# 18012 - Cosmology with the first gravitationally-lensed supernovae discovered by LSST within Euclid galaxy-galaxy lenses

Cycle: 33, Proposal Category: GO

(Availability Mode: SUPPORTED)

**INVESTIGATORS**

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|---|---|
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| Dr. Stefan Schuldt (CoI) (ESA Member) | Universita di Milano |


**VISITS**

| *Visit* | *Targets used in Visit* | *Configurations used in Visit* | *Orbits Used* | *Last Orbit Planner Run* | *OP Current with Visit?* |
|---|---|---|---|---|---|
| 01 | (1) GRAVITATIONALLY-LENSED-SN | WFC3/IR<br>WFC3/UVIS | 2 | 07-Oct-2025 03:00:15.0 | yes |
| 02 | (2) LENS-AFTER-SN-FADED | WFC3/UVIS | 2 | 07-Oct-2025 03:00:15.0 | yes |

4 Total Orbits Used

**ABSTRACT**

Local and early Universe measurements of the cosmic expansion rate disagree by 8% if the concordance cosmological model is correct. Before we claim new physics, additional high precision measurements of the expansion rate (H0) are desperately needed to rule out systematic errors. Strong gravitationally lensed supernovae (SNe) are perfect for such a measurement, but rates have historically been too low to build a cosmologically useful sample. With the advent of the Rubin Observatory's Legacy Survey of Space and Time we can now discover enough lensed SNe to make a precise constraint on H0, leveraging the standardisable nature of Type-Ia SNe to ensure that systematics are well controlled. The most exciting lensed SNe will occur in already known galaxy-galaxy lenses since they guarantee long time delays, large image separations and a multiply imaged host -- all of which are critical for precision cosmology. With the rapidly growing galaxy-galaxy lens sample of Euclid we can expect two doubly imaged SN-Ia to occur in a Euclid-discovered galaxy-galaxy lens during Cycle 33. We propose to use HST to 1) obtain astrometry of these SN images to milliarcsecond precision, and 2) obtain high resolution imaging of the lensed host galaxy after the SN has faded. This data will immediately allow us to measure the Hubble constant with 6% precision and build the foundation for a 2% measurement within 5 years.

**OBSERVING DESCRIPTION**

Our program consists of two epochs per gravitationally-lensed supernova (glSN) system: the first will occur immediately on discovery of the glSN, and will catch the multiple images of the glSN in F814W where they are brightest, providing milliarcsecond precision astrometry on the source positions. We also observe in F160W during this first epoch to constrain dust extinction when combined with ground optical colours. The second epoch is an observation taken much later when the glSN images have completely faded, which will provide accurate measurements of the lens galaxy's and lensed host galaxy's light profiles without contamination from the glSN. For this we observe again with F814W to ensure consistency with the first epoch, and this time with F475W as this provides excellent angular resolution in a wavelength where the lensed host is likely to be both bright and highly clumpy, which are the optimal conditions for precise lens modelling.

## Visit

**Proposal 18012, Supernova-visit (01), implementation** Tue Oct 07 07:00:16 GMT 2025

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: ON HOLD ; TOO RESPONSE TIME 21.0D

*Comments: This is the visit that will observe the multiple images of the lensed supernova. These observations will be in F814W and F160W.*

*On Hold Comments: Target of opportunity*

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=WFC3-UVIS-DITHER-BOX<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.145<br>Line Spacing=0.112 | Coordinate Frame=POS-TARG<br>Pattern Orientation=23.884<br>Angle Between Sides=81.785<br>Center Pattern=false | | (1) |
| (2) | Pattern Type=WFC3-IR-DITHER-BOX-MIN<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=1.716<br>Line Spacing=1.095 | Coordinate Frame=POS-TARG<br>Pattern Orientation=18.528<br>Angle Between Sides=74.653<br>Center Pattern=false | | (2) |

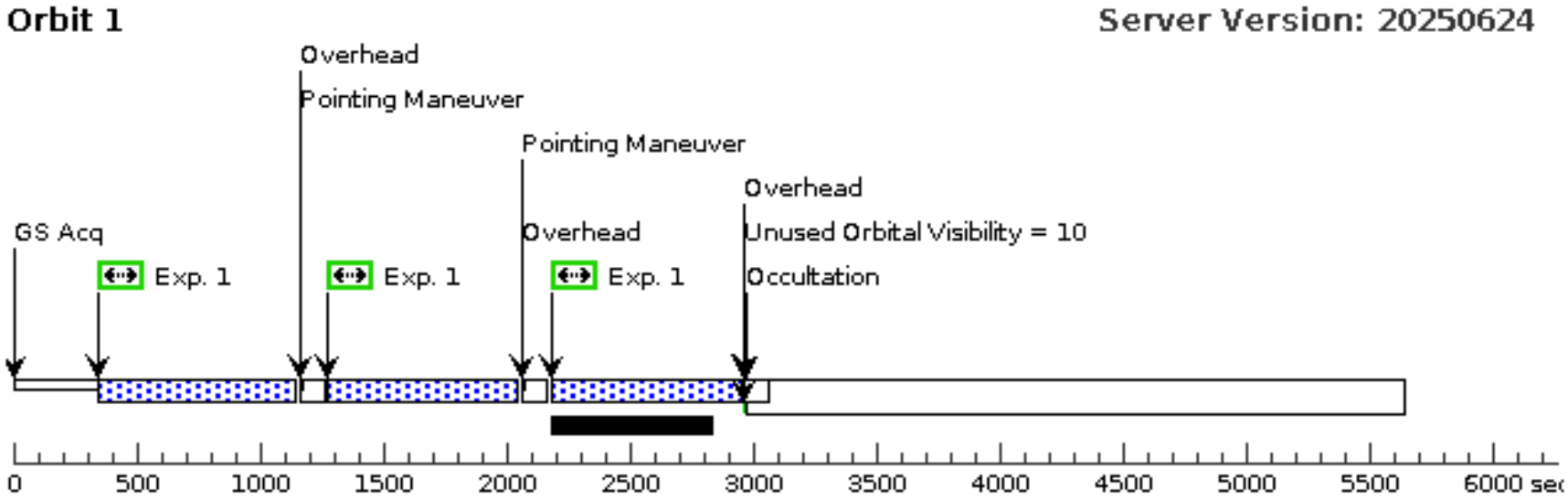
## Generic Targets

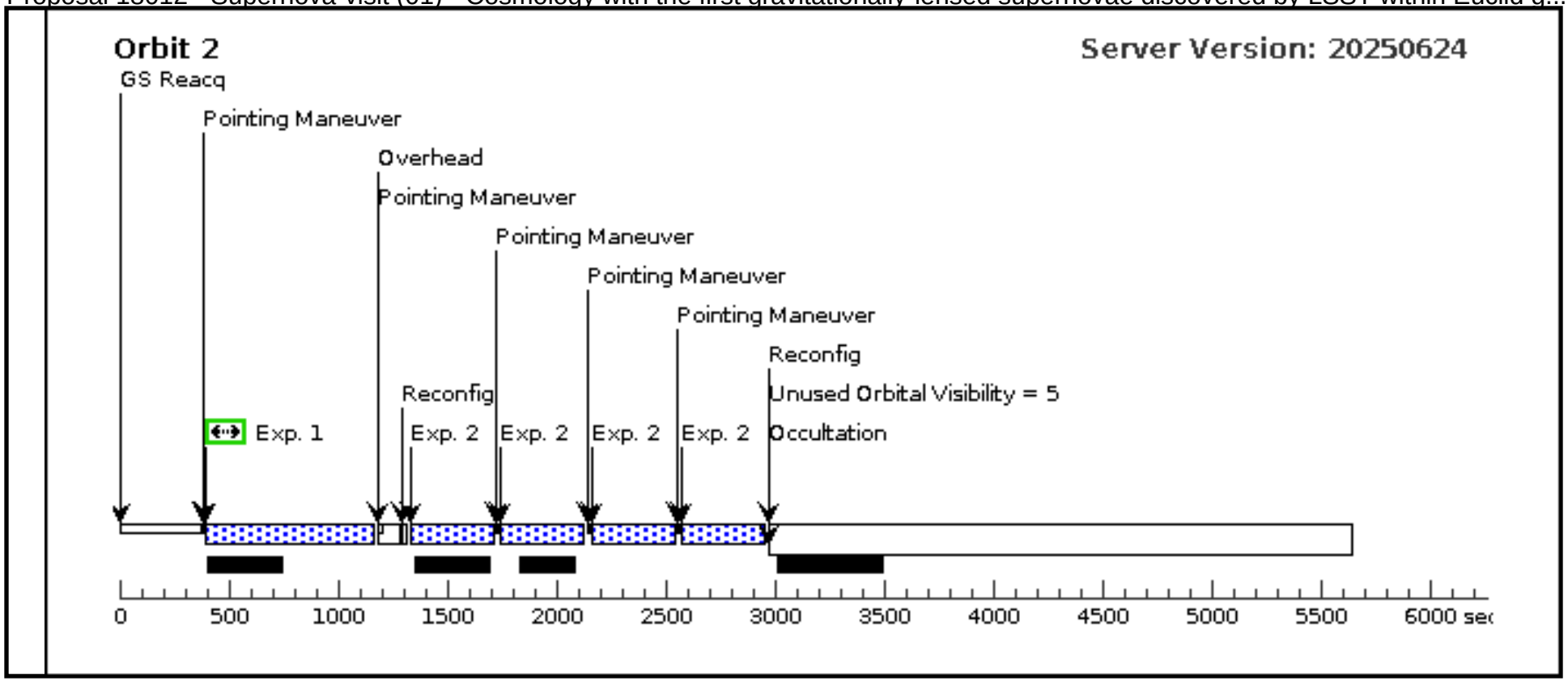
| # | Name | Criteria | Description |
|---|---|---|---|
| (1) | GRAVITATIONALLY-LENSED-SN | SN lensed by a Euclid-discovered galaxy-galaxy lens | SUPERNOVA |

## Exposures

| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F814W-exposure (WFC3UVIS.im.2023138) | (1) GRAVITATIONALLY-LENSED-SN | WFC3/UVIS, ACCUM, UVIS | F814W | | | Pattern 1, Exps 1-1 in Supernova-visit (01) (1) | 775 Secs (3100 Secs) | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 4)]* | ***[2]*** |
| 2 | F160W-exposure (WFC3IR.im.2023133) | (1) GRAVITATIONALLY-LENSED-SN | WFC3/IR, MULTIACCUM, IR | F160W | NSAMP=8;<br>SAMP-SEQ=SPARS50 | | Pattern 2, Exps 2-2 in Supernova-visit (01) (2) | 352.935448 Secs (1411.742 Secs) | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | ***[2]*** |

Orbit Structure




Orbit 2
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GS Reacq
Pointing Maneuver
Overhead
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Reconfig
Unused Orbital Visibility = 5
Reconfig
Exp. 1
Exp. 2
Exp. 2
Exp. 2
Exp. 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec

## Visit

**Proposal 18012, Lens-visit (02), implementation** Tue Oct 07 07:00:16 GMT 2025

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/UVIS

Special Requirements: SAME ORIENT AS 01; ON HOLD ; TOO RESPONSE TIME 21.0D

*Comments: This is the visit that will observe the lens system after the SN has completely faded, a few months after the first visit. These observations will be in F814W and F475W.*

*On Hold Comments: On hold until the SN (previous target of opportunity observation) has faded.*

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=WFC3-UVIS-DITHER-BOX<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.145<br>Line Spacing=0.112 | Coordinate Frame=POS-TARG<br>Pattern Orientation=23.884<br>Angle Between Sides=81.785<br>Center Pattern=false | | (1-2) |

## Generic Targets

| # | Name | Criteria | Description |
|---|---|---|---|
| (2) | LENS-AFTER-SN-FADED | Observations of the lens system after the supernova has completely faded | EINSTEIN RING<br>ELLIPTICAL<br>GRAVITATIONAL LENS |

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F814W-exposure | (2) LENS-AFTER-SN-FADED | WFC3/UVIS, ACCUM, UVIS | F814W | FLASH=9 | | Pattern 1, Exps 1-2 in Lens-visit (02) (1) | 500 Secs (2106 Secs) | |
| | | | | | | | | *[==>529.0 Secs (Pattern 1)]*<br>*[==>529.0 Secs (Pattern 2)]* | ***[1]*** |
| | | | | | | | | *[==>524.0 Secs (Pattern 3)]*<br>*[==>524.0 Secs (Pattern 4)]* | ***[2]*** |
| 2 | F475W-exposure | (2) LENS-AFTER-SN-FADED | WFC3/UVIS, ACCUM, UVIS | F475W | FLASH=10 | | Pattern 1, Exps 1-2 in Lens-visit (02) (1) | 500 Secs (2106 Secs) | |
| | | | | | | | | *[==>529.0 Secs (Pattern 1)]*<br>*[==>529.0 Secs (Pattern 2)]* | ***[1]*** |
| | | | | | | | | *[==>524.0 Secs (Pattern 3)]*<br>*[==>524.0 Secs (Pattern 4)]* | ***[2]*** |

Orbit Structure