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THE ARGO FULL COVERAGE DETECTOR

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ABSTRACT

The ARGO is a full coverage detector to be mounted in the high altitude laboratory of Yangbajing in Tibet. We have chosen to base this experiment on the RPC technique in order to obtain a good resolution whether in time or in space at a reasonably low cost. The main physics goals of ARGO are the gamma rays astrophysics, diffuse gamma rays, GRB, proton/antiproton ratio at low energy, primary proton spectrum and the helioispheric physics. The physics merits of this detector are presented in a different contribution to this conference. In this paper we describe the experimental lay-out, the tests performed to assure the proper working conditions for the RPC chambers at high altitude, and the electronics that we plan to use. A small test carpet (about 50 m^2) will be operating, starting from fall '97, in the Yangbajing Cosmic Ray Laboratory. Finally we present ours plans for the detector construction.

THE DETECTOR

ARGO is a telescope optimized for the detection of small size air showers. It consists of a layer (about 95% active area) of Resistive Plate Counters (RPC) covering an area $\sim 5000\ m^2$ and operating at an altitude of 4300 m a.s.l. ARGO will provide a detailed space-time picture of the shower front allowing to face a wide range of fundamental issues including gamma-ray from point sources, diffuse gamma-rays from the galactic plane, GRB's physics and the measurement of the p/p ratio at TeV energies. Additional objectives come from using ARGO as a traditional EAS array covering the full energy range from 10^{12} to $10^{16}\ eV$.

The Argo detector is conceived to take the maximum advantage from the RPCs performance. It fulfills the following basic requirements.

1. highest space-time resolution for the EAS pattern detection

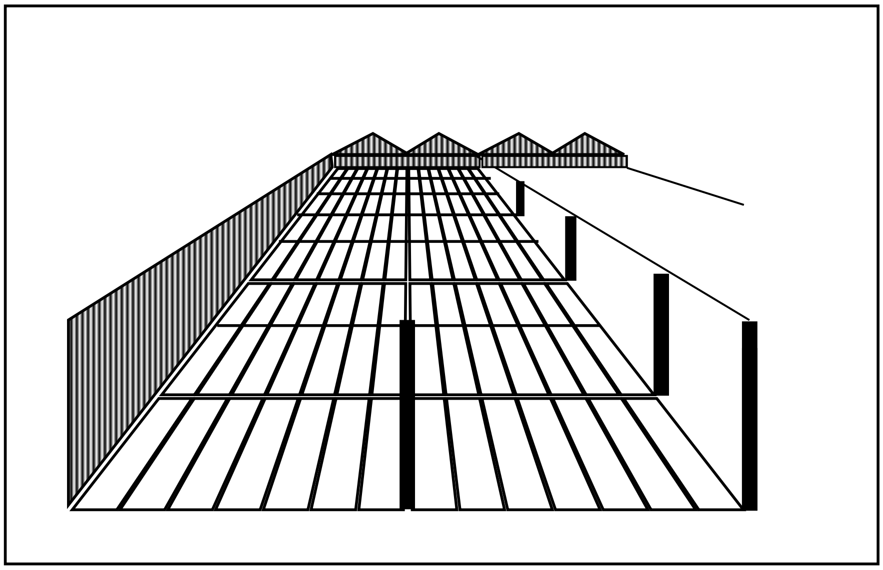

Figure 1: Artist's view of part of the ARGO experiment. On the floor of the laboratory is shown the RPC carpet

2.granularity to fulfill point 1 at an acceptable cost

3. capability for very high hits densities as expected at the shower core position

4. triggering capabilities even for low energy showers and for showers with the core falling outside of the detector

5. coverage near to 100% i.e. minimum uncovered space around each RPC module

6. performance of the front-end electronics giving a good space and time resolution

7. minimum data acquisition dead time to look for time correlations between consecutive events down to tenths of nanoseconds scale

The detector is supposed to be installed inside a covered room- laboratory giving protection against rain, snow, strong wind and extreme temperatures.

DETECTOR LAY OUT

The detector is an almost squared array of ~ 1500 Resistive Plate Counters (RPC) which has dimensions of 1.12×2.80 m^2 , disposed as full coverage carpet. as shown in fig 1 Around each module there is some uncovered space to allow for the gas, high and low voltage distribution systems as well as for the cable interconnections among different modules. The detector is organised in modules each composed of a RPC equipped with pick-up strips, front-electronics and a shield against noise. Each RPC module is read out by 128 aluminium strips 56 cm long 33 mm wide with 35 mm pitch running parallel to the 1.12 m side of the module which are connected to the front-end electronics at the edge of the RPC. Five front-end boards are fixed along each 2.80 m side of the RPC. Each board is connected to 16 strips and gives the Fast OR of the signals, as well as the serial and parallel read out. The Fast OR signal is used for triggering and timing purpose. The length of the strip introduces a time jitter of 0.7 ns r.m.s. that has to be added in quadrature to the intrinsic time jitter of the detector. The information collected by the strips of 3 chambers is collected in a electronic module (called PADM) and it is transmitted via optical cable (fiber) to the central controller that uses it to elaborate a fast trigger signal.

FRONT END ELECTRONICS

The front-end electronics is an improved, completely new version of the RPC dedicated circuit which was developed almost 10 years ago. It take into account the enormous experience that has been accumulated so far in the course of all the experiments which used RPC as a fundamental part of the detector. This new board will also contain the necessary circuitry for the multiplicity measurements, a specific requirement for the gamma-ray astronomy. Both digital and analog multiplicity measurements will be done by the new front-end: the first one turns out to be more accurate for low multiplicity and the second one is more suitable for large or very large multiplicities as those expected at the center of a high energy shower. A prototype of this new front end electronics, not yet including the multiplicity measurement, has been already built at Rome 2 and is going to be industrially produced.

TRIGGER AND STATION INTERCONNECTIONS

All the information of the detector is sent to a central station by the PADM electronics via optical links. The weighted FAST OR signals will create the trigger signal by requiring a multiplicity $\geq n$ within a time window corresponding to the maximum delay among the particles belonging to the same shower. This time window turns out to be $\sim 400\ ns$ corresponding to the dimensions ($70 \times 70\ m^2$) of the apparatus and the maximum incident accepted angle of the shower. The electronics of each sub–station is connected to a central control station through a multimodal optical fiber. All the fibers have the same length, about 100 m to preserve the physical time sequence of the signals at the central station. The same fiber could be used to send control signals from the central station to the sub–station. The trigger consists in a cascade of modules; each module performs the analog sum of 16 weighted FAST OR signals generated in a 4×4 PADM electronics corresponding to a square part of the detector.

GAS and HV SYSTEMS

The gas mixture is the typical mixture for the RPC detector modified in such way to work properly at high altitude. We take care to use gas not harmful to the atmosphere. The gas system is conceived in such a way to balance the simplicity with the need of a high segmentation which allows a detailed control of the system. The total flux is divided in different channels each feeding many chambers. The detector working point can be maintained stable taking into account the temperature and atmospheric pressure .

The HV system for the ARGO detector is slpitted in many channels and due to the large number of chambers each HV channel is connected to many tenth of chambers. Each power supply channel has a maximum voltage 10 KV and maximum current 2 mA, a largely dimensioned value as the current required by 100 chambers served by the line should range around .5 mA. Low cost high voltage connectors of aluminium or copper coated plastic, specially developed for large scale applications, will be used.

RPC's TEMPERATURE AND PRESSURE TESTS

The experiment Argo requires to operate the RPC's in a mountain laboratory where the environment conditions, particularly those related to the temperature and the pressure, are different and more severe than in a normal laboratory. Specific tests concerning the response of RPC's in different conditions of temperature and pressure have been carried out on two chambers of area $2 \times 2\ m^2$. The detection efficiency vs operating voltage was measured for different temperatures. A plateau is reached at 95% efficiency. Most of the 5% inefficiency is due to the dead areas of the spacers and seals as well as to the uncovered area between the two RPC modules.

The results of this study shows that the same efficiency is reached at higher voltage for a lower temperature. This is well explained as an effect of the temperature on the gas density: at lower temperature the density is higher and this is equivalent to a larger gas gap which requires a higher operating voltage. If this effect can be accounted for by renormalizing the

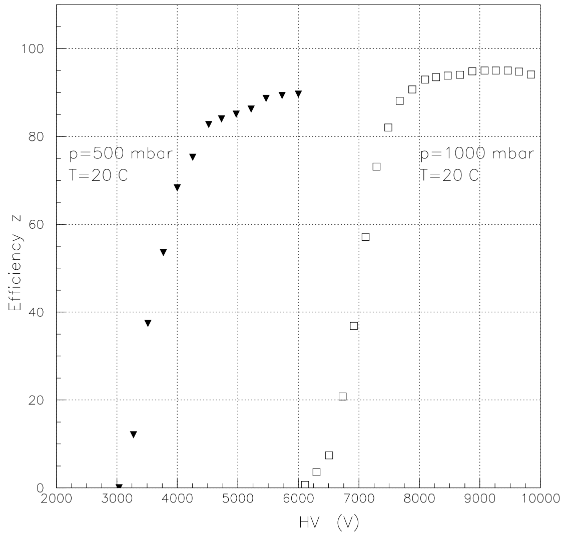

Figure 2: Efficiency for RPC at different value of the gas pressure

voltage scale with the factor T/T_o, where T is the actual temperature and $T_o = 293\ K$ is the standard room temperature. Pressure tests are in progress. Preliminary result on the detection efficiency vs operating voltage is shown in fig. 2 for two different pressures: 1000 and 500 mbar. The operating voltage scales with respect to the pressure in good agreement with the rule $E/p = constant$.

THE ARGO TESTS

A 30 m^2 RPC array is under test at the University of Roma 2. The array consists of 15 RPC modules of area $1 \times 2\ m^2$ grouped in 5 lines of $1 \times 6\ m^2$. The lay-out of each station is similar to that proposed for ARGO. This is intended to be a pilot experiment that except for the much smaller area and lower altitude reproduces the basic features of ARGO .

The ARGO Test at Yanbanjing

To test some technical and logistic aspects of the ARGO project a small scale experiment will be mounted in the fall 1997 in a new laboratory, now under construction, in the Yanbajing site. The test consists in mounting a carpet of 50 m^2 of RPC's, keeping it in operation and taking data for technical study. The results of the test at Yanbanjing will be presented in spring '98.

THE PLANS FOR THE ARGO CONSTRUCTION

If the full ARGO experiment will be funded we plane to build the 5000 m^2 detector in four years starting from the fall '98. It has to be remarked that with $\sim$ 1000 m^2, in principle operating in 99, the ARGO detector can give an important contribution to the GRB physics.

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