Frascati Physics Series Vol. XXXVII (2004) pp. 375–382
Frontier Science 2004, Physics and Astrophysics in Space
Frascati, 14-19 June, 2004

STATUS OF THE ARGO-YBJ EXPERIMENT

P. Bernardini [a,b]

on behalf of the ARGO-YBJ Collaboration

[a] *Dipartimento di Fisica, Università di Lecce, via per Arnesano, 73100 Lecce, Italy*

[b] *INFN, Sezione di Lecce, via per Arnesano, 73100 Lecce, Italy*

Abstract

The ARGO-YBJ experiment is devoted to the study of many issues in γ-astronomy and cosmic ray physics. The apparatus design is based on Resistive Plate Chambers operated in streamer mode and assembled in a single layer, fully covering a surface of 78×74 m^2 (the surface becomes 110×100 m^2 taking into account a partially instrumented ring). The mounting of the detector is going on in the YangBaJing Laboratory (Tibet, China) at 4300 m above the sea level. The present status of the experiment, the performances of the detector and some preliminary analysis of data will be presented.

1 Introduction

ARGO-YBJ is the acronym of *Astrophysical Radiation Ground-based Observatory* - *YangBaJing* and indicates a telescope optimized for the detection of small size air showers [1, 2] and located at the Yangbajing Cosmic Ray Laboratory (4300 m $a.s.l.$). The detector design is simply a single layer of Resistive Plate Chambers (RPCs) covering a large area and providing a detailed space-time image of the shower front.

Operated at high altitude this detector could image with high sensitivity and efficiency atmospheric showers initiated by primaries with energy in the range 100 $GeV \div 500\ TeV$. Therefore ARGO is a powerful tool to study cosmic γ-radiation at an energy threshold close to the limits of the satellite technology. Data gathered with ARGO will allow to face a wide range of fundamental issues:

- γ-ray astronomy, looking for point-like (galactic and extra-galactic) sources with an energy threshold of few hundreds GeV and for diffuse flux from Galactic plane and SuperNova Remnants;
- Gamma Ray Burst (GRB) physics, extending the satellite measurements over the $GeV - TeV$ energy range [3];
- Cosmic ray (CR) physics [4], that is measurements of proton/antiproton ratio at TeV energy, studies of spectrum and composition around the knee ($E > 10\ TeV$);
- Sun and Heliosphere physics ($E > 10\ GeV$), looking for CR modulation, monitoring the interplanetary magnetic field and observing flares of high energy gammas and neutrons from the Sun.

2 Main detector features and project performance

The active elements of the ARGO-YBJ detector are bakelite RPCs [5, 6] operated in streamer mode, with a mixture of argon (15%), isobutane (10%) and tetrafluoroethane (75%). The detector layout is shown in Fig. 1. The spatial measurement is gathered from strips ($6.5 \times 62\ cm^2$), the fast-OR signal from 8 strips (logical pad) provides the time measurement with a resolution of $\sim 1\ ns$.

The high space-time resolution allows to get a high granularity image of the shower front (an example in Fig. 2). The full coverage allows to decrease the energy threshold without losing shower details, therefore also small showers are detectable with this detector. The pointing resolution is expected to be better than 0.5°. Moreover the large aperture and the high duty-cycle ensure the continuous monitoring of the sky in the declination band $-10° \div 70°$.

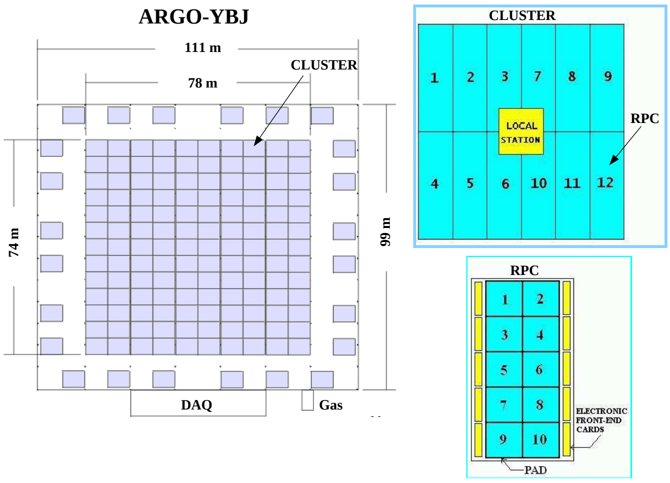

Figure 1: Layout of the detector

Two main kinds of trigger have been designed for the data-acquisition: the 'shower mode' and the 'scaler mode'. In the first one, a minimum pad multiplicity is required on the central carpet, with space/time consistency as for a shower front. In the 'scaler mode' the pad rate is measured from each cluster, with an integration time of 0.5 s. This last DAQ mode is devoted to the apparatus monitoring and the detection of unexpected increases in CR flux, as an effect of GRB, solar flares and so on.

3 Status of the experiment

The construction of the detector slowed up in 2003 because of the Severe Acute Respiratory Syndrome (SARS). Furthermore damages to the front-end electronics due to high density showers have been observed. This problem has been fixed thanks to the insertion of Zener diodes.

In the last months many cross-check measurements have been performed operating RPCs in Italy and in Tibet. Also an RPC telescope has been built in the YBJ laboratory. The goals of these measurements were the optimization of the gas mixture, the fine tuning of the electronics set-up and the monitoring of the RPC efficiency and stability.

Presently 16 cluster are in data-taking for many months with high stability and without significant damages. The RPC operation is also successfully monitored by a Detector Control System (DCS), able to record HV, currents, temperature, humidity, pressure and gas flow. Now the construction of the

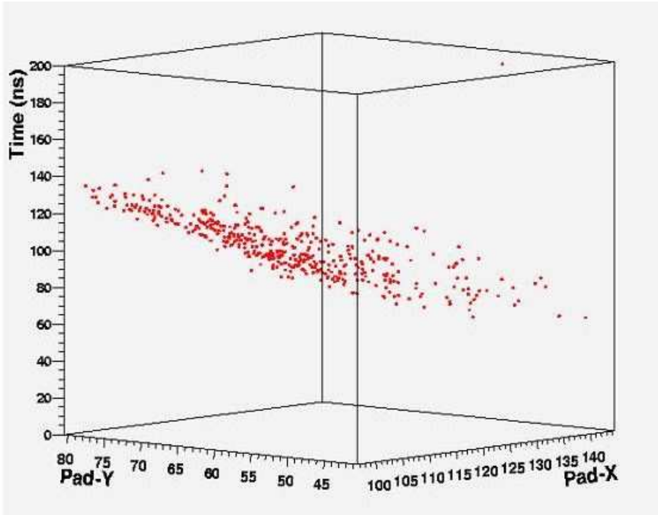

Figure 2: Display of a real event in space-time view

detector is going very fast and 48 clusters are expected to be operating within December 2004.

4 Detector performance and first measurements

Here the data collected in 'shower mode' with 6 clusters (260 m^2), after the modification of the front-end electronics, are presented. The analysis results are in full agreement with those of data collected in the past with 16 clusters, before electronics protection.

Rate measurements

In Fig. 3 differential and integral rates are plotted versus the hit multiplicity. The differential rate follows a power law with slope 2.5. This result demonstrates the physics consistency of the measurement and the agreement with what estimated on the basis of the CR spectrum. Also the rates of the different triggers are the expected ones and the distribution of the time difference between consecutive events (Fig. 4) confirms the regular operation of the detector.

Time calibration and angular resolution

Dedicated runs with high multiplicity trigger (more than 32 hits on each cluster) have been used for a preliminary time calibration. The goal of the procedure

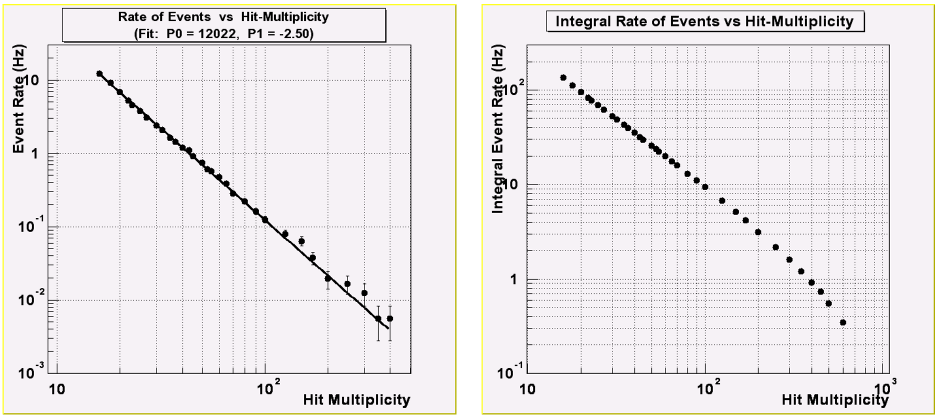

Figure 3: Differential and integral rates versus hit multiplicity (trigger condition: more than 15 hits)

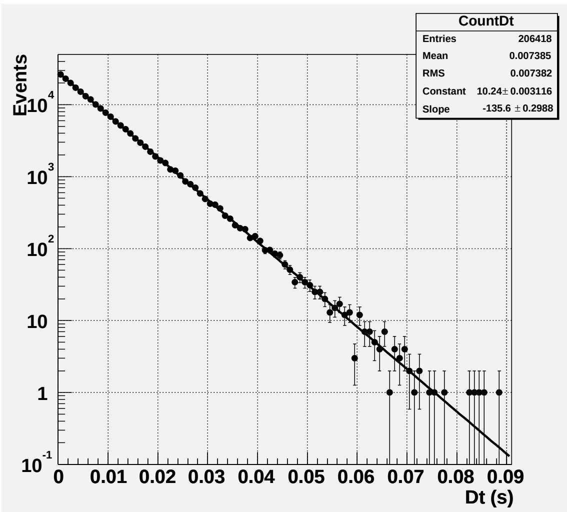

Figure 4: Time difference between events (trigger condition: more than 15 hits on each cluster)

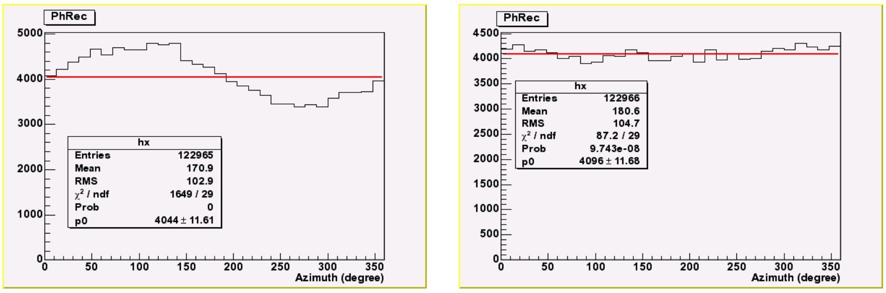

Figure 5: Azimuthal distribution before and after the time calibration. The χ^2 of the uniform fit is used as the estimator of the symmetry of the detector response

was to remove systematical time-offsets among the pads.

Corrections in the range $\pm 4\ ns$ have been introduced to minimize the time residuals, that is the difference between the time measured by the pad and the time of the shower estimated by the planar fit. After these corrections, the peak values of the residual distributions are very close to 0 ($|t_{peak}| < 0.2\ ns$).

The uniformity of the azimuthal distribution is another parameter taken into account in the calibration. A systematic correction of the time measurement has been introduced according to the method suggested in [7]. The effect of this second correction on the azimuthal distribution is shown in Fig. 5. Also the symmetry of the direction cosine distributions improves as an affect of this systematics correction.

The angular resolution of the 6-cluster carpet has been estimated by dividing the detector into two independent sub-arrays (”odd” and ”even” pads) and studying the angular difference $\Delta\varphi$ between the reconstructed shower directions. The angular resolution depends on the width of the $\Delta\varphi$ distribution [1] and decreases with the hit multiplicity, as shown in Fig. 6.

Angular distributions of Extensive Air Showers

In the first plot of Fig. 7 the distribution of the reconstructed zenith angle θ is shown. In the second plot the quantity $sec\ \theta - 1$ is displayed. By means of the fit with the function $e^{-\alpha(sec\theta-1)}$ we get $\alpha = 4.678 \pm 0.016$. Then we estimate $(128.3 \pm 0.4)\ g/cm^2$ as attenuation length of showers, in excellent agreement with previous measurements [1].

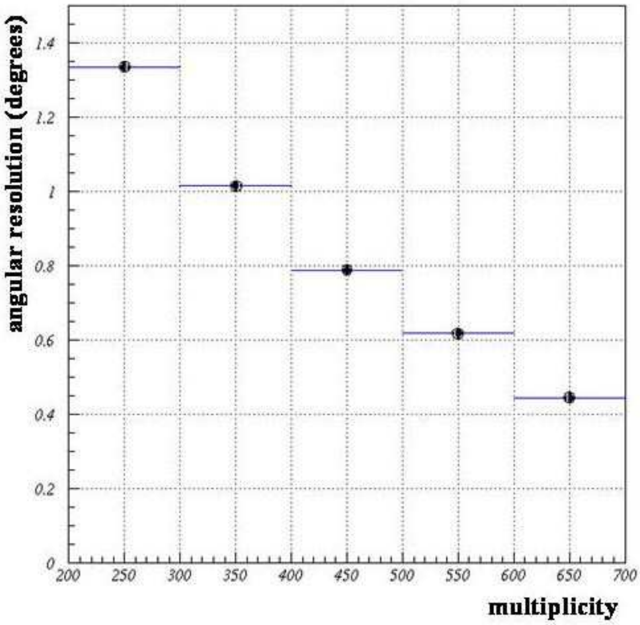

Figure 6: Angular resolution versus hit multiplicity

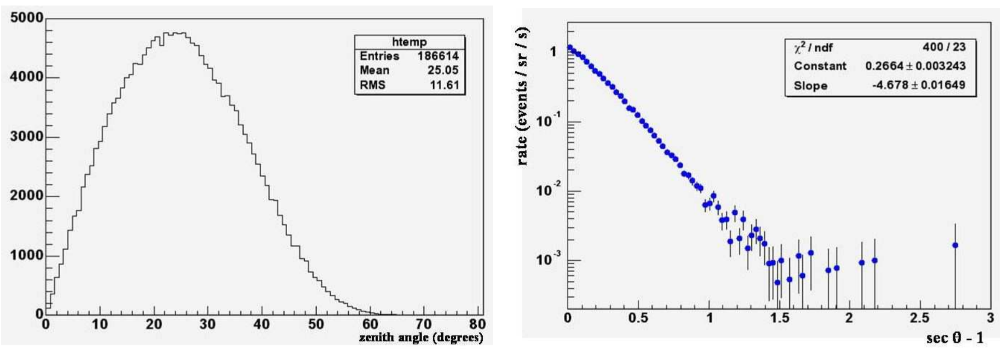

Figure 7: Distributions of the zenith angle θ and of the function $sec\ \theta - 1$

5 Conclusions

The construction of the ARGO-YBJ detector is going on. Some problems in the RPC front-end electronics have been studied and fixed. The data collected with portions of the apparatus have been used to check the detector performances and the analysis codes. The detector works as good as expected. Absolute trigger rates, shape of hit multiplicity distribution and preliminary shower reconstruction are consistent with the CR physics.

We foresee that 48 clusters ($\sim 2000\ m^2$) will be in data-taking at the end of December 2004 and the central carpet will be completed within the begin of 2006. Stable data-taking and physics runs are expected already at the end of 2004. First physics results are close.

References

[1] C. Bacci et al. (ARGO-YBJ Collaboration), *Astroparticle Physics 17* (2002) 151

[2] ARGO Collaboration, Proceedings of the 25th International Cosmic Ray Conference (Durban), *5* (1997) 265 and 269

[3] ARGO-YBJ Collaboration, Workshop "Gamma Ray Bursts in the Afterglow Era", Rome (1998), in *Astronomy and Astrophysics, Suppl. Series 138* (1999) 597, also astro-ph/9904373

[4] L. Saggese et al. (ARGO-YBJ Collaboration), Proceedings of the 28th International Cosmic Ray Conference (Tsukuba), (2003) 263 [HE.1.2.9]

[5] ARGO-YBJ Collaboration, 6th International Conference on Advanced Technology and Particle Physics, Como (1998), in *Nucl. Phys. B (Proc. Suppl.) 78* (1999) 38

[6] C. Bacci et al. (ARGO-YBJ Collaboration), *Nuclear Instr. and Methods A 443* (2000) 342

[7] A.M. Elø, H. Arvela, Proceedings of 26th International Cosmic Ray Conference (Salt Lake City), **5** (1999) 320 [OG.4.4.07], 324 [OG.4.4.08] and 328 [OG.4.4.09]