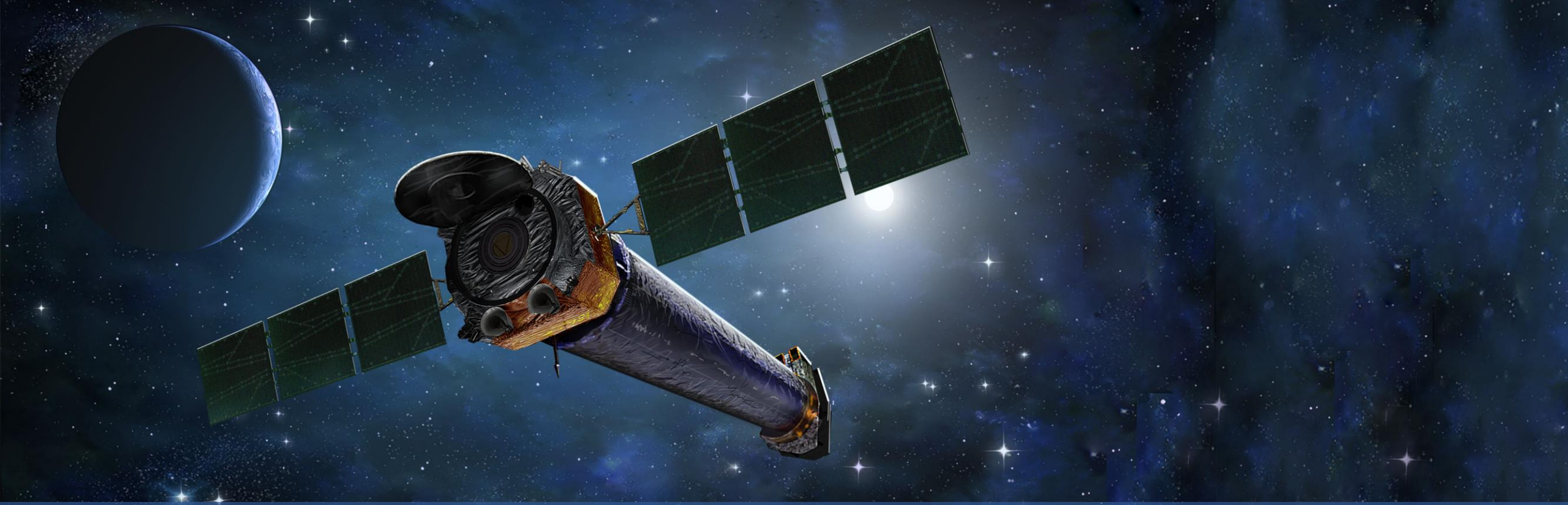


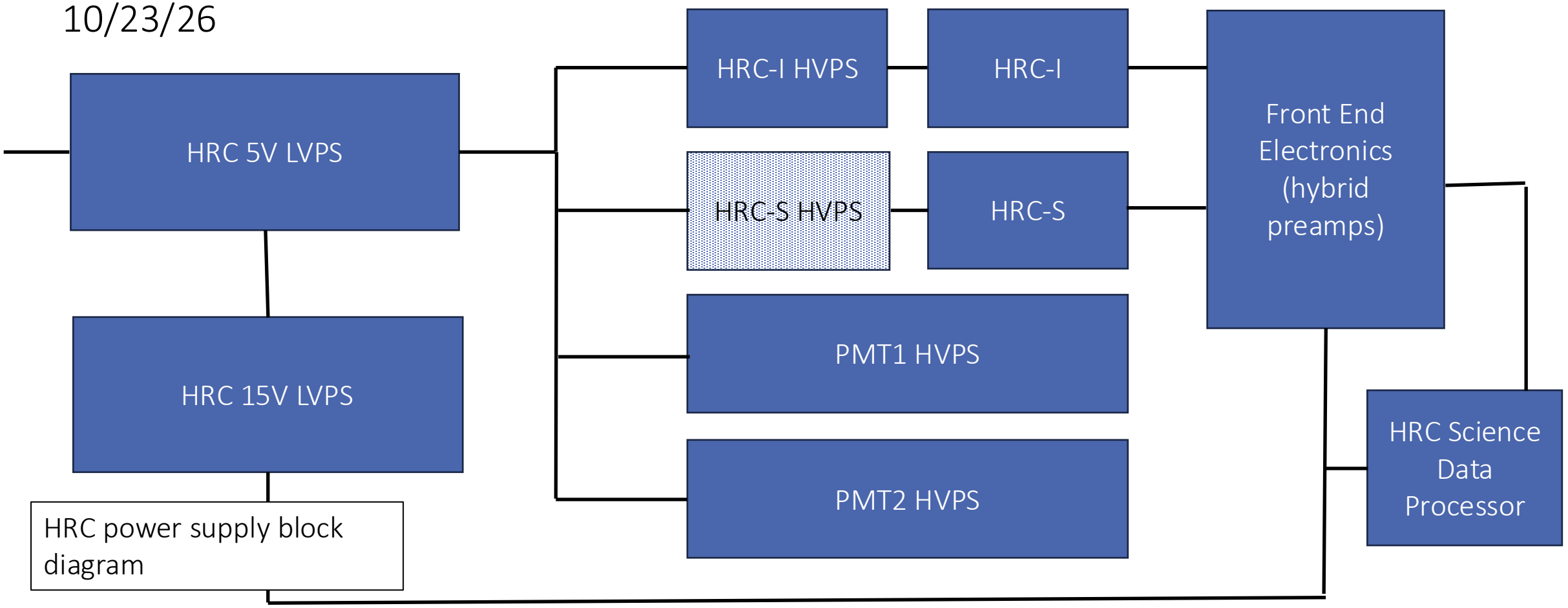
2026 HRC Status – CUC Briefing

Dan Patnaude

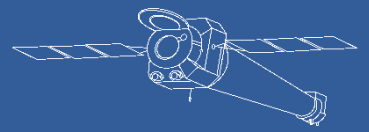
11/05/2026

Current Status of Chandra HRC

- HRC-I is performing nominally
- Following a thorough investigation, the HRC-S was returned to provisional operations on 10/23/26

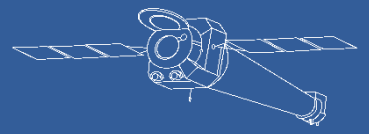


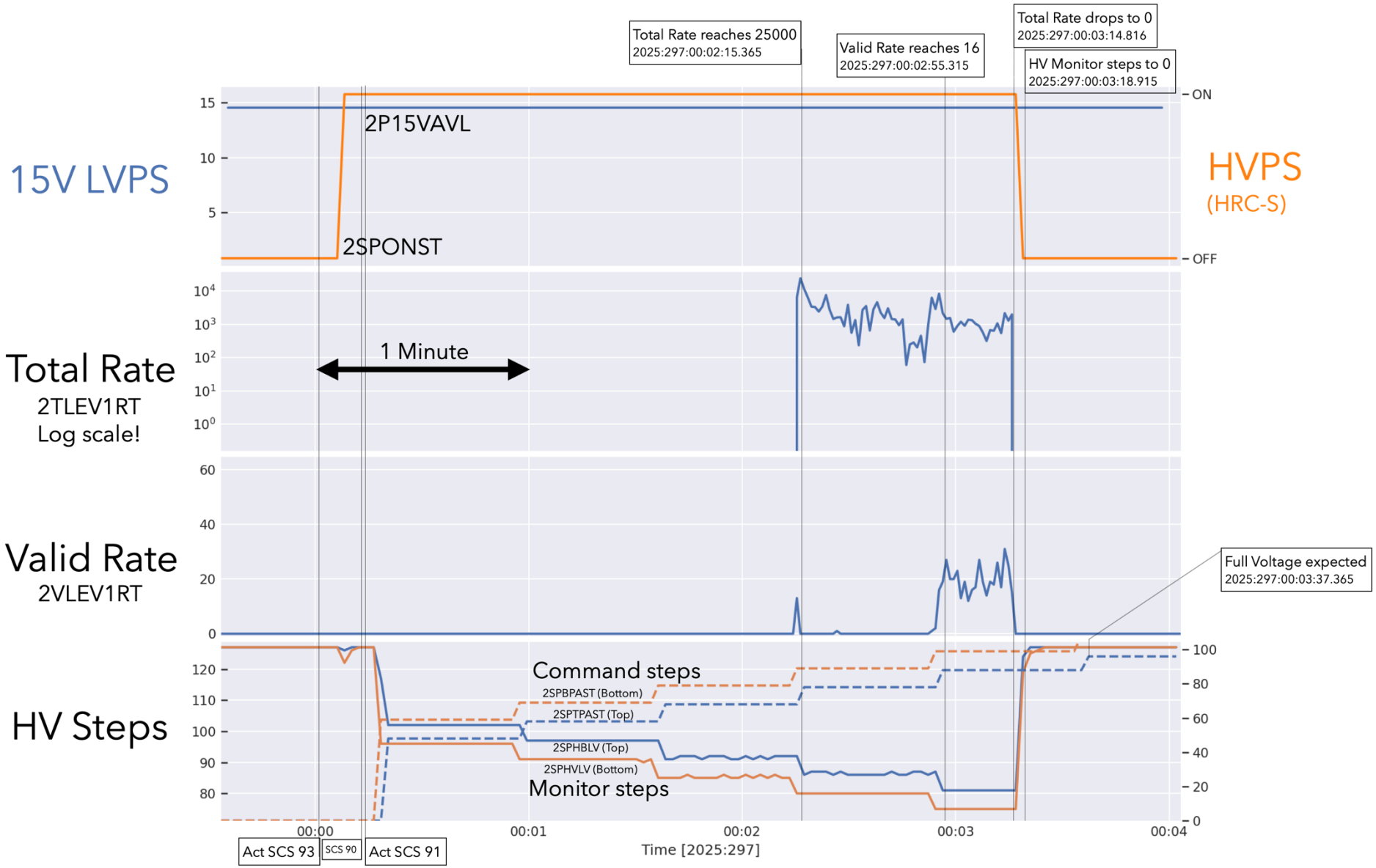
2025:297 HRC-S HVPS Anomaly



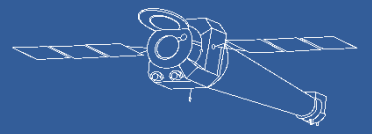
- During setup for an HRC-S/LETG observation of V1935 Cen, the HRC-S high voltage power supply (HVPS) shutdown during step 5 (out of 6 steps) of the HVPS ramp-up
  - Preliminary indications are that the HVPS current limiting circuit behaved as expected
- Ongoing analysis of available telemetry show high total event rates (> 10000 c/s average) prior to shutdown
- The shutdown occurred at 2025:297:00:03:15.815 UT
  - The HRC team noted the anomalous state at the start of a comm which overlapped with the observation
- The team, in consultation with the on duty FD and the LSE executed commands to halt the HRC observation and leave the HRC in a safe state
  - All subsequent observations in the schedule were treated as IDLE time (2 GO observations and 2 calibration observations)

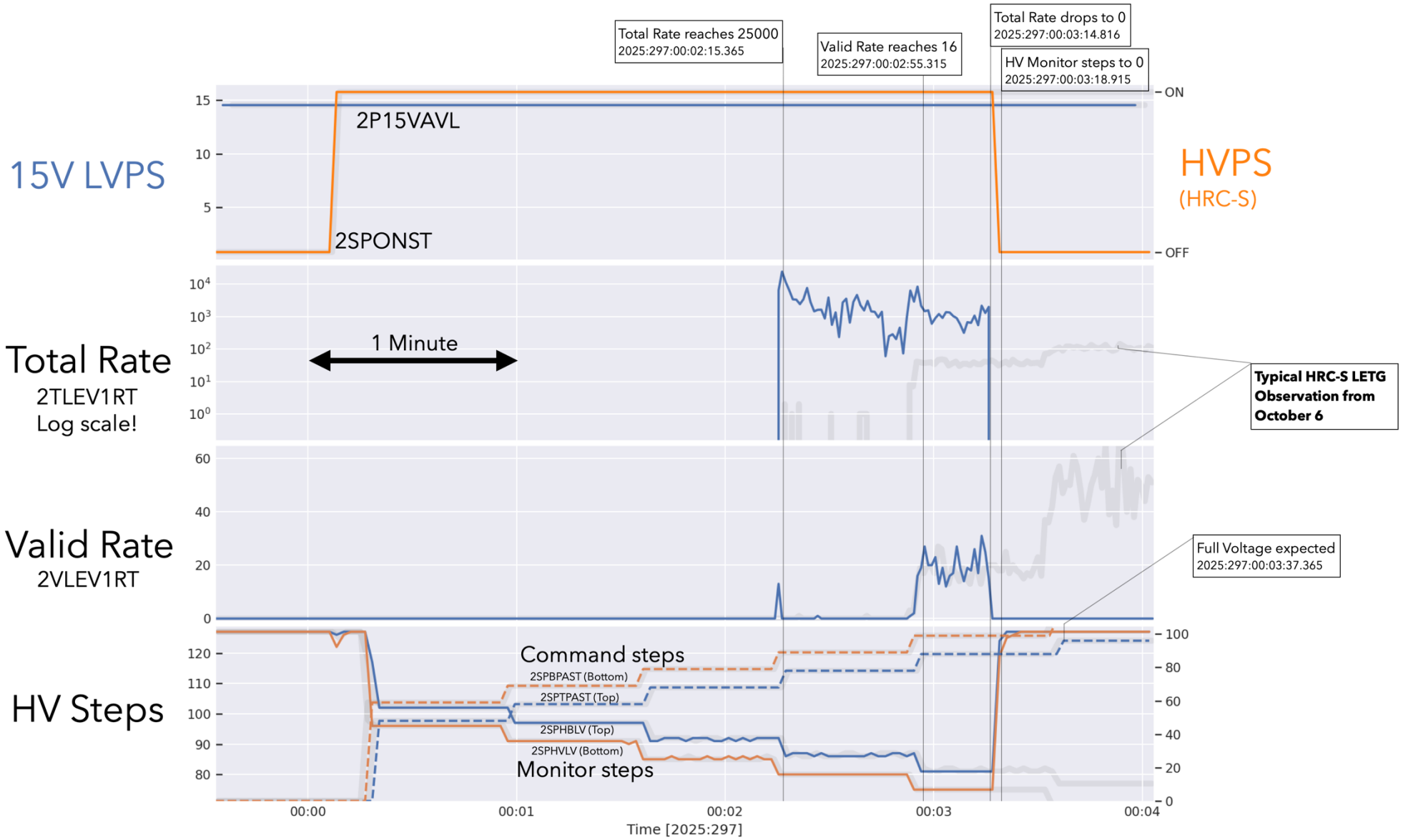
2025:297 HRC-S HVPS Anomaly





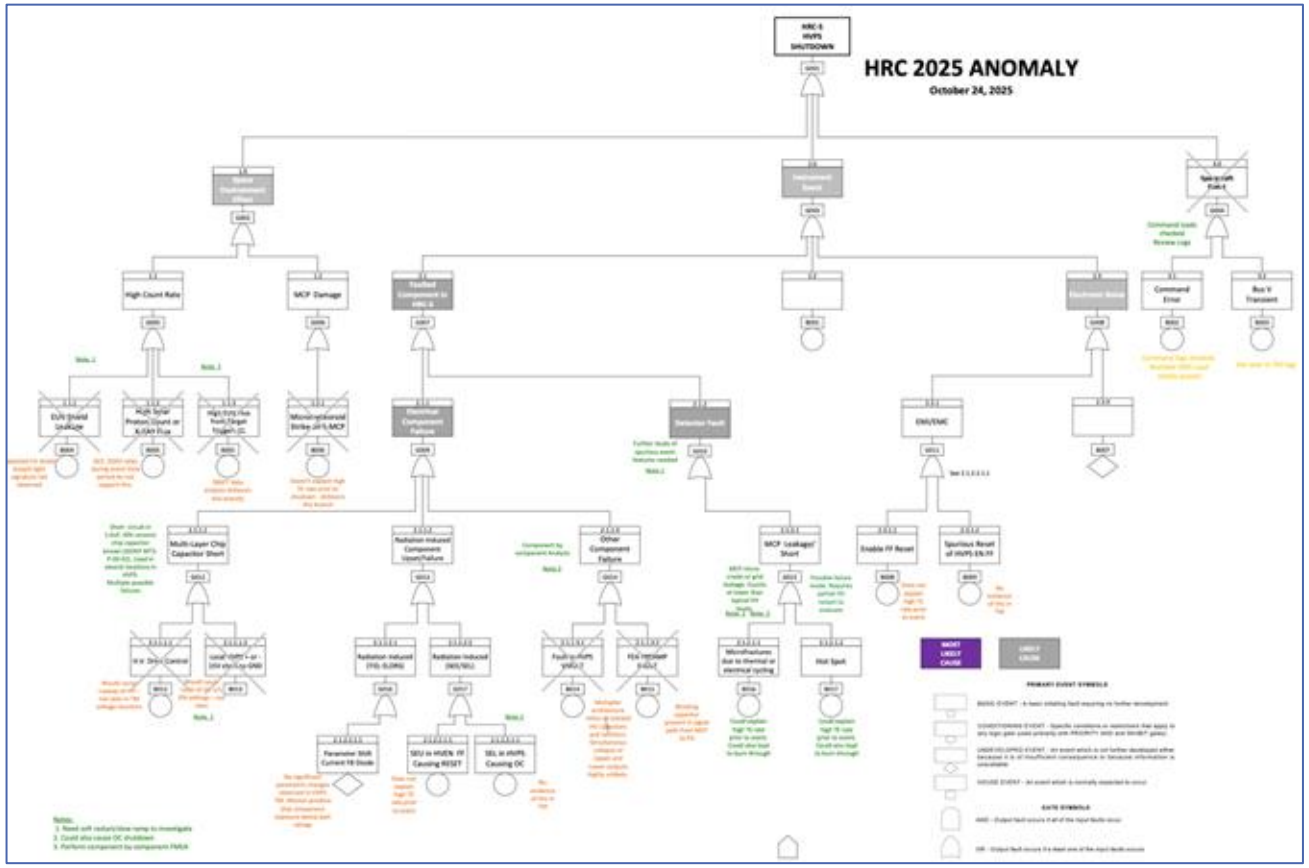
2025:297 HRC-S HVPS Anomaly



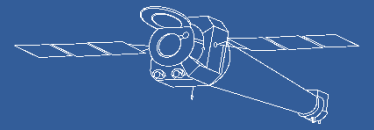


2025:297 HRC-S HVPS Anomaly Recovery Activities

- To diagnose the issue, the HRC team performed a set of real time diagnostic activities:
  - activities were designed to prune branches of fault tree
  - tested for issues with the HVPS ramp up sequence and timing, hot spot formation, or issues with the UVIS
- The HRC-I was quickly returned to operations after confirming that the root cause of the anomaly was not due to issues with shared components



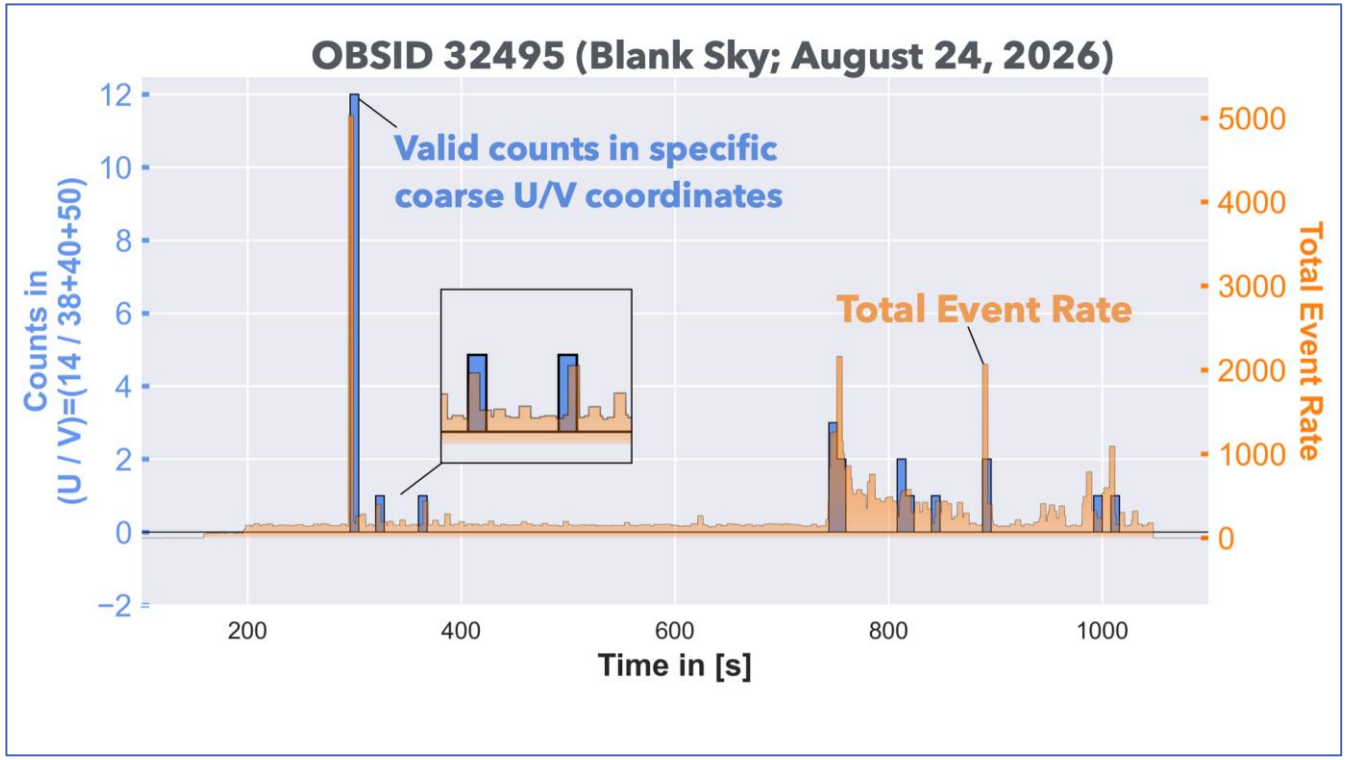
Summary Table of HRC-S Recovery Activities



	HV Ramp-up	Grating	Target	Edge Blank	Full HV?	Outcome
Typical HRC-S	Autonomous (6 steps with 37s intervals)	LETG		Default	Yes	Total Event Rates ~100-300
Oct 24, 2025 OBSID 31954	Autonomous (6 steps with 37s intervals)	LETG	V1935Cen Bright target with soft spectrum	Default	No	CL Trip? Large number of rejected events
Jan 27, 2026 OBSID 32109	Manual/Slow (16 steps with longer intervals)	None	Blank Sky No bright source	None	Yes	Total Event Rates ~ 100
Mar 6, 2026 OBSID 32173	Autonomous (6 steps with 37s intervals)	LETG	Capella Bright target with soft spectrum	Default	Only 10s	CL Trip? Large number of rejected events
May 26, 2026 OBSID 32347	Manual/Slow (16 steps with 4min intervals)	LETG	HZ43 Bright target with soft spectrum	None	No	CL Trip? Large number of rejected events
August 24, 2026 OBSID 32495	Autonomous (6 steps with 37s intervals)	None	Blank Sky No bright source	None	Yes for 870s	CL Trip? Large number of rejected events
August 25, 2026 OBSID 32496	Autonomous (6 steps with 37s intervals)	None	RTCru intermediate star with negligible UV flux	None	Yes	Total Event Rates ~ 140
August 26, 2026 OBSID 32497	Autonomous (6 steps with 37s intervals)	None	2CXO J225932.9+245505 brighter Seyfert galaxy	None	Yes	Total Event Rates ~ 130

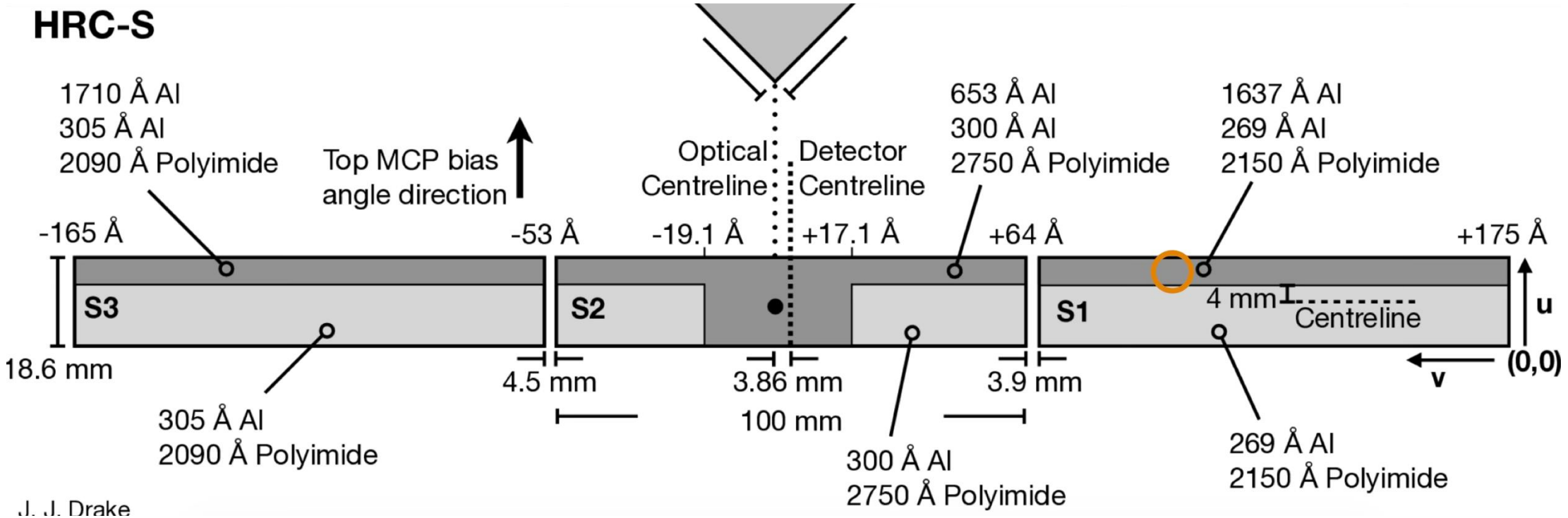
Results of August Activities

- Three real time activities with HRC-S were performed in succession
  - designed to rule out high UV source flux as a contributor to the anomaly
  - activities were all performed with no grating and with edge blanking disabled, as 3x1000s observations with increasing X-ray intensity, and low UV brightness
- First activity resulted in a shutdown after ~ 870 seconds, while next two were successful
  - light curve of August 24 activity provided a clue to the origin of the shutdowns



Total event rate light curve for obsid 32495. High event rates at localized coarse U and V positions are also highlighted, which correlate to increases in the total rate

Review of HRC Geometry and Event Processing

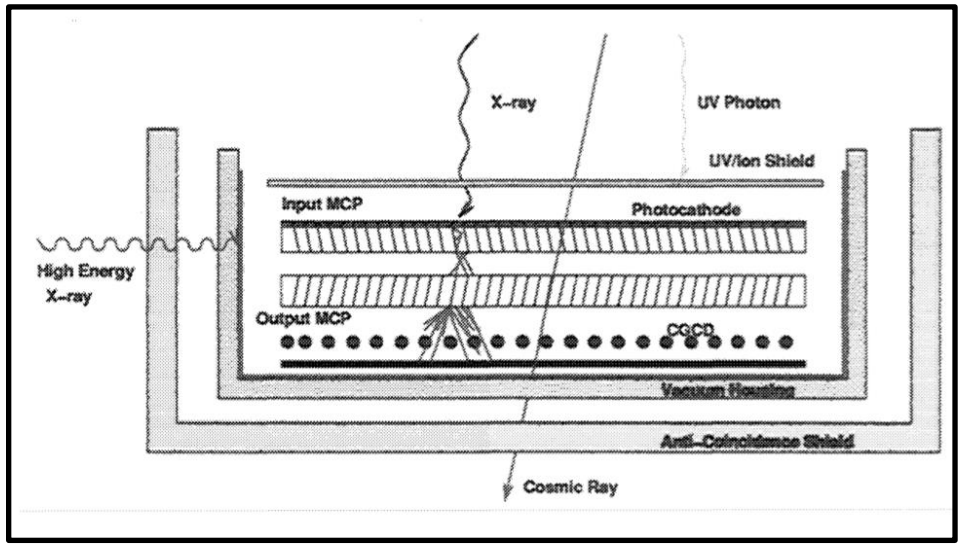


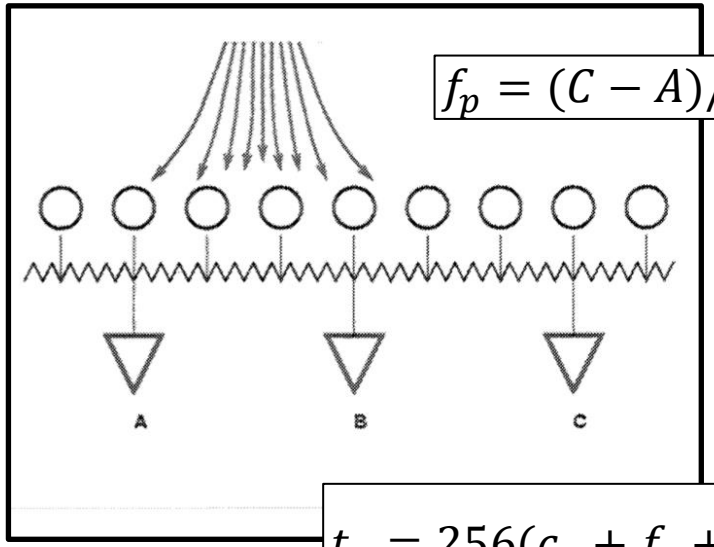
HRC-S consists of CsI coated glass MCPs with a conductive Ni layer on top. Clamps hold the MCPs in place over the crossed grid charge detector (CGCD). HV is applied to HRC-S along the long edge of the detector located farthest from the HRC-I (i.e., along the U=0 axis)

Review of HRC Geometry and Event Processing

Events are read out via the CGCD

- coarse position is determined from 3 highest amplifier signals along each axis
  - position along U or V axis is determined from the coarse position and a fine position correction
- each event takes ~ 16μs to process – processing electronics are paralyzaable during this time, and while total events continue to register, events are not processed, and are dropped on board
- Other onboard vetoing also rejects events (e.g., blanking, pulse height discrimination, etc.)
- Ground processing further screens events based on distribution of charge across the three taps along each axis





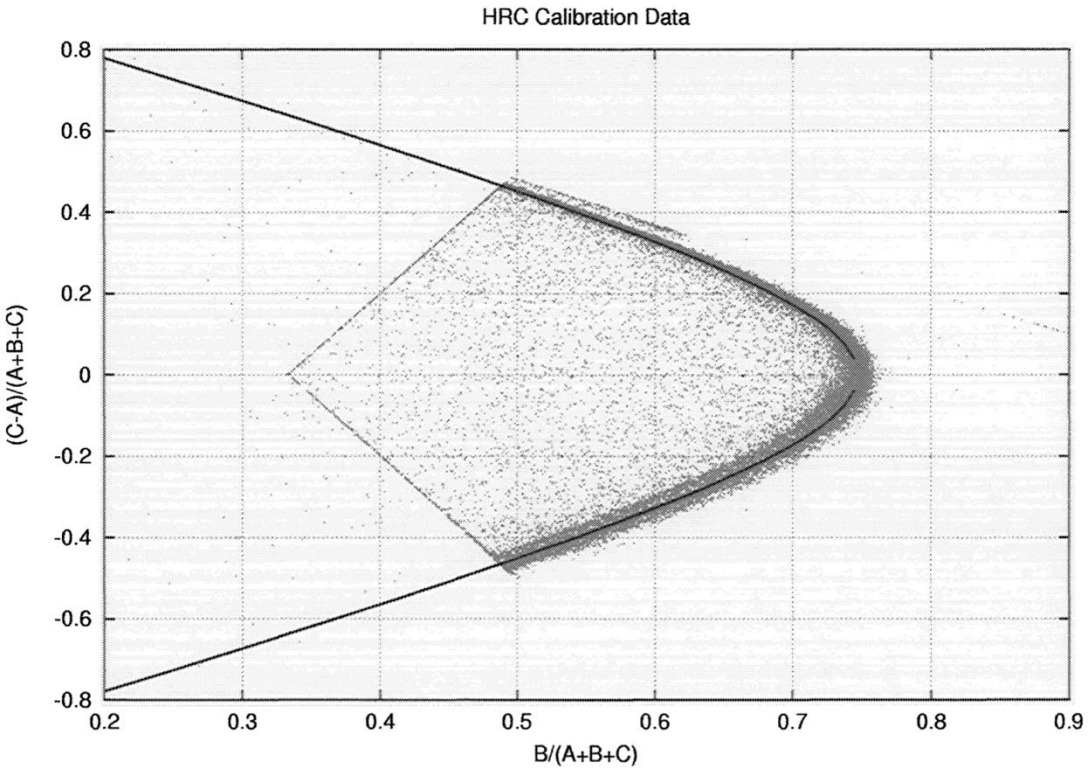
$$f_p = (C - A)/(A + B + C)$$

$$t_p = 256(c_p + f_p + \frac{1}{2})$$

Review of HRC Geometry and Event Processing

Events are read out via the CGCD

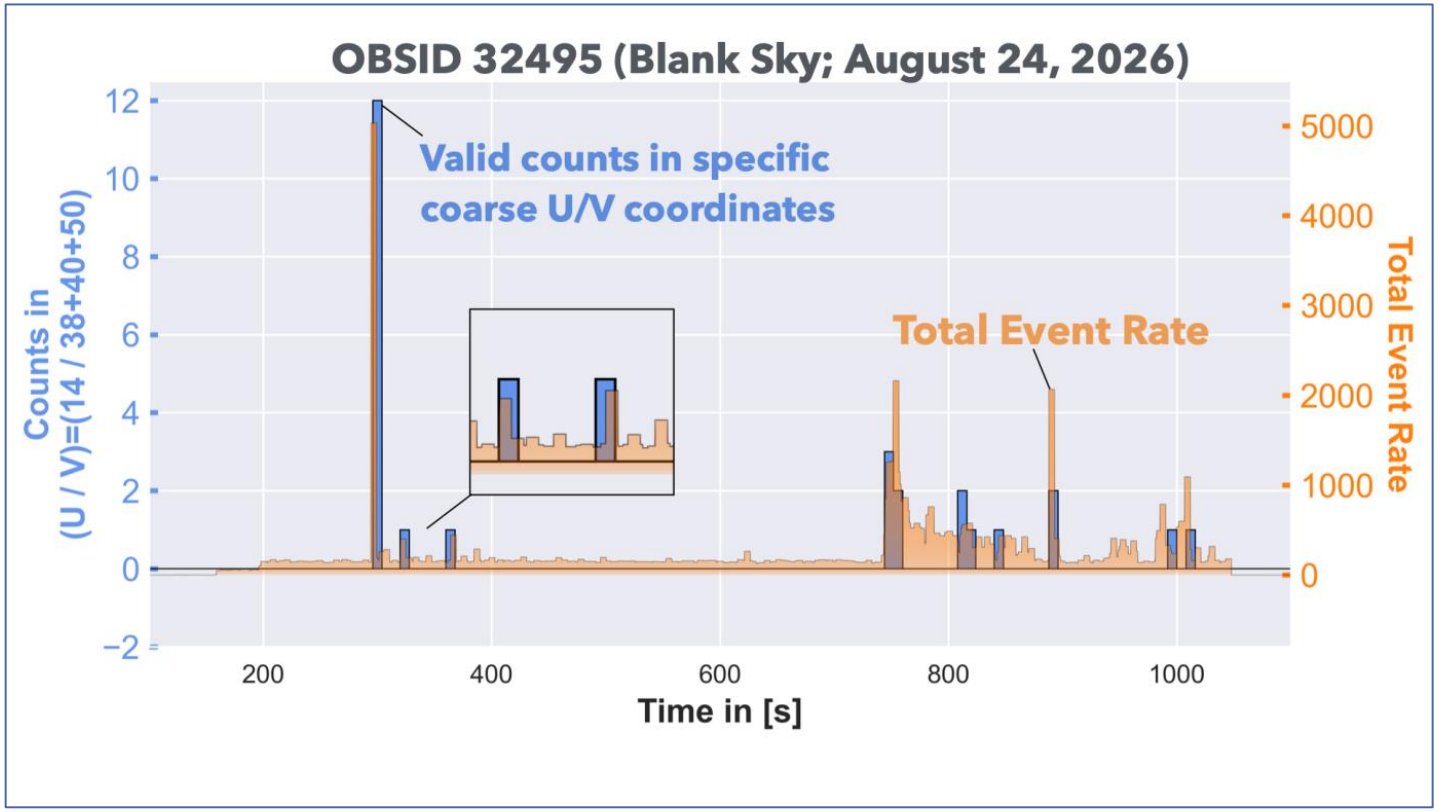
- coarse position is determined from 3 highest amplifier signals along each axis
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- each event takes ~ 16μs to process – processing electronics are paralyzaable during this time, and while total events continue to register, events are not processed, and are dropped on board
- Other onboard vetoing also rejects events (e.g., blanking, pulse height discrimination, etc.)
- Ground processing further screens events based on distribution of charge across the three taps along each axis



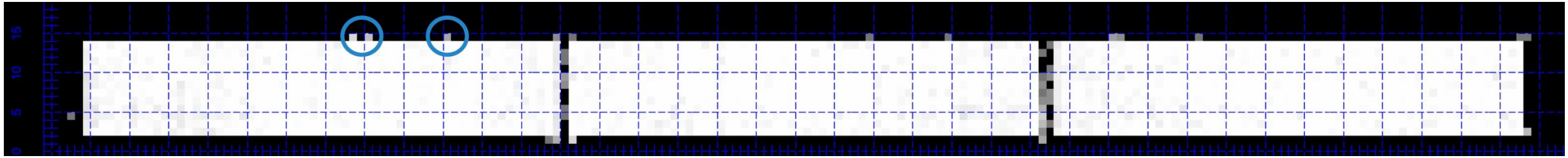
Distribution of HRC events plotted as a function of central tap value vs outer two tap values. Valid events are found to lie along a hyperbola defined by ratios of amplifier signals

Anomalous Events During 8/24 Observation

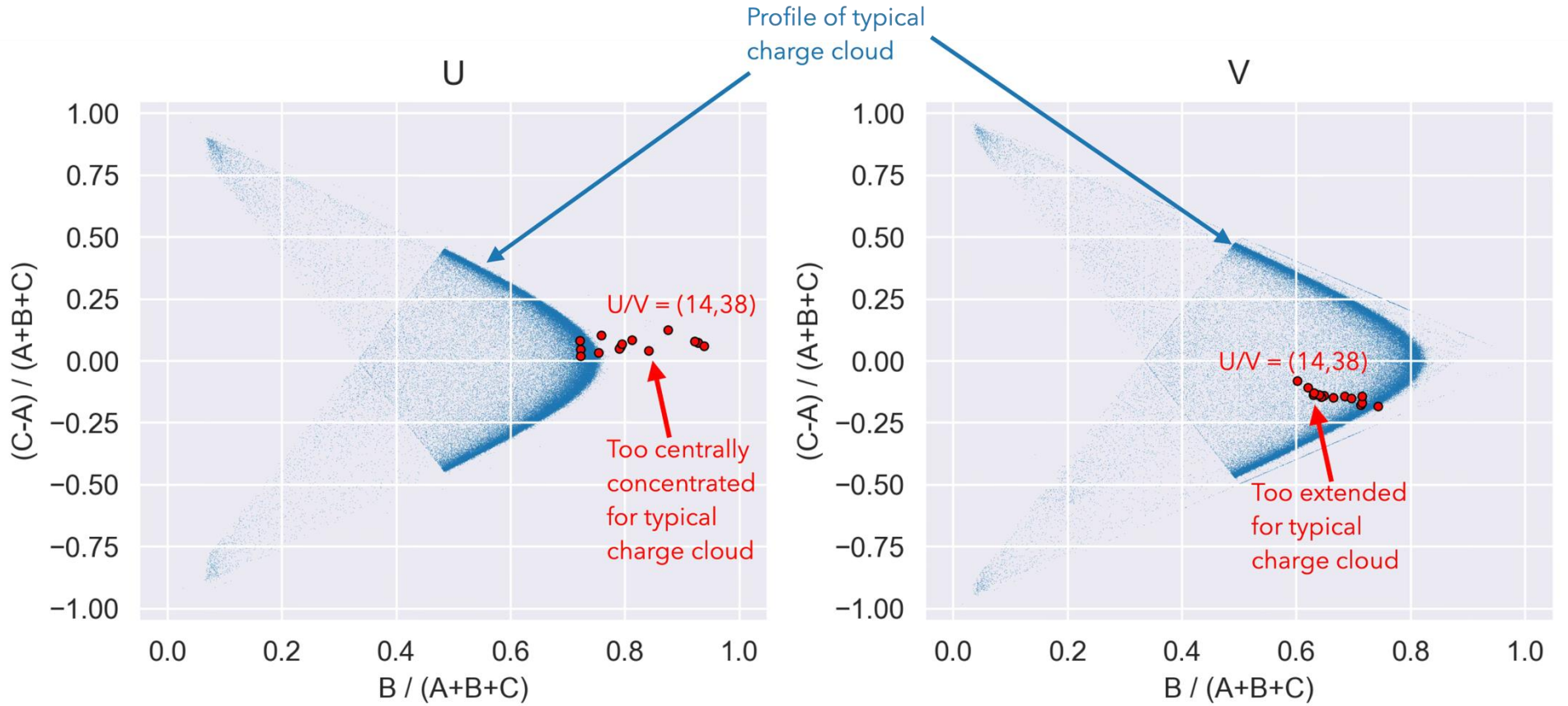
- HRC-S HV shut down ~1050s into the activity (~850 s after full HV)
- inspection of back orbit data revealed a high total event rate at ~ 300s and again from 750s on
  - high rates coincide with a number of valid events at U/V positions at edge of glass
  - Valid events at edge of glass in short time bursts (<< 1s)



Coarse U/V image highlighting the coordinates that correlate with the total event rate



Anomalous Events During 8/24 Observations

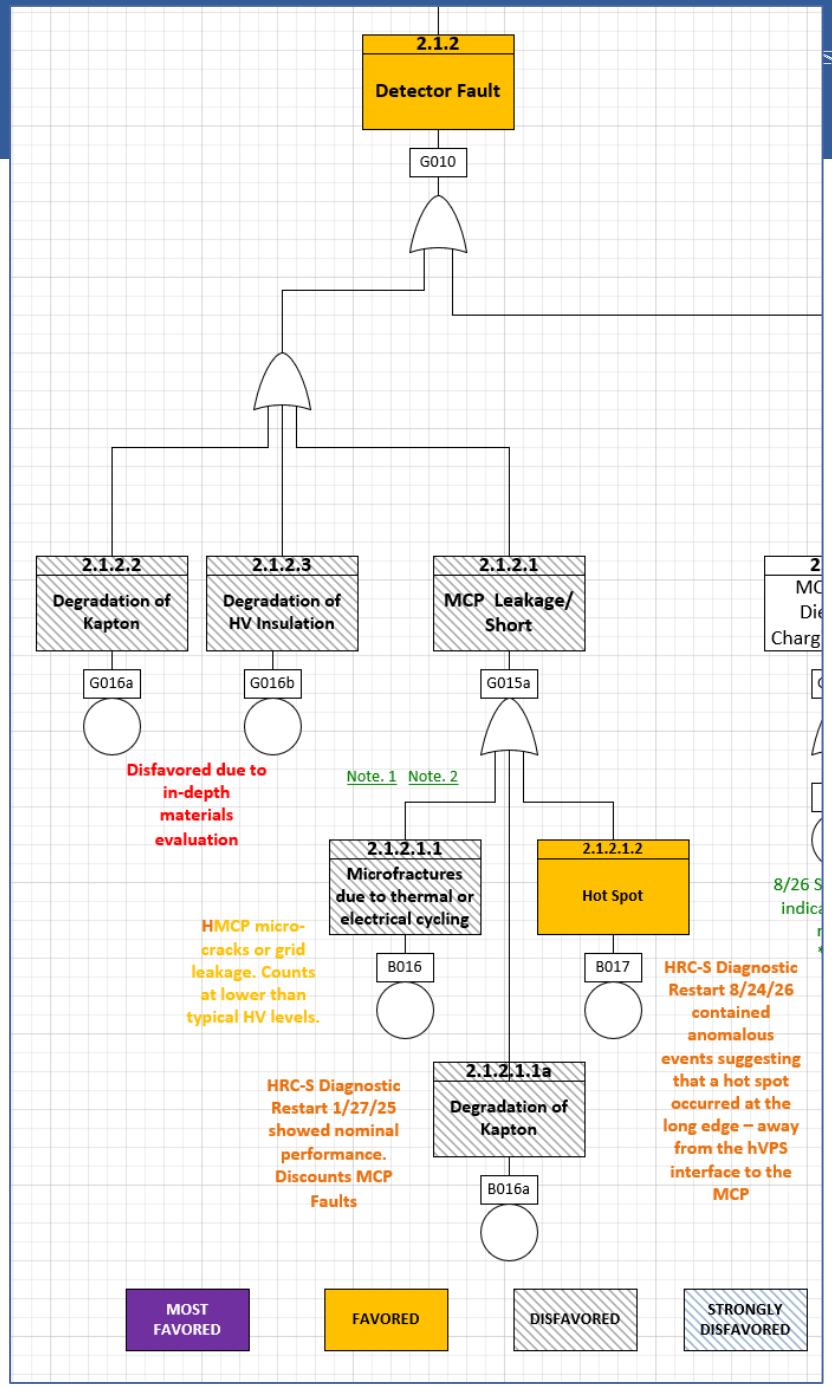


The profile of the counts in (14/38) is highly concentrated on the u-axis, and very extended on the v-axis.

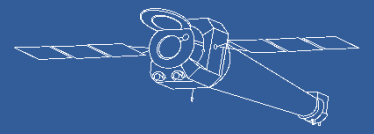
Events are atypical of valid HRC events and would be rejected during ground processing. A, B, and C correspond to the PHA value of the signal on the left, center, and right taps of a given event on the U (left figure) and V (right figure) planes.

Fault Tree Analysis

- analysis of August diagnostic restarts and review of HRC-S design now disfavors electrical breakdown in the connection between the HVPS and MCPs
- points to an intermittent hot spot which has formed along the edge of the detector



HRC Team Assessment of HVPS Anomaly



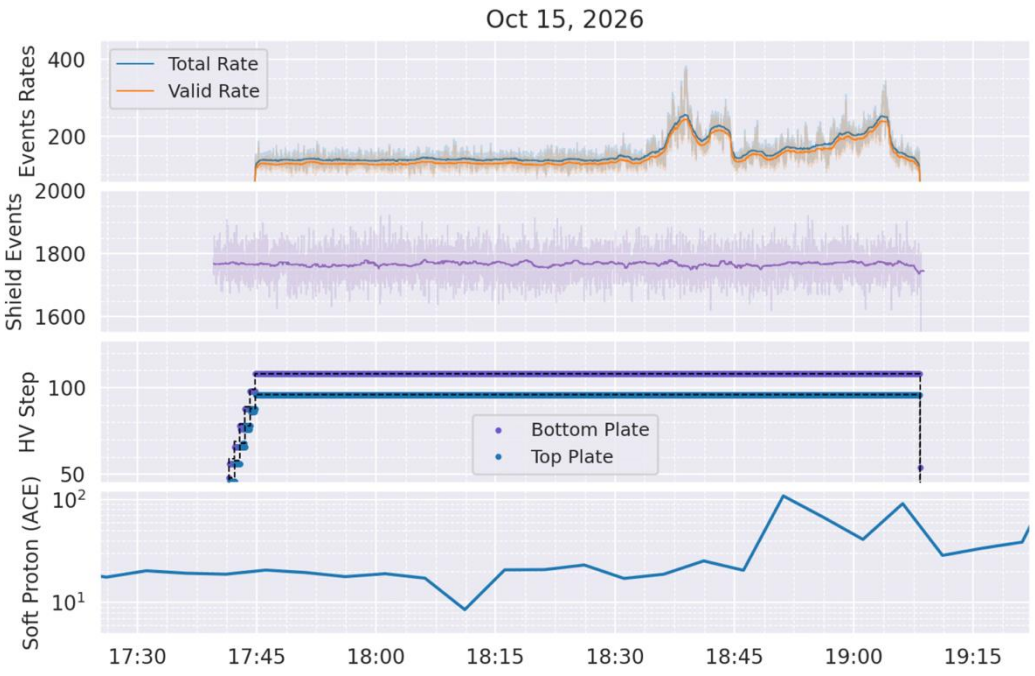
- Anomalous events during 8/24 activity suggest a hot spot along the long edge of the HRC-S (wing segment S1 – see figure on slide 4), on the side opposite to where the plates connect to the HVPS (there is a clamp there but no electrode)
  - small number of valid events, combined with a high total event rate at the same time suggest a localized event where only a fraction of events are processed, and the rest are discarded
- Event signature and location is not suggestive of electrical breakdown in the HVPS or its interface to the MCPs
- Unclear if shutdown on 10/24/25 had same signature, as edge blanking caused any events at that position to be vetoed
  - The trip on May 26, 2026 does not show this signature, despite edge blanking being disabled
  - The trip on March 6 occurred 10s into the observation, but edge blanking was enabled so all events at that location were vetoed on board
- HRC team recommended a series of 5 science observations to demonstrate feasibility of returning the HRC-S to operations – team would develop success criteria based on the outcome of the observations

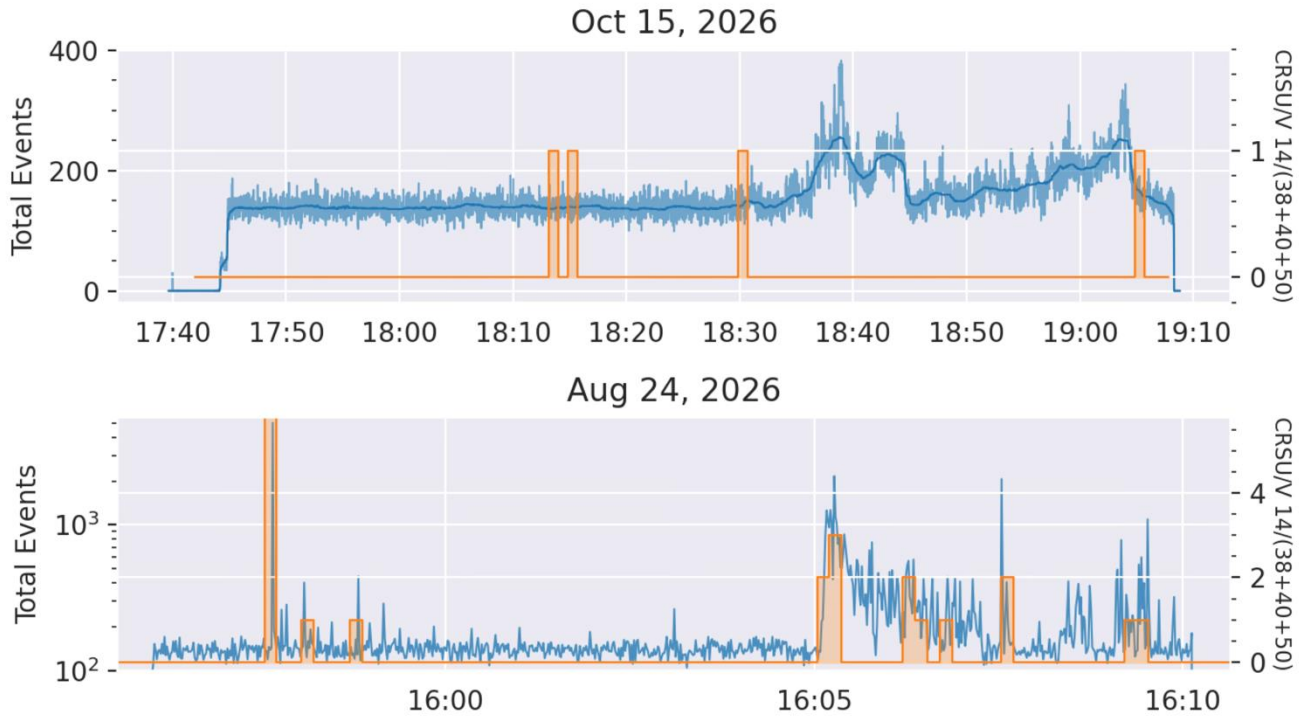
HRC-S Observations in the week of 10/12/2026



- HRC team worked with SOTMP, FOTMP, uplink support, and the calibration team to identify 5 suitable science targets
  - targets consisted of 3 HRC-S/LETG observations of Jupiter and 2 HRC-S calibration targets (Ar Lac and G21.5-0.9)
  - target SIMODEs were updated to disable edge blanking
- 3 of the 5 observations overlapped with available comm time, allowing the HRC team to monitor the detector in real time
- **All observations completed nominally**

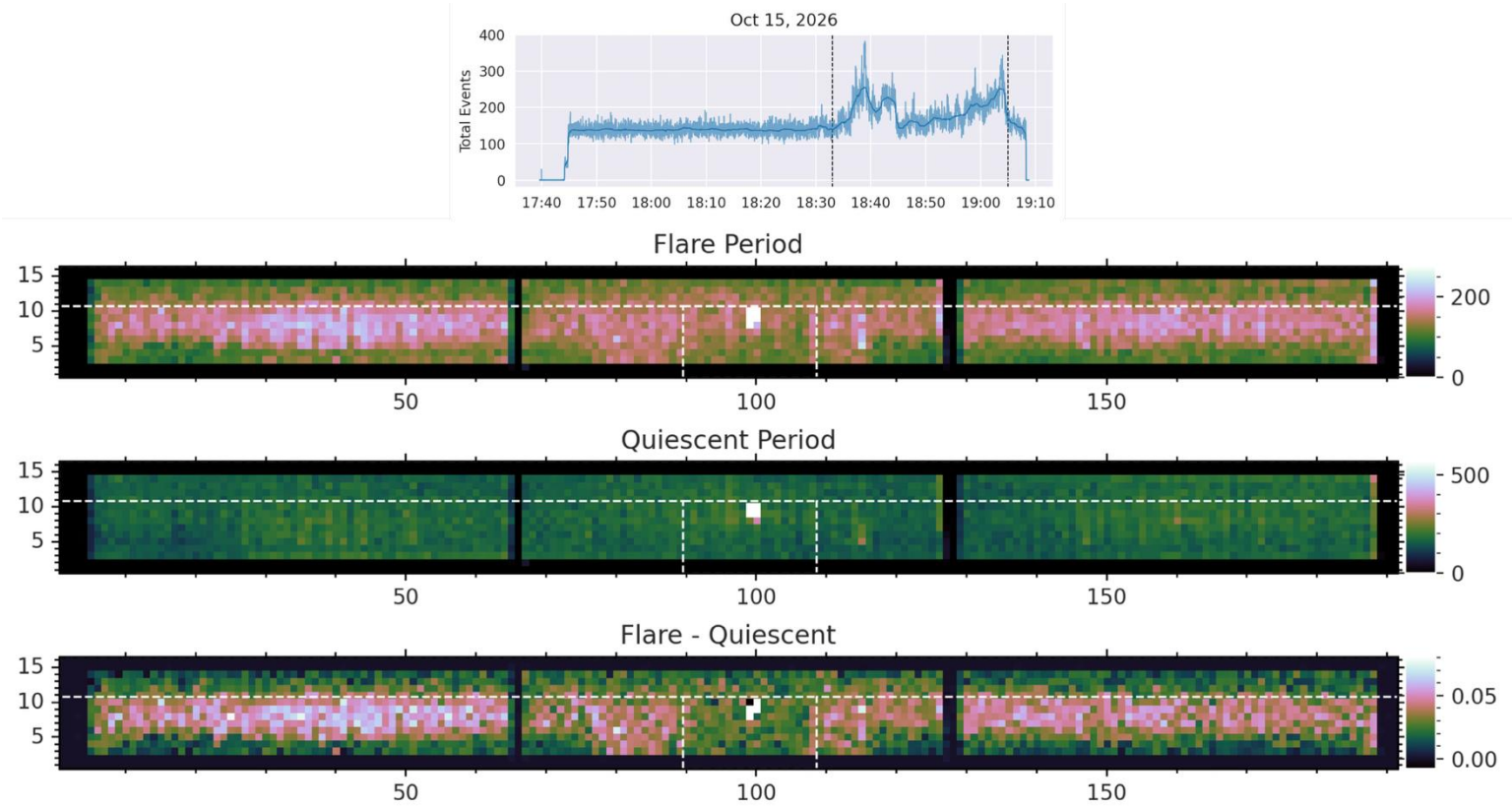
Example Results: ArLac

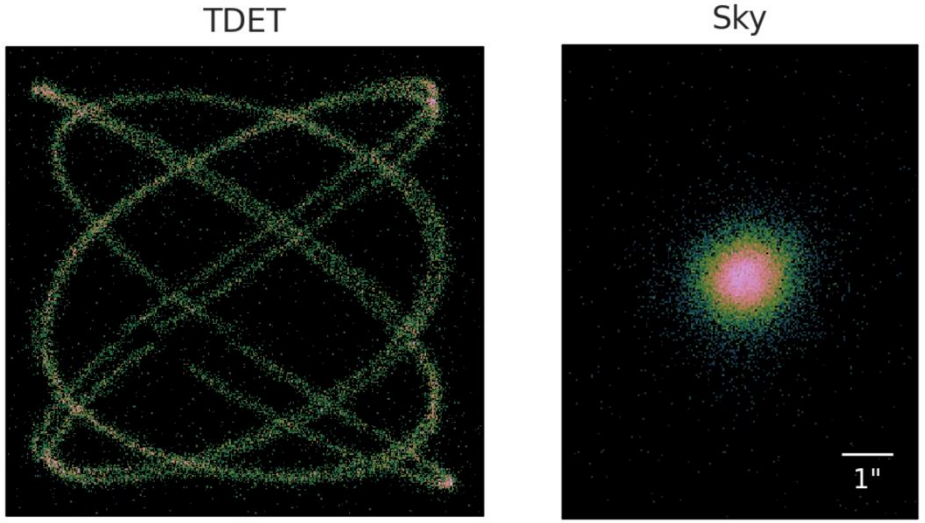




Left: Total and valid event rate (top), shield rate (middle) HVPS voltage setting (middle) and ACE rates; Right: Comparison of October 15 and August 24 observations. Events located at location of hotspot along the detector edge are shown in orange.

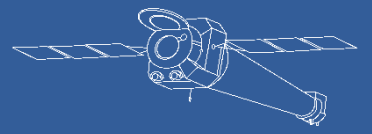
Example Results: ArLac





Left: Top: Total event rate Bottom: Comparison of of valid events during quiescent and flaring periods of the observation. Illumination of the UVIS establishes that the high event rates seen do not originate from the detector. Right: Image of ArLac in detector and sky coordinates

Summary of results and proposed future success criteria



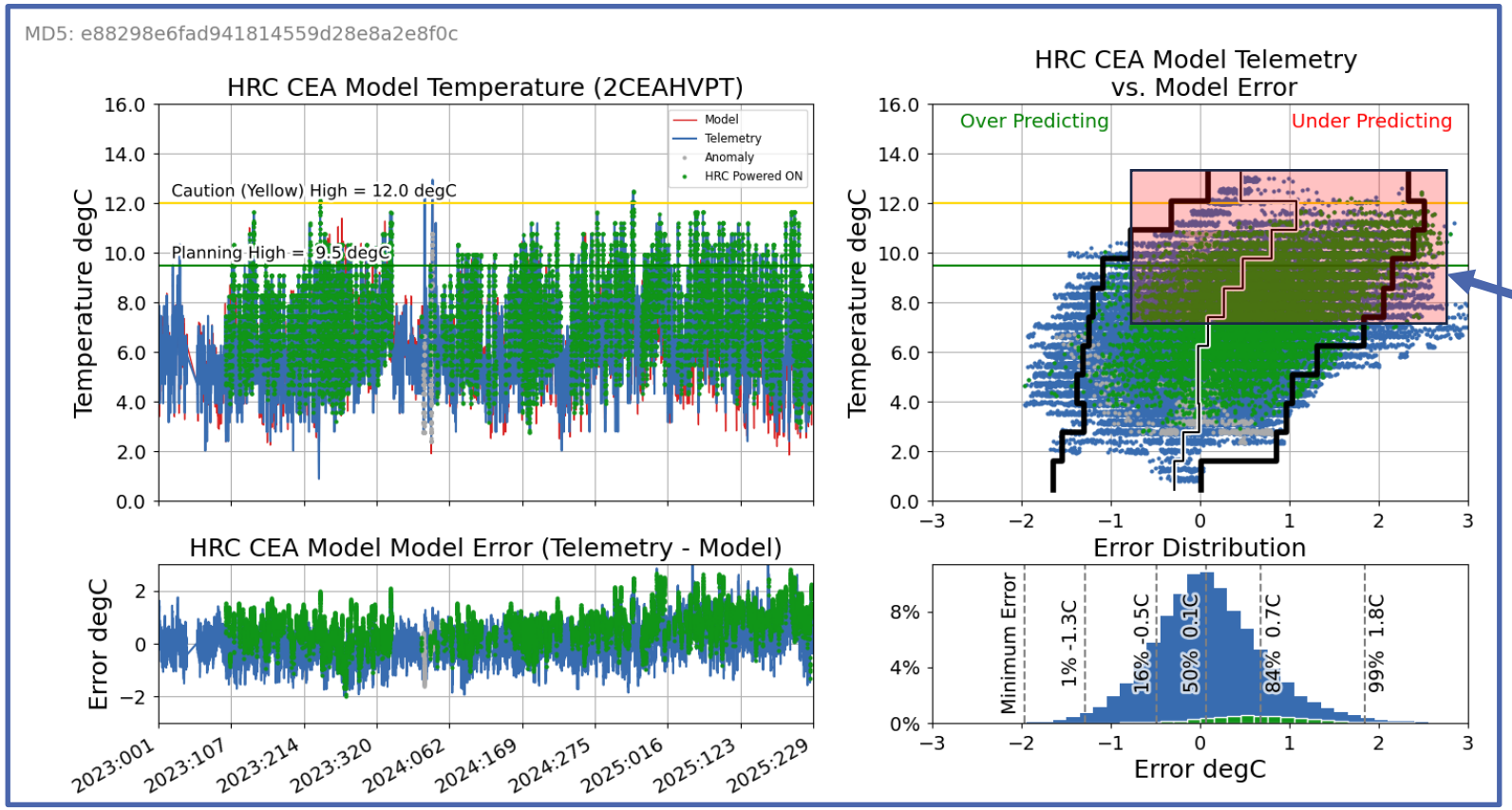
- All 5 observations ran to completion – periods of observed high rates are due to particle background and do not originate from the detector
  - HRC engineering telemetry was nominal for duration of each observation
- **HRC team proposed to continue HRC-S observations, subject to continued success as outlined below, for a period of not more than 2 months**
  - Proposed success criteria: over the proposed HRC-S provisional return to science time period of < 2 months, success is achieved by maintaining $\geq 80\%$ HRC-S observing time success rate averaged over 100ks of planned HRC-S observing time
- **HRC team received concurrence from CXC management teams and CXO project science on 10/23/2026 to continue provisional activities**
- Several HRC-S observations planned for upcoming weeks, including a recently approved ToO

HRC LVPS Thermal and Voltage Monitor



- 15V LVPS monitor uploaded as a flight software patch in early 2026
  - Onboard as SCS 85
- Patch controls LVPS power and HRC SCS control
- Monitor has performed as planned

HRC CEA Thermal Model



Performance of CEA thermal model from 2023:001 to present. Green points/lines indicate times when the HRC 15V is powered on.

- Heat from 15V is modeled as a constant input determined by the ON/OFF state of the power supply MSID
- Captures heating at low temperatures, but underpredicts heat input as the CEA temperature approaches the planning limit
- Work is underway to include a proportional heating component for the 15V LVPS , to better account for the heating at higher temperatures
  - The goal is to better characterize the heating at higher temperatures

Plans for HRC in FY27



- After a thorough and complete investigation, safely return the HRC-S to operations
- Complete work on updates to CEA thermal model
- Begin work on proposing HRC shields for use in radiation monitoring while the HRC is observing