Chandra Users' Committee Meeting Preliminary Report

2019 September 24-25

Overview

The CUC is pleased to hear that the observatory continues to be in generally good shape and the outcome from the recent NASA Senior Review was excellent. We were also impressed by the level of presentations given to the CUC and appreciate the summaries provided, which greatly aided our work. We commend the CXC staff for their efforts and hope that the observatory will continue performing at this level. There is a general concern for the continued degradation of ACIS response at low energy; nevertheless, the CUC endorses the decision not to attempt to bake off the contamination at the current time owing to a combination of high-risk and uncertain outcome.

Chandra Status Report

Dr R Brissenden presented a program summary for the CXC. Overall the Chandra spacecraft and instruments have continued to operate very well and science observing efficiency has remained close to optimal. The Operations Team responded to a transient gyroscope anomaly that has led to a mixed gyro configuration. Tests are ongoing with the goal of returning the gyro to full operation.

The CXC team accomplished a number of key milestones during the last year including the completion of the Chandra Source Catalog 2.0 due to be released next month, the successful completion and transition to the new Operations Control Center in Burlington, MA, and the finalization of a contract extension for the CXC between NASA and SAO to continue Chandra science operations through 2027, with a three year close out period if the mission concludes at that time.

The CXC continued to operate Chandra during the 2018-19 Government shutdown, however grants were not issued for two months prior or during the shutdown; all outstanding grants have now been issued. The CXC has also organized a series of events to celebrate Chandra's 20th year of operations, culminating in the 20th Anniversary Symposium to be held in Boston, December 3-6, 2019. Outreach activities were strong over the last year, and include 19 press releases, 39 image releases, Chandra 20th events (launch event, astronaut visit, MSFC event, symposium coming up), an ebook now in production, and several public talks at astronomy on tap and other venues.

The Chandra team also participated in the 2019 Senior Review and received an "Excellent" rating from the Panel. In response, NASA HQ has provided a modest budget augmentation to the Chandra program for FY21-24, to adjust for inflation for core labor, and provide a one-time adjustment to the grants program to partially mitigate the effect of inflation on what has been a flat budget since launch.

The CUC is very pleased to hear that NASA approved a long-due budget increase to help mitigate the effects of inflation.

Director's Report

CXC Director, Dr B. Wilkes, gave an overview of the telescope's Director Discretionary Time usage over 2019/2020. The program meets its purposes in that DDT remains competitive and leads to high science impact results. The CUC was pleased to see that the program covers a variety of science topics, including non-transient science, such as observations concurrent with the recent Juno fly-bye of Jupiter and quadruply-lensed quasars that can be employed for the inference of the hubble constant at moderate redshifts.

Overall, 2019 was an eventful and busy year for the CXC, which underwent a NASA Senior Review, a major relocation, a government shutdown and several events to celebrate the 20 year anniversary of the mission. These included special sessions at several relevant meetings, exhibits at a wider variety of meetings than in the past, science colloquia, often with CXC-provided speakers, public talks and events in various US-based locations, and multiple Astronomy on Tap events all over the world with a mix of CXC and local speakers. There will be two books released: a coffee table picture book "Light from the Void" (Smithsonian Books) which is already available for pre-order on Amazon, and an electronic book reviewing 20 years of Chandra science by community experts in each area. This is being published by IoP as part of their series in collaboration with the AAS and is currently in production.

The 20 year anniversary celebrations will culminate with a Symposium in early December. As well as a full science program, this meeting will include a special session honoring Nobel Prize winner, Riccardo Giacconi, and a session with several of Chandra's astronauts, including Commander Eileen Collins, Mission Specialists Cady Coleman, and Flight Engineer and Astrophysicist Steve Hawley

The Committee commend the CXC staff for their sustained efforts and high-level performance throughout an extraordinarily busy year.

Mission Planning Updates

The CUC received a detailed report from Dr P. Slane regarding the mission planning efforts of the CXC. A major part of these efforts, involving both the instrument and engineering teams, have focused on simultaneously managing the evolving thermal constraints for a variety of different spacecraft components. These are changing due to the gradual degradation of the insulation onboard the spacecraft, and are now understood to have a roll-angle dependence in addition to the known pitch-angle dependence. Despite the worsening constraints, Chandra Mission Planning for the period October 2018 – September 2019 continued with high observing efficiency (maintaining ~70% clock efficiency and ~93% planning efficiency), and included support for 1.6 Ms of TOO/DDT observations and over 2.7 Ms of observing time coordinated with other observatories. The vast majority of formal constraints and more informal preferences continue to be met. It is noted that even the effort to investigate whether informal preferences can be met is essentially equivalent to enacting a formal constraint, and so it may be that the distinction will be removed in the future, such that coordination with any facility may need to be considered a formal constraint.

The continued high observing efficiency is thanks in part to the development of new tools for selecting and assessing guide star catalogs, which have subsequently been integrated into both the short-term and long-term scheduling processes. Combined with new relaxation of ACIS focal plane and DPA

temperature limits, and incorporation of a large catalog of Chandra Cool Targets (CCTs) for use in helping to manage component temperatures, these improvements have been crucial in making the Mission Planning activities manageable.

The past year has included multiple significant planning challenges. These include executing complex observing programs, some of which have uncovered complexities that must be avoided in the future in order to avoid unreasonable risk to the continued performance of the Chandra detectors. An example is the particularly challenging observation of the bright source Sco X-1, which required complex maneuvers to and from the target to ensure that the bright source never fell directly onto any of the X-ray detectors. Also complex was a 2 Ms observing program for an "always bad pitch" target with a particularly poor star field, made exceedingly complicated by a need to adjust the pointing details of the many split observations depending upon the observing roll angle (which, in turn, impacts star selection). The latter is an example of programs that, because of the increasingly complex thermal environment of the spacecraft, introduce a very large burden on the normal planning process. Other examples include TOO programs with narrow response windows (including on follow-ups), and large amounts of requested observing time at high ecliptic latitudes.

An additional challenge has resulted from increased ACA temperatures associated with a gyro reconfiguration following anomalous behavior of IRU-2, Gyro-2 that lead to a Safe Mode in October of 2018. These increased temperatures, while partially mitigated through ACA performance modeling along with the star selection enhancements mentioned above, have introduced additional complexity into long-term planning for Cycle 21. Efforts to facilitate that planning process through updates and enhancements of the long-term scheduling software are underway. However, despite continued limits that have been imposed on the total time requested at high ecliptic latitudes (>60 deg) for Chandra LP/VLP programs, the amount of such time has increased significantly in Cycle 21, leading to scheduling difficulties that may require the use of significant CCT time. It may be necessary to introduce similar limitations on regular programs in the future.

Overall, the processes used to manage the planning and scheduling process in the face of evolving thermal constraints has continued to be highly successful, though labor intensive. Improvements on tools and thermal models, along with careful reassessment and (where possible) relaxation of temperature limits, are part of this process, but a reassessment of how to prioritize and support constrained observations and TOO programs will also need to work in parallel with such efforts to facilitate continued successful planning of Chandra observations.

The committee commends the CXC staff for continuing to both meet observers' constraints and preferences and maintain the efficiency of the observatory despite the increasingly challenging operational constraints, and the additional challenges posed by the government shutdown and the relocation of the Operations Control Center.

Recommendations:

In light of the continued planning efforts presented, the CUC did not have many detailed recommendations at the current time. However, a couple of broader points were noted:

1. *The CUC continues to strongly recommend that the current mission planning efforts are maintained at close to the same level of commitment. These efforts will be increasingly important as the constraints continue to tighten, particularly with the additional challenges posed by the Chandra orbit approaching perigee.*
2. *The CUC also recommends that efforts to ensure "succession planning" are continued, to ensure that key mission planning expertise is maintained as the mission continues to mature.*

Proposal Cycle Update, Plans for Future Cycle

Dr A. Prestwich gave an update of the last proposal cycle and future plans. Transient science is likely to become important in the next few years with several major transient surveys coming on-line. Science programs that arise from these surveys may be too big to be accommodated by the DDT program, but may benefit from a faster turn around than is possible via the peer review (where is it necessary to wait for the CfP, then approval, then the start of the nominal observing cycle). The CXC suggests setting up a working group to look at how best to facilitate this science, and will look into a possible Chandra workshop in the summer of 2020. The Chandra Cool Target Program started in Jan 2019. The CCTs are an important resource for keeping the spacecraft cool. The CXC suggests refreshing the CCT pool approximately every 3 years via the peer review. This is important to ensure that new science programs get a chance to be approved. NASA HQ has directed NASA missions to transition to dual-anonymous proposal reviews for CfPs released in CY2020. The CXC is planning for this change, which will probably be implemented for Cycle 23.

The CXC is developing a code of conduct hopefully to be released in Dec 2019 with the Cycle 22 CfP. The code will cover ethical expectations for proposers, reviewers and guests at CXC workshops and symposia.

The ageing of spacecraft systems alters the ability of Chandra to handle ToOs and requires an overhaul of how TOOs and constraints are counted at the peer review. The CXC expects to implement the following changes:

- Better align TOO response times with mission planning weekly schedules

- Recognize that TOO "exact CXC stop times" that are shorter than the nominal category stop times are more difficult. Possible mitigations include adding a constraint or not allowing exact stop times less than the nominal.

- All coordinated observations become formal constraints: no preferences allowed even for ground-based observatories.

- Account for the fact that multiple constraints are more difficult than single constraints.

- Limit high ecliptic latitude time review-wide.

CXC are also considering a one-time increase in the GO observing time of ~4Ms. The mission planning group currently can construct a stable LTS through August/Sept, but fresh targets from the peer review are not ready at that point. An increase in the amount of GO time would allow a stable LTS through November. Alternatively, CCTs could be used to bridge the gap: this would potentially be a dramatic increase in CCT usage.

Recommendations:

1. *The Committee agrees that a one-time increase of GO programs should be created to allow the creation of a longer stable schedule. The committee however also recognizes that the oversubscription to Large Programs is twice that of regular GO programs. We would therefore, like the CXC to look at whether there are ways that the fraction of time awarded to large programs could be increased without exacerbating the issue of telescope cooling.*
2. *The Observatory should consider creating a "Be Cool" program, whereby the program creation tool shows a score for how useful a target will be for cooling the telescope. This score would be visible to the observer and the reviewers. For now we do not recommend that this score be used for grading, but we think that getting the community thinking about this issue may get them ready for a time when it will be necessary.*
3. *The CUC recognizes that the present accounting scheme for constraints/TOOs is now inadequate, and that the CXC needs to move towards a single metric that replaces the old constraints/TOO categories as well as folding in ecliptic latitude. The Committee was in support of the proposal to use a single "point" system for measuring ToO difficulty, constrained observations, and other issues that make observation scheduling challenging. Since a similar system is already in use internally, the committee recognizes that this should be used in the reviews.*
4. *The CUC endorses the idea of creating a working group to look at the best way to handle the expected increase of requests for transient science, and the consideration of a related workshop.*
5. *We strongly recommend that the CXC keep exploring the possibility of Joint Observing programs with ALMA.*
6. *In some cases there are significant differences in proprietary times between the major observatories (in particular HST and Chandra, but also the VLA and ESO) for (typically transient) objects of great community interest, such as GW170817, so as to enable rapid, multi-wavelength follow-ups. We recommend that the Chandra Director approach the other observatories to see if a common set of rules could be adopted.*

CXC Response:

Thanks for the suggestions.

1. *We will include a one-time increase of time for Cycle 22, with a view to decreasing the over-subscription for LPs.*
2. *We will look at a "Be Cool" program for Cycle 23, and for Cycle 22 we will encourage proposers to choose low ecliptic latitude sources if there are equivalent targets.*

3. *We plan to implement Resource Costs for Cycle 22 and will keep the CUC updated as to how this is implemented*
4. *We will further explore setting up the transient working group and science symposium*
5. *We have renewed our discourse with ALMA concerning possibly joint programs via the US ALMA Science Center at NRAO.*
6. *The Director will approach other observatories to discuss proprietary time for targets of great community interest.*

Calibration: Goals, Priorities and Plans

The CUC received a comprehensive presentation from Dr J. Drake regarding the calibration activities being performed by the CXC. The vast majority of the Chandra calibration effort goes into understanding and characterizing the secular changes in the instrument performance. Even over timescales as short as a year, these changes are of sufficient magnitude to potentially have a significant impact on the results of scientific analyses if not accounted for properly. The decline in instrument performance, combined with the decay of the onboard Fe55 source, means that calibration is increasingly challenging, requiring revisions to methods and algorithms, and increasingly more complex analyses.

The main secular trends for ACIS are the continuing build-up of the contamination layer and the variable rate of gain drift due to CTI and for both HRC-S and I, the gain decline and declining quantum efficiency. The ACIS contamination layer has attenuated the effective area at the O K edge (0.5 keV) by a factor of approximately 40 since launch. Accurately characterizing the ACIS contamination is essential for understanding the ACIS low energy response. The HRC now has a larger effective area than ACIS at the oxygen edge and must be accurately calibrated if Chandra is to continue to have a well-characterized low-energy capability. Calibration releases reflecting these changes have continued to be released regularly, including a rapid fix for a defective T_GAIN file covering the Aug 2018-July 2019 epochs.

In addition to regular calibration releases to account for secular trends, in the near term, the Calibration Group is looking forward to a calibration release for the difficult ACIS "gain droop" problem, and a calibration of the EDSER ACIS PSF, complete with empirical PSFs. Several GO proposals requested the "new" HRC-S thick/think filter observing mode, for which the effective area below the C K edge (0.28 keV) requires verification. The HRC detectors require careful monitoring and will doubtless soon require a high voltage increase which will entail a complete recalibration. Meanwhile, Chandra Calibration is driving the Concordance project, which is getting closer to being able to make recommendations regarding effective area changes required to produce concordance between different X-ray observatories.

The HRC-S quantum efficiency continues to decline, and the performance of the detector is being monitored. The CXC calibration team is evaluating all possible effects (positive and negative) a voltage increase can lead to, before deciding on whether or not a voltage adjustment should be performed.

Recommendations:

1. *CUC recommends that the current calibration efforts are continued at the same level of commitment. The complex long-term trends shown by the instruments (e.g., quantum efficiency, contamination) need to be monitored regularly to ensure the continued success of the mission.*

2. *The CUC also recommends that the CXC calibration team continues to play an active role in the IACHEC collaboration in order to maintain efforts to characterize and understand the cross-calibration uncertainties between the various X-ray missions currently active.*

CXC Response:

1. *The CXC calibration team will continue to monitor all detector characteristics at the same level of commitment through periodic calibration observations and timely updates to calibration products. The CXC calibration team will also provide yearly updates on the current state of the detectors at the CUC meetings.*
2. *The CXC calibration team will continue to maintain a significant presence at IACHEC meetings. CXC calibration scientists chair several of the IACHEC working groups. There are also several ongoing cross-calibration projects with the present fleet of X-ray telescopes.*

CIAO updates

Dr J. McDowell gave an update on CIAO, which continues to be widely used by the community, with over 1000 downloads a year. The CXC continues to review and adjust the mix of operating systems supported and to follow community trends - in particular, the CXC is responding to community requests for better python integration. Already the current CIAO4.11 release (which now supports only Python 3) includes the Project Jupyter notebook system, matplotlib and pip3 to install additional python packages into the CIAO distribution. In the December release of CIAO 4.12 there will be an experimental option of a Conda installation to provide better interoperability of the system in users' python environments. As part of this process, the CXC has replaced the ChIPS plotting system with python's matplotlib. The CIAO4.12 release will also include an updated ciao_install script that simplifies the installation on different operating systems by providing a single Linux distribution and a single macOS distribution. CIAO and the processing system are modified each year to respond to changing spacecraft and instrument properties. In CIAO4.12 the CTI correction is improved to take the changing ACIS focal plane temperature into account. The CXC has also continued the development of Sherpa's capabilities with several significant improvements released over the past year.

In addition the CXC continues to expand its documentation, notably with the addition of an X-ray astronomy data product primer that has proved popular at meetings and workshops. The CXC has expanded its program of CIAO training with workshops at the January AAS meeting and at the X-ray Astronomy 2019 meeting in Bologna, to introduce a new generation of astronomers to the Chandra data analysis.

The CUC commends the CIAO team for their continued effort to promptly address community requests, making useful improvements and continuing to provide an excellent software and support the community especially through hands-on sessions at meetings and workshops.

Chandra Source Catalog

Dr I. Evans reported on the status of the Chandra Source Catalog (CSC). Processing has been completed and a release of CSC 2.0 with new and updated public interfaces to the catalog is planned for October 2019. CSC 2.0 includes 317,178 master sources, ~376K stacked-observation detections, and ~927K individual-observation detections. The source density of CSC 2.0 compared to other X-ray source catalogs is very high, with excellent limiting sensitivity and good cumulative sky coverage.

Statistics show significant community interest/uptake of CSC 2.0, with considerable interest in the release 2.0 science-ready data products. The team has been demoing the catalog at various meetings (e.g., AAS, HEAD) through the year.

The current plan is to update the catalog to include public data from 2015-2020, which will be released as CSC 2.1, once the planned efforts to reprocess the full Chandra archive with the latest calibration (Repro V) have been completed (expected to take ~1 year, commencing ~ Feb 2020). The subsequent processing for the additional data to be included in CSC2.1 is then expected to take another ~year. There are a number of efficiency and infrastructure upgrades that must be completed before this reprocessing starts, so that catalog operations can be transferred from the software team to the CXC Data System operations team.

The CUC is pleased to see that this high quality, high sensitivity catalog, containing plenty of ancillary information, will finally be frozen and delivered to the community in October 2019. Most urgent for the users is likely the ability to perform cone searches via a command line. The crossmatch with other catalogs and the access via CSCview, CSCweb, WWT, TAP and other VO tools will be a plus that will increment notably the usage of CSC2.0.

Recommendations:

1. *The CUC recommends close tracking of CSC2.0 usage and ensuing publications.*
2. *The CUC recommends in the strongest possible terms that priority be given to releasing 'new sky', rather than reprocessing of "old" data, particularly when it comes to exceedingly complex fields, that would arguably benefit a relatively small fraction of the community.*
3. *Similarly, the CUC also recommends that, for the near term, the focus of the catalog team be on bringing the catalog up-to-date with regards to publicly available data (as is currently the plan for CSC2.1) rather than implementing new functionality.*
4. *The timescale given for the release of CSC2.1 seems reasonable (1 year for Repro V, followed by 1 year for the production of CSC2.1), and once this has been released the CUC recommends the catalog team move towards a program of regular data releases to keep the catalog up-to-date, perhaps on an annual basis.*

CXC Response

1. *The CXC tracks all accesses to the catalog databases and data products served by the CXC from all catalog user interfaces (including CSCview, CSCweb, CSCWWT, CSCCLI, and the Virtual Observatory Interfaces). We plan to negotiate with other institutions that serve subsets of the*

catalog data (e.g., HEASARC, NED, Vizier) to obtain access statistics from them also. The Chandra Archive Operations team is developing CSC2-specific internal guidelines for the classification of scientific publications that use the catalog.

2. *The catalog team plans to prioritize processing "new sky" over updates to existing fields during release 2.1 processing. Similar to release 2.0, newly processed data will be immediately made available to the community via the CSCview* Current Database *view during release 2.1 processing.*
3. *The focus of the catalog team in the near term is to bring the catalog up-to-date with regards to publicly available data for release 2.1. For this release, only changes necessary to ensure that the catalog processing pipelines can operate reliably and efficiently on post-2014 data and run on the new processing cluster hardware will be implemented. These changes include updates to address larger astrometric errors in some post-2014 data that prevent automatic detection matching, and more robust MLE fitting to decimate the number of manual QA's required.*
4. *After release 2.1, the catalog team intends to perform regular releases to keep the catalog up-to-date, consistent with available resources.*

NASA Hubble Fellowship Program

Dr Paul Green reported on the NASA Hubble Fellowship Program (NHFP) that operates through participation of the Chandra X-ray Center (Lead: Paul Green), which supports the Einstein Fellowship. Three categories of the NHFP, described by topical science questions, are meant to span a wide range of astrophysics of interest to NASA's mission, namely "How does the Universe work?" [Einstein fellows], "How did we get here?" [Hubble fellows] and "Are we alone?" [Sagan fellows]. Twenty four fellows are selected out of a large pool of applicants (383 in 2019) during a review with 50 reviewers and 8 chairs. Panels are separated across a broad range of topics from compact objects and accretion to planets. The program continues to distribute fellows to different institutes throughout the US. with rules on the number of fellows resident at each institution in total as well as newly accepted each year.

In 2019, the NHFP symposium will be the first to merge the three individual symposiums that occurred in past years. This is an important activity to bring Fellows together to discuss science and to network. The workshop may include breakout sessions to provide advice with respect to career development, writing proposals, engagement in environmental and social issues from a cosmic perspective, career paths, and teaching. The program allows the ability for applicants to propose up to four years from obtaining a PhD for specific individual situations, to make the program more helpful to those with families.

Recommendations:

1. *The program should continue in its effort to enable fellows to be employees at their host institution, but we strongly endorse giving fellows both options at all institutions to the extent possible. Applicants should be encouraged to be fully aware of the employment situation at their chosen hosts prior to submission of the application. To encourage people to apply to the program, statistical information on the number of applicants and those selected should be posted*

on the web. The panel recommends that NASA continues to maintain a healthy balance of fellows across the three themes. This should be monitored.