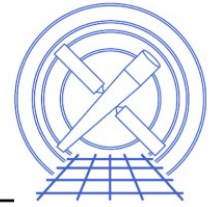


CHANDRA

X-ray Center 60 Garden St., Cambridge Massachusetts 02138 USA



Date: July 12, 2024
From: Gregg Germain
To: Chandra Operations Team
Subject: Chandra Radiation Event and Shutdown June 7, 2024
Cc: MSFC Project Science, CXC Director's Office

1 Abstract

On June 7, 2024, (2024:160:02:29 UTC) the JUN0324A load was interrupted by an ACIS Txings commanded SCS-107 which safed ACIS from the near the beginning of a radiation storm. During the shutdown a 24 hour Long Term ECS measurement was performed. Return to Science commenced with the activation of the JUN1124A load on 2024:163:00:00. In total, ACIS accumulated an attenuated ACE P3 fluence of 2.0×10^5 particles cm^{-2} MeV^{-1} sr^{-1} from the start of the orbit to the shutdown. The fluence saved because of the shutdown was 5.57×10^8 particles cm^{-2} MeV^{-1} sr^{-1} . This memo describes the shutdown and return to science decisions during the solar storm event.

2 Introduction

On June 7, 2024, (2024:160:02:29 UTC) a Txings-commanded SCS-107 executed which halted the ACIS accumulation of fluence near the beginning of a solar storm. The discussions during the shutdown revolved around a time at which operations could return to science as well as what observations will be included in the Return to Science load. During the shutdown a 24 hour Long Term ECS measurement was performed. Science Operations resumed with the uplink of the JUN1124 Return to Science load.

3. Detailed Timeline June 7-11, 2024

- 2024:155:02:43 Monday, June 3 the JUN0324A load is activated. ACE P3 rates quiescent.
- 2024:160:01:08 RADMON ENABLED: Orbit begins. ACE P3, ACE Electron, GOES Proton and Txings rates quiescent.
- 2024:160:02:00 ACE P3 rates begin to rise and the ACE Electron, GOES Proton rates and Txings rates were rising steeply.
- 2024:160:02:14 SpaceWeather Alert email: Earth-orbiting satellites detected a SpaceWeather

M9.7-class Solar Flare Alert.

- 2024:160:03:00 Comm begins; Telemetry reports an SCS-107 ran at 2024:160:02:29.
- 2024:160:03:06 sot_red_alert email and text announcing SCS-107 and calling for telecon.
- 2024:160:03:44 Telemetry analysis reveals Txings-triggered SCS-107. Next telecon scheduled for 2024:160:15:00 to review space weather and discuss Return to Science options.
- 2024:160:15:00 Rates are still high but decreasing. Return to Science planned for 2024:162:20:30 or 2024:163:00:00 comm pass pending decision on an AR Lac HRC observation and P3 rates. Next telecon scheduled to occur after the 2024:162:13:00 morning telecon (Monday, June 10, 9am EDT) for a status check.
- 2024:160:19:50 CAP 1746 executed to initiate a 24 hour LTECS measurement.
- 2024:162:13:15 Space Weather discussion following the 9am (EDT) telecon; decision to release the JUN1124A loads for review and possible uplink at 2024:163:00:00. Telecon scheduled for 2024:162:23:45 for final status check.
- 2024:162:13:25 JUN1124A Return to Science Load out for review.
- 2024:162:23:45 Final Decision Telecon to uplink JUN1124A return to Science load.
- 2024:163:00:00 8pm (local) Comm; JUN1124A Return to Science load uplinked and activated.

4. Discussion

Solar activity has increased this year as we approach solar maximum (Figure 1). This is the fifth shutdown of the year due to solar activity: SCS-107's were executed in January, February, March and May. Prior to this storm, the yearly accumulated fluence so far already exceeded 50% of the yearly budget.

On 2024:160:02:14 (June 7th, 10:14pm EDT), ACIS Ops received an alert via a SpaceWeather email: "SOLAR FLARE ALERT: Earth-orbiting satellites have just detected a M9.7 class solar flare at 08-Jun-2024 at 01:49:00 UTC." At this time, the JUN0324A load was executing. During the Real Time comm at 2024:160:03:00, telemetry showed that an SCS-107 had occurred at 2024:160:02:29:29.

A telecon was immediately held during which analysis of the telemetry data confirmed that the ACIS Txings radiation monitor triggered the SCS-107. Another telecon was scheduled for the next

day, 2024:160:15:00 (Saturday, June 8, 11am EDT) to assess the space weather status and formulate a Return to Science plan. At the 2024:160:15:00 telecon, it was observed that the HRC Proxy (Figure 2), GOES Proton rates (Figure 3), ACE Electron rates (Figure 4) and ACE Proton Flux rates – especially the ACE P3 flux - (Figure 5) were coming down (GOES P3 had leveled off and had not yet started down). However, models indicated a possible CME arrival on or about 2024:162:14:00. It was noted that there were time-constrained HRC observations of AR Lac in the schedule. A plan was formulated to restart science observations at either the 162:20:30z comm pass - if the AR Lac HRC observations are required – or 163:00:00z comm pass if the AR Lac observations could be delayed. The hope was that ACE P3 rates will be acceptable at those times. Another telecon was scheduled after the 9 am EDT telecon on Monday morning Jun 10 (2024:162:13:00) to review the space weather status and confirm an appropriate recovery to science timeline.

Meanwhile, ACIS Ops concluded that a 24 hour, 4CCD, Long Term ECS measurement could be executed so CAP1746 was prepared, reviewed, approved and uplinked at the 2024:160:19:50 comm. The measurement ran to completion, ending at 2024:161:20:50:00.

At the 2024:162:13:15 Status telecon (the 9am EDT telecon) a discussion of the space weather situation and of plans to return to science was conducted. GOES proxy rates were observed to be substantially below threshold and falling; ACE rates were still rising but were expected to turn over later that day (as they already had at higher energies). It was decided that the situation justified going ahead with steps to uplink JUN1124A loads at the 2024:163:00:00 comm. A final discussion of the radiation situation and a go/no-go decision for a return to science was scheduled for 2024:162:23:45 (shortly before BOT).

The JUN1124A load was released for review and subsequently approved.

At 2024:162:23:45 the team met to review the space weather situation and noted that ACE rates were at ~3000 and descending (Figure 6), and GOES proxy was at ~5000. With the criteria met and the concurrence of the HRC and ACIS teams, the decision was reached to go ahead with the recovery plan and uplink the JUN1124A loads for return to science at the 2024:163:00:00 comm. The uplink and activation of the JUN1124A loads were nominal.

In total, ACIS accumulated an attenuated ACE P3 fluence of 2.0×10^5 particles cm^{-2} MeV^{-1} sr^{-1} from the start of the orbit to the shutdown. The fluence saved because of the shutdown was 5.57×10^8 particles cm^{-2} MeV^{-1} sr^{-1} .

Figure 7 shows the Front Illuminated (FI) and Back Illuminated (BI) ACIS Txings values from prior to the perigee passage to the point of the SCS-107. The plot shows that the txings thresholds were quiescent prior to the SCS-107 and then rose rapidly with the FI Txings providing the SCS-107 trigger.

Figure 8 shows the Txing rates from the SCS-107 through the Long Term ECS measurement, to after the Return to Science.

The Txings-triggered shutdown was beneficial to the HRC. The high GOES rates (the proxy was in excess of 2×10^6 c/s) suggest that the anti-co shield would operate at rates well above where it has previously operated, and an HRC observation during these high rates would result in:

- 1) A drop in the detector gain for both the MCPs and the PMTs, and
- 2) A loss of useable science data, as the high detector rates would be well above the 184 c/s telemetry limit, resulting in a dead time fraction at or near 1 for the duration of the observation.

5 Plots and Images

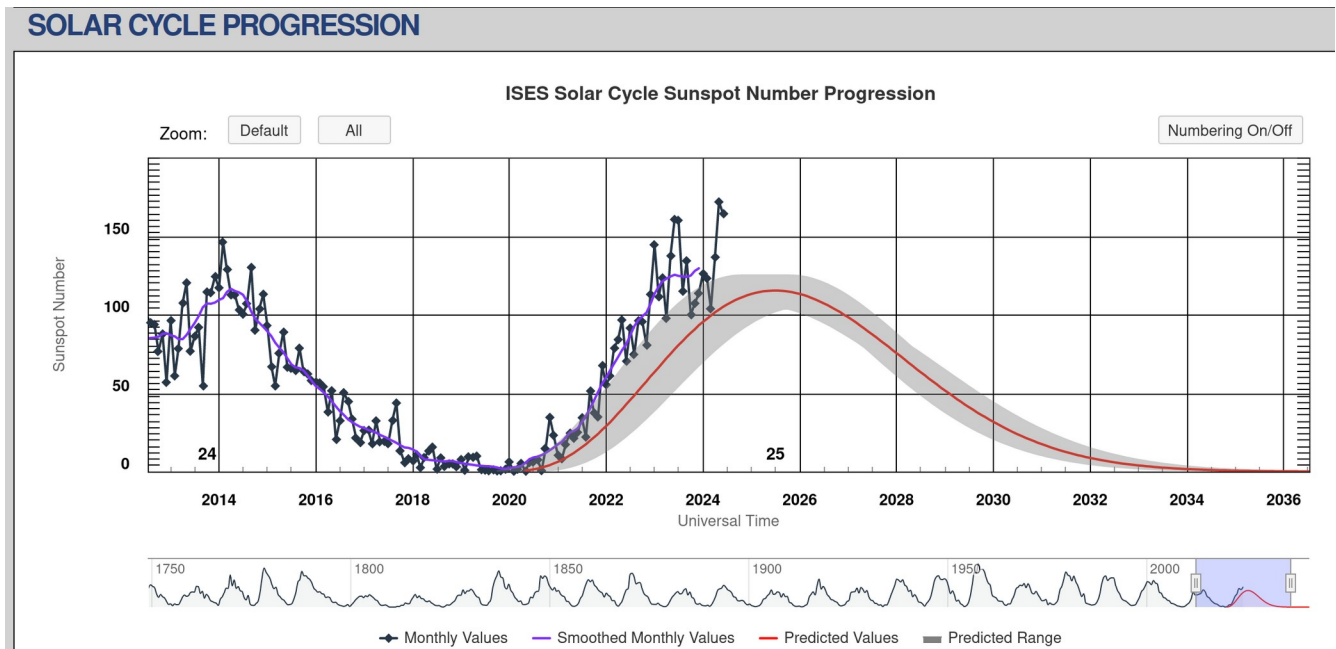


Figure 1: Solar Cycle Sunspot Progression - The number of sunspots are exceeding the predictions

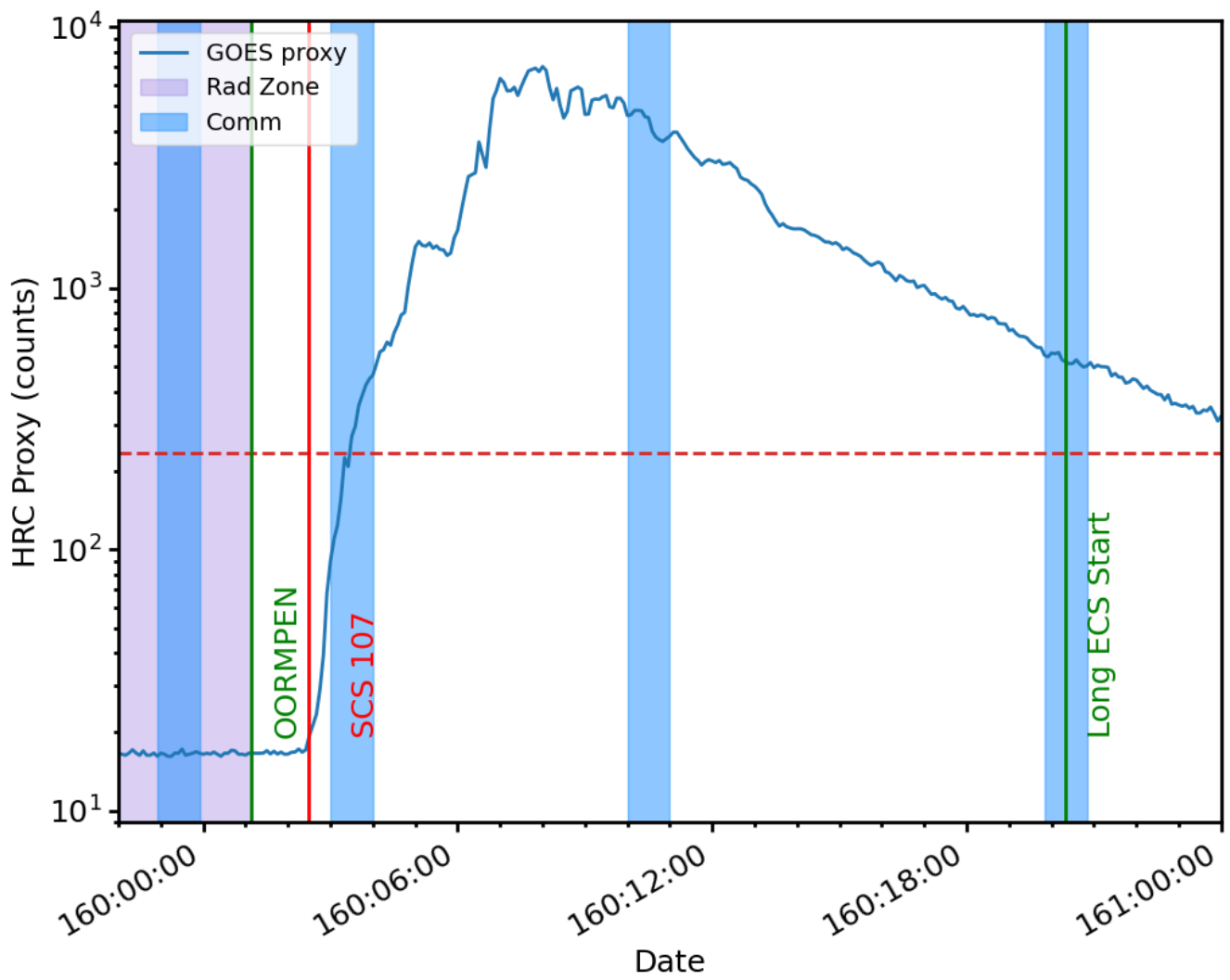


Figure 2: HRC Proxy rates during the June 7, 2024 solar storm.

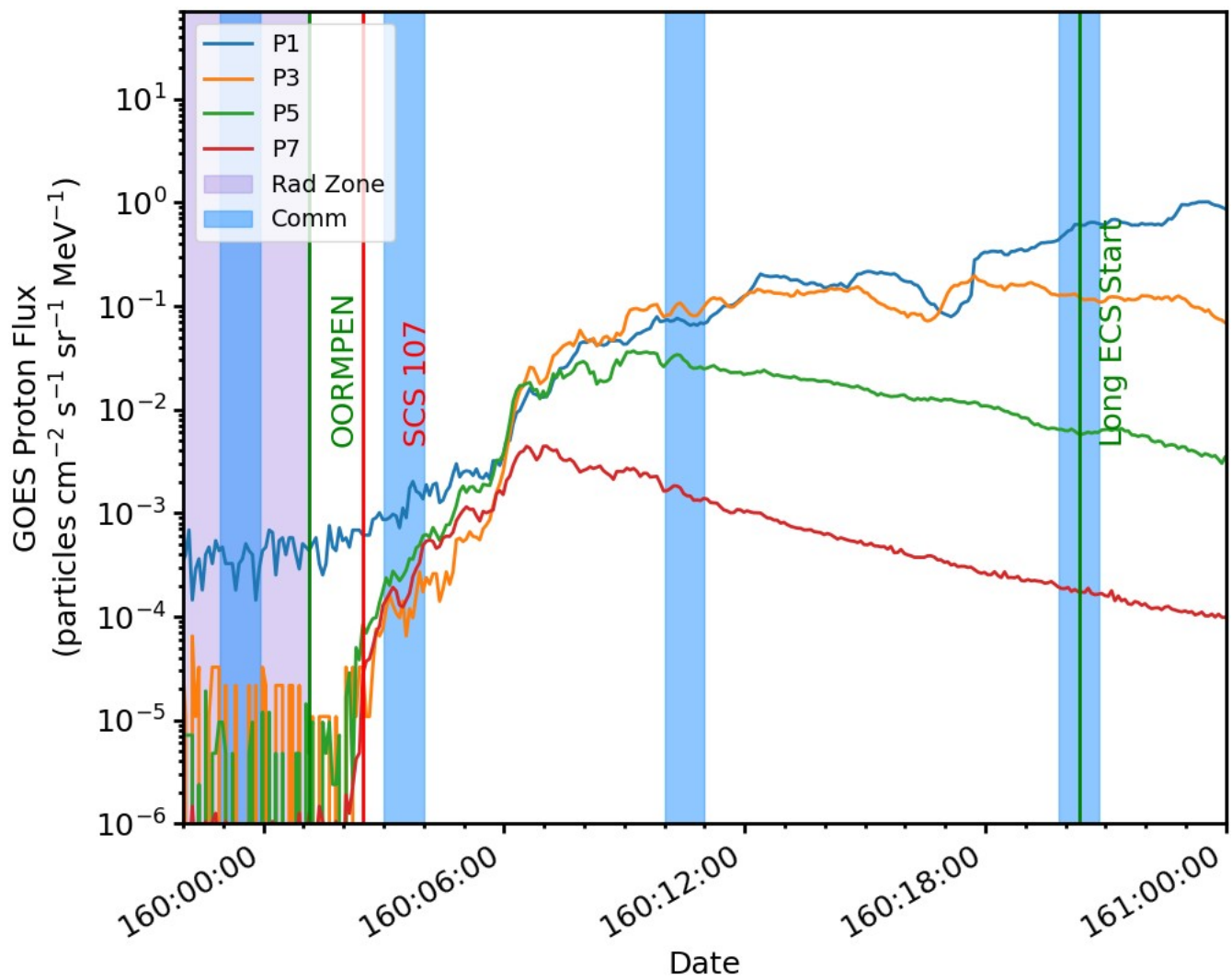


Figure 3: GOES Proton Flux during the June 7, 2024 solar storm.

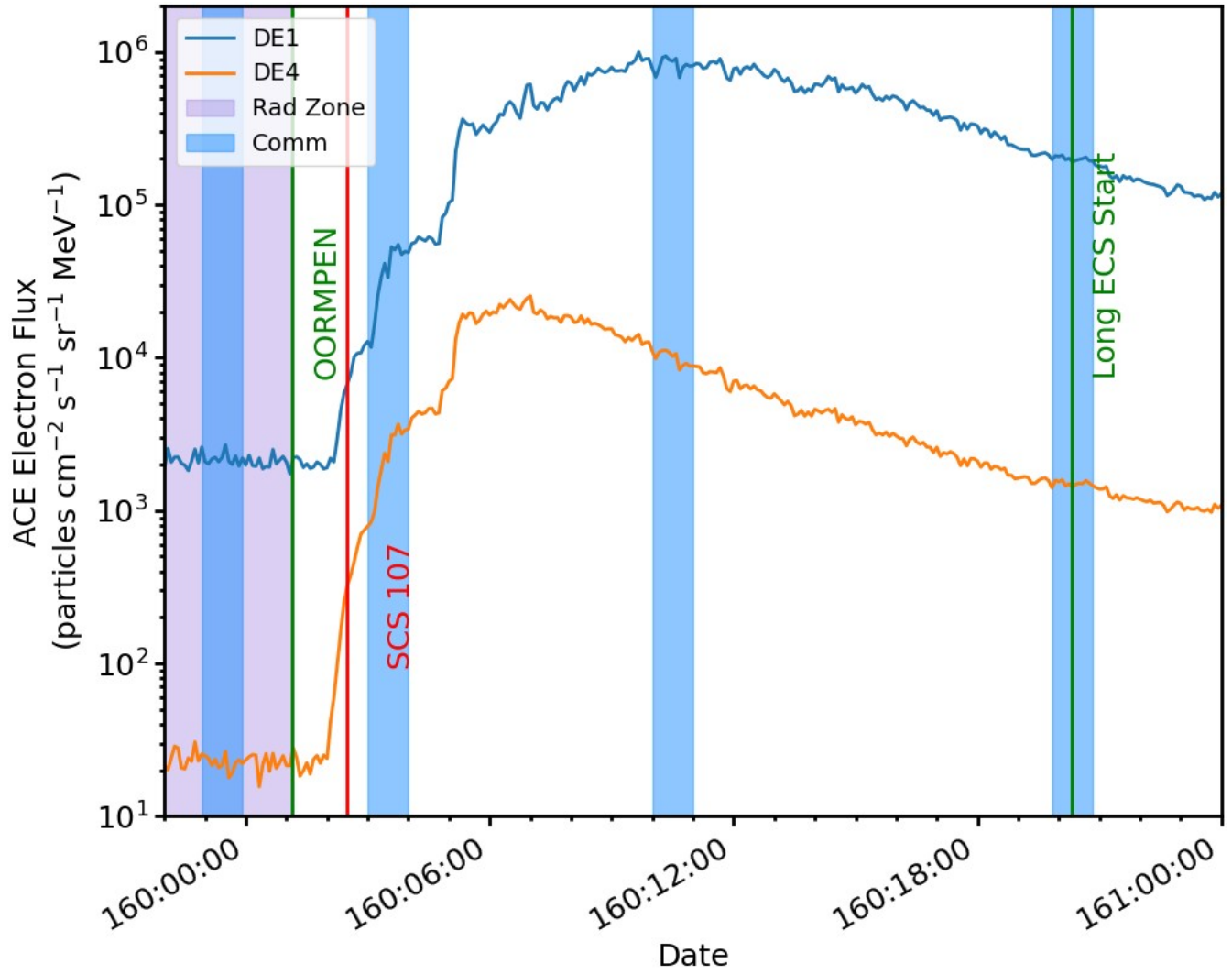


Figure 4: ACE Electron Flux during the June 7, 2024 solar storm.

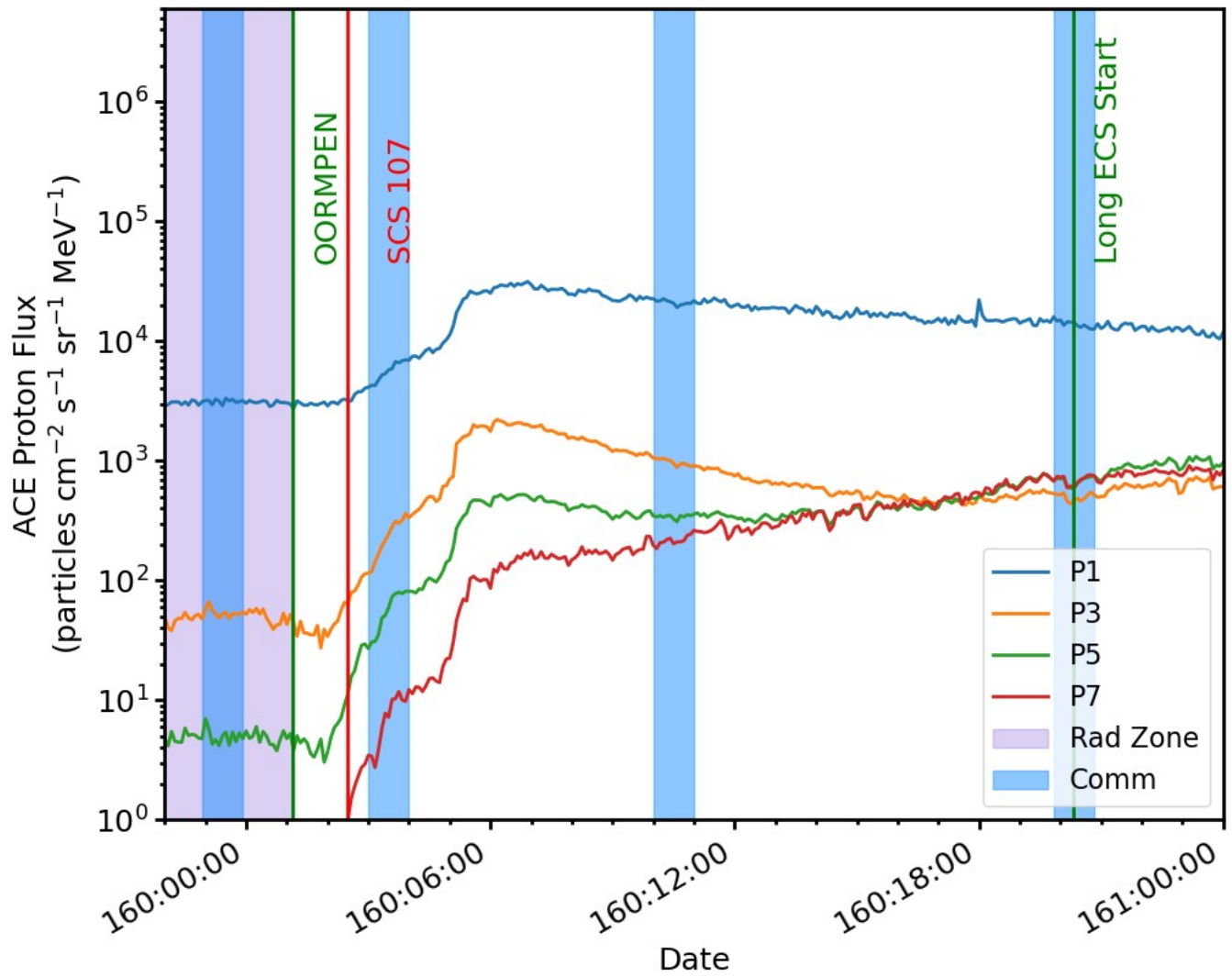


Figure 5: ACE Proton Flux during the June 7, 2024 solar storm

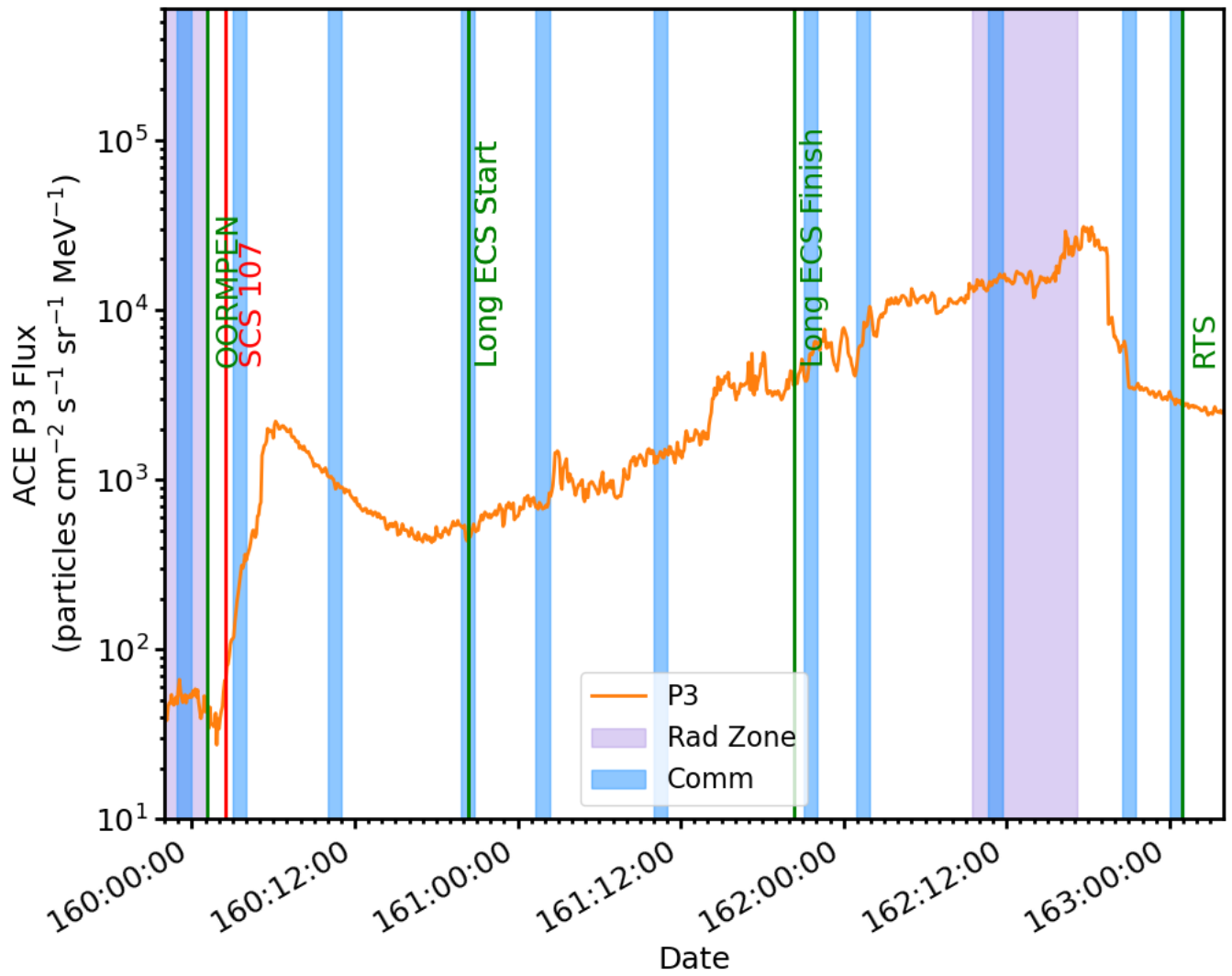


Figure 6: ACE P3 from the Perigee Passage to the Return to Science.

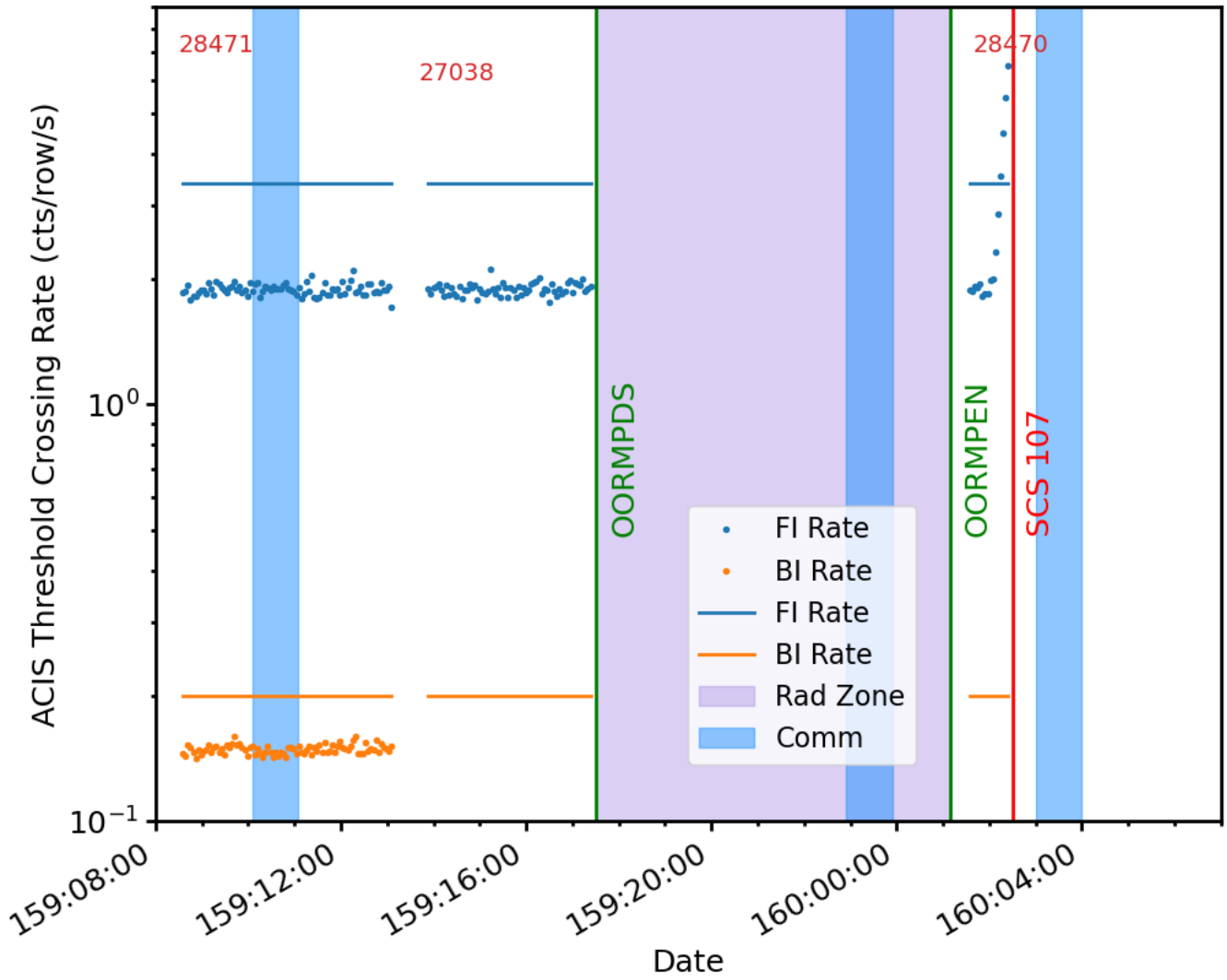


Figure 7: ACIS FI and BI Txing Rates from prior to the perigee passage up to the SCS-107

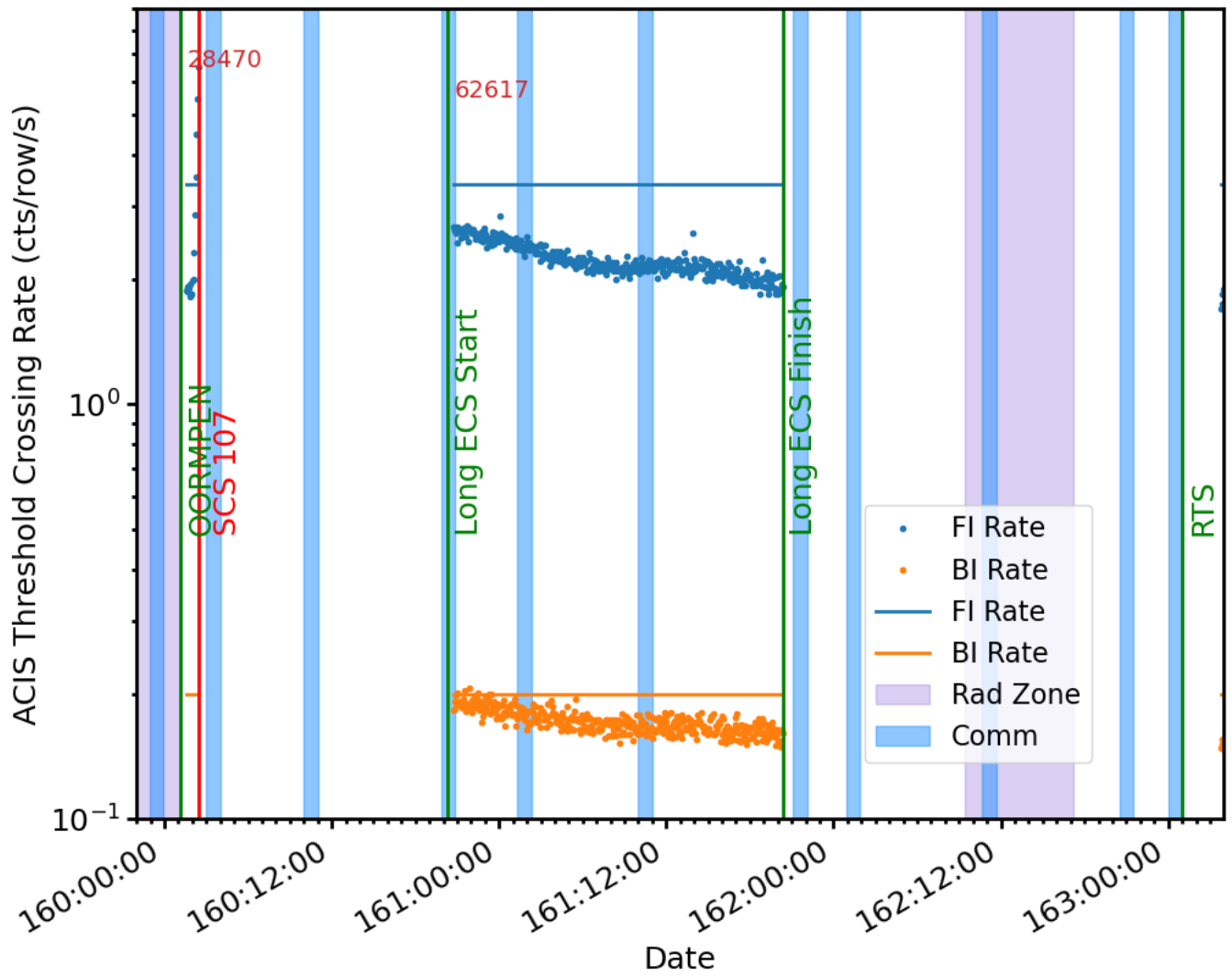


Figure 8: FI and BI Txings rates at the SCS-107, during the LTECS and at the Return to Science.

6 Resources and Notes

Peter Ford of MIT provided the data for the Txings plots

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

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