ACIS Update

Chandra Users Committee October 8, 2024

ACIS Overview

ACIS continues to function nominally and produce high quality data

Steiner (SAO)

- All 10 CCDs are fully functional
- Electronics are nominal, primary units are still in use
- Flight software is nominal, latest version running for over a year with no issues
- Over 90% of GO & GTO observations use ACIS

Cycle 24 GO & GTO Observing Statistics

Instrument	Grating	# of Obs	% of Obs	Time(ks)	% of Time
ACIS-I	NONE	413	43.3	7280	45.6
ACIS-S	NONE	428	44.9	6940	43.5
ACIS-S	HETG	63	6.6	1300	8.1
Total			94.8		97.2

Highlights:

- No ACIS anomalies in the last year, operations has been smooth
- Minimal impact from perigee minimum during 2023, ACIS continues to function nominally
- FP temperature limits for observations are set depending on the science objectives of the proposal
- ACIS is functioning as the radiation monitor for Chandra
- ACIS Ops developed a new thermal model as a contingency for the existing sensor failing

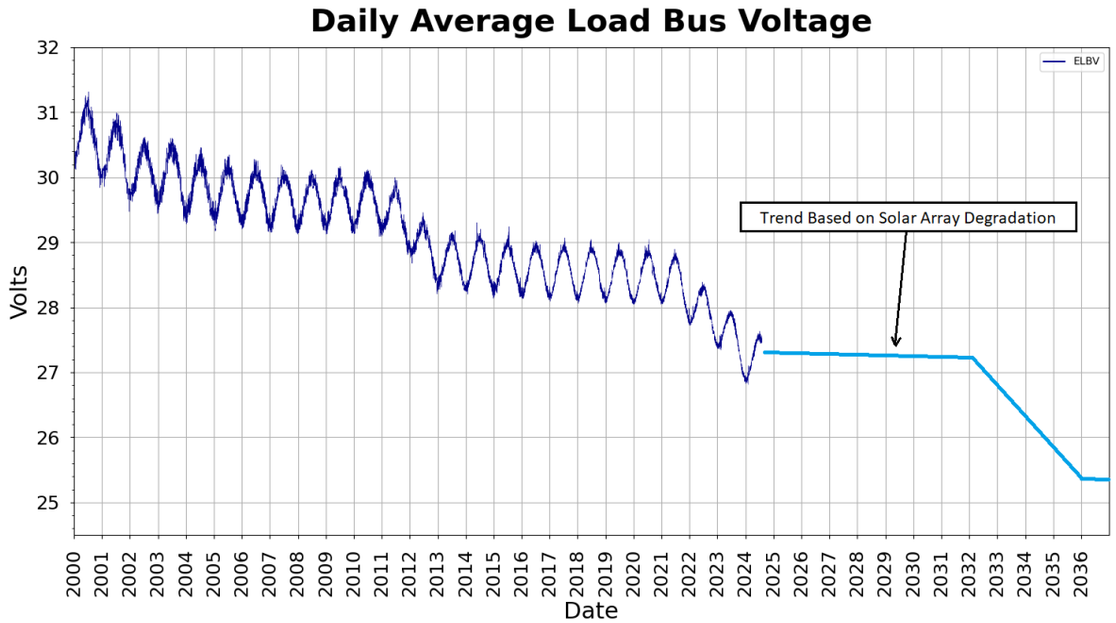
Chandra Low Perigee in 2023

CXC

- Chandra achieved a minimum perigee altitude of 1045 km in July 2023
- Minimal impact on ACIS
- Perigee altitude is now increasing (currently ~4000 km), no further impacts expected

Solar arrays degrade during low perigee times and spacecraft bus voltage decreases

Spacecraft Bus V

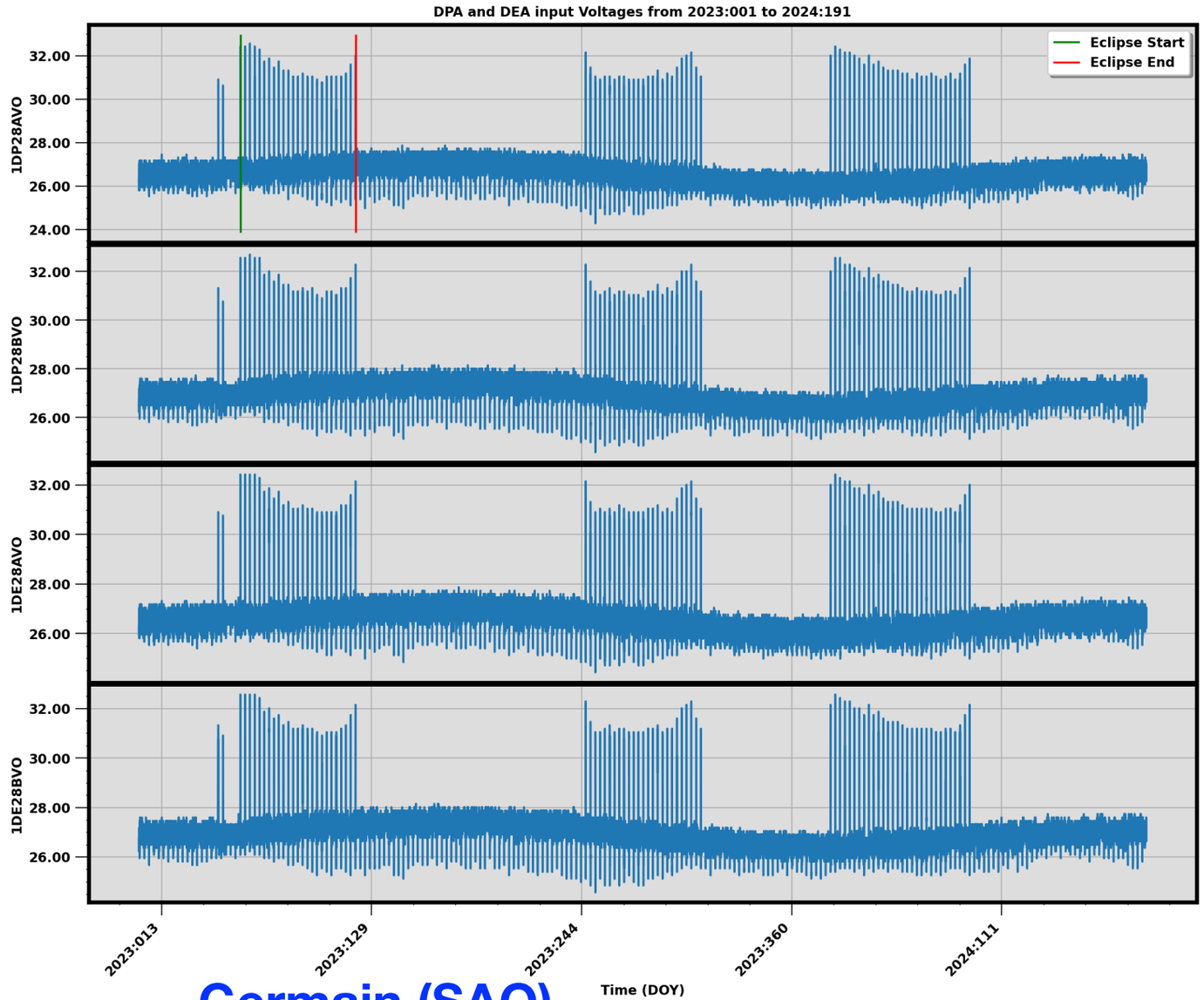


No impact on ACIS
Input voltages acceptable for next ~10 years

Minimum Values:
1DP28AVO = 24.288
1DP28BVO = 24.564
1DE28AVO = 24.426
1DE28BVO = 24.564

ACIS DPA & DEA Input Voltages

Yellow/Red low limits 24.5/22.0 V

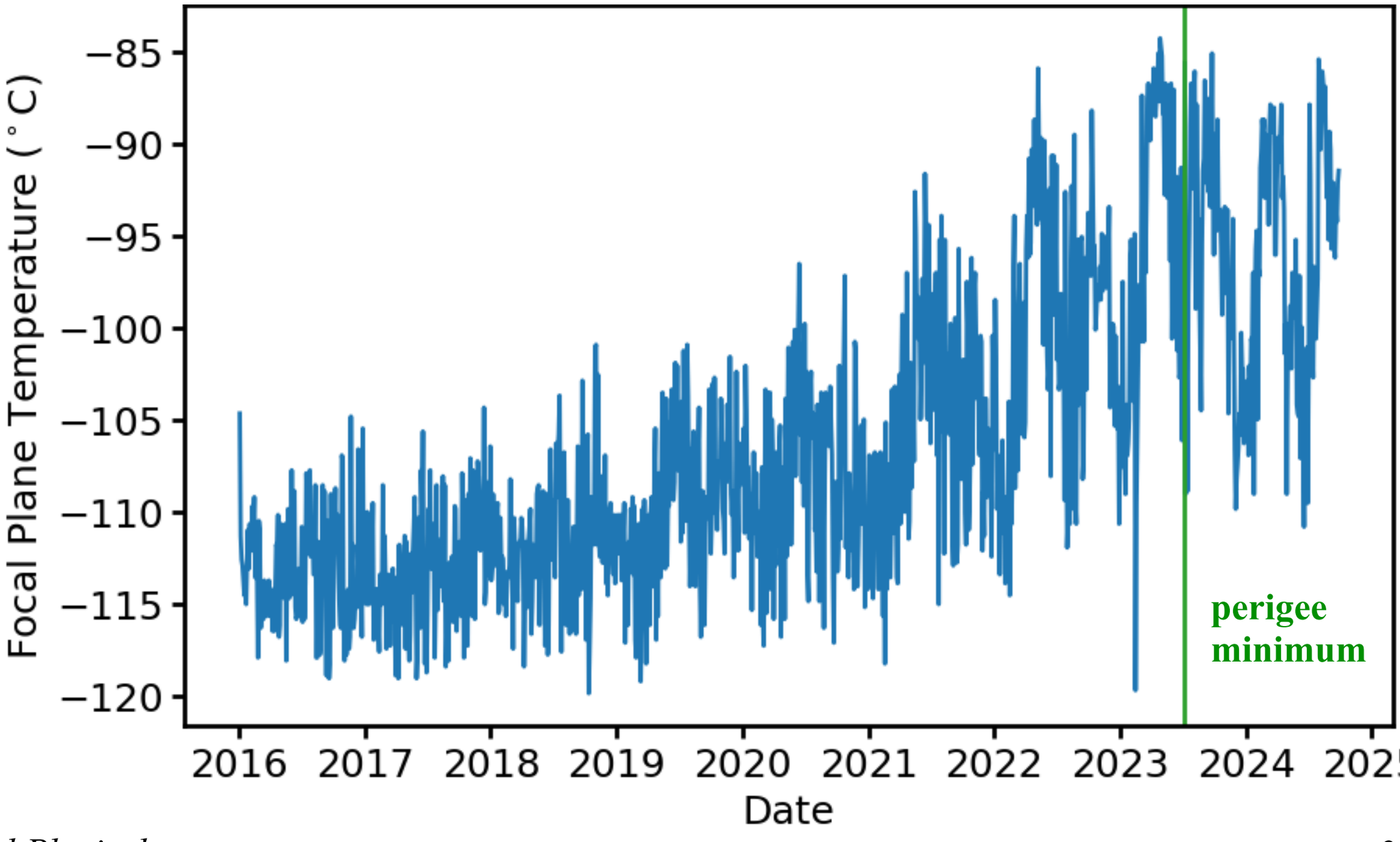


Germain (SAO)

Chandra Low Perigee in 2023

- ACIS FP temperature warms during perigee passages
- FP temperature was kept below the Yellow High limit of -80 C for all perigee passages
- Maximum temperatures are expected to decrease in the coming years

Maximum FP temperature during perigee passages



ZuHone (SAO)

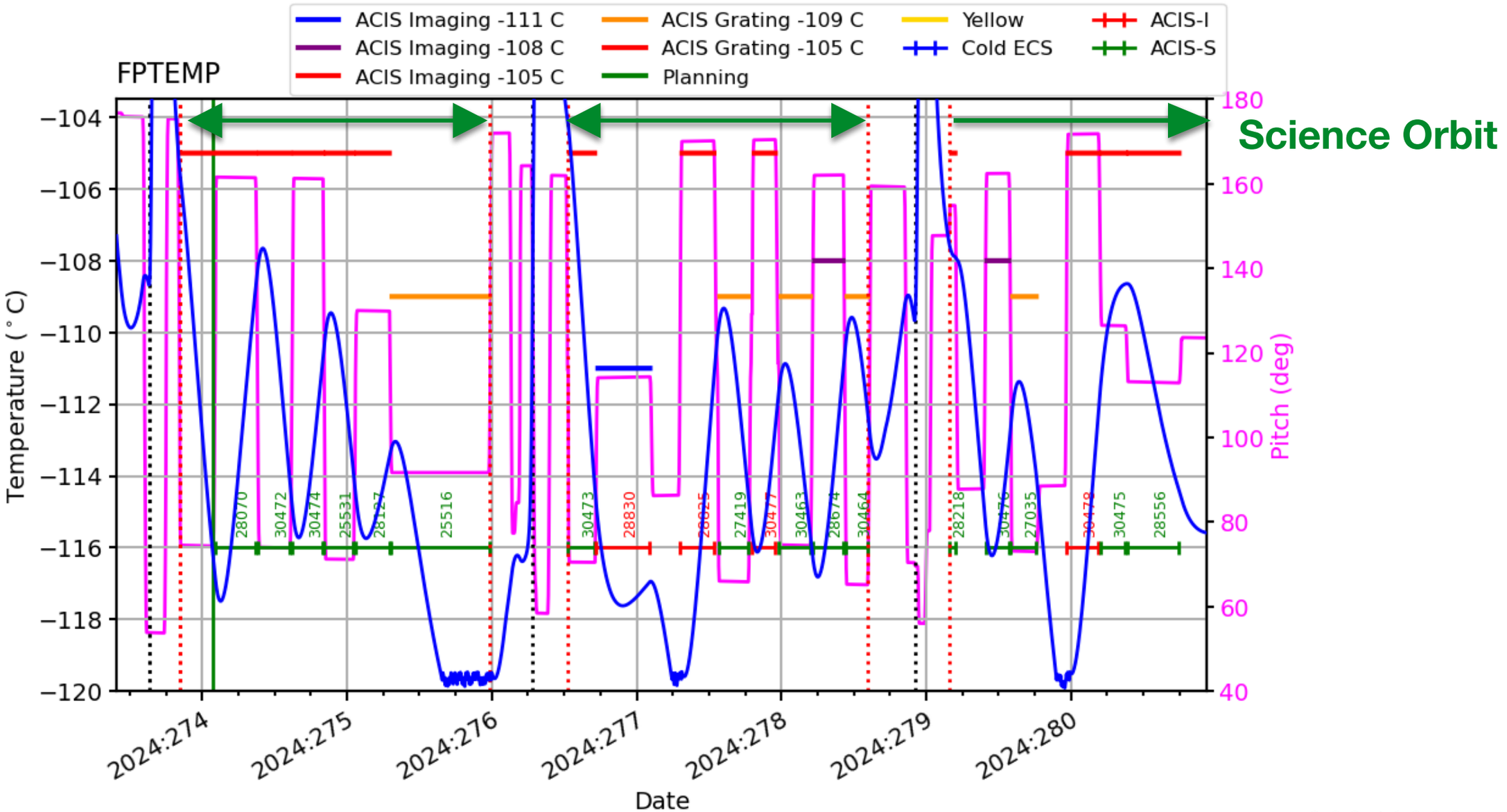
ACIS FP Temperature Limits for Observations

CXC

- **-111 C ACIS-S & ACIS-I observations that benefit from the most accurate spectral response**
- **-108 C ACIS-S & ACIS-I observations that can achieve the objectives with reduced spectral response**
- **-105 C ACIS-S & ACIS-I observations that can achieve the science objectives with even more reduced spectral response [New this year]**
- **-109 C All ACIS-S/LETG and ACIS-S/HETG observations with a SIM Z offset of -6.0 mm or more positive such that the dispersed spectrum is farther from the readout [New this year]**
- **-105 C ACIS-S/HETG observations with a SIM Z offset of -6.0 mm or more negative such that the dispersed spectrum is closer to the readout [New this year]**

SEP3024

ZuHone (SAO)

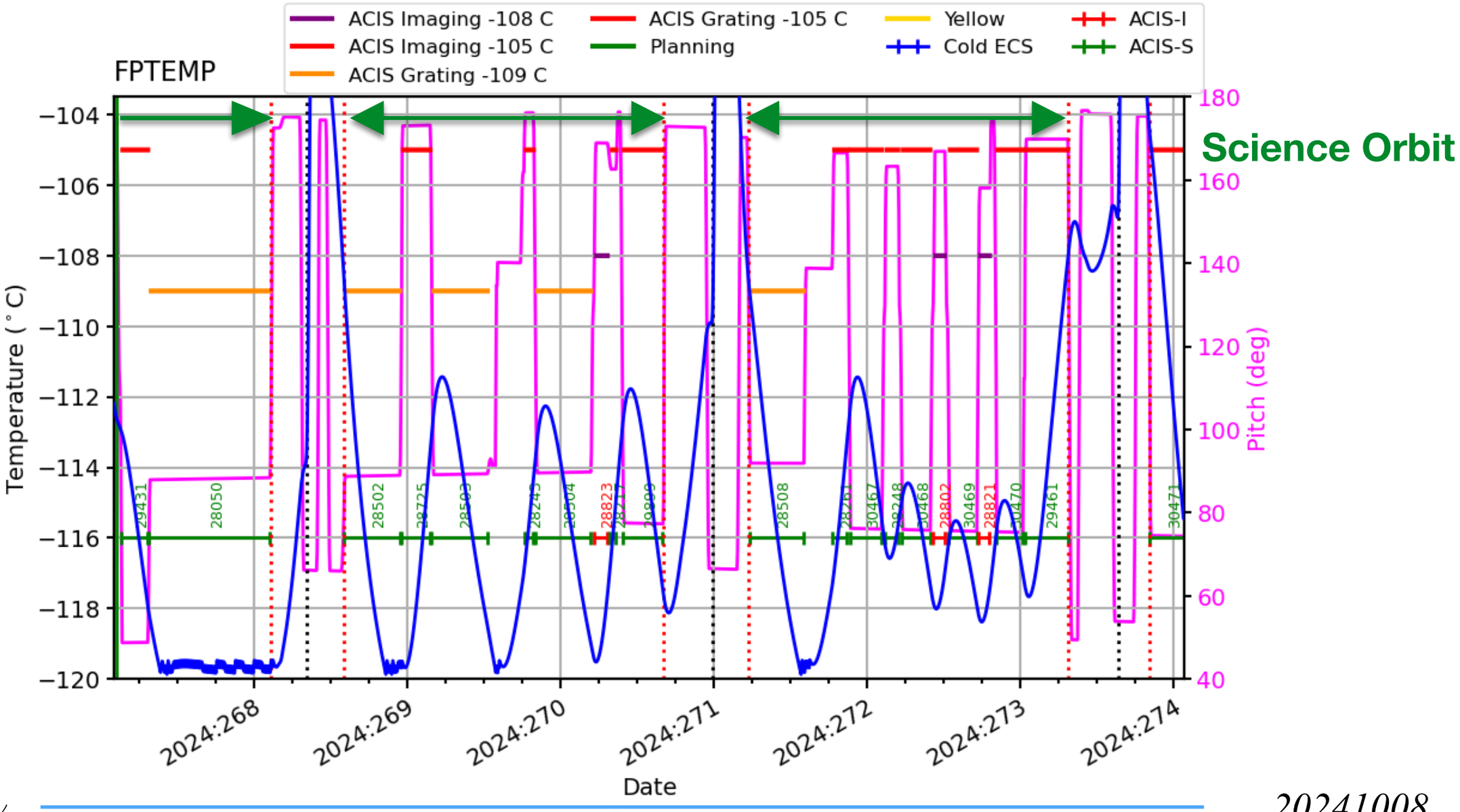


ACIS FP Temperature Limits for Observations

- **FP temperature is almost always increasing or decreasing**
- **KEY POINT: almost all of a GO observation will be executed with a FP temperature *less* than the limit providing higher quality data**
- **Calibration files account for this variable FP temperature**
- **Staying below these limits has gotten *easier* in the last year given the relaxation of other spacecraft thermal limits**

SEP2324

ZuHone (SAO)



ACIS Flight SW Update

- Flight SW updated on 19 September 2023, 8th modification since launch
- Four "patch loads" were included in this update:
  1. Alternating Exposure Mode bias computation bug fix → *GO impact*
  2. SW reports that science is idle when all video boards are powered off
  3. SW reports more diagnostic information when the BEP reboots due to a bus error
  4. SW forces a new bias map computation when a FEP has been powered off before the current science run

  } *minimal or no GO impact*

This Flight SW version has run for over a year without any issues.

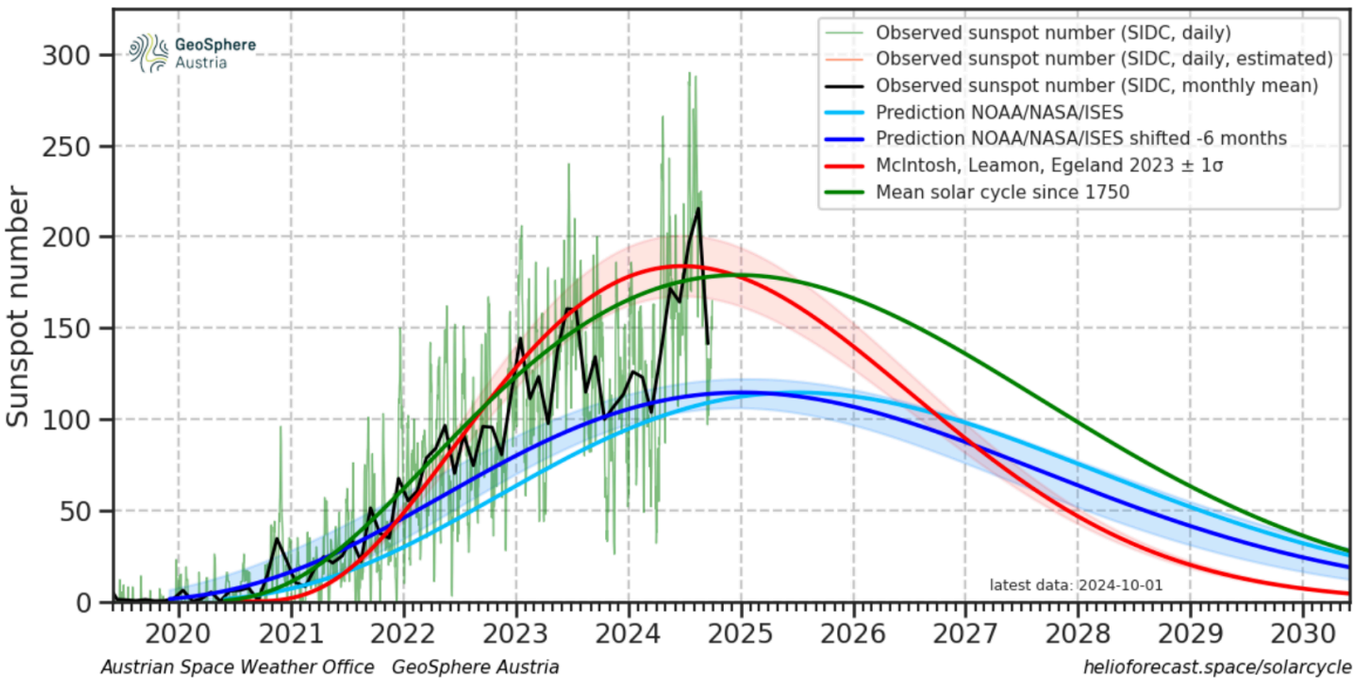
Chandra OCC: 19 September 2023, 8pm-10pm EDT

Solar Cycle Progression

- Solar Cycle 25 is close to its peak. This cycle is stronger than predictions
- Observations are suspended during strong storms and ACIS is moved to a safe position
- Safing ACIS during strong storms reduces the rate at which CTI increases
- There have been 7 radiation shutdowns in the past year (4 manual, 3 autonomous)
- Autonomous shutdowns are initiated by the ACIS radiation monitor called “txings”

Solar Cycle Progression

https://helioforecast.space/solarcycle



Fluence of low energy protons on ACIS

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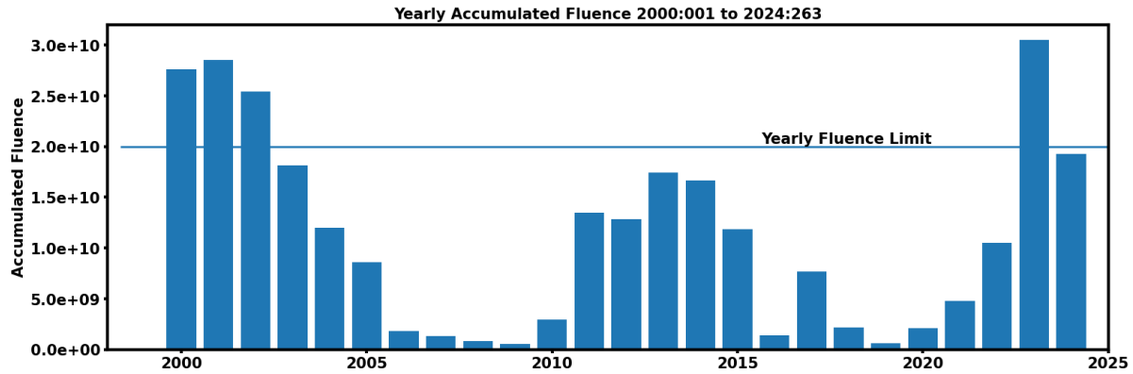
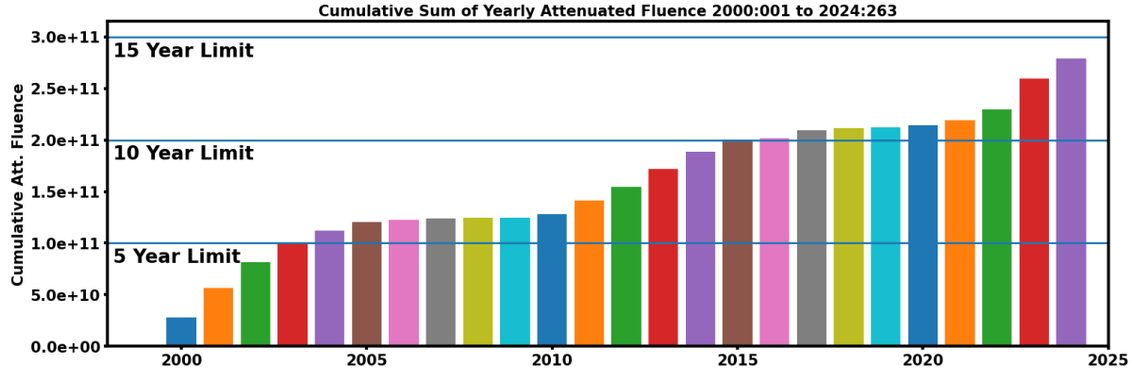
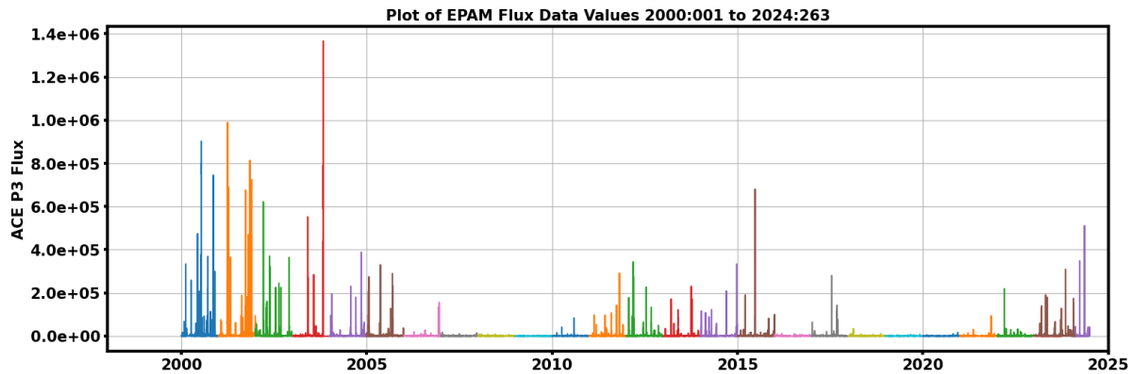


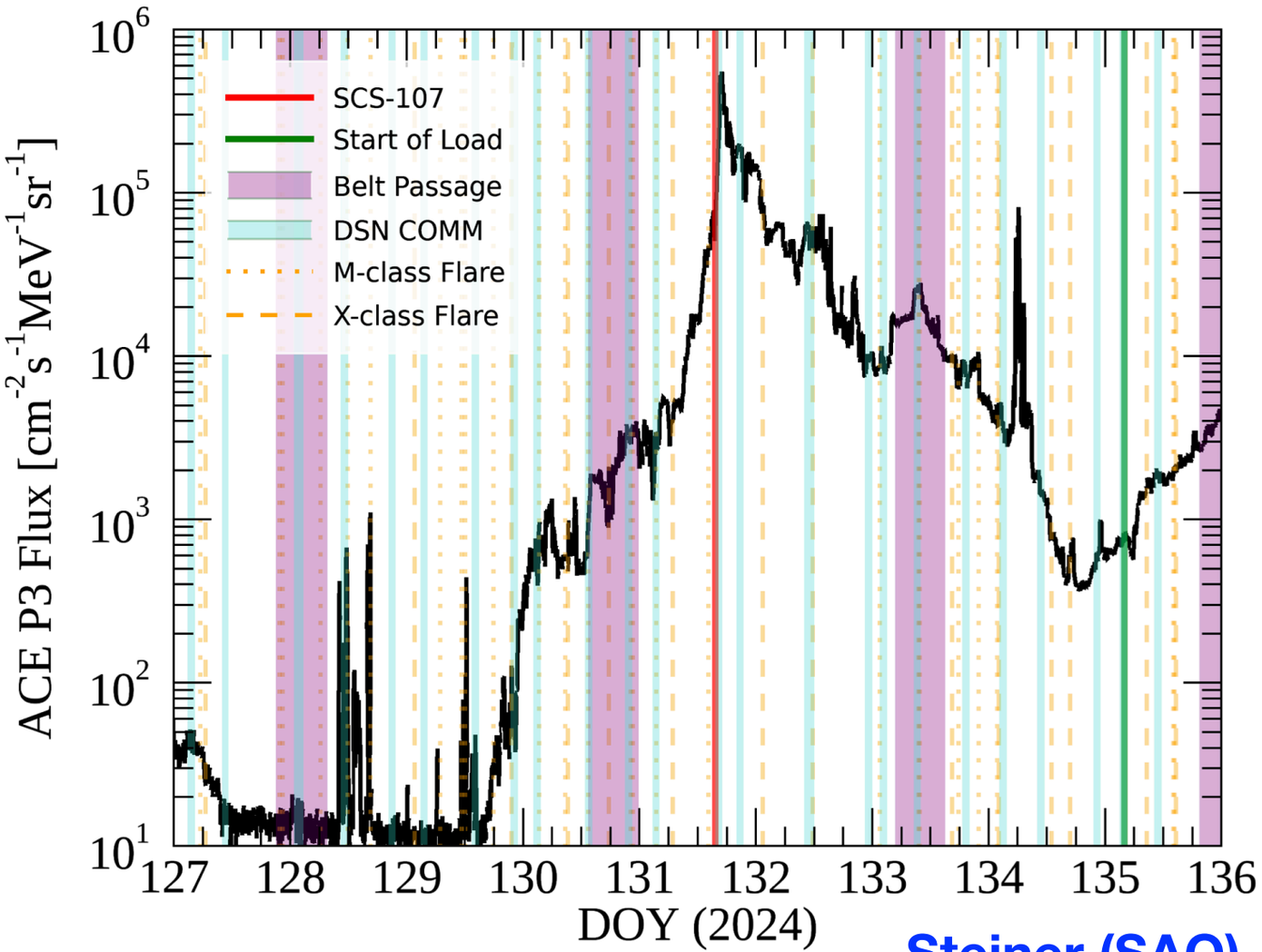




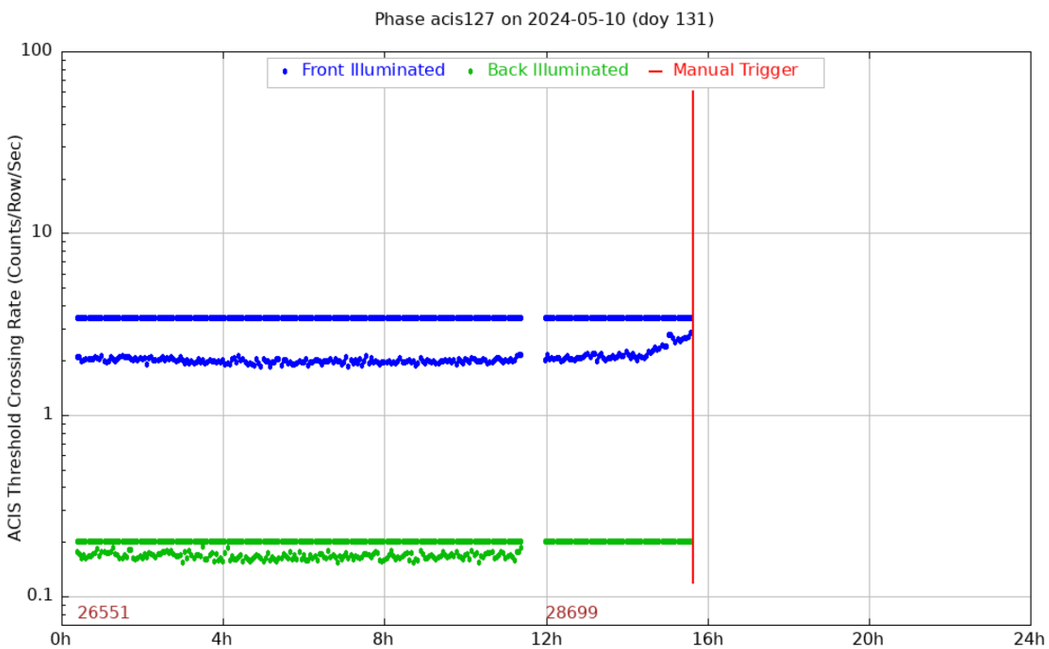
Manual Radiation Shutdown

- Large solar storm in May 2024
- Four X class flares and multiple M class flares in a 48 hour period
- Multiple Coronal Mass Ejections (CMEs) combined to produce a major storm
- Chandra had a scheduled realtime COM close to the rapid rise in the proton rates
- Shutdown saved ACIS from a fluence of 9.7e9 (annual fluence budget is 2.0e10)
- Orbital fluence was 8.5e8

ACE P3 rates



Steiner (SAO)



ACIS txings rates

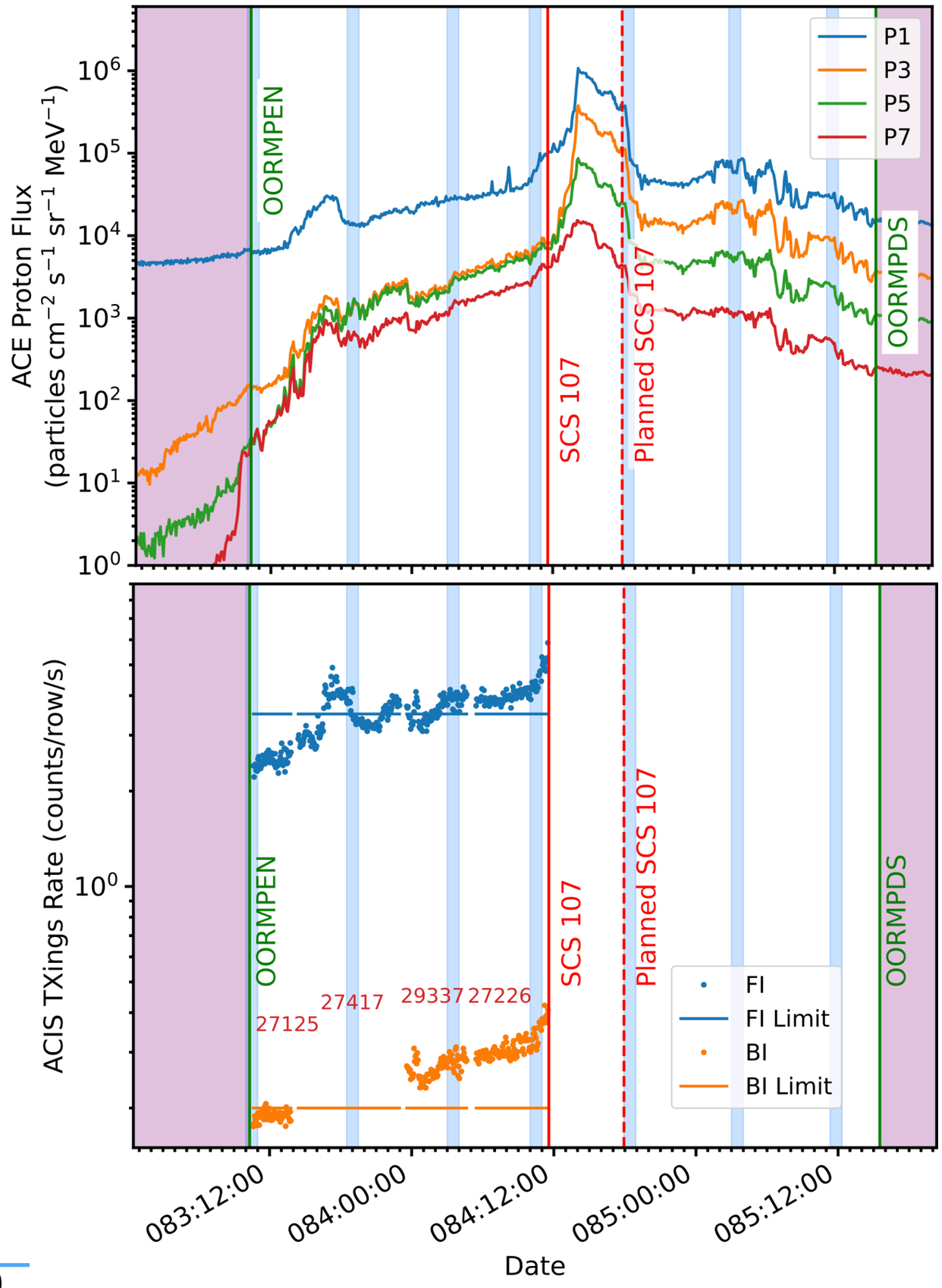
Ford (MIT)

Autonomous Radiation Shutdown

CXC

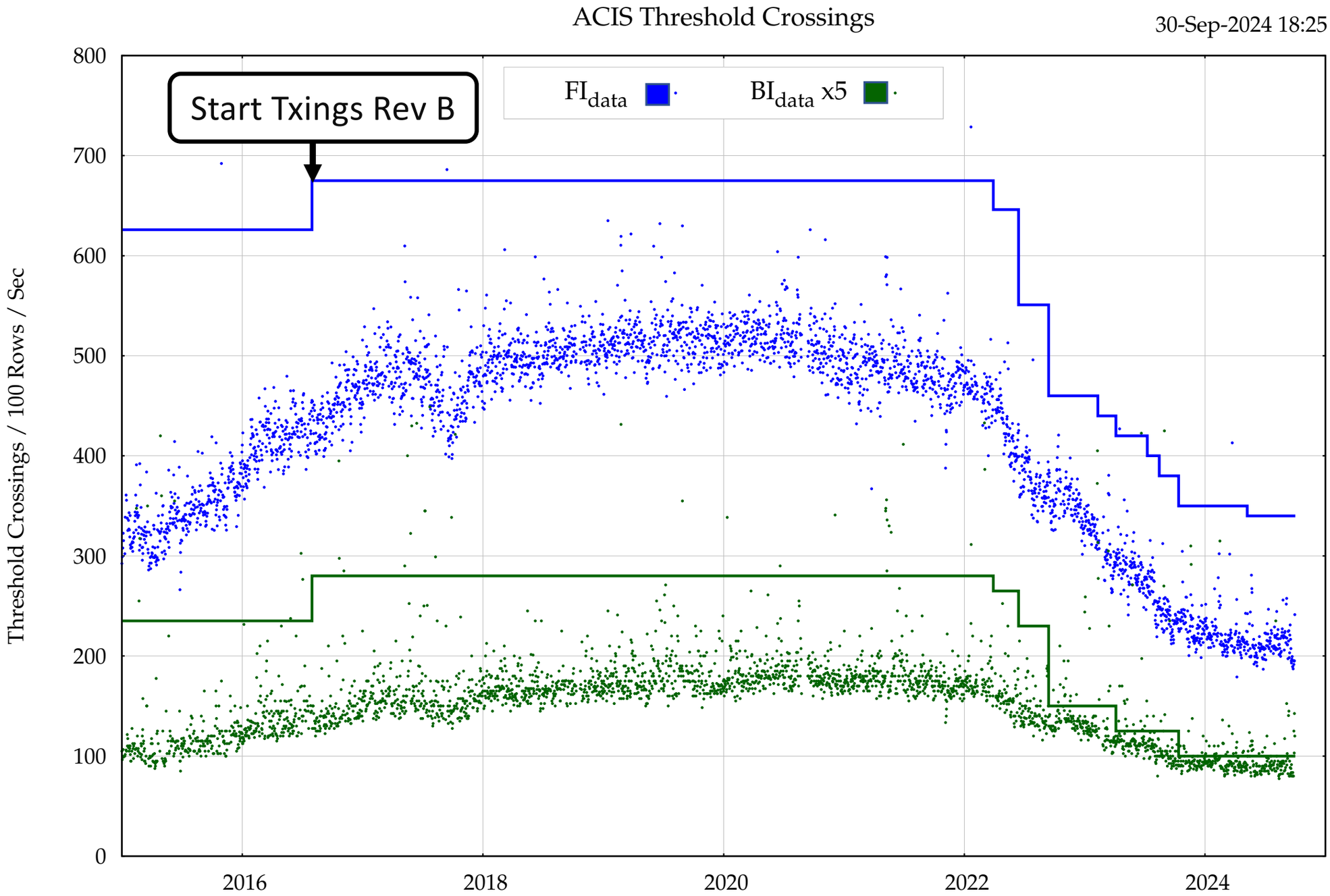
- **Single X class flare and associated CME in March 2024**
- **Sharp rise in rates occurred outside of COM**
- **Fortunately ACIS txings triggered the radiation safing**
- **Fluence for the orbit was 2.4e8 and the ACIS trigger saved ACIS from an additional 3.2e9 of fluence**
- **ACIS txings has triggered three times in the last year**

ZuHone (SAO)



Managing txings Thresholds

- **The ACIS background rate varies significantly during the Solar Cycle**
- **The txings thresholds must be adjusted as the background level changes**
- **The thresholds have been adjusted 9 times during this cycle**



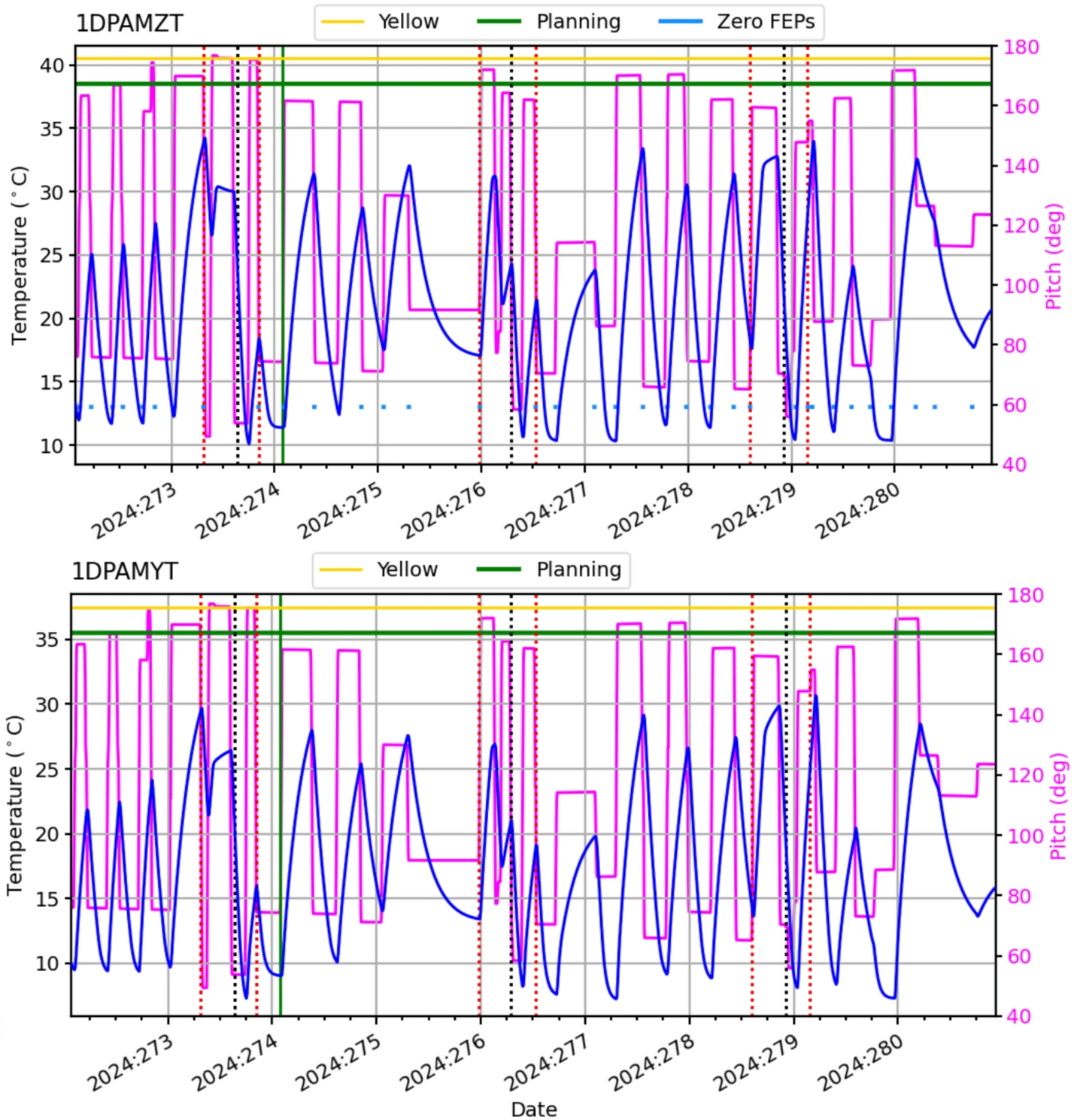
Ford (MIT)

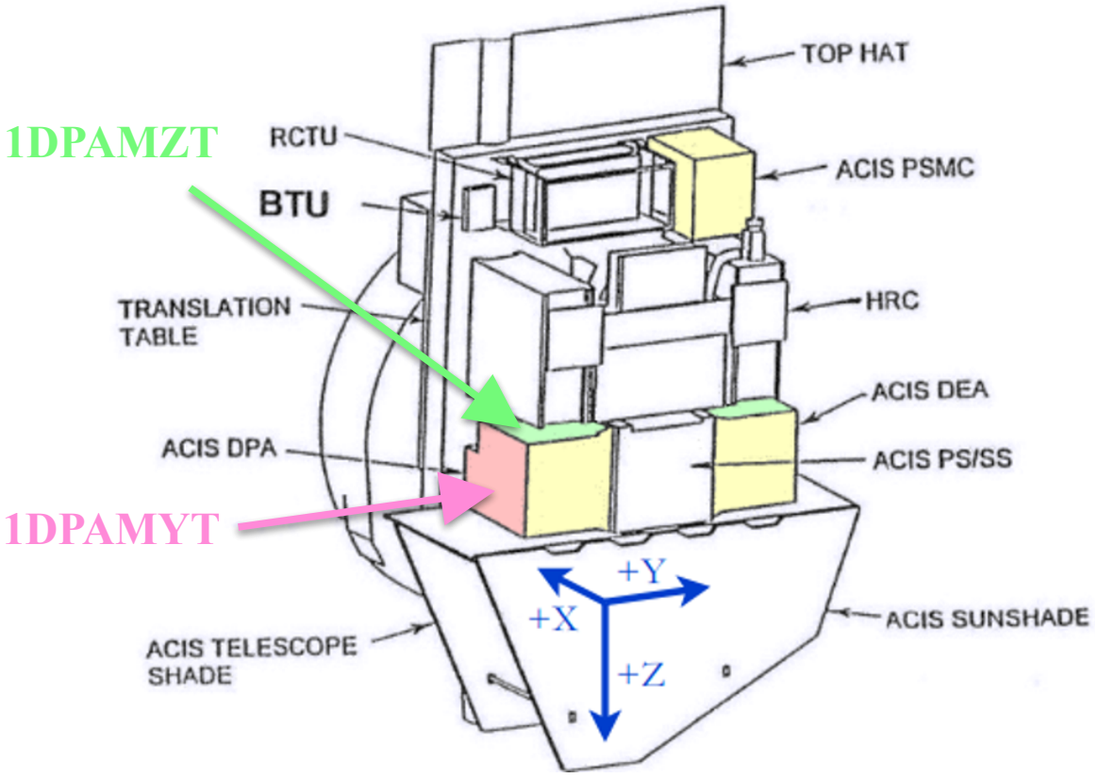
New Thermal Model of the ACIS DPA

CXC

- The DPA Minus-Z temperature (1DPAMZT) is used to protect the ACIS electronics from getting hot
- The Minus-Y temperature (1DPAMYT) tracks 1DPAMZT closely
- Given the importance of 1DPAMZT in planning the schedule, we developed a model for 1DPAMYT that could be quickly substituted for 1DPAMZT in case that sensor failed

Germain (SAO)





ACIS Summary

ACIS continues to function nominally and produce high quality data

- All 10 CCDs are fully functional
- Electronics are nominal, primary units are still in use
- No light leaks or damage due to micrometeorite impacts
- Additional absorption due to the contamination layer is well-modeled
- FP temperature is maintained within limits depending on the science objectives of the observation
- Flight software is nominal, latest version running for over a year with no issues
- Over 90% of GO & GTO observations use ACIS

Future Prospects:

- No ACIS anomalies in the last year, flight SW updates have minimized the impact of future anomalies depending on the anomaly
- Minimal impact from perigee minimum during 2023, impacts will decrease or disappear as the perigee altitude increases
- FP temperature limits for observations are easier to accommodate given relaxation of other constraints
- ACIS is functioning successfully as the radiation monitor for Chandra
- Contingency model for 1DPAMYT ready in case the 1DPAMZT sensor fails

ACIS should continue as the workhorse instrument for Chandra for years to come