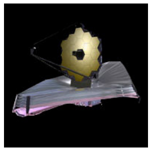

# 8322 - Astrometric monitoring of the fast stars around the intermediate-mass black hole in Omega Centauri

Cycle: 4, Proposal Category: GO

**INVESTIGATORS**

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**OBSERVATIONS**

| *Folder* | *Observation* | *Label* | *Observing Template* | *Science Target* |
|---|---|---|---|---|
| NIRCam Observations | | | | |
| | 1 | | NIRCam Imaging | (1) NGC-5139 |

**ABSTRACT**

The existence and frequency of intermediate-mass black holes is an unresolved mystery with important implications for our understanding of the formation of supermassive black holes in the early universe. Omega Centauri has long been suspected to host such a black hole and the recent detection of several fast-moving stars in its center has provided new, strong evidence, placing a lower limit on the black hole mass of 8200 M. Weighing this intermediate-mass black hole more precisely requires additional observations. Due to its superior resolution and high sensitivity, JWST is perfectly suited to follow up on the faint, fast stars and to determine their orbits.

By combining existing HST and JWST data with our proposed multi-cycle observations, we will measure their astrometric accelerations, allowing the first direct mass measurements of the intermediate-mass black hole. With just a single 2.6 hr observation in Cycles 4, 5, and 6, we can improve the acceleration measurements of these stars by more than a factor of 2 over the measurement from hundreds of HST observations taken over 20 years. In addition, the proposed multi-cycle observations will detect any additional faint stars in the vicinity of the black hole, monitor potential variable accretion emission, and provide an important astrometric reference for future observations.

**OBSERVING DESCRIPTION**

We request a set of identical NIRCam observations in Cycles 4, 5, and 6, targeting the photometric center of the globular cluster Omega Centauri.

The main goals of these observations are to (1) place acceleration constraints on the recently discovered fast stars in the center of Omega Centauri, and (2) detect additional faint stars in the vicinity of the black hole. Both will lead to better constraints on the mass and location of the intermediate-mass black hole candidate.

To achieve our science goals, we request observations in filters F115W and F200W. The filters are chosen as they:

a) Provide one filter (F200W) in which the NIRCam SWC detector is Nyquist sampled for the most reliable astrometric measurements, and one filter that is moderately undersampled but with higher spatial resolution (F115W), faciliating deblending of close sources.

b) Enable a sufficient color baseline to determine the cluster-membership of newly discovered stars using color-magnitude diagrams.

The Long-Wavelength-Channel Filters (F444W, F405N) are chosen to monitor potential variable accretion emission of the black hole.

We request an integration time of 419 s per exposure. This time is driven by the requirement of reaching the required sensitivity to detect the faintest main sequence stars (we reach a S/N=10 limit for magnitudes as low as $m_{F200W} = 23.9$ and $m_{F115W} = 24.5$, corresponding to stars close to the hydrogen burning limit). In addition, this exposure time will allow for high astrometric precision for the seven known fast stars. Expected measurement errors range from 0.33 - 0.45 mas (close to the astrometric noise floor of around 1% of a pixel).

We obtain 4 dithers using the FULLBOX4TIGHT pattern. We center the cluster on module B, and offset the center of the cluster X=5", Y=-30" to ensure that the cluster center with the fast stars does not fall close to a detector edge.
The observations taken with Module A will cover different areas of Omega Cen (depending on the position angle). In any case, they will overlap with existing HST data and provide significant archival value.

In addition, we added a special requirement on allowed position angles to prevent diffraction features from bright stars from falling into the region of interest.
We verified that this requirement only has minor influence on the schedulability.

We also request NIRISS parallel observations in filters matching our main observations (F115W, F200W). These come at no additional cost and will enable us to study the low-mass stars of Omega Cen at larger radii.

**Fixed Targets**

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | NGC-5139 | RA: 13 26 47.2400 (201.6968333d)<br>Dec: -47 28 46.45 (-47.47957d)<br>Equinox: J2000 | Proper Motion RA: -3.24 mas/yr<br>Proper Motion Dec: -6.729999904564465 mas/yr<br>Parallax: 1.93E-4"<br>Epoch of Position: 2000 | |

*Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*

*SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.This object was generated by the targetselector and retrieved from the SIMBAD database.*

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*Category=Stellar Cluster*
*Description=[Globular star clusters]*

# Proposal 8322 - Observation 1 - Astrometric monitoring of the fast stars around the intermediate-mass black hole in Omega Centauri

## Observation

**Proposal 8322, Observation 1**

Wed Jun 11 18:00:15 GMT 2025

**Diagnostic Status: Warning**

Observing Template: NIRCam Imaging

Coordinated Parallel Template(s): NIRISS Imaging

*Comments: The DX and DY offsets were chosen to place the central region of Omega Centauri (with coordinates R.A. = 13:26:47.24h decl. = –47:28:46.45deg) in a region, where it is observed during all 4 different dither positions and always falls either on detector A2 or A4 (to avoid the "claw" artefact).*

## Diagnostics

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

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | NGC-5139 | RA: 13 26 47.2400 (201.6968333d)<br>Dec: -47 28 46.45 (-47.47957d)<br>Equinox: J2000 | Proper Motion RA: -3.24 mas/yr<br>Proper Motion Dec: -6.729999904564465 mas/yr<br>Parallax: 1.93E-4"<br>Epoch of Position: 2000 | |

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*Category=Stellar Cluster*
*Description=[Globular star clusters]*

## Template

| NIRCam Imaging | NIRISS Imaging |
|---|---|
| Module: ALL | |
| Subarray: FULL | |
| Target Placement: Module A (A3 corner) | |

## Dithers

| # | Primary Dither Type | Primary Dithers | Dither Size | Subpixel Positions | Coordinated Parallel Subpixel Selector | Dither Direct Images Primes |
|---|---|---|---|---|---|---|
| 1 | FULLBOX | 4 | | 1 | NIRCam Only | NO_DITHERING |

## Spectral Elements

| NIRCam Imaging | Short Filter | Long Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F115W | F405N+F444W | SHALLOW4 | 4 | 2 | 8 | 4 | 1674.936 | |
| 2 | F200W | F444W | SHALLOW4 | 4 | 2 | 8 | 4 | 1674.936 | |

Proposal 8322 - Observation 1 - Astrometric monitoring of the fast stars around the intermediate-mass black hole in Omega Centauri

Spectral Elements

| NIRISS Imaging | Filter | Grism | Readout Pattern | Groups/Int | Integrations/Exp | Total Dithers | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F200W | | NISRAPID | 16 | 2 | 4 | 8 | 1460.201 | |
| 2 | F115W | | NISRAPID | 16 | 2 | 4 | 8 | 1460.201 | |

Special Requirements

Between Dates 08-JUN-2025:00:00:00 and 08-AUG-2025:00:00:00
Aperture PA Range 86.56565232 to 102.26565232 Degrees (V3 86.7 to 102.4)
Aperture PA Range 110.36565232 to 116.96565232 Degrees (V3 110.5 to 117.1)
Aperture PA Range 145.36565232 to 161.96565232 Degrees (V3 145.5 to 162.1)
Aperture PA Range 170.26565232 to 176.46565232 Degrees (V3 170.4 to 176.6)
Aperture PA Range 266.56565232 to 282.26565232 Degrees (V3 266.7 to 282.4)
Aperture PA Range 290.36565232 to 296.96565232 Degrees (V3 290.5 to 297.1)
Aperture PA Range 325.36565232 to 341.96565232 Degrees (V3 325.5 to 342.1)
Aperture PA Range 350.26565232 to 356.46565232 Degrees (V3 350.4 to 356.6)
Offset -5.0 arcsec, 37.0 arcsec
No Parallel Attachments
Fiducial Point Override NRCAS_FULL