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

MEMORANDUM

Date: March 27, 2003
From: Shanil N. Virani
To: ACIS Operations,file
Subject: The Chandra Radiation Environment at the Time of The 2 DPA-A Turn-Off Anomalies: Oct. 26, 2000 and Dec. 19, 2002
File: `/data/acis26/ACIS/RadEnv/DPA-A/memo/DPA-A.tex`

---

1 Introduction

At 15:42 GMT on October 26, 2000 (DOY 300) and again at 23:18 on December 19, 2002 (DOY 353), side A of the ACIS Digital Processing Assembly (DPA) anomalously turned off. As Flight Notes 394 (ref. 1) and 417 (ref. 2) point out, the most credible scenarios are either a static discharge to the opto-isolator or a single event upset (SEU) to the opto-isolator. In either case, a signal to the flip-flop was sent which resulted in turning off the DPA-A. In this short memo, we explore the radiation environment at Chandra as measured by the EPHIN instrument at the time of these two anomalies.

2 First Occurrence: October 26, 2000

Presented in Figures 1-3 are plots of EPHIN data around the time of the first instance of the DPA-A turn off. EPHIN has 4 proton channels, 4 electron channels, 4 helium channels, and one integrated channel. Table 1 below provides the name of each EPHIN channel as well as the energy range that they measure.

In these Figures, the green lines indicate the times of AE-8 entry/exit and the blue line indicates the time of RadMon EN. The black line labeled "PERIGEE" is of course the time of perigee. These times were obtained from the OCT2300 load. (The time of RadMon DS occurs just prior to 299.5 – it occurs at 299.47 to be exact.) The lines in red are self-explanatory and the times are taken from Flight Note 394.

As can be clearly seen from this series of plots, Chandra was in an elevated radiation environment due to the arrival of a CME. The EPHIN P4 reading at the time of DPA-A turn off is about an order of magnitude smaller than its SCS107 trigger value ($\approx$30 vs. 300). The two other EPHIN SCS107 channels were both well below their respective trigger values. The INT channel shows no noticeable departures from its nominal level at the time of the DPA-A turn off. Other than the elevated radiation environment at Chandra at the time of the DPA-A turn off, there is not much more that can be determined from these plots alone.

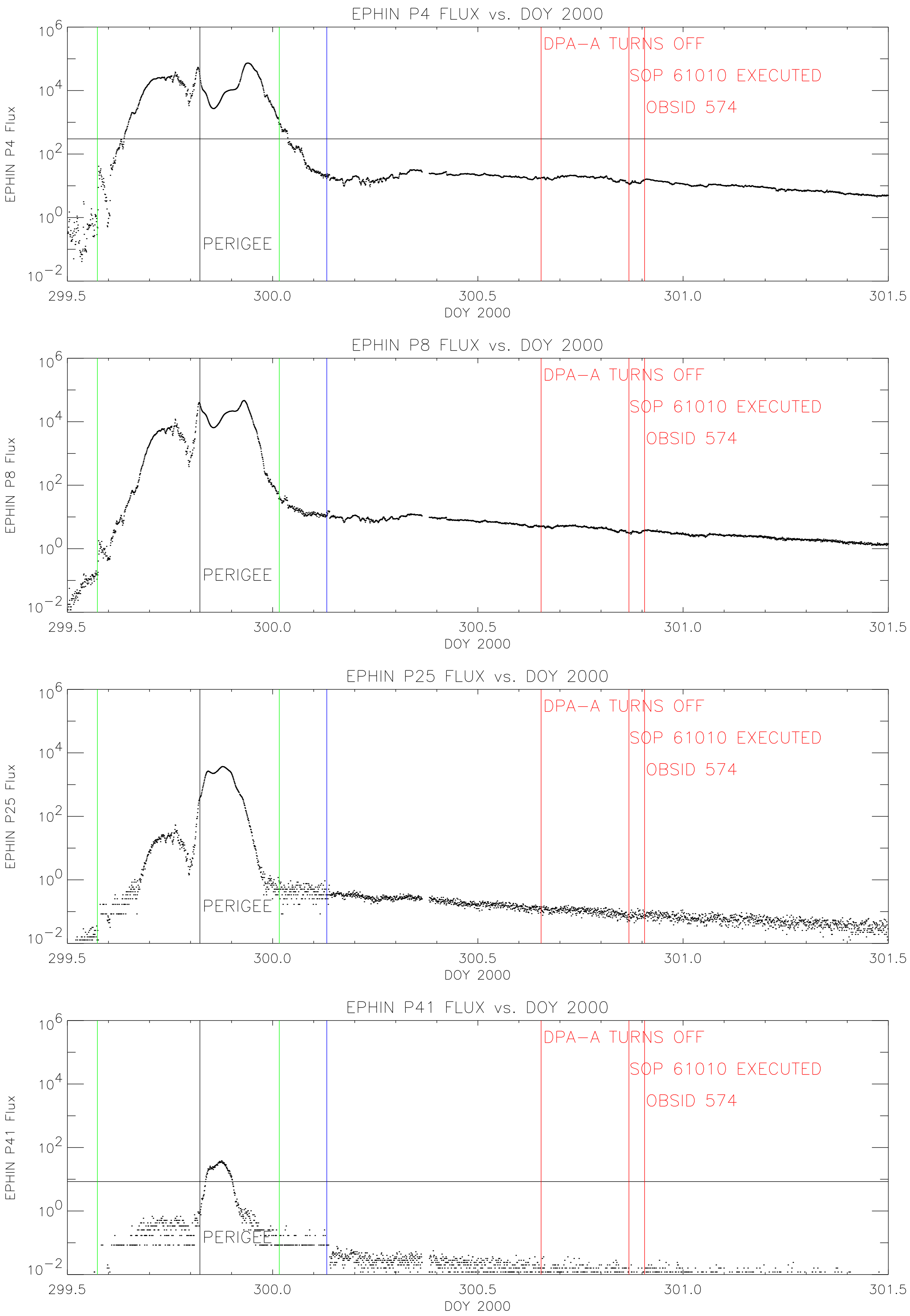

Figure 1: EPHIN-Proton data near the time of the first DPA-A anomaly. See text for details.

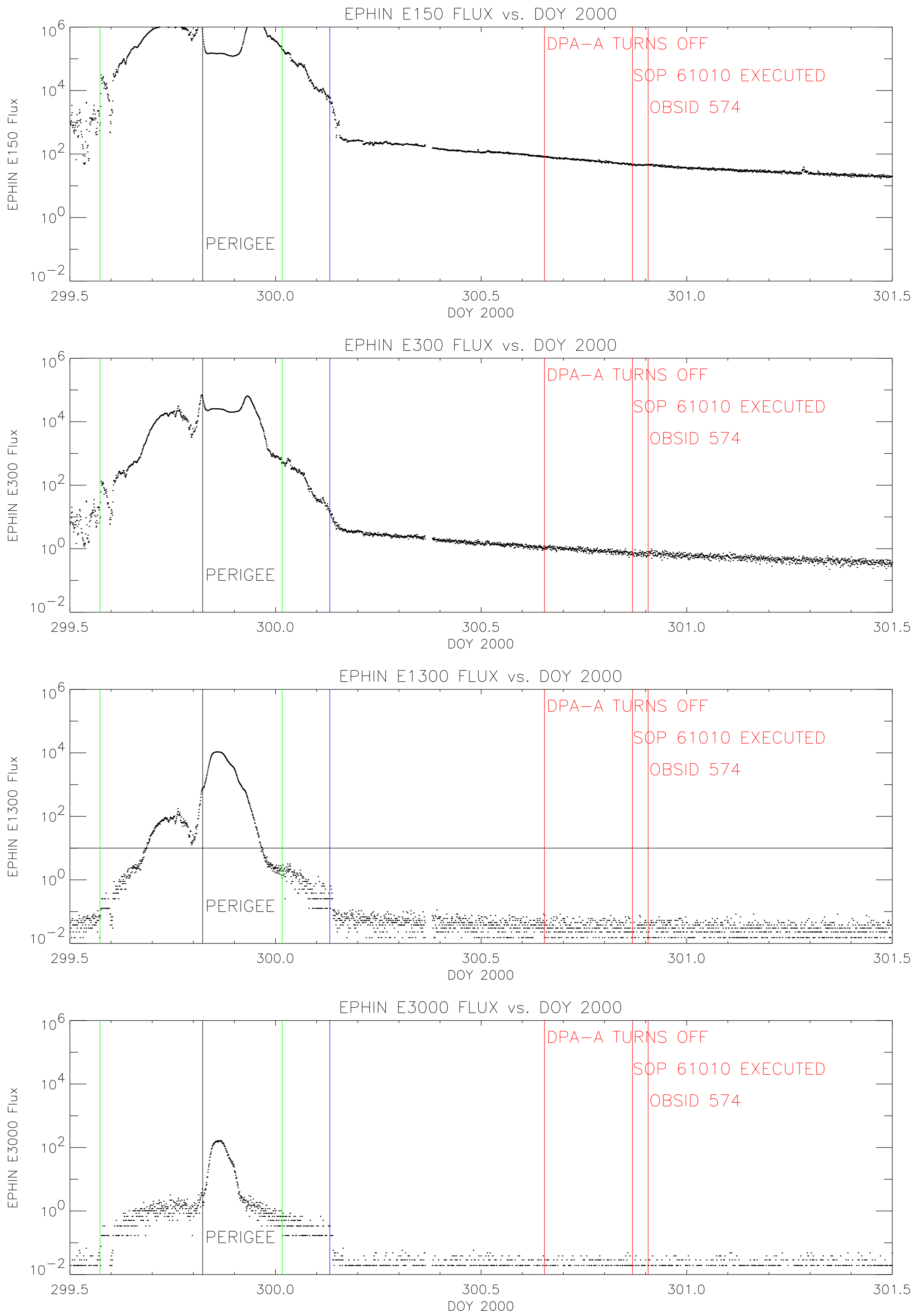

Figure 2: EPHIN-Electron data near the time of the first DPA-A anomaly. See text for details.

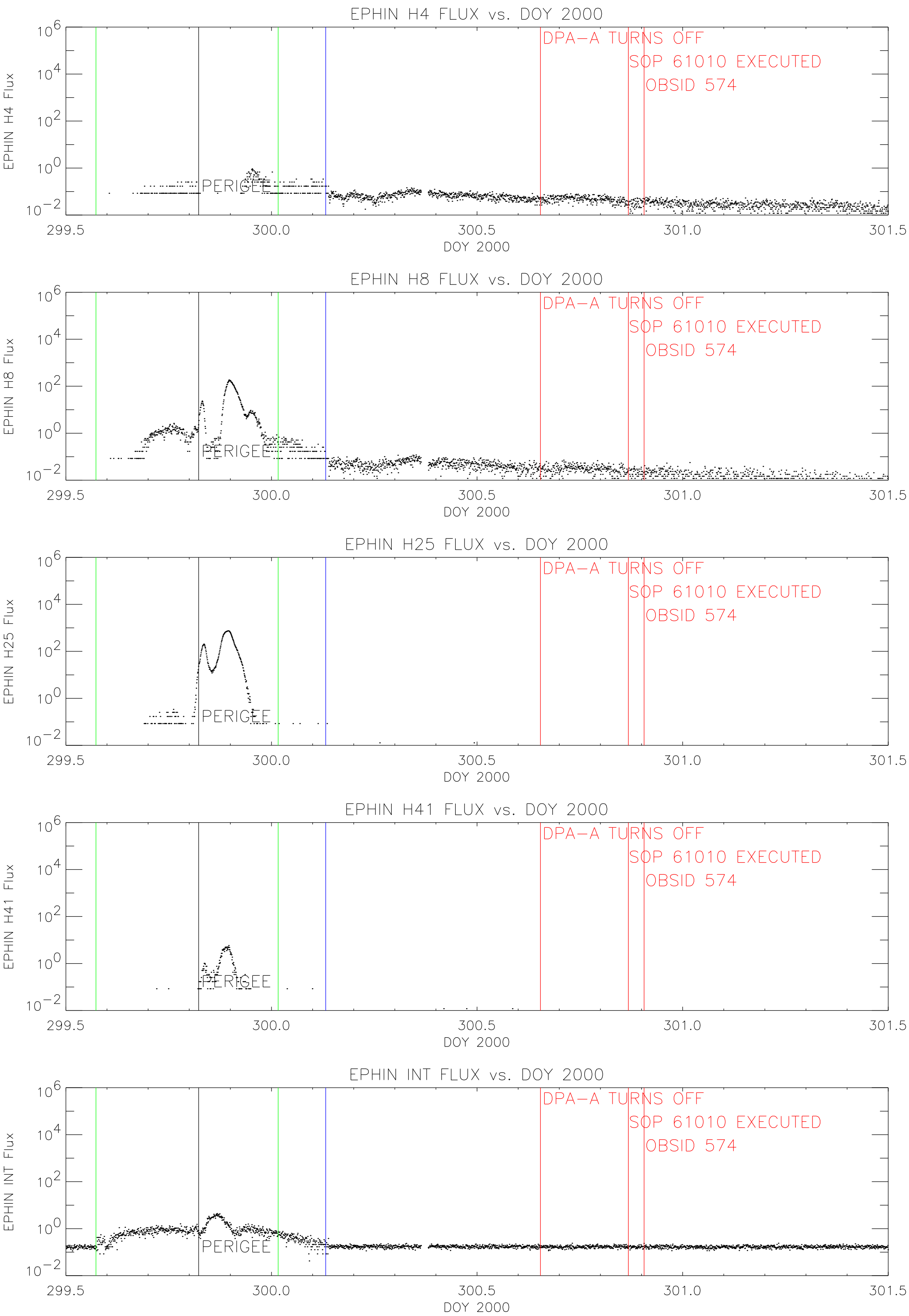

Figure 3: EPHIN-Helium and INT channel data near the time of the first DPA-A anomaly. See text for details.

Table 1: EPHIN Energy Ranges

EPHIN Channel	Energy Range [MeV] or [MeV/n]	Energy Width [MeV] or [MeV/n]
E150	0.25 - 0.70	0.45
E300	0.67 - 3.00	2.3
E1300	2.64 - 6.18	3.6
E3000	4.80 - 10.4	5.6
P4	5.0 - 8.3	3.3
P8	8.3 - 25.0	16.7
P25	25.0 - 41.0	16.0
P41	41.0 - 53.0	12.0
H4	5.0 - 8.3	3.3
H8	8.3 - 25.0	16.7
H25	25.0 - 41.0	16.0
H41	41.0 - 53.0	12.0
INT	e: > 8.7	
	p,h: > 53	

As Eric Martin has pointed out (ref 3):

> a very long duration C4.0 X-ray event was observed on 25 October 2000 that was associated with a filament eruption and a full halo CME. More significantly, a proton event also occurred, which caused both hard and soft proton levels to rise fairly quickly. The shock from the CME passed the Earth on 28 October 200. The DPA turned off at 2000:300:15:42, slightly more than 24 hr after the end of the X-ray event. Hard and soft proton levels had also been elevated for more than 24 hr.

3 Second Occurrence: December 19, 2002

Figures 4-6 are similar to the first three Figures but correspond to EPHIN data at the time of the second DPA-A anomaly (December 19, 2002). The blue lines in these Figures indicate times of RADMON DS/EN and the green lines indicate times of AE-8 entry/exit. The black line labelled "PERIGEE" is of course the time of perigee. These times were obtained from the DEC1602 load. The red lines are self-explanatory and were taken from Flight Note 417.

As these Figures illustrate, the DPA-A turn-off occurred soon after the arrival of a CME at

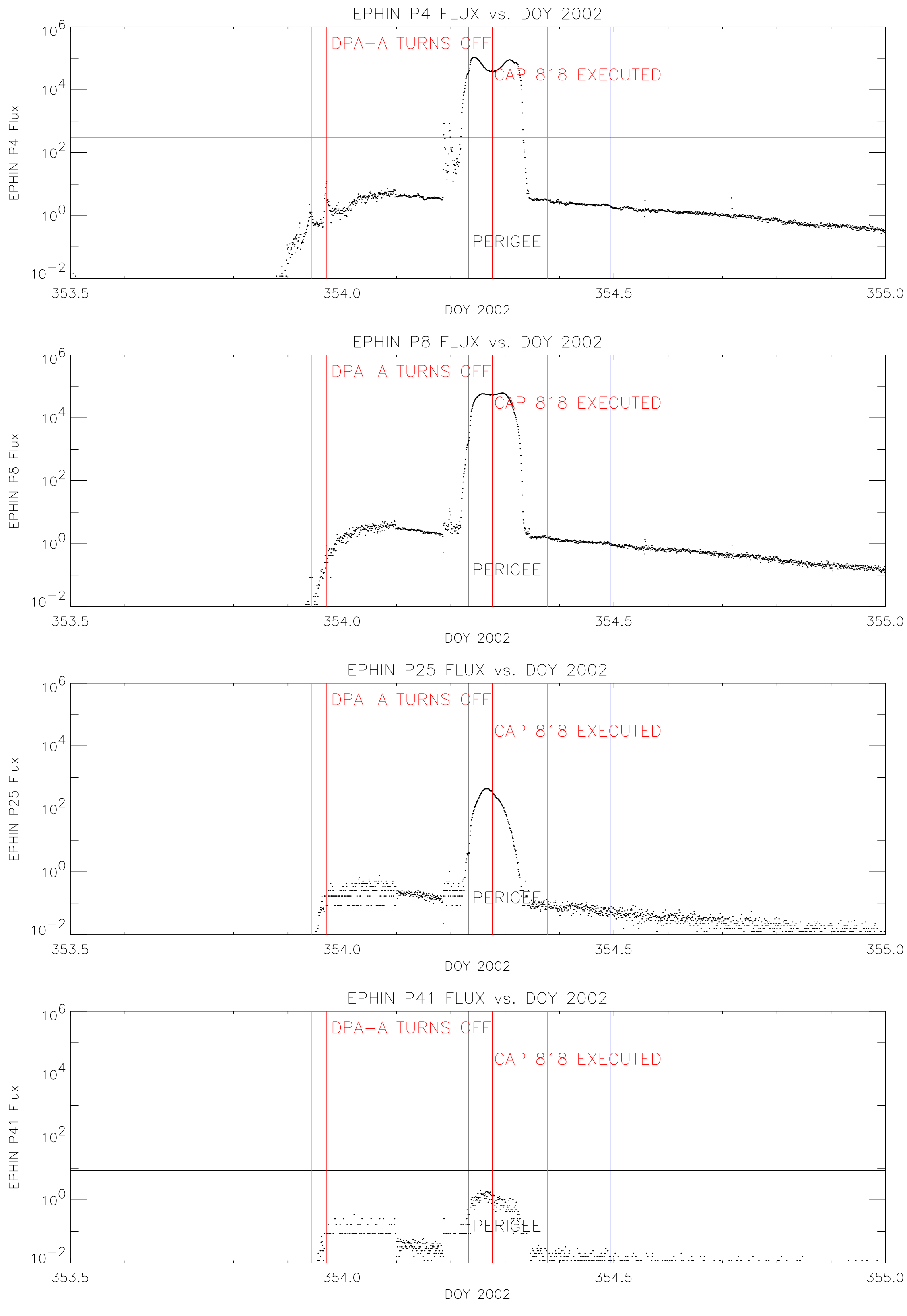

Figure 4: EPHIN-Proton data near the time of the first DPA-A anomaly. See text for details.

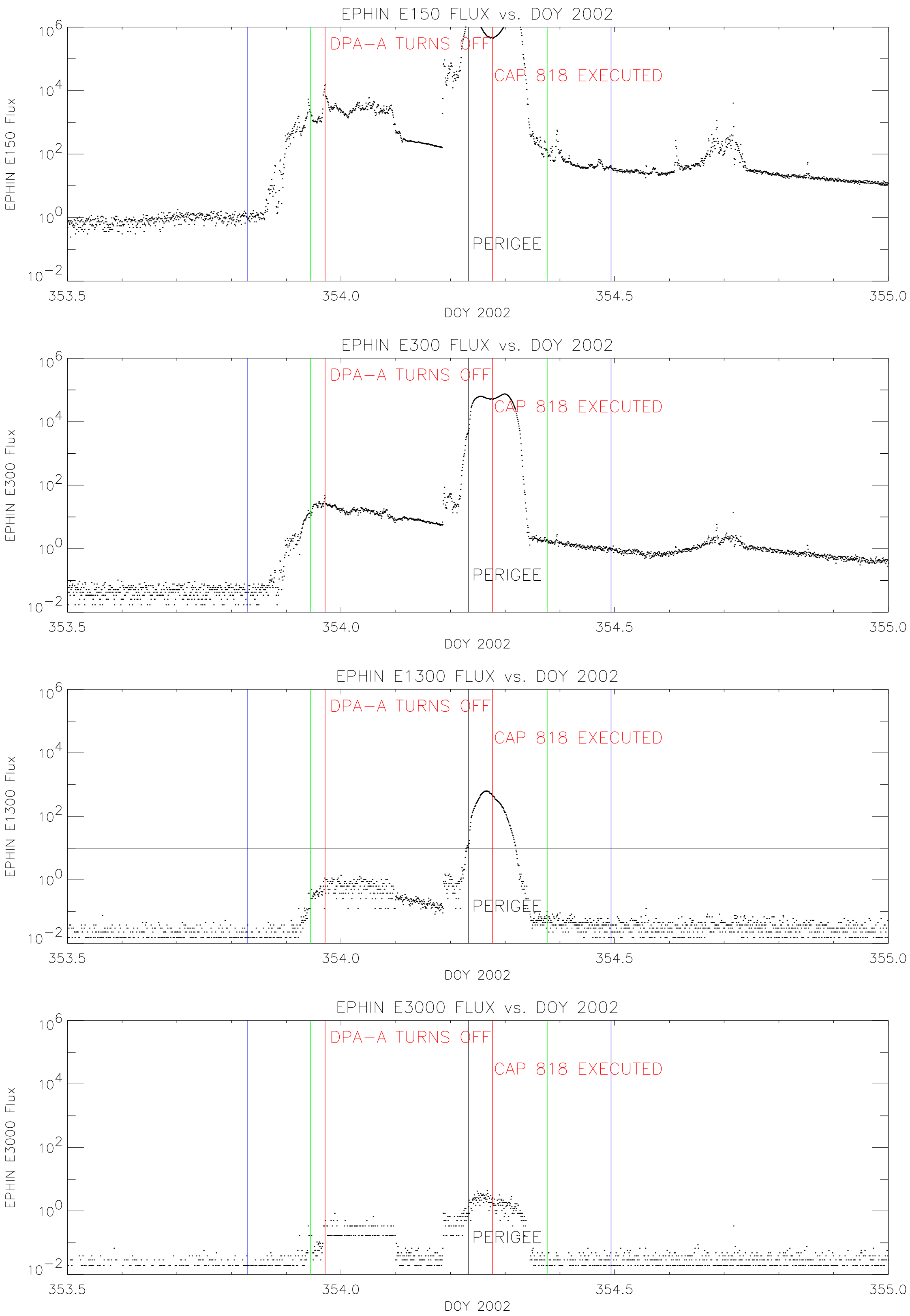

Figure 5: EPHIN-Electron data near the time of the second DPA-A anomaly. See text for details.

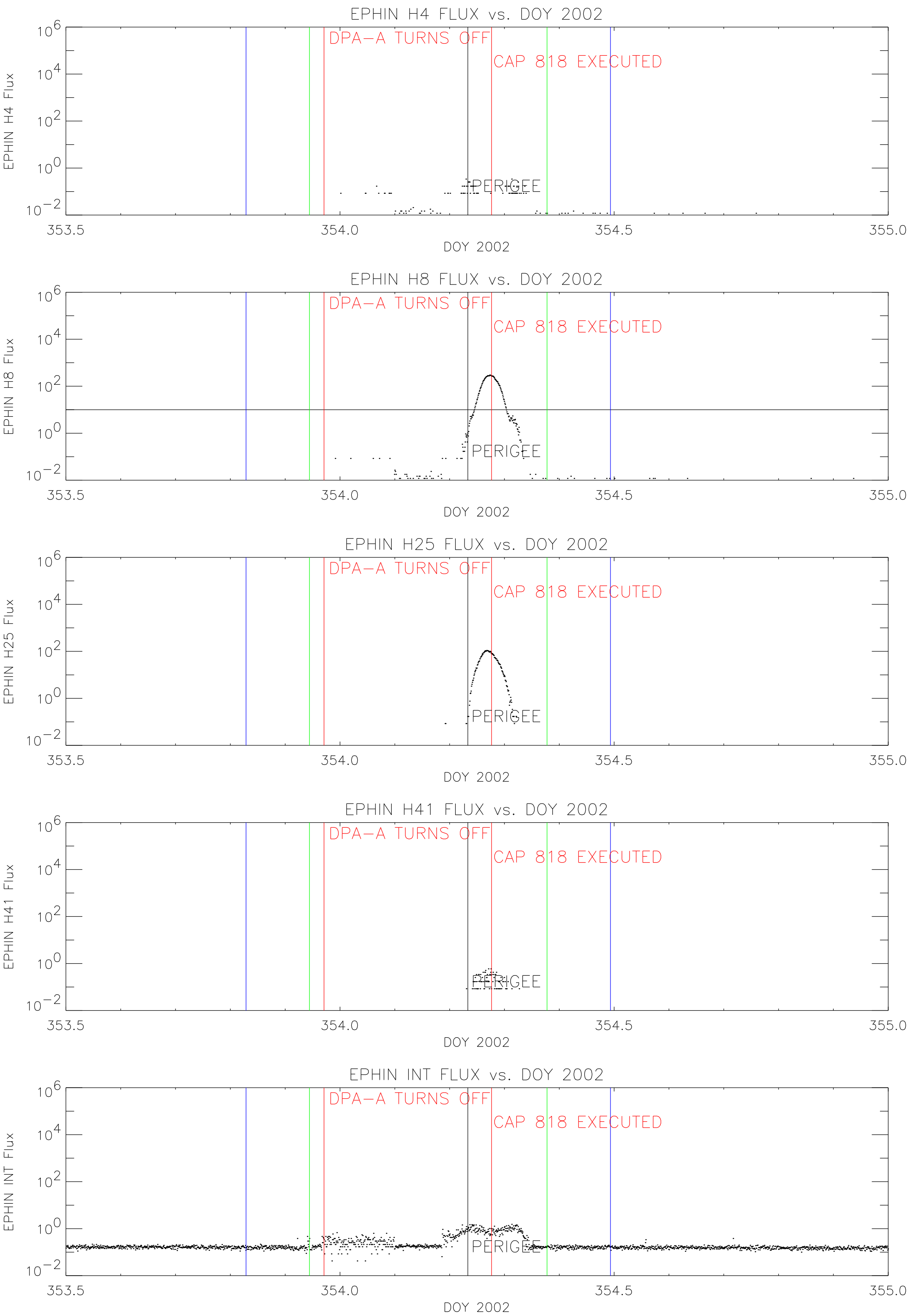

Figure 6: EPHIN-Helium and INT channel data near the time of the second DPA-A anomaly. See text for details.

Chandra. This elevated radiation level is also seen in all 8 electron/proton channels (*i.e.*, both the low energy and high energy channels indicate elevated flux levels). Interestingly, the INT channel did respond to the arrival of the CME and its level of response was approximately similar to that seen during the belts (bottom panel of Figure 6). The time of the DPA-A turn off does coincide with these small fluctuations in the INT channel. However, the signal is of course very small and it probably is just a coincidence. Of course, at the time of the DPA-A turn-off, ACIS had long been at the HRC-S position and there is of course no direct path from the mirrors to ACIS. Nevertheless, the data indicate that Chandra was not in a quiescent radiation environment.

As Eric Martin points out (ref 3.), the elevated radiation environment at Chandra was due to:

> a long duration M2.7 X-ray event on 19 December 2002 associated with a full halo CME and a relatively minor proton event. A weak shock from the CME passed the Earth on 22 Dec. The DPA turned off at 2002:353:23:18, about the time that the end of the X-ray event was detected at GOES. Hard and soft proton levels had only started rising shortly before the DPA turned off.

4 Conclusion

While both events occurred at times of elevated radiation, it is not possible to establish a causal connection between the two. Since launch, Chandra has experienced tens of events, if not at least a hundred, similar to the ones presented in Figures 1-6. Moreover, the flux levels seen in EPHIN at the times that the DPA-A powered off are at least an order of magnitude lower than what is typically seen during transit of the Van Allen belts. Yet, it was only on these two occasions that the DPA-A turned off. It is probably nothing more than a coincidence that these two events occurred during a time of elevated radiation levels.

Figures 1-6 also demonstrate that the two DPA-A turn-offs occurred at two different altitudes. In the first instance, the turn-off occurred well after perigee while Chandra was ascending towards apogee. In the second instance, the turn-off occurred while Chandra was in the radiation belts (*i.e.*, the magnetosphere) and descending towards perigee.

References

1 “DPA-A Turn Off Anomaly Report”, FN394, Sept. 18, 2001, J. Shirer, http://cxc.harvard.edu/acis/memos/FN394.ps

2 “December 2002 DPA-A Turn Off Anomaly Report”, FN417, March 25, 2003, D. Shropshire, http://cxc.harvard.edu/acis/memos/FN417.ps

3 “RE: Radiation Environment during DPA-A anomaly”, private communication, March 26, 2003, Eric Martin.