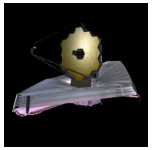

6940 - Determining the Origin of Water Ice in the Beta Pictoris Debris Disk

Cycle: 4, Proposal Category: GO

INVESTIGATORS

Name	*Institution*
Dr. Christine Chen (PI)	**The Johns Hopkins University**
Dr. Tracy Beck (CoI)	Space Telescope Science Institute
Dr. Bryce Bolin (CoI)	Eureka Scientific Inc.
Dr. Alexis Brandeker (CoI) (ESA Member)	Stockholm University
Dr. Sean Brittain (CoI)	Clemson University
Dr. Dean C. Hines (CoI)	Space Telescope Science Institute
Mr. Carl John Ingebretsen (CoI)	The Johns Hopkins University
Dr. Carey Michael Lisse (CoI)	The Johns Hopkins University Applied Physics Laboratory
Dr. Joan Najita (CoI)	NOIRLab - (AZ)
Dr. Marshall Perrin (CoI)	Space Telescope Science Institute
Dr. Laurent Pueyo (CoI)	Space Telescope Science Institute
Isabel Rebollido (CoI) (ESA Member)	ESA, European Space Astronomy Centre
Dr. John A. Stansberry (CoI)	Space Telescope Science Institute
Kadin Worthen (CoI)	Space Telescope Science Institute
Dr. Ian Wong (CoI)	Space Telescope Science Institute
Dr. Chen Xie (CoI)	The Johns Hopkins University
Dr. Sarah Betti (CoI)	Space Telescope Science Institute

OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
beta Pic - NIRSpec IFU				
	1	beta Pic Debris Disk - NIRSpec IFU	NIRSpec IFU Spectroscopy	(1) -BET-PIC

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
	2	alf Pic PSF Calibrator - NIRSpec IFU	NIRSpec IFU Spectroscopy	(2) -ALF-PIC-PSF-CALIBRATOR

ABSTRACT

We propose to obtain deep 1.88-5.2 micron NIRSpec IFU medium resolution spectroscopy to map and spectrally resolve the 3 micron water and 4 micron CO2 ices in the beta Pictoris debris disk. Recent PRISM observations revealed the presence of submicron ices across the whole disk for the first time in a debris disk, including a hint of a significant ice population at the outer edge of beta Pic dust clump. This discovery changed our understanding of debris disk chemisty as these grains were not expected to survive, and opened up new questions on the role of giant collisions in producing the observed ice grains. Therefore, characterizing their origin and composition is of vital importance to our understanding of late stage planet formation and the transport of ices in disks. Medium resolution (R~1000) IFU spectroscopy provides the only means to a) spectrally map down to 20 au separation, where PRISM mode saturates, but also where a giant collision could have produced the observed dust clump, and b) spectrally resolve the CO2 ice features, allowing us to model the molecular components of the ice, a key means to determine the collisional bodies required to produce the ice. By mapping the whole dust clump, we can uncover the origin, chemical composition, and thermal history of the ices in this disk.

OBSERVING DESCRIPTION

Overall Strategy

We propose to obtain high contrast medium resolution integral field unit spectroscopy of the beta Pictoris debris disk with the G235M/G395M gratings with NIRSpec. We aim to extract the scattered light emission radially throughout the disks in order to a) measure the 3 micron water ice feature down to 20 au, b) spectrally resolve the 12CO2 and 13CO2 ice features. These observations allow us to determine the origin of ices within beta Pic, determine the grain mixtures, and piece together a picture for ice and gas production in debris disks.

Beta Pic will be observed utilizing a 1x4 mosaic over the extended disk with a small 9-point small dithering cycle. We will also observe a PSF reference stars using identical configurations, in order to perform PSF subtraction to remove stellar residuals.

Exposure Times, Group, and Iterations

Exposure times for the science target are calculated using the JWST ETC in order to achieve a S/N>100 to statistically detect the faint 13CO2 with a depth of 1%. The maximum number of groups is selected to minimize noise with the number of integrations corresponding to the dither positions.

This S/N should provide sufficient sensitity to also search for faint signatures of CO2 ice as well (down to optical depths of 1%).

PA constraints

The PSF wings dominate the signal where they fall on the detector and any astronomical signal is not recoverable. Therefore, we set strict PA constraints (127-143 deg) so that the major axis of the beta Pic disk lies between two of the PSF wings.

Non-interruptable Scheduling

In order to minimize changes in the telescope thermal noise, detector characteristics, we require each PSF reference star to be observed with its corresponding science target in the non-interruptable mode.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	-BET-PIC	RA: 05 47 17.0953 (86.8212304d) Dec: -51 03 58.15 (-51.06615d) Equinox: J2000	Proper Motion RA: 4.932985550191305E-4 sec of time/yr Proper Motion Dec: 0.0831 arcsec/yr Epoch of Position: 2015.5	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Circumstellar disks, Circumstellar dust, Circumstellar gas, Debris disks]* *Extended=YES*				
(2)	-ALF-PIC-PSF-CALIBRATOR	RA: 06 48 11.2988 (102.0470783d) Dec: -61 56 24.54 (-61.94015d) Equinox: J2000	Proper Motion RA: -0.009363848394319287 sec of time/yr Proper Motion Dec: 0.24297 arcsec/yr Epoch of Position: 2015.5	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[A dwarfs]*				
(3)	OFFSET-TA-STAR-FOR-BETA-PIC	RA: 05 47 18.7964 (86.8283183d) Dec: -51 03 7.48 (-51.05208d) Equinox: J2000	Proper Motion RA: 0.36036217292430595 mas/yr Proper Motion Dec: -0.01676420975428233 mas/yr Epoch of Position: 2016	
Comments: This is one possible offset star for use in WATA TA for beta Pic. A few other candidates are available and could be used if it eases scheduling. *Coordinates from DR3, Gaia DR3 4792774694465888640.* *Gaia RUWE = 1.00, consistent with a good measrement of a single star.* *Gaia magnitudes G = 15.33; Bp = 15.78, Rp = 14.72; Teff = 4988 K; logg = 3.7* *Category=Star* *Description=[K stars]* *Extended=NO*				
(4)	OFFSET-TA-STAR-FOR-ALF-PIC	RA: 06 48 16.0654 (102.0669392d) Dec: -61 56 48.72 (-61.94687d) Equinox: J2000	Proper Motion RA: -2.6411654489047693 mas/yr Proper Motion Dec: 4.177059191637792 mas/yr Epoch of Position: 2016	
Comments: This is the closest possible faint GAIA offset star for use in WATA TA for alpha Pic. *Coordinates from DR3, Gaia DR3 5478862803373348096.* *Gaia RUWE = 1.00, consistent with a good measrement of a single star.* *Gaia magnitudes G = 17.147, Bp = 17.34, Rp = 16.38; Teff = 5221 K; logg = 4.64* *Category=Star* *Description=[G stars]* *Extended=NO*				

Observation

Proposal 6940, Observation 1: beta Pic Debris Disk - NIRSpec IFU

Tue Oct 28 13:00:11 GMT 2025

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)	-BET-PIC	RA: 05 47 17.0953 (86.8212304d) Dec: -51 03 58.15 (-51.06615d) Equinox: J2000	Proper Motion RA: 4.932985550191305E-4 sec of time/yr Proper Motion Dec: 0.0831 arcsec/yr Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Circumstellar disks, Circumstellar dust, Circumstellar gas, Debris disks]
Extended=YES

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	3 OFFSET-TA-STAR-FOR-BETA-PIC	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	278173

Template

HFF Readout Mode
false

Mosaic

Rows	Columns	Row Overlap %	Column Overlap %	Row shift (deg)	Column shift (deg)	Tile Order
1	5	25.0	35.0	0.0	15.0	ROW_ORDER

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	SMALL	1	9	

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	G235M/F170LP	NRSIRS2RAPID	10	1	false	true	NONE	9	9	1444.3	
2	G395M/F290LP	NRSIRS2RAPID	10	1	false	true	NONE	9	9	1444.3	

Special Requirements	
	Aperture PA Range 135 to 145 Degrees (V3 356.02835083 to 6.02835083) Group Observations 1, 2, Non-interruptible

Observation

Proposal 6940, Observation 2: alf Pic PSF Calibrator - NIRSpec IFU Tue Oct 28 13:00:11 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Comments: The target acquisition object is the closest available star to the target at 80" away (20" past the recommended splitting distance). However, scheduability does not seen to be affected via the visit planner.

Diagnostics

(alf Pic PSF Calibrator - NIRSpec IFU (Obs 2)) Warning (Form): The slew between the acquisition exposure and the farthest science exposure is 80.107 Arcsec (larger than the recommended limit of 60.000 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)	-ALF-PIC-PSF-CALIBRATOR	RA: 06 48 11.2988 (102.0470783d) Dec: -61 56 24.54 (-61.94015d) Equinox: J2000	Proper Motion RA: -0.009363848394319287 sec of time/yr Proper Motion Dec: 0.24297 arcsec/yr Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[A dwarfs]

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	4 OFFSET-TA-STAR-FOR-ALF-PIC	WATA	SUB32	F110W	NRSRAPIDD6	3	1	1	0.26	219194

Template

HFF Readout Mode
false

Mosaic

Rows	Columns	Row Overlap %	Column Overlap %	Row shift (deg)	Column shift (deg)	Tile Order
1	5	25.0	35.0	0.0	15.0	ROW_ORDER

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	SMALL	1	9	

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	G235M/F170LP	NRSIRS2RAPID	10	1	false	true	NONE	9	9	1444.3	
2	G395M/F290LP	NRSIRS2RAPID	10	1	false	true	NONE	9	9	1444.3	

Special Requirements	Group Observations 1, 2, Non-interruptible