The eROSITA Bulletin

No.5, November 2014

Between September 15 and 17, 2014, more than 70 members and guest of the German eROSITA Consortium gathered at the Leibnitz Institut für Astrophysik (AIP) in sunny Potsdam for the yearly Consortium meeting. Alongside plenary sessions and working group splinter meetings, special dedicated parallel sessions devoted to time-domain astrophysics, imaging and spectroscopic follow-up plans and the 'cosmology challenge' were also scheduled.
More information, and all the presentations are available on the eROSITA_DE Wiki pages.

1. Overall project status and milestones

The tests with the eROSITA Technological Model performed at Lavochkin Association (LA) last October were successful. eROSITA and the 'Navigator' platform were able to communicate as required. The clearing of this critical hurdle allows now the work on the interface and control electronics to proceed as planned.

A final recommendation from the independent review team for the adoption of a reliable Medium-Gain-Antenna (MGA) for the onboard radio-complex has been endorsed last spring. The new antenna design is ready, and manufacturing of the SRG radio-complex is now underway. The MGA will have a fixed mount and a much-increased reliability. This will enforce a change in the SRG all-sky scanning law, which will also affect the thermal profile of the telescopes, due to increased sun-avoidance angles during certain phases of the spacecraft orbit. The slight modification of the eROSITA telescope structure, needed to cope with this new thermal profile, is underway, and more details on the impact of the new antenna design on the all-sky survey exposure map have been presented by J. Robrade during the Consortium meeting in Potsdam.

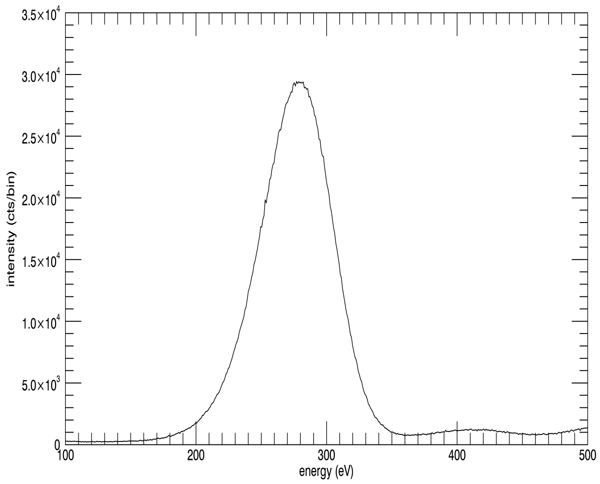
All other mechanical and optical subsystems are either ready, or close to be ready. The final calibration of the eight fully integrated Mirror Assemblies (MA) will resume early next year with the flight module cameras, immediately followed by their final integration into the telescope structure. Most of the remaining work now concentrates on the manufacturing and testing of the electronics.

The end-to-end test of the fully integrated eROSITA telescope is scheduled for June 2015, followed by shipment to Russia. The SRG launch from Baikonour is currently scheduled for March 26, 2016.

2. eROSITA detectors development

QM camera tests:
The vibration test of the Qualification Model (QM) camera and the thermal cycling test of the QM detector were successful, i.e. no degradation was found. In two measurements campaigns at the MPE PUMA facility, the entire camera assembly (camera head, electronics and filter wheel) was tested extensively. The figure below and the table on the right illustrate the main results on the achieved spectral resolution. The tests were carried out using the onboard calibration source, the PUMA multi-target X-ray tube and an array of LED light sources.

Furthermore, we evaluated the performance of the camera by carrying out measurements at different operating temperatures of the camera electronics, within the range from -25°C to +25°C. We observed no performance degradation, but the induced change of gain needs to be calibrated for the flight cameras.



QM camera test at PUMA: The C-K emission line spectrum is shown, with a measured energy of 277 eV and a FWHM of 64 eV

Finally, the LED array was used to check and verify the light tightness of the camera system after integration of the MLI foil. The light source served furthermore to confirm the (predicted) six orders of magnitude attenuation of visual light illumination thanks to the pnCCD on-chip light filter.

Photon Energy	FWHM
277 eV	64 eV
525 eV	62 eV
710 eV	62 eV
782 eV	64 eV
930 eV	72 eV
1486 eV	79 eV
2293 eV	95 eV
2984 eV	96 eV
4510 eV	117 eV
5412 eV	135 eV
5894 eV	141 eV
6400 eV	150 eV
6930 eV	158 eV
8040 eV	165 eV
8366 eV	181 eV
9705 eV	202 eV

Energy resolution (FWHM) of spectral lines measured with the eROSITA QM camera during the recent PUMA tests

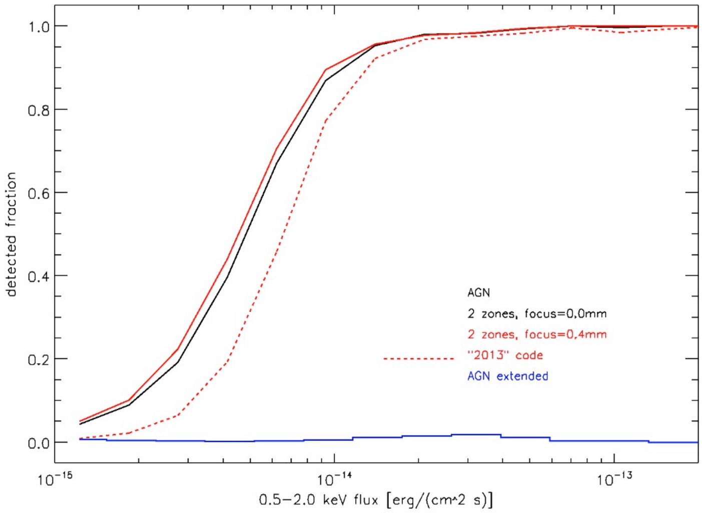
Flight detectors:
We measured first light of the FM1 detector at the GEPARD test facility on October 8th 2014. The FWHM of the Mn-Kα line (5.9 keV) is 130 eV with a read noise of 2.4 electrons ENC. The eROSITA detectors FM2 to FM5 are currently being assembled.

More details in Meidinger et al., *Report on the eROSITA camera system*, SPIE, Vol. 9144, 2014.

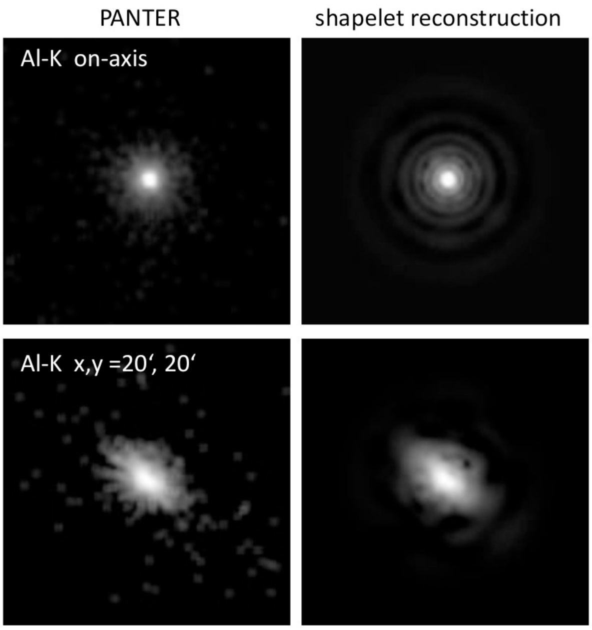
3. Ground Segment and Operations

Data analysis software:

An initial user release of the eSASS data analysis package, covering event selection, exposure map creation, source detection, and spectral and light-curve creation was made available to the eROSITA_DE Consortium members and was demoed at the Consortium meeting. Software updates and related information are reported in the eSASS Users News, available in the eROSITA Wiki and by email subscription. The eSASS team also set up an email help-desk for answering user questions. A team of eleven developers at four institutes continues to work on the software tasks (more than forty of them) for interactive and pipeline data analysis, comprising eSASS. Current activities are focused on integrating and testing the data processing pipeline, aiming to provide a fully functioning system by mid of next year. Two areas of recent progress are highlighted below.



Detected fraction of point sources in 2 ks exposures of simulated all-sky survey fields, obtained with improved eSASS detection software (solid lines) as compared to previous software version (dashed line). The red and black lines correspond to two different focus positions. Simulated point sources erroneously detected as extended objects are shown in blue. Courtesy of G. Lamer, AIP



Two example PSFs (1.5 keV on-axis and at 20',20' off-axis position) from FM1 focal plane mapping at PANTER (left column) and corresponding shapelet reconstruction (right, logarithmic scaling). Courtesy of A. Georgakakis, MPE

Source detection:

Upgrades of the eSASS source detection software resulted in a substantial improvement of the detection sensitivity. The updated software employs matched-filter detection using a range of beta model filters, as well as a significantly increased detection cell size. Background map creation was improved by properly considering the size of extended objects to be removed from the X-ray images before background fitting. The more accurate background maps and improved source candidate lists for the subsequent Maximum Likelihood fitting of the source profiles both contribute to increase significantly the detection sensitivity, as shown in the figure above.

Point spread function modeling:

After the completion of the focal plane mapping of the FM1 telescope at PANTER, shapelet model fits of the PSFs were created for a grid of 169 spatial positions at seven different energies (see image on the left). The core and wings of the PSFs were modeled separately by fitting a total of 157 shapelet coefficients to each PSF. The shapelet model is currently being integrated into the eSASS source detection software.

Installing and working with eSASS:
https://wiki.mpe.mpg.de/eRosita/eSASS
eSASS Users News:
https://wiki.mpe.mpg.de/eRosita/eSASSnews
or erocat@lists.mpe.mpg.de
Help-desk: eROSITA-helpdesk@mpe.mpg.de

Mission planning:
Procedures and strategies designed by the Hamburg mission planning team were updated to account for additional constraints resulting from the new fixed-medium-gain-antenna concept of SRG. Associated data formats as well as a general planning scheme were developed. A mock timeline, based on a preliminary list of eROSITA calibration targets and making use of the most up-to-date SRG orbit file, was created. The mission planning strategies are currently under discussion with our Russian colleagues.

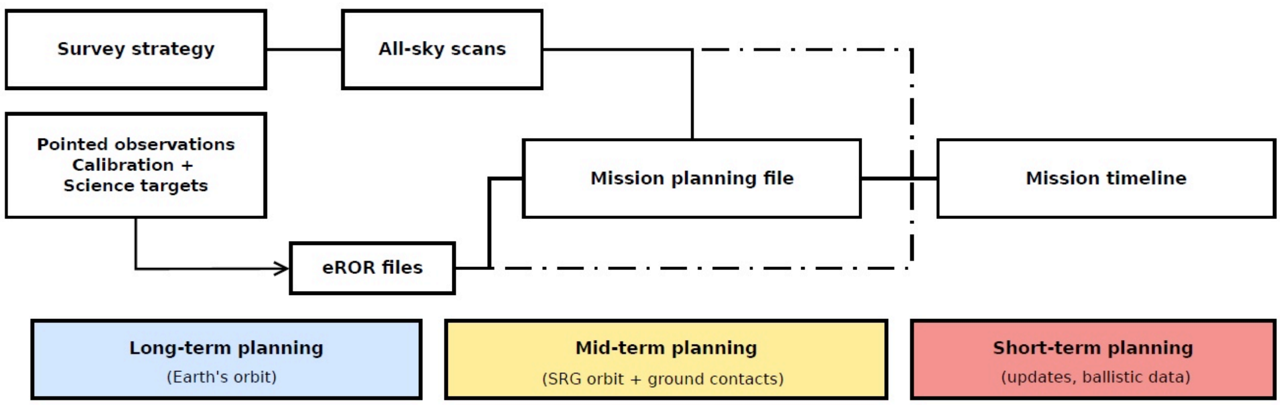


Diagram of mission planning steps and data flow. Courtesy of J. Robrade, Hamburger Sternwarte

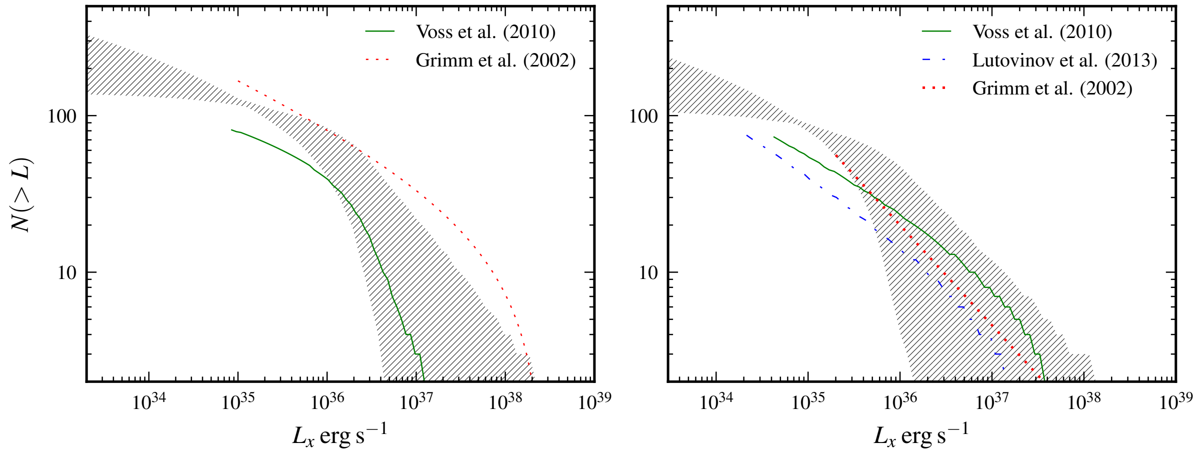
4. Scientific Highlights

Population of the Galactic X-ray binaries and eROSITA:
The population of the Galactic X-ray binaries (XRB) has been mostly probed with moderately sensitive hard X-ray surveys so far. eROSITA will provide, for the first time, a sensitive all-sky X-ray survey in the 2-10 keV energy range, where the X-ray binaries emit most of their flux, and will discover the still unobserved low-luminosity population of this class of objects. Based on the analysis of the current constraints for the X-ray luminosity functions of high- and low-mass X-ray binaries (HMXB and LMXB, respectively, see figure in page 5) a team of scientists from IAAT Tübingen (V. Doroshenko, L. Ducci, A. Santangelo and M. Sasaki) presented a detailed estimate of the galactic XRB content of the eROSITA all-sky survey. This is expect to yield

	LMXB	HMXB
L_{br}, 10^{36} erg s^{-1}	$8^{+7}_{-6.5}$	$0.55^{+4.6}_{-0.28}$
α_1	$0.9^{+0.2}_{-0.4}$	$0.3^{+0.8}_{-0.2}$
α_2	$2.6^{+3}_{-0.9}$	$2.1^{+3}_{-0.6}$
$N_{total,MW}$	200^{+175}_{-75}	110^{+180}_{-10}
$N_{INTEGRAL}$	108 (29-86%)	82 (27-82%)
$N_{eRosita}$	130-270 (75-95%)	105-220 (78-96%)
$N_{eRosita,new}$	22-162	23-138

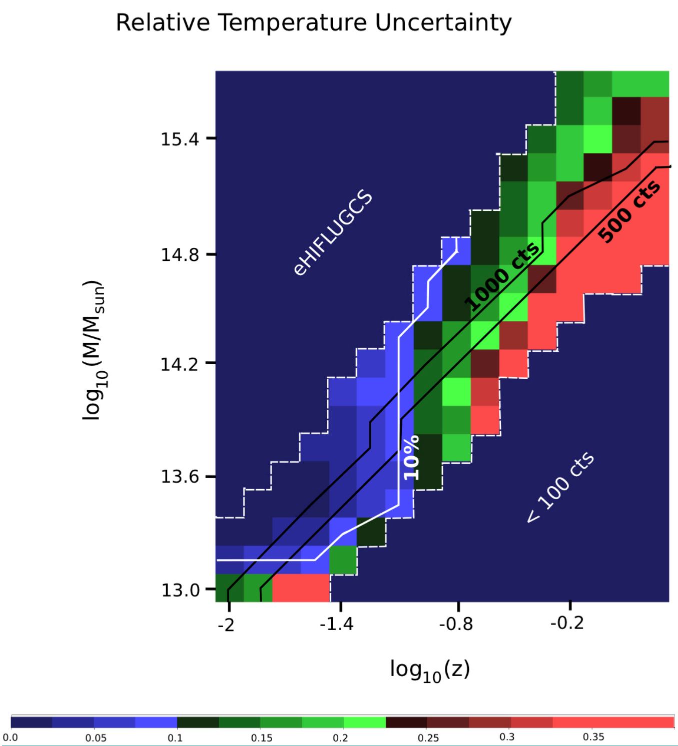
Estimated Luminosity Function parameters for high- and low- mass X- ray binaries from INTEGRAL 9-year survey, and expected number and fraction of sources to be detected by INTEGRAL and eROSITA. From Doroshenko et al. (2014)

detections of 50-300 new sources and provide vital new constrains on the X-ray Luminosity Function of the Galactic X-ray binaries, as illustrated in the table above.



Cumulative luminosity functions for LMXBs (left) and HMXBs (right) as derived using the INTEGRAL data (hatched area). Best-fit estimates by Grimm et al. (2002), Voss & Ajello (2010), and Lutovinov et al. (2013) are also plotted for reference. From Doroshenko et al. (2014)

Constraining galaxy cluster temperatures and redshifts with eROSITA survey data:



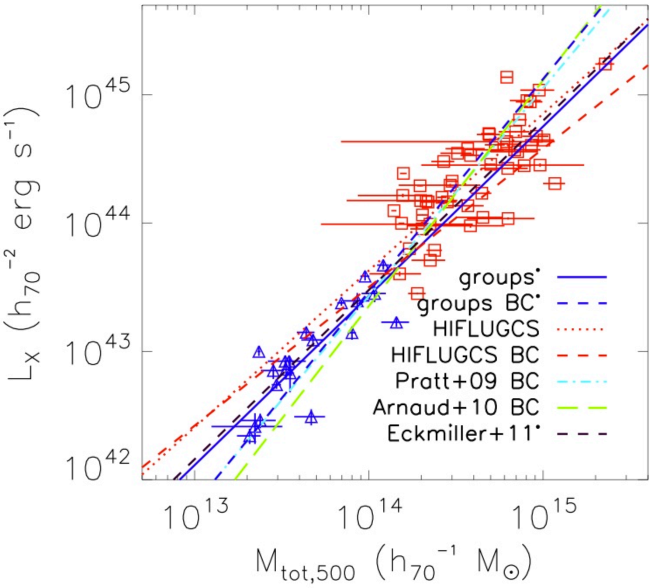
Expected relative temperature uncertainties ΔT/T as a function of cluster mass and redshift, for a 1.6ks eROSITA exposure on clusters of known redshift. White and black contours show the relative uncertainty and the number of counts, respectively. Objects in the top left and bottom right corner are either already available from ROSAT catalogs with XMM/Chandra follow-up (eHIFLUGCS), or will have too few photon counts for a reliable analysis. From Borm et al. (2014)

Detecting a large sample of about 100,000 galaxy clusters, eROSITA aims at studying the nature of dark energy based on the mass and redshift distribution of these objects. For this method of probing dark energy, not only the number of detected clusters, but also precisely and accurately measured cluster properties are of great importance. Since the cluster mass is not a direct observable, its estimate is improved by the measurement of the cluster temperatures in the X-ray band. In a recent paper, K. Borm, T. Reiprich, I. Mohammed and L. Lovisari (all from Univ. of Bonn) have assessed the precision and accuracy with which eROSITA will be able to determine galaxy cluster temperatures and redshifts directly from its survey data.

Based on a spectral analysis for a variety of different cluster masses and redshifts, they predict eROSITA to determine precise temperatures with relative uncertainties of ΔT/T<10% for clusters up to redshifts of z≈0.16. This estimate includes redshift information from optical follow-up observations, which will soon be available after the launch of SRG. This corresponds to precise temperature measurements for about 1700 new clusters. Accurate redshift determination, on the other hand, will be available with a precision of $\Delta z/(1+z)<10\%$ for clusters up to z≈0.45, which will result into a good redshift estimates for ≈23,000 new clusters from the eROSITA survey data alone. Crucially, the expected parameter biases for temperature as well as redshift will be negligible for all clusters with relative uncertainties below 10%.

In summary, eROSITA will increase the existing sample of galaxy clusters with precise and accurate temperature measurements by a factor of 5-10. According to this, the instrument presents itself as a powerful tool to place tight constraints on the cosmological parameters, including the nature of dark energy.

Scaling properties of X-ray selected groups:
eROSITA data will allow to determine the total hydrostatic mass only for a small fraction of detected groups and clusters of galaxies: the photon-count statistics will be insufficient to determine accurately the temperature and density profiles for most of the fainter eROSITA clusters. Thus, the mass will be inferred from other observable properties, and the cosmological studies will rely heavily on a detailed understanding of the scaling relations used to convert these properties into mass.



Clusters X-ray Luminosity-Mass relation. Blue triangles are groups and red boxes are clusters with temperature higher than 3 keV. The blue lines represent the best-fit values. They are compared with the best-fit results obtained with different samples. BC indicates the relation corrected for the selection effects. From Lovisari et al. (2014)

The analysis of complete samples is a key prerequisites for such studies, because only in this case selection effects can be corrected for. L. Lovisari, T. Reiprich and G. Schellenberger, from University of Bonn, have recently analyzed a complete sample of galaxy groups observed with XMM-Newton and corrected the L-M (luminosity-mass) and L-T (luminosity-temperature) relations for selection bias effects. Interestingly, the slope (1.66±0.22) of the corrected L-M relation derived at the group scale is steeper than the corrected slope (1.08±0.21) obtained with more massive systems. One possible explanation is that the true L-M relation is gradually steepening moving towards the low mass objects. If confirmed with larger samples, this would imply that for future X-ray surveys like eROSITA a relation with more freedom than a single power-law to convert the luminosities to the total masses is required to constrain the cosmological parameters.

5. Recent bibliography

Scientific papers published since the last bulletin and mentioning “eROSITA” in their abstract in the period February - October 2014 (from ADS):

- **Huetsi et al.**, *Probing large-scale structure with large samples of X-ray selected AGN: I Baryonic acoustic oscillations*, A&A, in press. arXiv:1403.5555

- **Israel et al.**, *The 400d Galaxy Cluster Survey weak lensing programme. III. Evidence for consistent WL and X-ray masses at z ≈ 0.5*, A&A, 564, 129 (2014)
- **Chandrachani Devi, Gonzalez, Alcaniz**, *Constraining thawing and freezing models with cluster number counts*, JCAP, 06, 055 (2014)
- **Doroshenko et al.**, *Population of the Galactic X-ray binaries and eROSITA*, A&A, 567, 7 (2014)
- **Borm et al.**, *Constraining galaxy cluster temperatures and redshifts with eROSITA survey data*, A&A, 567, 65 (2014)
- **Gonzalez-Martin et al.**, *Synapses of active galactic nuclei:. Comparing X-ray and optical classifications using artificial neural networks*, A&A, 567, 92 (2014)
- **Lovisari, Reiprich, Schellenberger**, *Scaling Properties of a Complete X-ray Selected Galaxy Group Sample, A&A, in press*. arXiv:1409.3845
- **Roncarelli, Carbone, Moscardini,** *The effect of massive neutrinos on the SZ and X-ray observables of galaxy clusters,* MNRAS, submitted. arXiv:1409.4285
- **Aghanim et al.**, *The Good, the Bad and the Ugly: Statistical quality assessment of SZ detections*, A&A, submitted. arXiv:1409.6543
- **Vajgel et al.,** *X-ray selected galaxy groups in Bootes,* ApJ, 794, 88 (2014)

6. Upcoming meetings and events

Meetings of General Interest (November 2014 - August 2015; from CADC):

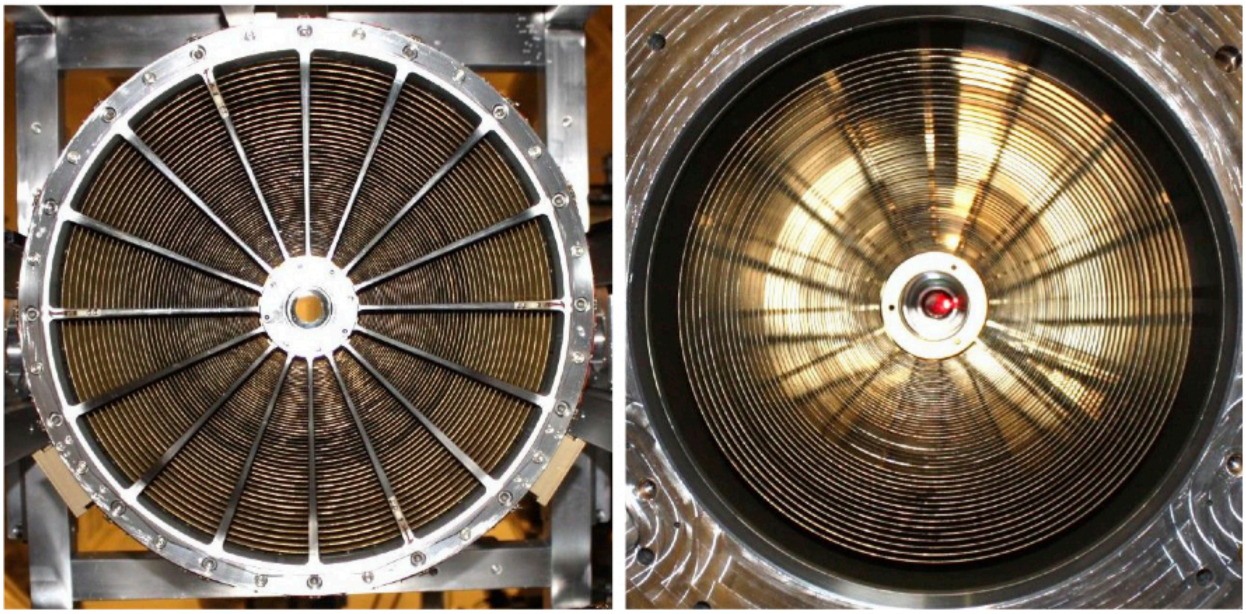
Meetings in 2014

- Madrid, Spain, November, 4-7: *Cosmology with Galaxy Clusters in the XXI century*
- Freising near Munich, Germany, November 10-14: *Superbubbles, HI holes and Supershells*
- La Serena, Chile, November 10-11: *Galaxy Groups: laboratories to study galaxy evolution*
- Potsdam, Germany, November 17-19: *4MOST Preliminary Design Science Kick-off meeting*
- Boston, MA, USA, November 18-21: *Fifteen Years of Science with Chandra*
- Rome, Italy, December 2-5: *Swift: 10 Years of Discovery*
- Prague, Czech Republic, December, 8-12: *AXRO2014 7th International Workshop on Astronomical X-Ray Optics*

Meetings in 2015

- Aspen, Co, USA, January, 16-21: *Black Holes in Dense Star Clusters*
- Palermo, Italy, February 2-5: *Solar and stellar magnetic activity*
- Santa Cruz de la Palma, Canary Islands, Spain, March 2-6: *Multi-Object Spectroscopy in the Next Decade: Big Questions, Large Surveys and Wide Fields*
- Puerto Varas, Chile, March 8-12: *Unveiling the AGN/Galaxy Evolution Connection*
- Tucson, Az, USA, March 9-11: *Tools for Astronomical Big Data*
- Shanghai, China, March 30-April 1: *Black Holes and Friends*
- Santa Barbara, Ca, USA, May 12-15: *Hot-wiring the Transient Universe IV*
- Bern, Switzerland, June 1-5: *Dick McCray Symposium*
- Abbazia di Spineto (SI), Italy, June 8-12: *IGM@50: is the Intergalactic Medium driving Star Formation?*
- Vilspa, Madrid, Spain, June 8-10:The *Extremes of Black Hole Accretion*
- La Laguna, Tenerife, Spain, June 22-26: *European Week of Astronomy and Space Science (EWASS 2015)*

- Aix en Provence, France, July 6-11: *Drifting through the Cosmic Web: the Evolution of Galaxies within the Large Scale Structure*
- 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*



eROSITA is watching you! The FM1 mirror module as seen from the parabola X-ray entrance side (left), and from the hyperbola X-ray exit side (right), in the PANTER X-ray test facility vacuum chamber. From Burwitz et al. (2014), SPIE 91441X

IMPRINT
Realisation: A. Merloni

Contributors: K. Borm (U. Bonn), H. Brunner (MPE), V. Doroshenko (IAAT), A. Georgakakis (MPE), G. Lamer (AIP), L. Lovisari (U. Bonn), N. Meidinger (MPE), P. Predehl (MPE), J. Robrade (U. Hamburg)

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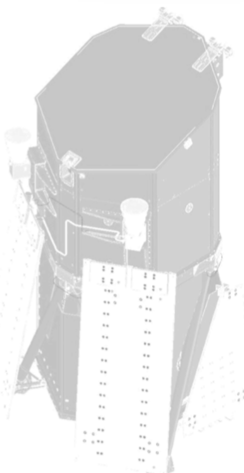

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