CORAM (COsmic RAy Mission) and the International Cosmic Day 2014 (ICD14)

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CORAM (Cosmic RAy Mission) is an experiment on cosmic rays proposed by Lecce Physics Department and INFN for outreach and educational purposes. Several High School students can be involved in this activity that provided the design, construction and test of a detector for the measurement of the cosmic ray flux as a function of the atmospheric altitude and Zenith angle.
Being an outreach program, the main goal of CORAM is the dissemination of (astro) particle physics, and related techniques, among high school students, through the measurements of several properties of the *natural particle beam* given by cosmic rays. In a first phase, students and teachers attend several seminars concerning the introduction to particle and cosmic ray physics, covering also the basic concepts related to detection techniques and data acquisition and analysis. Then they are fully involved in the design and building of a *cosmic ray detector*. Detailed test results can be found in [1]. Some properties of the cosmic ray flux can then be measured and data analyzed and compared with our current knowledge on this topic.
A first detector prototype has been realized and used for a test campaign with the students. The dependence of the cosmic ray flux (above a given energy threshold) on the altitude has been investigated by means of a set of measurements done in Lecce and in several places on the Gran Sasso massif in central Italy, up to about 2100 m a.s.l. [2].This approach allowed students to repeat (part of) the same type of investigations made in the summer 1939 by Bruno Rossi and J. Barton Hoag going from Chicago to Mount Evans [3]. The detector prototype, moreover, was used in several public events like European Researcher's Night.
The detector is made of four tiles of plastic scintillator [4] interposed with iron absorbers. Each tile has dimension of $14.3 \times 14.3 \times 1 cm^3$ and density of $1.032\ g/cm^3$ (BC-412); iron absorbers have the same size but a 2 cm thickness. Scintillation light is detected by two APDs (Avalanche Photo-Diodes) with $1 mm^2$ sensitive area and it

Figure 1. CORAM DAQ board.

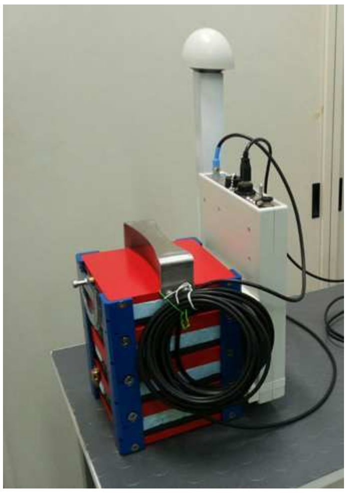

Figure 2. The Coram detector.

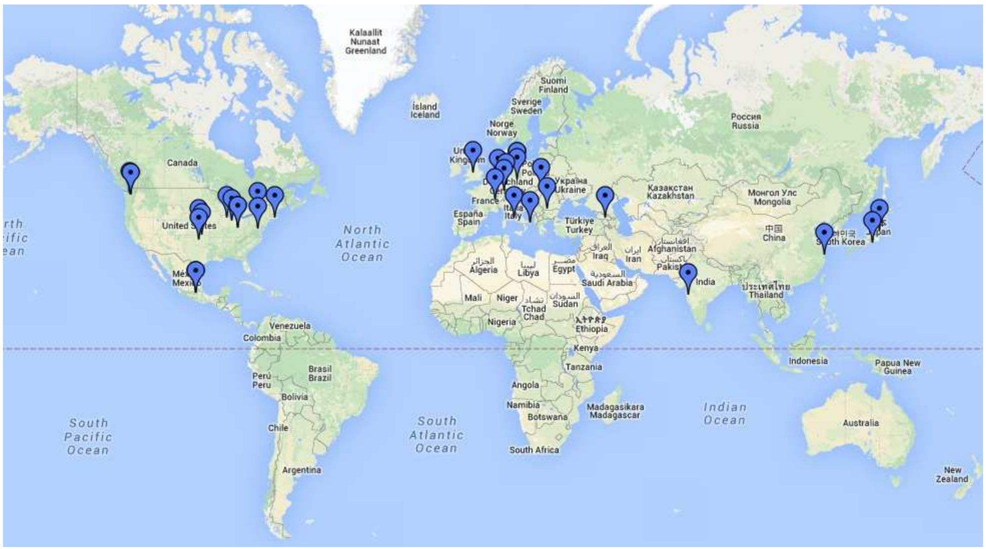

Figure 3. The map of the partecipating institutes for the ICD 2014.

is collected through a wavelength-shifting (WLS) optical fiber of $1mm$ diameter. Fibers flexibility allows for packing them in circular coils thus increasing the light collection efficiency over the plastic volume.
Each detector is provided by an electronics frontend board on top which allows for discriminating signals from the two APDs.
This setup has been chosen because it allows enough stability and it avoids to use high voltage supply as for the case of photomultipliers. Moreover, through the coincidence of four horizontal tiles, it is possible to detect particles with minimum energy of around $100MeV$.
Due to the relatively simple setup, we decided to read out just the single rate coming from each detector and the twofold, threefold and fourfold coincidences at $1Hz$ frequency.
The acquisition system has been engineered to create a compact object, redundant and which can be easily used for several measurements in the field. We present such acquisition system and the electronics used.
The DAQ must collect the signals from the detector, digitize and integrate them with the information for geolocation; perform time stamping and transfer such information to the computer.
As we said each detector is provided by an electronics frontend board on top that processes the signals from the two APDs. Therefore DAQ system can be simply implemented using a Field-Programmable Gate Array (FPGA), to manage the parallel processes logic, and a microprocessor (μC) for the communication with the computer. Moreover DAQ is provided of a GPS module for the coordinates (latitude, longitude and height) and time stamping. All data will be saved also locally in a mass storage device.
In Fig.1 is shown the DAQ system board. Data are processed from the FPGA (Xilinx Spartan 3E 500K) in a defined time window through a look-up-table for coincidence counting. Moreover FPGA labels each count with a specific flag (single count plane 1, etc.), increase the detected event counters and transfers the data to the μC (MicroChip PIC18F87J50). The micro controller provides the timestamp with the time information from a GPS receiver integrated in the DAQ. Moreover, it also provides the environment temperature records, defines the time window for data acquisition, saves data on a SD-Card and finally sends them serially to a computer for test purpose. An appropriate graphical user interface was also developed using the LabView [5] software.
Fig.2 shows the final detector assembly a compact, cheap and user friendly device that is actually used in several public events such as "hand-on"experiments, scientific demonstration, simulations, debates and for the International Cosmic Day (ICD). The ICD is an international project directed to the High School students and organized every year by DESY Accelerator Laboratory (Hamburg), Fermi National Laboratory (Chicago) and CERN (Geneva). Students from across the globe can participate and ask questions like: what are cosmic particles? Where do they come from? How can they be measured? Sci-

entists working to answer these questions invite school students to join up for a day of experimentation in this fascinating field. During the ICD, the students are in contact with the research activities, can carry out a little experiment on cosmic rays, analyze the data, compare their results with other groups connected via web with other universities or research centers in the world. They can work for a day as an international collaboration.
Our group did partecipate to all the editions, starting from ICD2012. With our setup the students can measure the zenith angle distribution of air shower particles. In Fig.3 we show the map that gives an overview of the partecipating institutes for the 2014 edition. Fig.4 shows the measurements results elaborated by one of the High School involved and published on a booklet. For the 2014 edition we hosted five high schools with a total of 33 students working together and interacting with foreing student from all over the world. Fig.5 shows a moment of the 2014 International Cosmic Day.

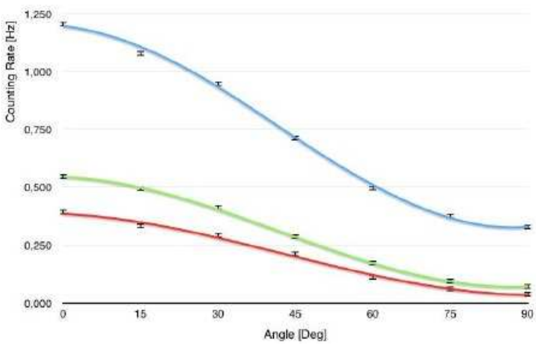

Figure 4. Results for Zenith angle distribution of the cosmic ray air shower elaborated by one high school. The different curves correspond to the twofold (blue line), threefold (green line) and fourfold (red line) coincidence.

REFERENCES

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Figure 5. A moment of the ICD2014.

5. *LabVIEW National Instruments*, www.ni.com/labview/.