Chandra X-ray Observatory

The 2020 HRC Anomaly

A successful Side B swap & plans for this week

Chandra Community Briefing

1 September 2020

HRC Operations Team

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CENTER FOR ASTROPHYSICS

HARVARD & SMITHSONIAN

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.

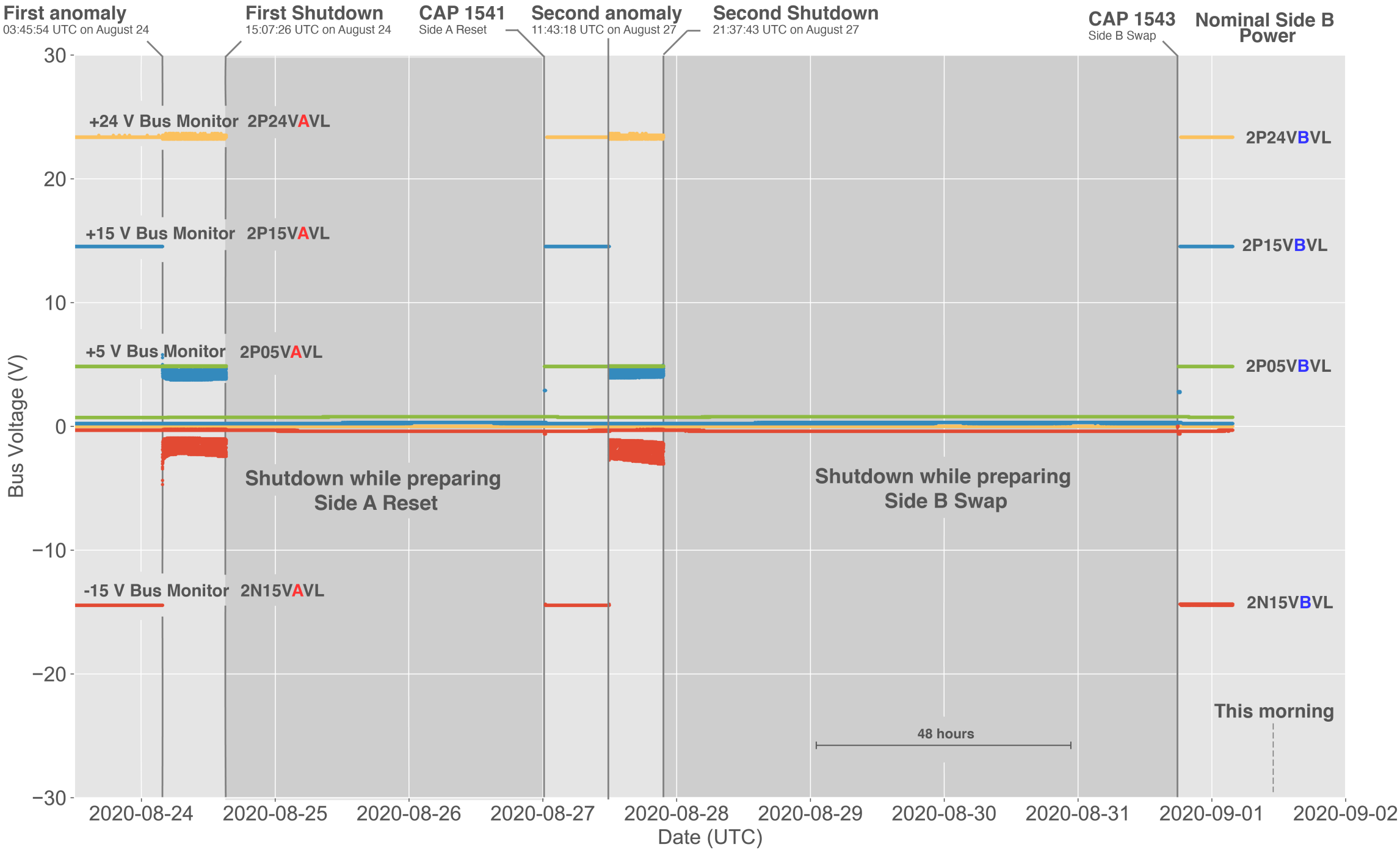
- Our next option was to **swap the HRC’s power configuration to CEA B on the redundant power bus**.

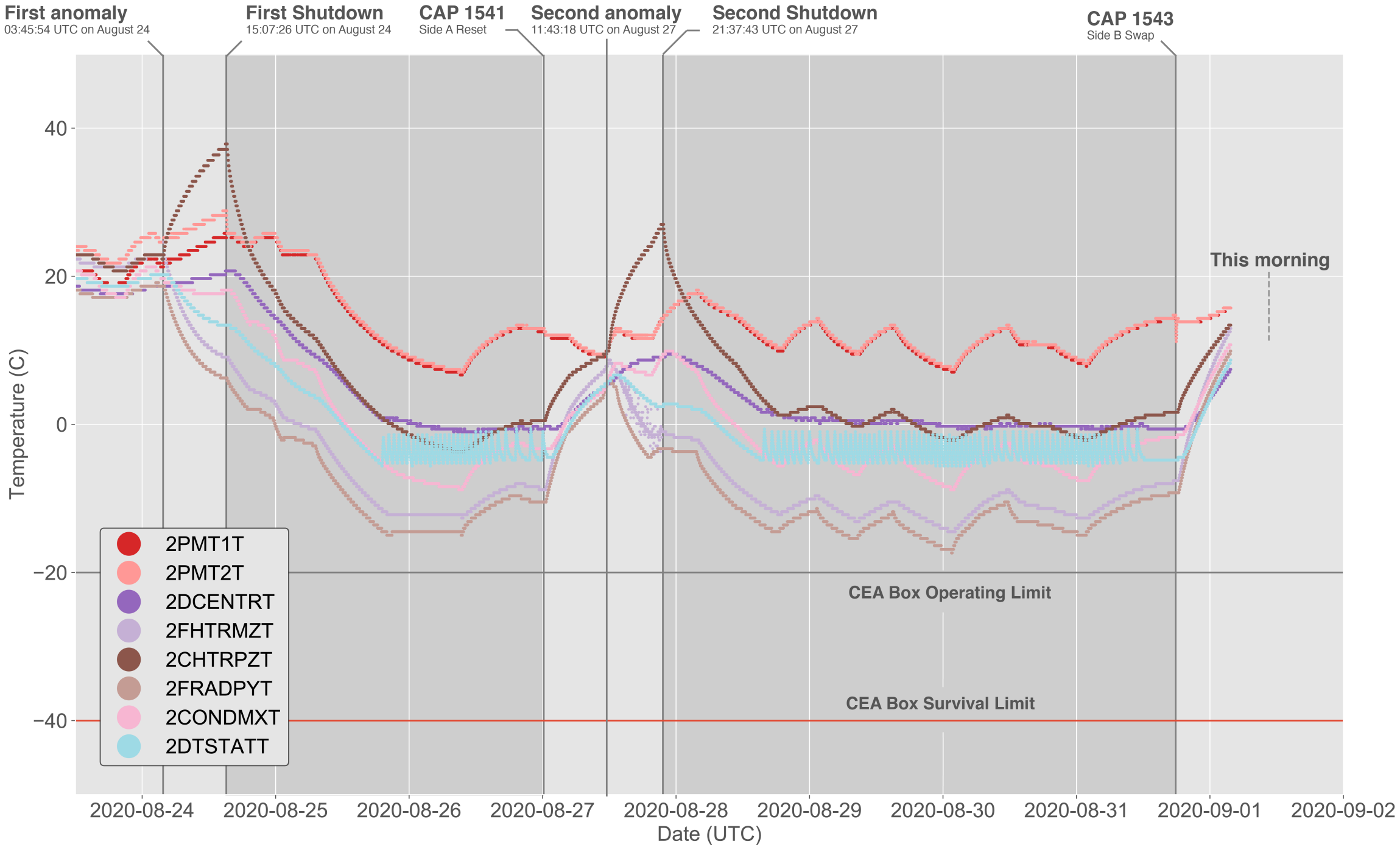
- We **successfully executed the Side B swap** via **CAP 1543** yesterday afternoon.

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.


First anomaly
03:45:54 UTC on August 24
First Shutdown
15:07:26 UTC on August 24
CAP 1541
Side A Reset
Second anomaly
11:43:18 UTC on August 27
Second Shutdown
21:37:43 UTC on August 27
CAP 1543
Side B Swap
Nominal Side B Power
+24 V Bus Monitor 2P24VAVL
+15 V Bus Monitor 2P15VAVL
+5 V Bus Monitor 2P05VAVL
-15 V Bus Monitor 2N15VAVL
2P24VBVL
2P15VBVL
2P05VBVL
2N15VBVL
Shutdown while preparing Side A Reset
Shutdown while preparing Side B Swap
48 hours
This morning
Bus Voltage (V)
30
20
10
0
−10
−20
−30
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
Date (UTC)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Second Shutdown
21:37:43 UTC on August 27
CAP 1543
Side B Swap
This morning
CEA Box Operating Limit
CEA Box Survival Limit
2PMT1T
2PMT2T
2DCENTRT
2FHTRMZT
2CHTRPZT
2FRADPYT
2CONDMXT
2DTSTATT
Temperature (C)
40
20
0
−20
−40
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
Date (UTC)

Plans moving forward

- The HRC Team is now preparing a CAP to interactively power on the PMTs and **bring the anticoincidence shield back online**.
- We could be ready to execute this CAP as early as Wednesday afternoon, but would prefer a longer “soak”.
- **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

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

Power down HRC

Activate SCS #41 - Power-down HRC

turn off primary bus

turn off redundant bus

Reconfigure HRC

power configure HRC to use CEA B with redundant power

turn on redundant bus

(using redundant bus is one less relay to switch)

Power up HRC

power up HRC on CEA B

configure for HRC-I on CEA B

or

configure for HRC-S on CEA B

Needed operational changes

make explicit reference to side A or B:

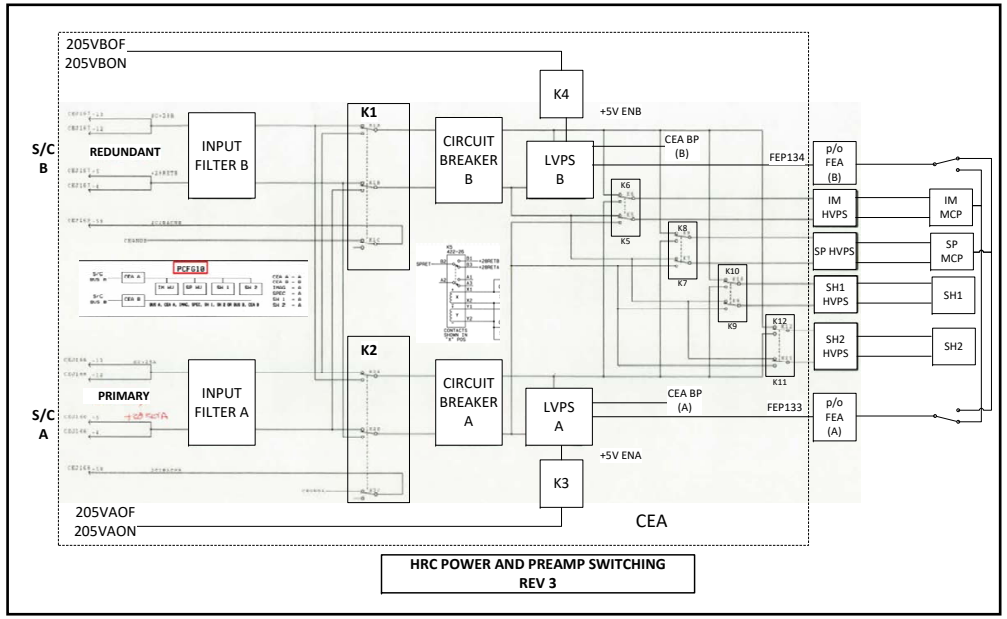
SCS 69 (maybe)

2_I_DEFAULTS.ATS

2_S_DEFAULTS.ATS

(preliminary)

HRC Power Switching



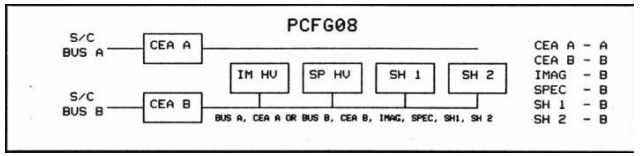
Post-power up HRC

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

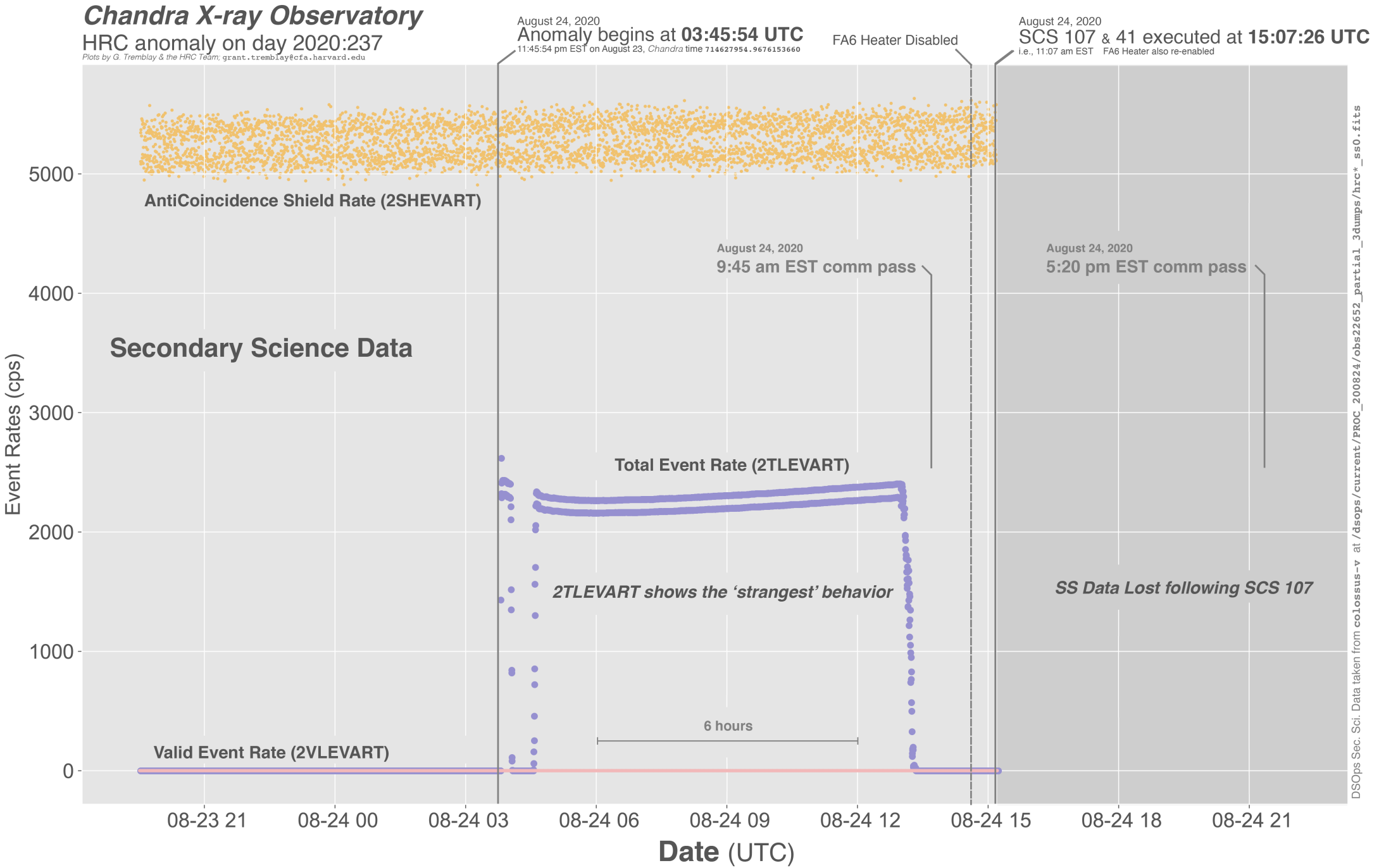
  - **There could be a fault in the electronics on this bus**
    - A load fault that is transient in nature (e.g. an SEL). This should clear with a power cycle.

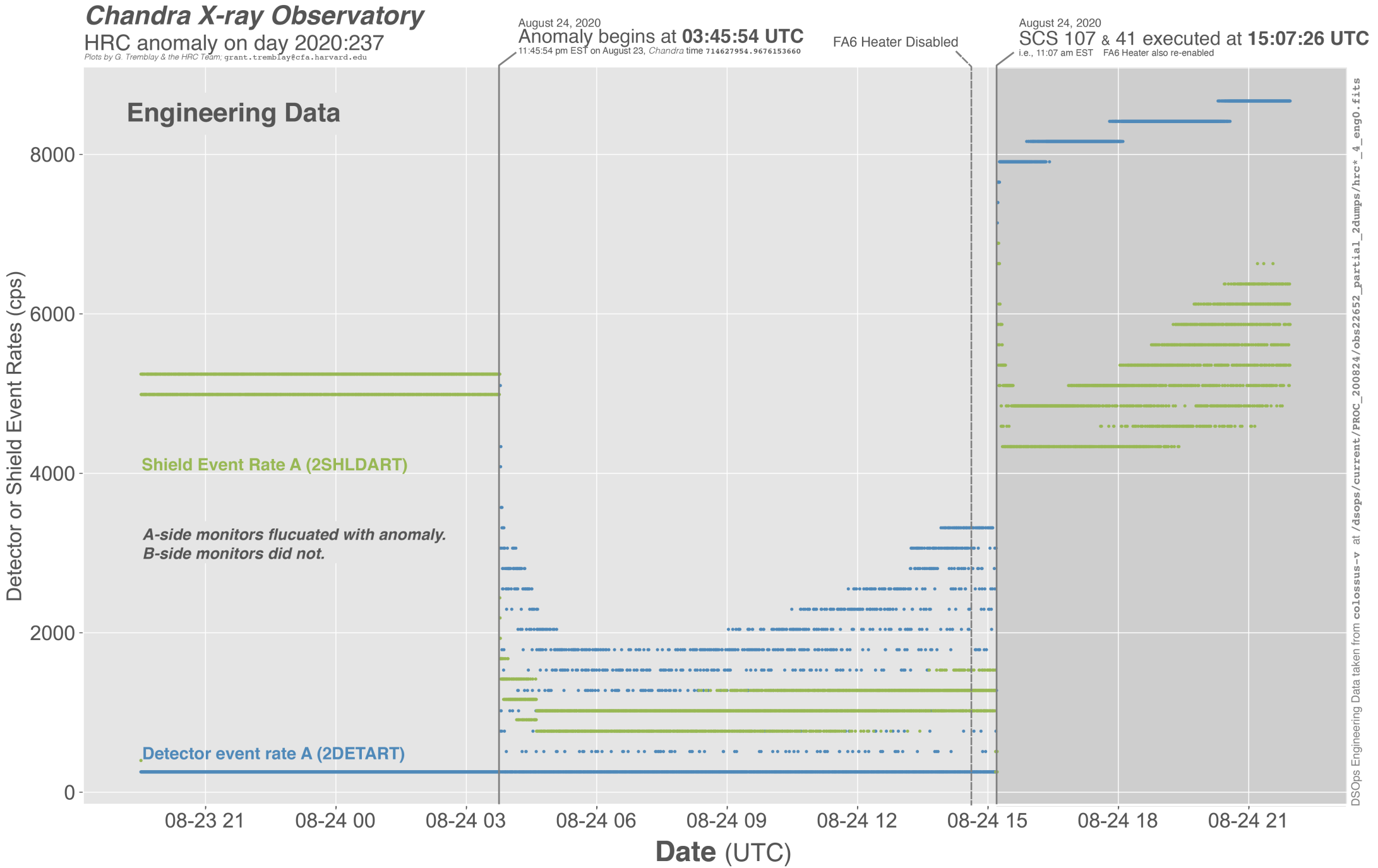
… *or* …

    - 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
August 24, 2020
Anomaly begins at 03:45:54 UTC
11:45:54 pm EST on August 23, Chandra time 714627954.9676153660
FA6 Heater Disabled
August 24, 2020
SCS 107 & 41 executed at 15:07:26 UTC
i.e., 11:07 am EST FA6 Heater also re-enabled
AntiCoincidence Shield Rate (2SHEVART)
August 24, 2020
9:45 am EST comm pass
August 24, 2020
5:20 pm EST comm pass
Secondary Science Data
Total Event Rate (2TLEVART)
2TLEVART shows the 'strangest' behavior
SS Data Lost following SCS 107
6 hours
Valid Event Rate (2VLEVART)
Event Rates (cps)
5000
4000
3000
2000
1000
0
08-23 21
08-24 00
08-24 03
08-24 06
08-24 09
08-24 12
08-24 15
08-24 18
08-24 21
Date (UTC)
DSOps Sec. Sci. Data taken from colossus-v at /dsops/current/PROC_200824/obs22652_partial_3dumps/hrc*_ss0.fits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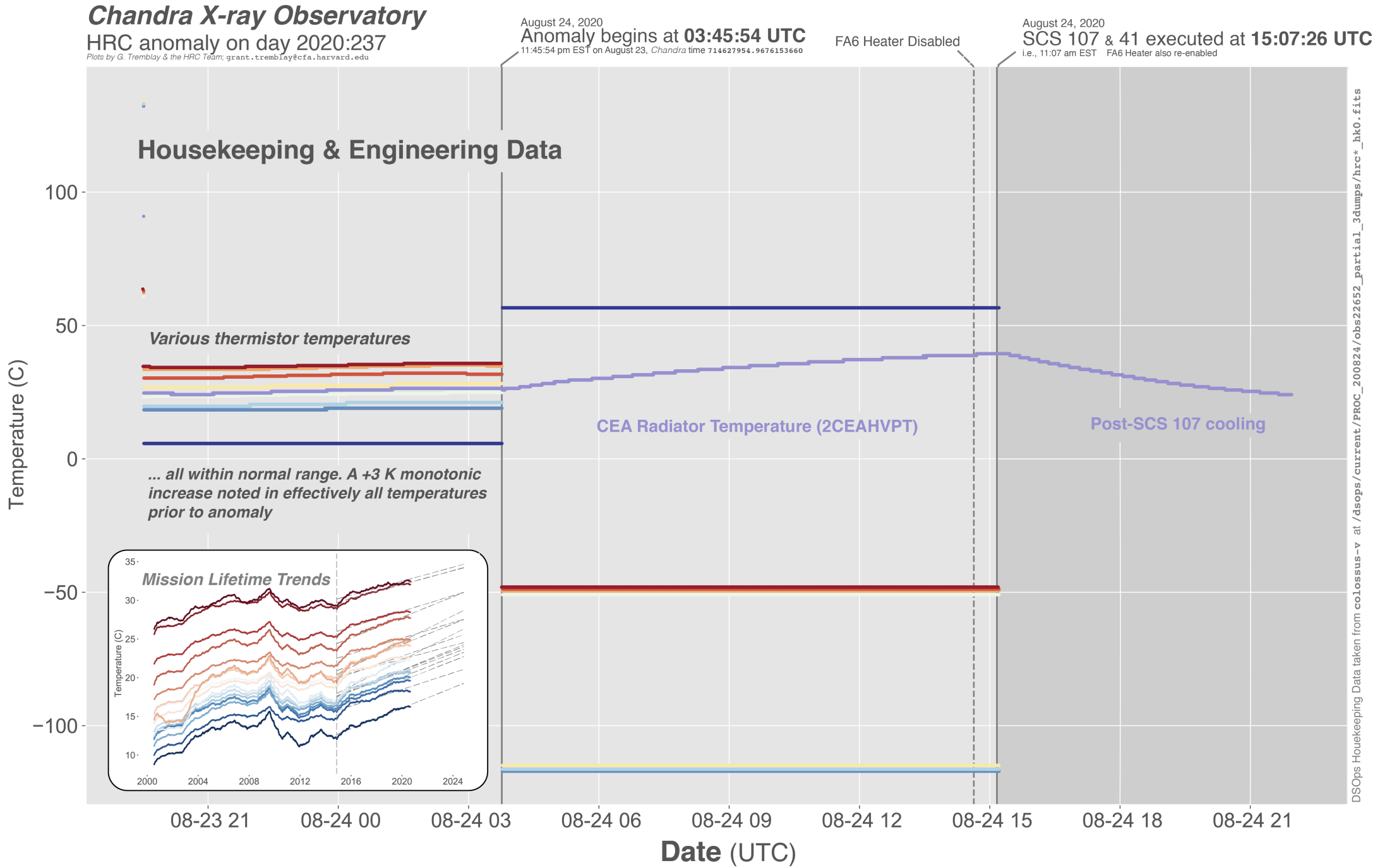
Engineering Data
Shield Event Rate A (2SHLDART)
A-side monitors flucuated with anomaly.
B-side monitors did not.
Detector event rate A (2DETART)
Detector or Shield Event Rates (cps)
0
2000
4000
6000
8000
08-23 21
08-24 00
08-24 03
08-24 06
08-24 09
08-24 12
08-24 15
08-24 18
08-24 21
Date (UTC)
DSOps Engineering Data taken from colossus-v at /dsops/current/PROC_200824/obs22652_partial_2dumps/hrc*_4_eng0.fits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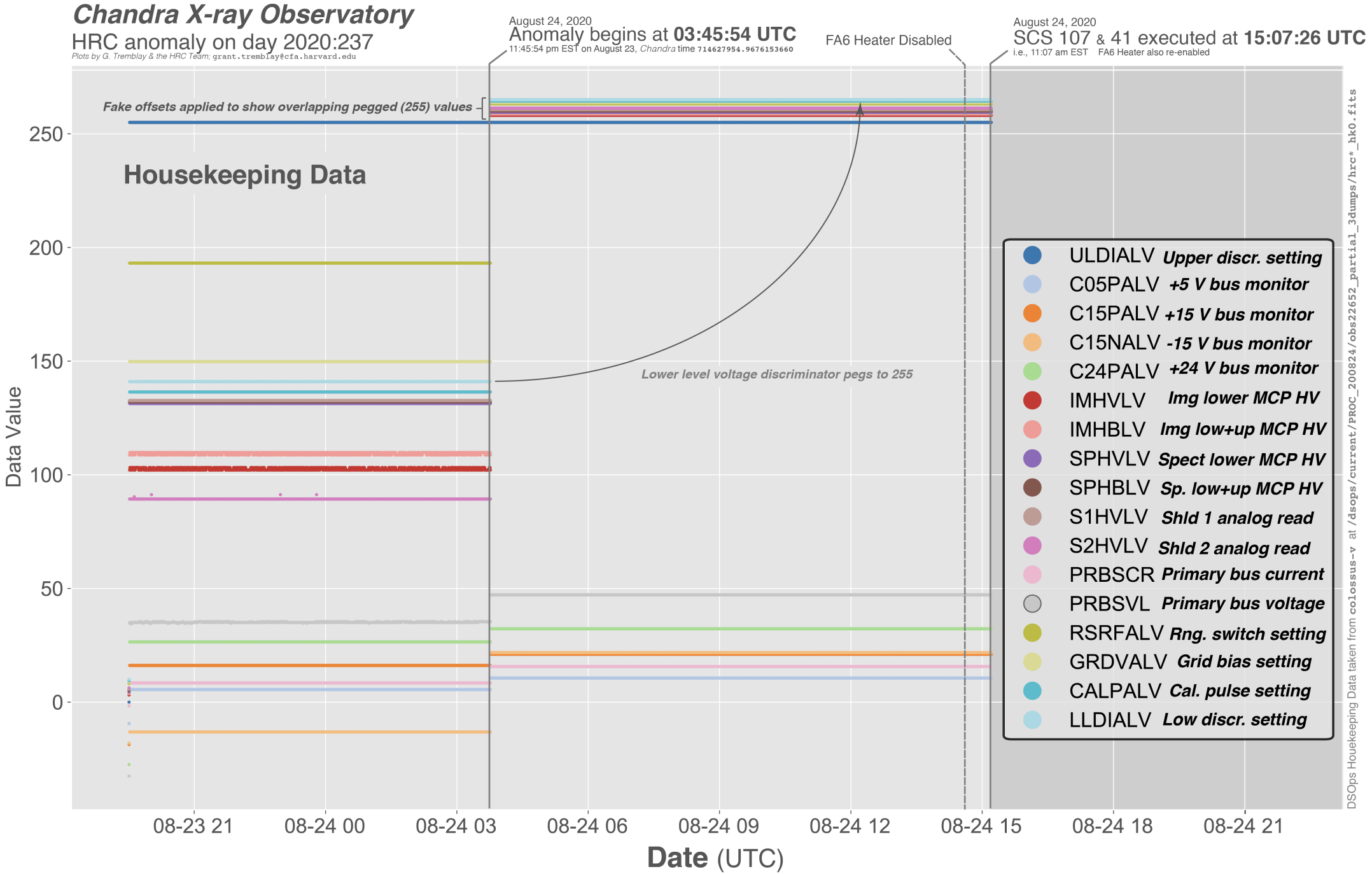
Housekeeping & Engineering Data
Various thermistor temperatures
... all within normal range. A +3 K monotonic increase noted in effectively all temperatures prior to anomaly
CEA Radiator Temperature (2CEAHVPT)
Post-SCS 107 cooling
Mission Lifetime Trends
Temperature (C)
100
50
0
−50
−100
08-23 21
08-24 00
08-24 03
08-24 06
08-24 09
08-24 12
08-24 15
08-24 18
08-24 21
Date (UTC)
DSOps Houekeeping Data taken from colossus-v at /dsops/current/PROC_200824/obs22652_partial_3dumps/hrc*_hk0.fits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FA6 Heater Disabled
August 24, 2020
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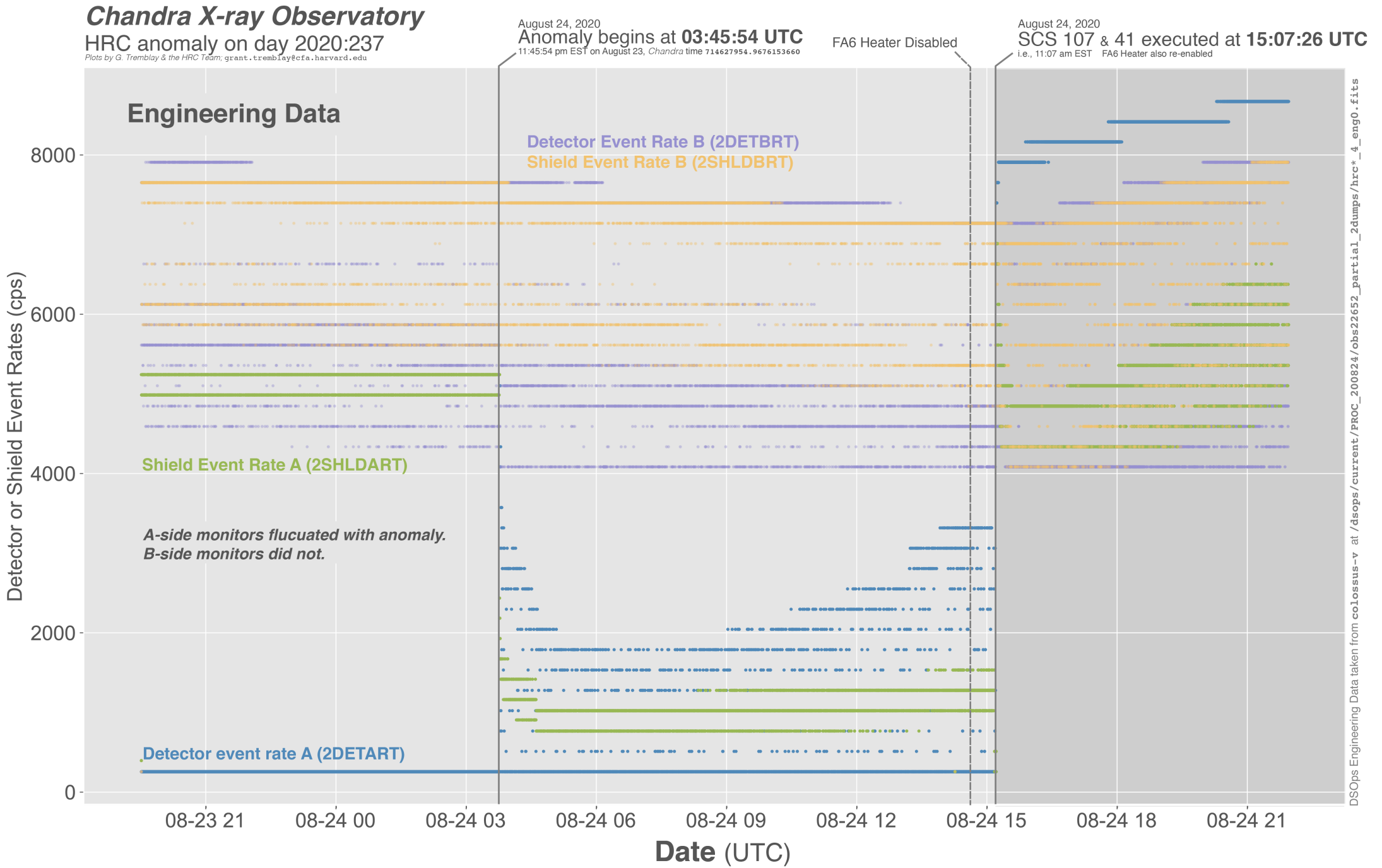
i.e., 11:07 am EST FA6 Heater also re-enabled
Fake offsets applied to show overlapping pegged (255) values
Housekeeping Data
Lower level voltage discriminator pegs to 255
Data Value
250
200
150
100
50
0
08-23 21
08-24 00
08-24 03
08-24 06
08-24 09
08-24 12
08-24 15
08-24 18
08-24 21
Date (UTC)
ULDIALV Upper discr. setting
C05PALV +5 V bus monitor
C15PALV +15 V bus monitor
C15NALV -15 V bus monitor
C24PALV +24 V bus monitor
IMHVLV Img lower MCP HV
IMHBLV Img low+up MCP HV
SPHVLV Spect lower MCP HV
SPHBLV Sp. low+up MCP HV
S1HVLV Shld 1 analog read
S2HVLV Shld 2 analog read
PRBSCR Primary bus current
PRBSVL Primary bus voltage
RSRFALV Rng. switch setting
GRDVALV Grid bias setting
CALPALV Cal. pulse setting
LLDIALV Low discr. setting
DSOps Houekeeping Data taken from colossus-v at /dsops/current/PROC_200824/obs22652_partial_3dumps/hrc*_hk0.fits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Engineering Data
Detector Event Rate B (2DETBRT)
Shield Event Rate B (2SHLDBRT)
Shield Event Rate A (2SHLDART)
A-side monitors flucuated with anomaly.
B-side monitors did not.
Detector event rate A (2DETART)
Detector or Shield Event Rates (cps)
8000
6000
4000
2000
0
08-23 21
08-24 00
08-24 03
08-24 06
08-24 09
08-24 12
08-24 15
08-24 18
08-24 21
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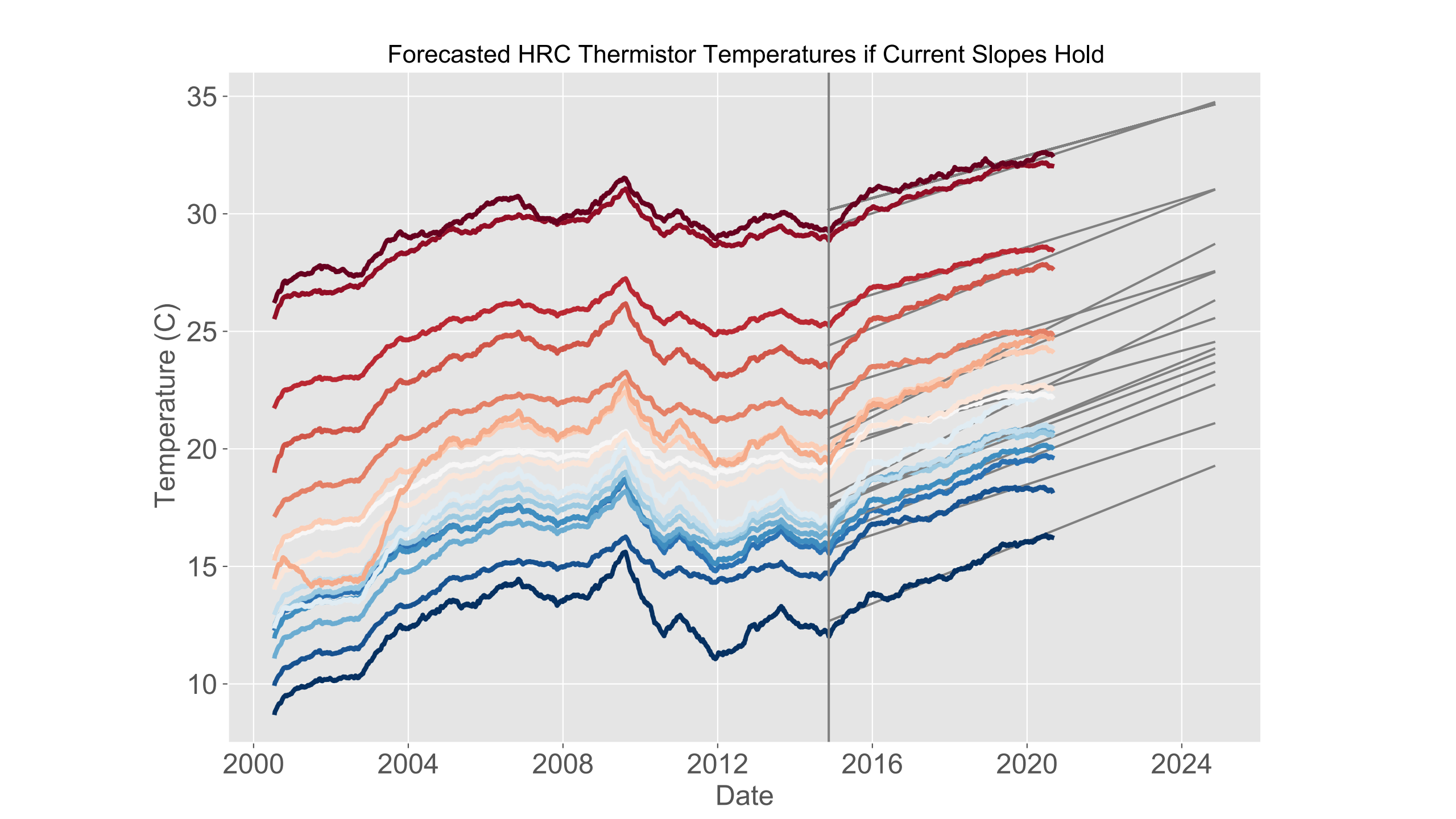
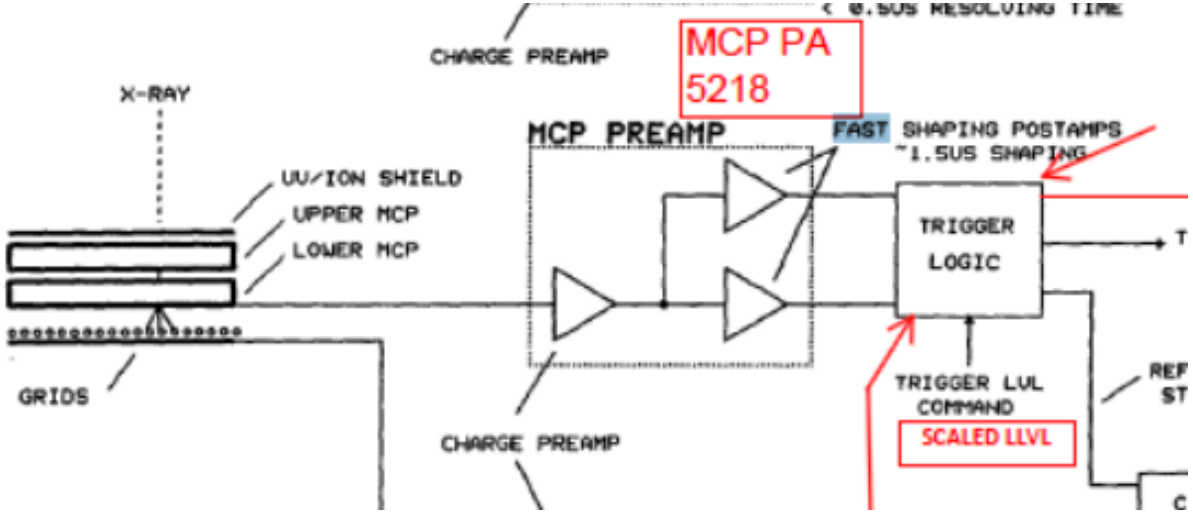
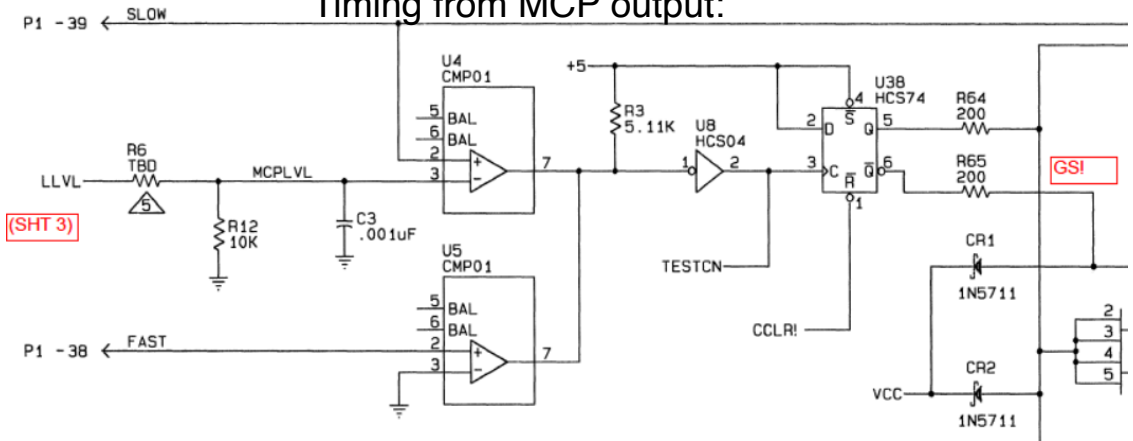

Forecasted HRC Thermistor Temperatures if Current Slopes Hold
Temperature (C)
35
30
25
20
15
10
2000
2004
2008
2012
2016
2020
2024
Date

Explanation of trigger noise
(T. Gauron)

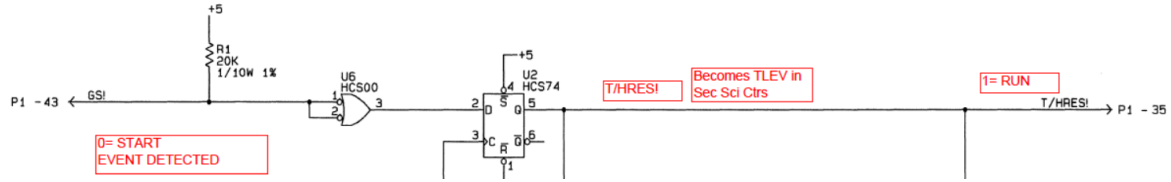
Top Level Trigger from MCP output:



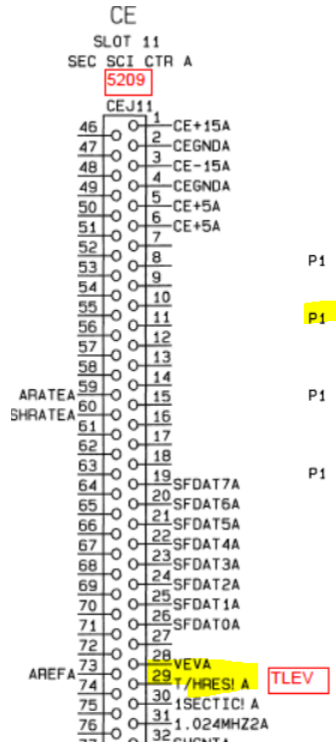
Timing from MCP output:



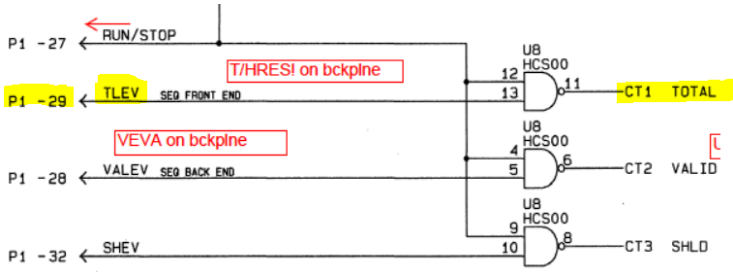
GS! is synced with S/C clock and becomes T/HRES! in SEQUENCER



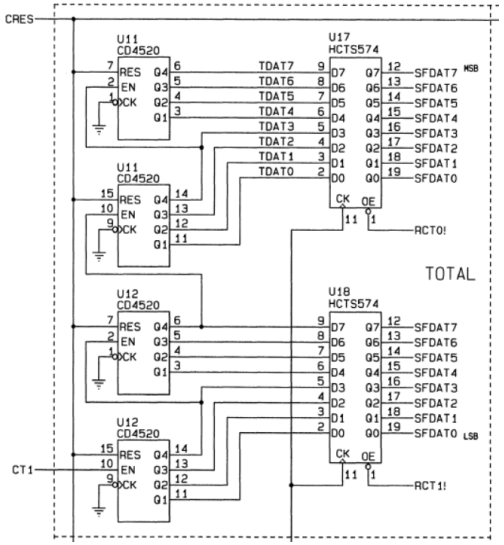
T/HRES! Routes to SEC_SCI_CTR pin 29 on backplane



It's called TLEV on the SEC_SCI PWA



…and gets counted for TOTAL EVENTS



Explanation of trigger noise
(T. Gauron)

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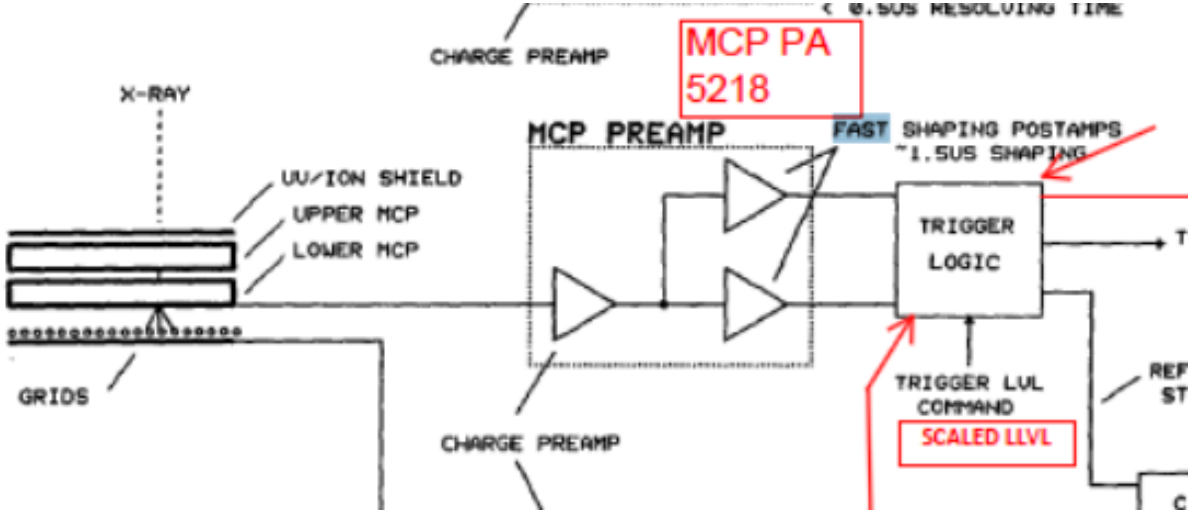

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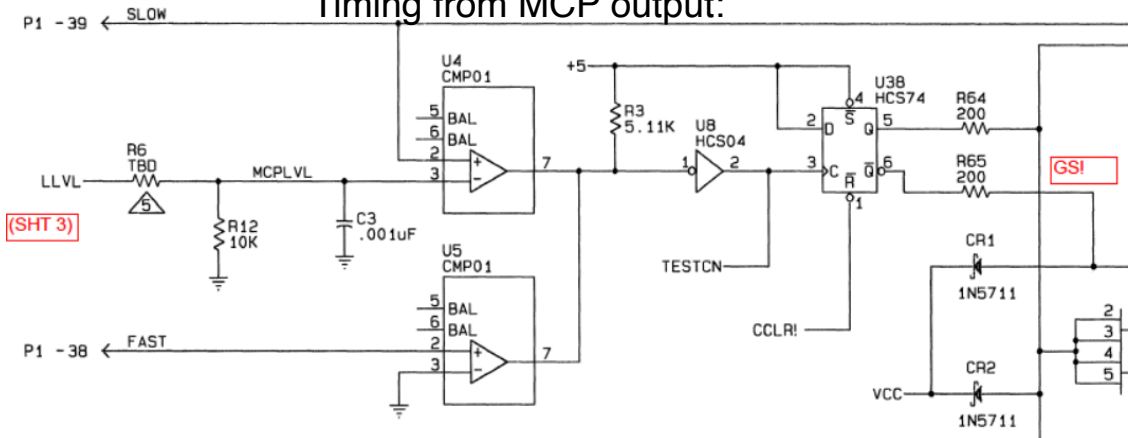
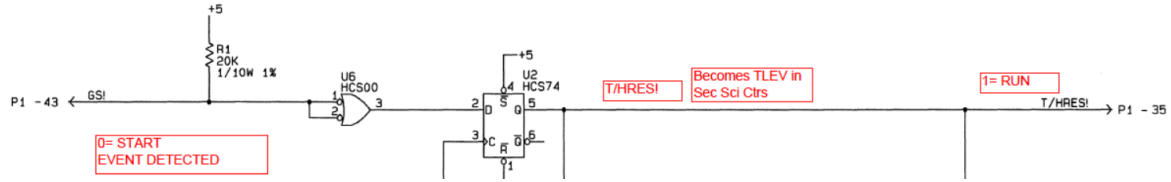


GS! is synced with S/C clock and becomes T/HRES! in SEQUENCER



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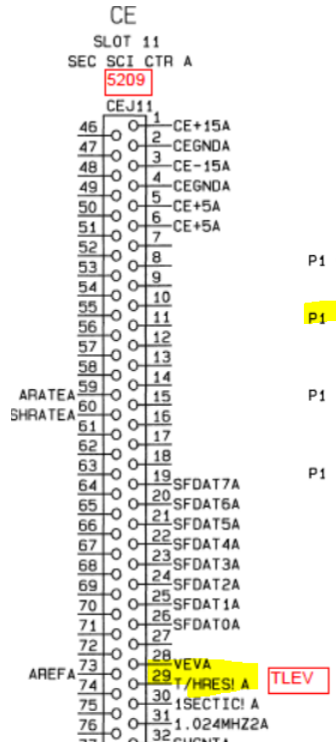

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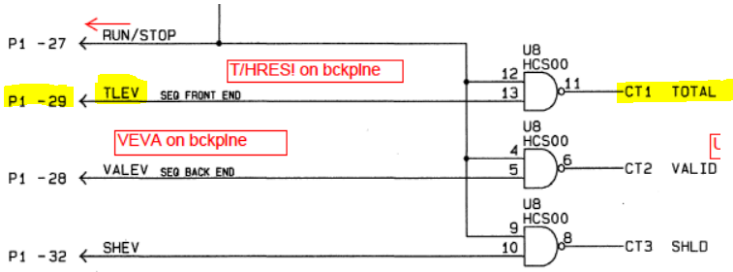
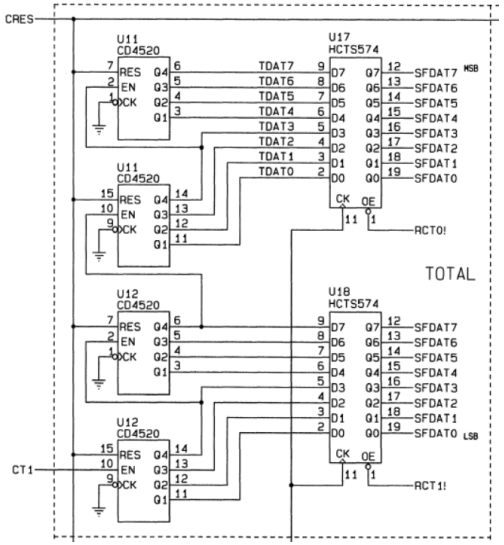


…and gets counted for TOTAL EVENTS



Prime and redundant side wiring

(T. Gauron)