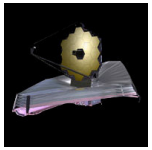

3399 - An Empirical Calibration of the NIRSpec IFU Point Spread Function to Enable High Contrast Imaging Spectroscopy

Cycle: 2, Proposal Category: GO

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	NRS IFU PSF Calibration - PSF core	NIRSpec IFU Spectroscopy	(1) J1757132
	2	NRS IFU PSF Calibration - PSF wings	NIRSpec IFU Spectroscopy	(2) HD1634665

ABSTRACT

This GO Calibration effort seeks to obtain a high quality empirical point spread function (PSF) calibration for the NIRSpec IFU. Improved knowledge of the NIRSpec IFU PSF will directly benefit diverse science cases involving precise spectroscopy of “faint things next to bright things”, spanning from imaging spectroscopy of exoplanets, brown dwarfs, and circumstellar disks, to minor bodies and faint rings in the solar system, to studies of quasar host galaxies. For high contrast imaging spectroscopy of exoplanetary systems, NIRSpec has tremendous promise, but making high contrast algorithms work to their full potential on NIRSpec data will require understanding in detail the PSF properties, effects of spatial undersampling, and datacube systematics. However there has not yet been any calibration program dedicated to measuring the NIRSpec IFU PSF. To fill that gap, the observations we propose will provide the first calibration measurements of the NIRSpec PSF with high SNR and high dynamic range (spanning from the PSF core to the outer wings across the full IFU FOV), finely dithered for better spatial sampling, covering 0.95 to 5.3 microns with all the high resolution gratings. The resulting improved knowledge of IFU imaging spectroscopy performance and systematics will benefit diverse studies using NIRSpec from the solar system to exoplanets and circumstellar disks to the distant universe.

OBSERVING DESCRIPTION

This program will obtain high SNR, well-dithered, high spectral resolution empirical calibrations for the NIRSpec IFU's point spread function, to enable and enhance high contrast science investigations using the IFU.

We observe two relatively bright A type photometric standards, using the cycling dither pattern with 16 points for fine sampling of the PSF, and with the high resolution gratings.

Targets:

To achieve high dynamic range we select 2 calibrator stars separated by 5 magnitudes in flux: 2MASS J17571324 (K_s = 11.16) and HD 163466 (K_s=6.34). Both of these stars are already used in JWST Absolute Flux Calibration programs (PIDs 1536, 1539); both have already been observed in cycle 1, though for other modes, not NIRSpec IFU. Both stars were Spitzer photometric standards too. 2MASS J17571324 will be used to calibrate the PSF core. HD 163466 is over 100x brighter to yield high SNR on the PSF wings. Exposure times were optimized in the ETC to yield SNR >100 without saturation in the PSF core exposures on J17571324, and >5 over the PSF wings for the entire FOV (and >50 for much of the FOV) on the exposures on HD 163466.

Using targets drawn from the JWST Abs Flux Cal programs ensures there exists already a high quality reference stellar spectrum for each star, as well as vetting to rule out e.g. binary companions or other complications. As a secondary bonus, these data may also serve as additional photometric calibrations.

Instrument settings:

We will use three high res grating+filter combos: G140H/F100LP, G240H/F170LP, F395H/F290LP, spanning 0.97 to 5.27 microns. The cycling dither pattern with 16 steps will be used to obtain a fine spatial sampling of the PSF. That set of gratings+filters, and the Small size of the Cycling dither pattern specifically, are selected because those instrument settings are preferred for the motivating science cases in exoplanetary and quasar host galaxy high contrast imaging.

Target Acquisitions:

We desire WATA TA to position the targets precisely within the IFU FOV. For 2MASS J17571324, we follow the setup of cycle 1 cal program 1536 and use WATA TA on that star itself. For HD 163466, the star is far too bright for TA, so we have selected a nearby field star from Gaia DR3 to use for offset WATA. There are other possible nearby stars that could be used to ease scheduling, if needed.

We note that APT displays a warning that the use of this offset star for WATA "may result in reduced or no schedulability", but nonetheless the visit planner indicates very wide schedulability (~10 months of the year for this near-CVZ target), so it appears no further action is needed. If necessary, a V3PA special requirement can be added to quiet this warning, and would still leave a ~3 month wide scheduling window.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	J1757132	RA: 17 57 13.2322 (269.3051342d) Dec: +67 03 40.76 (67.06132d) Equinox: J2000	Proper Motion RA: 0.841 mas/yr Proper Motion Dec: -12.945 mas/yr Parallax: 0.0009482" Epoch of Position: 2000.0	

Comments: Coordinates from Gaia DR3

Ks = 11.15

Target setup updated to use Gaia DR3 coordinates (back-propagated to epoch 2000.0) and Gaia DR3 proper motions and parallax.

Consistency check: The epoch-2000 position is offset by ~14 mas relative to the prior DR2 coordinates used in the initial submission of this program, which were copied from those successfully used in APT 1536 obs 6. The APT 1536 obs 6 TA images show a good NIRSpec WATA TA on this star using those coordinates. (Better than the coordinates used in APT 1678, which were ~0.38" discrepant at epoch 2018, and led to a more offset initial exposure in the WATA TA from 1678 obs 5.)
Category=Star
Description=[A dwarfs]
Extended=NO

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(2)	HD1634665	RA: 17 52 25.3741 (268.1057254d) Dec: +60 23 46.94 (60.39637d) Equinox: J2000	Proper Motion RA: -1.983 mas/yr Proper Motion Dec: 42.780 mas/yr Parallax: 0.0052084" Epoch of Position: 2000.0	

Comments: Coordinates from Gaia DR3

Ks = 6.33

Target setup updated to use Gaia DR3 coordinates (back-propagated to epoch 2000.0) and Gaia DR3 proper motions and parallax.

Consistency check: that has is an offset by 11 mas relative to the DR2 coordinates used in the initial submission of this program, and as used successfully in cal program APT 1536, for instance obs
Category=Star
Description=[A dwarfs]
Extended=NO

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(3)	OFFSET-TA-STAR-FOR-HD163466	RA: 17 52 31.8763 (268.1328179d) Dec: +60 23 52.90 (60.39803d) Equinox: J2000	Proper Motion RA: -2.613 mas/yr Proper Motion Dec: -3.056 mas/yr Parallax: 0" Epoch of Position: 2000.0	

Comments: This is one possible offset star for use in WATA TA for HD 163466. A few other candidates are available and could be used if it eases scheduling.

Coordinates from EDR3, Gaia EDR3 1435190745325598464 = Gaia DR3 1435190745325598464. This is also Pan-STARRS 18047268132778360

Gaia RUWE = 1.03, consistent with a good measrement of a single star.

Gaia magnitudes G = 19.7831, Bp = 20.2903, Rp = 18.97961
Pan-STARRS z mag = 18.832, y mag = 18.8067.

This field star has been imaged with JWST in MIRI image jw01539-o014_t003_miri_f770w_i2d.fits at coordinates consistent with the above.
Category=Star
Description=[A dwarfs]
Extended=NO

Observation

Proposal 3399, Observation 1: NRS IFU PSF Calibration - PSF core Thu Jan 04 22:00:54 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

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)	J1757132	RA: 17 57 13.2322 (269.3051342d)	Proper Motion RA: 0.841 mas/yr	
		Dec: +67 03 40.76 (67.06132d)	Proper Motion Dec: -12.945 mas/yr	
		Equinox: J2000	Parallax: 0.0009482"	
			Epoch of Position: 2000.0	

Comments: Coordinates from Gaia DR3

Ks = 11.15

Target setup updated to use Gaia DR3 coordinates (back-propagated to epoch 2000.0) and Gaia DR3 proper motions and parallax.

Consistency check: The epoch-2000 position is offset by ~14 mas relative to the prior DR2 coordinates used in the initial submission of this program, which were copied from those successfully used in APT 1536 obs 6. The APT 1536 obs 6 TA images show a good NIRSpec WATA TA on this star using those coordinates. (Better than the coordinates used in APT 1678, which were ~0.38" discrepant at epoch 2018, and led to a more offset initial exposure in the WATA TA from 1678 obs 5.)
Category=Star
Description=[A dwarfs]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	141149.17

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	SMALL	1	16	

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G140H/F100LP	NRSIRS2RAPID	12	1	false	true	NONE	16	16	3034.489	141149.15
2	G235H/F170LP	NRSIRS2RAPID	16	1	false	true	NONE	16	16	3968.178	141149.14
3	G395H/F290LP	NRSIRS2RAPID	20	1	false	true	NONE	16	16	4901.867	141149.13

Observation

Proposal 3399, Observation 2: NRS IFU PSF Calibration - PSF wings Thu Jan 04 22:00:54 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Diagnostics

(NRS IFU PSF Calibration - PSF wings (Obs 2)) Warning (Form): The slew between the acquisition exposure and the farthest science exposure is 80.860 Arcsec (larger than the recommended limit of 55.000 Arcsec) and may result in reduced or no schedulability. See more information in the diagnostic browser.

(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)	HD1634665	RA: 17 52 25.3741 (268.1057254d)	Proper Motion RA: -1.983 mas/yr	
		Dec: +60 23 46.94 (60.39637d)	Proper Motion Dec: 42.780 mas/yr	
		Equinox: J2000	Parallax: 0.0052084"	
			Epoch of Position: 2000.0	

Comments: Coordinates from Gaia DR3

Ks = 6.33

Target setup updated to use Gaia DR3 coordinates (back-propagated to epoch 2000.0) and Gaia DR3 proper motions and parallax.

Consistency check: that has is an offset by 11 mas relative to the DR2 coordinates used in the initial submission of this program, and as used successfully in cal program APT 1536, for instance obs
Category=Star
Description=[A dwarfs]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 OFFSET-TA-STAR-FOR-HD163466	WATA	SUB2048	F140X	NRSRAPIDD6	3	1	1	14.452	141149.16

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	SMALL	1	16	

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G140H/F100LP	NRSIRS2RAPID	8	1	false	true	NONE	16	16	2100.8	141149.12
2	G235H/F170LP	NRSIRS2RAPID	10	1	false	true	NONE	16	16	2567.645	141149.11
3	G395H/F290LP	NRSIRS2RAPID	12	1	false	true	NONE	16	16	3034.489	141149.10