IL NUOVO CIMENTO **41 C** (2018) 66
DOI 10.1393/ncc/i2018-18066-y

COLLOQUIA: IFAE 2017

The Extreme Energy Events Project and its most recent results

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received 21 April 2018

Summary. — The Extreme Energy Events Project is an experiment for the detection of Extensive Air Showers (EAS). It consists of a sparse array of about 50 muon telescopes distributed throughout the Italian territory plus CERN, covering an area of $3 \times 10^5\,\mathrm{km}^2$. Its distinctive feature is that the telescopes, based on Multigap Resistive Plate Chambers (MRPC), are housed in High Schools and managed by groups of students and teachers. About $\sim 40 \times 10^9$ muon tracks have been stored and analyzed since the first coordinated data taking in 2014. The analysis activity is currently in progress and focused on several items: coincidence searches of muons from the same EAS and long distance correlations between different EAS, study of time variations of the muon flux on ground level, searches for large scale cosmic ray anisotropy and for upward-going particles.

1. – The EEE Project: A large array of cosmic ray tracking detectors

The Extreme Energy Events (EEE) Project is devoted to the study of the EAS produced by the impact of primary cosmic rays with energy greater than 10^{11} eV on the Earth's atmosphere. It is both a scientific and outreach initiative by Centro Fermi, Museo Storico della Fisica e Centro Studi e Ricerche "Enrico Fermi" [1], in collaboration with INFN, CERN and MIUR. The project started with a few pilot stations taking data since 2008 [2] and it has been constantly extended, reaching at present 52 detectors: 47 EEE stations are located in school buildings; 4 at INFN sections plus 2 at CERN, in order to develop new tools and solutions for the detectors operations and data acquisition; 12 new stations are under construction and test at CERN. Each detector consists of a stack of three MRPCs [3] with 24 readout strips, used for particle detection and tracking (the EEE telescope), operated in avalanche mode, with characteristics similar to the ones built for the TOF array of the ALICE at LHC [4]. The absolute time of each

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event is recorded and synchronized by means of GPS in order to correlate the information collected by different telescopes.

2. – Recent results

The network data taking is organized in coordinated runs, during which the MRPCs inside schools are monitored both by means of automated reports and daily reports from the EEE student teams. The third combined data acquisition *Run-3* started in November 2016, with 48 stations simultaneously running, and lasted to the end of May, achieving $\sim 30 \times 10^9$ events.

An investigation of techniques for rejecting the accidentals background has allowed to detect coincidences between telescopes more than 1 km apart with a Signal/Noise ratio $S/\sqrt{S+B} \sim 9.7$ [5]. A search for long distance correlations [6] between individual EAS detected by pairs of EEE telescopes in different clusters is currently underway. In the overall period analyzed, a few candidate events with unusually small time difference and angular distance has been observed.

The network is able to detect the rapid variations, $\sim 5\%$, of the galactic cosmic ray flux (GCRD) [7], associated to solar phenomena (coronal mass emissions, solar flares). The MRPCs particle rate is normalized by applying a barometric coefficient evaluated in each station. These observations are high correlated with neutron monitor stations, therefore the EEE array has the capability of becoming a stable survey for GCRDs over a broad latitude and longitude range.

An analysis of 10^9 dataset of cosmic muon tracks from 23 EEE sites has been carried out in order to search for small anisotropies of the muon flux at the subTeV sky. Raw data were corrected for the time exposure and geometrical acceptance. Corrected data maps are compatible with an isotropic distribution at the level of 5×10^{-3}–10^{-2} [8].

3. – Conclusions

The EEE cosmic ray stations are operated by teams of teachers and students and the MRPC detectors themselves have been built at CERN by the same teams. The EEE Project proves to be an effective method to communicate the meaning of the scientific research to a wide, interested audience. The increase of the data amount collected and the implementation of new analysis techniques open up for more detailed results on cosmic-ray related topics, and for complex physics questions, as the observation of upward-going particles or the search for long distance correlations.

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