ICRC Summary

HEPD-02 is a particle detector that will fly on board the CSES-02 satellite with the aim of deepening our comprehension of ionosphere phenomena eventually connected to Earth strong seismic events. HEPD-02 is composed by a two trigger planes, a silicon MAPS tracker and a calorimeter composed by twelve layers of plastic scintillators and two layers of three LYSO bars disposed orthogonal to each other. All the detecting units are surrounded by a veto system. The event signature for a charged particle crossing the detector, is a signal in each sub-unit exept for the veto system. Whereas a MeV photon will cross the detector releasing energy only in the LYSO bars and could be identified by requiring a signal only in the LYSO scintillator.

Could this detector be used for Gamma Ray Bursts detection?

GRBs are extremely energetic events of cosmic origin, generated during nearby supernova explosions (long GRB) or neutron stars mergers up to redshift z = 8 (short GRB). The scintillator materials usually used for GRB detection are high density, low radioactivity but long decay time crystals incompatible with the fast PMTs used in HEPD-02. LYSO crystals instead, have a short decay time and can be read with the PMTs used for the plastic scintillators, but they have a high intrinsic radioactivity due to ^{176}Lu causing a limitation for low energy GRBs measurements while is not affecting it above a few MeV. Therefore, it is necessary to properly address the background spectrum in order to evaluate the minimum detectable energy with a sufficient sensitivity.

^{176}Lu is a natural occurring Luthetium isotope (2.6% ab., $T_{1/2} = 3.78 \times 10^{10}$ y) that decays β^- producing an electron, an anti-neutrino and ^{176}Hf, in an excited state. The Hafnium relaxation produces three X ray at 308, 201 and 83 keV (99.61% prob.) or also a forth X-ray at 401 keV (0.39% prob.).

LYSO characterization was carried out for a HEPD-01 spare crystal, on a small set-up, using also a ^{241}Am and a ^{137}Cs sources for energy calibration purpose. A simple Geant4 simulation for the set up was carried out then adding the energy resolution by fitting the 662 keV ^{137}Cs peak, and the calibration function was found by a global fit.

The obtained LYSO spectrum is described with a reasonable accuracy by the simulation, although there is still a low energy disagreement probably due to the voltage threshold imposed by the data acquisition system but also other effects, as a poor Geant4 material description or residual electronic noise events, could contribute.

It is possible to plot the LYSO radioactive rate as a function of the energy threshold, under three resolution hypothesis: no resolution effects, 10 % at 1 MeV or 15 % at 1 MeV. For thresholds greater than 1.5 MeV, the LYSO radioactivity has a rate of less than 1 Hz. This implies that GRBs measurements are feasible with good sensitivity in the 2-20 MeV energy range also in view of the large flux measured in the past for GRB generated at low redshift.

In conclusion HEPD-02 could be used has GRBs detector with a background rate due to ^{176}Lu of less than 1 Hz by setting a threshold of 2 MeV and requiring a signal only in the LYSO bars. With these features, HEPD-02 will be competitive in the 2-20 MeV energy range and, by joining the GRBs campaign, could help potentiate the sky coverage and better understand these phenomena, in particular in conjunction with Gravitational Wave detections.