



17283 - Confirming an accreting planet in a very young protoplanetary disk

Cycle: 30, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
Dr. Gabriele Cugno (PI) (Contact)	University of Michigan	gcugno@umich.edu
Dr. Richard Teague (CoI)	Smithsonian Institution Astrophysical Observatory	richard.d.teague@cfa.harvard.edu
Dr. Jaehan Bae (CoI)	University of Florida	jbae@ufl.edu
Dr. Stefano Facchini (CoI) (ESA Member)	University of Milan	stefano.facchini@unimi.it
Dr. Myriam Benisty (CoI) (ESA Member)	Institut de Planetologie et d'Astrophysique de Grenoble	myriam.benisty@univ-grenoble-alpes.fr
Prof. Michael R. Meyer (CoI)	University of Michigan	mrmeier@umich.edu
Dr. Per Calissendorff (CoI)	University of Michigan	percal@umich.edu
Mr. Matthew De Furio (CoI)	University of Michigan	defurio@umich.edu
Dr. Yifan Zhou (CoI)	University of Texas at Austin	yifan.zhou@utexas.edu
Dr. Jared Males (CoI)	University of Arizona	jrmale@email.arizona.edu
Dr. Edwin Anthony Bergin (CoI)	University of Michigan	ebergin@umich.edu
Ms. Maria Galloway-Sprietsma (CoI)	University of Florida	mgallowayspriets@ufl.edu

VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) EM-AS-209	WFC3/UVIS	1	16-Dec-2022 09:00:54.0	yes
02	(1) EM-AS-209	WFC3/UVIS	1	16-Dec-2022 09:00:57.0	yes
03	(1) EM-AS-209	WFC3/UVIS	1	16-Dec-2022 09:01:01.0	yes

3 Total Orbits Used

ABSTRACT

We will attempt to confirm the detection of an accreting protoplanet detected after the Cycle 30 deadline with the MagAO-X instrument in a narrow-band H-alpha filter. The observations were taken under exceptional conditions, and it is highly unlikely that similar conditions will be met during a second epoch observation from the ground. The protoplanet, detected with >4 sigma fidelity, is located at ~ 1 arcsec from the central star, and it is accreting at a relatively low rate ($\dot{M}_{\text{acc}} = 8.5 \times 10^{-9}$ MJ/yr assuming zero extinction).

The analysis will allow us to (1) confirm the existence of the accreting protoplanet, (2) investigate its accretion history, (3) search for indications of accretion variability, (4) provide valuable information to numerical simulations of planet formation and planet-disk interactions. Given the young age of the star ($< 1\text{-}2$ Myr), the protoplanet candidate AS209c has the potential of revolutionize the field of planet formation, demonstrating that planets can form quickly at large separation from their star via disk instability. Indeed, core accretion requires much longer timescales for the protoplanet candidate to form.

We will use the narrow-band filter F656N of the HST/WFC3 instrument for 3 orbit in order to achieve the sensitivity necessary to confirm the companion detection.

If confirmed, this candidate would be HST's first bona fide discovery of a protoplanet.

OBSERVING DESCRIPTION

The primary goal of our observations is to use the direct-imaging technique to confirm the presence of an accreting gas giant planet in the disk surrounding AS209. We will observe each target using WFC3/UVIS with the F656N filter for three consecutive orbits. The F656N filter will capture the H-alpha emission from the accreting planets. For all observations, we will use the UVIS2-C512C-SUB subarray to reduce readout time and improve observing efficiency. The images will be taken using a box dithering pattern with a dithering distance of 0.02 arcsec (0.5 pixels) on both sides. This will allow reconstructing Nyquist-sampled images, which are necessary for the post-processing of high-contrast images. At each dithering position, several copies of exposures will be taken. The exposure time and iteration numbers are determined to maximize the point spread function signal to noise ratio, avoid saturation and maximize the usage of orbital visibility.

Every visit contains one orbit. Observations are linked by timing requirements and will be executed continuously. To facilitate two-roll angular differential imaging, the second visit will have a 25 to 35 degrees difference in telescope orientation compared to those of the first and third visits. The first and third visits will have the same orientation. The orientation constraints ensure that in no visit the planet signal (PA 196 deg) coincides

with the position of one of the PSF spike.

Based on suggestions from STScI and the contact scientist on a similar program executed during the past cycles, we switch on the FLASH and set the level to 20 to mitigate the CTE loss, which has been aggravated in the past cycles.

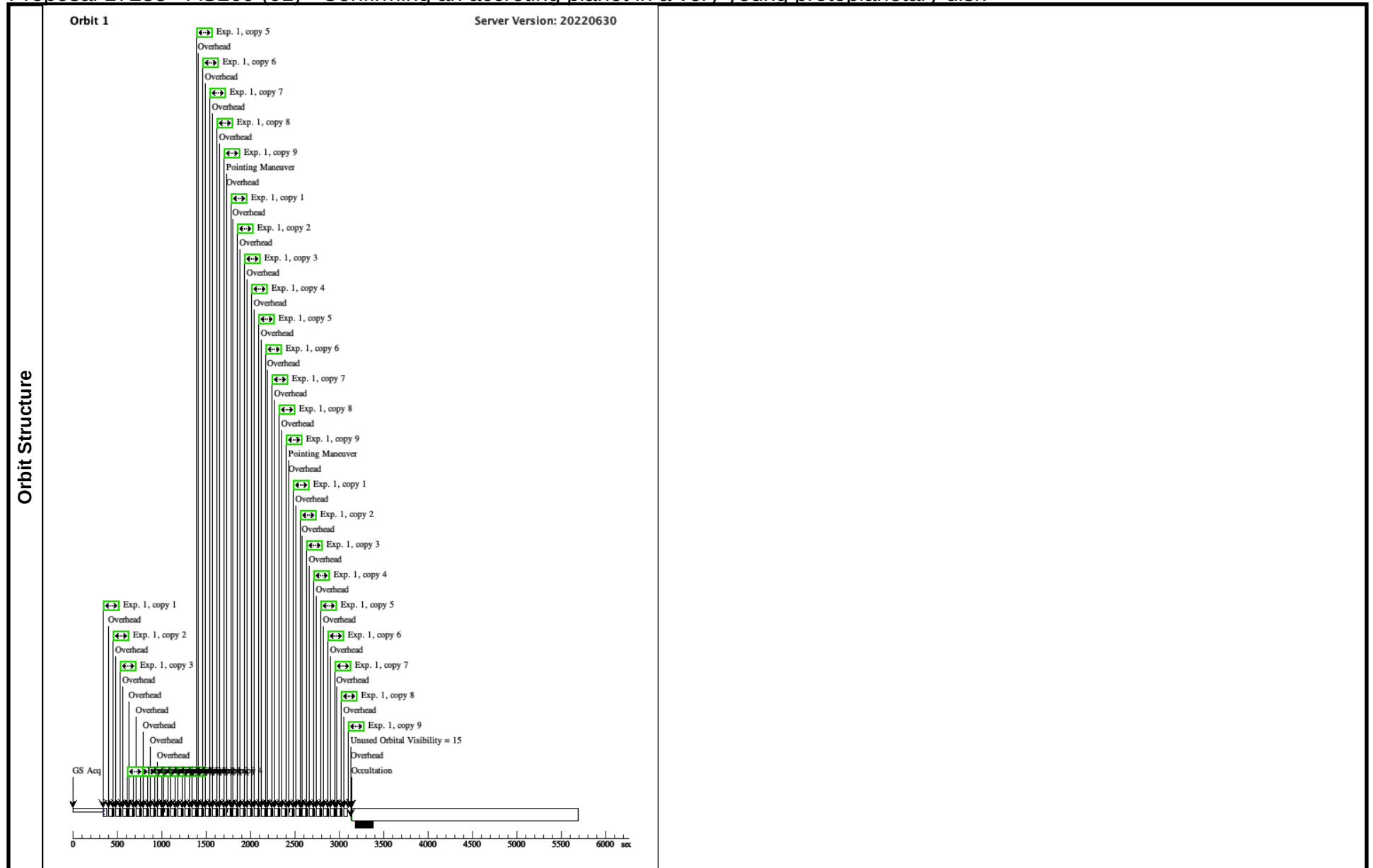
Reduced gyro operations will affect this program only in relation to the orientation of the spacecraft compared to the position of the planet. It is crucial to avoid the diffraction spikes, where the noise caused by the PSF is larger. Thus, we included some tight constraints on the orientation of HST and reduced gyro mode might limit our schedulability.

Proposal 17283 - AS209 (01) - Confirming an accreting planet in a very young protoplanetary disk

Visit	Proposal 17283, AS209 (01) Fri Dec 16 14:01:02 GMT 2022				
	Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: PCS MODE FINE; GUID TOL 0.05"; GYRO MODE 3GOBAD; ORIENT 206D TO 241 D; ORIENT 296D TO 331 D; ORIENT 26D TO 61 D; ORIENT 116D TO 151 D <i>Comments: The orientation requirements are meant to avoid the PSF spikes to end up at the position of the planet. The planet is located at a position angle of 196 deg East of North.</i>				
Patterns	#	Primary Pattern		Secondary Pattern	Exposures
	(1)	Pattern Type=BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.02 Line Spacing=0.02		Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides=90 Center Pattern=false	(1)
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes
	(1)	EM-AS-209	RA: 16 49 15.2956 (252.3137317d) Dec: -14 22 9.01 (-14.36917d) Equinox: J2000	Proper Motion RA: -5.069248789722364E-4 sec of time/yr Proper Motion Dec: -0.02365800007737562 arcsec/yr Epoch of Position: 2015.5	V=11.28 Reference Frame: SIMBAD
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=EXT-STAR Description=[K V-IV, PROTOPLANETARY DISK, T TAURI STAR, YSO]					

Proposal 17283 - AS209 (01) - Confirming an accreting planet in a very young protoplanetary disk

	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
Exposures	1	(WFC3UVI S.im.183650 5)	(1) EM-AS-209	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F656N	FLASH=20		Pattern 1, Exps 1-1 i n AS209 (01) (1)	13 Secs X 9 (468 Secs)	
									[==>(Pattern 1, Copy 1)]	
									[==>(Pattern 1, Copy 2)]	
									[==>(Pattern 1, Copy 3)]	
									[==>(Pattern 1, Copy 4)]	
									[==>(Pattern 1, Copy 5)]	
									[==>(Pattern 1, Copy 6)]	
									[==>(Pattern 1, Copy 7)]	
									[==>(Pattern 1, Copy 8)]	
									[==>(Pattern 1, Copy 9)]	
									[==>(Pattern 2, Copy 1)]	
									[==>(Pattern 2, Copy 2)]	
									[==>(Pattern 2, Copy 3)]	
									[==>(Pattern 2, Copy 4)]	
									[==>(Pattern 2, Copy 5)]	
									[==>(Pattern 2, Copy 6)]	
									[==>(Pattern 2, Copy 7)]	
									[==>(Pattern 2, Copy 8)]	
									[==>(Pattern 2, Copy 9)]	
									[==>(Pattern 3, Copy 1)]	
									[==>(Pattern 3, Copy 2)]	
									[==>(Pattern 3, Copy 3)]	
									[==>(Pattern 3, Copy 4)]	
									[==>(Pattern 3, Copy 5)]	
									[==>(Pattern 3, Copy 6)]	
									[==>(Pattern 3, Copy 7)]	
									[==>(Pattern 3, Copy 8)]	
									[==>(Pattern 3, Copy 9)]	
									[==>(Pattern 4, Copy 1)]	
									[==>(Pattern 4, Copy 2)]	
									[==>(Pattern 4, Copy 3)]	
									[==>(Pattern 4, Copy 4)]	
									[==>(Pattern 4, Copy 5)]	
									[==>(Pattern 4, Copy 6)]	
									[==>(Pattern 4, Copy 7)]	
									[==>(Pattern 4, Copy 8)]	
									[==>(Pattern 4, Copy 9)]	
Comments: From MagAO-X data (assuming the emission is constant in time) we know that continuum emission and H-alpha line emission have roughly similar intensity in filters 9nm wide. Considering V=11.3 mag in the continuum, and taking into account that the UVIS filter has a width 1/5 of the width of the MagAO-X filter (i.e., the continuum contribution in the HST data will be lower, while the H-alpha contribution remains unchanged), we estimated the flux measured by HST (see ETC). The exposure time to reach saturation is estimated to be 10 seconds. Given the large separation of the candidate, we plan to observe with exposures of 13 s, slightly saturating the PSF core. This will not affect our ability to center the image, as we can use the PSF spikes for that. This has been shown in past works on accreting exoplanets.										

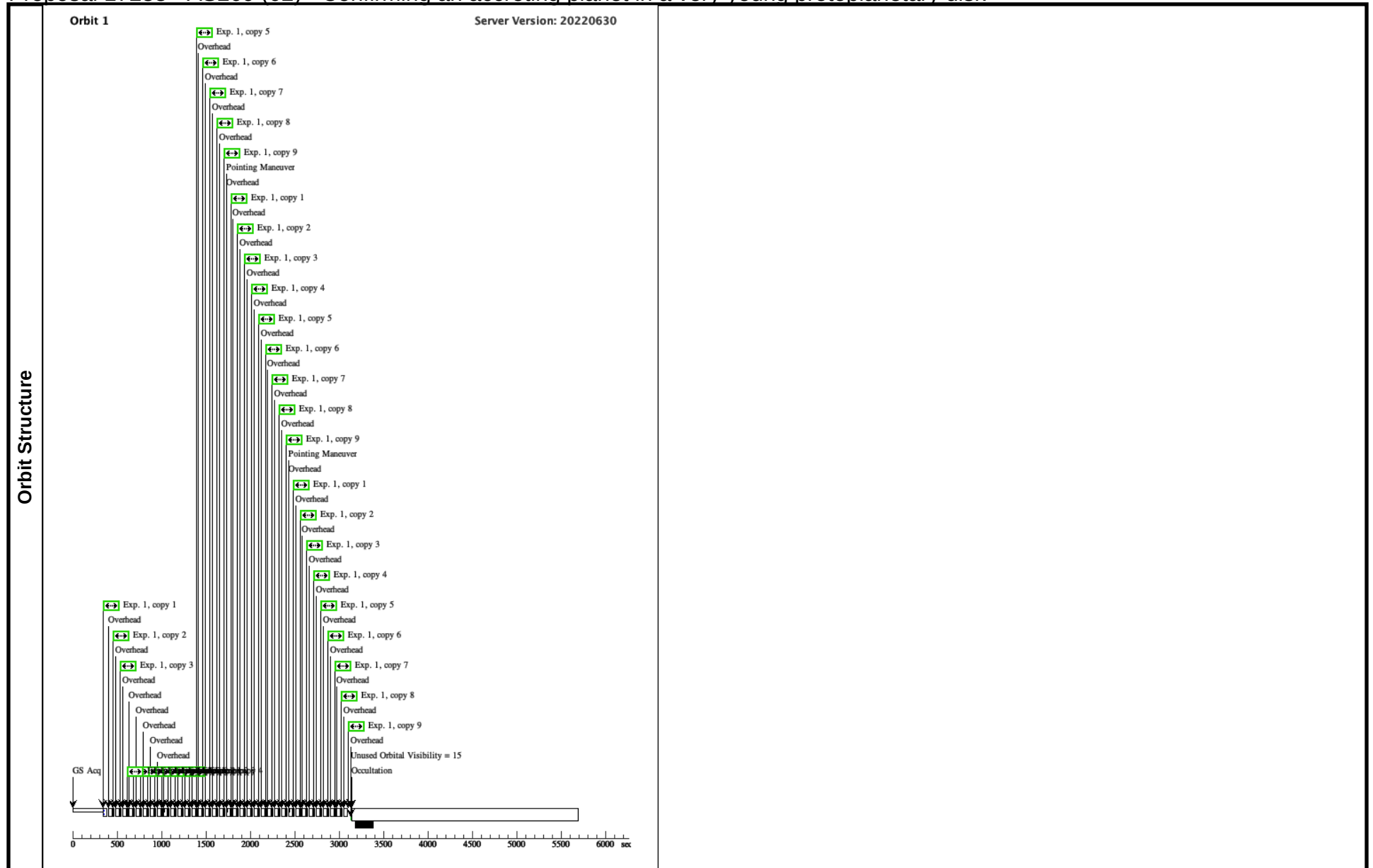


Proposal 17283 - AS209 (02) - Confirming an accreting planet in a very young protoplanetary disk

Visit	Proposal 17283, AS209 (02) Fri Dec 16 14:01:02 GMT 2022				
	Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: PCS MODE FINE; GUID TOL 0.05"; GYRO MODE 3GOBAD; ORIENT 25D TO 35D FROM 01; AFTER 01 BY 0.5 Orbits TO 1.5 Orbits <i>Comments: The orientation requirements are meant to avoid the PSF spikes to end up at the position of the planet. The planet is located at a position angle of 196 deg East of North.</i>				
Patterns	#	Primary Pattern		Secondary Pattern	Exposures
	(1)	Pattern Type=BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.02 Line Spacing=0.02	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides=90 Center Pattern=false		(1)
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes
	(1)	EM-AS-209	RA: 16 49 15.2956 (252.3137317d) Dec: -14 22 9.01 (-14.36917d) Equinox: J2000	Proper Motion RA: -5.069248789722364E-4 sec of time/yr Proper Motion Dec: -0.02365800007737562 arcsec/yr Epoch of Position: 2015.5	V=11.28 Reference Frame: SIMBAD
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=EXT-STAR Description=[K V-IV, PROTOPLANETARY DISK, T TAURI STAR, YSO]					

Proposal 17283 - AS209 (02) - Confirming an accreting planet in a very young protoplanetary disk

	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
Exposures	1	(WFC3UVI S.im.183650 5)	(1) EM-AS-209	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F656N	FLASH=20		Pattern 1, Exps 1-1 i n AS209 (02) (1)	13 Secs X 9 (468 Secs)	[1]
									[==>(Pattern 1, Copy 1)]	
									[==>(Pattern 1, Copy 2)]	
									[==>(Pattern 1, Copy 3)]	
									[==>(Pattern 1, Copy 4)]	
									[==>(Pattern 1, Copy 5)]	
									[==>(Pattern 1, Copy 6)]	
									[==>(Pattern 1, Copy 7)]	
									[==>(Pattern 1, Copy 8)]	
									[==>(Pattern 1, Copy 9)]	
									[==>(Pattern 2, Copy 1)]	
									[==>(Pattern 2, Copy 2)]	
									[==>(Pattern 2, Copy 3)]	
									[==>(Pattern 2, Copy 4)]	
									[==>(Pattern 2, Copy 5)]	
									[==>(Pattern 2, Copy 6)]	
									[==>(Pattern 2, Copy 7)]	
									[==>(Pattern 2, Copy 8)]	
									[==>(Pattern 2, Copy 9)]	
									[==>(Pattern 3, Copy 1)]	
									[==>(Pattern 3, Copy 2)]	
									[==>(Pattern 3, Copy 3)]	
									[==>(Pattern 3, Copy 4)]	
									[==>(Pattern 3, Copy 5)]	
									[==>(Pattern 3, Copy 6)]	
									[==>(Pattern 3, Copy 7)]	
									[==>(Pattern 3, Copy 8)]	
									[==>(Pattern 3, Copy 9)]	
									[==>(Pattern 4, Copy 1)]	
									[==>(Pattern 4, Copy 2)]	
									[==>(Pattern 4, Copy 3)]	
									[==>(Pattern 4, Copy 4)]	
									[==>(Pattern 4, Copy 5)]	
									[==>(Pattern 4, Copy 6)]	
									[==>(Pattern 4, Copy 7)]	
									[==>(Pattern 4, Copy 8)]	
									[==>(Pattern 4, Copy 9)]	



Proposal 17283 - AS209 (03) - Confirming an accreting planet in a very young protoplanetary disk

Visit	Proposal 17283, AS209 (03) Fri Dec 16 14:01:02 GMT 2022				
	Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: PCS MODE FINE; GUID TOL 0.05"; GYRO MODE 3GOBAD; SAME ORIENT AS 01; AFTER 02 BY 0.5 Orbits TO 1.5 Orbits <i>Comments: The orientation requirements are meant to avoid the PSF spikes to end up at the position of the planet. The planet is located at a position angle of 196 deg North through East.</i>				
Patterns	#	Primary Pattern		Secondary Pattern	Exposures
	(1)	Pattern Type=BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.02 Line Spacing=0.02	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides=90 Center Pattern=false		(1)
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes
	(1)	EM-AS-209	RA: 16 49 15.2956 (252.3137317d) Dec: -14 22 9.01 (-14.36917d) Equinox: J2000	Proper Motion RA: -5.069248789722364E-4 sec of time/yr Proper Motion Dec: -0.02365800007737562 arcsec/yr Epoch of Position: 2015.5	V=11.28 Reference Frame: SIMBAD
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=EXT-STAR Description=[K V-IV, PROTOPLANETARY DISK, T TAURI STAR, YSO]					

Proposal 17283 - AS209 (03) - Confirming an accreting planet in a very young protoplanetary disk

	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
Exposures	1	(WFC3UVI S.im.183650 5)	(1) EM-AS-209	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F656N	FLASH=20		Pattern 1, Exps 1-1 i n AS209 (03) (1)	13 Secs X 9 (468 Secs)	[1]
									[==>(Pattern 1, Copy 1)]	
									[==>(Pattern 1, Copy 2)]	
									[==>(Pattern 1, Copy 3)]	
									[==>(Pattern 1, Copy 4)]	
									[==>(Pattern 1, Copy 5)]	
									[==>(Pattern 1, Copy 6)]	
									[==>(Pattern 1, Copy 7)]	
									[==>(Pattern 1, Copy 8)]	
									[==>(Pattern 1, Copy 9)]	
									[==>(Pattern 2, Copy 1)]	
									[==>(Pattern 2, Copy 2)]	
									[==>(Pattern 2, Copy 3)]	
									[==>(Pattern 2, Copy 4)]	
									[==>(Pattern 2, Copy 5)]	
									[==>(Pattern 2, Copy 6)]	
									[==>(Pattern 2, Copy 7)]	
									[==>(Pattern 2, Copy 8)]	
									[==>(Pattern 2, Copy 9)]	
									[==>(Pattern 3, Copy 1)]	
									[==>(Pattern 3, Copy 2)]	
									[==>(Pattern 3, Copy 3)]	
									[==>(Pattern 3, Copy 4)]	
									[==>(Pattern 3, Copy 5)]	
									[==>(Pattern 3, Copy 6)]	
									[==>(Pattern 3, Copy 7)]	
									[==>(Pattern 3, Copy 8)]	
									[==>(Pattern 3, Copy 9)]	
									[==>(Pattern 4, Copy 1)]	
									[==>(Pattern 4, Copy 2)]	
									[==>(Pattern 4, Copy 3)]	
									[==>(Pattern 4, Copy 4)]	
									[==>(Pattern 4, Copy 5)]	
									[==>(Pattern 4, Copy 6)]	
									[==>(Pattern 4, Copy 7)]	
									[==>(Pattern 4, Copy 8)]	
									[==>(Pattern 4, Copy 9)]	

