



## 13480 - Super-luminous supernovae without host galaxies

Cycle: 21, Proposal Category: GO

(Availability Mode: SUPPORTED)

### INVESTIGATORS

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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> |
|--------------|------------------------------|-------------------------------------|--------------------|-------------------------------|-------------------------------|
| S1           | (1) SN2008ES                 | ACS/WFC                             | 2                  | 12-Jul-2013 13:45:17.0        | yes                           |
| S2           | (1) SN2008ES                 | WFC3/IR                             | 1                  | 12-Jul-2013 13:45:24.0        | yes                           |
| Z1           | (2) SN2008FZ                 | ACS/WFC                             | 2                  | 12-Jul-2013 13:45:30.0        | yes                           |
| Z2           | (2) SN2008FZ                 | WFC3/IR                             | 1                  | 12-Jul-2013 13:45:35.0        | yes                           |
| H1           | (3) SN2009JH                 | ACS/WFC                             | 2                  | 12-Jul-2013 13:45:40.0        | yes                           |
| H2           | (3) SN2009JH                 | WFC3/IR                             | 1                  | 12-Jul-2013 13:45:45.0        | yes                           |

9 Total Orbits Used

## **ABSTRACT**

Super-luminous supernovae (SLSNe) are a population of presumed core collapse events, whose peak luminosity is a factor up to a hundred greater than that of the majority of SNe (typically  $M_V < -22$ ). Several models have been proposed for their progenitors, including an origin in the collapse of massive low metallicity stars in so called pair instability SNe, potentially making SLSNe a powerful link to the early Universe. In Cycle 20 we are undertaking a survey of SLSNe hosts in the UV and IR. Remarkably, even at the deep limits of HST, 1/3 of these SLSNe have no detected host galaxy ( $F336W > 26.5$ , corresponding to absolute magnitude limits of  $M_{UV} \sim -13$  at  $z \sim 0.2$ ), and another 1/3 lie on regions within their host where there is no sign of ongoing star formation. This may suggest either that these events arise in extremely low luminosity (and possibly low metallicity) star forming galaxies, or alternatively that we need to reassess their interpretation as core collapse events. Here we propose to resolve this discrepancy, by obtaining deep observations of 3 events without host galaxies in both the optical and IR. We will place limits that are a factor of  $\sim 6-8$  deeper than those currently obtained, covering even the lowest luminosity star forming dwarf galaxies known, reaching limiting absolute magnitudes of  $M_V \sim -11$ . If we locate hosts in these images it would imply an origin in low metallicity star forming systems. Alternatively, their non-detection may suggest that they do not lie on host galaxies, and instead may be an older population, not formed through a conventional core-collapse mechanism, that has moved significantly from their birth sites before the supernova.

## **OBSERVING DESCRIPTION**

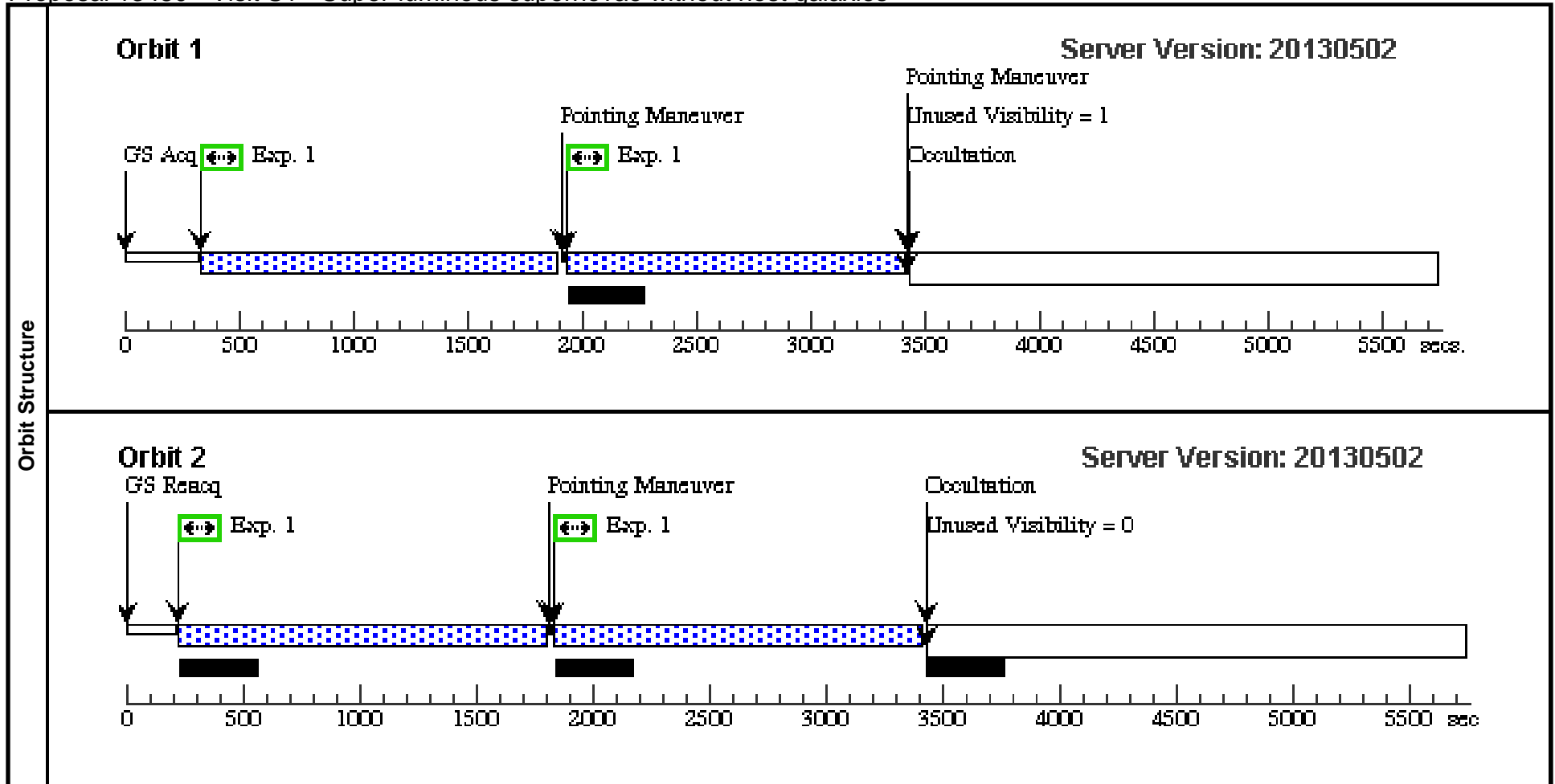
The purpose of these observations is to perform a deep optical and IR search for emission at the location of a sample of superluminous SNe whose host galaxies appear to be extremely underluminous.

We will obtain these observations by taking two orbits of ACS/F606W data, utilizing a 4-point dither and placing the target at the WFC1-CTE aperture to mitigate against any CTE losses. We will complement these data by observing a single orbit with WFC3/IR, again using a 4-point dither.

Proposal 13480 - Visit S1 - Super-luminous supernovae without host galaxies

Fri Jul 12 17:45:52 GMT 2013

| Visit         | <b>Proposal 13480, Visit S1</b><br><b>Diagnostic Status: No Diagnostics</b><br>Scientific Instruments: ACS/WFC<br>Special Requirements: (none) |          |  |   |               |                       |               |                                     |                                 |       |
|---------------|--|----------|--|---|---------------|-----------------------|---------------|-------------------------------------|---------------------------------|-------|
|               | Patterns   | #        | Primary Pattern  | Secondary Pattern   | Exposures     |                       |               |                                     |                                 |       |
|               |  | (1)      | Pattern Type=ACS-WFC-DITHER-BOX<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.265<br>Line Spacing=0.187 | Coordinate Frame=POS-TARG<br>Pattern Orientation=20.67<br>Angle Between Sides=69.05<br>Center Pattern=false |               | (1)                   |               |                                     |                                 |       |
| Fixed Targets | #  | Name     | Target Coordinates   | Targ. Coord. Corrections  | Fluxes        | Miscellaneous         |               |                                     |                                 |       |
|               | (1)  | SN2008ES | RA: 11 56 49.1300 (179.2047083d)<br>Dec: +54 27 25.70 (54.45714d)<br>Equinox: J2000                                  |   | V=28+/-1      | Reference Frame: SDSS |               |                                     |                                 |       |
| Exposures     | #  | Label    | Target   | Config,Mode,Aperture  | Spectral Els. | Opt. Params.          | Special Reqs. | Groups                              | Exp. Time (Total)/[Actual Dur.] | Orbit |
|               | 1  |          | (1) SN2008ES   | ACS/WFC, ACCUM, WFC1-CTE  | F606W         |                       |               | Pattern 1, Exps 1-1 in Visit S1 (1) | 900 Secs (5630 Secs)            |       |
|               |  |          |  |   |               |                       |               |                                     | [==>1359.0 Secs (Pattern 1)]    | [1]   |
|               |  |          |  |   |               |                       |               |                                     | [==>1359.0 Secs (Pattern 2)]    |       |
|               |  |          |  |   |               |                       |               | [==>1456.0 Secs (Pattern 3)]        |                                 |       |
|               |  |          |  |   |               |                       |               | [==>1456.0 Secs (Pattern 4)]        | [2]                             |       |



Proposal 13480 - Visit S2 - Super-luminous supernovae without host galaxies

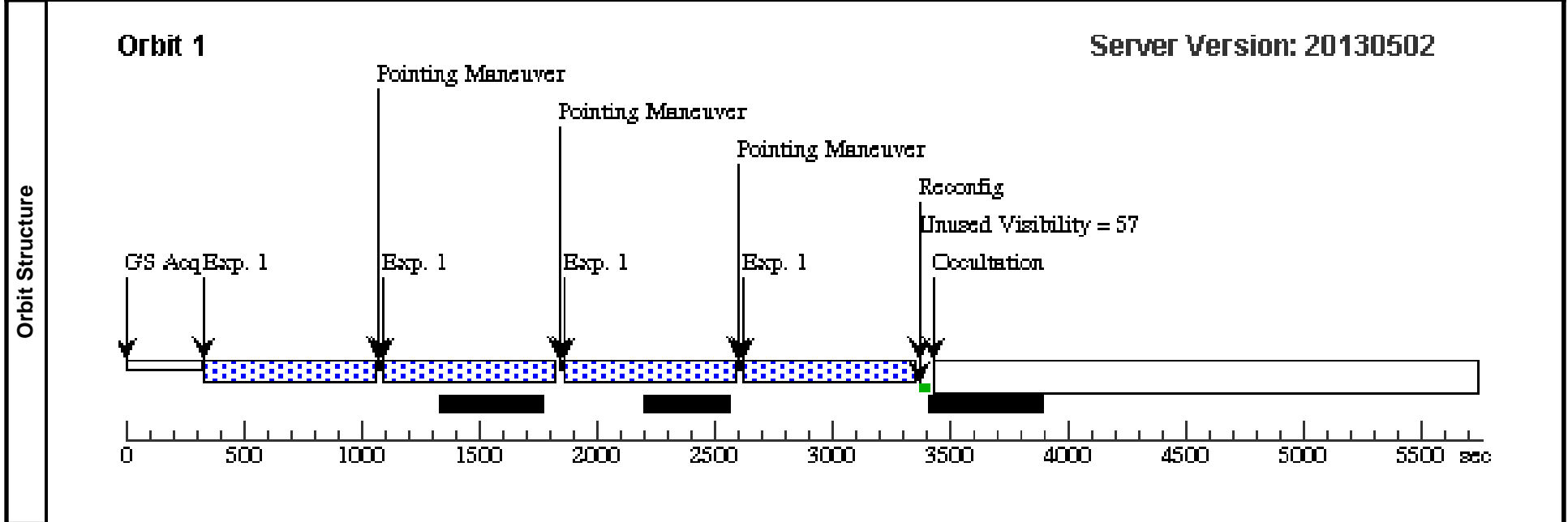
Fri Jul 12 17:45:54 GMT 2013

|              |  |  |  |
|--------------|--|--|--|
| <b>Visit</b> | <b>Proposal 13480, Visit S2</b>          |  |  |
|              | <b>Diagnostic Status: No Diagnostics</b> |  |  |
|              | Scientific Instruments: WFC3/IR          |  |  |
|              | Special Requirements: (none)             |  |  |

| <b>Patterns</b> | #   | Primary Pattern  | Secondary Pattern   | Exposures |
|-----------------|-----|--|---|-----------|
|                 | (2) | Pattern Type=WFC3-IR-DITHER-BOX-MIN<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.572<br>Line Spacing=0.365 | Coordinate Frame=POS-TARG<br>Pattern Orientation=18.528<br>Angle Between Sides=74.653<br>Center Pattern=false |           |

| <b>Fixed Targets</b> | #   | Name     | Target Coordinates  | Targ. Coord. Corrections | Fluxes   | Miscellaneous         |
|----------------------|-----|----------|---|--------------------------|----------|-----------------------|
|                      | (1) | SN2008ES | RA: 11 56 49.1300 (179.2047083d)<br>Dec: +54 27 25.70 (54.45714d)<br>Equinox: J2000 |                          | V=28+/-1 | Reference Frame: SDSS |

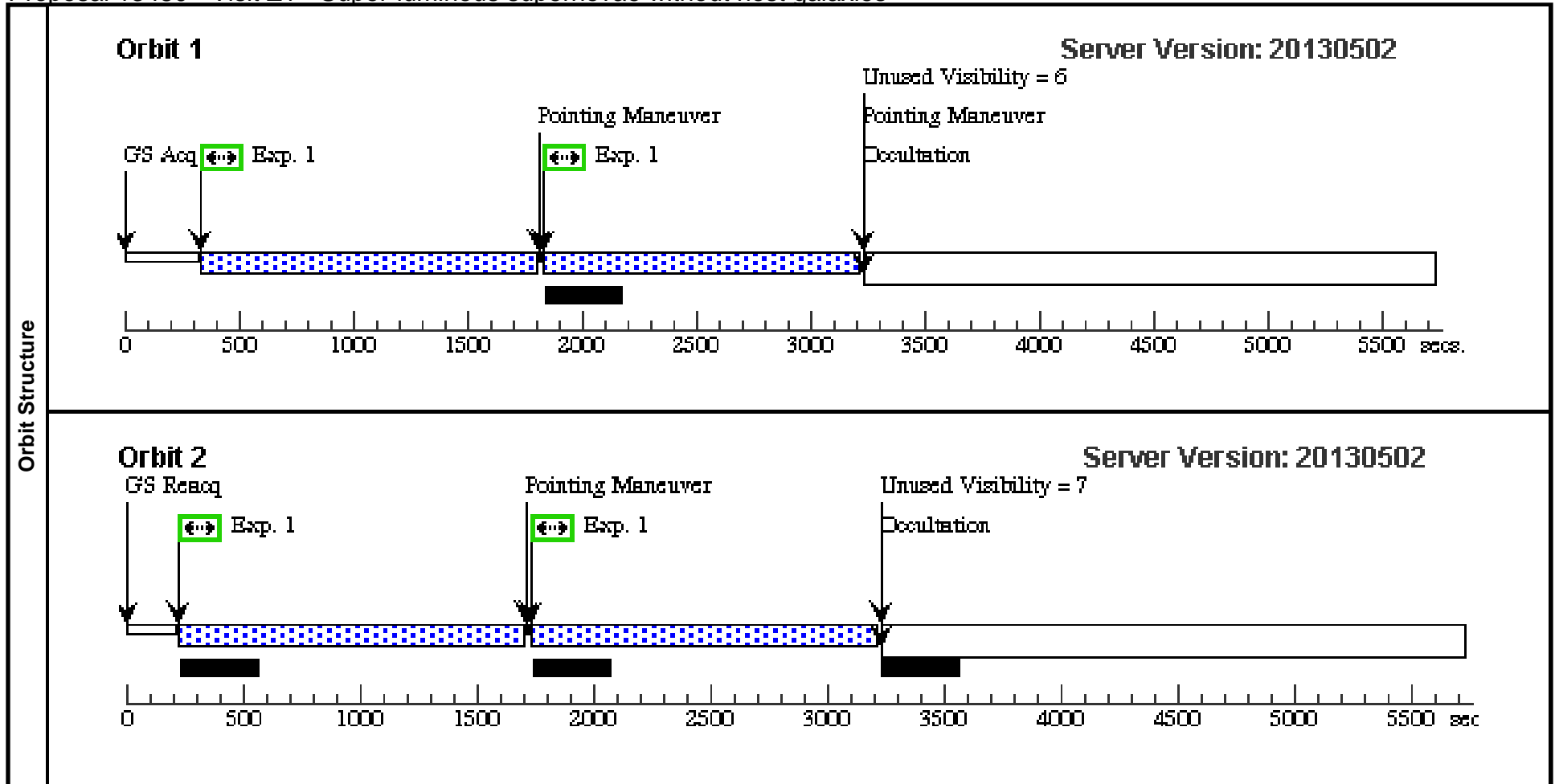
| <b>Exposures</b> | # | Label        | Target                  | Config,Mode,Aperture | Spectral Els.                     | Opt. Params. | Special Reqs. | Groups                                  | Exp. Time (Total)/[Actual Dur.]   | Orbit |
|------------------|---|--------------|-------------------------|----------------------|-----------------------------------|--------------|---------------|---|---|-------|
|                  | 1 | (1) SN2008ES | WFC3/IR, MULTIACCUM, IR | F160W                | NSAMP=15;<br>SAMP-SEQ=SPAR<br>S50 |              |               | Pattern 2, Exps 1-1 i<br>n Visit S2 (2) | 702.938605 Secs (2811.754 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]<br>[==>(Pattern 3)]<br>[==>(Pattern 4)] | [1]   |



Proposal 13480 - Visit Z1 - Super-luminous supernovae without host galaxies

Fri Jul 12 17:45:55 GMT 2013

| Visit         | <b>Proposal 13480, Visit Z1</b><br><b>Diagnostic Status: No Diagnostics</b><br>Scientific Instruments: ACS/WFC<br>Special Requirements: ORIENT 67D TO 137 D; ORIENT 157D TO 227 D; ORIENT 247D TO 317 D; ORIENT 337D TO 47 D |          |  |   |                          |              |                   |   |                                 |           |       |
|---------------|--|----------|--|---|--------------------------|--------------|-------------------|---|---------------------------------|-----------|-------|
|               | Patterns   | #        | Primary Pattern  |   |                          |              | Secondary Pattern |   |                                 | Exposures |       |
|               |  | (1)      | Pattern Type=ACS-WFC-DITHER-BOX<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.265<br>Line Spacing=0.187 | Coordinate Frame=POS-TARG<br>Pattern Orientation=20.67<br>Angle Between Sides=69.05<br>Center Pattern=false |                          |              |                   | (1)                                     |                                 |           |       |
| Fixed Targets | #  | Name     | Target Coordinates   |   | Targ. Coord. Corrections |              | Fluxes            | Miscellaneous                           |                                 |           |       |
|               | (2)  | SN2008FZ | RA: 23 16 16.6000 (349.0691667d)<br>Dec: +11 42 47.50 (11.71319d)<br>Equinox: J2000                                  |   |                          |              | V=28              | Reference Frame: SDSS                   |                                 |           |       |
| Exposures     | #  | Label    | Target   | Config,Mode,Aperture  | Spectral Els.            | Opt. Params. | Special Reqs.     | Groups                                  | Exp. Time (Total)/[Actual Dur.] |           | Orbit |
|               | 1  |          | (2) SN2008FZ   | ACS/WFC, ACCUM, WFC1-CTE  | F606W                    |              |                   | Pattern 1, Exps 1-1 i<br>n Visit Z1 (1) | 900 Secs (5236 Secs)            |           |       |
|               |  |          |  |   |                          |              |                   |   | [=>1261.0 Secs (Pattern 1)]     |           | [1]   |
|               |  |          |  |   |                          |              |                   |   | [=>1261.0 Secs (Pattern 2)]     |           |       |
|               |  |          |  |   |                          |              |                   |   | [=>1357.0 Secs (Pattern 3)]     |           |       |
|               |  |          |  |   |                          |              |                   |   | [=>1357.0 Secs (Pattern 4)]     |           | [2]   |



Proposal 13480 - Visit Z2 - Super-luminous supernovae without host galaxies

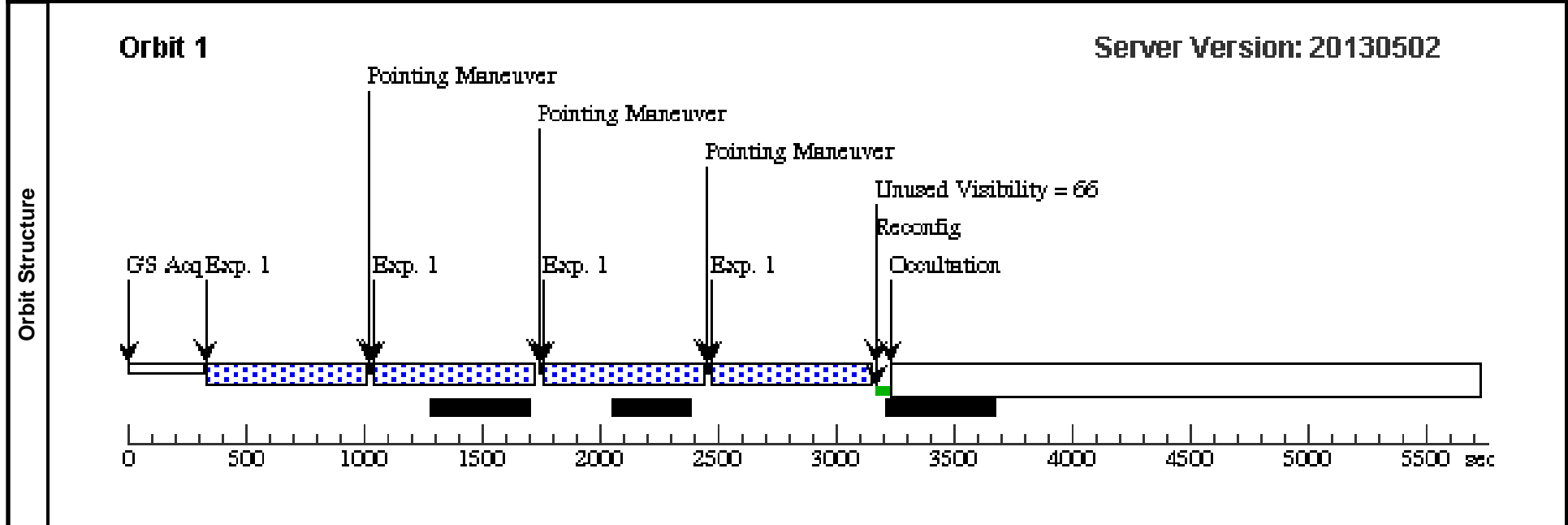
Fri Jul 12 17:45:56 GMT 2013

|              |  |  |  |
|--------------|--|--|--|
| <b>Visit</b> | <b>Proposal 13480, Visit Z2</b><br><b>Diagnostic Status: No Diagnostics</b><br>Scientific Instruments: WFC3/IR<br>Special Requirements: ORIENT 67D TO 137 D; ORIENT 157D TO 227 D; ORIENT 247D TO 317 D; ORIENT 337D TO 47 D |  |  |
|              |  |  |  |

| <b>Patterns</b> | #   | Primary Pattern  | Secondary Pattern   | Exposures |
|-----------------|-----|--|---|-----------|
|                 | (2) | Pattern Type=WFC3-IR-DITHER-BOX-MIN<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.572<br>Line Spacing=0.365 | Coordinate Frame=POS-TARG<br>Pattern Orientation=18.528<br>Angle Between Sides=74.653<br>Center Pattern=false | (1)       |

| <b>Fixed Targets</b> | #   | Name     | Target Coordinates  | Targ. Coord. Corrections | Fluxes | Miscellaneous         |
|----------------------|-----|----------|---|--------------------------|--------|-----------------------|
|                      | (2) | SN2008FZ | RA: 23 16 16.6000 (349.0691667d)<br>Dec: +11 42 47.50 (11.71319d)<br>Equinox: J2000 |                          | V=28   | Reference Frame: SDSS |

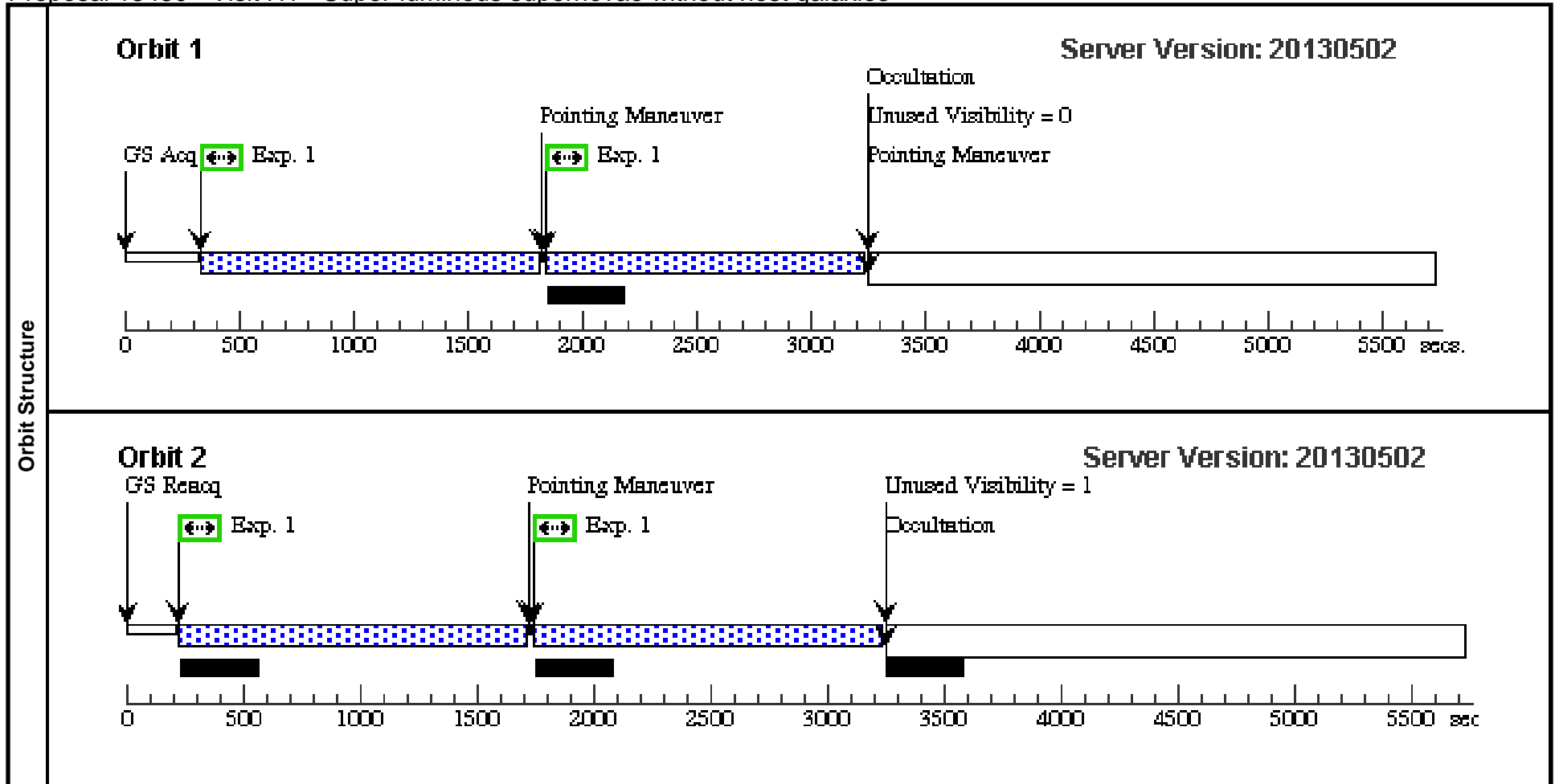
| <b>Exposures</b> | # | Label | Target       | Config,Mode,Aperture    | Spectral Els. | Opt. Params.                      | Special Reqs. | Groups                                  | Exp. Time (Total)/[Actual Dur.]  | Orbit |
|------------------|---|-------|--------------|-------------------------|---------------|-----------------------------------|---------------|---|--|-------|
|                  | 1 |       | (2) SN2008FZ | WFC3/IR, MULTIACCUM, IR | F160W         | NSAMP=14;<br>SAMP-SEQ=SPAR<br>S50 |               | Pattern 2, Exps 1-1 i<br>n Visit Z2 (2) | 652.938154 Secs (2611.753 Secs)  |       |
|                  |   |       |              |                         |               |                                   |               |   | [==>(Pattern 1)]<br>[==>(Pattern 2)]<br>[==>(Pattern 3)]<br>[==>(Pattern 4)] | [1]   |



Proposal 13480 - Visit H1 - Super-luminous supernovae without host galaxies

Fri Jul 12 17:45:57 GMT 2013

| Visit         | Proposal 13480, Visit H1<br>Diagnostic Status: No Diagnostics<br>Scientific Instruments: ACS/WFC<br>Special Requirements: (none) |          |  |   |                          |              |                   |                                     |                                 |                       |       |
|---------------|--|----------|--|---|--------------------------|--------------|-------------------|-------------------------------------|---------------------------------|-----------------------|-------|
|               | Patterns   | #        | Primary Pattern  |   |                          |              | Secondary Pattern |                                     |                                 | Exposures             |       |
|               |  | (1)      | Pattern Type=ACS-WFC-DITHER-BOX<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.265<br>Line Spacing=0.187 | Coordinate Frame=POS-TARG<br>Pattern Orientation=20.67<br>Angle Between Sides=69.05<br>Center Pattern=false |                          |              |                   |                                     |                                 | (1)                   |       |
| Fixed Targets | #  | Name     | Target Coordinates   |   | Targ. Coord. Corrections |              | Fluxes            |                                     | Miscellaneous                   |                       |       |
|               | (3)  | SN2009JH | RA: 14 49 10.0900 (222.2920417d)<br>Dec: +29 25 10.40 (29.41956d)<br>Equinox: J2000                                  |   |                          |              |                   | V=28+/-1                            |                                 | Reference Frame: SDSS |       |
| Exposures     | #  | Label    | Target   | Config,Mode,Aperture  | Spectral Els.            | Opt. Params. | Special Reqs.     | Groups                              | Exp. Time (Total)/[Actual Dur.] |                       | Orbit |
|               | 1  |          | (3) SN2009JH   | ACS/WFC, ACCUM, WFC1-CTE  | F606W                    |              |                   | Pattern 1, Exps 1-1 in Visit H1 (1) | 900 Secs (5276 Secs)            |                       |       |
|               |  |          |  |   |                          |              |                   |                                     | [=>1271.0 Secs (Pattern 1)]     |                       | [1]   |
|               |  |          |  |   |                          |              |                   |                                     | [=>1271.0 Secs (Pattern 2)]     |                       |       |
|               |  |          |  |   |                          |              |                   |                                     | [=>1367.0 Secs (Pattern 3)]     |                       | [2]   |
|               |  |          |  |   |                          |              |                   |                                     | [=>1367.0 Secs (Pattern 4)]     |                       |       |



Proposal 13480 - Visit H2 - Super-luminous supernovae without host galaxies

Fri Jul 12 17:45:58 GMT 2013

|              |  |  |  |
|--------------|--|--|--|
| <b>Visit</b> | <b>Proposal 13480, Visit H2</b><br><b>Diagnostic Status: No Diagnostics</b><br>Scientific Instruments: WFC3/IR<br>Special Requirements: (none) |  |  |
|--------------|--|--|--|

| <b>Patterns</b> | #   | Primary Pattern  | Secondary Pattern   | Exposures |
|-----------------|-----|--|---|-----------|
|                 | (2) | Pattern Type=WFC3-IR-DITHER-BOX-MIN<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.572<br>Line Spacing=0.365 | Coordinate Frame=POS-TARG<br>Pattern Orientation=18.528<br>Angle Between Sides=74.653<br>Center Pattern=false | (1)       |

| <b>Fixed Targets</b> | #   | Name     | Target Coordinates  | Targ. Coord. Corrections | Fluxes   | Miscellaneous         |
|----------------------|-----|----------|---|--------------------------|----------|-----------------------|
|                      | (3) | SN2009JH | RA: 14 49 10.0900 (222.2920417d)<br>Dec: +29 25 10.40 (29.41956d)<br>Equinox: J2000 |                          | V=28+/-1 | Reference Frame: SDSS |

| <b>Exposures</b> | # | Label | Target       | Config,Mode,Aperture    | Spectral Els. | Opt. Params.                      | Special Reqs. | Groups                              | Exp. Time (Total)/[Actual Dur.] | Orbit |
|------------------|---|-------|--------------|-------------------------|---------------|-----------------------------------|---------------|-------------------------------------|---------------------------------|-------|
|                  | 1 |       | (3) SN2009JH | WFC3/IR, MULTIACCUM, IR | F160W         | NSAMP=14;<br>SAMP-SEQ=SPAR<br>S50 |               | Pattern 2, Exps 1-1 in Visit H2 (2) | 652.938154 Secs (2611.753 Secs) | [1]   |

