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Searching for emission from gamma-ray bursts with the ARGO−YBJ detector

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Abstract. The ARGO−YBJ experiment has been designed to decrease the energy threshold of typical Extensive Air Shower arrays by exploiting the high altitude location (Tibet, P.R. China, 4300 m a.s.l.) and the full coverage. The lower energy limit of the detector (a few GeV) is reached with the single particle technique, recording the counting rate at fixed time intervals. We present first results concerning the search for emission from Gamma-Ray Bursts in coincidence with satellite detections.

1. Introduction

The ARGO−YBJ experiment is located at Yangbajing (Tibet, P.R. China, 4300 m a.s.l.) and consists of a single layer of Resistive Plate Counters (RPCs) [1].The detector has a modular structure, the basic module being a CLUSTER (5.7×7.6 m^2), made of 6×2 RPCs. Each RPC is divided into 10 PADs, whose data acquisition is independent and which represent the high granularity pixel of the detector (56×62 cm^2). The digital read-out of each PAD is made by means of 8 strips (6.5×62 cm^2). The detector carpet is connected to two different DAQ systems, which work independently: in shower mode, for each event the location and timing of each detected particle is recorded, allowing the reconstruction of the lateral distribution and of the arrival direction [2]; in scaler mode, the counting rate of each CLUSTER is measured every 0.5 s, with no information on the space distribution and arrival direction of the detected particles. In the scaler mode DAQ, for each CLUSTER four scalers record the rate of counts ≥ 1, ≥ 2, ≥ 3 and ≥ 4 in a time window of 150 ns. The corresponding measured rates are, respectively, ~ 40 kHz, ~ 2 kHz, ~ 300 Hz and ~ 120 Hz. The counting rates for a given multiplicity are then obtained with the relation $n_i = n_{\geq i} - n_{\geq i+1}$ for $i = 1, 2, 3$. The use of four different scalers may give an indication of the source spectrum in case of positive detection. In scaler mode, only 16 of the final 154 CLUSTERS (690 m^2) were working from October 1, 2004 to March 10, 2005, with a 79% efficiency. Since March 17, 2005 there are 42 CLUSTERS (1900 m^2) in data taking. Since mid August, the upgrade to 104 CLUSTERS has started. The data are checked continuously for an effective monitoring of the detector performance.

2. Determination of the detector effective areas

In order to study the detector response to Extensive Air Showers (EASs) developed in the atmosphere, a detailed MC simulation has been carried out for both protons and photons with fixed energies in the range 1 GeV - 1 TeV and zenith angles $\theta = 0°, 20°, 40°$. For our purposes it is crucial to correctly simulate the "cluster size", i.e., the correlation between the number of particles hitting the detector and the number of signals generated in the different multiplicity channels. Therefore, the results of the MC simulation have been compared with an analytical calculation of the multiplicity spreading based on the measured cluster size. Figure 1 shows the effective areas for primary photons and protons with zenith angle $\theta = 20°$ in the four multiplicity channels.

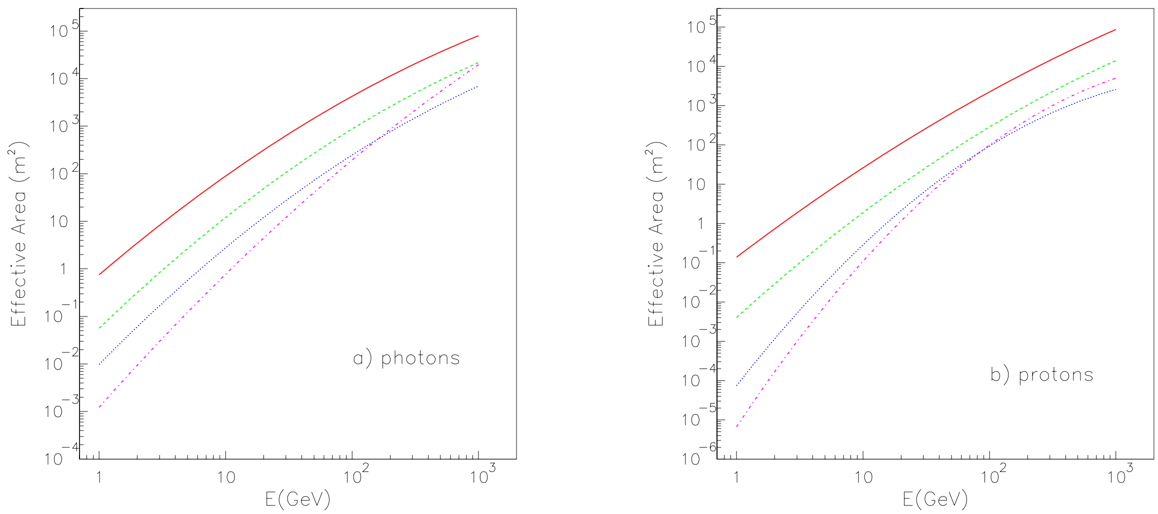

Figure 1. Effective areas for primary photons (a) and protons (b) with zenith angle $\theta = 20°$. The curves refer to different multiplicity channels: n=1 (continuous), n=2 (dashed), n=3 (dotted) and n≥4 (dot-dashed).

The effective areas are then convoluted with the following primary spectra: for photons, $dN_\gamma/dE \propto E^{-\Gamma}$ with $\Gamma = 2$ up to $E_{cut} = 100\ GeV$, for protons, $dN_p/dE \propto E^{-\Gamma}$ with $\Gamma = 2.7$ and taking into account the geomagnetic bending [3]. The mode of the distributions resulting for photons increases from 5 GeV (n=1) to E=100 GeV (n≥4). The distribution widhts give the energy region of interest for the detector. Table 1 reports our results for both photons and protons in the four multiplicity channels.

Table 1. Mode energy and energy range (Full Width at Half Maximum) resulting from the convolution of the effective area with the primary spectrum of both photons and protons, in the four multiplicity channels.

Multiplicity	$E_{mode}\gamma$(GeV)	$E_{range}\gamma$(GeV)	$E_{mode}p$(GeV)	$E_{range}p$(GeV)
=1	5	1-83	6.5	1.8-33
=2	16	1.2-100	11	2.8-65
=3	25	2-100	25	6.4-123
≥4	100	15-100	52	12.5-240

3. Results

Typical fluence upper limits in the $1 - 100\ GeV$ energy range are obtained using the measured counting rates and a model for the Gamma-Ray Burst (GRB). Assuming for this latter a power law spectrum with differential index $\Gamma = 2$ up to $E_{cut} = 100\ GeV$, no absorption by the Extragalctic Background Light (redhsift $z = 0$), a zenith angle $\theta = 20°$ and a duration $\Delta t = 10\ s$, the 3σ fluence upper limits for the four multiplicity channels are reported in figure 2.

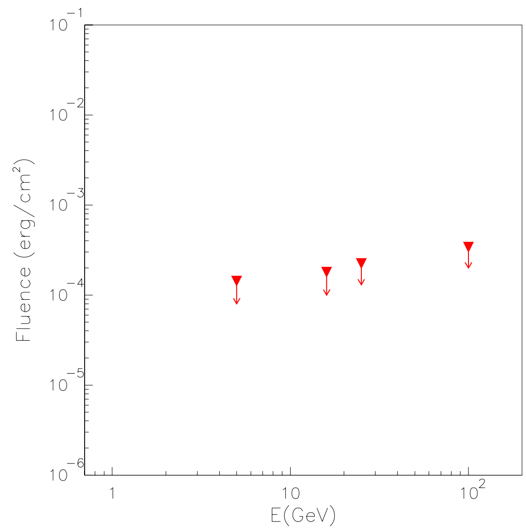

Figure 2. Typical fluence upper limits for the four multiplicity channels of ARGO−YBJ scaler mode.

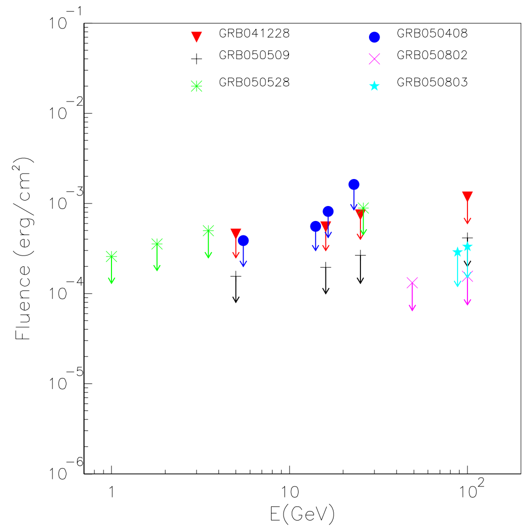

Figure 3. Fluence upper limits for 6 GRBs exploded within the ARGO−YBJ field of view ($\theta < 40°$). Only for GRB050408 ($z = 1.24$) the $\gamma\gamma$ absorption is considered.

The search for emission from GRBs started with the first GRB detection by the Swift satellite on December 17, 2004, since the ARGO−YBJ experiment participates to the Swift Follow-Up program. The search is triggered by detections with the Swift, HETE and Integral satellite experiments. Up to September 2005, 9 GRBs detected by these satellites were within the ARGO−YBJ field of view ($\theta < 40°$). Unfortunately, because of the upgrade to 104 CLUSTERS started in August, data for only 6 of these GRBs were available (3 GRBs exploded within the ARGO−YBJ field of view in the second half of August!). No excess in the scaler counts was observed during the duration time measured by the satellites, and therefore 3σ upper limits to the fluence of these events were calculated using the spectral indices determined at lower energies by satellites (when available, otherwise assuming again $\Gamma = 2$) and fixing $E_{max} = 100\ GeV$. Our results are reported in figure 3. For GRB050408 the redshift is also known ($z = 1.24$), so the upper limit is calculated including a $\gamma\gamma$ absorption model [4]. For the other GRBs $z = 0$ is assumed, since below 100 GeV the $\gamma\gamma$ absorption is almost negligible for $z < 0.5$.

We expect to increase the sensitivity by a factor ~ 2 with the detector completion, and an equivalent improvement converting secondary photons with a 0.5 cm thick layer of lead.

References

[1] Cao Z on behalf of the ARGO−YBJ collaboration 2005 *Proc. 29th Int. Cosmic Ray Conf.* August 3-10, 2005, Pune, India, Session OG.2.7

[2] Marsella G on behalf of the ARGO−YBJ collaboration 2005 *Proc. 9th Int. Conf. on Topics in Astroparticle and Underground Physics* September 10-14, 2005, Zaragoza, Spain

[3] Gaisser T K and Honda M 2002 *Ann. Rev. Nucl. Part. Sci.* **52** 153-99

[4] Salamon M H and Stecker F W 1998 *ApJ* **493** 547-54