NH Observations of the Termination Shock: *Scientific Planning and Traceability*

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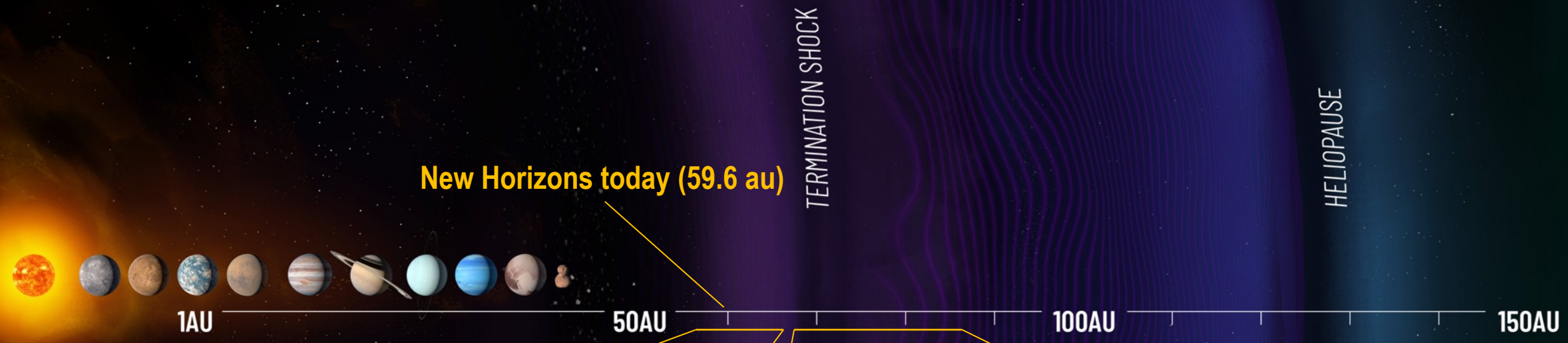
Outline

1. New Horizons TS Encounter Overview
2. New Horizons Instrumentation
3. Termination Shock Science Goals
4. Discussion

New Horizons Operations: The Big Picture



Approach Phase (FY25-FY26)

- Hibernation/awake
- PEPSSI / SWAP / SDC continuously collecting low- and high-resolution data

Termination Shock Campaign (FY27+)

- Continuously awake until crossing
- PEPSSI / SWAP / SDC continuously collecting low- and high-resolution data

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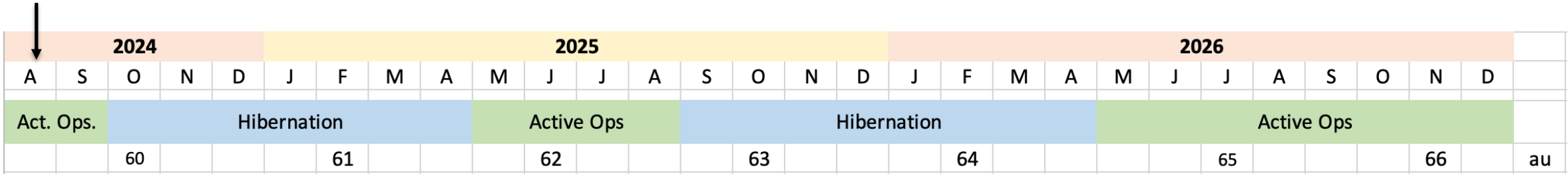
New Horizons Operation: Key Details

Hibernation

- Continuous particle data collection
- No science data downlink to Earth
- Weekly ‘beacon’ checks to monitor overall spacecraft health

Active Operations

- Semi-continuous particle data collection, some interruptions for other critical spacecraft operations & maintenance
- Data downlink to Earth of all previous Hibernation science data



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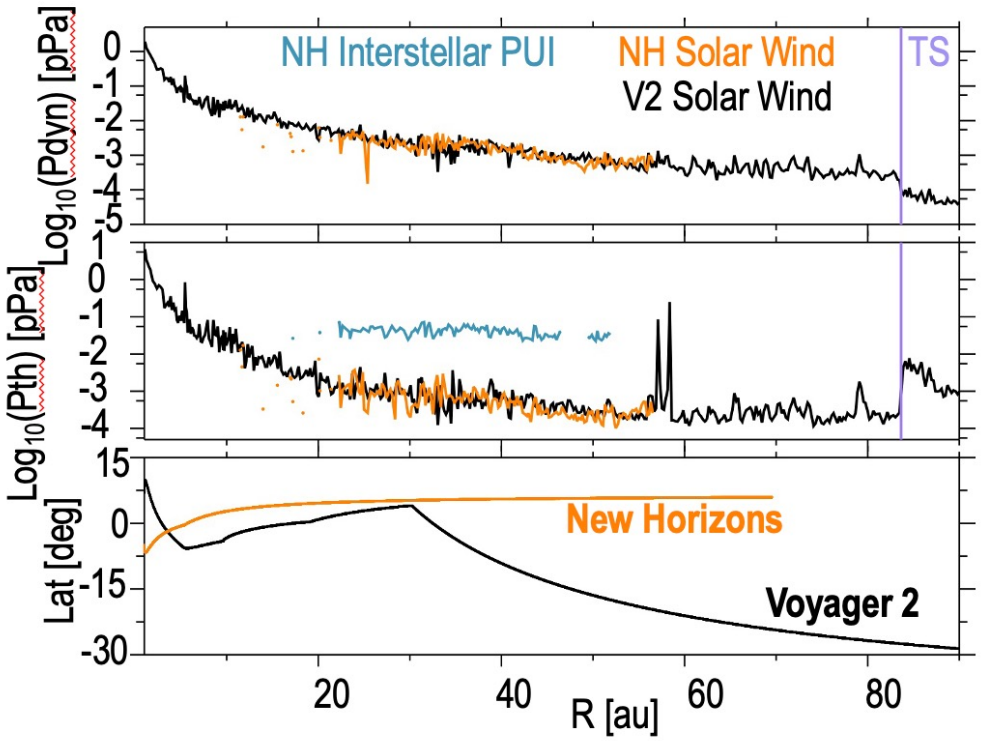
New Horizons Operation: Instrumentation

SWAP

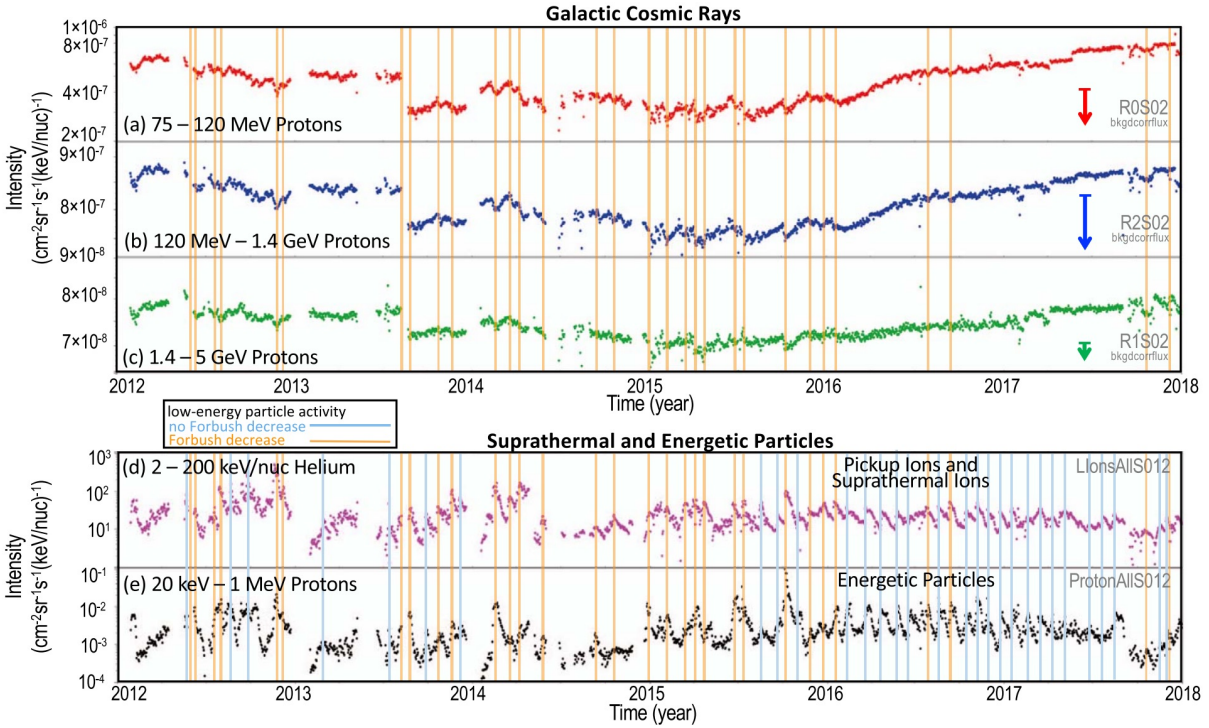
Solar wind / pickup ion measurements



H. Elliott

PEPSSI

Energetic particle measurements (PUIs – GCRs)

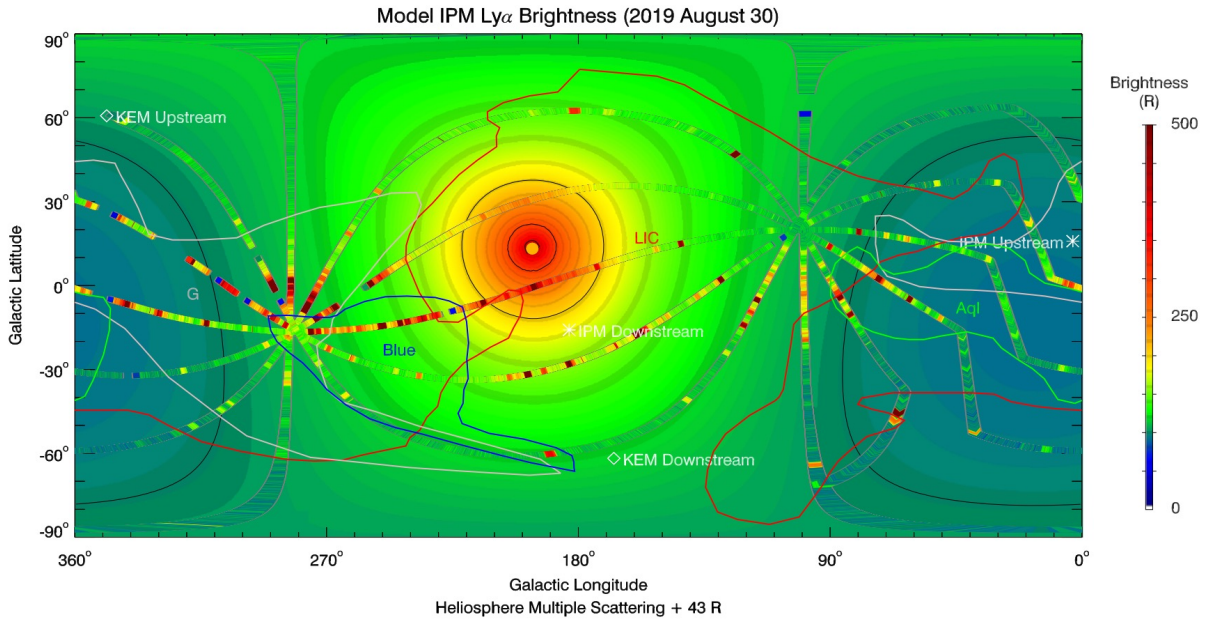


Hill et al. [2020]

New Horizons Operation: Instrumentation

Alice

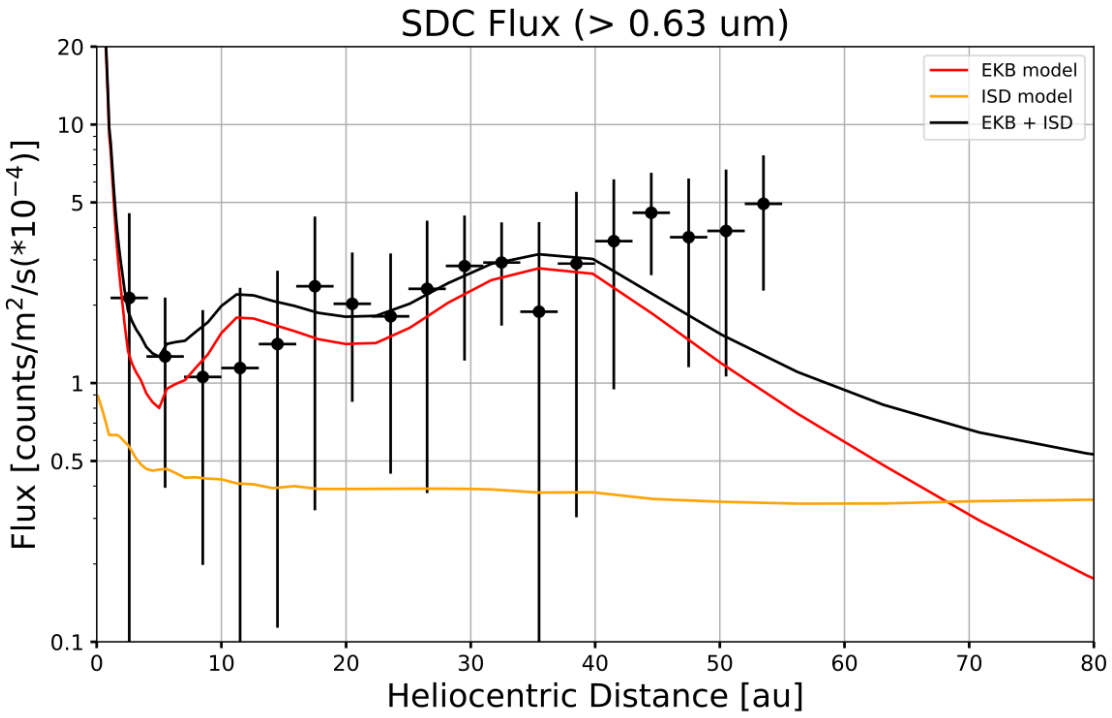
UV sky brightness – Ly-alpha
Point-to-point Ly-a brightness



Gladstone et al., 2021

SDC

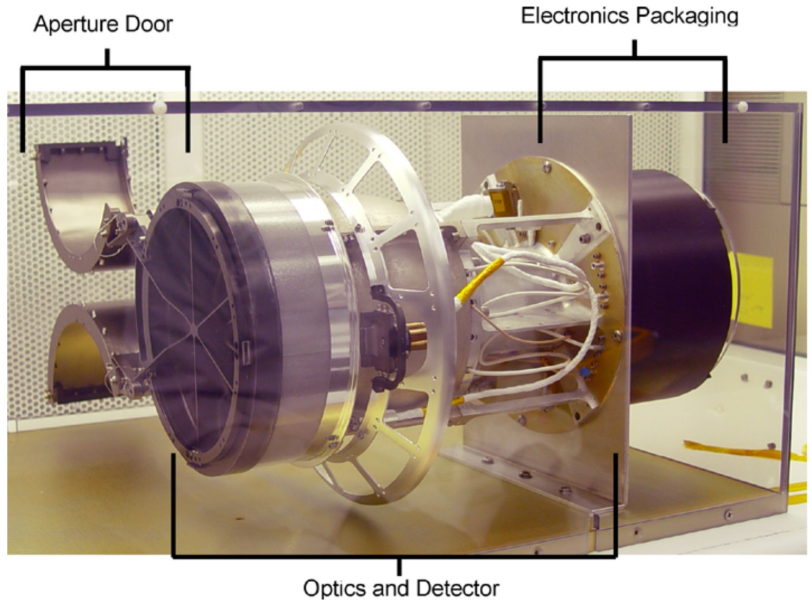
Interplanetary / interstellar dust densities



Doner et al. [2024]

SWAP: Solar Wind Around Pluto

- **Energy range: 35 eV – 7.5 keV**
- **Maximum time resolution: 64 sec**
  - Combinations of [64 sec / 5 min / 10 min] – data volume/downlink limited
  - PUI accumulation: max. time resolution of 29 min
- **Coarse vs. fine scans** – may not be applicable post-TSx

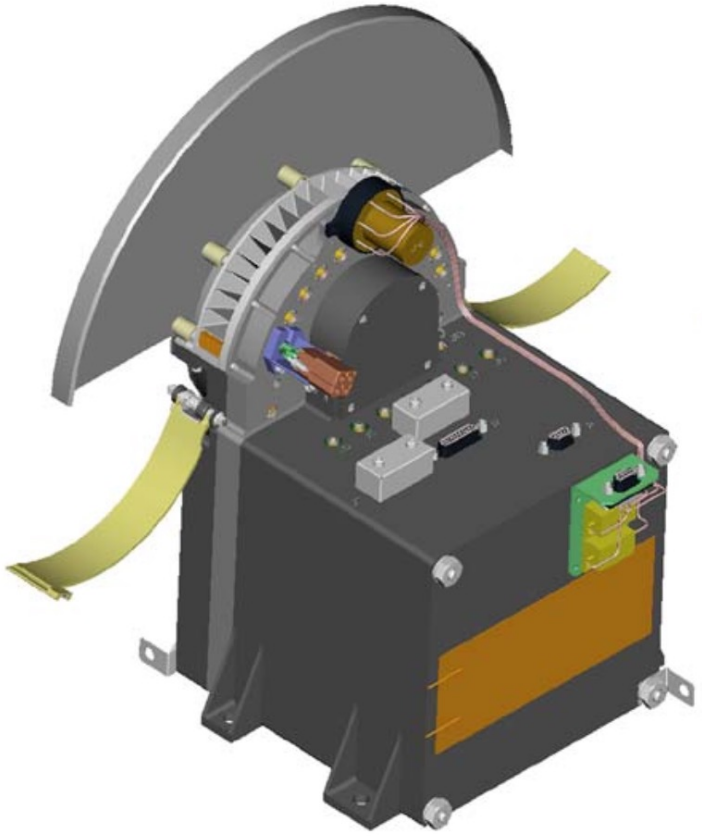


McComas et al., 2008

Option 2		
Mode	**Days**	**Mbits**
64 sec	5	61
5min	122	1492
10min	238	606
		Total: 2159

PEPSSI: Pluto Energetic Particle Spectrometer Sci. Inv.

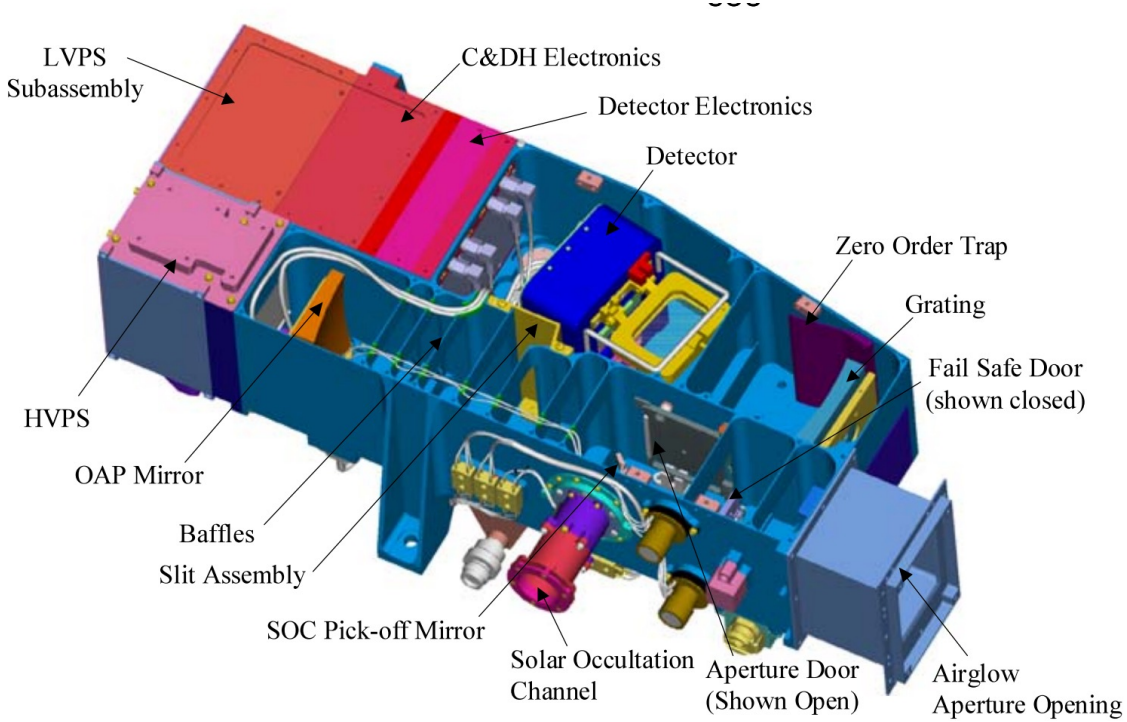
- **As proposed capabilities** [McNutt et al., 2008]:
  - Electrons: 25 – 500 keV
  - Low-energy Ions: 1 keV – 1 MeV
  - Low-energy CNO: 15 keV – 1 MeV
  - High-energy p^+: 40 keV – 1 MeV
  - High-energy CNO: 100 keV – 1.2 MeV
- **'Enhanced' capabilities:**
  - Galactic cosmic rays: 75 MeV – 5 GeV [Hill et al., 2020]
  - *Anomalous cosmic rays – in development*
  - 'Scientist-in-the-loop' *selective* data downlink at high time resolution (3 sec), augmented by standard 180 sec data products



McNutt et al., 2008

Alice UV Spectrograph

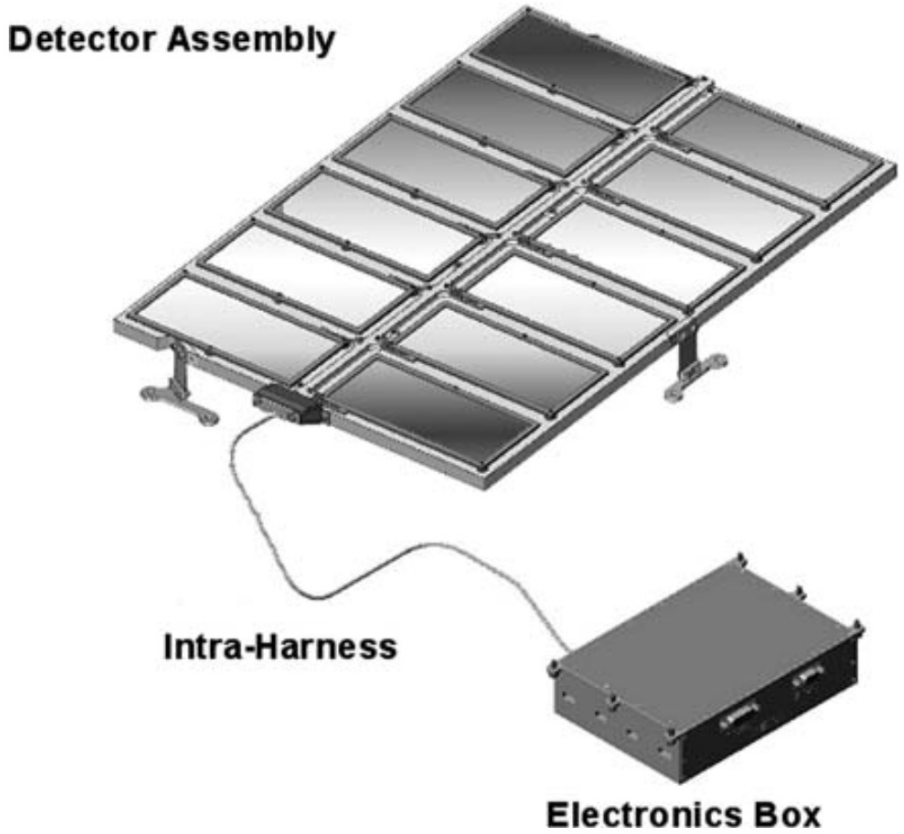
- **Spectral range: 52 – 187 nm**
- **Fields-of-view:**
  - 2°x2° box
  - 0.1°x4° slot
- **Ly-alpha sensitivity 500x greater than Voyager UVS**
- **Can make single ‘great circle’ scans during New Horizons spin modes**



Stern et al., 2008

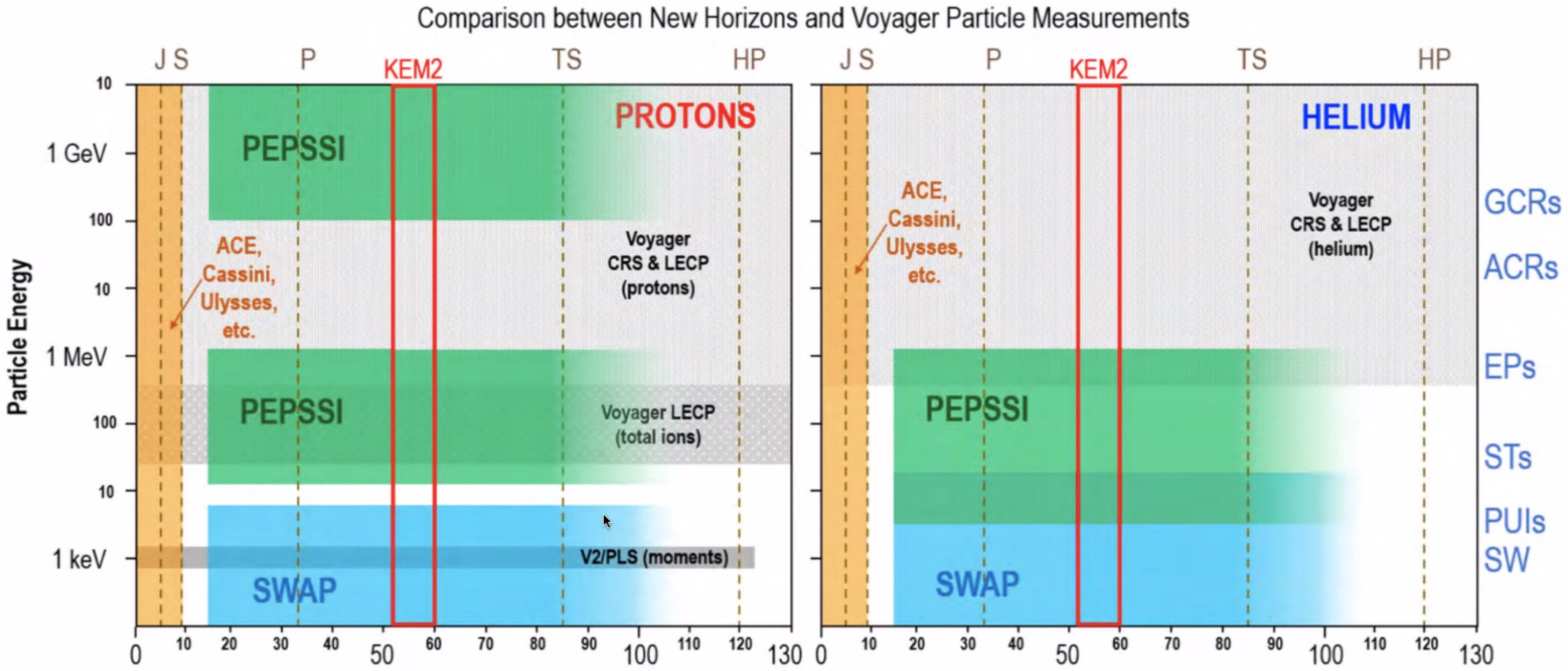
VBSDC: Venetia Burney Student Dust Counter

- **Dust size range: ~0.6 μm – 5 μm**
- **Only records dust impact timing and size**
  - Cannot distinguish interplanetary from interstellar dust
  - Models suggest interplanetary dust should dominate (but note latest model-data disagreement [*Doner et al., 2024*])
- **Typically requires months of averaging to acquire sufficient statistics**



Horányi et al., 2008

New Horizons Operation: Instrumentation



New Horizons Operation: Instrumentation

Challenges:

- No magnetometer
- Limited ability to change instrument modes / observing methods
- Data volume and data downlink are constrained
- TS is approaching *fast!*

New Horizons TS Science Traceability: Overview

NEW HORIZONS TERMINATION SHOCK ENCOUNTER:
Science Traceability Matrix

	Scientific Question	Scientific Measurement	Measurement Requirements	Comments	
BEFORE	What are the characteristics of the core SW and PUI populations leading up to the TS?	Flux, density, speed, temperature, (poly. index) of core solar wind and pick-up ion populations	Energy: 10 eV – 10 keV (core SW); PUIs (10 eV - 16 keV) Time Resolution: 1/day (desired 1/hour)		
	Is there an enhanced deceleration of the SW close to the TS (~months out)?	Speed of thermal proton population	Energy: 10 eV – 5 keV (core SW) Time Resolution: 1/day (desired 1/hour)	Also need 1 au concurrent measurements; Could also look at alpha behavior	
	What are the properties of suprathermal tails and energetic ion populations (non-TSP events)?	Flux, energy spectra, angular spectra of energetic particles	Energy: ~2 keV/n – ~hundreds of keV/n Energy resolution: 3 bins per decade Time Resolution: 1/day (for SR variability)	Suprathermals: behave similar to core SW; Energetic: accelerated particles somewhat separate from core SW; Need some way to verify variance on a daily basis	Nee Nor cycl Nee
	What are the characteristics of energetic TSP (precursor) events (e.g., frequency, duration, energy spectra, anisotropy)?	Flux, energy spectra, angular spectra of energetic particles	Energy: ~2 keV/n – ~hundreds of keV/n Energy resolution: 3 bins per decade Time Resolution: Hourly Angular resolution: 45° (22.5° Voy)		Com
	What are the characteristics of ACRs upstream of the TS, including anisotropies?	Flux, energy spectra, angular spectra of energetic particles	>1 MeV	Two competing theories: flank acceleration vs. stochastic / rxn in heliosheath 3-sec time resolution would be required for directionality Radial/time spectrum is useful for modeling comparison	Cont Wou
	What are the characteristics of turbulence while approaching the TS?				High Den
		Flux, density, speed, temperature of core			

New Horizons TS Science Traceability: Overview

Before the Termination Shock

At the Termination Shock

After the Termination Shock (…Into the Heliosheath…)

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Before the Termination Shock

- What are the characteristics of the SW and PUI populations leading up to the Termination Shock?
- Is there an enhanced deceleration of the SW close to the TS (<~1 au)?
- What are the properties of suprathermal tails and energetic ion populations during non-precursor conditions?
- What are the characteristics of energetic TS precursor events (e.g., frequency, duration energy spectra, anisotropies)?
- What are the characteristics of ACRs upstream of the TS, including anisotropies?
- What are the characteristics of turbulence leading up to the Termination Shock?

At the Termination Shock

- Where is the TS located and how does this depend on local SW and PUI conditions?
- Are there multiple TS crossings and if so, how do they relate to SW variability on approach?
- How do thermal, suprathermal, and energetic particle distributions change across the TS?
- Is there any signature of ACR acceleration at the TS? (*Where are ACRs accelerated?*)
- What is the neutral H density at/near the TS?

After the Termination Shock (…Into the Heliosheath…)

- Are solar wind-induced modulations (transients, perturbations) still present after the TS?
- Are there signatures of turbulence in the heliosheath?
- How do the distributions of PUIs evolve downstream of the TS?
- How do ACR distributions evolve downstream of the TS? (*What is the source of ACR acceleration?*)
- Are there changes in the interplanetary and/or interstellar dust flux across the TS?

TS Science Questions: Discussion

- What are the highest priority science questions that the community would like answered?
- How can New Horizons address such questions, within the scope of its existing instrumentation and operation profile?
- What is needed *before* the TS crossing? *After*?

Backup Slides