The eROSITA Bulletin

No.6, July 2015

1. Overall project status and milestones

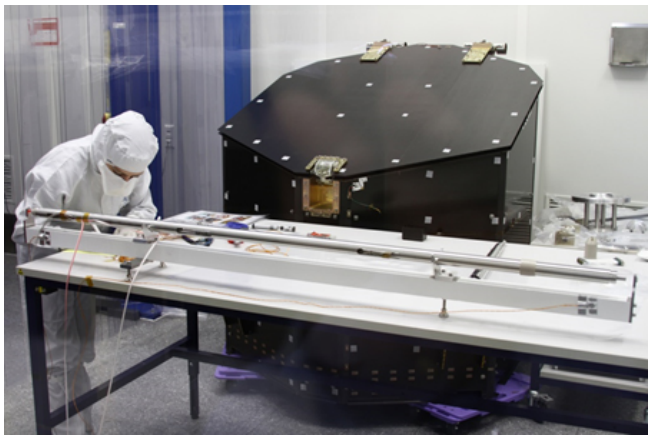
The latest SRG status meeting took place in Moscow on May 12. Despite tangible progress on the development, test and assembly of both scientific payloads, the launch date has now been officially moved to February 2017. The main reason for the delay is the new delivery date of the radio-complex, which is now expected in January 2016, with eROSITA and ART-XC to follow shortly afterwards. The launch of the second meteorological satellite Elektro-L2 with a Zenit/Fregat is now schedule for October 2015, and will constitute a critical test-bench for the SRG launch.

Alexis Finoguenov, currently at Helsinki University, will move to MPE in Summer 2016. He replaces Peter Predehl as the new co-chair of the Clusters and Cosmology Working Group.

2. The eROSITA Flight Module

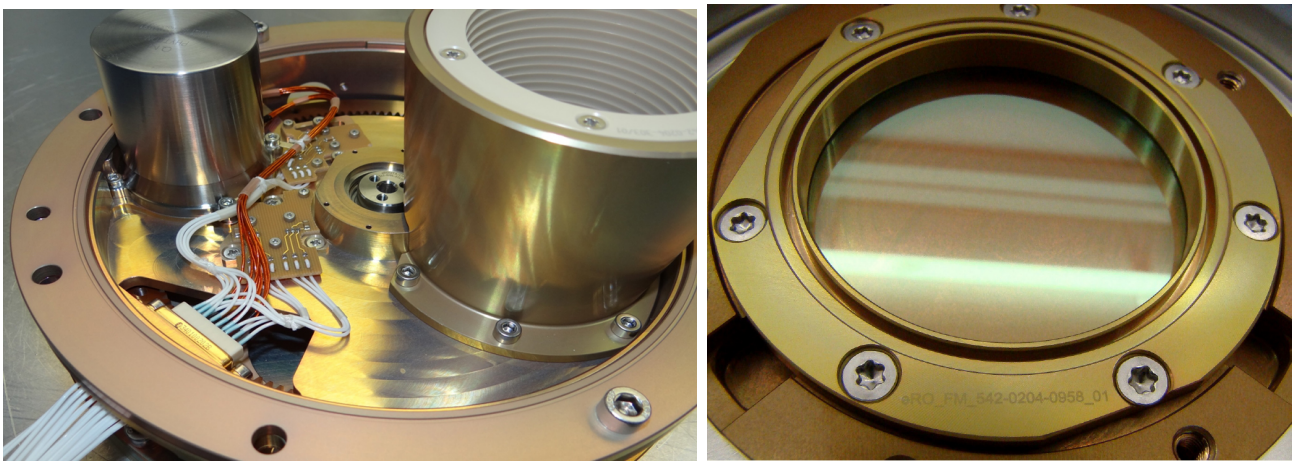
The eROSITA Flight Module preparation work is in full swing. During the recent meeting of the engineering teams in Ringberg, a detailed plan was presented, leading to the final end-to-end test in PANTER in Q1/2016.

The FM electronics manufacturing proceeds well, and, in conjunction with the progress of the CCD module integration, implies that the integration of the FM camera assemblies will begin in August 2015. In the meantime, camera electronics FPGA logics and software is working as expected, with fine-tuning and additional calibration work going on. More details about the camera Qualification Model (QM) tests can be found in Section 3 of this Bulletin.



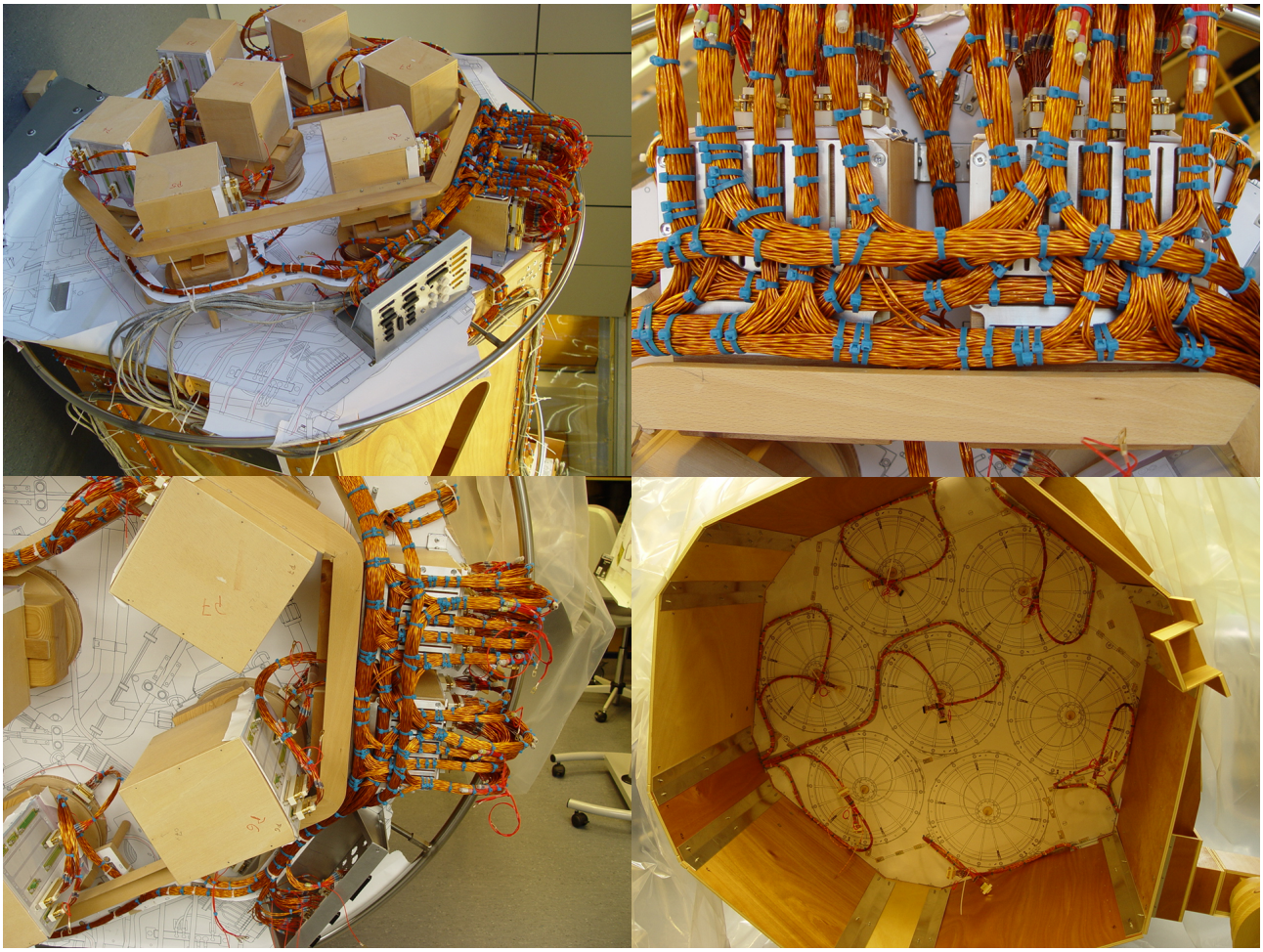
An ad-hoc measuring device "Jedi Sword" was designed and built, which allows the precise determination of the focal length under all environmental conditions including vacuum and cooled detectors.

Some metrology activity is also ongoing to refine our understanding of possible effects on mirror deformation (if any) of temperature changes and/or gradients in the mirror assembly and structure. Also additional work was required to improve our ability to measure tiny focal length changes and optimize the process of camera integration before the PANTER end-to-end test.



Left: One of the eight filter wheels, ready for integration. Right: detail of one of the filters.

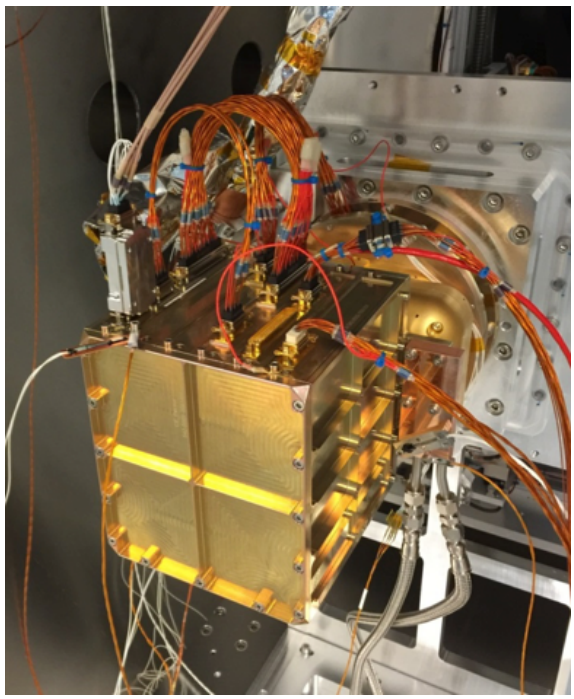
All other parts are available and ready for integration into the Telescope, which will be carried out at the latest possible time before shipping to Russia, to minimize the decay of the radio-active on-board Fe^{55} calibration source.



More than 1.6 km of cables had to be arranged in the focal plane of eROSITA. Accurate modelling of the harnesses was a crucial step in the FM preparation. The top left image shows the complete arrangement of all 9 electronics boxes; the top right and bottom left images instead show two details, highlighting the complexity of the cables arrangements. The bottom right image shows the cabling of the mirror assembly apertures.

3. eROSITA camera development

QM camera tests:
All qualification tests of the eROSITA QM camera have been passed successfully. No degradation was observed after completion of all environmental tests. This includes in particular the execution of vibration tests, thermal cycling, EMC and ESD tests, and of course functional and performance tests. The camera is conform with the requirements set for eROSITA at the beginning of the project.



QM Camera assembly mounted in the PUMA test facility at MPE for test and calibration

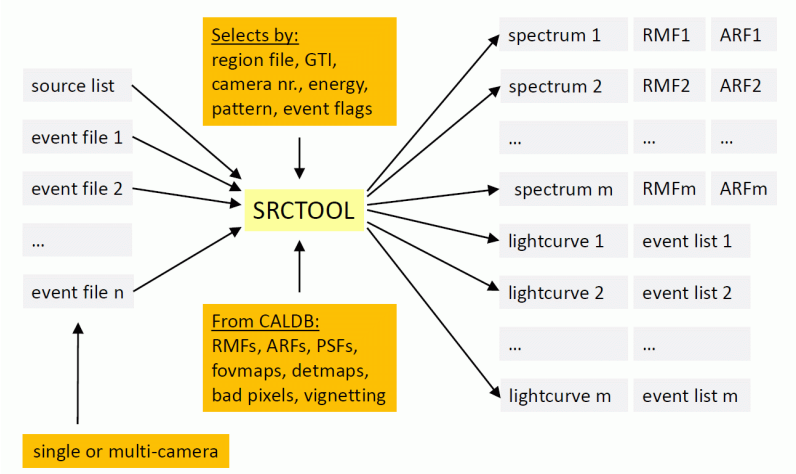
Flight detectors:
The first three flight detectors have been completed and their performance tested at the GEPARD test facility. Both detectors are well suitable for eROSITA. The integration of FM3 to FM6 detectors is finished and they are ready for test. FM7 needs only integration of the CCD sensor to be complete. All structural components of the seven flight model camera and of the flight spare camera have been produced, checked and and are ready for integration. The same applies for more than half of all electronics boards; with CE1, CE2 and CE4a ready and CE3 and CE5 currently under test.

All Proton shields of the seven flight cameras (plus spare) are ready for integration

4. Ground Segment and Operations

eSASS users release:
A new release of the users version of the eSASS data analysis package is available. It can either be accessed on the MPE ds-machines or downloaded and installed on your local computer. Instructions how to access or install the new release can be found in the 'eSASS Handbook' section of the wiki at https://wiki.mpe.mpg.de/eRosita/eSASS. The new release makes available a number of improvements:

- New eSASS task EVTOOL replaces and combines the functions of the previous tasks EVMERGE and EVSELECT for merging of event files, selecting events, and image binning;
- Task SRCTOOL now optionally creates appropriately weighted RMFs and ARFs for each extracted source spectrum. The new RMFs are for the first time derived from measured eROSITA camera data and replace the previously used XMM-derived RMFs;
- Source detection task ERMLDET now supports simultaneous multi-band and multi-camera PSF fits. The efficiency of the code was also significantly improved, resulting in a speed-up by a factor of 2-3 in the case of multiple input images (see figure on page 9).



eSASS task SRCTOOL for spectral extractions and light curve creation. Input and output files, command line input, and calibration interface are shown

Follow the directions in the eROSITA wiki to access the new eSASS release.

Data processing pipeline:
The eROSITA software team continues to work towards the integration and testing of a fully functioning data processing pipeline. Work currently focuses on the processing of star tracker data, the creation of final source catalogs, as well as on the improvement and streamlining of the pipeline control software.

Mission planning and operations:
The IKI, MPE and Hamburg technical teams have started to conduct regular video conferences to discuss technical procedures and interfaces in the areas of mission planning, telecommanding, and data exchange, with a focus on the early mission phases.

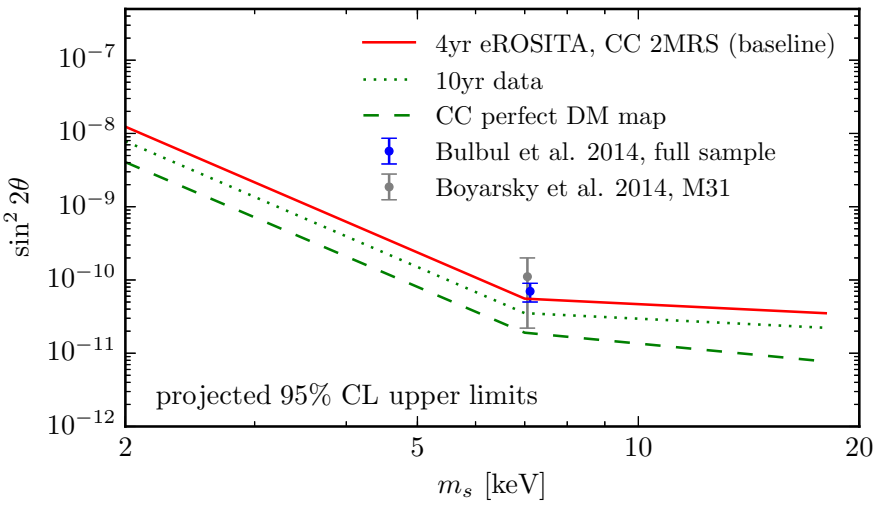
5. Scientific Highlights

The role of eROSITA in searching for sterile neutrino dark matter:
The discovery of the non-gravitational nature of dark matter particles is one of the most important goals of modern astrophysics and cosmology. Sterile neutrinos with keV masses are well-known and well-motivated candidates for dark matter. These have become a hot topic due to the recent claims of detection of an unidentified line at 3.56 keV from a stacked sample of galaxy clusters, with a subsequent number of works either confirmed or disproving such a claim. This is a highly interesting ongoing debate.

F. Zandanel, C. Weniger and S. Ando (all from the GRAPPA Institute in Amsterdam) recently investigated the potential of auto- and cross-correlation power spectra analysis of the cosmic X-ray background in identifying sterile neutrino dark matter, taking as reference the performances of eROSITA and its planned four-years all-sky survey.

Main astrophysical backgrounds for such an analysis are active galactic nuclei, galaxies powered by X-ray binaries, and clusters of galaxies. Sterile neutrino decays are subdominant both in the main

intensities and in the auto-correlation power spectra. However, they can be efficiently enhanced over the other components when cross-correlating with traces of the dark matter distribution, such as the 2MASS galaxy catalogue.



Projected upper limits on the sterile neutrino mixing angle as function of the mass. The baseline result assumes the 4-years eROSITA all-sky survey and the analysis of the cross-correlation (CC) angular power spectrum with the 2MASS 2MRS catalogue. For comparison purposes, the limits obtained for 10 years of data, and when cross-correlating with a hypothetical perfect model of the dark matter distribution are also shown.

The authors conclude that eROSITA will be able to potentially yield very stringent constraints on the sterile neutrino decay lifetime allowing to test the recently claimed 3.56-keV line and its sterile neutrino interpretation. They also underline that in order to fully exploit the eROSITA data for the angular power spectrum analysis, it will be fundamental to overcome the shot-noise limitations of current galaxy catalogues as tracers for the dark matter distribution.

Forecast for SPIDERS and eROSITA AGN population:
Active Galactic Nuclei (AGN) will constitute the most numerous class of objects detected by the eROSITA all-sky survey, with millions of objects over the entire celestial sphere. In order to fully capitalize on the huge scientific potential of the eROSITA AGN sample for the study of the evolution of supermassive black holes over cosmic time, dedicated follow-up programs will be needed to obtain redshift measurements and multi-wavelength characterization of the X-ray sources.

In the framework of the SDSS-III/BOSS survey, we performed a dedicated study to forecast the characteristics of the eROSITA AGN population and the prospects for spectroscopic follow-up programs (SDSS-IV/SPIDERS in particular). We started from 8445 X-ray point like AGN detected by *XMM-Newton* in the 18 deg^2 of the XMM-XXL north region. The sources have been matched to their optical (SDSS) and infrared (WISE) counterparts by likelihood-Ratio methods. 3042 X-ray sources with optical counterparts have been then observed by the BOSS spectrograph, within the magnitude range of 15 < r < 22.5 mag. In a second step, we performed visual inspection of all the BOSS spectra, and defined a sample of 2578 AGN with reliable redshift in the range of 0 < z < 5.

In order to characterize our spectroscopic AGN sample, we introduce a classification method which is based on optical emission line properties and standard emission line diagnostics. We define three classes of AGN: i) optically unobscured (broad line) AGN, ii) optically unobscured (narrow line) AGN and iii) elusive AGN without optical AGN line features. The narrow line and elusive AGN broad line objects reside at low X-ray luminosities and low redshifts, whereas the broad line objects typically reside at higher luminosity and span the entire redshift range. At the

eROSITA depths, and within the sampled optical magnitude range, we find the following fractions of classes: 81% of broad line AGN, 15% of narrow line AGN, 3% of elusive AGN is and 1% of stars.

The broad wavelength coverage of our sample furthermore enables us to compare the AGN selection via X-rays to different AGN selection criteria using photometric bands of SDSS in the optical (Bovy et al. 2011) and WISE in the Near IR (Stern et al. 2012). We find that the X-ray AGN selection largely benefits from the reduced influence of stellar emission processes in the host galaxy and retrieves a unique sample of AGN even at shallow fluxes. The results of this work have been submitted to MNRAS for publication (Menzel et al. 2015).

Fig. 1

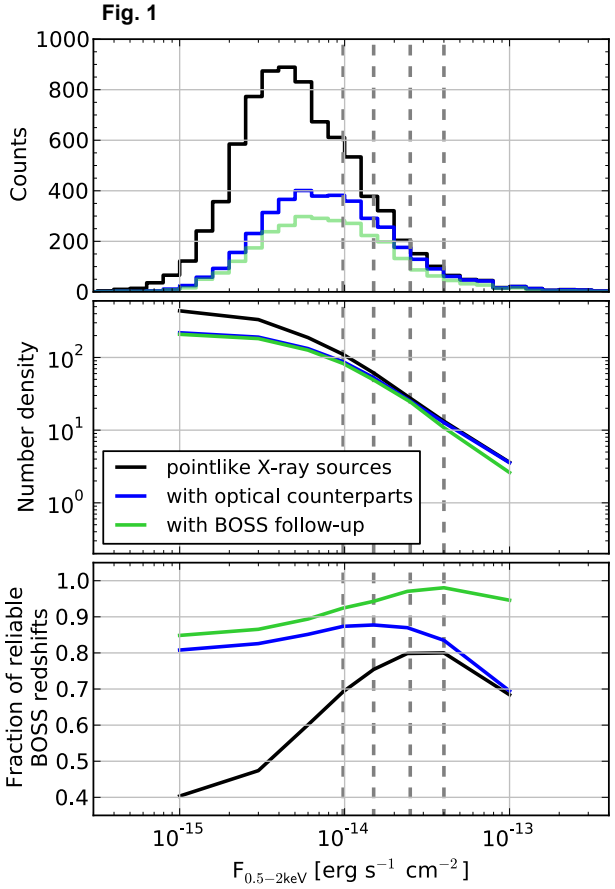


Fig. 2

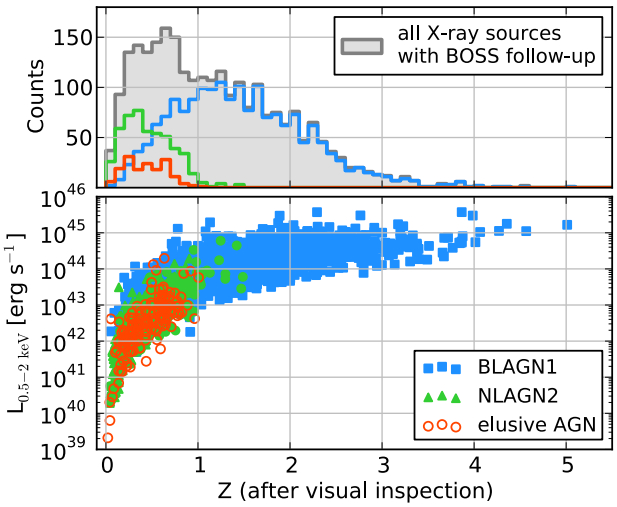


Fig. 3

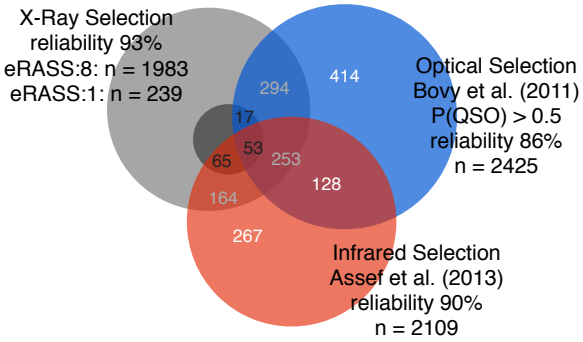
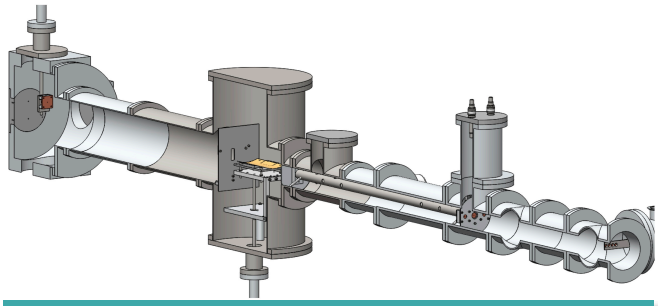


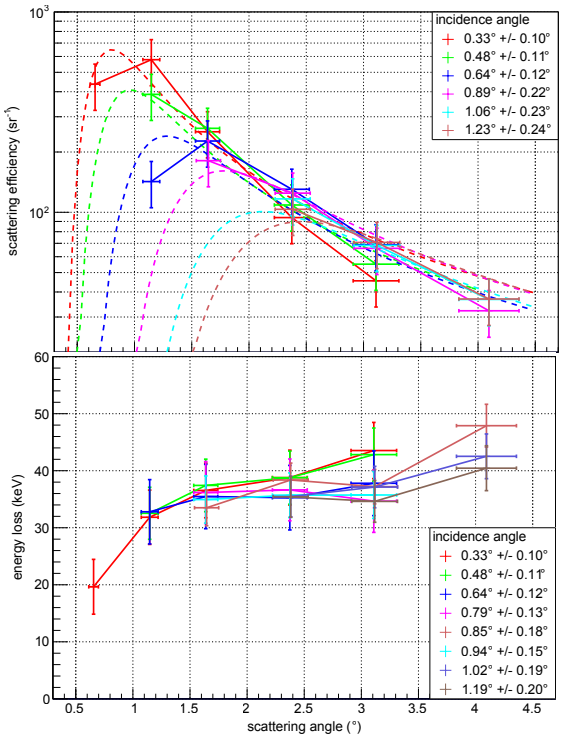
Figure 1: a.) Flux distribution, b.) number density and c.) fraction of reliable BOSS redshifts for point-like X-ray sources (black), with optical counterparts (blue) and BOSS follow-up (green, 15 < r < 22.5 mag, corrected for fiber collision). The vertical dashed lines mark the expected depths of eRASS:8, eRASS:4, eRASS:2 and eRASS:1 (from left to right). Figure 2: Luminosity-Redshift distribution of 2578 classified X-ray sources with BOSS follow-up. We define the groups of broad line AGN (BLAGN1, blue), narrow line AGN (NLAGN2, green) and elusive AGN (red). Figure 3: Comparison of X-ray, optical and infrared AGN selection criteria in the XMM-XXL survey. From Menzel et al. (2105)

Analysis of proton propagation through the eROSITA telescope:
An experiment for grazing angle reflections of low-energy protons on X-ray mirrors has been set up at the accelerator facility of the University of Tübingen. Detailed measurements at incidence angles ranging from 0.3° to 1.2° with proton energies at 250 keV, 500 keV, and 1 MeV have been carried out using spare mirror shells of the eROSITA instrument as scattering targets. The

experimental results are verified against Geant4 simulations and are implemented in the eROSITA raytracing model for the propagation of protons through the mirror modules down to the detector. A second measurement campaign is currently in preparation.



CAD model of the scattering setup in cross-sectional view showing, from right to left, the degrader foils on a movable holder, the collimator with the monitor detectors around the entrance, the tiltable target table, and the shiftable detector for scattered protons at the end of the beam line.



Top: Scattering efficiency of 500 keV protons as a function of scattering angle compared to the theoretical (Firsov-; dashed line) description. Bottom: Energy loss during scattering on the mirrors for 500 keV protons as a function of scattering angle.

6. X-ray surveys in the focus of next IAU General Assembly

The General Assembly of the International Astronomical Union takes place every three years and gather together thousands of professional astronomers from all-over the world. The XXIX edition of the IAU General Assembly will be hosted this summer at the Convention Center in Honolulu (Hawaii, US), from August 3rd to August 13th 2015. It presents a rich science program with six Symposia, twenty-two Focus meetings and the meetings of the nine IAU Divisions (here for a complete list: http://astronomy2015.org/symposia_focus_meetings).

The science drivers of the The Focus Meeting 6: '*X-ray Surveys of the Hot and Energetic Universe* (August 5th-6th) revolve around the inter-relation between black hole growth and the evolving large scale structure as traced by X-ray surveys complemented by multi-wavelength follow-up programs. The aim of the meeting will be to review and discuss the observational advances obtained in the past few years, alongside progress in theory/simulation. The way forward for forthcoming X-ray surveys missions, including synergies with future multi-band facilities, will be the topic of the final round table session chaired by Guenther Hasinger. As the next-to-come all sky X-ray survey, eROSITA will be a key-actor all-over the meeting, as witnessed by the number of invited (N. Clerc) and contributed (K. Dolag, A. Pillepich, A. Kolodzig) talks by eROSITA members and collaborators foreseen in the program, and by the presence of Paul Nandra among the pundits for the final round table (see program: https://sites.google.com/site/fm6xraysurveys/program). We expect to have a lively discussion and new ideas coming out.
(M. Brusa, SOC member of FM6)

7. Recent bibliography

Scientific papers published since the last bulletin and mentioning "eROSITA" in their abstract in the period November 2014 - June 2015 (from ADS):

- **Bocquet et al.**, *Baryon impact on the halo mass function: Fitting formulae and implications for cluster cosmology*, MNRAS, submitted. arXiv:1502.07357
- **Kuranov & Postnov**, *Symbiotic X-ray binaries systems in the galaxy*, Ast.L., 41, 114 (2015)
- **Donnarumma & Rossi**, *Radio--X-Ray Synergy to Discover and Study Jetted Tidal Disruption Events*, ApJ, 803, 36 (2015)
- **Churazov, Vikhlinin & Sunyaev**, *(No) dimming of X-ray clusters beyond z ˜ 1 at fixed mass: crude redshifts and masses from raw X-ray and SZ data*, MNRAS, 450, 1984 (2015)
- **Ghirlanda et al.**, *Unveiling the population of orphan Gamma Ray Bursts*, A&A, accepted. arXiv: 1504.02096
- **Singh et al.**, *Probing the circumgalactic baryons through cross-correlations*, MNRAS, submitted. arXiv:1505.03658
- **Risaliti & Lusso**, *A Hubble Diagram for Quasars*, ApJ, submitted. arXiv:1505.07118
- **Zandanel, Weniger & Ando**, *The role of the eROSITA all-sky survey in searches for sterile neutrino dark matter*, JCAP, submitted. arXiv:1505.07829
- **Kisaka et al.**, *Isotropic Detectable X-ray Counterparts to Gravitational Waves from Neutron Star Binary Mergers*, ApJ, submitted. arXiv:1506.02030

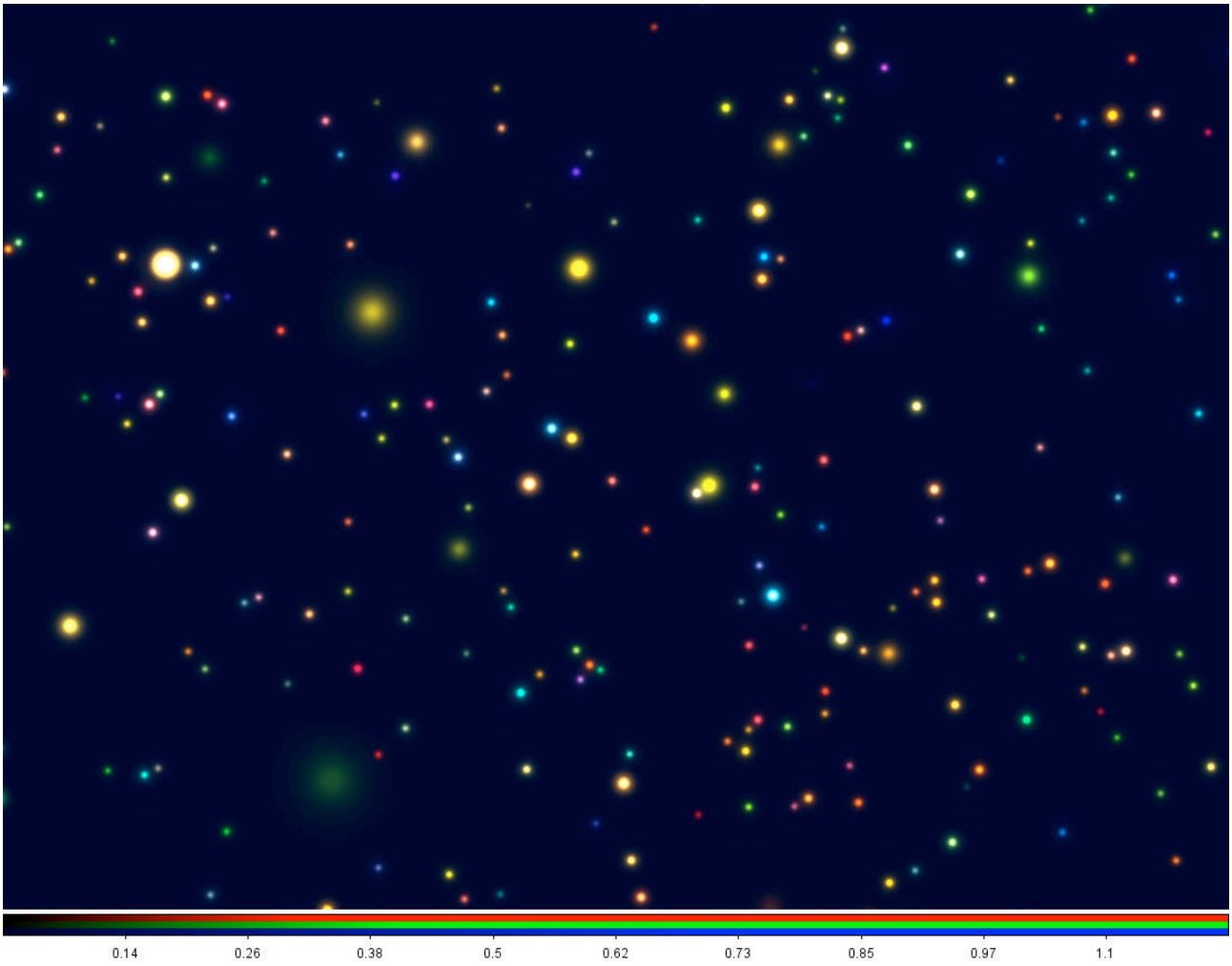
8. Upcoming meetings and events

Next eROSITA_DE Consortium Meeting will be held in Bamberg on October 12-13.

Meetings of General Interest (July 2015 - December 2016; from CADC):

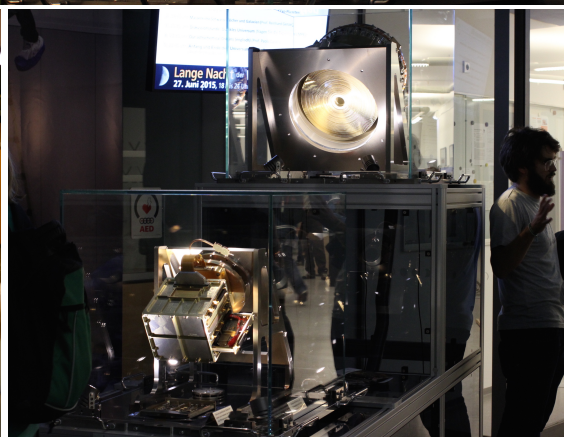
- Aix en Provence, France, July 6-11: *Drifting through the Cosmic Web: the Evolution of Galaxies within the Large Scale Structure*
- Rome, Italy, July 12-18: *The Fourteenth Marcel Grossman Meeting*
- Silvretta, Austria, July 20-24: *Alpine Cosmology Workshop 2015*
- Space Telescope Science Institute, Baltimore, MD, USA, July 27-29: *Mocking the Universe*
- Sexten center for Astrophysics, Italy, July 27-31: *The Metal Enrichment of Diffuse Gas in the Universe*
- Honolulu, Hi, USA, August 2-13: *IAU XXIX General Assembly*
- Honolulu, Hi, USA, August 5-6: *IAU FM 6: X-ray Surveys of the Hot and Energetic Cosmos*
- Cambridge, MA, USA, August 19-21: *The Universe in High-Resolution X-ray Spectra: Current Results and future Opportunities*
- ESA-ESAC, Madrid, Spain, September 8-10: *Exploring the Hot and Energetic Universe: The first scientific conference dedicated to the Athena X-ray observatory*
- Corfu, Greece, September 13-19: *Workshop on Particles and Cosmology*
- Kiel, Germany, September 14-18: *From the first quasars to life-bearing planets: From accretion physics to astrobiology - Annual meeting of the Astronomische Gesellschaft*
- Cambridge, UK, September 14-18: *Observing and modelling spectral energy distributions through cosmic times*
- Chania, Crete, Greece, September 21-24: *Demographics and environment of AGN from multi-wavelength surveys*

- Rome, Italy, October 5-9: *The New High-Energy Sky After a Decade of Discoveries (2015 INTEGRAL Workshop)*
- Byukaran, Armenia, October 5-9: *Astronomical Surveys and Big Data, International Symposium, dedicated to 50th anniversary of Markarian Survey and 10th anniversary of Armenian Virtual Observatory*
- ESO, Garching, October 5-9: *Rainbows on the Southern Sky: the legacy value of ESO Public Surveys and Large Programmes*
- Washington, DC, USA, October 6-8: *Advancing X-ray astronomy beyond Chandra with the "X-ray Surveyor" mission*
- Les Houches, France, October 11-16: *School of Astrostatistics 2015: Clustering and Classification*
- Annapolis, Md, USA, October 12-14: *The Physics of Supermassive Black Hole Formation and Feedback*
- Clemson University, SC, USA, October 19-21: *Time Domain Astrophysics with Swift*
- Washington, DC, USA, November 2-6: *6th International Fermi Symposium*
- Geneva, Switzerland, December 13-18: *Texas Symposium on Relativistic Astrophysics*



Color image derived from ERMLDET output source maps, demonstrating multi-energy band source detection on a simulated 2 ks exposure of an all-sky survey field. The image is 1.25 x 1 degrees in size; the colors represent the energy bands 0.2-0.5 keV (red), 0.5- 2.0 keV (green), and 2.0-5.0 keV (blue).



On June 27th MPE opened its doors to the public for the 2015 edition of "Die Lange Nacht der Wissenschaft". In the main entrance, the FM8 mirror module and a camera assembly were on display, to the amazement of the approximately 1700 visitors who came in during the evening.

IMPRINT
Realisation: A. Merloni

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