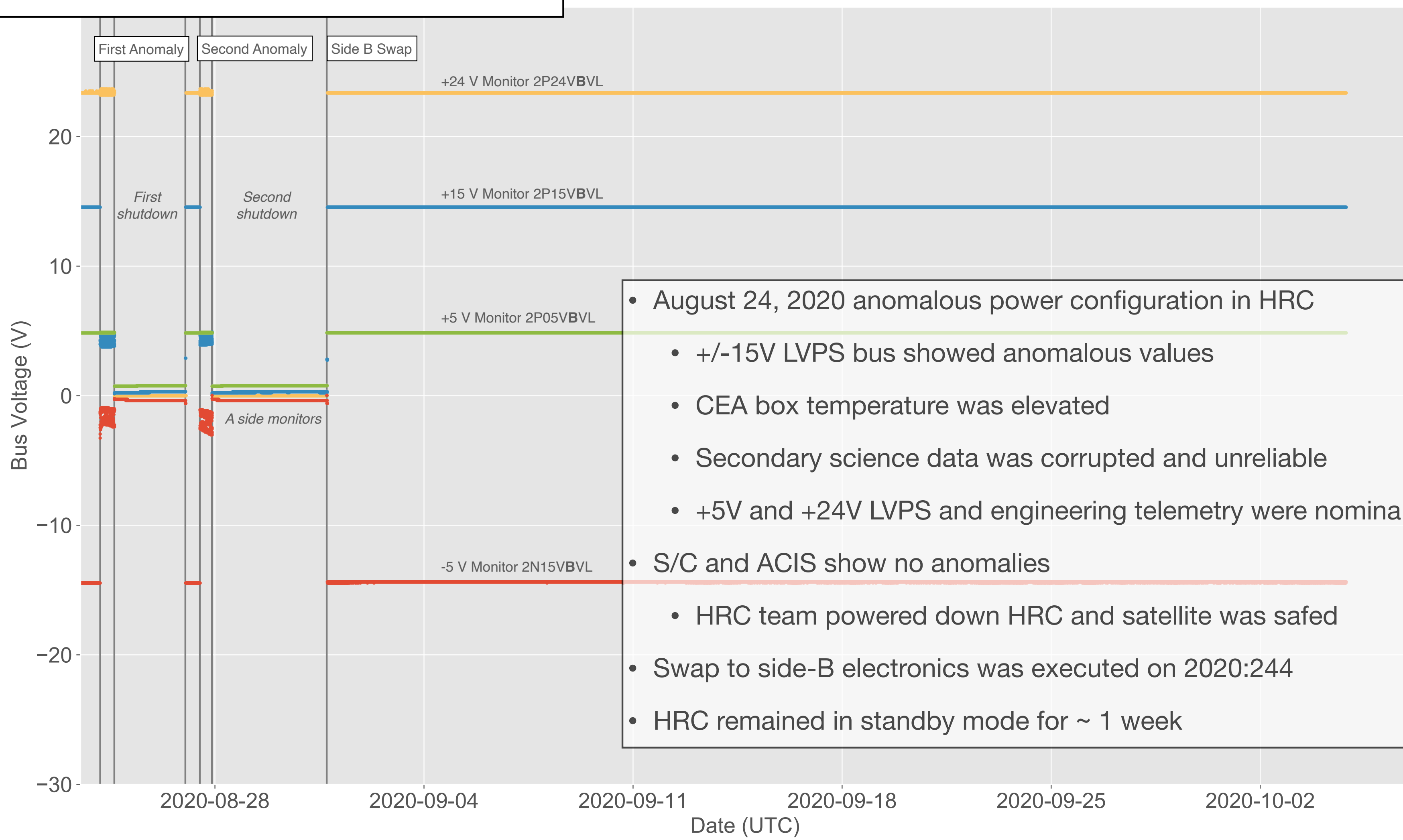
UPDATE ON HRC AND LETG ANOMALIES

D. PATNAUDE - 11/8/2021

HRC Anomaly Review

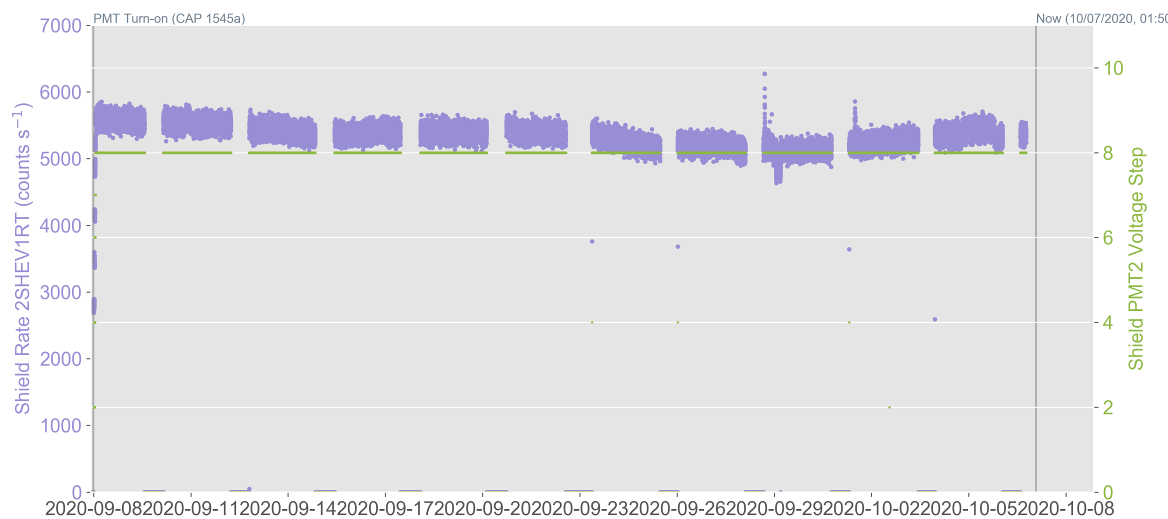


- August 24, 2020 anomalous power configuration in HRC
  - +/-15V LVPS bus showed anomalous values
  - CEA box temperature was elevated
  - Secondary science data was corrupted and unreliable
  - +5V and +24V LVPS and engineering telemetry were nominal
- S/C and ACIS show no anomalies
  - HRC team powered down HRC and satellite was safed
- Swap to side-B electronics was executed on 2020:244
- HRC remained in standby mode for ~ 1 week

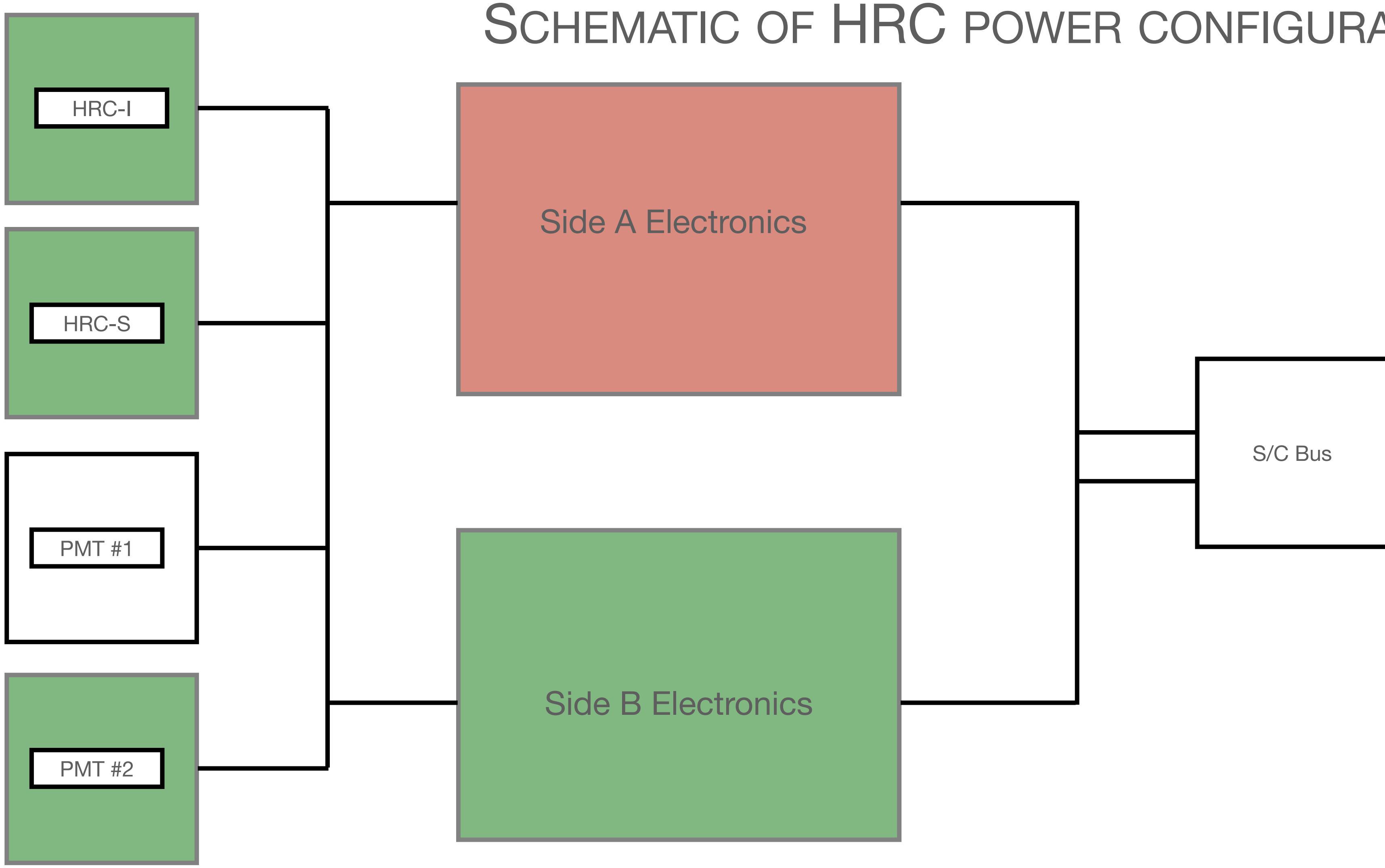
HRC ANOMALY REVIEW

HRC-I PMT#2 turn on:

- After remaining in standby mode for ~ 1 week, HRC PMT#2 was manually ramped up during a real time comm
- PMT rates were nominal and there has been no indication of issues while running on the B-side power supplies



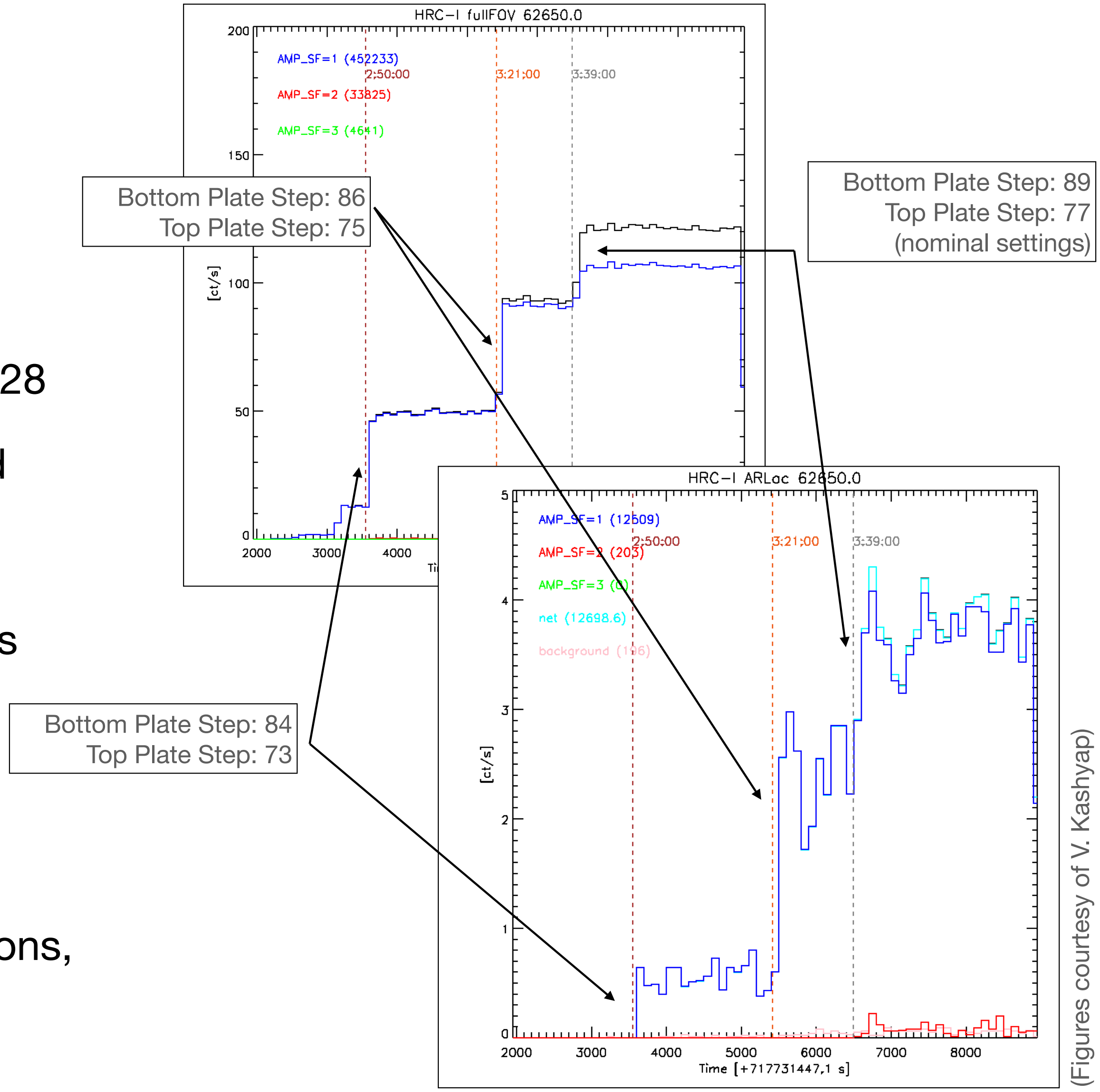
SCHEMATIC OF HRC POWER CONFIGURATION



ANOMALY REVIEW

HRC-I HV ramp up:

- HRC ramp up activity executed on Sep 28
  - voltage was ramped up manually and methodically
- source count rate of ~ 4 c/s and background rate of ~ 120 c/s, Both rates are consistent with expectations
- HRC instrument, SOT, and CAL teams conducted independent analyses of the observation
  - evaluated gain, PHA/SAMP distributions, degap, PSF, and encircled energy



(Figures courtesy of V. Kashyap)

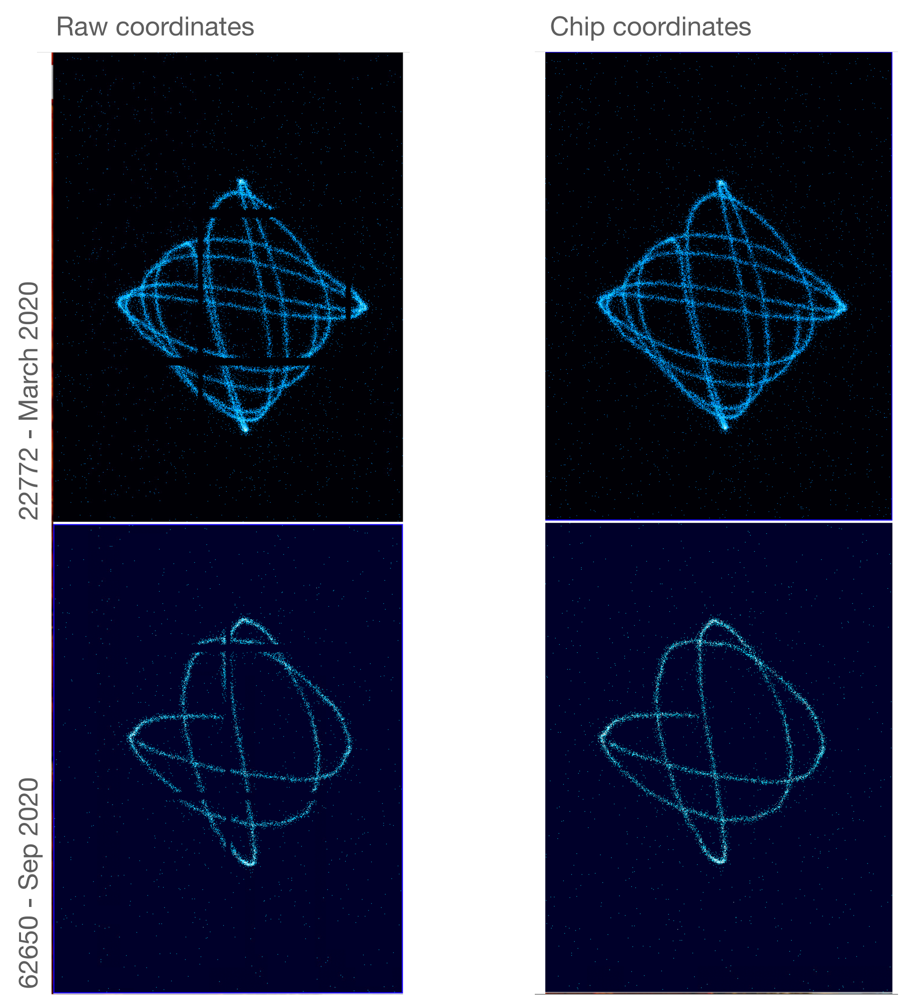
Post Ramp up Activities

Event position logic and degap:

Event position determination:

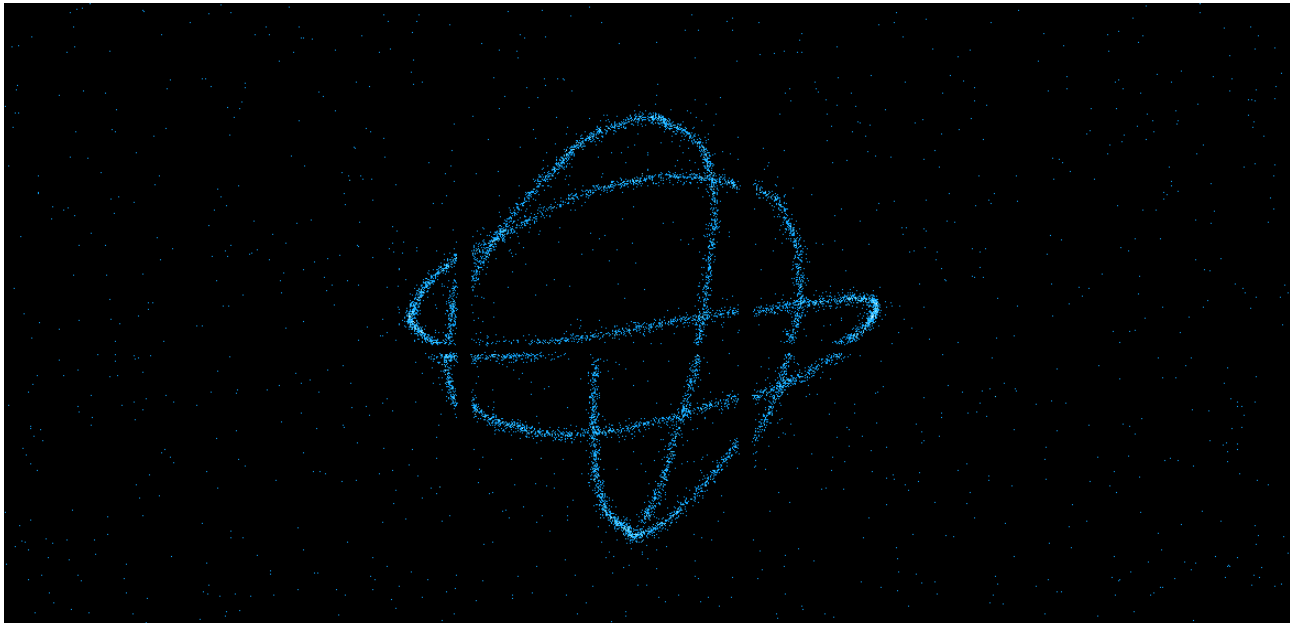
- Event positions are determined via position logic in a multiplexer which reads the signals of 4 amplifiers along the U and V axis of the detector, and determines the "tap" which has the highest signal. This is known as the "coarse" position.
- A fine position correction is computed by adding a factor which is determined by the amplitudes of the signals in the three strongest taps.
- Unfortunately, the three tap algorithm breaks down for events located near the midpoint between two taps, so a degapping correction needs to be applied, before the fine position can be added to the coarse position.
- Degap corrections are done in ground processing, but depend upon the characteristics of the detector amplifiers in the FEA-B, as well as the digital logic to determine the coarse event positions in the science data processor.
- Large differences in the amplifiers between FEA-A and FEA-B, or issues with the signal processing logic would be manifested as errors in the degapping corrections used in "`hrc_process_events`"

- we find no evidence for errors in the onboard processing of event positions at the HRC aimpoint -



Post Ramp up Activities

Event position logic and degap:



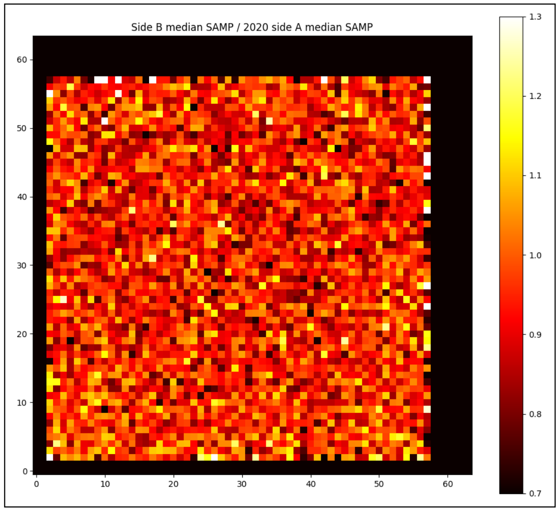
Comparison of AR Lac pre- and post-degap correction reveals no artifacts in dithered image. AR Lac observation only sampled signal processing at the detector aimpoint, and an observation which covers a larger fraction of the detector area is recommended

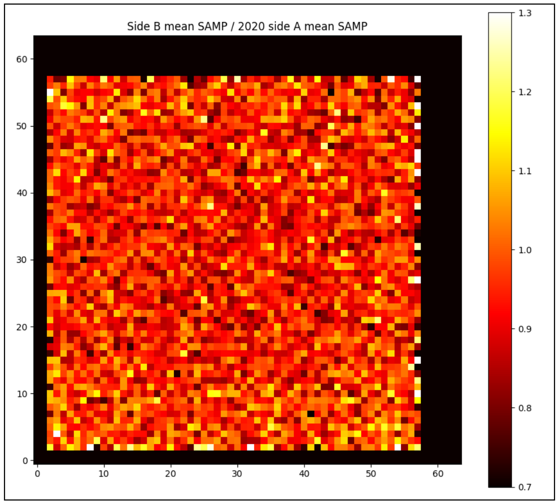
Post Ramp up Activities

Evaluation of detector gain:

Detector gain maps were made by looking at the particle background during the observation, and binning over the coarse tap positions. Gain can be evaluated in two ways:

- looking at the pulse height amplitude, which samples the entire detector response for an event
- looking at the “SAMP,” which uses the sum of the 6 U and V amplifier signals, weighted by “amp_sf,” which is a dynamic gain adjustment determined by event processing logic. Since SAMP only uses the event signal from the 6 amplifiers, it is a better representation of the detector gain
- excluding AR Lac, the mean and median SAMPs for each coarse U and V position were compared to observations in March 2020, and Oct 2019
- On side A, between October 2019 and March 2020, the detector experienced a drop in both the mean and median SAMP ~ 5%
- comparison of side B observation to March 2020 observation on side A reveals a similar drop of ~ 5%



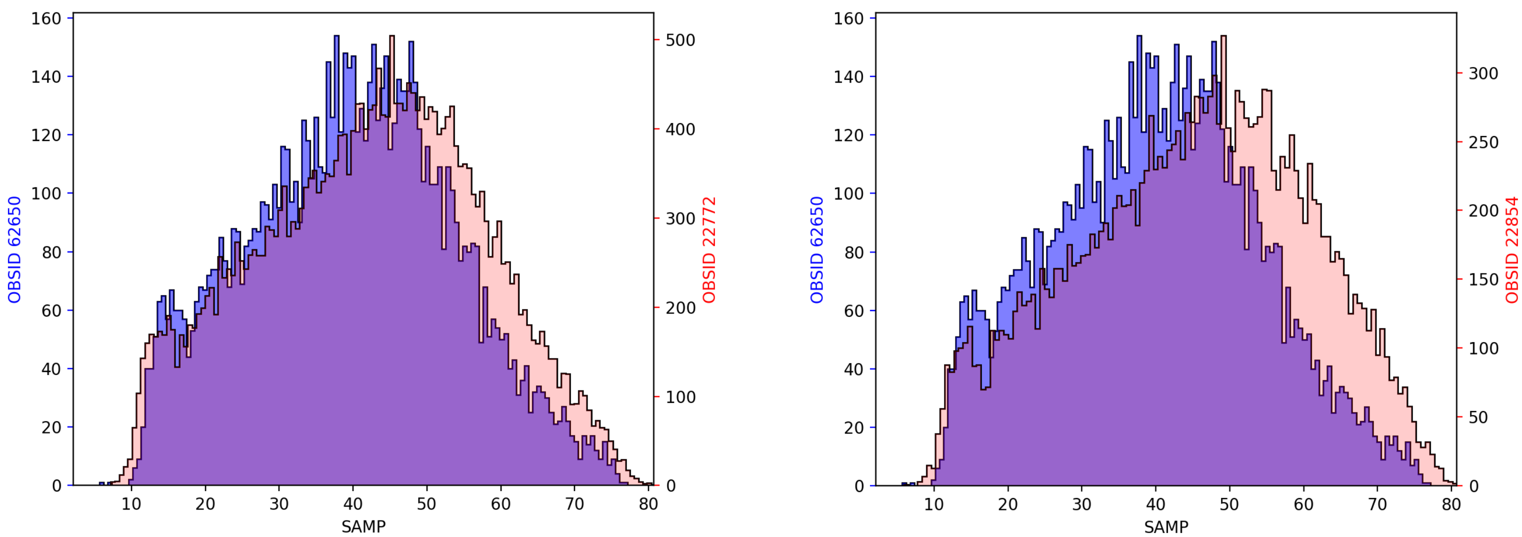


Post Ramp up Activities

Evaluation of detector gain:

The gain from a 4" radius extraction region around AR Lac was also considered and compared against both the March 2020 and October 2019 observations

- between Oct 2019 and March 2020, the median SAMP dropped by ~ 6%, while the mean SAMP dropped by ~ 6%
- between the A-side and B-side observations, the median SAMP dropped by ~ 7%, while the mean SAMP dropped by ~ 6%.
- *both comparisons look at amp_sf = 1 only

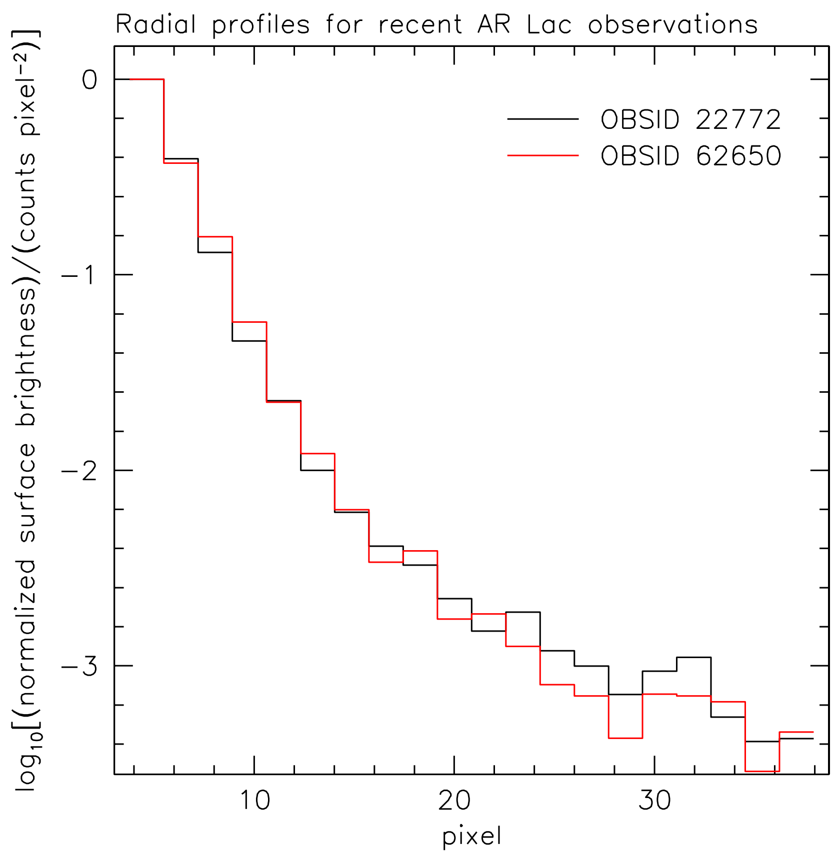


OBSID 62650 SAMP histogram for AR Lac, compared to OBSID 22772 (Mar, 2020; left panel) and OBSID 22854 (Oct 2020, right panel). For both plots, the left Y-axis corresponds to the blue histogram, while the right Y-axis corresponds to the red histogram.

Post Ramp up Activities

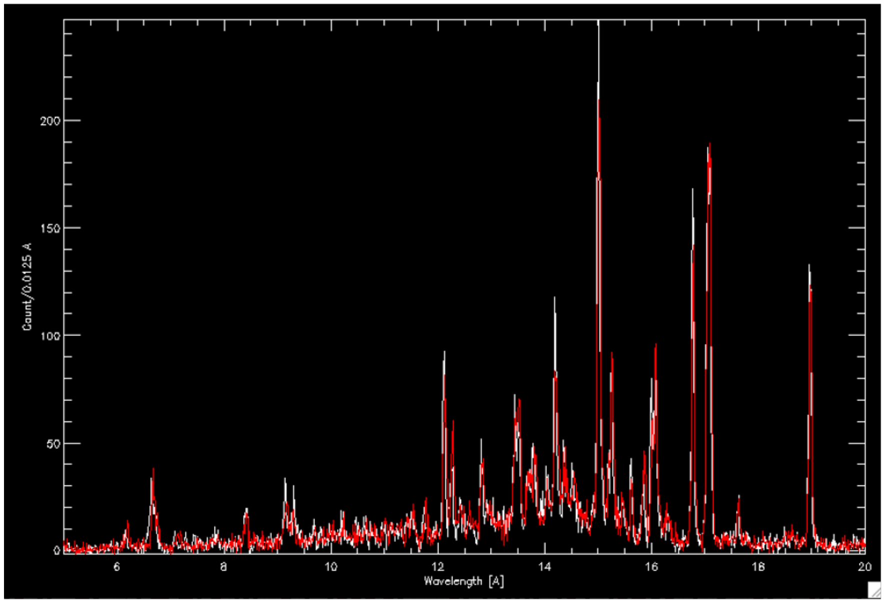
Evaluation of telescope/detector PSF and Encircled Energy:

- We evaluated any changes in the PSF by looking for differences in the radial profiles of AR Lac from observations done in Mar 2020 and the recent checkout observation.
- The microchannel plates and cross grid charge detector are the same as were used on the A-side, so no changes in PSF are expected from those components
- If there is a drop in the gain due to differences between the A- and B-side preamps, then electronics noise could broaden the PSF.
- Changes in 50% and 85% encircled energy are consistent with recent trends



HRC-S RAMP UP AND CHECKOUT ACTIVITIES

- HRC-S was powered up on the B-side electronics for the first time on October 24, 2020.
- The team performed an observation of AR Lac during an extended comm pass - as in the case of the HRC-I, the data were nominal
- A 2nd checkout observation was performed with the LETG to observe Capella



Current HRC Status

- The HRC is performing nominally on the B-side electronics
- The primary differences are:
  - B-side +/-15V and +5V LVPS
  - B-side science processing electronics
  - B-side preamplifiers
- HRC anomaly working group presented results on 08/31/21. Anomaly most likely caused by electro-mechanical failure of either
  - +/- 15 V DC-DC converter in the side-A +/-15 V LVPS
  - failure of a multilayer ceramic capacitor on the -15 V bus
- In spring of 2021, the HRC team performed additional activities to raise the HV on both the HRC-I and HRC-S. The detector response is now at the same level as it was at in 2017. Additional HV increases are planned over the coming years

Current HRC Status - Radiaton Monitoring

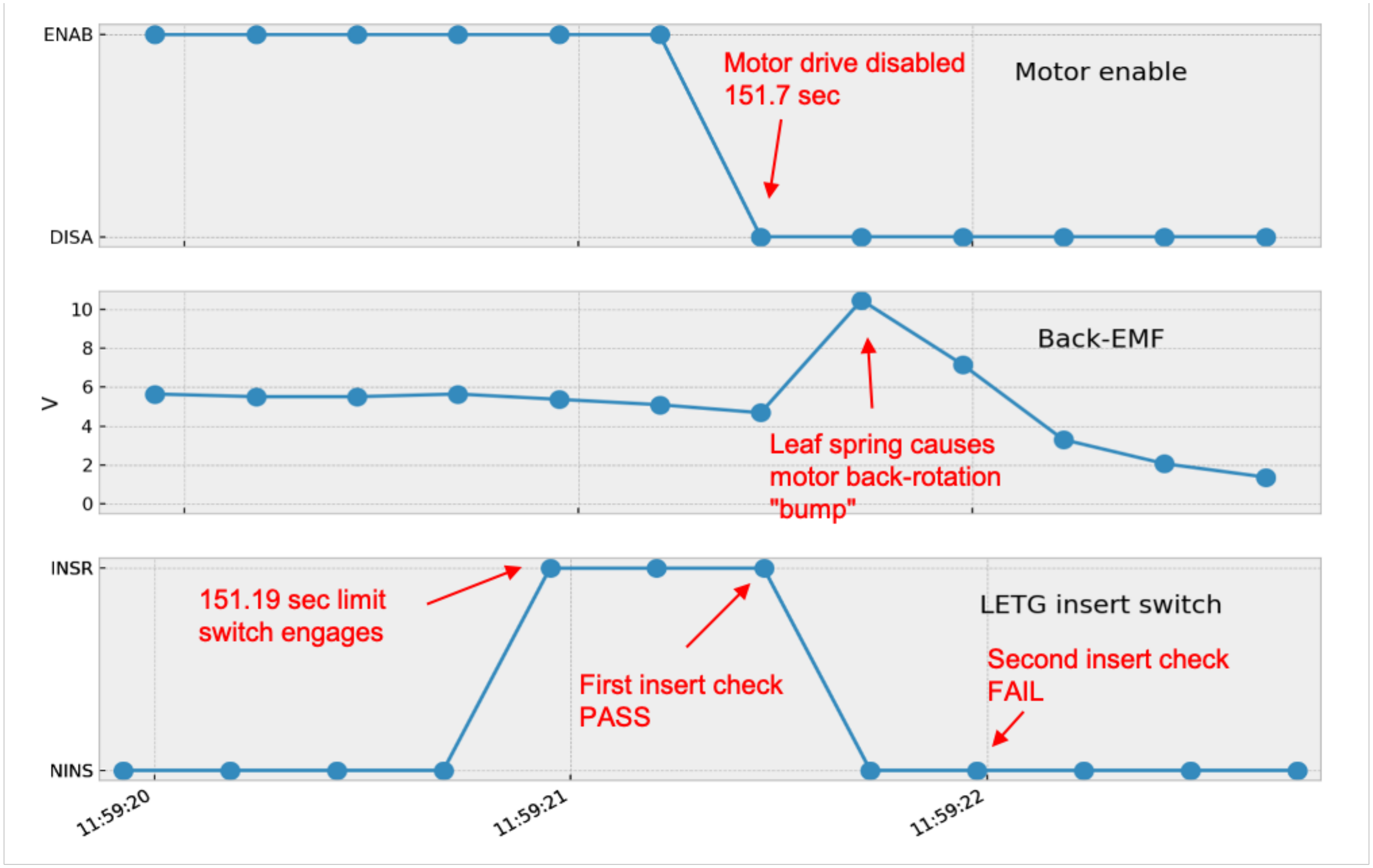
- HRC is now single strung
  - Anticoincidence shield is primary radiation monitor aboard Chandra
  - Work is being done to address potential loss of the PMT as a radiation monitor (courtesy P. Plucinsky):
    - more aggressive and conservative (safe ACIS sooner and more often) manual shutdowns based on ACE and GOES data during radiation events
    - more frequent realtime COMs to ensure that ACIS is safe for the radiation belt passages (it is unlikely that Chandra will get more frequent COMs due to JWST and SLS launches coming up)
    - command load independent of the regular weekly command load or an OBC process that would use the onboard ephemeris that would safe ACIS if the regular load fails to execute as expected
    - insert the HETG for every perigee passage to mitigate the effect of a failed SIM motion or hung command load
    - modification to the ACIS radiation monitor (TXINGs) that would trigger on more radiation events. ACIS scientists and engineers are investigating algorithm changes and are using historical data to characterize the false trip rate for different modifications to tradeoff against the additional protection

LETG Insertion Anomaly Details

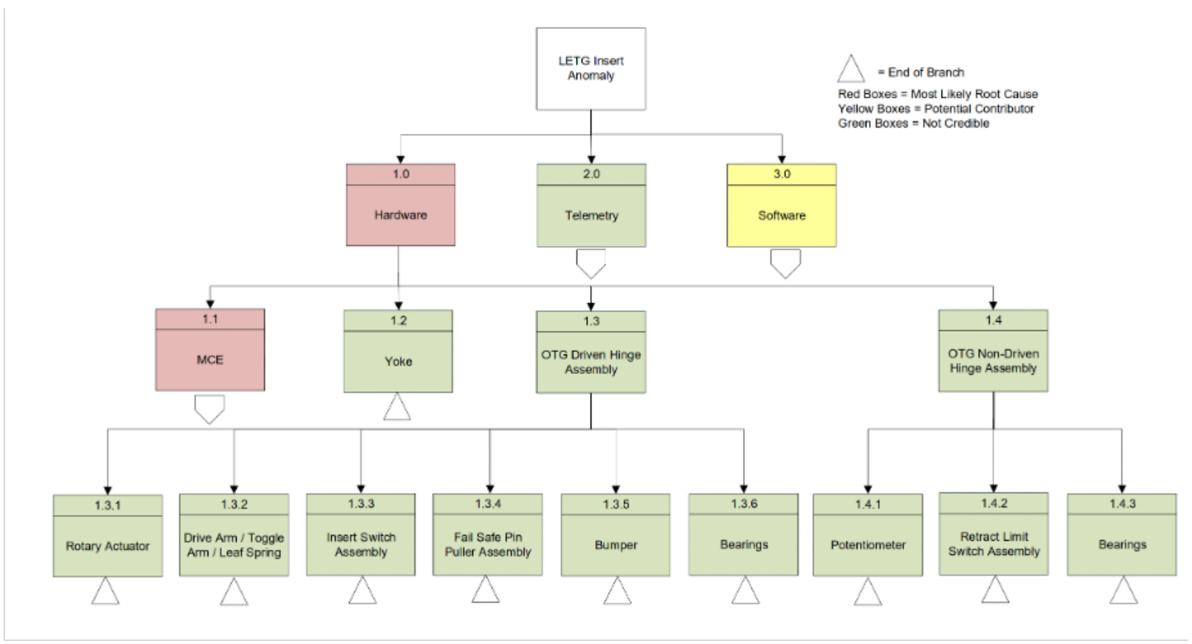
- During the setup for obsid 24785, starting ~ 2021:243:11:50 (Aug 31), the LETG insert switch engaged in 151.19 sec — about 1/2 seconds faster than previously seen
  - The expected duration was 151.7 seconds
- LETG insert switch showed INSERT for 3 samples (0.77s) which allowed the OBC to declare the insertion complete (first of two checks)
- Motor drive mechanism was pushed back by internal spring (seen as back EMF) and the switch was left at a not-inserted state
- OBC subsequently saw the LETG in a not-inserted state (second of two checks, 0.25 sec later) and set the grating motion failure flag
- With the grating motion failure flag set, no further grating motions are allowed
- Three subsequent observations in an incorrect configuration, with the LETG inserted
- A moratorium was placed on OTG moves until the root cause of the anomaly was identified and a solution was implemented

Apart from the insert time being about 1/2 second faster than previously seen, the OBC software and OTG hardware all performed nominally and according to design

LETG Insertion Anomaly Timeline



ANOMALY INVESTIGATION - SUMMARY



- Fault tree investigation completed
    - Most likely root cause identified
    - Temperature dependence in 58 Hz clock in MCE
    - Contributing cause identified as OTG support K-constants in OBC FSW
    - no other failures or contributing factors were identified

Operational Strategy

- Continue to limit OBA Forward Bulkhead and ACA temperatures as control for MCE temperatures
- No limit increases on OBA or ACA until MCE cleared for higher temperatures or a MCE specific model and guideline are in place
- Restore HETG to nominal operations - complete
  - Moves are safe
  - Speed variation does not change likelihood of move success
- Patch LETG move parameters to account for speed variation - complete
- Restore LETG to nominal operations - complete
- Add load review check of temperature adjusted OTG move angles - complete
- Investigate operation of MCE above temperatures demonstrated in flight - complete