Identification of Λ in FOPI using a neural network

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A high statistics of Λ, produced in Ni+Ni collisions at 1.93 AGeV, has been collected by the FOPI detector [1, 2, 3]. This neutral strange hadron, of mass M_Λ=1.115 GeV/c^2, is reconstructed through the $\Lambda \rightarrow p + \pi^-$ decay channel in the Central Drift Chamber. A Multilayer Neural Network (MLNN) has been used to optimize the reconstruction of the Λ in FOPI. Such a work was successfully carried out by the EOS Collaboration in Ni+Cu interactions at 2 AGeV [4].

In the standard analysis, cuts are applied on selective variables in order to minimize the combinatorial background. For example, a (p, π^-) pair is accepted as a possible candidate if it originates from a secondary vertex. A three layer neural network [5] is used in this analysis. Two files are prepared for the training of the neural network. The first one contains kinematic variables from Λ's generated with a Monte-Carlo simulation for the "recognition" of the signal by the MLNN. The second file is obtained from FOPI data by mixing a proton from one event with a pion from another event, in order to produce pure background events. Eleven selective variables, the same as in the standard analysis, are used. The first layer of the neural network mixes the data of the two files. The main part of the algorithm is executed in the hidden layer. The output layer is composed of two neurons, one for the signal and one for the background. Each neuron delivers one variable (referenced as NN), which is a non linear combination of the input variables.

The distributions of NN (Figure 1, left panel) exhibit a peak at +1 (signal) and -1 (background). A cut at +0.9 on NN would remove most of the background. The efficiency, defined as the number of reconstructed signals above a cut on NN divided by the number of input signals, is shown in the right panel of Figure 1 as a function of NN. The same plot presents also the purity, defined as the number of reconstructed signals above a cut on NN divided by the sum of signal plus background. A cut on NN close to +1 would give a good purity but a large fraction of the signal would be lost.

In order to compare the results obtained with the standard analysis and with the neural network, a cut on NN is applied in order to have the same level of purity in both cases. The invariant mass spectra are shown in Figure 2, for a total of 6.2 10^6 central events. The dashed curves show the combinatorial background from the mixed-event technique. The signal and the background, integrated in a $\pm 2\sigma$ range around the nominal mass ([1.103;1.13]GeV/c^2) are reported in Table 1. The signal identification is improved by 32 % with the MLNN.

This method will be tested for the identification of particles with a very low cross section, like the Ξ^-, in a large sample of Ni+Ni events at 1.93 AGeV which is presently being accumulated with FOPI.

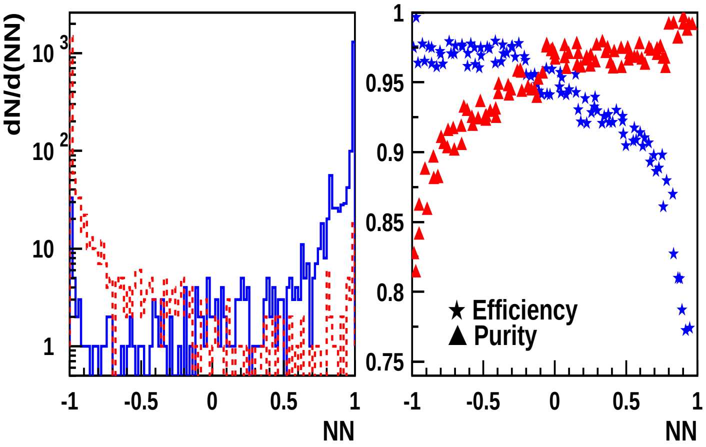

Figure 1: The output of the MLNN is shown in the left panel for signal (solid histogram) and background (dashed histogram). The efficiency and the purity are presented on the right panel as a function of NN.

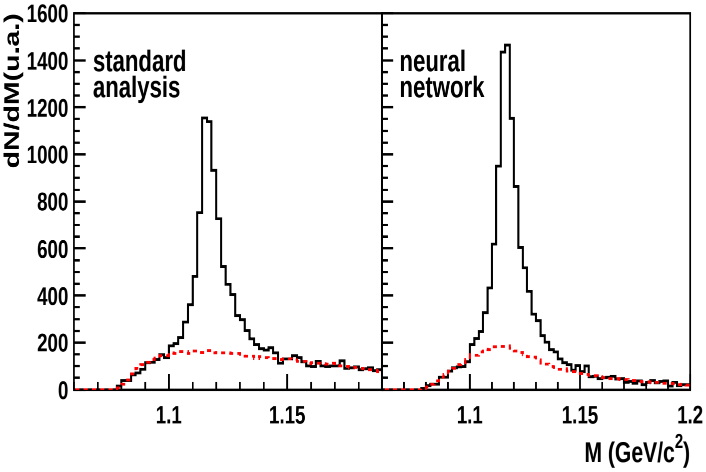

Figure 2: Invariant mass of Λ's obtained with a standard analysis (left panel) and with the Multilayered Neural Network (right panel). The dashed curves show the combinatorial background.

Integration	Standard Analysis	Neural Network
Signal	7941	9809
Background	2213	2236

Table 1: Integration of the signal and the background for the two analyses in a $\pm 2\sigma$ range around the nominal mass of Λ.

References

[1] R. Kutsche, PhD thesis (2000), GSI-Darmstadt.

[2] J. Ritman et al., FOPI Collaboration, Z. Phys. A 352 (1995) 355.

[3] R. Kutsche et al., GSI report 2000-1 p42.

[4] M. Justice, Nucl. Instr. Meth. A 400 (1997) 463.

[5] V. Breton et al., Nucl. Instr. Meth. A 362 (1995) 478.