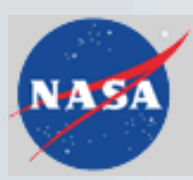




# NEW HORIZONS



## *The Exploration of The Pluto System And The Kuiper Belt*

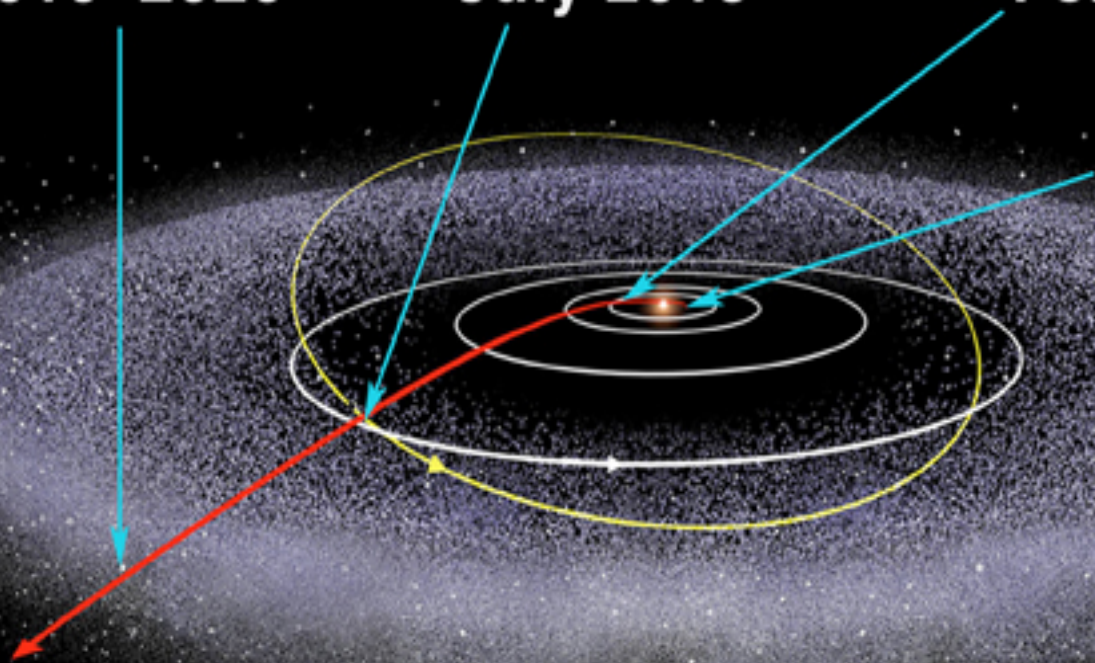
*Alan Stern,  
Principal Investigator*

**KBOs**  
**2016–2020**

**Pluto System**  
**July 2015**

**Jupiter System**  
**Feb 2007**

**Launch**  
**Jan 2006**

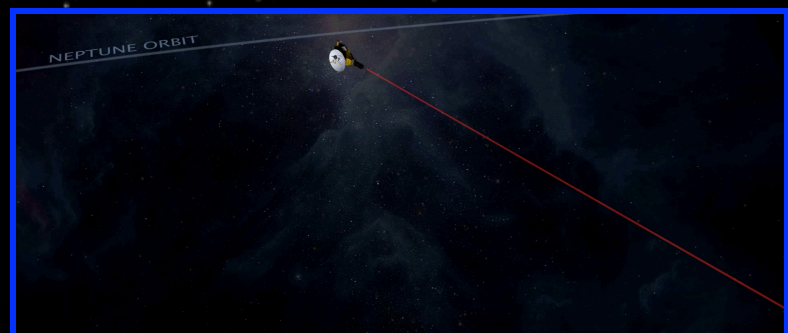


New Horizons Full Trajectory - Side View



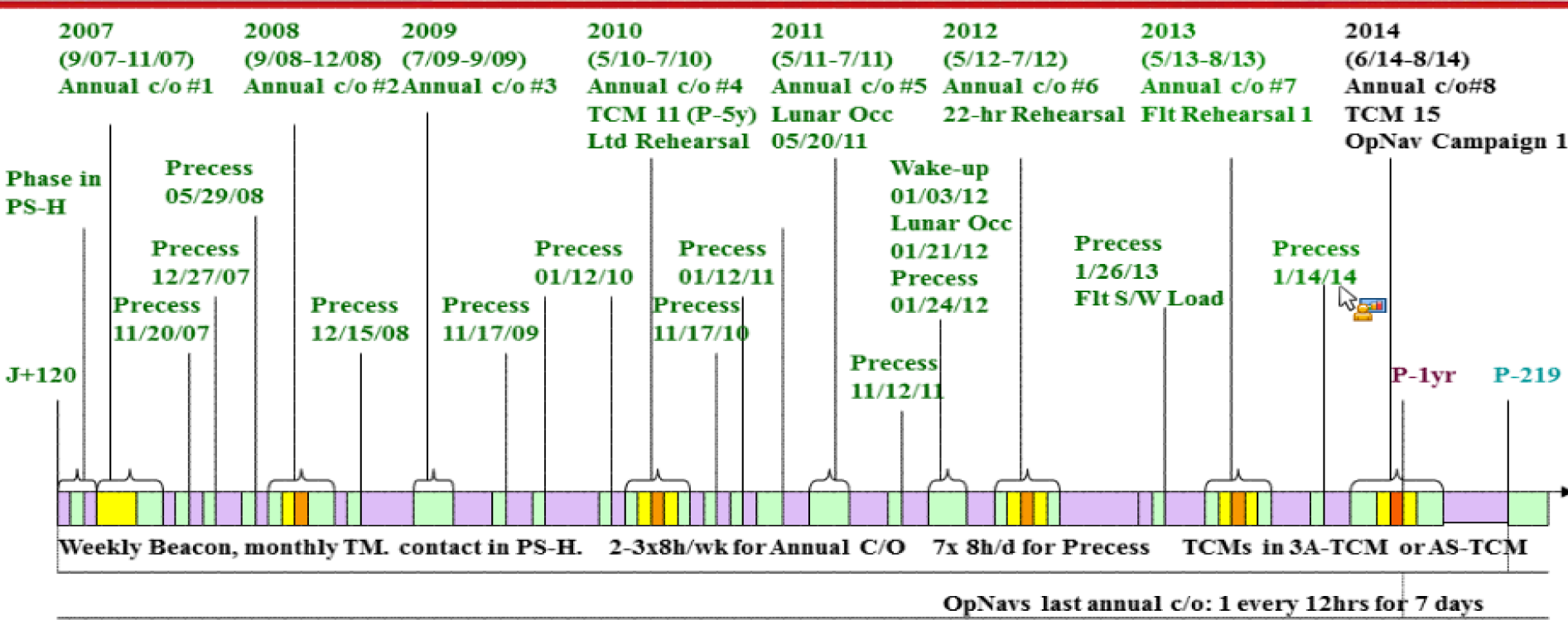
Distance from Earth (AU): 28.92  
Distance from Sun (AU): 29.91  
Distance from Pluto (AU): 2.87  
19 Jul 2014 16:00:00 UTC

**Science**





# 2007-2014: ACROSS THE DEEP

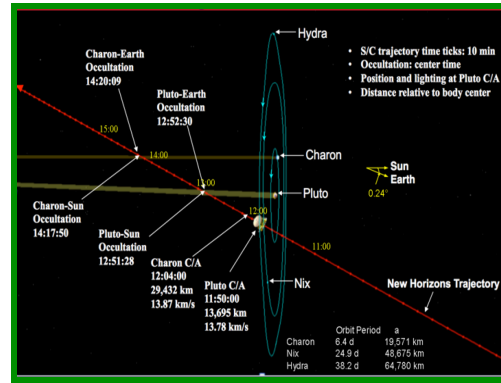
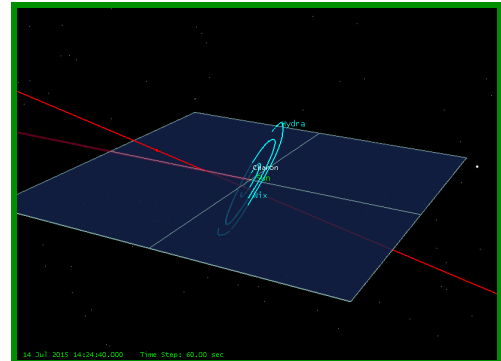




# NASA-DEFINED MEASUREMENT OBJECTIVES



<b>Group 1 Objectives:</b>	<b>Required</b>
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	
<b>Group 2 Objectives:</b>	<b>Important</b>
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 <sub>2</sub> , HCN, and C <sub>x</sub> H <sub>y</sub> , 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	
<b>Group 3 Objectives:</b>	<b>Desired</b>
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	

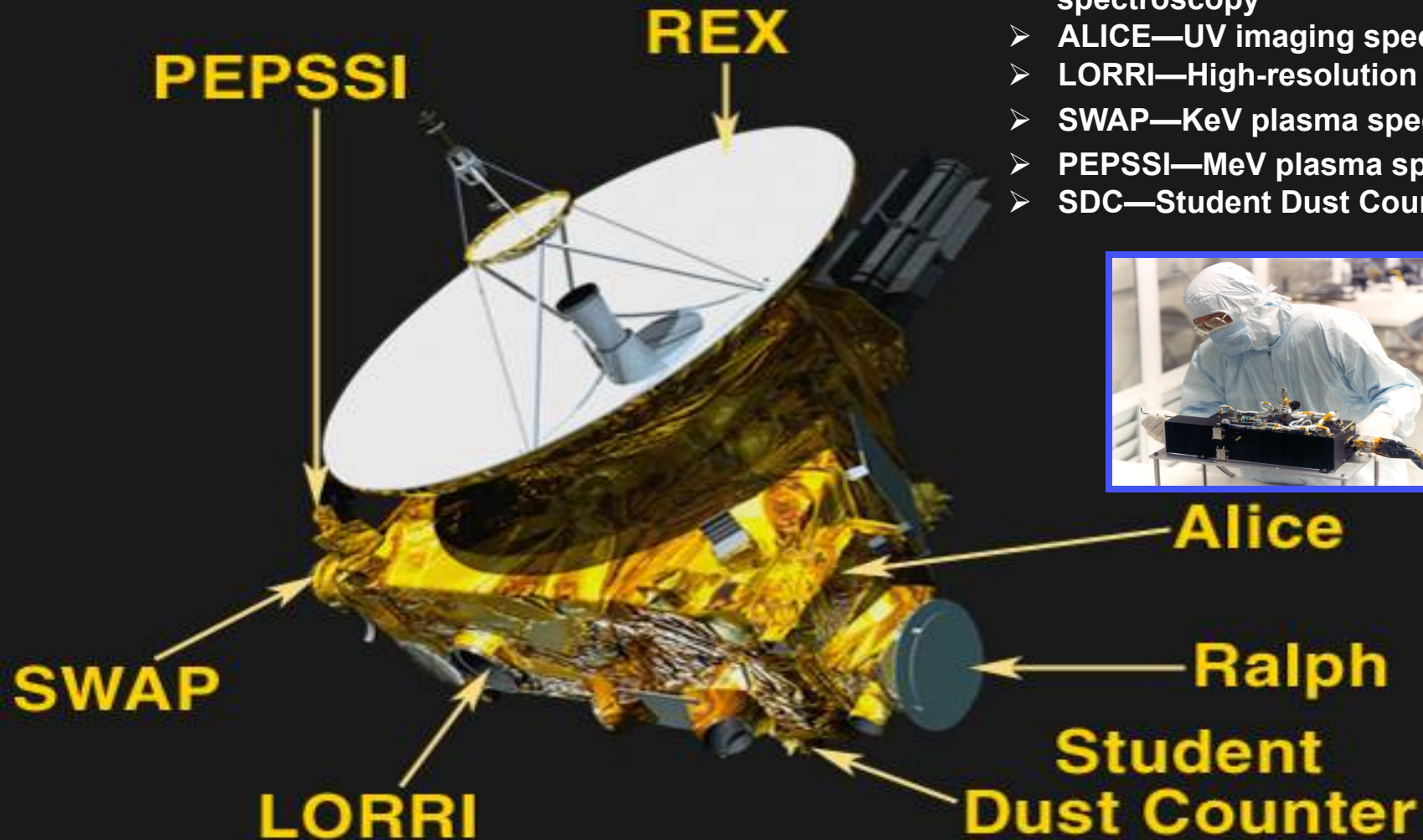




# SCIENTIFIC PAYLOAD

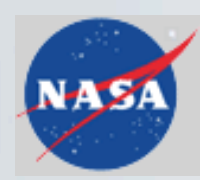


- REX—Radio science & radiometry
- RALPH—VIS/IR Pan/Color imaging & spectroscopy
- ALICE—UV imaging spectroscopy
- LORRI—High-resolution imager
- SWAP—KeV plasma spectrometer
- PEPSSI—MeV plasma spectrometer
- SDC—Student Dust Counter





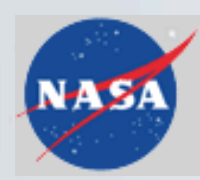
# Mission Status



- Spacecraft: Healthy**
- Payload: Healthy, Well Calibrated**
- Trajectory: On Course**
- Fuel: 1.3x Originally Expected for KBO EM**
- Final Active Checkout: In Progress**
- Final Hibernation: Late August—Early December**
- Encounter Begins: 15 January**



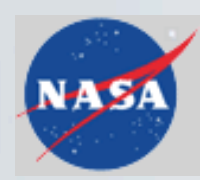
# ACO-8 Highlights



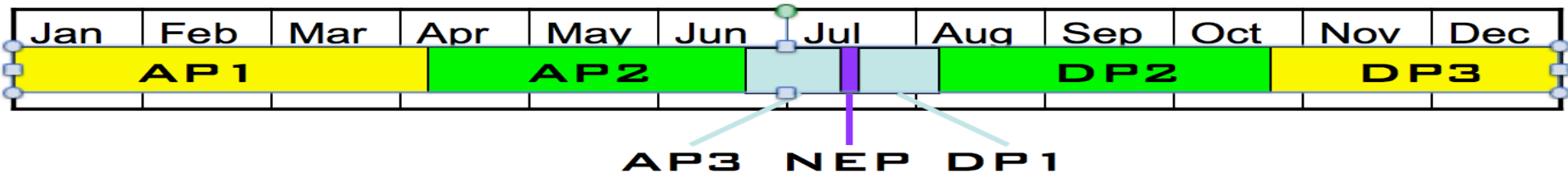
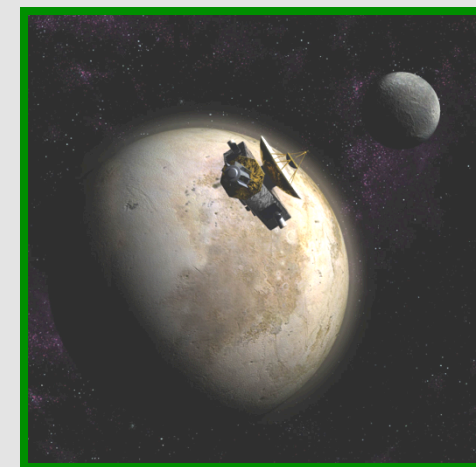
- ✓ **Spacecraft Checkout**
- ✓ **Payload Checkout and Selected Calibrations**
- ✓ **Encounter Final Autonomy/Fault Protection Load**
- ✓ **Trajectory Correction Completed 15 July 2014**
- ✓ **Neptune EPO Imaging Complete**
- ✓ **First Pluto OpNav Campaign (Derivative Science)**
- ☐ **Heliospheric Dust, Lya, and Plasma Measurements**



# Encounter Overview



- ❑ Encounter Runs January to July (Soon!)
- ❑ Downlink Lasts July '15 to October '16
- ❑ Better Than HST: ~1 May
- ❑ Intensive Pluto Science: June-July; C/A 14 July
- ❑ Hazard Imaging: May-July

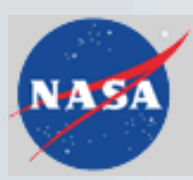


AP - Approach Phase, DP - Departure Phase, NEP - Near Encounter Phase





# Overview of Approach Science



Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AP1			AP2			AP3	DP1	DP2		DP3	

NEP

**Approach Phase 1**  
 Atm Escape: Ambient Plasma  
 OpNav/Orbits/Masses  
 Surface Albedo Variability  
 'High' Phase Photometry

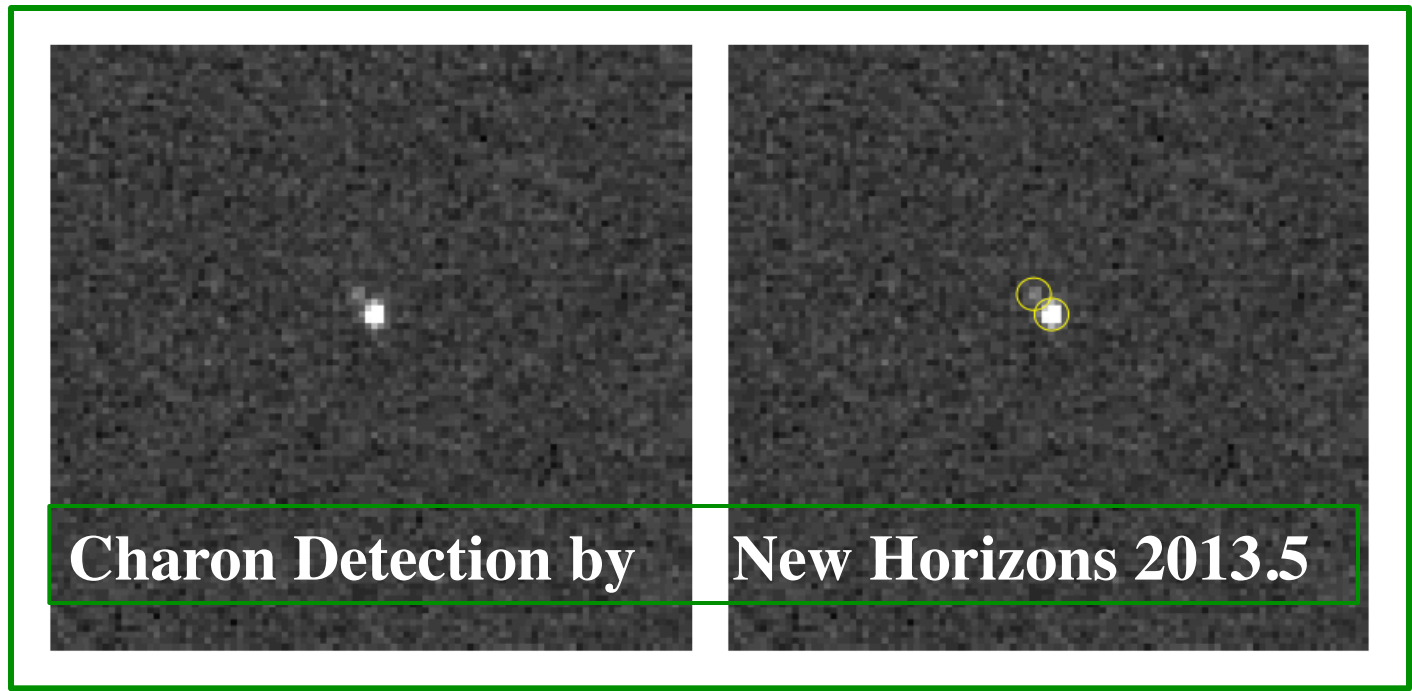
LORRI, SWAP, SDC, PEPSSI

**Approach Phase 2**  
 AP1 Plus:  
 Surface Color  
 Variability Studies  
 Satellite/Ring Search

RALPH, ALICE Too

**Approach Phase 3 (AP3): P-21 to P-1**  
 AP2 Plus:  
 Atm. Escape: Pickup Ions & Bow Shock  
 Surface Composition Variability  
 Airglow Variability  
 Clouds/Haze/Winds from Imaging  
 Pan, Color, and Composition Maps

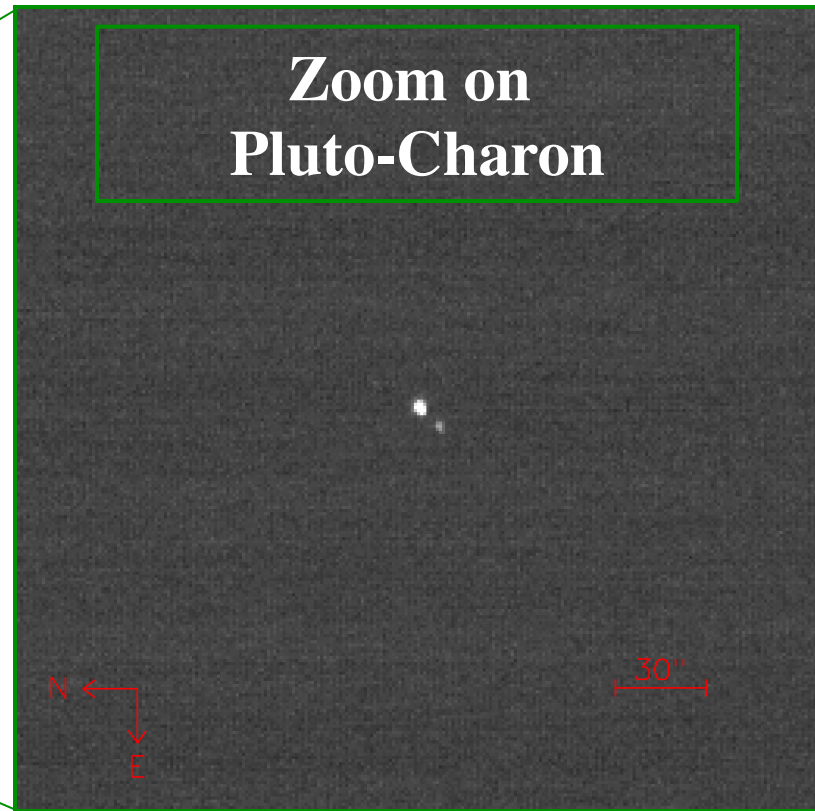
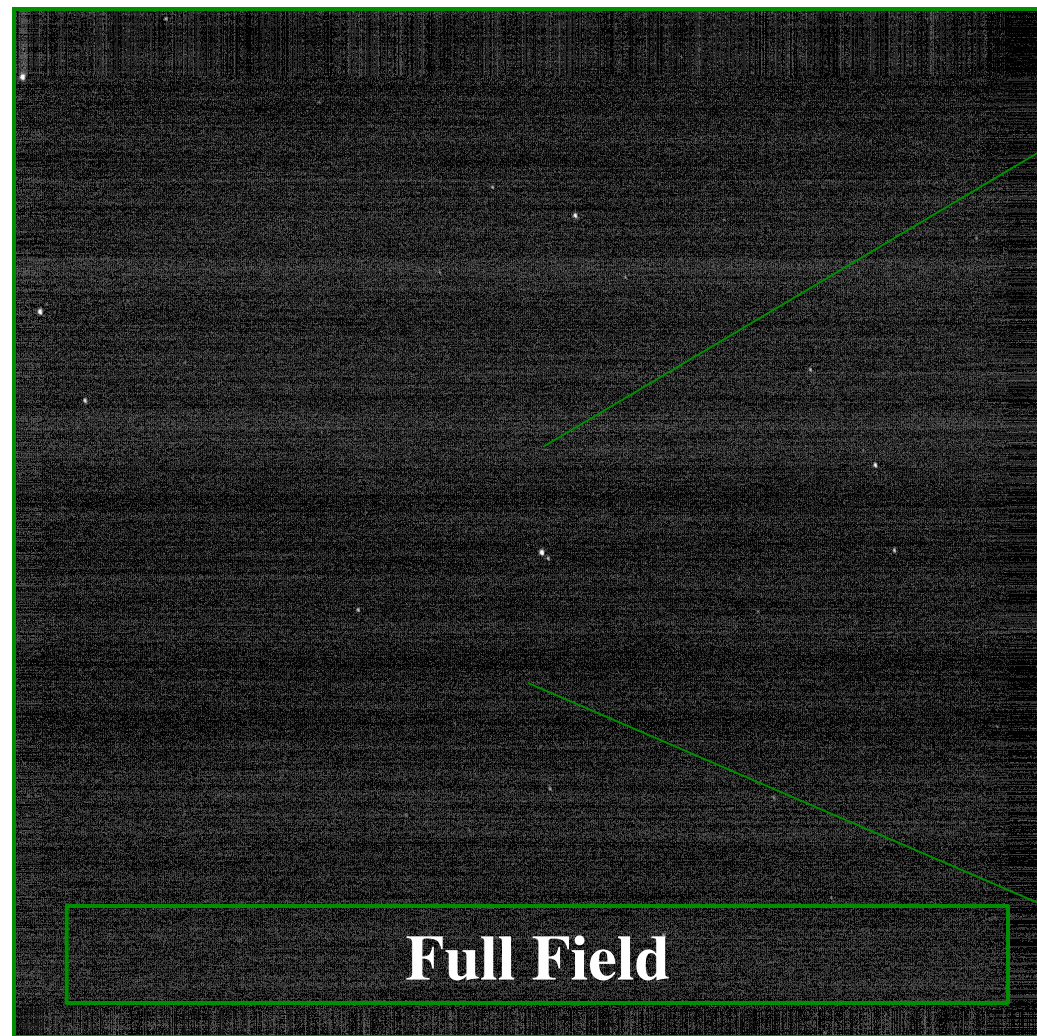
All But REX



Charon Detection by New Horizons 2013.5



# Latest Approach Imaging



2014 July 21 LORRI Imaging



# Encounter Highlights



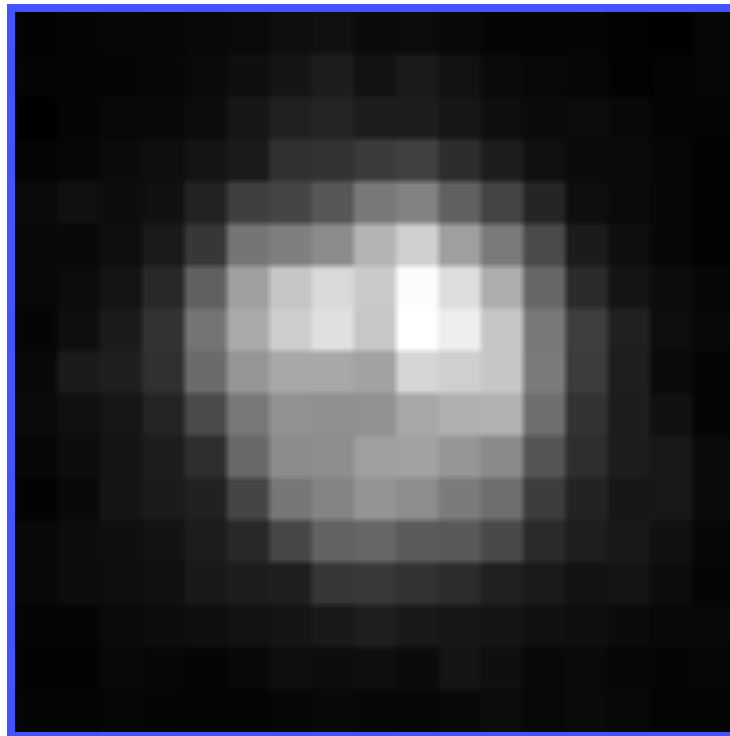
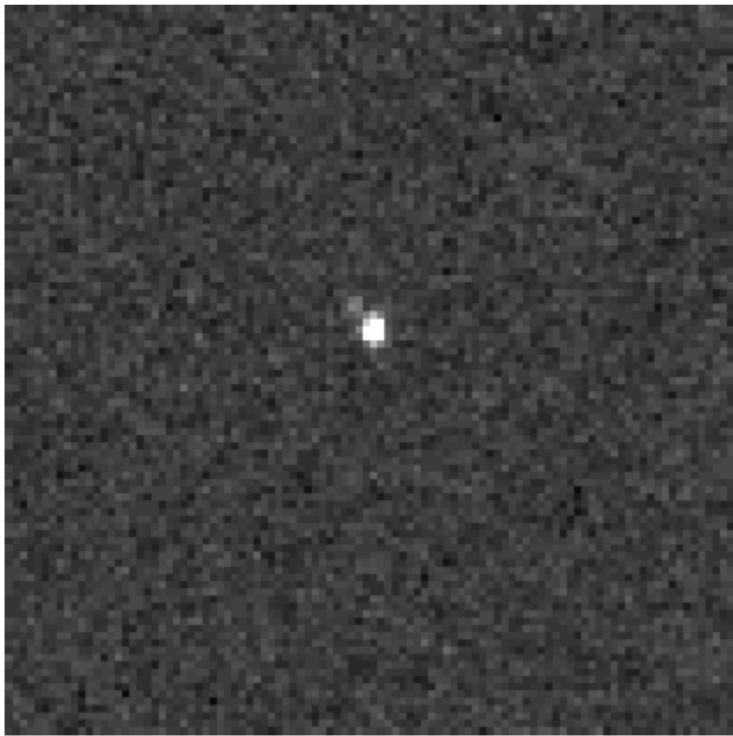
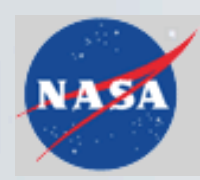
- Approximately 6 months of encounter science at Pluto
- Exceed Hubble resolution for ~3 months
- Map entire sunlit areas of Pluto and Charon
- Make global composition maps of Pluto and Charon
- Map Pluto and Charon surface temperatures
- Explore Pluto's atmosphere: Measure escape rate, pressure and temperature profile, composition; search for hazes
- Improve interior structure models; address if either Pluto or Charon is differentiated
- Obtain high resolution images of Nix and Hydra
- Make compositional measurements of Nix and Hydra
- Search for additional Pluto-system and rings

*The most exciting discoveries  
will likely be the ones  
not anticipated*



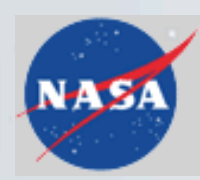


# What Will We Find?





# Predictions Are Risky



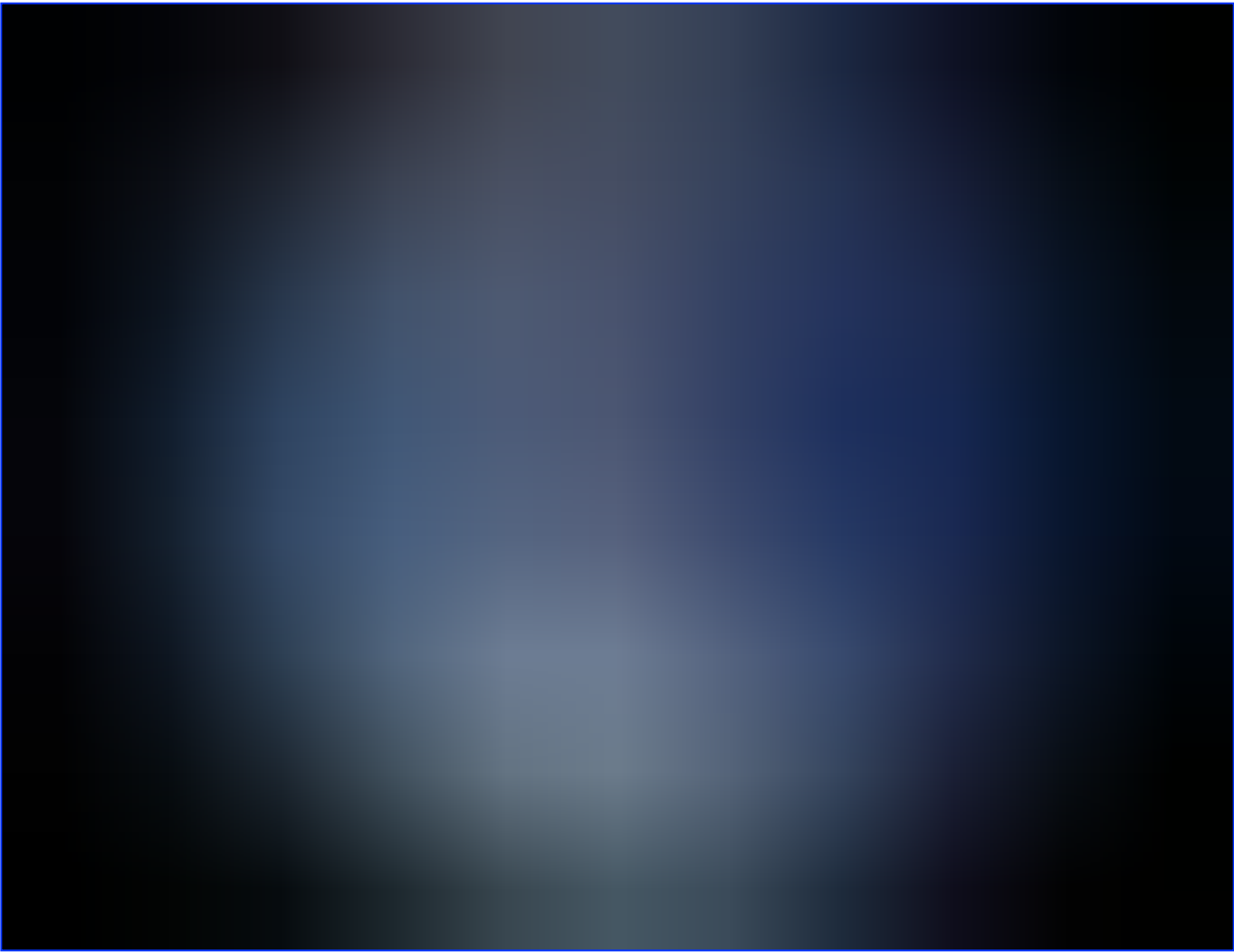
Earth From Space – Apollo 17  
NASA Langley Research Center

12/7/1972

Image # EL-1996-00155

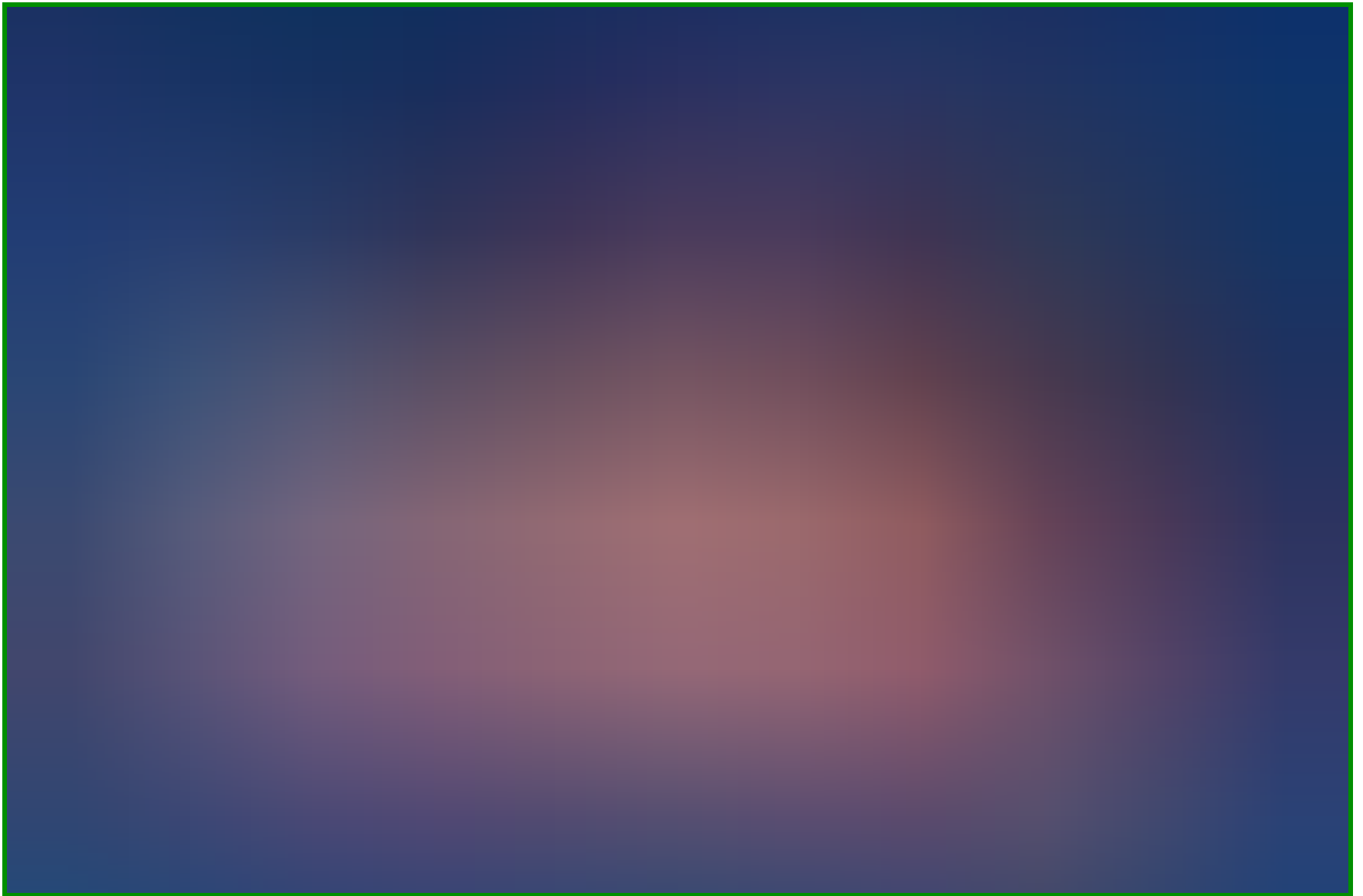


# Earth at Current Best Pluto Resolution



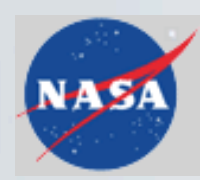


# Predictions Are Risky





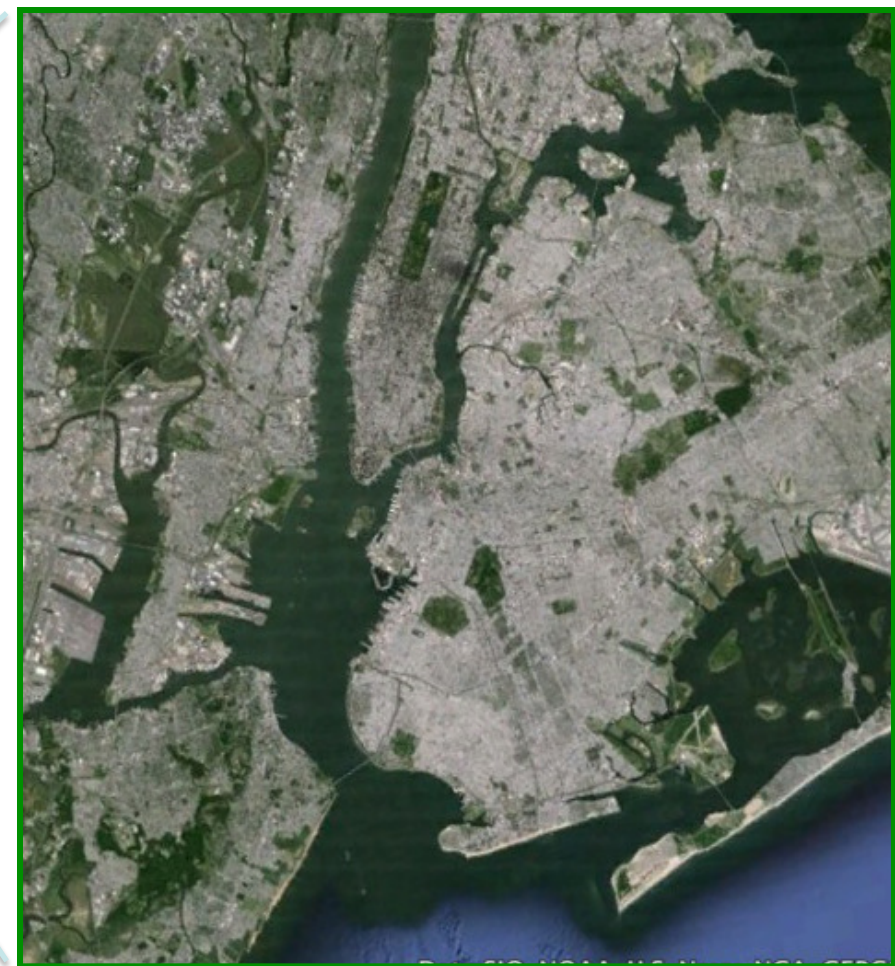
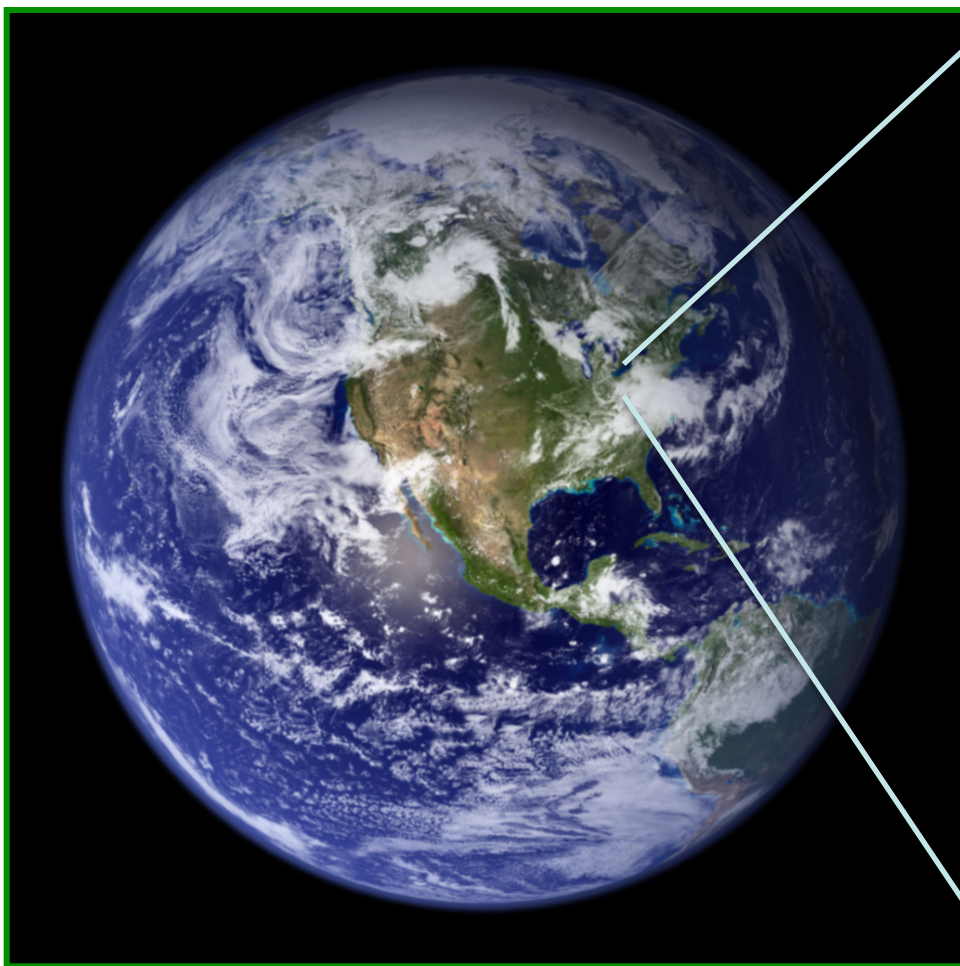
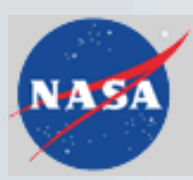
# Surprises Surely Await







# NEP Imaging Benchmarks

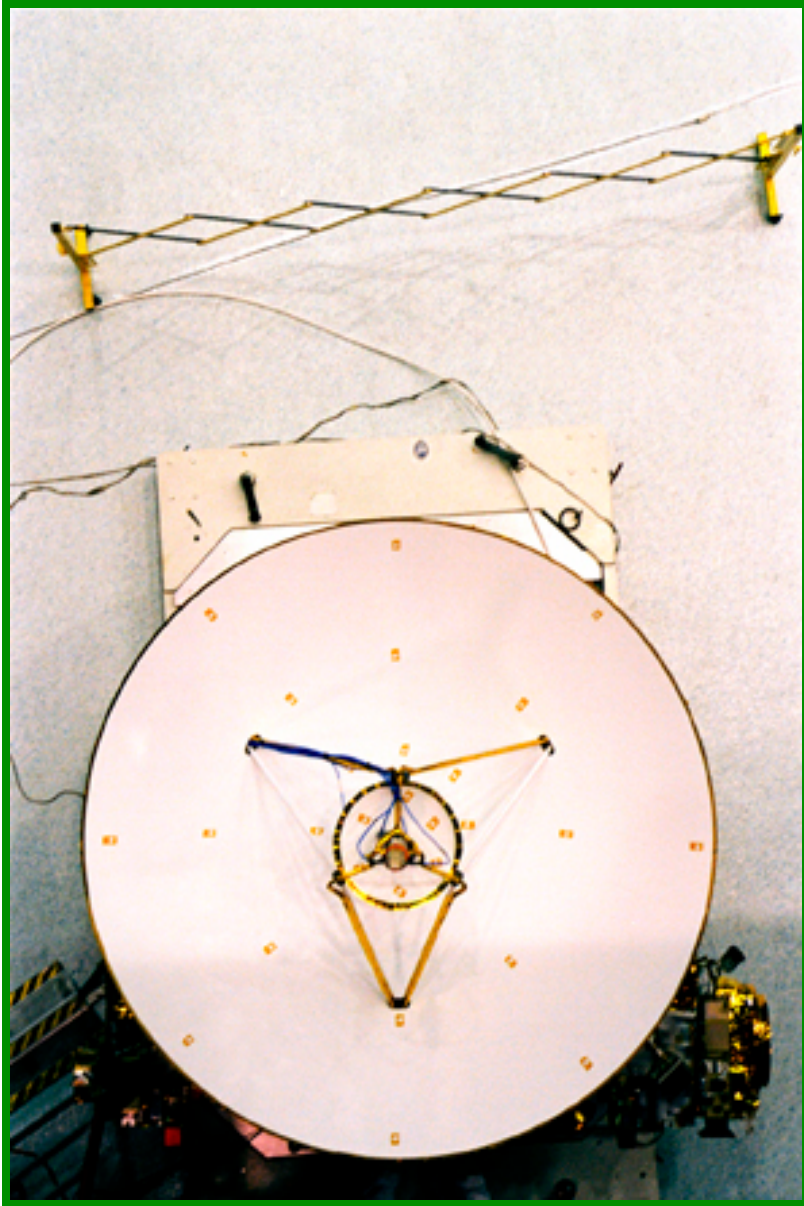


**July 14, 2015 2:00 (P-10h)**

**Highest Resolution 70m/px**



# Then on to KBOs 2017-2021

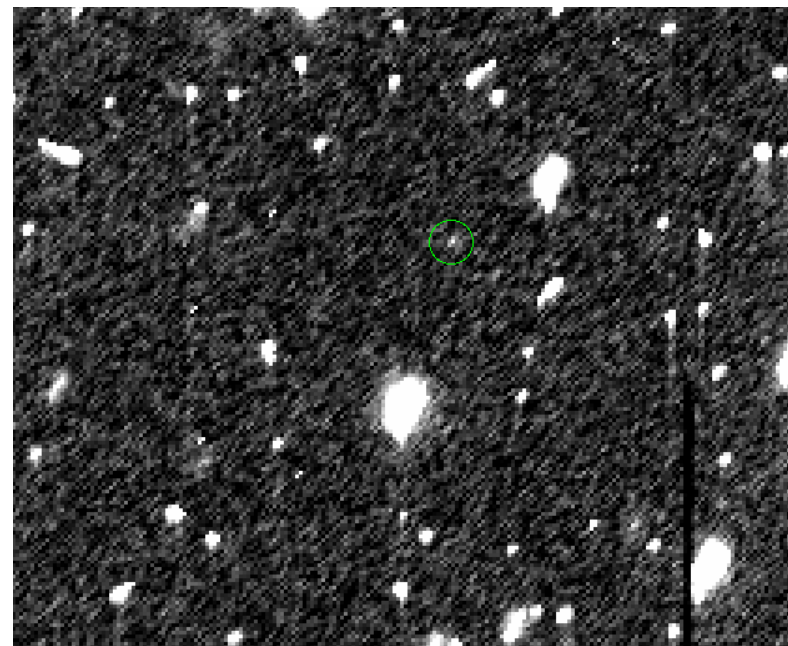




# HST Program Timing



- ❑ **April 2014: Submitted 160-orbit regular proposal, including use of 40 orbits of Director's Discretionary (DD) time offered by STScI**
  - ❑ **Proposed to use the DD time for a pilot study to demonstrate feasibility by finding at least 2 cold classical KBOs in order to qualify for the rest of the search time**
  - ❑ **Messages of support from OPAG, SBAG– *Thank You!***
  
- ❑ **June 13<sup>th</sup> 2014: Proposal accepted**
  - ❑ **June 16<sup>th</sup>: Pilot observations start**
  - ❑ **June 28<sup>th</sup>: 2 pilot program KBOs discovered**
  
  - ❑ **June 30<sup>th</sup>: Full program approved**
  - ❑ **July 7<sup>th</sup>: Full program started**
  - ❑ **July 22<sup>nd</sup>: 100 orbits completed**

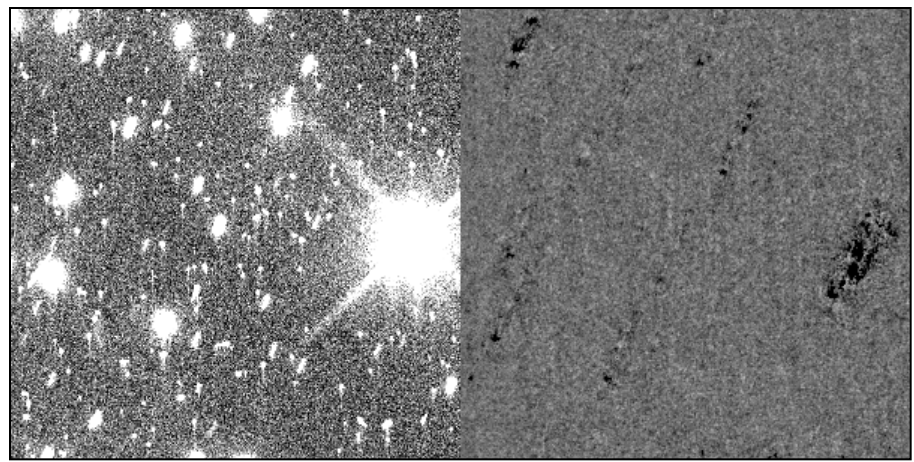




# Search Design

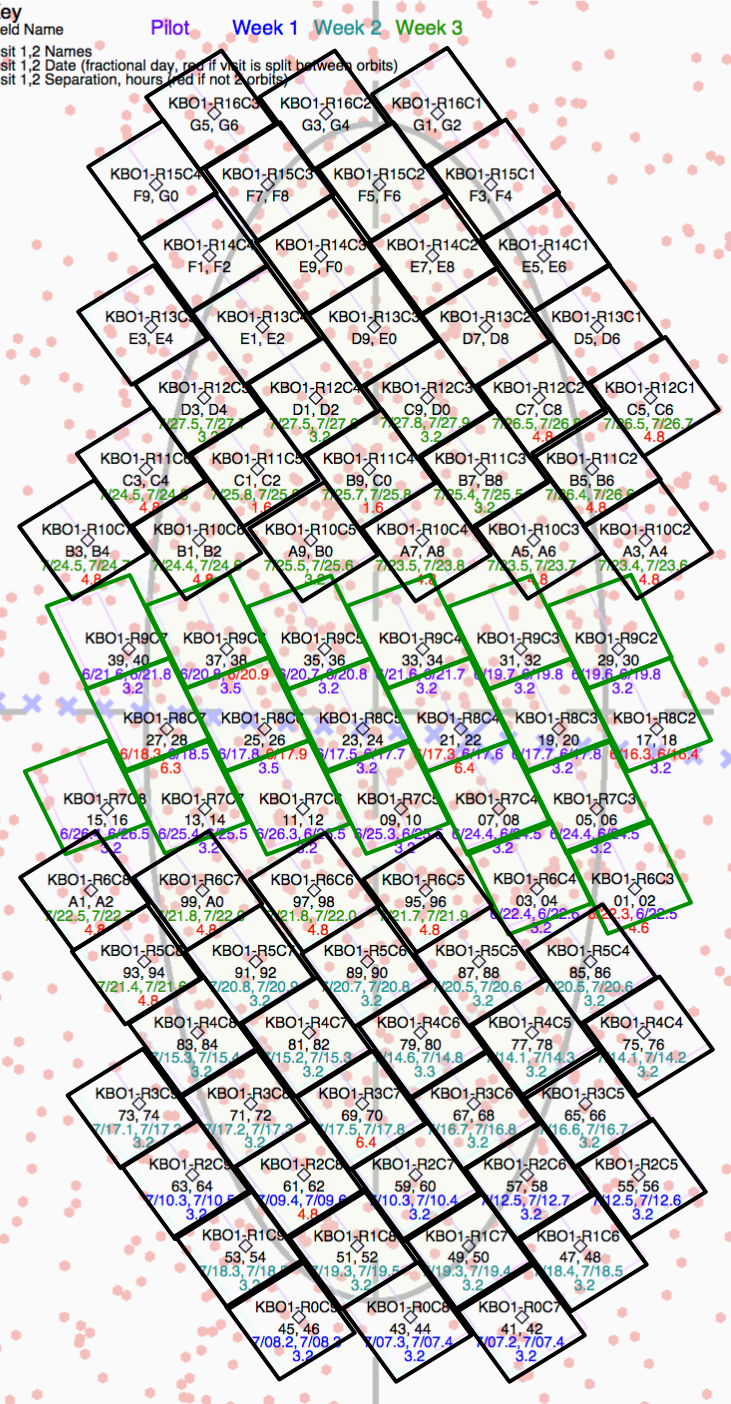
**Key**  
 Field Name Pilot Week 1 Week 2 Week 3  
 Visit 1,2 Names  
 Visit 1,2 Date (fractional day, red if visit is split between orbits)  
 Visit 1,2 Separation, hours (red if not 2 orbits)

- 83 WFC3 total
- Track at the rate of a hypothetical reference KBO near the center of each field
- Two 1-orbit visits per field, usually separated by 3 hours
- Images processed with 1-2 days of receipt to reveal moving objects at the full range of possible rates for cold classical KBOs.



Section of single image

5 images star-subtracted, robustly stacked at KBO rate (same stretch)





# Results Update



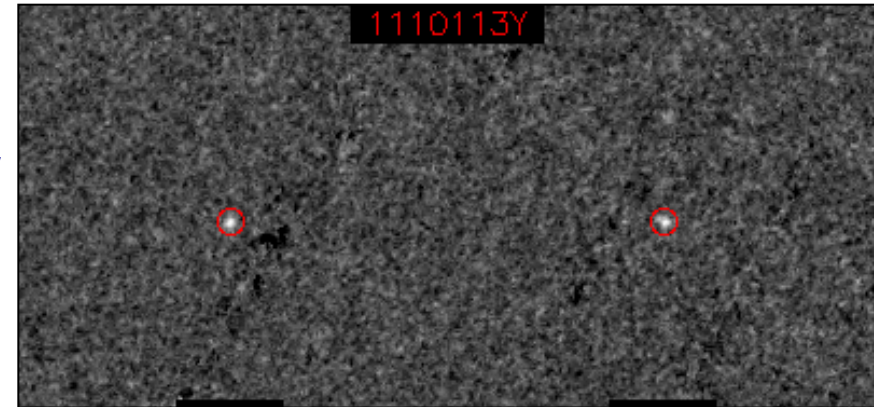
## As of July 18<sup>th</sup>

- 96% of search observations scheduled (through August 3rd), Limiting Mag R-27.5
- Several detections
- Expect ~20% of discoveries to be targetable by NH

## First follow-up observations of detected KBOs scheduled August 2-3 to determine targetability.

## Should complete both the survey and initial follow-up by September.

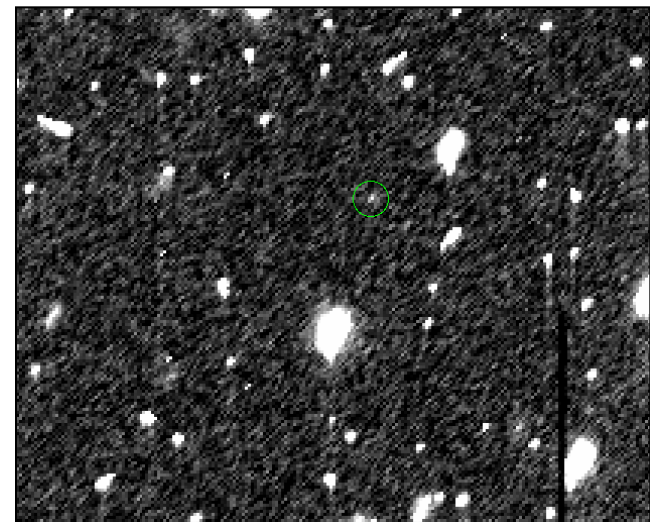
Stacked Images  
(stars and cosmic rays removed)



Visit 11

Visit 12

Visit 11, sidereal tracking  
(stars and cosmic rays not removed)



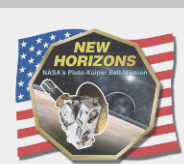


# For More Information



- ❑ Visit <http://pluto.jhuapl.edu>
- ❑ Read SSR 2008, V140, or Young & Stern 2010, IAU Symp. 263, 305.
- ❑ Ask me or any CoI.

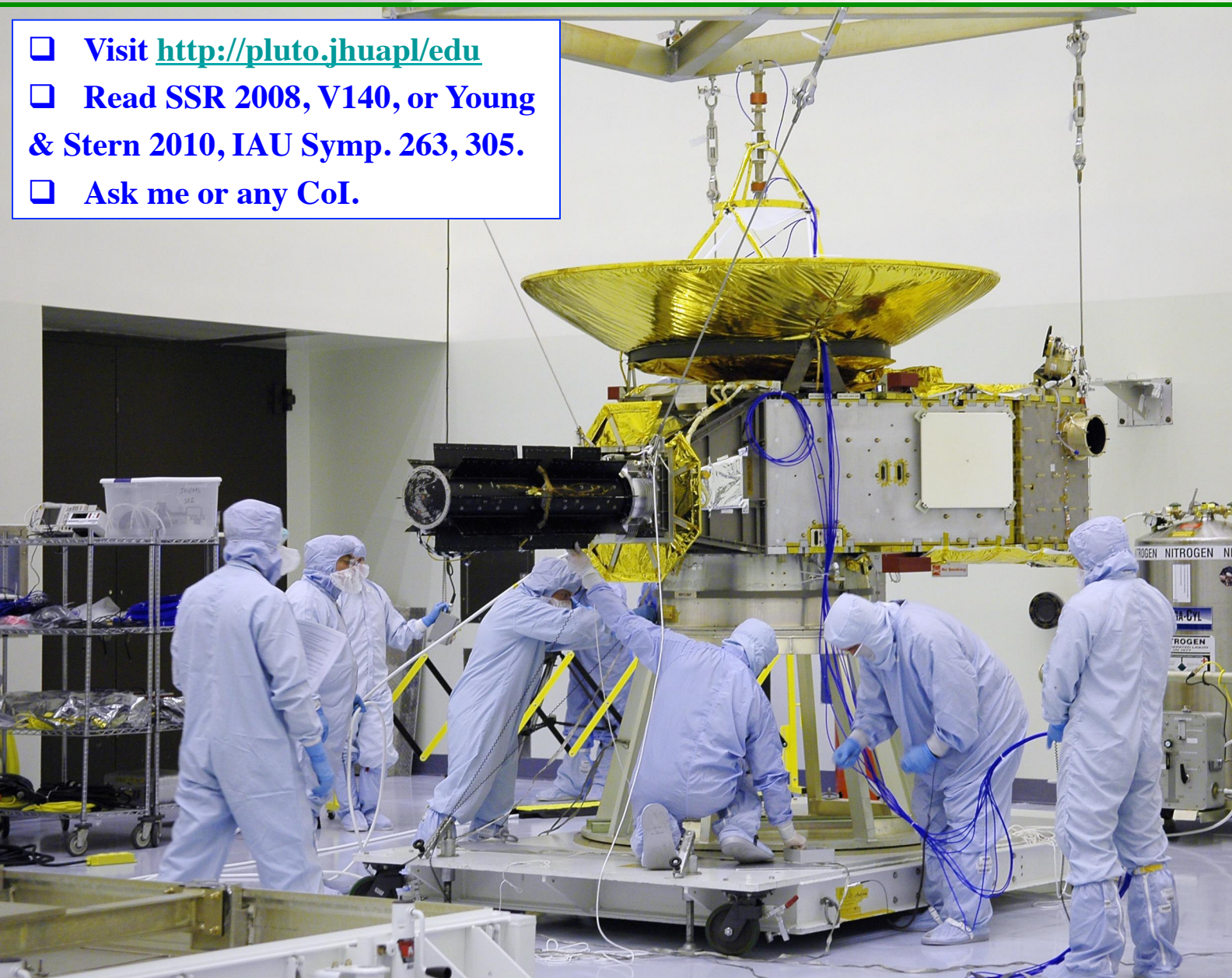




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**PI: Alan Stern**  
Fran Bagenal  
Rick Binzel  
Marc Buie  
Bonnie Buratti  
Andy Cheng  
Dale Cruikshank  
Heather Elliot  
Randy Gladstone  
Will Grundy  
Matt Hill  
Dave Hinson  
Mihaly Horanyi  
Don Jennings  
Ivan Linscott  
Jeff Moore  
Dave McComas  
Bill McKinnon  
Ralph McNutt  
Scott Murchie  
Cathy Olkin  
Joel Parker  
Carolyn Porco  
Harold Reitsema  
Dennis Reuter  
Mark Showalter  
John Spencer  
Darrell Strobel  
Mike Summers  
Len Tyler  
Hal Weaver  
Leslie Young



**My other vehicle is  
on its way to Pluto**





# Backup Charts



# Summary of Best Resolution of Pluto and its 5 moons

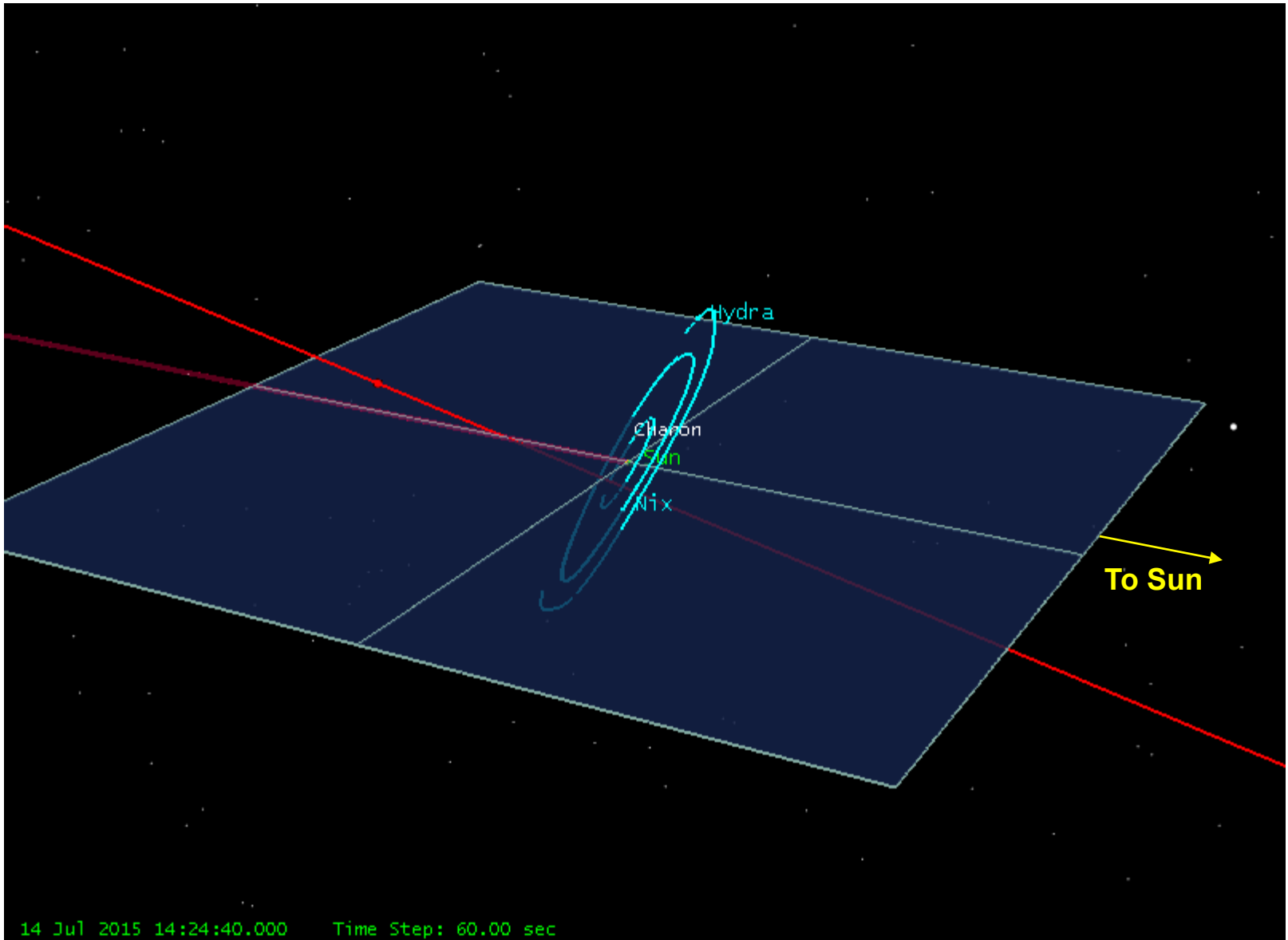


	Panchromatic	Color	Infrared
Pluto	0.46 km/pixel hemispheric 0.09 km/pixel regional	0.64 km/pixel	6.0 km/pixel hemispheric 2.7 km/pixel local
Charon	0.61 km/pixel hemispheric 0.15 km/pixel regional	1.40 km/pixel	8.4 km/pixel hemispheric 4.7 km/pixel local
Nix	0.46 km/pixel 0.29 km/pixel possible	1.98 km/pixel	3.6 km/pixel
Hydra	1.14 km/pixel	4.6 km/pixel	14.6 km/pixel
P4	3.2 km/pix 2.0 km/pix possible	(44 km/pix) 8 km/pix possible	(24 km/pix)
P5	3.2 km/pix	8 km/pix	(200 km/pix)

**Resolutions in parentheses indicate unresolved targets.**

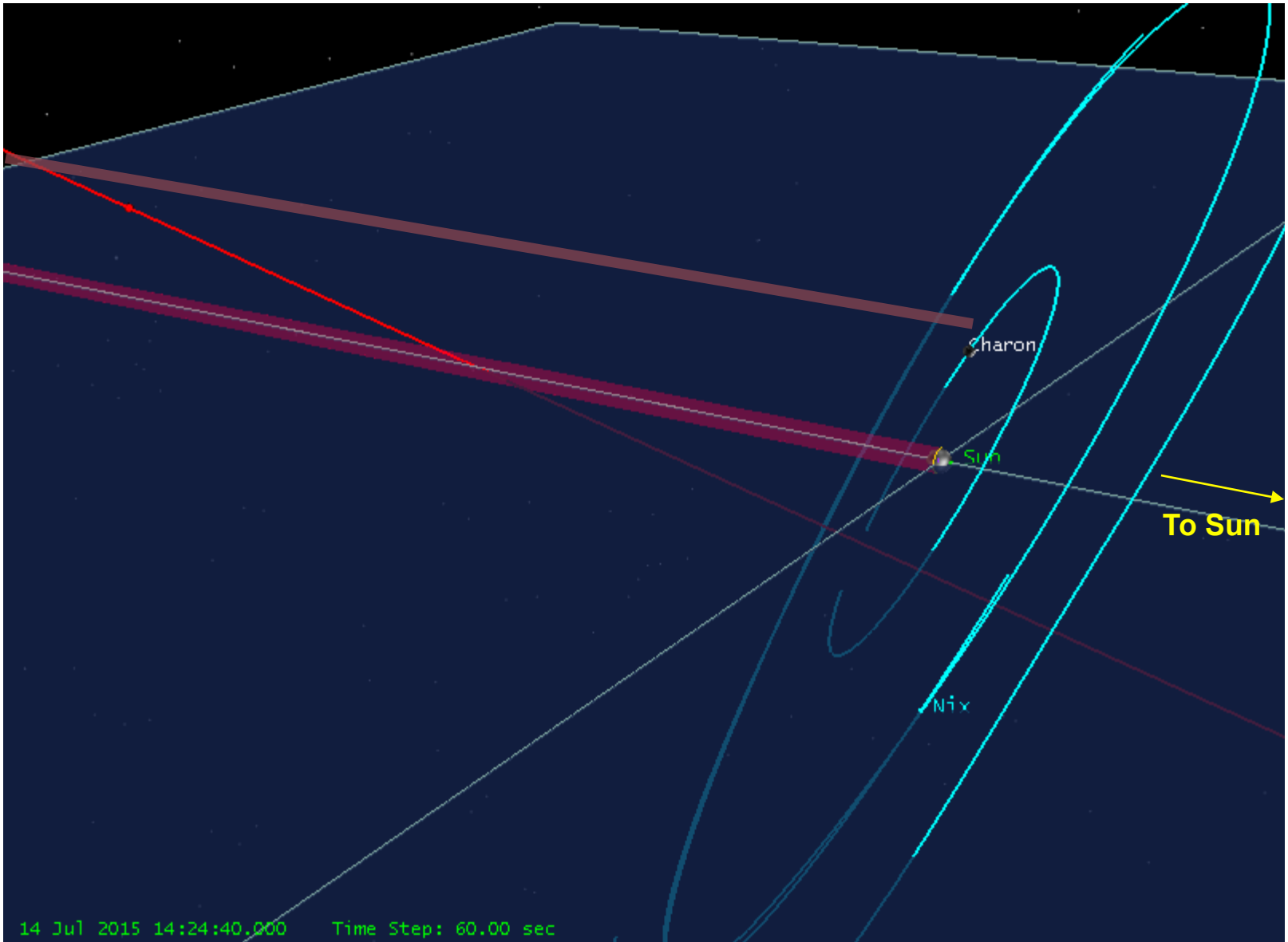


# Pluto Encounter Geometry





# Pluto Encounter Geometry

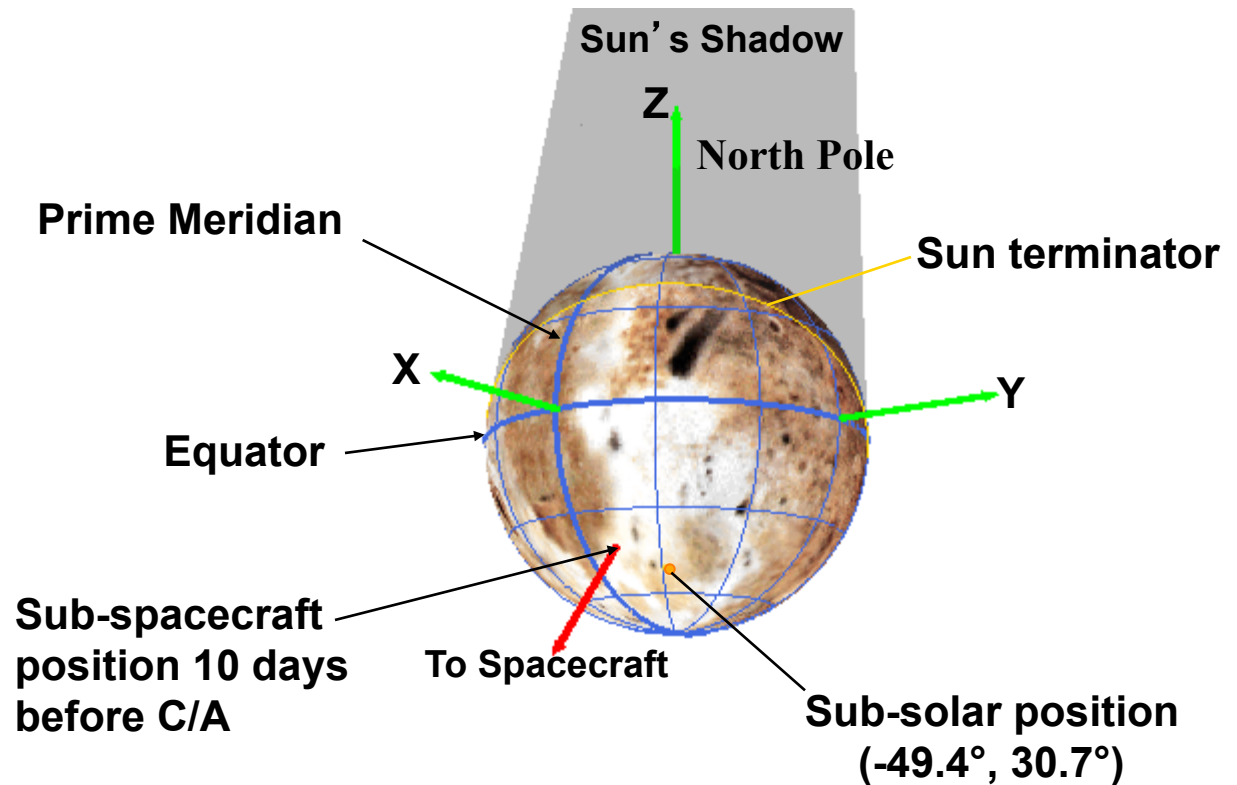




# Pluto at Approach



- Sunlit in southern hemisphere & dark in northern cap
- *New Horizons* approaches Pluto from southern hemisphere
- Solar phase angle at approach is  $15^\circ$
- Pluto makes one rotation every 6.4 Earth days





# New Horizons Ground Track on Pluto

