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The Status of the ARGO Experiment in Tibet

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About 4000 m^2 detector carpet of the ARGO Experiment is installed at Yangbajing, Tibet, China (4300 m a.s.l.). 1900 m^2 of the carpet have been operated since December 2004. With a trigger condition of >60 hits, corresponding to a mode energy of 2 TeV, the opening angle of EAS measurement is $<1^0$ as more than 500 PADs are fired. All sky survey for γ source and burst search has been carried out with about 1000 hours of data. The cosmic ray spectrum up to about 100 TeV is observed under digital mode. The Forbush decrease of the cosmic ray flux during January 17, 2005 is observed using the ARGO data taken under scaler mode.

1. The ARGO Detector Installation

The ARGO apparatus will consist of a full coverage array of dimension 74 × 78 m^2 realized with a single layer of Resistive Plate Counters (RPCs), 280 × 125 cm^2 each. The area surrounding this central carpet, up to 100 × 100 m^2, will be partially (> 50%) instrumented with RPCs. The basic detection unit is the cluster, a set of 12 contiguous RPCs. A 0.5 cm thick lead converter will uniformly cover the detector in order to improve the angular resolution.

The ARGO experiment is currently under construction at the YangBaJing Cosmic Ray Laboratory (Tibet, P.R. China, 4300 m a.s.l.). 89 clusters of RPCs have been installed for the final testing before operation. It covers about 4000 m^2 and 68% of the central detector carpet. The energy threshold of the detector will be a few hundreds of GeV in the full operational mode. The ARGO detector will be used for full sky survey for gamma ray bursts, search for stable gamma ray sources, studies on the cosmic ray spectrum etc.

2. Operation of 1900 m^2 of the ARGO Detector

2.1 Digital Readout

From November 2003 to December 2004, 16 clusters, covering about 690 m^2, have been operated for final test. Since then, 42 clusters have been put into operation. The data acquisition has been run for more than 2140 hours. About 7 TB data are acquired, i.e. about 2×10^9 cosmic ray events are recorded and transferred to the disk array at IHEP, Beijing, China. The current trigger condition requires more than 60 fired hits [1]. The event rate is about 160 Hz. The preliminary data analysis shows that the ARGO carpet detector is working properly. Some physics results based on this data set are reported in this conference.

2.2 Analog Readout

Analog readout electronics has been installed on 4 clusters since December 2004 [2]. The covered area is about 180 m^2. The charge read-out of each RPC is performed by means of two 1.40 × 1.25 m^2 BigPad. A stable correlation between the mean strip number and the mean amplitude of a BigPad is found during the operation in the last 7 months.

3. Calibration of the ARGO Detector

The performance of the RPCs is measured at YBJ with a telescope realized by 6 RPCs [3]. The resulting efficiency is about 95%, the detector time resolution ≤ 2 ns and the average strip multiplicity is about 1.1 strips per hit under a condition of HV = 7200 V and a gas mixture of argon (15%), isobuthane (10%) and R134a (75%). These results are consistent with those obtained at sea level. The calibration is done with two methods, i.e. manual calibration using a standard probe detector and offline calibration [4] using about 80k selected cosmic ray events with multiplicity greater than 500. 300 PADs out of 5040 are calibrated manually. The calibration shows that the relative time difference between PADs is less than 20 ns. The difference between off-line calibration and manual calibration follows a Gaussian with a width of 1.28 ns.

4. Performance of the ARGO Detector (1900 m^2)

4.1 Angular Resolution

The angular resolution has been studied by means of the even/odd method [5]. The experimental result is compared with MC simulation in Fig. 1. The results agree to each other very well. The angular resolution strongly depends on the fired numbers of PADs. The opening angle for internally reconstructed proton-induced events is <1^0 as more than 500 PADs are fired.

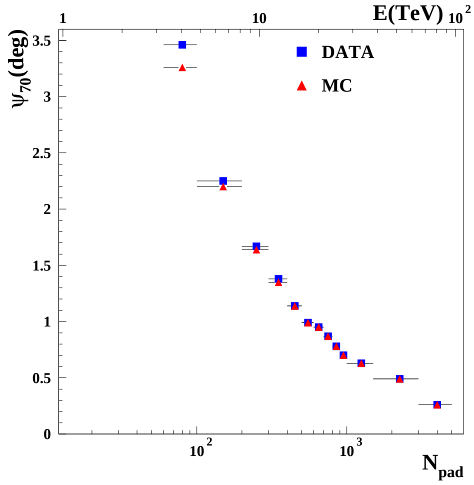

Fig 1. The opening angle Ψ_{70} measured via the even/odd method on 42 Clusters as a function of pad multiplicity (squares) compared to MC simulation (triangles).

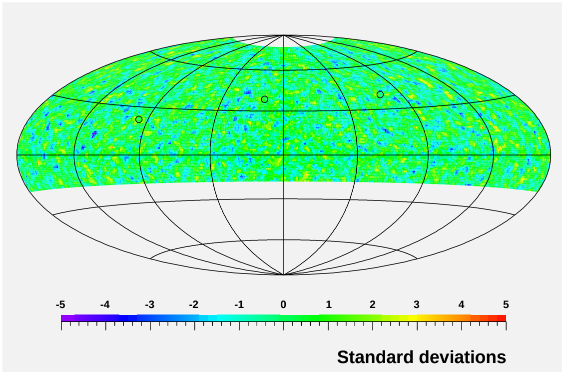

Fig 2. Preliminary sky map obtained in about 1000 hours of data taking.

4.2 Energy Scale

Simulation driven by Corsika 6.02 [6] with detailed detector setup is done for finding the energy scale of the current trigger condition of the ARGO detector [1]. The mode energy of the triggered event distribution is about 2 TeV and the median energy is about 5 TeV (see also Fig. 1). In the near future, the threshold will be lowered down to a few hundreds of GeV by setting the trigger condition to the hit multiplicity greater than 20 after the DAQ expansion.

4.3 Sensitivities for Gamma Ray Point Source and Gamma Ray Burst Search

Simulation is carried out for finding the sensitivities for both stable gamma ray source and gamma ray burst search. Based on the angular resolution found above, three algorithms are compared using the average sensitivities from 2000 toy MC experiments. The ARGO experiment is able to detect TeV gamma ray emission from Crab source at a significance level of 18 σ per year. Taking the standard of 5 σ/year, the ARGO experiment is expected to observe a point source with a flux of 0.3 I_{crab} [7]. The sensitivity curves of the ARGO detector to transient sources [8] are compared with the spectra of EGRET gamma bursts GRB930131 and GRB910503. The ARGO detector is able to observe similar events if E_{max} > 300 GeV and E_{max} > 700 GeV, respectively.

4.4 Operational Stability of the ARGO Detector (1900 m^2)

The efficiency of the RPC detector is stable during the operation since November 2003. The temperature in the experimental hall is monitored and found to be above 4°C that guarantees the normal operation of the RPC detector. Gas flow, high voltage, current and single particle rate are monitored and found stable. About 4 volumes of gas are exchanged every day. The 16 clusters starting from November 2003 are running under the Detector Control System (DCS) [9]. The DCS is working properly and is ready to be enlarged to 3500

m^2 of the detector. Some of the RPCs have been found malfunctioning because of HV leakages and front end electronics failures. 19 RPCs out of 504 operated are switched off for repairing. About 0.5 % of dead strips are found at the installation time. The number of dead strips increases by less than 1% per year.

5. Data Analysis and Physics Results

5.1 All Sky Survey for Gamma sources and GRBs

The data set used in this analysis has been recorded from December 24, 2004 to March 23, 2005, for a total running time of 1007 hours. The event rate is ~160 Hz. The events with zenith angle $\theta \leq 50^0$ are under consideration in this paper. The declination band $-20° < \delta < 80°$, corresponding to 8.3 sr (66% of the celestial sphere) is monitored. No gamma-hadron discrimination is applied in this preliminary analysis. The analysis of the first data taken by the ARGO detector of 1900 m^2 shows that the detector is working properly. In the 1007 hours of measurement [10] no gamma ray source with an average flux larger than ~5 Crab units has been observed in the declination range 20° – 40°. The sky map is shown in Fig. 2. Moreover, there is no significant transient of duration 10-300 seconds being detected.

5.2 Gamma Ray Burst Search using Single Particle Technique (SPT)

The GRB search is done in coincidence with Swift, HETE and Integral satellite experiments. As a member of the Swift Follow-Up project, the ARGO experiment can carry out a complete GRB analysis in "real time". The GRB search has been started in correspondence with the first GRB detected by Swift on December 17, 2004. Up to now (June 2005), 4 of the 49 detected GRBs [11] are in the field of view of the ARGO detector ($\theta < 40°$). None [12] of the 4 GRBs has been detected. Corresponding upper limits are estimated using the known low energy time duration and spectral index (when available, otherwise we assumed $\alpha = 2$), and E_{max} = 100 GeV. For GRB050408 the distance is known ($z = 1.24$) and the upper limit is calculated including a simple γ absorption model, while $z = 0$ is assumed for the others.

The SGR 1806-20 flare on December 27, 2004, that was under the ARGO horizon ($\theta = 99.4°$) but perturbed the whole ionosphere, was also studied, but no significant coincident change in the rate has been detected.

5.3 Cosmic Ray Spectrum below 100 TeV

The strip size spectrum (N_s) has been measured by using the RPC digital readout [13]. Working under digital readout mode, each induction strip serves as a shower particle counter. A preliminary study of the strip size spectrum up to $N_s=10^4$, which is due to primary cosmic rays with energies up to about 100 TeV, shows a fair agreement of data with the RUNJOB model, in particular at energies <50 TeV.

5.4 Forbush Decrease on January 2005 and Solar Activities Analysis Using SPT

After air pressure correction, the SPT data from 15th to 27th of January, 2005 are used to search for the Forbush Decrease (FD) that is well measured by devices at lower energies such as neutron monitors. The FD around noon on January 17, 2005 is observed by the ARGO detector. The SPT rates with multiplicity greater than 1 and 2 clearly decrease correspondingly [14]. All detailed structures of the light curves are similar to the results from neutron monitors. The maximum amplitudes of the FD are about -5% and -4%, respectively. The SPT rates of multiplicities greater than 3 and 4 show no signs of decrease.

The solar flare (Class X7) of Jan 20, 2005, that was connected to a GLE and detected by the Milagro scaler system [15], has been also studied but not detected by ARGO [12].

6. Looking ahead

6.1 Further Installation

130 clusters will be installed by the spring of 2006. This will complete the construction of the central detector carpet of the ARGO experiment. In order to complete the whole ARGO detector, the outskirts RPCs will be installed in the next year. All installed detectors will be timely merged into the DAQ. The operating detector area will reach about 6000 m^2 by the spring of 2006.

6.2 DAQ Expansion

The current DAQ is properly operating under a trigger condition of multiplicity>60 that corresponds to a mode energy of 2 TeV. In the near future the threshold energy is going to lower down to a few hundreds of GeV by setting the trigger condition to the hit multiplicity >20. This results in an event rate of about 10 kHz. The current DAQ system must be expanded by upgrading CPU boards, increasing the DAQ chains and adding an online event building system.

6.3 Calibration of the Analog Readout

The analog readout of the ARGO RPCs has been calibrated using digital readout at sea level. This results in a calibration up to 20 particles/m^2. The further calibration will be done by using the Beam Test Facility of the DAFNE accelerator at the INFN Frascati National Laboratories. A parallel calibration is carried out at IHEP, Beijing, by using scintillation detectors that have been calibrated over a dynamic range up to 10^4 particles/m^2.

7. Acknowledgements

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References

[1] S. Mastroianni *et al.* for the ARGO Collaboration, these proceedings.
[2] M. Iacovacci *et al.* for the ARGO Collaboration, these proceedings.
[3] C. Wu *et al.* for the ARGO Collaboration, these proceedings.
[4] P. Bernardini *et al.* for the ARGO Collaboration, these proceedings.
[5] G. Di Sciascio *et al.* for the ARGO Collaboration, these proceedings.
[6] D. Heck et al., Karlsruhe Report FZKA 6019 (1998).
[7] S. Cui *et al.* for the ARGO Collaboration, these proceedings.
[8] X. Zhou *et al.* for the ARGO Collaboration, these proceedings.
[9] P. Camarri *et al.* for the ARGO Collaboration, these proceedings.
[10] S. Vernetto *et al.* for the ARGO Collaboration, these proceedings.
[11] J. Greiner 2005 GRB webpage, http://www.mpe.mpg.de/ jcg/grbgen.html.
[12] T. Di Girolamo *et al.* for the ARGO Collaboration, these proceedings.
[13] L. Saggese *et al.* for the ARGO Collaboration, these proceedings.
[14] H. Jia *et al.* for the ARGO Collaboration, these proceedings.
[15] G. Sinnis, Presentation at the Conference "Towards a Network of Atmospheric Cherenkov Detectors", Palaiseau (France), 27-29 April 2005.