Two-Gyro Science Impact and Observer Information

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STUC Meeting
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Two-Gyro Handbook and Website

- STUC comments are welcomed

- Handbook
  - Central source of information about science and scheduling impacts of operating HST in two-gyro mode
  - Released with the Cycle 14 Call for Proposals
  - All necessary two-gyro information for Cycle 14 proposers

- Website (http://www.stsci.edu/hst/HST_overview/TwoGyroMode)
  - Site viewed frequently (>2700 top page hits since October 1)
  - Target visibility and orientation tools
  - A narrated movie showing sky availability for two-gyro and three-gyro modes over the course of a year
  - Links to two-gyro resources and Handbook
    - >130 Handbook retrievals (pdf document) since October 1
    - >1700 Handbook hits (all html pages) since October 1
Two-Gyro Handbook Chapters

1. Introduction
2. Special Considerations for Cycle 14
3. The HST Gyroscopes
4. Slewing and Pointing
5. Guiding and Jitter
6. Observation Planning
7. ACS Performance in Two-Gyro Mode
8. WFPC2 Performance in Two-Gyro Mode
9. NICMOS Performance in Two-Gyro Mode
10. STIS Performance in Two-Gyro Mode
11. FGS Performance in Two-Gyro Mode
12. Appendix A: Guide Star Magnitudes
13. Appendix B: Quiescent F2G-FL Jitter Predictions
Two Gyro Science Mode

HST normally uses three gyros out of the six installed onboard the spacecraft to provide accurate pointing information. Over time these gyros eventually fail, leaving the spacecraft with less redundancy, and eventually with fewer than the number required for normal pointing. The HST Project at GSFC and STScI are developing a Two Gyro Science (TGS) mode for use when fewer than three gyros are available. The TGS mode will use only two gyros to provide slew capability and spacecraft attitude control (guiding) of sufficient accuracy to continue obtaining high quality science data. When HST has fewer than two gyros available, no HST science operations are forseen.

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Warning: Since the TGS mode is still under development, the information on these pages is preliminary and fairly general. As we collect more exact data on this mode, it will be included and made available on this site. See the Site Change Log for a summary of the additions and changes to the information on this site.
Overview of Two-Gyro Science Impact

- **Instrument Performance / Jitter**
  - Should be sufficient to conduct all but the most demanding science observations (but there may be some demanding observations)
  - Expected jitter is not significantly larger than in three-gyro case
  - Full jitter characterization awaits on-orbit tests in February

- **Scheduling of Observations**
  - Less flexibility than in three-gyro mode
  - Can be a serious impact for some observations, especially those with orientation or timing constraints
  - Several tools are available on the two-gyro website to assist with planning observations
  - Examples later in this presentation
Types of Observations That May Be Affected By Entry into Two-Gyro Mode

- **Constrained Observations**
  - Makes scheduling of observations more difficult
    - Roll angle constraints
    - Timing constraints
- **Coronagraphy**
  - Not enough time to perform two acquisitions in an orbit
    - Precludes multiple roll angle positions in a single orbit
    - Jitter decreases light rejection performance
- **Astrometry**
  - Cannot schedule 180 degree separation of observations
- **Targets of Opportunity / Coordinated Observations**
  - Generally time/position constrained
  - Only ~50% of sky visible at any given time
- **Large observing campaigns like UDF / GOODS?**
  - May be somewhat less efficient depending upon how scheduled
  - Roll angle restrictions may make tiling more difficult
Instrument Performance / Jitter

• Jitter magnitude usually specified as RMS deviation in 60 sec interval

• Simulations indicate that pointing should be well within the 30x10 mas jitter ellipse requirement
  • Two-Gyro Handbook examples and exposure time calculators assume 30x10 mas ellipse to be conservative
  • Point spread function analyses predict only modest imaging/spectroscopic degradation even at this jitter level
  • Changes in $T_{\text{exp}}$ are also expected to be small
  • Coronagraphic observations may be impacted and will be characterized in the February on-orbit tests
Sample Two-Gyro Jitter Time Sequence

Disturbance sequence above specified to test response of control law, not to mimic actual 800 seconds of observing time.
Sample Two-Gyro Jitter Projection (sky plane)

ACS/WFC (~80% of time)

ACS/HRC (~20% of time)
# Jitter Predictions (including disturbances)

<table>
<thead>
<tr>
<th>Gyro Set</th>
<th>Angle of $G_x$ Axis on Plane of Sky</th>
<th>Maximum Boresight Jitter (mas, 60-second RMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$m_v = 9.58$</td>
</tr>
<tr>
<td>1-2</td>
<td>0.0</td>
<td>9.55</td>
</tr>
<tr>
<td>1-4</td>
<td>-22.7</td>
<td>10.65</td>
</tr>
<tr>
<td>1-6</td>
<td>+22.7</td>
<td>11.72</td>
</tr>
<tr>
<td>2-4</td>
<td>+55.6</td>
<td>12.20</td>
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<tr>
<td>2-6</td>
<td>-55.6</td>
<td>12.39</td>
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<tr>
<td>4-6</td>
<td>+90.0</td>
<td>12.26</td>
</tr>
</tbody>
</table>

## Two-Gyro F2G-FL Results

<table>
<thead>
<tr>
<th>Gyro Set</th>
<th>Angle of $G_x$ Axis on Plane of Sky</th>
<th>Maximum Boresight Jitter (mas, 60-second RMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2-4</td>
<td>...</td>
<td>9.73</td>
</tr>
</tbody>
</table>

## Three-Gyro Results

Most jitter will be well below maximum values listed above, even for faint guide stars.
## Effect of Jitter on the PSF

<table>
<thead>
<tr>
<th>Effect</th>
<th>Reduction in ACS PSF Central Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WFC (600 nm)</td>
</tr>
<tr>
<td>Detector Charge Diffusion</td>
<td>43%-59%</td>
</tr>
<tr>
<td>PSF on Pixel Corner vs. Pixel Center</td>
<td>47%</td>
</tr>
<tr>
<td>OTA Breathing (+ 5 microns)</td>
<td>16%</td>
</tr>
<tr>
<td>Two-Gyro Jitter (30 x 10 mas RMS)</td>
<td>27%</td>
</tr>
</tbody>
</table>
Scheduling of Observations

Scheduling is likely to be more restrictive on science than jitter.

Target availability changes with time
Low Latitude Orientation Example for Cycle 14

3-gyro
2-gyro (>30 min vis)
2-gyro (<30 min vis)
High Latitude Orientation Example for Cycle 14

- 3-gyro
- 2-gyro (>30 min vis)
- 2-gyro (<30 min vis)

Start of Cycle 14
Examples of Programs that May be More Difficult to Schedule in Two-Gyro Mode

- **Time series observations**
  - Supernova searches in known fields (e.g., GOODS)
  - Light curves (e.g., supernovae, Cepheids, GRBs, etc.)

- **Roll-constrained observations**
  - Experiments requiring same ORIENT for extended periods
    - May affect efficiency of future Deep Fields
  - Large tiling programs making use of 180 degree roll (e.g., recent large Orion mapping program)
    - Loss of efficiency would be main impact
Hubble Deep Field
Target Visibility in Cycle 14

<table>
<thead>
<tr>
<th>Observation Date</th>
<th>Target Visibility (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-Nov-2005</td>
<td>47</td>
</tr>
<tr>
<td>14-Dec-2005</td>
<td>49</td>
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<tr>
<td>15-Dec-2005</td>
<td>48</td>
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<tr>
<td>16-Dec-2005</td>
<td>48</td>
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<tr>
<td>31-Jan-2006</td>
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<tr>
<td>01-Feb-2006</td>
<td>52</td>
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<td>02-Feb-2006</td>
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<td>14-Mar-2006</td>
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<td>20</td>
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<tr>
<td>16-Mar-2006</td>
<td>64</td>
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<tr>
<td>09-May-2006</td>
<td>73</td>
</tr>
<tr>
<td>10-May-2006</td>
<td>75</td>
</tr>
<tr>
<td>11-May-2006</td>
<td>78</td>
</tr>
</tbody>
</table>

RA = 190, Dec = 60

Version 2

Target Visibility - Guide Star Acquisition (minutes)
(3 gyro = 6m, 2 gyro = 7m)

Month
Hubble UltraDeep Field
Target Visibility in Cycle 14

<table>
<thead>
<tr>
<th>Observation Date</th>
<th>Target Visibility (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-Jul-2005</td>
<td>46</td>
</tr>
<tr>
<td>15-Aug-2005</td>
<td>47</td>
</tr>
<tr>
<td>01-Oct-2005</td>
<td>47</td>
</tr>
<tr>
<td>14-27 Nov-2005</td>
<td>&lt;30</td>
</tr>
<tr>
<td>&gt;19-Dec-2005</td>
<td>&lt;30</td>
</tr>
</tbody>
</table>

RA = 55, Dec = −30

**Difficult Follow-up**