The effect of Timing on Energy reconstruction using Neural Networks

Fatma Ghrab

Supervisor: Mr. Kais Manai

Faculté des Sciences de Tunis
Université Tunis El Manar

June 17, 2022

Overview

1. Simulated Data
2. The Neural Networks
3. Results
4. Conclusion

Simulated Data

- 2000 events of π^- of energies 1GeV to 100GeV with a step of 1GeV using Monte Carlo simulation for the SDHCAL prototype.
- $\sim$ 75% of the simulated events were used to train the neural networks.
- $\sim$ 25% for testing

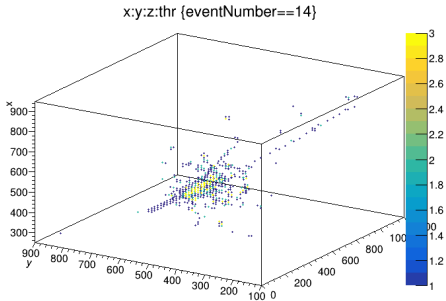


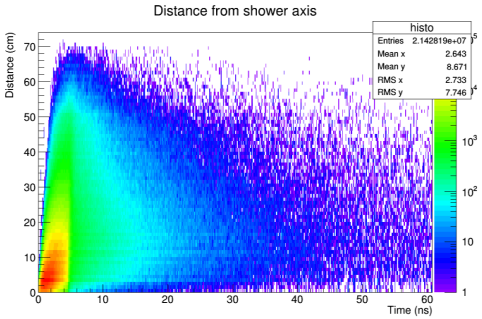
Figure: example of an event of a $50 GeV \pi^-$ shower

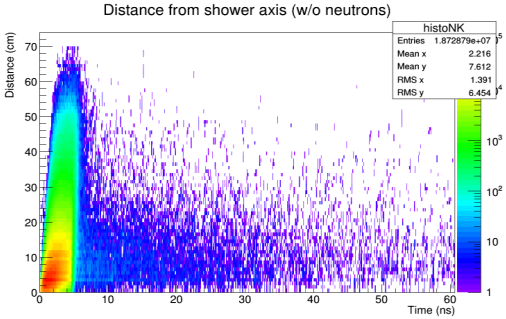
The Neural Networks

- We used the ROOT class TMultiLayerPerceptron to build our neural networks.
- We compare the results of two neural networks:
  - one where we used the timing information provided by the Geant4 simulation and applying a gaussian smearing of 100ps to the exact time.
  - one without considering the time.

Motivation

- Timing can be a powerful tool to identify late neutrons and therefore improve the energy resolution.





source: Prof. Laktineh

Variables

- Input variables for the first neural network (w/o timing) for each event:
  - **N1:** Number of hits exceeding threshold 1 but not 2
  - **N2:** Number of hits exceeding threshold 2 but not 3
  - **N3:** Number of hits exceeding threshold 3
  - **Nhits:** Number of total hits
  - **Begin:** Starting Layer of the shower
  - **LongiProfile:** Number of layers from begining of the shower to end
  - **Nclusters:** Number of clusters

Variables

Input variables for the second neural network

- We replace **N1**,**N2**,**N3** with: ($t_0 \sim 6.7ns$)
  - number of hits with thr=1,2,3 (separately) for $t_0 \leq t < 7ns$
  - number of hits with thr=1,2,3 (separately) for $7ns \leq t < 8ns$
  - number of hits with thr=1,2,3 (separately) for $8ns \leq t < 9ns$
  - number of hits with thr=1,2,3 (separately) for $9ns \leq t < 10ns$
  - number of hits with thr=1,2,3 (separately) for $10ns \leq t < 11ns$
  - number of hits with thr=1,2,3 (separately) for $11ns \leq t < 12ns$
  - number of hits with thr=1,2,3 (separately) for $t \geq 12ns$
- Nhits, Begin, LongiProfile, Nclusters

Results

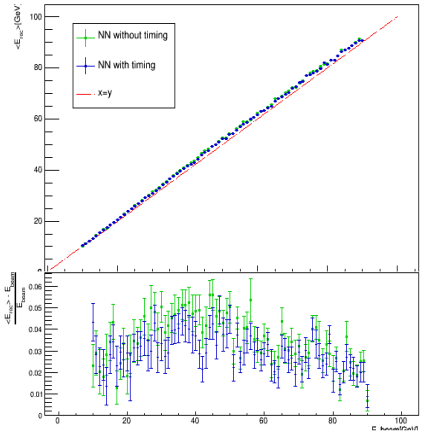


Figure: Comparaison of the linearity of the reconstructed energy between the different NNs

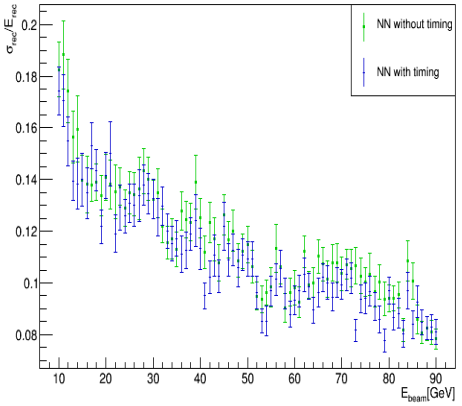
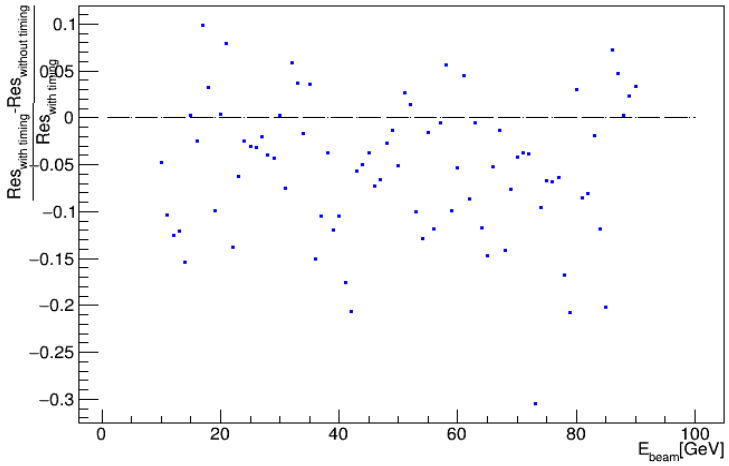


Figure: Comparaison of the resolution between the different NNs

Results


$\frac{Res_{without\ timing} - Res_{with\ timing}}{Res_{with\ timing}}$
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
−0.3
0
20
40
60
80
100
E_{beam}[GeV]

Conclusion

- We can see by adding the timing information we achieve better resolution and linearity overall.

- Future plans: -Add more variables describing the spatial properties of the shower.
  -Try a different approach, for example: Graphical Neural Networks...
  -Particle identification

Thank you for your attention :)

Backup Slides

Data for 50GeV Pions