



9496 - The Belated First Light: Spectroscopic Confirmation of a Population III Galaxy at Cosmic Noon

Cycle: 5, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

| <i>Folder</i> | <i>Observation</i> | <i>Label</i> | <i>Observing Template</i> | <i>Science Target</i> |
|--------------------|--------------------|-----------------|----------------------------------|-----------------------|
| Observation Folder | | | | |
| | 1 | proposal_CR3+z6 | NIRSpec MultiObject Spectroscopy | (1) COSMOS_CR3 |

ABSTRACT

The direct detection of Population III (Pop III) stars is a premier scientific goal for JWST. While searches have focused on the epoch of reionization ($z > 5$), recent JWST/NIRSpec prism data have revealed CR3, an unprecedented galaxy at $z = 3.19$ with an exceptionally low metallicity ($12 + \log(\text{O}/\text{H}) < 6.52$). This discovery challenges models that confine Pop III formation to the early universe and opens a new observational frontier at cosmic noon. We request deep NIRSpec/G235M observations to conclusively test the Pop III nature of CR3. Our primary goals are to (1) push the oxygen abundance limit down to a transformative $12 + \log(\text{O}/\text{H}) < 5.7$ ($\sim 0.1\%$ solar), providing a definitive test for a metal-free nature, and (2) search for the critical He II 4686 emission line, a key signature of a hard ionizing spectrum from massive, metal-free Pop III stars. A confirmation of Pop III stars in CR3 would be a paradigm-shifting discovery, fundamentally revising theories of early chemical enrichment and directly fulfilling one of JWST's most ambitious scientific objectives. The data will also provide a legacy dataset of deep spectroscopy for tens of galaxies in the COSMOS field.

OBSERVING DESCRIPTION

This proposal aims to confirm the metal-free nature of the Population III (Pop III) galaxy candidate CR3 at $z = 3.19$ by obtaining a definitive metallicity measurement and searching for key signatures of a hard ionizing spectrum. We require deep sensitivity from 1.7 to 3.1 μm , making NIRSpec with the G235M/F170LP grating ideal. G235M's resolution allows us to cleanly measure the faint [O III] lines and provides simultaneous coverage of the entire Balmer series (H-alpha to H-delta), the critical He II 4686 line, and multiple He I lines needed to probe the primordial helium abundance.

We request 24.3 hours of observing time (18.7 hours on-source) to achieve a 3-sigma upper limit of $[\text{O III}]5007/\text{H-beta} < 0.25$, corresponding to a transformative metallicity of $12 + \log(\text{O}/\text{H}) < 5.70$ ($\sim 0.1\%$ solar). This depth will also enable a > 3 -sigma detection of the He II 4686 line (assuming a conservative He II/H-beta = 0.1). This program offers an extraordinary opportunity to confirm Pop III star formation at cosmic noon, a discovery that would open a new frontier in studies of Pop III at lower redshift.

The MSA configuration will utilize filler slits to obtain deep G235M spectra for tens of serendipitous galaxies and candidate "little red dots" at $z > 5$ in the well-studied COSMOS field, creating a valuable public legacy dataset. We will use a 9×3 -point dither pattern (nine 3-point nods) with the NRSIRS2 readout, using 17 groups per integration.

Proposal 9496 - Targets - The Belated First Light: Spectroscopic Confirmation of a Population III Galaxy at Cosmic Noon

| Fixed Targets | # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---------------|-----|------------------------------------|----------------------------------|--------------------------|---------------|
| | (1) | COSMOS_CR3 | RA: 10 00 46.6028 (150.1941783d) | | |
| | | | Dec: +02 25 51.54 (2.43098d) | | |
| | | | Equinox: J2000 | | |
| | | <i>Comments:</i> Description=[] | | | |

Proposal 9496 - Observation 1 - The Belated First Light: Spectroscopic Confirmation of a Population III Galaxy at Cosmic Noon

Fri Mar 13 17:00:35 GMT 2026

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|------------------------|---|---------------------------|--|-------------------------|-------------------------------|---------------------------------|-----------------------------|-----------------------------------|---------------------------|----------------------------|------------------------|
| Observation | <p>Proposal 9496, Observation 1: proposal_CR3+z6</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec MultiObject Spectroscopy</p> | | | | | | | | | | |
| Diagnostics | <p>(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> | | | | | | | | | | |
| Fixed Targets | # | Name | Target Coordinates | | | Targ. Coord. Corrections | | | Miscellaneous | | |
| | (1) | COSMOS_CR3 | RA: 10 00 46.6028 (150.1941783d) Dec: +02 25 51.54 (2.43098d) Equinox: J2000 | | | | | | | | |
| | <p><i>Comments:</i> Description=[]</p> | | | | | | | | | | |
| Acquisition | # | Reference Star Bin | Target | Filter | MSA Configuration | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | Optional ETC ID |
| | 1 | | SAME | F140X | Auto Acq MSA Config | NRSRAPID | 3 | 1 | 4 | 171.788 | |
| Template | TA Method | HFF Readout Mode | Obtain Confirmation Images | Science Aperture | Primary Candidate List | Filler Candidate List | Spectral Overlap Map | Spectral Overlap Threshold | | | |
| | MSATA | false | No | MSA Center | CR3 (1 sources) | z>6 (2046 sources) | rwst-nirspec-g235m | 1.5 | | | |
| Reference Stars | | | | | | | | | | | |

Proposal 9496 - Observation 1 - The Belated First Light: Spectroscopic Confirmation of a Population III Galaxy at Cosmic Noon

| | # | Exposure Specification | MSA Configuration | Nod Pattern | Pointing | Aperture PA | Dispersion Offset (Shutters) | Cross-Dispersion Offset (Shutters) | Total Dithers | Total Integrations | Total Exposure Time |
|-----------------------------|--|------------------------|-------------------|-------------------|--|-----------------------|------------------------------|------------------------------------|---------------|--------------------|---------------------|
| Spectral Elements | 1 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 2 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 3 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 4 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 5 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 6 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 7 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 8 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| | 9 | 1 (G235M/F170LP) | c1 | 3 Shutter Slitlet | 150.151777375 Degrees 2.4563825 Degrees | 80.075277531039 82 | | | 3 | 6 | 7527.867 |
| Special Requirements | MSA Planned Aperture PA 80.0750 to 80.0750 Degrees (V3 301.5004303 to 301.5004303) | | | | | | | | | | |