Europa Clipper Science and Mission Status

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Jet Propulsion Laboratory, California Institute of Technology

May 3, 2018

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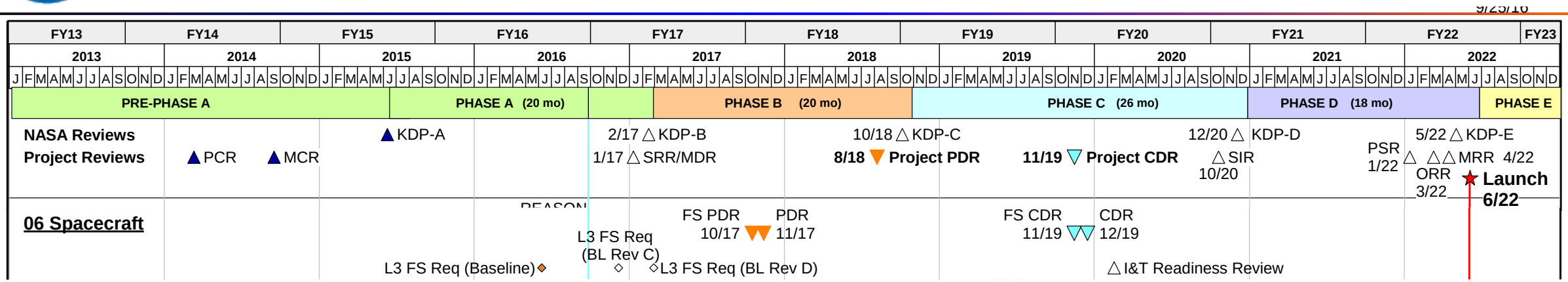
Europa Clipper Project-Level Lifecycle Schedule

Key Project Reviews



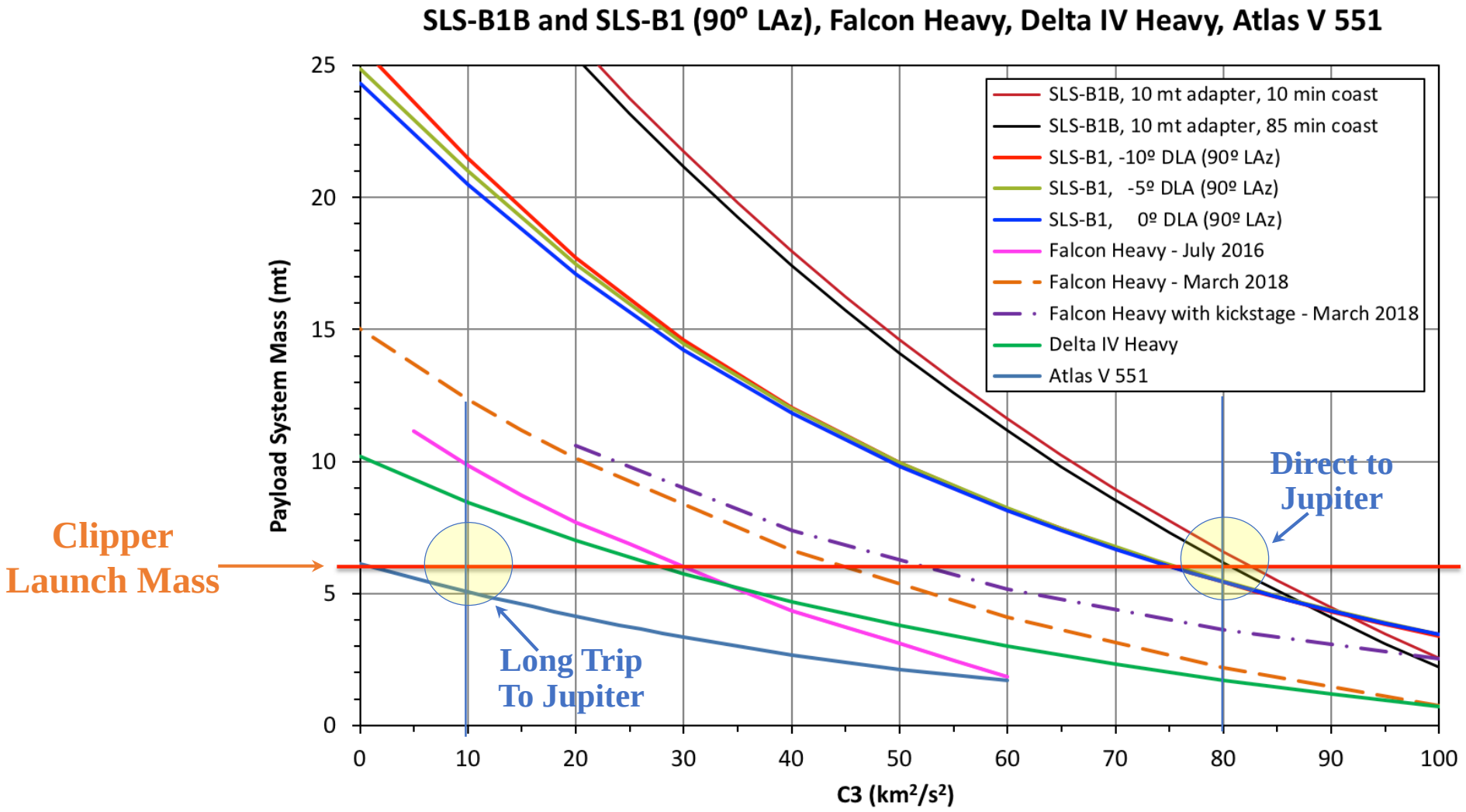
- **Propulsion Subsystem PDR** 6/27-29/17 (GSFC)
- **Propulsion Module PDR** 7/24-27/17 (APL)
- **Flight System PDR** 10/17-20/17 (JPL)
- **Europa-UVS PDR** 11/16-17/17 (SWRI)
- **PIMS PDR** 12/6-7/17 (APL)
- **EIS PDR** 1/9-11/18 (APL)
- **Solar Array Requirements Review** 1/22/18 (JPL)
- **Power PDR** 1/23-24/18 (JPL)
- **SUDA PDR** 1/30-31/18 (CU)
- **Guidance, Navigation & Control PDR** 2/7-9/18 (JPL)
- **Mechanical PDR** 2/20-22/18 (JPL))
- **Thermal PDR** 2/27-28/18 (JPL)
- **Radio Frequency Module / Telecom PDR** 3/14-15/18 (APL)

We are here

Spacecraft
Payload
Mission System
Project

- **REASON PDR** 3/26-27/18 (JPL)
- **Radiation Monitor System PDR** 4/17/18 (APL)
- **E-THEMIS PDR** 4/19-20/18 (ASU)
- **MISE PDR** 4/24-25/18 (JPL)
- **Avionics PDR** 5/7-10/18 (JPL)
- **MASPEX PDR** 5/15-16/18 (SWRI)
- **Fault Management PDR** 5/21-22/18 (JPL)
- **ICEMAG PDR** 5/23-24/18 (JPL)
- **Mag Boom PDR** 5/30 - 6/1/18 (JPL)
- **Mission System PDR** 6/19-21/18 (JPL)
- **Propulsion Subsystem CDR** 6/26-28/18 (GSFC)
- **Project PDR** 8/20-24/18 (JPL)
- **Solar Array PDR** 9/4-5/18 (Airbus, Leiden)

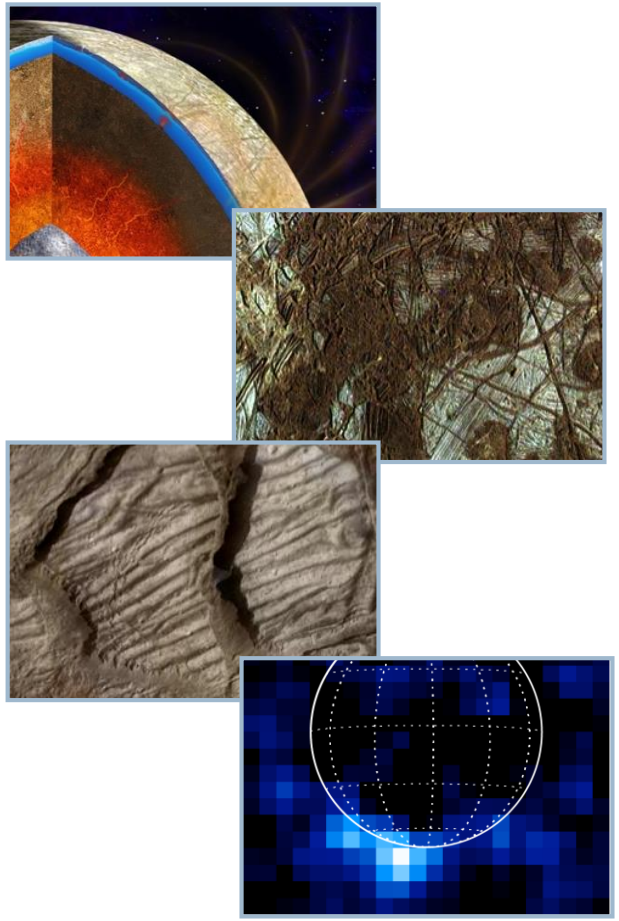
Launch Vehicle



As of today, only the SLS can launch Europa Clipper Directly to Jupiter

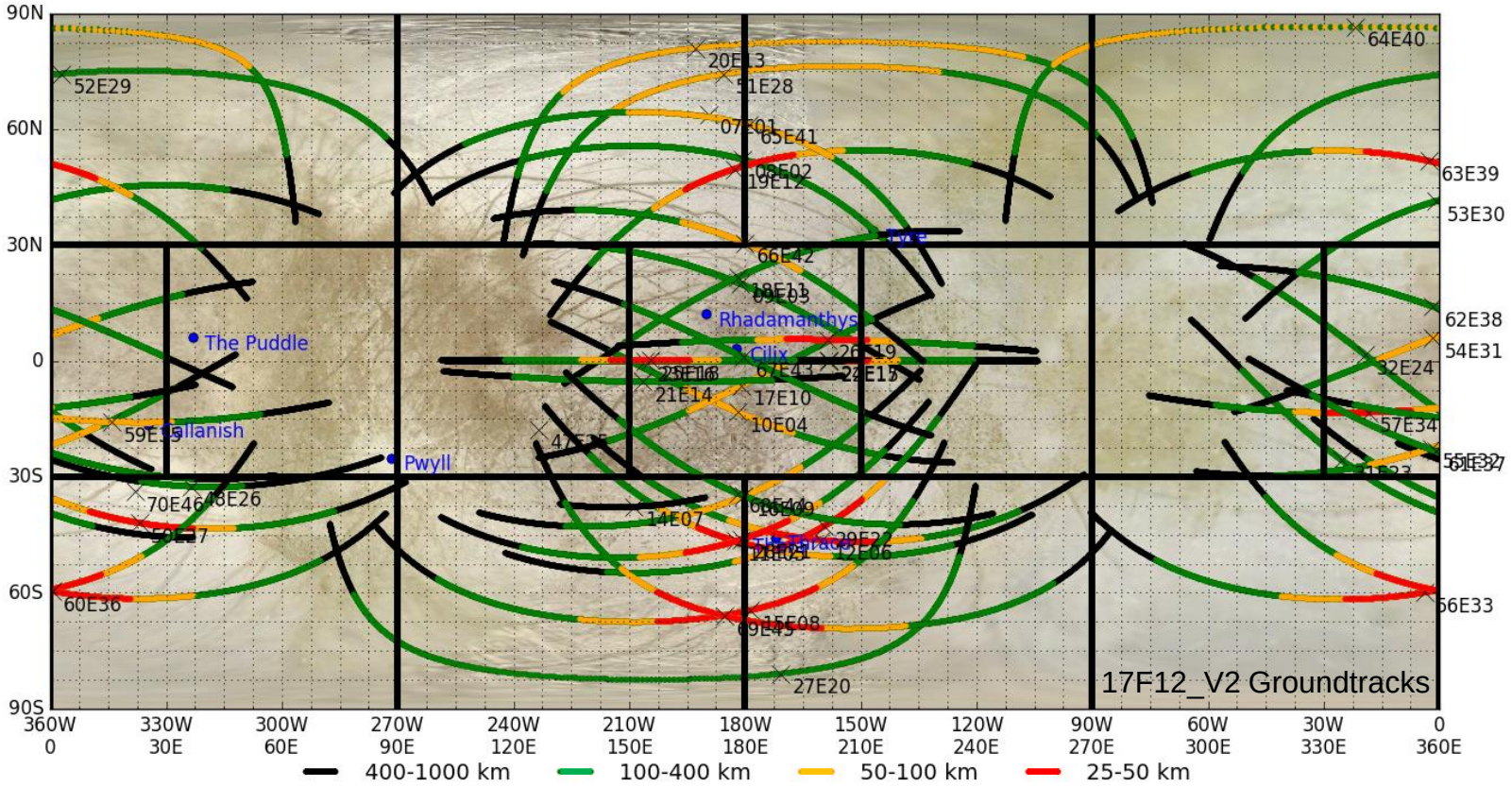
Europa Clipper Science Overview

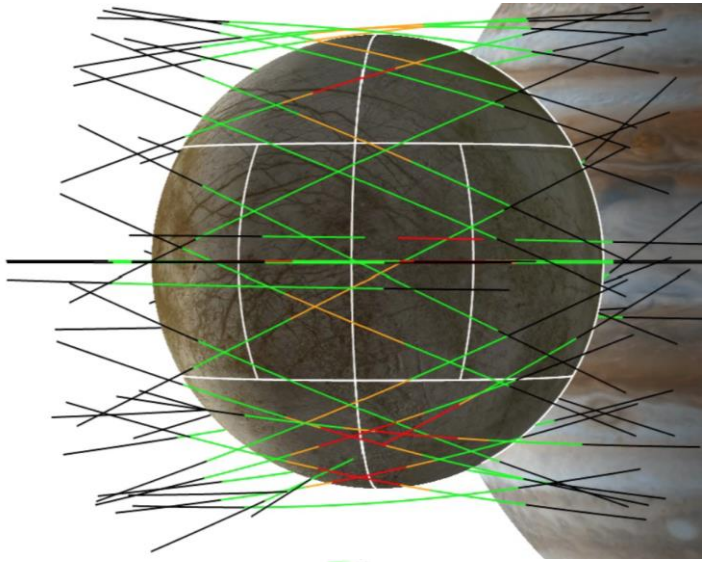
- ***Mission Goal:*** Explore Europa to investigate its habitability
- ***Level-1 Science Categories:***
  - **Ice Shell & Ocean:** Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange
  - **Composition:** Understand the habitability of Europa's ocean through composition and chemistry
  - **Geology:** Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities*
  - **Current Activity:** Search for and characterize any current activity, notably plumes and thermal anomalies

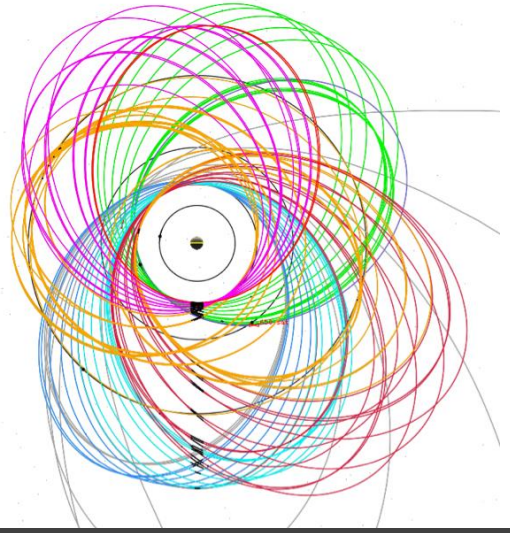


Europa Clipper Mission Approach

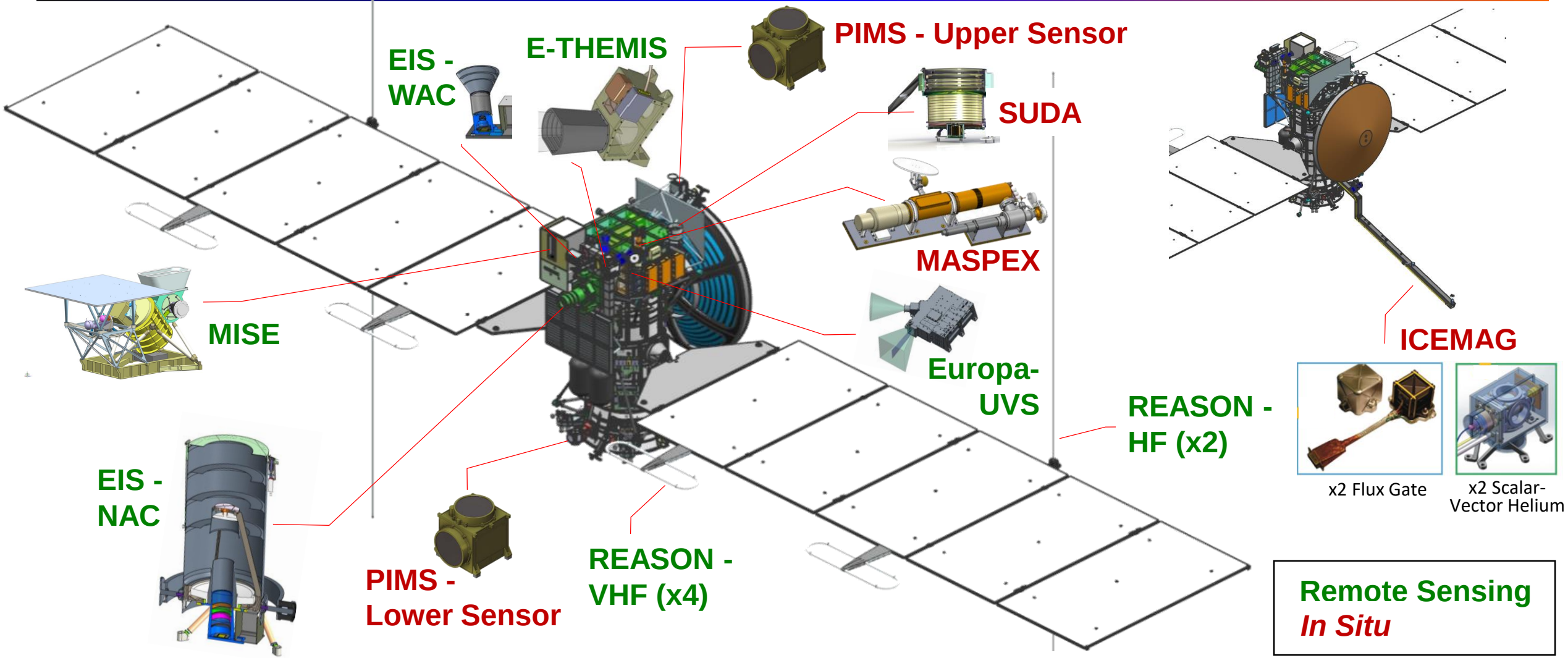
- Enable near-global coverage Europa regions from Jupiter orbit
- Acquire high-quality data despite the intense Europa radiation environment
- Ensure capability for obtaining synergistic data from all instruments simultaneously and during each flyby, in a simple and repeatable manner







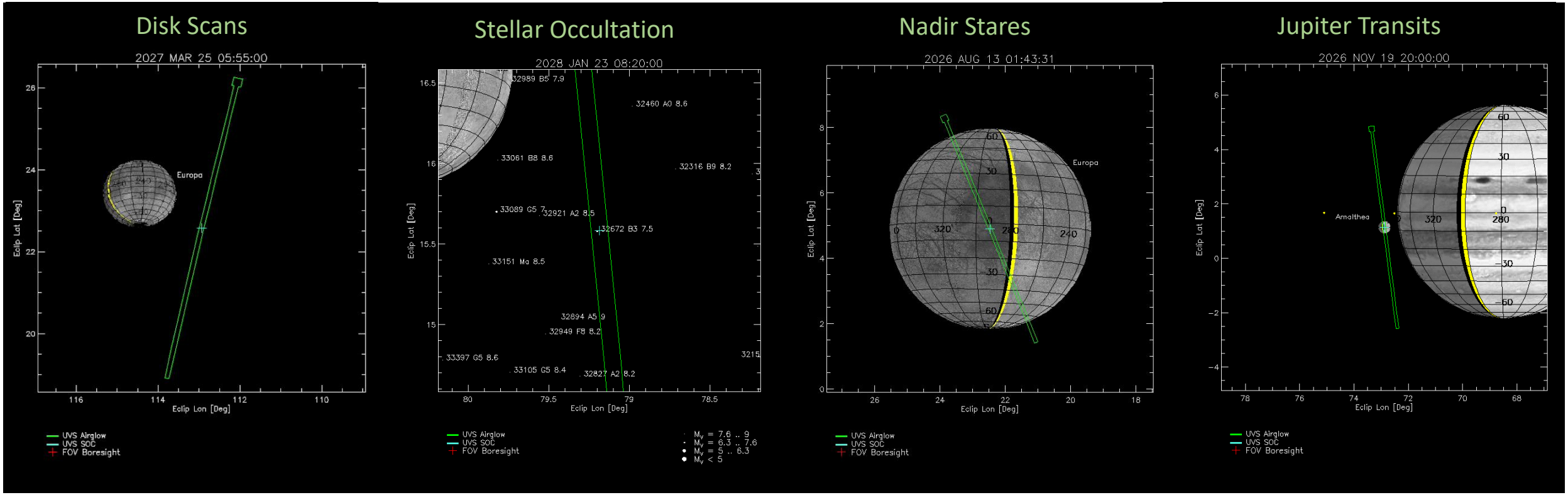
Europa Clipper Instrument Accommodation



Europa Ultraviolet Spectrograph (Europa-UVS)

PI: Kurt Retherford, Southwest Research Institute (SwRI), San Antonio

UV



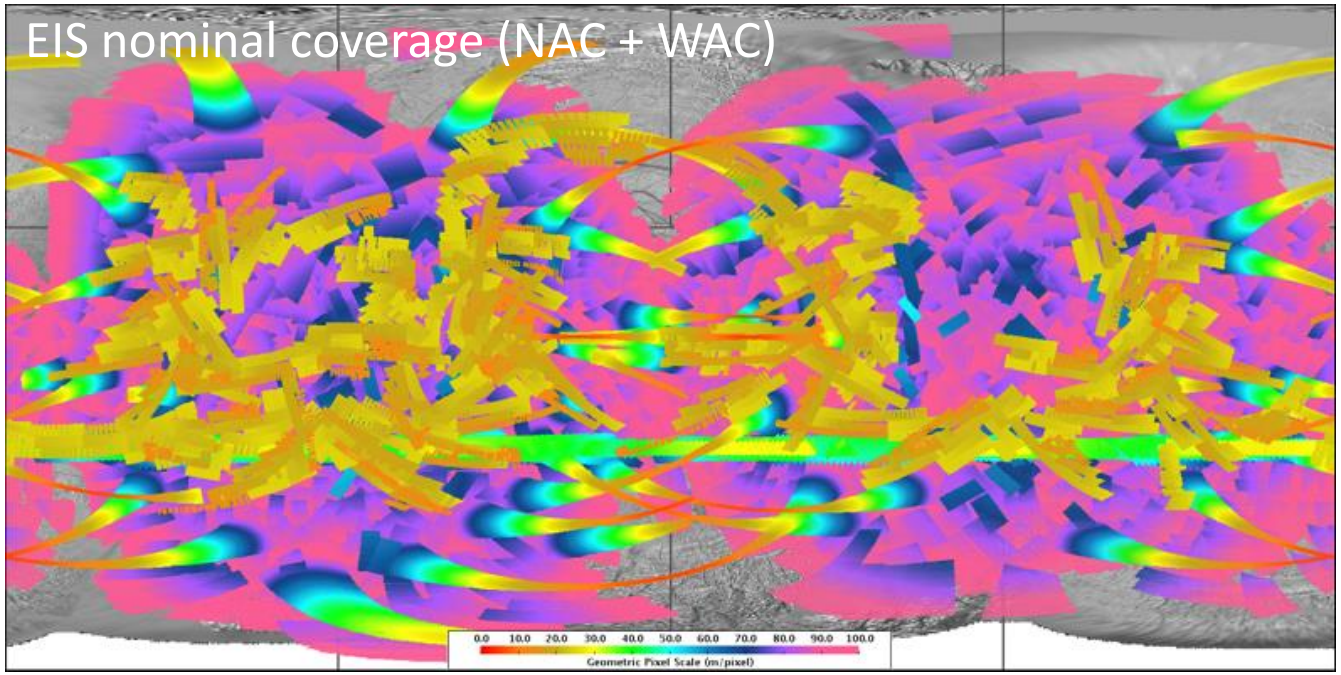
- Europa-UVS has identified >400 opportunities for occultation observations of >100 UV-bright stars, with nearly 200 scheduled, using the latest trajectory
- Europa-UVS EM electronics boards have been fabricated and are proceeding through board-level testing

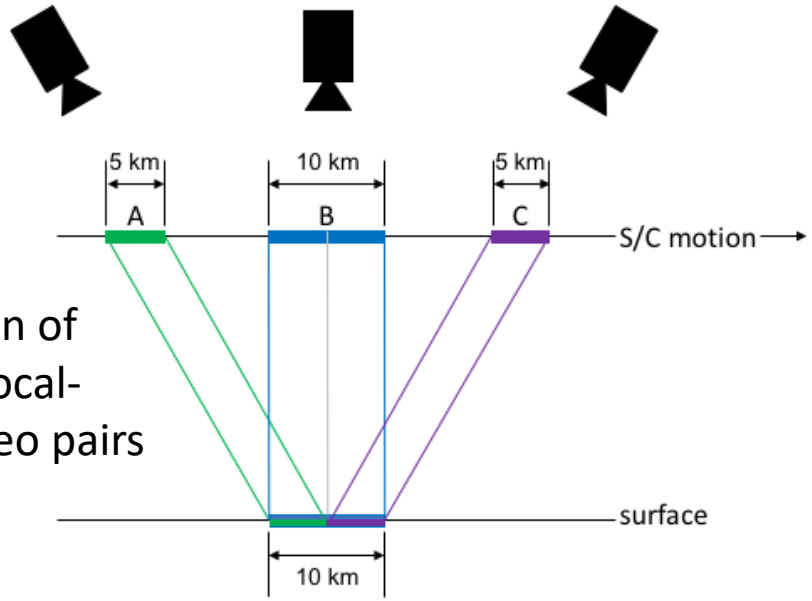
Europa Imaging System (EIS)

Zibi Turtle, Johns Hopkins U. Applied Physics Laboratory (APL)

VIS

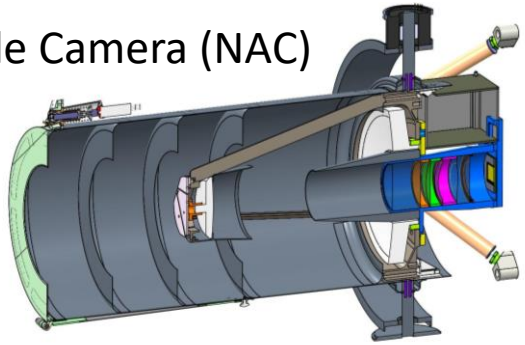
- Demonstrated a preliminary design and operations plan that meets all science requirements
- EIS-NAC gimbal enables near-global coverage (100 m/pixel) and local-scale imaging (1 m/pixel) with stereo topography

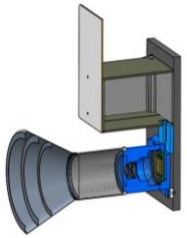




Acquisition of EIS-NAC local-scale stereo pairs

Narrow Angle Camera (NAC)



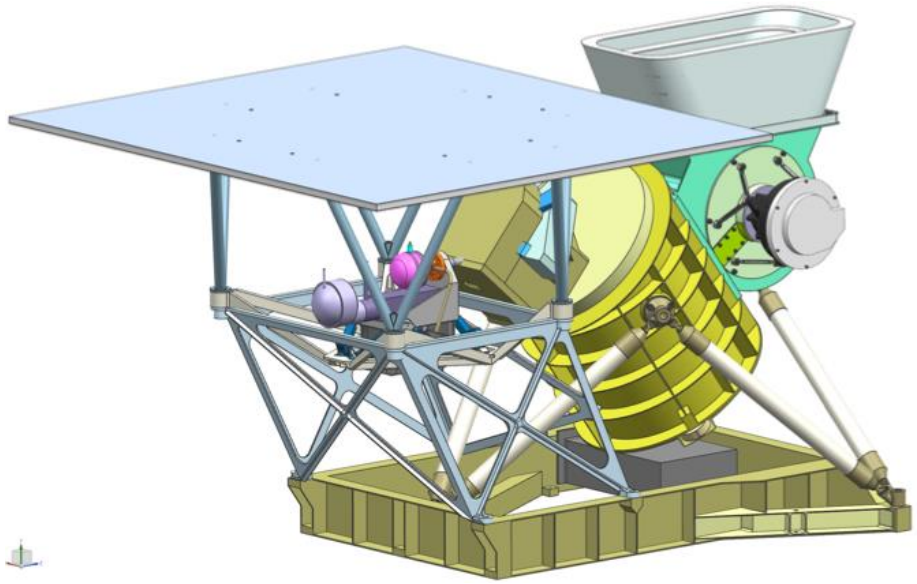


Wide Angle Camera (WAC)

Mapping Imaging Spectrometer for Europa (MISE)

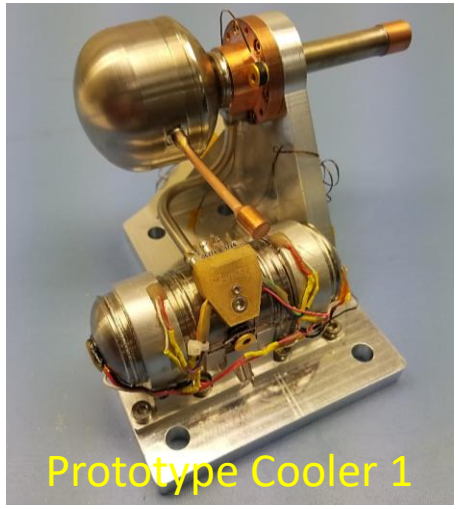
Diana Blaney, Jet Propulsion Laboratory (JPL)

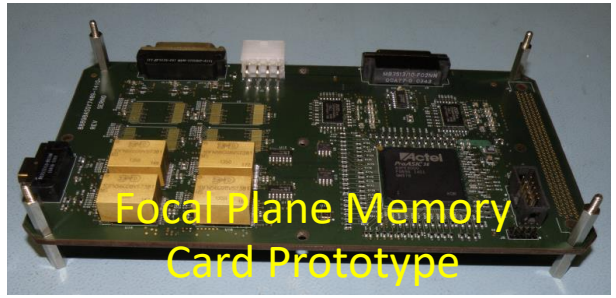
IR



Dyson Design

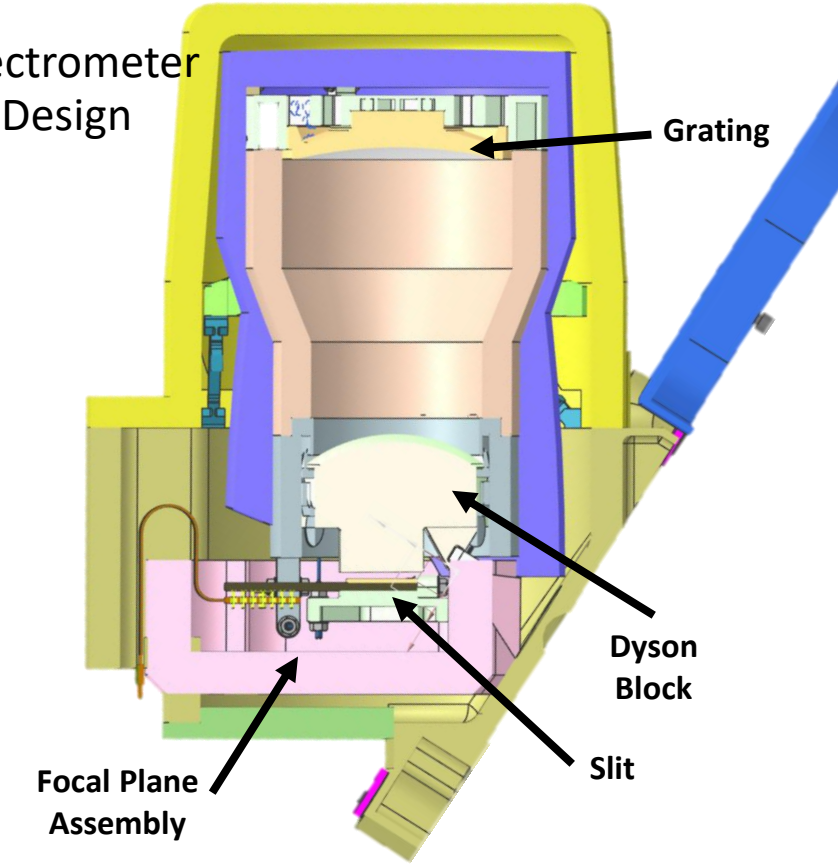
- The instrument changed from an Offner to a Dyson design, improving S/N and reducing energy needs (single cryo-cooler)





- MISE cryo-cooler completed radiation testing, and Data Processing Prototype boards fabricated and are being tested

Spectrometer Design



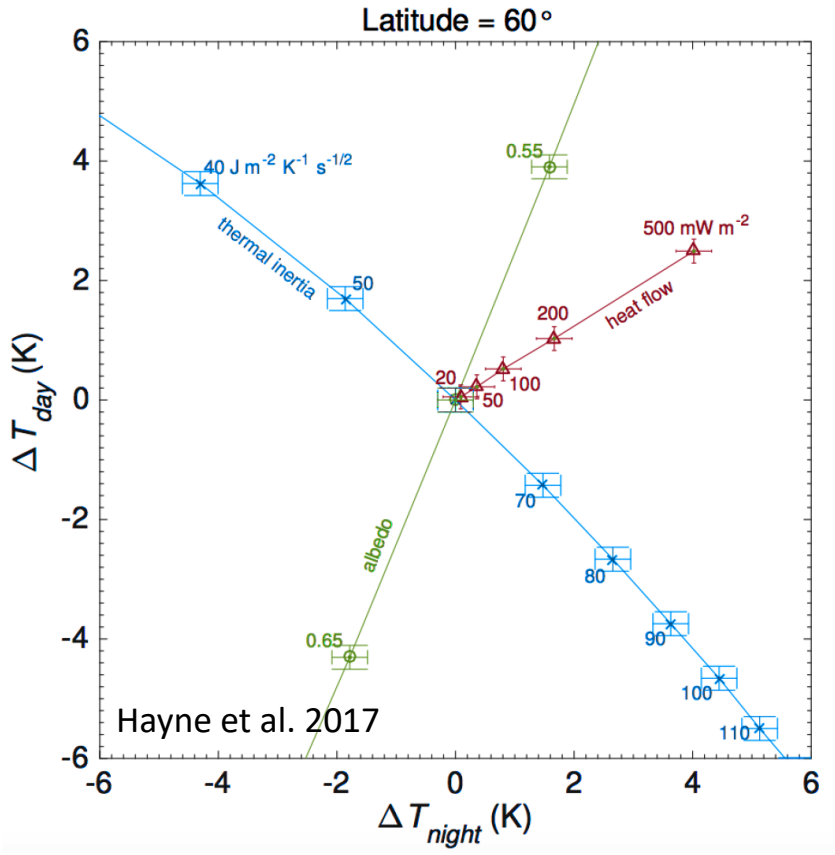
- Planned ZnSe refracting Dyson Block shows internal reflections; evaluating change to CaF2 material

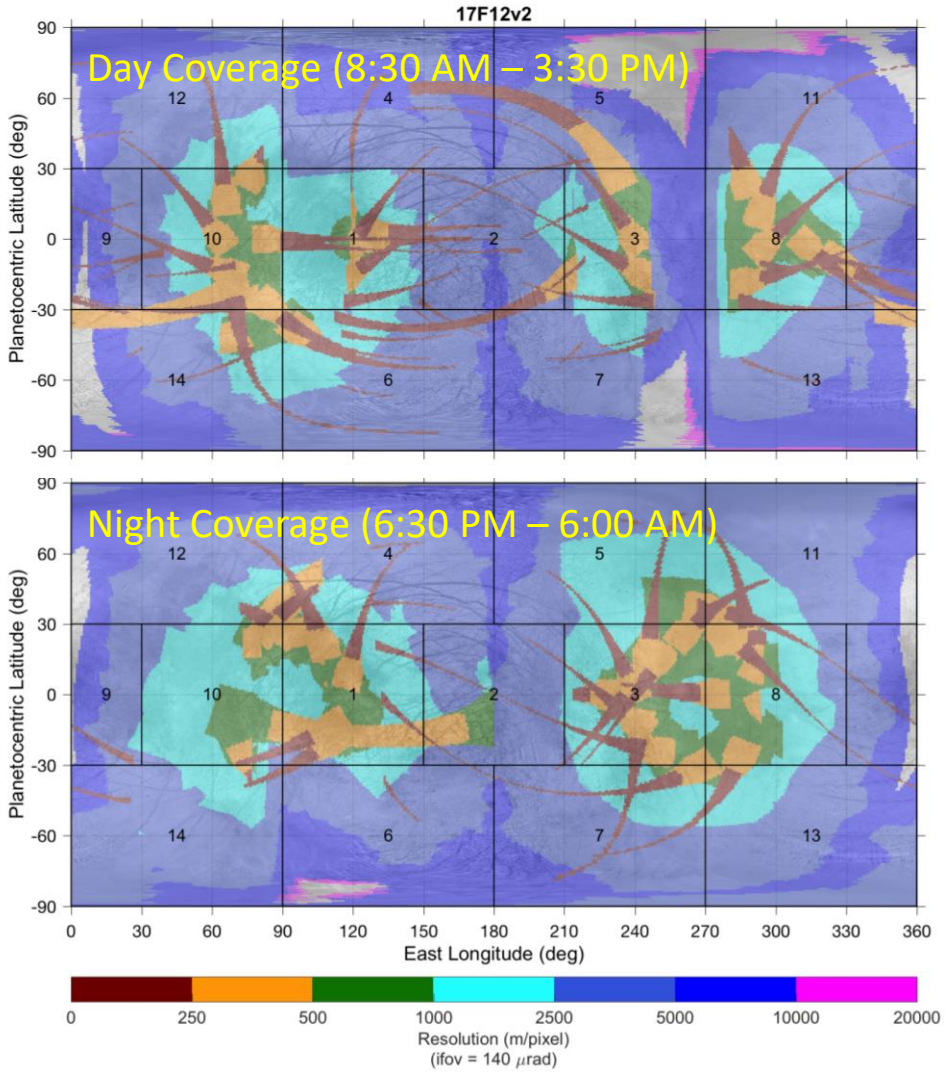
Europa Thermal Imaging System (E-THEMIS)

Philip Christensen, Arizona State University

MIR

- E-THEMIS microbolometer array successfully passed radiation testing
- Refining methodology using overlapping day-night observations to quickly identify endogenic hot spots with small (0–4 K) deviations from Standard Model prediction, distinguished from thermal inertia or albedo effects



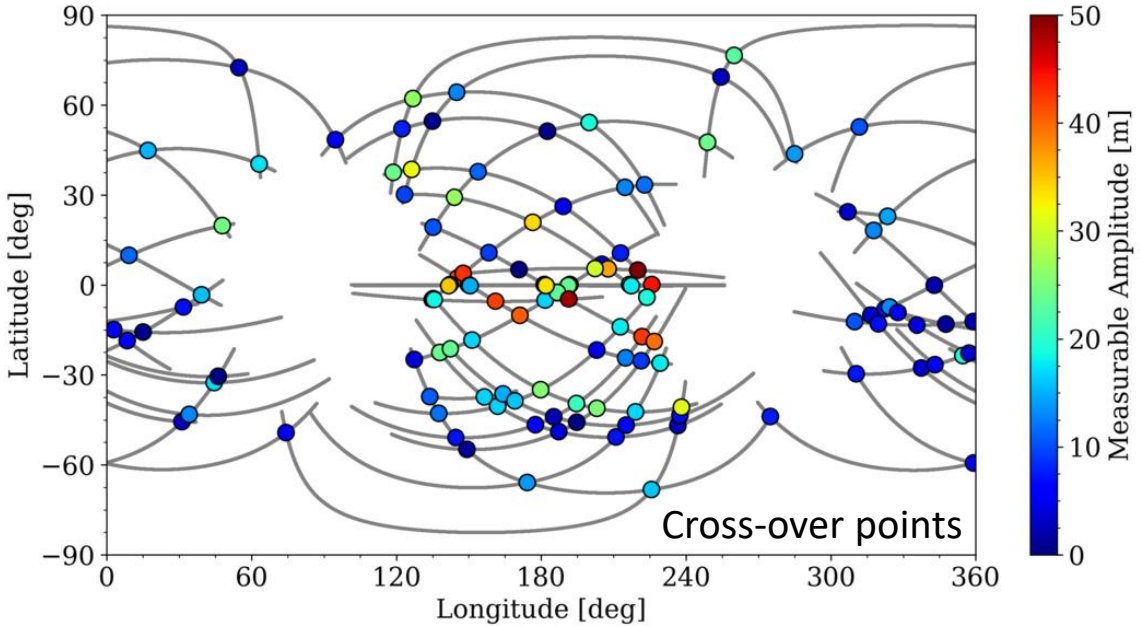


Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON)

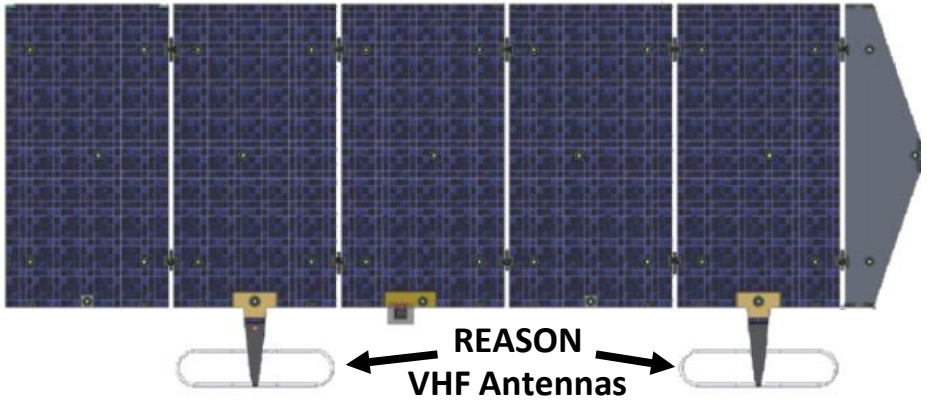
RADIO

Don Blankenship, University of Texas Institute for Geophysics, Austin

- Performed numerical simulations to assess the potential for estimating h_2 using altimetric measurements with a combination of radar altimetry and stereo imaging data (Steinbrügge et al., EPSL, 2018)
  - Love number h_2 accuracy sufficient to unambiguously confirm (or reject) global ocean hypothesis
  - Love number k_2 accuracy sufficient to constrain Europa's ice shell thickness to ±15 km



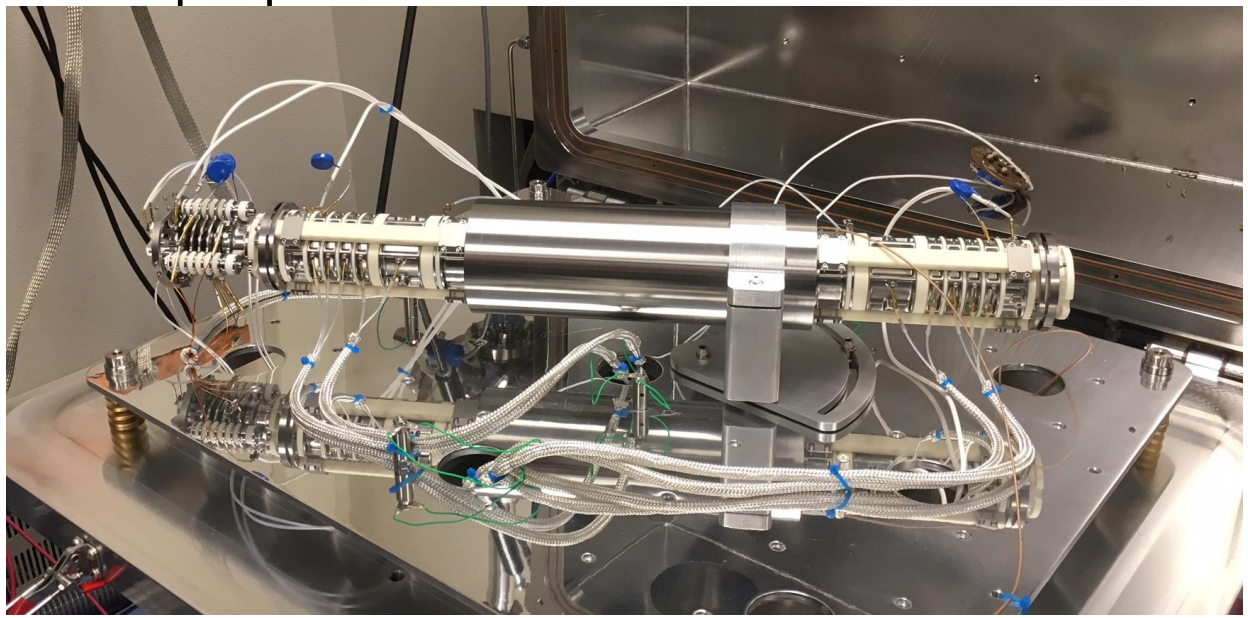
- Ensuring appropriate requirements are established for solar array (being built by Airbus), given the intimate association of the REASON VHF antennas which are mounted on the array

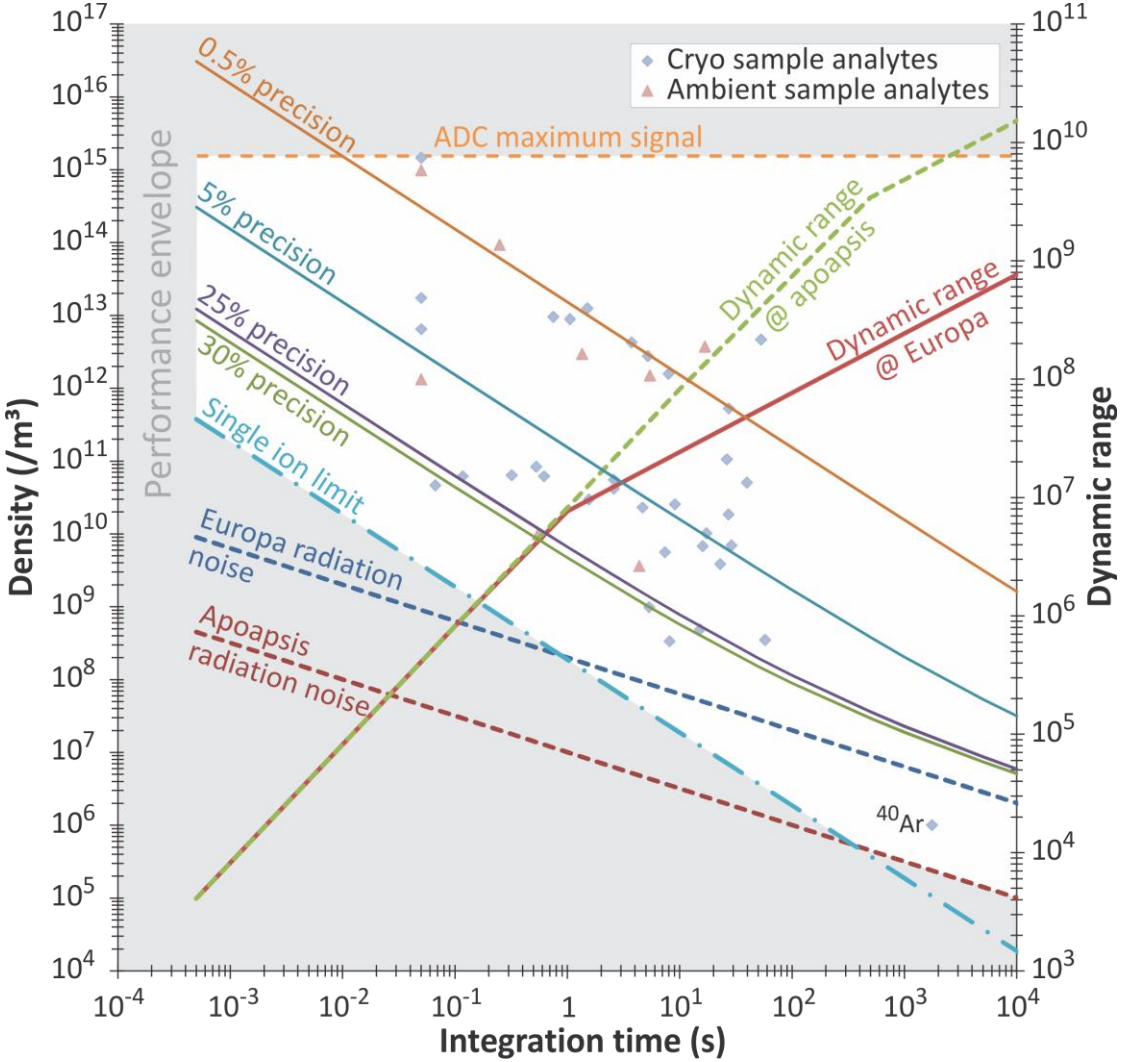


MAss Spectrometer for Planetary EXploration (MASPEX)

Jack “Hunter” Waite, Southwest Research Institute (SwRI), San Antonio

- MASPEX Engineering Model (EM) has been constructed, and completed vibration testing
- Ambient analytes that fall below the radiation noise line or that require integration in excess of a single flyby can be measured by cryotrapping, with analysis near apoapsis

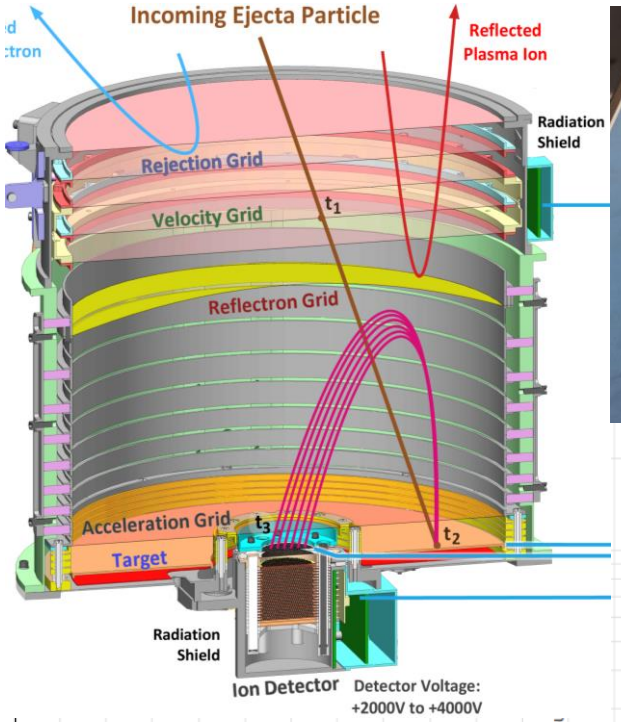


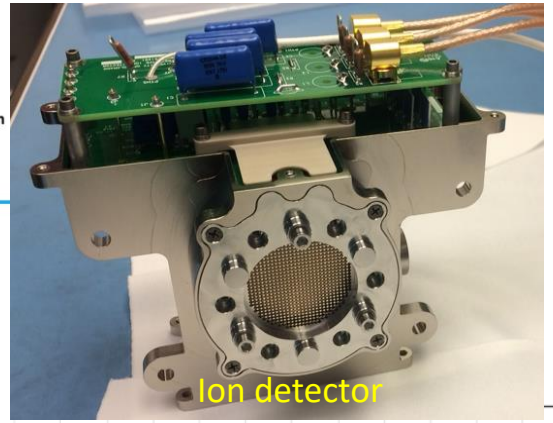


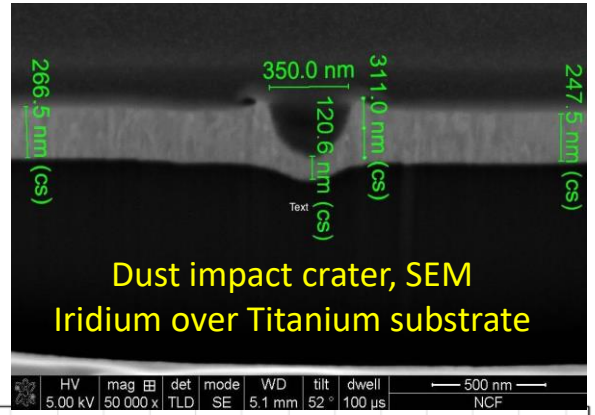
SUrface Dust Analyzer (SUDA)

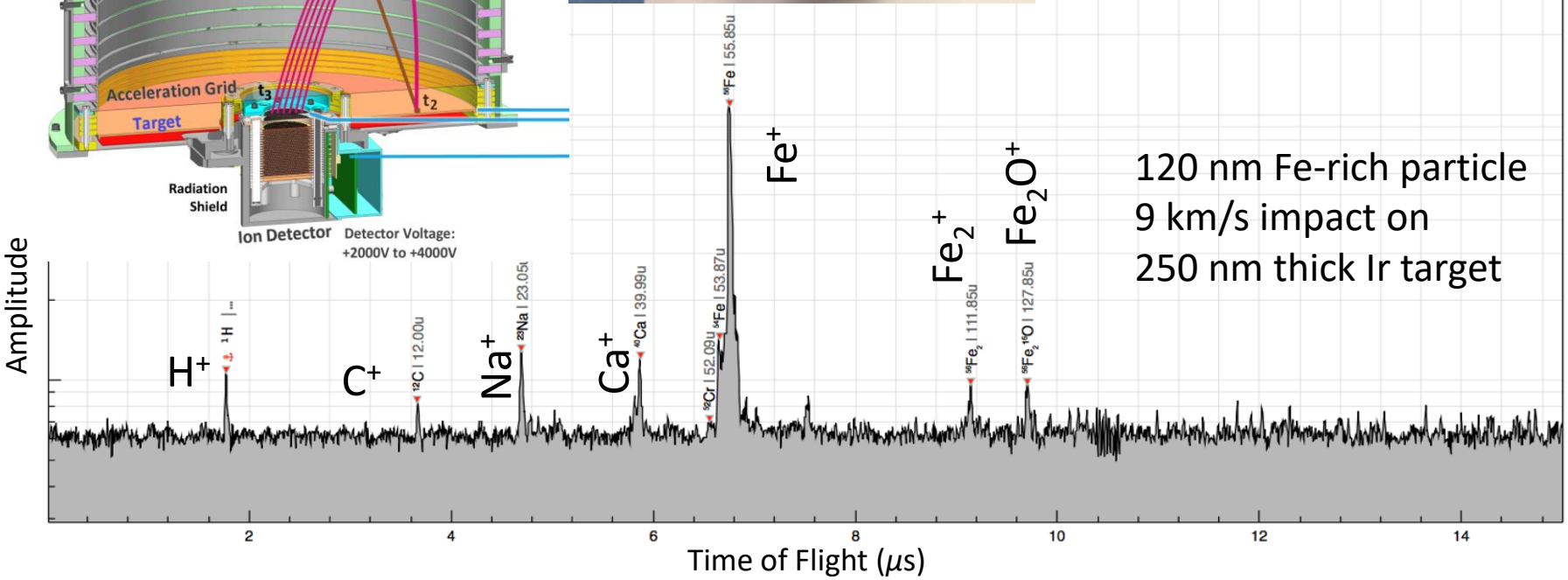
Sascha Kempf, U. Colorado, Boulder

- Ion Detector: 2 flight-like prototypes fully developed and successfully tested
  - Reached TRL 6
- Target: 4 flight-like prototypes developed and successfully tested
  - Ir-coated Ti substrate
- Successfully measured mass spectra of dust particles up to 30 km/s





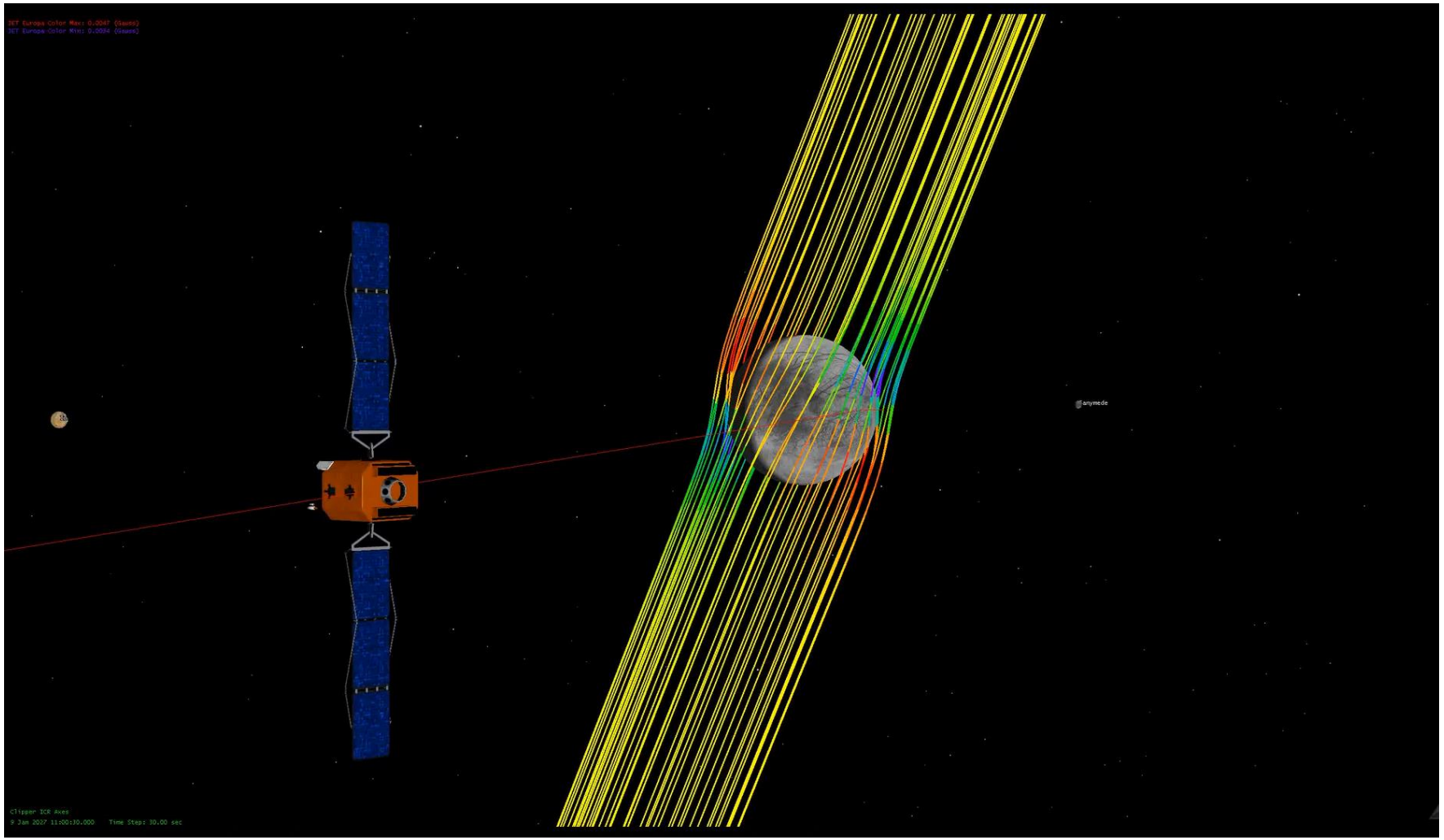




Interior Characterization of Europa using Magnetometry (ICEMAG)

Carol Raymond, Jet Propulsion Laboratory (JPL)

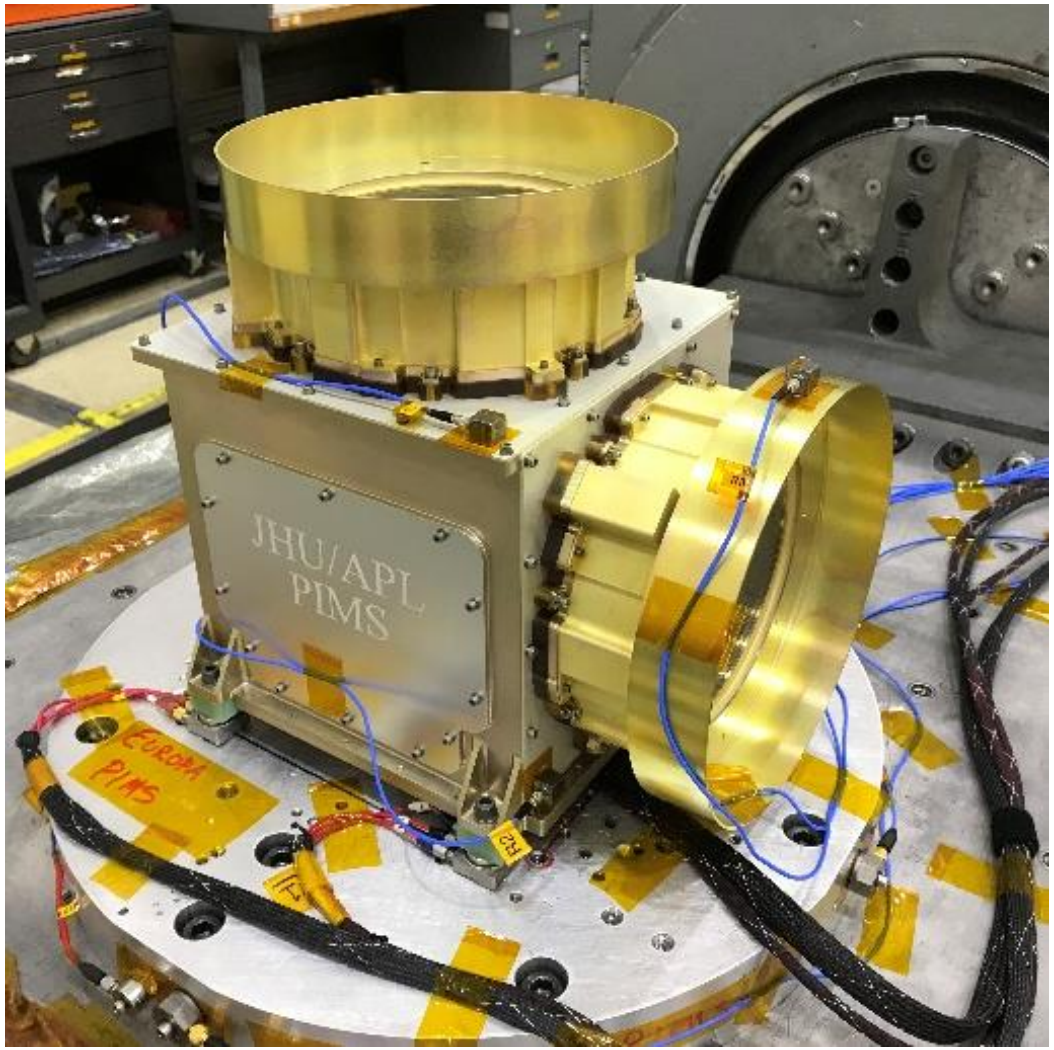
- Visualization of a simulation of Europa's induced magnetic field including 11 and 85 hr periods using the VIP4 model of Jupiter's magnetic field, to help in tour evaluation
- Testing low-temperature performance of sensors and optical fiber to minimize thermal energy requirements

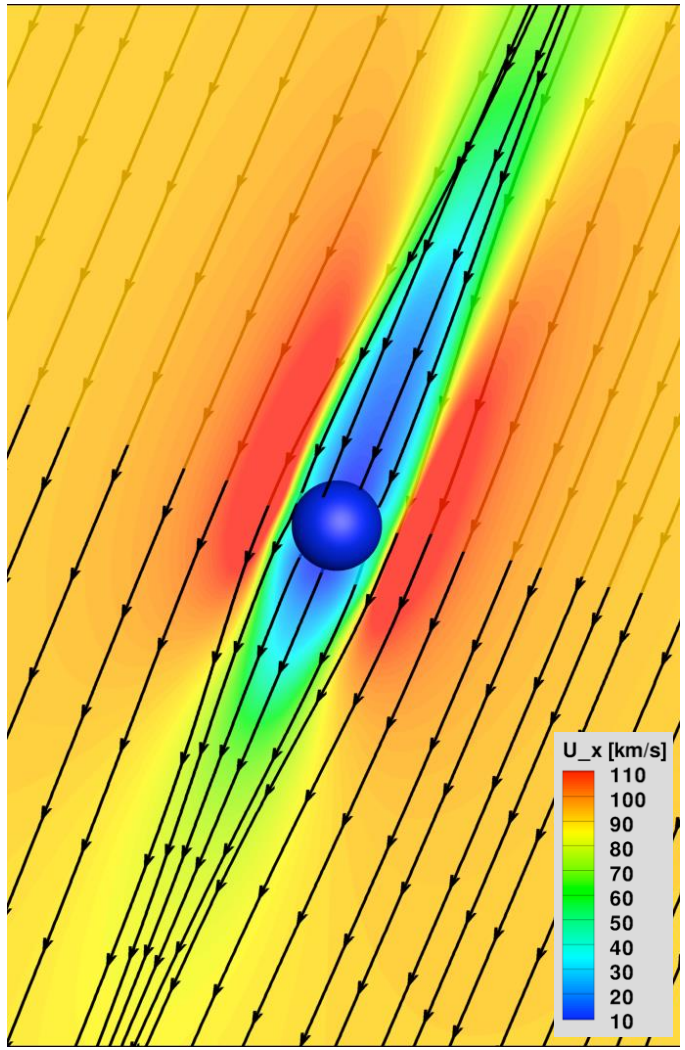


Plasma Instrument for Magnetic Sounding (PIMS)

Joseph Westlake, Johns Hopkins U. Applied Physics Laboratory (APL)

- PIMS prototype instrument has been fabricated, assembled, and successfully completed testing (vibration, ion/electron beam, etc.)
- Progressing to Engineering Model
- Developed a multi-fluid full 3-D magnetohydrodynamic interaction model, to derive moon-plasma interaction magnetic field from simulated Europa Clipper trajectory through the model

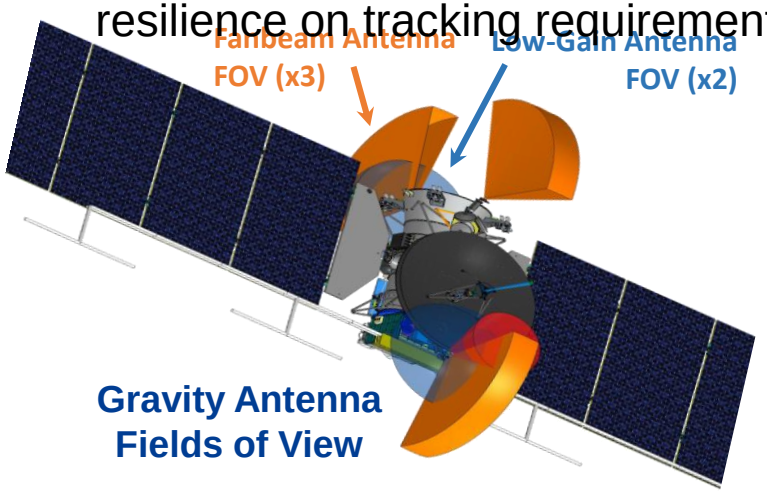


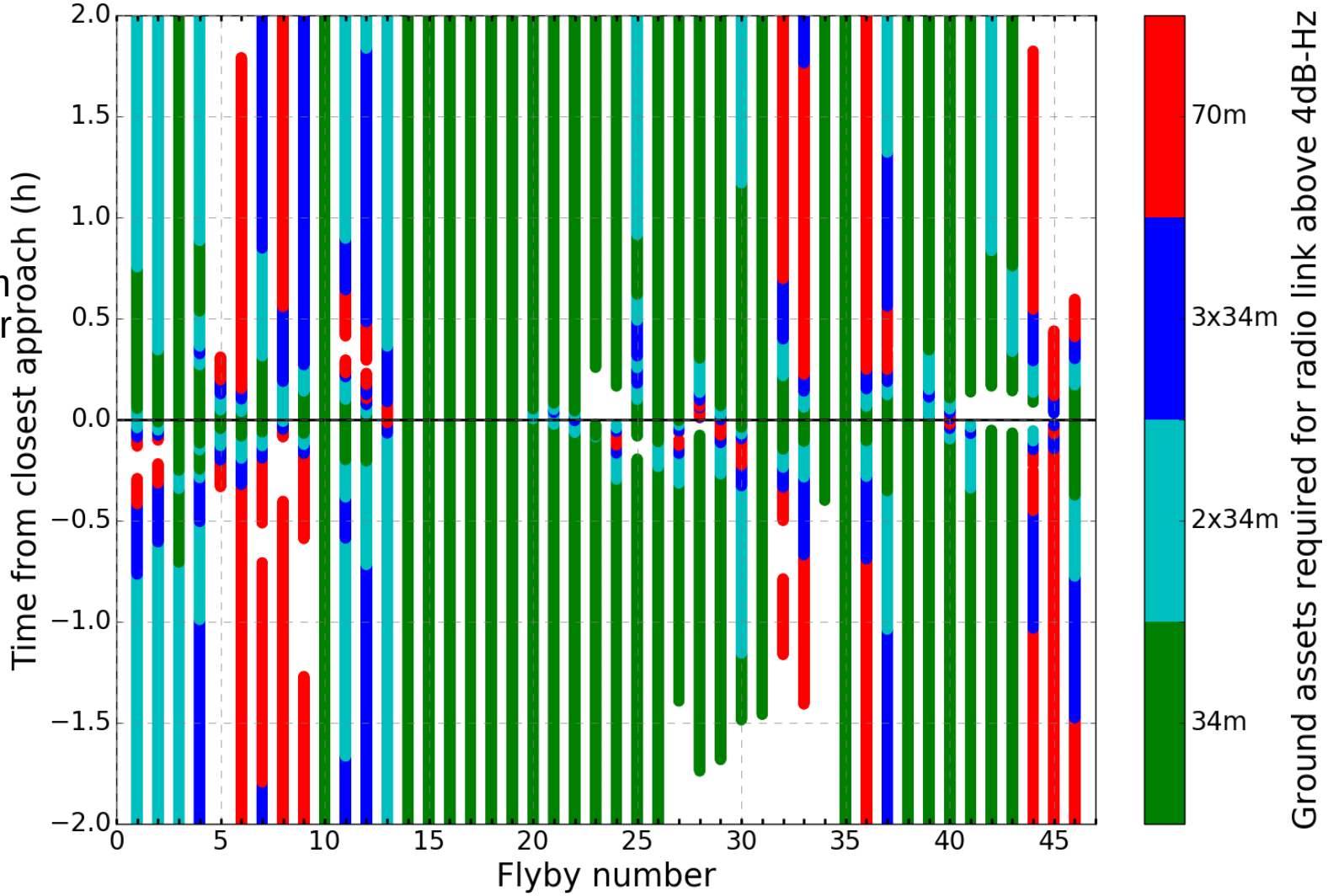


Gravity Science

Subject Matter Expert: Jean-Luc Margot (UCLA)

- Analysis of Gravity Science capabilities (Verma and Margot, 2017)
  - Two-way Doppler data can confirm presence or absence of ocean
  - Determination of hydrostatic equilibrium is possible, pending sufficient crossover range accuracy
  - Arraying DSN stations or use of 70-m antenna can provide additional resilience on tracking requirements





Europa Clipper Science Team

PIs, Co-Is, Project Science (Currently 120 total)

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Amy Barr Mlinar
Jordana Blacksberg
Diana Blaney
Don Blankenship
Scott Bolton
Christelle Briois
Tim Brockwell
Shawn Brooks
Lorenzo Bruzzone
Bruce Campbell
Lynn Carter
Tony Case
Phil Christensen
Roger Clark
Corey Cochrane
Geoff Collins
Kate Craft
Brad Dalton
Ingrid Daubar
Ashley Davies
Serina Diniega
Charles Elachi
Carolyn Ernst

Paul Feldman
Leigh Fletcher
Yonggyu Gim
Randy Gladstone
Thomas Greathouse
Robert Green
Cyril Grima
Eberhard Gruen
Murthy Gudipati
Kevin Hand
Candy Hansen
Alex Hayes
Paul Hayne
Matt Hedman
Alain Herique
Karl Hibbitts
Mihaly Horanyi
Carly Howett
Terry Hurford
Hauke Hussmann
Xianzhe Jia
Steven Joy
Justin Kasper
Sascha Kempf

Krishan Khurana
Randy Kirk
Margaret Kivelson
Rachel Klima
Wlodek Kofman
Haje Korth
William Kurth
Yves Langevin
Jonathan Lunine
Marco Mastrogiuseppe
Tom McCord
Alfred McEwen
Melissa McGrath
Bill McKinnon
Ralph McNutt
Mike Mellon
Jeff Moore
Olivier Mousis
Alina Moussessian
Scott Murchie
Neil Murphy
Francis Nimmo
Bob Pappalardo
Chris Paranicas

Wes Patterson
Carol Paty
Cynthia Phillips
Sylvain Piqueux
Jeff Plaut
Dirk Plettemeier
Frank Postberg
Louise Prockter
Lynnae Quick
Julie Rathbun
Trina Ray
Carol Raymond
Kurt Retherford
Christina Richey
James Roberts
Andrew Romero-Wolf
Lorenz Roth
Chris Russell
Abigail Rymer
Joachim Saur
Britney Schmidt
Juergen Schmidt
Dustin Schroeder
Frank Seelos

Dave Senske
Mark Sephton
Everett Shock
Jim Slavin
Todd Smith
Jason Soderblom
Krista Soderlund
John Spencer
Ralf Srama
Andrew Steffl
Alan Stern
Michael Stevens
Robert Strangeway
Ben Teolis
Nick Thomas
Gabriel Tobie
Zibi Turtle
Steve Vance
Hunter Waite
Ben Weiss
Joe Westlake
Danielle Wyrick
Duncan Young
Mikhail Zolotov

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SWRI ★ CU-LASP ★ GSFC
EUROPA
CLIPPER
JPL ★ NASA ★ APL