The LAD Event Simulator

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Abstract

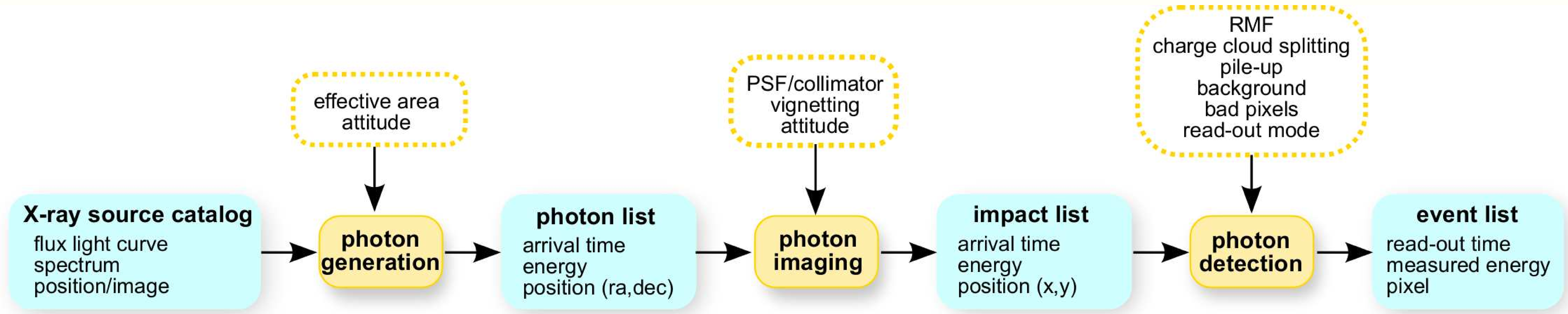
We present a Monte Carlo simulation software tool for the *LOFT* LAD. The software produces a sample of photons based on a given source specification and processes these photons through the instrument model consisting of a collimator and a detector component. The source specification is based on the so-called SIMPUT file format, which provides powerful means to describe various kinds of astronomical objects in a mission-independent way.

The simulation toolkit provides realistic estimates for observations of particular sources and enables the investigation of instrument-specific effects such as the dead time properties of the detector. The event files produced by the detector model can be used as a substitute for real observation data for software development and testing. For easy access we provide a web interface to the simulation software (http://cetus.sternwarte.uni-erlangen.de/~loftsim/).

Simulation Software

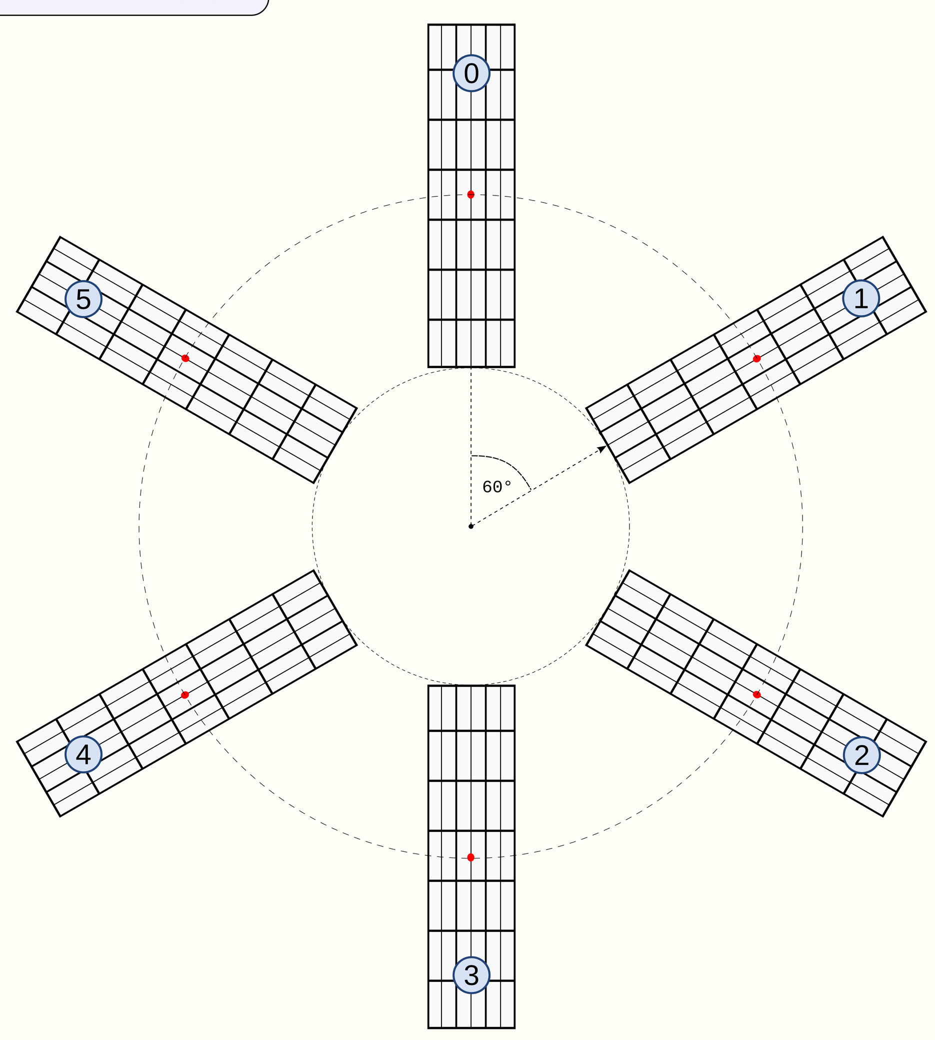
We have developed a Monte Carlo simulation toolkit for the LAD on *LOFT*. The software is based on a generic package, which has originally been established for eROSITA on *SRG* and *IXO*/*Athena*. The software has actually been designed for imaging instruments with pixelized detectors, however we have extended its functionality in order to be suitable for the LAD.
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 Wide Field Imager (WFI) and the X-ray Microcalorimeter Spectrometer (XMS) on *Athena*, the framestore pn-CCDs on eROSITA, or the EPIC-pn camera on *XMM-Newton*. The model implemented for the LAD is presented in the box below.

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 or the absorption of photons by a collimator, 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 such as the optics and detector properties are defined by standard calibration files, such as a PSF and vignetting function (for imaging instruments) and an ARF and RMF. The pointing direction of the telescope is specified in a particular attitude file.
As input data for the simulation appropriate models of astronomical X-ray sources have to be provided. For that purpose we use the SIMPUT file format described on the poster by M. Wille et al.



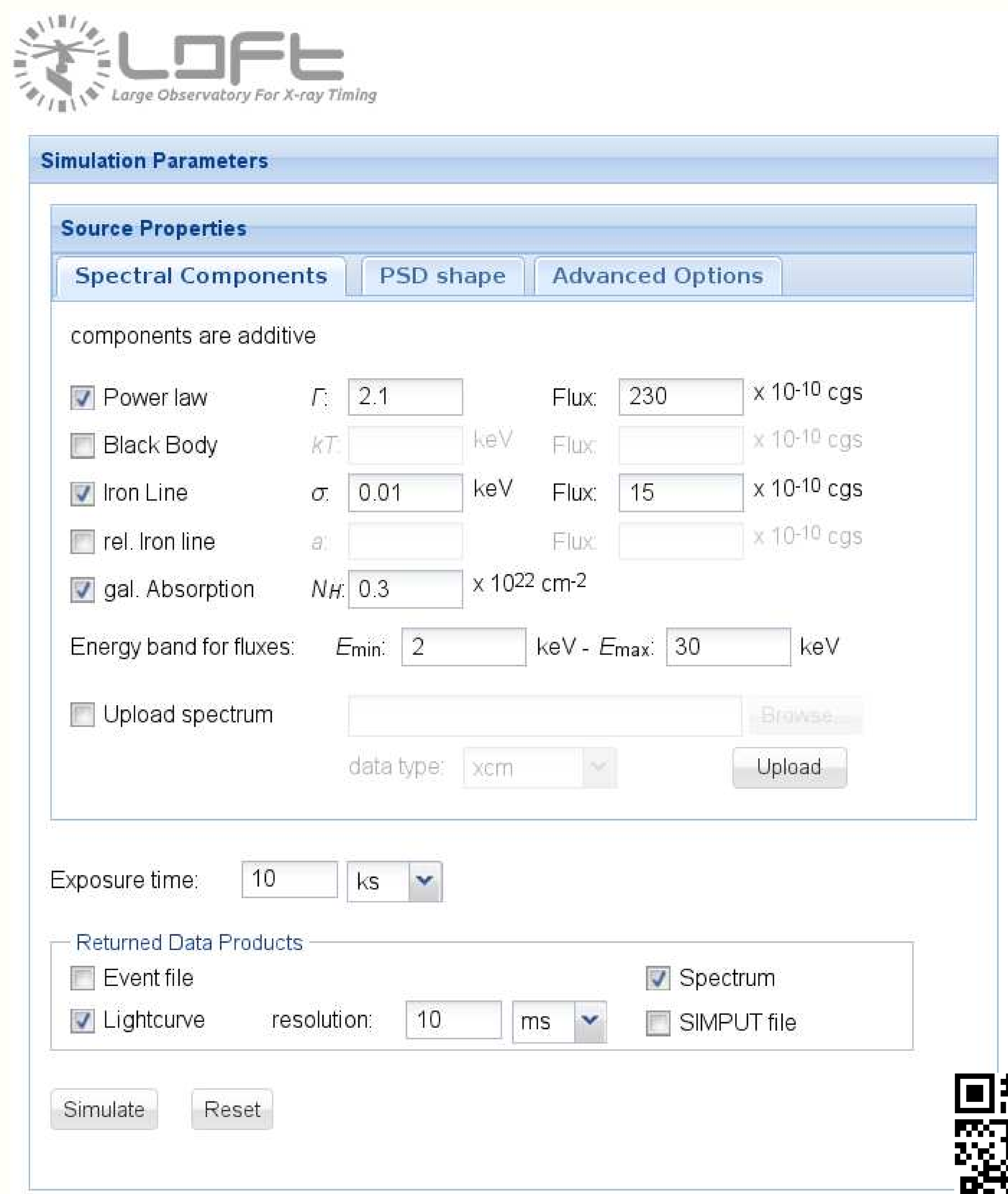
LAD Model

Our model of the LAD consists of the 6 instrument panels. Each of them contains 21 modules with 16 Silicon Drift Detector (SDD) elements per module. Each SDD element has 224 anodes to read out the collected charge.
The illumination of the detector model is determined by the collimator model in front of the LAD panels, i.e. the impact positions of the individual photons are based on the distribution of holes in the collimator. Depending on the impact position the spread of the charge cloud produced by a photon in the SDD and the corresponding signal at the respective anodes is calculated according to the model presented by Campana et al. (2011). The signal processing by the FEE is modelled in a simplified way in order to analyse phenomena such as dead time effects or pile-up.
The configuration of the LAD model can be modified easily in the simulation in order to investigate different instrument setups.



Web Interface

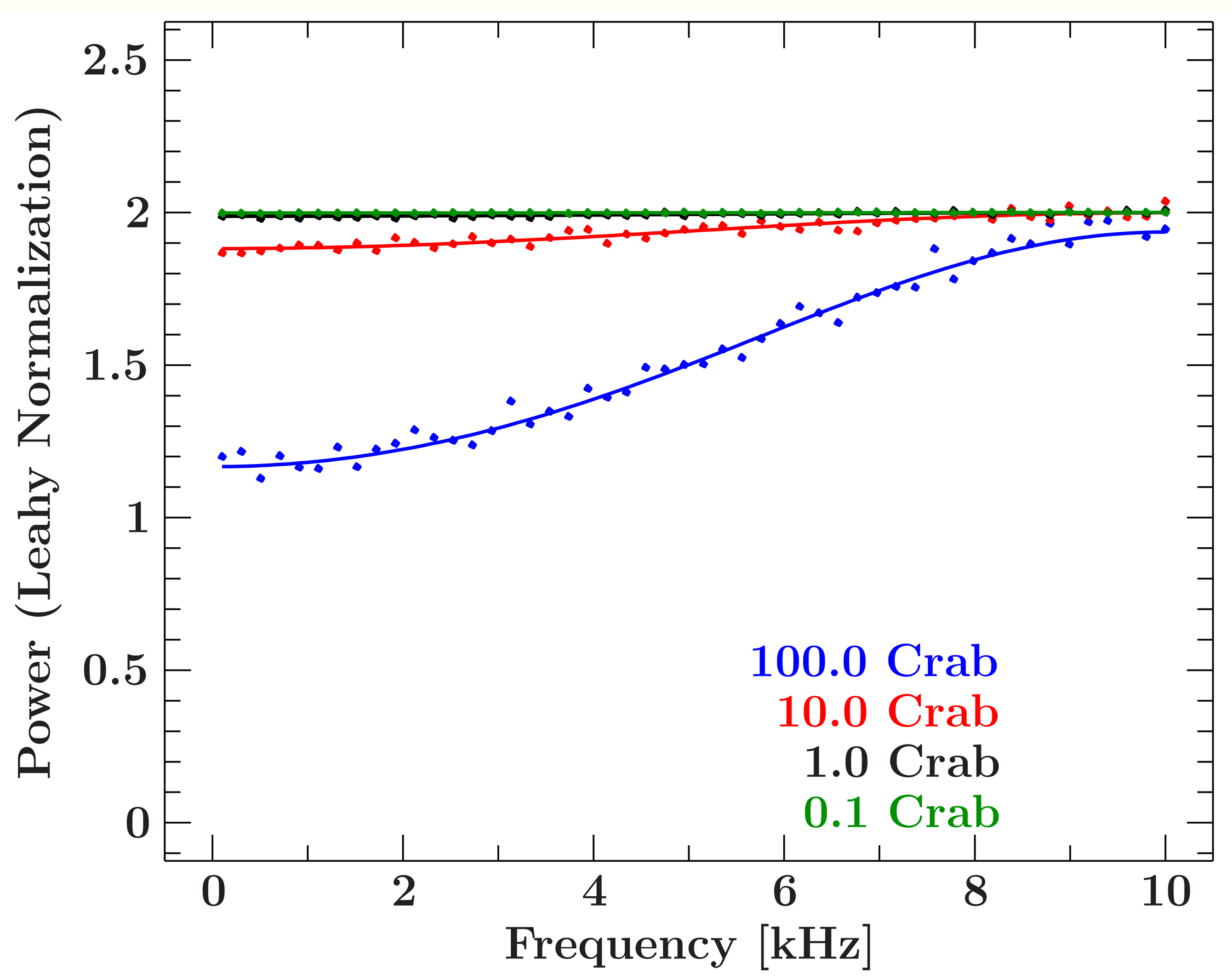
For quick access to simulations we provide a web interface for our model of the LAD. It allows to define a model of a point-like source with an energy spectrum assembled from different components and an optional time-variability. Alternatively, the user can also upload a SIMPUT file with a more sophisticated source definition. It is possible to select among various data products, such as an event file, a spectrum, a light curve, or the SIMPUT file with the source definition, which are delivered by the web application. With this functionality it is easy to see, how a particular source looks like with the LAD.



http://cetus.sternwarte.uni-erlangen.de/~loftsim/

Dead Time Analysis

Due to the implemented approach, the simulation software allows the investigation of detector-specific features such as dead time effects. The plot below displays a power spectrum in comparison between an analytical dead time model (according to Zhang et al., 1995) and the corresponding simulations. Both data sets exhibit the same features at high count rates induced by dead time.



For a detailed analysis additional complicated effects have to be included in the analysis, which lie beyond the scope of an analytical model.

Source Catalogs

As input data for simulations we have assembled various source catalogs stored in separate SIMPUT files (see the poster by M. Wille et al.). The sources in the catalogs are partly taken from real observations, partly they are generated according to common models for source distributions.
The most frequently used SIMPUT catalogs are the *ROSAT* All-Sky Surveys (BSC & FSC), a catalog of synthetic AGN (modelling the Cosmic X-ray Background (CXB) according to Gilli et al. 2007), a model of the Crab (composed of a spectrum of the nebula and the pulsar with the characteristic time-variability of the pulsar), a catalog with ASM (*RXTE*) sources (mainly for long-term time-variability studies for the WFM), a catalog with X-ray pulsars, a catalog with synthetic galaxy clusters (according to Tinker et al. 2008 and Vikhlinin et al. 2009), and several SIMPUT files for local fields such as the Galactic Center region and the *Chandra* Deep Field South.

References & Acknowledgements

FAU Friedrich-Alexander Universität Erlangen-Nürnberg

Campana R. et al., 2011, NIMPA 633, 22
Feroci M. et al., 2011, ExA, Online First, 100
Gilli R. et al., 2007, A&A 463, 79
Schmid C. et al., 2011, "SIMPUT", tech. report
Schmid C., 2012, PhD thesis
Tinker et al. 2008, ApJ 688, 709
Vikhlinin et al., 2009, ApJ 692, 1033
Zhang et al., 1995, ApJ 449, 930

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