14 - 25 JUNE 2004 SUMMER STAGE

PARTICLES REVELATION THROUGH SCINTILLATION COUNTER

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1) COSMIC RAYS

Earth atmosphere is continuously bombarded by high-energy particles, cosmic rays, coming from the outer space, which form the primary cosmic radiation.

"Primary" cosmic rays are those particles accelerated at astrophysical sources (such as electrons, protons and helium) and "secondaries" are those particles produced in interaction of the primaries with interstellar gas (such as lithium, beryllium and boron).

Except for protons and electrons near the top of the atmosphere, all particles are produced in interactions of primary cosmic rays in the air. Muons and neutrinos are products of the decay of charged mesons, while electrons and photons originate in decays of neutral mesons. But among all the cosmic rays, only muons reach the earth, because the others decade too early.

Moreover, only muons and neutrinos penetrate to significant depths underground. In particularly, the muons produce tertiary fluxes of photons, electrons and hadrons.

The Muons

Muons are the most numerous charged particles at sea level. Most muons are produced high in the atmosphere and lost about 2 GeV to ionization before reaching the ground. Their energy and angular distribution reflect a convolution of production spectrum, energy loss in the atmosphere, and decay (their decay length is of 15 km, which is reduced to 8.7 km by energy loss).

These cosmic rays are utilized for the calibration of particle physic counter.

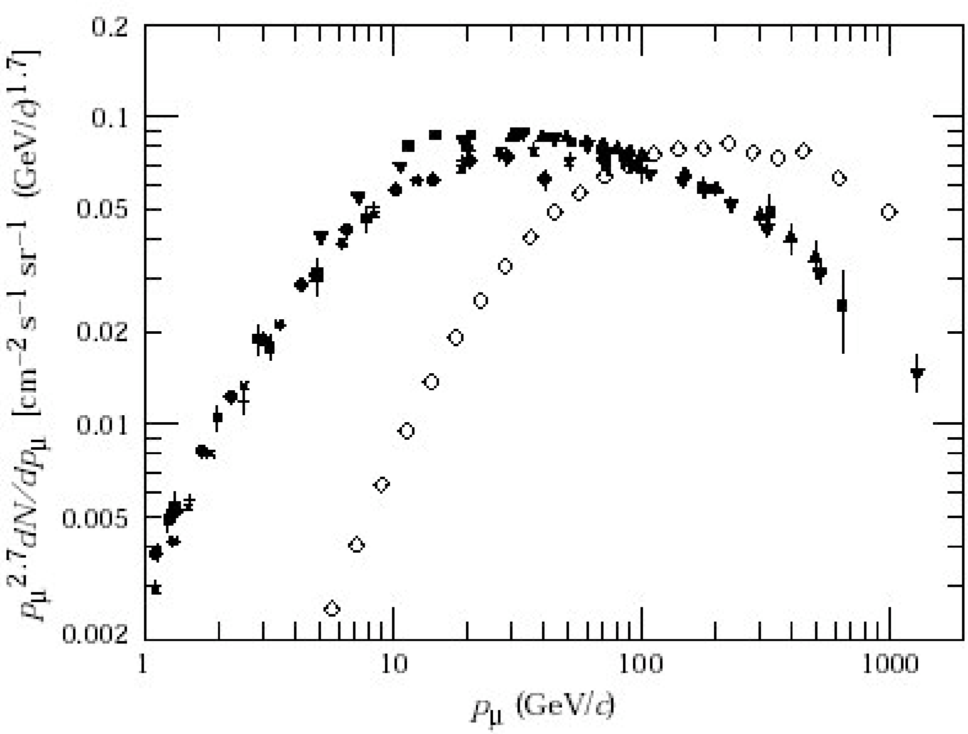

***Fig.1**: spectrum of muons at ϑ = 0° and 70°*

2) PARTICLE PHYSIC COUNTERS

A particle physic counter is composed by two parts: the counter itself that is the device in which the radiation interacts and the measure system that has the function to supply a signal for every recorded event.
A particle physic counter provides some information like:

a) Discrimination of the various kinds of particles
b) Measure of the intensity
c) Measure of the energy
d) Visualization of the tracks

There are several kinds of particle physic counters, the most common are:

1) Gaseous ionization detector
2) Scintillation detector (used for our activities)
3) Semiconductor detector

Some substances, called scintillators, hit from radiations, have the property to emit weak lightning bolts which, opportunely amplified, allow to reveal the incident radiation, giving some quantitative and qualitative information.
The photomultiplier transforms the radiation emitted in the scintillator in a detectable electric signal.

- Scintillation counters
The revelation methods to count the nuclear radiations are based on the phenomenon of ionization and rarely on excitation. In the first one, when the particle goes through the matter, it interacts with the medium and is detected. In the second one, the atoms are excited and are brought to advanced energetic levels from which decay emitting energy.
A scintillator is characterized by three important coefficients: the coefficient of transparency T, the coefficient of arrest ε, and the coefficient of conversion η.
A scintillator requires the following features:

a) Elevated coefficient of conversion;
b) Elevated coefficient of arrest;
c) Elevated transparency coefficient;
d) Proportionality between the amplitude of the impulse of luminescence and the lost energy from the particle in the scintillator;
e) The band of wave length of luminescence must coincide with the band of lengths in which the photocathode of the photomultiplier is sensitive;
f) Short time of decay in order to render minimum the total time of the detector.

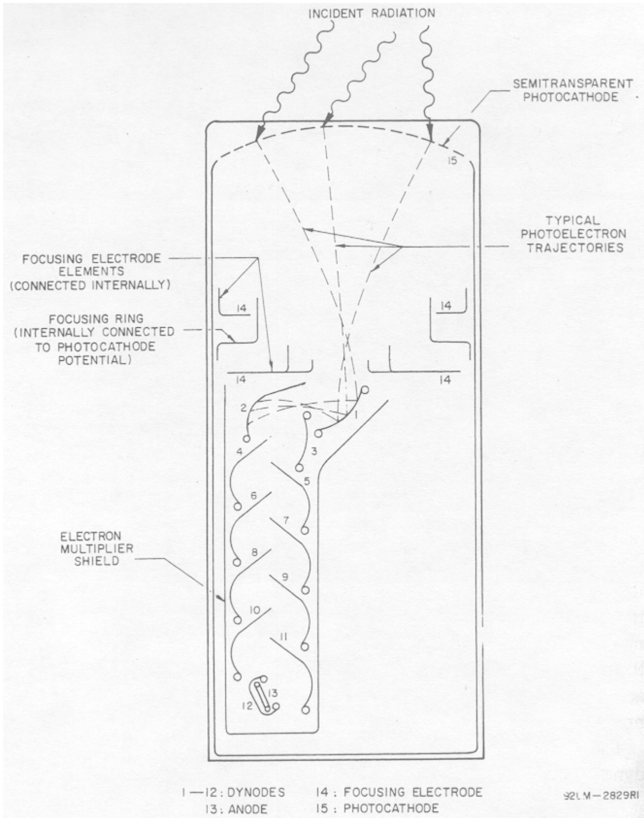

Fig.2: *the photomultiplier*

The scintillators, depending on the state of aggregation and the chemical structure, are divided in 5 groups:

1) Inorganic scintillators
2) Organic scintillators
3) Liquid scintillators
4) Plastic scintillators (used for our activities)
5) Gaseous scintillators

- The Photomultiplier

The photomultiplier is a photoelectric cell with dynodes with an opportune difference of potential. In this photoelectric cell, through the photoelectric effect, the emitted photons in the scintillator are converted in electrons. the high voltage applied to the dynodes system amplifies the number of electrons and produces an electric detectable signal.

3) LABORATORY EXPERIENCE

During our laboratory experience we measured the cosmic rays with adapted equipment that we had in disposition.
We used a plastic scintillator that was 0.7x5x2cm to reveal the muons.
They deposit 1.9 MeV per cm, so in 0.7 cm we have 1. 3 MeV.

- The acquisition system

We used an acquisition system composed by a scintillation counter with two PMT. The components were:

1) 3 FAN IN FAN OUT, that produce many equal output signals from one input signal;
2) 5 DELAYS, that are cables to delay the signals;
3) 2 DISCRIMINATORS, that give an output shaped signal with amplitude and duration variable, if the input is above and adjustable threshold;
4) 1 LOGIC, an AND logic, that makes a coincidence between two or more different shaped signals;
5) 1 AMPLIFIER, that increases the signals by a factor 10;
6) 1 ADC, that measures the signal amplitude.

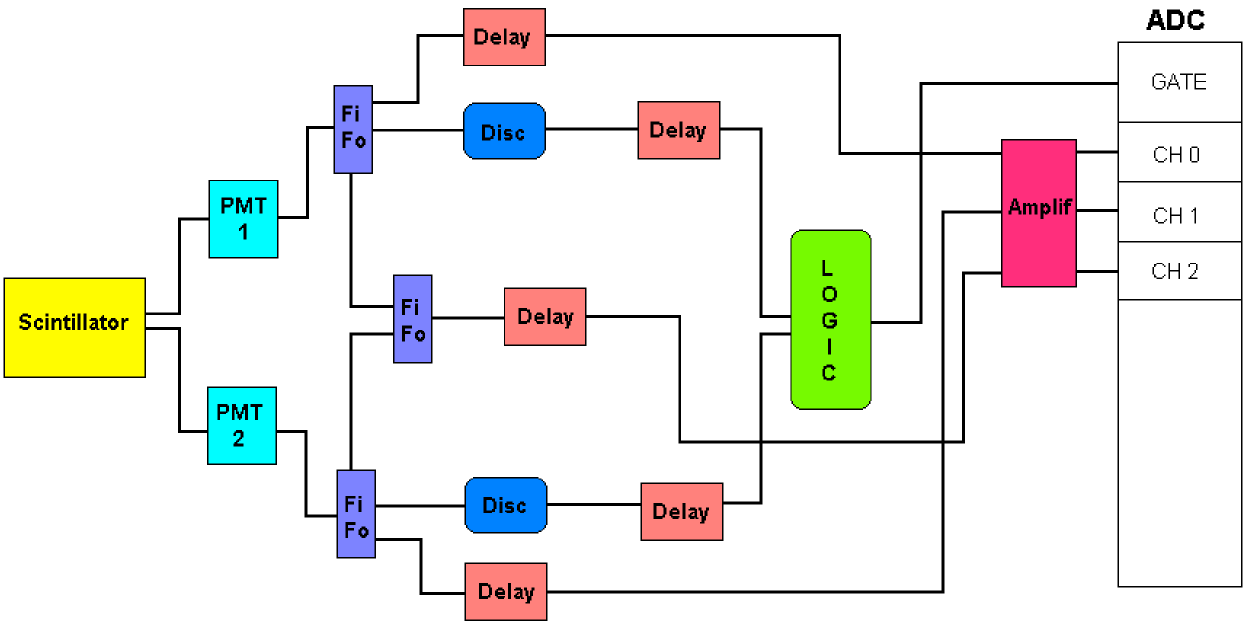

Fig.3: *acquisition system of two photomultiplier connected to one plastic scintillation counter*

- Acquisition through ADC and CAMAC systems

To measure the electronic signals, that are proportional to the energy collected in the scintillator, we use an ADC (Analog to Digital Converter) that allows us to read data through computer, in particular with CAMAC system. The acquisition program produces output files that can be analyzed with PAW++ and also with the help of graphics that show the waves of cosmic rays, depending by ADC channels.

4) RESULTS OF OUR ACTIVITY

- Data analysis with PAW++ on LINUX operative system

In the *fig.4* we can see the plot of the peaks measured by the two PMTs. As can be seen the position of the two peaks is the same for both. In the *fig.5* there is the sum of the two PMTs. In this case the peak position is twice that one of the single ones PMT.

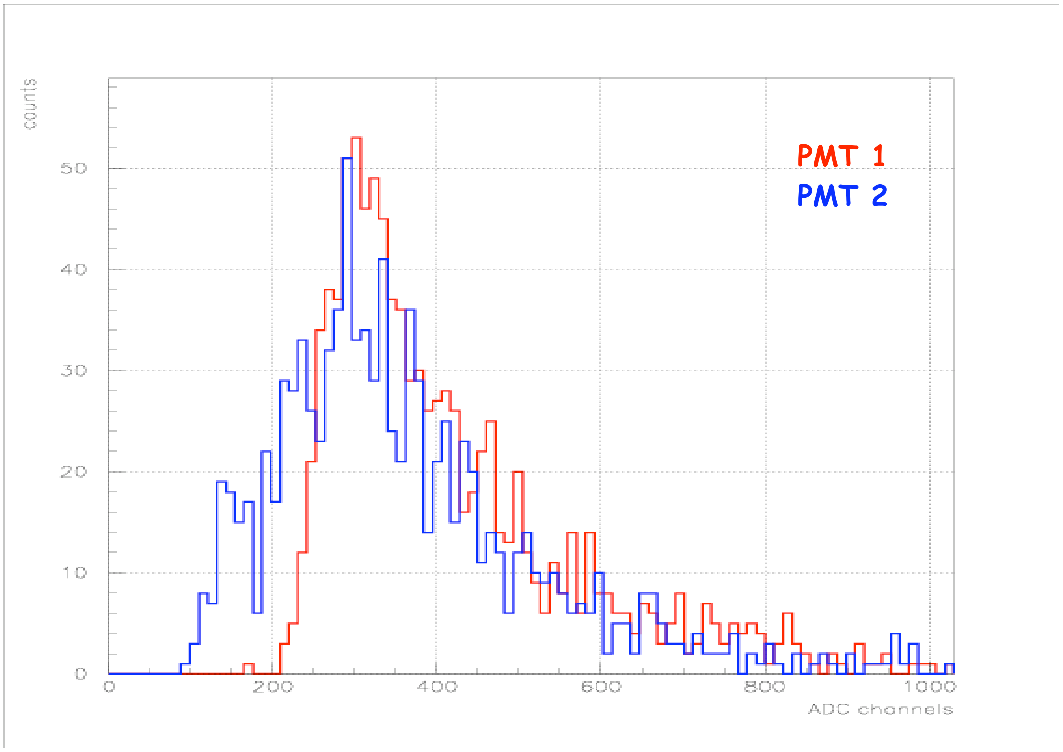

Fig.4: *spectrum of cosmic rays acquired with two photomultipliers*

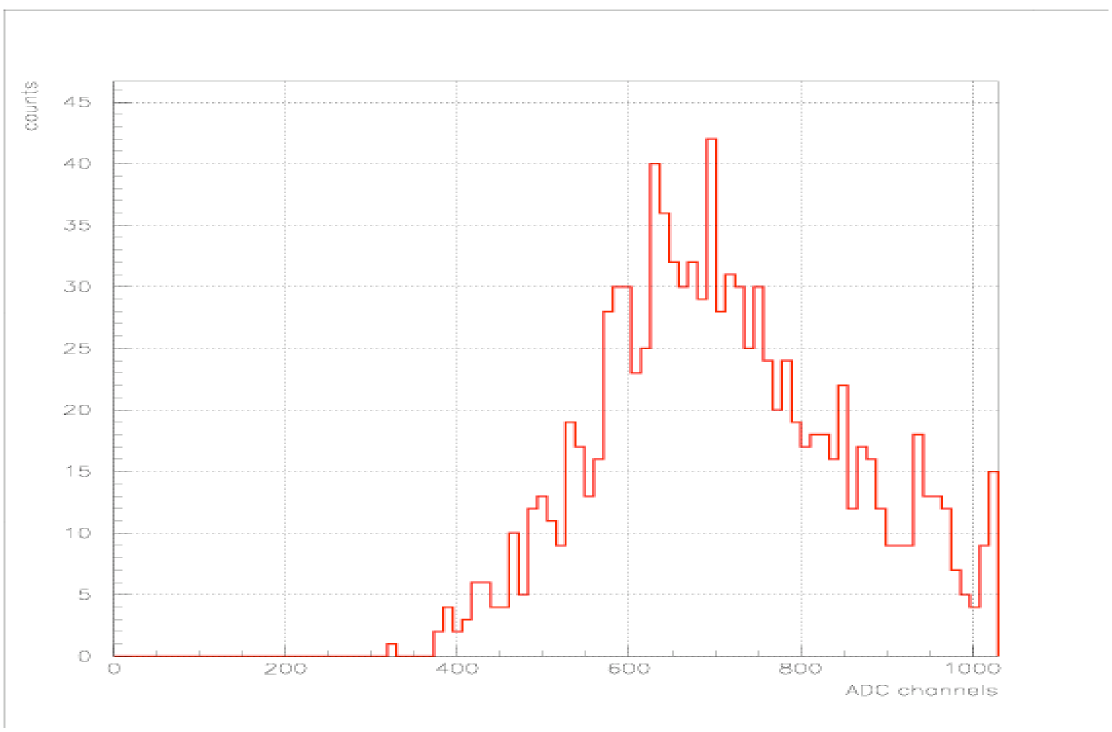

Fig.5: *Sum of the two signals of PMTs*

- **Calibration line**

The calibration line is the relationship between the measured peak position and the deposited energy by the particles crossing the scintillator. After that the calibration line is calculated, it is always valid for all the particles. In the fig.6 we can see the calibration line obtained by the plots of fig.4 and fig.5.

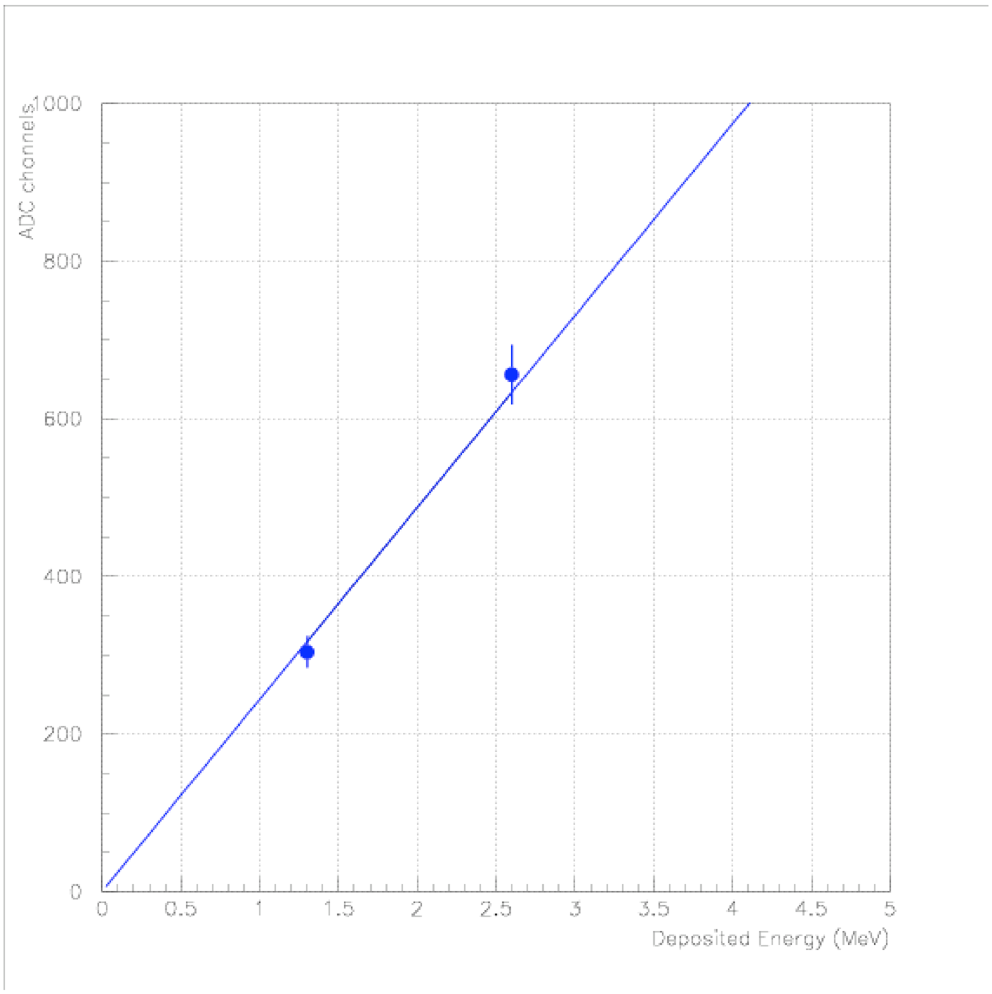

Fig.6: *Calibration line*