BoGEMMS simulation of the AGILE telescope: status and preliminary results

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ABSTRACT

BoGEMMS (Bologna Geant4 Multi-Mission Simulator [1]) is a modular and parameterized Monte Carlo simulator based on the Geant4 ([2], [3]) toolkit developed at INAF/IASF Bologna. A new BoGEMMS extension has been built that allows configuring at run time the tracker, calorimeter, and anticoincidence system geometry of a Gamma-ray telescope. The simulation output is then digitized to take into account the analogic read-out and the charge distribution of an AGILE-like tracker, and the hits are formatted to be read by the AGILE DHSIM. In order to validate the BoGEMMS overall simulation for the application to future Gamma-ray missions (e.g., GAMMA-400 and Gamma-Light), the AGILE satellite (GRID, MCAL, anticoincidence (AC) and electronic system) is being simulated with the aim of comparing the result to the on-flight measured point spread function. A key feature of the AGILE simulator is the conversion of the output to the geometry coordinate system of the Geant3-based GAMS simulator, to apply the standard filter and analysis pipeline. Once the data are well reproduced by the BoGEMMS simulation, the virtual AGILE model could be used for the production of the next release of the calibration suite. The status of the BoGEMMS extension is explained in detail, and preliminary results on the physics validation and comparison with real data are reported.

The AGILE BoGEMMS simulation

Geometry:

- Three main blocks: GRID, MCAL, and AC
- 13 trays (the 3 last trays without converter), 3072 (read-out and floating) strips each plane
- BoGEMMS allows to change the tracker, calorimeter, and anticoincidence geometry with a configuration file at run-time

Simulation output processing:

- Digitization (charge redistribution given by the capacitive coupling and minimum detection threshold of 0.25 MIP (~27 keV))
- Selection of the read-out strips
- Conversion of the output to AGILE-like format (e.g. energy units, reference system)

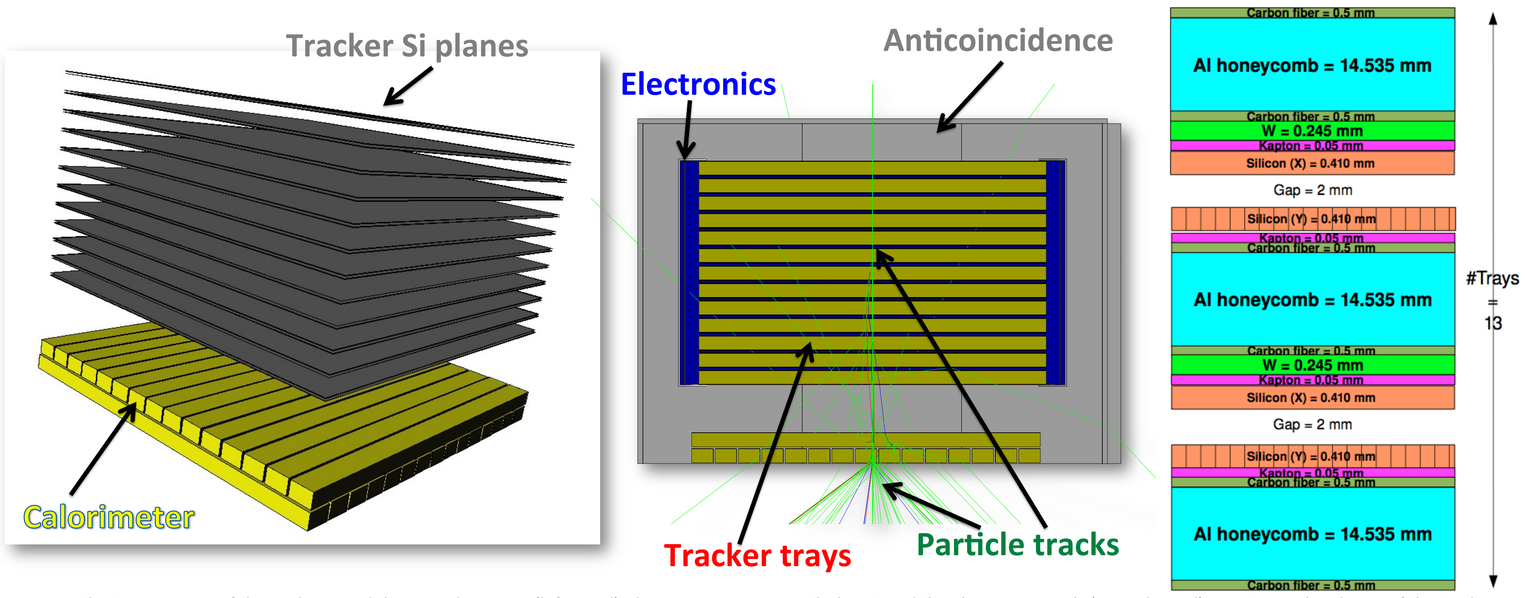
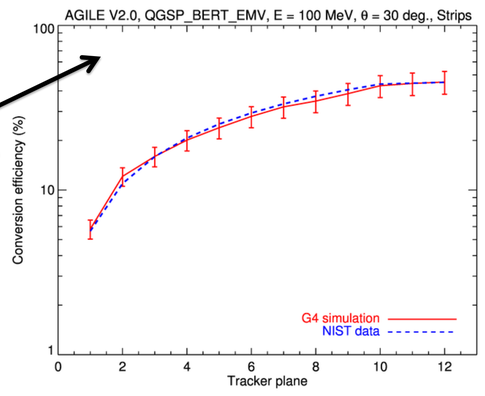


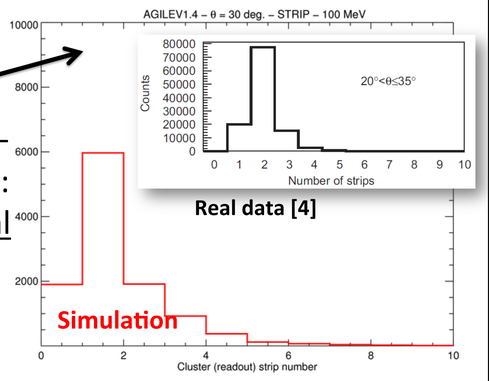
Figure 1. The 3D geometry of the Si planes and the NaI calorimeter (left panel), the entire geometry with the AC and the electronic panels (central panel), a not-in-scale schema of the tracker composition. In the central panel, a 100 MeV monochromatic beam of 10 photons (green tracks) is simulated parallel to the tracker axis.

Validation and preliminary comparison to real data

Photon conversion efficiency to e-/e+ pairs as a function of the number of crossed planes: the simulation well reproduces the tabulated NIST data!



Histogram of the number of read-out strips composing a hit cluster: both simulation and experimental data peak at 2!



Histogram of the maximum charge deposited in the strips: the simulation well reproduces the Landau form of the floating and read-out strips, the left and right peaks respectively!

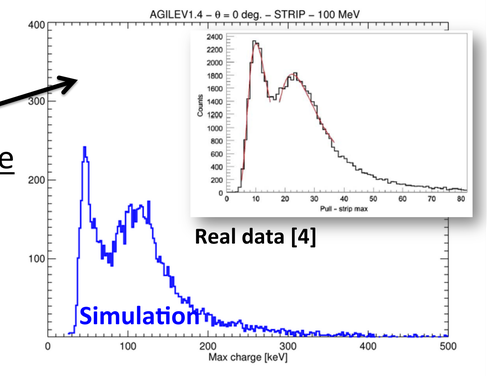


Figure 2. Simulation-data comparison using tabulated NIST cross sections (top panel) and laboratory experimental results testing the AGILE tracker prototype

Simulation processing by the DHSIM and AGILE Quick Look

The simulation output is saved in ASCII format following the reference system of the GAMS simulator. It is then converted by the DHSIM (Data Handling Simulator) into the same format of real data supplied by the on board scientific telemetry of AGILE.

To check the conversion, a DHSIM-like event monitor is built in Python and compared to the DHSIM output.

The simulation is correctly loaded by the DHSIM!

The DHSIM output is read by the AGILE Quick Look (QL), which contains the actual filter on board the satellite.

The simulation is correctly processed by the AGILE filtering pipeline!

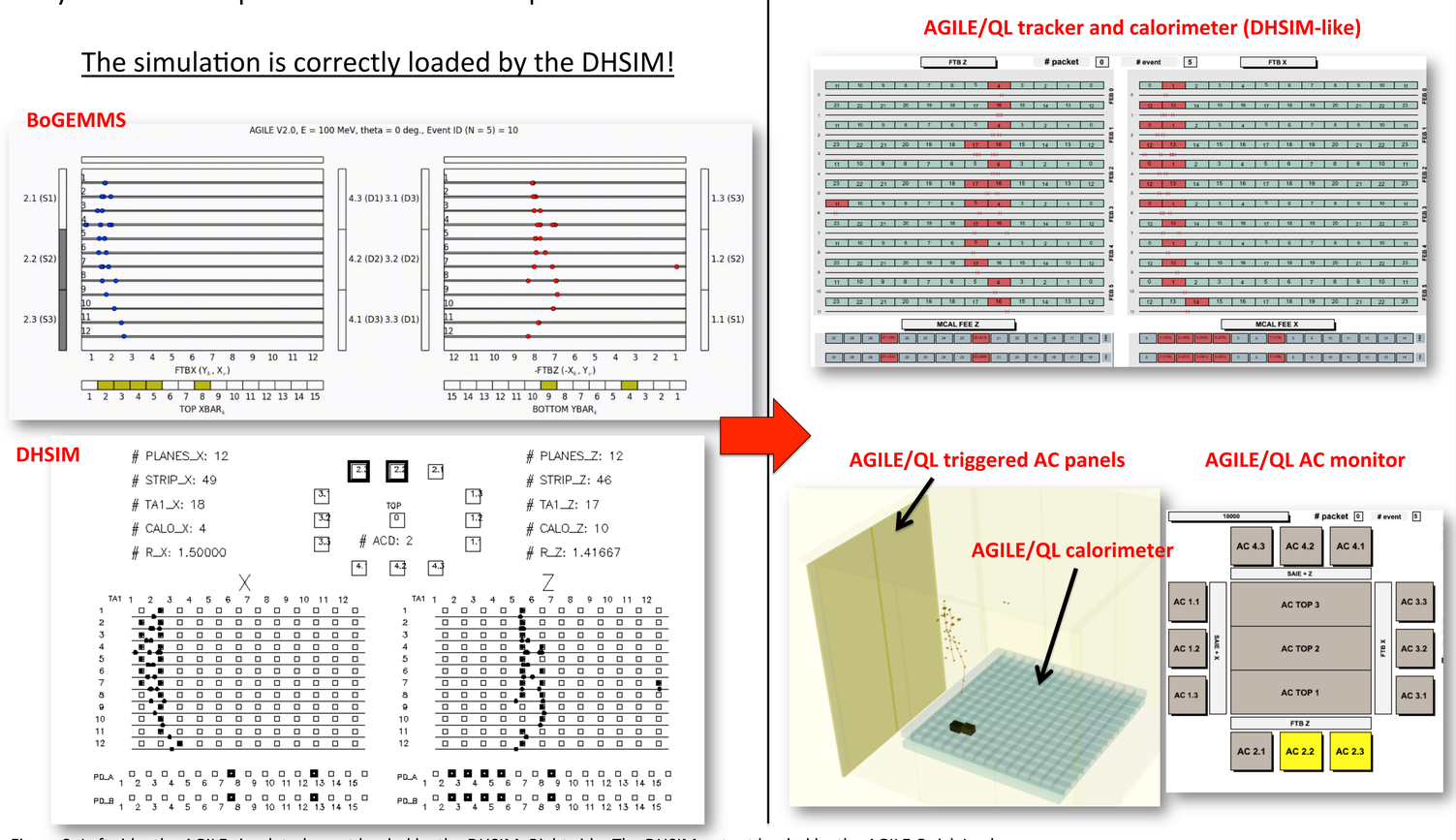


Figure 3. Left side: the AGILE simulated event loaded by the DHSIM. Right side: The DHSIM output loaded by the AGILE Quick Look.

Summary

- The AGILE satellite (GRID, MCAL, AC) has been simulated using BoGEMMS;
- Preliminary results well reproduce experimental data;
- The AGILE filter loads correctly the BoGEMMS output.

Planned actions

- Simulation campaign of test beams and Vela spectra;
- Comparison of the simulated point spread function with real on-ground [5] and on-flight [6] AGILE data;
- Validation of BoGEMMS for future Gamma-ray missions (GAMMA-400, GammaLight) and next AGILE calibration suite!

References

[1] Bulgarelli et al., Proc. of SPIE, 8453, 2012
[2] Agostinelli et al., NIM A, 506, 250 (2003)
[3] Allison et al., Nucl. Sc. IEEE Trans., 53, 270 (2006)
[4] Bulgarell et al., NIM, A614, 213, 2010
[5] Cattaneo et al., Proc. of SPIE, 8443, 2012
[6] Chen et al., A&A, 558, A37, 2013