DESIGN, DEVELOPMENT AND IN-FLIGHT EXPLOITATION OF

IGOSAT SATELLITE PAYLOADS

FOR MEASURING THE RADIATIVE CONTENT

ON LOW-EARTH ORBIT AND IN THE IONOSPHERE

iGOSAT – **i**onospheric **G**amma-ray **O**bservations **SAT**ellite

Hien PHAN

Paris, 10/11/2016

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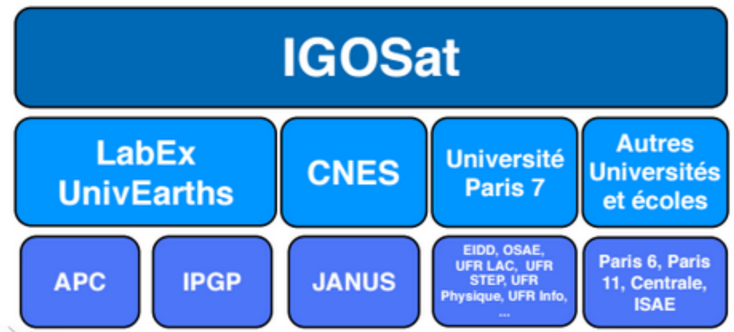
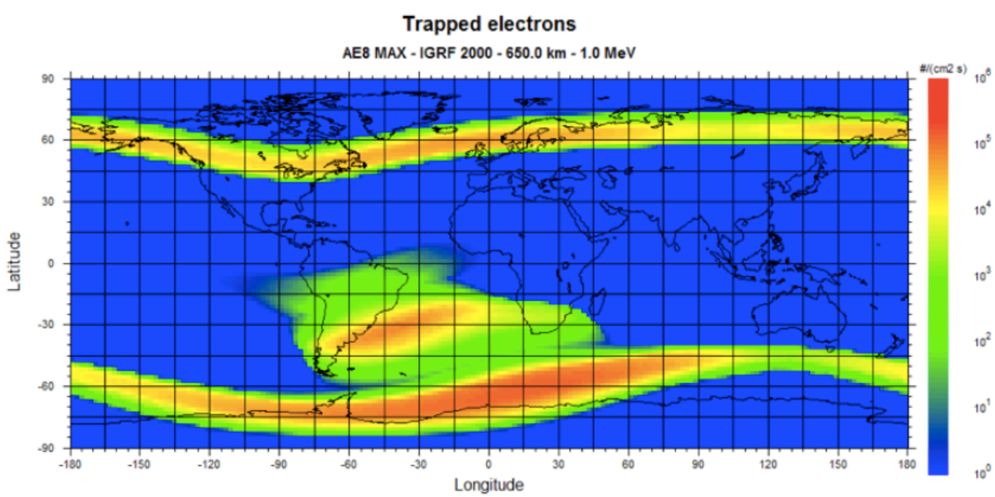
Introduction

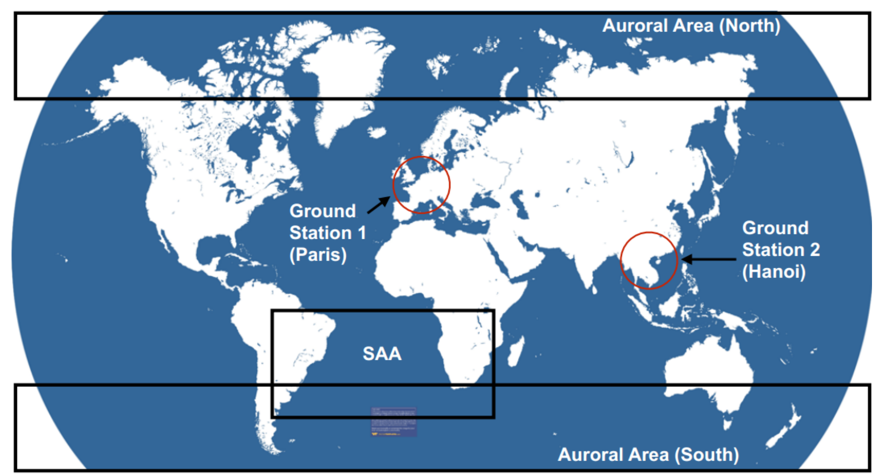
IGOSat (**I**onospheric **G**amma-ray **O**bservations **Sat**ellite) is a nanosatellite aims to measure The spectrum of gamma radiation (20 keV to 2 MeV) and electrons (1 MeV to 20 MeV) in the aurora zones and the South Alantic Anomaly.



IGOSat nanosatellite:

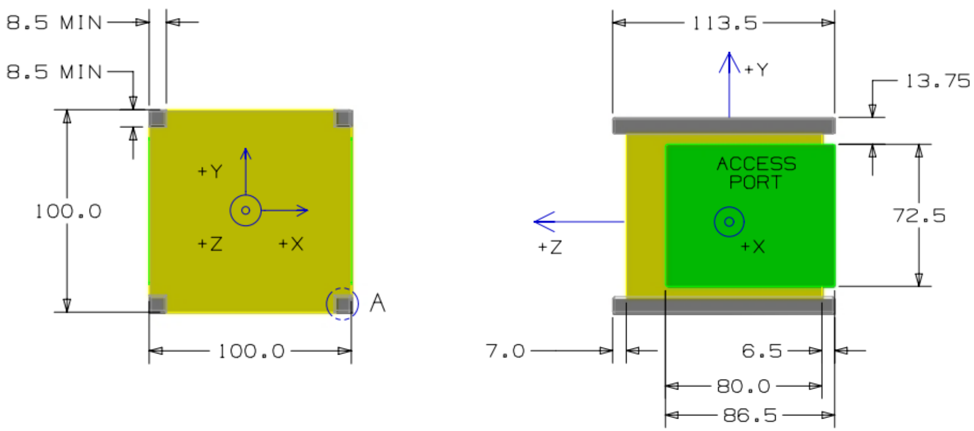
- From the LabEx (Laboratoire d'excellence) UnivEarthS
- Join project from University Paris Diderot laboratories : APC (AstroParticule et Cosmologie) and IPGP (Institut de Physique du Globe de Paris)
- Goals: conception and ready-to-launch satellite by the end of 2018

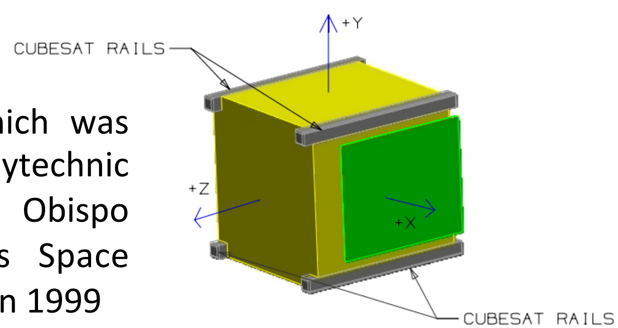




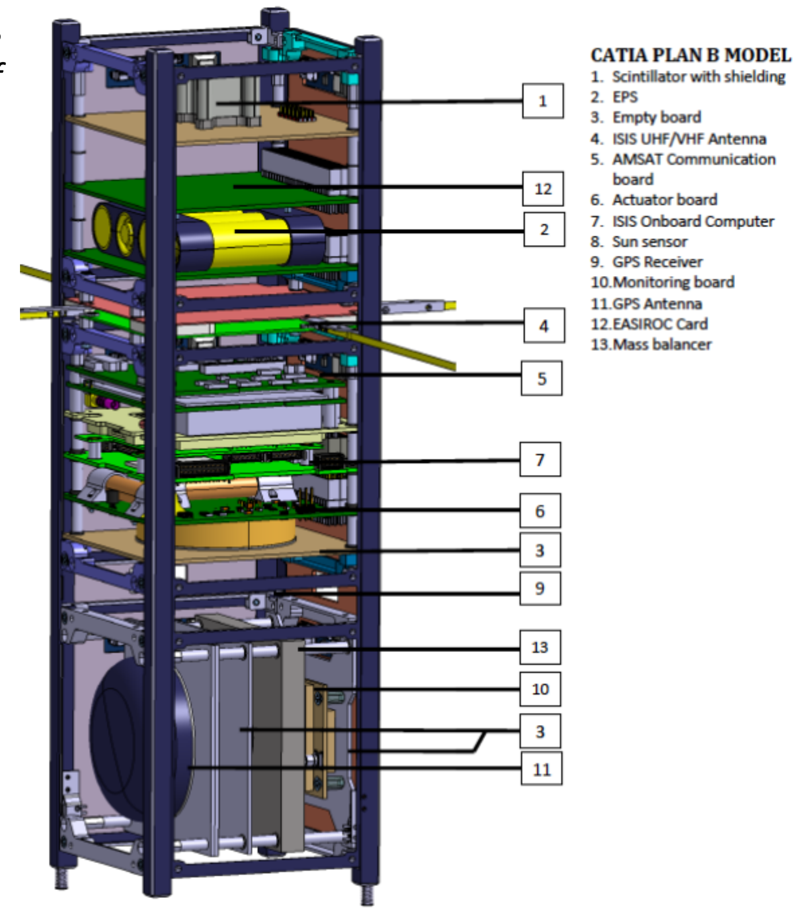
The iGOSAT Nanosatellite

The iGOSAT is a 3U nanosatellite based on the U-class spacecraft standard *(with 1U is a CubeSat Unit which has a size of 100 x 100 x 113.5 mm and a mass of 1.33 kg maximum)*.





The CubeSat standard which was created by California Polytechnic State University, San Luis Obispo and Stanford University's Space Systems Development Lab in 1999



The iGOSAT design

The Scintillator Payload

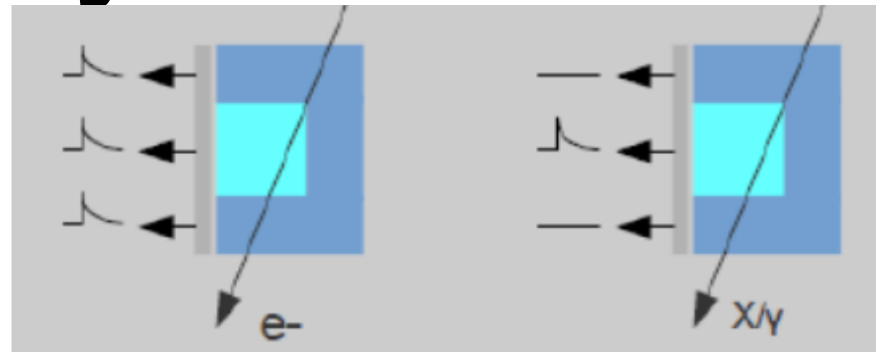
Containing the Plastic and Crystal scintillators and a MPPC (Multi-Pixel Photon Counter). The gamma-rays and electrons interact with matters inside the scintillators and then emit the luminosity photon which will be captured by the MPPC.

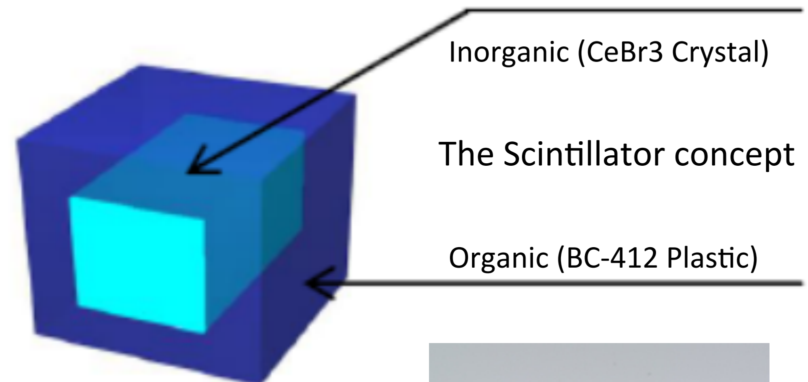
- When a high energy particle pass or is absorbed by a scintillator, it loses its energy and produces fluorescence. The longer the path is, the more fluorescence photons are produced.
- The Crystal part can detect gamma rays from 20 keV to 2 MeV while the Plastic scintillator can discover electrons from 1 MeV to 20 MeV.
- Since the CeBr3 can detect both gamma rays and electrons whereas the plastic scintillator can detect solely electron particles, the combination of two scintillator types is needed in order to discriminate these two kinds of particles.

✓ *CeBr3 emission wavelength: 380 nm*

✓ *BC-412 max. emission wavelength: 434 nm*

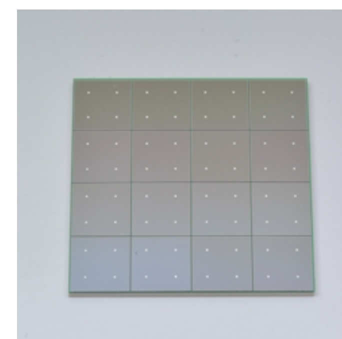
✓ *The MPPC spectral response range: 320 – 900 nm, peak sensitive wavelength: 450 nm*





The Scintillator concept

The 4x4 MPPC
S13361-6050AE-04
from HAMAMATSU

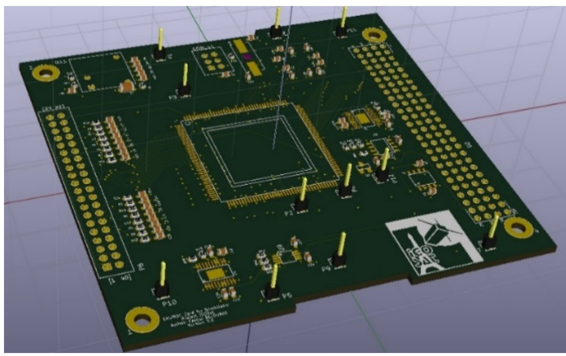


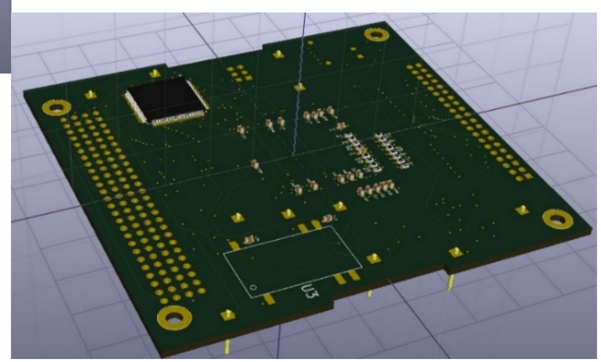
The EASIROC Board

Receive the signal from SiPM and convert it in a comprehensive language for the computer, and then, it send data to the OBC (On Board Computer).

EASIROC Chip:

- electronic component made for particle physics in accelerators;
- 32 inputs (16 needed).





Scintillator

Scintillator board

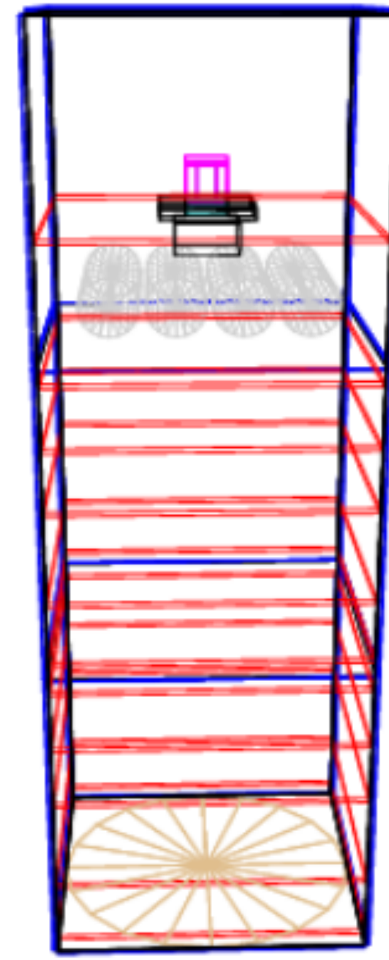
- Crystal: **CeBr3** from SCIONIX
- Plastic: **BC-412** from Saint-Gobain
- SiPM/MPPC: **S13361-6050AE-04** from HAMAMATSU

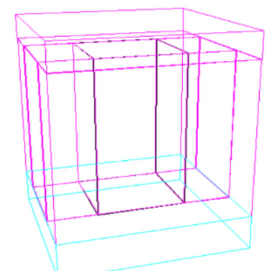
EASIROC board

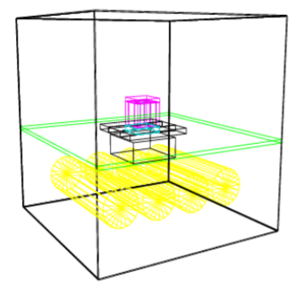
- EASIROC chip
- HV conversion
- Microcontroller

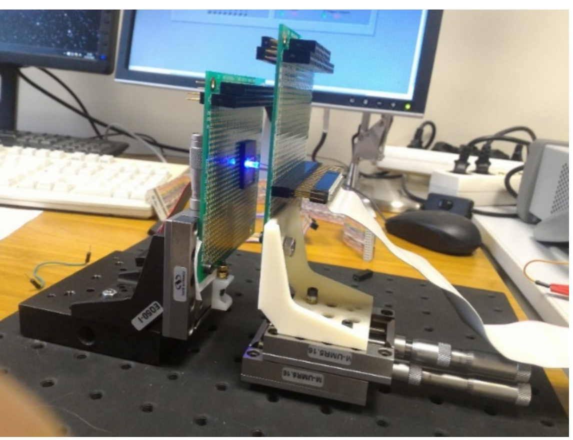
Simulation and test bench

- **Simulation with MegaLib:** Provides the sizing of the Scintillator, size of the shield. MegaLib is a simulation software for particle physics. Inside Megalib, we use three build-in softwares:
  - Geomega: defines the geometry of sensors and the satellite for the simulations.
  - Cosima: defines the characteristics of the simulations.
  - Revan: analyzes the simulations.
- **Test Bench:** Aimed to test the performance of the MPPC, the test bench was set up with a blue LED (it is near the wavelength of the scintillation photons) and a MPPC sticking on the translation system (allows us to change the position of the LED pointing to every pixels of the MPPC). All of them were put in a black box.

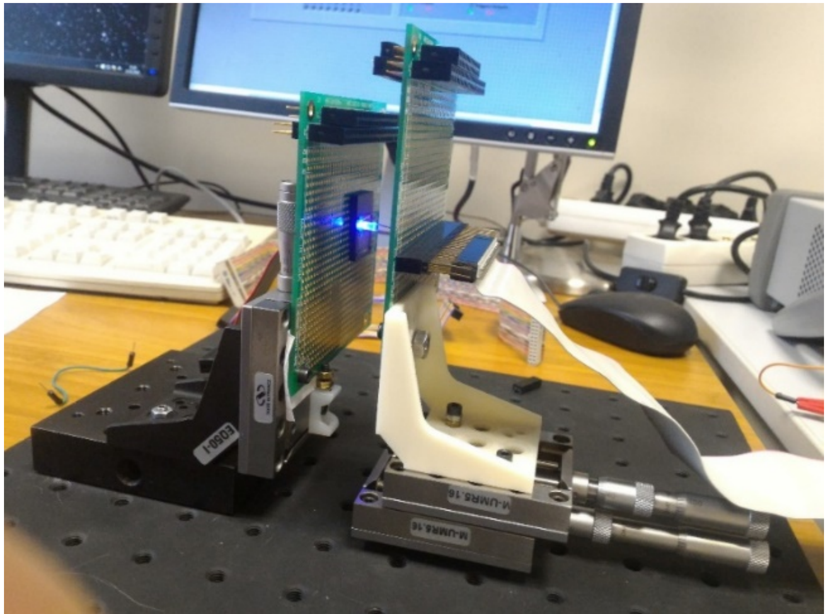


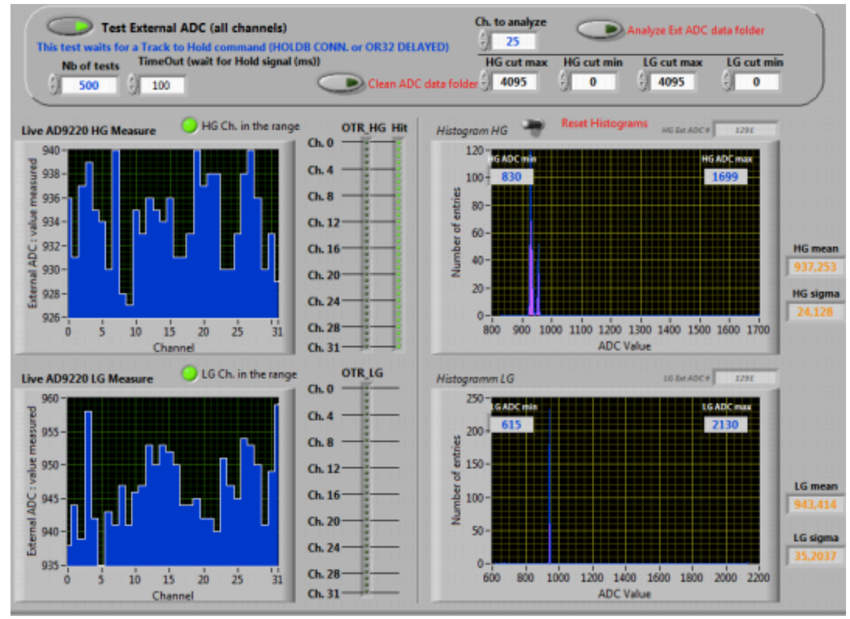




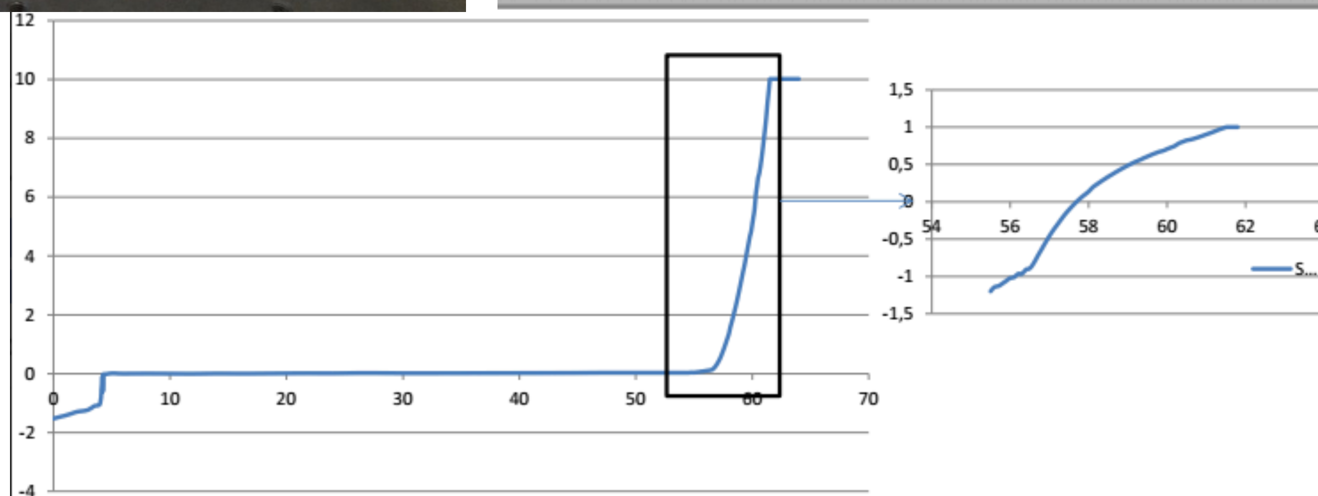


Simulation and test bench





Data from EASIROC board is analyzed by a LabView program. From that, we could confirm the characteristic of SiPM.



Simulation and test bench

First tests – Spectrum Na22

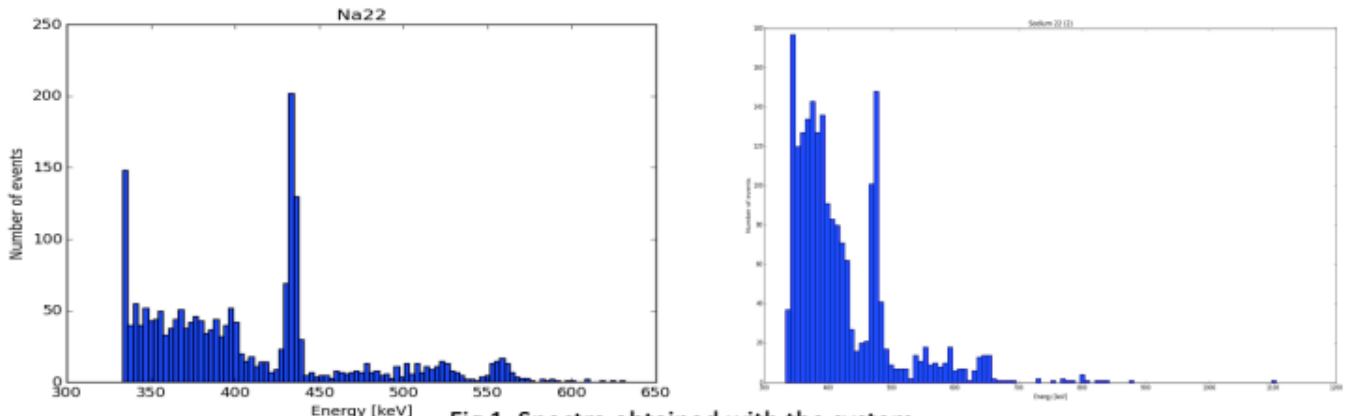


Fig 1. Spectra obtained with the system

Testing with Na22 by
Mathieu Leverge

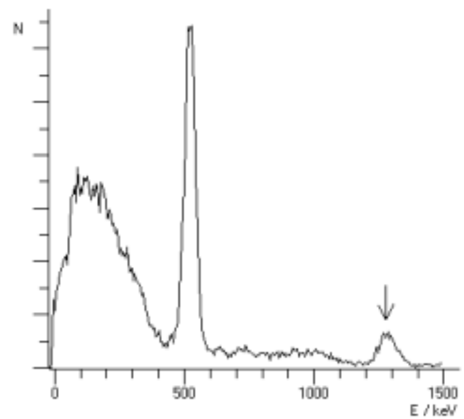
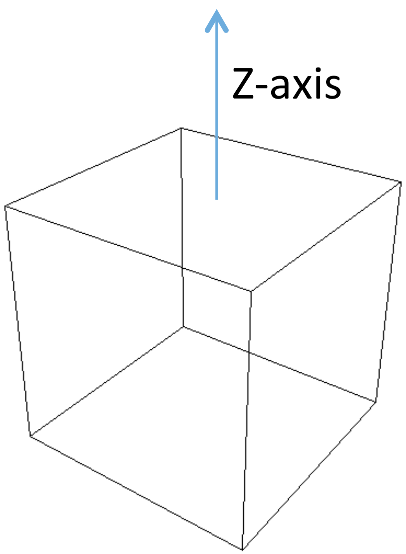
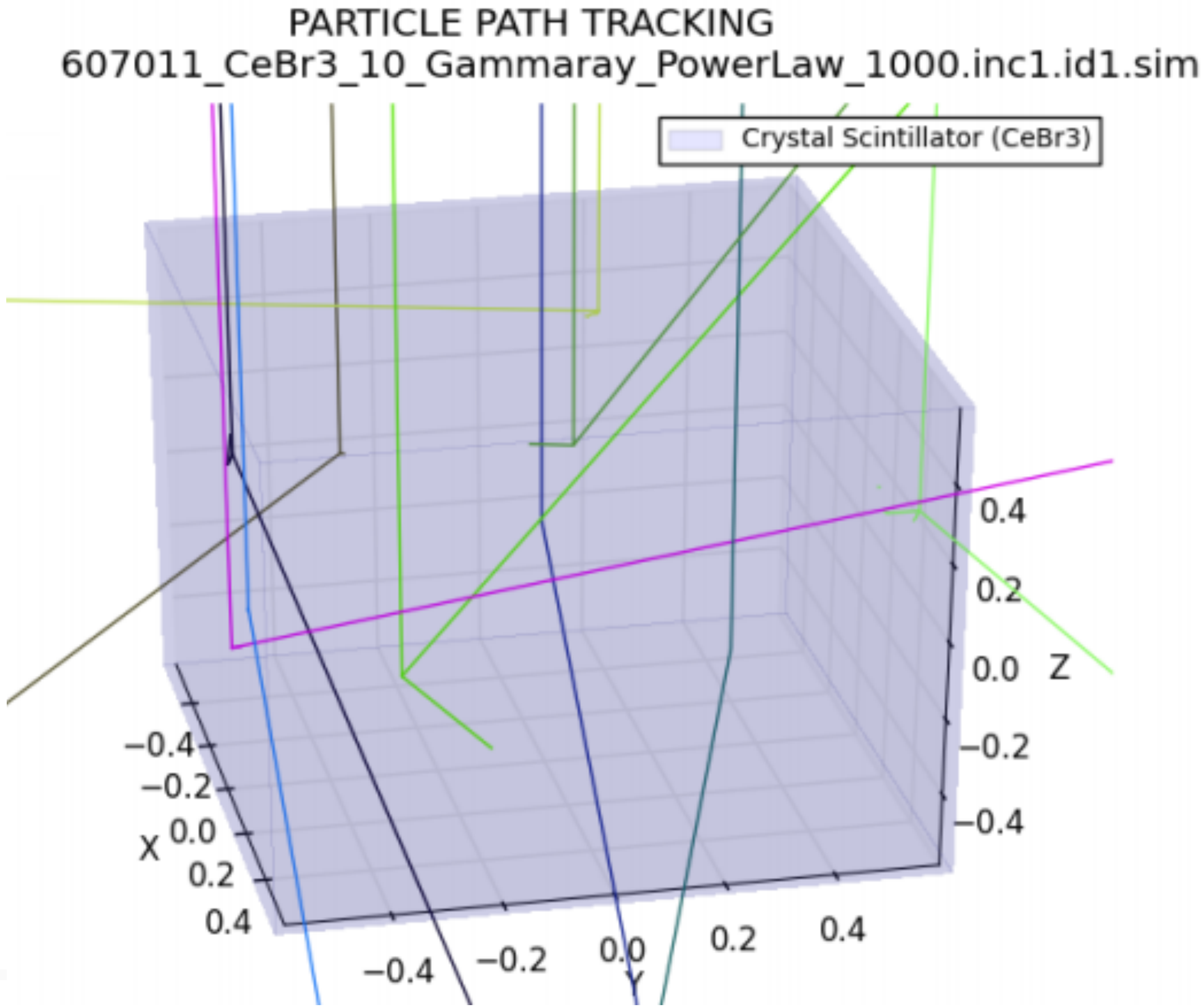


Fig 2. The experimental spectrum

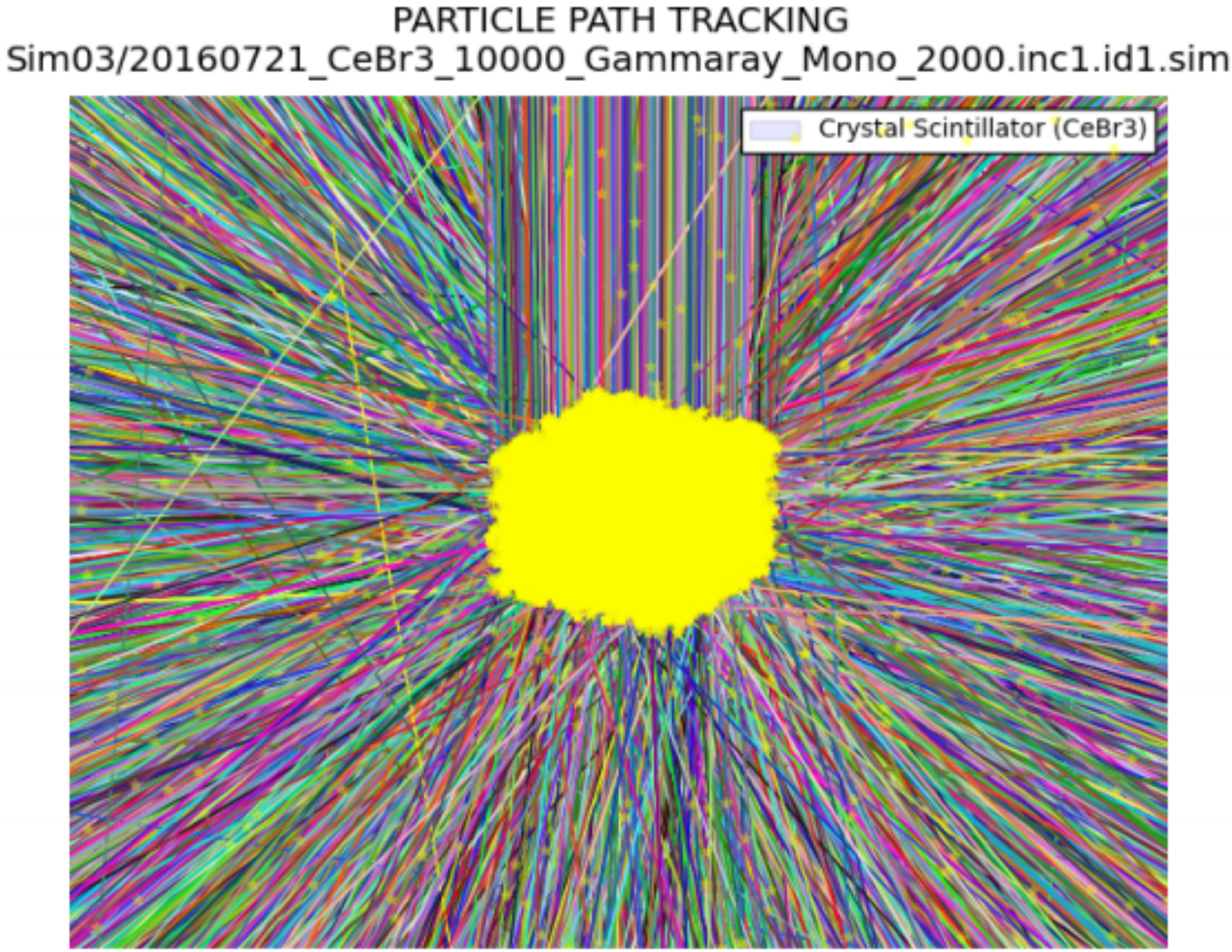
Simulation and test bench

Analysis program is written by **Python**, aim to track the path of particles and to know the deposited energy of each particle.



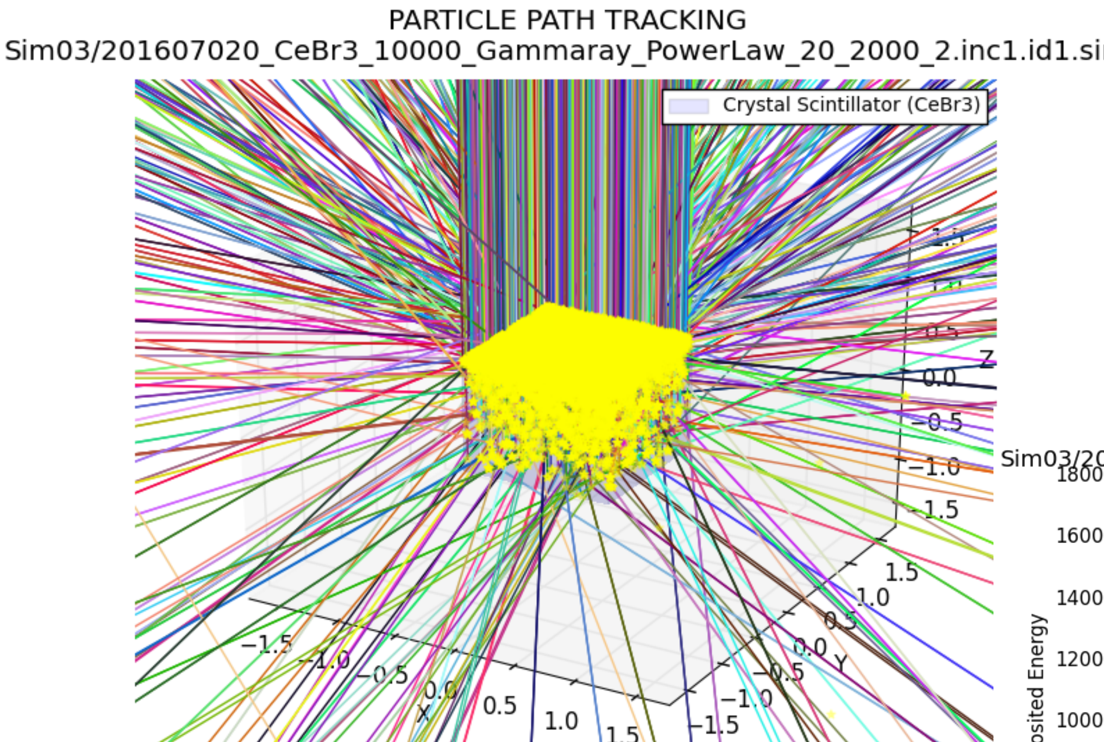


Simulation and test bench

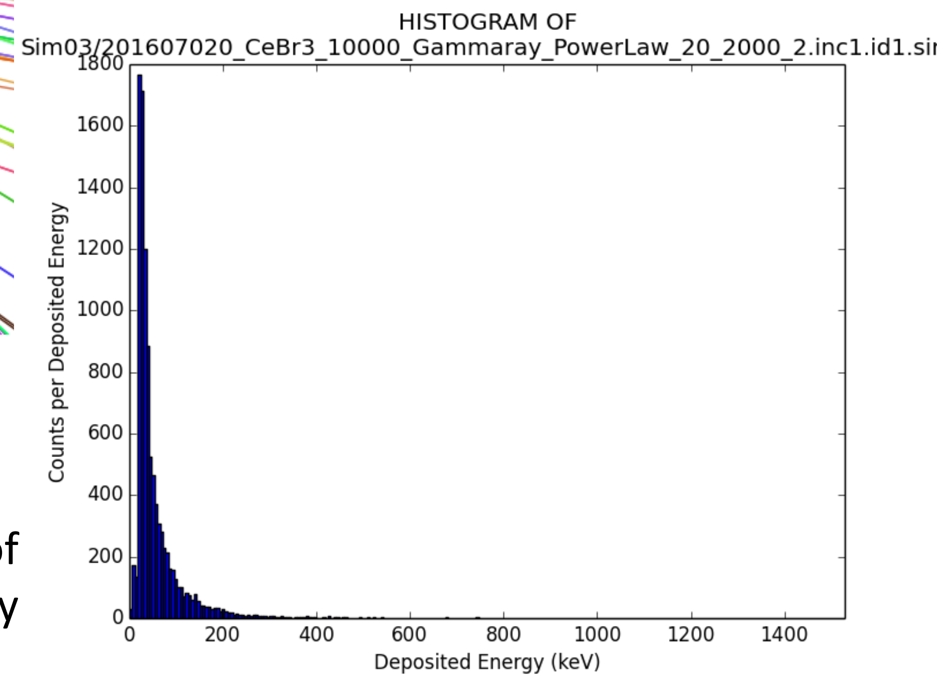


Simulation with
- 2 MeV gamma-rays
- CeBr3 scintillator

Simulation and test bench



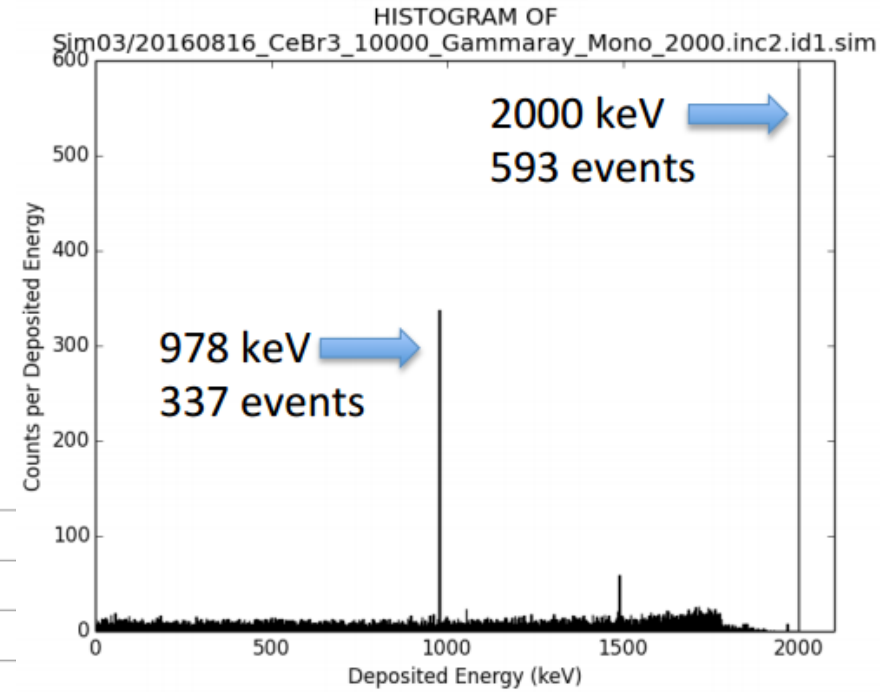
Simulation with gamma-rays energy distribution: power law from 20keV to 2 MeV



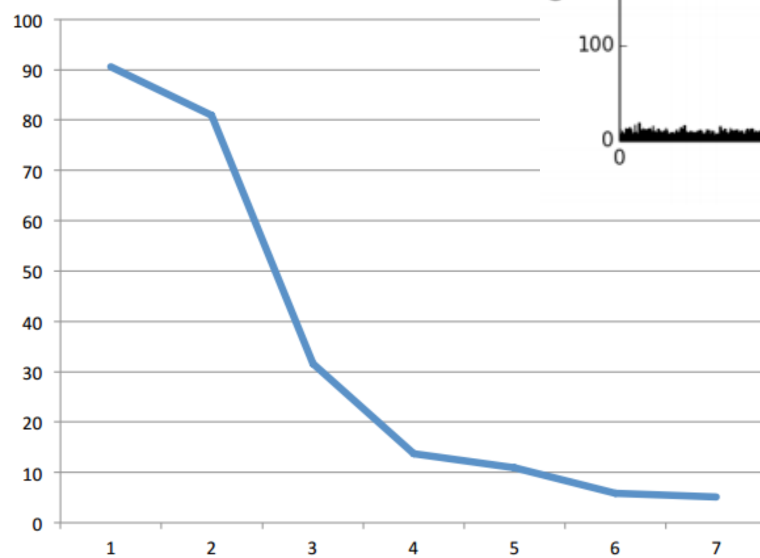
Histogram of deposited energy

Simulation and test bench

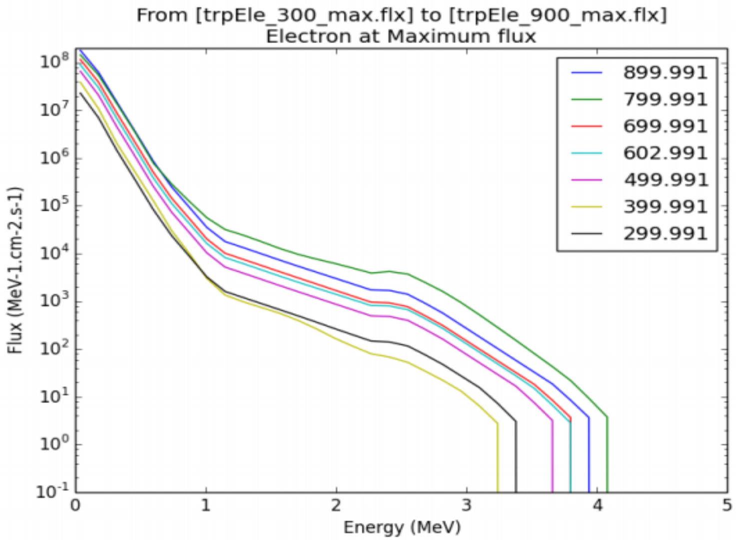
3 different simulations with FarField Point source of 2 MeV gave the similar results.
- Deposited Energy of 2MeV ~6%, 978keV ~ 3.3%

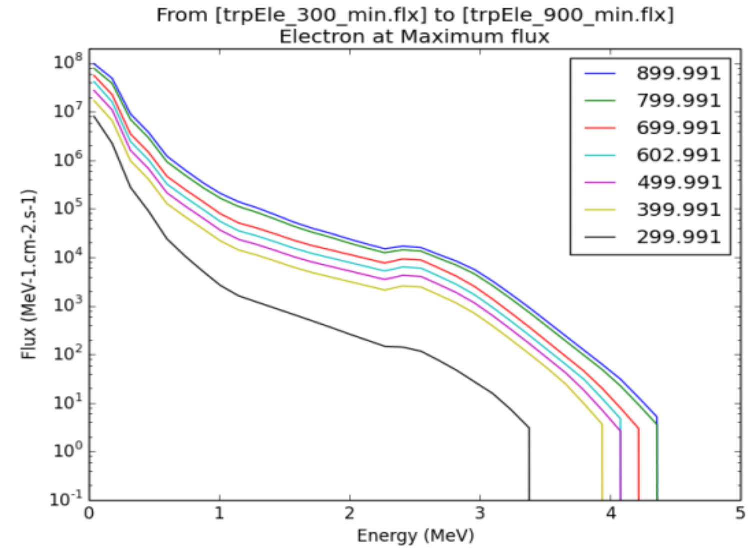


- 50 keV: 90.64% totaly absorbed
- 200 keV: 81%
- 500 keV: 31.64%
- 1000 keV: 13.7%
- 1200 keV: 10.91%
- 2000 keV: 5.88%
- 2300 keV: 5.12 %



Simulation and test bench



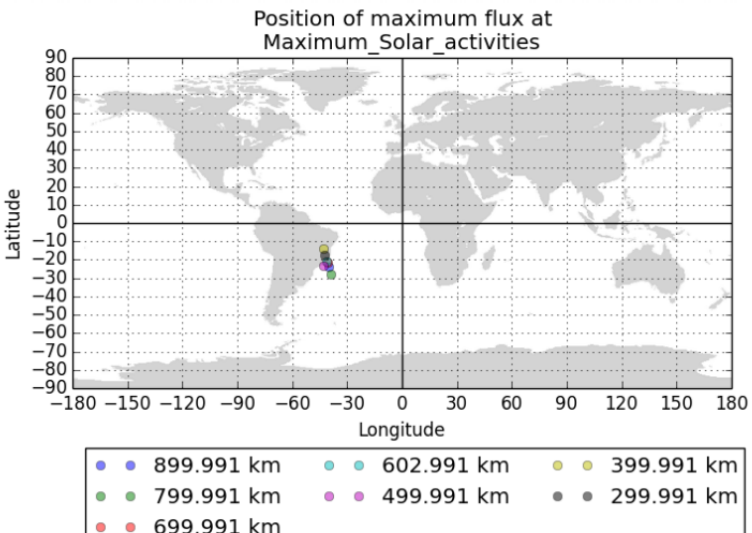


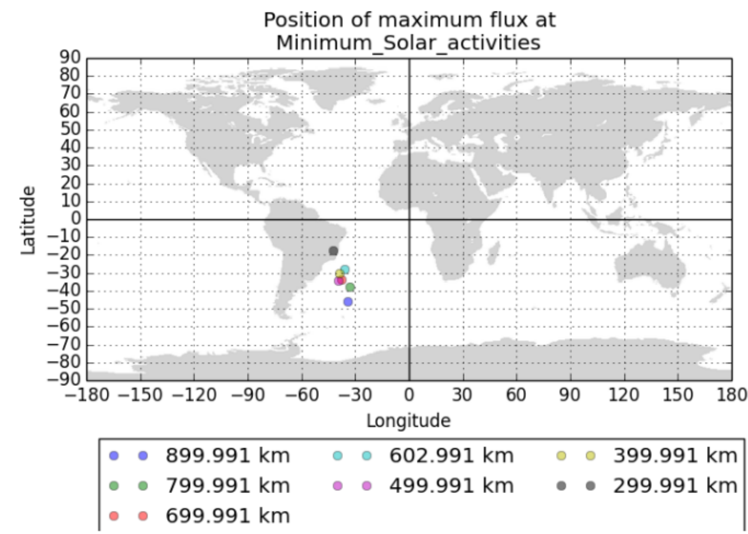
Simulation with electron data from OMERE.

The altitude: from 300 km to 900 km.

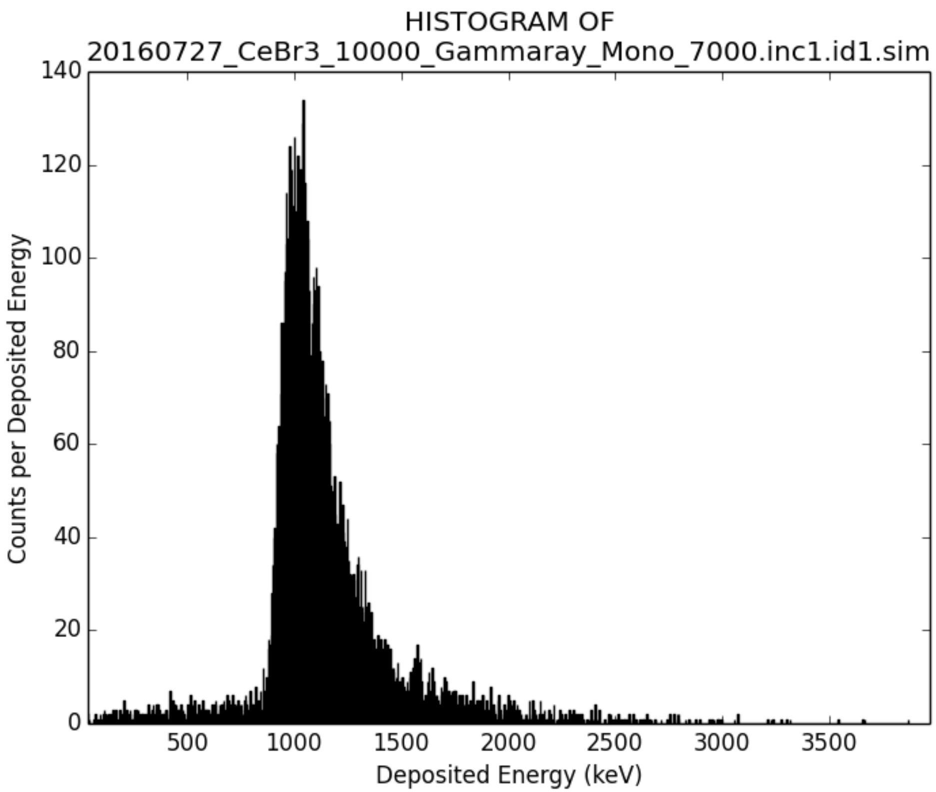
Left: Max. Solar activities

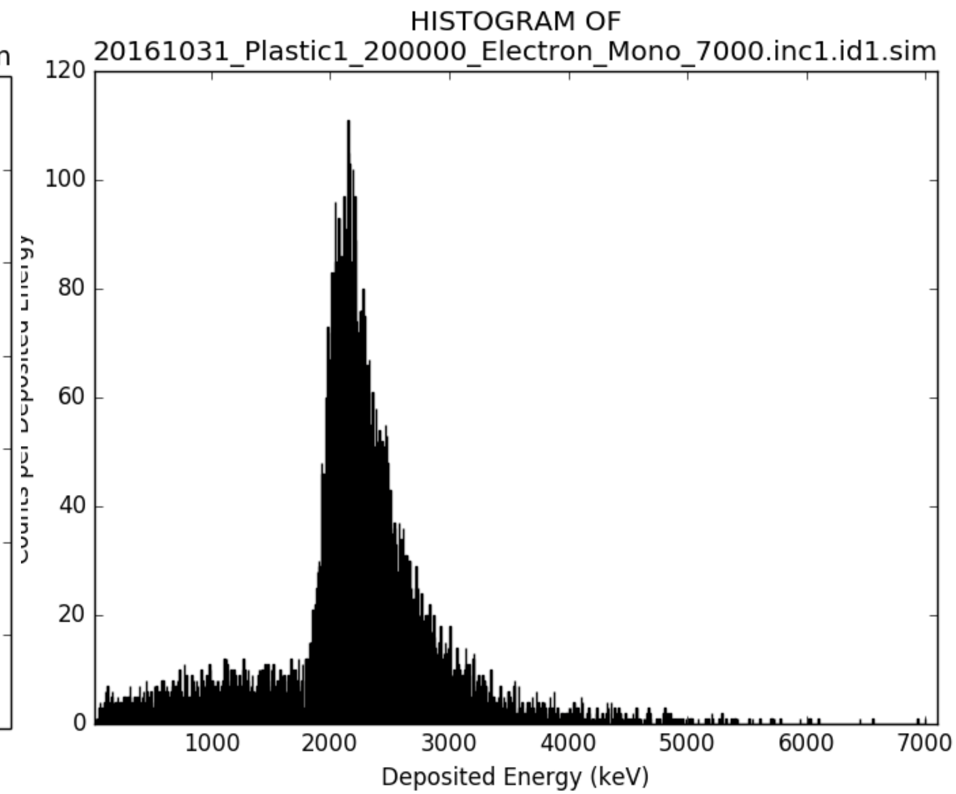
Right: Min. Solar activities





Simulation and test bench





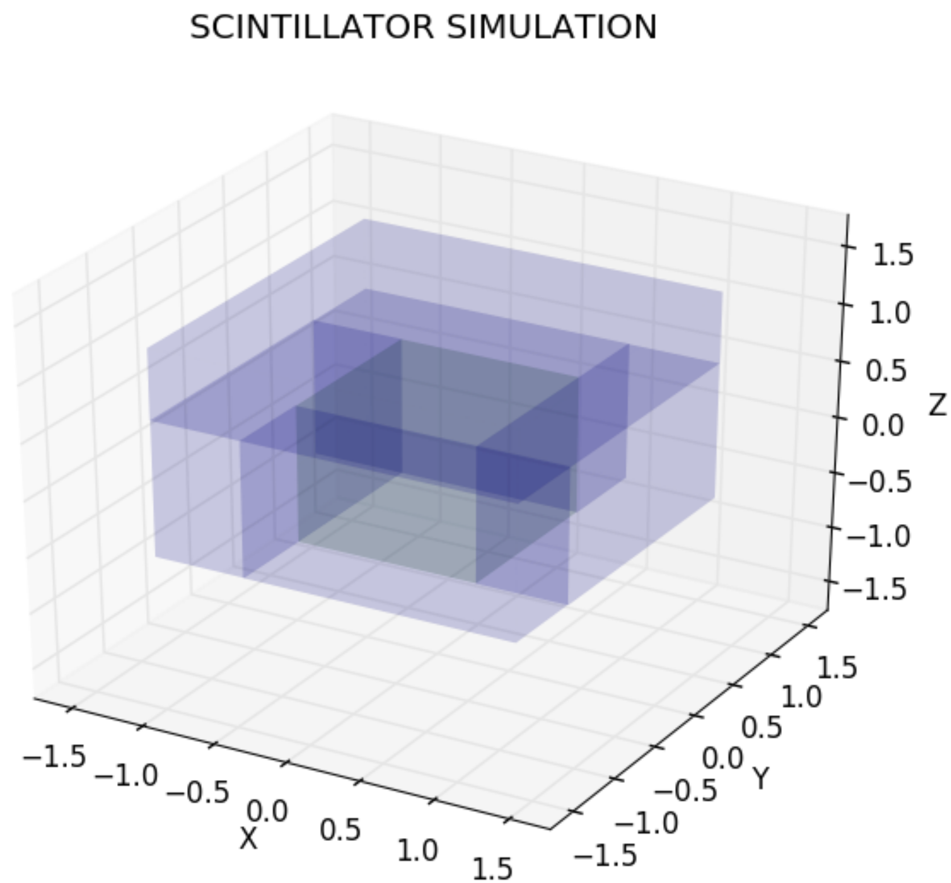
Scintillator: BC-412, thickness: 6.2 mm.
Simulation with electron flux at 7 MeV.

Scintillator: BC-412, thickness: 12.4 mm.
Simulation with electron flux at 7 MeV.

Simulation and test bench

NEXT:

- Simulations with all components of Scintilator payload.
- Tests with new scintillator which will be arrived soon.
- Define the good size of each scintillator.
- Communication with Onboard computer and ground stations.
- …



Thank you for your attention!