On electron/pion identification using a multilayer perceptron in the CBM TRD

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The problem of pion/electron identification based on their energy losses in the transition radiation detector (TRD) is considered in frames of the CBM experiment. For particles identification, an artificial neural network (ANN) was used. This is a multilayer perceptron built in JETNET and ROOT packages. It is demonstrated that, in order to get correct and comparable results, it is important to define the network structure correctly. In order to achieve an acceptable level of pions suppression, the energy losses need to be transformed to more "effective" variables.

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. We compare two neural networks (a multilayered perceptron - MLP) from JETNET3 and ROOT packages for the *e/π* identification using the TRD. The method is based on a set of energy losses $\{\Delta E_{i=1,...,n}\}$ measurements in the *n*-layered TRD for *π* and *e* with momenta $1\,\mathrm{GeV/c} \le p \le 13\,\mathrm{GeV/c}$

Choosing the MLP architecture

To obtain reliable and comparable results, it is important to select correctly the architecture of the network [1]. The choice of the MLP architecture includes the determination of:

a) number of the MLP layers,

b) number of neurons in each layer.

In our case, the network included *n*=12 input neurons, 12 neurons in the hidden layer, and 1 output neuron. To choose the number of neurons in the hidden layer, we analyzed the error distribution - difference between the target value and the MLP output signal (Fig. 1). It has to satisfy the following criteria: 1) to be symmetrical relative to zero average,

2) the dispersion must be minimal.

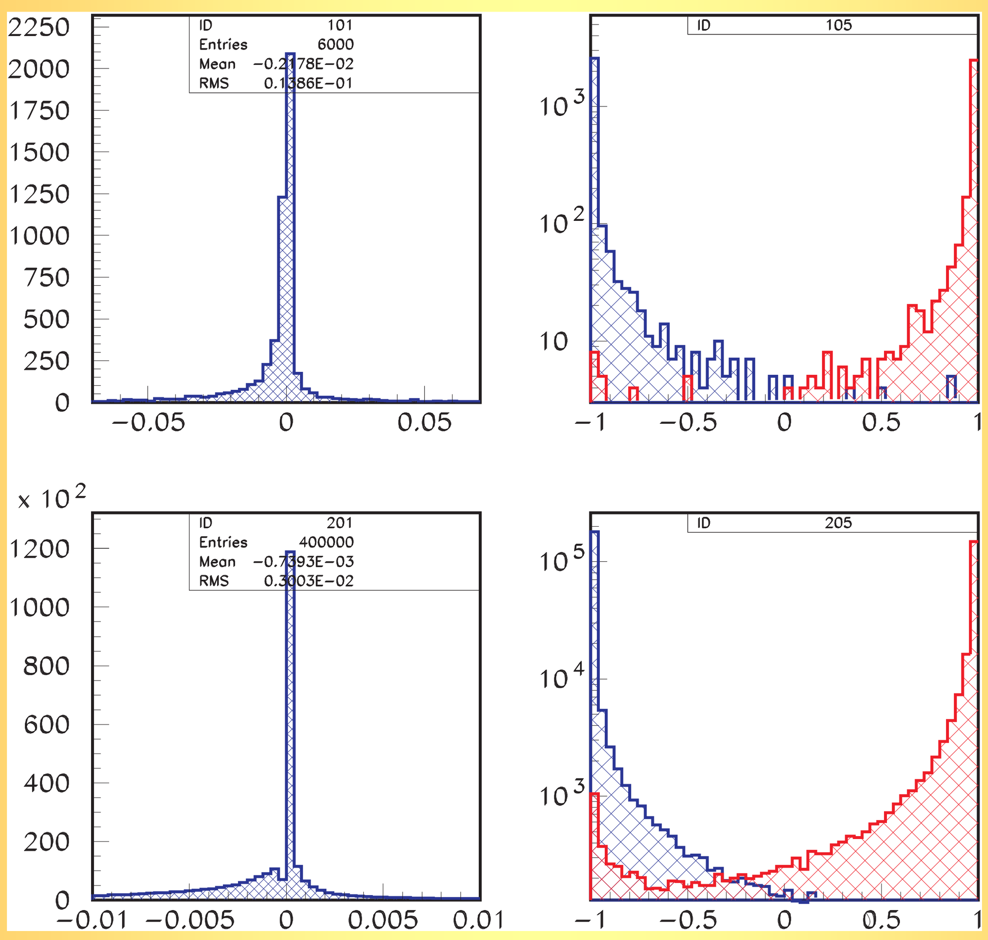

Figure 1: Distributions of errors obtained at the training and testing stages (right plots); left plots show the distributions of the MLP output signal at the training and testing stages

Preparation of input samples for the MLP

To obtain an acceptable level of pions suppression, the energy losses in the TRD layers should be transformed to more "effective" variables:

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

where ΔE_i is the energy loss in the *i*-th absorber, ΔE^i_{mp} is the most probable energy loss, $\xi_i = \frac{1}{4.02}$ FWHM of the distribution of pion's energy losses [2].

This transformation permits one to obtain a reliable level of the *e/π* identification by the network after a minimal number (around 50) of training epochs in conditions of practical absence of fluctuations against the trend (the red curve in Fig. 2). In case of original data, in spite of a large number of training epochs, one can not reach the needed level of particle identification (the blue curve in Fig. 2).

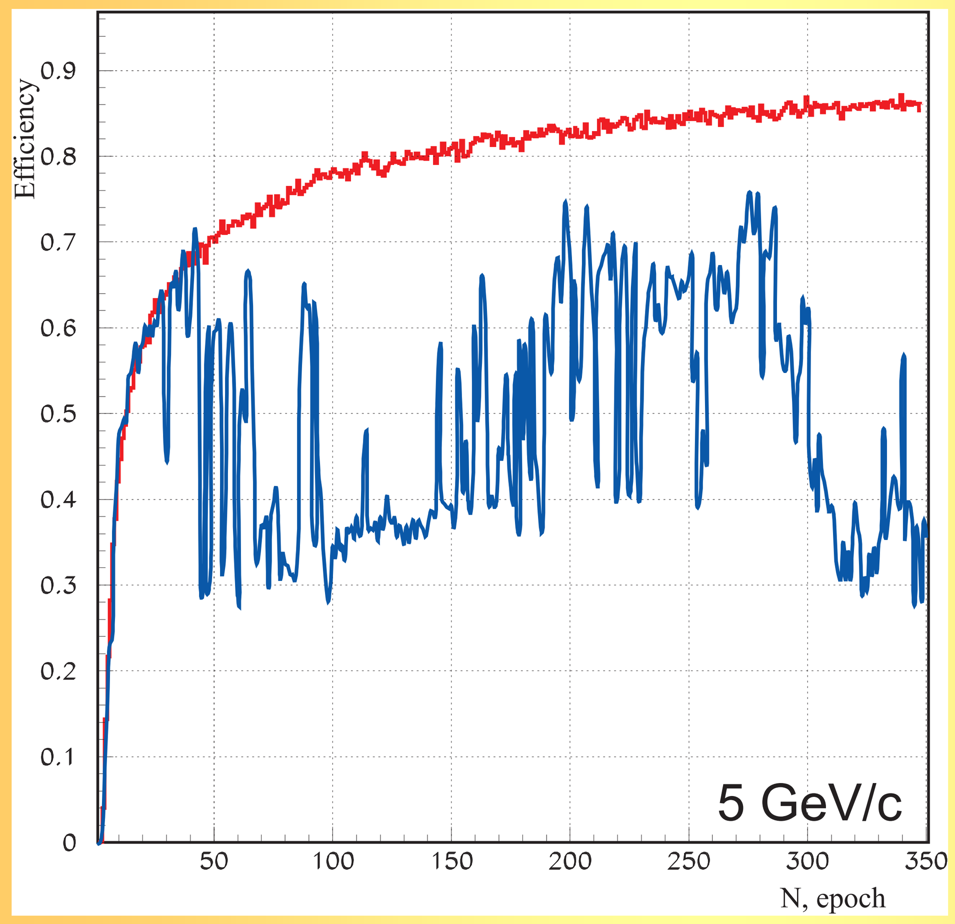

Figure 2: The efficiency of *e/π* identification by the MLP for original (blue curve) and transformed (red curve) samples for *e* and *π* with *p* = 5 GeV/c

Calculation of the transformation parameters

The formulas for enumerating the transformation parameters depending on the momentum are as follows:

$$\Delta E_{mp}(p) = 0.0005451 p^3 - 0.01572 p^2 + 0.1657 p + 0.8866$$

$$\xi(p) = 0.0001789 p^3 - 0.005178 p^2 + 0.05472 p + 0.4983$$

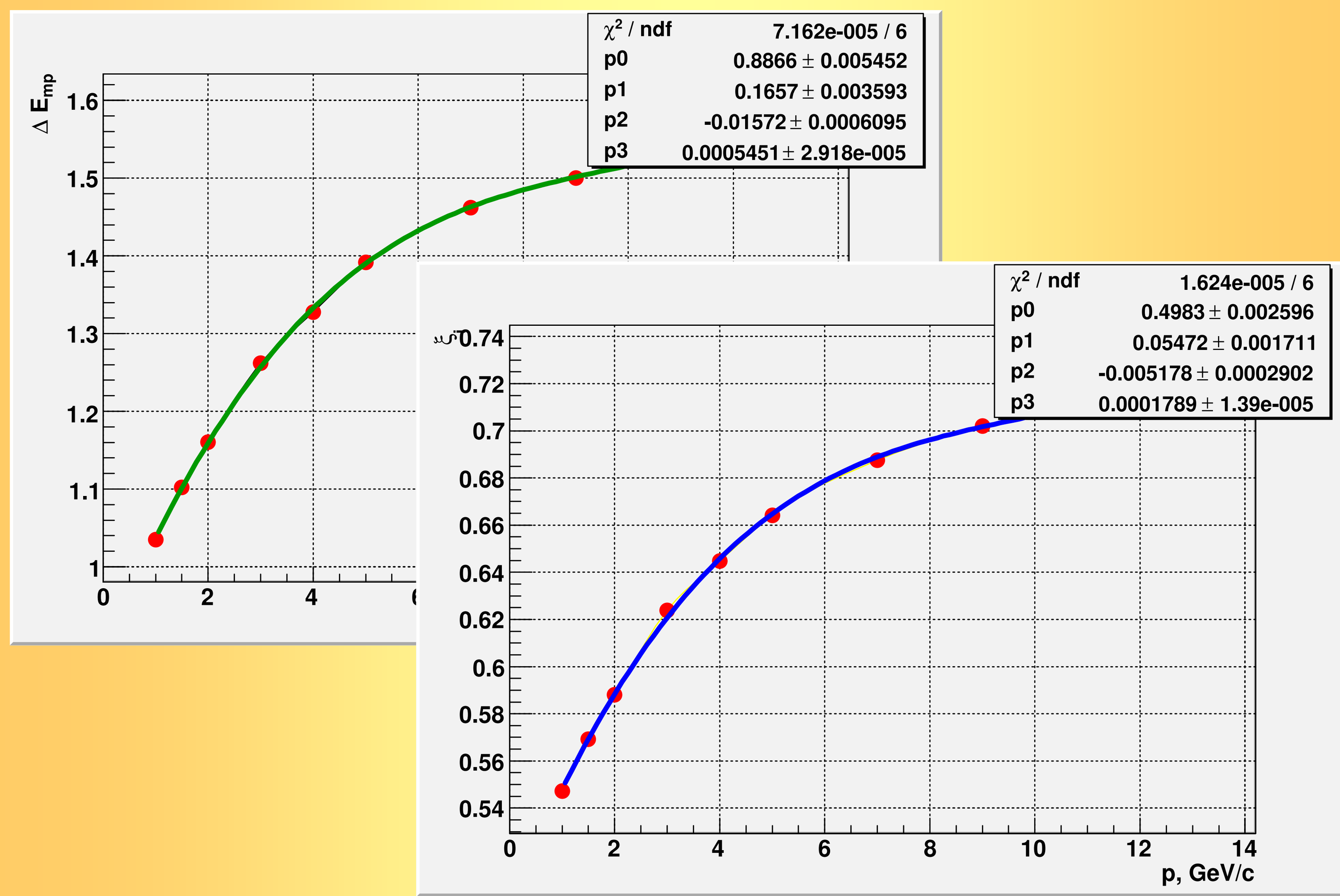

Figure 3: Dependence of the ΔE_{mp} (green line) and ξ_i (blue line) against the momentum and its approximation by a polynomial of the third degree

Results

The networks were trained for each momentum separately and with corresponding transformation parameters.

Table 1: The pion suppression factors for the 90% efficiency of electrons registration applying MLP

p, GeV/c	1	2	4	7	9	11
Jetnet	273	647	697	541	506	364
ROOT	294	447	549	524	448	323

Conclusion

• For the correctly chosen MLP architecture both networks give comparable results. In the opposite case, the pion suppression factor for networks may be essentially different.

• One succeeds in reaching the best π suppression level when transmitting from the initial energy losses in the TRD layers to a new variable typical for the ω^k_n criterion (1).

• Applying the networks from different packages gives us a possibility of verification of the results obtained with the help of MLP, thus providing the reliability of physical results.

References

[1] N.A. Ignat'ev : *Selection of the minimum configuration of the neural networks*, Comp. techn., t.6, No.1, 2001, p.23 –28

[2] T.P. Akishina et. all: *On electron/pion identification using a multilayer perceptron in the transition radiation detector of the CBM experiment*, JINR Communication, P10-2009-61, JINR, Dubna, 2009.