Pi0/gamma discrimination in ATHENA endcaps: ML approach

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ATHENA Calorimetry Meeting

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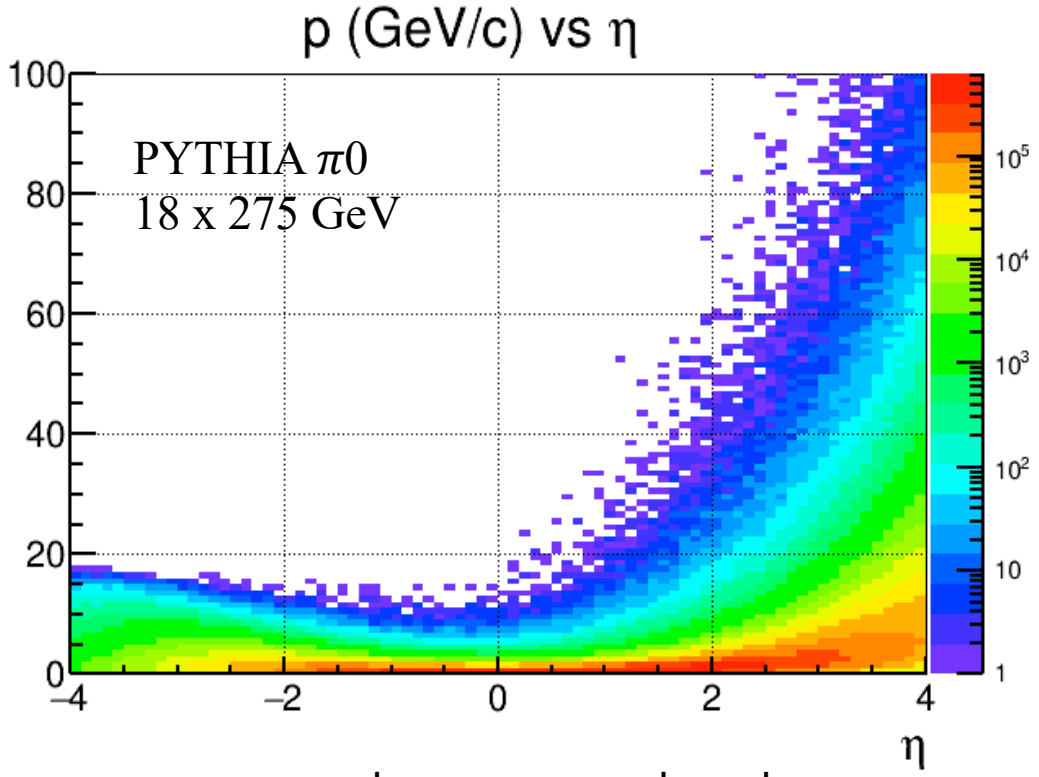
SIDIS π0

YR: Fig11.80



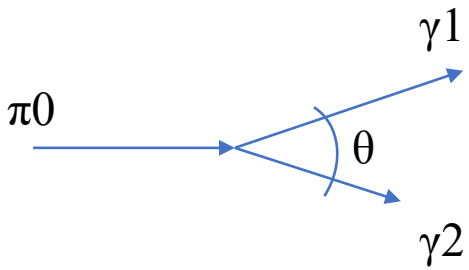
e-endcap:
up to e-beam momentum

h-endcap:
up to 50-100 GeV/c

Granularity and $\pi 0/\gamma$ discrimination in EMCal

"Usual" criteria:

$\pi \rightarrow \gamma\gamma$ distinguished if photons are separated by 1 tower size



$$\theta = \frac{2m_{\pi 0}}{E_{\pi 0}\sqrt{1-\alpha^2}} \qquad \alpha = \frac{E_{\gamma 1} - E_{\gamma 2}}{E_{\gamma 1} + E_{\gamma 2}}$$

$$\theta_{min} = \frac{2m_{\pi 0}}{E_{\pi 0}}$$

h-endcap: 2.5x2.5cm at z=3.5m

e-endcap (PWO): 2x2cm at z=-2.1m

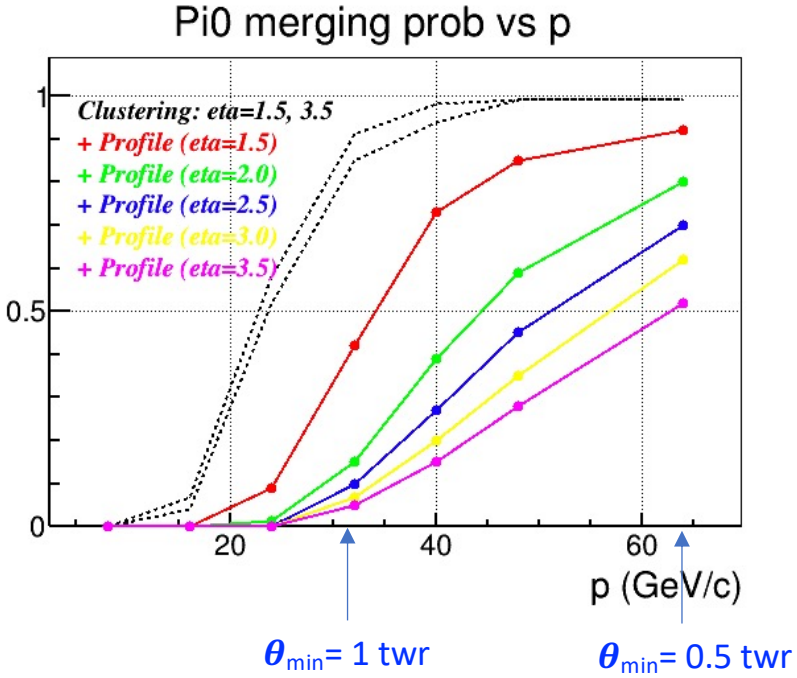
e-endcap (SciGl): 4x4cm at z=-2.1m

Θ_{min}	$E_{\pi 0}$ GeV
0.007	38
0.01	27
0.02	13.5

Shower Profile Analysis

YR: Fig11.80

GEANT4:
Forward EMCal with granularity ~0.008 (2.5×2.5 cm^2 at z=3m)



Shower Profile analysis:

$$\chi^2 = \sum \frac{(E_i^{meas} - E_i^{pred})^2}{\sigma_i^2}$$

E_i^{pred} and σ_i are f(x, y, E, $\boldsymbol{\theta}$, φ)

- Considerably extends the momentum range for $\pi 0/\boldsymbol{\gamma}$ discrimination
- Strong dependence on rapidity (for non-projective)
- There is room for improvement …

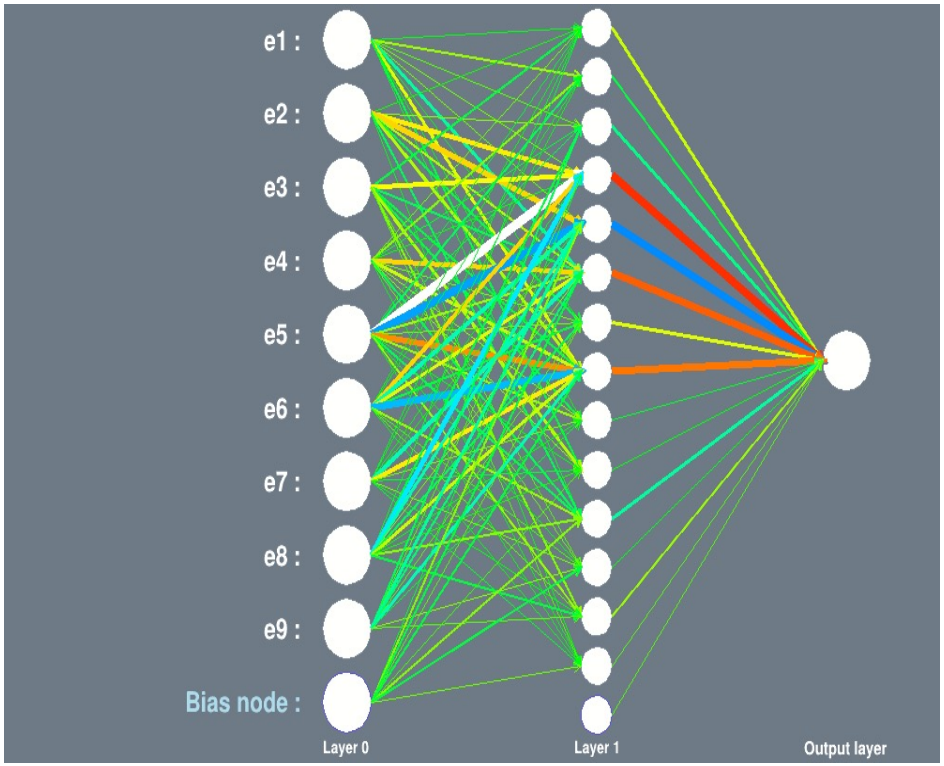
… But let's try different approach

Try ML !

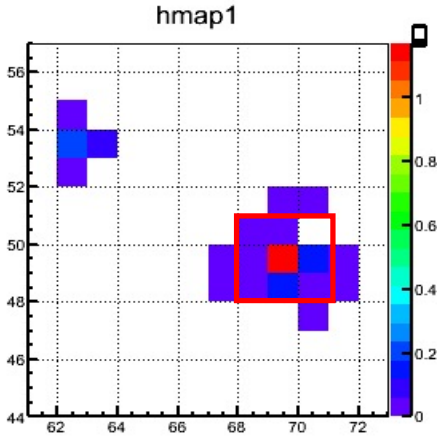
TMVA: Toolkit for Multivariate Data Analysis with ROOT

- Provides training, testing and performance evaluation algorithms and visualization scripts
- A lot of algorithms implemented
  - Rectangular cut optimisation
  - Projective likelihood estimator
  - Multidimensional likelihood estimator
  - k-Nearest Neighbour (k-NN) Classifier
  - H-Matrix discriminant
  - Linear discriminant analysis
  - Function discriminant analysis
  - Artificial Neural Networks (Clermont-Ferrand, **M**ultil**L**ayer **P**erceptron)
  - Support Vector Machine
  - Boosted Decision and Regression Trees
  - Predictive learning via rule ensembles
  - …

MPL Artificial Neural Network



Input: 3x3 central tower energies, normalized to total cluster energy



Default conf.

One hidden layer

N_{var}+5 neurons

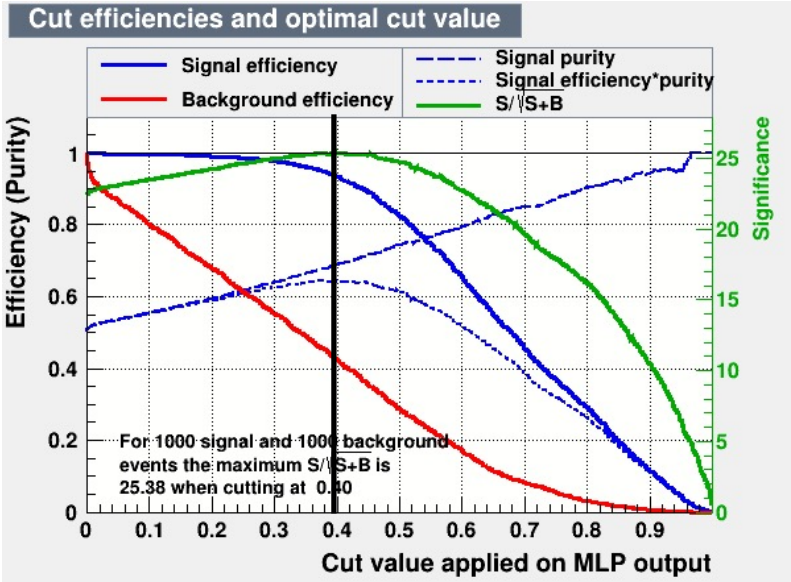
4k events generated at different energies and rapidity

A half is used for learning, and another half for evaluation

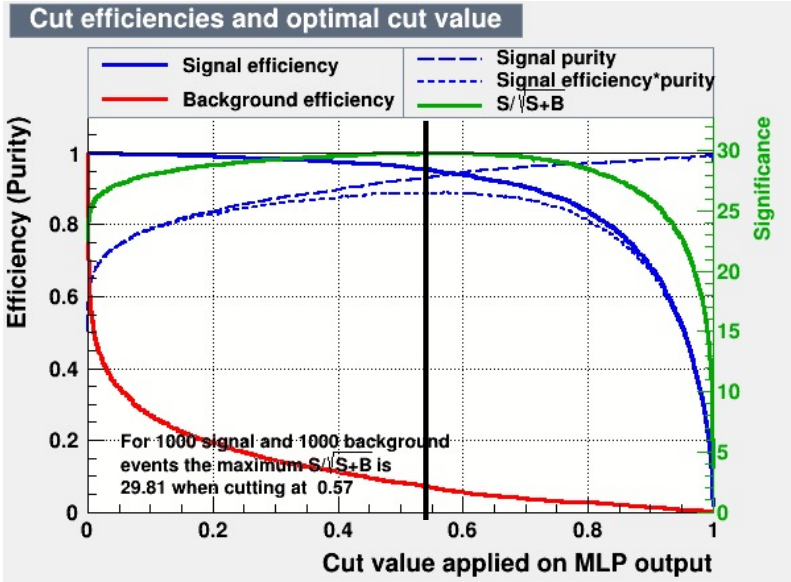
Signal/Background efficiency after MLP

h-endcap: 2.5x2.5cm at z=3.5m, η=3

100 GeV



60 GeV



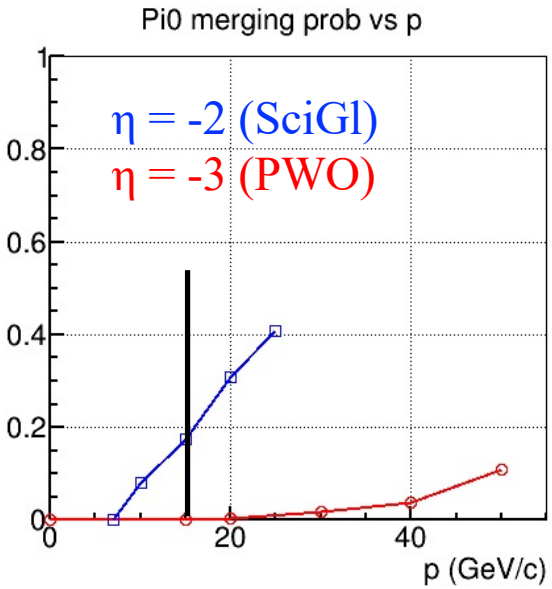
ε_{Bg} = 42% for ε_{Sg} = 95%

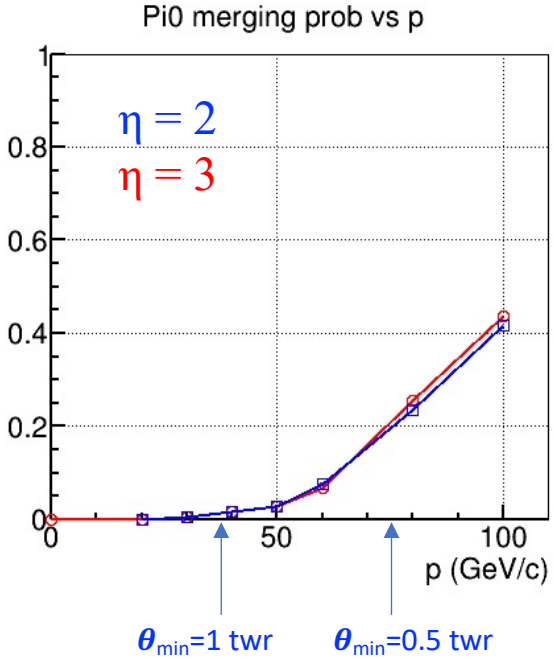
ε_{Bg} = 7% for ε_{Sg} = 95%

Pi0 merging prob after MLP

e-endcap:
PWO: 2x2cm at z=-2.1m
SciGl: 4x4 cm at z=-2.1m

h-endcap:
W/SciFi: 2.5x2.5cm at z=3.5m





Can effectively discriminate $\gamma/\pi 0$ even when two photons are separated by 0.5 tower size

PWO: Excellent performance
SciGl: Adequate performance

Excellent performance

Backup

Exclusive: DVCS and pi0

From Salvatore 10/29/20, 10:55 AM