EPIC-MOS focal plane temperature excursions

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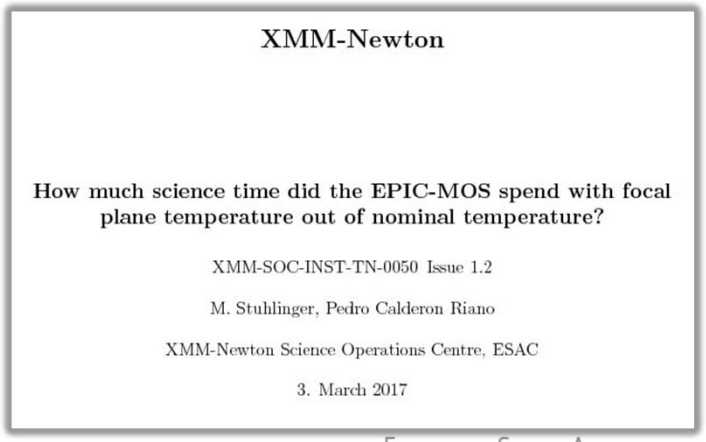
MPE, 27.04.2017


XMM-Newton

How much science time did the EPIC-MOS spend with focal plane temperature out of nominal temperature?

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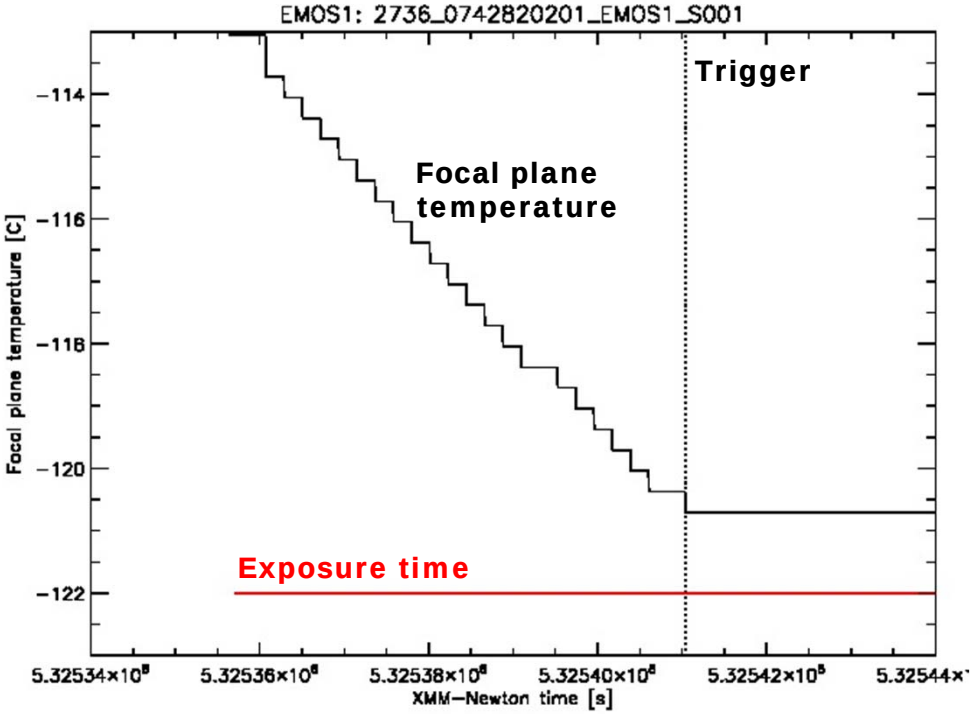
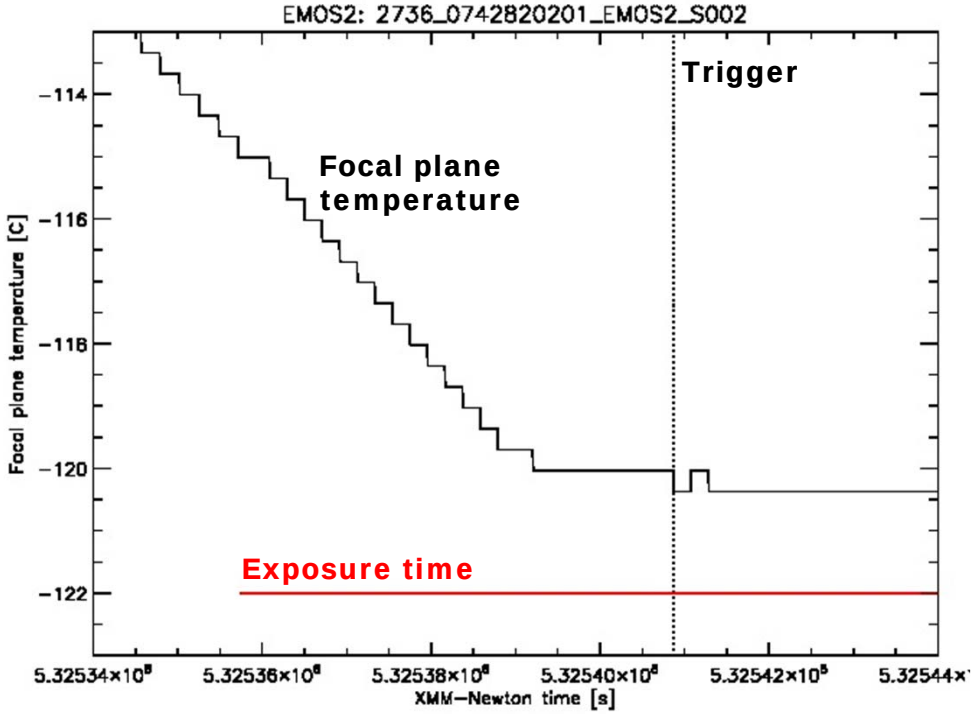
Introduction

- During autumn 2014 eclipse season (revs. 2731-2754):
  - every first exposure of the revolution started before the EPIC-MOS focal plane temperatures reached nominal operation temperature.
  - Temperature deviation up to +6° Celsius. All exposures were scientific programs.





- **Question**: How much exposure time is effected?

Analysis

- As focal plane temperature data, use PEH parameters E1253/K1253 for MOS1/MOS2.
  - Accuracy of parameters is about 0.33°C per digital digit.
  - At lower temperature, parameters can jitter.
  - Focal plane temperatures slightly different MOS1 (-120.7°C) and MOS2 (-120.4°C).

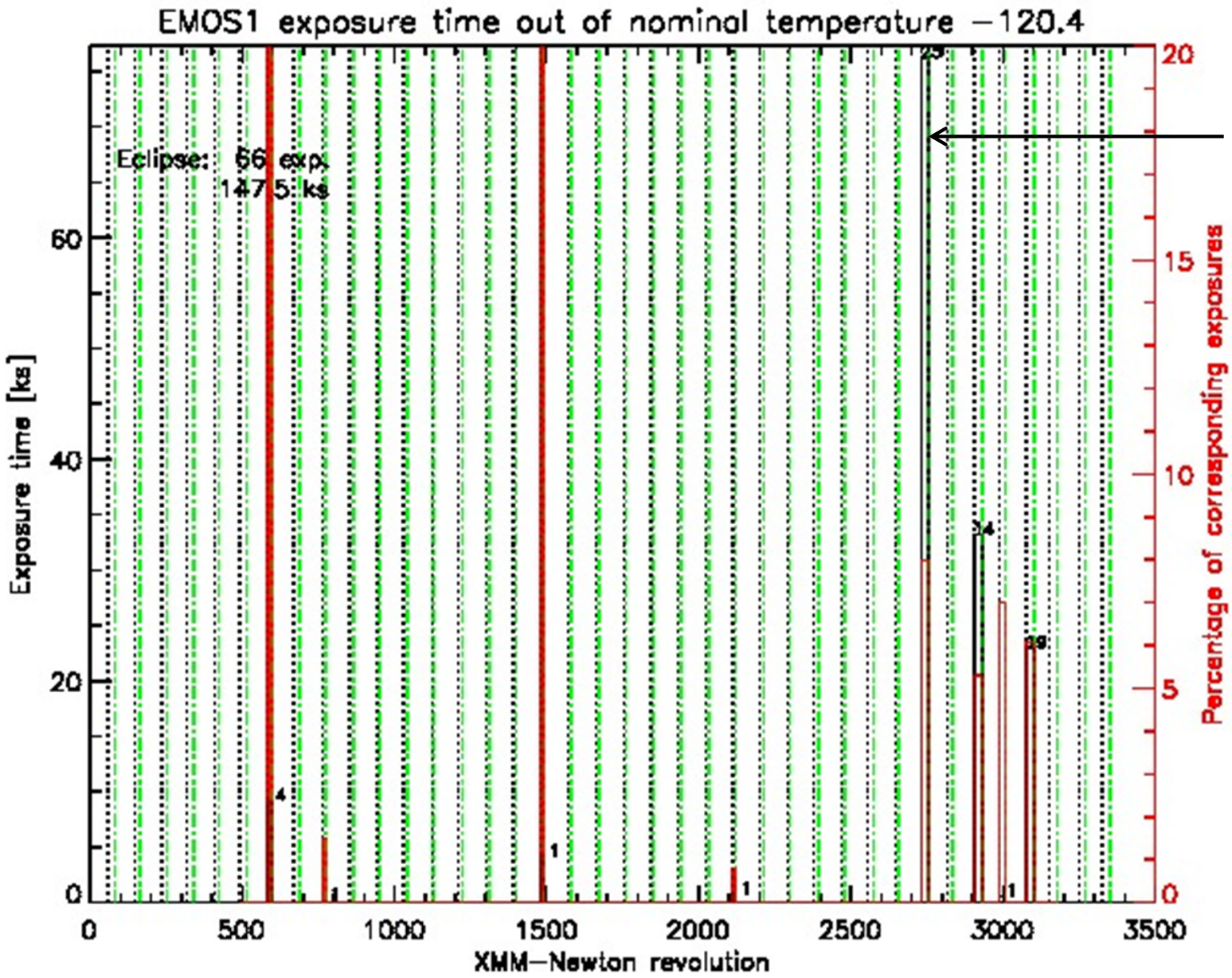
- As exposure time, use event times of eventlists.

- Search temperature decreases (increases) during exposure times.

- To avoid incorrect triggers by parameter jitter, use conditions:
  - Not the first (last) temperature change in PEH data.
  - The previous (next) temperature change is in same direction.
  - (Trigger temperatures 1 digital digit higher: MOS1@-120.4°C and MOS2@-120.0°C.)

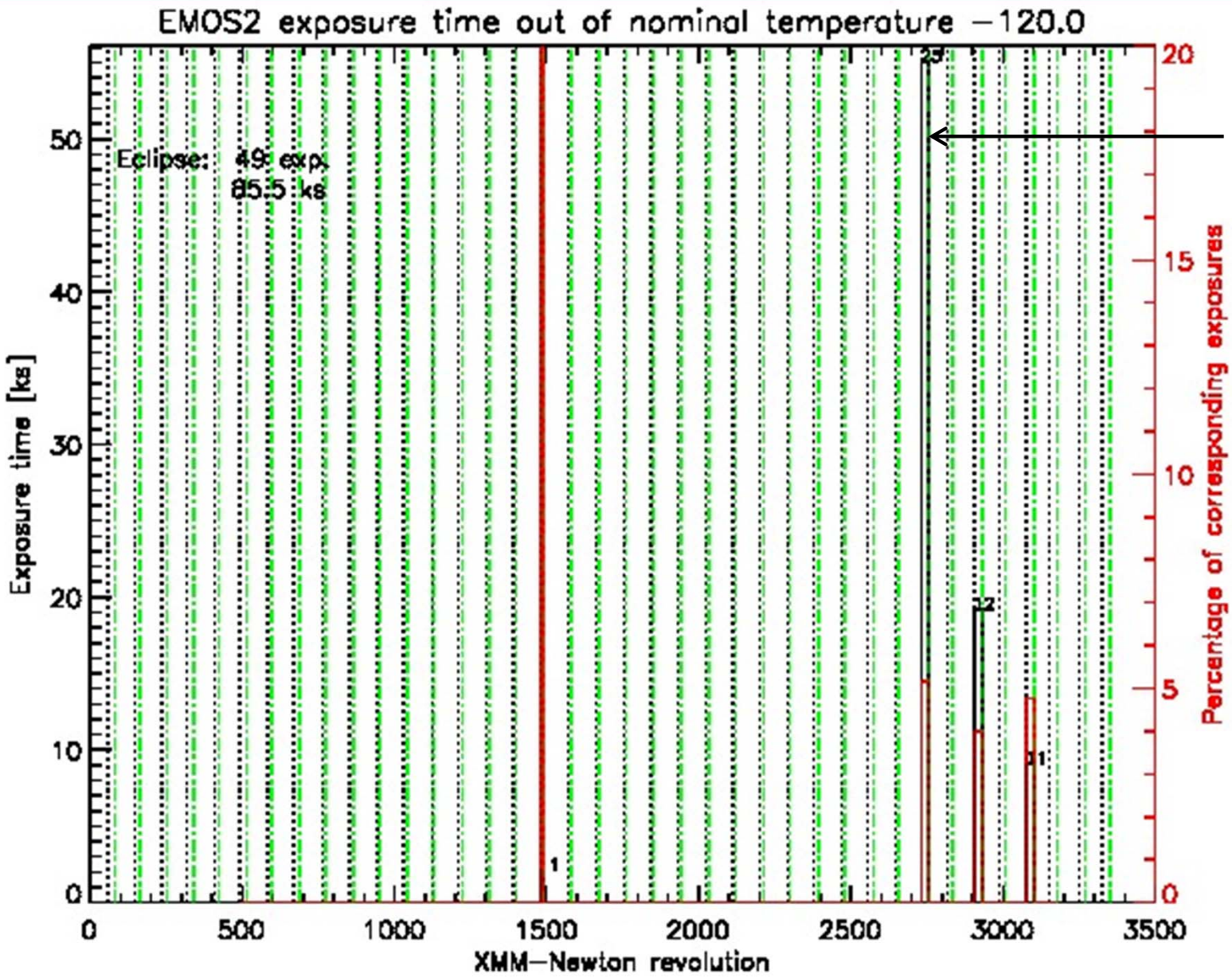
- Enable use of different trigger temperatures.

Eclipse seasons: EPIC-MOS1



2014 autumn: every revolution

Eclipse season: EPIC-MOS2



2014 autumn:
every revolution

Origin: eclipse independent

- May 2013: change of perigee pointing.

- Advantages:
  - Save fuel.
  - Enhance live time of the mission.

- Disadvantages:
  - Radiators point to Earth albedo for about 2 hours around perigee.
  - Radiators heat up by about +35°C and therefore MOS CCDs by about +7°C.
  - It takes about 3 hours for the MOS CCDs to reach nominal temperature again.
  - Required cooling time exceeds perigee break period.

- Detailed periods change along year due to orbital geometry.

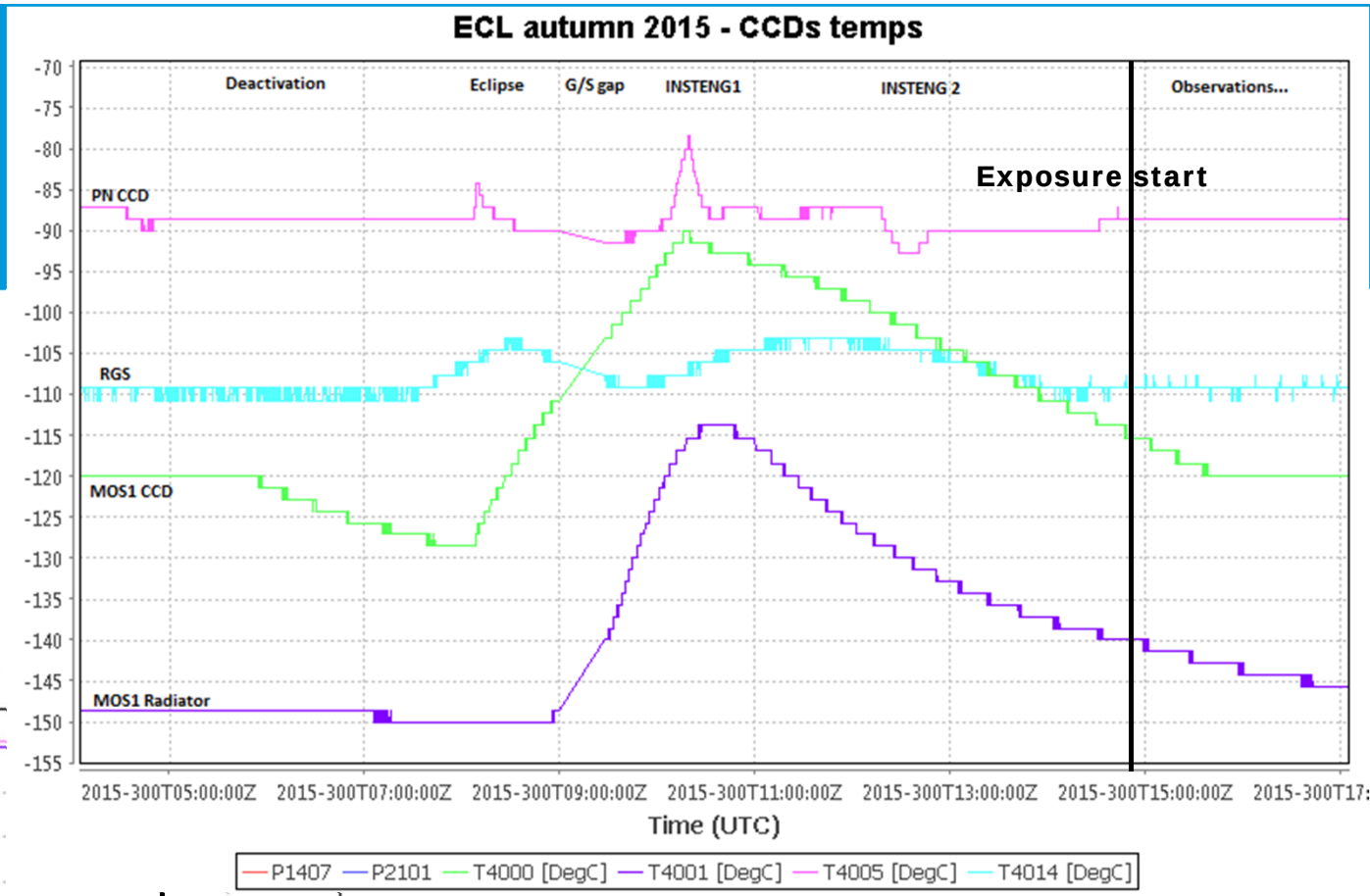
Origin: eclipse dependent

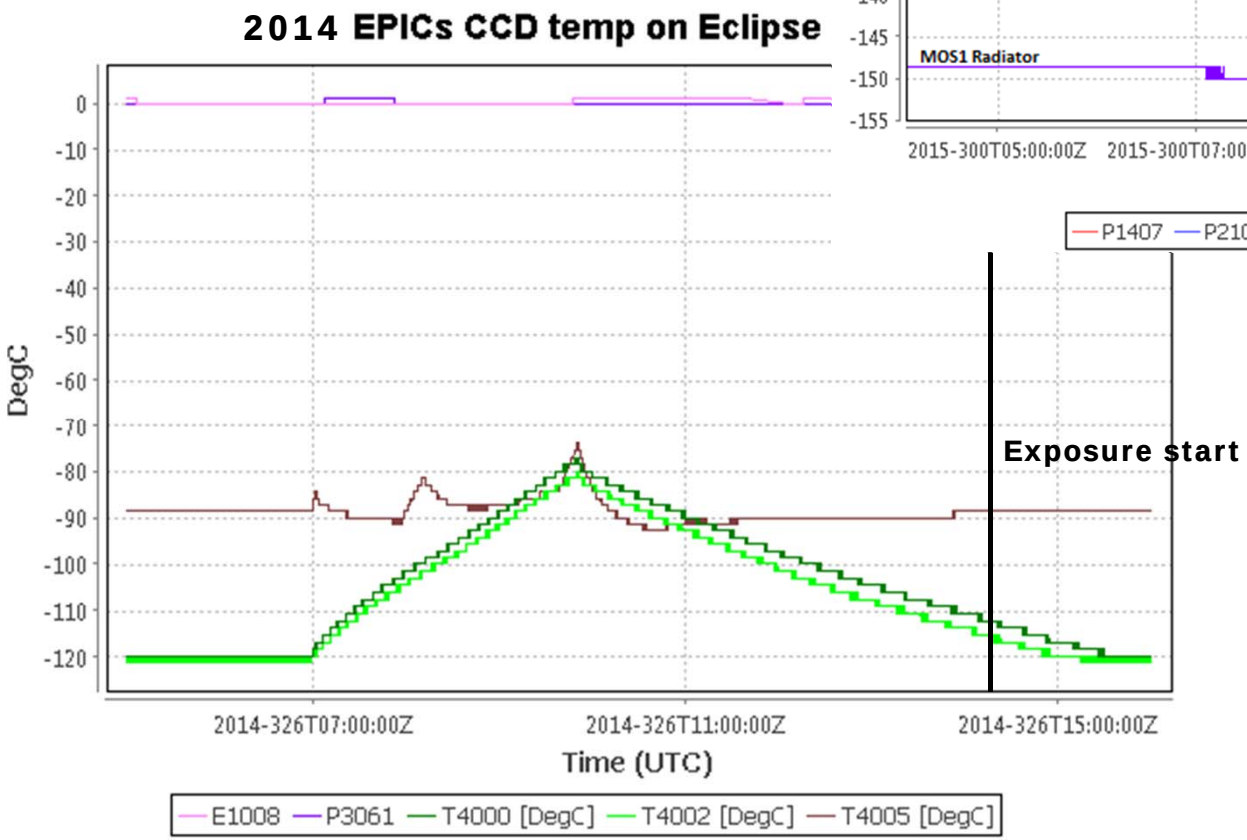
- Due to orbit adjustments, coverage of Kourou ground station became discontinued around perigee and eclipses.
- Solution: use other ground station to cover Kourou gap.
- Ground station hand-overs introduce additional constraints in instrument operation.
- Instruments remain longer in eclipse configuration.
  - Instruments in power-OFF.
  - No thermal control of the CCDs.
  - MOS CCDs heated by substitution heaters.

Origin: autumn eclipse

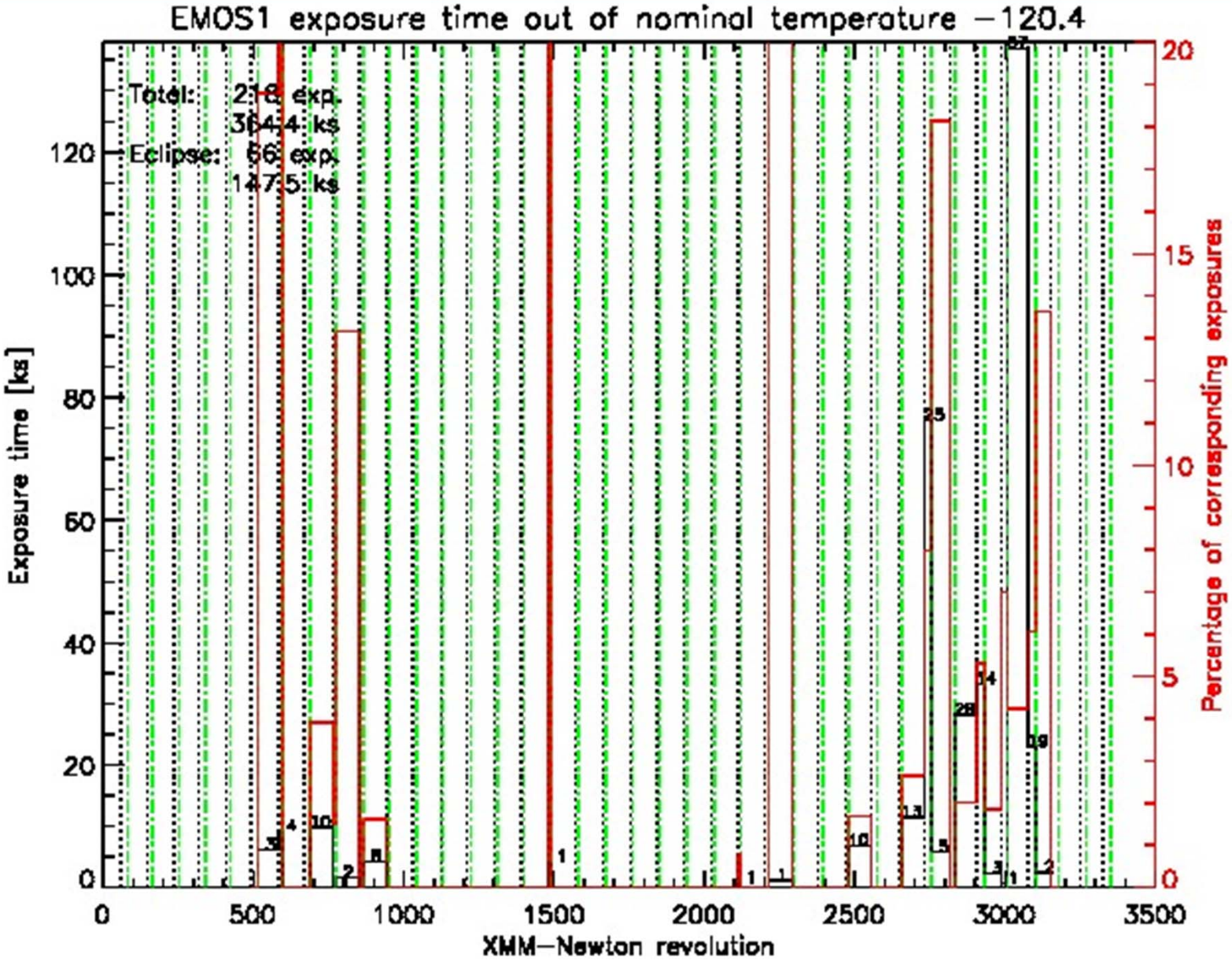
- Combine the worst out of the two previously mentioned scenarios.
- Heating period of substitution heaters end about the time when radiators start being illuminated be the Earth.
- Due to two different heating mechanisms the MOS CCD temperature excursions reach order of about +40°C.
- The temporary warmed-up radiators in addition to high CCD temperature excursions increase the required cool down time of the MOS CCDs.
- As result MOS instruments start first exposures with CCDs still not at nominal operation temperature.
- **Corrective action (2015)**: pre-cool the MOS CCDs (-130°C) before entering eclipse will decrease maximum temperature excursion and reduce cooling time.

Eclipse operations

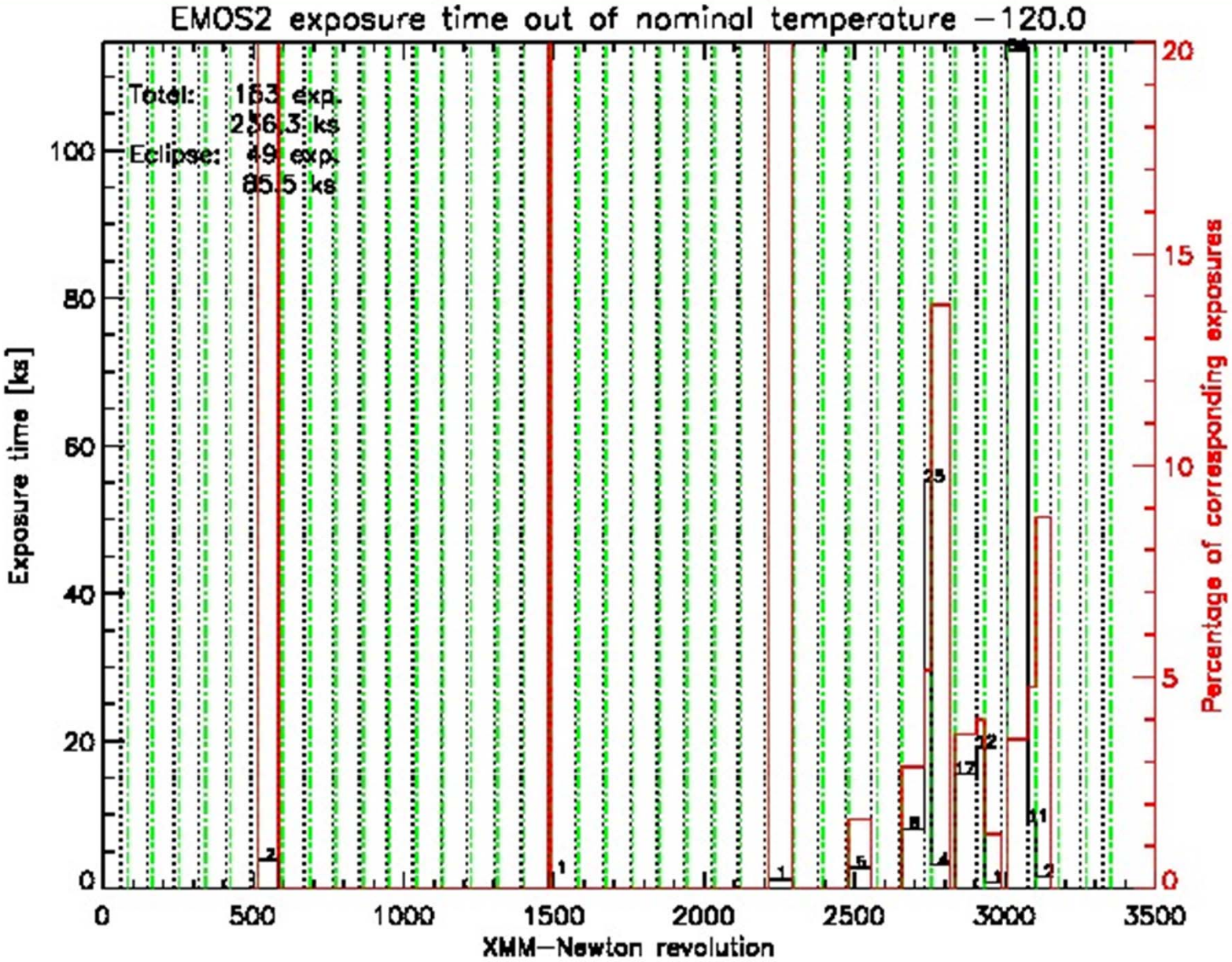




All seasons: EPIC-MOS1



All seasons: EPIC-MOS2



All seasons: different trigger temperatures

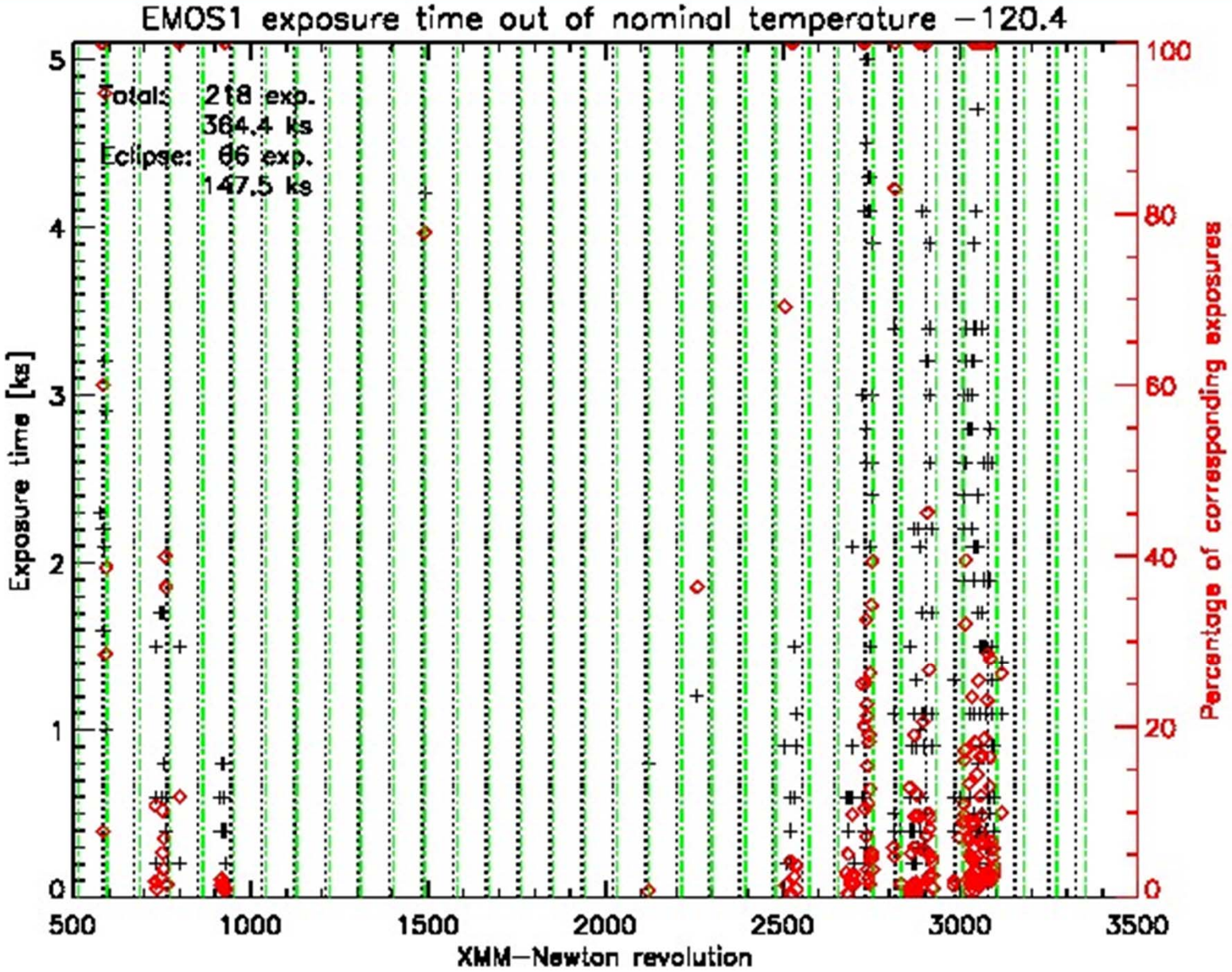
Table 1: Summary results for several trigger temperatures from the nominal focal plane temperatures of -120.7°C/-120.4°C for MOS1/2 up to -115.7°C/-115.4°C for MOS1/2 in steps of one degree for revolution range 0534-3148. In addition the results of the next feasible higher trigger than the nominal operation temperatures, (-120+°C: -120.4°C/ -120.0°C for MOS1/2), are included.

	Trigger temp.	-120°C	-120+°C	-119°C	-118°C	-117°C	-116°C	-115°C
MOS1	Total exposures	259	218	164	123	79	50	28
	Affected time	475.3	364.4	262.3	160.4	89.9	44.0	22.0
	In–eclipse exposures	76	66	60	50	39	28	20
	In–eclipse time	176.4	147.5	118.3	82.7	53.5	30.1	16.5
	Out–eclipse exposures	183	152	104	73	40	22	8
	Out–eclipse time	298.9	216.9	144.0	77.7	36.4	13.9	5.5
MOS2	Total exposures	257	153	125	83	65	29	10
	Affected time	639.6	236.3	166.3	89.6	45.4	16.0	4.0
	In–eclipse exposures	69	49	46	35	28	14	5
	In–eclipse time	162.8	85.5	62.6	38.0	20.1	8.4	1.8
	Out–eclipse exposures	188	104	79	48	37	15	5
	Out–eclipse time	476.8	150.8	103.7	51.6	25.3	7.6	2.2

Summary

- Found plenty of exposures which started before focal plane reached nominal operation temperature.
- Individual exposures are effected by up to about 5000 seconds.
- Both eclipse and non-eclipse seasons are effected.
- Amount of effected exposure time within autumn eclipse seasons is decreasing.
  - Corrective scheme with pre-cooling successful.
- Amount of effected exposure time in non-eclipse summer seasons is increasing.
  - We've just entered 2017 summer season…

All seasons: MOS1 individual exposures



All seasons: MOS2 individual exposures