

# The eROSITA Bulletin



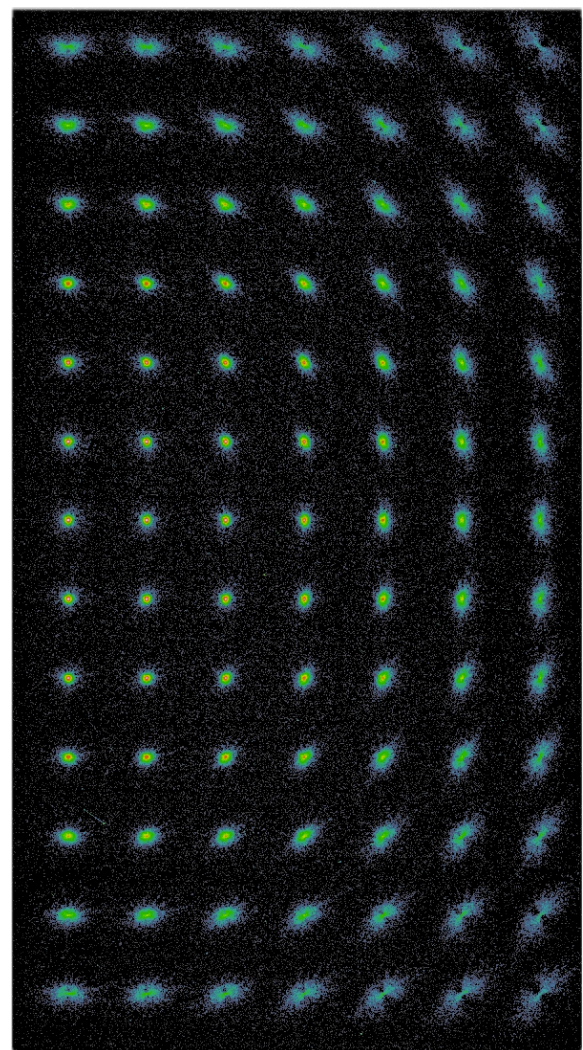
No.3, May 2013

## 1. Project status and milestones

**Qualification tests campaign at IABG:** All eROSITA mechanical hardware is now in place and the integration of the flight telescope structure is underway. The complete Qualification Module (QM) test campaign was carried out successfully at IABG in Ottobrunn, near Munich, between November 2012 and January 2013. Mass and moment of inertia measures, acoustic noise tests, vibrational tests and space vacuum tests were performed. In March, the Technology Model was delivered to Lavochkin (and successfully tested), after a long trip through Germany and Russia, a useful “dry run” of the planned eROSITA travel.

**Mission timeline:** The latest schedule for the SRG mission was presented during the last SRG status meeting by Lavochkin in December 2012, and foresees a launch window at the end of 2014. The next official SRG status meeting (including representatives of MPE, IKI, Lavochkin, Roskosmos and DLR) will be held on June 4-5 in Moscow.

**Joint German/Russian committees:** In order to facilitate cooperation and discussion at the project level between the German and the Russian scientific and technical teams, two specific committees have been established. A joint SRG committee (E. Churazov, K. Nandra, M. Pavlinsky, P. Predehl, R. Sunyaev) will discuss matters concerning the overall operations, mission planning and execution. A joint eROSITA committee (M. Gifanov, A. Merloni, P. Predehl, S. Sazonov, A. Schwöpe, R. Sunyaev) will be in charge of coordinating specific telescope operations, as well as the broad scientific cooperation between the teams.



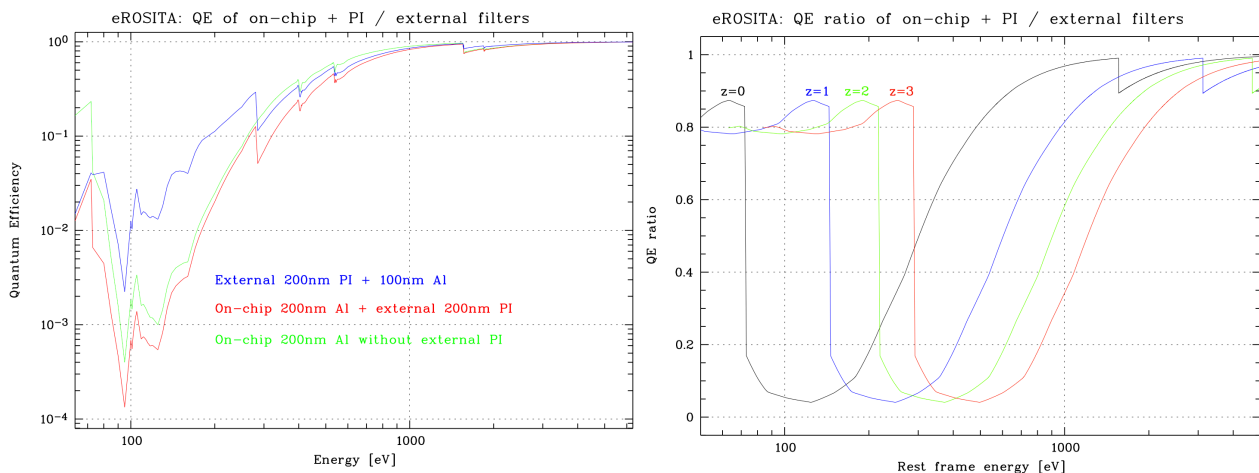
*eROSITA PSF focal plane mapping of FM2 without X-ray baffle, by steps of 5' in both off-axis directions at an energy of 1.49 keV (Al-K line), acquired with the PIXI camera at PANTER.*

## 2. Hardware development

**Mirror Modules tests:** Currently ~85% of all eROSITA X-ray mirror shells have been integrated, and the integration of the X-ray baffles into the mirror modules is also underway. Three fully integrated flight Mirror Modules are available, and the first two (including the baffles) were extensively tested in PANTER, according to the standard sequence: X-ray test -> integration of baffle -> X-ray test -> vibration -> thermal vacuum -> X-ray test. The results are marginally in line with the requested specifications (HEW=15.2" and 16.8" at 1.5keV for FM1 and FM2, respectively).

In parallel, ray-tracing simulations have been performed to investigate the impact on the overall sensitivity of eROSITA of possible small errors in the mechanical shaping and positioning of the baffles above the mirror modules, and to identify the ranges of acceptable tolerances. A SPIE paper on the output of these simulations will be published (E. Perinati, IAAT).

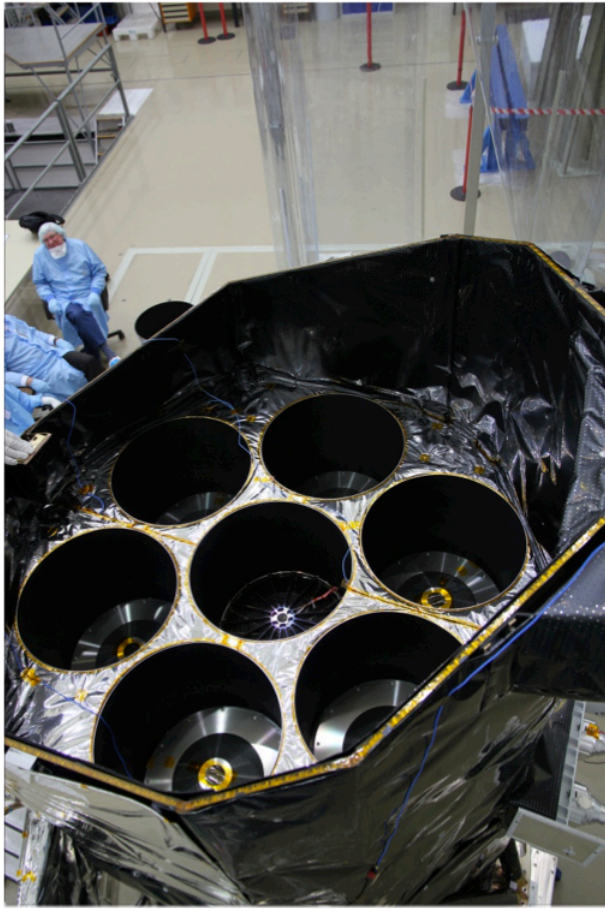
**Detectors:** As far the detectors are concerned, a second flight-like eROSITA detector module in combination with a fully equipped front-end electronics board has been successfully tested in the GEPARD test chamber at MPE. All seven flight detector boards have meanwhile been produced in the "Hybridlabor" of the Max-Planck Institute for Physics in Munich.



**LEFT:** Quantum efficiency of CCD with on-chip filter (200 nm Al, green curve), plus external polyimide filter (200 nm Al, 200 nm PI, red curve) and of CCD without on-chip filter but with external filter (200 nm PI, 100 nm Al) as function of energy (Granato 2012); **RIGHT:** Quantum efficiency ratio as function of rest frame energy for various redshifts:  $z = 0$  (black), 1 (blue), 2 (green), 3 (red)

**Ground Calibration:** A detailed ground calibration campaign will be performed later this year. The corresponding test plan is currently being set up. Please note that, if your key eROSITA science objective requires specific calibration parameters (special energy, accuracy) that may be only be obtained on-ground, you should please contact the eROSITA calibration group. The present idea is to have a mixture of CCDs, 5 with on-chip filter plus optional external polyimide filter for contamination protection and 2 CCDs without on-chip filter with an external polyimide/aluminum filter (see Figure above).

### 3. Ground Segment and Operations



*The eROSITA Qualification Module is inspected right after vibration test at IABG*

Work on the eROSITA ground software<sup>1</sup> is proceeding in several different areas and includes testing and integration of already completed software packages as well as ongoing software development.

**Pipeline data processing:** The event processing pipeline is currently integrated and tested using TRoPIC camera and simulated datasets. An initial version of a preprocessing package for FITS-converting and packaging the raw data was installed at MPE and is now integrated with the event processing pipeline. Various constituents of the event pipeline, such as software for identifying data quality intervals and for separating the calibrated events into all-sky survey fields and pointed observations are undergoing testing. Initial testing of the data link between IKI, Moscow and MPE is underway, intended to eventually lead to end-to-end tests of the processing pipeline, starting from the Russian SRG operations center.

**Source detection and catalog creation:** PSF-fitting software based on the XMM-Newton source detection package, as well as a program for creating exposure maps are ready for use and are undergoing testing. A

Bayesian background source separation package is currently integrated with the source detection pipeline. In addition, various wavelet source detection codes have been evaluated for eROSITA. Comparative testing of the different source detection approaches is ongoing. An MPE-developed source catalog access and cross-correlation tool is currently adapted for eROSITA.

**Interactive data analysis tools:** Work on interactive tools for extracting and flux-correcting spectra and lightcurves (SPECTOOL, LCTOOL) has recently started. Most pipeline programs also function as interactive command line tools, allowing the users to rerun and improve on the standard pipeline processing.

**Near real-time analysis (NRTA):** The NRTA performs health checks to assure instrument health and data quality. The tools to check the eROSITA housekeeping parameters for out-of-limit events and to raise appropriate alerts are currently under development. Secondly, the NRTA will perform an initial analysis of the data, using the same software components as the eROSITA science analysis pipeline.

<sup>1</sup> The components of the eROSITA ground software are provided by a team comprising MPE, Remeis-Sternwarte Bamberg, AIP, Hamburger Sternwarte, MPA, and AlfA members.



**Mission planning and coordination with the Russian team:** At a recent meeting with IKI colleagues procedures for SRG mission planning were discussed and an initial version of a FITS table format for exchanging mission planning information was agreed upon. Preparations for creating a timeline for the initial months of the mission are underway and it was agreed to create a mock timeline for the calibration and science verification phase, well ahead of the launch date, to test all mission planning procedures.

**Scanning observing mode:** Details of a special scanning observing mode, permitting the observation of rectangular areas, extending up to 12.5 degrees in either direction, are currently under discussion with the Russian SRG team.

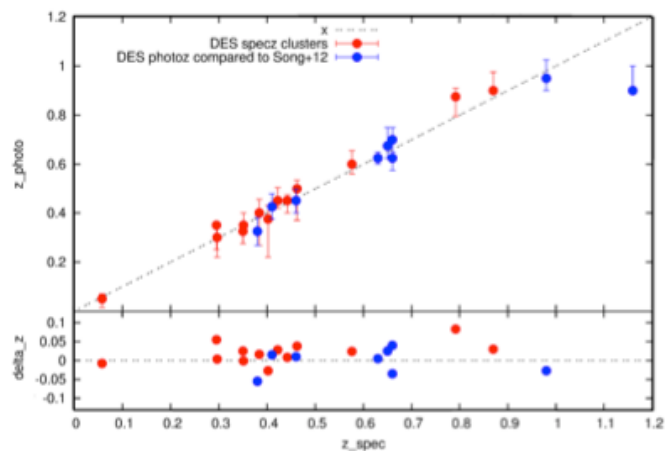
## 4. Multi-wavelength surveys and follow-up preparation

**Dark Energy Survey underway:** Last fall the commissioning and science verification (SV) of DECam, a new 570 Mpix camera on the Blanco 4m on Cerro Tololo in Chile, began. DECam will be used by the Dark Energy Survey (DES) over the coming five years to survey 5000 deg<sup>2</sup> of southern sky (mostly German eROSITA sky). The SV data cover a few hundred square degrees of sky, are all public, and provide the opportunity for a first look at the kind of data we can expect for cluster and AGN followup in the eROSITA survey.

At LMU Dr. Shantanu Desai has processed and calibrated approximately 150 deg<sup>2</sup> of the SV data that overlap the South Pole Telescope (SPT) survey. The delivered seeing peaks at around 1", consistent with the results of the 60 night Blanco Cosmology Survey at CTIO (Desai et al 2012); however, the DES goal is to push the median seeing to 0.8" through a series of efforts including improved guiding and active cooling of the primary mirror.

On the good news side, the photometric quality of the data from our LMU processing system is exquisite. The co-add images constructed from approximately 10 layers of imaging in each band are beautiful (see back cover image), and the photometric accuracy of the catalogs is impressive at this early stage. We are analyzing the stellar locus. Its location is an indicator that the photometric calibration is accurate, and it's scatter is an indicator of the photometric noise. Median scatter about the stellar locus for our SV reductions is 3% in g-r vs r-i and 2% in r-i vs i-z, notably smaller than the characteristic scatter of 4% and 5% in SDSS. In addition, we have carried out photometric repeatability analyses, which test the stability of the photometry during the ~10 visits per band on each object. These analyses indicate a systematic floor in the photometry of 0.7% to 0.85%, already quite good. Dr. K. Paech has detected persistent illumination-like errors that have characteristic scales of 0.5% to 0.7%. By correcting these we expect to reduce the systematic floor in the photometry to below 0.5%.

C. Hennig is using these data to explore the galaxy populations in about 50 SPT selected clusters. The Figure on the right shows initial galaxy cluster red sequence redshifts for a subset of SPT clusters that have spectroscopic redshifts or photo-z's published in Song et al



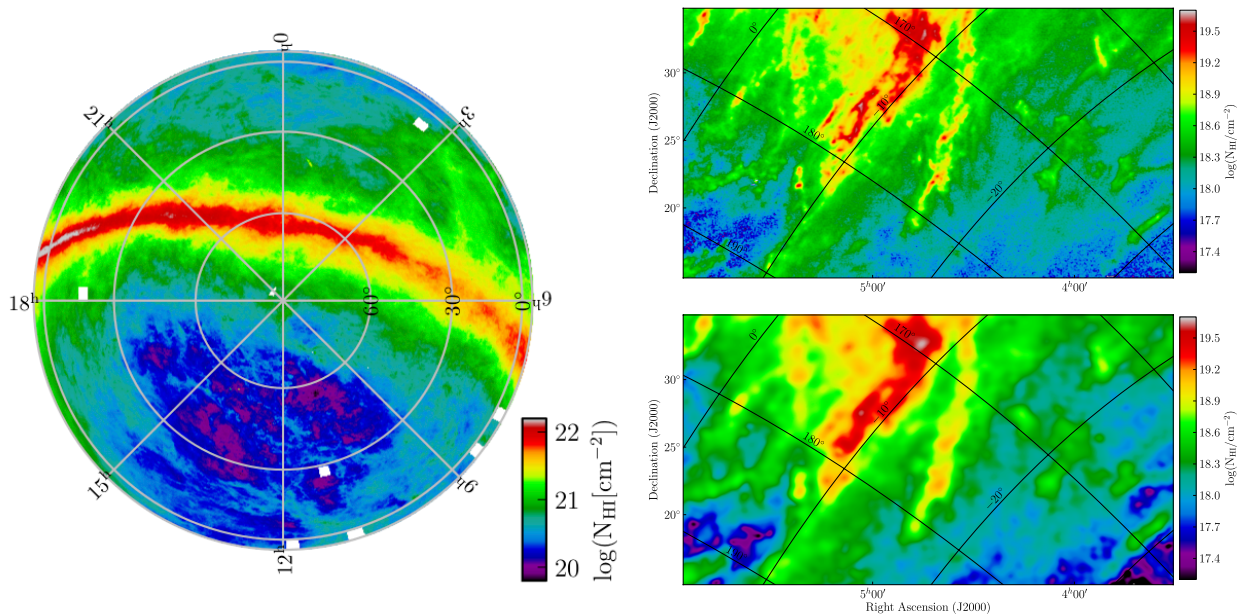
*Photometric redshift accuracy for red-sequence galaxies in SPT-selected clusters observed by DES.*



(2012). Christina's automated redshift measurement tool is performing quite well with griz data out to  $z \sim 1$ , an excellent test in preparation for the eROSITA selected cluster and group sample.

In summary, the official DES survey will begin next September 2013 and continue for 525 nights through early 2018. The SV data are quite encouraging in terms of photometric and imaging quality, and efforts continue to improve upon these initial results. The first eROSITA-like cluster studies are already underway using the SV data so that we will be in a position to move quickly toward eROSITA science soon after launch!

**New  $N_{\text{H}}$  maps from EBHIS:** A team of scientists led by J. Kerp, from the Argelander-Institut für Astronomie (Bonn), in collaboration with the Max-Planck-Institut für Radioastronomie have completed a new map of the neutral Hydrogen (HI) content of the Milky Way, the Effelsberg-Bonn HI Survey (EBHIS). EBHIS will serve as major source of information on the  $N_{\text{H}}$  across the whole sky, and thus will be critical for the analysis of the eROSITA all-sky survey. Column density maps and derived products will become available in 2013. The figure below shows the full  $N_{\text{H}}$  map from EBHIS, as well as the improvement with respect to the LAB (Kalberla et al. 2005, A&A 440, 775) in a portion of the galactic anti center.



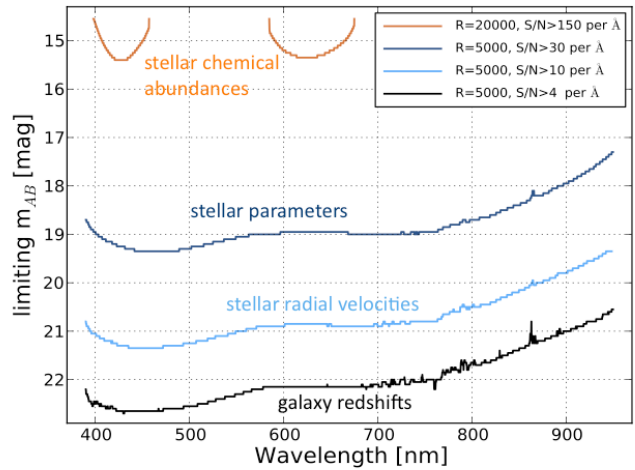
**LEFT:** All-sky HI column density map of the northern hemisphere obtained by EBHIS. **RIGHT:** A detailed comparison between EBHIS (top) and LAB (bottom)  $N_{\text{H}}$  maps of a region near the galactic anti-center.

**4MOST:** 4MOST is a wide-area, high multiplex multi-object spectroscopic (MOS) survey facility for ESO's 4m-class VISTA telescope, aiming to fill the MOS instrument need indicated in several European strategic documents. MOS facilities are required in particular to complement upcoming space missions (Gaia, eROSITA, Euclid) and ground-based projects (e.g., LSST, SKA). 4MOST has been going through a Phase A study in the last 1.5 years, concluded with a Conceptual Design Review that took place at ESO on March 5th. The 4MOST project office, including representatives of MPE and of the eROSITA follow-up survey teams, presented a strong case for the powerful multi-object optical spectrograph that will start surveying the southern skies after installation on VISTA at Paranal in 2019. Based on the study documents and the review, the ESO Review Board has recommended to ESO's Science Technical Committee (STC) to implement both 4MOST and MOONS (a Near-IR MOS instrument for the VLT). The STC is expected to support this recommendation, after which the ESO Council will need to confirm it officially on June 5-6, 2013. If all goes well

4MOST will go in full Preliminary Design phase in early 2014 and start operations in the fall of 2019.

A systematic follow-up of eROSITA Clusters and AGN over a large fraction of the German eROSITA sky represents, together with the follow-up of Gaia stars in the Milky Way, the backbone of the planned 4MOST surveys. A detailed 4MOST facility simulator was created at MPE to test the feasibility of these combined science cases. The expected sensitivity of the instrument is shown in the figure below, indicating that redshifts can be obtained to about the 22 AB-mag (somewhat less at high redshift).

These throughput sensitivities were used to simulate the expected 4MOST return for a 5-year full-time survey running seven science cases in parallel. A fibre-to-target allocation example for one hexagonal field-of-view is shown below on the left. The central figure shows the total sky coverage and number of 20 min exposures per pointing after 5 years. The table on the right shows the number of targets successfully observed after 5 years, including 1.4 million galaxies in 50,000 X-ray clusters and 700,000 AGN.



**4MOST sensitivity for four typical science cases for a 1-hour exposure during new moon and seeing FWHM=1.1'' (90%-tile).**

## 4 4MOST– 4-metre Multi-Object Spectroscopic Telescope

### Survey simulations

#### Highly efficient fibre assignment

- High- and low-resolution spectra in parallel
- Positioner with large patrol area for fibres: high fibre-target allocation efficiency at least 5 targets in 2 arcmin diameter area

#### Sky coverage after a 5 year survey

- Near full southern sky coverage with two visits of 3x20 min each
- More visits available for special areas: bulge, LMC/SMC, deep fields

#### Targets completed after a 5 year survey

Science case	S/N per Å	$r_{AB}$ mags	Targets (Millions)
MW halo HR	140	12–15.5	0.07
MW halo LR	10	16–20.0	1.5
MW disk/bulge HR	140	14–15.5	2.1
MW disk/bulge LR	10–30	14–18.5	10.7
X-ray galaxy clusters	4	18–22.0	1.4
X-ray AGN	4	18–22.0	0.7
BAO galaxies	4	20–22.5	12.8
<b>Total</b>			<b>&gt;27</b>

## 5. Recent bibliography

**5.1 Scientific papers** appeared since the last bulletin containing the word “eROSITA” in their abstract in the period November 2012-April 2013 (from ADS):

- **Schafieloo et al.**, *Searching for systematics in SNIa and galaxy cluster data using the cosmic duality relation*, eprint arXiv:1212.1277
- **Kolodzig, et al.**, *AGN and QSOs in the eROSITA All-Sky Survey -- Part I: Statistical properties*, A&A, submitted. arXiv: 1212.2151

- **Hill & Pajer**, *Cosmology from the Thermal Sunyaev-Zel'dovich Power Spectrum: Primordial non-Gaussianity and Massive Neutrinos*. PRD, submitted. arXiv:1303.4726
- **Tanaka**, *Recurring flares from supermassive black hole binaries: implications for tidal disruption candidates and OJ 287*, MNRAS, submitted. arXiv:1303.6279
- **Khabibullin, Sazonov & Sunyaev**: *SRG/eROSITA prospects for the detection of stellar tidal disruption flares*, MNRAS, submitted. arXiv:1304.3376

## 6. Upcoming meetings and events

**German eROSITA Consortium Meeting:** MPE, Garching, October 14-16, 2013

**Compact Objects WG Meeting:** Potsdam, June 11-12, 2013 (Contact: [aschwoppe@aip.de](mailto:aschwoppe@aip.de))

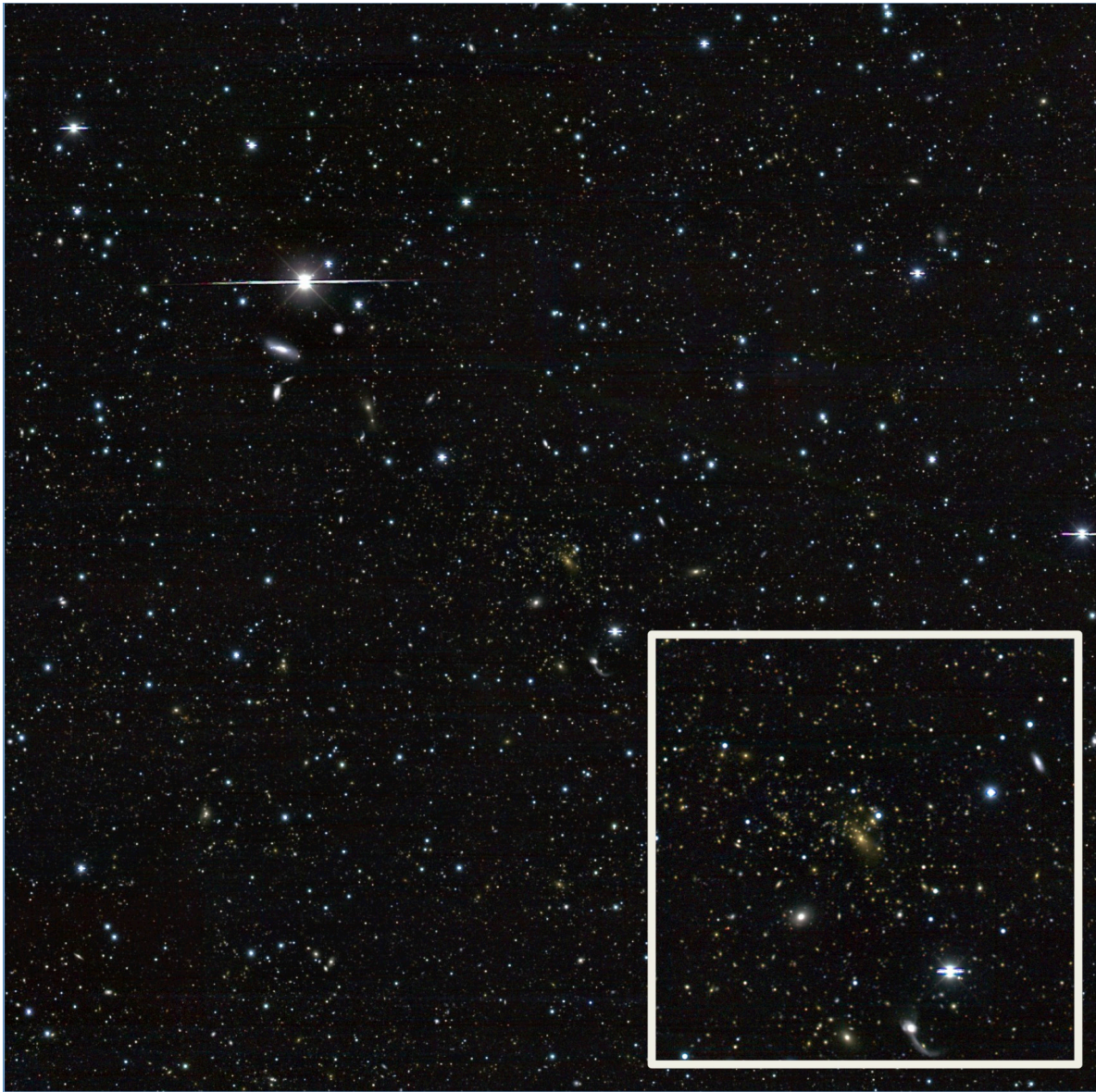
**Clusters WG Meeting:** Bonn, June 13-14, 2013 (Contact: [reiprich@astro.uni-bonn.de](mailto:reiprich@astro.uni-bonn.de))

**Joint Follow-up-Catalog WG meeting:** A face-to-face joint meeting of the follow-up and catalog Working Groups is in the planning for late June/July at LMU, Munich. Representatives of all Scientific Working Groups are expected to contribute to this critical assessment of the plans for collation, curation and analysis of the multi-wavelength catalogs (galactic and extragalactic) necessary for an efficient follow-up of the eROSITA all-sky survey [Contact: J. Mohr, LMU and H. Brunner, MPE].

### Meetings of General Interest (June 2013 - November 2013; from CADC):

- **EPFL, Lausanne, Switzerland**, June 24-26, 2013: *More than the sum of all parts: complementarity of cosmological probes*
- **Sexten (Dolomites), BZ, Italy**, July 1-6, 2013: *Sesto 2013: Tracing Cosmic Evolution with Clusters of Galaxies*
- **Turku, Finland**, July 8-9, 2013: *EWASS 2013, Symposium 2: The physics of accretion on compact objects: a multi-messenger approach*
- **Turku, Finland**, July 10-11, 2013: *EWASS 2013, Symposium 8: Deaths of massive stars as supernovae and gamma-ray bursts*
- **Turku, Finland**, July 10-11, 2013: *EWASS 2013, Symposium 9: Extreme physics of neutron stars*
- **Turku, Finland**, July 10-11, 2013: *EWASS 2013, Symposium 10: The co-Evolution of Black Holes and Galaxies*
- **Durham University, England**, July 22-26, 2013: *Ripples in the Cosmos*
- **Heidelberg, Max Planck Haus**, July 23-26, 2013: *High Energy Phenomena in Relativistic Outflows*
- **KITP, UC Santa Barbara, USA**, August 5-9, 2013: *Massive Black Holes: Birth, Growth and Impact*
- **Brindisi, Italy**, September 2-6, 2013: *Black Hole (g)Astronomy: exploring the different flavors of accretion*
- **Institute of Astronomy, University of Cambridge, UK**, September 9-12, 2013: *LSST@Europe: The Path to Science*
- **Heidelberg, Germany**, September 9-13, 2013: *IMPRS Summerschool on High Energy Astrophysics*
- **Santorini, Greece**, September 15-20, 2013: *Explosive Transients: Lighthouses of the Universe*
- **Oxford, UK**, September 16-18, 2013: *Synergistic Science with Euclid and the SKA*
- **Ioannina, Greece**, September 16-18, 2013: *Black Holes at all scales*
- **Tübingen, Germany**, September 24-27, 2013: *Fall Meeting of the Astronomische Gesellschaft*
- **Byurakan, Armenia**, October, 7-11, 2013: *Multiwavelength AGN Surveys and Studies*
- **Kyoto, Japan**, October, 15-16, 2013: *Supernovae and Gamma-ray bursts 2013*
- **Santa Fe, NM, USA**, November 13 - 15, 2013: *Hot-wiring the Transient Universe III*





*A 47'x47' wide field DES image centered on the Cluster SPT-CLJ0438-5419 ( $z_{\text{phot}}=0.42$ ). The inset shows a zoom on the cluster itself.*

## IMPRINT

**Realisation:** A. Merloni

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