Methods of *e/π* identification with the TRD in the CBM experiment

E.P. Akishina, T.P. Akishina, O.Yu. Derenovskaya, V.V. Ivanov

Laboratory of Information Technologies, JINR, Dubna

A problem of e/π identification using a n-layered transition radiation detector (TRD) in the CBM experiment is considered. To this aim, we elaborated algorithms and implemented various approaches. We discuss the characteristic properties of the energy losses by electrons and pions in the TRD layers and special features of the artificial neural networks (ANN) and statistical methods enabling the solution of the problem under consideration. A comparative analysis is performed on the power of the statistical criteria and ANN.

Introduction

The measurements of charmonium is one of the key goals of the CBM experiment. To detect J/ψ meson in its dielectron decay channel, the main task is the separation of electrons and pions. To this aim, we elaborated algorithms and implemented various approaches. These methods are based on a set of energy losses $\{\Delta E_{i=1,\dots,n}\}$ measurements in n TRD layers for π and e with momenta $1\,\mathrm{GeV/c} \le p \le 13\,\mathrm{GeV/c}$.

Methods

• **The mean value (MV):** $\overline{\Delta E} = \frac{1}{n}\sum_{i=1}^{n}\Delta E_i$

where ΔE_i is a particle energy loss in the i-th TRD layer;
n is the number of layers in the TRD.

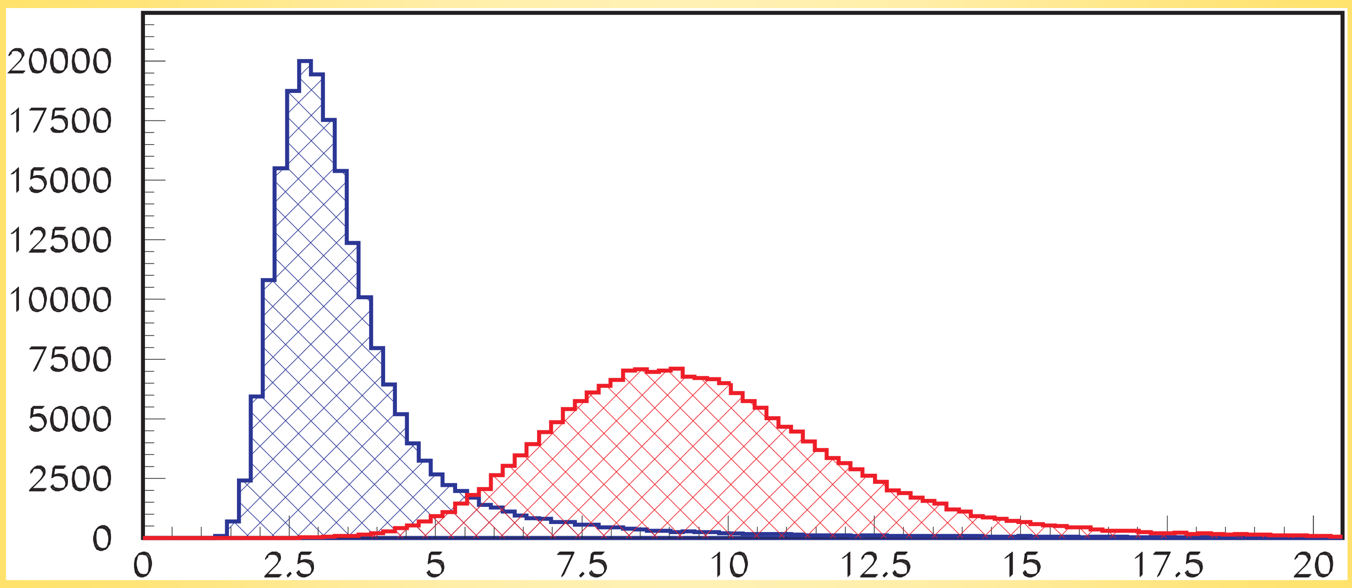

Figure 1: Distributions of variable $\overline{\Delta E}$ for π (blue histogram) and e (red histogram)

• ***The goodness-of-fit criterion*** ω_n^k [2]:

$$\omega_n^k = -\frac{n^{k/2}}{k+1}\sum_{j=1}^{n}\left\{\left[\frac{j-1}{n}-\phi(\lambda_j)\right]^{k+1}-\left[\frac{j}{n}-\phi(\lambda_j)\right]^{k+1}\right\}, \qquad (1)$$

where $\phi(\lambda)$ is Landau distribution function, which describes pion energy losses, with a new variable λ:

$$\lambda_i = \frac{\Delta E_i - \Delta E_{mp}^i}{\xi_i} - 0.225, \qquad i = 1,2,\dots,n \qquad (2)$$

ΔE_i - the energy loss in the i-th absorber,

ΔE_{mp}^i - the value of most probable energy loss,

$\xi_i = \frac{1}{4.02}$ FWHM of distribution of energy losses for π

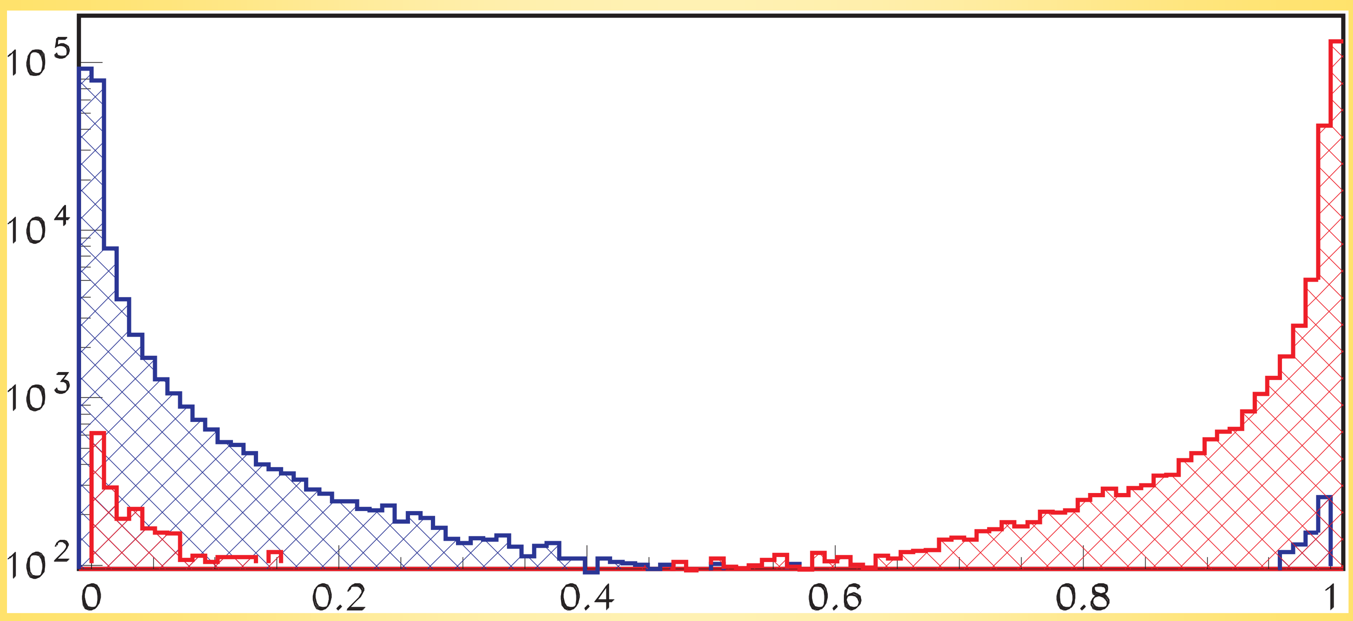

Figure 2: Distributions of variable ω_{12}^6 for π (blue histogram) and e (red histogram)

• ***The combined method:*** 1) the MV method,
2) the ω_n^k - test.

• ***A three-layered perceptron*** from the packages JETNET3.0 and ROOT [3].

• ***The likehood functions ratio (LFR):***

$$L = \frac{P_e}{P_e + P_\pi},\ P_e = \prod_{i=1}^{n} p_e(\Delta E_i),\ P_\pi = \prod_{i=1}^{n} p_\pi(\Delta E_i)$$

where $p_\pi(\Delta E_i)$ is the value of the density function p_π in the case when π loses energy ΔE_i in the i-th absorber, and $p_e(\Delta E_i)$ is a similar value for e. The approximations of the density functions which with a good accuracy reproduce the distributions of energy losses of π and e are described in [1].

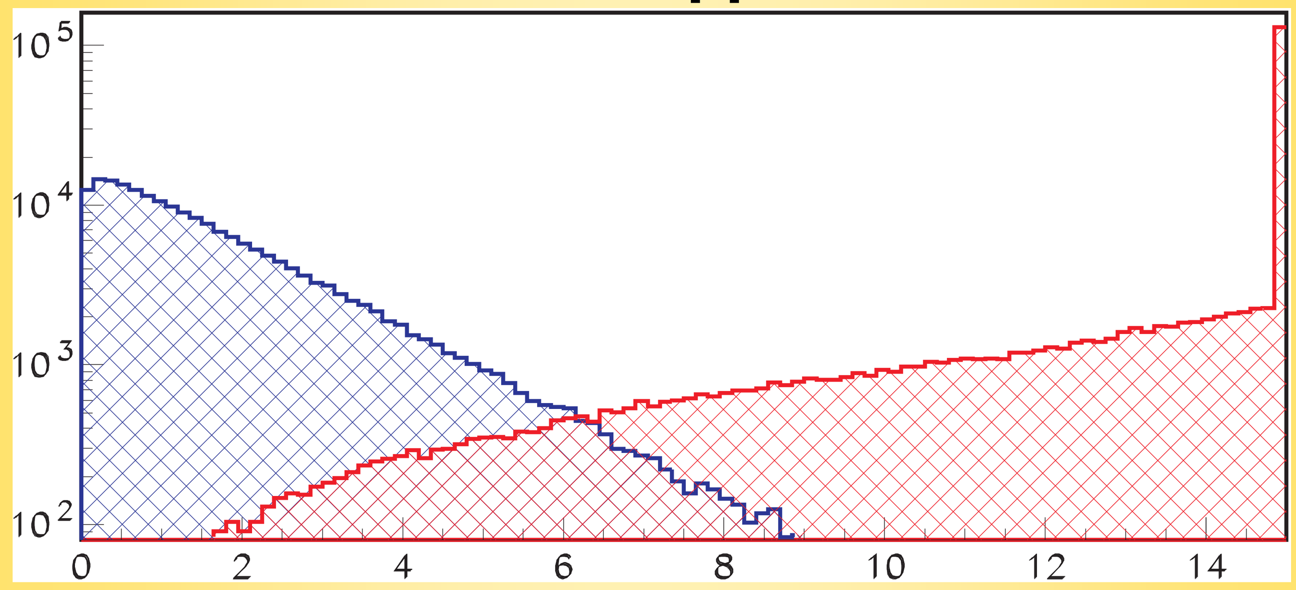

Figure 3: Distributions of variable L for π (blue histogram) and e (red histogram)

• ***The modified*** ω_n^k ***test:***

When calculating ω_n^k, in formula (1), one uses a sample of values, which are ordered due to their values. The λ_i value is directly proportional to the energy loss by a particle registered in the i-th layer of the TRD. In this connection and taking into account that the most probable value of TR counts in the TRD with 12 layers is 6 (Fig. 4), we may use in the ω_n^k test only that part of sample which corresponds to indexes $i > 6$, i.e. to large values of particle energy losses.

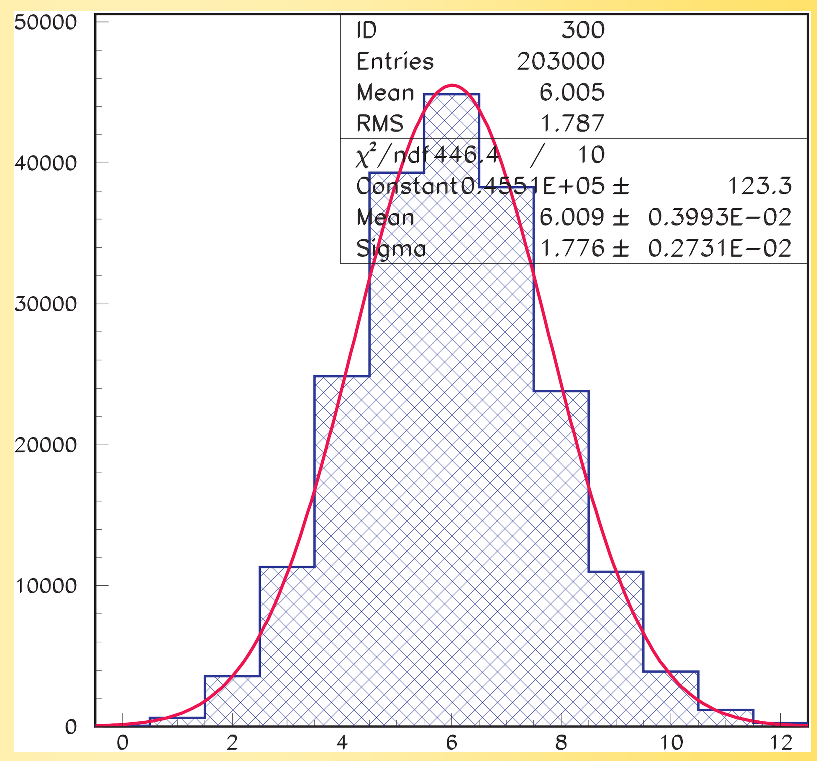

Figure 4: Distribution of events with different number of TR counts and its approximation by Gaussian distribution

Results

Table 1: Comparison of the given methods for 90% efficiency of electron registration

p, GeV/c	1	4	7	9	11
MV	10	14	14	14	14
ω_{12}^6	43	31	19	16	14
MV + ω_{12}^6	87	134	101	93	85
mod ω_6^6	81	281	244	211	196
LFR	272	509	403	363	320
ROOT	294	549	524	448	323
Jetnet	273	697	541	506	364

Conclusion

• The criteria simple from a practical viewpoint (the modified ω_n^k criterion and the composite criteria based on MV + ω_n^k) provide high levels of the pion suppression.

• One succeeds in reaching the best pion suppression level using: a) ANN when transmitting from the initial energy losses in the TRD layers to a new variable typical for the ω_n^k criterion (2), and b) LFR method with the energy losses approximated by a lognormal distribution for π and by a weighted sum of two lognormal distributions for e.

References

[1] E.P. Akishina et. all: *Distribution of energy losses for electrons and pions in the CBM TRD*, JINR Communications, E10-2007-158, Dubna, 2007.
[2] P.V. Zrelov and V.V. Ivanov, Nucl.Instr.Meth. **A310** (1991) 623-630.
[3] E.P. Akishina et. all: *Electron/pion identification in the CBM TRD using a multilayer perceptron*, JINR Communication, E10-2007-17, JINR, Dubna, 2007.