

## Project Scientist's Report

Martin C. Weisskopf

*We note that this write up includes material from the draft of the prolog, written by Harvey Tananbaum and myself, to the ebook\* being prepared as part of the activities celebrating 20 years of Chandra operation.*

**It turns out to be a bittersweet moment as we enter *Chandra*'s 20th year of operation.** It is sad that this momentous anniversary effectively coincides with the recent passing of Riccardo Giacconi, who truly was the father of our field. I know that those associated with *Chandra* feel his passing on a personal level, as we belong to the many privileged to have been able to facilitate his vision of the 10-meter focal length X-ray telescope to probe, amongst many other things, the nature of the once unresolved X-ray background. More personally, I owe my position as the *Chandra* Project Scientist to Riccardo, without whose blessing and confidence I would not have had the opportunity to help build and operate one of humanity's greatest scientific "cathedrals".

As we look backwards, I feel fortunate that I, and the Project Science Team at Marshall Space Flight Center (MSFC), have been able to contribute to the success of *Chandra*. The entire community should take pride in its amazing accomplishments under MSFC's leadership. *Chandra* is one of the most successful astrophysics missions ever flown—successful on a myriad of metrics including cost, schedule, performance, and scientific output of an observatory designed for 3 years of operation with a goal of 5 and now in the midst of its 20th year. This success was the result of a momentous team effort involving scientists and engineers—members of Riccardo's (and then Harvey's) Mission Support Team prior to launch which then morphed after a competition into the *Chandra* X-ray Center run by SAO and MIT. Kudos to the Instrument teams and their original PIs (ACIS: Gordon Garmire, PSU; HRC: Steve Murray (deceased), SAO; LETG: Bert Brinkman, SRON; HETG: Claude Canizares, MIT) for developing the instruments which continue to serve the science community so well. Thanks to our prime contractor (TRW at the time, now Northrop Grumman) and the outstanding subcontractors such as Hughes Danbury Optical Systems (mirrors), Eastman Kodak (HRMA) and Ball Aerospace (SIM, ACA) to name a few. No retrospective of *Chandra* accomplishments would be complete without acknowledging the major contribution of the Telescope

Scientist, Leon Van Speybroeck (also deceased).

The *Chandra* launch was scheduled for Tuesday, July 20, 1999. Notable celebrities in attendance included First Lady Hillary Clinton, composer/singer Judy Collins, who wrote and performed an original song in honor of Shuttle Commander Eileen Collins, the 1999 FIFA World Cup Champion U.S. women's soccer team, and the actor Fabio. Many of the notables were present, at least in part, to note the milestone of having the first female commander for a Shuttle mission. For his part, Fabio had received an invitation to attend as a guest of Mission Specialist Cady Coleman, although the invitation was actually extended by Cady's fellow crew members without her knowledge as a tension breaker of the sort often employed by the astronauts.

The countdown proceeded flawlessly until an indicator showed a possible fuel leak and the launch was aborted approximately seconds before liftoff. Subsequent analysis showed that the reading had been spurious, but of course no one knew that when the liftoff was canceled. Since the abort had occurred before the main engines had ignited, there would only be a 48-hour delay before a second attempt to launch could proceed. At a morning weather briefing on Wednesday, the lead meteorologist reported a zero percent chance of weather impacts for the launch. On the bus ride to the viewing bleachers that evening we saw regular light flashes. Alas, the flashes were due to lightning which had not been present on the earlier evening. Another delay.

Following another 24-hour wait, we were treated to a spectacular launch at 12:31 AM (EDT) on July 23, 1999. The Shuttle flight itself was not without challenges. A few seconds after liftoff a short circuit took out computers controlling two of the three engines but Commander Collins decided to continue using backup computers. When the Shuttle reached its parking orbit, it was a few miles short of the targeted altitude. Later analysis showed that a small patching plug had been blown out of a hydrogen tank and a bit of fuel was lost leading to the lower altitude. This leak was not a problem for *Chandra* given the capabilities of the Inertial Upper Stage (IUS) boosters and the engines built into the spacecraft for achieving the operational orbit, but these issues did lead to a subsequent grounding of the Space Transportation System lasting several months to checkout and rework the entire Shuttle fleet.

After the Shuttle achieved its orbit, the payload bay doors were opened and, about 8 hours after launch, *Chandra* was deployed. The Shuttle then backed away and shortly afterwards the IUS was fired—each of the two stages operated flawlessly for boosting *Chandra* to an intermediate orbit of around  $200 \times 30,000$  miles ( $300 \times 48,200$  km).

Of course, none of us were yet sure that *Chandra* would be a success. Over the next two weeks the spacecraft engines were fired 5 times to boost *Chandra* to its

\*"The *Chandra* X-ray Observatory: Exploring the high energy universe", Eds. B Wilkes and W Tucker (Bristol: IOP Publishing Ltd) AAS-IOP ebooks <https://iopscience.iop.org/bookListInfo/aas-iop-astronomy>

initial highly-elliptical working orbit of approximately  $6,000 \times 86,500$  miles ( $9,700 \times 139,000$  km). The day after the 5th firing was also special, since it marked a flawless opening of the ACIS door which had failed in the thermal vacuum test at TRW 14 months earlier. On August 12, almost 3 weeks after launch, the aft and then the front contamination doors on the mirror assembly were opened for the first time. Over the next hour or so, the observatory continued to point stably under gyro control, then the aspect camera locked on stars, and a first X-ray source was detected by the ACIS instrument. That source was about 3 arcseconds in size and was located around 3–4 arcminutes off-axis, just about the size expected for a point source that far off-axis per feedback from Telescope Scientist Leon Van Speybroeck. I, with concurrence of the team present, nick-named the source Leon X-1. We all left that day confident (perhaps knowing) for the first time that *Chandra* was going to be a great success.