

Date: December 6, 2024
From: Gregg Germain
To: Chandra Operations Team
Subject: Chandra Radiation Event and Shutdown November 21, 2024
Cc: MSFC Project Science, CXC Director's Office

1 Abstract

On November 21, 2024 (2024:326:18:50:02.00 UTC) the NOV1824 load was interrupted by an ACIS Txings commanded SCS-107 which safed ACIS due to high GOES Proxy for HRC rates. No long term ECS measurement was taken. Return to Science commenced with the activation of the NOV2324 load on DOY 328. This was a pick up of the NOV1824 load with NOV2524 added to it. In total, ACIS accumulated an attenuated ACE P3 fluence of 5.37×10^4 particles $\text{cm}^{-2} \text{MeV}^{-1} \text{sr}^{-1}$ from the start of the orbit to the shutdown. The fluence saved because of the shutdown was 1.53×10^7 particles $\text{cm}^{-2} \text{MeV}^{-1} \text{sr}^{-1}$. This memo describes the shutdown and return to science decisions during the solar storm event.

2 Introduction

ACIS Txings is the sole radiation monitor for Chandra. Its autonomous activation has been a key means of reducing soft proton dosing from several storms this year alone. The trigger on November 21, 2024 was the seventh Txings-initiated shutdown in 2024.

3. Detailed Timeline November 21-23, 2024

- 2024:323:02:19:57.81 Time of first command for the NOV1824A load. ACE P3 rates quiescent.
- 2024:326:19:41:00.00 HRC observed, on Slack, that the GOES Proxy for HRC had spiked steeply and was rising. In Figure 2, the value at that time was 500-600; well above the limit. ACE P3 rates were slightly elevated. A telecom was scheduled for the start of the 9:50pm Comm that evening. ACIS' stated opinion, in Slack, was that unless the P3 rates rose dramatically between now and the 9:50pm Comm that no shutdown would be called for. ACE P3 rates, at that time, were ~21-45.
- 2024:327:02:50:01.29 9:50pm Comm. Telemetry indicates an SCS-107, activated by ACIS FI chip Txings, occurred at 2024:326:18:50:02.00. ACE P3 rates

were ~100-300 at the time of the Comm.

- 2024:327:18:16 NOV2324A Return to Science Load out for review. B load required.
- 2024:328:02:20 The ACE P3 and GOES Proxy for HRC rates were acceptable so the NOV2324B Return to Science load uplinked and activated.

4. Discussion

Solar activity has increased this year as we approach solar maximum (Figure 1). On Thursday, November 21, 2024 at 2:41pm a steep spike was observed in the GOES proxy for HRC shield rates (Figure 2). GOES Proton Rates (Figure 3) ACE Electron (Figure 4) and ACE Proton (Figure 5) rates were only slightly elevated with the ACE P3 flux rates at 21-45 (Figure 6). The next Comm was scheduled for 9:50pm that evening. A Slack discussion ensued in which ACIS stated that if, at the 9:50pm Comm, Txings had not tripped and the P3 rates had not risen dramatically, then ACIS would not recommend a shutdown. The precipitating event seemed to be a solar flare beyond the west limb of the Sun, which caused a fast, energetic CME which was not earth directed. It was presumed that the direction of the flare explained why the GOES proxy was elevated but ACE P3 rates were not. The elevated proxy rates did represent a threat to the HRC and HRC was prepared to recommend running F_HRC_SAFING if a Txing shutdown had not occurred.

At the 9:50pm Comm, it was observed that an SCS-107 execution, at 2024:326:18:50:02.000, occurred. Both ACIS and HRC were safe. This interrupted the NOV1824 load observing Obsid 28831. The ACIS FI Threshold Crossing Rate triggered the SCS-107 (Figure 7). At this time the ACE P3 flux rates were slightly more elevated at 100-200 which represented no threat to ACIS and allowed a rapid return to science. Discussions revolved around a time at which operations could return to science, the possibility of a pick up of the NOV1824 load, and the addition of the NOV2524 load to the pick up. No ACIS Long Term ECS measurement was contemplated due to the rapid return to science.

The NOV2324 pick up load was released on November 22 for review. A B load review was necessary.

The decision to proceed with the NOV2324 load was made based upon the GOES HRC proxy and ACE P3 rates. As seen in Figure 2 the GOES HRC proxy rate had come down to well below the limit and the ACE P3 rate had stayed at an only slightly elevated value. Science Operations resumed with the uplink of the NOV2324 Return to Science load at the 2024:238:02:Comm.

5. Lessons Learned

It was determined that the remaining portion of the NOV1824 load, beginning at the restart time, could be used without modification. There were no constrained observations that had to be moved and the thermal situation at the restart time was acceptable. This allowed the pick up load procedure.

That, and the lack of elevated ACE P3 flux allowed a rapid return to science. The pick up load procedures worked smoothly, aided by a lack of any dropped chips in the NOV1824 load; an unusual occurrence. While the radiation levels were not a threat to ACIS, the automated Txing shutdown was necessary for the safety of the HRC.

5 Plots and Images

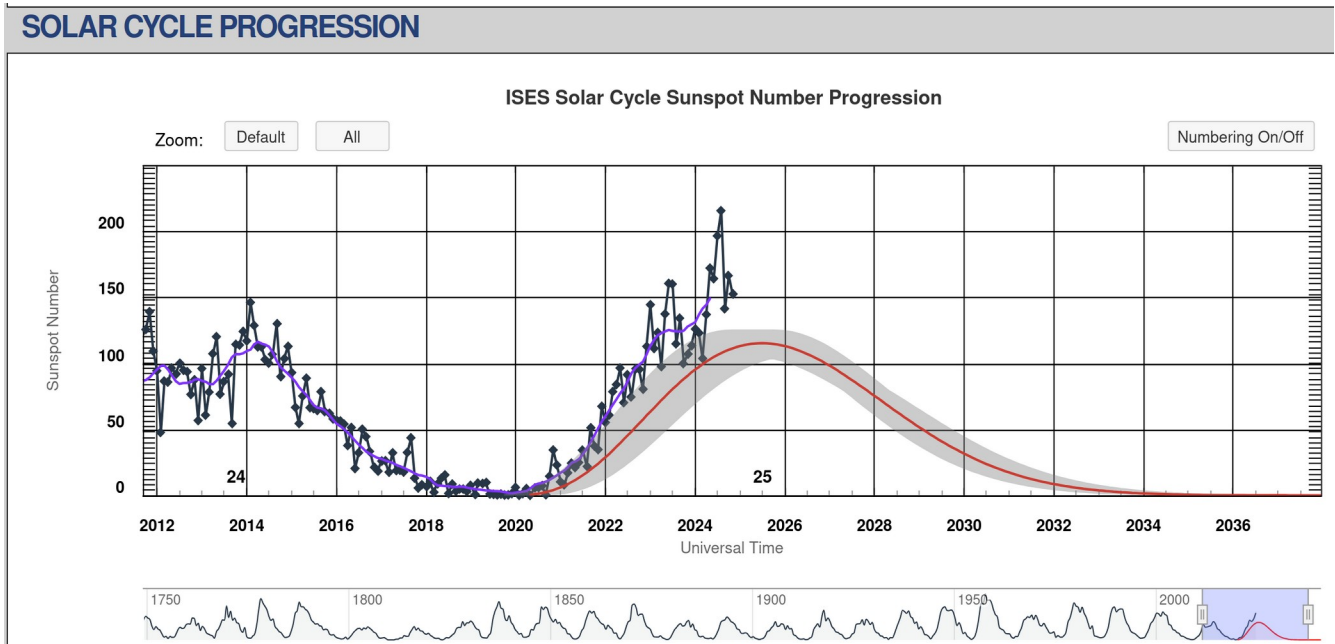


Figure 1: Solar Cycle Sunspot Progression - The number of sunspots are exceeding the predictions

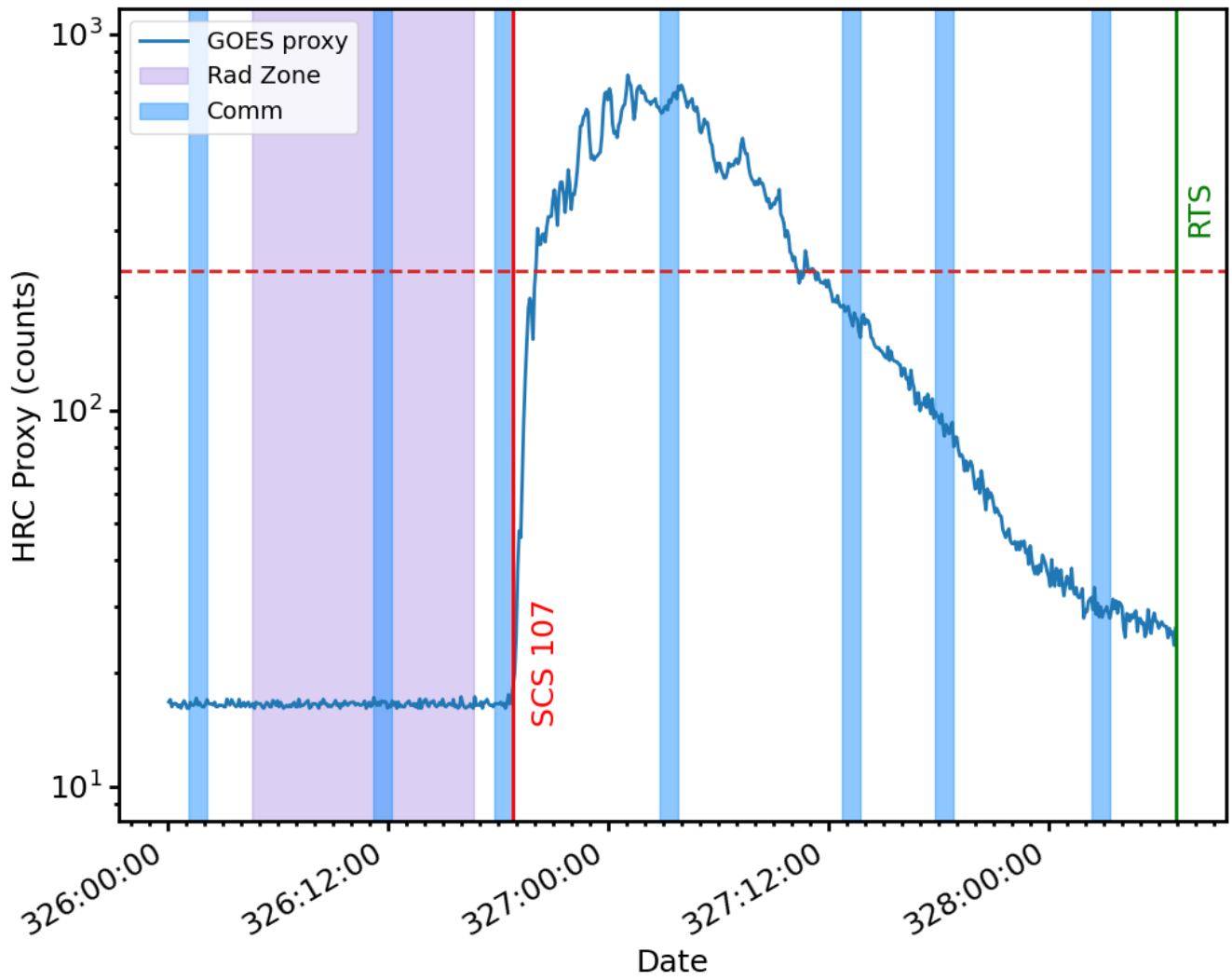


Figure 2: HRC Proxy rates during the November 21, 2024 solar storm.

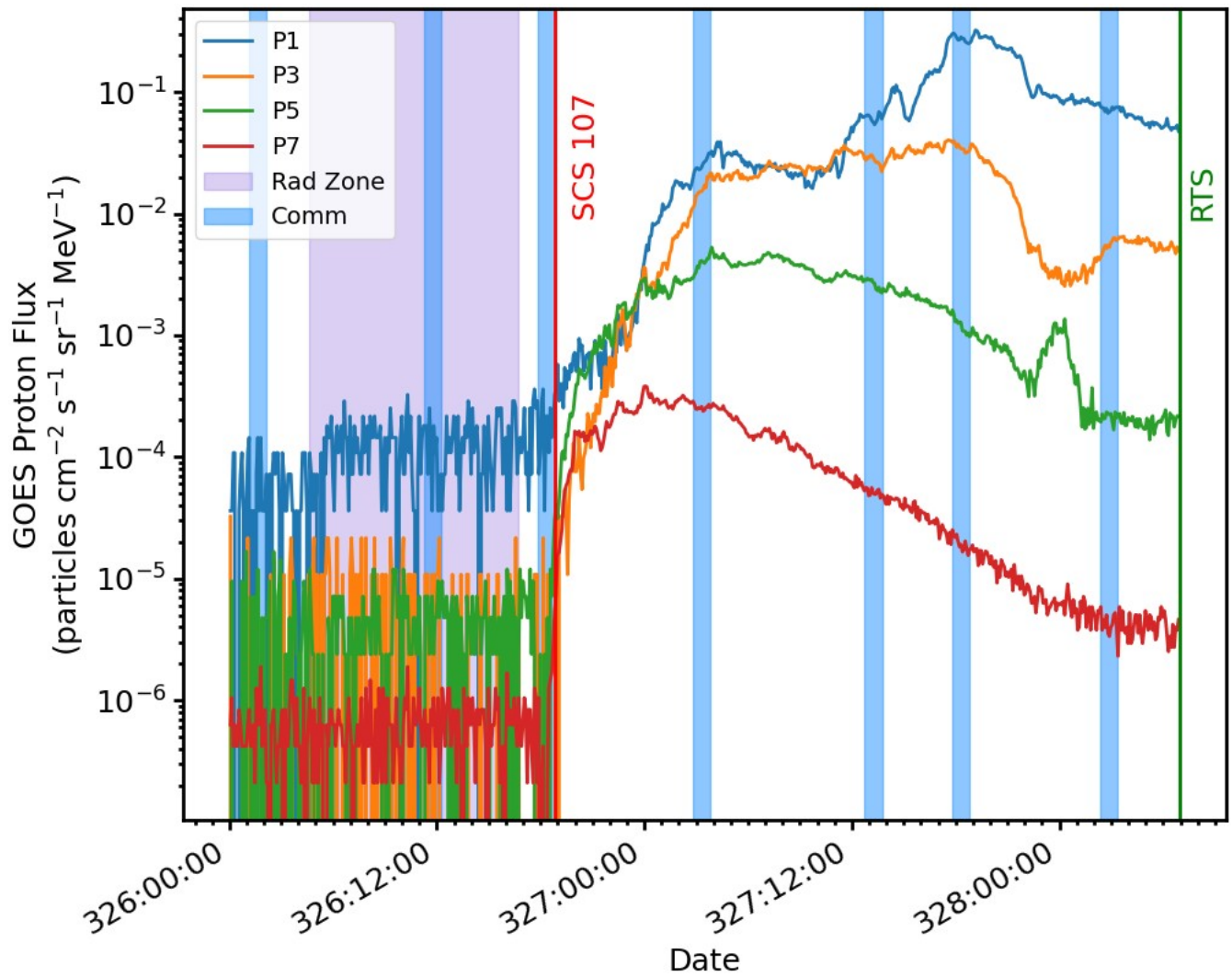


Figure 3: GOES Proton Flux during the November 21, 2024 solar storm.

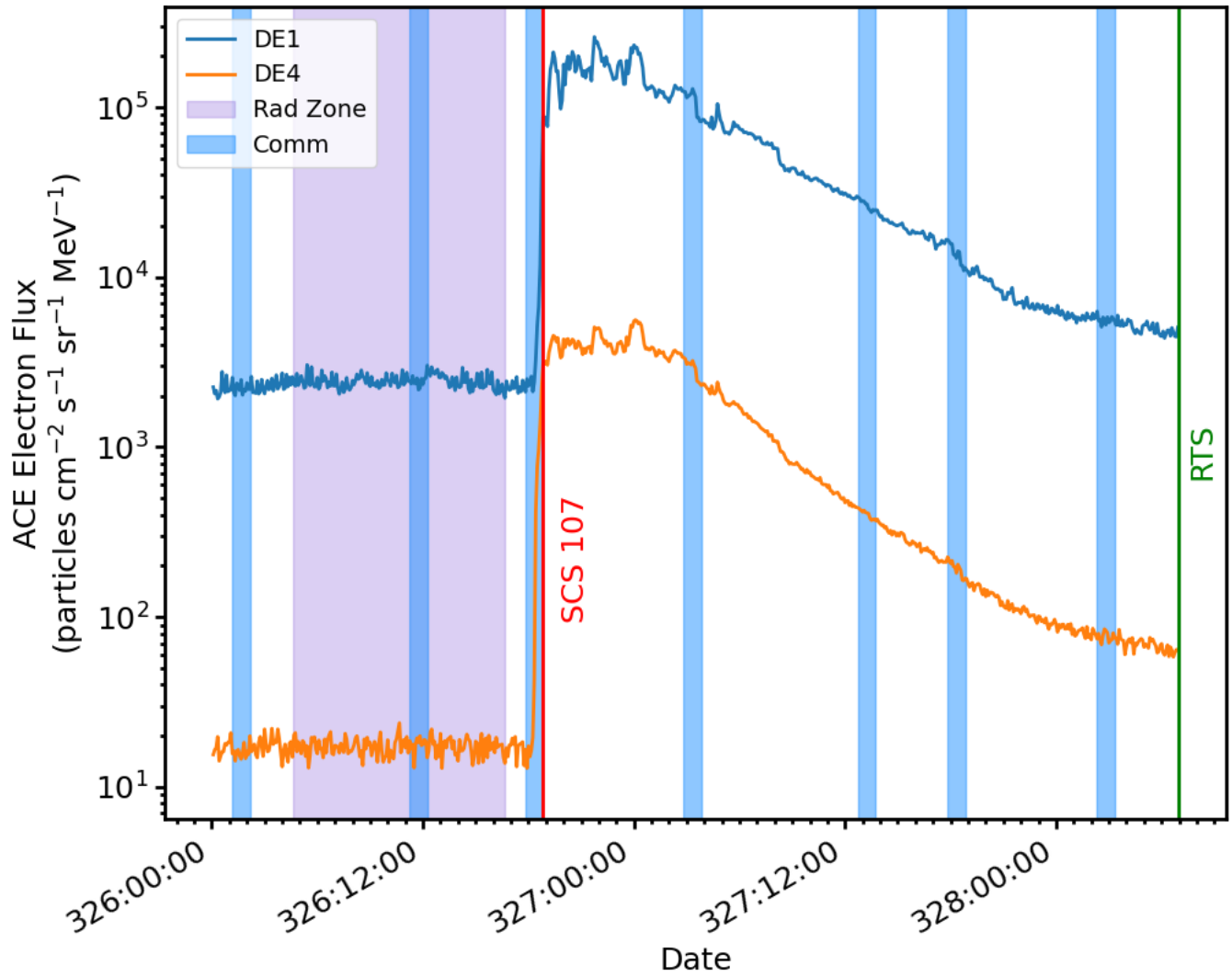


Figure 4: ACE Electron Flux during the November 21, 2024 solar storm.

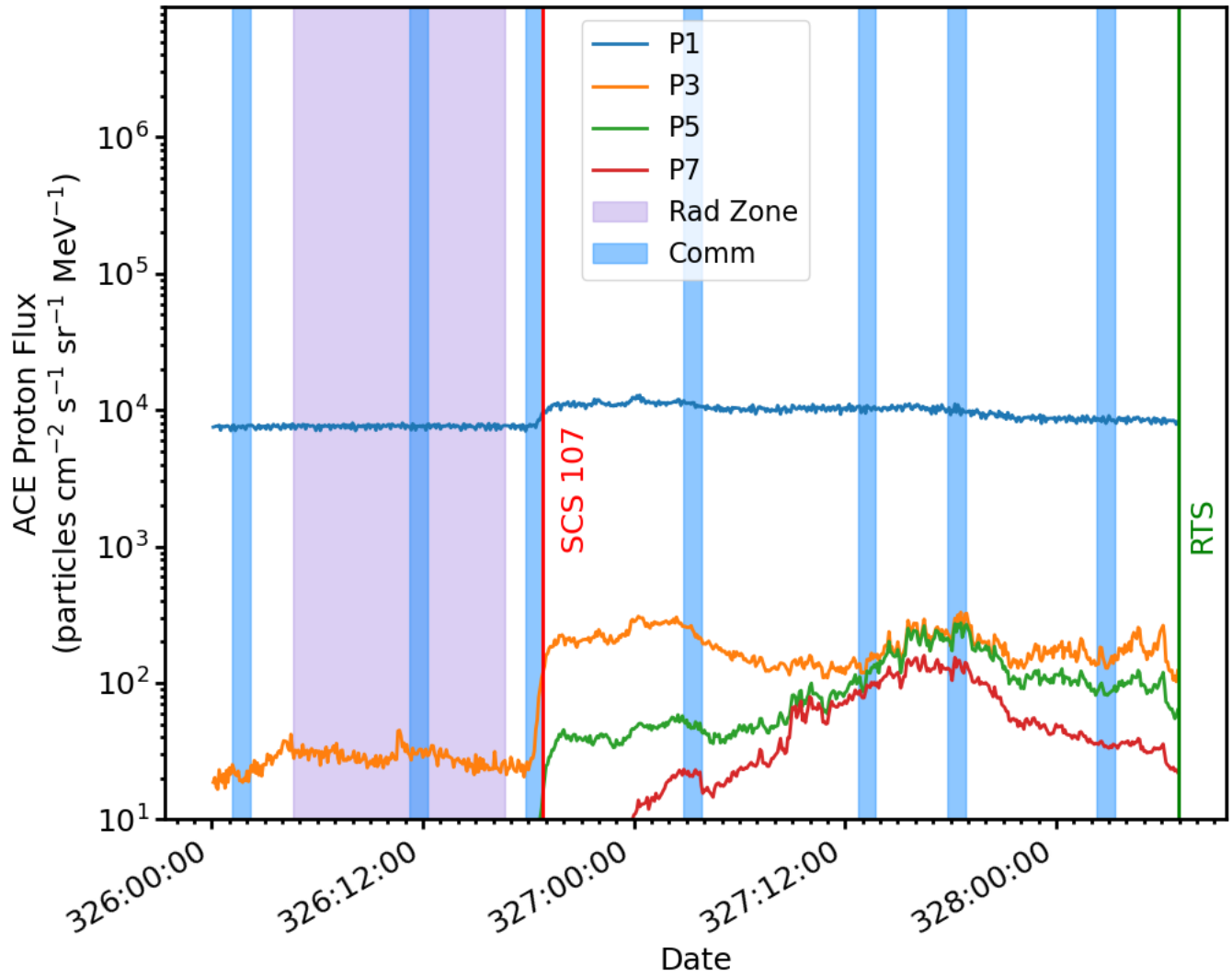


Figure 5: ACE Proton Flux during the November 21, 2024 solar storm

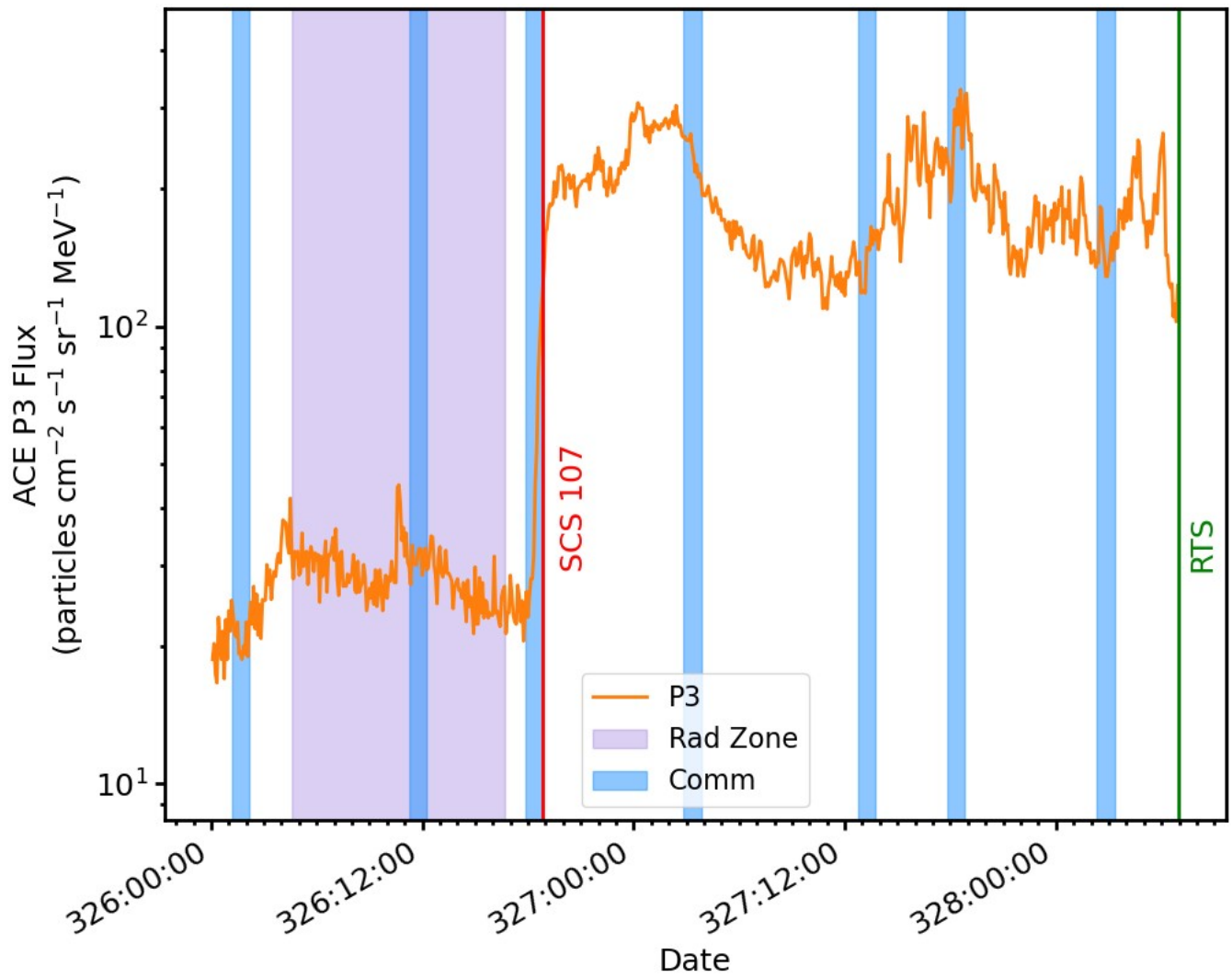


Figure 6: ACE P3 from before the November 21, 2024 SCS-107 to the Return to Science.

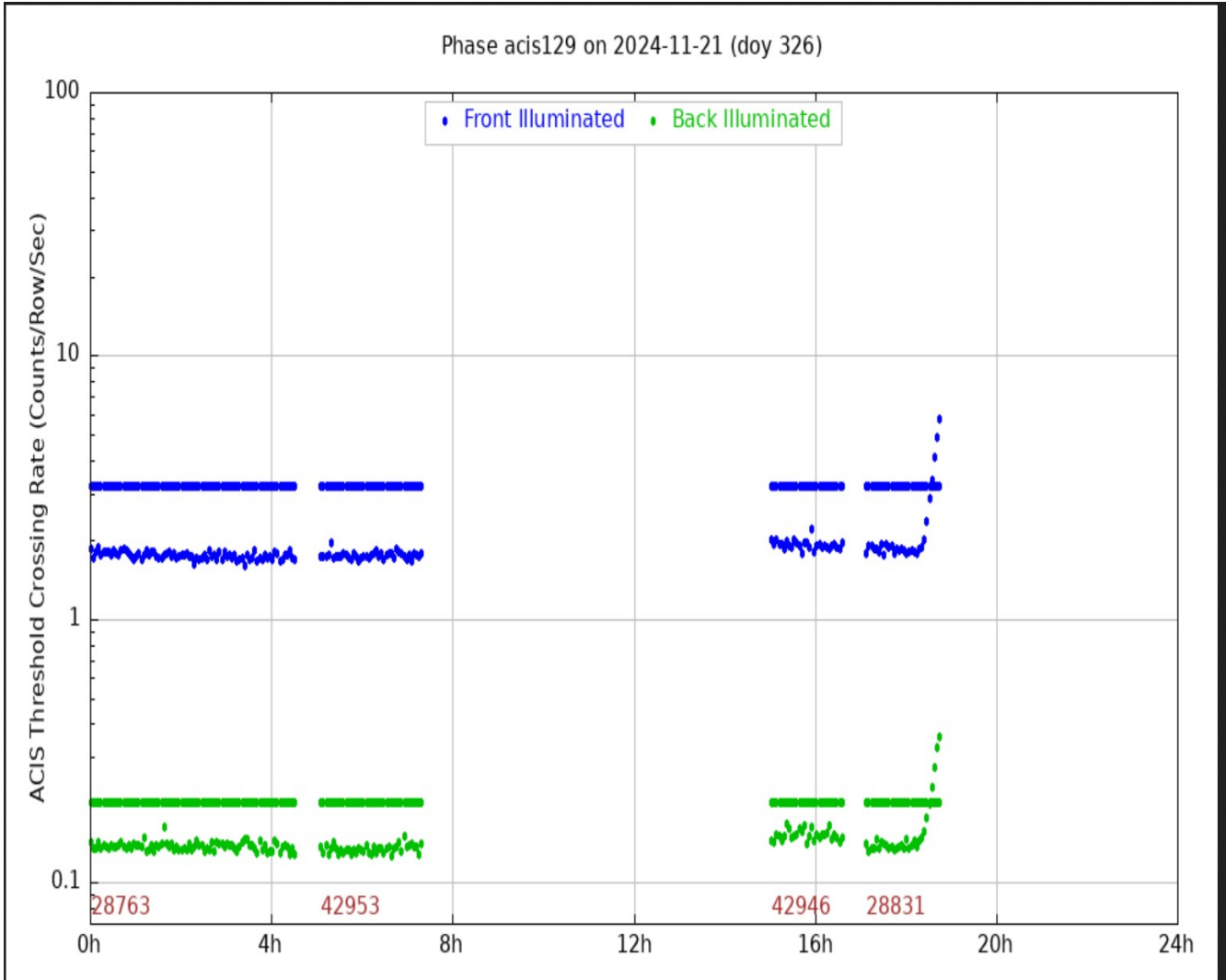


Figure 7: ACIS FI and BI Txing Rates leading up to the November 21, 2024 SCS-107

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 $\text{cm}^{-2} \text{MeV}^{-1} \text{sr}^{-1}$.