Chapter 4

Calorimeter Prototype Test

In this chapter, it is described the calorimeter prototype built to study the energy resolution and the particle discrimination achievable with the final scintillating fiber detector. This prototype will be tested at CERN PS beam. Few preliminary results obtained with cosmic rays are also reported.

4.1 Prototype Description

The prototype consists of 8 BCE's 1.5 m long, interleaved by $2 \times 0.25\ m^2$ streamer tubes, as shown in Figures 4.1 and 4.2. It is mounted on a mechanical structure that can rotate of 90^o around a horizontal axis in order to test the apparatus either with a beam or with cosmic rays.

Each BCE module is made of a $13 \times 13 \times 150\ cm^3$ aluminium box in which 330 scintillating fibers $2mm$ in diameter are inserted. Each fiber is enveloped in a plastic tube 3.1 mm external diameter. The correct position of each fiber inside the BCE is ensured by means of 3 masks 50 cm apart. The central part of the BCE is filled with iron ore for a length of 1 m; the total weight of the BCE is about 65 Kg.

The fibers are grouped at each end of BCE's and coupled to a Philips XP2020 PMT. To evaluate the gain as a function of the supply voltage for each PMT, we use single photoelectron spectra (one of these is shown in Fig. 4.3) obtained by pulsing the PMT's by a green light emitting diode for different high voltage values.

A typical measured single electron spectrum resolution is shown in Fig. 4.3.

In future it will be used the HAMAMATSU R5686 PMT's with better linearity, devoted to calorimetric applications.

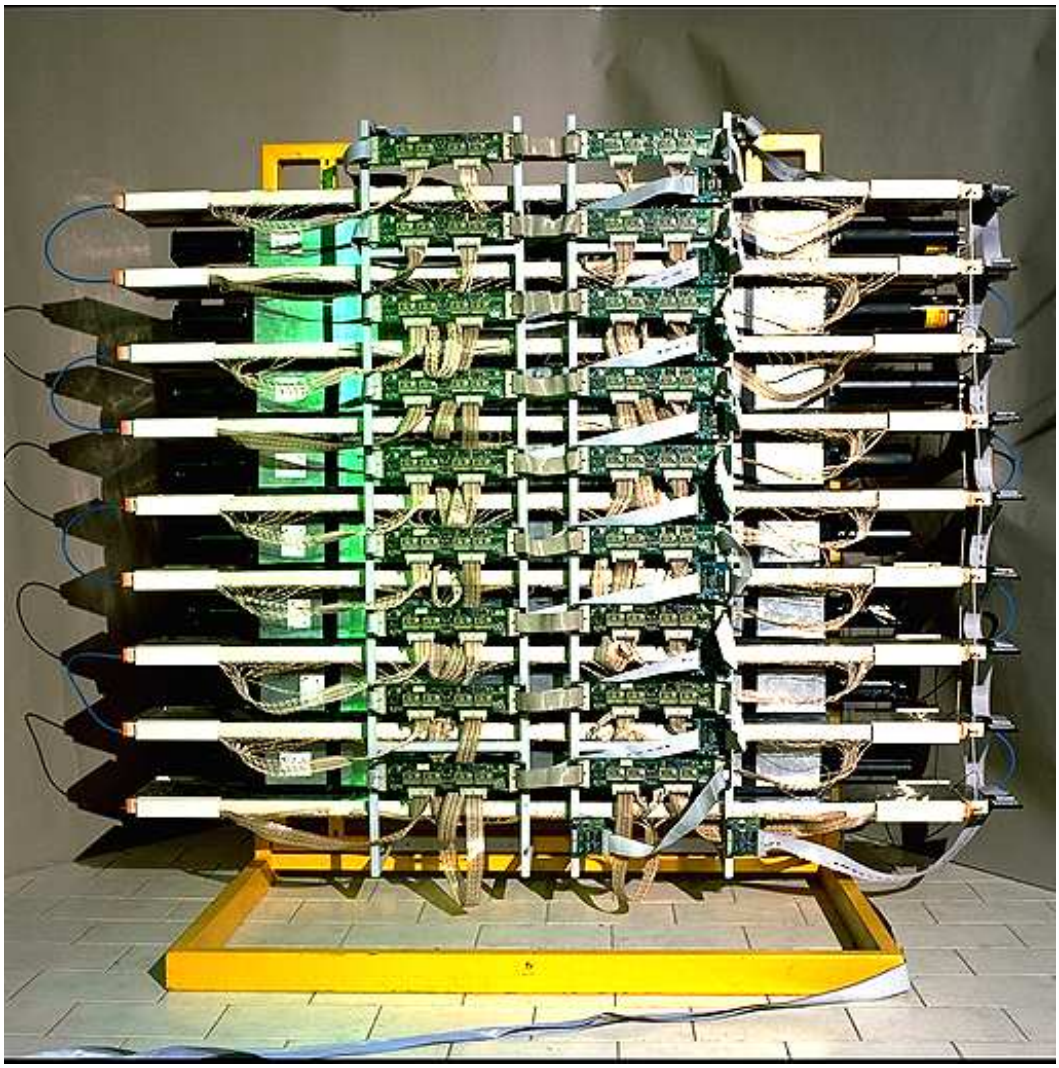

Figure 4.1: The calorimeter prototype, frontal view.

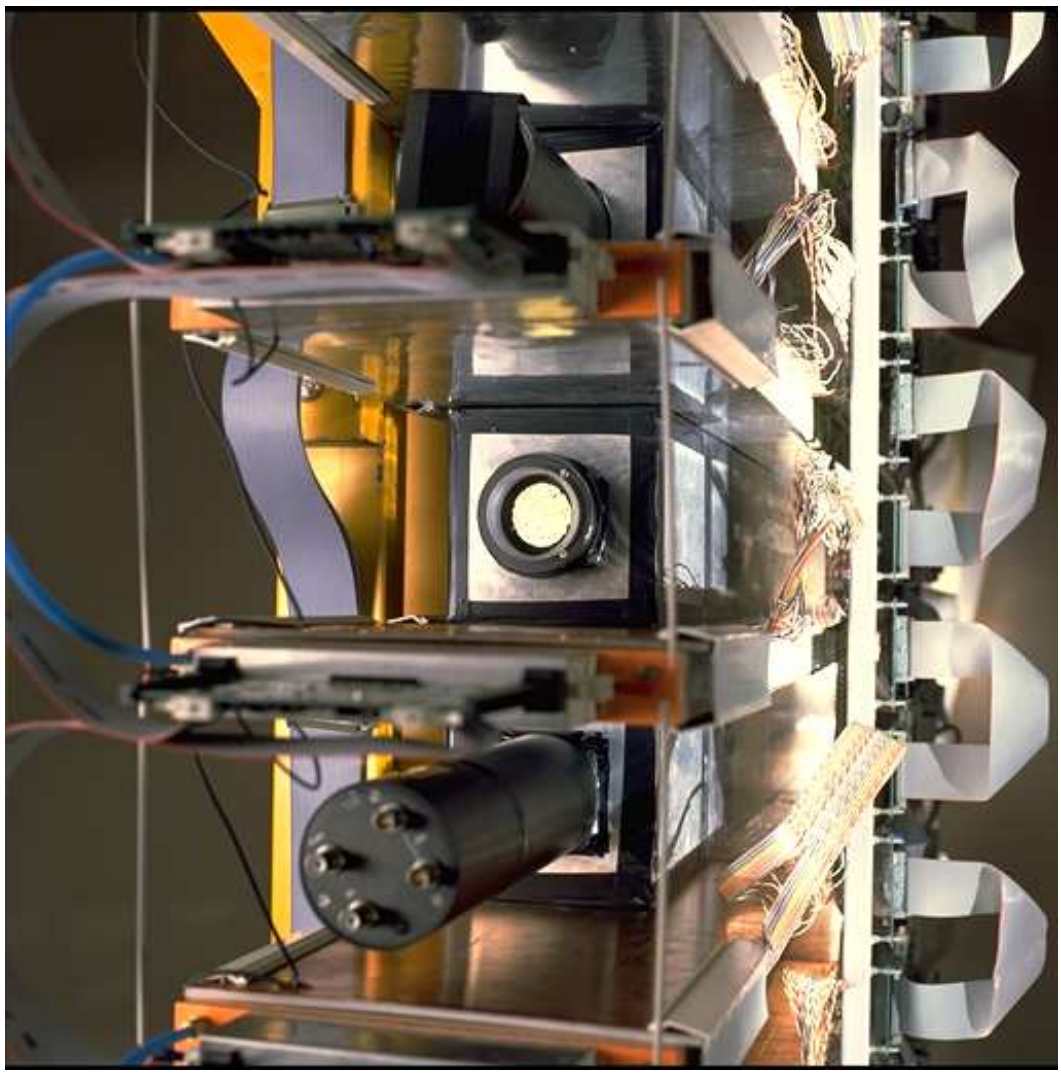

Figure 4.2: The calorimeter prototype, zoom on the lateral view.

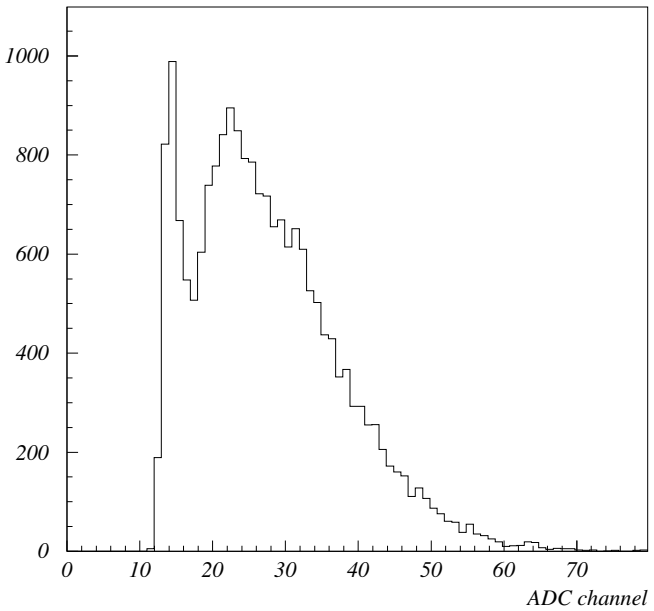

Figure 4.3: A typical single photoelectron spectrum.

The streamer tubes used in this prototype are of the same type of those used in MACRO detector [1] having a cell transversal area of 3×3 cm^2. Each plane consists of one unit containing 8 individual cells. The unit is 25 cm wide and 2 m long. The pick-up's are made of copper strips (~ 2.5 cm pitch) on the side of the 5 mm thick polycarbonate sheet facing the streamer tubes. The strips are placed at 90^o respect to the wire direction to allow for a complete track reconstruction. The total numbers of wires and strips are respectively 72 and 586.

The used gas is a mixture of 65% argon and 35% isobutane.

4.2 The detector prototype setup

In this section the measurements performed in order to set the operating voltages for PMT's and streamer tubes are briefly summarized.

The efficiency as function of supply voltage for muon crossing perpendicularly the BCE is shown in Fig. 4.4 for several threshold values.

At operating voltages of above 2.2 kV we have full efficiency to minimum ionizing particles. The working condition was chosen at ~ 2.3 kV supply voltage, corresponding to a PMT anodic current gain of $1.5 \cdot 10^7$. The

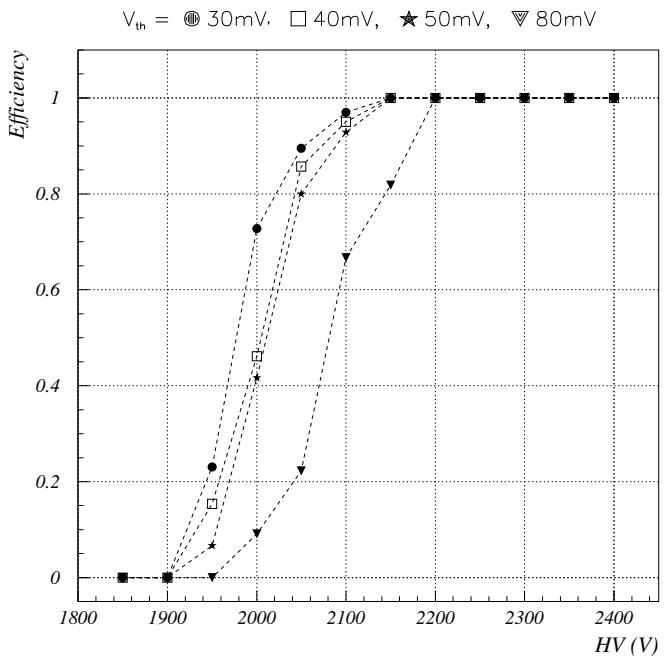

Figure 4.4: Efficiency curves of the BCE to crossing cosmic ray muons for different thresholds.

thresholds are set to 30 mV.

Fig. 4.5 shows the single counting rates of the BCE's as a function of supply voltage for discrimination thresholds ranging from 30 to 80 mV.

The counting rate of the single PMT, at the working conditions, is less than 500 Hz.

The operating high voltage supply for the streamer tubes is fixed at 4300 V, value chosen in the middle of the plateau region as shown in Fig. 4.6.

4.3 Prototype calibration with cosmic rays

The measurements described in the following are performed using only cosmic rays, with the telescope kept in the vertical position.

A tracking algorithm has been implemented to select muons and eliminate showers and spurious events from the data sample. On the reduced sample of cosmic ray events, composed by muons crossing the whole telescope, analyses of the charge and time response of the prototype have been performed.

A typical charge distribution for a muon crossing a BCE is presented in Fig. 4.7. The average pulse height corresponds to 30 photoelectrons at each

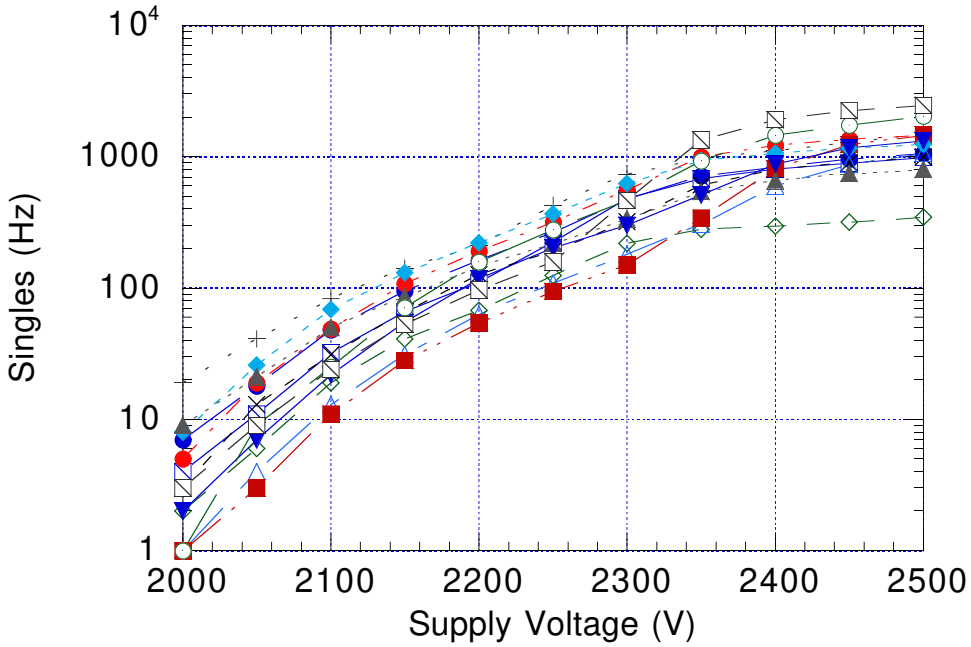

Figure 4.5: The singles rate of the BCE's as a function of supply voltage. The different curves correspond to different thresholds.

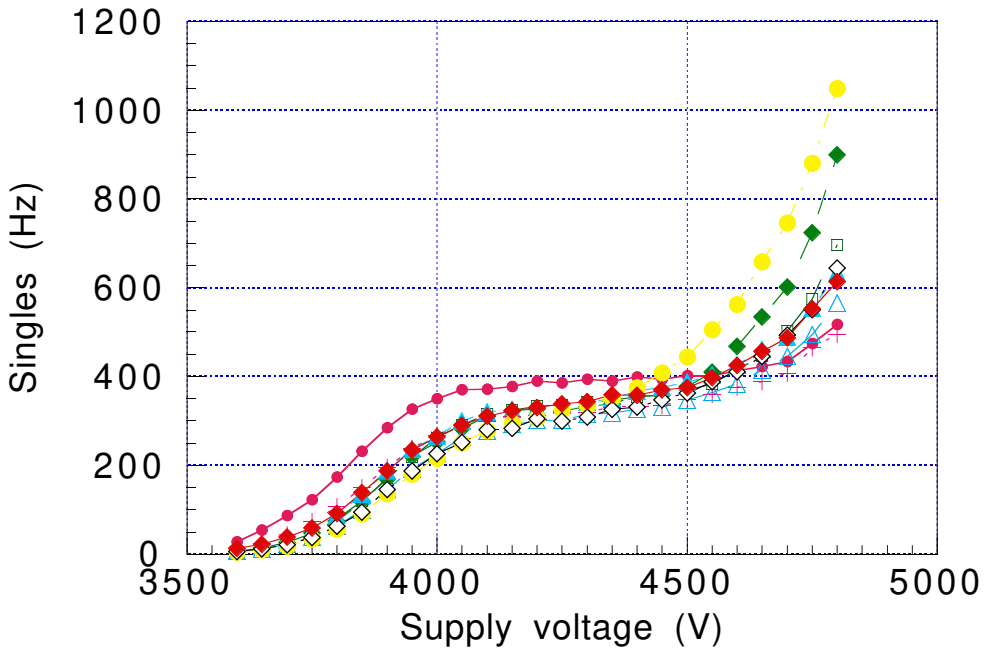

Figure 4.6: Single counting rate as a function of HV of the streamer tubes used in this test. The different curves correspond to different thresholds.

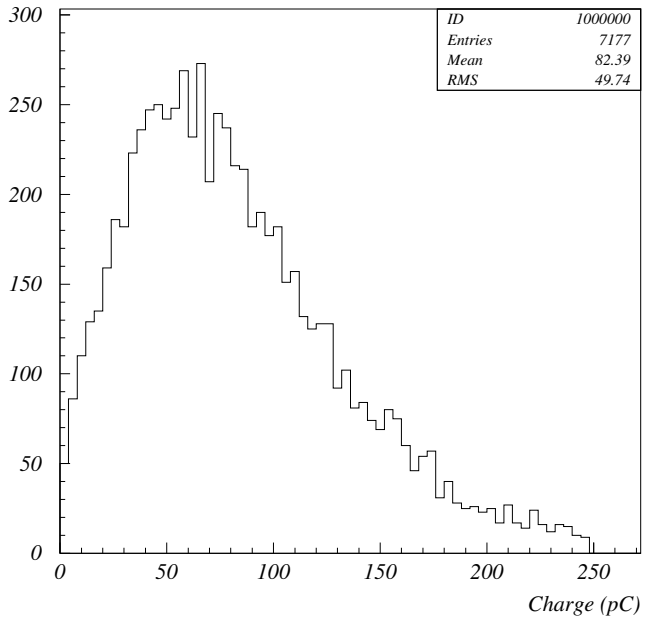

Figure 4.7: A typical charge distribution for a muon crossing a BCE.

side.

In Fig. 4.8 is shown the visible energy loss, dE/dx, of a muon crossing the telescope. This distribution, averaged over the 8 BCE's, is centered at $dE/dx \simeq 2\ MeV/cm$ in a reasonable agreement with the total thickness of active part crossed by a muon (Fig. 3.5). The charge resolution of 22% is comparable to that obtained dividing by $\sqrt{8}$ the single BCE charge resolution (Fig. 4.7). Typical muons produced in CC neutrino interactions cross, in average, more than 70 BCE's, leading to a charge resolution better than 7%.

A preliminary study of the timing capabilities of this apparatus has been performed by selecting single muons crossing all the 8 BCE's. Fig. 4.9 shows the time difference between the signals coming from two different BCE's . To correct the time spread due to the light propagation inside the BCE the signals coming from both PMT's of a single BCE are averaged. These data have not been corrected for the slewing due to the pulse height jitter.

From this measure we estimate that a $\sim 1\ ns$ time resolution for the $8\ m$ long BCE is achievable if the time walk due to the amplitude jitter is taken into account.

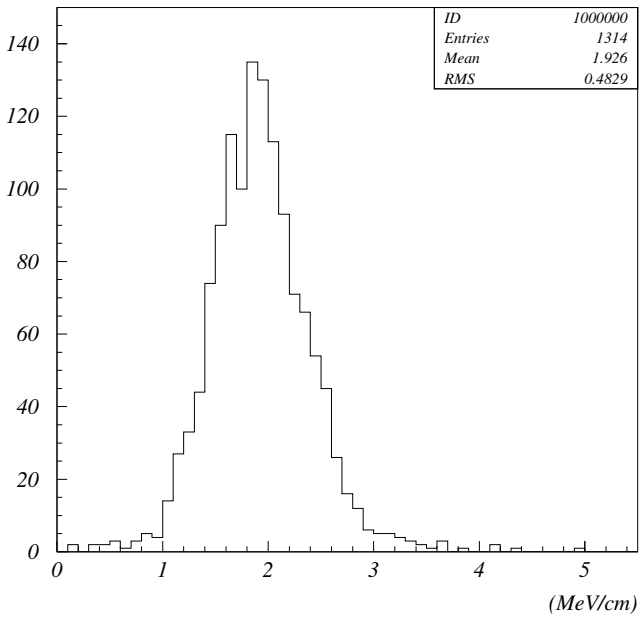

Figure 4.8: The visible energy loss of a muon crossing the telescope, averaged over the 8 BCE's.

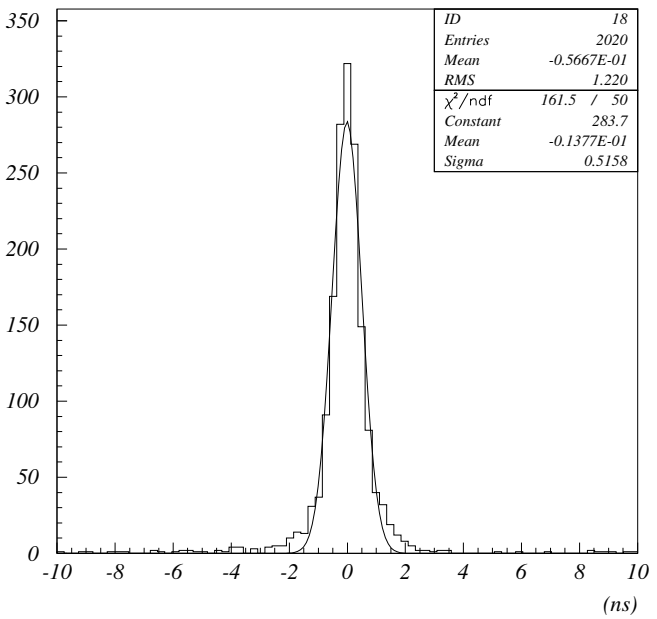

Figure 4.9: Distribution of the time difference between two BCE's.

Bibliography

[1] MACRO Proposal, November 1984.

[2] M. Ambrosio et al., Nucl. Instr. and Meth. A301 (1991) 275

[3] S. Ahlen et al., Nucl. Instr. and Meth. A324 (1993) 337