



# 12262 - Stellar Forensics II: A post-explosion view of the progenitors of core-collapse supernovae

Cycle: 18, Proposal Category: GO

(Availability Mode: SUPPORTED)

## INVESTIGATORS

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|----------------------------------------------|-------------------------------------------------------|--------------------------------------|
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## VISITS

| <i>Visit</i> | <i>Targets used in Visit</i> | <i>Configurations used in Visit</i> | <i>Orbits Used</i> | <i>Last Orbit Planner Run</i> | <i>OP Current with Visit?</i> |
|--------------|------------------------------|-------------------------------------|--------------------|-------------------------------|-------------------------------|
| 01           | (1) SN2008AX                 | WFC3/UVIS                           | 3                  | 28-Mar-2011 21:16:35.0        | yes                           |
| 02           | (2) SN2008BK                 | WFC3/IR<br>WFC3/UVIS                | 1                  | 28-Mar-2011 21:16:46.0        | yes                           |
| 03           | (3) SN2008CN                 | ACS/WFC                             | 2                  | 28-Mar-2011 21:16:54.0        | yes                           |

6 Total Orbits Used

## **ABSTRACT**

Recent studies have used high spatial resolution HST observations of supernova (SN) sites to directly identify the progenitors of core-collapse SNe on pre-explosion images. These studies have set constraints about the nature of massive stars and their evolution just prior to their explosion as SNe. Now, at late-times when the SNe have faded sufficiently, it is possible to return to the sites of these core-collapse SNe to search for clues about the nature of their progenitors.

We request time to conduct deep, late-time, high-resolution imaging with WFC3/UVIS+IR and ACS/WFC of the sites of three core-collapse SNe 2008ax, 2008bk and 2008cn. We aim to: 1) Confirm our original identifications, made in pre-explosion images, by confirming that the progenitors are now missing; 2) Apply image subtraction techniques for this late-time imaging with our pre-explosion images to determine accurate photometry of the progenitors to constrain their temperatures and luminosities; and 3) study the stellar populations in the immediate vicinities of these SNe, previously obscured by the progenitor and the SN, to provide a measure of the progenitor's age, as well. For SN 2008ax we aim to determine the possible presence of a binary companion, as a persistent source at the SN location once the SN has faded and the progenitor has disappeared. HST provides the unique combination of high-resolution optical/IR imaging at very faint magnitudes that will facilitate this study.

## **OBSERVING DESCRIPTION**

We require imaging of three SN sites with pre-explosion observations in which the progenitors were detected. We aim to confirm the progenitor identification, through the stars' disappearance - and accurately measure the progenitors' photometric properties using image subtraction techniques. Multi-colour imaging will be used to probe the nature of the surrounding stellar population.

The bands in which the SN sites will be observed are dictated by the nature of the available pre-explosion imaging.

The three SN sites to be observed are those of SN 2008ax (3 orbits), 2008bk (1 orbit), 2008cn (2 orbits). Each SN site is to be visited once. In order to improve the spatial sampling, and improve the resolution, all observations are grouped into box dither patterns.

To minimize the amount of time lost to reading out the detectors, subarrays will be adopted

SN2008ax - WFC3 UVIS 1kx1k - Visit 1 - 3 orbits

U F336W to reach down to 26 @ 3sigma

B F438W to reach down to 27 @ 3 sigma

V F606W to reach down to 27@ 5 sigma

R F625W to reach down to 26.5 @ 3 sigma

I F814W to reach down to 26.5 @ 3sigma

all exposures times have been selected to only saturate stars above the limit of  $X \sim 20$  (in Vega mags) in all bands

SN2008bk - WFC3 UVIS 1kx1k & IR 512x512 - Visit 2 - 1 orbit

I F814W UVIS to reach down to  $I=26$  at 3 sigma

J F125W IR to reach down to  $J=24$  at 5 sigma (3 iterations of 4x2xSPAR25 - i.e. 4x50s exposures) - with this observation we are balancing the need for depth, against the possibility of saturating on surrounding stars (which we would also like to observe, as well as to avoid persistence issues with the detector) - estimate that the saturation limit  $J=17$  should be brighter than surrounding stars

H 160W IR to reach down to  $H = 24$  at 3 sigma - similar to the J band obs, use 2 iterations of 4x4xSPAR25 to avoid saturating stars up to limit of  $H=16.5$

512x512 subarray is required to avoid being penalised by readout time

SN2008cn - ACS/WFC 1kx1k - Visit 3 - 2 orbits

B F435W to reach down to 27.5 at 3sigma

V F555W to reach down to 27.5 at 3sigma

I F814W to reach down to 27 at 3sigma

Again saturation limit is set for stars brighter than  $X \sim 20$  (vega mags)

### **REAL TIME JUSTIFICATION**

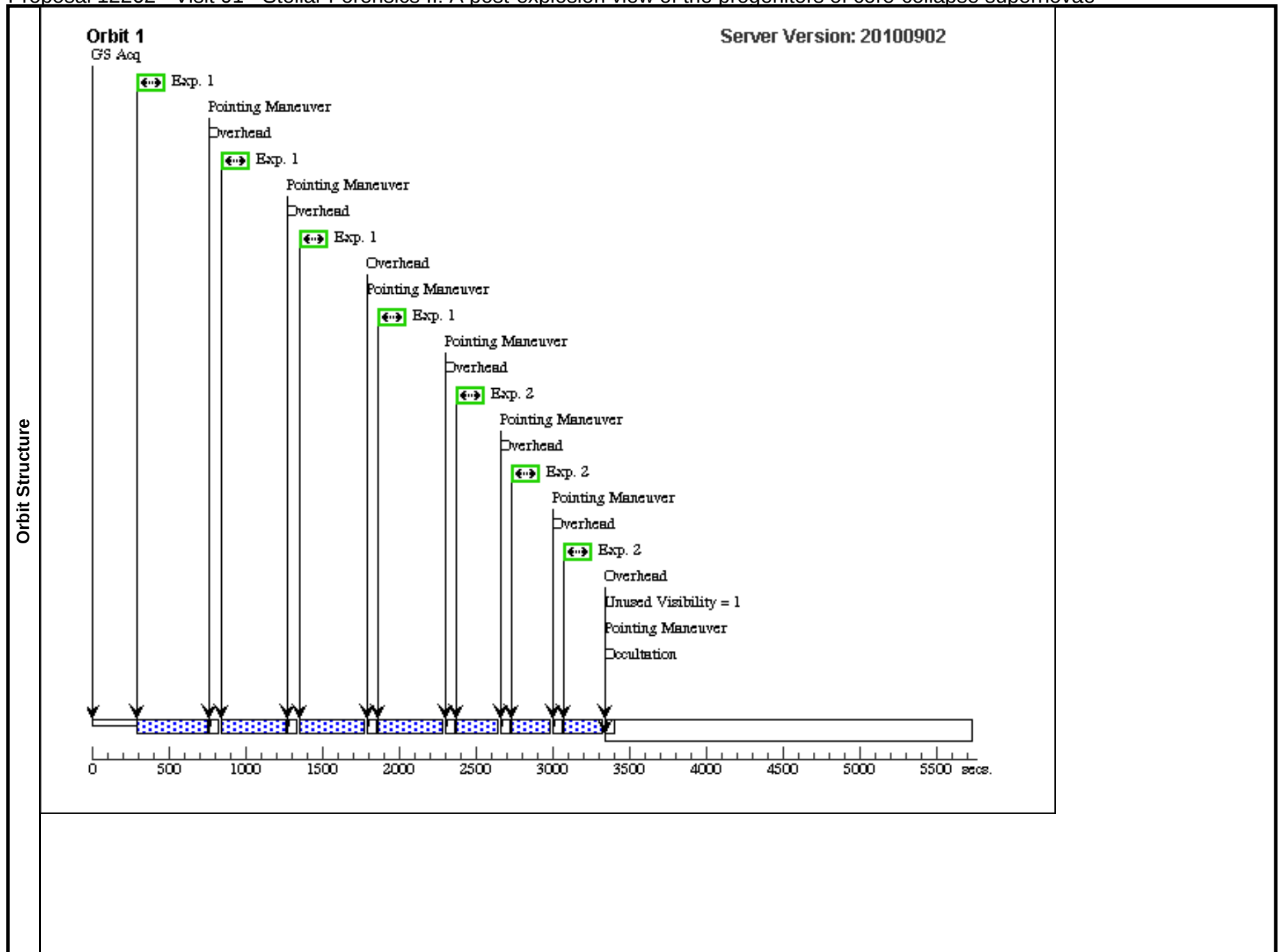
Further to our request in the Phase I proposal, we have requested that the SN2008cn observation (visit 3) be scheduled in the second half of Cycle 18 - i.e. after Feb 1st 2011

### **CALIBRATION JUSTIFICATION**

No special calibrations are required

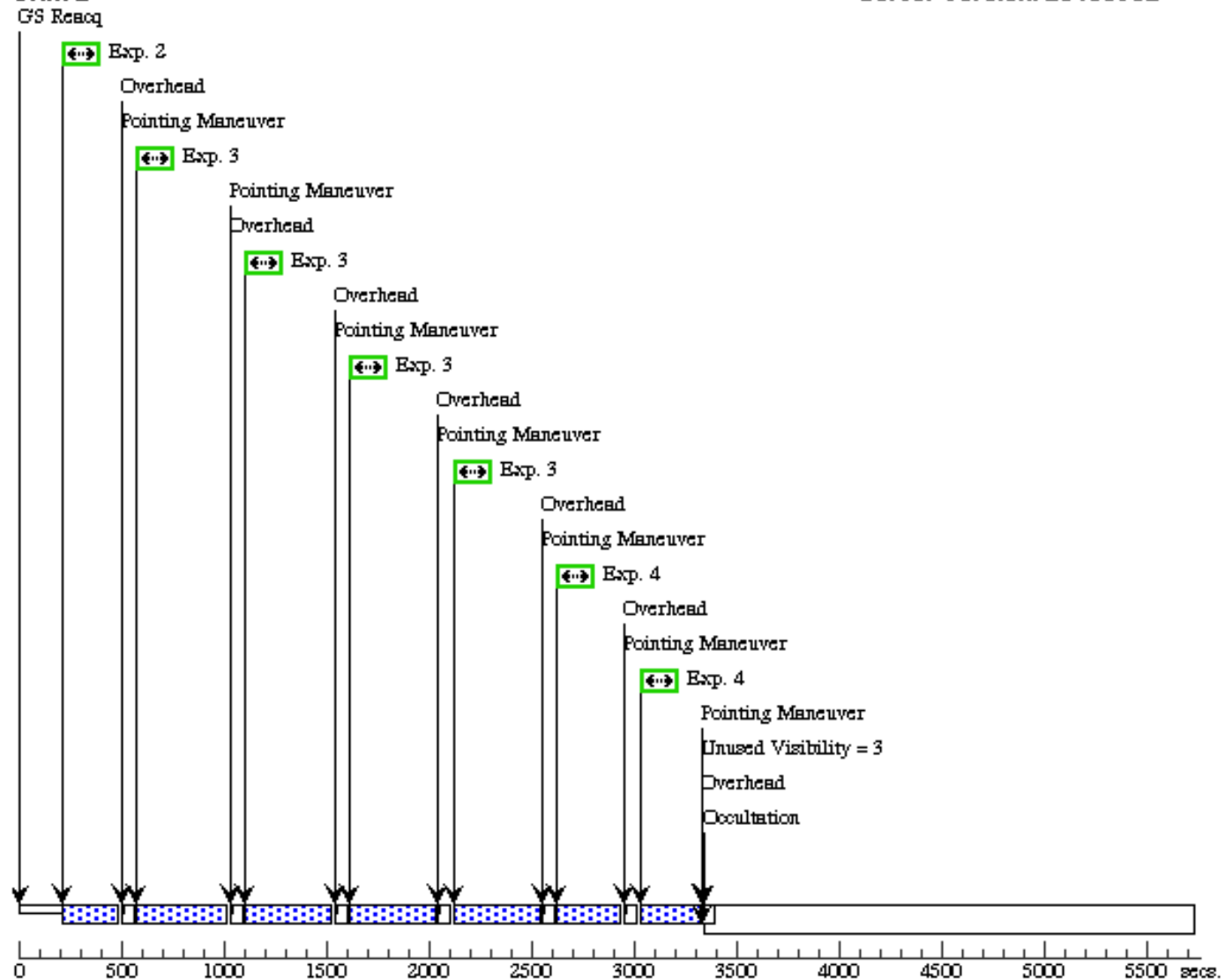
# Proposal 12262 - Visit 01 - Stellar Forensics II: A post-explosion view of the progenitors of core-collapse supernovae

|                                                                                                |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          |                              |            |
|------------------------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------------------------------------------------------------------------|--|--------------------------|-------------------|---------------|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------|------------|
| Visit                                                                                          | Proposal 12262, Visit 01, implementation |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          | Tue Mar 29 01:16:59 GMT 2011 |            |
|                                                                                                | Diagnostic Status: No Diagnostics        |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          |                              |            |
|                                                                                                | Scientific Instruments: WFC3/UVIS        |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          |                              |            |
|                                                                                                | Special Requirements: (none)             |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          |                              |            |
| Comments: Visit for SN2008AX                                                                   |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          |                              |            |
| Patterns                                                                                       | #                                        | Primary Pattern                                                                                                                                                                                                                         |              |                                                                                     |  |                          | Secondary Pattern |               |                                     |                                                                                                                          | Exposures                    |            |
|                                                                                                | (1)                                      | Pattern Type=WFC3-UVIS-DITHER-BOX<br>Coordinate Frame=POS-TARG<br>Pattern Orientation=23.884<br>Purpose=DITHER<br>Angle Between Sides=81.785<br>Number Of Points=4<br>Center Pattern=false<br>Point Spacing=0.173<br>Line Spacing=0.112 |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          | (1), (2), (3), (4), (5)      |            |
| Fixed Targets                                                                                  | #                                        | Name                                                                                                                                                                                                                                    |              | Target Coordinates                                                                  |  | Targ. Coord. Corrections |                   | Fluxes        |                                     | Miscellaneous                                                                                                            |                              |            |
|                                                                                                | (1)                                      | SN2008AX                                                                                                                                                                                                                                |              | RA: 12 30 40.8000 (187.6700000d)<br>Dec: +41 38 14.50 (41.63736d)<br>Equinox: J2000 |  |                          |                   | V=25+/-0.1    |                                     | Reference Frame: ICRS                                                                                                    |                              |            |
| Comments: This object was generated by the targetselector and retrieved from the NED database. |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     |                                                                                                                          |                              |            |
| Exposures                                                                                      | #                                        | Label                                                                                                                                                                                                                                   | Target       | Config,Mode,Aperture                                                                |  | Spectral Els.            | Opt. Params.      | Special Reqs. | Groups                              | Exp. Time/[Actual Dur.]                                                                                                  |                              | Orbit      |
|                                                                                                | 1                                        | SN2008AX_F336W                                                                                                                                                                                                                          | (1) SN2008AX | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB                                                   |  | F336W                    |                   |               | Pattern 1, Exps 1-1 in Visit 01 (1) | 426 Secs                                                                                                                 |                              |            |
|                                                                                                |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     | [==>(Pattern 1)]<br>[==>(Pattern 2)]<br>[==>(Pattern 3)]<br>[==>(Pattern 4)]                                             |                              | [1]        |
|                                                                                                | 2                                        | SN2008AX_F625W                                                                                                                                                                                                                          | (1) SN2008AX | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB                                                   |  | F625W                    |                   |               | Pattern 1, Exps 2-2 in Visit 01 (1) | 252 Secs                                                                                                                 |                              |            |
|                                                                                                |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     | [==>(Pattern 1)]<br>[==>(Pattern 2)]<br>[==>(Pattern 3)]<br>[==>273.0 Secs (Pattern 4)]                                  |                              | [1]<br>[2] |
|                                                                                                | 3                                        | SN2008AX_F438W                                                                                                                                                                                                                          | (1) SN2008AX | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB                                                   |  | F438W                    |                   |               | Pattern 1, Exps 3-3 in Visit 01 (1) | 400 Secs                                                                                                                 |                              |            |
|                                                                                                |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     | [==>421.0 Secs (Pattern 1)]<br>[==>421.0 Secs (Pattern 2)]<br>[==>421.0 Secs (Pattern 3)]<br>[==>421.0 Secs (Pattern 4)] |                              | [2]        |
|                                                                                                | 4                                        | SN2008AX_F606W                                                                                                                                                                                                                          | (1) SN2008AX | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB                                                   |  | F606W                    |                   |               | Pattern 1, Exps 4-4 in Visit 01 (1) | 275 Secs                                                                                                                 |                              |            |
|                                                                                                |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     | [==>296.0 Secs (Pattern 1)]<br>[==>296.0 Secs (Pattern 2)]<br>[==>359.0 Secs (Pattern 3)]<br>[==>359.0 Secs (Pattern 4)] |                              | [2]<br>[3] |
|                                                                                                | 5                                        | SN2008AX_F814W                                                                                                                                                                                                                          | (1) SN2008AX | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB                                                   |  | F814W                    |                   |               | Pattern 1, Exps 5-5 in Visit 01 (1) | 400 Secs                                                                                                                 |                              |            |
|                                                                                                |                                          |                                                                                                                                                                                                                                         |              |                                                                                     |  |                          |                   |               |                                     | [==>484.0 Secs (Pattern 1)]<br>[==>484.0 Secs (Pattern 2)]<br>[==>484.0 Secs (Pattern 3)]<br>[==>484.0 Secs (Pattern 4)] |                              | [3]        |



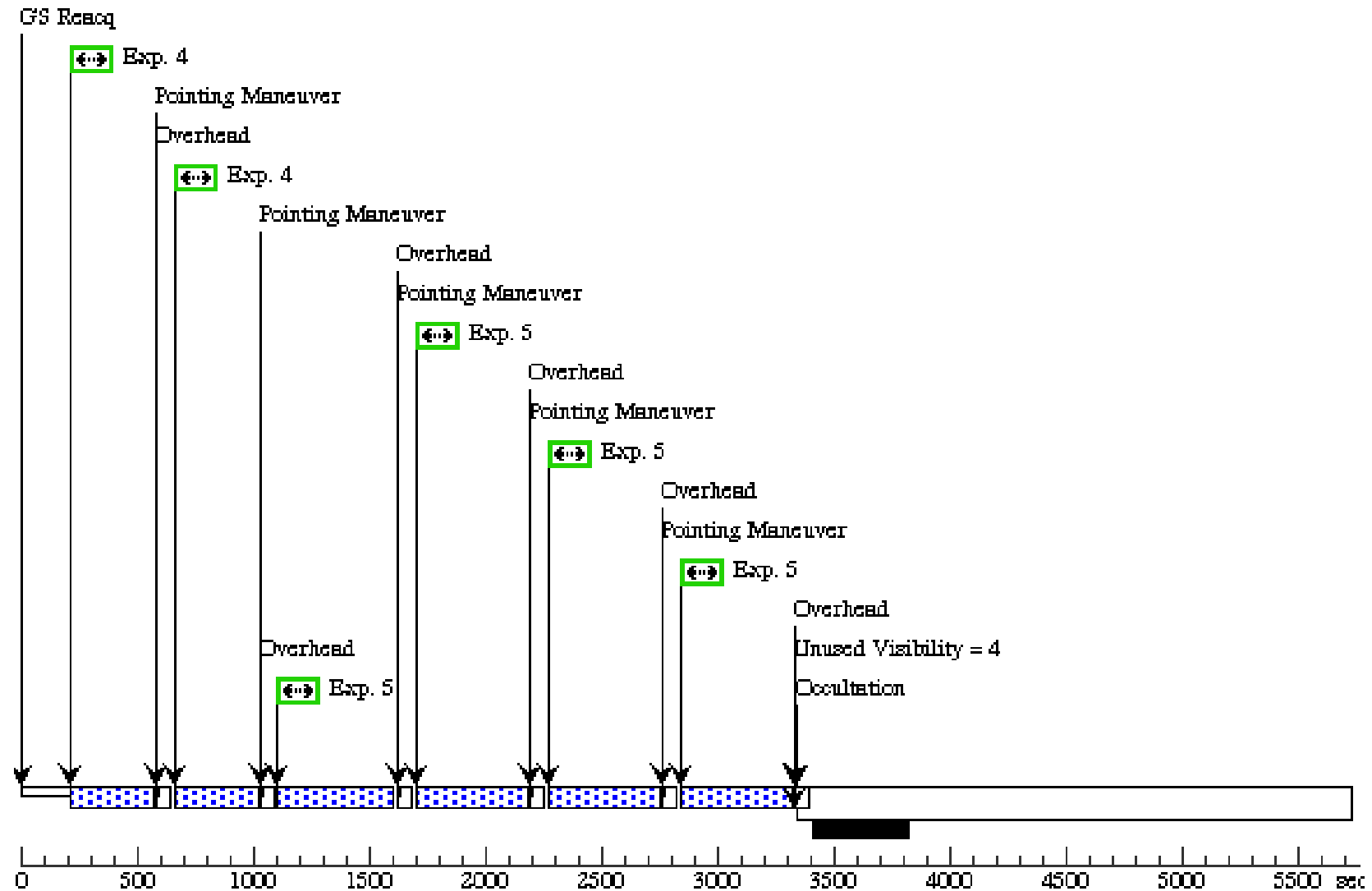
## Orbit 2

Server Version: 20100902



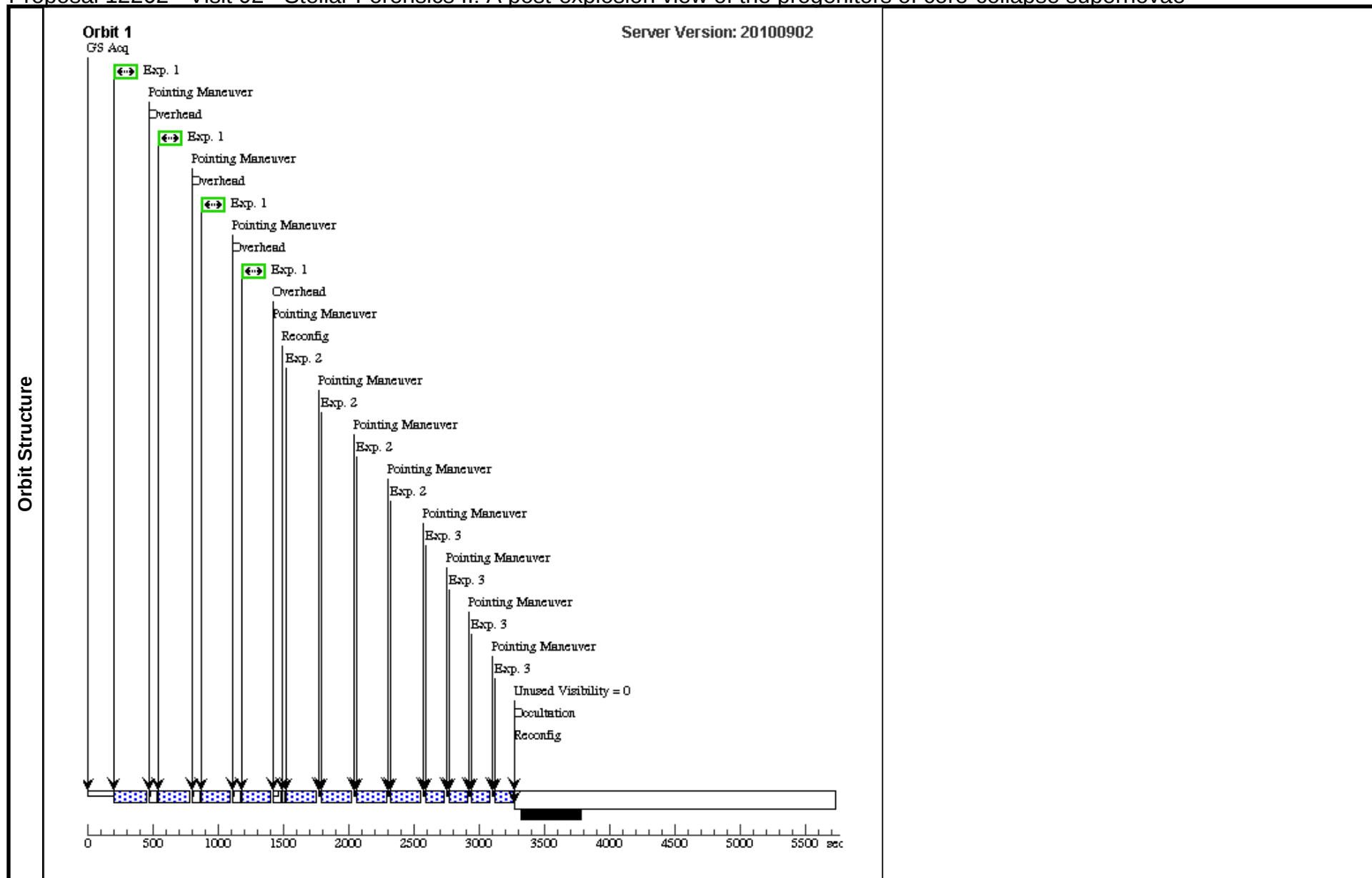
### Orbit 3

Server Version: 20100902



# Proposal 12262 - Visit 02 - Stellar Forensics II: A post-explosion view of the progenitors of core-collapse supernovae

|               |                                                                                                   |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
|---------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------|-------------------------------|--------------|------------------------|-------------------------------------|-----------------------------------------------------------------------------------------|--|------------------------------|-----------|--|
| Visit         | Proposal 12262, Visit 02, implementation                                                          |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  | Tue Mar 29 01:17:01 GMT 2011 |           |  |
|               | Diagnostic Status: No Diagnostics                                                                 |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
|               | Scientific Instruments: WFC3/IR, WFC3/UVIS                                                        |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
|               | Special Requirements: (none)                                                                      |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
|               | Comments: Visit for SN2008BK                                                                      |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
| Patterns      | #                                                                                                 | Primary Pattern                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              | Secondary Pattern      |                                     |                                                                                         |  |                              | Exposures |  |
|               | (1)                                                                                               | Pattern Type=WFC3-UVIS-DITHER-BOX<br>Coordinate Frame=POS-TARG<br>Pattern Orientation=23.884<br>Purpose=DITHER<br>Angle Between Sides=81.785<br>Number Of Points=4<br>Center Pattern=false<br>Point Spacing=0.173<br>Line Spacing=0.112   |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              | (1)       |  |
|               | (2)                                                                                               | Pattern Type=WFC3-IR-DITHER-BOX-MIN<br>Coordinate Frame=POS-TARG<br>Pattern Orientation=18.528<br>Purpose=DITHER<br>Angle Between Sides=74.653<br>Number Of Points=4<br>Center Pattern=false<br>Point Spacing=0.572<br>Line Spacing=0.365 |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              | (2), (3)  |  |
| Fixed Targets | #                                                                                                 | Name                                                                                                                                                                                                                                      | Target Coordinates                                                                   |                                   | Targ. Coord. Corrections      |              | Fluxes                 |                                     | Miscellaneous                                                                           |  |                              |           |  |
|               | (2)                                                                                               | SN2008BK                                                                                                                                                                                                                                  | RA: 23 57 50.4200 (359.4600833d)<br>Dec: -32 33 21.50 (-32.55597d)<br>Equinox: J2000 |                                   |                               |              | V=20+/-0.5             |                                     | Reference Frame: ICRS                                                                   |  |                              |           |  |
|               | Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
| Exposures     | #                                                                                                 | Label                                                                                                                                                                                                                                     | Target                                                                               | Config,Mode,Aperture              | Spectral Els.                 | Opt. Params. | Special Reqs.          | Groups                              | Exp. Time/[Actual Dur.]                                                                 |  | Orbit                        |           |  |
|               | 1                                                                                                 | SN2008BK_I                                                                                                                                                                                                                                | (2) SN2008BK                                                                         | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB | F814W                         |              | GS ACQ SCENARIO SINGLE | Pattern 1, Exps 1-1 in Visit 02 (1) | 225 Secs                                                                                |  | [1]                          |           |  |
|               |                                                                                                   |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     | [==>(Pattern 1)]<br>[==>240.0 Secs (Pattern 2)]<br>[==>(Pattern 3)]<br>[==>(Pattern 4)] |  |                              |           |  |
|               |                                                                                                   |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
|               |                                                                                                   |                                                                                                                                                                                                                                           |                                                                                      |                                   |                               |              |                        |                                     |                                                                                         |  |                              |           |  |
| 2             | SN2008BK_H                                                                                        | (2) SN2008BK                                                                                                                                                                                                                              | WFC3/IR, MULTIACCUM, IRSUB512                                                        | F160W                             | NSAMP=10;<br>SAMP-SEQ=SPARS25 |              |                        | Pattern 2, Exps 2-2 in Visit 02 (2) | [==>(Pattern 1)]<br>[==>(Pattern 2)]<br>[==>(Pattern 3)]<br>[==>(Pattern 4)]            |  | [1]                          |           |  |
| 3             | SN2008BK_J                                                                                        | (2) SN2008BK                                                                                                                                                                                                                              | WFC3/IR, MULTIACCUM, IRSUB512                                                        | F125W                             | NSAMP=6;<br>SAMP-SEQ=SPARS25  |              |                        | Pattern 2, Exps 3-3 in Visit 02 (2) | [==>(Pattern 1)]<br>[==>(Pattern 2)]<br>[==>(Pattern 3)]<br>[==>(Pattern 4)]            |  | [1]                          |           |  |



# Proposal 12262 - Visit 03 - Stellar Forensics II: A post-explosion view of the progenitors of core-collapse supernovae

|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     |                             |                              |                       |  |  |
|---------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------|-------|--------------------------|-------------------|-------------------------------------|-------------------------------------|-----------------------------|------------------------------|-----------------------|--|--|
| Visit         | Proposal 12262, Visit 03, implementation                                                          |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     |                             | Tue Mar 29 01:17:02 GMT 2011 |                       |  |  |
|               | Diagnostic Status: No Diagnostics                                                                 |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     |                             |                              |                       |  |  |
|               | Scientific Instruments: ACS/WFC                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     |                             |                              |                       |  |  |
|               | Special Requirements: AFTER 01-FEB-2011:00:00:00                                                  |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     |                             |                              |                       |  |  |
|               | Comments: Visit for SN2008CN                                                                      |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     |                             |                              |                       |  |  |
| Patterns      | #                                                                                                 | Primary Pattern                                                                                                                                                                                                                     |                                                                                      |                         |       |                          | Secondary Pattern |                                     |                                     |                             |                              | Exposures             |  |  |
|               | (3)                                                                                               | Pattern Type=ACS-WFC-DITHER-BOX<br>Coordinate Frame=POS-TARG<br>Pattern Orientation=20.67<br>Purpose=DITHER<br>Angle Between Sides=69.05<br>Number Of Points=4<br>Center Pattern=false<br>Point Spacing=0.265<br>Line Spacing=0.187 |                                                                                      |                         |       |                          |                   |                                     |                                     |                             |                              | (1), (2), (3)         |  |  |
| Fixed Targets | #                                                                                                 | Name                                                                                                                                                                                                                                | Target Coordinates                                                                   |                         |       | Targ. Coord. Corrections |                   |                                     | Fluxes                              |                             |                              | Miscellaneous         |  |  |
|               | (3)                                                                                               | SN2008CN                                                                                                                                                                                                                            | RA: 12 40 55.6600 (190.2319167d)<br>Dec: -40 58 12.10 (-40.97003d)<br>Equinox: J2000 |                         |       |                          |                   |                                     | V=25+/-0.1                          |                             |                              | Reference Frame: ICRS |  |  |
|               | Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     |                             |                              |                       |  |  |
| Exposures     | #                                                                                                 | Label                                                                                                                                                                                                                               | Target                                                                               | Config,Mode,Aperture    |       | Spectral Els.            | Opt. Params.      | Special Reqs.                       | Groups                              | Exp. Time/[Actual Dur.]     |                              | Orbit                 |  |  |
|               | 1                                                                                                 | SN2008CN_ (3) F555W                                                                                                                                                                                                                 | SN2008CN                                                                             | ACS/WFC, ACCUM, WFC1-1K |       | F555W                    |                   |                                     | Pattern 3, Exps 1-1 in Visit 03 (3) | 425 Secs                    |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     | [==>465.0 Secs (Pattern 1)] |                              | [1]                   |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     | [==>465.0 Secs (Pattern 2)] |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     | [==>465.0 Secs (Pattern 3)] |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     | [==>465.0 Secs (Pattern 4)] |                              |                       |  |  |
|               | 2                                                                                                 | SN2008CN_ (3) F814W                                                                                                                                                                                                                 | SN2008CN                                                                             | ACS/WFC, ACCUM, WFC1-1K |       | F814W                    |                   |                                     | Pattern 3, Exps 2-2 in Visit 03 (3) | 375 Secs                    |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     | [==>415.0 Secs (Pattern 1)] |                              | [1]                   |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     | [==>390.0 Secs (Pattern 2)] |                              | [2]                   |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     |                                     | [==>390.0 Secs (Pattern 3)] |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     | [==>390.0 Secs (Pattern 4)]         |                             |                              |                       |  |  |
| 3             | SN2008CN_ (3) F435W                                                                               | SN2008CN                                                                                                                                                                                                                            | ACS/WFC, ACCUM, WFC1-1K                                                              |                         | F435W |                          |                   | Pattern 3, Exps 3-3 in Visit 03 (3) | 250 Secs                            |                             |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     | [==>265.0 Secs (Pattern 1)]         |                             | [2]                          |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     | [==>265.0 Secs (Pattern 2)]         |                             |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     | [==>265.0 Secs (Pattern 3)]         |                             |                              |                       |  |  |
|               |                                                                                                   |                                                                                                                                                                                                                                     |                                                                                      |                         |       |                          |                   |                                     | [==>265.0 Secs (Pattern 4)]         |                             |                              |                       |  |  |

