



9976 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Ganymede, and Callisto

Cycle: 5, Proposal Category: GO

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Dr. Will M. Grundy (PI)	Northern Arizona University
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Dr. Bryan Jason Holler (CoI) (Contact)	Space Telescope Science Institute
Dr. Stephen Tegler (CoI)	Northern Arizona University

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	Europa Leading	NIRSpec IFU Spectroscopy	(1) Europa
	2	Europa Leading	NIRSpec IFU Spectroscopy	(4) Europa_sky
	3	Europa Trailing	NIRSpec IFU Spectroscopy	(1) Europa
	4	Europa Trailing	NIRSpec IFU Spectroscopy	(4) Europa_sky
	5	Ganymede Leading	NIRSpec IFU Spectroscopy	(2) Ganymede
	6	Ganymede Leading	NIRSpec IFU Spectroscopy	(5) Ganymede_sky
	7	Ganymede Trailing	NIRSpec IFU Spectroscopy	(2) Ganymede
	8	Ganymede Trailing	NIRSpec IFU Spectroscopy	(5) Ganymede_sky
	9	Callisto Leading	NIRSpec IFU Spectroscopy	(3) Callisto
	10	Callisto Leading	NIRSpec IFU Spectroscopy	(6) Callisto_sky
	11	Callisto Trailing	NIRSpec IFU Spectroscopy	(3) Callisto
	12	Callisto Trailing	NIRSpec IFU Spectroscopy	(6) Callisto_sky

ABSTRACT

We propose a major advancement in understanding the origins of giant planet satellite systems by measuring the deuterium/hydrogen (D/H) ratios of water ice on the surfaces of Europa, Ganymede, and Callisto. The Jupiter system is an archetype for such systems, yet there is a total lack of D/H data on Europa and Ganymede, and a wide uncertainty band for Callisto from Galileo NIMS. D/H ratios are one of our best sources of information to uncover the history of water in the solar system and can be a birthmark of the formation environment. These measurements will allow us to compare the Galilean satellites to other icy bodies (like comets), filling in crucial gaps in the bigger picture of water in the outer solar system. We will test the two main classes of satellite formation models (gas-starved disk vs. minimum-mass subnebula) by assessing how faithfully D/H ratios were inherited from the solar nebula. A critical cutoff interval near the Earth ocean D/H value can be used to discriminate between these hypotheses. Because the key O-D stretch at 4.13 μm is masked by Earth's atmosphere, JWST is the only current facility that can make these measurements. However, origins science in the Jupiter system has yet to be unlocked by JWST because previous observations in the necessary wavelength range used NIRSpec's integral field unit with the G395H grating, which has a gap right where we need to look. These will be the first G395M observations of the icy Galilean moons, offering new views both scientifically and spectroscopically. This work will also leverage newly measured optical constants of water isotopologues to bring an unprecedented degree of rigor to the analysis.

OBSERVING DESCRIPTION

Observe the leading and trailing hemispheres of the three icy Galilean satellites to measure the D/H ratio in their water ice. This requires the G395M grating since the previously used G395H grating has a coverage gap right at the 4.13 μm wavelength of the HDO band. We also request contemporaneous G235H observations so that we can use Hapke models to account for multiple scattering effects which influence the depth of the HDO band without distinct geometries between the wavelength regimes introducing additional uncertainties.

Proposal 9976 - Targets - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Ganymede,...

Solar System Targets	#	Name	Level 1	Level 2	Level 3
	(1)	Europa	STD=JUPITER	STD=EUROPA	
	<i>Comments: Extended=YES</i>				
	(2)	Ganymede	STD=JUPITER	STD=GANYMEDE	
	<i>Comments: Extended=YES</i>				
	(3)	Callisto	STD=JUPITER	STD=CALLISTO	
	<i>Comments: Extended=Unknown</i>				
(4)	Europa_sky	STD=JUPITER	STD=EUROPA	TYPE=POS_ANGLE,RAD=10,ANG=270,REF=NOR TH,R_RAD=0,R_ANG=0,EPOCH=01-JUL- 2025:00:00:00,EpochTimeScale=UTC	
<i>Comments: Extended=Unknown</i>					
(5)	Ganymede_sky	STD=JUPITER	STD=GANYMEDE	TYPE=POS_ANGLE,RAD=10,ANG=270,REF=NOR TH,R_RAD=0,R_ANG=0,EPOCH=01-JUL- 2025:00:00:00,EpochTimeScale=UTC	
<i>Comments: Extended=Unknown</i>					
(6)	Callisto_sky	STD=JUPITER	STD=CALLISTO	TYPE=POS_ANGLE,RAD=10,ANG=270,REF=NOR TH,R_RAD=0,R_ANG=0,EPOCH=01-JUL- 2025:00:00:00,EpochTimeScale=UTC	
<i>Comments: Extended=Unknown</i>					

Proposal 9976 - Observation 1 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 1: Europa Leading</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observations:[Europa Leading (Obs 2)]</p> <p><i>Comments: Europa leading hemisphere</i></p>																																															
Diagnostics	<p>(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Europa Leading (Obs 1)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Special Requirements	<p>Between Dates 12-MAR-2027:00:00:00 and 14-MAY-2027:00:00:00</p> <p>Group Observations 1, 2, Non-interruptible</p> <p>DEFAULT WINDOW: NOT OCCULTATION OF Europa BY JUPITER FROM JWST</p> <p>DEFAULT WINDOW: SEPARATION OF Europa IO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Europa GANYMEDE FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Europa CALLISTO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: ANGULAR RATE EUROPA FROM JWST LESS THAN 0.075</p> <p>CENTRAL MERIDIAN LONGITUDE OF Europa FROM JWST BETWEEN 75 105</p>																																															

Proposal 9976 - Observation 2 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 2: Europa Leading</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observation For: [Europa Leading (Obs 1)]</p> <p><i>Comments: Europa background</i></p>																																															
Diagnostics	<p>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Europa Leading (Obs 2)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Proposal 9976 - Observation 3 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 3: Europa Trailing</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observations:[Europa Trailing (Obs 4)]</p> <p><i>Comments: Europa trailing hemisphere</i></p>																																															
Diagnostics	<p>(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Europa Trailing (Obs 3)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p> <p>(Visit 3:1) Informational (Form): Visit schedulable, but most scheduling windows are when JWST is pointed in direction of greatest micrometeoroid impact risk. This is likely due to scheduling special requirements.</p>																																															
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Special Requirements	<p>Between Dates 13-NOV-2026:00:00:00 and 02-JAN-2027:00:00:00</p> <p>Group Observations 3, 4, Non-interruptible</p> <p>DEFAULT WINDOW: NOT OCCULTATION OF Europa BY JUPITER FROM JWST</p> <p>DEFAULT WINDOW: SEPARATION OF Europa IO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Europa GANYMEDE FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Europa CALLISTO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: ANGULAR RATE EUROPA FROM JWST LESS THAN 0.075</p> <p>CENTRAL MERIDIAN LONGITUDE OF Europa FROM JWST BETWEEN 255 285</p>																																															

Proposal 9976 - Observation 4 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 4: Europa Trailing</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observation For: [Europa Trailing (Obs 3)]</p> <p><i>Comments: Europa background</i></p>																																															
Diagnostics	<p>(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Europa Trailing (Obs 4)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Proposal 9976 - Observation 5 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 5: Ganymede Leading</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observations:[Ganymede Leading (Obs 6)]</p> <p><i>Comments: Ganymede leading hemisphere</i></p>																																															
Diagnostics	<p>(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Ganymede Leading (Obs 5)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Proposal 9976 - Observation 6 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 6: Ganymede Leading</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observation For: [Ganymede Leading (Obs 5)]</p> <p><i>Comments: Ganymede background</i></p>																																															
Diagnostics	<p>(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Ganymede Leading (Obs 6)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Special Requirements	<p>Group Observations 5, 6, Non-interruptible</p> <p>DEFAULT WINDOW: NOT OCCULTATION OF Ganymede_sky BY JUPITER FROM JWST</p> <p>DEFAULT WINDOW: SEPARATION OF Ganymede_sky IO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Ganymede_sky EUROPA FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Ganymede_sky CALLISTO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: ANGULAR RATE Ganymede_sky FROM JWST LESS THAN 0.075</p>																																															

Proposal 9976 - Observation 7 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 7: Ganymede Trailing</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observations:[Ganymede Trailing (Obs 8)]</p> <p><i>Comments: Ganymede trailing hemisphere</i></p>																																															
Diagnostics	<p>(Visit 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Ganymede Trailing (Obs 7)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p> <p>(Visit 7:1) Informational (Form): Visit schedulable, but most scheduling windows are when JWST is pointed in direction of greatest micrometeoroid impact risk. This is likely due to scheduling special requirements.</p>																																															
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Special Requirements	<p>Between Dates 13-NOV-2026:00:00:00 and 02-JAN-2027:00:00:00</p> <p>Group Observations 7, 8, Non-interruptible</p> <p>DEFAULT WINDOW: NOT OCCULTATION OF Ganymede BY JUPITER FROM JWST</p> <p>DEFAULT WINDOW: SEPARATION OF Ganymede IO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Ganymede EUROPA FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Ganymede CALLISTO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: ANGULAR RATE GANYMEDE FROM JWST LESS THAN 0.075</p> <p>CENTRAL MERIDIAN LONGITUDE OF Ganymede FROM JWST BETWEEN 255 285</p>																																															

Proposal 9976 - Observation 8 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 8: Ganymede Trailing</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observation For: [Ganymede Trailing (Obs 7)]</p> <p><i>Comments: Ganymede background</i></p>																																															
Diagnostics	<p>(Visit 8:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Ganymede Trailing (Obs 8)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Proposal 9976 - Observation 9 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gany...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 9: Callisto Leading</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observations:[Callisto Leading (Obs 10)]</p> <p><i>Comments: Callisto leading hemisphere</i></p>																																															
Diagnostics	<p>(Visit 9:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Callisto Leading (Obs 9)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Special Requirements	<p>Between Dates 12-MAR-2027:00:00:00 and 14-MAY-2027:00:00:00</p> <p>Group Observations 9, 10, Non-interruptible</p> <p>DEFAULT WINDOW: NOT OCCULTATION OF Callisto BY JUPITER FROM JWST</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto IO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto EUROPA FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto GANYMEDE FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: ANGULAR RATE CALLISTO FROM JWST LESS THAN 0.075</p> <p>CENTRAL MERIDIAN LONGITUDE OF Callisto FROM JWST BETWEEN 75 105</p>																																															

Proposal 9976 - Observation 10 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gan...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 10: Callisto Leading</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observation For: [Callisto Leading (Obs 9)]</p> <p><i>Comments: Callisto background</i></p>																																															
Diagnostics	<p>(Visit 10:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Callisto Leading (Obs 10)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>																																															
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Special Requirements	<p>Group Observations 9, 10, Non-interruptible</p> <p>DEFAULT WINDOW: NOT OCCULTATION OF Callisto_sky BY JUPITER FROM JWST</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto_sky IO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto_sky EUROPA FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto_sky GANYMEDE FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: ANGULAR RATE Callisto_sky FROM JWST LESS THAN 0.075</p>																																															

Proposal 9976 - Observation 11 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gan...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 11: Callisto Trailing</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observations:[Callisto Trailing (Obs 12)]</p> <p><i>Comments: Callisto trailing hemisphere</i></p>																																															
Diagnostics	<p>(Visit 11:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Callisto Trailing (Obs 11)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p> <p>(Visit 11:1) Informational (Form): Visit schedulable, but most scheduling windows are when JWST is pointed in direction of greatest micrometeoroid impact risk. This is likely due to scheduling special requirements.</p>																																															
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Special Requirements	<p>Between Dates 13-NOV-2026:00:00:00 and 02-JAN-2027:00:00:00</p> <p>Group Observations 11, 12, Non-interruptible</p> <p>DEFAULT WINDOW: NOT OCCULTATION OF Callisto BY JUPITER FROM JWST</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto IO FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto EUROPA FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: SEPARATION OF Callisto GANYMEDE FROM JWST GREATER THAN 10"</p> <p>DEFAULT WINDOW: ANGULAR RATE CALLISTO FROM JWST LESS THAN 0.075</p> <p>CENTRAL MERIDIAN LONGITUDE OF Callisto FROM JWST BETWEEN 255 285</p>																																															

Proposal 9976 - Observation 12 - Unlocking the Origins of Giant Planet Satellite Systems Through D/H Measurements of Europa, Gan...

Mon May 18 18:00:10 GMT 2026

Observation	<p>Proposal 9976, Observation 12: Callisto Trailing</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p> <p>Background Observation For: [Callisto Trailing (Obs 11)]</p> <p><i>Comments: Callisto background</i></p>																										
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