November 2024

The High Energy Astrophysics Division Newsletter

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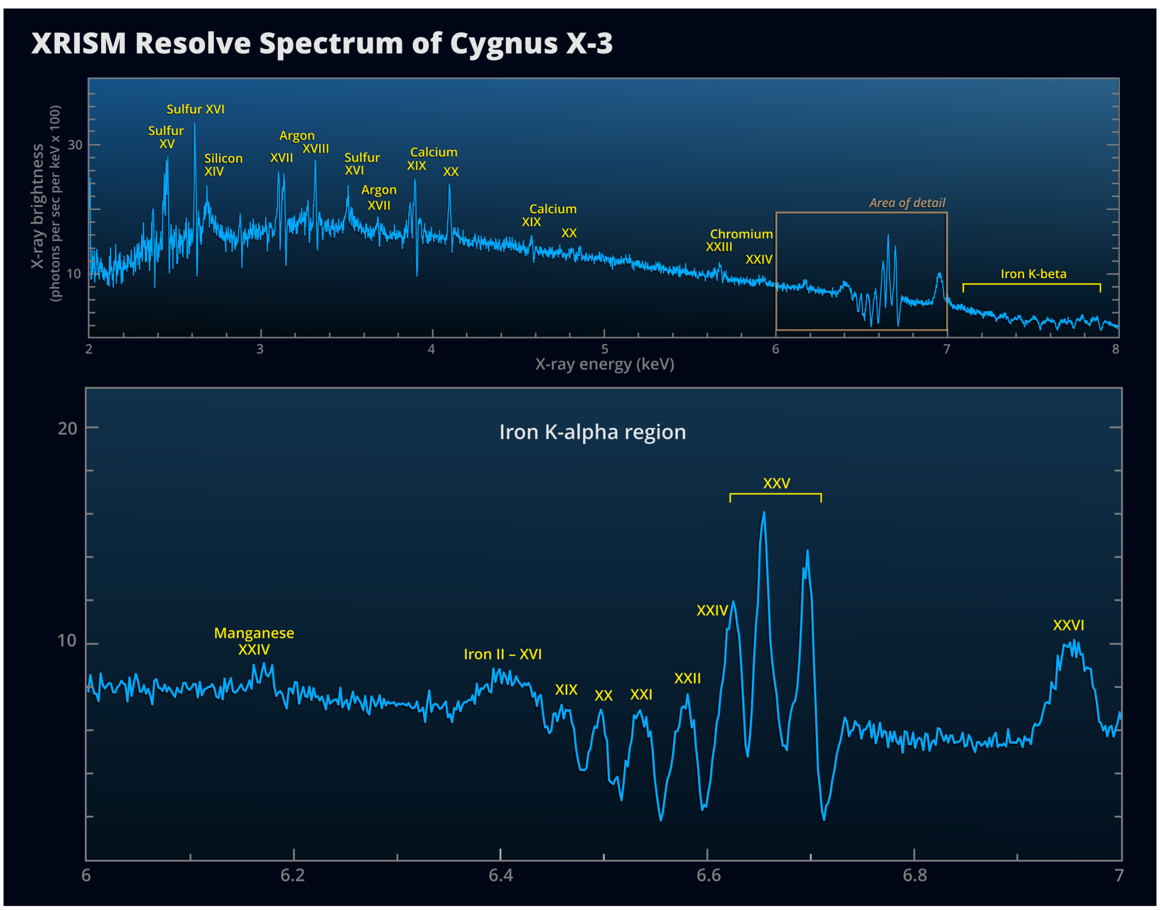

XRISM's Resolve instrument captured data from the high-mass X-ray binary Cygnus X-3, described in the text. More information can be found in the ApJL publication, posted on arXiv. Credit: NASA/XRISM Resolve

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The View from the Chair

Kristin Madsen (NASA GSFC)

This year continued to be stressful for many of our members, and just the other day, the AAS President, Dara Norman, sent out a statement ensuring that the AAS remains steadfast in continuing its mission: "to enhance and share humanity's scientific understanding of the universe as a diverse and inclusive community." This remains true for the HEAD as well, and the HEAD is committed to being a platform where our high-energy community can share its opinions equitably and respectfully.

In October, the results of the APEX Probe selection were announced. All the submitted X-ray probes were ranked highly, but NASA only has funding to support two Phase A studies, and they selected the AXIS X-ray mission concept along with the PRIMA Far-IR mission concept. Congratulations to the AXIS team on their selection! They are eagerly seeking your support, so don't hesitate to contact the AXIS team to get on board. I would also like to take a moment to thank all the other teams that were not selected. It takes an inordinate level of dedication and, in some cases, personal sacrifice to put together proposals of this magnitude, so appreciate your colleagues who went through this crucible to advocate for our science.

HEAD elections are coming up in December, and the secretary, treasurer and two executive committee positions are on the ballot this year. I hope you will all take a moment out of your busy schedule to cast your vote. The results will be announced at the HEAD Business meeting, which will take place at the 245th AAS winter meeting at National Harbor in DC. At the Business meeting, we will also announce the winners of the Bruno Rossi Prize, Distinguished Career Prize, Mid-Career Prize, Early-Career Prize, Dissertation Prize, and Innovation Prize.

In addition, this year, we will present a proposed bylaw amendment at the Business Meeting, which introduces a new Executive Committee officer position for a Deputy Secretary. Over the last couple of years, the demands on the HEAD Secretary have increased significantly, and the purpose of the Deputy Secretary is to ease the burden of the tasks and ensure a smooth transition between secretaries. The new Deputy Secretary's term is two years, and they transition to the Secretary position for another 2-year term. A special election for the Deputy Secretary will be held following the bylaw amendment, which the members must vote on.

We continue to strive towards inclusion and to help students and early career members connect with our community through our meetings and activities. To bridge the gap between meetings, we host our Frontiers Seminars, which focus on talks by students and early career people. The cadence is approximately every 2 – 3 months. You can sign up or propose a talk at the HEAD Frontier Seminar page.

As of Fall 2024, the HEAD has 1360 members (up from 1,215 in 2023), and I am very pleased to report that most of this increase comes from undergraduate and graduate students after we changed the HEAD registration fee to be complimentary for them. We are committed to making our meetings more affordable for everyone, and we hope to see many of you next year at the St. Louis meeting (October 10 – 16th).

News from the HEAD

Megan Watzke, the HEAD Press Officer (CfA)

This summer marked the 25th anniversary of the Chandra X-ray Observatory (with XMM-Newton's similar milestone not far behind in December). There was a great deal of press and public engagement around this high-energy birthday, ranging from Chandra being the subject of a question on the game show Jeopardy! to stories in the New York Times and on National Public Radio.

There was also a flurry of media attention around NASA's selection of its next Probe missions, which included the Advanced X-ray Imaging Satellite (AXIS). The first science results were released from XRISM in September, and eROSITA is continues to release exciting results. Look for more media coverage to come as the field of high-energy astronomy continues to evolve.

June 20, 2024: "Too young to be so cool: lessons from three neutron stars"

July 16, 2024: "XMM-Newton shows million-degree gas in Abell 2390"

July 22, 2024: "25 Images to celebrate NASA's Chandra 25th anniversary"

July 25, 2024: "NASA's Fermi finds new feature in brightest gamma-ray burst yet seen"

September 20, 2024: "XRISM unveils black hole and supernova remnant surroundings"

October 9, 2024: "Black hole destroys star, goes after another, NASA missions find"

October 17, 2024: "NASA's IXPE helps researchers determine shape of black hole corona"

November 4, 2024: "NSF NOIRLab astronomers discover the fastest-feeding black hole in the early universe"

November 19, 2024: "Unveiling the 'ghost' baryonic matter"

XRISM

Brian J. Williams, Richard L. Kelley (NASA GSFC)

The X-ray Imaging and Spectroscopy Mission (XRISM), is an international JAXA/NASA collaboration with participation from ESA. XRISM began science operations in February of 2024 and in September 2024, completed the Performance Verification (PV) phase of the mission. During the PV phase, the performance of the instruments was 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. All observations taken in the PV phase will go public one year after the conclusion of the phase. This public data release will happen in the late summer of 2025.

As of September 2024, XRISM is now in the General Observer phase of the mission, in which it will remain for the duration of its lifetime. Worldwide, we received over 300 proposals for the Cycle 1 solicitation, which was run as three parallel solicitations from the U.S., Japan, and Europe. The overall oversubscription rate was ∼4.5. The results of the Cycle 1 peer review are can be found here.

XRISM is performing exceptionally and already conducting exciting science despite an issue with the aperture door covering its detector. The door, designed to protect the detector before launch, has not opened as planned after several attempts. The door blocks lower-energy X-rays, effectively cutting the mission off at 1.7 keV compared to the planned 0.3 keV. The XRISM team will continue to explore the anomaly and is investigating different approaches to opening the door. The Xtend instrument is unaffected. There have been three attempts thus far to open the door. A fourth attempt will be evaluated for feasibility after the conclusion of the Cycle 1 observing program in the summer of 2025.

In the meantime, the results above 1.7 keV are spectacular. The cover of this newsletter shows a spectrum of the high-mass X-ray binary Cygnus X-3. The XRISM/Resolve spectrum of this object is the most detailed yet made. The system consists of a compact object (likely a black hole) and a Wolf-Rayet star. High-resolution X-ray spectroscopy uniquely probes the system's gas dynamics and reveals a rich set of emission and absorption lines with complex profiles. They indicate two gas components: a background wind from the star and a turbulent structure – perhaps a wake carved into the wind – located close to the orbiting companion.

XRISM will have a presence at the upcoming American Astronomical Society meeting in January 2025 in National Harbor, MD. We will have a 90-minute Special Session on Monday morning, January 13th, as well as a booth presence in the Exhibit Hall throughout the week. Come and get your XRISM swag and hear more about new results.

The 3rd XRISM Community Workshop will be held at the University of Maryland from February 3-5th, 2025. The primary objective of this workshop is to prepare the astronomical community for the upcoming Cycle 2 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 2 proposals, with the goal of maximizing the use of the unique high resolution spectroscopic and imaging data provided by XRISM. The workshop 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 12, 2024. 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 12, 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.

The Announcement of Opportunity for Cycle 2 is expected to be released in February 2025, with a due date in May 2025. 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.

Finally, the 1st International XRISM Symposium is planned for October 20 – 24th, 2025, in Kyoto, Japan. This will be open to the general astronomical community and will feature science results from both the PV and the GO phase. More information will be released soon, and we hope to see you there!

The Einstein Probe (Tianguan)

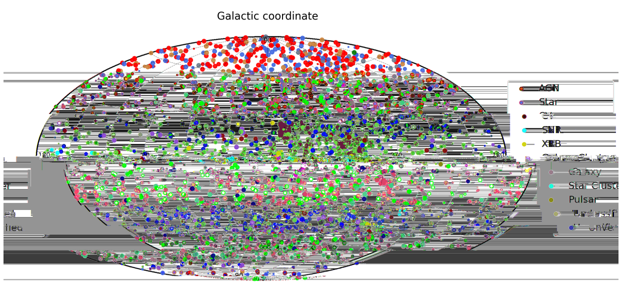
Weimin Yuan, Congying Bao, Hui Sun (NAO,CAS), on behalf of the EP team

The Einstein Probe (EP) is a space X-ray observatory dedicated to time-domain astronomy, with the main scientific goal being to detect cosmic transients in X-ray at unprecedented sensitivity. This international collaborative mission is spearheaded by the Chinese Academy of Sciences (CAS) and with participation from the European Space Agency (ESA), the Max Planck Institute for Extraterrestrial Physics (MPE) in Germany and the French National Centre for Space Studies (CNES). EP was successfully launched from the Xi'chang satellite launch center on January 9, 2024.

Equipped with two complementary instruments, EP is capable of detecting and characterizing cosmic transients, as well as monitoring variable celestial objects. The Wide-field X-ray Telescope (WXT) has the capability to cover an extensive area of 3,850 square degrees of the sky in a single observation, achieving a spatial resolution of 5 arcminutes. Its innovative design allows for the detection of faint X-ray transients by employing lobster-eye optics. The Follow-up X-ray Telescope (FXT) comprises two identical units, each possessing an effective area of approximately 300 cm^2 at 1 keV each. The primary function of the FXT is to conduct in-depth characterization and precise localization of newly discovered transients.

During survey observations conducted by the WXT, the FXT simultaneously gathers data while being pointed toward known sources, thereby optimizing the efficiency of the science operations.

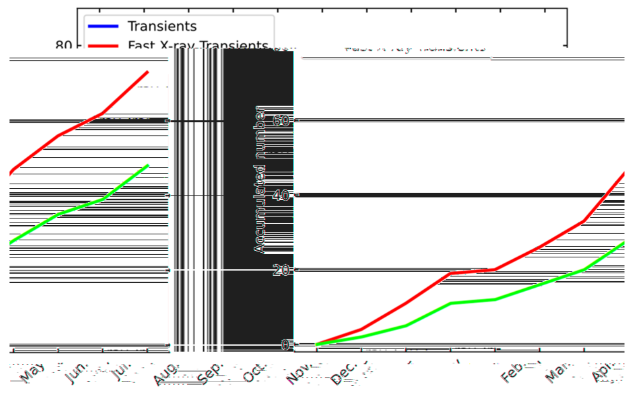
Since its launch, EP has been performing extensive tests of the spacecraft and payloads, along with meticulous calibrations during the commissioning phase. Both the spacecraft and the WXT and FXT have been performing well and have been validated to meet all requirements. The onboard data processing and triggering system has been demonstrated to function as designed, successfully triggering onboard follow-up observations with the FXT and enabling quick data downlink of alerts. The EP Science Center (EPSC) has been disseminating alerts of transient and variable sources to the astronomical community as quickly as possible. For transient alerts triggered onboard, the time latency for the automated dissemination of GCN notices can be as short as about 5 minutes. The announcement of transients found from analysis of the science data transmitted through the standard X-band telemetry is subject to a delay of typically several hours or longer.



Distribution of X-ray sources detected by EP-WXT in the Galactic coordinates. Colors correspond to source types. Credit: EPSC/CAS

EP officially began its nominal science operations phase in late July, 2024, following the successful conclusion of the commissioning phase review. By November 20, 2024, during the commissioning phase and the initial stage of the nominal operations, EP had detected more than 7000 X-ray sources, the majority of which were already cataloged. As its key science goal, EP has detected over 70 significant X-ray transients and about 500 stellar flares, along with many fainter candidates. Furthermore, EP has also detected outbursts from a considerable number of known sources. The EP science center has issued over 100 GCN/ATel alerts to the community, thereby triggering follow-up multi-wavelength observations with ground-based and space-borne telescopes. The EP has detected many different types of transients, including outbursts from stars, white dwarfs, neutron stars, black holes, gamma-ray bursts (GRB), supernovae, tidal disruption events (TDE), and potentially novel types yet to be classified. These transients display a diversity of timescales, ranging from seconds to months, and they are located at distances extending from the neighborhood of our solar system to the high-redshift universe.

Among these EP-detected transients, two-thirds are fast transients lasting for from seconds to several thousand seconds. Of particular interest, only about one-third of these fast X-ray transients were found to be associated with GRBs detected by current GRB detectors such as Fermi/GBM, Swift/BAT, Konus-Wind, GECAM and SVOM. EP is poised to substantially enlarge the sample of fast X-ray transients, on the legacy basis laid by the previous Beppo-SAX and HETE-II missions. This endeavor is anticipated to provide valuable insights into the nature of these mysterious fast X-ray transients.



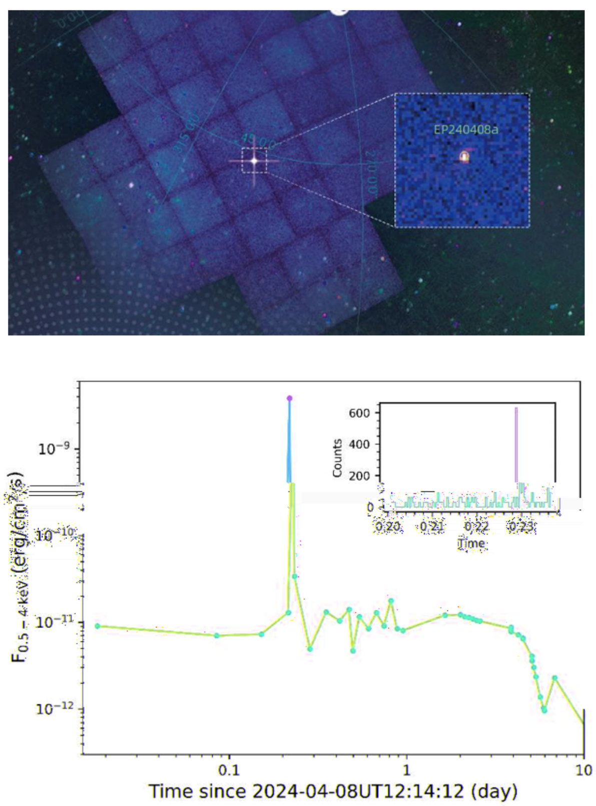
Number of EP detected X-ray transients with time since launch, as of November 20, 2024, for overall transients (blue) and specifically fast transients (red) with timescales up to several thousand seconds. Credit: EPSC/CAS

The most distant transient identified by the EP is EP240315a, a gamma-ray burst (GRB) with a redshift of 4.86, exhibiting X-ray emissions for over 1,000 seconds. Data obtained from EP suggests that relativistic jets are formed earlier and have a longer duration following the core collapse of a massive star than previously inferred from X-ray and gamma-ray observations alone. This event underscores the capacity of EP to detect high-redshift GRBs and contributes to a deeper understanding of GRB physics and the mechanisms of jet production (Liu Y., et al. accepted for publication in Nature Astronomy). Additionally, follow-up radio observations have provided corroborative evidence of the powerful relativistic jets produced by this extraordinary cosmic explosion (Ricci R., et al. 2024 ApJL, accepted).

On April 8, 2024, EP discovered a transient designated as EP240408a and recorded an intense X-ray flare lasting for only 12 seconds with peak brightness 300 times the underlying transient X-ray emission, which vanished in about 10 days. The distinctive features of this event, coupled with its temporal, X-ray, and broadband spectral properties, suggest that EP240408a may signify a potentially new category of transients (Zhang W., et al., 2024 Science China).

On April 22, 2024, a gravitational event wave

S240422ed was triggered by LIGO. EP promptly initiated a comprehensive search for its potential X-ray counterpart in the following four and half days. The EP-WXT provided complete coverage of the 90% gravitational wave error region. In conjunction, EP-FXT conducted over 200 observations of more than 100 galaxies, resulting in the detection of approximately 1200 sources. A possible X-ray counterpart candidate EP240426a and its potential optical counterpart were found. However, archival data show that this source is probably related to ongoing AGN variability, suggesting it may not be associated with S240422ed. Nevertheless, the large field of view of EP-WXT and the rapid response capabilities of the satellite position EP as a powerful instrument to search for potential X-ray counterparts of future gravitational wave events.



Top: Discovery image of the peculiar X-ray transient EP240408a obtained by EP-WXT. Bottom: The X-ray lightcurve of EP240408a; an intense yet brief flare is clearly visible around 0.2 days, with a close-up shown in the inset (Zhang W. et al. 2024). Credit: EPSC/CAS

On October 31st, the CAS held a satellite handover ceremony, marking the successful conclusion of the mission development phase and the delivery of EP to the science team. At this occasion, the CAS unveiled the official Chinese name for the mission, "Tianguan". This name is derived from the ancient Chinese terminology for the “Tianguan guest star” (in Chinese history transient phenomena such as novae and supernovae were referred to as “guest stars”) located in the Tianguan sky region in the ancient Chinese constellations. This celestial event, known historically as the supernova SN 1054, was observed at its outburst and documented by ancient Chinese imperial astronomers in AD 1054 during the Song Dynasty. SN1054 ultimately led to the formation of the Crab Nebula and its pulsar, which continue to be of significant interest in contemporary astronomical research.

More information on the EP mission can be found at the EP website.

The Imaging X-ray Polarimetry Explorer (IXPE)

PHILIP KAARET & STEVE O’DELL (NASA/MSFC)

Three years after its launch, IXPE continues to produce outstanding science. A set of papers reviewing its scientific accomplishments was published as a special issue in *Galaxies*, “X-Ray Polarimetry: A New Era Begins with the Imaging X-Ray Polarimetry Explorer”. These review papers, which are science-topic focused, provide a useful resource—particularly for those still unfamiliar with X-ray polarization. The review “Probing Magnetic Fields in Young Supernova Remnants with IXPE” by Pat Slane et al. made the October 2024 cover.

IXPE has transitioned fully to a General Observer (GO) mission. By the GO Cycle 2 deadline (August 29, 2024), 141 proposals were received, which is an increase over Cycle 1. Cycle 2 GO observations are planned to start in mid-January 2025.Currently, the IXPE Project is preparing to submit its proposal (due December 12) to the 2025 Astrophysics Senior Review of Operating Missions, requesting a mission extension to continue the GO program at least 3 more years.

To help the community in preparing proposals, the NICER and IXPE teams held a joint workshop in summer 2024. Of the 310 registrants, 65% were not previously familiar with IXPE analysis and 50% were interested in leading an IXPE GO proposal. An indication of success is that 22% of Cycle 2 proposals were led by scientists who did not propose in Cycle 1. The talks from the workshop are available (slides and recordings) and a github site provides data analysis tutorials from the meeting. These are a great resource to get started with (or delve deeper into) IXPE data analysis.

On September 16 – 19 , Universities Space Research Association (USRA) hosted the International X-ray POlarimetry Symposium (IXPO) in Huntsville. Presentations from the meeting—including several invited reviews—are available from the IXPO Symposium website.

Martin Weisskopf and Paolo Soffitta will give the award talks for the 2024 HEAD Bruno Rossi Prize at the AAS Meeting in National Harbor, MD, on Wednesday, January 15, 2025. We hope that you can attend.

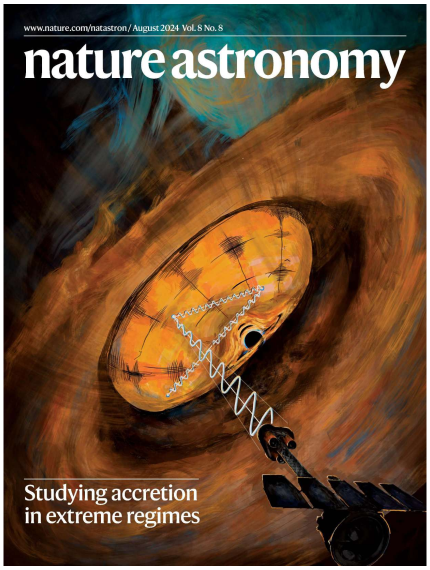


Illustration of IXPE viewing Cyg X-3. X-rays that IXPE observes from this source are scattered from the inner surface of the outflow surrounding the black hole. Credit: Alexander Mushtukov.

This issue's IXPE science highlight is Cyg X-3 (Veledina et al. 2024) and its relation to super-Eddington accretion. Super-Eddington accretion by black holes is an important process which enables rapid black hole mass growth in stellar-mass and supermassive black holes. IXPE observations of the enigmatic X-ray binary microquasar Cyg X-3 show that it is a super-Eddington accretor. The X-ray polarization degree is high (above 20%) and nearly energy-independent; the polarization angle is orthogonal to the radio jet. Both polarization degree and position angle vary with orbital phase. These properties indicate that the observed X-rays are not direct emission from the central accretion flow but rather result from scattering on the inner surface of an accretion funnel. This result appeared on the August 2024 cover of *Nature Astronomy*. An optically thick wind emanating from the accretion disk allows X-rays to escape directly only in a narrow cone directed away from IXPE's line of sight. X-rays observed by IXPE have been reflected by the walls and are thus highly polarized due to scattering. The IXPE data provide the first clear indication of super-Eddington accretion in Cyg X-3. Thus, this source serves as a laboratory for studying supercritical accretion.

The Chandra X-ray Observatory

EDWARD MATTISON & MARK WEBER (SAO); STEVEN EHLERT & STEVE O'DELL (NASA/MSFC)

The Chandra X-ray Observatory (CXO) marked its 25th year of operations on July 23, 2024 . Now in its 26th year, Chandra continues its highly successful science mission. With its unique capability for sub-arcsecond X-ray imaging, Chandra provides essential information for accomplishing many X-ray and multi-wavelength investigations in current astrophysical research.

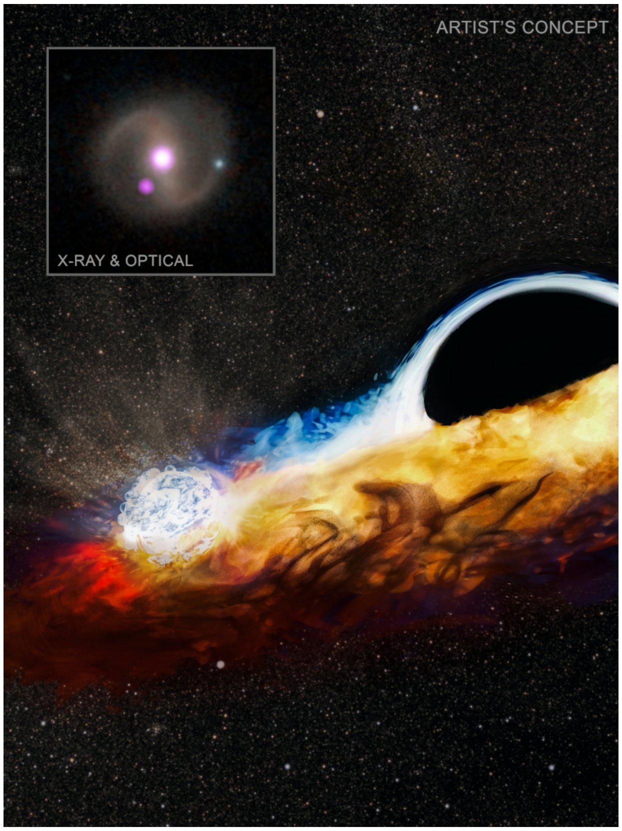
Chandra observing time continues to be highly valued. Scientists worldwide responded to Chandra's Cycle 26 call for General Observer (GO) proposals, with 325 observing proposals requesting 65.5 Ms of telescope time. In June, the dual-anonymous peer review recommended 107 GO proposals for a total of 15.8 Ms observing time.

Chandra's high angular resolution and sensitivity make it especially well suited to study fast varying systems such as tidal disruption events (TDEs). Recent Chandra observations have identified several new systems where predictable patterns in TDE behavior have been observed.

One such system, the supermassive black hole responsible for the transient event AT2018fyk, was monitored with multiple X-ray telescopes including Chandra to track its behavior on time scales of years. The sudden decreases and increases of X-ray emission were determined to originate in a repeating partial TDE, where a star is partially stripped by the black hole as it approaches its orbital periapsis with respect to the supermassive black hole. The long-term monitoring of AT2018fyk enabled a prediction that the TDE would have a sudden dropoff in brightness in August 2023 — a prediction that Chandra observations confirmed. An additional outburst and shutoff, if enough of the star survived this second outburst, are predicted for this TDE in May – August 2025 and in January – July 2027, respectively.

Another TDE whose nature was fully revealed by a coordinated multiwavelength effort is AT2019qiz, which Chandra observed 3 times to elucidate the nature of its quasi-periodic eruptions (QPEs). Chandra observations combined with coordinated observations from NICER, Hubble, and Swift were able to determine that the QPEs originate from the collision of one star orbiting the supermassive black hole associated with this transient and the stellar debris disk that resulted from the original TDE. This discovery is a significant step toward understanding QPEs in general, as well as the environments in the immediate vicinity of black holes fueling TDEs.

The Chandra Observatory continues to function at or near pre-launch expectations. Incremental changes in the performance of some components continue, generally in line with pre-launch predictions and without hindering operations. The performance of the spacecraft's thermal insulation continues to decline gradually; however, this trend has been mitigated by careful mission planning, aided by increasingly sophisticated software tools. Gradual accumulation of molecular contamination onto the ACIS UV/optical blocking filter reduces its sensitivity to low-energy (<1.5 keV) X-rays. Chandra maintains its mission-long observing efficiency of about 70%, close to the maximum time possible for collecting data on science targets. (To protect its instruments, Chandra does not observe during passages through Earth's radiation belts. In addition, spacecraft maneuvers, instrument setup, and other procedures necessarily use about 10% of the remaining available time.)



Artist's concept of a star colliding with a disk of material orbiting a supermassive black hole which originated from an earlier TDE. Inset: Observations of the galaxy in optical light (red/green/blue) and past TDE emisison in X-rays (purple). Credit: X-ray: NASA/CXC/Queen's Univ. Belfast/M. Nicholl et al.; Optical/IR: PanSTARRS, NSF/Legacy Survey/SDSS; Illustration: Soheb Mandhai / The Astro Phoenix; Image Processing: NASA/CXC/SAO/N. Wolk.

In Spring 2024, the Chandra program took part in an Operating Paradigm Change Review aimed at evaluating science return that could potentially be provided by the Chandra and Hubble observatories with reduced budgets, using revised mission-operations models. Currently, the program is participating in NASA's triennial Astrophysics Senior Review of Operating Missions, with documentation to be submitted in December.

The Astronomical Data Analysis Software and Systems (ADASS) organization, has awarded its annual prize for Outstanding Contribution to Astronomical Software to William Joye and Eric Mandel of the the Chandra X-ray Center (CXC) for their contributions to SAOImageDS9. The award was presented "in recognition of the outstanding contribution of SAOImageDS9 to the astronomical software community and the positive impact it has on many astronomy projects and scientists."

The CXC's leading work on astronomical data sonification was the focus of the documentary "Listen to the Universe," by NASA's Elizabeth Landau and CXC's Kimberly Arcand. This documentary received the Industry Award: Best New Media at the Raw Science Film Festival.

In early December, a silver jubilee science symposium in Boston will celebrate Chandra's 25th anniversary. Here's to many more years of productive scientific discovery with Chandra!

XMM-Newton

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

The 24th Announcement of Opportunity closed on October 11. In all, 462 proposals were received. As usual, the over-subscription factor was large – 7.2. A total of 36 proposals were received for Large Programmes, and 13 for Fulfil Programmes. Anticipated Target of Opportunity observations were requested in 65 proposals. Joint Programmes were again very popular, with 94 proposals submitted. Of these proposal, 45%, 26%, 12%, 11%, and 11% were joint projects with NuSTAR, HST, SWIFT, NRAO, and VLT, respectively. The final program will be announced in mid-December, and observations will begin in May 2025.

On June 5 – 7 2024, The SOC hosted a workshop on "The X-ray Mysteries of Neutron Stars and White Dwarfs" in Madrid, Spain. It covered many topics, including magnetars, ULXs, isolated neutron stars, and transitional pulsars. The presentations are available online at the workshop website

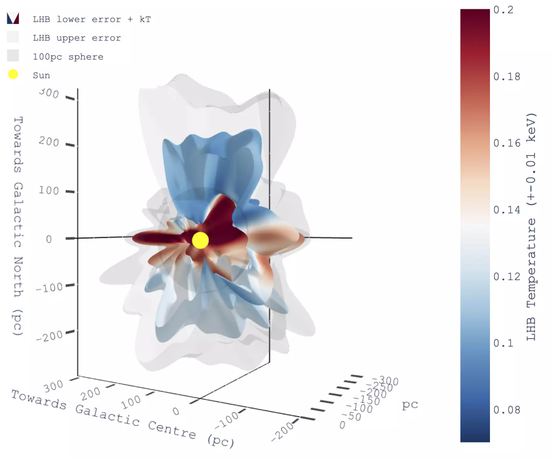
The U.S. XMM GOF will host a 2-day virtual workshop together with the SOC starting on April 1, 2025 on how to work with XMM data with pySAS (the python wrapper for SAS) in the cloud with SciServer. More information to come soon!

The GOF also will host a 3-day conference in late spring/early summer 2025 in honor of the 25th anniversary of XMM's first light. A website with more information will be available in December.

SRG/eROSITA/ART-XC

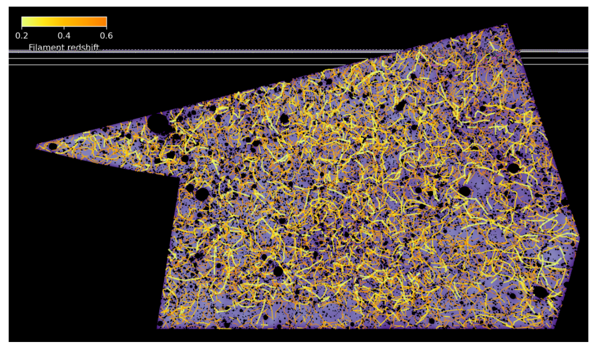
A. MERLONI (MPE), A. LUTOVINOV (IKI), P. PREDEHL (MPE), S. SAZONOV (IKI)

The recently released eRASS1 data from SRG/eROSITA continue to provide a rich legacy for investigations of the high-energy Universe, including our own 'cosmic backyard'. Our Solar System dwells in a low-density environment called the Local Hot Bubble (LHB), filled by a tenuous, million-degree hot gas emitting predominantly in soft X-rays. In the recently published work by Yeung et al. (2024), a team led by scientists at the Max Planck Institute for Extraterrestrial Physics (MPE) analysed in detail the spectrum of the diffuse emission in the eRASS1 data and found a large-scale temperature gradient in the LHB, possibly linked with past supernova explosions that expanded and reheated the bubble. The wealth of the eROSITA data also allowed the team to create a new 3D model of the hot gas in the solar neighborhood. The highlight of this work features the discovery of a new interstellar tunnel towards the constellation Centaurus, potentially joining our LHB with a neighbouring superbubble.



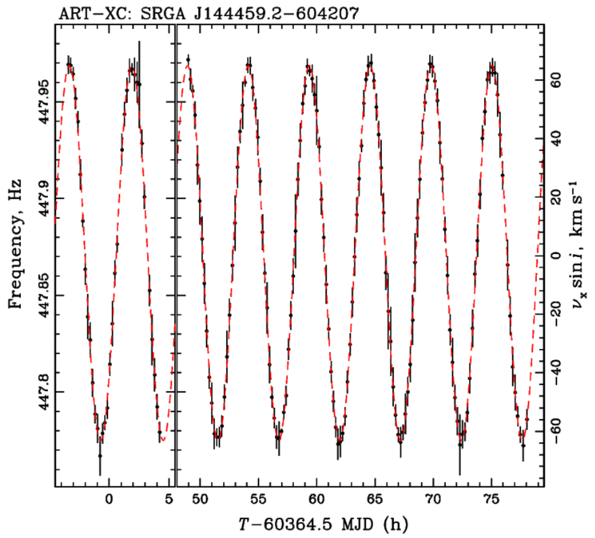
The 3D structure of the LHB with colors indicating its temperature. The two surfaces indicate the measurement uncertainty of the LHB extent: the most probable extent most likely lies between the two. The location of the Sun and a sphere of 100 parsec radius are marked for comparison. Credit: Adapted from Yeung et al. (2024); an interactive 3D map is available.

In another recent work (Zhang et al. 2024), a team of scientists revealed the existence of high-temperature, high-density regions of the Warm-Hot Intergalactic Medium (WHIM). Due to its extremely low density (tens of particles per cubic meter, on average), the WHIM is notoriously difficult to observe. The team looked in particular at cosmic filaments, the largest structures in the Universe, which form part of the intricate network of the cosmic web, connecting galaxies and galaxy clusters. Up to half of the matter in the Universe resides in these filaments, which occupy less than 10% of its volume. The most immediate way to detect them is through the galaxy distribution: large-scale spectroscopic surveys, coupled with complex algorithms, deliver catalogues of thousands of filaments. In this work, a sophisticated stacking method of the eROSITA signal at the locations of more than 7,000 cosmic filaments identified through the Sloan Digital Sky Survey (SDSS) resulted in a strong X-ray detection (9σ) of the hot cosmic web. However, in order to disclose how much of such signal is produced by the WHIM, it was necessary to carefully model the contamination from the undetected X-ray halos, active galactic nuclei, and X-ray binaries associated with filament galaxies. The analysis revealed an approximate 40% contamination fraction, indicating that around 60% of the detected X-ray signal may originate from the WHIM, with a detection significance of 5.4σ. Comparison with state-of-the-art numerical simulations indicate that the observed X-ray signal likely originates from WHIM regions with temperatures in the range of several million Kelvin and densities of approximately 100 particles per cubic meter. Over the next few years, new large-scale spectroscopic galaxy surveys such as DESI and 4MOST will provide larger, more detailed galaxy and filament maps. The much larger overlap of these surveys with the eROSITA all-sky data will ensure a more refined analysis of the stacked X-ray data and bring to light new information on the WHIM physical state.



The 2D projected structure of the over 7,000 cosmic filaments identified through SDSS optical surveys (yellow/orange, color-coded by their redshift), overlaid to the corresponding eRASS X-ray map in the same part of the sky (purple, approx. 2300 deg^2). Black regions mark masked-out X-ray sources. Credit: X. Zhang, N. Malavasi, MPE.

From October 2023 to November 2024, the Mikhail Pavlinsky ART-XC telescope aboard the SRG observatory conducted two new full scans of the sky in hard X-rays (4 – 12 keV). During survey observations on February 21, 2024, a new bright ($\sim$100 mCrab) X-ray source, SRGA J144459.2-604207, was discovered near the Galactic Plane. The SRG/ART-XC team decided to interrupt the all-sky survey for a few days to perform follow-up pointed observations of this transient. A timing analysis of the data obtained on February 24 and 26 revealed coherent pulsations with a frequency of 447.9 Hz, modulated by the Doppler effect due to the orbital motion with a period of 5.2 hours. This showed that SRGA J144459.2-604207 is a new accreting millisecond X-ray pulsar. Also, 19 thermonuclear X-ray bursts were detected during the ART-XC observations, as well as pulsations during these bursts. The spectral evolution during the bursts is consistent with the models of neutron star atmospheres that are heated by accretion and implies a neutron star radius of 11 – 12 km and a distance to the source of 8 – 9 kpc. These observations have once again demonstrated the excellent timing capabilities of the ART-XC telescope.



Orbital modulation of the pulsation period of the accreting millisecond pulsar SRGA J144459.2-604207 discovered by SRG/ART-XC. Credit: SRG/ART-XC

NICER

Keith Gendreau & Zaven Arzoumanian (NASA/GSFC)

NICER continues to operate productively despite damage sustained by its X-ray Timing Instrument (XTI) in May 2023 due to orbital debris: several of the thin optical-blocking filters that cover the 56 concentrator optics were punctured, allowing daylight into the instrument's interior. This "light leak" and the resulting optical loading of the silicon detectors during orbit day can cause 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, but the impact to overall capabilities remains significant. Much of the data collected in sunlit conditions exhibits unusual behaviors; NICER users are urged to exercise caution in interpreting 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.

Following extensive discussions and technical reviews, International Space Station (ISS) leadership has approved a plan for astronauts to "repair" NICER during a spacewalk currently expected to take place in January 2025. The hour-long task will patch the damaged thin films and restore dark conditions within the XTI, with minimal (<2%) impact to total X-ray collecting area. A custom patch kit has been developed and was successfully launched to the ISS in August; two astronauts who trained for the repair at NASA Johnson Space Center's Neutral Buoyancy Laboratory are also currently onboard ISS. The NICER team is keenly looking forward to the restoration of NICER's full observing efficiency during both orbit day and night.

In September, 120 proposals were received for Cycle 7 of NICER's General Observer (GO) program, through which investigators took advantage of joint programs with NuSTAR, Swift, TESS, and the National Radio Astronomy Observatory telescopes. Reciprocally, NICER observing time is available through proposals submitted to these facilities as well as the IXPE mission. Results of the Cycle 7 proposal review are likely to be announced in December, with observations beginning on March 1, 2025.

NICER's scheduling agility enables observations of a large number of ToOs — which may be proposed through the NICER Target of Opportunity/Discretionary Time Request form — including coordination with many other telescopes. Visibility windows for a given target are complicated by occultation from structures (such as the large solar arrays) on the ISS; an online Enhanced Visibility Calculator provides accurate start-stop visible times for any specified target coordinates within a 14-day horizon. Additional capabilities for responsiveness to transients include automated grid searches of localization uncertainty regions for new sources, such as those detected by JAXA's Monitor of All-sky X-ray Image (MAXI, also an ISS payload). In partnership with JAXA, the NICER team operates the Orbiting High-energy Monitor Alert Network (OHMAN): software running on an ISS laptop that implements automated triggering between MAXI and NICER. Through OHMAN, NICER can respond to MAXI-detected transients on timescales, in the best cases, of a few minutes. The NICER near-term observing schedule is always available on NICER's website at the HEASARC.

NICER data analysis software is distributed through the HEASoft package; the latest release, 6.34 (NICERDAS 13), includes features that address calibration and filtering related to the optical light leak. New end-to-end analysis threads, tools, and documentation are also available, to generate spectra, lightcurves, and background estimates based on the sophisticated SCORPEON model. Feedback on NICERDAS performance is welcome through the HEASARC helpdesk system.

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 highlights include:

- The discovery (Nichol et al. 2024) of quasi-periodic eruptions (QPEs) from the host galaxy of a well-studied, nearby stellar tidal disruption event (TDE), confirming a long-speculated association between these two phenomena. The 48-hour recurrence time of the QPEs and other observable properties suggest that a compact body orbiting the galaxy's central supermassive black hole is regularly plowing through the accretion disk left behind by the star disrupted in 2019. High-cadence (every 90 minutes) soft X-ray monitoring with NICER is proving to be a game-changing capability for the new field of QPE science, with implications for the highly anticipated "extreme mass-ratio inspiral" class of gravitational-wave emitters detectable by LISA.
- Measurement of a 3rd neutron star's radius (Choudhury et al. 2024), with the most statistically precise (5–8% uncertainties) yet. Together with its well-mesaured mass from radio-pulse timing, the 11.36 km equatorial radius of PSR J0437$-$4715 suggests that the dense matter in the star's core is somewhat softer than inferred from NICER's prior results (while remaining consistent with them). The inferred hot-spot geometry for J0437 departs substantially from the textbook picture of a simple dipolar magnetic field centered on the star, also in keeping with earlier studies. These results continue to drive significant theoretical work into the nature and evolution of neutron star interiors (e.g., Rutherford et al. 2024) as well as their magnetospheric geometries.
- The first direct measurement (Inoue et al. 2024) of outflowing plasma during a stellar flare in excess of a star's escape velocity. Following a superflare from the RS CVn-type star IM Peg detected by MAXI, NICER observations beginning 6 hours later detected Fe XXV and XXVI emission lines for ~ 1.5 days. The maximum observed blueshift, 2200 km/s, was seen one hour after the observed reheating of the flare plasma, and suggests a coronal mass ejection approximately along the line of sight.
- Comprehensive spectral-timing studies of accretion in stellar-mass black-hole binaries. For example: evidence for the geometric origin of quasi-periodic oscillations and a dynamic corona (Bollemeijer et al. 2024); a new low-energy timing phenomenon that appears to represent a physical mechanism connecting an accretion disk and Comptonizing plasma (König et al. 2024); phase-resolved analysis of the "heartbeat" mode in IGR J17091–3624 implying that disk instabilities are primarily responsible for the regular variations (Shui et al. 2024); and others.

Neil Gehrels Swift Observatory

S. Bradley Cenko (NASA/GSFC)

The Neil Gehrels Swift Observatory continues to operate exceptionally well. 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.

On Wednesday, November 20, Swifties around the world celebrated the satellite's 20th launch anniversary. The illustrious fermicakes team was enlisted to help with the commemoration, and as usual they delivered both artistically and gustatorily. Working with the communications team at NASA Goddard and scientists from across the partner institutions, postings on the NASAUniverse accounts on X and Facebook will highlight both the many groundbreaking science results from the mission, as well as the team members behind the scenes that enable those discoveries. This effort will culminate with a scientific conference on March 25 – 28, 2025 in Florence, Italy: "Celebrating 20 years of *Swift* Discoveries". We hope you all will join us there!

In September we received 159 Cycle 21 GI proposals from the community. These proposals are currently under review, and we expect to announce results sometime in January 2025. Cycle 21 observations will begin in April 2025.

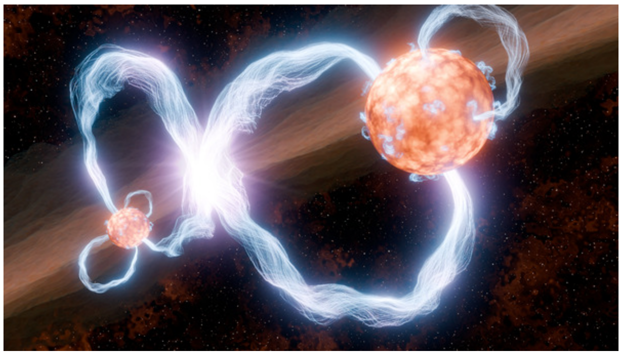
NuSTAR

Daniel Stern (JPL)

Like many of the missions contributing to this Newsletter, the NuSTAR project is currently deeply engaged in finalizing their Senior Review proposal, which seeks funding to maintain the observatory through 2028. NuSTAR continues to be healthy, and remains at a sufficiently high orbital altitude that surviving this solar maximum is not a concern. The 1500th NuSTAR paper was published in October, and the project looks forward to the next 1500 papers.

On the science front, the NuSTAR project recently posted a press release discussing the unique DQ Tau binary system. DQ Tau consists of two protostars, approximately 200 pc from earth, in a close binary orbit. Each protostar is roughly half the mass of the Sun and twice its radius. The stars are dancing in a highly elongated orbit which has them plunging in towards each other every 15.8 days. At closest approach, the separation between the two stars is only 8 – 10 stellar radii, leading to intense flares that impact the circumbinary protoplanetary disk.

DQ Tau provides an exceptional laboratory to study how intense flares, which are common for protostars, affect disk heating and chemistry. Like clockwork, the DQ Tau system brightens at closest approach. While large X-ray flares in young stars are generally rare and unpredictable, the predictable X-ray super-flares and outbursts in DQ Tau enable synchronized, multi-facility studies of these intense flares, probing how they affect the protoplanetary disk and planet formation. X-ray flares come as the protostar magnetospheres collide, while the lower energy optical and ultraviolet flares also come from accretion of material onto the young stars. Infrared and radio studies probe the changing temperature and chemistry of the protoplanetary disk.



Two young protostars in a cosmic tango that brings them within 10 stellar radii every two weeks. This artist's illustration of the DQ Tau system shows the intense fireworks that occur every fortnight as these two swiftly moving stars are ever, ever getting back together. Credit: NASA/JPL-Caltech/R. Hurt (IPAC)

Getman et al. (2023; ApJ, 959, 98) reports on observations of a single orbit of DQ Tau in July thru August 2022 by NuSTAR, Swift, and Chandra. The observations demonstrated that most of the X-ray emission is from interactions of the magnetospheres of these young stars at closest approach. Similar to the Sun, magnetic field collisions and reconnections produce strong high-energy X-ray emission, heating the surrounding region to high temperature, which is detectable as thermal emission in lower energy X-rays. However, while flares on the Sun occur among coronal magnetic loops much smaller than the star, the DQ Tau super-flares are a thousand times larger, reaching tens of stellar radii. This paper is part of a broader campaign using ground-based telescopes to investigate the influence of DQ Tau's stellar radiation on the chemistry within the protoplanetary disk. The swiftly moving stars in DQ Tau are almost ideally tailored for such studies.

Finally, we encourage users to subscribe to the NuSTAR users list by sending an email with 'subscribe' in the subject to `nustargo-join@lists.nasa.gov`. If you change institutions, please sign up again with your new address.

Insight-HXMT

Shijie Zheng & Shuang-Nan Zhang (IHEP, CAS)

Insight-Hard X-ray Modulation Telescope (*Insight*-HXMT) continued observations of black holes, neutron stars in 1 – 250 keV bandand GRBs in 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 V2.06 and V2.07, respectively. More information about the progress, user support and results of *Insight*-HXMT can be found at the mission website (in English and Chinese).

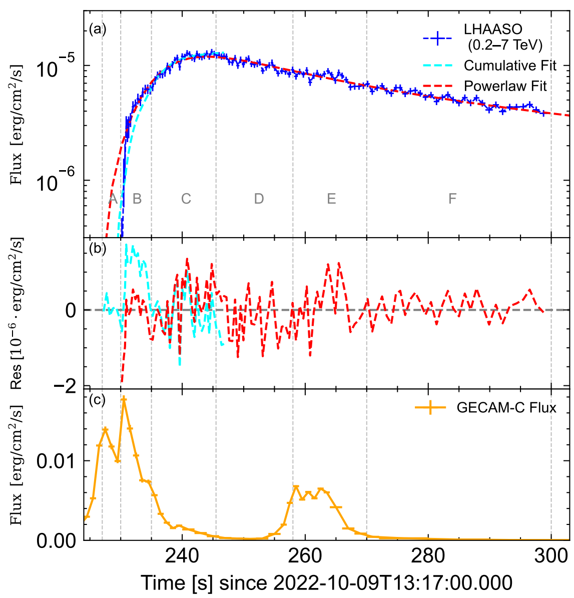
Some new important results have been published recently with *Insight*-HXMT data. First of all, we reported a peculiar precursor in a kilonova-associated long-duration gamma-ray burst, GRB 211211A, providing evidence of electromagnetic waves before the merger of compact stars (Xiao et al, APJ, 2024). Furthermore, additional significant discoveries concerning black holes and pulsars include: a timing view of the additional high-energy spectral component and the phase-resolved spectroscopy of low-frequency quasiperiodic oscillations from the newly discovered black hole X-Ray binary Swift J1727.8-1613 (Yang et al, ApJ, 2024; Shui et al, APJ, 2024); the delayed radio emission in the black hole X-ray binary MAXI J1348-630 (You et al, APJ, 2024); the energy-dependent hard X-ray deficit and cooling saturation of the corona during thermonuclear X-ray bursts from 4U 1608-52 in the low/hard state (Chen et al, MNRAS, 2024); the peculiar disk evolution of 4U 1630-472 during its 2022 and 2023 outburst (Wang et al, APJ, 2024); burst-recurrence properties revealed with Insight-HXMT and NICER for the newly discovered accreting millisecond pulsar MAXI J1816–195 (Wang et al, A&A, 2024); and broadband X-ray spectral and timing properties of the accreting millisecond X-ray pulsar IGR J17498-2921 (Li, et al, A&A 2024). All of these data have been made publicly available (from the archive), and we encourage in-depth investigations with these data. Please visit *Insight*-HXMT's publication list for more researh results.

The AO-7 Cycle Proposal Evaluation has been completed and announced. In total 1096 observations from 40 proposals have been approved. In particular, some observation time has been reserved for joint HXMT-EP observations. EP is a time-domain X-ray observatory launched in 2024. See the long-term and short-term plans, and list of observed sources for more information about Insight-HXMT observation plan.

GECAM

YAN-QIU ZHANG, ZHEN ZHANG, JIA-CONG LIU, SHAO-LIN XIONG, SHI-JIE ZHENG (IHEP, CAS)

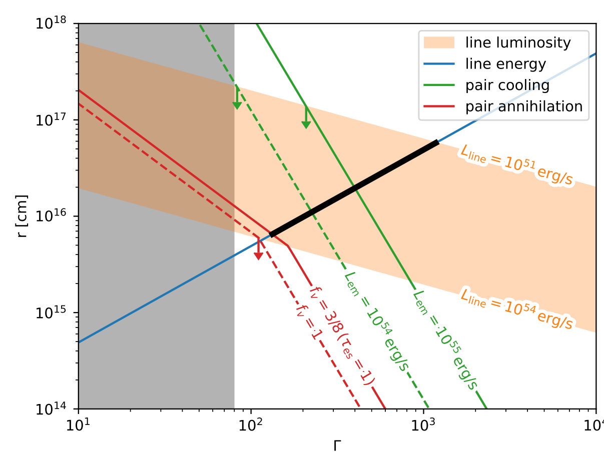
While GECAM-B and GECAM-C have been observing normally, GECAM-D has been under commissioning since April 2024. GECAM-D has demonstrated its all-sky monitoring capability of gamma-ray transients, especially gamma-ray bursts (GRBs). Despite of the limited data, GECAM-D has detected many GRBs, including GRB 240320A, GRB 240410A, GRB 240411A, GRB 240415A, GRB 240415B, GRB 240419B, GRB 240421A, GRB 240422A, GRB 240425A, GRB 240426A, GRB 240529A, GRB 240716A, GRB 240727D, GRB 240829B, GRB 240829A, GRB 240902B.



A close correlation was found between the keV-MeV prompt emission measured by GECAM-C (orange) and the TeV emission measured by LHAASO (blue) Credit: (Y.Q. Zhang et al., 2024a

Regarding the brightest ever burst, GRB 221009A, important progress has been made with the GECAM data together with other instruments. GECAM-C precisely observed the keV-MeV prompt emission of GRB 221009A, while LHAASO obtained high-statistics measurements of TeV emission (including the onset) predominantly generated by external shock. These unprecedented observations have been used to investigate the relation between prompt emission and afterglow, especially the prompt-to-afterglow transition and the impact of jet on the early dynamics of external shock (Y.Q. Zhang et al., 2024a). The cumulative curve of keV-MeV emission fits the rising phase of the TeV flux, with a time delay of 4.45 s. This close relationship reveals the continuous energy injection of the jet into the external shock, and the time delay of the TeV emission can be used to estimate the Lorentz factor of the jet. Moreover, there are two excesses in the TeV flux, which are aligned with the two main peaks of the prompt keV-MeV emission. The TeV excesses can be explained by inverse Compton scattering of the prompt emission by high-energy electrons in the external shock. (Y.Q. Zhang et al., 2024a)

Previous study with GECAM-C and Fermi/GBM data has revealed a surprising power-law evolution of the MeV emission line in GRB 221009A, with the power-law index of the line central energy of -1 and the maximum line energy up to 37 MeV (Y.Q. Zhang et al., 2024b). With an attempt to interpret the MeV line, a group of authors comprehensively investigated the mechanism of creation, cooling, and annihilation of electron-positron pairs in the jet, thereby directly measuring or constraining some important parameters of the jet based on the MeV line observation, such as the Lorentz factor of the jet and the emission radius of the MeV line (Z. Zhang et al., 2024). They found that the observed MeV line could be naturally explained as electron-positron annihilation line under the high-latitude curvature effect of the emitting shell in the jet. Together with the constraints on Lorentz factor from relation between the keV-MeV and TeV emission, the authors conclude that the GRB jet is dominated by magnetic flux (Z. Zhang et al., 2024).



Constraints of Lorentz factor of the jet and the radius of the gamma-ray line emission region Credit: Z. Zhang et al., 2024

Non-proprietary GECAM data can be downloaded from the GECAM archive. The GECAM data analysis tools (GECAMTools) and the CALDB have both been regularly updated. More information about GECAM can be found at the GECAM official website (in both English and Chinese).

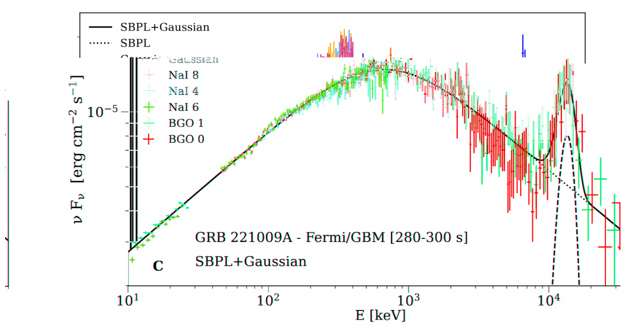
The Fermi Gamma-ray Space Telescope

Elizabeth Hays, Andrea Prestwich, Judy Racusin, Dave Thompson (GSFC), Lynn Cominsky (Sonoma State U.)

The Fermi scientific instruments, Gamma-ray Burst Monitor (GBM) and Large Area Telescope (LAT), continue to survey the entire gamma-ray sky. Operations have remained largely routine.

For the LIGO/Virgo/KAGRA O4 runs, the instrument teams have emphasized maintaining high uptime and are alerting the community about possible counterparts, and are watching for good candidate gamma-ray bursts to cross check against the gravitational wave data. Both the GBM and LAT teams will put out GCN notices and circulars for gravitational wave counterparts or for constraining upper limits. The LAT team has also set up a page to report automatic follow-ups to alerts. Announcements are using the new General Coordinates Network here.

GBM spectra of the GRB 221009A, the "Brightest Of All Time (BOAT)" gamma-ray burst, exhibited the first-ever high-confidence gamma-ray line seen in any gamma-ray burst. Observed at about 12 MeV, the most likely source is the annihilation of electrons and positrons blueshifted by the burst's jet.



Spectrum of GRB 221009A in interval 5 from Fermi-GBM detectors, in $\nu F\nu$ representation, with the data points corresponding to different detectors, along with possible models. The emission line is present in both BGO detectors (BGO 0 and BGO 1) data. Credit: Fermi-GBM

Fermi scientists, along with many multi-wavelength observers, are preparing for the expected outburst of the T CrB nova. Fermi scientists at Clemson University continue the search for gamma-ray evidence or constraints on dark matter. The 2025 Fermi Summer school will be held from May 27 to June 6, 2025,with registration open in December: see the Summer School website for more information. The deadline is January 30th, but we have a limited number of available positions at the school, so early applications will be favored.

The 11th International Fermi Symposium was held from September 9 – 13, 2024, at the University of Maryland, College Park. Almost 300 attendees participated in lively discussions and interesting keynote talks on topics ranging from merging supermassive black holes to gamma-ray pulsars to the BOAT gamma-ray burst. Closer to home, participants heard about gamma rays from the Sun, Moon, and thunderstorms. Related activities included the Fermi Mentor program, informal social activities and a report on sustainability and inclusivity of astronomy conferences.

Current Fermi software and documentation are available through the Fermi Science Support Center. Users can download the current version of the Fermitools, and 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 Cycle 17 Guest Investigator program saw a nearly 30% increase in proposal submissions compared to the Cycle 14 – 16 average. Results have been posted. Please find details here about the Guest Investigator program at the Fermi Science Support Center website. The Cycle 18 proposal deadline will be February 13, with a virtual proposers' workshop on January 21.

The Fermi EPO team has created a "Multi-Diverse Activities" book which is a hands-on sensory journey to outer space. Based on the popular "stained-glass" art poster set by Aurore Simonnet, this booklet is aimed at students in elementary and middle school, and features seven different activities, including: connect the dots, making clay models, puzzle games and more. These booklets will be available at the Fermi booth at the January 2025 AAS meeting, so please stop by and pick one up if you are interested. Or e-mail Lynn Cominsky if you would like to be mailed a hard copy of the booklet.

Finally please note that the LAT Collaboration has an Opportunity Board where job/research/degree opportunities relevant to the gamma-ray community can be posted.

INTEGRAL

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

The ESA Science Programme Committee (SPC) has approved some limited operations of instruments during the first two months of the post-operations phase that starts on 1 January 2025. This will allow for a continuation of INTEGRAL's support of the Gravitational Wave Campaign collaboration's O4b run until February 28, 2025, within manageable and time-limited disruption of the operations of the rest of the mission. Science data taken during this period will be immediately public. The TOO-alert tool remains open for highly important TOOs with priority for gravitational wave event follow-ups until

February 28, 2025. Science observations will ultimately end on March 1, 2025.

During the 2-year post-operations phase, the INTEGRAL Science Legacy Archive (ISLA) is being constructed as the long-term repository of INTEGRAL data and ESA DataLabs (EDL) is being developed as a platform for long-term preservation of data analysis capabilities with OSA. A beta version of ISLA is already available at and a beta version of EDL is available as well.

Group Picture of participants at the INTEGRAL Workshop 2024, taken at ESAC on October 22. Credit: INTEGRAL

The 2024 INTEGRAL Workshop was held from October 21 – 24 at ESAC near Madrid, Spain. There were 91 registered participants, with 53 oral and 3 poster presentations given. There were, following the presentations, many constructive exchanges touching on a great variety of science topics and perspectives. Links to the slides/posters and video recordings will be available on the conference web site.

The workshop took place with the knowledge that INTEGRAL will only be taking data for another 4 months, but it was emphasized that the end of taking new data is not the end of the mission, and the activities of the community determine how much longer INTEGRAL will live on. It is ESA's experience that the publication rate during the post-operations phase increases, indicating that science exploration during the operations phase focuses on new data while a large reservoir of archival data provides even more material for research.

The focus of this workshop was current and recent research. A legacy conference will take place towards the end of 2026 at which retrospectives and results from archival data can be presented. The current focus of the INTEGRAL science operations centre at ESAC is to lay the foundations for research with INTEGRAL data in the decades to come. The science community and Users Group were encouraged to take part in populating the INTEGRAL Science Legacy Archive (ISLA) whose basic functionalities were presented. In addition, perspectives for long-term preservation of the OSA software via ESA DataLabs were demonstrated.

IceCube

Alisa King-Klemperer (UW-Madison)

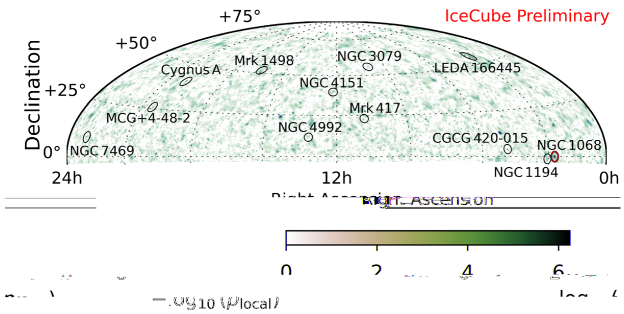
Since 2013, the IceCube Neutrino Observatory at the South Pole has detected a diffuse flux of high-energy cosmic neutrinos. An inevitable consequence of the unexpectedly high neutrino flux observed by IceCube is that the flux from the accompanying high-energy gamma rays from the decay of neutral pion decays exceeds the extragalactic flux directly observed by the NASA Fermi satellite. There is no contradiction here; the typical source producing IceCube neutrinos must be opaque to high-energy gamma rays, which lose energy in the dense target producing the neutrinos and appear at Earth with MeV energies, or below.

Two years ago, the IceCube Collaboration announced evidence for high-energy neutrinos from the "nearby" active galaxy NGC 1068, which indeed turned out to be strongly gamma-ray obscured. The origin of the gamma-ray obscuration is believed to be associated with its dense X-ray corona in the vicinity of the central black hole, where the neutrinos are produced and the associated gamma rays are absorbed by gamma-gamma interactions.

Now, recent results based on 13 years of data presented by the IceCube Collaboration confirms NGC 1068 as the most significant neutrino source among 110 preselected gamma-ray emitters while also being spatially compatible with the most significant location in the northern sky to within 0.04 degrees. The observed neutrino flux is, at some energies, at least two orders of magnitude higher than its gamma-ray counterpart, making this source—one of the brightest X-ray Seyfert galaxies—particularly intriguing. The NGC 1068 observations suggest searching for neutrino sources associated with X-ray emission rather than gamma-ray observations, as has been traditionally the case. Looking for sources with strong X-ray emission turned out to be a path to producing evidence for more sources in the neutrino sky, among them NGC 4151 and Circinus in the southern sky despite the reduced sensitivity to neutrinos.

This approach also motivated a new selection of 47 X-ray-bright Seyfert galaxies from the Swift/BAT spectroscopic survey to test for neutrino emission. A neutrino excess was observed from an ensemble of 11 sources at a 3.3σ significance level. This new finding adds to the growing body of evidence that dense environments near supermassive black holes, particularly X-ray-bright cores of AGNs, are good candidate sites for neutrino production. There is a long history of theoretical studies promoting active galaxies as the sources of cosmic rays.

All of these data have been made publicly available, and a full publication of the results is in progress.



Northern Sky p-value map under the floating gamma assumption. We highlight the 11 sources which contribute to the excess found for the binomial test for the Seyfert Catalog in the power-law model case. Credit: IceCube Collaboration

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VERITAS

Wystan Benbow (SAO)

Following the close of another successful season of VERITAS operations in June 2024, VERITAS held a face-to-face collaboration meeting (a hybrid-format event) at the University of Oxford. This well-attended meeting (∼50 attendees) in early July included ∼50 oral presentations, a poster session, lightning talks, hands-on small-group working sessions, and a joint CTAO workshop. The presentations (∼50% by junior scientists) formed the basis of the 26 papers presented by the VERITAS Collaboration at the three summer conferences emphasized by the project: TeVPA 2024 (6 papers), Gamma 2024 (12 papers); and the 11th International Fermi Symposium (8 papers). One highlight from these presentations included the VERITAS discovery of three VHE emitting blazars (B2 0912+29, 1ES 1028+511, and 1ES 1118+424) in 2024.

In September 2024, VERITAS began its eighteenth season of full-scale operations. Following a typical summer monsoon season, the array was brought back online after the annual ∼3-month pause without any major issues. Over the summer, the project performed significant maintenance to the array and was able to successfully restore operation to a significant number of pixels in the telescope cameras. These had gradually failed for a variety of reasons and regaining their functionality increases the array sensitivity. We are expecting strong yields this season due to a developing La Nina phenomena which typically leads to warm, dry weather in AZ. After two months of observing, it is clear the hardware systems continue to perform very well and this should continue to 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. Indeed, shortly after VERITAS resumed operations it detected a VHE flare from BL Lacertae as part of a world-wide effort during a historic outburst (see ATel #16854).

Over the winter, the observatory expects to continue its ongoing project to re-coat its mirror facets. By increasing the amount of light collected by the telescopes, we are maximizing the science achievable with VERITAS. Observatory operations are currently funded through Summer 2025, and the VERITAS Project Office has begun securing the necessary financial support to extend VERITAS site operations for another three years (i.e., through 2028). These operations were strongly endorsed by the VERITAS External Science Advisory Committee during its 2024 review. A corresponding proposal supporting these operations — in partnership with the Smithsonian Astrophysical Observatory — will be submitted to the U.S. National Science Foundation in December 2024.

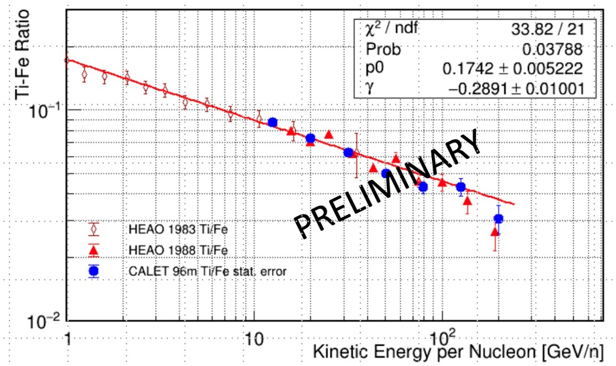
Since Spring 2024, the VERITAS Collaboration has published three journal articles. The first article reports the discovery VHE emission from the blazar OJ 287 during a flare, and results from an accompanying multi-wavelength study (arXiv:2407.11848). The second article provides limits from an indirect search for dark matter from dwarf spheroidal galaxies (arXiv:2407.16518). The third article details a multi-wavelength study of the pulsar wind nebula and Pevatron candidate MGRO J1908+06 (arXiv:2408.01625).

CALET

John Wefel (LSU)

The CALorimetric Electron Telescope (CALET) is completing 9 years of operations attached to port #9 on the JEM-EF platform of the KIBO module on the International Space Station (ISS). CALET is a joint project of Japan, Italy and USA designed to measure the energy spectra of electrons and nuclei to the highest energies, to study gamma rays at high energy, as well as gamma-ray bursts, to measure relative abundances of ultra-heavy (Z>30) nuclei and to monitor particle intensities in the ISS orbit. Over the past six months, the collaboration has continued analysis in these various areas, with particular attention paid to the sub-Fe group of elements.

The sub-Fe elements (Sc, Ti, V, Cr, Mn) are of interest mainly because they have a large secondary component due to fragmentation of Iron nuclei during propagation in the Interstellar Medium. Sc and V are very rare in nature and so are most certainly secondaries. Ti and Cr, however, do have, we believe, a primary (source) component along with the secondaries. On-going work has been devoted to separating these elements in the CALET data. The Mn signal rides on the low charge tail of the Fe peak and is not easily resolved. However, the correction for the tail of the Fe peak at Cr is moderate, so Cr may be separable. Titanium, however, is far enough from Fe to be separable. We are using the Ti/Fe ratio as a function of energy to check our analysis. The Figure shows previous data from HEAO on the Ti/Fe ratio as a function of energy with a fit to the HEAO data displayed (Binns, W.R. et al., 1988, ApJ 324, 1106). Our preliminary CALET results are shown for comparison.



The Ti/Fe ratio as measured by HEAO (red) and CALET (blue) as a function of kinetic energy. CALET uncertainties are statistical only. The red line is a power law fit to the HEAO data. Credit: Courtesy the CALET collaboration

CALET agrees well with the earlier HEAO results. With this validation, the CALET team is proceeding to analyze other sub-Fe elements and determine individual element energy spectra. We anticipate publishing the results in the coming months.

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, including the TDAMM, Cosmic Ray, Gamma Ray, X-ray, Gravitational Wave, Inflation Probe, and Cosmic Structure SIGs – please see their articles in this newsletter below for details. The PhysPAG provides a way for the PhysCOS community to regularly engage with the Program Office. We have 15 members in the PhysPAG Executive Committee (EC). 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 Gravitational Wave community on LISA preparatory science gaps, research areas where additional work is needed to enhance the science return of the LISA mission. The PhysCOS Program Office together with the LISA project has been soliciting community inputs on these preparatory gaps which will be included in the LISA Preparatory Science (LPS) call for proposals.

The 2024 NASA Astrophysics Biennial Technology Report (ABTR) was released at the end of September and includes an updated Technology Gap List based on input received from the science community during the Spring of 2024 to help NASA identify gaps between today's state-of-the-art technologies and what will be needed for future strategic astrophysics missions. The updated Technology Gap List includes technologies spanning the PhysCOS Program: X-rays, cosmic microwave background, gamma rays, and more. The ABTR is available for download as a pdf document and full descriptions of the Technology Gaps can be found at Astrophysics Projects Division webpage.

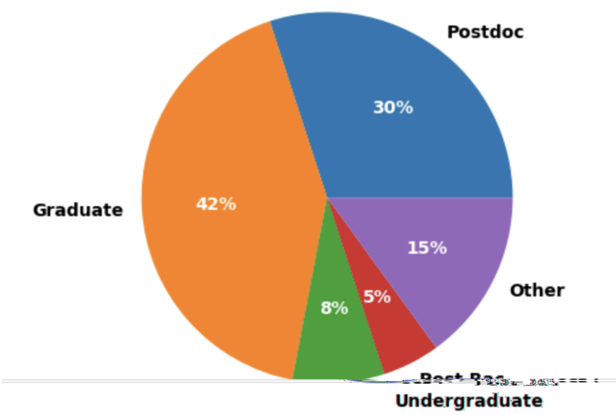
PhysCOS was active at several conferences during the summer and fall of 2024 including: the 3rd Time Domain and Multimessenger workshop, Multidisciplinary Science in the Multimessenger Era, which was held in Baton Rouge (LA) on September 23 – 26, 2024; SACNAS National Diversity in STEM (NDiSTEM) conference in Phoenix (AZ) from October 31 to November 2, 2024, and the joint conference of the National Society of Black Physicists (NSBP) and the National Society of Hispanic Physicists (NSHP) in Houston (TX) on November 13 – 17, 2024.

PhysCOS has also been working on ways to involve early-career scientists and provide them with insights about the fascinating work done in the Physics of the Cosmos Program, including exposing them to missions, opportunities, funding, and available tools for research. The culmination of this was the first Early Career Workshop, which was held virtually on November 19 – 21, 2024. This three-day workshop devoted a day each to the themes of Science, Missions, and Careers. More than 250 scientists at different career stages registered for this workshop, with more than 120 attendees that connected daily. Among the registrants, 30% are affiliated with international institutions, while the remaining 70% are affiliated with US universities and national labs. All the contributions for this workshop, including 12 contributed presentations from early-career scientists, are posted on the workshop website; see the figure below for a breakdown of the attendees by career stage.

PhysCOS will be participating in the 245th meeting of the American Astronomical Society at the National Harbor (MD) and will host a session on January 12, 2025, from 9 AM to 4 PM (Eastern). Save the date for an exciting session, featuring a range of talks on PhysCOS-related science and activities, including Athena, LISA, as well as

PhysCOS science with the Habitable Worlds Observatory (HWO).

There are three PhysCOS Science Analysis Groups (SAGs) currently active and working on their findings: the cross-PAG New Great Observatories (focusing on the science case for simultaneous operations of the future Great Observatories), the cross-PAG Astrophysics With Equity: Surmounting Obstacles to Membership (AWESOM), and Future Innovations in Gamma Rays (FIG) (focusing on identifying future science drivers, necessary capabilities, and priorities for the future of gamma-ray astronomy). Since the last newsletter, the Time-Domain And Multi-Messenger Astrophysics Communications (TDAMMComm) SAG has completed their work and delivered their report to the APAC in July 2024; their presentation to APAC serves as a summary.



Distribution of career stages among the Early Career Workshop participants. Credit: PhysCOS program Office

The PhysCOS program office is supporting the Astrophysics Cross-Observatory Science Support (ACROSS) pilot initiative, which will provide software infrastructure, communication channels, and a help desk to improve coordination between NASA missions (and eventually other ground- and space-based observatories) for responsiveness to time domain and multimessenger science observations.

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 upcoming meetings.

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.

Time-Domain and Multimessenger Astronomy Science Interest Group

Eric Burns (LSU), Brad Cenko (NASA/GSFC), Rebekah Hounsell (NASA/GSFC), Ian Crossfield (U Kansas)

The Time-Domain And MultiMessenger (TDAMM) Science Interest Group (SIG) is a partnership across the NASA Astrophysics programs, being led by Physics of the Cosmos with involvement from Cosmic Origins and ExoPAG. The goals of the SIG include making the community aware of NASA missions and initiatives of relevance, and soliciting input from the community back to NASA for scientific, technical, or programmatic priorities in the TDAMM umbrella. In our first year we had our kickoff meeting at the 2024 Winter AAS meeting, including the first TDAMM talk from NEO Surveyor, a future NASA Planetary mission that will provide a survey of the infrared sky that is complementary to the Rubin Legacy Survey of Space and Time. Our first virtual meeting included a discussion with Fiona Harrison on the topic of the TDAMM recommendations in the Astro2020 Decadal. TDAMM SIG also helped organize the 3rd TDAMM Workshop, hosted by Louisiana State University in Baton Rouge, Louisiana.

In 2025 we plan an in person session at the 245th AAS Meeting, monthly virtual presentations and discussions, and are contributing to the Fourth TDAMM workshop. The AAS session will include the first public summary of the findings in the 3rd TDAMM Workshop White Paper as well as presentations from the forthcoming COSI and UVEX missions. Topics for the monthly virtual meeting are planned to include an update from NASA's ACROSS initiative, which is responsible for fostering greater TDAMM science return with NASA's fleet, presentations from the two selected Probe concepts and their plans for TDAMM, an update on the Nancy Grace Roman Space Telescope, and preparatory work for the 4th TDAMM Workshop. The 4th TDAMM Workshop will be held in Fall of 2025 in Huntsville, Alabama on the topic of community-driven observation plans for rare and important TDAMM events. It is being led by ACROSS with anticipated involvement of Space Telescope Science Institute and National Science Foundation facilities. Dates will be announced at the 2025 Winter AAS Meeting.

Please visit our webpage to get involved!

The X-ray Science Interest Group

Kristin Madsen (NASA GSFC), David Pooley (Trinity U., Eureka Sci.), Chien-Ting Chen (USRA, NASA MSFC), Brian Grefenstette (Caltech)

The X-ray Science Interest Group (XR SIG) provides a platform for discussion between NASA PhysCOS and the X-ray Science community. The XR SIG chairs recently sent out a community engagement survey to ensure the platform reaches a broad and diverse community. We encourage the broader high energy community to participate in this survey.

The major news of the XR SIG community is the selection of the AXIS mission for the Phase A concept study as one of the two Astrophysics Probe Explorer (APEX) candidates. We congratulate the AXIS team for their efforts and dedication to this mission. Regarding the community's questions on the APEX selection process, the XR SIG chairs are planning to have an open discussion with the community during the upcoming winter AAS meeting. We expect to also discuss the broader impact of Chandra's funding reduction and the actions we can take to maintain a healthy and vibrant community. The XR SIG session will be held during the PhysCOS splinter session on Sunday, January 12th. We welcome the entire community to attend.

We also encourage the entire X-ray community to join the XR SIG mailing list to be informed of the progress of the Science Analysis Group and of future opportunities to present at XR SIG sessions at AAS or HEAD meetings. To subscribe, please send an email to `XRSAG-join@lists.nasa.gov` with "Join" as the subject line of the email. The XR SIG leadership is also soliciting self-nominations for XR SIG Co-Chairs. Self nominations should be sent to Brian Grefenstette (`bwgref@srl.caltech.edu`) and Chien-Ting Chen (`chien-ting.chen@nasa.gov`).

The XR SIG also strives to advocate for missions of all sizes and scientists at different career stages. To that end, we solicited updates from a recently selected hard X-ray balloon mission, the Super–High Energy Replicated Optics, or SuperHERO (updates prepared by the PI Nick Thomas, Jessica Gaskin, Steve Bongiorno from NASA/MSFC, and Chien-Ting Chen of USRA). The SuperHERO mission is a hard-X-ray balloon-borne telescope that was recently selected by the NASA Astrophysics Division via the Astrophysics Research and Analysis opportunity. SuperHERO builds on the success of its predecessors, the HERO and HEROES missions, by demonstrating better than 10 arc-second (HPD) angular resolution on a balloon platform. This advance represents nearly an order-of-magnitude improvement to the current state of the art in the hard-X-ray bandpass and will enable unprecedented observations of non-thermal astrophysical processes. SuperHERO is a five-year mission with an inaugural two-day North American flight planned in the fall of 2028. It will first focus on the Crab Nebula, revealing the torus, filamentary structure, and the relativistic jet of a pulsar wind nebula for the first time in the hard-X-ray band. Investment in SuperHERO will enable future balloon missions, allowing detailed observation of the Galactic center, additional SNRs, AGNs, and will provide the technical development necessary for an Explorer Class, hard-X-ray telescope.

The SuperHERO observatory uses NASA MSFC's enhanced X-ray full-shell optics mounted in seven identical mirror assemblies. Each mirror assembly is co-aligned with an iMAGINE-X Inc. CdTe Double-sided Strip Detector (CdTe-DSD), originally developed for the Hitomi mission, and has a 12-m focal length. Utilizing high-heritage technology, SuperHERO will feature a carbon-composite truss (optical bench) similar to that employed on the XL-Calibur balloon mission and will incorporate the Wallops Arc-Second Pointer (WASP) system for precise attitude control. SuperHERO is being designed to accommodate larger effective areas and improved angular resolution on subsequent flights to be proposed following a successful first flight. Managed by NASA's MSFC, SuperHERO is an international collaboration with technical and science team members from Universities Space Research Association, Washington University in St. Louis, University of New Hampshire, Kavli Institute for the Physics and Mathematics of the Universe, Middlebury College, JAXA, Columbia University, CfA, Kyoto University and GSFC.

The Gamma-ray Science Interest Group

Jeremy Perkins (GSFC), Manel Errando (WashU at St. Louis), Justin Finke (NRL)

The Gamma-ray Science Interest Group (GR SIG) engages with the gamma-ray astrophysics community and provides a forum for discussions between this community and NASA.

The Future Innovations in Gamma-ray Science Study Analysis Group (FIG SAG) continues to have monthly meetings. This group, led by co-chairs Chris Fryer and Michelle Hui, Paolo Coppi, Milena Crnogorčević, Tiffany Lewis, Marcos Santander, and Zorawar Wadiasingh, focuses on identifying future science drivers, necessary capabilities, and priorities for the future of gamma-ray astronomy. The group held an in-person workshop at Michigan Tech on 24 – 28 June 2024, focusing on defining key questions for future missions and outlining priorities for key science areas. FIG SAG will have a splinter session (ID# 189) at the upcoming 245th AAS meeting on Wednesday, January 15 at 1pm, to discuss the current draft of the report and solicit community feedback.

The GR SIG organized a webinar in September 2024 focusing on the Extragalactic Background Light (EBL). The EBL is the integrated back ground light from all of the stars and dust in the observable universe, and it can absorb cosmological gamma-rays through the Breit-Wheeler process. The webinar focused on synergies between infrared instruments and gamma-ray observatories on measuring the EBL, and featured talks by Marco Ajello (Clemson), Jordan Mirocha (JPL), and Alberto Saldana-Lopez (Stockholm University).

If you are interested in the GR SIG, please consider subscribing to the GR SIG 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 (Jeremy Perkins, Manel Errando, and Justin Finke) with any inquiries or feedback regarding the GR SIG program.

Participants at the FIG SAG workshop at Michigan Tech, June 24 – 28, 2024. Credit: Tiffany Lewis

The Cosmic Ray Science Interest Group

ATHINA MELI (NC A&T STATE U.) & STEPHANIE WISSEL(PENNSYLVANIA STATE U.)

The Cosmic-Ray Science Interest Group (CR SIG) acts 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 cosmic-ray and neutrino astrophysics community to provide comments, questions and updates, or express an interest to give a presentation, based on their present work and future plans for cosmic ray or neutrino related research, relevant to NASA's mission.

The CR SIG hosted a webinar on October 7, 2024, presented by Frank Schroeder (Bartol Research Institute, Department of Physics and Astronomy, University of Delaware) on "Implications of the Snowmass Whitepaper on Ultra-High-Energy Cosmic Rays for the Science Goals and Design of Future Experiments and Missions". The recording of the webinar can be found online at the NASA PhysCOS CRSIG website. Another webinar is planned for Spring 2025 on the topic of "UHECRs and Neutrinos".

The co-chairs (Athina Meli and Stephanie Wissel) invite the members of the CR and neutrino community to contact them directly via email at ameli@ncat.edu and wissel@psu.edu with any inquiries or feedback regarding the NASA cosmic-ray and neutrino program. People interested in the activities of the CR SIG are also invited to join our mailing list, available at the NASA PhysCOS website.

HEASARC

L.ANGELINI (NASA/GSFC) AND A. PTAK (NASA/GSFC)

The first eROSITA sky-survey data release data is now available at HEASARC (Sep 2024). The Data Release 1 (DR1) comprises data from the first six months of the SRG/eROSITA all-sky survey (eRASS1) whose proprietary rights lie with the German eROSITA consortium (eROSITA-DE). The primary data products of the eROSITA-DE DR1, created by the eROSITA-DE team, consist of calibrated event files, which contain the information generated by the cameras used during the eRASS1 observations and additional derived data products (see MPE DR1 site). The eROSITA-DE team has divided the eRASS1 observations into 4700 sky tiles, each with a size of 3.6×3.6 square degrees overlapping by approximately 20 arcmin.

Users can access all the data products associated with the sky tiles using the HEASARC ERASSMASTR table via the HEASARC Browse or Xamin services. Together with the eROSITA-DE DR1, two source catalogs, ERASS1MAIN and ERASS1HARD, are also now available via the HEASARC Browse or Xamin services. The ERASS1MAIN and ERASS1HARD catalogs include the sources detected respectively in the 0.2 – 2.3 keV and 2.3 – 5 keV energy ranges. Additional information for eRASS1 source catalogs is available from the MPE eROSITA-DE catalogs page.

HEASARC continues to maintain and update data from operating missions like CALET, Chandra, Fermi, INTEGRAL, IXPE, MAXI, NICER, NuSTAR, Swift, and XRISM. The HEASARC will soon host BurstCube data; BurstCube ended science operations in mid-September.

On August 24, HEASARC released version 6.34 of the HEASoft package. The release includes the first public software realease for XRISM as well as a new task and updates of the software package for the operating mission IXPE, and several upgrades and fixes for the NICER, NuStar, RXTE, SUZAKU and Swift. The XRISM package includes software to allow full data processing for the Xtend and Resolve instruments, uses common tasks developed for Hitomi and several general tasks included in in HEASsoft. The XRISM software uses calibration data that has been released in CALDB together with the XRISM software (CALDB version 20240815) with an update in

November (CALDB version 20241115). The HEASoft release also includes an update of the raytracing code and new tasks to account for the halo in the ARF calculation, new Xspec models and changes to existing models and several fixes in other mission-independent packages (see full release note). The next HEASoft release is planned for early spring 2025.

Lastly, the HEASARC is looking for a new director. The deadline for applications for the HEASARC director position closed on Oct 21 and selection is underway.

Cherenkov Telescope Array Observatory (CTAO)

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

This has been a busy period for the Cherenkov Telescope Array Observatory, CTAO, as major construction milestones are planned for 2025 and beyond. On October 14, the CTAO, together with its hosting partners and shareholders, Deutsches Elektronen-Synchrotron DESY, celebrated the official inauguration of the CTAO Science Data Management Centre (SDMC) at the DESY campus in Zeuthen, near Berlin. The ceremony was attended by over 250 guests and featured speeches from state and local dignitaries, as well as CTAO and DESY leadership.

The CTAO SDMC is one of the Observatory's four core facilities, together with the Headquarters in Bologna, Italy, and the two array sites in Spain and Chile. It serves as the scientific gateway for data received from the two telescope arrays and will coordinate both software and computing efforts, making CTAO's data products available to the worldwide community. The CTAO SDMC will also be the home of the CTAO Computing Department, which is working to develop a package of hardware and software products to support the flow of data.

CTAO SDMC building, located in Zeuthen, Germany. Credit: DESY

The CTAO Central Organisation has been undergoing a massive recruitment campaign to fill around 30 positions this year as it prepares for construction. Of note, two key positions within its senior management team were recently filled: Nadia Defrancesco has been promoted to Director of Administration and Maurizio Miccolis has joined the CTAO as its new Project Manager.

Moreover, Masahiro Teshima was elected as the new Spokesperson of the CTAO Consortium for the next three years. He succeeds Werner Hofmann, one of the founding figures of the CTAO, who served in that role for more than 15 years.

There were great advances on the technological front, too. Both the Array Control and Data Acquisition (ACADA) system, the software responsible for the supervision and control of telescopes and calibration instruments at both CTAO array sites, and the Large-Sized Telescope (LST), have passed their corresponding Critical Design Review (CDR). In the case of ACADA, this approval marks a new phase in the project, moving from testing to integrating the advanced software packages that will operate the arrays. For the LST, the largest of the three types of telescopes the Observatory will deploy, the CDR approval paves the way for the final acceptance and handover to the CTAO of the LSTs, which are currently under commissioning and construction at CTAO-North in La Palma (Spain).

In the U.S., work continues on the upgrade to the camera for the prototype Schwarzschild-Couder Telescope (SCT). The SCT uses the same telescope mount and drive system as the CTAO Medium-Sized Telescope (MST) and similar camera technology to the Small-Sized Telescope (SST), positioning U.S. groups to contribute to the construction of the MST and SST arrays, while continuing to develop the SCT design as a possible future enhancement to the CTAO.

Finally, the Astrophysics Centre for Multimessenger studies in Europe (ACME) has officially kicked-off. ACME is an EU-funded project, coordinated by the Centre National de la Recherche Scientifique (CNRS) in France, which aims to realize an ambitious coordinated European-wide optimization of the accessibility and cohesion between multiple leading astroparticle and astronomy research infrastructures. With 40 world-class collaborating institutions from 14 countries, the CTAO will participate in the project leading the development of the Center of Expertise on gamma-ray astronomy.

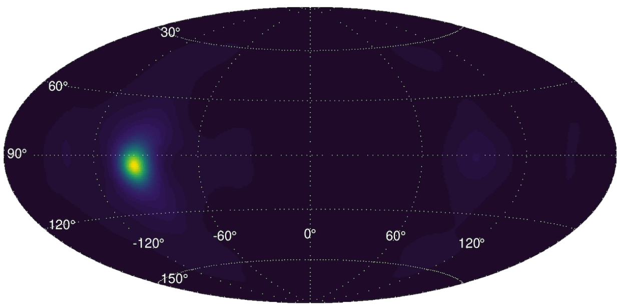
COSI: The Compton Spectrometer and Imager

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

COSI is a NASA Small Explorer 0.2 – 5 MeV gamma-ray mission planned for launch in 2027. There have been several milestones for COSI in the second half of 2024. In July, NASA selected SpaceX to be COSI's launch provider, and a kickoff meeting was held with SpaceX in August. In

September, the technical achievement of demonstrating Compton imaging with a flight-like detector, electronics, and software was achieved. In October, the first in-person science team meeting "COSIfest" was held in Berkeley, CA with more than 50 people attending. In November, COSI completed Payload Critical Design Review, and Mission CDR will be held in December.

With COSI's large (>25% sky) field of view, it will survey the sky in the MeV band, providing all-sky (and thus all-Galaxy) gamma-ray images for studying emission lines, including the electron-positron annihilation line at 511 keV and several nuclear lines. COSI science also includes polarization studies and transient detection for Time Domain and Multimessenger (TDAMM) science.



COSI first light image. This is a Compton-reconstructed image from data taken in September 2024 with a ^{137}Cs 662 keV source illuminating a 64-strip germanium detector. The image verifies the operation of the detector with flight-like electronics and software. However, it is not representative of the expected COSI angular resolution because it is a near-field image projected in the far-field. Credit: COSI

NewAthena

Kristin Madsen (NASA/GSFC) and Andy Ptak (NASA/GSFC)

NewAthena, formerly known as Athena, is an ESA L-class mission selected for study in 2014 for the Cosmic Vision Program. After its redefinition phase in 2022 – 2023, the project is once more steadily moving towards the ESA Mission Adoption Review (MAR) in 2027 and launch in 2037. It is firing on all cylinders and preparing for the Intermediate Review (IR), scheduled in the summer of 2025. The IR will evaluate all subcomponents of the mission and is a critical gateway to ensure that everything is on track going toward the MAR.

The NewAthena mission consists of two main instruments: the Wide-Field Imager (WFI) and the X-ray Integral Field Unit (X-IFU). The WFI will simultaneously provide imaging over a wide field (40×40 arcmin) with spectrally and time-resolved photon counting. The WFI sensor is a DEPFET (depleted p-channel field effect transistor) with a pixel size of 2.2 arcsec and an energy resolution of ≤170 eV at 7 keV. The X-IFU is an X-ray calorimeter that combines high spectral resolution with high-quality imaging. It has an approximate field of view of 4 arcmin, a pixel size of 5 arcsec, and an energy resolution at 7 kev of ≤4 eV. A mirror with a diameter of 2.3 m that is populated by Silicon Pore Optic (SPO) modules and capable of achieving more than 1 m^2 of effective area at 1 keV focuses at 12 meters onto one of the two instruments at a time. It is shifted between the two focal planes by a hexapod upon which it is mounted.

DSO	Description
1	Determine the location and nature of the primary source of X-rays and its connection to the inner accretion/ejection mechanisms in AGN and stellar compact objects
2	Determine how outflows are launched from around supermassive black holes and how they impact the evolution of galaxies since Cosmic Noon
3	Measure the space density of the AGN that dominate black hole growth out to the epoch of re-ionization
4	Constrain the kinematics of hot gas and metals in massive haloes
5	Map via deep X-ray imaging the properties of the most common ba[ryonic reservoirs in the Universe, and probe their] evolution and connection to the cosmic web
6	Map via deep X-ray spectroscopy the properties of the most comm[on baryonic reservoirs in the Universe, and probe] their evolution and connection to the cosmic web
7	Chemical enrichment over cosmic time
8	Multi-messenger astrophysics
9	Equation of State of Neutron Star *NEW!*

The Hot Universe · ***The Energetic Unive[rse]*** · ***Observatory and Discovery Science***

The NewAthena Driving Science Requirements. Credit: NASST

In the coming months leading up to the IR, the verification of the revised NewAthena science requirements takes center stage and is the responsibility for which the NewAthena Science Study Team (NASST) was assembled. There are an impressive 33 science requirements, 17 of which were revised during the reformulation. Eight were identified as Driving Science Objectives (DSO), and one new DSO was identified on the measurement of the NS equation of state. The NASST is tasked with confirming that the current instrument design meets these scientific requirements.

The NewAthena MAR will require the delivery of the Definition Assessment Report, called the "Red Book". An extensive summary of the NewAthena science case is at its core, covering the breadth of its transformational scientific objectives. The NASST shall submit the Red Book to ESA by the end of August 2026. In preparation for the Red Book, the NASST seeks support from the whole science community. In the most recent NewAthena Community e-Newsletter (issue 4), which was released by the NewAthena Community Outreach (ACO) office, the project warmly welcomes new or complementary approaches to the NewAthena scientific objectives, quantitative predictions of NewAthena observations and experiments. This is achieved by contributing to an Astronomy and Astrophysics Special Issue, the call for which will be issued at the end of 2025 with manuscripts prepared during the first half of 2026.

As a consequence of the redefinition of the mission and revision of the science requirements, the current set of SWGs is scheduled to be restructured early in 2025 to match the updated science profile of the mission more closely. This is coordinated by the NASST and facilitated by the ACO, who will open a call for participation for the whole science community worldwide to join the NewAthena science community. Due to legal issues, everyone on the current SWGs must reconfirm their commitment.

NASA is contributing the X-IFU sensor and readout and, since the redefinition, the cryocooler for X-IFU. For the WFI, NASA is contributing background analysis work and design consultation for the WFI ASIC. NASA is also providing a vibration isolation system for launch. At the end of this year, NASA will no longer contribute to the X-ray and Cryogenic Facility (XRCF) as the baseline calibration facility. The detailed calibration design and concept work conducted at XRCF were incredibly valuable and highlighted several challenges with calibrating a large segmented mirror, which will be used to inform the future calibration plan of the NewAthena mirror. More information on the US contribution can be seen NewAthena presentations webpage.

You can keep up-to-date with NewAthena via the NewAthena community website, or through the Twitter handle @AthenaXobs and via Facebook. To find out more about the science enabled by the instrument and the technology, explore the NewAthena Science Nuggets and Tech Nuggets.

LIGO-Virgo-KAGRA Collaboration

J. McIver (The University of British Columbia) and P. R. Brady (U. Wisconsin-Milwaukee)

The two LIGO detectors (LIGO Hanford and LIGO Livingston) and the Virgo detector began the second part of the fourth observing run, O4b, on April 10, 2024. LIGO Hanford was down July 13 – 25 August 2024 to address an issue with the output optics and again October 22 – 29 2024 to swap a laser component. Virgo took advantage of LIGO Hanford's downtime during the summer to pursue detector performance improvements July 22 – August 2, 2024. LIGO Livingston was down October 10 – 30, 2024 to address an issue with a fast shutter that protects sensitive optics from bursts of high power when the interferometer loses light resonance. O4 has been extended until June 9, 2025.

The two LIGO detectors are currently operating with a sensitivity of 155 – 175 Mpc. The Virgo detector is currently running with a sensitivity of 55 – 60 Mpc. Thus far in O4b the detector network has had 30% triple coincidence observing time (with all three detectors observing) and 67% uptime with two or more detectors observing.

The KAGRA detector continues to recover from a 7.6 magnitude earthquake that occurred close to the site in January 2024 and aims to join the end of O4 with a target BNS range of $\sim$ 10 Mpc.

As of mid-November 2024, the LIGO-Virgo-KAGRA collaboration has identified 79 significant gravitational-wave candidate events with low-latency searches in O4b (since 10 April 2024), plus 7 retracted alerts. In addition, more than 1080 low-significance alerts have been released. Together with O4a observations (May 24, 2023 through January 16, 2024) the LIGO-Virgo-KAGRA collaboration has thus far identified 160 significant gravitational-wave candidate events and 2690 low significance candidates in total during O4, plus 18 retracted candidates. 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.

The LVK recently announced improved upper limits on gravitational-wave emission from a core-collapse supernova from a non-detection of SN 2023ixf. This supernova, in the galaxy Messier 101, was the closest in decades at an estimated distance of 6.7 Mpc. It was observed May 19, 2023, during LIGO-Virgo-KAGRA Engineering Run 15 and ahead of the start of the current O4 observing run, resulting in limited uptime of the LIGO and Virgo detectors. Even with limited observing time, the proximity of SN 2023ixf allowed for an improved upper limit on the energy released by the supernova in gravitational waves.

Although there are not yet any unretracted binary neutron star event candidates during O4, the collaboration continues to run 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.

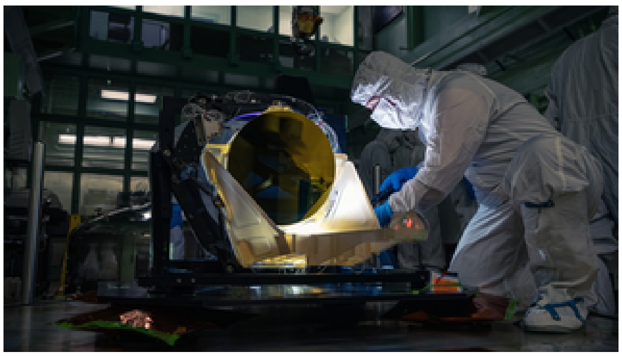
The Collaboration's observing plans are also available. The LVK Collaboration is reviewing the timetable for an expected O5 run at improved sensitivity.

Laser Interferometer Space Antenna

James Ira Thorpe (NASA/GSFC)

The *LISA* mission continues its rapid transition from the formulation phase into the implementation phase. Following on January's decision by ESA's Science Programme Committee to adopt LISA into the flight program, ESA issued an invitation to tender for the three LISA spacecraft. Bids were received in August and the evaluation and selection process is ongoing. An award is expected to be made in late 2024 or early 2025. Once the spacecraft vendor is onboard, the project will enter the co-engineering phase, in which detailed design and interface requirements are consolidated and confirmed between ESA, ESA's spacecraft vendor, and the other entities responsible for the LISA hardware, including NASA and several ESA member states. This consolidation process will allow all partners to proceed with their long-lead procurement items and will support a mission-level Preliminary Design Review in 2027. The launch readiness date remains on target for 2035.

Following ESA's Adoption decision, ESA and NASA signed a Memorandum of Understanding governing the LISA partnership in May 2024. NASA formally transitioned LISA from a study office to a Project Office within the Explorers Program Office in August 2024. The NASA project is preparing for a System Requirements Review/System Definition Review (SRR/SDR) in January 2025, which will then lead to a Key Decision point A/B and transition to NASA Phase B in Spring 2025. This review process is intended to confirm the requirements baseline for the NASA deliverables so that the acquisition process can begin in time to support ESA's schedule.



The prototype LISA telescope undergoes post-delivery inspection in a darkened NASA Goddard clean room. Credit: NASA/Dennis Henry

In parallel to the programmatic developments, the final elements of the *LISA* technology development program are being completed. In May 2024, NASA took delivery of an Engineering Development Unit (EDU) for the LISA Telescope from L3 Harris Technologies. The EDU is a quasi-monolithic all-glass telescope which is designed to meet the stringent wavefront quality, scattered light, and dimensional stability requirements for LISA. The EDU is currently undergoing a series of tests at the Goddard Space Flight Center to verify its requirements. The NASA-developed laser system and the UF-developed Charge Management Device are also completing their technology development activities and transitioning towards acquisition. In Europe, preparations are underway to build other key elements of the LISA instruments including the Gravitational Reference Sensor (led by Italy, with contributions from Switzerland and NASA), the Interferometric Detection System (led by Germany, with contributions from UK, France, Netherlands, Belgium, and Denmark), and the Science Diagnostic System (Spain).

The LISA science community is evolving to serve the needs of the project. A joint ESA/NASA science team was selected in July, which will provide scientific guidance to the project. Preparations for LISA data analysis are being made through a collaboration of ESA, ESA Member States (led by France), and NASA. The goal of this combined team is the system which will convert LISA telemetry to a series of scientific data products suitable for conducting the full range of LISA science investigations. These data products will be provided to the public following a schedule defined in the LISA Science Management Plan.

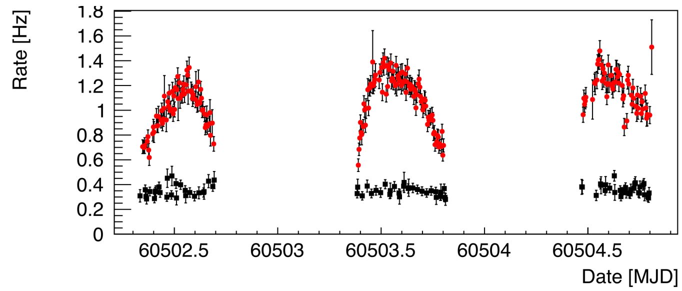
The LISA Consortium is making progress with its reorganization to accommodate the needs of the flight project and the broader scientific community. The results of this reorganization are expected in late 2024. In the US, the GW Science Interest Group (GWSIG) of the Physics of the Cosmos Program Analysis Group (PhysPAG) has started a LISA subgroup with bi-weekly calls to exchange news and information. A large fraction of the LISA community gathered in Dublin, Ireland for the 15th LISA Symposium. This was the first in-person Symposium since 2018 and drew over 400 attendees from around the world. The next LISA Symposium is planned for North America in 2026. The LISA Consortium and the Gravitational Wave International Committee are currently seeking potential hosts.

XL-Calibur

E. Gau, M. Kiss, M. Pearce,
H. Takahashi, F. Kislat, S. Spooner, H. Krawczynski
on behalf of the XL-Calibur team

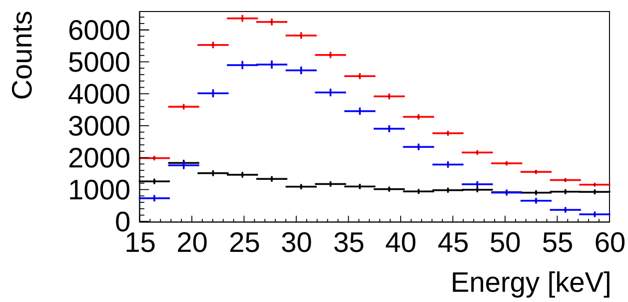
The XL-Calibur mission was launched on a Long Duration Balloon (LDB) flight from the Esrange Space Center in Sweden on July 9, 2024. Over the course of five days, the mission observed the Crab nebula and pulsar, as well as the stellar mass black hole Cygnus X-1. The experiment is a collaborative effort involving 66 scientists from 21 institutions across the United States, Japan, and Sweden, led by Principal Investigator H. Krawczynski from Washington University in St. Louis. The XL-Calibur experiment uses a 12 meter focal length grazing incidence mirror that was fabricated as a spare mirror for the *JAXA* Hitomi mission. The mirror focuses 15 – 80 keV X-rays onto a scattering polarimeter, comprised of a beryllium scattering element surrounded by Cadmium Zinc Telluride (CZT) detectors. The mirror and polarimeter are suspended on a 12 meter carbon-fiber tube/aluminum joint composite optical bench; the whole experiment is pointed with the Wallops Arc Second Pointer (WASP), offering arc-second pointing stability. The use of the powerful X-ray mirror with its high effective area, the 0.8 millimeter thin CZT detectors, and a thick $Bi_4Ge_3O_{12}$ anticoincidence shield led to a high signal-to-noise ratio during the observations of the two sources. The 15 – 80 keV XL-Calibur results complement the results from the 2 – 8 keV Imaging X-ray Polarimetry Explorer *IXPE*, which was launched on December 9, 2021. *IXPE* has made precision measurements of the X-ray polarization from a diverse sample of galactic and extragalactic sources.

XL-Calibur collected about fifty thousand 15-60 keV X-rays from the Crab nebula and pulsar and a similar number of photons from Cygnus X-1. The two sources were detected at a rate of 1 Hz above a background of 0.3 Hz. The detailed polarization results will be published in the near future. The data will be made available via NASA's HEASARC archive. The XL-Calibur Cygnus X-1 observations were accompanied by simultaneous observations with NICER and with NuSTAR, and by preceding observations with IXPE. XL-Calibur demonstrated that balloon-borne missions can perform high signal-to-noise X-ray spectropolarimetric measurements of bright X-ray sources. The NASA APRA program has committed to fund one XL-Calibur flight from McMurdo (Antarctica). Depending on NASA launch scheduling, the mission may be launched in December 2026, 2027, or 2028.



Preliminary light curve from XL-Calibur's three days of observing the Crab nebula and pulsar. Red data points show the detection rate during the observations of the source. Black data points show the background rate measured during the observations of background regions. Both source and background data have a bin width of 5 minutes. For each of the three days, the Crab detection rate changes with the source elevation and the atmospheric column density. Credit: E. Gau, M. Kiss, et al.

The hard X-ray polarization mission XL-Calibur was launched on July 9, 2024 from the Esrange Space Center (Sweden) and acquired high signal-to-noise spectropolarimetric data sets on the Crab nebula and pulsar and the stellar-mass black hole Cygnus X-1. Credit: XL-Calibur Collaboration



Preliminary energy spectrum from XL-Calibur's three days of observing the Crab nebula and pulsar. Red data points show the hard X-ray energy spectrum acquired when pointing at the source, black data points show the off-source (background) energy spectrum (scaled for exposure time), and blue data points show the background-subtracted source energy spectrum. Credit: E. Gau, M. Kiss, et al.

HEAPoetry Corner

Pity the Nation (after Kahlil Gibran)

Pity the nation whose people are sheep,
and whose shepherds mislead them.
Pity the nation whose leaders are liars,
whose sages are silenced
and whose bigots haunt the airwaves.
Pity the nation that raises not its voice,
except to praise conquerors and acclaim the bully as hero
and aims to rule the world with force and by torture.
Pity the nation that knows no other language but its own
and no other culture but its own.
Pity the nation whose breath is money
and sleeps the sleep of the too well fed.
Pity the nation —
or, pity the people who allow their rights to erode
and their freedoms to be washed away.
My country, tears of thee, sweet land of liberty.

— Lawrence Ferlinghetti