9/27 JUNE 2003 SUMMER STAGE

PARTICLES REVELATION THROUGH CERENKOV AND SCINTILLATION COUNTER AND THE CEBAF EXPERIMENT

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COSMIC RAYS

Earth atmosphere is continuously bombarded by high-energy particles, cosmic rays, coming from the outer space, which form the primary cosmic radiation. It interacts with the atmosphere producing different secondary particles which constitute the secondary cosmic radiation in a particular latitude and height over the sea. As matter of fact at the sea altitude they are constituted mainly by particles called muons (μ, mass: 105 MeV).

These cosmic rays are utilized for the calibrations of particle physic counters.

CALIBRATION OF A SCINTILLATION COUNTER

When charged particles go through the matter, they lose part of their energy interacting with the medium, thus producing the emission of photons that permit to detect the particle passage.

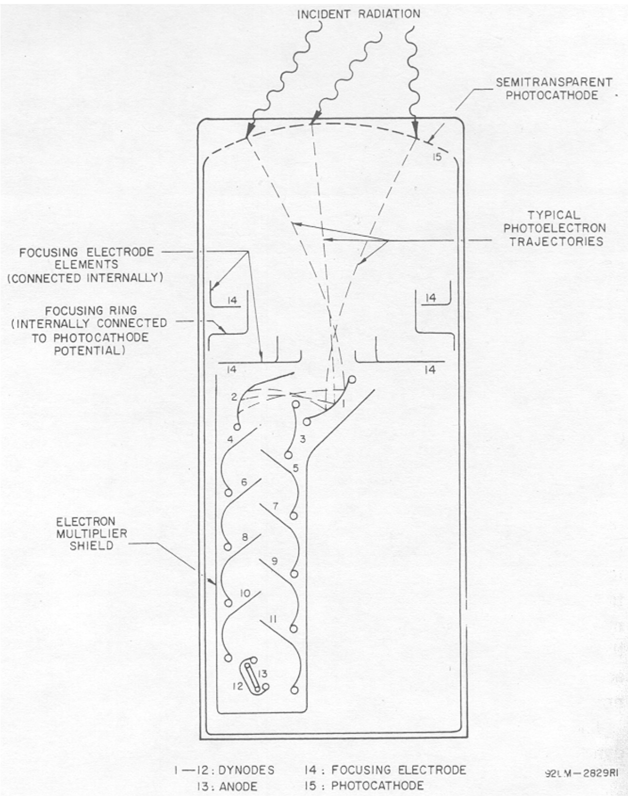


Fig. 1 – The photomultiplier

Two examples of particle counters are:

- ✘ Cerenkov counter

The Cerenkov effect occurs when the velocity of a charged particle traversing a dielectric medium exceed the velocity of light in that medium. A small number of photons will be emitted at a fixed angle, which is determined by the velocity of the particle and the index of refraction of the medium.

- ✘ Scintillation counter

The most common scintillation counters are the plastic ones, in which the passage of charged particles produces an isotropic emission of fluorescence light.

The light produced in the detector is collected by light guides and sent to photo-cathode of a photomultiplier (PMT), where thanks to the photo-electric effect, this light is transformed into electrons which are amplified by ‘dinods’ to give a fast electronic pulse.

These electronic signals are proportional to the energy deposited in the detector and it is measured with ADC (Analogical Digital Converter) which can be read by computer through the CAMAC system. The acquisition program produces output files that can be analyzed with PAW.

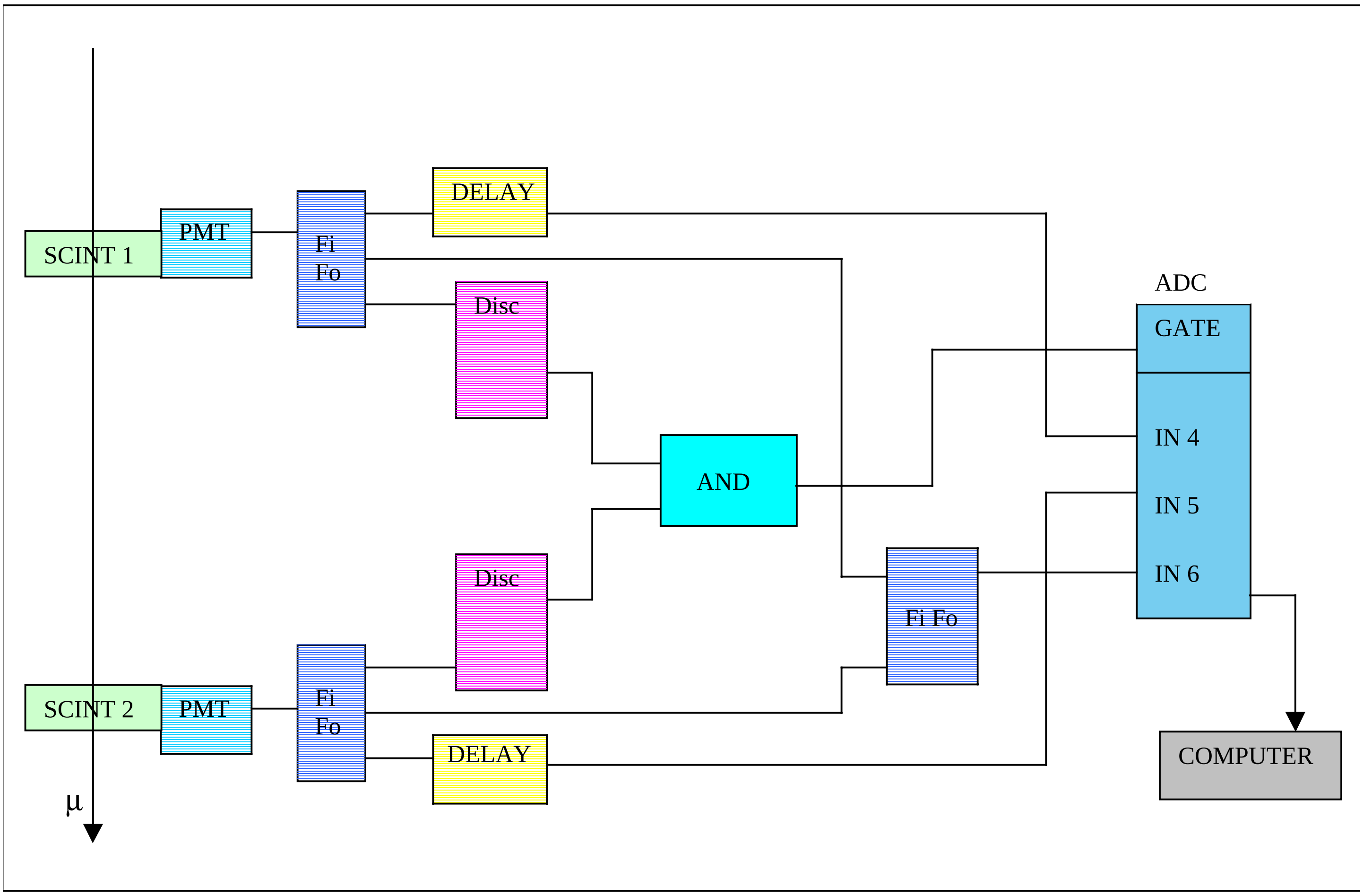


Fig. 2 – Acquisition system of two plastic scintillation counters

In our lab experience we have utilized two scintillation counters (dimensions 0.7cm*5cm*2cm) everyone with a PMT which we have read both singularly and in coincidence. Fig.2 describes the acquisition system in the coincidence case, whose main components are:

- FAN IN, FAN OUT: produces four equal output signals from one input signal;
- DISCRIMINATOR: gives an output shaped signal (with fixed amplitude but variable duration) if the input is above an adjustable threshold;
- AND: makes a coincidence between two or more different shaped signals;
- DELAY: it is a cable to delay the signal;
- ADC: measures the signal amplitude.

Since the PMT itself produces a background with smaller amplitude than the physical signal but with a higher rate, it is necessary to choose an appropriate threshold to cut this background. Two different runs with thresholds 30 and 61 mV are shown in fig.3 , where it is clear that the higher threshold eliminates most of the background.

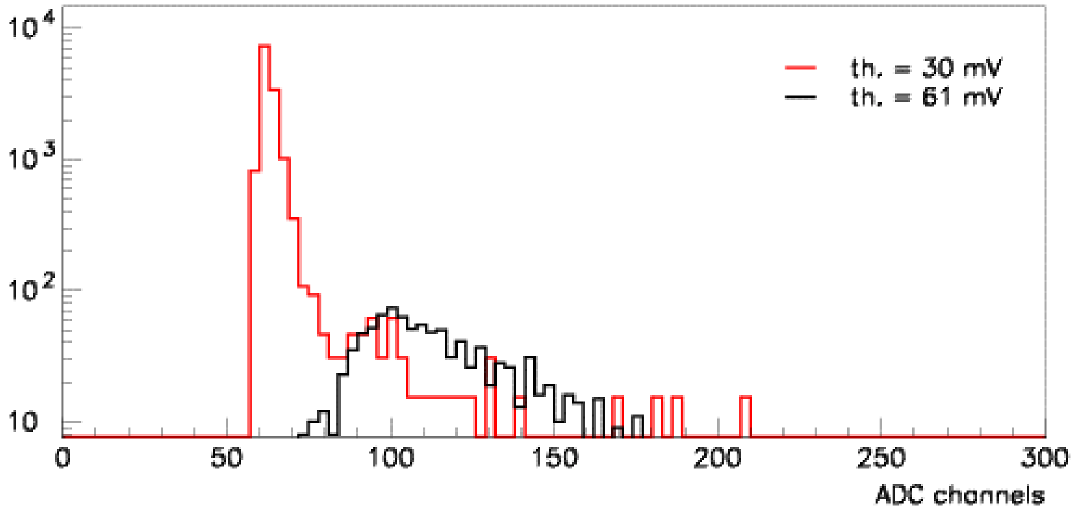


Fig. 3 – Different runs with threshold 30 and 61 mV

A more effective way to reduce the background is to use the coincidence of the two scintillation counters: in fact in this way we select only the signals coming from the passage of a μ in both counters. In fig.4 the blue and the red lines are the spectrum of each counter and the black line is the sum of the two spectra. Comparing this black spectrum with the one of fig.3, we can see that the cosmic ray signal is more evident using the coincidence.

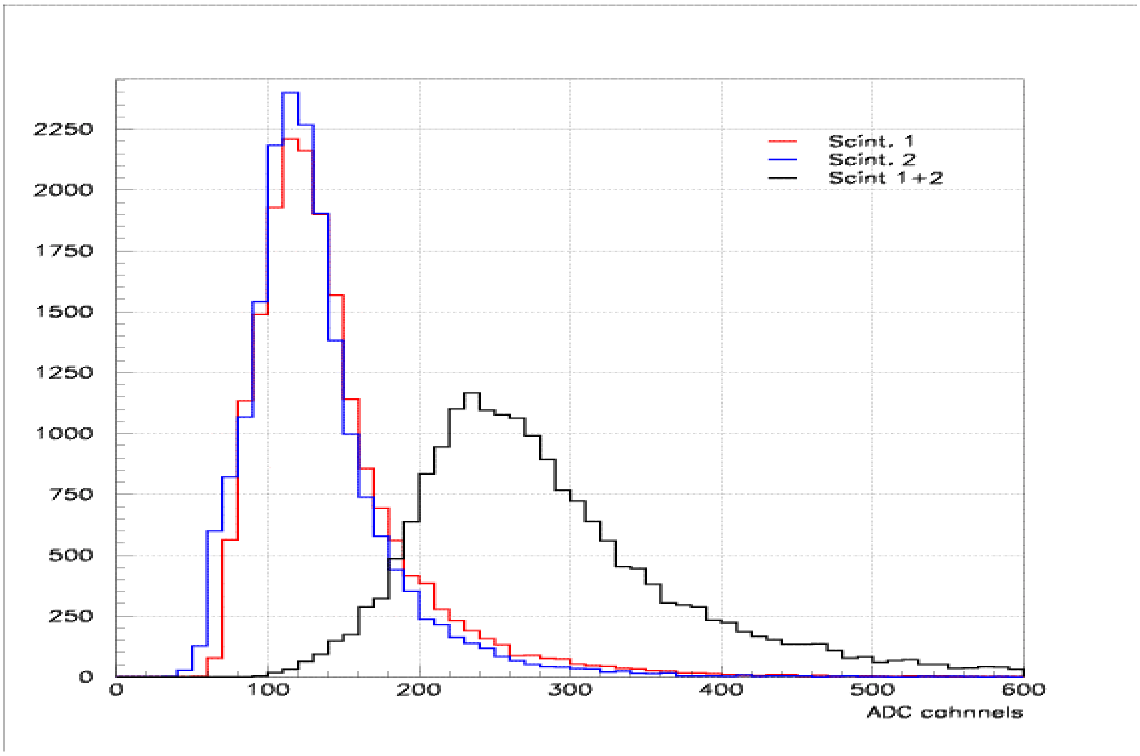


Fig. 4 - Run with two scintillators in coincidence

Knowing the energy loss tables (dE/dX), the thickness and the density of the scintillators, these spectra can be utilized to calibrate our detector. In table 1 there are all the calculated deposited energies and the peak positions of the ADC spectra from which the calibration line can be derived as it is shown in fig.5

SCINTILLATOR	**LOST ENERGY**	**PEAK**	**PEDESTAL**	**PEAK – PEDESTAL**	**ERROR**
1	1.3	117	27	90	±9
2	1.3	114	19	95	±6
1&2 AVERAGE	1.3			92.5	±2.5
1+2	2.6	233	22	211	±5

Table 1

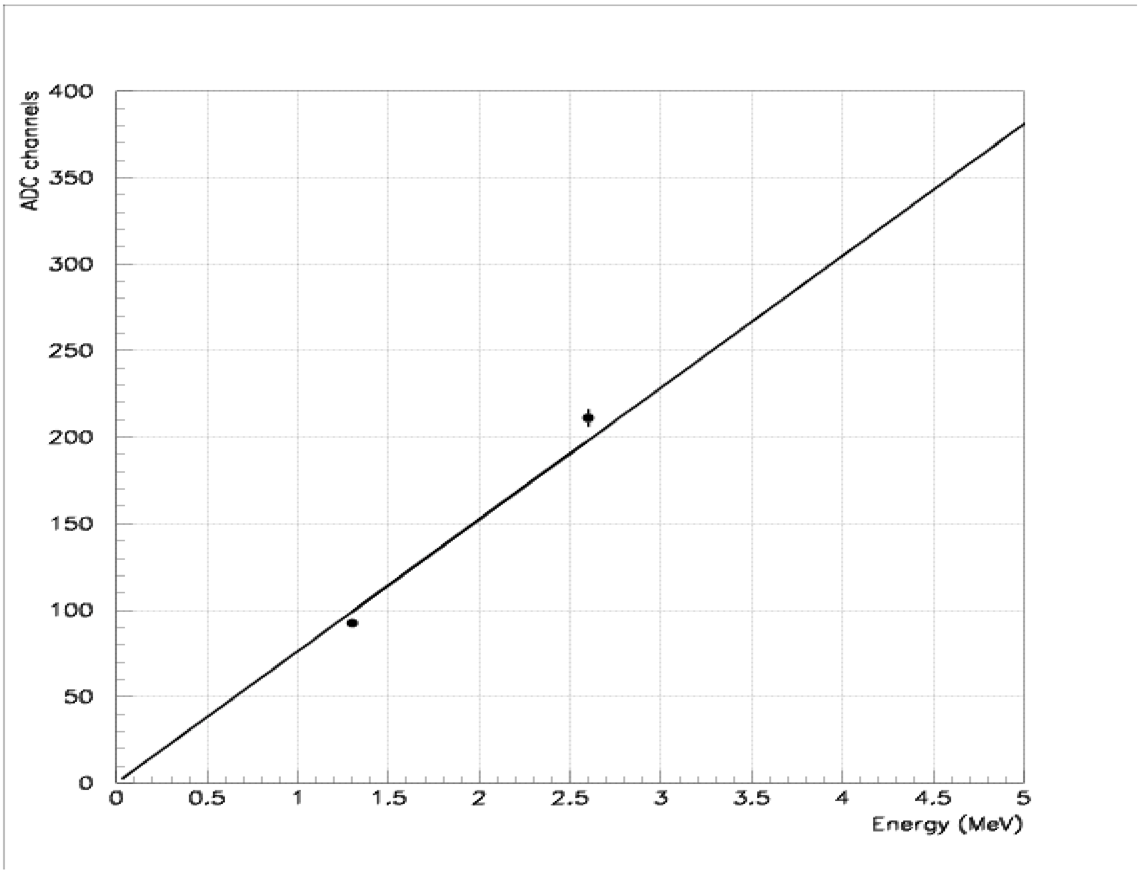


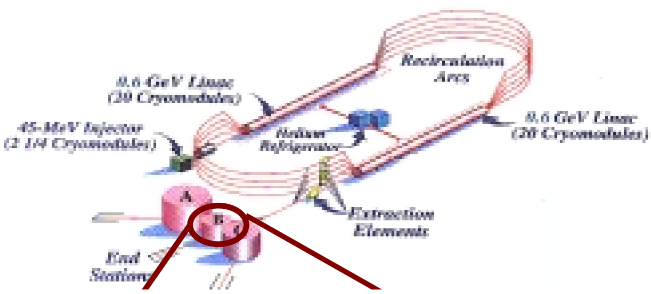
Fig.5 - The calibration line

MEASURE OF DEPOSITED ENERGY OF CEBAF DATA

The CEBAF Large Acceptance Spectrometer (CLAS) is used to study photo and electro-induced nuclear and hadronic reactions by providing efficient detection of neutral and charged particles over a good fraction of the full solid angle.

The CLAS detector consists of drift chambers to determine the trajectories of charged particles; gas Cerenkov counters for electron identification; scintillation counters for measuring the time of flight; electromagnetic calorimeters to detect neutral particles. The scheme of the experimental hall and of the detector is shown in fig.6.

TOF counters are located radially outside the tracking system and the Cerenkov counters but in front of the calorimeters. They cover the polar angular range between 8º and 142º and almost all the azimuthal angle. Their thickness is 5.08 cm, width 15 or 22cm and length from 32 to 376cm. They are also equipped with ADC to measure energy loss of the produced particles and this information is used to identify them.



The CLAS detector

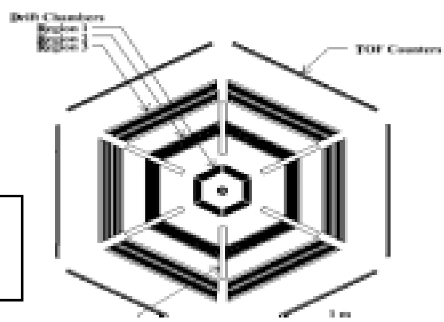


Fig.6 – Hall B and CLAS detector

Using the real data of G2 experiment of CLAS, we have studied energy deposited by different charged particles in TOF scintillators. The particles we have studied are described in table 2.

PARTICLES	**SYMBOL**	**MOMENTUM**
POSITIVE PIONS	π^+	0,45 GeV/c ÷ 2,5 GeV/c
PROTONS	P	0,45 GeV/c ÷ 2,5 GeV/c
DEUTONS	D	0,45 GeV/c ÷ 2,5 GeV/c

Table 2

Each particle's momentum range has been divided into bins of ~100 MeV amplitude. In each bin we have calculated the mean energy loss. Below, in fig.7, it's shown a example of the bin 1-1.1 GeV.

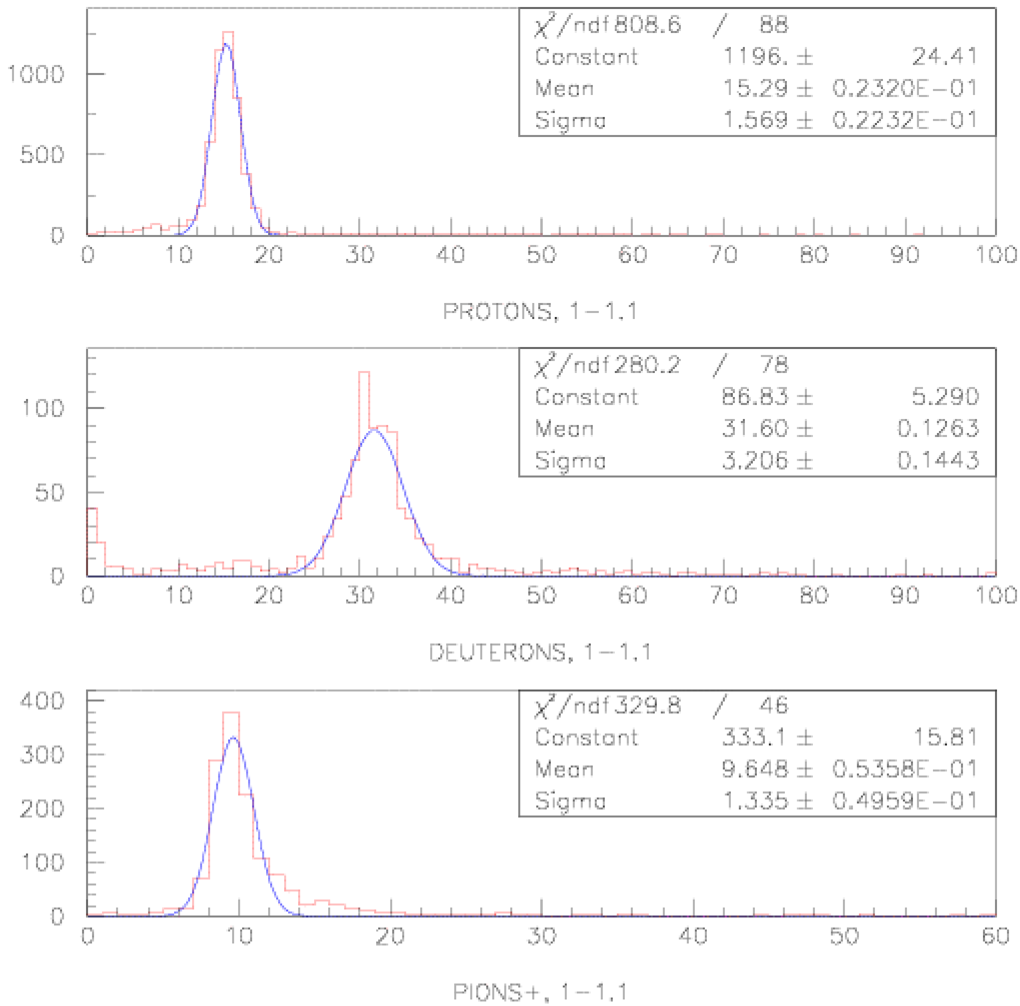


Fig. 7 – Examples of a bin 1-1.1 GeV

Finally we have plotted the mean values (with their errors –the vertical lines-) obtained as a function of the momentum as shown in fig.8.

The range of the π^+ momentum corresponds to the ionization minimum, so the deposited energy results constant, while this isn't verified for the protons and deutons so the energy loss decreases when the momentum increases. Our data elaborations are in good agreement with those published on NIM **A 432** (1999) 265 and shown in fig.8.

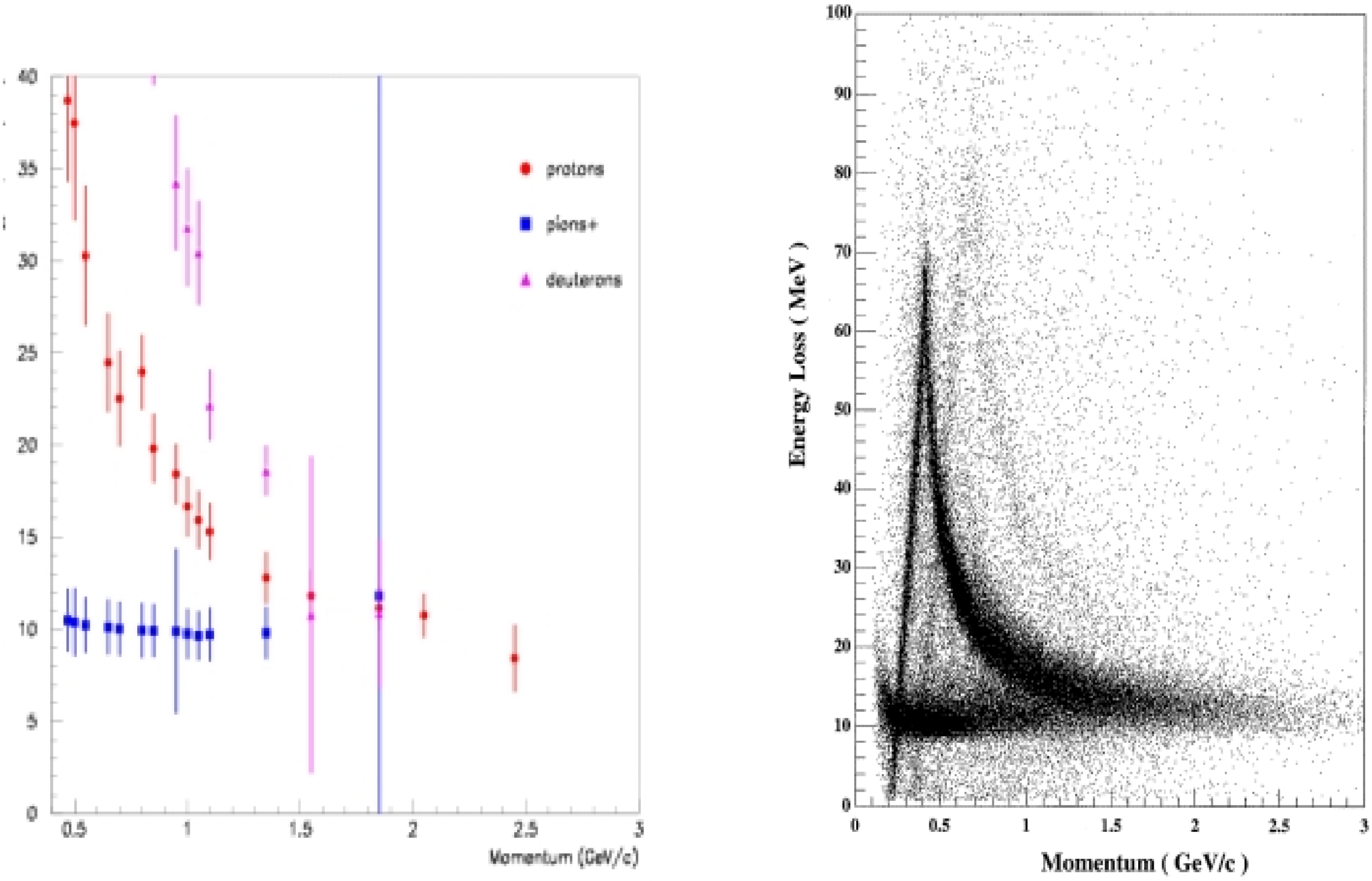


Fig.8 – Comparison between NIM **A 432** (1999) 265 and our data elaborations