

*Chandra X-ray Observatory*  
**HRC Anomaly on 24 August 2020**

*Results of CAP 1541 & Plan for the next few days*  
Chandra Community Briefing  
27 August 2020

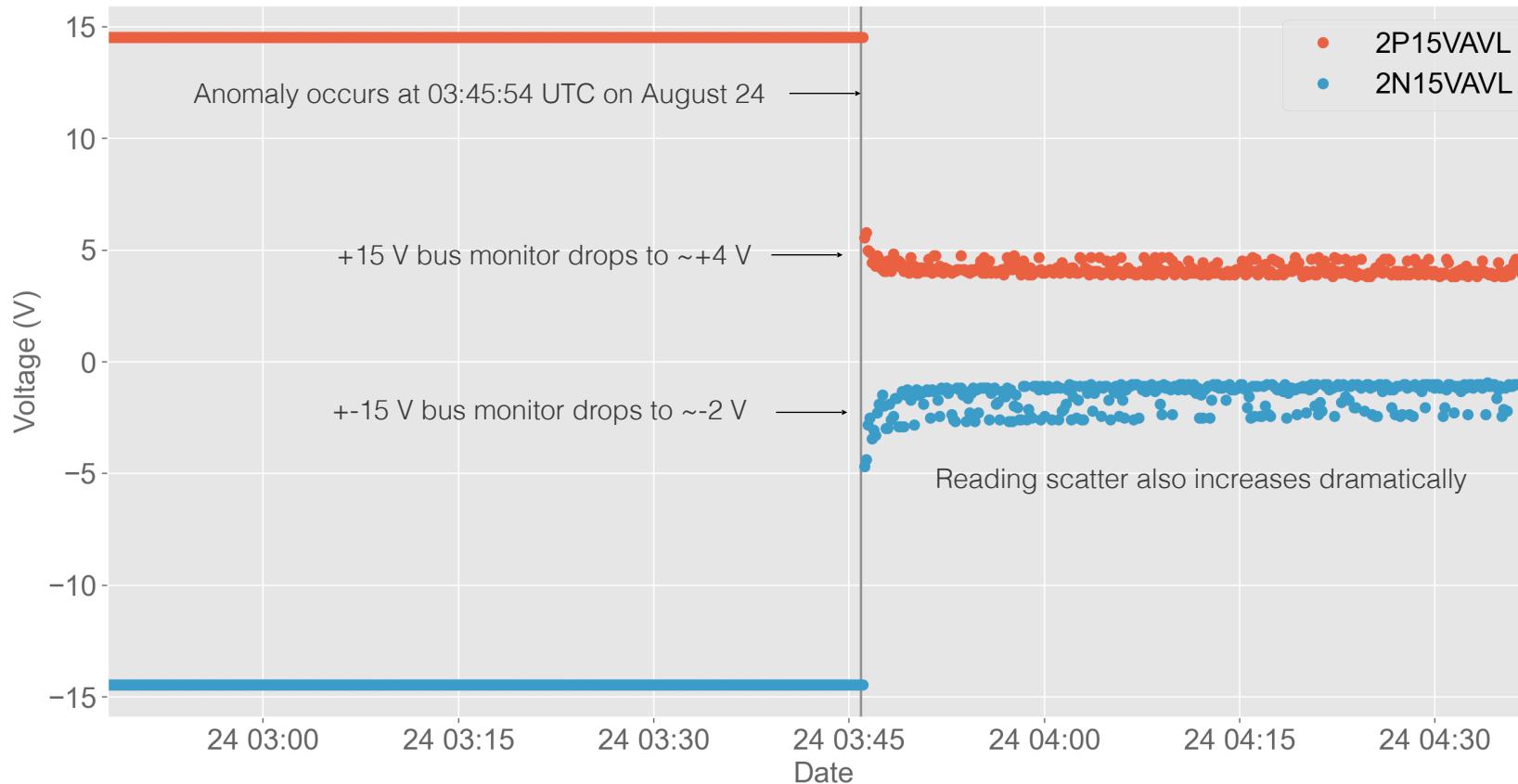
HRC Operations Team

D. Patnaude, R. Kraft, P. Nulsen, G. Tremblay, T. Gauron, A. Kenter, K. Gage, B. Bissell, G. Austin, J. Chappell

CENTER FOR **ASTROPHYSICS**  
HARVARD & SMITHSONIAN

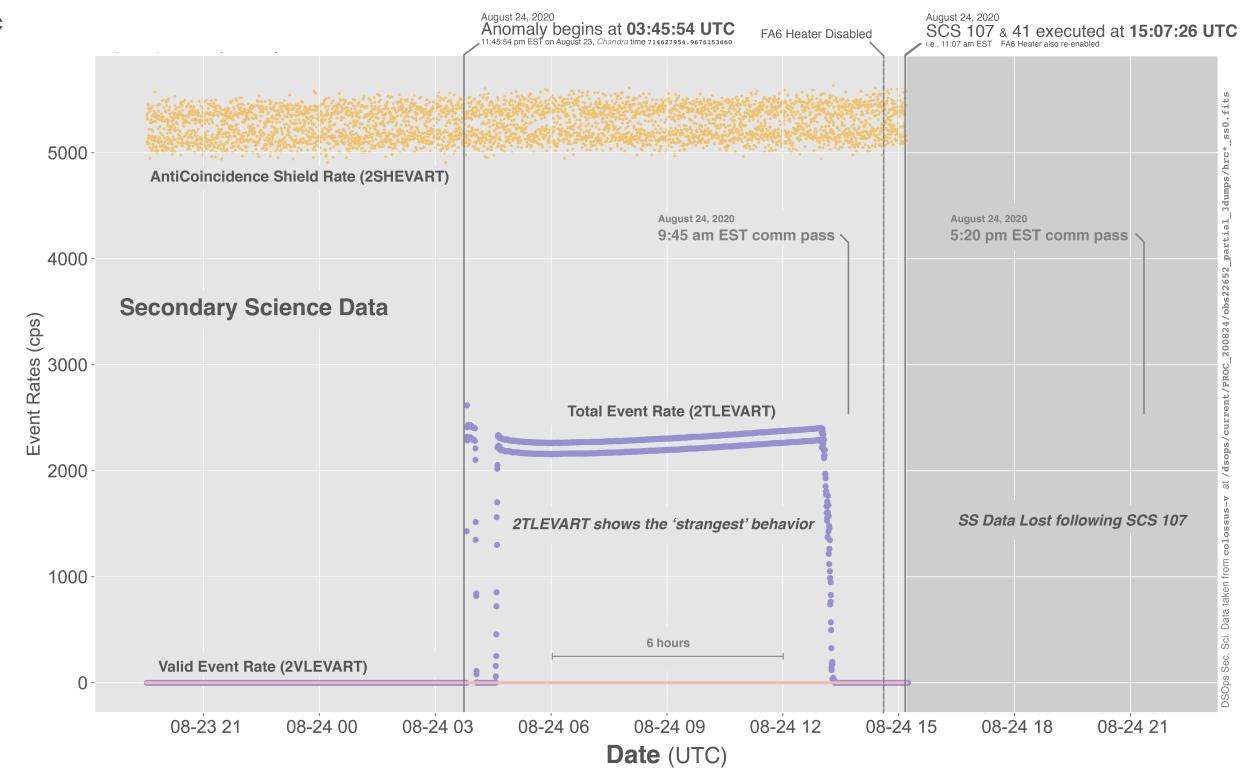
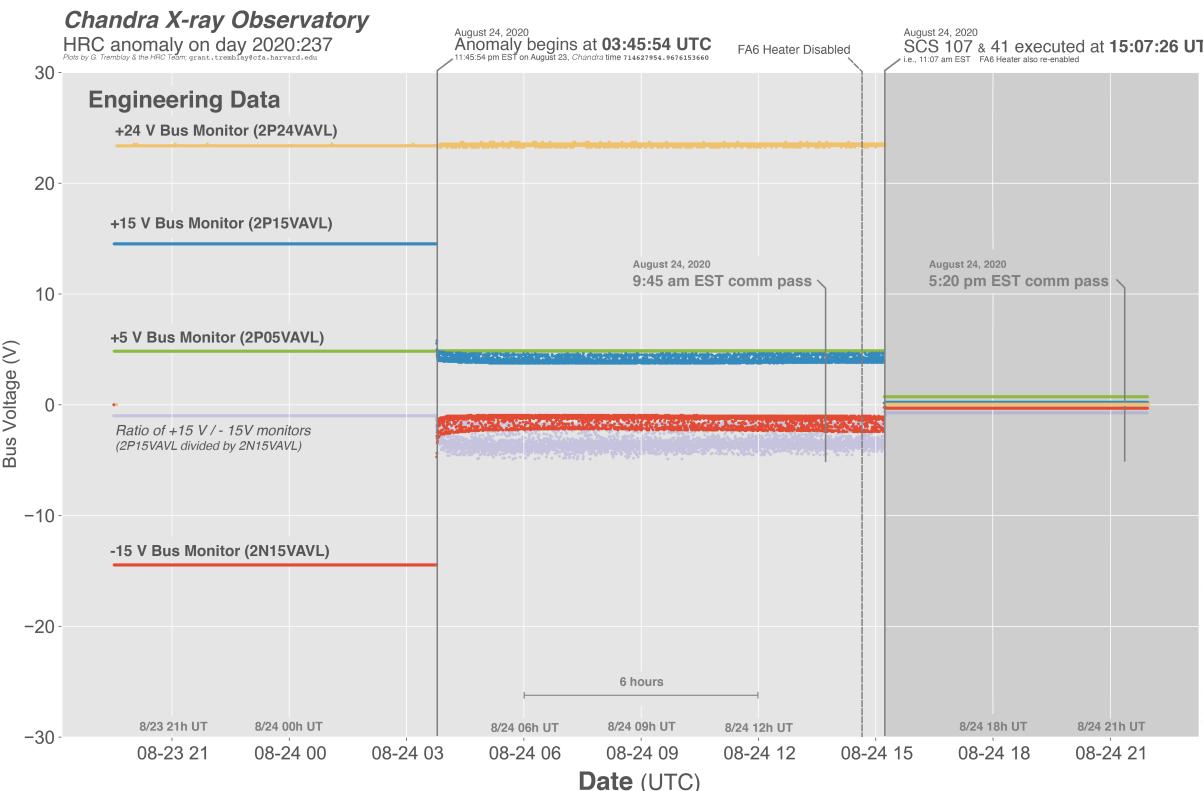
# The anomaly (a short summary)

- At the start of Monday morning's comm pass (Aug 24), HRC limit violations were noted in the +15V and -15V bus voltage monitors.
- At the time, the HRC was not observing and was at half voltage (as expected). The selected detector was HRC-I. Shield rates were nominal. The HRC had not observed for a full week prior to the anomaly, and all telemetry had been normal leading up to the event.



# The anomaly (a short summary)

- The HRC was in this anomalous state for 11h 21min. The apparent problem with the +/-15 V bus caused a number of other issues, notably unreliable secondary science and housekeeping telemetry due to e.g. trigger noise, etc. The anticoincidence shield continued to function properly.
  - More details about these various issues can be found in [yesterday's briefing slide deck](#).
- The anomaly was immediately noticed at the start of the morning comm pass on Monday. We manually shut down the instrument via SCS 107 & SCS 41.



## Plan of action from yesterday's briefing

- The HRC Team recommended that we **attempt a reset of the Side A electronics on the +/- 15 V power supply**. This action was approved by the Flight Director.
- **The broad consensus was that this procedure was *lower risk* than attempting a swap to Side B.**
  - The option of switching to Side B remains in the event of any further issues.
- **CAP 1541 for the Side A power-on procedure was approved on Wednesday afternoon.**

## Results from last night

- We executed CAP 1541 during the 8:05pm (EDT, BOT) pass (which was extended to 2h).
- The CAP execution was successful at all steps.
- HRC bus voltages have returned to their nominal states, and have remained stable through the night and through this morning's 6am comm.

August 24, 2020

Anomaly begins at 03:45:54 UTC

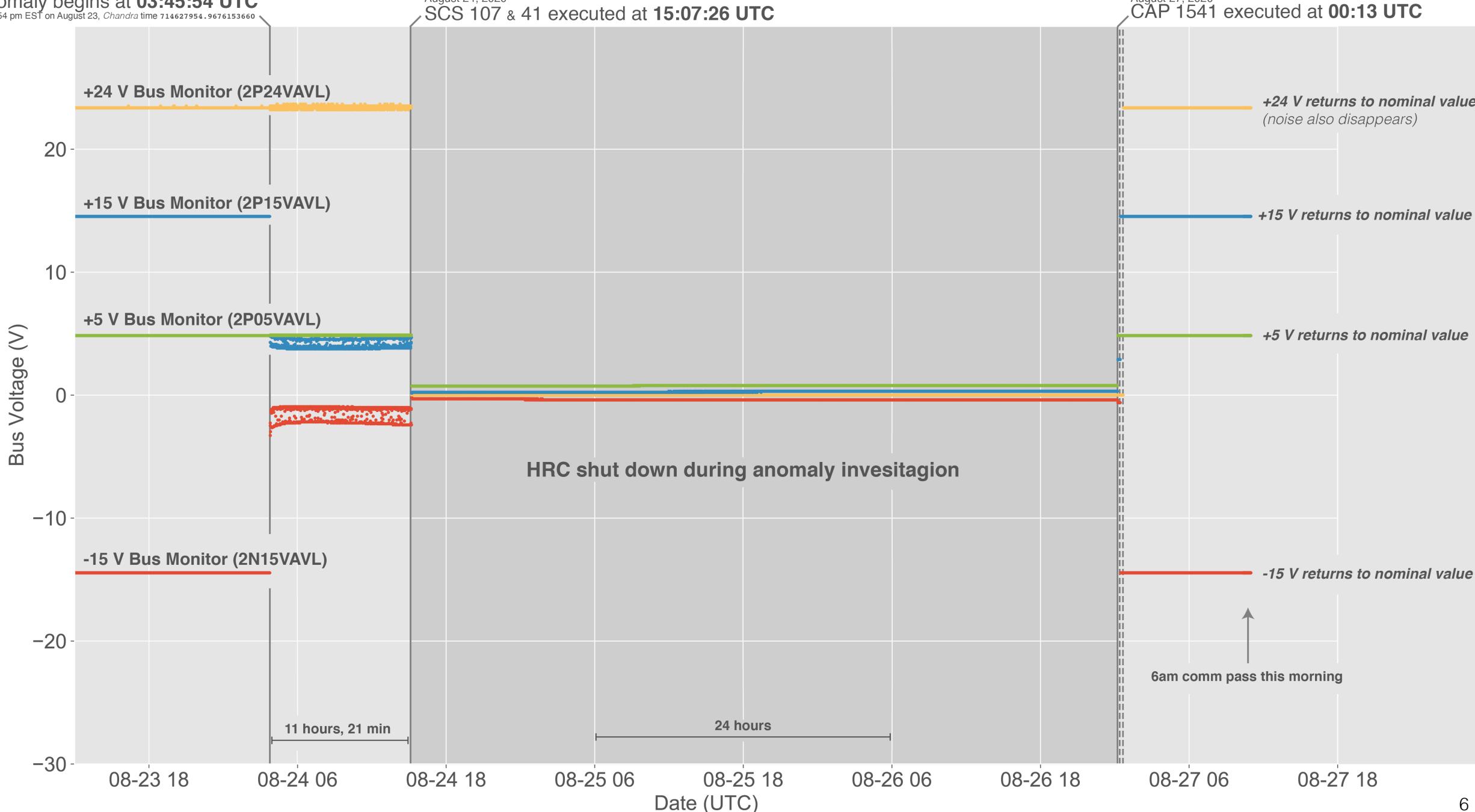
11:45:54 pm EST on August 23, Chandra time 714627954.9676153660

August 24, 2020

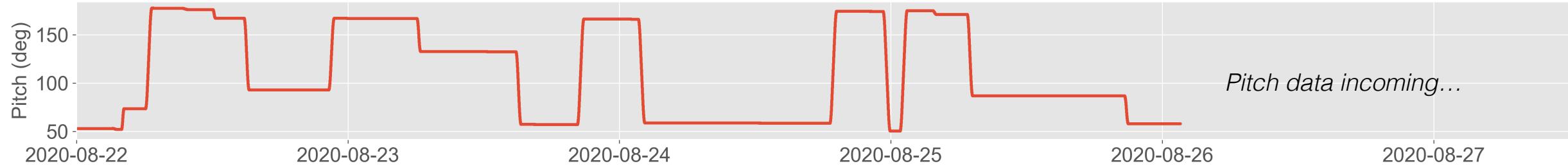
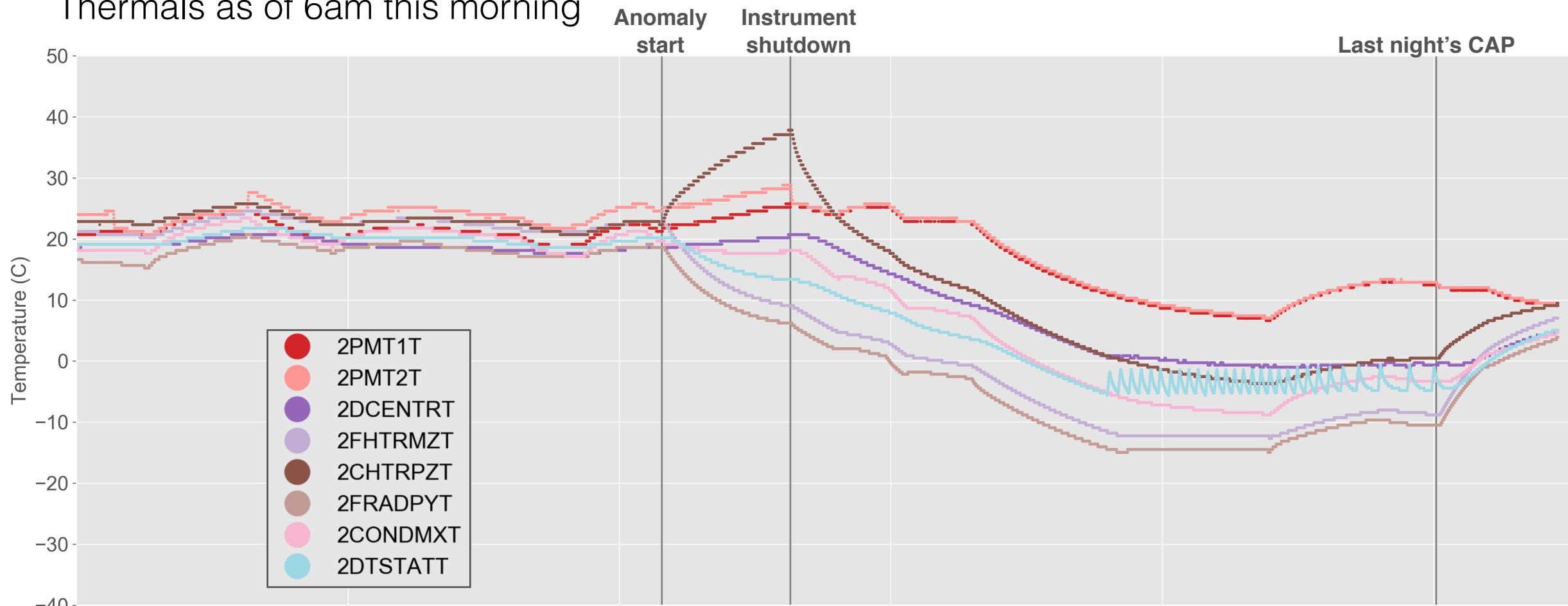
SCS 107 & 41 executed at 15:07:26 UTC

August 27, 2020

CAP 1541 executed at 00:13 UTC



Thermals as of 6am this morning



# **What have we learned about the anomaly since last night?**

- **Despite restoration of the supply voltages last night, the cause of the anomaly remains uncertain.**
  - Considering that the -15 V and +15 V bus monitors returned to their nominal values after a power cycle, a single event upset (SEU) remains a plausible explanation.
  - A permanent hardware fault now seems *less likely*.
  - The HRC Team will continue to investigate the cause of the anomaly.

## Plan for today

- **We are now preparing a new CAP to place the instrument in a known configuration, as well as to turn the HRC Shield on.**
  - Intended time for this activity is during tomorrow's extended comm pass (BOT Friday 11:30am EDT).
  - We also intend to send additional commands (as part of this CAP) to clean up some event processing parameters.

## **Recommended actions for the weekend**

- **The HRC team recommends a short period of monitoring to boost our confidence in the health and operational stability of the instrument.**
- **We are working with Mission Planning for a potential test HRC observation next week.**
  - We *require* that this observation be conducted *during a real-time pass*.
  - The HRC team will carefully analyze the data, both in real-time and after the fact (e.g. pulse heights, etc.).
- **Our expectation is that return-to-science will be ACIS-only for the time being.**

# EXTRA SLIDES

# Hypotheses from 8/26 tagup

- The anomaly is due to a problem **with the +/- 15 V power supply bus on Side A**
    - **A problem in the +15 V bus would also take out the -15 V power supply due to DC-to-DC design**
      - A problem in the -15 V bus would not cause issues with the +15 V bus
    - **There could be a fault in the electronics on this bus**
      - A load fault that is transient in nature (e.g. an SEL). This should clear with a power cycle.
- ... or ...
- A failed component that is dragging down the +15V bus. This would not clear with a power cycle and would require an A/B swap.
- ... or ...
- A latched-up component downstream of DC-DC converter may clear with power cycle. Otherwise an A / B swap is indicated.

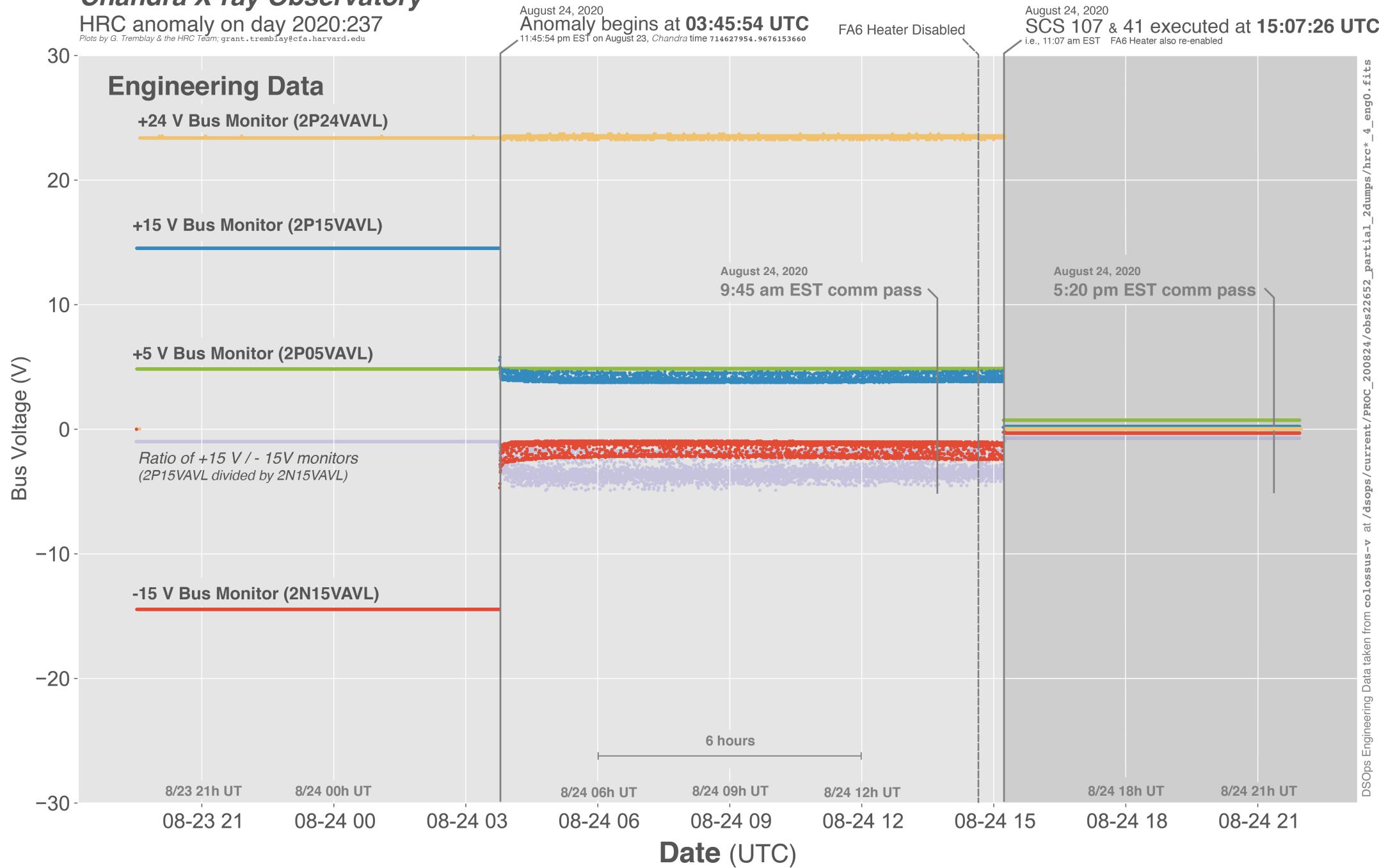
# Decision tree during CAP execution

- Following CAP Step 2 (205VAON with telemetry verifier **2PS5A0N=ON**):
  - **Success:** We expect to see the +5 V bus return to a nominal value (i.e. around +5 V and stable for several frames).
  - **Failure:** The +5 V bus does *not* return to a nominal value, or only stays there for a very short period of time before returning to an off-nominal value.
  - If this step is **successful**, we will proceed to the next step. If it is **not successful**, we will execute contingency steps 6 and 7 in the CAP to safely shutdown the instrument. The CAP will end there.
- Assuming the above step is **successful**, following CAP Step 5 (215PCA0N with telemetry verifier **215PCAST=ON**):
  - **Success:** We expect to see the +15 V and -15 V bus monitors return to nominal values (i.e., *roughly* -14.5 V to -15 V for the -15 V monitor, and +14.5 V to +15 V monitor. Note that these thresholds are *not* exact. **Important note:** it is *possible* that we will see some secondary ~~science~~ corruption in the telemetry. This is not surprising and will not necessarily constitute a failure. The HRC Team will decide if the exact returned values can be considered "nominal".
  - **Failure:** One or both of the +15 V and -15 V monitors do *not* return to their expected values.
  - If this step is **successful**, we will proceed to the next step. If it is **not successful**, we will execute contingency steps 6 and 7 in the CAP to safely shutdown the instrument. The CAP will end there.
- Assuming the above step is **successful**, following CAP Step 8 (224PCA0N with telemetry verifier **225PCAST=ON**):
  - **Success:** We expect to see the +24 V return to a nominal value of *roughly* +24 V. The HRC Team will decide if the exact returned values can be considered "nominal". Again, some SSC might be present, and this does not necessarily mean failure.
  - **Failure:** The +24 V monitor does *not* return to its expected values.
  - If this step is **successful**, we will proceed to the next step. If it is **not successful**, we will execute contingency steps 6 and 7 in the CAP to safely shutdown the instrument. The CAP will end there.

# Chandra X-ray Observatory

HRC anomaly on day 2020:237

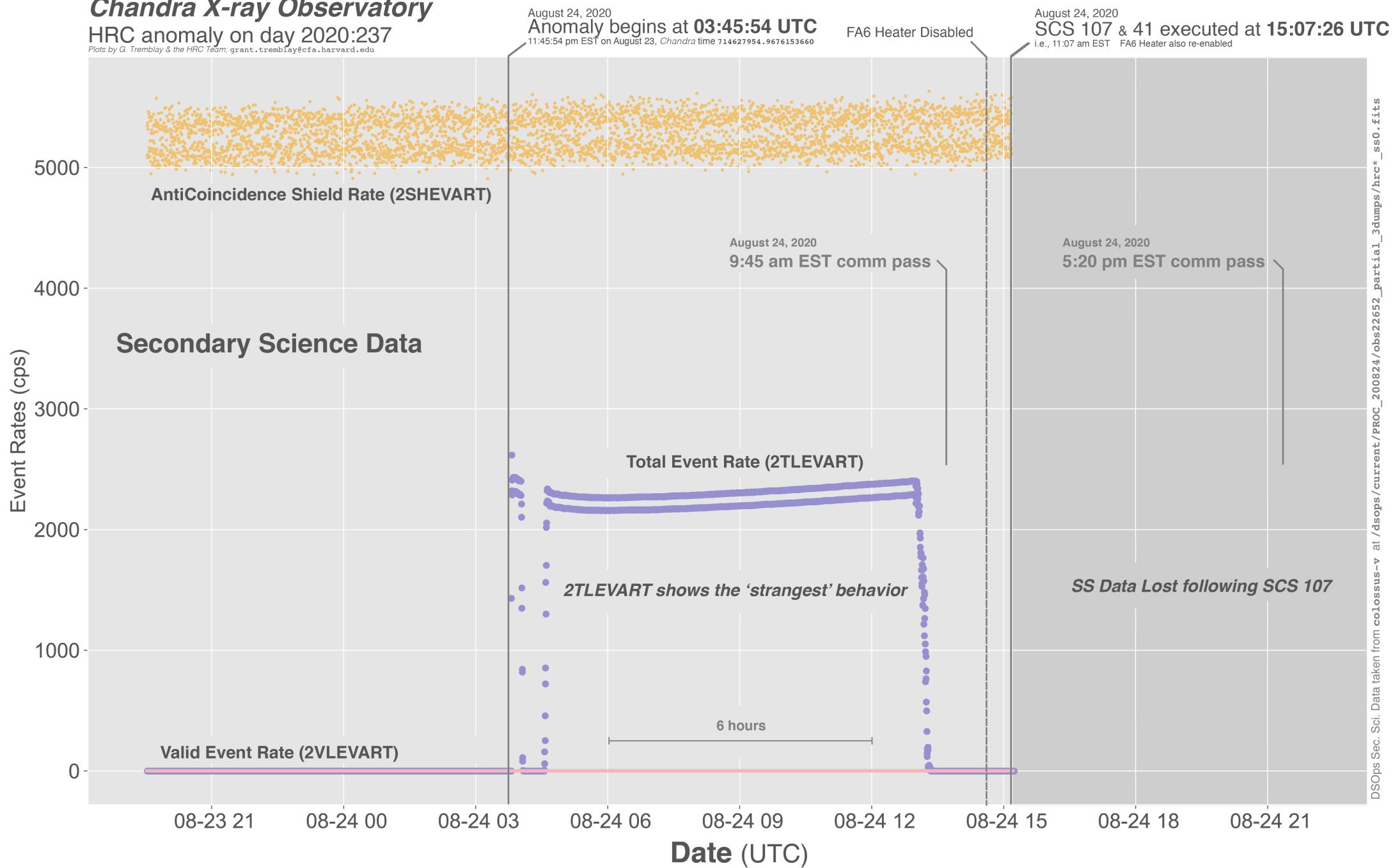
Plots by G. Tremblay & the HRC Team; grant.tremblay@cfa.harvard.edu



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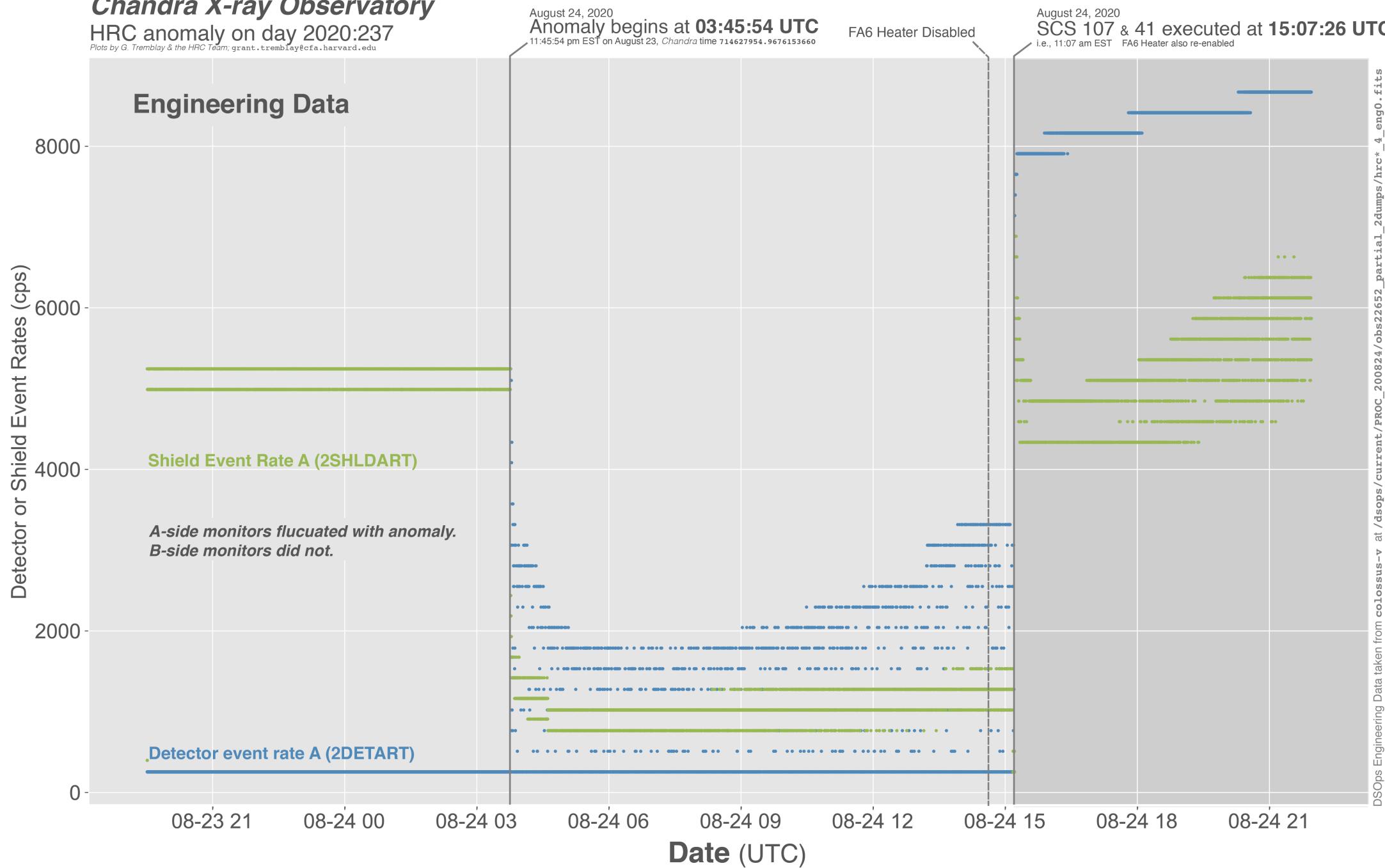
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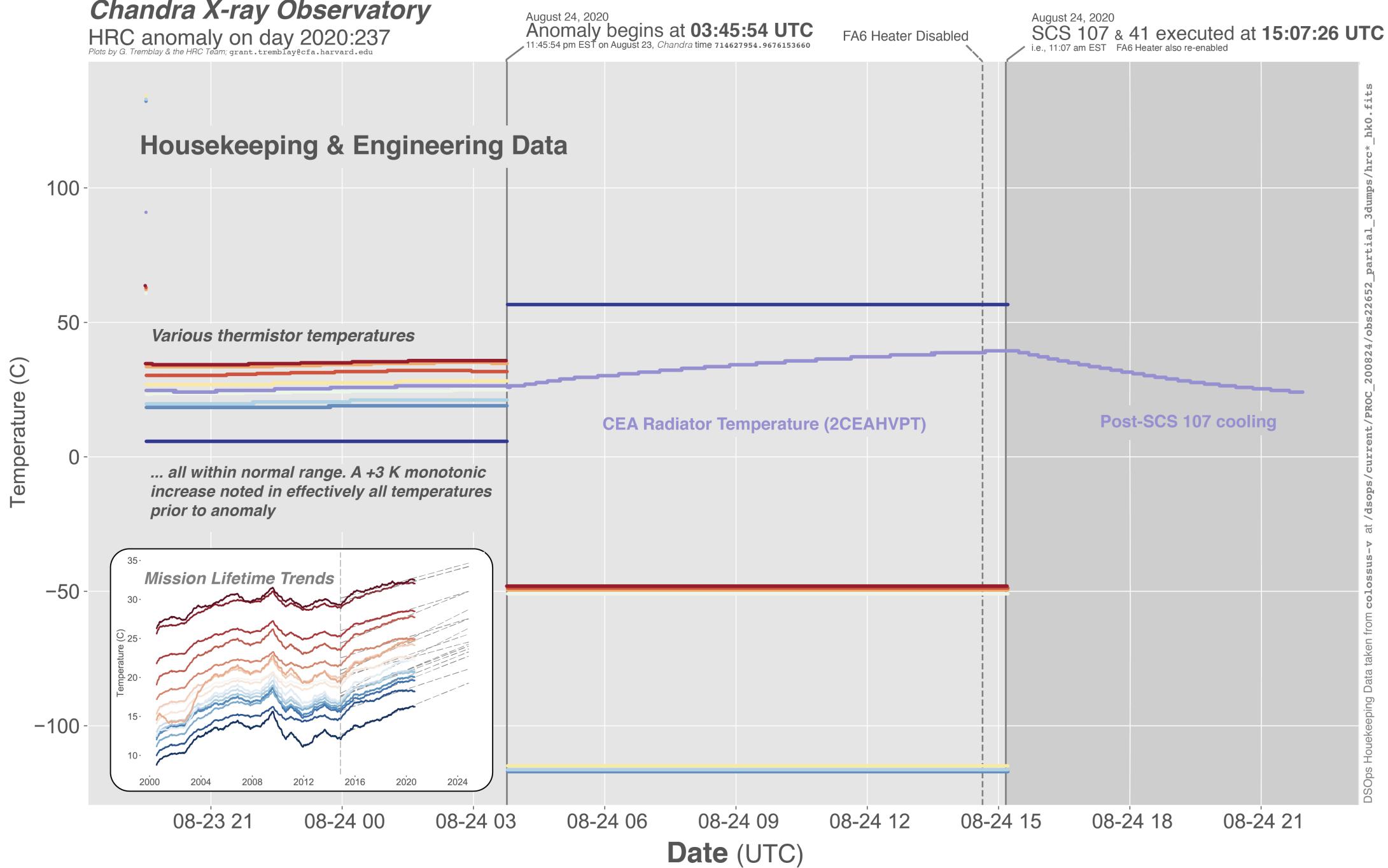
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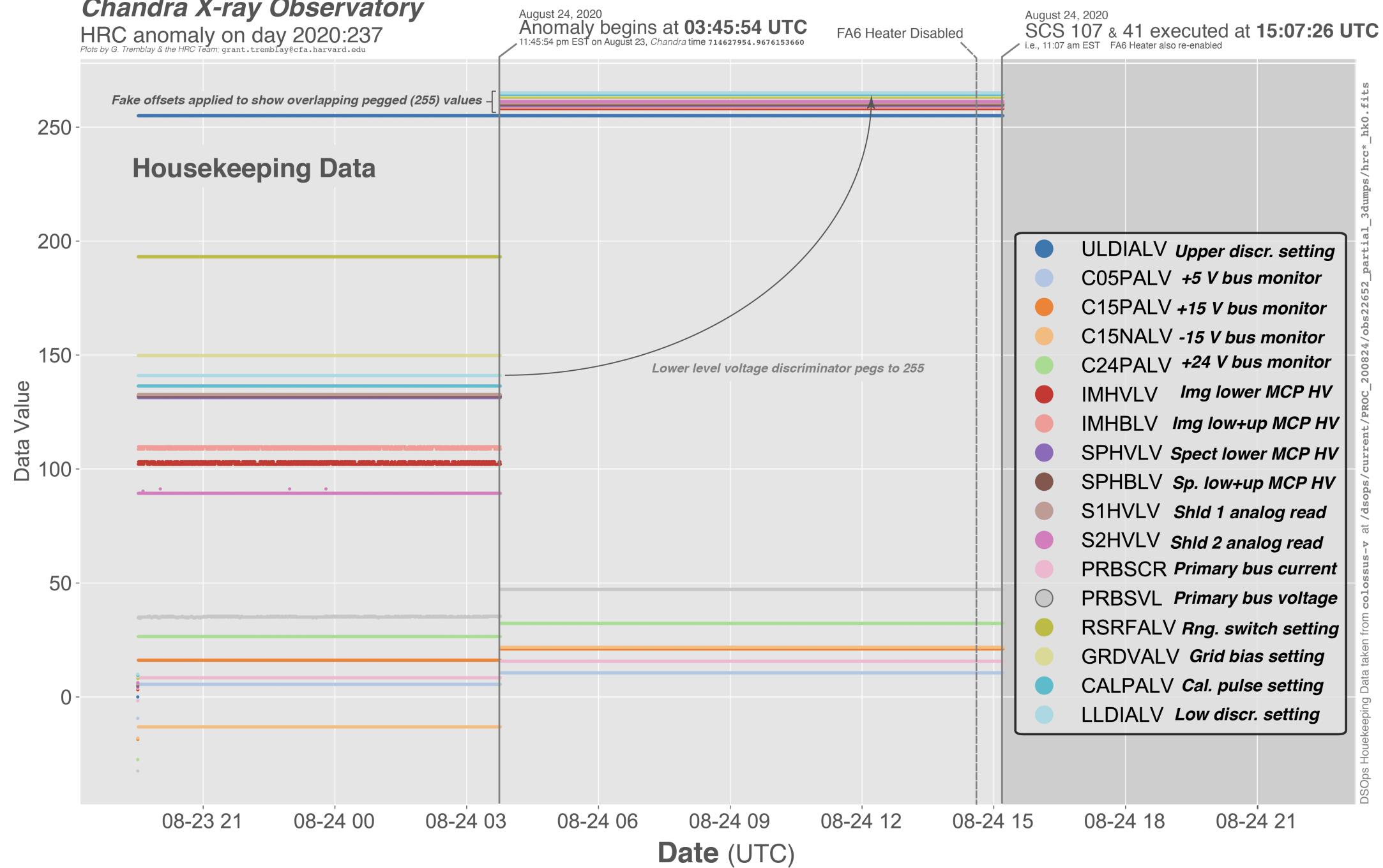
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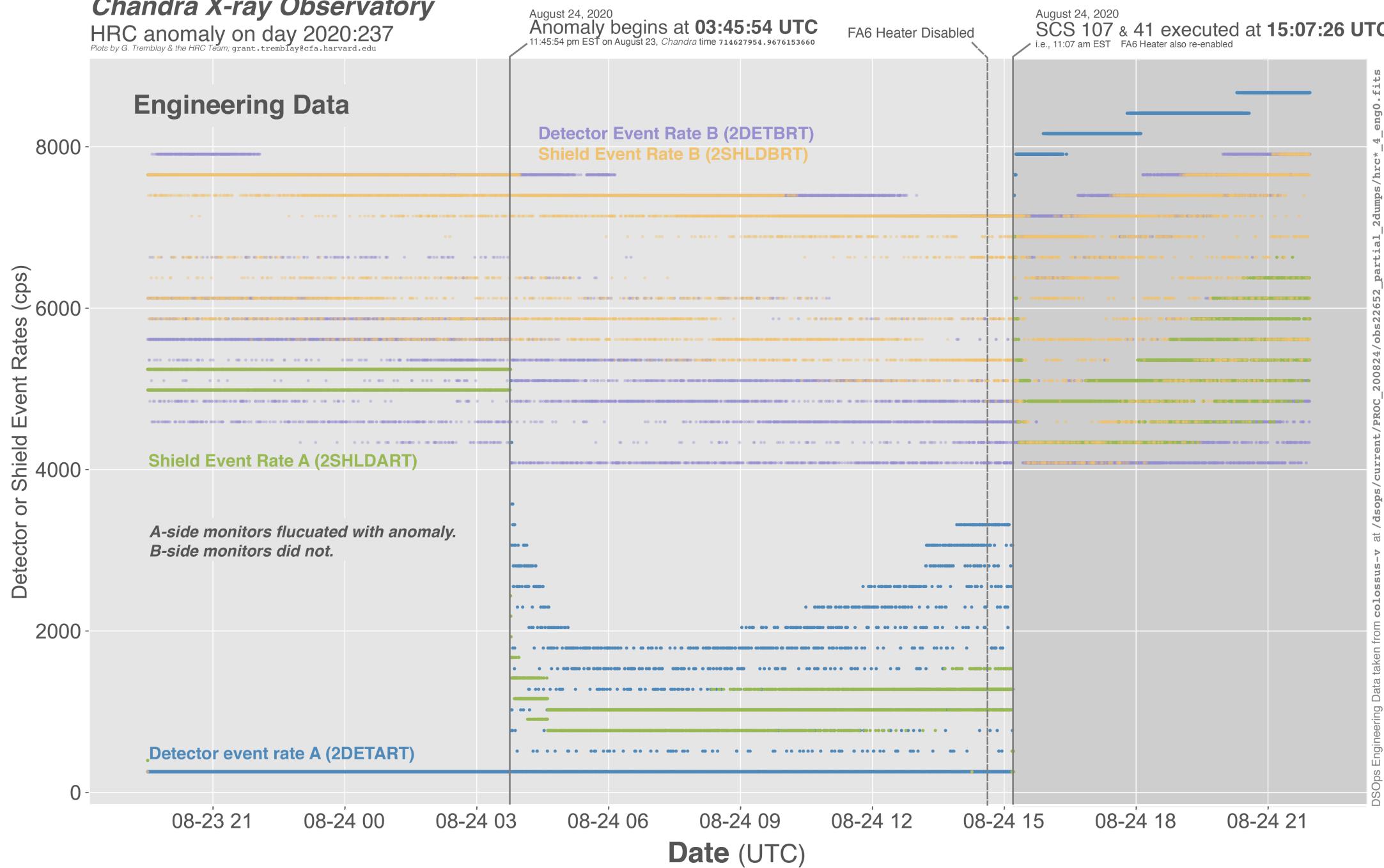
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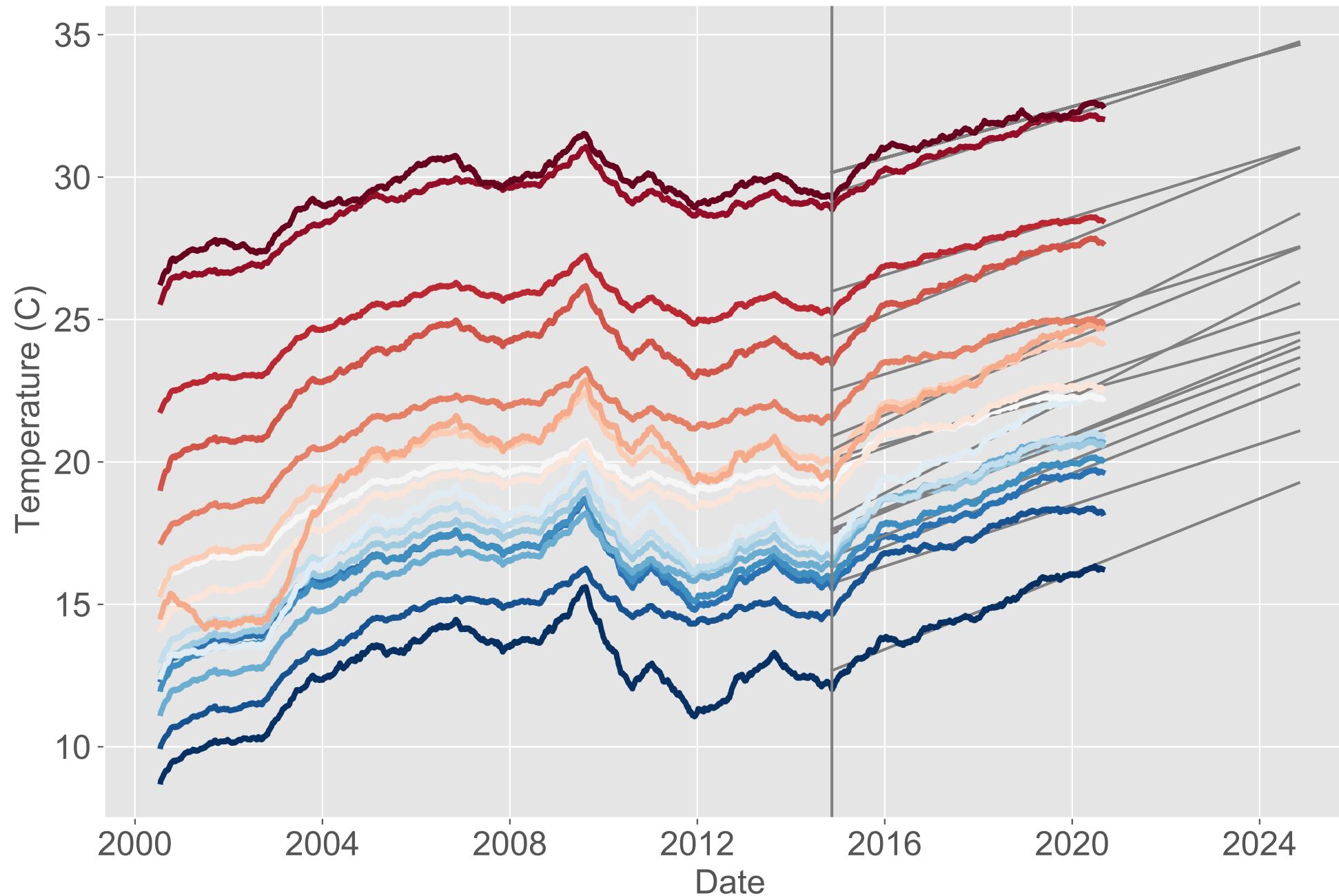
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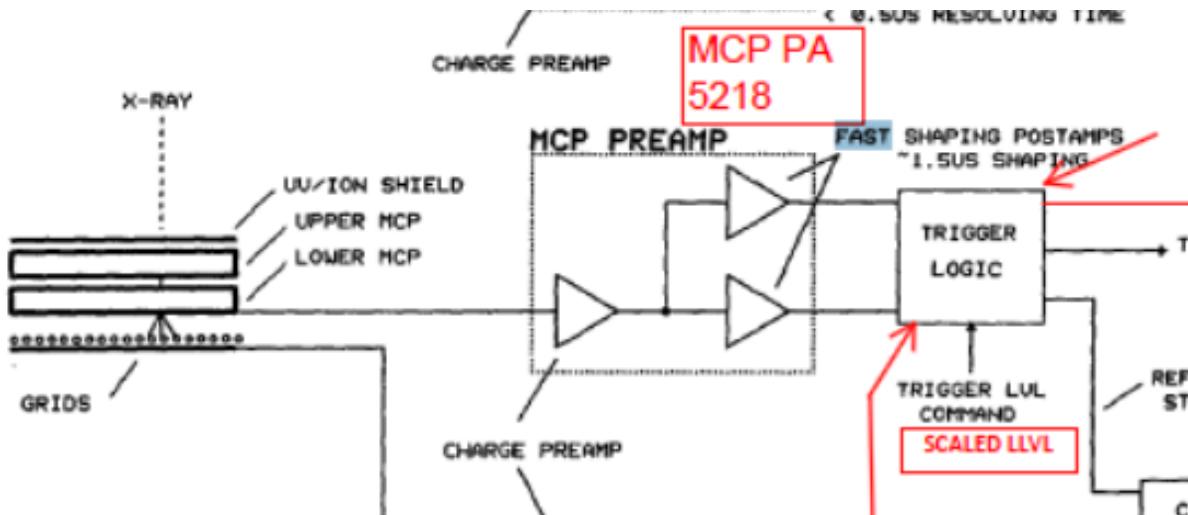
## Forecasted HRC Thermistor Temperatures if Current Slopes Hold



# Explanation of trigger noise

(T. Gauron)

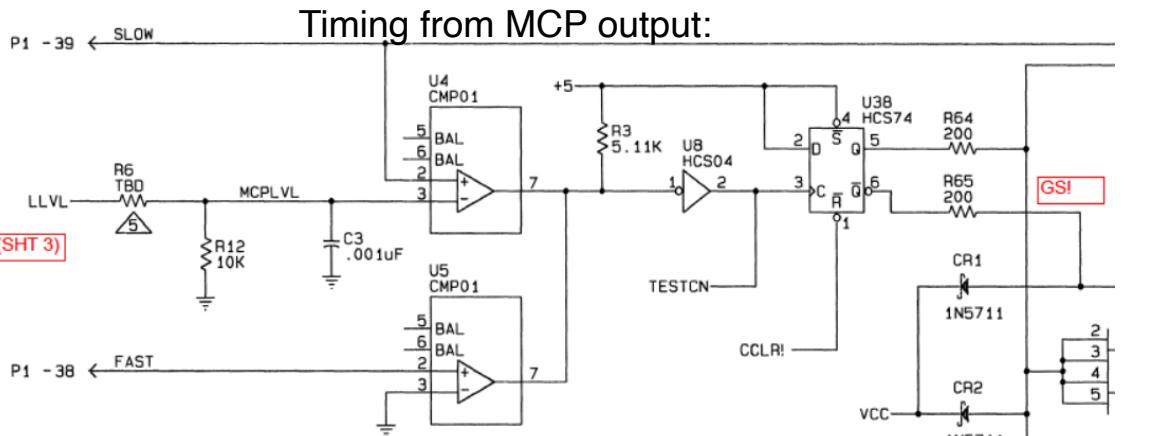
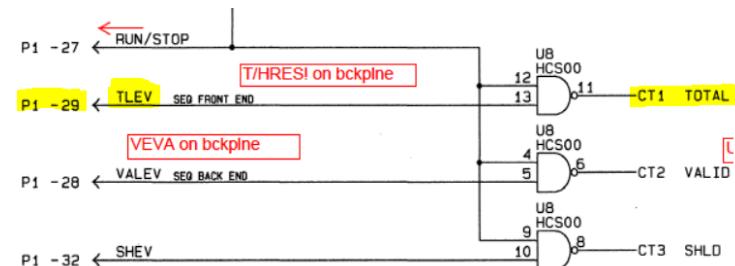
Top Level Trigger from MCP output:



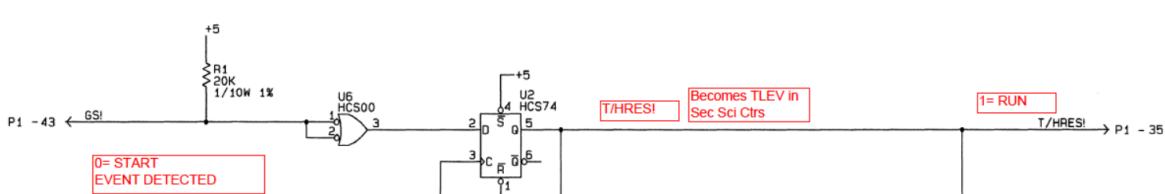
T/HRES! Routes to SEC\_SCI\_CTR pin 29 on backplane

CE	SLOT 11	SEC SCI CTR A
5209		
CEJ11	0 1	CE+15A
46	0 2	CEGND
47	0 3	CE-15A
48	0 4	CEGND
49	0 5	CE+5A
50	0 6	CE+5A
51	0 7	
52	0 8	
53	0 9	
54	0 10	
55	0 11	
56	0 12	
57	0 13	
58	0 14	
59	0 15	
60	0 16	
61	0 17	
62	0 18	
63	0 19	
64	0 20	
65	0 21	
66	0 22	
67	0 23	
68	0 24	
69	0 25	
70	0 26	
71	0 27	
72	0 28	
73	0 29	T/HRES!
74	0 30	SECCTC! A
75	0 31	1.024MHZ2A
76	0 32	

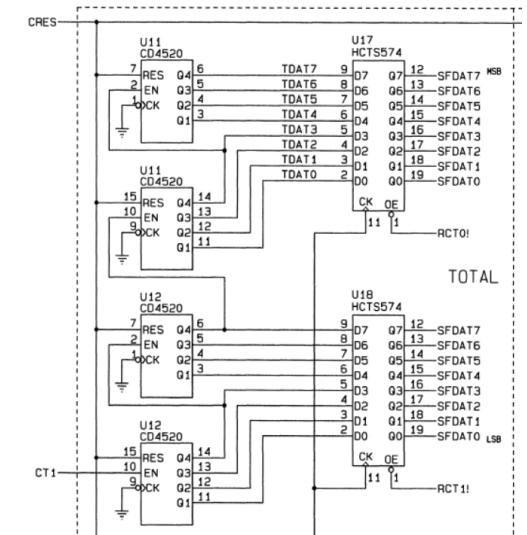
It's called TLEV on the SEC\_SCI PWA



GSI! is synced with S/C clock and becomes T/HRES! in SEQUENCER



...and gets counted for TOTAL EVENTS



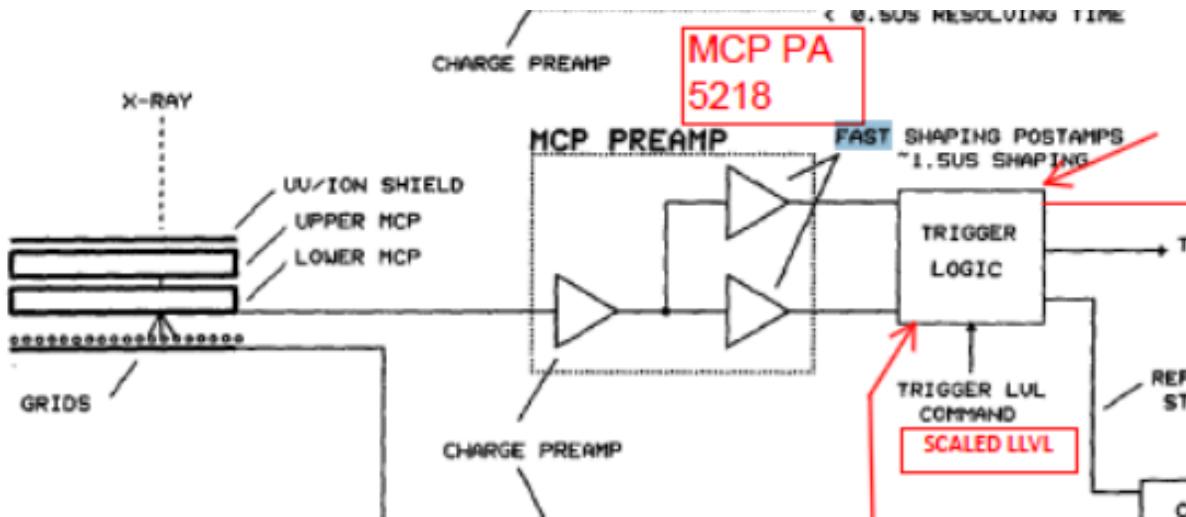
# Why is a Side A reset preferred?

- Resetting Side A offers *lower risk* than swapping to Side B.
  - The HRC team ***cannot find any plausible scenario*** in which turning on the 5 and 15 V would cause any damage to the single stream components (e.g., MCPs, crossed grid array, etc.)
  - This is a **straightforward procedure** derived from an SCS
  - This addresses the possible “single event latchup” hypothesis
- **Swapping to Side B is more complicated and risky.**
  - It requires switching of latching relays which we haven’t activated in 20 years.
  - It requires shutting the 28 V bus power to the HRC off.
  - B-side electronics have not been used in 20 years
  - It entails significant alteration of all HRC commanding, including protected SCSs, ATSs, and support software
  - It would require a complete calibration of the detectors

# Explanation of trigger noise

(T. Gauron)

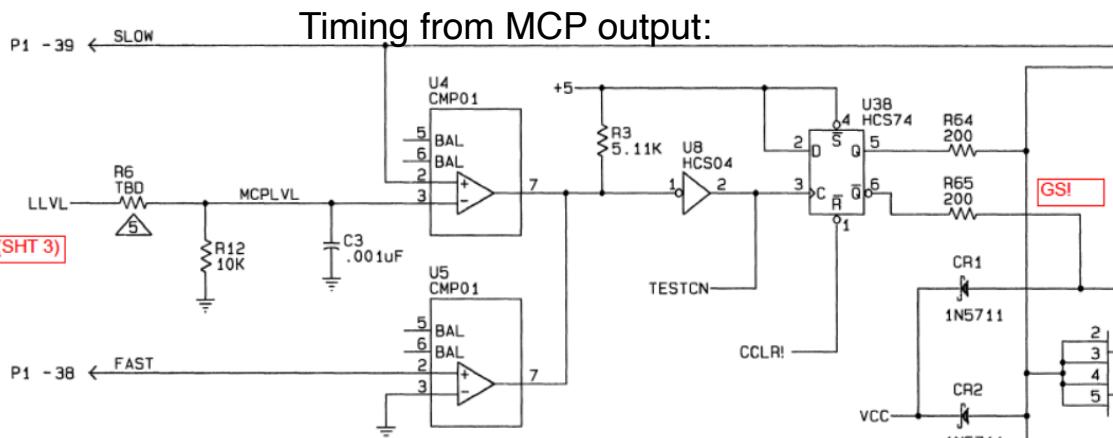
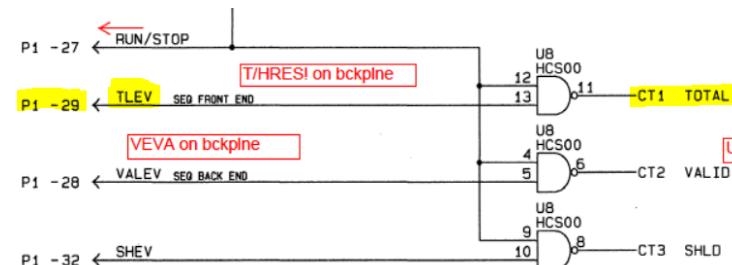
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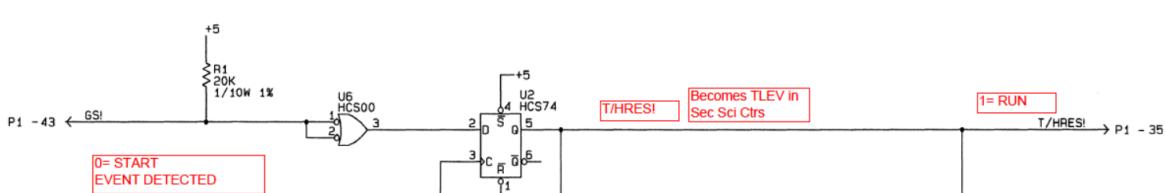
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52	0 7	
53	0 8	
54	0 9	
55	0 10	
56	0 11	
57	0 12	
58	0 13	
59	0 14	
60	0 15	
61	0 16	
62	0 17	
63	0 18	
64	0 19	SFDAT7A
65	0 20	SFDAT6A
66	0 21	SFDAT5A
67	0 22	SFDAT4A
68	0 23	SFDAT3A
69	0 24	SFDAT2A
70	0 25	SFDAT1A
71	0 26	SFDAT0A
72	0 27	
73	0 28	VEVA
74	0 29	T/HRES! A
75	0 30	SECTIC! A
76	0 31	1.024MHZ2A
	0 32	

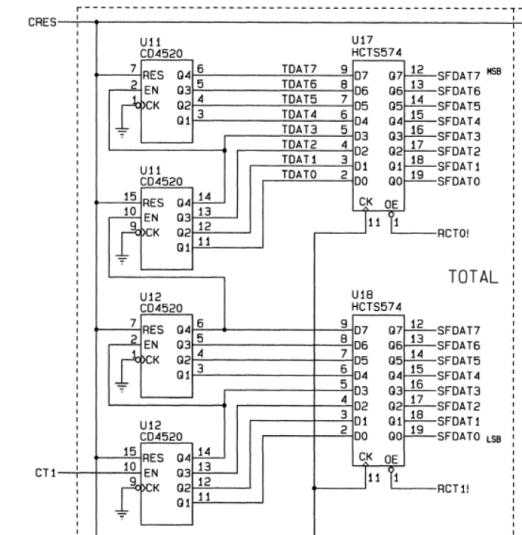
It's called TLEV on the SEC\_SCI PWA



GSI is synced with S/C clock and becomes T/HRES! in SEQUENCER



...and gets counted for TOTAL EVENTS



# Prime and redundant side wiring

## (T. Gauron)

