The Extreme Energy Events Project at Lecce

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1. Introduction

The EEE Extreme Energy Event Project [1][2] aims to detect Ultra High Energy extensive air showers over a very large surface, using an array of more than 40 muon telescopes distributed all over the Italian territory (plus CERN).

The Project involves the Italian High Schools, it's supported by many institution as MIUR, Centro Fermi, INFN, CERN etc, and it aims to introduce young people to Physics, countervailing the recent crisis of university scientific courses enrolments. Its innovative aspect is that the stations are located in Italian high schools, in INFN sections, plus two at CERN, and are operated by teachers and students of these schools. The single tracking telescope is composed by three large ($\sim 2\ m^2$ each) Multi-gap Resistive Plate Chambers (MRPC). The detection of EAS is made by looking for muon events seen in coincidence among different stations [7]. The detectors themselves have been built at CERN by teachers and students, and have been sent to their institutes. The final installation and commissioning was performed by these mixed teams under the supervision of researchers from scientific institutions [4]. The direct involvement of young students in the project is the most efficient way to contribute to their learning while doing advanced research in physics. Students are personally involved in advanced research, therefore they acquire a deeper knowledge of particle and astroparticle physics, experimental tools, data-acquisition systems, software, networks, etc. They gain direct access to the data and to the working methods typical of modern research work.

The detection of an Extensive Air Shower (EAS, in the following) is operatively achieved by measuring the coincidences in time among events recorded at different sites of the EEE network. Therefore, the detectors used must combine a good tracking performance with an excellent time resolution. In addition to EAS of extreme energy, the EEE network will study other phenomena, as a systematic study of the single muon flux variation and angular distribution, correlated with the relevant environmental parameters (local or astrophysical). All this closely joins in the same activity the important didactic aspect, deriving from taking direct part to a real scientific experiment, with the interest of performing a research in an advanced field of investigation.

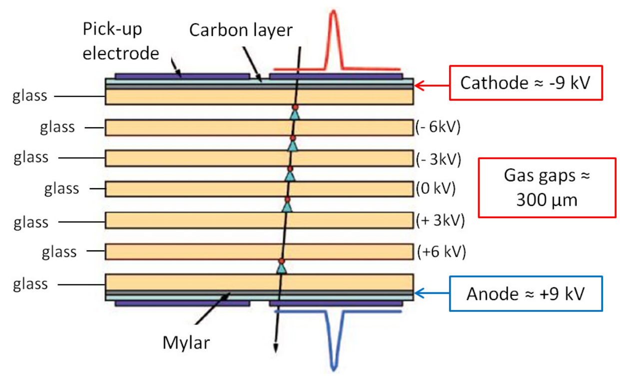

Figure 1. Lay-out of a Multigap Resistive Plate Chamber used in the EEE telescopes [4].

2. A brief description of telescopes

Each EEE telescope is composed by three MRPC [3] of $0.82 \times 1.58\ m^2$ active area and characterized by a volume resistivity of about $10^6\ \Omega/\text{cm}$. Each chamber consists of six gas gaps obtained interleaving two glass plates with five electrically floating glasses, Fig.1. Commercial nylon fishing line 300 μm thick is used as spacer between glasses.

The outer glass plates are coated with special resistive paint, Licron 1755, in order to be able to apply high voltage up to 20kV, and to generate a uniform electric field between the glass electrodes.

A continuous gas flow with a mixture of $C_2H_2F_4$ (98%) and SF_6 (2%) in the chambers is provided by a gas mixing station. Each MRPC is equipped with 24 copper strips 160cm long on each side as signal pick-up electrodes, with a pitch of 3.2cm. When an ionizing particle passes through the gas, it creates a certain number of primary ion-electrons pairs, which are amplified in the usual avalanche process. The resistive plates terminate the avalanche development in each gap. Since these glass plates have high resistivity, they act as dielectric plates for the fast signal produced by the movement of electrons in the gas avalanches. The induced signal on the pickup electrodes is the consequence of all gas avalanches in all the gas gaps. A six-fold coincidence of both front-end cards of the three MRPCs generates the data acquisition trigger.

At the operating voltage of 18 kV, the measured MRPC efficiency is typically 95% and the time resolution is of the order of 100 ps, so that strip dimension and time differences provide a spatial resolution of about 0,7 cm in both coordinates. The absolute time of each event is also recorded by a GPS unit in order to correlate the information collected by different telescopes.

3. The EEE Project in Lecce

Three Lecce's Schools have joined the EEE Project. The Lecce's EEE experiment group supports high school teams in their work, monitoring and operating on three stations of the telescopes array, and it's involved in data analysis and main telescopes improvements.

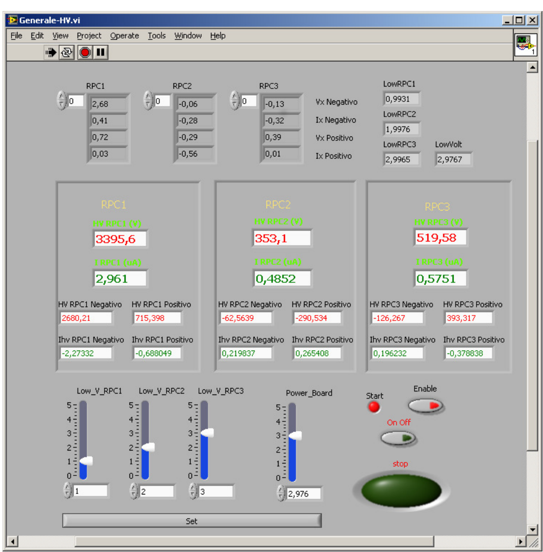

Figure 2. LV/HV Power Supply Conntrol panel of the EEE system [4].

The DC Power supply

Two DC/DC converters provide the high voltage to each MRPC. A voltage up to 20 kV is obtained by means of a positive plus a negative DC/DC converter, the positive one produces 10 kV, and the negative one -10kV, both with an input voltage between 0 and 5 V. The two DC/DC converters were mounted onto each MRPC; so, no high-voltage cables were needed.

All DC/DC converters are set up and tested in the INFN Electronic Laboratory of Lecce.
The power supply unit which provides DC/DC converters with the input voltage, are designed, developed and tested in Lecce.
The unit is interfaced with the DAQ computer, controlled by means of a dedicated software, and it is able to check on voltage and current in MRPC by means a feedback from DC/DC converter. Since the computer is permanently online, the LV/HV system can be continuously monitored from remote, Fig. 2. Power supply unit also checks and commands front-end voltage and monitors temperature of the printed circuit board.

Trigger card

Lecce's group is working on the upgrade of the telescope trigger card. Its main improvements have been to implement on a Field-Programmable Gate Arrays (FPGA) the logic to build the trigger signal and to monitor the MRPC single counting rate both. Moreover the aim of this development is to integrate the trigger card with an embedded GPS module for timing application to implement the time stamping at level of the trigger card.

Muons angular distribution

To study the muons angular distribuition it is necessary to evaluate angular acceptance ε of EEE telescopes.

As the geometrical acceptance [5], angular acceptance is defined as the ratio between the number of muon reconstructed tracks $N_{accepted}$ in MRPCs and the number of tracks $N_{generated}$ isotropically generated at different values of right ascension RA and declination Dec:

$$\varepsilon(RA, Dec) = \frac{N_{accepted}(RA, Dec)}{N_{generated}(RA, Dec)}. \quad (1)$$

It is expected an isotropic distribution of the EAS muon component as first approximation. Muons were generated in altazimuthal coordinates with

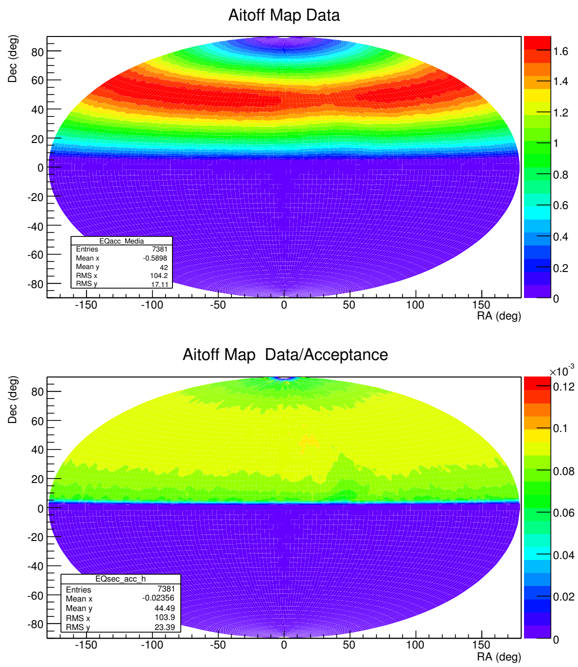

Figure 3. A dataset of 23-days yields in SAVO-02 station - *top* Aitoff map of real experimental muons in equatorial coordinates system - *bottom* same data corrected for angular acceptance ε.

their distribuition at sea level and which is proportional to $sen^2\theta cos^2\theta$ (where θ is the zenith angle), with a random azimuth angle. The impact point has been randomly generated inside the middle telescope chamber. Each generated muon is considered as reconstructed if the track hits all the MRPC planes. Muons were also generated in the same time of a “real” recostructed tracks. Their coordinates have been eventually converted from altazimuthal to equatorial system [6].

In Fig.3 it's show the Aitoff [6] map of real experimental data tested on a 23-days dataset of SAVO-02, a telescopes located in a school in Savona, compared to data corrected for angular acceptance.

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