

## Update on the activities of the "Extreme Energy Events - Science in the Schools" – project

Rome, April 2018

The **Extreme Energy Events - Science in the Schools** project started in 2004 and is financed and coordinated by the Italian Research Institute “*Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi*” (*Centro Fermi*) in Rome (<https://www.centrofermi.it/it/>). *Centro Fermi* is under the supervision of the Italian Ministero dell’Università e Ricerca (MIUR). INFN and CERN participate to this project.

At the moment, about fifty physicists and 104 high schools, corresponding to an estimated total of about 200 teachers and two thousands students each year, take part to the EEE project (<https://eee.centrofermi.it/>). For an overview of the status of the EEE experiment up to 2017, please refer to the presentations during the IPPOG meeting, held in Rome, from 14th to 15th February 2017 (<https://indico.cern.ch/event/596002/>):

- Extreme Energy Events: physics programme and perspectives by F. Noferini,
- Extreme Energy Events: impacts on didactic and science awareness by I. Gnesi

Since then, on the scientific side, the following items have been pursued:

**Data taking:** Up to now, 57 MRPC-based telescopes are installed, mainly in Italian high schools (see Figure). Since 2014, the experiment has collected more than 65 Billion events, reaching a weekly rate of about 600 millions muon tracks. Data are sent in real time to INFN-CNAF center for quality checks, calibrations and reconstruction. All data are available to researchers and students for detector studies and physics analysis.

**Network upgrade:** An important program of upgrade of the EEE network, foreseeing the construction of additional 20 stations, has started in 2017 and is planned to finish in 2019. In 2017 the first bunch of twenty-one chambers have been built by the students of seven schools. The detectors have been/are being shipped to their final destinations, where the telescopes are in the commissioning phase. The first two -in Siena and Cariatì (CS) - have already started taking data. Another bunch of five schools is foreseen for the end of 2018, and the remaining in 2019. Several improvements are underway, as a new custom electronic board, joining it the functionalities of the trigger card and of the GPS, that is being installed in all new stations and will progressively be installed in all other stations.



**Physics analysis:** Many analysis on the collected data sample are ongoing, and several results have been or are being published on scientific journals. As few examples, the study of extensive atmospheric showers by means of the events detected in coincidence between two or more stations, the study of local variations of the cosmic ray flux related to Forbush events, the study of the isotropy of the cosmic rays, the study of the upward going events and the study of the performance of the chambers and networks, can be cited. Particularly interesting is the recently published search for long distance (i.e. among stations hundreds of kilometers far away) correlations, an analysis particularly suited to the EEE experiment, thanks to its large area coverage (Eur. Phys. J. Plus (2018) 133: 34 ).

A recent agreement with the University of Santiago de Compostela - USC (Spain), started a collaboration to use the EEE data to correlate cosmic rays with atmosphere properties.

In the period of July-August, the PolarQuest2018 mission will follow the route of the ITALIA airship to the North Pole, 90 years after its crash (<http://www.polarquest2018.org/>). The mission will use a high-tech boat (Polar Nanuq) and include also scientific experiments, like a measurement of the micro-plastic concentration at the North Pole. The EEE project will participate to the mission with a measurement of the cosmic-rays flux at this high latitude. Three detectors (implemented with scintillators and SiPM, featuring also GPS tagging and data storage) will be built at CERN with the collaboration of students from Italy, Switzerland and Norway. The devices will be placed on the boat, in Norway (Tromsø) and in Italy, in order to allow a simultaneous measurement of the cosmic-rays flux over almost forty latitude degrees. We are in contact with IPPOG members in Norway to coordinate this project.

**Outreach:** the following activities have been pursued in 2017 and beginning of 2018:

*Local activities:* each school refers to its local responsible to organize the day by day telescope data taking and monitoring. Typically, these activities are complemented by cycles of seminars and masterclasses, when EEE researchers teach how to access EEE data and analyze them. Schools without telescopes are paired with schools with telescopes for better coordination on data analysis. As an example, measurements of the telescopes angle with respect to the geographic North, and of the middle chamber efficiency have been performed. A special agreement between Centro Fermi and the schools was prepared and signed to make all these activities fall in the "Alternanza Scuola Lavoro" (Alternating School and Work) protocol of the Italian Ministry for Education.

*Monthly vidyo meetings:* Every four weeks, a plenary Run coordination open to schools is held, where students and teachers are informed of the progresses of the experiment. Moreover, they can present the activities they have been carrying on, like simple analysis on the data made available to them by the EEE collaboration by means of the EEE Open Data Platform. Usually the meeting include also lectures on modern and particle physics and masterclasses on various aspects of the data analysis. Hundreds of contacts (entire classes or single teachers/students) are usual during these Run coordination meetings.

*International contacts:* Schools from Albania and Russian Federation have taken part at CERN to the chamber construction, coordinating themselves with the Italian schools present in the same period, and establishing profitable connections. In February, an Italian-Russian school devoted to the EEE project has taken place at Zveni Gorod, close to Moscow, and, since then, a Russian group

periodically takes part to the Run coordination meetings proposing analysis or custom software they write to be put at the disposal of the EEE collaboration.

More than 550 students from 47 schools took part to the ICD 2017, with students gathering in 9 different meeting points (usually one of the schools), strengthening the collaboration and cultural exchanges among students and teachers. Schools are presently involved also in a measurement of the speed of cosmic muons, recently organized within the IPPOG.

*Plenary meetings:* In May and December 2017, two conferences have been organized at the "Ettore Majorana" Foundation and Center for Scientific Culture, at Erice, in Sicily. Each conference had the participation of about 45 schools each, with about 150 students and teachers, plus researchers from the EEE collaboration. The agenda included presentations from schools, and masterclasses on a specific analysis items, followed by practical exercises. During each conference an experimental measurement, performed by the students, has been organized: in May it was the measurement of the Earth radius by means of the Eratosthenes' method (important to correlate information from telescopes hundreds of km away), in December the study of the variations of the cosmic rays flux with altitude, performed using the Cosmic Boxes, small detectors implemented with scintillators and readout by Silicon Photo Multipliers. Both measurements have been described in papers (signed by the students and teachers as well) submitted to the Italian *Giornale di Fisica*, which is devoted to activities related to teaching physics in school.