The High Energy Astrophysics Division Newsletter

Editors: Michael F. Corcoran (NASA/GSFC & The Catholic University of America), Renee M. Ludlam (Wayne State University), Drew M. Miles (The California Institute of Technology)

In this Issue:

The XRISM observatory at JAXA's Tsukuba Space Center undergoing final tests before launch. XRISM is a collaboration between JAXA, NASA and ESA and was launched from the Tanegashima Space Center at 8:42 a.m on September 7, 2023 JST (7:42 p.m on September 6, 2023 EDT) on a JAXA HII-A rocket. First light is expected towards the end of 2023. Credit: JAXA/NEC

The View from the Chair

RANDALL SMITH (CFA)

This will be my final communique as HEAD Chair, as I will be passing the baton to Kristin Madsen at the HEAD business meeting, held at the upcoming AAS meeting - specifically on January 9th at 7 PM CST in Room 225. Please come to hear about what HEAD is working on, how you can get involved, and to get a free drink and some chips (for a second free drink, just say the secret phrase to me... first 3 people only, read on for the secret phrase).

It's been a busy year for HEAD - the successful launch of *XRISM* on September 6th was certainly a highlight. Commissioning is well underway, and the 2nd Community Workshop will be held January 17 – 19 in College Park, MD– see the *XRISM* article for more details. *IXPE* continues to return great results, making the cover of Nature Astronomy in May and holding its first AO for general observers, results coming soon.

Most recently, the biggest activity within HEAD has been the Astrophysics Probe call, NASA's first ever call for $1B missions in either X-ray or Far-IR astronomy. A large fraction of the X-ray astronomers within HEAD have been involved in one or more of the X-ray mission proposals (*Strobe-X*, *LEM*, *HEX-P*, *AXIS*, and *Arcus* in reverse alphabetical order), all of which were presented at the Hawaii HEAD meeting and have now been submitted to NASA for evaluation. While hard-fought, as a field I think we can take some pride that the entire process has remained collegial. Some colleagues of mine from another waveband attended the HEAD meeting and noted how friendly the atmosphere was, despite the looming competition. Of course I hope most HEAD members would agree that "APEX should be an X-ray probe," even if that's only a "secret" amongst the membership.

Upcoming events include a continuation of the Frontier Seminar talk series with the next session on December 8th, and future sessions in the new year. We're especially looking for early-career researchers with interesting new results, so please consider proposing for a talk if you have something to say. The next HEAD meeting in Horseshoe Bay, Texas is shaping up to be an amazing time — with a total eclipse to boot — so please make time in your schedule to attend.

It has been an honor to be HEAD Chair, and I look forward to continuing to help the division as Past Chair.

News from the HEAD

MEGAN WATZKE, THE HEAD PRESS OFFICER (CFA)

Just before the close of this newsletter deadline, there were two stories that showed the extraordinary public interest in the topics that HEAD missions explore.

The day before Halloween, *IXPE* and *Chandra* released a new image of MSH 15-52 that, as has been previously mentioned, resembles a human hand. The combination of the image, the "bones" angle, and the timing right before Halloween made it explode across social and popular media.

Only a week later, another multiple-telescope result made big news. By combining data from *Chandra* and *JWST*, a team of astronomers was able to identify the most distant black hole ever seen in X-rays. The story grabbed the attention of hundreds of news outlets and, of course, stretched far and wide across the internet.

Between these two results, HEAD missions were covered in two separate Washington Post articles, USA Today, NPR (Science Friday), and hundreds more. This is an example of the power that HEAD missions can have in reaching people far outside the astronomy community.

These two, however, were just a sample of the many excellent stories put forth by HEAD missions in the last six months. Some others include:

- September 26, 2023 "NASA's *Chandra* Rewinds Story of the Great Eruption of the 1840s"
- August 22, 2023 "A Giant Black Hole Destroys a Massive Star"
- July 17, 2023 "Astronomers Discover a New Type of Stellar Object Hiding in Plain Sight"
- July 17, 2023 "*XRISM* Mission to Study 'Rainbow' of X-rays"
- June 21, 2023 "Milky Way's Black Hole Woke Up About 200 Years Ago, NASA's *IXPE* Finds"
- June 9, 2023 "NASA Looks Back at 50 Years of Gamma-ray Burst Science"
- May 24, 2023 "LIGO Ready to Explore Secrets of the Universe"
- May 19, 2023 "eROSITA Sees Changes in the Most Powerful Quasar"

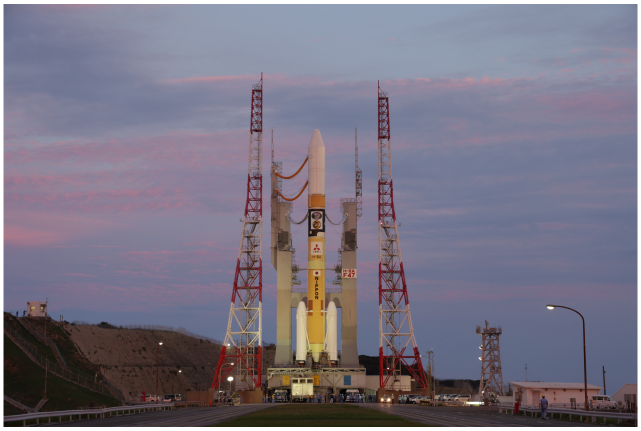
As always, we encourage shameless self-promotion. If you've got a recent science result that may be of interest to the public at large, please contact the HEAD press officer, Megan Watzke. And if you've got an interesting image based on (or involving) high-energy observations, objects or processes, contact Mike Corcoran for consideration as a High Energy Astrophysics Picture of the Week.

The X-ray Imaging and Spectroscopy Mission

RICHARD KELLEY (NASA/GSFC) & BRIAN WILLIAMS (NASA/GSFC)

LAUNCH!!

At 23:42 UTC on September 6, 2023, the X-ray Imaging and Spectroscopy Mission (*XRISM*) lifted off from Tanegashima Space Center in Japan on the 47th flight of the H-IIA rocket, ushering in a new era of high-energy astrophysics. *XRISM*, an international JAXA/NASA collaboration including participation from ESA, is an advanced X-ray observatory capable of carrying out a science program that will address some of the most important questions in astrophysics in the 2020s. *XRISM* will study all manner of astrophysical objects, including galaxies and clusters, AGN, X-ray binaries, supernova remnants, transient phenomena, stars, and the interstellar medium.



XRISM, along with our co-manifest SLIM (Smart Lander for Investigating Moon) being rolled out to the launchpad the night before a morning launch. Credit: Rich Kelley, NASA

The XRISM/SLIM launch, approximately 30 seconds after launch at the point when the launch vehicle passed the speed of sound, as evidenced by the sonic boom cone appearing at the top of the rocket. Credit: Leslie Hartz, NASA

A JAXA launch vehicle placed the observatory into an approximately circular orbit with an inclination of 31 degrees and an altitude of 575 km. *XRISM* operations are managed by scientists and engineers at ISAS/JAXA. The operations team is responsible for scheduling the observations, command/control of the satellite, data collection, and monitoring the health of the spacecraft and scientific payload. At the time of this writing, *XRISM* is in the commissioning phase of the mission, with the instruments being carefully turned on and calibrated.

At the end of this commissioning phase, the Performance Verification (PV) phase will begin. The PV phase of the mission will last approximately 6 months (following the checkout and initial calibration phases), during which the performance of the instruments will be verified through observations of a wide variety of celestial targets, including (but not limited to): X-ray binaries, active galactic nuclei, clusters of galaxies, and supernova remnants. The list of targets, along with a brief description of the observations and the immediate science goals, can be found here.

As a reminder, once the PV phase of the mission is concluded, the mission will enter the General Observer (GO) phase, in which it will remain for the duration of the mission. Yearly calls for observing proposals will be issued simultaneously by NASA (for scientists in the US and Canada), ESA (for scientists located in ESA member states) and JAXA (for scientists located in Japan and the rest of the world). It is anticipated that the Call for Proposals for Cycle 1 will be released in mid-November 2023, with proposals due in **late February 2024.** Proposals submitted to the NASA solicitation will be done in a similar manner as previous missions and must be written following the guidelines for Dual-Anonymous Peer Review. Funding will be available through NASA for successful proposers based at US institutions. Cycle 1 of GO observations will begin approximately 10 months after launch.

The 2nd *XRISM* Community Workshop will be held at the University of Maryland from January 17 – 19, 2024. The primary objective of this workshop is to prepare the astronomical community for the upcoming Cycle 1 General Observer (GO) Call for Proposals for *XRISM*. This workshop will consist of talks and hands-on sessions with experts from the *XRISM* team that will cover XRISM techniques and software relevant for Cycle 1 proposals, with the goal of maximizing the use of the unique high resolution spectroscopic and imaging data provided by *XRISM*.

The event will be held in a hybrid format with both in-person and virtual attendance possible. There is no cost for the workshop, but registration is required. Please see our website and register by December 22, 2023. There is a small amount of travel support available for those who would otherwise not be able to attend. For space reasons, in-person attendance at the meeting is limited to 60 participants. If more than 60 participants have registered by December 22, then participation will be determined by a lottery. If the demand for online participation is high, we may have to cap the number for practical reasons.

LIGO-Virgo-KAGRA Collaboration

J. McIver (The University of British Columbia) & P. R. Brady (UW-Milwaukee)

The latest *LIGO-Virgo-KAGRA* observing run, O4, began on 24 May 2023. O4 is expected to last 20 calendar months, including a planned commissioning break expected to start on 16 January 2024 and last until mid-March.

The *LIGO* detectors are now both reaching binary-neutron-star detection ranges of 160 Mpc or above. *LIGO* Hanford made a $\approx$20% improvement in range relative to the start of O4 thanks to improvements in the efficiency of the squeezed light system, removal of environmental noise from the air-handling system, and reduction of low frequency control noise. *LIGO* Livingston recently exceeded 170 Mpc.

Both *LIGO* detectors have strong average up-times for the beginning of O4, with *LIGO* Hanford observing time approaching nearly 70% of the time and *LIGO* Livingston reaching just over 75% of the time. However, during the winter months we expect higher microseismic ground motion may negatively impact observing time, especially at LIGO Livingston.

The *Virgo* detector recently reached a binary-neutron-star range up to 35 Mpc after commissioning activities. The *Virgo* team plans to reduce known noise sources to increase the detector's sensitivity. *Virgo* plans to join O4 in March 2024, with the exact date to be announced as commissioning progresses.

KAGRA restarted commissioning in July and plans to re-join O4 in the spring with a target binary-neutron-star range of around 10 Mpc.

As of early November, the *LIGO-Virgo-KAGRA* collaboration has identified 59 significant gravitational-wave candidate events with low-latency searches, plus 10 retracted significant candidates. Of the 59 identified candidates, our current understanding is that 57 are most likely binary black holes, while 2 currently have a higher probability of being neutron star-black hole events. In addition, 1245 low-significance alerts have been released. As offline analyses are completed with improved understanding of detector performance and noise background, the list of candidates is expected to change and their estimated source properties may also shift.

Although there are not yet any confirmed binary neutron star event candidates during O4, the collaboration has deployed early-warning gravitational wave searches for binary neutron star mergers capable of issuing alerts ahead of merger times.

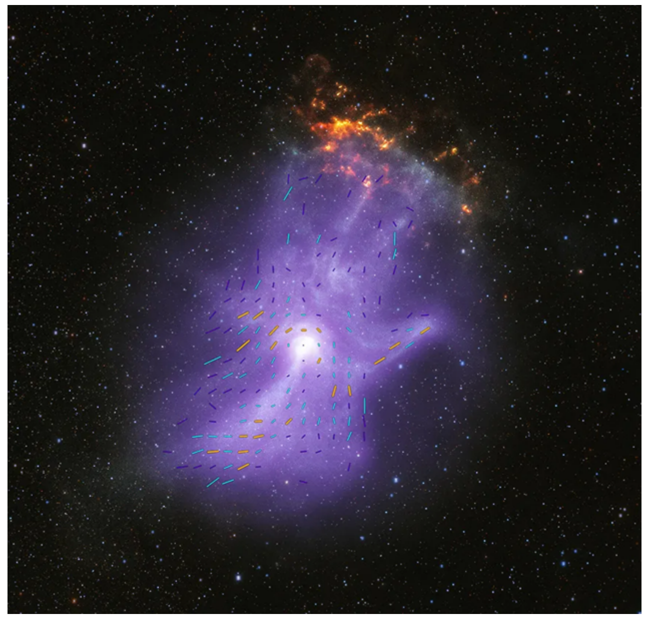
More information about public alerts, including instructions for subscribing to alert notifications, can be found in the *LIGO-Virgo-KAGRA* public alerts user guide. If you would like to keep track of the status of the observatories during the observing run, you can visit the Gravitational Wave Open Science Center's detector status page.

The Imaging X-ray Polarimetry Explorer

Philip Kaaret & Steve O'Dell (NASA/MSFC)

The *IXPE* mission has been extended! Dr. Mark Clampin, Astrophysics Division Director, noted that "*IXPE* exploits X-ray polarization as a new way of understanding the high-energy universe." He approved an extension to September 2025, featuring a General Observer (GO) program starting in early February 2024. Subsequently, *IXPE* will participate in NASA's Senior Review for Astrophysics Operating Missions. We thank Dr. Clampin for granting the extension, Dr. Hashima Hasan for organizing the review, and the five members of the panel who carried out the review. A total of 135 proposals were received for cycle 1 of the *IXPE* GO program including both observation and theory. GO observations are planned to start in early February 2024.

There have been some changes in the leadership of *IXPE*. Philip Kaaret was appointed Principal Investigator (PI) of *IXPE* in June 2023, taking over from Martin Weisskopf. Steve O'Dell is now Deputy PI and Steven Ehlert is *IXPE* Project Scientist.



The "Cosmic hand", MSH 15-5(2). Purple shows IXPE X-rays superposed on a Chandra X-ray image, where blue denotes higher-energy X-rays and orange lower energy X-rays. The bars show magnetic field direction with length proportional to polarization degree and color indicating significance (orange, $> 5\sigma$; blue, $> 3\sigma$; black, $> 2\sigma$). The stellar field is an infrared image. Credit: X-ray: NASA/CXC/Stanford Univ./R. Romani et al. (Chandra), NASA/MSFC (IXPE); Infrared: NASA/JPL-Caltech/DECaPS; Image Processing: NASA/CXC/SAO/J. Schmidt)

A science highlight for *IXPE* is MSH 15-5 *2*, the "Cosmic Hand" (Romani, R. et al. 2023, ApJ, 957, 23). The *IXPE* data on the synchrotron X-rays from this pulsar wind nebula (PWN) give us the first map of the magnetic field in the "Hand". The magnetic field generally aligns with filamentary X-ray structures. Strong polarization is seen in arcs surrounding the pulsar (PSR B1509-58) and towards the end of the jet emanating from the pulsar. In some locations, the polarization degree exceeds 70%, which approaches the maximum allowed synchrotron value and implies that there is little turbulence in those regions. In contrast, the base of the jet has lower polarization, indicating a complex magnetic field at a significant angle to the jet axis. Also, polarization is detected from the pulsar itself, which can be used to constrain rotating-vector-model solutions for the pulsar geometry. The press release on the "Cosmic Hand" generated 387 media pickups within 24 hours.

There will be two *IXPE*-related special sessions at the April 2024 HEAD meeting: "Probing Blazar Jets with Multi-wavelength Polarization", scheduled for April 11 at 1:40 pm; and "Recent advances in X-ray polarimetric and spectroscopic studies of accreting stellar-mass black holes", scheduled for April 9 at 5:20 pm. In addition, we plan to hold an *IXPE* workshop in Huntsville, Alabama, in summer 2024. Details will be forthcoming.

On October 25, 2023, the *IXPE* team received the National Space Club of Huntsville's Distinguished Science Award. Dr. Martin C. Weisskopf, *IXPE* PI Emeritus, accepted the award on behalf of the *IXPE* Team, at the 35th annual Von Braun Memorial Dinner, with over 1000 people in attendance.

We are seeking individuals to serve on the *IXPE* Users' Committee (IUC). The purpose of the IUC is to ensure that the interests of scientists who use *IXPE* are well served by the *IXPE* mission, to help disseminate *IXPE* science results, and to assist in preparing for NASA Senior Reviews. If interested, please email Phil Kaaret with the subject "*IXPE* Users' Committee (IUC)". In the body of the text, please describe your motivation for serving on the committee and a brief summary of your relevant expertise.

The Chandra X-ray Observatory

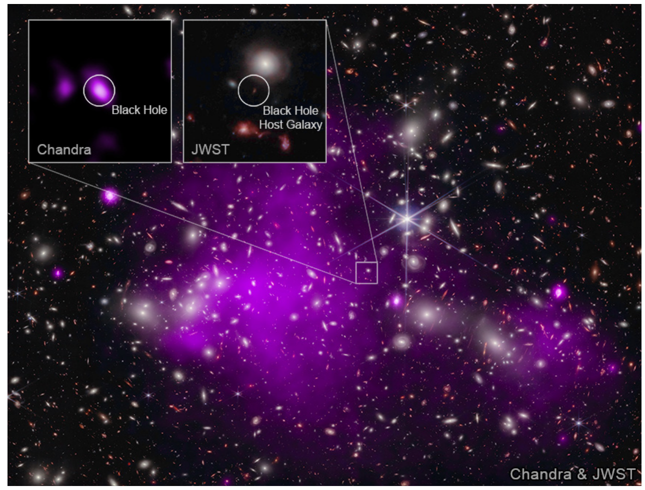
Edward Mattison (SAO) Steve O'Dell & and Steven Ehlert (NASA/MSFC)

Now in its 25th year, the *Chandra X-ray Observatory* (CXO) continues its highly successful science mission. With its unique capability for sub-arcsecond X-ray imaging, *Chandra* provides key information for accomplishing many X-ray and multi-wavelength investigations in current astrophysical research.

Scientists worldwide responded to *Chandra*'s Cycle-25 call for proposals, submitting 408 proposals requesting 4.9 times more observing time than available. Held in June, the dual-anonymous peer review approved 103 observing proposals and 21 archive and theory proposals.

Chandra plays an essential role in key science goals of other NASA missions. For example, *Chandra*'s high-resolution imaging spectrometry provided crucial information for the Imaging X-ray Polarimetry Explorer (*IXPE*) to measure X-ray polarization in the Sagittarius A complex. This polarization measurement provided evidence that Sgr A* may have been a million times brighter than its current luminosity, as recently as 200 years ago .

Another important recent result was the *Chandra* detection of an AGN within a $z \approx 10$ galaxy discovered by *JWST*. The galaxy, gravitationally lensed by the cluster Abell 2744, was inferred to host a black hole of roughly 40 million solar masses, based upon *Chandra* observations. This discovery of a supermassive black hole formed less than 500 million years after the Big Bang places powerful constraints on the formation histories of supermassive black holes and their co-evolution with early galaxies, which remains a crucial science goal of both observatories.



Ultra high-redshift ($z \approx 10$) galaxy UHZ1 gravitationally lensed by cluster Abell 2744. Magenta denotes X-ray (CXO); red and white, infrared (JWST). Credit: X ray (CXO): NASA/CXC/SAO/Ákos Bogdán; Infrared (JWST): NASA/ESA/CSA/STScI; Image Processing: NASA/CXC/SAO/L. Frattare & K. Arcand)

Chandra observations have led to several important discoveries of unusual galaxy and galaxy cluster systems. *Chandra* confirmed that the galaxy cluster SPT-CL J2215-3537, originally discovered by the South Pole Telescope, is currently the most distant (z = 1.16) relaxed galaxy cluster identified, suggesting that galaxy clusters can grow to high masses surprisingly fast. Another unusual galaxy system is observed around the radio source 3C 297, which exhibits multiple signatures of a galaxy cluster but no other galaxies. Such an observation suggests that 3C 297 (z = 1.408) may be the highest redshift fossil group yet identified. In addition, *Chandra*'s imaging capabilities have also identified two pairs of merging dwarf galaxies, each residing within a galaxy cluster. These three results offer important insights and constraints as to how large-scale structure forms throughout cosmic time. As evident in the science discussion above, the *Chandra* Public Communications group has been active in issuing image releases, science press releases, and other communications of *Chandra* research results.

The *Chandra Observatory* continues to function at or near pre-launch expectations, with no significant or unmitigated subsystem issues. Incremental changes in some component performance continue, in line with pre-launch predictions, and without hindering operations. The performance of the spacecraft thermal insulation continues to trend downwards in a predicted fashion; however, this is – and has been for the majority of the mission – mitigated by thorough mission scheduling, sustained with support from increasingly sophisticated software scheduling tools. The gradual accumulation of molecular contamination on the UV filter that protects the ACIS detector reduces ACIS's sensitivity to low-energy (below about 1.5 keV) X-rays. *Chandra* has maintained its mission-long run of high observation efficiency, collecting data on science targets for about 90% of the available observing time. (Maneuvers, instrument setup, etc. necessarily take up some observing time.)

The *Chandra X-ray Center* (CXC) conducted the annual *Chandra* summer science conference, this year on High-Resolution X-ray Spectroscopy, in August in Cambridge, Massachusetts. The CXC also hosted this year's NASA Hubble Fellowship Program NHFP symposium in September in Cambridge. The *Chandra* Project is looking forward to celebrating *Chandra*'s 25th anniversary next year, and to many more years of scientific discovery.

XMM-Newton

LYNNE VALENCIC (JHU/NASA) & KIM WEAVER (NASA)

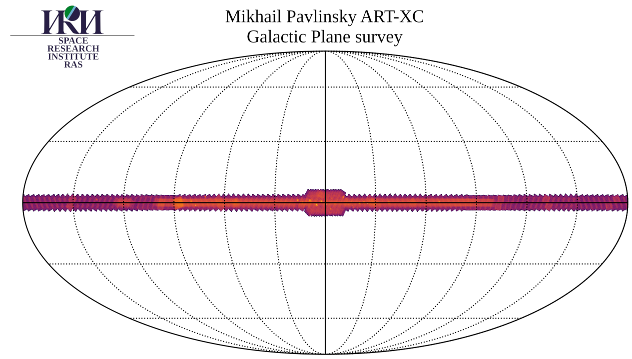
The 23rd Announcement of Opportunity closed on October 6. In all, 441 proposals were received. This AO, Multi-Year Heritage Programs, with 6 Ms of observing time over 3 consecutive years, were available in addition to the standard programs. Both were heavily oversubscribed: Multi-Year Heritage Programs by 6.2, and the rest by 6.4. Joint programs were also very popular, with 93 proposals submitted. Of these, projects with *NuSTAR*, *HST*, *Swift*, and *VLT* had the most, with 43%, 17%, 16%, and 15% of all submitted joint proposals, respectively. The final program will be announced in mid-December, and observations will begin in May 2024.

The SOC hosted the 6th meeting in "The X-ray Universe" series on June 13-16 2023 in Athens, Greece. The conference focused on results and discoveries from *XMM-Newton* and other current missions, as well as the science potential of future missions. Next year, ESAC in Madrid will host a workshop on the topic "The X-ray Mysteries of Neutron Stars and White Dwarfs", with particular attention paid to timing studies and spectral analysis techniques, on 5-7 June 2024. More information will be available at the 2024 workshop page.

SRG/eROSITA/ART-XC

A. LUTOVINOV (IKI), S. SAZONOV (IKI)

The Mikhail Pavlinsky ART-XC telescope aboard the *SRG* observatory has finished its deep Galactic Plane Survey, which lasted for one and a half years and fully covered the Galactic Plane ($l = 0 - 360°$, $|b| < 2.7°$) and Galactic Bulge ($|l| < 10°$, $|b| < 4.2°$) regions of the sky in the 4 – 12 keV energy band. Recently, *SRG*/ART-XC has also taken active part in X-ray monitoring of two spectacular astrophysical objects: the core-collapse supernova SN 2023ixf in the nearby galaxy M101 and the extremely bright ($\simeq$7 Crab) Galactic X-ray nova Swift J1727.8-1613. These pointing-mode observations, together with data from other X-ray telescopes, have made it possible to sample the X-ray curves of these objects in great detail and to study their spectral evolution and timing properties.



Survey of the Galactic plane performed by the Mikhail Pavlinsky ART-XC telescope on board the SRG observatory in 2022-2023 (Credit: I. Mereminskiy).

On October 19, 2023, *SRG*/ART-XC resumed the all-sky survey. It is currently planned that four new scans of the sky will be conducted over the next two years, in addition to four scans that were performed in December 2019 – March 2022.

The Neutron Star Interior Composition Explorer

KEITH GENDREAU & ZAVEN ARZOUMANIAN (NASA/GSFC)

NICER recently received 130 proposals for Cycle 6 of its General Observer (GO) program, nearly identical to the record number that was received in Cycle 5. Dual-anonymous peer review of the proposals is now complete, and announcement of results is imminent. In this Cycle, *NICER* offered a new joint program with the National Radio Astronomy Observatory for time on its Karl G. Jansky Very Large Array (VLA), Very Long Baseline Array (VLBA), and Robert C. Byrd Green Bank Telescope (GBT) facilities; this complements existing reciprocal joint programs with *Swift*, *TESS*, and *NuSTAR*, through which GO proposers can request time or data from any partnering facility for coordinated investigations. Successful *NICER* proposals are also eligible for allocations of time on NASA's High-End Computing facilities. Finally, *NICER* makes available observing time allocated through the *IXPE* GO program. *NICER* Cycle 6 observations will begin on March 1, 2024. The near-term observing schedule is always available on *NICER*'s website at the HEASARC.

From its berth on the International Space Station (ISS), *NICER* continues to operate productively despite damage sustained by the payload in late May due to orbital debris: the thin optical-blocking filters that cover a handful of the 56 X-ray concentrator optics were punctured, allowing daylight into the X-ray Timing Instrument's (XTI) interior. This "light leak" and the resulting optical loading of *NICER*'s silicon drift detectors during orbit day causes internal telemetry saturation, substantially degrading data quality. During orbit night, all detectors operate nominally and data quality remains excellent. In addition to prioritizing scheduling during orbit night, the *NICER* team has introduced some daytime-only operational changes to mitigate the effects of the light leak, enabling recovery of some fruitful daytime observations, but the impact to overall capabilities remains significant, especially for monitoring programs that require sampling across a wide range of Sun angles. Discussions are underway with ISS management and technical teams about the possibility of patching *NICER*, to cover the damaged thin films and restore dark conditions within the XTI. Approaches involving both ISS robotics and astronaut spacewalks are being evaluated, with implementation of a possible repair – following launch to ISS of a dedicated patch kit – to take place in the second half of 2024. Some data collected in sunlit conditions exhibit unusual behaviors; we urge *NICER* users to exercise caution in interpreting any unexpected spectral or timing features, which may be spurious and unrelated to any astrophysical phenomenon. Additional information and best practices for analyzing data in the presence of the light leak are available on *NICER*'s Analysis Tips and Caveats page.

NICER data analysis software (NICERDAS) is distributed through the HEASoft package. The latest HEASoft release, 6.32.1, offers several new capabilities as part of NICERDAS 11, including features that specifically address calibration and filtering related to the optical light leak. Feedback on NICERDAS performance is welcome through the HEASARC helpdesk system.

NICER's scheduling agility enables it to coordinate with many other astronomical facilities, and to observe a large number of ToOs, which may be proposed by any observer at any time through the *NICER* Target of Opportunity/Discretionary Time Request form. *NICER*'s visibility windows for a given target are complicated by occultation from structures (such as the large solar arrays) on the ISS; the *NICER* team maintains a web-based Enhanced Visibility Calculator to provide accurate start-stop visible times for any specified target within a 14-day horizon. Additional capabilities to improve responsiveness to transients include the ability to perform automated grid searches of localization uncertainty regions for new sources, in particular those detected by JAXA's *Monitor of All-sky X-ray Image* (MAXI), which is also an ISS payload. In partnership with JAXA, *NICER* has developed the Orbiting High-energy Monitor Alert Network (OHMAN), a software payload running on an ISS laptop that implements automated triggering between *MAXI* and *NICER*. OHMAN enables *NICER* to respond to *MAXI*-detected transients on timescales, in the best cases, of just a few minutes.

The *NICER* Users Group (NUG) continues to provide the mission with expert guidance on data-analysis capabilities, calibration, and other user support functions. The NUG meets, independently of *NICER* mission leadership, in the spring and fall of each year. The community is encouraged to communicate with the NUG; contact information, the NUG Charter, and meeting details are provided at the website above. Expressions of interest to serve on the NUG are also welcome.

Recent *NICER* science results include:

- Intensive monitoring of the bright outburst of black-hole binary Swift J1727.8−1613 – from its discovery in late August through mid-October and occasionally in coordination with *NuSTAR* and *IXPE* – enabled the community to track the system's evolution through spectral and timing changes reported in a number of Astronomer's Telegrams. Among other benefits, such as high-quality spectral-timing analysis of the system's prominent quasi-periodic oscillations, the *NICER* data will serve to anchor multiwavelength campaigns carried out by many facilities, providing context of transitions from one accretion state to another (and sometimes back again) during the rise, plateau, and early decline of the outburst.

- Evidence for X-ray emission powered by magnetic reconnection in the unique binary system Eps Lupi, the only known example of two highly magnetic stars orbiting closely enough that their magnetospheres overlap at all times. Das et al. (2023) report a series of *NICER* observations at periastron and apastron, in which enhanced hard X-ray flux is seen only within a 5% orbital-phase interval around periastron, too narrow to be explained by a wind-wind shock hypothesis but consistent with heating of the intra-binary plasma from reconnection interactions between the magnetic fields of the two stars.

- Definitive characterization of the accreting companion star to the hot subdwarf HD 49798. Rigoselli et al. (2023) describe a *NICER* timing study of the 13.2-second pulsations from the associated source RX J0648.0−4418, phase-connected to data acquired with *XMM–Newton* and *ROSAT* extending back 30 years. The *NICER* data provide the first sampling of the full 1.55-day orbit, multiple times, and the resulting orbital ephemeris of the compact object, coupled with radial-velocity measurements from optical spectroscopy of HD 49798, yield the masses of both stars and the system's orbital inclination. Steady spin-up of the 1.22 Msun white dwarf and an X-ray eclipse over approximately 10% of the orbit are also evident. The *NICER* results support a scenario in which the white dwarf accretes directly from the subdwarf star's wind, and suggest that the HD 49798/RX J0648.0 system is a candidate for a future, nearby Type Ia supernova.

- Discovery of super-soft pulsations, with period varying between 75 and 80 seconds, from the classical nova V1716 Sco, by two *NICER* summer interns at NASA GSFC; see Dethero et al. (2023).

Other *NICER* science results are given on the Results section of the *NICER* website. These results include weekly Science Nuggets which are shared with the ISS mission and crew.

Neil Gehrels Swift Observatory

BRAD CENKO (NASA/GSFC)

The Neil Gehrels *Swift* Observatory continues to operate exceptionally well as it approaches its 19 year launch anniversary (November 20, 2023). The mission supports five Target-of-Opportunity (ToO) requests per day from the community, in addition to observing gamma-ray bursts (GRBs) and Guest Investigator (GI) targets. *Swift* is by far the most active mission in terms of number of ToOs accepted and different sources observed.

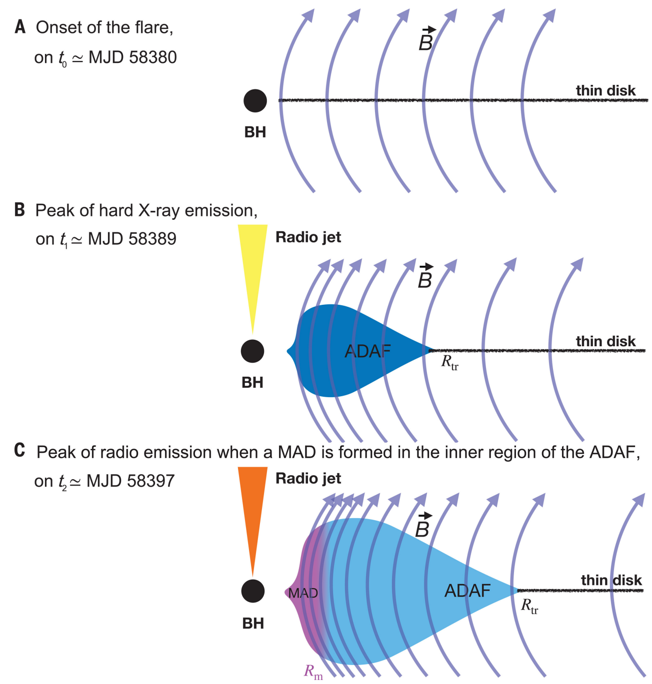
Cycle 20 GI proposals were due on September 21, 2023. Nearly 180 proposals were received, a nearly 30% increase over Cycle 19, demonstrating the continuing strong community demand for *Swift* observations. Scientific review of these proposals is planned for early December, and notifications should be available in January 2024. Cycle 20 observations commence on April 1, 2024.

Using a new capability developed by the X-Ray Telescope (XRT) team, scientists recently discovered a black hole in a distant galaxy nibbling on a Sun-like star. When a star strays too close to a monster black hole, gravitational forces create intense tides that break the star apart into a stream of gas. The leading edge swings around the black hole, and the trailing edge escapes the system. These destructive episodes are called tidal disruption events. Astronomers see them as flares of multiwavelength light created when the debris collides with a disk of material already orbiting the black hole. Recently, astronomers have been investigating variations on this phenomena, which they call partial or repeating tidal disruptions. During these events, every time an orbiting star passes close to a black hole, the star bulges outward and sheds material, but survives. The process repeats until the star loses too much gas and finally breaks apart. The characteristics of the individual star and black hole system determine what kind of emission scientists observe, creating a wide array of behaviors to categorize. This new partial TDE discovery was recently reported in Evans et al. in Nature Astronomy. More information about the Living Swift XRT Point Source Catalog can be found at the Living *Swift* XRT Point Source Catalog page.

Insight-HXMT

SHIJIE ZHENG & SHUANG-NAN ZHANG (IHEP, CAS)

The *Insight*-Hard X-ray Modulation Telescope (*Insight*-HXMT) continued observations of black holes, neutron stars in the 1 – 250 keV band, and GRBs in the 80 – 2000 keV band. Non-proprietary data can be downloaded freely from the *Insight*-HXMT official website. The *Insight*-HXMT Data Analysis Software (HXMTDAS) and the CALDB have been regularly updated and the latest versions are V2.05 and V2.06, respectively. More information about the progress, user support and results of *Insight*-HXMT can be found at the *Insight-HXMT* website (in English and Chinese).



Schematic diagram of the formation of a magnetically arrested disk. Credit: You et al., Science, 2023

Some new important results have been published recently with *Insight*-HXMT data. First of all, with the multiwavelength observations of an outburst from the black hole x-ray binary MAXI J1820+070, evidence was found for the formation of a magnetically arrested disk (You et al., Science, 2023). Furthermore, accurate time delays of the two X-ray peaks of FRB 200428 with respect to their corresponding radio pulses have been reported (Ge et al., ApJ, 2023). Moreover, there are some other important results, including the timing and spectral analysis of SGR J1935+2154 (Xiao et al., MNRAS, 2023; Xiao et al., ApJS, 2023; Zhu et al., SciA, 2023; Zhang et al., RAA, 2023) and X-ray binaries (Li et al., MNRAS, 2023ab; Yu et al., ApJ, 2023). For the new black hole transient Swift J1727.8-1613, *Insight*-HXMT has performed continuous observations from 2023-08-25 to 2023-10-04. All of these data have been made publicly available, and we encourage in-depth investigations with them. Please visit *Insight*-HXMT's publication list for more details.

AO-6 Cycle Proposal Evaluation has been completed and announced. In total, 334 observations from 50 proposals have been approved. In particular, some observation time has been reserved for joint HXMT-EP observations. The *Einstein Probe* (EP) is a time-domain X-ray observatory to be launched by the end of 2023. See the long-term and short-term plans, and list of observed sources for more information about the Insight-HXMT observation plan.

GECAM

Shijie Zheng & Shaolin Xiong (IHEP, CAS)

The *GECAM* (Gravitational wave high-energy Electromagnetic Counterpart All-sky Monitor) mission, composed of three monitors (*GECAM*-A, B and C), is dedicated to detecting high-energy transients from about 10 keV to 5 MeV in the multi-messenger and multi-wavelength era. The main scientific objects include Gamma-Ray Bursts (GRBs), especially those associated with Gravitational Waves (GW-GRB), high energy counterparts of Fast Radio Burst (FRBs), Soft Gamma-ray Repeaters (SGRs), X-ray bursts from X-ray Binary (XRBs), Solar Flares (SFLs), Terrestrial Gamma-ray Flashes (TGFs) and Terrestrial Electron Beams (TEBs).

There are a number of new and interesting results which feature *GECAM* observations. Joint *GECAM*-C, *Fermi*/GBM and *Insight*-HXMT observations allowed an unprecedented measurement of the early afterglow of the "Brightest of All Time" burst, BOAT GRB 221009A. This campaign found very interesting afterglow features, including an unusual V-shape spectrum, achromatic jet break and energy-dependent flux decay slopes, providing new insights into this remarkable burst (Zheng et al., 2023). *GECAM* TGF and TEB observations include 147 bright TGFs, two typical TEBs, and two special TEB-like events which pose challenge to current TEB theory. Observations with *GECAM* and GLD360 in the east Asia region showed very high TGF-lightning association rate (up to ≈80%, Zhao et al., 2023).

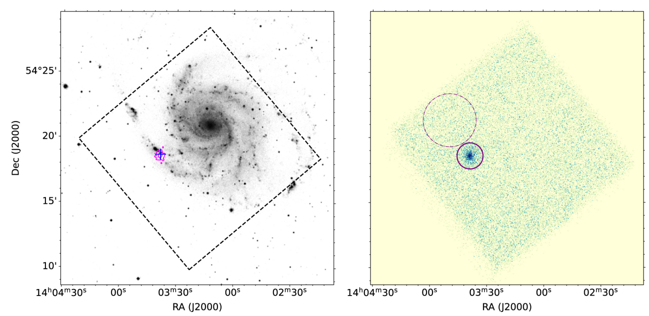
Initiated by the *GECAM* mission, a collective burst alert platform for astronomical transient (dubbed as AstroBurstHub) has been developed. It automatically gathers real-time alerts from various platforms (such as GCN and ATel), and analyzes the alert data to retrieve useful information including burst classification, source matching, etc. It also provides statistics of the burst Events and Messages and highlights the most popular events ("Hot Events"). This system provides helpful information to the community and facilitate the joint observation and research of astronomical transients. Comments, suggestions and contributions to this alert system are very welcome.

Last but not least, more *GECAM* data has been released recently which can be downloaded from the *GECAM* website. We also provide the *GECAM* data analysis software (GECAMTools) and calibration database CALDB. Please see the *GECAM* website for more information about *GECAM*.

NuSTAR

Daniel Stern (JPL), Karl Forster (Caltech)

NuSTAR continues to operate nominally in orbit, and continues to support a high level of coordinated observations with other observatories, primarily low-energy telescopes, in order to provide broadband X-ray coverage. *NuSTAR* observing time, available through the Gehrels-*Swift*, *XMM–Newton*, *NICER*, *Chandra*, and *INTEGRAL* time allocation committees, continues to have high levels of oversubscription, particularly for Target of Opportunity proposals. *NuSTAR* coordinated observations with *XRISM* will begin in December, supporting *XRISM* calibration activities and Performance Verification (PV) targets. *NuSTAR* Cycle 10 is also now officially open, with proposals accepted through January 25, 2024.



Left: Digitized Sky Survey image of M101, with the NuSTAR field of view (black dashed line), NuSTAR contours (magenta), and optical position of SN 2023ixf (blue cross) indicated. Right: the NuSTAR image. The source extraction region is marked with a solid circle, and the background region is marked with a dotted-dashed circle. Credit: Grefenstette et al. (2023).

On the science front, recent *NuSTAR* observations of SN 2023ixf in the Pinwheel Galaxy (M101; d = 6.9 Mpc) provide the earliest hard X-ray detection of a non-relativistic stellar explosion to date, with a highly absorbed source detected just four days after the supernova explosion. At that early time, *Swift* only obtained upper limits at soft X-ray energies. These observations, reported in Grefenstette et al. (2023, ApJ, 952, L3), found a hot thermal bremsstrahlung component initially observed through a thick neutral column ($N_{\rm H} = 2.6\times10^{23}$ cm^{-2}). A week later, the absorption had dropped substantially, suggesting a dense but confined circumstellar shell of material likely ejected in the final few to 10 years of the star's life. These results demonstrate the power of hard X-ray observations to probe the final stages of stellar evolution.

The Fermi Gamma-ray Space Telescope

Elizabeth Hays (NASA/GSFC), Chris Shrader (CUA & NASA/GSFC), Judy Racusin, Dave Thompson (NASA/GSFC), & Lynn Cominsky (Sonoma State)

The *Fermi* scientific instruments, Gamma-ray Burst Monitor (GBM) and Large Area Telescope (LAT), continue to monitor the entire gamma-ray sky continuously. Operations have remained largely routine as the mission has entered its 15th year of operation. An e-book is in preparation to highlight the scientific discoveries by *Fermi* during these 15 years.

For the *LIGO/Virgo/KAGRA* O4 runs, the instruments are alerting the community about possible counterparts and are watching for good candidate gamma-ray bursts for cross checks in the gravitational wave data. The GBM team puts out regular GCN notices and circulars, while the LAT team has set up a page to report automatic follow-ups to alerts. Calibrations that disrupt data are planned for the 2-month break this winter.

Fermi-LAT data have been used to produce two new products for the community: the Data Release 4 all-sky LAT catalog, containing 6658 sources (a preprint is available) and the Third LAT Pulsar Catalog (3PC), containing 294 gamma-ray pulsars (a preprint of the 3rd catalog is also available). Automatically generated daily and weekly LAT light curves of the recurrent nova T CrB, which is nearing an expected peak in its 80-year cycle, are also publicly available.

Current *Fermi* software and documentation are available through the *Fermi* Science Support Center, including the current version of the Fermitools. The latest source code is now hosted on GitHub. For instructions on how to install the tools, release notes, troubleshooting, error reporting, and other related documentation see the Fermitools Wiki. The latest release of the GBM Data Tools is available on GitHub as a package in the Gamma-ray Data Tools.

The FSSC will support a virtual workshop for prospective Cycle 17 proposers on January 24; please see the registration form to register for the workshop. You can find details about the Guest Investigator program at the *Fermi* Science Support Center website. The Cycle 17 proposals will be due on February 15.

The 2023 *Fermi* Summer School was held May 30 to June 9. Links to talks are available. The 2024 school will again be held in Lewes, Delaware. The dates will be May 28 to June 7. Please see the *Fermi* Summerschool webpage for more information .

Fermi will join with *NuSTAR* and *Swift* in staffing a booth at the 243rd meeting of the American Astronomical Society in New Orleans. There are now six "stained glass" gamma-ray art posters available through the *Fermi* project. If you are missing a few or would like a set, please send email to Lynn Cominsky.

If you have job/research/degree opportunities relevant to the gamma-ray community, the LAT Collaboration has an Opportunity Board where those can be posted.

Looking farther ahead, the next International *Fermi* Symposium will be held a year from now, in the Washington, D.C. area.

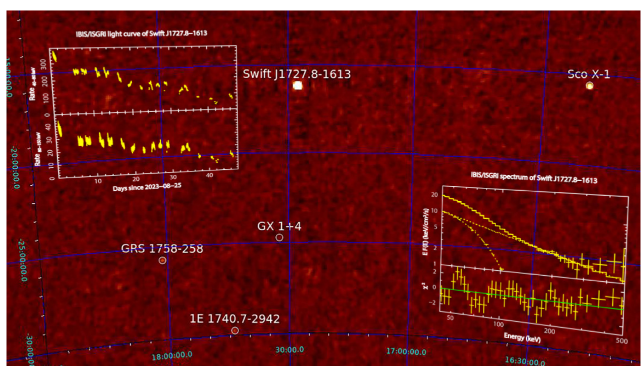
INTEGRAL

Jan-Uwe Ness (ESA-ESAC), Steven Sturner (UMBC & NASA/GSFC)

Apart from the non-performing thrusters and the use of the redundant power supply converter for the Optical Monitoring Camera (OMC), the status and performance of the platform is nominal with all prime units still in use.

SPI annealing #41 was completed on September 28, and, during camera switch-on, the performance of the Ge detector number 12 (GeD #12) was found to be degraded (energy resolution at 198 keV of 3.5 keV). Therefore, the high-voltage (HV) for this detector was decreased to 1.5 kV, improving the energy resolution to 2.3 keV, while for all other detectors, the HV was set to the nominal 2.5kV value. This lower voltage has been retained for the moment while the situation is monitored.

Tests on increasing tank temperatures and gas volume to try and optimize future de-orbiting maneuvers continue. Bypassing thermostats, tank heaters managed to increase temperatures by 1-3 degrees but effects on gas pressure have not yet been noticed. A study with TEC has begun to estimate impulse strengths depending on gas pressure and on the amount of hydrazine mixed into the cold gas.



INTEGRAL IBIS image of the sky region around the Black-Hole LMXB Swift J1727.8-1613 with the insets showing on the left a light curve in two energy bands over the first 46 days of the outburst, and on the right an energy spectrum of the source described by two main components: a thermal Comptonization and a non-thermal power-law component extending up to about 500 keV. Credit: This figure has been produced by Carlo Ferrigno (ISDC) and Melania Del Santo (INAF/IASF Palermo), assembled by Giuseppe Fiasconaro (INAF/IASF Palermo).

The 21st announcement of opportunity (AO) opened on September 4, and on September 29, the AO closed with 61 valid proposals received. The total requested time exceeded the available time by a factor 4.1. During October, the members of three science panels assessed the scientific value, importance of *INTEGRAL*, and feasibility of all proposals, leading to a priority list of proposals. The chair panel then selected 6 proposals in the A category (must do, 9.4Ms), 5 in the B category (will do, 4.3Ms), and 6 proposals into the C category (might do, 5.6Ms). The fraction of proposals in the C category is higher than in the past because the ESA Science Programme Committee (SPC) has mandated ESA to start the Post-Science Operations phase on January 1, 2025, at which time there should not be any unobserved, must-do observations in the scheduling system. In addition to the normal observations, 15 Target of Opportunity (ToO) follow-up observations were recommended, plus 3 Gamma-Ray Burst (GRB) and 1 multi-messenger observations, which request data rights without extra observing time.

Scientific observations during the reporting period were executed following the long-term plan (AO-20, covering 2023) and included coordinated observations with other ground- and space-based facilities, and several Targets-of-Opportunity. Science data continues to be routinely processed and delivered to the observers via the *INTEGRAL* Science Data Centre (ISDC) at the University of Geneva.

At the May 27 *INTEGRAL* Users' Group (IUG) Meeting, the main topic was the preparation of the *INTEGRAL* Science Legacy Archive (ISLA) and the role of the *INTEGRAL* community in driving the definition of the ISLA requirements. Based on input collected from the community, coordinated by the IUG, a requirements document has been written and is being consolidated with the IUG and members of the *INTEGRAL* community. A meeting has been scheduled for November 17 .

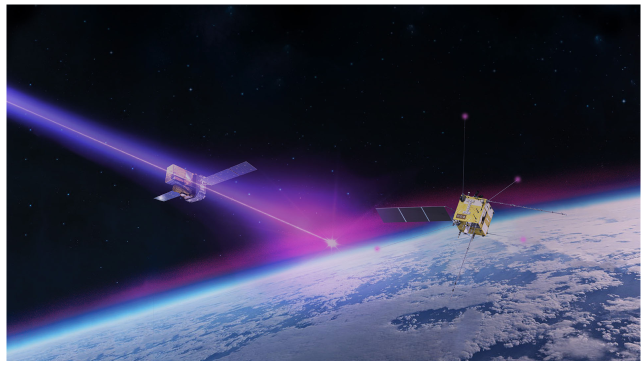
The latest science highlight is the discovery of substantial effects of the brightest Gamma-Ray Burst (GRB) ever, GRB221009A, on Earth's ionosphere. Such disturbances are usually associated with energetic particle events from the Sun, but this one was the result of an exploding star almost two billion light-years away. Analyzing the effects of the blast could provide information about mass extinctions in Earth's history.

INTEGRAL plays an important role in constraining candidate particles for dark matter (DM) by confronting predicted high-energy emission, e.g., electron-positron annihilations, with observations. DM candidate models which predict more high energy emission than observed can be ruled out (see, e.g, Cirelli et al. 2023, or P. de la Torre Luque, S. Balaji, and P. Carenza).

3C120 is a type 1 Seyfert (Sy1)/broad-line radio galaxy that exhibits intriguing variable jet activity featuring so-called "dip" and "outburst" phases. Fedorova & Del Popolo analyzed 3C120 data collected from high energy facilities including *INTEGRAL* and *XMM–Newton* and showed that its X-ray spectrum is too soft for a typical radio-loud AGN. Separating the "jet base" and nuclear (disk/corona) components in the X-ray spectrum of 3C120 allowed its variability to be studied in detail, and allowed the accretion disk/corona and jet states at different phases to be compared to predictions of "jet/disk cycle" and "magnetic plasmoid reconnection" models.

Finally, the recent bright low-mass X-ray binary Swift J1727.8-1613 has been observed with >1Ms of observing time with *INTEGRAL* under the proposals of 6 PIs. Most of the data are publicly accessible, and the teams are working together. The unique coverage in the hard X-ray band led to the only measured spectrum above 70 keV. The IBIS-ISGRI significance map shows that the new black-hole candidate outshines all the other sources.

Other *INTEGRAL* science highlights are reported as Pictures Of the Month (POM). All refereed publications making use of *INTEGRAL* data can be found here.



An image of the Earth from above showing INTEGRAL and the China Seismo-Electromagnetic Satellite. The magenta beam represents the energy of the gamma-ray burst hitting Earth's ionosphere resulting in an intense magenta-coloured diffuse cloud around the white strike point. In the figure, the magenta beam intersects ESA's Integral spacecraft. Credit: ESA/ATG Europe; CC BY-SA 3.0 IGO

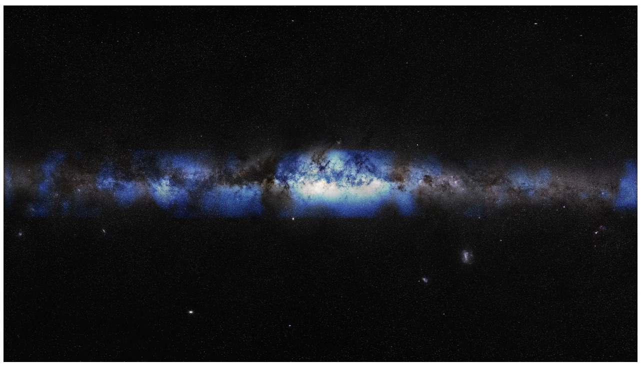
IceCube Alisa King-Klemperer (UW-Madison)

Our Milky Way galaxy is an awe-inspiring feature of the night sky, viewable with the naked eye as a horizon-to-horizon hazy band of stars. Now, for the first time, the *IceCube* Neutrino Observatory has produced an image of the Milky Way using neutrinos. In an article published in *Science* in June, the *IceCube* Collaboration, an international group of over 350 scientists, presented evidence of high-energy neutrino emission from the Milky Way.

The high-energy neutrinos, with energies millions to billions of times higher than those produced by the fusion reactions that power stars, were detected by the *IceCube* Neutrino Observatory, a gigaton detector operating at the Amundsen-Scott South Pole Station. It was built and is operated with National Science Foundation (NSF) funding and additional support from the fourteen countries that host institutional members of the *IceCube* Collaboration. This one-of-a-kind detector encompasses a cubic kilometer of deep Antarctic ice instrumented with over 5,000 light sensors. *IceCube* searches for signs of high-energy neutrinos originating from our galaxy and beyond, out to the farthest reaches of the universe.

"What's intriguing is that, unlike light of any wavelength, in neutrinos, the universe outshines the nearby sources in our own galaxy," says Francis Halzen, a professor of physics at the University of Wisconsin–Madison and principal investigator of *IceCube*.

"As is so often the case, significant breakthroughs in science are enabled by advances in technology," says Denise Caldwell, director of NSF's Physics Division. "The capabilities provided by the highly sensitive *IceCube* detector, coupled with new data analysis tools, have given us an entirely new view of our galaxy—one that had only been hinted at before. As these capabilities continue to be refined, we can look forward to watching this picture emerge with ever-increasing resolution, potentially revealing hidden features of our galaxy never before seen by humanity."



An artist's composition of the Milky Way seen with a neutrino lens (blue). Credit: IceCube Collaboration/U.S. National Science Foundation (Lily Le and Shawn Johnson)/ESO (S. Brunier)

Interactions between cosmic rays — high-energy protons and heavier nuclei, also produced in our galaxy — and galactic gas and dust inevitably produce both gamma rays and neutrinos. Given the observation of gamma rays from the galactic plane, the Milky Way was expected to be a source of high-energy neutrinos.

"A neutrino counterpart has now been measured, thus confirming what we know about our galaxy and cosmic ray sources," says Steve Sclafani, a physics PhD student at Drexel University, IceCube member, and co-lead analyzer.

The search focused on the southern sky, where the bulk of neutrino emission from the galactic plane is expected near the center of our galaxy. However, until now, the background of muons and neutrinos produced by cosmic-ray interactions with the Earth's atmosphere posed significant challenges.

To overcome them, *IceCube* collaborators at Drexel University developed analyses that select for "cascade" events, or neutrino interactions in the ice that result in roughly spherical showers of light. Because the deposited energy from cascade events starts within the instrumented volume, contamination of atmospheric muons and neutrinos is reduced. Ultimately, the higher purity of the cascade events gave a better sensitivity to astrophysical neutrinos from the southern sky.

However, the final breakthrough came from the implementation of machine learning methods, developed by *IceCube* collaborators at TU Dortmund University, that improve the identification of cascades produced by neutrinos as well as their direction and energy reconstruction. The observation of neutrinos from the Milky Way is a hallmark of the emerging critical value that machine learning provides in data analysis and event reconstruction in *IceCube*.

"The improved methods allowed us to retain over an order of magnitude more neutrino events with better angular reconstruction, resulting in an analysis that is three times more sensitive than the previous search," says *IceCube* member, TU Dortmund physics PhD student, and co-lead analyzer Mirco Hüennefeld.

The dataset used in the study included 60,000 neutrinos spanning 10 years of *IceCube* data, 30 times as many events as the selection used in a previous analysis of the galactic plane using cascade events. These neutrinos were compared to previously published prediction maps of locations in the sky where the galaxy was expected to shine in neutrinos.

The maps included one made from extrapolating *Fermi* Large Area Telescope gamma-ray observations of the Milky Way and two alternative maps identified as KRA-gamma by the group of theorists who produced them.

"This long-awaited detection of cosmic ray-interactions in the galaxy is also a wonderful example of what can be achieved when modern methods of knowledge discovery in machine learning are consistently applied," says Wolfgang Rhode, professor of physics at TU Dortmund University, *IceCube* member, and Hünnefeld's advisor.

The power of machine learning offers great future potential, bringing other observations closer within reach.

"The strong evidence for the Milky Way as a source of high-energy neutrinos has survived rigorous tests by the collaboration," says Ignacio Taboada, a professor of physics at the Georgia Institute of Technology and *IceCube* spokesperson. "Now the next step is to identify specific sources within the galaxy."

These and other questions will be addressed in planned follow-up analyses by *IceCube*.

"Observing our own galaxy for the first time using particles instead of light is a huge step," says Naoko Kurahashi Neilson, professor of physics at Drexel University, *IceCube* member, and Sclafani's advisor. "As neutrino astronomy evolves, we will get a new lens with which to observe the universe."

VERITAS — Wystan Benbow (SAO)

Following the close of another successful season of *VERITAS* operations in June 2023, *VERITAS* held a face-to-face collaboration meeting (a hybrid-format event) at the University of California, Santa Cruz, in early

July. This well-attended meeting was notable for the on-site participation of junior scientists (undergraduate and graduate students), and accordingly the meeting model was evolved from its long-standing format to improve their participation. This meeting included poster sessions, lightning talks, software tutorials, hands-on small-group working sessions, and a joint CTA-US workshop, as well as nearly 40 traditional presentations, many of which formed the basis of the ∼30 papers presented by the *VERITAS* Collaboration at the 38th International Cosmic Ray Conference (ICRC2023).

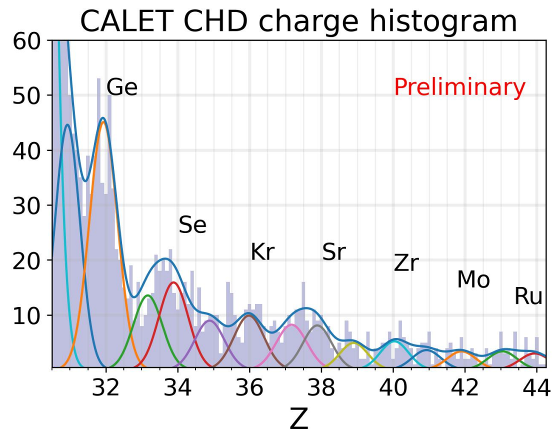
In September 2023, *VERITAS* began its seventeenth season of full-scale operations. Following an unusual summer monsoon season, the array was brought back online after the annual ≈3-month pause without any major issues. We are expecting modest yields this season due to the ongoing El Niño phenomena which typically leads to increased precipitation in Arizona. Regardless, the hardware systems continue to perform very well and this should enable a suite of Galactic and extragalactic gamma-ray studies, growth in the stellar-diameter catalog from the intensity interferometry program, and significant multi-messenger collaboration.

Over the winter, the observatory expects to complete much of its ongoing project to rapidly re-coat its mirror facets. By increasing the amount of light collected by the telescopes (by ≈50%), we are maximizing the science achievable with *VERITAS* in the near term. Observatory operations are currently funded through Summer 2025, and the *VERITAS* Science Board strongly supports continuing to operate the facility through 2028. The collaboration has already begun preparations to secure the necessary financial support to extend *VERITAS* operations for another three years.

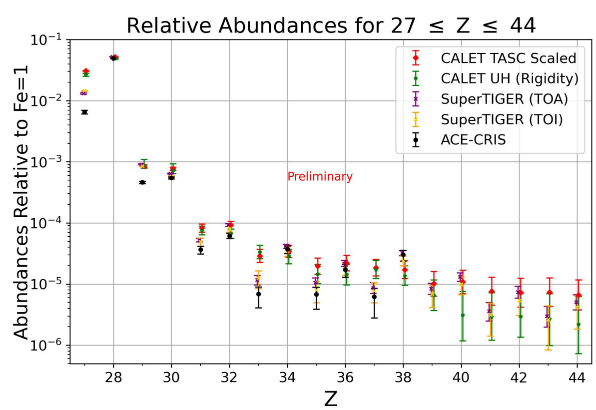
Since Spring 2023, the *VERITAS* Collaboration has published two manuscripts. The first article describes constraints derived from a *VERITAS* search for optical technosignatures, as discussed in arXiv:2306.17680. The second article details *VERITAS* and multi-wavelength observations of the blazar PKS 0735+178 in coincidence with the astrophysical neutrino candidate IceCube-211208A detected on December 8, 2021, as discussed in arXiv:2306.17819.

CALET — John Wefel (LSU)

The instrumentation (calorimeter and gamma burst monitor) for the CALorimetric Electron Telescope (*CALET*) continues to function nominally on board the International Space Station (port #9, Exposed Platform of the Kibo module), actively returning data on high-energy charged cosmic rays, gamma rays, transient gamma bursts, and heliosphere/magnetosphere events. *CALET*'s main telescope consists of a thick Lead-Tungstate total absorbing calorimeter (TASC), preceded by a mixed tungsten and scintillating fiber imaging calorimeter (IMC), preceded by a scintillator strip hodoscope (CHD). The CHD counting rates provide the means to monitor low-energy particle fluence, including precipitation events. The *CALET* collaboration team, led by Japan and including Italy and the US (Louisiana State University, lead; Goddard Space Flight Center; and Washington University in St. Louis) has continued its analysis of this rich dataset, and here we present the preliminary results for ultra-heavy (UH) cosmic rays.



The charge spectrum of the elements above Z=30 from the CALET data using the TASC for energy determination. The "best" fit for the different element peaks and the sum of the fits are shown as the superposed curves. Credit: Courtesy W. Zober, Washington University in St. Louis.



The measured relative abundances of the UH cosmic ray up to Ruthenium from balloon and space experiments are compared, with each dataset is normalized to Iron. The two separate CALET analyses are shown. Credit:Courtesy W. Zober, Washington University in St. Louis.

The UH cosmic rays are the elements beyond the iron peak (roughly Z > 28). These are elements formed by neutron capture nucleosynthesis and carry information on the cosmic-ray source material and the acceleration process. Measurements from space are particularly useful since balloon measurements must correct for the residual atmosphere above the balloon, and these corrections are particularly severe for the UH nuclei with their large interaction cross section. *CALET* can measure UH cosmic rays because its unique front-end electronics have a large enough dynamic range to cover up to or just beyond Z=40 in the CHD and the top layer of the IMC. The IMC plus TASC provide an energy measurement just as is done for the lighter cosmic rays. Separating elements in this high charge region, however, requires minimizing as many systematic errors as possible. The analysis involved using the abundant Silicon and Iron nuclei to "map" each of the scintillator paddles in both the CHDx and CHDy layers, allowing spatial non-uniformities to be eliminated, and following the mean response as a function of time to eliminate any changes in the behavior of the detectors or the electronics. This provided a well calibrated dataset that was used for UH analysis. The relative abundance of UH elements is ≈4–5 orders of magnitude below the iron peak, making this a statistically difficult measurement. However, events up to Z=44 have been isolated.

There have been previous measurements of this charge group from the balloon flights of SuperTIGER and from space with the ACE spacecraft's CRIS instrument at lower energy. In addition, the *CALET* data have been analyzed, in a separate study, using a rigidity for each event, with the rigidity derived from the geomagnetic cutoff at that point in the ISS orbit, and at the measured angles (zenith, azimuth) for each event. This cutoff rigidity was derived using trajectory tracing through a model of the geomagnetic field.

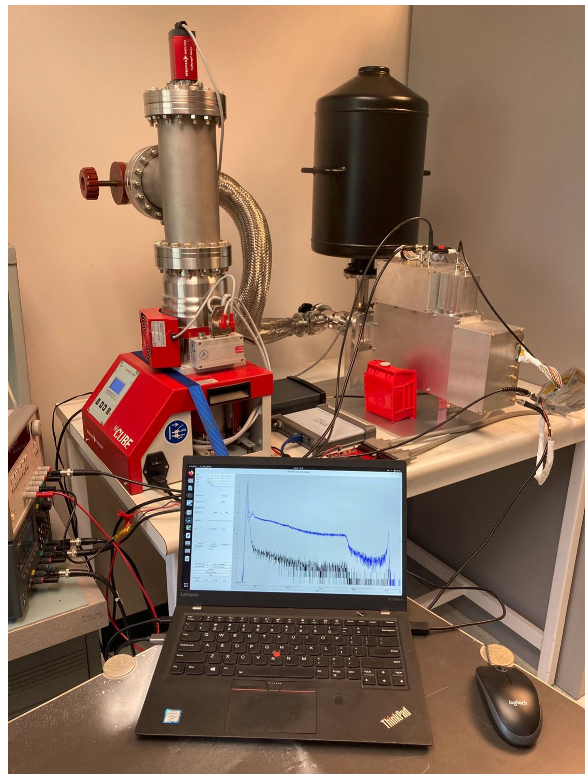
The element Nickel (Z=28) provides a check on the normalization, and all results are in agreement for Nickel. The two different *CALET* analyses are in good agreement up to Z=40 but appear to differ for higher charges, though the statistics are too low for any hard conclusions. Moreover, *CALET* and SuperTIGER are in good agreement, suggesting that the atmospheric corrections applied by SuperTIGER were well done. ACE/CRIS data come from much lower energy, but do have better charge resolution as evidenced by the odd-Z element abundances. For even-Z elements, the agreement is reasonably good. In conclusion, we are at a point where there is reasonably good confidence in the measured relative abundances up to about Z=40.

COSI: The Compton Spectrometer and Imager

John Tomsick, Andreas Zoglauer, and Alex Lowell (UC Berkeley/Space Sciences Laboratory)

COSI is a NASA Small Explorer satellite mission planned for launch in 2027. With its large field of view, it will survey the sky in the 0.2 – 5 MeV band, providing all-Galaxy and all-sky gamma-ray images for studying emission lines, including the electron-positron annihilation line at 511 keV as well as nuclear lines (e.g., ^{26}Al, ^{60}Fe, ^{44}Ti). Other *COSI* capabilities include polarization sensitivity and transient detection for Time Domain and Multimessenger (TDAMM) science. The project is in Phase B and completed a combined Systems Requirements Review and Mission Definition Review during the first part of 2023. The next milestone review is Preliminary Design Review, which will be in February 2024.

The primary *COSI* instrument consists of 16 cross-strip germanium detectors with 64 strips per side and custom readout with an Application Specific Integrated Circuit (ASIC) developed by the Naval Research Laboratory. In addition to detector and electronics development, the *COSI* team has been working on data pipeline and analysis software with yearly public data challenges (DCs). The first DC is available (DC1 github link), and the second DC is expected to be released in early 2024. More information about *COSI* can be found at the COSI website.



A vacuum test cryostat (aluminum box on the right), which encloses a 64-strip COSI germanium detector being cooled by liquid nitrogen. The computer display shows the measured ^{137}Cs spectrum with the expected 662 keV emission line and the Compton continuum. Credit: Alex Lowell

Physics of the COSMOS

Francesca Civano, Brian Humensky & Bernard Kelly (NASA/GSFC)

NASA's Physics of the Cosmos (PhysCOS) is one of three thematic programs that encompass NASA Astrophysics and seeks to answer the enduring question "How does our Universe work?". The PhysCOS Program Office, along with our counterparts in Cosmic Origins (COR) and Exoplanet Exploration (ExEP), will continue to engage with NASA HQ to implement Astro2020's broad vision of the next decade in astronomy.

The PhysCOS Program Analysis Group (PhysPAG) includes everyone interested in the PhysCOS program via seven Science Interest Groups (SIGs); this probably means you! Many of the SIGs have activities ramping up – please see their articles in this newsletter for details, including the Gamma Ray, Gravitational Wave, X-ray and Cosmic Ray SIGS. The PhysPAG provides a way for the PhysCOS community to regularly engage with the Program Office. We have 14 members in the PhysPAG Executive Committee (EC), 3 of whom are going to rotate off at the end of 2023 after a 3-year term. We thank every member of the EC for their commitment and inputs provided. The EC members organize meetings, collect and summarize community inputs, and report to the Astrophysics Advisory Committee (APAC) and NASA's Astrophysics Division Director.

The PhysCOS Program Office has been very active in the past few months collecting inputs from the community on science gaps (research areas where additional work is needed), with the goal of building a science gap list including both strategic and non strategic gaps. In particular, the PhysCOS Program Office together with NASA HQ has been soliciting community inputs on precursor science gaps, relevant to Future Great Observatories, to guide the community submissions to the Astrophysics Decadal Survey Precursor Science (ADSPS) opportunity. On the PhysCOS website, a new page with details on science gaps is available as well as a form for gaps submission, that will remain open. Your inputs are all welcome!

Several members of the PhysCOS Program Office supported NASA participation at the 2023 National Diversity in STEM Conference (Portland, OR), which was attended by several thousands of young scientists. The team supporting the booth really enjoyed interacting with the broad variety of students attending the conference and introducing them to possible career paths in NASA Astrophysics using a newly printed handout.

Members of the PhysPAG EC and the program office attended the "Windows on the Universe: Establishing the Infrastructure for a Collaborative Multi-messenger Ecosystem" workshop (October 2023) organized by NSF's NOIRLab, in partnership with NSF and NASA. The workshop aimed to foster the infrastructure for a vibrant and collaborative multi-messenger Astrophysics ecosystem and a summary of the workshop will be reported in a white paper. During the workshop, the Astrophysics Cross-Observatory Science Support (ACROSS) initiative was presented. ACROSS is led by the PhysCOS Program Office and has the goal of enabling community-validated science cases that exceed the capability of a single observatory or science team and of providing services to realize the full potential of time-domain and multi-messenger science.

Recently, the Gamma-ray Transient Network Science Analysis Group (SAG), which focused on the future of the Interplanetary Network, delivered their findings in a report available on the SAG page and on arxiv. Three SAGs are currently active and working on their findings: the New Great Observatories (focusing on the science case for simultaneous operations of the future Great Observatories), the Astrophysics With Equity: Surmounting Obstacles to Membership (AWESOM) and the Time-Domain And Multi-Messenger Astrophysics Communications (TDAMMComm). In addition, a new SAG focused on the Future Innovations in Gamma-rays (FIG) is launching now and you can fill out this brief form to sign up for its email list!

The PhysCOS team and friends supporting the NASA booth at the 2023 National Diversity in STEM Conference.

The PhysCOS program office is always eager to hear how we can assist the community in developing and carrying out your science. Feel free to reach out to the Chief Scientists by email, ask us about PhysCOS, and look for us at the special session on Sunday January 7, 2024 (9 – 3pm) at the 243rd AAS meeting in New Orleans. Details on the session can be found on its dedicated page.

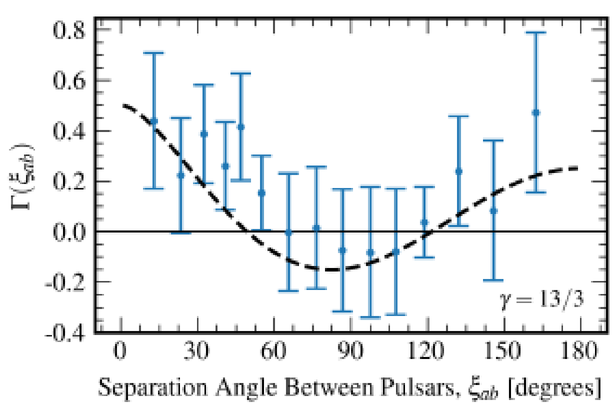
We encourage anyone interested in PhysCOS science to join our email list, where we regularly highlight items of interest to the PhysCOS community, including workshop announcements and funding or employment/internship opportunities.

The Gravitational Wave Science Interest Group

ALESSANDRA CORSI (TTU) & CHIARA MINGARELLI (UCONN/YALE)

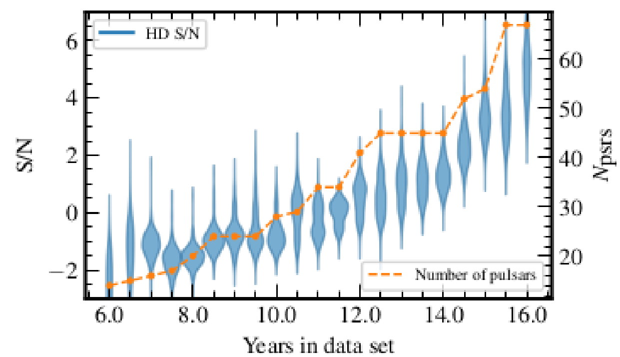
The Universe is speaking to us in different ways. As scientists we are still in the process of learning how to listen. In June 2023 the world heard about new findings from the gravitational wave universe. Scientists from the International Pulsar Timing Array (IPTA) Collaboration found the first evidence of a stochastic gravitational wave background. The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) contributed a significant part to this discovery. The NANOGrav Collaboration has been observing a set of selected pulsars with several radio telescopes and timed them since October 2007. Numerous results were published by the collaboration throughout the years, including the status of the gravitational wave search result using 5, 9, 11, 12 and 15 years of data (Demorest et al. 2013, Arzoumanian et al. 2015, Arzoumanian et al. 2017, Alam et al. 2021a,b and Agazie et al. 2023a). The latest findings though are proof that the search for gravitational waves using pulsars as an experiment is worth the wait.

Pulsar timing arrays (PTAs) like NANOGrav use the radio arrival times of millisecond pulsars as the primary source of information. Such pulsars are known to be very stable rotators. The arrival times of their radio emission are subject to various processes, one of them being variations in the proper distance between pulsars and the observer due to the passing of gravitational waves (Becsy et al. 2023). The characteristic signature of a passing gravitational wave signal is the Hellings and Downs curve which describes the time of arrival perturbations of multiple pulsars (Hellings and Downs 1983). The gravitational wave signal is buried in pulsar noise and needs to be unraveled via a careful analysis. Finding this signature curve in the radio data of millisecond pulsars is the goal in detecting gravitational waves with PTAs.



The Hellings and Downs curve of interpulsar correlations (black dashed line) and NANOGrav data (blue curves). Credit: Agazie et al. (2023)

In the Summer of 2023 NANOGrav, as part of the IPTA, reported evidence for the detection of a nanohertz gravitational wave background (GWB) using more than 15 years of data (Agazie et al. 2023a). A GWB is a noise-like broadband signal in the nanohertz range. Supermassive black holes (SMBHs) emit gravitational waves with slowly evolving frequencies which contribute to this signal. Due to their technical nature PTAs are more likely to observe a GWB rather than the signal from individual events that result in the generation of gravitational waves (as LIGO, for instance). Using in total 16.03 years of data from 67 radio pulsars with twice the amount of pulsar pairs in comparison with previously released data sets, the current NANOGrav results provide the very first compelling evidence of interpulsar correlations according to Hellings and Downs with a statistical significance ranging from 3 to 4 sigma. More data are regularly being taken by NANOGrav and the IPTA to improve these results. The persistence of the GWB signal is demonstrated in the 15 year data release of the NANOGrav Collaboration: the analysis of data slices shows a rise when examining the signal to noise ratio growth as a function of the number of pulsars and time.



The signal to noise ratio growth in dependence of time and the number of pulsars. Credit: Agazie et al. (2023)

The amplitude of the GWB signal is primarily determined by SMBH masses and the occurrence rate of close binaries. The latter depends on the galaxy merger rate, the occupation fraction of SMBHs and the binary evolution time scale (Agazie et al. 2023a). Population models are currently being studied. Apart from SMBHs also other sources such as inflation, cosmic strings, phase transition, domain walls and curvature-induced gravitational waves can contribute to a GWB. Investigations of the spectral shapes of such cosmological and astrophysical signals are currently ongoing. No matter what the next steps will be, the future of gravitational wave astrophysics looks very promising as scientists constantly explore new methods and techniques on how to listen to the whispers of our Universe.

The X-ray Science Interest Group

Grant Tremblay (CfA), Kristin Madsen (UMBC & NASA/GSFC), David Pooley (Trinity U. & Eureka Sci.) & Chien-Ting Chen (USRA & NASA/MSFC)

The NASA PhysCOS X-ray Science Interest Group (XR SIG) serves to provide quantitative metrics and assessments to NASA in regard to future observatories. Specifically, the XR SIG aims to:

- Track and analyze evolving science goals and requirements in X-ray astronomy,
- Provide an active communication forum for X-ray astrophysics (e.g., via town hall meetings at venues such as AAS and APS meetings).

- Support mission studies and concept development for future X-ray observatories.
- Analyze technology development and prioritization plans with respect to redefined science goals and the evolution of mission concepts (i.e., the XR SIG will aid the PhysPAG in analyzing technology needs).

The XR SIG joined with other science interest groups in a PhysPAG organized retreat where community engagement was discussed, and the XR SIG is committed to being the X-ray community's voice and ears to and from NASA. The priority is to represent the X-ray community in the PhysCOS activities for the development of NASA Astrophysics Future Great Observatories. To that end the XR SIG has been sending out announcements for input to the Precursor Science Gaps, which are integral to defining the next strategic missions, including Great Observatories, Probes, and any future TDAMM-related missions. At the 243rd AAS meeting in New Orleans the XR SIG will hold an open forum, discussing the current plans and outlook for technology development for X-ray instrumentation for a Future Great Observatory.

In other mission related news, July 2023 saw the much anticipated release of the Announcement of Opportunity for the Astrophysics Probe Explorer (APEX). This has kept the community very busy, and a total of five X-ray Probe proposals were submitted on Nov 16. The Step-1 selection is currently planned for Q4 2024, and the final down-select to occur in Q2 2026. The launch of the Probe will be no later than mid-2032.

The next X-ray mission to launch will be the Einstein Probe (EP), a mission of the Chinese Academy of Sciences (CAS) dedicated to time-domain high-energy astrophysics. Its primary goals are to discover high-energy transients and monitor variable objects. To achieve this, EP employs a very large instantaneous field-of-view (3600 square degrees), along with moderate spatial resolution (FWHM 5 arcmin) and energy resolution. EP also carries a narrow-field X-ray telescope for follow-up observations. EP is a CAS mission in collaboration with ESA, MPE and CNES. The launch date is tentatively set to January, 2024.

You can subscribe to the XR SIG "News and Announcements Email List", and if you wish to serve on the XR SIG please reach out to the PhysPAG EC.

The Gamma-ray Science Interest Group

Eric Burns (LSU), Manel Errando (WashU at St. Louis) & Justin Finke (NRL)

The GRSIG organized virtual sessions on June 16 and September 22. The June session included talks by Peter Michelson on "Lessons Learned from the 1997 Roadmap for Gamma-ray Astronomy," and by Tiffany Lewis on "Key Investments in the High-Energy Space Infrastructure Environment for 2040". There was also a discussion on a future gamma-ray SAG. The virtual session in September included a discussion on the new SAG (Future Innovations in Gamma-ray Science Study Analysis Group, or FIGS SAG); a discussion of PhysPAG Science Gaps; and a science talk by Joshua Foster on indirect dark matter detection in the gamma-ray band.

The GR SIG had an open call for chairs for the FIGS SAG from July 11 to August 10. We are happy to announce the chairs for this new SAG: lead co-chairs Chris Fryer and Michelle Hui; and co-chairs Paolo Coppi, Milena Crnogorčević, Tiffany Lewis, Marcos Santander, and Zorawar Wadiasingh. The FIGS SAG will focus on identifying future science drivers, necessary capabilities, and priorities for the future of gamma-ray astronomy. The SAG's Terms of Reference was presented to the Astrophysics Advisory Committee for their approval on October 19. There will be a FIGS SAG kickoff meeting at the American Astronomical Society meeting In New Orleans in January 2024. Those interested in participating can sign up here.

If you are interested in the GRSIG, please consider subscribing to the GRSIG mailing list. The SIG will continue organizing events at different national and international meetings and invites members of the gamma-ray community to contact the current chairs (Eric Burns, Manel Errando, and Justin Finke) with any inquiries or feedback regarding the GRSIG program.

The Cosmic Ray Science Interest Group

Andrew Romero-Wolf (JPL/Caltec) & Athina Meli (NC A&T State U.)

The Cosmic-Ray Science Interest Group (CR SIG) aims to act as a forum to discuss the current status of cosmic-ray and high-energy neutrino science and to provide input for NASA regarding future goals for the field.

As such, the CR SIG encourages members of the community to provide comments, questions and updates based on their present work and future plans for cosmic ray research relevant to NASA's mission. The CR SIG hosted a virtual forum on the topic of the Origin of Heavy Elements. Recordings and presentation slides for all virtual forums and meetings can be found online at the NASA PhysCOS CRSIG website.

Moreover, the chairs (Andres Romero-Wolf and Athina Meli) invite the members of the CR community to contact them directly email andrew.romero-wolf@jpl.nasa.gov and ameli@ncat.edu with any inquiries or feedback regarding the NASA cosmic-ray program.

People interested in the activities of the group are also invited to join our mailing list, available in the NASA PhysCOS website.

HEASARC

L.Angelini (NASA/GSFC) and A. Ptak (NASA/GSFC)

The HEASARC director, Alan Smale, retired at the end of August 2023, and Andy Ptak is stepping in as director for the next six months, until the director position will be filled on a permanent basis. Best wishes to Alan and congratulation to Andy!

As part of NASA's Open Science Initiative, and in collaboration with the Amazon Web Services (AWS) Open Data project, HEASARC data are now available in the cloud at the AWS Open Data Registry. A tutorial is available to explain how to access the data on AWS, and data for operating missions are updated regular. Having the data on the cloud and taking advantage of large computing capability and data storage is the first step towards next-generation cloud computing.

While HEASARC is working in the next-generation platform, as a reminder, HEASARC@SciServer is the current science platform, modest in compute resourses compare to the cloud, where however users can analyze the HEASARC data holdings without having to download data or install any software.

HEASARC continues to sustain data ingest of these operating missions: *CALET*, *Chandra*, *Fermi*, *INTEGRAL*, *IXPE*, *MAXI*, *NICER*, *NuSTAR*, *Swift*. HEASARC will soon be ingesting *XRISM* data, and it is in preparation to host the BurstCube data which launch is foreseen in Spring 2024.

In Jul 2023, HEASARC released version 6.32 of the HEASoft package, with a patch (6.32.1) on Aug 2023. The release included major updates of the software packages for the operating missions *NICER* (version 11a), *IXPE*(version 3.1.0), and minor update for *Swift* and *MAXI*. This release also incorporate numerous updates for the mission-independent packages, FITS manipulation packages, the XSPEC spectral analysis package, as well as updates for the *RXTE* package mission (which ended operation in 2012). See the complete 6.32 release notes for more detailed information. The next HEASoft release is planned for spring 2024, and is to include software updates for all the operating missions archived at the HEASARC.

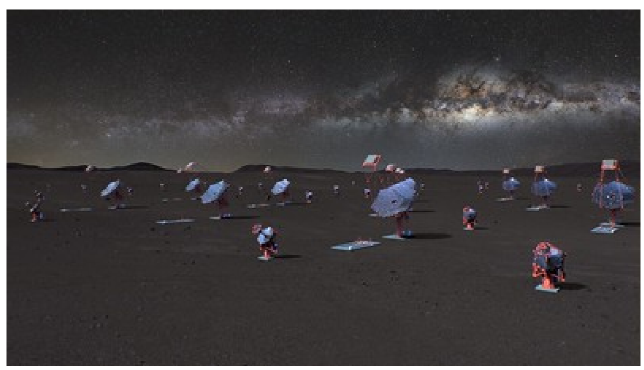
The Cherenkov Telescope Array Observatory (CTAO)

David Williams (UCSC) & Alba Fernández-Barral (CTAO)

The Cherenkov Telescope Array Observatory (CTAO) is organizing the 2nd CTAO Science Symposium to take place in Bologna, Italy, April 15 – 18, 2024. The symposium, which aims to become a meeting point for researchers worldwide interested in very high-energy astrophysics, will focus on the new phase of development and growth that the Observatory is undergoing, and its subsequent upcoming scientific impact. It will delve into the status of gamma-ray astronomy and beyond, with highlighted results from other instruments and observatories, as well as the big open questions in the field and how to address them. Registration and abstract submission are now open.

On September 6, 2023, the CTAO's two governing bodies, the Board of Governmental Representatives (BGR) and the CTAO gGmbH Council, gathered to agree on the significant forthcoming measures to advance the Observatory to its construction phase. During the meeting, both bodies unanimously certified their commitment to the progress of the CTAO, including a foreseen endorsement of up to approximately 30 million euro for 2024. This represents a significant increase in annual funding, which will enable the Observatory to not only move forward with substantial infrastructure development but also to double its workforce.

The CTAO gGmbH and its partners have carried out extensive design and pre-construction activities, including the advancement of telescopes, such as the construction of the LST-1, the prototype of the Large-Sized Telescope under commissioning on the CTAO-North site in La Palma, Spain. In 2024, the Observatory plans to open at least 30 new positions and start major infrastructure development including building roads, power systems, and foundations for its southern array site in the Atacama Desert (Chile). Among the positions already available is that of CTAO Project Manager, responsible for leading the construction and commissioning of the Observatory and directing the Project Office.



Rendering of the CTAO-South site. Credit: CTAO.

Also in September, the U.S. National Science Foundation awarded $3.9M for the project "WoU-MMA: Development of the Optical Alignment Systems for the Medium-Sized Telescopes of the Cherenkov Telescope Array." A collaboration between the University of California Santa Cruz, UCLA, the Smithsonian Astrophysical Observatory, NASA Goddard Space Flight Center, DESY Zeuthen, and the University of Tübingen, the project funds the optics alignment system for the first six Medium-Sized Telescopes (MST) to be installed at the

CTAO sites, five in the north and one in the south. It also funds an upgraded optics alignment system for the prototype Schwarzschild-Couder Telescope at the Whipple Observatory in Arizona. The Schwarzschild-Couder Telescope is an alternative MST design that achieves significantly improved performance with an optical system including a secondary mirror and is a candidate for additional telescopes to enhance the CTAO.

These steps will bring the Observatory closer to realizing its planned 64 telescopes, which will deliver an unprecedented sensitivity in the quest to unveil new discoveries in the high-energy gamma-ray Universe.

Athena

Andy Ptak (NASA/GSFC), Rachel Osten (STScI), Lia Corrales (UMich), Matteo Guianazzi (ESA), Didier Barret (IRAP), Paul Nandra (MPE), Kristin Madsen (NASA/GSFC) & Rob Petre (NASA/GSFC)

On November 8, ESA's Science Programme Committee (SPC) endorsed a rescoped version of the *Athena* X-ray observatory. The SPC has recognized that *NewAthena*, as a flagship mission of the ESA Science Program, will transform our knowledge in almost every corner of modern astrophysics. This great achievement has been the result of a year-long collective design effort by ESA, the Instrument Consortia, and the Science Redefinition Team (SRDT) with the active participation of many members of the *Athena* community. This effort led to a new mission concept that is technically and financially affordable, while enabling transformational science. A key role in demonstrating the flagship nature of *NewAthena* has been played by the SRDT, who presented the excellent science case of *NewAthena* to the meetings of the Advisory Structure of the ESA Science Program. The US participants on the SRDT are Lia Corrales and Rachel Osten. It is expected that the industrial activities will restart in the second quarter of 2024, aiming at Mission Adoption in 2027. The current expected launch date is 2037.

The current NASA Athena contribution plan is to supply the X-IFU sensor and readout, a 4.5 K cryocooler, consultation on the WFI ASIC and background modeling, with later contributions to the science ground system, including a NASA *Athena* data center. The NASA contribution of optics testing at the MSFC XRCF is being phased out. Kristin Madsen, who has been part of the NASA *Athena* team since 2020, has been appointed as the deputy NASA *Athena* project scientist.

Laser Interferometer Space Antenna

James Ira Thorpe (NASA/GSFC)

The European Space Agency's Mission Adoption milestone continues to be the primary focus of the *LISA* community. The Adoption decision, which is taken by ESA's Science Programme Committee (SPC), represents an endorsement of the specific mission implementation developed during the definition phase and an approval to proceed with implementation. ESA is currently planning to propose *LISA* for Adoption at a special meeting of the SPC in late January, 2024. A number of activities have been completed or are underway to support that proposal, including:

- The Instrument Systems Requirement Review (I-SRR) was held by ESA and completed successfully in June. The I-SRR was a comprehensive review of the requirements and development status of the critical technologies for the LISA insturment, including those provided by NASA (telescopes, lasers, and charge management devices.)
- The ESA Science Study Team delivered the *LISA* Definition Study Report to the SPC in September. This document, also know as the "Red book", presents a comprehensive summary of *LISA*'s science case, mission design, payload elements, ground segment, and management approach. The Definition Study Report will be published after the Adoption process is complete.
- The international agreements that formalize the *LISA* partnership are actively under development. These include the ESA-NASA Memorandum of Understanding and the ESA-Member State Multi Lateral Agreement. After a series of intense discussions on topics including data policy and science participation, these agreements are nearing completion.
- The ESA Mission Adoption Review (MAR), with a primary focus on the two spacecraft designs developed by ESA's study contractors, kicked off in September, with a board meeting scheduled for early January 2024.

In parallel with the programmatic activities described above, the *LISA* technical teams in Europe and the US continue their work to develop the key *LISA* hardware items. One highlight was the delivery of a structural-thermal model of the *LISA* telescope from L3 Harris Corp. to the University of Florida for specialized dimensional stability testing. By attaching small witness mirrors to the all-glass telescope model and locking a laser to the resulting optical cavity, the UF team track changes of the telescope length to the few picometer level. Progress also continues in defining both the technical and management approaches for the *LISA* science ground segment. This important element of *LISA* will receive the data from the three individual spacecraft and perform an extensive amount of processing to produce observables which are sensitive to gravitational waves, search these observables for potential signals, and filter the results of these searches into a catalog of sources. The ground segment efforts in Europe and the US will be independently funded and managed but will coordinate to perform cross checks and a consolidated catalog for public release.

Looking forward to next year, the *LISA* community is eagerly anticipating Mission Adoption. Assuming this is successful, ESA will begin the process of selecting a prime contractor for the implementation phase. NASA will also transition its effort from a Study to a Project. The *LISA* Consortium, which has been the focus for the LISA community since the 2017 Mission Proposal, is preparing to reorganize itself to serve the needs of the implementation phase. An open call was issued in September for members to join the Consortium Constituent Council which will define this new organization.

HEAPoetry Corner

The Brain — is Wider than the Sky

The Brain—is wider than the Sky—
For—-put them side by side—
The one the other will contain
With ease—and You—beside—

The Brain is deeper than the sea—
For—hold them—Blue to Blue—
The one the other will absorb—
As Sponges—Buckets—do—

The Brain is just the weight of God—
For—Heft them—Pound for Pound—
And they will differ—if they do—
As Syllable from Sound—

— Emily Dickenson