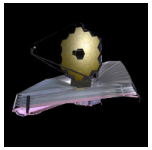

# 6541 - JWST NIRSpec/NIRCam Follow-Up of the High-Redshift Transients Discovered in the GOODS-S JADES-Deep Field

Cycle: 2, Proposal Category: DD

**INVESTIGATORS**

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**OBSERVATIONS**

| *Folder* | *Observation* | *Label* | *Observing Template* | *Science Target* |
|---|---|---|---|---|
| NIRSpec MSA | | | | |

| *Folder* | *Observation* | *Label* | *Observing Template* | *Science Target* |
|---|---|---|---|---|
| | 1 | p2, p1, p3 | NIRSpec MultiObject Spectroscopy | (6) egami_rev2_trim_ref |
| NIRCam Imaging | | | | |
| | 2 | | NIRCam Imaging | (2) JADES-Deep2 |
| | 3 | | NIRCam Imaging | (3) JADES-Deep3 |
| | 4 | | NIRCam Imaging | (4) JADES-Deep4 |
| | 5 | | NIRCam Imaging | (5) JADES-Deep5 |

**ABSTRACT**

The JWST Advanced Deep Extragalactic Survey (JADES) has obtained two sets of deep NIRCam images over the GOODS-S field with a separation of 1 year, which has enabled a transient survey of an unprecedented depth (down to ~30 AB mag). By differencing the 2022 and 2023 JADES-Deep NIRCam images covering an area of ~27 arcmin^2, we have securely identified 26 and 27 transients in the 2023 and 2022 data, respectively (i.e., ~1 transient/arcmin^2 per epoch) with their host redshifts ranging from z=0.5 to 4.4. In terms of the number of discovered transients (53 sources) and their redshifts (z_median~2), this is clearly a breakthrough result, and timely JWST follow-up observations are crucial to study the properties of the discovered high-redshift transients. Observationally we will, (1) obtain transient and host spectra with NIRSpec/MSA R~100 prism spectroscopy, and (2) measure light curves with NIRCam with 6 filters at 2 epochs (3 epochs with the discovery data), for a representative sample of the discovered transients. Scientifically, one primary goal is to estimate the fraction of core-collapse supernovae (SNe) among these transients and determine their rates accurately, which will allow us to constrain the top-heaviness in the IMF of high-redshift galaxies, a topic of great interest since this may be related to the unexpected abundance of luminous galaxies at z>10. The obtained light curves will also enable us to measure Type-Ia distances with a ~20% accuracy at z>2. Note that two epochs of the JADES-Deep NIRCam observations took ~230 hours, making this follow-up opportunity extremely valuable because such an experiment will be difficult to repeat anytime soon.

**OBSERVING DESCRIPTION**

Dec 8, 2023 (EE)

Obs 4 and 5: F115W has been replaced with F200W.
Obs 4 and 5 are ready for scheduling.

Dec 4, 2023 (EE)

Obs 4 and 5 NIRCam pointings have been adjusted.

Nov 27, 2023 (EE):

NIRSpec/MSA design for Obs 1 has been updated with an APA of 184 deg.
Obs 1 is ready for scheduling.

Nov 17, 2023 (EE):

Obs 2 and 3 NIRCam pointings have been adjusted.
Only Obs 2 and 3 are ready for scheduling at this point.

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This is a non-disruptive but time-critcal DDT.  We would greatly appreciate a timely review and decision of our proposal.

* Program design

This proposal consists of two parts: (1) NIRSpec/MSA spectroscopy (10.1 hrs), which will allow spectroscopic classification/characterization of the transients as well as spectroscopic determination of host redshifts, and (2) 2-epoch NIRCam imaging (8.2 hrs) (3-epoch when the discovery data is included), which will allow photometric classification of a larger number of the transients as well as Type Ia distance measurements. Each part will produce substantial scientific results, and is technically independent of the other. Knowing that the reviewers are typically advised not to split/modify a submitted program, we were planning to submit two DDT proposals to allow separate evaluation of the two parts, but we were advised by the STScI DDT team to combine the two and submit one for the efficiency of the review.  We believe that our proposal is especially compelling when the two parts are considered in combination, but we leave the possibility of partial acceptance to the reviewers and STScI.

* Scheduling

Note that all the special requirement contraints provided with this APT are tentative and are not meant to be strict requirements for our observations

in any sense. In general, we would like to obtain our 1st NIRCam and NIRSpec data as soon as possible, and if we get observing slots that are earlier/later than assumed below, we can adjust our observing strategy quickly. Our team is very experienced in producing MSA designs with a short timescale.

* NIRSpec spectroscopy

We will use the NIRSpec/MSA mode to take spectra of multiple transients and their host galaxies. We will use the low-resolution (R~100) prism to capture the spectra of the transients (e.g., supernovae) and to measure the redshifts of the host galaxies. Considering the faintness of many of our targets, we adopted the observing strategy successfully employed by the JADES NIRSpec Deep survey: the triple dithered, nodded, 19 group NRSIRS2 exposures with two ramps in each exposure. Hence, each sub-exposure ramp is of 1400 s duration, and each target is observed in six ramps for a total of 8400 s at each dither. Targets covered at all three dithers are therefore exposed for a total of 25200 s, which should yield a usable but low S/N continuum spectrum of a source as faint as 29 mag. The above choices lead to a total charged time of 10.1 hours.

* NIRCam imaging

We will also conduct 2-epoch NIRCam imaging to measure the light curves of the transients. With the 2023 discovery images obtained in Sep-Oct 2023, the proposed observations will produce 3-epoch light curves, which is sufficient to robustly identify the SN types with light curve fitting and obtain distance measurements for SNe Ia. With 2 pointings at each epoch, we will try to cover as many NIRSpec-targeted transients as possible. We will also maximize the coverage of other high-priority sources (e.g., high-redshift SNe Ia) by carefully designing the footprints of both modules.

We will obtain the 1st-epoch images as soon as possible, and will repeat the observation one more time ~40+-10 days later, which will likely coincide with the NIRSpec/MSA observation (although there is no special requirement directly connecting the NIRCam and NIRSpec observations). For the robust identification of SN types, we will construct 6-band light curves using the F115W, F150W, F200W, F277W, F356W, and F444W filters. With an integration time of ~1200 s per filter (SHALLOW4, 8 groups, 3 subpixel dithers), these images will achieve a 5-sigma detection limit of ~28--28.5 AB mag. A significant number of our transients are brighter than this threshold, allowing us to measure their light curves. The observing time is ~4 hours per epoch, with a total NIRCam time request of 8.2 hours.

The total time request is therefore 18.3 hours.

**Fixed Targets**

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | sn_trim_ref | RA: 03 32 38.9356 (53.1622317d)<br>Dec: -27 47 36.75 (-27.79354d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Description=[]* | | | | |
| (2) | JADES-Deep2 | RA: 03 32 43.1398 (53.1797492d)<br>Dec: -27 49 32.97 (-27.82583d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Category=Unidentified*<br>*Description=[Blank field]* | | | | |
| (3) | JADES-Deep3 | RA: 03 32 42.3550 (53.1764792d)<br>Dec: -27 46 25.06 (-27.77363d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Category=Unidentified*<br>*Description=[Blank field]* | | | | |
| (4) | JADES-Deep4 | RA: 03 32 39.7599 (53.1656662d)<br>Dec: -27 50 14.73 (-27.83742d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Category=Unidentified*<br>*Description=[Blank field]* | | | | |
| (5) | JADES-Deep5 | RA: 03 32 41.6430 (53.1735125d)<br>Dec: -27 46 25.63 (-27.77379d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Category=Unidentified*<br>*Description=[Blank field]* | | | | |
| (6) | egami_rev2_trim_ref | RA: 03 32 35.3630 (53.1473458d)<br>Dec: -27 48 34.47 (-27.80957d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Description=[]* | | | | |

## Observation

**Proposal 6541, Observation 1: p2, p1, p3** Mon Dec 11 18:01:15 GMT 2023

**Diagnostic Status: Warning**

Observing Template: NIRSpec MultiObject Spectroscopy

## Diagnostics

(p2, p1, p3 (Obs 1)) Warning (Form): Config c1 : p1 (#2) has 1 primary slit traces affected by failed open shutters.

(p2, p1, p3 (Obs 1)) Warning (Form): Config c1 : p1 (#2) has 3 master background shutters affected by failed open or closed shutters.

(p2, p1, p3 (Obs 1)) Warning (Form): Config c1 : p2 (#1) has 1 primary slit traces affected by failed open shutters.

(p2, p1, p3 (Obs 1)) Warning (Form): Config c1 : p3 (#3) has 1 master background shutters affected by failed open or closed shutters.

(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (6) | egami_rev2_trim_ref | RA: 03 32 35.3630 (53.1473458d)<br>Dec: -27 48 34.47 (-27.80957d)<br>Equinox: J2000 | | |

*Comments:*
*Description=[]*

## Acquisition

| # | Reference Star Bin | Target | Filter | MSA Configuration | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Filter: CLEAR; Readout: NRSRAPIDD6; 8 sources in 3 quads; [ Optimal TA Accuracy ] | SAME | CLEAR | Auto Acq MSA Config | NRSRAPIDD6 | 3 | 1 | 4 | 687.153 | |

## Template

| TA Method | Obtain Confirmation Images | Science Aperture | Primary Candidate List | Filler Candidate List | Spectral Overlap Map | Spectral Overlap Threshold |
|---|---|---|---|---|---|---|
| MSATA | No | MSA Center | egami_rev2_trim_ref (2877 sources) | | jwst-nirspec-prism | 1.5 |

## Reference Stars

| Visit | ID | RA | Dec | Magnitude | Visit | ID | RA | Dec | Magnitude |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 87407 | 53.170829 | -27.832415 | 25.15 | 1 | 197052 | 53.158416 | -27.819085 | 24.17 |
| 1 | 101988 | 53.130418 | -27.814584 | 24.01 | 1 | 202147 | 53.120509 | -27.800716 | 25.13 |
| 1 | 194437 | 53.173389 | -27.826625 | 24.66 | 1 | 203547 | 53.124264 | -27.795434 | 24.27 |
| 1 | 194822 | 53.136469 | -27.825290 | 24.92 | 1 | 206345 | 53.131743 | -27.785630 | 24.15 |

## Spectral Elements

| # | Exposure Specification | MSA Configuration | Nod Pattern | Pointing | Aperture PA | Dispersion Offset (Shutters) | Cross-Dispersion Offset (Shutters) | Total Dithers | Total Integrations | Total Exposure Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 (PRISM/CLEAR) | c1 : p2 | 3 Shutter Slitlet | 53.147389999999994 Degrees -27.809247222222 21 Degrees | 183.99997895057106 | | | 3 | 6 | 8403.201 |
| 2 | 1 (PRISM/CLEAR) | c1 : p1 | 3 Shutter Slitlet | 53.14747416666667 Degrees -27.809252777777772 Degrees | 183.99993980092842 | | | 3 | 6 | 8403.201 |
| 3 | 1 (PRISM/CLEAR) | c1 : p3 | 3 Shutter Slitlet | 53.14730541666667 Degrees -27.809241666666 65 Degrees | 184.00001829410593 | | | 3 | 6 | 8403.201 |

| Special Requirements | |
|---|---|
| | Aperture PA Range 184 to 184 Degrees (V3 45.4254303 to 45.4254303) [MSA Selected]<br>MSA Scheduled Aperture PA 184.0000 to 184.0000 Degrees (V3 45.4254303 to 45.4254303) |

## Observation

**Proposal 6541, Observation 2**

Mon Dec 11 18:01:15 GMT 2023

**Diagnostic Status: Warning**

Observing Template: NIRCam Imaging

## Diagnostics

(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (2) | JADES-Deep2 | RA: 03 32 43.1398 (53.1797492d)<br>Dec: -27 49 32.97 (-27.82583d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Unidentified*
*Description=[Blank field]*

## Template

| Module | Subarray | Target Placement |
|---|---|---|
| ALL | FULL | A Short (on A3) |

## Dithers

| # | Primary Dither Type | Primary Dithers | Subpixel Dither Type | Dither Size | Subpixel Positions |
|---|---|---|---|---|---|
| 1 | NONE | | STANDARD | | 3 |

## Spectral Elements

| # | Short Filter | Long Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F200W | F277W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 2 | F115W | F444W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 3 | F150W | F356W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |

## Special Requirements

Aperture PA Range 14.86947913 to 14.86947913 Degrees (V3 15.0 to 15.0)
Fiducial Point Override NRCAS_FULL

Sequence Observations 2, 3, Non-interruptible

## Observation

**Proposal 6541, Observation 3**

Mon Dec 11 18:01:15 GMT 2023

**Diagnostic Status: Warning**

Observing Template: NIRCam Imaging

## Diagnostics

(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (3) | JADES-Deep3 | RA: 03 32 42.3550 (53.1764792d)<br>Dec: -27 46 25.06 (-27.77363d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Unidentified*
*Description=[Blank field]*

## Template

| Module | Subarray | Target Placement |
|---|---|---|
| ALL | FULL | A Short (on A3) |

## Dithers

| # | Primary Dither Type | Primary Dithers | Subpixel Dither Type | Dither Size | Subpixel Positions |
|---|---|---|---|---|---|
| 1 | NONE | | STANDARD | | 3 |

## Spectral Elements

| # | Short Filter | Long Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F200W | F277W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 2 | F115W | F444W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 3 | F150W | F356W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |

## Special Requirements

Aperture PA Range 13.86947913 to 13.86947913 Degrees (V3 14.0 to 14.0)
Fiducial Point Override NRCAS_FULL

Sequence Observations 2, 3, Non-interruptible

## Observation

**Proposal 6541, Observation 4**

Mon Dec 11 18:01:15 GMT 2023

**Diagnostic Status: Warning**

Observing Template: NIRCam Imaging

## Diagnostics

(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (4) | JADES-Deep4 | RA: 03 32 39.7599 (53.1656662d)<br>Dec: -27 50 14.73 (-27.83742d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Unidentified*
*Description=[Blank field]*

## Template

| Module | Subarray | Target Placement |
|---|---|---|
| ALL | FULL | A Short (on A3) |

## Dithers

| # | Primary Dither Type | Primary Dithers | Subpixel Dither Type | Dither Size | Subpixel Positions |
|---|---|---|---|---|---|
| 1 | NONE | | STANDARD | | 3 |

## Spectral Elements

| # | Short Filter | Long Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F200W | F277W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 2 | F200W | F444W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 3 | F150W | F356W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |

## Special Requirements

Aperture PA Range 45.29447913 to 45.29447913 Degrees (V3 45.425 to 45.425)
Fiducial Point Override NRCAS_FULL

Sequence Observations 4, 5, Non-interruptible

## Observation

**Proposal 6541, Observation 5**

Mon Dec 11 18:01:15 GMT 2023

**Diagnostic Status: Warning**

Observing Template: NIRCam Imaging

## Diagnostics

(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (5) | JADES-Deep5 | RA: 03 32 41.6430 (53.1735125d)<br>Dec: -27 46 25.63 (-27.77379d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Unidentified*
*Description=[Blank field]*

## Template

| Module | Subarray | Target Placement |
|---|---|---|
| ALL | FULL | A Short (on A3) |

## Dithers

| # | Primary Dither Type | Primary Dithers | Subpixel Dither Type | Dither Size | Subpixel Positions |
|---|---|---|---|---|---|
| 1 | NONE | | STANDARD | | 3 |

## Spectral Elements

| # | Short Filter | Long Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F200W | F277W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 2 | F200W | F444W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |
| 3 | F150W | F356W | SHALLOW4 | 8 | 1 | 3 | 3 | 1256.202 | |

## Special Requirements

Aperture PA Range 45.29447913 to 45.29447913 Degrees (V3 45.425 to 45.425)
Fiducial Point Override NRCAS_FULL

Sequence Observations 4, 5, Non-interruptible