Photon-Hadron discrimination using Neural Network in a preshower detector

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Introduction

The artificial neural network (ANN) technique has been used to discriminate photons from hadrons clusters in a preshower Detector [1] assuming square pads, long before the present implementation with hexagonal cells of the detector [2] which is designed to take data at $\sqrt{s_{NN}} = 5.5 TeV$ per nucleon. In the present work we have studied photon hadron discrimination in the hexagonal configuration using a new clustering algorithm [3] and ANN with modified set of inputs. The results have been obtained from the simulated output using a preshower configuration including a chagre particle veto.

Photon-Hadron discrimination

ANN offers a simple way of combining the information from many kinamatic and geometric variables, which in principle increases our potential to resolve the signal in the data. Our Network is a two layer perceptron with standard activation function: $g(x =$ 0.5[1+tanh(x)]. For training, we use JETNET v3.5 [4] subroutines interfaced to ROOT [5] via the Root-Jetnet[56] package. The weights and thresholds are updated according to the Manhattan Back-Propagation algorithm with the default parameters. The following twelve variables are considered in the input layer of the ANN for the discrimination of photons and hadrons.

1. Number of cells of the primary cluster in Preshower plane ($nCell^{Pre}$).
1a. Number of cells of the cluster in CPV plane situated just opposite to that primary cluster in the Preshower Plane ($nCell^{CPV}$).
2. Signal strength of the primary cluster in Preshower plane ($clAdc^{Pre}$).
2a. Signal strength of the cluster in CPV plane situated just opposite to that primary cluster in the Preshower Plane ($clAdc^{CPV}$).
3. Kurtosis value of the primary cluster in Preshower plane ($KurtoSis^{Pre}$).
3a. Kurtosis value of the cluster in CPV plane situated just opposite to that primary cluster in the Preshower Plane ($KurtoSis^{CPV}$).
4. Sigma of X-position of the cells of the primary cluster in Preshower plane w.r.t its peak position ($SigX^{Pre}$).
4a. Sigma of X-position of the cells of the cluster in CPV plane situated just opposite to that primary cluster in Preshower plane w.r.t its peak position ($SigX^{CPV}$).
5. Sigma of Y-position of the cells of the primary cluster in Preshower plane w.r.t its peak position ($SigY^{Pre}$).
5a. Sigma of Y-position of the cells of the cluster in CPV plane situated just opposite to that primary cluster in Preshower plane w.r.t its peak position ($SigY^{CPV}$).
6. Skewness value of the primary cluster in Preshower plane ($Skew^{Pre}$).
6a. Skewness value of the cluster in CPV plane situated just opposite to that primary cluster in the Preshower Plane ($Skew^{CPV}$).

Fig. 1 shows the performance of the network for different combination of input variables with varying number of hidden nodes. It is found that ANN gives the optimum performance with only six numberes variables 1($nCell^{Pre}$), 1a($nCell^{CPV}$), 2($clAdc^{Pre}$), 2a($clAdc^{CPV}$), 3($KurtoSis^{Pre}$) and 3a($KurtoSis^{CPV}$) in which the variables from both preshower and veto planes are considered.

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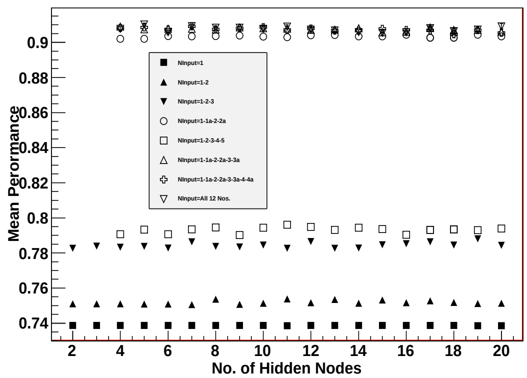

FIG. 1: NN perfomance with different hidden nodes for different combination of input variables

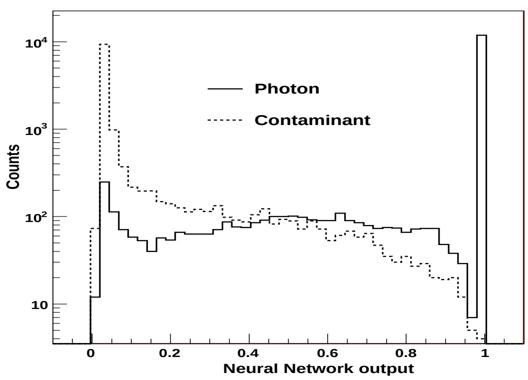

FIG. 2: Neural Network Output Spectra

Results and Discussion

Fig. 2 shows the Neural Network (NN) output spectra. The discrimination of photons and hadrons are done by applying a threshold chosen from the NN spectra. We consider the photon selection efficiency (ϵ_γ) and purity of photon sample (f_p) from [1] to quantify the effectiveness of the algorithm.

$\epsilon_\gamma = N_{cls}^{\gamma_{th}}/N_{cls}^{\gamma}$ and $f_p = N_{cls}^{\gamma_{th}}/N_{\gamma-like}$, where $N_{cls}^{\gamma_{th}}$ is the number of photon clusteres above threshold, N_{cls}^{γ} is the number of input photon clusters on PMD zone obtained from kinametics and $N_{\gamma-like}$ is the number of clusters above threshold.

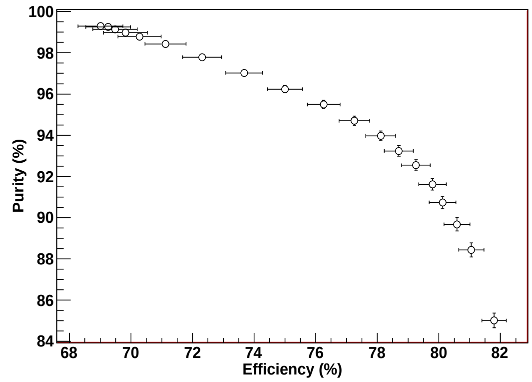

FIG. 3: Photon Selection Efficiency and Purity obtained from different thresholds for optimised Input parameters and Hidden Nodes

Fig. 3 shows the variation of purity of photon sample (f_p) with the photon selection efficiency (ϵ_γ). One can choose the operating zone of detecting photon clusters with desired purity level using PMD. It is seen that highest purity (99%) of photon clusters is achieved when the detection efficiency is around 70% which shows the usefullness of this method.

References

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