# ARGO-YBJ resolution and sensitivity to detect gamma rays sources

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**Abstract.** ARGO-YBJ is a full coverage EAS array consisting of a $\sim 74 \times 78\ m^2$ layer of RPCs (Resistive Plate Counters). ARGO-YBJ will provide a detailed space-time picture of the shower front allowing to face a wide range of fundamental issues including the study of gamma-rays ($100\ GeV - 10\ TeV$) from point sources. A detailed simulation has been performed to estimate the angular resolution and the sensitivity of the apparatus. We present the results obtained and (as an example) the sensitivity of ARGO-YBJ to detect a known gamma rays source (CRAB).

## INTRODUCTION

The ARGO-YBJ experiment (Astrophysical Radiation with Ground-based Observatory at YangBaJing) is under construction at the YangBaJing High Altitude Cosmic Ray Laboratory (4300 $m$ $a.s.l.$ equivalent to 606 $g/cm^2$) 90 $Km$ North to Lhasa (Tibet). The main aim of the experiment is the study of cosmic $\gamma$ rays at an energy threshold of $\sim 100\ GeV$ [1].

The apparatus will consist of a full coverage array ($\sim 74 \times 78\ m^2$) realized with a single layer of RPCs (Resistive Plate Counters) surrounded by a *guard ring* for a total area of $\sim 100 \times 100\ m^2$ (see figure 1).

The basic element providing the time pattern of the shower is the logic PAD. It is defined as the fast-OR of 8 strips each 6 $cm$ wide and 62 $cm$ long used to pick up the signals of the RPC [2]. These logic PADs ($56 \times 62\ cm^2$) define the time granularity of the detector (there are $\sim$ 17400 PADs in the carpet) while the space granularity is defined by the strips ($\sim$ 125000 in the carpet). The basic detection unit will be the *cluster* that is a set of 12 contiguous RPCs (see figure 1).

## THE ARGO-YBJ PERFORMANCES

To evaluate the performance of the detector in the reconstruction of the shower parameters an intense simulation activity has been performed. For the simulation of the development of the EAS in the atmosphere has been mainly used the Corsika

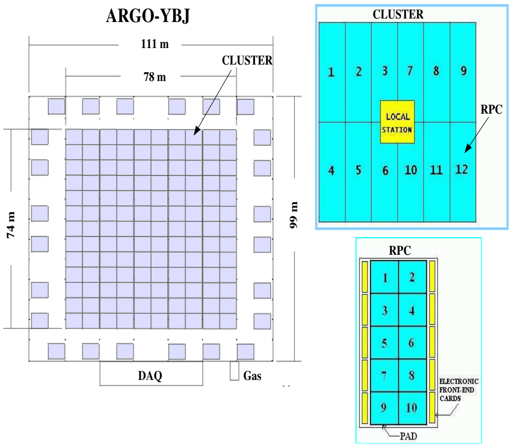


**FIGURE 1.** Schematic view of the ARGO-YBJ detector

5.624 [3] program and, for comparisons, EPAS [4] and HADRAS [5]. A total of $\sim 10^6$ gamma induced and of $\sim 10^7$ hadron induced showers has been generated in an energy range of $10 - 10^5\ GeV$ for the gammas and of $10^2 - 10^5\ GeV$ for the hadrons.

The simulated EAS have been processed with a GEANT 3.21 [6] based program that simulates the detector in all details. The simulation of the performances of the RPCs included in this Monte Carlo takes into account the results of a test performed in the YangBaJing laboratory [7].

The output of the detector simulation program has been read and processed with the analysis program that we plan to use for the real data.

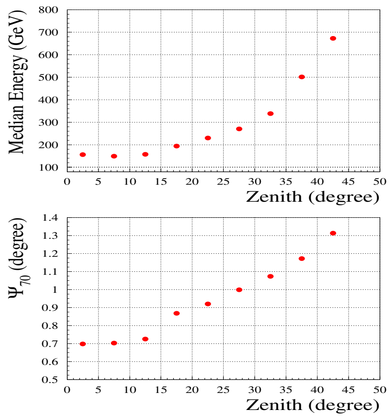


**FIGURE 2.** Dependency on the zenith angle of the median energy (upper panel) and of the ARGO-YBJ resolution (lower panel).

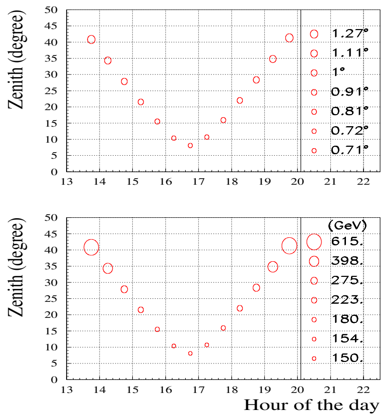


**FIGURE 3.** Detector angular resolution (upper panel) and median energy of the reconstructed gamma induced showers (lower panel) for the CRAB Nebula source during a hypothetical day of data taking.

One importan factor in the estimation of the performances of the detector is the dependency of the energy threshold on the zenith angle of the gamma inducing the shower. This is mainly due to the different depth of atmosphere that the showers have to cross for different zenith angle (see upper panel of figure 2). Moreover, the resolution of the detector is itself dependent on the zenith angle of the shower due to the different acceptance of the detector. In fact, for inclined showers, the detector area and the PADs area become smaller and, at the same time, the detector became strongly asymmetric (see lower panel of figure 2).

Another important element in order to estimate the sensitivity of ARGO-YBJ is its capability to discriminate between gamma induced and hadron induced showers. Thanks to very high space granularity, ARGO-YBJ can discriminate between these two types of showers looking at the spatial distribution of the particles [8].

## THE ARGO-YBJ SENSITIVITY

The sensitivity of ARGO-YBJ to a point source of gamma rays depends on its angular resolution $\psi_{70}$ (defined as the width of the angular bin that contains the 70% of the reconstructed showers of a point source), its effective area for gamma induced and hadron induced showers ($A_\gamma(E,\theta)$, $A_h(E,\theta)$), and on the quality factor of the $\gamma$/hadron separation ($Q(E,\theta)$). However, due to the fact that all these quantities are function of the energy, the sensitivity depends on the spectrum of the gamma rays source itself.

As showed before, it is not possible to quote a sensitivity of the detector to a generic gamma rays source. The well know CRAB Nebula has been used as a test for the calculation of the ARGO-YBJ sensitivity.

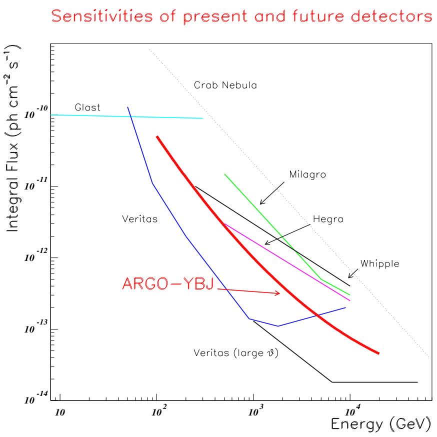


**FIGURE 4.** Sensitivity of ARGO-YBJ to the CRAB Nebula compared with other experiments ( [10]- [13])

The figure 3 (lower panel) shows the median energy of the gamma induced showers detected by ARGO-YBJ as function of the zenith position of the source ($y-axis$

in the plot) during a day ($x - axis$) of data taking. In the same figure, the upper panel shows, using the same representation, the detector resolution.

The sensitivity of ARGO-YBJ to the CRAB Nebula can been calculated from the following equation:

$$S = \frac{0.7 \cdot T \cdot \int\int \Phi_\gamma(E) A_\gamma(E,\theta) f'(\theta) Q(E,\theta) dE d\theta}{\sqrt{T \cdot \int\int \Phi_h(E) A_h(E,\theta) f'(\theta) \Delta\Omega(E,\theta) dE d\theta}}$$

where $T$ is the total detection time (in days), $\Phi_\gamma(E)$ and $\Phi_h(E)$ are respectively the gamma rays source flux and the cosmic rays flux (background), $f(\theta)$ is the time of the day at which the source is at the zenith position $\theta$ and $\Delta\Omega(E,\theta)$ is the bin in the sky defined by the angular resolution of the detector in $sr$.

The sensitivity obtained is shown in figure 4 compared with the quoted sensitivity of other present and future experiments.

This curve can assumed as the ARGO-YBJ sensitivity to gamma ray sources with an energy spectrum *similar* to the CRAB Nebula and with a *similar* position in the sky.

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