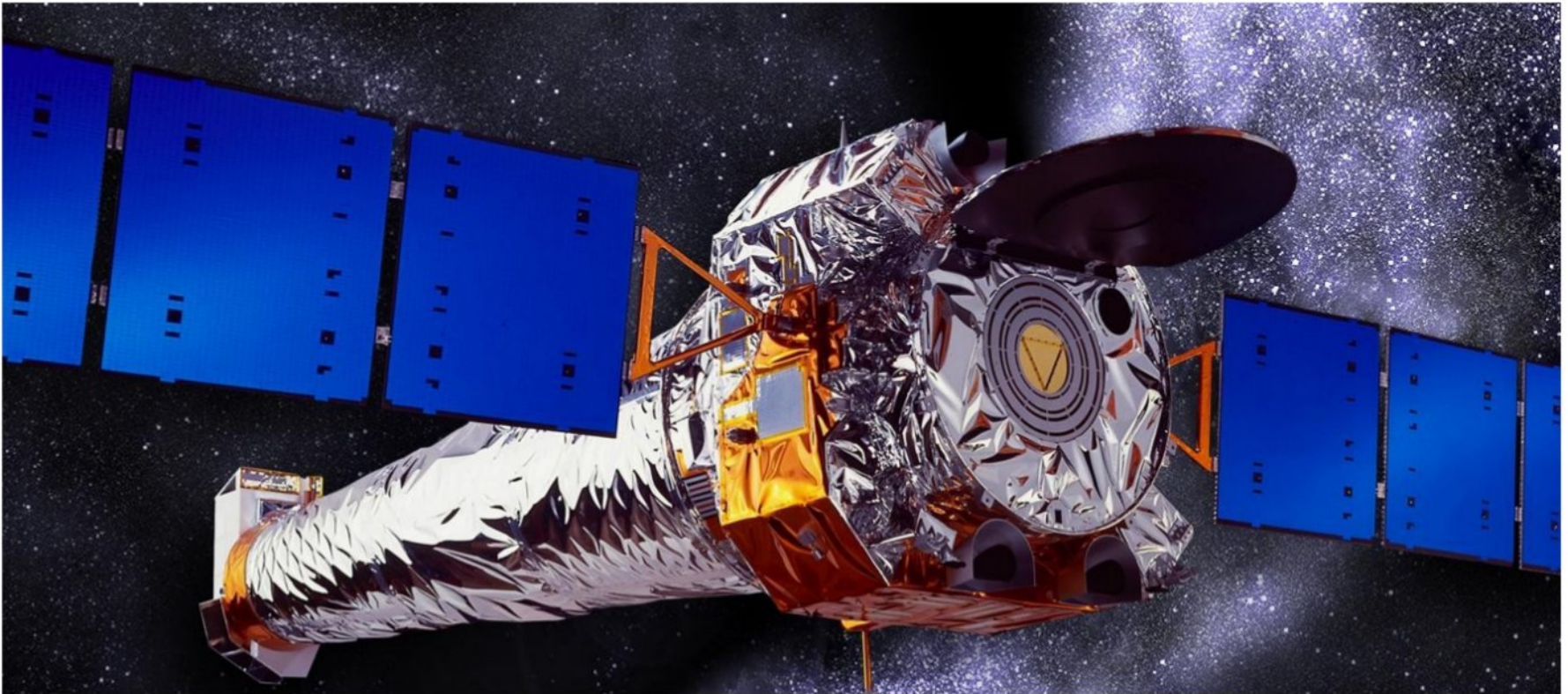


Increasing the 1DPAMZT Planning, Yellow and Red Limits,



Smithsonian

NORTHROP GRUMMAN

Proposed Limit Increase

Raise the 1DPAMZT Planning, Yellow, and Red High Limits by 1° C.

Present:

Red High: +40.5° C

Caution Yellow Limit: +38.5° C

Model Error: 2.0° C

Planning Limit: + 36.5° C

Proposed:

Red High: +41.5° C

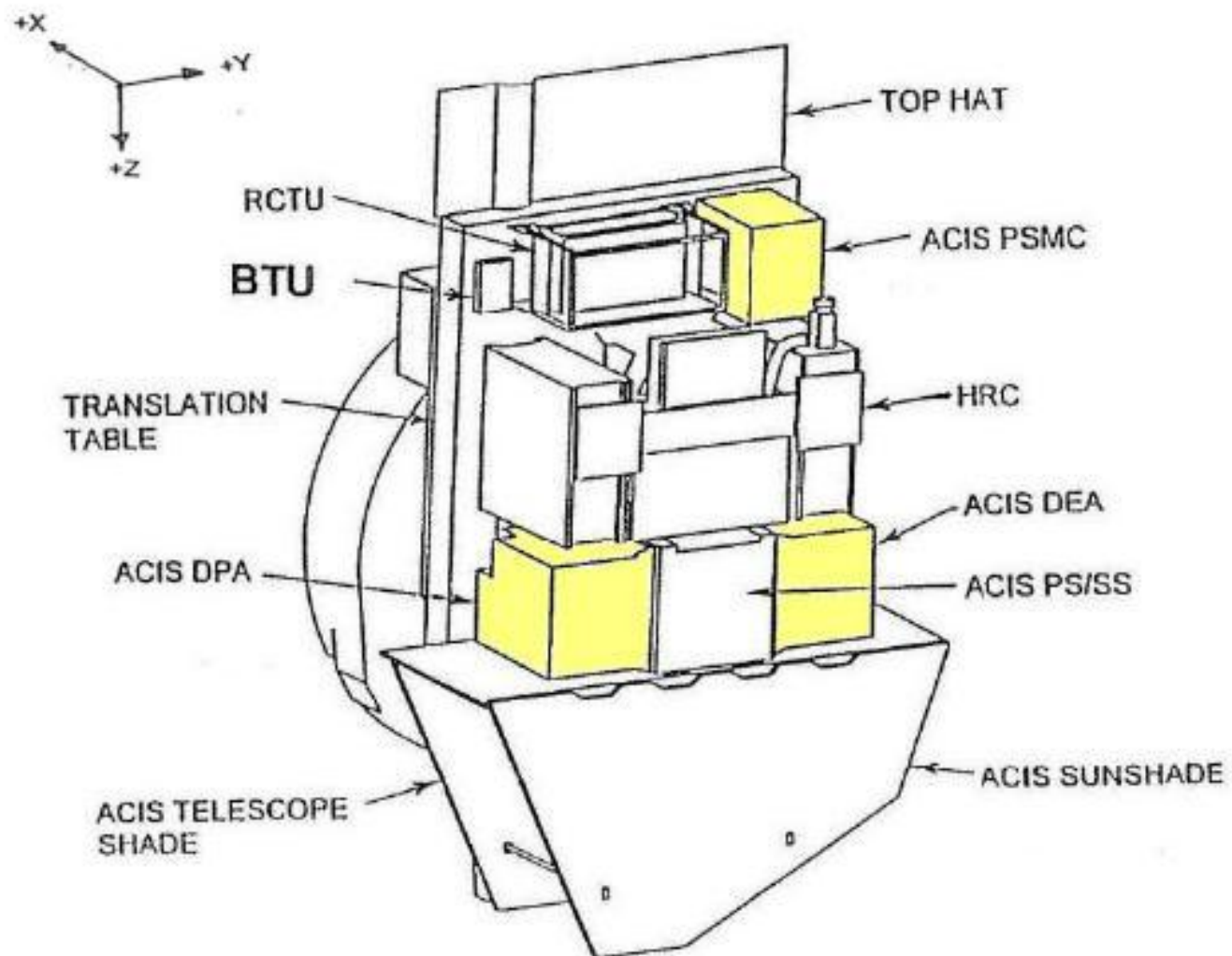
Caution Yellow Limit: +39.5° C

Model Error: 2.0° C

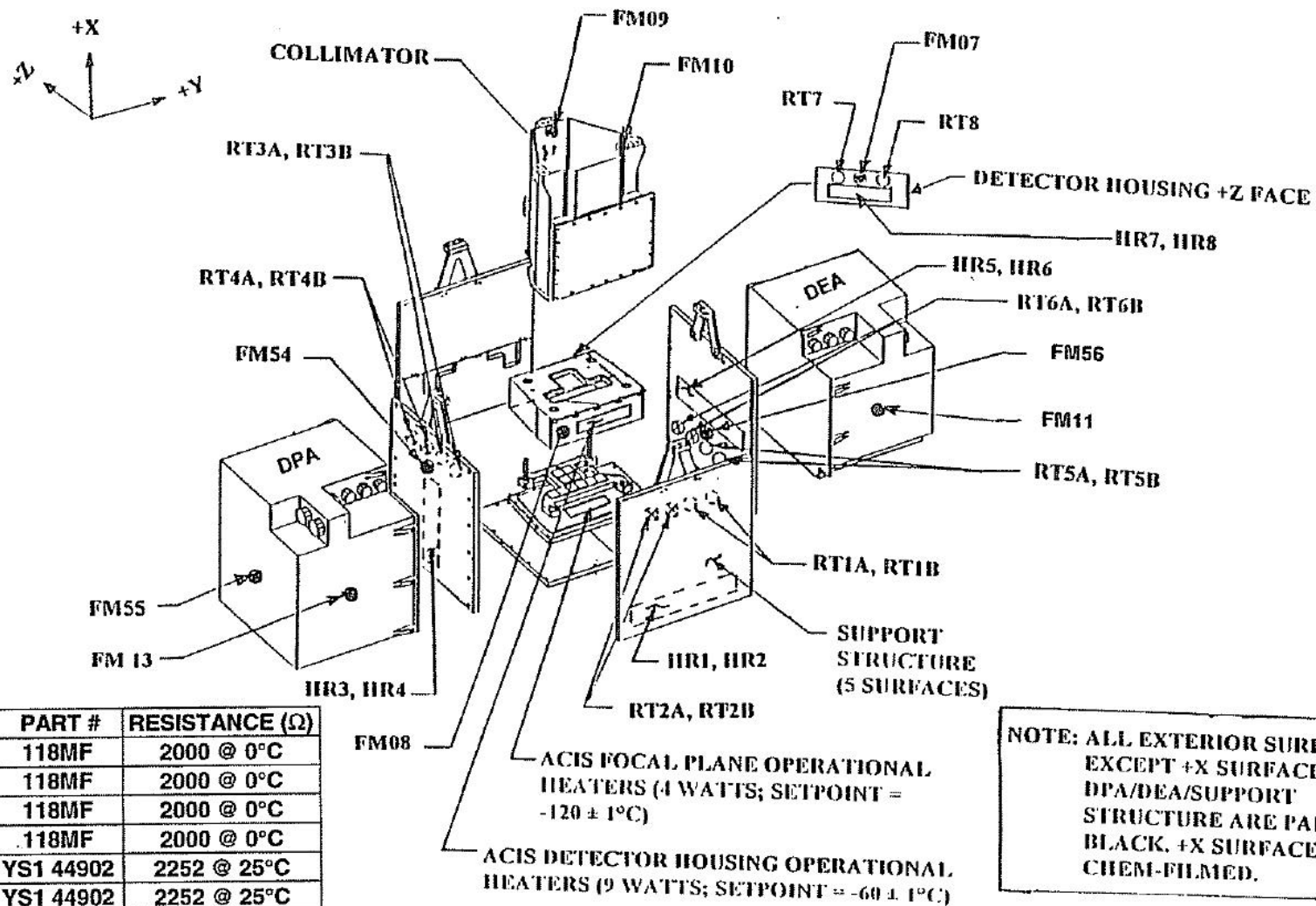
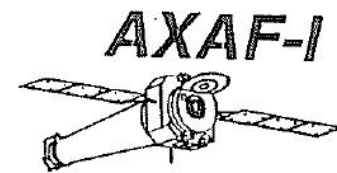
Planning Limit: + 37.5° C

Description of 1DPAMZT

- 1DPAMZT DPA Minus Z Panel Temperature
- External Thermistor located on the ACIS Digital Processor Assembly (DPA) which contains the Back End Processors (BEPs) and the Front End Processors (FEPs).



ACIS SS & DETECTOR HOUSING TRIM & SURVIVAL HEATERS & TEMP. TELEMETRY



ID	MNEMONIC	PART #	RESISTANCE (Ω)
FM07	1CBAT	118MF	2000 @ 0°C
FM08	1CBBT	118MF	2000 @ 0°C
FM09	DELETED	118MF	2000 @ 0°C
FM10	1DACTBT	118MF	2000 @ 0°C
FM11	1DEAMZT	YS1 44902	2252 @ 25°C
FM13	1DPAMZT	YS1 44902	2252 @ 25°C
FM54	1SSMYT	YS1 44902	2252 @ 25°C
FM55	1DPAMYT	YS1 44902	2252 @ 25°C
FM56	1SSPYT	YS1 44902	2252 @ 25°C

K-35

What Does 1DPAMZT Tell Us?

- Thermistor measures temperature of the Minus Z Panel – the box.
- Used as a proxy for the BEP and FEP Board temperatures because BEP/FEP temps appear in ACIS Housekeeping (science) data
 - OCC has no insight into BEP/FEP Thermistor values
- BEP/FEP Board temps are the **KEY** values.
 - Temp of aluminum box not of direct value.

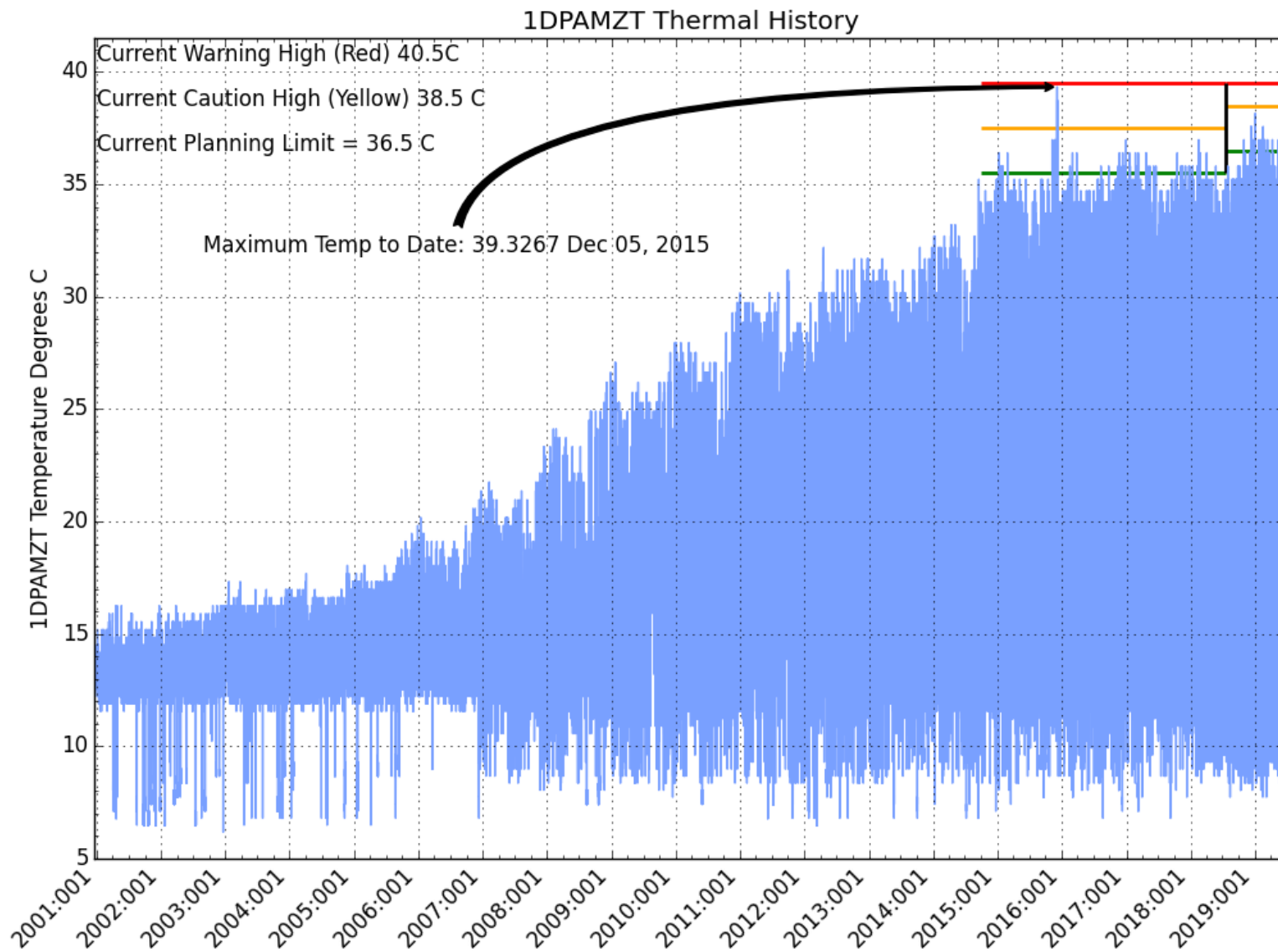
1DPAMZT as a BEP/FEP Proxy

1DPAMZT: R/W: +40.5 Y/C: +38.5 P/L: + 36.5

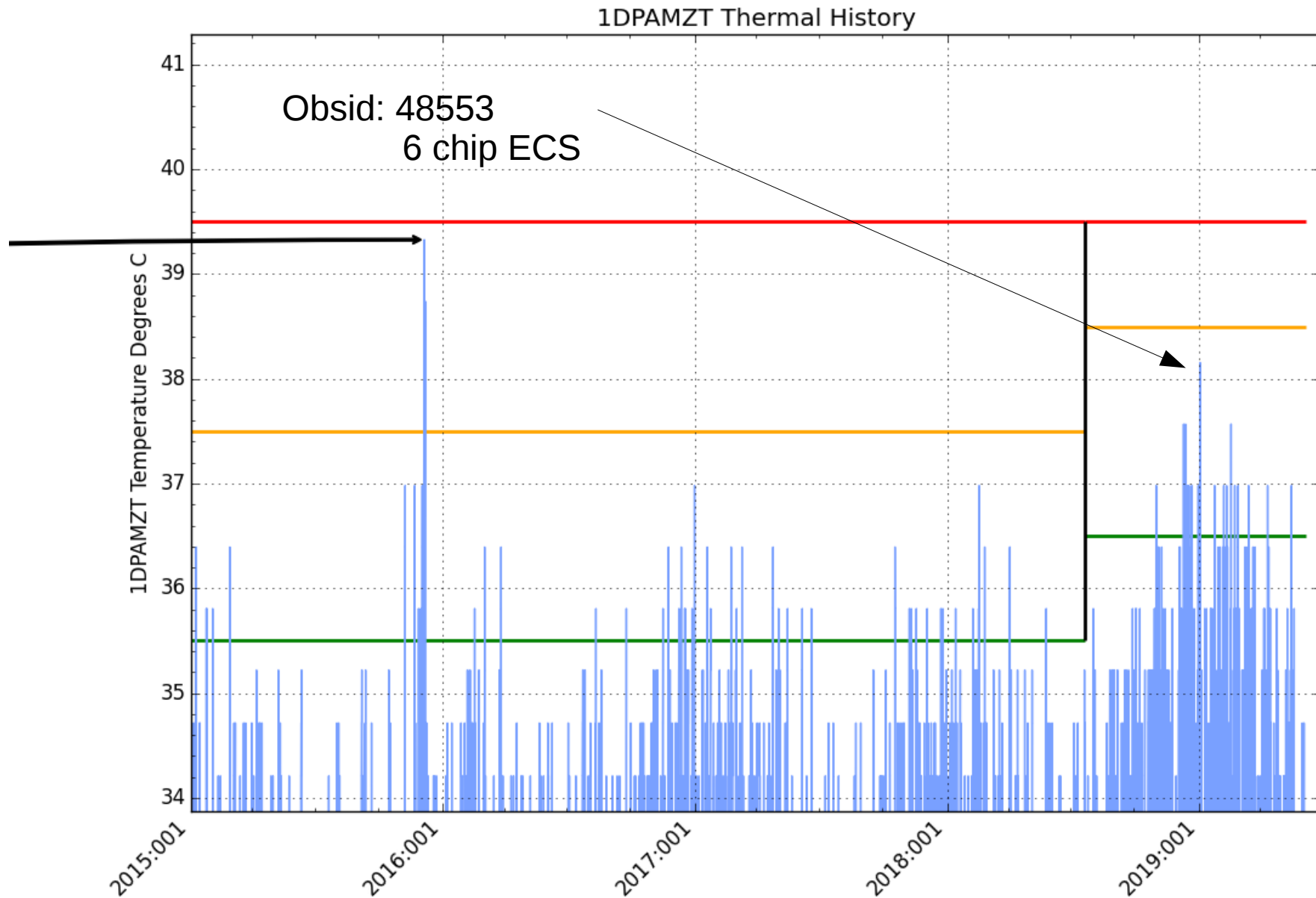
# Channel	ccd	size	red_lo	yel_lo	yel_hi	red_hi	# Description
#-----							
ADC_TMP_BEP_PCB	10	3	-10.0	6.5	44.0	49.0	# DPA Thermistor 1 - BEP PC Board
ADC_TMP_BEP_OSC	10	3	-10.0	6.5	42.0	47.0	# DPA Thermistor 2 - BEP Oscillator
ADC_TMP_FEP0_MONG	10	3	-10.0	0.0	48.0	53.0	# DPA Thermistor 3 - FEP 0 Mongoose
ADC_TMP_FEP0_PCB	10	3	-10.0	0.0	45.0	50.0	# DPA Thermistor 4 - FEP 0 PC Board
ADC_TMP_FEP0_ACTEL	10	3	-10.0	0.0	47.0	52.0	# DPA Thermistor 5 - FEP 0 ACTEL
ADC_TMP_FEP0_RAM	10	3	-10.0	0.0	46.0	51.0	# DPA Thermistor 6 - FEP 0 RAM
ADC_TMP_FEP0_FB	10	3	-10.0	0.0	43.0	48.0	# DPA Thermistor 7 - FEP 0 Frame Buf
ADC_TMP_FEP1_MONG	10	3	-10.0	0.0	49.0	54.0	# DPA Thermistor 8 - FEP 1 Mongoose
ADC_TMP_FEP1_PCB	10	3	-10.0	0.0	46.0	51.0	# DPA Thermistor 9 - FEP 1 PC Board
ADC_TMP_FEP1_ACTEL	10	3	-10.0	0.0	48.0	53.0	# DPA Thermistor 10 - FEP 1 ACTEL
ADC_TMP_FEP1_RAM	10	3	-10.0	0.0	48.0	53.0	# DPA Thermistor 11 - FEP 1 RAM
ADC_TMP_FEP1_FB	10	3	-10.0	0.0	43.0	48.0	# DPA Thermistor 12 - FEP 1 Frame Buf

These limits approved by MIT ACIS Instrument Team September 19, 2017

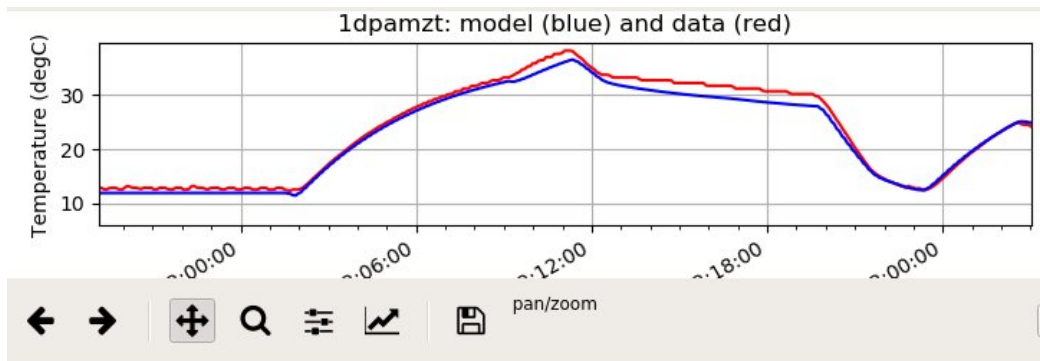
We model BEP PCB, FEP1 Mong and FEP1 ACTEL because they run the hottest. We track violations for FEP0/FEP1 Mong, ACTEL, FB, and BEP OSC and PCB.



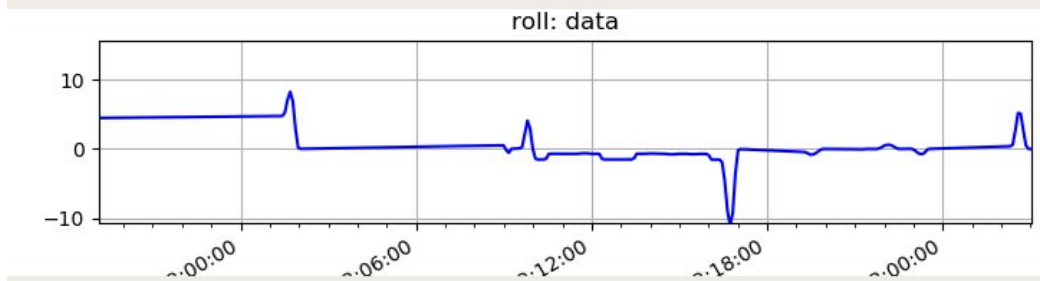
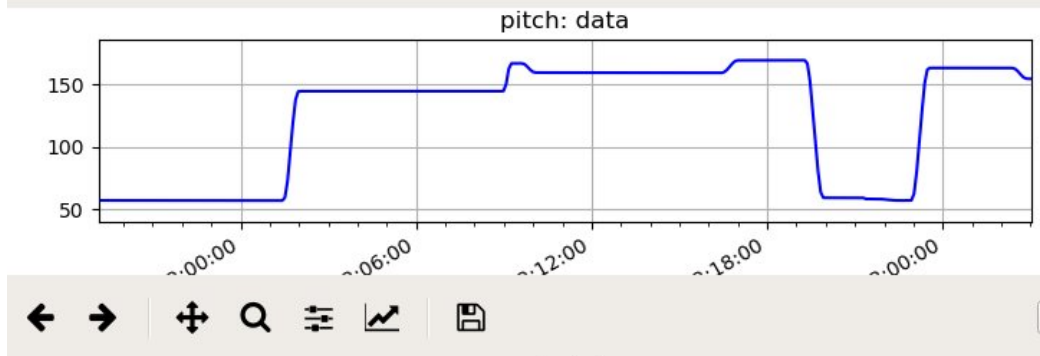
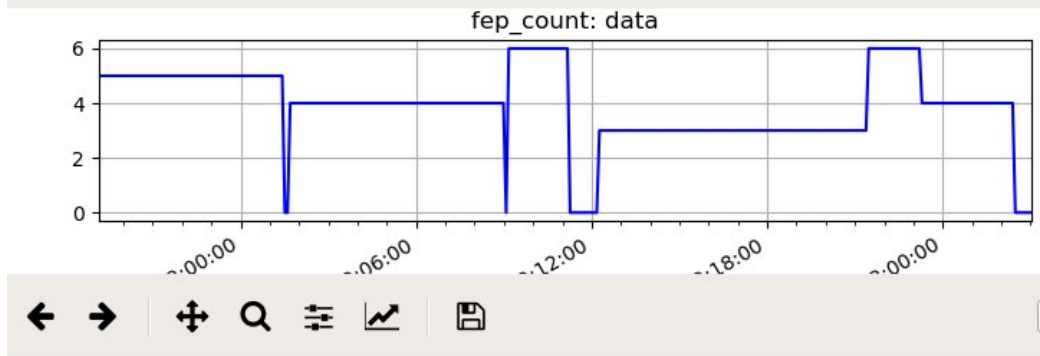
19 P.L. violations since the last limit increase. None hit the Yellow Caution Limit.



Worst Case Violation Since the Last Limit increase (Production Model)



~2.26 degree under-prediction



No Yellow Caution Limit violation since Dec. 2015

So long as the Thermal Model maintains its 2°C accuracy, FOT MP can build plans which avoid Yellow Caution violations.

1DPAMZT measures the temperature of a metal box. It's actual value is not a Health & Safety issue. No credible failure mechanism for 1DPAMZT if it hits 41.5°C.

The critical temperatures are the FEP/BEP boards.

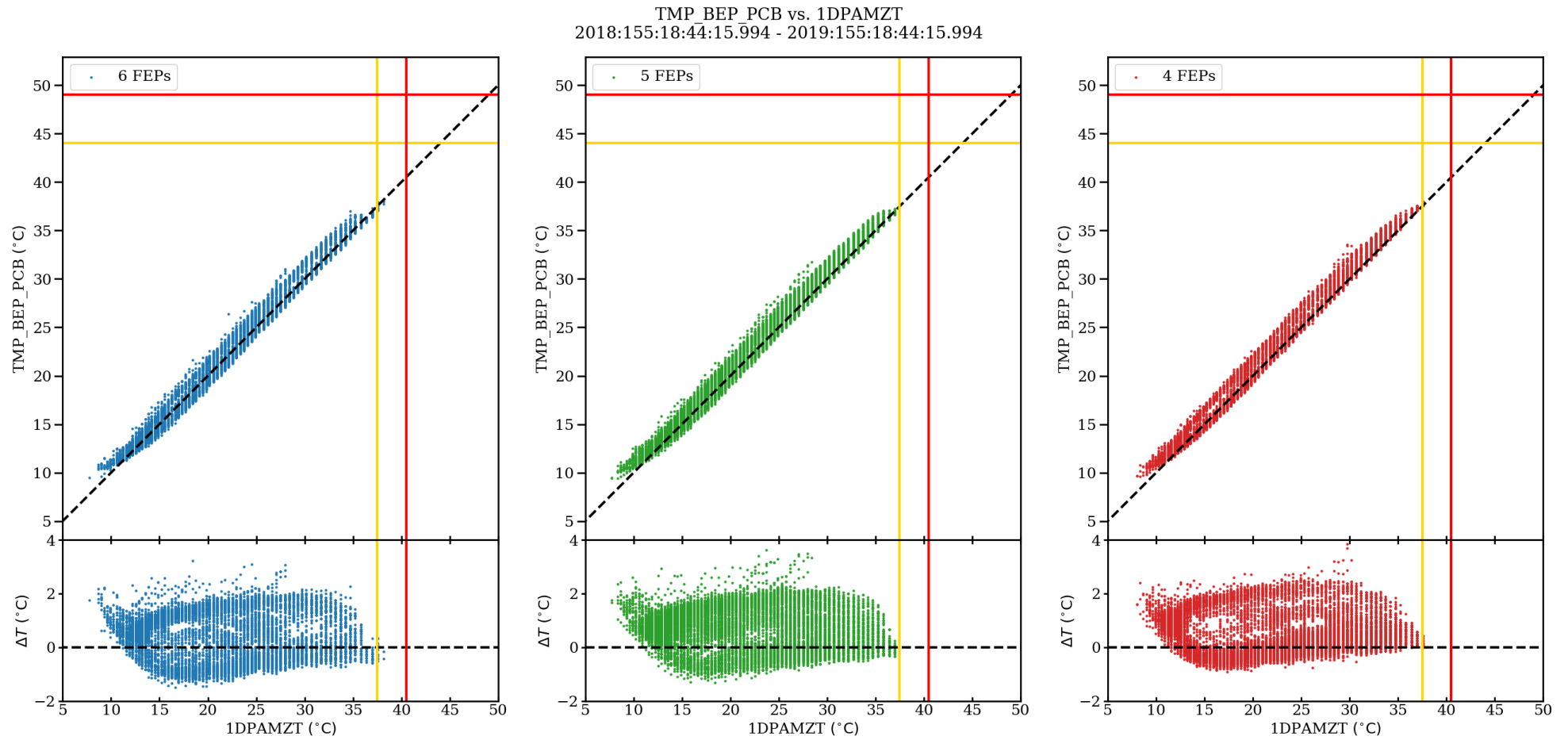
So can we safely move the 1DPAMZT Red High Warning limit one degree and still keep the FEPs/BEPs safe?

ACIS Ops studied the thermal risks to the DPA P.C. boards by raising the 1DPAMZT Red High Warning Limit.

The ACIS Instrument team believes the answer is yes because:

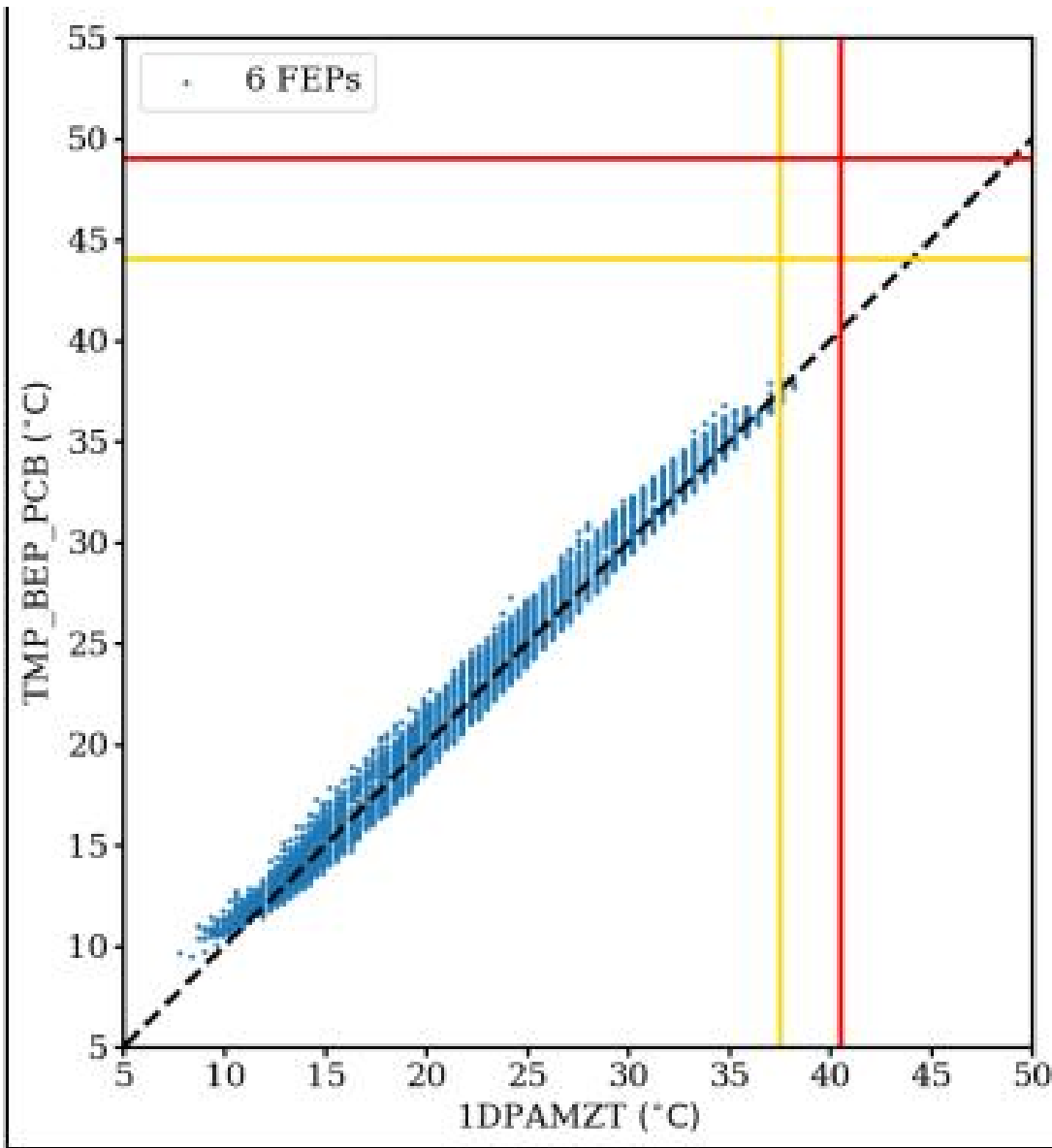
- margin available with the BEP/FEP temperatures.
- Experience with models and Mission planning.

BEP PCB v 1DPAMZT



1DPAMZT as a BEP/FEP Proxy (con't)

BEP PCB v 1DPAMZT 6 FEPs (One Year of Data)



49.0°C

44.0°C

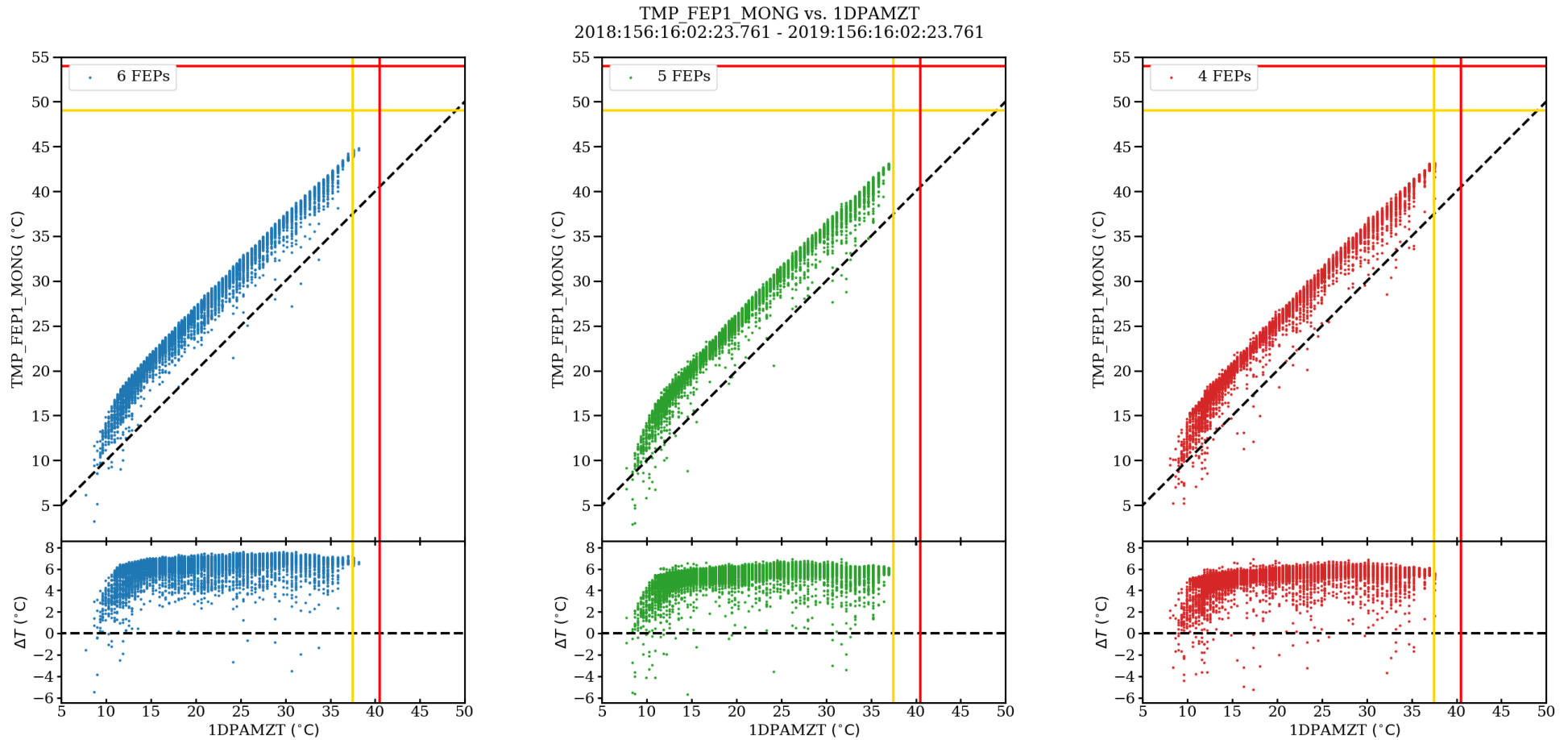
Worst Case diff between 1DPAMZT
and BEP PCB ~3.0°C.

If you hit 41.5 → BEP PCB = 44.5°C
- BEP PCB Yellow Caution viol 0.5

Still 4.5°C away from BEP PCB
Red Warning.

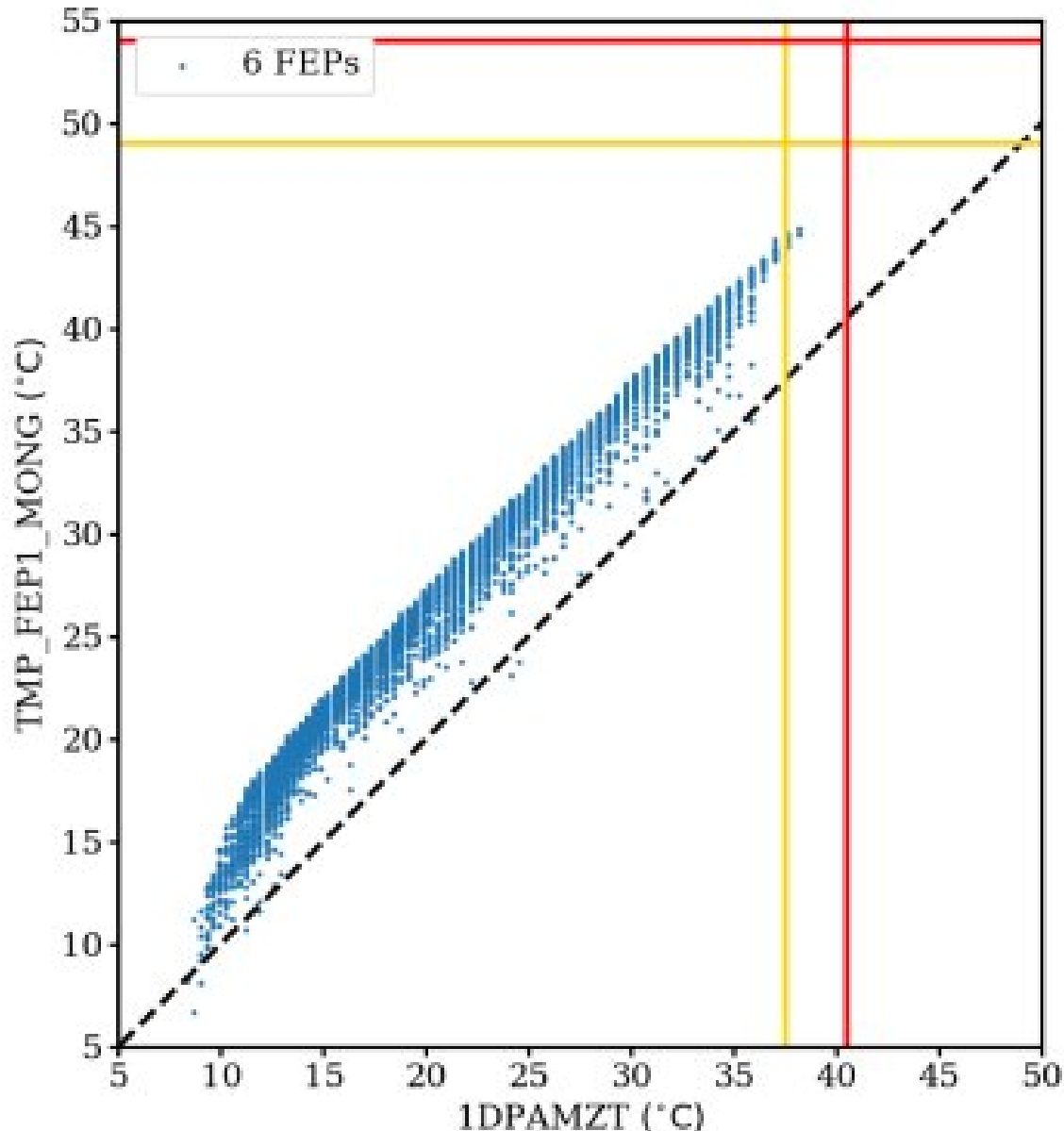
Still 8 1DPAMZT Bit Flips away from
BEP PCB Red High Warning
violation

FEP1 Mongoose v 1DPAMZT



1DPAMZT as a BEP/FEP Proxy (con't)

1DPAMZT v FEP1 Mongoose 6 FEPs (One Year of Data)



54 °C (cleared to set at 55°C)

49°C

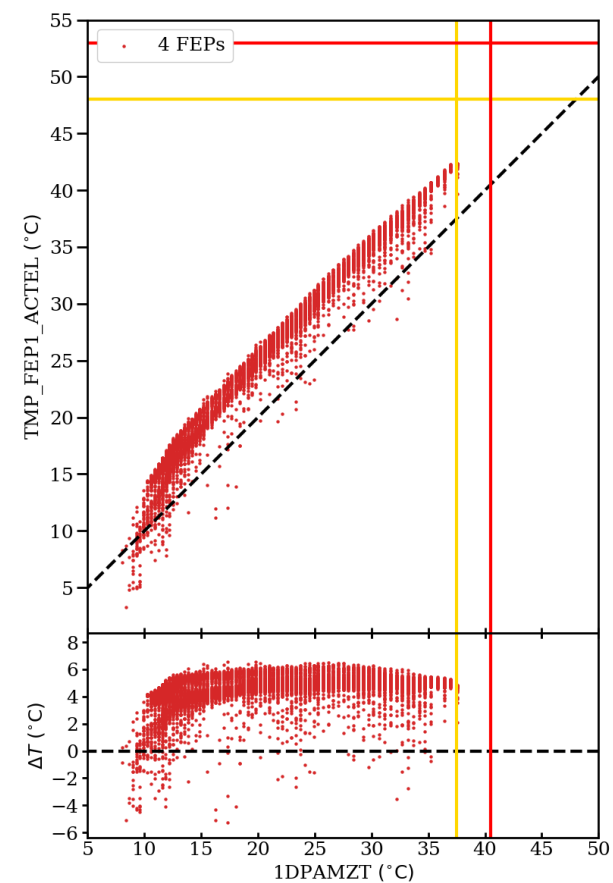
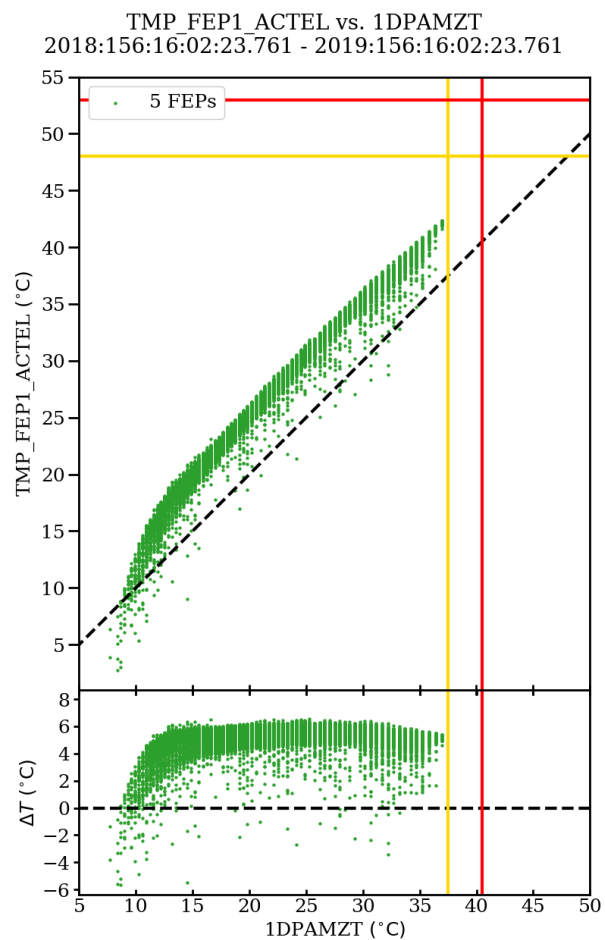
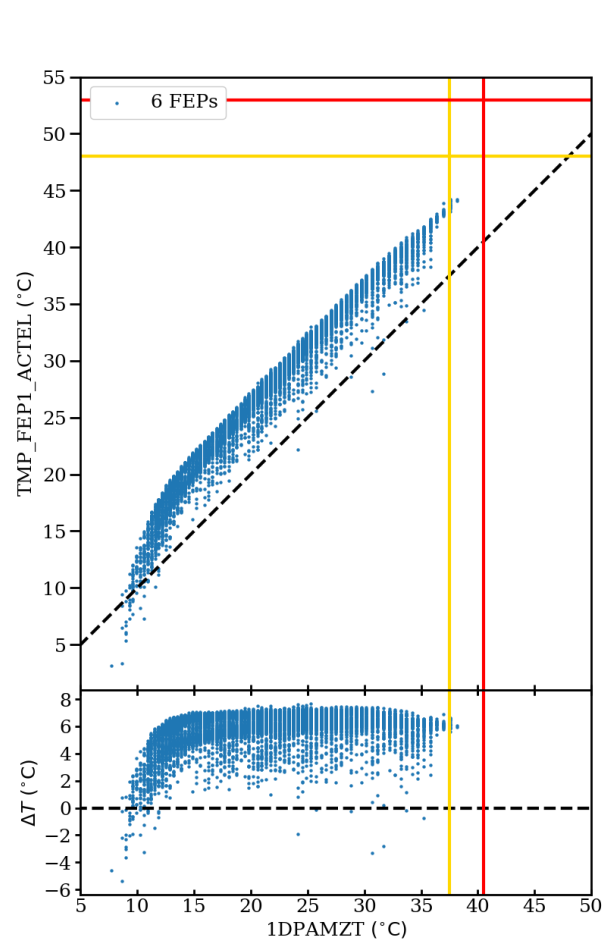
Worst Case diff between 1DPAMZT and FEP 1 MONG. ~7.5°C.

If you hit 41.5 → FEP1 M. = 49.0°C
- Right on Yellow High Limit

Still 5°C away from FEP1 M.
Red Warning.

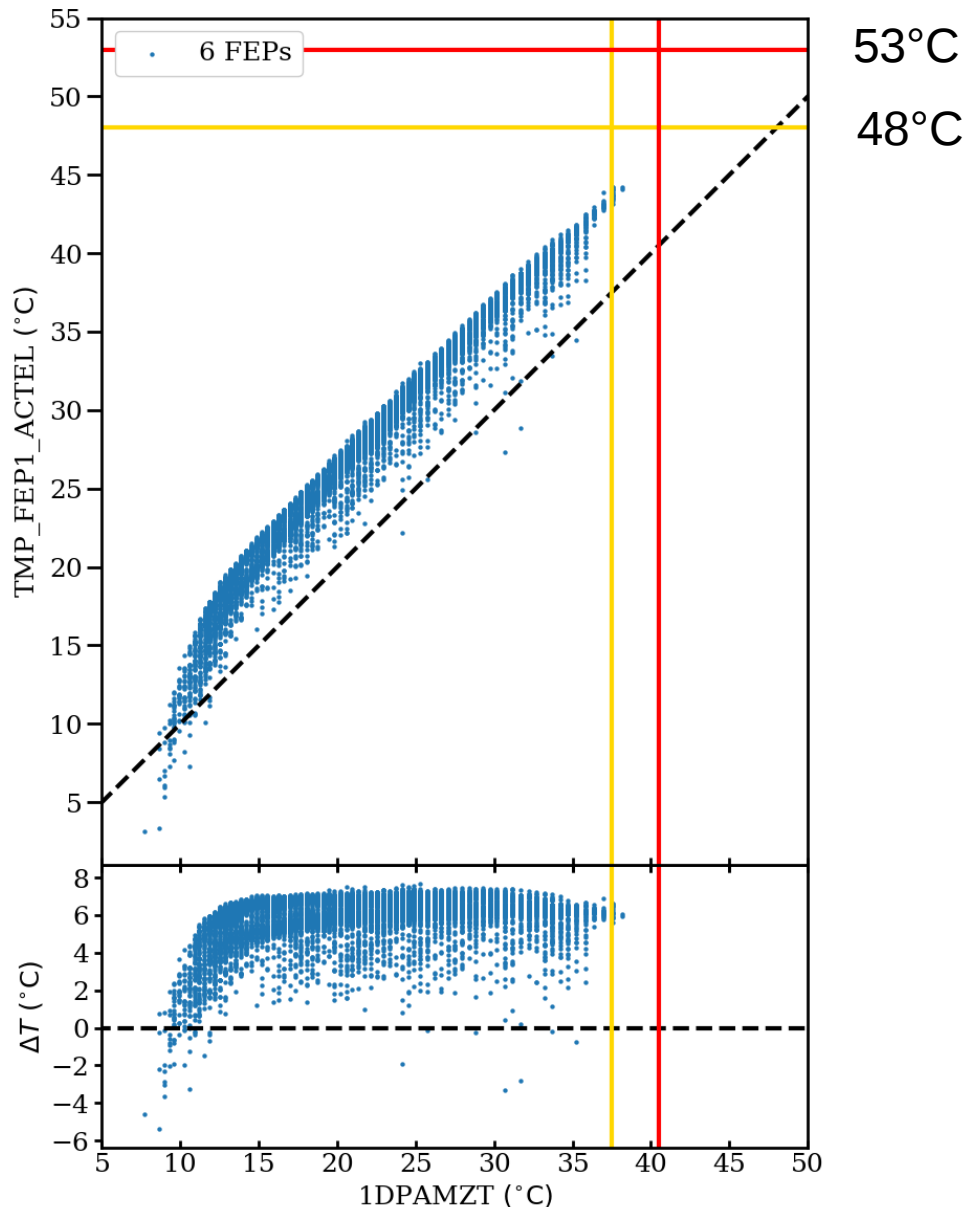
Still 9 1DPAMZT Bit Flips away from
FEP1 Red High Warning violation

FEP1 ACTEL v 1DPAMZT



1DPAMZT as a BEP/FEP Proxy (con't)

1DPAMZT v FEP1 ACTEL 6 FEPs (One Year of Data)



Worst Case diff between 1DPAMZT and FEP 1 ACTEL $\sim 7.5^{\circ}\text{C}$.

If you hit 41.5 \rightarrow FEP1 A. = 49.0°C
- 1°C Yellow High Limit viol.

Still 4°C away from FEP1 A.
Red Warning.

Still 7 1DPAMZT Bit Flips away from
FEP1 Red High Warning violation

BEP and FEP Violations Tracking

Emails sent whenever a violation is noted.

Note the Violation is at low Temperature.

2019 TMP_FEP1_MONG Low Violations

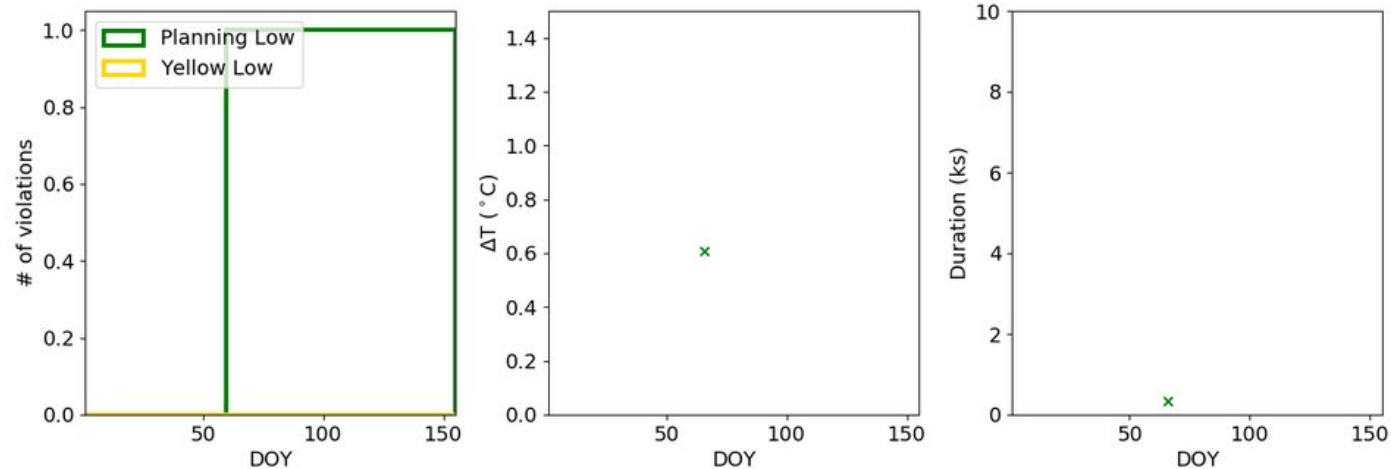
TMP_FEP1_MONG Planning Low Limit Violations

Date start	Date stop	Min temperature	Duration (ks)	Plot
2019:066:18:24:46.816	2019:066:18:30:14.816	1.39	0.33	link

TMP_FEP1_MONG Yellow Low Limit Violations

No yellow low limit violations during this period.

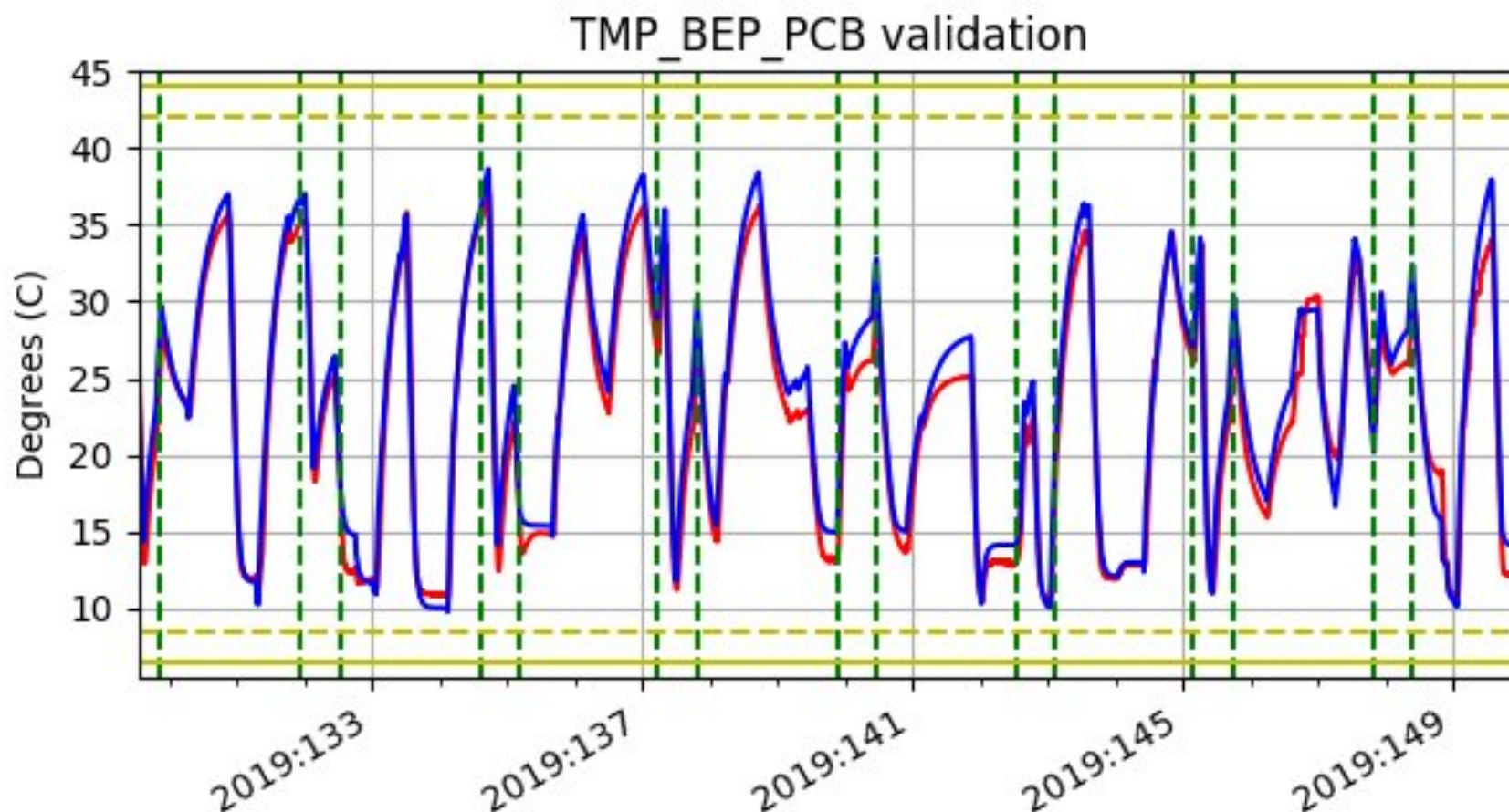
Low Violation Trends



This page was last updated at 2019:155:12:23:29.

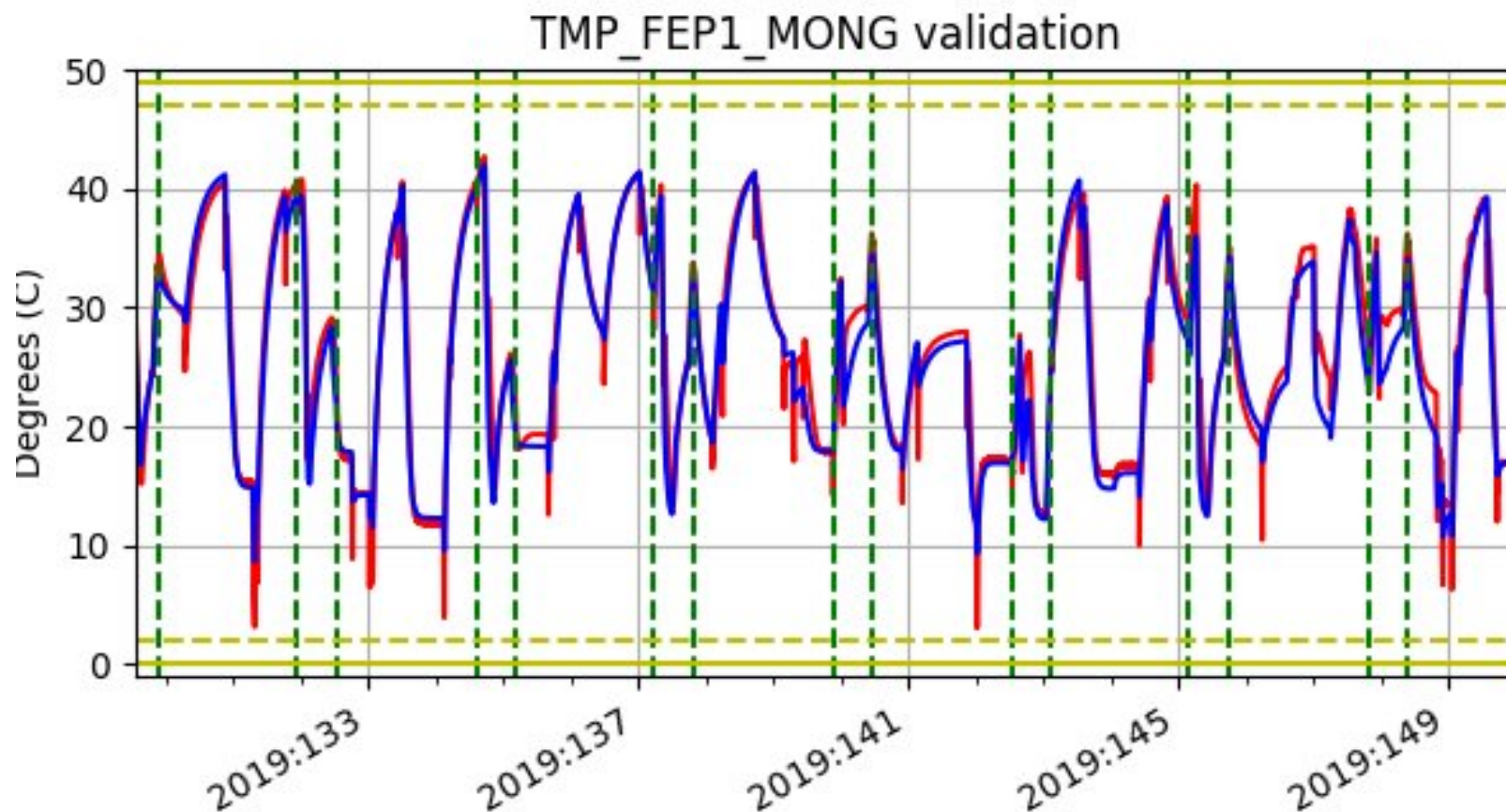
BEP and FEP Model Validation

MSID	1%	5%	16%	50%	84%	95%	99%
TMP_BEP_PCB	-3.66	-2.80	-2.18	-1.23	0.07	1.40	2.66
PITCH	-3.478	-0.238	-0.183	-0.070	0.080	0.220	3.497
TSCPOS	-1	-1	-1	0	0	0	0
ROLL	-2.914	-0.837	-0.432	-0.050	0.306	1.017	1.578



BEP and FEP Model Validation (cont'd)

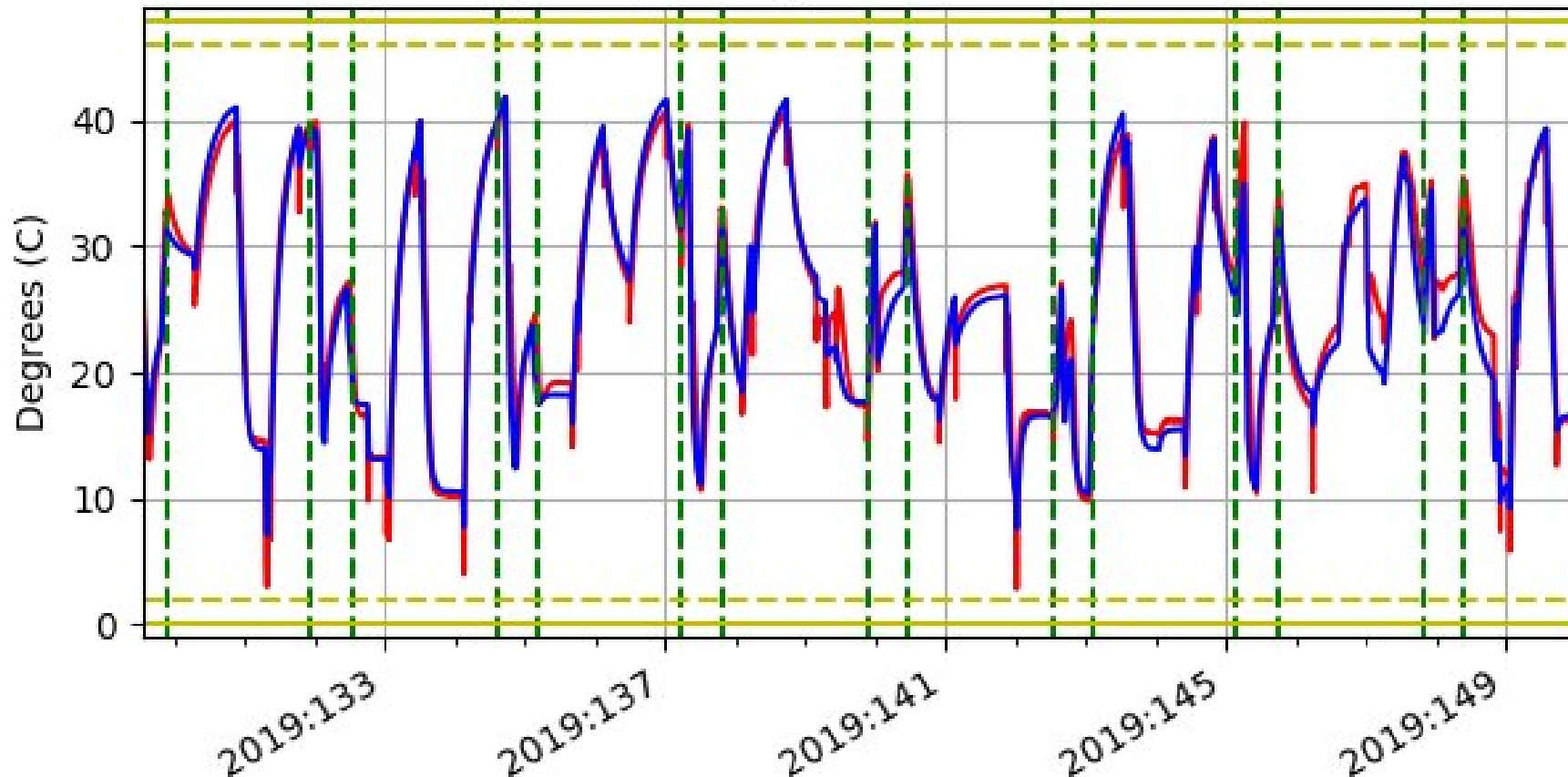
MSID	1%	5%	16%	50%	84%	95%	99%
TMP_FEP1_MONG	-3.53	-1.59	-0.22	0.83	2.41	4.33	5.69
PITCH	-3.622	-0.238	-0.183	-0.070	0.080	0.220	3.497
TSCPOS	-1	-1	-1	0	0	0	0
ROLL	-2.914	-0.839	-0.433	-0.050	0.306	1.017	1.578



BEP and FEP Model Validation (cont'd)

MSID	1%	5%	16%	50%	84%	95%	99%
TMP_FEP1_ACTEL	-3.11	-1.75	-1.01	0.63	2.45	4.08	5.86
PITCH	-3.622	-0.238	-0.183	-0.070	0.080	0.220	3.497
TSCPOS	-1	-1	-1	0	0	0	0
ROLL	-2.914	-0.839	-0.433	-0.050	0.306	1.017	1.578

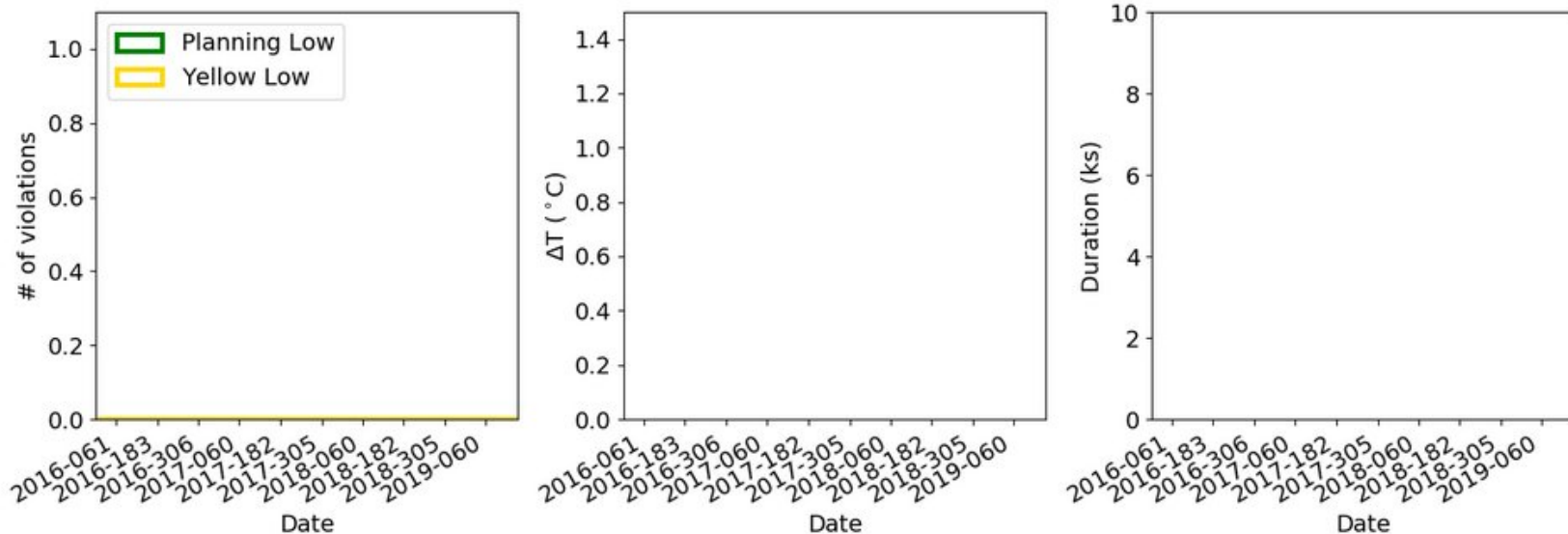
TMP_FEP1_ACTEL validation



BEP and FEP Violations Tracking (cont'd)

No BEP PCB Violations:

Long-Term TMP_BEP_PCB Low Violation Trends



This page was last updated at 2019:155:12:23:40.

BEP and FEP Violations Tracking (cont'd)

30 Yellow Low Caution Violations in 2019

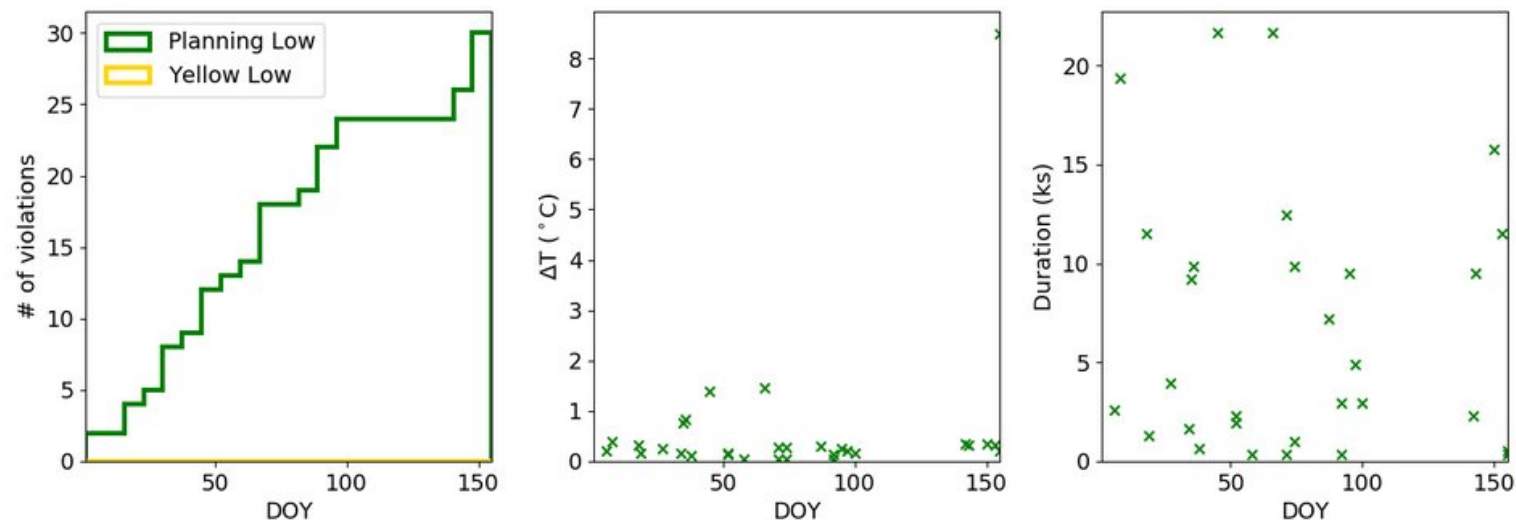
No Yellow High Caution violations

Date start	Date stop	Min temperature	Duration (ks)	Plot
2019:006:18:45:58.816	2019:006:19:29:42.816	8.28	2.62	link
.....				
2019:155:09:21:14.850	2019:155:09:26:49.000	0.00	0.33	link
2019:155:09:27:13.600	2019:155:09:35:48.150	8.30	0.51	link

TMP_BEP_OSC Yellow Low Limit Violations

No yellow low limit violations during this period.

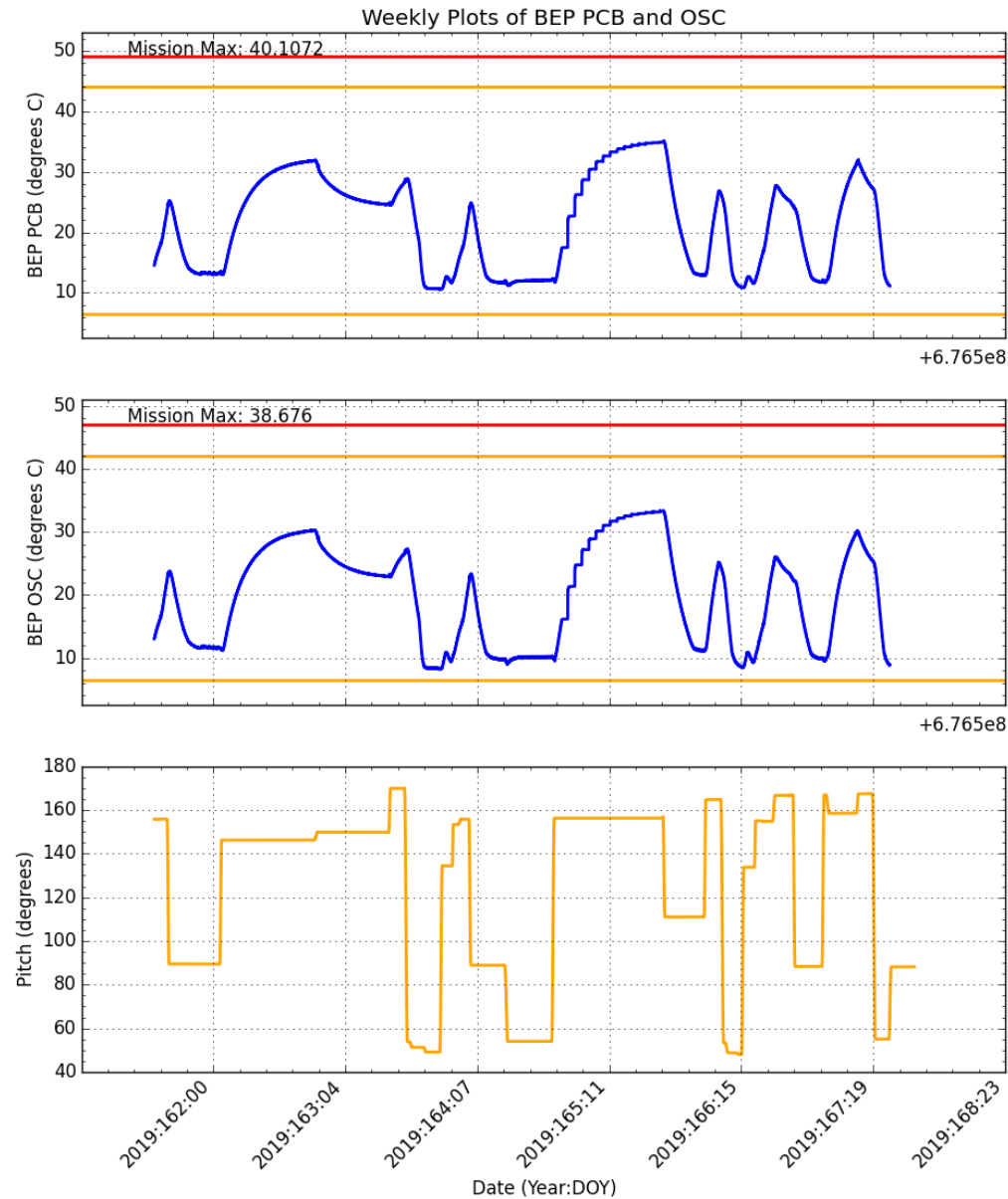
Low Violation Trends



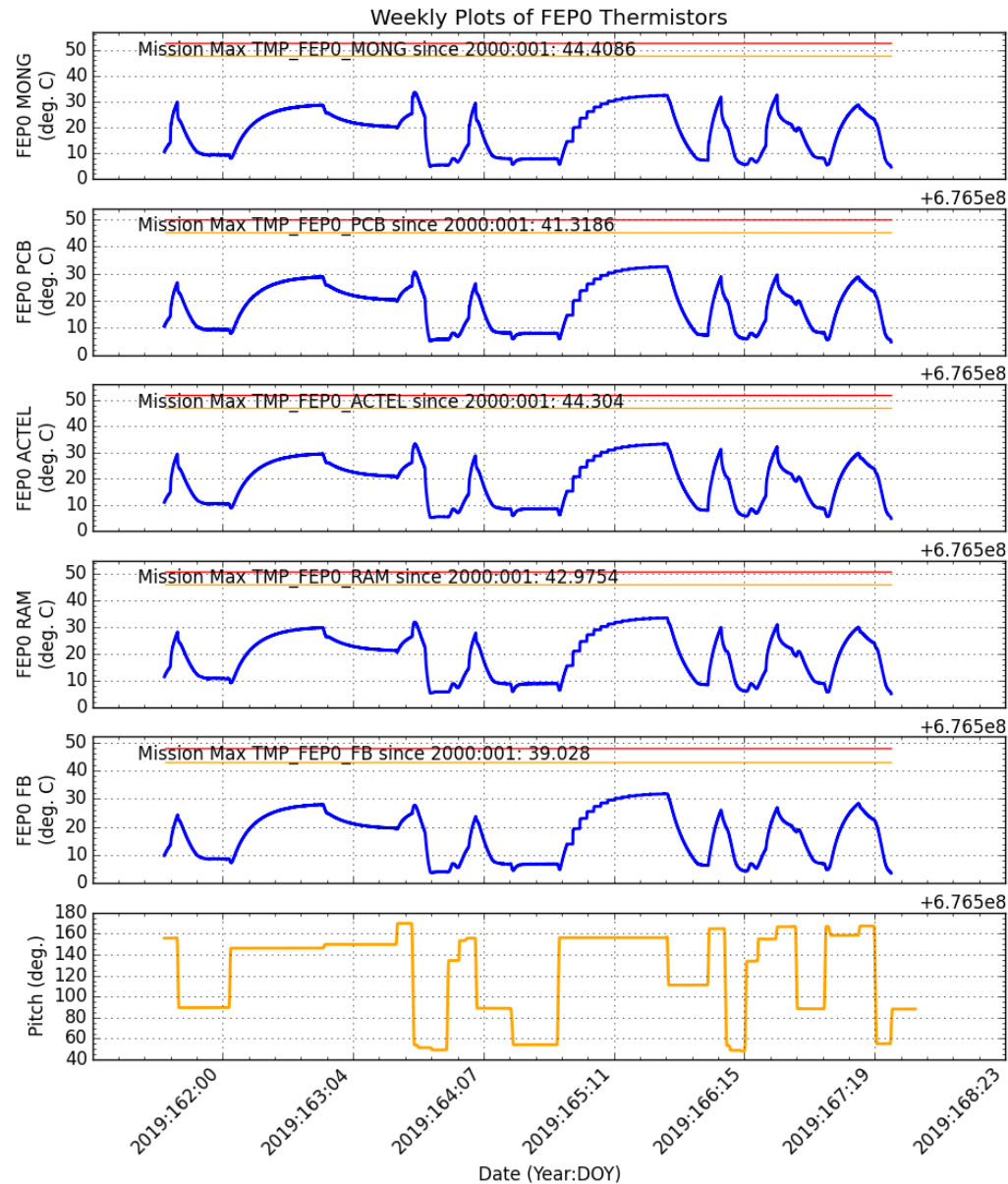
Is it safe?

- 1DPAMZT was sufficient to monitor the BEP/FEP board temps because we were not close to the 1DPAMZT Red High limit and the BEP/FEP Temperature margin is large. Only 1DPAMZT was available to controllers.
- When increasing P.L. and Y.H.C. limits, increasing the Red Warning Limit was not necessary or desired because we maintained 2°C model accuracy and the 2°C limits spacing could be maintained.
- However to increase the Planning and Yellow High limit and maintain the 2°C spacing, we must consider raising the 1DPAMZT Red High limit.
- The risks are low because of the available margin on the BEP/FEP boards. Worst case scenarios of the hottest boards show that Red High Warning Limit violations on BEP/FEP boards not likely to occur. **But this requires maintaining the 2°C limits spacing.**
 - Experience shows we can adequately predict and manage the temperatures.
- **ACIS Ops assesses model performance every week.**
- ACIS Ops generates weekly plots of 1DPAMZT, BEP and FEP Temps and also tracks violations at both the hot and cool ends.
- BEP and FEP Thermal Models exist and are accurate at the hot end
 - Need Refinement.
 - LR uses them to generate BEP and FEP plots for each load.
- 2°C 1DPAMZT Model accuracy must be maintained.

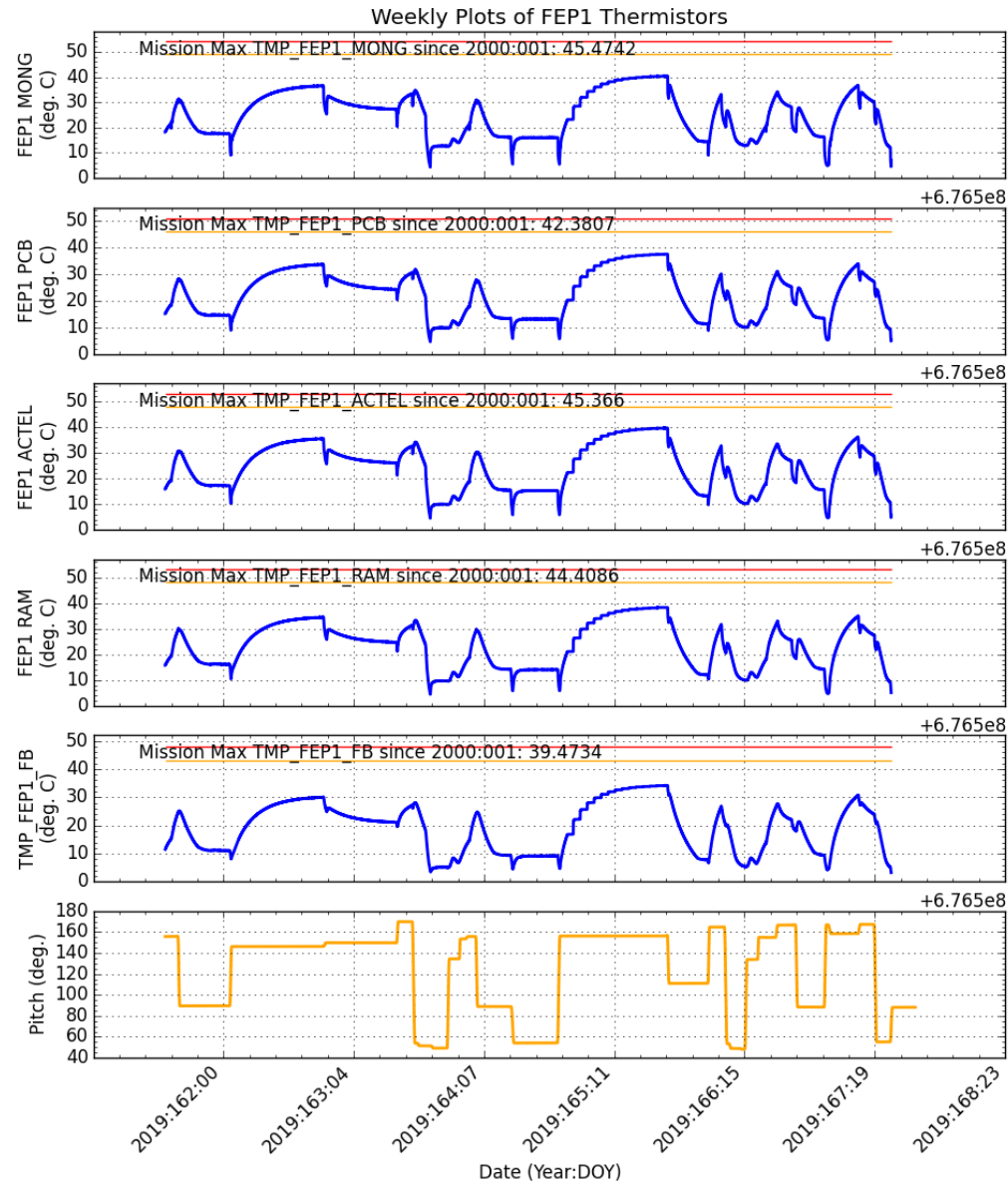
Weekly Model Performance Check



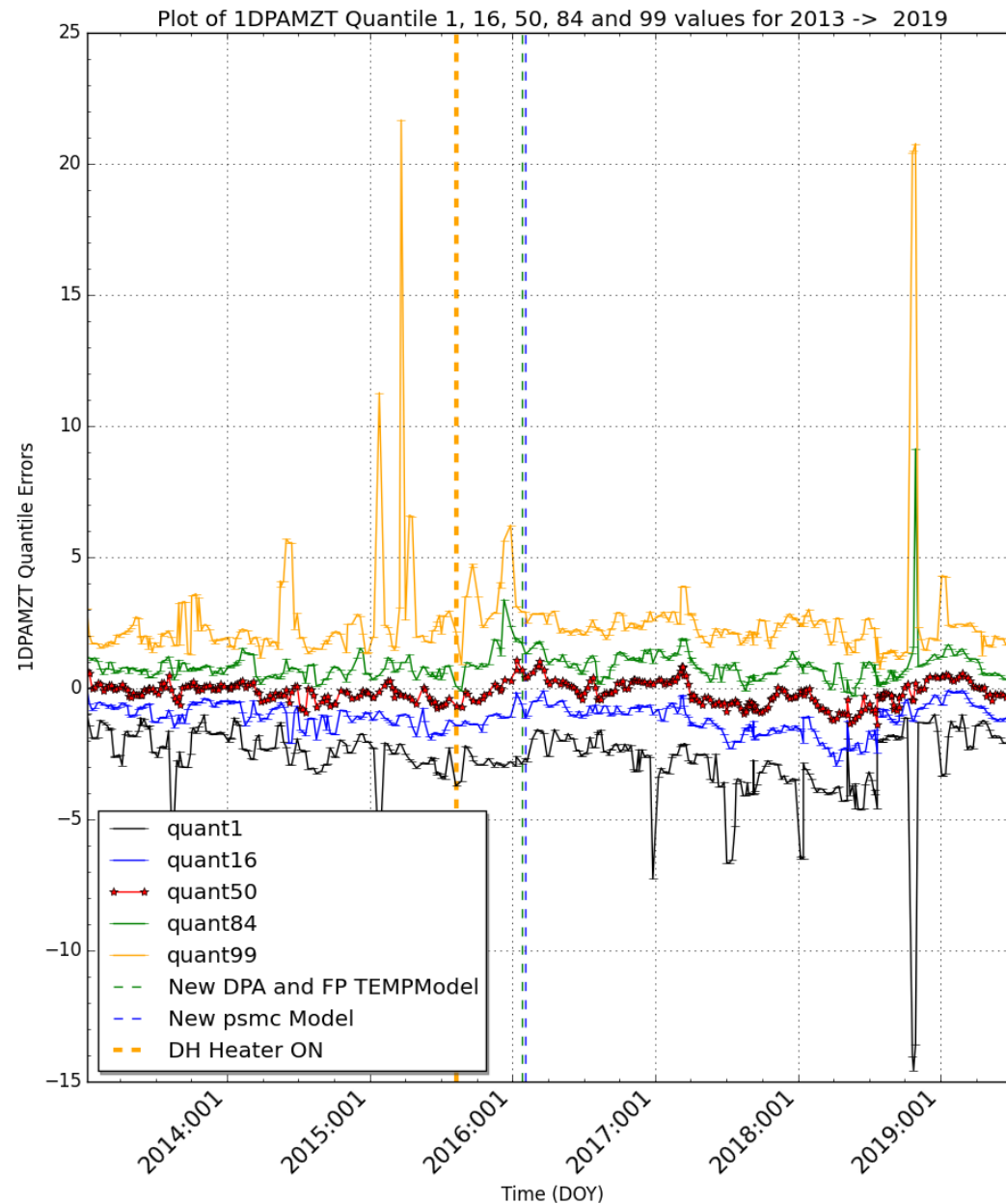
Weekly Model Performance Check (cont'd)



Weekly Model Performance Check (cont'd)

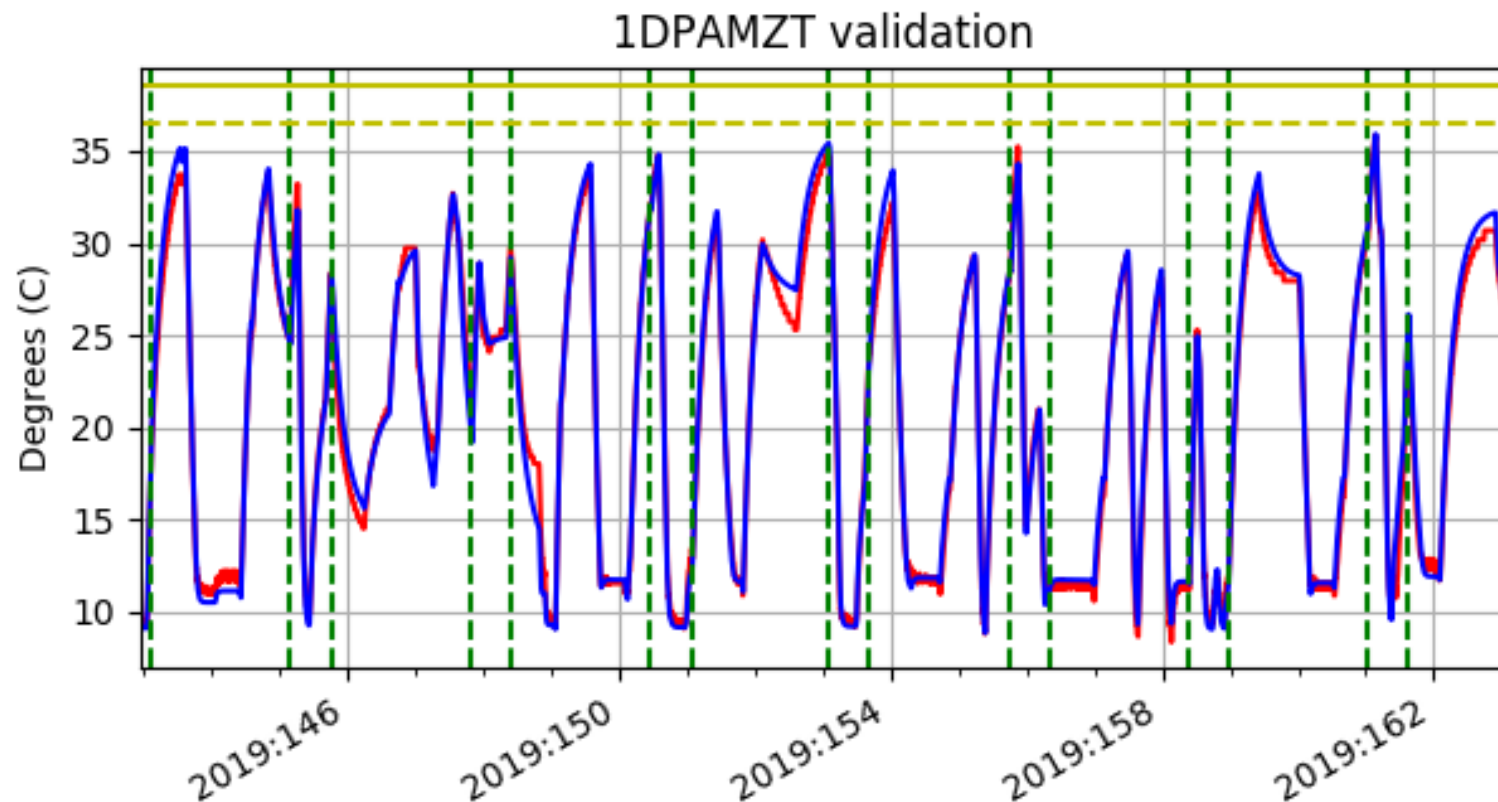


Weekly Model Performance Check (cont'd)



Weekly Model Performance Check (cont'd)

MSID	1%	5%	16%	50%	84%	95%	99%
1DPAMZT	-2.09	-1.76	-1.14	-0.34	0.35	1.07	1.66
PITCH	-4.565	-0.234	-0.135	0.026	0.161	0.230	3.098
TSCPOS	-1	-1	-1	-1	0	0	1
ROLL	-1.474	-0.806	-0.484	0.118	0.338	0.865	3.154



The ACIS Team approves the 1DPAMZT Limits increase.

The limits increase makes MP load scheduling easier and increases observing efficiency.

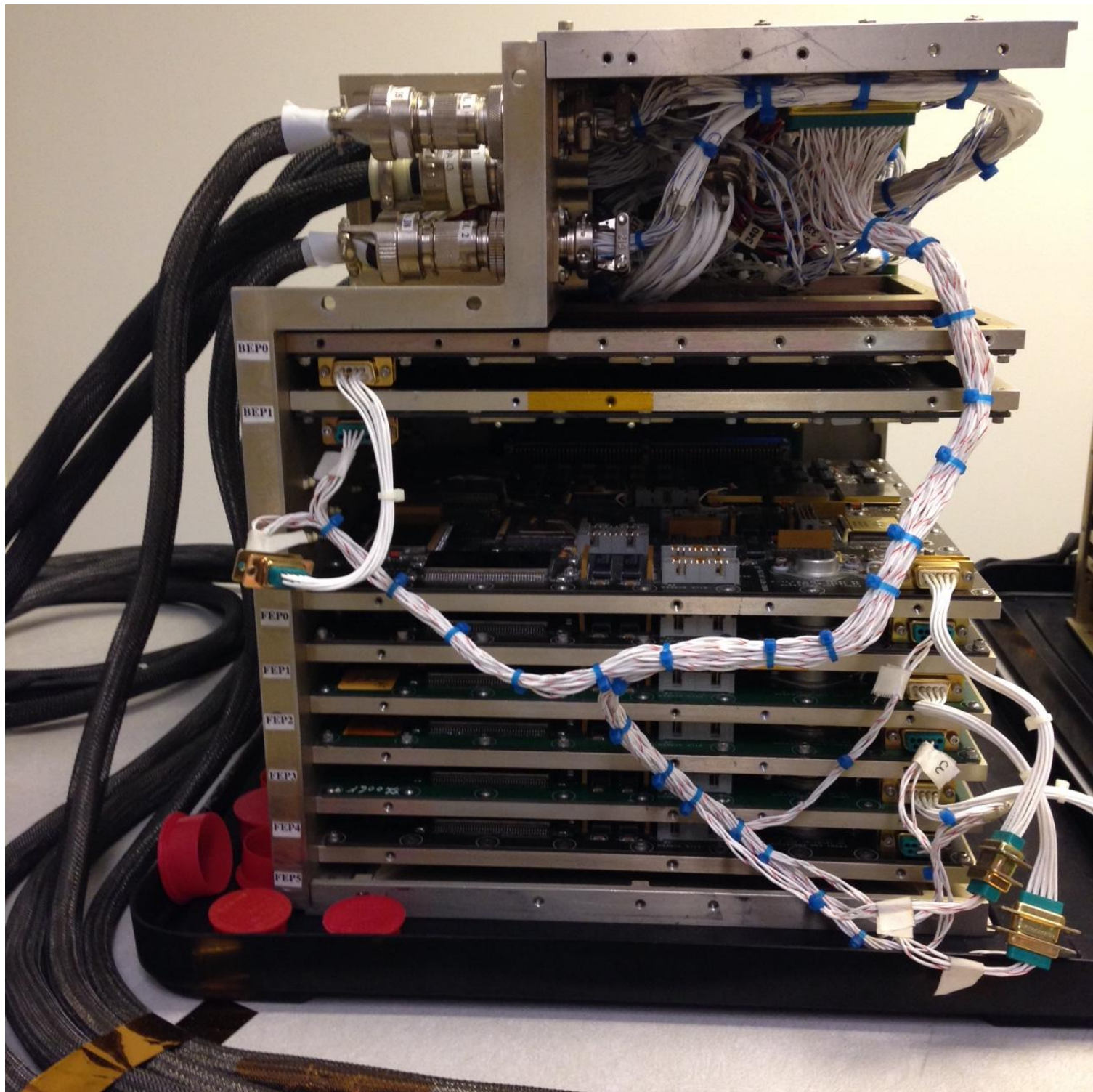
ACIS Team believes the thermal risk to the DPA PC boards is negligible and therefore acceptable.

- BEP/FEP margins
- ACIS Ops reviews model performance weekly

Limit Rationale and Budget

Limit	Value	Budget	Rationale
Red Warning	41.5°C.		Sufficient margin between the BEP/FEP temps we are seeing and the R/Y limits. Worst case 1DPAMZT scenario is still safe. Maintain 2° C Spacing on all limits
Yellow Caution	39.5° C.	2.0° C.	Limit provides warning before the Red limit is reached; ensures that BEP/FEP board temps are below their limits if this limit were to be reached. One bit is 0.62° C, there are 3 bit transitions between the Yellow High limit and Red High limit. ACIS Instrument team confirms 2° C pad is sufficient.
Planning Limit	37.5° C.	2.0° C.	Model error of less than 2 degrees indicates a 2° C pad between the P.L and Y.C. Sufficient for a well-calibrated

Appendix



The Future

- Moving to building loads using BEP/FEP temperatures rather than 1DPAMZT would provide several degrees of planning relief.
- Further model refinement is required (though we are close)
 - Spikes at low temperatures have to be modeled.
 - Models have to be delivered to FOT MP
- Issues to be resolved:
 - 1) Values appear in science telemetry
 - 2) Software required to decom and present BEP/FEP values if FOT monitoring is required.
 - 3) ONLY BEPS, FEP0 and FEP1 instrumented
 - Different SI modes required for FEP heat contribution study

Efficiency benefits

- 1) Benefits tail-sun observations by reducing the need to drop optional chips
- 2) Provides more off-nominal roll options (impacts ACIS thermals) for maneuvering or better star catalogs
- 3) Allows for the potential completion of a target that would otherwise be split or dropped from the week