18002 - Probing the Interior of the Dwarf Planet Haumea

Cycle: 33, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Dr. Benjamin Proudfoot (PI) (Contact)	**University of Central Florida Board of Trustees**
Prof. Darin Ragozzine (CoI)	Brigham Young University
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Dra. Estela Fernandez-Valenzuela (CoI)	University of Central Florida Board of Trustees
Dr. Bryan Jason Holler (CoI)	Space Telescope Science Institute

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) HAUMEA	WFC3/UVIS	1	29-Jul-2025 13:00:38.0	yes
02	(1) HAUMEA	WFC3/UVIS	1	29-Jul-2025 13:00:40.0	yes
03	(1) HAUMEA	WFC3/UVIS	1	29-Jul-2025 13:00:42.0	yes

3 Total Orbits Used

ABSTRACT

In the region beyond Neptune, a diverse population of small, icy bodies exists. These transneptunian objects (TNOs) are some of the most enigmatic bodies in our solar system. The most mysterious of these bodies is Haumea, a large (~1500 km diameter), rapidly rotating body (3.9 hours) hosting two moons (Hi'iaka and Namaka). Haumea, like most of the other large TNOs, is thought to be differentiated, with a dense, rocky core surrounded by a water-ice mantle. Between these layers, a thin subsurface ocean may have once existed, with significant astrobiological potential. Although indirect

evidence indicates Haumea may be differentiated, no direct probe of Haumea's interior has yet to be made. In this program, we use astrometric tracking of Haumea's moons to infer the interior structure of Haumea. We require 3, well-timed single-orbit visits using WFC3/UVIS, which will enable detection of Haumea's differentiated core at a significance of ~3 sigma. This low-risk, high-reward program will provide the first direct probe into the interior of a TNO, acting as a touchstone for understanding the interiors of the icy transneptunian population.

OBSERVING DESCRIPTION

Our observations call for 3 single-orbit visits to image the Haumea system using the WFC3/UVIS instrument. During each visit, images will be acquired using the UVIS2-C512C-SUB aperture, paired with the F350LP filter to optimize astrometric precision. Exposure times are chosen to optimize SNR and schedulability, with 10+ dithered images taken during each visit. This allows us to remain robust to unlucky cosmic ray hits.

Scheduling of observations is important to the goals of our program. The timing windows input into the Phase II are somewhat flexible, and can be changed if needed. If more observing windows are needed, we can provide them, although these are our "optimal" windows. We would prefer if each visit is at least 20 days apart, although this is not necessary. Once observations are scheduled, we are happy to check if any bright stars are too close to our targets, although Haumea is currently in a fairly empty part of the sky.

Reduced gyro operations will not significantly affect the execution of this program, apart from potentially requiring a rescheduling of observations due to reductions in observing windows. As needed, we can flexibly reschedule observations without significantly harming the goals of this program. Reduced spatial scan speed will not prohibit observations of our target as the maximum needed spatial scan speed is ~5 arcseconds/hour, well within the limits of reduced gyro operations.

Visit

Proposal 18002, Namaka Focus (01) Tue Jul 29 17:00:42 GMT 2025

Diagnostic Status: Informational

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 30-JAN-2026:00:00:00 AND 03-FEB-2026:00:00:00; BETWEEN 18-FEB-2026:00:00:00 AND 21-FEB-2026:00:00:00; BETWEEN 08-MAR-2026:00:00:00 AND 11-MAR-2026:00:00:00; VISIBILITY INTERVAL NO GYRO BIAS UPDATE ON MOVING TARGET

Comments: Visit to focus on Namaka's position

Diagnostics

(Namaka Focus (01)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1-2), (3-4)
(2)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(5-6)

Solar System Targets

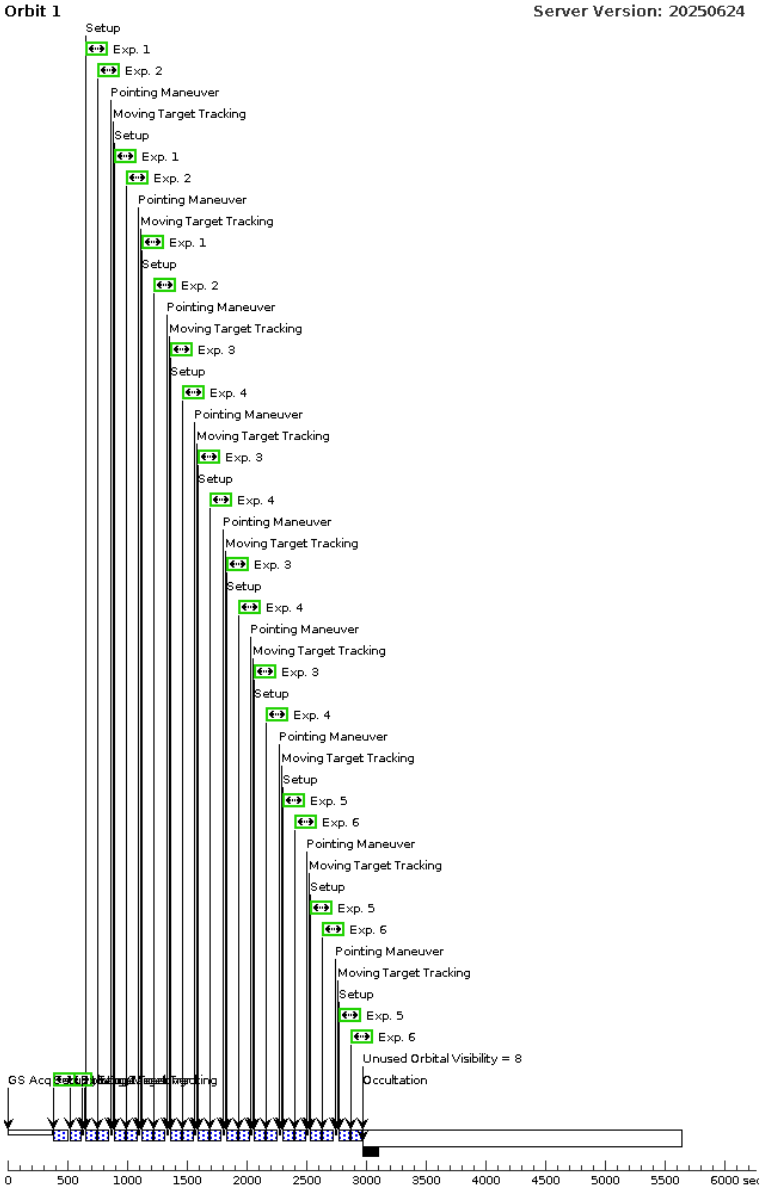
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	HAUMEA	STD=HAUMEA				EARTH

Comments: Description=Haumea

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Namaka Focus (01) Pattern 1, Exps 1-2 in Sequence 1-6 Non-Int in Namaka Focus (01) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
2		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Namaka Focus (01) Pattern 1, Exps 1-2 in Sequence 1-6 Non-Int in Namaka Focus (01) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
3		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Namaka Focus (01) Pattern 1, Exps 3-4 in Sequence 1-6 Non-Int in Namaka Focus (01) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
4		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Namaka Focus (01) Pattern 1, Exps 3-4 in Sequence 1-6 Non-Int in Namaka Focus (01) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
5		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Namaka Focus (01) Pattern 2, Exps 5-6 in Sequence 1-6 Non-Int in Namaka Focus (01) (2)	40 Secs (129 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]*	***[1]***
6		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Namaka Focus (01) Pattern 2, Exps 5-6 in Sequence 1-6 Non-Int in Namaka Focus (01) (2)	40 Secs (129 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 18002, Both Focus (02) Tue Jul 29 17:00:43 GMT 2025

Diagnostic Status: Informational

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 13-JAN-2026:00:00:00 AND 17-JAN-2026:00:00:00; BETWEEN 15-APR-2026:00:00:00 AND 18-APR-2026:00:00:00; VISIBILITY INTERVAL NO GYRO BIAS UPDATE ON MOVING TARGET

Comments: Visit to focus on both moons

Diagnostics

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

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1-2), (3-4)
(2)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(5-6)

Solar System Targets

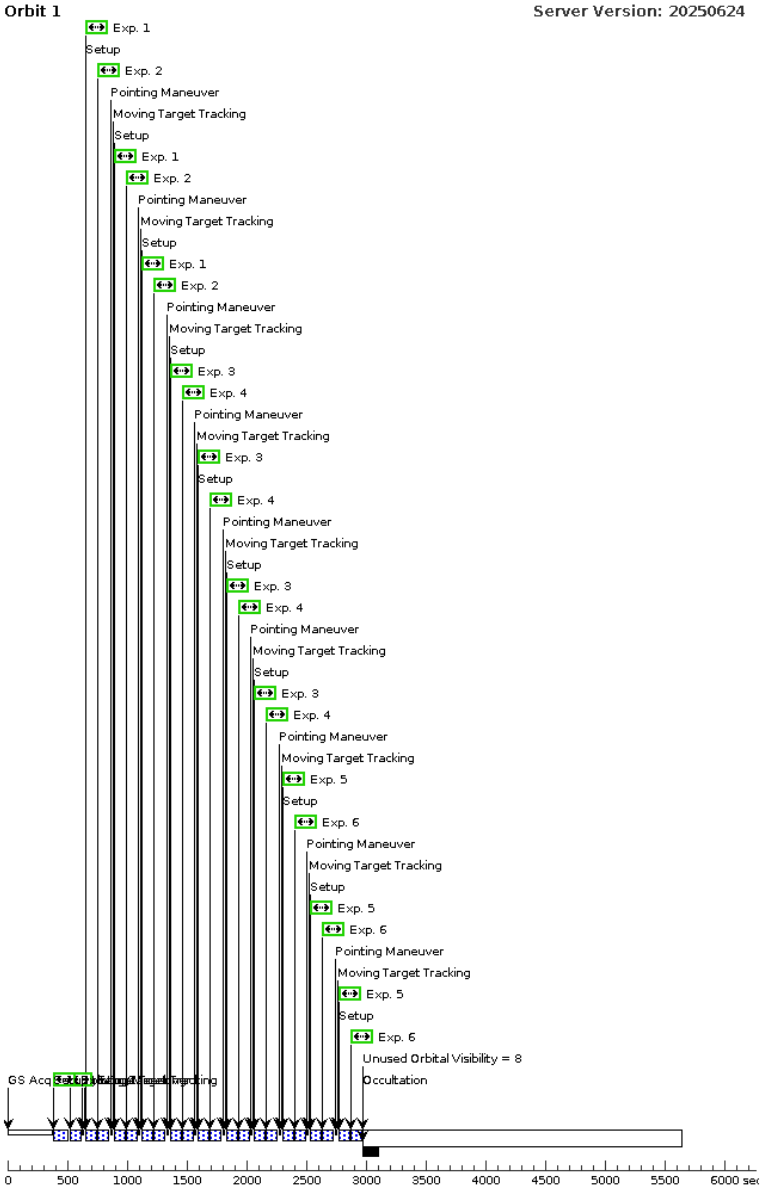
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	HAUMEA	STD=HAUMEA				EARTH

Comments: Description=Haumea

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Both Focus (02) Pattern 1, Exps 1-2 in Sequence 1-6 Non-Int in Both Focus (02) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
2		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Both Focus (02) Pattern 1, Exps 1-2 in Sequence 1-6 Non-Int in Both Focus (02) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
3		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Both Focus (02) Pattern 1, Exps 3-4 in Sequence 1-6 Non-Int in Both Focus (02) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
4		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Both Focus (02) Pattern 1, Exps 3-4 in Sequence 1-6 Non-Int in Both Focus (02) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
5		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Both Focus (02) Pattern 2, Exps 5-6 in Sequence 1-6 Non-Int in Both Focus (02) (2)	40 Secs (129 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]*	***[1]***
6		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Both Focus (02) Pattern 2, Exps 5-6 in Sequence 1-6 Non-Int in Both Focus (02) (2)	40 Secs (129 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 18002, Other node (03) Tue Jul 29 17:00:43 GMT 2025

Diagnostic Status: Informational

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 27-FEB-2026:00:00:00 AND 02-MAR-2026:00:00:00; BETWEEN 08-FEB-2026:00:00:00 AND 11-FEB-2026:00:00:00; BETWEEN 04-APR-2026:00:00:00 AND 07-APR-2026:00:00:00; VISIBILITY INTERVAL NO GYRO BIAS UPDATE ON MOVING TARGET

Comments: Visit to focus on the secondary uncertainty peak

Diagnostics

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

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1-2), (3-4)
(2)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(5-6)

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	HAUMEA	STD=HAUMEA				EARTH

Comments: Description=Haumea

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Other node (03) Pattern 1, Exps 1-2 in Sequence 1-6 Non-Int in Other node (03) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
2		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Other node (03) Pattern 1, Exps 1-2 in Sequence 1-6 Non-Int in Other node (03) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
3		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Other node (03) Pattern 1, Exps 3-4 in Sequence 1-6 Non-Int in Other node (03) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
4		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Other node (03) Pattern 1, Exps 3-4 in Sequence 1-6 Non-Int in Other node (03) (1)	40 Secs (172 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]* *[==>43.0 Secs (Pattern 4)]*	***[1]***
5		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Other node (03) Pattern 2, Exps 5-6 in Sequence 1-6 Non-Int in Other node (03) (2)	40 Secs (129 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]*	***[1]***
6		(1) HAUMEA	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	FLASH=14		Sequence 1-6 Non-Int in Other node (03) Pattern 2, Exps 5-6 in Sequence 1-6 Non-Int in Other node (03) (2)	40 Secs (129 Secs) *[==>43.0 Secs (Pattern 1)]* *[==>43.0 Secs (Pattern 2)]* *[==>43.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure