16998 - A comparative study of atmospheric escape in the brightest system of super-earths straddling the evaporation valley

Cycle: 30, Proposal Category: GO

(UV Initiative)

(Availability Mode: AVAILABLE)

INVESTIGATORS

Name	*Institution*
Prof. David Ehrenreich (PI) (ESA Member) (Contact)	**University of Geneva, Department of Astronomy**
Dr. Laetitia Delrez (CoI) (ESA Member)	Universite de Liege
Dr. Malcolm Fridlund (CoI) (ESA Member)	Universiteit Leiden
Dr. Leonardo Dos Santos (CoI) (Contact)	Space Telescope Science Institute
Dr. Vincent Bourrier (CoI) (ESA Member) (Contact)	University of Geneva, Department of Astronomy
Prof. Monika Lendl (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Prof. Yann Alibert (CoI) (ESA Member)	University of Bern
Dr. Isabella Pagano (CoI) (ESA Member)	INAF, Osservatorio Astrofisico di Catania
Dr. Luca Fossati (CoI) (ESA Member)	Space Research Institute, Austrian Academy of Sciences
Prof. Kevin Heng (CoI) (ESA Member)	Ludwig Maximilian Universitat of Munich
Dr. Alexis Brandeker (CoI) (ESA Member)	Stockholm University
Dr. Alfred Vidal-Madjar (CoI) (ESA Member)	CNRS, Institut d'Astrophysique de Paris
Dr. Baptiste Lavie (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Dr. Adrien Deline (CoI) (ESA Member) (Contact)	University of Geneva, Department of Astronomy
Dr. Alain Lecavelier des Etangs (CoI) (ESA Member)	CNRS, Institut d'Astrophysique de Paris

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
03	(1) -NU.02-LUP	COS/FUV COS/NUV	5	03-Feb-2025 16:00:12.0	yes

5 Total Orbits Used

ABSTRACT

Photo-evaporation of planetary atmospheres plays a key role in the evolution of exoplanets, carving their whole population. However, direct observations of atmospheric escape are scarce and almost non-existent in the mass range of super-Earths and mini-Neptunes, while these planets are among the most impacted by the phenomenon. A huge step forward could be made by achieving a comparative study of several super-Earths, volatile-rich or not, in a single multi-planet system: such planets would indeed experience the same evolution of the stellar X and EUV flux that are driving atmospheric escape. The perfect system for such a study has just been identified: the nearby, solar-type, and naked-eye star nu^2 Lupi hosts transiting planets spanning a remarkably large range of insolation (~100 to ~5x the insolation of Earth). TESS found the transits of the two inner planets and CHEOPS detected the transit of planet d, a volatile-rich super-Earth with an exceptional period of 107 day. These super-Earths straddle the radius gap of the "evaporation valley" and could have retained different fractions of gas and volatiles. Like for previously observed warm Neptunes, they could be enshrouded in huge comet-like exospheric clouds of escaping gas, which could have built up in the mild radiative environment. The system unique combination of proximity, brightness and favorable planet characteristics offers a fantastic opportunity to exploit HST ultraviolet capabilities to search for the hydrogen, oxygen and carbon escaping three planets in whole new mass and irradiation regimes. It is the ideal testbed for advancing both observations and theories of atmospheric evaporation of exoplanets.

OBSERVING DESCRIPTION

We are targetting transits of exoplanets in the Nu2 Lupi system at Lyman-alpha. Nu2 Lupi is a naked-eye star (V=5.65). We will observe it with COS/FUV/G130M using both segments B (incl. Lyman-alpha) and A. The Lyman-alpha airglow will be corrected using available airglow templates, as in programs GO14877 (Bourrier et al. 2018, A&A 615, A117) and GO14767 (Dos Santos et al. 2019, A&A 629, A47). We wish to use only one FP-POS setting per visit so we are not impacted by the restriction to FP-POS=3 or 4 that applies when using segment B. We have set FP-POS=3 through the whole program. Each visit will consist in 5 HST orbits, spent in a single, orbit-long exposure in time-tag mode. The first orbit in each visit additionally contains an acquisition performed with COS/NUV in imaging mode, using the Bright Object Aperture and MIRRORB.

The transit observations are time-critical: we aim at obtaining two transits (2x5 orbits) of planet b, three transits (3x5 orbits) of planet c, and three

transits (3x5 orbits) of planet d. Planet b transits every ~11 days and there is a dozen windows available until March 2023. Planets c and d have longer periods and they are much more constraining in terms of planning: with its ~27-day period, there are only 4 windows available for transits of c between now and March 2023, with a first opportunity on 21 September 2021 (still in Cycle 28) and two beyond Cycle 29. Finally, planet d has an even longer period of ~107 days; there are 3 opportunites: one on 11 August 2021 (Cycle 28), one on 14 March 2022 (Cycle 29) and one on 29 Jan 2023 (Cycle 30). The proposal anticipated that one visit (5 orbits) would be carried over in Cycle 30; it might actually be up to three visits (15 orbits). Besides, the visits have slightly difference phase constraints, set to cover different parts of the transits.

Visit

Proposal 16998, Planet d (03), implementation Mon Feb 03 21:00:13 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 107.1360 D AND ZERO-PHASE HJD2459331.18760

Diagnostics

(Planet d (03)) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave.

Fixed Targets

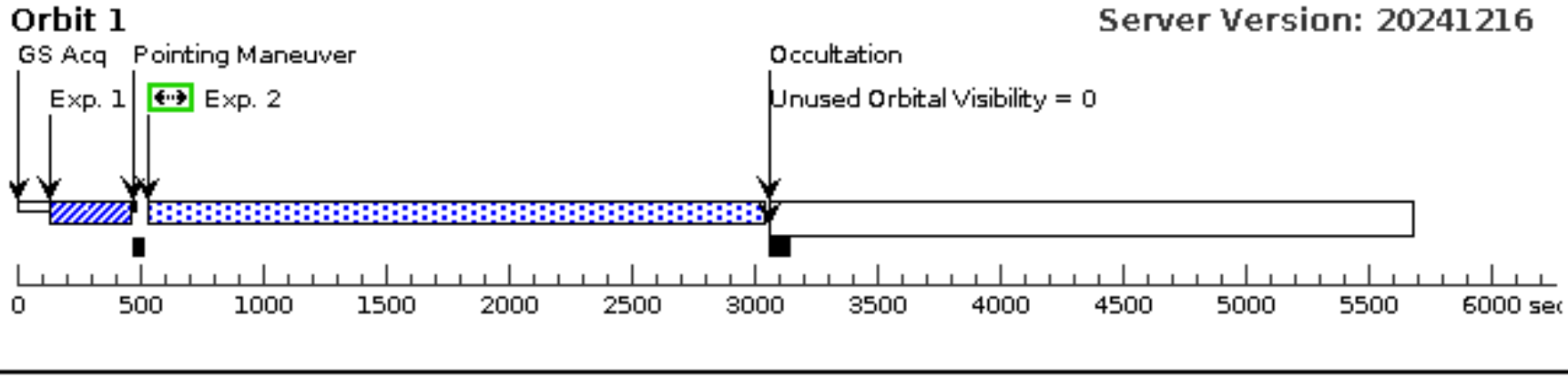
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	-NU.02-LUP	RA: 15 21 48.1511 (230.4506296d)	Proper Motion RA: -1624.047 mas/yr	V=5.65	Reference Frame: ICRS
	Alt Name1: HD136352	Dec: -48 19 3.46 (-48.31763d)	Proper Motion Dec: -276.024 mas/yr		
		Equinox: J2000	Parallax: 0.0680818"		
			Epoch of Position: 2000		
			Radial Velocity: -68.780 km/sec		

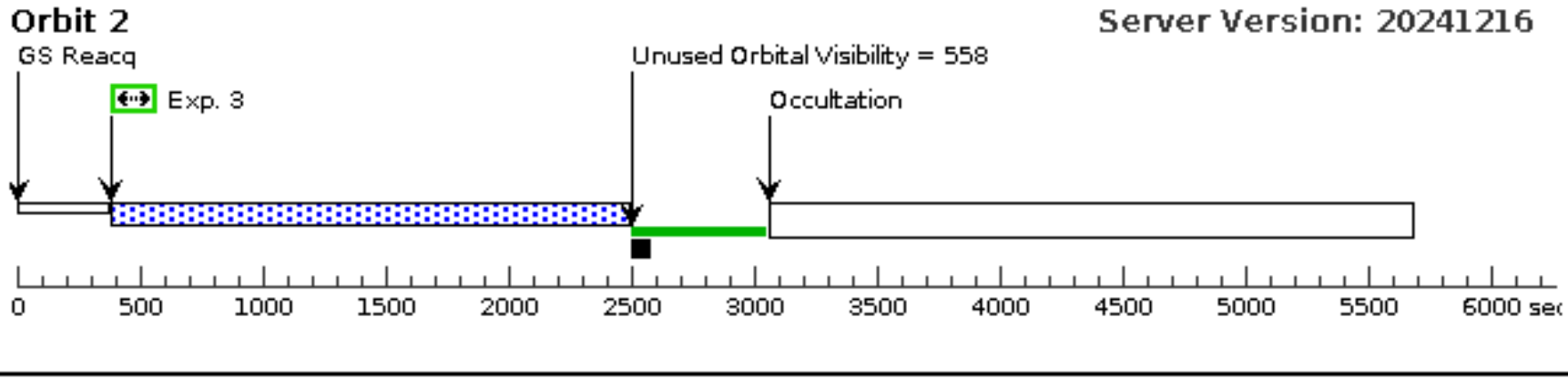
Comments:
Category=STAR
Description=[EXTRA-SOLAR PLANETARY SYSTEM, G V-IV]
Extended=NO

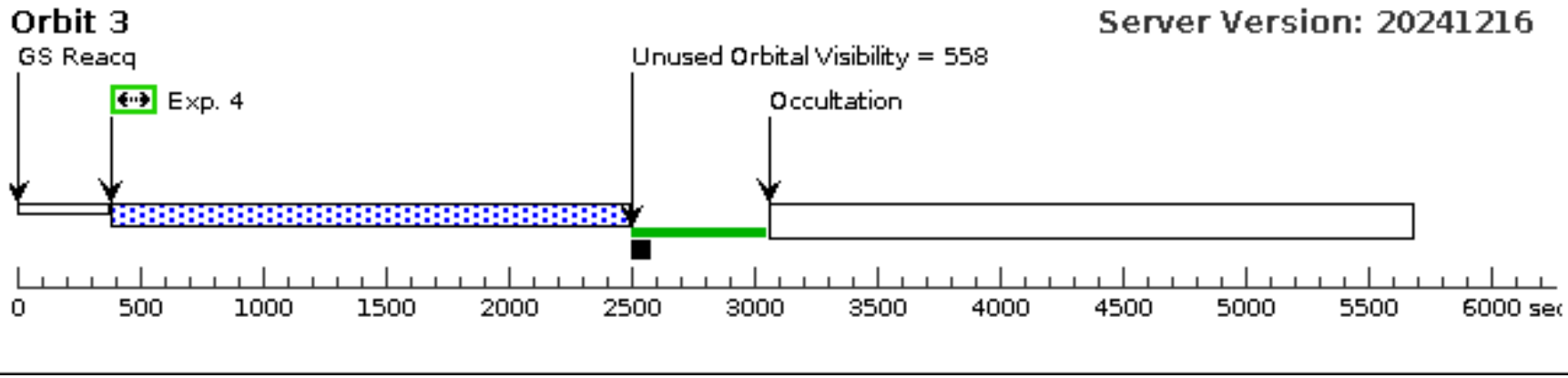
Exposures

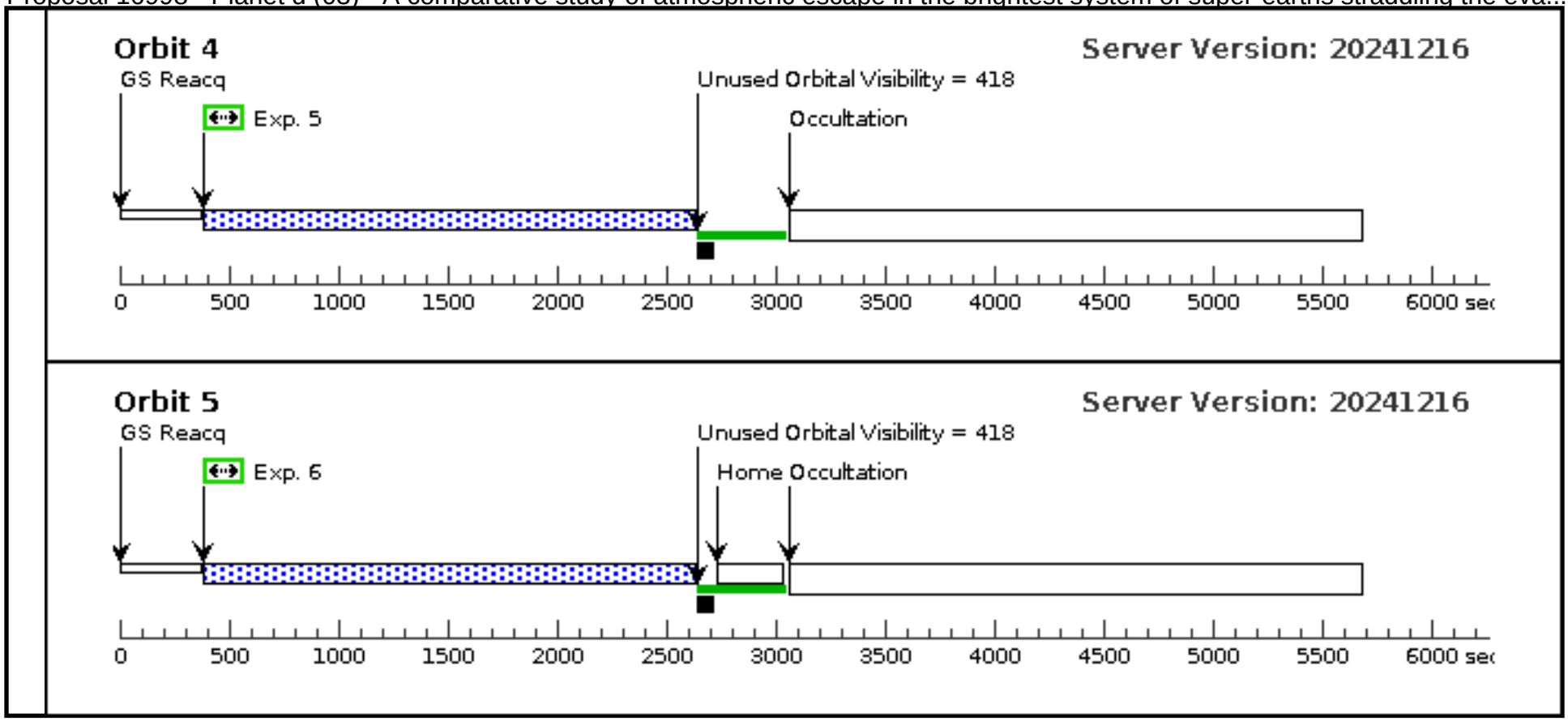
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.1522351)	(1) -NU.02-LUP	COS/NUV, ACQ/IMAGE, BOA	MIRRORB		PHASE 0.0003 TO 0.0011		13 Secs (13 Secs) *[==>]*	***[1]***
2	(COS.sp.1746796)	(1) -NU.02-LUP	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=3400; FP-POS=3; FLASH=YES; SEGMENT=BOTH; LIFETIME-POS=LP3			2550 Secs (2326 Secs) *[==>2326.0 Secs]*	***[1]***
3	(COS.sp.1746797)	(1) -NU.02-LUP	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=3400; FP-POS=3; FLASH=YES; SEGMENT=BOTH; LIFETIME-POS=LP3			2829 Secs (2060 Secs) *[==>2060 Secs]*	***[2]***
4	(COS.sp.1746797)	(1) -NU.02-LUP	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=3400; FP-POS=3; FLASH=YES; SEGMENT=BOTH; LIFETIME-POS=LP3			2829 Secs (2060 Secs) *[==>2060 Secs]*	***[3]***
5	(COS.sp.1746797)	(1) -NU.02-LUP	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=3400; FP-POS=3; FLASH=YES; SEGMENT=BOTH; LIFETIME-POS=LP3			2829 Secs (2200 Secs) *[==>2200 Secs]*	***[4]***
6	(COS.sp.1746797)	(1) -NU.02-LUP	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=3400; FP-POS=3; FLASH=YES; SEGMENT=BOTH; LIFETIME-POS=LP3			2829 Secs (2200 Secs) *[==>2200 Secs]*	***[5]***

Orbit Structure








Orbit 4
Server Version: 20241216
GS Reacq
Exp. 5
Unused Orbital Visibility = 418
Occultation
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1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec
Orbit 5
Server Version: 20241216
GS Reacq
Exp. 6
Unused Orbital Visibility = 418
Home Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec