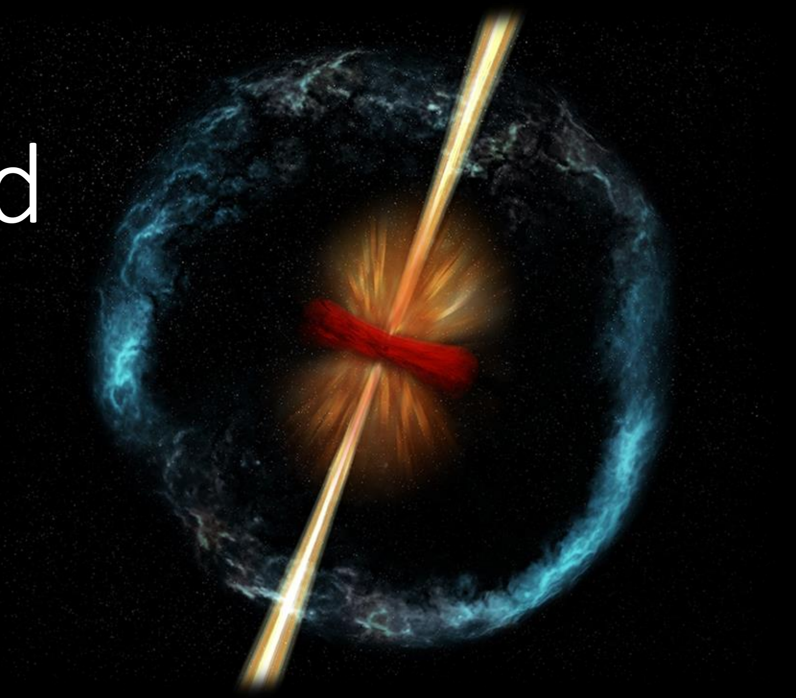
HEPD LYSO crystals calibration and expected sensitivity to GRB

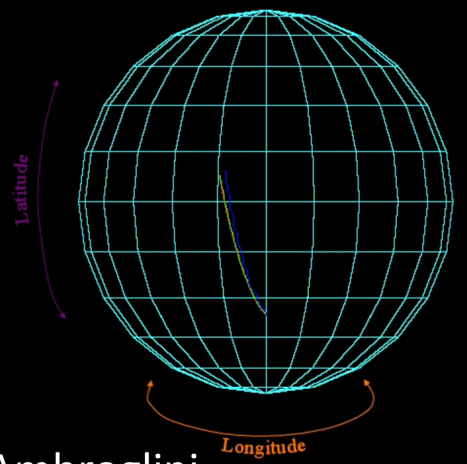


Author:

Stefania Perciballi

China Seismo–Electromagnetic Satellite (CSES): Why a payload for particle physics?

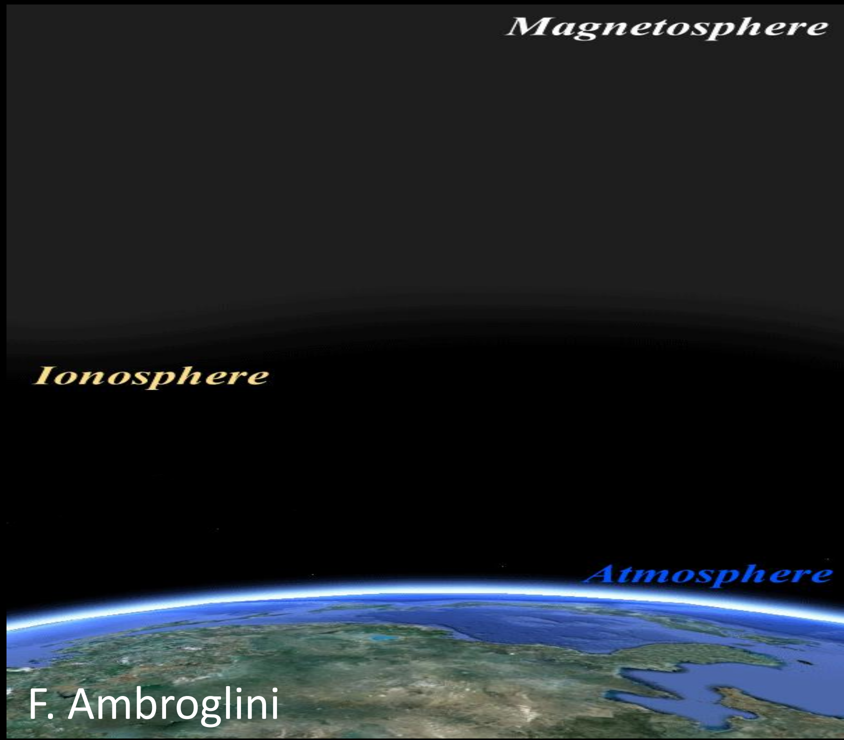
The **CSES mission** is devoted to **study phenomena in high ionosphere related to seismic activity on Earth.**



F. Ambroglini

There exist some observations from previous missions (NOAA, MARIA, MARIA-2 and others) that show a hint of correlation between particle bursts (mainly electrons) and earthquakes.

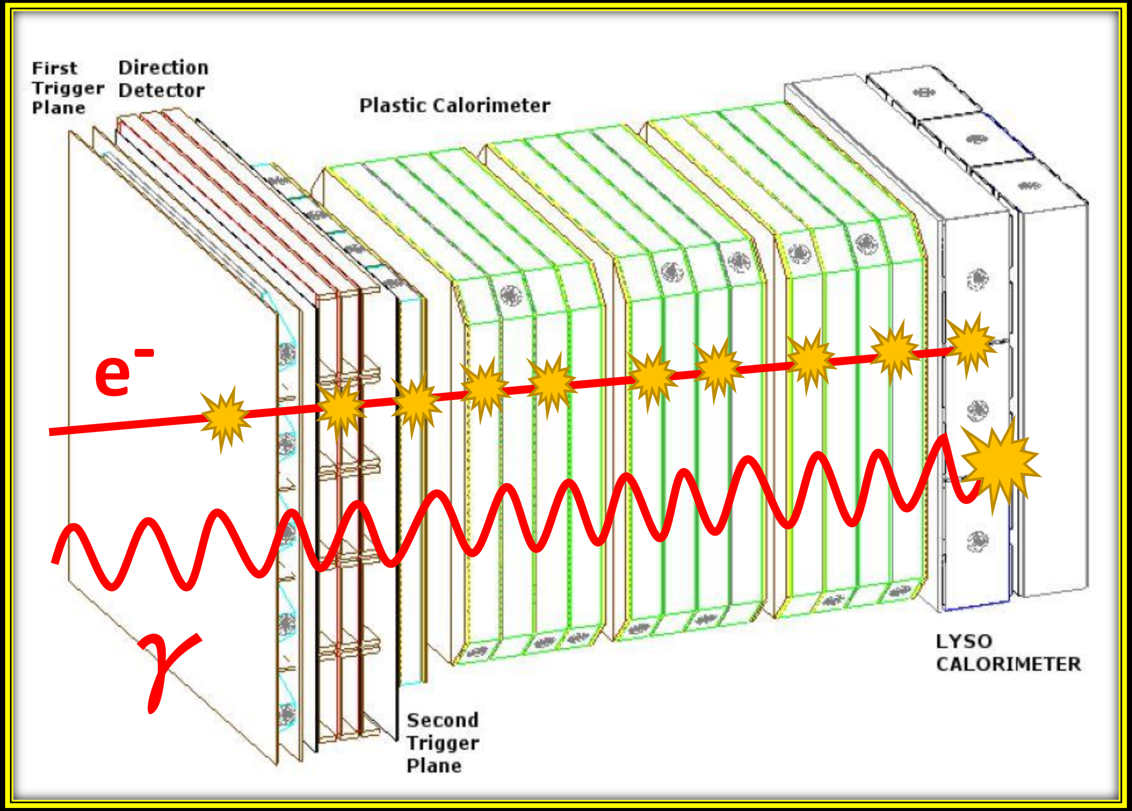
Galper A M, Dmitrenko V V, Nikitina N V, et al. Interrelation of fluxes of high energy charged particles in radiation belt with seismicity of Earth. Cosmic Res, 1989, 27: 789–792



High Energy Particle Detector (**HEPD**) is aimed at **observing particle precipitations and study their correlation with major earthquakes.**

HEPD-2 SetUp

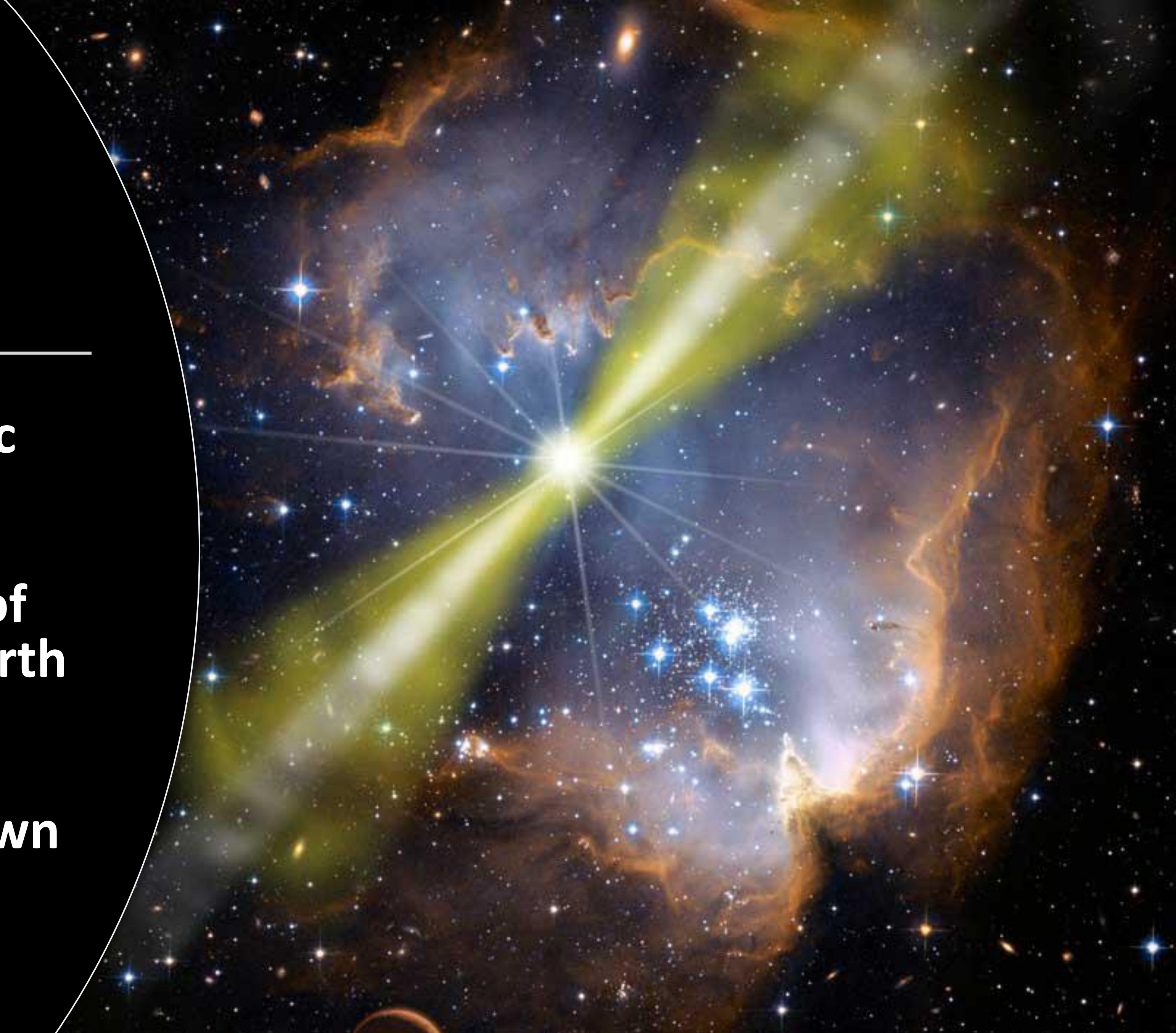
- First trigger plane
- MAPS tracker
- Second trigger plane
- 12 layers of plastic scintillators
- 2 layers of 3 LYSO bars 15x5x5 cm^3
- A veto system around the calorimeter



What about Gamma Ray Bursts detection?

Gamma Ray Bursts (GRB)

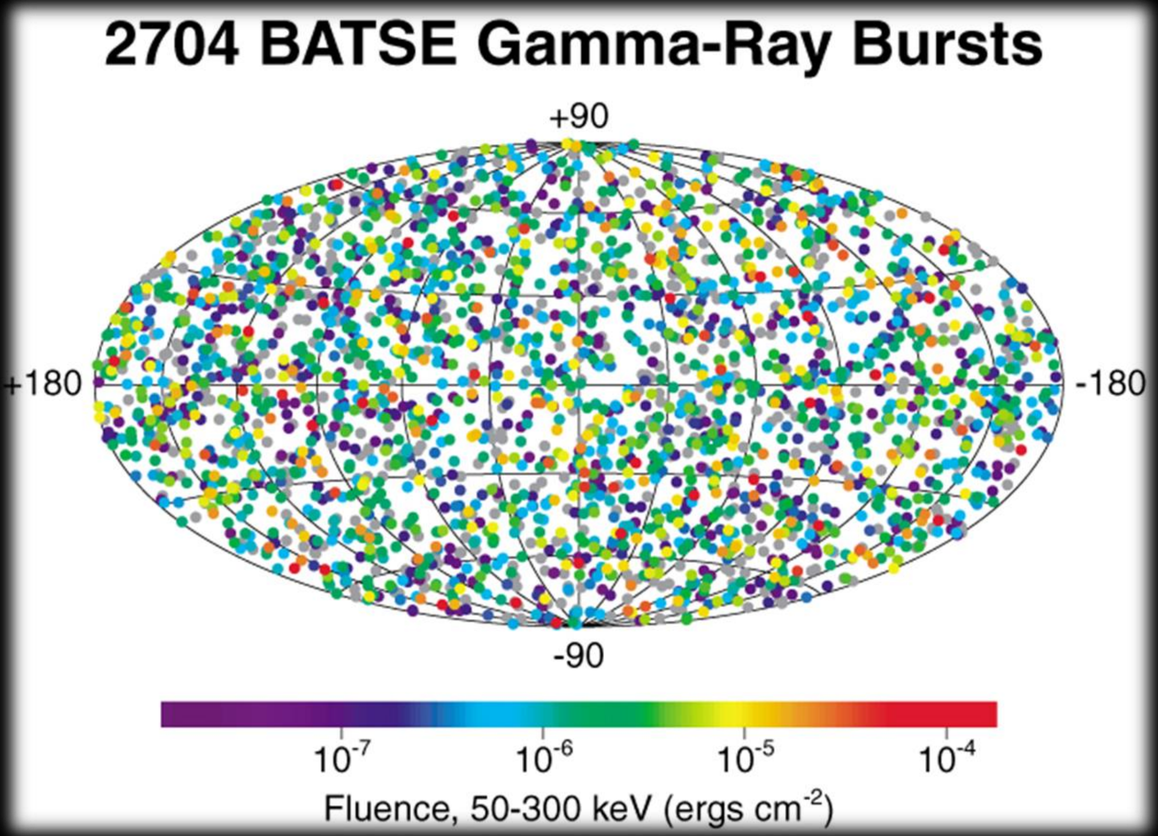
- They are **extremely energetic explosions**
- They are originated **billions of light years** away **from the Earth**
- They are the **brightest Electromagnetic events known in the Universe**



Artist's illustration of a gamma-ray burst

Gamma Ray Bursts (GRB)

- They come from **isotropic direction** around the Earth
- They have a rate of about **one per day**
- They produce an **initial flash** of gamma rays and an **afterglow** of lower energy



BATSE observation of GRB directions. The distribution is isotropic with no concentration on the galactic plane which lies in the middle of the figure

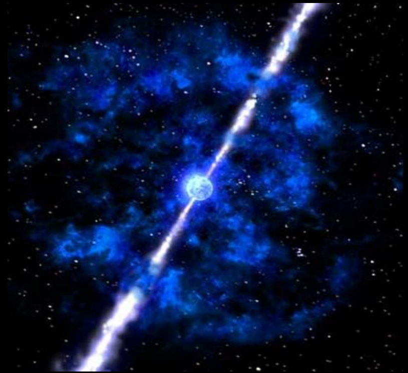
Gamma Ray Bursts: Origins

GRB are divided in 2 categories:

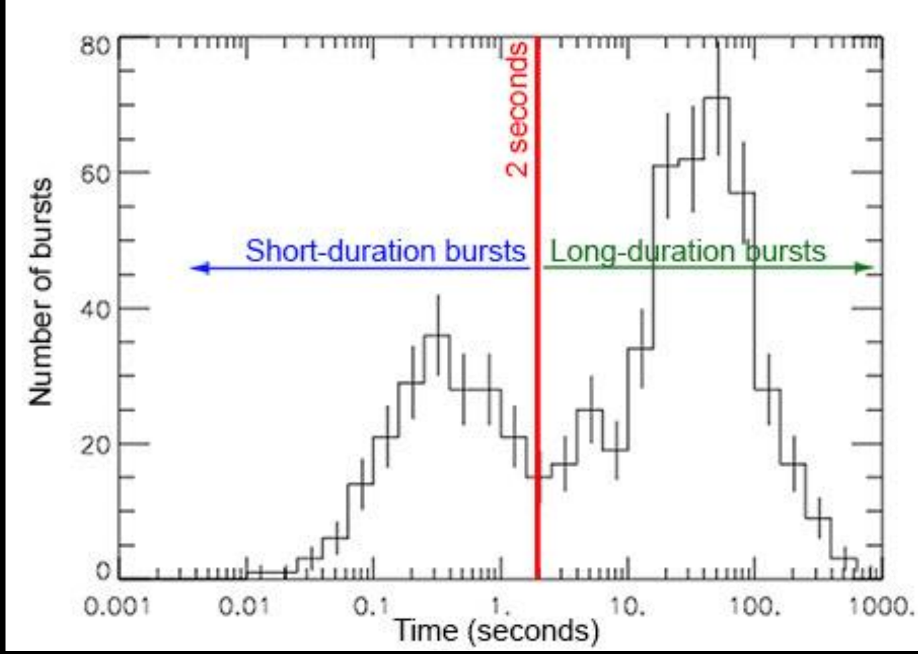
Short GRB:
probably originated by **Neutron star mergers**
they last about 0.3 s

GRB from neutron star merger
Artist representation

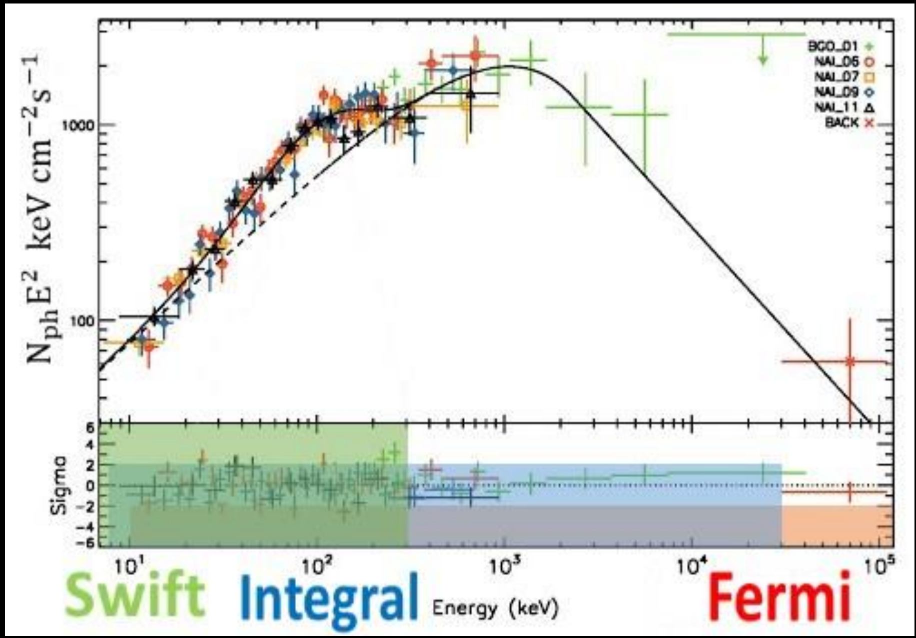
Long GRB:
probably originated by **Supernova explosions**
they last about 30 s



GRB from supernovae explosion
Artist representation



BATSE measured T_{90} distribution for GRB

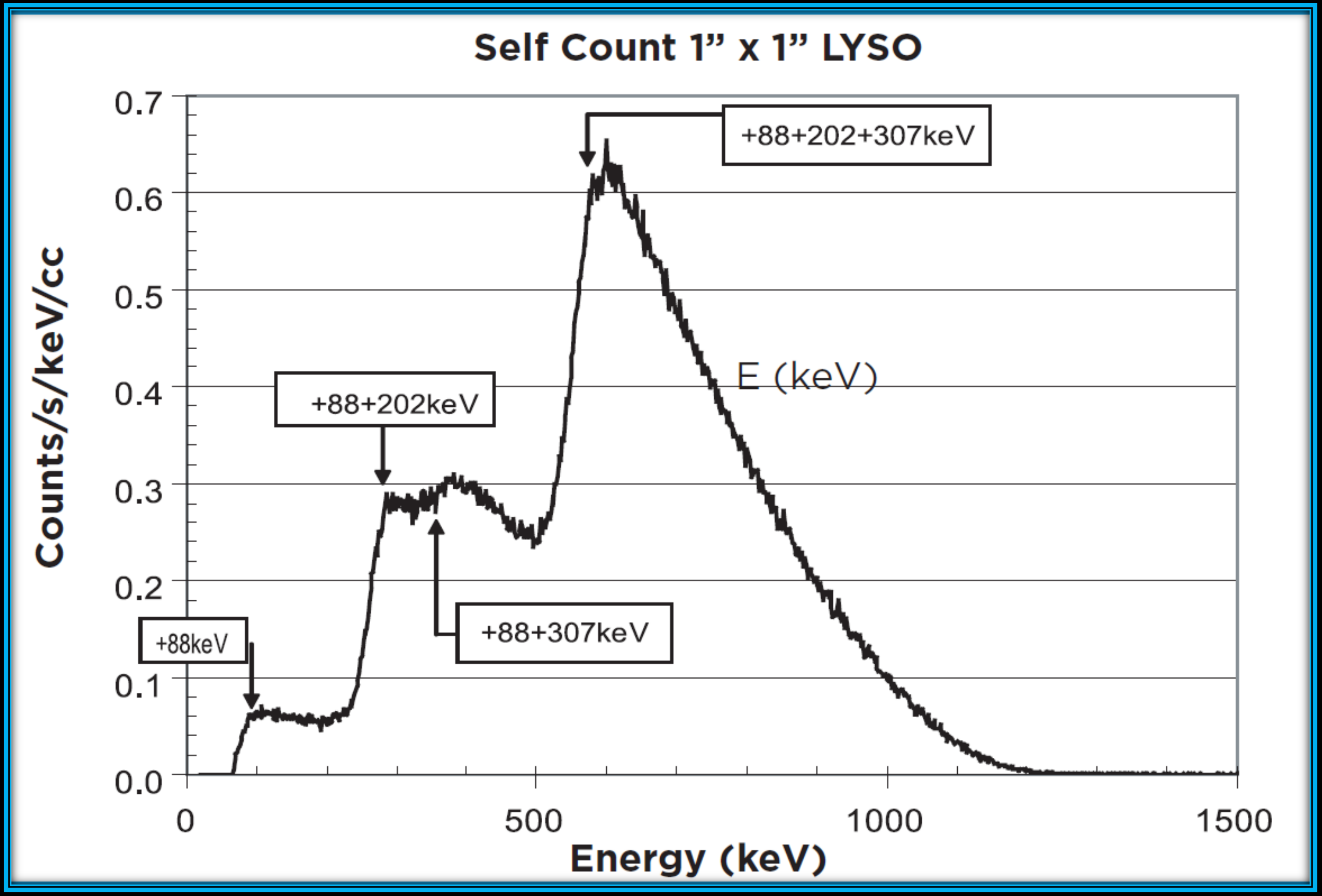


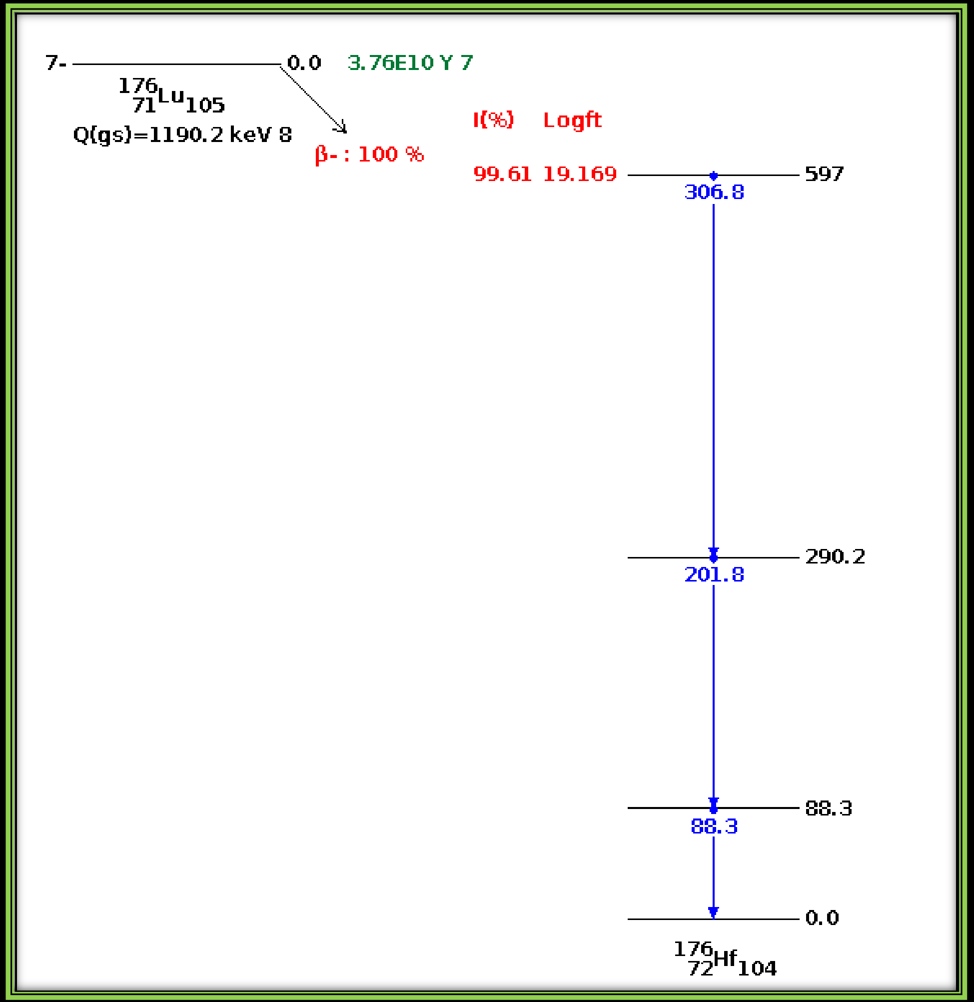
Energy Spectrum of GRB110721A

	BGO	LYSO
	Standardly used for GRB detection	Used in HEPD-2
Light decay time:	300 ns ✗	40 ns ✓
Light yield:	8,000-10,000 ph/MeV ✗	27,600 ph/MeV ✓
Radioactivity:	**1-10 Bq/kg** ✓	**39,000 Bq/kg** ✗

LYSO Radioactivity

$$^{176}Lu \xrightarrow{\beta^-} {}^{176}Hf^* + e^- + \overline{\nu_e}$$

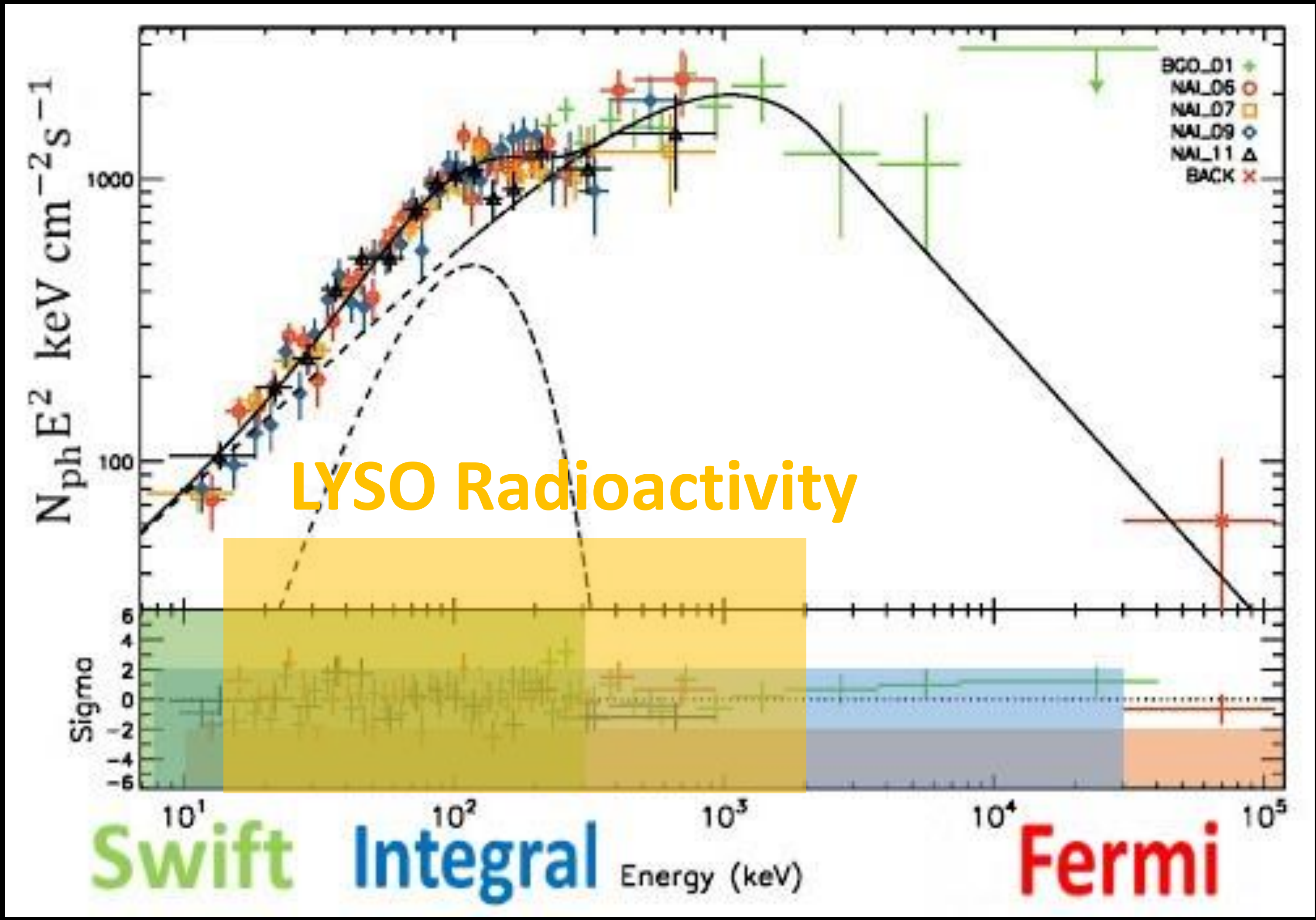




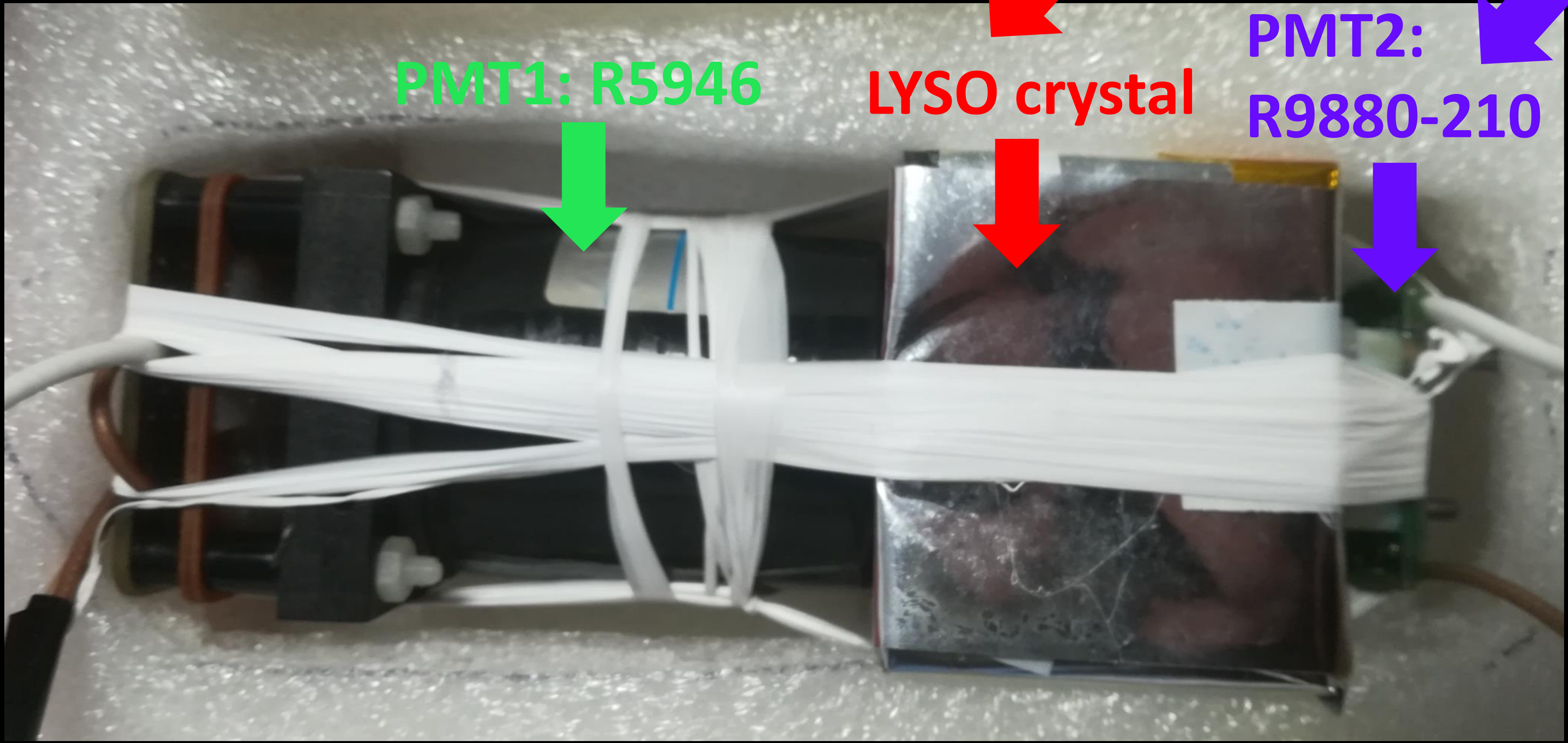
LYSO Radioactivity

- **LYSO radioactivity** constitutes an important **background** for GRB detection at low energy

- For this reason, an **experimental study** of LYSO radioactivity was carried out on an HEPD-1 flight spare crystal



Experimental Set-up

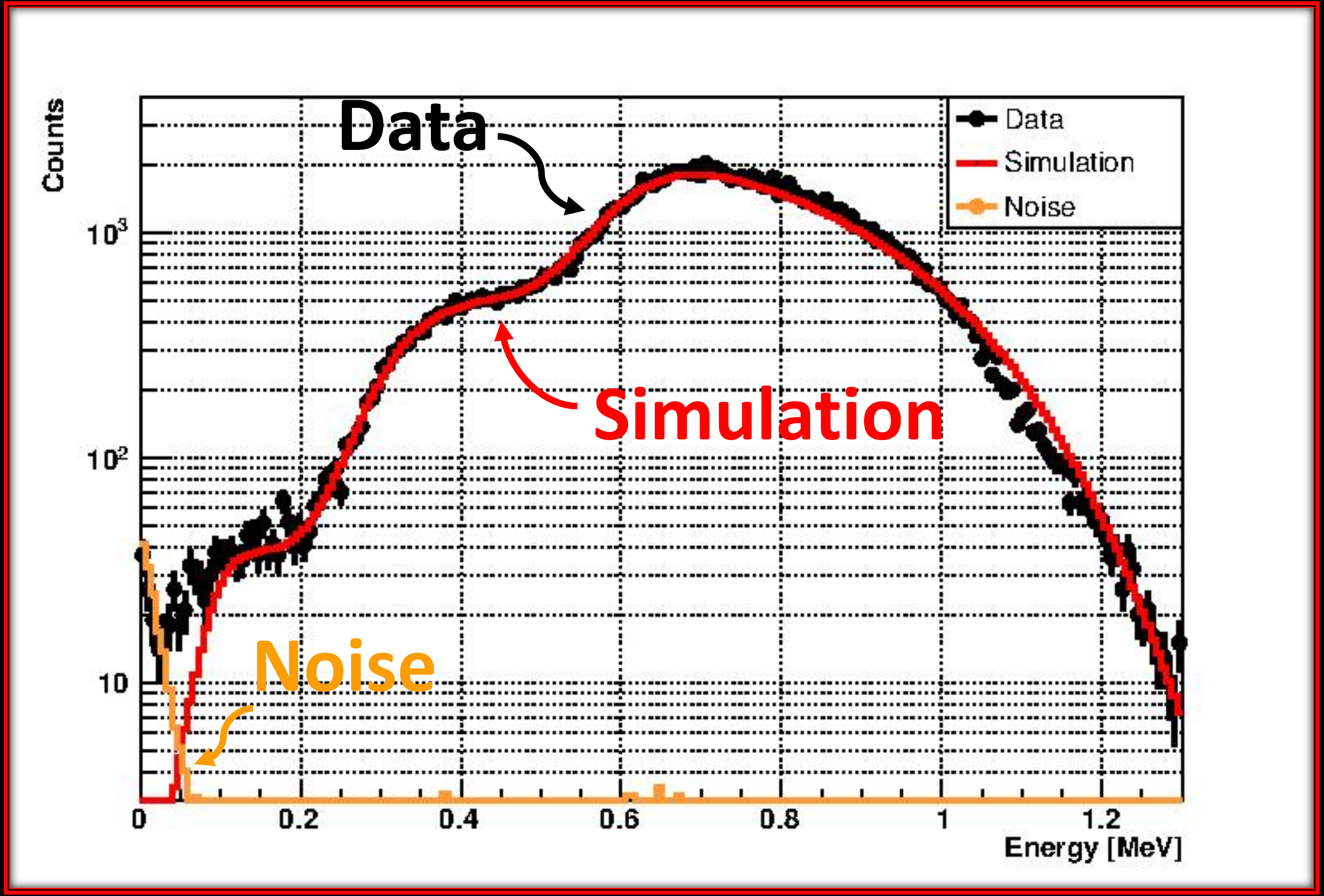


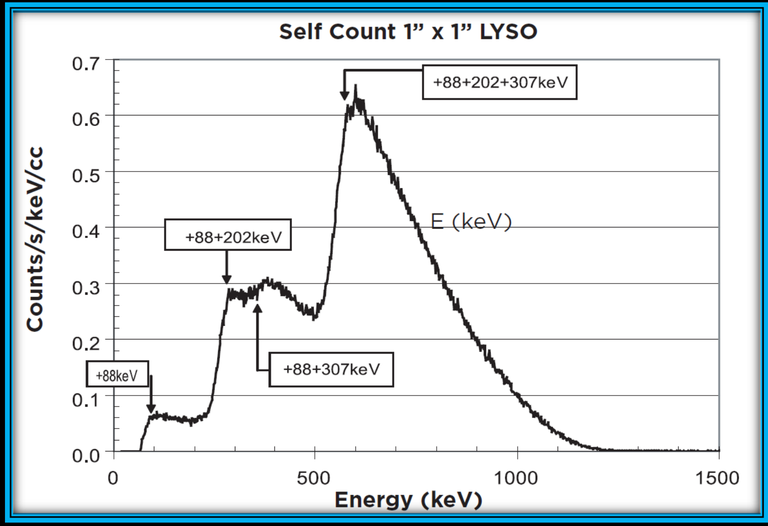
Sources placed 2 cm over LYSO crystal's face center

Operating Voltage: -2000 V
Diameter: 38 mm

Operating Voltage: -850 V
Diameter: 16 mm

LYSO Spectrum



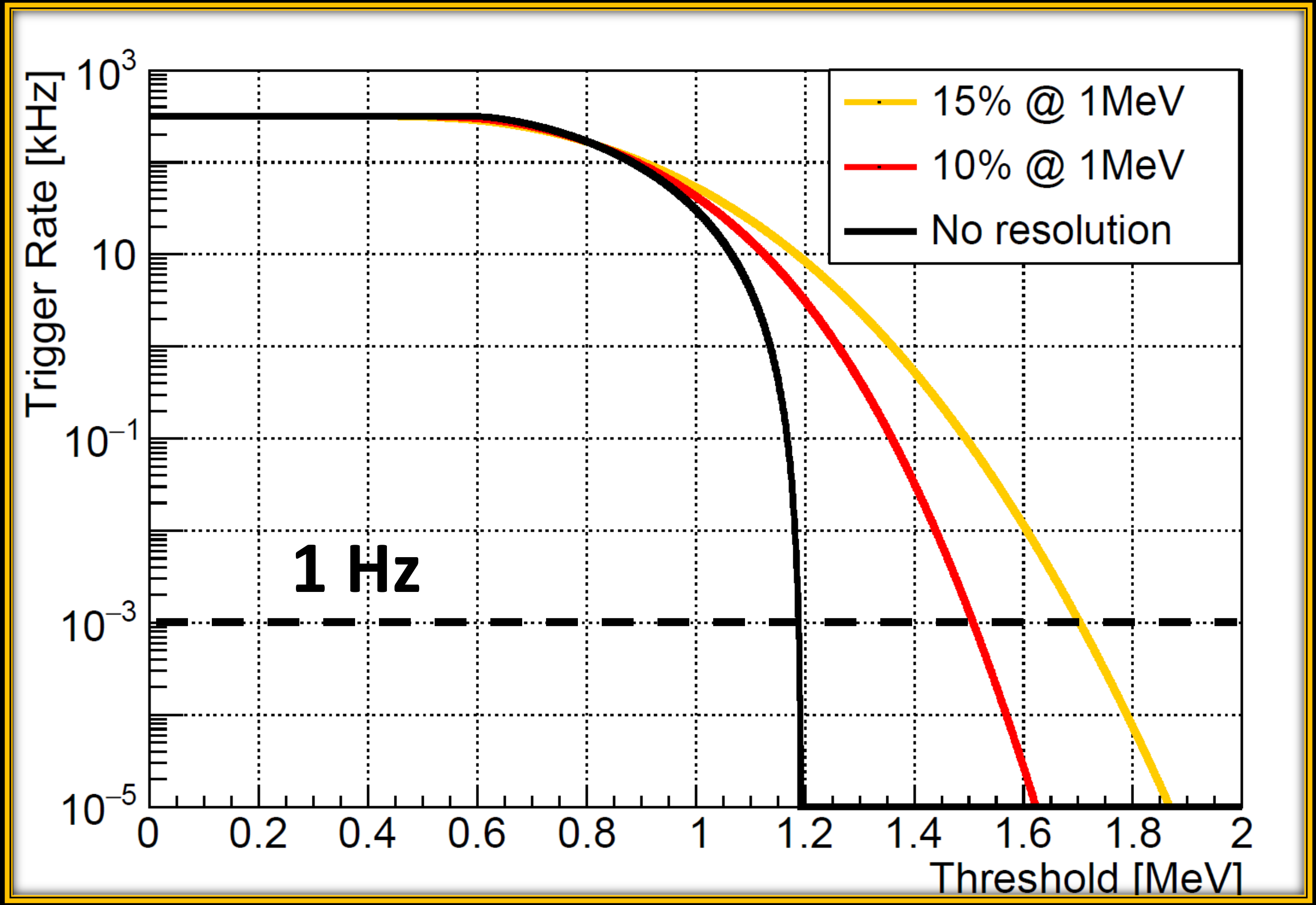


LYSO spectrum from datasheet

- LYSO radioactivity upper limit 1.5 MeV
- It is possible to **measure GRB of energy greater than 2 MeV**

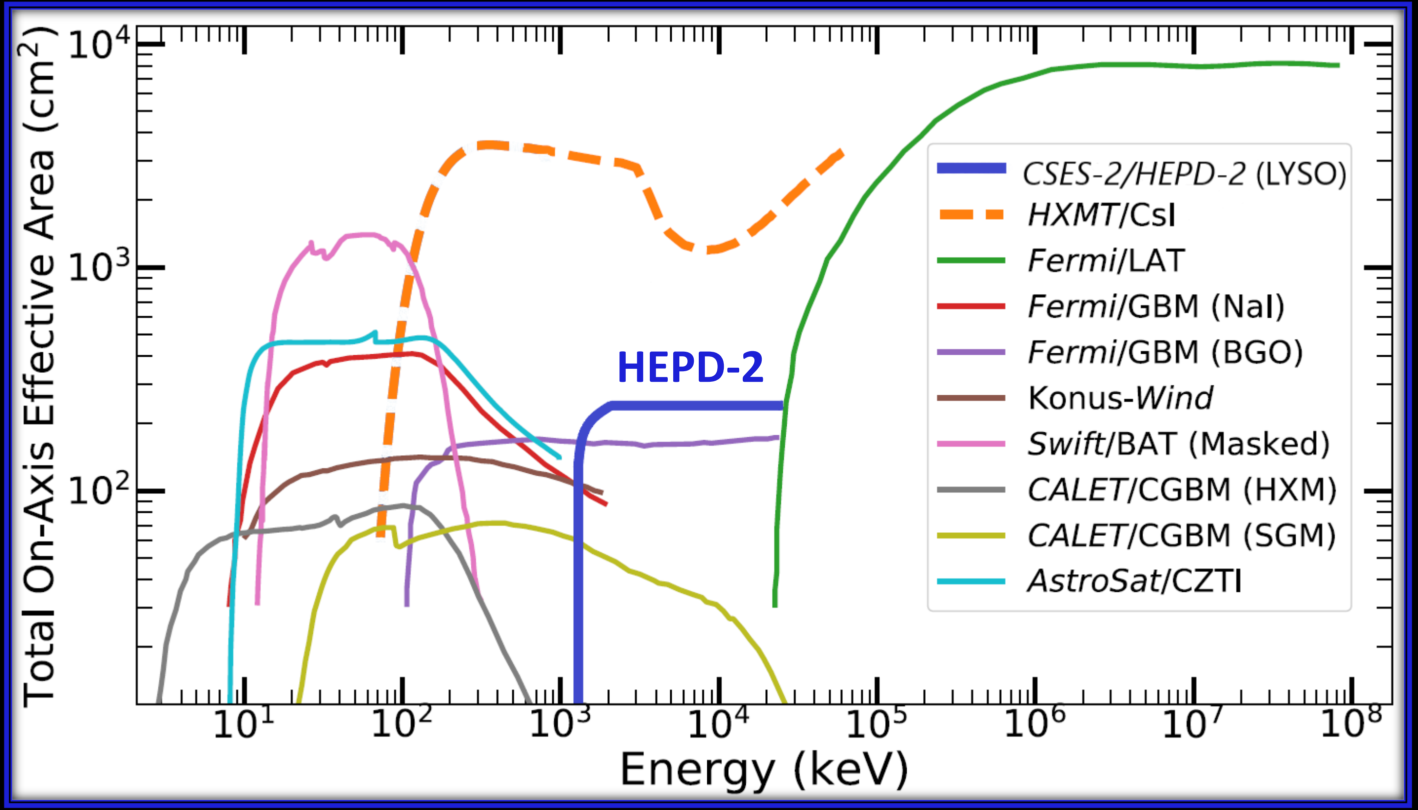
LYSO energy threshold for GRB detection

- Changing the energy resolution it is possible to reach a **lower energy threshold** for the GRB detection
- Measuring **GRB of energy larger than 2 MeV** becomes possible, having a **background below 1 Hz** due to ^{176}Lu decay



HEPD-2 sensitivity for GRB detection

- **HEPD-2 is sensible to GRB detection for energies from 2-20 MeV**, that are explored only by Fermi (BGO) and HXMT and with very low acceptance by CALET
- In that part of the spectrum **HEPD-2 contribution is important** being the **2nd most sensitive detector investigating a different field of view**



Thank you for your attention!