

*Chandra X-ray Observatory*  
**The 2020 HRC Anomaly**

*Nominal HRC Telemetry and Plans for this week*  
Chandra Community Briefing  
2 September 2020

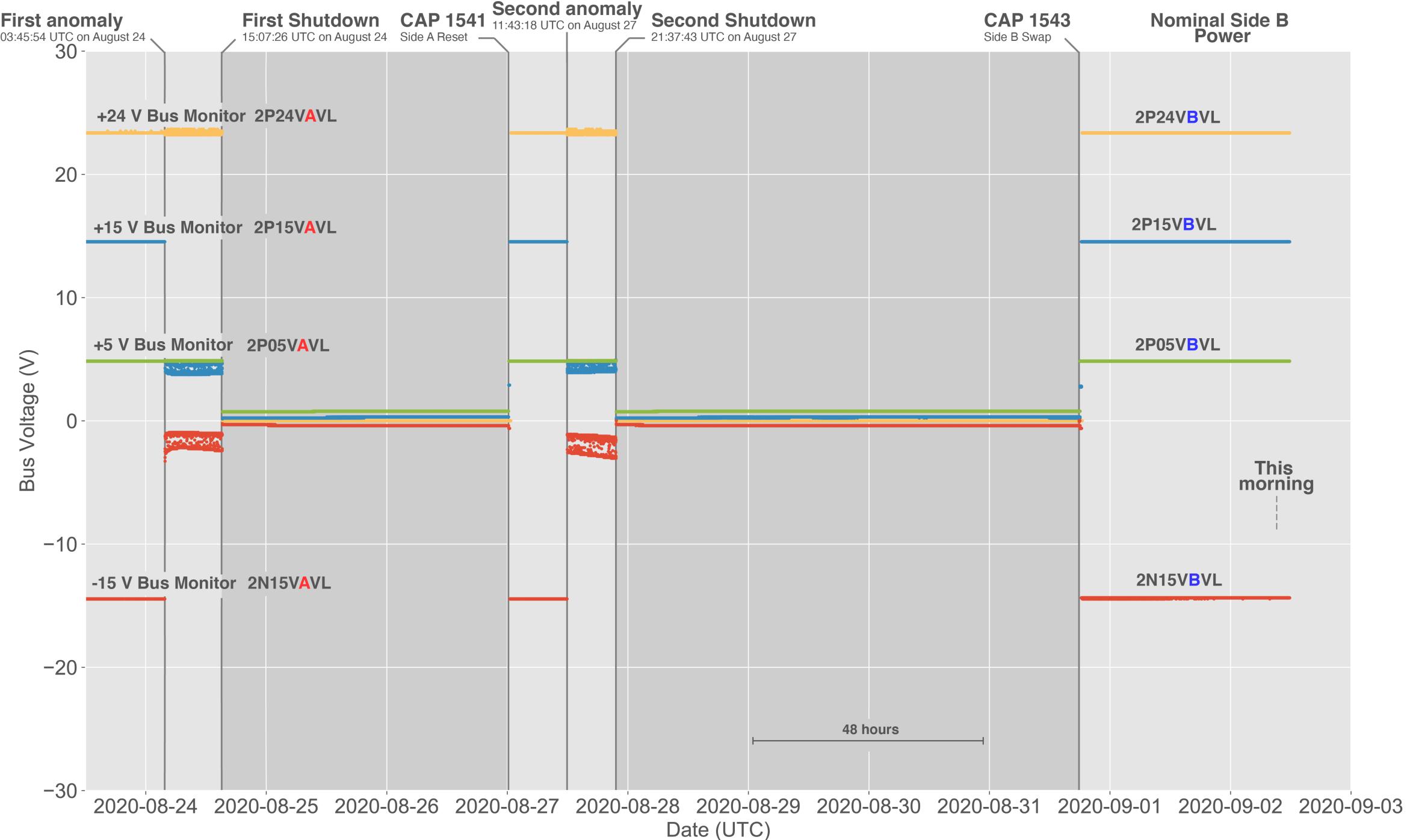
HRC Operations Team

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

CENTER FOR **ASTROPHYSICS**  
HARVARD & SMITHSONIAN

## Nominal telemetry thus far

- Since the Side B swap on Monday afternoon, **HRC telemetry has been nominal and stable**, including through this morning's pass (i.e., for about ~41 hours now).
- The instrument has warmed ~37° C since the Side B swap and bus power-on. **HRC temperatures are nominal**, and the rate of warming is slowing.
  - HRC temperatures are now higher than they were when both anomalies occurred.
  - This slightly higher temperature is partly due to our tail-sun attitude.
- The HRC Team has successfully made changes to our monitoring software to account for the Side B Swap. Patching of our command load review software is ongoing.



**First anomaly**

03:45:54 UTC on August 24

**First Shutdown**

15:07:26 UTC on August 24

**CAP 1541**  
Side A Reset

11:43:18 UTC on August 27

**Second anomaly**

21:37:43 UTC on August 27

**CAP 1543**

Side B Swap

This morning

Temperature (C)

2020-08-24 2020-08-25 2020-08-26 2020-08-27 2020-08-28 2020-08-29 2020-08-30 2020-08-31 2020-09-01 2020-09-02 2020-09-03

Date (UTC)

- 2PMT1T
- 2PMT2T
- 2DCENTRT
- 2FHTRMZT
- 2CHTRPZT
- 2FRADPYT
- 2CONDMMXT
- 2DTSTATT

CEA Box Operating Limit

CEA Box Survival Limit

## Plans for the coming days

- We are preparing a CAP to interactively power on the PMTs and **bring the anticoincidence shield back online**.
  - Pending a successful CAP review, we are targeting this **Friday evening** (8:15pm EDT) for this activity.
- **We will ramp-up the HRC-I high voltage at a later date.** This will need to be coordinated with ACIS return-to-science and **must take place during an extended real-time pass**, as it will require real-time commanding.
- The HRC-S turn-on will require a similar, separate activity.
- The HRC Team continues our investigation as to the anomaly's root cause.

# EXTRA SLIDES

# A timeline of the anomaly

- Last Monday, the HRC suffered from an anomaly of unknown cause, leading to off-nominal voltages on its +/- 15 V bus. The HRC cannot be used for science in this state.
  - A detailed discussion of the anomaly and our subsequent actions can be found in our prior community briefings from last week, [linked here](#).
- Our first plan of action was to **attempt a reset of the Side A power supply bus**, which we successfully completed last Wednesday evening via CAP 1541.
- While the Side A reset did initially return the voltages to nominal values, **the anomaly occurred for a second time** ~11 hours later.
  - Our analysis suggests that the anomaly is confined to the Side A electronics, and is not “upstream” of the CEA A.
- Our next option was to **swap the HRC’s power configuration to CEA B on the redundant power bus**.
- We **successfully executed the Side B swap** via **CAP 1543** Monday afternoon (Aug 31).

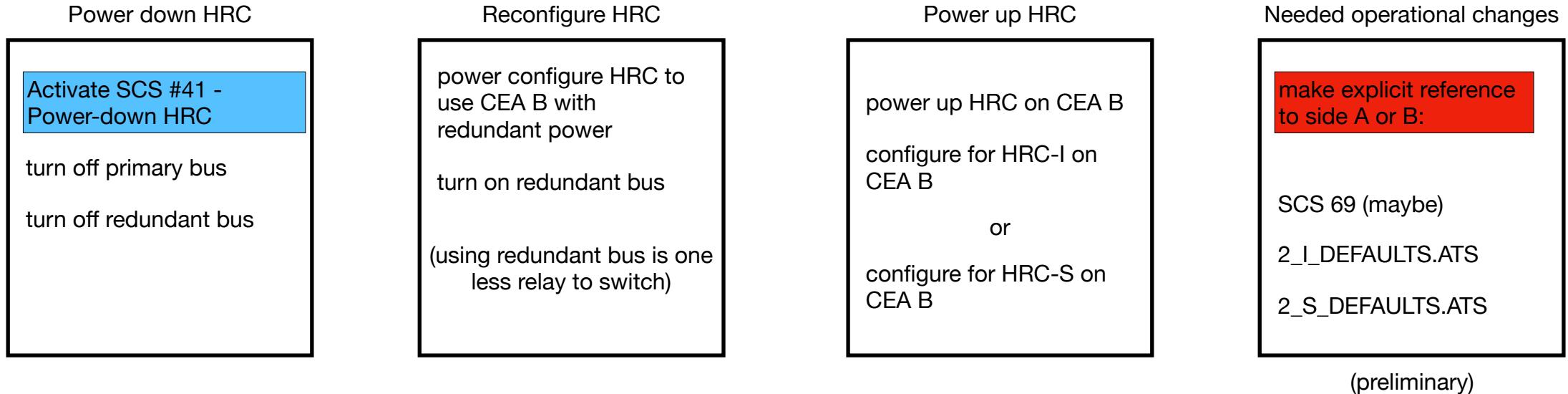
# A Successful Side B Swap

- All steps of CAP 1543 executed successfully, including all major milestones:
  1. Configuring power to use the redundant S/C +28 V bus
  2. Turn on the Side B +5 V LVPS
  3. Turn on the Side B +/- 15 V LVPS
  4. Turn on the +24 V Power Supply
  5. Configure the HRC-I to its default configuration
  6. Tie pre-amp B to PMT 2 and pre-amp A to PMT 1
- By design, the CAP did *not* power up the voltages on the microchannel plates, nor did it bring up the anti-coincidence shield. The HRC Team is planning to do this following a “soak” period to verify the health and stability of the instrument following this successful Side B swap.

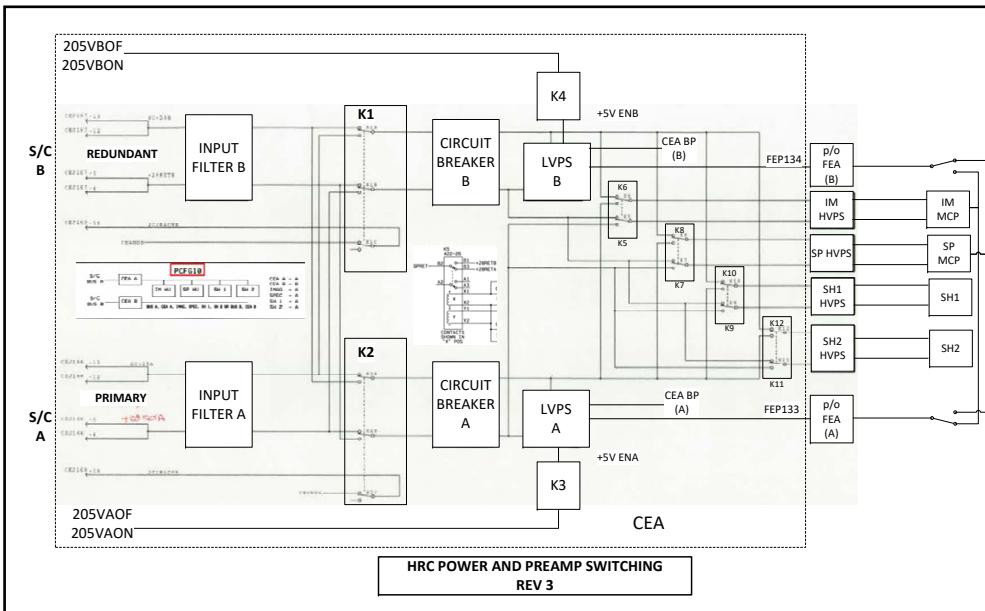
# Preparations for the Side B Swap

- For the past three days, the HRC Team has been reviewing, analyzing, and discussing the commanding and procedures necessary to make this change.
  - This includes an informative search through shift reports, early logs and notes, etc.
- We have now prepared **CAP 1543**, which will switch the +5 V, +/- 15 V, and +24 V power supplies to Side B electronics using the redundant +28 V power bus from the spacecraft.
  - The CAP is essentially a sequence of three known Standard Operating Procedures, **SOPs 62035, 62036, & 62021**, with breakpoints between them for operator and HRC Team confirmation. There has been a clear plan for a Side B swap since launch.
  - The CAP also performs a configuration of the instrument to its default state. It does *not* power up the voltages on the microchannel plates, nor does it bring up the anti-coincidence shield. This will be done after the HRC Team is satisfied with the health and stability of the instrument following the CAP.

## Top level diagram to switch from Side A on the Prime Bus to Side B on the Redundant Bus



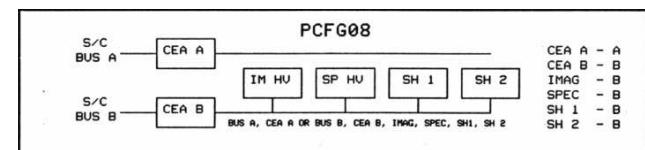
### HRC Power Switching



### Post-power up HRC

turn on PMT#2  
turn on HRC-I/S HV  
ramp up HRC-I/S HV - point at blank sky

Swap to side B on redundant bus is represented by power configuration PCFG08



## Hypotheses from 8/28 tag

- The rapid reoccurrence of the anomaly **now disfavors a single event upset (SEU) scenario.**
- Timescales argue that **the thermal environment is one potential driver of whatever is causing the anomaly.**

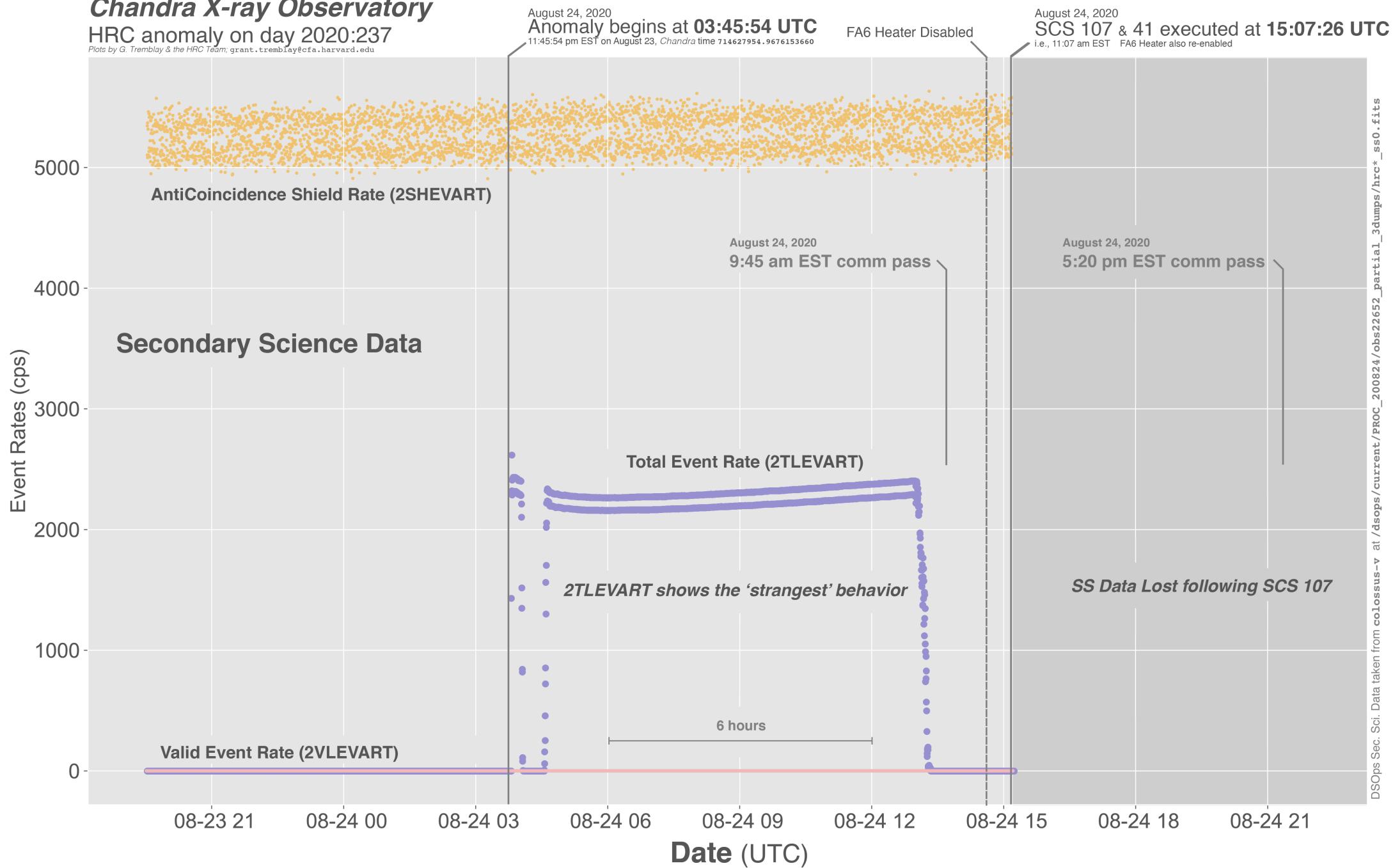
# Hypotheses from 8/26 tagup

- 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.

# Chandra X-ray Observatory

HRC anomaly on day 2020:237

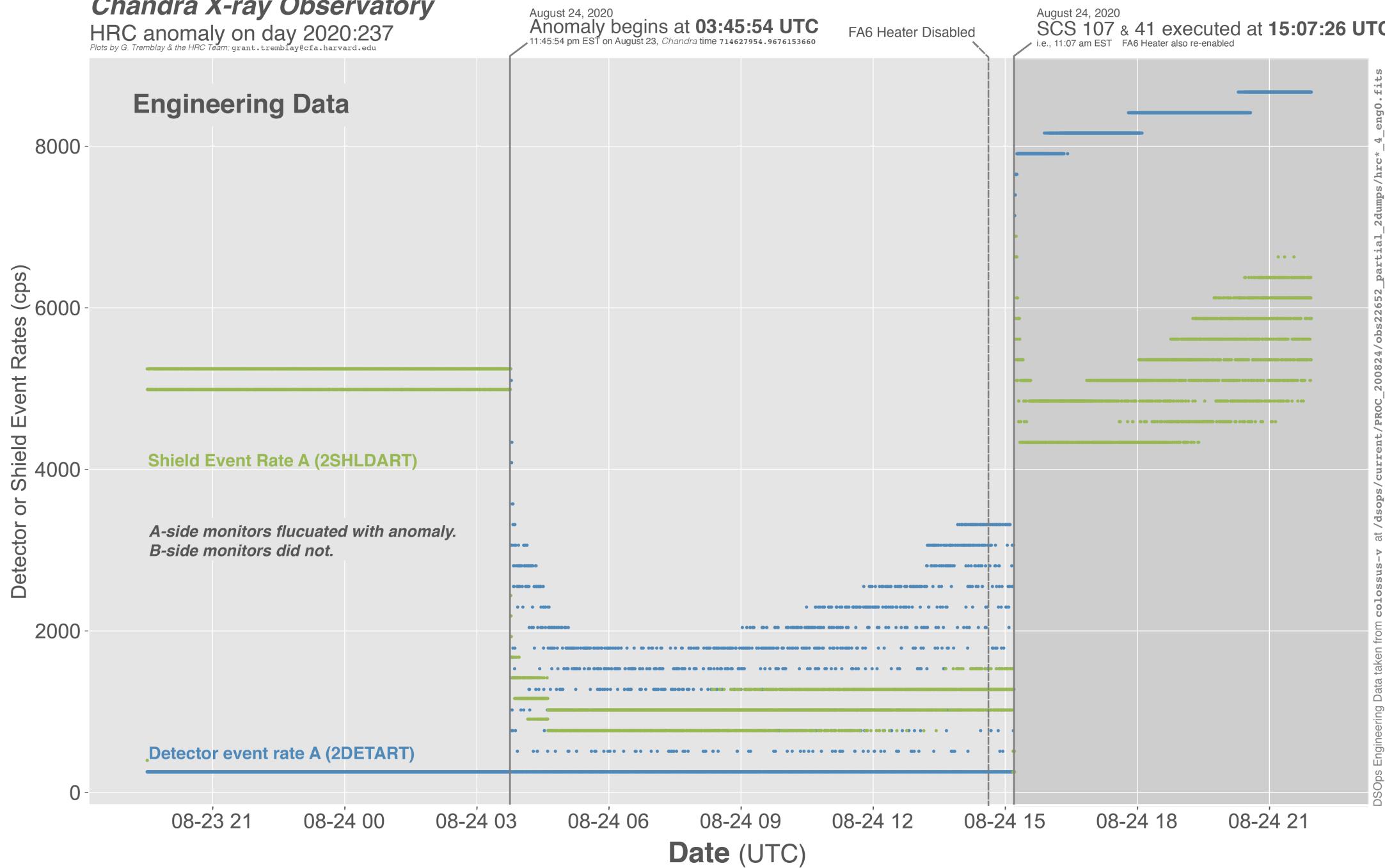
Plots by G. Tremblay & the HRC Team: grant.tremblay@cfa.harvard.edu



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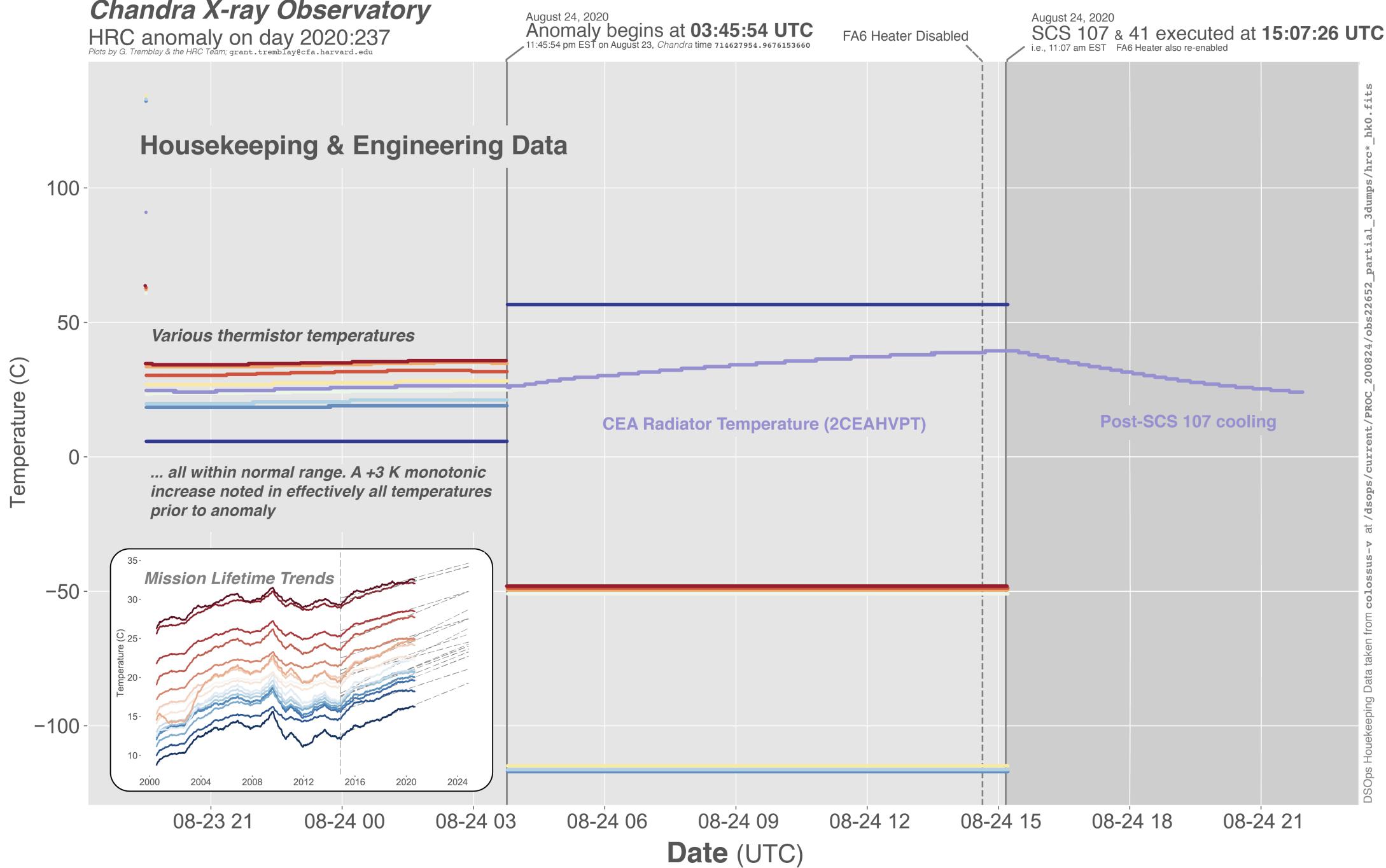
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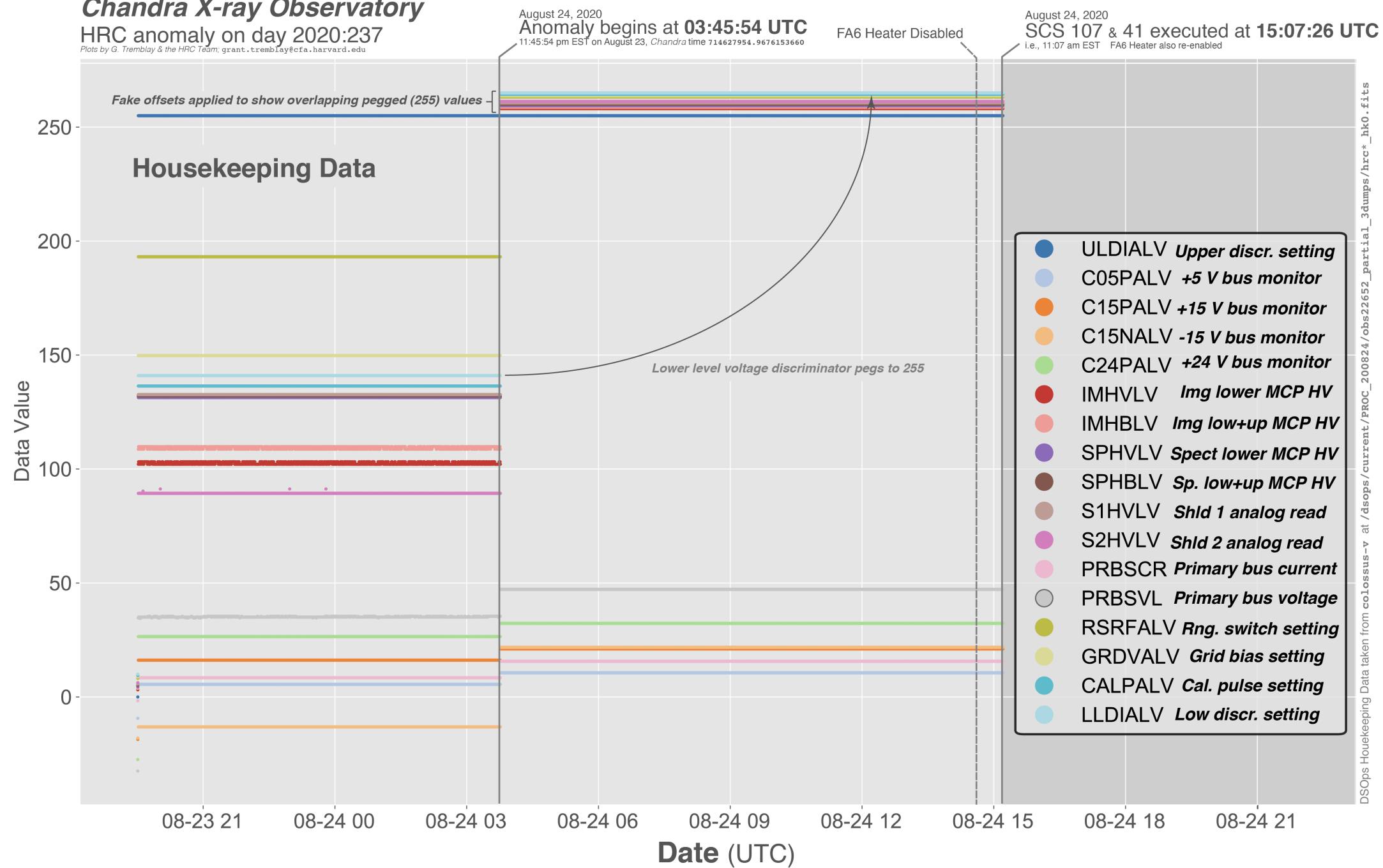
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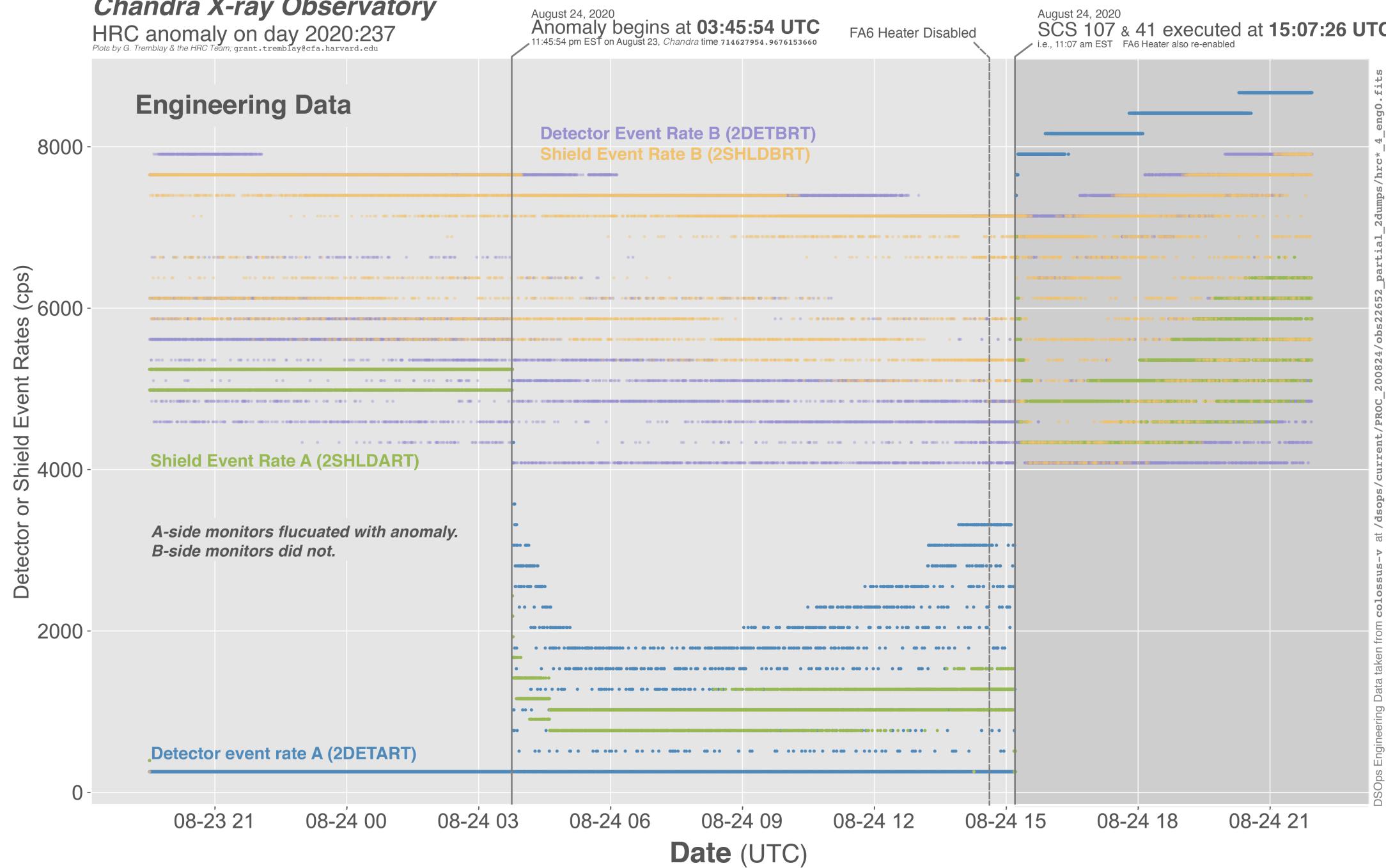
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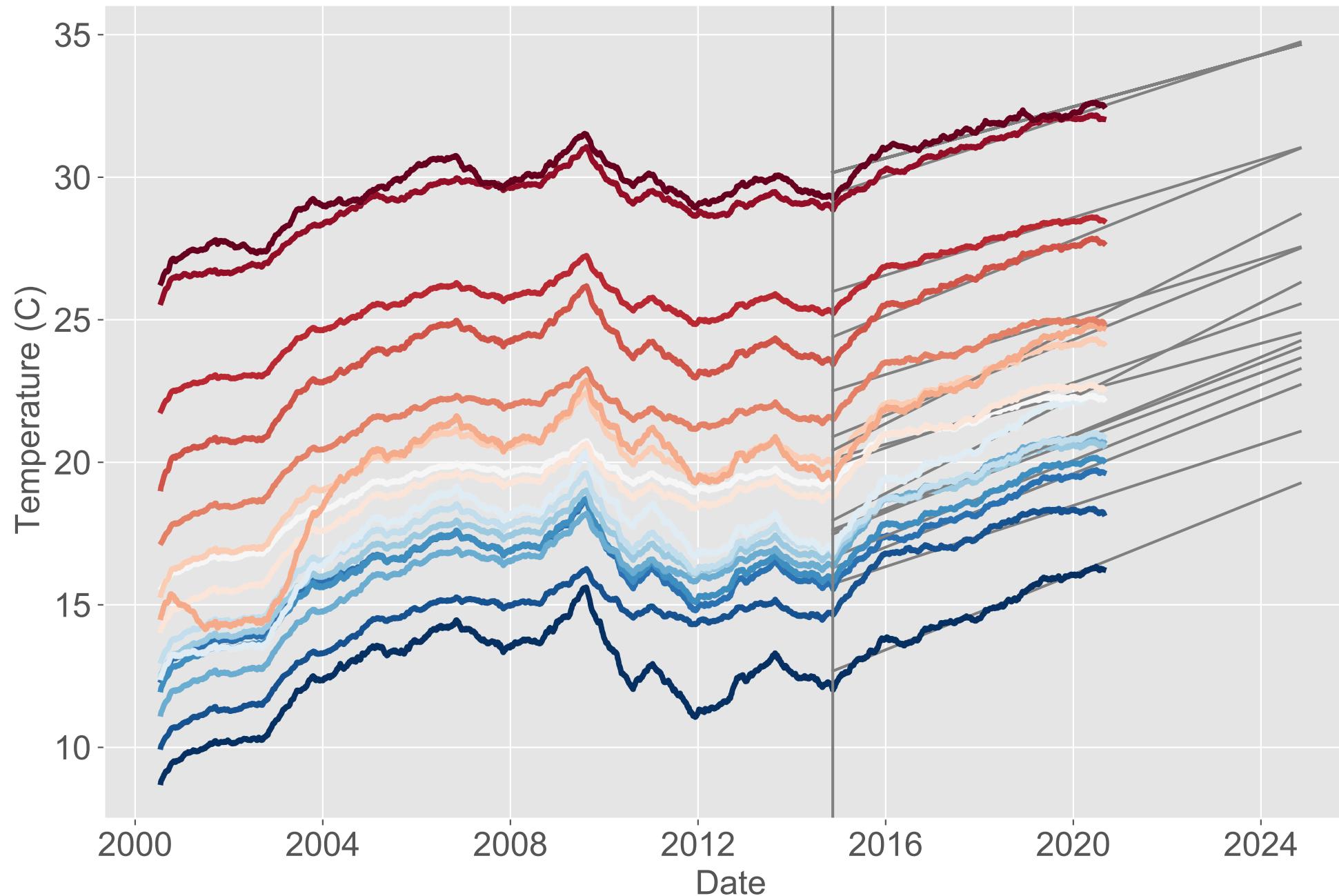
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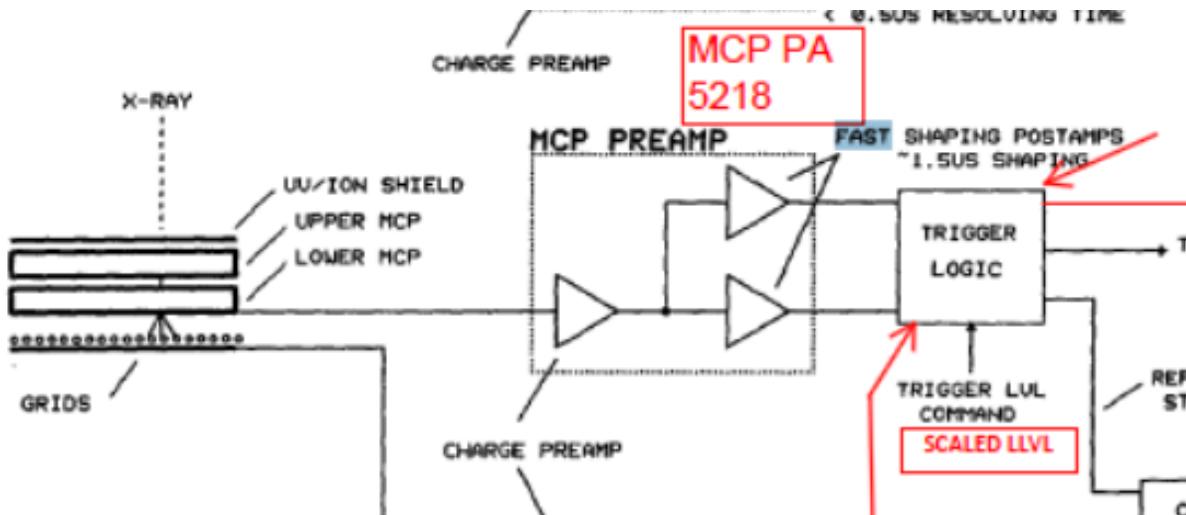
## Forecasted HRC Thermistor Temperatures if Current Slopes Hold



# Explanation of trigger noise

(T. Gauron)

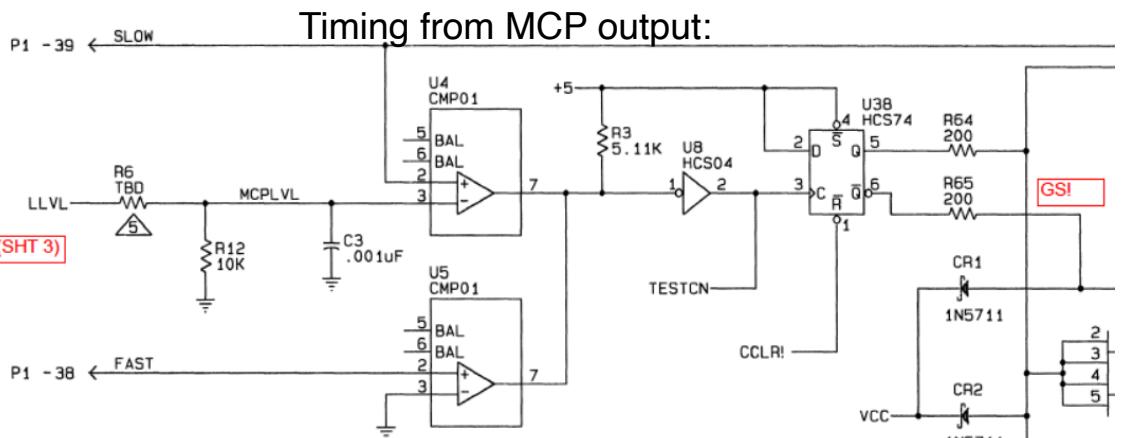
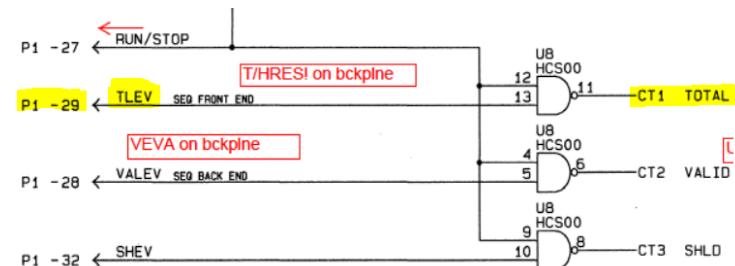
Top Level Trigger from MCP output:



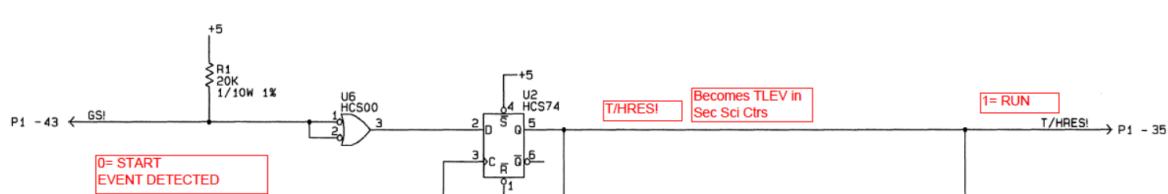
T/HRES! Routes to SEC\_SCI\_CTR pin 29 on backplane

CE	SLOT 11	SEC SCI CTR A
5209		
CEJ11	0 1	CE+15A
46	0 2	CEGND0
47	0 3	CE-15A
48	0 4	CEGND0
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! A
74	0 30	SECTIC! A
75	0 31	1.024MHZ2A
76	0 32	

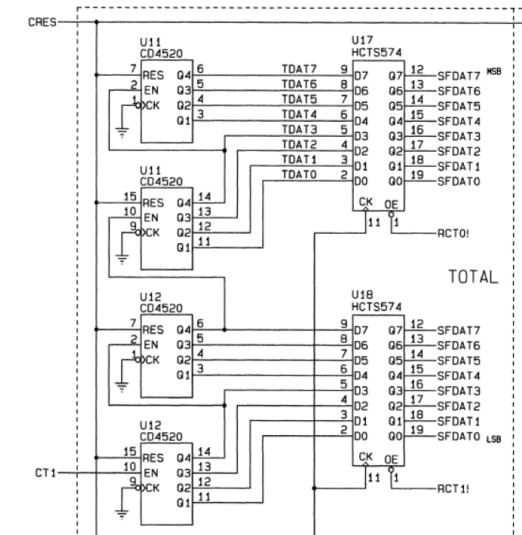
It's called TLEV on the SEC\_SCI PWA



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



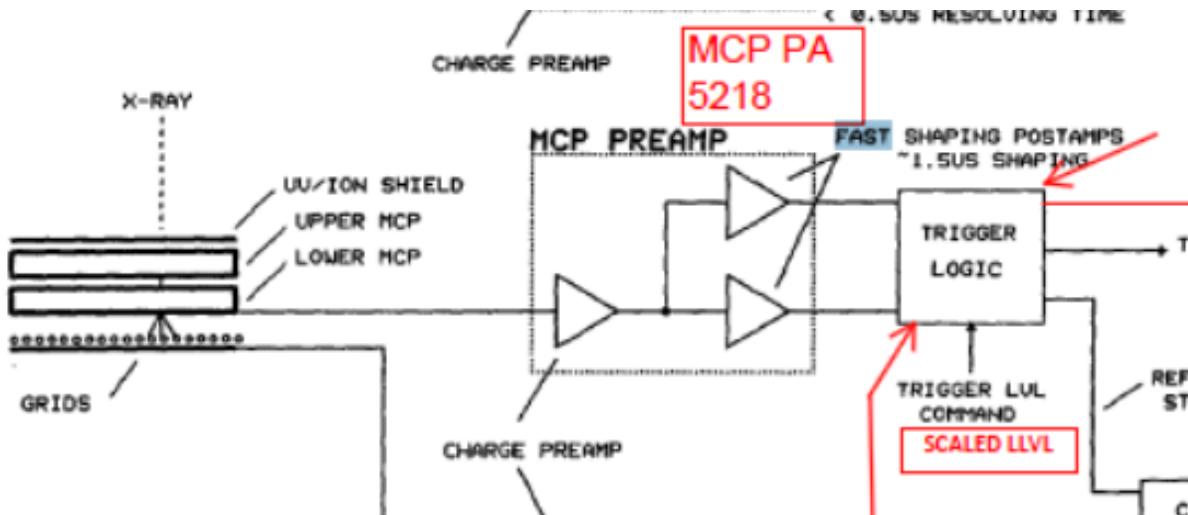
...and gets counted for TOTAL EVENTS



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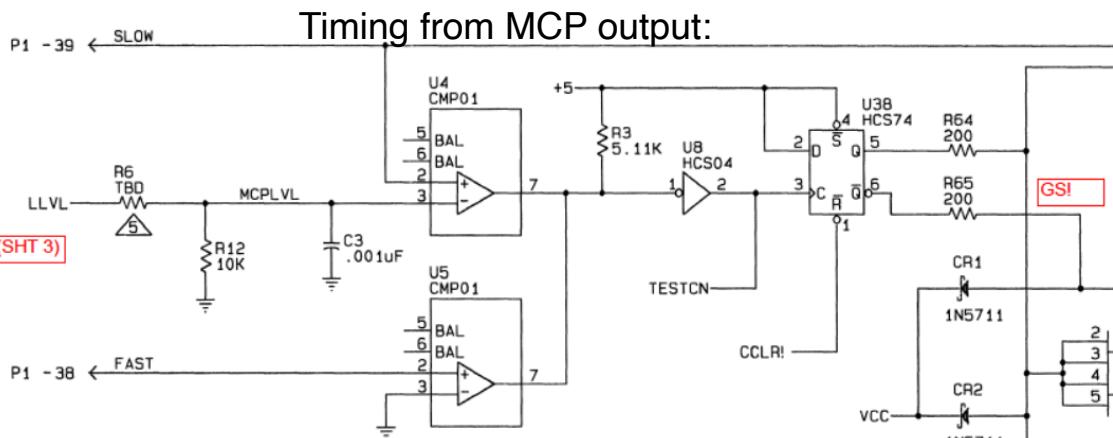
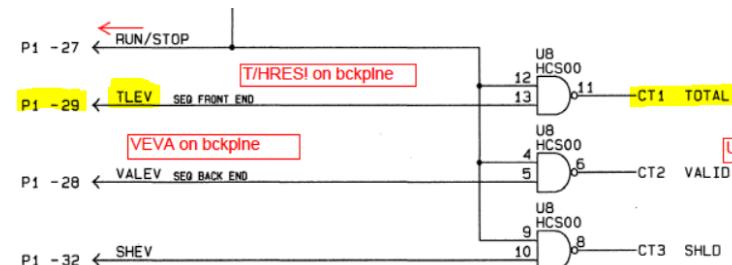
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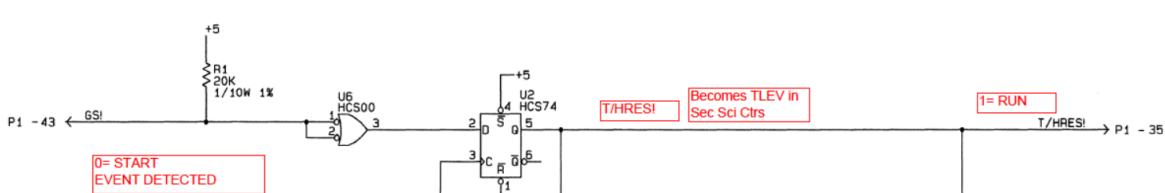
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53	0 8	
54	0 9	
55	0 10	
56	0 11	
57	0 12	
58	0 13	
59	0 14	
60	0 15	
61	0 16	
62	0 17	
63	0 18	
64	0 19	SFDAT7A
65	0 20	SFDAT6A
66	0 21	SFDAT5A
67	0 22	SFDAT4A
68	0 23	SFDAT3A
69	0 24	SFDAT2A
70	0 25	SFDAT1A
71	0 26	SFDAT0A
72	0 27	
73	0 28	VEVA
74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

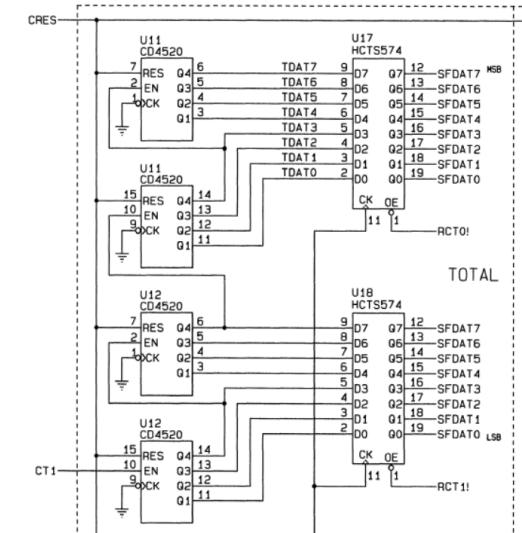
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...and gets counted for TOTAL EVENTS



# Prime and redundant side wiring

## (T. Gauron)

