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A Multigap Resistive Plate Chambers array for the Extreme Energy Events Project

D. De Gruttola[a,k,*], M. Abbrescia[a,b], C. Avanzini[a,c], L. Baldini[a,c], R. Baldini Ferroli[a,d], G. Batignani[a,c], G. Bencivenni[d], E. Bossini[a,e], E. Bressan[a,f], A. Chiavassa[g], C. Cicalò[a,h], L. Cifarelli[a,f], E. Coccia[i], A. Corvaglia[a,j], S. De Pasquale[a,k], A. Di Giovanni[l], M. D'Incecco[l], M. Dreucci[d], F.L. Fabbri[d], E. Fattibene[m], A. Ferraro[m], R. Forster[n,o], V. Frolov[p], P. Galeotti[a,g], M. Garbini[a,f], G. Gemme[q], I. Gnesi[a,g], S. Grazzi[a,q], C. Gustavino[l], D. Hatzifotiadou[a,f,o], P. La Rocca[a,r], A. Maggiora[g], G. Maron[m], B. Martelli[m], M. N. Mazziotta[s], S. Miozzi[a,d,i], F. Noferini[a,m], F. Nozzoli[i,t], M. Panareo[a,j], M. P. Panetta[a,j], R. Paoletti[a,e], L. Perasso[a,q], F. Pilo[a,c], G. Piragino[a,g], F. Riggi[a,r], G.C. Righini[a], A. R. Rodriguez[n,o], G. Sartorelli[a,f], E. Scapparone[f], M. Schioppa[a,u], A. Scribano[a,c], M. Selvi[f], S. Serci[g], E. Siddi[h], S. Squarcia[q], M. Taiuti[q], G. Terreni[c], M. C. Vistoli[m], L. Votano[l], M.C.S. Williams[f,o], G. Zani[m], A. Zichichi[a,f,o], R. Zouyevski[a,o]

[a] *Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi, Roma, Italy*
[b] *INFN and Dipartimento di Fisica, Università di Bari, Bari, Italy*
[c] *INFN and Dipartimento di Fisica, Università di Pisa, Pisa, Italy*
[d] *INFN, Laboratori Nazionali di Frascati, Frascati (RM), Italy*
[e] *INFN Gruppo Collegato di Siena and Dipartimento di Fisica, Universit di Siena, Siena, Italy*
[f] *INFN and Dipartimento di Fisica, Università di Bologna, Bologna, Italy*
[g] *INFN and Dipartimento di Fisica, Università di Torino, Torino, Italy*
[h] *INFN and Dipartimento di Fisica, Università di Cagliari, Cagliari, Italy*
[i] *INFN and Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
[j] *INFN and Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
[k] *INFN and Dipartimento di Fisica, Università di Salerno, Salerno, Italy*
[l] *INFN, Laboratori Nazionali del Gran Sasso, Assergi (AQ), Italy*
[m] *INFN-CNAF, Bologna, Italy*
[n] *ICSC World Laboratory, Erice, Italy*
[o] *CERN, Geneva, Switzerland*
[p] *JINR Joint Institute for Nuclear Research, Dubna, Russia*
[q] *INFN and Dipartimento di Fisica, Università di Genova, Genova, Italy*
[r] *INFN and Dipartimento di Fisica e Astronomia, Università di Catania, Catania, Italy*
[s] *INFN, sezione di Bari, Bari, Italy*
[t] *ASI Science Data Center, Roma, Italy*
[u] *Dipartimento di Fisica, Unversit della Calabria, Cosenza, Italy*

Abstract

The Extreme Energy Events (EEE) Project is a Centro Fermi - CERN - INFN - MIUR Collaboration Project, for the study of extremely high-energy cosmic rays, which exploits the Multigap Resistive Plate Chamber (MRPC) technology. The excellent time resolution and good tracking capability of this detector allows us to study Extensive Air Showers (EAS) with an array of telescopes distributed all over the Italian territory. Each telescope is installed in a High School, with the additional goal to introduce students to particle and astroparticle Physics. The EEE array is composed, so far, of 47 telescopes, each made of three MRPC planes, spanning more than 10 degrees in latitude and 11 in longitude, organized in clusters and single telescope stations. The status of the experiment and the results, obtained during two recent coordinated data taking periods, will be reported. The observation of Forbush decreases, coincidence events among different telescopes and the muon decay, using more than 5 billion tracks collected in the last few months, are of particular interest.

Keywords: cosmic rays, Multigap Resistive Plate Chambers, Extensive Air Showers

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1. Introduction

EEE is a challenging project, its aim being to join research activity in a still rich field such as cosmic ray physics, with daily teaching activities. The EEE Project has a powerful impact on education, introducing high-school students and teachers to research in high-energy physics, through their direct involvement in the construction, operation and data analysis of a complex detector. The telescopes are constructed at CERN by teams of students and teachers: this peculiarity enhances the scientific relevance of its goals with an effective outreach action.

The EEE Project [1] is an experiment for the detection of EAS of energy greater than 10^{11} eV. The setup of the experiment is an array of cosmic-ray detectors, distributed across the Italian territory, spanning an area of about $3{\times}10^5$ km^2. In order to detect the muon component of the showers, the EEE project makes use of MRPC chambers, with similar operation characteristics to the ones built for the Time-Of-Flight system of the ALICE experiment at LHC [2, 3]. The activity of the project is focused on the detection of EAS by looking at the coincidences between telescopes located in the same town and, possibly, the search for long-distance correlations between far telescopes. The study of local properties of the cosmic-ray flux and in particular the observation of Forbush decreases, was also an important result obtained by the project and it will be reported in Section 3.2. The description of the system, composed of three MRPC layers, can be found in Section 2, while the results on different physics items, possible with such an array, are shown in Section 3. The first coordinated data taking (Pilot-Run) took place at the end of 2014, followed by Run-1 from February to April 2015. A new data taking period will start at the end of 2015 and will continue until May 2016. More than 5 billion tracks have been collected during the first two coordinated runs.

2. MRPC for the EEE telescopes: description and performance

Three MRPC chambers (160×80 cm^2 active area), each of them with six gas gaps obtained by a sandwich of glass plates, are assembled in a telescope, shown in Fig. 1. The gap between the glass plates is obtained by means of 300 μm spacers (common fishing line). Fig. 2 shows the layout of the MRPC used in EEE: the pick-up electrodes, the glass plates and the avalanches generated in the gaps are visible. The induced signal on the external electrodes is the sum over all the gaps. A gas consisting of a 98%/2% mixture of Freon ($C_2F_4H_2$) and SF_6, with a continuous flow of 40 cc/minute, is used at atmospheric pressure. The high voltage to the chambers is provided by a set of DC/DC converters, able to provide a voltage up to $\pm$10 kV. A chamber is equipped with two readout planes (anode and cathode) each with 24 copper strips and can provide two-dimensional information when a cosmic muon crosses the chamber: one coordinate is given by the hit strip, while the second is obtained by the time comparison of the arrival signals at the opposite ends in each strip. The strips are read out by front-end (FEA) cards, which incorporate an ultrafast and low power ASIC amplifier/discriminator specifically designed for MRPC operation [4]. In Fig. 3 a schematic top view of a chamber is shown.

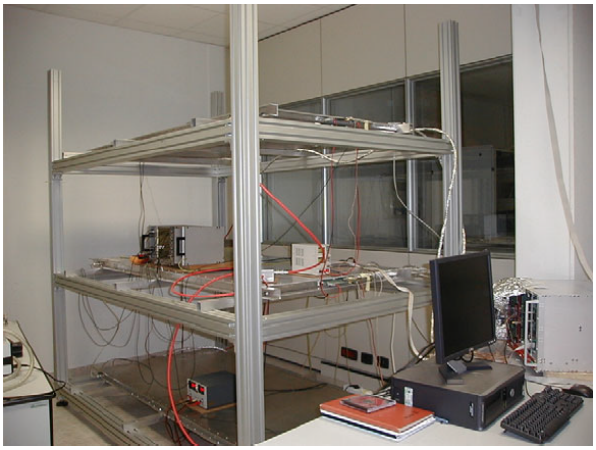

Figure 1: One EEE telescope composed of three MRPC chambers.

The trigger logic foresees a six-fold coincidence of the OR signals of the FEA cards (corresponding to a triple coincidence of the chambers), whose signals are combined in a VME module. Two TDC modules (64 and 128 channels each) are used to get the signal trasmitted by twisted pairs Amphenol cables from the front-end; the TDC bin is 100 ps. A GPS unit, providing a time stamp associated to each measured event, is used for the time synchronization between far telescopes; its precision is of the order of 40 ns. Data acquisition, monitoring and control are managed by a software based on LabVIEW.

*email address: daniele.de.gruttola@cern.ch

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