# The High Energy Astrophysics Division Newsletter

In this Issue:



## From the Chair

Rob Petre (NASA/GSFC)

With upcoming meetings and changes afoot, HEAD will have an exciting next few months.

The most pressing activity that I would like to draw your attention to is the HEAD election, now in progress. This year we are electing the critical posts of Secretary and Treasurer, in addition to two Executive Committee members. I urge all of you to take a few minutes to read the candidates' statements and cast a ballot before the polls close on December 28. HEAD elections historically draw a higher fractional turnout than other Society elections; let's make the turnout for this election a record.

As always, HEAD has exciting plans for its sessions at the January AAS meeting. This year our two special sessions (Tuesday morning and afternoon) commemorate the 20th anniversary of the launch of the *Chandra* X-ray Observatory and the 10th anniversary of the launch of the *Fermi* Gamma Ray Space Telescope. The highlight for HEAD will be the Tuesday afternoon Bruno Rossi Prize lecture by Colleen Wilson-Hodge (NASA / MSFC) who is being awarded the Prize for her leadership of the *Fermi* GBM team and their detection of GRB170817a = GW170817. I hope all of you coming to the Seattle meeting will attend these sessions. Additionally, all are encouraged to attend the HEAD business meeting on Wednesday evening, where we will announce this year's winners of the Rossi, Dissertation, and Mid-Career prizes, the results of the HEAD election, and more.

An important topic that will be addressed at the business meeting is the revision of the HEAD by-laws, currently underway. The by-laws must be changed to reflect the new AAS governance structure. The need to make these changes has induced the HEAD Executive Committee (EC) to perform a more extensive scrubbing of the by-laws, addressing topics like membership classes and discussion of Division prizes, and clarifying the language. The revised by-laws, once approved by the AAS, will be put to a vote by the HEAD membership early next year.

A second topic of interest to HEAD members is the potential creation of new Division prizes. The Rossi Prize emphasizes "Recent original work in High Energy Astrophysics." This makes it difficult to recognize HEAD members in important categories like lifetime achievement, service to the community, and instrumentation development. The EC is considering recommending the addition of one or more prizes to cover some or all of these areas.

The EC has also been busy planning our 17th Divisional meeting, which will be held on March 17–21, 2019, at the Portola Hotel in Monterey, CA. We have an exciting lineup of special sessions planned, and will pay special tribute to the 20th anniversaries of *Chandra* and *XMM–Newton*, and the 10th anniversary of *Fermi*. An especially significant milestone is that 2019 marks HEAD's 50th anniversary. We are planning a retrospective on the Division, and will reach out to the Division's charter members in the hope some will attend the meeting and share with us their reminiscences. I hope to see all of you in Seattle and at Monterey.

And finally, some breaking news as we go to press. We'd like to extend our heartiest congratulations to Fiona Harrison, the HEAD Vice Chair, for being named co-chair (with Rob Kennicutt, Jr.) of the 2020 Decadal Review.

## HEADlines

Megan Watzke (CXC)

The era of "multimessenger" astronomy continues with a press conference at NSF headquarters in Washington, DC, on July 12, announcing the discovery of neutrinos from an identified cosmic source. Observations from instruments on the ground, such as IceCube, MAGIC, and VERITAS, plus those in space including *Fermi*, contributed to this exciting result. Meanwhile, new observations and papers continue to emerge in the evolving area of gravitational wave astrophysics. A steady stream of newsworthy discoveries continues to flow out of other high-energy missions such as *Chandra*, *XMM–Newton*, *Swift*, *NuSTAR* and more. A personal selection of these exciting discoveries is below:

May 31, 2018 "Gravitational Wave Event Likely Signaled the Birth of a Black Hole"

June 11, 2018 "NASA's Fermi Satellite Celebrates 10 Years of Discoveries"

June 20, 2018 "XMM-Newton Finds Missing Intergalactic Material"

July 3, 2018 "NASA's NuSTAR Mission Proves Superstar Eta Carinae Shoots Cosmic Rays"

July 12, 2018 "IceCube Neutrinos Point to Long-Sought Cosmic Ray Accelerator"

July 12, 2018 "NASA's Fermi Traces Source of Cosmic Neutrino to Monster Black Hole"

July 18, 2018 "Chandra May Have First Evidence of a Young Star Devouring a Planet"

August 9, 2018 "Finding the Happy Medium of Black Holes"

October 8, 2018 "Hot X-ray Glow from Massive Cluster of Galaxies"

October 10, 2018 "'Pulsar in a Box' Reveals a Surprising Picture of a Neutron Star's Surroundings"

October 16, 2018 "All in the Family: Kin of Gravitational-Wave Source Discovered"

As people start to prepare for the upcoming HEAD meeting in Monterey in March, please consider if you have a potentially newsworthy abstract that you will be submitting. What constitutes a result worthy of a press release? Contact me with a short synopsis at mwatzke@cfa.harvard.edu and I will do my best to provide guidance and/or advice.

The news offices of the various HEAD missions are always ready to help reporters trying to work on a story, or to help scientists prepare a press release for distribution. Please contact the relevant news office if you believe you have a potentially newsworthy result. If you don't know who to contact, please email me at mwatzke@cfa.harvard.edu.

## LIGO-Virgo Scientific Collaborations

David Shoemaker, LSC Spokesperson

*LIGO*'s focus in the last half-year has been on wrapping up the analyses of the second observing run, 'O2', and preparing for the next run, 'O3', planned to start in early 2019. Since the last Newsletter, the Collaboration has published a handful of papers with more interpretation of the binary neutron star coalescence GW170817, with a suite of papers in preparation which summarize the findings and science from the O2 run.

A core activity of the *LIGO* Laboratory is bringing the detectors to the desired sensitivity. For O2, *LIGO* had one detector at roughly 80 Mpc reach for binary neutron stars (for an SNR of 8, averaged over positions and polarizations), and a second at roughly 100; *Virgo* joined with a sensitivity of roughly 25 Mpc sensitivity. For O3, we expect a sensitivity of 120 Mpc for both *LIGO* detectors and 60 Mpc for *Virgo*. Because the detection rate goes with the cube of this distance, we anticipate a significant increase in the detections of known sources. The improved sensitivity in the instruments is achieved with increased laser power and the use of 'squeezed light' to improve the high-frequency quantum-limited sensitivity, and at lower frequencies improved baffling and refined control systems.

In parallel, work is underway in the Collaboration for the new regime of public alerts. As noted in the previous HEAD Newsletter, those alerts will be distributed using the standard GCN/TAN approach, with first alerts within minutes of triggers and updates with refined information to follow. We are starting more regular interaction with the greater observing community via email and teleconferences to ensure observers can prepare for the alerts and discoveries. An engineering run (ER13) is planned for December 2018, allowing a test of this capability as well as exercising both the hardware and software for O3.

## The Laser Interferometer Space Antenna

Ira Thorpe (NASA/GSFC), Guido Mueller (U. Florida)

The Laser Interferometer Space Antenna (*LISA*) mission continues to make progress on a number of fronts. The European Space Agency-led *LISA* project is currently in Phase A, and is on track to complete a mid-Phase A review in 2019. ESA has partnered with European industry to develop a detailed design of the spacecraft that will be used to inform later phases of the project. In parallel, the *LISA* Consortium, supported by and in collaboration with a group of European National agencies, is working to finalize the design of the *LISA* payload, which will include contributions from a number of European institutions and NASA. NASA's *LISA* effort is supporting both of these activities by developing a number of subsystems that could potentially be contributed. In addition, NASA

and ESA are investigating other opportunities for NASA to contribute to the non-payload elements of the flight system. All three groups collaborate through the ESA-led Systems Engineering Office to ensure that the tightly-integrated *LISA* measurement system will deliver the desired performance.

The international *LISA* scientific community has organized itself into the *LISA* Consortium, which now includes more than 900 members working on *LISA* in more than 20 different countries. Grown out of the proto-consortium which submitted the *LISA* mission proposal to ESA in 2017, the *LISA* Consortium will contribute to the payload design, the development of data analysis tools, and the scientific exploitation of the *LISA* data. The Consortium gathered in Marseille, France in early November to discuss progress in each of these areas. Researchers interested in joining the Consortium should visit the *LISA* consortium website.

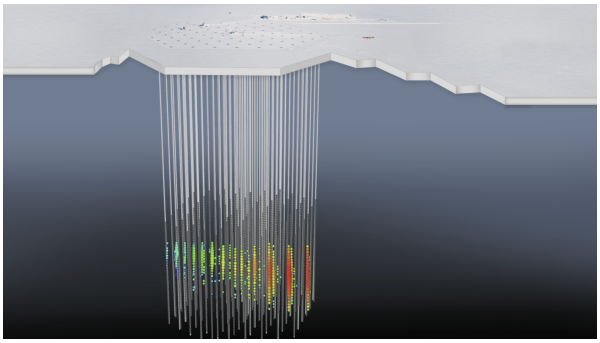
The NASA *LISA* Study Team (NLST), a US community team that provides input to NASA on *LISA* science, is busily preparing for the 2020 Decadal Survey of Astronomy and Astrophysics. The NLST has drafted more than a dozen whitepapers on elements of the *LISA* science case, many of them in collaboration with colleagues in other areas of astrophysics including electromagnetic observers, computational modelers, and theorists. Readers interested in the *LISA* science whitepaper activity should contact NLST chair, Kelly Holley Bockelmann (k.holley@vanderbilt.edu).

## IceCube

Sílvia Bravo Gallart and Francis Halzen
(University of Wisconsin-Madison)

Cosmic rays were first detected by Victor Hess over one hundred years ago, and the origin of these high-energy subatomic particles from deep space have posed an enduring mystery ever since. IceCube, operated by the Wisconsin IceCube Astroparticle Physics Center (WIPAC) for the NSF at the South Pole, was designed to use cosmic neutrinos to explore the extreme universe and to identify the sources of cosmic rays. Neutrinos unambiguously pinpoint cosmic ray accelerators in the sky, since they are produced near sites of cosmic-ray acceleration and travel directly from the source undeflected by the Galactic magnetic field.

Once a very high energy cosmic neutrino candidate is detected, the IceCube team sends a neutrino alert to the Gamma-ray Coordinates Network within a minute of the detection, alerting high-energy researchers for follow-up observations. The tenth such alert, IceCube-170922A, (Circular Service, No. 21916, #1, 2017) on September 22, 2017, reported a well-reconstructed muon neutrino with an energy of 290 TeV and a high probability of originating in a cosmic source.



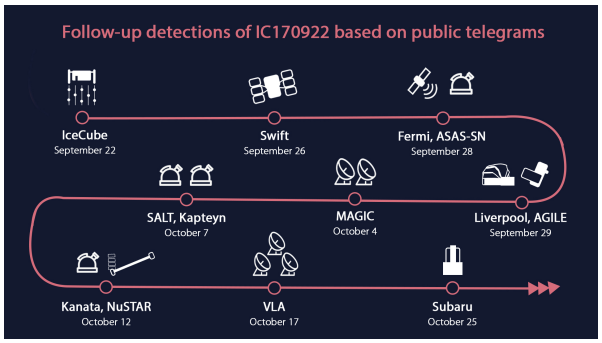
*IceCube encompasses a cubic kilometer of pristine ice deep below Antarctica's surface and next to the NSF Amundsen-Scott South Pole Station. In this illustration, based on an aerial view near the South Pole, an artistic rendering of the IceCube detector shows a muon track created by the interaction of a neutrino with a molecule of ice. The display pattern is how scientists represent data on recorded light. Every colored circle represents light collected by one of the IceCube sensors. The color gradient, from red to green/blue, shows the time sequence. Credit: IceCube Collaboration/NSF*

*Fermi* (Astronomer's Telegram 10791, 2017) and *Swift* (Astronomer's Telegram 10792, 2017) both found a high-energy variable source within $0.06^\circ$ of the reconstructed position of the cosmic neutrino. This source is a blazar, TXS 0506+056, a supermassive spinning black hole whose high-energy jets are pointed directly at Earth. This blazar is notable as the highest energy gamma ray blazar detected by EGRET. Observations with MAGIC (Astronomer's Telegram 10817, 2017) then identified the "Texas" source as a rare TeV blazar. The source was subsequently observed throughout the electromagnetic spectrum, from the X-ray, to optical and radio bands. This marks the first truly multi-messenger, multi-wavelength observation of particle acceleration. In total, more than 20 telescopes observed the blazar as a highly variable source in a high-energy flaring state (IceCube Collaboration et al., Science 361, 6398, 2018). The observations triggered by the September 22, 2017 neutrino detection have yielded a treasure trove of data and allow us, for the first time, to probe the physics of an identified cosmic ray accelerator in detail.

A subsequent search of the IceCube neutrino archive revealed a spectacular burst of 15 high-energy neutrinos over a span of 110 days. This suggests that a subset ($\sim 10\%$) of all known blazars, bursting once per decade at the level of the "Texas" source, could account for all neutrinos detected by IceCube to date. But the picture gets even more exciting, because the energy of the neutrinos coming from these flaring blazars is comparable to the energy detected in extragalactic cosmic rays.

As you might guess, getting all the elements of this puzzle to fit together is not easy, but they build a compelling case that blazars are a source of high-energy cosmic rays and neutrinos. Importantly, we also found that the high-energy spectra for both photons and neutrinos of the 2017 flare from the "Texas" source, and an earlier

outburst from 2014, are consistent with the energy variation expected for a cosmic accelerator.




*Follow-up detections of electromagnetic radiation announced via telegrams to the international community by telescopes around the world and in space are shown. This system of alerts is a unique tool to multimessenger astronomy and turns the collaboration of different telescopes into the largest observatory in the world. Other follow-up detections have also been documented in scientific papers. Credit: IceCube Collaboration*

It is also interesting to note that on July 31, 2016, IceCube had sent out a similar alert, and the *AGILE* collaboration reported a day-long gamma ray flare in the direction of the neutrino, one day before the IceCube detection. This may be merely an interesting coincidence.

We now have an identified source of cosmic rays. This breakthrough is just the beginning and raises intriguing questions. What is special about it? Can the subclass of blazars to which it belongs accommodate the diffuse flux observed by IceCube? Are they the sources of all high-energy cosmic rays or only some of them? The TXS06506+056 emission over the last 10 years is dominated by the single flare in 2014. If this is characteristic of this subclass of sources, identifying additional sources will be difficult without larger neutrino telescopes to accelerate progress.

## The Chandra X-ray Observatory

ROGER BRISSENDEN (SAO) AND MARTIN C. WEISSKOPF (NASA/MSFC)

*Chandra* has carried out more than 19 years of highly successful and productive science operations. The *Chandra* X-ray Observatory is unique in its capability for producing the sub-arcsecond X-ray images that are essential to accomplish the science goals of many key X-ray and multi-wavelength investigations in current astrophysical research. The Project is looking forward to many more years of scientific productivity. In recognition of this, NASA has chosen to continue the mission and has extended the contract to operate the *Chandra* X-ray Observatory, potentially through September 2027.

The Observatory continues to operate extremely well overall but with a number of incremental changes in performance, due primarily to the gradual accumulation of molecular contamination on the UV filter that protects the ACIS detector, and to progressive degradation of the spacecraft's multi-layer insulation. Condensation on the filter reduces ACIS's sensitivity to low-energy X-rays (but does not affect the HRC). Recent measurements indicate that the accumulation rate of the contamination has decreased over the past year. The decline in insulation effectiveness requires extra effort in scheduling observations, but has not significantly affected *Chandra*'s observing efficiency. In addition, a 3-second burst of noise from one of *Chandra*'s gyroscopes led to a spacecraft safe mode in October. Although the gyroscope has operated nominally since, in order to minimize risk, the decision was made to hold that gyro in reserve and reconfigure to use one gyroscope from each of *Chandra*'s two inertial reference units. The need to operate with both units powered on has resulted in an additional thermal load, adding to scheduling constraints. Following the safe mode recovery, *Chandra* has returned to science operations.

The *Chandra* Operations Control Center (OCC), from which mission operations are conducted, is in the process of moving from its current site in Cambridge, Massachusetts. With the OCC lease ending in 2019, SAO, MSFC and the Smithsonian Institution collaborated to find a new location. After defining requirements and carrying out an extensive search, we identified and leased space in Burlington, Massachusetts. Interior construction on the new space is now complete, and the facility will be available for the data system and operations testing phase beginning in November 2018. Following testing and readiness reviews, operations in the new facility are planned for Q2 of 2019.

Release 2.0 of the *Chandra* Source Catalog (CSC) is nearing completion. The catalog contains complete source property data for $\sim 316,000$ detected sources. Properties for the remaining sources are being be added to the catalog as they are processed. The CSC2 website provides access to the Release 2 data, as well as documentation that describes the organization and content of the catalog, including important information that should be reviewed before using the catalog data.

In December 2017, the *Chandra* X-ray Center (CXC) issued a call for proposals for Cycle 20 observations. Scientists worldwide submitted 527 proposals, including 431 proposals for observing and 96 for archive and theory research. The observing proposals requested a total of 9.9 Msec of telescope time, an oversubscription factor of approximately 6. The Cycle 20 peer review, held in June 2018, approved 133 observing proposals and 24 proposals for archive and theory research.

NASA announced the selection of 24 Fellows for the 2018 NASA Hubble Fellowship Program (NHFP), which supports postdoctoral researchers performing research across all of NASA astrophysics. NHFP postdocs are named as Hubble, Einstein, and Sagan fellows, depending on their research topics. Seven of those selected for 2018 were named as Einstein Fellows. The Einstein Fellows Symposium was held at the Harvard-Smithsonian

Center for Astrophysics on October 2–3, 2018.

The CXC hosted a workshop, "Accretion in Stellar Systems" at the Center for Astrophysics from August 8-10, 2019. The workshop brought together researchers working on accretion, outflows, and related processes in diverse astrophysical objects. The workshop included a special session dedicated to the late Jeffrey McClintock's legacy to the field.

The *Chandra* Press Office has been active in issuing image releases, science press releases and other communications of *Chandra* research results. A complete listing is available at the *Chandra* press release website. The annual Newsletter (#24) was released and distributed in April. As always, additional information about the *Chandra* Observatory and the *Chandra* X-ray Center can be found at the CXC website.

## XMM-Newton

Lynne Valencic (JHU & NASA/GSFC)

The 18th Call for Proposals for *XMM–Newton* closed on October 5, 2018. There were 442 proposals submitted; 15 were for Fulfil Programs, 54 were for Triggered/ToO observations, 61 were for Large Programs, and 100 were for joint programs with *HST*, *Swift*, VLT, *Chandra*, NRAO, or *NuSTAR*. Taking both principal and co-investigators into account, about 1500 scientists were involved in the response to the AO. The oversubscription rate was 7.7.

The results of the AO18 peer review were released on November 28, 2018. Funding may be available for A/B-ranked proposals with US PIs depending on the outcome of the 2019 Senior Review. Phase II proposal submission for approved proposals will run from January 8 - February 1, 2018. Approved observations are planned to be performed starting May 2019.

Presentations shown at the *XMM–Newton* Science Operations Center (SOC)'s workshop on "Time Domain Astronomy: A High Energy View" are now available online. The agenda, minutes, and presentations from the May 2018 Users Group Meeting are also available online.

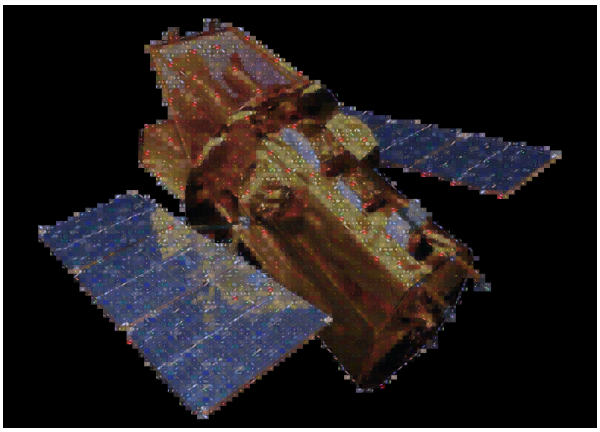
## The Neil Gehrels Swift Observatory

Eleonora Troja (NASA/GSFC), Brad Cenko (NASA/GSFC)

Approaching the 14th anniversary of its launch on November 20, 2004, the Neil Gehrels Swift Observatory continues to operate flawlessly. It supports four Target of Opportunity (ToO) requests per day 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 the variety of sources observed.

The Ultraviolet/Optical Telescope (UVOT) aboard *Swift* captured its millionth image on May 13, 2018. It took an image of an active galaxy called 2MASX J16110570+0234002, which scientists think exhibited some unusual behavior. A mosaic created using UVOT images since *Swift* launched in 2004 celebrates this major milestone for the mission.

About a year ago, astronomers excitedly reported the first detection of electromagnetic waves from a gravitational wave source. Now, a year later, a cosmic relative to that historic event was found in the archival *Swift* data. GRB150101B was a gamma-ray burst that lasted less than a second, localized by *Swift* and *Chandra* in an old elliptical galaxy 1.7 billion years away. The apparent similarities between GRB 150101B and GW170817 are striking: both produced an unusually faint and short-lived gamma ray burst, and both were a source of luminous optical light lasting a few days, and X-ray emission which lasted much longer. The host galaxies are also remarkably similar. Both are bright elliptical galaxies with a population of stars a few billion years old with no evidence for new star formation. The slow rise in the X-ray emission compared to most GRBs implies that, for both GRB 150101B and GW170817, the explosion was likely viewed "off-axis", with the jet not pointing directly towards the Earth.



*This mosaic of the Neil Gehrels Swift Observatory is created from images of astronomical objects captured by the satellite's Ultraviolet/Optical Telescope which recently captured its millionth image. See the high resolution mosaic for full details of the images used in the mosaic. Credit: NASA/Swift and AndreaMosaic*

*Swift* discovered a burst of X-rays from a slowly spinning neutron star, called Swift J0243.6+6124, pulling material from a massive companion star. The characteristics of the emission at X-ray and radio wavelengths convinced astronomers that they were seeing light produced by a jet. Common theories for jet formation in these systems imply that a very strong magnetic field overpowers and prevents the jet from forming. The presence of a jet in Swift J0243.6+6124 contradicts this longstanding idea, and suggests that the jet is powered by the neutron star's rotation.

The *Swift* Cycle 15 GI program proposal deadline was September 27, 2018. NASA received 141 proposals for Cycle 15, requesting a total observing time of 14.9 Ms and $5.0M in funds for 1,309 targets. The *Swift* Cycle 15

Peer Review will be held in December; cycle 15 observations will commence on or around April 1, 2019, and will last 12 months.

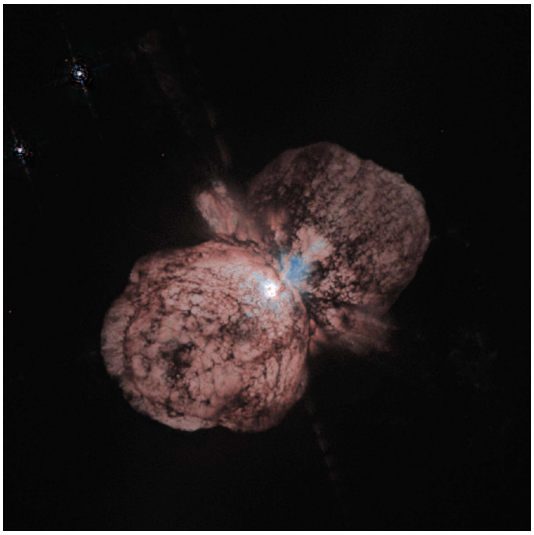
## NuSTAR

DANIEL STERN (JPL), FIONA HARRISON (CALTECH)

The *NuSTAR* mission continues to operate nominally on orbit. Over the past six months, *NuSTAR* crossed the exciting threshhold of 500 refereed publications. Recognizing the enhancing value of including hard X-ray (>10 keV) photons in lower energy studies of extreme phenomena, *NuSTAR* – besides having its own annual Announcements of Opportunity (AOs) – now makes time available through the *Chandra*, *INTEGRAL*, *NICER*, *Swift*, and *XMM–Newton* observatories. Many of these facilities also provide time through the *NuSTAR* AOs for joint observations. The joint observing program with *NICER* is new, with up to 400 ks of *NuSTAR* time available for coordinated observations with *NICER* in the *NICER* Cycle 1 AO (due December 20, 2018), and up to 250 ks of *NICER* time available for coordinated observations through the *NuSTAR* Cycle 5 AO (due January 25, 2019).

The other big change for *NuSTAR* Cycle 5 is the introduction of a Large Program category for observations longer than 500 ks. These programs will be evaluated separately by the Time Allocation Committee (TAC), and will enhance community-driven science on a scale larger than enabled by previous *NuSTAR* AOs. Up to 2 Ms of time has been made available during *NuSTAR* Cycle 5 for these Large Programs. For additional details, see the *NuSTAR* AO webpage

On the science front, a recent study using *NuSTAR* data suggested that Eta Carinae, the most luminous and massive stellar system within 3 kpc, is accelerating particles to very high energies, some of which may be detectable on Earth as cosmic rays. In a paper led by Kenji Hamaguchi of NASA's Goddard Space Flight Center and published in Nature Astronomy in July 2018, the team analyzed *NuSTAR* observations of this extreme system. Eta Carinae consists of a pair of massive stars, with masses of 90 and (perhaps) 30 times that of the Sun, whose eccentric orbits bring them within 1.5 AU of each other every 5.5 years. The collision of the strong stellar winds creates powerful shocks that are expected to produce high-energy cosmic rays through Fermi acceleration at the shock interface. The accelerated particles should then produce non-thermal emission observable in high-energy X-rays and gamma-rays. While previous non-focussing observatories identified a high-energy source in the vicinity of Eta Carinae, their poor angular resolution prevented conclusive demonstration of Eta Carinae as the source. This recent *NuSTAR* study showed that the high-energy X-ray emission is coincident, within a few arcseconds, of the stellar binary, further demonstrating that the non-thermal emission varies with the orbital phase of the binary and has a similar spectral photon index to the gamma-ray emission. This work provided conclusive evidence that high-energy emission indeed can originate from non-thermal particles accelerated by colliding wind shocks.



*Hubble Space telescope image of the massive stellar binary Eta Carinae. NuSTAR has conclusively demonstrated non-thermal emission accelerated by shocks due to colliding stellar winds in this system.*

## The Neutron Star Interior Composition Explorer

KEITH GENDREAU (NASA/GSFC), ZAVEN ARZOUMANIAN (NASA/GSFC)

Nearing the end of its baseline-science mission, and soon to embark on a Guest Observer program, NASA's Neutron star Interior Composition Explorer (*NICER*) continues to pursue and fulfill the promises of its unique capabilities, namely fast and sensitive timing spectroscopy in soft (0.2–12 keV) X-rays, with unprecedented throughput for bright sources and scheduling agility to pursue rapidly evolving phenomena. A Focus Issue of The Astrophysical Journal Letters highlights some early *NICER* science results, a recent sampling of which includes:

- The discovery, together with *NuSTAR*, of coherent 527 Hz pulsations in the new transient IGR J17591-2342, together with determination of its 8.8 hr orbit (Ferrigno et al., ATel #11957; Sanna et al. A&A 617, L8).
- Monitoring of the giant outburst of *Swift* J0243.6+6124, our Galaxy's first known ultra-luminous X-ray (ULX) pulsar, demonstrating a consistent transition between accretion regimes at a critical luminosity of $10^{38}$ erg s$^{-1}$, the highest yet observed (Wilson-Hodge et al., ApJ 863, 9).
- The detection of a millihertz quasi-periodic oscillation (QPO) from the "clocked" burster GS

1826−238, suggesting marginally stable thermonuclear burning of accreted material on the neutron star's surface (Strohmayer et al., ApJ 865, 63).

- Evidence for a warped accretion disk around a rapidly spinning black hole (Miller et al., ApJ 860, L28), and spectral-timing study of a low-frequency QPO (Stevens et al., ApJ 865, L15), in the transient MAXI J1535−571.

- Intensive monitoring across the full outburst of another bright black-hole binary, MAXI J1820+070 (e.g., Homan et al., ATels #11820 and #12068).

The *NICER* data archive at HEASARC offers, as of mid-November 2018, public access to more than 8,800 observations for nearly 270 unique targets. Upgrades to software tools and calibration products are being made available as part of each successive HEAsoft release.

We anticipate that these datasets and tools will generate significant participation in *NICER*'s Cycle 1 Guest Observer program (ROSES element D.12), with a proposal due date of December 20, 2018. Information and instructions for prospective proposers—including requests for Target of Opportunity observations—are available at NICER's website at the HEASARC.

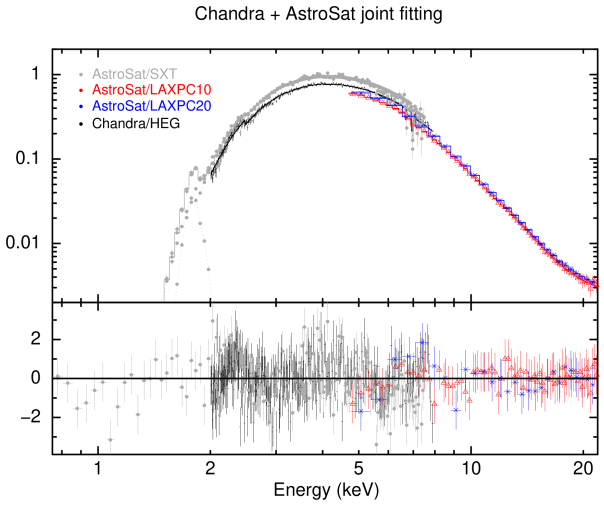
## AstroSat

K.P. Singh (IISER, Mohali), Dipankar Bhattacharya (IUCAA, Pune), S. Seetha (URSC, Bengaluru)

The Indian Space Research Organisation (ISRO) celebrated 3 years of operations of *AstroSat* on September 28, 2018 by releasing the first set of archival data to public from the ISSDC (ISRO Space Science Data Center). Observations for the proposals selected for the cycle AO5 have begun on schedule on Oct.1, 2018. As reported in the previous newsletter, the Near Ultraviolet (NUV) channel of the Ultraviolet Imaging Telescope (UVIT) continues to be inoperable. Only one of the three units of the Large Area X-ray Proportional Counter (LAXPC) is fully functional as per qualification, whereas the second unit has a higher background due to a problem with anti-coincidence. The Far Ultra-Violet (FUV) and the Visible (VIS) channels of the UVIT, the Soft X-ray Telescope (SXT) and the Cadmium-Zinc Telluride Imager (CZTI) continue to function as per expectations. A new observational programme, called the *AstroSat* Legacy Programme, has been launched, with a call of proposals from the members of the Science Working Group (SWG) of *AstroSat*, with a deadline of November 30, 2018. A limited number of observations under this programme will be carried out after a review process. These will be of a nature where a specific long-term goal is achieved via multiple observations spaced over one or more observational cycles, for a total of several hundred kiloseconds of stare time per programme. No specific cadence is guaranteed, however. At present this opportunity is open to teams led or coordinated by one or more members of the SWG. There will be no restriction on the composition of the rest of the team. Announcement of opportunity for Proposals for the next regular cycle of observations (Oct 1, 2019- Sept 30, 2020) is scheduled for release in February 2019.

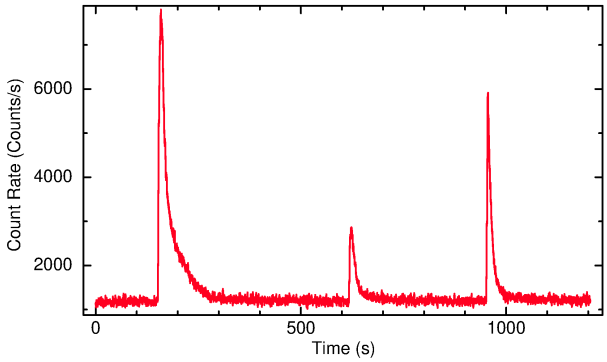
Some of the recent science highlights from *AstroSat* are as follows:

A joint analysis of the X-ray spectral data (Figure 1) obtained with the SXT, the LAXPC, and the *Chandra* High-Energy Transmission Grating Spectrometer (HETGS), from a transient black hole X-ray binary 4U 1630-47 observed in October 2016, has led to an estimate of the black hole spin. The X-ray source was found to be in a soft state with the disk flux fraction of about 0.97. The black hole Kerr parameter is constrained to be $0.92 \pm 0.04$, by fitting the disk blackbody spectrum. The results are scheduled to appear in the ApJ, M. Pahari et al. (2018).




*Joint fitting of Chandra/HEG, AstroSat/SXT+LAXPC10+LAXPC20 spectra with an absorbed, relativistic,disk-blackbody model 'kerrbb' along with Gaussian absorption features, and Comptonization model 'simpl'. Credit: AstroSat teams, NASA*

Seven thermonuclear X-ray bursts were detected with LAXPC during a two day long observation of a Low Mass X-ray Binary 4U 1636-536. One of these bursts is a rare triplet, having a wait time of only about 5.5 minutes between the second and the third bursts. This is the first time that such a short recurrence time between bursts has been seen in any thermonuclear X-ray burst source. The profile of the observed triple X-ray bursts is consistent with a recent theoretical model proposed for explaining short recurrence bursts based on the spreading layer of accreting matter over the neutron star surface. The results are scheduled to appear in the MNRAS, A. Beri et al. (2018).




*Part of X-ray light curve in 3-80 keV energy band created by using data from the three proportional counters of the LAXPC, showing the triplet of X-ray bursts observed from the LMXB 4U 1636-536. The light curve is with a binsize of 1 second. Credit: AstroSat teams*

Observations of planetary nebulae with the FUV channel have revealed the presence of new large scale diffuse features like a halo in NGC 40, and extended wings in NGC 6302 (the Butterfly nebula). The FUV features are most likely due to UV fluorescence emission from $H_2$, indicating the existence of such molecules in the regions beyond those seen in the NUV, optical or IR. These results on NGC 40 are published, and on NGC 6302 will appear, in A&A, N. K. Rao et al (2018). The *AstroSat* picture of the month can be seen at http://astronsoc.in/outreach/apom/.

## The Fermi Gamma-Ray Space Telescope

JULIE MCENERY, ELIZABETH HAYS, CHRIS SHRADER, DAVE THOMPSON (GSFC), LYNN COMINSKY (SONOMA STATE U.)

The Fermi Gamma-ray Space Telescope is celebrating its tenth year of operation in 2018, having been launched on 11 July, 2008, and having started regular science operations on 4 August, 2008. The Eighth International Fermi Symposium was held in Baltimore from 14-19 October as part of this celebration.

The Fermi spacecraft and both instruments continue routine operations, scanning the gamma-ray sky continuously. The solar panel issue that occurred in March has been circumvented by modifications to the observing strategy.

In July, the Fermi team joined the IceCube and MAGIC teams for a press conference announcing that for the first time a likely source of one of the high-energy neutrinos has been identified: a flaring blazar, TXS 0506-056.

At the Fermi Symposium in Baltimore, the team announced that because the number of gamma-ray sources is now about the same number as the naked-eye stars, we could invent an unofficial set of gamma-ray constellations, drawing on modern locations and characters, including the Hulk, the TARDIS, and Godzilla. In a second release, the Fermi LAT team announced that the quasi-periodic variability of blazar PG 1553+113 has now completed five cycles, strengthening the case for periodic emission.

One of the many tenth anniversary outreach activities was a popular playoff for the top Fermi science result, with the story about colliding neutron stars producing gravitational waves and a short gamma-ray burst coming out on top.

Current Fermi software and documentation are available through the Fermi Science Support Center. On October 15, the FSSC released a major software update, Fermitools 1.0.0, which uses the Conda package manager to install the tools. The 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.

Cycle 11 proposals were received in February and results have been announced. Additional information is available at the Fermi Science Support Center website. Cycle-12 stage-I proposals are due on 02/20/2019.

As part of NASA's Universe of Learning, Elizabeth Ferrara and Lynn Cominsky participated in a Museum Science Briefing on the Deaths and Afterlives of Stars. Along with Dr. Bethany Cobb Kung from George Washington University who explained stellar evolution and Swift's role in studying GRBs, Ferrara discussed how neutron stars are formed, and Fermi's observation of GW170817, and Cominsky reviewed related educator guides originally created by the Swift and Fermi missions.

A new Fermi skymap is now available! Fermi's latest discoveries are highlighted in a beautiful new skymap poster by SSU's Aurore Simonnet that includes the 10-year gamma-ray skymap. If you would like a hard copy, send email to Lynne Cominsky at lynnc@universe.sonoma.edu.

## INTEGRAL

ERIK KUULKERS (ESA/ESTEC) AND STEVE STURNER (CRESST/UMBC & NASA/GSFC)

*INTEGRAL* marked 16 years of operations on October 17! The spacecraft, payload and ground segment have been generally performing nominally. The most noticeable anomaly occurred on July 13, when JEM-X1 crashed but was recovered within three days. SPI annealing #31 took place from July 21 to August 6. The recovery is satisfactory with $\Delta E/E \sim 0.2\%$ at 1764 keV. The global energy resolution continues slowly to drift, most likely due to aging. Coordinated calibration observations of 3C273 and the Crab were conducted with other high-energy missions including *NICER*, *NuSTAR*, and *XMM–Newton*. The *INTEGRAL* Science and Mission Operation Centers are investigating the possibility of reducing times between ToO triggers and observations in order to do very rapid ToO follow-up observations, within

a few hours, of important events such as GW170817. If operational, this would be done only in exceptional, favorable, situations as a best effort activity, without risk to spacecraft and payload. As of 17 September 2018, the total number of *INTEGRAL* refereed publications since launch is 1577 including 37 thus far in 2018.

On 1 July, Lorraine Hanlon (UCD Dublin, Ireland) took over the position as *INTEGRAL* Users' Group (IUG) chair. The next IUG meeting is scheduled for November 7 & 8 at ESTEC. The *INTEGRAL* community was saddened that Giorgio Palumbo, one of *INTEGRAL*'s Mission Scientists from 1995 - 2014, passed away on June 19.

Registration and abstract submission is now open for the 12th *INTEGRAL* Conference and 1st AHEAD Gamma-ray workshop, "*INTEGRAL* looks AHEAD to Multi-Messenger Astrophysics" to be held in Geneva, February 11 – 14, 2019. The deadline for abstracts requesting talks is November 20, 2018 while the registration and poster abstract deadlines are January 4, 2019.

The ESA Mission Extensions Operations Review (MEOR) for *INTEGRAL* took place on June 5. The spacecraft, payload and Ground Segment are in good condition and can deliver the expected science return in both the confirmation interval (2019 – 2020) and the extension interval (2019 – 20). The confirmation and extension case was presented to ESA's Astronomy Working Group (AWG) and Solar System Working Group (SSWG) in their meeting on 10 October.

The AO-16 TAC meeting took place from May 29 - 31 at ESAC. Out of the 62 proposals submitted, 46 were selected, including 20 ToO follow-up observations, and 3 GRB (including GW, neutrino events) proposals. Also, 360 ks of *XMM–Newton*, 144 ks of *Swift* and 45 ks of *NuSTAR* observing time was granted. The TAC acknowledged that *INTEGRAL* is still a high-valued contributor to time-domain high-energy astrophysics, and recommends to keep the capability to react to ToO events.

The *INTEGRAL* analysis software, OSA, version 11.0, was released on October 19. This release contains major improvements, especially regarding IBIS/ISGRI. Response files for IBIS/ISGRI data back to 2016 have been generated. It is important to note that OSA 11.0 for IBIS/ISGRI is currently limited to data starting from 2015-12-26 (start of revolution 1626). For earlier data, the user should use OSA 10.2 with the limitations described in the user manual. Calibration files for earlier times will continue to be provided over the coming months as soon as they are available. For more information, see the OSA11 website.

Scientific observations of the AO-15 cycle were performed mostly as planned. During this period 3 unsolicited, public, out-of-TAC ToO observations were conducted (AT2018cow, MAXI J1820+070, and ASASSN-18fv) with most of them coordinated with other high-energy facilities. In addition, TAC-accepted ToO observations were conducted for IGR J17591-2342, a new transient source discovered by *INTEGRAL* as well as for MAXI J1820+070 triggered on its transition from the soft to the hard state. A total of 2.9 Msec on ASASSN-18fv was scheduled between April 23 and June 11. This source was very bright in the optical (V∼6.8 mag) at the start of the observations and was thus observed with the optical monitoring camera (OMC) in Fast monitoring mode (Domingo *et al.* 2018, ATel #11677). On May 18, the OMC was configured back to Normal monitoring mode when the source brightness declined to V∼8.5 mag. In addition to the general decline over long timescales, short time-scale variability superposed on the general decline could clearly be seen. The long *INTEGRAL* ToO program on ASASSN-18fv means that the OMC has collected a unique set of well calibrated optical data for this source.

*INTEGRAL* participated in the follow-up campaign of IceCube-170922A, a high-energy neutrino event with a direction consistent with the blazar TXS 0506+056. This campaign was coordinated with 14 other observatories spanning the electromagnetic spectrum. Data from the SPI-ACS and IBIS/Veto instruments onboard *INTEGRAL* were used to set upper limits on short X-ray bursts from the direction of the neutrino around the time of the detection, while observations with the IBIS/ISGRI instrument set constraints on the flux from the blazar in the 20 – 250 keV range. The sensitivity and large field of view of *INTEGRAL* makes it a great follow-up instrument for these types of searches. This multi-messenger result led to a paper published in Science and an NSF/IceCube press event in which *INTEGRAL* participated. An ESA press release was also issued.

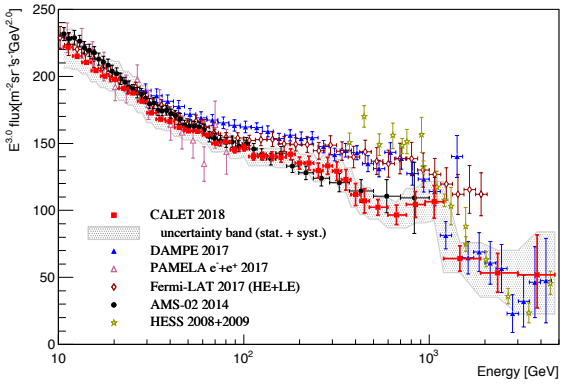
## CALET

JOHN WEFEL (LSU)

The CALorimetric Electron Telescope (*CALET*) on the International Space Station (JEM-EF, port #9) has continued to return excellent data since its launch in August 2015, with three years of data processed and under analysis. The primary objective of *CALET* is the measurement of the total electron (electron + positron) spectrum to as high an energy as possible. The *CALET* team has now been able to open up the acceptance of the instrument, as well as analyzing additional data, to approximately double the number of electron events. This allows the spectrum to be extended into the trans-TeV region. In addition, a complementary experiment, DAMPE (Dark Matter Particle Explorer), has reported first results.

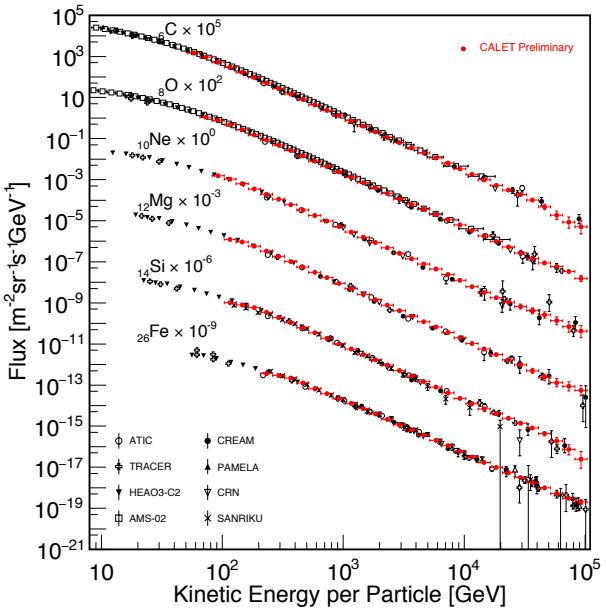
Surprisingly, the new data do not resolve the dichotomy in the spectrum since DAMPE agrees most closely with *Fermi* while *CALET* favors the AMS-02 result. The flux in Figure 1 is multiplied by the cube of the energy, so small differences in the energy scale can result in large differences in the points. This is but one of the effects that the two collaborations are investigating. However, in the trans-TeV region, both experiments show a fall-off in the spectrum consistent with ground based measurements from the HESS atmospheric Cherenkov telescope. There may be hints of structure at the highest energies, but the uncertainties (statistical + system-

atic) are still too large for any conclusions to be drawn. Hopefully, with additional work on the systematics and increased data from continuing observations, the highest energy behavior can be clarified.




*The total electron spectrum (multiplied by $E^3$) observed by CALET compared to other space-based results plus the atmospheric Cherenkov result from HESS. The uncertainty band for CALET is indicated as the gray band. (PRL 120, 261102, 2018). Credit: CALET*

Progress in the analysis of the heavy cosmic ray nuclei has continued with a full publication expected in the near future. An example of the preliminary results for the major primary heavy nuclei is shown in the Boyle-Mueller plot below. Such detailed data allow investigation of the individual spectra to assess any differences or spectral structures.




*Preliminary results from CALET on the energy spectra of the major, primary, heavy elements in the cosmic ray beam compared to previous balloon and satellite data. Credit: CALET*

*CALET* has also published a characterization of the instrument for gamma-ray analysis (ApJS, 238, 5, 2018). Covered are optimization of event selection, calculation of effective area, determination of the point spread function, confirmation of the absolute pointing accuracy, observations of bright point sources and study of diffuse components. In addition, *CALET* continues to search for counterparts of *LIGO-Virgo* gravitational wave events (ApJ, 863, 160, 2018) as well as IceCube neutrino events and other transients.

Finally, *CALET* was recognized with the 2018 ISS Compelling Results Award "Physical Sciences and Materials Development" by the American Astronautical Society. The award citation was for "Direct Measurements of High Energy Cosmic-ray Electron and Positron to the TeV Region" and was presented on 26 July at the meeting in San Francisco, CA.

## The High Energy Astrophysics Science Archive Research Center

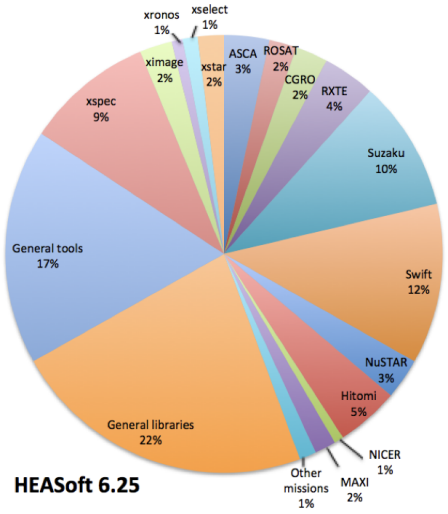
LORELLA ANGELINI & ALAN SMALE (NASA/GSFC)

*MAXI* data, hosted at DARTS/JAXA, are now also available at the *HEASARC*. *MAXI* was the first high energy astrophysics experiment placed on the International Space Station and has been monitoring the X-ray sky since Aug 2009. The *MAXI* archive is populated with the cleaned event files from both *MAXI* instruments, the GSC (2-30 keV) and the SSC (0.5-12 keV), created by the data processing that occurs in Japan. The *MAXI* archive opened at the HEASARC on October 25, 2018. Together with the *MAXI* data, the *MAXI* software package was released with HEASoft 6.25 and the *MAXI* calibration data are now included in CALDB. The two archives, DARTS/JAXA and HEASARC/NASA, contain all data collected since the start of the mission and are synchronized weekly with new data updates. The *MAXI* software package includes tasks to retrieve data from the archives for specific positions and times and allows the user to generate spectra, light curves and responses. Further information about the *MAXI* archive is available from the DARTS/JAXA and HEASARC *MAXI* websites.

HEASARC released the HEASoft 6.25 software package on October 24, 2018. This release was mainly driven by the updates of the *NICER* software package and the first release of the *MAXI* software package, along with enhancements and fixes in other tasks. One important enhancement is for xisrmfgen, the *Suzaku* response builder, where the model of the Si-K edge has changed and which requires the new XIS CALDB (version 20181010).

With this software release, the HEASoft the software package exceeded the milestone of 2M lines of code. The majority of the software is written in Fortran (77 and 90), C, C++ , Perl, Tcl/Tk and now there is an initial support for Python. More than half of the code is for general libraries, among which are included CFITSIO; general multi-mission tasks to manipulate FITS files, interface with the CALDB, generate good time intervals and

others used in many of the mission packages; and multi-mission data analysis software such as XSPEC. HEASoft also includes mission specific packages mainly dedicated to instrument calibration and generation of spectral responses.




*HEASoft 6.25 software holdings color coded by missions, general tools, general libraries, multi-mission software as for Oct 2018. The percentage in each slice corresponds to the percentage of the numbers of lines of code compared to the total. The "Other mission" slice includes specific packages for Einstein, EXOSAT, HEAO-1, OSO8, and Vela5B, as well as support software developed at the HEASARC for XMM-Newton and INTEGRAL. Credit: NASA/HEASARC*

We want to hear from you! The HEASARC has created a user survey to capture how users access and utilize the HEASARC data and services. The outcome of the survey will be used to guide, prioritize, and plan the HEASARC activities in the upcoming years. The survey is divided into six sections with 18 questions in total and two boxes for your optional comments. It generally takes 10-15 minutes to complete and it is completely anonymous. The HEASARC kindly requests your participation to the survey, and thanks you in advance for your valuable feedback. The survey will remain open until December 21, 2018.

## Physics of the Cosmos News

T. J. Brandt (NASA/GSFC, PCOS Chief Scientist, acting), Panayiotis Tzanavaris (NASA/CRESST, Assistant Research Scientist)

NASA's Physics of the Cosmos (PCOS) program explores some of the most fundamental questions regarding the physical forces and laws of the universe: from testing General Relativity to better understanding the behavior of matter and energy in extreme environments, the cosmological parameters governing inflation and the evolution of the universe, and the nature of dark matter and dark energy. To enable current and future missions to address these questions, the PCOS Program Office (PO) supports a number of community activities, including in facilitating 2020 Decadal Survey preparations, and reviews strategic technology capability gaps, prioritization, and development.

We will be holding PCOS sessions with both exciting science results and forward-looking themes at the next AAS January meeting. Please note two important dates: On Sunday, January 6, 2019 (early afternoon, exact time to be announced), the Program Analysis Groups for PCOS (PhysPAG) and Cosmic Origins (COPAG) will hold a joint meeting, with Astrophysics Division director Paul Hertz scheduled to talk. On Thursday, January 20, 2019 we will hold meetings of the Gravitational Wave Science Interest Group (SIG), PhysPAG, Gamma-ray SIG, and X-ray SIG (9 a.m. – 5 p.m., please see the PCOS AAS 233 agenda page for further details). We will also hold PhysPAG and SIG/SAG meetings at the APS April 2019 and HEAD March 2019 meeting, please see the PhysPAG upcoming meeting page for details. We will continue to provide remote connection for those who are not able to attend in person. Other articles in this newsletter include updates on the activities of our SIGs, including X-ray, Gamma-ray, and Cosmic Ray SIGs.

As a new era in synergistic astrophysics is dawning, the Multimessenger Astrophysics Science Analysis Group (MMA SAG) kicked off last June. The MMA SAG is analyzing the potential scientific benefits of multimessenger observations made possible by NASA observatories in the 2020s and beyond, both working in conjunction with each other and with other ground- and space-based instruments. This roughly one-year activity is completely open to anyone who wishes to participate, and we are hoping that you do! Please check the MMA SAG website for how to get involved.

There has been a lot of exciting activity in mission study and development. Two Explorer Missions of Opportunity of interest to the Gamma-ray community (COSI-X and ISS-TAO) have finished their Phase A Concept Study Reports and had NASA site visits; the *Lynx* mission concept study interim report was published; and five X-ray probe concept mission studies commissioned by NASA HQ, as well as additional probe mission studies, are also in advanced states. Please see the Gamma-ray and X-ray SIG articles in this issue for further details.

PhysPAG has been supporting community preparations for the 2020 Decadal Survey in several ways. The SIGs and MMA SAG have been providing fora for community discussion and organization. NASA would like to have comprehensive and detailed input to the Decadal such that the Committee's recommendations are the best possible. To that end, we encourage you to lead and/or co-author white papers you think are most important. Please check the Decadal announcement by the National Academies for details. White papers for the 2020 Decadal Survey are due between January 7 to February 19 2019.

An open call for nominations to serve on the Executive Committee of NASA's Physics of the Cosmos Program Analysis Group (PhysPAG) has now ended, and we are happy to announce two new members: Ryan Hickox and Marcos Santander. Please join us in welcoming them in their new roles!

We welcome your input on PCOS science topics, particularly through the relevant PhysPAG SIGs, and by submitting technology gaps by June 2019. We also look forward to seeing you either in person or virtually at our upcoming meetings and encourage you to join our email list and/or check our website for news.

## The X-ray Science Interest Group

RALPH KRAFT (SAO), JOHN TOMSICK (UC BERKELEY)

It seems as if much of the US X-ray astronomy community is working furiously on science white papers and mission concept studies as we approach the Decadal review. Over the past year, the Lynx mission concept study interim report was published. The five probe concept mission studies commissioned by NASA HQ most relevant to the X-ray community (*AXIS*, *STROBE-X*, *TAP*, and *PO-EMMA*) are in advanced states. *Arcus*, a proposed MIDEX mission to provide high resolution ($R = 3000$) soft X-ray spectrometry, awaits a decision by NASA expected by early next year. Beyond mission concepts studies, it has been a busy year in X-ray astronomy. JAXA announced the establishment of the project team for the X-Ray Imaging and Spectroscopy Mission (*XRISM* - formerly *XARM*) with a launch date of 2021. The Imaging X-ray Polarimeter Explorer (*IXPE*) is under development with launch scheduled for 2021. Finally, the *Chandra* X-ray Center contract at SAO was extended by NASA's MSFC to continue science and mission operations of *Chandra* for up to an additional nine years to 2027, followed by a three year close-out period for the mission.

Two Science Analysis Groups (SAGs) were formed over the past year that are of great interest to the X-ray astronomy community. The Multi-Messenger Astronomy SAG, chaired by John Conklin, the PhysPAG executive committee chair, is studying the scientific investigations and synergies in Multi-Messenger Astronomy that will be made with NASA observatories and other ground-based and space-based facilities in the 2020s. The MMA SAG is providing a convenient forum for anyone interested in submitting a MMA white paper to the Decadal review, and will submit a final report on their findings to the Astrophysics Advisory Committee (APAC) in 2019. The Great Observatories SAG (GO SAG), was formed by Cosmis Origins PAG (COPAG) members Lee Armus and Tom Megeath in conjuction with the PhysPAG and ExoPAG analyze two key questions. First, what gaps in wavelength coverage and scientific capabilities are anticipated over the next 10–20 years as the Great Observatories age or are decommissioned? Second, what are the options for maintaining the multi-wavelength coverage from space now provided by the Great Observatories? The GO SAG will also submit a final report to the APAC in 2019. Even though both PAGs have already started their work, it is not too late to participate, and we *strongly* recommend anyone interested in MMA or the fate of the GOs to participate.

The most recent XRSIG meetings were held at the 2018 Winter AAS meeting in Washington, DC and the special HEAD meeting in Chicago, IL. We heard a status update on the *Lynx* mission concept study and reports on US involvement in *Athena*, the US contribution to the XRISM mission, and development status and potential Guest Observer participation in the *IXPE* mission. The next XRSIG meetings will be at the 2019 Winter AAS meeting (January) in Seattle, WA and the 17th Divisional HEAD meeting (March 2019) in Monterey CA. The agenda for the XRSIG meeting in Seattle is currently being developed, and we welcome recommendations or suggestions for presentation topics. We anticipate presentations from representatives of the SAGs as well as several mission-oriented presentations. See everyone in Seattle!

## Gamma-ray Science Interest Group (GammaSIG)

SYLVAIN GUIRIEC (GEORGE WASHINGTON UNIVERSITY / NASA GODDARD SPACE FLIGHT CENTER), JOHN TOMSICK (UNIVERSITY OF CALIFORNIA BERKELEY), AND HENRIC KRAWCZYNSKI (WASHINGTON UNIVERSITY IN ST. LOUIS)

The PhysPAG Gamma-ray Science Interest Group (GammaSIG) has been focusing its efforts on facilitating science white paper discussions for the gamma-ray astrophysics community in the context of the 2020 Decadal Review. This is in addition to more thematic and mission specific white papers written by subsets of the gamma-ray community. GammaSIG organized special Decadal Review sessions at the AAS meeting in January 2018, at the Special HEAD meeting in March 2018, and at the AAS meeting in April 2018. In addition, GammaSIG held telecon meetings and organized two special workshops on the Decadal Review. The first workshop was held at the George Washington University in May 2018; we discussed how to approach the Decadal Review via a series of talks. The second workshop was organized at the Clemson University in September 2018 and was more focused on the drafting of the white papers. A special workshop entitled "To 2020 and Beyond: Radionuclide Astronomy" organized by the gamma-ray community at the Los Alamos National Laboratory produced a draft of a white paper, which is open to the community for signing.

Five general white papers will be written by the gamma-ray community at large and experts from the community have volunteered to take the lead for each of them. GammaSIG works in close collaboration with the PhysPAG Multi-Messenger Astronomy Science Analysis Group (MMA SAG), which is directly relevant to the activities of the gamma-ray astronomy community. GammaSIG will continue this facilitating effort until the sub-

mission of the white papers concludes on February 19, 2019. The drafts are expected to be completed by the end of November 2018, and a final presentation of the documents will be made during the special GammaSIG session at the AAS meeting in January 2019. This is a community effort and the white papers resulting from this work will be signed by individuals. Everybody is welcome to support this effort in signing the articles and/or in contributing to the drafting; significant contributors will be listed first, with all other signers in alphabetical order. You can join the GammaSIG mailing list if interested.

GammaSIG will continue regular telecon meetings to share news and results about current missions, and information about future missions as well as technology development.

Three noticeable specific conferences in gamma-ray astronomy were organized in the United States in 2018: The Neil Gehrels Memorial Symposium organized at the National Academy of Science in Washington in May 2018, Time-Domain Astrophysics with Swift III organized at the Clemson University in September 2018, and the Eight International Fermi Symposium organized in Baltimore in October 2018. The start and the future of observational gravitational wave astronomy continued to be an exciting central topic of these three meetings.

Two gamma-ray missions competing for the Explorer Mission of Opportunity call, the International Space Station Transient Astrophysics Observatory (ISS-TAO) and the Compton Spectrometer and Imager (COSI-X), completed their Phase A Concept Study Reports and had NASA site visits. One of the concept missions for gamma-ray astronomy in the MeV energy regime, the All-sky Medium Energy Gamma-ray Observatory (AMEGO), performed a beam test campaign in 2018 and will conduct a balloon-flight test in 2019. The GammaSIG community is very eager to hear from you about all the exciting news concerning the future gamma-ray missions, as we extend the limit of our knowledge of our universe in its most extreme physical conditions.

For more information, please contact Sylvain Guiriec (sguiriec@gwu.edu), John Tomsick (jtomsick@ssl.berkeley.edu) and Henric Krawczynski (krawcz@wustl.edu).

## The Cosmic Ray Science Interest Group

IGOR MOSKALENKO (STANFORD), JAMES BEATTY (OHIO STATE)

Colleagues and friends of Dr. W Vernon Jones gathered at NASA Headquarters on October 15 to honor him on the occasion of his retirement. Vernon served at Headquarters for over three decades and has made numerous contributions to the field, including his service as program monitor for cosmic rays and particle astrophysics, advocacy and leadership in the balloon program, advancement of balloon technology toward long-duration and ultra-long duration flights, and the development of a portfolio of particle astrophysics experiments now taking data on the International Space Station.

Two of these space station experiments, CALET and ISS-CREAM, have been operating on the station for several years. See the article elsewhere in this newsletter for recent CALET results.

Voyager 1 crossed the heliospheric boundary in 2012. Data are now showing early signs that Voyager 2 is approaching the heliopause as well. We look forward to further developments in the coming months!

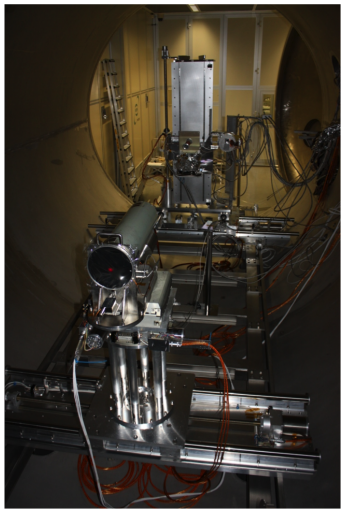
## Spectrum Röntgen Gamma/eROSITA

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

The final launch preparation activities are underway at NPOL Lavochkin Association. The final integration of the two scientific payloads has been completed. The final acceptance tests (vibration etc.) are scheduled for January/February 2019. Final packaging and transportation of SRG to Baykonour will happen at the beginning of March 2019. Launch date is now fixed for two windows: either April 1-2 or April 11-12, 2019.

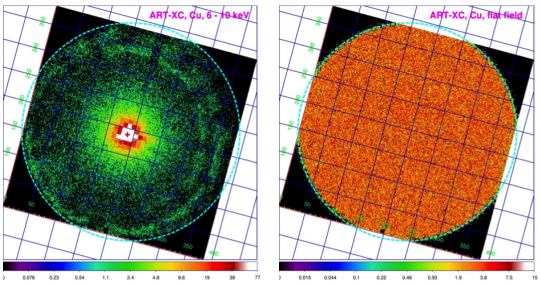
*The eROSITA X-ray telescope integrated onto the SRG Navigator platform during the final assembly in September 2018 in the laboratory of NPOL Lavochkin, near Moscow. Credit: Lavochkin Association*

On October 15–25, 2018, the spare mirror system of the ART-XC telescope was subjected to tests at the PANTER facility near Munich, using the spare unit of the ART-XC URD detector and the TRoPIC pn-CCD detector that was previously used for calibrations of the eROSITA mirror systems at the same facility. These tests have provided on-ground cross-calibration of the ART-XC and eROSITA telescopes in their overlapping energy range, in five spectral lines, Ti (4.51 keV), Cr (5.41 keV), Fe (6.4 keV), Cu (8.04 keV), Ge (9.98 keV), for a distance of ∼130 meters to the source.



*Optical adjustment of the ART-XC mirror system during the test campaign at PANTER. Credit: MPE/IKI*

During an upcoming meeting of the German and Russian Science teams, the final plan for the early Calibration and Performance Verification program of eROSITA and ART-XC will be defined. Activities are ongoing to coordinate these observations, which will take place during the $\sim$ 115 days of travel the final L2 orbit, with other major observatories worldwide.




*Example images obtained in the copper line by illuminating the ART-XC URD detector through the mirror system (left) and directly (right). The color scale is logarithmic, with the depth limited at 1% of the maximum value in the left panel. The dashed blue circle indicates the boundaries of the detector's beryllium entrance window, with a diameter of 30 mm and width of 100 micron. Credit: MPE/IKI*

## Athena: Revealing the Hot and Energetic Universe

KIRPAL NANDRA (MPE), DIDIER BARRET (IRAP), MATTEO GUAINAZZI (ESA), RANDALL SMITH (CFA), AND FRANCISCO J. CARRERA (IFCA, CSIC-UC) FOR THE *Athena* SCIENCE STUDY TEAM AND THE *Athena* COMMUNITY OFFICE

*Athena* continues to progress through Phase A. In October the mission successfully passed Status Review 2 (SR2) that closed out the extension of the industrial Phase A1. This will allow responsibility for the design of the Science Instrument Module (SIM), which houses the instruments, to be handed over to the industrial Prime contractors. The Mission Formulation Review (MFR) that will signify the end of Phase A is currently scheduled for Q4 2019, with mission adoption in Q4 2021. The implementation schedule is less certain, with optimization options still being investigated, and launch currently envisioned in the early 2030s. At the instrument level, the primary activity has been the Instrument Preliminary Requirements Reviews (I-PRRs), the first formal reviews of the instruments, which are co-chaired by ESA and the responsible lead funding agency. The WFI I-PRR, co-chaired by the German Space agency DLR, kicked off on September 19th this year, concluding successfully on October 31st. Preparations for the X-IFU I-PRR, co-chaired by the French space agency CNES, are underway, with kickoff expected in mid-January 2019. ESA is currently completing a process to recognize the *Athena* instrument teams formally, via the so-called Instrument Consortium Consolidation (ICC), a simpler process compared to a full AO to avoid duplication with the I-PRRs. Responses to the ICC solicitation were submitted by the two teams in early October, and the process is expected to be complete before the end of 2018.

The second scientific conference devoted to *Athena* was held in Palermo, Sicily, from September 24-28. There were 71 scientific talks covering topics such as the mission status, programmatics and technology, core science i.e., the Hot Universe and Energetic Universe, and the expected observatory science. The strong synergies of *Athena* with other contemporary facilities over the entire electromagnetic and multi-messenger spectrum was also highlighted.

The main focus of X-ray optics activities (no pun intended) in 2018 has been to improve the PSF at a 12m focal length; all work at the old IXO 20m focal length having been completed. SPOs at a range of radius of curvature are being tested, including the innermost radius (250mm), a median radius (737mm), and an outer radius mirror with r=1500mm. The transition to 12m focal length has progressed so that the latest 12m stacks are approaching the best performance achieved for the 20m focal length stacks. In July 2018, testing at BESSY showed a PSF HEW of $9''$ over 70% of the silicon pore optics (SPOs), with the next round of tests expected in December 2018.

Other progress includes the installation of a large industrial magnetron sputtering coating machine at the SPO manufacturing site. This machine will be able to handle whatever coating recipe is chosen for *Athena*. The Technical University of Denmark (DTU) is studying a range of options, primarily examining different thicknesses of Ir/SiC. ESA has also recently completed a study of SPO alignment options, comparing alignment methods in the UV or X-rays. Although both methods proved to meet requirements, ESA has selected the UV option. This

will be done by Media Lario, the company also responsible for the alignment of the eRosita and *XMM–Newton* X-ray optics. The optics will be aligned into a mirror support structure made of titanium. The manufacturing is also the subject of dedicated technology development. A "hybrid" robotic solution using both additive and subtractive elements, together with integrated metrology to characterize the structure as it is built, is an innovative option currently being studied.

In June 2018, the *Athena* Community Office (ACO) released the fifth issue of the *Athena* Community Newsletter. On top of the usual welcome, updates on the project, news from the instruments and short bios from some members of the *Athena* community, this issue included a science nugget on "The Fast and the Furious: extreme stellar flares".

During the European Researcher's Night on 28 Sep 2018 the ACO presented materials on X-ray astronomy and premiered the VR film "The X-ray Universe" by T. Matsopoulos, funded by the AHEAD EU project in a joint initiative with the ACO.

The ACO also released updated versions of the *Athena* factsheet (both in text and leaflet formats) which were handed to the participants of the second *Athena* conference. The ACO also provided *Athena* stickers, pens and pen drives.

You can keep up-to-date with *Athena* via the *Athena* community website (where you can view the *Athena* community map), or through our new Twitter handle @AthenaXobs and via Facebook. Urgent or important notifications are sent to the *Athena* Community through bimonthly Brief News emails.

By the late 2020s and early 2030s there will be an assortment of major astronomical facilities working together across the electromagnetic spectrum (and beyond) in which Athena will figure prominently. The ASST has set in motion several studies to explore the scientific potential of these facilities working in synergy.

The second study explored synergies between the Square Kilometer Array and *Athena*, ranging from studies of galaxy clusters, large-scale structure, AGN and surveys, X-ray binaries, accretion physics and transient phenomena. A White Paper detailing these synergies, coordinated by the SKA-*Athena* Synergy Team (SAST, Rossella Cassano), INAF/IRA (Chair Chiara Ferrari), OCA (Rob Fender, Oxford, and Andrea Merloni, MPE) was published in July 2018. New exercises with gamma-ray/multi-messenger facilities and LSST are in their initial stages.

In addition to the conference devoted to *Athena* mentioned above, *Athena* was also present at several national and international conferences in the last few months. Some of those conferences are highlighted below:

The attendants to the COSPAR assembly in Pasadena (14-22 July 2018) got a foretaste of the many aspects of *Athena* science from AGN (J. Aird, G. Ponti) to Supernova Remnants (Sezer, Ergin) and X-ray binaries (M. Cappi), including a specific talk about the X-IFU by F. Pajot.

*Athena* had a significant presence at the SPIE Optics and Photonics 2018 meeting in San Diego, 19–23 August 2018, with several sessions dedicated to *Athena*, its optics and its instruments (summarized here).

A general talk on *Athena* was given by D. Barret at the IAU General Assembly in Vienna (Austria, August, 20–21, 2018), with additional talks on the WHIM and *Athena*'s capabilities in its study by F. Nicastro, M. Galeazzi and J.-W. den Herder.

## The Imaging X-ray Polarimetry Explorer

M. C. Weisskopf, Brian Ramsey, & Steve O'Dell (NASA/MSFC)

On November 1, *IXPE* passed Key Decision Point C (KDP-C) at NASA Headquarters and is now proceeding into Final Design and Fabrication (Phase C/D). This followed a successful Mission Preliminary Design Review (M-PDR) in 2018 June at Ball Aerospace (Boulder), *IXPE*'s industry partner. The next major reviews are the Ground System Preliminary Design Review (GS-PDR, in 2019 February) and the Mission Critical Design Review (M-CDR, in 2019 April).

*The IXPE Mirror Module Assembly (MMA) engineering unit. Credit: NASA/MSFC*

Technical preparation of the mission is continuing (see SPIE 106991X for a technical overview). The observatory design is mature and stable, allowing us to initiate several long-lead procurements of flight components. MSFC has completed the engineering unit of the Mirror Module Assembly (MMA EU) and is preparing for environmental and x-ray testing of this unit. The MMA EU is comprised of 3 inner shells and 3 outer shells, with mass dummies for the remaining 18 shells. The Italian partners at INAF/IAPS and INFN-Pisa are building instrument calibration equipment and working toward fabrication of the engineering unit of the polarization-sensitive detector.

## The X-ray Imaging and Spectroscopy Mission

Richard Kelley (NASA/GSFC), & Brian Williams (NASA/GSFC)

Perhaps no update on this mission is more important than the official change of the name and formal kick-off of the mission.

The mission formerly known as the X-ray Astronomy Recovery Mission (*XARM*) is now known as the X-ray Imaging and Spectroscopy Mission, or *XRISM* (pronounced "chrism"). Following the Project Initiation Review in June, JAXA officially established the *XRISM* project on July 1, 2018.

Things are proceeding quite rapidly on the development of the mission hardware. As with the Astro-H mission, NASA is contributing key elements of the Resolve high-resolution X-ray spectrometer and X-ray mirrors for both the Resolve instrument and the JAXA Xtend X-ray imager. The development of the flight hardware for Resolve is about 70% complete, and integration and testing of the X-ray calorimeter detector system, low temperature cooling stages (base temperature of 50mK), and electronics will begin in February 2019. X-ray reflector production for the X-ray Mirror Assemblies (XMA) is about 50% complete. The detector system is complete and the energy resolution performance is very close to that of the Astro-H/Soft X-ray Spectrometer ($\sim 4.5$ eV FWHM). An extensive X-ray calibration campaign has begun and numerous measurements have been carried out with fluorescent sources, crystal and grating monochromators, and an electron beam ion trap. The detector system and cooling stages will be integrated into what is referred to as the Calorimeter Spectrometer Insert (CSI), and this will be delivered to Japan in October 2019 to begin the process of building up the full Resolve instrument system, starting with integration of the CSI into the JAXA dewar system. This will be followed about four months later with the delivery of the thermal blocking filters and their installation in the dewar. The mirror will be delivered in November 2020.

The first official *XRISM* Science Team Meeting was held in Kanazawa, Japan, from October 1-3. Despite a powerful typhoon hitting Japan the day prior (affecting or canceling travel for several team members coming from the US), the meeting was attended by the majority of the *XRISM* team. The meeting consisted of updates from the instrument teams, science cases presented by the *XRISM* Participating Scientists, discussions on laboratory measurements needed for the interpretation of microcalorimeter observations, lessons learned from *Hitomi*, and plans for a mission white paper for the Astro2020 Decadal Survey. The next Science Team meeting will be held in Japan in May of 2019.

The Science Operations Team for the mission will consist of both the Science Data Center (SDC) at NASA and the Science Operations Center (SOC) at JAXA. These two organizations will work closely together to implement the science operations goals of the mission. They are developing the pipeline software that will process the data from the telescope and turn it into usable science products for the user. The SDC and SOC will work closely with the HEASARC to ensure that all *XRISM* data is archived and available to the community. The Guest Observer phase of the mission will begin 6-8 months after launch, following the calibration and Performance Verification phases.

## The Cherenkov Telescope Array

Megan Grunewald (CTAO)

On Wednesday, 10 October 2018, more than 200 guests from around the world gathered on the northern array site of the Cherenkov Telescope Array (CTA) to celebrate the inauguration of the first prototype Large-Sized Telescope (LST). The telescope, named LST-1, is intended to become the first of four LSTs on the north site of the CTA Observatory, which is located on the existing site of the Instituto de Astrofisica de Canarias' (IAC's) Observatorio del Roque de los Muchachos on the island of La Palma. The plan for the site also includes 15 Medium-Sized Telescopes (MSTs).

The first stone-laying ceremony for the LST-1 took place on October 9 2015. After the telescope foundation was completed in January 2017, the team moved swiftly and steadily toward its next major milestones: installation of the center pin and rails (September 2017) and mounting of the dish (December 2017). In February 2018, the LST-1 structure was completed, and the camera support structure was installed in June. The final step, the camera installation, was completed on September 25 2018.

*Distinguished representatives, including 2015 Nobel Prize for Physics winner, Prof. Takaaki Kajita (third from left), and Spanish Minister of Science, Innovation and Universities, Sr. Pedro Duque (sixth from left), participate in a traditional Japanese ribbon-cutting ceremony at the LST-1 inauguration. Credit: Akira Okumura.*

The LST team consists of more than 200 scientists from ten countries: Brazil, Croatia, France, Germany, India, Italy, Japan, Poland, Spain and Sweden. In this truly

international effort, the design and management leadership was shared among LAPP, Annecy, France; Max Planck Institute for Physics, Munich, Germany; INFN, Italy; ICRR, University of Tokyo, Japan; IFAE, Barcelona and CIEMAT, Madrid, Spain.

The LSTs are required because low-energy gamma rays produce only a small amount of Cherenkov light. Four LSTs will be arranged at the center of both the northern and the southern hemisphere arrays of the Observatory to provide the CTA's sensitivity between 20 and 150 GeV. The LST has a 23-meter diameter parabolic reflective surface, which is supported by a tubular structure made of reinforced carbon fiber and steel tubes. A reflective surface of 400 $m^2$ collects and focuses the Cherenkov light into the camera, where photomultiplier tubes convert the light into electrical signals that can be processed by dedicated electronics. Although the LST-1 stands 45 meters tall and weighs around 100 tons, it is extremely nimble, with the ability to re-position within 20 seconds to capture brief, low-energy gamma-ray signals.

The LSTs will expand the science reach to cosmological distances and fainter sources with soft energy spectra. Both the re-positioning speed and the low energy threshold provided by the LSTs are critical for CTA studies of transient gamma-ray sources in our own Galaxy and for the study of active galactic nuclei and gamma-ray bursts at high redshift.

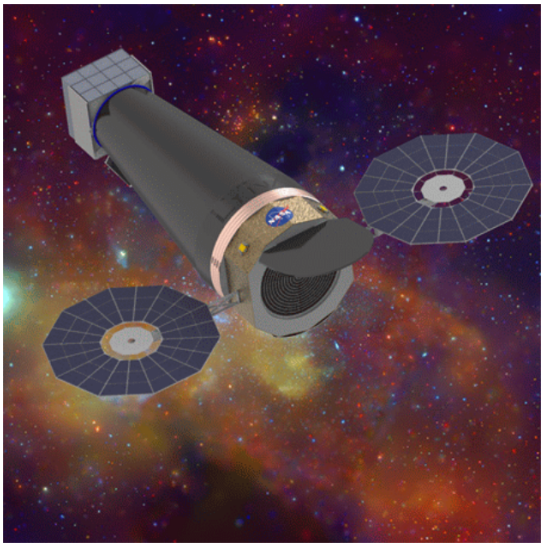
The prototype should become the first LST telescope of CTA, (and, in fact, the first telescope on a CTA site) to be operated by the CTA Observatory (CTAO). As any other technical delivery in the large, multinational CTA project, the LST-1 will need to undergo a critical design review to verify that the design complies with CTA science goals, operational needs, safety standards, etc. before it is formally accepted by CTAO.

In addition to the LST, two other classes of telescope are required to cover CTA's full energy range from 20 GeV to 300 TeV: Medium-Sized Telescopes and Small-Sized Telescopes. Development work in the United States for CTA has concentrated on the Medium-Sized Telescopes. Go to the LST-1 Inauguration webpage on the CTA website for more information, materials, images and video.

## Lynx

DOUG SWARTZ (USRA & NASA/MSFC), JESSICA GASKIN (NASA/MSFC)

*Lynx* is one of four large-scale mission concept studies NASA is sponsoring as part of its preparations for the 2020 Astrophysics Decadal Survey. The *Lynx* concept study is led by a community-driven Science and Technology Definition Team (STDT) with the goal of defining an ambitious and forward-looking yet feasible high-energy mission for the 2030s.



*Lynx, illustrated. Credit: NASA/M. Baysinger*

The *Lynx* team released an Interim Report in mid-August and is now developing its Final Report for submission next summer. In advance of that submission, NASA HQ will assemble a Large Mission Concept Independent Assessment Team (LCIT) to conduct a technical, risk, and cost assessment of all four flagship concept studies. The LCIT will perform a validation of the technical, cost, and schedule requirements that are described in the draft final reports.

After the Interim Report was filed and evaluated, a nearly six-month optics decision process was concluded by the *Lynx* Mirror Architecture Team (LMAT) working group. The purpose of the LMAT was to recommend one primary optics architecture to focus the baseline Design Reference Mission (DRM) for *Lynx*. The LMAT conducted an open scientific, technical, and programmatic evaluation of three architectures as described in the Interim Report. The study team weighed current and near-future demonstrated performance and technology maturation plans, relative simplicity of assembly production processes, and relative impacts of technical accommodation to the Observatory. The Silicon Meta-shell Optics design led by a team at NASA's Goddard Space Flight Center was considered the most mature technology, with the shortest path to achieving a high technology readiness level by Preliminary Design Review, and offered the most improved off-axis angular resolution among the three architectures, although all three designs were deemed feasible. The LMAT recommended this architecture to the STDT, who adopted it for the DRM.

In late August, engineering experts from the *Lynx* study team along with scientists from the STDT examined two feasible options for the *Lynx* X-ray Grating Spectrometer. Though both Critical Angle Transmission (CAT) gratings developed at MIT and Off-Plane Gratings (developed at PSU) are equally feasible and are at similar Technology Maturity Levels, the team recommended the CAT

technology as the less complex design with fewer perceived impacts on observatory resources. This design was subsequently adopted by the STDT for the DRM study.

The *Lynx* engineering design team at NASA's Marshall Space Flight Center, with support from the Smithsonian Astrophysical Observatory and the several optics and focal plane instrument teams, concluded a detailed end-to-end integrated analysis of the *Lynx* observatory design in October. This study represents the baseline *Lynx* DRM. It incorporates the LMAT-recommended optics architecture and CAT grating arrays. The study emphasized complete observatory structures, dynamics, thermal environment, and mechanisms. The *Lynx* study team also commissioned the GSFC Mission Design Laboratory to perform an independent assessment of the *Lynx* spacecraft design as a validation of the various subsystems.

The 5th STDT face-to-face meeting will be held in November in Huntsville, AL. This meeting is to finalize the design for a second *Lynx* architecture by considering various science capability trades against mission costs and to develop a series of *Lynx* science white papers to accompany the final report to the Decadal Survey committee. An alternative architecture was requested by NASA to provide the Decadal Committee a wider range of options to consider. The *Lynx* engineering design team will perform an analysis of any alternative architectures to identify system-wide impacts of any design alterations. In parallel, the Final Report draft will be updated to include more detailed technology roadmaps, a thorough costing analysis will be performed, and an independent cost estimate will be made early next year. These activities are in preparation for and independent of the LCIT activities.

There were several *Lynx* instrument and optics contributions to the June SPIE meeting in Austin, TX. There is a special section of the Journal of Astronomical Telescopes, Instruments, and Systems underway focusing on *Lynx*-specific technology developments. The special section will be published in May 2019. *Lynx* will have exhibit booths and displays at the upcoming winter AAS meeting in Seattle. A *Lynx* splinter session and a Decadal Large Mission Studies special session is also planned for this meeting. Finally, *Lynx* has recently unveiled a new informational website highlighting the exciting discovery space opened by *Lynx*.

## AstroPoetry Corner

*Sisters Rising: An Autumn Prayer Song of the Skidi Pawnee*

The Skidi Pawnee originally inhabited the regions near the Platte, Loup, and Republican Rivers in present-day Nebraska. They were considered to be extraordinarily skilled sky watchers.

> Look as they rise, up rise
> Over the line where sky meets the earth;
> The Seven Stars!
> Lo! They are ascending, come to guide us,
> Leading us safely, keeping us one:
> The Seven Stars,
> Teach us to be, like you, united.

*(from "When Stars Came Down To Earth: Cosmology of the Skidi Pawnee Indians of North America" by Von Del Chamberlain, Ballena Press, 1982.)*