Fluxes:] [Comments:]

[Solar_System_Targets]
Target_Number:
Target_Name:
Description:
Level_1:
[Level_2:] [Level_3:] [Window:] [Ephem_Uncert:] [Acq_Uncert:] Flux:
[Other_Fluxes:]
[Comments:]

[Generic_Targets]
Target_Number:
Target_Name:
Description:
Criteria:
Flux:
[Other_Fluxes:]
[Comments:]

[Pattern_Data]
Pattern_Number:
Primary_Pattern:
Pattern_Type:
Pattern_Purpose:
Number_Of_Points:
Point_Spacing:
Line_Spacing:
Coordinate_Frame:
Pattern_Orient:
Angle_Between_Sides:
Center_Pattern:
[Secondary_Pattern:
Pattern_Type:
Pattern_Purpose:
Number_Of_Points:
Point_Spacing:
Line_Spacing:
Coordinate_Frame:
Pattern_Orient:
Angle_Between_Sides:
Center_Pattern:]
[Pattern_Comments:]

Visits
Visit_Number:
[Visit_Priority:]
[Visit_Requirements:]
[On_Hold_Comments:]
[Visit_Comments:]

Exposure_Number:
[Exposure_Label:]
Target_Name:
Chapter 2: The Basics of Phase II Proposals

Config:
Opmode:
Aperture:
Sp_Element:
[Wavelength:]
[Optional_Parameters:]
Number_of_Iterations:
Time_Per_Exposure:
[Special_Requirements:]
[Sub_Exposures:]
[Comments:]
CHAPTER 3: Fixed and Generic Targets

In this Chapter . . .

3.1 Target Number [Target_Number] / 27
3.2 Target Name [Target_Name and Alternate_Names] / 27
3.3 Target Category and Target Description [Description] / 31
3.4 Target Position Type [Position] / 36
3.5 Equinox for Coordinates [Equinox] / 44
3.6 Coordinate Reference Frame [Reference_Frame] / 45
3.7 Radial Velocity or Redshift [RV_ or _Z] / 45
3.8 Is Proper Motion or Parallax Relevant? / 45
3.9 Flux Data [Flux and Other_Fluxes] / 47
3.10 Bright-Object Constraints / 51
3.11 Comments [Comments] / 53
3.12 Generic Targets List [Generic_Targets] / 53
3.13 Getting Coordinates Coordinated / 57
The Target List tells us where you wish to point HST and so must be filled out with care, precision, and accuracy. The Target List also provides the information that defines and describe the targets, and which was used to determine exposure times. Three different kinds of Target Lists exist for the following three classes of targets, but only the Target List(s) required for your proposal need be submitted:

- Fixed targets (all targets outside the solar system whose positions can be defined by specific celestial coordinates);
- Solar-system targets (all moving targets);
• Generic targets (targets defined by certain properties, rather than by specific coordinates).

In this chapter, each heading has a description followed by a keyword in square brackets (e.g., [Number]). Elsewhere, items in boldface (e.g., RA) show words or phrases that are used as APT Phase II keywords or properties. Items in <> brackets (e.g., <value>) show values you provide. Values of items listed in square brackets (e.g., [A1: <value>]) are optional, whereas those not in square brackets are required. As you enter information in the APT interface, you will be told (via a tooltips message) if an item is required.

3.1 Target Number [Target_Number]

Each target in your program will be assigned its own unique number by APT (they are base 10 and go from 1 to 999). A different target must be defined whenever different coordinates or a different target description are required. Separate targets should be defined and listed if you plan to take observations at several points within an extended object. For example, if you were to take spectra at three different locations in the Crab Nebula, each point must have its own target number, name, and coordinates, such as CRAB1, CRAB2, and CRAB3.

If you are using the Text Proposal File, all target numbers and names within a proposal must be unique.

3.2 Target Name [Target_Name and Alternate_Names]

Target names provide unique designations for the targets that will be used throughout the proposal. These names will also be used to designate targets in the HST data archive. Prospective proposers and archival researchers use these names to determine whether HST has observed a particular object. This facility will be most useful if consistent naming conventions are used.

The following conventions must be followed in naming targets:

• A new target name must be defined for each (celestial) target. For example, for several pointings within a galaxy, one might define target names such as NGC4486-NUC, NGC4486-JET, NGC4486-POS1, and NGC4486-POS2.

• The length of a target name must be anywhere from 2 to 31 characters.
No blanks are permitted in target names. Blanks between a letter and a numeral must be suppressed (e.g., HD140283, NGC4378), but a hyphen (and not an underscore) must replace blanks between two letters or two numerals (e.g., ALPHA-CEN, NGC224-0040+4058). Also, a hyphen should be used where required for clarity (e.g., NGC4486-POS1).

Only letters, numerals, hyphens, periods (.), and + or – are allowed in target names; other punctuation is not permitted (e.g., BARNARDS-STAR is valid, but BARNARD’S-STAR is not). Greek letters must be spelled out (e.g., ALPHA-ORI). Letters may be upper-case or lower-case, but will always be treated as if they are upper case (e.g. Alpha-Cen will be treated as if written ALPHA-CEN).

Degree signs must be represented by an upper-case “D” (e.g., CD-42°14462 becomes CD-42D14462).

Some special target names are reserved for calibrations and other purposes and may not be used for names of external pointings; see Table 3.1: Designations of Special Targets.

Whenever possible, two types of designations should be provided for each target. The first will be a “catalog name” (for example, HD124897), and the second will be at most two “common names” (e.g., ALPHA-BOO, ARCTURUS). The “catalog name” is entered in Name and the “common names” are entered in Alternate_Names.

Only Target_Name is used when the target name is repeated in the Visit and Exposure Specifications. If the target is in the STScI Guide Star Catalog (GSC), the GSC name should be included as one of the common names (e.g., GSC5637-12345).

### 3.2.1 Catalog Name

The preferred order for catalogs to be used for the designation of various classes of objects is provided below. It is arranged in order of decreasing preference.

If a target is not contained in these catalogs, other catalog designations may be used (e.g., 4U X-ray catalog designation, Villanova white-dwarf catalog number, etc.). The use of positional catalogs (SAO, Boss, GC, AGK3, FK4, etc.) is discouraged.

For uncataloged targets, see Section 3.2.2 on page 29.

### Stars

1. Henry Draper Catalog number (e.g., HD140283) is preferred. HDE numbers are discouraged, except in the Magellanic Clouds.
2. *Durchmusterung* number (BD, CD, or CPD). In the southern hemisphere, adopt the convention of using CD north of −52 degrees and CPD south of there (e.g., BD+30D3639, CD-42D14462, CPD-65D7691).

3. General Catalog of Variable Stars designation, if one exists (e.g., RR-LYR, SS-CYG).

4. AFGL designation.

5. IRC designation.

6. IRAS designation.

**Star Clusters and Nebulae**

1. New General Catalog (NGC) number (e.g., NGC6397, NGC7027).

2. Index Catalog (IC) number (e.g., IC418).

3. For planetary nebulae for which you do not have an NGC or IC designation, the Perek-Kohoutek designation (e.g., PK208+33D1) may be used.

4. For H II regions for which you do not have an NGC or IC designation, the Sharpless catalog number (e.g., S106) may be used.

5. For IR nebulae, AFGL designation.

**Galaxies and Clusters of Galaxies**

1. NGC number (e.g., NGC4536).

2. IRAS designation.

3. IC number (e.g., IC724).

4. Uppsala Catalog number, only if an NGC or IC number is not available (e.g., UGC11810).

5. For clusters of galaxies, the Abell catalog number, but only if an NGC or IC number is not available (e.g., ABELL2029).

**Quasars and Active Galaxies**

1. The name defined in the compilation by Veron-Cetty and Veron (*ESO Report No. 7, 1989*) must be used (e.g., 3C273).

### 3.2.2 Uncataloged Targets

Objects that have not been cataloged or named must be assigned one of the following designations:
1. Isolated objects must be designated by a code name (the allowed codes are STAR, NEB, GAL, STAR-CLUS, GAL-CLUS, QSO, SKY, FIELD, and OBJ), followed by a hyphen and the object’s J2000 equatorial coordinates, if possible, rounded to seconds of time and seconds of arc (e.g., for a star at J2000 coordinates RA: 1H 34M 28S, DEC: –15D 31’ 38", the designation would be STAR-013428-153138).

2. Uncataloged objects within star clusters, nebulae, or galaxies must be designated by the name of the parent body followed by a hyphen and the rounded J2000 coordinates, if possible, of the object (e.g., for a target within NGC 224 with J2000 coordinates RA: 0H 40M 12S, DEC: +40D 58’ 48", the designation would be NGC224-04012+405848).

3. Positions within nebulae or galaxies may also be designated by the name of the parent object followed by a hyphen and a qualifier. The qualifier should be brief, but informative (e.g., the jet in NGC 4486 could be designated NGC4486-JET). Other examples are: NGC5139-ROA24, LMC-R136A, ABELL30-CENTRAL-STAR, NGC205-NUC.

3.2.3 Common Names

In addition to the catalog name, a target should be assigned at most two “common names,” or aliases, if they exist. Examples of common names are the following:

1. Stars: The Bayer (Greek-letter) designation or Flamsteed number with standard three-letter constellation abbreviation (e.g., ZETA-CAP, 22VUL, OMICRON2-ERI-B); the Bright Star Catalog number (e.g., HR5270); other names, if they exist (e.g., CYG-X1, BARNARDS-STAR, PROXIMA-CEN).

2. Star clusters, nebulae, galaxies, and clusters of galaxies: Commonly used names (e.g., HYADES, OMEGA-CEN, CRAB-NEBULA, ABELL63, COMA-CLUSTER); Messier numbers (e.g., M13, M31, M67).

3.2.4 Special Targets

The names of certain types of targets must be designated by appending a code to the target name. For example, -CALIB should be appended to the name of a target that is being observed only as a calibration standard for other observations. These designations will assist in planning of the observing schedule. The possible codes are listed in Table 3.1.
### 3.3 Target Category and Target Description

A target description must be selected for each target. The Target Description will be one of the key fields used by archival researchers in searching through the HST data archive; thus it is extremely important that the information be filled out completely and accurately for each target.

Each target must be assigned a single primary category from Table 3.2, and at least one descriptive keyword, chosen from the appropriate Table 3.3 through Table 3.9 (see Table 3.2 for which table is appropriate for each category). The discrete features and descriptors in Table 3.10 may be used as descriptive keywords for any category. A maximum of five descriptive keywords may be selected.

The categories in Table 3.2, and some of the descriptive keywords in Table 3.3 through Table 3.10, are followed by explanatory text in parentheses. This text is provided only for explanatory purposes and is not part of the category or keyword itself.

---

#### Table 3.1: Designations of Special Targets

<table>
<thead>
<tr>
<th>Target Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>External calibration target</td>
<td>-CALIB</td>
<td>An astronomical target used for calibration (e.g., BD+28D4211-CALIB). Internal calibration sources (e.g., WAVE) and calibrations using the Earth must not be included in the Target List.</td>
</tr>
<tr>
<td>Offset acquisition target</td>
<td>-OFFSET</td>
<td>A target that will be used for an offset acquisition; it is the object that will be acquired first, from which an offset will be applied to move to the target of interest (e.g., 3C273-OFFSET). Two separate exposures must be defined on the Visit and Exposure Specifications; an acquisition of the -OFFSET target, and a science exposure of the (target of interest) program target. The location of the latter target may be specified either by equatorial coordinates or by an offset (see Section 3.4 on page 36). For example: to observe the JET in 3C273, first acquire “stellar-like” source 3C273-OFFSET, then offset to program target 3C273-JET.</td>
</tr>
<tr>
<td>Special designations</td>
<td></td>
<td>These are reserved designations and may not be used as the names of external pointing in a target list: ANTI-SUN, ANY, BIAS, CCDFLAT, DARK, EARTH-CALIB, DARK-EARTH-CALIB, INT-FLAT, KSPOTS, NONE, ORBIT-POLE, ORBIT-POLE-NORTH, ORBIT-POLE-SOUTH, UVFLAT, VISFLAT, WAVE</td>
</tr>
</tbody>
</table>

---
Text Proposal File

If you are using the Text Proposal File, target description items must be separated by commas.

Table 3.2: Target Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Descriptive Keywords</th>
<th>Discrete Features and Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLAR SYSTEM (Solar System Object)</td>
<td></td>
<td>Chapter 4: Solar System Targets on page 59</td>
</tr>
<tr>
<td>STAR (Galactic Stellar Object)</td>
<td></td>
<td>Table 3.3</td>
</tr>
<tr>
<td>EXT-STAR (Star in an External Galaxy)</td>
<td></td>
<td>See Table 3.10</td>
</tr>
<tr>
<td>STELLAR CLUSTER (Galactic Star Cluster, Group, or Association)</td>
<td></td>
<td>Table 3.4</td>
</tr>
<tr>
<td>EXT-CLUSTER (Star Cluster in an External Galaxy)</td>
<td></td>
<td>Table 3.4</td>
</tr>
<tr>
<td>GALAXY (Galaxy or AGN)</td>
<td></td>
<td>Table 3.5</td>
</tr>
<tr>
<td>CLUSTER OF GALAXIES (Galaxy Groupings, Clusters, Large-scale Structure)</td>
<td></td>
<td>Table 3.6</td>
</tr>
<tr>
<td>ISM (Interstellar Medium of the Galaxy)</td>
<td></td>
<td>Table 3.7</td>
</tr>
<tr>
<td>EXT-MEDIUM (Interstellar Medium of an External Galaxy)</td>
<td></td>
<td>Table 3.7</td>
</tr>
<tr>
<td>UNIDENTIFIED (Unidentified Objects)</td>
<td></td>
<td>Table 3.8</td>
</tr>
<tr>
<td>CALIBRATION (Calibration Observations)</td>
<td></td>
<td>Table 3.9</td>
</tr>
</tbody>
</table>

Table 3.3: Descriptive Keywords for STAR and EXT-STAR

<table>
<thead>
<tr>
<th>Brown Dwarf</th>
<th>F0-F2</th>
<th>Herbig Ae/Be</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wolf Rayet</td>
<td>F3-F9</td>
<td>Horizontal Branch Star</td>
</tr>
<tr>
<td>Wolf Rayet – WC</td>
<td>FP</td>
<td>Interacting Binary</td>
</tr>
<tr>
<td>Wolf Rayet – WN</td>
<td>Late-type Degenerate</td>
<td>X-ray Novae</td>
</tr>
<tr>
<td>Main Sequence O</td>
<td>G V-IV</td>
<td>X-ray Burster</td>
</tr>
<tr>
<td>Giant O</td>
<td>G III-I</td>
<td>X-ray Transient</td>
</tr>
<tr>
<td>Supergiant O</td>
<td>K V-IV</td>
<td>LMXB (Low Mass X-ray Binary)</td>
</tr>
<tr>
<td>OE</td>
<td>K III-I</td>
<td>Gamma Ray Burster</td>
</tr>
<tr>
<td>OF</td>
<td>M V-IV</td>
<td>MXB (Massive X-ray Binary)</td>
</tr>
<tr>
<td>SDO</td>
<td>M III-I</td>
<td>RS CVn Star</td>
</tr>
<tr>
<td>WDO</td>
<td>L</td>
<td>W UMa Star</td>
</tr>
<tr>
<td>Target Category and Target Description [Description]</td>
<td>Table 3.3: Descriptive Keywords for STAR and EXT-STAR(Cont)</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>B0-B2 V-IV T</td>
<td>Beta Lyrae Star</td>
<td></td>
</tr>
<tr>
<td>B3-B5 V-IV S Star</td>
<td>Algol System</td>
<td></td>
</tr>
<tr>
<td>B6-B9.5 V-IV Carbon Star</td>
<td>Barium Star</td>
<td></td>
</tr>
<tr>
<td>B0-B2 III-I Long Period Variable</td>
<td>Blue Straggler</td>
<td></td>
</tr>
<tr>
<td>B3-B5 III-I Irregular Variable</td>
<td>Neutron Star</td>
<td></td>
</tr>
<tr>
<td>B6-B9.5 III-I Regular Variable</td>
<td>Pulsar</td>
<td></td>
</tr>
<tr>
<td>E Luminous Blue Variable</td>
<td>Binary Pulsar</td>
<td></td>
</tr>
<tr>
<td>B Dwarf Nova</td>
<td>FK Comae Star</td>
<td></td>
</tr>
<tr>
<td>SDB Classical Nova</td>
<td>Pulsating Variable</td>
<td></td>
</tr>
<tr>
<td>D Nova-like</td>
<td>PG1159 Star</td>
<td></td>
</tr>
<tr>
<td>DA Recurrent Nova</td>
<td>ZZ Ceti Star</td>
<td></td>
</tr>
<tr>
<td>DC Polar (AM Her Star)</td>
<td>Cepheid</td>
<td></td>
</tr>
<tr>
<td>DZ Intermediate Polar (DQ Her Star)</td>
<td>Supernova</td>
<td></td>
</tr>
<tr>
<td>A0-A3 V-IV Symbiotic Star</td>
<td>Supernova Type Ia</td>
<td></td>
</tr>
<tr>
<td>A4-A9 V-IV T Tauri Star</td>
<td>Supernova Type Ib</td>
<td></td>
</tr>
<tr>
<td>A0-A3 III-I FU Orionis Star</td>
<td>Supernova Type II</td>
<td></td>
</tr>
<tr>
<td>A4-A9 III-I Shell Star</td>
<td>RR Lyrae Star</td>
<td></td>
</tr>
<tr>
<td>A Eta Carinae Star</td>
<td>Planetary Nebula Central Star</td>
<td></td>
</tr>
<tr>
<td>AM YSO</td>
<td>Emission Line Star</td>
<td></td>
</tr>
<tr>
<td>AP Extra-solar Planet</td>
<td>Circumstellar Matter</td>
<td></td>
</tr>
<tr>
<td>AGB Star Extra-solar Planetary System</td>
<td>Post-AGB Star Pre-main sequence Star Population II</td>
<td></td>
</tr>
<tr>
<td>Composite Spectral Type Low Mass Companion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3.4: Descriptive Keywords for STELLAR CLUSTER and EXT-CLUSTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globular Cluster OB Association</td>
</tr>
<tr>
<td>Open Cluster T Association</td>
</tr>
<tr>
<td>Young Association</td>
</tr>
</tbody>
</table>
### Table 3.5: Descriptive Keywords for GALAXY

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiral</td>
<td>(Spiral Galaxy)</td>
</tr>
<tr>
<td>Lenticular</td>
<td>(Lenticular Galaxy)</td>
</tr>
<tr>
<td>Elliptical</td>
<td>(Elliptical Galaxy; Not A Dwarf Elliptical)</td>
</tr>
<tr>
<td>Dwarf Elliptical</td>
<td></td>
</tr>
<tr>
<td>Magellanic Irregular</td>
<td></td>
</tr>
<tr>
<td>Amorphous Irregular</td>
<td></td>
</tr>
<tr>
<td>Dwarf Compact</td>
<td>(Dwarf Compact/HII Galaxy)</td>
</tr>
<tr>
<td>Dwarf Spheroidal</td>
<td></td>
</tr>
<tr>
<td>BCM</td>
<td>(Brightest Cluster Member)</td>
</tr>
<tr>
<td>BGM</td>
<td>(Brightest Group Member)</td>
</tr>
<tr>
<td>LSB</td>
<td>(Low Surface Brightness/HI Rich Galaxy)</td>
</tr>
<tr>
<td>Seyfert</td>
<td></td>
</tr>
<tr>
<td>QSO</td>
<td>(Radio Quiet)</td>
</tr>
<tr>
<td>Quasar</td>
<td>(Radio Loud)</td>
</tr>
<tr>
<td>Radio Galaxy</td>
<td></td>
</tr>
<tr>
<td>BL Lac</td>
<td>(BL Lac or BLAZAR)</td>
</tr>
<tr>
<td>Liner</td>
<td></td>
</tr>
<tr>
<td>Starburst</td>
<td></td>
</tr>
<tr>
<td>Ultraluminous IR Gal</td>
<td></td>
</tr>
<tr>
<td>Interacting Galaxy</td>
<td></td>
</tr>
<tr>
<td>Lyman Alpha Cloud</td>
<td></td>
</tr>
<tr>
<td>Protogalaxy</td>
<td></td>
</tr>
<tr>
<td>Einstein Ring</td>
<td></td>
</tr>
<tr>
<td>High Redshift Galaxy</td>
<td>(z &gt; 0.5)</td>
</tr>
</tbody>
</table>

### Table 3.6: Descriptive Keywords for CLUSTER OF GALAXIES

<table>
<thead>
<tr>
<th>Cluster Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supercluster</td>
<td>Interacting Galaxy</td>
</tr>
<tr>
<td>Void</td>
<td>BCM (Brightest Cluster Member)</td>
</tr>
<tr>
<td>Group</td>
<td>BGM (Brightest Group Member)</td>
</tr>
<tr>
<td>Rich Cluster</td>
<td></td>
</tr>
<tr>
<td>Poor Cluster</td>
<td>Einstein Ring</td>
</tr>
<tr>
<td>High Redshift Cluster</td>
<td>(z &gt; 0.5) Blank Sky</td>
</tr>
<tr>
<td>Galaxy Pair</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3.7: Descriptive Keywords for ISM and EXT-MEDIUM

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbig-Haro Object</td>
<td>Cometary Nebula</td>
</tr>
<tr>
<td>Planetary Nebula</td>
<td>Molecular Cloud</td>
</tr>
<tr>
<td>HII Region</td>
<td>Bipolar Outflow</td>
</tr>
<tr>
<td>Reflection Nebula</td>
<td>Absorption Line System</td>
</tr>
<tr>
<td>Dark Cloud</td>
<td>Absorption Line System – Galactic</td>
</tr>
</tbody>
</table>
Table 3.7: Descriptive Keywords for ISM and EXT-MEDIUM (Cont)

<table>
<thead>
<tr>
<th>SNR (Supernova Remnant)</th>
<th>Absorption Line System – Extragalactic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring Nebula</td>
<td>Damped Lyman Alpha Cloud (Extragalactic)</td>
</tr>
<tr>
<td>HI Cloud</td>
<td>Coronal Gas ((10^5–10^6 \text{ K}))</td>
</tr>
<tr>
<td>High Velocity Cloud</td>
<td>Hot Gas ((10^7–10^8 \text{ K}))</td>
</tr>
<tr>
<td>Intermediate Velocity Cloud</td>
<td>IGM</td>
</tr>
<tr>
<td>IRAS Cirrus</td>
<td>ICM</td>
</tr>
<tr>
<td>PDR (Photon Dominated Region)</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.8: Descriptive Keywords for UNIDENTIFIED

<table>
<thead>
<tr>
<th>Radio Emitter</th>
<th>Ultraviolet Emitter</th>
<th>Blank Field</th>
<th>Low Latitude Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrared Emitter</td>
<td>X-ray Emitter</td>
<td>Parallel Field</td>
<td></td>
</tr>
<tr>
<td>Optical Emitter</td>
<td>Gamma Ray Emitter</td>
<td>High Latitude Field</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.9: Descriptive Keywords for CALIBRATION

<table>
<thead>
<tr>
<th>Astrometric</th>
<th>Narrow Band Filter Calibration</th>
<th>Target Acquisition Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photometric</td>
<td>FGS Stability</td>
<td>Detector Sensitivity Test</td>
</tr>
<tr>
<td>Wavelength</td>
<td>Quantum Efficiency Test</td>
<td>Focus Test</td>
</tr>
<tr>
<td>Point Spread Function</td>
<td>Pointing and Jitter Test</td>
<td>Spacecraft Glow</td>
</tr>
<tr>
<td>Occulting Finger Location</td>
<td>Raster &amp; Step/Dwell Scan Verification</td>
<td>Occultation Mode Test</td>
</tr>
<tr>
<td>Ion</td>
<td>Spatial Distortion Test</td>
<td>Throughput Test</td>
</tr>
<tr>
<td>Taled</td>
<td>Polariometry</td>
<td>Echelle Blaze Function</td>
</tr>
<tr>
<td>Scattered Light Test</td>
<td>Aperture Location</td>
<td>Virtual Pointing</td>
</tr>
<tr>
<td>Sky Background</td>
<td>Detector Linearity Test</td>
<td>FGS Transfer Function Test</td>
</tr>
<tr>
<td>Instrument Sensitivity Test</td>
<td>Carrousel Stability Test</td>
<td>Shutter Control Test</td>
</tr>
</tbody>
</table>

Table 3.10: Discrete Features and Descriptors for All Categories

<table>
<thead>
<tr>
<th>Corona</th>
<th>Disk</th>
<th>BLR (Broad Line Region)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring</td>
<td>Bulge</td>
<td>NLR (Narrow Line Region)</td>
</tr>
<tr>
<td>Ansae</td>
<td>Polar Ring</td>
<td>Filament</td>
</tr>
<tr>
<td>Protoplanetary Disk</td>
<td>Dust Lane</td>
<td>Ejecta</td>
</tr>
</tbody>
</table>
A position type is required for each fixed target. It may be expressed in any one of three different ways:

- By specifying the equatorial coordinates (RA and DEC) of the target;
- By specifying a positional offset from another target; or
- By specifying a region (area) of the sky.

It is also possible to specify that the coordinates were obtained using the Guide Star Selection System (GSSS; see 3.4.5 Determining Coordinates in the Guide Star Selection System (GSSS) Reference Frame on page 42), or that they are currently uncertain or unknown, and that more accurate coordinates will be provided by the observer after an early acquisition exposure is taken, or in real time during the HST observations.

**Text Proposal File**

If you are using the Text Proposal File, target position items must be separated by commas.

### 3.4.1 Required Accuracies of Target Positions

The HST Scientific Instruments (SIs) typically have very small apertures and fields of view. Target-acquisition apertures for several of the SIs are only a few seconds of arc in size. Since the HST has no analog to the video acquisition cameras common on many ground-based telescopes, it is essential to have accurate coordinates for targets. In many cases targets will be placed in the final observing aperture after a sequence of target-acquisition observations. This will only work, however, if the target
coordinates are sufficiently accurate and precise to place the target in the
first of these acquisition apertures.

HST uses two guide stars to stabilize the pointing of the telescope and to
place the target in the desired aperture. The fundamental problem, then, is
to determine the position of the target relative to the guide stars in the
surrounding area with sufficient accuracy to place the target in the
aperture. The specific pair of guide stars to be used cannot be determined in
advance of the observation; several possible pairs will often be available
for each target. The guide stars are chosen from the Guide Star Catalog 2
(GSC2). Over the HST FOV, the relative position errors between guide
stars is 0.15" (1 sigma), while the absolute positions on the ICRS have
errors of 0.25" (1 sigma). Note that these errors are derived at the epoch of
the GSC plate and will increase slowly in time due to proper motion.

The accuracies of positions typically needed for target acquisition with
each of the SIs are shown in Table 3.11; these are predicated upon the
positions being in International Celestial Reference System (ICRS), which
is the reference frame of the GSC2 catalog. Note that several of the SIs
have multiple acquisition apertures of different sizes that may be used. Be
sure when selecting acquisition apertures to keep the coordinate
uncertainties in mind. Furthermore, be sure to provide one sigma
uncertainties with your positions so that STScI may check the
appropriateness of your acquisition exposures. Inaccurate target
coordinates can result in failed target acquisitions and can therefore waste
valuable HST observing time. As indicated in Table 3.11, it is the
observer’s responsibility to provide accurate coordinates in all cases,
but in particular they must be in the ICRS reference frame when using
STIS, COS and with the NIC1 and NIC2 detectors. Please contact your
PC if you need additional information. Although ICRS frame-based
coordinates are not required for FGS observations, it is still prudent to
check the accuracy of your coordinates. All observers will be provided
target confirmation charts by their PC to help them verify the target
coordinates in the ICRS reference frame. The Principal Investigator of a
program is responsible for ensuring that target coordinates are accurate,
both at the time of program submission, and later when phase 2 finder
charts are provided. These charts can be found at

http://HSTsupport/HSTsupport.htm

Note: HST proposals executed before July 1991, as well as engineering
proposals of type OV, SV, SMOV, and CAL, should not be used to derive
target coordinates. Coordinates from such proposals may be unreliable
owing to poor calibration and/or engineering-related pointing changes
made during the observations.
3.4.2 Equatorial Coordinates

If you specify the target position directly in terms of equatorial coordinates (as opposed to specifying an offset or a region), then the right ascension and declination values must be provided:

**RA:** \(<\text{value}>\)  \hspace{1cm} **DEC:** \(<\text{value}>\)

**RA:** +/- \(<\text{uncertainty}>\)  \hspace{1cm} **DEC:** +/- \(<\text{uncertainty}>\).

- The uncertainties default to 0.1". They should represent the accuracy (1 sigma) of the target coordinates, not the region within which a target could be observed (e.g., for a sky measurement). See 3.4.4 Region of Sky (Extended Targets) on page 41 for instructions on how to designate regions as targets.

- The right-ascension value must be expressed in hours\((H)\), minutes\((M)\), and seconds of time\((S)\).

---

<table>
<thead>
<tr>
<th>Instrument Configuration</th>
<th>Accuracy Required (1 sigma, arcsec)</th>
<th>ICRS Coordinates Required?</th>
</tr>
</thead>
<tbody>
<tr>
<td>STIS</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>FGS</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>ACS/WFC</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>ACS/SBC</td>
<td>5</td>
<td>No</td>
</tr>
<tr>
<td>NIC1</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>NIC2 (2)</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>NIC3 (2)</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>COS/FUV</td>
<td>0.3</td>
<td>Yes</td>
</tr>
<tr>
<td>COS/NUV</td>
<td>0.3</td>
<td>Yes</td>
</tr>
<tr>
<td>WFC3/UVIS</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>WFC3/IR</td>
<td>10</td>
<td>No</td>
</tr>
</tbody>
</table>

1. If multiple NICMOS detectors are being used in parallel, the primary detector (the detector used for the exposures in the <primary-exp-list> of the PARallel WITH Special Requirement; see PARallel <parallel-exp-list> WITH <primary-exp-list> (replaced by Coordinated Parallel Containers in the APT User Interface)) determines the required coordinate accuracy for the observation and whether GSC2 frame-based coordinates are required.
• The declination value must be expressed in degrees (D), minutes ('), and seconds (") of arc.

• The units must be selected (from a pull down list) for both the value and its uncertainty. The uncertainty must be expressed in one and only one of the units used to express the related RA and/or DEC, with the additional units of minutes (') of arc or seconds (") of arc being allowed for right ascension. (In other words, the RA may be expressed as a combination of three units (H M S), but its uncertainty must be in terms of a single unit such as S or "). To clarify:

<table>
<thead>
<tr>
<th>Quantity and units specified</th>
<th>Acceptable units for uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA: H-M-S</td>
<td>timemin, timesec, arcmin, arcsec</td>
</tr>
<tr>
<td>DEC: D-M-S</td>
<td>degrees, arcmin, arcsec</td>
</tr>
</tbody>
</table>

**Note:** If the sign of the declination is not indicated, a positive declination is assumed, but we urge you to always include the sign as a way of reducing errors.

**Text Proposal File**

In the Text Proposal File you must use the following format for RA and DEC (note the comma delimiters):

```
RA = <value> +/- <uncertainty>, DEC = <value> +/- <uncertainty>
```

The comma following the right-ascension uncertainty is required.

• The right-ascension value must be expressed in hours (H), minutes (M), and seconds (S) of time. The declination value must be expressed in degrees (D), minutes ('), and seconds (") of arc (For example: RA = 12H 7M 13.33S +/- 0.15S, DEC = +27D 3' 8.0" +/- 0.1")

• Units must be provided for both a value and its uncertainty (see "Acceptable units for uncertainty")

### 3.4.3 Positional Offsets

The position of a target may alternatively be specified as an offset from a reference target. Note, however, that offsets larger than 30 arcsec may complicate the target acquisition procedure. If larger offsets are desired, please contact your Program Coordinator.

Offsets are always in the sense offset = target-coordinates minus offset-reference-coordinates. As with other similar quantities, we urge
you to include the sign of the offset, even when it is positive, as a means of removing ambiguity.

Note that you select the <target name> which has the equatorial coordinates of the reference target, and that reference-target names have –OFFSET appended to them (see Table 3.1).

Positional offsets are only a convenient method of specifying target coordinates, and do not automatically imply a particular method of target acquisition; observers must explicitly specify any target acquisitions on the Visit and Exposure Specifications via Special Requirements (see Chapter 7: Special Requirements [Visit and Exposure Special_Requirements] on page 111).

**Warning:** If your object has significant proper motion no correction may be applied. See 3.8 Is Proper Motion or Parallax Relevant? on page 45, where it notes that the proper motion for the target is taken to be the same as for the offset object.

You specify the offset as a difference in EQUATORIAL coordinates from a target <name>:

**Position Type:** Offset

**Offset:** RA: <value>  DEC: <value>

**Uncertainty:** RA: <value>  DEC: <value>

**From Target:** <target name>

The value for RA offset may be in units of seconds of time or in decimal degrees, and the value for DEC offset may be in units of arcmin (') or arcsec ("), or in decimal degrees (see example below). The uncertainty must be expressed in one and only one of the units used to express the related RA and/or DEC.

By default APT provides a value of 0.1" for the uncertainties.

**Example:** NGC2654’s right ascension is 2.34 seconds of time less than the reference target (NGC2654-OFFSET), and its declination is 1.6 arcsec greater than NGC2654-OFFSET. The specifications for NGC2654 would be:

**Position Type:** Offset

**Offset:** RA: -2.34S  DEC: 1.6"

**Uncertainty:** RA: 0.01S  DEC: 0.1"

**From Target:** NGC2654-OFFSET

**Text Proposal File**

The format for an offset specification as a difference in equatorial coordinates is:
RA-OFF = <value> +/- <uncertainty>,  DEC-OFF = <value> +/- <uncertainty>,  FROM <target number>

Note the uncertainties and the commas separating the three items. The value for RA-OFF may be in units of seconds (S) of time, or in decimal degrees (D), and the value for DEC-OFF may be in units of arcmin (') or arcsec ("), or in decimal degrees (D). The uncertainty must be expressed in one and only one of the units used to express the related RA and/or DEC.

3.4.4 Region of Sky (Extended Targets)

Sometimes it is necessary to define a region of sky rather than a specific point. Examples are extended targets (such as emission nebulae and galaxies) and blank-sky regions for background measurements (if it is acceptable to make the observation anywhere within a region). An Equinox value should be specified with the region coordinates (see Section 3.5 on page 44).

The units used for regions should be used in the same way as for coordinates; see Section 3.4.2 on page 38. You can choose either a rectangular or a circular region.

- **Rectangular**: Specify the equatorial coordinates and the sides of a rectangle (for RA in arcsec, arcmin, minutes of time or seconds of time; for DEC in arcsec, arcmin or degrees)
- **Circular**: Specify the equatorial coordinates and a radius (in arcsec, arcmin or degrees)

**Text Proposal File**

For a rectangular region, the format for equatorial coordinates must be used followed by a comma and the word REGION; the values following +/- will then be interpreted as one-half the lengths of the sides of the rectangular area, rather than as uncertainties in the coordinates.

In the following example, a region 4 arcmin wide in right ascension by 2 arcmin high in declination is specified:

RA = 3H 51M 27S +/- 2', DEC = -37D 13' 25" +/- 1', REGION

For a circular region, REGION must be followed by another comma and the radius of the region in the format R = <radius>; in this case, no uncertainties should be attached to the RA and DEC. Here is an example of a circular region with a radius of 2 arcmin:

RA = 3H 51M 27S, DEC = -37D 13' 25", REGION, R = 2'

Note that the units of R must be specified.
Circular Region

If it is desired to specify a circular region, **REGION** must be followed by another comma and the radius of the region in the format **R = <radius>;** in this case, no uncertainties should be attached to the **RA** and **DEC.** Here is an example of a circular region with a radius of 2 arcmin:

\[ RA = 3H 51M 27S, \ DEC = -37D 13' 25'', \ REGION, \ R = 2' \]

Note that the units of **R** must be specified.

3.4.5 Determining Coordinates in the Guide Star Selection System (GSSS) Reference Frame

The HST reference frame is effectively defined by the positions of the Guide Stars that are selected for each pointing. Since launch, we have used the Guide Star Catalog (GSC1) which was an all-sky catalog of stars down to 15th magnitude built from Schmidt Sky Survey plates. This catalog has been updated (GSC2) with more recent epoch plates and calibrated to be on the International Celestial Reference System (ICRS), which has been adopted by the IAU as the new fundamental reference frame. This simplifies the procedure for providing HST coordinates since it removes the necessity to tie the object coordinates back to the GSC1 and the plates used to construct it.

For observations that require accurate coordinates, such as those listed as "ICRS Coordinates Required" in Table 3.11, it is vital that you provide positions derived in the ICRS reference frame.

General Guidelines

- If your target has a position that is in a catalog using the ICRS you may use the coordinates directly. These include GSC2, Hipparcos, Tycho, SDSS, 2MASS and FIRST.

- If your target is an extended object where the observation position does not correspond to the catalog coordinates, we recommend that you obtain an image of the field and measure your target coordinates in the ICRS reference frame. Typically, this is done by measuring a sufficient number of reference stars (for example, from GSC2, Tycho, Hipparcos, 2MASS, SDSS - any catalog that uses the ICRS) to derive your astrometric transformation.

- If your target has a relevant proper motion, you must provide the epoch of the coordinate as well as the proper motion values (see Section 3.8, “Is Proper Motion or Parallax Relevant?,” on page 45.)
• Access to the GSC2, the Digitized Sky Survey (DSS) and other catalogs/surveys is built into the Aladin interface in APT (Note: for the DSS use the POSS2UKSTU-Red plates that were used to build GSC2). You can also find links to query the GSC2 catalog and retrieve POSS2UKSTU-Red DSS images on the HST Support web page at http://gsss.stsci.edu/HSTsupport/HSTsupport.htm.

Getting Coordinates from the GSC2 or DSS

• If your target is a star brighter than m(V)~20 then it typically will be visible on the DSS images and present in the GSC2 catalog. Using the GSC2 position will ensure that the target is in the same reference frame as the selected guide stars.

• Please enter the GSC2 name as a target alias in Alternate_Names.

• For extended sources visible on the photographic survey plates, we strongly recommend that you examine the DSS image and check your coordinates. Depending on the brightness, morphology and structure of the galaxy the GSC2 coordinate may not correspond to the aperture location you require for your observation. The DSS headers downloaded from STScI contain ICRS-based FITS WCS information to allow you to measure the image using Aladin (or other image analysis tool).

• Please note that the GSC2 coordinates for bright stars come from the Tycho2 catalog as these are more accurate than positions measured from the Schmidt plates.

• Using coordinates from GSC 1.1 associated special catalogs will be permitted only under exceptional circumstances (contact your Program Coordinator). Other uses of GSC 1.1 are not allowed. Coordinates from the development version GSC 1.2 cannot be used at all as it is not available in the HST ground system.

• If you have used HST to observe a target in an earlier cycle and already have GSC1 based coordinates, you also have the option of using a ‘Coordinate-Convertor’ that is available at the HST Support page. This is a simple web-based tool that allows one to enter either a GSC1 ID or coordinate. In the case of an ID it will directly look up the GSC2 coordinate for that object. If you enter a coordinate, it will derive a mean offset between GSC1 and GSC2 over the HST FOV and apply that correction to the position.

As part of preparing your observations your Program Coordinator will provide, as a final check that the coordinates are correct, a Confirmation Chart showing the target coordinates (as entered in the proposal) overlaid on the field from the DSS. Ultimately, you are responsible for verifying
that the coordinates are correct (see Section 3.4.1, “Required Accuracies of Target Positions,” on page 36).

3.4.6 A Caution on Astrometry Prepared from STScI Plate Scans

Note that the set of plates used to construct the GSC2 coordinates is NOT the same one that is contained in the 102-volume set of CD ROMs distributed as the Digitized Sky Survey (DSS-I). The GSC2 coordinates are primarily derived from the POSS-II Red survey in the northern hemisphere and the AAO-SES/ER Red surveys in the south. These images are only available on-line. If you wish to measure your target coordinates from these images, please download the images using the links from the CASG Web server listed above.

3.4.7 Early Acquisitions

If it is impossible to obtain adequate plate material to measure coordinates to the required accuracy (for example, a very crowded field which cannot be resolved using ground-based observations), it may be necessary to obtain an early acquisition image or to perform an acquisition that involves real-time interaction with the telescope (see Section 7.3.1 on page 133). In that case, enter coordinates as accurate as possible on the Target List.

3.5 Equinox for Coordinates [Equinox]

The year of the equator and equinox to which the coordinates are referred must be J2000 (Julian).

It is not necessary to apply precession corrections to coordinates from positional catalogs. The Guide Star Catalog and the Hipparcos Input Catalogue both use the J2000 equinox. (Note, however, that the Hipparcos output catalogue is epoch 1991.25, which means proper motions can have significant effects if you are not careful.)

For some notes on Equinox, Epoch, and units, see Section 3.13 on page 57.
3.6 Coordinate Reference Frame [Reference_Frame]

This keyword replaces Coordinate_Source starting with Cycle 14 Calibration and all Cycle 15 programs. Select one of the following Reference_Frame values for each target.

ICRS
To be used if the coordinate reference frame is tied to the International Celestial Reference System (ICRS). Catalogs tied to the ICRS include: HST Guide Star Catalog 2 (GSC2), Hipparcos Catalog and the Tycho-2 Catalog.

GSC1
To be used if the coordinate reference frame is tied to the HST Guide Star Catalog 1. The Plate ID of the special catalogs (those with an ID ZZZx, where x=0-9, a-z) must be included with your coordinates.

Other
To be used if the coordinates are not GSC1 or ICRS.

3.7 Radial Velocity or Redshift [RV_ or _Z]

Give, if known, the heliocentric radial velocity or redshift of the target. The format is <velocity in km/sec> or <redshift>; examples are +1198 (Radial Velocity) and 1.95 (Z). The units must not be specified.

Text Proposal File
In the Text Proposal File the format is V = +1198 and Z = 1.95.

3.8 Is Proper Motion or Parallax Relevant?

If a small aperture or occulting spot is to be used, even a relatively small proper motion or parallax may cause difficulties in acquiring the target. In such cases, the Proper Motion/Parallax data must be provided. Note, however, that proper motion and parallax values may not be specified for a target which is specified by a positional offset. Such targets will be taken to have the same proper motion and parallax as the reference target.
The observer must determine whether or not proper motion or parallax is relevant. In general, this will depend on the size of the acquisition aperture of the SI that will be used and the epoch of the coordinates that have been provided. For example, the STIS uses a target acquisition area of 5 arcsec square. For a star whose coordinates are given for the epoch 1950, and that will be observed in 1997, a proper motion of approximately $0.5 \times 2.5/(1997–1950) = 0.027$ arcsec per year would be “relevant,” with a resulting offset of half the minimum center-to-edge distance.

3.8.1 Proper Motion and Parallax Data

The following information is required for targets where proper motion and parallax are “relevant”; note that uncertainties for $\text{RA}_{\text{PM}}, \text{Dec}_{\text{PM}},$ and $\text{Annual}_{\text{Parallax}}$ are not required. If a sign is not given for $\text{RA}_{\text{PM}}$ or $\text{Dec}_{\text{PM}}$, a positive value will be assumed, but it is better to be explicit.

- $\text{RA}_{\text{PM}}$: For Proper Motion in RA, the value can be in units of mas/year, arcsec/year or seconds of time/year. To convert from arcsec/year to seconds of time/year, divide by $15 \cos \text{DEC}$.
- $\text{Dec}_{\text{PM}}$: For Proper Motion in DEC, the value can be in units of mas/year or arcsec/year.
- $\text{Epoch}$: The “Epoch of position” is the date of the “Target Position” which was defined in the Target List (see Section 3.4 on page 36).
- The “Epoch of position” may or may not be the same as the date of “Equinox for Coordinates” in the Target List (see Section 3.5 on page 44). Remember that the “Epoch of position” is the date the target position is referred to, whereas the “Equinox of Coordinates” is the date of orientation of the coordinate system in which the position is measured. For example, a star with a large proper motion may have its coordinates given in the J2000 system, but the numbers themselves are for epoch 1984, meaning that the star was at the specified position on January 1, 1984. Epoch should be of the form 20yy.y or 19yy.y.
- Ordinarily the epoch of position is earlier than the present date. In the Guide Star Catalog (GSC), the equinox is J2000 while the epoch depends on the individual plate. Do not adjust your coordinates to be those that would be measured if the plate were taken in the year 2000. However, some catalogs contain coordinates already adjusted to an epoch of J2000: the Hipparcos Input Catalogue (often used in the GSC for stars brighter than $m(V) \approx 9$) and the PPM Star Catalog. When these catalogs are being used, it is appropriate to specify an epoch of J2000. (These remarks do not apply to the Hipparcos Output Catalog.)

- $\text{Annual}_{\text{Parallax}}$: The unit for parallax is arcsec.
The example below is for the object **DM–9D697 (Epsilon Eridani)**, where the proper motion data are taken from the SAO Catalog.

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Explanation</th>
<th>Units</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA_PM</td>
<td>Proper Motion in RA</td>
<td>mas/yr, arcsec/yr or sec/yr</td>
<td>–0.0662</td>
</tr>
<tr>
<td>DEC_PM</td>
<td>Proper Motion in DEC</td>
<td>mas/yr or arcsec/yr</td>
<td>19 mas/yr</td>
</tr>
<tr>
<td>Epoch</td>
<td>Epoch of Position</td>
<td>20yy.yy or 19yy.y</td>
<td>1984.5</td>
</tr>
<tr>
<td>Annual_Parallax</td>
<td>Annual parallax</td>
<td>arcsec</td>
<td>0.30488</td>
</tr>
</tbody>
</table>

For some notes on proper motions and units, see **Section 3.13 on page 57**.

### 3.9 Flux Data [Flux and Other_Fluxes]

Flux information must be provided for all targets, and there can be more than one entry for a given target. STScI uses flux information to test for over-illumination of sensitive detectors. All entries are values as observed at the Earth, rather than intrinsic values.

COS, ACS/SBC and STIS proposals cannot be implemented without flux information for all targets and other sources in the fields of view because of the critical requirements to protect its detectors from damage by excessively bright objects.

The flux information is provided in two separate fields:

- **Flux in V Magnitude with an uncertainty**, This is required for targets observed by the FGS, STIS/FUV-MAMA, STIS/NUV-MAMA, COS and ACS/SBC. For all other instrument configurations, it’s optional.

- **Other Fluxes** (separated by commas), which is entered in free text.

In the **“Other Fluxes”** field, the spectral type and color index could be provided if you think it’s important. As many additional flux values as appropriate for the requested exposures should be provided. For example, ultraviolet or emission-line fluxes should be given if the target is to be observed in the ultraviolet or through a narrow-band filter, or several magnitudes might be provided if the target is a variable star to be observed at various brightness levels. In some cases (Targets of Opportunity, variable objects, etc.) the estimated flux data may be very uncertain, but the best available estimates should nevertheless be given, along with appropriate uncertainties and comments.

It may be important to specify the flux of a background source as well as the target flux. For example, a globular cluster in M87 may be seen against
the bright background of the galaxy. The keyword –BKG should be appended to a background flux specification in this case (see footnote 2 to Table 3.12). Use a comma to separate entries if more than one flux value is given.

Flux must be given as F(\lambda) rather than F(\nu). Recall that the conversion is:

$$F(\lambda) = \left(3 \times 10^{18} F(\nu)\right) / \lambda^2,$$

where \lambda is in Ångstroms and F(\nu) is in erg/(cm² sec Hz). For example, if \lambda = 1500Å, and F(\nu) = 1.0 \times 10^{-26}, then F(\lambda) = 1.3 \times 10^{-14}.

The flux data are to be expressed in the format shown in Table 3.12. Do not enter explicit units.

**Text Proposal File**

If you are using the Text Proposal File, flux items in a list must be separated by commas.

### 3.9.1 General Guidelines on What Flux Data to Include

The following summary provides general guidelines for what flux information must be included in five general cases. See the *Instrument Handbooks* for more detailed descriptions of how to make the exposure time calculations.

#### Point source, non-dispersive instrument

1. Target flux: V magnitude, (B–V), E(B–V), spectral type.
   Flux at specified wavelength may be substituted for V magnitude.
   If no entry for E(B–V) is given, E(B–V) = 0 will be assumed.

2. Background (optional): Broad-band surface brightness or surface brightness at specified wavelength; –BKG must be specified in the name of the flux parameter.

3. Flux in wavelength range of observation.

#### Extended source, non-dispersive instrument

1. Target flux: V surface brightness, (B–V), E(B–V).
   Flux at specified wavelength may be substituted for V surface brightness.
   If no entry for E(B–V) is given, E(B–V) = 0 will be assumed.

2. Background (optional): Broad-band surface brightness or surface brightness at specified wavelength; –BKG must be specified in the name of the flux parameter.
3. Surface flux at wavelength of observation and size of the region specified.

**Point source, dispersive instrument**

1. Target flux: $V$ magnitude, $(B-V)$, $E(B-V)$, spectral type.
   Flux at specified wavelength may be substituted for $V$ magnitude.
   If no entry for $E(B-V)$ is given, $E(B-V) = 0$ will be assumed.
2. Background (optional): Surface brightness of continuum; $-BKG$ must be specified in the name of the flux parameter.
3. Continuum flux in wavelength range of observation.
4. Line flux and line width of brightest emission line in the wavelength range of observation.

**Extended source, dispersive instrument**

1. Target flux: $V$ surface brightness, $(B-V)$, $E(B-V)$.
   Flux at specified wavelength may be substituted for $V$ surface brightness.
   If no entry for $E(B-V)$ is given, $E(B-V) = 0$ will be assumed.
2. Background (optional): Surface brightness of continuum; $-BKG$ must be specified in the name of the flux parameter.
3. Surface flux at wavelength of observation and size of the region specified.
4. Line surface flux and line width of brightest emission line in the wavelength range of observation.

**Infrared source**

1. Target flux: $J$ magnitude, $(J-K)$. Flux at specified wavelength may be substituted for $J$ magnitude.
2. Background (optional): Broad-band surface brightness at specified wavelength; $-BKG$ must be specified in the name of the flux parameter.
3. Note that this refers to the astronomical background and not the thermal background.
4. Flux in wavelength range of observation. Note that this must be in units of erg/(cm$^2$ sec Å). The NICMOS units conversion tool on the STScI WWW pages can help you convert your source flux from $J$ magnitude or flux in Janskys into this flux unit.
**Note:** Details of how the above flux information was derived should have been given in the Description of Observations in the Call for Proposals. If any of the required flux data cannot be provided or are deemed to be unnecessary, these points must also be explained in that section. Incomplete flux information may delay the implementation of your proposal, especially in the case of ACS/SBC, COS and STIS/MAMA observations.

### Table 3.12: Formats for Specification of Target Flux Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Format example</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples for Stars:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad-band magnitude(^1)</td>
<td>V = 13.1 +/- 0.5</td>
<td>magnitude</td>
</tr>
<tr>
<td>Spectral type</td>
<td>TYPE = G5III</td>
<td></td>
</tr>
<tr>
<td>Color Index(^1)</td>
<td>B-V = 0.86 +/- 0.2</td>
<td>magnitude</td>
</tr>
<tr>
<td>Color Excess</td>
<td>E(B-V) = 0.3 +/- 0.2</td>
<td>magnitude</td>
</tr>
<tr>
<td>Background Surface Brightness(^2)</td>
<td>SURF-BKG(B) = 20 +/- 0.2</td>
<td>mag/arcsec(^2)</td>
</tr>
<tr>
<td><strong>Examples for Galaxies, Nebulae, and other extended sources:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Brightness(^1,2)</td>
<td>SURF(V) = 25.0 +/- 1.0</td>
<td>mag/arcsec(^2)</td>
</tr>
<tr>
<td>Surface Brightness(^1)</td>
<td>SURF(B) = 24.5 +/- 0.5</td>
<td>mag/arcsec(^2)</td>
</tr>
<tr>
<td>Color Excess</td>
<td>E(B-V) = 2.5 +/- 0.2</td>
<td>mag</td>
</tr>
<tr>
<td><strong>Plus whatever other fluxes are relevant to your science program. Some other examples are listed below:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interstellar Extinction</td>
<td>A(V) = 1.3 +/- 0.1</td>
<td>mag</td>
</tr>
<tr>
<td>Flux at a specified wavelength</td>
<td>F(5100) = 51 +/- 3 E-15</td>
<td>erg/(cm(^2) sec Å)</td>
</tr>
<tr>
<td>Continuum Flux(^3)</td>
<td>F-CONT(3500) = 57 +/- 3 E-15</td>
<td>erg/(cm(^2) sec Å)</td>
</tr>
<tr>
<td>Line Flux(^3,4,5)</td>
<td>F-LINE(3727) = 5 +/- 1 E-14</td>
<td>erg/(cm(^2) sec Å)</td>
</tr>
<tr>
<td>Line Width(^6)</td>
<td>W-LINE(3727) = 2.4 +/- 0.2</td>
<td>Å</td>
</tr>
</tbody>
</table>
3.10 Bright-Object Constraints

Several of the Scientific Instruments must be protected against over-illumination. Table 3.13 summarizes the safety restrictions by instrument. You should not propose observations which violate these guidelines. Non-linearity, saturation, or other temporary effects which may occur at substantially fainter limits than those identified below are described in the Instrument Handbooks.

APT contains a Bright Object Tool (BOT) that can be used to check on these constraints. Proposers should check both the target and the entire field (35" radius from the target for a single default pointing at any
orientation, larger plus 5" buffer with POS TARGets or other displacements), using the Aladin interface provided in APT.

Table 3.13: Bright-Object Constraints

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STIS</td>
<td>The STIS MAMA (UV) detectors are subject to strict bright-object controls to prevent potentially fatal damage. Maximum permissible local and global count rates have been established for the STIS MAMA detectors, both for imaging and spectroscopy, and are given in the <em>STIS Instrument Handbook</em>. These limits have been translated into limiting magnitudes and fluxes for the various configurations and modes. Some of these limits are quite faint. All potential targets and field objects within a certain field of view, which depends on the configuration selected, should be checked for safety with the STIS Exposure Time Calculator (ETC available at <a href="http://www.stsci.edu/hst/stis/software/etcs">http://www.stsci.edu/hst/stis/software/etcs</a>) and with the Bright Object tool in APT. Measured UV fluxes must be provided for any object within 1 magnitude of the brightness limits; if not previously available, they must be first observed with a safe STIS mode. Unless they can be screened with GSC2/DSS, magnitudes and colors, or a UV image, must be provided for all objects in the fields of proposed STIS MAMA observations, including the background fields of solar-system targets. ORIENTs and/or POS TARGs may be used to avoid potentially problematic objects. There are no safety-related brightness limits for the STIS CCD. See the <em>STIS Instrument Handbook</em> for a description of saturation levels, residual charge, and other effects.</td>
</tr>
<tr>
<td>ACS</td>
<td>The ACS/SBC MAMA detector is subject to strict bright-object controls to prevent potentially fatal damage. Maximum permissible local and global count rates have been established for both imaging and spectroscopy; see the <em>ACS Instrument Handbook</em> (Section 7.2). These limits have been translated into a table of magnitudes as a function of spectral type for the various configurations and modes (<em>ACS Instrument Handbook</em>, Table 7.4). Some of these limits are quite faint. All potential targets should be checked for safety with the ACS Exposure Time Calculator (ETC available at <a href="http://etc.stsci.edu/etc/input/acs/imaging">http://etc.stsci.edu/etc/input/acs/imaging</a>). Measured UV fluxes must be provided for any objects within one magnitude of the spectroscopic limits. This requirement extends to both targets and field objects on the detector. ORIENTs and/or POS TARGs may be used to avoid the latter. Unless they can be screened with GSC2/DSS, magnitudes and colors, or a UV image, must be provided for all objects in the fields of proposed SBC observations, including the background fields of solar-system targets. There are no safety-related brightness limits for the ACSWFC CCD cameras. See the <em>ACS Instrument Handbook</em> for a description of saturation levels, residual charge, and other effects.</td>
</tr>
<tr>
<td>FGS</td>
<td>The FGS may not be used to view objects brighter than $m_V = 1.8$. The FGS may view objects brighter than $m_V = 8.0$ only if the neutral-density filter is in place.</td>
</tr>
<tr>
<td>NICMOS</td>
<td>There are no safety-related brightness limits for the NICMOS. See the <em>NICMOS Instrument Handbook</em> for a description of saturation levels, residual charge, etc.</td>
</tr>
</tbody>
</table>
3.11 Comments [Comments]

Information that cannot be made to conform to the required formats may be entered in “Comments” area. Comments are not interpreted by the software, but are maintained in the database and do appear on printouts of the forms.

3.12 Generic Targets List [Generic_Targets]

Generic targets are those that can only be described in terms of astronomical characteristics or general location in the sky. This category is used only for Targets of Opportunity and parallel exposures.

For parallel exposures, both pure-parallel and coordinated-parallel (see Chapter 6: Parallel Science Exposures on page 103), the pointing is determined by the primary observation, and the specification of a generic target for the parallel exposure denotes a region within which the parallel aperture is expected to point. If the parallel pointing does not matter and the intent is simply to sample whatever the parallel aperture happens to detect, it is not necessary to define a generic target; instead the special
target \textit{ANY} should be used (see Section 5.7 \textit{Target Name [Target\_Name]} on page 94).

Generic targets or target \textit{ANY} (see Table 5.1: Special External Target Names) should only be used in one of these three cases:

1. The exposure is a coordinated parallel or \textit{SAME POS AS} another exposure (so that the pointing is determined by the other exposure), or
2. The visit is a pure parallel (in which case the target will be matched against already-scheduled observations), or
3. The visit is \textit{ON HOLD} (as with Targets of Opportunity, for example). In this case the target should be replaced by a fixed target when the \textit{ON HOLD} is removed.

\textbf{Note:} Generic Target region coordinates are assumed to be in the J2000 reference frame.

\subsection{3.12.1 Target Number(s) [Target\_Number]}

The target number will be assigned by the APT software. If you are using the \textit{Text Proposal File}, generic targets should be given individual names and numbers just like fixed targets.

\subsection{3.12.2 Target Name [Target\_Name]}

A descriptive name must be provided for each target. If a name cannot be specified in advance, a provisional name should be supplied. When the actual observation is made, a more specific name will be added to the target designation. Either the provisional name or the updated name can then be used for archival searches (e.g., SN might be the provisional name, while \textit{SN-1995D} might be the updated name). A unique target name \textbf{must} be assigned to each generic target.

\subsection{3.12.3 Target Description [Description]}

See Section 3.3, “Target Category and Target Description [Description],” on page 31.

\subsection{3.12.4 Flux Data [Flux]}

See Section 3.9, “Flux Data [Flux and Other\_Fluxes],” on page 47.

Flux data are not required for pure parallel observations of generic targets.
3.12.5 Comments [Comments]
See Section 3.11, “Comments [Comments],” on page 53.

3.12.6 Generic Target Specifications [Criteria]
The "Criteria" field is a way to specify generic celestial regions and target lists is described below, and should be used for Generic Targets. These instructions should be followed in order for pure parallels with generic targets to be schedulable.

Two types of generic target specifications are permitted:
- Region generic targets: a celestial region specified in one of three coordinate systems
- Target Lists: lists of fixed or generic targets

The Selection Criteria field should use the syntax specified below whenever the selection criteria can be fully specified by a celestial region in one of the supported coordinate systems, or by a list of fixed or generic targets.

**Region Generic Targets**

Three coordinate systems are supported:
- Equatorial: right ascension (RA) and declination (DEC)
- Galactic: Galactic longitude (LII) and Galactic latitude (BII)
- Ecliptic: ecliptic longitude (LAMBDA) and ecliptic latitude (BETA)

Regions may be any of:
1. “Rectangular” regions, i.e. bounded by latitude and longitude limits in the appropriate coordinate system
2. Circular regions, specified as within some angular limit of a point specified in any of the three supported coordinate systems
3. Polar caps or equatorial bands in any supported coordinate system

The following table provides examples of each of these types of region specifications. Note that the same rules for specifying RA and Dec apply as for fixed targets (Section 3.4.2 on page 38) and that the angle specifications must include ’ and " (or M and S).
Note that for rectangular and circular regions, the syntax is identical to that of fixed target regions except that the indicator \texttt{REGION} is omitted, and galactic and ecliptic coordinates are allowed.

### Target Lists

In some cases it may be desirable to specify as a Generic Target any of a list of Fixed Target positions or Generic Target regions. In this case the fixed targets should be provided as usual on the Fixed Target List, and the generic target regions should be specified as above on the Generic Target List. Then a new generic target can be defined with Selection Criteria specified by:

\texttt{TARGETS = <target-number-list>}

This will be taken to indicate that any of the targets in \texttt{<target-number-list>} are suitable as targets. Note that target numbers are required to be unique across all targets in a proposal, whether on the Fixed, Generic, or Solar System Target Lists.

This type of target is particularly useful when a known list of objects of interest is available, and it is desired to observe one of these objects with an imaging SI when a primary exposure with a spectrograph is positioned appropriately nearby.
3.13 Getting Coordinates Coordinated

Observers are responsible for the accuracy and appropriateness of the coordinates they supply and any changes made to them. Only you can determine where we should point HST.

**Equinox** is always a critical quantity when specifying coordinates. All astronomical coordinates change with time because of the precession of the Earth’s rotation axis. Equinox specifies a time to which a coordinate system is tied. Thus J2000 refers to the location of an object in celestial coordinates for the coordinate reference frame of January 1, 2000.

**Epoch** is generally important only for objects that move. In particular, the epoch of a star’s coordinates refers to a specific time at which the star is at that location. For example, the Hipparcos output catalogue lists coordinates of the brighter stars in the ICRS reference system (which is very nearly the same as J2000), and the coordinates themselves are for epoch 1991.25. The proper motions in the Hipparcos output catalogue are also epoch 1991.25, the midpoint of the mission. If you specify the epoch and equinox correctly, we can easily compute the location of an object at the time it will be observed with HST. (Note: An epoch is purely a time, and one of the form "J1991.25" is nonsensical.)

**Proper motions** sometimes cause problems. Units are especially crucial. The proper motion in Right Ascension (**RA_PM**) can be in sec. of time/yr, arcsec/yr or mas/yr. **DEC_PM** can be listed in arcsec/yr or mas/yr.

As we have emphasized above, we urge you to use signs on quantities, even when they are not required. A value of +0.060 for **RA_PM**, say, makes it clear that the sign has been considered. Just specifying 0.060 leaves ambiguity because sometimes observers forget a minus.

**Notes on Special Targets**

**Targets near the Celestial Poles:** Be very careful if your target lies near a celestial pole. Many precession routines break down in this regime, and uncertainties in position can cause problems too. Also, patterns that you may execute with an instrument could cross the pole, leading to confusion in position. All these issues can be resolved, but careful attention is needed.

**Targets in Binaries with Large Orbital Motion:** If a target’s apparent orbital motion is large, the position and proper motion of a target in a catalogue may not characterize the target’s location to the accuracy required by the target acquisition aperture. For such objects, a custom proper motion calculation is recommended to ensure the the target will be in the target acquisition aperture at the time of the observation.
CHAPTER 4: Solar System Targets

In this chapter . . .

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Target Number [Target_Number]</td>
<td>61</td>
</tr>
<tr>
<td>4.2 Target Name [Target_Name]</td>
<td>62</td>
</tr>
<tr>
<td>4.3 Target Description [Description]</td>
<td>64</td>
</tr>
<tr>
<td>4.4 Target Position</td>
<td>65</td>
</tr>
<tr>
<td>4.4.1 Target Position Level 1 [Level_1]</td>
<td>67</td>
</tr>
<tr>
<td>4.4.2 Target Position Level 2 [Level_2]</td>
<td>69</td>
</tr>
<tr>
<td>4.4.3 Target Position Level 3 [Level_3]</td>
<td>76</td>
</tr>
<tr>
<td>4.6 Ephemeris Uncertainty [Ephem_Uncert]</td>
<td>76</td>
</tr>
<tr>
<td>4.7 Acquisition Uncertainty [Acq_Uncert]</td>
<td>77</td>
</tr>
<tr>
<td>4.8 Observing Windows [Windows]</td>
<td>77</td>
</tr>
<tr>
<td>4.9 Flux Data [Flux and Other_Fluxes]</td>
<td>83</td>
</tr>
<tr>
<td>4.10 Comments [Comments]</td>
<td>85</td>
</tr>
<tr>
<td>4.11 Illustrations of Orbital Longitude</td>
<td>85</td>
</tr>
<tr>
<td>4.12 Examples of Target List Blocks</td>
<td>86</td>
</tr>
</tbody>
</table>
Chapter 4: Solar System Targets

Tables and Figures

Table 4.1: Solar System Standard Targets
Table 4.2: Target Description Keywords
Table 4.3: Positional Parameters for TYPE = COMET
Table 4.4: Positional Parameters for TYPE = ASTEROID
Table 4.5: Parameters for TYPE = PGRAPHIC
Table 4.6: Parameters for TYPE = POS_ANGLE
Table 4.7: Parameters for TYPE = MAGNETO
Table 4.8: Parameters for TYPE = TORUS
Table 4.9: Parameters for TYPE = SAT
Table 4.10: Parameters for TYPE = PCENTRIC
Table 4.11: Keywords for Observing Windows
Table 4.12: Operators for Observing Windows
Table 4.13: Formats for Specification of Target Flux Data
Figure 4.1: Orbital Longitude for Satellites / 85
Figure 4.2: Orbital Longitude for Planets / 86

HST is able to point at and track solar system targets with sub-arcsecond accuracy. In order for target acquisition and tracking to succeed, planetary observers must specify positions for their targets in a precise and unambiguous manner. Therefore, it is imperative that the Solar System Target List (SSTL) be carefully and correctly completed. This section explains how to fill out the SSTL for any solar system target.

Ephemerides are generated using fundamental ephemeris information from NASA’s Jet Propulsion Laboratory (JPL). Ephemerides can be generated for all known types of solar system targets, including planets, satellites, comets, asteroids, surface features on planets and satellites, and offset positions with respect to the centers of all the above bodies. The following instructions demonstrate how to define solar system targets in a way that allows accurate ephemeris generation.

The body-axes definitions, body dimensions, directions of rotation poles, rotation rates, and the definitions of cartographic coordinates used by STScI are normally identical to the values adopted in the report of the
“IAU Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 1982” (Davies, M.E., et al., *Celestial Mechanics*, 29, 309-321, 1983). In a few instances, the latter data have been updated due to new results obtained from the flyby spacecraft. Also, some new bodies have been added which were unknown at the time of the IAU report. For Jupiter and Saturn, the lambda(III) coordinate system is assumed, but lambda(I) or lambda(II) can be used. For Uranus and Neptune, coordinates follow the “Report of the IAU/IAG/COSPAR Working Group on Cartographic Coordinates and Rotation Rates of the Planets and Satellites” (Celestial Mechanics and Dynamic Astronomy, 46, 197, 1989). If you need further information on these, please contact your Program Coordinator.

One exception exists to the requirements outlined above. Observers for solar system Targets of Opportunity (e.g. a “new” comet or asteroid, a solar-wind disturbance reaching the Jovian magnetosphere, etc.), should complete the Generic Target List (See “Generic Targets List [Generic_Targets]” in Chapter 3.) and the Visit and Exposure Specifications (to the extent possible) in time for the Phase II deadline. If and when a suitable target appears, the proposer must complete the Solar System Target List and update the Visit and Exposure Specifications. No target can be observed until the complete Phase II information is provided.

In this chapter, each heading has a description followed by a keyword in square brackets (e.g., [Target_Number]). Elsewhere, items in boldface (e.g., RA) show words or phrases that are used as APT Phase II items or properties. Items in <> brackets (e.g., <value>) show values you provide. Items listed in square brackets (e.g., [A1 : <value>]) are optional, whereas those not in square brackets are required. As you enter information in the APT interface. You will be told (via a tooltips message) if an item is required, and its format.

### 4.1 Target Number [Target_Number]

Each target must have a unique target number (base 10 from 1 to 999) and are usually assigned by the APT software. Target numbers must be positive, monotonically increasing integers. You should define a different target whenever a different target position or timing description is required. For example, separate targets should be defined if you plan to take spectra of several different surface features on a planet, or if you plan to observe the same feature with different timing constraints.
4.2 Target Name [Target_Name]

The name is used to identify a target; **all target names within a proposal must be unique**. The target name can be selected from the STScI list of standard targets (see Table 4.1; explanations of “Level 1” and “Level 2” are given below), or a name can be defined by the GO. The use of standard names is encouraged whenever possible.

The following conventions should be followed in naming targets:

- The length of a target name can be anywhere from 2 to 31 characters.
- **No blanks are permitted in target names.** A hyphen should replace blanks that would normally be used to separate fields (e.g. IO-TORUS, COMET-BRADFIELD-1979X).
- Only letters and numerals are allowed in target names; punctuation (other than hyphens and + or –) is not permitted.
- Construct target names so they make sense for your observing program. For example, if your program consisted of consecutive observations of three surface features on Mars, then three appropriate target names might be: MARS-FEATURE1, MARS-FEATURE2, and MARS-FEATURE3.

Do not use just a standard name for a target when a specific portion of a body is being observed. For example, do not use “Saturn” as the target name for a feature or specific location that is defined relative to the position of Saturn as a standard target because this is confusing for the software that computes the positions of moving targets.

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td></td>
</tr>
<tr>
<td>Venus</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td>Moon</td>
</tr>
<tr>
<td>Mars</td>
<td>Phobos</td>
</tr>
<tr>
<td></td>
<td>Deimos</td>
</tr>
<tr>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Jupiter</td>
<td>Io</td>
</tr>
<tr>
<td></td>
<td>Callisto</td>
</tr>
<tr>
<td></td>
<td>Elara</td>
</tr>
<tr>
<td></td>
<td>Lysithea</td>
</tr>
<tr>
<td></td>
<td>Leda</td>
</tr>
<tr>
<td></td>
<td>Metis</td>
</tr>
<tr>
<td></td>
<td>Taygete</td>
</tr>
<tr>
<td></td>
<td>Kalyke</td>
</tr>
<tr>
<td></td>
<td>Isonoe</td>
</tr>
<tr>
<td></td>
<td>Thyone</td>
</tr>
<tr>
<td></td>
<td>Eurydome</td>
</tr>
<tr>
<td></td>
<td>Orthosie</td>
</tr>
<tr>
<td></td>
<td>Megaclite</td>
</tr>
<tr>
<td></td>
<td>Mneme</td>
</tr>
<tr>
<td></td>
<td>Arche</td>
</tr>
<tr>
<td></td>
<td>Carpo</td>
</tr>
<tr>
<td></td>
<td>Kore</td>
</tr>
<tr>
<td>Saturn</td>
<td>Mimas</td>
</tr>
<tr>
<td></td>
<td>Dione</td>
</tr>
<tr>
<td></td>
<td>Hyperion</td>
</tr>
<tr>
<td></td>
<td>Janus</td>
</tr>
<tr>
<td></td>
<td>Telesto</td>
</tr>
<tr>
<td></td>
<td>Prometheus</td>
</tr>
<tr>
<td></td>
<td>Paaliaq</td>
</tr>
<tr>
<td></td>
<td>Suttungr</td>
</tr>
<tr>
<td></td>
<td>Albiorix</td>
</tr>
<tr>
<td></td>
<td>Siarnaq</td>
</tr>
<tr>
<td></td>
<td>Narvi</td>
</tr>
<tr>
<td></td>
<td>Polydeuces</td>
</tr>
<tr>
<td></td>
<td>Bebbionn</td>
</tr>
<tr>
<td></td>
<td>Farhauti</td>
</tr>
</tbody>
</table>
Table 4.1: Solar System Standard Targets (Cont)

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hati</td>
<td>Hyrrokkin</td>
</tr>
<tr>
<td>Loge</td>
<td>Skoll</td>
</tr>
<tr>
<td>Anthe</td>
<td>Jarnsaxa</td>
</tr>
<tr>
<td>Tarqeq</td>
<td>Aegaeon</td>
</tr>
<tr>
<td>Uranus</td>
<td>Ariel</td>
</tr>
<tr>
<td>Oberon</td>
<td>Miranda</td>
</tr>
<tr>
<td>Ophelia</td>
<td>Bianca</td>
</tr>
<tr>
<td>Desdemona</td>
<td>Juliet</td>
</tr>
<tr>
<td>Rosalind</td>
<td>Belinda</td>
</tr>
<tr>
<td>Caliban</td>
<td>Sycorax</td>
</tr>
<tr>
<td>Setebos</td>
<td>Stephano</td>
</tr>
<tr>
<td>Francisco</td>
<td>Margaret</td>
</tr>
<tr>
<td>Perdita</td>
<td>Mab</td>
</tr>
<tr>
<td>Neptune</td>
<td>Triton</td>
</tr>
<tr>
<td>Thalassa</td>
<td>Despina</td>
</tr>
<tr>
<td>Larissa</td>
<td>Proteus</td>
</tr>
<tr>
<td>Psamathe</td>
<td>Sao</td>
</tr>
<tr>
<td>Neso</td>
<td>Charon</td>
</tr>
</tbody>
</table>

If you are uncertain whether or not your target can be referenced by name, contact your Program Coordinator for guidance.

4.3 Target Description [Description]

The target description is used to sort the solar system targets by class and will be useful to archival researchers. The first word in any target
description **must** be one of the keywords listed below. The keyword is then followed with text that depends on the target class as described below.

Table 4.2: Target Description Keywords

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLANET</td>
<td>If the target is the center of a planet, enter PLANET followed by the name of the planet (e.g., PLANET JUPITER, PLANET SATURN).</td>
</tr>
<tr>
<td>SATELLITE</td>
<td>If the target is the center of the satellite of a planet, enter SATELLITE followed by the satellite name (e.g., SATELLITE GANYMEDE, SATELLITE 1980S27).</td>
</tr>
<tr>
<td>COMET</td>
<td>If the target is the nucleus of a comet, enter COMET followed by its common name or catalog designation (e.g., COMET HALLEY, COMET 1979X).</td>
</tr>
<tr>
<td>ASTEROID</td>
<td>If the target is the center of an asteroid, enter ASTEROID followed by its common name or its catalog number (e.g., ASTEROID CERES, ASTEROID 452).</td>
</tr>
<tr>
<td>FEATURE</td>
<td>If the target is a surface feature, enter FEATURE followed by the name of the parent body (e.g., FEATURE JUPITER, FEATURE IO).</td>
</tr>
<tr>
<td>OFFSET</td>
<td>If the target is an offset position with respect to a solar system body (but not a feature on its surface), enter OFFSET followed by the name of the parent (reference) object (e.g., OFFSET COMET HALLEY, OFFSET JUPITER).</td>
</tr>
<tr>
<td>RING</td>
<td>If the target is in a ring, enter RING followed by the name of the parent object (e.g., RING JUPITER, RING SATURN).</td>
</tr>
<tr>
<td>TORUS</td>
<td>If the target is a plasma torus, enter TORUS followed by the name of the parent object (e.g., TORUS JUPITER).</td>
</tr>
<tr>
<td>OTHER</td>
<td>If your target cannot be classified under any of the categories above, then enter OTHER followed by some description of the type of observation planned (e.g., ASTROMETRIC REFERENCE, INTERPLANETARY MEDIUM, ZODIACAL LIGHT)</td>
</tr>
</tbody>
</table>

4.4 Target Position

**Target Pointing Specification (TPS) and “Levels”**

Three fields are used to describe the target’s position, referred to here as the **Target Pointing Specification** (TPS). The TPS has been defined using a hierarchical structure.

- **Level 1 refers to a target in orbit about the Sun.** Examples of Level 1 targets include planets, asteroids, and comets. When a Level 1 object is the desired target for observation, complete the Level 1 field and leave the other two target position fields blank.
• **Level 2** refers to a target whose motion is normally described with respect to a Level 1 object. Examples of Level 2 targets include planetary satellites, surface features on planets or asteroids, and non-nuclear positions in the coma of a comet. When a Level 2 object is the desired target for observations, the Level 1 field contains information on the **parent** body, and the Level 2 field gives positions relative to this body. In this case, leave the Level 3 field blank.

• **Level 3** refers to a target whose motion is normally described with respect to a Level 2 object. Examples are a surface feature on a planetary satellite or a pointing which is offset from the center of a planetary satellite. When a Level 3 object is the desired target for observation, then all three fields must be completed, with Level 1 giving the **parent** of the body described in Level 2, and Level 3 giving the position of the observed target with respect to the body in Level 2.

---

**Text Proposal File**

If you are using the Text Proposal File, **TPS** items must be separated by commas.

**Describing Targets**

The targets specified in the target position fields can be described in up to four ways:

• By a name selected from a list of targets
• By orbital elements
• By coordinates with respect to another object
• Via target selection during a real-time observing session

Table 4.1 gives the list of valid names for solar system targets. PIs are responsible for obtaining up-to-date orbital elements for bodies not in this table. Objects must be denoted by their IAU-adopted name. A good reference for object names can be found in the *Astronomical Almanac*, and in the Marsden comet catalog (Marsden, B. G., *Catalog of Cometary Orbits*, Enslow Publishers, Hillside, NJ, 1983). If you are uncertain whether or not your target can be referenced by name, contact your Program Coordinator.
In those cases where the target’s position is given with respect to one of the standard targets, the latest available data from JPL on the bodies’ physical dimensions, orientation, and rotation rates are used in calculating the target’s position. In those cases where all or part of the TPS for your target can be described using standard names, we strongly recommend that you do so. Generally, this will result in the most accurate ephemeris generation for your target.

**Specifying Time**
Wherever there is an entry involving time, the format for that entry must be:

```
DD-MMM-YYYY:hh:mm:ss.s
```

where DD is the day of the month, MMM is the first three letters of the month name, YYYY are the full four digits of the Gregorian calendar year, hh is the hour, mm is the minute, and ss.s are the decimal seconds. Only the necessary precision need be specified. *But the time after the colon must be completely specified or not at all.*

Examples:

- **02-AUG-1993:13:04:31**
- **15-JAN-1994**

Two different systems of time are used in this document. TDB refers to *Barycentric Dynamical Time* and can be considered synonymous with ET (*Ephemeris Time*), which was used before 1984. UTC refers to *Coordinated Universal Time*. The precise interpretation of each time value depends on the context in which it is used.

### 4.4.1 Target Position Level 1 [Level_1]

Specify your target in this field in one of the following ways:

1. STD = `<object name>`, where the name must be from Table 4.1, or
2. TYPE = `<name>`.

The TYPE = `<name>` target description allows the specification of non-standard targets in a variety of formats and must be the first entry in the field if it is used.

- If **COMET** is chosen, then a set of 2-body orbital elements in the *IAU Circular* format must be supplied for the target.
- If **ASTEROID** is chosen, then a set of 2-body orbital elements in the *Minor Planet Circular* format must be supplied.

For all cases, the required input data are described below. If the data are valid only over a specific period of time, then specify this time interval in the Window field according to the rules given later.
COMET and ASTEROID Positional Parameters

Table 4.3: Positional Parameters for TYPE = COMET

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>Perihelion distance, in AU</td>
</tr>
<tr>
<td>E</td>
<td>Eccentricity</td>
</tr>
<tr>
<td>I</td>
<td>Inclination, in degrees</td>
</tr>
<tr>
<td>O</td>
<td>Longitude of ascending node, in degrees</td>
</tr>
<tr>
<td>W</td>
<td>Argument of perihelion, in degrees</td>
</tr>
<tr>
<td>T</td>
<td>Time of perihelion passage, in TDB</td>
</tr>
<tr>
<td>EQUINOX</td>
<td>either B1950, or J2000</td>
</tr>
<tr>
<td>EPOCH</td>
<td>Osculation date, in TDB (4 digits)</td>
</tr>
<tr>
<td>A1</td>
<td>Radial component of non-gravitational acceleration (AU/day²)</td>
</tr>
<tr>
<td>A2</td>
<td>Component of non-gravitational acceleration lying in the orbital plane and parallel to the instantaneous velocity vector (AU/day²)</td>
</tr>
<tr>
<td>A3</td>
<td>Component of non-gravitational acceleration directed perpendicular to the plane defined by A1 and A2 (AU/day²)</td>
</tr>
</tbody>
</table>

Table 4.4: Positional Parameters for TYPE = ASTEROID

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Semi-major axis, in AU</td>
</tr>
<tr>
<td>E</td>
<td>Eccentricity</td>
</tr>
<tr>
<td>I</td>
<td>Inclination, in degrees</td>
</tr>
<tr>
<td>O</td>
<td>Longitude of ascending node, in degrees</td>
</tr>
<tr>
<td>W</td>
<td>Argument of perihelion, in degrees</td>
</tr>
<tr>
<td>M</td>
<td>Mean anomaly at EPOCH, in degrees</td>
</tr>
<tr>
<td>EQUINOX</td>
<td>J2000</td>
</tr>
<tr>
<td>EPOCH</td>
<td>Osculation date, in TDB (4 digits)</td>
</tr>
</tbody>
</table>

The elements given above refer to the mean ecliptic and equinox of either B1950 or J2000 depending on which “value” is specified for EQUINOX.
An example of TYPE = COMET is shown in the “Example Target List Blocks” below for Example 3.

It is the responsibility of the observer to supply accurate orbital elements to STScI when specifying TYPE=COMET or TYPE=ASTEROID.

4.4.2 Target Position Level 2 [Level_2]
Six Target Reference Systems (TRSs) are described in the following paragraphs. Please pay careful attention to the definitions of each TRS. Specify your target in one of the following ways:

STD = <object name> or TYPE = <name>
In this case <object name> is from Table 4.1: Solar System Standard Targets, or the Type is:

PGRAPHIC
planetographic coordinates relative to Level 1 target
POS_ANGLE
polar coordinate offsets from Level 1 target
MAGNETO
position in magnetic coordinate system
TORUS
line-of-sight projected coordinate system
SAT
orbital elements of a satellite
PCENTRIC
planetocentric coordinates relative to Level 1 target

For the PGRAPHIC, MAGNETO, and TORUS coordinate systems, the north pole is defined to be the rotational pole in the northern celestial hemisphere. For planets with direct rotation, the angular momentum vector coincides with the north pole. For planets with retrograde rotation, the angular momentum vector coincides with the south pole.
Planetographic Coordinate System

Table 4.5: Parameters for TYPE = PGRAPHIC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONG = &lt;value&gt;</td>
<td>planetographic longitude in degrees,</td>
</tr>
<tr>
<td>LAT = &lt;value&gt;</td>
<td>planetographic latitude in degrees; use – to denote south latitude.</td>
</tr>
<tr>
<td>[ALT = &lt;value&gt;]</td>
<td>planetographic altitude above the reference ellipsoid, in kilometers,</td>
</tr>
<tr>
<td>[R_LONG = &lt;value&gt;]</td>
<td>rate of change of planetographic longitude, in degrees/day,</td>
</tr>
<tr>
<td>[R_LAT = &lt;value&gt;]</td>
<td>rate of change of planetographic latitude, in degrees/day,</td>
</tr>
<tr>
<td>[R_RAD = &lt;value&gt;]</td>
<td>rate of change of planetographic altitude, in kilometers/day, and</td>
</tr>
<tr>
<td>[EPOCH = &lt;value&gt;]</td>
<td>the reference time for the temporal variation, in UTC (4 digits).</td>
</tr>
</tbody>
</table>

1. EPOCH must also be specified with this quantity.

The PGRAPHIC TRS is the IAU planetographic coordinate system. It is a non-spherical coordinate system aligned with and rotating about the rotation axis of the Level 1 body, positive north, whose origin lies at the center of the reference body. Locations within this TRS are specified by longitude, latitude, and altitude above the surface. (The lambda(III) coordinate system defines the prime meridian in this coordinate system; if lambda(I) or lambda(II) coordinate systems are desired, note this in the Comments field.)

Planetographic Latitude is defined as the angle between the equator and the normal to the surface of the reference ellipsoid at the point of interest.

By definition, the planetographic longitude of the sub-Earth point increases with time. For planets with direct rotation, the planetographic longitude increases in a left-handed direction. For planets with retrograde rotation, the planetographic longitude increases in a right-handed direction.

If ALT is omitted, then the surface of the reference ellipsoid is assumed.

If the coordinates are constant in time, then none of the other optional entries should be used. If any coordinate is given as a function of time, then EPOCH is required and the time-varying coordinate is interpreted in the following way.

Example:

LONG = 20
LAT = -5
R_LONG = 45
EPOCH = 5-JAN-1990:15

For this example the longitude at any time, T, is given by:
longitude = \text{LONG} + R\_\text{LONG} \times (T - \text{EPOCH})

or, numerically,

longitude = 20 + 45 \times (t - 5-\text{JAN}-1990:00:15:00)

---

The same interpretation for time-varying coordinates also applies to the other TRSs described below.

---

### Position Angle Coordinate System

Table 4.6: Parameters for TYPE = POS\_ANGLE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAD = &lt;value&gt;</td>
<td>Radius, in arcseconds</td>
</tr>
<tr>
<td>ANG = &lt;value&gt;</td>
<td>Position angle relative to the reference axis, in degrees</td>
</tr>
<tr>
<td>REF = NORTH</td>
<td>Reference axis is celestial north, or</td>
</tr>
<tr>
<td>REF = SUN</td>
<td>Reference axis is the apparent direction to the Sun as projected on the sky.</td>
</tr>
<tr>
<td>[R_RAD = &lt;value&gt;]</td>
<td>Rate of change of radius, in arcseconds/day</td>
</tr>
<tr>
<td>[R_ANG = &lt;value&gt;]</td>
<td>Rate of change of position angle, in degrees/day</td>
</tr>
<tr>
<td>[EPOCH = &lt;value&gt;]</td>
<td>the reference time for the temporal variation, in UTC (4 digits).</td>
</tr>
</tbody>
</table>

1. \text{EPOCH} must also be specified with this quantity.

The \text{POS\_ANGLE} TRS is a position-angle coordinate system (i.e. a two-dimensional polar-coordinate system). This TRS is useful for pointing at targets whose positions are known only in terms of an offset in projected celestial coordinates from another body. The origin of the system lies at the center of the Level 1 body. Locations are specified by giving the \textit{apparent} distance from the origin (in projected celestial coordinates as viewed from the Earth) and the position angle from some \textit{reference axis} to the target point. For \text{REF} = \text{NORTH}, angles are measured from celestial north (positive angles are measured in the same sense as rotating from celestial north through east). For \text{REF} = \text{SUN}, angles are measured from the direction to the Sun as projected on the sky (positive angles are measured in the same sense as rotating from celestial north through east).
Magnetic Coordinate System

Table 4.7: Parameters for TYPE = MAGNETO

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONG = &lt;value&gt;</td>
<td>Magnetic longitude, in degrees</td>
</tr>
<tr>
<td>LAT = &lt;value&gt;</td>
<td>Magnetic latitude, in degrees; use – to denote south latitude.</td>
</tr>
<tr>
<td>RAD = &lt;value&gt;</td>
<td>Magnetic radius, in kilometers</td>
</tr>
<tr>
<td>[POLE_LAT = &lt;value&gt;]</td>
<td>Cartographic latitude of the pole, in degrees</td>
</tr>
<tr>
<td>[POLE_LONG = &lt;value&gt;]</td>
<td>Cartographic longitude of the pole, in degrees</td>
</tr>
<tr>
<td>[O_LAT = &lt;value&gt;]</td>
<td>Cartographic latitude of the origin in degrees; use – to denote south latitude.</td>
</tr>
<tr>
<td>[O_LONG = &lt;value&gt;]</td>
<td>Cartographic longitude of the origin in degrees</td>
</tr>
<tr>
<td>[O_RAD = &lt;value&gt;]</td>
<td>Cartographic radius of the origin, in kilometers</td>
</tr>
</tbody>
</table>

The MAGNETO TRS is intended to support observations fixed with respect to a planetary magnetic field. It is a spherical coordinate system rotating with the Level 1 body around the rotation axis, with a specified offset of the coordinate origin and inclination of the coordinate pole. The MAGNETO coordinate system is defined in the following manner:

- Define a “cartographic” reference frame identical to the planeto-graphic TRS, except use spherical latitudes.
- Rotate the new coordinate system relative to the cartographic frame so the new pole is located at POLE_LAT (latitude) and POLE_LONG (longitude).
- The final step is to translate the origin of the new system to the specified cartographic latitude, longitude, and radius (O_LAT, O_LONG, and O_RAD, respectively).

While the origin and coordinate axes may differ from those of the cartographic system, the rotation axis and rotation rate are identical to those of the cartographic system. Locations in the MAGNETO TRS are specified by longitude, latitude, and radius from the origin of the defined coordinate system.

Torus Coordinate System

Table 4.8: Parameters for TYPE = TORUS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONG = &lt;value&gt;</td>
<td>Torus longitude, in degrees</td>
</tr>
<tr>
<td>LAT = &lt;value&gt;</td>
<td>Torus latitude, in degrees; use – to denote south latitude.</td>
</tr>
</tbody>
</table>
If the optional fields above are left blank, the following default values are used:

**O_LONG = 0**

**O_LAT = +0**

**O_RAD = 0**

**POLE_LAT = +83**

**POLE_LONG = 202**

The TORUS TRS is defined primarily to support observations of Jupiter’s plasma torus and is closely related to the MAGNETO TRS. TORUS is also useful for observers who want to observe in a coordinate system that is fixed relative to the apparent disk of the Level 1 body, e.g. central meridian observations (see special instructions below). The difference between the two systems is in the definition of the prime meridian. For the TORUS TRS, the prime meridian is defined by the instantaneous longitude of the sub-Earth point. Therefore, the TORUS TRS does not rotate with the Level 1 body. A typical observation would be of the east or west ansa (point of maximum elongation) of an equatorial circle whose radius is roughly five times the equatorial radius of Jupiter (in this case, **LONG = 270** (90 for the west ansa), **LAT = 0, RAD = 3.57E05**). As the planet rotates, the target moves up and down in celestial coordinates as Jupiter rotates. This coordinate system can also be used to support observations of a planetary ring ansa.

### Table 4.8: Parameters for TYPE = TORUS (Cont)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAD = &lt;value&gt;</td>
<td>Torus radius, in kilometers</td>
</tr>
<tr>
<td>[POLE_LAT = &lt;value&gt;]</td>
<td>Cartographic latitude of the pole, in degrees</td>
</tr>
<tr>
<td>[POLE_LONG = &lt;value&gt;]</td>
<td>Cartographic longitude of the pole, in degrees</td>
</tr>
<tr>
<td>[O_LAT = &lt;value&gt;]</td>
<td>Cartographic latitude of the origin in degrees; use – to denote south latitude.</td>
</tr>
<tr>
<td>[O_LONG = &lt;value&gt;]</td>
<td>Cartographic longitude of the origin in degrees</td>
</tr>
<tr>
<td>[O_RAD = &lt;value&gt;]</td>
<td>Cartographic radius of the origin, in kilometers</td>
</tr>
</tbody>
</table>

**Special Instructions:** The TORUS system can be useful for observations that want to remain fixed at a position of the observable disk of the Level 1 body rather than tracking a particular longitude. The most frequent example is observations on the central meridian at a specified latitude without regard to the longitude. To use TORUS in this way you must set the optional parameter **POLE_LAT = +90**.
Satellite Elements Coordinate System

Table 4.9: Parameters for TYPE = SAT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = &lt;value&gt;</td>
<td>Semi-major axis of satellite orbit, in km</td>
</tr>
<tr>
<td>EPOCH = &lt;value&gt;</td>
<td>Epoch of the elements, in TDB (4 digits)</td>
</tr>
<tr>
<td>N = &lt;value&gt;</td>
<td>Mean motion of satellite, in degrees/day</td>
</tr>
<tr>
<td>L = &lt;value&gt;</td>
<td>Mean longitude at EPOCH, in degrees</td>
</tr>
<tr>
<td>[E = &lt;value&gt;]</td>
<td>Eccentricity of satellite orbit</td>
</tr>
<tr>
<td>[I = &lt;value&gt;]</td>
<td>Inclination of satellite orbit to the planetary equator, in degrees</td>
</tr>
<tr>
<td>[O = &lt;value&gt;]</td>
<td>Longitude of ascending node of the satellite orbit, in degrees</td>
</tr>
<tr>
<td>[W = &lt;value&gt;]</td>
<td>Longitude of periapse, in degrees</td>
</tr>
<tr>
<td>[O_RATE = &lt;value&gt;]</td>
<td>Rate of change of longitude of ascending node, in degrees/day</td>
</tr>
<tr>
<td>[W_RATE = &lt;value&gt;]</td>
<td>Rate of change of periapse, in degrees/day</td>
</tr>
<tr>
<td>[RAP = &lt;value&gt;]</td>
<td>Right Ascension of the parent planet pole at EPOCH</td>
</tr>
<tr>
<td>[DECP = &lt;value&gt;]</td>
<td>Declination of the parent planet pole at EPOCH</td>
</tr>
<tr>
<td>[EQUINOX = &lt;value&gt;]</td>
<td>B1950 or J2000</td>
</tr>
</tbody>
</table>

When the target is a satellite of the object defined in the Level 1 field, but the satellite itself is not among the standard targets, then orbital elements must be specified. These elements refer to the motion of the satellite around the Level 1 object.

The “reference” axis for the angles defined above is the intersection of the Earth’s equator at the standard epoch implied by the EQUINOX with the parent planet’s equator at the EPOCH of the elements. The positive X-axis for the coordinate system used in the orbit calculation is obtained by taking the cross product of the Z-axis of the standard system (i.e. the system defined by the standard equator and equinox given by EQUINOX) with the pole of the planet. If E, I, O, W, O_RATE, and W_RATE are not supplied, then their values are assumed to be 0. If RAP and DECP are not supplied, then the standard IAU values are used. If RAP and DECP are supplied, then they should be referred to the standard equator and equinox given by EQUINOX. If EQUINOX is not provided, we will assume J2000.

STScI maintains its ephemeris data base with the best available elements, and you should use the STD = form for objects in Table 4.1: Solar System Standard Targets unless there is compelling scientific justification for specifying orbital elements. Note: It is the responsibility of the observer to supply accurate orbital elements to STScI when specifying TYPE=SAT.
**Planetocentric Coordinates**

PCENTRIC: planetocentric coordinates relative to Level 1 target

For the PCENTRIC coordinate system, the north pole is defined to be the rotational pole in the northern celestial hemisphere. For planets with direct rotation, the angular momentum vector coincides with the north pole. For planets with retrograde rotation, the angular momentum vector coincides with the south pole.

Table 4.10: Parameters for TYPE = PCENTRIC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONG = &lt;value&gt;</td>
<td>planetocentric longitude in degrees,</td>
</tr>
<tr>
<td>LAT = &lt;value&gt;</td>
<td>planetocentric latitude in degrees; use – to denote south latitude.</td>
</tr>
<tr>
<td>[RAD = &lt;value&gt;]</td>
<td>planetocentric radius in kilometers,</td>
</tr>
<tr>
<td>[R_LONG = &lt;value&gt;]</td>
<td>rate of change of planetocentric longitude, in degrees/day,</td>
</tr>
<tr>
<td>[R_LAT = &lt;value&gt;]</td>
<td>rate of change of planetocentric latitude, in degrees/day,</td>
</tr>
<tr>
<td>[R_RAD = &lt;value&gt;]</td>
<td>rate of change of planetocentric radius, in kilometers/day, and</td>
</tr>
<tr>
<td>[EPOCH = &lt;value&gt;]</td>
<td>the reference time for the temporal variation, in UTC (4 digits).</td>
</tr>
</tbody>
</table>

1. EPOCH must also be specified with this quantity.

The PCENTRIC TRS is the IAU planetocentric coordinate system. It is a right-handed spherical coordinate system aligned with and rotating about the rotation axis of the Level 1 body, positive north, whose origin lies at the center of the Level 1 body. Locations within this TRS are specified by longitude, latitude, and radius from the origin. (The lambda(III) coordinate system defines the prime meridian in this coordinate system; if lambda(I) or lambda(II) coordinate systems are desired, note this in the Comments field.)

Planetocentric longitude is always measured positively to the east relative to the prime meridian, regardless of which way the planet rotates. East is defined as the counter-clockwise direction around the planet, as seen from above its north pole, and the north pole is whichever pole more closely aligns with the Earth’s north pole. Imagine a distant, non-orbiting observer viewing a directly rotating planet. Also, suppose that this observer is within the plane of the planet's equator. A point on the Equator that passes directly in front of this observer later in time has a lower planetocentric longitude than a point that did so earlier in time.

If RAD is omitted, then RAD is assumed to be the equatorial radius of the Level 1 body. Note that in general, if RAD is omitted, the point specified will not necessarily be on the visible surface of the planet. This is of special concern for oblate planets, e.g. Jupiter and Saturn, where a point at high latitude at the equatorial radius can appear above the limb of the planet in
projection. When using this coordinate system for surface features on Jovian planets, it is best to specify the radius explicitly.

For spherical planets, planetographic and planetocentric latitudes are identical. For significantly nonspherical objects, there is no simple conversion between the two latitude systems.

For planets with retrograde rotation, the planetocentric and planetographic longitudes of a point are identical. For planets with direct rotation, the planetocentric and planetographic longitudes of a point have opposite sign.

4.4.3 Target Position Level 3 [Level_3]

The instructions for this field are identical to those for the Level 2 field except that “Level 3” should be substituted wherever “Level 2” occurs, and “Level 2” should be substituted wherever “Level 1” occurs.

4.5 Ephemeris Center [Ephem_Center]

Used to support HST observations of the Moon and other close moving targets closer than 3.8 million kilometers. Ephemeris Center must have one of two possible values: EARTH or HUBBLE.

EARTH (default)
A geocentric target ephemeris is computed and provided to HST. HST’s on-board software then computes a correction for the parallax induced by the telescope’s orbit. This is the default method and will work for most cases. However, HST’s on-board parallax correction may be insufficient for a target closer than 3.8 million kilometers.

HUBBLE
An HST-centric target ephemeris is generated. In this case, no parallax correction is needed and none is performed. However, due to uncertainties in HST’s own ephemeris, an HST-centric target ephemeris will have sufficient accuracy for only about 4 weeks into the future. An HST-centric ephemeris should be specified only for very close targets such as the Moon.

4.6 Ephemeris Uncertainty [Ephem_Uncert]

The <value> for ephemeris uncertainty is the distance along its trajectory that the target is expected to be from its ephemeris position, in kilometers
Acquisition Uncertainty [Acq_Uncert]

The <value> for acquisition uncertainty is the uncertainty in the position of the target in a direction perpendicular to the line of sight, in kilometers (KM) or arcsec ( '').

Note: A realistic estimate of acquisition uncertainty is needed to schedule the time necessary to repoint the telescope to the improved position when it is known. It will not be possible for STScI to apply a correction larger than the specified uncertainty.

4.8 Observing Windows [Windows]

The observability of solar system targets is often constrained by various geometrical conditions (e.g. satellites observed at greatest elongation from their parent planet), or the desirability of coordinated observations (e.g. the observation of a planetary system at the same time as a spacecraft encounter with the system). The Window field is provided to allow the proposer to define geometric and timing constraints. The proposer should specify any constraints necessary to achieve the scientific objectives of the program. However, care should be taken in specifying constraints, since they can render the observations difficult or impossible to schedule.

In general, “windows” which define when the target is visible to HST need not be explicitly identified, since these windows will be calculated by the STScI. Windows in this category include:

- Times when the target is not occulted by the Earth.
- Times when the target is not too close to the Sun, Moon, or the bright Earth limb.
Chapter 4: Solar System Targets

- If the target is a planetary satellite, the times when it is not occulted by any other object in the planetary system.

- If the target is a surface feature on a body, the times when the feature is within the field of view of the HST (i.e. the feature is on that part of the body “facing” HST).

If you require other specific conditions to be satisfied (e.g. to observe when a satellite is near elongation, to observe when the central meridian longitude lies in a particular range, etc.), then these conditions must be specified in the Window field. However, the proposer must recognize that proposer-supplied windows might not overlap with the “visibility” windows defined above (calculated by STScI), in which case the observation cannot be scheduled. Note that atmospheric drag and other effects make it difficult to predict the exact position of the HST in its orbit far in advance. This leads to uncertainty in the exact timing of the “visibility” windows more than two or three months in advance.

The various keywords used to define windows are given in the following table and described in detail below.

Table 4.11: Keywords for Observing Windows

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEP</td>
<td>angular separation of two bodies as viewed from a third body</td>
</tr>
<tr>
<td>RANGE</td>
<td>distance between two bodies in AU</td>
</tr>
<tr>
<td>AVEL</td>
<td>angular velocity in arcsec/sec</td>
</tr>
<tr>
<td>RVEL</td>
<td>radial velocity of one body relative to another in km/sec</td>
</tr>
<tr>
<td>SIZE</td>
<td>angular diameter of one body as seen from another in arc-sec</td>
</tr>
<tr>
<td>PHASE</td>
<td>phase of one body as seen from another</td>
</tr>
<tr>
<td>OCC</td>
<td>when two bodies overlap as viewed from a third body</td>
</tr>
<tr>
<td>TRANSIT</td>
<td>when one body crosses another as viewed from a third body</td>
</tr>
<tr>
<td>ECL</td>
<td>when one body is in the shadow of another body</td>
</tr>
<tr>
<td>CML</td>
<td>central meridian longitude</td>
</tr>
<tr>
<td>OLG</td>
<td>orbital longitude</td>
</tr>
</tbody>
</table>

Table 4.12: Operators for Observing Windows

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT</td>
<td>short for less than</td>
</tr>
<tr>
<td>GT</td>
<td>short for greater than</td>
</tr>
<tr>
<td>MAX</td>
<td>short for local maximum (i.e. inflection point). Accompanied by a non-zero tolerance value.</td>
</tr>
</tbody>
</table>
Observing Windows [Windows]  ■  79

The operator NOT, if present, should precede the keyword for the solar system target observing window, as in these examples:

- NOT SEP OF IO JUPITER FROM EARTH GT 10
- NOT RANGE JUPITER EARTH GT 10
- NOT A_VEL IO RELATIVE JUPITER FROM EARTH GT 10

**SEP**

SEP is short for “Separation” and is used to find the times when the apparent separation between two objects, as observed from a third object, satisfies certain conditions. The separation between two bodies is defined as the angle between the closest points on the observed limbs of the spheres representing the objects as viewed from the observer (the radius of the sphere is equal to the largest radius of the tri-axial ellipsoid representation of the object). The syntax is:

```
[NOT] SEP OF <object 1> <object 2> FROM <observer> <condition> <angle>
```

where <object 1>, <object 2>, and <observer> must be standard targets that have been previously defined in the target position fields. The units for “angle” must be chosen from one of D (degrees), ' (arc-minutes), or " (arc-seconds). The interpretation of the SEP keyword is as follows: when the <condition> is either LT or GT then times are found when the separation of "objects 1 and 2", as viewed from <observer>, is less than <angle> or greater than <angle> respectively. When the <condition> is MAX (MIN), then times are found when “objects 1 and 2” are at maximum elongation (minimum separation), as viewed from <observer>.

**RANGE**

RANGE is used to select windows based on the separation of objects in terms of distance (AU). The syntax is:

```
[NOT] RANGE <object 1> <object 2> <condition> <distance>
```

**A_VEL**

A_VEL is used to select windows based on the angular velocity of objects in terms of arcsec/sec. The syntax is:
[NOT] A_VEL <object 1> [RELATIVE <object 2>] FROM <object 3> <condition> <velocity>

<Velocity> is the angular velocity of <object 1> as observed from <object 3>. If RELATIVE is used, <velocity> is the apparent angular velocity of <object 1> relative to <object 2> as observed from <object 3>.

R_VEL

R_VEL is used to select windows based on the change in distance between two objects (i.e. the Radial Velocity) in km/sec. The syntax is:

[NOT] R_VEL <object 1> <object 2> <condition> <velocity>

Positive values of <velocity> mean that the objects are moving away from each other while negative values mean that the objects are moving closer to each other.

SIZE

SIZE is used to select windows based on the apparent angular diameter of an object in arc-seconds. The syntax is:

[NOT] SIZE <object> <condition> <angle>

PHASE

PHASE is used for solar phase angle, and is used to find times when the angular phase of one body as seen from another is within a specified range. The syntax is:

[NOT] PHASE OF <object> FROM <observer> BETWEEN <angle 1> <angle 2>

where <angle> is the observer-object-sun angle, in degrees.

OCC

OCC is short for “Occultation” and is used to find times when one body appears to pass behind another body as viewed from a third body. The syntax is:

[NOT] OCC OF <occulted object> BY <occulting object> FROM <observer>

The <occulted object>, <occulting object>, and <observer> must be standard targets from Table 4.1: Solar System Standard Targets. An occultation is defined to begin when the limb of the sphere representing the <occulted object> first touches the limb of the sphere representing the <occulting object>, as seen from the vantage point of the <observer>. 
TRANSIT

TRANSIT is used to find times when one body appears to pass across the disk of another body as viewed from a third body. The syntax is:

[NOT] TRANSIT OF <transiting object> ACROSS <transited object> FROM <observer>

The <transiting object>, <transited object>, and <observer> must be standard targets from Table 4.1: Solar System Standard Targets. A transit is defined to begin when the disk representing the <transiting object> is entirely in front of the disk representing the <transited object>, as seen from the vantage point of the <observer>. The transit ends when the limbs of the two disks come into contact again. Thus at any time in the transit the <transiting object> is entirely surrounded by the <transited object>.

ECL

ECL is short for “Eclipse” and is used to find times when one body is in the shadow (cast in sunlight) of another body. The syntax is:

[NOT] ECL <type> OF <eclipsed object> BY <eclipsing object>

The <eclipsed object> and <eclipsing object> must be standard targets from Table 4.1. An eclipse is defined to begin when the trailing limb of the <eclipsed object> enters the penumbra (<type> = P) or the umbra (<type> = U) of the <eclipsing object>. An eclipse is defined to end when the leading limb of the <eclipsed object> exits the penumbra (<type> = P) or the umbra (<type> = U) of the <eclipsing object>. One of the values P or U must be specified.

CML

CML is short for “Central Meridian Longitude” and is used to find times when the planetographic sub-observer meridian of an object lies within a particular range (in the case of Jupiter, lambda(III) is used). The syntax is:

[NOT] CML OF <object> FROM <observer> BETWEEN <angle 1> <angle 2>

The <object> and <observer> must be standard targets from Table 4.1: Solar System Standard Targets. The keyword specifies those times when the central meridian longitude lies between <angle 1> and <angle 2> (both in degrees) as seen by the <observer>.

OLG

OLG is short for “Orbital Longitude” and is used to select observation times based on a geocentric view (usually) of the object. OLG can be used on either a Level 1 or a Level 2 object. The syntax is:
[NOT] OLG OF <object 1> [FROM <object 2>] BETWEEN <angle 1> <angle 2>

where <angle 1> and <angle 2> are in degrees. OLG specifies those times when the orbital longitude lies between <angle 1> and <angle 2>. The default for <object 2> is the Earth. If <object 1> refers to a Level 2 body, usually a satellite, the orbital longitude is defined as follows (see Figure 4.1 Orbital Longitude for Satellites):

1. Construct a vector from <object 2> (Earth) to the Level 1 parent (planet) of the <object 1> (satellite).
2. Extend the vector “behind” the planet and project it onto the orbital plane of the satellite. This is the reference axis.
3. The orbital longitude is the angle from the reference axis to the position of the satellite measured in the direction of motion of the satellite. Valid values for the orbital longitude lie in the range 0–360 degrees.

Orbital Longitude of 0 degrees corresponds to superior conjunction, Orbital Longitude of 180 degrees corresponds to inferior conjunction, and 90 degrees and 270 degrees correspond to greatest eastern and western elongation, respectively.

If “object 1” refers to a Level 1 body, e.g. a planet, asteroid, or comet, the orbital longitude is defined to be the angle between the Sun-Earth vector and the Sun-Planet vector, projected onto the planet’s orbital plane, increasing in the direction of the planet’s orbital motion (see Figure 4.2: Orbital Longitude for Planets).

Orbital Longitude of 0 degrees corresponds to opposition, Orbital Longitude of 180 degrees corresponds to conjunction with the Sun. However, Orbital Longitude of 90 degrees or 270 degrees does not correspond with quadrature. Orbital Longitude is not synonymous with “elongation” or “separation” from the sun.

4.8.1 Default Target Windows

Please note that the following defaults apply for solar system targets.

All targets in the Martian system except Mars:

SEP OF <target> MARS FROM EARTH GT 10"

All targets in the Jovian system except Jupiter:

SEP OF <target> JUPITER FROM EARTH GT 30"

All targets in the Jovian system except Io:

SEP OF <target> IO FROM EARTH GT 10"

All targets in the Jovian system except Europa:
SEP OF <target> EUROPA FROM EARTH GT 10"
All targets in the Jovian system except Ganymede:

SEP OF <target> GANYMEDE FROM EARTH GT 10"
All targets in the Jovian system except Callisto:

SEP OF <target> CALLISTO FROM EARTH GT 10"
All targets in the Saturnian system except Saturn:

SEP OF <target> SATURN FROM EARTH GT 45"
All targets in the Saturnian system except Rhea:

SEP OF <target> RHEA FROM EARTH GT 10"
All targets in the Saturnian system except Titan:

SEP OF <target> TITAN FROM EARTH GT 10"
All targets in the Uranian system except Uranus:

NOT OCC OF <target> BY URANUS FROM EARTH
All targets in the Neptunian system except Neptune:

NOT OCC OF <target> BY NEPTUNE FROM EARTH
All TYPE=PGRAPHIC, TYPE=PCENTRIC, and TYPE=MAGNETIC targets:

NOT OCC OF <target> BY <parent body> FROM EARTH
These default windows will be superseded by any similar windows specified in the solar system target list. For example, if the target is Io and an Io-Callisto separation window is specified by the observer, then the observer’s Io-Callisto separation window will apply and the default will not.

4.9 Flux Data [Flux and Other Fluxes]

Flux information for all targets is required. There can be more than one entry for a given target. STScI will use this flux information to prevent over-illumination of sensitive detectors. Proposers should refer to Section 3.9 on page 47 for instructions and guidelines on how to provide flux data for their targets. The flux data must be given in the format and units shown in Table 4.13: Formats for Specification of Target Flux Data. The units should not be entered on the Target List.
**Text Proposal File**

If you are using the Text Proposal File, other flux items must be separated by commas.

Table 4.13: Formats for Specification of Target Flux Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Format example</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples for Stars:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad-band magnitude¹</td>
<td>V=13.1 +/- 0.5</td>
<td>magnitude</td>
</tr>
<tr>
<td>Spectral type</td>
<td>TYPE=G5III</td>
<td></td>
</tr>
<tr>
<td>Color Index¹</td>
<td>B-V = 0.86 +/- 0.2</td>
<td>magnitude</td>
</tr>
<tr>
<td>Color Excess</td>
<td>E(B-V) = 0.3 +/- 0.2</td>
<td>magnitude</td>
</tr>
<tr>
<td>Background Surface Brightness²</td>
<td>SURF-BKG(B) = 20 +/- 0.2</td>
<td>mag/arcsec²</td>
</tr>
<tr>
<td><strong>Examples for Galaxies, Nebulae, and other extended sources:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Brightness¹</td>
<td>SURF(V) = 25.0 +/- 1.0</td>
<td>mag/arcsec²</td>
</tr>
<tr>
<td>Surface Brightness¹</td>
<td>SURF(B) = 24.5 +/- 0.5</td>
<td>mag/arcsec²</td>
</tr>
<tr>
<td>Color Excess</td>
<td>E(B-V) = 2.5 +/- 0.2</td>
<td>mag</td>
</tr>
<tr>
<td>Interstellar Extinction</td>
<td>A(V) = 1.3 +/- 0.1</td>
<td>mag</td>
</tr>
<tr>
<td>Flux at a specified wavelength</td>
<td>F(5100) = 51 +/- 3 E-15</td>
<td>erg/(cm² sec Å)</td>
</tr>
<tr>
<td>Continuum Flux³</td>
<td>F-CONT(3500) = 57 +/- 3 E-15</td>
<td>erg/(cm² sec Å)</td>
</tr>
<tr>
<td>Line Flux³,⁴,⁵</td>
<td>F-LINE(3727) = 5 +/- 1 E-14</td>
<td>erg/(cm² sec Å)</td>
</tr>
<tr>
<td>Line Width⁶</td>
<td>W-LINE(3727) = 2.4 +/- 0.2</td>
<td>Å</td>
</tr>
<tr>
<td>Surface Brightness at specified wavelength²</td>
<td>SURF(5100) = 11 +/- 2 E-15</td>
<td>erg/(cm² sec Å arcsec²)</td>
</tr>
<tr>
<td>Surface Brightness at continuum wavelength²</td>
<td>SURF-CONT(5000) = 52 +/- 2 E-15</td>
<td>erg/(cm² sec Å arcsec²)</td>
</tr>
<tr>
<td>Surface Brightness of line emission³,⁴,⁵</td>
<td>SURF-LINE(5007) = 52 +/- 2 E-15</td>
<td>erg/(cm² sec arcsec²)</td>
</tr>
<tr>
<td>Size (FWHM of circular region)⁷</td>
<td>SIZE = 25 +/- 5</td>
<td>arcsec</td>
</tr>
</tbody>
</table>

¹. The following broad-band magnitudes may be used: U, B, V, R, I, J, H, K.
². You may append “–BKG” to this reference (just before the wavelength designation) to indicate that it is a background flux value (e.g., SURF-BKG(V) = 18.2 +/- 0.5; SURF-CONT-BKG(5100) = 10 +/- 3 E-15).
³. Give wavelength used in keyword in rest frame, but flux in observed frame.
4. Line flux should be relative to the continuum, if specified, or relative to zero if not specified.
5. Whenever the S/N refers to a spectral line, W-LINE must be given along with F-LINE or SURF-LINE. Values of F-LINE and SURF-LINE outside the Earth’s atmosphere are required.
6. W-LINE is the full width at half maximum (FWHM).
7. SIZE should be included if the exposure time estimate assumed the flux was spread over an extended region; if omitted, the highest spatial resolution of the observing mode will be assumed.

4.10 Comments [Comments]

This field should include in words what you are trying to define by coordinates and windows in the other fields. For example, for Target No. 3 on the sample form the TPS and Window fields define mathematically the location of the target and the valid observation times, but the Comments field is probably much more useful in helping an observation planner determine the proposer’s objectives. Use only alphanumeric characters and hyphens.

4.11 Illustrations of Orbital Longitude

Figure 4.1: Orbital Longitude for Satellites
4.12 Examples of Target List Blocks

The sample targets defined in this section are provided as examples of completed forms using the syntax described in these instructions. This collection does not provide an example for every type of keyword but does give a good overall representation of the types of target selections that can be accommodated. Numerical data in these examples is fictional.

- **Example 1**: In this example the proposer wants to perform spectroscopy of a volcano on Io. The position of the target is given in planetographic coordinates. The proposer also wants to observe the target when it lies close to the central meridian and, thus, uses CML to specify the allowable range of the central meridian longitude.

```
Target_Number: 1
Name: IO-VOLCANO
Description: FEATURE IO
Level_1: STD = JUPITER
Level_2: STD = IO
Level_3: TYPE = PGRAPHIC,
         LONG = 310,
         LAT = 13
Window: CML OF IO FROM EARTH BETWEEN 280 340
Flux: SURF(V) = 5 +/- 0.5,
      SURF-CONT(2300) = 5.2 +/- 0.2 E–14,
      SIZE = 1.0
Comments: Observe IO volcano Loki when it is near the central meridian.
```
- **Example 2:** In this example the proposer wants to perform spectroscopy of the western ansa of the Io torus when Io is near greatest eastern elongation. The elongation condition is specified using the OLG keyword.

```
| Target_Number: | 2 |
| Name:         | IO-TORUS |
| Description:  | TORUS JUPITER |
| Level_1:      | STD = JUPITER |
| Level_2:      | TYPE = TORUS, LONG = 90, LAT = 0, RAD = 4.3E5 |
| Window:       | OLG OF IO BETWEEN 90 100 |
| Flux:         | SURF-LINE(1304) = 1 +/- 0.5E-13, W-LINE(1304) = 2 +/- 1, SIZE = 1 |
| Comments:     | West ansa of IO Torus when IO is at greatest eastern elongation. |
```

- **Example 3:** In this example the proposer wants to perform spectroscopy in the tail of comet Halley near the time of the Giotto spacecraft encounter. The latest orbital elements for the comet have been supplied by the proposer and these will be used for the ephemeris generation. The POS_ANGLE target reference system is used to specify the tailward pointing.

```
| Target_Number: | 3 |
| Name:         | COMET-HALLEY-TAIL |
| Description:  | OFFSET COMET HALLEY |
| Level_1:      | TYPE = COMET, Q = 0.5871167, E = 0.9672815, I = 162.2397156, O = 58.144397, W = 111.8489075, T = 09-FEB-86:11:01:04, EPOCH = 01-MAR-86, EQUINOX = B1950 |
| Level_2:      | TYPE = POS_ANGLE, RAD = 30, ANG = 180, |
```
REF = SUN

Flux:
- SURF(V) = 12 +/- 1,
- SURF-LINE(1216) = 3.1 +/- 0.5E10,
- W-LINE(1216) = 0.1 +/- 0.5,
- SIZE = 1

Comments: 30 arcsec into tail of Halley during Giotto encounter. New orbital elements based on recent observations are provided.
# CHAPTER 5: Visits, Exposures and Exposure Groups

In this chapter . . .

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Visit Number and Status</td>
<td>91</td>
</tr>
<tr>
<td>5.2 Visit-level Special Requirements [Visit_Requirements]</td>
<td>92</td>
</tr>
<tr>
<td>5.3 On Hold Comments [On_Hold_Comments]</td>
<td>93</td>
</tr>
<tr>
<td>5.4 Visit Comments [Visit_Comments]</td>
<td>93</td>
</tr>
<tr>
<td>5.5 Exposure Number [Exposure_Number]</td>
<td>93</td>
</tr>
<tr>
<td>5.6 Exposure Label [Exposure_Label]</td>
<td>93</td>
</tr>
<tr>
<td>5.7 Target Name [Target_Name]</td>
<td>94</td>
</tr>
<tr>
<td>5.8 Instrument Configuration [Config]</td>
<td>95</td>
</tr>
<tr>
<td>5.9 Operating Mode [Opmode]</td>
<td>96</td>
</tr>
<tr>
<td>5.10 Aperture or Field of View [Aperture]</td>
<td>96</td>
</tr>
<tr>
<td>5.11 Spectral Element [Sp_Element]</td>
<td>97</td>
</tr>
<tr>
<td>5.12 Central Wavelength or Range if Grating or Prism Used [Wavelength]</td>
<td>98</td>
</tr>
<tr>
<td>5.13 Number of Times to Iterate the Exposure [Number_of_Iterations]</td>
<td>98</td>
</tr>
<tr>
<td>5.14 Time per Exposure [Time_Per_Exposure]</td>
<td>98</td>
</tr>
<tr>
<td>5.15 Exposure-level Comments [Comments]</td>
<td>99</td>
</tr>
<tr>
<td>5.16 Optional Parameters [Optional_Parameters]</td>
<td>100</td>
</tr>
<tr>
<td>5.17 Exposure-level Special Requirements [Special_Requirements]</td>
<td>100</td>
</tr>
<tr>
<td>5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns</td>
<td>101</td>
</tr>
<tr>
<td>5.19 Subexposures</td>
<td>102</td>
</tr>
</tbody>
</table>
Tables and Figures

Table 5.1: Special External Target Names
Table 5.2: Instrument Configurations and Operating Modes
Table 5.3: Aperture and Field of View Names

The Visit and Exposure Specifications are used to define the proposed exposures for all the Scientific Instruments. While the number of parameters needed to define all possible instrument configurations is large, the Visit and Exposure Specifications has been simplified by using standard Instrument Configurations and Operating Modes to set most of the instrument parameters to default values. The rest of the exposure keywords are used to define parameters that usually change from one exposure to the next, such as filters, exposure times, and special scheduling requirements.

Before proceeding further, it is useful to define more carefully what is meant by an exposure, a subexposure, and by a visit. (Note: APT also uses Exposure Groups or Containers; see Section 5.18, “Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns,” on page 101)

Exposures

An exposure consists of the events and data corresponding to a unique Exposure_Number within a given visit. The full description of an exposure is called an Exposure Specification. Although many data samples (see APT subexposures) may result from a single execution of an Exposure Specification (due to the Instrument Configuration, Operating Mode, and Optional Parameters chosen), they are considered to be one exposure. Also, you may specify multiple exposures in an Exposure Specification by entering an integer greater than 1 for the Number_of_Iterations keyword (see Section 5.13 on page 98); additional exposures will be obtained consecutively (except for possible interruptions by Earth occultations, guide star acquisitions, and SAA passages).

Exposures defined within a visit will be obtained consecutively and in the order specified within a visit.

APT subexposures

Within an Exposure Specification, each data sample that will be taken onboard HST is represented in APT by a separate entity called a subexposure. Subexposures are used to track the duration of the sample (actual_duration) and the orbit number in which it occurs (orbit_number).
Visits
A visit is an exposure or series of consecutive exposures, with overheads, on a given target, and may consist of the following parts:

1. Guide-star acquisition (to point HST at the target)
2. Target acquisition (to place the target in an instrument aperture)
3. Science exposure(s) (to obtain the data)
4. Instrument overheads (to set up the instrument and read out the data)
5. Instrument calibrations (if more than the standard calibration is required)

If the visit lasts more than one orbit, it will continue with the following for each subsequent orbit:

6. Guide-star re-acquisition (to keep HST pointed and locked after Earth occultations)
7. Science exposure(s)
8. Instrument overheads
9. Instrument calibrations

Whenever one of the following occurs, a new visit must be defined:

- A change in target position of greater than 1 degree. (Contact your Program Coordinator for details regarding solar system objects that move more than about 30 arcsec during the observation and thus are likely to require multiple sets of guide stars).
- Repeated, periodic, or other time-separated observations with an interval between exposures such that one or more empty visibility periods (orbits with no exposures) would otherwise be required.
- Required change in spacecraft roll orientation.

5.1 Visit Number and Status

[Visit_Number]
You must assign each visit a unique visit number (base 36 values ranging from 01 - ZZ).

Visit_Status
This field reflects the visit’s execution status and cannot be edited. If you are attached to the internet, the status value is read from the proposal
Visit_Status can have the following values: pi, implementation, scheduling, completed, failed, withdrawn. Note that visits with a status of "completed" or "failed" cannot be edited in APT. Also, if you attempt to edit visits with a status of "scheduling" or "withdrawn" you will get a pop up warning that you should let your PC know that you are changing that visit.

(Visit Priority Section for Pure Parallels Deleted)

5.2 Visit-level Special Requirements
[Visit_Requirements]

A variety of visit-level Special Requirements may be chosen; these requirements apply to all exposures in the visit (exposure-level Special Requirements are discussed in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111). These requirements will be interpreted by the computer software that is used to schedule the observations; therefore it is essential that the specific formats shown in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111 are followed precisely. If none of the allowed Special Requirements appears to be sufficient, you can describe the requirements with a text explanation in Visit_Comments. You should contact your Program Coordinator prior to entering such a comment in your proposal.

Several of these Special Requirements require the use of limited resources or may impose serious constraints on the scheduling system (e.g., ORIENT, CVZ, BETWEEN). Use these Special Requirements with care.

The visit-level Special Requirements are described in detail in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111.

Text Proposal File

If you are using a Text Proposal File to modify your program, please be aware that only the shortest form of the special requirements will be accepted when you import your template back into APT (e.g., use ORIENT <angle1> TO <angle2>). Also, new lines will not be sufficient delimiters for a list of special requirements. You must use semicolons to separate special requirements items.
5.3 On Hold Comments [On_Hold_Comments]

If you have requested via the Special Requirement ON HOLD that a given visit be placed “on hold” (which means that the visit will not be scheduled until you have cleared the hold), then indicate why the visit is on hold, and how the hold is to be released. Examples of On_Hold_Comments are:

- Target of Opportunity
- Waiting for Early Acquisition data from visit <number>
- Waiting for non-HST data [to be obtained <date>]
- Conditional if <text>
- Conditional on <exposure-list> if <text>
- Select <number> of <exposure-list>

5.4 Visit Comments [Visit_Comments]

The comments field should be used only to record observing notes; it should not be used to specify scheduling requirements. Comments are not interpreted by the software, but are maintained in the database and do appear on printouts of the programs. Please contact your Program Coordinator prior to inserting comments to make certain there is no other way to specify the information. An Example of a Visit Comments is:

- UV observation of Target X

5.5 Exposure Number [Exposure_Number]

APT will assign a unique integer number to an exposure. The smallest exposure number permitted is 1, and the largest is 999.

Note that exposure numbers for coordinated parallels must (and will be) sequential; see Section 6.3 on page 105.

5.6 Exposure Label [Exposure_Label]

You can assign a label to each exposure. This allows you to call each exposure by a name that has more meaning than just the exposure number.
For example given three filters and multiple positions, the you might elect to call a sequence of 6 exposures North/U, North/V, North/B, Center/U, Center/V, and Center/B.

5.7 Target Name [Target_Name]

Choose a target from the Target List provided. In the case of certain internal and external calibration sources, a special code must be used (see Table 5.1). In general, calibration observations will be requested only rarely, since most calibrations will be carried out by STScI (see the Call for Proposals).

Due to scheduling constraints, fixed external targets and solar system targets may not be used in the same visit. Also, none of the external calibration targets (EARTH-CALIB, DARK-EARTH-CALIB, ANTI-SUN, ORBIT-POLE-NORTH, ORBIT-POLE-SOUTH) may be used in the same visit with another external target.

5.7.1 Astronomical Targets

The target name should be exactly as you entered it in the Target List (see Section 3.2 on page 27). Only the prime target name is used; alternate names are not used.

5.7.2 Special Targets

If an internal calibration observation is requested on the Visit and Exposure Specifications, one of the specific “target” names in Table 5.1 must be chosen. The calibration source should not be chosen in the Target List. See the Call for Proposals for discussions of the routine calibrations that will be performed by STScI. See the Instrument Handbooks for further details of the calibrations for each instrument.

Name without including them in the Target List.
Specific astronomical objects used as external calibrators (e.g., standard stars) should be chosen in the Target List and Visit and Exposure Specifications as normal exposures, and the suffix -CALIB should be appended to their names, as discussed in Section 3.2.4 on page 30.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARTH-CALIB</td>
<td>The sunlit Earth is used for a flat-field calibration. Because of bright object constraints, EARTH–CALIB may not be used in the STIS/FUV–MAMA, STIS/NUV–MAMA and ACS/SBC configuration.</td>
</tr>
<tr>
<td>DARK-EARTH-CALIB</td>
<td>The non-sunlit Earth is used for a flat-field calibration. Because of bright object constraints, DARK-EARTH-CALIB may not be used in the STIS/FUV-MAMA, STIS/NUV-MAMA and ACS/SBC configurations. EARTH-CALIB and DARK-EARTH-CALIB targeted exposures may not be used in the same visit.</td>
</tr>
<tr>
<td>ANTI-SUN</td>
<td>Target will be nearly opposite the Sun whenever scheduled.</td>
</tr>
<tr>
<td>ORBIT-POLE or</td>
<td>Target will be the North orbit pole.</td>
</tr>
<tr>
<td>ORBIT-POLE-NORTH</td>
<td></td>
</tr>
<tr>
<td>ORBIT-POLE-SOUTH</td>
<td>Target will be the South orbit pole</td>
</tr>
<tr>
<td>ANY</td>
<td>Allowed on pure-parallel and coordinated-parallel exposures. The target will be wherever the parallel aperture happens to point.</td>
</tr>
</tbody>
</table>

5.8 Instrument Configuration [Config]

Choose the Instrument Configuration to be used. The available choices are listed in Table 5.2, along with the corresponding Operating Modes that may be chosen in “Opmode” (see Section 5.9 on page 96). Legal Apertures, Spectral Elements, and Optional Parameters are uniquely determined by the choice of the Instrument Configuration and Operating Mode. Detailed descriptions are provided in Part II: Supported Science Instruments of these Instructions and the Instrument Handbooks.
Table 5.2: Instrument Configurations and Operating Modes

<table>
<thead>
<tr>
<th>Instrument Configuration</th>
<th>Operating Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>STIS/CCD</td>
<td>ACQ, ACQ/PEAK, ACCUM</td>
</tr>
<tr>
<td>STIS/FUV–MAMA or STIS/NUV–MAMA</td>
<td>ACCUM, TIME–TAG</td>
</tr>
<tr>
<td>FGS</td>
<td>POS, TRANS</td>
</tr>
<tr>
<td>NIC1 or NIC2 or NIC3</td>
<td>ACCUM, MULTIACCUM</td>
</tr>
<tr>
<td>NIC2</td>
<td>ACQ</td>
</tr>
<tr>
<td>ACS/WFC or ACS/SBC</td>
<td>ACCUM</td>
</tr>
<tr>
<td>COS/FUV</td>
<td>ACQ/SEARCH, ACQ/PEAKD, ACQ/PEAKXD, TIME-TAG, ACCUM</td>
</tr>
<tr>
<td>COS/NUV</td>
<td>ACQ/SEARCH, ACQ/IMAGE, ACQ/PEAKD, ACQ/PEAKXD, TIME-TAG, ACCUM</td>
</tr>
<tr>
<td>WFC3/UVIS</td>
<td>ACCUM</td>
</tr>
<tr>
<td>WFC3/IR</td>
<td>MULTIACCUM</td>
</tr>
</tbody>
</table>

5.9 Operating Mode [Opmode]

Choose the Operating Mode to be used. Table 5.2 lists all possibilities. See the Instrument Handbooks and the Instrument Chapters in this document for detailed discussions of the Operating Modes.

5.10 Aperture or Field of View [Aperture]

The desired aperture or field of view of the Scientific Instrument should be chosen (see Table 5.3). However, observers are cautioned that not all combinations of Apertures, Operating Modes, and Spectral Elements are available. See the Instrument Handbooks for details.
Table 5.3: Aperture and Field of View Names

<table>
<thead>
<tr>
<th>STIS</th>
<th>FGS</th>
<th>ACS</th>
<th>NICMOS</th>
<th>COS</th>
<th>WFC3</th>
</tr>
</thead>
</table>

5.11 Spectral Element [Sp_Element]

The desired Spectral Element should be chosen. Spectral Elements include filters (F), gratings and grisms (G), echelles (E), prisms (PR), polarizers (POL), linear ramps (FR), quadrant filters (FQ) and mirrors (MIRROR). The names of the filters, gratings, grisms, and echelles include the wavelength of the approximate midpoint of the bandpass, in nanometers.

Examples of the Spectral Element designations are the following:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F098M</td>
<td>A medium-band (M) WFC3 IR filter (F) with midpoint of coverage near 0.98 microns</td>
</tr>
<tr>
<td>G140L</td>
<td>A low-dispersion (L) STIS grating (G) with midpoint of coverage near 1400 Å</td>
</tr>
<tr>
<td>G206</td>
<td>A NICMOS grism (G) with midpoint of coverage near 2.06 microns</td>
</tr>
<tr>
<td>E230H</td>
<td>A high-dispersion (H) STIS echelle (E) with midpoint of coverage near 2300 Å</td>
</tr>
<tr>
<td>FQ232N</td>
<td>A narrow-band (N) WFC3 UVIS quadrant filter (FQ) with midpoint of coverage near 2320 Å</td>
</tr>
</tbody>
</table>

**Polarizer or Crossed Filter**

More than one element may be specified, if necessary, using these fields. Choose the desired element from the list provided in Part II of these Instructions. They are also described in the Instrument Handbooks.

**Text Proposal File (Sp_Element)**

If you are using the Text Proposal File, a second spectral element can be specified after the first one separated by a comma.
5.12 Central Wavelength or Range if Grating or Prism Used [Wavelength]

If a linear ramp filter, quadrant filter, grating, or prism is to be used, the central wavelength should be entered. NICMOS exposures do not require a central wavelength or range.

Wavelengths should be expressed in Å in the observed frame (but the units should be omitted). Use vacuum wavelengths below 2000 Å, and air wavelengths above 2000 Å.

For STIS and COS exposures, the central wavelength must obey one of the legal spectral element/wavelength combinations given in Table 9.2: Supported Central Wavelengths for STIS Gratings and Table 13.3: COS Spectral Elements and Central Wavelengths.

5.13 Number of Times to Iterate the Exposure [Number_of_Iterations]

Choose the number of times the defined exposure is to be iterated; Choose 1 if only one execution of the exposure is desired. Typical reasons for iterating an exposure are to monitor temporal changes in a target or to keep CCD exposures short to minimize blooming by a bright star. If more than one execution is requested, iterations (in the form of additional subexposures) will be created and executed contiguously. Also note that for STIS, these subexposures can be interrupted by an wavecal. The wavecal can be suppressed; see SEQuence <exposure-list> NON-INTerruptible (replaced by Exposure Group Containers in the APT User Interface).

5.14 Time per Exposure [Time_Per_Exposure]

Enter the exposure time (in seconds) for each separate exposure. It is important that observers consult the Instrument Handbooks, and the tools on the STScI Web pages.

Note that the exposure time is the total time for one execution of a defined exposure. Multiple executions may be specified by entering a value for Number_of_Iterations (see Section 5.13 on page 98), or with certain Special Requirements. The exposure time entered may be divided among many samples or spectra (subexposures), depending on the Instrument Configuration, Operating Mode, and Optional Parameters. Generally, the
exposure time is used only for the collection of photons, but there are exceptions for which instrumental overheads are included in the exposure time. For details, see the specification for each Operating Mode in Part B of these Instructions. In the normal case, the exposure time entered may be used to obtain a single image, to obtain a series of spectra, or to perform a complex, nomous target acquisition.

Routine calibration exposures will be performed by STScI. If special internal calibrations are required for your program, consult the Internal Calibration Target tables in Part II of these Instructions for information about what exposure times to use.

Use the Target Acquisition sections of the Instrument Handbooks and STScI Web tools to estimate exposure times used for acquisition exposures.

Exposure times may be changed during scheduling by STScI in order to place exposures in observing windows defined by orbital constraints (Earth blockage, passage through the SAA, etc.) and to improve overall efficiency. Changes to exposure times will be such that the exposure time is not changed by more than about 20%; note that increases, as well as decreases, in exposure time are possible.

---

Target acquisition and peakup exposure times are not altered during scheduling.

---

5.15 Exposure-level Comments [Comments]

Information that cannot be made to conform to the required formats may be entered as a comment. Comments are not interpreted by the software, but are maintained in the database and do appear on printouts of the programs. Comments should be used sparingly, if at all. They are intended only for the small number of programs whose requirements cannot be met with standard and supported features. Please contact your Program Coordinator before entering comments that would affect the execution of an exposure.
5.16 Optional Parameters [Optional_Parameters]

The Operating Modes of the instruments frequently have parameters that may be adjusted. The default parameter values that have been defined for the various Instrument Configurations and Operating Modes can be overridden by entries in the Optional Parameters form. See the instrument chapters in this document and the Instrument Handbooks for descriptions of the Optional Parameters.

If no values are changed in the Optional Parameters form, default values will be used.

Text Proposal File
If you use more than one Optional Parameter, they must be separated by commas (e.g., BINAXIS1=1, BINAXIS2=1).

5.17 Exposure-level Special Requirements [Special_Requirements]

A variety of exposure-level Special Requirements may be chosen; these requirements apply to individual exposures in a visit (visit-level Special Requirements are discussed in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111). These requirements will be interpreted by the computer software that is used to schedule the observations; therefore it is essential that the formats of the keyword values shown in Chapter 7 are followed precisely. If none of the allowed Special Requirements appears to be sufficient, you can describe the requirements with a text explanation using the “Comments” keyword. You should contact your Program Coordinator prior to entering such a comment in your proposal.

Several of these Special Requirements require the use of limited resources or may impose serious constraints on the scheduling system (e.g., RT ANALYSIS, REQ UPLINK). These Special Requirements should be used with care.

Text Proposal File
If you are using a Text Proposal File to modify your program, please be aware that only the shortest form of the special requirements will be accepted by APT (e.g., POSition TARGet must be entered as POS TARG). Also, new lines will not be sufficient delimiters for a list of special requirements. You must use semicolons to separate special requirements items.
Whenever you wanted to create a set of exposures to be executed in a special way in RPS2 (e.g., a mosaic pattern on a region of the sky), you could specify exposures separately and then link them with exposure-level special requirements. In APT, some of these exposure-level special requirements (listed below) have been replaced with the use of exposure "containers" or groupings. Once an exposure container has been created in APT, you then place the related exposures in this container instead of using Special Requirements to link them.

See APT Help for the mechanics (i.e., a "how to") of placing exposures into containers.

The special requirements (see Table 7.2: "Supported Formats for Exposure Level Special Requirements" on page 115) that have been replaced by these exposure containers or groupings (in parenthesis) are:

- **Exposure Group Container** (Type: Sequence)
  (replaces SEQuence <exposure-list> NON-INTeruptible): The exposures placed in this container will be observed without gaps due to Earth occultation or SAA passages. See Section 7.3.3 on page 135.

- **Coordinated Parallel Container**
  (replaces PARallel <parallel-exp-list> WITH <primary-exp-list>): The exposures in this container using the “primary” SI will execute in parallel with a sequence of exposures using a “parallel” SI. The “primary” SI will be the SI used in the first exposure in this container. See Section 6.3 on page 105 for more information.

- **Pattern Container**
  (replaces PATTERN <#> [<exposure-list>]): Each exposure placed in this container will be repeated at each point in a pattern of discrete pointing offsets from a target. The pattern # is assigned by APT. See Section 8.2, “Introduction to Patterns,” on page 145 for more information.

Note: You can place containers within containers (e.g., a coordinated parallel container can be inside a pattern container).
5.19 Subexposures

In an Exposure Specification, each data sample collected is represented in APT by a separate entity called a subexposure. A subexposure tracks the orbit number (orbit_number) of the sample, as well as any override to the default duration (actual_duration). You need not supply these values.

5.19.1 Actual_Duration

Unless the user (or the adjust feature in the Orbit Planner) fills in this field, it will be blank and defaults used. For example, if the exposure is CR-SPLIT, the sum of the exposure times of the subexposures will be equal to the parent exposure’s exposure time. In all other cases the exposure time of each subexposure will be equal to the exposure time of the parent exposure.

Note, however, that if the actual_duration field is filled, this value overrides the default. So the total exposure time for an exposure will be equal to the sum of the actual_durations of the subexposures regardless of the original exposure time.

5.19.2 Orbit_Number

This determines which orbit the subexposure will be placed in. Generally, unless you need to control the orbit structure of the visit, this field can be left alone and will be filled in by the Orbit Planner.
The instruments onboard HST have small apertures that must be accurately pointed to achieve useful scientific results. However, the value of “parallel” observations was recognized during the earliest stages of HST’s design because by turning on other instruments one could discover new objects and new phenomena, or just acquire highly detailed images of random regions of the sky that are the equivalent of a survey. This parallel capability was present to a limited degree at launch, but it has become especially important since the fourth servicing mission. Now WFC3 and ACS can work at the same time with COS or STIS.

Parallel science uses two or more Science Instruments at the same time. The primary observation determines the pointing of HST and always takes precedence. The parallel observation is the one enabled to take place because the primary observation permits suitable conditions, but the parallel observation must never interfere with the primary. Although parallel observations are conceptually simple (e.g., “Turn on ACS while COS is in use”), they are, in fact, complex to execute. Commanding the instruments for parallels and primaries at the same time requires strict observance of complex timing rules in order to avoid damage to instruments. Some special restrictions must be applied in order to effectively schedule and execute parallel observations. For additional information see *Parallel Observations with HST*.

From the point of view of the HST ground systems there are two types of parallel exposures: pure and coordinated parallels.

- **Coordinated parallels** are written to be part of the same proposal, with the intention of scheduling the primary and the parallels together. Coordinated parallels are inextricably linked with their primaries: both must be scheduled in order for either to be scheduled.

- **Pure parallels** are defined at the beginning of the observing cycle based on the structure of available primary visits. They are scheduled simultaneously with and according to the plan windows of those pri-
mary visits. Pure parallels may not affect the scheduling of primary
visits. This type of parallel must be used whenever the primary and
parallel exposures come from different proposals.

The HST pointing control system will automatically correct for differ-
ential aberration effects for the Primary observations. There will be a
small smearing effect in the parallel SI which cannot be corrected
on-board. The magnitude of the effect will vary with the primary target
location and aperture, but will be a maximum of +/- 0.020 arcsec.

6.1 Parallel Science Limitations

These restrictions are to ensure that parallels can be scheduled and
executed safely and efficiently:

• Parallel observations have some special restrictions on the targets
  that may be specified; see Section 6.2 Pure Parallels on page 105 and
  Section 6.3 Coordinated Parallel Containers on page 105 for details.

• All scheduling constraints (pointing, orientation, and relative timing)
  that apply to coordinated primaries and parallels must be specified
  only on the primary exposure.

• No visit-level special requirements, and only a few exposure-level
  special requirements, are applicable to pure parallel visits.

• Exposures parallel with any instrument mode which permits interac-
  tive or nomous motion of HST (e.g., interactive or onboard acquisi-
  tions) are not supported.

• Neither parallel exposures nor the primary of a coordinated parallel
  may have real-time (i.e., TDRS contact) requirements of any kind.

• In order to protect the COS and STIS/MAMA detectors from inad-
  vertent overillumination, these configurations may be used for coor-
  dinated parallels only if an exact ORIENT (e.g., ORIENT 20D to
  20D) is specified. Also, the coordinates of the parallel field must be
determined and the parallel target or field must pass the same
bright-object screening applied to COS and STIS/MAMA primary
observations.

• ACS/SBC may not be used for coordinated parallels.

• Parallel observations may not be made during STIS MAMA
  TIME-TAG observations.

These limitations are discussed further in the following sections.
6.2 Pure Parallels

Pure parallel proposals are identified by the Proposal Category (see Section 2.3.1 Proposal Information [Proposal Information] on page 13). All visits in such proposals will be interpreted as pure parallel visits.

**Instrument Configuration**

Pure parallel exposures are limited to the following instrument configurations and modes:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Operating Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS/WFC</td>
<td>ACCUM</td>
</tr>
<tr>
<td>WFC3/UVIS</td>
<td>ACCUM</td>
</tr>
<tr>
<td>WFC3/IR</td>
<td>MULTIACCUM</td>
</tr>
</tbody>
</table>

Every exposure in a pure parallel proposal must use the same instrument.

**Special Requirements**

No visit-level or exposure special requirements are allowed in pure-parallel visits.

**Exposure Containers**

In pure-parallel visits you can use the following container (see Section 5.18, “Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns,” on page 101):

- Exposure Group Container (Type: Sequence)
- Coordinated Parallel Container
  
  For example, a pure parallel Visit may include an exposure using WFC3/IR and a coordinated exposure using ACS/WFC.

6.3 Coordinated Parallel Containers

**Text Proposal File**

In the text proposal file format, coordinated parallel exposures are indicated with the exposure-level special requirement:

```plaintext
PAR <parallel-exp-list> WITH <primary-exp-list>
```
This designates a set of one or more parallel exposures which will execute in parallel with a set of one or more primary exposures in the same visit. The PAR WITH special requirement must be specified on the first exposure in the <primary-exp-list>. Exposures in the <parallel-exp-list> have to appear immediately after the exposures in <primary-exp-list>. Parallel exposure numbers must follow this sequence as well.

The APT User Interface.

This special requirement has been replaced in the APT GUI with the use of Coordinated Parallel Exposure Containers. See Section 5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 101.

A Coordinated Parallel Container designates a set of one or more parallel exposures (<parallel-exp-list>) that will execute in parallel with a set of one or more primary exposures (<primary-exp-list>) in the same visit. The SI used in the first exposure defines the primary SI (and therefore defines the <primary-exp-list>). All other exposures that use the same SI will also be considered primary.

All exposures using a different SI will be considered parallel. Parallel exposures using the same SI or NICMOS detector will be executed in the order specified in the container. The first parallel exposure which uses a given instrument or NICMOS detector will be executed as early as possible, but not before the first primary exposure.

### 6.3.1 Instrument Configuration

The exposures in <primary-exp-list> and <parallel-exp-list> are limited to the following instrument configurations and modes:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Operating Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>STIS/FUV-MAMA¹</td>
<td>ACCUM</td>
</tr>
<tr>
<td>STIS/NUV-MAMA¹</td>
<td>ACCUM</td>
</tr>
<tr>
<td>STIS/CCD</td>
<td>ACCUM</td>
</tr>
<tr>
<td>FGS²</td>
<td>POS</td>
</tr>
<tr>
<td>ACS/WFC³</td>
<td>ACCUM</td>
</tr>
<tr>
<td>NIC1 or NIC2 or NIC3⁴</td>
<td>ACCUM, MULTIACCUM</td>
</tr>
<tr>
<td>COS/FUV⁵</td>
<td>TIME-TAG or ACCUM</td>
</tr>
</tbody>
</table>
Coordinated Parallel Containers

All exposures in `<primary-exp-list>` must have the same Instrument Configuration (Config) and the same Aperture or Field of View (Aperture). Except for the NICMOS, no exposure in `<parallel-exp-list>` may use the same SI as the primary exposures. NICMOS parallel exposures may use the same SI but only in a different configuration.

### 6.3.2 Targets

Coordinated parallels may specify fixed, generic, or solar system targets; the special target `ANY`; or internal targets. However, the pointing of HST will be determined only by the primary exposures. Any pointing conditions to be applied on the primary+parallel combination must be specified on the `primary` exposures via exposure-level special requirements, or on the visit as a whole via visit-level special requirements. All external exposures in a given `<primary-exp-list>` must have the same pointing (this generally means the same target, aperture, and POS TARG), except for NICMOS background patterns (see the discussion of optional parameters below).

If a parallel exposure specifies a fixed target, it should be a different target from the primary ones and should appear in the Target List. In this case, an `ORIENT` special requirement is required to ensure that the parallel target is in the aperture. It is the observer’s responsibility to verify that the specified orientation will place the parallel target in the aperture; STScI

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Operating Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>COS/NUV</td>
<td>TIME-TAG or ACCUM</td>
</tr>
<tr>
<td>WFC3/UVIS</td>
<td>ACCUM</td>
</tr>
<tr>
<td>WFC3/IR</td>
<td>MULTUACCUM</td>
</tr>
</tbody>
</table>

1. In order to protect the STIS MAMA detectors from inadvertent overillumination, these configurations may be used as coordinated parallels only if an exact `ORIENT` (e.g., `ORIENT 20D to 20D`) is specified. Also, the coordinates of the parallel field must be determined and the parallel target or field must pass the same bright-object screening applied to MAMA primary observations.

2. FGS may only be used as primary, never parallel.

3. ACS exposures cannot be used in both the `<primary-exp-list>` and the `<parallel-exp-list>`, and all ACS exposures in the `<parallel-exp-list>` must use the same configuration.

4. The foci of NIC1 and NIC2 are close enough that they can be used simultaneously, whereas the focus of NIC3 is sufficiently different from the foci of NIC1 and NIC2 that it should not be used in parallel with either camera. See section 2.4.4 of the NICMOS Instrument Handbook.

5. In order to protect the COS FUV and NUV detectors from inadvertent overillumination, these configurations may be used as the coordinated parallel observation only if an exact `ORIENT` (e.g., `ORIENT 20D to 20D`) is specified. Also, the coordinates of the parallel field must be determined and the parallel target or field must pass the same bright-object screening applied to COS primary observations.

All exposures in `<primary-exp-list>` must have the same Instrument Configuration (Config) and the same Aperture or Field of View (Aperture). Except for the NICMOS, no exposure in `<parallel-exp-list>` may use the same SI as the primary exposures. NICMOS parallel exposures may use the same SI but only in a different configuration.
will not check the geometry. Contact your Program Coordinator if you
need assistance.

If the parallel target is diffuse and the orientation does not matter, or if
there is no parallel target as such and the intent is just to sample whatever
the parallel aperture happens to fall on, you should select the ANY target
(which should not appear in your Target List).

### 6.3.3 Special Requirements

The following exposure-level special requirements are disallowed for both
primary exposures (any exposure in a <primary-exp-list>) and parallel
exposures:

- EXPAND
- MAXimum DURation [<time or percentage>]
- MINimum DURation [<time or percentage>]
- RT ANALYSIS

The following exposure-level special requirements are allowed for primary
exposures, but not for parallels:

- LOW-SKY
- PHASE <number1> TO <number2>
- POSition TARget <x-value>, <y-value>
- REQuires EPHEMeris CORRection <id>
- REQuires UPLINK
- SAME POSition AS <exposure>
- SAVE OFFSET <id>
- SHADOW
- USE OFFSET <id>

Allowed without restriction:

- SEQuence <exposure-list> NON-INTerruptible (replaced by the Expo-
sure Group Container in APT; see Section 5.18 Exposure Containers:
Exposure Groups, Coordinated Parallels and Patterns on page 101)

No parallel exposure may appear in the <exposure-list> of an RT
ANALYSIS FOR Special Requirement, or be the <exposure> referenced
by a SAME POS AS special requirement.
6.3.4 Optional Parameters

The parameters used with patterns for NICMOS may be used for coordinated parallels subject to the following restrictions and interpretations:

1. Only a single NICMOS exposure in a coordinated parallel container may use a pattern; this exposure must be the only exposure designated as primary. Background pattern parameters may not be used on a parallel exposure, because they involve pointing changes.

2. All NICMOS parallel exposures will be taken at each pattern position (defined in the primary exposure). Any parallel exposures using other SIs will also be taken at each pattern position.

3. If the primary is a NICMOS exposure that uses a pattern, no other exposure in the container may use the same configuration.

4. Background pattern parameters may be used on a parallel exposure only if OFFSET=FOM and the primary exposures use an SI other than NICMOS.

5. All other NICMOS parallel exposures will be taken at each pattern position. If the exposure using the background patterns is the primary, parallel exposures using other SIs will also be taken at each pattern position.

6. If OFFSET=FOM, each sequence of NICMOS exposures in the parallel exposure list using a different detector must take no longer to execute than the exposure with OFFSET=FOM.

In a Coordinated Parallel container, the NICMOS CAMERA-FOCUS, FOMXPOS, FOMYPOS optional parameters (see Sections 12.2.4 and 12.3.4) may be used only by one NICMOS detector, referred to as the “primary detector,” which is the SI detector used in the first exposure in the container. If the primary exposures use the NICMOS, the primary detector is the one used in those exposures. Otherwise, the primary detector is determined by the configuration used for the first NICMOS exposure in the parallel exposures.

The COS Optional Parameter value FP-POS cannot be specified on either a primary exposure or a parallel exposure in a coordinated parallel container. Number_Of_Iterations must be set to 1 for any COS exposure in a coordinated parallel container.
6.3.5 Ordering Restrictions and Interpretations

In Coordinated Parallel Containers, the SI used in the first exposure defines the “primary” SI.

If the exposures in the <parallel-exp-list> contain exposures that use different SIs or NICMOS detectors, an attempt will be made to execute each set of exposures with the same SI or NICMOS detector in parallel with the other sets. All exposures within a given set must be contiguous in the container. Also, sets of parallel exposures using different NICMOS detectors must be contiguous in the container. Within a set, exposures will be executed in the order they appear.

Due to readout conflicts and limits on the number of SIs which may execute simultaneously, parallel exposures sometimes have to be delayed. If a parallel exposure conflicts with an exposure in its primary list, the parallel will be delayed. If two parallel exposures using different SIs or NICMOS detectors conflict, the exposure which appears later in the container will be delayed.

Following a set of exposures in a Parallel Container, subsequent exposures not in the container will be delayed until after all the primary and parallel exposures have completed.

Text Proposal File

In the Text Proposal File, the exposures in the <parallel-exp-list> of a PAR WITH special requirement must appear immediately after the exposures in <primary-exp-list>.

6.3.6 Efficiency Considerations

Within a set of coordinated-parallel exposures, the ground system will not break up sequences of exposures that are too long to fit in one orbit, as it does for non-coordinated-parallel exposures. Each group of exposures with the same SI or NICMOS detector must be short enough to fit in one orbit. If it is necessary to take coordinated-parallel data over multiple orbits, a separate Parallel Container – with a new set of exposures – should be specified for each orbit.
CHAPTER 7: Special Requirements [Visit and Exposure Special_Requirements]

In this chapter . . .

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 Introduction to Special Requirements: Syntax and Rules</td>
<td>113</td>
</tr>
<tr>
<td>7.2 Visit-level Special Requirements</td>
<td>116</td>
</tr>
<tr>
<td>7.2.1 Guiding</td>
<td>116</td>
</tr>
<tr>
<td>7.2.2 Target Orientation</td>
<td>118</td>
</tr>
<tr>
<td>7.2.3 Special Observation Requirements</td>
<td>128</td>
</tr>
<tr>
<td>7.2.4 Timing Requirements</td>
<td>130</td>
</tr>
<tr>
<td>7.2.5 Conditional Requirements</td>
<td>133</td>
</tr>
<tr>
<td>7.3 Exposure-level Special Requirements</td>
<td>133</td>
</tr>
<tr>
<td>7.3.1 Target Acquisition</td>
<td>133</td>
</tr>
<tr>
<td>7.3.2 Target Position</td>
<td>134</td>
</tr>
<tr>
<td>7.3.3 Special Observation Requirements</td>
<td>135</td>
</tr>
<tr>
<td>7.3.4 Special Communications Requirements</td>
<td>139</td>
</tr>
<tr>
<td>7.3.5 Timing Requirements</td>
<td>141</td>
</tr>
</tbody>
</table>
Tables and Figures

Table 7.1: Supported Formats for Visit Level Special Requirements
Table 7.2: Supported Formats for Exposure Level Special Requirements
Table 7.3: Accuracies of Guiding Modes
Figure 7.1 ORIENTation computation for WFC3/UVIS
Figure 7.2 ORIENTation computation for STIS.
Figure 7.3 ORIENTation computation for FGS1R, in TRANS mode
Figure 7.4: ORIENTation computation for ACS/WFC
Figure 7.5: Deleted
Table 7.4: Instrument Orientations with respect to U3-Direction
Table 7.5: Approximate Separation and Orientations between WFC3 and the other Science Instruments
Table 7.6: Spatial Scan Parameters (See also General Considerations for Spatial Scans)
7.1 Introduction to Special Requirements: Syntax and Rules

Special requirements provide flexibility in specifying the scheduling requirements of observations. Many Special Requirements, directly or indirectly, restrict the times when observations can be scheduled. These should be used to provide the schedulers at STScI with enough constraints to ensure that the observations are properly scheduled. **Special Requirements should not be used unless necessary to accomplish the scientific objectives of the program.**

The Special Requirements are summarized in Table 7.1: Supported Formats for Visit Level Special Requirements and Table 7.2: Supported Formats for Exposure Level Special Requirements, and a detailed description of each requirement is provided in the following subsections.

Rules and Conventions

You should observe the following conventions and rules for Special Requirements:

- Items inside angular brackets (< >) in the Special Requirement descriptions are to be replaced with the relevant information. All indicated items must be provided, except for items inside square brackets ([ ]), which are optional.

- A <date> specification in a Special Requirement must either be a geocentric date expressed in Universal Time (UT) or a heliocentric Julian Date. A UT date must be entered in the form DD-MMM-YYYY:hh:mm:ss, where MMM represents the first three letters of the month name. Fractional seconds are not allowed and anything beyond the day specification is optional. For example, **14-DEC-2001:17:05:41** refers to 14 December 2001, geocentric UT 17H05M41S. Only the necessary precision need be employed (e.g., **14-DEC-2001** might be adequate). The SOGS day of the year format, YYYY.ddd:hh:mm:ss (where ddd is the day of the year from 001 to 365), is also accepted.

Julian Dates must be entered in the form JDn nn nnn nnn (e.g., **JD2444123.4**) and are legal only for the ZERO-PHASE special requirement. All Julian Dates will be interpreted as **heliocentric**.

- You should select the units of all <time> specifications from a list provided to you. The options are: days (D), orbits (ORBITS), hours (H), minutes (M), or seconds (S).
• A visit-level Special Requirement (Visit_Requirements) applies to ALL the exposures within that visit.

• An exposure-level Special Requirement (Special_Requirements) applies ONLY to that exposure and any other referenced exposures within the same visit.

Additional Rules and Conventions for the Text Proposal File

If you are editing the Text Proposal File to modify your program, please observe these additional syntax rules:

• You must use only the portions of the keywords that are shown in upper-case letters in Table 7.1 and Table 7.2 and in the discussion below. The portions in lower-case letters are included for clarity only. For example, SEQ must be entered rather than SEQUENTIAL.

• Exposures must be referred to by their exposure numbers. <exposure> must be replaced by the number of a single exposure. An <exposure-list> must be replaced by a single range of exposure numbers separated by a hyphen (e.g. SEQ 2-5 NON-INT). Commas are NOT allowed in exposure lists.

• Multiple Special Requirements must be separated by a semi-colon (;). Please note that separate lines are not sufficient to delimit items in a list. Do not use commas to separate Special Requirements items.

Table 7.1: Supported Formats for Visit Level Special Requirements

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guiding Requirements</td>
<td></td>
</tr>
<tr>
<td>PCS MODE Fine</td>
<td>PCS MODE Fine</td>
</tr>
<tr>
<td>PCS MODE Gyro</td>
<td>PCS MODE Gyro</td>
</tr>
<tr>
<td>GUIDing TOLerance &lt;angle&gt; (arcsec)</td>
<td>GUID TOL 0.020&quot;</td>
</tr>
<tr>
<td>DROP TO GYRO [NO REACquisition]</td>
<td>DROP TO GYRO</td>
</tr>
<tr>
<td>Target Orientation Requirements</td>
<td></td>
</tr>
<tr>
<td>ORIENTation &lt;angle1&gt; TO &lt;angle2&gt;</td>
<td>ORIENT 18D TO 22D</td>
</tr>
<tr>
<td>ORIENTation &lt;angle1&gt; TO &lt;angle2&gt; FROM &lt;visit&gt;</td>
<td>ORIENT 18D TO 22D FROM 5</td>
</tr>
<tr>
<td>SAME ORIENTation AS &lt;visit&gt;</td>
<td>SAME ORIENT AS 5</td>
</tr>
<tr>
<td>Special Observation Requirements</td>
<td></td>
</tr>
<tr>
<td>CVZ</td>
<td>CVZ</td>
</tr>
<tr>
<td>SCHEDulability &lt;percentage&gt;</td>
<td>SCHED 100%</td>
</tr>
<tr>
<td>NOTRACK</td>
<td>NOTRACK</td>
</tr>
</tbody>
</table>
### Timing Requirements

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFTER &lt;date&gt;</td>
<td>AFTER 12-JUL-2001:12:06</td>
</tr>
<tr>
<td>AFTER &lt;visit&gt; [BY &lt;time1&gt; TO &lt;time2&gt;]</td>
<td>AFTER 6 BY 7D TO 9D</td>
</tr>
<tr>
<td>BEFORE &lt;date&gt;</td>
<td>BEFORE 14-SEP-1999</td>
</tr>
<tr>
<td>GROUP &lt;visits&gt; WITHIN &lt;time&gt;</td>
<td>GROUP 5-10 WITHIN 60D</td>
</tr>
<tr>
<td>PERIOD &lt;time&gt; ZERO-PHASE (HJD) &lt;date&gt;</td>
<td>PERIOD 1.23H AND ZERO-PHASE (HJD) 2444000</td>
</tr>
<tr>
<td>SEQUENCE &lt;visits-checked&gt; WITHIN &lt;time&gt;</td>
<td>SEQ Visits 5-7 WITHIN 24H</td>
</tr>
<tr>
<td>VISIBILITY INTERVAL CORON</td>
<td>VISIBILITY INTERVAL CORON (Note: For NICMOS Only)</td>
</tr>
</tbody>
</table>

### Conditional Requirements

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON HOLD [FOR &lt;visit-list&gt;]</td>
<td>ON HOLD FOR 15</td>
</tr>
</tbody>
</table>

---

### Table 7.2: Supported Formats for Exposure Level Special Requirements

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Acquisition Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>INTeractive ACQuisition (obsolete)</td>
<td>No longer available; see text.</td>
</tr>
<tr>
<td><strong>Target Position Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>POSition TARGet &lt;X-value&gt;,&lt;Y-value&gt;</td>
<td>POS TARG +6.3,-8.1</td>
</tr>
<tr>
<td>SAME POSition AS &lt;exposure&gt;</td>
<td>SAME POS AS 6</td>
</tr>
<tr>
<td>PATTERN &lt;#&gt; [&lt;exposure-list&gt;] (Replaced by Pattern Containers in the APT User Interface)</td>
<td>See 5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 101 and Chapter 8: Pointings and Patterns on page 145</td>
</tr>
</tbody>
</table>
Table 7.2: Supported Formats for Exposure Level Special Requirements

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Special Observation Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>SPATIAL SCAN &lt;Scan_Rate&gt;, &lt;Scan_Orient&gt;, &lt;Scan_Direction&gt;</td>
<td></td>
</tr>
<tr>
<td>PARallel &lt;parallel-exp-list&gt; WITH &lt;primary-exp-list&gt; (replaced by Coordinated Parallel Containers in the APT User Interface)</td>
<td>See 5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 101 PAR 4-6 WITH 1-3</td>
</tr>
<tr>
<td><strong>Special Communications Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>RT ANALYSIS</td>
<td>RT ANALYSIS</td>
</tr>
<tr>
<td>REQuires UPLINK</td>
<td>REQu UPLINK</td>
</tr>
<tr>
<td>REQuires EPHEMeris CORRection &lt;id&gt;</td>
<td>REQ EPHEM CORR OFF-13</td>
</tr>
<tr>
<td><strong>Timing Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>EXPAND (pure parallel exposures only)</td>
<td>EXPAND</td>
</tr>
<tr>
<td>LOW-SKY</td>
<td>LOW-SKY</td>
</tr>
<tr>
<td>MAXimum DURation (time or %) &lt;value&gt; (supported only for pure parallel exposures)</td>
<td>MAX DUR 115%</td>
</tr>
<tr>
<td>MINimum DURation (time or %) &lt;value&gt; (supported only for pure parallel exposures)</td>
<td>MIN DUR 1800S</td>
</tr>
<tr>
<td>PHASE &lt;number1&gt; TO &lt;number2&gt;</td>
<td>PHASE 0.09 TO 0.11</td>
</tr>
<tr>
<td>SEQuence &lt;exposure-list&gt; NON-INTerruptible (replaced by Exposure Group Containers in the APT User Interface)</td>
<td>See 5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 101 SEQ 2-5 NON-INT</td>
</tr>
<tr>
<td>SHADOW</td>
<td>SHADOW</td>
</tr>
</tbody>
</table>

7.2 Visit-level Special Requirements

The following Special Requirements are applicable at the visit level, and they will affect **all** the exposures within that particular visit.

7.2.1 Guiding

There are currently two tracking modes available during HST observations. One of the modes employs guide stars and the Fine Guidance Sensors: Fine Lock. Alternatively, observations can be made while the HST is stabilized with gyros. (In this scenario no guide star acquisition occurs, and the absolute error of positioning is 14 arcsec with a drift rate of about 0.0014 arcsec/sec.) The typical guiding accuracies for the two modes are listed in Table 7.3.
All observations will be performed using Fine Lock guiding by default whenever possible. If difficulties are encountered finding guide stars, you will be contacted by STScI. If you cannot find what you feel to be an appropriate tracking mode, you are urged to contact your Program Coordinator for help resolving the issue.

**PCS MODE Fine**

Specifies the use of Fine Lock as the guiding mode for the exposures defined in that particular visit. This Special Requirement is the default and any use of the **GUIDing TO Lerance <angle>** overrides this Special Requirement.

**PCS MODE Gyro**

Specifies the use of Gyro hold (see Table 7.3) as the guiding mode for the exposures defined in that particular visit. This mode is available ONLY with the ACS/WFC, NICMOS, STIS/CCD and WFC3. It is prohibited with other SIs because of concern that gyro drift will result in inadvertent exposure to bright objects. Note that the RMS absolute pointing error for gyro hold is 14 arcsec with a drift rate of about 0.0014 arcsec/sec. This Special Requirement overrides the default and any use of the **GUIDing TO Lerance <angle>** Special Requirement.

**GUIDing TO Lerance <angle>**

This special requirement specifies a non-default guiding tolerance for the exposures contained within that particular visit. The <angle> is the allowed maximum pointing error for the observations; the units must be given in arcsec. It should be used in situations when it is permissible for a portion of the observation to be taken while guiding on gyros. It is also used as a trigger for the guide star handoff capability and is useful for fast moving targets. The handoff process involves using a single pair of guide stars for as long as possible. When a given exposure cannot be completed with a given pair of guide stars, guidance is transferred to gyro control. The fine guidance sensors are slewed to and acquire a new pair of guide stars before the exposure in question begins. The error in this procedure is due to the accumulated drift during gyro control, typically a few tenths of an arcsec at most. Note that this is much less than the nominal error between guide star pairs. The planning system will schedule the observations so that the

### Table 7.3: Accuracies of Guiding Modes

<table>
<thead>
<tr>
<th>Guiding Mode</th>
<th>Guiding Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyro hold</td>
<td>Drift rate 0.0014 arcsec/sec</td>
</tr>
<tr>
<td>Fine lock</td>
<td>RMS jitter 0.005 arcsec</td>
</tr>
</tbody>
</table>

1. Excluding periods during day/night terminator crossings, where jitter can be as high as 0.035 arcsec rms over a period of 5 minutes.
expected pointing-error buildup remains below the <angle> specified. Guide star handoff will only be used if a single pair of guide stars cannot be found for the observation. If you need to use the guide star handoff capability, then set **GUIDing TOLerance** to at least 0.11".

Note that the difficulty in finding guide stars for these types of observations may prevent them from being scheduled. **If you plan to use this Special Requirement, please contact your Program Coordinator for further details and discussions.**

**DROP TO GYRO [NO REACQuisition]**

This Special Requirement allows the system to drop guide-star control for exposures with pointings (target/aperture positions) that are too far (more than 2 arcmin) from the first pointing in the visit to use the same guide stars. If this Special Requirement is not used, such exposures will have to be taken using a separate pair of guide stars. The **NO REACQ** qualifier will disable guide-star reacquisition after dropping to gyro control, even if subsequent pointings are close enough to the first pointing in the visit to allow guide-star control to be resumed. This Special Requirement has no meaning for internal observations and visits with **PCS MODE Gyro**. This Special Requirement is allowed **ONLY** with the NICMOS, ACS/WFC, WFC3 and STIS/CCD SI/detector combinations (see the above discussion of **PCS MODE Gyro**). **DROP TO GYRO** is not allowed with the ACS/SBC, STIS/MAMA and COS configurations because of concern about bright objects.

See the discussion of the **GUIDing TOLerance <angle>** Special Requirement concerning the pointing drift that will occur while the spacecraft is under gyro control. Due to this drift, this requirement is useful primarily for short observations (bright targets) where pointing is not critical (e.g. imaging). This capability might be used if, after spending most of an orbit obtaining spectra of a target, you want to get a quick image without having to acquire a new set of guide stars. Some uses of the WFPC-2 linear ramp filters might be more efficient if this requirement is used.

### 7.2.2 Target Orientation

The solar arrays of HST must be kept pointed at the Sun (to within a modest angle) in order for the spacecraft to have the electrical power it needs. As the Sun moves through the heavens over the course of a year, this requirement for the solar arrays translates into a position angle on the sky on which HST’s detectors lie. Therefore an observer-imposed requirement to, say, orient a slit in a particular position angle means that observation must be done at a specific time. When a special aperture orientation is
requested, this will generally be accommodated by scheduling the observation during the time interval when that orientation naturally results in the solar array being positioned nearly perpendicular to the Sun (this is called the “nominal” orientation).

In order to achieve a specific orientation and satisfy spacecraft roll constraints, an observation generally must be scheduled within a fairly narrow time interval. The placement and duration of time intervals that satisfy this constraint will depend on the ecliptic coordinates of the target. The observer must take this into consideration when specifying additional timing constraints (e.g. BETWEEN, BEFORE, AFTER). For a discussion of nominal roll and how it changes with time based on ecliptic latitude, see the section on Nominal and Off-Nominal Roll below.

Observers should specify orientations by specifying the position angle of the orientation reference vector U3, as listed in Table 7.4: Instrument Orientations with respect to U3-Direction. To avoid confusion with the spacecraft V2, V3 axes, we define U2, U3 axes that lie in the HST focal plane as projected onto the sky. The U2- and U3-directions are defined by the “nominal” Optical Telescope Assembly (OTA) axis.

To specify a special orientation of an aperture, slit, aperture pair, etc., the observer should algebraically add two angles:

- The position angle on the sky of the feature to be aligned.
- The “offset angle,” which is the angle from an aperture axis to the +U3 axis.

This aperture axis may be the X or Y axis of an SI, or one of the aperture-related features given in Table 7.4. The “offset angle” could also be the angle of the line separating two instruments (Table 7.5) if that is the relevant orientation. The axes for the SIs are given in the SI-specific chapters in Part B.

The algebraic sum of the aperture orientation and the offset angle is the U3 orientation, which should be specified in the ORIENTation <angle1> TO <angle2> and ORIENTation <angle1> TO <angle2> FROM <visit> Special Requirements described below. All angles are measured North through East, or counterclockwise when referring to the figures in this section. If there is any uncertainty in specifying an orientation, please document the calculations in the Visit_Comments and contact your Program Coordinator for clarification.

If a visit contains multiple targets requiring different guide stars, the spacecraft orientation will normally be reset to the “nominal” orientation each time a new set of guide stars is acquired. However, if the visit has an ORIENTation <angle1> TO <angle2> FROM <visit>, SAME ORIENTation AS <visit>, or ORIENTation <angle1> TO <angle2>
FROM <visit> Special Requirement, the spacecraft orientation will *not* change during the visit, even if multiple sets of guide stars are needed.

**ORIENTation <angle1> TO <angle2>**

Specifies that a specific absolute roll angle or orientation of the spacecraft is required for the exposures within the current visit. <angle1> and <angle2> denote a region within which the position of the U3 axis on the sky (measured North through East) must fall at the time of the observation; both limits must be between 0 (0°) and 360 degrees (360°). If necessary, it is possible for <angle1> and <angle2> to be equal, but the size of the region between the two limits should be made as large as possible to make scheduling easier. Note that in most instances the angles can have a 180 degree offset and still work. If this is desired (for greater scheduling flexibility), please specify the additional possible angles.

Note also that this Special Requirement can now list several acceptable angle ranges:

- **ORIENTation <angle1> TO <angle2>**
- **ORIENTation <angle3> TO <angle4>**
- **ORIENTation <angle5> TO <angle6>**
- **ORIENTation <angle7> TO <angle8>** . . .

Both angles are measured in a counterclockwise direction, so if the orientation region crosses zero (celestial North), <angle1> would be greater than <angle2>. Otherwise, <angle1> should be less than <angle2>. It is also possible for the orientation region to be larger than 180 degrees.

You are encouraged to enter both the aperture angle(s) and the offset angle used to calculate these angles in the **Visit_Comments**.

**Note:** If the visit uses multiple targets, the direction of North from the first target will be used. The spacecraft will not roll between targets, so that the U3 position angle at the new target may be slightly different from that of the first target.

It is sometimes desirable for a new observation to be taken at the same orientation as an existing archival image, using the “PA_V3” field from the header in the archive.

---

**ORIENTation Special Requirements are a limited resource and should be used only when necessary.**
Examples of Orientation Angle Computations

We show four examples in Figures 7.1 to 7.4 of how to compute an orientation angle for WFC3 STIS, FGS and ACS/WFC.

Figure 7.1: ORIENTation computation for WFC3/UVIS

Using the WFC3 UVIS CCD, we wish to image a faint object that is in the vicinity of a bright star. We also want to minimize bleeding of the signals of the bright star onto the faint target. Therefore, the telescope is rolled so that both the target and bright star are imaged on the same row (signals bleed along columns). The target is imaged at the default UVIS aperture position, as shown in Figure 7.1. For this example, the position angle of the bright star with respect to the faint target is 60 deg. Note that the CCD rows are not aligned with the X_POSTARG direction, whereas columns are aligned with the Y_POSTARG direction. The value of the ORIENT angle (the position angle of U3) is 60 deg (the position angle of the feature of interest) + 221.38 deg (the offset angle of the CCD row to U3 as given in Table 7.4) = 281.38 deg.
In this example we consider a close binary system in which the position angle of the line joining the stars is 60D. We wish to position the slit to exclude light from the companion star, so that the +Y axis (the long direction of the slit) is at –30 degrees. The U3 axis (Table 7.4) lies at 45 degrees from +Y, or at PA 15D. If a tolerance of 12D is allowed, we would then specify ORIENT 3D TO 27D.

Because of the symmetry of the slit, it would also work if the orientation were flipped 180 degrees, so the net specification is:

ORIENT 3D TO 27D
ORIENT 183D TO 207D
In this example we consider the same close binary system in which the position angle of the line joining the stars is 60°. The scans will be done parallel to the line joining the binary components, with a tolerance of 20 degrees. TRANS mode scans move the instantaneous field of view at an angle of 45 degrees relative to the FGS1 axes. The +X axis will have a PA of 60 degrees, minus the 45 degree offset, or 15°. The U3 axis is 180 degrees from +X (Table 7.4), thus we specify:

ORIENT 175D TO 215D
The target has a very bright neighboring star 10" away Northeast (PA = 45°). This star will saturate, leaving a bleeding trail along the entire y-axis of the detector. A user should therefore orient the telescope so the bleeding trail does not run through the target; in other words, the target should not be placed on the y-column of the bright star.

From Table 7.4, we know that the U3 axis is 2° from the +y axis (measured north to east). Therefore, avoid the ORIENT angle that places the bright star on the y-axis: 47° (45° + 2°, PA_star + angle from U3 to Y). Since blooming affects the entire detector y-axis, also avoid the angle 180° away, 227° (47° + 180°). For added caution, avoid ±10° about those angles. The ORIENTs to avoid are from 37° to 57° and from 217° to 237°.

Therefore, it's safe to use ORIENT 57° TO 217° and ORIENT -123° TO 37°

**ORIENTation <angle1> TO <angle2> FROM <visit>**

Specifies that a roll angle or orientation of the spacecraft, relative to another visit's spacecraft orientation, is required for the exposures within the current visit. <angle1> and <angle2> denote a region of permitted orientation of the current visit relative to <visit>. <angle1> and <angle2>
must be between $-180$ degrees ($-180D$) and $+180$ degrees ($180D$). If necessary, it is possible for $\langle\text{angle1}\rangle$ and $\langle\text{angle2}\rangle$ to be equal, but the size of the region between the two limits should be made as large as possible to make scheduling easier.

Both angles are measured in a counterclockwise direction, so if the orientation region crosses a point 180 degrees from $\langle\text{visit}\rangle$, $\langle\text{angle1}\rangle$ should be positive and $\langle\text{angle2}\rangle$ negative. Otherwise, $\langle\text{angle1}\rangle$ should be less than $\langle\text{angle2}\rangle$. It is possible for the orientation region to be larger than 180 degrees.

This Special Requirement is a limited resource and should be used only when necessary. To specify that the current visit be scheduled at the same orientation as another visit, use the $\text{SAME ORIENTation AS } \langle\text{visit}\rangle$ Special Requirement.

Note that only one "ORIENT ... FROM " may be specified for a visit.

**Nominal and Off-Nominal Roll**

Orientation constraints translate into timing constraints. Generally, if the spacecraft is unable to roll far enough "off-nominal" to satisfy the required difference in orientation between the two visits, they will be forced apart in time in order to schedule both at near nominal roll. "Nominal roll" is the orientation determined by the necessity of keeping the solar panels perpendicular to the Sun. Targets near the ecliptic have two values of nominal roll through the year 180 degrees apart. Near the ecliptic pole, nominal roll varies by about a degree per day.

In general, the off-nominal roll is limited to less than $+/-$ 30 degrees except when the target is within two degrees of opposition (i.e., exactly opposite the Sun in the sky as viewed from the Earth). Observations scheduled with solar elongations between 90 degrees and 178 degrees can be done at up to 15 to 30 degrees off nominal, depending on the exact elongation. For observations scheduled when the target is within 90 degrees of the Sun, the off-nominal roll is limited to 5 degrees. The legal syntax for $\langle\text{angle1}\rangle$ and $\langle\text{angle2}\rangle$ allows angles between $-180$ degrees ($-180D$) and $+180$ degrees ($180D$). Please contact your Program Coordinator for details if necessary.
## Instrument Orientation Tables

### Table 7.4: Instrument Orientations with respect to U3-Direction

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Item</th>
<th>Offset Angle</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FGS</strong> (see Figure 10.1: The FGS POSTARG and interferometer coordinate systems.)</td>
<td>+X axis for FGS1</td>
<td>180°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+X axis for FGS2</td>
<td>90°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+X axis for FGS3</td>
<td>0°</td>
<td></td>
</tr>
<tr>
<td><strong>STIS</strong> (see Figure 9.1 STIS coordinate system)</td>
<td>All configurations:</td>
<td></td>
<td>Nominal, +/– 4D</td>
</tr>
<tr>
<td></td>
<td>Long Slit Spatial/+AXIS2/+Y</td>
<td>45D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dispersion/+AXIS1/+X</td>
<td>135D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toward increasing occultation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEDGEA</td>
<td>45D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEDGEB</td>
<td>135D</td>
<td></td>
</tr>
<tr>
<td><strong>WFC3</strong> (see Figure 14.1 and Figure 14.2)</td>
<td>UVIS CCD column (same as the Y_POSTARG direction)</td>
<td>137.18D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IR +Y</td>
<td>135.37D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UVIS CCD row</td>
<td>221.38D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IR +X</td>
<td>225.18D</td>
<td></td>
</tr>
<tr>
<td><strong>COS</strong> (see Figure 13.1 COS Aperture Coordinate System)</td>
<td>FUV +Y (spatial axis)</td>
<td>135D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NUV +Y (spatial axis)</td>
<td>135D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FUV +X (dispersion axis)</td>
<td>45D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NUV +X (dispersion axis)</td>
<td>45D</td>
<td></td>
</tr>
<tr>
<td><strong>ACS</strong> (see Figure 11.1 ACS Coordinate system)</td>
<td>WFC1 + Y axis</td>
<td>2D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WFC2 + Y axis</td>
<td>2D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SBC + Y axis</td>
<td>180D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WFCENTER + Y axis</td>
<td>2D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WFC + Y axis</td>
<td>2D</td>
<td></td>
</tr>
</tbody>
</table>
Visit-level Special Requirements

NICMOS

(see Figure 12.1: NICMOS Coordinate System, and Figure 12.2: Definition of Orientation for NICMOS.)

NIC1 +Y axis 225D Nominal, +/– 4D

NIC2 +Y axis 225D

NIC3 +Y axis 225D

Line joining NIC3 and NIC1 225D

Line joining NIC3 and NIC2 225D

NIC3 Grism Dispersion (toward increasing wavelength) 135D

1. The Offset Angle is the angle from the axis defined in the Item column to the +U3 axis in the counterclockwise (or +U3 through +U2) direction. To compute the angle needed in the ORIENT Special Requirement, add this Offset Angle in column 3 to the Sky Position Angle (measured North through East). These angles are calculated from current alignment calibrations and reflect uncertainties of +/– 1 degrees, except where greater uncertainties are indicated in the table comments. For the best estimate of an error for a specific SI, which is usually much less than 1 degree, consult with the SI team or go to the SI web pages available on the HST website at http://www.stsci.edu/hst/HST_overview/instruments

WARNING: For any detailed orientation requirements, please describe your requirements clearly in the proposal text and give angles and offsets. Please feel free to contact your Program Coordinator for assistance in preparing your orientations.

Table 7.5: Approximate Separation and Orientations between WFC3 and the other Science Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Apertures</th>
<th>Separation¹ (arcsec)</th>
<th>Offset Angle² (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS</td>
<td>WFC3 to ACS/WFC</td>
<td>356</td>
<td>133D</td>
</tr>
<tr>
<td></td>
<td>STIS to WFC</td>
<td>663</td>
<td>315.7D</td>
</tr>
<tr>
<td></td>
<td>STIS to SBC</td>
<td>817</td>
<td>330.0D</td>
</tr>
<tr>
<td>STIS</td>
<td>WFC3 to STIS</td>
<td>308</td>
<td>315D</td>
</tr>
<tr>
<td>COS</td>
<td>WFC3 to COS</td>
<td>318</td>
<td>45D</td>
</tr>
</tbody>
</table>
SAME ORIENTATION AS <visit>

Sometimes any orientation (or any orientation within the range of the ORIENT Special Requirement) is acceptable the first time an object is observed, but must then be the same for subsequent observations of that target. This Special Requirement requests that the exposures in the current visit be made at the same telescope roll angle as the observations specified in <visit>. If timing Special Requirements are also used, then an incompatibility may result or the observations may be difficult to schedule.

7.2.3 Special Observation Requirements

CVZ

Requests that a visit be scheduled within the Continuous Viewing Zone. When this requirement is specified, observers are allowed the entire 96-minute orbit in which to schedule their observations, instead of
restricting them to a visibility interval. Only observers with proposals approved by the TAC for CVZ-usage should use this Special Requirement.

---

**Caution:** CVZ visits are limited to a few narrow scheduling opportunities during a cycle. A detailed definition of the CVZ is given in the Call for Proposals.

---

**Note:** The CVZ Special Requirement does not necessarily enforce scheduling in an uninterrupted manner. Observations could be scheduled in SAA impacted or earth occulted orbits if that would benefit the overall efficiency of the telescope. If it is required that all (or a subset) of the exposures be done without interruption, the exposure level Special Requirement `SEQ <exposure-list> NON-INTerruptible` should be used.

**SCHEDulability <percentage>**

This Special Requirement allows the observer to adjust the amount of target visibility allowed in each orbit. The visibility at a given pointing varies throughout the year with the 56-day precessional cycle of the HST orbit. This variation is small at zero declination (about 4 minutes between best case and worst case) but increases sharply as the Continuous Viewing Zone is approached. There is a trade-off between visibility and schedulability: visits with longer visibilities allow more science to be packed into each orbit, but are harder to schedule because the long visibility may only be attainable for a few short intervals during the year. Visits with shorter visibilities are less efficient in terms of how much can be done in each orbit, but are easier to schedule.

`<Percentage>` specifies the percent of HST orbits in which the visit should be schedulable. The higher the percentage, the shorter the visibility. For example, `SCHEDulability 80` would allow only enough visibility in each orbit for the visit to be schedulable in the best 80% of HST orbits. `SCHEDulability 100` would allow the least amount of time per orbit, but would ensure that the visit would “fit” in every available HST orbit. Schedulability values are only defined at 10% intervals, so percentages will be rounded to the nearest multiple of 10%. If this Special Requirement is not supplied, visits will default to 30% schedulability. `<Percentage>` values below 30% are not allowed.

The `SCHEDulability` Special Requirement may be necessary when an `ORIENTation <angle1> TO <angle2> or BETWEEN <date1> AND <date2>` or `PHASE <number1> TO`
<number2> exposure-level Special Requirement is specified with a very small tolerance, restricting the visit to only a few days during the cycle. In this case <percentage> should be set to a high enough number to ensure that the visit can schedule in orbits within its time window.

**NOTRACK**

In certain cases a program will observe a moving target, but without tracking it. For example, a fast-moving comet might be observed by first executing a guide star acquisition, to remove pointing uncertainty, followed by an observation on gyros to acquire the comet data. This should be done without tracking both to save time and to avoid unnecessary use of spacecraft hardware.

The default is to track a moving target, but tracking can be turned off by specifying `NOTRACK` for each exposure as appropriate. `NOTRACK` has no effect on an exposure unless it is for a moving target.

### 7.2.4 Timing Requirements

For examples of formats of times, see Section 7.1 on page 113, and Table 7.1: Supported Formats for Visit Level Special Requirements.

**AFTER <date>**

Specifies that the visit must start after the date given by `<date>`. The capability to designate a specific exposure within a visit to start after a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

**AFTER <visit> [BY <time1> TO <time2>]**

Specifies that the visit must start after the indicated `<visit>`. The `BY` `<time1> TO <time2>` option allows specification of the time interval (and its allowable range) that must elapse between the `start` of the referenced visit and the `start` of the current visit. For example, `AFTER 6 BY 7H TO 9H` requests that the current visit start no earlier than 7 hours and no later than 9 hours after the start of visit 6. The capability to designate a specific exposure within a visit to start after a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

**Note:** If the difference between `<time1>` and `<time2>` is too small, the visit may be impossible to schedule. A difference of at least 90 minutes (about 1 orbit) is recommended. Also note that `<time1>` must be as long as the anticipated duration of the referenced visit.
**BEFORE <date>**

Specifies that the current visit must start before the <date> given. The capability to designate a specific exposure within a visit to start before a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

**BETWEEN <date1> AND <date2>**

Specifies that the current visit must start between <date1> and <date2>. For example, BETWEEN 14-SEP-1999 AND 21-SEP-1999 indicates that the visit must be started after 14 September 1999 and before 21 September 1999. The capability to designate a specific exposure within a visit to start at a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

Multiple BETWEEN Special Requirements may be specified on a visit. The visit will be allowed to execute during any of the time intervals specified. For example, the combination of BETWEEN 14-SEP-1999 AND 21-SEP-1999 and BETWEEN 10-OCT-1999 AND 1-NOV-1999 means that the visit must be started either between 14 September 1999 and 21 September 1999, or between 10 October 1999 and 1 November 1999. Multiple BETWEEN intervals on the same visit may not overlap: all the other intervals must either end earlier than <date1> or start later than <date2>.

---

**Note:** The BEFORE, AFTER <date>, and BETWEEN Special Requirements are mutually exclusive. A visit which specifies one may not specify either of the other two, although multiple BETWEENs are allowed. Note that any BEFORE or AFTER <date> may be replaced by a BETWEEN with a sufficiently early start date or late end date. However, AFTER <visit> may be combined with BETWEEN or BEFORE.

---

**GROUP <visits> WITHIN <time>**

Specifies that visits included in the visit list provided must all start within the <time> given. The number of visits in a Group Within set cannot exceed 32. If the interval given is shorter than the least interval possible, the visits will be scheduled as close together as possible. For example, GROUP 7–10 WITHIN 12H requests that visits 7 through 10 all start execution within a 12-hour interval.

Note that GROUP WITHIN is only a timing Special Requirement, and it implies nothing about relative ordering. GROUP 7-10 WITHIN 12H could possibly execute in the order 10, 7, 9, 8, for example.
PERIOD <time> ZERO-PHASE (HJD) <date>
Supplies the period and zero-phase for observations to be made at a specific phase of a periodically variable target. <time> is the period in days, hours, minutes or seconds, and <date> is the date of the zero-phase with respect to the Sun (i.e., HJD, not a calendar date). Note that, while this requirement is at the visit level, the actual PHASE Special Requirement is on the exposure level.

If a target has multiple periods which must be satisfied simultaneously, the PERIOD ZERO-PHASE Special Requirement should refer to the shorter of the two periods and the longer period can be specified using multiple BETWEEN Special Requirements that cover the next year and a half. Be sure to discuss this with your Program Coordinator. (Example: The target is a X-ray pulsar. The observation needs to occur in a particular phase of the 35-hour binary period as well as a particular phase of the 2-month on/off period. Use the PERIOD ZERO-PHASE Special Requirement for the 35-hour period and then specify the 2-month period with multiple BETWEENs.)

SEQuence <visits-checked> WITHIN <time>
Specifies that visits included in the provided visit list must start within the <time> given, and must be ordered according to their visit number. If the interval given is shorter than the least interval possible, the visits will be scheduled as close together as possible. For example, SEQuence Visits 7–10 WITHIN 10H means that visit 10 must begin execution within 10 hours of the start time of visit 7, with visits 8 and 9 executing between. SEQuence does not change the order of visits.

Note that all SEQ WITHIN visits will be executed in numerical order, so SEQuence Visits 2, 1, 4 WITHIN and SEQuence Visits 1, 2, 4 WITHIN do the same thing.

VISIBILITY INTERVAL CORON
This special requirement overrides the visibility interval normally computed for the visit. The calculated CORON visibility interval is based on the target declination and the amount of slew time needed to execute the orientation change specified in the proposal. This should not be used in conjunction with the CVZ or SCHEDulability <percentage> Special Requirements.

This special requirement may only be used with NICMOS coronagraphic observations. Please note that this special requirement reduces the visibility interval used to plan your orbits to a half orbit.
7.2.5 Conditional Requirements

**ON HOLD [FOR <visit-list>]**

Specifies that the current visit should not be executed without further guidance from the observer (such as with a Target of Opportunity program, for example). When the **FOR <visit-list>** is specified, the current visit is linked to follow all the visits in <visit-list> by at least sixty days. This will allow these visits to execute early enough in the Cycle to provide needed data. This Special Requirement should be used for early acquisitions: the acquisition image is taken in the visit in <visit-list>, and the **ON HOLD** visit will be modified later based on the acquisition data.

7.3 Exposure-level Special Requirements

The following Special Requirements apply to individual exposures within a visit. All instances of <exposure-list> or <exposure> refer only to exposures in the same visit as the exposure carrying the requirement.

7.3.1 Target Acquisition

Separate target acquisition exposures must be specified at the beginning of most visits, depending on the target and the science instrument used. Target acquisition exposures are used to remove coordinate uncertainties and to identify targets. Once a target acquisition has been performed, HST can move the target from aperture to aperture or move the aperture around the target (with slew accuracies of about 10 milliarcseconds) as long as the same guide stars can be used. Onboard acquisitions are automatically identified by the software. Acquisition exposures must still be specified, but no Special Requirement is needed or appropriate.

Acquisition of a target using an offset target requires that both be defined in the Target List(s). The first exposure will be an onboard or interactive acquisition of a target from which the offset will be made. This target must be designated as an offset acquisition target by appending -OFFSET to the end of the target name (see Table 3.1: Designations of Special Targets). The appropriate offsets will automatically be made from this position to slew to the target of interest.

**INTeractive ACQuisition (obsolete)**

Interactive acquisitions may no longer be performed with HST. However, the same results can be achieved in other ways, and you should consult your Program Coordinator for more information.
7.3.2 Target Position

**PATTERN**

The Pattern Special Requirement has been replaced in the APT User Interface with the use of Pattern containers. See 5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 101.

Patterns used with instruments to create dithers or mosaics fall within “target position,” but the details have been incorporated into a separate chapter because of the scope of the subject. See Chapter 8: Pointings and Patterns on page 145

**POSition TARGet <X-value>,<Y-value>**

Specifies a non-default placement of the target, relative to the aperture fiducial point in the instrument field of view, for the current exposure, which must be on an external target. The X and Y positions are implicitly assumed to be in units of arcseconds (i.e. do not enter “arcsec” after each value). The X-Y coordinate system and the default positioning for each scientific instrument are defined in Part II of these Instructions. An aperture’s fiducial point is ordinarily close to the geometric center of that aperture. Details may be found in the Instrument Handbooks.

*Note that a POS TARG is a motion relative to the aperture fiducial point, and so they are not cumulative.*

**Note:** Changing the pointing in this way can cause overheads to be repeated at each POS TARG pointing. If a large number of pointings need to be obtained within one visibility period, it may be more efficient to use a pattern designed for this purpose; see Chapter 8: Pointings and Patterns on page 145.

**SAME POSition AS <exposure>**

SAME POS AS <exposure> requests that the current exposure be done at the same position on the sky and with the same telescope roll as
<exposure>. Note that <exposure> must be in the same visit as the current exposure. This requirement is implicit for exposures within a visit with the same aperture, target, and POS TARG combination.

This requirement is used in many astrometric observations, so that the telescope doesn’t try to center successive targets in the astrometer pickle before observing it.

For other instruments, SAME POS AS should be used sparingly and with caution. For example, SAME POS AS 1 will cause the spacecraft to return to the pointing of exposure 1. Thus if the current exposure has a different (non concentric) aperture from 1 and specifies SAME POS AS 1, the target will be placed in the aperture used by exposure 1, not the aperture currently requested. Further, specifying SAME POS AS an onboard acquisition exposure will undo the offsets determined in the acquisition process.

Do not use SAME POS AS with dithering patterns (Chapter 8: Pointings and Patterns on page 145) because it will negate them. SAME POS AS means exactly the same position as another exposure.

7.3.3 Special Observation Requirements

SPATIAL SCAN <Scan_Rate>, <Scan_Orient>, <Scan_Direction>

HST has the capability of performing a single-line continuous scan relative to the target. Such scans may be useful for observing very bright targets without sacrificing visibility to serial buffer dumps, for example.

Spatial Scans are obtained by moving the spacecraft in a way that moves the target in the instrument aperture along a path designated by the observer. The scan is defined relative to the aperture fiducial point within the instrument field of view. Only one exposure may be executed during a spatial scan, and only one spatial scan may be executed during an exposure. STScI will schedule a spatial scan so that the constant rate portion of the scan begins at the start of the exposure and ends at the end of the exposure.
Table 7.6: Spatial Scan Parameters (See also General Considerations for Spatial Scans)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Allowed Values</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan_Rate</td>
<td>Specifies the angular rate at which the target will move across the detector during the exposure.</td>
<td>0.0 to 0.999999 arcsec/sec under FGS control</td>
<td>Yes</td>
</tr>
<tr>
<td>Scan_Orient</td>
<td>Specifies the orientation of the scan line with respect to the POS TARG coordinate frame, and is measured from the POS TARG +X-axis toward the +Y-axis.</td>
<td>0 to 360 degrees</td>
<td>Yes</td>
</tr>
<tr>
<td>Scan_Direction</td>
<td>Specifies the &quot;direction&quot; of the scan.</td>
<td>&quot;Forward&quot; and &quot;Reverse&quot;^1</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1. A "Forward" scan always starts at the aperture fiducial point (see point a in Figure 7.5) and proceed to the end of the scan (point b in Figure 7.5). A "Reverse" scan will run opposite to the "Forward" one, with it ending at the aperture fiducial point (see Figure 7.6)

General Considerations for Spatial Scans

1. The allowed combinations are WFC3/IR MULTIACCUM and WFC3/UVIS ACCUM.

2. The maximum scan rate is 0.999999 arcsec/sec.

3. The SI Optional Parameter CR-SPLIT must be NO via default or an explicit specification.

4. The angular length of a scan will be determined from the total exposure time (including some overheads in the case of WFC3/IR). It is your responsibility to ensure that the scan does not extend off the detector. Such errors not only waste time, but could also compromise data quality.

5. During a scan the telescope moves. Consequently, for a scan under FGS control, the guide stars will move within the fields of view of the FGS being used. It is essential that none of the guide stars moves out of the field of view of its FGS. Therefore, requesting a scan under FGS control imposes additional selection requirements on the available guide stars, which will effectively reduce the number of stars that can be used for the observation. The degree of this reduction will depend on the length of the scan relative to the width of the FGS fields of view (4 arcmin). If the scan length precludes finding good guide stars, the observation will not be schedulable unless Gyro Hold (see Table 7.3) can be used (see special requirements GUIDing TOLERance <angle>, DROP TO GYRO [NO REACquisition], PCS
**Exposure-level Special Requirements**

**MODE Gyro**. Please contact your PC to discuss the advantages and disadvantages of using these special requirements).

6. The entire scan must complete during a single target visibility period.

7. Scan specifications in Table 7.6 apply to the aperture fiducial point in the SI aperture for the exposure unless you use a **POStion TARGet** `<X-value>,<Y-value>` or **PATTERN** special requirement. When you use **POSt TARG**, the scan is performed relative to the point defined by the **POSt TARG**. When you use **PATTERN**, the scan will be performed for each exposure of the pattern relative to its pattern point.

8. Scans are not permitted for exposures with Moving Targets.

9. Scans are not permitted for exposures with Internal Targets.

10. Special Requirement **SAME POStion AS <exposure>** is not permitted on and can not refer to a Spatial Scan exposure.

11. Spatial Scan exposures are not permitted in Coordinated Parallel containers (Special Requirement **PARallel WITH** is not permitted on and can not refer to a Spatial Scan exposure).

12. Spatial Scan exposures are not permitted in Pure Parallel visits. Pure Parallel visits may not be in parallel with Spatial Scan exposures.

---

**Figure 7.5: "Forward" Spatial Scan**

![Diagram of a single-line "Forward" scan](image)

*Figure 7.5 shows a single-line "Forward" scan from point a to point b at a **Scan-Orient** angle α with the target at the aperture fiducial point at the start of the scan.*
Figure 7.6 shows a "Reverse" scan starting with the target at point \( b \), moving at \( \text{Scan\_Orient} \) angle \( \alpha \), and ending with the target at the aperture fiducial point (point \( a \)).

**PARallel** \(<\text{parallel-exp-list}>\) **WITH** \(<\text{primary-exp-list}>\)

(replaced by Coordinated Parallel Containers in the APT User Interface)

This special requirement specifies that the exposures in \(<\text{parallel-exp-list}>\) will execute in parallel with a sequence of exposures in \(<\text{primary-exp-list}>\). In the Text Proposal File, both \(<\text{primary-exp-list}>\) and \(<\text{parallel-exp-list}>\) must be replaced by either a single exposure number, or a range of exposure numbers separated by a hyphen. See Section 6.3 on page 105 for more details.
7.3.4 Special Communications Requirements

**RT ANALYSIS**

Specifies that the current science exposure must be made available to the observer for analysis in real time. (See the *Call for Proposals* for a discussion of real-time observing.) Any science exposures whose execution depends upon a decision based on the real-time analysis should have **RT ANALYSIS** specified. The REquires UPLINK Special Requirement may also be used with **RT ANALYSIS** to establish the ground-to-spacecraft link. The current exposure will be available for analysis at least 16 minutes (for fixed targets) prior to that uplink; for moving targets the time is 24 minutes.

This Special Requirement is a limited resource and should only be used when necessary. Justification for its necessity should be included in the **Real_Time_Justification** text. Note that:

- the exposures in the `<exposure-list>` **must** be in the same visit as the current exposure, and
- **RT ANALYSIS** may not be used if the exposure uses patterns or if `Number_of_Iterations > 1`.

**REquires UPLINK**

Indicates that a real-time command uplink is needed to execute this exposure. An uplink will be scheduled prior to the current exposure. This Special Requirement should be used with **RT ANALYSIS** to replace the capability formerly available with **INTeractive ACquisititon (obsolete)** and it should specifically identify which exposures need an uplink, assuming that the uplink already provided is not sufficient. This Special Requirement can also be used without **RT ANALYSIS** if the information which needs to be uplinked is not dependent on real-time analysis of HST.

---

*This special requirement has been replaced in the APT User Interface with the use of Coordinated Parallel Containers. See 5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 101.*
data. Usage of this Special Requirement is considered a limited resource and should only be used when necessary. Justification for its necessity should be included in the Real_Time_Justification text.

REquires EPHEMeris CORRection <id>
Indicates that a correction for position errors due to moving-target and/or HST ephemeris uncertainty may be needed to execute the exposure. This Special Requirement is only valid for exposures with moving targets. The offset will be uplinked during an available (“generic”) uplink prior to the earliest exposure that uses it. The pointing correction may require a minute or two of target visibility time.

An ephemeris correction is needed in two cases:

1. When observing an object within about 1 AU of the Earth. In this case, the uncertainty in the position of HST accumulated between the time the schedule is built and the time it is executed can cause the observation to miss the target. (The HST ephemeris is inaccurate by as much as 60 seconds, which translates into a positional error on the moving target). The offset can be easily calculated by STScI personnel in this case.

2. When observing an object with an uncertain ephemeris. In this case, updated positions may be used until shortly before the observation actually executes, even though the elements in the program are out of date. Again, STScI personnel can easily determine the proper offset.

With moving targets, the maximum target ephemeris uncertainty must be specified in the solar-system target list (see Section 4.6 on page 76). STScI will be unable to schedule corrections larger than the maximum offset derived from this uncertainty, so too small an uncertainty may limit the usefulness of the REQ EPHEM CORR procedure. However, offsets larger than about 1 arcminute may make scheduling difficult. If your observation requires a correction this large, contact your Program Coordinator.

The <id> is an alphanumeric string of up to six characters in length. Exposures with the same REQ EPHEM CORR ID (whether in the same visit or in different visits) will use the same offset and must be taken at the same orientation. If exposures in different visits use the same ID, the visits involved are all subject to the same scheduling restrictions as SAME
ORIENTation AS <visit>. The SAME ORIENT Special Requirement is implied across such a set of visits, and need not be specified directly.

**Note that REQ EPHEM CORR uses the uncertainties in target coordinates to determine the size of a possible offset maneuver. Therefore those uncertainties must be supplied accurately.**

7.3.5 Timing Requirements

**EXPAND (pure parallel exposures only)**

Allows the proposer to choose which exposures within an orbit will be expanded to take advantage of unused time at the end of the orbit (note that the exposures will be expanded to fill the orbit unless the MAXimum DURation (time or %) <value> (supported only for pure parallel exposures) Special Requirement is also listed). This special requirement can only be used in pure parallel observations; it has no effect on primary exposures. If there is no EXPAND within the orbit, the last exposure in the orbit will be considered for expansion (up to an additional 20%) first, followed by the previous one and the one before that, etc. Exposures containing the EXPAND requirement are considered first for expansion. See the discussion of MINimum DURation (time or %) <value> (supported only for pure parallel exposures) below for a list of types of exposures which cannot be expanded.

**LOW-SKY**

Requests that the current exposure be taken when the total background light is no more than 30% greater than the yearly minimum value of the zodiacal background for that target. To minimize Earth shine, the exposure will also be taken when the target is at least 40 degrees from the bright Earth. This limits visibility time to about 48 minutes per orbit. Efficiency and schedulability are reduced with this Special Requirement, but to a much lesser degree than with SHADOW. This Special Requirement may not be combined with SHADOW or used in a CVZ visit.

**MAXimum DURation (time or %) <value> (supported only for pure parallel exposures)**

Allows the proposer to set limits on the expansion of exposures to take advantage of unused visibility. This special requirement can only be used in pure parallel observations; it has no effect on primary exposures. If the MAX DUR requirement is not given, exposures with the EXPAND (pure parallel exposures only) requirement may be lengthened up to 120% of
the specified exposure time. **MAX DUR** allows the proposer to increase or decrease this limit, and to apply it to exposures with **EXPAND**. If <time> is specified, the exposure will not be lengthened beyond <time>. If <percentage> is specified, (e.g., **MAX DUR (%) 125**), the exposure will not be lengthened beyond <percentage> of the specified exposure time. If <time or percentage> is omitted, the exposure will not be lengthened at all.

**MINimum DURation (time or %) <value> (supported only for pure parallel exposures)**

Allows the proposer to limit shortening of exposures to allow them to fit in a visibility period. This special requirement can only be used in pure parallel observations; it has no effect on primary exposures. If the **MIN DUR** requirement is not given, exposures will not be shortened to less than 80% of the specified exposure time. **MIN DUR** allows the proposer to increase or decrease this limit. The exposure may be shortened until its duration is <time> but not further. If <time or percentage> is omitted, the exposure will not be shortened at all. If a percentage is used (e.g., **MIN DUR (%) 80**) the exposure will be shortened until its duration is decreased to, at most, <percentage> of the specified exposure time.

**PHASE <number1> TO <number2>**

Requests that the exposure start in the specified phase range (<number1> to <number2>) of a periodic variation. <number1> and <number2> should be between 0.0 and 1.0. The **PERIOD <time> ZERO-PHASE (HJD) <date>** used in the calculation should have been already entered at the visit level. With short periods, the phase range (difference between <number1> and <number2>) should be made as wide as possible to make scheduling easier.

Please note that there is no need to repeat the **PHASE** Special Requirement for multiple exposures within the same Visit (unless you are attempting to specify different phases for those exposures). Instead, specify **PHASE** for only the first exposure in the Visit. If the phase window you specify is short, you may need to adjust **PHASE** for the first exposure so that the subsequent ones start before the phase window ends.

---

Note that **Number_of_Iterations must be 1 if PHASE is specified**
SEQUence <exposure-list> NON-INTerruptible
(replaced by Exposure Group Containers in the APT User Interface)

This has been replaced in APT with the use of Exposure Group Containers. See 5.18 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 101.

Specifies that exposures defined in the <exposure-list> be observed without gaps due to Earth occultation or SAA passages. Gaps between exposures may still be necessary to allow time for activities which are necessary to set up for the next exposure, such as pointing changes, readouts of the SI buffers, and SI reconfigurations. This requirement must be included for a series of FGS exposures which are to be executed within the same orbit.

In the Text Proposal File, the exposure list must be a range of numbers separated by a hyphen, such as SEQ NON-INT 55-60.

Note: If this requirement is placed on one exposure (e.g., SEQ 20 NON-INT) and Number_of_Iterations > 1, the sequence of subexposures will not be split.

SHADOW
Requests that the current exposure be taken while HST is in the umbral shadow of the Earth. It is primarily useful when contamination by geocoronal emission (Lyman alpha, OI 1304Å, etc.) must be minimized. However, it does not minimize zodiacal light, which is the principal source of background at wavelengths longer than 3500Å (see the LOW-SKY Special Requirement).

Exposures using this Special Requirement are limited to about 32 minutes per orbit (including overheads). Scheduling may only be feasible for a small percentage of the year. This Special Requirement is a limited resource and should only be used when necessary; most usages of SHADOW will have been approved by the TAC during the Phase I review process. This Special Requirement may not be combined with LOW-SKY or used in a CVZ visit.
CHAPTER 8: Pointings and Patterns

In this chapter . . .

8.1 Pointing the Telescope / 145
8.2 Introduction to Patterns / 145
8.3 How to Fill Out the Pattern Parameters Form / 148
  8.3.1 Pattern Parameters / 149
8.4 Convenience Patterns / 152
  8.4.1 STIS Patterns / 152
  8.4.2 ACS Patterns / 156
  8.4.3 NICMOS Patterns / 160
  8.4.4 WFC3 Patterns / 167
  8.4.5 COS Patterns / 172

8.1 Pointing the Telescope

Acquiring an astronomical target and keeping it fixed in an aperture is the heart of observing with HST. Properly specifying target coordinates and motions is essential, of course, as is finding and acquiring suitable guide stars. Earlier chapters in this document have provided detailed instructions on how to specify coordinates and acquisitions for both fixed and moving targets; see Chapter 3: Fixed and Generic Targets on page 25 and Chapter 4: Solar System Targets on page 59.

8.2 Introduction to Patterns

Rarely does an observer ask to look at precisely one point on the sky. Instead, small-scale repositionings of the aperture may be made to fully sample a region spatially, or larger-scale movements may be made to mosaic a region of the sky. These movements are known as patterns.

In the past we have defined patterns on an case-by-case basis in a manner that seemed appropriate to each instrument. In rewriting the software that transforms your Phase II program into detailed observations, we realized
that these different patterns were sometimes contradictory and incompatible, and that a common basis for describing patterns was needed for the current and future instruments. At the same time, we do not wish to further confuse observers by abandoning terms they may be familiar with, especially if they have continuing programs that could be affected by a change at an arbitrary time.

Here we describe the patterns syntax in APT for both the User Interface and the Text Proposal File; these descriptions provide both general capabilities and pre-defined “convenience” patterns.

8.2.1 APT User Interface

Creating Patterns

1. First, you specify the pattern or patterns you want to use by using the “Patterns” form; then you select the type of pattern (or patterns) you want from a list, filling in the fields (where you can) with the values you want, or leave them to their assigned default values.

2. Then you can create a Pattern Container (see Section 5.18 on page 101) in a visit, and then place your exposures in this container.

If the exposures in the Pattern Container contain other expansion constructs (such as Number_Of_Iterations > 1 or one of the CR-SPLIT Optional Parameters), the multiple exposures will be taken at each pattern point.

General Pattern Container Rules

If the exposures contain coordinated parallels, it must contain the entire parallel sequence (both parallel and primary exposures in the Coordinated Parallel Container; see Section 5.18 on page 101), and only those exposures. All parallel exposures will be taken at each pattern point. Only one pattern is allowed within any sequence.

All primary exposures in the exposure list (container) must have the same initial pointing: i.e., the same instrument configuration, aperture, target, and POS TARG offsets (if any).

Patterns may be specified for a moving target. In this case the pattern is taken while the target is being tracked and the offsets obtained will be a combination of target motion and motion imposed by the pattern relative to the target.

The following exposure-level Special Requirement is not allowed on an exposure that is part of a pattern:

SAME POSition AS <exposure>
Patterns are also not allowed with FGS TRANS mode (which specifies a separate scan with the FGS star selectors).

### 8.2.2 Text Proposal File

In the Text Proposal File, a pattern is specified as an exposure-level Special Requirement.

**PATTERN <#> [<exposure-list>]**

This specifies that each exposure in <exposure-list> (or the current exposure if no <exposure-list> is provided) should be repeated at each point in a pattern of discrete pointing offsets from the target. The <#> should be an integer between 1 and 999 that corresponds to the Pattern_Number of a pattern defined in the Pattern_Data block of the Text Proposal File. Details for providing Pattern_Data are given in the next section.

If the exposures in the <exposure-list> contain other expansion constructs (such as Number_of_Iterations > 1 or one of the CR-SPLIT Optional Parameters), the multiple exposures will be taken at each pattern point.

If the <exposure-list> contains coordinated parallels, it must contain the entire parallel sequence (both <parallel-exp-list> and <primary-exp-list> from the PARALLEL WITH Special Requirement; see PARallel <parallel-exp-list> WITH <primary-exp-list> (replaced by Coordinated Parallel Containers in the APT User Interface)), and only those exposures. All parallel exposures will be taken at each pattern point. Only one PATTERN Special Requirement is allowed within any sequence.

All primary exposures in <exposure-list> must have the same initial pointing: i.e., the same instrument configuration, aperture, target, and POS TARG offsets (if any).

Patterns may be specified for a moving target. In this case the pattern is taken while the target is being tracked and the offsets obtained will be a combination of target motion and motion imposed by the pattern relative to the target.

**Notes:** The exposure-level Special Requirement, SAME POSition AS <exposure>, is not allowed on an exposure that is part of a pattern: Also, Patterns are not allowed with FGS TRANS mode (which specifies a separate scan with the FGS star selectors).
8.3 How to Fill Out the Pattern Parameters Form

The Pattern Parameters Form allows a pattern of pointing offsets to be defined. Patterns are useful for several different purposes: dithering to remove the effects of detector artifacts or to increase spatial resolution, mosaicing to cover a larger area on the sky, or moving away from the target to sample the background.

It is also possible to specify two nested patterns for an exposure or set of exposures. In this case, instead of taking the exposures at each point of the first pattern, the entire Sub-Pattern (or Secondary_Pattern in the Text Proposal File) will be executed at each point, creating a two-dimensional matrix of pointing offsets.

**Text Proposal File**

Patterns are identified by the Pattern_Number field under the Pattern_Data block in the Text Proposal File. The value of Pattern_Number must be an integer between 1 and 999. If an exposure anywhere in the proposal uses the PATTERN <#> [<exposure-list>] Special Requirement and <#> matches Pattern_Number, the specified exposures will be repeated at each point of the pattern. It is also possible to specify two nested patterns for an exposure or set of exposures. In this case, instead of taking the exposures at each point of the first pattern, the entire Secondary_Pattern will be executed at each point, creating a two-dimensional matrix of pointing offsets. The parameters for the first pattern appear under the Primary_Pattern label in the Text Proposal File. If a second pattern is to be used, a similar Secondary_Pattern label followed by the same set of parameters should be added below the first.

The Pattern Parameters form looks like this in the Text Proposal File:

```
Pattern_Data

Pattern_Number:11 !unique identifier
Primary_Pattern:
Pattern_Type:STIS-MAMA-BOX
Pattern_Purpose:DITHER
Number_of_Points:4
PointSpacing:0.559
LineSpacing:0.559
CoordinateFrame:POS-TARG
PatternOrient:26.565
AngleBetweenSides:143.1
CenterPattern:NO
```

Not all fields are required in all cases (see the examples below), and for some patterns both a Primary_Pattern and a Secondary_Pattern must be
described. If none of the instrument-specific patterns will work, it is also possible to specify more generic lines and spirals.

### 8.3.1 Pattern Parameters

The Pattern Parameters Form has the following fields:

**Pattern Number**
A unique identifier from 1 to 999; this is assigned in APT.

**Pattern Type**
This specifies the type (and shape) of a pattern (generally an instrument-specific name; see “Convenience Patterns” on page 152), and, depending on the type, may constrain or completely determine the values of the other parameters. Many pattern types have been defined for the different instruments, as given below. Pattern parameters that are determined by the pattern type, or have default values, need not (or cannot) be changed in the form.

Some pattern types are intended for use with a combination of two patterns (Primary Pattern and Sub-Pattern). With such pattern types the Sub-Pattern is mandatory. The Pattern Type may specify that a parameter of the Sub-Pattern is constrained or determined by the value of the corresponding parameter of the Primary Pattern. Whenever two patterns are used, the Pattern Type of the Sub-Pattern defaults to the pattern type of the Primary Pattern.

A Pattern Type defined for a particular instrument is legal only if the first primary exposure in the pattern uses that instrument. Generic pattern types are valid with any instrument. Patterns specific to individual instruments are described in Section 8.4 on page 152. The following are generic pattern types.

- **Pattern Type: LINE**
  This specifies a linear pattern of offsets; all other parameters are open.

- **Pattern Type: SPIRAL**
  This specifies a spiral pattern: all other parameters are open.

- **Pattern Type: BOX**
  This specifies a box pattern; the Number Of Points = 4 and all other parameters are open.

**Pattern Purpose**
This is a required text field which describes the scientific purpose of the pattern, but it is treated as a comment to help evaluate the Phase II
program. There are four legal values: DITHER, MOSAIC, BACKGROUND, and OTHER:

- **DITHER** means small-scale motions used to improve spatial resolution and data quality.
- **MOSAIC** means movement of the aperture to sample different parts of an object or regions of sky.
- **BACKGROUND** means a movement away from a source to sample the sky background, ordinarily used with infrared instruments.
- If **OTHER** is used, the reason for the pattern should be provided in the Comments field. Unless a default is determined via the Pattern_Type, this parameter is required, although you may edit it from the default value to another valid value.

**Number_Of_Points**

This specifies the number of points in the pattern; allowed values are from 2 to 50. Unless a default is determined via the Pattern_Type, this parameter is required.

**Point_Spacing**

This specifies the spacing between adjacent points in a pattern, in arcsec. For parallelogram patterns **Point_Spacing** will specify the length of the segment between the first two pattern points. The value of **Point_Spacing** ranges from 0 to 1440 arcsec. Unless a default is determined via the Pattern_Type, this parameter is required.

Note: patterns larger than about 130 arcsec (defined by the maximum pointing change between any two points in the pattern) may not be done on a single set of guide stars. For such patterns, unless the entire visit uses gyro guiding (PCS MODE Gyro; see PCS MODE Gyro), the visit-level Special Requirement DROP TO GYRO IF NECESSARY (see DROP TO GYRO [NO REACquisition]) must be specified to allow the farther pattern points to execute under gyro guiding.

Unless PCS MODE Gyro is specified on the visit, all patterns must be contained within a circle of radius 24 arcmin (1440 arcsec), with the first pattern point at the center.

**Line_Spacing**

This parameter is relevant only for parallelogram (box) patterns; it specifies the length of the second pattern segment of the parallelogram in arcsec. The allowed range is from 0 to 1440.0 arcsec.
How to Fill Out the Pattern Parameters Form

Angle_Between_Sides
This parameter is relevant only for parallelogram (box) patterns; it specifies the angle (from 0 to 360) between sides of the parallelogram in degrees measured clockwise from the first pattern segment to the second.

Coordinate_Frame
This field has two legal values, POS-TARG and CELESTIAL. It specifies whether the pattern is being done in the POS TARG (spacecraft) frame or the celestial frame (by specifying offsets from the original target position on the sky). For patterns with a Pattern_Purpose of DITHER, POS-TARG is the only legal value.

Note: If the NICMOS OFFSET=FOM optional parameter is used, the pattern will be executed by moving the NICMOS Field Offset Mirror, rather than the telescope. In this case, Coordinate_Frame must be set to POS-TARG. All primary exposures in a pattern must use this parameter if any do, and all such exposures must specify the same set of values (if any) for the FOMXPOS and FOMYPOS Optional Parameters.

Pattern_Orient
This field specifies the orientation of the first segment of the pattern with respect to the chosen frame, in degrees. If Coordinate_Frame: POS-TARG, this angle will be measured from the POS TARG +X axis toward the +Y axis. If Coordinate_Frame: CELESTIAL, it will be measured North through East, and will specify the direction of an offset from the target on the sky.

A value of 0 will cause the first pattern segment to be oriented along the POS TARG +X axis if Coordinate_Frame: POS-TARG, and along the North vector on the sky if Coordinate_Frame: CELESTIAL.

Center_Pattern
This indicates whether the pattern should be centered relative to the pointing (hereafter referred to as the “default pointing”) that the exposures would have had in the absence of a pattern. For a primary pattern (Primary_Pattern), the default pointing is the target position, unless the POS TARG Special Requirement (see POSition TARGet <X-value>,<Y-value>) is used to shift the target relative to the aperture. For a secondary pattern (Sub-Pattern), the default pointing is the pointing offset from the target determined by the given pattern point in Primary_Pattern.

Legal values for Center_Pattern are YES (check in box provided) and NO (no check). The default is NO, unless overridden via the Pattern_Type. If Center_Pattern: NO, the first pattern point is placed at the default pointing. If Center_Pattern: YES, the first pattern point is...
offset so that the default pointing is placed at the geometric center of the pattern.

**Sub-Pattern (or Secondary_Pattern in the Text Proposal File) Information**

If applicable, the Sub-Pattern information must be provided (Type, Shape, Number of Points, etc.).

Note that if you are using the Text Proposal File, a Sub-Pattern is labeled as a Secondary_Pattern.

### 8.4 Convenience Patterns

The following patterns use the new syntax but have been constructed to duplicate the earlier pattern forms (if applicable). Their nomenclature is meant to be obvious; for example, “STIS-CCD-BOX” means the former "box" pattern for the STIS CCD. After each description we show what the information would look like.

A specific entry for a parameter (such as 4 for Number_of_Points with STIS-CCD-BOX) means that value may not be changed and doing so will cause an error. An indicated range (such as 0.0275-2.75 for Point_Spacing in STIS-MAMA-BOX) means you may select from within that range, and a “?” means any numeric value may be entered.

As previously noted, you may also nest patterns, but not all combinations make sense. If you use both a Primary_Pattern and a Sub-Pattern (or Secondary_Pattern in the Text Proposal File), they should be for the same instrument or at least one should be generic. Note that any convenience pattern can be added as a Sub-Pattern when a generic pattern is selected as the Primary_Pattern. If a pattern with large steps is to be combined with a pattern with small steps, the Primary_Pattern should contain the large steps, to minimize the time spent on pointing maneuvers. In the following sections, we show which patterns may be selected as a Sub-Pattern when the indicated convenience pattern is the Primary_Pattern. The observer should consult the references given within the instrument-specific subsections for detailed advice on selecting patterns and modifying pattern parameters. Do not mix instrument-specific patterns.

#### 8.4.1 STIS Patterns

To see an illustration of the STIS POS-TARG reference frame, go to Section 9.9 on page 196.
**Pattern_Type: STIS-PERP-TO-SLIT**

This is normally used with a spectroscopic slit. It produces a scan along the POS TARG X-axis of the aperture; this is used to map a two-dimensional region of the sky (see Chapter 11 of the STIS Instrument Handbook). The target is moved perpendicular to the slit along the AXIS1 (dispersion) direction.

```
Pattern_Type:STIS-PERP-TO-SLIT
Pattern_Purpose:MOSAIC
Number_of_Points:? 
Point_Spacing:? 
Coordinate_Frame:POS-TARG 
Pattern_Orient:0 
Center_Pattern:? 
```

Permitted Sub-Pattern (Secondary_Pattern) values: STIS-ALONG-SLIT, LINE.

**Pattern_Type: STIS-ALONG-SLIT**

This is also normally used with a spectroscopic slit. It produces a scan along the POS TARG Y-axis of the aperture; this is used to step a target along the long slit to dither bad pixels or improve spatial resolution (see the STIS Instrument Handbook). The target is moved along the slit in the AXIS2 (cross-dispersion or spatial) direction.

```
Pattern_Type:STIS-ALONG-SLIT
Pattern_Purpose:DITHER
Number_of_Points:? 
Point_Spacing:? 
Coordinate_Frame:POS-TARG 
Pattern_Orient:90 
Center_Pattern:? 
```

Permitted Sub-Pattern (Secondary_Pattern) values: none.

To see an illustration of the STIS POS-TARG reference frame, go to Section 9.9 on page 196.
Pattern_Type: STIS-CCD-BOX
This will produce a four-point parallelogram scan designed for dithering across the CCD pixels. With the default Point_Spacing of 0.567, the four points of the parallelogram will be obtained at the following POS TARG (X,Y) offsets relative to the default aperture position:

(0.0", 0.0") (0.5070", 0.2535") (0.7605", 0.7605") (0.2535", 0.5070"

This default produces a parallelogram pattern (see diagram) with projected offsets from the starting point of 5n integer pixels in each coordinate, so that the above arcsec values correspond to pixel values of (0, 0), (10, 5), (15, 15), and (5, 10). With these integer-pixel offsets, the pattern is optimized to simultaneously compensate for hot pixels and small-scale detector non-uniformities. The pattern can be rescaled (e.g., by a factor of 0.5) to achieve shifts of N+half pixels for resolution enhancement by changing the Point_Spacing.

Pattern_Type:STIS-CCD-BOX
Pattern_Purpose:DITHER
Number_of_Points:4
Point_Spacing:0.0567-5.67 (default 0.567)
Line_Spacing:Equal to Point_Spacing (may not be changed)
Angle_Between_Sides:143.1 (may not be changed)
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 26.6)
Center_PATTERN:?

Permitted Sub-Pattern (Secondary_Pattern) values: none.
To see an illustration of the STIS POS-TARG reference frame, go to Section 9.9 on page 196.
**Pattern Type: STIS-MAMA-BOX**

This will produce a four-point parallelogram scan designed for dithering across the MAMA pixels. With the default Point_Spacing of 0.275, the four points of the parallelogram will be obtained at the following POS TARG (X,Y) offsets relative to the default aperture position:

$$(0.0", 0.0") (0.246", 0.123") (0.369", 0.369") (0.123", 0.246")$$

This default produces a parallelogram pattern (see diagram) with projected offsets from the starting point of 5n integer pixels in each coordinate, so that the above arcsec values correspond to pixel values of (0, 0), (10, 5), (15, 15), and (5, 10). With these integer-pixel offsets, the pattern is optimized to simultaneously compensate for hot pixels and small-scale detector non-uniformities. The pattern can be rescaled (e.g., by a factor of 0.5) to achieve shifts of N+half pixels for resolution enhancement by changing the Point_Spacing.

```
Pattern_Type:STIS-MAMA-BOX
Pattern_Purpose:DITHER
Number_of_Points:4
Point_Spacing:0.0275-2.75 (default 0.275)
Line_Spacing:Equal to Point_Spacing (may not be changed)
Angle_Between_Sides:143.1 (may not be changed)
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 26.6)
Center_Pattern:? 
```

Permitted Sub-Pattern (Secondary_Pattern) values: none.

**Pattern Type: STIS-SPIRAL-DITH**

This produces a spiral dither pattern, starting at the center and moving outward counterclockwise. Note that a STIS-SPIRAL-DITH with four points yields a square pattern, but the optimum pattern for detector
dithering to enhance resolution is either STIS-CCD-BOX or STIS-MAMA-BOX.

Pattern_Type: STIS-SPIRAL-DITH
Pattern_Purpose: DITHER
Number_of_Points: ?
Point_Spacing: ?
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center_Pattern: ?

Permitted Sub-Pattern values: none.

To see an illustration of the STIS POS-TARG reference frame, go to Section 9.9 on page 196.

8.4.2 ACS Patterns

For general information on ACS pointing, and a library of carefully designed dither and mosaic pointing patterns (ready for use in a Phase II proposal), see the following Web page:

http://www.stsci.edu/hst/acs/proposing/dither

In addition to the default patterns provided below, many non-default variations are included in the pattern library (e.g., for hot pixel rejection, sub-pixel dithering, etc.) and parameters are updated using the latest distortion solution. Helpful diagrams and descriptions are provided along with Phase II pattern parameters.

Pattern_Type: ACS-WFC-DITHER-LINE

General WFC dither line pattern. The default for this pattern shifts the image by 5 pixels in x and 60 in y in order to span the gap between the two WFC detectors.

Pattern_Type: ACS-WFC-DITHER-LINE
Pattern_Purpose: DITHER
Number_of_Points: 2-9 (default 2)
Point_Spacing: 0.01 - 10.0 (default 3.011)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 85.28)
Center_Pattern: ? (default NO)

Permitted Sub_Pattern (Secondary_Pattern) values: any other ACS/WFC patterns, LINE, BOX, SPIRAL

Note: All ACS/WFC users are encouraged to use some form of dithering to allow for correction of hot pixels during data processing. The standard CR-SPLIT approach does not eliminate hot pixels (See Section 11.2.4). Users who would normally have taken that approach in the past are now encouraged to define and use instead the pattern:

Pattern_Type: ACS-WFC-DITHER-LINE
Pattern_Purpose: DITHER
Number_Of_Points: 2
Point_Spacing: 0.146
Coordinate_Frame: POS-TARG
Pattern_Orient: 47.17
Center_Pattern: NO

This pattern will allow simultaneous elimination of hot pixels and cosmic ray hits in post-observation processing. The pattern parameters shift the image by 2 pixels in x and 2 in y along the direction that minimizes the effects of scale variation across the detector.

Pattern_Type: ACS-WFC-DITHER-BOX
This is the default WFC box pattern. It is a 4-point pattern with relative pixel coordinates (0, 0), (5.0, 1.5), (2.5, 4.5), (-2.5, 3.0)—a parallelogram pattern with a combination of integer and sub-pixel shifts, which is relatively compressed in one dimension compared to its STIS counterpart. This minimizes the effect of scale variation across the detector.

Pattern_Type: ACS-WFC-DITHER-BOX
Pattern_Purpose: DITHER
Number_Of_Points: 4
Point_Spacing: 0.01 - 10.0 (default 0.265)
Line_Spacing: 0.01 - 10.0 (default 0.187)
Angle_Between_Sides: 0 - 360 (default 69.05)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 20.67)
Center_Pattern: ? (default NO)
Permitted Sub_Pattern (Secondary_Pattern) values: any other ACS/WFC patterns, LINE, BOX, SPIRAL

**Pattern_Type: ACS-WFC-MOSAIC-LINE**

General WFC mosaic line pattern. The default shift is in the y direction by 47% of the detector dimension, resulting in a field-of-view that is about 200x300 arcsec. This is a compromise which allows the 2-point WFC mosaic to be performed with one set of guide stars and to cover the inter chip gap as well.

- Pattern_Type: ACS-WFC-MOSAIC-LINE
- Pattern_Purpose: MOSAIC
- Number_Of_Points: 2-9 (default 2)
- Point_Spacing: 10.0 - 130.0 (default 96.816)
- Coordinate_Frame: POS-TARG
- Pattern_Orient:? (default 90.0)
- Center_Pattern:? (default YES)

Permitted Sub_Pattern (Secondary_Pattern) values: any other ACS/WFC patterns, LINE, BOX, SPIRAL

**Pattern_Type: ACS-WFC-MOSAIC-BOX**

This is a 4-point box pattern for creating a WFC mosaic roughly 400x300 arc seconds. This pattern strikes a compromise with a y-shift that covers the inter chip gap (with one set of guide stars) and the maximum x-shift to expand the field of view. So another set of guide stars would be needed only for the x shifts, which are 95% of the detector x dimension (~193 arcsec).

- Pattern_Type: ACS-WFC-MOSAIC-BOX
- Pattern_Purpose: MOSAIC
- Number_Of_Points: 2-9 (default 2)
- Point_Spacing: 10.0 - 130.0 (default 96.816)
- Coordinate_Frame: POS-TARG
- Pattern_Orient:? (default 90.0)
- Center_Pattern:? (default YES)

**Note:** This pattern is not supported in the STScI ground system because it would require two sets of guide stars, so no pattern parameters are given. The pattern can be set up by hand using the following POS TARG offsets:

- Point 1: -96.497, -55.801
- Point 2: -96.497, 41.015
- Point 3: 96.497, 55.801
- Point 4: 96.497, -41.015

Another useful WFC mosaic box pattern would maximize the field of view (~400x400 arcseconds). For this pattern, both the x and y shifts are ~95% of the detector dimensions, and would require multiple guide stars.

This pattern is also not supported in the ground system, but may be set up by hand using the following POS TARG offsets:
Point 1: -96.497, -104.084  
Point 2: -96.497, 89.298  
Point 3: 96.497, 104.084  
Point 4: 96.497, -89.298

**Pattern_Type: ACS-SBC-DITHER-LINE**
General SBC dither line pattern. This pattern shifts the image on the diagonal (10 pixels in x and y).

```
Pattern_Type: ACS-SBC-DITHER-LINE
Pattern_Purpose: DITHER
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 0.01 - 10.0 (default 0.472)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 44.40)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/SBC patterns, LINE, BOX, SPIRAL

**Pattern_Type: ACS-SBC-DITHER-BOX**
Same as ACS-WFC-DITHER-BOX, but for the SBC detector.

```
Pattern_Type: ACS-SBC-DITHER-BOX
Pattern_Purpose: DITHER
Number_Of_Points: 4
Point_Spacing: 0.01 - 10.0 (default 0.179)
Line_Spacing: 0.01 - 10.0 (default 0.116)
Angle_Between_Sides: 0 - 360 (default 63.65)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 20.02)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/SBC patterns, LINE, BOX, SPIRAL

**Pattern_Type: ACS-SBC-MOSAIC-LINE**
General SBC mosaic line pattern. This pattern shifts the image by 95% in y to roughly double the FOV.

```
Pattern_Type: ACS-SBC-MOSAIC-LINE
Pattern_Purpose: MOSAIC
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 10.0 - 130.0 (default 28.801)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 90.0)
Center_Pattern: ? (default YES)
```
Permitted Sub_Pattern (Secondary_Pattern) values: any other ACS/SBC patterns, LINE, BOX, SPIRAL

**Pattern_Type: ACS-SBC-MOSAIC-BOX**

This is a large 4-point box pattern for creating a mosaic roughly 4 times the SBC field-of-view, or ~64x64 arcsec. The shifts are 95% of the detector dimensions (~973 pixels or ~32 arcsec) along both the x and y axes of the detector.

```plaintext
Pattern_Type: ACS-SBC-MOSAIC-BOX
Pattern_Purpose: MOSAIC
Number_Of_Points: 4
Point_Spacing: 10.0 - 130.0 (default 28.801)
Line_Spacing: 10.0 - 130.0 (default 32.957)
Angle_Between_Sides: 0 - 360 (default 95.76)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 90.0)
Center_Pattern: ? (default YES)
```

Permitted Sub_Pattern (Secondary_Pattern) values: any other ACS/SBC patterns, LINE, BOX, SPIRAL

### 8.4.3 NICMOS Patterns

See the NICMOS Instrument Handbook for a full discussion of how and why to use patterns and for complete illustrations of their geometries.

**Pattern_Type: NIC-XSTRIP-DITH**

This specifies a linear pattern of offsets in the POS TARG +X direction.

```plaintext
Pattern_Type: NIC-XSTRIP-DITH
Pattern_Purpose: DITHER
Number_of_Points: ?
Point_Spacing: ?
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center_Pattern: ?
```

Permitted Sub-Pattern (Secondary_Pattern) values: NIC-YSTRIP-DITH, NIC-SPRAL-DITH, NIC-SPIRAL-MAP, NIC-SQUARE-WAVE-DITH, LINE, SPIRAL.

**Pattern_Type: NIC-YSTRIP-DITH**

This specifies a linear pattern of offsets in the POS TARG +Y direction.

```plaintext
Pattern_Type: NIC-YSTRIP-DITH
Pattern_Purpose: DITHER
Number_of_Points: ?
```
Patterns: NIC-SPIRAL-DITH
This specifies a spiral dither pattern.

Pattern_Type: NIC-SPIRAL-DITH
Pattern_Purpose: DITHER
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame: POS-TARG
Pattern_Orient:? (default 0)
Center_PATTERN:?
Permitted Sub-Pattern (Secondary_PATTERN) values:
NIC-XSTRIP-DITH, NIC-YSTRIP-DITH, NIC-SPIRAL-MAP,
NIC-SQUARE-WAVE-DITH, LINE, SPIRAL.
Pattern_Type: NIC-SPIRAL-MAP
This specifies a spiral mosaic pattern.

Pattern_Type: NIC-SPIRAL-MAP
Pattern_Purpose: MOSAIC
Number_of_Points: ?
Point_Spacing: ?
Coordinate_Frame: CELESTIAL
Pattern_Orient: ?
Center_Pattern: ?

Permitted Sub-Patterns (Secondary_Pattern) values:
NIC-XSTRIP-DITH, NIC-YSTRIP-DITH, NIC-SPINDAL-DITH,
NIC-SQUARE-WAVE-DITH, LINE, SPIRAL.

Pattern_Type: NIC-SQUARE-WAVE-DITH
This specifies a square-wave pattern with the “amplitude” of the square wave along the POS TARG +Y axis and the main direction of motion along the POS TARG +X axis.

Pattern_Type: NIC-SQUARE-WAVE-DITH
Pattern_Purpose: DITHER
Number_of_Points: ?
Point_Spacing: ?
Line_Spacing: Equal to Point_Spacing (may not be changed)
Angle_Between_Sides: 270 (may not be changed)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 90)
Center_Pattern: ?

Permitted Sub-Patterns (Secondary_Pattern) values:
NIC-XSTRIP-DITH, NIC-YSTRIP-DITH, NIC-SPINDAL-DITH,
NIC-SPIRAL-MAP, LINE, SPIRAL.

Pattern_Type: NIC-ONE-CHOP
This requires two pattern definitions. It specifies a repeated “chop” back and forth along the POS TARG +X axis.

Primary pattern:

Pattern_Type: NIC-ONE-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: ?
Point_Spacing: 0
Coordinate_Frame: POS-TARG
Pattern_Orient: 0
Center_Pattern: NO

Sub-pattern:
Pattern_Type: NIC-ONE-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: 2
Point_Spacing: ?
Coordinate Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center Pattern: NO

Other permitted Sub-Pattern (Secondary Pattern) values: none.

**Pattern Type: NIC-TWO-CHOP**
This requires two pattern definitions. It specifies a repeated “chop” along the POS TARG +X axis, similar to NIC-ONE-CHOP, but using four points instead of two.

Primary pattern:
Pattern_Type: NIC-TWO-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: 4
Point_Spacing: ?
Line_Spacing: Equal to Point_Spacing (may not be changed)
Angle_Between_Sides: 0 (may not be changed)
Coordinate Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center Pattern: NO

Sub-pattern:
Pattern_Type: NIC-TWO-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: 4
Point_Spacing: ?
Line_Spacing: Equal to Point_Spacing (may not be changed)
Angle_Between_Sides: 0 (may not be changed)
Coordinate Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center Pattern: NO

Other permitted Sub-Pattern (Secondary Pattern) values: none.

**Pattern Type: NIC-XSTRIP-DITH-CHOP**
This requires two pattern definitions. It specifies a combination of a line pattern and a two-point line at right angles (the “chop”).

Primary pattern:
Pattern_Type: NIC-XSTRIP-DITH-CHOP
Pattern_Purpose: DITHER
Number_of_Points: ?
Point_Spacing: ?
Coordinate Frame: POS-TARG
Pattern_Type: NIC-XSTRIP-DITH-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: 2
Point_Spacing: ?
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center_Pattern: NO

Other permitted Sub-Pattern (Secondary_Pattern) values: none.

Pattern_Type: NIC-YSTRIP-DITH-CHOP
This requires two pattern definitions. It specifies a combination of a line pattern and a two-point line at right angles (the “chop”).

Primary pattern:
Pattern_Type: NIC-YSTRIP-DITH-CHOP
Pattern_Purpose: DITHER
Number_of_Points: ?
Point_Spacing: ?
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 90)
Center_Pattern: ? (default NO)

Sub-pattern:
Pattern_Type: NIC-YSTRIP-DITH-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: 2
Point_Spacing: ?
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center_Pattern: NO

Other permitted Sub-Pattern (Secondary_Pattern) values: none.

Pattern_Type: NIC-SPIRAL-DITH-CHOP
This requires two pattern definitions. It specifies a combination of a spiral pattern and a two-point line (the “chop”).

Primary pattern:
Pattern_Type: NIC-SPIRAL-DITH-CHOP
Pattern_Purpose: DITHER
Number_of_Points: ?
Point_Spacing: ?
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 0)
Center_Pattern: ?

Sub-pattern:
Pattern_Type: NIC-SPIRAL-DITH-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: 2
Point_Spacing: ?
Coordinate_Frame: POS-TARG
Pattern_Orient: Equal to <Primary_Pattern value>
Center_Pattern: NO

Other permitted Sub-Pattern (Secondary_Pattern) values: none.

**Pattern_Type: NIC-MAP**

This specifies a linear mosaic pattern oriented on the sky.

Primary pattern:

Pattern_Type: NIC-MAP
Pattern_Purpose: MOSAIC
Number_of_Points: ?
Point_Spacing: ?
Coordinate_Frame: CELESTIAL
Pattern_Orient: ?
Center_Pattern: ?

Sub-pattern:

Pattern_Type: NIC-MAP
Pattern_Purpose: MOSAIC
Number_of_Points: ?
Point_Spacing: ?
Coordinate_Frame: CELESTIAL
Pattern_Orient: ?
Center_Pattern: ?

Other permitted Sub-Pattern (Secondary_Pattern) values: none.

**Pattern_Type: NIC-SKY-ONE-CHOP**

This requires two pattern definitions. It specifies a pattern similar to NIC-ONE-CHOP, except that it is oriented on the sky.

Primary pattern:

Pattern_Type: NIC-SKY-ONE-CHOP
Pattern_Purpose: BACKGROUND
Number_of_Points: ?
Point_Spacing: 0
Coordinate_Frame: CELESTIAL
Pattern_Orient: 0
Center_Pattern: NO

Sub-pattern:

Pattern_Type: NIC-SKY-ONE-CHOP
Pattern_Purpose: BACKGROUND
Chapter 8: Pointings and Patterns

Number_of_Points: 2
Point_Spacing: ?
Coordinate_Frame: CELESTIAL
Pattern_Orient: ?
Center_Pattern: NO

Other permitted Sub-Pattern (Secondary_Pattern) values: none.

**Pattern_Type: NIC-SKY-TWO-CHOP**

This requires two pattern definitions. It specifies a pattern similar to NIC-TWO-CHOP, except that it is oriented on the sky.

Primary pattern:

- Pattern_Type: NIC-SKY-TWO-CHOP
- Pattern_Purpose: BACKGROUND
- Number_of_Points: ?
- Point_Spacing: 0
- Coordinate_Frame: CELESTIAL
- Pattern_Orient: 0
- Center_Pattern: NO

Sub-pattern:

- Pattern_Type: NIC-SKY-TWO-CHOP
- Pattern_Purpose: BACKGROUND
- Number_of_Points: 4
- Point_Spacing: ?
- Line_Spacing: Equal to Point_Spacing (may not be changed)
- Angle_Between_Sides: 0 (may not be changed)
- Coordinate_Frame: CELESTIAL
- Pattern_Orient: ?
- Center_Pattern: NO

Other permitted Sub-Pattern (Secondary_Pattern) values: none.

(Secondary_Pattern) **Pattern_Type:**

**NIC-SKY-SPIRAL-DITH-CHOP**

This requires two pattern definitions. It specifies a combination of a spiral pattern and a two-point line (the “chop”), similar to NIC-SPIRAL-DITH-CHOP except that the pattern is oriented on the sky.

Primary pattern:

- Pattern_Type: NIC-SKY-SPIRAL-DITH-CHOP
- Pattern_Purpose: DITHER
- Number_of_Points: ?
- Point_Spacing: ?
- Coordinate_Frame: POS-TARG
- Pattern_Orient: ? (default 0)
- Center_Pattern: ? (default NO)

Sub-pattern:

- Pattern_Type: NIC-SKY-SPIRAL-DITH-CHOP
8.4.4 WFC3 Patterns

Please see ISR WFC3 2010-09 and the WFC3 Instrument Handbook (Sections 6.10, 7.10 and Appendix C) for information on dither strategies and patterns. For general advice on dither strategies, see Sections 2.4 and 2.5 of the Multidrizzle Handbook. The step sizes in pixels specified below apply to the central regions of the detectors. For smaller steps, the step sizes are accurate over a larger region of the detectors. (The step size in pixels depends on the geometric distortion; see Appendix B of the WFC3 Instrument Handbook).

WFC3 dither patterns designed to subsample pixels can now optionally be selected as secondary patterns when WFC3 patterns with larger steps are selected as primary patterns. WFC3 patterns can also be added as secondary patterns to any of the generic pattern types (BOX, LINE, SPIRAL). When combining patterns, the smaller dither pattern should be the secondary pattern to minimize the time spent moving the telescope.

**Pattern_Type: WFC3-UVIS-DITHER-LINE**

This pattern dithers the UVIS aperture by (2.5, 2.5) pixels to sample the point spread function with fractional pixel steps. The default values are optimized for a 2-step pattern.

```
Pattern_Type: WFC3-UVIS-DITHER-LINE
Pattern_Purpose: DITHER
Number_Of_Points: 2 - 9 (default 2)
Point_Spacing: ? (default 0.145)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 46.840)
Center_Pattern: ? (default NO)
```

**Pattern_Type: WFC3-UVIS-DITHER-LINE-3PT**

This pattern dithers the UVIS aperture by (2.33, 2.33) pixels to sample the point spread function with fractional pixel steps. The default values are optimized for a 3-step pattern.

```
Pattern_Type: WFC3-UVIS-DITHER-LINE-3PT
Pattern_Purpose: DITHER
Number_Of_Points: 3 - 9 (default 3)
```
Point_Spacing: ? (default 0.135)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 46.840)
Center_Pattern: ? (default NO)

**Pattern_Type: WFC3-UVIS-DITHER-BOX**
This pattern for WFC3/UVIS samples the point spread function with fractional pixel steps and produces spacings of more than one column to move hot columns. The relative steps in pixels are (0, 0), (4.0, 1.5), (2.5, 4.0), and (-1.5, 2.5).

Pattern_Type: WFC3-UVIS-DITHER-BOX
Pattern_Purpose: DITHER
Number_Of_Points: 4
Point_Spacing: ? (default 0.173)
Line_Spacing: ? (default 0.112)
Angle_Between_Sides: ? (default 81.785)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 23.884)
Center_Pattern: NO

**Pattern_Type: WFC3-UVIS-GAP-LINE**
This pattern dithers over the gap between the two chips of the UVIS detector with relative steps of (-2.25,-30.25) and (2.25,30.25) pixels. Additional subpixel dithering can be achieved by adding one of the WFC3-UVIS dither patterns as a Secondary Pattern.

Primary_Pattern:

Pattern_Type: WFC3-UVIS-GAP-LINE
Pattern_Purpose: MOSAIC
Number_of_Points: ? (default 2)
Point_Spacing: ? (default 2.414)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 85.759)
Center_Pattern: YES

Permitted Sub-Pattern (Secondary_Pattern) values:
WFC3-UVIS-DITHER-BOX, WFC3-UVIS-DITHER-LINE, WFC3-UVIS-DITHER-LINE-3PT

**Pattern_Type: WFC3-UVIS-MOS-DITH-LINE**
The primary pattern dithers over the gap between the two chips of the UVIS detector with relative steps of (-4.5,-60.25), (0, 0), and (4.5, 60.25) pixels. The secondary pattern adds a dither of (2.5, 1.5) pixels to the primary pattern (Use WFC3-UVIS-GAP-LINE if you need a greater selection of permitted Secondary Patterns.).
Primary Pattern:

- **Pattern Type**: WFC3-UVIS-MOS-DITH-LINE
- **Pattern Purpose**: MOSAIC
- **Number of Points**: ? (default 3)
- **Point Spacing**: ? (default 2.400)
- **Coordinate Frame**: POS-TARG
- **Pattern Orient**: ? (default 85.754)
- **Center Pattern**: YES

Secondary Pattern:

- **Pattern Type**: WFC3-UVIS-MOS-DITH-LINE
- **Number of Points**: ? (default 2)
- **Pattern Purpose**: DITHER
- **Point Spacing**: ? (default 0.119)
- **Coordinate Frame**: POS-TARG
- **Pattern Orient**: ? (default 33.606)
- **Center Pattern**: NO

**Pattern Type**: WFC3-UVIS-MOS-BOX-LRG

This pattern produces a UVIS mosaic that can be executed with a single set of guide stars. It dithers the gap between the chips so that no region lies in the gap more than once. The relative steps in pixels are approximately (-1000, -997), (1000, -1001), (1000, 997), and (-1000,1001). Subpixel dithering can be achieved by adding one of the WFC3-UVIS dither patterns as a Secondary Pattern.

- **Pattern Type**: WFC3-UVIS-MOS-BOX-LRG
- **Pattern Purpose**: MOSAIC
- **Number of Points**: 4
- **Point Spacing**: ? (default 79.40)
- **Line Spacing**: ? (default 77.50)
- **Angle Between Sides**: ? (default 95.30)
- **Coordinate Frame**: POS-TARG
- **Pattern Orient**: ? (default 5.55)
- **Center Pattern**: YES

Permitted Sub-Pattern (Secondary Pattern) values:
- WFC3-UVIS-DITHER-BOX,
- WFC3-UVIS-DITHER-LINE,
- WFC3-UVIS-DITHER-LINE-3PT

**Pattern Type**: WFC3-UVIS-MOSAIC-LINE

This pattern is designed for observations using the full WFC3/UVIS detector for primary exposures and the full ACS/WFC detector for parallel exposures. It dithers over the inter-chip gap on both detectors. The relative steps on the WFC3/UVIS detector are (0, 0) and (36.5, 71.5) pixels. Subpixel dithering can be achieved by adding one of the WFC3-UVIS dither patterns as a Secondary Pattern.
Pattern Type: WFC3-UVIS-MOSAIC-LINE
Pattern Purpose: MOSAIC
Number of Points: 2-9 (default 2)
Point Spacing: ? (default 3.264)
Coordinate Frame: POS-TARG
Pattern Orient: ? (default 63.697)
Center Pattern: NO

Permitted Sub-Pattern (Secondary Pattern) values:
WFC3-UVIS-DITHER-BOX, WFC3-UVIS-DITHER-LINE, WFC3-UVIS-DITHER-LINE-3PT

Pattern Type: WFC3-IR-DITHER-LINE
This pattern for WFC3/IR takes steps large enough for photometric accuracy and samples the point spread function with fractional pixel steps. The relative steps in pixels are (0, 0) and (3.5, 3.5). The default values are optimized for a 2-step pattern.

Pattern Type: WFC3-IR-DITHER-LINE-3PT
This pattern for WFC3/IR takes steps large enough for photometric accuracy and samples the point spread function with fractional pixel steps. The relative steps in pixels are (0, 0) and (3.33, 3.33). The default values are optimized for a 3-step pattern.

Pattern Type: WFC3-IR-DITHER-BOX-MIN
This pattern for WFC3/IR takes steps just large enough for photometric accuracy and samples the point spread function with fractional pixel steps. The relative steps in pixels are (0, 0), (4.0, 1.5), (2.5, 4.0), and (-1.5, 2.5).
Pattern Type: WFC3-IR-DITHER-BOX-UVIS

This is a four-point box pattern that produces an IR mosaic covering approximately the same area as the UVIS detector. IR imaging with aperture IR-FIX is intended to be accompanied by a UVIS exposure (or small dither pattern) using the aperture UVIS-FIX or UVIS-CENTER. If UVIS-FIX is used, the UVIS exposures should use the Target Position Requirement POS TARG 0.0", -12" to achieve the same centering of the target in the UVIS exposures and the IR mosaic. Subpixel dithering can be achieved by adding one of the WFC3-IR dither patterns as a Secondary Pattern.

Pattern Type: WFC3-IR-DITHER-BLOB

This pattern dithers over the IR "blobs," described in ISR WFC3 2010-09, using relative steps of (-14.25,-14.25) and (14.25,14.25) pixels. Additional subpixel dithering can be achieved by adding one of the WFC3-IR dither patterns as a Secondary Pattern.
Permitted Sub-Pattern (Secondary_Pattern) values:
WFC3-IR-DITHER-BOX-MIN, WFC3-IR-DITHER-LINE,
WFC3-IR-DITHER-LINE-3PT

8.4.5 COS Patterns

There are no predefined patterns for COS.
PART II: Supported Science Instruments

The chapters in this part describe the configurations and modes for the supported instruments on HST for Cycle 19: ACS, NICMOS (tentative), COS, WFC3 and FGS.

Chapter 9: Space Telescope Imaging Spectrograph (STIS) / 175
Chapter 10: Fine Guidance Sensors (FGS) / 209
Chapter 11: Advanced Camera for Surveys (ACS) / 219
Chapter 12: Near Infrared Camera and Multi-Object Spectrometer (NICMOS) / 233
Chapter 13: Cosmic Origins Spectrograph (COS) / 253
Chapter 14: Wide Field Camera 3 (WFC3) / 291
CHAPTER 9: Space Telescope Imaging Spectrograph (STIS)

In this chapter . . .

9.1 Introduction to STIS / 176
ACQUISITION MODES / 178
9.2 Mode = ACQ Config = STIS/CCD / 178
9.3 Mode = ACQ/PEAK Config = STIS/CCD / 181
IMAGING AND SPECTROSCOPIC MODES / 183
9.4 Mode = ACCUM Config = STIS/CCD / 183
9.5 Mode = ACCUM Config = STIS/FUV–MAMA, Config = STIS/NUV–MAMA / 186
9.6 Mode = TIME–TAG Config = STIS/FUV–MAMA, Config = STIS/NUV–MAMA / 188
REFERENCE INFORMATION / 190
9.7 STIS Central Wavelengths / 190
9.8 STIS Internal Calibration Targets / 191
9.8.1 Target_Name = WAVE / 191
9.8.2 Target_Name = CCDFLAT / 193
9.9 STIS Coordinate System / 196
The Official STIS Aperture List for Cycle 19 / 197

Tables and Figures

Table 9.1: Supported Optional Parameters for STIS Instrument Modes
Table 9.2: Supported Central Wavelengths for STIS Gratings
Table 9.3: Legal aperture-grating combinations when TARGET=WAVE
Table 9.4: Time_Factor for Spectral Elements and Wavelengths.
Table 9.5: Supported STIS Apertures
Figure 9.1 STIS coordinate system
9.1 Introduction to STIS

The Instrument Configurations and Operating Modes described here are used for the Visit and Exposure Specifications. The legal Specifications are discussed in a summary fashion in the following sections. More complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, etc. are available in the STIS Instrument Handbook.

Note that many of the Optional Parameters have default values; in such cases, an entry for an Optional Parameter in the Visit and Exposure Specifications is necessary only if it is desired to override the default value. In the STScI proposal system, the physical units of Optional Parameter quantities are always implicit and should never be entered by the observer.

STIS has a large number of apertures. A complete list of supported apertures is provided at the end of this chapter (see Table 9.5 on page 198). That table should be taken as definitive if any additional information in this chapter appears to conflict.

Table 9.1 lists the permitted Instrument Configurations, Operating Modes, Spectral Elements, and Optional Parameters for the STIS.

Note also that in addition to the automatic wavelength calibrations added by the system, the following observer-added contemporaneous calibrations may also be made:

- CCDFLAT (fringe flats) for G750L and G750M observations longward of 7000 Å.
- WAVE calibrations for added wavelength precision.

See the STIS Instrument Handbook for more information.

---

Some STIS modes will work without an initial ACQuisition (such as slitless spectroscopy and imaging), but in general the user must ensure that ACQuisitions are included where needed. An ACQ/PEAK should always be preceded by an ACQuisition.
STIS Optional Parameters

Table 9.1: Supported Optional Parameters for STIS Instrument Modes

<table>
<thead>
<tr>
<th>Config.</th>
<th>Mode</th>
<th>Spectral Elements</th>
<th>Optional Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>STIS/CCD</td>
<td>ACQ</td>
<td>MIRROR</td>
<td>ACQTYPE, DIFFUSE–CENTER, CHECKBOX</td>
</tr>
<tr>
<td></td>
<td>ACQ/PEAK</td>
<td>MIRROR, G230LB,</td>
<td>SIZEAXIS2</td>
</tr>
<tr>
<td></td>
<td>ACCUM</td>
<td>G230MB, G430L,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>G430M, G750L, G750M</td>
<td></td>
</tr>
<tr>
<td>STIS/FUV–MAMA</td>
<td>ACCUM</td>
<td>MIRROR, G140L,</td>
<td>BINAXIS1, BINAXIS2</td>
</tr>
<tr>
<td></td>
<td>TIME–TAG</td>
<td>G140M, E140M, E140H</td>
<td>BUFFER–TIME</td>
</tr>
<tr>
<td>STIS/NUV–MAMA</td>
<td>ACCUM</td>
<td>MIRROR, G230L,</td>
<td>BINAXIS1, BINAXIS2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PRISM</td>
<td></td>
</tr>
</tbody>
</table>

The following sections provide further details of the entries to be made on the Visit and Exposure Specifications when a particular STIS/CCD, STIS/FUV–MAMA, or STIS/NUV–MAMA Mode/Configuration is chosen.

Note: The AXIS1 and AXIS2 coordinate system is defined in Section 3.1 of the STIS Instrument Handbook. Array sizes are given as AXIS1 x AXIS2. For CCD and MAMA first-order grating and MAMA echelle spectroscopic modes, AXIS1 is in the dispersion direction, and AXIS2 is in the "cross-dispersion" (or spatial) direction.
ACQUISITION MODES

HST pointing now uses the GSC2 catalog to determine the position of guide stars. Following the initial guide star acquisition for your visit, the target location in the aperture plane should now be known to an accuracy of 0.2 to 0.5 arcseconds. This is a considerable improvement over the 1-2 arcsecond accuracy achieved using GSC1. However, for STIS spectroscopic observations of an external target, any uncertainty in the target position along the dispersion direction will directly translate into an uncertainty in the zero point of the wavelength scale. Therefore, for most STIS spectroscopic science observations, even those using large apertures, and for any science observations using the coronagraphic bars, it is strongly recommended that a target acquisition (ACQ Mode) exposure and possibly one or more acquisition peakup exposures (ACQ/PEAK Mode) be done to center your target. The CCD detector may be used for acquisitions of targets that will be observed in the CCD and MAMA ACCUM and TIME-TAG modes. Details on STIS target acquisition modes are in the STIS Instrument Handbook.

The STIS Target Acquisition Exposure Time Calculator (ETC) and Target Acquisition Simulator are tools provided by STScI to help plan acquisitions. You can find these tools at: http://www.stsci.edu/hst/stis/software/planning

9.2 Mode = ACQ
Config = STIS/CCD

The STIS onboard flight software locates the target in the STIS FOV for subsequent science exposures. At the end of the onboard acquisition process, HST is repositioned to place the target in the aperture specified on the first science exposure in the series.

Onboard acquisitions of two different types of targets are supported: point and extended sources. The total flux within a sequence of overlapping “checkboxes” within an acquisition subarray is determined, and the target position is located within the brightest checkbox.

The visual magnitude from the Target List, along with the exposure time, will be used to verify that the integrated target flux through the selected
acquisition aperture is appropriate for CCD target acquisition. Details on the CCD target acquisition sequence and limiting magnitudes for the acquisition apertures and spectroscopic slits can be found in the *STIS Instrument Handbook*.

### 9.2.1 Aperture or FOV

See Table 9.1: Supported Optional Parameters for STIS Instrument Modes and Table 9.5: Supported STIS Apertures.

Enter one of the following apertures:

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F28X50LP</td>
<td>Optical longpass; preferred target acquisition aperture</td>
</tr>
<tr>
<td>F28X50OII</td>
<td>[OII] 3740 Å; use for bright sources or emission-line objects</td>
</tr>
<tr>
<td>F28X50OIII</td>
<td>[OIII] 5007 Å; use for bright sources or emission-line objects¹</td>
</tr>
<tr>
<td>F25ND3</td>
<td>Neutral density filter for overly bright targets; ND = (10^{-3})</td>
</tr>
<tr>
<td>F25ND5</td>
<td>Neutral density filter for overly bright targets; ND = (10^{-5})</td>
</tr>
<tr>
<td>50CCD</td>
<td>Clear aperture for very faint sources</td>
</tr>
</tbody>
</table>

¹. Please note that this filter has a substantial red leak; see the *STIS Instrument Handbook*.

### 9.2.2 Spectral Element

*MIRROR* is the only valid spectral element for this Mode.

### 9.2.3 Optional Parameters

See Table 9.1 for a listing by operating mode of all Optional Parameters. Here are descriptions for those Optional Parameters for **ACQ** mode.

**ACQTYPE**

=POINT (default), DIFFUSE

Specifies the type of onboard target acquisition algorithm used in locating the target. Onboard algorithms are available for acquiring a point or extended (diffuse) source.

With the default value of **POINT**, an acquisition subarray of 100 x 100 CCD pixels (5x5 arcsec) and a checkbox of 3x3 CCD pixels are always used. The target position is the flux-weighted centroid of the brightest checkbox within the subarray.

With the **DIFFUSE** acquisition type, the acquisition subarray is a square array. The number of pixels on each side is 101 + **CHECKBOX** (see
below). The target position is either the geometric center or the flux-weighted centroid of the brightest checkbox, depending on the \texttt{DIFFUSE–CENTER} parameter.

\textbf{DIFFUSE–CENTER =FLUX–CENTROID (default), GEOMETRIC–CENTER}

Specifies whether the target position of a extended source is to be located as the flux weighted centroid (\texttt{FLUX–CENTROID}) or the geometric center (\texttt{GEOMETRIC–CENTER}) of the brightest checkbox. \texttt{DIFFUSE–CENTER} is only permitted if \texttt{ACQTYPE=DIFFUSE}.

\textbf{CHECKBOX =3–105 (pixels; odd only)}

Specifies the length of a side of a square pixel array over which the light intensity is summed to locate the brightest region of the acquisition. This parameter is required for extended targets (\texttt{ACQTYPE=DIFFUSE}). It is not allowed for point sources (\texttt{ACQTYPE=POINT}), for which a fixed checkbox size based on the PSF will be used. The value of \texttt{CHECKBOX} should equal the size of the brightest area of the source the observation is attempting to locate. The dimension of the acquisition subarray will be 101 pixels plus the \texttt{CHECKBOX} parameter. The value of \texttt{CHECKBOX} must be an odd number.

\textbf{9.2.4 Number of Iterations}

The \texttt{Number\_of\_Iterations} must be 1 in this Mode.

\textbf{9.2.5 Time Per Exposure}

The procedures to determine the exposure time for the \texttt{ACQ} exposures are given in the \textit{STIS Instrument Handbook}.

The exposure time for \texttt{ACQ} exposures on GO proposals must be less than 5 minutes for \texttt{ACQTYPE=POINT} acquisitions, and for \texttt{ACQTYPE=DIFFUSE} acquisitions must be less than $500/(101+\texttt{CHECKBOX})$ minutes.

\textbf{9.2.6 Special Requirements}

None.
9.3 Mode = ACQ/PEAK
Config = STIS/CCD

In ACQ/PEAK Mode, a series of exposures is taken at several HST pointings offset along the detector axes, and the HST is repositioned to maximize (peak up) or minimize (peak down) the light intensity within a default or proposer-specified detector subarray. AXIS1 and AXIS2 are in the dispersion and cross-dispersion (or spatial) directions respectively. For more information, including when peakups are required, see the STIS Instrument Handbook.

Mode ACQ/PEAK should always be preceded by an ACQuisition.

9.3.1 Aperture or FOV

The aperture used for the ACQ/PEAK exposure will generally be identical to the aperture used for the subsequent ACCUM science exposure. For maximum centering accuracy, a peakup aperture smaller than the science exposure may be chosen. Peakups are required whenever an aperture dimension is less than or equal to 0.1 arcsec. Two peakups are recommended for the 0.1X0.03 aperture: one with the 0.2X0.09 aperture followed by another with the 0.1X0.03 aperture.

See Table 9.5 for the allowed ACQ/PEAK apertures. Note that you cannot perform a peakup with an E2 aperture (i.e. 52X... apertures ending with the E2 suffix), which are designed for use in conjunction with CCD Fringe Flats. If you need an ACQ/PEAK exposure prior to using an E2 aperture, perform the peakup using the 52X0.1E1 aperture. Then select the appropriate E2 aperture for the following science exposures.

When an ACQ/PEAK exposure using the occulting bar aperture 52X0.2F1 is specified, a peakdown rather than a peakup will automatically be performed.

A peakup will be performed otherwise. To peak up on the width of a slit with an occulting bar before peaking down on the bar itself, the occulting bar aperture name with –R appended to it should be used. Such exposures will peak up on a reference point offset from the occulting bar along the slit’s length.

9.3.2 Spectral Element

See Table 9.1: Supported Optional Parameters for STIS Instrument Modes.
9.3.3 Optional Parameters

See Table 9.1 for a listing by operating mode of all Optional Parameters. Here are descriptions for those Optional Parameters for ACQ/PEAK mode.

**SIZEAXIS2**

=DEF (default); 30–1022 (pixels, dispersive elements), 16–1022 (pixels, MIRROR)

Specifies the size of a CCD subarray in detector coordinates along the AXIS2 (cross-dispersion or spatial) direction.

The default subarray with SIZEAXIS2=DEF depends on the aperture and spectral element. With the MIRROR element, the default subarray will generally be 32x32 CCD pixels centered on the aperture. However, the F1 fiducial slits use a 32x64 subarray. A subarray of 16x16 is also allowed when MIRROR is used.

With a first-order CCD grating (G230LB, G230MB, G430L, G430M, G750L, G750M), the default subarray will generally be 1022 x 32 CCD pixels. However, the F1 fiducial slits use a 1022 x 64 subarray. These subarrays have been chosen to minimize cosmic ray perturbations on the acquisition process.

9.3.4 Number of Iterations

The Number_of_Iterations must be 1 in this Mode.

9.3.5 Time Per Exposure

The procedures to determine the exposure time for the ACQ/PEAK exposure are given in the STIS Instrument Handbook.

9.3.6 Special Requirements

None.
IMAGING AND SPECTROSCOPIC MODES

9.4 Mode = ACCUM
Config = STIS/CCD

The STIS CCD has only one operating mode. ACCUM, in addition to the target acquisition modes. ACCUM Mode is used for both imaging and spectroscopy. Photons are counted on the CCD as accumulated charge which is read out at the end of the exposure and converted to DN at a selectable gain. The DN are stored as 16-bit words in a data memory array. A full detector readout is 1062 x 1044 pixels, which includes 19 leading pixels and 19 trailing pixels of overscan per line and 20 virtual overscan lines. A CCD subarray does not include the virtual overscan or any of the physical pixels bordering the outer edges of the array, so that the maximum permitted subarray size is 1060 x 1022 pixels.

9.4.1 Aperture or FOV
See Table 9.5: Supported STIS Apertures.

9.4.2 Spectral Element
See Table 9.1: Supported Optional Parameters for STIS Instrument Modes.

9.4.3 Wavelength
Enter the value of the central wavelength in Angstroms. Table 9.2 gives the allowed values of the central wavelength for each grating. Consult the STIS Instrument Handbook for the associated minimum and maximum wavelength and other information pertaining to the gratings.

No wavelength should be specified if MIRROR is the spectral element

9.4.4 Optional Parameters
See Table 9.1 for a listing by operating mode of all Optional Parameters. Here are descriptions for those Optional Parameters for the imaging and spectroscopic modes.
CR–SPLIT
= 2 (default) – 8; NO (primary and coordinated parallel exposures)
= NO (pure parallel exposures)
Specifies the number of subexposures into which the specified exposure is to be split for the purpose of cosmic ray elimination in post-observation data processing (see the STIS Instrument Handbook). The specified exposure time will be divided equally among the number of CR–SPLIT exposures requested. If CR–SPLIT=NO, the exposure is taken as specified without splitting. If a pattern of offsets is specified (see Chapter 8: Pointings and Patterns), the specified number of exposures will be taken at each pattern point.

CR–SPLIT=NO must always be used with pure parallel exposures in this mode. If omitted, the default value of CR–SPLIT for pure parallels is NO.

CR–SPLIT=NO is always assumed for internal exposures. If explicitly stated, the only permitted value for internals is CR–SPLIT=NO.

GAIN
=1 (default), 4(e/DN)
Specifies the gain of the CCD electronics in e/DN.

BINAXIS1, BINAXIS2
=1 (default), 2, 4 (pixels) for either
Specifies the number of CCD pixels along the AXIS1 or dispersion (BINAXIS1) and the AXIS2 or cross-dispersion (BINAXIS2) directions that are binned to a single signal value as the detector is read out. The default values result in each pixel being read out and downlinked to the ground. See the discussion of binning in the STIS Instrument Handbook.

BINAXIS1 and BINAXIS2 are not permitted in conjunction with CCD subarray parameter SIZEAXIS2.

SIZEAXIS2
=FULL (default); 30–1022 (pixels)
Specifies the size of a CCD subarray in detector coordinates along the AXIS2 (cross-dispersion or spatial) direction. The default value of FULL for science exposures will result in the readout of a full detector array of 1044 pixels (including virtual overscan) in the AXIS2 direction. The subarray will be centered on the detector coordinates of the target (which change with POSition TARGet offsets); however, the subarray edge will never be shifted beyond the top or bottom edge of the detector.
9.4.5 Number of Iterations and Time Per Exposure

Enter the number of times this exposure should be iterated. For instance, specifying 10 iterations and a Time_Per_Exposure of 10 seconds will give a total exposure time of 100 seconds. There are many observational situations when two or more exposures should be taken of the same field (e.g., to keep a bright object from blooming by keeping the exposure time short).

The value entered for the Time_Per_Exposure is the total exposure time for a particular exposure specification. If the Number_of_Iterations is n, the entire exposure specification will be iterated n times. However, if CR–SPLIT is used, the total exposure time will actually be apportioned among shorter exposures: specifying an exposure time of 10 seconds and CR–SPLIT=2 results in two exposures of 5 seconds each.

If Number_of_Iterations > 1 is specified with a pattern, the pattern is executed once with the specified number of iterations being taken at each point in the pattern. If no pattern is specified, the specified number of iterations will be taken at the single pointing.

Number_of_Iterations must be 1 for STIS pure parallels (except for CCDFLAT; see Section 9.8.2 on page 193).

CR–SPLIT and multiple iterations are mutually exclusive capabilities. If Number_of_Iterations > 1 on an external exposure, CR–SPLIT=NO must be specified.

Time_Per_Exposure must be an integral multiple of 0.1 second. If it is not its value will be truncated down to the next lower integral multiple of 0.1 sec. If the exposure time is less than 0.1 sec, it will be set to the CCD minimum value of 0.1 sec. The maximum permissible Time_Per_Exposure for this mode is 17179.8 seconds.
9.5 Mode = ACCUM  
Config = STIS/FUV–MAMA,  
Config = STIS/NUV–MAMA

The two MAMAs are photon-counting detectors that provide a two-dimensional ultraviolet capability. ACCUM Mode should be used for all observations that do not require time resolution on scales of minutes or less. Dispersion (in spectroscopic modes) runs along AXIS1; the spatial direction of the slit (cross-dispersion) is along AXIS2.

There are 1024 x 1024 physical pixels in the MAMA array, but each physical pixel is sampled by three electrodes, allowing centroiding of electron clouds to half-pixel accuracy. In ACCUM Mode, the MAMAs accumulate counts in the STIS data buffer as they are received, producing images with 2048 x 2048 “high-resolution” pixels with half physical pixel coordinates. Images can be binned either by the STIS flight software (using the BINAXIS1 and BINAXIS2 optional parameters described below) or on the ground, to produce images with 1024 x 1024 physical pixels. All optional parameters are specified in physical pixel coordinates. For a more detailed description, see the discussion of MAMA ACCUM mode in the *STIS Instrument Handbook*.

Subarrays may not be used with the MAMA detectors.

9.5.1 Aperture or FOV
See Table 9.5: Supported STIS Apertures.

9.5.2 Supported Spectral Elements
See Table 9.1: Supported Optional Parameters for STIS Instrument Modes.

9.5.3 Wavelength
Enter the value of the central wavelength in Angstroms. Table 9.2 gives the allowed values of the central wavelength for each spectroscopic spectral element. Consult the *STIS Instrument Handbook* for the associated...
minimum and maximum wavelength and other information pertaining to the spectroscopic elements.

No wavelength should be specified if the MIRROR is the spectral element.

9.5.4 Optional Parameters

See Table 9.1 for a listing by operating mode of all Optional Parameters. Here are descriptions for those Optional Parameters for MAMA ACCUM mode.

BINAXIS1, BINAXIS2
=DEF (default), NO, YES (for either)
These parameters specify whether onboard rebinning is to be performed on the accumulated image in memory after the exposure is completed. MAMA photon events are stored in memory in half-pixel coordinates (high-resolution pixels). This rebinning is a summation of two high-resolution pixels in the AXIS1 or dispersion (BINAXIS1) and the AXIS2 or cross dispersion (BINAXIS2) directions to values corresponding to the physical pixels of the detector. The default values for all spectral elements and apertures are not to rebin in either direction, resulting in four high-resolution pixel values for each physical pixel.

When used with the MAMA detectors, BINAXIS1 and BINAXIS2 must have the same value!

9.5.5

Number of Iterations and Time Per Exposure

Enter the number of times (Number_of_Iterations) this exposure should be iterated, and the exposure time (Time_Per_Exposure) per iteration.

If Number_of_Iterations > 1 is specified with a pattern, the pattern is executed once with the specified number of iterations being taken at each point in the pattern. If no pattern is specified, the specified number of iterations will be taken at the single pointing.

Time_Per_Exposure must be an integral multiple of 0.1 second. If it is not its value will be truncated down to the next lower integral multiple of 0.1 sec. If the exposure time is less than 0.1 sec, it will be set to the MAMA
minimum value of 0.1 sec. The maximum permissible Time_Per_Exposure for this mode is 6553.5 seconds.

9.6 Mode = TIME–TAG
Config = STIS/FUV–MAMA,
Config = STIS/NUV–MAMA

TIME–TAG Mode is used for imaging and spectroscopy with high time resolution. When used in TIME–TAG Mode, the MAMA produces an event stream with a time resolution of 125 microseconds. If the incoming event rate exceeds about 770,000 counts per second, not all events get registered due to finite electronic response time. The AXIS1 and AXIS2 half-pixel coordinates (11 bits each) of each photon event, along with 9 bits of fine-resolution time data, are stored as a 32-bit word in data buffer memory. See the discussion of TIME–TAG Mode in the STIS Instrument Handbook.

9.6.1 Aperture or FOV
See Table 9.5: Supported STIS Apertures.

9.6.2 Spectral Element
See Table 9.1: Supported Optional Parameters for STIS Instrument Modes.

9.6.3 Wavelength
Enter the value of the central wavelength in Angstroms. Table 9.2 gives the allowed values of the central wavelength for each spectroscopic spectral element. Consult the STIS Instrument Handbook for the associated minimum and maximum wavelength and other information pertaining to the spectroscopic elements.

No wavelength should be specified if the MIRROR is the spectral element.
9.6.4 Optional Parameters

See Table 9.1 for a listing by operating mode of all Optional Parameters. Here are descriptions for those Optional Parameters for MAMA TIME-TAG mode.

**BUFFER–TIME**

=40 or greater (integer seconds)

This required parameter should be equal to or less than the time to fill half the STIS buffer (2 x 10^6 photon events) during a TIME–TAG exposure.

If the predicted total number of events from a TIME–TAG exposure exceeds the STIS data buffer capacity of 4 x 10^6 photon events, data must be transferred to the HST onboard science data recorder during the exposure. Transfers of data from the STIS buffer during an exposure will be made in 8-MByte blocks (half the buffer capacity). The value of **BUFFER–TIME** should be equal to or less than the half-buffer capacity (2 x 10^6 counts) divided by the estimated maximum average count rate in photons per second (see the *STIS Instrument Handbook*). If the actual count rate is less than expected and fewer than 2 x 10^6 counts are received during this time, the 8-MByte blocks will contain fill data.

Note that **BUFFER–TIME** should include expected counts from the detector dark current as well as the detected photon events, factoring in the instrument quantum efficiency. A conservative value of **BUFFER–TIME** is recommended (err slightly on the low side) to avoid data loss. For more details, see the *STIS Instrument Handbook*.

9.6.5 Number of Iterations and Time Per Exposure

**Number_of_Iterations** must be 1 in this mode.

**Time_Per_Exposure** must be an integral multiple of 0.1 second. If it is not its value will be truncated down to the next lower integral multiple of 0.1 sec. Enter the total time of data collection as **Time_Per_Exposure**. An exposure time of less than 0.1 sec will be set to the minimum MAMA exposure time of 0.1 second. The maximum permissible **Time_Per_Exposure** for this mode is 6553.5 seconds.

If **BUFFER–TIME** < 99 seconds, photon events will be generated faster than data can be transferred out of the buffer during the exposure. In this case, **Time_Per_Exposure should be less than or equal to 2 * BUFFER–TIME** so that the exposure can complete before data transfer is necessary. A **BUFFER–TIME** of 99 seconds corresponds to a maximum average count rate of 20,200 counts/sec.

Note that TIME–TAG exposures have the potential to rapidly use up the HST onboard storage capacity. Caution is advised on any exposure with an
exposure time greater than 30 * BUFFER–TIME, which corresponds to \(6 \times 10^7\) counts, or about 2 GBits (close to 20% of the solid-state recorder capacity). Please see the STIS Instrument Handbook.

### 9.6.6 Special Requirements

The special requirements RT ANALYSIS and PARallel WITH are not permitted on TIME–TAG Mode exposures.

## REFERENCE INFORMATION

### 9.7 STIS Central Wavelengths

Table 9.2: Supported Central Wavelengths for STIS Gratings

<table>
<thead>
<tr>
<th>Spectral Element</th>
<th>Central Wavelength (Angstroms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E140H</td>
<td>1234, 1271, 1307, 1343, 1380, 1416, 1453, 1489, 1526, 1562, 1598</td>
</tr>
<tr>
<td>E140M</td>
<td>1425</td>
</tr>
<tr>
<td>E230H</td>
<td>1763, 1813, 1863, 1913, 1963, 2013, 2063, 2113, 2163, 2213, 2263, 2313, 2363, 2413, 2463, 2513, 2563, 2613, 2663, 2713, 2762, 2812, 2862, 2912, 2962, 3012</td>
</tr>
<tr>
<td>E230M</td>
<td>1978, 2124, 2269, 2415, 2561, 2707</td>
</tr>
<tr>
<td>G140L</td>
<td>1425</td>
</tr>
<tr>
<td>G140M</td>
<td>1173, 1218, 1222, 1272, 1321, 1371, 1387, 1400, 1420, 1470, 1518, 1540, 1550, 1567, 1616, 1640, 1665, 1714</td>
</tr>
<tr>
<td>G230L</td>
<td>2376</td>
</tr>
<tr>
<td>G230LB</td>
<td>2375</td>
</tr>
<tr>
<td>G230M</td>
<td>1687, 1769, 1851, 1884, 1933, 2014, 2095, 2176, 2257, 2338, 2419, 2499, 2579, 2600, 2659, 2739, 2800, 2818, 2828, 2898, 2977, 3055</td>
</tr>
<tr>
<td>G230MB</td>
<td>1713, 1854, 1995, 2135, 2276, 2416, 2557, 2697, 2794, 2836, 2976, 3115</td>
</tr>
<tr>
<td>G430L</td>
<td>4300</td>
</tr>
<tr>
<td>G430M</td>
<td>3165, 3305, 3423, 3680, 3843, 3936, 4194, 4451, 4706, 4781, 4961, 5093, 5216, 5471</td>
</tr>
<tr>
<td>G750L</td>
<td>7751</td>
</tr>
<tr>
<td>G750M</td>
<td>5734, 6094, 6252, 6581, 6768, 7283, 7795, 8311, 8561, 8825, 9286, 9336, 9806, 9851</td>
</tr>
</tbody>
</table>
The following internal calibration targets are available for the STIS. These should not be included in your proposal if the routine calibrations are sufficient for your program. See the *STIS Instrument Handbook* for details.

### 9.8.1 Target Name = WAVE

An observer-specified wavelength calibration exposure for a selected spectral element, central wavelength, and aperture. Permitted in the STIS/CCD, STIS/FUV–MAMA, and STIS/NUV–MAMA configurations, only in ACCUM Mode. Few optional parameters may be specified (see Optional Parameter in this section). The Number of Iterations must be 1. Note: For the STIS/CCD configuration, a gain of 4 e/DN will be used. Observer-specified wavecals may be used in addition to or in place of automatic wavecals.

Exposures with the WAVE internal target must immediately precede or follow an external science exposure (i.e., an ACCUM or TIME–TAG Mode exposure with an external pointing) which uses the same spectral element and central wavelength as the WAVE exposure. These exposures will use the same calibration lamp configuration as the automatic wave calibrations discussed below (based on the spectral element, central wavelength, and aperture specified). If the exposure time for a WAVE exposure is specified as DEF, the same default exposure time as the automatic wave calibrations will be used. Otherwise, the specified exposure time will be used. To avoid overuse of the line lamps, the exposure time should not exceed 5 minutes.

An ACCUM Mode wavelength calibration will be automatically performed for external STIS/CCD, STIS/FUV–MAMA, and STIS/NUV–MAMA spectrographic science exposures which use ACCUM or TIME–TAG Mode at a single central wavelength with any of the spectral elements in Table 9.2. A wavelength calibration exposure will be added prior to the first such science exposure and after each subsequent science exposure at the same central wavelength if more than 40 minutes of visibility time have elapsed since the previous wavelength calibration (see

<table>
<thead>
<tr>
<th>Spectral Element</th>
<th>Central Wavelength (Angstroms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRISM</td>
<td>1200, 2125</td>
</tr>
</tbody>
</table>
the *STIS Instrument Handbook* for an explanation). The calibration lamp configuration, exposure time, and calibration aperture (if different from the science aperture) will be based on the grating, central wavelength, and aperture of the science exposure. Setting `WA_VE_CAL=NO` will disable all automatic wavecals for that entire visit.

PIs are advised to use an **Exposure Group Container** *(Type: Sequence)* with their wavelength calibrations and science observation so they schedule close together.

For a detailed description of wavelength calibration exposures, see the *STIS Instrument Handbook*.

### Aperture

Only certain aperture-grating combinations can be used for MAMA **TARGET=WAVE** observations because the line lamps can be too bright for the MAMA detectors when used with wide slits. The apertures that may be selected depend on the grating being used, and are given in the following table.

**Table 9.3: Legal aperture-grating combinations when **TARGET=WAVE**

<table>
<thead>
<tr>
<th>Grating</th>
<th>Legal Aperture for <strong>TARGET=WAVE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>G230LB</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G230MB</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G430L</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G430M</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G750L</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G750M</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G140L</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G140M</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>G230L</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2 31X0.05NDC</td>
</tr>
<tr>
<td>G230M</td>
<td>52X0.05 52X0.1 52X0.2 52X0.2F2</td>
</tr>
<tr>
<td>PRISM</td>
<td>52X0.05 52X0.2</td>
</tr>
<tr>
<td>E140H</td>
<td>0.2X0.2 6X0.2 0.1X0.03 0.2X0.09</td>
</tr>
<tr>
<td>E140M</td>
<td>0.2X0.2 6X0.2 0.1X0.03 0.2X0.06</td>
</tr>
<tr>
<td>E230H</td>
<td>0.1X0.09 0.1X0.2 6X0.2 0.1X0.03 0.2X0.2 0.2X0.09</td>
</tr>
<tr>
<td>E230M</td>
<td>0.2X0.2 6X0.2 0.1X0.03 0.2X0.06</td>
</tr>
</tbody>
</table>

**Spectral Element**

Any legal value except **MIRROR**.
Optional Parameter

In general, no Optional Parameters are allowed for a WAVE exposure. However, CR-SPLIT=NO is allowed. No other value of CR-SPLIT is legal.

9.8.2 Target_Name = CCDFLAT

A calibration exposure using the internal STIS CCD flat field lamps. Observations using the G750L and G750M elements at wavelengths longer than about 7000 Angstroms are affected by fringing in the CCD. Due to shifting of the spectrum relative to the detector caused by the Mode Select Mechanism uncertainty (see the STIS Instrument Handbook), the reference flats taken by the Institute and maintained in the Calibration Data Base will often not rectify the fringes as well as a flat field taken contemporaneously with the science data at the same Mode Select Mechanism setting (i.e., without moving the grating wheel between the science and flat field observations).

A CCDFLAT exposure is permitted only with the STIS/CCD configuration in ACCUM mode. No optional parameters except BINAXIS1 and BINAXIS2 are permitted. The number of iterations must be 2. A CCDFLAT exposure is taken to calibrate fringing. The user may specify Time_Per_Exposure as DEF, in which case the default exposure time is used, or as a duration less than the default exposure time. The default exposure time is

\[ \text{MAX} \left\{ 0.1 \text{ sec}, \left[ \frac{\text{Time}_\text{Factor} \times 0.1}{\text{Width} \times \text{BINAXIS1} \times \text{BINAXIS2}} \right] \right\} \]

(9.1) where:

- **Time_Factor** is a function of Spectral Element and Wavelength and is given in Table 9.4,
- **Width** (in arcsec) can be obtained from Table 9.5: Supported STIS Apertures
- and BINAXIS1 and BINAXIS2 are defined in Section 9.4.4 on page 184. The default is set to BINAXIS1=1 and BINAXIS2=1, but you may specify a value of 1, 2, or 4 for either quantity.

**Note:** A gain of 4 e/DN will be used with Target = CCDFLAT.

Exposures with the CCDFLAT internal target must immediately precede or follow an external science exposure (i.e., an ACCUM exposure with an external pointing) which uses the same spectral element and central wavelength as the CCDFLAT exposure.

The STIS Instrument Handbook describes the use of CCDFLAT. It recommends the following procedure:
• Specify `Target_Name=CCDFLAT` to indicate that the exposure is a fringe flat. `GAIN=4` is automatically used, and the exposure uses two bulbs in the tungsten lamp.

• Specify `Number_of_Iterations=2`, to allow cosmic ray rejection and to assure adequate signal to noise. (Other STIS pure parallel exposures may not have `Number_of_Iterations`>1, but `CCDFLAT` is an exception.)

• Specify `Config`, `Opmode`, `Sp_Element`, and `Wavelength`. `Config` must be `STIS/CCD`. `Opmode` must be `ACCUM`. `Sp_Element` and `Wavelength` must be from Table 9.4: `Time_Factor` for Spectral Elements and Wavelengths.

• Specify `Aperture`, using one of those listed below for `CCDFLAT`. For an extended source, you generally should use the same slit for the flat as for the science exposure. For a point source, you should use the appropriate small echelle slit (0.3X0.09, 0.2X0.06). However, for a point source observed with the E1 and E2 series of apertures (except for the 52X0.05E1 aperture), you should use the 52X0.1 slit for `CCDFLAT` exposures. For example, if you were using the 52X0.2E1 slit for your science exposure, you would use the 52X0.1 (for a point source) or the 52X0.2 slit (for an extended source) for the `CCDFLAT` exposures. (See the `STIS Instrument Handbook` for further details and discussion)

• Specify `Time_Per_Exposure` as DEFAULT. The default exposure time (in seconds) is given by equation 9.1, which assures a signal to noise of 100 per pixel over the wavelength range of 6000 Å to 1 micron. You may also specify your own value for `Time_Per_Exposure`, but it must then be shorter than the default.

Note that CCD flats are moved into the occultation period whenever they occur in the first or last exposure in an orbit. Fringe flats only work if there is no movement of the Mode Select Mechanism: be sure to place the fringe flat exposure immediately before or after the science exposure to which it pertains. In some instances (such as a long series of exposures), you may wish to bracket your science observing with fringe flats in order to take into account any possible thermal shifts.

Table 9.4: `Time_Factor` for Spectral Elements and Wavelengths.

<table>
<thead>
<tr>
<th>Spectral Element</th>
<th>Central Wavelength</th>
<th>Time_Factor (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G750L</td>
<td>7751</td>
<td>25</td>
</tr>
</tbody>
</table>
## Aperture

52X0.05, 52X0.1, 52X0.2, 52X0.2F1, 52X0.5, 52X2, 0.3X0.09, or 0.2X0.06.

The 0.3X0.09 and 0.2X0.06 slits should be used for point-source targets. The 52X0.1 slit should be used for point sources observed in the E1, E2 apertures. The remaining slits are intended for use on extended targets. To choose the best slit, see the *STIS Instrument Handbook*.

## Spectral Element

Must be **G750L** or **G750M**. A central wavelength must be specified for **CCDFLAT**. Use only the central wavelengths in Table 9.4: Time_Factor for Spectral Elements and Wavelengths.

<table>
<thead>
<tr>
<th>Spectral Element</th>
<th>Central Wavelength</th>
<th>Time_Factor (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G750M</td>
<td>6768</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>7283</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>7795</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>8311</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>8561</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>8825</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>9286</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>9336</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>9806</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>9851</td>
<td>90</td>
</tr>
</tbody>
</table>
9.9 STIS Coordinate System

Knowledge of the STIS coordinate system relative to the spacecraft coordinate system is necessary to use the POSition TARGet <X-value>,<Y-value> Special Requirement properly. The Figure below shows the sense of the U2 and U3 axes for the various STIS apertures.

Figure 9.1: STIS coordinate system

Shown projected onto the sky, as used with the POS TARG Special Requirement
Table 9.5 lists the apertures in STIS that are Supported for Cycle 19; they are noted with an “Ok.” This table has been carefully checked for completeness and accuracy, and should be taken as the final word for Cycle 19.

Revisions to documents occur as needed to keep them up-to-date. If a discrepancy is found in this or other documents (such as the Data Handbook or STIS Instrument Handbook), the table here should be considered definitive and correct.
Table 9.5: Supported STIS Apertures

<table>
<thead>
<tr>
<th>Aperture Name</th>
<th>Dimensions (arcsec)</th>
<th>Description</th>
<th>STIS/CCD</th>
<th>STIS/FUV-MAMA</th>
<th>STIS/NUV-MAMA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Width</td>
<td></td>
<td>ACQ</td>
<td>ACQ/PEAK</td>
</tr>
<tr>
<td>MIRROR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G230LB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G230MB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G430L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G430M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G750L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G750M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIRROR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G230LB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G230MB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G430L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G430M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G750L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G750M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIRROR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G140L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G140M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E140H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E140M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRISM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G230L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G230M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E230H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E230M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Echelle Slits**

- **0.1X0.03**: 0.1 0.025 Very high spectral resolution
- **0.1X0.09**: 0.1 0.09 Echelle slit
- **0.1X0.2**: 0.1 0.2 Echelle slit
- **0.2X0.06**: 0.2 0.063 Echelle slit
- **0.2X0.09**: 0.2 0.09 Echelle slit
- **0.2X0.2**: 0.2 0.2 Echelle slit
- **0.2X0.05ND**: 0.2 0.05 Filtered Slit; Neutral Density=2.0
- **0.2X0.06FPA**: 0.2 0.063 Offset in dispersion direction
- **0.2X0.06FPB**: 0.2 0.063 Offset in dispersion direction
- **0.2X0.06FPC**: 0.2 0.063 Offset in dispersion direction
- **0.2X0.06FPD**: 0.2 0.063 Offset in dispersion direction
- **0.2X0.06FPE**: 0.2 0.063 Offset in dispersion direction
- **0.2X0.2FPA**: 0.2 0.2 Offset in dispersion direction
- **0.2X0.2FPB**: 0.2 0.2 Offset in dispersion direction
- **0.2X0.2FPC**: 0.2 0.2 Offset in dispersion direction
- **0.2X0.2FPD**: 0.2 0.2 Offset in dispersion direction
- **0.2X0.2FPE**: 0.2 0.2 Offset in dispersion direction
- **0.3X0.05ND**: 0.33 0.05 Filtered Slit; Neutral Density=3.0
- **6X0.2**: 6.0 0.2 Echelle slit
<table>
<thead>
<tr>
<th>Aperture Name</th>
<th>Dimensions (arcsec)</th>
<th>Description</th>
<th>STIS/CCD</th>
<th>STIS/FUV-MAMA</th>
<th>STIS/NUV-MAMA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Width</td>
<td></td>
<td>ACQ</td>
<td>ACQ/PEAK</td>
</tr>
<tr>
<td>52X0.05</td>
<td>52.0</td>
<td>0.034</td>
<td>Long slit</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.1</td>
<td>52.0</td>
<td>0.1</td>
<td>First order slit</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.2</td>
<td>52.0</td>
<td>0.2</td>
<td>First order slit</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.2F1</td>
<td>52.0</td>
<td>0.2</td>
<td>First order slit; Fiducial=0.5 arcsec</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.2F1–R</td>
<td>52.0</td>
<td>0.2</td>
<td>Reference for peaking up in slit width</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.5</td>
<td>52.0</td>
<td>0.5</td>
<td>First order slit</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X2</td>
<td>52.0</td>
<td>2.0</td>
<td>First order slit</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>25MAMA</td>
<td>24.7</td>
<td>24.7</td>
<td>Clear MAMA aperture</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>50CCD</td>
<td>50.0</td>
<td>50.0</td>
<td>Clear CCD aperture</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>50CORON</td>
<td>50.0</td>
<td>50.0</td>
<td>Coronagraph aperture</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25CIII</td>
<td>24.7</td>
<td>24.7</td>
<td>CIII filtered NUV-MAMA</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25CN182</td>
<td>24.7</td>
<td>24.7</td>
<td>182nm Cont. filtered NUV-MAMA</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25CN270</td>
<td>24.7</td>
<td>24.7</td>
<td>270nm Cont. filtered NUV-MAMA</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25LYA</td>
<td>24.7</td>
<td>24.7</td>
<td>Lyman-alpha filtered FUV-MAMA</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25MGII</td>
<td>24.7</td>
<td>24.7</td>
<td>MGII filtered NUV-MAMA</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25ND3</td>
<td>24.7</td>
<td>24.7</td>
<td>ND 3 filtered MAMA &amp; CCD</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25ND5</td>
<td>24.7</td>
<td>24.7</td>
<td>ND 5 filtered MAMA &amp; CCD</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25NDQ1</td>
<td>13.4</td>
<td>9.7</td>
<td>ND step filtered MAMA &amp; CCD (Quad1)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25NDQ2</td>
<td>13.8</td>
<td>15.1</td>
<td>ND step filtered MAMA &amp; CCD (Quad2)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25NDQ3</td>
<td>11.4</td>
<td>15.3</td>
<td>ND step filtered MAMA &amp; CCD (Quad3)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>Aperture Name</td>
<td>Dimensions (arcsec)</td>
<td>Description</td>
<td>STIS/CCD</td>
<td>STIS/FUV-MAMA</td>
<td>STIS/NUV-MAMA</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------</td>
<td>--------------------------------------------------</td>
<td>----------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>F25NDQ4</td>
<td>11.8 9.5</td>
<td>ND step filtered MAMA &amp; CCD (Quad4)</td>
<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25QTZ</td>
<td>24.7 24.7</td>
<td>Quartz filtered MAMA aperture</td>
<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F25SRF2</td>
<td>24.7 24.7</td>
<td>SrF2 filtered MAMA aperture</td>
<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F28X50LP</td>
<td>28.0 50.0</td>
<td>Long pass filtered CCD aperture</td>
<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F28X50OII</td>
<td>28.0 50.0</td>
<td>OII filtered CCD aperture</td>
<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>F28X50OIII</td>
<td>28.0 50.0</td>
<td>OIII filtered CCD aperture</td>
<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
</tr>
</tbody>
</table>

**Coronagraphic Apertures**

<table>
<thead>
<tr>
<th>Aperture Name</th>
<th>Dimensions (arcsec)</th>
<th>Description</th>
<th>STIS/CCD</th>
<th>STIS/FUV-MAMA</th>
<th>STIS/NUV-MAMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAR10</td>
<td>50.0 50.0</td>
<td>Bar in coronagraph aperture; 10.0x3.0 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEA0.6</td>
<td>50.0 50.0</td>
<td>Wedge A in coronagraph aperture; Width=0.6 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEA1.0</td>
<td>50.0 50.0</td>
<td>Wedge A in coronagraph aperture; Width=1.0 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEA1.8</td>
<td>50.0 50.0</td>
<td>Wedge A in coronagraph aperture; Width=1.8 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEA2.0</td>
<td>50.0 50.0</td>
<td>Wedge A in coronagraph aperture; Width=2.0 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEA2.5</td>
<td>50.0 50.0</td>
<td>Wedge A in coronagraph aperture; Width=2.5 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEA2.8</td>
<td>50.0 50.0</td>
<td>Wedge A in coronagraph aperture; Width=2.8 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEB1.0</td>
<td>50.0 50.0</td>
<td>Wedge B in coronagraph aperture; Width=1.0 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEB1.8</td>
<td>50.0 50.0</td>
<td>Wedge B in coronagraph aperture; Width=1.8 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEDGEB2.0</td>
<td>50.0 50.0</td>
<td>Wedge B in coronagraph aperture; Width=2.0 arcsec</td>
<td>Ok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aperture Name</td>
<td>Dimensions (arcsec)</td>
<td>Description</td>
<td>STIS/CCD</td>
<td>STIS/FUV-MAMA</td>
<td>STIS/NUV-MAMA</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------</td>
<td>-------------</td>
<td>----------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>Width</td>
<td>ACQ</td>
<td>ACQ/PEAK</td>
<td>ACCUM</td>
</tr>
</tbody>
</table>

**Offset CCD Slits**

<table>
<thead>
<tr>
<th>Aperture Name</th>
<th>Dimensions (arcsec)</th>
<th>Description</th>
<th>STIS/CCD</th>
<th>STIS/FUV-MAMA</th>
<th>STIS/NUV-MAMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>52X0.05E1</td>
<td>52.0 0.034</td>
<td>Offset 19.7 arcsec in +Y POS (spatial) from center of 52X0.05 slit</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
</tr>
<tr>
<td>52X0.1E1</td>
<td>52.0 0.1</td>
<td>Offset 19.7 arcsec in +Y POS (spatial) from center of 52X0.1 slit</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
</tr>
<tr>
<td>52X0.2E1</td>
<td>52.0 0.2</td>
<td>Offset 19.7 arcsec in +Y POS (spatial) from center of 52X0.2 slit</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
</tr>
<tr>
<td>52X0.5E1</td>
<td>52.0 0.5</td>
<td>Offset 19.7 arcsec in +Y POS (spatial) from center of 52X0.5 slit</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
</tr>
<tr>
<td>52X2E1</td>
<td>52.0 2.0</td>
<td>Offset 19.7 arcsec in +Y POS (spatial) from center of 52X2 slit</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
<td>Ok Ok Ok Ok Ok</td>
</tr>
<tr>
<td>52X0.2E2</td>
<td>52.0 0.2</td>
<td>Offset from E1 by 0.06 arcsec in -X POS (dispersion)</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
</tr>
<tr>
<td>52X0.5E2</td>
<td>52.0 0.5</td>
<td>Offset from E1 by 0.053 arcsec in -X POS (dispersion)</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
</tr>
<tr>
<td>52X2E2</td>
<td>52.0 2.0</td>
<td>Offset from E1 by 0.048 arcsec in -X POS (dispersion)</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
</tr>
</tbody>
</table>

**Low Background Offset FUV MAMA Slits**

<table>
<thead>
<tr>
<th>Aperture Name</th>
<th>Dimensions (arcsec)</th>
<th>Description</th>
<th>STIS/CCD</th>
<th>STIS/FUV-MAMA</th>
<th>STIS/NUV-MAMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>25MAMAD1</td>
<td>24.7 24.7</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
</tr>
<tr>
<td>F25QTZD1</td>
<td>24.7 24.7</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
<td>Ok Ok</td>
</tr>
<tr>
<td>Aperture Name</td>
<td>Dimensions (arcsec)</td>
<td>Description</td>
<td>STIS/CCD</td>
<td>STIS/FUV-MAMA</td>
<td>STIS/NUV-MAMA</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------</td>
<td>-------------------------------</td>
<td>----------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>Width</td>
<td></td>
<td>ACQ</td>
<td>ACQ/PEAK</td>
</tr>
<tr>
<td>F25SRF2D1</td>
<td>24.7</td>
<td>24.7</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.05D1</td>
<td>52.0</td>
<td>0.034</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.1D1</td>
<td>52.0</td>
<td>0.1</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.2D1</td>
<td>52.0</td>
<td>0.2</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X0.5D1</td>
<td>52.0</td>
<td>0.5</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
<tr>
<td>52X2D1</td>
<td>52.0</td>
<td>2.0</td>
<td>Offset by 6.8 arcsec in -Y POS (spatial)</td>
<td>Ok</td>
<td>Ok</td>
</tr>
</tbody>
</table>
CHAPTER 10: Fine Guidance Sensors (FGS)

In this chapter . . .

10.1 Introduction to the FGS / 210
10.2 Mode = POS Config = FGS / 211
10.3 Mode = TRANS Config = FGS / 214
10.4 Tables and Illustrations / 216
10.1 Introduction to the FGS

The Instrument Configurations and Operating Modes described in the following section are used for the Visit and Exposure Specifications. A summary of the legal Visit and Exposure Specifications entries is provided; more complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, etc. are available in the FGS Instrument Handbook.

Note that many of the Optional Parameters have default values; in such cases, an Optional Parameter entry in the Visit and Exposure Specifications is necessary only if it is desired to override the default value. In the STScI proposal system the physical units of Optional Parameter quantities are always implicit and should never be entered by the observer.

Optional Parameters whose descriptions begin with the phrase “USE WITH CAUTION” pose a risk to the intended science if a non-default value is used inappropriately. These parameters are italicized in Table 10.1. You may wish to discuss the use of these parameters with your Contact Scientist, if you have one, or with an Instrument Scientist via help@stsci.edu.

Please note that spatial scans are not permitted with the FGSs. Also note that only FGS1 will be calibrated as a science instrument for Cycle 19.

Table 10.1 lists the permitted Instrument Configuration, Operating Modes, Fields of View, Spectral Elements, and Optional Parameters for the FGS.
Table 10.1: Supported Instrument Parameters for the FGS

<table>
<thead>
<tr>
<th>Config</th>
<th>Mode</th>
<th>Field of View</th>
<th>Spectral Elements</th>
<th>Optional Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGS</td>
<td>POS</td>
<td>1, 2, 3</td>
<td>FGS 1, 2, and 3: F583W, F5ND, F550W, PUPIL FGS 1 and 3: F605W; FGS 2 only: F650W</td>
<td>NULL, ACQ-DIST, COUNT, FES-TIME</td>
</tr>
<tr>
<td>TRANS</td>
<td>10.3</td>
<td>1, 2, 3</td>
<td>FGS 1, 2, and 3: F583W, F5ND, F550W, PUPIL FGS 1 and 3: F605W; FGS 2 only: F650W</td>
<td>SCANS, STEP-SIZE, ACQ-DIST</td>
</tr>
</tbody>
</table>

The sections on the following pages provide further details of the entries to be made on the Visit and Exposure Specifications when a particular FGS Mode/Configuration is chosen.

10.2 Mode = POS Config = FGS

This is the basic single-star positional Operating Mode of the FGS. It may be used to measure the relative positions of fixed or slowly moving (<= 0.080 arcsec/sec) targets with a precision of 0.001 to 0.002 arcsec per single observation. To measure the relative position of a target with respect to field stars, several reference targets must be observed in the same visit. In addition, a few stars (reference and/or target) should be observed multiple times during a visit to map any positional drift of the field due to HST pointing characteristics (see the FGS Instrument Handbook). In this Operating Mode the program star or asteroid is first acquired and then held in fine lock for the specified exposure time. This procedure is repeated for the other targets.

The default values of the Optional Parameters are set in this Mode to provide acceptable data for single, zero angular diameter stars. The default acquisition consists of a spiral search for a target within a radius of 15 arcsec, followed by fine-lock tracking of the target. In this default mode star selectors are moved to null the Fine Error Signal and their positions are recorded every 0.025 sec.

10.2.1 Aperture or FOV

1, 2, 3
Requests use of a specific FGS (see Figure 10.1 The FGS POS TARG and interferometer coordinate systems.).

10.2.2 Spectral Element

The available spectral elements are listed in Table 10.2: Spectral Elements for the FGS. Only one filter can be used at a time. The \textbf{F583W} is the recommended element for all observations requiring the Optical Field Angle Distortion (OFAD) calibration. \textbf{F583W} cannot be used if the target magnitude \( m < 8.0 \). \textbf{F5ND} must be used if \( m < 8.0 \). An \textbf{F5ND/F583W} cross-filter calibration is supported.

10.2.3 Optional Parameters

\textbf{NULL} =\text{YES (default), NO}

\textbf{NULL} determines whether the Star Selectors will be repositioned immediately after the \textbf{FES-TIME} or after a small delay. Consult with your Contact Scientist or an Instrument Scientist (via help@stsci.edu) before specifying the non-default value; most astrometry programs require \textbf{NULL=YES}.

\textbf{NULL=YES} (the default) means that the next fine-error-averaging time (FEAT) interval will not begin until the star selectors have completed the repositioning of the FGS instantaneous field of view (IFOV) to the null position determined by the just-completed FEAT. This is the recommended procedure for all fixed targets.

\textbf{NULL=NO} means that the next FEAT begins immediately after the previous FEAT, implying that the star selectors will not necessarily remain fixed during the FEAT. If the FES-TIME = 0.025 sec, \textbf{NULL=NO} has no effect. \textbf{NULL=NO} is ordinarily useful only for observations of moving targets.

\textbf{ACQ-DIST} =\text{DEF (default); 0.0 - 90.0}

\text{USE WITH CAUTION—This Optional Parameter determines the size (in arcsec) of the acquisition search region. The default value is 15 arcsec. A larger search radius takes more time and is generally not necessary given HST’s pointing performance.}

\textbf{COUNT} =\text{DEF (default); 1 - 2621400}

\text{USE WITH CAUTION—The default count rate will be determined from the target \( V \) magnitude, and the filter and FGS, using simple scaling rules.}
The FGS Instrument Handbook should be consulted for the default background rates. These Optional Parameters are used to verify the value of FES-TIME. If a non-default value is needed, enter the expected target and sky count rates (in counts per second) for the FGS (see the FGS Instrument Handbook and consult with your Contact Scientist or an Instrument Scientist).

**FES-TIME**

=DEF (default); 0.025, 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2

USE WITH CAUTION—This optional parameter sets the averaging time (in seconds) for the Fine Error Signal, and consequently, the interval at which the star selectors are adjusted to null the Fine Error Signal.

For POS mode, the default value DEF will be calculated from the default or specified COUNT optional parameter value and the selected FGS and FILTER. For TRANSfer mode, the default (and required) value is 0.025 sec, regardless of target brightness. See the FGS Instrument Handbook for details.

It is necessary that the proposer include the target $V$ magnitude for all targets. We recommend including the $B-V$ index so that the Instrument Scientist who reviews your Phase II program can assess your calibration needs.

### 10.2.4 Special Requirements

Enter the ORIENTation visit-level Special Requirement (see ORIENTation <angle1> TO <angle2>) if the arrangement of the target or reference stars requires a particular orientation of the FGS field of view. ORIENTation may be required to keep the targets in the field of view when more than one target is observed.

The POSition TARGet <X-value>,<Y-value> special requirement can be used to offset a target from the aperture reference position. For the FGS, the aperture reference frame is centered near the geometric center of the field of view, and is not equivalent to the FGS detector reference frame. The two frames have different parities and origins (see Figure 10.1 The FGS POS TARG and interferometer coordinate systems. and the FGS Instrument Handbook).

The SAME POSition AS <exposure> special requirement should be used to keep the position of the spacecraft held constant over the course of all observations within a visit. To ensure that all exposures within a visit are scheduled within the same orbit, use the SEQuence <exposure-list> NON-INTrerruptible (replaced by Exposure Group Containers in the APT User Interface) special requirement.
10.2.5 Time Per Exposure

The value to be entered is the photon-collecting time (in seconds) for measuring the position of the target. See the *FGS Instrument Handbook* for exposure time calculations.

10.3 Mode = TRANS
Config = FGS

This Operating Mode is useful for the measurement of the relative positions of close binary stars or the sizes of extended targets. In this Mode the interference fringe pattern (or “S-curve”) is measured by scanning the FGS instantaneous FOV across the target at 45 degrees with respect to the interferometer axes and recording the Fine Error Signal (FES) every 0.025 sec.

Acquisition is accomplished with a nominal 15 arcsec-radius spiral search. The S-curve is measured by a series of continuous sweeps of the field of view across the target.

Moving targets can be observed if they are listed as a series of fixed targets. This observing strategy is discussed in the *FGS Instrument Handbook*.

10.3.1 Aperture or FOV

1, 2, 3

Requests use of a specific FGS (see Figure 10.1 The FGS POS TARG and interferometer coordinate systems.).

10.3.2 Spectral Element

The available spectral elements are listed in Table 10.2: Spectral Elements for the FGS. Only one filter can be used at a time. The F583W is the recommended element for programs requiring the use of POS and TRANS modes combined because of the Optical Field Angle Distortion (OFAD) calibration, which is available only for F583W. F583W cannot be used if the target magnitude m<8.0. F5ND must be used if m<8.0. Unless special S-curve calibration observations are requested, only certain combinations of filter and target color will be calibrated. Please refer to the Instrument Handbook for more information.
10.3.3 Optional Parameters

**SCANS**

=1 (default) - 200

The value entered is the number of individual scans to make through the target, with alternate scan lines taken in the same direction.

**STEP-SIZE**

=1.0 (default); 0.3 - 10.0

The resolution by which the S-curve is sampled (in milliarcseconds) is specified by this Optional Parameter. The instantaneous field of view moves SQRT(2) x **STEP-SIZE** between samples (since the motion is always at 45 degrees with respect to the interferometer axes). **STEP-SIZE** values of 0.6 or 1.0 are recommended (see the FGS Instrument Handbook).

The exposure time is calculated as follows:

- \( T_{\text{exp}} = \left[ \text{SCANS} \times t(\text{samp}) \times L(\text{axis}) \right] / \text{STEP–SIZE}, \)
- **SCANS** = the number of individual scan lines,
- **t(samp)** = 0.025 sec, and
- **L(axis)** = the length of each scan in milliarcseconds as projected onto the \( x \) or \( y \) axis (see the FGS Instrument Handbook for recommendations and minimum length)

The minimum scan rate is 0.035 arcsec/sec along the diagonal.

**ACQ-DIST**

=0.0 - 90.0

USE WITH CAUTION—This Optional Parameter determines the size (in arcsec) of the acquisition search region. The default value is 15 arcsec. A larger search radius takes more time and is generally not necessary given HST’s pointing performance.

10.3.4 Time Per Exposure

The exposure time (\( T_{\text{exp}} \)) is the total photon-collecting time (in seconds) for all \( N_{\text{scan}} \) scans. The time per individual scan line is \( T_{\text{exp}}/N_{\text{scan}} \). See the discussion in **STEP-SIZE** above and the FGS Instrument Handbook.

10.3.5 Special Requirements

Enter the **ORIENT**ation visit-level Special Requirement (see **ORIENT**ation <angle1> TO <angle2>) if the arrangement of the target or reference stars requires a particular orientation of the FGS field of view.
ORIENTation may be required to keep the targets in the field of view when more than one target is observed.

The **POSition TARGet \(<X-value>,<Y-value>\)** special requirement can be used to offset a target from the aperture reference position. For the FGS, the aperture reference frame is centered near the geometric center of the field of view, and is *not* equivalent to the FGS detector reference frame. The two frames have different parities and origins (see Figure 10.1 *The FGS POS TARG and interferometer coordinate systems.* and the FGS Instrument Handbook).

The **SAME POSition AS <exposure>** special requirement should be used to keep the position of the spacecraft held constant over the course of all observations within a visit. To ensure that all exposures within a visit are scheduled within the same orbit, use the **SEQuence <exposure-list> NON-INTerruptible** (replaced by Exposure Group Containers in the APT User Interface) special requirement.

### 10.4 Tables and Illustrations

**Table 10.2: Spectral Elements for the FGS**

<table>
<thead>
<tr>
<th>Name</th>
<th>Comments</th>
<th>Effective Wavelength (Å)</th>
<th>Full Width at Half Maximum (Å)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F583W</td>
<td>“Clear” filter</td>
<td>5830</td>
<td>2340</td>
</tr>
<tr>
<td>F5ND</td>
<td>Neutral Density (5 mag)</td>
<td>.....</td>
<td>.....</td>
</tr>
<tr>
<td>F605W(^1)</td>
<td>“Astrometry Clear” filter</td>
<td>6050</td>
<td>1900</td>
</tr>
<tr>
<td>F650W(^2)</td>
<td>“Red” filter</td>
<td>6500</td>
<td>750</td>
</tr>
<tr>
<td>F550W</td>
<td>“Yellow” filter</td>
<td>5500</td>
<td>750</td>
</tr>
<tr>
<td>PUPIL</td>
<td>Pupil stop</td>
<td>5830</td>
<td>2340</td>
</tr>
</tbody>
</table>

1. F605W is to be specified with FGS3 and FGS1.
2. F650W is to be specified with FGS2 only.
The\ POS TARG\ reference frame must be used to specify Special Requirements\ POS TARG\ and ORIENTation. Note that the FGS interferometer axes and\ POS TARG\ axes have different origins and parities. The interferometer reference frame is used in pipeline processing only.
CHAPTER 11: Advanced Camera for Surveys (ACS)

In this chapter...

11.1 Introduction to the ACS / 220
11.2 Mode = ACCUM Config = ACS/WFC / 221
11.3 Mode = ACCUM Config = ACS/SBC / 224
11.4 Tabular Reference Data / 226
11.5 ACS Aperture Coordinate System / 231
11.1 Introduction to the ACS

The Instrument Configurations and Operating Modes described in this chapter are used for the Visit and Exposure Specifications. The legal Visit and Exposure Specifications entries are discussed in the following sections. More complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, etc. are available in the ACS Instrument Handbook.

Many of the Optional Parameters have default values. In such cases an Optional Parameter entry in these Specifications is necessary only if it is desired to override the default value. In the STScI proposal system, the physical units of Optional Parameter quantities are always implicit and should never be entered by the observer.

The following tables list the permitted Instrument Configurations, Operating Modes, Apertures, Spectral Elements, and Optional Parameters for the ACS.
11.2  Mode = ACCUM  
Config = ACS/WFC

Photons are counted on the Wide Field Channel CCD as accumulated charge, which is read out at the end of the exposure and converted to DN at a selectable gain. The DN are stored as 16-bit words in a data memory array. A full detector readout is 4144x4136 pixels, which includes 24 leading pixels and 24 trailing pixels of overscan per line and 40 virtual overscan lines.

11.2.1 Aperture or FOV

Allowed apertures for this mode are:

WFC, WFC-FIX, WFC1, WFC2, WFC1-FIX, WFC2-FIX, WFCENTER, WFC1-CTE, WFC1-512, WFC1-1K, WFC1-2K, WFC1-IRAMP, WFC1-MRAMP, WFC2-MRAMP, WFC2-ORAMP, WFC1-IRAMPQ, WFC1-MRAMPQ, WFC2-ORAMPQ

An appropriate ramp aperture (names contain "RAMP") must be specified when a ramp filter (names begin with "FR") is used, and may be specified for other spectral elements.
Only apertures WFC, WFC1 or WFC2 may be used with the following spectral elements: POL0UV, POL60UV, POL120UV, POL0V, POL60V, POL120V, and F892N (unless a ramp aperture and filter are also specified).

The actual position of the target within the FOV for these spectral element/aperture combinations will be determined by the STScI based on detector performance.

The aperture WFC1-CTE is available to mitigate CTE loss. The WFC1-CTE aperture has the same area as the WFC1 aperture except that the reference position is 200 pixels from the upper-right corner of Chip 1, in both the AXIS1 and AXIS2 directions. Therefore WFC1-CTE is not appropriate for highly extended targets. Observations of targets placed here will be less affected by CTE loss than those placed at other commonly used apertures that are closer to the center of the detector.

For apertures WFC1-512, WFC1-1K, WFC1-2K, and the quadrant ramp apertures (names end with "RAMPQ"), the proposal processing software will assign a subarray encompassing the field of view of the aperture. Applicable overscan and bias calibrations are automatically available. See the ACS Instrument Handbook for details. These subarrays cannot be modified.

Target location on the detector is the same for a full-frame ramp aperture and the corresponding subarray readout quadrant ramp aperture.

**Table 11.6** summarizes rules for Aperture and Spectral Element combinations, and whether a full-frame or fixed subarray readout is done.

### 11.2.2 Spectral Element

For the available ACS/WFC spectral elements, see **Table 11.2** on page 226. Note: When F892N or a polarizer is specified, STScI will automatically assign a subarray containing the entire FOV provided by those spectral elements. The subarray is approximately one-quarter the size of the full WFC array. Those subarray parameters may not be overridden.

### 11.2.3 Wavelength

If a ramp filter (any spectral element beginning with the letters “FR”) is specified, enter the desired central wavelength in Ångstroms. **Table 11.4** gives the allowed minimum and maximum wavelength for each ramp filter.

Note: A wavelength should not be specified if a ramp filter is not being used.
11.2.4 Optional Parameters

CR-SPLIT

\[= 2 - 8; \text{NO (default)}\]

Specifies the number of sub-exposures into which the exposure is to be split for the purpose of cosmic ray elimination in post-observation data processing (see the ACS Instrument Handbook). The specified exposure time will be divided equally among the number of CR-SPLIT exposures requested. If CR-SPLIT=NO, the exposure is taken without splitting. If a pattern is also specified (see Chapter 8: Pointings and Patterns on page 167), the specified number of sub-exposures will be taken at each pattern point.

GAIN

\[= 2 \text{ (default) (e/DN)}\]

Specifies the gain of the CCD electronics in e/DN.

IMAGE

\[= \text{YES (default), NO}\]

Controls the automatic scheduling of image exposures for the purpose of spectra zero point determination of grism observations. By default, a single short image through a standard filter will be taken in conjunction with each Exposure Specification using the grism for external science observations.

---

*In August 2010, the number of hot pixels were measured to be 1.3% of the total number of available pixels, which is similar to the number of pixels affected by cosmic rays in a 1000 sec exposure (between 1.5% and 3%). Hot pixels are growing at a rate of 0.16% per year. The standard CR-SPLIT approach allows for cosmic-ray subtraction, but without additional dithering, does not allow for correction of hot pixels. Hence, we recommend that users who would otherwise have used a single CR-SPLIT, now use some form of dithering instead. For example, a simple ACS-WFC-DITHER-LINE pattern has been developed based on integer pixel offsets (see Section 8.4.2). This will allow the simultaneous removal of both hot pixels and cosmic ray hits in post-observation processing. For more details, refer to item #7 in ACS STAN 19-Apr-2004:

http://www.stsci.edu/hst/acs/documents/newsletters/stan0404.html*
A value IMAGE=NO will disable the automatic scheduling of the image exposure for the Exposure Specification on which it is specified. The parameter is allowed only on external science observations using the grism.

### 11.2.5 Number of Iterations

Enter the number of times this Exposure Specification should be iterated, each with the specified Time_per_Exposure. Note: CR-SPLIT and multiple iterations are mutually exclusive capabilities. If Number_of_Iterations > 1 on an external exposure, CR-SPLIT=NO must be specified.

### 11.2.6 Time Per Exposure

Enter the exposure time, in seconds, for the Exposure Specification. If Number_of_Iterations = 1, the Time_per_Exposure is divided equally among the CR-SPLIT copies, if any. If Number_of_Iterations > 1, each iteration comprises a single exposure whose duration is Time_per_Exposure.

Note that exposure time for an individual WFC exposure, after any CR-SPLIT is applied, must be an integer multiple of 0.1 second and in the range of 0.5 to 3600 sec. The value 0.6 sec. is not allowed.

### 11.3 Mode = ACCUM

Config = ACS/SBC

The SBC uses a MAMA detector which is a photon-counting device that provides a two-dimensional ultraviolet capability. The MAMA accumulates photons in the ACS data buffer as they are received, producing images with 1024x1024 pixels. For a more detailed description, see the discussion of SBC ACCUM mode in the ACS Instrument Handbook.

### 11.3.1 Aperture or FOV

The permitted apertures for this mode are SBC or SBC-FIX.

SBC must be specified if spectral element PR110L or PR130L is specified (STScI software will adjust the HST pointing to compensate for the refraction).
11.3.2 Spectral Element

See Table 11.5: Spectral Elements for use with the ACS/SBC Configuration.

11.3.3 Wavelength

No wavelength should be specified for this mode.

11.3.4 Optional Parameters

There are no Optional Parameters in this Mode.

Unlike WFC, SBC exposures with a dispersing spectral element (PR110L or PR130L) will not have an additional image exposure scheduled automatically. If an image exposure is desired in combination with a prism exposure, it must be entered as a separate exposure specification. It is best to place it immediately before or after the prism exposure in the same visit (see the ACS Instrument Handbook for more details).

A direct imaging exposure is required for the prism wavelength calibration. Note that its bright-object constraints will be more stringent than those of the prism exposure, so the least sensitive filter feasible is recommended.

11.3.5 Number of Iterations

Enter the number of times this Exposure Specification should be iterated.

11.3.6 Time Per Exposure

Enter the exposure time to apply to each iteration.

Note that Time_per_Exposure for individual SBC exposures must be an integer multiple of 0.1 second and must be in the range of 0.1 to 3600 sec.
## 11.4 Tabular Reference Data

### 11.4.1 Spectral Elements for WFC

Table 11.2: Spectral Elements for use with ACS/WFC Configuration

<table>
<thead>
<tr>
<th>Wheel</th>
<th>Position</th>
<th>Name</th>
<th>Description</th>
<th>Allowed Configurations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>F555W</td>
<td>Johnson V</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>F775W</td>
<td>SDSS i</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>F625W</td>
<td>SDSS r</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>F550M</td>
<td>narrow V</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>F850LP</td>
<td>SDSS z</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>POL0UV</td>
<td>UV polarizer 0 deg</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>POL60UV</td>
<td>UV polarizer 60 deg</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>POL120UV</td>
<td>UV polarizer 120 deg</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>F892N</td>
<td>methane</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>F606W</td>
<td>broad V</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>F502N</td>
<td>O III</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>G800L</td>
<td>GRISIM</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>F658N</td>
<td>Hα</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>1</td>
<td>16</td>
<td>F475W</td>
<td>SDSS g</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>F660N</td>
<td>N II</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>F814W</td>
<td>Johnson I</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>FR388N</td>
<td>O II Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>FR423N</td>
<td>O II Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>FR462N</td>
<td>O II Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>F435W</td>
<td>Johnson B</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>FR656N</td>
<td>Hα ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>FR716N</td>
<td>Hα ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>FR782N</td>
<td>Hα ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>POL0V</td>
<td>visible polarizer 0 deg</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>POL60V</td>
<td>visible polarizer 60 deg</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>POL120V</td>
<td>visible polarizer 120 deg</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>FR914M</td>
<td>Broad Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>FR853N</td>
<td>IR Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>FR931N</td>
<td>IR Ramp</td>
<td>ACS/WFC</td>
</tr>
</tbody>
</table>
Tabular Reference Data

<table>
<thead>
<tr>
<th>Wheel</th>
<th>Position</th>
<th>Name</th>
<th>Description</th>
<th>Allowed Configurations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>17</td>
<td>FR459M</td>
<td>Broad Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>FR647M</td>
<td>Broad Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>FR1016N</td>
<td>IR Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>FR505N</td>
<td>O III Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>FR551N</td>
<td>O III Ramp</td>
<td>ACS/WFC</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>FR601N</td>
<td>O III Ramp</td>
<td>ACS/WFC</td>
</tr>
</tbody>
</table>

a. Note: Normally only one spectral element may be specified for an exposure. The exceptions are:

1) The polarizers must be used with another spectral element. This is required to maintain focus. The UV polarizers (POL0UV, POL60UV, POL120UV) must be used with a spectral element on wheel 2 except for: POL0V, POL60V, POL120V, and any inner or outer ramp filter segment (see Table 11.4). The visible polarizers (POL0V, POL60V, POL120V) must be used with a spectral element on wheel 1 except for: F850LP, F892N, POL0UV, POL60UV, and POL120UV.
11.4.2 Permitted Filter Combinations

Only a subset of possible combinations of spectral elements are permitted. In the following tables, an "S" indicates combinations that are supported. Combinations marked with "O" are permitted ONLY for Mode = ACQ exposures and are intended for use with bright targets.

Table 11.3: Permitted WFC filter combinations for Mode = ACCUM

<table>
<thead>
<tr>
<th>Filter Wheel 1 Spectral Element</th>
<th>Filter Wheel 2 Spectral Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>F555W</td>
<td>F660N</td>
</tr>
<tr>
<td>F775WM</td>
<td>F814W</td>
</tr>
<tr>
<td>F625WM</td>
<td>FR388N</td>
</tr>
<tr>
<td>F550M</td>
<td>FR423N</td>
</tr>
<tr>
<td>F650LP</td>
<td>FR462N</td>
</tr>
<tr>
<td>POL0UV</td>
<td>F435W</td>
</tr>
<tr>
<td>POL60UV</td>
<td>FR656N</td>
</tr>
<tr>
<td>POL120UV</td>
<td>FR716N</td>
</tr>
<tr>
<td>POL0V</td>
<td>FR782N</td>
</tr>
<tr>
<td>POL60V</td>
<td>POL0V S</td>
</tr>
<tr>
<td>POL120V</td>
<td>POL60V S</td>
</tr>
<tr>
<td>PR200L</td>
<td>POL120V S</td>
</tr>
<tr>
<td>F344N</td>
<td>F344N</td>
</tr>
<tr>
<td>FR914N</td>
<td>FR914N</td>
</tr>
<tr>
<td>FR853N</td>
<td>FR853N</td>
</tr>
<tr>
<td>FR931N</td>
<td>FR459M</td>
</tr>
<tr>
<td>FR647M</td>
<td>FR1016N</td>
</tr>
<tr>
<td>FR505N</td>
<td>FR505N</td>
</tr>
<tr>
<td>FR551N</td>
<td>FR551N</td>
</tr>
<tr>
<td>FR601N</td>
<td>FR601N</td>
</tr>
</tbody>
</table>
### 11.4.3 Ramp Filter Wavelength Ranges

Table 11.4: Wavelength Ranges for the WFCRamp Filters

<table>
<thead>
<tr>
<th>Name</th>
<th>Minimum Wavelength (Å)</th>
<th>Maximum Wavelength (Å)</th>
<th>WFC FOV location</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR388N</td>
<td>3710</td>
<td>4049</td>
<td>middle</td>
</tr>
<tr>
<td>FR423N</td>
<td>4049</td>
<td>4420</td>
<td>inner</td>
</tr>
<tr>
<td>FR462N</td>
<td>4420</td>
<td>4824</td>
<td>outer</td>
</tr>
<tr>
<td>FR505N</td>
<td>4824</td>
<td>5266</td>
<td>middle</td>
</tr>
<tr>
<td>FR551N</td>
<td>5266</td>
<td>5748</td>
<td>inner</td>
</tr>
<tr>
<td>FR601N</td>
<td>5748</td>
<td>6274</td>
<td>outer</td>
</tr>
<tr>
<td>FR656N</td>
<td>6274</td>
<td>6848</td>
<td>middle</td>
</tr>
<tr>
<td>FR716N</td>
<td>6848</td>
<td>7474</td>
<td>inner</td>
</tr>
<tr>
<td>FR782N</td>
<td>7474</td>
<td>8158</td>
<td>outer</td>
</tr>
<tr>
<td>FR853N</td>
<td>8158</td>
<td>8905</td>
<td>inner</td>
</tr>
<tr>
<td>FR931N</td>
<td>8905</td>
<td>9719</td>
<td>outer</td>
</tr>
<tr>
<td>FR1016N</td>
<td>9719</td>
<td>10609</td>
<td>outer</td>
</tr>
<tr>
<td>FR459M</td>
<td>3810</td>
<td>5366</td>
<td>middle</td>
</tr>
<tr>
<td>FR647M</td>
<td>5366</td>
<td>7574</td>
<td>inner</td>
</tr>
<tr>
<td>FR914M</td>
<td>7574</td>
<td>10709</td>
<td>middle</td>
</tr>
</tbody>
</table>

### 11.4.4 Spectral Elements for ACS/SBC

Table 11.5: Spectral Elements for use with the ACS/SBC Configuration

<table>
<thead>
<tr>
<th>Wheel</th>
<th>Position</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>F115LP</td>
<td>MgF$_2$</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>F125LP</td>
<td>CaF$_2$</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>F140LP</td>
<td>BaF$_2$</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>F150LP</td>
<td>crystal quartz</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>F165LP</td>
<td>Suprasil</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>F122M</td>
<td>Ly-α</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>PR130L</td>
<td>CaF$_2$ PRISM</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>PR110L</td>
<td>LiF$_2$ PRISM</td>
</tr>
</tbody>
</table>
### 11.4.5 Allowed Combinations of Aperture, Spectral Element & Readout

Table 11.6: Allowed Aperture, Spectral Element & Readout Combinations

<table>
<thead>
<tr>
<th>Aperture</th>
<th>Allowed Spectral Elements(^1)</th>
<th>Readout</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFC</td>
<td>F S</td>
<td>full frame(^2)</td>
</tr>
<tr>
<td>WFC-FIX</td>
<td>F</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC1</td>
<td>F S</td>
<td>full frame(^2)</td>
</tr>
<tr>
<td>WFC1-FIX</td>
<td>F</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC2</td>
<td>F S</td>
<td>full frame(^2)</td>
</tr>
<tr>
<td>WFC2-FIX</td>
<td>F</td>
<td>full frame</td>
</tr>
<tr>
<td>WFCENTER</td>
<td>F</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC1-CTE</td>
<td>F</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC1-512</td>
<td>F</td>
<td>subarray fixed by STScI</td>
</tr>
<tr>
<td>WFC1-1K</td>
<td>F</td>
<td>subarray fixed by STScI</td>
</tr>
<tr>
<td>WFC1-2K</td>
<td>F</td>
<td>subarray fixed by STScI</td>
</tr>
<tr>
<td>WFC1-IRAMP</td>
<td>F I</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC1-MRAMP</td>
<td>F M S</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC2-MRAMP</td>
<td>F M S</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC2-ORAMP</td>
<td>F O</td>
<td>full frame</td>
</tr>
<tr>
<td>WFC1-IRAMPQ</td>
<td>F I</td>
<td>subarray fixed by STScI</td>
</tr>
<tr>
<td>WFC1-MRAMPQ</td>
<td>F M S</td>
<td>subarray fixed by STScI</td>
</tr>
<tr>
<td>WFC2-ORAMPQ</td>
<td>F O</td>
<td>subarray fixed by STScI</td>
</tr>
</tbody>
</table>

1. F = normal WFC filters and G800L  
   S = small elements (polarizers and F892N)  
   I = inner ramp filter segments  
   M = middle ramp filter segments  
   O = outer ramp filter segments  

2. A subarray fixed by STScI will apply to WFC, WFC1, WFC2 when a small spectral element (polarizer of F892N) is selected.
11.5 ACS Aperture Coordinate System

Figure 11.1 shows how the POS-TARG coordinates, X and Y, are related to the U2,U3 and detector Axis1 and Axis2 directions. The Y axis is parallel to Axis2. The X axis is normal to Y but differs from the Axis1 direction by about 5 degrees. This diagram correctly shows the WFC and SBC orientations, but it does not represent their relative sizes or positions.

Figure 11.1: ACS Coordinate system
In this chapter . . .

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.1 Introduction to NICMOS</td>
<td>234</td>
</tr>
<tr>
<td>12.2 Mode = ACCUM Config = NIC1 or NIC2 or NIC3</td>
<td>235</td>
</tr>
<tr>
<td>12.3 Mode = MULTIACCUM Config = NIC1 or NIC2 or NIC3</td>
<td>238</td>
</tr>
<tr>
<td>12.4 Mode = ACQ Config = NIC2</td>
<td>243</td>
</tr>
<tr>
<td>12.5 Tabular Data</td>
<td>244</td>
</tr>
<tr>
<td>12.6 Illustrations</td>
<td>249</td>
</tr>
</tbody>
</table>
12.1 Introduction to NICMOS

There are three cameras available for use on the NICMOS. The choice of camera will be dictated by the desired filter, pixel scale and field of view.

- Camera 1 (NIC1) provides the highest available spatial resolution with an 11x11 arcsec field of view and pixels that subtend 0.043 arcsec on a side. NIC1 will fully sample a diffraction-limited image at wavelengths 1.0 microns or greater.

- Camera 2 (NIC2) provides intermediate spatial resolution with a 19.2x19.2 arcsec field of view and 0.075 arcsec pixels. NIC2 will fully sample a diffraction-limited image for wavelengths 1.75 microns or greater. NIC2 contains a coronagraphic hole and must be selected for all observations that require use of this feature.

- Camera 3 (NIC3) provides a large field of view, 51.2x51.2 arcsec, with 0.200 arcsec pixels. NIC3 will undersample the Point-Spread Function at all wavelengths, though some recovery of information may be possible by employing dithering techniques. NIC3 must be specified for all observations that use the grism Spectral Elements (see Table 12.5: Spectral Elements for the NICMOS).

Note: Target flux for NICMOS observations must be given in units of erg/(cm² sec Å) (see Section 3.9 on page 47 or Section 4.9 on page 83). The NICMOS units conversion tool on the STScI WWW pages can help you convert your source flux units.
The following table lists the permitted Instrument Configurations, Operating Modes, Apertures, Spectral Elements, and Optional Parameters for the NICMOS.

<table>
<thead>
<tr>
<th>Config.</th>
<th>Mode</th>
<th>Aperture</th>
<th>Spectral Elements</th>
<th>Optional Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIC1, NIC2, NIC3</td>
<td>ACCUM</td>
<td>See Table 12.4</td>
<td>See Table 12.5</td>
<td>CAMERA-FOCUS, NREAD, OFFSET</td>
</tr>
<tr>
<td></td>
<td>MULTIACCUM</td>
<td>See Table 12.4</td>
<td>See Table 12.5</td>
<td>CAMERA-FOCUS, SAMP-SEQ, NSAMP, OFFSET</td>
</tr>
<tr>
<td>NIC2</td>
<td>ACQ</td>
<td>NIC2–ACQ</td>
<td>See Table 12.5</td>
<td></td>
</tr>
</tbody>
</table>

The following sections provide further details of the entries to be made on the Visit and Exposure Specifications when a particular NIC1, NIC2, or NIC3 Mode/Configuration is chosen. The two modes that will be used by the majority of NICMOS observers are described first: ACCUM Mode in “Mode = ACCUM Config = NIC1 or NIC2 or NIC3” on page 235, and MULTIACCUM Mode in “Mode = MULTIACCUM Config = NIC1 or NIC2 or NIC3” on page 238.

- **ACCUM** is the simplest operational mode for NICMOS observing. ACCUM exposures begin with one or more initial readouts of the array, followed by a specified integration period, and end with one or more readouts of the array (the number of initial and final readouts is the same).

- **MULTIACCUM** is a more flexible operational mode which allows for a wide variety of initial, intermediate, and final readouts. More information on ACCUM and MULTIACCUM Modes can be found in Chapter 8 of the NICMOS Instrument Handbook.

- **ACQ** is a specialized mode used for coronagraphic observations, and is described in “Mode = ACQ Config = NIC2” on page 243. More information on this Mode can be found in Chapter 5 of the NICMOS Instrument Handbook.

## 12.2 Mode = ACCUM
**Config = NIC1 or NIC2 or NIC3**

ACCUM is the simplest readout mode available on NICMOS. One or more non-destructive readouts occur at the beginning and at the end of the...
exposure. **ACCUM** Mode will be appropriate for many targets, particularly for short integrations of relatively bright targets.

### 12.2.1 Aperture or FOV

See Table 12.4: NICMOS Apertures.

### 12.2.2 Spectral Elements

See Table 12.5: Spectral Elements for the NICMOS.

### 12.2.3 Wavelength

The **Wavelength** parameter is not required for NICMOS observations and should be left blank.

### 12.2.4 Optional Parameters

**CAMERA-FOCUS**  
=DEF (default); 1-2  
Specifies the NICMOS focus position to be used. If **DEF** is specified or this parameter is omitted, NICMOS will be focussed in the best position for the selected camera. A value of 1-2 selects a compromise focus position between the optimum foci for cameras 1 and 2. This will mainly be useful with coordinated parallels, but **CAMERA-FOCUS** may be specified only on exposures using the primary NICMOS detector in the sequence as defined in Section 6.3, “Coordinated Parallel Containers,” on page 105.

**CAMERA-FOCUS** = DEF or 1-2 is allowed only with **NIC1**, **NIC1-FIX**, **NIC2**, or **NIC2-FIX** as the chosen aperture. **NREAD**  
=1 (default), 9Each **ACCUM** exposure is preceded and followed by a set of detector readouts, which are used to determine the initial and final pixel values. **NREAD** specifies the number of readouts. Multiple readouts may be used to reduce read noise at the cost of extra overhead.

**OFFSET**  
=SAM (default)  
Specifies the method of FOV offset to be used in a predefined pattern of offsets.

If the default value of **SAM** is used, offsets from the target that cannot be supported by small angle maneuvers (**SAMs**) while locked onto the target guide stars will require new guide star acquisitions.
12.2.5 Number of Iterations

If \texttt{Number\_Of\_Iterations > 1}, the specified number of iterations will be taken at a single pointing. For a pattern (see \textit{Chapter 8: Pointings and Patterns}) the specified number of iterations will be taken at each point in the pattern.

12.2.6 Time Per Exposure

Exposure times in \texttt{ACCUM} Mode are quantized. The exposure consists of a set of \texttt{NREAD} initial readouts, followed by a period of data accumulation, followed by a set of \texttt{NREAD} final readouts. The \texttt{Time\_Per\_Exposure} (in seconds) refers to the total integration time, which begins at the start of the first initial readout and ends at the start of the first final readout. The NICMOS Timing Pattern Generator (TPG) uses a list of discrete values for the time between the last initial readout and the first final readout, known as TPG expose time (\texttt{TPG\_TIME}), which is given in Table 12.3. The specified exposure time will be one of a set of possible values allowed by the following table:

<table>
<thead>
<tr>
<th>\texttt{NREAD}</th>
<th>Exposure Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>\texttt{TPG_TIME} + 0.598</td>
</tr>
<tr>
<td>9</td>
<td>\texttt{TPG_TIME} + 5.158</td>
</tr>
</tbody>
</table>

For example, suppose the desired exposure time is 10 seconds. With \texttt{NREAD=1}, the ideal TPG expose time is 9.402. The closest TPG expose time to that, from Table 12.3, is 9.117. So the corresponding exposure time is 9.117 + 0.598 = 9.715 seconds.

With \texttt{NREAD=9}, the ideal TPG expose time is 4.842. The closest TPG expose time to that is 4.781. So the corresponding exposure time is 4.781 + 5.158 = 9.939 seconds.

If the exposure time entered by the user is not one of the values allowed by the above formula, it will be reduced to the next lowest legal value. It is illegal to specify an exposure time which corresponds to a \texttt{TPG\_TIME} below the minimum value of 0.0. In other words, do not specify an exposure time shorter than 0.598 sec, which is the fastest \texttt{ACCUM} read time for \texttt{NREAD=1}. If the brightness of the source requires a shorter exposure time, \texttt{MULTIACCUM} Mode or \texttt{BRIGHTOBJ} Mode is suggested instead.
12.2.7 Special Requirements

The three NICMOS detectors may be operated in parallel. Coordinated parallels are not possible with certain special requirements; see Chapter 6: Parallel Science Exposures on page 103 for details.

12.3 Mode = MULTIACCUM
Config = NIC1 or NIC2 or NIC3

MULTIACCUM is a flexible mode that allows multiple non-destructive readouts of the array during integration spaced at user-specified intervals throughout the integration, with the results from each readout being recorded onboard and returned to the ground for analysis. See the NICMOS Instrument Handbook for more information. This mode differs from the use of multiple readouts with NREAD in ACCUM Mode, because it actually produces multiple images whereas the multiple initial and final readouts in ACCUM Mode are used to reduce read noise in the generation of a single image. MULTIACCUM Mode may also be used with a single sample time to achieve integration times as short as 0.203 seconds (the shortest allowed in ACCUM Mode is 0.598 seconds).

12.3.1 Aperture or FOV
See Table 12.4: NICMOS Apertures.

12.3.2 Spectral Elements
See Table 12.5: Spectral Elements for the NICMOS.

12.3.3 Wavelength
The Wavelength parameter is not required for NICMOS observations and should be left blank.

12.3.4 Optional Parameters

CAMERA-FOCUS
  =DEF (default); 1-2
Specifies the NICMOS focus position to be used. If DEF is specified or this parameter is omitted, NICMOS will be focussed in the best position for the selected camera. A value of 1-2 selects a compromise focus position between the optimum foci for cameras 1 and 2. This will mainly be useful...
with coordinated parallels, but **CAMERA-FOCUS** may be specified only on exposures using the primary NICMOS detector in the sequence as defined in Section 6.3 on page 105.

**CAMERA-FOCUS** = DEF or 1-2 is allowed only with NIC1, NIC1-FIX, NIC2, or NIC2-FIX as the chosen aperture.

**SAMP-SEQ**

=SCAMRR, MCAMRR, STEP1, STEP2, STEP8, STEP16, STEP32, STEP64, STEP128, STEP256, SPARS4, SPARS16, SPARS32, SPARS64, SPARS128, SPARS256

Specifies the name of a predefined sequence of times from the start of the exposure at which the nondestructive readouts (samples) are performed. The number of samples (up to 25) taken for each exposure is controlled by the **NSAMP** parameter (see below). **Table 12.2** gives the sample times (from the start of the exposure) for each sequence. **SAMP-SEQ** is required.

Four different types of sequences are provided. The SCAMRR and MCAMRR sequences are rapid sequences with linear steps, which obtain the densest temporal sampling. SCAMRR is designed for use with a single camera and provides the densest sampling available, but may not be used with multiple cameras. MCAMRR should be used if rapid sequencing is desired with two or three cameras (NIC1, NIC2, NIC3) operating in parallel.

Sequences **STEP1**, **STEP2**, **STEP8**, **STEP16**, **STEP32**, **STEP64**, **STEP128**, and **STEP256** begin with logarithmic spacing up to the given number of seconds (1–256), and then continue with linear spacing for the remainder of the sequence, with adjacent steps separated by 1–256 seconds. These sequences all include three readouts during the first second to compensate for any nonlinear effects which may arise at the start of the exposure.

Sequences **SPARS4**, **SPARS16**, **SPARS32**, **SPARS64**, **SPARS128** and **SPARS256** begin with two readouts during the first second, and then continue with sparse linear spacing for the remainder of the sequence, with adjacent steps separated by the given number of seconds (4, 16, 32, 64 128 or 256). These are similar to **STEP1** to **STEP256**, except that the linear sampling begins immediately after the first two readouts rather than being preceded by a series of readouts with logarithmic spacing.

**NSAMP**

=1–25

Specifies the number of samples in a predefined sequence that should actually be taken. **Table 12.3** defines 25 sample times for each sequence. If an **NSAMP** value smaller than 25 is used, samples will be taken at only the first **NSAMP** times from this table. **NSAMP** must be specified.
The number of readouts will be **NSAMP** plus one for the initial readout, giving a maximum of 26 readouts (the initial readout plus a maximum of 25 samples) for a single execution of a **MULTIACCUM** exposure. Each readout will be recorded and will appear in the final data set.

**OFFSET**

=**SAM** (default)

This is the same as in **ACCUM** Mode; see “OFFSET =**SAM** (default)” on page 236.

### 12.3.5 Number of Iterations

If **Number_Of_Iterations** > 1, the specified number of iterations will be taken at a single pointing. For a pattern (see Chapter 8: Pointings and Patterns) the specified number of iterations will be taken at each point in the pattern.

### 12.3.6 Time Per Exposure

**Time_Per_Exposure** must be **DEF** in this Mode. The exposure time is unnecessary, because it is specified by **SAMP–SEQ** and **NSAMP**.

### 12.3.7 Special Requirements

The three NICMOS detectors may be operated in parallel. Coordinated parallels are not possible with certain special requirements; see Chapter 6: Parallel Science Exposures on page 103 for details.

The exposure time sequences denoted by **SAMP–SEQ** are defined in the following table. These values are approximated for simplicity; actual exposure times may be reduced by up to 7 msec.
Table 12.2: Predefined Sample Sequences for MULTIACCUM Mode (seconds)

<table>
<thead>
<tr>
<th>Sequence Name</th>
<th>Sample Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAMRR</td>
<td>0.203 0.406 0.609 0.812 1.015</td>
</tr>
<tr>
<td></td>
<td>1.218 1.421 1.624 1.827 2.030</td>
</tr>
<tr>
<td></td>
<td>2.233 2.436 2.639 2.842 3.045</td>
</tr>
<tr>
<td></td>
<td>4.263 4.466 4.669 4.872 5.075</td>
</tr>
<tr>
<td>MCAMRR</td>
<td>0.303 0.606 0.909 1.212 1.515</td>
</tr>
<tr>
<td></td>
<td>1.818 2.121 2.424 2.727 3.030</td>
</tr>
<tr>
<td></td>
<td>3.333 3.636 3.939 4.242 4.545</td>
</tr>
<tr>
<td></td>
<td>4.848 5.151 5.454 5.757 6.060</td>
</tr>
<tr>
<td></td>
<td>6.363 6.666 6.969 7.272 7.575</td>
</tr>
<tr>
<td>STEP1</td>
<td>0.303 0.606 0.995 1.993 2.991</td>
</tr>
<tr>
<td></td>
<td>3.989 4.987 5.985 6.983 7.981</td>
</tr>
<tr>
<td></td>
<td>8.979 9.977 10.975 11.973 12.971</td>
</tr>
<tr>
<td></td>
<td>13.969 14.967 15.965 16.963 17.961</td>
</tr>
<tr>
<td>STEP2</td>
<td>0.303 0.606 0.995 1.993 3.987</td>
</tr>
<tr>
<td></td>
<td>5.981 7.975 9.969 11.963 13.957</td>
</tr>
<tr>
<td></td>
<td>15.951 17.945 19.939 21.933 23.927</td>
</tr>
<tr>
<td></td>
<td>25.921 27.915 29.909 31.903 33.897</td>
</tr>
<tr>
<td></td>
<td>35.891 37.885 39.879 41.873 43.867</td>
</tr>
<tr>
<td>STEP8</td>
<td>0.303 0.606 0.995 1.993 3.987</td>
</tr>
<tr>
<td></td>
<td>7.981 15.975 23.969 31.963 39.957</td>
</tr>
<tr>
<td></td>
<td>47.951 55.945 63.939 71.933 79.927</td>
</tr>
<tr>
<td></td>
<td>87.921 95.915 103.909 111.903 119.897</td>
</tr>
<tr>
<td></td>
<td>127.891 135.885 143.879 151.873 159.867</td>
</tr>
<tr>
<td>STEP16</td>
<td>0.303 0.606 0.995 1.993 3.987</td>
</tr>
<tr>
<td></td>
<td>7.981 15.975 31.969 47.963 63.957</td>
</tr>
<tr>
<td></td>
<td>79.951 95.945 111.939 127.933 143.927</td>
</tr>
<tr>
<td></td>
<td>159.921 175.915 191.909 207.903 223.897</td>
</tr>
<tr>
<td></td>
<td>239.891 255.885 271.879 287.873 303.867</td>
</tr>
<tr>
<td>STEP32</td>
<td>0.303 0.606 0.995 1.993 3.987</td>
</tr>
<tr>
<td></td>
<td>7.981 15.975 31.969 63.969 95.969</td>
</tr>
<tr>
<td></td>
<td>127.969 159.969 191.969 223.969 255.969</td>
</tr>
<tr>
<td></td>
<td>287.969 319.969 351.969 383.969 415.969</td>
</tr>
<tr>
<td></td>
<td>447.969 479.969 511.969 543.969 575.969</td>
</tr>
<tr>
<td>STEP64</td>
<td>0.303 0.606 0.995 1.993 3.987</td>
</tr>
<tr>
<td></td>
<td>7.981 15.975 31.969 63.969 127.967</td>
</tr>
<tr>
<td></td>
<td>191.965 255.963 319.961 383.959 447.957</td>
</tr>
<tr>
<td></td>
<td>511.955 575.953 639.951 703.949 767.947</td>
</tr>
<tr>
<td></td>
<td>831.945 895.943 959.941 1023.939 1087.937</td>
</tr>
<tr>
<td>Sequence Name</td>
<td>Sample Times</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>STEP128</td>
<td>0.303 0.606 0.995 1.993 3.987</td>
</tr>
<tr>
<td></td>
<td>7.981 15.975 31.969 63.969 127.967</td>
</tr>
<tr>
<td></td>
<td>255.961 383.955 511.949 639.943 767.937</td>
</tr>
<tr>
<td></td>
<td>895.931 1023.925 1151.919 1279.913 1407.907</td>
</tr>
<tr>
<td></td>
<td>1535.901 1663.895 1791.889 1919.883 2047.877</td>
</tr>
<tr>
<td>STEP256</td>
<td>0.303 0.606 0.995 1.993 3.987</td>
</tr>
<tr>
<td></td>
<td>7.981 15.975 31.969 63.969 127.967</td>
</tr>
<tr>
<td></td>
<td>255.961 511.961 767.961 1023.961 1279.961</td>
</tr>
<tr>
<td></td>
<td>1535.961 1791.961 2047.961 2303.961 2559.961</td>
</tr>
<tr>
<td></td>
<td>2815.961 3071.961 3327.961 3583.961 3839.961</td>
</tr>
<tr>
<td>SPARS4</td>
<td>0.303 0.606 3.998 8.000 12.002</td>
</tr>
<tr>
<td></td>
<td>16.004 20.006 24.008 28.010 32.012</td>
</tr>
<tr>
<td></td>
<td>36.014 40.016 44.018 48.020 52.022</td>
</tr>
<tr>
<td></td>
<td>56.024 60.026 64.028 68.030 72.032</td>
</tr>
<tr>
<td></td>
<td>76.034 80.036 84.038 88.040 92.042</td>
</tr>
<tr>
<td>SPARS16</td>
<td>0.303 0.606 15.977 31.998 47.999</td>
</tr>
<tr>
<td></td>
<td>64.000 80.001 96.002 112.003 128.004</td>
</tr>
<tr>
<td></td>
<td>144.005 160.006 176.007 192.008 208.009</td>
</tr>
<tr>
<td></td>
<td>224.010 240.011 256.012 272.013 288.014</td>
</tr>
<tr>
<td></td>
<td>304.015 320.016 336.017 352.018 368.019</td>
</tr>
<tr>
<td>SPARS32</td>
<td>0.303 0.606 32.004 64.004 96.004</td>
</tr>
<tr>
<td></td>
<td>128.004 160.004 192.004 224.004 256.004</td>
</tr>
<tr>
<td></td>
<td>288.004 320.004 352.004 384.004 416.004</td>
</tr>
<tr>
<td></td>
<td>448.004 480.004 512.004 544.004 576.004</td>
</tr>
<tr>
<td></td>
<td>608.004 640.004 672.004 704.004 736.004</td>
</tr>
<tr>
<td>SPARS64</td>
<td>0.303 0.606 63.994 127.992 191.990</td>
</tr>
<tr>
<td></td>
<td>255.988 319.986 383.984 447.982 511.980</td>
</tr>
<tr>
<td></td>
<td>575.978 639.976 703.974 767.972 831.970</td>
</tr>
<tr>
<td></td>
<td>895.968 959.966 1023.964 1087.962 1151.960</td>
</tr>
<tr>
<td></td>
<td>1215.958 1279.956 1343.954 1407.952 1471.950</td>
</tr>
<tr>
<td>SPARS128</td>
<td>0.303 0.606 127.997 255.998 383.990</td>
</tr>
<tr>
<td></td>
<td>512.000 640.001 768.002 896.003 1024.004</td>
</tr>
<tr>
<td></td>
<td>1152.005 1280.006 1408.007 1536.008 1664.009</td>
</tr>
<tr>
<td></td>
<td>1792.010 1920.011 2048.012 2176.013 2304.014</td>
</tr>
<tr>
<td></td>
<td>2432.015 2560.015 2688.017 2816.018 2944.019</td>
</tr>
<tr>
<td>SPARS256</td>
<td>0.303 0.606 255.996 511.996 767.996</td>
</tr>
<tr>
<td></td>
<td>1023.996 1279.996 1535.996 1791.996 2047.996</td>
</tr>
<tr>
<td></td>
<td>2303.996 2559.996 2815.996 3071.996 3327.996</td>
</tr>
<tr>
<td></td>
<td>3583.996 3839.996 4095.996 4351.996 4607.996</td>
</tr>
<tr>
<td></td>
<td>4863.996 5119.996 5375.996 5631.996 5887.996</td>
</tr>
</tbody>
</table>
12.4 Mode = ACQ  
Config = NIC2

This mode requests the NICMOS flight software to locate the brightest target in the acquisition aperture of camera 2 (one quarter of the full NIC2 FOV, or 9.6x 9.6 arcsec) and place it behind the coronagraphic spot of camera 2. It is only necessary as a preparation for coronagraphy with the NIC2-CORON aperture. Two images will be taken and downlinked, each with a single non-destructive readout at the beginning and the end of the exposure. Two each of background and lamp-on exposures will be taken to locate the coronagraphic hole.

12.4.1 Aperture or FOV
The NIC2–ACQ aperture must be used in this Mode.

12.4.2 Spectral Elements
Use any in Table 12.5: Spectral Elements for the NICMOS for the NIC2 configuration.

12.4.3 Wavelength
The Wavelength parameter is not required for NICMOS observations and should be left blank.

12.4.4 Optional Parameters
There are no Optional Parameters in this Mode.

12.4.5 Number of Iterations
Always enter 1. However, two exposures of the duration given in Time_Per_Exposure will be executed, for purposes of onboard cosmic ray elimination by the NICMOS flight software.

12.4.6 Time Per Exposure
Exposure times in ACQ Mode are quantized. The exposure consists of an initial readout, followed by a period of data accumulation, followed by a final readout. The Time_Per_Exposure (in seconds) refers to the total integration time, which begins at the start of the initial readout and ends at the start of the final readout. The NICMOS Timing Pattern Generator
(TPG) uses a list of discrete values for the time between readouts (TPG\_TIME), which is given in Table 12.3: Quantized Legal NICMOS TPG Expose Times. The specified exposure time should be one of a set of possible values allowed by the following formula:

\[
\text{Time\_Per\_Exposure} = \text{TPG\_TIME} + 0.228
\]

If the exposure time entered by the user is not one of the values allowed by the above formula, it will be reduced to the next lowest legal value. It is illegal to specify an exposure time below the minimum of 0.228 seconds.

### 12.4.7 Special Requirements

Science exposures associated with this acquisition must be identified as part of the <exposure–list> and must use the NIC2 configuration and the coronagraphic aperture NIC2–CORON.

The Special Requirement PARallel WITH is not allowed in this Mode.

---

### 12.5 Tabular Data

#### 12.5.1 TPG\_TIME Values

The following table gives the legal TPG expose times (TPG\_TIME) in seconds, needed to calculate legal exposure times in ACCUM and ACQ Modes. These values are approximated for simplicity, so that exposure times derived from them may be reduced by up to 1 msec.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.014</td>
<td>0.021</td>
<td>0.028</td>
<td>0.035</td>
</tr>
<tr>
<td>0.042</td>
<td>0.050</td>
<td>0.057</td>
<td>0.064</td>
<td>0.071</td>
</tr>
<tr>
<td>0.078</td>
<td>0.085</td>
<td>0.100</td>
<td>0.107</td>
<td>0.114</td>
</tr>
<tr>
<td>0.128</td>
<td>0.143</td>
<td>0.157</td>
<td>0.172</td>
<td>0.186</td>
</tr>
<tr>
<td>0.207</td>
<td>0.229</td>
<td>0.250</td>
<td>0.272</td>
<td>0.301</td>
</tr>
<tr>
<td>0.329</td>
<td>0.358</td>
<td>0.394</td>
<td>0.437</td>
<td>0.473</td>
</tr>
<tr>
<td>0.523</td>
<td>0.573</td>
<td>0.630</td>
<td>0.688</td>
<td>0.759</td>
</tr>
<tr>
<td>0.831</td>
<td>0.910</td>
<td>0.996</td>
<td>1.096</td>
<td>1.197</td>
</tr>
<tr>
<td>1.318</td>
<td>1.440</td>
<td>1.584</td>
<td>1.734</td>
<td>1.906</td>
</tr>
<tr>
<td>2.085</td>
<td>2.286</td>
<td>2.508</td>
<td>2.752</td>
<td>3.017</td>
</tr>
<tr>
<td>3.311</td>
<td>3.626</td>
<td>3.978</td>
<td>4.365</td>
<td>4.781</td>
</tr>
<tr>
<td>5.246</td>
<td>5.755</td>
<td>6.307</td>
<td>6.917</td>
<td>7.583</td>
</tr>
</tbody>
</table>
Tabular Data

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20.887</td>
<td>22.908</td>
<td>25.116</td>
<td>27.539</td>
<td>30.198</td>
</tr>
<tr>
<td>33.108</td>
<td>36.305</td>
<td>39.811</td>
<td>43.645</td>
<td>47.860</td>
</tr>
<tr>
<td>52.476</td>
<td>57.544</td>
<td>63.092</td>
<td>69.178</td>
<td>75.858</td>
</tr>
<tr>
<td>83.177</td>
<td>91.198</td>
<td>100.000</td>
<td>109.648</td>
<td>120.221</td>
</tr>
<tr>
<td>131.826</td>
<td>144.542</td>
<td>158.484</td>
<td>173.780</td>
<td>190.546</td>
</tr>
<tr>
<td>208.925</td>
<td>229.082</td>
<td>251.188</td>
<td>275.423</td>
<td>299.980</td>
</tr>
<tr>
<td>301.994</td>
<td>331.125</td>
<td>359.998</td>
<td>363.073</td>
<td>398.103</td>
</tr>
<tr>
<td>419.994</td>
<td>436.516</td>
<td>478.628</td>
<td>479.990</td>
<td>524.805</td>
</tr>
<tr>
<td>575.439</td>
<td>630.956</td>
<td>691.826</td>
<td>758.575</td>
<td>831.760</td>
</tr>
<tr>
<td>839.989</td>
<td>899.985</td>
<td>912.006</td>
<td>959.981</td>
<td>1000.000</td>
</tr>
<tr>
<td>1079.995</td>
<td>1096.474</td>
<td>1199.987</td>
<td>1202.259</td>
<td>1259.983</td>
</tr>
<tr>
<td>1318.252</td>
<td>1319.980</td>
<td>1379.997</td>
<td>1439.993</td>
<td>1445.434</td>
</tr>
<tr>
<td>1559.986</td>
<td>1584.887</td>
<td>1679.999</td>
<td>1737.795</td>
<td>1739.996</td>
</tr>
<tr>
<td>1859.988</td>
<td>1905.455</td>
<td>1919.984</td>
<td>2039.998</td>
<td>2089.292</td>
</tr>
<tr>
<td>2099.994</td>
<td>2219.986</td>
<td>2279.983</td>
<td>2290.864</td>
<td>2339.979</td>
</tr>
<tr>
<td>2399.996</td>
<td>2459.993</td>
<td>2511.882</td>
<td>2519.989</td>
<td>2639.981</td>
</tr>
<tr>
<td>2699.999</td>
<td>2754.225</td>
<td>2759.995</td>
<td>2819.991</td>
<td>2879.987</td>
</tr>
<tr>
<td>2939.983</td>
<td>2999.980</td>
<td>3019.950</td>
<td>3059.997</td>
<td>3179.989</td>
</tr>
<tr>
<td>3239.986</td>
<td>3299.982</td>
<td>3311.307</td>
<td>3359.999</td>
<td>3479.992</td>
</tr>
<tr>
<td>3539.988</td>
<td>3599.984</td>
<td>3630.778</td>
<td>3981.071</td>
<td>4365.154</td>
</tr>
<tr>
<td>4786.295</td>
<td>5248.072</td>
<td>5754.398</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 12.5.2 NICMOS Apertures

Each camera has two apertures defined near the center of the FOV. Only exposures using the corresponding configuration (**NIC1**, **NIC2**, **NIC3**) may use a given camera’s apertures. The **CAMERA-FOCUS** optional parameter may be used to select a compromise focus position not optimized for either **NIC1** or **NIC2**, but intended to work well with both.

One of the two FOV-center apertures (**NIC1, NIC2, NIC3**) is an optimal location near the center of the FOV considering detector efficiency and pixel quality, which will be updated by the STScI as the detectors change on orbit. One aperture in each camera (**NIC1–FIX, NIC2–FIX, NIC3–FIX**) corresponds to a fixed pixel at or near the center of the detector array, which will not change on orbit.

The aperture **NIC2–CORON** is the location of the coronagraphic spot in the **NIC2** camera. It will be used by science exposures which have been preceded by a target acquisition exposure using the **NIC2–ACQ** aperture or by a real-time acquisition image obtained using the **NIC2–CORON** aperture. The acquisition aperture will be slightly offset from the coronagraphic aperture, but within the acquisition detector subarray.
Table 12.4: NICMOS Apertures

<table>
<thead>
<tr>
<th>Aperture</th>
<th>Required Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIC1</td>
<td>NIC1</td>
<td>Optimum Location of NIC1 FOV</td>
</tr>
<tr>
<td>NIC1–FIX</td>
<td>NIC1</td>
<td>Geometric Center of NIC1 FOV</td>
</tr>
<tr>
<td>NIC2</td>
<td>NIC2</td>
<td>Optimum Location of NIC2 FOV</td>
</tr>
<tr>
<td>NIC2–ACQ</td>
<td>NIC2</td>
<td>Coronagraphic Acquisition Aperture</td>
</tr>
<tr>
<td>NIC2–CORON</td>
<td>NIC2</td>
<td>NIC2 Coronagraphic Spot</td>
</tr>
<tr>
<td>NIC2–FIX</td>
<td>NIC2</td>
<td>Geometric Center of NIC2 FOV</td>
</tr>
<tr>
<td>NIC3</td>
<td>NIC3</td>
<td>Optimum Location of NIC3 FOV</td>
</tr>
<tr>
<td>NIC3–FIX</td>
<td>NIC3</td>
<td>Geometric Center of NIC3 FOV</td>
</tr>
</tbody>
</table>

12.5.3 NICMOS Spectral Elements

The following Spectral Elements in Table 12.5, including filters, polarizers, and grisms, are available for the three NICMOS cameras. Only exposures using the corresponding configuration (NIC1, NIC2, NIC3) may use a given camera’s spectral elements. The CAMERA-FOCUS optional parameter may be used to select a compromise focus position not optimized for either NIC1 or NIC2, but designed to work well for both. See the NICMOS Instrument Handbook for details.

Table 12.5: Spectral Elements for the NICMOS

<table>
<thead>
<tr>
<th>Name</th>
<th>Wheel Position</th>
<th>Central Wavelength (microns)</th>
<th>Bandwidth (microns)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Config = NIC1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F090M</td>
<td>18</td>
<td>0.900</td>
<td>0.800 – 1.000</td>
<td>S III</td>
</tr>
<tr>
<td>F095N</td>
<td>19</td>
<td>0.953</td>
<td>1%</td>
<td>S III Continuum</td>
</tr>
<tr>
<td>F097N</td>
<td>20</td>
<td>0.970</td>
<td>1%</td>
<td>He I</td>
</tr>
<tr>
<td>F108N</td>
<td>16</td>
<td>1.083</td>
<td>1.000 – 1.200</td>
<td>He I Continuum</td>
</tr>
<tr>
<td>F110M</td>
<td>17</td>
<td>1.100</td>
<td>0.800 – 1.400</td>
<td>Broad Band</td>
</tr>
<tr>
<td>F110W</td>
<td>2</td>
<td>1.100</td>
<td>1%</td>
<td>Water</td>
</tr>
<tr>
<td>F113N</td>
<td>15</td>
<td>1.130</td>
<td>1.000 – 1.800</td>
<td>Fe II</td>
</tr>
<tr>
<td>F140W</td>
<td>6</td>
<td>1.400</td>
<td>1.350 – 1.550</td>
<td>Fe II Continuum</td>
</tr>
<tr>
<td>F145M</td>
<td>13</td>
<td>1.450</td>
<td>1.400 – 1.800</td>
<td>Paschen Alpha</td>
</tr>
<tr>
<td>F160W</td>
<td>14</td>
<td>1.600</td>
<td>1.550 – 1.750</td>
<td>Paschen Alpha Continuum</td>
</tr>
<tr>
<td>F164N</td>
<td>11</td>
<td>1.644</td>
<td>1.600 – 1.800</td>
<td>Paschen Alpha Continuum</td>
</tr>
<tr>
<td>Name</td>
<td>Wheel Position</td>
<td>Central Wavelength (microns)</td>
<td>Bandwidth (microns)</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
<td>------------------------------</td>
<td>---------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>POL0S</td>
<td>5</td>
<td>1.050</td>
<td>0.810 – 1.290</td>
<td>Short Polarizer – 0 deg</td>
</tr>
<tr>
<td>POL120S</td>
<td>4</td>
<td>1.050</td>
<td>0.810 – 1.290</td>
<td>Short Polarizer – 120 deg</td>
</tr>
<tr>
<td>POL240S</td>
<td>3</td>
<td>1.050</td>
<td>0.810 – 1.290</td>
<td>Short Polarizer – 240 deg</td>
</tr>
<tr>
<td>BLANK</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
<td>Blank (opaque)</td>
</tr>
</tbody>
</table>
### Config = NIC2

<table>
<thead>
<tr>
<th>Name</th>
<th>Wheel Position</th>
<th>Central Wavelength (microns)</th>
<th>Bandwidth (microns)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F110W</td>
<td>18</td>
<td>1.100</td>
<td>0.800 – 1.400</td>
<td>Minimum Background</td>
</tr>
<tr>
<td>F160W</td>
<td>19</td>
<td>1.600</td>
<td>1.400 – 1.800</td>
<td></td>
</tr>
<tr>
<td>F165M</td>
<td>20</td>
<td>1.650</td>
<td>1.550 – 1.750</td>
<td></td>
</tr>
<tr>
<td>F171M</td>
<td>7</td>
<td>1.715</td>
<td>1.680 – 1.750</td>
<td>HCO₂ &amp; C₂ Continuum</td>
</tr>
<tr>
<td>F180M</td>
<td>8</td>
<td>1.800</td>
<td>1.765 – 1.835</td>
<td>HCO₂ &amp; C₂</td>
</tr>
<tr>
<td>F187N</td>
<td>10</td>
<td>1.875</td>
<td>1%</td>
<td>Paschen Alpha</td>
</tr>
<tr>
<td>F187W</td>
<td>9</td>
<td>1.875</td>
<td>1.750 – 2.000</td>
<td></td>
</tr>
<tr>
<td>F190N</td>
<td>11</td>
<td>1.900</td>
<td>1%</td>
<td>Paschen Alpha</td>
</tr>
<tr>
<td>F204M</td>
<td>2</td>
<td>2.040</td>
<td>1.990 – 2.090</td>
<td>Continuum</td>
</tr>
<tr>
<td>F205W</td>
<td>17</td>
<td>2.050</td>
<td>1.750 – 2.350</td>
<td>Methane Imaging</td>
</tr>
<tr>
<td>F207M</td>
<td>6</td>
<td>2.075</td>
<td>2.000 – 2.150</td>
<td>Broad Band</td>
</tr>
<tr>
<td>F212N</td>
<td>12</td>
<td>2.121</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>F215N</td>
<td>13</td>
<td>2.150</td>
<td>1%</td>
<td>H₂</td>
</tr>
<tr>
<td>F216N</td>
<td>14</td>
<td>2.165</td>
<td>1%</td>
<td>H₂ &amp; Brackett Gamma Continuum</td>
</tr>
<tr>
<td>F222M</td>
<td>15</td>
<td>2.225</td>
<td>2.150 – 2.300</td>
<td>Brackett Gamma</td>
</tr>
<tr>
<td>F237M</td>
<td>16</td>
<td>2.375</td>
<td>2.300 – 2.450</td>
<td>CO Continuum CO Band</td>
</tr>
<tr>
<td>POL0L</td>
<td>3</td>
<td>2.050</td>
<td>1.900 – 2.100</td>
<td>Long Polarizer – 0 deg</td>
</tr>
<tr>
<td>POL120L</td>
<td>4</td>
<td>2.050</td>
<td>1.900 – 2.100</td>
<td>Long Polarizer – 120 deg</td>
</tr>
<tr>
<td>POL240L</td>
<td>5</td>
<td>2.050</td>
<td>1.900 – 2.100</td>
<td>Long Polarizer – 240 deg</td>
</tr>
</tbody>
</table>

### Config = NIC3

<table>
<thead>
<tr>
<th>Name</th>
<th>Wheel Position</th>
<th>Central Wavelength (microns)</th>
<th>Bandwidth (microns)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F108N</td>
<td>4</td>
<td>1.083</td>
<td>1%</td>
<td>He I</td>
</tr>
<tr>
<td>F110W</td>
<td>2</td>
<td>1.100</td>
<td>0.800 – 1.400</td>
<td>He I Continuum</td>
</tr>
<tr>
<td>F113N</td>
<td>5</td>
<td>1.130</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>F150W</td>
<td>9</td>
<td>1.500</td>
<td>1.100 – 1.900</td>
<td>Grism B Continuum</td>
</tr>
<tr>
<td>F160W</td>
<td>6</td>
<td>1.600</td>
<td>1.400 – 1.800</td>
<td>Minimum Background</td>
</tr>
<tr>
<td>F164N</td>
<td>8</td>
<td>1.644</td>
<td>1%</td>
<td>Fe II</td>
</tr>
<tr>
<td>F166N</td>
<td>7</td>
<td>1.660</td>
<td>1%</td>
<td>Fe II Continuum</td>
</tr>
<tr>
<td>F175W</td>
<td>20</td>
<td>1.750</td>
<td>1.200 – 2.300</td>
<td></td>
</tr>
<tr>
<td>F187N</td>
<td>11</td>
<td>1.875</td>
<td>1%</td>
<td>Paschen Alpha</td>
</tr>
<tr>
<td>F190N</td>
<td>12</td>
<td>1.900</td>
<td>1%</td>
<td>Paschen Alpha</td>
</tr>
<tr>
<td>F196N</td>
<td>13</td>
<td>1.962</td>
<td>1%</td>
<td>Continuum</td>
</tr>
<tr>
<td>F200N</td>
<td>14</td>
<td>2.000</td>
<td>1%</td>
<td>Si VI</td>
</tr>
<tr>
<td>F212N</td>
<td>18</td>
<td>2.121</td>
<td>1%</td>
<td>Si VI Continuum</td>
</tr>
<tr>
<td>F215N</td>
<td>19</td>
<td>2.150</td>
<td>1%</td>
<td>H₂</td>
</tr>
<tr>
<td>F222M</td>
<td>15</td>
<td>2.225</td>
<td>2.150 – 2.300</td>
<td>H₂ Continuum</td>
</tr>
<tr>
<td>F240M</td>
<td>16</td>
<td>2.400</td>
<td>2.300 – 2.500</td>
<td>CO Continuum CO Band</td>
</tr>
</tbody>
</table>
12.6 Illustrations

Figure 12.1: NICMOS Coordinate System.

This figure shows the NICMOS coordinate system projected onto the sky for the POSition TARGet Special Requirement. The POS TARG coordinate system will be aligned parallel to rows and columns in each camera as shown in the diagram above. The alignment of each camera is not exact, and the internal coordinate systems attached to each of them will differ by small rotations (probably less than 2 degrees). The FITS format data files generated for NICMOS observers will have a World Coordinate System specified appropriately for each camera. The origin of the coordinate system will be located as shown in the diagram above.
Figure 12.2: Definition of Orientation for NICMOS.
Due to the linear arrangement of the three NICMOS cameras on the sky, it is sometimes advantageous to specify a unique telescope orientation. A simple example is shown above. A binary star with a position angle (PA) of 30 degrees measured east from north is to be positioned with the southern star in Camera 3 and the northern star in Camera 2. That is, we want the line connecting the two stars to lie along the NICMOS +Y axis. The resulting HST orientation is $225 + 30 = 255$ degrees. (The NICMOS offset angle for orientation specifications is 225 degrees; see Table 7.4: Instrument Orientations with respect to U3-Direction.)

Figure 12.3: Guide-Star Availability with NICMOS Patterns.

The above graph shows the probability that guide stars will not be available (“failure rate”) as a function of the tolerance in roll (“roll range”) that the visit allows, for targets at high galactic latitude. For visits with ORIENTation requirements, the roll range would be half the difference between $\text{angle1}$ and $\text{angle2}$. Note however that other special requirements, such as SAME ORIENT, ORIENT FROM, and BETWEEN, can also restrict the orientation at which a visit may be scheduled. Unavailability versus roll range is plotted for the full range of
pointings within each of the NIC1, NIC2, and NIC3 apertures. Note that in all three cases the unavailability rises dramatically as the roll range shrinks to zero. The risk of not finding guide stars is considerably higher for patterns that cover the larger NIC3 aperture. For patterns larger than the NIC3 aperture, and which may approach the maximum pointing variation of 2 arcmin, unavailability will be still higher. Therefore, observations at high galactic latitude (above 45 degrees) with large patterns and tight ORIENT restrictions carry a high risk of having to be reworked later for lack of guide stars. At lower galactic latitudes, the risk still exists but is considerably reduced.
## CHAPTER 13: Cosmic Origins Spectrograph (COS)

In this chapter . . .

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1 Introduction to the COS</td>
<td>254</td>
</tr>
<tr>
<td>13.2 Mode = ACQ/SEARCH Config = COS/FUV</td>
<td>256</td>
</tr>
<tr>
<td>13.3 Mode = ACQ/PEAKXD Config = COS/FUV</td>
<td>259</td>
</tr>
<tr>
<td>13.4 Mode = ACQ/PEAKD Config = COS/FUV</td>
<td>261</td>
</tr>
<tr>
<td>13.5 Mode = ACQ/SEARCH Config = COS/NUV</td>
<td>263</td>
</tr>
<tr>
<td>13.6 Mode = ACQ/IMAGE Config = COS/NUV</td>
<td>266</td>
</tr>
<tr>
<td>13.7 Mode = ACQ/PEAKXD Config = COS/NUV</td>
<td>268</td>
</tr>
<tr>
<td>13.8 Mode = ACQ/PEAKD Config = COS/NUV</td>
<td>270</td>
</tr>
<tr>
<td>13.9 Mode = TIME-TAG Config = COS/FUV</td>
<td>274</td>
</tr>
<tr>
<td>13.10 Mode = ACCUM Config = COS/FUV</td>
<td>278</td>
</tr>
<tr>
<td>13.11 Mode = TIME-TAG Config = COS/NUV</td>
<td>280</td>
</tr>
<tr>
<td>13.12 Mode = ACCUM Config = COS/NUV</td>
<td>283</td>
</tr>
<tr>
<td>13.13 COS Apertures</td>
<td>285</td>
</tr>
<tr>
<td>13.14 COS Spectral Elements and Central Wavelengths</td>
<td>285</td>
</tr>
<tr>
<td>13.15 COS Internal Calibration Targets</td>
<td>286</td>
</tr>
<tr>
<td>13.16 WAVECAL Exposure Parameters</td>
<td>287</td>
</tr>
<tr>
<td>13.17 COS Coordinate System</td>
<td>290</td>
</tr>
</tbody>
</table>
13.1 Introduction to the COS

The Instrument Configurations and Operating Modes described in this chapter are used to specify exposures on the Visit and Exposure Specifications. More complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, etc. are available in the COS Instrument Handbook.

Table 13.1 lists the permitted Instrument Configurations, Operating Modes, Apertures, Spectral Elements, and Optional Parameters for COS

<table>
<thead>
<tr>
<th>Config</th>
<th>Mode</th>
<th>Aperture</th>
<th>Spectral Elements</th>
<th>Optional Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>COS/FUV</td>
<td>ACQ/SEARCH</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td>SEGMENT, SCAN-SIZE, STEP-SIZE, CENTER</td>
</tr>
<tr>
<td>ACQ/PEAKXD</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td>SEGMENT</td>
<td></td>
</tr>
<tr>
<td>ACQ/PEAKD</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td>SEGMENT, NUM-POS, STEP-POS, CENTER</td>
<td></td>
</tr>
<tr>
<td>TIME-TAG</td>
<td>PSA, BOA, WCA</td>
<td>See Table 13.3</td>
<td>SEGMENT, BUFFER-TIME, EXTENDED, FP-POS, FLASH</td>
<td></td>
</tr>
<tr>
<td>ACCUM</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td>SEGMENT, EXTENDED, FP-POS</td>
<td></td>
</tr>
</tbody>
</table>
Table 13.1: Instrument Parameters for COS

<table>
<thead>
<tr>
<th>Config</th>
<th>Mode</th>
<th>Aperture</th>
<th>Spectral Elements</th>
<th>Optional Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>COS/NUV</td>
<td>ACQ/SEARCH</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td>SCAN-SIZE, STEP-SIZE, CENTER</td>
</tr>
<tr>
<td></td>
<td>ACQ/IMAGE</td>
<td>PSA, BOA</td>
<td>MIRRORA, MIRRORB</td>
<td>STRIPE</td>
</tr>
<tr>
<td></td>
<td>ACQ/PEAKXD</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td>NUM-POS, STEP-SIZE, CENTER</td>
</tr>
<tr>
<td></td>
<td>ACQ/PEAKD</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TIME-TAG</td>
<td>PSA, BOA, WCA</td>
<td>See Table 13.3</td>
<td>BUFFER-TIME EXTENDED, FP-POS, FLASH</td>
</tr>
<tr>
<td></td>
<td>ACCUM</td>
<td>PSA, BOA</td>
<td>See Table 13.3</td>
<td>EXTENDED, FP-POS</td>
</tr>
</tbody>
</table>
ACQUISITION MODES

For COS science observations of targets whose coordinates are not known to at least 0.4", you need to use the target search (ACQ/SEARCH Mode) and possibly the image acquisition (ACQ/IMAGE Mode) or peakup stages (ACQ/PEAKXD Mode followed by ACQ/PEAKD Mode) to center your target. For targets whose coordinates are accurate to 0.4" or better, the target search step can be slipped. For more details on these modes, see the COS Instrument Handbook.

13.2 Mode = ACQ/SEARCH
Config = COS/FUV

This mode invokes a procedure in the COS onboard flight software that searches for the target and locates it in the selected COS aperture for subsequent science exposures. A series of exposures are taken at different HST pointings in a spiral pattern from the initial pointing, and then the HST is repositioned to maximize the light intensity through the COS aperture. This mode is required for targets whose coordinates are not known to at least 0.4". Most COS observation sequences that use ACQ/SEARCH Mode will also need to use other acquisition exposures (ACQ/IMAGE, ACQ/PEAKD, and/or ACQ/PEAKXD) to achieve proper centering of the target in the science aperture.

Information from the Target List, along with the exposure time, will be used to verify that the integrated target flux through the selected aperture is appropriate for target acquisition. Details on the target acquisition sequence and limiting magnitudes for the PSA and BOA apertures can be found in the COS Instrument Handbook.

This method uses dispersed light from the object to be observed. Subarrays are used to avoid geocoronal airglow lines, which could bias the target acquisition calculations, as well as portions of the detector which are not illuminated by the input spectrum. The subarray dimensions depend on the selected grating; see the COS Instrument Handbook for details.

13.2.1 Aperture or FOV

The aperture used for the ACQ/SEARCH Mode exposure does not need to be the same as the aperture used for the subsequent TIME-TAG or ACCUM science exposures. The following apertures are allowed:

- PSA Primary Science Aperture
• **BOA** Bright Object Aperture

Use of the **BOA** is recommended on bright targets to attenuate the flux and allow the acquisition to proceed without triggering bright object violations.

### 13.2.2 Spectral Element

Enter a spectral element from Table 13.3 for the **COS/FUV** configuration. In order to minimize overheads, this will generally be the same as the one used for the subsequent **TIME-TAG** or **ACCUM** science observation. Target acquisition with the COS FUV detector is in dispersed light only.

### 13.2.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

### 13.2.4 Optional Parameters

**SEGMENT**

- **BOTH** (default except for G140L, \(\lambda=1105\) Å)
- **A** (default and only allowed value for G140L, \(\lambda=1105\) Å)
- **B** (not permitted for G140L, \(\lambda=1230\) Å)

Indicates which segment of the FUV detector to use for an acquisition. A value of **BOTH** will activate both segments. Segments A and B record the long and short wavelength portions of the spectrum respectively. If **A** is selected, only segment A of the detector will be activated for photon detection, and the spectrum will contain data from only that half of the detector. If **B** is selected, only segment B of the detector will be activated and used to generate data. Use of a single segment may be warranted for sources that are too bright to observe safely over the entire detector. See the **COS Instrument Handbook** for more information.

If you use the **G140L** grating at the 1105 Angstrom wavelength setting, **SEGMENT** defaults to **A** (see the following explanatory note). For all other central wavelength settings, the default is **BOTH**.

**Note:** No subarrays are defined for segment **B** when the **G140L** grating is used, because the count rate after excluding areas contaminated by geocoronal airglow lines is expected to be too low to support target acquisition. Also, when **G140L** is used at the 1105 Angstrom setting, the zeroth-order light from the target falls onto segment **B** and becomes a bright object concern.
Scan-Size

- 2, 3, 4, 5 (points)

A required parameter which specifies the size of the square spiral search region in terms of the number of dwell points on a side (e.g. 2x2, 3x3, 4x4, or 5x5). A larger search pattern samples a larger area, but the time required scales as the square of Scan-Size. In some cases it may be advisable to use two ACQ exposures, such as a 3x3 search followed by a 2x2 search; this strategy uses less time than a single 4x4 search. For more details on target acquisition strategies, consult the COS Instrument Handbook.

Step-Size

- 1.767 (default); 0.2 - 2.0 (arcsec)

Specifies the size in arcseconds of each step in the spiral search. Both the PSA and BOA are 2.5 arcsec in diameter. The recommended offset of 1.767 arcsec is the offset at which diagonal dwell points just overlap, and the maximum spacing that provides continuous coverage. Simulations show that offsets larger than 1.767 arcsec will introduce errors due to unsampled areas within the search pattern.

Center

- FLUX-WT (default), FLUX-WT-FLR, BRIGHTEST

Specifies the method used for locating the target within the search pattern. Two methods are available: a flux-weighted centroiding algorithm (FLUX-WT or FLUX-WT-FLR), and a return to the brightest dwell point (BRIGHTEST).

If FLUX-WT-FLR is used, the minimum number of counts measured from any of the dwell points (the "floor") will be subtracted from the number at other dwell points before computing the centroid. The idea behind this threshold is to reduce the contribution of background counts. Note that this has the effect of eliminating the dwell point with the minimum counts from the centroid calculation, which can be a problem especially with small patterns. A value of FLUX-WT-FLR is not allowed with SCAN-SIZE=2. See the COS Instrument Handbook for recommendations on when to use these different methods.

13.2.5 Number of Iterations

The Number_Of_Iterations must be 1 in this Mode.

13.2.6 Time Per Exposure

Enter the total time of data collection at each dwell point as Time_Per_Exposure. Time_Per_Exposure must be an integral multiple of 0.1 seconds. If it is not, its value will be rounded down to the next lower
integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified.

The procedures to determine the exposure time for the ACQ/SEARCH Mode exposure are given in the COS Instrument Handbook. The COS Exposure Time Calculator should be used to estimate the exposure time based on the nature of the source. The exposure time will be repeated at every dwell point in the search.

13.2.7 Special Requirements

The special requirement POSition TARGet <X-value>,<Y-value> is not permitted on ACQ/SEARCH exposures.

13.3 Mode = ACQ/PEAKXD Config = COS/FUV

ACQ/PEAKXD Mode invokes a procedure in the COS onboard flight software that places the target near an optimal position within the selected aperture in the cross-dispersion direction on the detector. This procedure consists of several steps.

1. The optimum cross-dispersion position of the science aperture on the detector is located by flashing the calibration lamp and measuring the mean cross-dispersion location of the calibration spectrum.
2. The target spectrum is recorded for the specified period of time, and its mean cross-dispersion position is also computed.
3. Then, HST is repositioned so that the target location coincides with the optimum cross-dispersion position for the target spectrum within the aperture.

If the target coordinates are not accurate to 0.4", ACQ/PEAKXD Mode should normally be preceded by an ACQ/SEARCH to ensure that the target is positioned in the aperture. Details on the target acquisition sequence and limiting magnitudes for the PSA and BOA can be found in the COS Instrument Handbook.

Subarrays are used during target acquisition to avoid geocoronal airglow lines, which could bias the target acquisition calculations, as well as portions of the detector which are not illuminated by the input spectrum. The subarray dimensions depend on the selected grating and central wavelength; see the COS Instrument Handbook for details.
13.3.1 Aperture or FOV

The aperture used for the ACQ/PEAKXD Mode exposure need not be the same as the aperture used for the subsequent TIME-TAG or ACCUM science exposures. The following apertures are allowed:

- PSA Primary Science Aperture
- BOA Bright Object Aperture

As with spectroscopic observations, use of the BOA is recommended on relatively bright targets to attenuate the flux and allow the acquisition to proceed without triggering bright object violations.

13.3.2 Spectral Element

Enter a spectral element from Table 13.3 for the COS/FUV configuration. In order to minimize overheads, this will generally be the same as the one used for the subsequent TIME-TAG or ACCUM science observation.

13.3.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

13.3.4 Optional Parameters

SEGMENT

\[
\begin{align*}
= \text{BOTH} & \quad (\text{default except for G140L, } \lambda=1105 \text{ Å}) \\
= \text{A} & \quad (\text{default and only allowed value for G140L, } \lambda=1105 \text{ Å})
\end{align*}
\]

For a description see Section 13.2.4.

13.3.5 Number of Iterations

The Number_Of_Iterations must be 1.

13.3.6 Time Per Exposure

Enter the total time of data collection as Time_Per_Exposure. Time_Per_Exposure must be an integral multiple of 0.1 seconds. If it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified.

The procedures to determine the exposure time for the ACQ/PEAKXD Mode exposure are given in the COS Instrument Handbook.
13.3.7 Special Requirements

The special requirement POSition TARGet <X-value>,<Y-value> is not permitted on ACQ/PEAKXD exposures.

13.4 Mode = ACQ/PEAKD
Config = COS/FUV

ACQ/PEAKD Mode invokes a procedure in the COS onboard flight software that takes a series of exposures at different HST pointings offset in the dispersion direction, and HST is repositioned to maximize (peak up) the light intensity through the COS aperture. Details on the target acquisition sequence and limiting magnitudes for the PSA and BOA can be found in the COS Instrument Handbook.

ACQ/PEAKD Mode should always be preceded by an ACQ/PEAKXD exposure. In addition, if the target coordinates are not accurate to 0.4", the ACQ/PEAKD should be preceded by both an ACQ/SEARCH and an ACQ/PEAKXD exposure to ensure that the target is positioned in the aperture and well centered in the cross-dispersion direction.

Subarrays are used during target acquisition to avoid geocoronal airglow lines, which could bias the target acquisition calculations, as well as portions of the detector which are not illuminated by the input spectrum. The subarray dimensions depend on the selected grating and central wavelength; see the COS Instrument Handbook for details.

13.4.1 Aperture or FOV

The aperture used for the ACQ/PEAKD Mode exposure need not be the same as the aperture used for the subsequent TIME-TAG or ACCUM science exposures. The following apertures are allowed:

- PSA Primary Science Aperture
- BOA Bright Object Aperture

As with spectroscopic observations, use of the BOA is recommended on relatively bright targets to attenuate the flux and allow the acquisition to proceed without triggering bright object violations.

13.4.2 Spectral Element

Enter a spectral element from Table 13.3 for the COS/FUV configuration. This will generally be the same as the one used for the subsequent
TIME-TAG or ACCUM science observation. Target acquisition with the COS FUV detector is in dispersed light only.

13.4.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

13.4.4 Optional Parameters

**SEGMENT**

- BOTH (default except for G140L, \( \lambda = 1105 \) Å)
- A (default and only allowed value for G140L, \( \lambda = 1105 \) Å)
- B (not permitted for G140L, \( \lambda = 1230 \) Å)

This is the same as in ACQ/SEARCH Mode; see Section 13.2.4.

**NUM-POS**

- 3 (default), 5, 7, 9 (points)

Specifies the number of dwell positions (including the initial target position) in an ACQ/PEAKD scan. The time required for the scan scales with the number of positions. The default value of 3 is recommended when the flux-weighted centroiding method is used without the "flooring" option. With the other centering options, more positions will improve the accuracy. For more details consult the COS Instrument Handbook.

**STEP-SIZE**

- 0.01 - 2.0 (arcsec)

A required parameter that specifies the size in arcseconds of each step in the linear scan. The optimal step size may depend on the number of positions and the centering method; see the COS Instrument Handbook for details. Note that both the PSA and BOA are 2.5 arcsec in diameter. Assuming the target is already positioned in the aperture, a scan that greatly exceeds the aperture diameter is not likely to be useful.

**CENTER**

- DEF (default), FLUX-WT, FLUX-WT-FLR, BRIGHTEST

Specifies the method used for locating the target within the search pattern. Two methods are available: (1) a flux-weighted centroiding algorithm (FLUX-WT or FLUX-WT-FLR), or (2) a return to the brightest dwell point (BRIGHTEST).

If FLUX-WT-FLR is used, the minimum number of counts measured from any of the dwell points (the "floor") will be subtracted from the number at other dwell points before computing the centroid. The idea behind this
threshold is to reduce the contribution of background counts and extreme points at the edges of the scan.

The default is to use the flux-weighted centroid algorithm without the "flooring" option when NUM-POS=3, and with the "flooring" option when NUM-POS > 3. See the COS Instrument Handbook for more details on these recommendations.

13.4.5 Number of Iterations

The Number_Of_Iterations must be 1 in this Mode.

13.4.6 Time Per Exposure

Enter the total time of data collection at each dwell point as Time_Per_Exposure. Time_Per_Exposure must be an integral multiple of 0.1 seconds. If it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified.

The procedures to determine the exposure time for the ACQ/PEAKD exposure are given in the COS Instrument Handbook. The exposure time will be repeated at every dwell point in the search.

13.4.7 Special Requirements

The special requirement POSition TARGet <X-value>,<Y-value> is not permitted for ACQ/PEAKD exposures.

13.5 Mode = ACQ/SEARCH
Config = COS/NUV

This mode invokes a procedure in the COS onboard flight software that searches for the target and locates it in the selected COS aperture for subsequent science exposures. A series of exposures are taken at different HST pointings in a spiral pattern from the initial pointing, and then the HST is repositioned to maximize the light intensity through the COS aperture. This mode is required for targets whose coordinates are not known to at least 0.4". Most COS observation sequences that use ACQ/SEARCH mode will also need to use other acquisition exposures (ACQ/IMAGE, ACQ/PEAKD, and/or ACQ/PEAKXD) to achieve proper centering of the target in the science aperture.
Details on the target acquisition sequence and limiting magnitudes for the PSA and BOA can be found in the COS Instrument Handbook.

This method in the NUV uses undispersed or dispersed light from the object to be observed. In dispersed light, the total counts from all three stripes are used to maximize the photon counting statistics. There are no appreciably bright airglow lines in the NUV portion of the spectrum, but subarrays are still used to exclude portions of the detector which are not illuminated by the input spectrum or image; this improves accuracy by reducing the contribution from background counts. The subarray dimensions depend on the selected spectral element; see the COS Instrument Handbook for details.

13.5.1 Aperture or FOV

The following apertures are allowed:

- **PSA** Primary Science Aperture
- **BOA** Bright Object Aperture

Use of the BOA is recommended on bright targets to attenuate the flux and allow the acquisition to proceed without triggering bright object violations.

13.5.2 Spectral Element

Enter a spectral element from Table 14.3 for the COS/NUV configuration. If a grating is selected, this will generally be the same as the one used for the subsequent TIME-TAG or ACCUM science observation. If the MIRRORA or MIRRORB spectral element is selected, the search for the target will be done in undispersed light. Use of the MIRRORB spectral element (possibly in conjunction with the BOA aperture) will attenuate the flux and allow undispersed-light acquisitions to be done on targets that would otherwise trigger bright object checks.

13.5.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

*Note:* No wavelength should be specified if MIRRORA or MIRRORB is the spectral element.
13.5.4 Optional Parameters

**SCAN-SIZE**

= 2, 3, 4, 5 (points)

This is a required parameter that specifies the size of the square spiral
search region in terms of the number of dwell points on a side (e.g. 2x2,
3x3, 4x4, or 5x5). A larger search pattern samples a larger area, but the
time required scales as the square of SCAN-SIZE.

*Note:* 2x2 dispersed light searches with the NUV channel should be
avoided in most cases, as simulations show significantly degraded
accuracy; a 2x2 search can even worsen the alignment of a target that is
initially well centered. For more details on target acquisition strategies,
please consult the COS Instrument Handbook.

**STEP-SIZE**

= 1.767 (default); 0.2 - 2.0 (arcsec)

Specifies the size in arcseconds of each step in the spiral search. Both the
PSA and BOA are 2.5 arcsec in diameter. The recommended offset of
1.767 arcsec is the offset at which diagonal dwell points just overlap, and
the maximum spacing that provides continuous coverage. Simulations
show that offsets larger than 1.767 arcsec will introduce errors due to
unsampled areas within the search pattern.

**CENTER**

= FLUX-WT (default), FLUX-WT-FLR, BRIGHTEST

Specifies the method used for locating the target within the search pattern.
Two methods are available: (1) a flux-weighted centroiding algorithm
(FLUX-WT or FLUX-WT-FLR), or (2) a return to the brightest dwell
point (BRIGHTEST).

If FLUX-WT-FLR is used, the minimum number of counts measured from
any of the dwell points (the "floor") will be subtracted from the number at
other dwell points before computing the centroid. The idea behind this
threshold is to reduce the contribution of background counts. Note that this
has the effect of eliminating the dwell point with the minimum counts from
the centroid calculation, which can be a problem with small patterns.

Because of the higher detector background of the NUV detector, use of the
floored threshold is considered necessary to achieve acceptable accuracy
with the flux-weighted centroiding algorithm. The default is to use
FLUX-WT-FLR for a SCAN-SIZE of 3 or larger. For SCAN-SIZE=2,
FLUX-WT performs better and is used as the default. See the COS
Instrument Handbook for recommendations on using these different
methods.
13.5.5 Number of Iterations

The Number_Of_Iterations must be 1 in this Mode.

13.5.6 Time Per Exposure

Enter the total time of data collection at each dwell point as Time_Per_Exposure. Time_Per_Exposure must be an integral multiple of 0.1 seconds. If it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified.

The procedures to determine the exposure time for the ACQ/SEARCH Mode exposure are given in the COS Instrument Handbook. The exposure time will be repeated at every dwell point in the search.

13.5.7 Special Requirements

The special requirement POSition TARGet <X-value>,<Y-value> is not permitted on ACQ/SEARCH exposures.

13.6 Mode = ACQ/IMAGE
Config = COS/NUV

ACQ/IMAGE Mode invokes a procedure in the COS onboard flight software that takes an image in undispersed light using the NUV mirror to center the target within the selected aperture. This procedure consists of several steps.

1. The position of the science aperture on the detector (which may drift with time) is located by flashing the calibration lamp (also in undispersed light) and measuring the location of the calibration image.

2. The target acquisition image is then taken within a 4x4 arcsec subarray centered at the expected center of the science aperture.

3. Next, a 9x9 pixel checkbox is passed across the subarray to identify the region with the maximum counts. Within the checkbox, a flux-weighted centroiding algorithm is used to calculate the expected target position.

4. Finally, HST is repositioned to place that location at the center of the science aperture, and a subsequent exposure is commanded and downlinked to verify that the target ended up in the preferred location.
Use of **ACQ/IMAGE** Mode requires that the science aperture (1.25 arcsec radius) contain appreciable flux from the target. This operation is theoretically limited to sources within 2 arcsec of the center of the aperture; an initial pointing error less than 1.0 arcsec is recommended. If the uncertainty in the initial target position is greater than this, the use of **ACQ/IMAGE** should be preceded by an exposure in **ACQ/SEARCH** mode to locate the target. Details on the target acquisition sequence and limiting magnitudes for the **PSA** and **BOA**, as well as subarray dimensions for the calibration and acquisition images, can be found in the **COS Instrument Handbook**.

### 13.6.1 Aperture or FOV

The following apertures are allowed:

- **PSA** Primary Science Aperture
- **BOA** Bright Object Aperture

### 13.6.2 Spectral Element

Enter either **MIRRORA** or **MIRRORB**. The gratings are not allowed in this Mode. Use of the **MIRRORB** spectral element and/or the **BOA** aperture will attenuate the flux and allow an image acquisition to be done on targets that would otherwise trigger bright object violations.

### 13.6.3 Wavelength

The Wavelength parameter does not apply to this Mode and should be left blank.

### 13.6.4 Optional Parameters

There are no Optional Parameters for this Mode.

### 13.6.5 Number of Iterations

The **Number_Of_Iterations** must be 1 in this Mode.

### 13.6.6 Time Per Exposure

Enter the total time of data collection as **Time_Per_Exposure**. **Time_Per_Exposure** must be an integral multiple of 0.1 seconds. If it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified. This time will
be used both for the acquisition image and the subsequent confirmation image.

The procedures to determine the exposure time for the ACQ/IMAGE exposure are given in the COS Instrument Handbook.

13.6.7 Special Requirements

The special requirement POSition TARGet <X-value>,<Y-value> is not permitted on ACQ/IMAGE exposures.

13.7 Mode = ACQ/PEAKXD
Config = COS/NUV

ACQ/PEAKXD Mode invokes a procedure in the COS onboard flight software that places the target near an optimal position within the selected aperture in the cross-dispersion direction on the detector. This procedure consists of several steps.

1. The optimum cross-dispersion position of the science aperture on the detector is located by flashing the calibration lamp and measuring the mean cross-dispersion location of the calibration spectrum.

2. Then the target spectrum is recorded in dispersed light for the specified period of time, and its mean cross-dispersion position is also computed.

3. Finally, HST is repositioned so that the target location coincides with the optimum cross-dispersion position for the target spectrum within the aperture.

If the target coordinates are not accurate to 0.4", an ACQ/PEAKXD should be preceded by an ACQ/SEARCH to ensure that the target is positioned in the aperture.

Information from the Target List, along with the exposure time, will be used to verify that the integrated target flux through the selected aperture is appropriate for target acquisition. Details on the target acquisition sequence and limiting magnitudes for the PSA and BOA can be found in the COS Instrument Handbook.

In ACQ/PEAKXD Mode, acquisition subarrays are limited to a single stripe. The subarray dimensions may also depend on the selected grating; see the COS Instrument Handbook for details.
13.7.1 Aperture or FOV

The aperture used for the ACQ/PEAKXD Mode exposure will generally be the same as the aperture used for the subsequent TIME-TAG or ACCUM science exposures. The following apertures are allowed:

- PSA Primary Science Aperture
- BOA Bright Object Aperture

As with spectroscopic observations, use of the BOA is recommended on relatively bright targets to attenuate the flux and allow the acquisition to proceed without triggering bright object violations.

13.7.2 Spectral Element

Enter one of the gratings from Table 13.3 for the COS/NUV configuration. This will generally be the same as the one used for the subsequent TIME-TAG or ACCUM science observation. This Mode only uses dispersed light, so the mirror may not be used.

13.7.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

13.7.4 Optional Parameters

STRIPE

= DEF (default), SHORT, MEDIUM, LONG

Identifies the spectral stripe to use for the acquisition subarray. The shortest wavelengths of the spectrum are projected onto the stripe designated by SHORT, wavelengths in the middle of the range onto the stripe designated by MEDIUM, and the longest wavelengths onto the stripe designated by LONG. See the COS Instrument Handbook for the mapping between the selected spectral wavelength and the wavelength coverage in each stripe.

There are special restrictions with the G230L grating, which positions first-order light on the detector only for certain stripes. The MEDIUM stripe is required for the 2635 central wavelength, the SHORT stripe is required for the 3360 wavelength, and either SHORT or MEDIUM may be used for the 2950 and 3000 wavelengths. The LONG stripe may not be used with G230L at all.

Note: A value of DEF is normally the same as MEDIUM. The one exception is with the G230L grating and the 3360 wavelength, where only the SHORT stripe is allowed. The middle stripe (MEDIUM) is preferred.
because the flight software only stores the cross-dispersion offset between the location of the calibration spectrum and the optimal location of the science spectrum for that stripe. The true offset varies by +/- 2.5 pixels between stripes, so there will be a slight error in the calculated "optimal" position of the target spectrum if SHORT or LONG is used. This might cause a small drop in flux, but is not expected to affect the success of target acquisition.

13.7.5 Number of Iterations

The Number_Of_Iterations must be 1 in this Mode.

13.7.6 Time Per Exposure

Enter the total time of data collection as Time_Per_Exposure. Time_Per_Exposure must be an integral multiple of 0.1 seconds. If it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified.

The procedures to determine the exposure time for the ACQ/PEAKXD exposure are given in the COS Instrument Handbook.

13.7.7 Special Requirements

The special requirement POSition TARGet <X-value>,<Y-value> is not permitted for ACQ/PEAKXD exposures.

13.8 Mode = ACQ/PEAKD  
Config = COS/NUV

ACQ/PEAKD Mode invokes a procedure in the COS onboard flight software that takes a series of exposures at different HST pointings offset in the dispersion direction, and the HST is repositioned to maximize (peak up) the light intensity through the COS aperture.

The visual magnitude from the Target List, along with the exposure time, will be used to verify that the integrated target flux through the selected aperture is appropriate for target acquisition. Details on the target acquisition sequence and limiting magnitudes for the PSA and BOA can be found in the COS Instrument Handbook.

An ACQ/PEAKD should always be preceded by an ACQ/PEAKXD exposure. In addition, if the target coordinates are not accurate to 0.4", the ACQ/PEAKD should be preceded by both ACQ/SEARCH and
ACQ/PEAKXD exposures to ensure that the target is positioned in the aperture and well centered in the cross-dispersion direction.

There are no appreciably bright airglow lines in the NUV portion of the spectrum, but subarrays are still used to exclude portions of the detector which are not illuminated by the input spectrum or image; this improves accuracy by reducing the contribution from background counts. The subarray dimensions depend on the selected grating; see the COS Instrument Handbook for details. For this Mode, there is no need to specify the spectral stripe as in ACQ/PEAKXD Mode because the subarrays include counts from all stripes to maximize the photon counting statistics.

13.8.1 Aperture or FOV

The aperture used for the ACQ/PEAKD Mode exposure will generally be the same as the aperture used for the subsequent TIME-TAG or ACCUM science exposures. The following apertures are allowed:

- **PSA** Primary Science Aperture
- **BOA** Bright Object Aperture

Use of the BOA is recommended on relatively bright targets to attenuate the flux and allow the acquisition to proceed without triggering bright object violations.

13.8.2 Spectral Element

Enter one of the gratings from Table 13.3 for the COS/NUV configuration. This will generally be the same as the one used for the subsequent TIME-TAG or ACCUM science observation. This Mode only uses dispersed light, so the mirror may not be used.

13.8.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

13.8.4 Optional Parameters

**NUM-POS**

= 3, 5(default), 7, 9 (points)

Specifies the number of dwell positions (including the initial target position) in an ACQ/PEAKD scan. The time required for the scan scales with the number of positions. When the flux-weighted centroid centering method with the “flooring” option is used (the default), increasing the
number of positions will improve the accuracy, but simulations show that value of a 5 does almost as well as 9. For more details consult the COS Instrument Handbook.

**STEP-SIZE**

\[= 0.01 - 2.0 \text{ (arcsec)}\]

This is a required parameter that specifies the size in arcseconds of each step in the linear scan. The optimal step size may depend on the number of positions and the centering method; see the COS Instrument Handbook for details. Note that both the PSA and BOA are 2.5 arcsec in diameter. Assuming the target is already positioned in the aperture, a scan that greatly exceeds the aperture diameter is not likely to be useful.

**CENTER**

\[= \text{DEF (default), FLUX-WT, FLUX-WT-FLR, BRIGHTEST}\]

Specifies the method used for locating the target within the search pattern. Two methods are available: (1) a flux-weighted centroiding algorithm (FLUX-WT or FLUX-WT-FLR), or (2) a return to the brightest dwell point (BRIGHTTEST).

If FLUX-WT-FLR is used, the minimum number of counts measured from any of the dwell points will be subtracted from the number at other dwell points before computing the centroid. The idea behind this threshold is to reduce the contribution of background counts and extreme points at the edges of the scan.

See the COS Instrument Handbook for recommendations on when to use these different methods.

### 13.8.5 Number of Iterations

The **Number_Of_Iterations** must be 1 in this Mode.

### 13.8.6 Time Per Exposure

Enter the total time of data collection as **Time_Per_Exposure**. **Time_Per_Exposure** must be an integral multiple of 0.1 seconds. If it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified.

The procedures to determine the exposure time for the ACQ/PEAKD exposure are given in the COS Instrument Handbook.
13.8.7 Special Requirements

The special requirement POSition TARGet <X-value>,<Y-value> is not permitted for ACQ/PEAKXD exposures.
OBSERVING MODES

13.9 Mode = TIME-TAG  
Config = COS/FUV

In TIME-TAG Mode, the COS FUV detector produces an event stream with a time resolution of 32 milliseconds. The X and Y pixel coordinates of each photon event are stored in a 32-bit word in data buffer memory. At the start of an exposure and after every subsequent 32-millisecond period which contains photon events, a 32-bit time-of-day word is written to the data memory. The TIME-TAG is the recommended data-taking mode unless the target’s brightness leads to a total count rate in excess of that supported by this mode.

13.9.1 Aperture or FOV

The following apertures are allowed:

- PSA Primary Science Aperture
- BOA Bright Object Aperture
- WCA Wavelength Calibration Aperture; required for Target=WAVE

13.9.2 Spectral Element

Enter a spectral element from Table 13.3 for the COS/FUV configuration.

13.9.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.
13.9.4 Optional Parameters

**SEGMENT**

- **BOTH** (default except for G140L, $\lambda=1105$ Å)
- **A** (default and only allowed value for G140L, $\lambda=1105$ Å)
- **B**

Specifies which segment of the FUV detector to use for an observation. A value of **BOTH** will activate both segments. If **A** is selected, only segment A of the detector will be activated for photon detection, and the spectrum will contain data from only that half of the detector. If **B** is selected, only segment B of the detector will be activated and used to generate data. The use of only a single segment may be warranted with sources that are too bright to observe safely over the entire detector, or when a source has a much higher expected count rate in one segment than the other and the important science is in the segment with the low count rate. See the COS Instrument Handbook for more information.

If you specify grating G140L with the 1105 Angstrom wavelength setting, **SEGMENT** defaults to **A**. For all other grating, central wavelength settings, **BOTH** is the default.

**BUFFER-TIME**

- 80 or greater (integer seconds)

Specifies the estimated minimum time in which $2.35 \times 10^6$ photon events (half of the COS data buffer capacity) will be accumulated during a **TIME-TAG** exposure. **BUFFER-TIME** is a required parameter if the target is not **WAVE**. If the target is **WAVE**, then **BUFFER-TIME** may not be specified.

If the predicted total number of events from a **TIME-TAG** exposure exceeds the COS data buffer capacity of $4.7 \times 10^6$ photon events, data must be transferred to the HST onboard science recorder during the exposure. Transfers of data from the COS buffer during an exposure will be made in 9-MByte blocks (half the buffer capacity). The value of **BUFFER-TIME** should be the half-buffer capacity ($2.35 \times 10^6$ counts) divided by the estimated maximum average count rate in photons per second.

Note that **BUFFER-TIME** should include expected counts from the detector dark current and stim pulses (see the COS Instrument Handbook) as well as the detected photon events, factoring in the instrument quantum efficiency. A conservative value of **BUFFER-TIME** is recommended (err slightly on the low side) to avoid data loss.

The absolute minimum **BUFFER-TIME** of 80 seconds corresponds to a maximum average count rate of $\sim 30,000$ counts/sec over the entire detector, which is the maximum rate at which the flight software is capable of processing counts. The COS Exposure Time Calculator (ETC) should be
used to estimate a suitable value for **BUFFER-TIME**. See the COS Instrument Handbook for more information.

**EXTENDED**

= **NO** (default), **YES**

Indicates whether the target is an extended source. This parameter is used only for data reduction.

**FP-POS**

= **ALL 1, 2, 3** (pre-Cycle 19 default), **4**

This optional parameter is **required** for external and **WAVE** targets. It specifies whether to take the exposure at a single offset, at multiple offsets, or at no offset from the nominal central wavelength. Obtaining exposures at small wavelength offsets from the specified central wavelength aids in the correction of the fixed-pattern defects of the detector. For the best data quality, we strongly recommend using all four FP-POS positions (the value **ALL**).

For **FP-POS=All** the specified exposure time will not be split for external targets (i.e., it is the exposure time for each FP-POS exposures).

The values **FP-POS=1, 2, or 4** will result in the exposure being taken at an offset from the specified central wavelength. **FP-POS=3** will result in the exposure being obtained at the nominal central wavelength (i.e., at zero offset). The exposure will be for the specified exposure duration. See the COS Instrument Handbook for specifics of the offsets and for guidance on how to use this capability.

*Note for internal targets*: **FP-POS** is not allowed for internal targets except Target=**WAVE**. Allowed values for exposures with Target=**WAVE** are **FP-POS=1, 2, 3** or **4**.

**FLASH**

= **YES** (default), **NO**

Indicates whether or not to "flash" the wavelength calibration lamp during exposures. These flashes are needed to compensate for the effect of post-move drift of the Optic Select Mechanisms. The default behavior will be that the wavecal lamp is turned on briefly at the start of an externally targeted exposure, and at intervals later in the exposure. The grating-dependent "flash" durations and the time-since-move-dependent flash intervals will be defined by the STScI. Specifying the value **NO** will disable automatic flashing for the current exposure.

*Note*: For the **G130M** λ=1105 and 1096 Å settings, the default flash durations could be larger than the science exposure times. In these cases **FLASH** should be set to **NO** (but mechanism drifts of zero point offsets of the wavelength scales will not be corrected).
When flashing is enabled, the exposure time must be at least as long as a single flash. Flash durations, as functions of grating and central wavelength, are given in Table 13.5.

When aperture BOA is selected, FLASH may not be specified and defaults to NO.

13.9.5 Number_Of_Iterations

Number_Of_Iterations must be 1 in this Mode.

13.9.6 Time Per Exposure

Enter the total time of data collection as Time_Per_Exposure. Time_Per_Exposure must be an integral multiple of 0.1 seconds (if it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified), and may range from 0.1 to 6500 seconds. Values much larger than 3000 seconds are normally appropriate only for visits with the CVZ special requirement.

For Target=WAVE, enter DEF for Time_Per_Exposure.

If BUFFER-TIME < 110 seconds, photon events may be generated faster than data can be transferred out of the buffer during the exposure. In this case, Time_Per_Exposure should be less than or equal to 2 * BUFFER-TIME so that the exposure can complete before data transfer is necessary. A BUFFER-TIME of 110 seconds corresponds to an average count rate of ~21,000 counts/sec.

Note that TIME-TAG exposures have the potential to rapidly use up the HST onboard storage capacity. Caution is advised on any exposure with an exposure time greater than 25 * BUFFER-TIME, which corresponds to ~6 x 10^7 counts, or about 2 GBits (close to 20% of the solid-state recorder capacity).

13.9.7 Special Requirements

The special requirement RT ANALYSIS is not permitted on TIME-TAG exposures.
13.10 Mode = ACCUM  
Config = COS/FUV

In ACCUM Mode, the detector coordinates of each photon event are used to reference a 16-bit word in a memory array, which is incremented as each event occurs. An ACCUM mode image in the COS/FUV configuration is 16,384 x 128 pixels in each of the two detector segments. The COS data buffer can hold two such images, assuming both segments are used. ACCUM should be used only when absolutely necessary, such as for high count-rate targets. TIME-TAG is the recommended data-taking mode unless the target’s brightness leads to a total count rate in excess of that possible with this mode.

13.10.1 Aperture or FOV

The following apertures are allowed:

PSA Primary Science Aperture
BOA Bright Object Aperture

13.10.2 Spectral Element

Enter a spectral element from Table 13.3 for the COS/FUV configuration.

13.10.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

13.10.4 Optional Parameters

```
SEGMENT
  = BOTH (default except for G140L, \( \lambda = 1105 \text{ Å} \))
  = A (default and only allowed value for G140L, \( \lambda = 1105 \text{ Å} \))
  = B

This is the same as in TIME-TAG Mode; see Section 13.9.
```

```
EXTENDED
  = NO (default), YES

Indicates whether the target is an extended source. This parameter is used only for data reduction.
```
**FP-POS**

= ALL, 1, 2, 3 (pre-Cycle 19 default), 4

This optional parameter is **required** for external and WAVE targets. It specifies whether to take the exposure at a single offset, at multiple offsets, or at no offset from the nominal central wavelength. Obtaining exposures at small wavelength offsets from the specified central wavelength aids in the correction of the fixed-pattern defects of the detector. For the best data quality, we strongly recommend using all four FP-POS positions (value **ALL**).

**FP-POS=ALL** indicates that the specified exposure time will be the exposure time for each FP-POS position.

The values **FP-POS=1, 2** or **4** will result in the exposure being taken at an offset from the specified central wavelength. **FP-POS=3** will result in the exposure being obtained at the nominal central wavelength (i.e., at a zero offset). The exposure will be for the specified exposure duration. See the COS Instrument Handbook for specifics of the offsets and for guidance on how to use this capability.

---

**13.10.5 Number of Iterations**

Enter the number of times this exposure should be iterated, and the exposure time (**Time_Per_Exposure**) per iteration.

**13.10.6 Time Per Exposure**

**Time_Per_Exposure** must be an integral multiple of 0.1 seconds (if it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified), and may range from 0.1 to 6500 seconds. Values much larger than 3000 seconds are normally appropriate only for visits with the CVZ special requirement.

Note: ACCUM Mode exposures longer than 900 seconds using the G130M or G160M gratings may blur the FUV spectra by 1-2 pixels (~1/6 to 1/3 of a resolution element) due to wavelength dependent deviations from the mean Doppler correction.
13.11 Mode = TIME-TAG  
Config = COS/NUV

In TIME-TAG mode, the COS detectors produce an event stream with a time resolution of 32 millisec. The X and Y pixel coordinates of each photon event are stored in a 32-bit word in data buffer memory. At the start of an exposure, and after every subsequent 32 millisec interval which contains photons events, a 32-bit time-of-day word is written to the data memory.

13.11.1 Aperture or FOV
Allowed apertures for this mode are:
   - PSA: Primary Science Aperture
   - BOA: Bright Object Aperture
   - WCA Wavelength Calibration Aperture; required for Target=WAVE

13.11.2 Spectral Element
See Table 13.3: COS Spectral Elements and Central Wavelengths.

13.11.3 Wavelength
Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

Note: No wavelength should be specified if MIRRORA or MIRRORB is the Spectral Element.

13.11.4 Optional Parameters

   BUFFER-TIME
   = 80 or greater (integer seconds)

Specifies the estimated minimum time in which $2.35 \times 10^6$ photon events (half of the COS data buffer capacity) will be accumulated during a TIME-TAG exposure. BUFFER-TIME is a required parameter if the target is not WAVE. If the target is WAVE, then BUFFER-TIME may not be specified.

If the predicted total number of events from a TIME-TAG exposure exceeds the COS data buffer capacity of $4.7 \times 10^6$ photon events, data must be transferred to the HST onboard science recorder during the exposure.
Transfers of data from the COS buffer during an exposure will be made in 9-MByte blocks (half the buffer capacity). The value of \texttt{BUFFER-TIME} should be the half-buffer capacity \((2.35 \times 10^6 \text{ counts})\) divided by the estimated maximum average count rate in photons per second.

Note that \texttt{BUFFER-TIME} should include expected counts from the detector dark current (see the COS Instrument Handbook) as well as the detected photon events, factoring in the instrument quantum efficiency. A conservative value of \texttt{BUFFER-TIME} is recommended (err slightly on the low side) to avoid data loss.

The absolute minimum \texttt{BUFFER-TIME} of 80 seconds corresponds to a maximum average count rate of \(~30,000 \text{ counts/sec}\) over the entire detector, which is the maximum rate at which the flight software is capable of processing counts.

\begin{itemize}
\item \texttt{EXTENDED} = NO (default), YES
\end{itemize}

Indicates whether the target is an extended source. This parameter is used only for data reduction.

\begin{itemize}
\item \texttt{FP-POS} = All, 1, 2, 3 (pre-Cycle 19 default), 4
\end{itemize}

This optional parameter is \textbf{required} for external and \texttt{WAVE} targets. It specifies whether to take the exposure at a single offset, at multiple offsets, or at no offset from the nominal central wavelength. Obtaining exposures at small wavelength offsets from the specified central wavelength aids in the correction of the fixed-pattern defects of the detector. For the best data quality, we strongly recommend using all four \texttt{FP-POS} positions (value \texttt{ALL}).

\texttt{FP-POS=All} indicates that the specified exposure time will be the exposure time for each \texttt{FP-POS} position.

The values \texttt{FP-POS=1}, \texttt{2} or \texttt{4} will result in the exposure being taken at an offset from the specified central wavelength. \texttt{FP-POS=3} will result in the exposure being obtained at the nominal central wavelength (i.e., at a zero offset). The exposure will be for the specified exposure duration. See the COS Instrument Handbook for specifics of the offsets and for guidance on how to use this capability.

\textbf{Note:} \texttt{FP-POS} is not allowed to be specified when the spectral element is \texttt{MIRRORA} or \texttt{MIRRORB}.

\textbf{Note for internal targets:} \texttt{FP-POS} is not allowed for internal targets except \texttt{Target=WAVE}. Allowed values for exposures with \texttt{Target=WAVE} are \texttt{FP-POS=1, 2, 3} or \texttt{4}.
FLASH
    = YES (default), NO
Indicates whether or not to "flash" the wavelength calibration lamp during exposures. These flashes are needed to compensate for the effect of post-move drift of the Optic Select Mechanisms. The default behavior will be that the wavecal lamp is turned on briefly at the start of an externally targeted exposure, and at intervals later in the exposure. The grating-dependent "flash" durations and the time-since-move-dependent flash intervals will be defined by the STScI. Specifying the value NO will disable automatic flashing for the current exposure.

Note: FLASH is not allowed to be specified (and defaults to NO) when the spectral element is MIRRORA or MIRRORB, or the aperture is BOA.

When flashing is enabled, the exposure time must be at least as long as a single flash. Flash durations, as functions of grating and central wavelength, are given in Table 13.5.

13.11.5 Number of Iterations
Number_Of_Iterations must be 1 in this Mode.

13.11.6 Time Per Exposure
Enter the total time of data collection as Time_Per_Exposure. Time_Per_Exposure must be an integral multiple of 0.1 seconds (if it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified), and may range from 0.1 to 6500 seconds. Values much larger than 3000 seconds are normally appropriate only for visits with the CVZ special requirement.

For Target=WAVE, enter DEF for Time_Per_Exposure.

If BUFFER-TIME < 110 seconds, photon events may be generated faster than data can be transferred out of the buffer during the exposure. In this case, Time_Per_Exposure should be less than or equal to 2 * BUFFER-TIME so that the exposure can complete before data transfer is necessary. A BUFFER-TIME of 110 seconds corresponds to an average count rate of ~21,000 counts/sec.

Note that TIME-TAG exposures have the potential to rapidly use up the HST onboard storage capacity. Caution is advised on any exposure with an exposure time greater than 25 * BUFFER-TIME, which corresponds to ~6 x 10^7 counts, or about 2 GBits (close to 20% of the solid-state recorder capacity).
13.11.7 Special Requirements

The special requirement RT ANALYSIS is not permitted on TIME-TAG exposures.

13.12 Mode = ACCUM
Config = COS/NUV

In ACCUM Mode, the detector coordinates of each photon event are used to reference a 16-bit word in a memory array, which is incremented, as each event occurs. An ACCUM mode image in the COS/NUV configuration is 1024 x 1024 pixels. The COS data buffer can hold 9 such images. ACCUM should be used only when absolutely necessary, such as for high count-rate targets. TIME-TAG is the recommended data-taking mode unless the target’s brightness leads to a total count rate in excess of that possible with this mode.

13.12.1 Aperture or FOV

The following apertures are allowed:

PSA Primary Science Aperture
BOA Bright Object Aperture

13.12.2 Spectral Element

Enter a spectral element from Table 13.3 for the COS/NUV configuration.

13.12.3 Wavelength

Enter the value of the central wavelength in Angstroms. Table 13.3 gives the allowed values of the central wavelength for each grating.

Note: No wavelength should be specified if MIRRORA or MIRRORB is the spectral element.

13.12.4 Optional Parameters

EXTENDED
= NO (default), YES
Indicates whether the target is an extended source. This parameter is used only for data reduction.
FP-POS
   = All, 1, 2, 3 (pre-Cycle 19 default), 4
This optional parameter is \textbf{required} for external and WAVE targets. It specifies whether to take the exposure at a single offset, at multiple offsets, or at no offset from the nominal central wavelength. Obtaining exposures at small wavelength offsets from the specified central wavelength aids in the correction of the fixed-pattern defects of the detector. For the best data quality, we strongly recommend using all four FP-POS positions (value \textbf{ALL}).

FP-POS=\textbf{All} indicates that the specified exposure time will be the exposure time for each FP-POS position.

The values FP-POS=1, 2 or 4 will result in the exposure being taken at an offset from the specified central wavelength. FP-POS=3 will result in the exposure being obtained at the nominal central wavelength (i.e., at a zero offset). The exposure will be for the specified exposure duration. See the COS Instrument Handbook for specifics of the offsets and for guidance on how to use this capability.

\textit{Note:} FP-POS is not allowed to be specified when the spectral element is MIRRORA or MIRRORB.

13.12.5 Number of Iterations
Enter the number of times this exposure logsheet line should be iterated, and the exposure time (\textit{Time Per Exposure}) per iteration.

13.12.6 Time Per Exposure
\textit{Time Per Exposure} must be an integral multiple of 0.1 seconds (if it is not, its value will be rounded down to the next lower integral multiple of 0.1 sec, or set to 0.1 seconds if a smaller value is specified), and may range from 0.1 to 6500 seconds. Values much larger than 3000 seconds are normally appropriate only for visits with the CVZ special requirement.
13.13 COS Apertures

Valid COS apertures are listed in Table 13.2 below. Science observations should use the PSA or BOA apertures. The BOA aperture is the same size as the PSA but contains a neutral-density filter that attenuates the source by a factor of ~200. The WCA is intended for wavelength calibrations using the WAVE target.

Table 13.2: COS Apertures

<table>
<thead>
<tr>
<th>Aperture</th>
<th>Definition</th>
<th>Size</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSA</td>
<td>Primary Science Aperture</td>
<td>2.5 arc-seconds</td>
<td>Default science aperture</td>
</tr>
<tr>
<td>BOA</td>
<td>Bright Object Aperture</td>
<td>2.5 arc-seconds</td>
<td>Contains neutral density filter (ND2) for bright objects</td>
</tr>
<tr>
<td>WCA</td>
<td>Wavelength Calibration Aperture</td>
<td>20 microns (dispersion) x 100 microns (cross-dispersion)</td>
<td>Wavelength Calibrations</td>
</tr>
</tbody>
</table>

13.14 COS Spectral Elements and Central Wavelengths

The following table specifies the legal COS spectral element/wavelength combinations for the COS/FUV and COS/NUV configurations.
Note: the wavelengths in this table are listed in OP-01, Rev 17 (Feb.6, 2002).

Table 13.3: COS Spectral Elements and Central Wavelengths

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Spectral Element</th>
<th>Central Wavelengths (Angstroms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COS/FUV</td>
<td>G130M</td>
<td>1055, 1096 (not allowed for ACQ modes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1291, 1300, 1309, 1318, 1327</td>
</tr>
<tr>
<td></td>
<td>G140L</td>
<td>1105, 1280</td>
</tr>
<tr>
<td></td>
<td>G160M</td>
<td>1577, 1589, 1600, 1611, 1623</td>
</tr>
<tr>
<td></td>
<td>G225M</td>
<td>2186, 2217, 2233, 2250, 2268, 2283, 2306, 2325, 2339, 2357, 2373, 2390, 2410</td>
</tr>
<tr>
<td></td>
<td>G230L</td>
<td>2635, 2950, 3000, 3360</td>
</tr>
<tr>
<td></td>
<td>G285M</td>
<td>2617, 2637, 2657, 2676, 2695, 2697, 2709, 2719, 2739, 2850, 2952, 2979, 2996, 3018, 3035, 3057, 3074, 3094</td>
</tr>
<tr>
<td>MIRRORA¹</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>MIRRORB²</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

1. The MIRRORA spectral element positions a flat mirror in the beam to produce an image of the sky with a field of view slightly larger than the diameter of the aperture. If you intend to produce an image and there are no special bright object concerns, MIRRORA should be used. Restricted for wavecals and forbidden for flats.
2. MIRRORB uses the same mirror which has an order-blocking filter in front of it, so that the light is reflected off the front surface of the filter rather than the mirror itself. MIRRORB attenuates the image and is suitable for use with bright objects.

13.15 COS Internal Calibration Targets

The following internal calibration targets are available for the COS. These should not be included in your proposal if the routine calibrations are sufficient for your program. See the COS Instrument Handbook for details.

Table 13.4: Internal Calibration Targets for COS

<table>
<thead>
<tr>
<th>Target Name</th>
<th>Mode</th>
<th>Description</th>
<th>Aperture and Spectral Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAVE¹</td>
<td>TIME-TAG</td>
<td>A wavelength calibration exposure for the grating and central wavelength being used for the spectroscopic science observations. The number of iterations must be 1.</td>
<td>Aperture = WCA, Spectral Element = Any element from Table 13.3² except MIRRORA and MIRRORB</td>
</tr>
</tbody>
</table>
1. Exposures specified with the WAVE internal target will use the same calibration lamp configuration and exposure time as the automatic wave calibrations discussed below (based on the spectral element and central wavelength used). Unless specifically requested in the Exposure Specification, a TIME-TAG Mode wavelength calibration will be automatically performed for each set of external spectrographic science exposures using the same spectral element, central wavelength, and OSM offset, including each subexposure of an exposure specification with optional parameter **FP-POS=ALL**. A wavelength calibration exposure will be added prior to the first such science exposure and after each subsequent science exposure if more than 40 minutes of visibility time have elapsed since the previous wavelength calibration exposure. The calibration lamp configuration and exposure time will be based on the grating and central wavelength of the science exposure. For a detailed description of wavelength calibration exposures, see the COS Instrument Handbook.

2. **DEF** = same as the prior or subsequent spectroscopic science observation (i.e., if no element is specified, then the previously used one is assumed.

## 13.16 WAVECAL Exposure Parameters

Table 13.5 lists the exposure times and current settings for the wavelength calibration lamp exposures as a function of spectral element and central wavelength\(^1\)

Table 13.5: WAVECAL Exposure Parameters

<table>
<thead>
<tr>
<th>Grating</th>
<th>Central Wavelength (Å)</th>
<th>Lamp Current Specification</th>
<th>Exposure Time (seconds)</th>
<th>BUFFER TIME (sec)</th>
<th>Flash Duration (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G130M</td>
<td>1055</td>
<td>MEDIUM</td>
<td>102</td>
<td>510</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>1096</td>
<td>MEDIUM</td>
<td>35</td>
<td>180</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>1291</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1300</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1309</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1318</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1327</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td>G160M</td>
<td>1577</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1589</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1600</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1611</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1623</td>
<td>MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td>G140L</td>
<td>1105</td>
<td>MEDIUM</td>
<td>7</td>
<td>120</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>1230</td>
<td>MEDIUM</td>
<td>7</td>
<td>120</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>1280</td>
<td>MEDIUM</td>
<td>7</td>
<td>120</td>
<td>7</td>
</tr>
</tbody>
</table>
Table 13.5: WAVECAL Exposure Parameters (Cont)

<table>
<thead>
<tr>
<th>Grating</th>
<th>Central Wavelength (Å)</th>
<th>Lamp Current Specification</th>
<th>Exposure Time (seconds)</th>
<th>BUFFER TIME (sec)</th>
<th>Flash Duration (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G185M</td>
<td>1786 MEDIUM</td>
<td>12</td>
<td>220</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1817 MEDIUM</td>
<td>12</td>
<td>220</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1835 MEDIUM</td>
<td>12</td>
<td>240</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1850 MEDIUM</td>
<td>22</td>
<td>180</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1864 MEDIUM</td>
<td>32</td>
<td>180</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1882 MEDIUM</td>
<td>17</td>
<td>120</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1890 MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1900 MEDIUM</td>
<td>22</td>
<td>140</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1913 MEDIUM</td>
<td>17</td>
<td>140</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1921 MEDIUM</td>
<td>12</td>
<td>140</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1941 MEDIUM</td>
<td>12</td>
<td>180</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1953 MEDIUM</td>
<td>17</td>
<td>180</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1971 MEDIUM</td>
<td>17</td>
<td>180</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1986 MEDIUM</td>
<td>12</td>
<td>180</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2010 MEDIUM</td>
<td>12</td>
<td>180</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>G225M</td>
<td>2186 MEDIUM</td>
<td>7</td>
<td>120</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2217 MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2233 MEDIUM</td>
<td>7</td>
<td>120</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2250 MEDIUM</td>
<td>2</td>
<td>120</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2268 MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2283 MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2306 MEDIUM</td>
<td>12</td>
<td>120</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2325 MEDIUM</td>
<td>12</td>
<td>280</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2339 MEDIUM</td>
<td>12</td>
<td>280</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2357 MEDIUM</td>
<td>12</td>
<td>240</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2373 MEDIUM</td>
<td>22</td>
<td>240</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2390 MEDIUM</td>
<td>7</td>
<td>240</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2410 MEDIUM</td>
<td>7</td>
<td>280</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Table 13.5: WAVECAL Exposure Parameters (Cont)

<table>
<thead>
<tr>
<th>Grating</th>
<th>Central Wavelength (Å)</th>
<th>Lamp Current Specification</th>
<th>Exposure Time (seconds)</th>
<th>BUFFER TIME (sec)</th>
<th>Flash Duration (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G285M</td>
<td>2617</td>
<td>MEDIUM</td>
<td>12</td>
<td>300</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>2637</td>
<td>MEDIUM</td>
<td>12</td>
<td>300</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>2657</td>
<td>MEDIUM</td>
<td>7</td>
<td>300</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>2676</td>
<td>MEDIUM</td>
<td>22</td>
<td>300</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>2695</td>
<td>MEDIUM</td>
<td>22</td>
<td>330</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>2709</td>
<td>MEDIUM</td>
<td>12</td>
<td>330</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>2719</td>
<td>MEDIUM</td>
<td>7</td>
<td>330</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>2739</td>
<td>MEDIUM</td>
<td>7</td>
<td>430</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>2850</td>
<td>MEDIUM</td>
<td>22</td>
<td>430</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>2952</td>
<td>MEDIUM</td>
<td>7</td>
<td>430</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>2979</td>
<td>MEDIUM</td>
<td>17</td>
<td>430</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>2996</td>
<td>MEDIUM</td>
<td>17</td>
<td>140</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>3018</td>
<td>MEDIUM</td>
<td>22</td>
<td>140</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>3035</td>
<td>MEDIUM</td>
<td>27</td>
<td>160</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>3057</td>
<td>MEDIUM</td>
<td>32</td>
<td>160</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>3074</td>
<td>MEDIUM</td>
<td>32</td>
<td>160</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>3094</td>
<td>MEDIUM</td>
<td>32</td>
<td>160</td>
<td>32</td>
</tr>
<tr>
<td>G230L</td>
<td>2635</td>
<td>MEDIUM</td>
<td>7</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>2950</td>
<td>MEDIUM</td>
<td>7</td>
<td>180</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>MEDIUM</td>
<td>7</td>
<td>180</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>3360</td>
<td>MEDIUM</td>
<td>12</td>
<td>140</td>
<td>12</td>
</tr>
<tr>
<td>MIRRORA</td>
<td>3360</td>
<td>MEDIUM</td>
<td>7</td>
<td>80</td>
<td>7</td>
</tr>
<tr>
<td>MIRRORB</td>
<td>3360</td>
<td>MEDIUM</td>
<td>27</td>
<td>80</td>
<td>27</td>
</tr>
</tbody>
</table>
13.17 COS Coordinate System

Knowledge of the COS coordinate system relative to the spacecraft coordinate system is necessary to use the POSition TARGet $<X\text{-value}>,<Y\text{-value}>$ Special Requirement properly. The figure below shows the sense of the U2 and U3 axes relative to the COS apertures.

Figure 13.1: COS Aperture Coordinate System
CHAPTER 14: Wide Field Camera 3 (WFC3)

In this chapter . . .

14.1 Introduction to WFC3 / 292
14.2 Mode = ACCUM Config = WFC3/UVIS / 293
14.3 Mode = MULTIACCUM Config = WFC3/IR / 297
14.4 Tabular Reference Data / 308
14.5 WFC3 Aperture Coordinate System / 312
14.1 Introduction to WFC3

The Instrument Configurations and Operating Modes described in the following section are used to define exposures on the Visit and Exposure Specifications. The legal Visit and Exposure Specifications entries are summarized in the following sections. More complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, Detector Characteristics, etc. are available in the WFC3 Instrument Handbook.

Note that many of the Optional Parameters have default values; in such cases, an entry for an Optional Parameter in the Visit and Exposure Specifications is necessary only if it is desired to override the default value. The physical units of Optional Parameter quantities are always implicit and should never be entered by the observer.

Table 14.1 lists the permitted WFC3 Instrument Configurations, Operating Modes, Apertures, Spectral Elements, and Optional Parameters.

Table 14.1: Supported Instrument Parameters for WFC3

<table>
<thead>
<tr>
<th>Config</th>
<th>Mode</th>
<th>Aperture</th>
<th>Spectral Elements</th>
<th>Optional Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFC3/UVIS</td>
<td>ACCUM</td>
<td>See Table 14.2: Apertures for WFC3/UVIS</td>
<td>See Table 14.5</td>
<td>CR-SPLIT, BIN, INJECT</td>
</tr>
<tr>
<td>WFC3/IR</td>
<td>MULTIACCUM</td>
<td>See Table 14.3: Apertures for WFC3/IR</td>
<td>See Table 14.6</td>
<td>SAMP-SEQ, NSAMP</td>
</tr>
</tbody>
</table>
14.2 Mode = ACCUM  
Config = WFC3/UVIS

**ACCUM** is the only observing mode for the UVIS channel. Photons are detected in the WFC3 CCD as accumulated charge, which is read out at the end of the exposure and converted to DN. The DN are stored as 16-bit words in a data memory array. Detector dimensions are specified with the parallel direction first and the serial direction second (i.e. row x column). A full detector readout is 4140 rows by 4206 columns, which includes 110 columns of serial overscan (of which 50 are physical and 60 are virtual) and 38 rows of parallel overscan (all virtual). The light sensitive area of the detector is 4102 x 4096 pixels. Subarrays are comprised only of the physical pixels, which are contained within a 4102 x 4146 pixel region. Subarrays may contain light sensitive pixels and physical overscan pixels, but they do not contain virtual pixels.

14.2.1 Aperture or FOV

Observers determine the placement of the FOV of a WFC3 image on a target by specifying the telescope orientation (via the ORIENT special requirement, or by default), the target coordinates, the WFC3 fiducial point, and the WFC3 detector readout. HST will be pointed so that the target is imaged at the fiducial point, plus any displacement from that point, which is specified by the observer with the **POSition** **TARGet** `<X-value>,<Y-value>` special requirement. Each WFC3 Aperture has a predefined fiducial point (Table 14.2), or if a quadrant filter or grism spectral element is used, the fiducial point is determined from the combination of aperture and spectral element in use. The full detector is read out unless the aperture name ends in "SUB".

With regard to fiducial points, two types of apertures are defined in Table 14.2. The first type is designed for placing targets at the “optimum location” of a region on the detector: either the entire 4102x4096 pixel array, one of the two physical 2051x4096 CCD chips, one of the 2051x2048 quadrants of the detector, or within a predefined subarray. These are identified as **UVIS**, **UVIS-CENTER**, **UVIS1**, **UVIS2**, **UVIS-QUAD**, or any aperture with the suffix -SUB, respectively. The default location within these apertures will be routinely adjusted by STScI to reflect any changes in CCD performance (e.g., new charge transfer traps, bad columns, etc.). These apertures are appropriate for targets that are small compared to the scale size of defects in the chips.

The second set of apertures defines the “geometric center” of the region and will remain fixed in aperture coordinates. These will not be adjusted for changes in CCD characteristics. These apertures are designated with the
suffix -FIX, and should be used to specify the location of the target relative to the CCDs. These “geometric center” apertures are appropriate for pointings designed to position an extended scene within the WFC3 FOV. For UVIS-FIX, the “geometric center” is on CCD chip 1, ~10 arcseconds above the gap between the two chips. The fiducial point of the UVIS-IR-FIX aperture is the same as that of the IR-FIX aperture. Switching between the UVIS and IR channels using those two apertures will not cause HST to repoint. The fiducial points of the UVIS1-FIX and UVIS2-FIX apertures are at the centers of those chips.

The UVIS aperture is required for exposures using the G280 spectral element. In this case the STScI ground system will substitute a special aperture that has approximately the same pointing, but is optimized for use with the grism. An undispersed (i.e., bandpass filter) image exposure should be taken in conjunction with the grism exposure using the G280-REF aperture to enable measurement of the grism exposure wavelength zero-point.

The UVIS-QUAD, UVIS-QUAD-FIX, and UVIS-QUAD-SUB apertures are allowed only with one of the quadrant filters (see Table 14.5), and one of these apertures must be specified if a quadrant filter is used. The choice of aperture only affects the telescope pointing; it does not restrict the area of the detector that is read out, except for UVIS-QUAD-SUB which will read out only the quadrant of the detector corresponding to the filter specified.

Apertures with sub-array readouts are provided in order to reduce operational overhead time when imaging targets that do not require the full FOV of the UVIS channel. 2K x 2K apertures for each of the four quadrants are provided (UVIS1-2K2A-SUB, UVIS1-2K2B-SUB, UVIS2-2K2C-SUB, and UVIS2-2K2D-SUB). For the Amplifier C quadrant, 1K x 1K and 512 x 512 subarray apertures are provided both near the center of the FOV (UVIS2-M1K1C-SUB and UVIS2-M512C-SUB), and near the amplifier (UVIS2-C1K1C-SUB and UVIS2-C512C-SUB).
Table 14.2: Apertures for WFC3/UVIS

<table>
<thead>
<tr>
<th>Aperture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVIS</td>
<td>Two-CCD mosaic with the reference point at a targetable location near the geometric center (Optimum Center).</td>
</tr>
<tr>
<td>UVIS-FIX</td>
<td>Initial version of UVIS that remains fixed even if UVIS is modified later. Geometric center of full two-CCD FOV.</td>
</tr>
<tr>
<td>UVIS-CENTER</td>
<td>Two-CCD mosaic with the reference point at the &quot;center&quot; of a distortion corrected view. This point is equidistant from each pair of opposite corners and falls on UVIS2 close to the gap. Useful for designing mosaics, especially if combining images with different orientations.</td>
</tr>
<tr>
<td>UVIS1</td>
<td>Optimum center of CCD 1</td>
</tr>
<tr>
<td>UVIS1-FIX</td>
<td>Geometric center of CCD 1</td>
</tr>
<tr>
<td>UVIS2</td>
<td>Optimum center of CCD 2</td>
</tr>
<tr>
<td>UVIS2-FIX</td>
<td>Geometric center of CCD 2</td>
</tr>
<tr>
<td>UVIS-1R-FIX</td>
<td>Same fiducial point as IR-FIX in Table 14.3</td>
</tr>
<tr>
<td>G280-REF</td>
<td>Grism reference aperture for undispersed exposures</td>
</tr>
<tr>
<td>UVIS-QUAD</td>
<td>Optimum center of quadrant corresponding to selected quadrant filter</td>
</tr>
<tr>
<td>UVIS-QUAD-FIX</td>
<td>Geometric center of quadrant corresponding to selected quadrant filter</td>
</tr>
<tr>
<td>UVIS-QUAD-SUB</td>
<td>Optimum center of the quadrant corresponding to the selected quadrant filter, with a 2050x2072 subarray (includes 23 pixels of the physical overscan and 2049 image pixels) to read out approximately on that quadrant</td>
</tr>
<tr>
<td>UVIS1-2K2A-SUB</td>
<td>2048x2050 full quadrant subarrays (optimum center)</td>
</tr>
<tr>
<td>UVIS1-2K2B-SUB</td>
<td></td>
</tr>
<tr>
<td>UVIS2-2K2C-SUB</td>
<td></td>
</tr>
<tr>
<td>UVIS2-2K2D-SUB</td>
<td></td>
</tr>
<tr>
<td>UVIS2-M1K1C-SUB</td>
<td>1024×1024 subarray, quadrant C near detector center (optimum center)</td>
</tr>
<tr>
<td>UVIS2-C1K1C-SUB</td>
<td>1024×1024 subarray, near amp C (optimum center)</td>
</tr>
<tr>
<td>UVIS2-M512C-SUB</td>
<td>512x512 subarray on CCD 2 near the center of UVIS FOV; for best image quality</td>
</tr>
</tbody>
</table>

14.2.2 Spectral Elements

See Table 14.5: Spectral Elements for use with WFC3/UVIS.

14.2.3 Wavelength

This parameter does not apply to WFC3 observations and should be left blank.
14.2.4 Optional Parameters

**CR-SPLIT**

\[= \text{2 - 8, NO (default)}\]

Specifies the number of sub-exposures into which the original exposure is to be split for the purpose of cosmic ray elimination in post-observation data processing (see the WFC3 Instrument Handbook). The specified exposure time will be divided equally among the number of CR-SPLIT exposures requested. If CR-SPLIT=NO, the exposure is taken without splitting.

If the exposure is a Spatial Scan (See 7.3.3 Special Observation Requirements), numerical values of CR-SPLIT are not permitted.

**BIN**

\[= \text{NONE (default), 2, 3 (pixels)}\]

Specifies the number of CCD pixels in each dimension that are binned to a single signal value as the detector is read out. If the value NONE is specified, or the optional parameter is not provided, the exposure will be read out unbinned. A value of 2 produces 2x2 binning; a value of 3 produces 3x3 binning. See the discussion of binning in the WFC3 Instrument Handbook.

BIN=2 or 3 are not permitted in conjunction with any subarray aperture (-SUB).

**INJECT**

\[= \text{NONE (default), YES}\]

Specifies whether to do charge injection or not. Charge injection is used for correcting the effects of charge transfer inefficiency.

14.2.5 Number of Iterations and Time Per Exposure

Enter the number of times this exposure should be iterated, and the duration in seconds of each iteration. There are many observational situations when two or more identical exposures should be taken of the same field (e.g., to keep a bright object from blooming by keeping the exposure time short). If the Number_Of_Iterations is n, the entire exposure will be iterated n times.

The value entered for the Time_Per_Exposure is the exposure time for each iteration of the specified exposure. For instance, specifying Number_Of_Iterations = 10 and a Time_Per_Exposure of 10 seconds...
will produce a total exposure time of 100 seconds. This differs from the situation with a **CR-SPLIT**, when the total exposure time will be apportioned among shorter exposures: specifying an exposure time of 10 seconds and **CR-SPLIT=2** results in two exposures of 5 seconds each.

Note: **CR-SPLIT** and multiple iterations are mutually exclusive capabilities. If **Number_Of_Iterations > 1**, **CR-SPLIT=NO** must be specified.

**Time_Per_Exposure** must be an integer multiple of 0.1 second and in the range of 0.5 to 3600 sec. The value of 0.6 sec is not allowed.

If the exposure is a **Spatial Scan** (See 7.3.3 Special Observation Requirements) and **Number of Iterations > 1**, a small slew will be inserted between the exposures so the scans will repeat the same path on the detector each time. Depending on detector setup and slew length, this may sacrifice visibility time. Consider alternating the **Scan_Direction** instead.

### 14.2.6 Special Requirements

**SPATIAL SCAN <Scan_Rate>, <Scan_Orient>, <Scan_Direction>**

See Section 7.3.3 Special Observation Requirements for information on executing an exposure as a Spatial Scan. Special Requirement **SAME POSITION AS** is not permitted on and may not refer to a Spatial Scan exposure. Spatial Scan exposures are not permitted in Coordinated Parallel containers or in Pure Parallel visits.

Special requirement **PARallel WITH** is not permitted on and may not refer to a Spatial Scan exposure. Pure Parallel visits may not contain Spatial Scan exposures.

---

### 14.3 Mode = MULTIACCUM

**Config = WFC3/IR**

**MULTIACCUM** is the only observing mode for the IR channel. An exposure in **MULTIACCUM** mode begins with an array reset followed by an initial readout. Next, one or more nondestructive readouts are obtained at user-selectable times. All of the readouts, including the initial readout, are recorded onboard and returned to the ground for analysis. The
difference between each successive pair of reads is the image data accumulated between reads.

There are two major advantages of this approach. First, the multiple readouts provide a way to record what is happening in a pixel before it saturates, increasing dynamic range. Second, the multiple readouts can be compared to remove cosmic ray effects. See the WFC3 Instrument Handbook for more information.

14.3.1 Aperture or FOV

Placement of the target on the detector is controlled by the specified Aperture, the POSition TARGet <X-value>,<Y-value> special requirement (if used), the telescope orientation (via the ORIENTation <angle1> TO <angle2> special requirement or by default), and in some instances according to the Spectral Element. The apertures for the IR channel and their valid combinations with spectral elements are defined in Table 14.3. The current values of the aperture coordinates of the Aperture+Spectral Element combinations in Table 14.3 may be found on the HST Apertures Web Page.

The IR aperture is designed for placing targets at the “optimum center” of the detector. The default location within this aperture will be routinely adjusted by STScI to reflect any changes in detector performance. This aperture is appropriate for targets that are small compared to the scale size of defects in the chips.

The IR-FIX aperture defines the geometric center of the detector and will remain FIXED in aperture coordinates. This location will not be adjusted for changes in detector characteristics, and should be used to specify the location of the target relative to the detector. This geometric center aperture is appropriate for pointings designed to position an extended scene within the WFC3 FOV.

Three apertures are provided that use the same pointing of the telescope as used for three associated UVIS apertures. Using an associated pair of apertures for UVIS and IR exposures will avoid a small angle maneuver between the exposures. The IR apertures are IR-UVIS, IR-UVIS-CENTER, and IR-UVIS-FIX, which are associated with, respectively, the apertures UVIS, UVIS-CENTER, and UVIS-FIX.

IR subarrays are specified by selecting the appropriate aperture. The IRSUBnn or IRSUBnn-FIX apertures will result in the use of the subarray readout mode of the IR detector with the size of the subarray being that indicated by the aperture name (nn = 512, 256, 128, or 64). The use of the subarray readout mode will result in different sample times than for full detector readouts listed in Table 14.4. Not all combinations of subarray size and sample sequence are supported. See the discussion under the
SAMP-SEQ optional parameter (Section 14.3.4) for more details. The subarray readouts will have a border of five reference pixels added around the edge of the subarray used for imaging, making the total data sizes 1024x1024 (full-frame), 74x74, 138x138, 266x266, and 522x522 pixels.

The IRSUBnn apertures will place the target at the "optimum center" of the corresponding subarray; note that these positions may be different for the different subarrays. The default position of each of these apertures will be updated by STScI to reflect changes in instrument performance. These apertures are appropriate for targets that are small compared to the scale size of defects on the detector.

The IRSUBnn-FIX apertures define the geometric center of the subarray and will remain fixed in aperture coordinates. These locations will not be adjusted for changes in detector performance.

Five apertures are specialized for use with the two IR grisms (G102 and G141) and to obtain band pass filter images for use as wavelength zero-point references. According to the FOV, the apertures are named GRISMMmm, where mm = 1024 (full frame), 512, 256, 128, 64. The subarrays are the same as the IRSUBnn apertures. The fiducial pixel for each Aperture+Spectral Element combination is optimized to best position the first-order spectrum in the FOV. For GRISM1024, GRISM512, and GRISM256, the same fiducial pixel is used for G102 and G141 and for reference band pass filter exposures. For GRISM128 and GRISM64 different fiducial pixels are used for G102 and G141 that best center each first-order spectrum in the FOV. The fiducial pixel for a bandpass filter exposure with those two apertures is midway between the two grism fiducial pixels.

Table 14.3: Apertures for WFC3/IR

<table>
<thead>
<tr>
<th>Aperture</th>
<th>Spectral Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>Fnnn</td>
<td>Full frame, Optimum center of detector</td>
</tr>
<tr>
<td>IR-FIX</td>
<td>Fnnn</td>
<td>Full frame, Geometric center of detector</td>
</tr>
<tr>
<td>IR-UVIS</td>
<td>Fnnn</td>
<td>Full frame, Fiducial points match paired UVIS apertures in Table 14.2</td>
</tr>
<tr>
<td>IR-UVIS-CENTER</td>
<td>Fnnn</td>
<td></td>
</tr>
<tr>
<td>IR-UVIS-FIX</td>
<td>Fnnn</td>
<td></td>
</tr>
<tr>
<td>IRSUB64</td>
<td>Fnnn</td>
<td>Optimum center of the 64x64 subarray</td>
</tr>
<tr>
<td>IRSUB64-FIX</td>
<td>Fnnn</td>
<td>Geometric center of the 64x64 subarray</td>
</tr>
<tr>
<td>IRSUB128</td>
<td>Fnnn</td>
<td>Optimum center of the 128x128 subarray</td>
</tr>
<tr>
<td>IRSUB128-FIX</td>
<td>Fnnn</td>
<td>Geometric center of the 128x128 subarray</td>
</tr>
<tr>
<td>IRSUB256</td>
<td>Fnnn</td>
<td>Optimum center of the 256x256 subarray</td>
</tr>
<tr>
<td>IRSUB256-FIX</td>
<td>Fnnn</td>
<td>Geometric center of the 256x256 subarray</td>
</tr>
<tr>
<td>IRSUB512</td>
<td>Fnnn</td>
<td>Optimum center of the 512x512 subarray</td>
</tr>
</tbody>
</table>
14.3.2 Spectral Elements

See Table 14.6: Spectral Elements for use with WFC3/IR.

14.3.3 Wavelength

This parameter should be left blank.

14.3.4 Optional Parameters

\texttt{SAMPSEQ}
\begin{verbatim}
=RAPID, SPARS10, SPARS25, SPARS50, SPARS100, SPARS200, STEP25, STEP50, STEP100, STEP200, STEP400
\end{verbatim}

A required parameter specifying the name of a predefined sequence of times from the start of the exposure at which the nondestructive readouts (samples) are performed. The number of readouts (up to 15, plus one for the initial readout) taken for each exposure is controlled by the \texttt{NSAMP} parameter (see below).

Table 14.4 gives the sample times (defined as the time from the start of the initial readout to the start of a given readout) for each sequence and image size. Different types of sequences are provided. The \texttt{RAPID} sequence provides linear sampling as fast as possible (limited by the readout time for the selected image size) and is intended for bright targets that could saturate in the other sample sequences. All sample sequences with the full detector apertures are supported. But note that only a limited number of combinations of subarray size and sample sequence are supported.
Sequences **STEP25, STEP50, STEP100, STEP200, and STEP400** begin with four rapid samples (five readouts), switch to logarithmic spacing up to the given number of seconds (25-400), and then continue with linear spacing for the remainder of the sequence with adjacent steps separated by 25-400 seconds depending on the selected sequence. These sequences are intended to compensate for any nonlinearities near the start of the exposure and to provide increased dynamic range for images that contain both faint and bright targets.

Sequences **SPARS10, SPARS25, SPARS50, SPARS100, and SPARS200** begin with one rapid sample (two readouts) then provide linear spacing to allow observers to "read up the ramp" at evenly spaced intervals. The variety of sampling intervals allows this basic strategy to be applied over a wide range in target flux.

The different sequences are designed to efficiently fill the target visibility period with one, two, or several exposures. See the WFC3 Instrument Handbook for recommendations on which sequences to use in different situations.

**NSAMP =1-15**

A required parameter specifying the number of samples in a predefined sequence that should actually be taken, not counting the initial readout. Table 14.4 defines 15 sample times for each sequence. If an **NSAMP** value smaller than 15 is used, samples will be taken at only the first **NSAMP** times from this table.

The total number of readouts will be **NSAMP** plus one (for the initial readout, giving a maximum of 16 readouts for a single execution of a MULTIACCUM exposure). Each readout will be recorded and will appear in the final data set.

**14.3.5 Number of Iterations**

Enter the number of times this exposure should be iterated, and the duration in seconds of each iteration. This option should be used in observational situations when two or more identical exposures should be taken of the same field. If the **Number_Of_Iterations** is n, the exposure will be iterated n times.

If the exposure is a Spatial Scan (see Section 7.3.3) and **Number of Iterations** > 1, a small slew will be inserted between the exposures so the scans will repeat the same path on the detector each time. This will sacrifice visibility time. Consider alternating the Scan_Direction instead.
14.3.6 Time Per Exposure

*Time Per Exposure* must be DEF in this Mode. The exposure time is unnecessary, because it is specified by **SAMPSEQ** and **NSAMP**.

Table 14.4 shows the sequence of 15 sample times corresponding to the different **SAMP-SEQ** values, in seconds from the start of the initial readout to the start of the readout for the given sample. These values are given to the nearest millisecond.

**Table 14.4: Predefined Sample Sequences for MULTIACCUM Mode.**

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
<th>512x512</th>
<th>256x256</th>
<th>128x128</th>
<th>64x64</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
<td>0.853</td>
<td>0.278</td>
<td>0.113</td>
<td>0.061</td>
</tr>
<tr>
<td>2</td>
<td>5.865</td>
<td>1.706</td>
<td>0.556</td>
<td>0.225</td>
<td>0.122</td>
</tr>
<tr>
<td>3</td>
<td>8.797</td>
<td>2.559</td>
<td>0.833</td>
<td>0.338</td>
<td>0.182</td>
</tr>
<tr>
<td>4</td>
<td>11.729</td>
<td>3.412</td>
<td>1.111</td>
<td>0.451</td>
<td>0.243</td>
</tr>
<tr>
<td>5</td>
<td>14.661</td>
<td>4.265</td>
<td>1.389</td>
<td>0.564</td>
<td>0.304</td>
</tr>
<tr>
<td>6</td>
<td>17.594</td>
<td>5.118</td>
<td>1.667</td>
<td>0.676</td>
<td>0.365</td>
</tr>
<tr>
<td>7</td>
<td>20.526</td>
<td>5.971</td>
<td>1.945</td>
<td>0.789</td>
<td>0.425</td>
</tr>
<tr>
<td>8</td>
<td>23.458</td>
<td>6.824</td>
<td>2.223</td>
<td>0.902</td>
<td>0.486</td>
</tr>
<tr>
<td>9</td>
<td>26.391</td>
<td>7.677</td>
<td>2.500</td>
<td>1.014</td>
<td>0.547</td>
</tr>
<tr>
<td>10</td>
<td>29.323</td>
<td>8.530</td>
<td>2.778</td>
<td>1.127</td>
<td>0.608</td>
</tr>
<tr>
<td>11</td>
<td>32.255</td>
<td>9.383</td>
<td>3.056</td>
<td>1.240</td>
<td>0.669</td>
</tr>
<tr>
<td>12</td>
<td>35.187</td>
<td>10.236</td>
<td>3.334</td>
<td>1.352</td>
<td>0.729</td>
</tr>
<tr>
<td>13</td>
<td>38.120</td>
<td>11.089</td>
<td>3.612</td>
<td>1.465</td>
<td>0.790</td>
</tr>
<tr>
<td>14</td>
<td>41.052</td>
<td>11.942</td>
<td>3.889</td>
<td>1.578</td>
<td>0.851</td>
</tr>
<tr>
<td>15</td>
<td>43.984</td>
<td>12.795</td>
<td>4.167</td>
<td>1.691</td>
<td>0.912</td>
</tr>
</tbody>
</table>

**SAMP-SEQ=SPARS10**

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
<th>256x256</th>
<th>128x128</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
<td>0.278</td>
<td>0.113</td>
</tr>
<tr>
<td>2</td>
<td>12.933</td>
<td>7.624</td>
<td>7.294</td>
</tr>
<tr>
<td>3</td>
<td>22.934</td>
<td>14.971</td>
<td>14.475</td>
</tr>
<tr>
<td>4</td>
<td>32.935</td>
<td>22.317</td>
<td>21.657</td>
</tr>
<tr>
<td>5</td>
<td>42.936</td>
<td>29.664</td>
<td>28.838</td>
</tr>
<tr>
<td>6</td>
<td>52.937</td>
<td>37.010</td>
<td>36.020</td>
</tr>
<tr>
<td>7</td>
<td>62.938</td>
<td>44.357</td>
<td>43.201</td>
</tr>
<tr>
<td>8</td>
<td>72.939</td>
<td>51.703</td>
<td>50.382</td>
</tr>
</tbody>
</table>
SAMP-SEQ=SPARS10 (Cont)

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Image Size</th>
<th>Full Frame</th>
<th>256x256</th>
<th>128x128</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>82.940</td>
<td>59.050</td>
<td>57.564</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>92.941</td>
<td>66.396</td>
<td>64.745</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>102.942</td>
<td>73.743</td>
<td>71.926</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>112.943</td>
<td>81.089</td>
<td>79.108</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>122.944</td>
<td>88.436</td>
<td>86.289</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>132.945</td>
<td>95.782</td>
<td>93.471</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>142.946</td>
<td>103.129</td>
<td>100.652</td>
<td></td>
</tr>
</tbody>
</table>

SAMP-SEQ= SPARS25

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Image Size</th>
<th>Full Frame</th>
<th>512x512</th>
<th>256x256</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
<td>0.853</td>
<td>0.278</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>27.933</td>
<td>23.774</td>
<td>22.624</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>52.933</td>
<td>46.696</td>
<td>44.970</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>77.934</td>
<td>69.617</td>
<td>67.316</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>102.934</td>
<td>92.538</td>
<td>89.662</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>127.935</td>
<td>115.459</td>
<td>112.008</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>152.935</td>
<td>138.381</td>
<td>134.354</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>177.936</td>
<td>161.302</td>
<td>156.700</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>202.936</td>
<td>184.223</td>
<td>179.046</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>227.937</td>
<td>207.144</td>
<td>201.392</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>252.937</td>
<td>230.066</td>
<td>223.738</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>277.938</td>
<td>252.987</td>
<td>246.084</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>302.938</td>
<td>275.908</td>
<td>268.430</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>327.939</td>
<td>298.829</td>
<td>290.776</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>352.940</td>
<td>321.751</td>
<td>313.122</td>
<td></td>
</tr>
</tbody>
</table>
### SAMP-SEQ=SPARS50

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
</tr>
<tr>
<td>2</td>
<td>52.933</td>
</tr>
<tr>
<td>3</td>
<td>102.933</td>
</tr>
<tr>
<td>4</td>
<td>152.934</td>
</tr>
<tr>
<td>5</td>
<td>202.934</td>
</tr>
<tr>
<td>6</td>
<td>252.935</td>
</tr>
<tr>
<td>7</td>
<td>302.935</td>
</tr>
<tr>
<td>8</td>
<td>352.935</td>
</tr>
<tr>
<td>9</td>
<td>402.936</td>
</tr>
<tr>
<td>10</td>
<td>452.936</td>
</tr>
<tr>
<td>11</td>
<td>502.937</td>
</tr>
<tr>
<td>12</td>
<td>552.937</td>
</tr>
<tr>
<td>13</td>
<td>602.938</td>
</tr>
<tr>
<td>14</td>
<td>652.938</td>
</tr>
<tr>
<td>15</td>
<td>702.939</td>
</tr>
</tbody>
</table>

### SAMP-SEQ=SPARS100

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
</tr>
<tr>
<td>2</td>
<td>102.933</td>
</tr>
<tr>
<td>3</td>
<td>202.933</td>
</tr>
<tr>
<td>4</td>
<td>302.933</td>
</tr>
<tr>
<td>5</td>
<td>402.934</td>
</tr>
<tr>
<td>6</td>
<td>502.934</td>
</tr>
<tr>
<td>7</td>
<td>602.934</td>
</tr>
<tr>
<td>8</td>
<td>702.935</td>
</tr>
<tr>
<td>9</td>
<td>802.935</td>
</tr>
<tr>
<td>10</td>
<td>902.935</td>
</tr>
<tr>
<td>11</td>
<td>1002.936</td>
</tr>
<tr>
<td>12</td>
<td>1102.936</td>
</tr>
<tr>
<td>13</td>
<td>1202.936</td>
</tr>
<tr>
<td>14</td>
<td>1302.936</td>
</tr>
<tr>
<td>15</td>
<td>1402.937</td>
</tr>
</tbody>
</table>
### SAMP-SEQ=SPARS200

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Image Size</th>
<th>Full Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>2.932</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>202.932</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>402.932</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>602.932</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>802.933</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>1002.933</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>1202.933</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>1402.933</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>1602.933</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>1802.933</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>2002.933</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>2202.933</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>2402.933</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>2602.933</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>2802.933</td>
</tr>
</tbody>
</table>

### SAMP-SEQ=STEP25

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Image Size</th>
<th>Full Frame</th>
<th>512x512</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>2.932</td>
<td>0.853</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>5.865</td>
<td>1.706</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>8.797</td>
<td>2.559</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>11.729</td>
<td>3.412</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>24.230</td>
<td>13.833</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>49.230</td>
<td>36.755</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>74.231</td>
<td>59.676</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>99.231</td>
<td>82.597</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>124.232</td>
<td>105.518</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>149.232</td>
<td>128.440</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>174.233</td>
<td>151.361</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>199.233</td>
<td>174.282</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>224.234</td>
<td>197.203</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>249.234</td>
<td>220.125</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>274.235</td>
<td>243.046</td>
</tr>
</tbody>
</table>
### SAMP-SEQ=STEP50

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
</tr>
<tr>
<td>2</td>
<td>5.865</td>
</tr>
<tr>
<td>3</td>
<td>8.797</td>
</tr>
<tr>
<td>4</td>
<td>11.729</td>
</tr>
<tr>
<td>5</td>
<td>24.230</td>
</tr>
<tr>
<td>6</td>
<td>49.230</td>
</tr>
<tr>
<td>7</td>
<td>99.231</td>
</tr>
<tr>
<td>8</td>
<td>149.231</td>
</tr>
<tr>
<td>9</td>
<td>199.232</td>
</tr>
<tr>
<td>10</td>
<td>249.232</td>
</tr>
<tr>
<td>11</td>
<td>299.232</td>
</tr>
<tr>
<td>12</td>
<td>349.233</td>
</tr>
<tr>
<td>13</td>
<td>399.233</td>
</tr>
<tr>
<td>14</td>
<td>449.234</td>
</tr>
<tr>
<td>15</td>
<td>499.234</td>
</tr>
</tbody>
</table>

### SAMP-SEQ=STEP100

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
</tr>
<tr>
<td>2</td>
<td>5.865</td>
</tr>
<tr>
<td>3</td>
<td>8.797</td>
</tr>
<tr>
<td>4</td>
<td>11.729</td>
</tr>
<tr>
<td>5</td>
<td>24.230</td>
</tr>
<tr>
<td>6</td>
<td>49.230</td>
</tr>
<tr>
<td>7</td>
<td>99.231</td>
</tr>
<tr>
<td>8</td>
<td>149.231</td>
</tr>
<tr>
<td>9</td>
<td>199.232</td>
</tr>
<tr>
<td>10</td>
<td>249.232</td>
</tr>
<tr>
<td>11</td>
<td>299.232</td>
</tr>
<tr>
<td>12</td>
<td>349.233</td>
</tr>
<tr>
<td>13</td>
<td>399.233</td>
</tr>
<tr>
<td>14</td>
<td>449.234</td>
</tr>
<tr>
<td>15</td>
<td>499.234</td>
</tr>
</tbody>
</table>
### SAMP-SEQ=STEP200

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
</tr>
<tr>
<td>2</td>
<td>5.865</td>
</tr>
<tr>
<td>3</td>
<td>8.797</td>
</tr>
<tr>
<td>4</td>
<td>11.729</td>
</tr>
<tr>
<td>5</td>
<td>24.230</td>
</tr>
<tr>
<td>6</td>
<td>49.230</td>
</tr>
<tr>
<td>7</td>
<td>99.231</td>
</tr>
<tr>
<td>8</td>
<td>199.231</td>
</tr>
<tr>
<td>9</td>
<td>399.231</td>
</tr>
<tr>
<td>10</td>
<td>599.231</td>
</tr>
<tr>
<td>11</td>
<td>799.231</td>
</tr>
<tr>
<td>12</td>
<td>999.231</td>
</tr>
<tr>
<td>13</td>
<td>1199.231</td>
</tr>
<tr>
<td>14</td>
<td>1399.231</td>
</tr>
<tr>
<td>15</td>
<td>1599.231</td>
</tr>
</tbody>
</table>

### SAMP-SEQ=STEP400

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Full Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.932</td>
</tr>
<tr>
<td>2</td>
<td>5.865</td>
</tr>
<tr>
<td>3</td>
<td>8.797</td>
</tr>
<tr>
<td>4</td>
<td>11.729</td>
</tr>
<tr>
<td>5</td>
<td>24.230</td>
</tr>
<tr>
<td>6</td>
<td>49.230</td>
</tr>
<tr>
<td>7</td>
<td>99.231</td>
</tr>
<tr>
<td>8</td>
<td>199.231</td>
</tr>
<tr>
<td>9</td>
<td>399.231</td>
</tr>
<tr>
<td>10</td>
<td>599.231</td>
</tr>
<tr>
<td>11</td>
<td>799.232</td>
</tr>
<tr>
<td>12</td>
<td>999.232</td>
</tr>
<tr>
<td>13</td>
<td>1199.232</td>
</tr>
<tr>
<td>14</td>
<td>1399.233</td>
</tr>
<tr>
<td>15</td>
<td>1599.234</td>
</tr>
</tbody>
</table>
14.3.7 Special Requirements

**SPATIAL SCAN** `<Scan_Rate>`, `<Scan_Orient>`, `<Scan_Direction>`

See 7.3.3 Special Observation Requirements for information on executing an exposure as a Spatial Scan.

Special requirement **SAME POSition AS** `<exposure>` is not permitted on and may not refer to a Spatial Scan exposure. Spatial Scan exposures are not permitted in Coordinated Parallel containers or in Pure Parallel visits.

Special requirements **SAME ALIGNMENT** and **PARallel WITH** are not permitted on and may not refer to a Spatial Scan exposure. Pure Parallel visits may not contain Spatial Scan exposures.

14.4 Tabular Reference Data

14.4.1 Spectral Elements for WFC3/UVIS

The UVIS channel has 12 filter wheels with four spectral elements each. Only one spectral element may be specified for an exposure.

The quadrant filters pass light in four discrete bands in different quadrants of the detector. These may be selected just like any other filter, but the selected filter will only produce data in one quadrant of the detector, and the image will contain data from all four quad filters in that slot. Exposures with a quad filter must be done with the **UVIS-QUAD**, **UVIS-QUAD-FIX** or **UVIS-QUAD-SUB** aperture.

Table 14.5: Spectral Elements for use with WFC3/UVIS

<table>
<thead>
<tr>
<th>Name</th>
<th>Wheel</th>
<th>Position</th>
<th>Pivot $^1$ Wavelength (Å)</th>
<th>Effective Width$^2$ (Å)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F200LP</td>
<td>2</td>
<td>3</td>
<td>5686.9</td>
<td>(6500)</td>
<td>Clear; grism reference</td>
</tr>
<tr>
<td>F218W</td>
<td>3</td>
<td>1</td>
<td>2183.0</td>
<td>351.7</td>
<td>ISM feature</td>
</tr>
<tr>
<td>F225W</td>
<td>3</td>
<td>2</td>
<td>2341.0</td>
<td>547.3</td>
<td>UV Wide</td>
</tr>
<tr>
<td>F275W</td>
<td>9</td>
<td>1</td>
<td>2715.3</td>
<td>480.8</td>
<td>UV Wide</td>
</tr>
<tr>
<td>F280N</td>
<td>4</td>
<td>2</td>
<td>2796.8</td>
<td>22.9</td>
<td>MgII 2795/2802</td>
</tr>
<tr>
<td>F300X</td>
<td>1</td>
<td>2</td>
<td>2829.8</td>
<td>753.0</td>
<td>Extremely wide UV</td>
</tr>
<tr>
<td>Name</td>
<td>Wheel</td>
<td>Position</td>
<td>Pivot (^1) Wavelength (Å)</td>
<td>Effective Width (^2) (Å)</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------</td>
<td>----------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>F336W</td>
<td>4</td>
<td>1</td>
<td>3361.1</td>
<td>553.8</td>
<td>U, Stromgren u</td>
</tr>
<tr>
<td>F343N</td>
<td>4</td>
<td>3</td>
<td>3438.0</td>
<td>140.0</td>
<td>[NeV] 3426</td>
</tr>
<tr>
<td>F350LP</td>
<td>11</td>
<td>2</td>
<td>6812.0</td>
<td>(4500)</td>
<td>Long Pass</td>
</tr>
<tr>
<td>F373N</td>
<td>9</td>
<td>4</td>
<td>3729.6</td>
<td>39.2</td>
<td>[OII] 3726/3728</td>
</tr>
<tr>
<td>F390M</td>
<td>8</td>
<td>1</td>
<td>3893.8</td>
<td>210.5</td>
<td>CaII continuum</td>
</tr>
<tr>
<td>F390W</td>
<td>11</td>
<td>1</td>
<td>3904.6</td>
<td>953.0</td>
<td>Washington C</td>
</tr>
<tr>
<td>F395N</td>
<td>10</td>
<td>4</td>
<td>3953.7</td>
<td>72.9</td>
<td>CaII H&amp;K (3933/3968)</td>
</tr>
<tr>
<td>F410M</td>
<td>9</td>
<td>2</td>
<td>4107.0</td>
<td>182.8</td>
<td>Stromgren v</td>
</tr>
<tr>
<td>F438W</td>
<td>10</td>
<td>1</td>
<td>4318.7</td>
<td>676.8</td>
<td>WFPC2 B</td>
</tr>
<tr>
<td>F467M</td>
<td>9</td>
<td>3</td>
<td>4680.7</td>
<td>218.0</td>
<td>Stromgren b</td>
</tr>
<tr>
<td>F469N</td>
<td>3</td>
<td>4</td>
<td>4687.5</td>
<td>37.2</td>
<td>HeII 4686</td>
</tr>
<tr>
<td>F475W</td>
<td>6</td>
<td>1</td>
<td>4760.6</td>
<td>1488.9</td>
<td>SDSS g'</td>
</tr>
<tr>
<td>F475X</td>
<td>10</td>
<td>3</td>
<td>4917.1</td>
<td>2199.6</td>
<td>Extremely wide blue</td>
</tr>
<tr>
<td>F487N</td>
<td>2</td>
<td>1</td>
<td>4870.7</td>
<td>48.4</td>
<td>Hβ 4861</td>
</tr>
<tr>
<td>F502N</td>
<td>2</td>
<td>2</td>
<td>5009.0</td>
<td>57.8</td>
<td>[OIII] 5007</td>
</tr>
<tr>
<td>F547M</td>
<td>8</td>
<td>2</td>
<td>5447.0</td>
<td>714.0</td>
<td>Stromgren y</td>
</tr>
<tr>
<td>F555W</td>
<td>7</td>
<td>1</td>
<td>5309.8</td>
<td>1595.1</td>
<td>WFPC2 V</td>
</tr>
<tr>
<td>F600LP</td>
<td>6</td>
<td>3</td>
<td>8430.2</td>
<td>(4000)</td>
<td>Long Pass</td>
</tr>
<tr>
<td>F606W</td>
<td>6</td>
<td>2</td>
<td>5907.0</td>
<td>2304.2</td>
<td>WFPC2 Wide V</td>
</tr>
<tr>
<td>F621M</td>
<td>8</td>
<td>3</td>
<td>6216.7</td>
<td>631.0</td>
<td>11% passband</td>
</tr>
<tr>
<td>F625W</td>
<td>5</td>
<td>1</td>
<td>6254.0</td>
<td>1575.4</td>
<td>SDSS r'</td>
</tr>
<tr>
<td>F631N</td>
<td>1</td>
<td>3</td>
<td>6303.0</td>
<td>43.1</td>
<td>[OI] 6300</td>
</tr>
<tr>
<td>F645N</td>
<td>4</td>
<td>4</td>
<td>6451.6</td>
<td>85.0</td>
<td>Continuum</td>
</tr>
<tr>
<td>F656N</td>
<td>1</td>
<td>4</td>
<td>6561.1</td>
<td>13.9</td>
<td>Hα 6563</td>
</tr>
<tr>
<td>F657N</td>
<td>3</td>
<td>3</td>
<td>6565.1</td>
<td>96.3</td>
<td>Wide (Hα +[NII])</td>
</tr>
<tr>
<td>F658N</td>
<td>11</td>
<td>3</td>
<td>6585.2</td>
<td>23.6</td>
<td>[NII] 6583</td>
</tr>
<tr>
<td>F665N</td>
<td>5</td>
<td>2</td>
<td>6654.4</td>
<td>109.0</td>
<td>z (Hα + [NII])</td>
</tr>
<tr>
<td>F673N</td>
<td>5</td>
<td>3</td>
<td>6764.5</td>
<td>100.5</td>
<td>[SII] 6717/6731</td>
</tr>
<tr>
<td>F680N</td>
<td>5</td>
<td>4</td>
<td>6878.6</td>
<td>323.6</td>
<td>z (Hα + [NII])</td>
</tr>
<tr>
<td>F689M</td>
<td>7</td>
<td>4</td>
<td>6886.0</td>
<td>708.6</td>
<td>11% passband</td>
</tr>
<tr>
<td>F763M</td>
<td>8</td>
<td>4</td>
<td>7636.3</td>
<td>798.6</td>
<td>11% passband</td>
</tr>
<tr>
<td>F775W</td>
<td>10</td>
<td>2</td>
<td>7733.6</td>
<td>1486.0</td>
<td>SDSS i’</td>
</tr>
<tr>
<td>F814W</td>
<td>7</td>
<td>2</td>
<td>8304.7</td>
<td>2543.3</td>
<td>WFPC2 Wide I</td>
</tr>
<tr>
<td>F845M</td>
<td>6</td>
<td>4</td>
<td>8468.9</td>
<td>886.7</td>
<td>11% passband</td>
</tr>
<tr>
<td>F850LP</td>
<td>7</td>
<td>3</td>
<td>9756.4</td>
<td>(1500)</td>
<td>SDSS z’</td>
</tr>
<tr>
<td>F953N</td>
<td>2</td>
<td>4</td>
<td>9529.7</td>
<td>84.6</td>
<td>[SIII] 9532</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quadrant Filters (Readout Amplifier included in the Position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FQ232N</td>
</tr>
<tr>
<td>FQ243N</td>
</tr>
</tbody>
</table>
14.4.2 Spectral Elements for WFC3/IR

The IR channel has a single filter wheel with 17 spectral elements. Only one spectral element may be specified for an exposure.
Table 14.6: Spectral Elements for use with WFC3/IR

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Pivot$^1$ Wavelength (nm)</th>
<th>Effective Width$^2$ (nm)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F098M</td>
<td>6</td>
<td>982.93</td>
<td>169.48</td>
<td>Blue grism reference</td>
</tr>
<tr>
<td>F105W</td>
<td>5</td>
<td>1048.95</td>
<td>292.30</td>
<td>Wide $Y$</td>
</tr>
<tr>
<td>F110W</td>
<td>4</td>
<td>1141.40</td>
<td>503.40</td>
<td>Wide $YJ$</td>
</tr>
<tr>
<td>F125W</td>
<td>2</td>
<td>1245.90</td>
<td>301.50</td>
<td>Wide $J$</td>
</tr>
<tr>
<td>F126N</td>
<td>15</td>
<td>1258.26</td>
<td>11.83</td>
<td>$[\text{FeII}]$</td>
</tr>
<tr>
<td>F127M</td>
<td>11</td>
<td>1273.64</td>
<td>68.79</td>
<td>$\text{H}_2\text{O}/\text{CH}_4$ continuum</td>
</tr>
<tr>
<td>F128N</td>
<td>12</td>
<td>1283.30</td>
<td>13.54</td>
<td>Paschen$\beta$</td>
</tr>
<tr>
<td>F130N</td>
<td>13</td>
<td>1300.62</td>
<td>13.28</td>
<td>Paschen$\beta$ continuum</td>
</tr>
<tr>
<td>F132N</td>
<td>14</td>
<td>1319.04</td>
<td>13.07</td>
<td>Paschen$\beta$ (redshifted)</td>
</tr>
<tr>
<td>F139M</td>
<td>10</td>
<td>1383.80</td>
<td>64.58</td>
<td>$\text{H}_2\text{O}/\text{CH}_4$ line</td>
</tr>
<tr>
<td>F140W</td>
<td>8</td>
<td>1392.10</td>
<td>399.00</td>
<td>Wide $JH$ gap; red grism reference</td>
</tr>
<tr>
<td>F153M</td>
<td>9</td>
<td>1533.31</td>
<td>68.78</td>
<td>$\text{H}_2\text{O}$ and $\text{NH}_3$</td>
</tr>
<tr>
<td>F160W</td>
<td>1</td>
<td>1540.52</td>
<td>287.88</td>
<td>WFC3 $H$</td>
</tr>
<tr>
<td>F164N</td>
<td>17</td>
<td>1645.13</td>
<td>17.48</td>
<td>$[\text{FeII}]$</td>
</tr>
<tr>
<td>F167N</td>
<td>16</td>
<td>1667.26</td>
<td>17.16</td>
<td>$[\text{FeII}]$ continuum</td>
</tr>
<tr>
<td>G102</td>
<td>7</td>
<td>(1025)</td>
<td>250</td>
<td>Blue high-resolution grism</td>
</tr>
<tr>
<td>G141</td>
<td>3</td>
<td>(1410)</td>
<td>600</td>
<td>Red low-resolution grism</td>
</tr>
</tbody>
</table>

1. “Pivot wavelength” is defined as in Table 14.5. All wavelength measurements in this table were made in air.
2. Full width at 50% of peak transmission.
14.5 WFC3 Aperture Coordinate System

Figures 14.1 and 14.2 illustrate the locations of the UVIS and IR apertures. In the figures, the outlines of the full-detector apertures of both the UVIS and IR channels are indicated, as projected onto the sky and with respect to the HST U2-U3 coordinate system.

Figure 14.1: UVIS Aperture Diagram

Figure 14.1 illustrates the fiducial points of the full-detector apertures (UVIS, UVIS1, UVIS2, and UVIS-CENTER), and the outlines of the 2Kx2K, 1Kx1K, and 512x512 subarray apertures. Also indicated are the positions of the four readout amplifiers (A, B, C, and D). The regions imaged by the UVIS detector (represented by blue fill) and by the IR detector (represented by red fill) are also indicated. The POSition TARGet coordinate system for the UVIS-CENTER aperture, with its origin at that aperture's fiducial point, is illustrated. Although the POSition TARGet coordinate systems for the other apertures are not illustrated, they are oriented the same, but have origins at each aperture's fiducial point.
Figure 14.2 illustrates the fiducial points of two of the full-detector apertures (IR and IR-FIX), and the outlines of the concentric subarray apertures (512x512, 256x256, 128x128, and 64x64). The regions imaged by the UVIS detector (represented by blue fill) and by the IR detector (represented by red fill) are also indicated. The POSition TARGet coordinate system for the IR-FIX Aperture, with its origin at that aperture's fiducial point, is illustrated. Although the POSition TARGet coordinate systems for the other apertures are not illustrated, they are oriented the same, but have origins at each aperture's fiducial point.
Index

A
ACQ-DIST Optional Parameter for FGS 212, 215
ACQTYPE Optional Parameter for STIS 179
Acquisition modes
STIS 178
Acquisition uncertainty 77
ACQuisitions 17
ACS 220
Aperture Coordinate System 231
ACS/SBC
ACCUM 224
Spectral Elements 229
ACS/WFC
ACCUM 221
ACS/WFC and HRC
Spectral Elements 226
AFTER – BY – TO – Special Requirement 130
AFTER – Special Requirement 130
APT 9
AXIS1 and AXIS2 coordinate system for STIS 177

B
BACKGROUND patterns 150
BEFORE – Special Requirement 131
BETWEEN – AND – Special Requirement 131
BINAXIS1, BINAXIS2 Optional Parameters for STIS 184, 187
Bright object constraints 51
BUFFER-TIME Optional Parameter for STIS 189

C
CHECKBOX Optional Parameter for STIS 180
Containers
Coordinated Parallels 138
Exposure Groups 143
Patterns 146
Continuous Viewing Zone (CVZ) 128
COS 254
Acquisition Modes 256
Aperture Coordinate System 290
Apertures 285
Calibration Targets 286
Spectral Elements 285
Wavecal Exposures 287
COS/FUV
ACCUM 278
TIME-TAG 274
COS/NUV
ACCUM 283
TIME-TAG 280
COUNT Optional Parameter for FGS 212
CR-SPLIT Optional Parameter for STIS 184
CVZ Special Requirement 128

D
DIFFUSE-CENTER Optional Parameter for STIS 180
DITHER patterns 150
DROP TO GYRO Special Requirement 118

E
Ephemeris uncertainty 76
Examples, Phase II 18
Examples, target list blocks 86
EXPAND Special Requirement 141
Exposure, definition 90

F
FES-TIME Optional Parameter for FGS 213
FGS
   ACQ-DIST Optional Parameter 212, 215
   Aperture coordinate system 217
   COUNT Optional Parameter 212
   FES-TIME Optional Parameter 213
   NULL Optional Parameter 212
   POS mode 211
   SCANS Optional Parameter 215
   Spectral elements (table) 216
   STEP-SIZE Optional Parameter 215
   TRANS mode 214
Flux 47

G
GAIN Optional Parameter for STIS 184
GROUP WITHIN Special Requirement 131
GSC2 42
GSSS 42
Guiding
   Accuracies of guiding modes (table) 117
   GUIDing TOLerance Special Requirement 117
Guiding-related Special requirements 116
Gyro
   Use of for guiding 117, 118

I
INT ACQ Special Requirement 133

L
Longitude, orbital 85
LOW-SKY Special Requirement 141

M
MAGNETO coordinates 72
MAXimum DURation Special Requirement 141
MINimum DURation Special Requirement 142
MOSAIC patterns 150

N
NICMOS 234
   ACCUM 235
   Apertures 245
   MULTIACCUM 238
   NIC2, ACQ 243
   Spectral Elements 246
NOCMOS
   Coordinate System 249
NULL Optional Parameter for FGS 212

O
Observing windows 77
ON HOLD Special Requirement 133
Orbital longitude 85
ORIENT – TO – FROM – Special Requirement 124
ORIENT – TO – Special Requirement 120
Orientation and separation between instruments (table) 127
Orientation of instruments relative to U3 (table) 126
Orientation Special Requirements 118

P
P2PI
   Changes since previous version 4
   Document design 4
Parallax 46
Parallel observations
   Coordinated 103, 105
   Limitations 104
   Pure 103, 105
PARallel WITH Special Requirement 147
PATTERN Container
   Center Pattern 151
   Number Of Points 150
   Pattern Number 149, 151
   Pattern Purpose 149
   Pattern Type 149
   Pattern Type=LINE 149
   Pattern Type=SPIRAL 149
Pattern_Type=STIS-ALONG-SLIT 153
Pattern_Type=STIS-CCD-BOX 154
Pattern_Type=STIS-MAMA-BOX 155
Pattern_Type=STIS-SPIRAL-DITH 155
Point_Spacing 150
STIS-PERP-TO-SLIT 153
Pattern Container 146
PATTERN Special Requirement 147
Pattern_Purpose: BACKGROUND 150
Pattern_Purpose: DITHER 150
Pattern_Purpose: MOSAIC 150
PCS MODE Fine Special Requirement 117
PCS MODE Gyro Special Requirement 117
PERIOD AND ZERO-PHASE Special Requirement 132
PGRAPHIC coordinates 70
Phase II Proposal
Entries
  Abstract 14
  Acq_Uncert 77
  Alternate_Names 27
  Aperture 96
  Calibration_Justification 15
  Comments 53, 55, 85, 99
  Config 95
  Ephem_Uncert 76
  Epoch 57
  Equinox 44, 57
  Exposure_Number 93
  Flux 47–51, 54, 83–85
  Generic target specifications 55
  Generic_Targets 53
  Investigators 16
  Number_of_Iterations 98
  Observing_Description 15
  On_Hold_Comments 93
  Opmode 96
  Optional_Parameters 100
  Parallax 46
  Position 36
  Position, solar system targets 65
  Proper motion 46, 57
  Proposal_Information 13, 14, 15
  Questions 15
  Real_Time_Justification 15
  Reference Frame 45
  RV_or_Z 45
  Sp_Element 97
  Special_Requirements 100
  Target description 31, 54, 64
  Target position, comet and asteroid 68
  Target position, Level 1 67
  Target position, Level 2 69
  Target position, Level 3 76
  Target position, MAGNETO 72
  Target position, PGRAPHIC 70
  Target position, POS_ANGLE 71
  Target position, SATellite 74
  Target position, TORUS 72
  Target_Name 27, 54, 62, 94
  Target_Number 27, 54, 61
  Time_Per_Exposure 98
  Visit_Comments 93
  Visit_Number 91
  Visit_Requirements 92
  Wavelength 98
  Window 77
  Examples 18
  General instructions 13
  How to submit 9
  Limited resources 19
  Problems 18
  Special targets 94
  Template 20
PHASE Special Requirement 142
POS_TARG Special Requirement 134, 151
POS_ANGLE coordinates 71
Position 36
  Equatorial coordinates 38
  Guide Star Selection System 42
  Offsets 39
  Region of sky 41
  Required accuracy 36
Proper Motion 45
R
  Radial Velocity 45
  Redshift 45
REQUESTS EPHEMERIS CORRECTION Special Requirement 140
REQuires UPLINK Special Requirement 139
RT ANALYSIS Special Requirement 139

S
SAME ORIENT AS Special Requirement 128
SAME POS AS Special Requirement 134, 146, 147
SATellite coordinates 74
SCANS Optional Parameter for FGS 215
SCHEDulability Special Requirement 129
SEQUence NON-INterruptiontible 143
SEQUence WITHIN Special Requirement 132
SHADOW Special Requirement 143
SIZEAXIS2 Optional Parameter for STIS 182, 184
Solar system standard targets 62
Special Requirements
    Acquisition of targets 133
    AFTER – 130
    AFTER – BY – TO – 130
    BEFORE – 131
    BETWEEN – AND – 131
    Communications-related 139
    CVZ 128
    Dates and times 113
    DROP TO GYRO 118
    EXPAND 141
    Exposure number, reference to 114
    Exposure-level, definition 114
    GROUP WITHIN 131
    GUIDing TOlerance 117
    Guiding-related 116
    INT ACQ 133
    LOW-SKY 141
    MAXimum DURation 141
    MINimum DURation 142
    ON HOLD 133
    ORIENT – TO – 120
    ORIENT – TO – FROM – 124
    Orientation examples 121
    Orientation of target in aperture 118
    PARallel WITH 147
    PATTERN: see Containers
        Pattern Containers
        PCS MODE Fine 117
        PCS MODE Gyro 117
        PERIOD AND ZERO-PHASE 132
        PHASE 142
        POS TARG 134, 151
        Position of target 134
        REQuires EPHEMeris CORRection 140
        REQuires UPLINK 139
        RT ANALYSIS 139
        SAME ORIENT AS 128
        SAME POS AS 134, 146, 147
        SCHEDulability 129
        SEQuence WITHIN 132
        SHADOW 143
        Syntax and rules 113
        Timing-related 141
        Visit-level, definition 114
        STEP-SIZE Optional Parameter for FGS 215
        STIS
            Acquisition modes 178
            Aperture coordinate system 196
            Apertures, supported 197
            AXIS1 and AXIS2 coordinate system 177
            CDFFLAT internal target 193
            Imaging modes 183
            Internal calibration targets 191
            Pattern illustrations 196
            Spectroscopic modes 183
            STIS/CCD
                ACCUM mode 183
                ACQ mode 178
                ACQ mode, apertures 179
                ACQ/PEAK mode 181
                ACQType Optional Parameter 179
                BINAXIS1, BINAXIS2 Optional Parameters 184
                CHECKBOX Optional Parameter 180
                CR-SPLIT Optional Parameter 184
                DIFFUSE-CENTER Optional Parameter 180
                GAIN Optional Parameter 184
                SIZEAXIS2 Optional Parameter 182, 184
                Time_Per_Exposure 185
                STIS/FUV-MAMA
                    ACCUM mode 186
TIME-TAG mode 188

STIS/MAMA
   BINAXIS1, BINAXIS2 Optional Parameters 187

STIS/NUV-MAMA
   ACCUM mode 186
   TIME-TAG mode 188

TIME-TAG
   BUFFER-TIME Optional Parameter 189

WAVE internal target 191
Wavelengths, supported (table) 190
subexposure 90, 98

T
Target Acquisition
   Special Requirements 133
Target name 27
   Catalog name 28
   Common name 30
   Galaxies and clusters of galaxies 29
   Quasars and active galaxies 29
   Special targets 30
   Star clusters and nebulae 29
   Stars 28
   Uncataloged targets 29
Text Proposal File 10
Timing-related Special Requirements 130
TORUS coordinates 72

V
Visit and Exposure Specifications 90
Visit, definition 91
VTT 11

W
WFC3 292
   Aperture Coordinate System 312
WFC3/IR
   Apertures 299
   MULTIACCUM 297
   Spectral Elements 310
WFC3/UVIS
   ACCUM 293