ISTITUTO NAZIONALE DI FISICA NUCLEARE
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FRASCATI PHYSICS SERIES

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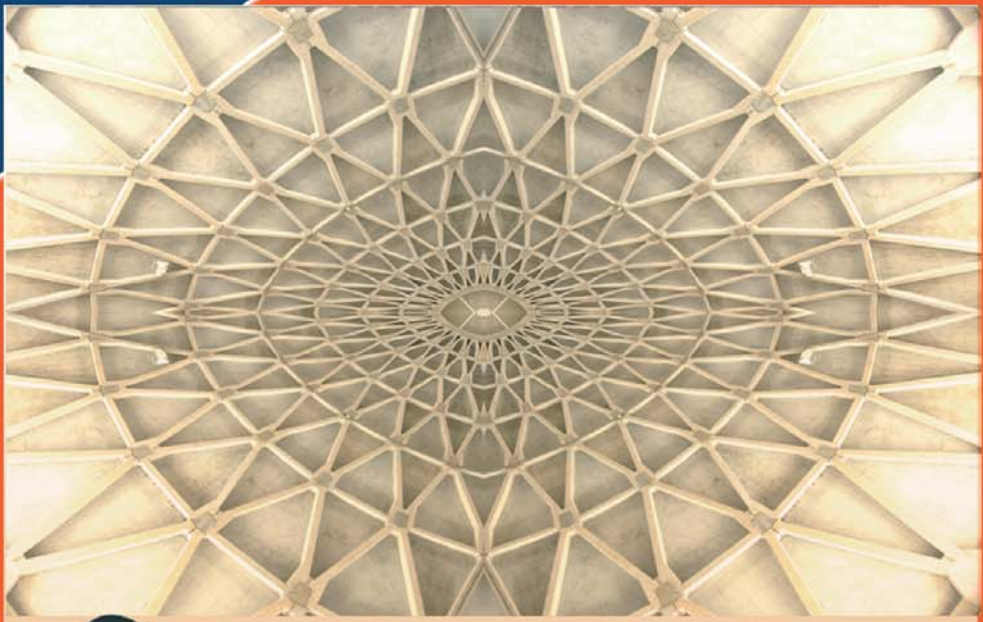

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Collana Scienza Aperta – Volume IV

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ComunicareFisica2012

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Prefazione

ComunicareFisica giunge nel 2012 per la sua quarta edizione a Torino, organizzata dall'Istituto Nazionale di Fisica Nucleare e con la collaborazione dei tre atenei piemontesi, Università di Torino, Università del Piemonte Orientale e Politecnico di Torino, con il patrocinio di Comune e Provincia di Torino, della Regione Piemonte e dell'Ufficio Scolastico Regionale del Piemonte, del Museo di Scienze Naturali di Torino (che sponsorizza e ospita l'incontro), e delle associazioni e fondazioni locali InfiniTo, CentroScienza, Agorà Scienza, e Museo A come Ambiente.

Questo appuntamento biennale, ideato nel 2005 presso i Laboratori Nazionali dell'Infn di Frascati, è nato per confrontare i diversi protagonisti della comunicazione nel campo delle scienze fisiche, ricercatori universitari e degli enti di ricerca, docenti delle scuole, organizzatori di eventi e musei, giornalisti scientifici e artisti, ovvero attori molto diversi tra loro per formazione e che utilizzano strumenti di comunicazione molto eterogenei e in rapida evoluzione. La comunicazione della scienza, in particolar modo delle cosiddette "hard sciences" tra le quali si colloca tradizionalmente la fisica, ha acquisito nel corso degli ultimi anni una importanza sempre più strategica, sollecitata da un lato dalla politica, che vede nello sviluppo delle scienze fondamentali uno dei pilastri di una società moderna in grado di competere con le sfide tecnologiche dei paesi più avanzati, e dall'altra dalla cosiddetta "società della conoscenza" che, grazie ai rapidi progressi delle forme della comunicazione, richiede nozioni e informazioni sempre più ampie e articolate. Questa "fame" di conoscenza e divulgazione dei risultati scientifici, deve ovviamente coniugarsi sempre con le opposte esigenze di efficacia e semplicità del messaggio, anche e soprattutto per i non addetti ai lavori, con la imprescindibile esattezza della comunicazione del fenomeno, che non può e non deve in nessun caso essere banalizzato o distorto. L'Infn persegue in varie forme questi obbiettivi come "terza missione" della propria attività di ricerca fondamentale, e l'organizzazione periodica di questo convegno ne è testimonianza ed esempio.

In particolare, per questa edizione, il comitato organizzatore ha proposto di organizzare l'agenda intorno ad un tema che corre trasversalmente alle diverse metodologie utilizzate nella comunicazione della fisica, ovvero "il racconto della scoperta". Ed infatti non a caso è stata scelta come simbolo di questa edizione una immagine di Richard Feynman, premio Nobel per la fisica nel 1965. Quest'anno infatti ricorre il 50°

anniversario della pubblicazione di Quantum Electrodynamics, un'opera certamente fondamentale nella storia della scienza, scritta da un fisico che fu non solo un insigne scienziato ma anche un grandissimo divulgatore, e autore (tra gli altri) del famoso trattato The Pleasure of Finding Things Out. Piacere della scoperta e capacità di comunicarla sono quindi il filo rosso che unisce idealmente le diverse sessioni che sono state proposte nella edizione di ComunicareFisica 2012, ovvero divulgazione attraverso la carta stampata (sessione 1), musei, mostre ed eventi speciali (sessione 2), didattica e divulgazione nelle scuole (sessioni 3 e 4), mass media tradizionali (sessione 5), nuovi linguaggi del Web 2.0 (sessione 6) e infine Fisica e Arte (sessione 7). Nell'ambito di queste sessioni sono state presentate 82 comunicazioni, nell'arco delle cinque giornate, dal 8 al 12 ottobre 2012, con la partecipazione di un centinaio di iscritti all'evento.

Gli organizzatori ringraziano la Regione Piemonte e la direzione del Museo di Scienze Naturali per aver ospitato l'incontro nella propria sede, la Fondazione CRT, la Rad-Tech Srl e il CeSeDi della Provincia di Torino per il cofinanziamento dell'iniziativa, il Comune di Torino e l'Ufficio Scolastico Regionale del Piemonte per aver patrocinato l'iniziativa.

AS e *MF*

di G. Chiarello[a,b]
M.R. Coluccia[a,b]
A. Corvaglia[b]
P. Creti[b]
I. De Mitri[a,b]
M. Panareo[a,b]
M.Solters[c]
C. Pinto[a,b]

(a)
Università del Salento, Dipartimento di Matematica e Fisica "E. De Giorgi", Lecce, Italy

(b)
INFN - Istituto Nazionale di Fisica Nucleare, Lecce, Italy

(c)
Univeristy of Florida, Department of Physics, Gainesville, Florida, USA

The CORAM (COsmic RAy Mission) outreach program

COSMIC RAY MEASUREMENTS AT HIGH ALTITUDE

ABSTRACT

CORAM (COsmic RAy Mission) is an outreach program carried out by INFN and the University of Salento in close collaboration with high schools. Students and their teachers are involved in the design, construction, test and operation of detectors for the measurement of several properties of the cosmic ray flux. The results of a set of measurements, made with a first detector prototype at different altitudes and underground, will be described.

INTRODUCTION

At the beginning of the 20th century, Domenico Pacini performed several underwater measurements in order to establish the variation of an electroscope discharge velocity, i.e. the radiation intensity, as a function of depth[1]. At the same time, Victor Hess measured a variation of the radiation intensity with the altitude[2], discovering that going up in the atmosphere with a balloon the electroscope discharged more quickly. These and other subsequent works lead to the demonstration that the unknown radiation come from the outer space, hence the name cosmic rays.

Today it is well known that cosmic rays entering the Earth's atmosphere (i.e. the primary cosmic rays) are mainly composed by atomic nuclei and a small amount of photons, electrons and positrons. Their energy varies in a wide interval reaching about 1020 eV. Primary cosmic rays interacting in the atmosphere generate extensive air showers (EAS) of secondary particles that reach the ground. The muon flux at sea level is about 300Hz/m2[3].

The dependence of secondary cosmic ray flux on the altitude is then characterized by a maximum followed by an exponential decay (towards sea level). This behaviour is also known as Pfotzer plot from the name of the physicist that first performed different measurements with weather balloons and using particle detectors put into coincidence at different altitudes[4]. The position of the maximum in the Pfotzer plot depends on different factors, like the considered particle type, the geomagnetic latitude, the detection energy threshold, etc. However all the components show a peak at about 100-150 g/cm2 of atmospheric depth, corresponding to about 18 km above sea level (a.s.l.).

The goal of CORAM is the dissemination of (astro-)particle physics, and related techni-

1. D. Pacini, Nuovo Cimento 3 (1912) 93.
2. V. Hess, Phys. Z. 13 (1913) 1084.
3. J. Beringer et al. (Particle Data Group), Phys. Rev. D 86 (2012) 010001
4. G. Pfotzer, Zeits. f. Physik, 102 (1936) 23.

ques, 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 attended 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 were fully involved in the design and building of a cosmic ray detector. Some properties of the cosmic ray flux can then be measured and data analyzed and compared with our current knowledge on this topic.

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 around the Gran Sasso massif in central Italy, up to about 2100 m a.s.l. 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 [5].

In the following sections we will illustrate the experimental setup and the measurement results.

THE EXPERIMENTAL SETUP

The detector prototype is made of four tiles of plastic scintillator interposed with iron absorbers. Each tile has dimensions of 14.3 cm x 14.3 cm x 1.0 cm and density of 1.032g/cm3 (BC-412). Iron absorbers have the same size but a 2 cm thickness. Scintillation light is detected by two APDs (Avalanche Photo-Diodes) with 1mm2 sensitive area and it is collected through a wavelength-shifting (WLS) optical fiber with a diameter of 1mm[6].

The flexibility of the fiber allows packing them in circular coils thus increasing the light collection efficiency over the plastic volume.This setup has been chosen because it allows enough stability and avoids the use of high voltage supply as is the case for photomultipliers. Through the coincidence of four horizontal tiles, it is possible to detect cosmic ray muons with minimum energy of about 150 MeV.

Front-end electronics are placed over each tile, which allows for discriminating signals from the two APDs and for sending the signals to the DAQ system, which comprises an FPGA and a controller. Data are processed from the FPGA in a defined time window through a look-up-table for coincidence counting. The results are sent to the controller that 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 telemetry system or to a computer for test purpose. An appropriate graphical user interface was also developed using the LabView software[7].

RESULTS OF THE MEASUREMENTS

Students participating to the project were directly involved in the construction and test of the detector prototype. In small groups, they worked at the Astroparticle Physics laboratory of the University of Salento and INFN Lecce, for assembling and testing the detector. Detailed test results can be found in [8]. In March 2012 a first measurement

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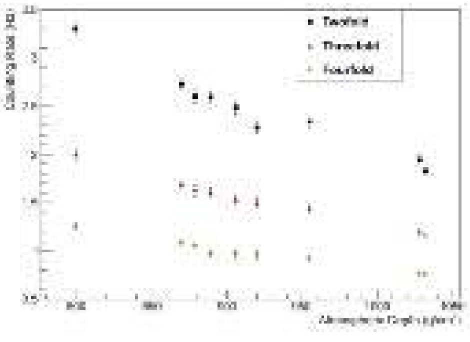
5. B. Rossi and J. Barton Hoag, Phys. Rev. 57 (1940) 461
6. A. Akindinov et al., Nucl. Instrum. Methods A 539 (2005) 172.
7. LabVIEW National Instruments, www.ni.com/labview/

campaign has been organized with students and their teachers, the main goal being the study of the dependence of the detected cosmic ray flux on the atmospheric depth.
Measurements were done in differet locations starting from Lecce and going toward the Abruzzo mountains up to Campo Imperatore, a plateau in the Gran Sasso massif at about 2100 m above sea level.

As a first check, the ratios of several coincidence types (e.g. twofold to threefold, etc.) were studied as a function of the altitude. As expected, those ratios tourned out to be independent from the atmospheric depth. Moreover their absolute values are in agreement with calculations taking into account the single detector efficiency measurements made in the Lecce laboratory (see[8]) and simple acceptance estimations.

In Fig.1 the measured rates for two, three and four-fold coincidence, are reported as a function of the atmospheric depth. We can see that the counting rates increase going from sea level (about 1035 g/cm^2) to Campo Imperatore (about 800 g/cm^2) as expected. The single tile counting rates, even showing an average encrease with altitude, were affected by the noise of each detector plate and by the different radiation backgrounds at each site.



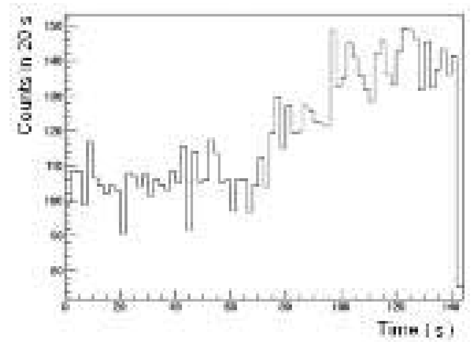


Fig.1: Measured counting rates for 2,3, or 4 fold coincidences as a function of the atmospheric depths. The detected flux raises with altitude as expected.

Fig.2: Single layer counting rates as measured during the ascent on the Gran Sasso cableway. Similar behaviors were obtained for 2,3, or 4 fold coincidence rates.

In Campo Imperatore we also studied the rate dependence on the zenith angle. The counting rates were measured after having tilted the detector vertical axis towards the east and west directions. The results are in agreement with the expectations considering the detector wide field of view and shower background for large zenith angles. As expected no east-west effect was detected due to the site location, the energy threshold and detector field of view.

Measurements were also performed during the ascent from Fonte Cerreto to Campo Imperatore (from 1120m to 2140m a.s.l.) with the Gran Sasso cableway. Since the ascent usually lasts about ten minutes, statistical fluctuations in the measured rates are large, due to the small detector acceptance. By the way, a clear raising of the counting rate was observed for each type of coincidence, in agreement with the expectations (see Fig.2).

Underground measurements were made in the INFN's Laboratori Nazionali del Gran Sasso (LNGS), where the students also had the possibility to visit the experimental faci-

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[8] M.R. Coluccia et al., Nuovo Cimento C 5 (2012) 35.

lities. Because of the rock overburden (about 3000 m water equivalent in the vertical direction) the secondary cosmic ray flux inside the Gran Sasso tunnel is reduced by a factor of about 106. This reduces the cosmic ray particles to about one muon per square meter per hour[9]. This flux is below the sensitivity of our detector in the used short time bins. We then expect to have a null result for the coincidence rates, the accidental background being negligible, while the single rates would just give a measure of the electronic noise and the environment radioactivity. This is what we actually observed.

CONCLUSIONS

High school students (with the help of their teachers) were involved in the design and operation of a small cosmic ray detector. Some properties of the cosmic ray flux have been measured and data analyzed and compared with our current knowledge in the field. 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 around the Gran Sasso massif in central Italy, up to about 2100 m a.s.l. Underground measurements were also made inside the INFN Laboratori Nazionali del Gran Sasso. The students were fully involved in detector operation and data analysis. The results of the measurements were in agreement with the expectations. The next phase of the outreach program includes the building of a larger detector and new measurements at high altitude or even underwater.

ACKNOWLEDGEMENTS

We kindly acknowledge the LNGS staff and its Director for their support and warm hospitality. INFN encouraged and supported this outreach program by funding the detector and the DAQ system. One of the authors, M.S., participated to this activity in the framework of the summer students exchange program 2012 beteewn INFN and the US Department of Energy[10].

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[9] M. Ambrosio et al. (The MACRO coll.), Phys. Rev. D 52 (1995) 3793

[10] See http://web2.infn.it/DOE-INFN-SSEP/