KLOE Note 100

π/μ Rejection using KLOE calorimeter

M.Antonelli
F.Murtas†

INFN - Laboratori Nazionali di Frascati, P.O.Box 13, I-00044 Frascati

March 1994

Abstract

The $K_{\mu3}$ ($K_L \rightarrow \pi\mu\nu$) decay provides the most significant background to the CP violating $K_L \rightarrow \pi\pi$ signal. Kinematical constraint provide the largest contribution to the rejection factor. Aniway, ortogonal methods are require for a systematic error check. For this reason, a study on $\pi - \mu$ rejection using the EmC prototype at PSI test beam is shown with two kind of read-out granularity. These results show a rejection factor ∼5 indipently to the granularuty.

†The coauthors are: M. Barone, S. Bertolucci, S. Bianco, C. Bini, C. Bloise, V. Bolognesi, F. Bossi, R. Caloi, F. Cervelli, G. De Zorzi, G. Di Cosimo, A. Di Domenico, F. L. Fabbri, A. Farilla, A. Ferrari, F. Garufi, S. Giovannella, R. Haydar, W. Kim, G. Lanfranchi, A. Martinis, S. Miscetti, F. Murtas, A. Parri, A. Passeri, S. Sarwar, F. Scuri, L. Tortora and X. L. Wang. S. Wö lfle

1 Introduction

To perform $Re(\frac{\varepsilon'}{\varepsilon})$ measurement in the KLOE experiment at 10^{-4} level of accuracy [1] high rejection factor on muons coming from $K_{\mu 3}$ (4.4×10^4), without losing more then 10% of the signal $K_L^0 \to \pi\pi$, is required.

Kinematical constraints [2] give us a rejection factor two to four times worse than the needed one. The surviving muons show an almost flat momentum distribution in the range $150 \div 280$ MeV/c. For this reason we have concentrated our studies on particle identification in a momentum range of $200 \div 250$ MeV/c using the KLOE EmC prototype [3] [4].

2 Test Beam DATA Analysis

An analysis on Test Beam data has been performed using pions,muons at 200 and 250 MeV/c. Three finger scintillators, placed in front the calorimeter(fig. 1), were used to create the trigger signal. The particles are tagged with T.o.F. measurement using the machine Radio Frequency and trigger time. The time distributions for the three particles types are well separated, as shown in fig. 3 ; only particles within 2σ around the peaks have been used for a better momentum definition. A further cut on the finger charge distribution has been applied in order to have a cleaner environment. The beam position has been tuned to have impinging particles near the prototype center. Two types of read out granularities have been used: one with 3.5×3.5 cm^2 cells and one with 4.2×4.2 cm^2 (see fig. 2).

A study on Monte Carlo has been tried to find the better granularity read out. Up to now $\pi - \mu$ rejection cannot be studied through the calorimeter M.C., (i.e. M.C. doesn't reproduce the tail on the energy distribution).

3 Cluster Variables

The energy released in the calorimeter has a different topology for each type of particles as a function of momentum (see fig. 4). In order to distinguish the particles from each other, a certain number of variables has been created. The cluster centroid and cluster variance can be easily defined as follows:

$$XBAR = \frac{\sum_{i=1}^{Ncell} X_i \times E_i}{\sum_{i=1}^{Ncell} E_i} \qquad YBAR = \frac{\sum_{i=1}^{Ncell} Y_i \times E_i}{\sum_{i=1}^{Ncell} E_i}$$

$$XVAR = \sqrt{\frac{\sum_{i=1}^{Ncell} (X_i - XBAR)^2 \times E_i}{\sum_{i=1}^{Ncell} E_i}} \qquad YVAR = \sqrt{\frac{\sum_{i=1}^{Ncell} (Y_i - YBAR)^2 \times E_i}{\sum_{i=1}^{Ncell} E_i}}$$

where X_i, Y_i and E_i are coordinates and energy released in the i^{th} calorimeter cell, respectively. Together with these cluster variables, the

energy released in each plane has been used. Some distributions of these variables are shown in fig. 5 and in fig. 6.

4 Methods

Several studies have been performed to combine the variables and find the most powerful $\pi - \mu$ rejection. Discriminant Analysis and χ^2 methods are used. χ^2 is defined as follow:

$$\chi^2 = xC^{-1}x^t$$

where x is the arrow vector:

$$x = (Pl1, Pl2, ..Pln, .., XBAR)$$

and

$$C_{i,j} = \rho_{i,j}\sigma_i\sigma_j$$

where $\rho_{i,j}$ are the elements of the correlation matrix and σ_i are the standard deviations of variable distributions. The use of Discriminant Analysis [5] [6] has been applied to find the correlation between variables and to determine the correlation matrix for χ^2 studies. Since the variables are not gaussian distributed, neither Discriminant Analysis, nor χ^2 have shown a good performance on $\pi - \mu$ rejection compared with simpler cuts applied on a single variable.

5 Results

Performing different cuts on these variables, the rejection factors versus pion identification efficiencies have been obtained as shown in fig. 7 and in fig. 8. The final results of rejection factors estimated at 95% pion efficiency are shown on tab. 1.

Table 1: Rejection factors at 95% efficency

Granularity	*Momentum*	*Angle*	*XBAR*	*XVAR*	*PLANE (num)*	*Dis.Anal.*	χ^2
3.5 (cm)	200 MeV/c	0°	5.3	4.3	6.5 (4)	6.1	2.4
3.5 (cm)	250 MeV/c	0°	5.7	6.1	2.3 (5)	3.6	2.4
3.5 (cm)	200 MeV/c	30°	3.2	2.2	1.9 (3)	2.7	1.3
3.5 (cm)	250 MeV/c	30°	3.5	3.2	4.2 (5)	3.9	1.5
4.2 (cm)	200 MeV/c	0°	16.4	7.6	16.3 (3)	4.7	7.6
4.2 (cm)	250 MeV/c	0°	5.4	8.7	8.0 (5)	3.2	3.3
4.2 (cm)	200 MeV/c	30°	4.2	3.6	5.0 (3)	2.7	2.3
4.2 (cm)	250 MeV/c	30°	–	–	—	–	–

We think that the 200 Mev/c at 0 degrees result in the 4.2 granularity is a lucky case: the line between the 2^{nd} plane and the 3^{rd} plane is a very good separation line of the two particle ranges. Looking globally at the table's results, there aren't any appreciable differences between the two granularities giving both a rejection factor greater than 5, while a decreasing discriminating power appear going from 0 to 30 degree of incidence angle (roughly 60 %). For a final conclusion however we need more data with a fine incidence angle scan as foreseen in the next future.

Acknowledgements

First we want to acknowledge the effort, the dedication and the skill shown from the SPECAS mechanical shop led by Giovanni Bisogni. We want also to tank A.Balla and G.Corradi for the design and realization of the active splitters and for the general organization of the F.E. electronics. We would like to give a special thank at all the analysis group persons: S. Giovannella, R. Haydar, S. Miscetti, S. Wö lfle for the discussions about the data. Thanks for the fruitful discussion on useful variables and on interpretation of results to S. Bertolucci, P. Campana and P. Franzini.

References

[1] KLOE Collaboration *The KLOE Proposal* KLOE NOTE 1

[2] F.Bossi, G.Capon *A preliminary study of $K_{\mu 3}$ Rejection* KLOE NOTE 5

[3] A.Antonelli et al., *A Pb-SCIFI Calorimeter for DAΦNE Proceeding of the Workshop on Phisics and Detectors for DAΦNE Frascati, April 9-12 1991.*

[4] S.Bertolucci, S.Miscetti *Status Report on PSI Test Beam result of the KLOE EMCAL prototype* KLOE NOTE 45

[5] W.W. Cooley and P.R.Lohnes *Multivariate Data Analysis* Wiley, New York 1971

[6] SPSS Inc. *SPSS: Statistical Package for the Social Sciences* 2nd ed. by Norman H.Nie et al. (New York: Mc Grow-Hill)

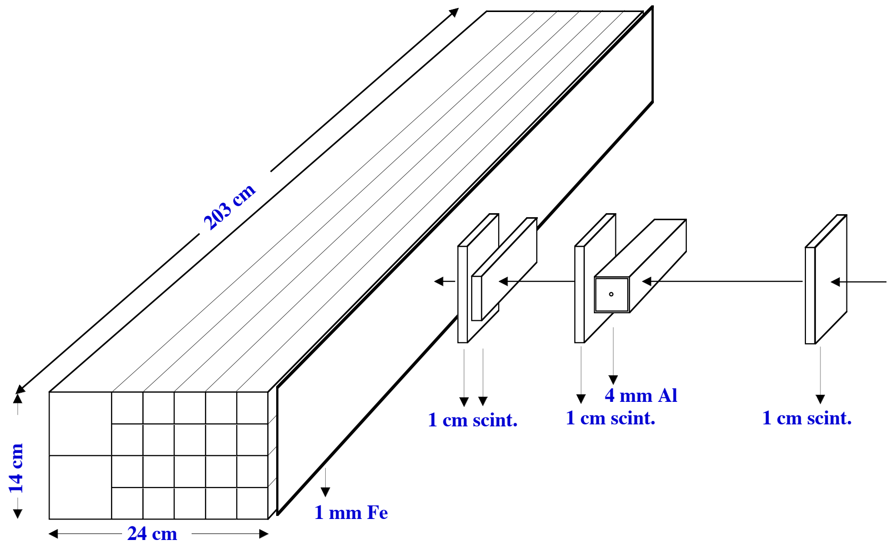


Figure 1: Experimental setup

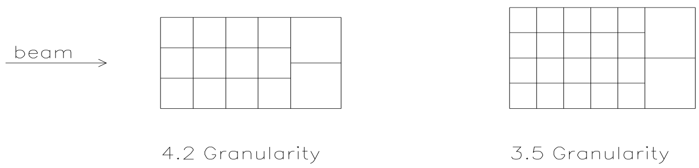


Figure 2: Calorimeter granularities used

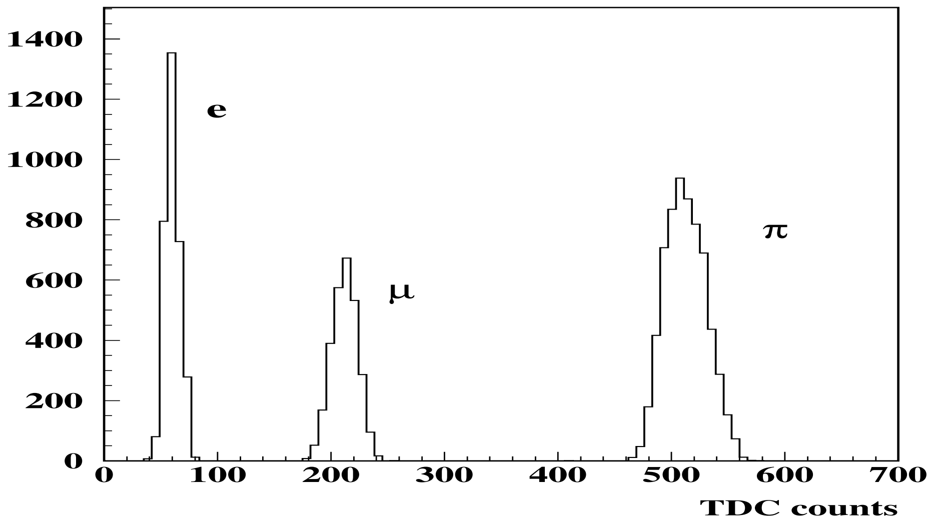


Figure 3: Time of Flight distribution for the different particles

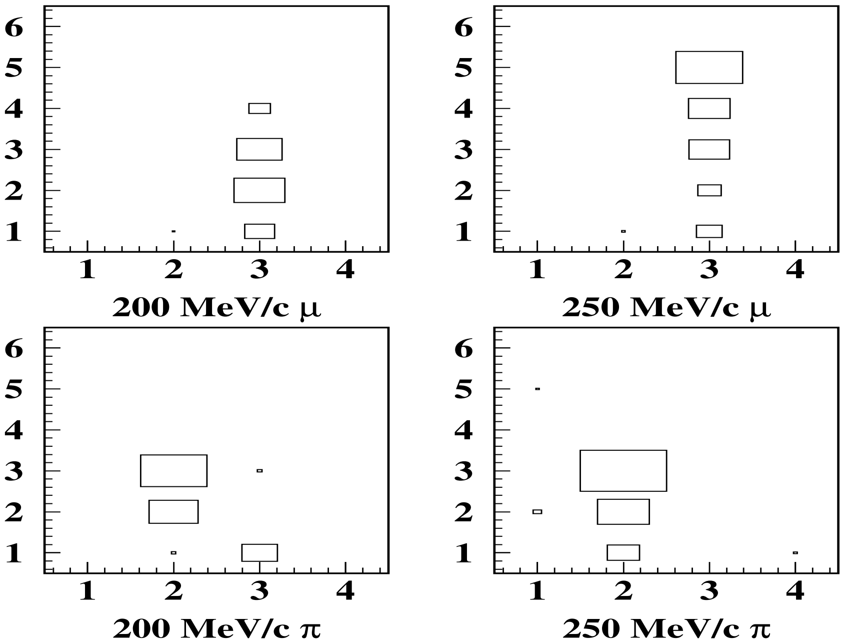
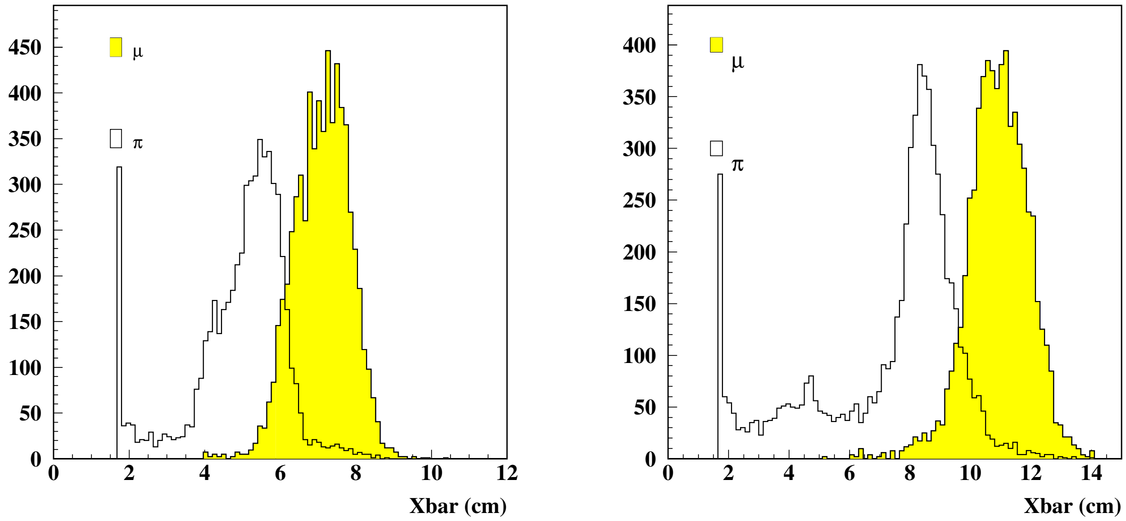
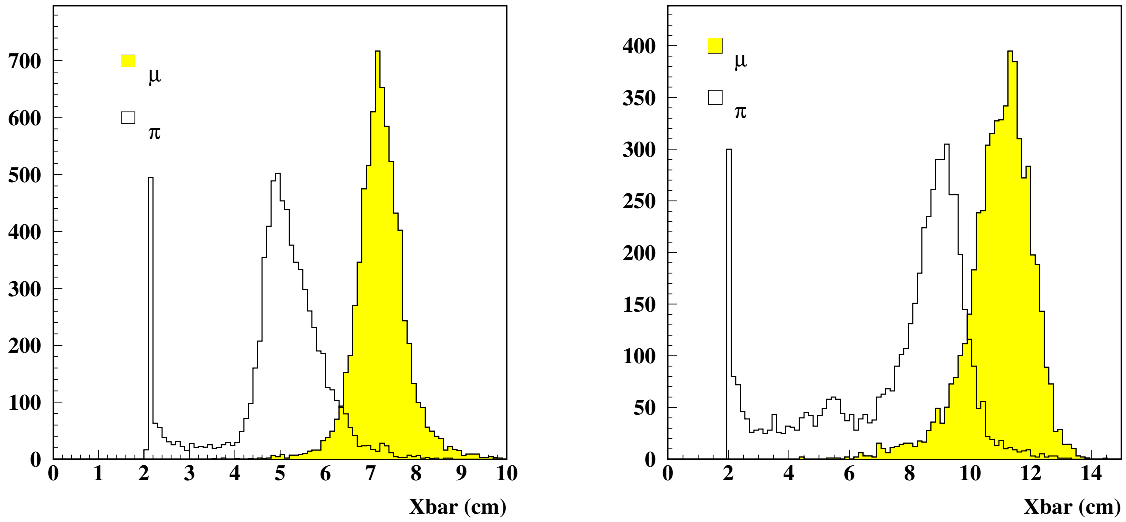


Figure 4: Events display (the box size is proportional to the energy released)



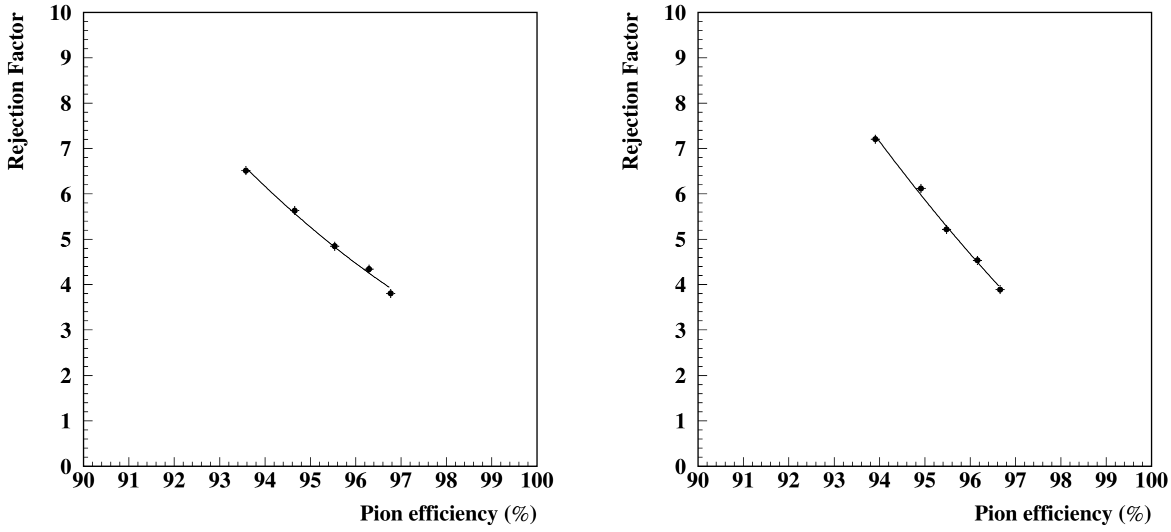
(a) (b)

Figure 5: XBAR distributions for 3.5 granularity: (a) 200 Mev/c, (b) 250 MeV/c



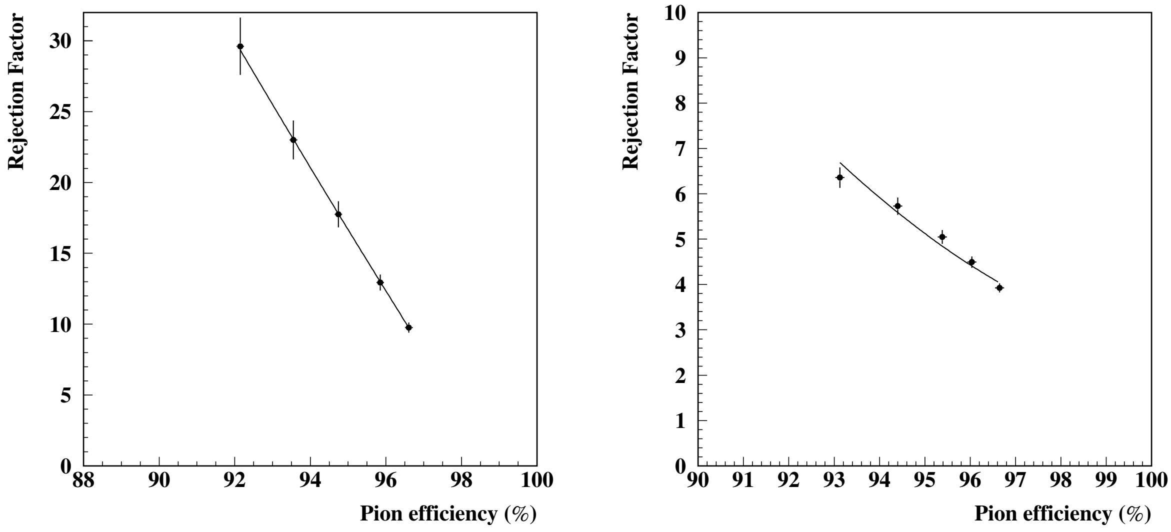
(a) (b)

Figure 6: XBAR distributions for 4.2 granularity: (a) 200 Mev/c, (b) 250 MeV/c



(a) (b)

Figure 7: Rejection vs efficency for 3.5 granularity: (a) 200 Mev/c, (b) 250 MeV/c



(a) (b)

Figure 8: Rejection vs efficency for 4.2 granularity: (a) 200 Mev/c, (b) 250 MeV/c