

# THE JUICE ULTRAVIOLET SPECTROGRAPH NEAR-EARTH COMMISSIONING RESULTS

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ON BEHALF OF THE JUICE-UVS TEAM



# Outline



## JUICE-UVS

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- Instrument and Mission Overview
- Optics and Detector Overview
- Instrument Timeline
- Calibration Summary
- Near-Earth Commissioning





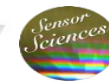
# UVS Basics



## JUICE-UVS

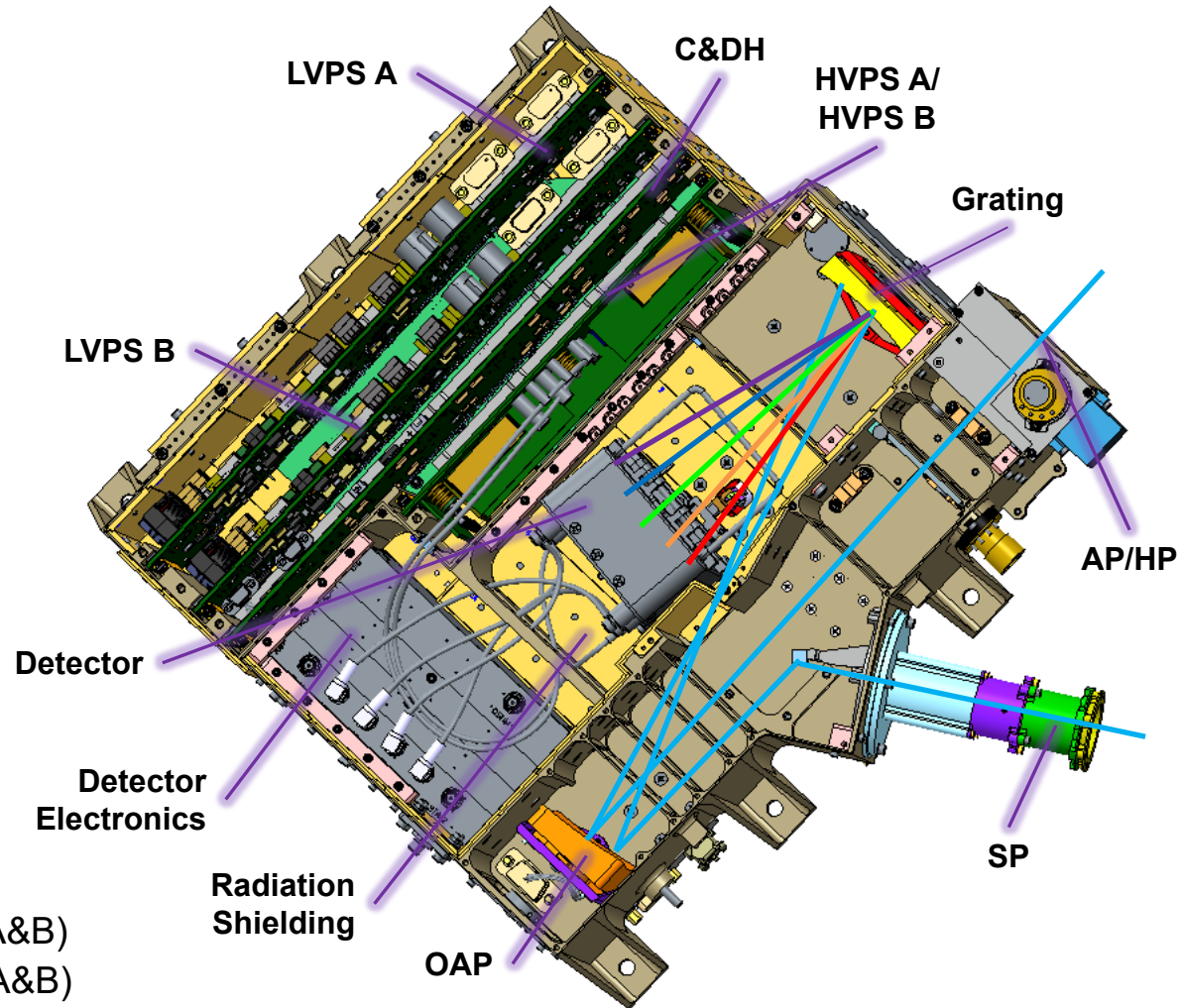
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- JUICE = Jupiter ICy moons Explorer
- First ESA mission to the Outer Planets
- Characterizes Jupiter and interaction with Galilean satellites
- UVS = Ultraviolet Spectrograph
- UVS will characterize interaction between magnetospheres of Jupiter and its satellites, search for water plumes, and investigate permanently shadowed regions of satellites
- UVS must survive the harsh Jovian environment
  - High radiation (>1 MeV electrons)
  - Thermal extremes (expected operating temperatures around 0° C at Jupiter, but must survive >+40° C during Venus flyby)
  - Limited solar power (will only be second/third solar powered mission at Jupiter, where solar power is ~3% Earth levels)

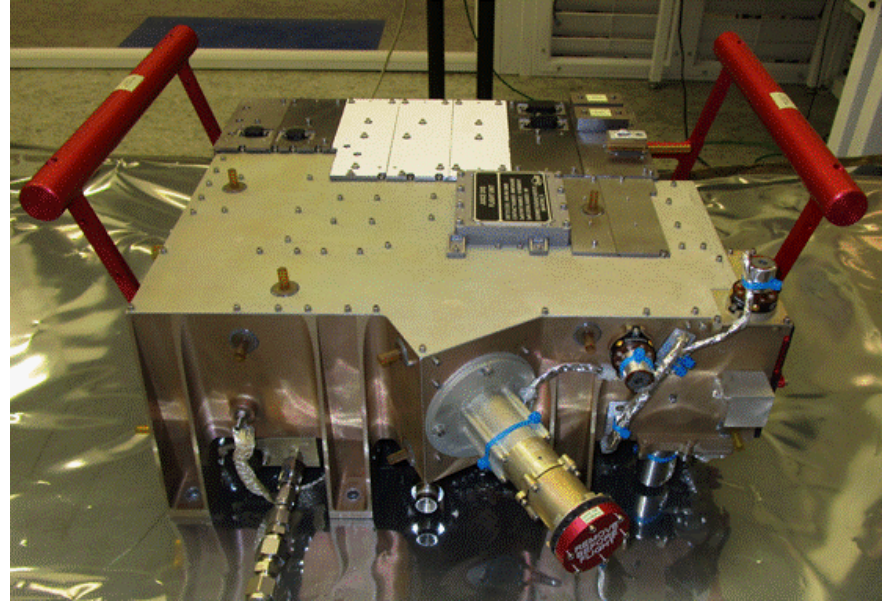


## JUICE-UVS Components

- Housing
  - Al Structure
  - Doors
  - TaW Shielding
- Apertures
  - Airglow Port (AP)
  - High-spatial-resolution Port (HP)
  - Solar Port (SP)
- Optics
  - Off-axis Paraboloid (OAP) Mirror
  - Solar pickoff mirror
  - Grating
  - Slit
- MCP XDL Detector Assembly
- Electronics
  - Detector
  - Command & Data Handling (C&DH)
  - Low Voltage Power Supply (LVPS A&B)
  - High Voltage Power Supply (HVPS A&B)



# Changes from Heritage



Changes from heritage instruments (Juno-UVS, LRO-LAMP, NH-Alice, & R-Alice):

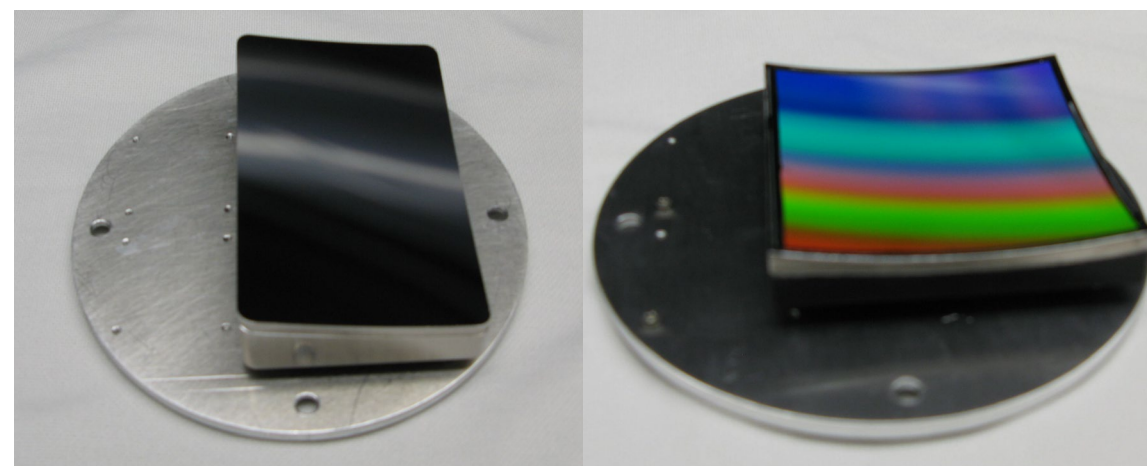
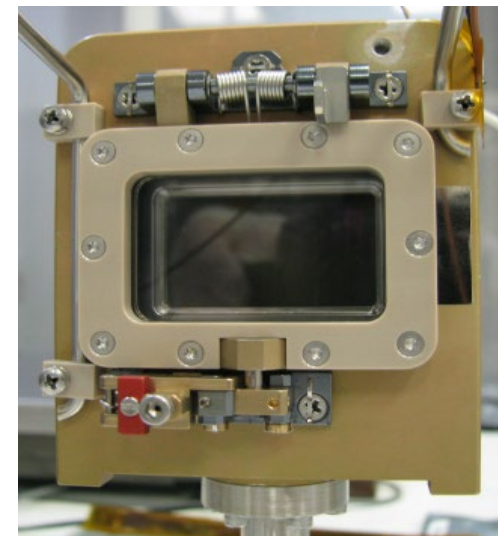
- Solar port from NH-Alice re-instated at 60° angle to avoid solar panels; pinhole reduced to 0.25 mm diameter
- Detector incorporates ALD coating to eliminate gain sag
- Electronics re-incorporated into main instrument body with extension of Ta shielding
- Addition of high resolution port (HP) door to allow observations with higher spatial resolution
- Additional ADC in detector electronics to ensure proper pulse height recording at >100 kHz input rates
- Programmable acquisition resolution allows on-board data binning to reduce data volume

# Resource Summary

Attribute	Value
Nominal Mass:	19.4 kg Measured [Allocation: 22.8 kg]
Nominal Power:	8.1 W Science [Allocation: 11.6 W]
Dimensions:	37.2 cm x 43.5 cm x 16.8 cm
Spectral Range:	50-204 nm
Spectral Resolution:	<0.8 nm (point source); <1.2 nm (extended source)
Spatial Resolution:	0.09-0.29° (AP); 0.04°-0.12° (HP)
Field of View:	0.1° x 7.3° (slit) + 0.2° x 0.2° (solar occultation box)
Effective Area:	0.8 cm <sup>2</sup> @ 125 nm
Telescope / Spectrograph:	Off-axis Primary / Rowland circle mount
Detector Type:	2D MCP (solar blind), CsI photocathode, cross-delay-line (XDL) readout, 4096 spectral x 4096 spatial x 256 PHD
Radiation Mitigation:	Contiguous shielding (4π sr @ detector and electronics)

## JUICE-UVS

- Detector: curved microchannel plate
  - Conventional MCP Z-stack with ALD
  - XDL - cross delay line readout
  - Vacuum enclosure with windowed-door (opens once in flight)
- Off-axis primary mirror
  - Al/MgF<sub>2</sub> coated off-axis parabolic mirror (same design as Juno-UVS, slightly enlarged)
- Diffraction grating
  - Al/MgF<sub>2</sub> coated
  - 1600 grooves/mm toroidal grating
  - Baseline based on Alice replica from Horiba Jobin-Yvon
    - New master takes advantage of 20+years of manufacturing improvements & scatter reduction



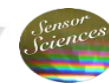


JUICE-UVS

# Data and Operations



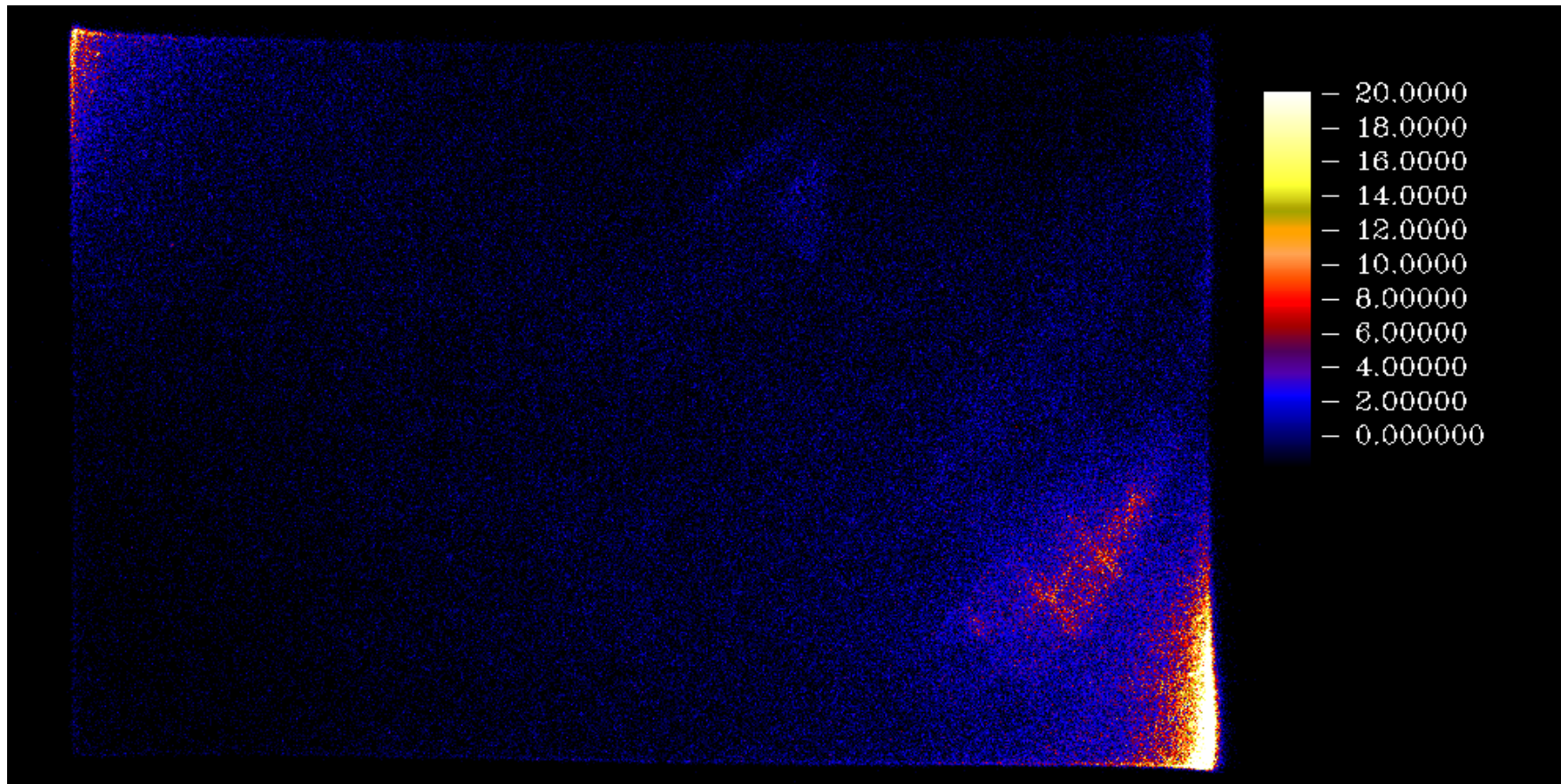
- Two data taking modes: Pixel List and Histogram
- Pixel List mode records the position and pulse height (12 bit X, 12 bit Y, 8 bit PH) of every detected event
  - This list is interspersed with a time tag to record the time at which the events are recorded
  - The time tags can be set to a rate between 1-250 ms depending on desired time resolution and data volume
  - Pixel list observations maximize temporal, spatial, and spectral resolution, but can produce large amounts of data
- Histogram mode integrates detected events over a given observation time and assigns these events to a position within a 1 MB maximum histogram
  - The 1 MB file size limitation means a full 4k x 4k image cannot be recorded in histogram mode
  - Histogram resolution is programmable via lookup table (LUT) that can vary spatial and spectral resolution as desired to minimize data volume





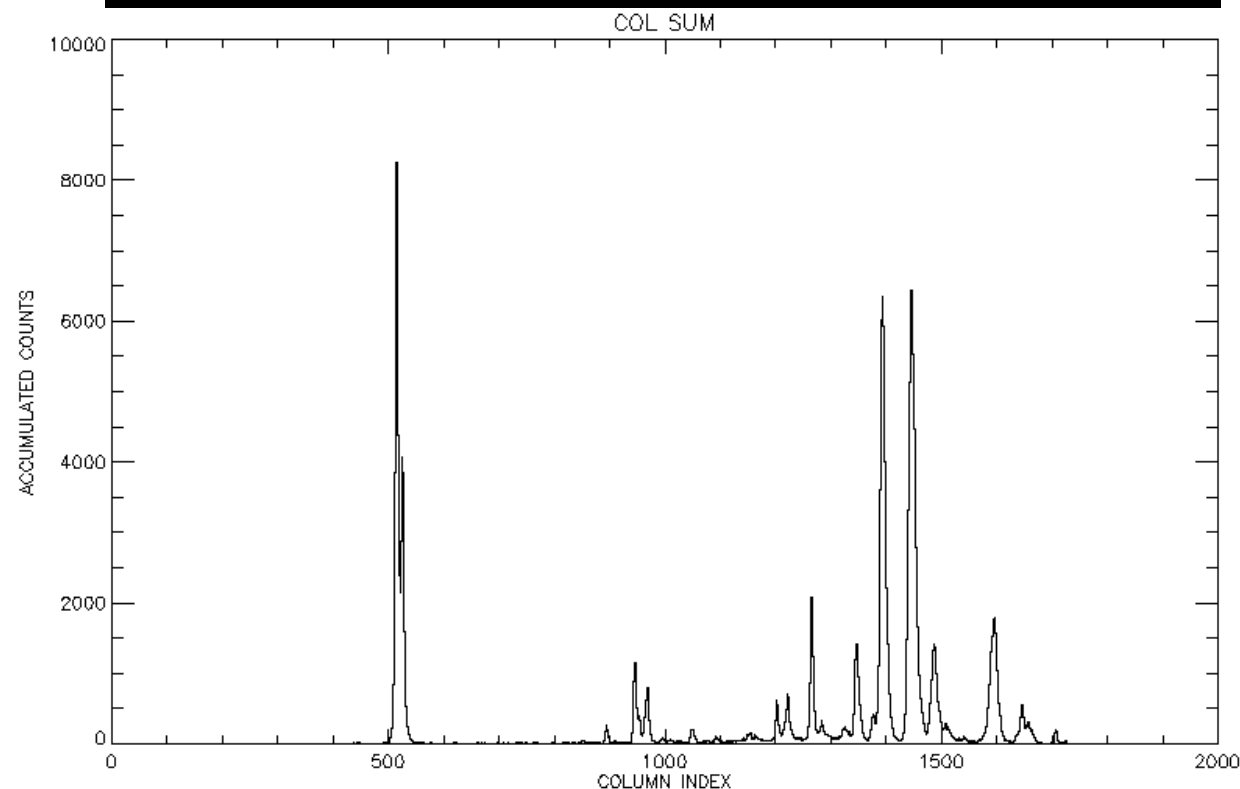
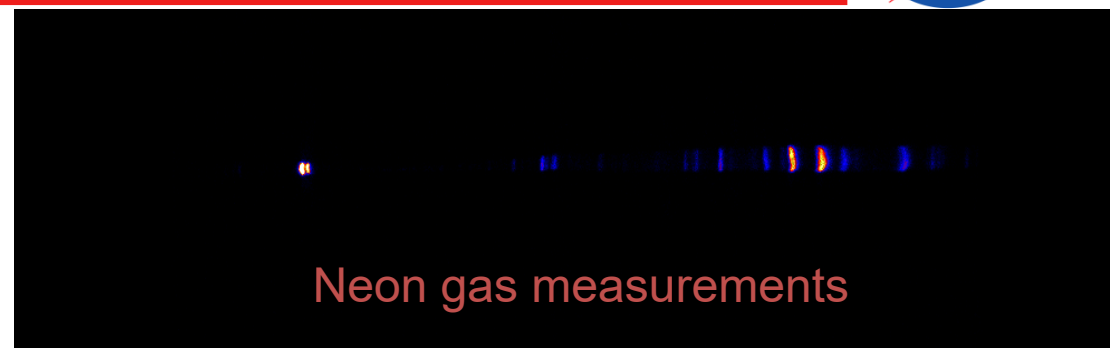
# Dark Image

- A 14 hour dark exposure taken over multiple testing days
- Time hack rate: 250 msec
- Average count rate: 24.5 c/s (0.000002 c/s/pixel)
- “Warm” spots in corners are highest contributors to dark noise

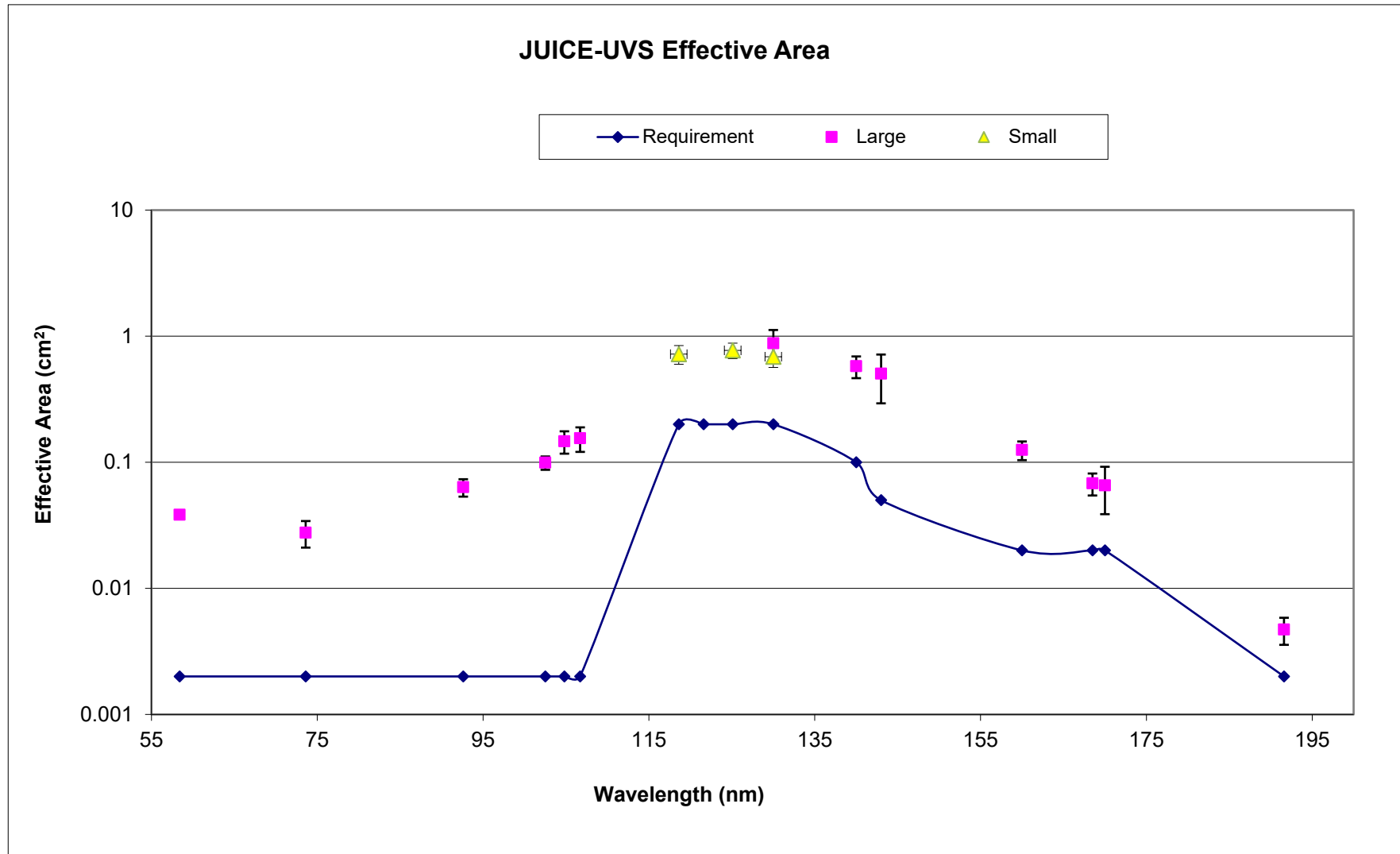


## JUICE-UVS

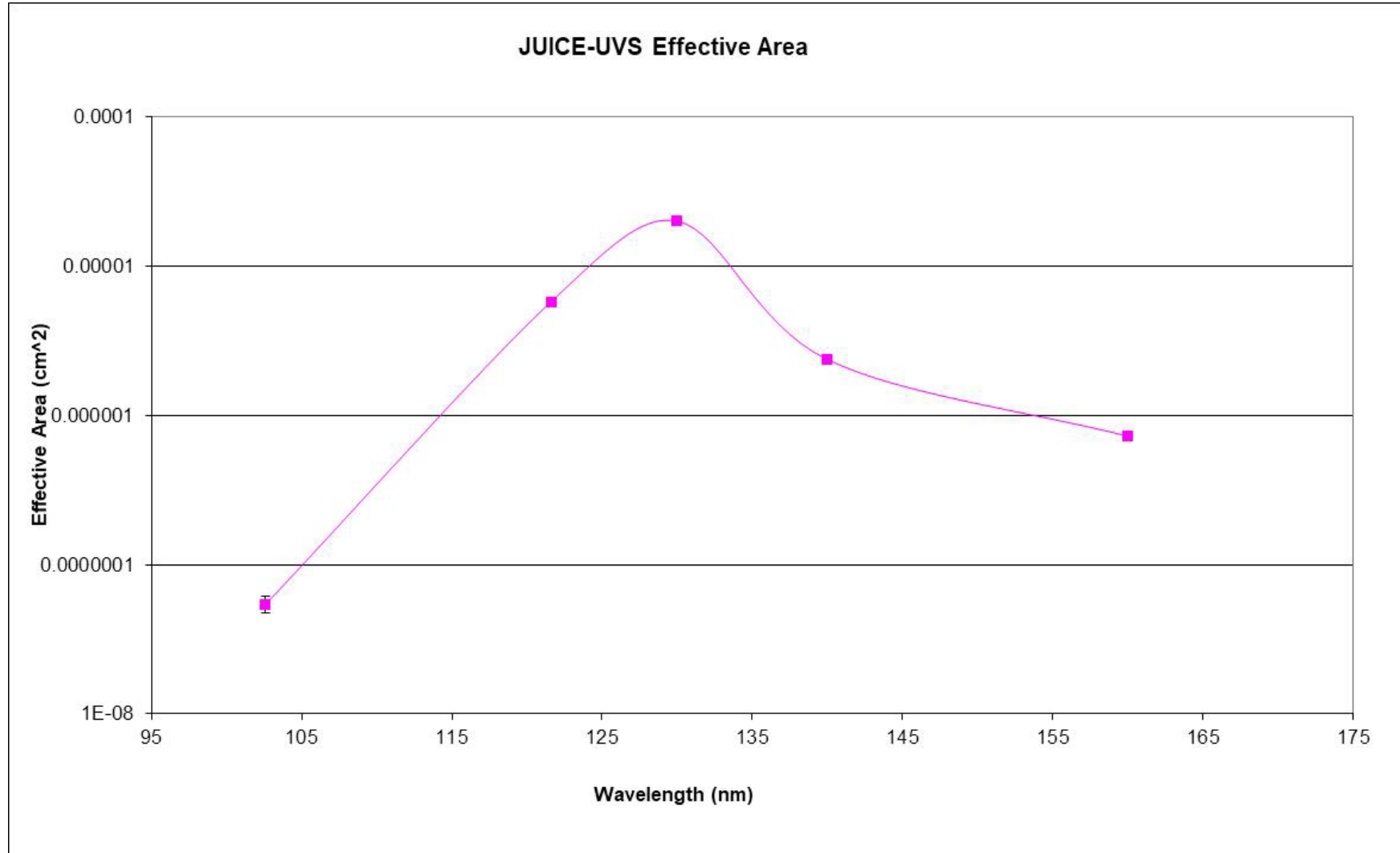
- PSF measurements across the UVS passband using H/He, Ar, and Ne gas
- Measurements made along the length of the slit axis ( $7.5^\circ$ )
- Spectral resolution requirement:  $< 2$  nm FWHM;  $< 0.6$  nm FWHM on-axis
- Spatial resolution requirement:  $< 0.3^\circ$  FWHM



# Effective Area

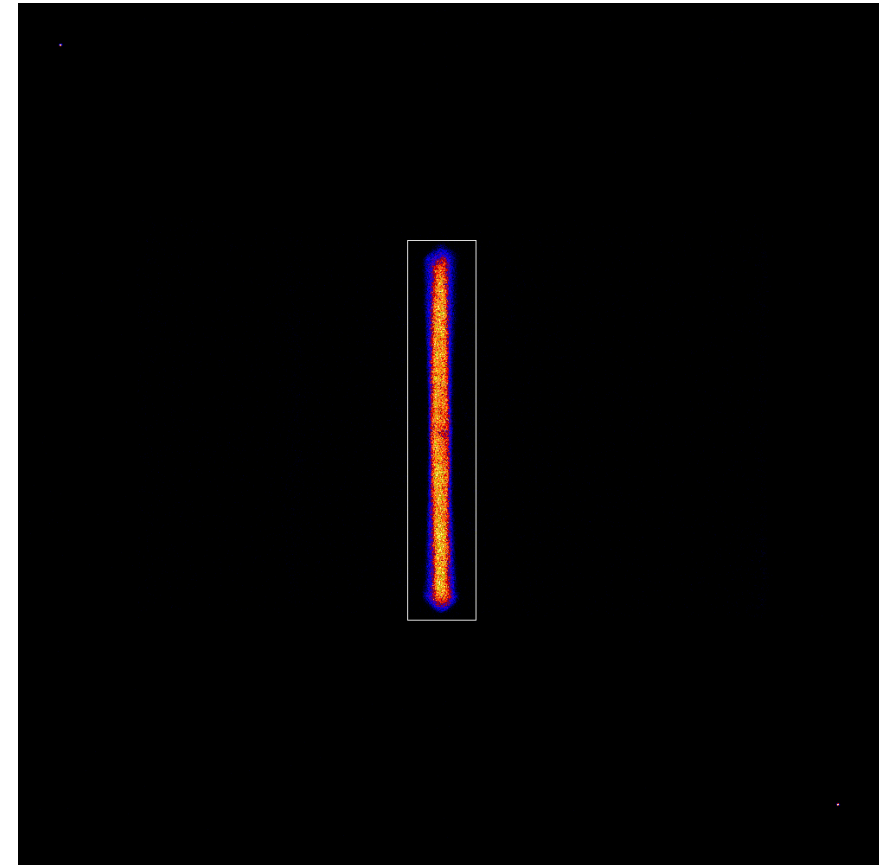


# Solar Port Effective Area

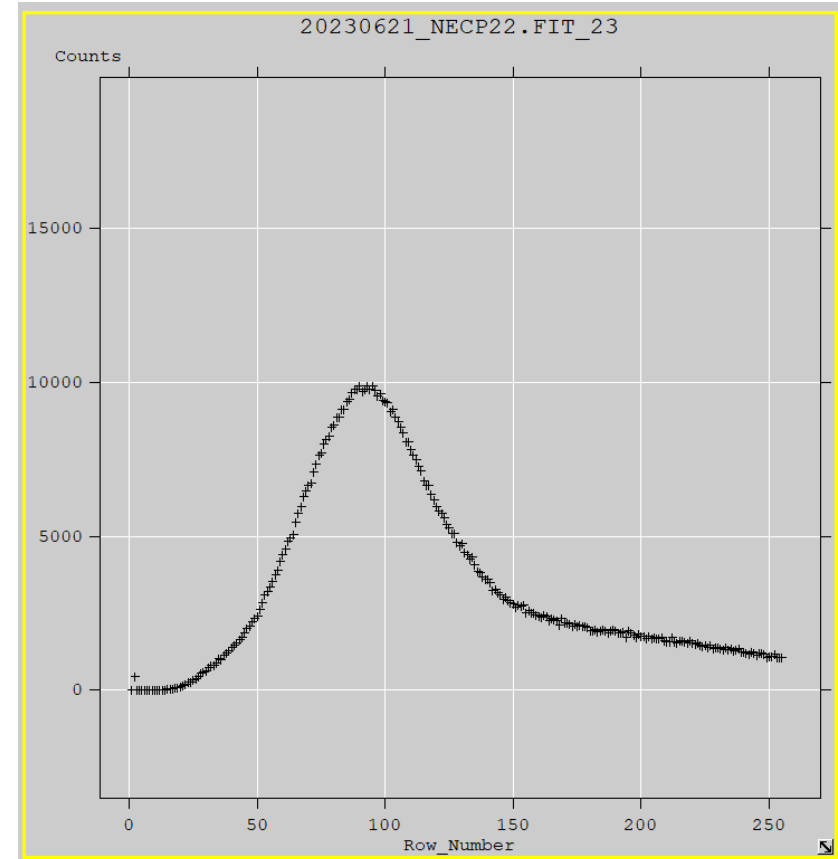


- JUICE-UVS Near-Earth Commissioning ran from 14 June to 24 June 2023.
- All doors and latches were deployed aside from the Solar Port latch
  - Solar Port is deployed when spacecraft passes beyond 2 AU for the last time to prevent excessive solar input
- High voltage level set via multiple observations of interplanetary Lyman-alpha (121.5 nm)
- Long (50+ hour) dark and 360° sky-roll images taken
  - The HGA must be pointed at the sun within 2 AU

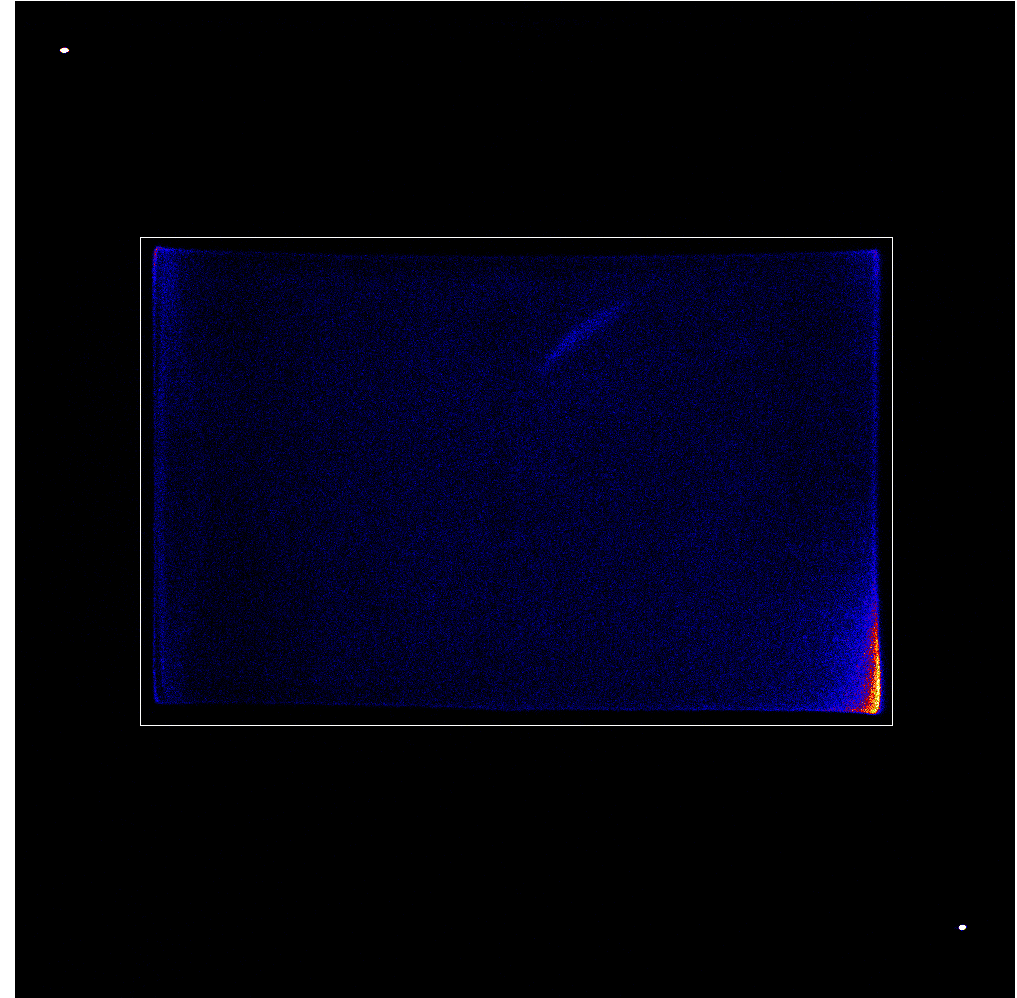
- Slit image of Lyman-alpha
- Stimulation pixels seen in upper left and lower right
- 2-minute exposure
  - Count rate  $\sim 9550$  Hz



- 3-axis pointing not possible due to solar and thermal constraints, so observations made of Lyman-alpha background at multiple voltages (-4.35, -4.4, -4.45, -4.5, -4.55 kV)
- -4450 chosen as “best” operational voltage
  - PHD peak  $\sim 1$  pC gain

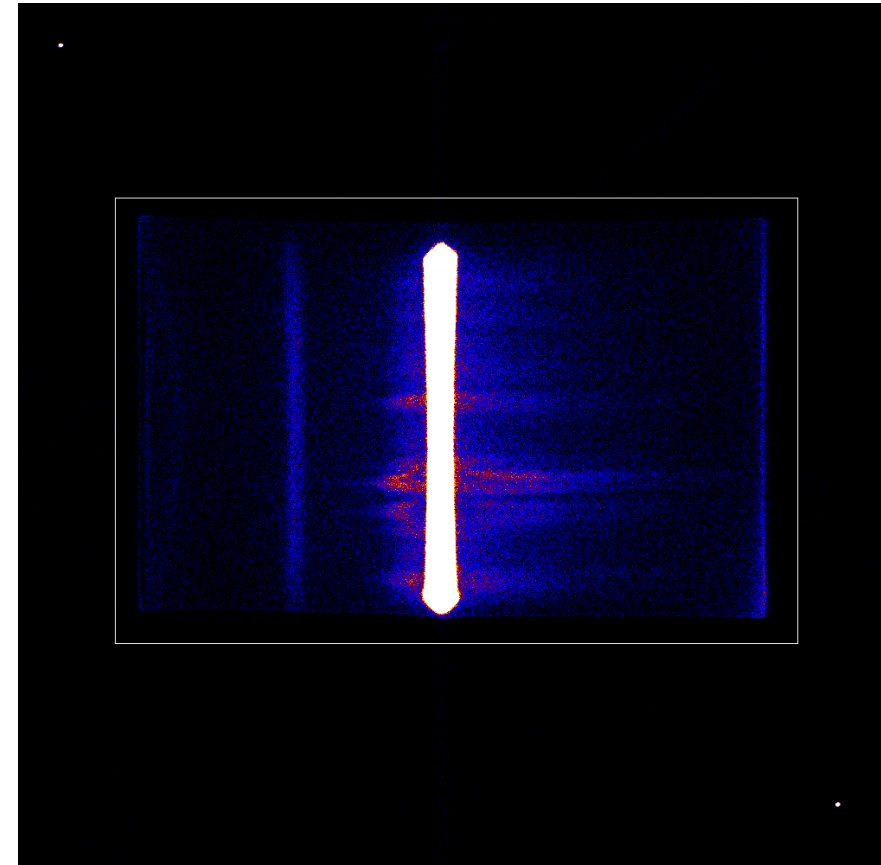


- 44.25-hour dark taken over 23-25 June
  - Short interruption due to S/C reaction wheel momentum dumps
- Measured dark rate is 33 Hz, mostly concentrated at edges
  - Approximately 1 count/pix/12 hours



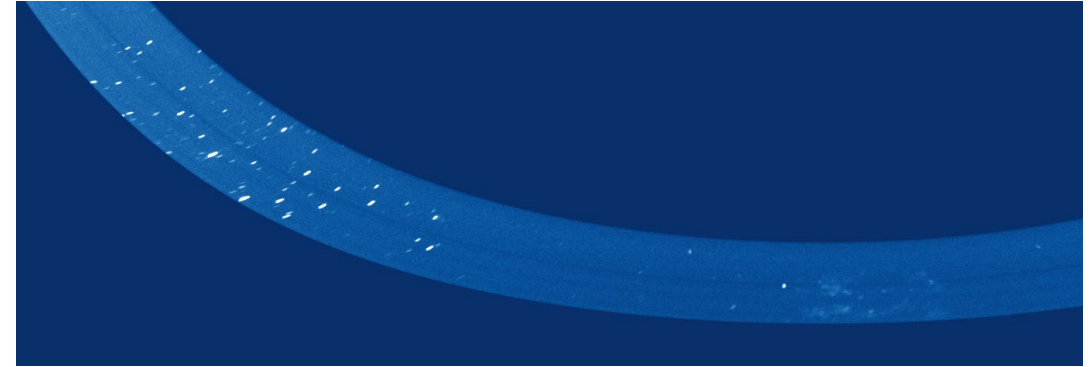


- S/C spun 360° around HGA axis over the course of 1 hour on 23 June
- Spin allowed for observations of a 360° x 7.5° swath of sky
- Raw image shown at right with high saturation to show star observations

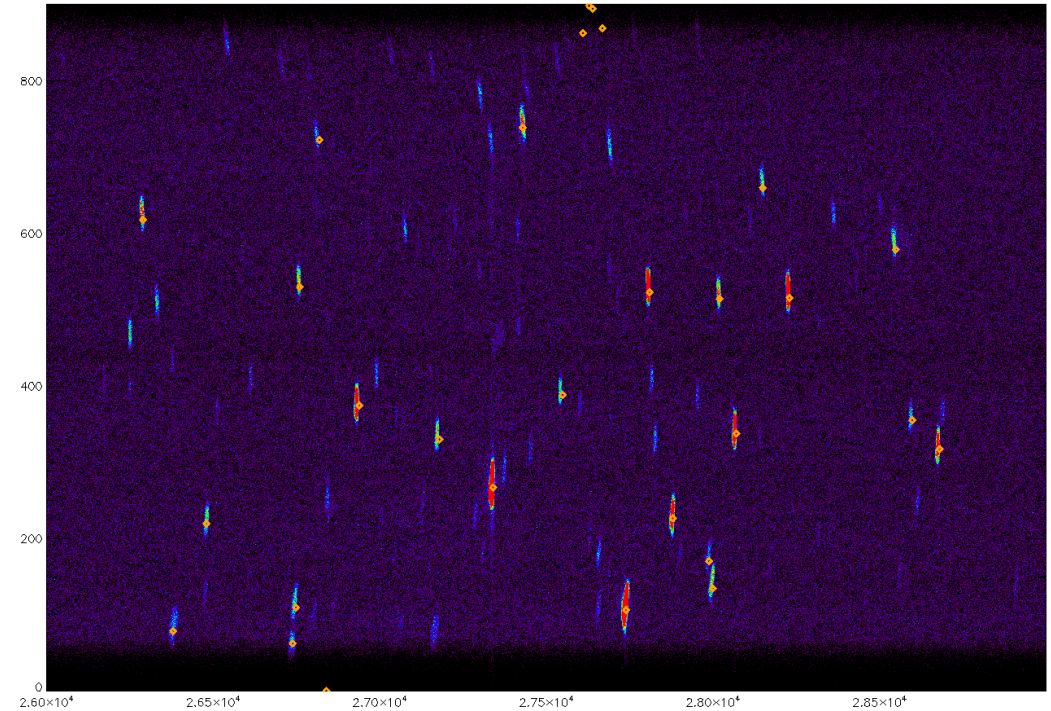


## Sky-roll Image (2)

- The sky-roll observation was taken in time-tag mode, so the data could be separated into 1-ms bins to allow for spatial mapping
- The bright stars on the left are in Carina
- The patches on the right are the Magellanic Clouds



- The pointing solution still needs to be refined
  - Right image is a portion of galactic plane with preliminary star identifications
- The effective area between 115-205 nm needs to be determined based on stellar observations
  - SwRI has a full-sky map between 115 and 200 nm from Juno-UVS observations



# Conclusions

- JUICE-UVS features many improvements over previous UV spectrographs.
  - JUICE-UVS is the fifth of six in the Alice/UVS series of spectrographs from Southwest Research Institute.
  - Key new technologies are ALD-coated lead-glass MCPs, 4k x 4k XDL readout, programmable histogram mode.
- JUICE-UVS was launched on 14 April 2023. Near-Earth commissioning performed from 14-24 June 2023.
- Performance to date meets or exceeds all performance specifications.
  - Dark rate well below 50 Hz
  - Sensitivity consistent with previous Lyman-alpha measurements, but full effective area still to be calculated
- Further pointed observations are needed once full spacecraft pointing is allowed.
  - Solar distance > 2 AU