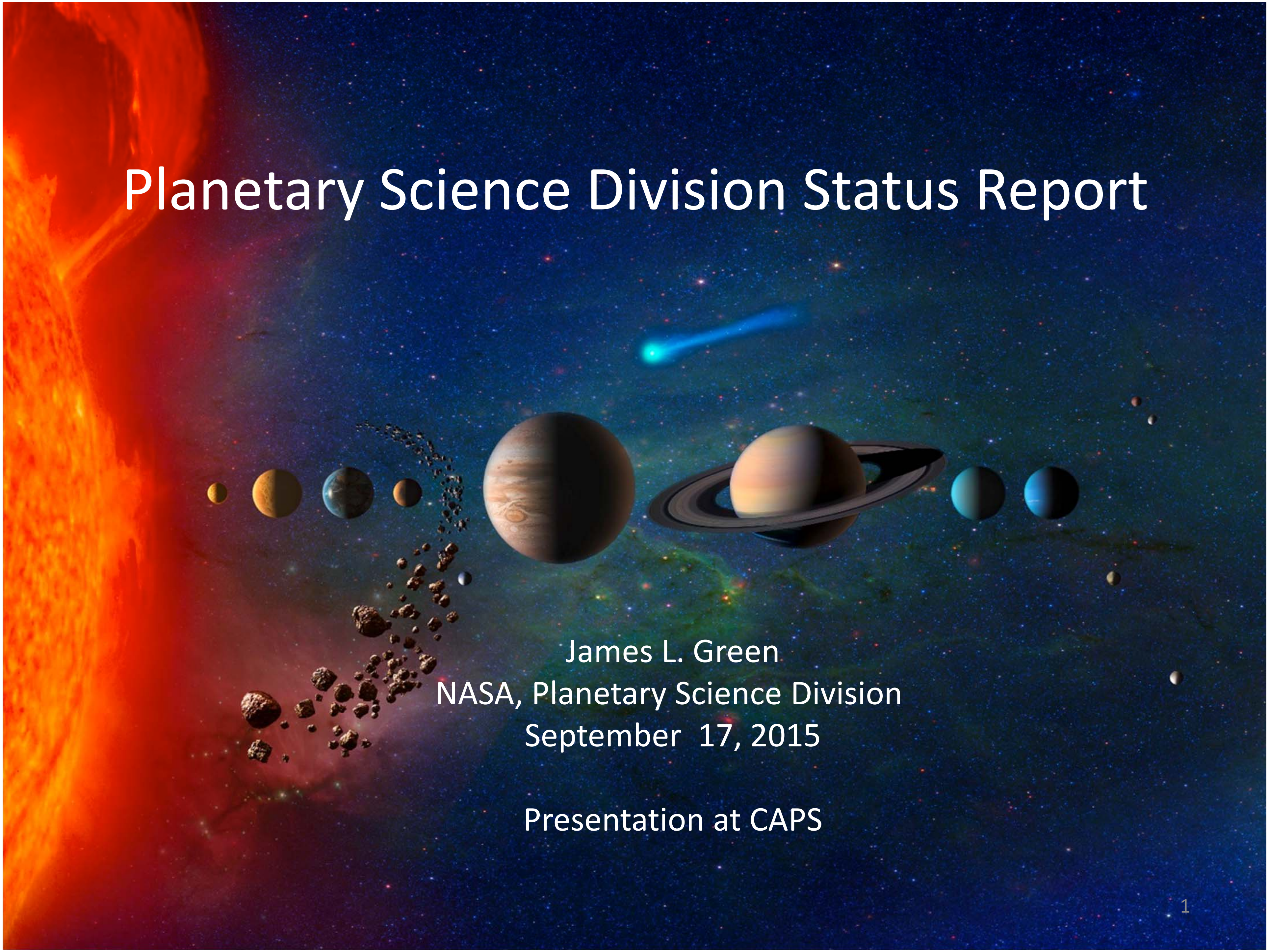


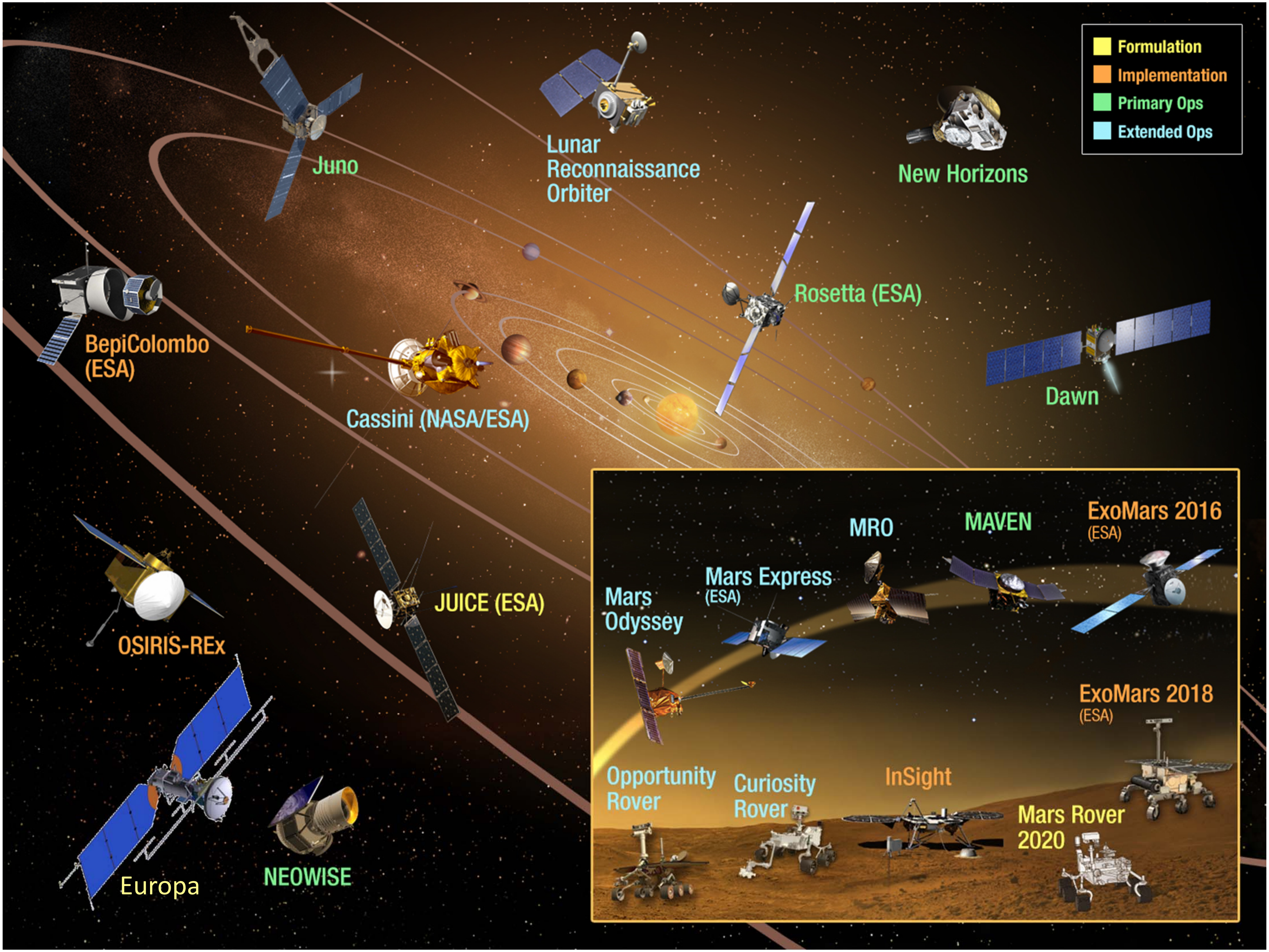
Planetary Science Division Status Report

James L. Green
NASA, Planetary Science Division
September 17, 2015

Presentation at CAPS

Outline

- Mission Events Overview
- Summer Of Going Further Than Ever
- Discovery, New Frontiers, Mars Programs Status
- New Cubesat Selections
- Astrophysics Assets
- Initiate New Studies


Formulation
Implementation
Primary Ops
Extended Ops
Juno
Lunar Reconnaissance Orbiter
New Horizons
BepiColombo (ESA)
Rosetta (ESA)
Cassini (NASA/ESA)
Dawn
JUICE (ESA)
OSIRIS-REx
Europa
NEOWISE
MRO
MAVEN
ExoMars 2016 (ESA)
Mars Express (ESA)
Mars Odyssey
ExoMars 2018 (ESA)
Opportunity Rover
Curiosity Rover
InSight
Mars Rover 2020

Planetary Science Missions Events

2014

July – *Mars 2020* Rover instrument selection announcement

*** Completed**

August 6 – 2nd Year Anniversary of *Curiosity* Landing on Mars
September 21 – *MAVEN* inserted in Mars orbit
October 19 – Comet Siding Spring encountered Mars
September – *Curiosity* arrives at Mt. Sharp
November 12 – ESA's *Rosetta* mission lands on Comet Churyumov–Gerasimenko
December 2/3 – Launch of *Hayabusa-2* to asteroid 1999 JU_3

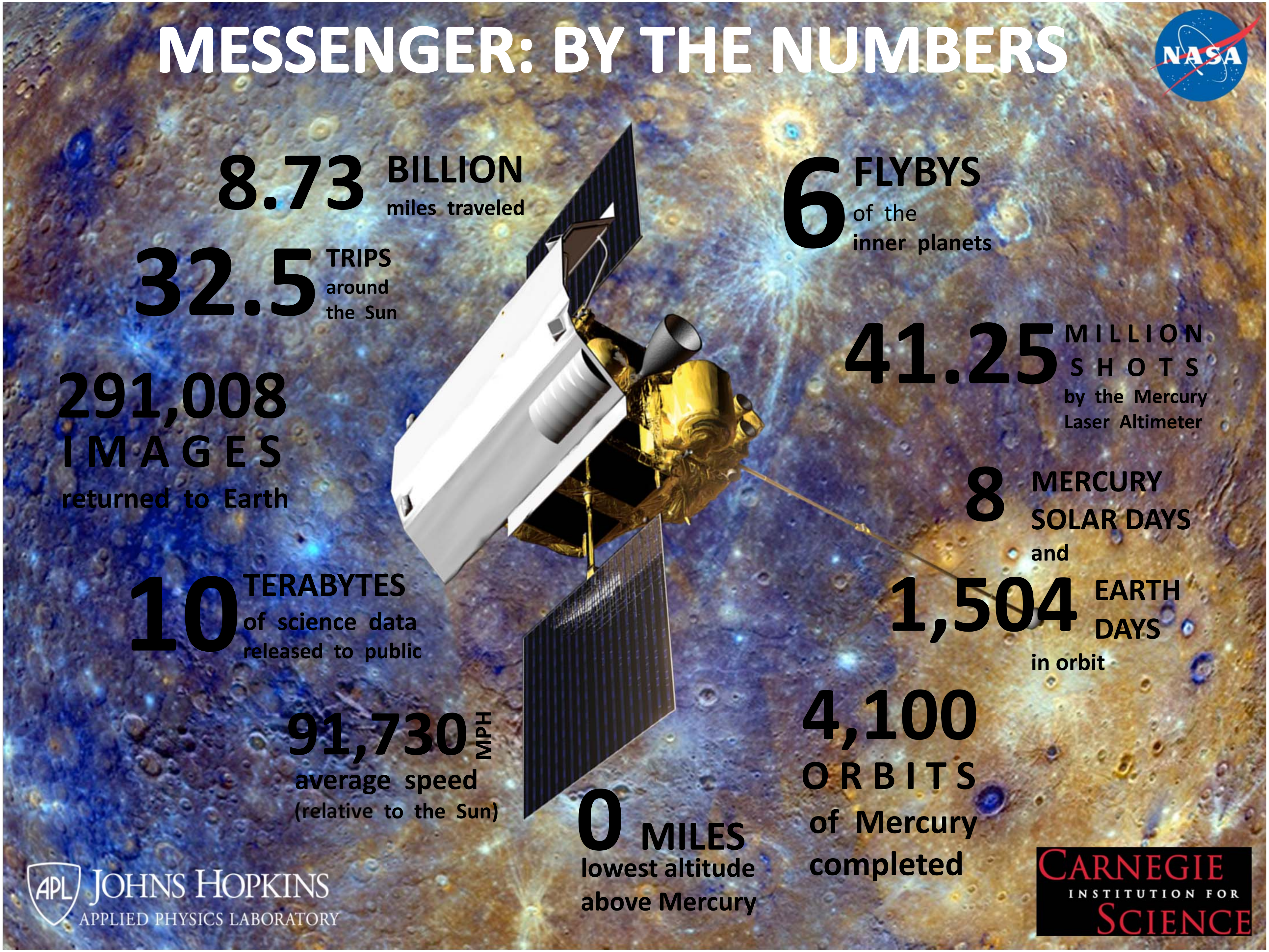
2015

March 6 – *Dawn* inserted into orbit around dwarf planet Ceres
April 30 – *MESSENGER* spacecraft impacted Mercury
May 26 – Europa instrument Step 1 selection
July 14 – *New Horizons* flies through the Pluto system
September – Discovery 2014 Step 1 selection
December 7 – Akatsuki inserted into orbit around Venus

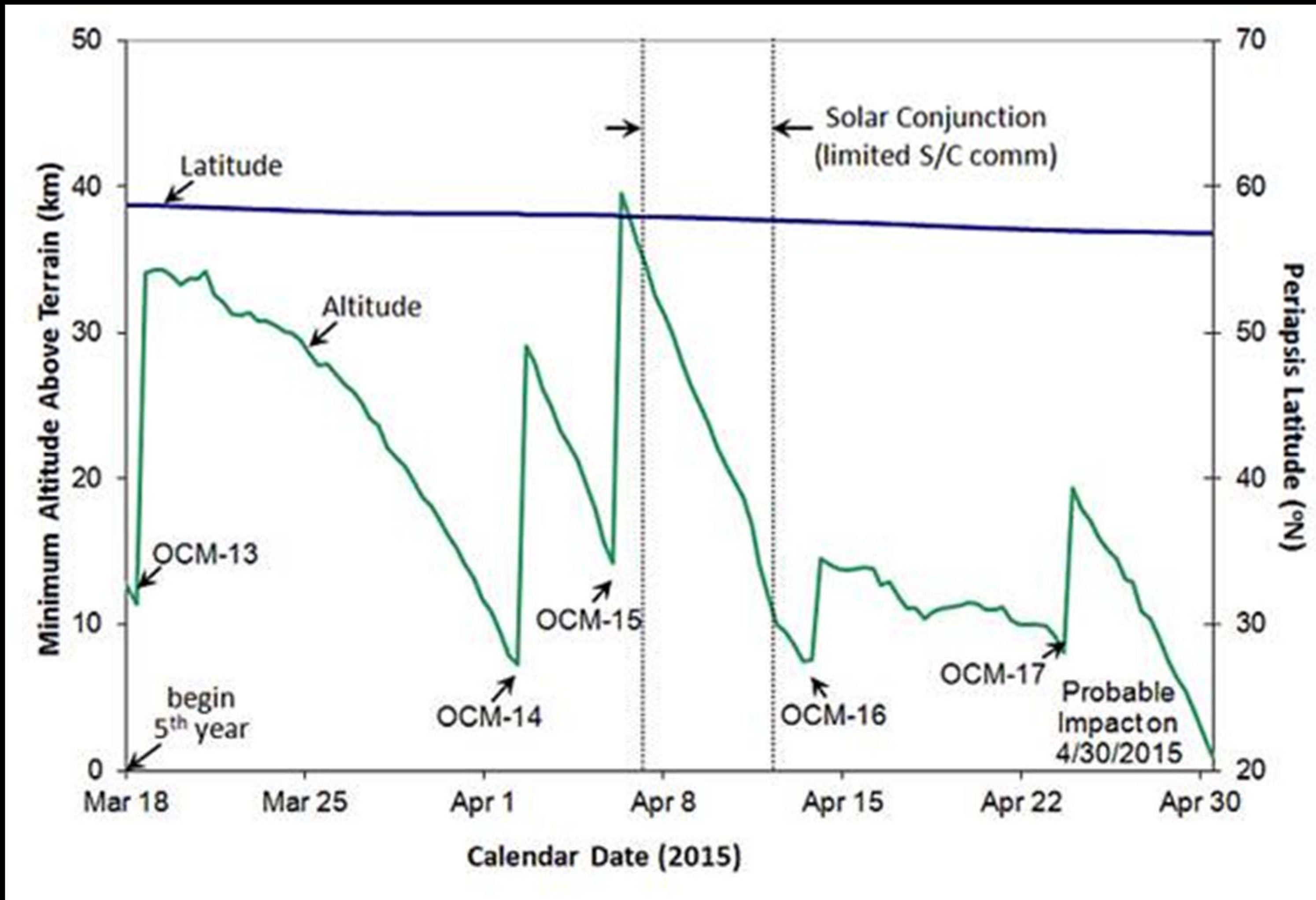
2016

March – Launch of *InSight &* ESA's *ExoMars Trace Gas Orbiter*
July 4 – *Juno* inserted in Jupiter orbit
September – Discovery 2014 Step 2 selection
September – *InSight* Mars landing
September – Launch of Asteroid mission *OSIRIS – REx* to asteroid Bennu
September – *Cassini* begins to orbit between Saturn's rings & planet

Summer Of Going Further Than Ever

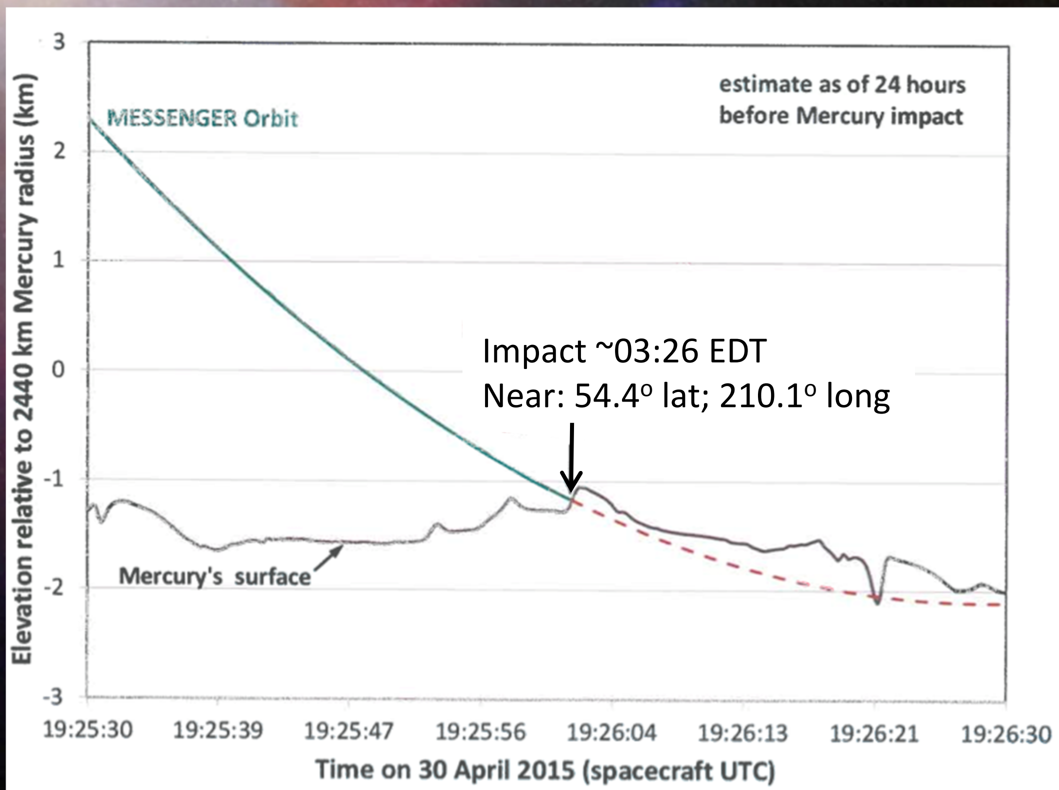

MESSENGER: BY THE NUMBERS
NASA
8.73 BILLION miles traveled
32.5 TRIPS around the Sun
291,008 IMAGES returned to Earth
10 TERABYTES of science data released to public
91,730 MPH average speed (relative to the Sun)
0 MILES lowest altitude above Mercury
6 FLYBYS of the inner planets
41.25 MILLION SHOTS by the Mercury Laser Altimeter
8 MERCURY SOLAR DAYS and 1,504 EARTH DAYS in orbit
4,100 ORBITS of Mercury completed
APL JOHNS HOPKINS APPLIED PHYSICS LABORATORY
CARNEGIE INSTITUTION FOR SCIENCE

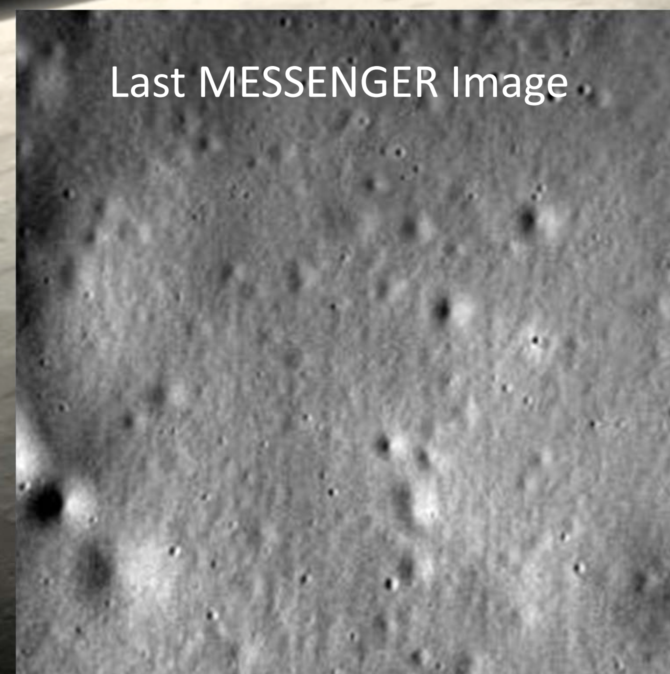
MESSENGER

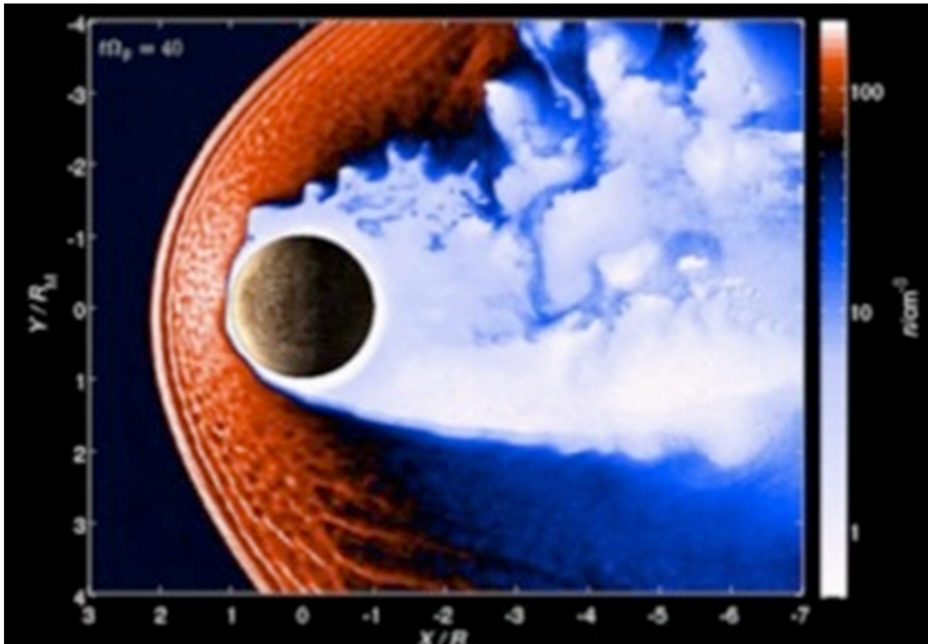


Solar Conjunction
(limited S/C comm)
Latitude
Altitude
OCM-13
OCM-14
OCM-15
OCM-16
OCM-17
begin
5th year
Probable
Impact on
4/30/2015
Minimum Altitude Above Terrain (km)
Periapsis Latitude (°N)
Calendar Date (2015)
Mar 18
Mar 25
Apr 1
Apr 8
Apr 15
Apr 22
Apr 30
0
10
20
30
40
50
20
30
40
50
60
70

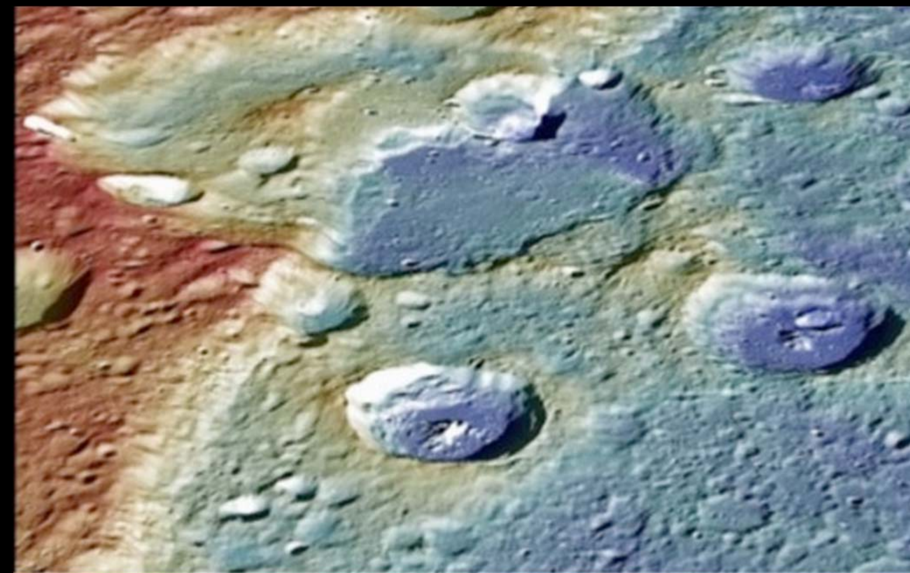
EOM for MESSENGER





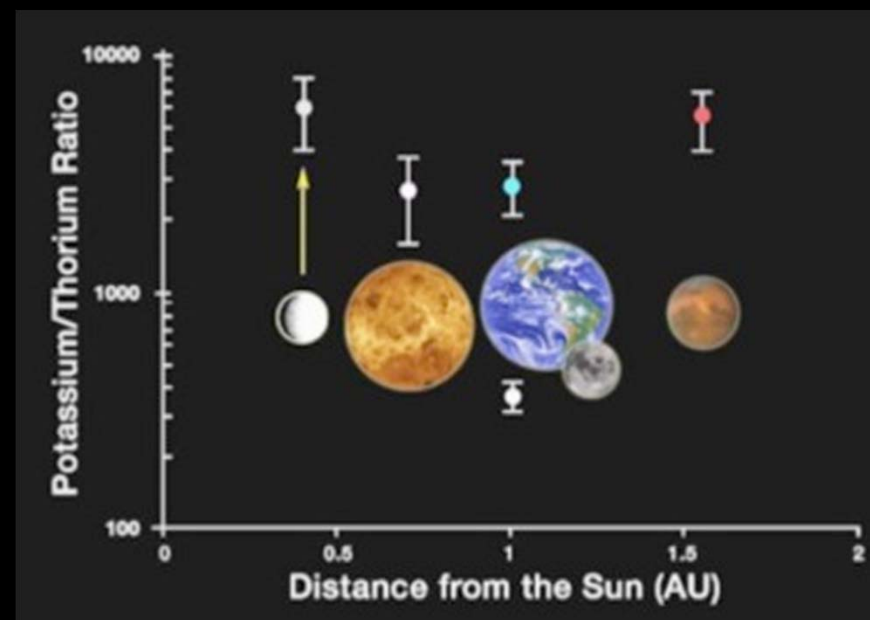


Dynamic Magnetosphere



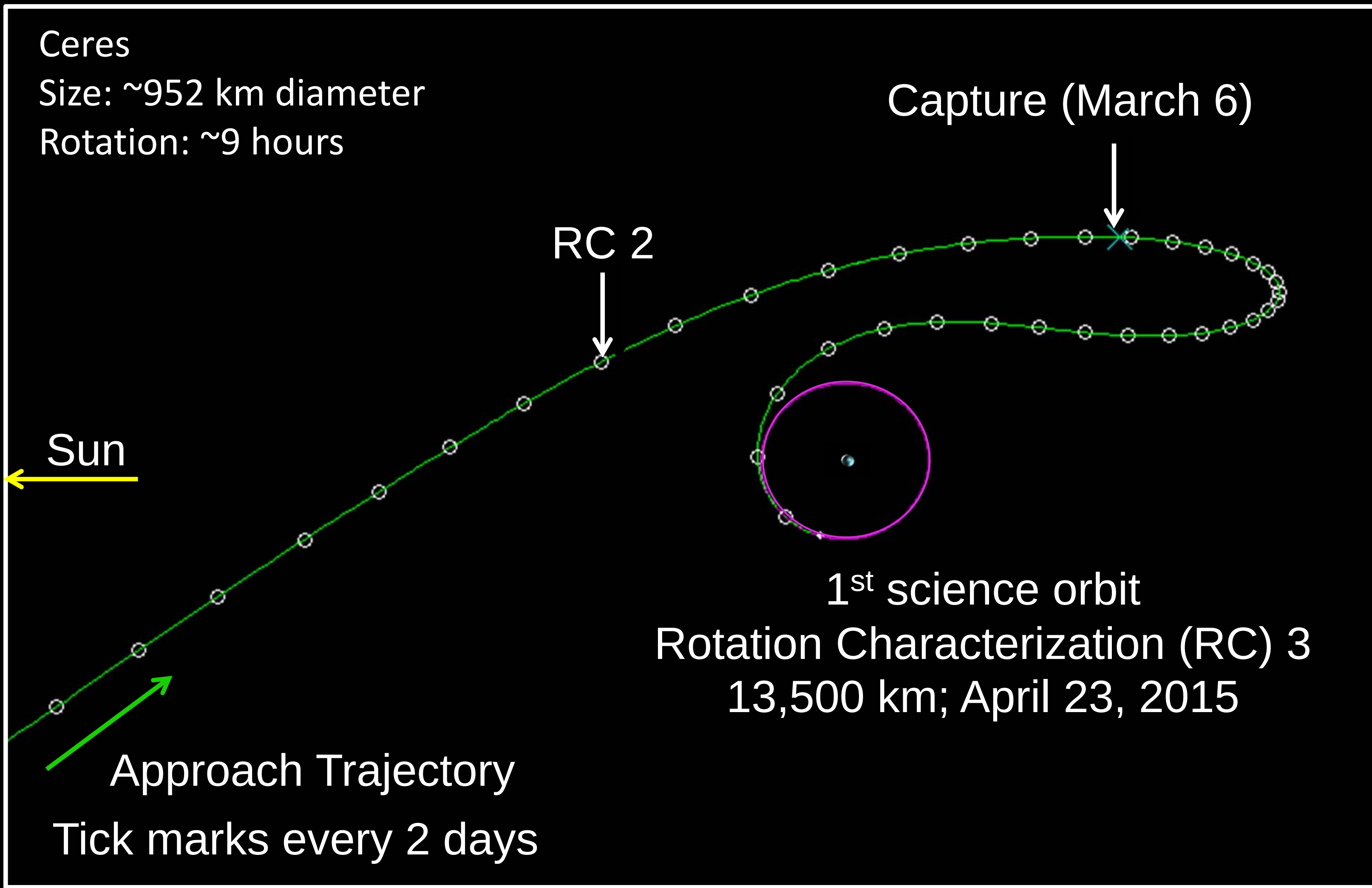
Global Contraction

Polar Deposits



Volatile-Rich Planet

Dawn's Approach

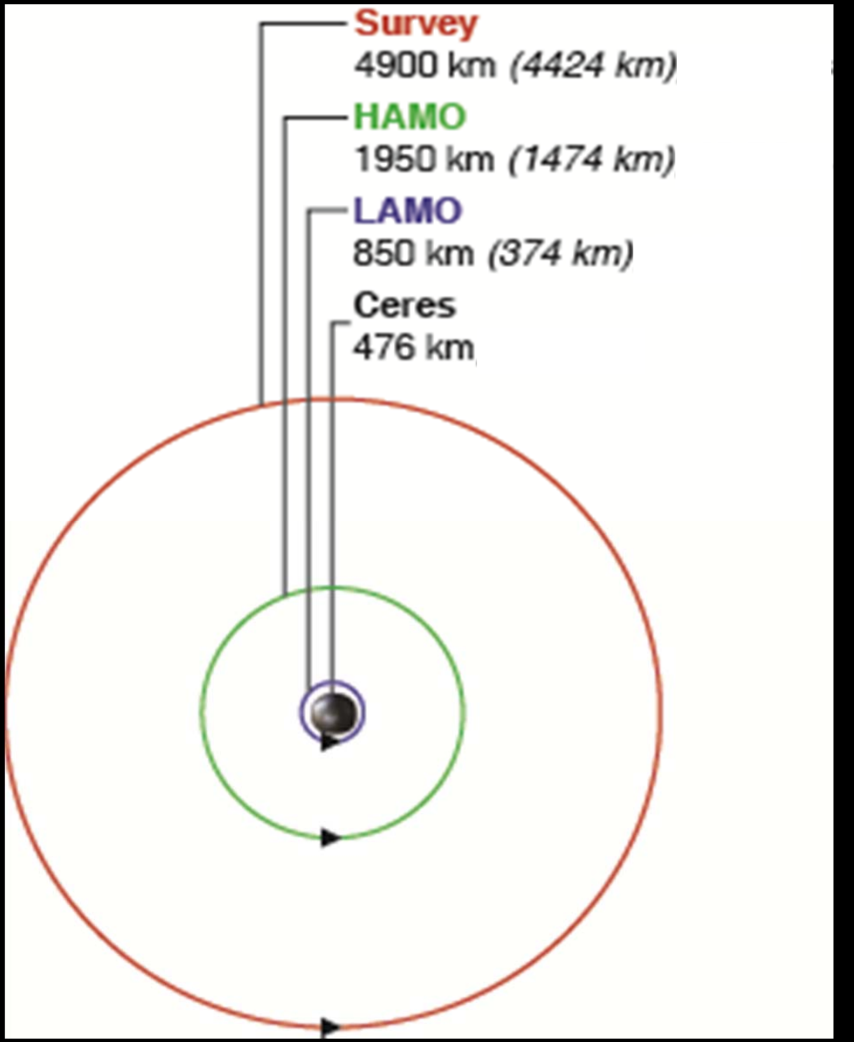


Ceres Science Orbits

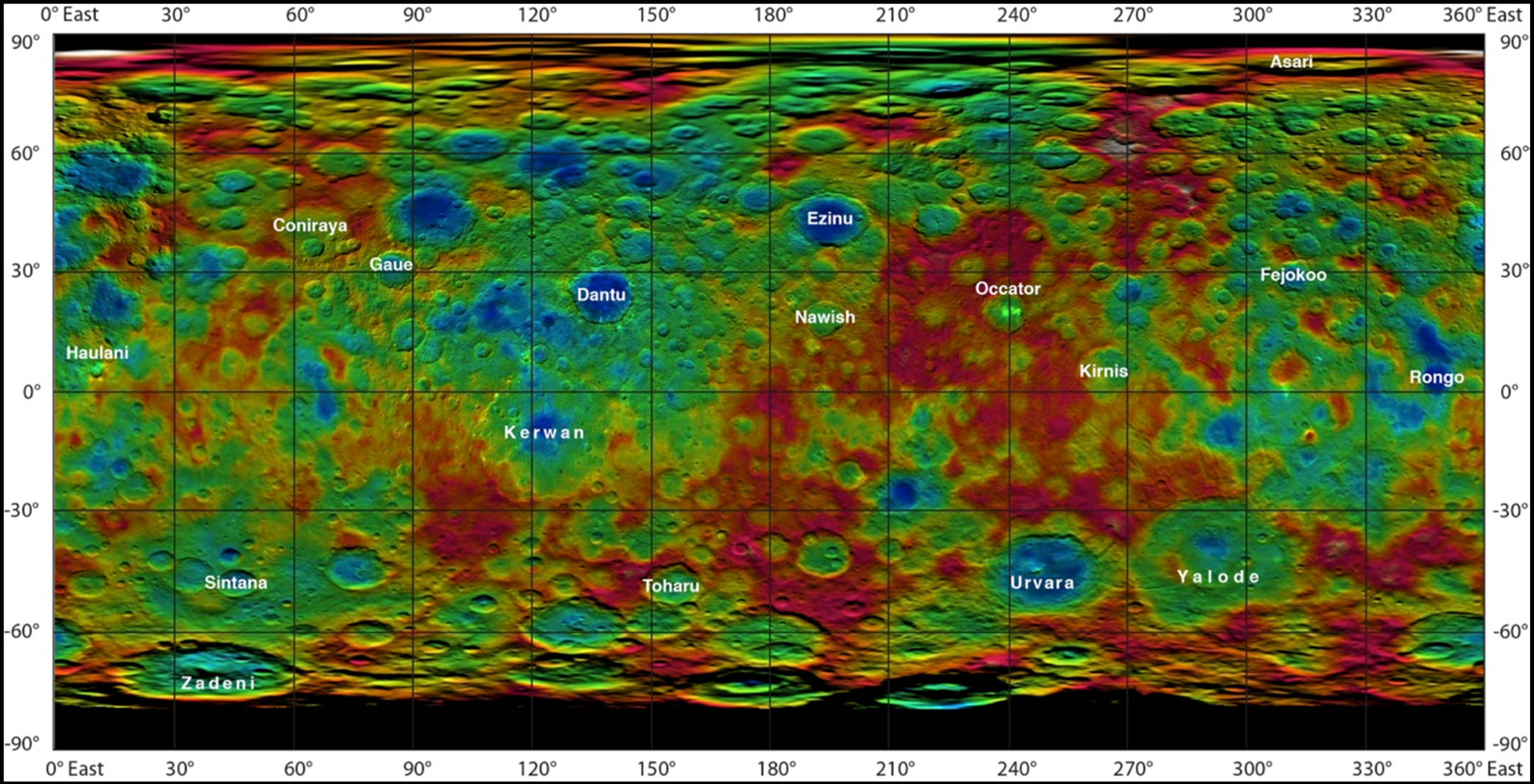
- Survey Orbit – started June 5th
  - Duration 7 orbits (22 days)
- High Altitude Mapping Orbit (HAMO)
  - Duration ~70 orbits (67 days)
- Low Altitude Mapping Orbit (LAMO)
  - Duration 404 orbits (92 days)

Total of ~400 days of operations

are planned at Ceres

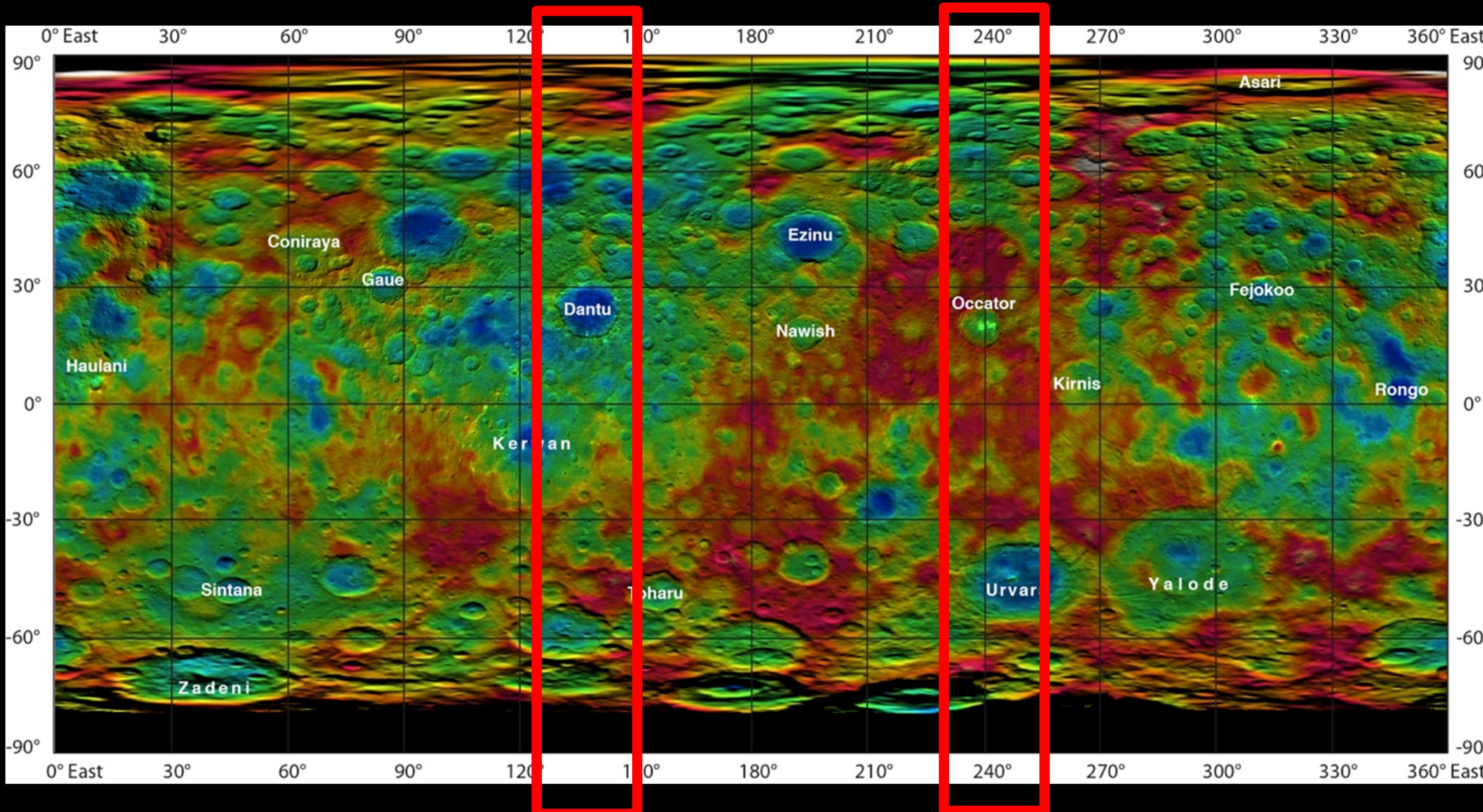


Ceres Topography (+/- 7 km)



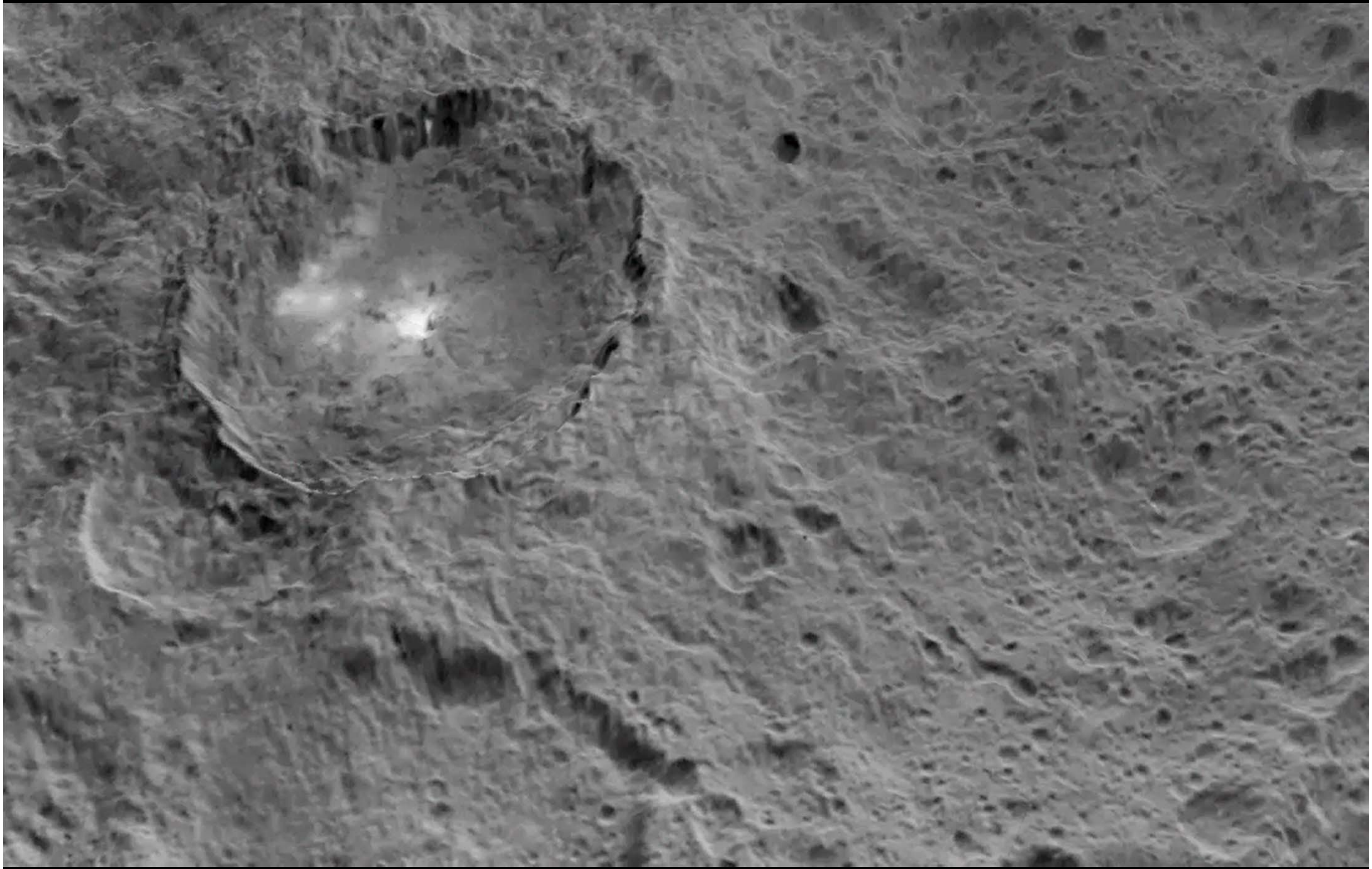
Mapping completed during the Survey Orbit sequence

Ceres Topography (+/- 7 km)



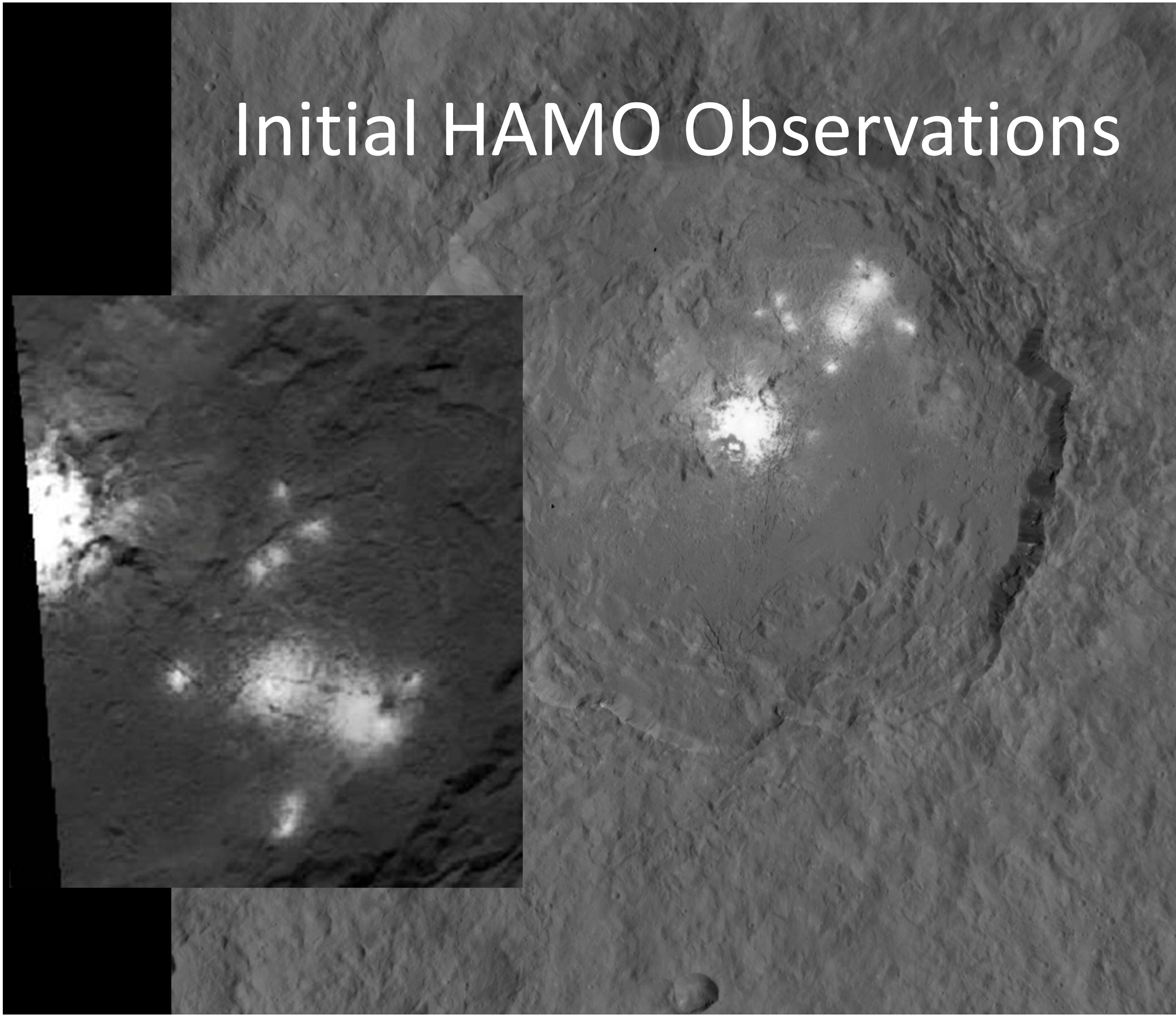
Active Water Vapor Regions Observed by ESA's Herschel Space Telescope

Dawn at Ceres: Bright Spots Crater (Ogmios)



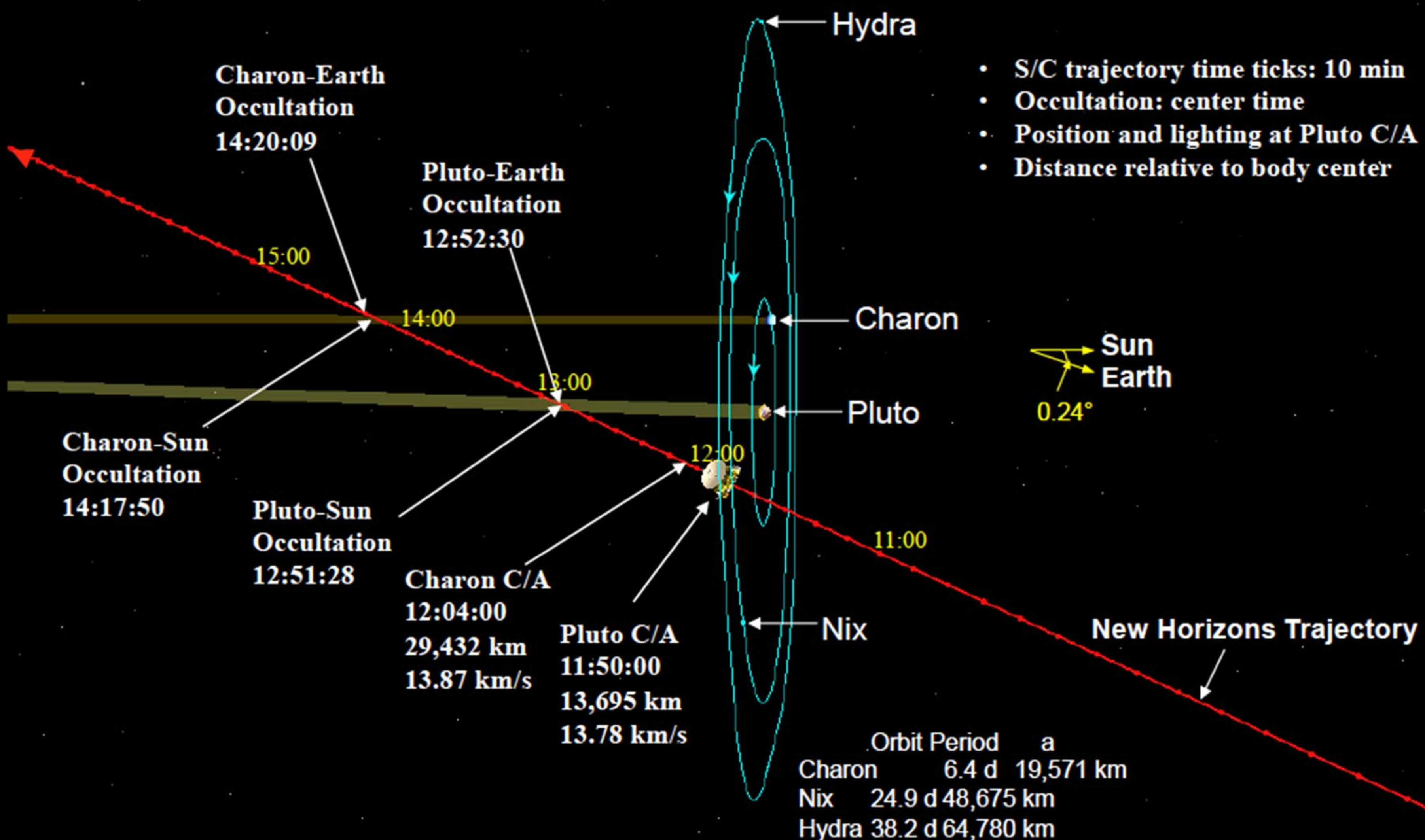
Animation by P. Schenk, LPI

Initial HAMO Observations

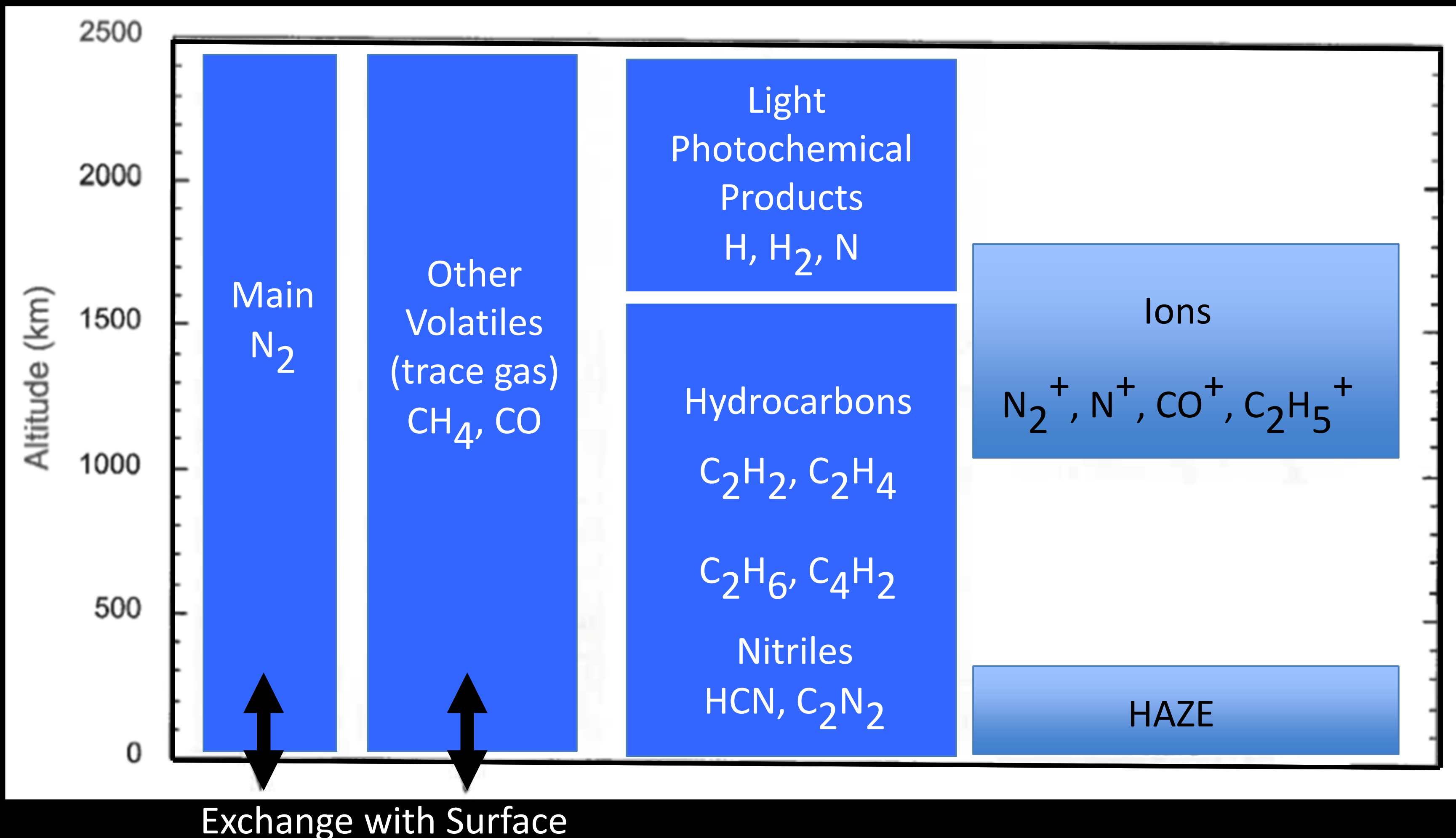


New Horizons Flyby of the Pluto System

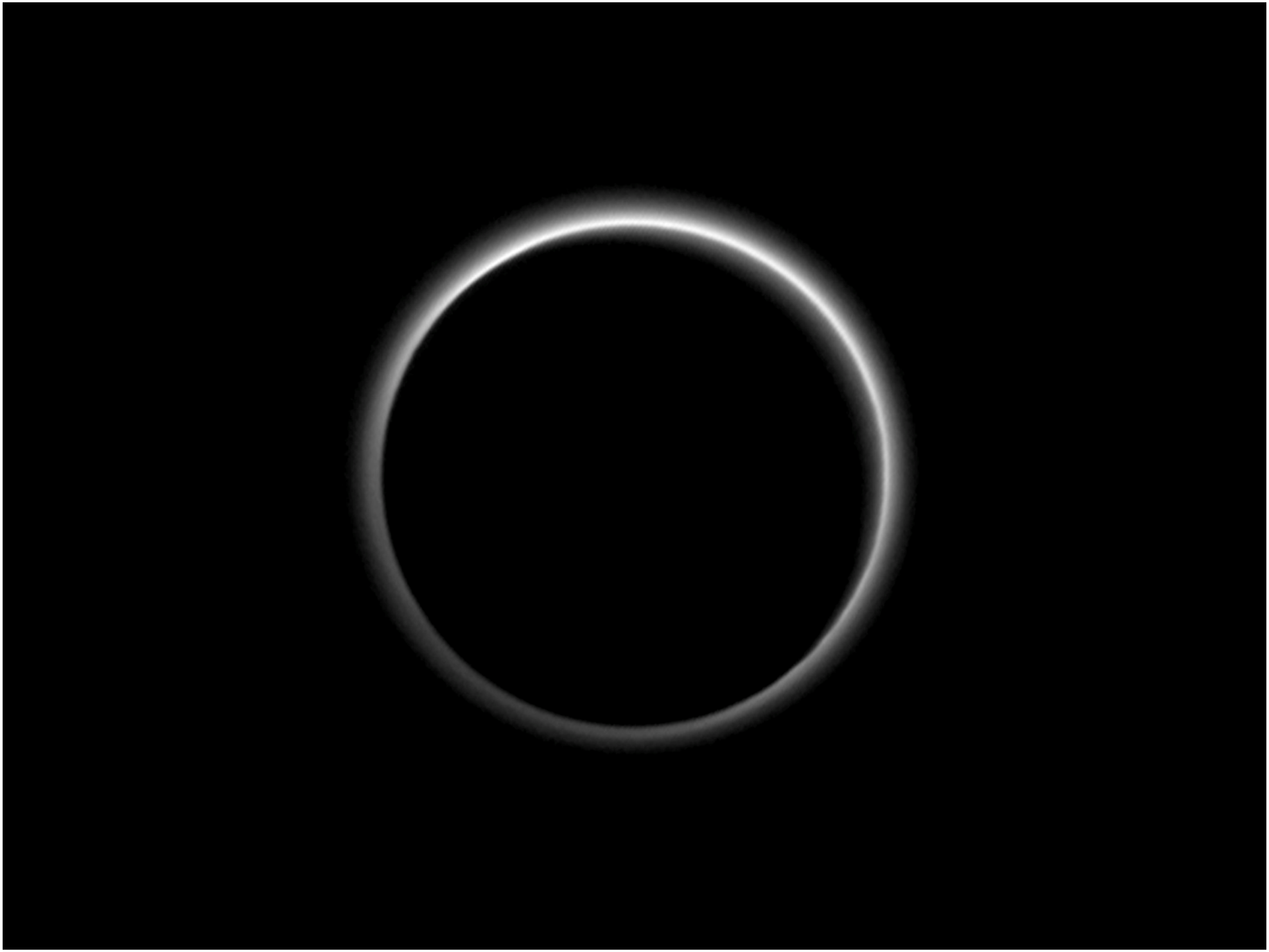
Closest Approach On July 14, 2015

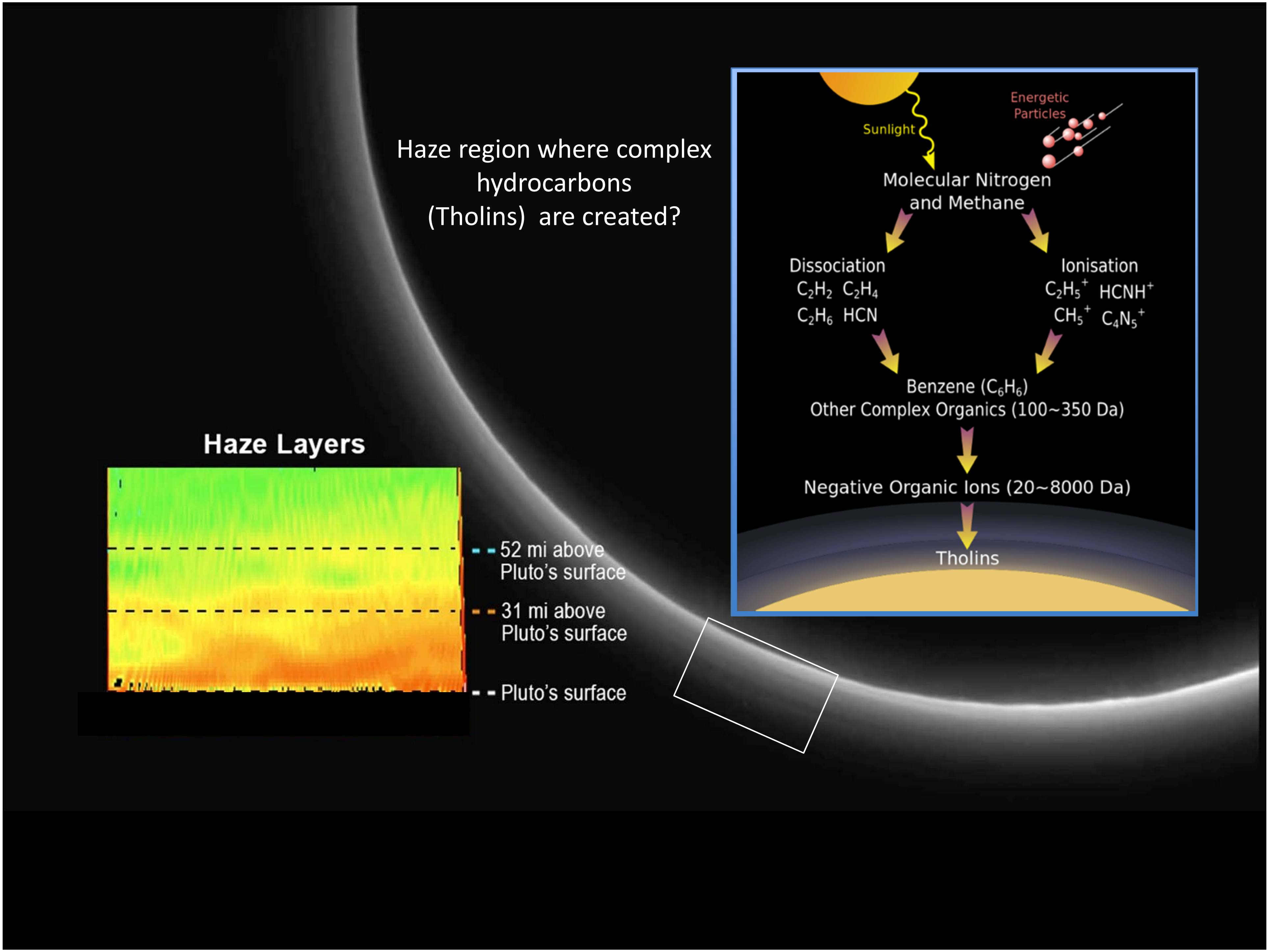


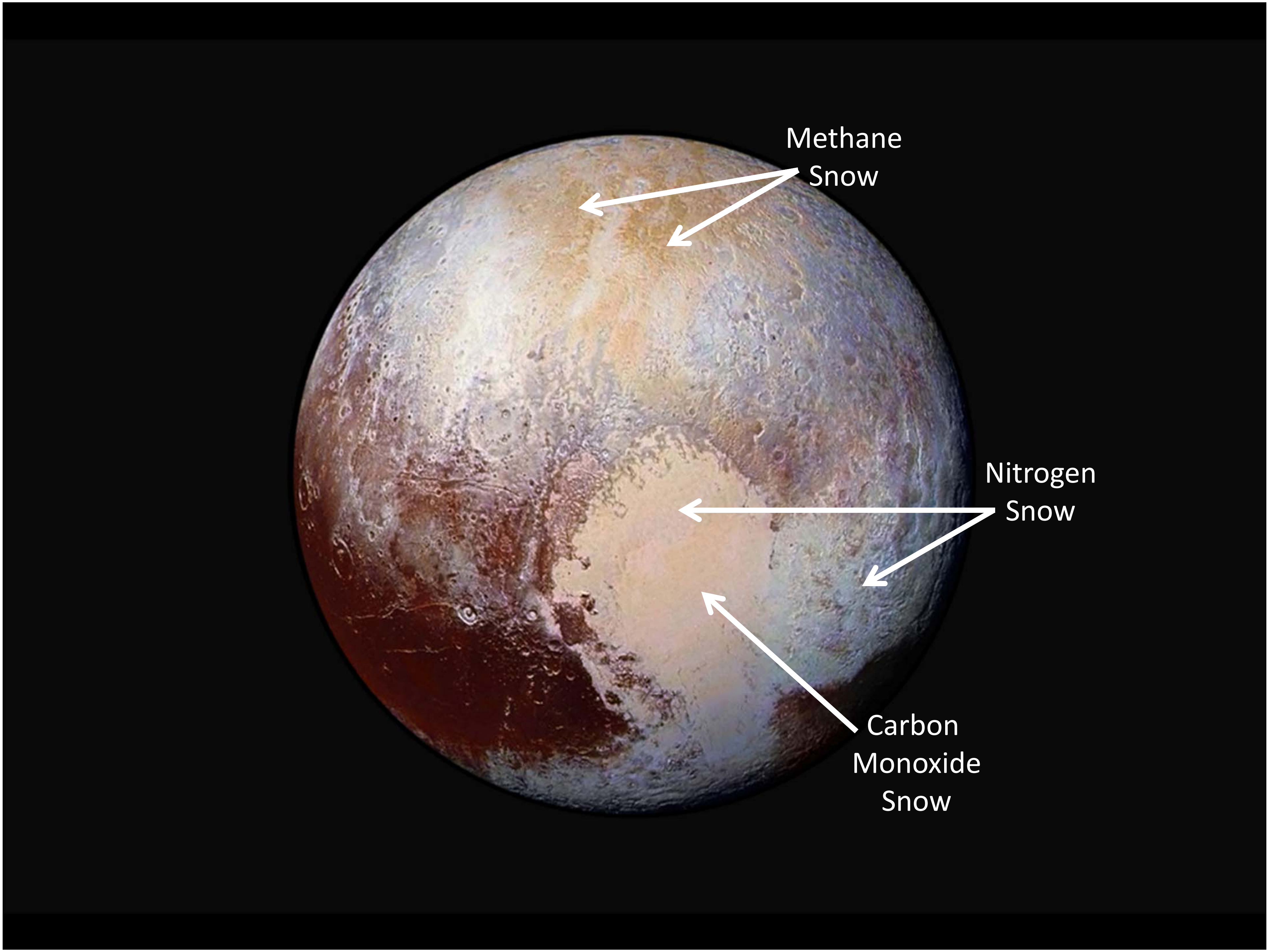
Pluto’s Atmosphere

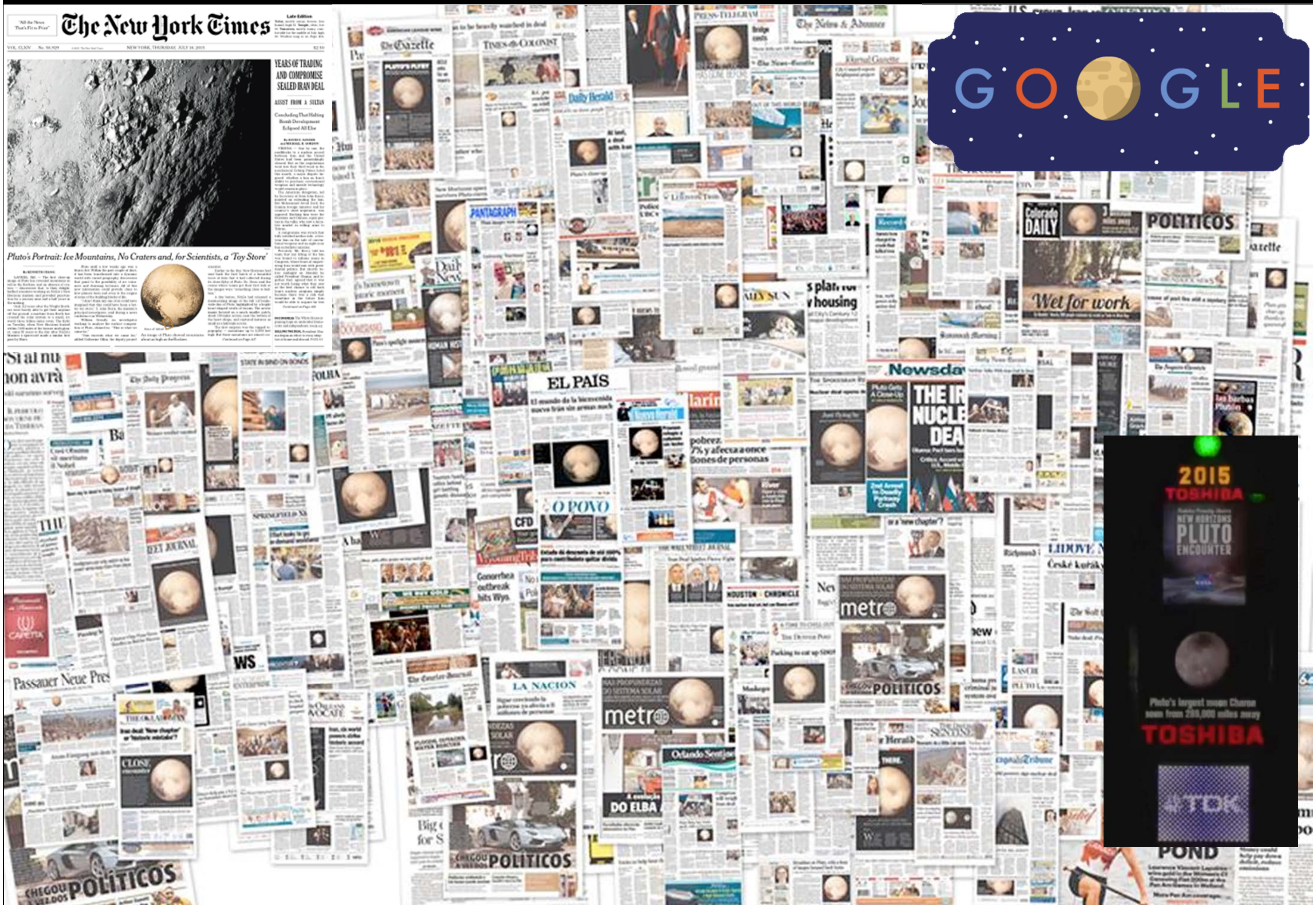


Pluto's temperature is about 43 K (−230 °C)




Haze region where complex hydrocarbons (Tholins) are created?
Haze Layers
52 mi above Pluto's surface
31 mi above Pluto's surface
Pluto's surface
Energetic Particles
Sunlight
Molecular Nitrogen and Methane
Dissociation
C_2H_2 C_2H_4
C_2H_6 HCN
Ionisation
$C_2H_5^+$ $HCNH^+$
CH_5^+ $C_4N_5^+$
Benzene (C_6H_6)
Other Complex Organics (100~350 Da)
Negative Organic Ions (20~8000 Da)
Tholins


Methane Snow
Nitrogen Snow
Carbon Monoxide Snow


The New York Times
YEARS OF TRADING AND COMPROMISE SEALED IRAN DEAL
Pluto's Portrait: Ice Mountains, No Craters and, for Scientists, a 'Toy Story'
GOOGLE
EL PAIS
O POVO
LA NACION
metro
POLITICOS
Newsday
Wet for work
Passauer Neue Presse
DO ELBA
2015
TOSHIBA
NEW HORIZONS
PLUTO
ENCOUNTER
TOSHIBA
TDK

Discovery and New Frontiers Status

Discovery and New Frontiers

- Address high-priority science objectives in solar system exploration
- Opportunities for the science community to propose full investigations
- Fixed-price cost cap full and open competition missions
- Principal Investigator-led project

- Established in 1992
- **$450M cap** per mission excluding launch vehicle and operations phase (FY15$)
- Open science competition for all solar system objects, except for the Earth and Sun

- Established in 2003
- **$850M** cap per mission excluding launch vehicle and operations phase (FY15$)
- Addresses high-priority investigations identified by the National Academy of Sciences

Discovery Program

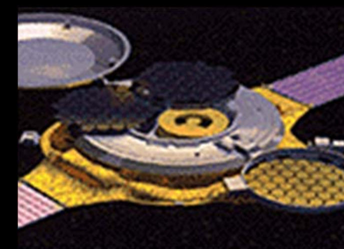
Completed

Mars evolution:
Mars Pathfinder (1996-1997)

Lunar formation:
Lunar Prospector (1998-1999)

NEO characteristics:
NEAR (1996-1999)

Solar wind sampling:
Genesis (2001-2004)

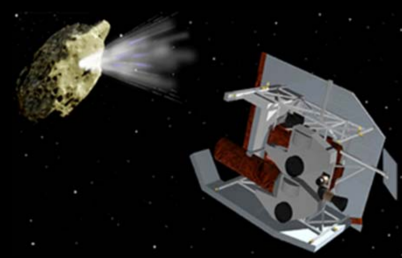


Completed

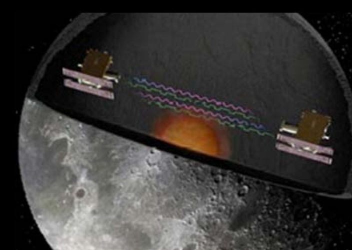
Comet diversity:
CONTOUR (2002)

Nature of dust/coma:
Stardust (1999-2011)

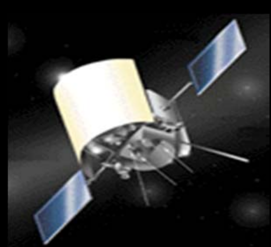
Comet internal structure:
Deep Impact (2005-2012)



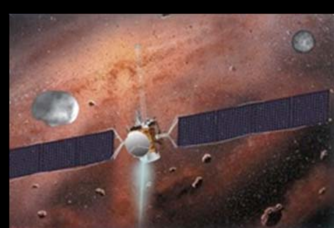
Lunar Internal Structure
GRAIL (2011-2012)



Mercury environment:
MESSENGER (2004-*2015*)



Main-belt asteroids:
Dawn (2007-*2016*)



Lunar surface:
LRO (2009-*TBD*)

ESA/Mercury Surface:
Strofio (*2016-TBD*)

Mars Interior:
InSight (2016-*TBD*)

Status of Discovery Program

Discovery 2014 - Proposals in review for September Selection

- About 3-year mission cadence for future opportunities

Missions in Development

– *InSight*: Launch window opens March 4, 2016 (Vandenberg)

– Strofio: Delivered to SERENA Suite (ASI) for BepiColombo

Missions in Operation

– *Dawn*: Science observations now in HAMO

Missions in Extended Operations

– *MESSENGER*: Completed low altitude science operations before impact with Mercury

– *LRO*: In stable elliptical orbit, passing low over the lunar south pole

New Frontiers Program

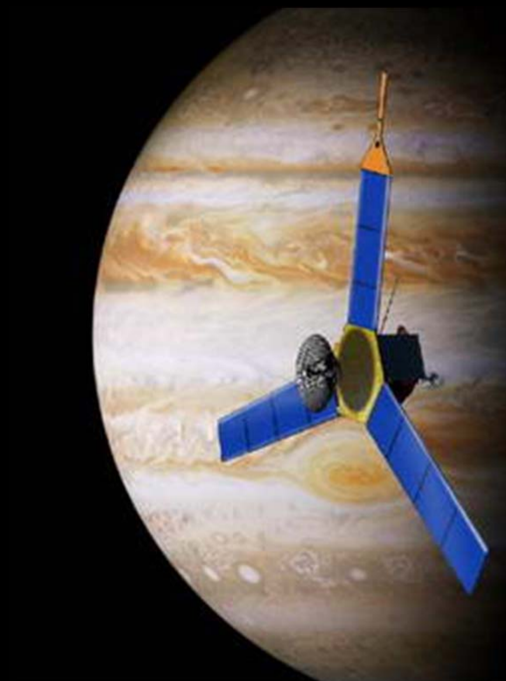
1st NF mission
New Horizons:

Pluto-Kuiper Belt

Launched January 2006
Flyby July 14, 2015
PI: Alan Stern (SwRI-CO)

2nd NF mission
JUNO:

Jupiter Polar Orbiter



Launched August 2011
Arrives July 2016
PI: Scott Bolton (SwRI-TX)

3rd NF mission
OSIRIS-REx:

Asteroid Sample Return

To be launched: Sept. 2016
PI: Dante Lauretta (UA)

Status of New Frontiers Program

Next New Frontiers AO - to be released by end of Fiscal Year 2016

- New ROSES call for instrument/technology investments released

Missions in Development - OSIRIS REx

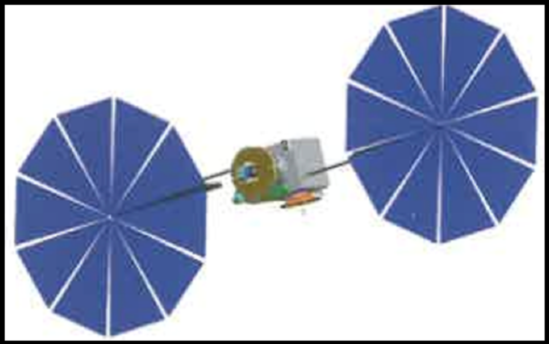
  - Launch in Sept 2016 & encounter asteroid Bennu in Oct 2018.
  - Operate at Bennu for over 400 days.
  - Returns a sample in 2023 that scientists will study for decades with ever more capable instruments and techniques.

Missions in Operation

- New Horizons:
  - Pluto system encounter July 14, 2015
  - HST identified 2 KBO’s beyond Pluto for potential extended mission
  - NH approved to target small Kuiper Belt object 2014 MU69
- Juno:
  - Spacecraft is 5.01 AU from the sun and 1.02 AU from Jupiter
  - Orbit insertion is July 4, 2016

New Frontiers #4 Focused Missions

Comet Surface Sample Return

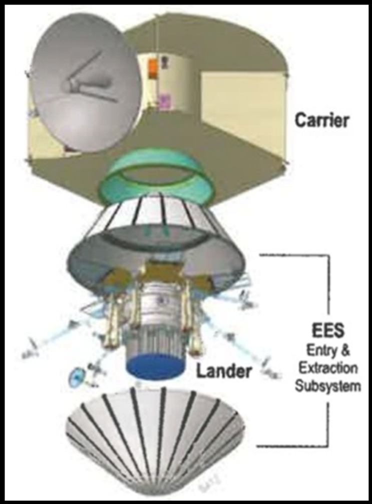


Saturn Probes

Lunar South Pole Aitken Basin Sample Return

Trojan Tour & Rendezvous

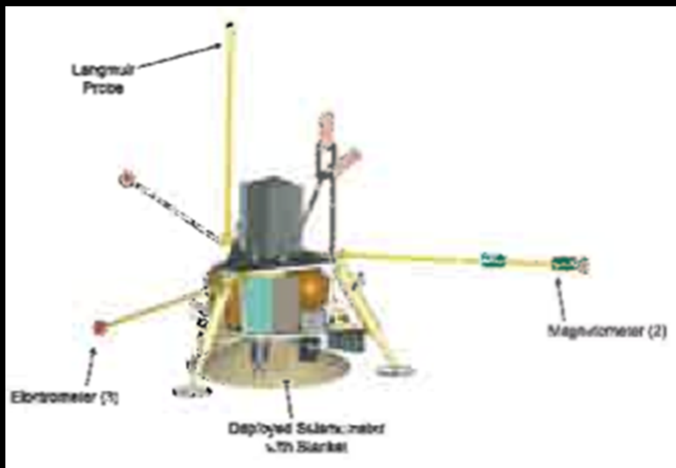
Venus In-Situ Explorer



New Frontiers #5 Focused Missions

- Added to the remaining list of candidates:

Lunar Geophysical Network



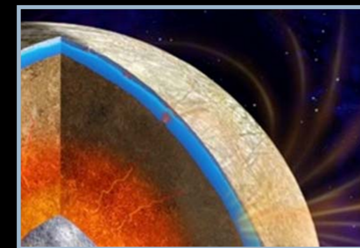
Io Observer

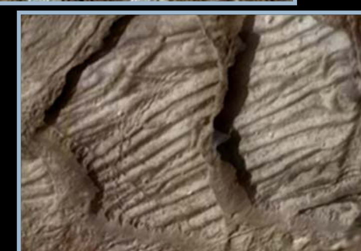
Europa Activities

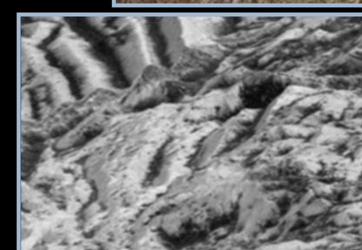
Now in Formulation (Phase A)

Europa Multi-Flyby Mission Science Goal & Objectives

- *Goal:* **Explore Europa to investigate its habitability**
- *Objectives:*
  - **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
  - **Reconnaissance:** Characterize scientifically compelling sites, and hazards, for a potential future landed mission to Europa



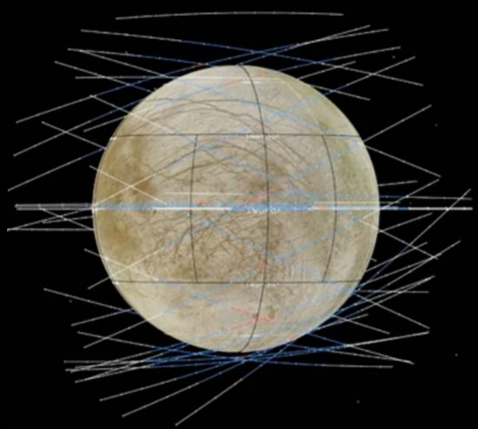




Overview of Selected Proposals

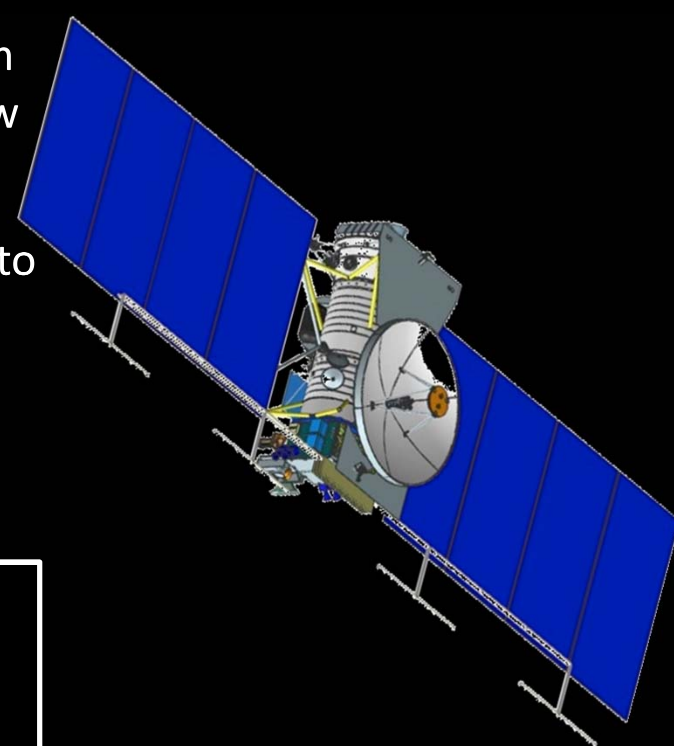
Instrument Type	Name	PI	instituion
Plasma	PIMS	Joseph Westlake	APL
Magnetometer	ICEMAG	Carol Raymond	JPL
Shortwave IR Spectrometer	MISE	Diana Blaney	JPL
Camera	EIS	Elizabeth Turtle	APL
Ice Penetrating Radar	REASON	Don Blankenship	Univ. Texas/JPL
Thermal Imager	E-THEMIS	Phil Christensen	ASU/Ball
Neutral Mass Spectrometer	MASPEX	Hunter Waite	SWRI
UV Spectrograph	E-UVS	Kurt Retherford	SWRI
Dust Analyzer	SUDA	Sascha Kempf	Univ. Colorado

Europa Multi-Flyby Mission Concept Overview



Science	
Objective	**Description**
Ice Shell & Ocean	Characterize the ice shell and any subsurface water, including their heterogeneity, 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.
Recon	Characterize scientifically compelling sites, and hazards for a potential future landed mission to Europa

- Conduct 45 low altitude flybys with lowest 25 km (less than the ice crust) and a vast majority below 100 km to obtain global regional coverage
- Traded enormous amounts of fuel used to get into Europa orbit for shielding (lower total dose)
- Simpler operations strategy
- No need for real time down link

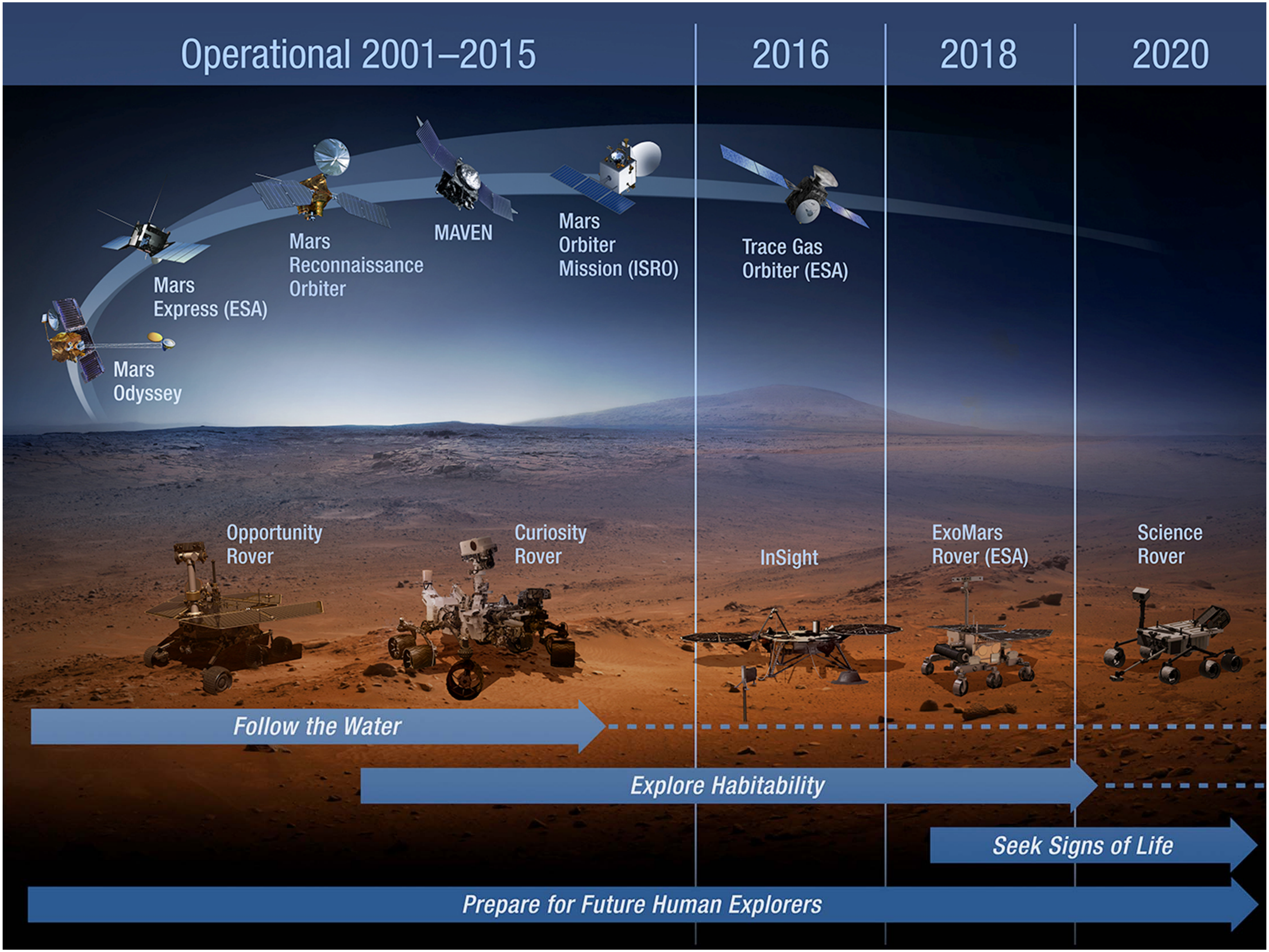


Key Technical Margins

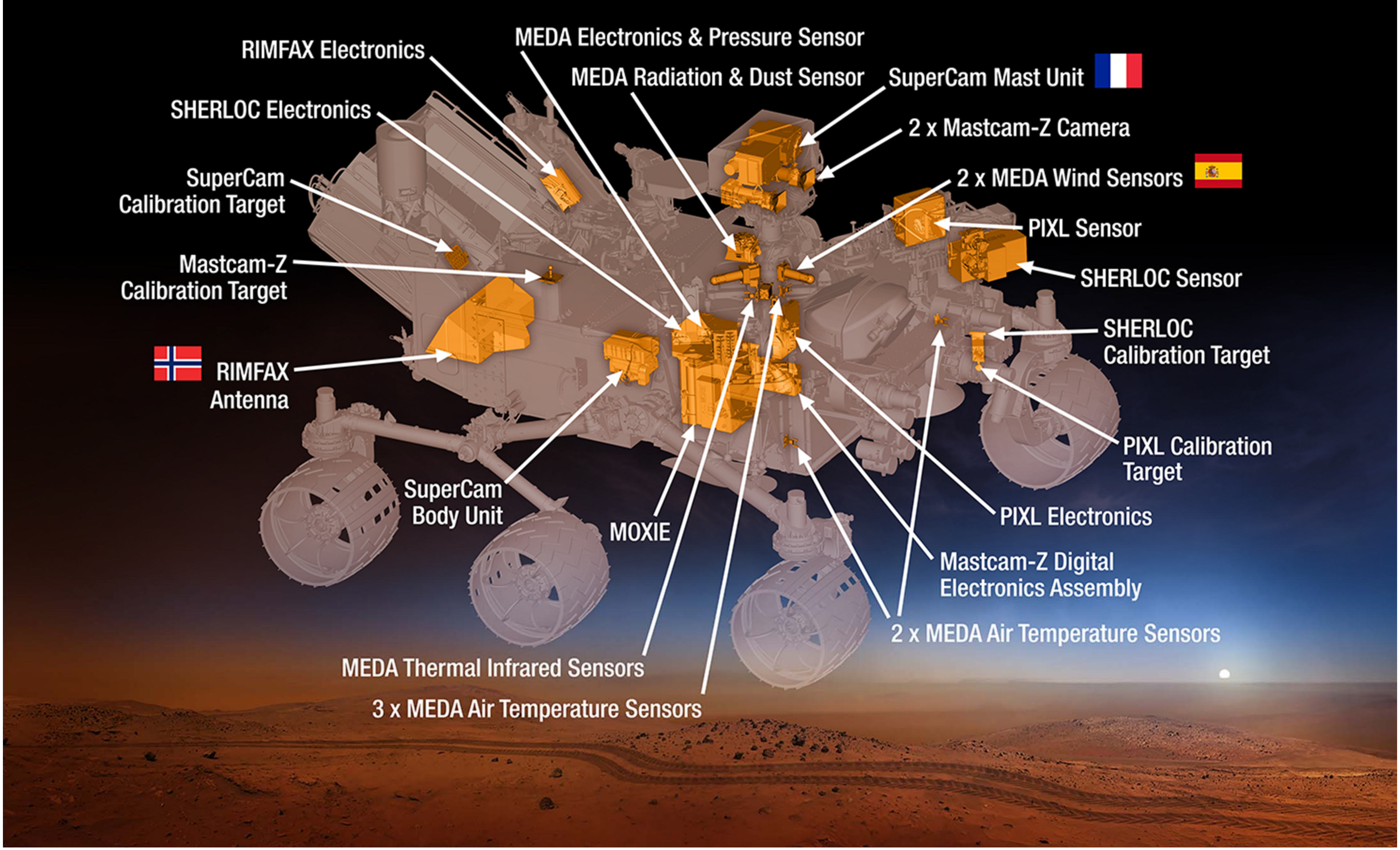
*37 - 41%	40%
Mass	**Power**

* Depends on Launch Opportunity and Launch Vehicle

tjf4 Major comments; see notes section
Jens Feeley, 6/5/2015


Operational 2001–2015
2016
2018
2020
Mars Odyssey
Mars Express (ESA)
Mars Reconnaissance Orbiter
MAVEN
Mars Orbiter Mission (ISRO)
Trace Gas Orbiter (ESA)
Opportunity Rover
Curiosity Rover
InSight
ExoMars Rover (ESA)
Science Rover
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers

Mars 2020 Instrument Payload Accommodated on Rover

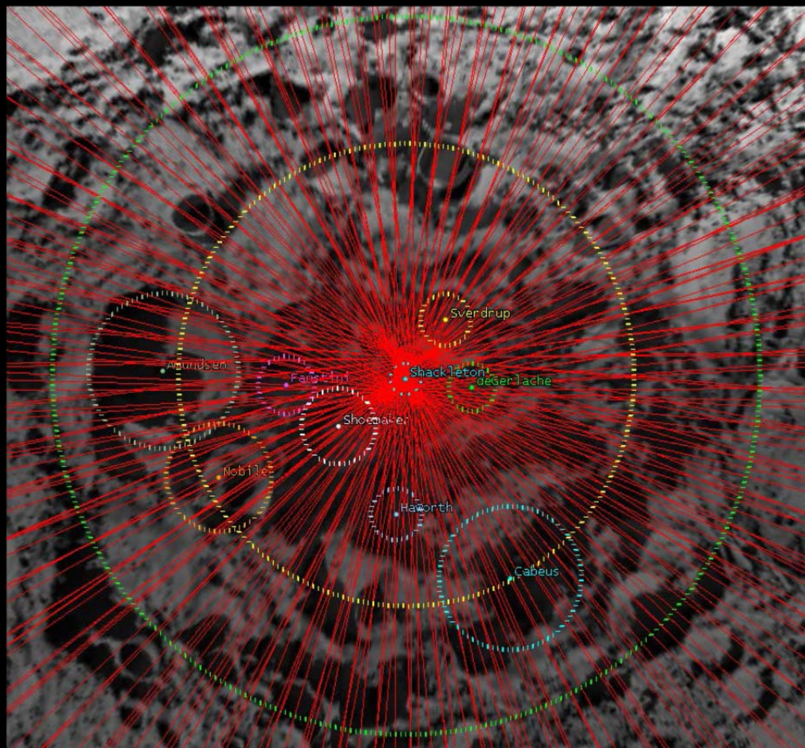


Small Innovative Missions for Planetary Exploration (SIMPLEx-2014)

New Awards in FY15

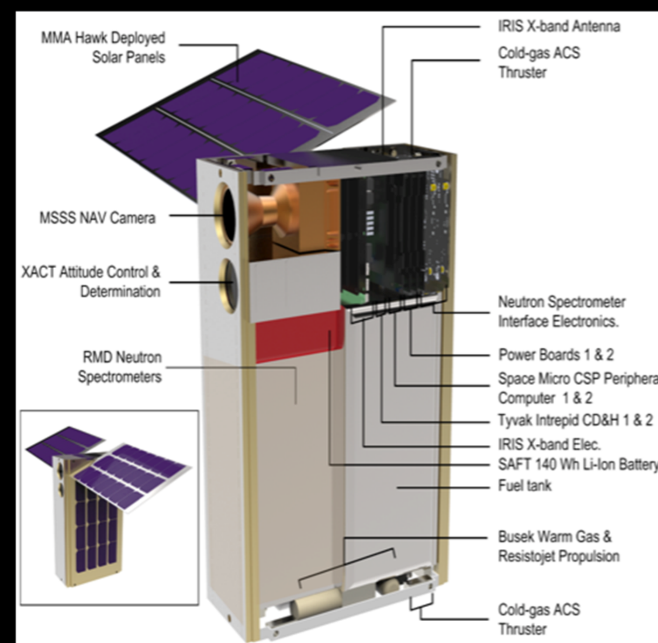
LunaH-Map: Lunar Polar Hydrogen Mapper

PI: Craig Hardgrove, ASU School of Earth and Space Exploration



(LunaH-Map) is a 6U CubeSat that will enter a polar orbit around the Moon with a low altitude (5-12km) perilune centered on the lunar South Pole. LunaH-Map carries two neutron spectrometers that will produce maps of near-surface hydrogen (H). LunaH-Map will map H within permanently shadowed craters to determine its spatial distribution, map H distributions with depth (< 1 meter), and map the distribution of H in other permanently shadowed regions (PSRs) throughout the South Pole.

Orbit ground track shown for entire 60 (Earth) day science phase: 141 passes over target area initially (and periodically) centered on Shackleton Crater with close-approach of 5 km at each perilune crossing. Yellow circle denotes LunaH-Map altitude of 8 km; green circle denotes LunaH-Map altitude of 12 km.



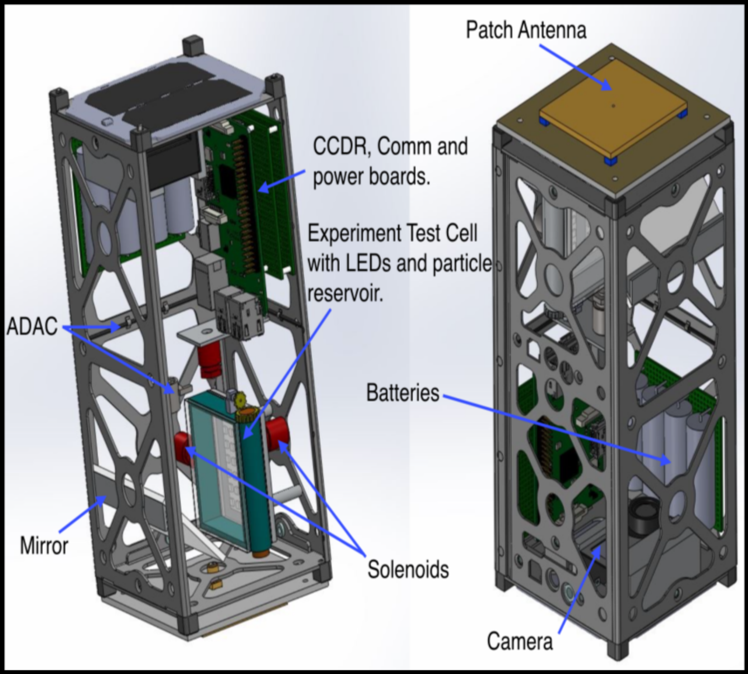
(Q-PACE): CubeSat Particle Aggregation and Collision Experiment

PI: Josh Colwell, University of Central Florida

Q-PACE is a thermos sized, LEO CubeSat, that will explore the fundamental properties of low-velocity (< 10 m/s) particle collision in a microgravity environment in an effort to better understand the mechanics of early planetoid development.

Q-PACE is a 2U CubeSat with a collision test cell and several particle reservoirs that contain meteoritic chondrules, dust particles, dust aggregates, and larger spherical monomers. Particles will be introduced into the test cell for a series of separate zero gravity experimental runs. The test cell will be mechanically agitated to induce collisions, which will be recorded by on-board video for later downlink and analysis.

Q-PACE has been accepted by the NASA CubeSat Launch Initiative program in the 2015 round of selections.



Q-PACE from opposite ends with the outer walls and solar panels removed to reveal the spacecraft components.

Simplex Cubesats

Approved for Phase A (1 year) Study ONLY

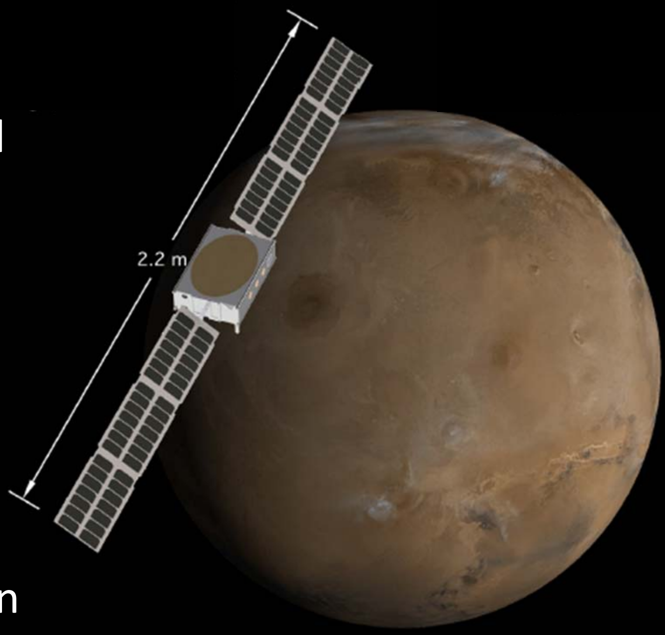
Mars Micro Orbiter

PI: Michael Malin, Malin Space Science Systems

The **Mars Micro Orbiter (MMO)** mission uses a 6U-class Cubesat to measure the Mars atmosphere in visible and infrared wavelengths from Mars orbit.

These science measurements will:

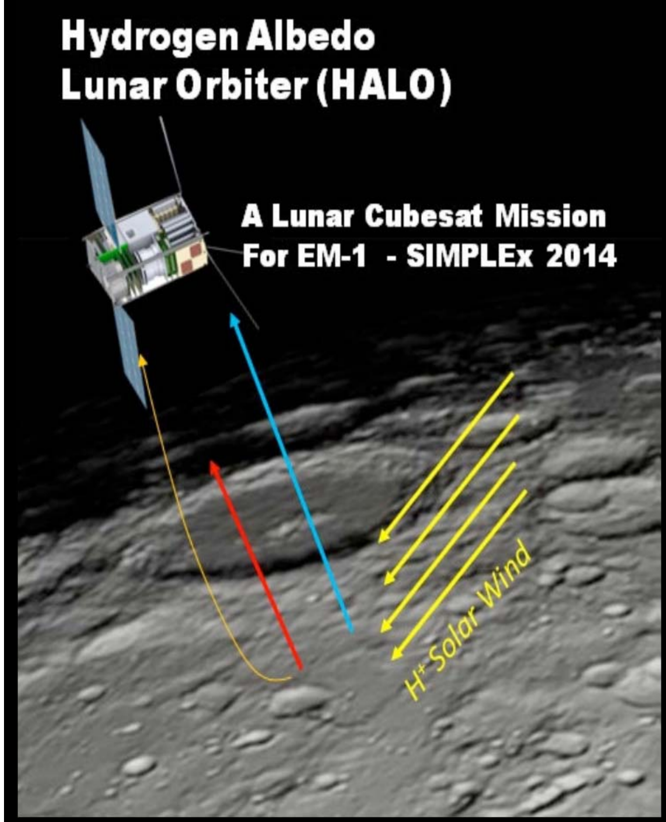
(1) Extend the temporal coverage of the global synoptic meteorological record of Mars, which includes atmospheric thermal structure, dust and condensate clouds, and seasonal and perennial polar cap behavior,
(2) Characterize the dynamics and energy budget of the current Mars atmosphere,
(3) Support present and future Mars missions
(4) Characterize present-day habitability



The CubeSat can also act as an orbital communication relay for Mars surface-based missions.

HALO: Hydrogen Albedo Lunar Orbiter

PI: Michael Collier, NASA GSFC



HALO is a propulsion-driven 6U CubeSat with an ion spectrometer that simultaneously observes the impinging solar wind and the reflected ion component with a nadir-facing low-energy neutral atom imager that observes the upward moving neutral hydrogen.

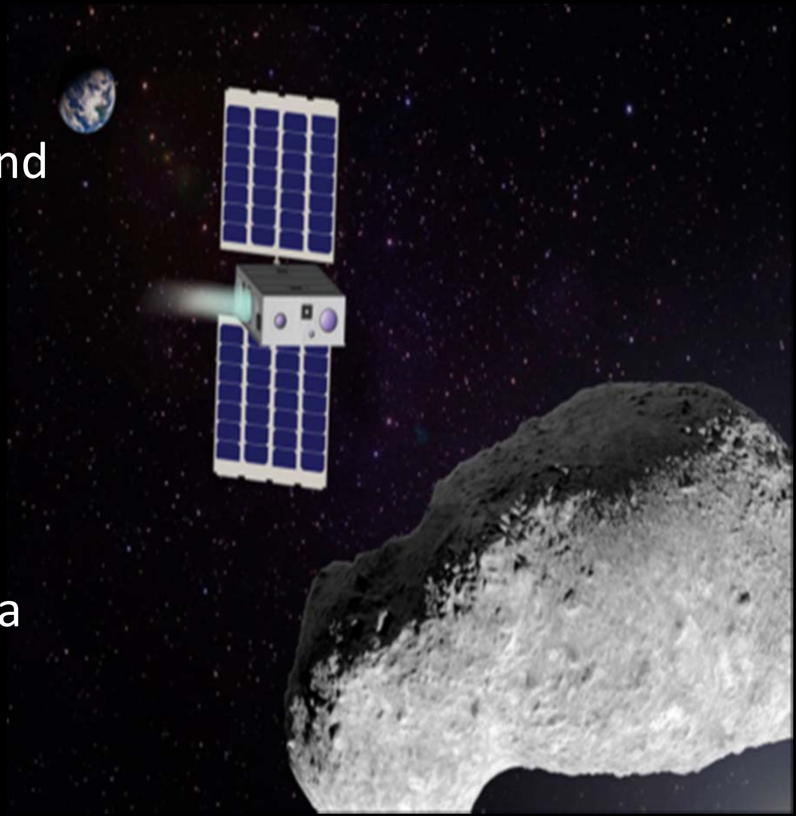
The HALO mission will survey the surface of the Moon for a minimum of 3 months, allowing it to measure multiple trajectories of the solar wind, follow the moon into the wake region of the Earth's magnetosphere, and sample meteoric impact.

The goal is to measure the flux as a function of location, solar phase angle, subsurface mineralogy, magnetic anomaly condition, and under meteor shower conditions in order to map the potential for the formation of water and OH in the lunar regolith.

DAVID: Diminutive Asteroid Visitor using Ion Drive

PI: Geoffrey Landis, NASA Glenn Research Center

DAVID is a 6U CubeSat mission that will investigate an asteroid much smaller than any investigated by previous spacecraft missions and will be the first NASA mission to investigate an Earth-crossing asteroid.

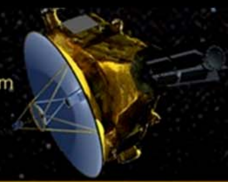


Despite its small size, the DAVID CubeSat will have three primary instruments that would operate for a short-duration flyby, including a wide-field camera, a narrow-field camera and a point VNIR spectrometer.

DAVID will provide critical first-order data on 2001–GP2's size, shape, composition, and source region in the main belt, while scouting its rotational state and physical properties.

Planetary use of Astrophysics Assets

NEW HORIZONS NASA's First Mission to the Pluto System



NASA Assets ALL Looking

- SOFIA occultation 12-mag star by Pluto on June 29
- Simultaneous SOFIA observations with HIPO, FLITECAM & Focal Plane Imager
- Comparison of multi-wavelength observations will allow detailed analysis of atmospheric profiles and aerosol content

Hubble:
February 1 – November 1, 2015

Keck – NIRSPEC
May 28, June 05, June 07, 2014
Future dates this month

IRTF-SpeXI instrument

- NeoWISE September 30 – October 3, 2014

- Chandra – ACIS instrument
- July 31 – August 14, 2015

- Swift – UVOT & XRT instruments
- Daily snapshots during encounter and past month

- K2 – Selections made
- Release in NEAR FUTURE

- Spitzer – Cycle 10 & 11
- Mapping Pluto at 18 different longitudes

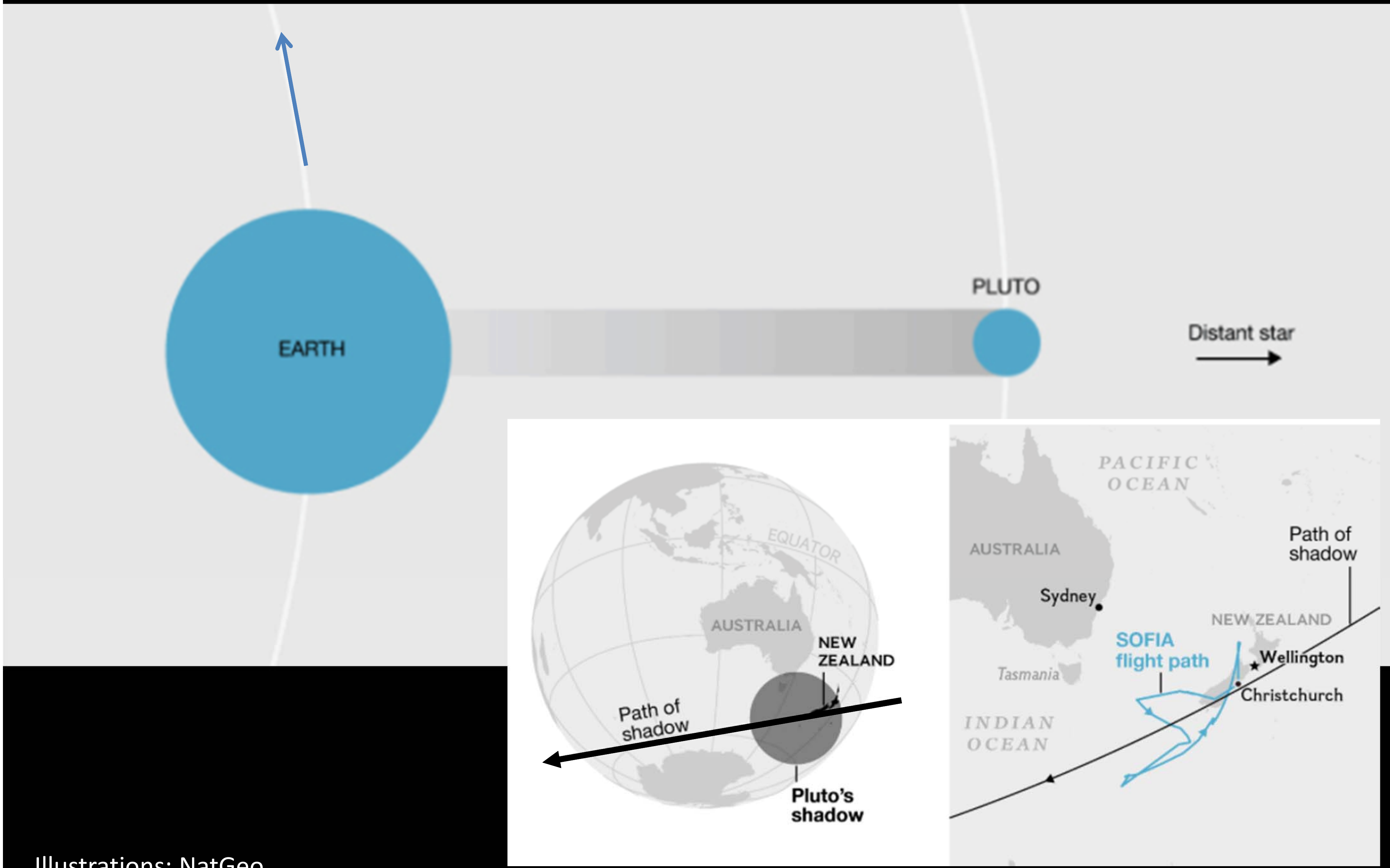
Stratospheric Observatory for Infrared Astronomy (SOFIA)

- Pluto passed directly between a distant star and the Earth on June 30, New Zealand time (June 29 in U.S.)
  - Shadow sweeps across the Earth at ~53,000 mph
  - Precise path determined by ground-based observations
- SOFIA is the only observatory capable of positioning itself above terrestrial weather and in Pluto's shadow
  - Observed the occultation for 90 seconds
  - Purpose: Determine pressure and temperature at various altitudes in the atmosphere and about possible haze layers

Boeing 747SP jetliner modified to carry a 100-inch (2.5-meter) diameter telescope

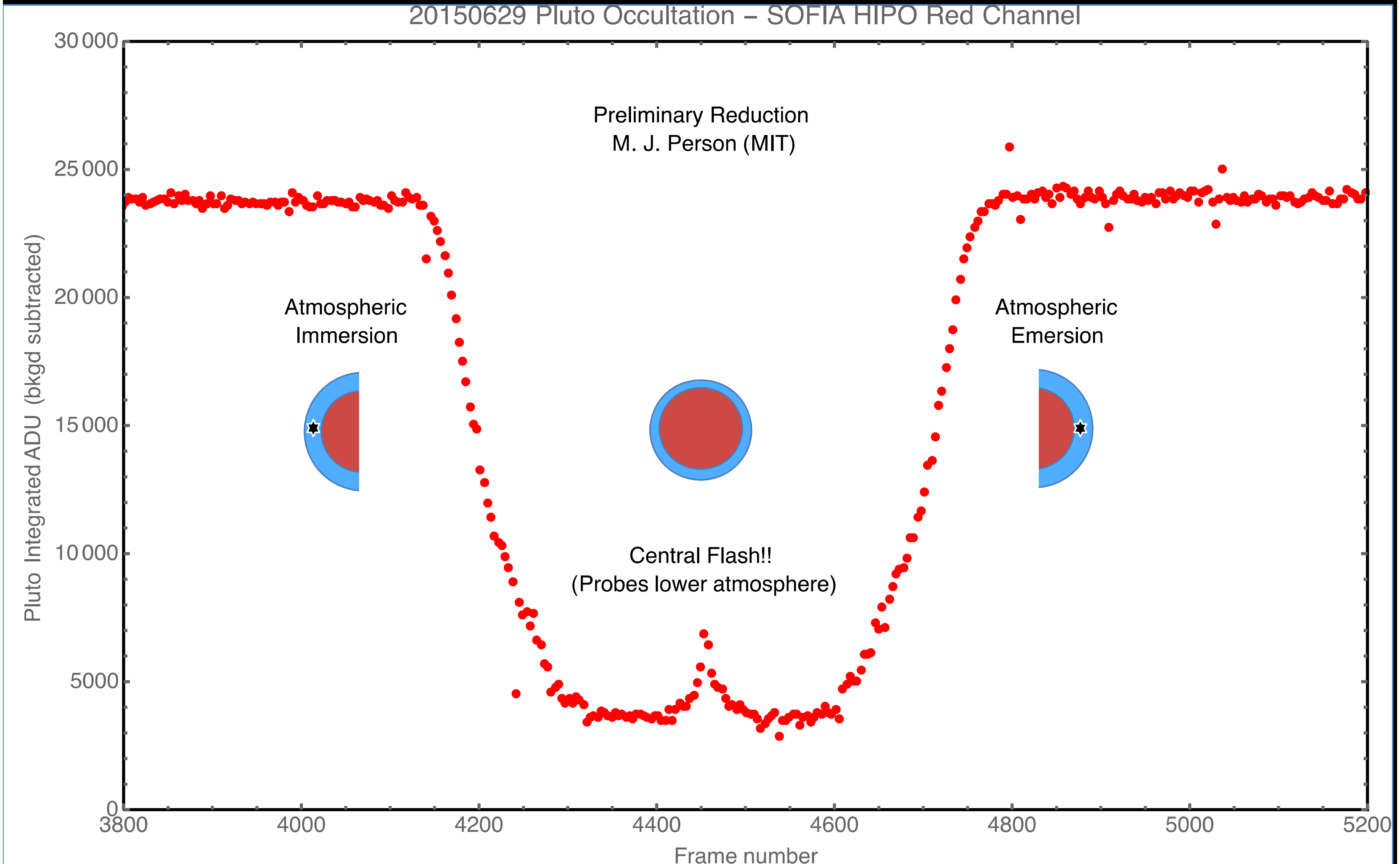
NASA/DLR

Pluto Occultation



Illustrations: NatGeo

Pluto Occultation Data



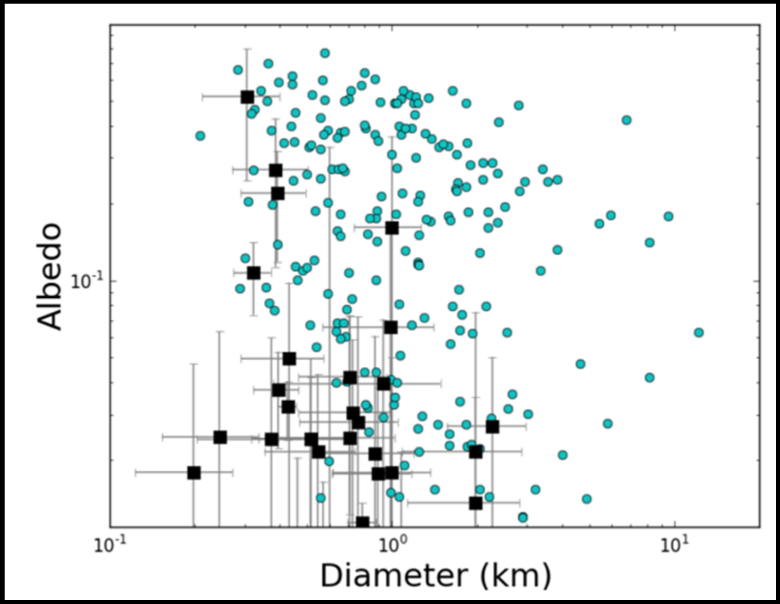
NEOWISE Going Strong!

- Reactivated in Dec 2013, NEOWISE is observing, discovering, and characterizing asteroids & comets at 3.4 and 4.6 μm

- ~13,200 minor planets observed, including 343 near-Earth objects (NEOs) and 53 comets.
  - 180 discoveries, including 60 NEOs and comets.
  - NEO discoveries tend to be large, dark

- First data delivery from Reactivation began in March 2015 to astro's infrared science archive (IRSA)

http://irsa.ipac.caltech.edu/Missions/wise.html



Ground Breaking Solar System Science - K2

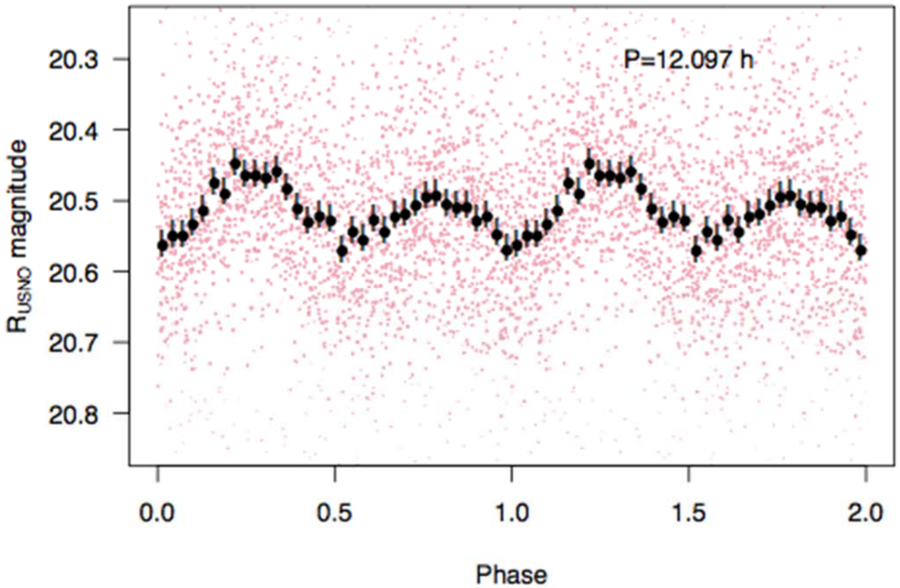
- K2 Opportunities For Solar System Observations.
  Possible Targets: Slow Moving Sources
  Major Planets Between V=4 and 20
  K2 has a funded GO program accepting proposals twice a year.

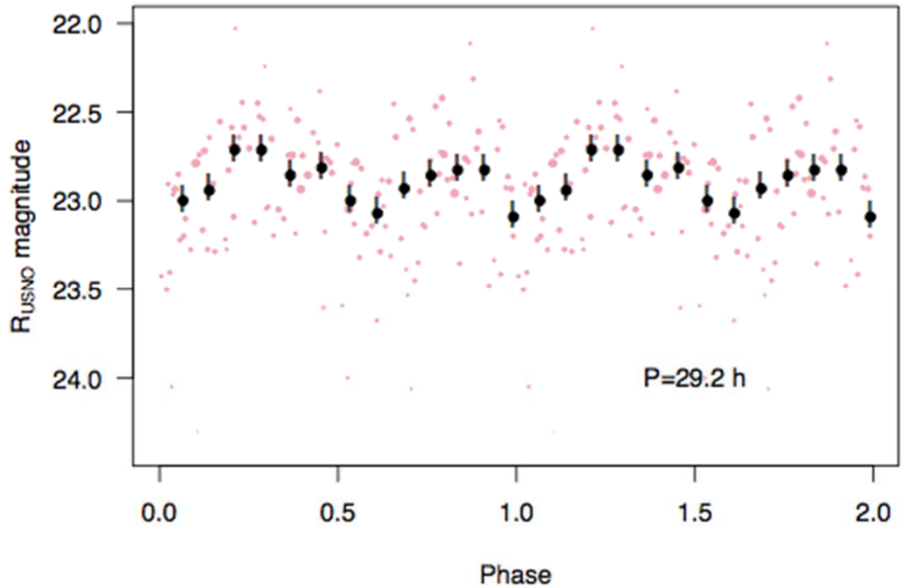
K2 photometric observations of the Trans-Neptunian Objects:
A. Pál *et al.* 2015 *ApJ* 804 L45 (doi:10.1088/2041-8205/804/2/L45)

Measure rotational periods and amplitudes in the unfiltered K2 band as follows:
(278361) 2007 JJ43 ➔ P_rot=12.097 hr ➔ Total Amplitude = 0.1 mag
2002 GV31 ➔ P_rot=29.2 hr ➔ Total Amplitude = 0.35 mag

"…the brightest TNOs around their stationary points in each observing campaign [are used] to exploit this unique capability of the K2 Mission -- and therefore to provide unbiased rotational, shape and albedo characteristics of many objects."

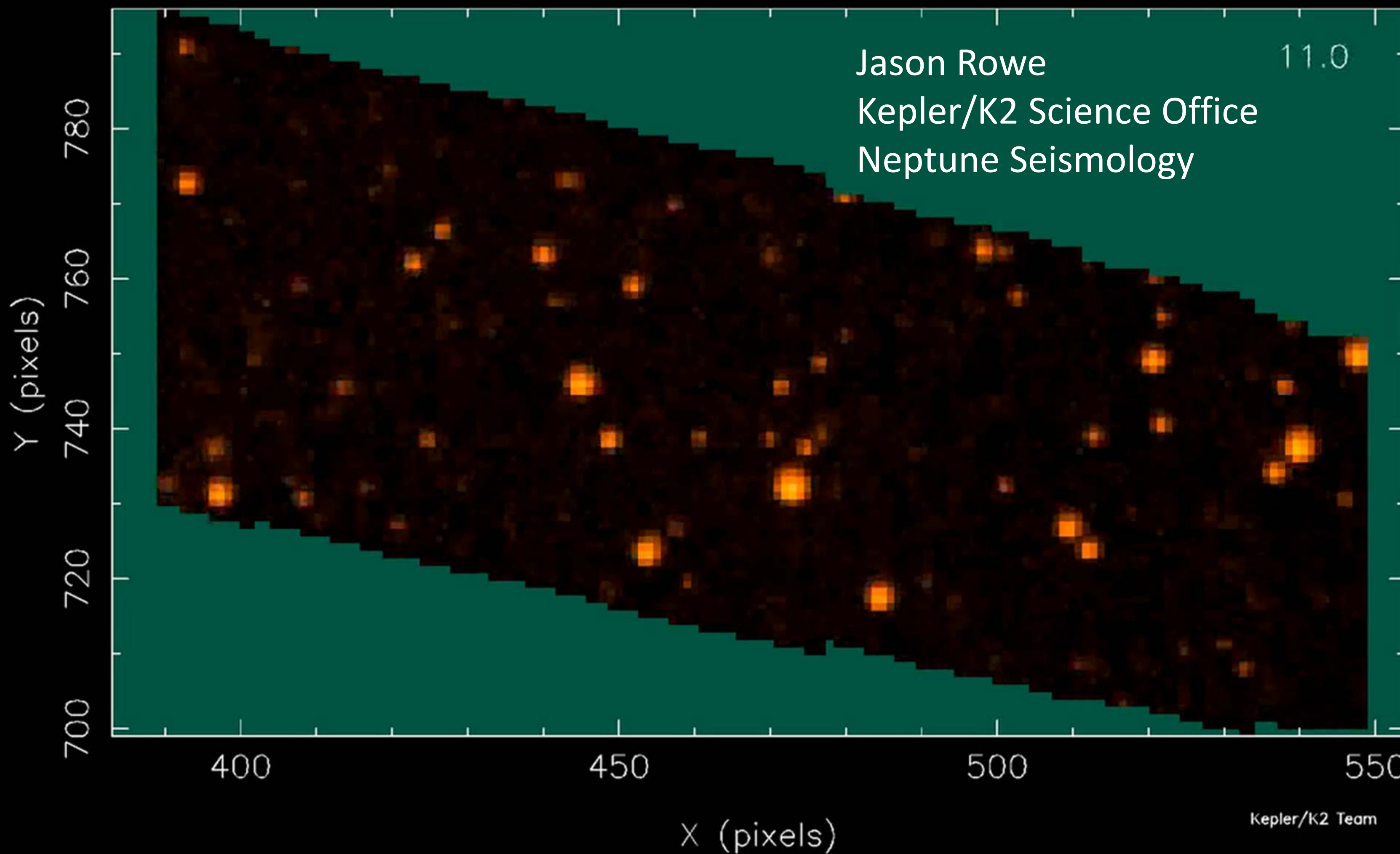
K2 light curves: TNO's 2007 JJ43 & 2002 GV31



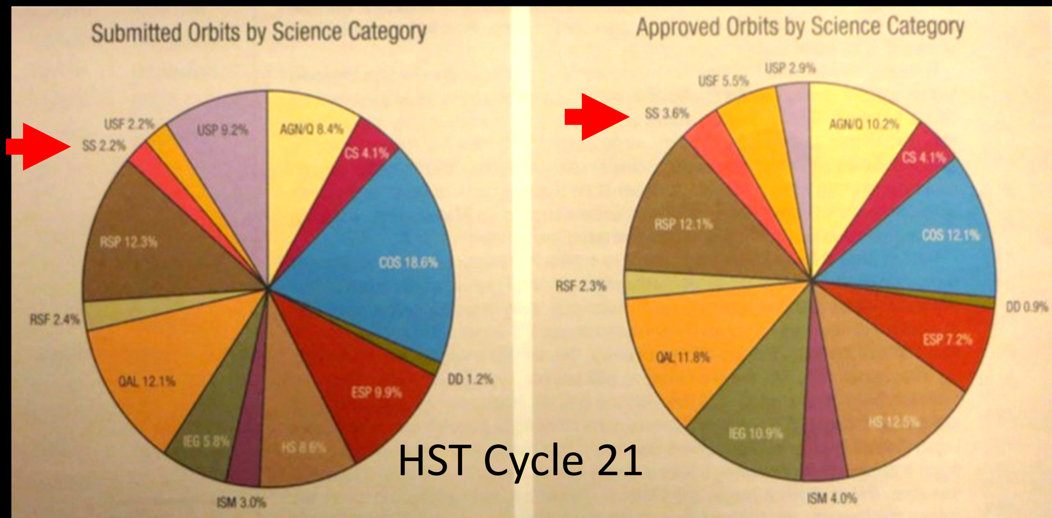


(Pal et al., 2015 in press)

K2 Mission Catches Neptune



Planetary Science and HST



- Proposal pressure matters!
- Cycle 22: 3% submitted were planetary; Planetary obtained 11% of the approved
  - Medium and Large SS programs needed, fare particularly well…
- Solar system astronomy fairs reasonably well
- Diverse/unique proposals help boost selection stats

HST surveys approved:

- NH KBO (3 found)
- Europa plumes
- DD program to execute every year until the end of mission:
  - Two global maps each for Jupiter, Uranus, Neptune and Saturn (starting after end of Cassini).
  - A total of 29 orbits/yr for Cycles 22-24, 41 orbits per Cycle thereafter.

More planetary proposals to HST are encouraged!

Spitzer Cycle-11 Overview

- 157 proposals received – 41,970 hours!
  - 137 proposals in Cycle-10 – 31,817 hours
- Oversubscription of ~5.4

- 15 proposals – twice as many as Cycle-10
- 5 times the hours requested in Cycle-10
- Planetary observations are ~10% of the total time available

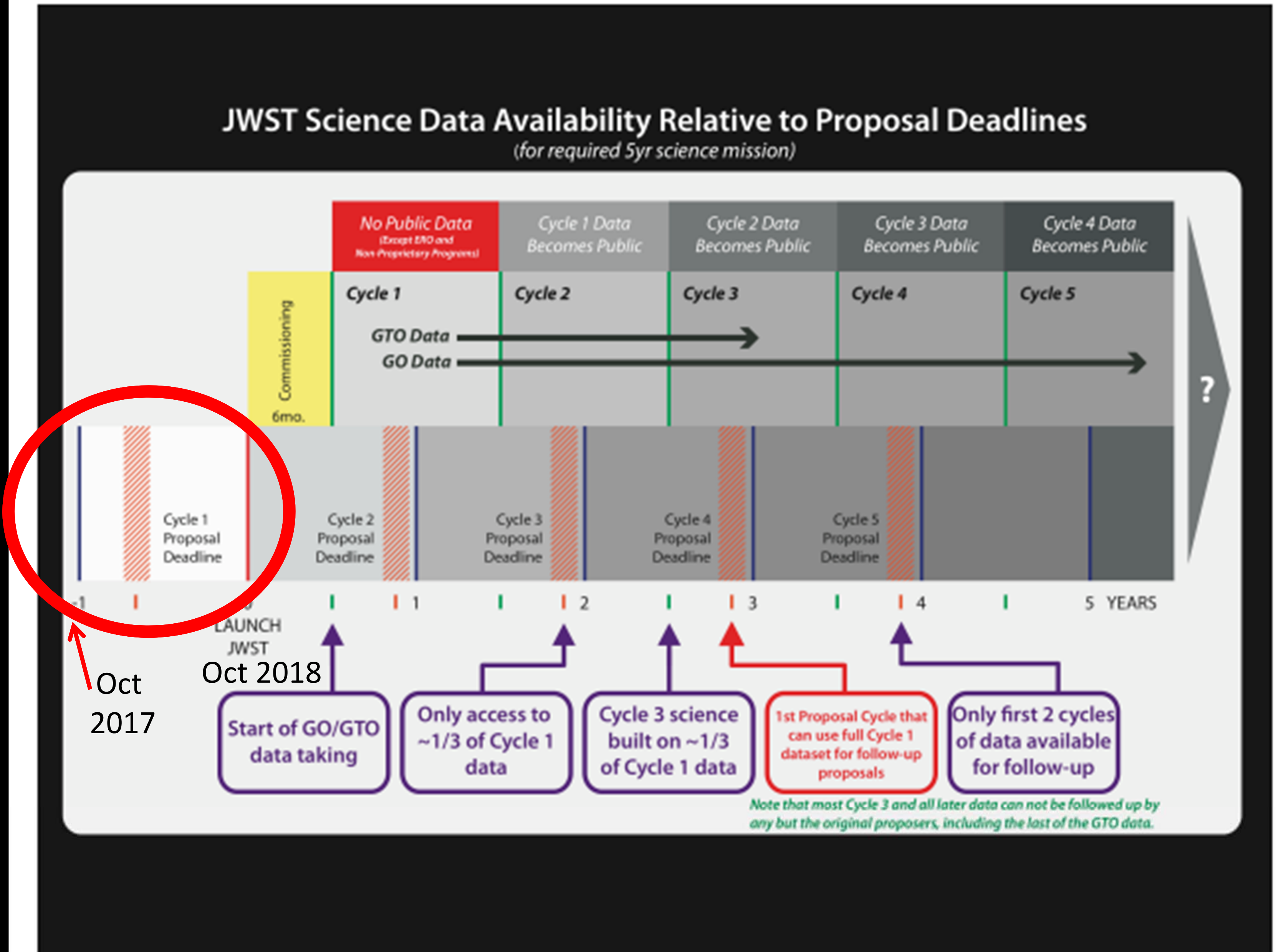
SciCat	Number	Hours
SOLAR SYSTEM		
asteroids	5	142.3
comets	4	597.8
KBO	2	44.3
NEO	2	2710.1
satellites	2	19.7
Total	**15**	**3514.2**

Call for Spitzer Planetary Proposals

Initiatives that will significantly enhance Spitzer's planetary science legacy from the next years of observations.

- The schedule for the Cycle-12 call for proposals is
  - June 5 - released the CP
  - Sept 11 - proposals due
  - Oct 30 - release results
  - December - start observations

- Questions can be addressed to Doris Daou (*Doris.Daou@nasa.gov*) or Lisa Storrie-Lombardi (*lisa@ipac.caltech.edu*)



GDI – 11/04/09 JSTAC
(with 7-8 months between proposal deadline and start of science observations)

Initiate New Studies

National Academy R&A Study

Objective: Examine the program elements of the PSD R&A programs, as they currently exist following restructuring, for their consistency with past NRC advice.

The committee will address the following questions:

1. Are the PSD R&A program elements appropriately linked to, and do they encompass the range and scope of activities needed to support, the NASA Strategic Objective for Planetary Science and the PSD Science Goals, as articulated in the 2014 *NASA Science Plan*?

2. Are the PSD R&A program elements appropriately structured to develop the broad base of knowledge and broad range of activities needed both to enable new spaceflight missions and to interpret and maximize the scientific return from existing missions?

Ice Giants Study

- Initiate an Ice Giants Study assigned to JPL
- Goal: Assess science priorities and affordable mission concepts & options in preparation for the next Decadal Survey
- Objectives:
  - Identify mission concepts that can address science priorities based on what has been learned since the 2013-2022 Decadal
  - Identify potential concepts across a spectrum of price points
  - Identify enabling/enhancing technologies
  - Assess capabilities afforded by SLS

Study Ground-Rules

- Address both Uranus and Neptune Orbiters
- Target cost range NTE $2B (FY15$) per mission
- Technical aspects to investigate:
  - Determine pros/cons in using one spacecraft design for both missions (possibility of joint development of two copies)
  - Evaluate use of realistic emerging enabling technologies: distinguish mission specific vs. broad applicability
  - Constrain missions to fit on a commercial LV
  - Identify benefits/cost savings if SLS were available (e.g., time, trajectory…)
- Identify clean-interface roles for potential international partnerships
- Establish a Science Definition Team (SDT)

Questions?

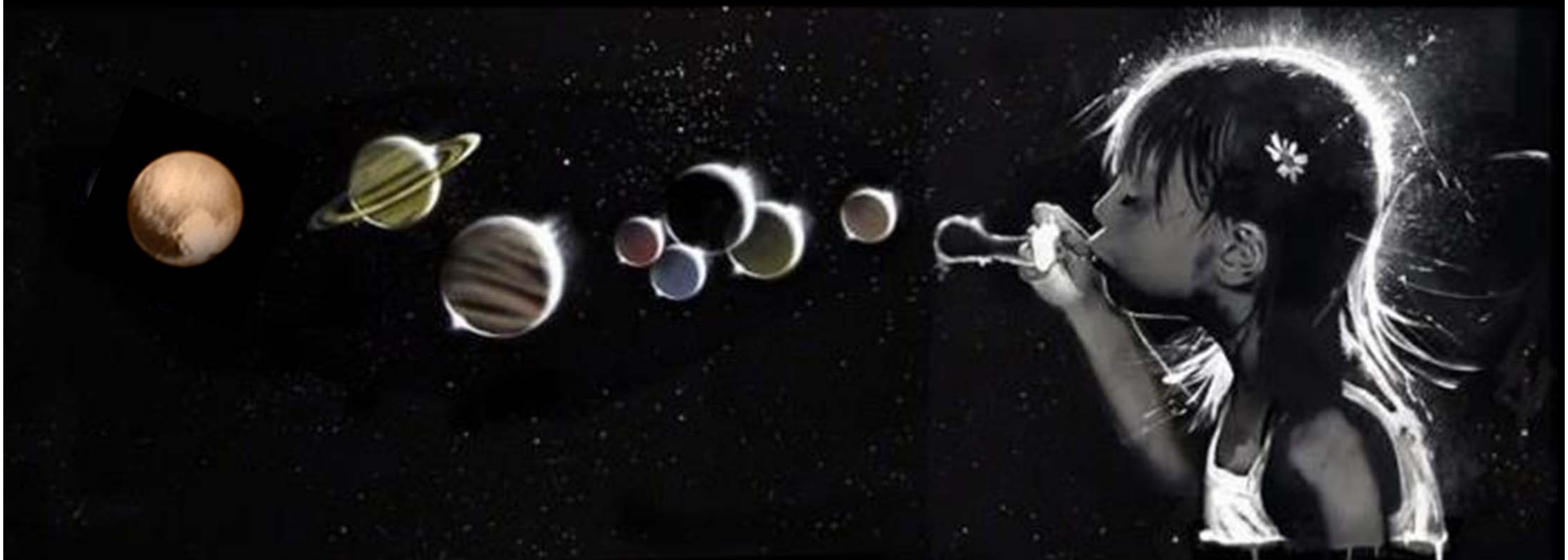


Image by john doe

RPS Mission Planning

Strategic / New Frontiers / Discovery / Mars / Lunar / Other	Projected Launch Year	Power Reqmnt (W_e)	RPS Type (Flight + Spare)	Pu-238 Availability
Mars Science Lab **Operational**	2011	100	1 MMRTG	Yes
Mars 2020 **In Development**	2020	120	1 MMRTG + Spare	Yes
New Frontiers 4 **In Planning**	2024	300	3 MMRTG or 2 eMMRTG	Yes
New Frontiers 5 **Notional**	2030	300	TBD	Requires new

- Potential 5-6 year-cadence for New Frontier mission opportunities
  - RPS not required for all mission concepts
- Radioisotope heater units may be used on missions that do not require RPS
- Strategic missions often require RPS; 2 highest priority strategic missions in current decadal (Mars 2020 and Europa) are already in work
  - Mars 2020 will us an MMRTG
  - Europa mission will be solar powered

RPS Budget and Technology Investments

$M	FY12	FY13	FY14	FY15	FY16
ASRG	$55.1	$56.2	$14.2	$1.2	$0.0
Stirling Cycle Tech Development	$5.8	$7.4	$4.5	$8.5	$8.7
Thermoelectric Tech Development	$4.4	$4.3	$3.5	$3.5	$3.3
MMRTG	$5.0	$3.0	$1.3	$4.7	$8.6
Multi-Mission Launch Approval E	$3.2	$5.4	$4.6	$1.8	$2.2
Studies/Sytems Eng/Safety	$3.7	$4.6	$3.3	$3.9	$3.8
Program Mgmt/E&PO/Misc	$5.5	$5.6	$5.6	$2.6	$3.2
Pu-238 Supply Project	$10.0	$10.0	$14.5	$17.0	$15.0
DOE Operations & Analysis			$51.3	$57.4	$57.3
Total	**$92.7**	**$96.6**	**$102.8**	**$100.6**	**$102.1**

FY 14 Budget reflects Congressional change to NASA funding of DOE infrastructure

Occultation if Pluto Had No Atmosphere