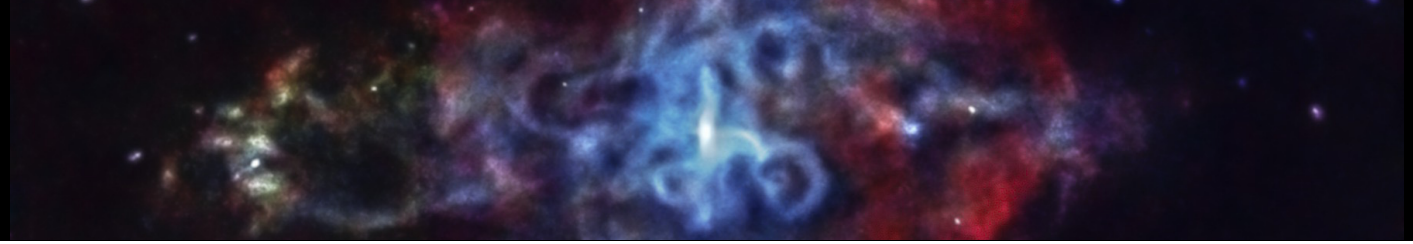


AGENDA

CDO Report
(Rudy Montez)

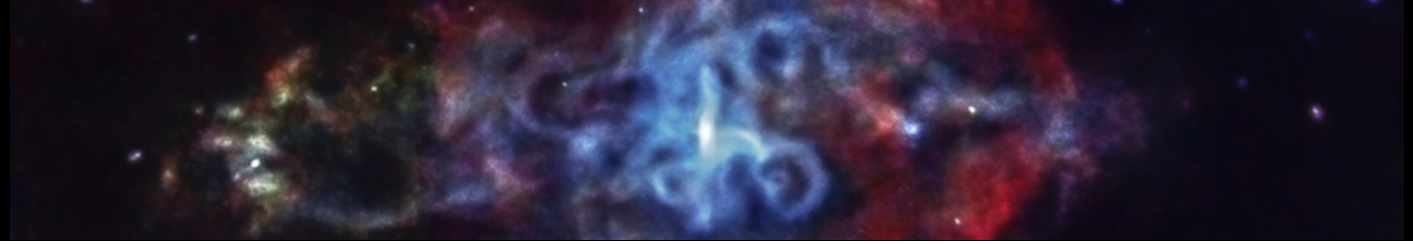
- Cycle 26 Peer Review
- Chandra Legacy Program Update

Director's Report
(Pat Slane)

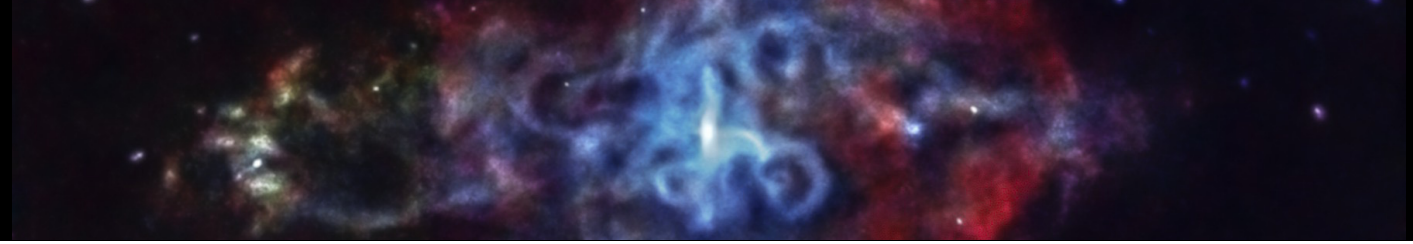
- Quick Status
- Chandra Budget

Concluding Remarks
(Antonella Fruscione)

- Update on CUC composition and membership dates
- Plans for next CUC meeting

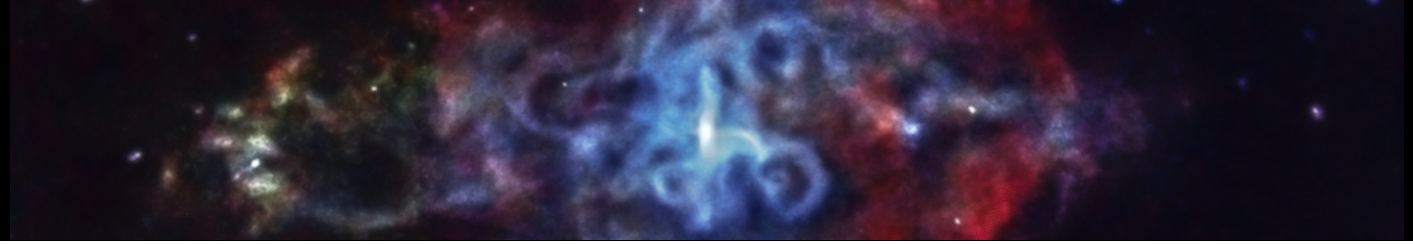


Director's Report



Quick Status

- Observatory functioning nominally.
- Data processing and delivery functioning nominally.
- Since last CUC meeting (28 Sep 2023), two star-field related shut-downs and five radiation events were encountered.
  - 24 Jan 2024: Star field acquisition failure due to sparse star field and chance occurrence of known issue with ACA software. 154 ks lost science time.
  - 04 Feb 2024: Guide star re-acquisition failure due to ACA high background event. 172 ks lost science time.
  - 06 Nov 2023, 23 Jan 2024, 25 Mar 2024, and 11 May 2024: Four manual solar radiation safings and one safing triggered by ACIS txings. 582 ks lost science time (combined).
- CSC 2.1 released 02 Apr 2024.
- Legacy Program review complete. Cycle 26 proposal Cycle underway. (See CDO report.)



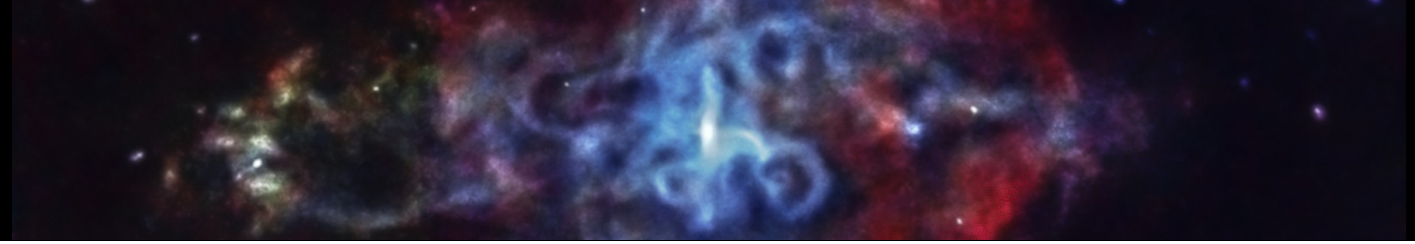
Chandra Budget: Reductions in FY24

- The Chandra budget for FY24 was reduced significantly. In addition, guidance for funding beyond FY24 was not provided.

  - As reported at the last CUC meeting, direction from NASA was to address FY24 shortfalls by "preserving mission infrastructure while maximizing General Observer program funding."

- This budget cut resulted in a 30% reduction in Cycle 25 grants.

  - This was enacted in Feb 2024 through letters to grantees.



Chandra Budget: Guidelines for FY25 and Beyond

- Following FY24 budget reductions, the Chandra project was asked to present impacts of a potential flat budget going from FY24 to FY25.

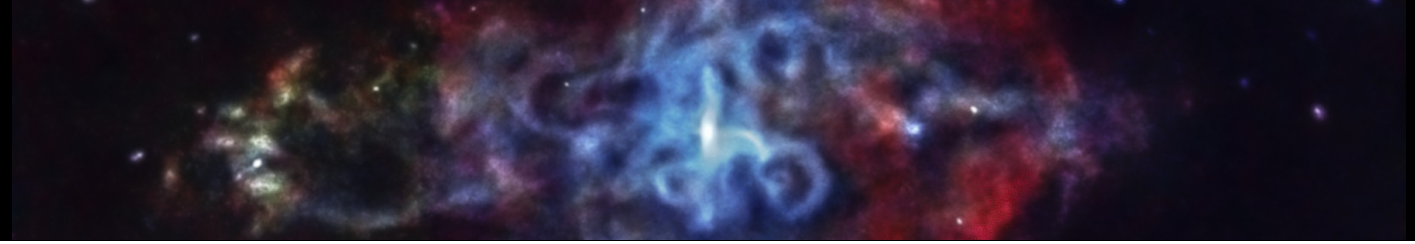
  - Significant budget reduction exercise undertaken, with presentation at NASA HQ on 01 Feb 2024.

- President's Budget Release on 11 Mar 2024 shows significant reductions for Chandra budget:

Budget Authority (in $ millions)	Op Plan FY 2023	CR FY 2024	Request FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
Chandra X-Ray Observatory	68.3	--	**41.1**	26.6	26.6	26.6	5.2

  - These values are far below previous budget exercises, and roughly consistent with existing closeout plans for Chandra.

- The rationale put forth to justify for these reductions was problematic (to be discussed).



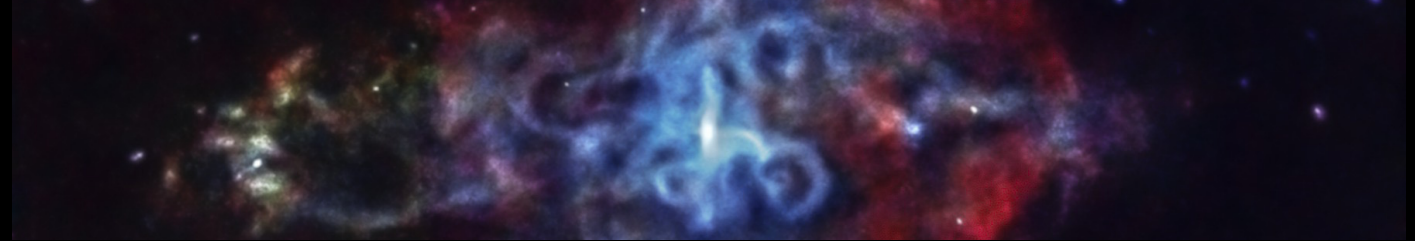
Chandra Budget: Operating Paradigm Change Review

- The Chandra Project (along with Hubble) was directed to participate in an “Operating Paradigm Change Review” (OPCR) in which up to four options were presented for new operating scenarios that fit within the budget guidelines.

  - NASA will use the findings from the OPCR to:
    - Define an implementation approach consistent with astrophysics strategic objectives;
    - Prioritize the operating model(s);
    - Provide programmatic direction to the missions and projects concerned for FY25, FY26 and FY27;
    - Issue initial funding guidelines for FY28 (possibly to be revisited in the 2025 Senior Review).

    “NASA actions resulting from the OPCR could include authorizing a mission to: maintain the status quo; restructure the project; or terminate an ongoing science mission.”

  - Chandra noted that only decommissioning would satisfy the budget guidelines, and successfully challenged the direction to produce only options that did not exceed these amounts given that “status quo” was stated as a potential outcome. One option was required to meet the guidelines while up the three additional option could be “over-guide” options.



Chandra Budget: Operating Paradigm Change Review

- Additional requirements and guidelines:

  "All CXO project options shall exclude any funding strictly for continuing Guaranteed Time Observer science research."

  "NASA HQ authorizes the reduction or elimination of General Observer grant funding for either mission as a component of proposed options."

- The Project carried out a thorough review of all CXC tasks and costs to assess the viability and costs for reduced Chandra science mission scenarios.

  - Two additional options (in addition to close-out and status quo) were developed and presented. A summary of those options and the OPCR presentation follows.

Introduction

Key Points:

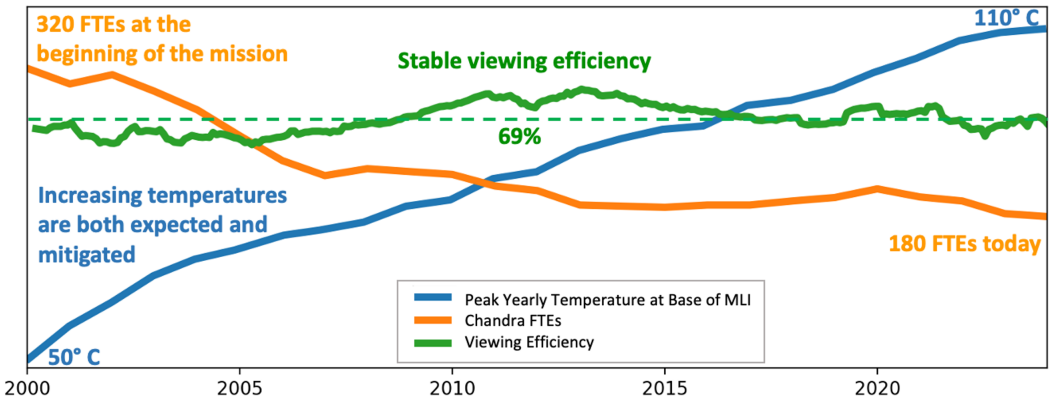
- **A fully operational Chandra** mission, with science impact that spans nearly every domain in astrophysics, **can be continued** at budget levels recommended through the Senior Review process and long recognized within NASA as being cost effective.
  - **Chandra remains uniquely capable** of conducting relevant, meritorious X-ray science.
  - **Chandra is highly functional**, incredibly productive, cost-effective, and capable of many more years of operation and scientific discovery.
  - The **2022 Senior Review** rated Chandra as **Excellent** and strongly supported budget *increases* to Chandra in future years.
  - There has been **no decline in Chandra performance, efficiency, or productivity** in the time since the highly successful 2022 Senior Review.
  - **Aging is not an immediate issue for Chandra.** The Chandra team has consistently shown the ability to successfully mitigate spacecraft aging challenges since early in the mission, with no loss in observing efficiency.
- **The current NASA FY25-28 budget guidelines will lead to an immediate shutdown of Chandra**, which will render unattainable important APD mission science goals requiring joint observation by a Chandra-like X-ray observatory.
- **A reduced-cost mission** for Chandra is viable at costs that exceed the current guidelines. The science element preserves several key SMD and Decadal 2020 themes but represents a very significant reduction over Chandra's current mission.

Preserving Chandra Should be a Priority; Reduced Mission Concepts Are Viable But Significantly Reduce Science

Correcting the Narrative

NASA FY25 Budget Estimates Document (Page ASTRO-22):

"The Chandra **spacecraft has been degrading over its mission lifetime** to the extent that **several systems require active management** to **keep temperatures within acceptable ranges** for spacecraft operations. This makes **scheduling and the post processing of data more complex**, **increasing mission management costs** beyond what NASA can currently afford. The reduction to Chandra will start orderly mission drawdown to minimal operations."



Regarding the highlighted points:

- All spacecraft "degrade" with time, but Chandra is extremely healthy. All primary instruments and subsystems continue to function well. The important metrics of mission **efficiency**, **cost**, and **science return** per taxpayer dollar have remained stable.
- As expected, Chandra temperatures have increased over the lifetime of the mission due to the eventual increase of absorptance of the multi-layer insulation (MLI) from exposure to the space environment.
  - The associated increase in complexity of mission planning has been managed through the development of **thermal models and tools** that are integrated into the planning process. This has been done over most of the life of the mission and has been spectacularly successful. The **observing efficiency has not been impacted**.
  - Chandra is in communication with the ground only once every ~8 hours. **Nothing on the spacecraft is "actively managed."** All schedules and activities are planned in advance, reviewed in detail, and then executed autonomously on the spacecraft.
  - Temperature data are encoded into calibration and data analysis tools. **Post-processing of data has not become more complex.**
- The staffing level for Chandra has decreased by 44% over the course of the mission, yet high observing efficiency has been maintained despite increasing temperatures. **Mission management costs have not increased** beyond inflation.

Chandra is Healthy and Producing Outstanding Science Without Increased Resources

Chandra Status: Thermal Lookahead Through 2028

2022 Senior Review identified 2 key areas of thermal concern

Aspect Camera CCD thermal and radiation dark current degradation

This concern has been *substantially mitigated* with an Aspect Camera software patch uplinked in 2023 (see notes for more).

This introduced an innovative algorithm to dynamically measure CCD dark current and dramatically improve on-board star centroiding.

Patch recovered about 8 years of guide star tracking performance.

Propulsion system hardware limits

Updates in 2024 to on-board software, ground software, procedures and safing responses are **now in place** that *substantially mitigate* this concern (shown in 2025 observation time curve).

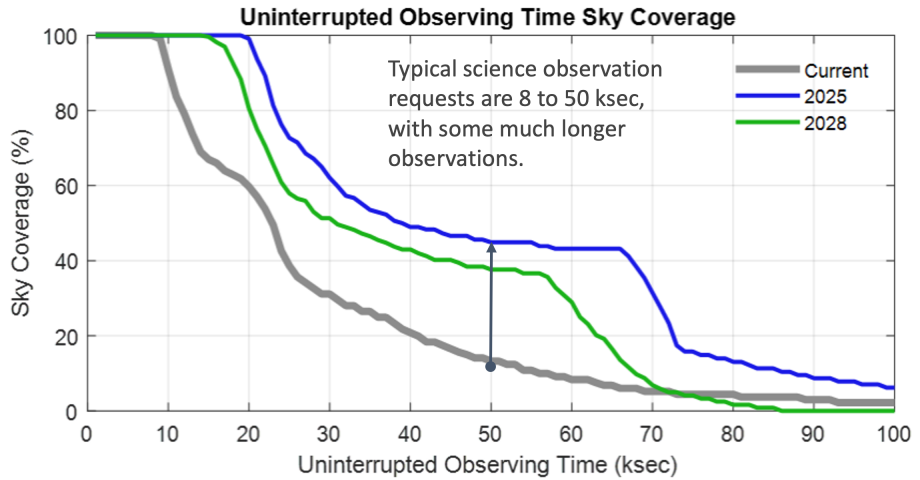
Engineering analysis to expand the propulsion component operating temperature limits is currently in progress.

Based on initial study results and industry experience from propulsion experts, a modest increase in thermal limits is expected to be approved (shown in 2028 observation time curve).

Chandra's dwell capability is *increased* over the next 4 years

This plot shows the fraction of sky as a function of uninterrupted observing time. For example, with the current capability, 50 ks uninterrupted observations are possible in only 13% of the sky, while in 2025 45% of the sky is available for 50 ks.

- Longer observations will be allowed
- Fewer "split" observations ⇒ reduced analysis complexity
- Improved time-domain capability



Chandra Overall Dwell Capability is ***Increased*** From Current In Years 2025 - 2028

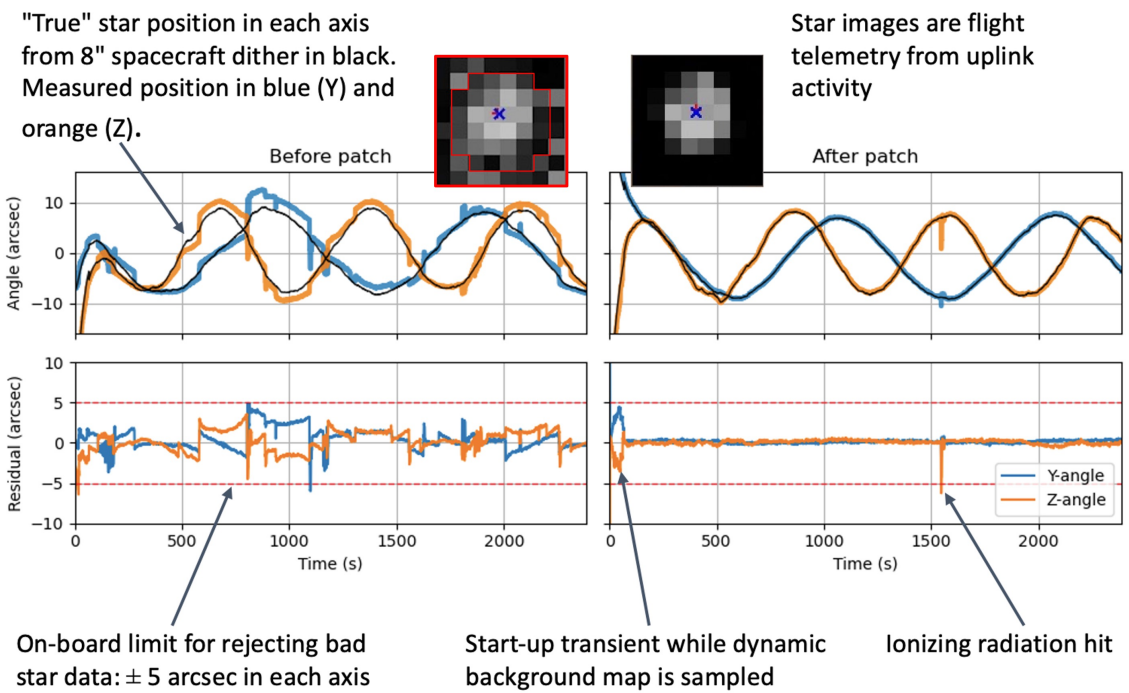
Chandra Aspect Camera Innovations

PEA Dynamic Background Flight Software Patch

- Installed May 2023
- On-going Aspect Camera CCD radiation damage and increasing temperature make the CCD dark current background highly non-uniform ⇒ large centroiding errors
- Patch algorithm samples readout edge pixels as spacecraft dithers to dynamically assemble an accurate background map
- Significantly improves ability to track stars and maintain accurate attitude reference
  - Reduces the likelihood of safing actions
  - Recovered equivalent of 8 years of star tracking performance

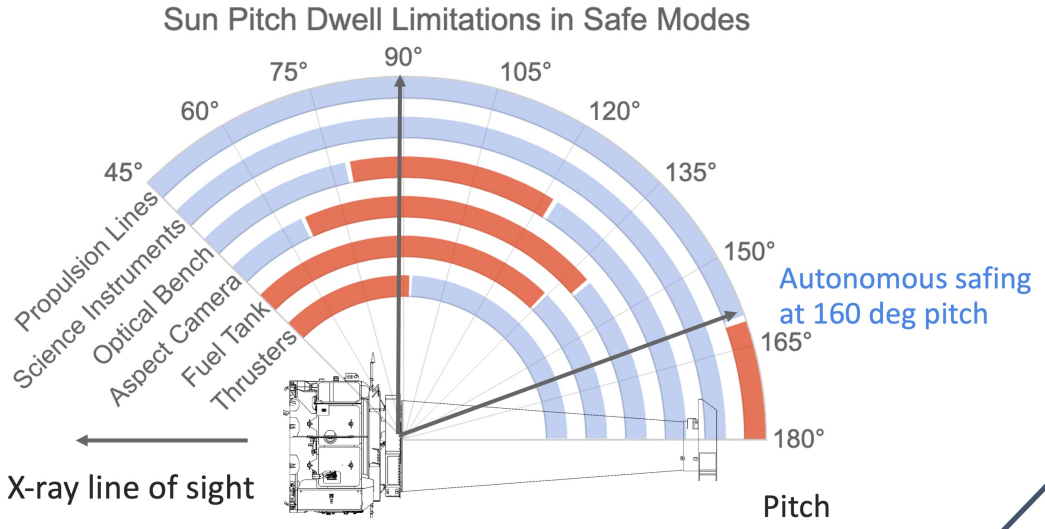
PEA Dynamic Background Flight Software Patch

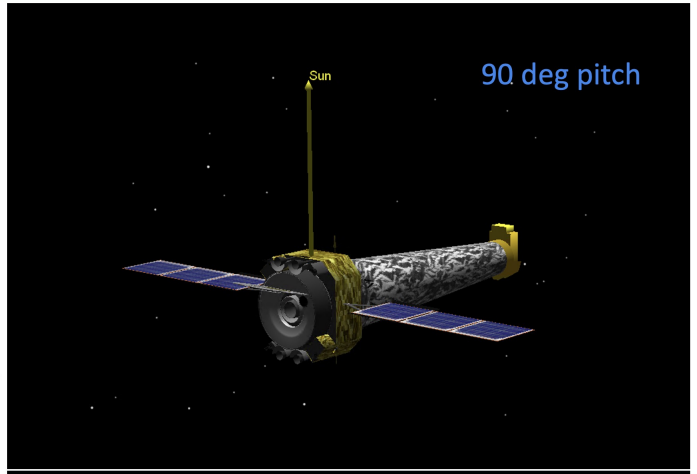
Centroid angles and residuals for the same 10.0 mag star before and after patch

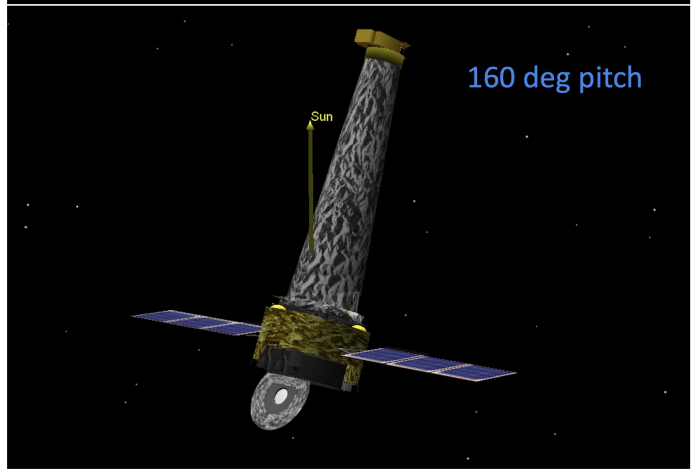


Development of the Dynamic Background Capability Recovered 8 Years of Tracking Performance

Spacecraft Offset Capability







Default safing actions maneuver vehicle so both body and solar panels are normal to the sun

- This orientation strongly heats a number of subsystems (red bars above)
- Thrusters and Aspect camera reach unacceptable temperatures at extended durations at 90 deg pitch

In 2023, a set of ground commanded software patches were developed allowing for the vehicle to be offset from the sun normal, reducing temperatures on critical subsystems during safing recovery

By the end of 2024, all safing actions will be updated to autonomously apply an offset to 160 deg

- Thrusters and propulsion lines stay well within safe operating temperatures
- Aspect Camera cools, simplifying recovery

Software Now Allows for Spacecraft Body to be Offset to Cool Critical Subsystems During Safing Actions

Option I: Ending the Chandra Mission

The budget guidelines for FY25-FY28 are insufficient to operate a science mission with Chandra and are consistent with the existing post-mission closeout budget.

- As Option I we provide a summary of the closeout activities and costs.
- The existing closeout plan was developed for a three-year series of activities including the decommissioning of the spacecraft, final processing and delivery of archive and related products to the HEASARC. An updated cost estimate for this plan was provided to NASA in January 2024.
- The total three-year closeout cost is slightly below the total from the four-year budget guideline and would require re-phasing of the budget guidelines to match the required budget and work plan.

The complete loss of Chandra's capabilities would represent a devastating loss to all of astrophysics.

- There is no viable replacement for Chandra's capabilities in NASA's portfolio of approved missions.
- The decommissioning of a highly functioning Great Observatory would be unprecedented.
- The loss of the Chandra mission would represent a major loss to US and International astronomy.

Adoption of Option I – ending the Chandra mission – is not recommended.

Ending the Chandra Mission is NOT Recommended

Option II: Chandra TDAMM/Synergy/Legacy (TSL) Mission

A reduced science mission with Chandra that approaches FY25 guidelines is feasible with major reductions (~65 FTEs) and restructuring.

Chandra TSL introduces reductions in every area to reach a minimum cost level for science operations with Chandra:

- **Eliminate the Chandra GO program, including funding and standard proposal cycle.**
- Chandra archival research through ADAP only.
- Remove HRC from use. Grating use available only with ACIS.
- Minimize available operating modes for ACIS. No new configurations.
- Place all software into maintenance mode. No new updates/algorithms/functionality to analysis software (ciao, sherpa, MARX, SAOTrace, ds9).
- No new updates to Data System software beyond mission-critical needs.
- Halt any further work on Chandra Source Catalog (frozen at CSC 2.1) and TGCAT.
- Eliminate Chandra conferences/symposia, newsletters, and training workshops.
- Freeze HRC/LETG/HETG calibration. Minimize ACIS calibration.
- Eliminate Uplink Support for observations. Reduce HelpDesk to minimal levels.
- Eliminate V&V task and special processing of observations.
- Minimize monitoring and trending of instruments.
- Eliminate bibliography and other mission statistics tracking.
- Reduce rapid return-to-science support following anomalies.
- **Introduce ≥50% idle time for observing to simplify planning and scheduling, significantly reducing observing efficiency.**

Observations accepted through DDT Requests, Joint Observing Programs with other observatories, and Legacy Program.

- Up to 1 Ms available for DDT requests to support **TDAMM** initiatives.
- Up to 2 Ms available for Chandra **Synergy** observations approved in Joint Programs from JWST, HST, XMM, etc.)
- 5-6 Ms available for annual **Legacy** Program observations.

Full onset of Legacy portion of Chandra TSL would commence after completion of approved Cycle 25 observations.

- Cycle 25 would be extended to accommodate reduced observing efficiency.
- Cycle 26 proposals would not be approved.

Chandra TSL costs exceed the NASA guidelines for FY25 by a modest amount. Adoption would require significant increases for FY26-28.

Chandra TSL Represents a Dramatically Reduced but Scientifically Important Mission

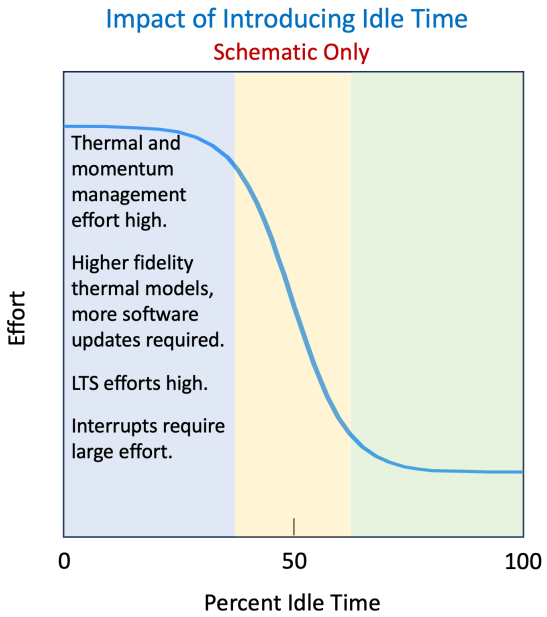
Option II: Chandra TSL Observations

Current Chandra Mission Planning includes:

- Building long-term schedule with science, thermal, and momentum constraints roughly balanced each week.
- Scheduling pointing attitudes and maneuvers to carry out science observations, manage temperatures, and manage momentum.
- Scheduling instrument/mechanism configurations for observations.
- Scheduling communications for uplink/downlink (~1 hr every ~8 hours).
- Scheduling radiation zone activities and managing eclipses.

Introducing idle time (i.e., time outside radiation zones with no science observations) **reduces planning effort**:

- Adding science observations (i.e., decreasing idle time) adds complexity to planning.
- As idle time fraction fraction is decreased (by adding science observations), a threshold at a value of ~50% is reached, below which planning complexity increases rapidly, largely driven by heating/cooling timescales.
- As fraction is decreased, fidelity of thermal models must also increase, including more software updates.
- **Chandra TSL minimizes planning-related costs by maintaining ≳50% idle time.**
  - Total available observing time per cycle in Chandra TSL is ~9 Ms.



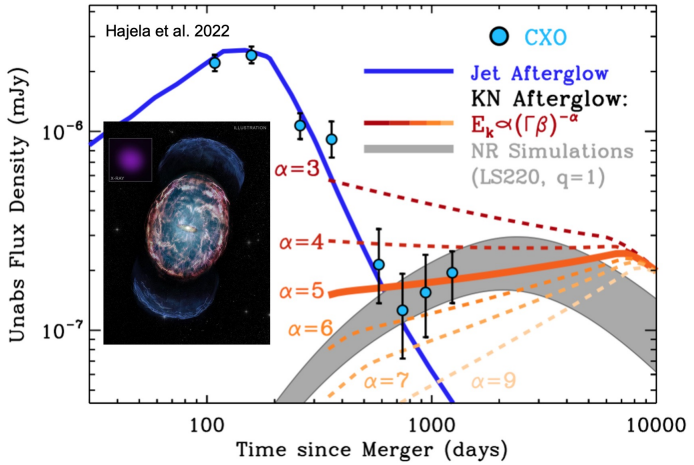
Considerations for how to allocate the available time:

- A normal GO program requires resources for preparing CfP, maintaining/updating peer review software, soliciting reviewers, conducting peer review, and managing a large number of targets and programs. **Eliminating GO program reduces costs.**
- A TOO-like program for transients increases effort. However, **TDAMM efforts are deemed highly important** by the community. A DDT program with 1 Ms available for transients represents a ~50% reduction while still supporting TDAMM efforts. DDT review continues to be done internally.
- The **Chandra Legacy Program** solicits projects requiring very large amounts of Chandra time. It is highly oversubscribed, reviews are much smaller than the annual GO peer reviews, and new programs need only be solicited every few years.
- Synergy observations from **Joint Programs** require minimal (though nonzero) CXC effort.

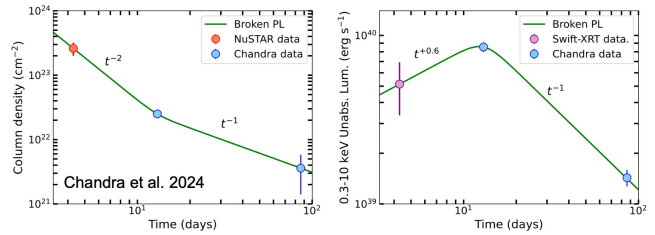
Chandra TSL Represents a Dramatically Reduced but Scientifically Important Mission

Option II: Science and Implementation (Time Domain)

- **Time-domain and multi-messenger (TDAMM) astrophysics** was identified in the 2020 Decadal Survey as a top priority for sustaining capabilities for the future, in recognition of recent breakthrough science results in these areas as well as anticipated future investigations. Chandra TSL provides continued TDAMM support through a 1 Ms/yr DDT transient program through which requests can continue to be submitted for evaluation using existing processes and tools.
- **The TDAMM community white paper ((**https://pcos.gsfc.nasa.gov/TDAMM/docs/TDAMM_Report.pdf) identifies Chandra as crucial to TDAMM science:
  - On **NS-NS and NS-BH Mergers**: "spectroscopy, radio sensitive (Very Large Array (VLA)/next generation (ng)VLA) and X-ray (Chandra type) telescopes for late follow-up are indispensable."
  - On **fast X-ray transients** (FXTs), a new class of fast evolving X-ray transients has been recently discovered in archival Chandra data: "progress requires prompt detection of FXTs (e.g., via X-ray instruments with… sharp point spread function"
  - On continuity of **monitoring**: "The continuity of monitoring across the electromagnetic spectrum with an appropriate suite of missions must be ensured. While NASA traditionally focuses on ground-breaking new capabilities, there is substantial risk that aging observatories critical to TDAMM event detection, localization, and follow-up (such as Fermi, Swift, and Chandra) may lack timely replacements if one degrades or ends operations in the coming decade."
- **The PCOS Gravitational Wave – Electromagnetic Wave Counterpart Report (2019)** states:
  - "Maintaining operations for existing facilities, particularly those most actively engaged in GW-EM science (Fermi, Swift, Chandra, HST), is critical towards achieving this portfolio balance, as no suitable replacements are currently planned."
- **The Chandra TOO and DDT programs have a long history of TDAMM support.**
  - Over the past 6 years, Chandra has carried out an average of ~1.3 Ms/yr of TOO observations, and 730 ks/yr of DDT observations – mostly of transients.
  - Chandra supports more Very Fast (< 5 days) and Fast (5-20 days) TOO/DDT observations than any other flagship mission; Chandra is a TDAMM Great Observatory.
  - Chandra TSL maintains TDAMM programs for Chandra, with similar response times, though at a ~50% reduction in available time.



Chandra observed early emission from GW170817, then observed emergence of kilonova afterglow. Chandra was able to monitor mission from GW170817 longer than any other telescope.

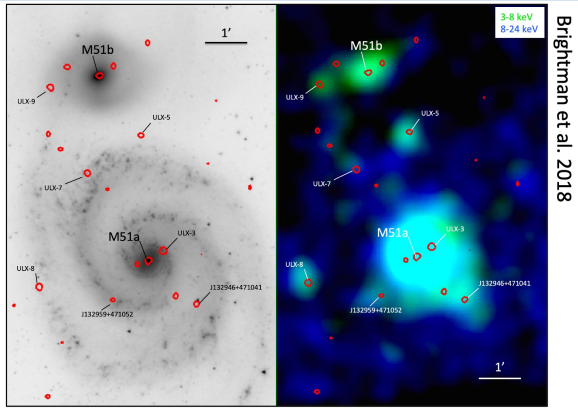


Chandra observations of SN 3023ifx show the column density and 0.3–10 keV luminosity decline as t^{-1}, indicating that the SN ejecta is expanding into the wind of a red supergiant progenitor.

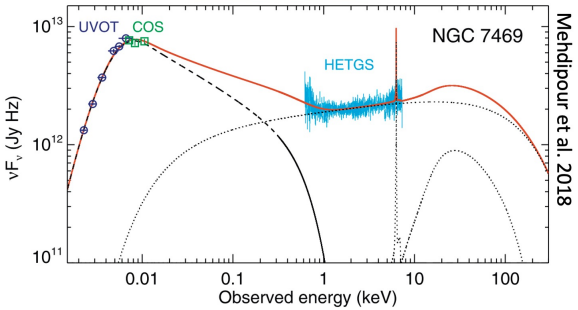
TDAMM Support is a NASA Priority Provided by Chandra's DDT Program

Option II: Science and Implementation (Synergy)

- **The fundamental goal behind the NASA Great Observatory series** is the enabling of critical, force-multiplying synergies through observations across the electromagnetic spectrum. Chandra TSL supports continued support for such synergy initiatives through continuation of a core element of the existing Chandra Joint Observatory Program.
- **The 2020 Decadal Survey in Astronomy** identifies X-ray capabilities such as those provided by Chandra as crucial:
  - On **Stellar and Black Hole Feedback**: "Observations of galaxy clusters have revealed the critical role of black hole feedback by jets… This is a prime example of the need for multiwavelength observations: the **combination of radio, X-ray, and optical data** reveals the interplay between the cm-wave-emitting relativistic jets, mm-emitting molecular gas, X-ray emitting thermal intracluster plasma, and the optical-emitting photoionized gas."
  - On **Physical Conditions of the Circumgalactic Medium:** "The multiphase nature of the diffuse CGM/ICM and its complex dynamics, where all mechanisms are superposed, necessitate a multiwavelength and multiscale approach that includes imaging and spectroscopic studies of individual galaxy halos and clusters over the full **spectral range from X ray to radio**.
  - **Overall:** "The importance of joint analysis of observations from **different facilities and wavelengths**, and of sophisticated archiving with associated science platform tools, will grow dramatically over the next decade."
- **Chandra has established X-ray astronomy as a crucial element of modern astrophysics.**
  - Chandra observations provide unique and stand-alone science results, but also crucial elements of broad multiwavelength investigations – both by leading studies that other observatories follow, and by complementing and expanding the results from other observatories.
- **The Chandra Joint Observatory Program** has a long and successful history of multiwavelength studies that multiply the impact of each individual observatory.
  - Over the past 6 years, Chandra has carried out an average of ~1.3 Ms/yr for studies approved the Joint programs.
  - Chandra TSL maintains participation in Joint Observatory programs. In the absence of Chandra-led proposal solicitations and reviews (other than Legacy observations), proposals requesting Chandra time will be available only through Joint programs of other observatories with Chandra agreements. Observations identified as crucial for completing the science goals of the programs from the other observatories will be carried out by Chandra.



Simultaneous Chandra and deep NuSTAR observations of the AGN and off-nuclear sources in galaxies in M51 show low accretion rates for the SMBHs and spectral turnovers for ULXs.

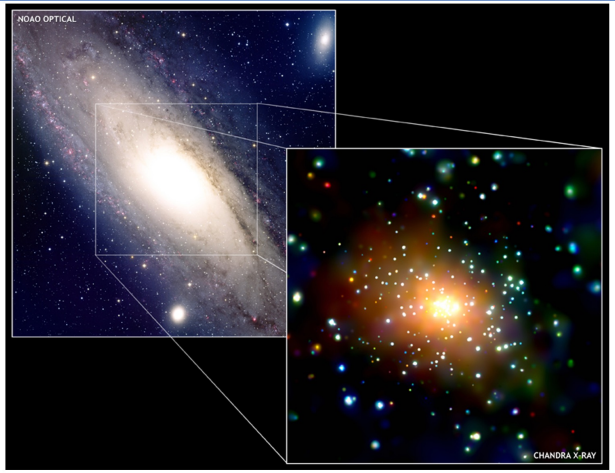


Chandra, HST, and Swift observations of AGN photoionization in NGC 7469, indicating absorption by torus wind. HETG zeroth order shows soft X-rays extended by 1.5-12", associated with coronal emission from the nuclear starburst ring.

Incoming Proposals from Joint Programs Will Maximize Science from Multiple Missions

Option II: Science and Implementation (Legacy)

- **In its nearly 25-year history, the Chandra X-ray Observatory has revolutionized X-ray astronomy:**
  - The sub-arcsecond angular resolution, combined with the ACIS and HRC instruments plus LETG and HETG spectrometers, have enabled observations that have broken new ground in studies of objects and phenomena ranging from planets in our own Solar System to extremely distant black holes.
  - Each year brings exciting results along with highly oversubscribed requests for new observations.
- **The 2022 Chandra Senior Review panel** identified support for Legacy-value programs to be of considerable importance:
  - "Chandra should consider a mission-directed observation or set of observations to contribute to its science legacy."
  - "As the observatory ages, science legacy planning becomes essential."
- **Chandra's unique observing capabilities** represent a resource that may not be supplanted for a decade or longer.
  - These capabilities will thus help lay the groundwork for next-generation studies. Chandra legacy themes that help establish this foundation, and provide guidance for the future of X-ray astrophysics, are of critical importance.
  - High impact programs that maximize use of Chandra's observing capabilities often require long exposures. Chandra has routinely implemented larger programs to accommodate such programs.
  - Chandra LP/VLP programs are routinely oversubscribed by a much larger factor than other programs. The recent call for Legacy White Papers was oversubscribed by a factor of 15.
- **The Chandra Legacy Program was introduced in Cycle 26**
  - The CLP applies unique Chandra capabilities to address Decadal 2020 science themes in "Worlds and Suns in Context," "New Messengers and New Physics," and "Cosmic Ecosystems."
  - The Cycle 26 CLP is soliciting proposals to support studies of the physics of baryon cycles and feedback through deep observations of nearby galaxies, and to investigate key physical processes of AGN feedback, the microphysics of astrophysical plasmas, and the nature of dark matter using deep observations of a selected galaxy cluster.
  - Chandra TSL supports Chandra Legacy science with a dedicated 5-6 Ms program each year. If adopted, the first such program, selected in the upcoming CLP peer review, would be carried out in 2026, with a future review to select a ranked list of Legacy programs for subsequent years.



NOAO and Chandra images of M31. Chandra reveals a central region of hot gas, likely driven by supernovae, along with point sources primarily consisting of neutron star or black hole binaries.

Chandra deep observation of Bullet Cluster, with HST background, demonstrates detailed structure of merging clusters, including bowshocks, and probes the nature and distribution of dark matter.

Chandra Legacy Program Will Continue to Produce Top Tier Science

Option III: Chandra TSL with GO Support (TSL+)

A minimal science mission with Chandra should still include GO support.

The 2020 Decadal Survey ("Pathways to Discovery in Astronomy and Astrophysics for the 2020s") identifies funding for scientists as a crucial element of national science programs:

"It is people who are the source of American scientific and technical prowess, and supporting those scientists is the way to realize the scientific visions that are put forward in Chapter 2, A New Cosmic Perspective. Access to world-leading facilities is not enough to produce science. Individual scientists need access to the financial resources that allow them to collect, analyze, and interpret data from those facilities. That funding unlocks the effort of scientists and trainees to explore new ideas or to execute the hard but important projects that drive the field forward. Without resources, however, scientists' insights and talent lie unrealized and discoveries unmade."

The plan for Chandra TSL does not include funding to support Chandra observers after winding down of existing Cycle 25 grants.

- The Chandra GO program has always included funding to support the analysis, presentation, and publication of Chandra scientific results.
- GO funding is critical for training of students and postdocs.
- GO funding is critical for a large portion of the community in soft-money positions.
- Chandra GO funding has always been much lower than that for other flagship missions. Complete elimination would be devastating to the X-ray community.

Chandra TSL+ introduces modest observing support for DDT and Legacy observing programs.

- Funding at levels commensurate with previous Chandra proposals.
- Total funds scaled from previous Chandra levels by factor by which observing time is reduced.

The Chandra project regards support for the community as being critical; Chandra TSL+ is recommended over Chandra TSL.

Chandra Community Support is Vital Even With a Reduced Mission

Option IV: Chandra Full Capability (FC) Mission

Continue current utilization of Chandra's full capabilities and provide GO Program to support the U.S. X-Ray Astronomy community.

- Chandra FC continues the current mission model with the exception that Guaranteed Time Observer funding is eliminated, as directed in the Call for Proposals.
- This program maintains all of Chandra's Great Observatory-class services and operations. It preserves the world's most important X-ray facility, continuing the legacy of broad support to all of astrophysics.
- Chandra's state of health is very good; continued efficient and productive operation is anticipated for at least another 5 years.
- **Maintaining status quo for Chandra**, modified by some attrition and elimination of funds for the GTO program, will optimize the science return from other observatories and continue breaking new ground in high energy astrophysics.

Chandra has consistently received high ratings in Senior Reviews, and been recognized for unique, ongoing scientific value in the astronomy portfolio of observatories.

- Current performance as well as long-term prospects for continued successful Chandra operations make Chandra FC the best scientific option.
- Proposals solicited for the upcoming Cycle 26 show an oversubscription factor of ~5, and Chandra Legacy Program proposals were oversubscribed by a factor of ~15. **The scientific community clearly still has great need for Chandra's capabilities.**

Chandra FC costs exceed the NASA guidelines for FY25-F28 but represent levels that have long been recognized as highly cost-effective.

Full Utilization of Chandra's Capabilities is Project's Highest Recommendation

Summary and Takeaway Messages

- **A fully operational Chandra** mission, with science impact that spans nearly every domain in astrophysics, **should be continued** at budget levels recommended through the Senior Review process and long recognized within NASA as being cost effective.
  - **Chandra remains uniquely capable** of conducting relevant, meritorious science in an efficient manner.
  - **Chandra is highly functional**, incredibly productive, cost-effective, and capable of many more years of operation and scientific discovery. Narratives to characterize it as otherwise are inaccurate.
  - The **2022 Senior Review** rated Chandra as **Excellent** and strongly supported budget *increases* to Chandra in future years.
  - There has been **no decline in Chandra performance, efficiency, or productivity** in the time since the highly successful 2022 Senior Review.
  - **Aging is not an immediate issue for Chandra.** The Chandra team has consistently shown the ability to successfully mitigate spacecraft aging challenges since early in the mission, with no loss in observing efficiency.

- Shutdown of Chandra would significantly disrupt the X-ray science community today and the pipeline to tomorrow's X-ray astrophysicists, severely compromising NASA's ability to realize Astro2020's vision for astrophysics in the 2030s and 2040s.

- A **reduced Chandra mission** that supports several key APD science initiatives is viable at reduced cost – though not within current guidelines – but results in significant science losses along with drastic reductions in service to the science community.
  - If continuation of the full Chandra mission is impossible, the unique capabilities of the observatory must not be lost; a reduced mission will represent a major setback for astronomy but still provide crucial support of critical science areas. Ideally, this would include funding for observers.

Preserving Chandra Should be a Priority; Reduced Mission Concepts Are Viable But Significantly Reduce Science

Closing Statement

In closing, we would like to reiterate that we understand the pressures that NASA is facing due to reductions in discretionary spending across the US budget that have impacted the agency. In the presence of such reductions, we understand that difficult decisions need to be made about how taxpayer dollars should be allocated to public science initiatives. The Decadal Survey process helps to set the guidelines for such initiatives, and the Senior Review process provides the necessary assessments on progress and viability for the projects that provide the resources for the identified science areas.

That Senior Review process, carried out two short years ago, recognized the scientific importance and overall performance of the Chandra X-ray observatory with its highest rankings — confirming the results of the Senior Review that preceded it. There has been no drop in production from Chandra since this review, and operational performance has actually been improved through the expert management of the observatory. Narratives have been put forth to suggest that the observatory status has declined; these are incorrect, as we have described and demonstrated here. Chandra is healthy, and its use is in high demand from the scientific community.

The Chandra budget is modest for a NASA Class 1 flagship mission, and has always been regarded as such within NASA HQ. With no successor mission currently under development, the question is whether or not dramatically reducing — or terminating — this fully functioning Great Observatory is the right scientific choice for addressing the existing budget issues. The astronomy community has already weighed in on this issue, through town meetings and signed letters to the NASA Science Mission Directorate. The broad consensus — and not just from the X-ray astronomy community — is that Chandra is a crucial observational element of modern astrophysics. The availability of the facility, along with funding to support its community of students, postdocs, and professional researchers needs to continue.

We have put forth a plan for a reduced mission that would continue to achieve some of the important goals that Chandra currently addresses. This plan would still require significant adjustments to the current NASA budget guidelines for Chandra, but would manage to avert the tragedy of losing the facility entirely. We hope you consider this as a last resort option — preferably the version that provides funding for observers — recognizing that maintaining the full observatory capabilities is the best decision for astrophysics.

We thank you for agreeing to participate on the panel to assess these important decisions and welcome any additional questions.

Chandra Budget: Other Activities

- Communication with community
  - CXC, **CUC**, SAO, AAS, many others
  - savechandra.org provides information to community and public
  - Whitepaper on X-ray flagships (draft) – L. Kewley

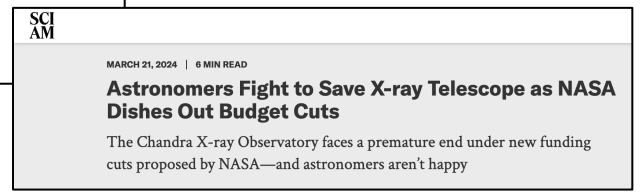
- Discussions with NASA Management
  - CXC, SAO, SI, MIT, AAS, others


A NASA telescope unlocked the mysteries of black holes. Now it's on the chopping block.

Karen Weintraub
USA TODAY

Published 5:04 a.m. ET April 11, 2024 | Updated 9:10 p.m. ET April 11, 2024

- Discussions with committees (CCA, APAC, others)
  - CXC, MIT, **CUC members**, AAS, community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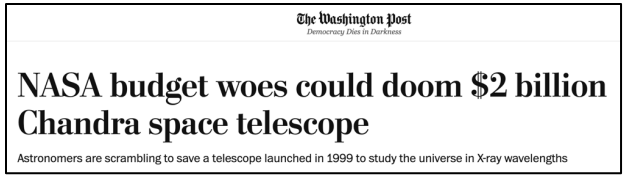
Astronomers Fight to Save X-ray Telescope as NASA Dishes Out Budget Cuts

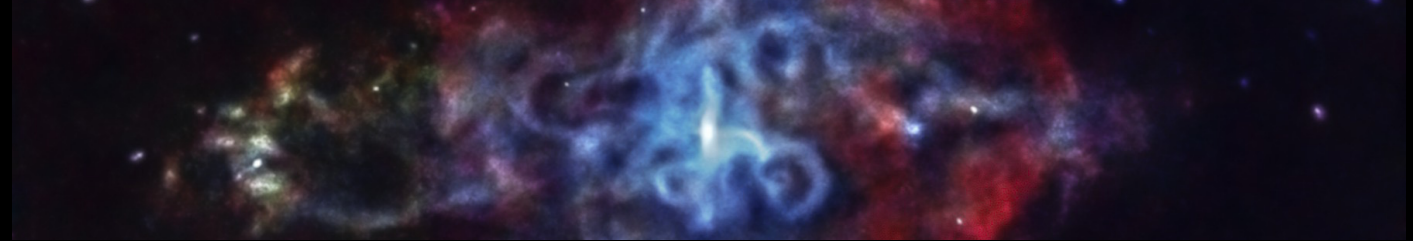
The Chandra X-ray Observatory faces a premature end under new funding cuts proposed by NASA—and astronomers aren't happy

- Press (Washington Post, USA Today, space.com, Scientific American, Popular Science, many others)
  - Interviews w/ members of community, including **CUC**


The Washington Post
Democracy Dies in Darkness

NASA budget woes could doom $2 billion Chandra space telescope

Astronomers are scrambling to save a telescope launched in 1999 to study the universe in X-ray wavelengths



Chandra Budget: Other Activities

- Communication with Congress

  - Congressional visits, communications with staffers (huge, broad effort)

  - Letter to House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies (CJSR) Chair and Ranking Member supporting increased funding for NASA and mentioning Chandra directly (signed by 44 Members of Congress)

  - Rep. S. Moulton written testimony : CJSR FY25 Member Day Hearing (“I urge the Appropriations Committee to continue supporting NASA’s Chandra X-ray Observatory mission.”)

  - Letter from Representative S. Moulton to House CJSR Chair and Ranking Member (“I therefore request that the Committee encourage NASA to continue to fund the Chandra mission consistent with FY24 levels (approximately $70 million) and to provide sufficient funding to enable NASA to do so.”)

  - Letter from Senators Markey, Casey, and Warren to Senate CJSR Chair and Ranking Member with above language.

  - Additional activities underway