Neural Network technique for Energy reconstruction in SDHCAL using timing

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Overview

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

SDHCAL

- Semi-Digital Hadronic CALorimeter technological prototype
- Dimensions: $1m \times 1m \times 1.3m$ equivalent to $6\lambda_I$
- High granularity calorimeter based on GRPC ($1cm \times 1cm$ cells)
- Semi-digital readout using three thresholds

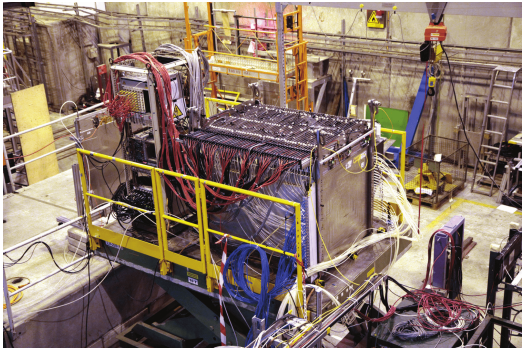


Figure: The SDHCAL prototype during a test beam at SPS/CERN H2 line.

Simulated Data

- Simulated data: 2000 events of π^- showers for each energy ranging from 1GeV to 100GeV using Monte Carlo simulation.

- Output of the simulation for every hit in the detector:
  - the coordinates x,y,z
  - threshold
  - time

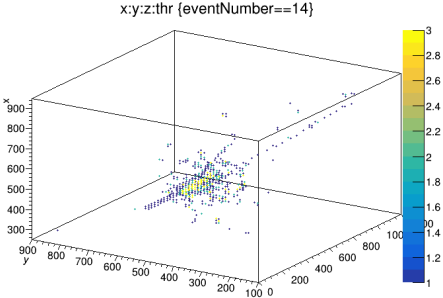


Figure: example of an event of a $50 GeV \pi^-$ shower

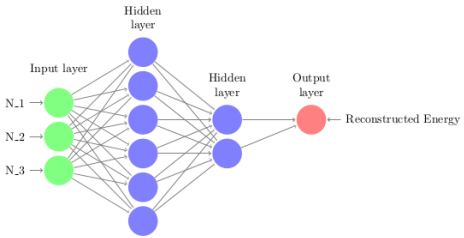
The Neural Networks

- We used the ROOT class TMultiLayerPerceptron to build our neural networks.
- The neural networks have been built, trained and tested using the simulation samples.
- We compared the results of 2 neural networks using two different approaches.
- Motivation: the time information can be used in a similar manner to that proposed by Dual-Readout calorimetry to correct for the fluctuations of energy loss due to nuclear effects [2]

The Neural Networks

Structure of the first neural network[1] (Green plot in the following figure):

- Input:
  - number of hits with thr=1
  - number of hits with thr=2
  - number of hits with thr=3
- 2 hidden layers with 6 and 2 nodes respectively
- Output: Reconstructed Energy



The Neural Networks

Structure of the second neural network (Blue plot):

- 21 Input nodes:
  - 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 $t \geq 12ns$
- 2 hidden layers with 20 and 20 nodes respectively
- Output: Reconstructed Energy

Results

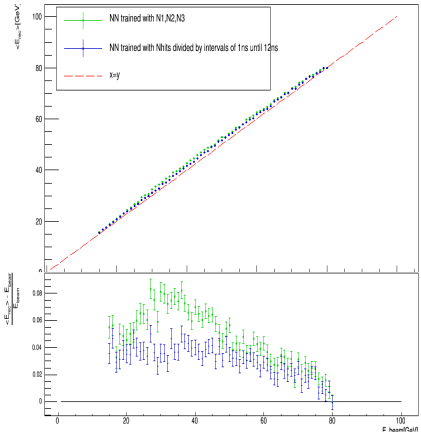


Figure: Comparaison of the linearity of the reconstructed energy between the different NNs

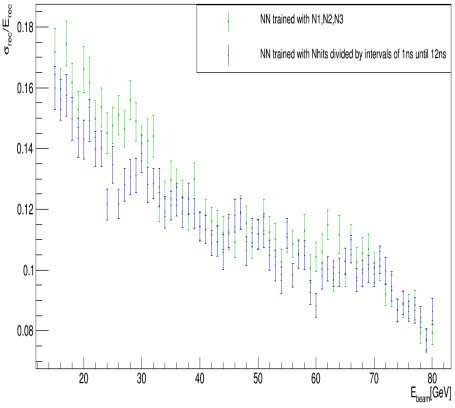


Figure: Comparaison of the resolution between the different NNs

Results

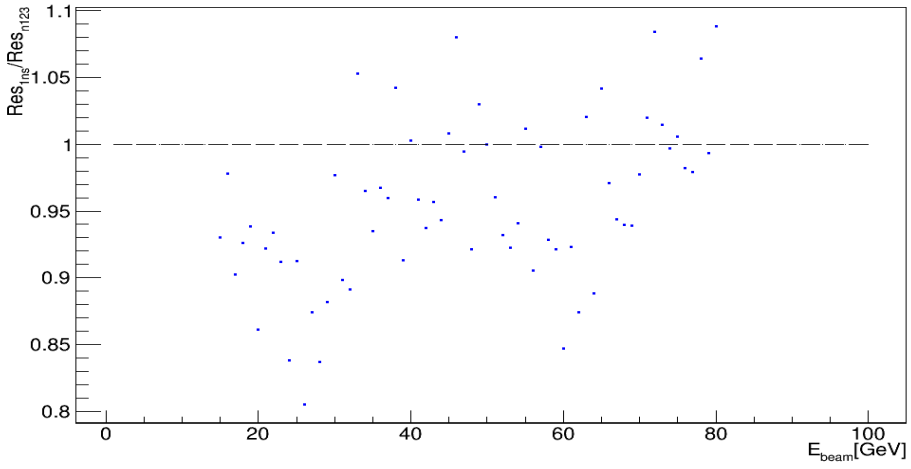


Figure: Ratio of the two resolutions

Results

- We can see a better performance by dividing the number of hits into 1ns intervals.
- The results are still very preliminary, and could be improved by working with more data.

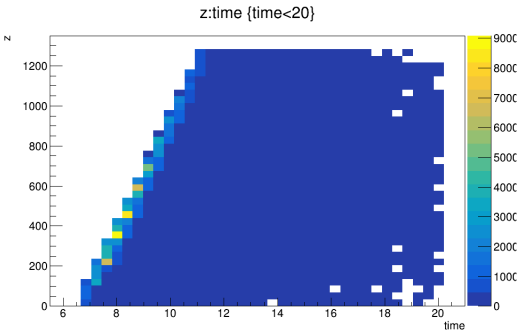
Thank you for your attention :)

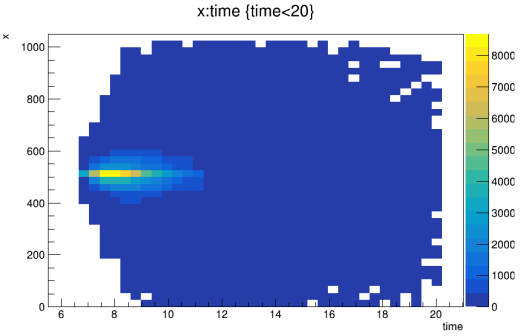
Refrences

- Mannai, Sameh. Energy reconstruction and particle identification in a high granularity semi-digital hadronic calorimeter. Prom. : Cortina, Eduardo http://hdl.handle.net/2078.1/185407
- Benaglia, A., Auffray, E., Lecoq, P., Wenzel, H. & Para, A. Space-Time Development of Electromagnetic and Hadronic Showers and Perspectives for Novel Calorimetric Techniques. *IEEE Trans. Nucl. Sci.*. **63** pp. 574-579. 6 p (2016), https://cds.cern.ch/record/2262300

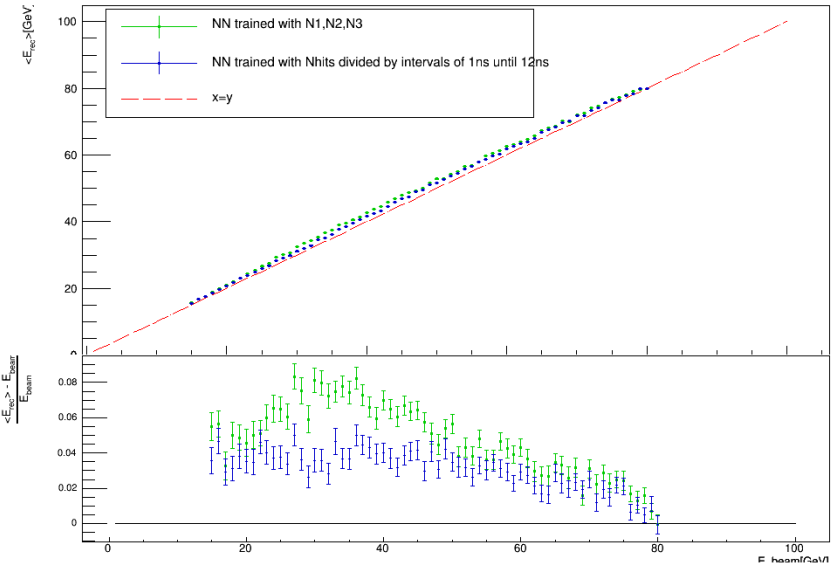
Backup Slides

Data for 50GeV Pions

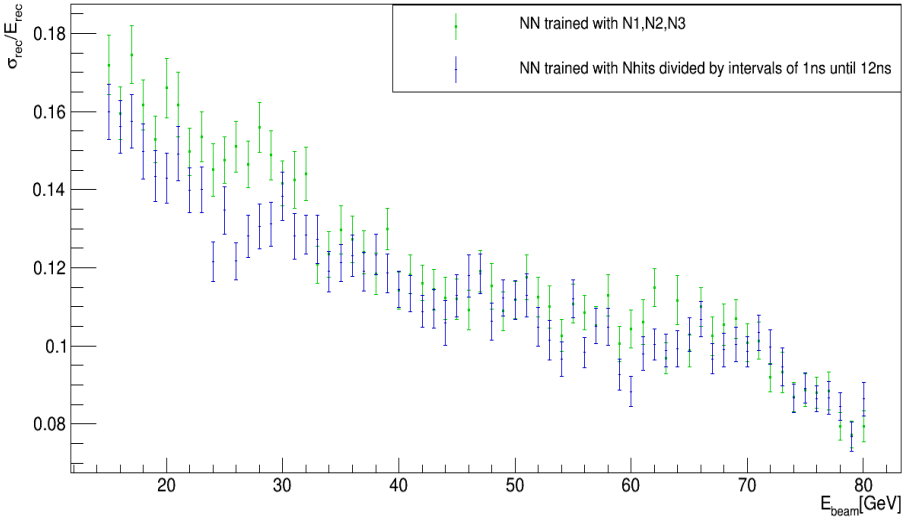


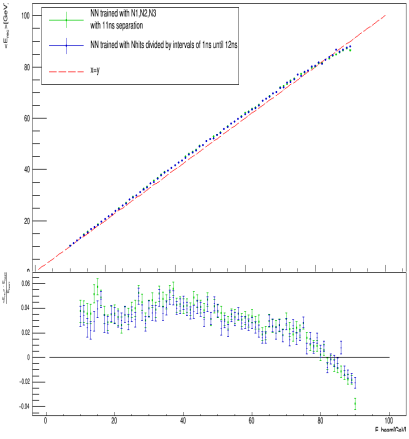


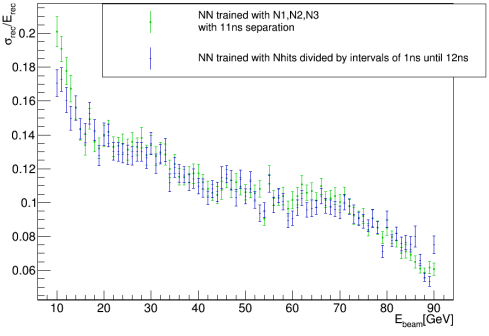
Backup


NN trained with N1,N2,N3
NN trained with Nhits divided by intervals of 1ns until 12ns
x=y
<E_rec>[GeV]
(<E_rec> - E_beam) / E_beam
E_beam[GeV]

Backup


NN trained with N1,N2,N3
NN trained with Nhits divided by intervals of 1ns until 12ns
σ_{rec}/E_{rec}
0.18
0.16
0.14
0.12
0.1
0.08
20
30
40
50
60
70
80
E_{beam}[GeV]


NN trained with N1,N2,N3
with 11ns separation
NN trained with Nhits divided by intervals of 1ns until 12ns
f=y


NN trained with N1,N2,N3
with 11ns separation
NN trained with Nhits divided by intervals of 1ns until 12ns
σ_{rec}/E_{rec}
E_{beam}[GeV]