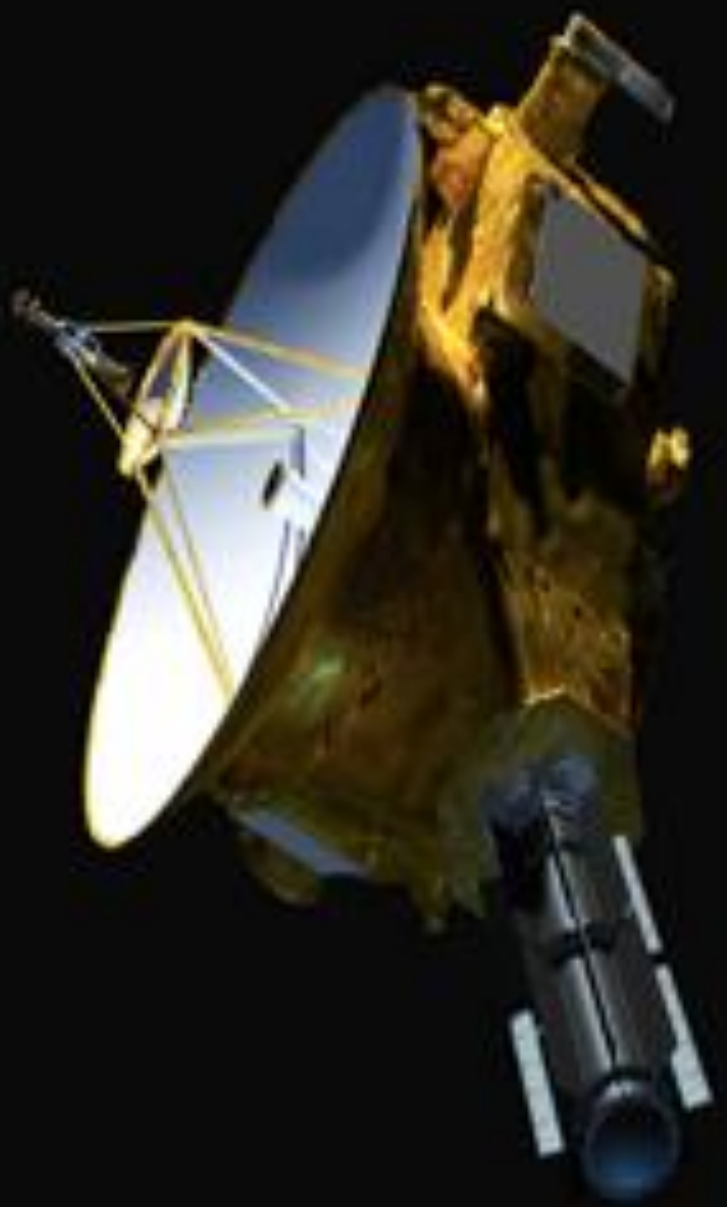
The Exploration of the Pluto System by New Horizons

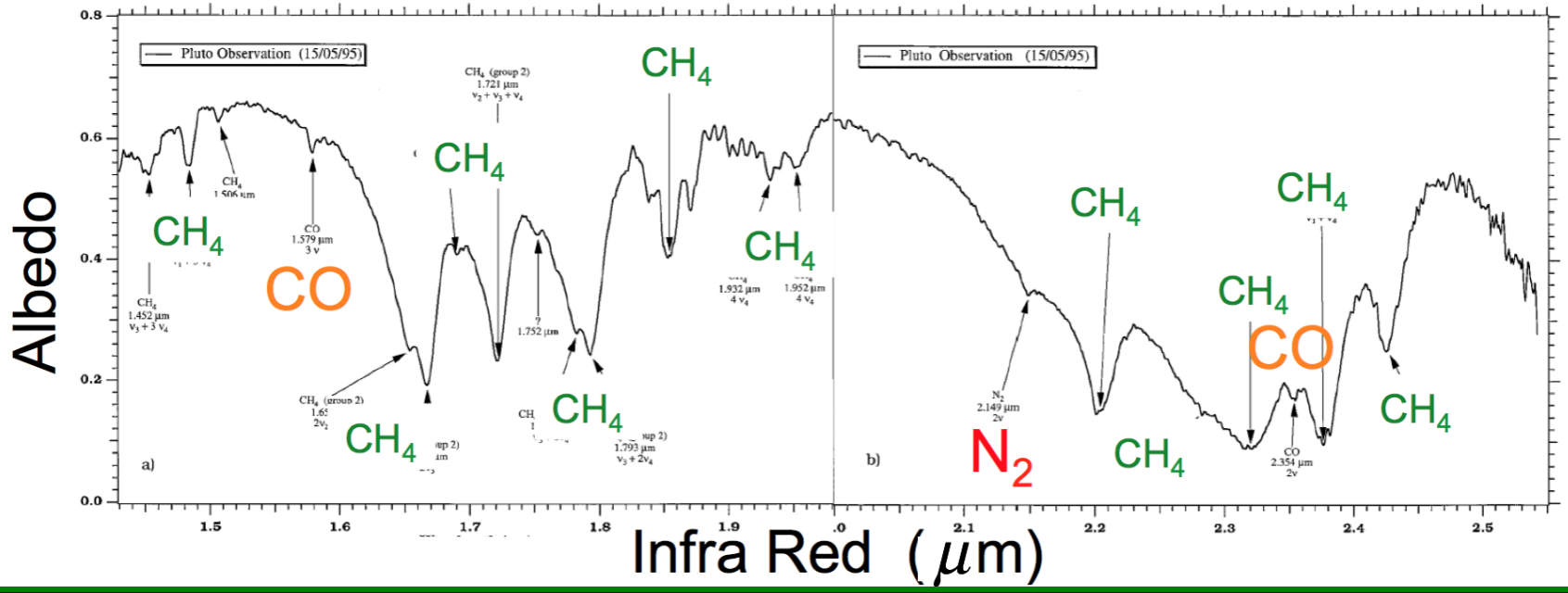
Alan Stern

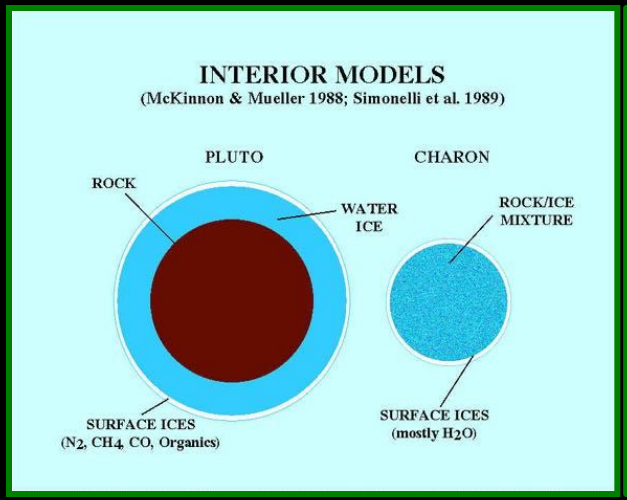
Mission History

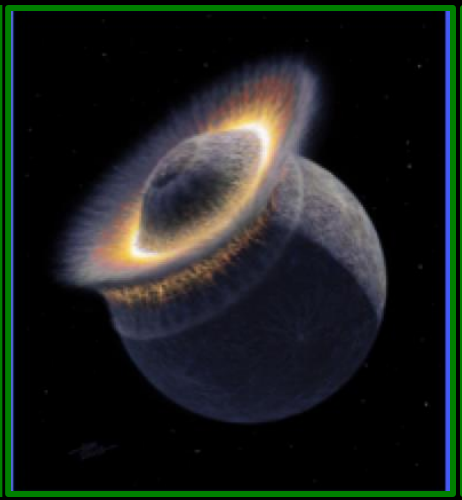
- 1990: Pluto 350
- 1991: Pluto Mariner Mark II
- 1992: Pluto Fast Flyby
- 1994: Pluto Express
- 1997: Pluto Kuiper Express
- 2001: New Horizons

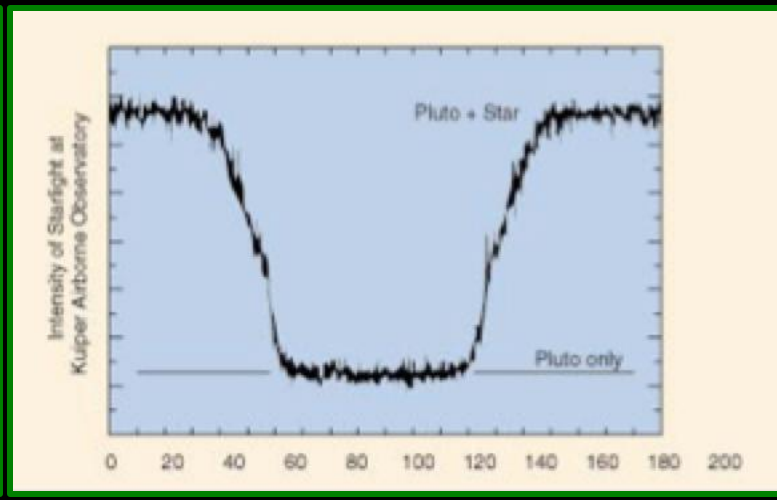


Pluto's Surface Composition Is Complex





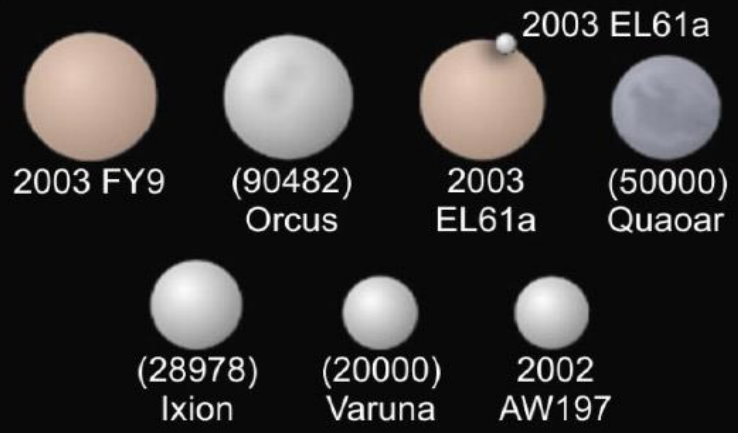




New View of the Solar System

- Third class of planetary body
- Dwarf planets most common type

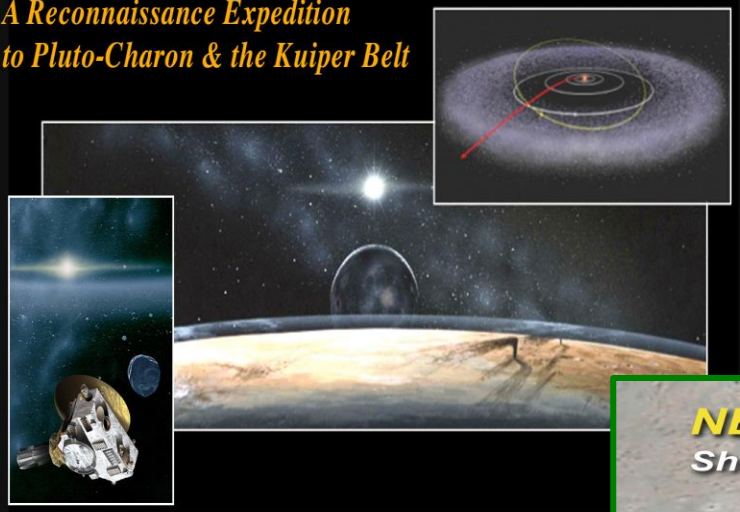
Kuiper Belt



Asteroid Belt

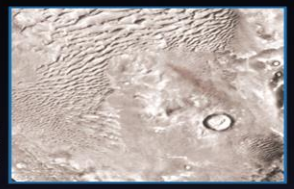
Highest Funding Priority Medium-Scale Mission
New Start of the 2003 Planetary Decadal Survey:

A Reconnaissance Expedition
to Pluto-Charon & the Kuiper Belt

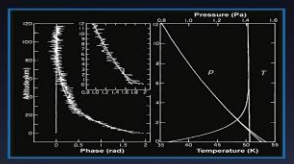


NEW HORIZONS:
Shedding Light on Frontier Worlds

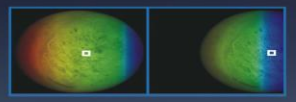
Global Mapping & High-Res Imagery



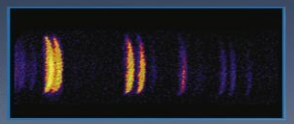
Radio Science Occultation, Gravity, & Radiometry



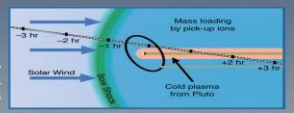
IR Surface Composition & Temperature Mapping



UV Airglow & Occultation Imaging Spectroscopy



In Situ Particles & Plasma Measurements



Concept Study Report for
the Pluto-Kuiper Belt Mission
NASA AO-OSS-01

Principal Investigator:
S. Alan Stern
Southwest Research Institute

PLUTO SYSTEM MEASUREMENT OBJECTIVES

Group 1 Objectives: Required

- Characterize the global geology and morphology of Pluto and Charon
- Map surface composition of Pluto and Charon
- Characterize the neutral atmosphere of Pluto and its escape rate

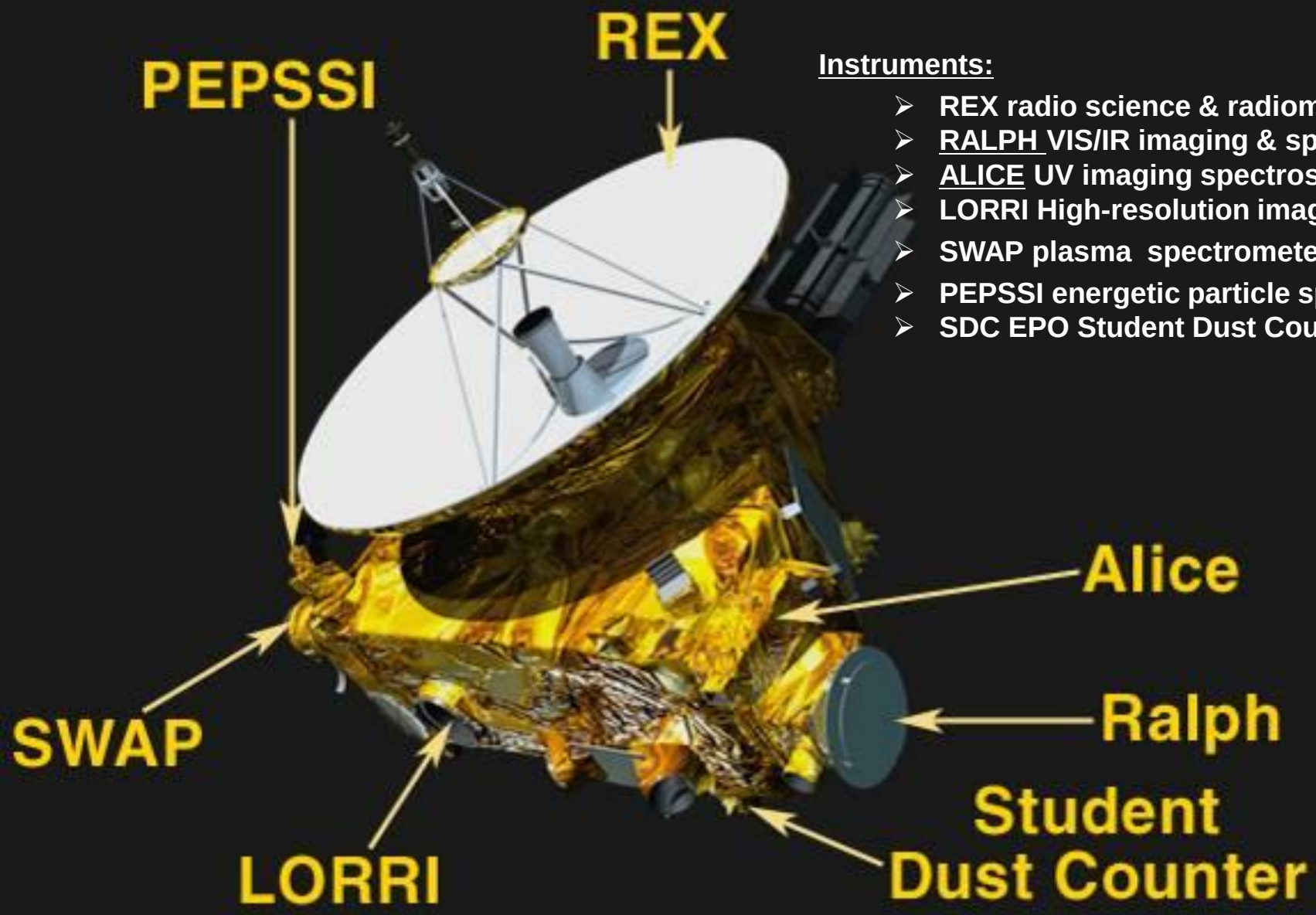
Group 2 Objectives: Important

- Characterize the time variability of Pluto's surface and atmosphere
- Image Pluto and Charon in stereo
- Map the terminators of Pluto and Charon with high resolution
- Map the composition of selected areas of Pluto & Charon at high resolution
- Characterize Pluto's ionosphere and solar wind interaction
- Search for neutral species including H, H_2, HCN, and C_xH_y, and other hydrocarbons and nitriles in Pluto's upper atmosphere
- Search for an atmosphere around Charon
- Determine bolometric Bond albedos for Pluto and Charon
- Map the surface temperatures of Pluto and Charon

Group 3 Objectives: Desired

- Characterize the energetic particle environment of Pluto and Charon
- Refine bulk parameters (radii, masses, densities) and orbits of Pluto & Charon
- Search for magnetic fields of Pluto and Charon
- Search for additional satellites and rings

THE SCIENTIFIC PAYLOAD

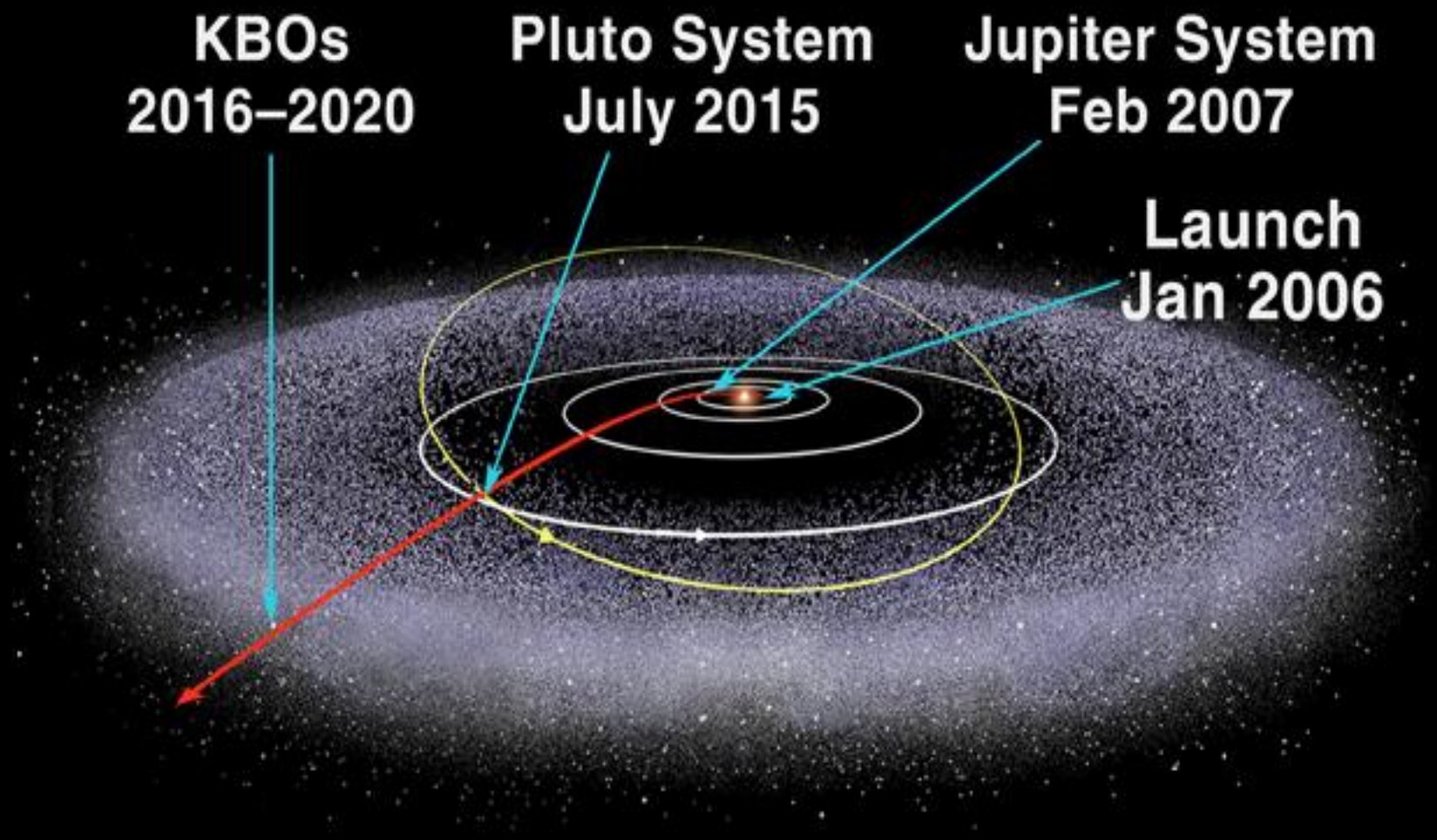


Instruments:

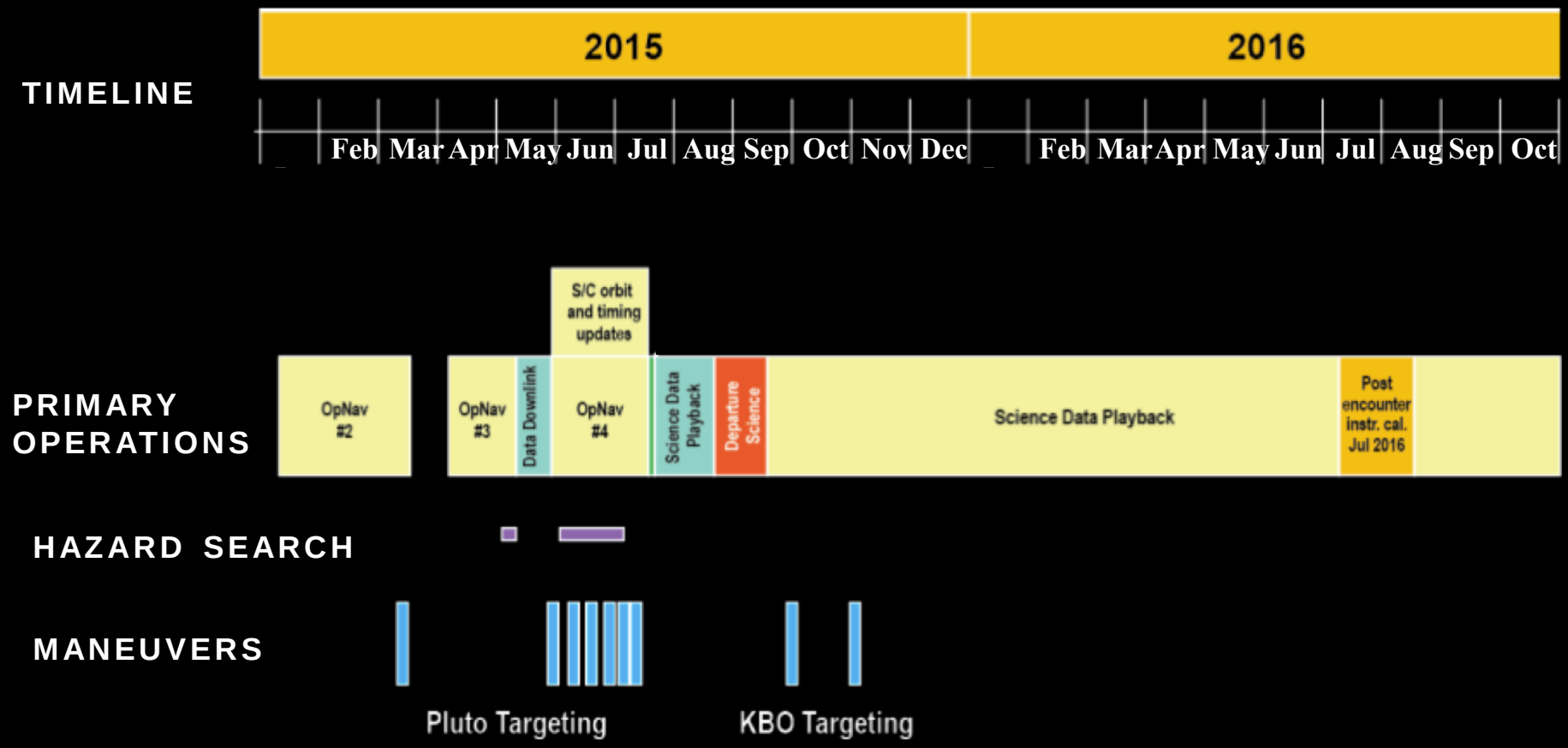
- REX radio science & radiometry
- RALPH VIS/IR imaging & spectroscopy
- ALICE UV imaging spectroscopy
- LORRI High-resolution imager
- SWAP plasma spectrometer
- PEPSSI energetic particle spectrometer
- SDC EPO Student Dust Counter

PRIMARY CHALLENGES

- Cost
- Development Schedule
- Launch Vehicle Development
- Instrument Miniaturization
- Nuclear Launch Approval


KBOs
2016–2020
Pluto System
July 2015
Jupiter System
Feb 2007
Launch
Jan 2006

ENCOUNTER OVERVIEW

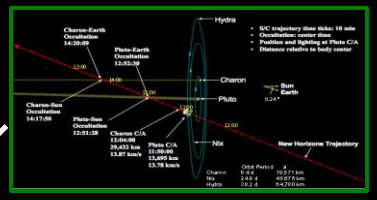


ENCOUNTER OVERVIEW

TIMELINE

2015 2016

Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Feb Mar Apr May Jun Jul Aug Sep Oct



S/C orbit and timing updates

PRIMARY OPERATIONS

OpNav #2 | OpNav #3 | Data Downlink | OpNav #4 | Science Data Playback | Departure Science | Science Data Playback | Post encounter instr. cal. Jul 2016

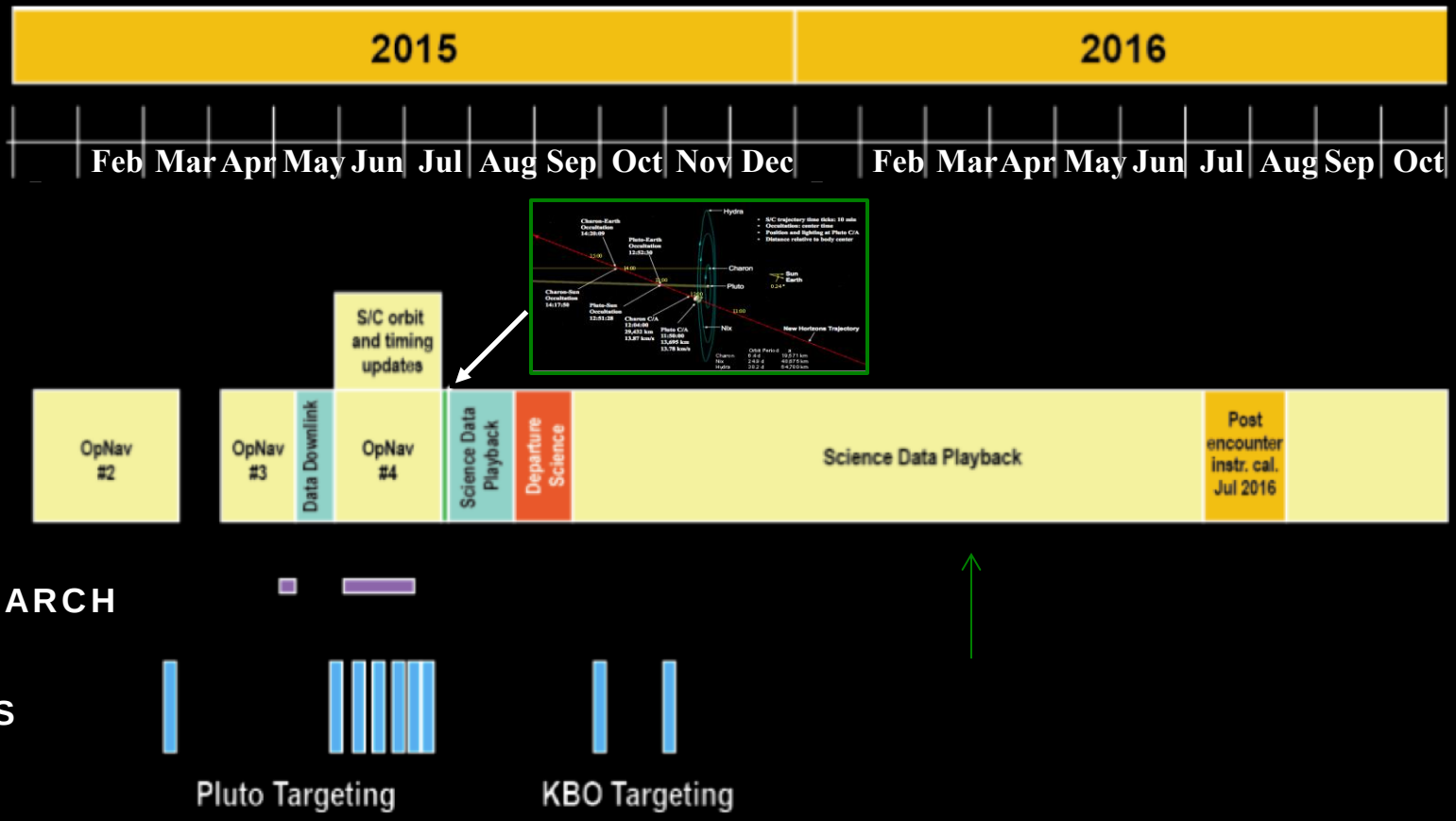
HAZARD SEARCH

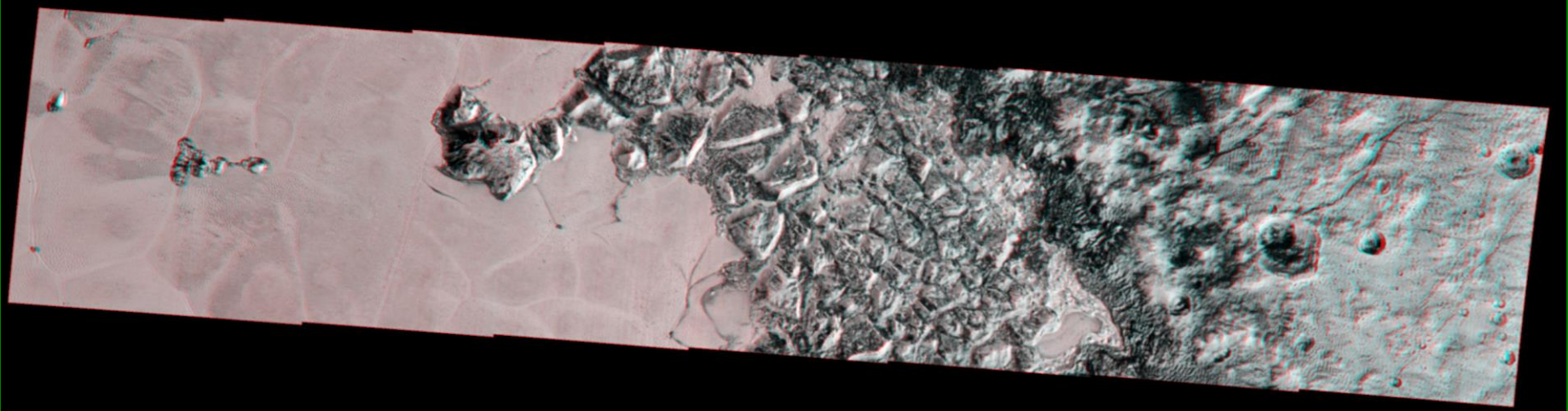
MANEUVERS

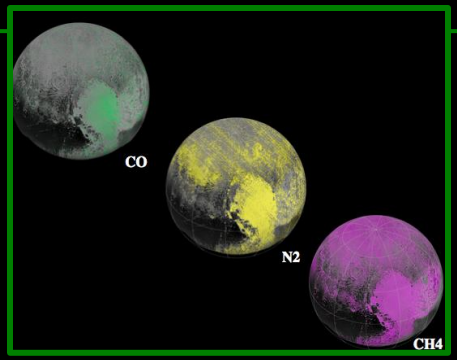
Pluto Targeting

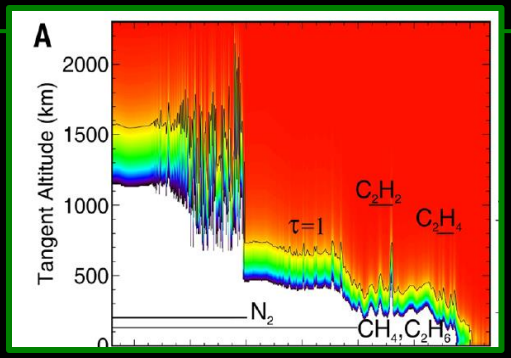
KBO Targeting

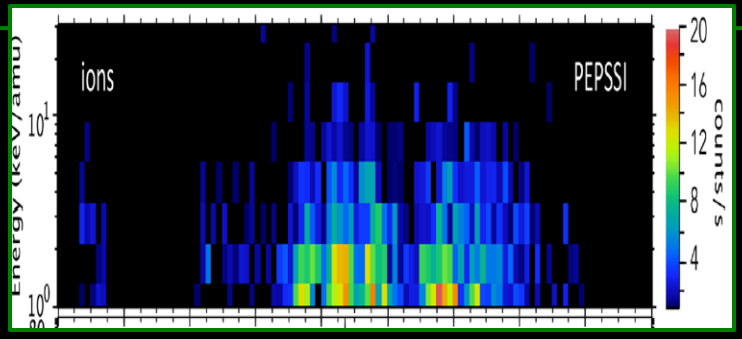
ENCOUNTER OVERVIEW

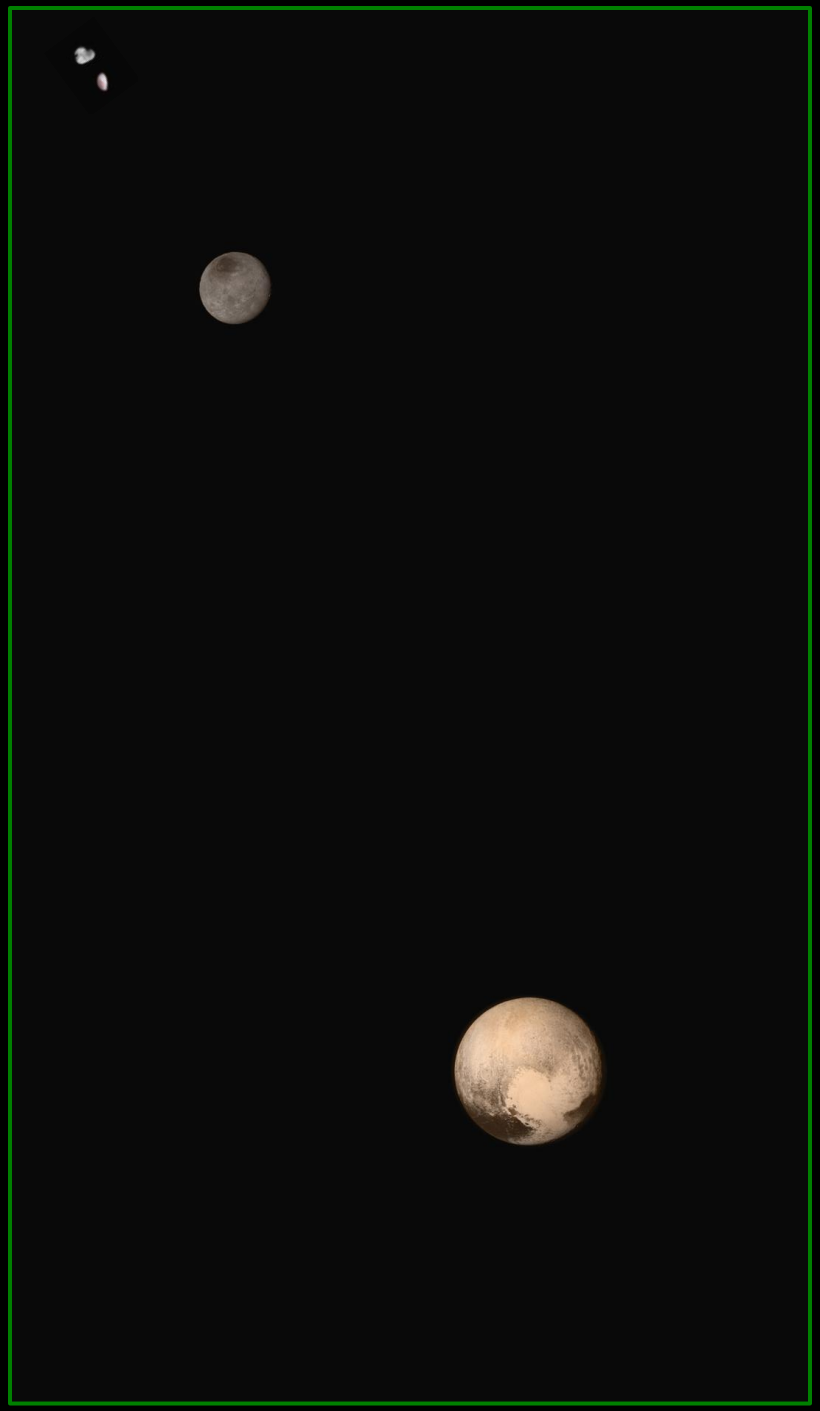




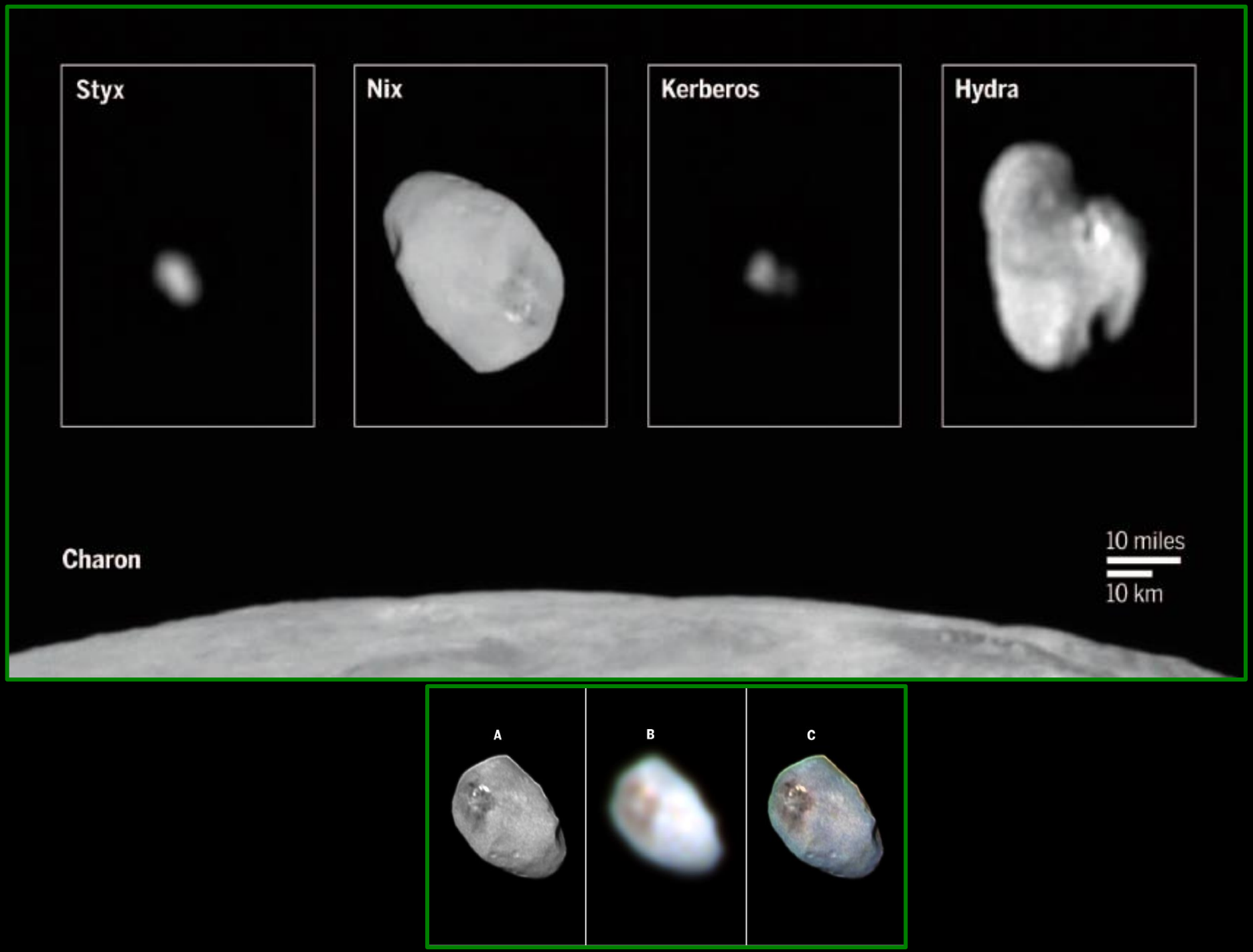

CO
N2
CH4


A
Tangent Altitude (km)
2000
1500
1000
500
0
τ=1
C_2H_2
C_2H_4
N_2
CH_4, C_2H_6

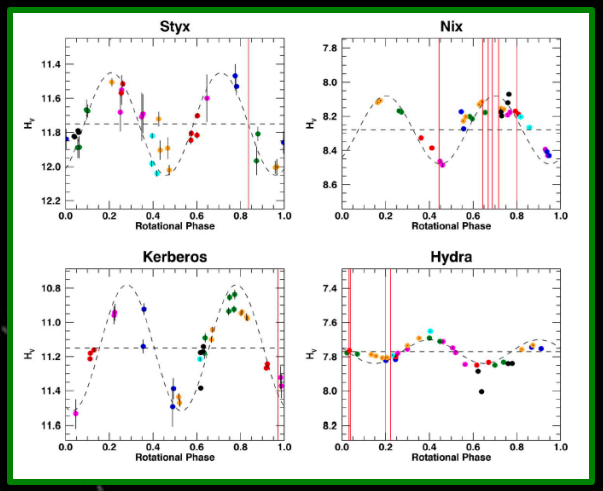

ions
PEPSSI
Energy (keV/amu)
10^{-1}
10^{0}
20
16
12
8
4
counts/s



All surface feature names in this talk and all others are informal.

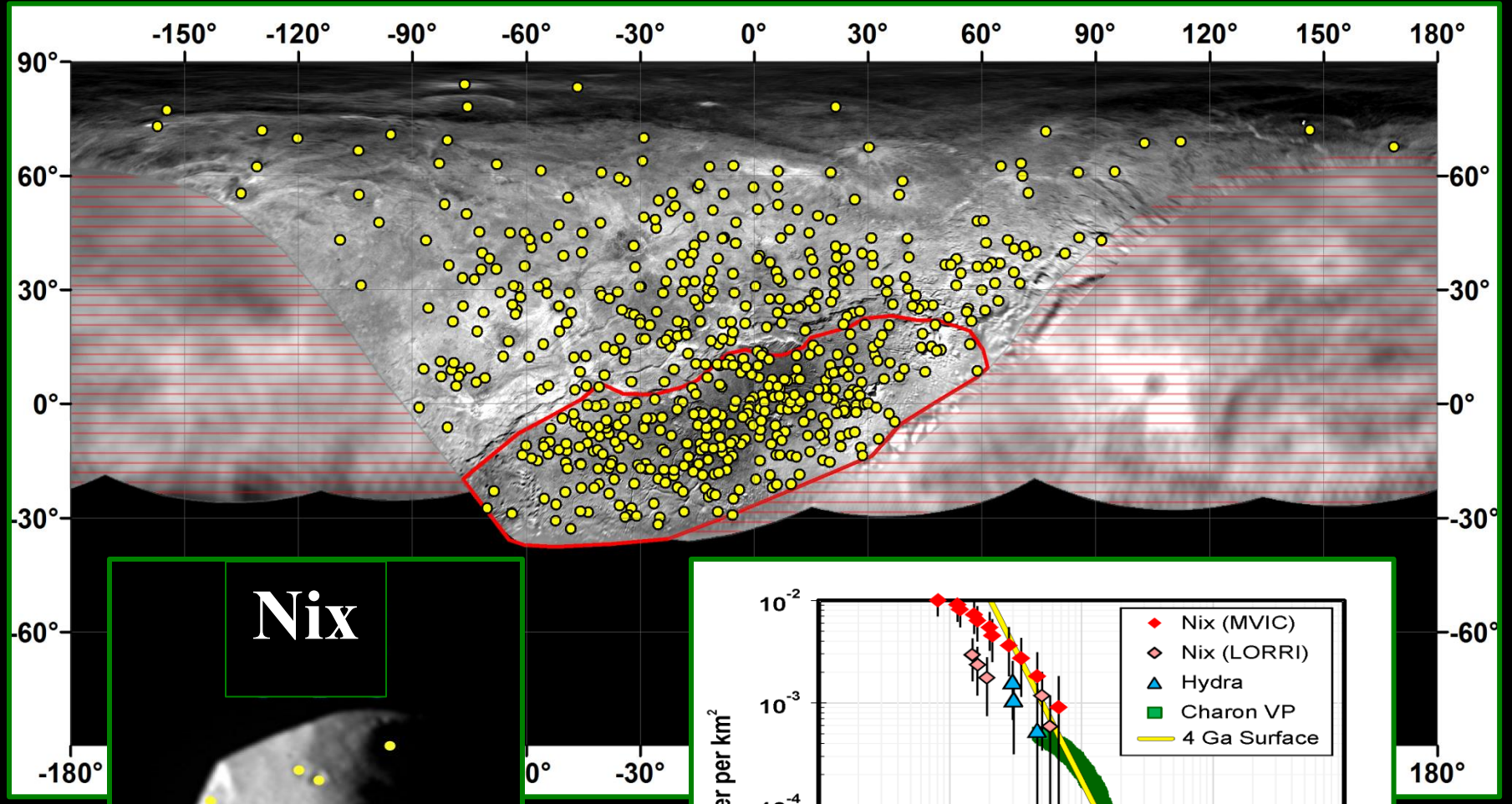

Styx
Nix
Kerberos
Hydra
Charon
10 miles
10 km

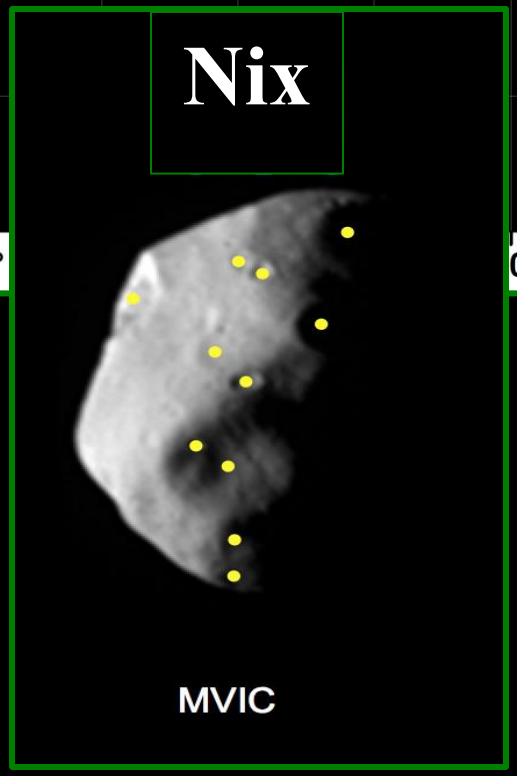
A
B
C

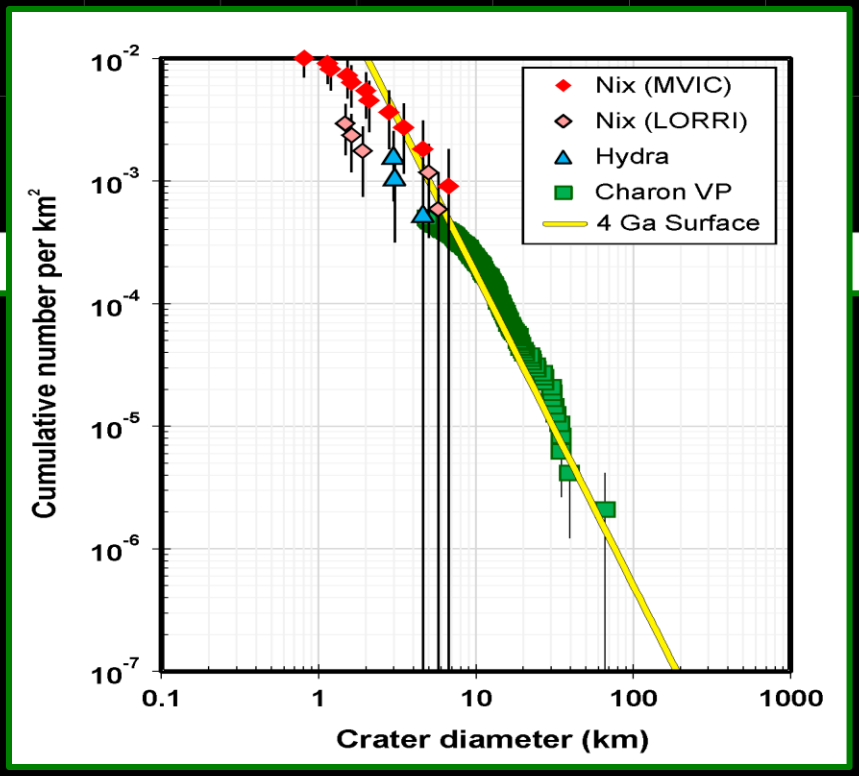


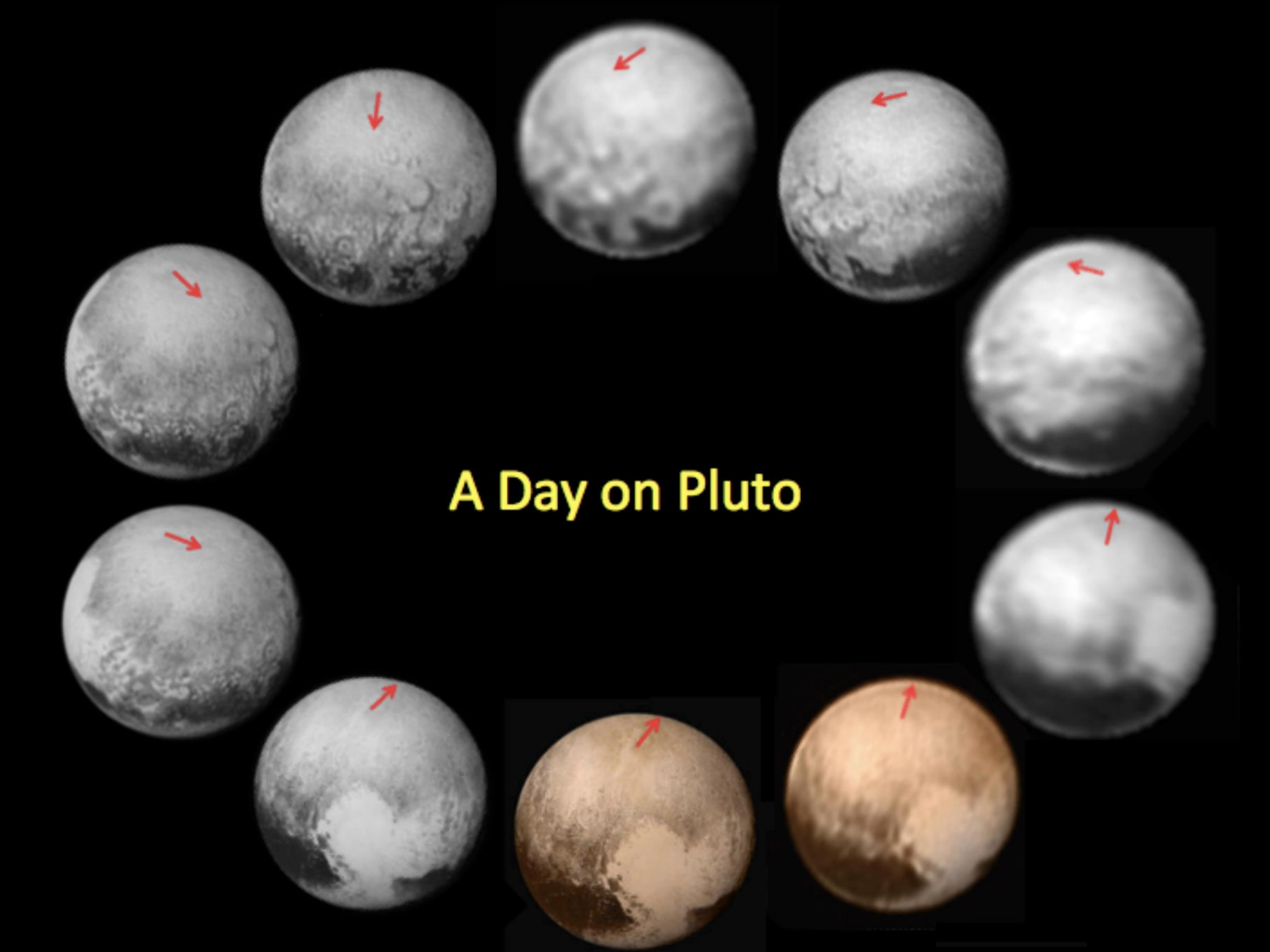
Body	Spin Period	
	Days	Orbits
Pluto	6.387	1
Charon	6.387	1
Styx	3.239	6.22
Nix	1.829	13.6
Kerberos	5.33	6.04
Hydra	0.4295	88.9

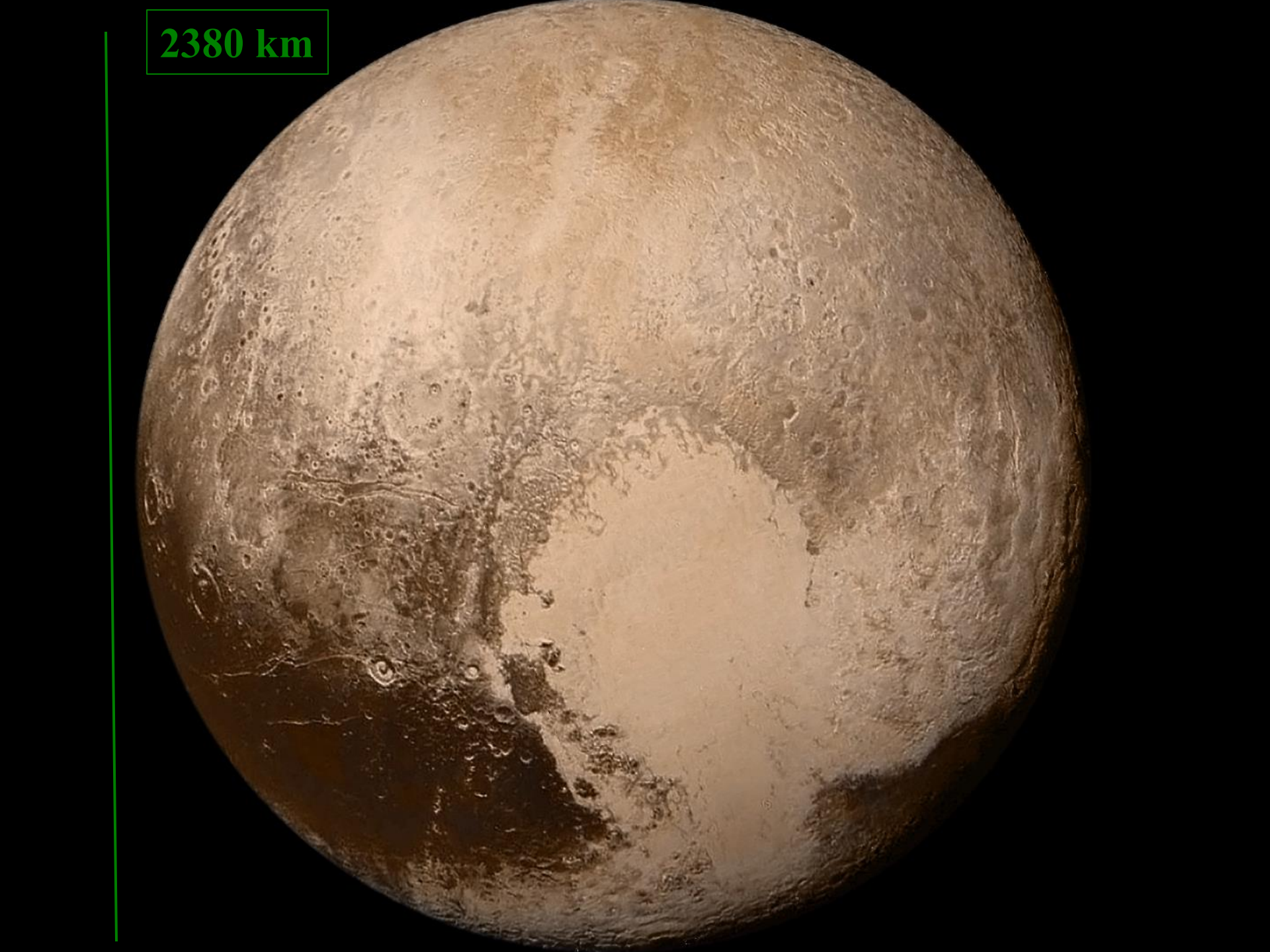
PLUTO'S SMALL SATELLITES ARE ALL NON-SYNCHRONOUS ROTATORS

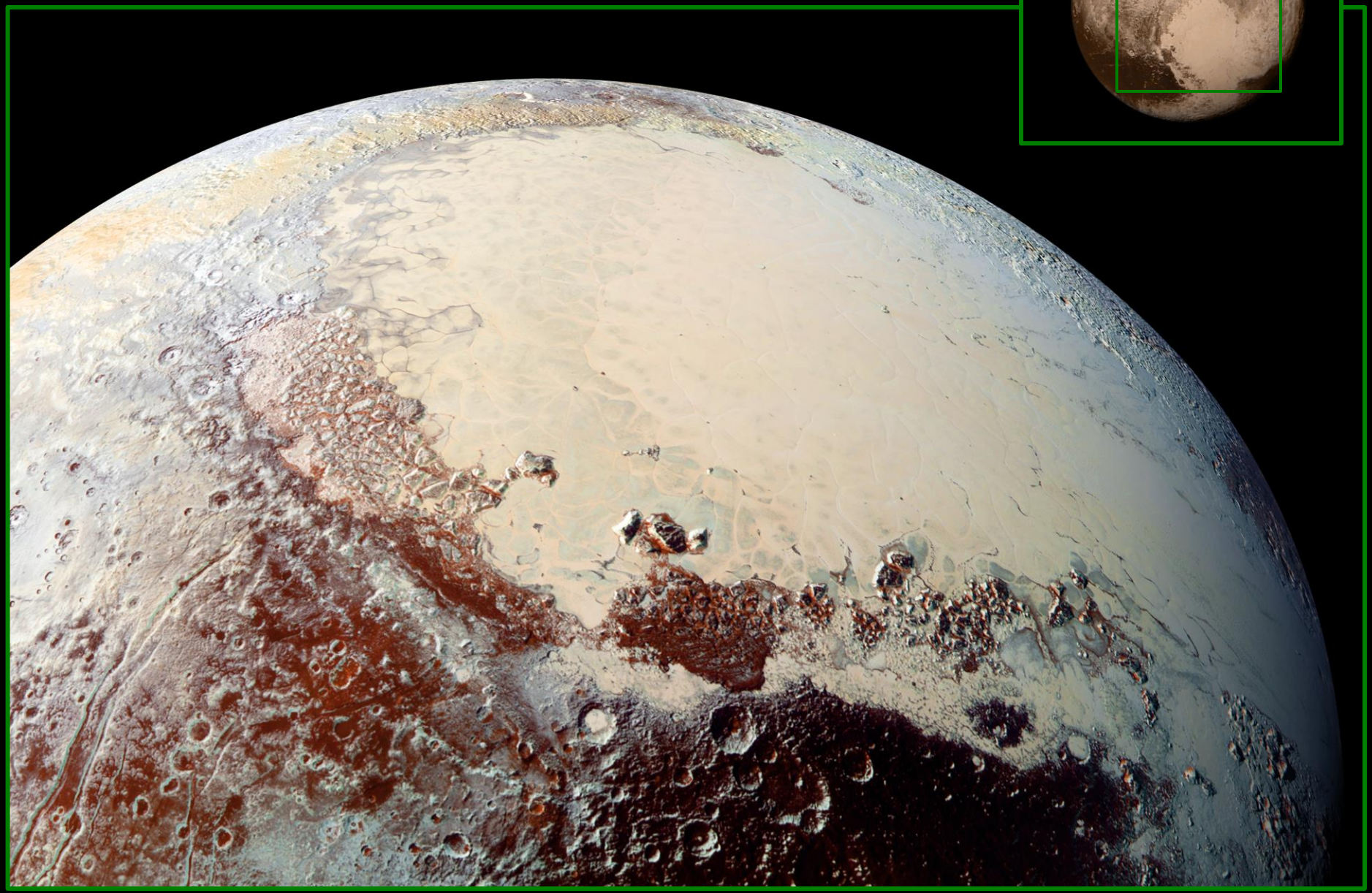

-150°
-120°
-90°
-60°
-30°
0°
30°
60°
90°
120°
150°
180°
90°
60°
30°
0°
-30°
-60°
-180°


Nix
MVIC

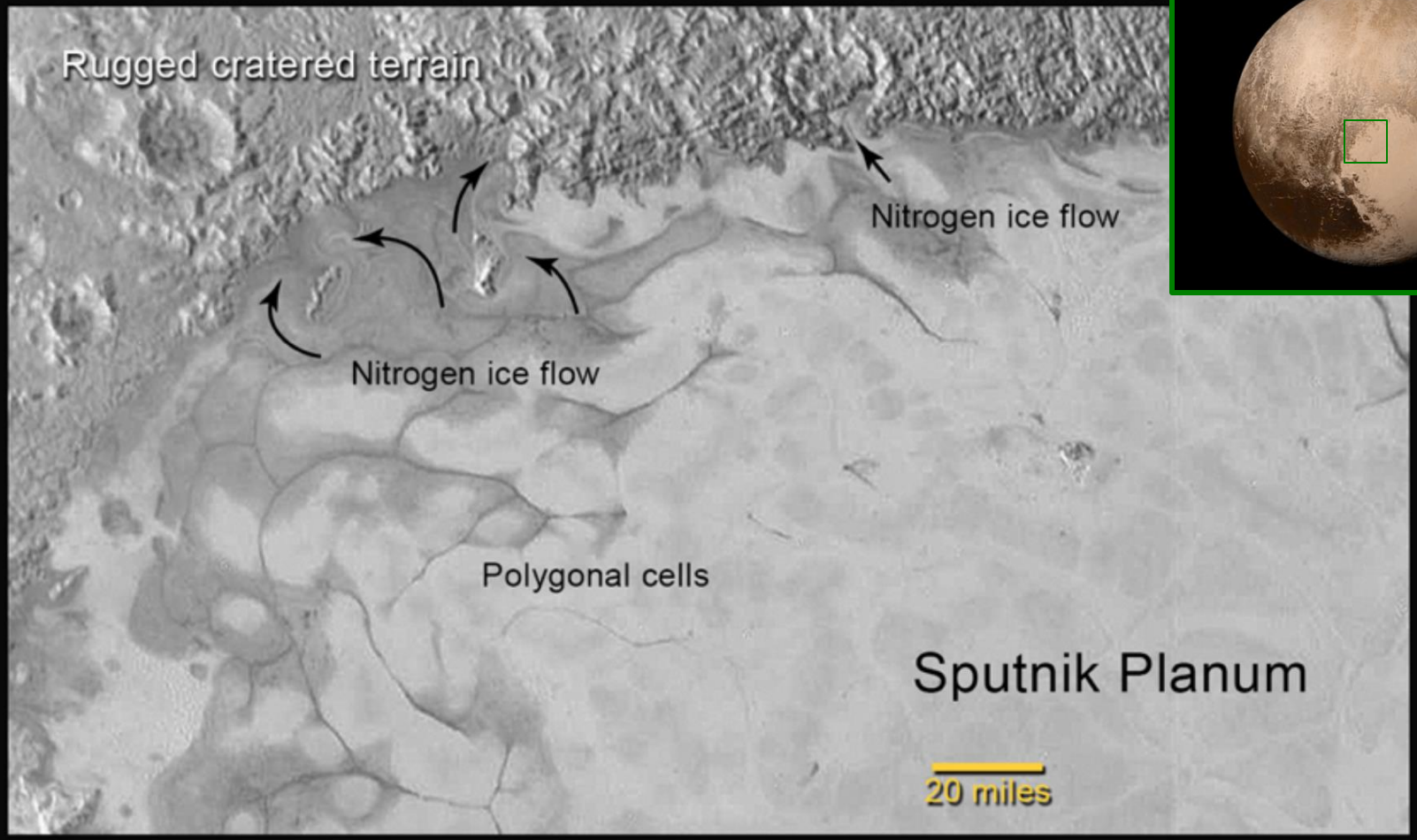

Nix (MVIC)
Nix (LORRI)
Hydra
Charon VP
4 Ga Surface
Cumulative number per km²
Crater diameter (km)
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
0.1
1
10
100
1000

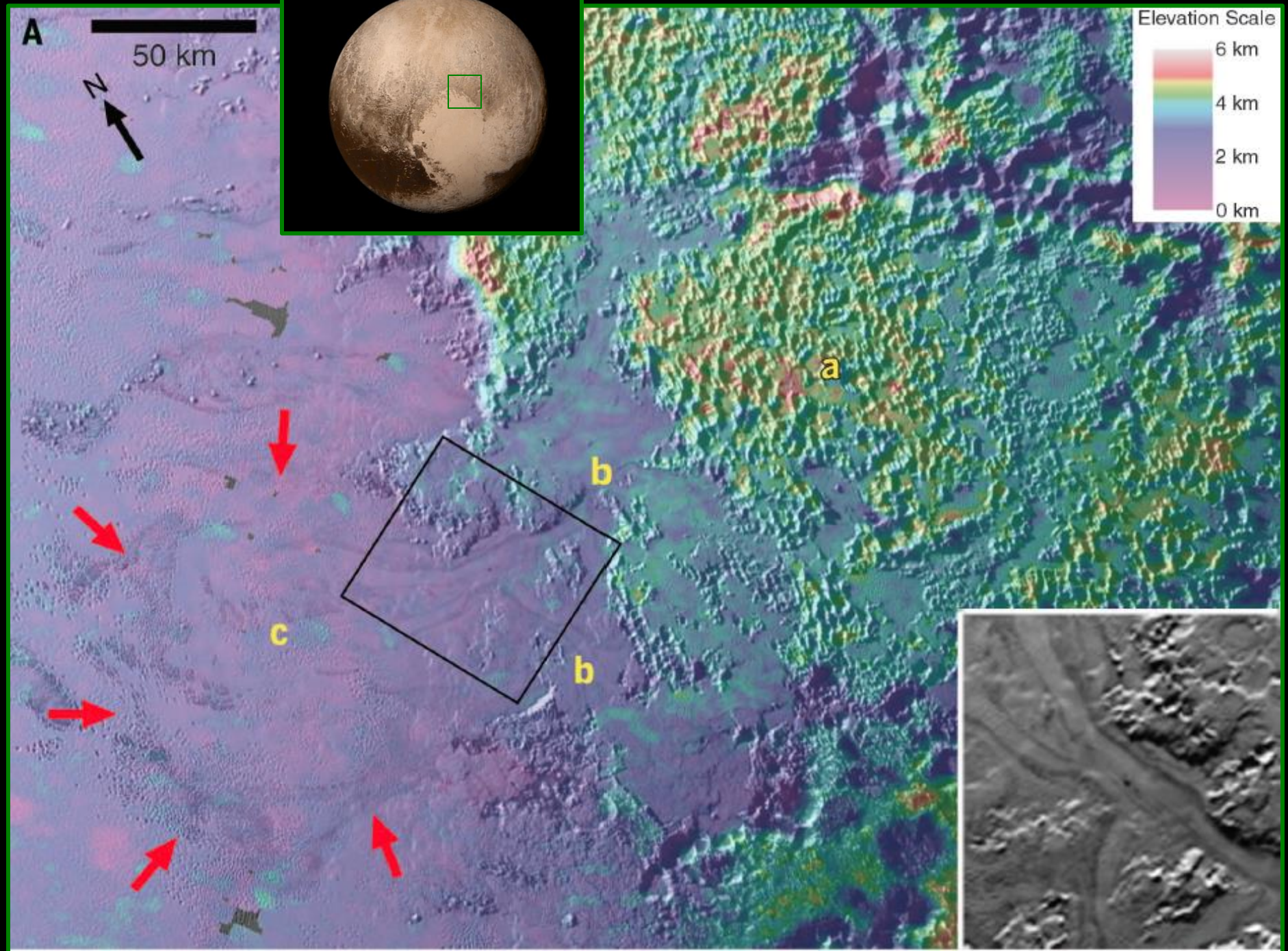

A Day on Pluto

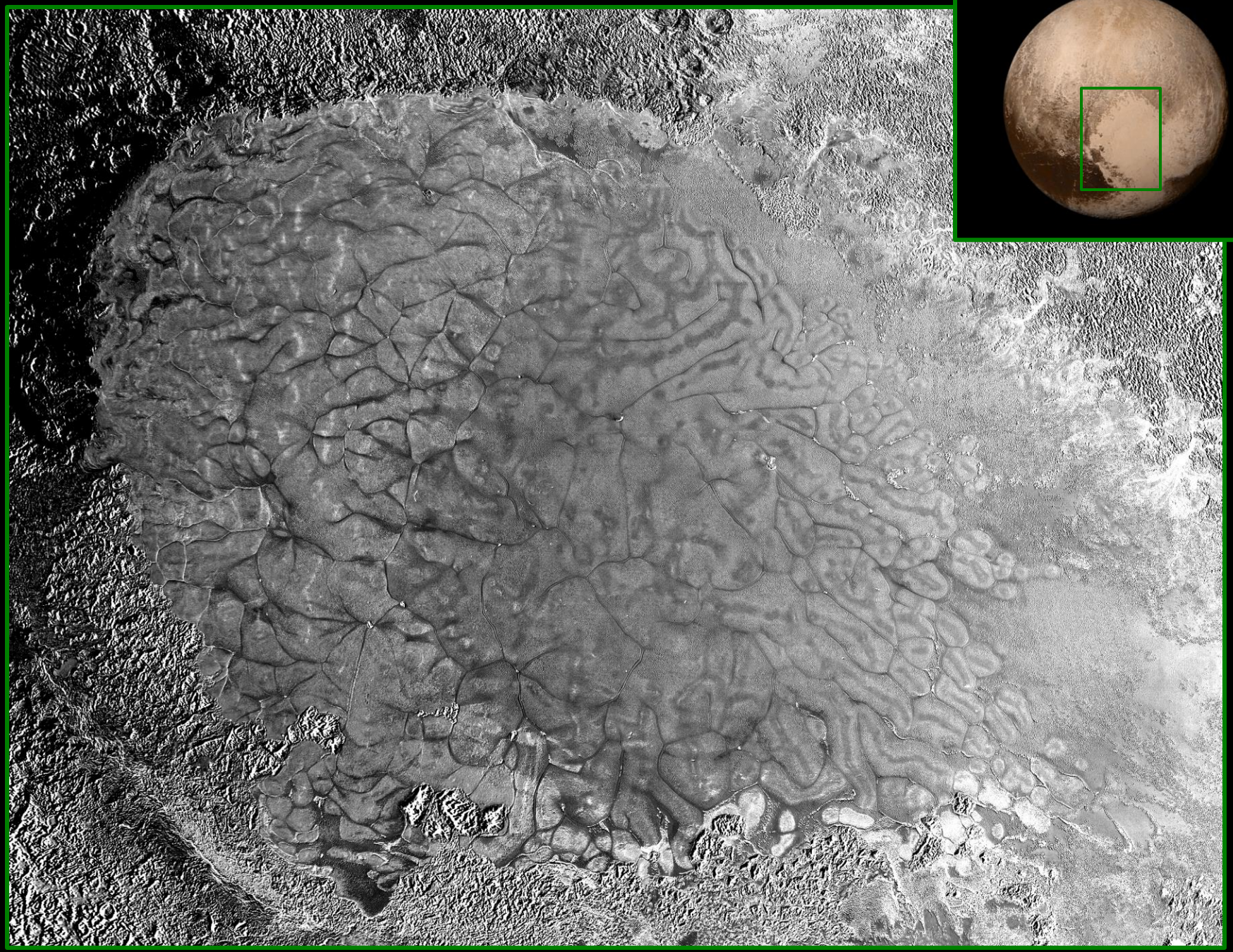

2380 km

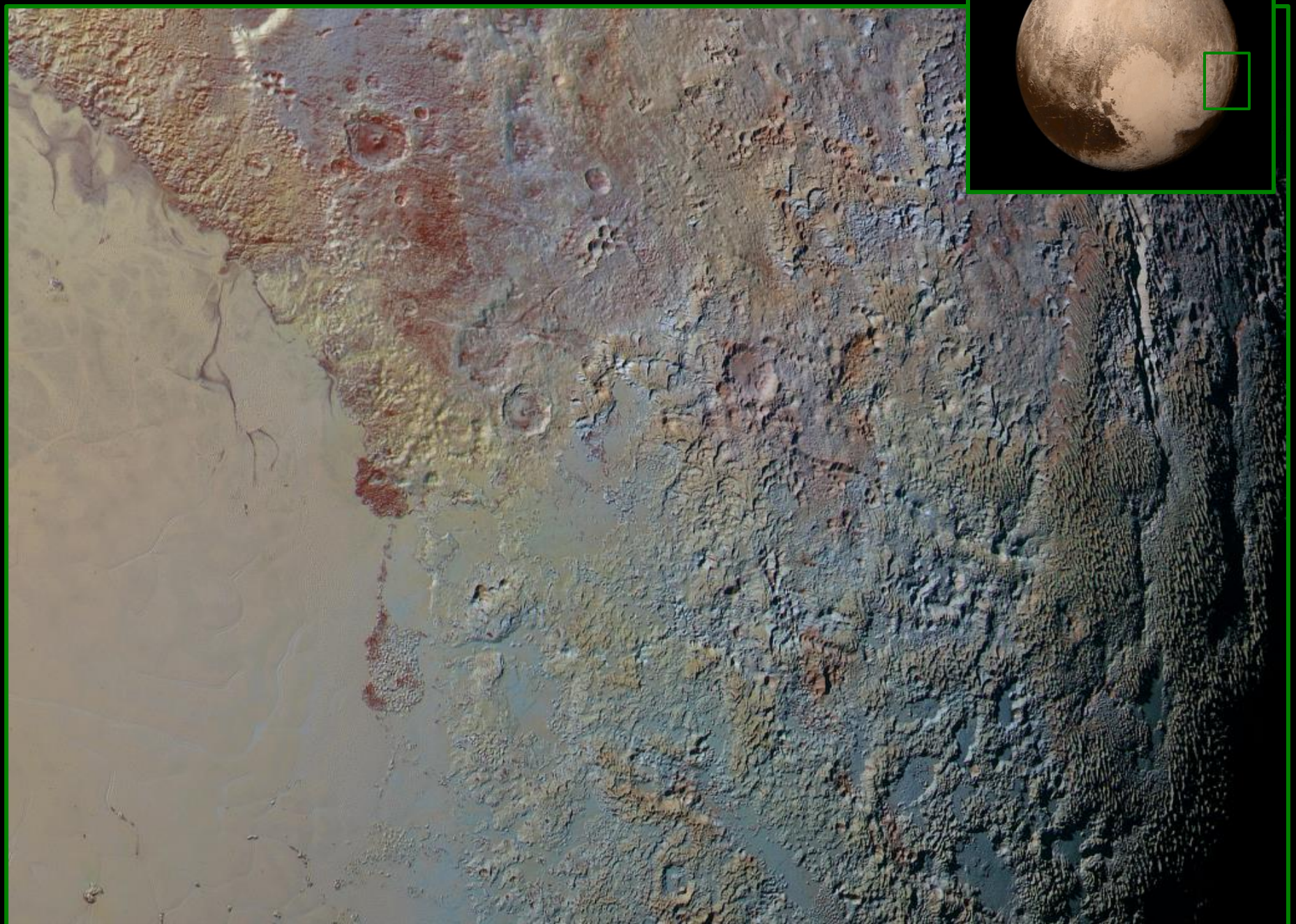


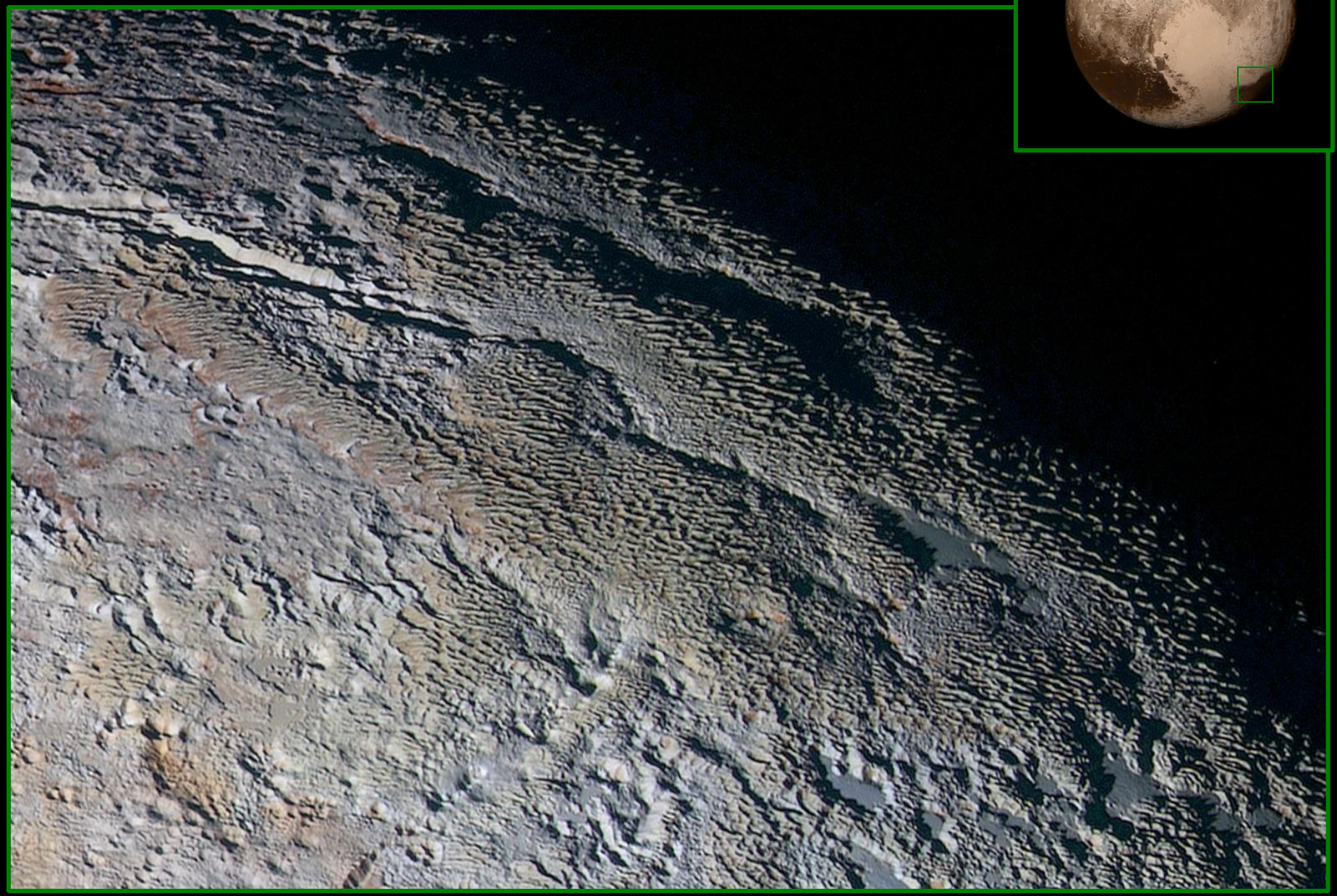
NEW HORIZONS:
GLACIAL FLOW ON PLUTO

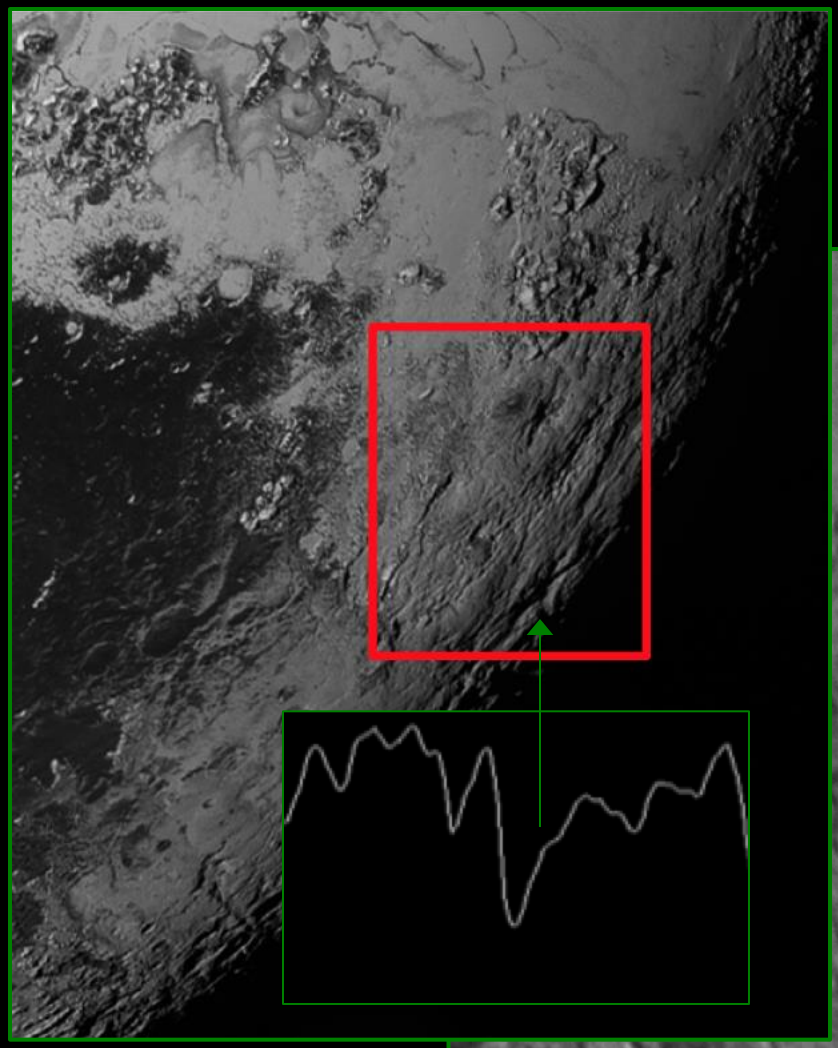


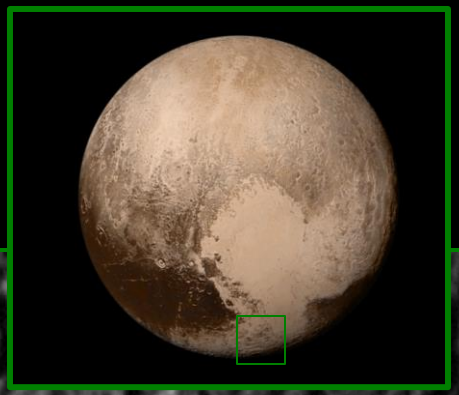

A
50 km
N
Elevation Scale
6 km
4 km
2 km
0 km
a
b
b
c


PA-F







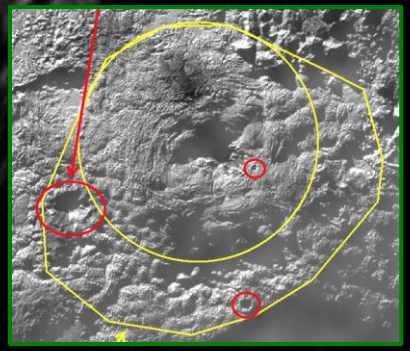


Morgoth Macula

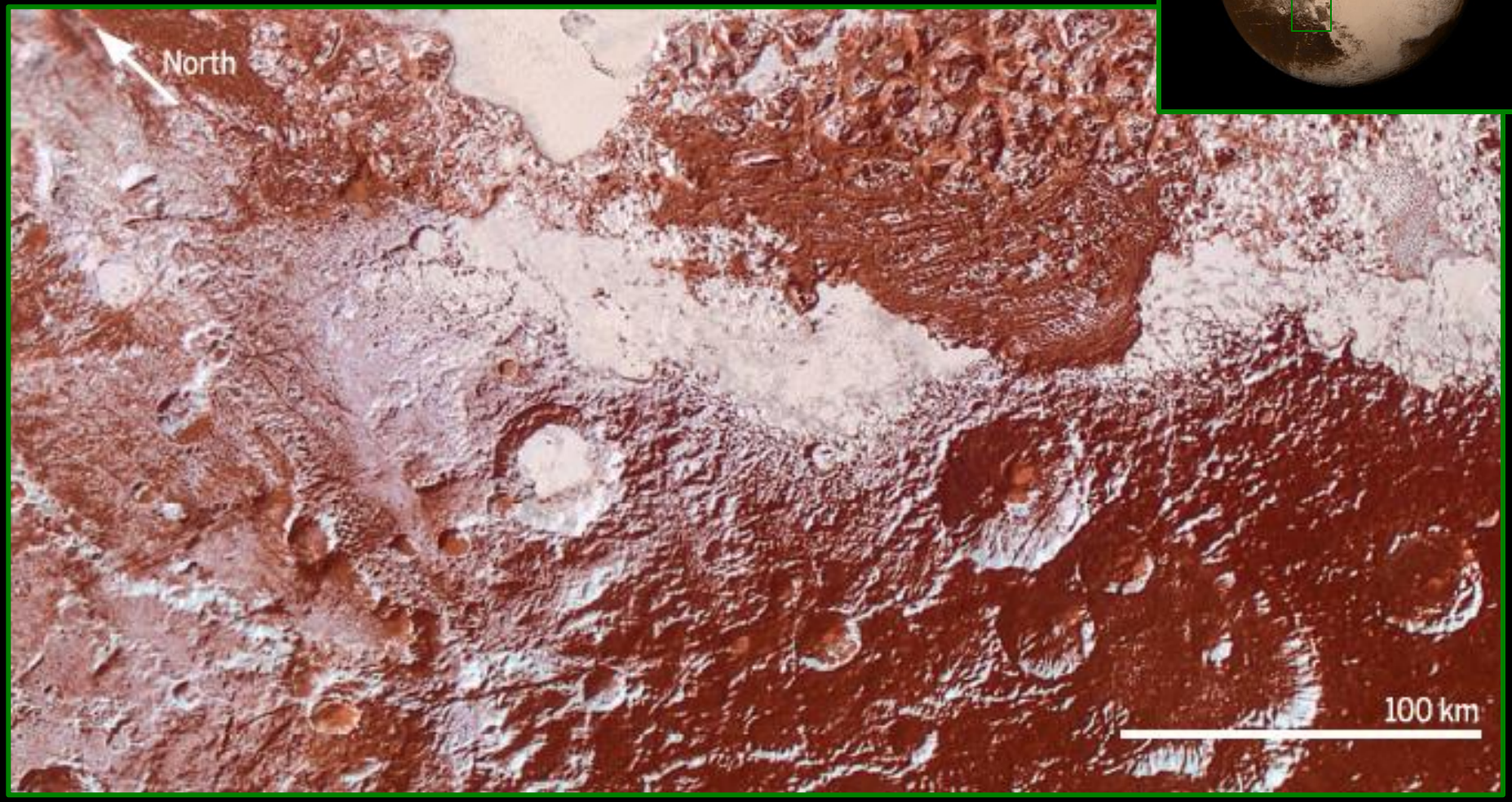
Quidlivun Cavus

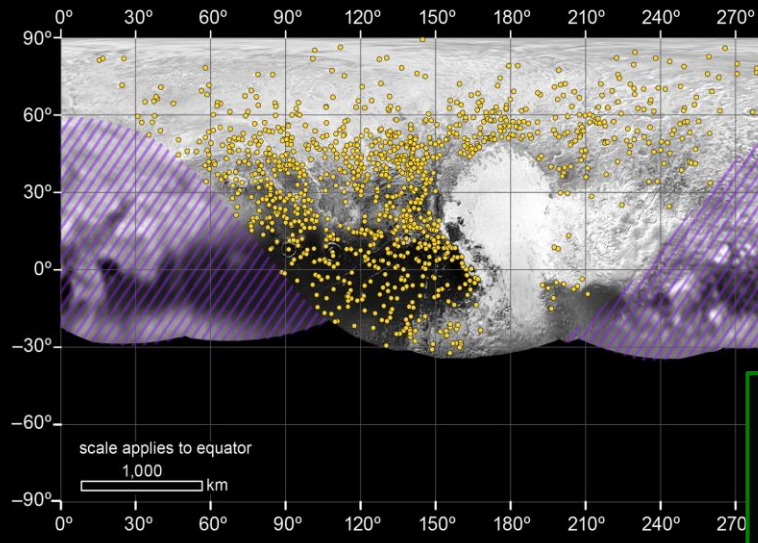
~50 km

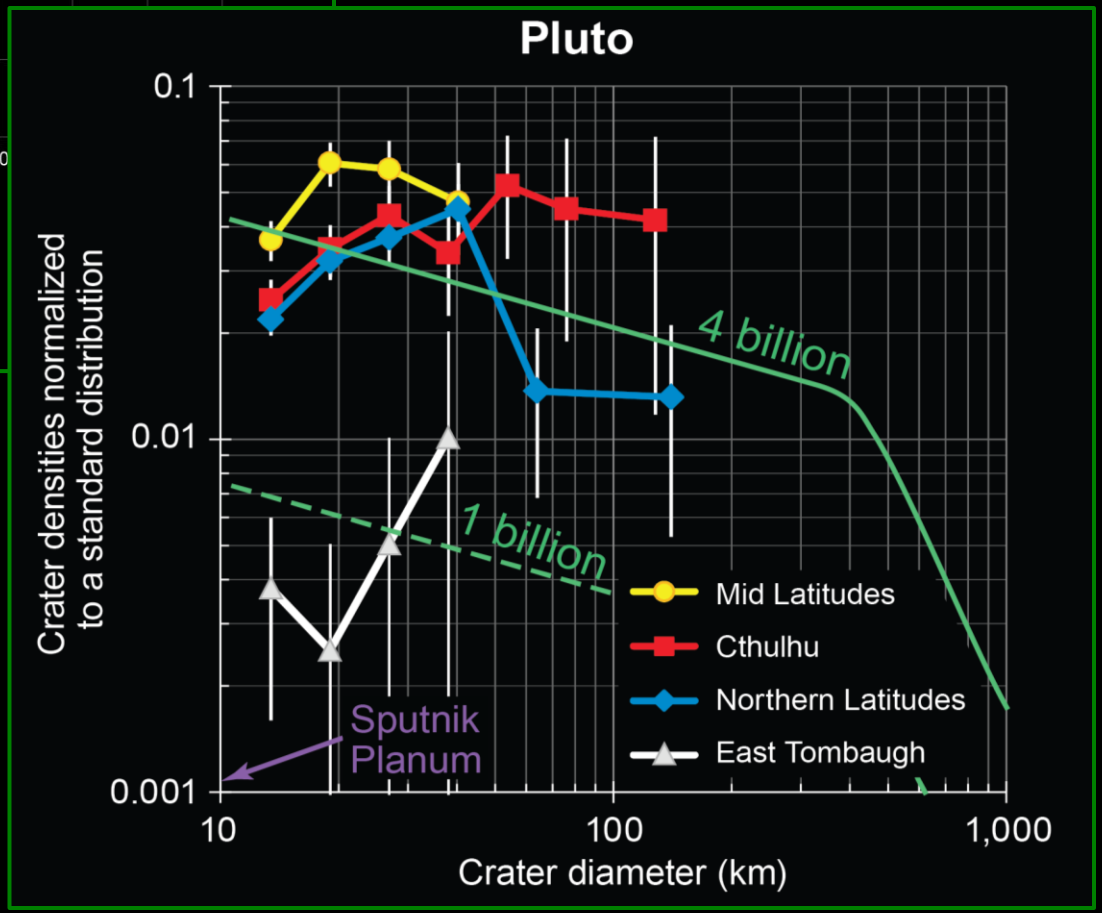
Smaller cousin?

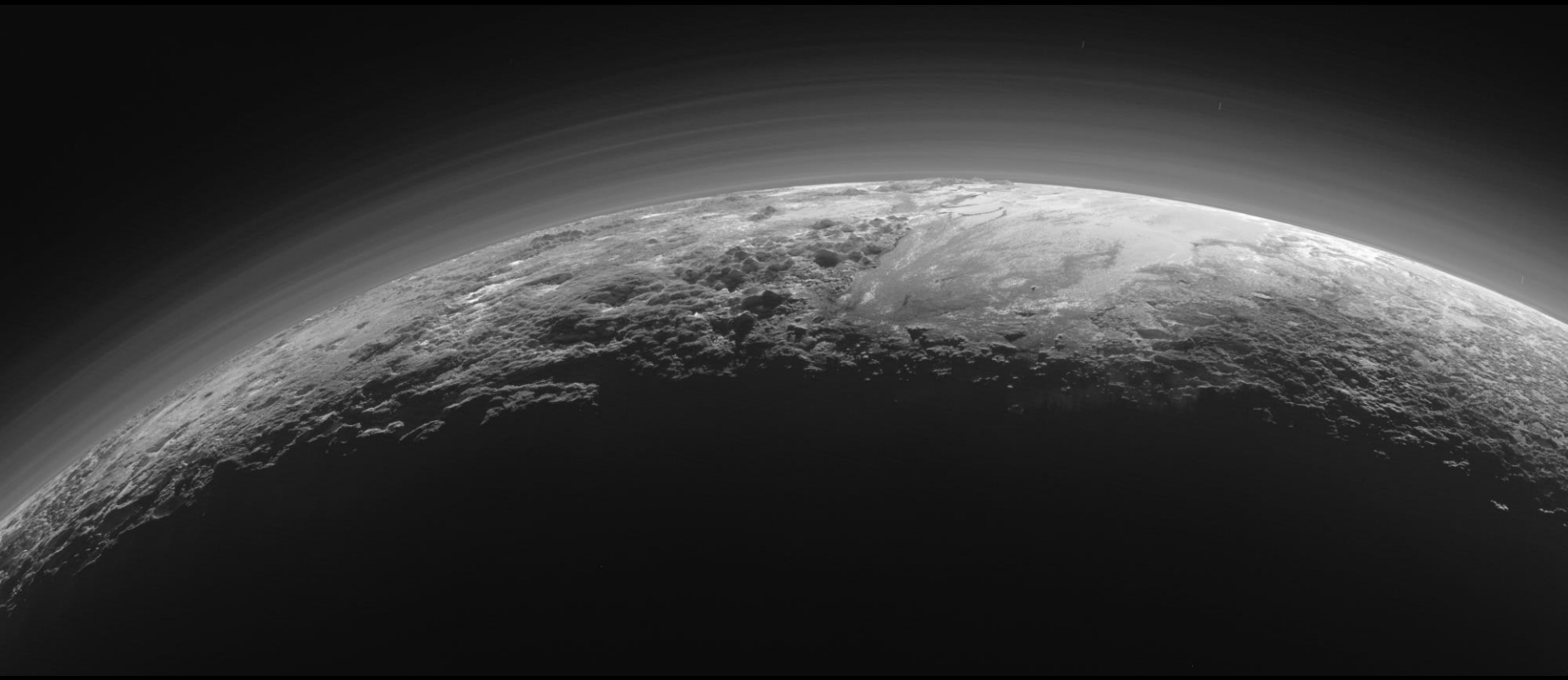


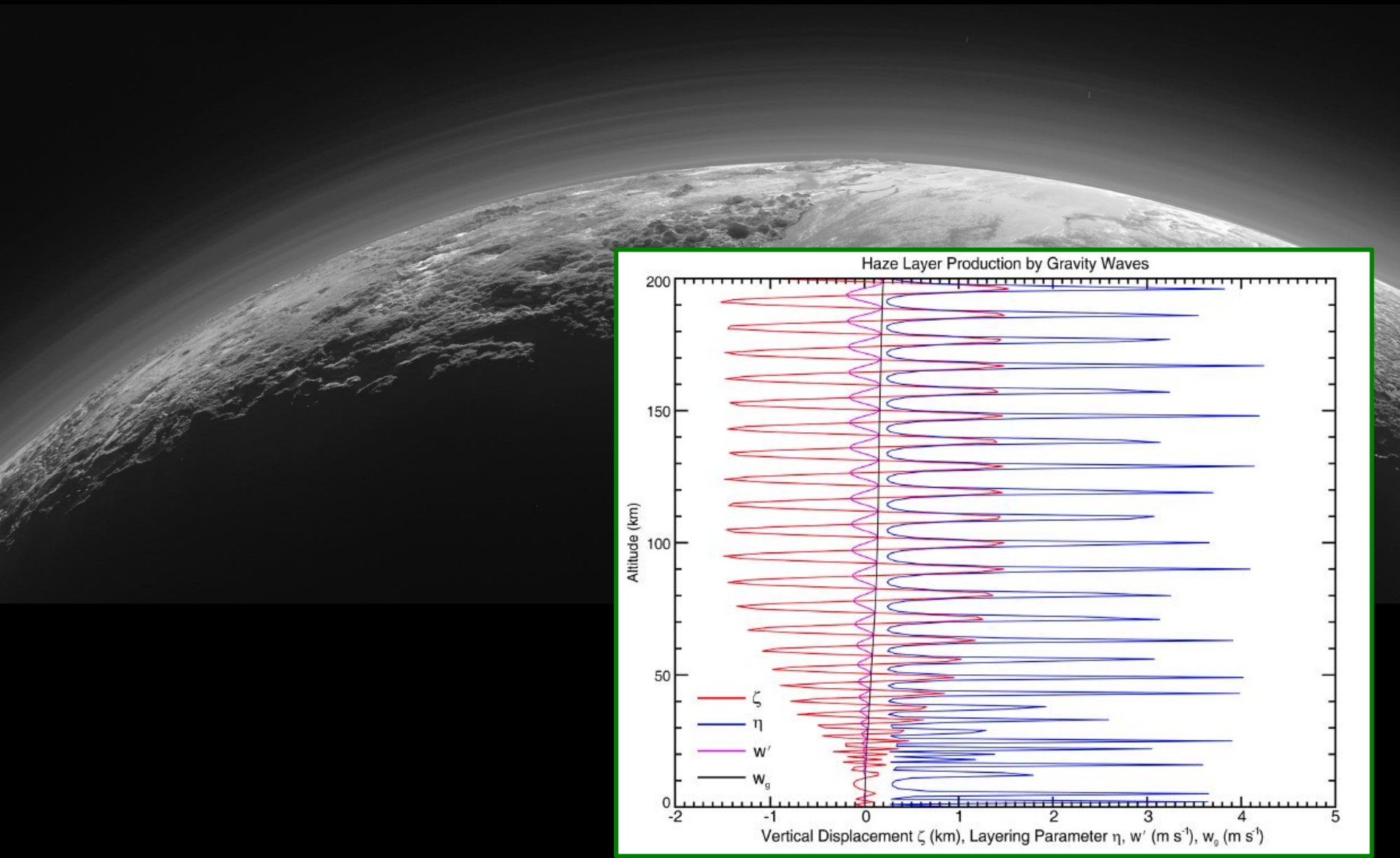
Darker flow feature


North
100 km


0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°
90°
60°
30°
0°
−30°
−60°
−90°
scale applies to equator
1,000
km

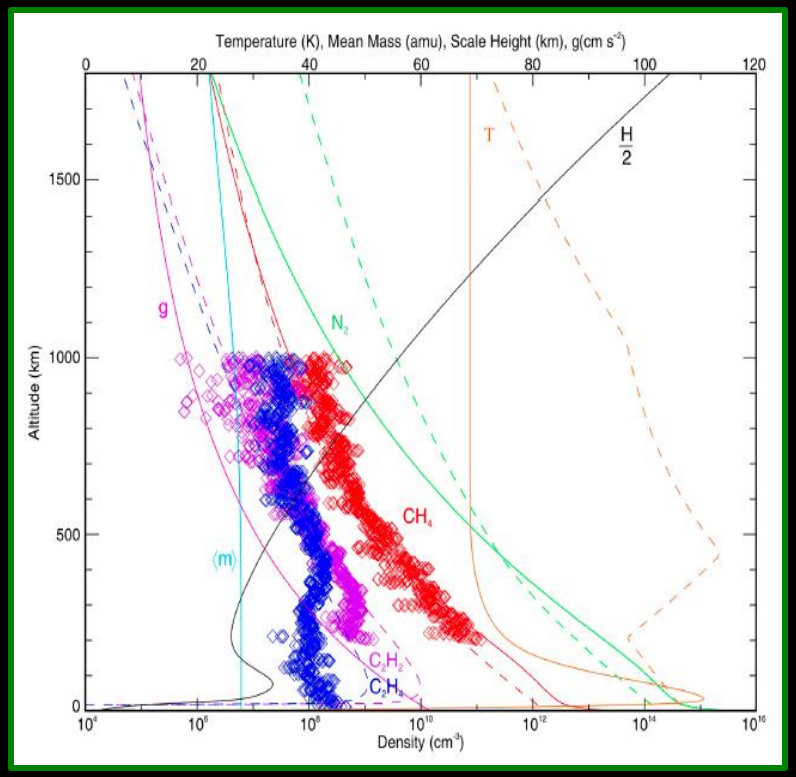

Pluto
0.1
0.01
0.001
Crater densities normalized to a standard distribution
4 billion
1 billion
Sputnik Planum
Mid Latitudes
Cthulhu
Northern Latitudes
East Tombaugh
10
100
1,000
Crater diameter (km)




Haze Layer Production by Gravity Waves
Altitude (km)
200
150
100
50
0
-2
-1
0
1
2
3
4
5
ζ
η
w′
w_g
Vertical Displacement ζ (km), Layering Parameter η, w′ (m s^-1), w_g (m s^-1)

Pre

Post


Temperature (K), Mean Mass (amu), Scale Height (km), g(cm s^{-2})
0
20
40
60
80
100
120
T
H/2
1500
1000
500
0
Altitude (km)
g
N$_2$
CH$_4$
⟨m⟩
C$_2$H$_2$
C$_2$H$_2$
10^4
10^6
10^8
10^{10}
10^{12}
10^{14}
10^{16}
Density (cm^{-3})

Ultimate bodybuilding: The quest for exoskeletons *p. 270*

Giving a boost to quantum electronics *pp. 280 & 307*

Engineering remote-controlled T cells *p. 293*

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Flying past Pluto

New Horizons finds surprises at Pluto and Charon *pp. 260 & 292*

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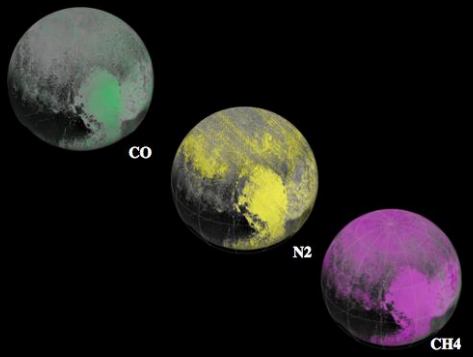
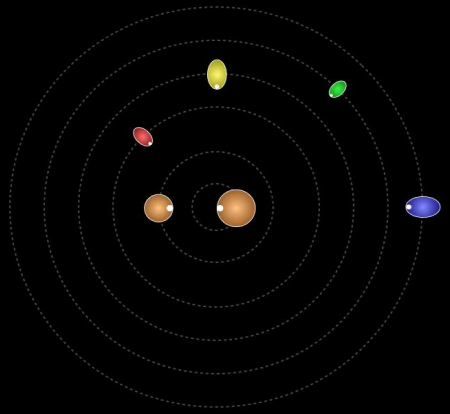
A new horizon

The Pluto system seen up close

pp. 1280–1293

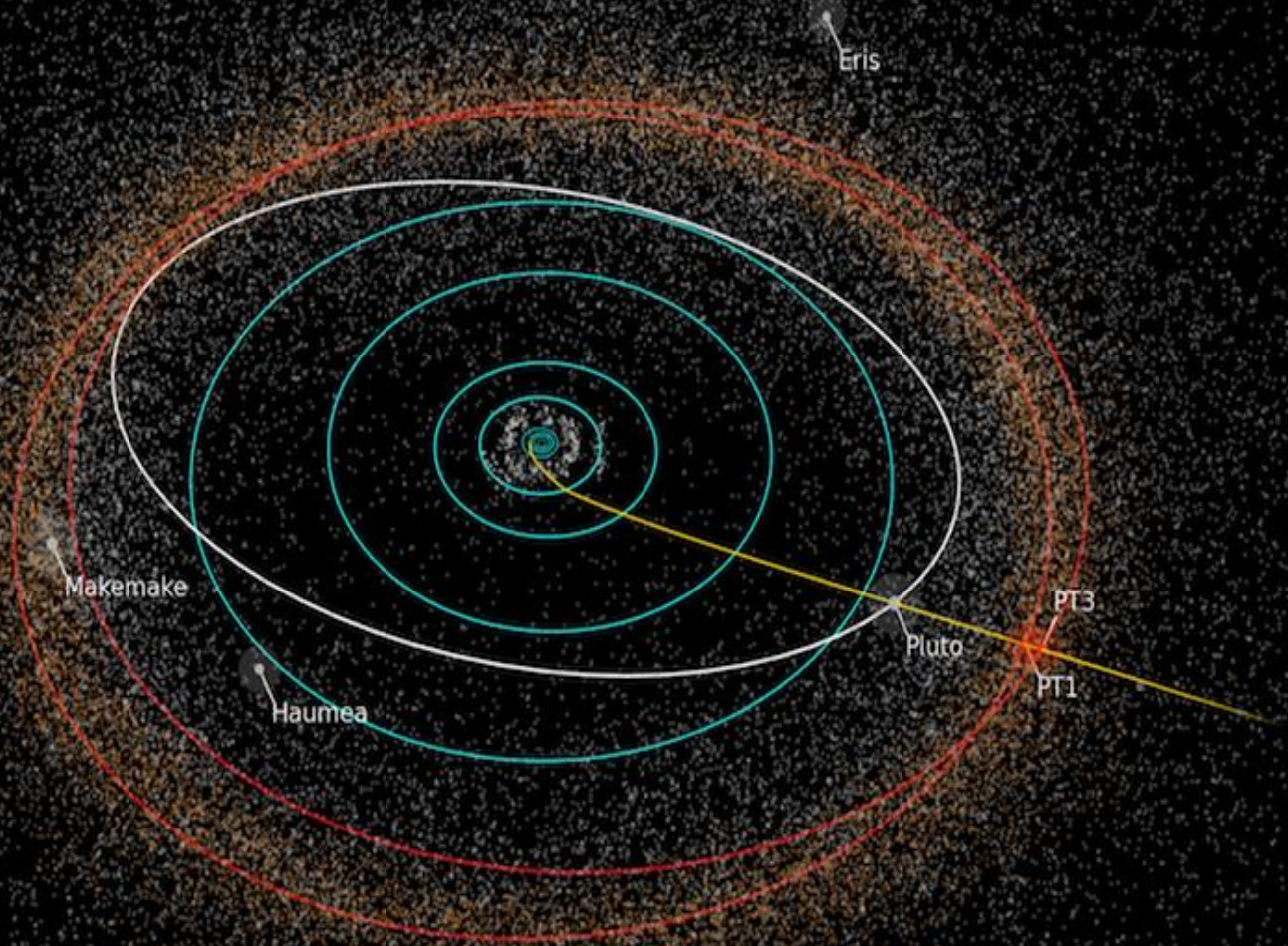
RECAP





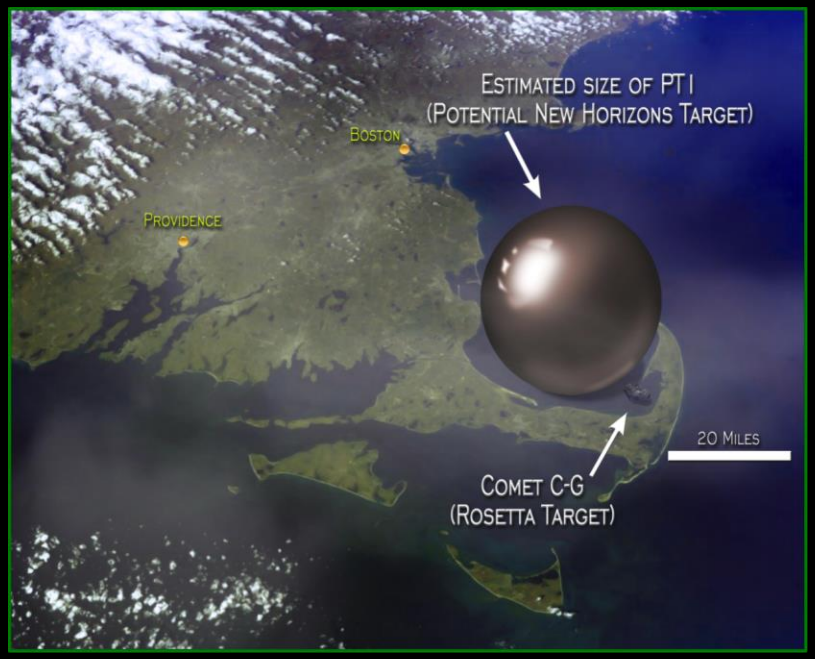
- **Breakthrough Mission Cost and Development Time.**
- **All flyby objectives met or exceeded.**
- **First PDS Archiving Delivery: April; ROSES DAP Call 2016.**
- **About 20 Publications Already Submitted.**

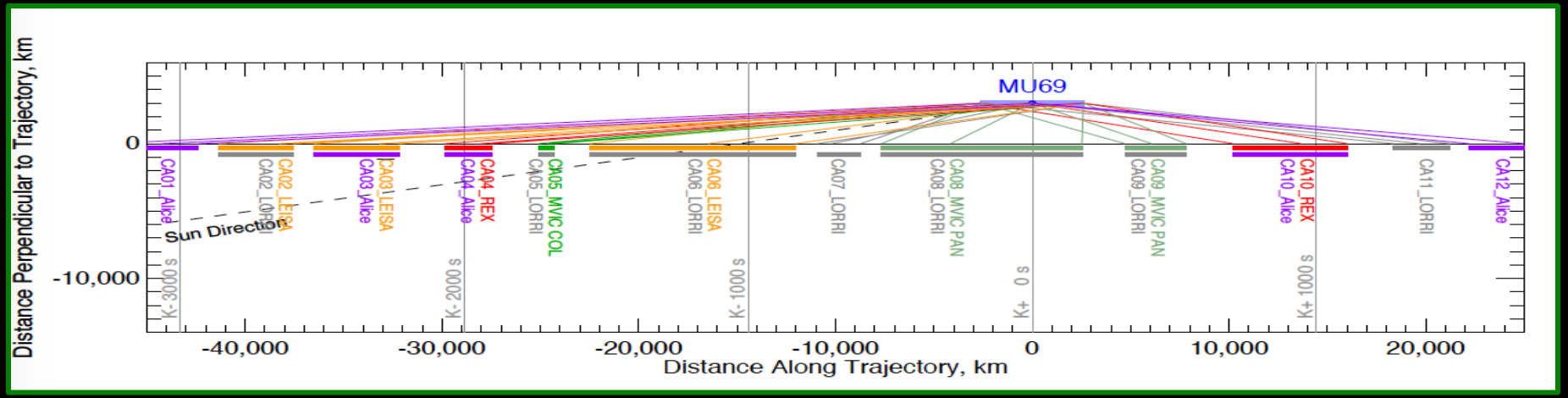
EXTENDED MISSION: 2016-2021



KBO CLOSE (3,000 KM) FLYBY

	PT1
MPC Designator	2014 MU69
Diameter Range	21-40 km
Orbital Semi-major Axis	44.2 AU
Orbital Eccentricity	0.036
Orbital Inclination	1.9 deg
KBO Type	Cold Classical
Encounter Date	1 Jan 2019





KBO EXTENDED MISSION SCIENCE OBJECTIVES

- **Close flyby of a primordial KBO planetesimal: 2019.**
- **Distant flyby observations of ~20 other KBOs: 2016-2020.**
- **Search for Centaur and KBO Rings: 2016-2020.**
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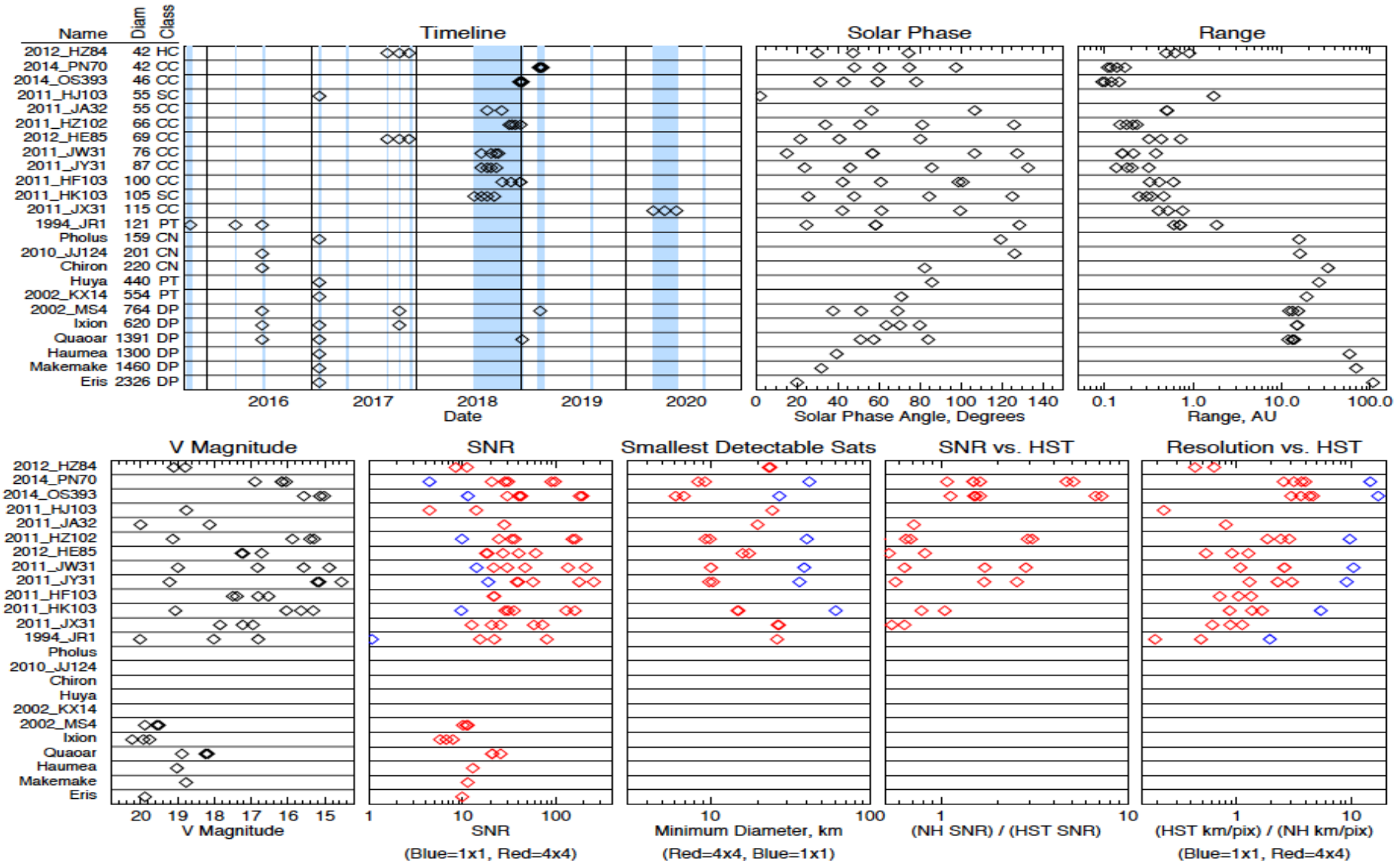
KBO EXTENDED MISSION
KBO SURVEY SCIENCE




last slide for

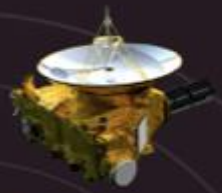

Countdown

A PEEK INSIDE THE PLUTO PUBLIC RELATIONS MACHINE

News Media Reports

2,800

on New Horizons' Pluto Flyby



450

Number of newspapers around the world that featured the Pluto image on the front page (7/15).

783K

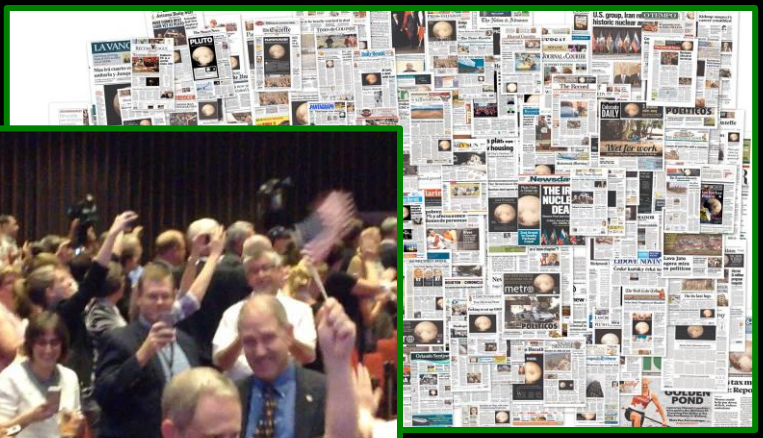
Number of web stream plays on NASA TV. The normal average is 10K plays per day.

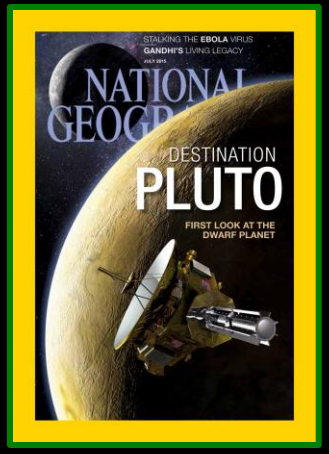
42%

Percentage of web traffic to all U.S. Govt. sites that was going to NASA.gov an hour prior to the flyby.

9.9M

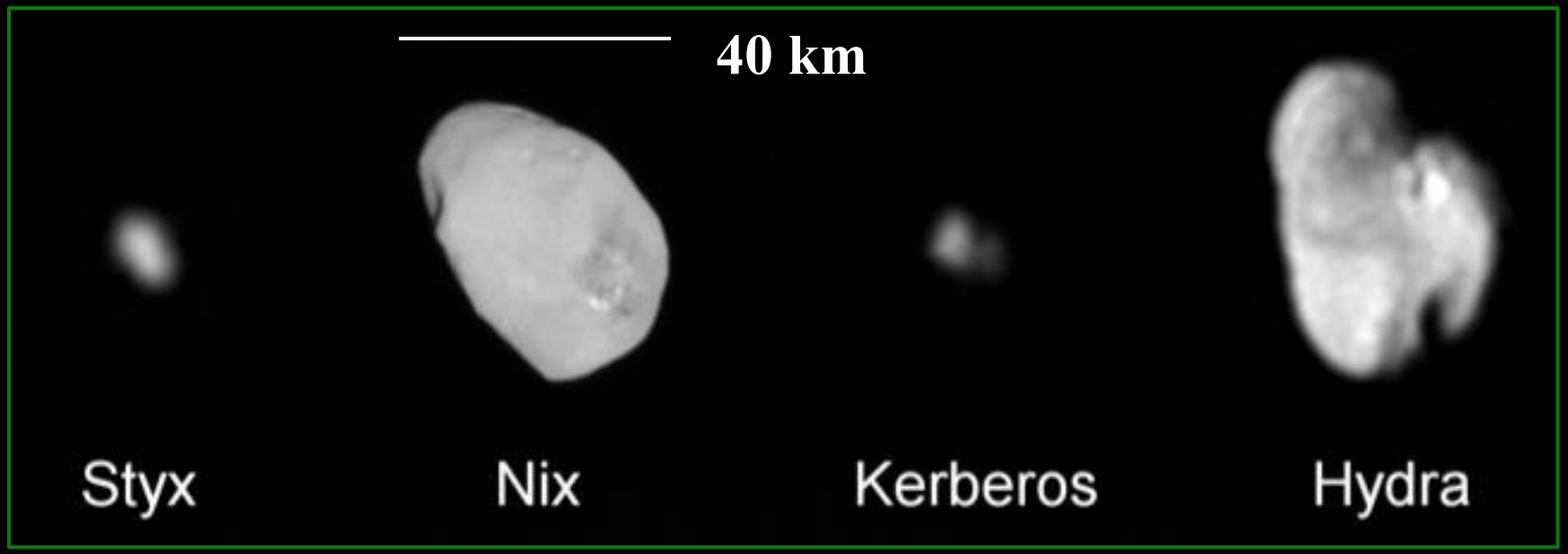
Number of page views on NASA.gov resulting from 4.1 million sessions and 3.4 million users.






NEW
HORIZONS
NASA's Pluto-Kuiper Belt Mission
SwRI • NASA • JHU/APL

Backups


40 km
Styx
Nix
Kerberos
Hydra