Electron/pion Identification in the CBM TRD Using a Multilayer Perceptron

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The measurement of charmonium is one of the key goals of the CBM experiment: see Maevskaya et al., "J/ψ detection via electron-positron decay in CBM", this report. To detect J/ψ meson in this decay channel, the main task is the separation of electrons and pions. Here we present the electron/pion identification using energy losses in $n = 12$ layers of the CBM TRD detector applying a multilayer perceptron (MLP).

A three-layered perceptron from the package JETNET3 [1] has been used for particle identification. The network included n input neurons (according to the number of the TRD layers), 35 neurons in the hidden layer and one output neuron. It was assumed that for pion events[1] the output signal has to be equal to -1, and for electron events – +1. To estimate the efficiency of the MLP training, we assumed that the network correctly recognized the sample given to the input, if the absolute error between the output signal and the target value did not exceed 0.05. An algorithm of the backward error propagation has been used for the error functional minimization at the stage of MLP training [2].

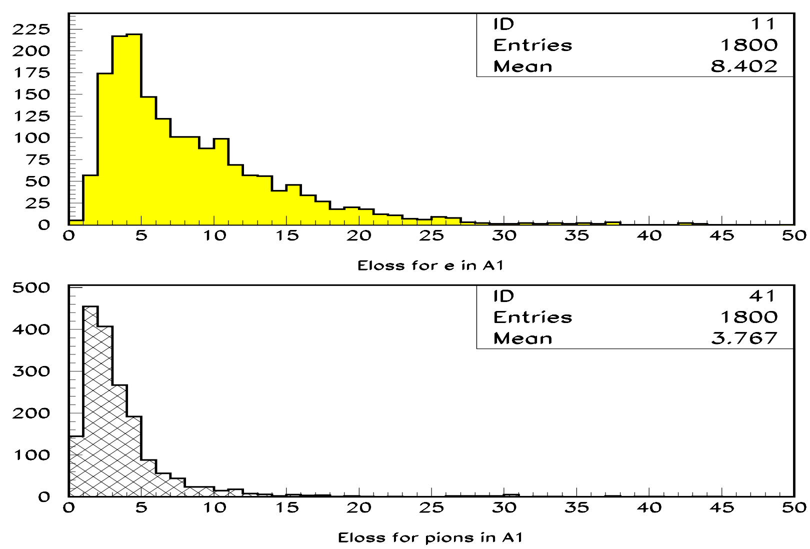

Fig. 1: Distributions of energy losses (including transition radiation) by electrons (top plot) and energy losses by pions (bottom plot) in the first absorber of the TRD

Initially the events were formed using a set of energy losses $\Delta E_i,\ i = 1, ..., n$ corresponding to passage of pions or electrons through the TRD (Fig. 1). Although the distribution of energy losses by electrons significantly differs from the character of the distribution of energy losses by pions, for such a choice of input data the training process was going on very slow (see bottom curve in Fig. 2). There were large fluctuations (against the trend) of the efficiency of events recognition by the network.

[1]As event we define a data sample of the size n composed from energy losses of pion or electron detected by the TRD.

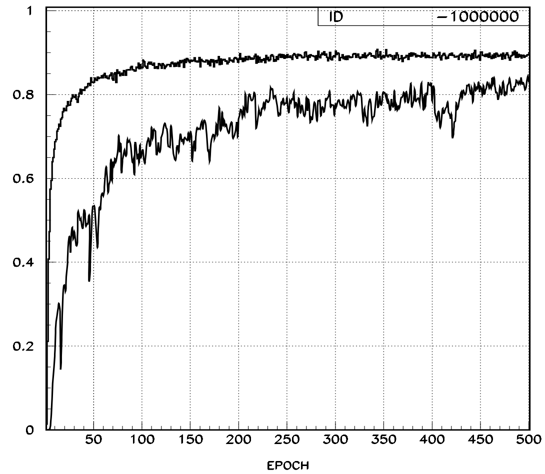

Fig. 2: The efficiency of pion/electron identification by the MLP for original (bottom curve) and transformed (top curve) samples

In this connection, sets of a new variable λ were formed on the basis of the original samples:

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

where ΔE_i is the value of energy loss in the i-th TRD absorber, ΔE^i_{mp} is the most probable value of energy loss, $\xi_i = \frac{1}{4.02}$ FWHM of distribution of energy loss for pion in the i-th absorber (see details in [3]).

In order to determine the value of the most probable energy loss ΔE^i_{mp} and the value FWHM of distribution of energy losses by pions in the i-th absorber, the indicated distributions were approximated by the density function of a log-normal distribution

$$f(x) = \frac{A}{\sqrt{2\pi}\sigma x} \exp^{-\frac{1}{2\sigma^2}(\ln x - \mu)^2}, \tag{2}$$

where σ is the dispersion, μ is a mean value, and A is a normalizing factor [4]. The sample of obtained values $\lambda_i,\ i = 1, ..., n$ was ordered due to values $(\lambda_j,\ j = 1, ..., n)$ and for each of them were calculated the values of Landau distribution function $\phi(\lambda)$ with the help of the DSTLAN function (CERNLIB, **G110** [5]), which were used to form the input pattern for the network.

In this case the reliable level of pion/electron identification by the network is reached after 10-20 training epoches in conditions of practical absence of fluctuations against the trend, and very quickly the needed level of pions suppression under the condition of a minimal loss of electrons is reached (see the behaviour of the top curve in Fig. 2).

At the stage of the MLP testing the event type was determined by the value of the output signal y: when it does not exceed the preassigned threshold y_t, the event was assumed to belong to pion, in the opposite case – to electron.

Table 1 shows the results of comparison of the given methods MLP and ω^k_n (see E.P. Akishina et al., "Application of the ω^k_n test for J/ψ detection in the CBM experiment", this report): α is part of lost electrons, β is the fraction of pions identified as electrons, pion suppression factor equals $100/\beta$.

Table 1: Comparison of the given methods MLP and ω_n^k

method	y_t	α,%	β, %	suppression of pions
MLP	0.84	9.4	0.6	167
ω_n^k	11.0	11.0	0.78	128

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