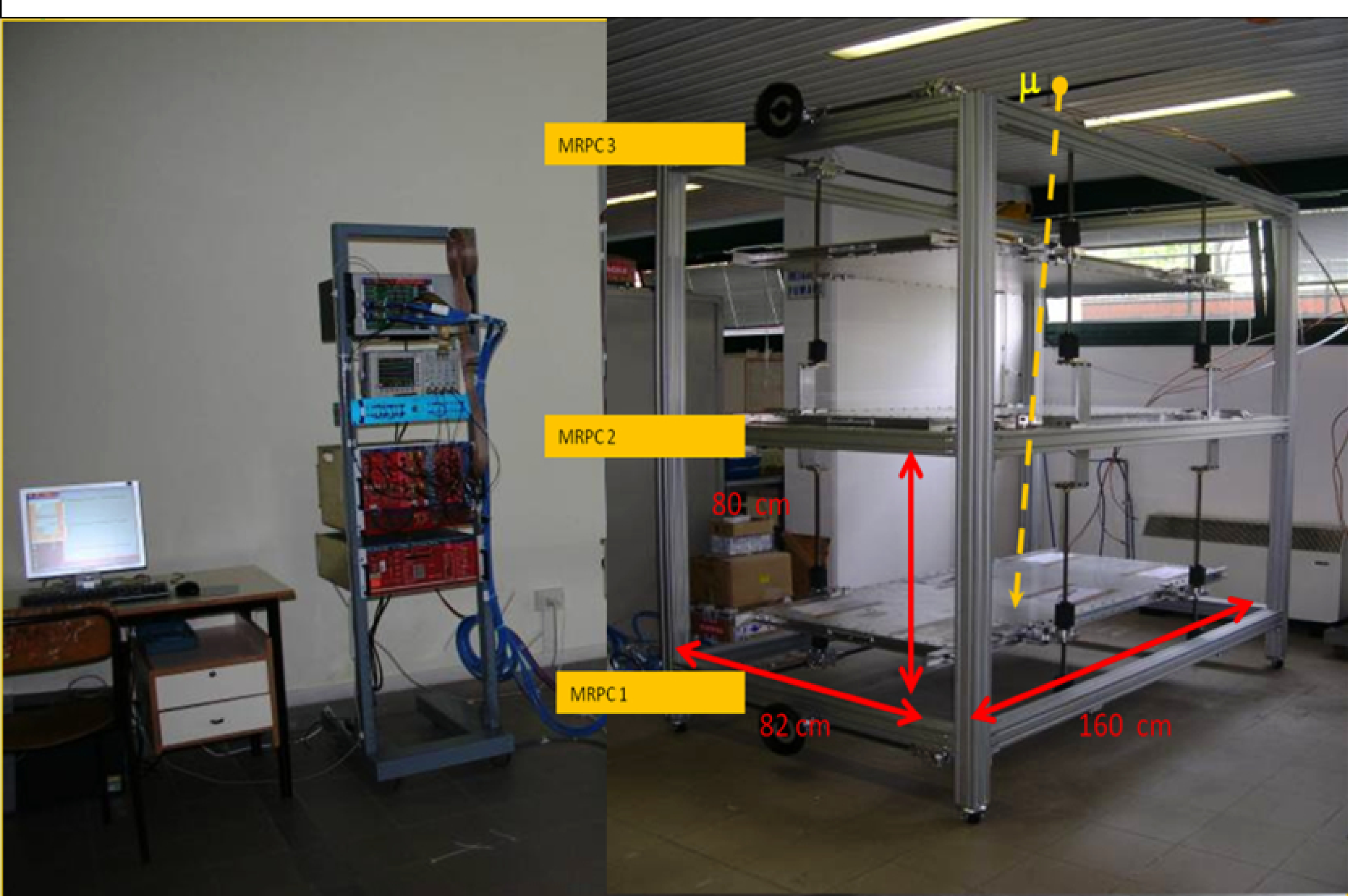
DETERMINATION OF COSMIC RAY SPEED USING DQM DATABASE

Del Vecchio E, Gargiulo F., La Ferrara L., La Franca A., Lolli Ghetti M., Nacca G.
Rosati F., Sordini D., Gennari A. and Antonucci A.

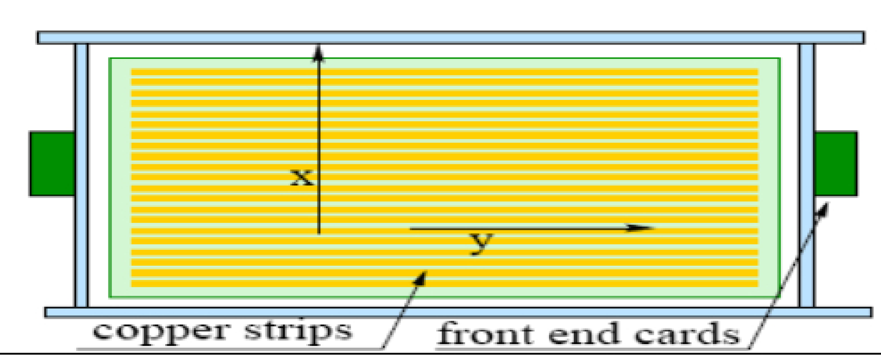
C. Cavour . Scientific High School, Via Delle Carine, 1,00184, Roma.
e-mail: angela.antonucci@gmail.com

The EEE project is a research activity carried out through the collaboration of scientists with high school students and teachers. The aim of the project EEE (Extreme Energy Events) it's the survey of swarms of cosmic rays of great energy through a system of "muon telescopes".
Each school has available a telescope that allows to take tracks of muon particles; of the latter only the one which crosses the three chambers of the telescope in a rectilinear way can be chosen and then analyzed.
The tracks taken record some dates which at a later time are reworked through the program Excel in order to calculate the speed registered by the used telescopes and to compare it with that of other schools' telescopes.
It has been analyzed the variation of this speed taking into account different parameters.



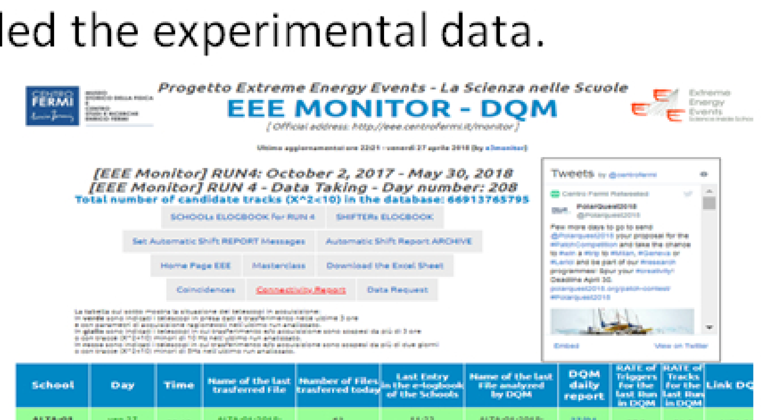
The Extreme Energy Event (EEE) project - Science inside Schools - is promoted by various institutions, first of all the Centro Fermi and sponsored by the Italian MIUR, INFN and CERN (Abbrescia et al, 2012)
It was born with the purpose "to bring science to the students' heart". (Zichichi, 2017) through the measure of the primary cosmic rays speed , and particularly the muon component , which reaches the earth.
The detection of this component is carried out through a network of telescopes distributed throughout Italy, mainly within high school institutions and put in coincidence with GPS. Several schools spread throughout Italy possess a telescope to capture this type of rays, in order to have a greater numbers of evidence that the data obtained actually refer to rays of extraterrestrial origin.
Each telescope consists of three floors of MRPC (Multigap Resistive Plate Chambers) as shown in figure 1; each floor is able to measure with great precision the point of impact of the incident cosmic particle and the crossing time.
The reading system takes place through metal electrodes divided into strips-
.Each strip is connected to each of its extremities with an electronic reading and a signal acquisition system as shown in figure 2. By measuring the 3 impact points, it will be possible to reconstruct, for example, a straight line of the searched particle and its crossing time.

All the collected data are sent to a database (DQM) and the researchers around all the word, e.g. CERN, can use this data to identify the muonic traces that can really be considered primary cosmic rays.
In this paper, we show how it is possible to use the DQM data to determine the cosmic rays speed taking into account the length of the muonic trace and the time spent to cross the three chambers of MRPC telescope.
The problems related to the sensitivity and variability of experimental data against specific parameters such as the inclination of the muon track with respect to the telescope will also be analyzed.



Methods and Materials

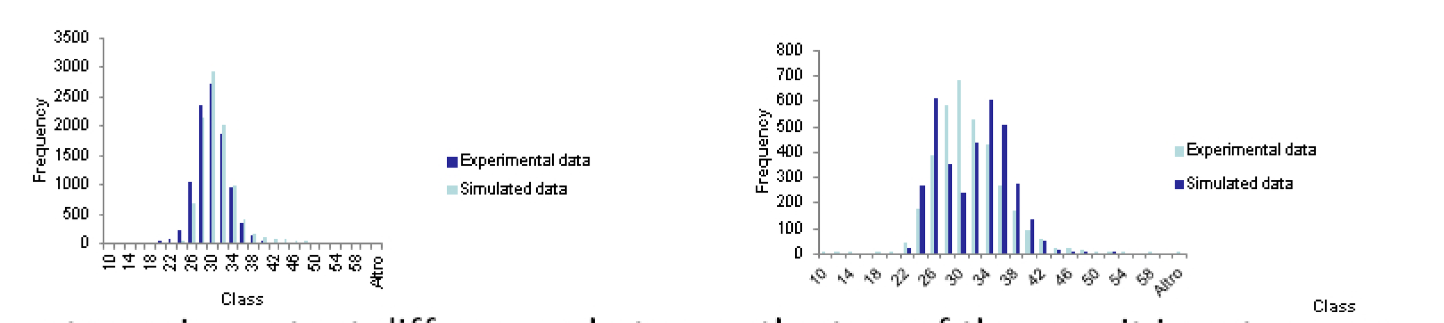
The cosmic ray speed has been determined taking into account the length of muonic trace ad the time that the same ray spent to cross the three telescope chambers.
The DQM database has provided the experimental data.



They were chosen, among all, some specific telescopes to analyze and compare the experimental data. The selected DQM data have been processed with the Excel program and for each data set (track length and time of fly)it was determined the muon speed. The data were reported in a histogram and were determined the average speed and the standard deviation. Only 1000 data were processed to reduce the elaboration time.
The first analysis is about the correspondence between theoretical data and experimental observations and has been carried out taking into account experimental data and simulated data of CERN01 and Bologna 01 telescopes. The aim of this kind of analysis is to verify that no systematic errors occur during data collection.
The second analysis is about the cosmic rays speed. The DQM database provides the data of the track length and the time of flight of muon particles but we noticed that the length of the track increases with respect to the distance between the bottom and top chambers (1m) as the theta incidence angle increases (La Rocca et al, 2017)so we decided to filter the data settled the value of the observation angle to a specific range (0≤θ≤10) that allows us to analyze the traces as vertical as possible with respect to the telescope chambers.
Moreover, we decided to use only the experimental data that refer to very likely muons traces by setting a specific value for a parameter calculated by the data detection system (chi square) that allows us to discard data that may be due, for example, to electronic fluctuations of the experimental device.
A preliminary elaboration was made to analyze the dependence of the results on the validity of the applied filters.
The average muon speed of different telescopes (Arezzo, L'Aquila, Lodi, Bologna01) has then been compared and it was also determined a little sample average .

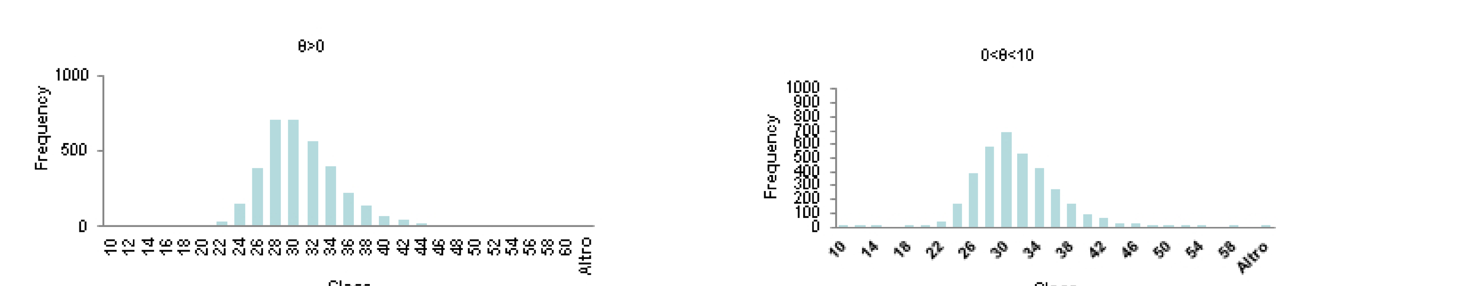
Correspondence between theoretical data and experimental observations

The experimental results from the telescopes Bolo-01 and Cern-01 were compared with the MC results from the same telescopes are shown in figure.



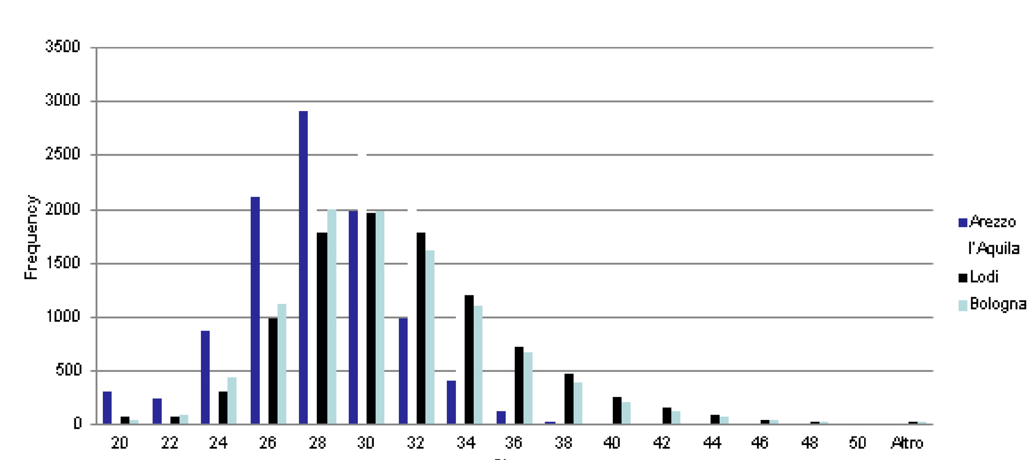
There are not very important differences between the two of them so it is not necessary a correction of the experimental results.

Dependence of the results on the value of theta



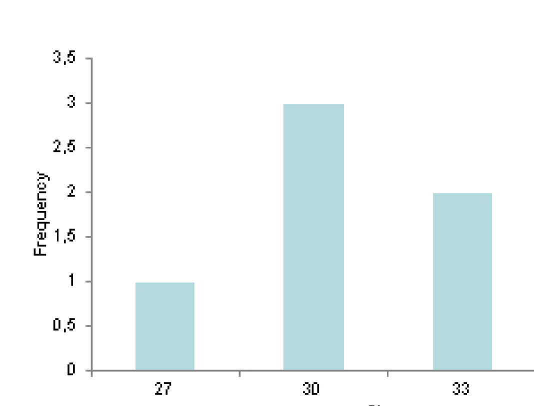
Comparison between data with cut theta<10 and theta>0 and data with only theta>0
The histograms are similar, but when the angle is limited the concentration around the average is higher while instead when it is absent the data are more scattered

Average muon speed



Comparison between the speed calculated with different telescopes.
The distribution is quite similar. The highest frequency is reached by Arezzo and L'Aquila as shown in the table

Telescopes	Average cm/ns	Dev.St cm/ns
Cern 01	28	4
Bologna 01	31	17
Arezzo	27	4
l'Aquila	29	4
Lodi	31	22
Bologna	30	5



Distribution of the cosmic rays averages.

What results evident is that all of them are very similar to the real speed of the muon, which represents a good efficiency of the telescopes used to compare the results. The standard deviation in Bolo-01 and Lodi-01 is, which means that the results are more scattered while for the rest of the telescopes the results are more gathered around the average.

Conclusion

The paper presents the results of determination of cosmic rays speed using DQM data.
Analyzing the data collected in the database, it was possible to determine the velocity of the muon using, for selected telescopes, the data related to the length of the trace and to the flight time.
The comparison between the experimental data and the simulated data allowed to exclude corrections on the collected data.
The data were selected using tracks compatible with muonic traces, the most possible vertical with respect to the detector.The variability of the data was analyzed by comparing data without limitations with respect to the perpendicularity of the trace and between data from different telescopes.
The averages of the velocities obtained from the different telescopes were analyzed and a small sample distribution of the averages was constructed
The final result $v = (2.9 \pm 0.3)\ 10^8$ m / s is compatible with the expected result given that the values greater than 3 10^8 m / s have no physical significance.