The High Energy Astrophysics Division Newsletter

In this Issue:

From the Chair

CHRIS REYNOLDS (U. MD)

All systems are go for our 16th Divisional meeting to be held in Sun Valley, Idaho, 20-24 August 2017! Registration and abstract submission is now open and we're looking forward to an exciting scientific program covering all aspects of high-energy astrophysics, kicked off by a total solar eclipse!

One of the most important aspects of these meetings is the chance to honor a new batch of HEAD prize winners. Dr. Nadia Drake is the winner of the 2017 David N. Schramm Award for high-energy astrophysics science journalism for her fabulous piece "Found! Gravitational Waves, or a Wrinkle in Spacetime", and will be honored in a short ceremony at the HEAD meeting banquet. Dr. Jon Miller is the winner of the 2017 HEAD Mid-Career Prize for his seminal contributions to high resolution X-ray observations of accreting black hole systems, and he will give a prize lecture during the 16th HEAD meeting. Dr. Eric Coughlin is the winner of the 2017 HEAD Dissertation Prize for his thesis "The Evolutionary Pathways of Tidal Disruption Events: From Stars to Debris Streams, Accretion Disks, and Relativistic Jets", and will also give a prize lecture during the meeting. Finally, Prof. Gabriela González and the LIGO Scientific Collaboration have been awarded the 2017 Bruno Rossi Prize for the first direct detections of gravitational waves, for the discovery of merging black hole binaries, and for beginning the new era of gravitational-wave astronomy. Prof. González will give the Rossi Prize Lecture at the 231st AAS meeting to be held at National Harbor, MD in January 2018. Please join me in congratulating all of this year's HEAD prize winners.

The past few months has been eventful in the world of high-energy astrophysics missions. *NICER* and *ISS-CREAM* are at the Kennedy Space Center and ready for launch to the International Space Station. Further in the future, NASA has formally selected the Imaging X-ray Polarimetry Explorer (*IXPE*) for flight in 2020 – congratulations to the PI, Dr. Martin Weisskopf, and the rest of the IXPE team on their success! NASA has also recently selected to fund three high-energy Probe mission concept studies, *STROBE-X* (PI P. Ray; X-ray timing), *TAP* (PI J. Camp; wide field transient survey) and *AXIS* (PI R. Mushotzky; high-angular resolution X-ray observatory). Congratulations to these teams and best of luck with your studies.

In the meantime, the *Lynx* X-ray Surveyor science and technology definition team (STDT) continues to develop the scientific and technical case for the next large US X-ray observatory for consideration by the upcoming decadal survey. Finally, we have recently heard that NASA and JAXA are proceeding with the X-ray Astronomy Recovery Mission (*XARM*) to launch in 2021 to recover high

spectral resolution X-ray science lost due to the failure of Hitomi. Let it never be said that high-energy astrophysics isn't an active field!

Let me end my column with a remembrance of our friend and colleague, Dr. Neil Gehrels, who passed away on February 6, 2017. During his distinguished career at the NASA Goddard Space Flight Center, he served as Project Scientist for the Compton Gamma-Ray Observatory and WFIRST missions, Principal Investigator of the *Swift* mission, Mission Scientist for *INTEGRAL*, and as a member of the *LIGO* Collaboration. He won the Henry Draper Medal in 2009 for his work on CGRO and *Swift*, and he was appointed to the National Academy of Sciences in 2010. Along with Shri Kulkarni, Neil was awarded this year's prestigious Dan David Prize. In addition to being a scientist of the highest caliber, he was a dedicated mentor and guide to many younger scientists in our field. And, somehow, Neil found the time to have a full and rich life outside of science – he had a passion for music, was an accomplished mountain climber, and was an active volunteer in disadvantaged communities in Maryland and DC. We miss you Neil!

A Special Eclipse Advertisement

HUGH HUDSON (UC BERKELEY)

Going to the 16th Divisional meeting? The Megamovie project aims at systematically collecting imagery of the August 21 eclipse into a public-domain archive for outreach, as well as making nice movies on the basis of some of these data via Google help. We are developing a free app (Megamovie Mobile, to be released in June) that will automate Android or IOS smartphone usage for this purpose. Do not waste your pixels! We are most interested, of course, in contributions made with serious photographic equipment, such as a DSLR camera, long lens, and tracker. Please see Megamovie project to join in this unique adventure, and read the Eclipse Megamovie forum important information.

HEAD in the News

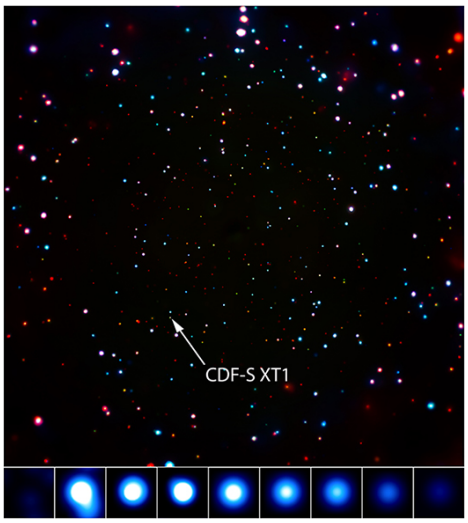
MEGAN WATZKE (CXC)

It's of course been a good year for gravitational wave science. As noted above, in January, Dr. Gabriela González and the LIGO Scientific Collaboration were awarded the HEAD's prestigious Bruno Rossi Prize, for the first direct detections of gravitational waves, for the discovery of merging black hole binaries, and for ushering in the new era of observational gravitational-wave astronomy. As part of the prize, Dr. González will present an invited talk at the 231st meeting of the American Astronomical Society, in January, 2018.

In March, Nadia Drake was named the 2017 winner of the David N. Schramm Award for for high-energy astrophysics science journalism, for her story "Found! Gravitational Waves, or a Wrinkle in Spacetime" which appeared on National Geographic's website on February 11, 2016. Ms. Drake will be attending this summer's 16th Divisional meeting of the HEAD in Sun Valley, ID, where she'll be presented with the Award. Competition for the Schramm Award was especially fierce this year, as 15 science journalists were nominated (and each nominee is allowed to submit two entries, which are considered separately), covering the full suite of high-energy astrophysics activities over the past year and a half, many in the burgeoning field of gravitational wave detection.

A personal selection of recent stories that made news from HEAD missions since the beginning of the year:

- Black Holes Hide in Our Cosmic Backyard (January 7, 2017)
- NASA's *Fermi* Sees Gamma Rays from "Hidden" Solar Flares (January 30, 2017)
- Mind the Gap: Rapid Burster Behavior Explained (January 31, 2017)
- Black Hole Meal Sets Record for Length and Size (February 6, 2017)
- NASA's *Fermi* Finds Possible Dark Matter Ties in Andromeda Galaxy (February 21, 2017)
- *NuSTAR* Spots Temperature Swings of Black Hole Winds (March 1, 2017)
- NASA's *Swift* Mission Maps a Star's "Death Spiral" into a Black Hole (March 20, 2017)
- Mysterious Cosmic Explosion Puzzles Astronomers (March 30, 2017)



A puzzling flash of X-rays seen in the Chandra Deep Field South, dubbed CDF-S XT1. The inset shows the time variability of the variable source. Credit: NASA/CXC/Pontifical Catholic Univ./F.Bauer et al.

Please contact Megan Watzke, the HEAD Press Officer, if you feel like you have a result that you'll be presenting at the 16h Divisional Meeting that you consider newsworthy. Newsworthiness, like beauty, is in the eye of the

beholder, but in general, the HEAD seeks to publicize results that are novel, of significance, and which have not been previously discussed in the media. If you believe you have such a newsworthy result, please let Megan know as soon as possible. As always, weekly highlights of high-energy astrophysics science are featured at the High Energy Astrophysics Picture of the Week. Please e-mail Mike Corcoran if you have a result worth highlighting.

Laser Interferometer Gravitational-Wave Observatory

FRED RAAB (CALTECH), DAVID SHOEMAKER (MIT)

Changing of the guard: Gabriela González, after 6 years as the Spokesperson for the *LIGO* Scientific Collaboration, has stepped down, and David Shoemaker of MIT has been elected as the new LSC Spokesperson for a two year term; Laura Cadonati of the Georgia Institute of Technology is to be Shoemaker's Deputy, a new position. Gabriela led the collaboration through a very rich, exciting, and sometimes stressful period as the Advanced LIGO Project was brought to a close, instrument commissioning started, the electromagnetic follow-up program initiated, analysis pipelines perfected and tested, and gravitational waves observed. The Collaboration gave her a well-deserved extended standing ovation at our last Collaboration meeting.

Gabriela Gonzalez, former spokesperson of the LIGO Scientific Collaboration and winner of the 2017 Bruno Rossi Prize. Credit: LIGO

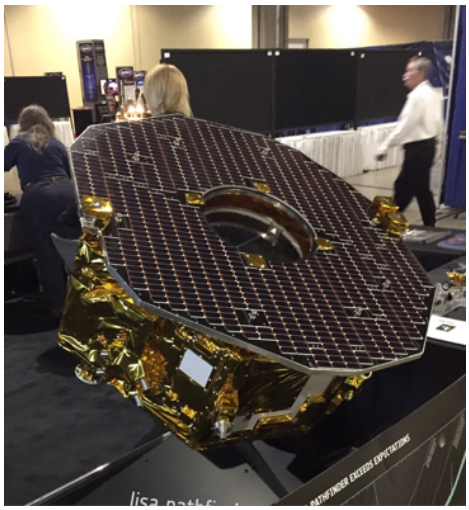
The *LIGO* detectors are currently observing in their second run, "O2". The O2 run began on November 30, 2016. As of March 23, approximately 48 days of Hanford-Livingston coincident science data have been collected, with a scheduled break between December 22, 2016 and January 4, 2017. The average reach of the LIGO network for binary merger events has been around 70 Mpc for 1.4+1.4 $M_\odot$, 300 Mpc for 10+10 $M_\odot$, and 700 Mpc for 30+30 $M_\odot$ mergers, with relative variations in time of the order of 10%. As of March 23, six triggers, identified by online analysis using a loose false-alarm-rate threshold of one per month, have been identified and shared with astronomers who have signed memoranda of understanding with LIGO and the Virgo Collaboration for electromagnetic followup. A thorough investigation of the data and offline analysis are in progress; results will be shared when available.

The O2 run is expected to continue to the end of August 2017. The Advanced Virgo Detector (near Pisa, Italy) is nearing readiness, and it is likely that Virgo will join the *LIGO* detectors toward the end of O2 for joint observation. After O2, a commissioning break of 12-18 months will be used to address limitations and opportunities, with the objective of significantly increasing the sensitivity of the *LIGO* detectors, while Virgo will continue with commissioning. In parallel, the community is working on upgrades of the Advanced *LIGO* detectors, and defining third-generation detectors for use in new observatories; these could come on line at the time of *LISA*.

Laser Interferometer Space Antenna

IRA THORPE (NASA/GSFC), GUIDO MUELLER (U. FLORIDA)

LISA Pathfinder (LPF) nears end of its historic mission as LISA gathers steam. The European Space Agency's LISA Pathfinder (LPF) mission is entering the final phases of operations after a successful demonstration of several key technologies for a future space-based gravitational wave observatory. After successful runs of both the European LISA Technology Package and NASA Disturbance Reduction System payloads in 2016, the mission entered an extended mission phase in December. During this phase, both payloads were exercised to tease out more information from the instrument with particular emphasis on low-frequency performance, which is a major science driver for LISA and especially difficult to verify with on-ground tests. Preliminary indications suggest that performance has continued to improve beyond its already-groundbreaking performance published in June of 2016.



A half-scale model of ESA's LISA Pathfinder made a U.S. tour with stops at the AAS winter meeting in Grapevine, TX (shown here), the American Physical Society April meeting in Washington, DC, and the Goddard Space Flight Center. Credit: ESA; NASA

On April 6th, LPF began a 'de-orbit' maneuver to move the spacecraft out of its Lissajous orbit around Earth-Sun L1 and into a Heliocentric drift-away orbit. Despite only requiring $\Delta v \sim 1$ m s^{-1}, the maneuver took several days to complete with LPF's micropropulsion system. Science operations with LPF will continue for several months during the drift away, with the last telecommand to the spacecraft expected to be sent in mid-July, a little over a year and a half after mission launch.

In parallel with LPF operations, the LISA consortium prepared the LISA mission proposal to respond to ESA's call for mission concepts for their L3 mission. The proposal was submitted in mid January and is now under study at ESA's concurrent design facility (CDF) at ESTEC. The assumption is that ESA will select the design for an initial phase 0 study this summer, which will be followed by two industrial Phase A studies scheduled to end in 2020. Furthermore, NASA's L3-Study Team (L3ST) is evaluating NASA's options to participate in L3 and starting to prepare material for the next Decadal survey. A fraction of the L3ST members are also on the LISA consortium board. For anyone who has been involved in LISA for now more than 15 years, the programmatic progress over the last 18 months has been unbelievably fast and satisfying. Everything is in flux but all appears to be moving into the right direction.

IceCube

ERIK BLAUFUSS (U. MD)

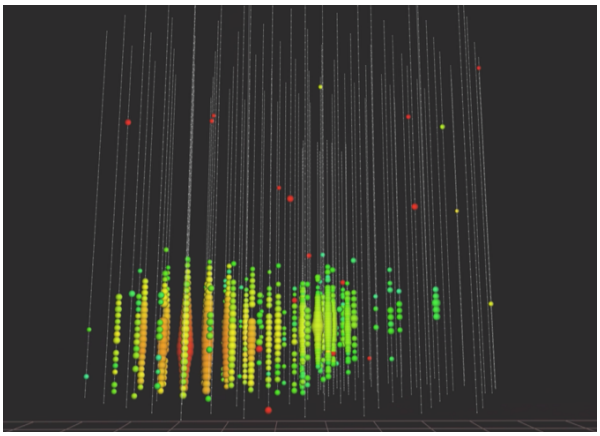
Although high-energy astrophysical neutrinos were discovered by IceCube with the observation of neutrino events originating inside the detector (the HESE sample) in 2013, their origin still remains unknown. This diffuse signal of high-energy neutrinos has also been observed in up-going, detector-crossing muon tracks. Searches for point sources in the IceCube data and dedicated followup searches have failed to locate a potential source. These searches were performed after the publication of the neutrino results, well after the detection of the neutrino.

Given the depth and the size of IceCube, the observed event rate for penetrating atmospheric muons is approximately 2.7 kHz. The neutrino detection rate (a few mHz) is dominated by atmospheric neutrinos. The first challenge of the realtime alert system is to find a pure sample of neutrinos, and the second is to identify the small fraction of neutrinos that are likely to be astrophysical in origin.

Aiming to identify an electromagnetic counterpart of a rapidly fading source, IceCube has implemented an online real-time analysis system at the detector site in Antarctica. Single neutrino events, identified as being consistent with an astrophysical origin, are identified in real time, and alert messages are generated and transmitted north for distribution to a wide variety of follow-up instruments, all within approximately 1 minute of the neutrino event's detection.

Although IceCube detects many types of neutrino interactions, these alerts focus on muon tracks produced primarily through the charge-current interaction of muon-type neutrinos near our instrumented volume. The muons produced in these interactions have track lengths of several kilometers, travel in the same direction as the neutrino that created them, and can be reconstructed to an accuracy of one degree or better at the highest energies.

Neutrino starting track events from the HESE sample and through-going tracks consistent with extremely high energy track events were selected as the first set of analyses to generate public alerts to broadcast to the astronomical community as GCN alerts. Since the initial activation of these alerts in April 2016, eight alerts have been issued, and all received prompt observations on several instruments.



High-energy starting event view from alert IceCube-160427A. Color represents the time of the hits (red, early to green, late) and size represents detected charge. This event started in the IceCube detector volume and exited, depositing more than 100 TeV of energy. Credit: IceCube

In addition to these public alerts, IceCube also has several agreements with optical, x-ray, and gamma-ray observatories to perform observations based on IceCube observed multiplets. These multiplets, observed on timescales of seconds to weeks, are dominated by accidental coincidences in the atmospheric background events. However, a nearby neutrino burst from a gamma-ray burst, or an AGN flare would also trigger these follow-up observations. Searches for bursts of low energy neutrinos from nearby Supernova are also performed as part of the SNEWS network.

With these IceCube neutrino alerts and the possible discovery of transient astronomical sources associated with them, the era of multi-messenger time domain astronomy has arrived. A clear multi-messenger detection of a source will enrich our understanding of the most energetic cosmic phenomena, shed light on the mysterious origins of the highest energy cosmic rays, and provide a unique window into the cosmos. For further information, please contact the IceCube realtime group at roc@icecube.wisc.edu.

The Chandra X-ray Observatory

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

Chandra has carried out more than 17 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.

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 thermal control surfaces. Condensation on the filter reduces ACIS's sensitivity to low-energy X-rays (but does not affect the HRC). The decline in insulation effectiveness requires extra effort in scheduling observations but has not significantly affected Chandra's observing efficiency.

The Operations team responded extremely well to anomalies on four occasions since December 2016, when the spacecraft failed to acquire the expected aspect guide stars following a maneuver. In these cases, Chandra's science program was stopped but the spacecraft redundancy configuration remained unchanged, allowing for rapid diagnosis and return to science. Two independent root causes for the anomalies have been determined, the first relating to the effect of increased noise in the gyro bias rate during a maneuver, and the second, to the aspect camera tracking hot pixels during the prior observation. Neither of the causes relates to a new concern about the hardware, but rather, are typical of the engineering trends being managed by the operations team as the spacecraft ages. A number of near-term mitigations have been implemented in order to minimize recurrences, and the team is working on strategies to address these issues over the longer term.

The preliminary detection list for the *Chandra* Source Catalog release 2.0 was made available to the community in March 2017. The list provides an initial set of key data – positions, likelihoods, extents, and associated errors – for over 360,000 of the 370,000 detections expected in the full catalog to be released later this year.

In December 2016, the *Chandra* X-ray Center (CXC) issued a call for proposals for Cycle 19 observations, with a deadline for proposals in March 2017. Scientists worldwide submitted 577 proposals, including 40 Large and 15 Very Large projects, an oversubscription of 6.4 of the available observing time. The peer review of Cycle 19 proposals will be held in June 2017. The call for proposals for Einstein fellowships attracted 163 applications for 2017. The Einstein peer review, held in January, selected 8 Fellows, who will begin their three-year terms in Fall of 2017. NASA plans to consolidate its named fellowships programs, so this was the final Fellows review held by the CXC.

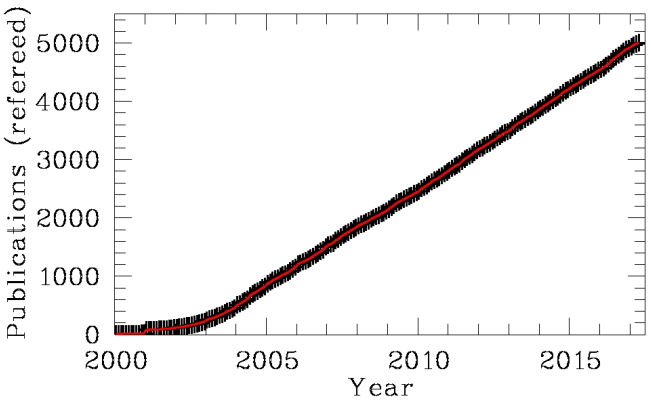
The CXC will hold a workshop, "From *Chandra* to *Lynx*: Taking the Sharpest X-ray Vision Fainter and Farther", in August 2017. *Lynx*, formerly known as the X-ray Surveyor, is one of the large strategic mission concepts being studied by NASA in preparation for the 2020 U.S. Decadal Survey. *Lynx* is the first future X-ray mission concept planned to match the spatial resolution of the *Chandra* X-ray Observatory. This workshop seeks to leverage *Chandra*'s legacy and maximize its impact on the development of *Lynx* science and design objectives.

In its 17th year, *Chandra* has continued its high level of scientific productivity, and as a result the *Chandra* Press Office has continued to be active in issuing image releases, science press releases and other communications of *Chandra* research results. Issue No. 24 of the annual CXO newsletter was released and distributed in April. As always, please see the CXC website for more information about the *Chandra* Observatory and the *Chandra* X-ray Center.

XMM-Newton

LYNN VALENCIC (JHU & GSFC)

XMM–Newton has passed a major scientific milestone with the publication of the 5000th refereed paper based on *XMM–Newton* observations. In its 17th year, *XMM–Newton* remains a remarkably productive facility. Recent science highlights include the determination that absorption lines from an extreme ultrafast gas flow in the X-ray spectrum of an active galactic nucleus is anti-correlated with the X-ray emission from the inner regions of the accretion disk; identification of a tidal disruption event lasting ten years which shows temporal and spectral features never seen before; the detection of the brightest and most distant known pulsar; and providing new constraint on the geometry of the accretion disk in the "Rapid Burster".



Cumulative XMM–Newton refereed publications by year. Credit: XMM–Newton

Successful submissions from the Sixteenth Call for

Proposals for *XMM–Newton* were announced in December 2016, with observations beginning in May. The Seventeenth Call for Proposals will open August 22, and the final date to submit proposals will be October 6.

The SOC is hosting the 2017 symposium June 6-9 in Rome, Italy. It will be the fifth international meeting in the series "The X-ray Universe", and will gather a general collection of research in high energy astrophysics. The symposium will provide a showcase for results, discoveries, and expectations from current and future X-ray missions. More information can be found here: Proceedings and presentations from the 2016 workshop, "*XMM–Newton*: The Next Decade" are now available online.

Swift

ELEONORA TROJA (NASA/GSFC), BRAD CENKO (NASA/GSFC)

On February 6, 2017, the *Swift* mission lost its tireless leader, as Principal Investigator Neil Gehrels passed away after a year-long battle with pancreatic cancer. Neil's impact on *Swift* cannot be understated – his vision for the project was instrumental from the early proposal stages nearly two decades ago to the more recent reinvention of the mission as the go-to facility for multi-wavelength time-domain astrophysics. Neil will be remembered not only for his exceptional leadership and unwavering enthusiasm for science, but also for his unselfish generosity in daily personal interactions with everyone who came across his path. The *Swift* team is very grateful for the opportunity we had to explore the Universe together, and will do our best to carry forward his legacy of curiosity and discovery.

Neil Gehrels.

The *Swift* mission continues to operate flawlessly and to support 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 ToO accepted and different sources observed.

An international team of astronomers used *Swift* data to study stellar explosions from the ancient Universe. The study found that one of the GRBs detected by *Swift* occurred when the Universe was only 670 million years old, less than five percent of its present age. Only two of the more than 1,000 GRBs seen by *Swift* have earlier measured ages. This result shows that GRBs represent a powerful tracer of star-formation in the early Universe, and are the only known signature of primordial stars at such distances.

Swift data were instrumental in the study of the peculiar behavior of the tidal disruption flare ASASSN-14li, a dramatic burst of electromagnetic activity that occurred when a distant supermassive black hole ripped a star apart. A group of researchers identified a curious pattern in the brightness of the flare: as the obliterated star's dust fell into the black hole, the optical and ultraviolet (UV) emission from the flare showed small fluctuations, in a distinctive pattern. This very same pattern was seen 32 days later in the X-ray band. These echoes were probably produced as the stellar debris, swirling ever closer to the black hole, collided with itself, giving off bursts of optical and UV light at the collision sites; as the colliding debris heated up as it was pulled further in, it produced X-ray flares in the same pattern just before the material fell through the event horizon.

The Swift Guest Investigator (GI) program will continue to solicit proposals in GRB and non-GRB research during Cycle 14. NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2017 and the Swift Appendix were released on February 14, 2017. The deadline for submitting Swift Cycle 14 GI Program proposals is September 21 at 4:30 PM EST. Please visit the Swift proposal web site for more details.

NuSTAR

DANIEL STERN (JPL), FIONA HARRISON (CALTECH)

The *NuSTAR* mission continues to operate nominally on orbit. The accepted targets from *NuSTAR* Cycle 3 will shortly be made available at the *NuSTAR* HEASARC webpage, and, as of this writing, 95% of non-ToO Cycle 2 *NuSTAR* observations have been completed. *NuSTAR* Cycle 3 will begin on June 1st, and *NuSTAR* joint observations in *XMM–Newton* Cycle 16 have already begun.

Recent mission highlights include a press release at the January AAS meeting in which two UK graduate students, Ady Annuar (Durham) and Peter Boorman (Southampton), reported on NuSTAR observations of obscured, supermassive black holes lurking in our cosmic backyard. Ady reported on NGC 1448, while Peter reported on IC 3639. Thanks to NuSTAR's sensitivity to the penetrating high-energy photons above 10 keV, in

both studies we were able to determine the intrinsic, unobscured high-energy emission from these sources, and thus determine the accretion rates of these nearby active galaxies. NGC 1448 has a large population of young (5 million year old) stars, suggesting that the galaxy produces new stars as its black hole feeds on gas and dust.

NuSTAR observation of the supermassive black hole at the center of NGC 1448. Credit: NASA/JPL-Caltech/Carnegie-Irvine Galaxy Survey

Other recent science highlights include the discovery of two more ultraluminous neutron stars, i.e., ultraluminous X-ray sources (ULXs) with pulsating X-ray emission, implying super-Eddington accretion onto a neutron star. The first such object was found by *NuSTAR* in 2014, near the center of M82. Relatedly, *NuSTAR* found that the brightest high-energy source in the Andromeda galaxy is also a pulsar, albeit not nearly as luminous as the ULX pulsars.

INTEGRAL

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

INTEGRAL will mark 15 years in operation on October 17, 2017, and *INTEGRAL* and its instruments continue to operate nominally. In recognition of this milestone, ESA Communications is planning to produce a booklet highlighting *INTEGRAL*'s many scientific discoveries. The text will be based on the 2016 mission extension document, but other science highlights from the *INTEGRAL* scientific community are welcome; please send contributions to Erik Kuulkers.

At its 152nd meeting on November 22-23, 2016, the ESA Science Program Committee (SPC) confirmed two-year mission extensions for *INTEGRAL* (and eight other scientific missions with ESA participation). This secures *INTEGRAL*'s operations through the end of 2018. Extension of *INTEGRAL*'s science operations through the end of 2020 (subject to a mid-term review in 2018) should be decided at the June 2017 SPC meeting. However, *INTEGRAL* funding provided by the French national space centre (Centre national d'études spatiales, CNES) has been reduced. As a result, *INTEGRAL* operations support from France is now minimal, and mostly provided via institutional support. Potential impacts and fallback solutions have been identified.

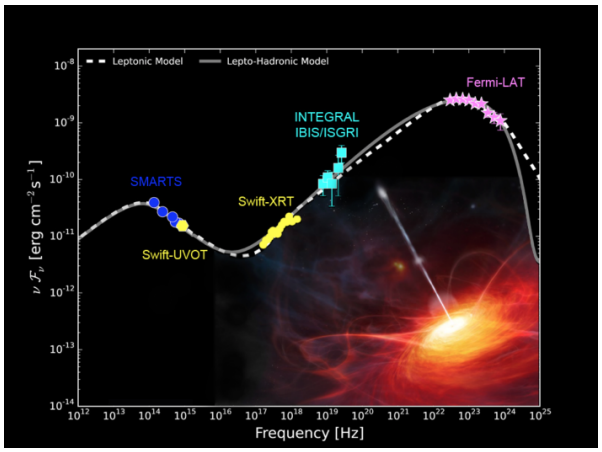
The 19th *INTEGRAL* Users' Group (IUG) meeting was held on March 1-2, 2017 at ESTEC. Four invitees presented 1) the status of *INTEGRAL* mission operations, (i.e. fuel, battery, orbit, etc), 2) a comparison of absolute timing with *INTEGRAL* and other observatories, 3) the high-energy cross-mission calibration status, and 4) methods to respond to "multi-messenger" triggers (GW events, ultra high-energy neutrino events, as well as GRBs). As part of this response, the *INTEGRAL* Project signed a Letter of Intent for follow-up of Fast Radio Bursts (FRBs) discovered by the SUPERB project (using Parkes radio observatory), in collaboration with the SUPERB team. The IUG also noted that the last *INTEGRAL* instrumental cross-calibration report was produced in 2007. An update of this well-used report should be published sometime after the release of the OSA11 *INTEGRAL* analysis software package. The IUG also encouraged that public *INTEGRAL* data be advertised more broadly to the astronomical community. *INTEGRAL* data can be accessed from the *INTEGRAL* Data Archive at the ISDC, or from NASA's HEASARC.

The 15th call for proposals for observations to be performed in 2018 opened on February 20, 2017 and closed on March 31, 2017. Announcements were sent to the *INTEGRAL* community, as well as to other high-energy communities (including the *AstroSat*, *Fermi*, HXMT, *NuSTAR*, and *Swift* communities). Preliminary results show that the number of proposals has increased (65, versus 57 last year), whereas the total time asked for has decreased although the oversubscription is still high, i.e., 4.2 (versus 5.5 last year). Half of the proposals are for Target-of-Opportunity (ToO) observations. The community has shown high interest in coordinated observations with *NuSTAR*, *Swift*, and *XMM–Newton*. 20 submitted proposals requested coordinated observations. The non-ToO proposals requested data rights for 341 sources in total. Preparations for the TAC meeting (May 15–17) are in full swing.

The 28th SPI annealing was performed during January 14–30. During this annealing interval, no SPI observations were performed, though other observations not depending on SPI were carried out. The SPI energy resolution has recovered, but the behavior of the degradation was unusual, showing at first a fast degradation and then flattening. We are investigating if this is a real physical effect or simply an issue with the derivation of these values.

Some other operational anomalies were encountered during the last year as well. Most notably, the *INTEGRAL* spacecraft went into Emergency Sun Acquisition Mode (ESAM) on January 18, for the 6th time since launch. The ESAM was triggered by a startracker anomaly. All active instruments went into safe mode (SPI was already inactive because of the annealing). JEM-X and OMC were recovered on January 20, while IBIS was recovered a day later, on January 21. Also, on January 20 the IBIS Data Processing Electronics stopped because of some as-

yet unidentified reason. Recovery of the IBIS Data Processing Electronics took more than 2 working days. On March 22, 24–25, and April 7–11, *INTEGRAL*'s observations were affected by a malfunction of the IBIS Veto system. The cause of this problem has been identified, and IBIS is running in the correct configuration again. A new reaction wheel biasing strategy was successfully tested from March 27–29. This new strategy allows stable pointing operations within the zero speed region, in order to reduce propellant consumption. This mode will be implemented for routine operational planning in August 2017.



Quasi-simultaneous SED of 3C 279, along with two complementary radiation transfer models: a so-called leptonic model and a lepto-hadronic model. These two models, shown as a gray solid line and as a white dashed line, respectively, can equally well represent the data. On the background an artist's rendering of 3C 273 is shown. Credit: Eugenio Bottacini (GCSU) and ESO/M. Kornmesser.

Scientific observations for the AO-13 (2016) and AO-14 (2017) cycles were performed mostly as planned. A new and improved OMC flatfield observation was performed successfully on November 11. The transient Gamma-ray source and black-hole binary candidate GRS 1716-249 was the subject of a public out-of-TAC ToO observation to study the high-energy tail above 100 keV. Another ToO observation to follow-up on the high-energy neutrino event IC-170321A was performed in March. A coordinated observation of GRS 1915+105 to support calibration observations with *AstroSat* was also done in March. Simultaneous *Swift* and radio observations were also obtained. *INTEGRAL* also detected two GRBs (GRB 161214A and GRB 161219A).

Final delivery to Guest Observers of the new *INTEGRAL* data analysis software, OSA11, has been further delayed, and will now probably take place during the late spring or early summer timeframe. ESA's discovery portal ESASky now also contains pointing positions for IBIS observations (the corresponding data are directly downloaded from the archive at the ISDC Data Centre for Astrophysics). Also now available are an updated *INTEGRAL* RGB HiPS map, and three new maps corresponding to the energy ranges 20-35 keV, 35-65 keV and 65-100 keV, as well as the *INTEGRAL* IBIS/ISGRI soft Gamma-ray catalogue.

From *INTEGRAL* launch to April 12, 2017, a total of 1012 of *INTEGRAL*-related refereed papers have been published. Of these, 26 refereed papers have been published in 2017, including an article by E P. van den Heuvel, "*INTEGRAL* Reloaded," in Nature Astronomy.

Some recent *INTEGRAL* science highlights include a search for prompt Gamma-ray counterparts to the cosmic neutrino candidates IceCube-161103 and IceCube-161210 and IceCube-170321A, but no significant source was seen. The Swift/XRT + *INTEGRAL*/JEM-X + *INTEGRAL*/IBIS-ISGRI high-energy emission spectrum of V404 Cyg during a particularly stable low state resembles a highly-accreting, obscured AGN. The spectrum could be well fitted with a model which assumes that the X-ray emission from a point source is heavily reprocessed by a toroidal, non-uniform, high-density absorber.

The blazar 3C 279 was caught in its brightest flare ever at high energies by *INTEGRAL*/IBIS/ISGRI The multi-frequency campaign around this event covered 10 orders of magnitude in energy, involving observations by *Fermi*/LAT at Gamma-ray energies, by *INTEGRAL*/IBIS at hard X-rays, by *Swift* at X-rays and UV, and by SMARTS in optical to near-IR wavelengths.

Finally, this has been a year of personal loss for the *INTEGRAL* community, which sadly marked the passing of Mikhail Revnivtsev, Neil Gehrels and Lars Hansson. Mikhail G. Revnivtsev passed away on November 23 after a long illness. Mike was the Head of the Laboratory of Experimental Astrophysics Space Research Institute, a renowned scientist in the field of X-ray astronomy and high-energy astrophysics. He was also a very pleasant colleague and good friend to many of us. Mike served on the *INTEGRAL* Time Allocation Committee (TAC) and was a member of the IUG from 2011 to 2015. His contributions were paramount to the success of the mission, and he will be dearly missed.

Neil Gehrels served as *INTEGRAL* Mission Scientist for the IUG from the beginning of the mission. Through his service to *INTEGRAL* as Mission Scientist, and as Principal Investigator of *Swift*, Project Scientist for WFIRST, and his major roles in CGRO and *Fermi*, Neil made outstanding contributions to high energy astrophysics in particular, and astrophysics in general. His ideas, scientific advice, contributions, and insightful reviews through all phases of the *INTEGRAL* mission development were critical to the development and operation of *INTEGRAL*. The IUG recommended replacing Neil (as if that were possible) with a renowned high-energy astrophysicist from the US *INTEGRAL* community.

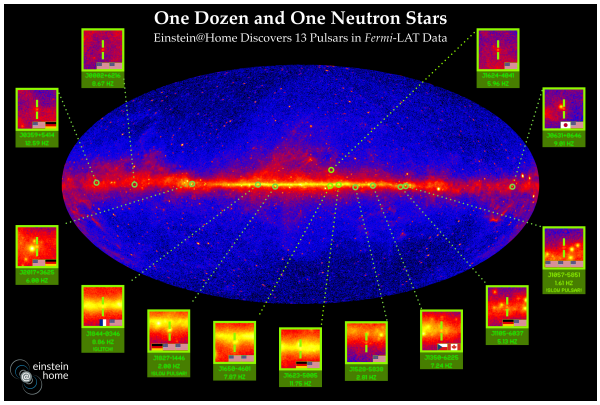
Lars Hansson, former *INTEGRAL* Science Operations Manager, passed away on March 15. Lars contributed to a wide range of missions during his career, including COS-B, EXOSAT, Hipparcos, and ISO in addition to *INTEGRAL*. He retired at the end of 2006, having seen the *INTEGRAL*

Science Operations Centre (ISOC) through its development and the early mission phase. Lars was a positive, forward thinking person who was always supportive of the people on his team, and we will miss him.

The *Fermi* Gamma-ray Space Telescope

JULIE MCENERY (NASA/GSFC), ELIZABETH HAYS (NASA/GSFC), CHRIS SHRADER (NASA/GSFC & CRESST/CUA), DAVE THOMPSON (NASA/GSFC), LYNN COMINSKY (SONOMA STATE)

The *Fermi Gamma-ray Space Telescope* continues to operate nominally. Updated software and documentation are available from the *Fermi* Science Support Center. *Fermi* results continue to span a broad range of topics, with studies carried out by the national and international *Fermi* community. A total of 183 proposals were received for Cycle 10. Reviews are in progress, with results to be announced this summer.



The entire sky as seen by the Fermi Gamma-ray Space Telescope and the 13 pulsars discovered by Einstein@Home. Credit: Knispel/Clark/Max Planck Institute for Gravitational Physics/NASA/DOE/Fermi LAT Collaboration

This year has seen a number of interesting and important new results from *Fermi*. JPL scientists, using *Fermi*, *Swift*, *NuSTAR*, and radio observatories, discovered a pulsar that appears to transition between being a normal rotation-powered neutron star and a magnetar. A group from the Max Planck Institute for Physics used a trigger from *Fermi*'s Large Area Telescope to enable a detection of gravitationally lensed TeV gamma rays. Albert Einstein Institute scientists have used the Einstein@Home distributed computing resource to discover 13 new gamma-ray pulsars in the *Fermi*-LAT data. Thanks to the improvements in the *Fermi*-LAT Pass 8 data processing, a group led by Clemson University scientists have discovered gamma-ray blazars out to a redshift of 4.31. The Stanford University *Fermi* group showed that some solar flares seen by *Fermi* actually originated on the far side of the sun. Analysis of *Fermi* observations of M31 by a group including scientists from the National Center for Scientific Research and the Research Institute in Astrophysics and Planetology in Toulouse, France, revealed an unexpected concentration of Gamma-ray emission toward the central part of the galaxy. This concentration may be similar to the GeV excess seen in our own Galaxy. The implications of this result for dark matter searches were recently discussed in Symmetry magazine.

Julie McEnery, *Fermi* Project Scientist, was featured in a Universe of Learning-sponsored Museum Science briefing entitled "Women in STEM: Hidden Figures, Modern Figures." This briefing coincided with national publicity for the movie "Hidden Figures," the story of the African-American female mathematicians who worked for NASA during the early days of the human spaceflight program. NASA's Universe of Learning program is also sponsoring many events involving girls at public libraries this spring in conjunction with Women's History month. If you would like to get involved in future Universe of Learning events as a Subject Matter Expert, please contact Dr. Lynn Cominsky at Sonoma State University.

CALET

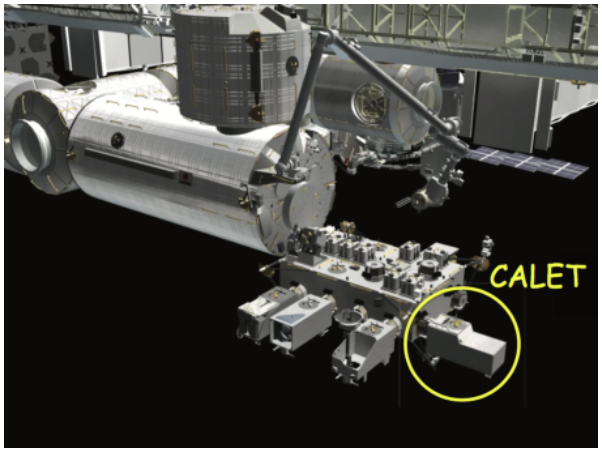
JOHN WEFEL (LSU)

The CALorimetric Electron Telescope (CALET) is a deep (32 radiation lengths) dual calorimeter astroparticle physics observatory for the International Space Station (ISS). CALET is designed to investigate the total electron spectrum into the trans-TeV energy region and gamma-rays to similar energy. The mission is an international effort (Japan, Italy, USA), led by Japan, to provide the highest energy measurements of galactic cosmic rays and Gamma-rays plus observations of Gamma-ray bursts.

CALET was constructed mainly in Japan with advice/help provided by the US and Italy (who also provided the high voltage system). In spring 2015, CALET was delivered to the Tanegashima Space Center where it was mated with the HTV-5 carrier (named Kounotori5) for a successful launch on August 19, 2015. Kounotori5 arrived at the ISS five days later, was captured by the ISS robotic arm and berthed. CALET was then removed from Kounotori5 and robotically transferred to the Japanese Experiment Module Exposed Facility (JEM-EF) where it was mounted on port #9 and data, thermal and power connected. After completing a 60-day check-out and calibration period, routine operations commenced at the end of October, 2015.

JAXA is responsible for the health and safety monitoring of CALET, as well as for providing the Level-0 data to the Waseda Control and Operations Center (WCOC), where it is pre-processed to a Level-1 format. Detailed calibrations have been developed (Asaoka et al., "Energy Calibration of CALET Onboard the International Space Station", Astroparticle Physics, in press, 2017) and applied to obtain the Level-2 data which is used for science analysis. The US CALET Data Center (USCDC), located at Louisiana State University, provides data distribution to the US teams, performs analysis of both simulated and

flight datasets, provides in-flight monitoring and establishes an archive for CALET data. Links to the USCDC at LSU, as well as the equivalent center in Pisa, Italy, are used to transfer data to the science team.



The Japanese Experiment Module-Exposed Facility on the ISS. CALET is attached at the #9 port as indicated. Credit: S. Torii and the CALET collaboration.

CALET continues to function well, and approximately 16 months of data are under analysis for presentation/publication. The goal is to look for evidence of nearby sources of particle acceleration, to search for indirect signatures of dark matter and to investigate the (possible?) end of the galactic electron spectrum. In addition, the instrument also measures the nuclear component of cosmic rays to near PeV energies. Due to the large dynamic range of the charge determination system, CALET can also measure relative abundances for nuclei heavier than the iron peak, to about Z=40. Further, CALET has observed over 50 Gamma-ray bursts and participates in searches for electromagnetic counterparts of LIGO gravity wave events and high energy neutrino events. Preliminary results from this multitude of science topics will be presented at the 35th International Cosmic Ray Conference in South Korea in July.

Physics of the Cosmos News

T. J. Brandt (NASA/GSFC)

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 facilitates a number of community activities, including meetings and articles, and annually reviews strategic technology capability gaps, prioritization, and development.

To provide appropriate input to the 2020 Decadal Survey, in addition to funding four large mission concept studies including the *Lynx* X-ray mission, NASA is also funding medium sized mission concept studies. This includes Probe class missions, with a total lifecycle cost larger than a MIDEX but less than $\sim$ \$1B. In March 2017, NASA selected or partially selected 10 Probe mission concepts for an 18 month study, including design lab runs and an independent cost assessment. Of those, 5 have particular relevance for the PCOS community and will be discussed further at the upcoming HEAD meeting PCOS Town Hall.

The PCOS Program Office also supports the Physics of the Cosmos Program Analysis Group (PhysPAG), which solicits and coordinates interdisciplinary community analysis and input to enable direct, regular communication between NASA and the community. The full PhysPAG consists of all community members who choose to participate. The PhysPAG provides findings to NASA's Astrophysics Division Director, Dr Paul Hertz.

Recent meetings included PCOS and PhysPAG community town halls at the January AAS meeting and at the APS April meeting (which was also held in January this year). The AAS meeting included an open PhysPAG meeting, a session on the Decadal Studies, and an X-ray Science Interest Group (SIG) meeting. Special sessions included Gravitational Waves, *Hitomi* highlights, *Lynx* science, and the US involvement in *Athena*. At APS, PCOS organized a mini-symposium on high energy astrophysics. The Cosmic Ray SIG, Gravitational Wave SIG, and Gamma-ray SIGs held special sessions as well. The L3 Study Team had an open meeting following APS. Information about all past meetings, including agendas and most slides, as well as upcoming meetings, is available at the PCOS Meetings page.

We welcome your input on PCOS science topics, particularly through the relevant PhysPAG Science Interest Group (SIG), several of which have articles in this newsletter, and by providing input on technology gaps between the current state of the art and technology needed for the strategic missions of the coming decades by June. We also look forward to seeing you at the 16th HEAD meeting! We will host a Town Hall on Tuesday, August 22 from 12-1:30pm. We plan to have remote connection available for those unable to attend in person.

The X-ray Science Interest Group

Mark Bautz (MIT)

NASA is your space agency and the X-ray Science Interest Group (XRSIG) is one of your tools for guiding it. Last year our community's support, much of it voiced via the XRSIG, was an important factor in NASA's decision to move rapdily toward development of the X-ray Astrophysics Recovery Mission (*XARM*; see Rich Kelley's article elsewhere in this newsletter). Over the past several years XRSIG has helped to channel the HEAD community's en-

thusiasm for Probe-class missions to NASA (in this case via the Physics of the Cosmos Program Analysis Group), and recently we've seen tangible results. Ten Probe mission concepts have been funded for study and presentation to the next Decadal survey, four of which aim to provide new capabilities for high-energy astrophysics (see the Physics of the Cosmos Program article by Ann Hornschemeier and Terri Brandt elsewhere in this newsletter.)

What's next? That's up to you as well. For example, the 2020 Decadal Survey is approaching relentlessly; what technology must we develop to convince the Decadal that our boldest scientific aspirations are matched by our technical means? XRSIG will soon be reminding you to participate in NASA's annual call to identify technology development needs, a process which is described in detail in the Physics of the Cosmos Program Annual Technology Report. A related question: to make the most of *XARM* (and eventually *Athena* and *Lynx*), do we also need a similar, *strategic* laboratory astrophysics development program? And, while having four funded probe mission concept studies is fantastic, are there other great concepts that ought to be presented to the Decadal as well? If so, what can be done about that?

We'll be discussing these and similar questions at the XRSIG meeting to be held as part of the August HEAD meeting in Sun Valley. Please join us Tuesday evening, August 22 for that, and please let us know if you have ideas for its agenda. Our goals are to encourage community conversation and to make sure that NASA hears us.

Finally, we welcome Dr. John Tomsick's appointment by NASA to the Executive Committee of the Physics of the Cosmos Program Analysis Group. John is at the Space Sciences Laboratory of the University of California at Berkeley, and we are delighted that he has agreed to join the XRSIG leadership.

The Gamma-ray Science Interest Group

Henric Krawczynski (Washington University, St. Louis), Sylvain Guiriec (NASA/GSFC & CRESST/UMCP), John Tomsick (UC Berkeley)

The Gamma-Ray Science Interest Group (GammaSIG) is currently discussing several mission concepts including hard X-ray imaging spectroscopy and polarization missions, and MeV and GeV gamma-ray observatories, and their synergy with ground based gamma-ray, neutrino, and gravitational wave detectors. The SIG is furthermore organizing a special session entitled "High-Energy Polarimetry: Current and Future Opportunities" during the 16th HEAD meeting. The invited talks include a status update from Martin Weisskopf, the PI of the recently selected Imaging X-ray Polarization Explorer (*IXPE*), and first results from several balloon borne and space borne hard X-ray and gamma-ray polarimetry missions. The GammaSIG will organize additional special sessions during the 2018 AAS January meeting, the 2019 APS April meeting, and the 2019 HEAD meeting.

The Universe of Learning

Lynn Cominsky (Sonoma State University)

In 2015, NASA's Science Mission Directorate issued a cooperative agreement notice to implement a new approach to its science education program. NASA's Universe of Learning (UoL) project was competitively selected to bring together content and expertise from all past, current and future Astrophysics missions to support NASA education objectives. UoL is led by PI Denise Smith (STScI), together with Co-investigators Kathleen Lestition (SAO/CXC), Lynn Cominsky (SSU), Gordon Squires (Caltech/IPAC) and Anya Biferno (JPL/Exoplanet Exploration Program). NASA's Universe of Learning provides resources and experiences that enable educators to engage their audiences in the science, the story, and the adventure of NASA's scientific explorations of the Universe. We are creating an integrated team of scientists, educators, and communications professionals who work together and with the education community to strengthen science education and scientific literacy, and to enable learners of all ages and backgrounds to be engaged and immersed in exploring the Universe for themselves. In order to accomplish our goals, we are reaching out to subject matter experts (SMEs) to help us convey how NASA's Astrophysics missions advance our understanding of fundamental questions about our Universe. Example projects which have already tapped SMEs include Viewspace (short captioned videos that play in a continuous feed to libraries and museums nationwide), Universe of Learning Science Briefings (webinars for museum professionals offered in partnership with NASA's Museum Alliance), and Girls STEAM Ahead with NASA (family-oriented science events at public libraries). We will also be creating participatory experiences that enable educational use of Astrophysics mission data; providing professional development for pre-service educators, undergraduate instructors, and informal educators; and creating exhibit and community programs. A particular focus for all UoL activities is engaging under-represented individuals, including audiences with special needs. If you are a Subject Matter Expert who would like to become involved with UoL projects, please contact info@universe-of-learning.org. For more information about UoL, see NASA's Universe of Learning website.

The Neutron Star Interior Composition Explorer

Keith Gendreau (NASA/GSFC), Zaven Arzoumanian (NASA/GSFC)

The Neutron Star Interior Composition Explorer, *NICER*, is manifested on the SpaceX-11 Commercial Resupply Services flight to the International Space Station

(ISS), with launch scheduled for no earlier than June 1, 2017. SpaceX has integrated *NICER* into the Dragon vehicle's Trunk, and a final electrical check of some of the *NICER* heaters—to be powered by the Dragon during the 3–4 day ride to the ISS—has been completed. At launch minus 5 days, *NICER*'s contamination bag will be removed and the Dragon capsule will be integrated to the Falcon 9 rocket for launch.

NICER will be robotically removed from the Dragon Trunk about three days after arrival and berthing at ISS. Integration onto the Space Station's ExPRESS Logistics Carrier (ELC) 2 will take an additional day or two. Once the payload is installed, the *NICER* team will begin to activate *NICER*'s systems.

Following on-orbit checkout for up to one month, *NICER*'s science program will commence. The mission's primary science goal is to infer the radii and masses of a handful of neutron stars to high precision, via the timing profiles of soft X-ray pulses from millisecond-period pulsars. *NICER*'s X-ray Timing Instrument (XTI) offers a novel combination of capabilities: photon time-tagging to better than 100 ns RMS, energy resolution comparable to X-ray CCDs, high throughput (a telemetry limit exceeding 3 Crabs, with no pile-up), and good sensitivity. *NICER*'s peak effective area is approximately 1800 cm^2 at 1.5 keV, and its in-band background count rate is expected to be substantially less than 1 count per second. In addition to its primary science objectives, *NICER* will demonstrate spacecraft navigation technologies that use X-ray-bright pulsars as celestial beacons.

The *NICER* Science Team's topical Working Groups (on lightcurve modeling, precise timing, magnetar science, pulsation searches, burst and accretion phenomena, and observatory science) have completed their assessment and prioritization of *NICER*'s initial science targets. As time allows during *NICER*'s 18-month baseline mission, and on a non-interference basis with its core science goals, the *NICER* team may consider requests from the community for Discretionary Time observations, including time-sensitive targets of opportunity. Such data will be promptly made public through the HEASARC archive, following the model of the *Swift* mission. Upon completion of the baseline mission, a dedicated *NICER* Guest Observer program is anticipated if *NICER* is approved for continuation, e.g., through the NASA Senior Review process for ongoing astrophysics missions.

The *NICER* Science and Mission Operations Center (SMOC) is located at the Goddard Space Flight Center and provides ground system functionality including payload commanding, science planning, and pipeline data processing to enable *NICER* to carry out its science mission. Preparations for mission and science operations are nearly complete. Development work at NASA's High Energy Astrophysics Science Archive Research Center (HEASARC) to archive and disseminate *NICER* data is continuing, and the maturity of procedures and tools developed for the *NICER* SMOC enabled the team to pass its Operations Readiness Review last October. The widely-used HEASARC tools WebPIMMS and WebSPEC can be used to predict XTI source countrates and generate simulated spectra. A *NICER* special session is planned at the 16th Divisional meeting of the HEAD in Sun Valley, ID, in August to present initial results.

NICER at the Space Station Processing Facility at NASA's Kennedy Space Center, prepared for integration into the SpaceX Dragon Trunk in anticipation of launch. Credit: NICER Project, K. Gendreau; NASA

Spectrum Röntgen Gamma/eROSITA

A. Merloni (MPE), M. Pavlinsky (IKI), P. Predehl (MPE), S. Sazonov (IKI)

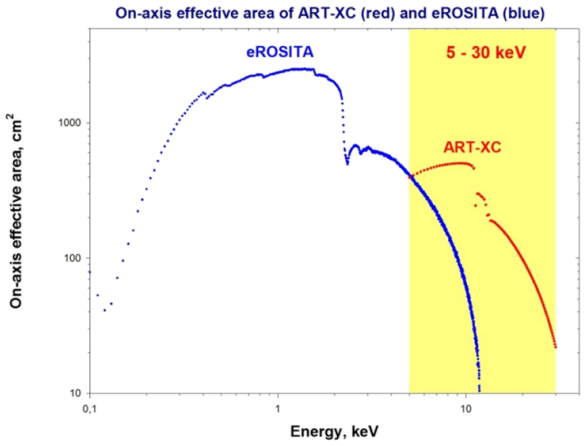
Since January 2017, both fully integrated scientific payloads, the eROSITA and ART-XC telescopes, are in Moscow's outskirts, in the assembly hall of NPOL Lavochkin Association. After a preliminary acceptance tests, passed successfully, further interface tests will be carried out throughout Spring and Summer 2017, before the final space qualification test campaign for the SRG Navigator Spacecraft. Shipment to Baykonour is foreseen at the end of 2017/beginning of 2018, for a launch with a Proton/Block-DM vehicle sometime between March 1st and April 14th 2018.

The eROSITA telescope after incoming inspection tests at NPOL Lavochkin Association, near Moscow, guarded by five members of the MPE team. Credit: MPE; IKI

After almost 10 years of development, the complete eROSITA telescope was shipped from Munich to Moscow on January 20th, 2017. The telescope is completely calibrated, with performances within specifications, completely assembled, and has passed successfully end-to-end & acceptance tests.

The ART-XC telescope in the NPOL assembly hall. Credit: MPE; IKI

The fully integrated ART-XC telescope, on the other hand, was delivered to NPOL Lavochkin already on December 16, 2016. It will be first mounted on the Navigator platform together with eROSITA for a first interface test, after which the spacecraft will undergo the final vibration and thermal vacuum tests without the payloads. Only then will the final integration begin.



On-axis effective area of the combined 7 telescopes for eROSITA (blue) and ART-XC (red). Credit: MPE; IKI

During the calibration campaign of the seven eROSITA Flight Module pnCCD cameras, 3.3 billion calibrated events were collected, which constitute a treasure of information for future in-depth calibration work. The Field-of-View average effective area of the seven mirrors combined is about 1700 cm^2 at 1keV, comparable with the XMM-Newton one.

Athena: Revealing the Hot and Energetic Universe

KIRPAL NANDRA (MPE), DIDIER BARRET (IRAP), RANDALL SMITH (CFA), AND FRANCISCO CARRERA (CISC-UC) FOR THE *Athena* SCIENCE STUDY TEAM AND ATHENA COMMUNITY OFFICE

The *Athena* mission continues to progress through Phase A, with an important step being the closeout of the Delta Mission Consolidation Review (dMCR) in April. A major item under scrutiny at the dMCR was the system mass (including reserves) relative to the estimated Ariane 64 launch capability.

One of the key inputs to this effort was the "Science Impacts of the Mass-Saving Options" (SIMO) exercise led by the *Athena* Science Study Team (ASST), which evaluated the science implications of a range of different mass-reducing changes to the Athena design. All of the Athena Science Working Groups participated in this effort, culminating in a meeting of the ASST and Topical Panel chairs at SRON (Utrecht) on February 22-23. These results were considered by the ASST at a later meeting with the ESA project team, resulting in a recommendation to maintain the current design as baseline. Due to uncertainties in both the current mass estimates and the eventual launcher capabilities, however, the ASST also made a recommendation that if a mass issue persists at a later stage, e,g. at the time of the Ariane 6 Critical Design Review, a decision to remove the outermost (20th) mirror row can be taken. This measure was considered by ESA to be sufficient to consider the mass-risk issue identified at the dMCR to be fully mitigated.

The other major issue identified at the dMCR was the estimates of the mission cost to ESA. Actions to assess and address this issue are currently being formulated in collaboration with ESA.

Athena will form part of a suite of major facilities across the wavebands operating in the late 2020s which will work together to revolutionize astrophysics. To probe this topic more deeply the ASST has initiated a series of synergy studies. The first such exercise was the ESO-*Athena* Synergy Workshop, which took place on September 16-18 at ESO in Garching; an ESO-Athena Synergy White Paper covering both optical/IR and sub/mm, will be published soon on the *Athena* web site.

Synergies between the Square Kilometer Array telescope and the *Athena* X-ray observatory mission were discussed at a workshop held April 24-25 at SKA Organization Headquarters at Jodrell Bank, near Manchester, UK. *Athena* and SKA have some common science objectives, including galaxy clusters and large-scale structure, AGN and surveys, X-ray binaries, accretion physics and transient phenomena. Members of both the *Athena* and SKA communities engaged in lively discussions during the meeting, identifying several science areas in which the facilities transcended their individual capabilities by working together. The identified synergies will be collected in

a white paper (published in Fall 2017) co-ordinated by the SKA-Athena Synergy Team (SAST): Rossella Cassano (INAF/IRA, Chair), Chiara Ferrari (OCA), Rob Fender (Oxford) and Andrea Merloni (MPE). In addition to the synergy workshops the new *Athena* study-scientist Matteo Guainazzi gave a presentation on "Synergies with *Athena*" at the Astrophysics Mission Synergy Workshop, held at Caltech's Cahill Center for Astronomy and Astrophysics on March 31st, 2017.

On the 21st of December 2016, the *Athena* Community Office (ACO) released the second issue of the *Athena* Community Newsletter. This newsletter contained the first Athena technical nugget entitled "The Athena X-ray telescope mirror by numbers" describing how the largest X-ray mirror will be developed. The *Athena* "nuggets" provide interesting scientific or technical information of interest to both the scientific community and the general public. "Nuggets" are released every month on the *Athena* Community Support portal (under the outreach/nuggets section) and on social media.

The ACO has engaged in several activities during this last semester, starting with the celebration of the European Researcher's Night on September 30, 2016 and participating in the International Day of Women and Girls in Science on February 11, 2017. The ACO Outreach team prepared materials to give highlight the more than 200 female scientists who are part of the Athena community. These materials included a series of short videos where some prominent female Athena team members shared their passion for science. The materials were distributed on social media during the week of February 11-18, 2017, reaching several thousands of people. The materials are available to the public in the outreach material section of the *Athena* website. Also, interesting videos are available on the *Athena* Youtube channel.

Recently, the ACO has collaborated in the management of the 2016 Call to join the *Athena* Community Working Groups and Topical Panels. The selection process has finished, with the appointment of the 38 new members, for a total of 860 members worldwide.

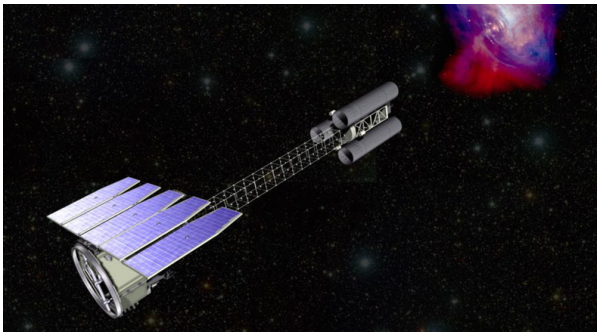
You can keep up-to-date with *Athena* via our website, or through @athena2028 Twitter and Facebook. Urgent or important notifications are sent to the *Athena* Community through bimonthly "Brief News" emails.

Finally, please note that a special session on *Athena* will be held during the The X-ray Universe 2017 symposium, which is being held June 6-9, 2017, in Rome. We hope to see you there.

Imaging X-ray Polarimetry Explorer

M. C. Weisskopf (NASA/MSFC)

A new experiment, the Imaging X-ray Polarimetry Explorer (*IXPE*), has been added to NASA's Small Explorer Program. Chosen to enter phase B this year, the final confirmation decision will be made shortly after the Preliminary Design Review to take place in early 2018. Scheduled to launch in late November 2020, IXPE offers, for the first time, high-sensitivity imaging spectro-polarimtery and will study dozens of X-ray sources per year of observing. The most unique feature of this mission provides image-resolved polarization measurements for a significant number of extended objects such as supernova remnants and pulsar wind nebulae. The imaging capability will also be exploited to accomplish a unique study of our galactic center to understand if Sgr A* was substantially more active several hundred years ago. The sensitivity also allows one to perform the first X-ray polarization map of the bright active galaxy Cen-A.



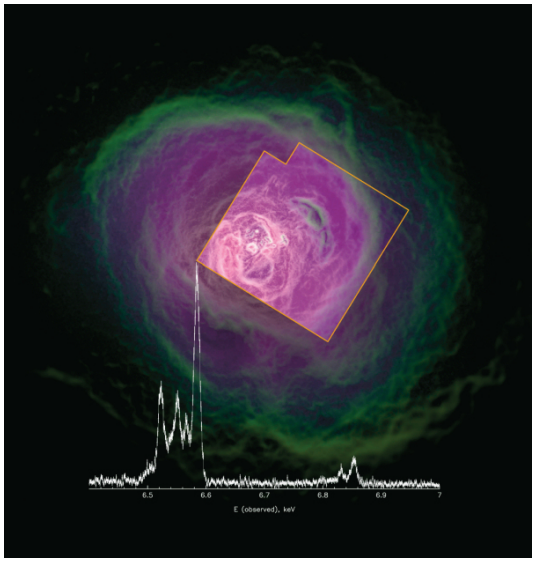
Artist illustration of IXPE. Credit:NASA

The mission is a partnership with the Italian Space Agency and NASA and involves several institutions in Italy with the Italian partners providing the polarization-sensitive X-ray detectors and the use of the ground station at Malindi. The IAPS/INAF at Rome and INFN in Pisa and Turin will lead the detector development. Ball Aerospace, in Boulder Colorado, will build the spacecraft and perform systems integration. NASA's Marshall Space Flight Center leads the program and will supply the X-ray Telescopes, use its facilities to perform end-to-end X-ray calibration, and provide the Science Operations Center. Mission operations will be conducted at the Laboratory for Atmospheric Physics (LASP), also in Boulder Colorado. In addition there are Co-Investigators at McGill University, Stanford University and MIT. Collaborators from 10 different nations throughout the world are also involved. Please see the official *IXPE* web site for news and updates.

The X-ray Recovery Mission

Rich Kelley (NASA/GSFC)

NASA and JAXA are working to plan the X-ray Recovery Mission (*XARM*) to recover the essential capabilities of the *Hitomi* X-ray observatory that was lost to an operational mishap in March 2016. *Hitomi* demonstrated the viability and capabilities of the high resolution Soft X-ray Spectrometer (SXS) that combined X-ray microcalorimeter technology with high throughput X-ray optics. *Hitomi* obtained the first high resolution X-ray spectrum of the Perseus Cluster



Hitomi's view of the Perseus Cluster with the outline of the Soft X-ray Spectrometer shown. The inset shows the remarkable spectrum obtained by the SXS calorimeter in the iron line region. Credit: Background: NASA/CXO; Spectrum: Hitomi Collaboration/JAXA, NASA, ESA, SRON, CSA

which revealed a surprisingly low degree of turbulent motion in the intracluster medium. For the recovery mission, both agencies have embarked on a process to redefine the scope of the collaboration and are in the process of developing a Joint Project Implementation Plan together with a NASA-JAXA Memorandum of Understanding. NASA's Goddard Space Flight Center plans to rebuild the SXS, and JAXA will rebuild the Soft X-ray Imager, both without changes other than incorporating critical experience from *Hitomi*. The mission is expected to be ready to launch in the early 2020's.

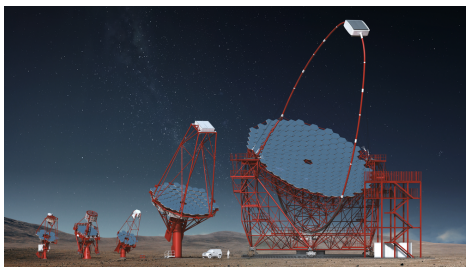
The Cherenkov Telescope Array

MEGAN GRUNEWALD (CTAO)

With array site locations and layouts confirmed, the Cherenkov Telescope Array (CTA) is moving quickly toward pre-production and construction. Three classes of telescope are required to cover the full CTA energy range (20 GeV to 300 TeV). CTA's Medium-Sized Telescopes (MSTs) will cover its core energy range (100 GeV to 10 TeV) while the Large-Sized Telescopes (LSTs) and Small-Sized Telescopes (SSTs) are planned to extend the energy range below 100 GeV and above 10 TeV, respectively.

The plan for the southern hemisphere array site, which is located 10 km from the European Southern Observatory's (ESO's) existing Paranal Observatory in Chile, is to include four 23-m LSTs, twenty-five 12-m MSTs and seventy SSTs spread across an area of five square kilometres. The northern hemisphere array site, located on the existing site of the Instituto de Astrofisica de Canarias' Observatorio del Roque de los Muchachos on the island of La Palma, will include four LSTs and fifteen MSTs.

Prototypes exist or are under construction for the LST, MST and three proposed SST designs and site infrastructure work is underway in preparation for the first pre-production telescopes, which are expected on site as early as 2018.



The Small-Sized, Medium-Sized and Large-Sized Telescopes proposed for the CTA. Credit: CTA

The proposed SST prototypes have been constructed and are undergoing testing in Meudon, France (GCT), Serre La Nave, Italy (ASTRI) and Krakow, Poland (SST-1M). The MST prototype has been constructed and is undergoing testing in Zeuthen, Germany.

The construction of the mechanical system of the Schwarzschild-Couder Telescope prototype at the Fred Lawrence Whipple Observatory in Arizona. Credit: CTA

On La Palma, an LST prototype is under construction and will serve as the first telescope of the final array in the northern hemisphere. The main elements of the foundation, the telescope and the camera access tower foundations, were completed in January 2017. Six hundred twenty cubic meters (about fifteen hundred tons) of concrete will help keep the telescope and its four-hundred-square-meter mirror stable in windy conditions. The next step is to install the circular 23 m diameter rail used to

spin the telescope, followed by the installation of a six-wheel undercarriage. The telescope structure is planned for installation between now and October and the camera access tower is planned for September. In the final step, the camera is scheduled to be installed in November 2017.

In the United States, a consortium of institutions from the U.S. is leading the construction of a 9.6 m Schwarzschild-Couder Telescope (SCT) prototype at the Fred Lawrence Whipple Observatory in Arizona. A dual-mirrored version of the MST, the SCT is proposed as an alternative type of medium telescope with significantly reduced aberrations and increased image angular resolution. In addition, the SCT's two-mirror optical system reduces focal plane plate scale, allowing installation of the compact imaging camera based on new silicon photomultiplier technology. The SCT prototype is being built in collaboration with international partners from DESY (Germany), INAF (Italy), INFN (Italy), MPIK (Germany), STEL (Japan) and UNAM (Mexico) and is funded by the major research instrumentation program of the U.S. National Science Foundation.

The construction of the mechanical system of the SCT prototype is complete and the commissioning of the positioning system is underway. The fabrication of the optical system is near completion and its integration with the alignment system is ongoing at the University of California Los Angeles (UCLA). The installation is scheduled to start in early June 2017. The SCT prototype camera integration is underway at the University of Wisconsin. The delivery and the installation of the SCT camera is planned for August-September of 2017, after which the prototype will be commissioned to begin SCT performance verification and validation which will be followed by observations.

Follow the progress of the LST prototype in La Palma and the SCT prototype in Arizona live on the LST webcam and the SCT webcam. Visit the CTA website to learn more about CTA and to sign up for the CTA e-newsletter.

Lynx

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

Lynx, formerly called X-ray Surveyor, is one of four Decadal Survey Mission Concept Studies initiated in January 2016. The study is being executed by Marshall Space Flight Center in partnership with the Smithsonian Astrophysical Observatory under the leadership of a Science and Technology Definition Team (STDT) drawn from the community. It is anticipated that the 2020 NRC Decadal Survey Committee will use this and other studies in formulating their recommendation for the priorities for future NASA missions.

The name *Lynx* was adopted because it is a symbol of science and the search for knowledge, keen insight, and the ability to see the true nature of things. The name is appropriate because much of the baryonic matter and the settings of the most active energy release in the Universe are visible primarily, and often exclusively, in X-radiation.

The STDT is in the process of defining the key science objectives for *Lynx* that will drive the observatory requirements. To this end, the STDT holds weekly teleconferences and (roughly) triannual face-to-face meetings.The most recent face-to-face meetings were held in Washington, DC, in 2016 November and in Huntsville, AL, in 2017 April.

In addition, eight Science Working Groups meet regularly to examine details of the science case, results of observation simulations, and implications for instrument architectures. Recent Science Working Group meetings included a workshop sponsored by the "X-rays in the Multi-Wavelength Multi-Messenger Era" working group held this March at the Stanford Accelerator Laboratory, and a simulations workshop sponsored by the "Cycles of Baryons" working group held in 2017 April at the Flatiron Institute in New York. The primary output of the simulations workshop is a repository of mock observations that can be analyzed by observers for a variety of halo masses, redshifts and instrument configurations. Upcoming workshops include a meeting of the "Stellar Lifecycles" working group to be held 2017 July 24-26 at STScI, Baltimore, MD.

In parallel, the *Lynx* Instrument and Optics Working Groups are helping the STDT translate science goals into technical instrument requirements, providing the STDT information and metrics needed to make scientific trade-off decisions, assessing technology readiness and preparing technology development roadmaps, and demonstrating that a credible and feasible path exists to fabricate an X-ray telescope to support the *Lynx* science goals. The *Lynx* Instrument and Optics Working Groups will host a Technical Interchange Meeting with industry on May 22-23 in Huntsville, AL.

A software suite dedicated to creating simulated X-ray observations of astrophysical sources with *Lynx* is available to the public. The Simulated Observations with X-ray Surveyor (SOXS) package was released last December. The tool provides a comprehensive set of tools to design source models which can be convolved with simulated models of the *Lynx* instrument to provide support for *Lynx* mission science and help in the the design of the instruments.

Astropoetry Corner

M. F. Corcoran

Ascent (for Neil)

up in that wild high country,
a new handhold,
a sharp ear waiting
for a call or command, eyes wide. Your orbit
follows another path, bounding homeward
but not home.
Here is a precious nugget, out of
this unending stream of dross. A brilliance flaring in
that ostensible darkness.

Excitement
lights your eyes, your blood cascades
from head to foot. Wonder
at these unerring alignments,
those connections so precisely drawn
in this wobbly universe.
at the summit, revel in
the afterglow of a new day;
your eyes transfixed by the
promise of the next ascent