



REALTA – MEGAlib's Real-time Analysis Tool for Gamma-ray Detectors



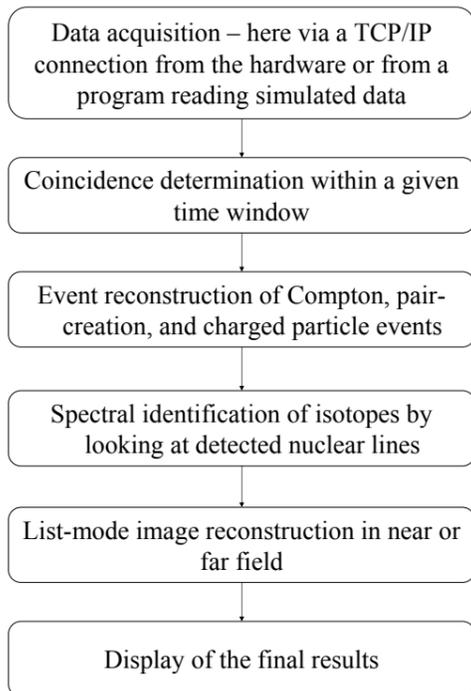
Andreas Zoglauer (UCB), Michelle Galloway (UCB), Mark Amman (LBNL), Steven E. Boggs (UCB)

Overview

REALTA is the REAL-Time Analyzer of MEGAlib [1], a software tool to simulate and analyze the data from soft-to-medium energy gamma-ray detectors in space and on ground. Realta encompasses the complete analysis path from coincidence determination, Compton event reconstruction, event selection, image reconstruction, and spectral identification. Realta is highly multi-threaded to fully utilize today's multi-core CPU's and to enable real-time processing. Taking advantage of the versatility of MEGAlib, Realta can be applied to a wide variety of gamma-ray detectors (e.g. pixel detectors, strip detectors, scintillators) and measurement scenarios (near field 2D and 3D, far field). Realta & MEGAlib are open source, freely available, written in C++, and based on ROOT [2].

The Data Flow

The data of an imaging gamma-ray detector needs to pass through several analysis steps, which are all reproduced within Realta, each in its own analysis thread:



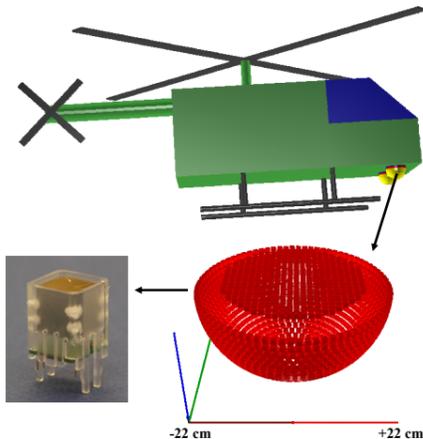
Internally, all event data is stored in one class which in turn is stored in a thread-safe double-linked list, which allows concurrent adding, sorting, and deleting of elements. Each thread only adds newly generated information to the event (e.g. a new response slice for image reconstruction) and sets flags that this event has been processed by it. The next thread waits until this flag is set before it reads and processes the data. This way, no mutex needs to guard the data, and efficient, multi-threaded data handling is achieved.

Geometry

Realta uses MEGAlib's universal geometry and detector library Geomega [4]. It provides:

- Various detector types: strip detectors, voxel detectors, scintillators etc.
- A sophisticated detector effects engine including energy, position, time resolutions, noise and trigger thresholds, ADC overflows, etc.
- Complex trigger and veto criteria

The geometry is described in an object-oriented ASCII file format, which provides advanced features such as constants, math functions, for-loops, if conditions, matrices, etc. to simplify constructing a geometry. For example, the arrangement of detectors to the right only required two for-loops.

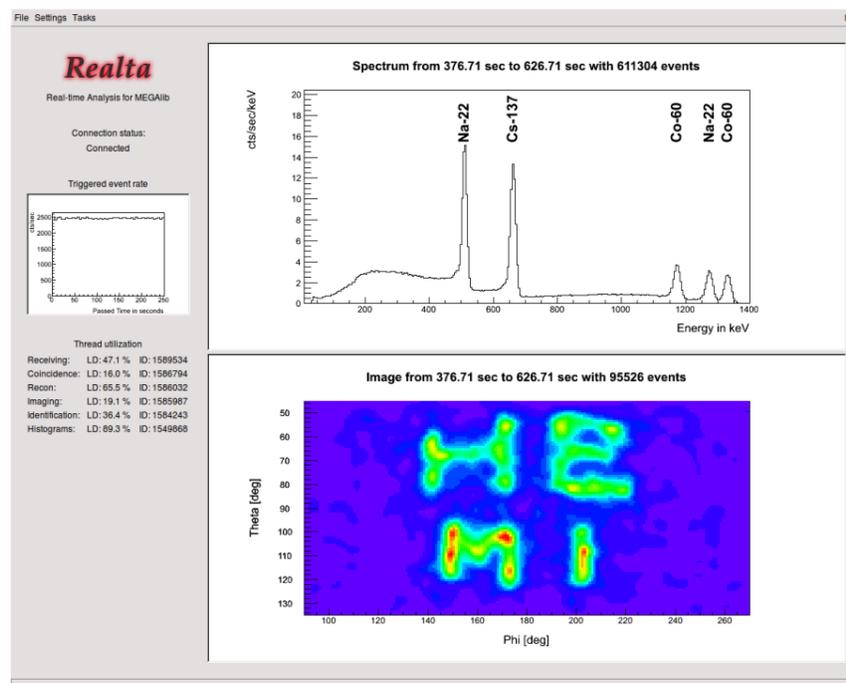


Example geometry constructed with MEGAlib's Geomega tool which is used for the Realta analysis: This helicopter version of HEMI [5] consists of ~2000 1-cm³ CZT detectors on half-spherical geometry are mounted on a helicopter platform for nuclear surveillance. For more details about HEMI see the talk of M. Galloway: N23-3

Data Input

In order to decouple data acquisition and data analysis, and to enable remote analysis, Realta receives its input data via a simple TCP/IP interface. The user only has to specify host (or IP address) and port. The data is transferred in a simple ASCII format containing position, energy, and time of the event. Since data calibration is usually very specific to a given detector system and Realta aims to be a universal analysis tool, the transferred data has to be calibrated.

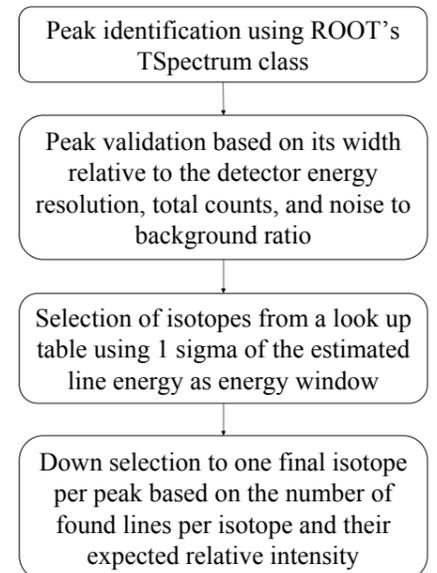
The Realta UI



The main Realta user interface with the three main histograms: The rate of triggered events, the detected spectrum, and the reconstructed image. In addition, a table giving the utilization of the individual thread can be seen. The full set of MEGAlib's event reconstruction, image reconstruction, and event selection options is accessible via the Settings menu, while the Tasks menu allows to start, stop, and reset the analysis. The example spectrum and image is a simulation using the HEMI [5] helicopter version (see N23-3 for more details) hovering 25 m above the "writing" and shows only Compton-scatter events with at least 10 cm distance between the interactions.

Spectral ID

Nuclear threat detection applications require the instantaneous identification of radioactive elements. Realta uses MEGAlib's Spectralyzer tool [3] to accomplish this in the following steps:



Imaging

Realta is also using MEGAlib's imaging library Mimrec [6], which generated the image to the left. Within Realta one can:

- Perform event selections on all performance-relevant parameters of single-site, Compton and pair events (e.g. energies, interaction distances, scatter or opening angles, etc.)
- Perform list-mode likelihood image reconstruction in spherical, Galactic, as well as Cartesian coordinates (2D, 3D) including different response calculation approaches

Event Reconstruction

Event reconstruction in Realta consists of two parts: coincidence determination and event reconstruction.

The coincidence thread sorts all incoming hits within a given sorting time window by time and combines those within the coincidence time window into one event.

A second thread then searches for charged particle, pair creation and Compton event signatures and determines the parameters of the found event type (e.g. Compton, pair, etc.).

A wide variety of different reconstructions options is available for Compton scatter events such as different variants of the classic Compton sequence reconstruction and Bayesian event reconstruction as well as electron tracking options.

For more information and for instructions on how to checkout the source code from cvs, please visit the MEGAlib website:



www.mpe.mpg.de/MEGA/megalib.html

Or google "MEGAlib"

References: [1] Zoglauer et al., NewAR 50 (pp. 629) , 2006 [2] Brun & Rademakers, NIM A, 389, 1997 [3] Galloway et al., NSS conf. rec. 2009

[4] Zoglauer et al., NSS conf. rec. 2009 [5] Amman et al., NSS conf. rec. 2009 [6] Zoglauer et al., NIM A, 652, 2011

Acknowledgements:

Part of this work was supported by the U.S. Department of Homeland Security, Domestic Nuclear Detection Office, under Interagency Agreement HSHQDC-08-X-00832 and by the U.S. Department of Energy, Office of Science, under Contract DE-AC02-05CH11231.