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**MEMORANDUM**

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| Date: | May 28, 2025 |
| From: | Jack Steiner |
| To: | Chandra Operations Team |
| Subject: | Chandra Anomalous Radiation Shutdown on March 24, 2025 |
| Cc: | MSFC Project Science, CXC Director's Office |
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## 1 Abstract

An ACIS-S/HETG observation of the bright neutron-star X-ray binary system Cygnus X–2 produced an unintended *txings* trigger in the MAR2325 load. This was the second observation of the source in the same week; the two observations were identically configured. The ACIS Operations team identified the root cause of the shutdown: the first-order dispersed signal was dithered fully or almost fully off the S3-subarray during the observation, using a Z-axis dither period commensurate with the *txings* trigger-sampling duration. Having identified the cause of source-instigated trigger, mitigation efforts have been put in place to avoid a repeat of such a *txings* trip, with additional steps under consideration.

## 2 Introduction

ACIS *txings* is the sole radiation monitor for *Chandra*, and its autonomous activation has been a key means of reducing soft-proton dosing from numerous storms in recent years. As we are now in the period of Solar maximum, *txings* safing capabilities are crucial, and all the more given the lack of additional radiation monitoring aboard *Chandra*. On 2025 March 24, the *txings* increasing-rate search triggered, initiating a SCS-107 safing action. This trigger was not radiation-induced and was therefore unintended, and appeared to have been caused by the observation of a bright source (Cyg X–2). A source-induced trigger was quite surprising, given the reliable performance of *txings* without such a trigger event across years of operations, including many dozens of bright-source observations. Moreover, the bright-source data has been included in *txings* algorithm calibration to avoid such a circumstance.

This memo discusses the trigger event and describes the ACIS Ops analysis of the trigger event, its cause, and steps taken to avoid a repeat occurence.

## 3 Cyg X–2 trigger

Cyg X–2 is a persistently X-ray bright neutron source at $\sim 0.5$ Crab brightness (among the brightest objects in the X-ray sky, but an order of magnitude fainter than the brightest systems *Chandra* has observed in a similar configuration. This GTO observation program was being carried out using HETG on ACIS-S using S2 and S3. The *txings* record of 2025 March 24, including both Cyg X–2 observations, is shown in Fig. 1. Cyg X–2 was first observed in ObsID 30534 for 15ks, and next in ObsID 30869; the latter which triggered *txings* $\sim 30$ minutes into the observation. Both observations made use of SI-mode TE_00C82, which has a 134-row subarray near the bottom of the chip (starting at row 10), and had a SIM-offset of -12.3 mm placing the source near the lower-edge of the subarray. This setup was intentionally designed so that the source would be dithered-off subarray much of the time, preventing telemetry saturation. Such a setup has, in fact, been used many times in the past, all without issue.

We determined that these observations of Cyg X–2 were the first implementation of this setup making use of the present, larger, dither pattern which was updated in late 2022 (although notably there were several observations using the same configuration in 2023, but those had been planned earlier and made use of the the previous reduced dither with lower amplitude and shorter period). The 2000 s dither period along the Z-axis is readily apparent in the patterning of BI rates in both of the Cyg X–2 observations in Fig. 1. As can be gleaned from the event data seen in Fig. 2, over the dither cycle the MEG +1 order signal ranges from spanning $\sim 1/3$ to spanning $\sim 2/3$ the columns of S3; this dispersed signal being dithered off/onto the subarray drives the visible large BI *txings* variations. These variations are essentially geometric in nature, rising monotonically with the increasing length of MEG +1 signal landing on the subarray over the dither cycle. Given that the observations were above background throughout, over the half-period (1000 s) of increasing S3 threshold-crossing rates, the 6-samples of $3\times64$ s-averaged frames ($\approx$ 19-minute) long BI-check run by *txings* for monotonically increasing-rates was able to latch, producing the *txings* trip and associated SCS-107.

Note that the HEG -1 order on S2 spans $\sim 1/2 - 2/3$ of the chip throughout the dither pattern and at lower intensity with the result that it produces less variation in the FI rates. Although it may have simply been fortuitous that a trigger wasn't produced in the first Cyg X–2 observation (ObsID 30534), normal pointing variation between observations of Cyg X–2 could have served to reduce the probability of a dither-induced trigger in the first observation compared to the second.

## 4 Lessons Learned

Having identified the correspondence between the Z-axis dither duration and the *txings* trigger duration, and the key role of the gratings-dispersed signal, ACIS Ops has taken several steps to prevent recurrence of such a trigger event. USINT and ACA approved a

change to use a reduced dither amplitude and period along the subarray minor axis for $\leq$134-row subarray observations (NB: previously, the cutoff for reduced dither was $\leq$128 rows). This addresses the only observations presently in the LTS which are candidates for producing another trigger (all of them being additional observations of Cyg X–2 from the same program). In addition to this, we have discussed the cause of the trip with the HETG USINT scientists who have agreed that for any similar observations, a reduced dither period should be implemented along the Z-axis.

ACIS Ops is also now aware of candidate conditions to check for:

- An on-axis bright source ($\gtrsim$100 mCrab).
- HETG observation using a subarray.
- Standard (large-amplitude/long-period) dither along the subarray minor axis.
- Large-amplitude negative SIM offset ($\lesssim -10$mm) positioning the source at the boundary or off the subarray. We caution that this last item depends on the location of the subarray, but that the usual goal of such observations (reducing telemetry) favors positioning them near the bottom of the chip.

For candidate matches during bright-source checks of a load, the ACIS Ops reviewer will examine the OCAT to see if the target position is near the center or edge of the subarray. If near the edge, this will be followed-up with USINT and HETG as necessary.

## 5 Additional Steps

Under longer-term inquiry is a proposal to recalibrate the *txings* increasing checks to utilize a timescale several minutes longer than the $\sim$ 1000 s half-period of the dither cycle (e.g., 22 minutes) as a further preventative action. Key details related to the impact of such recalibration including whether it would reduce radiation sensitivity are presently unknown and would be studied prior to additional action.


Figure 1: *txings* data taken on 2025 March 24 in which two observations of Cyg X–2 can be seen: ObsID 30534 and 30869. The affect of the dither on the BI rates is pronounced, not so for the FI rates which are below threshold and only weakly affected by the dither of the source. Each data point represents a $\sim$ 3.2 minute interval, although notably the ground-processing intervals plotted may not exactly match those running onboard ACIS.

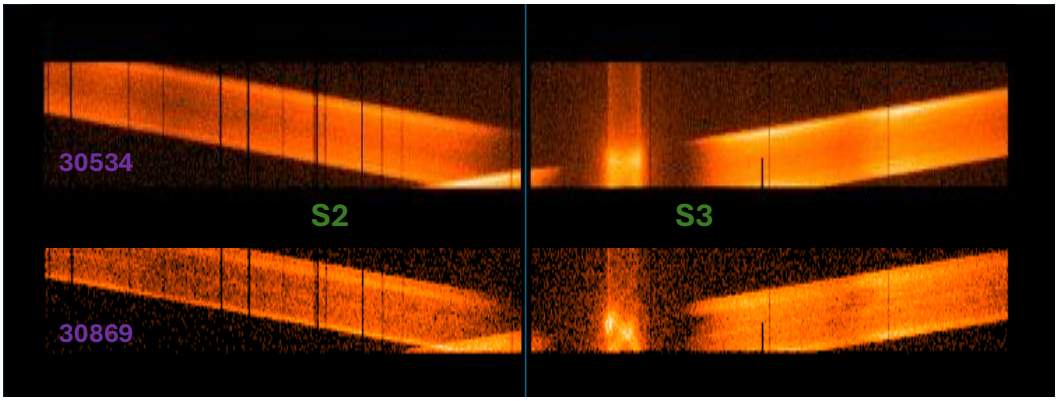


Figure 2: Event data for ObsIDs 30534 and 30869 in *detector* coordinates, revealing the source pattern across S2 (left) and S3 (right), while the source dithered.