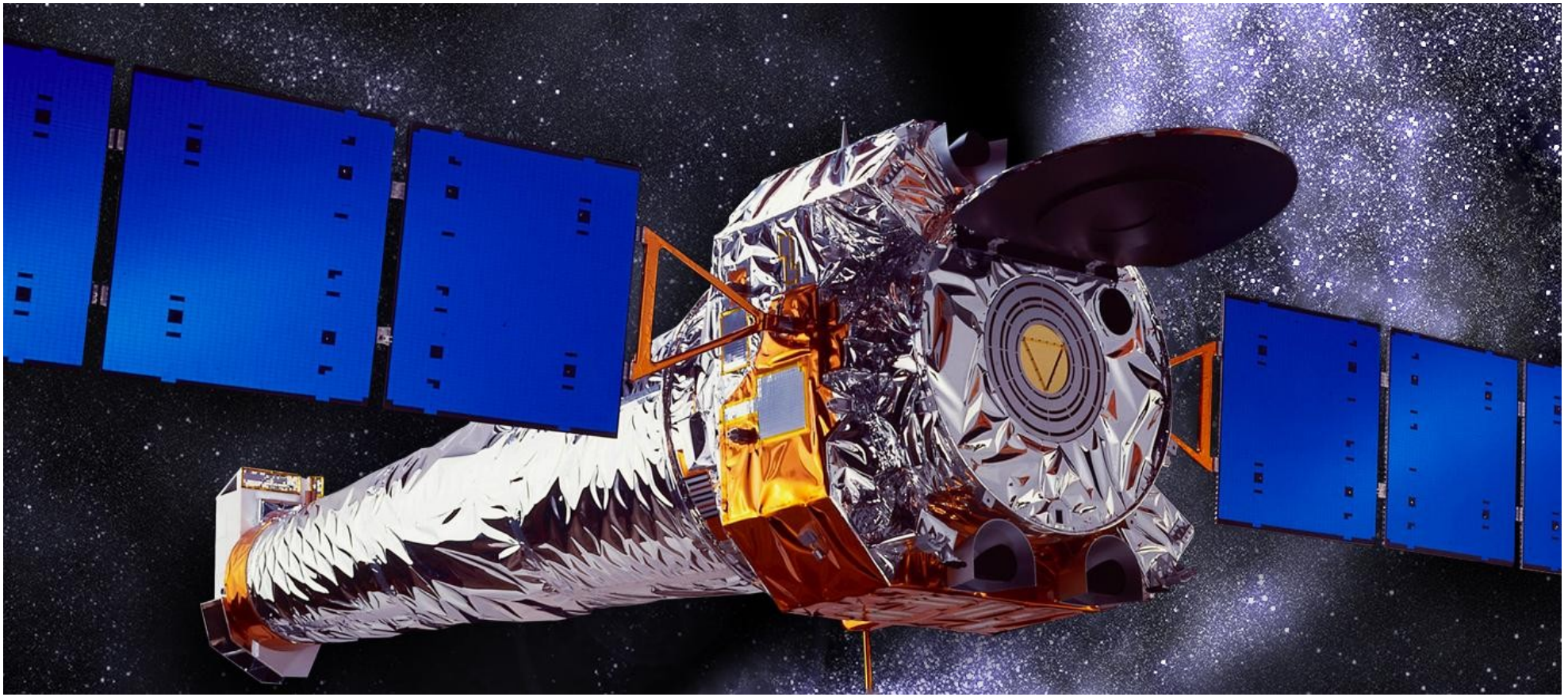
Proposal to Increase the 1DPAMZT Planning and Yellow Caution Limits



Smithsonian

NORTHROP GRUMMAN

Proposal to Increase 1DPAMZT Limits

Raise the 1DPAMZT Planning and Yellow Caution Limits by 1 degree C.

Present:

Red Warning Limit: + 40.5 deg. C.
Yellow Caution Limit: +37.5 deg. C.
Planning Limit: + 35.5 deg. C.

Proposed:

Red Warning Limit: + 40.5 deg. C. (Unchanged)
Yellow Caution Limit: +38.5 deg. C.
Planning Limit: + 36.5 deg. C.

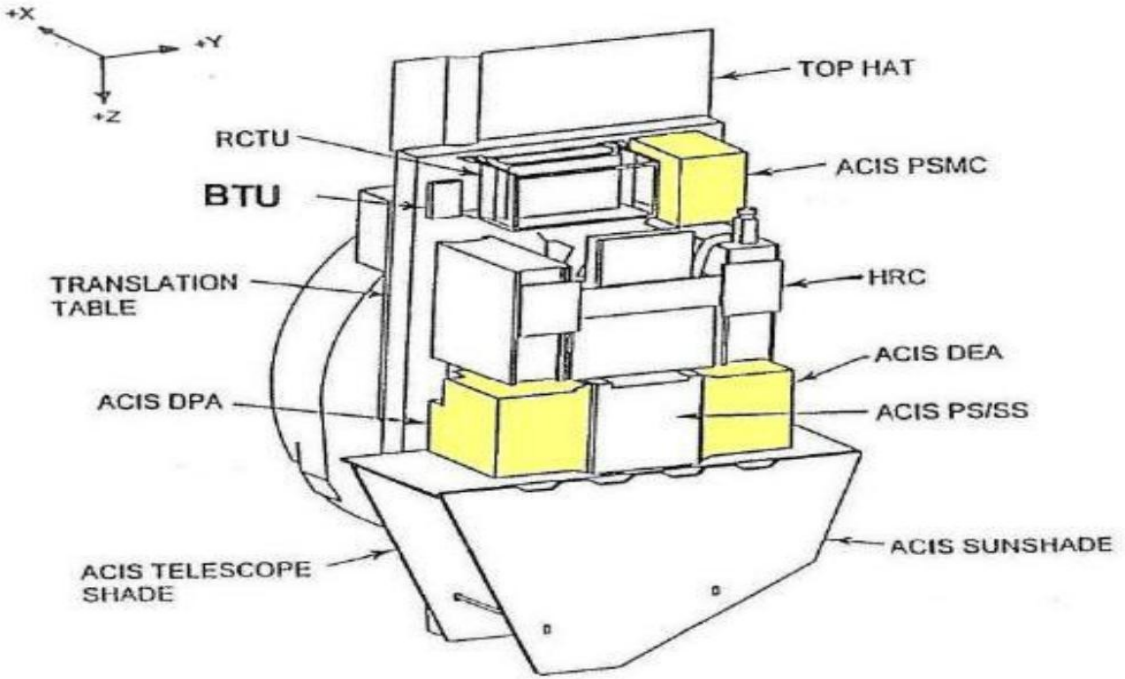
Two degree margin between Planning and Yellow Caution to be maintained.

Main Presentation Points

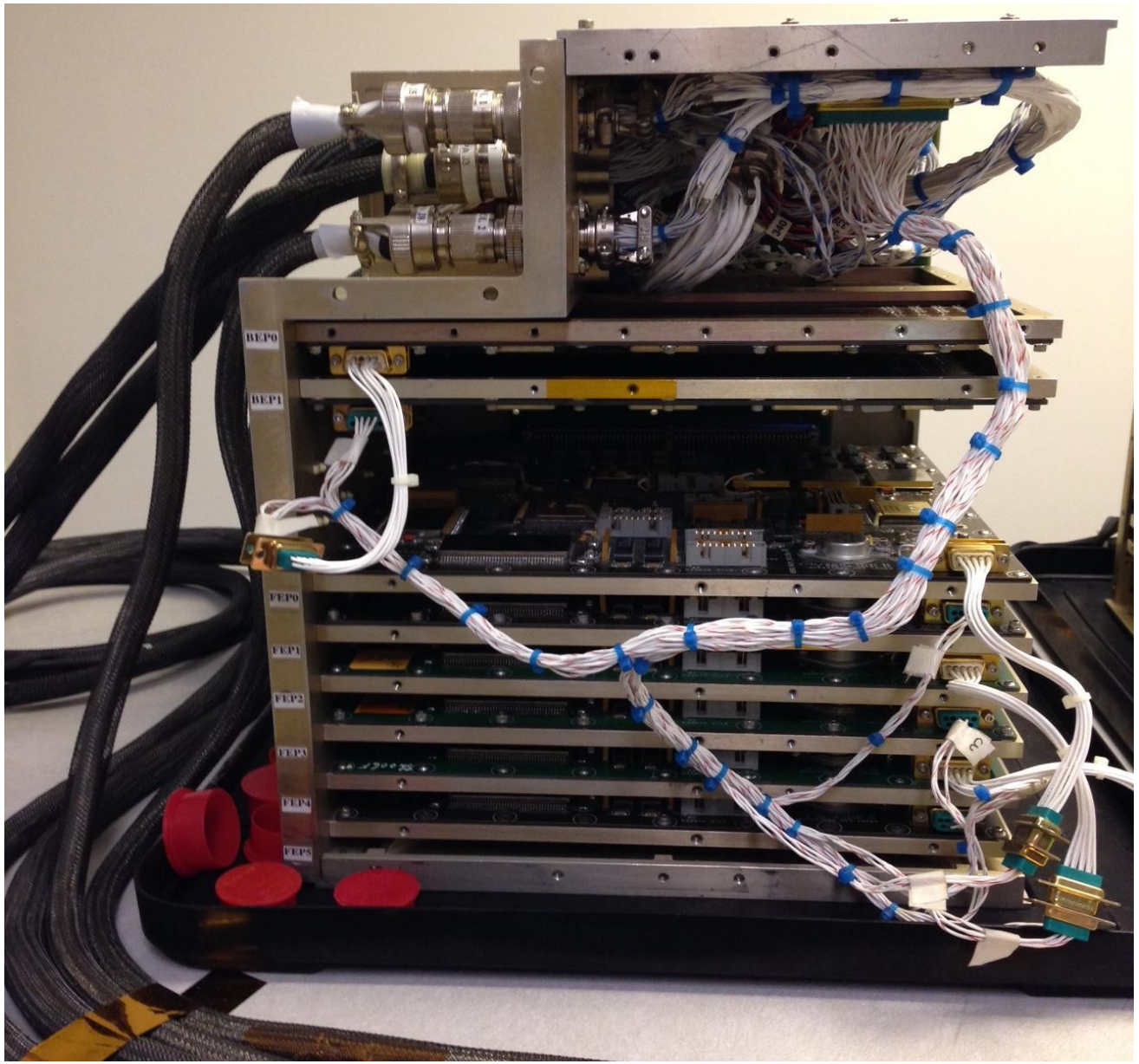
- Increasing the Planning and Yellow Caution limits provides load planning flexibility
- 1DPAMZT is a proxy for BEP and FEP boards
- 1DPAMZT Thermal History
- Explore Yellow Caution violations
- Model Accuracy and Tracking are the keys to safely increasing the limits.
- Since implementation of the roll-aware model, there have been no violations of the Yellow Caution limit.
- Two+ years experience with the roll-aware model increases our confidence that unexpected violations are unlikely as long as operational constraints remain unchanged.

1DPAMZT – DPA Minus Z Panel Temperature

External Thermistor located on the ACIS Digital Processor Assembly (DPA).....



……which contains the Back End Processors (BEPs) and Front End Processors (FEPS)



What does 1DPAMZT Tell Us?

- Thermistor measures temperature of the minus Z Panel.
- Used as a Proxy for the BEP and FEP board temperatures (the important values).
- BEPs/FEP0,1 temperatures appear in ACIS Housekeeping (science) data;

  OCC has no insight into BEP/FEP thermistor values.
- New thermal models exist tracking BEP PCB, FEP1 Mongoose and FEP1 ACTEL boards.

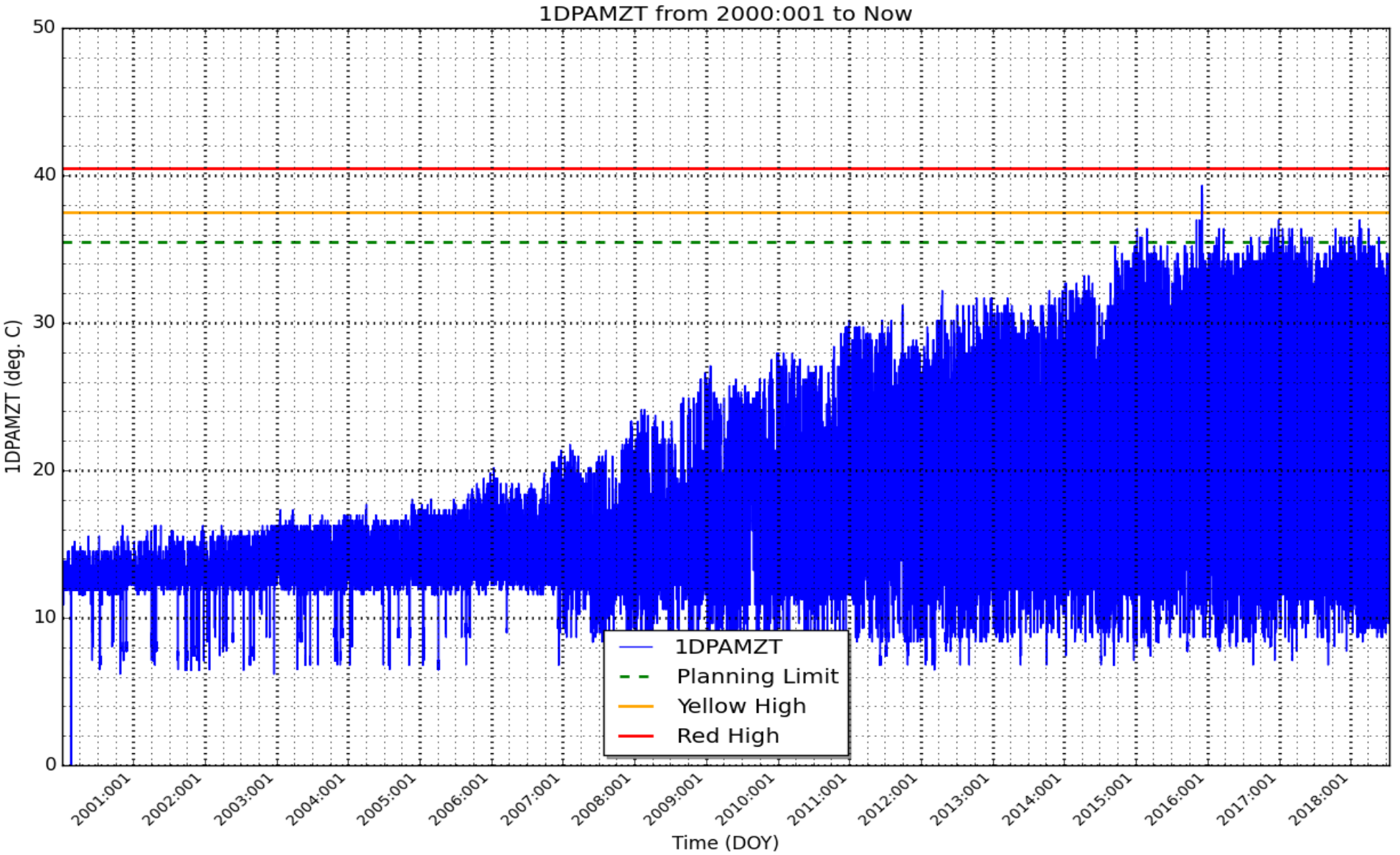
Reason for Adjustment

- Intention to ease the thermal constraint which will simplify the Mission Planning task.

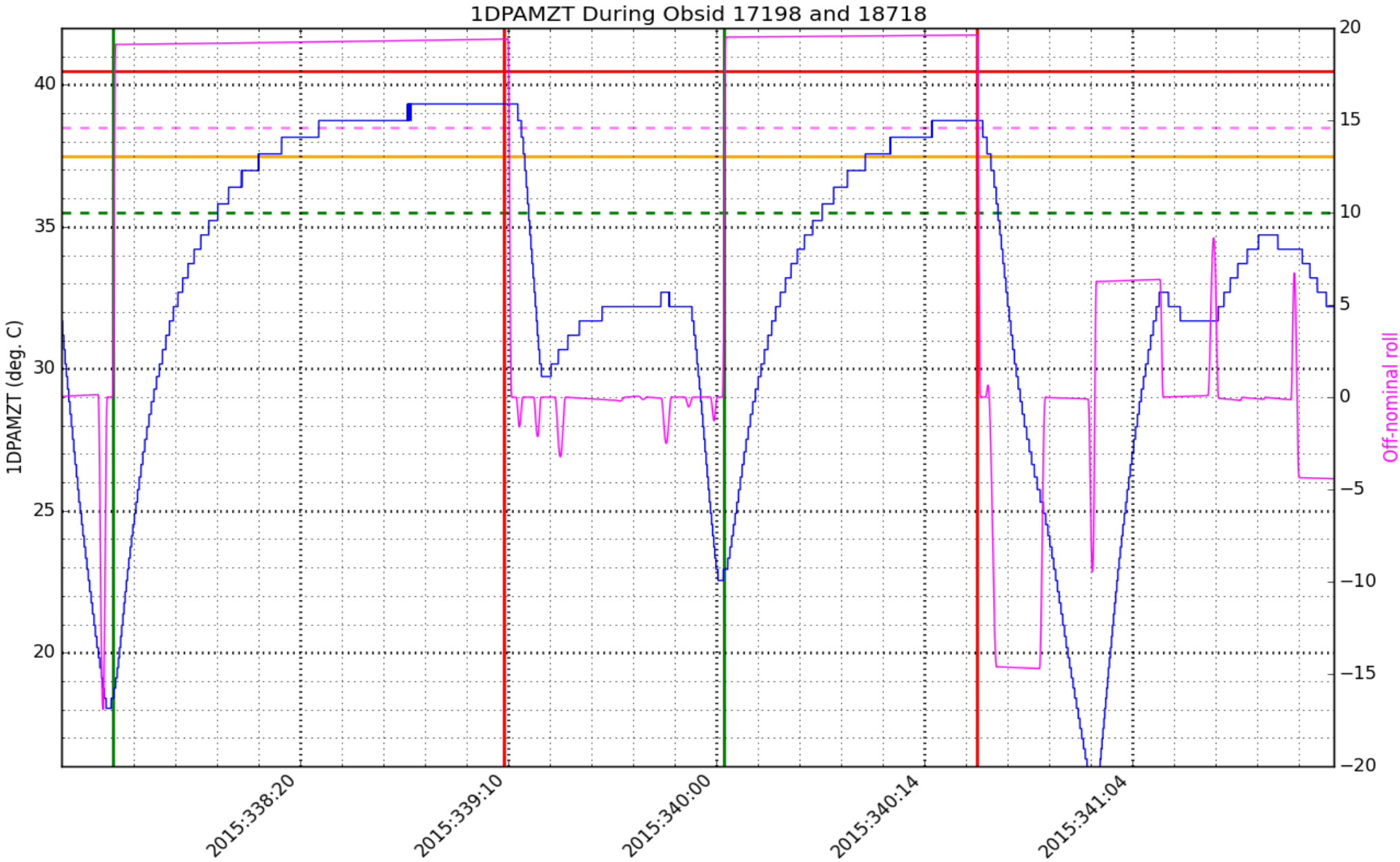
- Updates to the 1DPAMZT thermal model have increased accuracy which raises the confidence that the 1DPAMZT limits can be safely raised.

- Red Warning limit not increased.

1DPAMZT Thermal History



Two Yellow Caution Violations in the Mission.



Similar Configurations

- 17198: TE_0075A 5 chips

  Exposure = 92.58ks

  Pitch = 137.05

  Off-nominal roll ~ 20 degrees

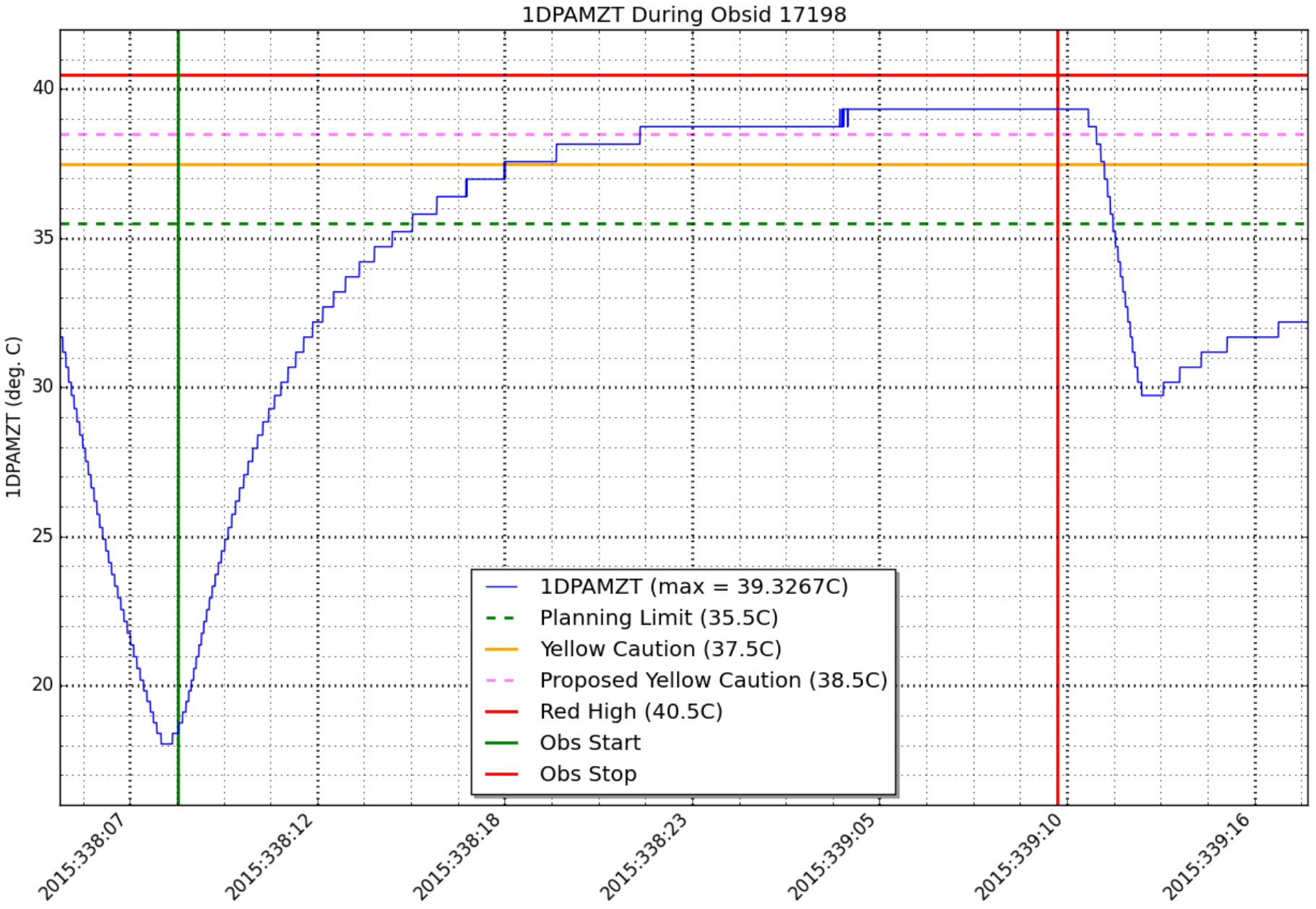
- 18718 TE_0075A 5 chips

  Exposure = 59.38ks

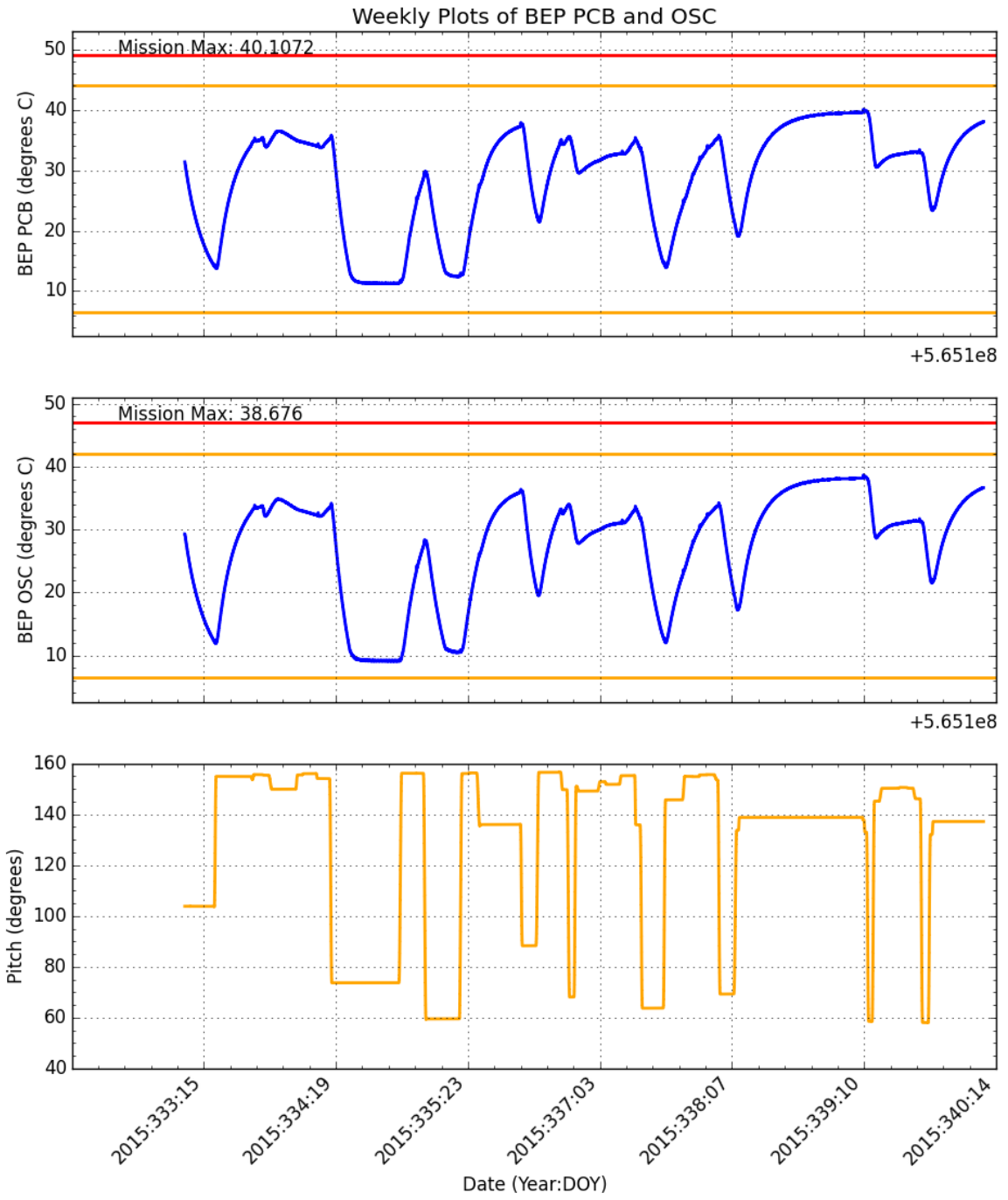
  Pitch = 135.36

  Off-nominal roll ~ 20 degrees

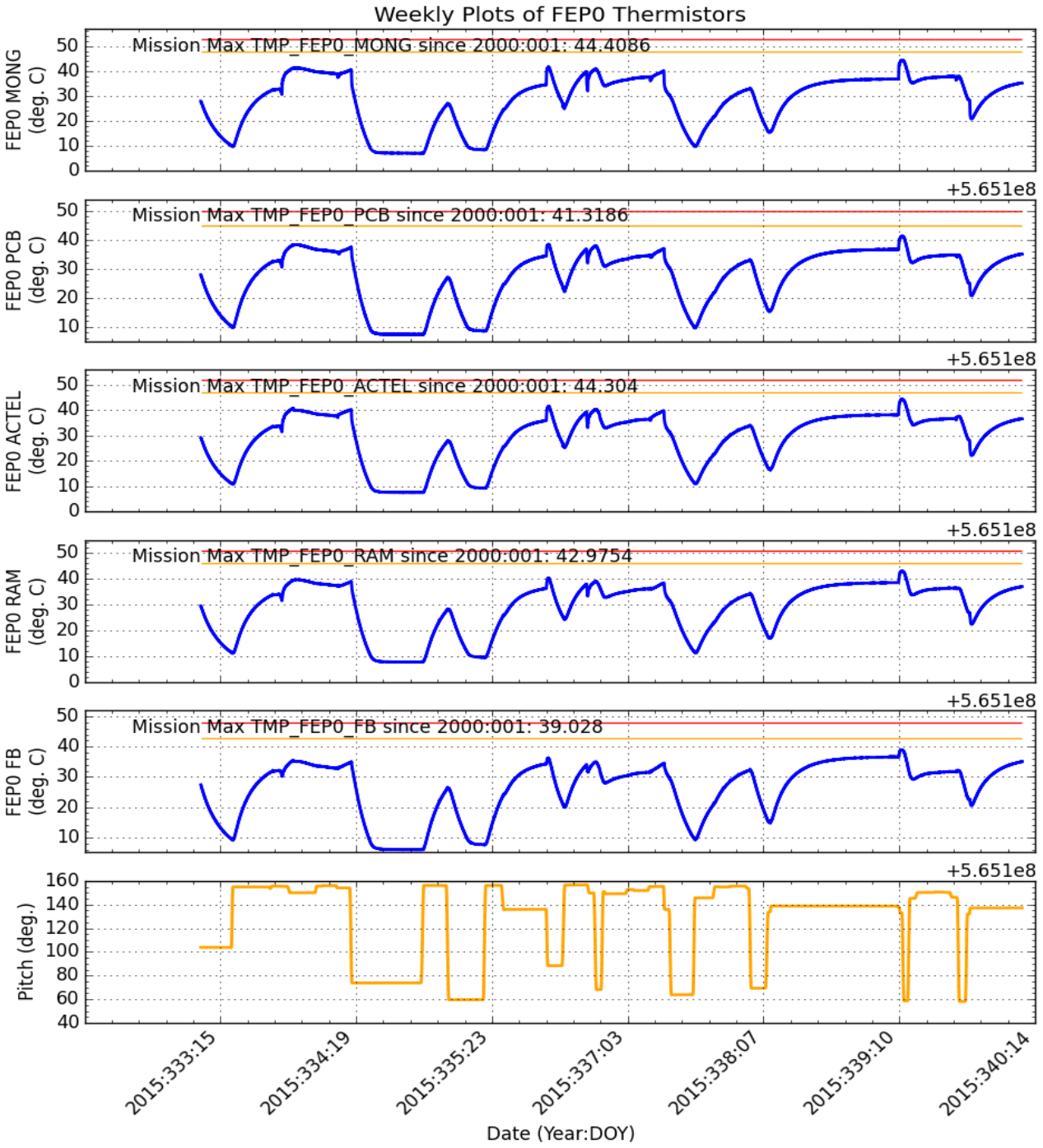
Obsid 17198 – Off Nominal Roll



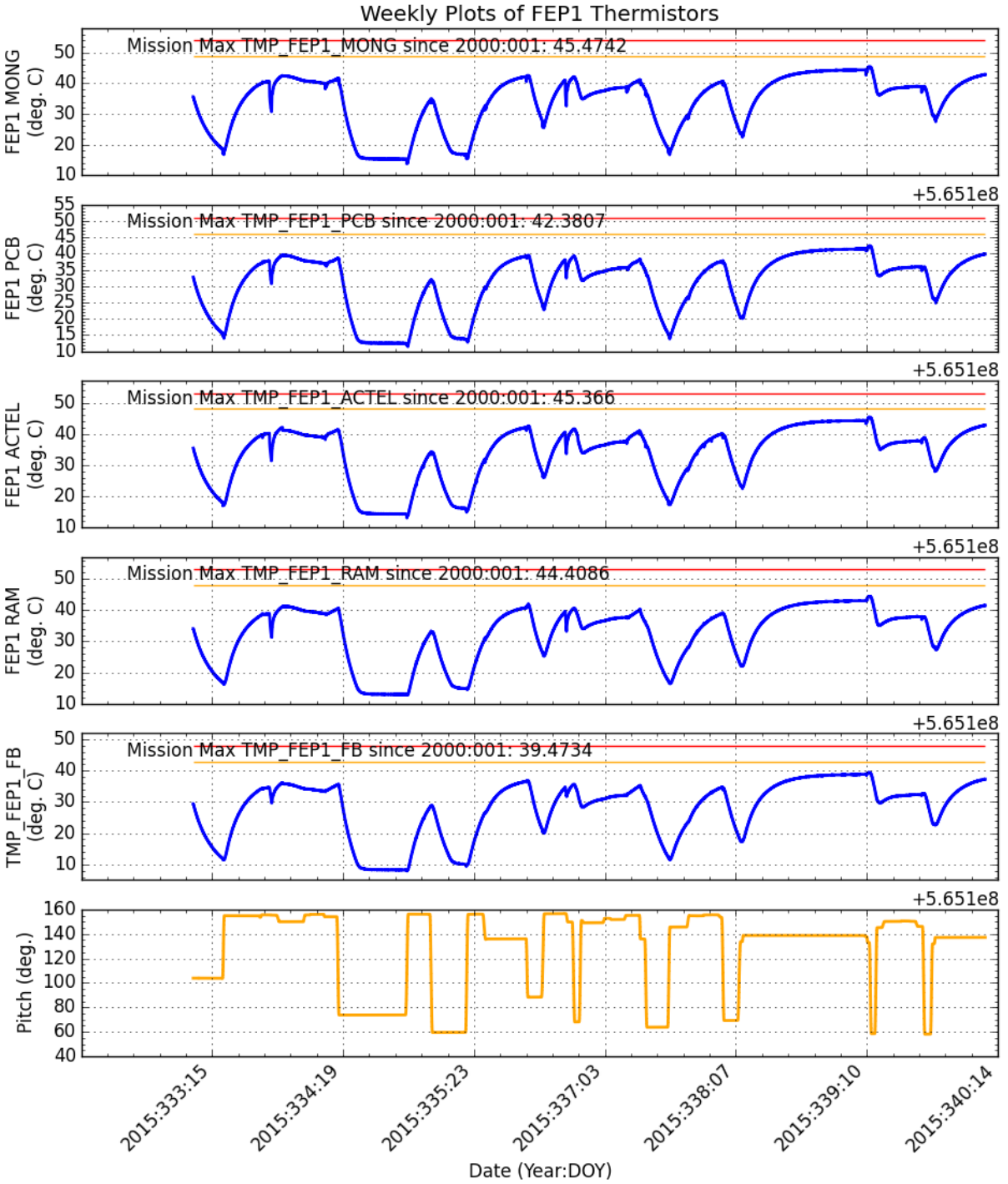
BEP and FEP Boards Remained Below Limits



FEP0


Weekly Plots of FEP0 Thermistors
Mission Max TMP_FEP0_MONG since 2000:001: 44.4086
FEP0 MONG (deg. C)
Mission Max TMP_FEP0_PCB since 2000:001: 41.3186
FEP0 PCB (deg. C)
Mission Max TMP_FEP0_ACTEL since 2000:001: 44.304
FEP0 ACTEL (deg. C)
Mission Max TMP_FEP0_RAM since 2000:001: 42.9754
FEP0 RAM (deg. C)
Mission Max TMP_FEP0_FB since 2000:001: 39.028
FEP0 FB (deg. C)
Pitch (deg.)
+5.651e8
2015:333:15
2015:334:19
2015:335:23
2015:337:03
2015:338:07
2015:339:10
2015:340:14
Date (Year:DOY)

FEP1


Weekly Plots of FEP1 Thermistors
Mission Max TMP_FEP1_MONG since 2000:001: 45.4742
FEP1 MONG (deg. C)
Mission Max TMP_FEP1_PCB since 2000:001: 42.3807
FEP1 PCB (deg. C)
Mission Max TMP_FEP1_ACTEL since 2000:001: 45.366
FEP1 ACTEL (deg. C)
Mission Max TMP_FEP1_RAM since 2000:001: 44.4086
FEP1 RAM (deg. C)
Mission Max TMP_FEP1_FB since 2000:001: 39.4734
TMP_FEP1_FB (deg. C)
Pitch (deg.)
+5.651e8
2015:333:15
2015:334:19
2015:335:23
2015:337:03
2015:338:07
2015:339:10
2015:340:14
Date (Year:DOY)

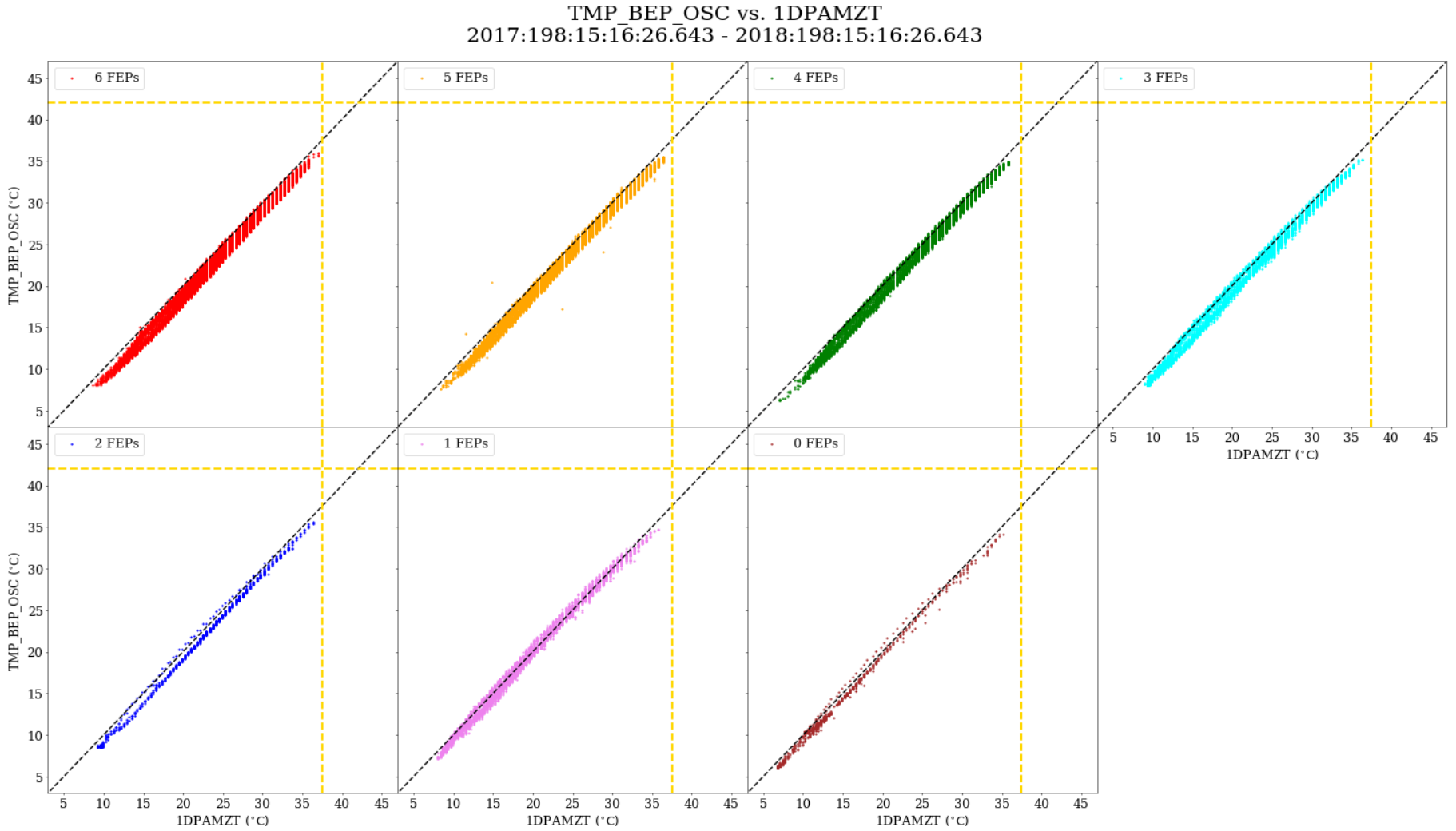
BEP and FEP Temperature Limits

- BEP and FEP board temperatures are the values of interest.
- BEP/FEP limits established at Thermal Vac
- BEP and FEP board temperature limits higher than 1DPAMZT.
- BEP/FEP temps did not come close to Yellow Caution during the 12/2015 excursion.
- So there is additional margin on the temperatures that matter.

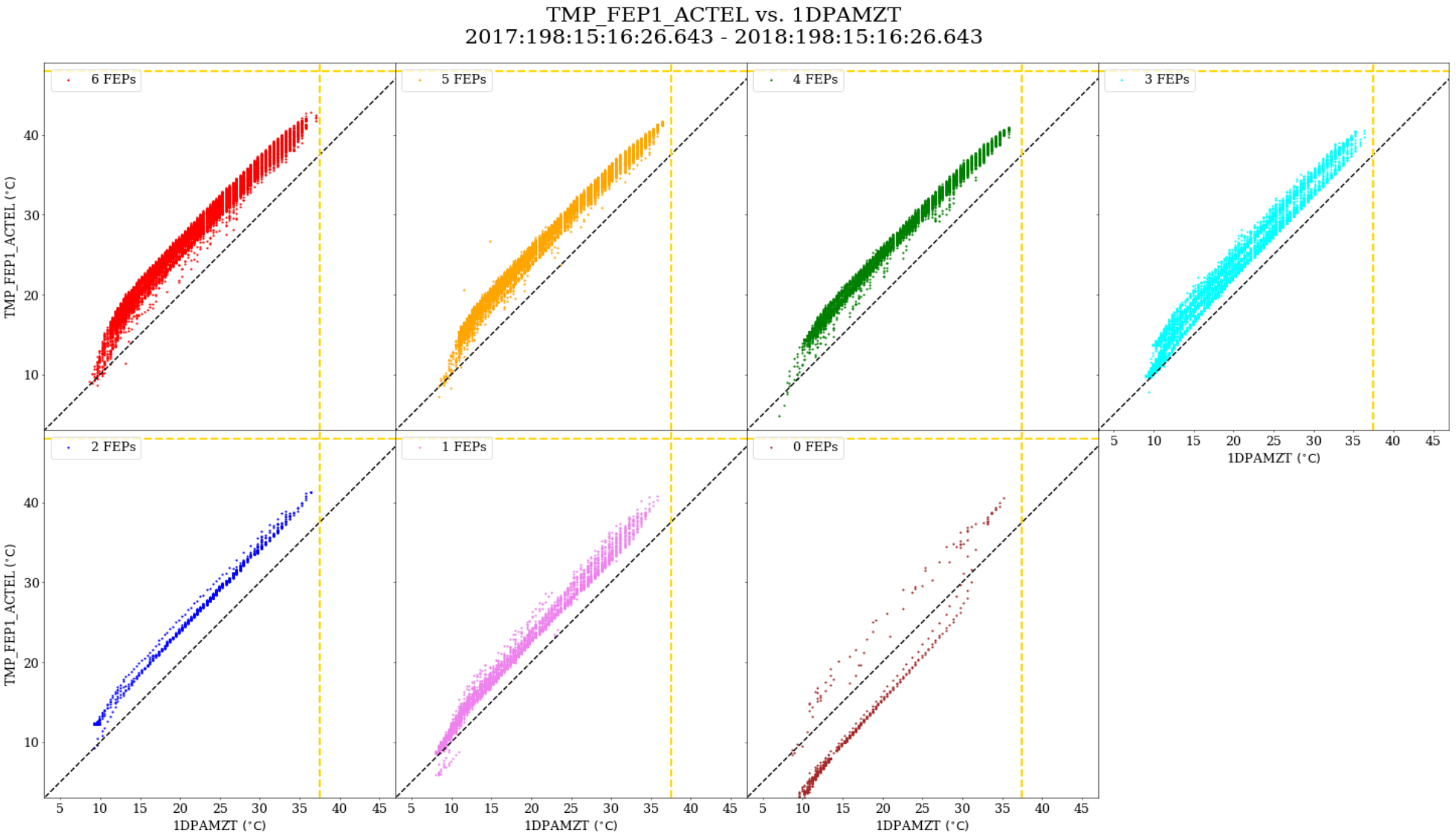
```
# Channel          ccd  size  red_lo  yel_lo  yel_hi  red_hi  # Description
#-------------------------------------------------------------------------

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
```

Relationship between BEP/FEP and 1DPAMZT temps: 1 degree 1DPAMZT rise ~= 1 degree BEP/FEP rise

- Gives an indirect method of estimating BEP/FEP temperatures
- 1DPAMZT closer to Y.C. than BEP and FEP temperatures



FEP1 ACTEL


TMP_FEP1_ACTEL vs. 1DPAMZT
2017:198:15:16:26.643 - 2018:198:15:16:26.643
6 FEPs
5 FEPs
4 FEPs
3 FEPs
2 FEPs
1 FEPs
0 FEPs
TMP_FEP1_ACTEL (°C)
1DPAMZT (°C)

What would have happened With Higher Planning Limit?

- Approved Exposure: 97.00ks; Actual 91.41ks (5.59ks delta)

- Max 1DPAMZT Temp = 39.327 deg. C (1.83 deg C over Y.C.)
- Max BEP OSC temp = 38.676 deg. C @ 2015:339:10:45

  BEP OSC Yellow Caution = 42.0 deg. C (3.33 deg. C margin)
- Max FEP1 ACTEL temp = 45.366 deg. C @ 2015:339:11

  FEP1 ACTEL Yellow Caution = 48.0 deg. C (2.63 deg. C margin)

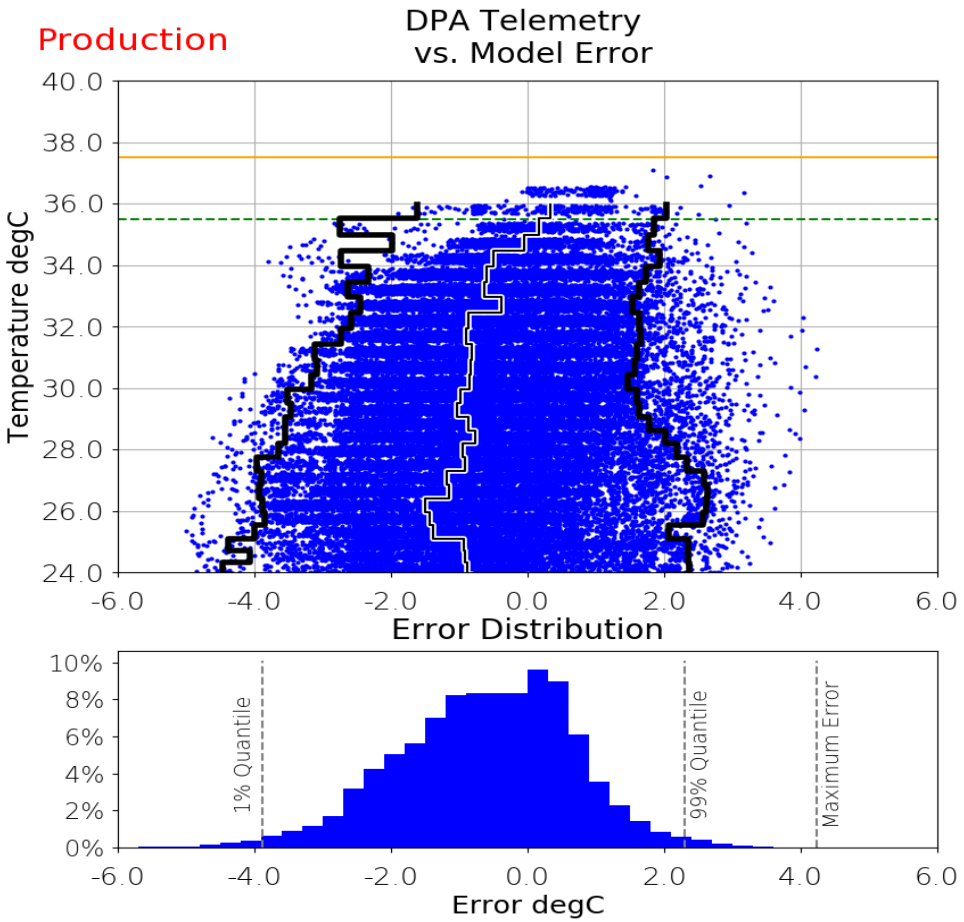
If we planned 1 degree C hotter, and

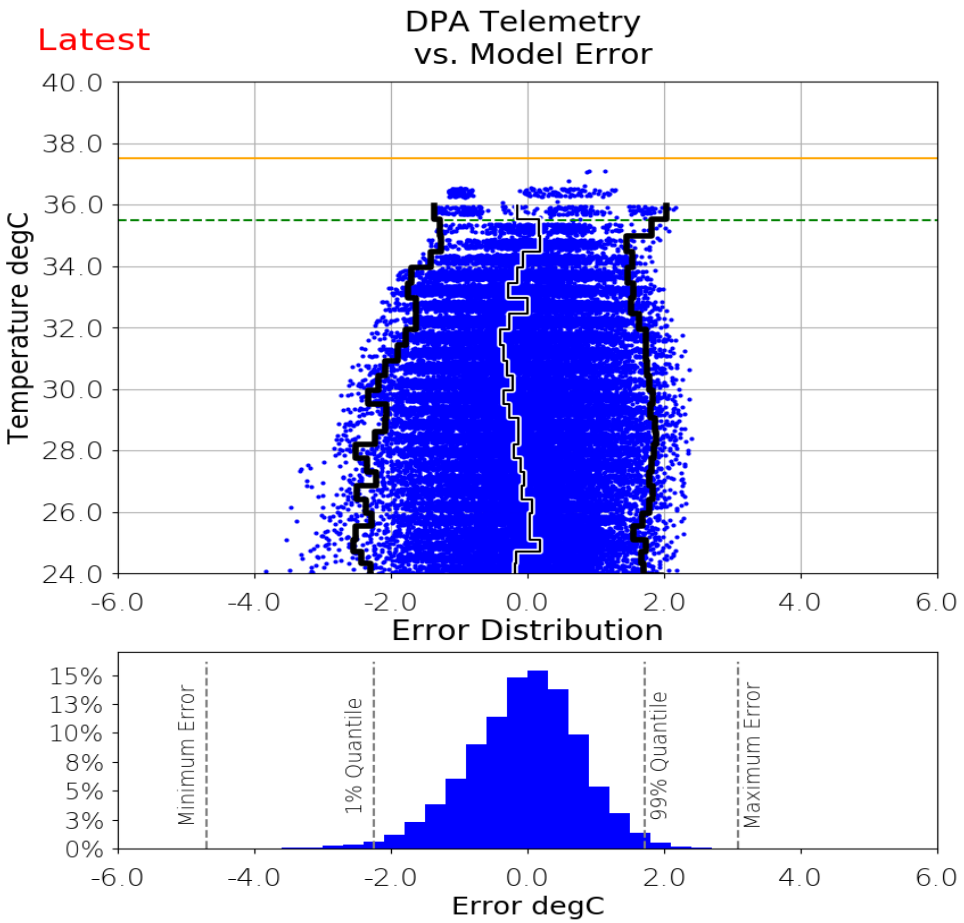
max 1DPAMZT temp went 1 degree hotter, then

BEP and FEP temperatures would still be under their Yellow Caution Limit; 1DPAMZT would still be below the Red Warning limit.

Model Accuracy Key to Minimizing Risk

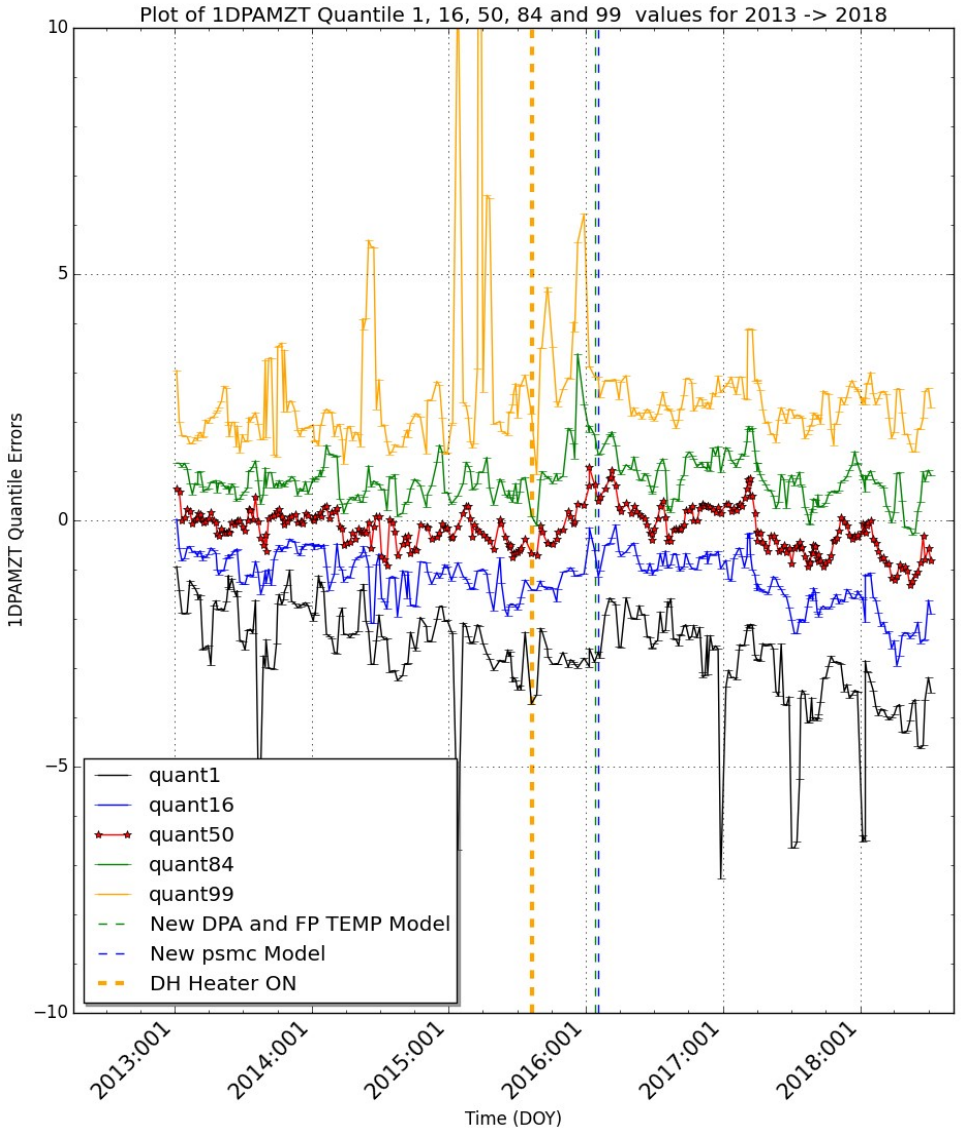
- DPA model adjusted for Off-Nominal Roll after 17198
- Recent Model re-calibration increased accuracy



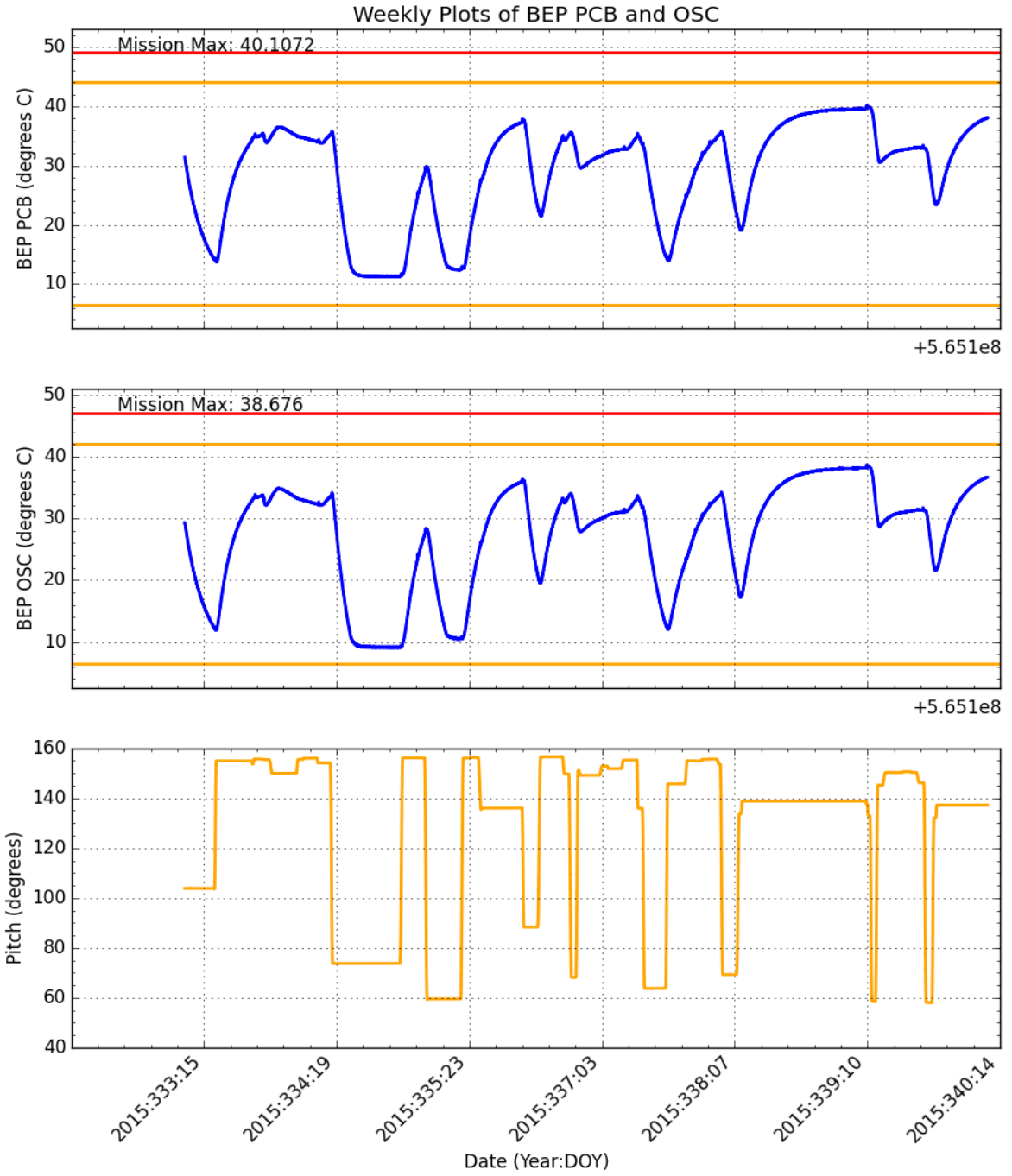


Model Performance Tracking Important

- ACIS Ops weekly checks on model performance
- Responsibility of ACIS Ops to keep the 1DPAMZT model well calibrated.



Weekly Tracking of BEPs/FEP0,1 Temperatures



Planning and Yellow High Limit Violations Reported

- ACIS Ops alerted to Yellow or Red violations during real time pass
- Email sent if dump data violation found; web page updated
  - Checked once per day.

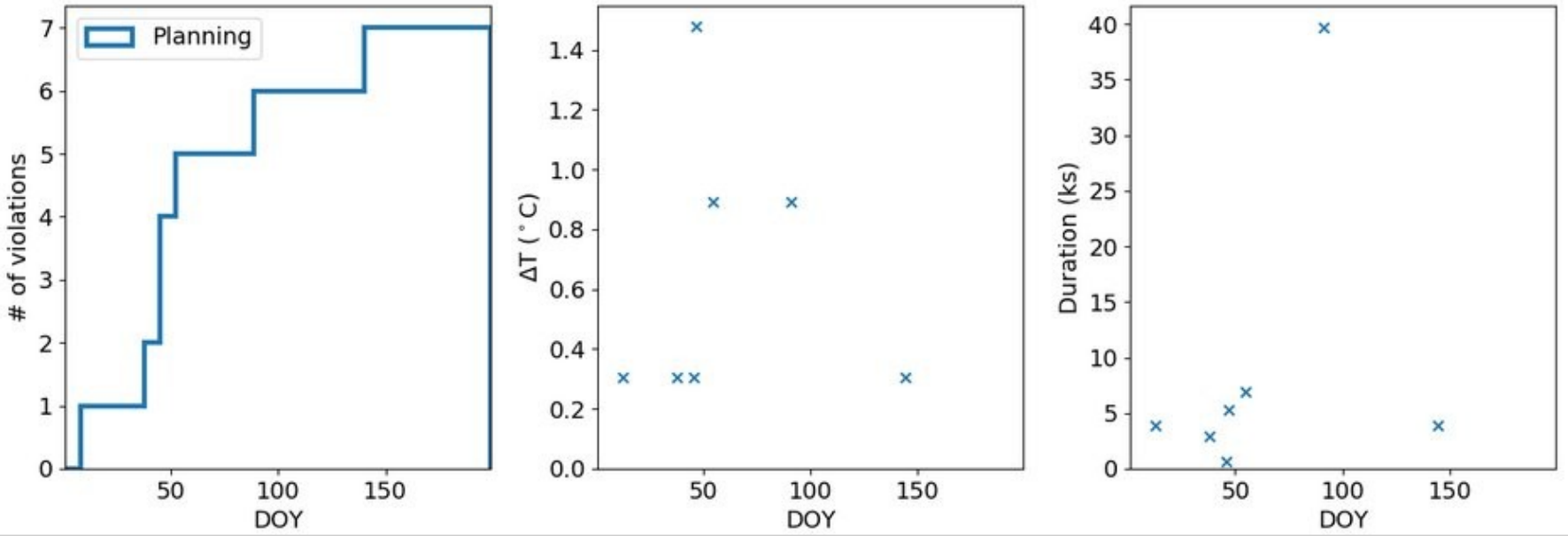
- http://cxc.cfa.harvard.edu/acis/acis_viols_tracking/index.html

2018 1DPAMZT Violations

1DPAMZT Planning Limit Violations

Date start	Date stop	Max temperature	Duration (ks)	Plot
2018:013:04:19:10.816	2018:013:05:24:46.816	35.81	3.94	link
2018:038:04:39:02.816	2018:038:05:28:14.816	35.81	2.95	link
2018:046:14:05:50.816	2018:046:14:16:46.816	35.81	0.66	link
2018:047:08:19:10.816	2018:047:09:46:38.816	36.98	5.25	link
2018:055:08:06:30.816	2018:055:10:01:18.816	36.39	6.89	link
2018:091:11:29:10.816	2018:091:22:30:38.816	36.39	39.69	link
2018:144:11:01:58.816	2018:144:12:07:34.816	35.81	3.94	link

1DPAMZT 2018 Violations Plots



Real Time Pass Monitoring

- ACIS Ops alerted to 1DPAMZT Yellow Caution and Red Warning limit violations. (limitpager)
- ACIS Team alerted to BEPs/FEP0,1 temperature violations during real time contacts (PMON)

Future Safety Enhancement

- Programming and testing is being done to execute an SCS-107 at a 1DPAMZT and/or BEP/FEP board overtemp.
- ACIS Flight Software monitors BEPs/FEPs and if a Red Warning violation, sends status bit pattern to the OBC which then causes SCS-107 execution.
- OBC software update monitoring 1DPAMZT; if a Red Warning violation then SCS-107 executed.

Summary

- Propose increasing 1DPAMZT Yellow Caution and Planning Limit by one degree Celsius.
- Helps MP by easing the thermal constraint.
- Only two instances of a 1DPAMZT Yellow Limit violation during the mission
  - 1DPAMZT Red Warning and BEPs/FEP0,1 Y.C. limits not violated
  - Roll-aware models implemented – no violations since.
- Very good model re-calibration allows confident planning
  - Even the present deteriorated model keeps us safe
    - P.L. violations but no Y.C. violations.
  - Weekly Model tracking is important: re-cal when necessary

Summary (cont'd)

- BEP and FEP boards are the components of interest: 1DPAMZT is a proxy
- BEPs/FEP0,1 margin larger than 1DPAMZT margin
- 1 degree C increase in 1DPAMZT ~= 1 degree C increase in BEPs/FEP0,1 temperatures
- ACIS Team and FOT working on on-board monitors that will execute an SCS-107 if BEPs/FEP0,1 or 1DPAMZT temperatures exceed Red Warning.
  - When implemented this will further mitigate the risk.
- Present tracking of 1DPAMZT and BEPs/FEP0,1 P.L. and Y.C. violations will alert us to any violation during R/T passes and in SSR dumps.
  - We can then respond with planning limit adjustment if necessary

Conclusion

The probability of a Yellow Caution limit is low with the current accuracy of the model and operational constraints on the spacecraft. However as the model accuracy degrades with time and/or if the operational constraints on the spacecraft change, a Yellow Caution limit violation may become more likely.

The ACIS Team believes that with vigilant tracking, thermal model re-calibration when necessary, and with the BEPs/FEP0,1 margins larger than 1DPAMZT, it is safe to raise the 1DPAMZT Planning and Yellow Caution limit by 1 degree C.

Limit Rationale and Budget

Limit	Value	Budget	Rationale
Red Warning	40.5 degrees C.		Established during ground testing; maximum temp at which the unit was operated.
Yellow Caution	38.5 degrees C.	2.0 degrees 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 deg. C. pad is sufficient.
Planning Limit	36.5 degrees C.	2.0 degrees C.	Model error of less than 2 degrees indicates a 2 degree pad between the P.L and Y.C. Sufficient for a well-calibrated model.