Energy reconstuction of hadron showers with a neural network approach

Katja Seidel

Max-Planck-Institut für Physik

07.12.2009

Analsysis Overview

- Test beam and simulated data for CERN-07 pion runs: 10 GeV - 80 GeV

- Clustering in HCal. Search for showers that begin in HCAL
- Define cluster properties. Each property should show large differences for the different energies.

- Simulated 200000 events with energies between 5 GeV - 105 GeV in 0.1 GeV steps. $\Rightarrow$ data set for training of neural network.
- Train a neural network with a simulated data set. Input values are the cluster properties. Target value is the beam energy.
- Test neural network on test beam and simulated data for the chosen runs.

Clustering in AHCAL

Seed finding: Seed finding: Projection of all hits on front of HCal. Local maxima are chosen as seeds.

Cluster hist: Only cells which have a gap of more than 2 cells to the nearest cluster hit are not collected to the cluster.

Lost energy: For all energies an energy amount of $\approx 20 - 30\,\mathrm{MIP}$ is lost/not counted.

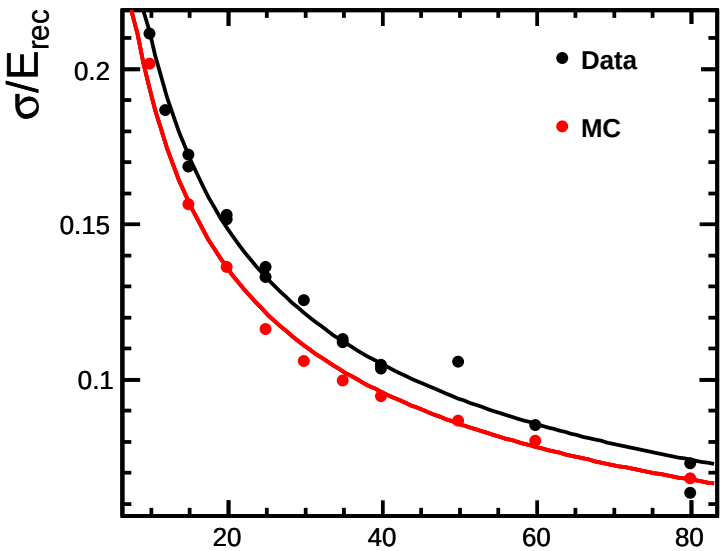
Cut on ECAL to only look at clusters which start in the HCAL. Clusters can leak in Tcmt. Energy loss results in a worse stochastic term of the energy resolution:

$$\frac{\sigma}{E} = \frac{66.3 \pm 1.2\%}{\sqrt{E}} \oplus 0.0 \pm 1.1\% \oplus \frac{0.0}{GeV}$$

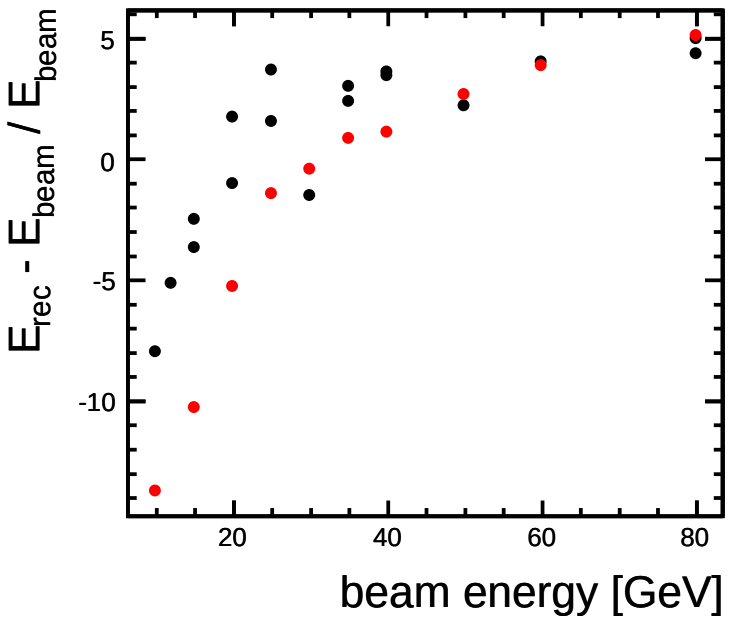
compared to the energy resolution of the full CALICE setup (CAN15) of

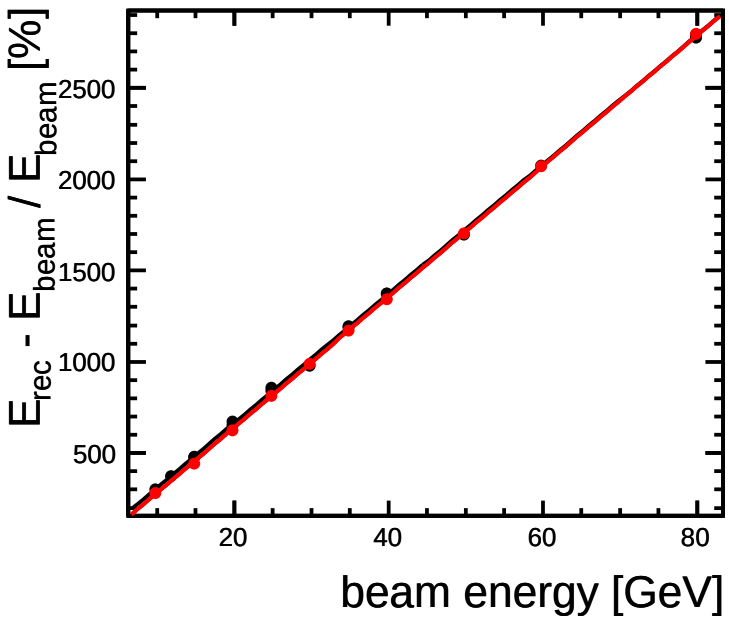
$$\frac{\sigma}{E} = \frac{61.3 \pm 0.1\%}{\sqrt{E}} \oplus 2.54 \pm 0.1\% \oplus \frac{0.0}{GeV}$$

but a smaller constant term.



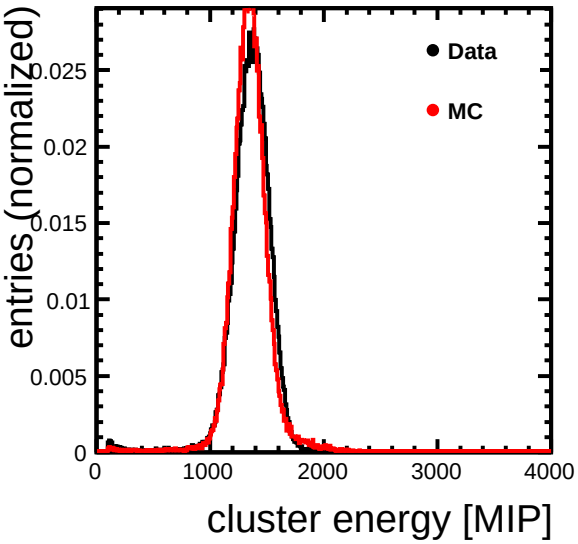
Linearity

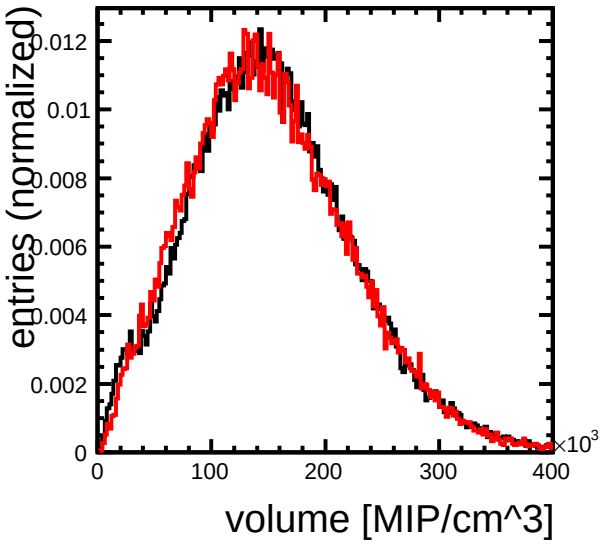


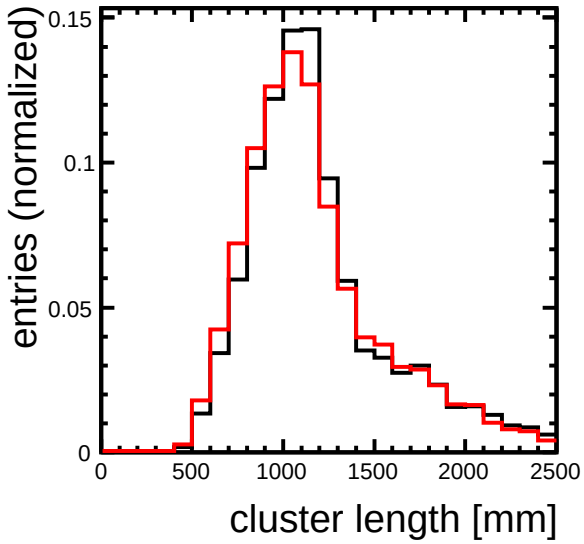


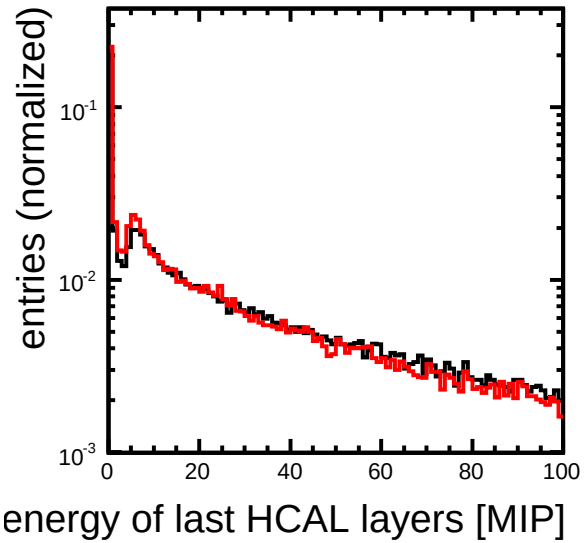
Mip to GeV factor $0.03\ \frac{\mathrm{GeV}}{\mathrm{MIP}}$.

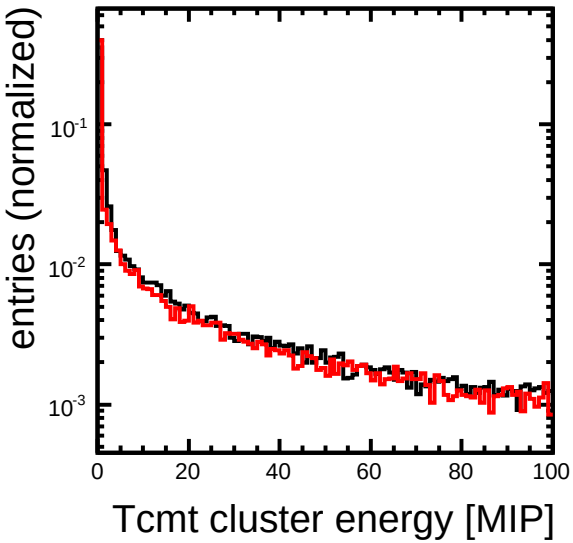
Cluster Properties for 40 GeV π^- run

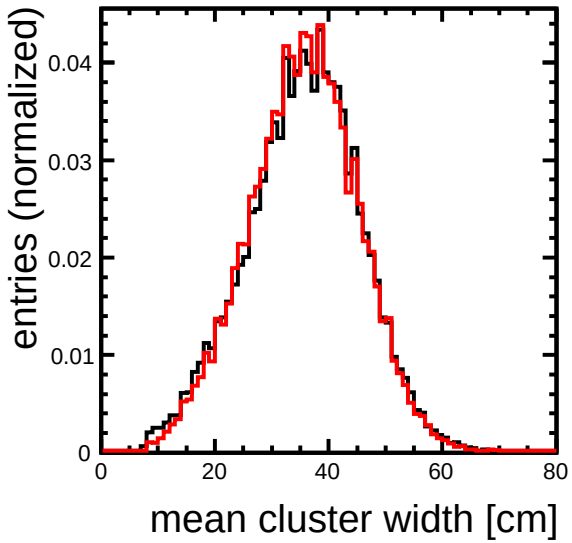










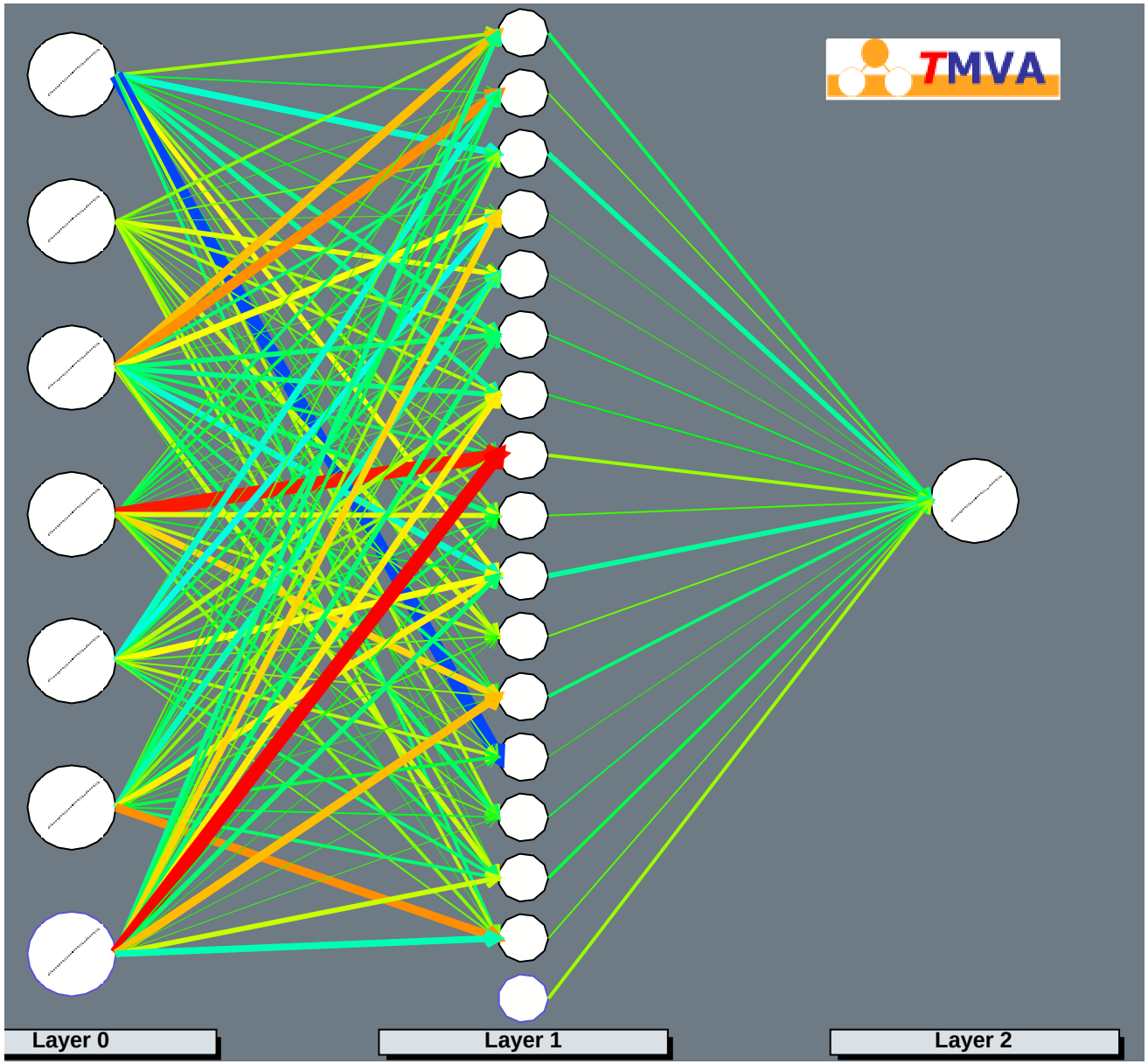


TMVA - MLP Neural Network

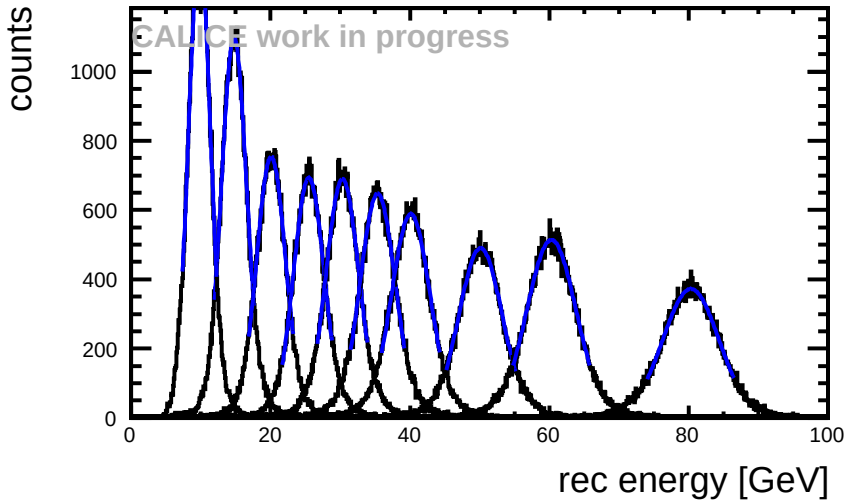
TMVA - Toolkit for Multivariate Data Analysis with ROOT
Input:

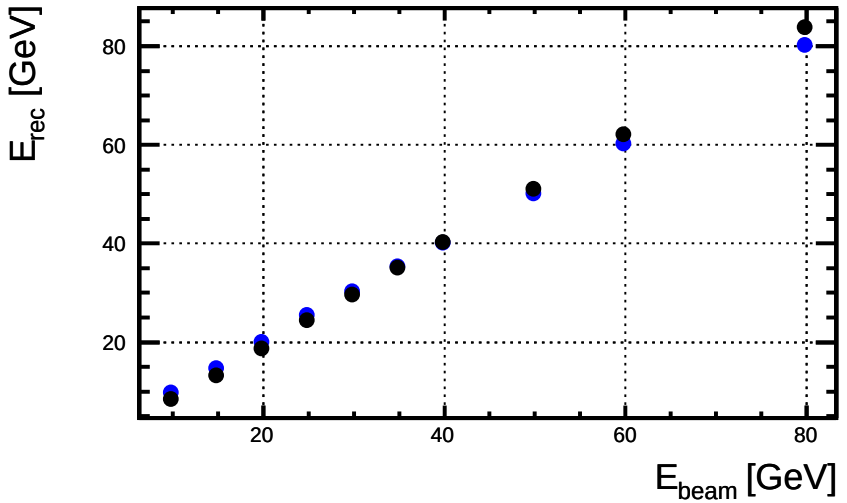
- $\approx$ 200000 MonteCarlo events (QGSP_BERTINI) simulated (π^- beam)
- nearly continuous energy (energy steps of 0.1 GeV)
- energy range 5.0 - 105.0 GeV
- 6 input variables
- function used (called "weight expression" in TMVA), to improve reconstructed energy for small energies (< 30 GeV)
- Trained network with different number of hidden layers and neurons. Following results with one hidden layers and 16 neurons.

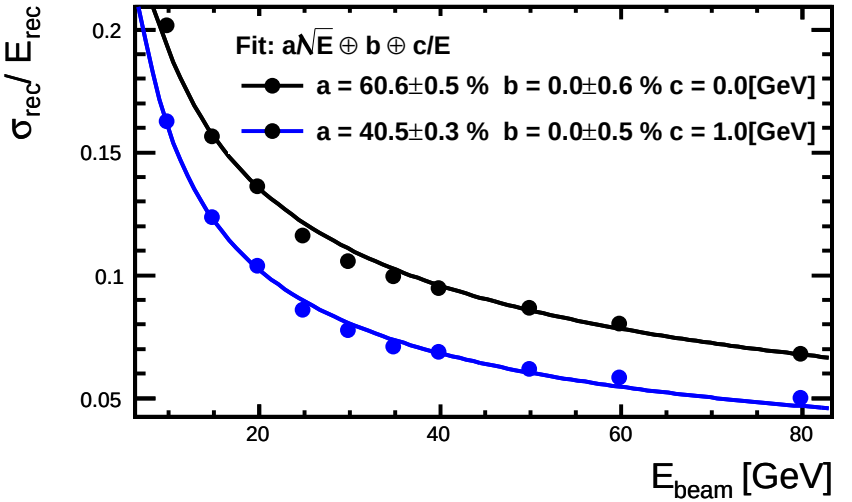
TMVA - Neural Network architecture

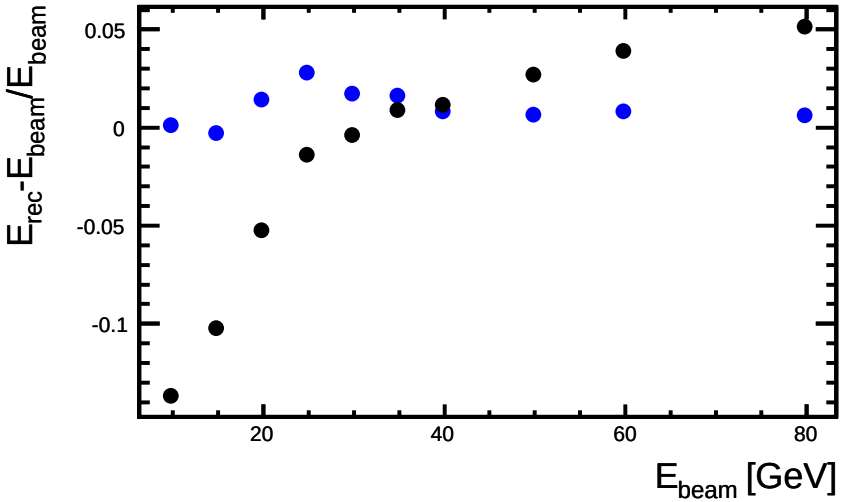


Neural Network - MC - QGSP_BERT

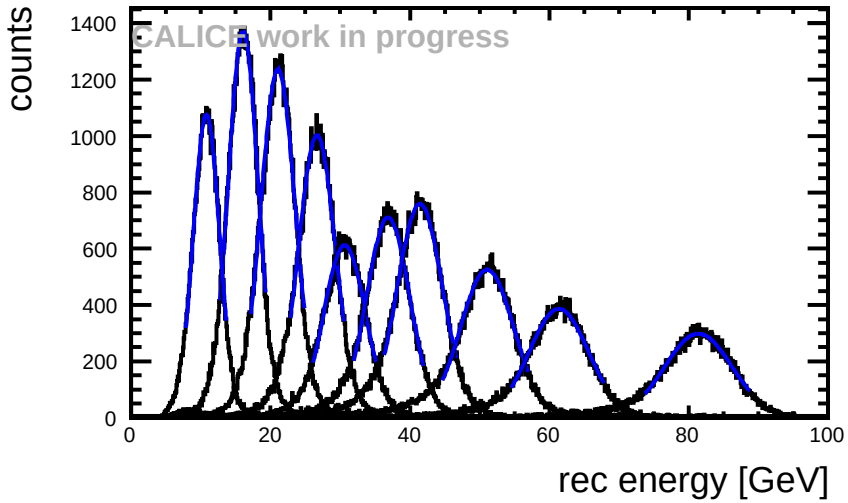


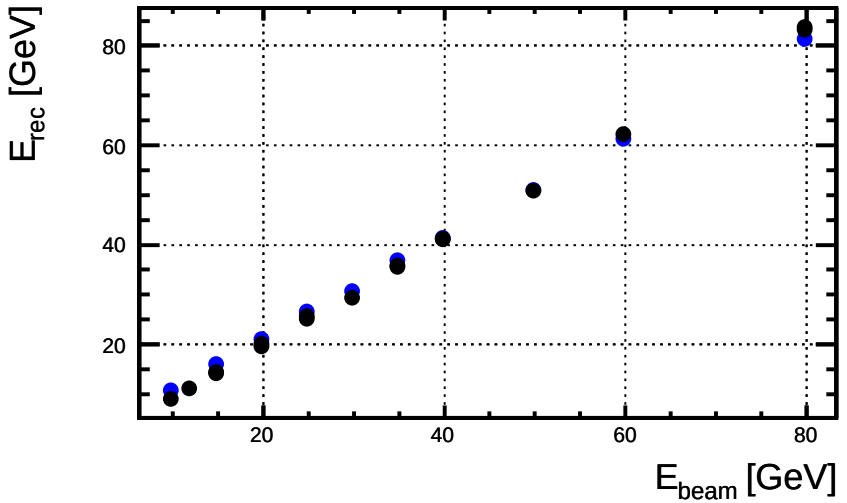


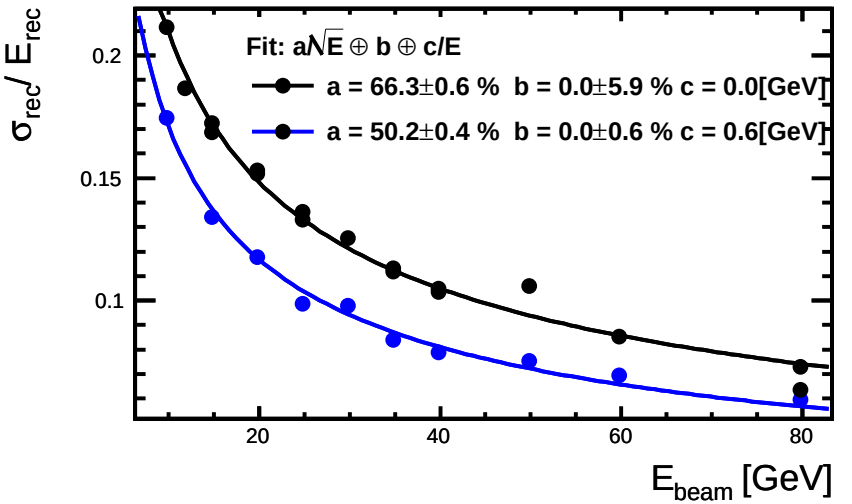


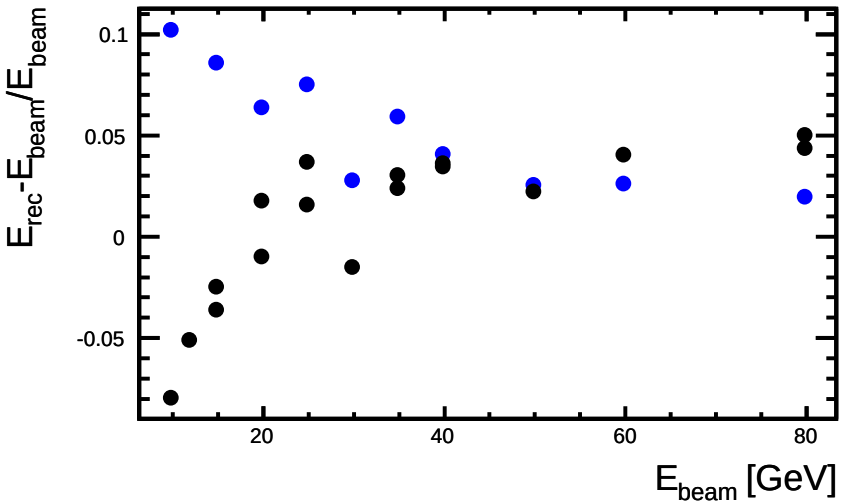


Neural Network - Data









Summary

- Very simple clustering algorithm developed
- Input variables for neural net defined
- Neural network approach work for simulated and test beam data
- Proplem: Linearity in data. $\Rightarrow$ Try to use a better "weight expression"