17741 - Monitoring for Collisions in the Beta Pictoris Debris Disk to Enable JWST Follow-Up Spectroscopy

Cycle: 32, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Dr. Kevin Wagner (PI) (Contact)	**University of Arizona**
Prof. Daniel Apai (CoI)	University of Arizona
Arin Muratcan Avsar (CoI)	University of Arizona

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) BETA-PIC	STIS/CCD	1	28-Jan-2025 15:00:13.0	yes
02	(2) ALPHA-PIC	STIS/CCD	1	28-Jan-2025 15:00:16.0	yes
03	(1) BETA-PIC	STIS/CCD	1	28-Jan-2025 15:00:19.0	yes

3 Total Orbits Used

ABSTRACT

Debris disks are readily detectable tracers of planetesimal collisions within young planetary systems; however, few collisions have been observed in detail. Among the earliest and most noteworthy JWST results of debris disks was evidence of major (Ceres-mass) collisions having occurred over the past century within Beta Pictoris. This indicates that the chance to observe a major planetesimal collision shortly after it occurrs may be non-neglegible over decade timescales, and the chance of observing lower-mass collisions, which should be more frequent but visible only for months to years, may be substantial. Observing such a collision shortly after it occurs and tracking the evolution of its dust cloud would open a major window

into the dust produced via planetesimal collisions -- including measurements of planetesimal composition, grain-size constraints, collisional frequency estimates, and dust production rates, to name a few possibilities. Additionally, recent time-differential HST/STIS imaging has demonstrated that multi-epoch observations have the capability to push orders of magnitude lower in collisional mass detection limits compared to single-epoch imaging. Here, we propose to build off of 27 years of HST/STIS observations of the Beta Pictoris system in order to monitor for collisions over the next three cycles. Regular re-visits allow detecting collisions shortly after they occur, enabling follow up proposals for JWST to place unique constraints on the resulting dust. In the absence of such a detection, we will continue to place meaningful constraints on the frequency of collisions and the distribution of major planetessimals within the Beta Pictoris system.

OBSERVING DESCRIPTION

The proposed observations aim to obtain STIS coronagraphic images of the Beta Pictoris debris disk. The primary goal is to compare the disk surface brightness distribution to prior STIS observations of the same disk, to identify or constrain changes in the disk structure.

WThis data set will allow PSF subtraction both through roll (self)subtraction and through PSF subtraction, thus allowing two alternate reduction methods. The combination of the data sets will provide an optimal spatial coverage and can correct for the field lost due to wedge obscuration and diffraction spike contamination.

Based on the comparison of the reduced 1997 and 2012 data and a set of PSF stars from other programs we identified that the following strategy provides the best quality data and best comparison to the earlier data sets:

We will observe the two targets using three single-orbit visits (01, 02, 03) that are linked both in time and orientation angles.
The three visits must be scheduled "back-to-back" in sequential visibility periods, each uninterrupted by Earth occultation -- hence the AFTER scheduling requirements of 0.5 to 1.5 orbit (start-to-start) times on Visits 02 and 03.

In Visit 01 we observe our science target (Beta Pic). In Visit 02 we will observe our PSF calibration target (Alpha Pic).
The Alpha Pic visit (02) MUST be scheduled in time in between Visits 01 and 03. In Visit 03 we again observe Beta Pic, but at an orientation angle differing by 10-20 deg from the absolute orientation specified for Visit 01.

We begin each Visit with an on-board autonomous coronagraphic target acquisition. Target acquisition exposure times

were chosen to provide SNR ~ 100 in the central pixel of the target acq images. In all cases we use the F25ND5 filter due to the brightness of our target stars.

First orbit: We will observe Beta Pic at the WedgeB1.0 position. We will obtain a series of long and short exposures to enable high dynamic range of the bright (inner) and faint (outer) regions. Absolute orientation ensures the edge-on disk is not overlapping the wedge or difraction spikes.

Second Orbit: Carry out the same observing sequence as in Orbit 1 on the PSF star Alpha Pictoris.
This star is slightly brighter, so exposures are shorter to avoid saturation.
In this visit we observe our PSF template calibration star. In order to minimize variations in PSF structure from thermal driven changes in OTA wavefront errors, we constrain the orientation of this calibration target which is nearby in the sky to our science target (similar spacecraft attitude and sun angle) to be as close as possible to the orientations of Visits 1 and 3.

Third Orbit: Repeat the observations of Beta Pic (1st orbit) but at a different spacecraft orientation.

EXPOSURE TIMES:
Individual coronagraphic exposure times (Ex. Time / # CR Splits) have been carefully chosen at all wedge positions based upon prior coronagraphic imaging so as not to saturate at the smallest IWA for each wedge position while also providing > appx 70% full well depth. NOTE TO OUR PC: Please do *NOT* allow "automatic" adjustment of any exposure times in our coronagraphic exposures to fill any (small) "dead time" in the orbits

ORIENTATIONS:
The observations are sensitive to the roll angles: the right angles will ensure that the disk is optimally placed between the wedges and the diffraction spikes at both orientations and minimize the spatial coverage lost due to obscuration.

DISK AND SPACECRAFT ORIENTATIONS:
The "northern" semi-major axis of the nearly-edge on Beta Pic disk is at a celestial position angle of appx 30.8 deg.
(The inner disk itself is warped and PAs varying by a few degrees appear in the literature, depending upon how and at what distances measures have been made. For our observation planning we adopt 30.8 deg).

If a suitable GS pair cannot be found to enable this geometry, we would later suggest possible specific alternates depending upon schedualbility with

more restrictive differential roll ranges with trades in science return.

The three orbits must be executed back-to-back to minimize the changes in the instrumental PSF and the spacecraft/instrument state.

Visit

Proposal 17741, Visit 01, implementation Tue Jan 28 20:00:20 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; ORIENT 354D TO 360 D; ORIENT 157D TO 177 D

Comments: Timing: Must be executed in sequential orbit immediately prior to Visit 02 with only intervening inter-visit Earth occultation.
Orientation: Absolute Orientation range set to place disk away from difraction spikes and WedgeA.

Diagnostics

(Visit 01) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	BETA-PIC	RA: 05 47 17.0877 (86.8211988d)	Proper Motion RA: 4.65 mas/yr	V=3.86	Reference Frame: ICRS
		Dec: -51 03 59.45 (-51.06651d)	Proper Motion Dec: 83.10 mas/yr	B=4.03	
		Equinox: J2000	Parallax: 0.05144"		
			Epoch of Position: 2000		

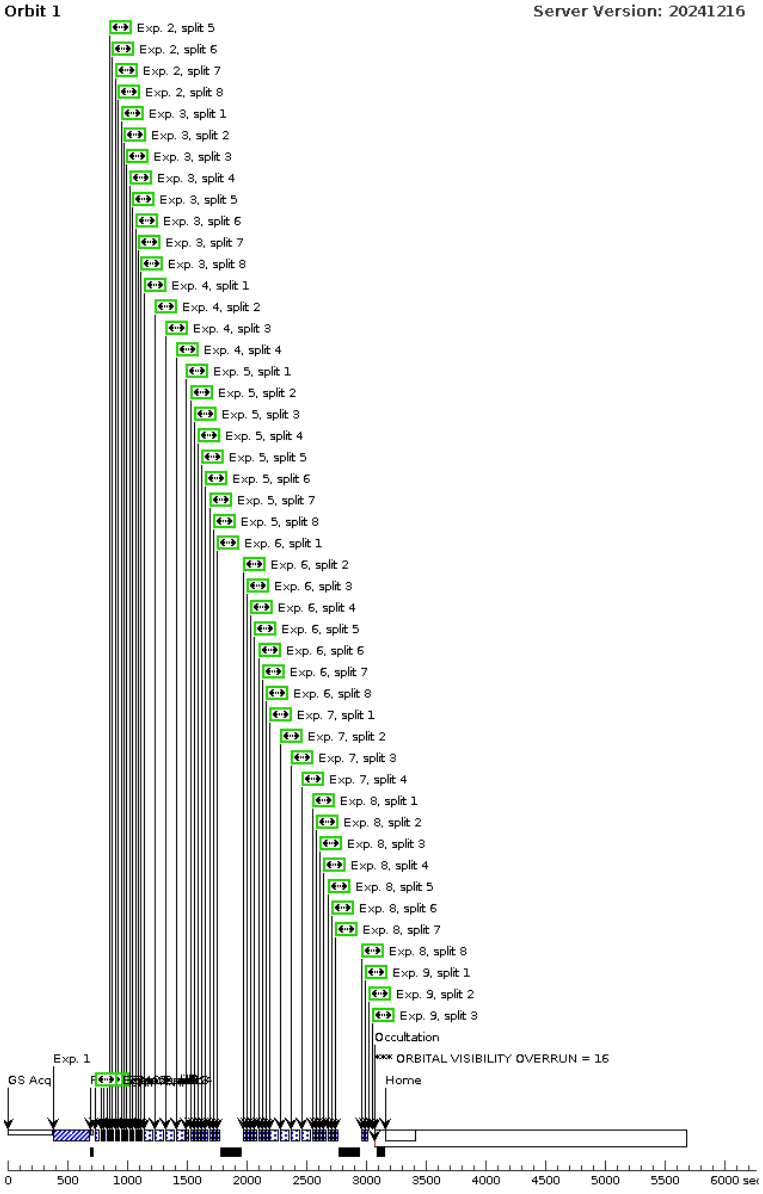
Comments: Beta Pictoris, debris disk: semi-major axis P.A.: +30.8 degree (E of N)
A6V
Category=STAR
Description=[A4-A9 V-IV]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	BPic-V1-ACQ	(1) BETA-PIC	STIS/CCD, ACQ, F25ND5	MIRROR		GS ACQ SCENARIO BASE1O3		3.1 Secs (3.1 Secs)	
								[==>]	***[1]***
2	WEDGE1.0A1.2sX8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=8; GAIN=4			9.6 Secs (9.6 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	***[1]***
3	WEDGE1.0A1.2sX8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=8; GAIN=4			9.6 Secs (9.6 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	***[1]***
4	WEDGE1.0A_60Sx4	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=4; GAIN=4			240 Secs (240 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	***[1]***
5	WEDGE1.0A_3Sx8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=8; GAIN=4			24 Secs (24 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	***[1]***
6	WEDGE1.0A_3Sx8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=8; GAIN=4			24 Secs (24 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	***[1]***

	7	WEDGE1.0A_60Sx4	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=4; GAIN=4; SIZEAXIS2=427	240 Secs (240 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	 ***[1]***
	8	WEDGE1.0A_3Sx8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=8; GAIN=4; SIZEAXIS2=427	24 Secs (24 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	 ***[1]***
	9	WEDGE1.0A_3Sx3	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=3; GAIN=4; SIZEAXIS2=427	9 Secs (9 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]*	 ***[1]***

Orbit Structure



Visit

Proposal 17741, Visit 02, implementation Tue Jan 28 20:00:20 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; ORIENT -6.1D TO 6.1D FROM 01; AFTER 01 BY .5 Orbits TO 1.5 Orbits

Comments: Timing: Must be executed in sequential orbit immediately after Visit 01 with only intervening inter-visit Earth occultation.
Orientation: set to be as close as possible to Visit 1 and/or Visit 2 to minimize Sun-spacecraft angle differences.

Diagnostics

(Visit 02) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Visit 02) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	ALPHA-PIC	RA: 06 48 11.4600 (102.0477500d)	Proper Motion RA: -66.07 mas/yr	V=3.30	Reference Frame: ICRS
	Alt Name1: HD50241	Dec: -61 56 29.00 (-61.94139d)	Proper Motion Dec: 242.97 mas/yr	B=3.48	
		Equinox: J2000	Parallax: 0.03378"		
			Epoch of Position: 2000		

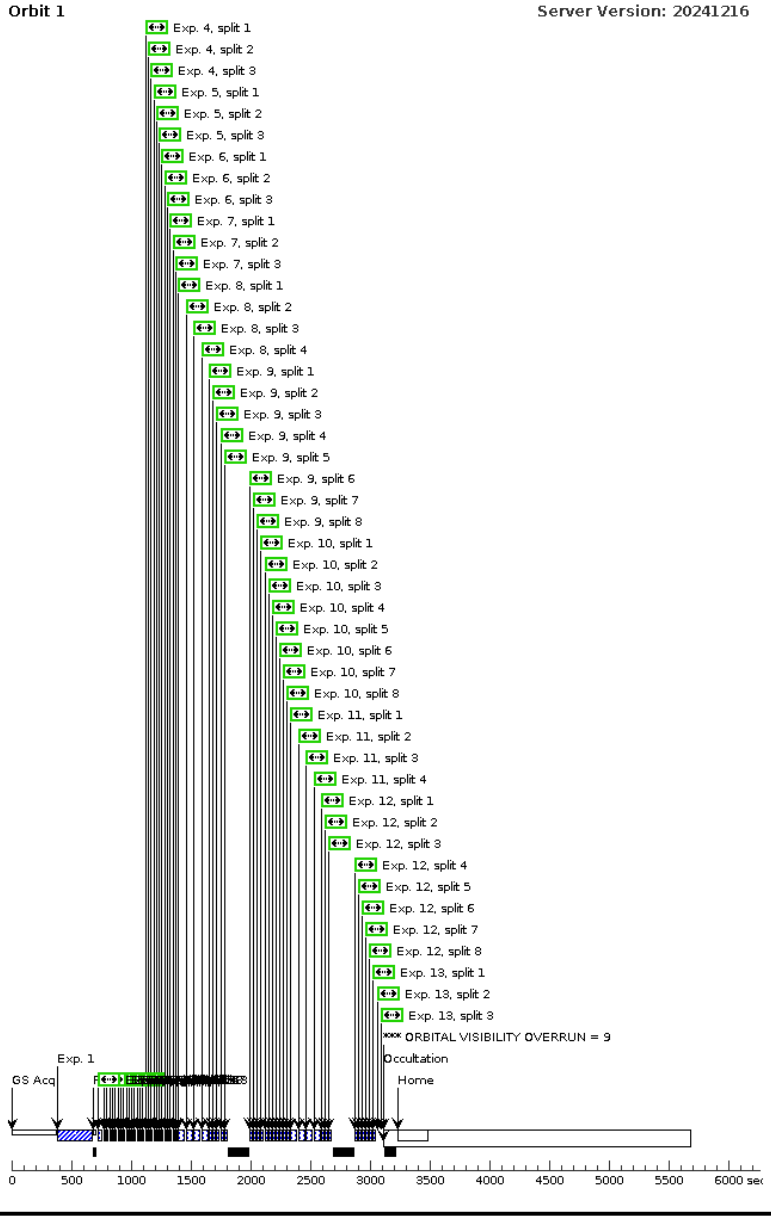
Comments: PSF calibrator for Beta Pictoris
Category=CALIBRATION
Description=[POINT SPREAD FUNCTION]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	APic-V1-ACQ	(2) ALPHA-PIC	STIS/CCD, ACQ, F25ND5	MIRROR		GS ACQ SCENARIO BASE1O3		1.9 Secs (1.9 Secs)	
								[==>]	***[1]***
2	WEDGE1.0A_0.7x8	(2) ALPHA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=8; GAIN=4			5.6 Secs (5.6 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	***[1]***
3	WEDGE1.0A_0.7x8	(2) ALPHA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=8; GAIN=4			5.6 Secs (5.6 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	***[1]***
4	WEDGE1.0A_0.7x3	(2) ALPHA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=3; GAIN=4			2.1 Secs (2.1 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]*	***[1]***
5	WEDGE1.0A_0.7x3	(2) ALPHA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=3; GAIN=4			2.1 Secs (2.1 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]*	***[1]***
6	WEDGE1.0A_0.7x3	(2) ALPHA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=3; GAIN=4			2.1 Secs (2.1 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]*	***[1]***
7	WEDGE1.0A_0.7x3	(2) ALPHA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=3; GAIN=4			2.1 Secs (2.1 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]*	***[1]***
8	WEDGE1.0A_36Sx4	(2) ALPHA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=4; GAIN=4			144 Secs (144 Secs)	
								[==>(Split 1)] *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	***[1]***

	9	WEDGE1.0A_1.9Sx8	(2) ALPHA-PICA	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=8; GAIN=4	15.2 Secs (15.2 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	 ***[1]***
	10	WEDGE1.0A_1.9Sx8	(2) ALPHA-PICA	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=8; GAIN=4	15.2 Secs (15.2 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	 ***[1]***
	11	WEDGE1.0A_36Sx4	(2) ALPHA-PICA	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=4; GAIN=4; SIZEAXIS2=427	144 Secs (144 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	 ***[1]***
	12	WEDGE1.0A_1.9x8	(2) ALPHA-PICA	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=8; GAIN=4; SIZEAXIS2=427	15.2 Secs (15.2 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	 ***[1]***
	13	WEDGE1.0A_1.9Sx3	(2) ALPHA-PICA	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=3; GAIN=4; SIZEAXIS2=427	5.7 Secs (5.7 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]*	 ***[1]***

Orbit Structure



Visit

Proposal 17741, Visit 03, implementation Tue Jan 28 20:00:20 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; ORIENT 6.9D TO 20D FROM 01; AFTER 02 BY 0.5 Orbits TO 1.5 Orbits

Comments: Timing: Must be executed in sequential orbit immediately after Visit 03 with only intervening inter-visit Earth occultation.
Orientation: set relative to Visit01 while keeping disk between difraction spikes and WedgeA.

Diagnostics

(Visit 03) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Visit 03) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	BETA-PIC	RA: 05 47 17.0877 (86.8211988d)	Proper Motion RA: 4.65 mas/yr	V=3.86	Reference Frame: ICRS
		Dec: -51 03 59.45 (-51.06651d)	Proper Motion Dec: 83.10 mas/yr	B=4.03	
		Equinox: J2000	Parallax: 0.05144"		
			Epoch of Position: 2000		

Comments: Beta Pictoris, debris disk: semi-major axis P.A.: +30.8 degree (E of N)
A6V
Category=STAR
Description=[A4-A9 V-IV]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	BPic-V1-ACQ	(1) BETA-PIC	STIS/CCD, ACQ, F25ND5	MIRROR		GS ACQ SCENARIO BASE1O3		3.1 Secs (3.1 Secs) *[==>]*	 ***[1]***
2	WEDGE1.0A_1.2x7	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=7; GAIN=4			8.4 Secs (8.4 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]*	 ***[1]***
3	WEDGE1.0A_1.2x7	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=7; GAIN=4			8.4 Secs (8.4 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]*	 ***[1]***
4	WEDGE1.0A_1.2x2	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=137; CR-SPLIT=2; GAIN=4			2.4 Secs (2.4 Secs) *[==>(Split 1)]* *[==>(Split 2)]*	 ***[1]***
5	WEDGE1.0A_60Sx4	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=4; GAIN=4			240 Secs (240 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	 ***[1]***
6	WEDGE1.0A_3Sx8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=8; GAIN=4			24 Secs (24 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	 ***[1]***
7	WEDGE1.0A_3Sx8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	SIZEAXIS2=427; CR-SPLIT=8; GAIN=4			24 Secs (24 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	 ***[1]***

	8	WEDGE1.0A_60Sx4	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=4; GAIN=4; SIZEAXIS2=427	240 Secs (240 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	 ***[1]***
	9	WEDGE1.0A_3Sx8	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=8; GAIN=4; SIZEAXIS2=427	24 Secs (24 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]* *[==>(Split 5)]* *[==>(Split 6)]* *[==>(Split 7)]* *[==>(Split 8)]*	 ***[1]***
	10	WEDGE1.0A_3Sx3	(1) BETA-PIC	STIS/CCD, ACCUM, WEDGEA1.0	MIRROR	CR-SPLIT=3; GAIN=4; SIZEAXIS2=427	9 Secs (9 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]*	 ***[1]***

Orbit Structure