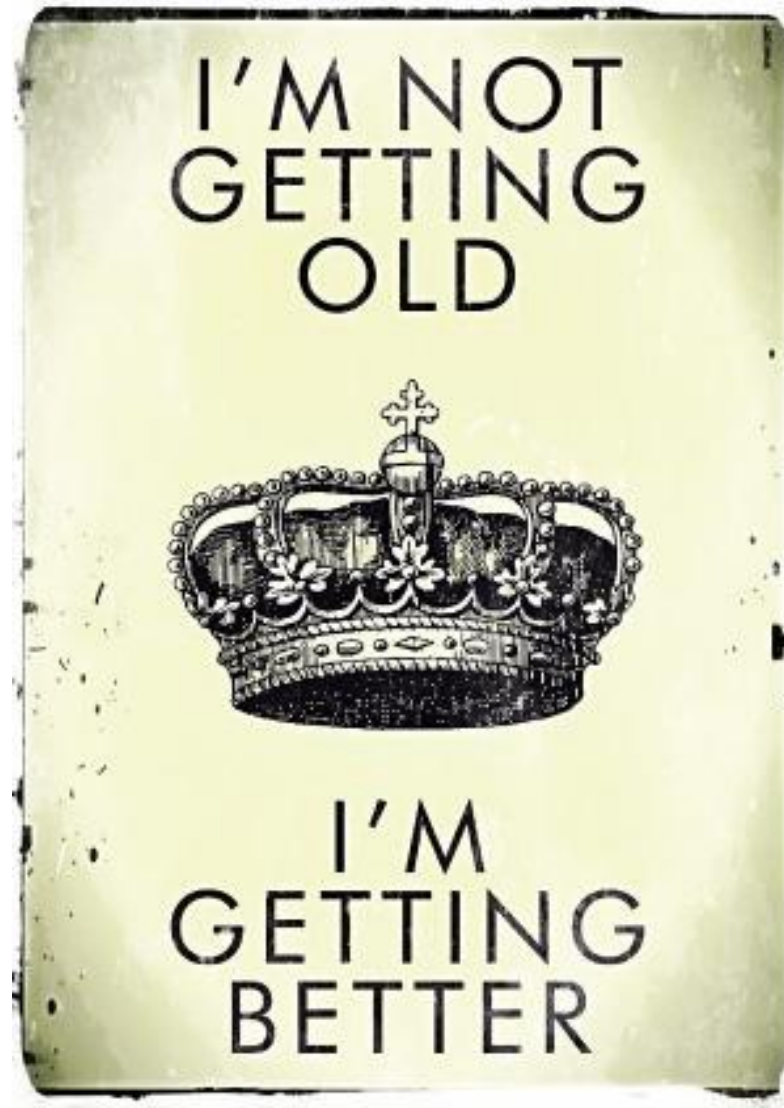


NuSTAR status update

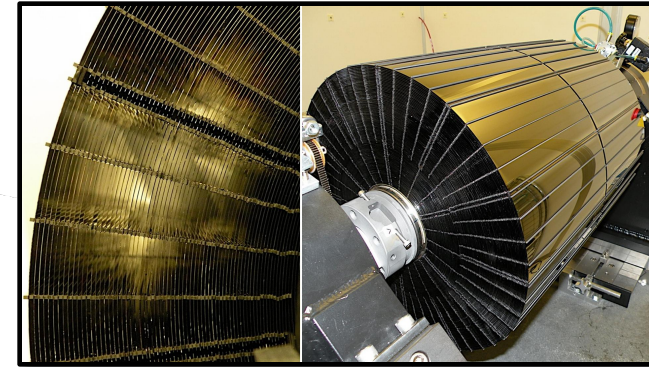
Kristin K Madsen

Caltech



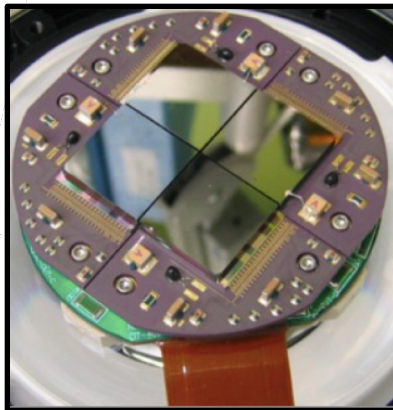
NuSTAR Observatory

- NASA small explorer astrophysics mission
- PI Fiona Harrison (Caltech)
- Partners: ASI, SSCC, DTK, HEASARC
- Launched on June 2012, 620 km, 6° orbit
- Orbital-ATK LeoStar-2 spacecraft bus



Conical Wolter-I approximation
133 shells (43 W/Si, 90 Pt/C)
HPD = 1 arcminute
FOV = 12' x 12'

10.14m focal length
Extendable Mast

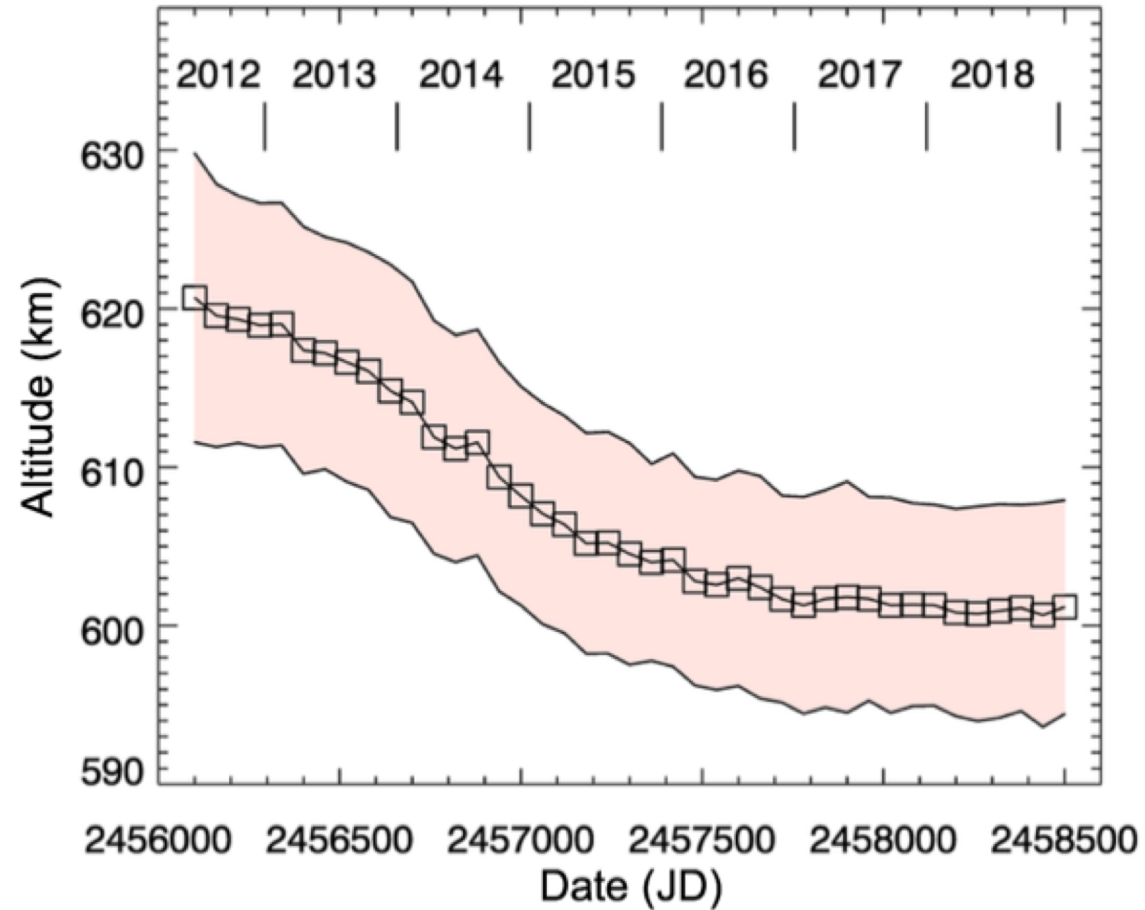


CdZnTe detectors
4x(32x32 pixels)

Resolution:
400 eV @ 6 keV
900 eV @ 60 keV
3 ms time resolution

- No consumables
- Single string
- >10 year lifetime

Orbit = lifetime



Calibration & Status

Observatory status is green – no significant anomalies in 2018/19

2018-19 Calibration news

- Monthly Crab calibration observations – focus and straylight
 - Monitor detector absorption parameters, absolute normalization and vignetting
 - Update on Crab cross-calibration: **Kristin Madsen – Non-thermal WG, Wednesday morning**
- RMF calibration
 - Adjustment of detector threshold and long term gain monitoring: **Hiromasa Miyasaka – Detector WG, Monday afternoon**
- Timing calibration improvements
 - Achieved 20 μ s stability over \sim 1 day: **Matteo Bachetti – Timing WG, Tuesday morning**

2018-19 Operations news

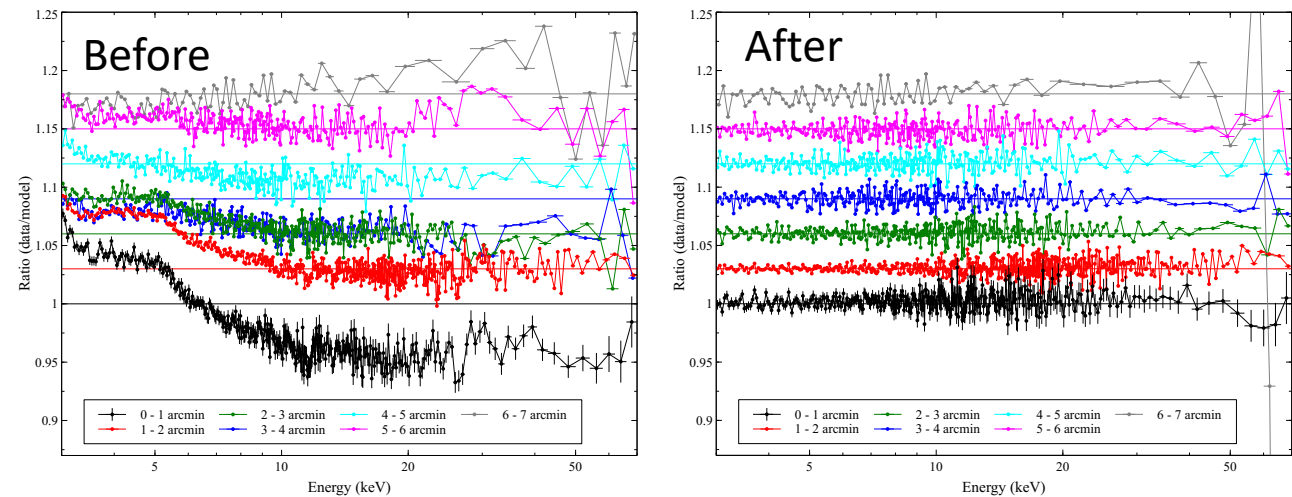
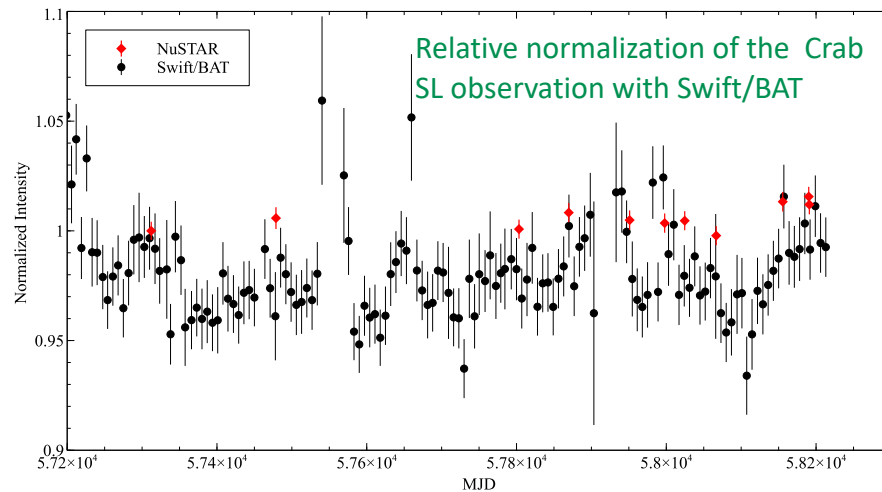
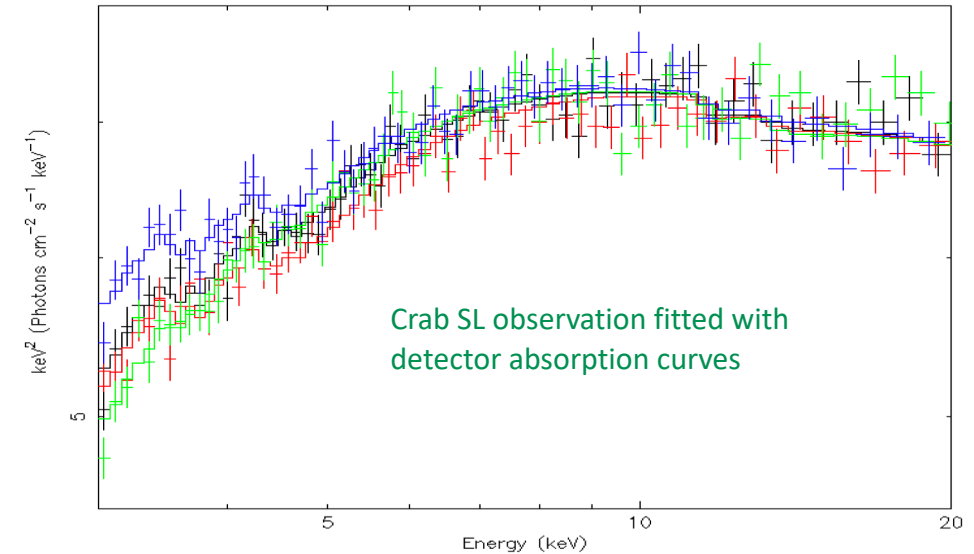
- Mast adjustment performed May 22, 2018
- Observing constraints updated
 - Sun avoidance update $Saa > 43^\circ$ (was 39° , improvement in knowledge of astrometry star tracker behavior)
 - ~~• Mast leaning constraints ($-X$ $90^\circ < Saa < 110^\circ$, $+X$ $70^\circ < Saa < 80^\circ$)~~
 - ~~• Metrology calibration limit ($104^\circ < Saa < 106^\circ$)~~
 - Optics thermal avoidance ($145^\circ < Saa < 160^\circ$)
- Metrology performance

Crab Calibration

Re-calibration of detector absorption, absolute normalization, and the vignetting files

Scope: The new Crab campaign expands upon our focused Crab data base (50 observations) and complements it with StrayLight observations.

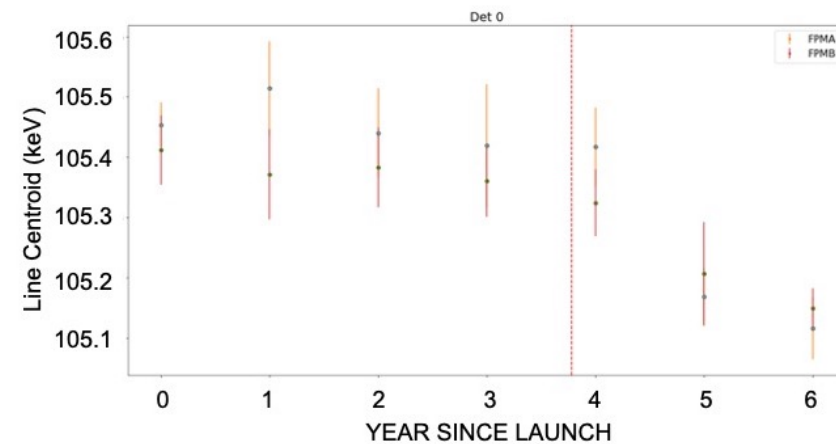
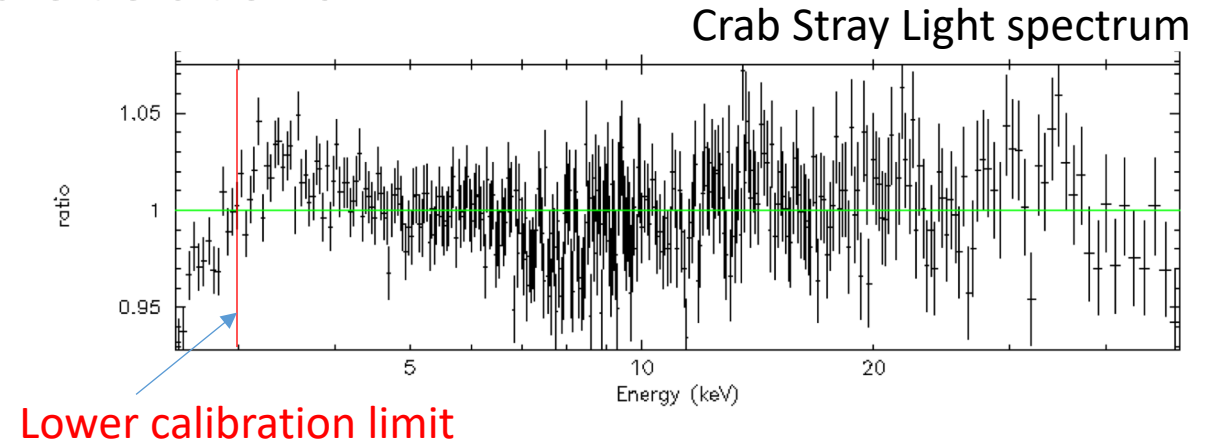
- Absolute normalization: StrayLight observations
- Detector absorption: StrayLight observations
- Vignetting files: focused Crab observations from the entire mission lifetime



Status: procedure completed and documented in SPIE 2018 – but full application awaits completion of RMF study

Low energy response calibration and long term gain monitoring of the NuSTAR detectors

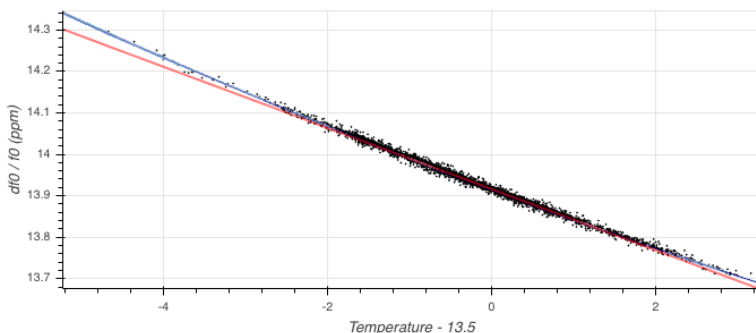
- **Low energy discrepancy is still under investigation.**
 - New RMF is generated based on threshold measurements
 - It is now under validation
 - Need more study
- **Long term gain monitoring**
 - Slope (gain) indicate a deviation from the current 0.2% per year linear correction.
 - Require CALDB update
 - Offset still show no time dependence



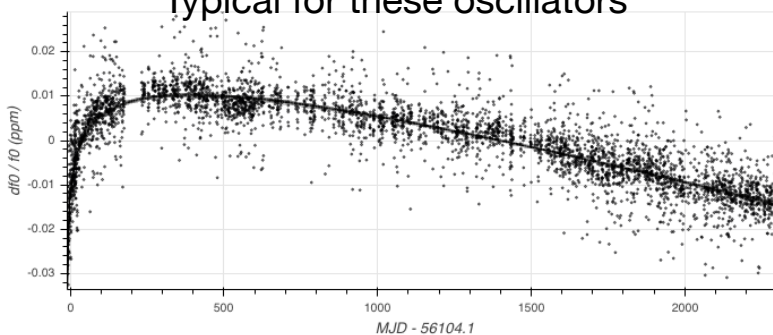
Hiromasa Miyasaka – Detector WG, Monday afternoon

Timing calibration

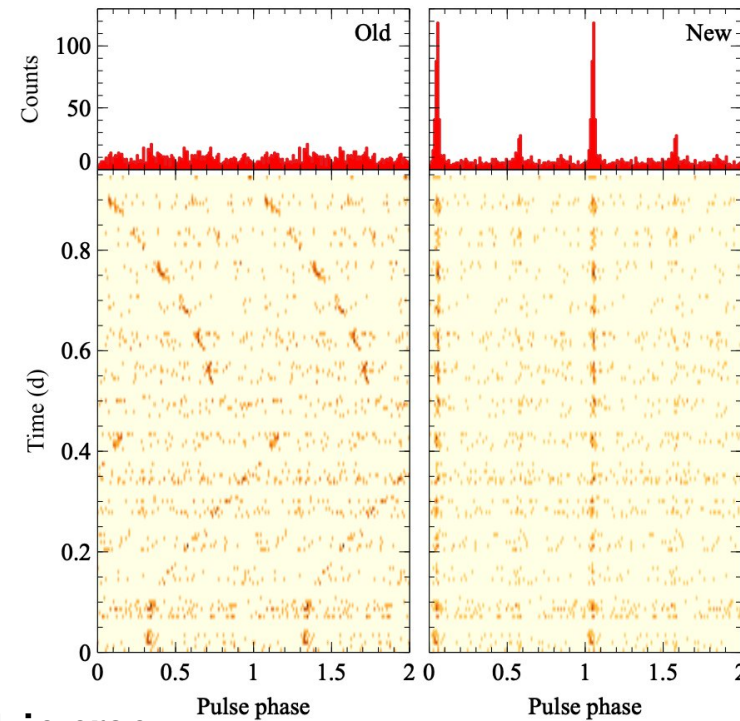
Temperature model for spacecraft TCXO
 The temperature compensation of the TXCO needed a refinement



Aging of spacecraft TCXO
 Typical for these oscillators

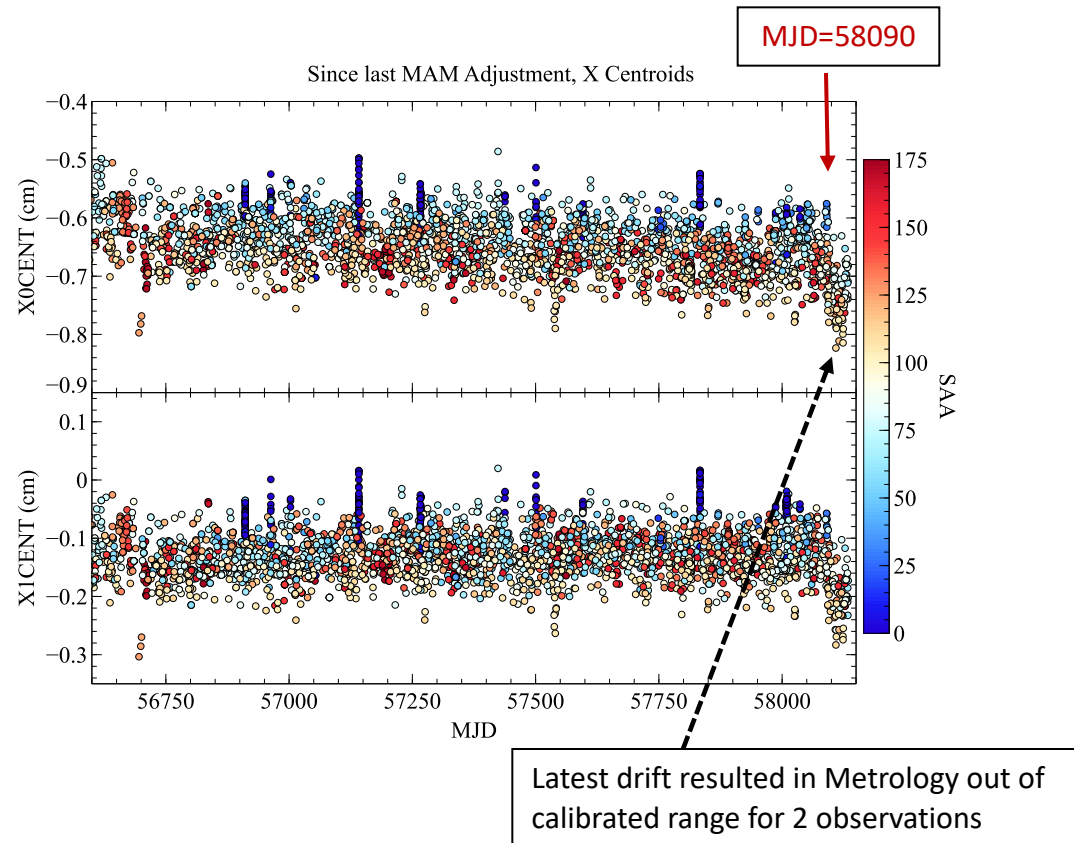
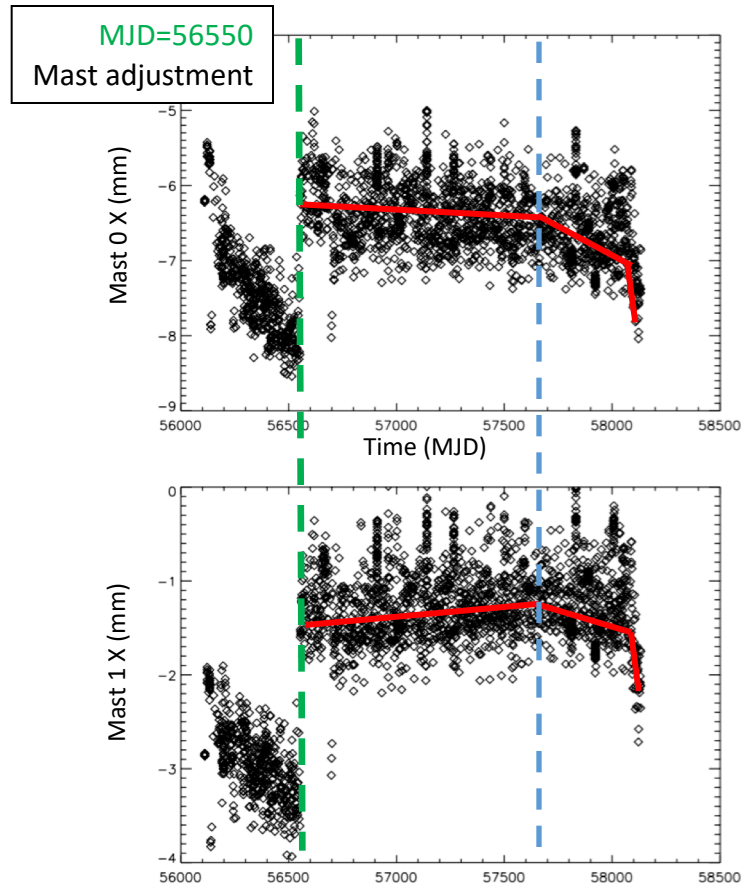


Mission requirements: 100 ms
Current clock file: 2 ms
New calibration -> 20 microsec
 stability over ~1 day



Bachetti, Markwardt et al. in prep.

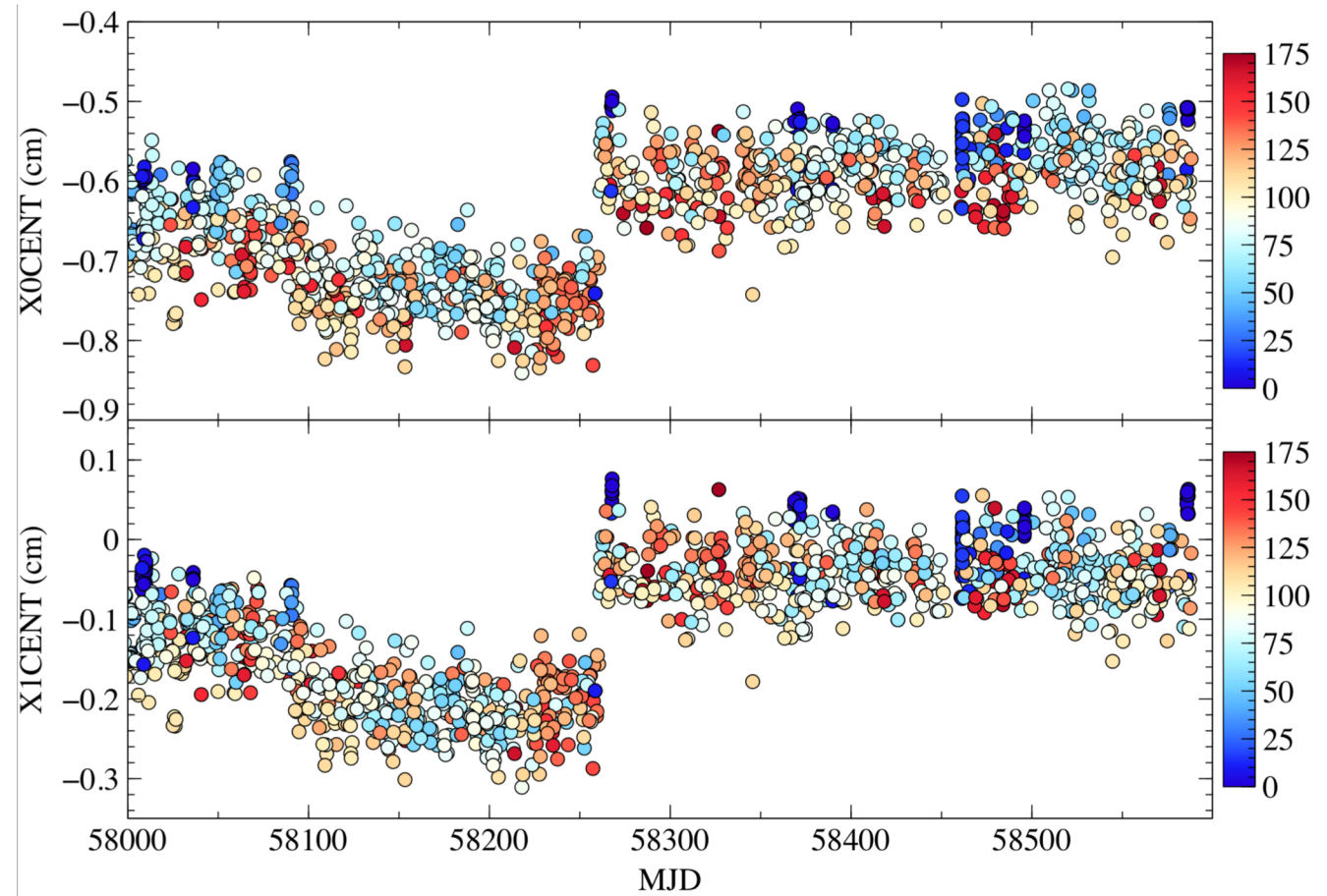
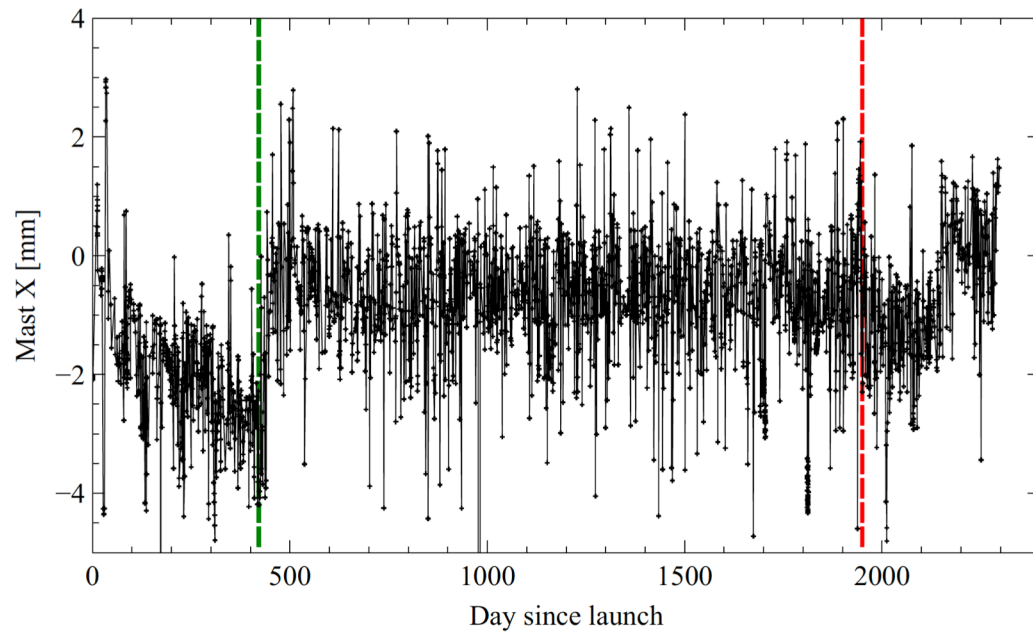
Mast Creep



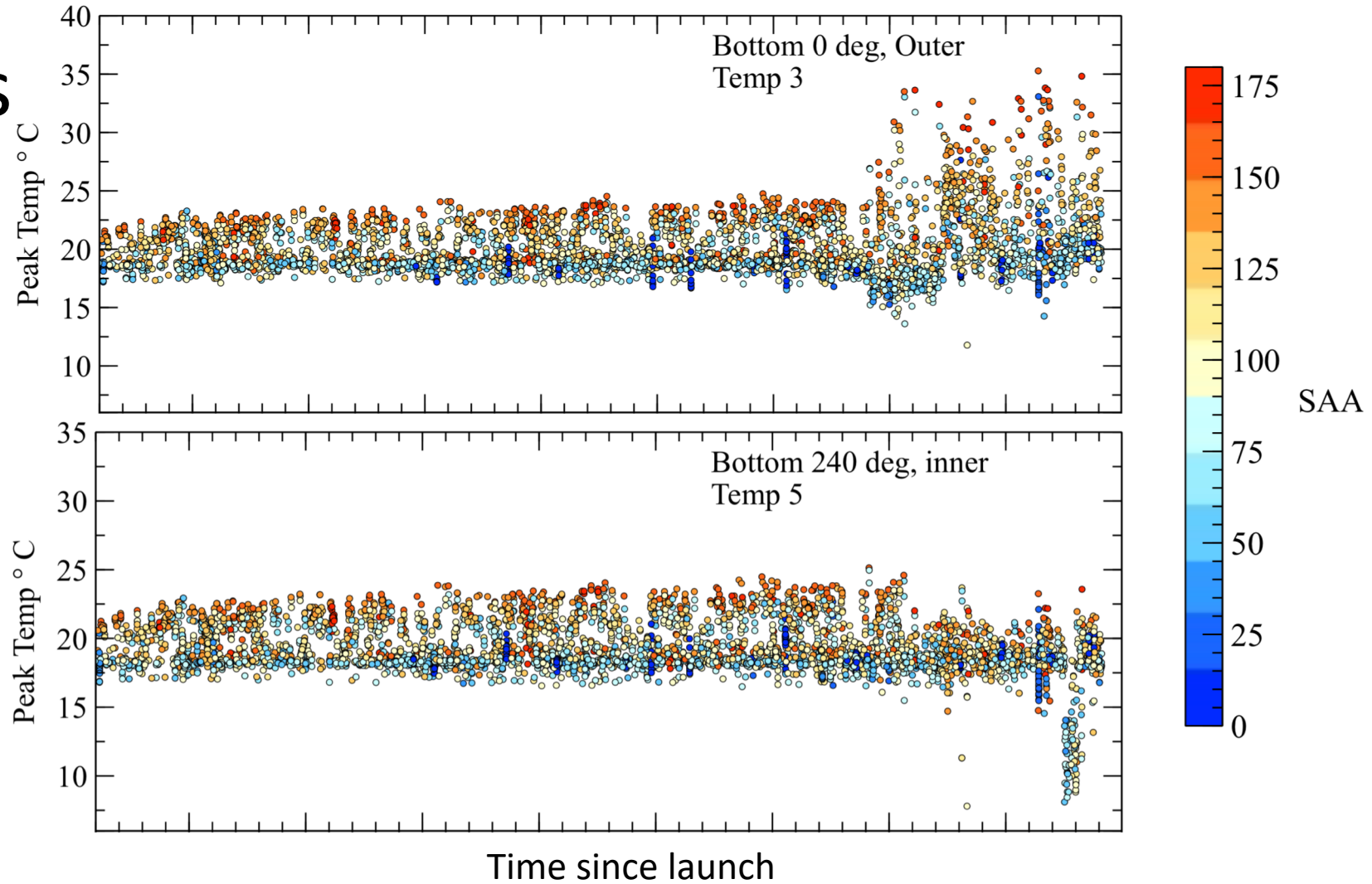
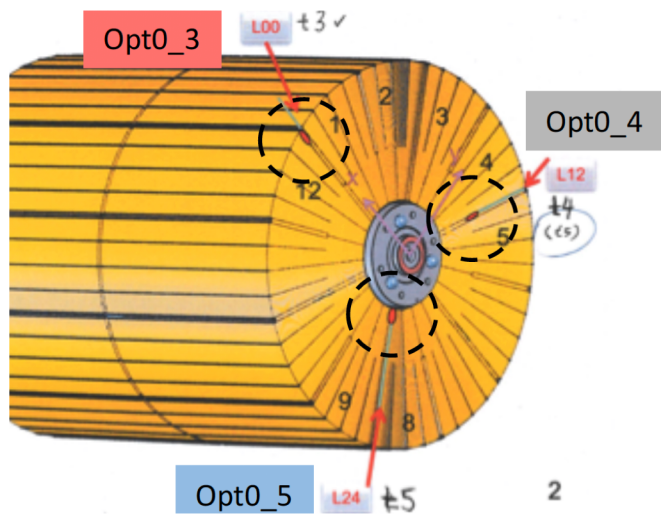
Mast adjustment

Performed May 22, 2018

Result: The Creep has stabilized



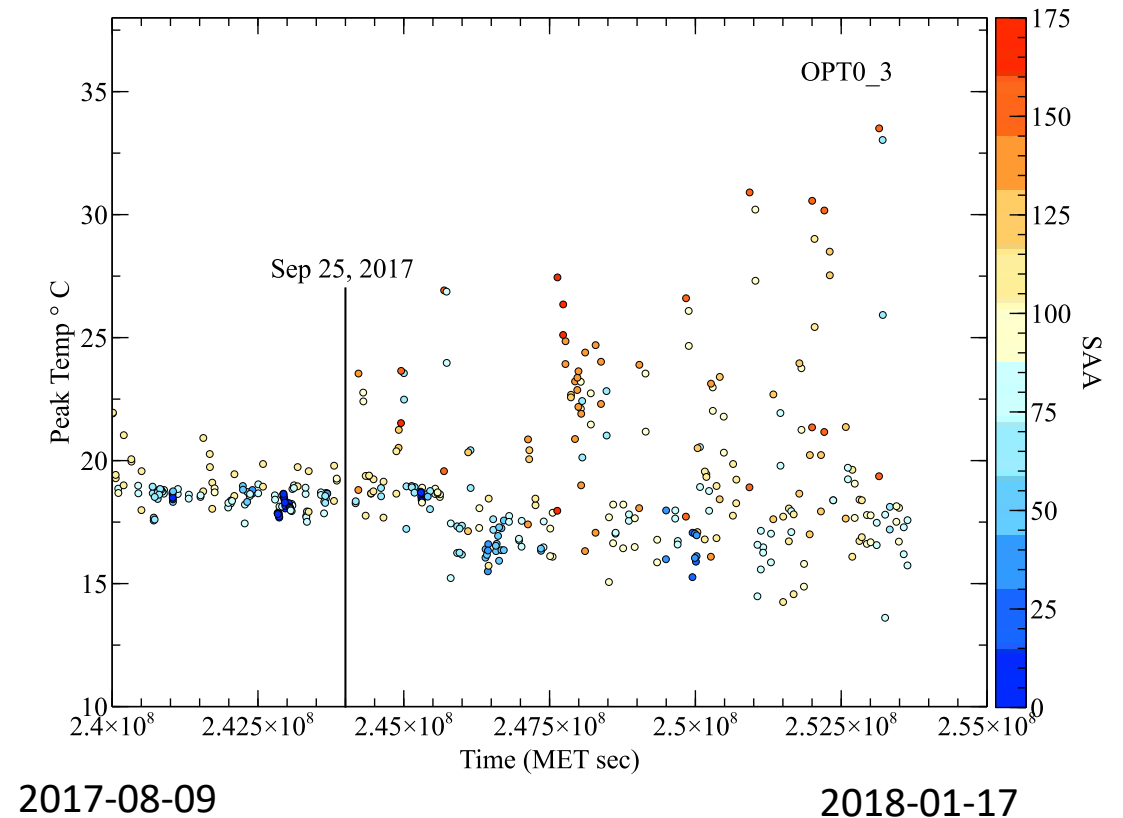
Temperature Woes



Optics thermal constraints

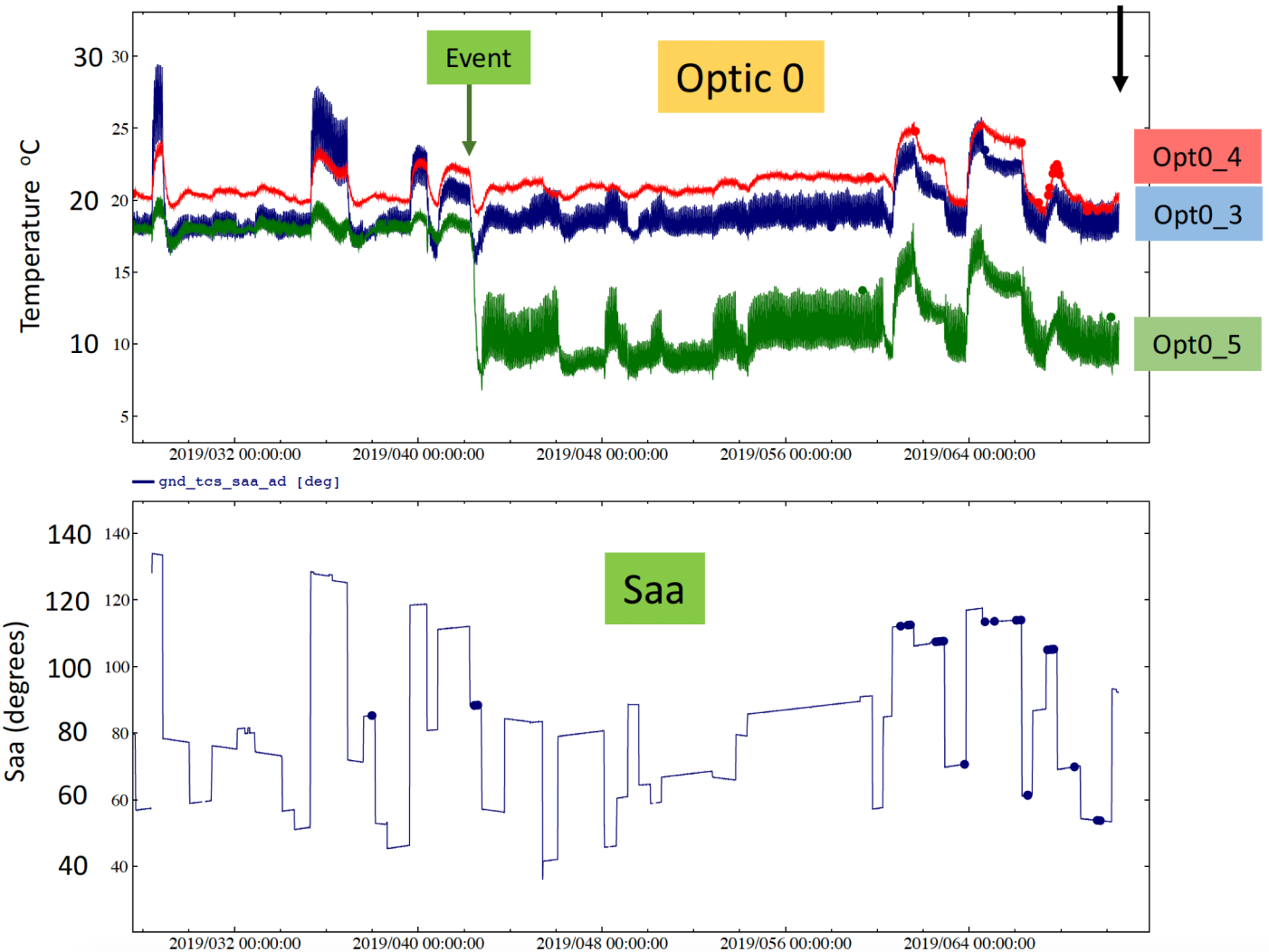
- Avoid observing at certain ranges of Solar aspect angle (Saa)
 - Translates into scheduling constraints
- Apparent degradation has occurred near the thermal sensor on the rear exterior of Optic 0
- Likely a hole or tear in optics cover
- Optics bench qualified to 70 °C
- Current Red limit set at 55 °C
- Avoid observations in range

145 ° < Saa < 160 °
- Waivers for short observations of time constrained targets may be granted



Low 'Temp 5' temperature

- Event seemed to coincide with pointing towards the sun, which faces the optics backside towards cold space
- **Hypothesis:** another tear
- **Issue:** optical thermal control is tied to Temp 5

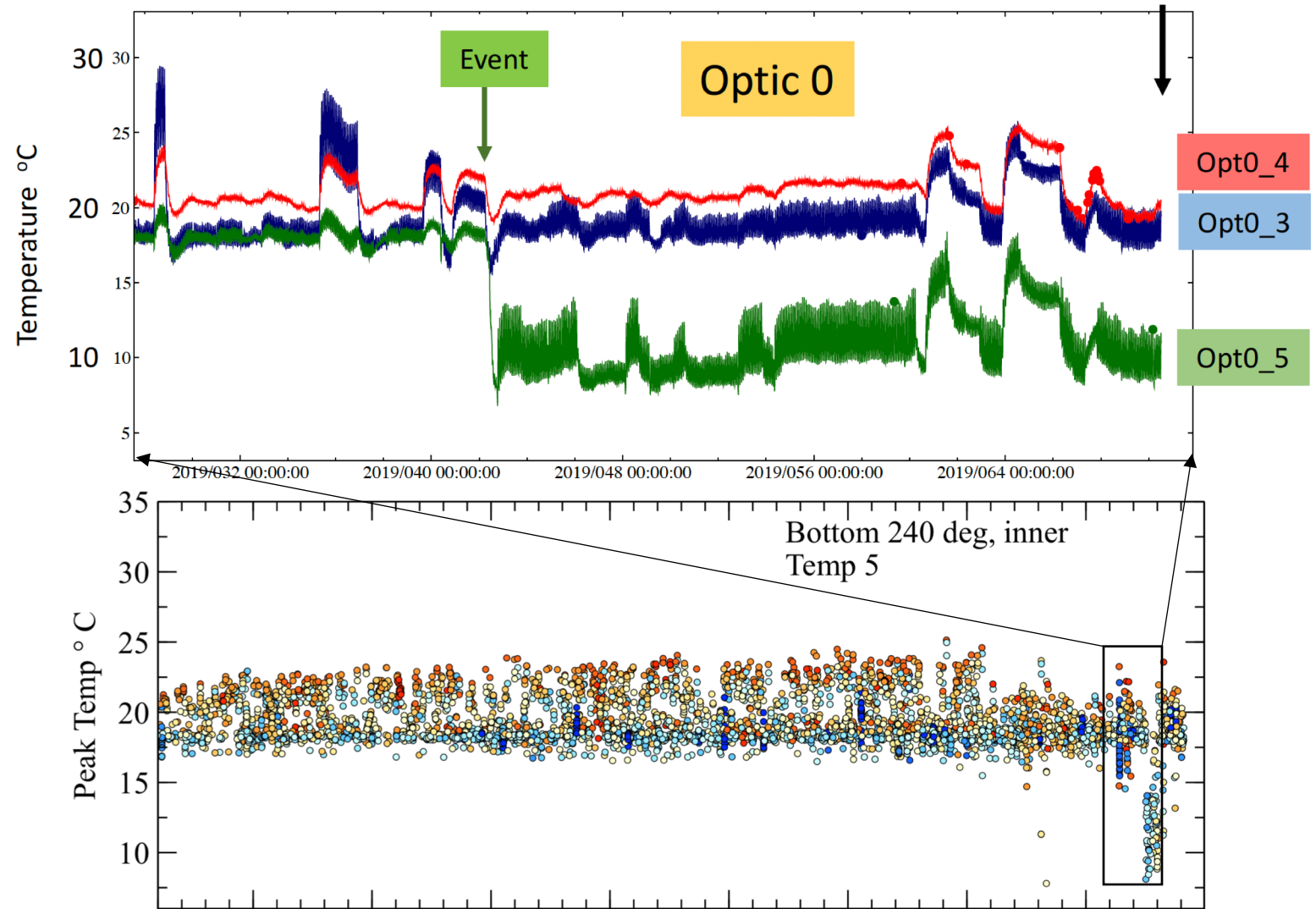


However...

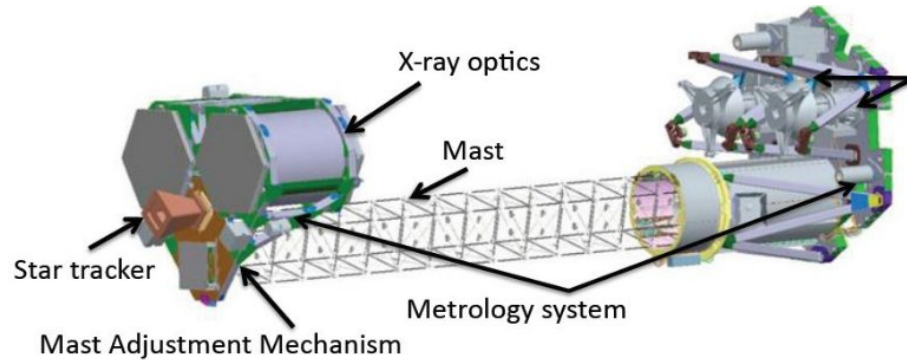
- Pointing away from the sun to heat the backside, increased the temperature, but not in a way indicative of a tear like for Temp 3
- **New hypothesis:** A loose temperature sensor

Action plan:

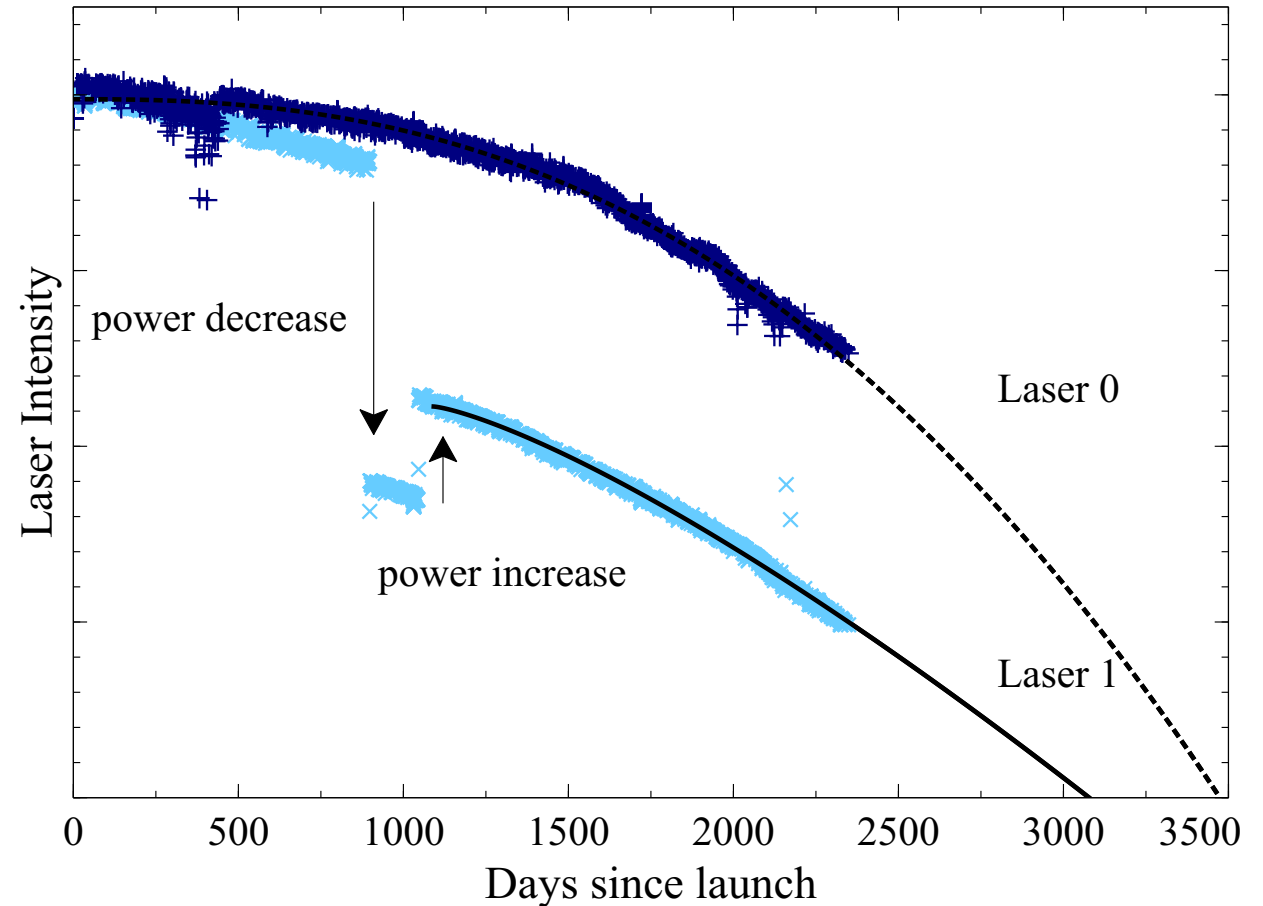
- Monitoring behavior
- Move temperature control of optics to Temp 4
- No impact on observing constraints yet



Metrology system: laser power



- Steady decay since launch
- Power adjustments have had no apparent effect on decay rate
- Current power setting is at ~30% so the power can be increased to lengthen lifetime
- The decay is not exponential and not in family with a failing laser
- Possible reason for decay is radiation damage to the photo-diodes, which increases scatter and lowers the output efficiency. If this is the case there is no mitigation.



Summary

- Calibration update planned for later this year
 - Absolute normalization, vignetting, detector absorption parameters
 - New clock correction FTOOL - relative timing accuracy improvement
- Mast adjustment solved mast creep
- Optics thermal behavior monitored
 - Saa avoidance remains in place
- ***Observatory status is***

