Methods of e/π Identification with the TRD in the CBM Experiment

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A problem of e/π identification using n-layered transition radiation detector (TRD) in the CBM experiment is considered. With 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 applying artificial neural networks (ANN) and statistical methods to the problem under consideration. A comparative analysis is performed on the power of the statistical criteria and ANN for π and e with momenta 1 GeV/c$\leq p \leq$ 11 GeV/c.

In the *mean value* (MV) method the particle identification (PID) is based on a variable $\overline{\Delta E} = \frac{1}{n}\sum_{i=1}^{n} \Delta E_i$ (where ΔE_i is a particle energy loss in the i-th TRD layer and n is the number of layers in the TRD).

While applying the *likelihood functions ratio* (LFR) test to the PID problem, the value

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

is calculated for each set of energy losses, 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].

The ω_n^k test is based on the comparison of the distribution function corresponding to the preassigned hypothesis (H_0) with empirical distribution function [2]:

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

where $\phi(\lambda)$ is Landau distribution function, which describes pion energy losses and corresponds to H_0-hypothesis, with a new variable λ:

$$\lambda_i = \frac{\Delta E_i - \Delta E^i_{mp}}{\xi_i} - 0.225, \qquad \text{i = 1,2,...,n}, \quad (2)$$

ΔE_i – the energy loss in the i-th absorber, ΔE^i_{mp} – the value of most probable energy loss, $\xi_i = \frac{1}{4.02}$ FWHM of distribution of energy losses for π.

The *combined method* involves a successive application of two statistical criteria: 1) the MV method, and 2) the ω_n^k-test.

Main idea of the *modified* ω_n^k test consists in the following. When calculating ω_n^k, in formula (1), one uses a sample of λ_i 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. 1), we may use in the ω_n^k test only that part of $\{\lambda_i\}$ sample which corresponds to indexes $i > 6$, i.e. to large values of particle energy losses.

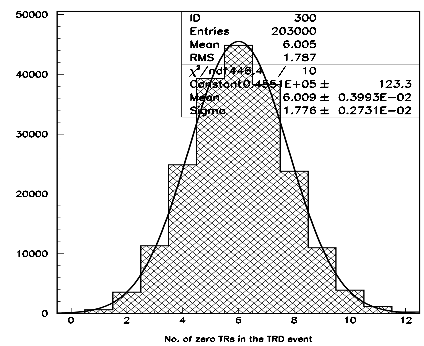

Figure 1: Distribution of events with different number of TR counts and its approximation by Gaussian distribution

We also applied a three-layered perceptron from the packages JETNET3.0 and ROOT to estimate the efficiency of PID [3]. One succeeds in reaching the best pion suppression level using ANN when transmitting from the initial energy losses in the TRD layers to a new variable typical for the ω_n^k criterion (2).

Table 1 presents the results of comparison of the given methods for the 90 % efficiency of electrons.

Table 1: Comparison of the given methods

$p, GeV/c$	1	4	7	9	11
MVM	10	14	14	14	14
ω_{12}^6	43	31	19	16	14
MVM + 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

References

[1] E.P. Akishina et. all, 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: *On electron/pion identification using a multilayer perceptron in the CBM TRD*, this report.