

CHANDRA

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MEMORANDUM

Date: November 18, 2024
From: Jack Steiner
To: Chandra Operations Team
Subject: Chandra Radiation Shutdown on October 27, 2024
Cc: MSFC Project Science, CXC Director's Office
File: OCT2724_memo.tex
Version: 0.2

1 Abstract

A halo CME associated with an X3.3 flare on 24 October 2024, was expected to be Earth-glancing. It impacted on October 26 and resulted in a steady and protracted increase in radiation levels over the day ahead. A second inbound CME threatened to elevate levels further; in light of the high rates and inbound CME, the ACIS and HRC teams met separately, both agreeing that a manual SCS-107 was warranted. This action was approved by the team. However, at the following comm, it was found that *txings* had already tripped and produced an autonomous shutdown.

The estimated attenuated fluence saved from this shutdown is 7.8×10^9 . This memo discusses the event timeline and relevance for future *txings* trips.

2 Introduction

This solar cycle has been associated with heightened activity compared to previous cycles. ACIS *txings* is the sole radiation monitor for *Chandra*, and its autonomous activation has been a key means of reducing soft proton dosing from several storms this year alone. The trigger on October 27, 2024 was the sixth *txings*-initiated shutdown in 2024.

3 October 24-31 2024 Detailed Timeline

- 2024:298:03:57:00 X3.3 class solar flare detected.
- 2024:298:10:29:00 M1.2 class solar flare detected.

- 2024:299:07:33:00 M1.1 class solar flare detected.
- 2024:300:06:23:00 M9.5 class solar flare detected.
- 2024:300:07:19:00 X1.8 class solar flare detected.
- 2024:300:14:16:00 M1.6 class solar flare detected.
- 2024:300:17:00:00 grazing CME impact.
- 2024:301:09:25:41 autonomous *txings* trigger.
- 2024:301:15:00:00 ACIS team meets on google-meet and agrees on shutdown (ACE-P3 rates sustained near $\sim 30,000$). HRC team meets at the same time and also decides to recommend a manual shutdown.
- 2024:301:16:15:00 Team-wide radiation discussion held during which manual SCS-107 run approved.
- 2024:301:16:30:00 During comm to execute manual SCS-107, the autonomous *txings* trigger is detected.
- 2024:301:21:58:15 First command of OCT2824A load.
- 2024:301:23:24:00 M2.8 class solar flare detected.
- 2024:302:04:09:00 M1.3 class solar flare detected.
- 2024:302:05:00:00 second CME impact.
- 2024:302:14:44:00 M1.2 class solar flare detected.
- 2024:302:16:28:00 M4.2 class solar flare detected.
- 2024:303:01:30 LTECS run waived off during comm (CAP 1762) owing to a high HRC proxy (410).
- 2024:303:16:33:00 M1.1 class solar flare detected.
- 2024:304:01:38:00 OCT3024A science-resumption load begins.
- 2024:304:20:53:00 M7.2 class solar flare detected.
- 2024:305:03:30:00 M1.0 class solar flare detected.
- 2024:305:09:37:00 M1.3 class solar flare detected.
- 2024:305:12:54:00 M2.4 class solar flare detected.

- 2024:305:19:07:00 M1.0 class solar flare detected.
- 2024:305:21:10:00 M4.6 class solar flare detected.
- 2024:305:21:20:00 X2.0 class solar flare detected.

4 October 27, 2024 Shutdown-Event Discussion

A glancing CME from the long-duration X3.3 flare caused slow-rising ACE P3 rates at the same time that a second inbound CME was anticipated. ACE P3 rates grew over a 12 hour period to $> 30,000$, with nearly a day left in the science orbit and a projected $\sim 3 \times 10^9$ orbital fluence, without factoring in the second CME. The autonomous SCS-107 initiated by *txings* was fortuitous and saved an additional $\sim 10^9$ fluence. The ACIS team's internal discussion had included speculation that *txings* may have triggered, but in case not it was determined that a manual shutdown was warranted. It was decided to hold off on science resumption until the radiation enhancement associated with the second CME impact was likely to have appreciably declined. OCT3024 was chosen as a sensible target. In the interim, a LTECS was prepared, but highly-elevated particle rates (viz. the HRC proxy was nearly double its trigger level at the time of CAP execution) resulted in the CAP being terminated prior to the ECS run.

Figure 1 shows the ACE P3 rate over the period in question, and a corresponding plot of the other ACE proton rates is shown in Figure 2. The prolonged run of elevated particle rates is seen which led up to the shutdown, with the second CME impact causing a sharp spike in radiation peaking at an ACE-P3 rate of $\sim 2.9 \times 10^5$. The rates decayed thereafter, steadily but slowly, spanning a several day period. ACE-P3 rates were still elevated, $\sim 2 \times 10^4$ at the time of science resumption, but the hard proton fluxes had decreased significantly. E.g., at the start of science resumption, the ACE P5 and P7 rates were below their amplitudes at the time of the *txings* trigger and were descending. A plot of the *txings* rates leading up to the trigger is shown in Figure 3.

The attenuated fluence accumulated over the first part of the orbit leading up to the radiation shutdown was 9.5×10^8 . Had *txings* not tripped, another $\sim 9.4 \times 10^8$ of attenuated fluence would have been accumulated by the time of manual shutdown. The total science-orbit time lost due to the radiation shutdown was ~ 185 ks, and the corresponding attenuated ACE P3 fluence averted was 7.8×10^9 . For comparison, the unattenuated fluence over the same period (namely, the science-orbit time lost to the shutdown) was 9.9×10^9 .

5 Lessons Learned

The inability to run the ECS in this case motivates consideration of whether it would be worth having an option to run an ECS option with RADMON disabled.

6 Notes

ACE data was obtained from <ftp://mussel.srl.caltech.edu/pub/ace/browse/>.

ACE fluxes are given in units of $\text{particles s}^{-1} \text{cm}^{-2} \text{MeV}^{-1} \text{sr}^{-1}$, and ACE fluences are in units of $\text{particles cm}^{-2} \text{MeV}^{-1} \text{sr}^{-1}$.

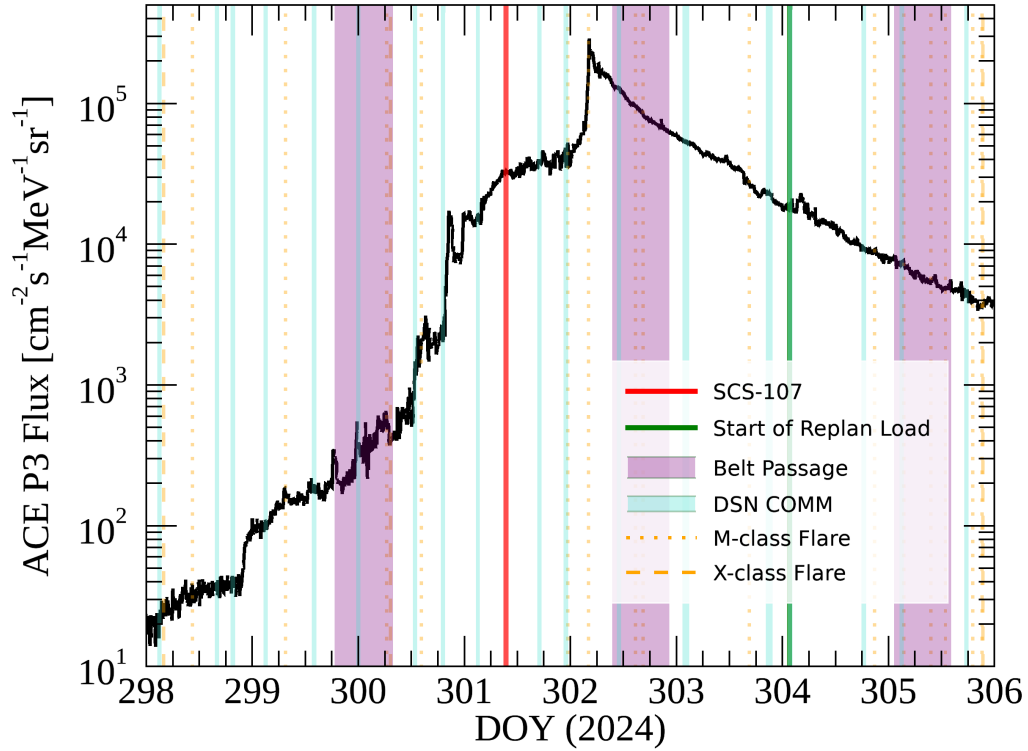


Figure 1: The ACE P3 flux associated with the X3.3 flare and ensuing activity, with time markers indicating the start of the science-resumption load (dark green), the autonomous SCS-107 (solid red), and the times of flares (orange). Shaded regions indicate belt passages (purple) and DSN comms (blue).

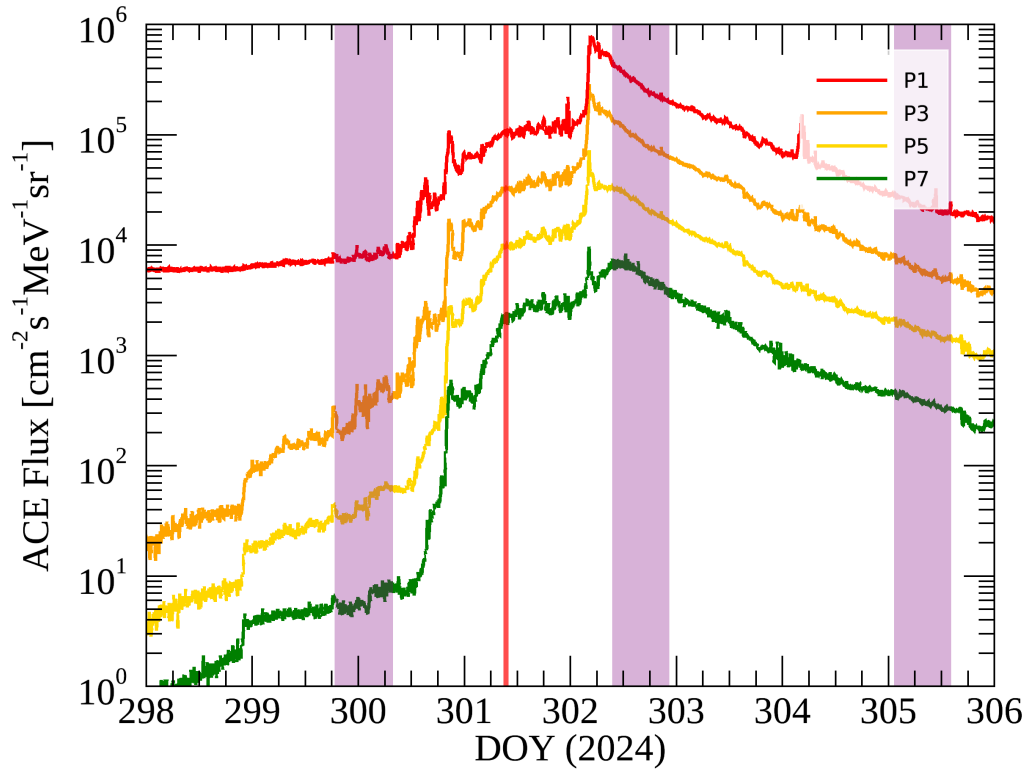


Figure 2: ACE proton bands associated with the X3.3 and X1.8 CMEs. The red vertical line marks the time of shutdown and purple shaded regions depict the belt passages.

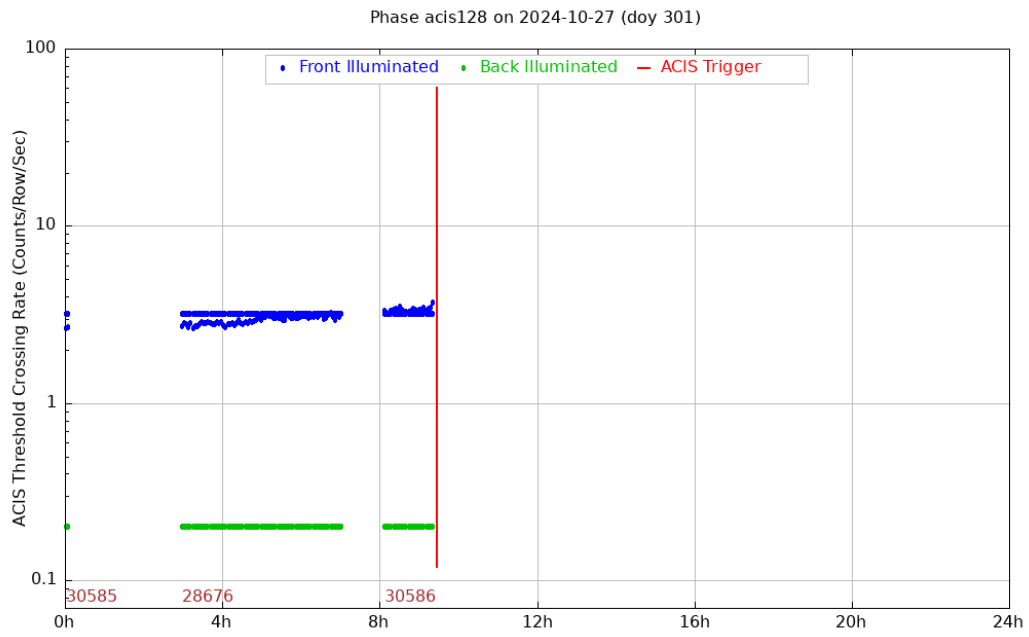


Figure 3: *txings* data for October 27, 2024 showing the rate-crossing which produced the autonomous SCS-107.