The High Energy Astrophysics Division Newsletter

In this Newsletter

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From the Chair

CHRIS REYNOLDS (UMD)

It is barely four months since I took over as chair from Nick White, and what a wild few months it has been in the high-energy astrophysics world! With February's announcement of a high signal-to-noise detection by LIGO of gravitational waves from two merging $\sim 30M_{\odot}$ black holes, we have seen the dawn of gravitational wave astronomy. As we saw during Laura Cadonati's plenary talk at the 15^{th} Divisional meeting in Naples, Florida in April, as well as the accompanying Special Sessions, this opens an entirely new window on the Universe, allowing us to finally see phenomena that were literally dark to us until now. We also witnessed the flawless launch and then the heartbreaking failure of the *ASTRO-H/Hitomi* mission. The precious datasets that were obtained, including an observation of the Perseus cluster of galaxies that was shown in Andy Fabian's talk at the April HEAD meeting, have demonstrated the transformational nature of high-spectral resolution X-ray microcalorimeter data and may already be changing our view of physical processes within cluster cores. These past few months have also seen the formal beginning of NASA's planning for the 2020 Decadal Survey, including the formation of the Science and Technology Definition Team (STDT) for the X-ray Surveyor, likely capable of observing the very first black holes in the Universe.

All of these topics and more made for an extremely stimulating and productive HEAD meeting in April. Over 260 people attended this four day meeting. Highlights included the very first HEAD Mid-Career Prize talk by Prof. Sebastian Heinz, and the HEAD Dissertation Prize talk by Dr. Ashley King. We also had the pleasure of awarding Dr. Phil Plait the David Schramm Award for High-Energy Astrophysics Science Journalism for his article on "A Supermassive Black Hole's Fiery and Furious Wind", which appeared on slate.com. As announced during the HEAD business meeting at the 227^{th} AAS meeting in Kissimee, Fl, in January, the 2016 Bruno Rossi Prize has been awarded to Prof. Niel Brandt for his work on the nature of the sources in the deepest X-ray fields ever obtained by *CHANDRA*. Prof. Brandt will give his Rossi Prize Lecture at the 229^{th} AAS meeting in Grapevine, Texas this coming January. Also announced at the Kissimee meeting were the results of the HEAD election: in addition to my replacing Nick White as HEAD Chair, Rob Petre was elected Vice Chair, Mike Corcoran was elected Secretary (replacing Randall Smith) and Keith Arnaud was re-elected as Treasurer. New Executive Committee members are Niel Brandt and Laura Lopez. Nick White assumes the role of Past Chair, replacing Joel Bregman. We'd like to thank Joel, Randall, and past committee members Daryl Haggard and Henric Krawczynski for their much-appreciated service.

High-Energy Astrophysics continues to be a fast moving and exciting field, both in space and on the ground, with LISA Pathfinder in orbit already, the launch of NICER less than a year away, and not one but two X-ray polarimeters under study. Let's continue to push the high-energy frontiers at an ever increasing pace!

HEAD in the News

MEGAN WATZKE (CXC)

On February 11, 2016, a (literally) earth-shaking scientific discovery was announced: the detection of gravitational waves by the LIGO Collaboration. The announcement of this discovery was made in a press conference sponsored by the National Science Foundation and held at the National Press Club in Washington, D.C. This story was picked up by countless media outlets: the strain felt round the world. The excitement of the LIGO discovery and the search for electromagnetic counterparts quickly spread to other high-energy missions. Opportunities to combine gamma-ray data from *Fermi*, X-ray data from *CHANDRA*, and other space– and ground–based observatories, will be the focus of major scientific activity for years to come.

Major news for the high-energy community was the successful launch and then tragic loss of the *ASTRO-H* mission (renamed *Hitomi* after launch). There were many positive stories about the successful launch and initial operations, followed by continuing coverage of what might have happened.

Exciting discoveries continue to be made across the portfolio of high-energy missions. Some highlights over the past six months:

- "Destroyed Star Rains onto Black Hole, Winds Blow it Back" (October 21, 2015);
- "Black Hole Has Major Flare" (October 27, 2015);
- "NASA's Fermi Satellite Kicks Off a Blazar-detecting Bonaza" (December 15, 2015);
- "Chandra Finds Remarkable Galactic Ribbon Unfurled" (December 21, 2015);
- "Andromeda Galaxy Scanned with High-Energy X-ray Vision" (January 5,2016);
- "A Milky Way Twin Swept by an Ultra-Fast Wind" (January 14, 2016);
- "Integral X-rays Earth's Aurora" (January 26, 2016);
- "Glow from the Big Bang Allows Discovery of Distant Black Hole Jet" (February 16, 2016);
- "Found: Andromeda's First Spinning Neutron Star" (March 31, 2016); and
- "NASA Celebrates 25 Years of Breakthrough Gamma-ray Science" (April 7, 2016).

As always, weekly highlights of high-energy astrophysics science are featured at the High Energy Astrophysics Picture of the Week.

Gravitational Waves

Norna Robertson (Caltech), James Ira Thorpe (GSFC), David Shoemaker (MIT), Guido Mueller (UFL)

As reported in the previous newsletter, Advanced LIGO started its first observing run in September 2015. On September 14th 2015 at 09:50:45 UTC, the two LIGO detectors, LIGO Hanford and LIGO Livingston, observed a transient gravitational-wave signal increasing in frequency from 35 Hz to 250 Hz with a peak gravitational-wave strain of 1.0×10^{-21}. The signal matched the waveform predicted by general relativity of the inspiral and merger of a pair of black holes. Analysis of the LIGO signals indicated the merger of a pair of black holes having surprisingly large masses of 36 and $29 M_{\odot}$, at a distance of 1.3 billion light years, forming a final black hole of mass $62 M_{\odot}$, and releasing 5.4×10^{54} ergs as gravitational radiation. This momentous discovery was reported (and celebrated) in several press conferences on February 11. This marks the first direct detection of gravitational waves, and the first observation of a binary black hole merger. It also heralds the beginning of the era of gravitational wave astronomy. The first observing run of Advanced LIGO lasted for four months, finishing on January 12, 2016. Currently, data from the whole run are being analyzed, while in parallel work is going on at the two observatories to improve the detectors' sensitivities before resuming observations in late 2016.

Another major event for the gravitational wave community was the successful launch of the LISA Pathfinder mission on December 3rd, 2015 from Kourou, French Guiana aboard a VEGA rocket. The spacecraft reached its operational orbit around the Earth–Sun L1 point in late 2015 and began an instrument commissioning phase. LPF's twin gold-platinum test masses were released from their caging mechanisms on February 15th and 16th, a major milestone for the mission that coincidentally came just days after LIGO's historic announcement. The commissioning of the LISA Technology Package (LTP), the European-provided primary science instrument, was completed on schedule allowing science operations to begin on March 1, 2016. LTP science operations consist of a mixture of quiescent runs to measure overall system noise performance, interspersed with signal injections to measure various coupling and calibration factors. The science team has been working seven days a week to analyze and interpret these experiments so that the activities during the remaining phases of the mission can be optimally planned. Initial indications are that the instrument is performing beautifully, with all systems meeting requirements and performance consistent with pre-flight estimates. The LTP science team is working to produce an interim result to be published prior to the end of LTP operations. Baseline LTP operations will conclude in late June 2016, after which the NASA-provided Disturbance

Reduction System (DRS) payload will undergo its commissioning and begin a 90-day operations phase focusing on thruster and control-system performance. Discussions are underway in the US and Europe for an extended mission that would perform further LISA-related investigations as well as other possible science opportunities.

Following the 2013 selection of the Gravitational Universe science theme for ESA's L3 mission, ESA appointed the Gravitational Observatory Advisory Team (GOAT) and invited NASA and JAXA to participate. The GOAT was tasked to identify the best technology as well as evaluate the technical readiness for a space-based gravitational wave observatory following an ESA-provided schedule which assumed mission adoption in 2025 and a launch in 2034. The GOAT surveyed the scientific literature for proposed technologies to measure gravitational waves in the mHz frequency band and identified two technologies, laser interferometry and atom interferometry, as the only promising technologies for the foreseeable future. The GOAT studied both approaches and concluded that laser interferometry, based on the LISA concept, is the most mature technology for L3 and will meet the scientific goals of the L3 mission. The GOAT also reevaluated the scientific capabilities of LISA-like missions as a function of the number of laser links, the arm length and mission duration. The committee concluded that a 6-link mission with three identical spacecraft (six identical payloads) of longer duration ($\sim$5 years) with at least intermediate arm length ($\geq$2.5 Gm) provides a much greater impact. The GOAT also studied the technical readiness of all critical parts of the payload of a LISA-like mission and recommended several technologies for immediate development. The selection was motivated by the goal of finalizing the mission architecture and to study manufacturing issues of long lead items such as the six optical benches as early as possible. Following the announcement of the first LIGO detection and the success of the LISA Pathfinder and after submission of the final report, the GOAT was also asked to develop its own schedule independent of programmatic restrictions. The committee concluded that a launch in the Spring of 2029 with mission adoption in the Fall of 2020 is realistic based solely on the current status of the technology and the maturity of already existing mission designs. This schedule would mirror in many ways the GAIA schedule but is not as aggressive as the TEAM-X schedule developed during an earlier NASA study. The final report is available at GOAT's home page.

NASA has appointed a Study Team for participation in the ESA's L3 mission for a space-based gravitational wave observatory. This study is motivated by the recommendation for a NASA-led new start of LISA in New Worlds, New Horizons in Astronomy and Astrophysics (the 2010 decadal survey), and by NASA's decision, described in the Astrophysics Implementation Plan, to participate as a minority partner in an ESA-led gravitational wave astrophysics mission. This study, which was endorsed by the NASA Advisory Committee's Astrophysics Subcommittee in the fall of 2015, will draw on the extensive study of LISA and other gravitational wave mission concepts, to understand how NASA might participate as a minority partner in ESA's L3 mission. A robust team of US astrophysicists, astronomers, and technologists has been appointed to the L3 Study Team (L3ST). The first in-person meeting of this team was held on April 19-20 in Salt Lake City. The team looks forward to working closely with ESA-appointed groups and with NASA leadership to determine elements that the US can contribute, and modes of collaboration to the ESA L3 mission, with the overarching goal of realizing a superb L3 gravitational-wave mission.

Last but not least, the gravitational-wave community would like to recognize the contributions of one its principal members as he prepares to retire from public service. Fifteen years ago, Robin 'Tuck' Stebbins moved from his beloved mountains in Boulder, Colorado, to suburban Washington, DC to become the project scientist for the Laser Interferometer Space Antenna (LISA) at Goddard Space Flight Center. Guiding LISA through Pre-phase A into Phase A before its programmatically-driven cancellation in 2011, Tuck experienced the ups and downs of the space business like no one in our community before. This was certainly not what he hoped for. Still, Tuck steered us through the stormy waters of NASA politics, often pounding the doors at GSFC and NASA HQ to make sure that some form of a LISA team continued to exist to keep our dream alive. Now, following the LIGO detection and the success of the LISA Pathfinder, Tuck is retiring at a time when his successors should have a much easier way forward. We all owe Tuck a big thank you for guiding us through these often challenging times and putting us on a path which will hopefully soon result in the launch of a LISA-like mission. Thank you from all of us and may the bears, bisons, and elks in the Northwestern mountains maintain just the right distance from you that you can enjoy them.

Robin 'Tuck' Stebbins, off to the mountains.

CHANDRA

Roger Brissenden (SAO) and Martin C. Weisskopf (MSFC)

CHANDRA has carried out more than 16 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 with only minor incremental changes in performance, due primarily to the gradual accumulation of molecular contamination on the UV filter that protects the ACIS detector, and to slow degradation of the spacecraft's thermal insulation. Condensation on the filter reduces ACIS's sensitivity to low-energy X-rays (but does not affect the HRC). The *CHANDRA* Project Science group at NASA, together with the CXC, continues to consider the possibility of baking out the ACIS filter to remove this condensed contamination. The teams are working to fully understand the consequences of a bakeout and to define any ground-based experiments that would inform a decision. The decline in insulation effectiveness requires extra effort in scheduling observations and the use of special strategies to ensure continued safe operation in the evolving thermal environment, but has not significantly affected *CHANDRA*'s observing efficiency. Science data processing, archiving, and distribution are also proceeding smoothly, with average time from observation to data delivery to observers remaining at about a day.

CHANDRA observations of the "Jaws" SNR G1.9+0.3, which helped identify the trigger of a Type Ia supernova as a double-degenerate merger (NASA/CXC/CfA/S.Chakraborti et al.).

As part of NASA's biennial Senior Review of operating missions, *CHANDRA* X-ray Center (CXC) and Marshall Space Flight Center program staff submitted the *CHANDRA* Senior Review proposal in January 2016, and the NASA review committee held a site visit at the CXC in March 2016.

In December 2015, the CXC issued a call for proposals for Cycle 18 observations, with a deadline for proposals in March 2016. Scientists worldwide submitted 550 proposals (including archive and theory research), requesting 4.8$\times$ the available observing time. The peer review of Cycle 18 proposals will be held in June 2016. The call for proposals for Einstein fellowships attracted 163 applications for 2016. The Einstein peer review, held in January, selected 13 Fellows, who will begin their three-year terms in Fall of 2016.

The Chandra Press Office has been active in issuing image releases, science press releases and other communications of Chandra research results. More information about the Chandra Observatory and the Chandra X-ray Center can be found at Chandra X-ray Center web page.

XMM-Newton

Lynn Valencic (JHU & GSFC)

Successful submissions from the Fifteenth Call for Proposals for *XMM–Newton* were announced in December 2015, and observations will begin in May. The Sixteenth Call for Proposals will open August 23, and the final date to submit proposals will be October 7. The SOC is hosting a workshop May 9 – 11, 2016, at ESAC in Madrid, Spain, "XMM-Newton: The Next Decade". This workshop will summarize our current knowledge of astrophysics derived from X-ray observations, and identify a set of fundamental questions that still need to be addressed. A main goal of this workshop is to define the key topics which will have the highest scientific importance and to identify observing programs of the highest long-term value to the scientific community.

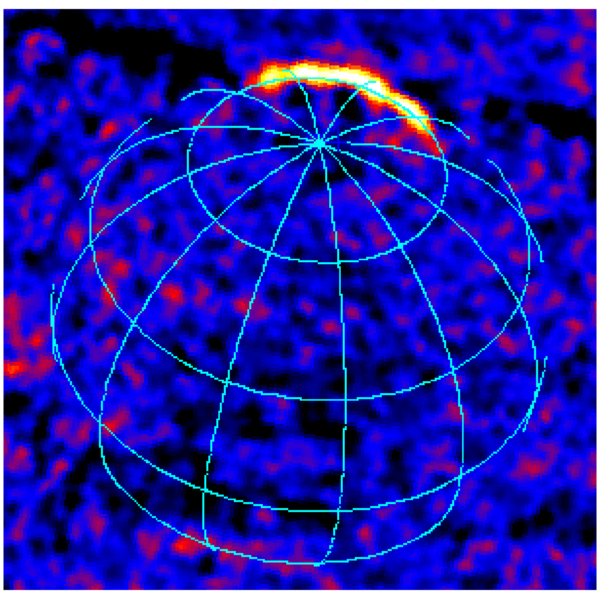
INTEGRAL

Erik Kuulkers (ESA/ESTEC) and Steve Sturner (CRESST & GSFC)

Last year, *INTEGRAL* operations were indicatively approved through December 31, 2018, subject to a mid-term review and confirmation in the fall of this year. In addition, approval for extended operations for 2019 and 2020 will then be requested. Meeting #18 of the *INTEGRAL* User Group occurred on March 9–10, 2016 at ESTEC, The Netherlands. The main focus of this meeting was the science case for the operations extension. It was recognized that *INTEGRAL*'s Target of Opportunity capabilities should be maximized within the current working frame. D. Götz, A. Malizia & D. Torres will replace T. Bird, L. Hanlon & D. Hartmann in the IUG beginning

July 2016. Two mission scientists have accepted the extension of their membership (N. Gehrels & W. Hermsen). F. Lebrun retired the end of December 2015; P. Laurent has taken over the French IBIS co-PI responsibility.

The 14th Announcement of Opportunity (AO-14) was released on February 29, 2016. Prior to the April 8, 2016 deadline, 57 proposals were received (31 normal, asking for data rights on 359 sources, and 26 ToO). The total time requested is ≃115 Msec (for all types of observation; only 10% of the total requested ToO time has been taken into account). Given that up to approximately 21 Msec of observing time will be available in AO-14 (January 1 – December 31 2017), this corresponds to an oversubscription of about 5.5 (i.e., an increase with respect to the previous AO). The *INTEGRAL* TAC meeting will be May 17–19, 2016. New in AO-14, ESA provided the opportunity to propose for coordinated observations with NASA's *NuSTAR* telescope. The opportunity for coordinated observations with *XMM–Newton* and/or NASA's *Swift* satellite continued as before. In total, 12 proposals requested time with *NuSTAR*, *Swift*, and/or *XMM–Newton*. Note that through an agreement with ESA, NASA's *Fermi* project offers the possibility to obtain observing time with *INTEGRAL* through a single proposal to NASA via the *Fermi* AO (one ToO proposal was received as part of the *Fermi-INTEGRAL* Joint Program Agreement, during the call for *Fermi* Cycle-9 Guest Investigator proposals by 22 January 2016).



Hard X-ray (17–60 keV) image taken by IBIS/ISGRI instrument on 10 November 2015. The image shows the intense auroral emission visible on the opposite side of the pole above Canada. The Earth's position is shown by its coordinate grid. Credits: E. Churazov (IKI/MPA)/ M. Türler (ISDC/Univ. of Geneva).

The spacecraft, payload and ground segment have been generally performing nominally. However, due to a malfunction, the integration of histograms in the IBIS/PICsIT layer was interrupted between December 14, 2015 and January 14, 2016. At the end of January the thruster tranquilisation phase post reaction wheel momentum off-loading was suppressed; this has reduced propellant usage very significantly, roughly by a factor 2 at present. On March 26, 2016, a single event upset (SEU) occurred on Payload Module Power Distribution Unit B (PPDU-B) leading to switch-off of all instruments and changed heater configuration. The payload module was, however, back the same day in a thermally stable configuration. First SPI (March 27), then IBIS (March 29), and finally JEM-X and OMC (March 30) were successfully recovered and taking science data again. Routine annealing #26 of the SPI detectors, took place March 3–18, 2016, with a relatively short annealing time to reduce lithium drift risk. The operations were successful, but the energy resolution recovery was less pronounced (∼6% improvement instead of 12% in last annealing) due to the shorter duration.

When *INTEGRAL* changed its orbit in January/February 2015, its new orbit information was not updated everywhere. At the end of November 2015, J. McDowell (Harvard-Smithsonian Center for Astrophysics) tweeted that asteroid-observing astronomers had been tracking an unidentified object, WJ2B5AC, with a 3831 min period. It had been found by the Catalina Sky Survey, while looking for asteroids; it was checked against known satellites using the two-line element sets (TLEs), but no match was found. And thus *INTEGRAL* became, temporarily, a candidate space rock.

Scientific observations of the AO-12 cycle in 2015 and AO-13 cycle in 2016 were performed mostly as planned. During the Earth-occultation observations on 10 November 2015 (EO 4.1), with the goal to measure the diffuse cosmic X-ray background (CXB), INTEGRAL detected high-energy auroral X-rays from Earth (as shown in the image above). The question remains if there is a part of this data not affected by the aurora flares that can be used for studying the Cosmic X-ray Background. It was a featured public relations (PR) story, including a movie, on the ESA Web portal on January 26, 2016. Further analysis is on-going. The planning for another such an observation (EO 4.2) on May 11/12, 2016 is in progress. On November 15, 2015, cross-calibration observations of Cyg X-1 were carried out with the Indian high-energy satellite observatory *AstroSat*. Two out-of-TAC ToO observations were performed. Bright TeV gamma-ray flares observed by the First G-APD Cherenkov Telescope (FACT) triggered a ToO on the blazar Mrk 421, to provide simultaneous data in the optical/UV, X-ray, GeV- and very-high gamma-ray bands (December 18–20, 2015). Unexpectedly, the black-hole binary X-ray transient V404 Cyg (GS 2023+338) re-emerged from quiescence again, only 4 months after the end of its previous activity. This triggered a public ToO on the source, in 4 consecutive revolutions, from December 26, 2015 to January 4, 2016 (despite the holiday period and sparse manpower!). The activity as seen by *INTEGRAL* was weaker (peaks at $\simeq$15 Crab) than that seen in June/July 2015. As in the previous period of activity, the ISDC provided ready-to-use scientific data products of these publicly available observations. During the reporting period, four Gamma-Ray Bursts (GRBs) were detected in the fields of view of the high-energy instruments (GRB 151120A, GRB 160221A, GRB 160223B and GRB 160401A).

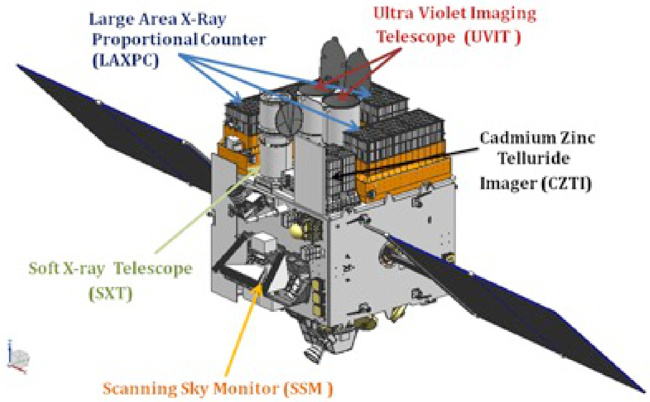
AstroSat

Kulinder Pal Singh (TIFR, Mumbai), S. Seetha (ISRO Headquarters, Bengaluru) for the AstroSat payload teams

AstroSat, India's first space astronomy observatory for studies of cosmic objects, was launched by the Indian Space Research Organization (ISRO) on September 28, 2015 at 10:00 IST into a circular orbit ~ 650 km above the Earth at an inclination of 6° and orbital period of 98 minutes. *AstroSat* carries five major co-aligned instruments enabling multi-wavelength studies by observing astrophysical sources simultaneously in the limited visible, near-ultraviolet, far-ultraviolet, and in X-rays from 0.3 keV up to 100 keV. This multi-wavelength capability is a powerful tool to measure the spectral energy distribution and time variability of compact sources such as white dwarfs, neutron stars and black holes, including the supermassive black holes at the centers of galaxies. It will also be able to study stars, novae and supernovae of various types.

AstroSat's instruments have been built by a consortium of institutes in India: The Tata Institute for Fundamental Research, (TIFR), Mumbai, the Indian Institute of Astrophysics (IIA), Bengaluru and the Inter-University Center for Astronomy and Astrophysics, (IUCAA), Pune, ISRO Satellite Centre (ISAC) in Bengaluru, Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram, the Canadian Space Agency and the University of Leicester in the UK.

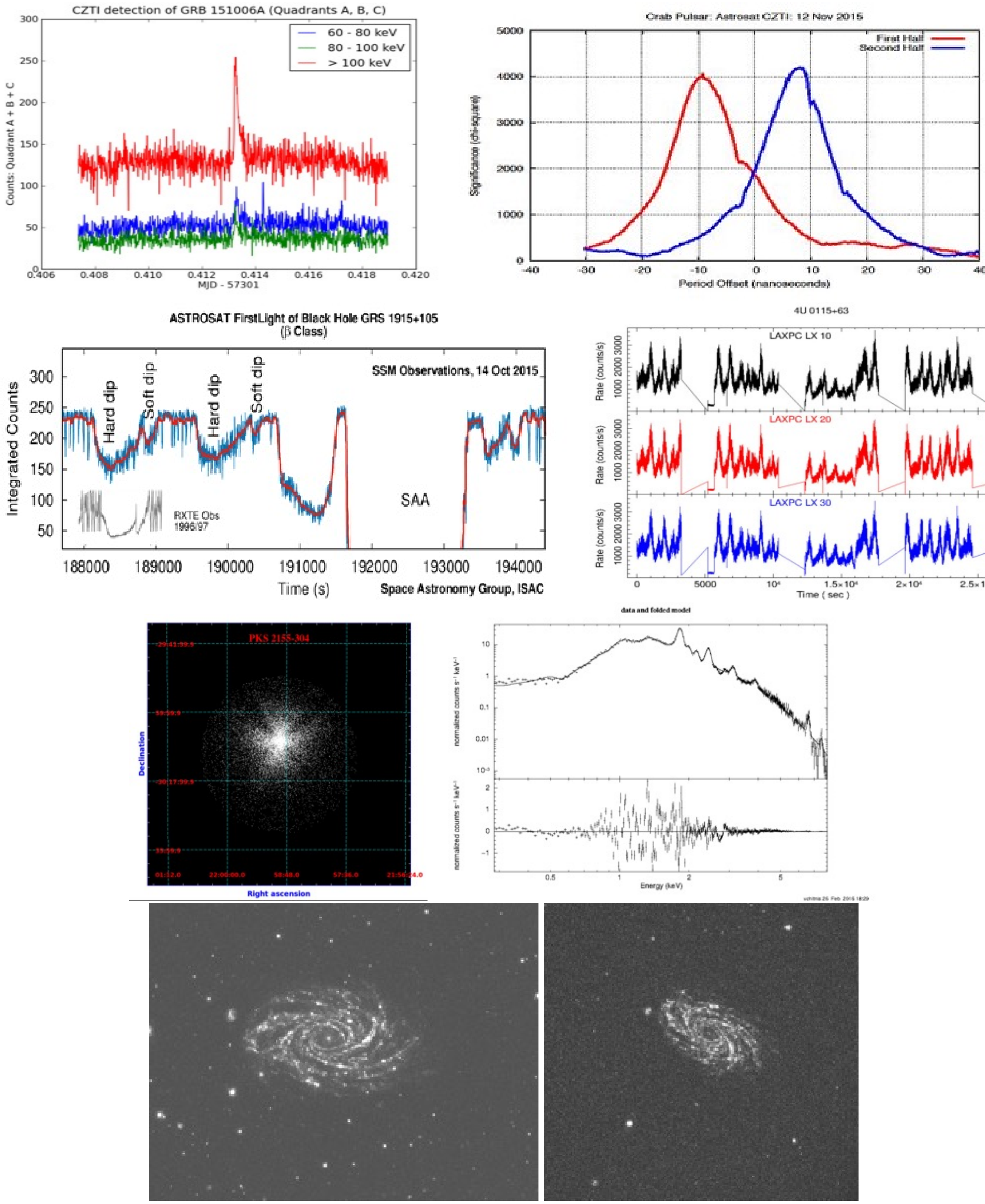
The fully assembled AstroSat spacecraft just before launch.



Schematic of the five co-aligned AstroSat instruments.

A description of the principal instruments onboard *AstroSat*, their specifications and capabilities, is given in Singh et al. (2014), "ASTROSAT mission", Proc. SPIE 9144, Space Telescopes and Instrumentation 2014: Ultraviolet to Gamma Ray. The principal instruments were activated in a pre-defined sequence from October to November 2015. First light observations were obtained with the Charged Particle Monitor (CPM) on October 1, followed by the Cadmium-Zinc Telluride Imager (CZTI) on October 6, Scanning Sky Monitor (SSM) on October 12, three Large Area Xenon Proportional Counters (LAXPCs) on October 19, Soft X-ray imaging Telescope (SXT) on October 26, and the visible and UV telescopes on December 1, 2015. The data are received by a ground station in Bengaluru for $\sim$12 out of $\sim$14 orbits per day, and are analyzed at the Payload Operation Centers of the respective teams set up at IUCAA (Pune), TIFR (Mumbai), and at ISAC and IIA (Bengaluru). These observations show that all the payloads are healthy and working as expected. The calibration and payload verification phase of the satellite lasted until March 31, 2016, and has now entered the guaranteed time phase for the payload teams, that will last for the next six months. An announcement of opportunity (AO) for Indian researchers will be made shortly, with observations starting in October 2016. From April 2017, international observers will be able to write proposals as principal investigators, as 10% of *AstroSat*'s observing time will be available to the international community. The payload PIs (see below) may be contacted for any collaborative studies.

Some of the representative results obtained so far demonstrating the capability of each instrument are shown below. The CZTI has detected hints of X-ray polarization in two GRBs, and has observed the Crab pulsar. The SSM and LAXPC have seen several X-ray binaries and obtained their light curves, power density spectra and energy spectra. The SXT has observed blazars, stars, supernova remnants and clusters of galaxies. The UVIT telescopes are providing NUV and FUV images with $\sim 1.7''$ resolution. In addition, the CPM is providing alerts to the hard X-ray instruments for the South Atlantic Anomaly



A montage of early results from AstroSat. Top row left: CZTI X-ray Light curve of GRB151006A; Top row, right: CZTI detection of spin down in the Crab pulsar; Second row, right: SSM Light curve of GRS 1915+105 exhibiting β class variability; Second row left: LAXPC X-ray light curve of a Transient Binary: 4U0115-63; Third row, left: First light X-ray image of PKS2155-304 taken with the SXT; Third row, right: SXT X-ray Spectrum of Cas A; Bottom row, left: UVIT NUV image of NGC 2336; Bottom row, right: UVIT FUV image of NGC 2336. These figures have been provided by the payload teams headed by A.R. Rao (CZTI and CPM), M. C. Ramadevi (SSM), J. S. Yadav (LAXPC), K. P. Singh (SXT), and S. N. Tandon (UVIT).

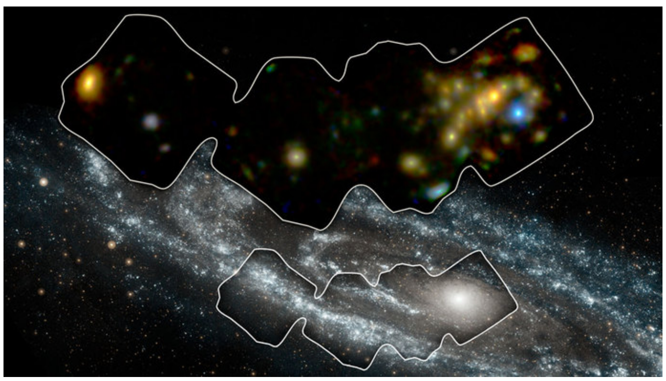
(SAA) and its data have also been used to create a model of the SAA and for screening of data.

More information on *AstroSat* is available from the IUCAA *AstroSat* web page, the ISRO *AstroSat* mission web page, and the *AstroSat* gallery.

NuSTAR

Daniel Stern (JPL), Fiona Harrison (Caltech)

The *NuSTAR* mission continues to operate nominally on orbit. Recent highlights include the acceptance of the 200th refereed paper reporting on *NuSTAR* results, and the public release of accepted targets from *NuSTAR* Cycle 2. As of this writing, 99.3% of approved Cycle 1 *NuSTAR* observations have been completed, which includes all non-ToO category A and B observations and most of the category C observations. *NuSTAR* Cycle 2 observations begin on May 3, 2016, and *NuSTAR* joint observations from *XMM–Newton* Cycle 15 will begin on April 28.



NuSTAR map of a portion of the Andromeda galaxy, which was released at the 227^{th} AAS meeting. NuSTAR has detected 40 X-ray binaries in M31, including several Z-type sources (Maccarone et al., 2016).

The dates have been set for the first public *NuSTAR* Science Meeting, which will be November 15–17, 2016 at the California Institute of Technology, in Pasadena, CA. We welcome the community, in particular Cycle 1 and Cycle 2 Guest Observers, to come to the meeting and discuss their results. For more details and registration, see the *NuSTAR* home page.

During the next Cycle, 25% of observing time is reserved for Legacy programs, which are meant to be large, community-driven programs beyond the scale of individual GO programs and which will take advantage of *NuSTAR*'s unique hard X-ray sensitivity. Current ideas range from tiling a wider area extragalactic field than has been done to date, to extending the Galactic Plane Survey, to observing complete flux-limited samples of certain source classes. We are soliciting additional ideas from the community. Ideas can be submitted to the *NuSTAR* Principal Investigator (PI) and Project Scientist. Legacy programs will be planned and executed by the *NuSTAR* Science Team (e.g., determining optimal tiling for large fields, with consideration of observing windows and scattered light issues), and data will be made publicly available immediately after quality assurance review. During the April HEAD meeting in Naples, Florida, the *NuSTAR* project held a Town Hall session dedicated to discussing previous Legacy programs, followed by an open discussion of potential future programs.

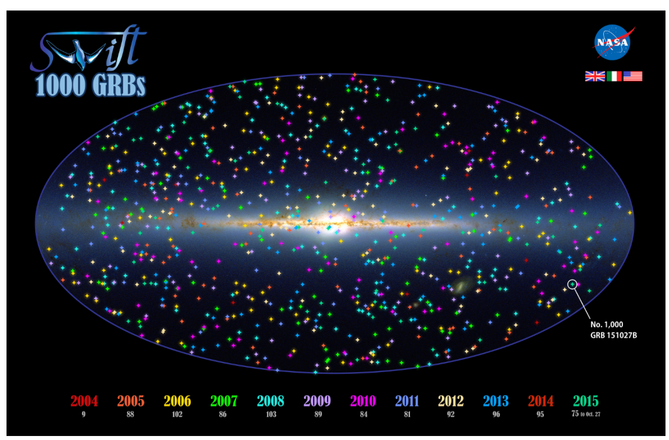
We would like to congratulate the *NuSTAR* PI, Dr. Fiona Harrison, who was awarded the 2015 Bruno Rossi Prize at the AAS meeting, for her "groundbreaking work on supernova remnants, neutron stars, and black holes enabled by *NuSTAR*".

Swift

Eleonora Troja (GSFC), Lynn Cominsky (Sonoma State) and Neil Gehrels (GSFC)

The *Swift* mission continues to operate flawlessly. A proposal to extend *Swift*'s operations and guest observer program was submitted to the 2016 Senior Review and a presentation made to the panel. The mission continues to support 4 Target of Opportunity requests per day in addition to observing gamma-ray bursts (GRBs) and Guest Investigator targets.

Shortly before 6:41 p.m. EDT on Oct. 27, 2015, the Swift's Burst Alert Telescope detected its 1,000th GRB as a sudden pulse of gamma rays arising from a location toward the constellation Eridanus. Astronomers dubbed the event GRB 151027B, after the detection date and the fact that it was the second burst of the day. Swift automatically determined its location, broadcast the position to astronomers around the world, and turned to investigate the source with its own sensitive X-ray, ultraviolet and optical telescopes. Additional observations from ground-based telescopes showed that the burst happened at a redshift z=4.063, placing it in the most distant few percent of GRBs that Swift has recorded.



Positions of the first 1,000 Swift GRBs on an all-sky map ofthe Milky Way. Bursts are color coded by year, and the location of GRB 151027B is shown at lower right. An annual tally of the number of bursts Swift has detected appears below the label for each year.

The *Swift* Guest Investigator (GI) program will continue to solicit proposals in GRB and non-GRB research during Cycle 13. NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2016 and the Swift Appendix were released on February 19, 2016. The deadline for submitting Swift Cycle 13 GI Program proposals is September 23 at 4:30 PM EST. Please visit the *Swift* Proposals web page for more details.

Dr. Lynn Cominsky gave a talk at the *Swift* meeting at Clemson University in October 2015 summarizing the impacts of sixteen years of education with *Swift*. Beginning in 2016, NASA is funding new, integrated teams to do education programming, and missions will support communications and outreach. Since 1999, *Swift* education programs have provided informal materials to over 20,000 students and teachers; provided informal multimedia experiences to more than ten million people through websites, news programs, International Year of Astronomy exhibits and more; trained more than 20,000 teachers to use formal materials through hour-long evaluated workshops conducted by master teachers known as Educator Ambassadors; trained 50 teachers through "NASA's Multiwavelength Universe", a month-long course for academic credit; provided formal educational materials to more than 100,000 teachers via web downloads; and involved more than a thousand students in authentic STEM research through visible light observations with the Global Telescope network of robotic telescopes. *Swift* will continue to be represented through Sonoma State's participation in the new comprehensive Astrophysics-division education program, "NASA's Universe of Learning", led by STScI. Using robotic telescopes to chase GRB afterglows will be one of the projects to continue through this new program.

The Fermi Gamma-ray Space Telescope

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

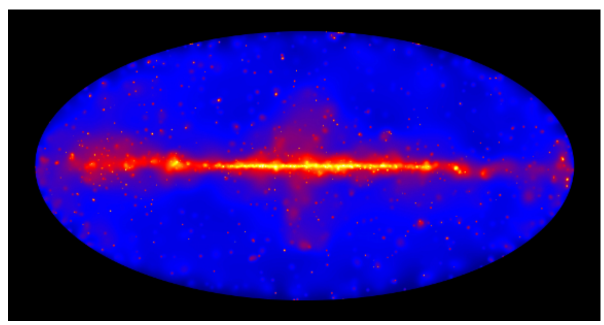
The *Fermi* Gamma-ray Space Telescope continues to operate nominally. The Large Area Telescope (LAT) Pass 8 data, which provide substantial improvements on the entire database back to the beginning of the mission, are available for use, including updated software and documentation, through the *Fermi* Science Support Center. A new search pipeline for untriggered GBM short gamma-ray bursts is now running. The results can be found at the NSSTC's Gamma-Ray Astrophysics web page.

Fermi has produced a number of important science results in the last six months. The *Fermi* LAT identified PSR J0540−6919 in the Large Magellanic Cloud, the first known extragalactic gamma-ray pulsar. *Fermi* observations of the Blazar PG 1553+113 shows hints of periodic emission. Three cycles of a ∼2-year period seen in the LAT data are also suggested by radio and optical observations of this active galactic nucleus.

Another blazar seen by the *Fermi* LAT, PKS 1441+25, triggered observations by ground-based TeV telescopes VERITAS and MAGIC, producing a detection of one of the two most distant objects visible at very high energies. At a redshift of 0.94, intergalactic absorption by photon-photon pair production tends to make such distant sources fade away at energies above the *Fermi* range.

One of the most enticing results obtained by *Fermi* was the observation by the Gamma-ray Burst Monitor (GBM) of a faint signal just 0.4 seconds after the LIGO gravitational wave event of September 15, 2015. Interestingly, the (poorly-determined) position of this Gamma-ray source is also consistent with the (poorly-determined) localization of the LIGO gravitational wave source. Although the probability this was a chance coincidence is non-negligible (0.0022), this result emphasized the opportunity offered by the huge field of view of the GBM to detect future counterparts of gravitational wave signals.

A total of 185 Guest Investigator Proposals were received in response to the *Fermi* Cycle-9 solicitation. The proposals have now undergone peer review evaluation. The final selection process, to be made by NASA HQ on the basis the peer evaluations, are forthcoming pending clarification of the *Fermi* mission budget following the 2016 Senior Review of Operating Missions. It is anticipated that approximately 40 guest investigations will be supported.



The Fermi Large Area Telescope all-sky map at energies above 50 GeV.

The *Fermi* program has continued its strong tradition of public education and outreach. In November 2015, Dr. Lynn Cominsky gave a talk at the Sixth International *Fermi* Science Symposium in Arlington, summarizing the impacts of fourteen years of education with *Fermi*. As noted above, beginning in 2016, NASA is funding new, integrated teams to do education programming, and missions will support communications and outreach. Since 2001, *Fermi* education programs have provided informal materials to over 50,000 students and teachers; provided informal multimedia experiences to more than one million people through websites, planetarium programs, International Year of Astronomy exhibits and more; trained more than 37,000 teachers to use formal materials through hour-long evaluated workshops conducted by master teachers known as Educator Ambassadors; trained 50 teachers through "NASA's

Multi-wavelength Universe", a month-long course for academic credit; provided formal educational materials to more than 100,000 teachers via web downloads; and involved more than a thousand students in authentic STEM research through visible light observations with the Global Telescope network of robotic telescopes, providing more than 4000 calibrated photometric measurements of about 30 active galaxies. *Fermi* will continue to be represented through Sonoma State's participation in the new comprehensive Astrophysics-division education program, "NASA's Universe of Learning", led by STScI. Using robotic telescopes to monitor active galaxies, and supporting pre-service teacher learning will be projects that include *Fermi* content in this new program. Other *Fermi*-education events included Cominsky's talk at the IAU General Assembly meeting to promote the *Fermi*-funded "Big Ideas in Cosmology" curriculum for college students. This curriculum is now being adopted by college instructors nationwide.

The X-ray Science Interest Group

Mark Bautz (MIT)

The X-ray Science Interest Group (XRSIG) has been busy this year. We met in conjunction with the winter AAS meeting in January, and heard updates on the *NICER*, *ASTRO-H*, and *Athena* missions, thanks to Ron Remillard, Rob Petre, and Randall Smith, respectively. Doug Swartz then gave us an overview of the X-ray Surveyor Mission Study process. Led by XRSIG co-chair Ralph Kraft, we also discussed whether and how NASA should consider preparing and presenting so-called probe-class missions (total mission cost ~$1B) to the 2020 Decadal Survey. The latter topic was also addressed by NASA Astrophysics Division Director Paul Hertz at a joint NASA Astrophysics Program Analysis Group (PAG) meeting shortly after our XRSIG meeting. Although the XRSIG and the PAGs expressed strong interest in probes, there was little consensus on the best method of presenting them to the 2020 Decadal Survey.

Accordingly, in mid-January Paul Hertz directed the PAG Executive Committees to make recommendations on this matter within 60 days. As part of their efforts to solicit community input on the matter, the committees requested brief white papers on probe mission concepts. Despite a response period of only 30 days, the Physics of the Cosmos community, of which XRSIG is a part, submitted 14 distinct white papers, many of which described X-ray and Gamma-ray mission concepts. This vigorous response featured prominently in the committee's report to the Astrophysics Subcommittee of the NASA Advisory Committee in March.

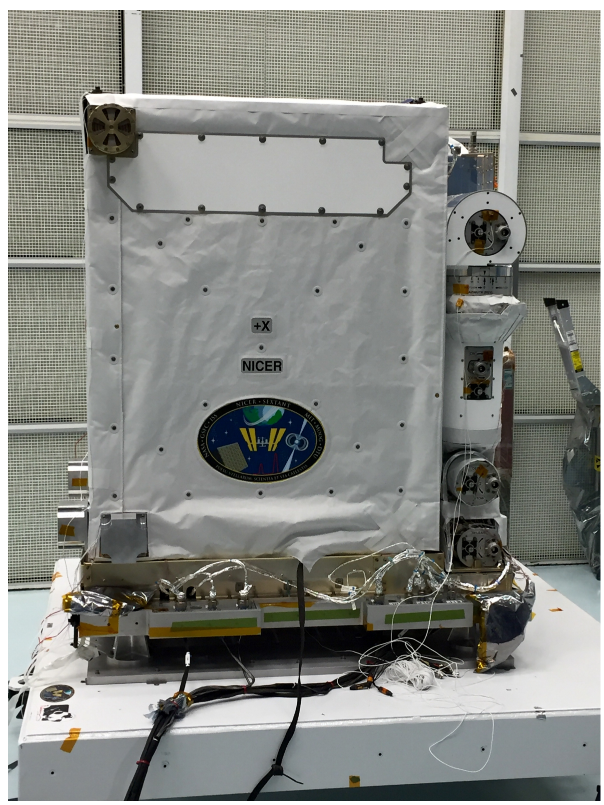
The XRSIG held a second face-to-face meeting during the 15th Divisional meeting of the HEAD in early April. We heard and discussed a stimulating report from Mark Schattenburg summarizing a recent X-ray optics workshop. The workshop aimed to identify technology development needs for, and paths towards, the high-resolution, large-area lightweight optics required for the X-ray Surveyor Mission. We also had a wide-ranging discussion of the goals and methods of the recently constituted X-ray Surveyor Science and Technology Definition Team, led by Jessica Gaskin (X-ray Surveyor Study Scientist) and Alexey Vikhlinin (X-ray Surveyor STDT co-chair). We dutifully discussed the aforementioned report on probe missions as well.

More recently, Ralph Kraft represented the XRSIG at a Physics of the Cosmos mini-symposium at the recent Salt Lake City meeting of the American Physical Society. XRSIG website; the report on probes is available at the Physics of the Cosmos Program Analysis Group (PhysPAG) website.

If you have questions or concerns about the XRSIG or its goings on, please contact Mark Bautz (mwb@space.mit.edu) and/or Ralph Kraft (rkraft@cfa.harvard.edu), and please subscribe to the XRSIG mailing list.

NICER

Keith Gendreau (GSFC), Zaven Arzoumanian (GSFC & USRA)



The Neutron star Interior Composition Explorer payload, sitting atop ground support equipment in a clean-tent at NASA's Goddard Space Flight Center, awaits thermal vacuum testing in its stowed configuration.

The Neutron star Interior Composition Explorer (*NICER*), NASA's next X-ray astrophysics mission, is a 0.2–

12 keV timing spectrometer that will reside for a minimum of 18 months on the International Space Station (ISS) as an external attached payload. Launch on the SpaceX-11 Commercial Resupply Services flight is currently scheduled in February 2017.

The *NICER* payload underwent comprehensive environmental (thermal vacuum, electromagnetic, acoustic, vibration, and range-of-motion) testing during the first three months of 2016, meeting all performance requirements. Final closeouts as well as integration of the optical bench and pointing system onto the ISS interface plate are ongoing; the completed payload will ship to Kennedy Space Center in June. Following testing at an ISS simulator facility, including command and data telemetry from/to *NICER* mission operations at Goddard Space Flight Center, *NICER* will be held in storage until launch.

NICER's scientific objective is to address outstanding questions about neutron stars. To this and other X-ray astrophysics pursuits, *NICER* brings a unique 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* offers peak effective area at 1.5 keV better than 1800 cm^2, with a broadband background countrate expected to be substantially less than 1 count per second. The HEASARC tools WebPIMMS and WebSPEC can be used to predict source countrates and generate simulated *NICER* spectra; release of up-to-date response files based on recent ground calibration of *NICER*'s X-ray Timing Instrument is imminent.

As time allows during its 18-month baseline mission, and on a non-interference basis with *NICER*'s core scientific agenda, the *NICER* team will consider requests from the community for Discretionary Time observations, including time-sensitive targets of opportunity. Such data will be promptly made public through a 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 in the 2018 Senior Review process.

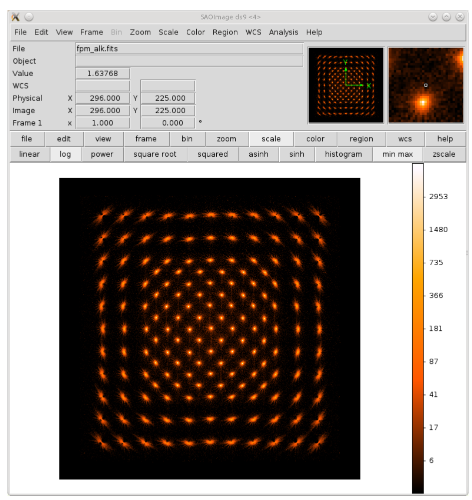
Spectrum Roentgen Gamma/eROSITA

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

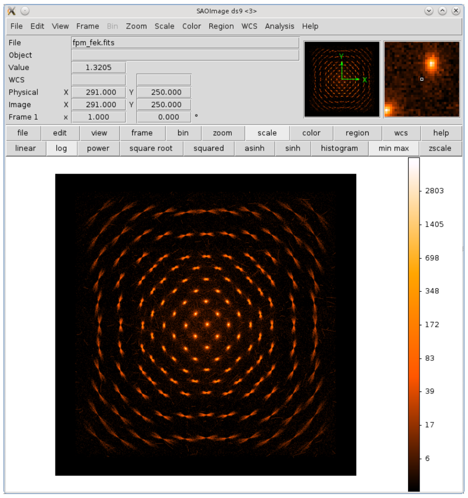
The Spectrum Roentgen Gamma (SRG) spacecraft has been assembled in proto-flight configuration, waiting for the integration of the radio complex flight model (FM), expected in May 2016. The creation of the ground control segment is ongoing, with no delays. The SRG Ground Control Center will be operative in the second quarter of 2017, and a compatibility test with the MPE Ground Control System is scheduled for the beginning of 2017. The launch vehicles are available, and the SRG launch is scheduled for the 25th of September, 2017.

Work is going well with the Qualification Model (QM) and Flight Model of ART-XC. Qualification level mechanical tests of the QM have been successfully completed. Thermo-vacuum tests of the QM are to begin shortly. All FM subsystems for ART-XC are ready. Tests of the disassembled complex of FM subsystems have been successful. Preliminary alignment of the FM mirror systems on the support plate was completed, all 7 mirror systems are co-aligned to within $30''$. Alignment of the focal detector plane with the mirror systems plane is also done. Tests of the 7 FM and 3 spare focal detectors at an X-ray test facility at IKI have demonstrated good correspondence of the measured characteristics with the requirements.

Testing and calibration of eROSITA is ongoing. In the MPE test facilities PANTER and PUMA, calibration of the eROSITA flight model mirror assembly and detectors, respectively, is underway. As of the end of April, mirror assemblies FM1 to FM6 have been tested, calibrated and ready for integration, with FM7 undergoing its calibration.



PSF mapping of the eROSITA Flight Mirror Assembly FM2 at Al-Kα. The data were collected at PANTER during the test and calibration campaign in March 2016. The mirror performance is well within the expectation, with a measured on-axis HEW of 16.3$''$ for Al-Kα.



PSF mapping of the eROSITA Flight Mirror Assembly FM2 at Fe-Kα. The data were collected at PANTER during the test and calibration campaign in March 2016. The mirror performance is well within the expectation, with a measured on-axis HEW 14.7$''$ for Fe-Kα. The much stronger vignetting of the system at higher energies is evident at Fe-K.

Cameras FM1 to FM5 are also ready for integration, with FM6 currently being calibrated in PUMA. Camera calibration tests have also provided very good results, with the energy resolution of the FM1 camera (without an on-chip filter) outperforming expectations ($\sim$ 76eV at 1.5 keV; $\sim$136eV at 6.4keV). Not only is the spectral resolution superb, but the precision to which the absolute energy can be reconstructed for all patterns is outstanding: the deviation is below 1 eV except for Fe-Kα, where it is $\approx$1 eV. Moreover, the detectors also show extremely high level of uniformity in their response, and only weak dependence on temperature of CCD and electronics (unlike XMM-EPIC pn!).

By the end of May, we expect all 7 FM mirrors and cameras to be ready for integration. In parallel, we have started the preparation for the complete telescope integration: each of the seven mirror-camera pairs will be mounted first, thereby precisely adjusting the distance between mirror and camera to the individual focal lengths which has been measured during the mirror calibration. eROSITA's Delivery Acceptance Review (DAR) by DLR will take place between May 24, 2016 (date of the first DAR meeting at MPE) and June 23, 2016 (DAR closure in Bonn). Shipment of the telescope to Moscow will then follow.

Athena: Revealing the Hot and Energetic Universe

KIRPAL NANDRA (MPE), XAVIER BARCONS (CSIC-UC), DIDIER BARRET (IRAP), AND RANDALL SMITH (CFA) FOR THE ATHENA SCIENCE STUDY TEAM

The Athena mission continues to progress, most recently with ESA's Mission Consolidation Review (MCR) in May. MCR occurs after the initial studies by potential spacecraft vendors have been completed, including evaluations of the mass, power, and other resources required. This information will be used to inform a decision on the Athena baseline configuration for follow-up studies (second part of the phase A). Once the MCR is complete, the next step will be to issue an AO for proposals to provide the Athena instruments, likely at the start of Q3/2016, with selections made towards the end of the year. More information about the Athena mission and timeline is available at http://sci.esa.int/cosmic-vision/54517-athena/.

To assist in Athena's development, ESA has appointed a 10 member Athena Science Study Team (ASST) who advise ESA on all scientific aspects of the mission. The ASST in turn has created three Science Working Groups, focusing on the Hot Universe (SWG1), The Energetic Universe (SWG2), and Observatory Science (SWG3). Each WG contains a number of Topical Panels (TPs) that address different scientific areas of interest; see http://www.cosmos.esa.int/web/athena/community-wg for details. The ASST also created a Telescope Working Group (TWG) and a Mission Performance Working Groups (MWG). The latter has topical panels addressing issues such as end-to-end simulations, and inter-calibration. Recently, a call for new members of these working groups was answered by a number of scientists worldwide, increasing the total membership to 818.

Most recently the ASST has been finalizing the Science Requirements Document and the Mock Observing Plan, both of which are needed to inform the engineering requirements on the observatory. The Science Working Groups and Topical Panels have been instrumental in formulating the detailed scientific questions and performing the necessary simulations to inform the Science Requirements exercise. A major forthcoming step will involve defining in more detail the Athena calibration requirements, and developing them into the Athena calibration plan. These again must flow from the science requirements to ensure that all needed ground calibration is completed prior to launch. The ASST has also been advising ESA on the management of the science ground segment. This will be led by a Science Operations Centre at ESA's ESAC facility outside of Madrid, with instrument-specific operational support, science analysis software and calibration efforts performed by the instrument teams.

As recommended by the 2010 Decadal Review's strong support for IXO, NASA has committed between \$100-150M in direct hardware support for Athena. After discussions with the X-ray Integral Field Unit (X-IFU) proto-consortium, it has been agreed that NASA will provide the prime sensor array for the X-IFU, and assist with associated integration, testing, and calibration work. NASA has also agreed to provide important contributions to the Wide Field Imager (WFI), including the primary structure, support for electronics development, and TBD on-board data processing. Finally, NASA and ESA are considering additional NASA contributions, including the use of NASA calibration and test facilities. In addition to these hardware contributions, NASA has also set aside funding for US members of the Athena science team, and is planning a US science data center, and US guest observers funding during operation.

The X-ray Surveyor

JENNIFER GASKIN (MSFC)

As announced during the 227th meeting of the AAS in January, NASA selected four large mission concepts to study for prioritization by the 2020 Astrophysics Decadal Survey. One of these missions is the X-Ray Surveyor. Leading up to the 2020 Decadal, a study will be carried out to define the science case for X-ray Surveyor, provide a technology assessment, a Design Reference Mission, and a cost assessment. The X-Ray Surveyor concept study is led by a Science and Technology Definition Team (STDT) that consists of NASA appointed individuals from across the science community. X-Ray Surveyor STDT Chairs are Feryal Ozel (University of Arizona) and Alexey Vikhlinin (Smithsonian Astrophysical Observatory).

The STDT is supported by a Study Office that is a partnership between Marshall Space Flight Center (MSFC) and the Smithsonian Astrophysical Observatory (SAO). The MSFC Study Scientist is Jessica Gaskin, Deputy Study Scientist is Douglas Swartz, Study Manager is Gregg Gelmis (interim) and Senior Scientist is Martin Weisskopf. SAO Study Office leadership includes Alexey Vikhlinin and Harvey Tananbaum. MSFC and SAO will use allocated resources (both internal and NASA HQ-provided) to support the STDT in developing their design products for submission to the 2020 Decadal committee. Direct oversight of the X-Ray Surveyor at NASA HQ is provided by Daniel Evans (Program Scientist) and additional support is provided by the Physics of the Cosmos Program Office.

The STDT kickoff teleconference was held on March 30th, 2016 with discussions centered on summarizing required study deliverables, Study Office available resources, Astrophysics Roadmap goals and their applicability to the X-Ray Surveyor mission, and the development of Working Groups (consisting of science community members) to help define the science case and technology needs. The first face-to-face STDT meeting is currently being planned for July 25–26th in Boston, MA. Details will be posted in the near-future.

The Study Office is in the process of constructing a webpage which will provide general information on the X-Ray Surveyor concept as it is being developed, inform the community of STDT activities and collect input and questions from the community. For more information about the X-Ray Surveyor and how you can participate, please contact the MSFC Study Scientist Jessica Gaskin (jessica.gaskin@nasa.gov) and/or the Deputy Study Scientist Doug Swartz (doug.swartz@nasa.gov).

Remembering CGRO

NEIL GEHRELS (GSFC)

April 5, 2016 marked the 25th anniversary of the launch of the Compton Gamma Ray Observatory. CGRO was the second of four Great Observatories: Hubble, Compton, Chandra and Spitzer. It was launched aboard the Space Shuttle Atlantis/STS-37 on April 5, 1991. At 17 tons, it was the heaviest scientific payload flown. Two days later, the observatory was set for deployment from the Shuttle bay when the high-gain antenna became stuck. In an unscheduled space walk, astronauts Jay Apt and Jerry Ross were able to pull on the antenna with sufficient force to free it and the observatory was successfully deployed.

The four instruments on CGRO were BATSE (a gamma-ray burst monitor), OSSE (a low energy gamma-ray spectrometer), COMPTEL (a medium energy gamma-ray imager), and EGRET (a high energy gamma-ray imager). Each were pioneering instruments, exploring the gamma-ray sky in their wavelength band with much better sensitivity and coverage than previous experiments. In my view, the top discoveries from each of the instruments were:

- Demonstration of the isotropic sky distribution of gamma-ray bursts, indicating an extragalactic origin (BATSE)
- The map of the 511 keV gamma-ray line from positron antimatter annihilation, showing where energetic processes are occurring at the center of our galaxy (OSSE)
- The map of the 1809 keV gamma-ray line from radioactive ^{26}Al decay showing where supernovae have occurred in the Milky Way over the past million years (COMPEL)
- The discovery of gamma-ray blazars, with powerful beams of gamma rays coming from the central black hole of the galaxy (EGRET)

CGRO was in orbit for 9 years, until June 4, 2000. The observatory suffered a gyro failure and was then commanded for a controlled re-entry into the Pacific Ocean, a decision still debated to this day. The legacy of CGRO is carried on by the *Fermi* and *Swift* missions. These missions were developed specifically to answer the top science questions raised by Compton.

Hitomi

ASTRO-H was launched at 5:45 pm (JST) on February 17, 2016, and, upon reaching orbit, was renamed Hitomi, a Japanese name meaning "pupil of the eye" and "wisdom, *intellect" and "beautiful". It carried aboard a number of advanced instruments, the most highly anticipated of which was the Soft X-ray Spectrometer, a microcalorimeter which provides extremely high-resolution X-ray spectra. In-orbit checkout was proceeding well, and the initial data obtained were called "transformative" by astronomers. On March 26, 2016, Hitomi suffered a series of events which caused a partial break-up of the spacecraft. The following is derived from the April 15, 2016 Status Update by JAXA:*

JAXA previously identified 3 events associated with the spacecraft anomaly: an "attitude anomaly", "objects separation" and a "communication anomaly", which occurred around the in-flight anomaly of *Hitomi* at 16:40 (JST), March 26, 2016. In summary, on March 26th, an attitude maneuver to orient *Hitomi* toward an active galactic nucleus was completed as planned. After the maneuver, an attitude control system (ACS) error caused an incorrect determination that the spacecraft was rotating, although in fact *Hitomi* was not rotating. As a result, the spacecraft's Reaction Wheel was activated to stop the (false) rotation; the activation of the Reaction Wheel led to an actual rotation of the satellite, in a direction opposite to that of the spurious rotation direction. In addition, unloading of angular momentum by the Magnetic Torquer operated by the ACS did not work properly because of the attitude anomaly, and as a result angular momentum kept accumulating in the Reaction Wheel. Believing that the satellite was in a critical situation, the ACS switched to Safe Hold mode, and the thrusters were fired. At this time, the ACS provided an atypical command to the thrusters because of inappropriate thruster control parameters. As a result, it is believed that the thruster firing resulted in an acceleration of the satellite rotation. Since the rotation speed of the satellite exceeded the design limits, the parts of the spacecraft that are vulnerable to rotation, such as the solar array paddles (SAP), the Extensible Optical Bench (EOB), and others, separated from the satellite.

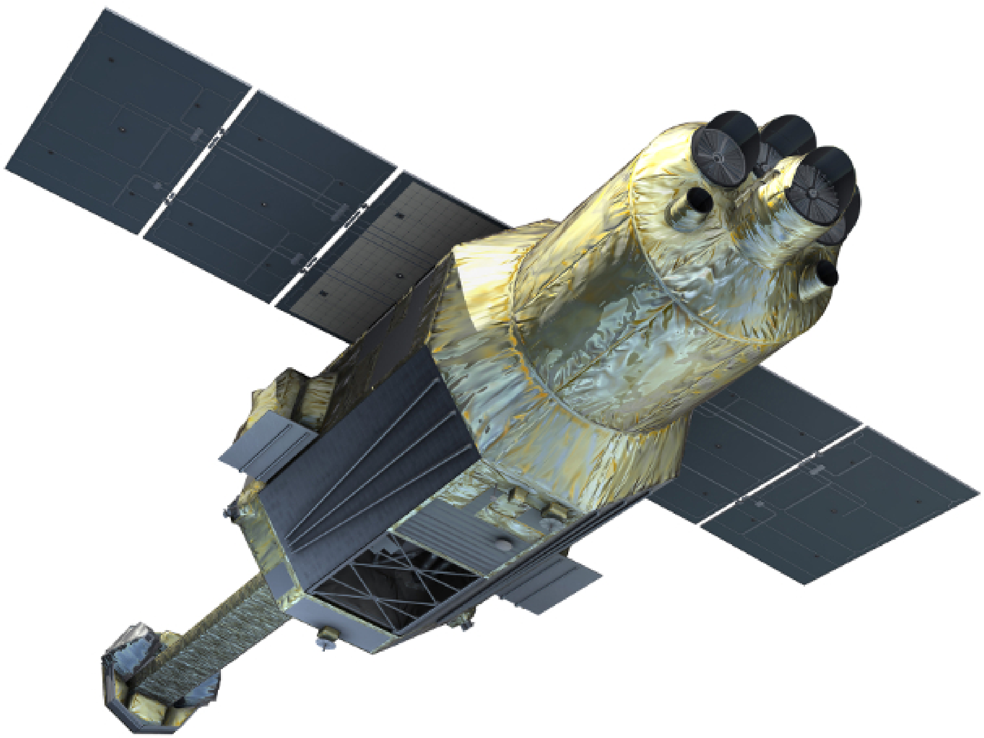
Currently, the main body of the satellite is spinning rapidly around the satellite Z-axis. Some parts of the spacecraft which are vulnerable to rotation have or might still break up and separate from the main body. Battery power is low. Recovery of communication with *Hitomi* is necessary to command battery charging; however, since March 28 there has been no communication with the satellite. Radio signals were received three times from *Hitomi* in the March 26 – 28 interval, but telemetry data were not received.

The Joint Space Operations Center (JSpOC) has released trajectory information on 11 objects that separated from *Hitomi*, including the main body, and predicts that 2 of the 11 objects (ID: 41438 and 41443) started to decrease their altitude compared with the other 9 objects. Re-entry times for these two objects were April 29, 2016 for Object 41443 and May 10th, 2016 for Object 41438.

Update from JAXA, April 28, 2016: JAXA established the emergency headquarters and has been doing its utmost to understand the anomaly of ASTRO-H ("Hitomi"). We have made every effort to confirm the status of ASTRO-H and to regain its functions. Unfortunately, based on our rigorous technical investigation, we had to conclude. On April 28 (JST), JAXA held a press briefing and sent out press releases on ASTRO-H ("Hitomi").

JAXA have determined that we cannot restore the ASTRO-H's functions. Accordingly, JAXA will cease the efforts to restore ASTRO-H and will focus on the investigation of anomaly causes. We will carefully review all phases from design, manufacturing, verification, and operations to identify the causes that may have led to this anomaly including background factors.

JAXA expresses the deepest regret for the fact that we had to discontinue the operations of ASTRO-H and extends our most sincere apologies to everyone who has supported ASTRO-H believing in the excellent results ASTRO-H would bring, to all overseas and domestic partners including NASA, and to all foreign and Japanese astrophysicists who were planning to use the observational results from ASTRO-H for their studies.



Artist rendition of Hitomi on orbit. Courtesy of JAXA