Physics education and Astroparticle Physics

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Abstract. The Extreme Energy Events (EEE) project is a 56 detector network distributed all over the italian territory. Its main scientific goal is the detection of Extensive Air Showers produced by high-energy cosmic rays. Since 50 school buildings were chosen as detector sites, EEE is both a scientific experiment and a beautiful didactic laboratory. Detectors are built, monitored and operated by secondary school students, inside their own schools. This unusual scenario give rise to a special learning environment allowing to test interesting educational approaches. Four educational activities are proposed, ranging from the search fot Ultra-high energy particles to Space Weather and Coronal Mass Ejection monitoring.

1 Introduction

The EEE [1] scientific goal is to measure extensive air showers produced by very high energy cosmic rays (above 10^{19} eV). The network of telescopes for cosmic rays is distributed over the Italian territory, mainly inside high school institutes. Teacher and students from more than 100 schools (50 with a telescope inside their buildings) are actively involved in a huge scientific experiment [2]. In addition to technology and scientific difficulties, EEE also faces educational challenges being itself a wide laboratory where to test new didactic techniques and methods. Detector working principles, statistics for data analysis, interactions of cosmic rays with the CMB as well as the capability of the network to detect cosmic rays flux variations and relate them with sun activities are some among the interesting fields in which the educational effort of the EEE Collaboration is at work [3]. Web meetings and conferences involving large number of participants are also regularly held, with both the aim of growing the interest of students and giving the teachers updated instruments for the didactical activities. Some of the activities developed and tested for the Turin area of the EEE Observatory are hereafter briefly described.

2 Ultra energetic particles and Active Galactic Nuclei

Being a school member of the EEE Project is a good opportunity for studying Cosmic Ray (CR) physics and several related phenomena, also giving them an overview of the open problems that the various experiments are addressing at present. Here we present a set of three educational activities designed to introduce students to the physics related to ultra energetic particles (above 10^{19} eV), where we know that possible sources are Active Galactic Nuclei (AGN). One of the problems in the detection of such cosmic rays is related to the rarity of their arrival due to the interaction with the photons of the Cosmic Microwave Background (CMB). The key concepts we want to teach them are the mean free path, the exponential reduction of such energetic particles and giving them simple information about the possible sources laying in the AGN core. Each one of this aspects was addressed with a practical activity. In example the exponential reduction due to interaction with the CMB was

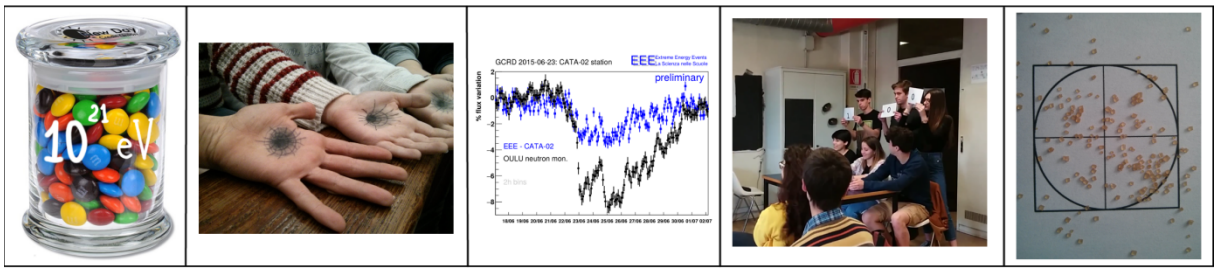

Fig. 1 (from left to right) M&m's to find the exponential decay of ultra-high energy cosmic rays due to the interaction with the CMB; 3D Black-hole on the hands of students; Forbush Decrease detected by the EEE observatory; Playing the role of the EEE detectors; Learning Monte Carlo technique with sugar randomly pured on a on a circle to extract the value of π.

investigated flipping iteratively a glass full of m&m's and removing each time from the sample those with the label 'm' visible in the front face. The distribution of the remaining one is a good example of exponential decay.

3 Space Weather and Coronal Mass Ejection

The EEE network allows the detection of Coronal Mass Ejection and Solar Flares via the sudden decrease in the cosmic ray flux (Forbush Decrease). Secondary school students learn how to perform data analysis in order to discover this kind of solar events.

4 Learning statistics and how probability is fundamental in Physics.

The distribution function of several variables in cosmic ray physics is poissonian. An introduction to this distribution was given with hands-on activities and software simulations. In example by letting them to randomly fill a grid of square boxes and studying the distribution of the number of events per each box, students can address the main features of a poisson variable. The same results can be obtained with a C++ simulation as well as by studying the muon flux measured by the EEE telescopes at different time intervals.

The EEE telescopes are complex 3-planes tracking detectors, using the same technology as the ALICE experiments at the LHC. The concept of joint probability is one of the main techniques used to allow a complex detector made of several tracking planes to detect particles. In order to make students to understand their working principle they were asked to "play the role of the detector" simulating particle detection events and spurious events using dices. Each one acted as a part of the whole apparatus. A role play in which each important task involved in the detection was undertaken by a student. They were therefore able to demonstrate how the joint probability of several spurious events is strongly suppressed with respect to real particle detection event probability, thus understanding the way EEE telescopes work.

5 Conclusion

The EEE project is a scientific experiment carried out in educational environment. This situation naturally leads the didactic research to accomplish the engaging task of introducing modern physics and cutting edge technology concepts to secondary school students.

References

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[3] F. Coccetti et al. “Masterclass del Progetto EEE”, GdF, VOL. LVII, N. 2 2016