HRC Anomaly Recovery

HRC-I Checkout and Next Steps

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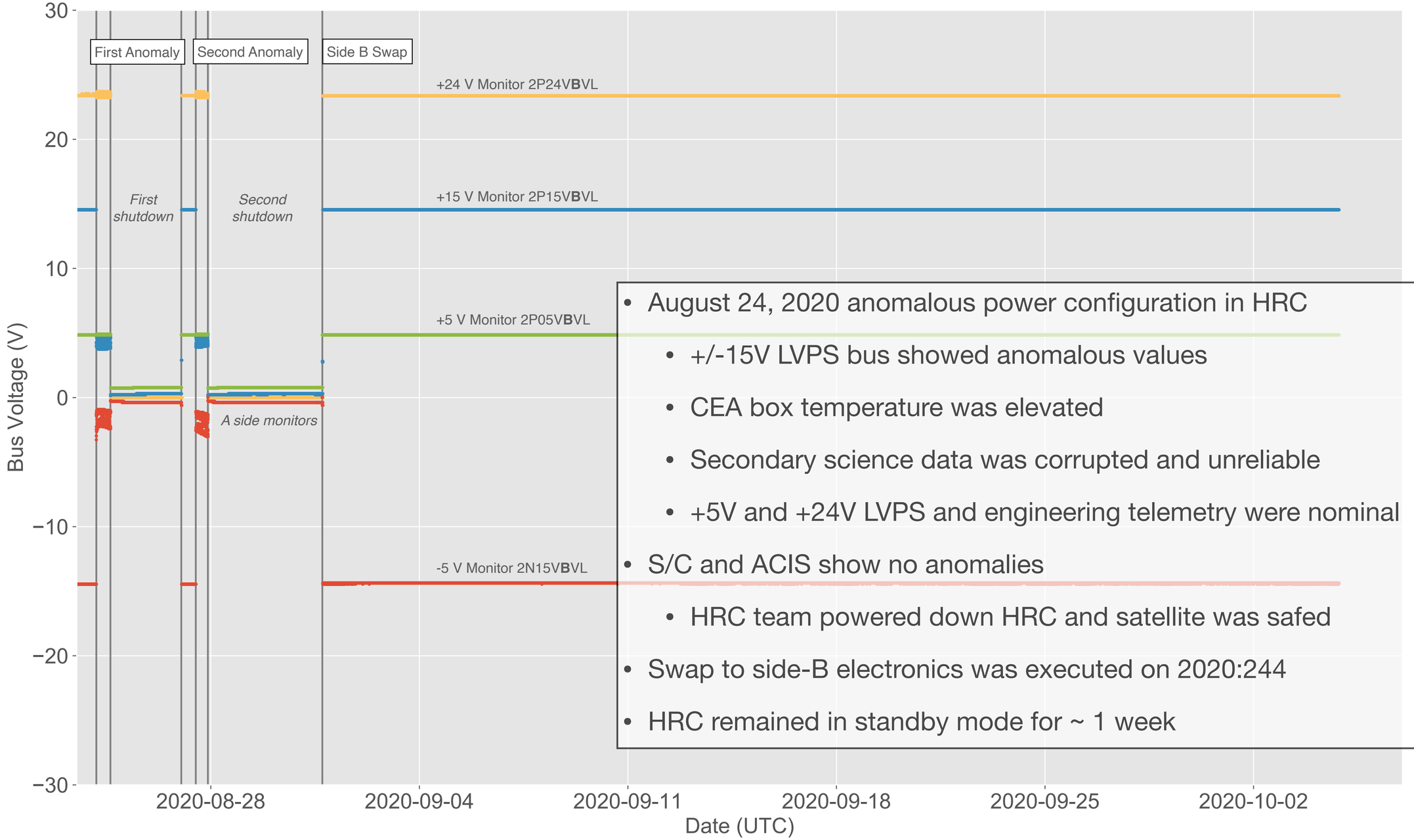
ANOMALY REVIEW



- 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

ANOMALY REVIEW

HRC-I PMT#2 turn on:

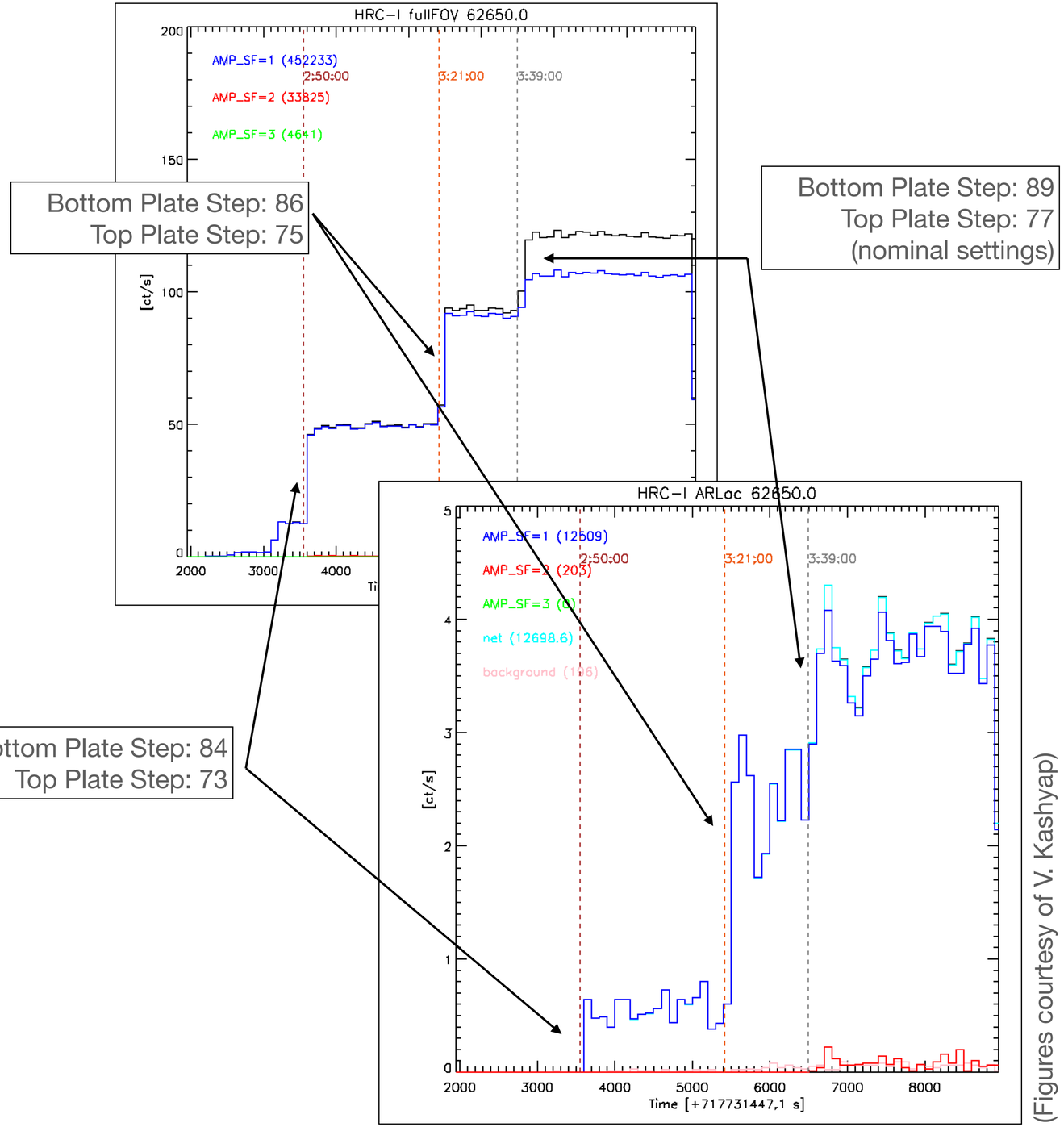
- After remaining in standby mode for ~ 1 week, HRC PMT#2 was manually ramped up during a real time comm (CAP 1545A)
- PMT rates were nominal at startup and have remained so for > 4 weeks

Upper: PMT#2 shield rate since turn-on. Lower: PMT#2 temperature and HRC Bus Current Monitor since PMT#2 turn-on.

ANOMALY REVIEW

HRC-I HV ramp up:

- HRC ramp up activity executed on Sep 28 (CAP 1548)
  - 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)

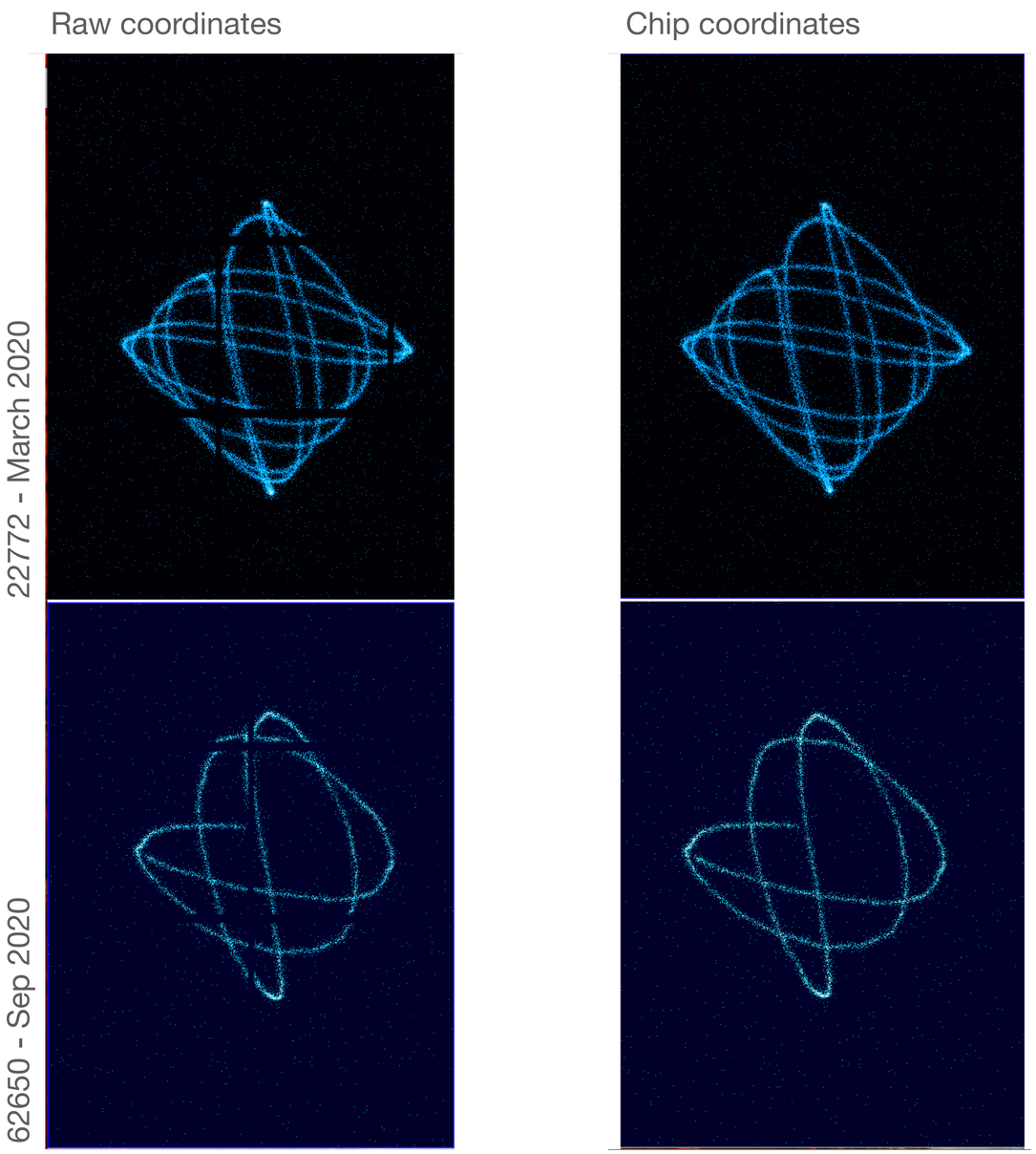
POST RAMP UP ACTIVITIES

Event position logic and degap:

Event position determination:

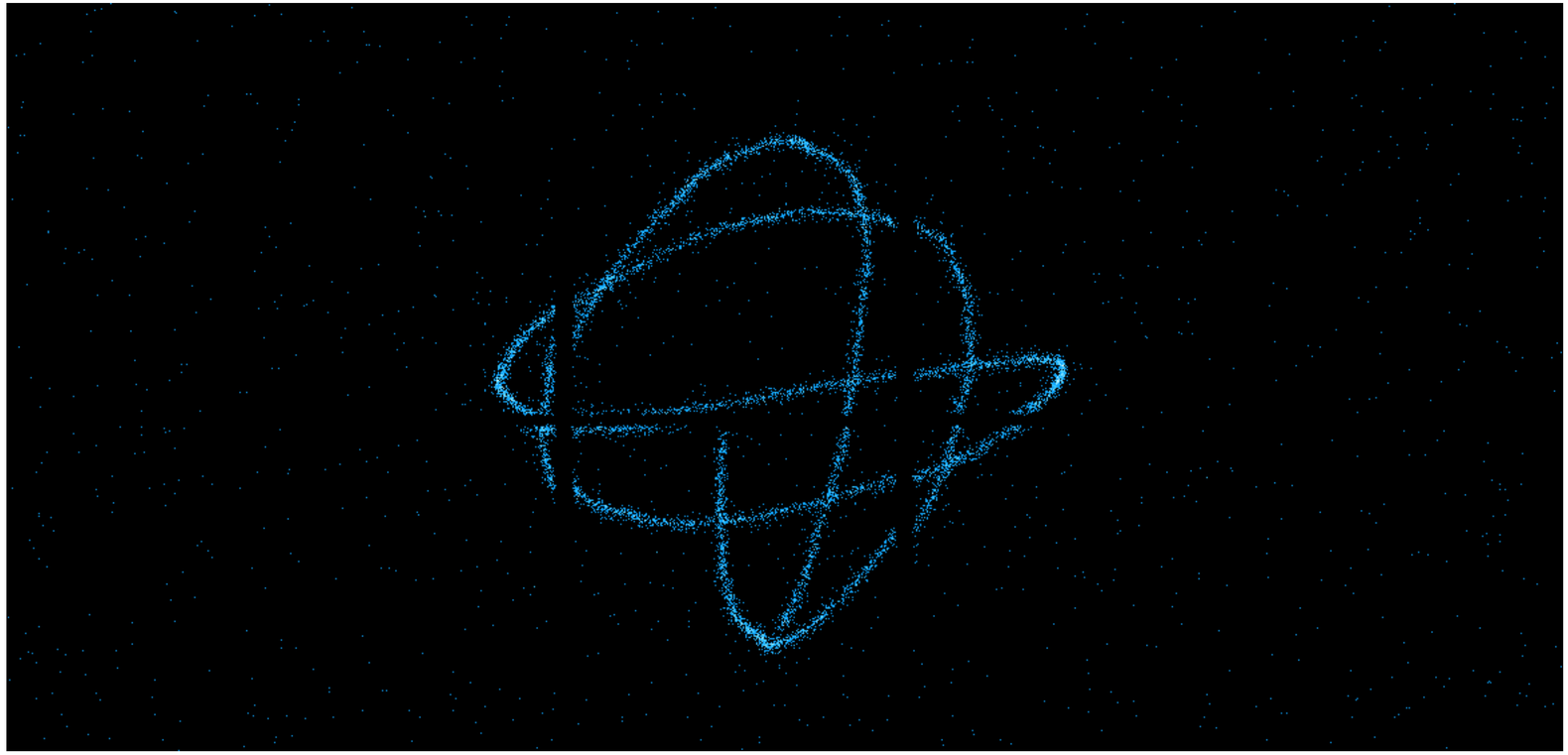
- Event positions are determined via position logic in a multiplexer which reads the signals of 4 amplifiers along the U and V axis of the detector, and determines the “tap” which has the highest signal. This is known as the “coarse” position.
- A fine position correction is computed by adding a factor 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:



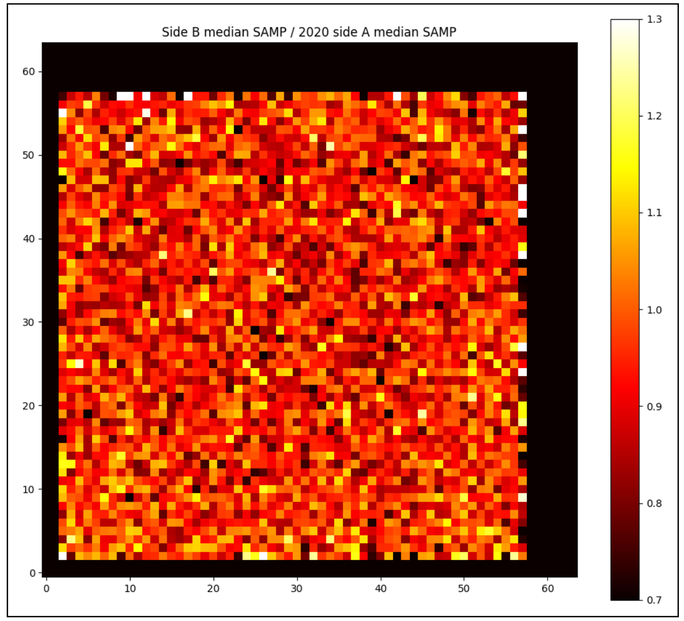
Comparison of AR Lac pre- and post-degap correction reveals no artifacts in dithered image. AR Lac observation only sampled signal processing at the detector aimpoint, and an observation which covers a larger fraction of the detector area is recommended

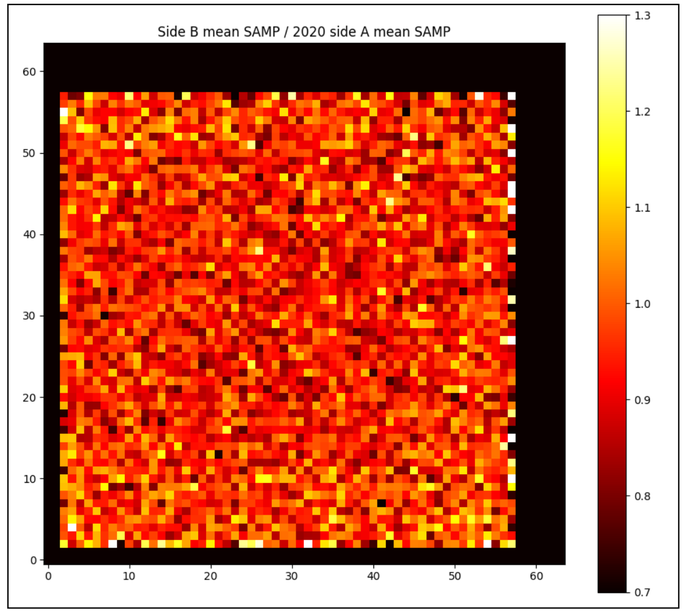
POST RAMP UP ACTIVITIES

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%



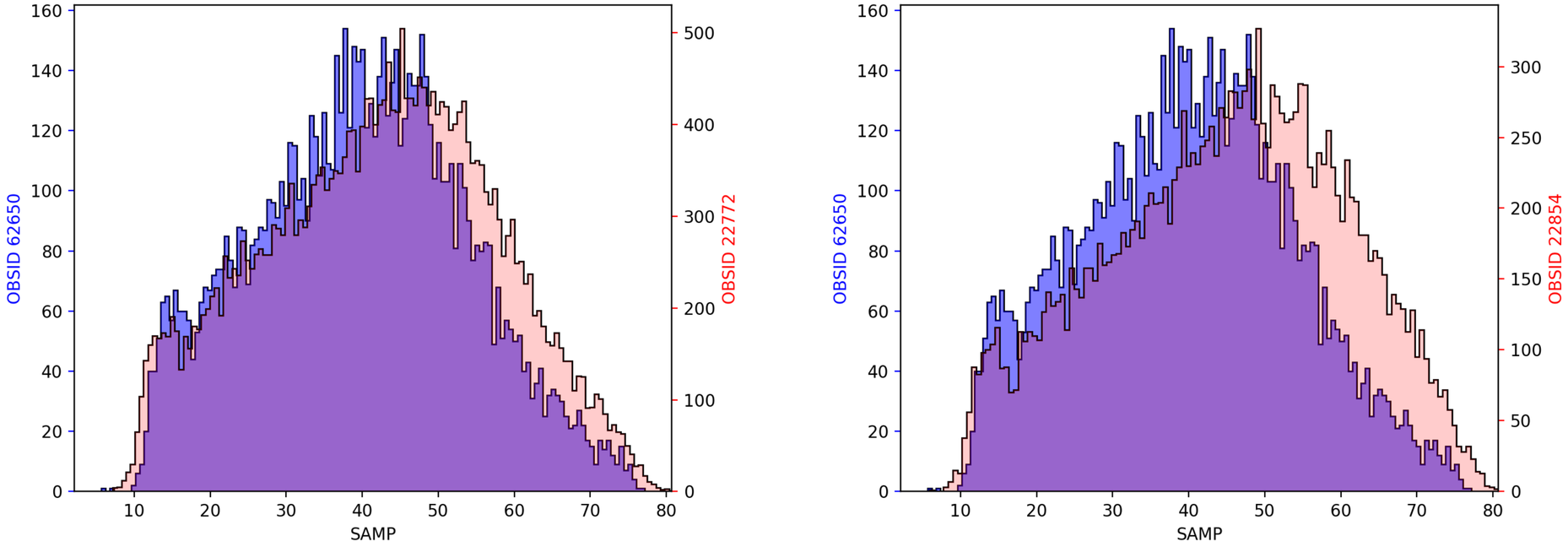


POST RAMP UP ACTIVITIES

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

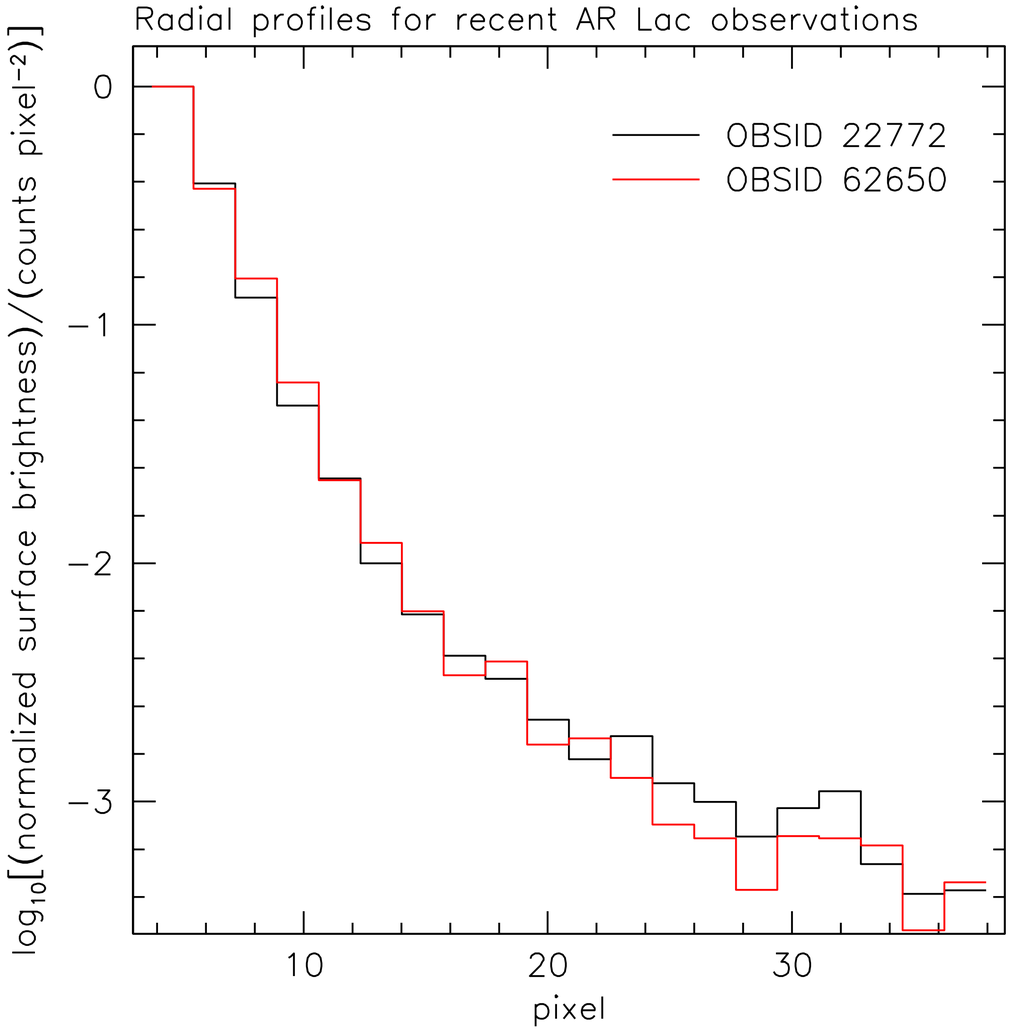


OBSID 62650 SAMP histogram for AR Lac, compared to OBSID 22772 (Mar, 2020; left panel) and OBSID 22854 (Oct 2020, right panel). For both plots, the left Y-axis corresponds to the blue histogram, while the right Y-axis corresponds to the red histogram.

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



POST RAMP UP ACTIVITIES

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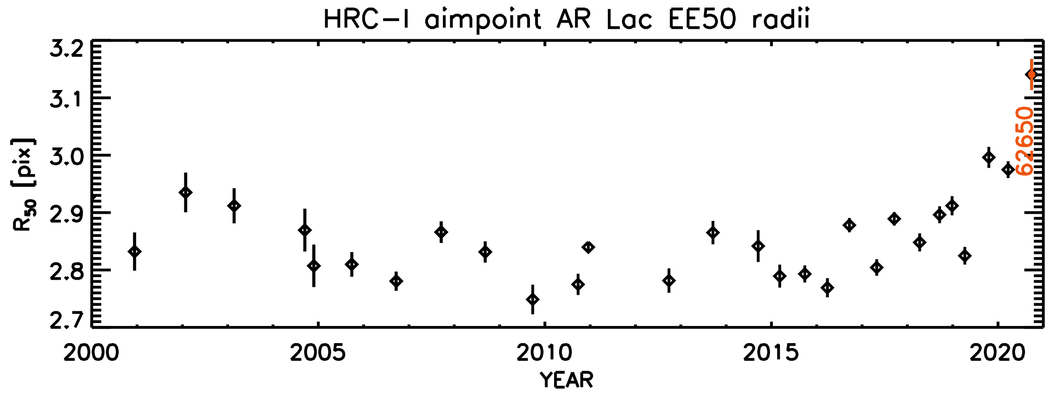
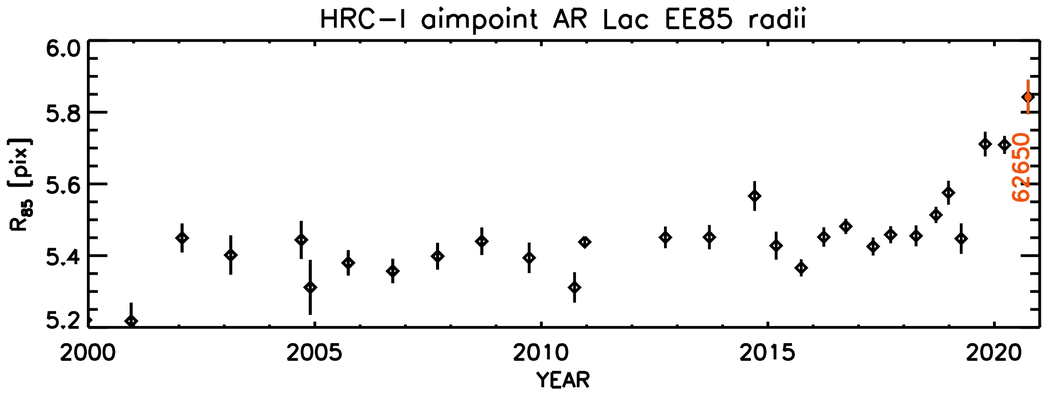
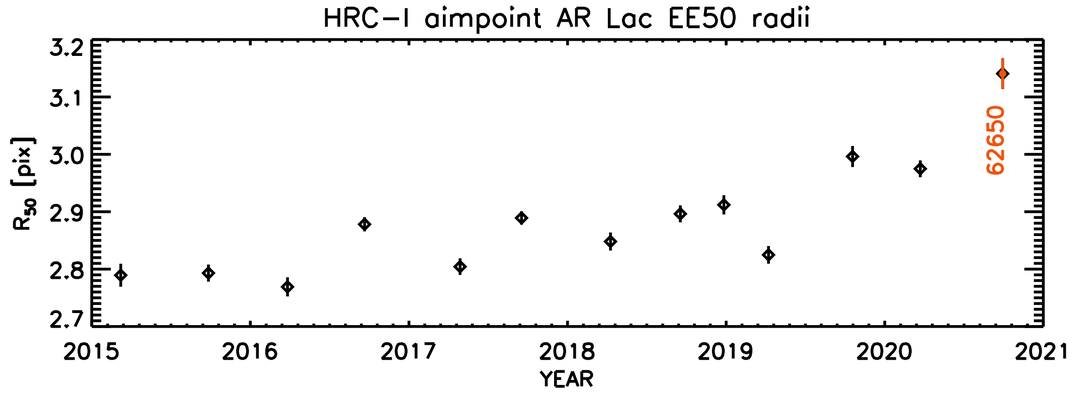
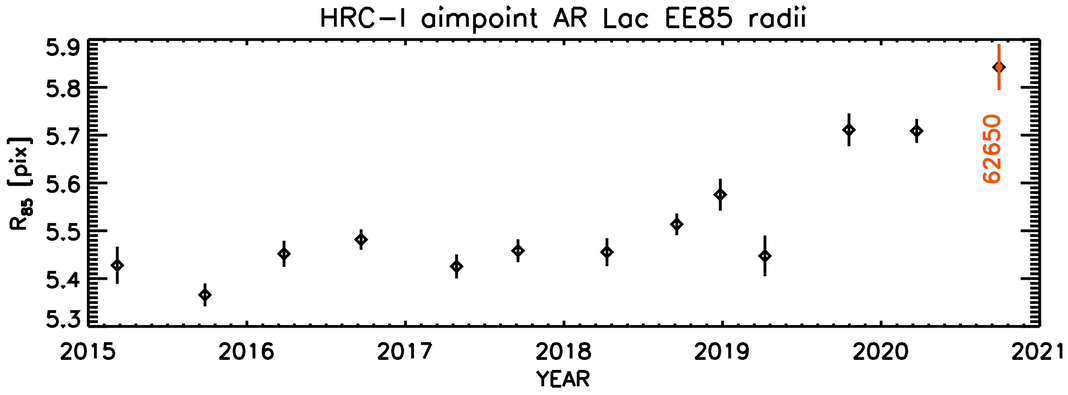






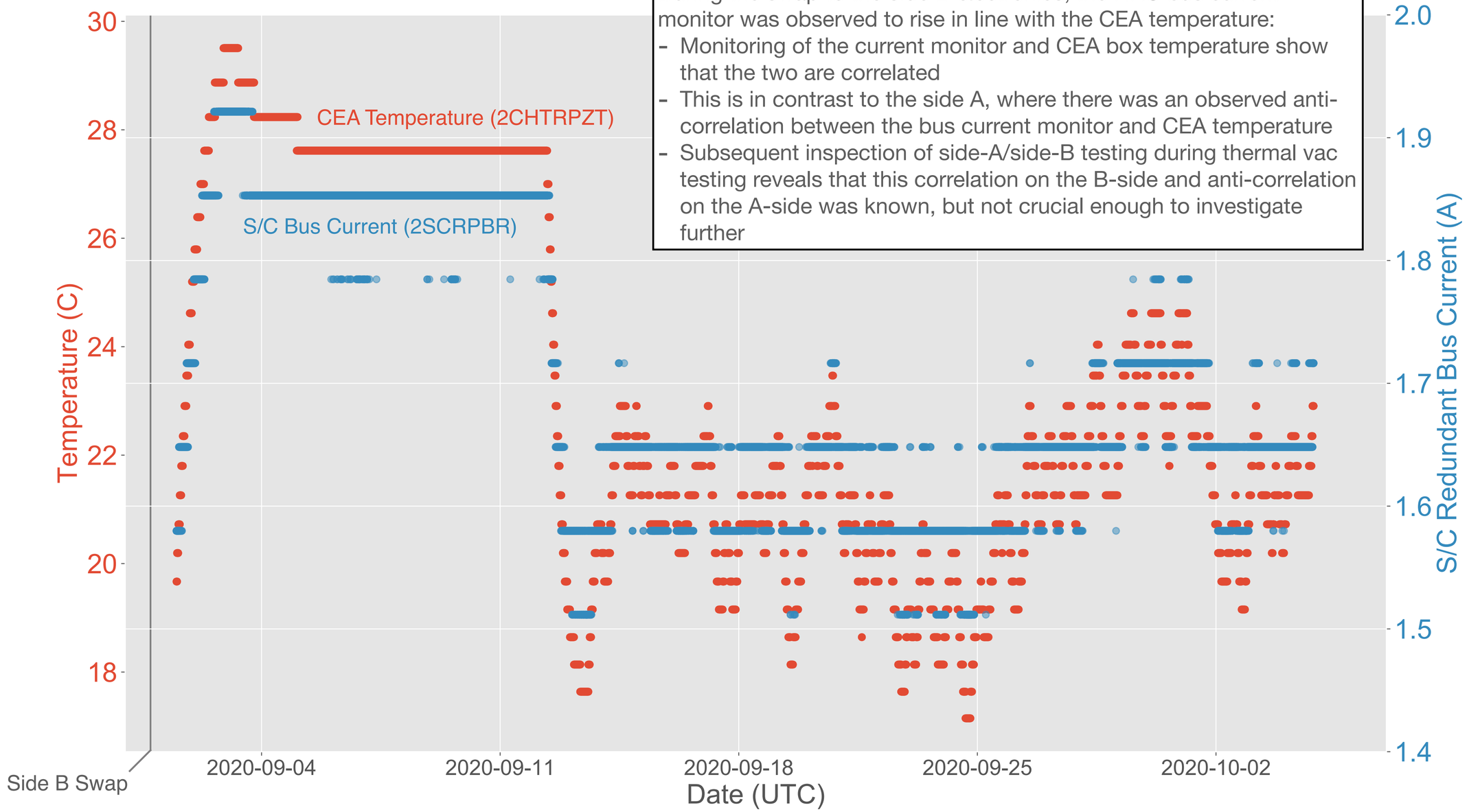


50% (left) and 85% (right) Encircled Energy for OBSID 62650 compared to mission (top panels) and recent trends (bottom panels). (Courtesy of V. Kashyap)

Bus Current Monitor Behavior

During the swap to the side B electronics, the HRC bus current monitor was observed to rise in line with the CEA temperature:

- Monitoring of the current monitor and CEA box temperature show that the two are correlated
- This is in contrast to the side A, where there was an observed anti-correlation between the bus current monitor and CEA temperature
- Subsequent inspection of side-A/side-B testing during thermal vac testing reveals that this correlation on the B-side and anti-correlation on the A-side was known, but not crucial enough to investigate further



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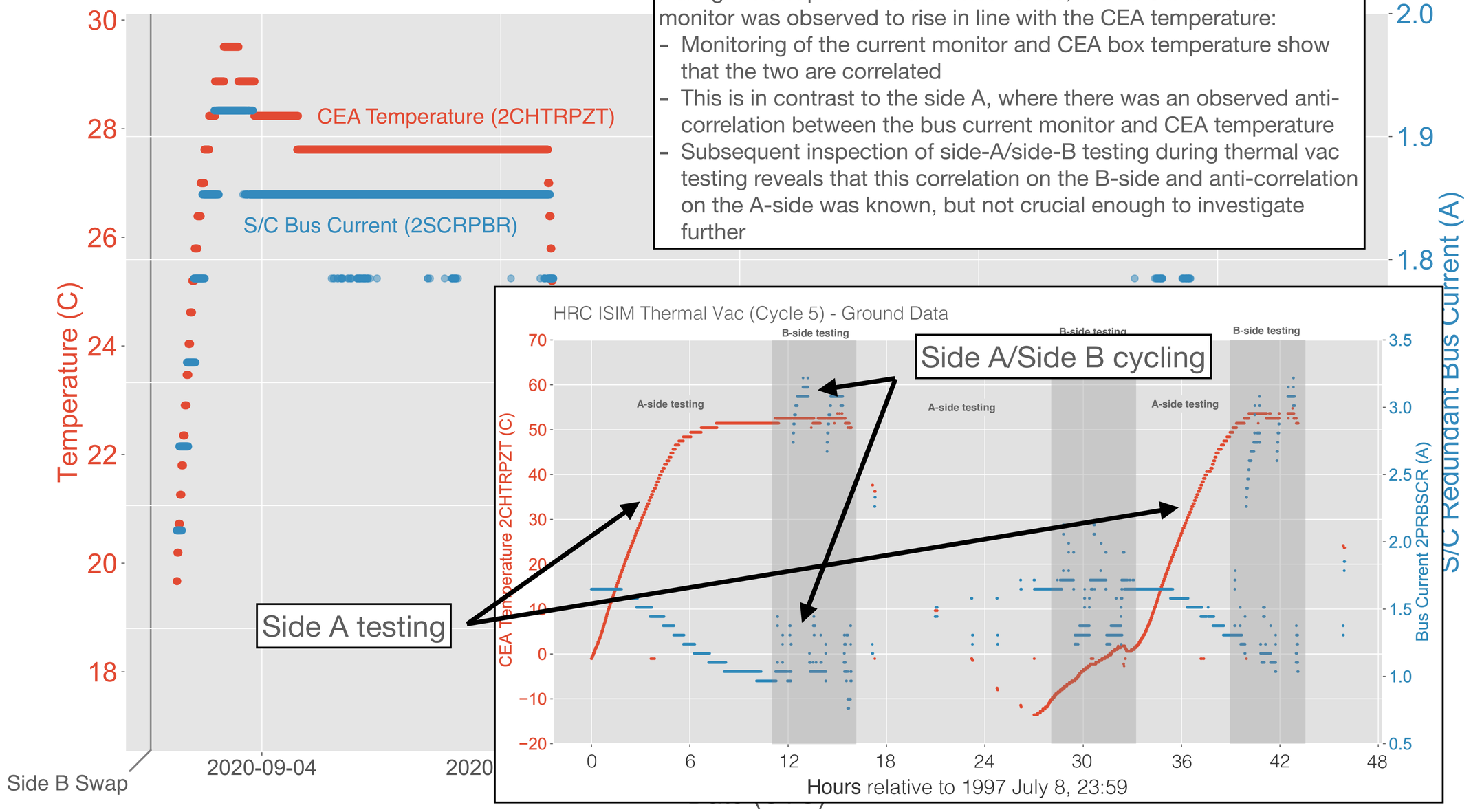
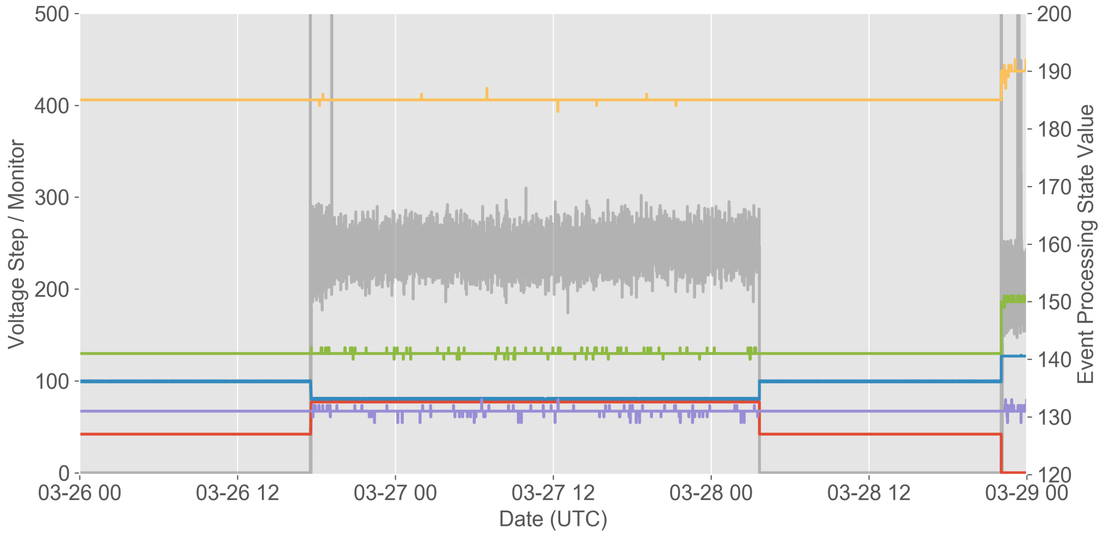
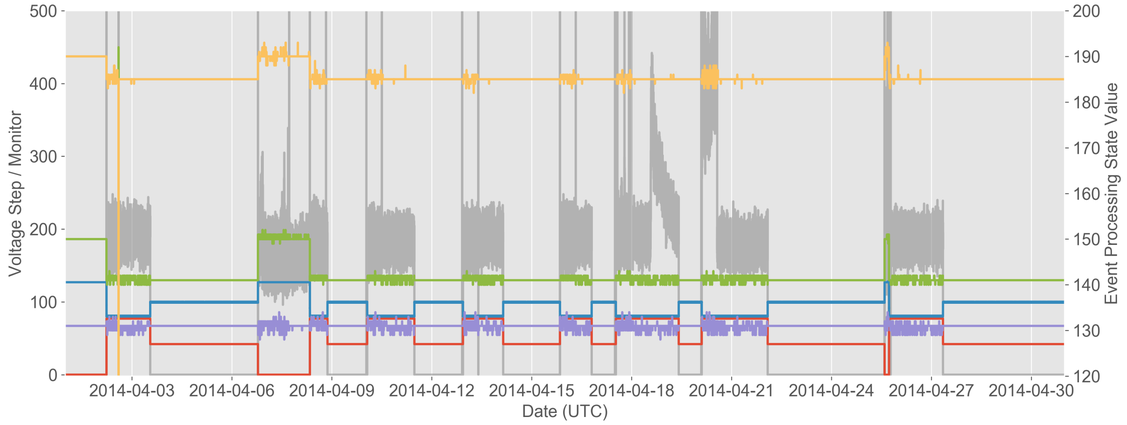


FLICKERING OF INSTRUMENT SETTINGS DURING RAMP UP

Noise in processing electronics settings:

- During manual ramp up of the HRC-I high voltage, instrument settings such as the grid bias and range switch were observed to change by 1 or 2 dn values.
- Inspection of back data from the side A electronics showed that this behavior also existed on the A side, and even predates the emergence of secondary science corruption.
- The working hypothesis is that the values flicker due to EMI from unshielded wiring between the FEA and CEA.





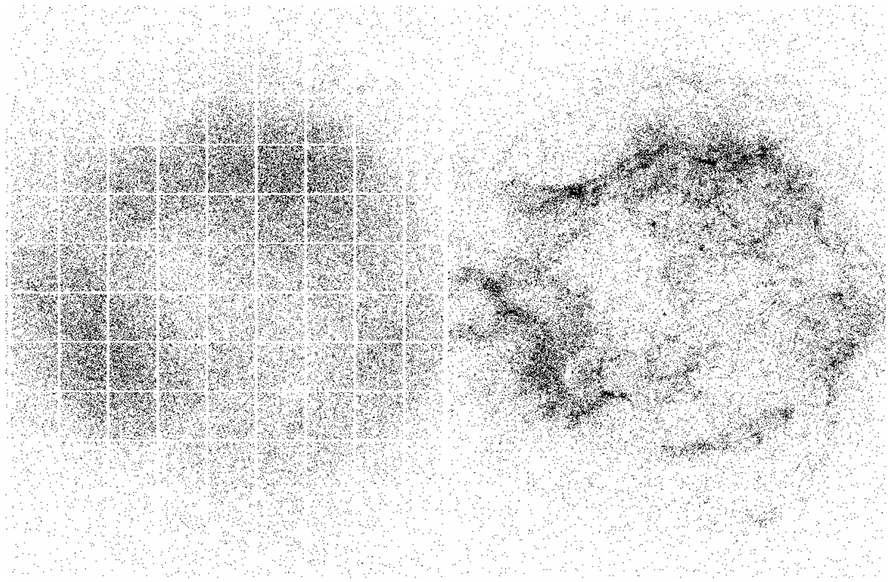
Recommended Future Activities

HRC-S ramp up:

- similar to HRC-I:
  - AR Lac observation done with real time commanding of HRC-S HV ramp up to nominal operating settings
  - Requires additional products to switch detectors (HRC-I is the currently “active” detector)
  - Currently developing CAPs and SARs similar to those used for the HRC-I manual HV ramp up
  - A 3 hr comm has been identified Oct 25th (BOT: 8:15am EDT)

RECOMMENDED FUTURE ACTIVITIES

Additional HRC-I and S checkout observations:



- A 20ks observation of a bright extended source such as Cas A would enable the HRC team to evaluate the degap over ~ 20% of the detector, out to a radius of 3’ from the nominal aimpoint.
- Additionally, edge blanking can be tested - both the commanding and the edge blank processing which is done at the event processing level.
- Evaluate ramp up commands during a real time comm

- Pending successful ramp up of the HRC-S high voltage, the HRC team would like to conduct a second HRC-S activity, similar to the proposed second HRC-I observation.
- This 2nd observation would make use of the grating in order to check the degap in the two outrigger plates of the spectroscopy array. As HRC-S/LETG observations also employ edge blanking, this functionality would be tested as well.
- The HRC team is recommending Capella as the target for this second HRC-S/LETG observation.