eROSITA Event Simulator

Christian Schmid[1], Thorsten Brand[1],
Hermann Brunner[2], Nicolas Clerc[2], Fabrizia Guglielmetti[2],
Ingo Kreykenbohm[1], Matthias Kühnel[1], Michael Wille[1], Jörn Wilms[1]

[1] Dr. Remeis-Observatory & Erlangen Centre for Astroparticle Physics, Germany
[2] Max Planck Institute for Extraterrestrial Physics, Germany

e-mail: christian.schmid@sternwarte.uni-erlangen.de

Abstract

We present an instrument simulation toolkit for eROSITA. It comprises the most relevant telescope and detector characteristics by applying specific calibration data, such as the PSF and RMF. The simulation software processes a set of predefined X-ray sources stored in the SIMPUT format and produces an event file for the particular observation setup. Thereby it takes into account the motion of the telescope during the all-sky survey.

The simulated data can be used to study the performance of the instrument and to develop and verify data analysis software. We present examples demonstrating the capabilities of the simulation software. For fast and easy access to simulations we provide a web interface.

Science with eROSITA and ART-XC aboard *Spectrum-RG*, 3rd – 7th of September 2012, Kazan, Russia

Simulation Software

We have developed a generic simulation software for X-ray telescopes with pixelized detectors. The software package is written in C and implements a common interface by using the APE/PIL library for parameter input and standard FITS files for data access. It contains models for different instruments such as the framestore pn-CCDs of eROSITA, and it can be easily extended for other detectors. For instance, we can also simulate *ATHENA*, *LOFT*, or the EPIC-pn camera on *XMM-Newton*.

The simulation is set up as a pipeline of the relevant tasks such as the generation of a sample of X-ray photons, the imaging process in a Wolter telescope, and the photon detection by the respective detector. Individual tools in this pipeline can be replaced easily to adjust the simulation to different missions. The instrument characteristics like the mirror and detector properties are defined by standard calibration files, such as the PSF, vignetting, ARF, and RMF. The X-ray sources used as input for the simulation are defined according to the SIMPUT file format.
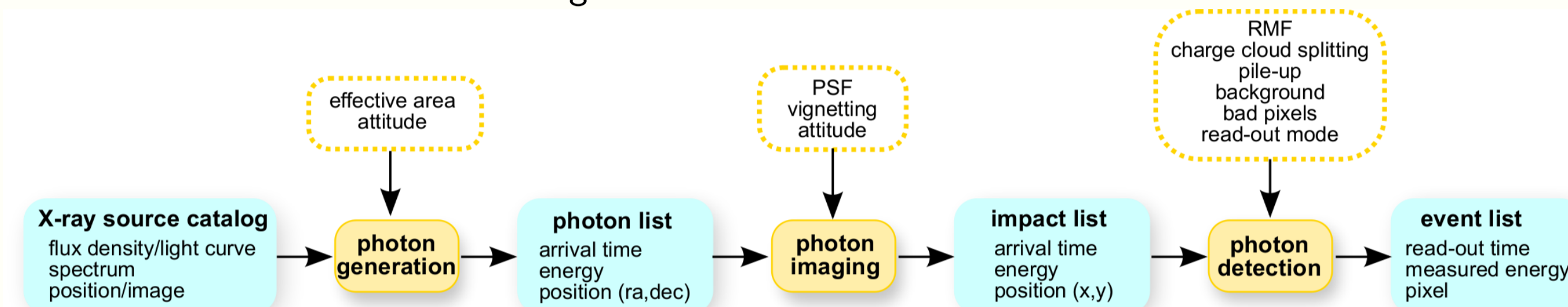
In order to provide fast and easy access to the simulation software, we have developed a web interface.

SIMPUT File Format

The SIMulation inPUT (SIMPUT) file format can be used to define sources as input for simulated observations. A SIMPUT file contains a catalog with one or multiple sources, which are described by specific properties such as position, brightness, and energy spectrum, as well as optional characteristics such as time variability, polarization, and spatial extent.

SRC_ID	RA	DEC	E_MIN	E_MAX	FLUX	SPECTRUM	IMAGE	LIGHTCUR
J	E	E	D	D	D	9A	8A	4A
	deg	deg	keV	keV	erg/s/cm**2			
Modify	Modify	Modify	Modify	Modify	Modify	Modify	Modify	Modify
1	2.664168E+02	-2.900781E+01	1.000000000000E+00	3.000000000000E+00	2.201472536489E-10	[SPEC0,1]	[IM00,1]	[LIGHTCUR0,1]
2	2.664168E+02	-2.900781E+01	3.000000000000E+00	5.000000000000E+00	2.928009771413E-10	[SPEC1,1]	[IM01,1]	[LIGHTCUR1,1]
3	2.664168E+02	-2.900781E+01	5.000000000000E+00	8.000000000000E+00	1.127028265459E-09	[SPEC2,1]	[IM02,1]	[LIGHTCUR2,1]

Spectrum **Image** **Lightcurve**
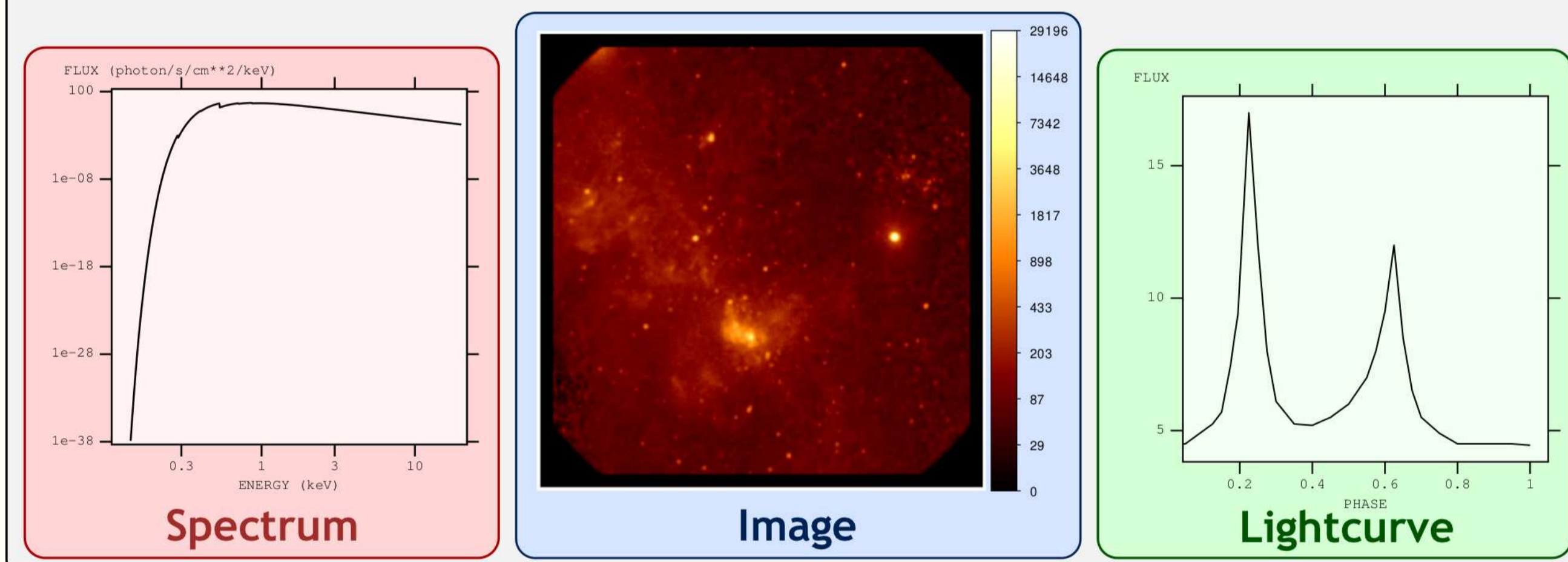
The file format defines a common basis to exchange data between different software packages and scientific groups. It was developed in particular for the simulation of X-ray telescopes, but can also be used in different wavelength domains. A formal description can be found here:
http://hea-www.harvard.edu/HEASARC/formats/simput-1.0.0.pdf

AGN Catalog

For virtual observations, as described on the left-hand side, we have developed a program which generates a source catalog in the SIMPUT file format filled with AGN. To achieve this, the light cone up to a given redshift is filled with point sources according to distributions as measured in real observations. Thereby, spatial density and intrinsic luminosity are correlated with distance, a fact that is commonly described by the X-ray Luminosity Function (XLF, Ueda et al., 2003).
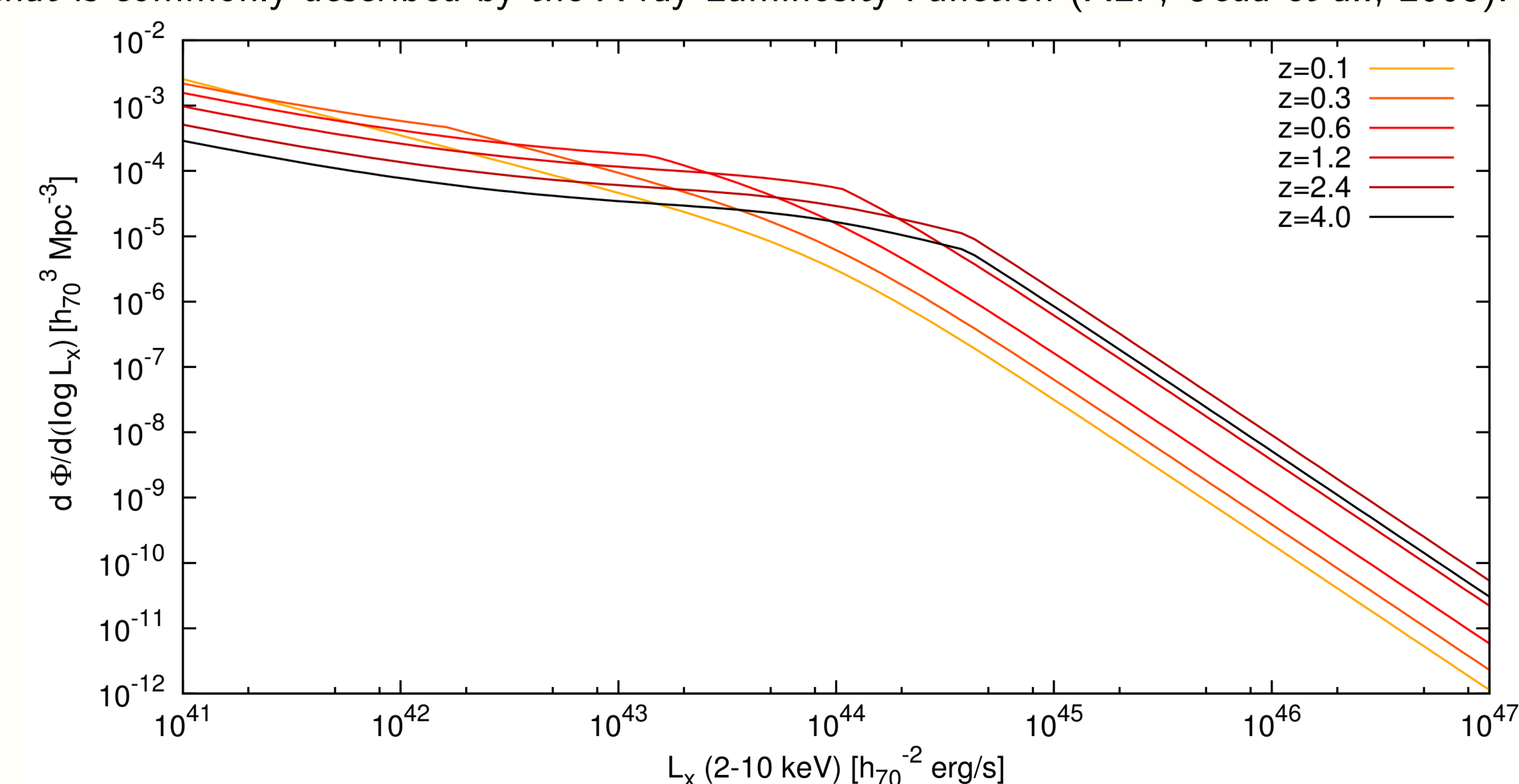
The XLF for various values of redshift as used for our simulation.

The "raw" central engines are then built into realistic environments, each consisting of a dust torus and a reflecting accretion disk. This results in a broad variety of X-ray spectra. The single parameters such as column density and spectral index are set randomly with probabilities taken from recent publications (Gilli et al., 2007). The initially generated intrinsic luminosity is then absorbed and converted into the brightness as seen on earth, before the sources are stowed in the catalog.

Light Cone Simulations

We have simulated observations of small $3.6° \times 3.6°$ fields of the sky populated with galaxy clusters and AGN. The cluster input data are provided by F. Pace and M. Roncarelli in the form of 2-dimensional surface brightness maps in 146 different energy bins covering a range from $0.2–10\,\mathrm{keV}$. They are obtained from cosmological hydrodynamical simulations. The composition of the AGN input catalog is described in the box on the left-hand side. Detector background caused by cosmic ray protons is modelled according to a GEANT4 simulation by Tenzer et al. (2010).
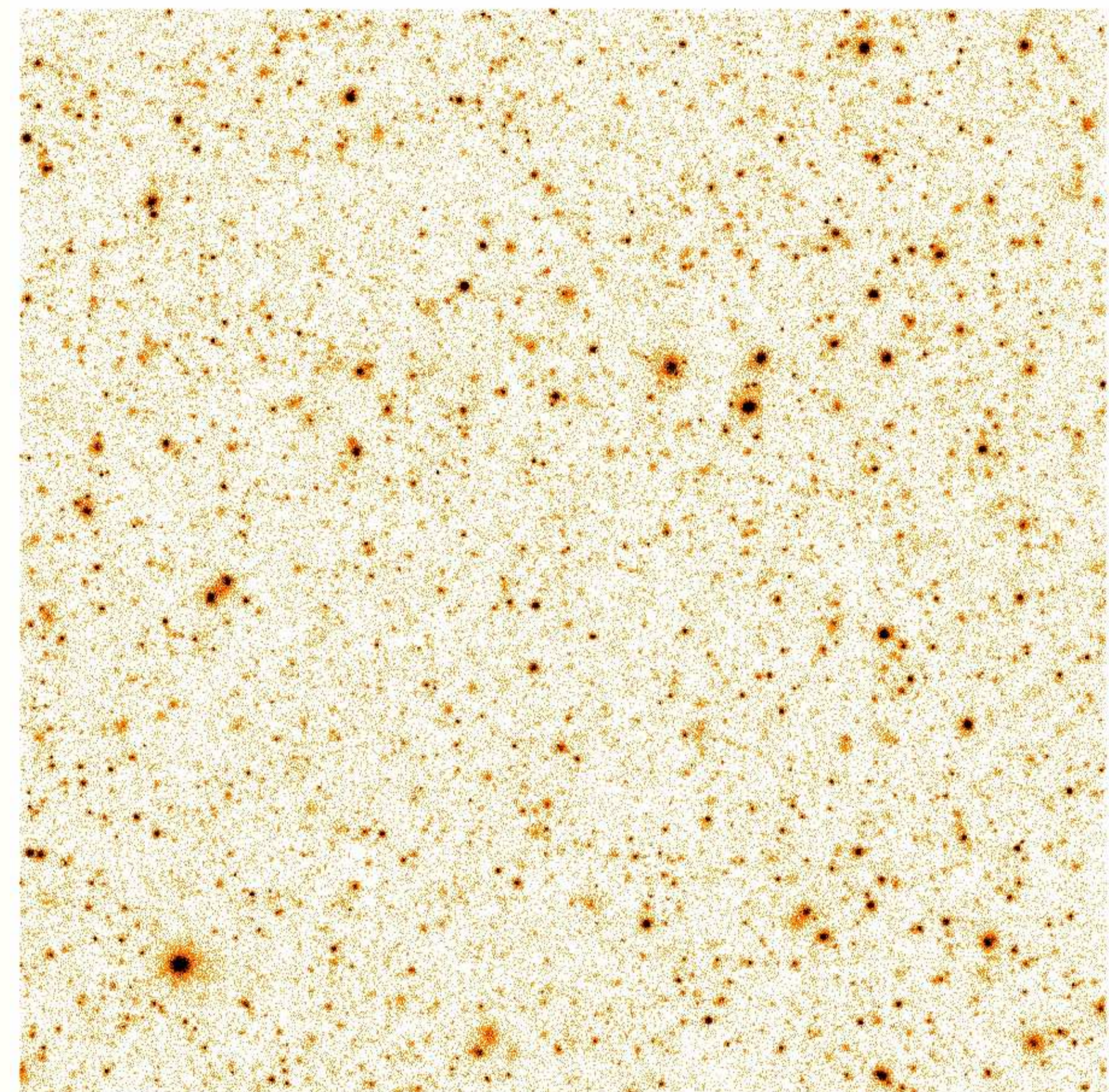
Simulated image of a light cone located at the survey equator after 4 years of all-sky survey.

Simulations via the Web

For fast and easy access to simulations we provide a web interface. It is ideal to obtain an estimated view of a particular source with eROSITA. A simple simulation can be run with a few clicks.

Selection of telescope attitude:
- eROSITA All-Sky Survey (eRASS)
- pointed observation
- specific attitude

Selection of several input source components (SIMPUT)

Selection of data products:
- event file
- image
- visibility intervals
- exposure map
- calibration files (PSF, vignetting, ARF, RMF)

The web interface is publicly accessible at the following address:
http://cetus.sternwarte.uni-erlangen.de/~erosim/

References & Acknowledgments

Gilli R. et al., 2007, A&A 463, 79
Roncarelli M. et al., 2006, MNRAS 368, 74
Schmid C. et al., 2011, SIMPUT, tech. report
Schmid C., 2012, PhD thesis
Tenzer C. et al., 2010, Proc. of SPIE 7742, 0Y
Ueda Y. et al., 2003, ApJ 598, 886

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS