Simulations and Estimation of Background for ECLAIRs Camera …

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Outline

- Goal of this work
- Method of obtaining the expected background
- Validation of the results
- Current status of work
- Future directions and applications

Goal of the Work

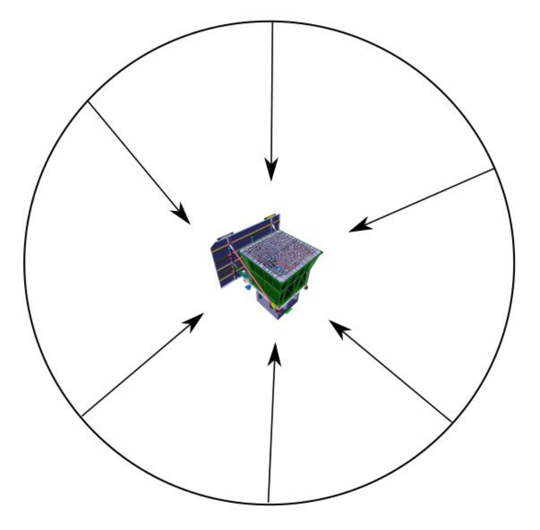
- To estimate the various background components which are CXB, Reflection (CXB reflection from Earth), Albedo (Emission from Earth's atmosphere due to cosmic ray interactions) and Charged particles (e-/p+)) as function of SVOM orbit.
- To continue and improve of Laurent's work on background estimation (document "SIMULATEUR DE DONNEES "BRUIT" SVOM/ECLAIRs").
- The aim is to estimate the background without having to do Monte Carlo simulations for every possible scenario but to estimate it from a pre-calculated database. This way we save a lot of time (at least factor of 100) as Monte Carlo is computationally expensive.
- Generate a tool (software) which can be run to estimate the background and produce the event list for a given time interval (one orbit, several orbits).

Simulation and The Database

- For the database, GEANT4 simulation is carried out with spectrum of known shape for each component. For CXB, *Moretti 2009 and Gruber 1999* ; for Reflection, *Churazov 2006* and for Albedo, *Sazonov 2007*.

- The photons are shone from a surface of sphere (uniform isotropic distribution) on to the ECLAIRs mass model placed at the centre of the sphere. Following information is stored for each component,
  - **Source photon/particle list** : Photons / particles which interact with the ECLAIRs DPIX. In this file eventID, initial energy, theta, phi, x, y ,z of origin wrt Geant4 frame of each photon is stored.
  - **DPIX photon list** : All the energy deposit on the ECLAIRs detector plane for each event. For each energy deposition, the eventID, energy, pixel X and Y coordinates.

- For each component, large number of photons are simulated with multiple sets of run (to get better statistics).



Schematic diagram of GEANT4 simulation

Next --> Go from static Monte Carlo to dynamic (adding notion of time) Monte Carlo

Method to Obtain Background

- ***CXB*** : Most simple, each photon is time tagged with time drawn from Poisson distribution. At this time Earth position is calculated by interpolating known orbital coordinates. If the photon crosses Earth disk we discard the photon else we save the photon and corresponding DPIX information. (Already done in Zhao et al. 2012)
- ***Reflection*** : Similar to CXB except exactly opposite in selection, we save the photon if it is coming from the Earth.
- ***Albedo*** : More involved as the emission from the Earth's surface is not uniform and the rate varies depending on the satellite latitude / longitude (because of change in magnetic field). We divide Earth disk in smaller pixels and estimate emission rate in each pixel. We assign the time based on maximum rate (and corresponding Poisson distribution) and select the photons based on the ratio of rate in pixel to which the photon belongs to that of the maximum rate.
- ***Charged Particles*** : We vary the rate based on expected spectrum and scale the simulated spectrum. The time is assigned based on this rate (and corresponding Poisson distribution) and the particle is selected based on energy ratio of expected spectrum to that of scaled simulated spectrum.

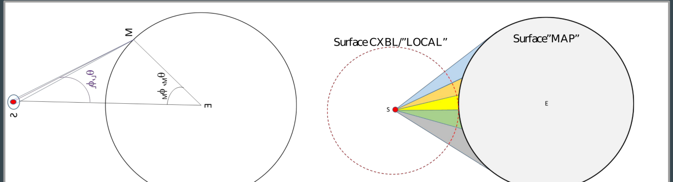
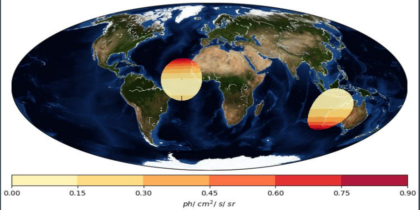
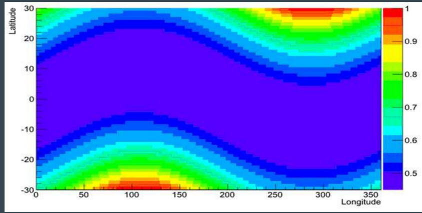


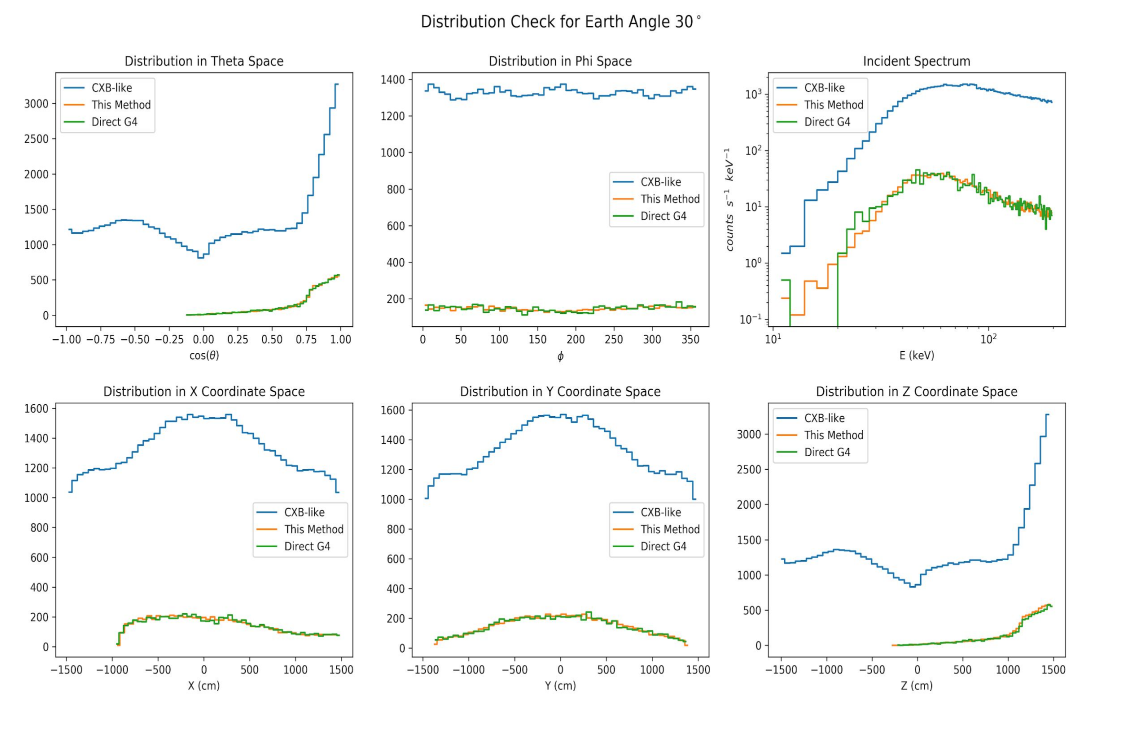
Image source : Laurent's report





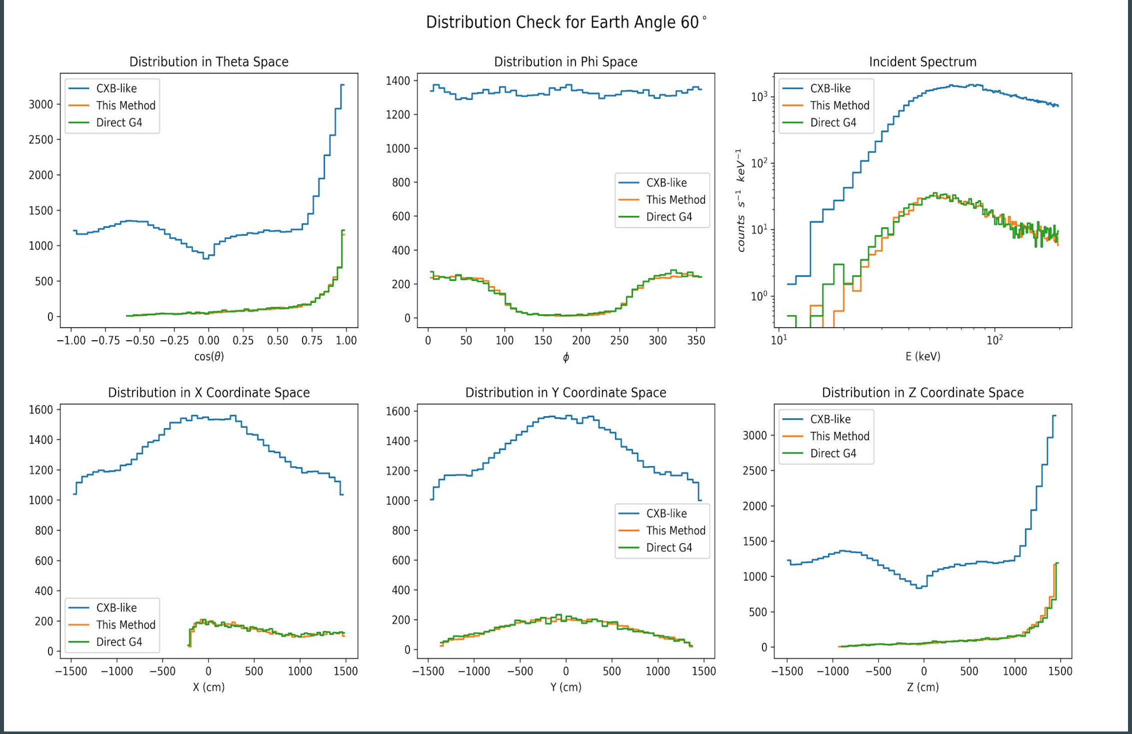
Zhao et al. 2012

Validation



Validation of method by comparing various distributions for Earth angle 30° with direct G4 simulations

Validation

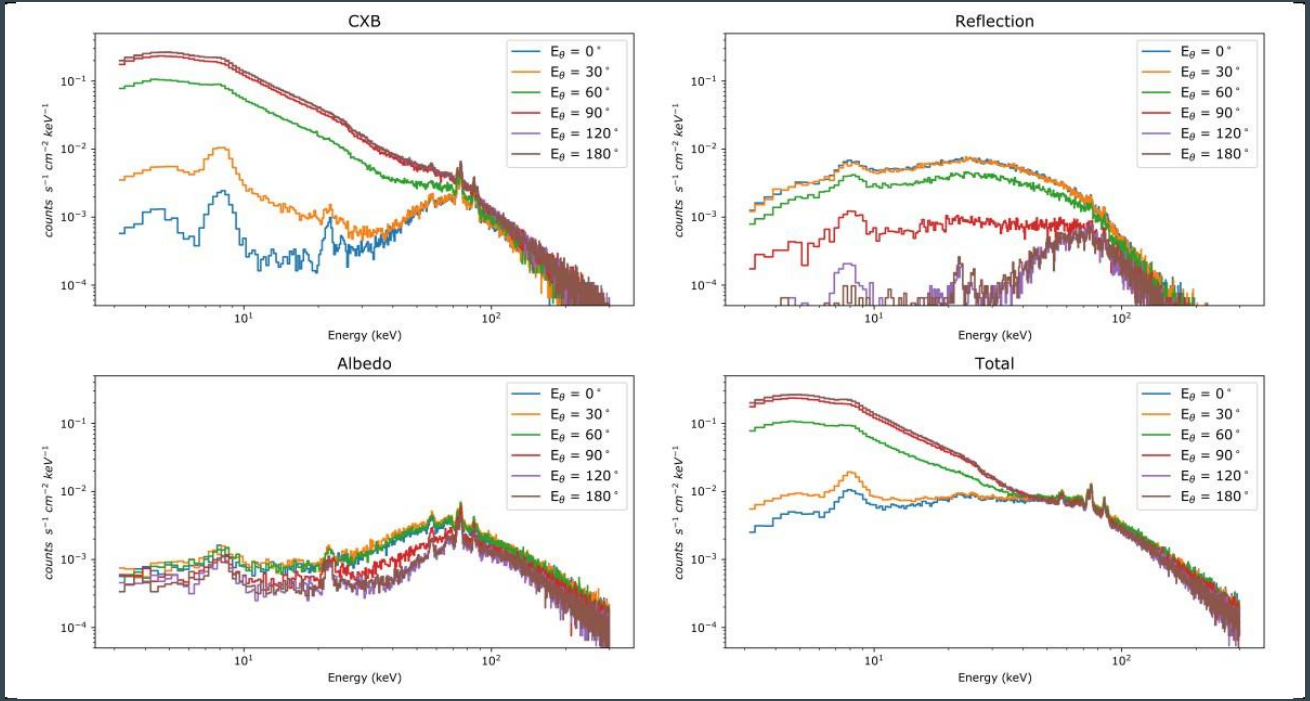


Validation of method by comparing various distributions for Earth angle 60° with direct G4 simulations

Current Status

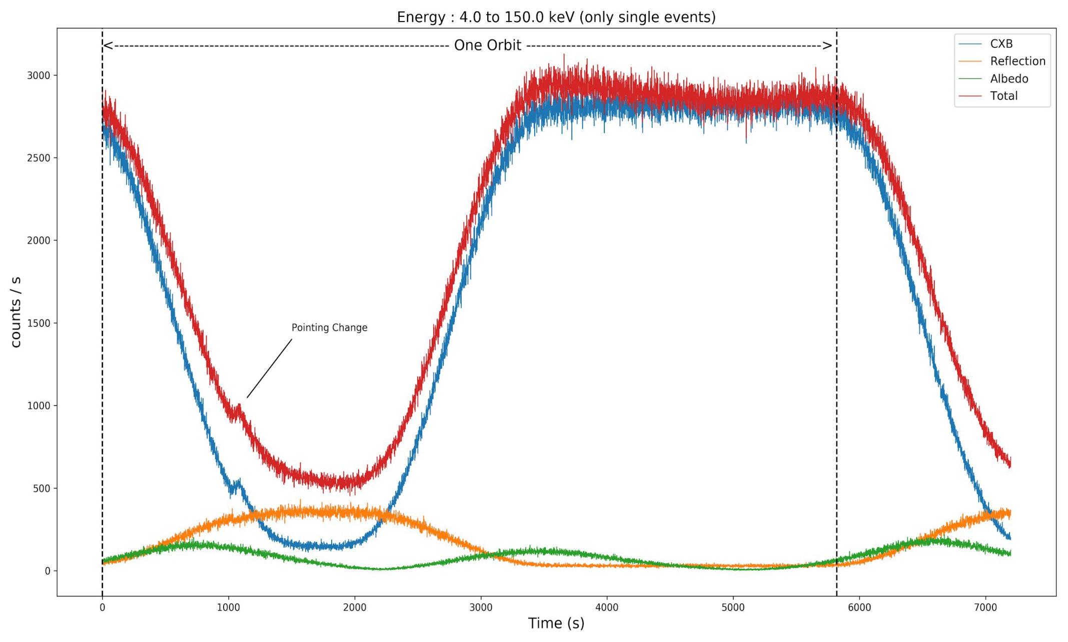
- Currently the tool is able to produce expected background events from all the components.
- The software is,
  - Written in python
  - Has two modes, photon by photon which delivers each event individually (slow but can be integrated with other codes, preliminary version ready) and ΔT list mode which delivers list of all events expected in interval ΔT (fast, to do, ready soon)
  - **Orbit Parameters** : CNES file (one year), processed by H.Triou to compute particle flux in SAA or A. Claret orbit and flux file.
  - **Input data** : contains orbit file (attitude) and Geant4 simulation files for each component. For charged particle, additionally, the particle (e-/p+) flux information as function of orbit
  - **Output data** : Time tagged DPIX event list with energy and pixel location. It contains t (E_i, X_i, Y_i ; i = 1, multiplicity). Also, additionally, input source photon/particle list is generated. With this user can reconstruct incident photon/particle distributions (spectrum, angular/ position dist. etc.) if needed
- Currently the software takes 173 minutes for 2 hours of data (single core @ 2.2 GHz) with 3 components (CXB, Reflection, Albedo), which is 1.4 times slower than real time, however, ΔT list mode will be much faster (at least three to four times).
- Distributable version of the software (with both modes) under way and should be ready soon (end of May).

Current Status (Results)

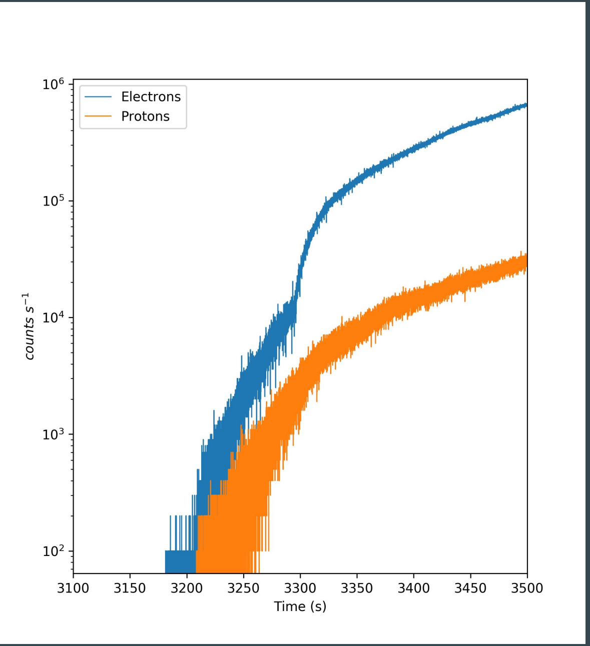


Example : Expected spectrum of three components as function of *constant* Earth positions

Current Status (Results)

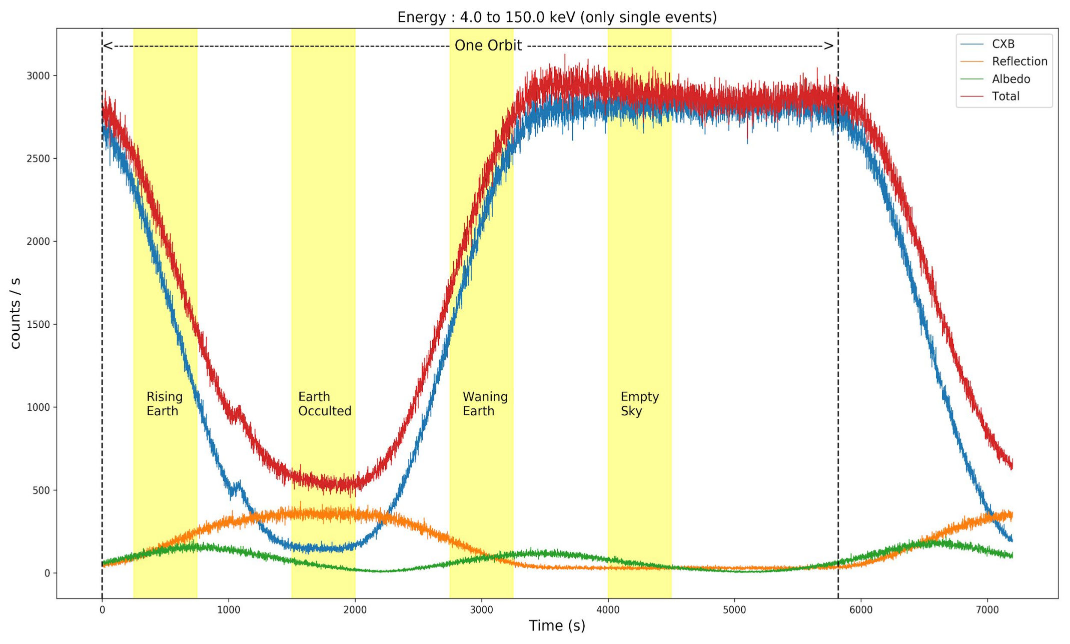


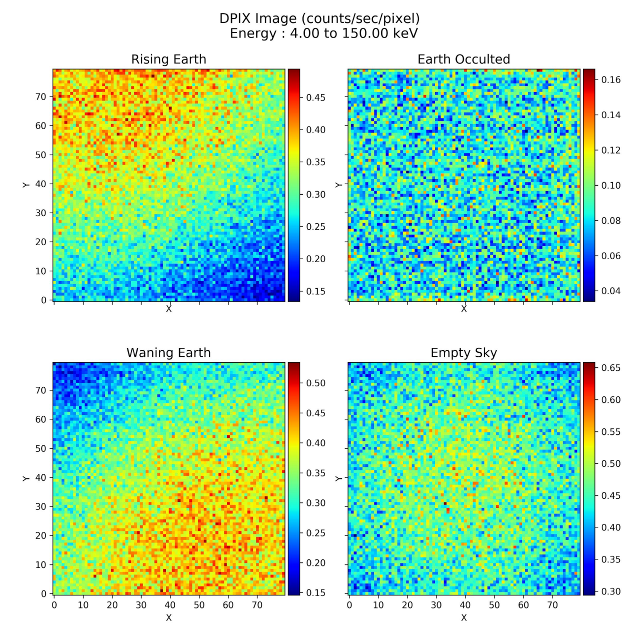
Example : Background variation as function of orbit (output from software)



Example : Expected charged particle rate in part of SAA (output from test code not from the software)

Current Status (Results)





Example : DPIX Image (right) at various times in orbit shown on left

Future Directions

- Add known sources (from N. Dagoneau) and GRBs (from F. Daigne and M. Bocquier) to the generated background photon list
- Pass the event list through the hardware simulator to generate near real data
- Use this data as template to develop and test algorithms to search for bursts as part of ground trigger program
- The data can also be used to test pipelines
- Which standard scenarios we should use to test the validity of future algorithms?

>> This method of estimation of background is independent of the instrument and hence can be extended on GRM as well<<

Thank You

DPIX Image for Individual Component