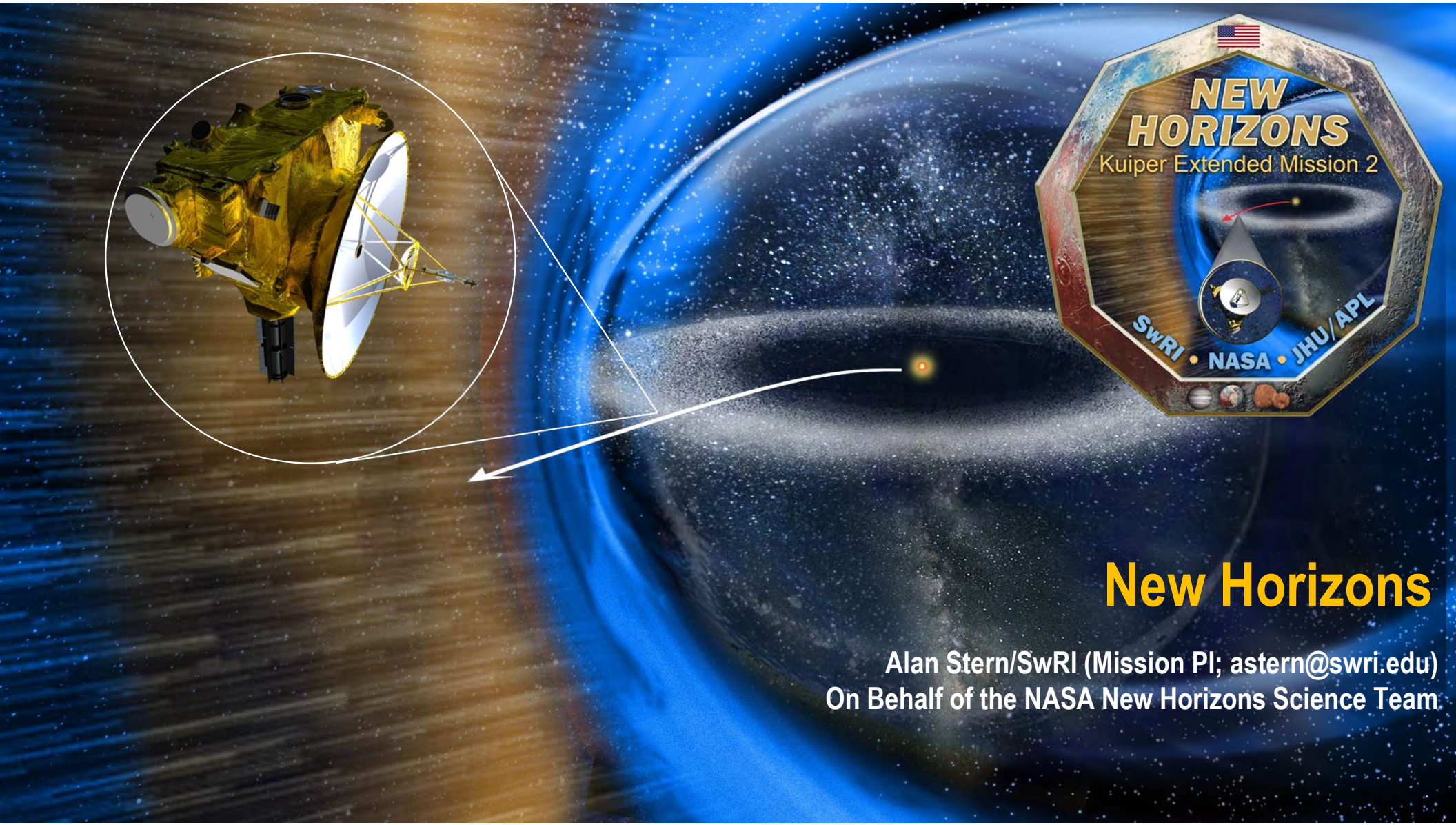
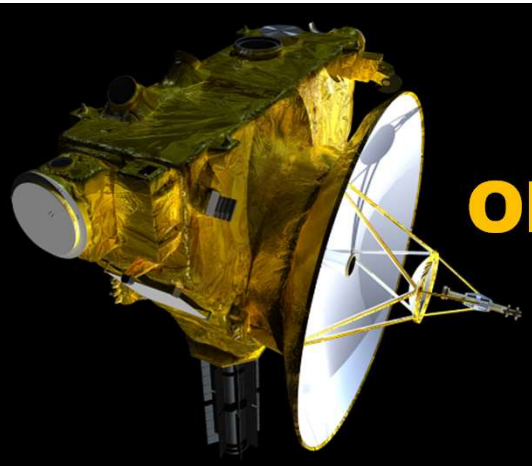



# New Horizons

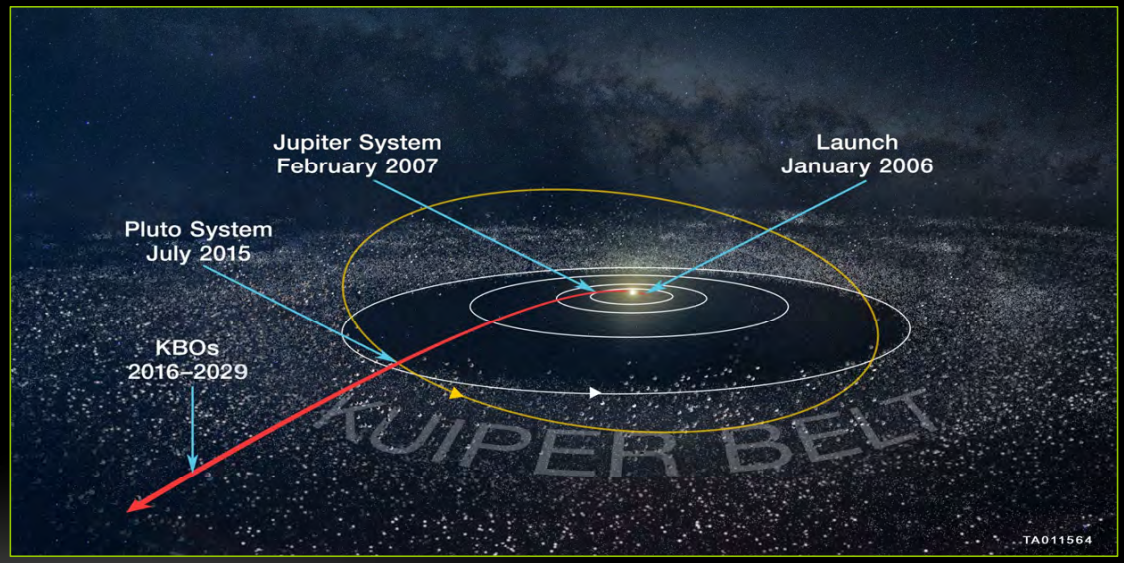
Alan Stern/SwRI (Mission PI; astern@swri.edu)
On Behalf of the NASA New Horizons Science Team

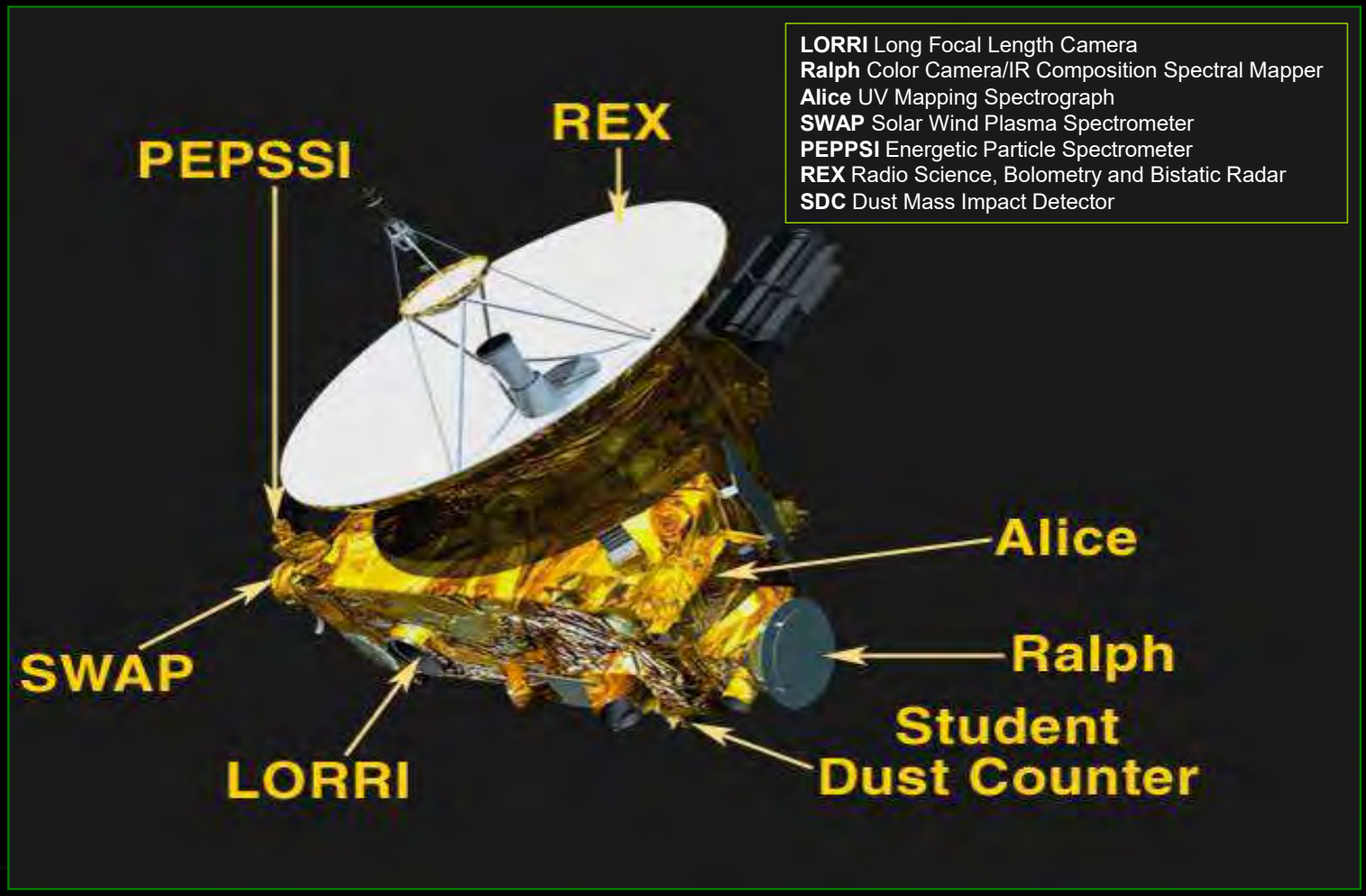
# New Horizons Mission

## Objective: Make the First Spacecraft Exploration of the Pluto System and Kuiper Belt Planetesimals

| | |
|---|---|
| Mission | New Frontiers 1 |
| Launch | Jan 2006 |
| Launch Wet Mass | 478.3 kg |
| P/L Mass | 30.4 kg |
| Power | GPHS RTG |
| Current Speed | 2.89 AU/yr |
| Expected Max Lifetime | ~2050 |



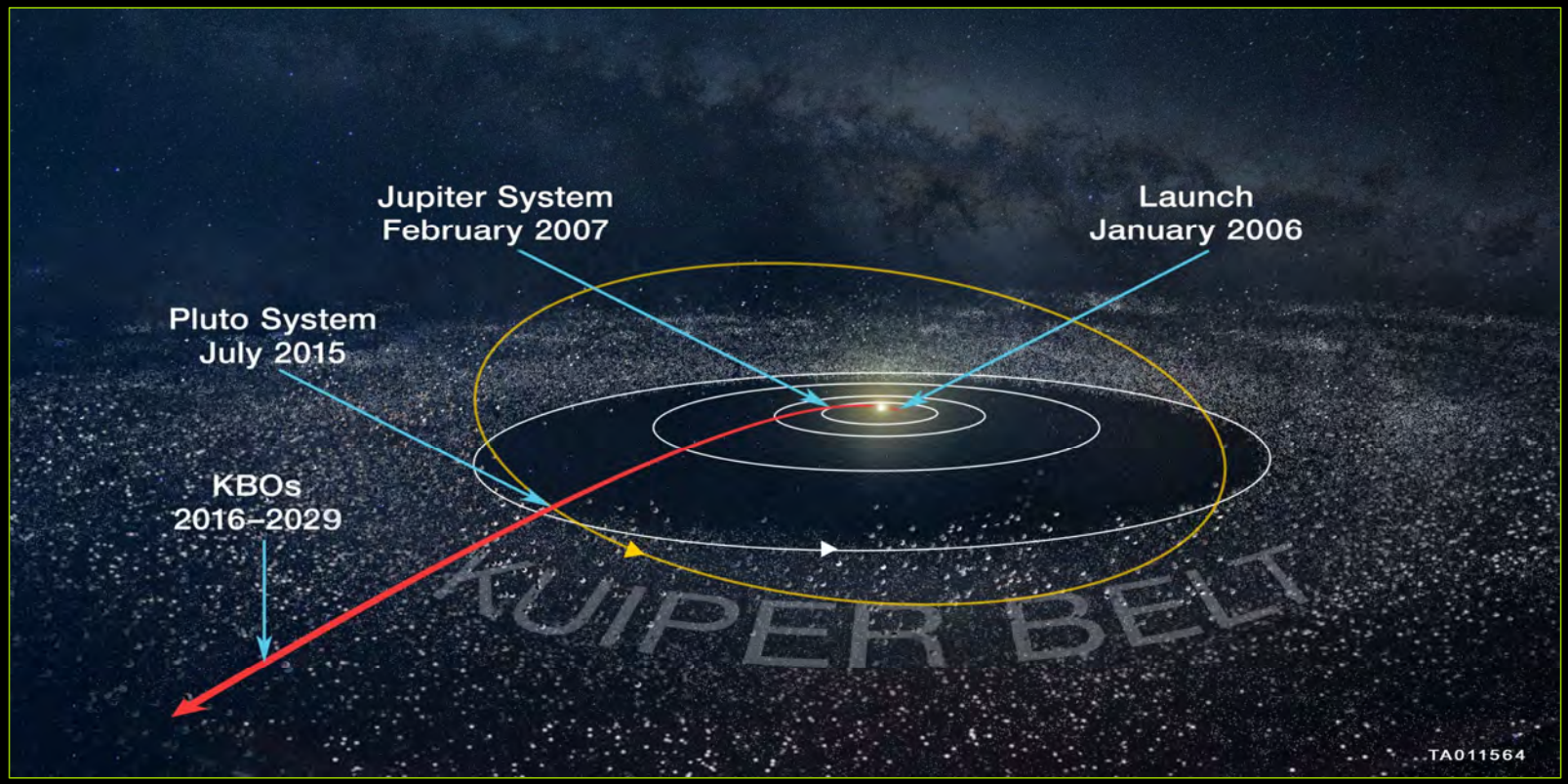
# Payload




**LORRI** Long Focal Length Camera
**Ralph** Color Camera/IR Composition Spectral Mapper
**Alice** UV Mapping Spectrograph
**SWAP** Solar Wind Plasma Spectrometer
**PEPPSI** Energetic Particle Spectrometer
**REX** Radio Science, Bolometry and Bistatic Radar
**SDC** Dust Mass Impact Detector

# Primary Challenges

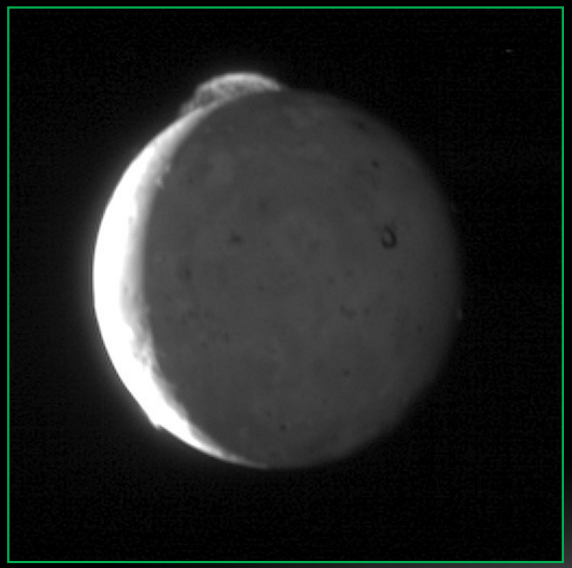
- ✓ Breakthrough Low Cost
- ✓ Short Development Schedule
- ✓ Launch Vehicle Development
- ✓ Instrument Miniaturization
- ✓ Nuclear Launch Approval
- ✓ No Second Chances
- ➢ Finding KBO Targets
- ➢ Cross Divisional Science/NH as a Multi-Divisional Pathfinder


Jupiter System
February 2007
Launch
January 2006
Pluto System
July 2015
KBOs
2016–2029
KUIPER BELT
TA011564

# 2007 Jupiter Gravity Assist

**700+ Scientific Observations, Including:**

- Magnetotail Survey to >1000 $R_J$
- Io Tvashtar Plume Time Lapse
- Io Torus UV Spectroscopy
- Jovian Meteorological Dynamics



# Pluto System Flyby 2015

# Pluto-Charon Binary

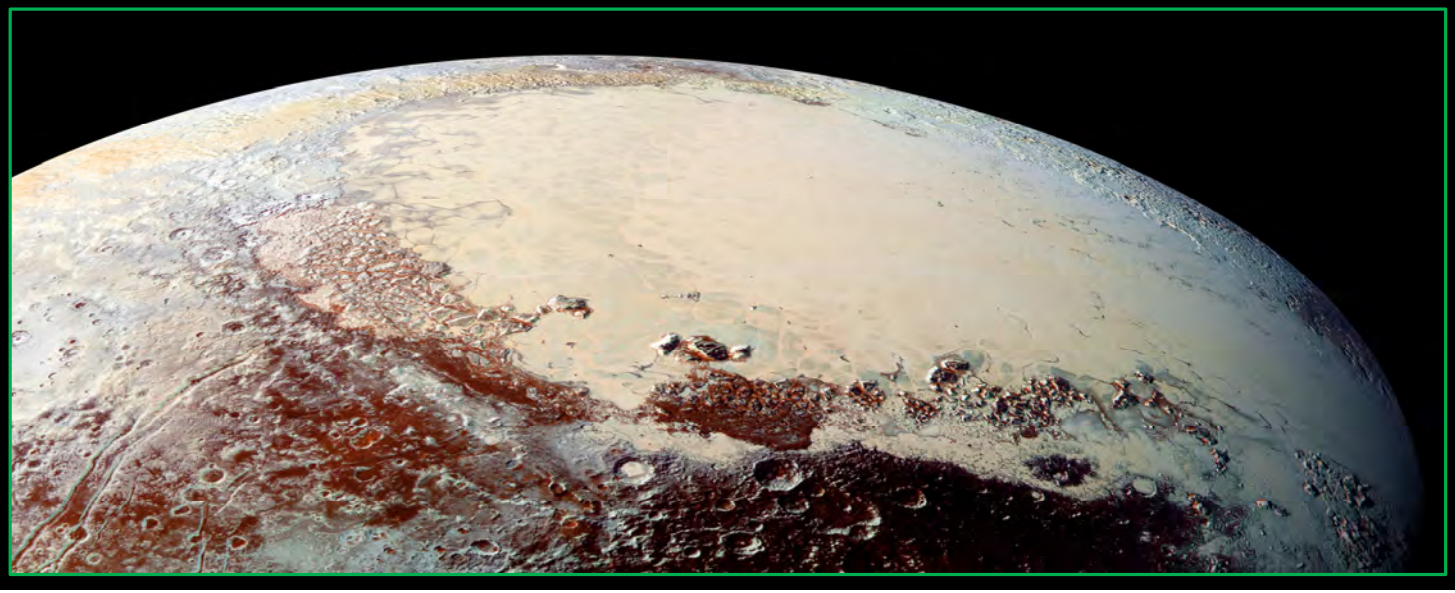

# Measurement Objectives: 100% Accomplished!

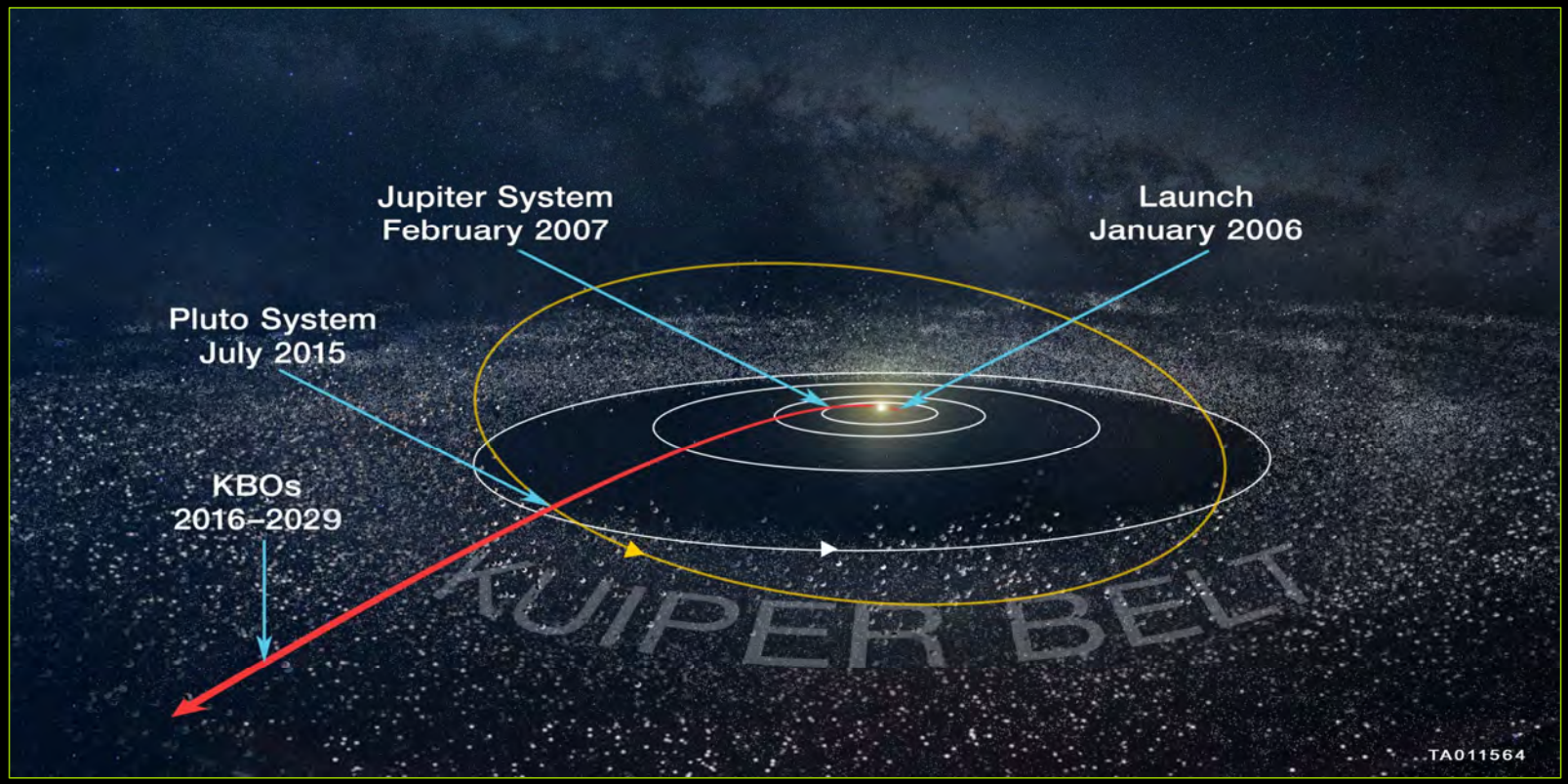
| | |
|---|---|
| **Group 1 Objectives:** | **Required** |
| Characterize the global geology and morphology of Pluto and Charon | |
| Map surface composition of Pluto and Charon | |
| Characterize the neutral atmosphere of Pluto and its escape rate | |
| **Group 2 Objectives:** | **Important** |
| Characterize 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 | |

# High Impact Results


# Pluto Paradigm Shift Examples

- Astounding Geologic Diversity/Complexity
- Sustained Geologic Activity over 4+ Gyrs
- An Isolated Heliocentric Ocean World
- Jeans Escape (Not Hydrodynamic)
- Binary Atmospheric Transfer
- Glacial Convection
- Global True Polar Wander

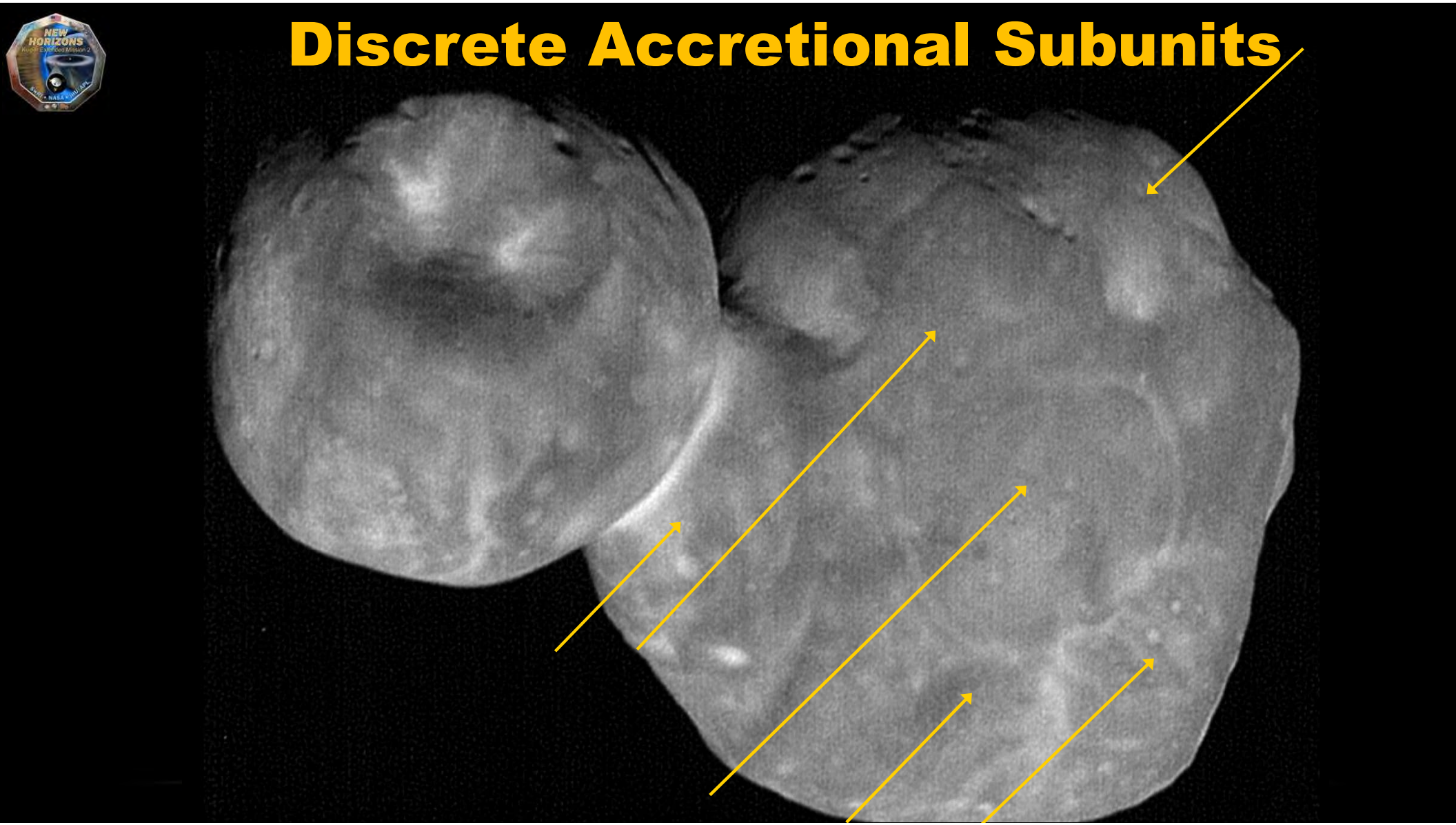




Jupiter System
February 2007
Launch
January 2006
Pluto System
July 2015
KBOs
2016–2029
KUIPER BELT
TA011564

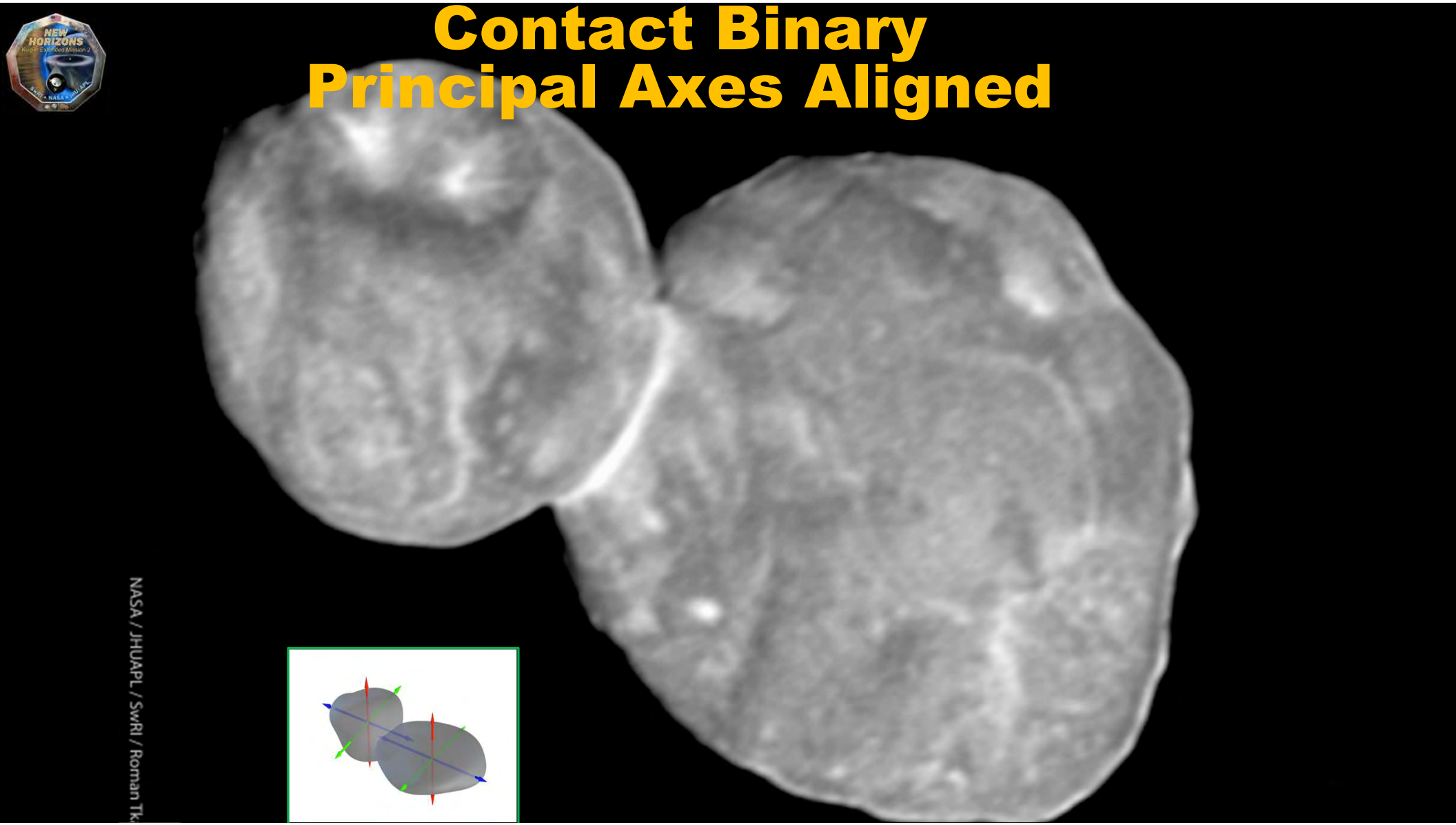
# KEM 1: Arrokoth KBO Flyby 2019

# Comparing Pluto To Kuiper Belt Planetesimal Arrokoth

# Discrete Accretional Subunits



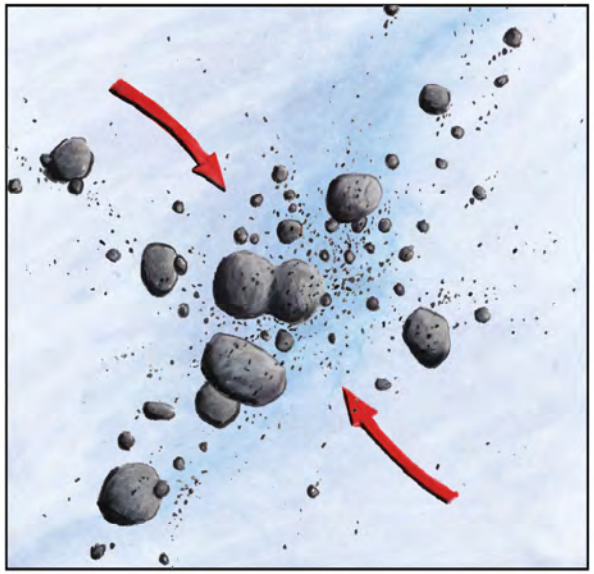
# Contact Binary
# Principal Axes Aligned



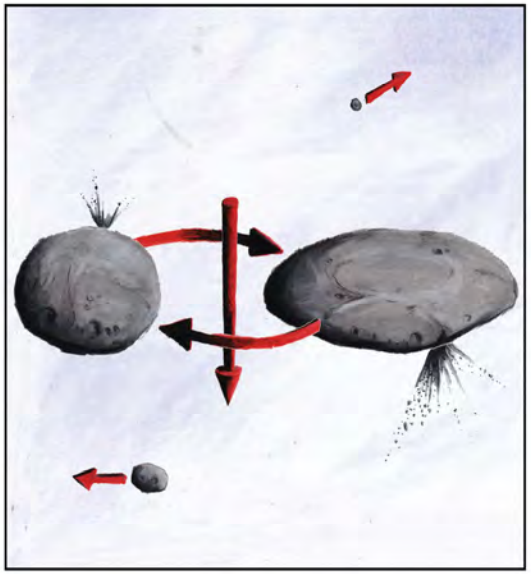


NASA / JHUAPL / SwRI / Roman Tk

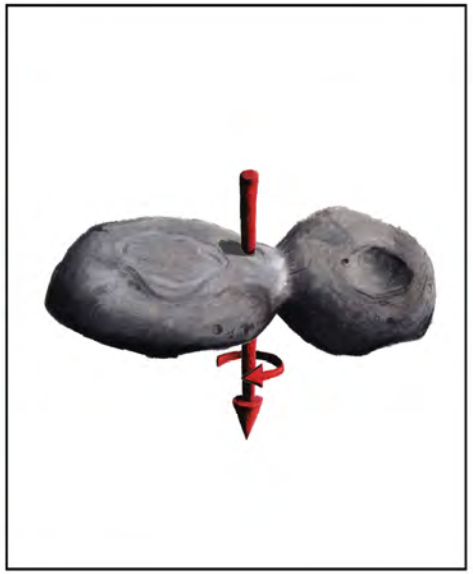
# Paradigm Shift: Formation by Gentle, Tidal Merger After Streaming Instability



A rotating cloud of small, icy bodies starts to coalesce in the outer solar system.



Eventually two larger bodies remain.

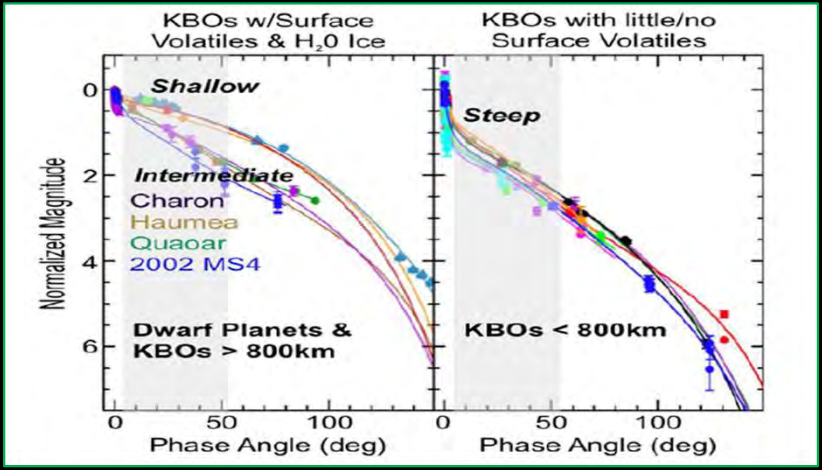


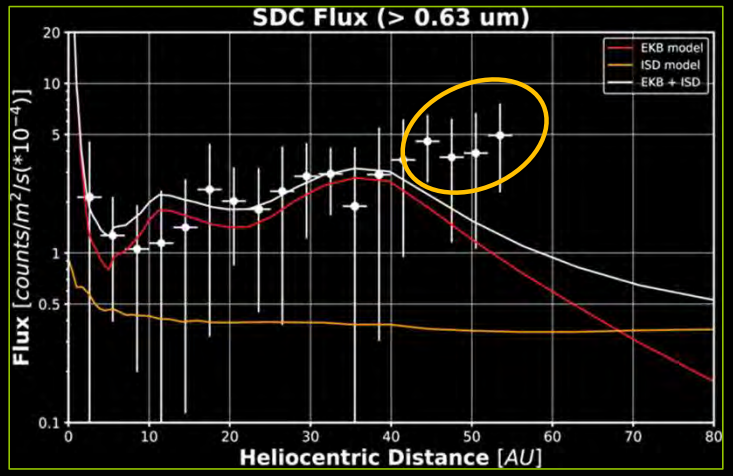
The two bodies slowly spiral closer until they touch, forming the bi-lobed object we see today.

New Horizons / NASA / JHUAPL / SwRI / James Tuttle Keane

# Other KEM2 Planetary Science

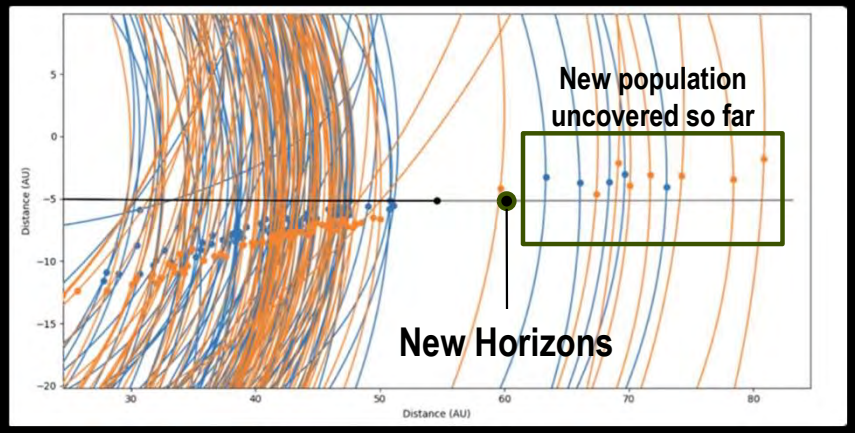
- KBO Studies: Over 30 Planetesimals Observed
  - Known future targets out to ~80 AU (2031)
  - Revealing shapes, poles, surface properties, and satellites.
- High phase dwarf planet studies
- High phase Uranus-Neptune ice giant observations
- Measuring the radial distribution of dust as a KBO population tracer.



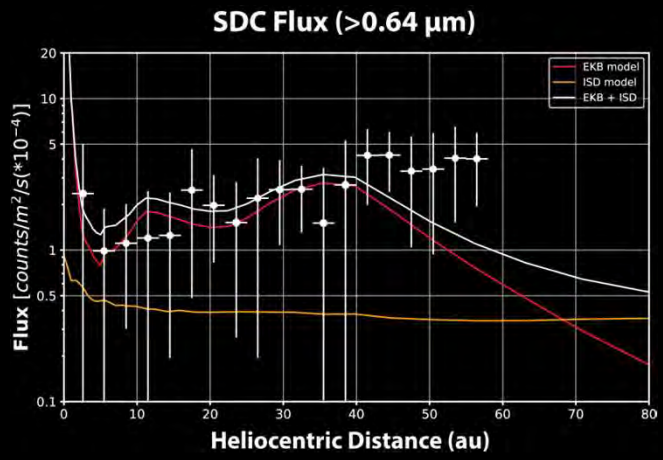
# Evidence for an Extended Kuiper Belt

## (1) Distant Population Uncovered by Ground based Telescopes




The Subaru Telescope reveals dozen of faint KBOs in 60-80 au range (Fraser et al. 2024)

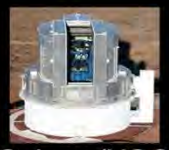
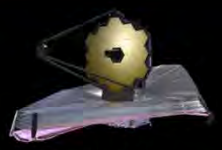
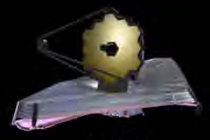
## (2) Increasing Dust Fluxes Discovered by New Horizons SDC Dust Counter




Dust fluxes detected by SDC do <u>not</u> fall off as expected at the "Kuiper Cliff", but instead continue to rise (Doner et al. 2024)

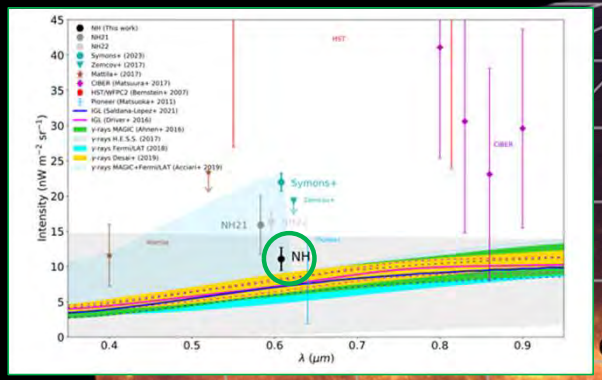
# KBO Observing/Flyby Target Searches

**The spacecraft is capable of another flyby; the search for an additional flyby target is our highest priority planetary objective.**

| Era | Discovery | Follow Up | Result |
|---|---|---|---|
| Current Gen 2020-2024 |  Subaru/HSC |  HST | Search down to V~26.5<br>~1 modern GPU<br>1x |
| Next Gen 2024+ |  LSST (100 hr)  Subaru/HSC |  JWST | Search down to V~28.5<br>(multi-night stacks)<br>~100 modern GPUs<br>~8x |
| Future 2027+ |  RST |  JWST | Search down to V~30<br>XXX? modern GPUs<br>~50x |

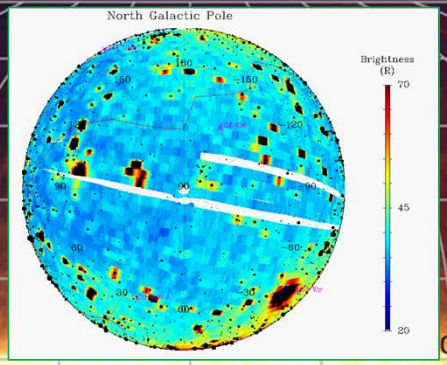
# KEM 2: Astrophysical Studies

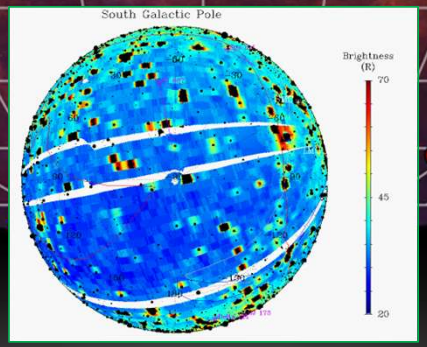
## Most Accurate Cosmic Background Determination




LORRI has obtained multiple observations of the darkest regions of the sky and achieved the most accurate direct measurements of the COB to date (Postman+2024).

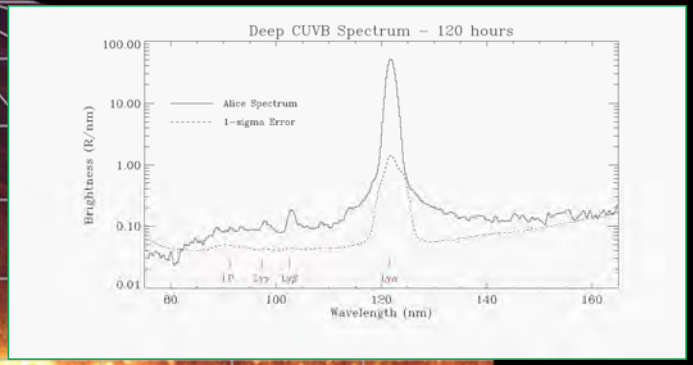
## Peering into the Local Clouds




Alice all-sky maps in total Lyman-alpha show ~10R unexplained north-south asymmetry. Signature of Local Clouds? Gladstone+2024, in preparation.

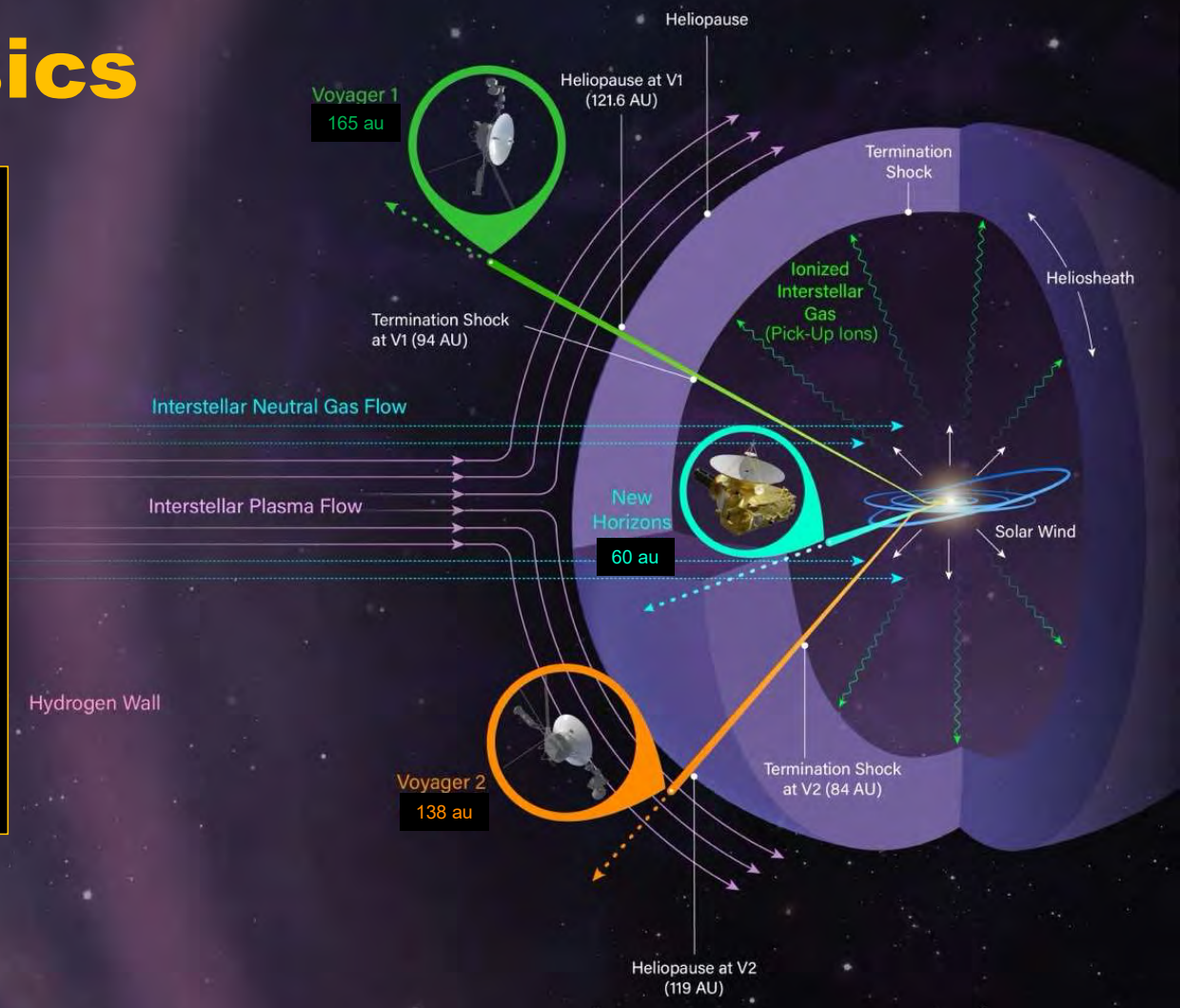
## Rich Cosmic UV Background Spectrum




Multiple Alice spectra have been obtained across the sky and are used to study the CUVB, shock fields in the Fermi Bubble, H2 emissions and fluorescence features. Murthy+ 2024, in prep.

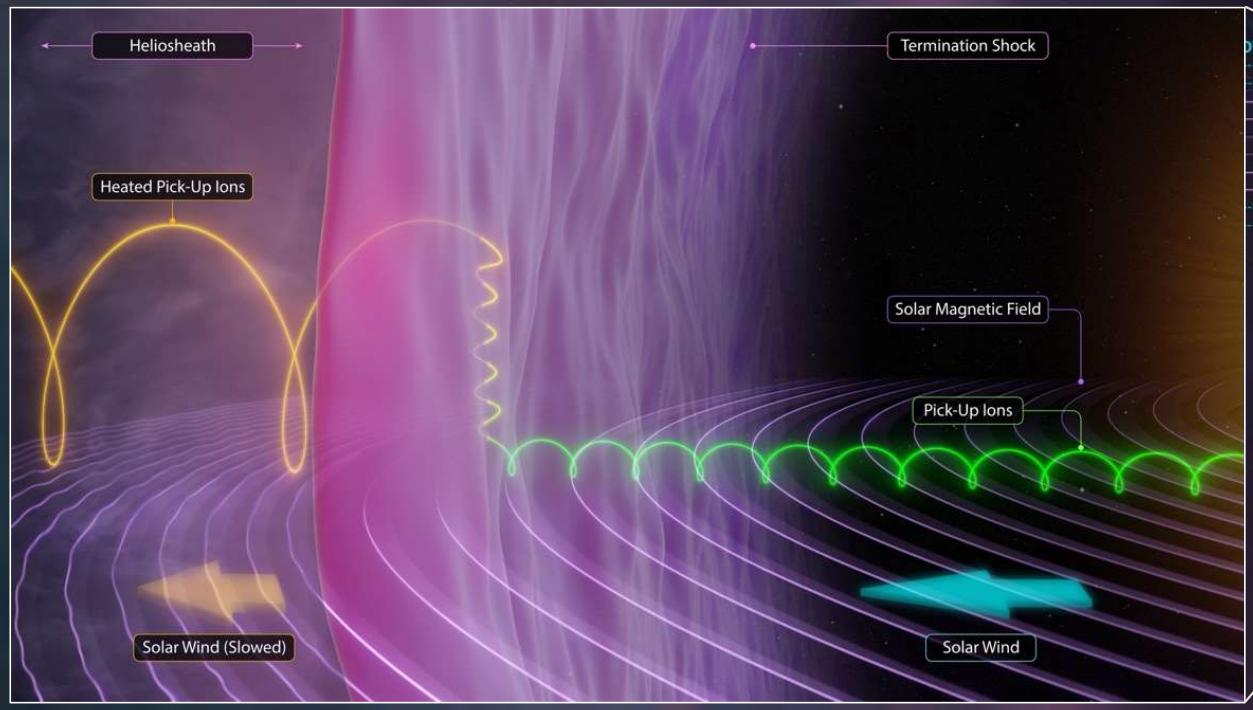
# KEM 2: Heliophysics

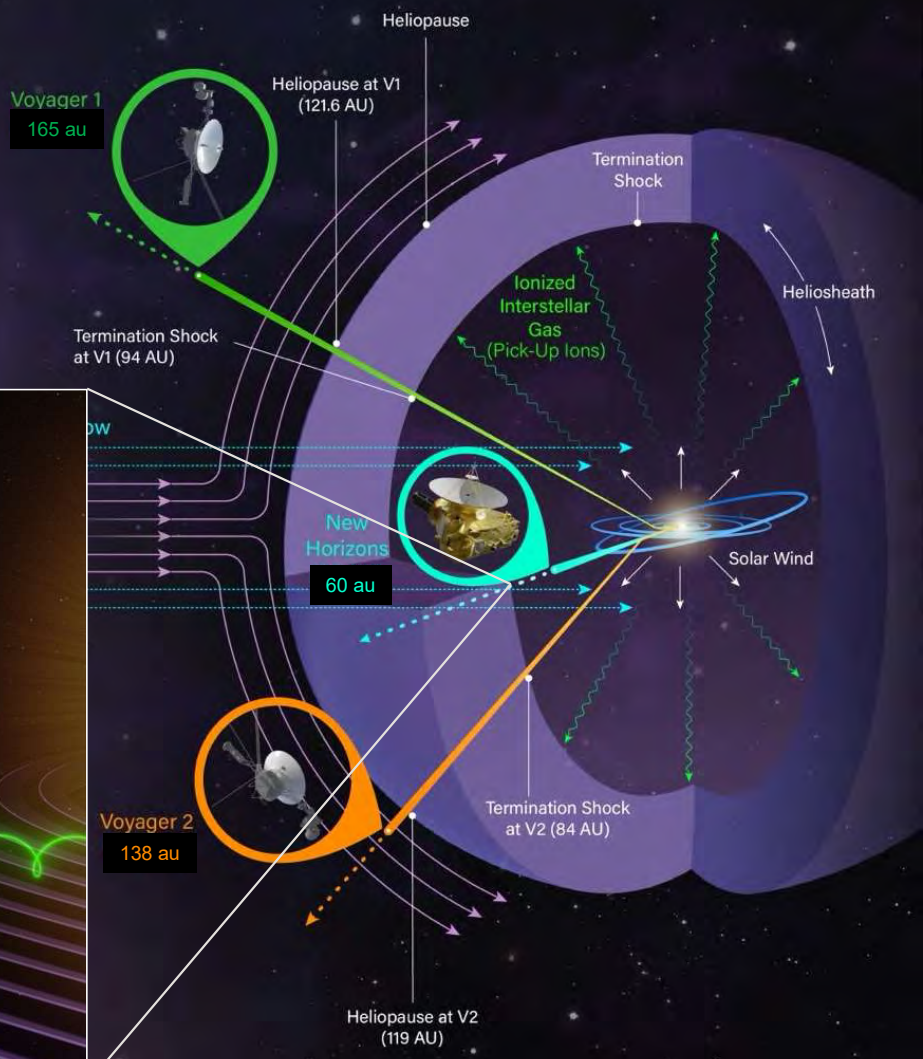
- New Horizons is currently the only spacecraft in the outer heliosphere.
- Measures the unique Pick-Up Ions, crucial for understanding the force balance of the entire heliosphere.
- Determines how the solar wind and disturbances evolve through the heliosphere.
- Explores the heliospheric Termination Shock to resolve the mystery left behind by Voyager.
- Characterizes the distribution of the interplanetary and interstellar hydrogen.



# KEM 2: Heliophysics

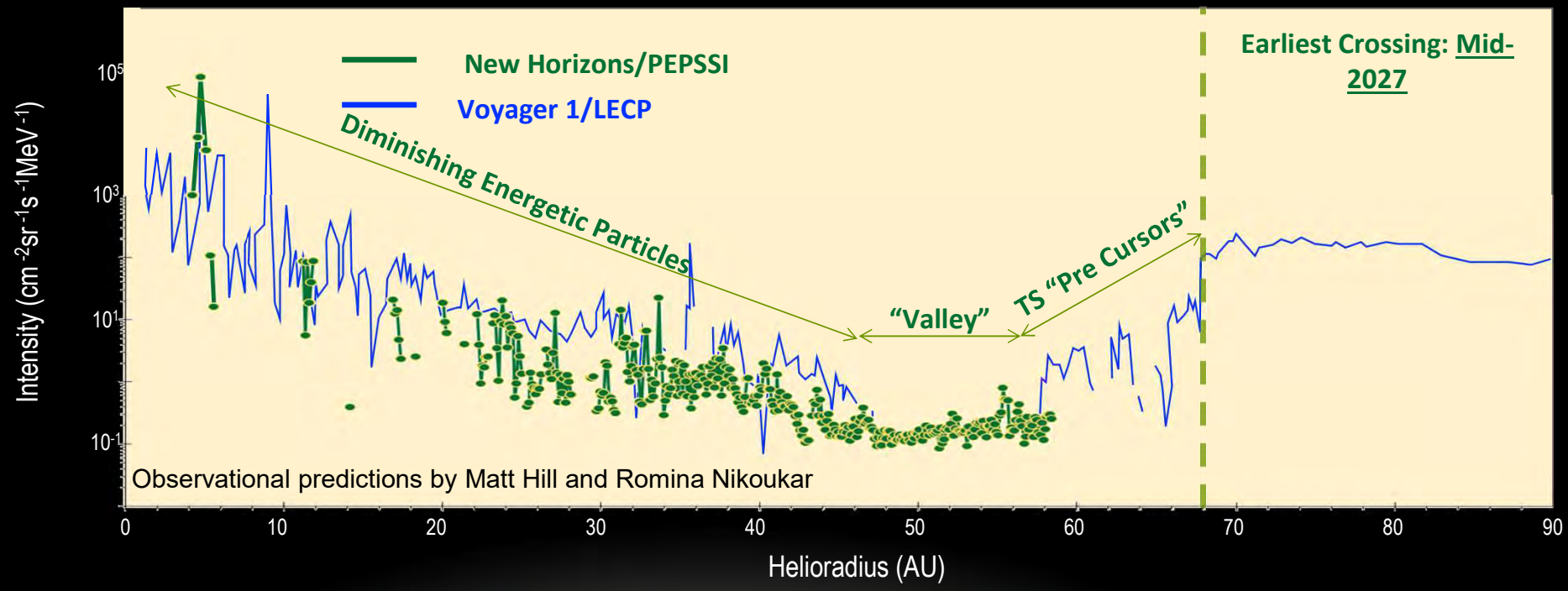
## The Termination Shock



# When Will New Horizons Reach the TS?

**No earlier than mid-2027 (~68 AU) from scaling the large-scale trends in the Voyager energetic particle data.**



# KEM 2 Termination Shock Campaign

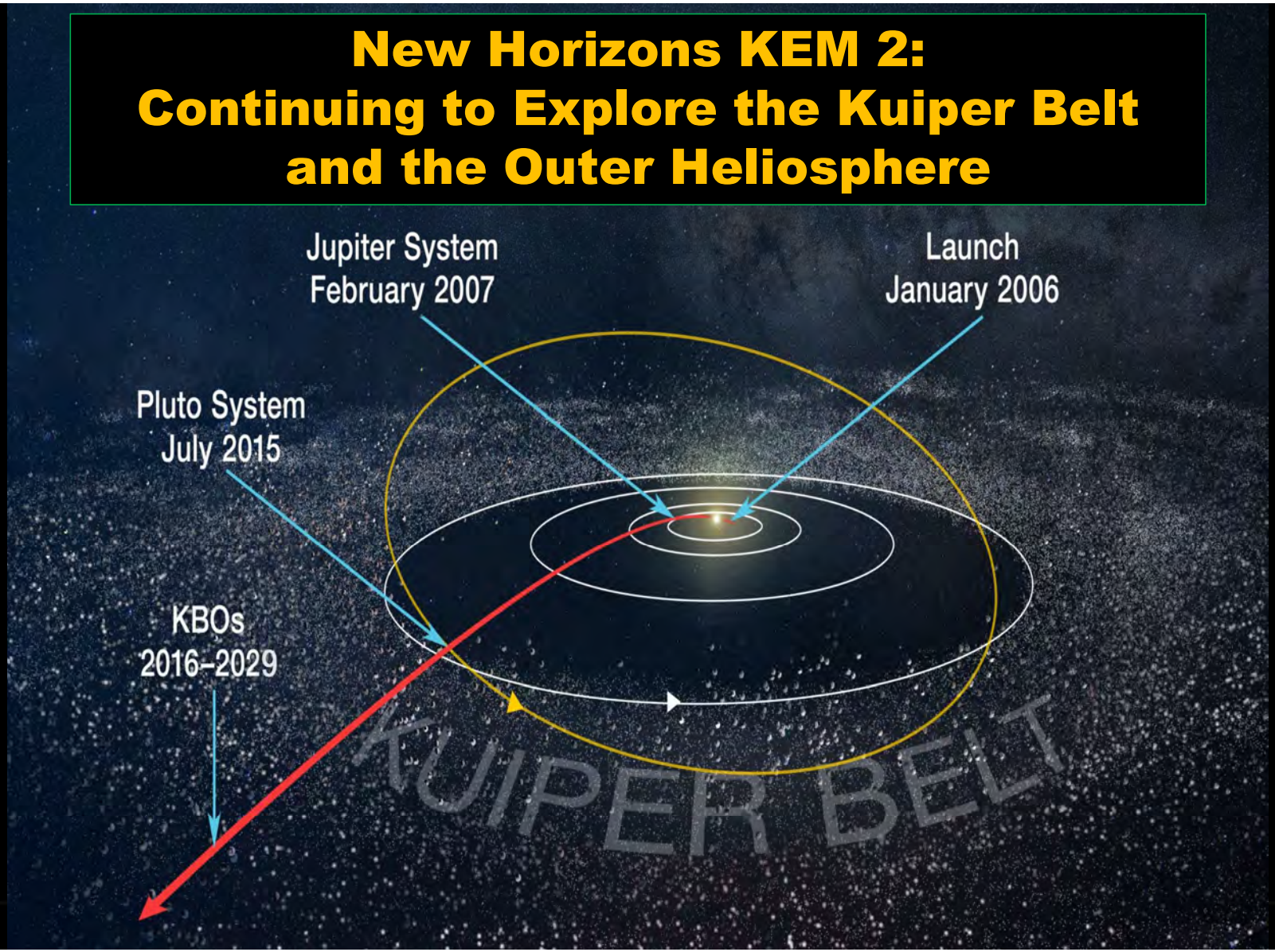

## Approach Phase (FY25-FY26)

- Hibernation/awake
- PEPSSI, SWAP and SDC continuously on
- Alice Lya Great-Circle Scan in 2026

## Termination Shock Campaign (FY27+)

- Continuously awake until crossing
- PEPSSI, SWAP and SDC continuously on
- Alice Lya Great-Circle Scan every two years (TBC)

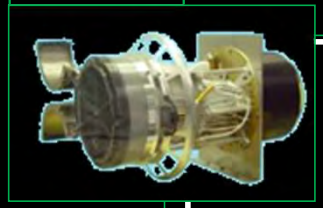
# New Horizons KEM 2: Continuing to Explore the Kuiper Belt and the Outer Heliosphere




# Backup Slides

# SWAP and PEPSSI Measurements

## SWAP






**Energy Range:** 35 eV/e – 7.5 kV/e
**Species:** Ions
**Target:** Solar wind and $H^+$ PUI speed, density, and temperature

## PEPSSI




**Energy Range (ions):** ~1 keV/nuc – 1 MeV/nuc
**Energy Range (electrons):** 25-500 keV
**Energy Resolution:** <5 keV
**Species:** H, He, CNO, e
**Target:** $He^+$ PUIs, energetic particles, GCRs