New Horizons: Beyond Pluto

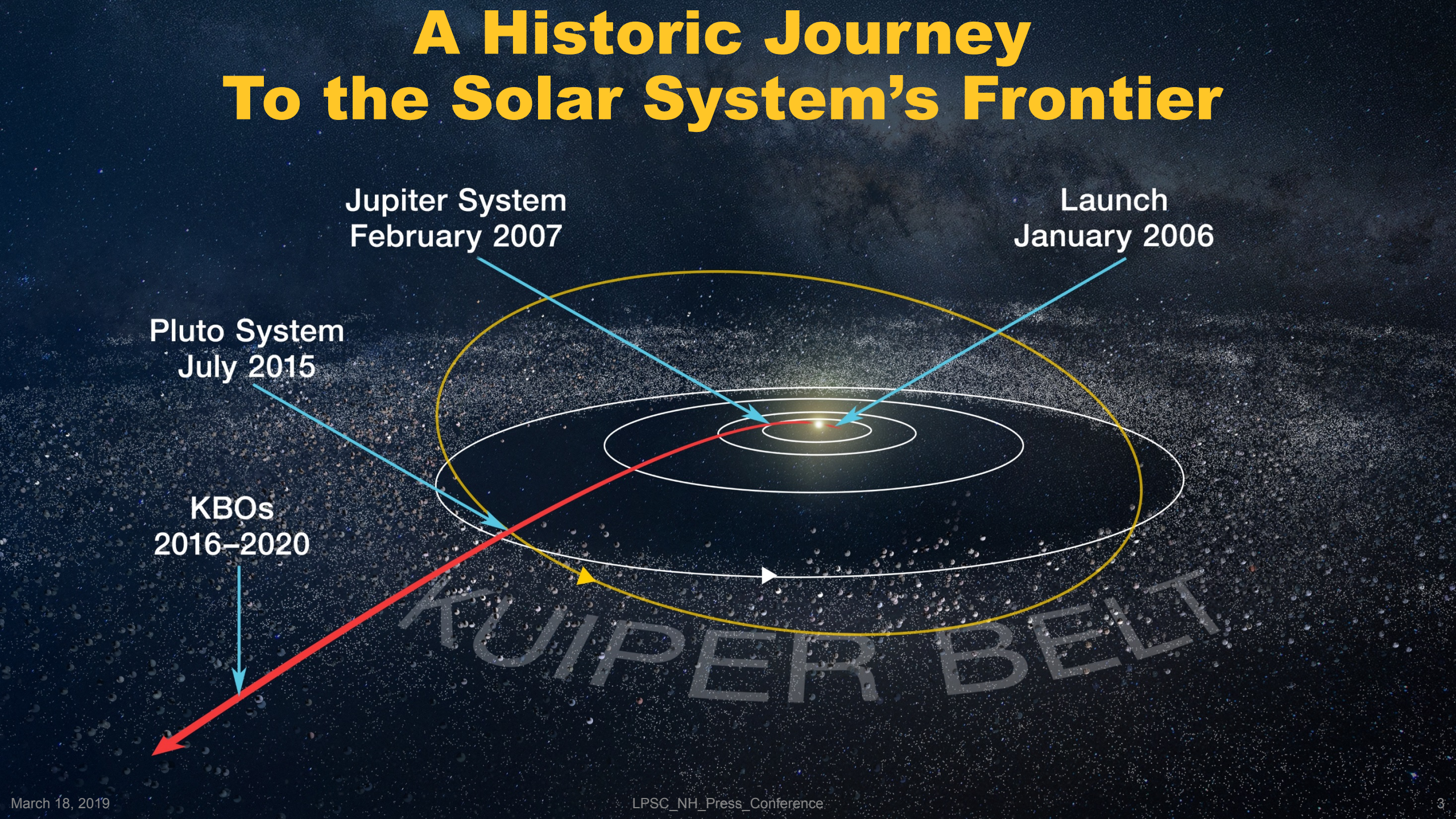
Revealing the First Primordial Planetesimal

Lunar and Planetary Science Conference
March 18, 2019

Meet Ultima Thule (2014 MU69)

Dr. Alan Stern
New Horizons Principal Investigator
Southwest Research Institute

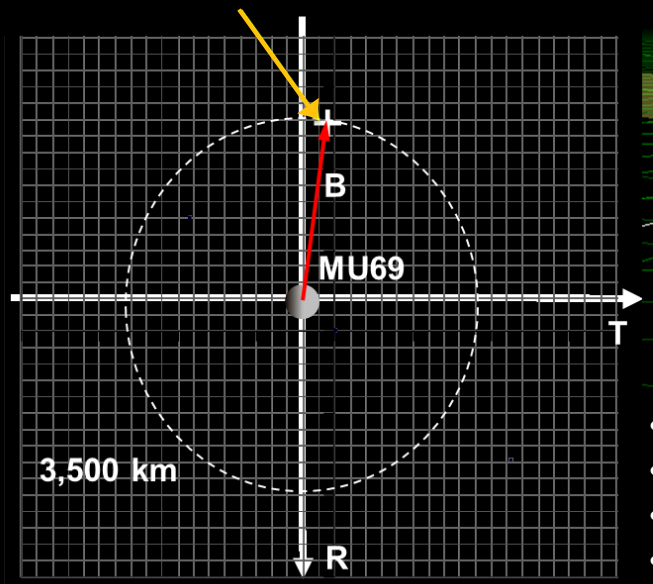
A Historic Journey To the Solar System's Frontier

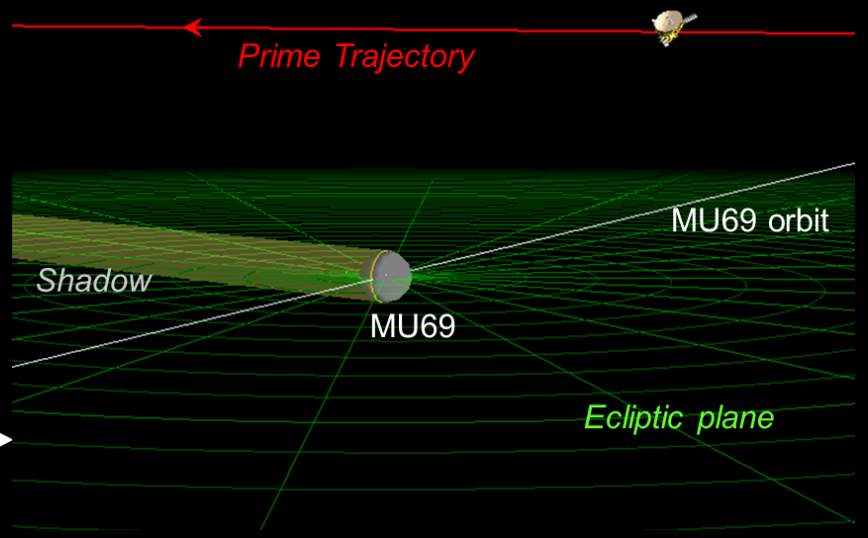


Approach and Departure

Flyby Overview

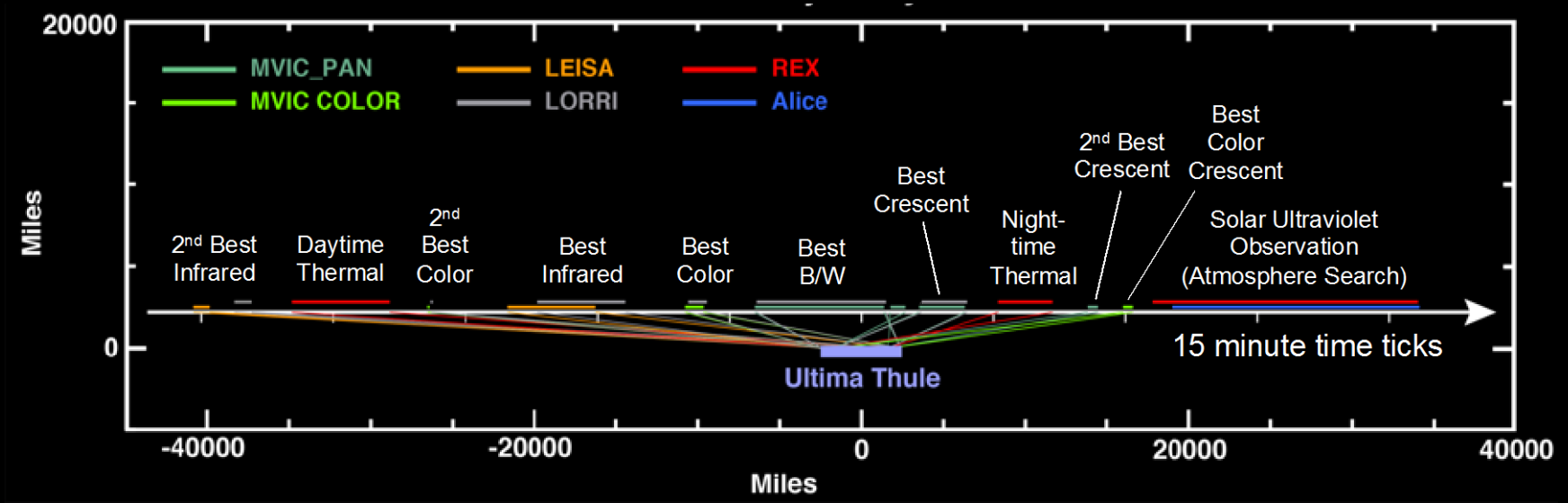
Prime B-Plane Target (EME2000):
B · T = 452.0 km
B · R = –3470.7 km



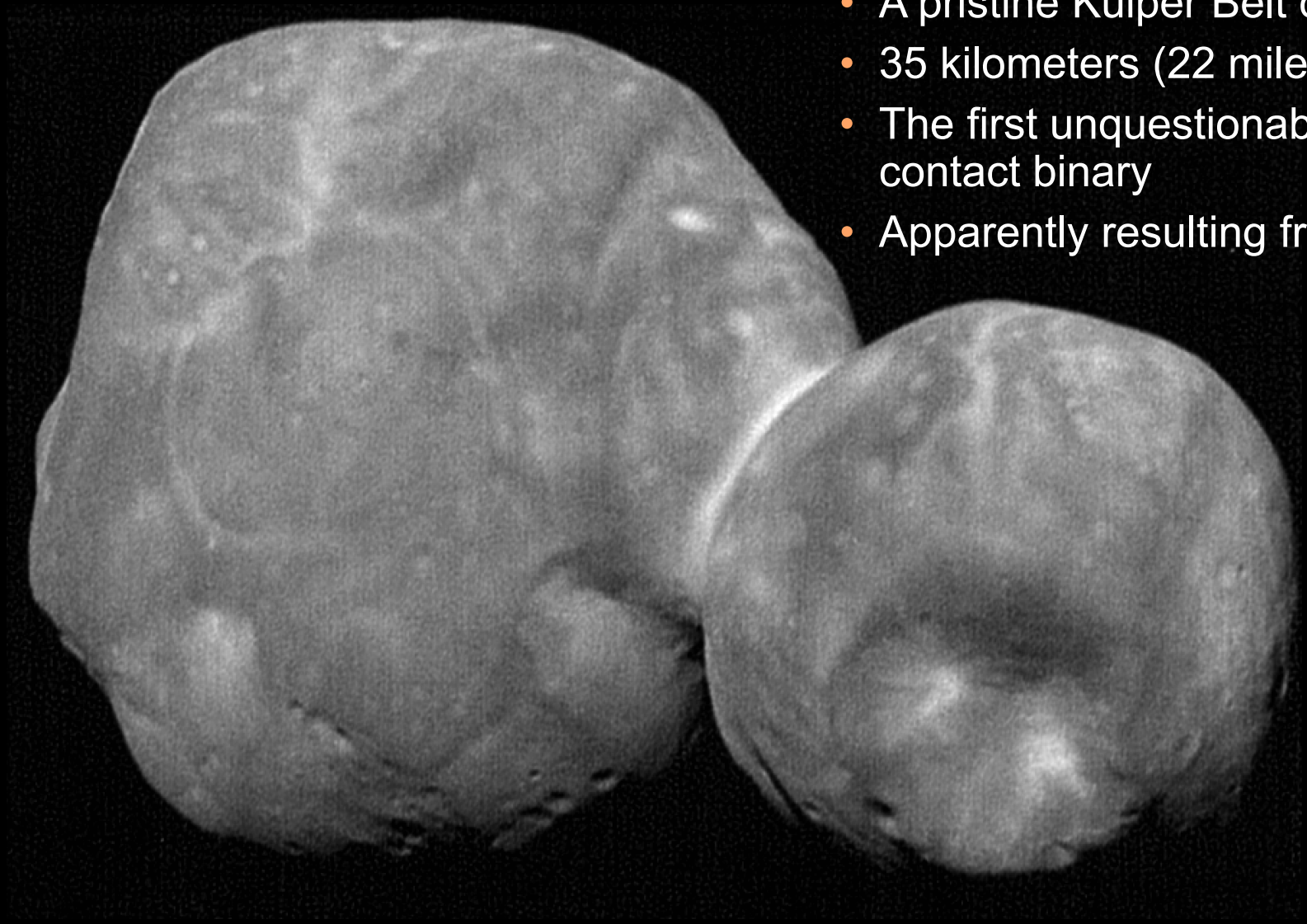


- Close approach distance: 3,500 kilometers (2,200 miles) from object center
- Close approach time: 12:33 a.m. EST, Jan. 1, 2019
- Flyby speed: 14.4 km/s (32,200 mph)
- Solar phase at C/A: 88.4º

Flyby Sequence

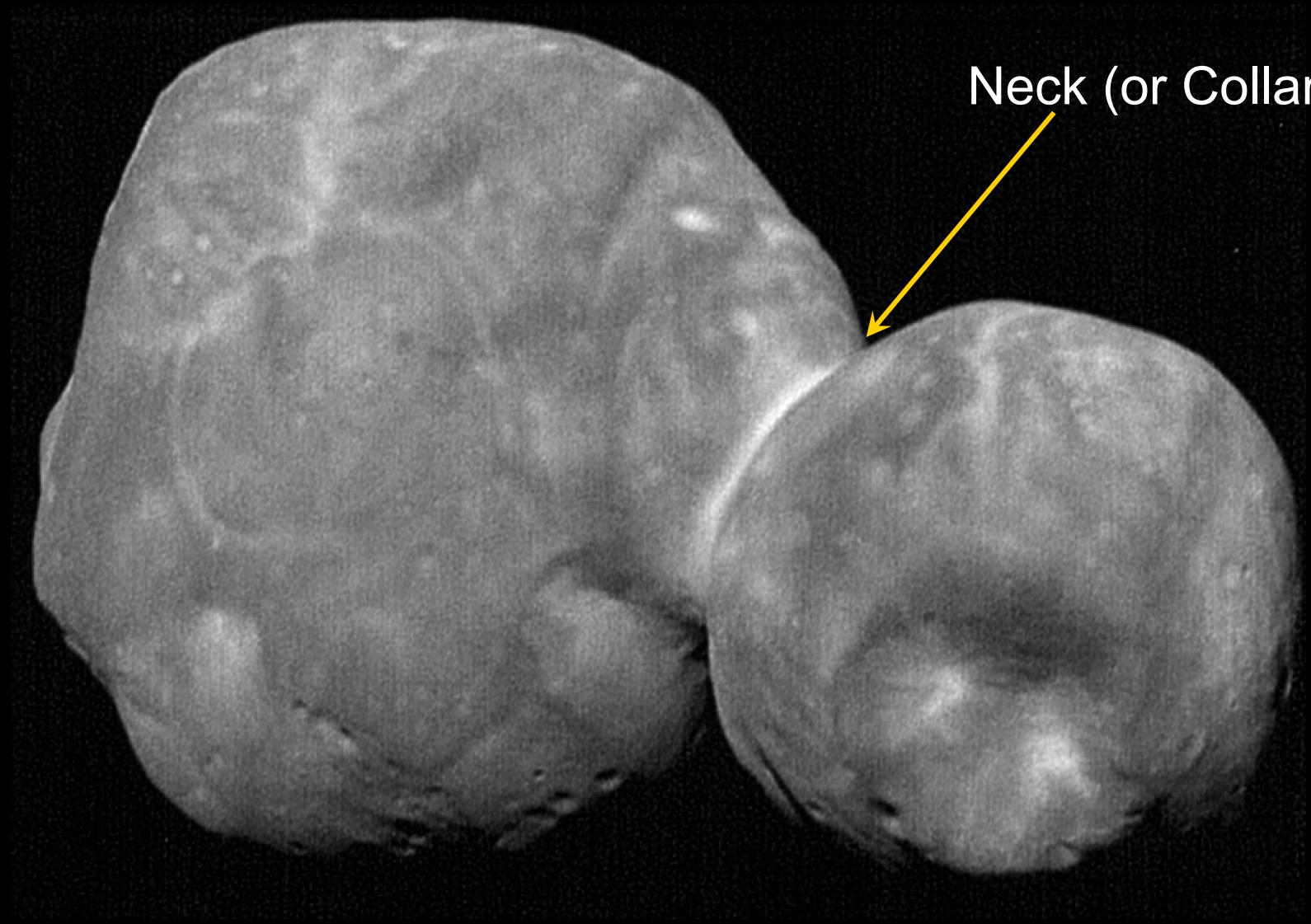


Meet Ultima Thule

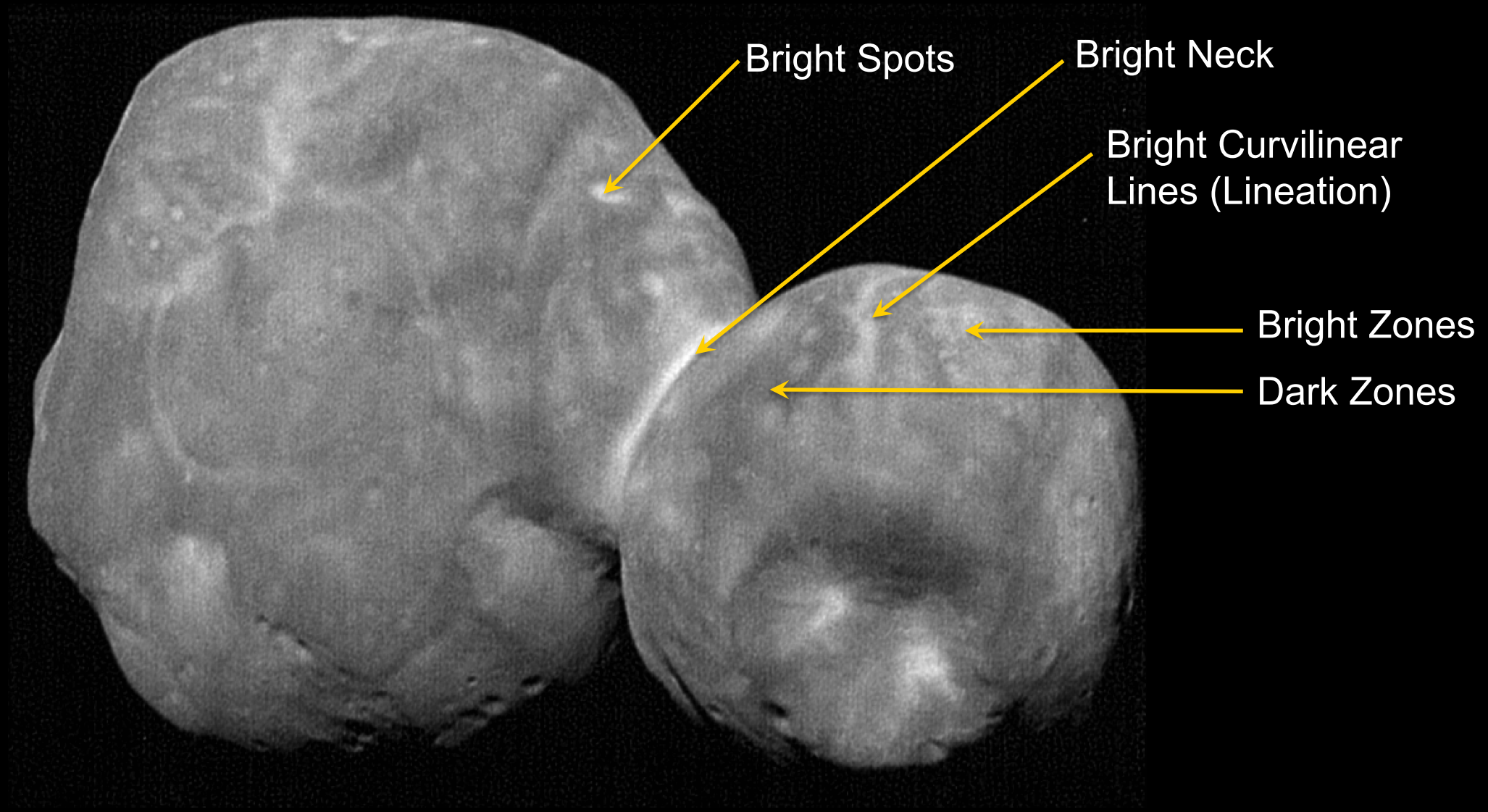


- A pristine Kuiper Belt object
- 35 kilometers (22 miles) long
- The first unquestionable primordial contact binary
- Apparently resulting from a gentle merger

Some Informal Terminology

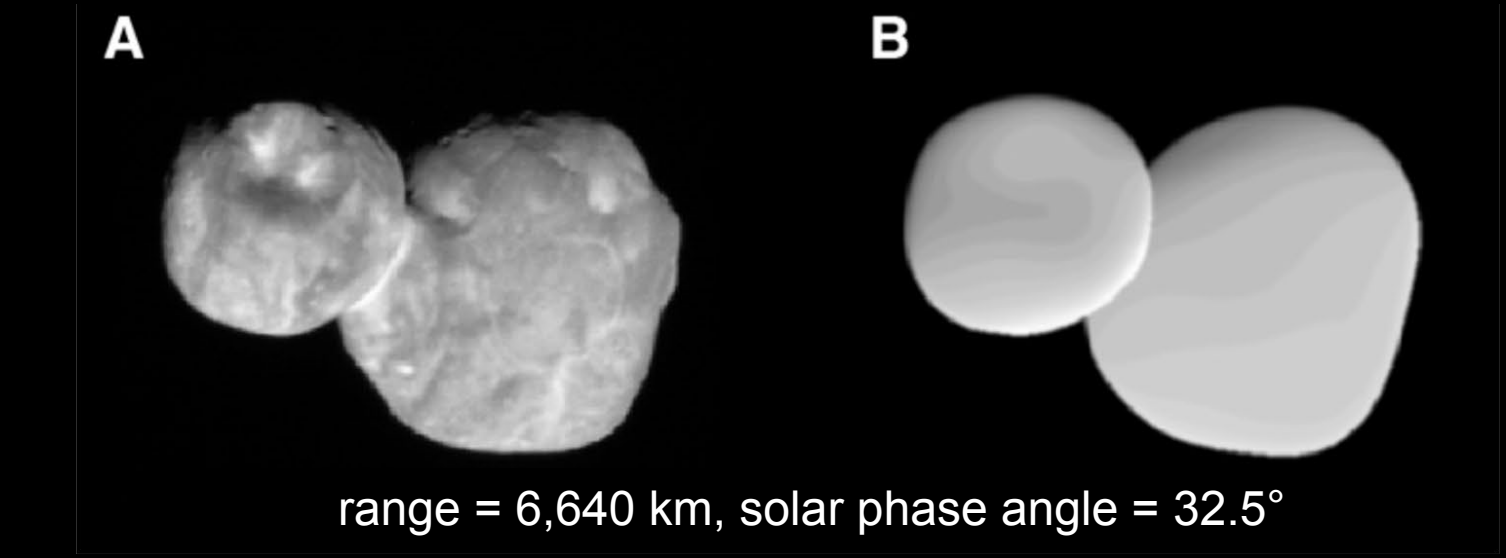


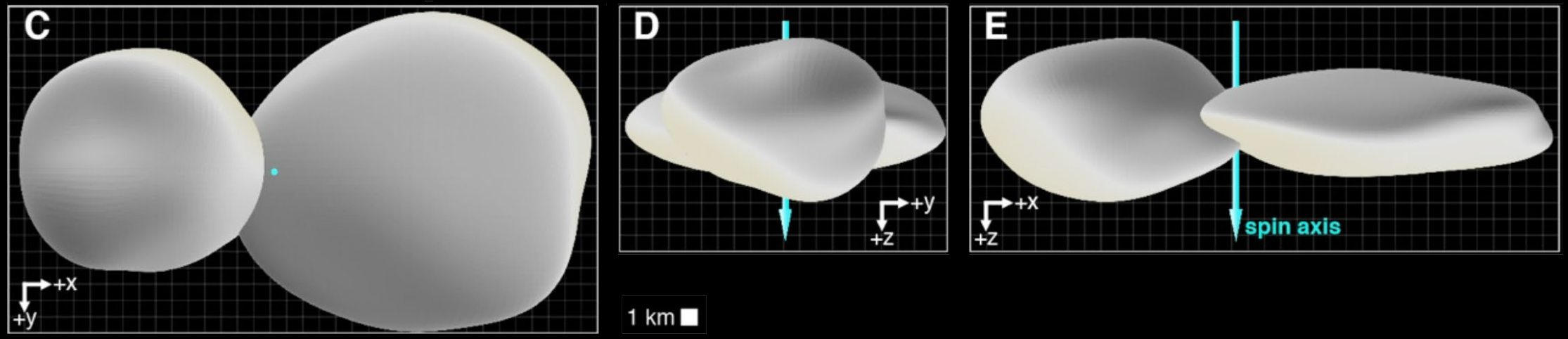
Enigmatic Albedo Markings



Shape

A Remarkably Shaped KBO





Surface Color

Dr. Carly J.A. Howett
New Horizons Science Team
Southwest Research Institute

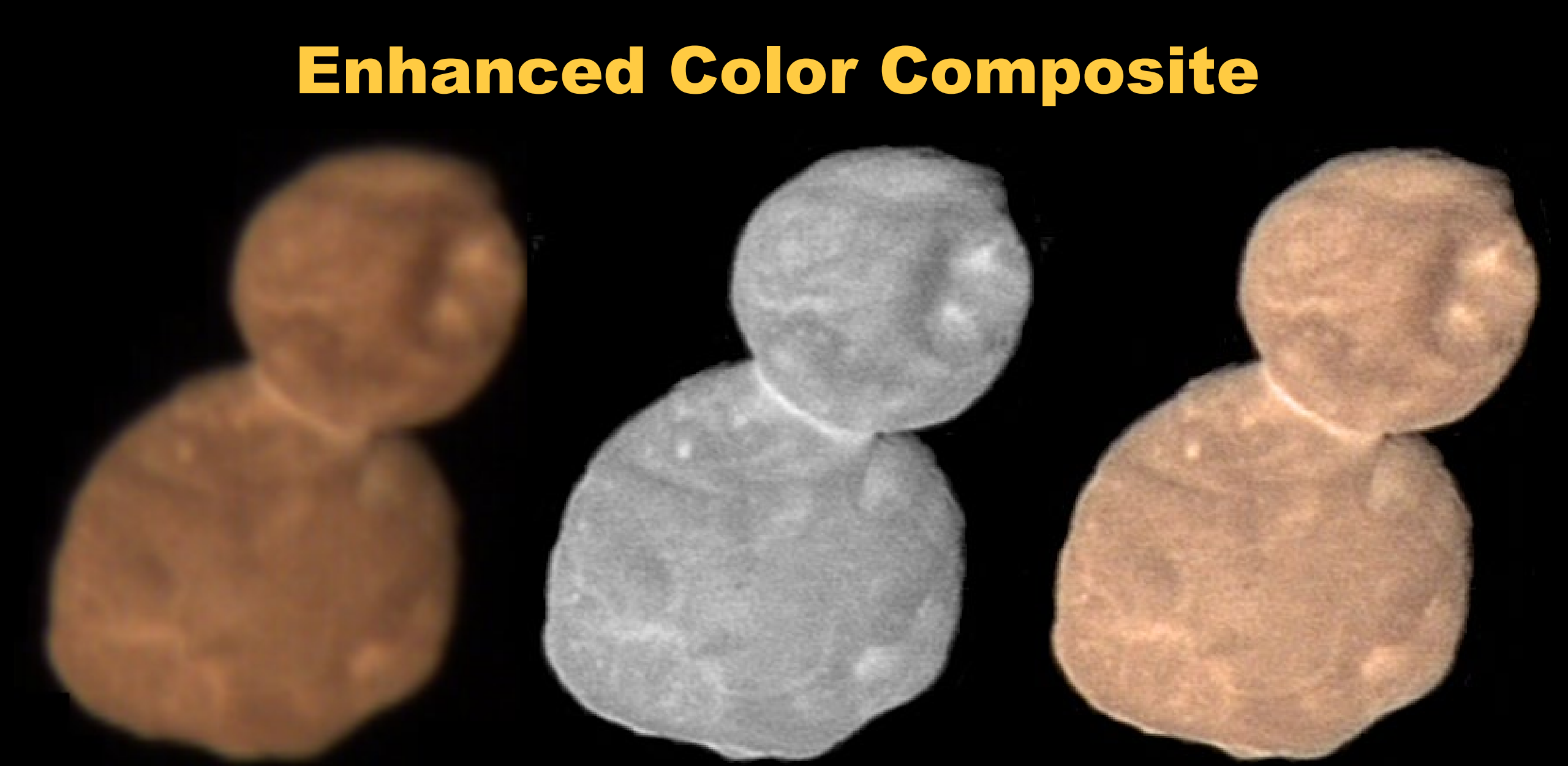
Old View

- Resolution: 1.5 km/pixel
- Taken: Dec. 31, 2018 11:08:41 p.m. EST
- Distance: 73,000 kilometers (45,000 miles)

New View

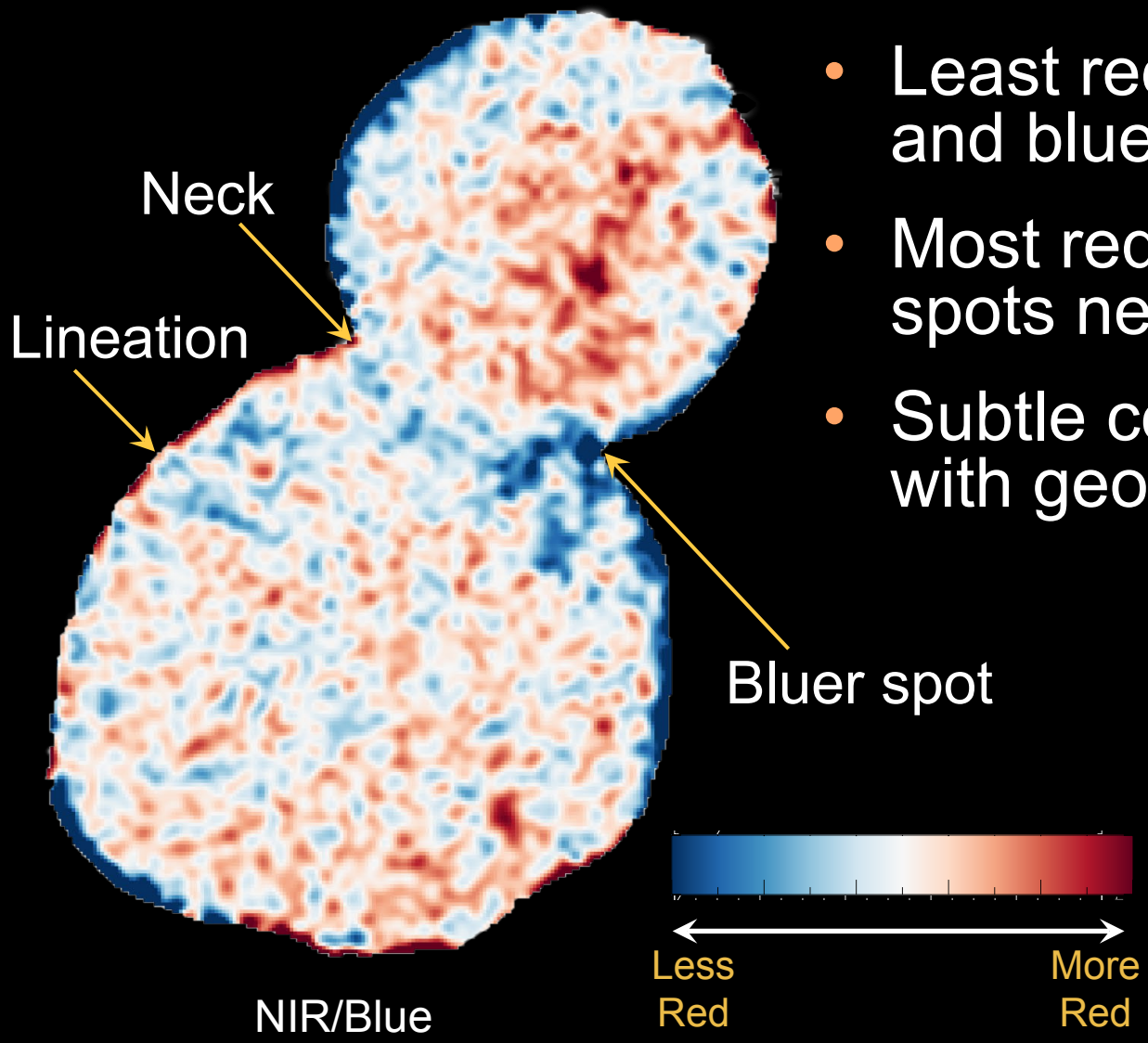
- Resolution: 0.3 km/pixel
- Taken: Jan. 1, 2019 12:13:45 a.m. EST
- Distance: 17,300 kilometers (10,700 miles)

Enhanced Color Composite



MVIC LORRI Combined

Color Variation

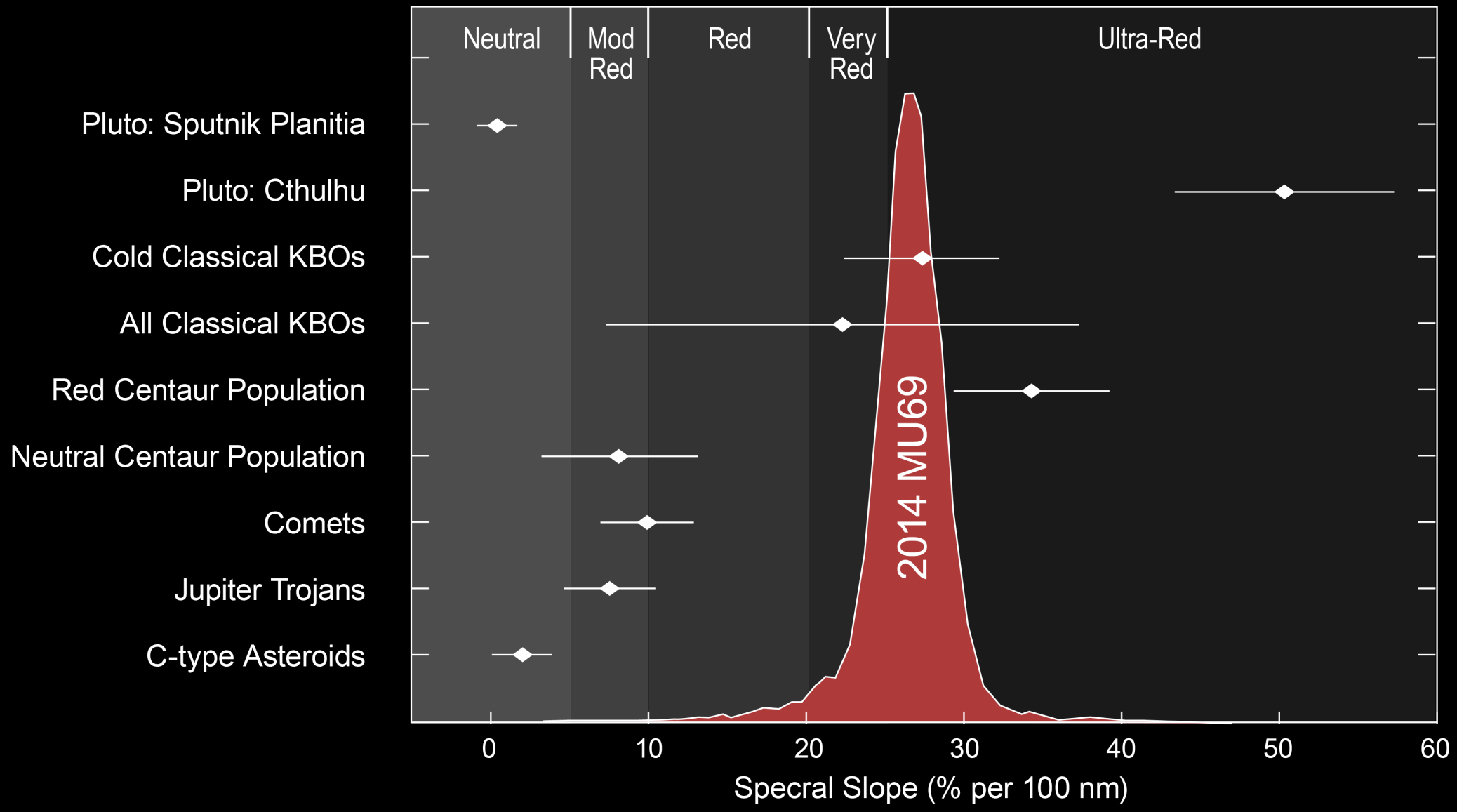


NIR/Blue

- Least red: neck, lineation and bluer spot regions
- Most red: center of Thule, spots near Ultima's limb
- Subtle color variations with geology

LORRI & MVIC
Contrast Enhanced Color

Color Comparison



Ultima Thule Surface Composition

Dr. Silvia Protopapa
New Horizons Co-Investigator
Southwest Research Institute

Ralph/LEISA Image of Ultima Thule

- Dec. 31, 2018
  11:57:34 p.m. EST
- Distance:
  31,200 km (19,400 miles)
- Spatial scale:
  1.9 km/pixel
- Wavelengths co-added:
  1.2–2.4 μm

Ralph/LEISA

MVIC, LEISA Images of Ultima Thule

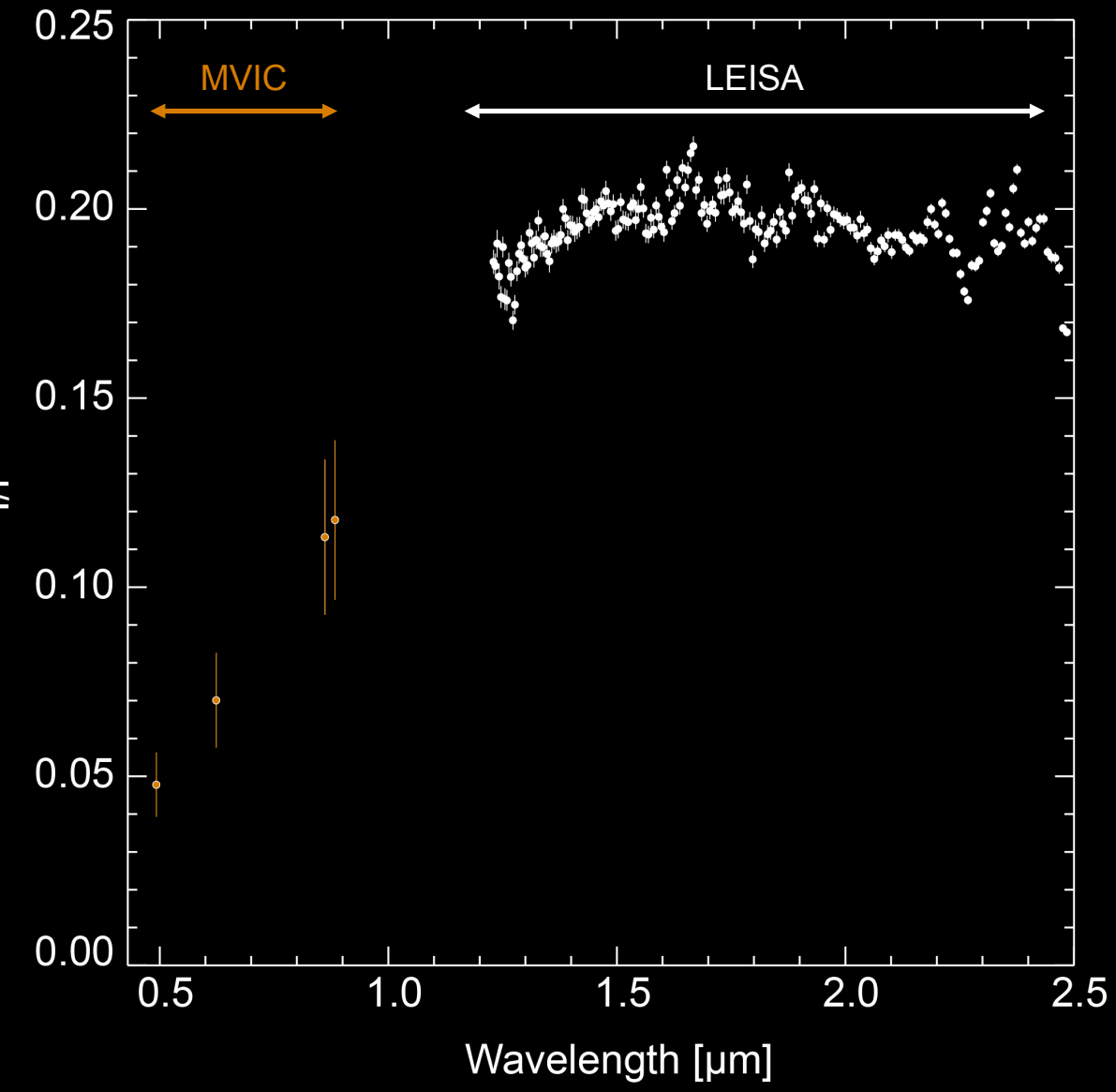
LORRI + Ralph/MVIC

Ralph/LEISA
Wavelengths co-added: 1.2–2.4 μm

Ultima Thule Surface Composition

LORRI + Ralph/MVIC

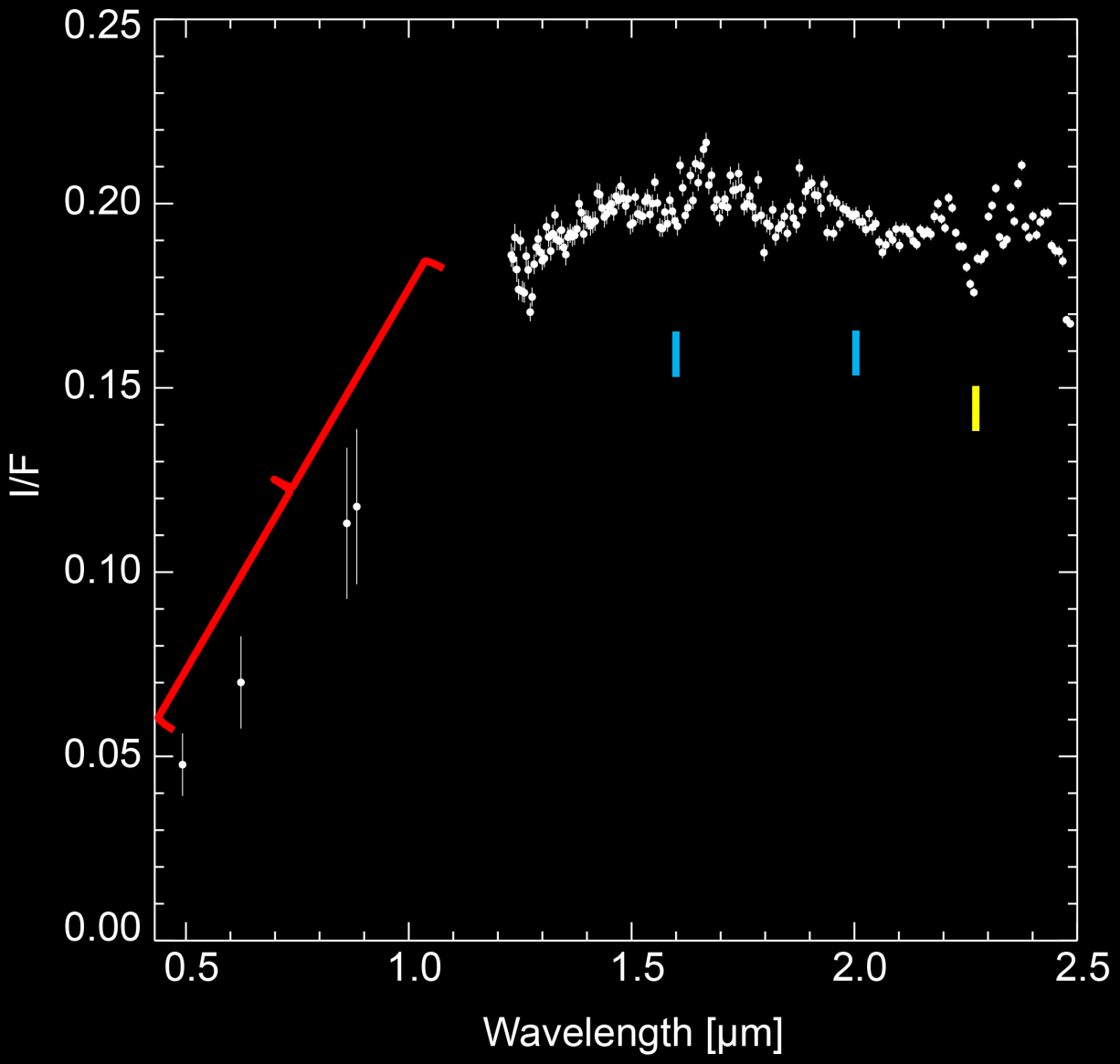
Ralph/LEISA



Ultima Thule Surface Composition

LORRI + Ralph/MVIC

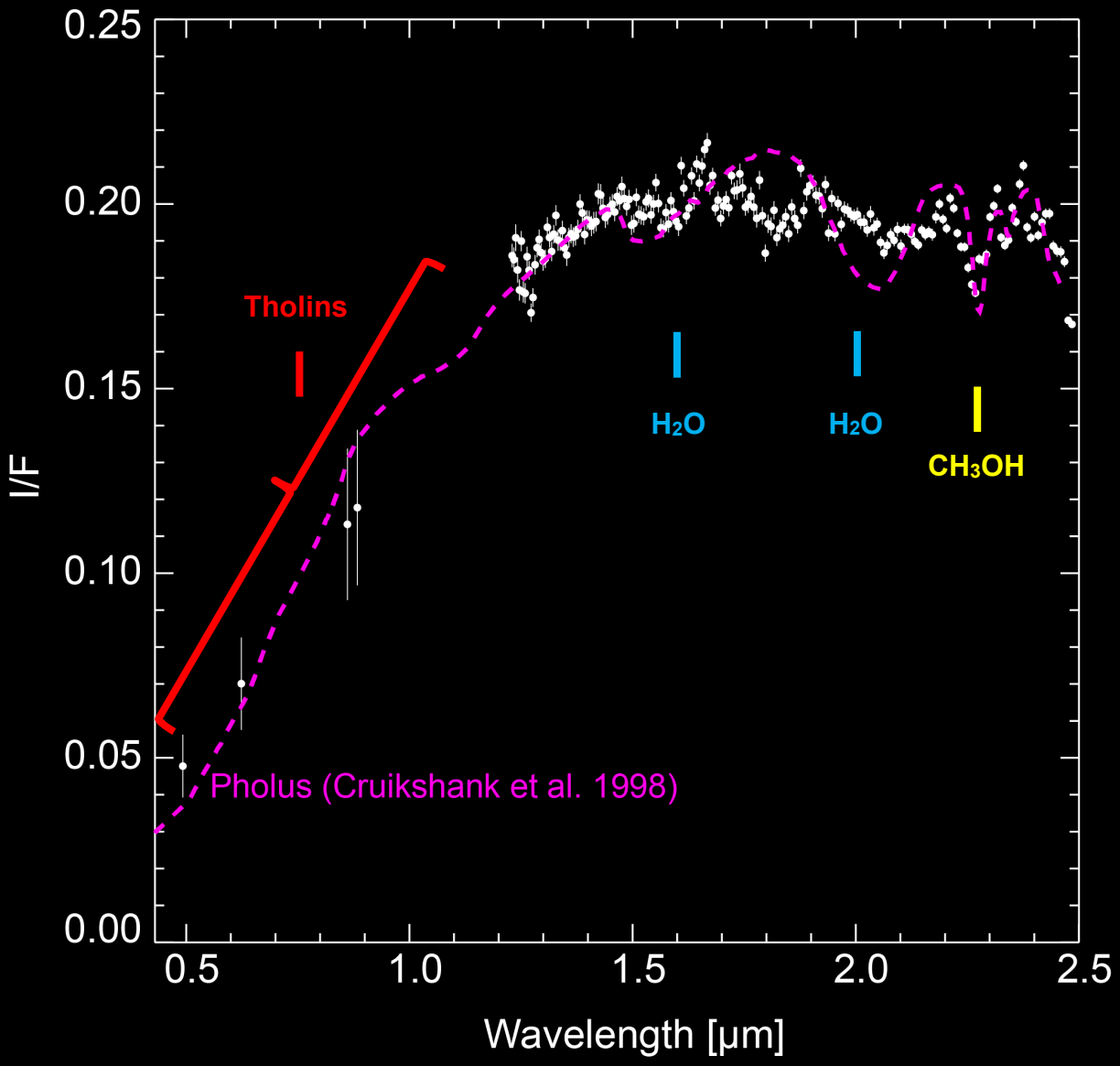
Ralph/LEISA



Preliminary Composition Analysis

LORRI + Ralph/MVIC

Ralph/LEISA



Ultima Thule Surface Composition

LORRI + Ralph/MVIC

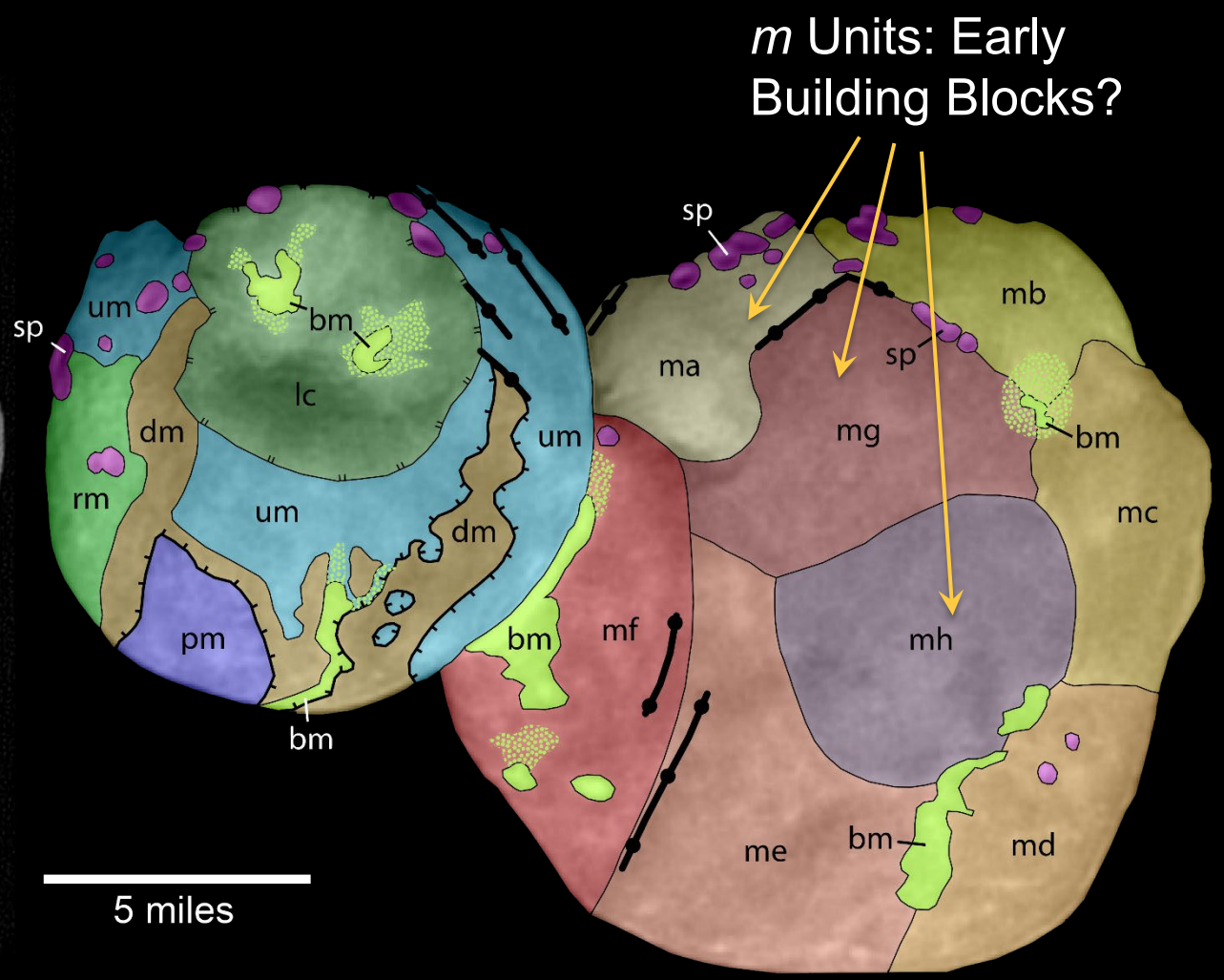
Ralph/LEISA

- Evidence for:
  - Methanol
  - Water ice
  - Organic molecules

Geology of Ultima Thule

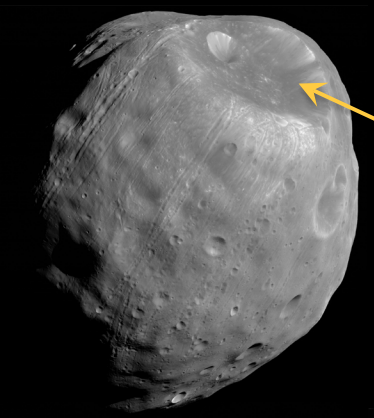
Dr. Kirby Runyon
New Horizons Postdoctoral Scientist
Johns Hopkins Applied Physics Laboratory

Ultima Thule's Complex Geology



Rolling hills, troughs, pits, bright & dark areas

Troughs and Craters



Stickney Crater
(Phobos)

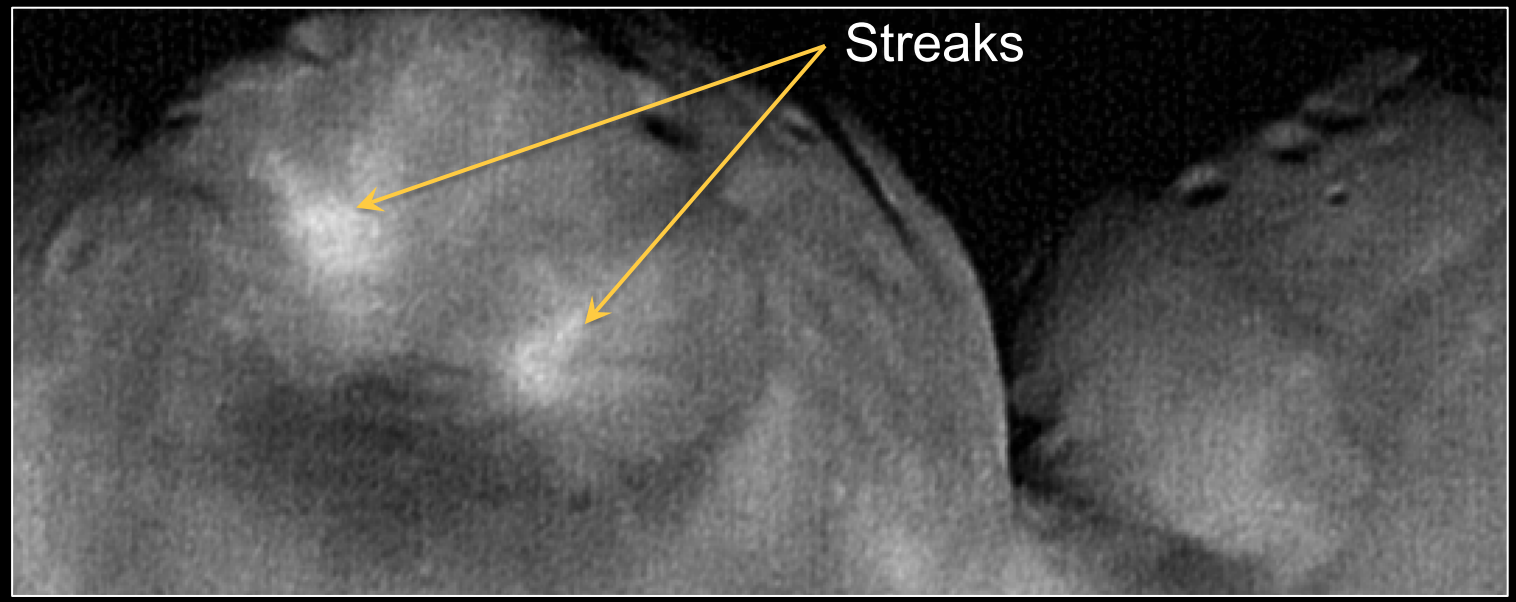
Maryland Crater

Troughs

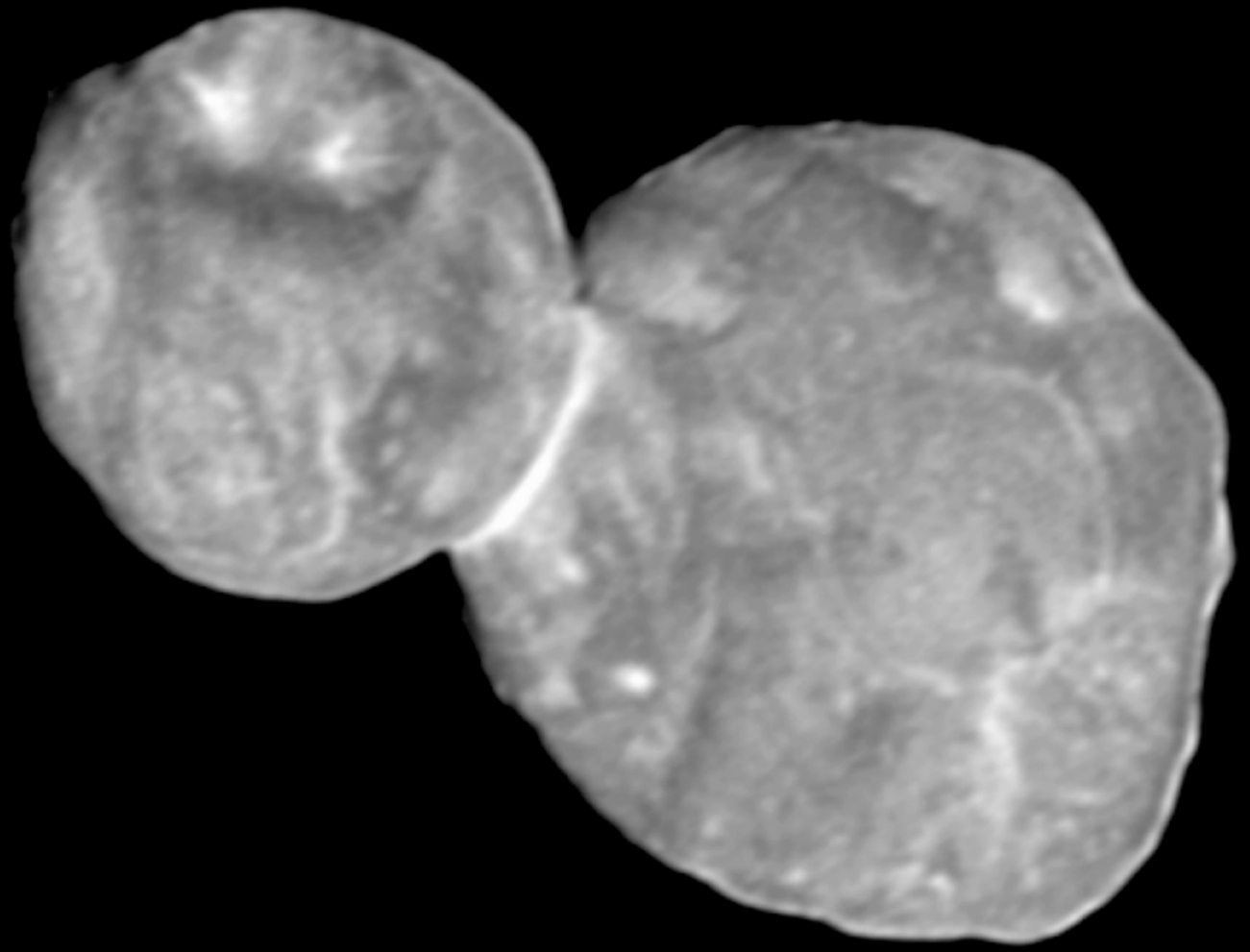
Impact or
Sublimation
Craters

Pit Craters

Hills and Streaks



Landscape Perspectives: Sheared Neck

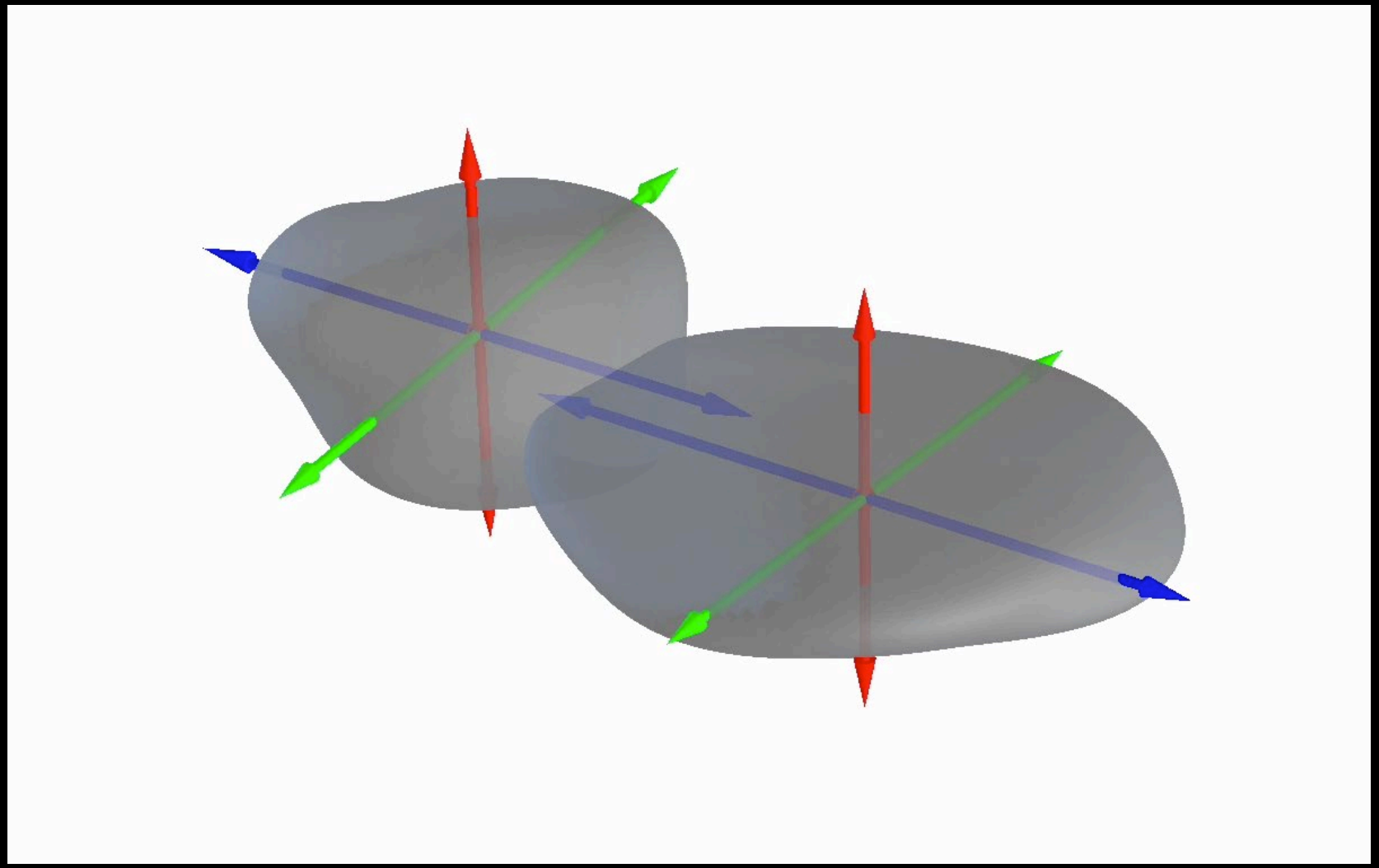


Animation Credit: Roman Tkachenko

Origin of Ultima Thule

Dr. William B. McKinnon
New Horizons Co-Investigator
Washington University in St. Louis

Geometric Alignment of ‘Ultima’ and ‘Thule’

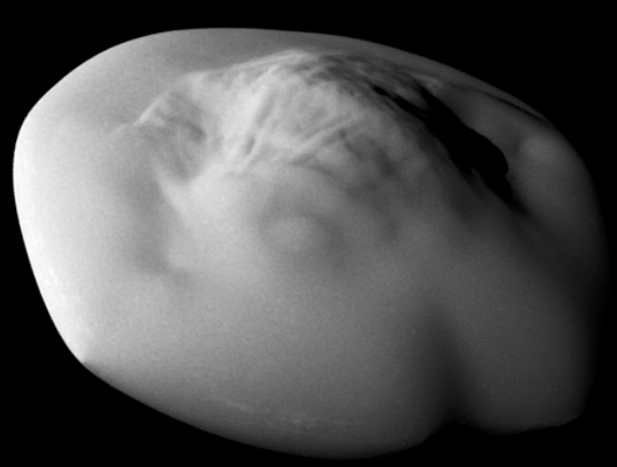


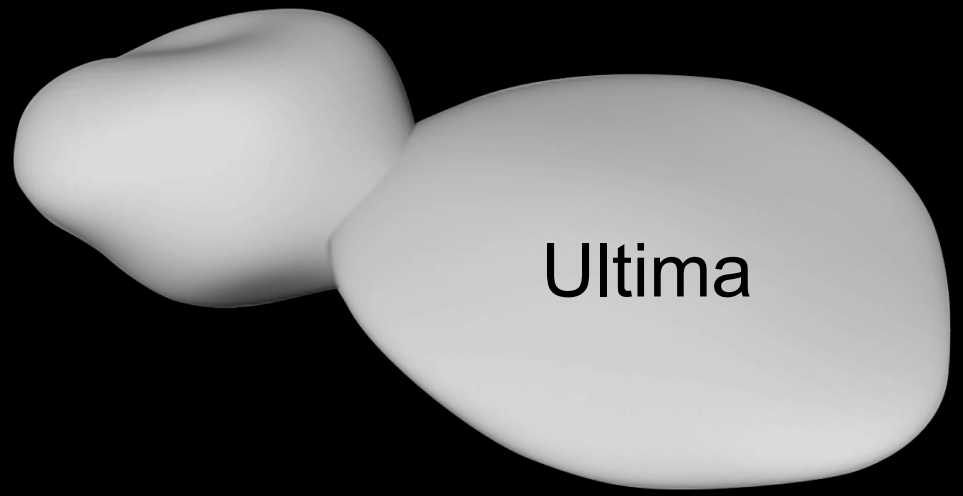
NASA/JHUAPL/SwRI/James Tuttle Keane

- Major axes of both lobes are aligned
- Highly unlikely to be due to chance
- Indicates lobes once orbited one another – aligned by mutual tides

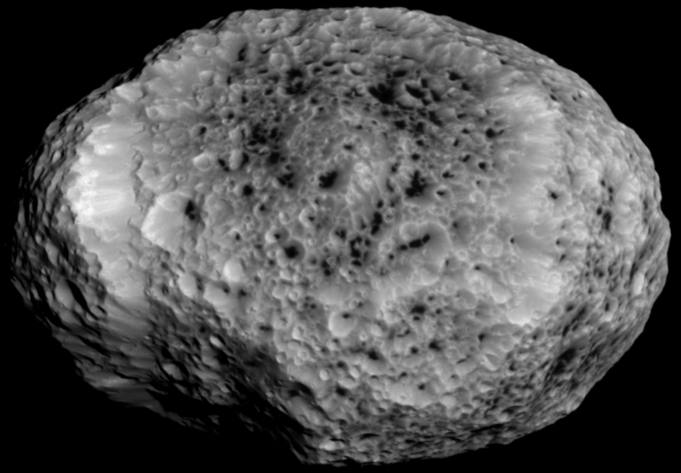
Different Lobes: Why Is Ultima so Flat?

Atlas (Saturn)





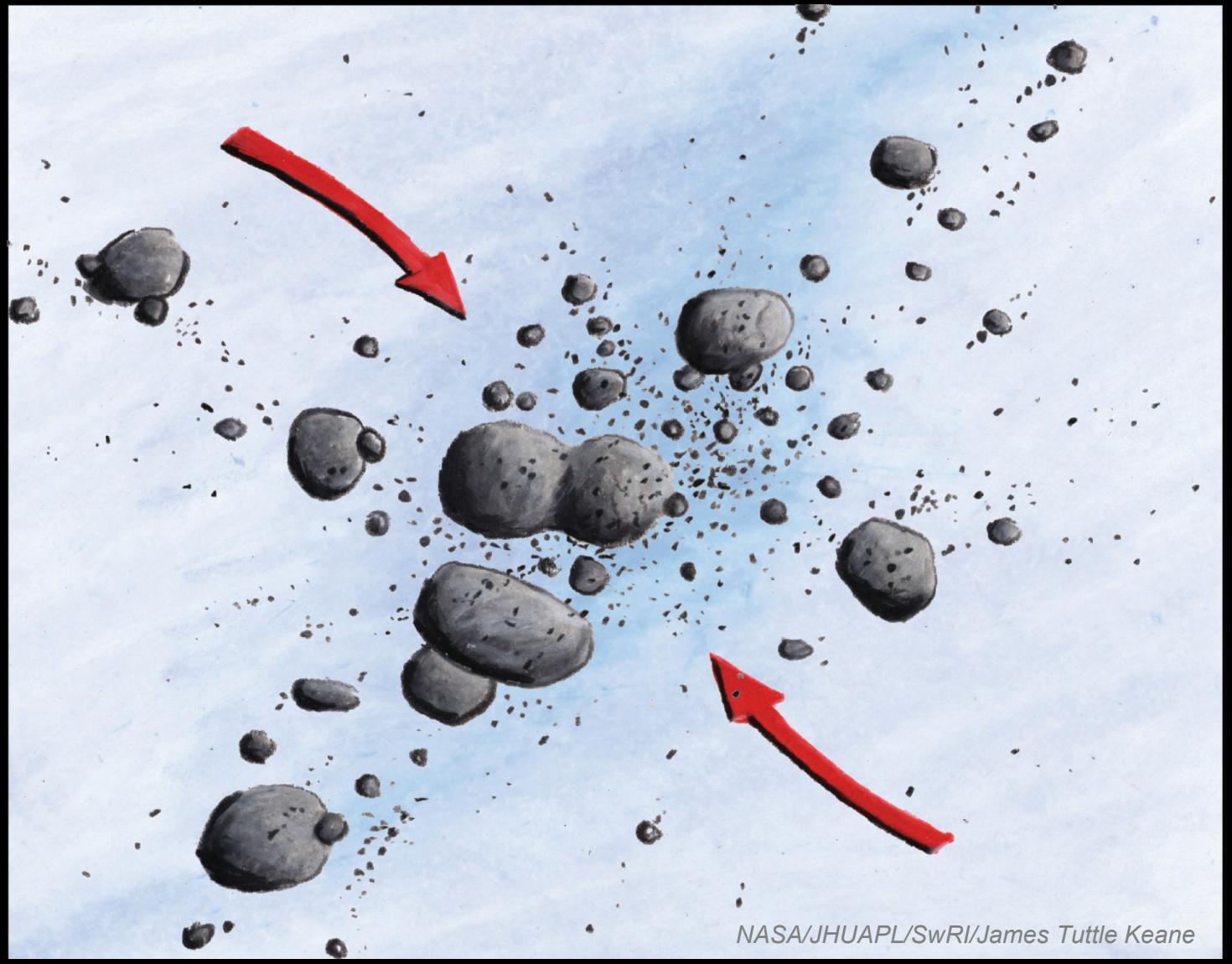
Hyperion (Saturn)



Some satellites are almost as flat, but for different reasons

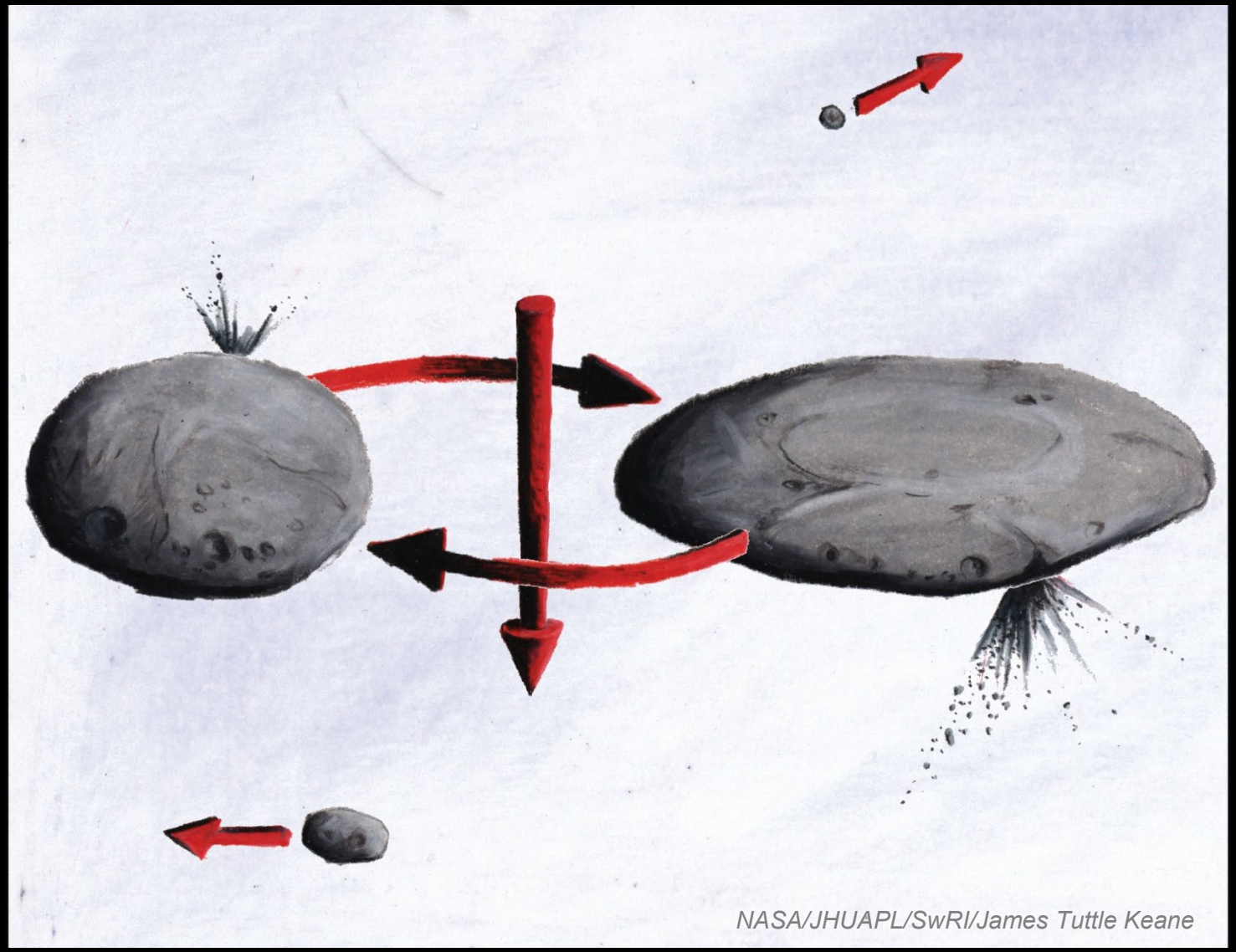
(Sizes not to scale)

Gravitational Collapse of a Particle Cloud



- 4.56 billion years ago – in a remote part of the solar nebula
- A swirling collection of icy particles begins to coalesce

…Two Bodies Form in Mutual Orbit

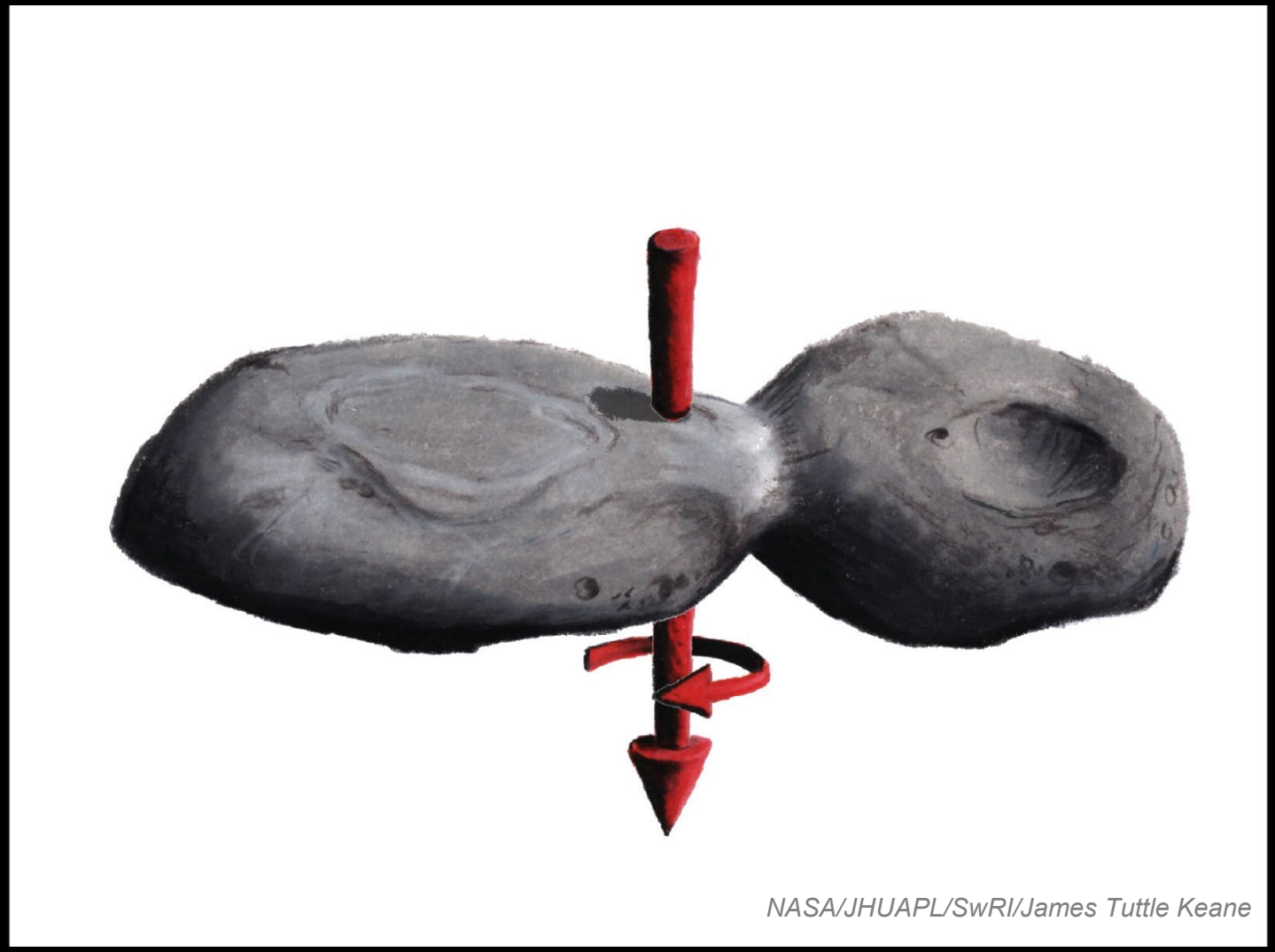


NASA/JHUAPL/SwRI/James Tuttle Keane

Orbit shrinks due to:

- Tides with other bodies and/or
- Collisions with other bodies and/or
- Drag from nebular gas

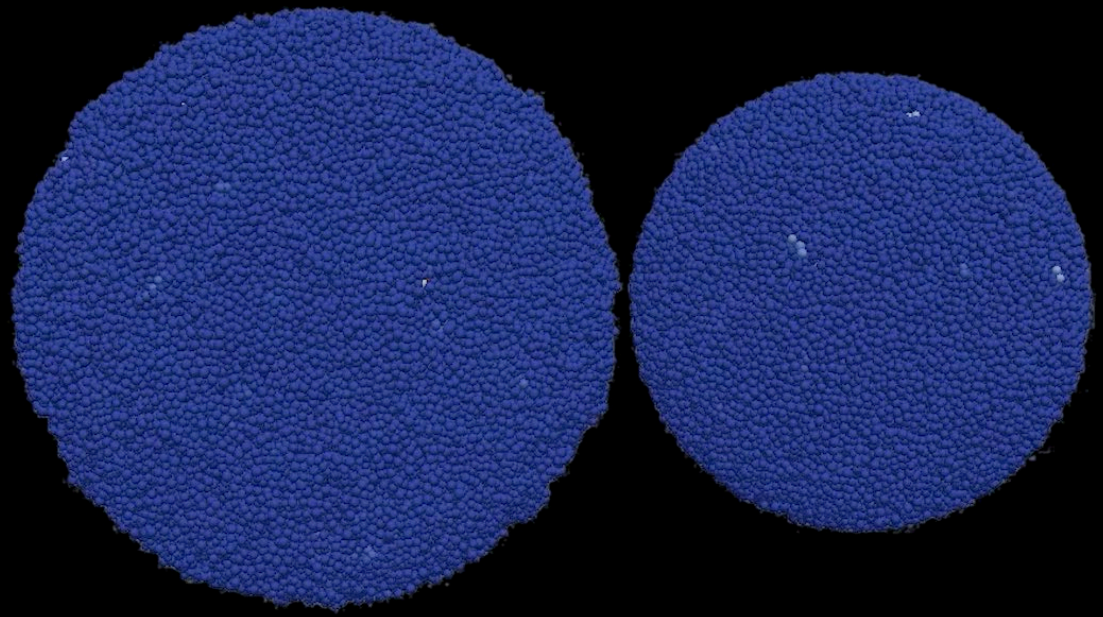
… Slow Merger

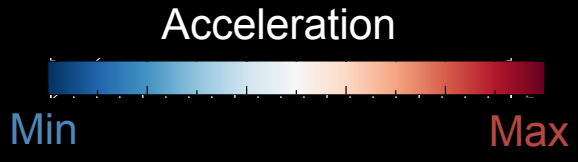


NASA/JHUAPL/SwRI/James Tuttle Keane

- Lobes appear undamaged by final merger – except at neck
- No evidence for catastrophic impacts or fragmentation
- Merger speed was gentle

Numerical Simulation of Merger





- Impact at 2 meters/sec
- Hot (red) colors indicate max acceleration
- 200,000 particles in all, gravity and sliding friction included

Derek Richardson & Julian Marohnic (University of Maryland)

What Is Ultima Thule Teaching Us?

- Our clearest look back to the era of planetesimal accretion
- Lobes are similar in color, composition
- Yet dissimilar in shape, assembly?
- Gentle merger of two separate planetesimals
- Alignment of lobes due to tides between co-orbiting bodies
- Consistent with origin in collapsing particle cloud

Follow New Horizons

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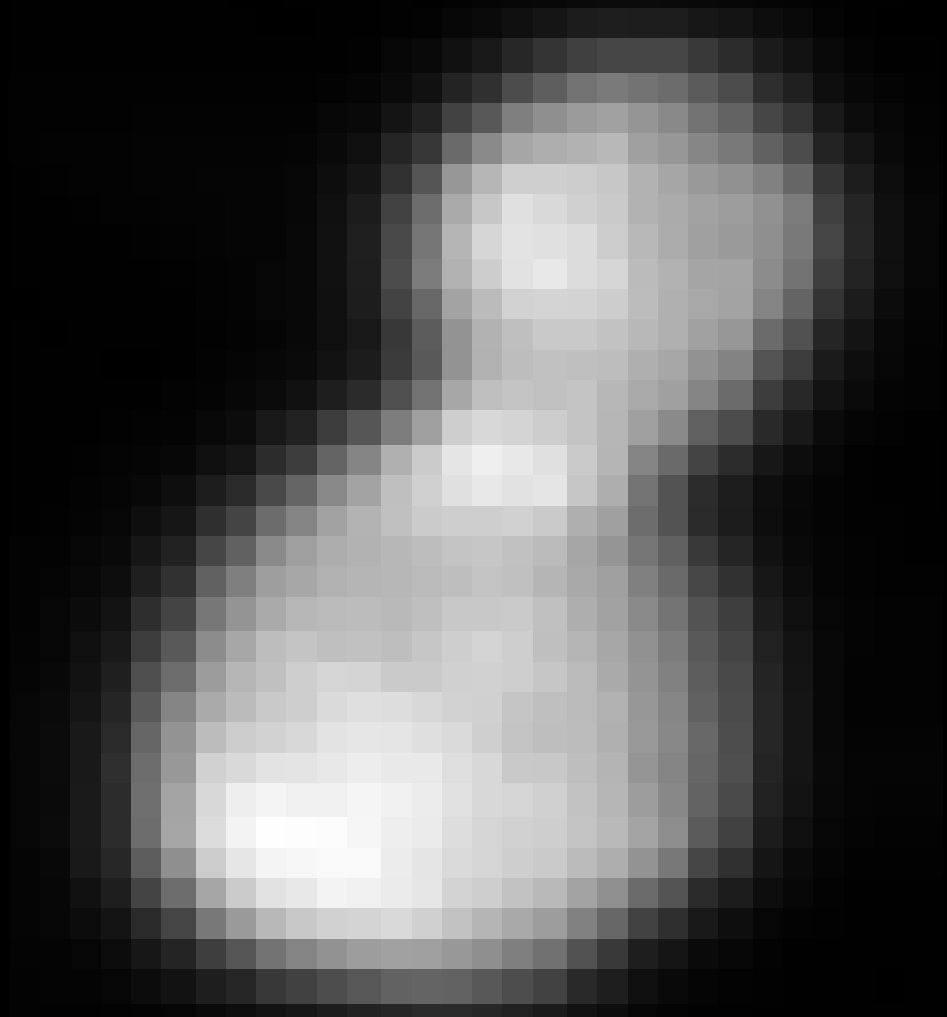
Back up slides

MVIC and LEISA Maps of Ultima Thule

LORRI



Ralph/LEISA