The EEE Project

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Abstract: The EEE (Extreme Energy Events) Project is an experiment for the study of very high-energy extensive air showers, actually starting in Italy. It is based on the detection of the shower muon component by means of a network of tracking detectors, installed in Italian High Schools.
The Project, supported by the Ministero dellUniversit e della Ricerca (MIUR), Istituto Nazionale di Fisica Nucleare (INFN), European Organization for Nuclear Research (CERN) and Museo Storico della Fisica e Centro Studi e Ricerche E. Fermi has been conceived by its leader Professor Antonino Zichichi.
In its first phase the detector telescopes will be installed in 21 High Schools in 7 piloting cities all over Italy. The network will soon be heavily upgraded by increasing the number of High Schools and cities.
The single tracking telescope is composed by 3 large ($\sim\ 2\ m^2$) Multi-gap Resistive Plate Chambers (MRPC), realized with float glass electrodes. The use of particle detectors based on such MRPCs will allow to determine with a very high accuracy the direction of the axis of cosmic ray showers initiated by primaries of ultra-high energy, together with a high temporal resolution.
The first MRPC telescope, installed in the Liceo Scientifico B.Touschek in Grottaferrata near the LNF-INFN site (nearby Rome), is successfully running. By the end of year 2007, the installation of the other telescopes will open the way for the first search of high-energy cosmic rays distant coincidences.
In the future, serving many High Schools scattered all over the Italian territory, the EEE Project will also allow to investigate coincidences between multiple primaries producing distant showers. Here we present the experimental apparatus and its tasks.

Introduction

The EEE Project aims to the study of extended air showers over a very large area of coverage using an array of muon detectors located inside many high school buildings over the Italian territory [1, 3]. The main goal of the Project is to involve the Italian students in a scientific experiment with very precise instruments, telescopes made as a stack of three Multigap Resistive Plate Chambers (MR-

PCs), as in figure 1.
The modular characteristics of the design provide a multiple approach to the study and detection of cosmic rays: the first one is the detection of the single shower, offered by several detectors scattered within the same city, displaced of about some hundreds of meters; the other one is given by the larger pacing provided by the distance between different cities, thus tens or hundreds of kilometers away. The accurate timing of events as from a GPS timestamp event per event opens the way to investigate a possible time correlation between distant sites.
The Project started in 2005, involving seven piloting schools and has fastly grown up to 20, whose students and teachers have carried on the construction and testing in the CERN Labs under the guidance and supervision of CERN INFN and Centro Fermi researchers.
Presently, a set of 72 detectors (i.e. 24 telescopes) has been built and installation inside schools has started with many stations in the phase of efficiency tests and preliminary data taking. The present network will be upgraded in the next months.
the experiment is supported by INFN, Centro ”E. Fermi” (Rome), CERN, Ministero dell'Universitá e della Ricerca, as conceived by its leader Antonino Zichichi.

Telescope outlook

The telescopes built for the EEE Project are composed as a tower of three MRPCs muons detectors spaced between them a distance varying between 40 and 100 cm in different setups, corresponding to various acceptance values, as in figure 1. Such MRPCs are a wider and cheaper version of the detectors developed for the Time-Of-Flight group of the ALICE experiment at LHC. Each MRPC measures $80 \times 160 cm^2$ and is made as a stack of resistive glass plates, transparent to avalanches generated inside the gas gaps: the signal induced on the pick-up electrodes results as the sum over all the gaps providing high gain. The voltage of operation is about 18 KV, with a time resolution of order of 100 ps.
Each MRPC, assembled as in figure 1, is made of six gaps spaced 300 μm in a stack of glass sheets (for more details, see [2, 3]), filled with a mixture of gas working in avalanche mode (98$\%$ of $C_2F_4H_2$ and 2 $\%$ of SF_6). Through EMCO DC-DC converters, the low voltage supplied (0-5 V) a high voltage (0 ± 10 kV) is generated on top and bottom glass sheets. The signal that forms on the 24 copper strips along the chambers is sent to front end electronics based on ultra-fast 24 channel amplifier/discriminator cards based on NINO-ASIC cards [4, 5].
A total of 144 channels provides time measurements on each telescope using commercial multi-hit TDSs.
The Data Aquisition system is based on a LabView Program running on PC platform, connected to a VME crate via a CAEN USM-VME bridge.

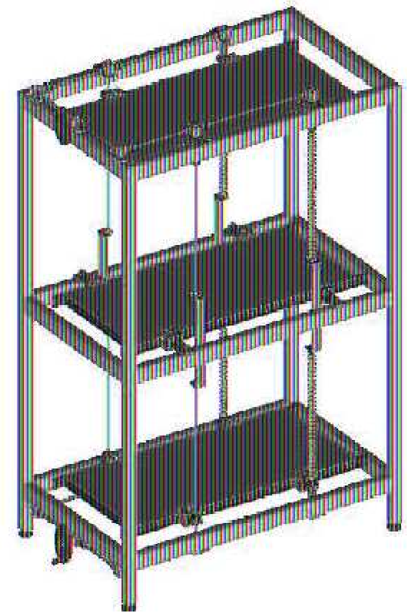

Figure 1: Design of the MRPC telescope as already installed in some INFN Labs and several schools.

Efficiency tests

The efficiency tests were performed in the CERN, INFN and LNF Labs, using three scintillators in coincidence with each chamber with a gas flow at 40cc/min and also without.
The working point for the test without gas flow has been chosen at 18,5 KV.

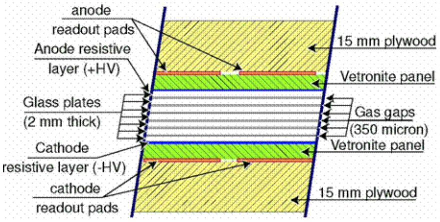

Figure 2: Internal structure of the MRPC: a stack of thin glass plates between two high voltage plates and copper strips applied over two vetronite panels to transport the signal to the front end.

The first efficiency measure after regular gas flowing for several days provided satisfactory values, higher than 95%, which were maintained high also when turning off the gas flow for about one month, as reported in figure 3 . The resulted efficiencies ϵ for the some of the chambers under test are summarized in the table 1.

MRPC	ϵ $\pm 0.2\%$	ϵ $\pm 4\%$ no flow
#15	96,0	96
#13	94,4	97
#19	92,3	96

Table 1: Efficiency results at 18.5 KV and after 25 days without gas flow.

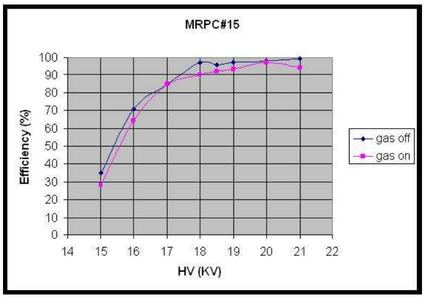

Figure 3: Comparison of the efficiencies measured after more than one month without gas flow and after re-starting gas flow again.

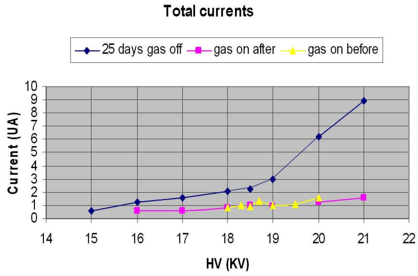

Figure 4: Current measured at varying high voltage.

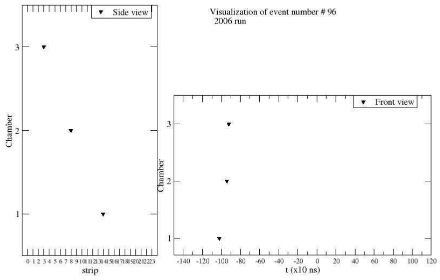

Figure 5: Graphic of the particle's track: on the left, the view from the side of the telescope, on the right from the front.

Tracking of muons and performance

Each MRPC detector is designed to measure the two coordinates of the impact point of a particle in the horizontal plane, provided in pone direction from the strip on which the signal is read and on the othe direction by the time difference of the signals arriving to the two ends. With these informations is is possible to reconstruct the track of a particle crossing the detector, as for example in figure 5.

A Monte Carlo simulation of the telescope provided a geometrical acceptance of 0.34 $m^2 \cdot srad$, with chamber at distance of 1 m and, in this configuration, the cosmic muon expected rate is about 40 Hz and an angular resolution of the muon zenith angle better than 0.5 deg. Such very accurate tracking capability allows to reconstruct the shower axis direction with an uncertainty smaller than 2 deg [1].

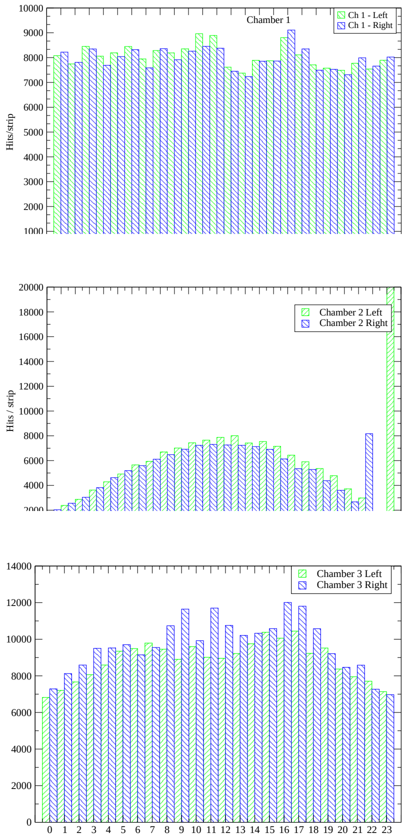

Figure 6: Cumulative distribution of hits per strip per chamber, highlighting the functionality of the single components of the apparatus.

In figure 6 we show the cumulative distribution of hits recorded from every strip in each chamber: we can see if the strips are working properly or easily note, like for example for strip 22 in chamber 2 of this sample, if something is not working. The functionality of the single pieces of the apparatus is therefore under full control. From these plots we note that the counting rate for strips belonging to chamber 1 and 3, i.e. at top and bottom of the telescope, is rather uniform, while that for chamber 2, the MRPC in the middle, is affected by the geometrical effects of acceptance.

Conclusions

The EEE Project is on the final stage of preliminary tests: the construction of the MRPCs detectors, started in 2005, has arrived to provide 24 telescopes for the corresponding schools. All detectors have been shipped from CERN to Italy and installed in some INFN Labs and several schools, while the first group of seven piloting towns has been successfully completely installed and some stations started data-taking and advanced set-up. The efficiency of such devices is rather higher than 95 % and first measures show spatial resolution better than 2 cm. Soon other telescopes will start data taking and will be ready for the search of coincidences.

References

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