Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Nuclear Instruments and Methods in Physics Research A 588 (2008) 211–214
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

Extreme Energy Events Project: Construction of the detectors and installation in Italian High Schools

M. Abbrescia[i], S. An[k], R. Antolini[f], A. Badalà[d], R. Baldini Ferroli[b], G. Bencivenni[c], F. Blanco[d], E. Bressan[b,a], A. Chiavassa[e], C. Chiri[b,h], L. Cifarelli[a], F. Cindolo[a], E. Coccia[f], S. De Pasquale[g], A. Di Giovanni[f], M. D'Incecco[f], F.L. Fabbri[c], V. Frolov[e], M. Garbini[b,a], C. Gustavino[f], D. Hatzifotiadou[a], G. Imponente[b], J. Kim[k], P. La Rocca[d], F. Librizzi[d], A. Maggiora[e], H. Menghetti[a], S. Miozzi[c], R. Moro[b,f], M. Panareo[h], G.S. Pappalardo[d], G. Piragino[e], F. Riggi[d], F. Romano[i], G. Sartorelli[a], C. Sbarra[b,a,*], M. Selvi[a], S. Serci[j], C. Williams[a], A. Zichichi[a,b,l], R. Zuyeuski[k]

[a]*INFN, Department of Physics, University of Bologna, Italy*
[b]*Museo Storico della Fisica e Centro Studi e Ricerche "E.Fermi", Rome, Italy*
[c]*INFN, Laboratori Nazionali di Frascati, Italy*
[d]*INFN, Department of Physics and Astronomy, University of Catania, Italy*
[e]*INFN, Department of Physics, University of Torino, Italy*
[f]*INFN, Laboratori Nazionali del Gran Sasso, Italy*
[g]*INFN, Department of Physics, University of Salerno, Italy*
[h]*INFN, Department of Physics, University of Lecce, Italy*
[i]*INFN, Department of Physics, University of Bari, Italy*
[j]*INFN, Department of Physics, University of Cagliari, Italy*
[k]*World Laboratory, Lausanne, Switzerland*
[l]*CERN, Geneva, Switzerland*

Available online 17 January 2008

Abstract

The EEE Project, conceived by its leader Antonino Zichichi, aims to detect Extreme Energy Events of cosmic rays with an array of muon telescopes distributed over the Italian territory. The Project involves Italian High Schools in order to introduce young people to Physics, also countervailing the recent crisis of university scientific classes inscriptions. The detectors for the EEE telescopes are Multigap Resistive Plate Chambers (MRPC) and have been constructed by teams of High School students who went in shift at the CERN laboratories. The mechanics and the electronics were developed by groups of researchers from CERN, the Italian Centro Fermi and INFN. The first group of schools of the EEE Project has inaugurated their telescopes recently. A status report of the Project and the preliminary results are presented.

PACS: 29.40.Cs; 52.80.Dy

Keywords: UHE cosmic rays; EAS; Multigap Resistive Plate Chambers

1. Introduction

The clue of the EEE Project is to study Extreme Energy Cosmic Rays through the detection of the shower muon component inside many High School buildings scattered over the Italian territory (Fig. 1) [1]. The EEE detectors are

*Corresponding author at: INFN, Department of Physics, University of Bologna, Italy. Tel.: +39 51 2095035.
E-mail address: cristina.sbarra@bo.infn.it (C. Sbarra).

0168-9002/$ - see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.nima.2008.01.042

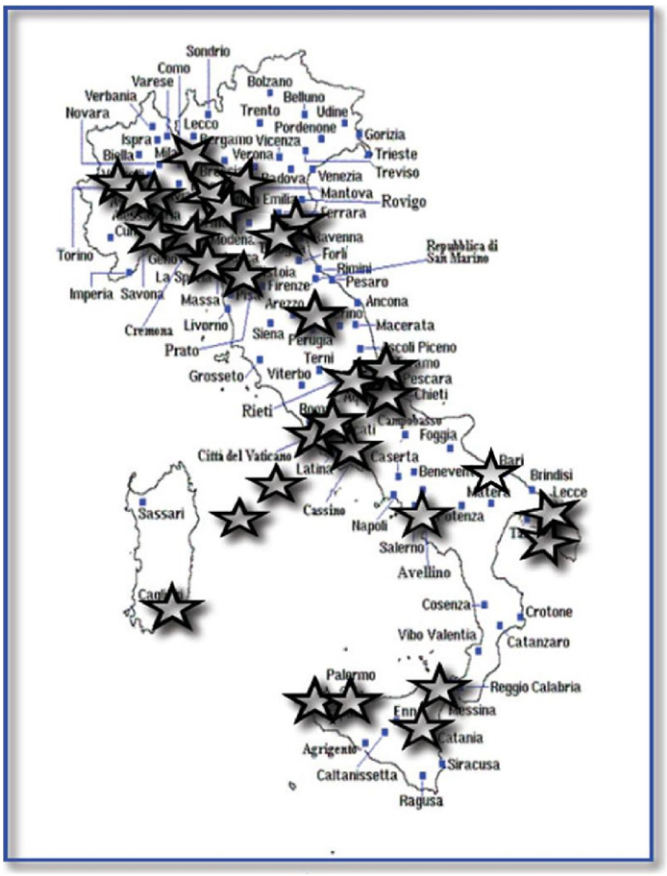

Fig. 1. Map of the involved towns in the EEE Project (2007), the seven dark stars refer to pilot towns.

muon tracking telescopes (Fig. 2a) made of three Multigap Resistive Plate Chambers (MRPC), a wider ($\sim 2\,m^2$) and cheaper version of the chambers developed by the TOF group of the Alice experiment at LHC [2].

The operative goal of the Project is to search for telescopes coincidence within the same town and eventually also investigate for coincidences between faraway sites [1]. The time correlation is made possible thanks to a GPS unit for each telescope, providing a precision time stamp event by event.

The educational purpose of the Project is to introduce young students to High Energy Physics making them to participate directly to the construction and to the operation and monitoring of their school telescopes [1].

The EEE Project was conceived many years ago by its leader Prof. Antonino Zichichi, but it is since 2003 that schools were involved in the Project, with seven pilot towns (dark stars in Fig. 1). The Project is mainly supported by the "Ministero dell'Istruzione, Università e Ricerca (MIUR)", the "Museo Storico della Fisica e Centro Studi e Ricerche E. Fermi", the "Istituto Nazionale di Fisica Nucleare (INFN)" and the European Organization for Nuclear Research (CERN).

Presently, a set of 72 MRPCs have been built at the CERN laboratories and subsequently tested. After the installation of the first telescopes in the pilot towns, as soon as new fundings will be provided, the network will be upgraded.

2. Detector outlook, construction and testing

The muons of cosmic ray showers arriving at the schools level are detected with very high accuracy by wide ($80 \times 160\,cm^2$ of active area) MRPCs [1,2] developed for the EEE Project: they are made of six gas gaps obtained interleaving two glass plates, coated with resistive paint and acting as electrodes, with five floating glasses. Commercial nylon fishing line[1] is used as spacer between glasses. The readout electrodes are copper strips (24 strips per chamber) attached on two vetronite panels (see Fig. 2b). The MRPC gas mixture is 98% of $C_2F_4H_2$ and 2% of SF_6 and the chambers operate in avalanche mode with typical working $\Delta HV = 18\,kV$ supplied by safe DC/DC converters [3,5]. The signals induced on the pickup electrodes by the muons crossing the MRPCs are read by NINO-ASIC chips [4] based Front End electronics boards at the short side of the chambers. The muon impact point is given by the hit strip in one direction (x) and by the signal arrival time difference at the strip ends in the other direction (y), so that 144 channels provide time measurements using commercial multi hit TDCs. The EEE tracking telescope is composed by three MRPCs mounted on a movable mechanical structure (see Fig. 2a). The telescope data acquisition system is VME based, and a LabView daq program runs on a windows PC, which is connected to the VME crate through a CAEN USB-VME bridge.

During 2005 and 2006, High School students and teachers constructed their chambers at the CERN laboratories (see Fig. 3).

They were organized in assembly line and supervisioned by the CERN, INFN and Centro Fermi researchers. The construction phase of the EEE Project helped the students in understanding how a high-accuracy detector can be built starting from very simple materials of common use.

Before final installation inside schools, some tests have been performed. For example, the MRPCs efficiency has been measured: all the tested chambers showed an efficiency $\geqslant 95\%$ at about 18 kV of working HV (in Fig. 4, you can see the efficiency for three chambers).

The spatial resolution, for the x and the y direction, turned out to be $0.8 \times 1.4\,cm^2$ [5].

3. Telescopes installation and first data taking

The first EEE telescopes have been installed in two schools nearby Rome and in one school nearby Bologna (see Fig. 5) and are successfully running.

A dedicated software was developed to organize and analyze the telescope data and to monitor the detector functionality. In particular, a user-friendly commands

[1] Three hundred micrometers thick.

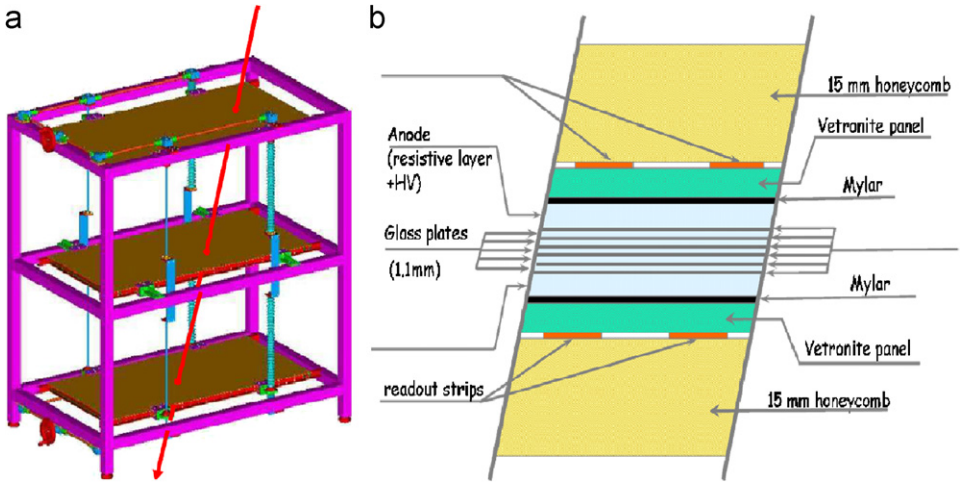

Fig. 2. (a) The EEE telescope and (b) internal structure of a MRPC.

Fig. 3. Students involved in their MRPCs construction at CERN.

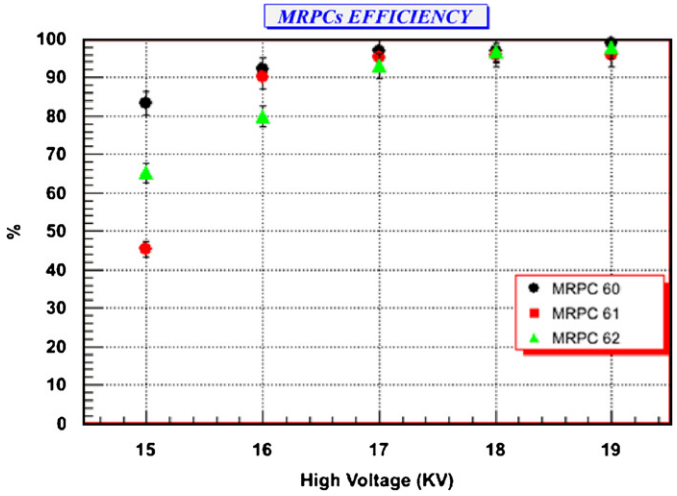

Fig. 4. Efficiency of three MRPCs for a school telescope.

panel interface[2] (Fig. 6) has been developed to help students in monitoring the apparatus by themselves.

The "Event Display" button of the panel allows to perform hits tracking (Fig. 7) and to reconstruct the incoming muon angle.

[2]Based on shell-scripting language (cygwin) installed in the school PC.

Fig. 5. Telescope inaugurated by Prof. Antonino Zichichi at the I.T.I.S. Nobili of Reggio Emilia (North Italy).

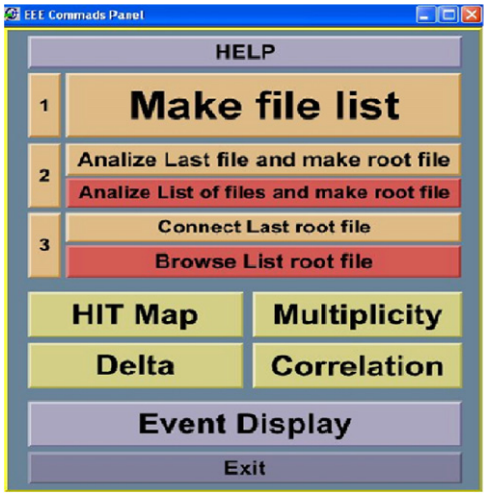

Fig. 6. Proper user-friendly commands interface (a panel of buttons) to enable automatic chamber monitor analysis: channels Hit Map, Multiplicity, time correlation and event display.

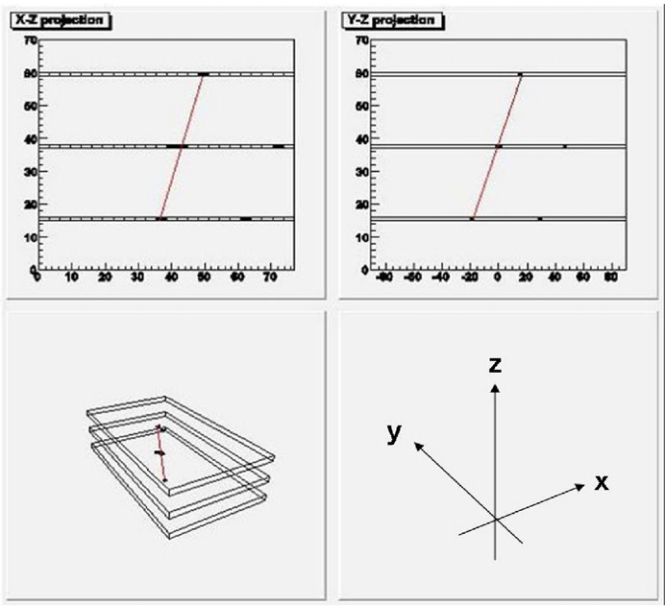

Fig. 7. Event display of a muon crossing three chambers of the EEE telescope: the two planes projection and the three-dimensional view.

As shown in Fig. 8, the muon reconstructed zenith angle from data is compatible with Monte Carlo expectation [1].

4. Conclusion

The EEE telescopes to detect cosmic ray high-energy showers are installed in several Italian High Schools. The construction of the muon chambers of the telescopes was performed during dedicated stages at CERN by High School students and teachers, supervisioned by the researchers from CERN, INFN and Centro Fermi. The chambers were tested before final installation inside schools, their performances were found to be good. The installation started in 2005, the first data taken with the EEE telescopes were analyzed and the results are in agreement with the expectation.

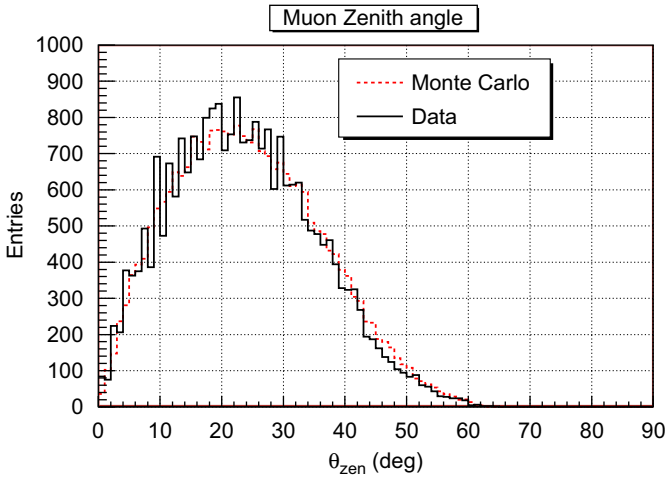

Fig. 8. Muons zenithal angle reconstructed from data (solid line) and from simulation [1] (dashed line).

References

[1] Progetto "La scienza nelle scuole," EEE Extreme Energy Events, Antonino Zichichi, Italian Physical Society, 2005, also at ⟨http://www.centrofermi.it/eee⟩.
[2] A.N. Akindinov, et al., Nucl. Instr. and Meth. A 456 (2000) 16.
[3] R. Antolini, et al., Nucl. Phys. B 165 (Proc. Suppl.) (2007) 333.
[4] A. Anghinolfi, et al., Nucl. Instr. and Meth. A 533 (2004) 183.
[5] M. Abbrescia, et al., Multigap resistive plate chambers for EAS studies in the EEE project, in: Proceedings of the 30th ICRC.