ENERGY RECONSTRUCTION IN GRPC SEMI-DIGITAL HCAL

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# Simulation study of RPC based HCAL

- Introduction
- Resistive Plate Chamber (RPC) based Hadron Calorimeter
- Monte Carlo study: Single Pion Studies
  - o Digital calorimeter: Resolution & Linearity
  - o Semi-Digital calorimeter: Resolution & Linearity
- Energy reconstruction using Neural Network
- Summary

Glass Resistive Plate Chamber (GRPC) based Hadron Calorimeter

- A simulation of a 1m x 1m x 1.24m prototype calorimeter was done based on Geant4 package
  - Number of layers 48
  - Default cell size: 1cm x 1cm
  - Gaz: 93%TFE($C_2H_2F_4$)+5%isobutane+2%SF6
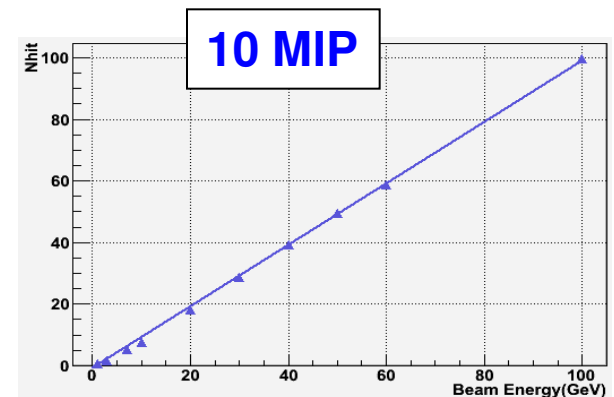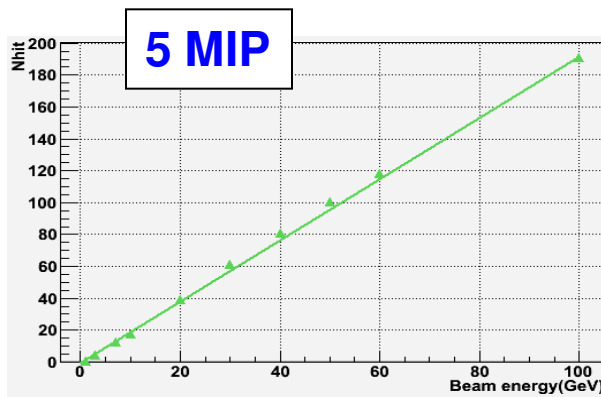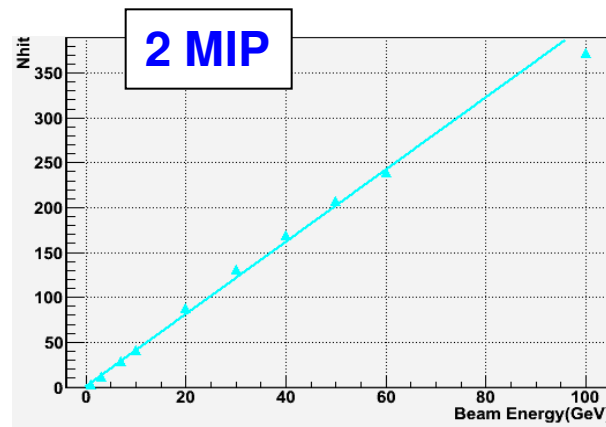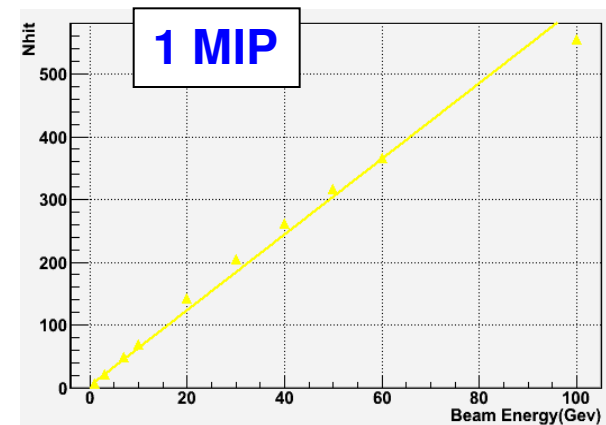
- Single pion events : incident energy range: 1 – 100GeV
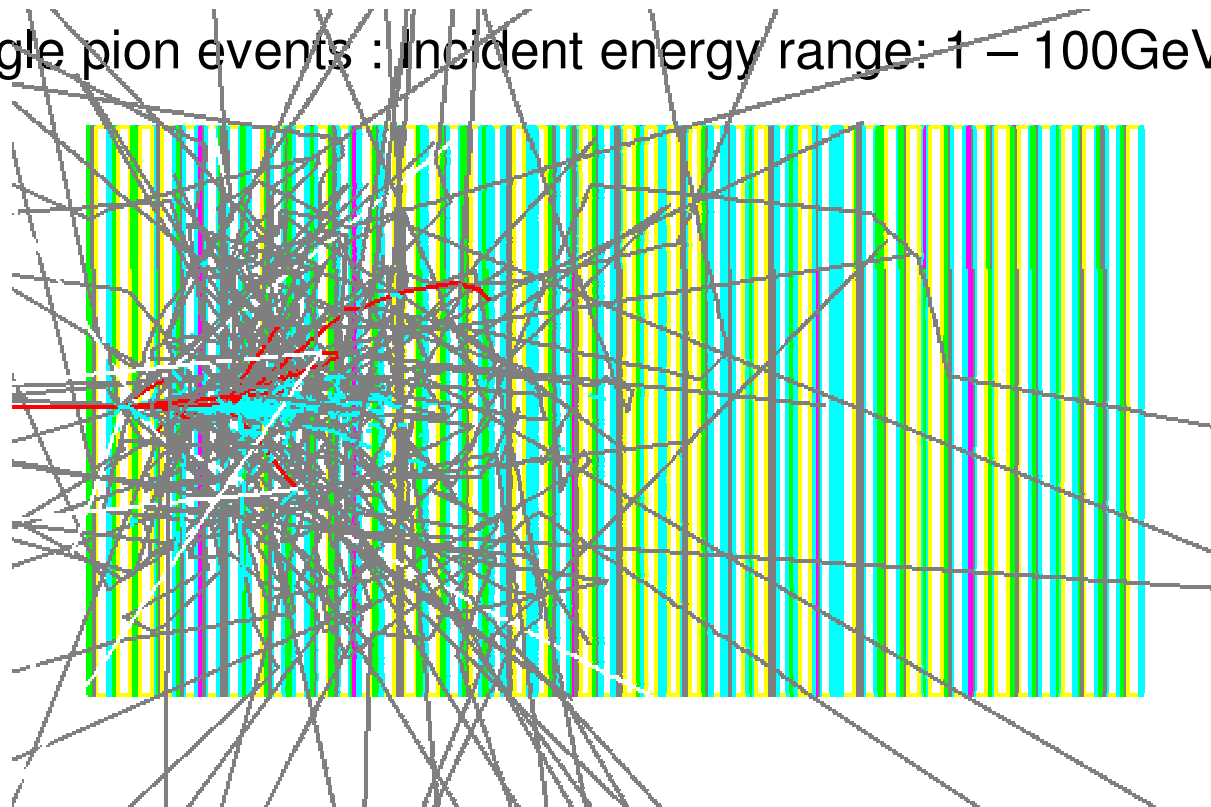
Glass Resistive Plate Chamber (RPC) as an Active Medium of Digital Hadron Calorimeter
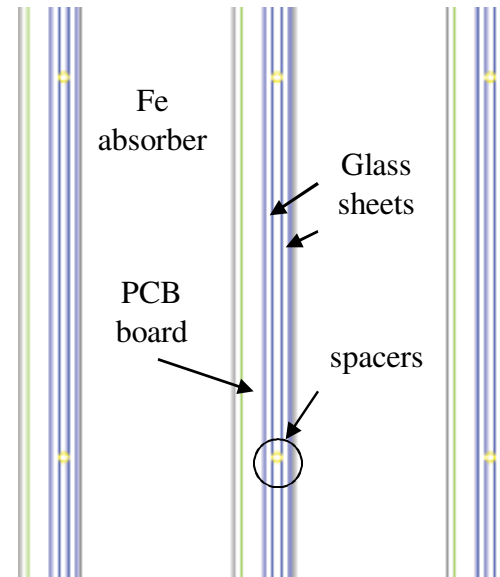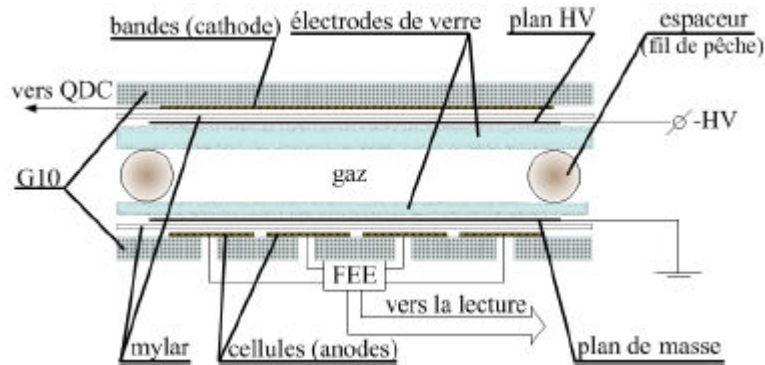
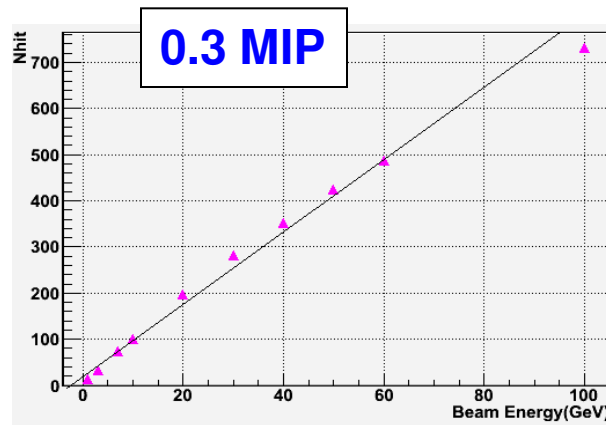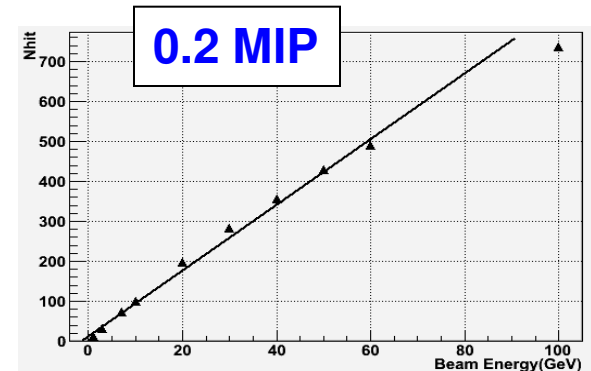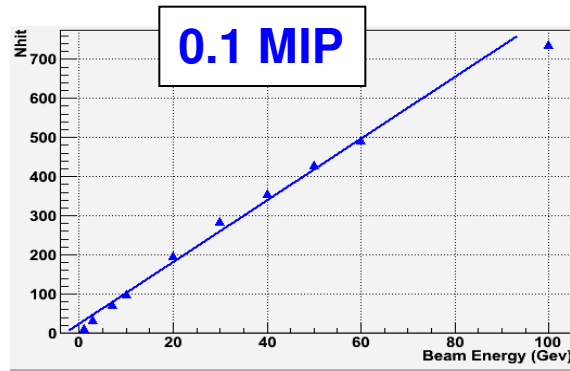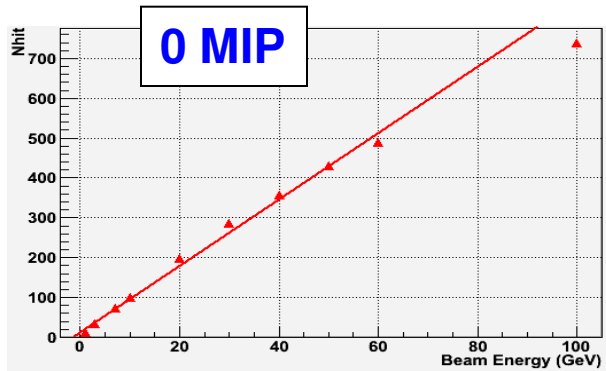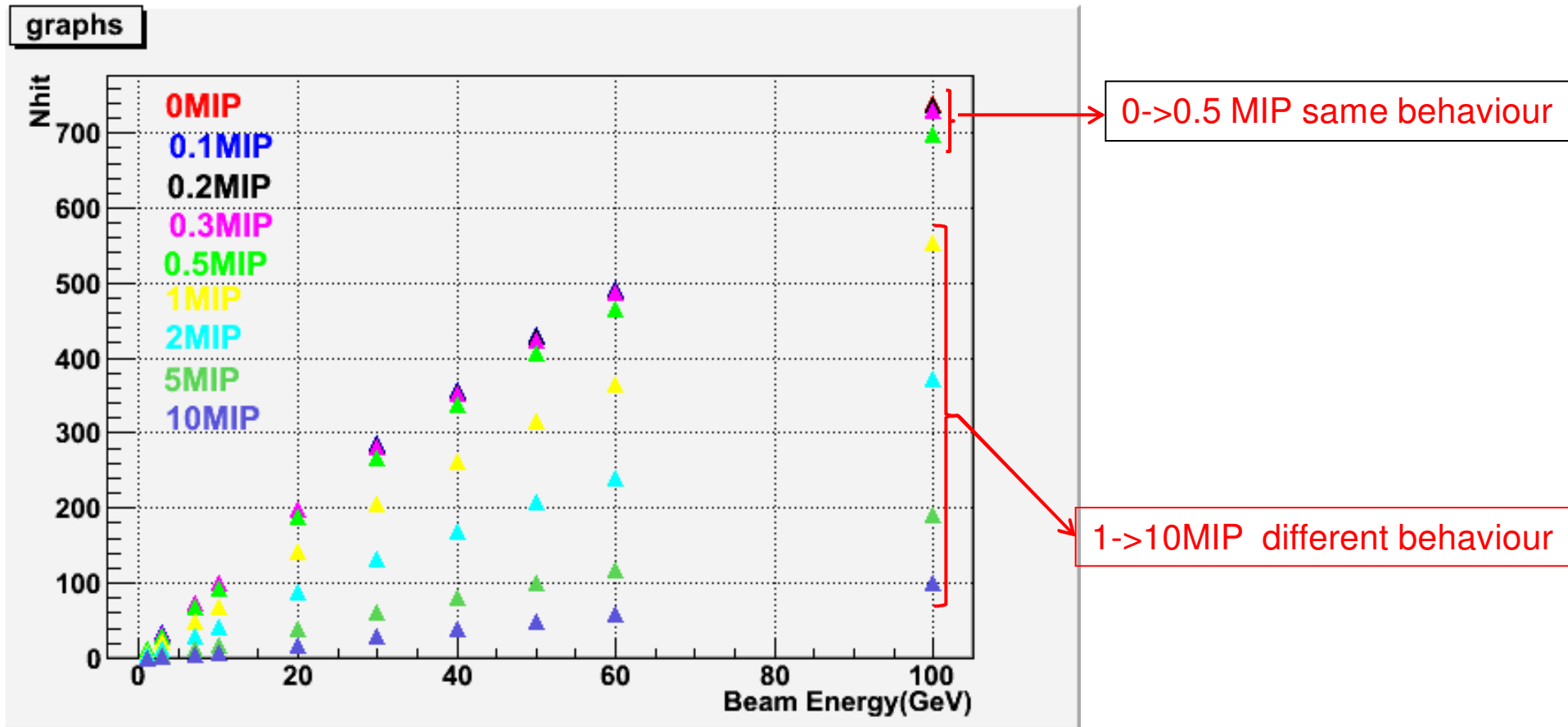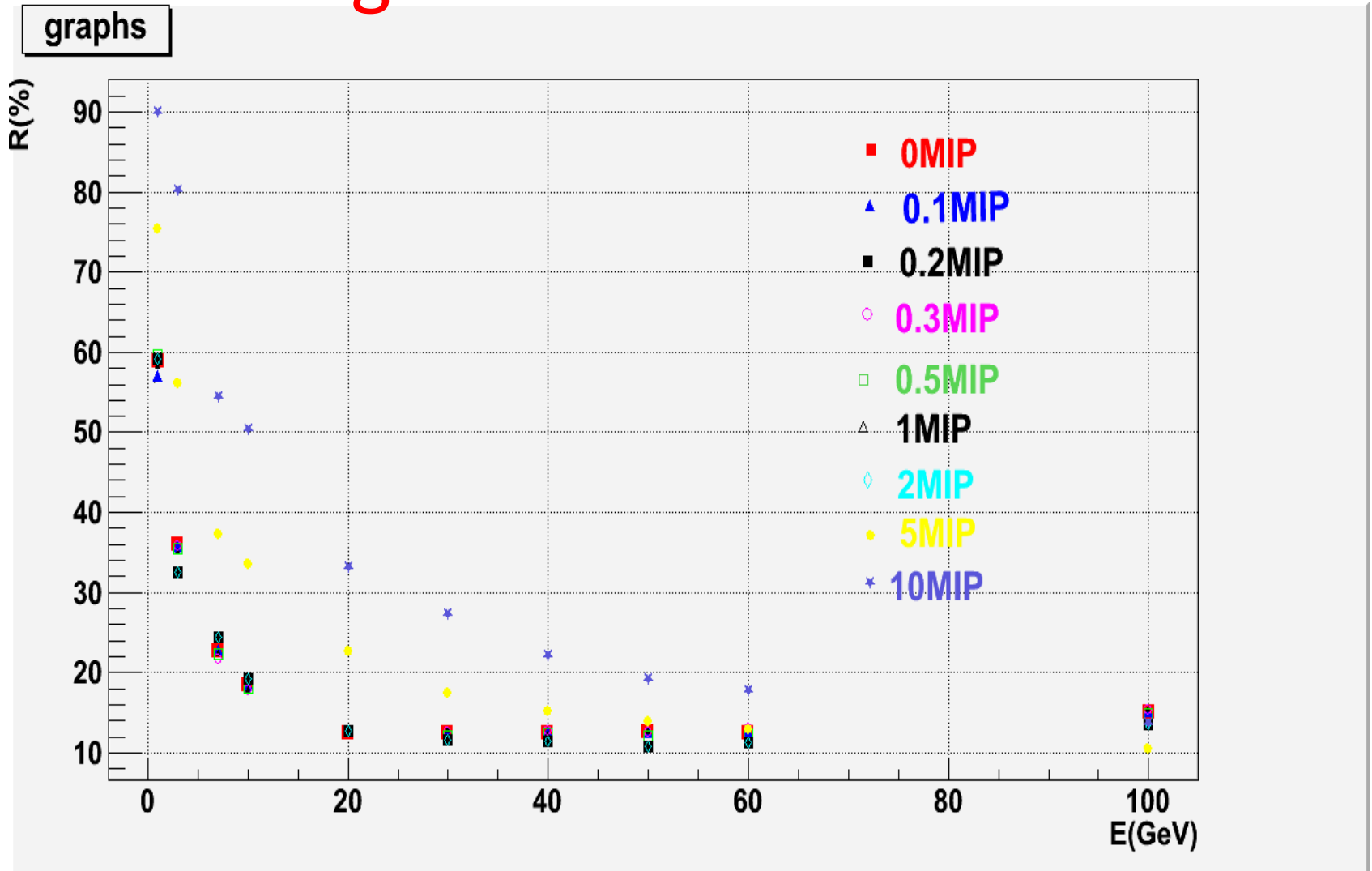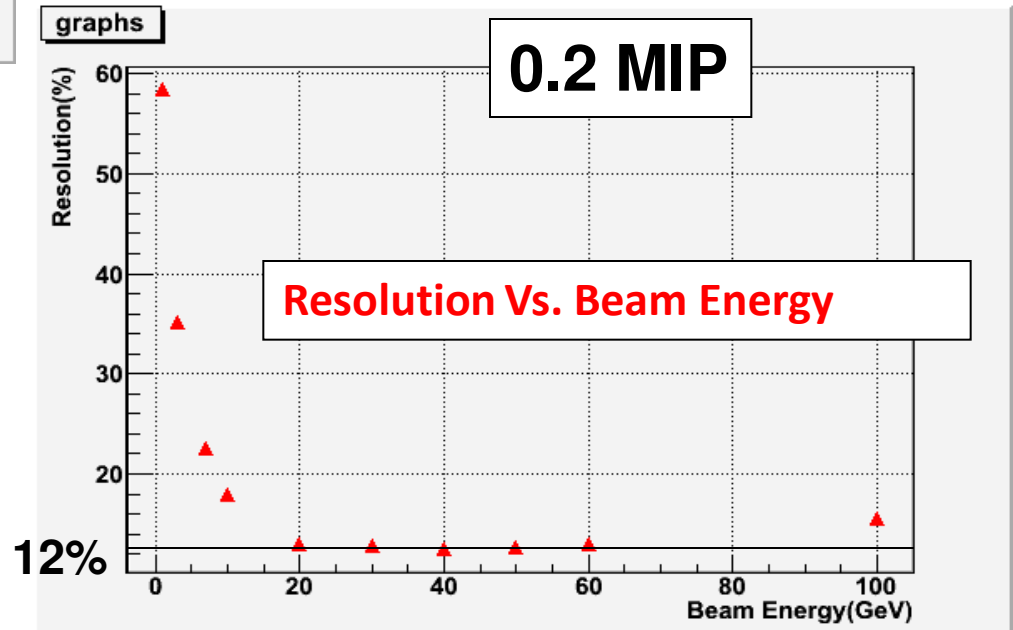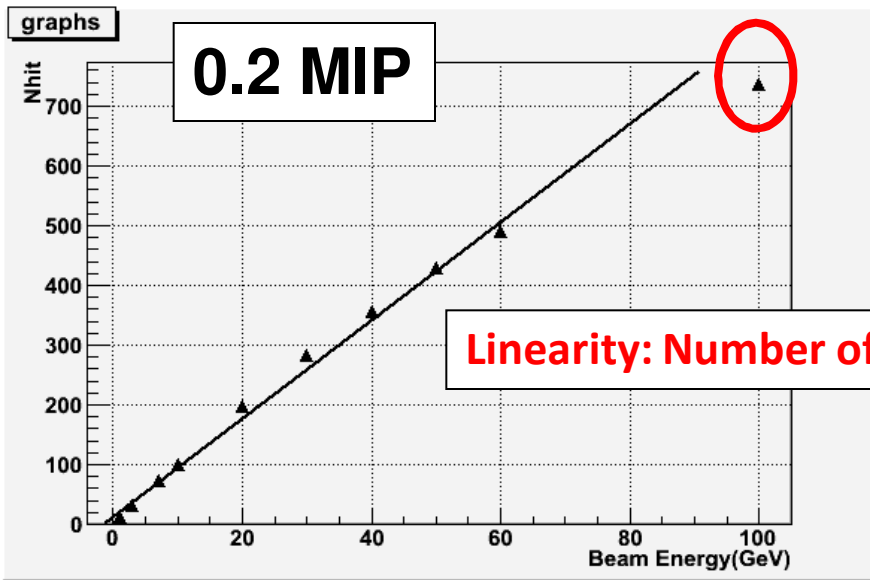GRPC

Linearity: Digital solution
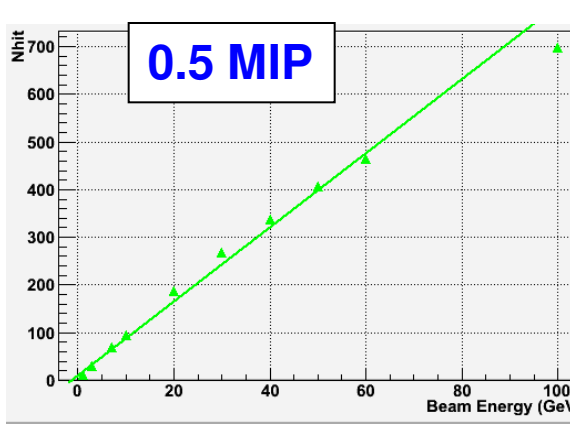
Linearity for different thresholds: Digital solution

Resolution for different thresholds: Digital Solution

Linearity & resolution: Digital Case

0.2 MIP

Linearity: Number of Hits(0.2MIP) Vs. Incident Energy

0.2 MIP

Resolution Vs. Beam Energy

12%

Semi-Digital solution

Energy reconstruction

Semi-digital solution: 3 thresholds ⟷ **NS1, NS2, NS3**

Where: NS1 = number of hits exceeds the threshold 1 (**0.2 MIP**)
NS2 = number of hits exceeds the threshold 2 (**5 MIP**)
NS3 = number of hits exceeds the threshold 3 (**10 MIP**)

Reconstructed Energy:

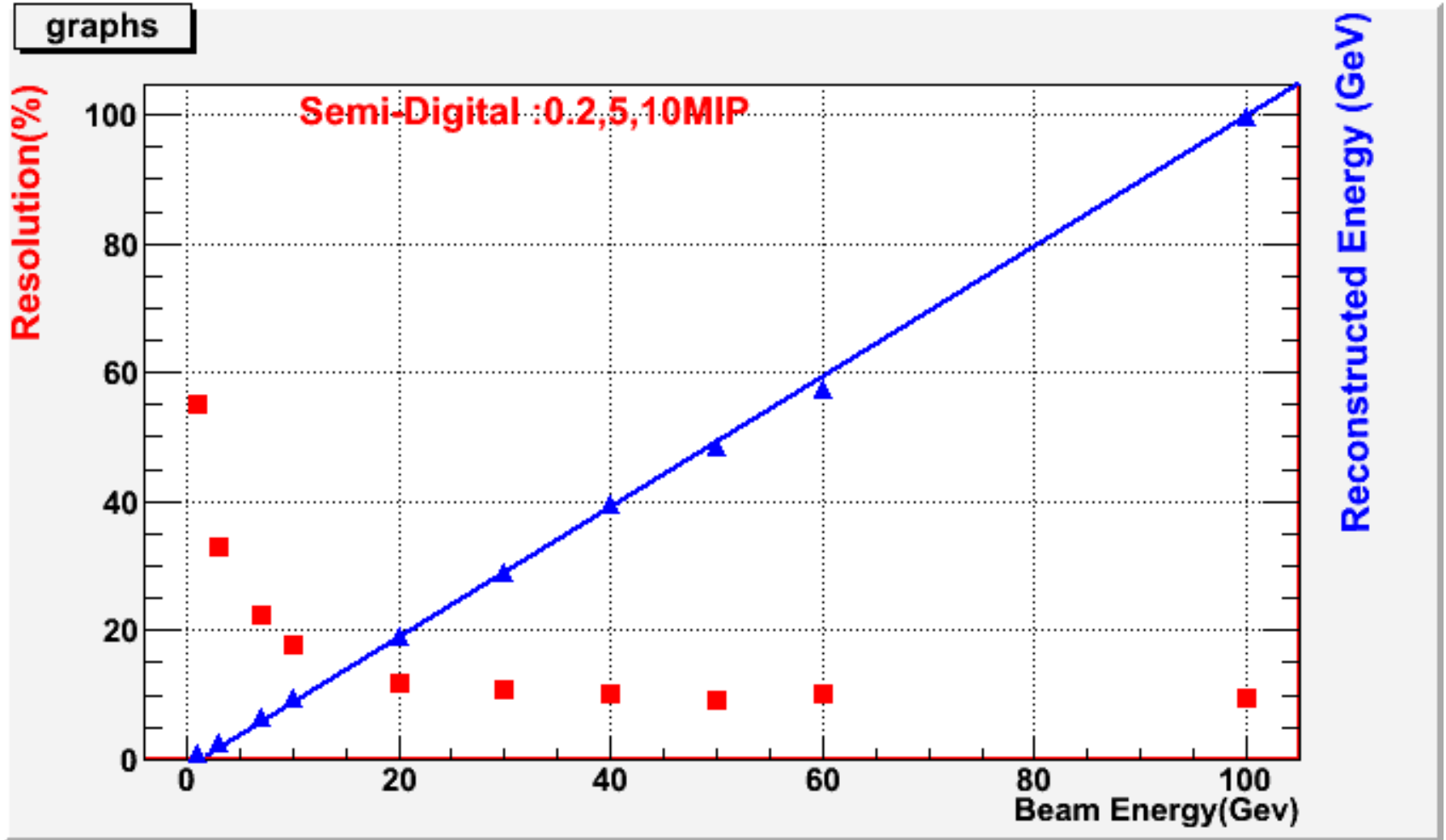$$E_{rec} = (a \times N_{S1} + b \times N_{S2} + c \times N_{S3})$$

a, b et c optimum ⟶ **Minimisation :** χi^2

$$\chi i^2 = \frac{1}{N} \times \sum_{i=1}^{N} \frac{(E_{beam} - (a \times N_{S1} + b \times N_{S2} + c \times N_{S3}))^2}{\sigma^2} + \frac{1}{N} \times \sum_{i=1}^{N} \frac{\sigma_k^2}{\sigma'^2}$$
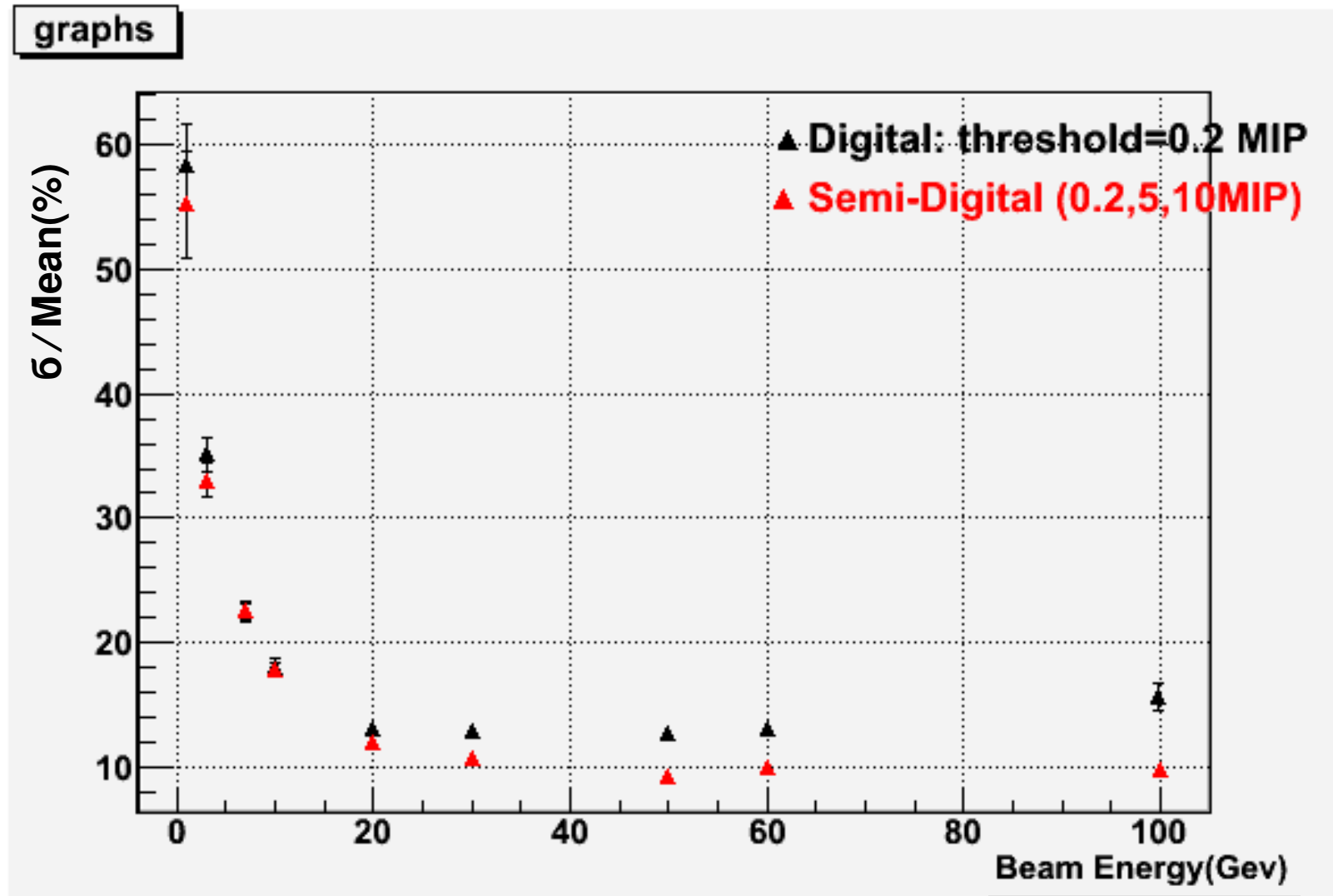
Where :

$$\sigma_k^2 = \left(F_{rec} - \overline{F_{rec}} \right)^2$$
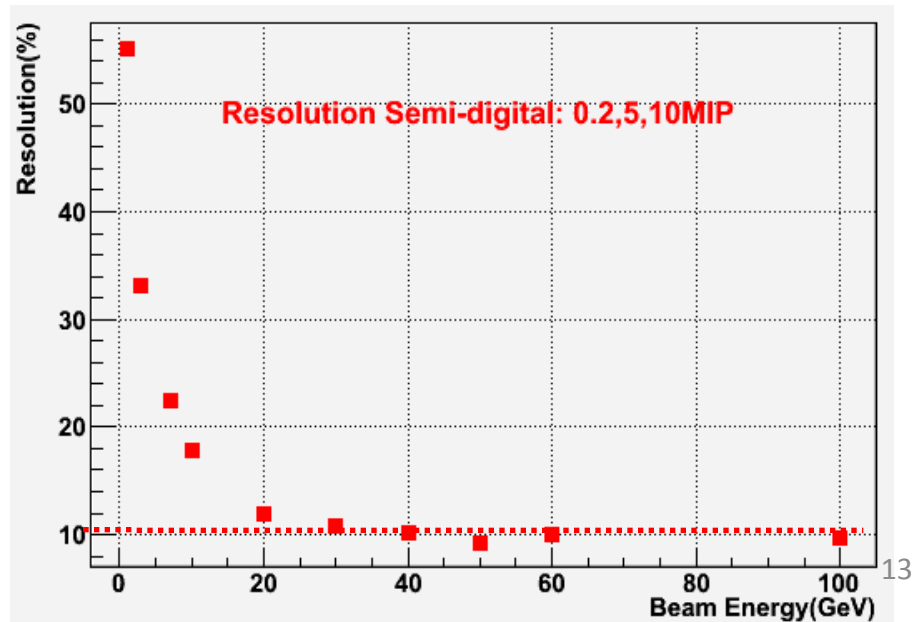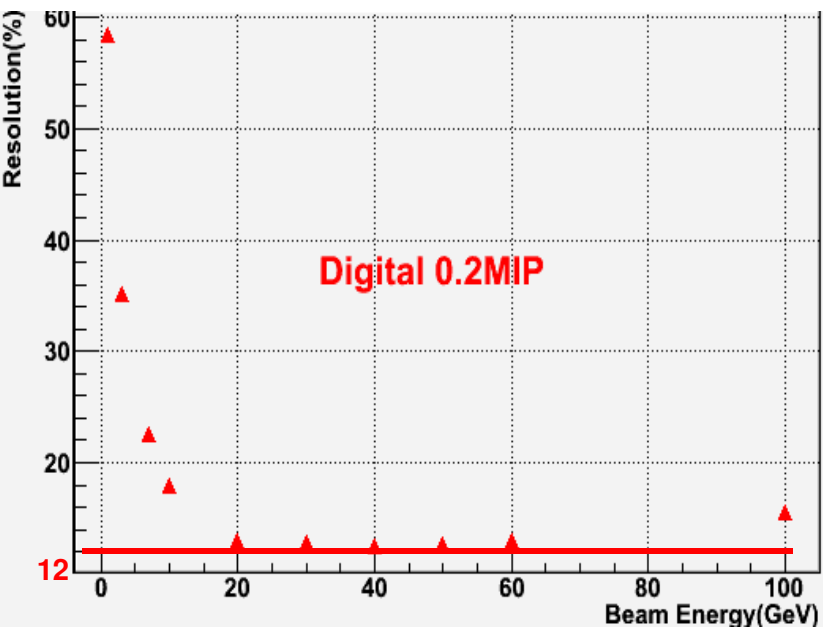
$$\overline{E_{rec}} - \sqrt{\frac{\sum_{i=1}^{N} E_{rec}}{N}}$$
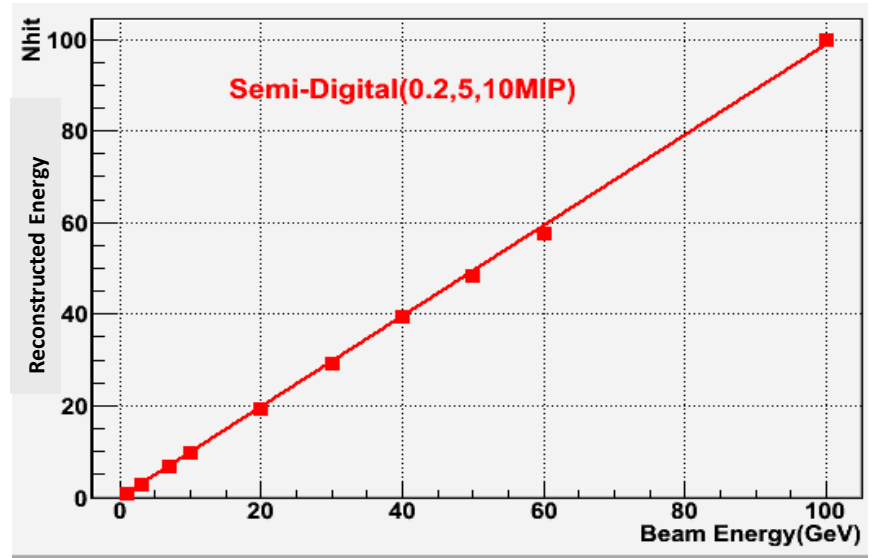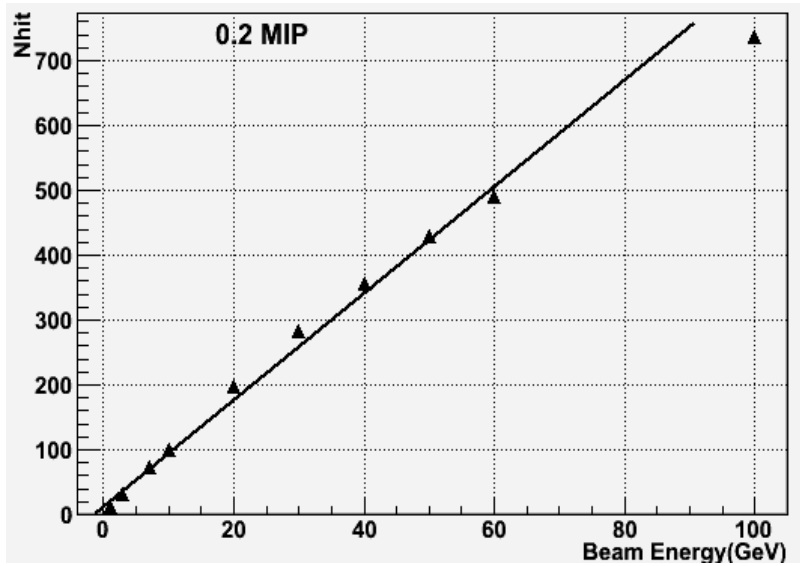
Resolution & Linearity Vs Beam Energy: Semi-Digital (0.2,5,10MIP)
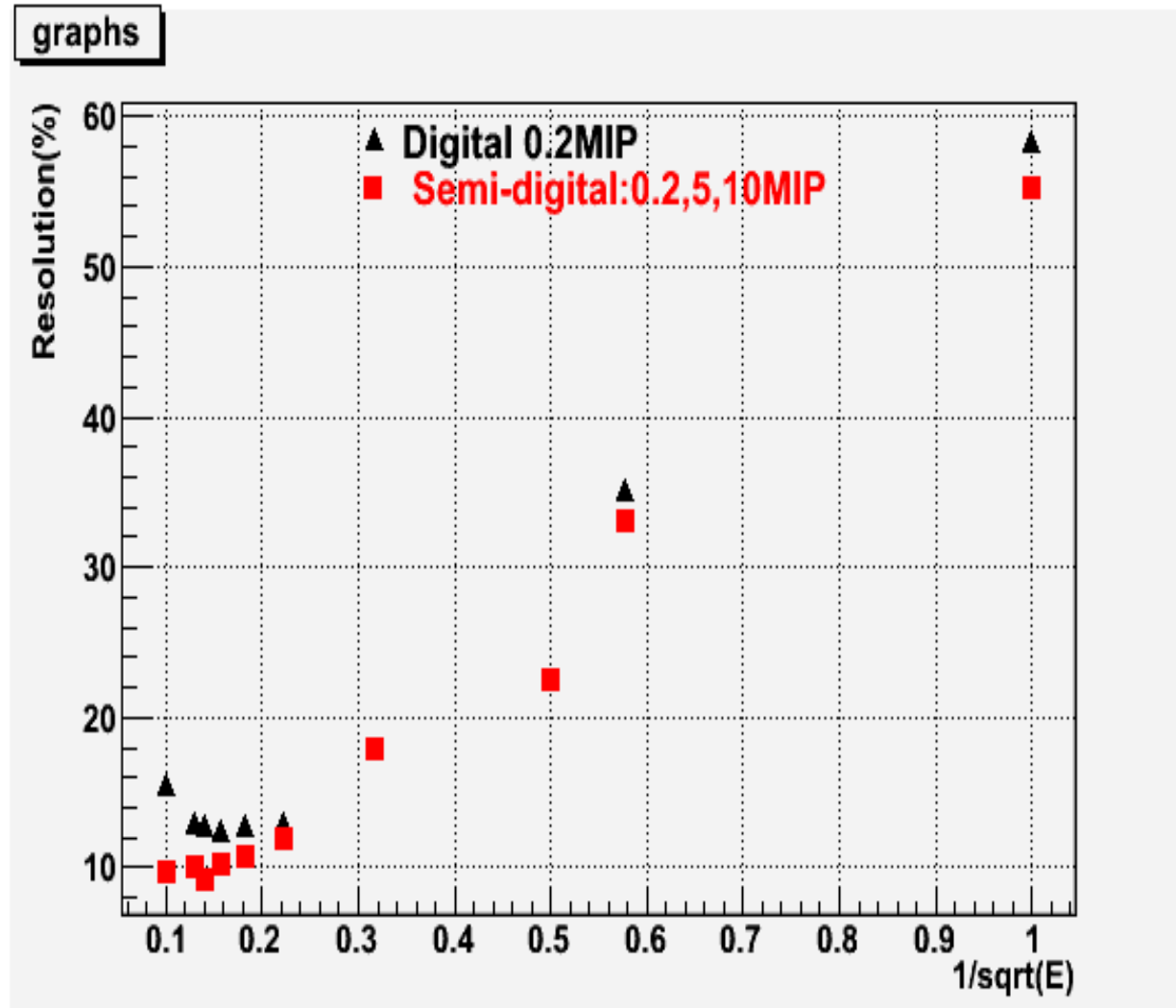
Comparison: Digital Vs. Semi-Digital

Comparaison Digital vs. Semi-Digital

Comparaison Digital vs. Semi-Digital

Energy reconstruction using Neural Network

The Neural Network class used is : TMultiLayerPerception (root)

1500 π^- are generated for each energy (1,10,20,30,40,50,60,70,80,90,100 GeV)

NS1= number of hits exceeds the threshold 1
NS2= number of hits exceeds the threshold 2 } **used for the tranning of the NN**
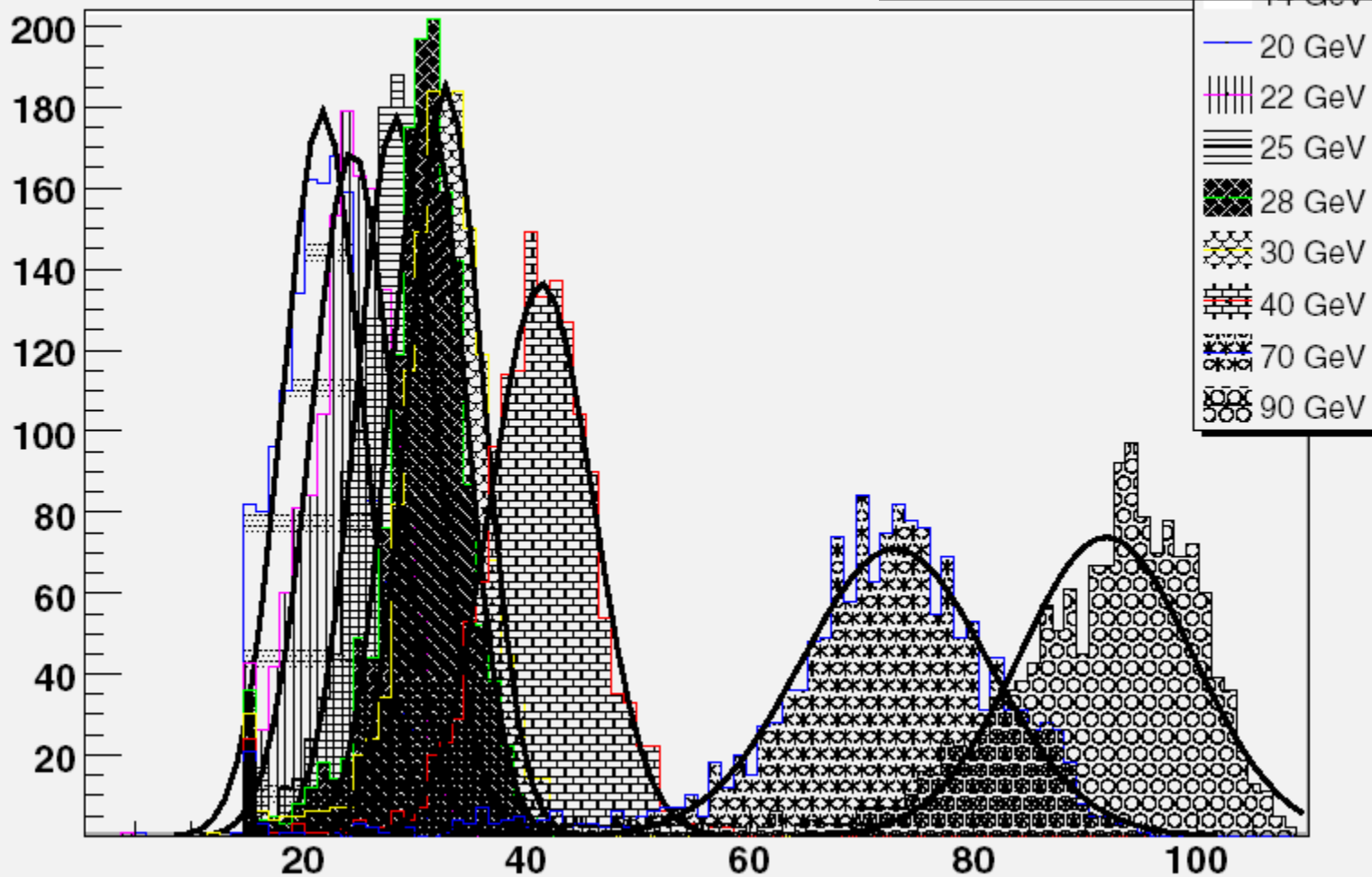NS3= number of hits exceeds the threshold 3

1500 π^- are generated for each energy (20,22,25,28,30,40,70,90 GeV)

used for the Test

NN output : Probability α Energy

NN output1

Energy reconstruction

Legend:
- 14 GeV
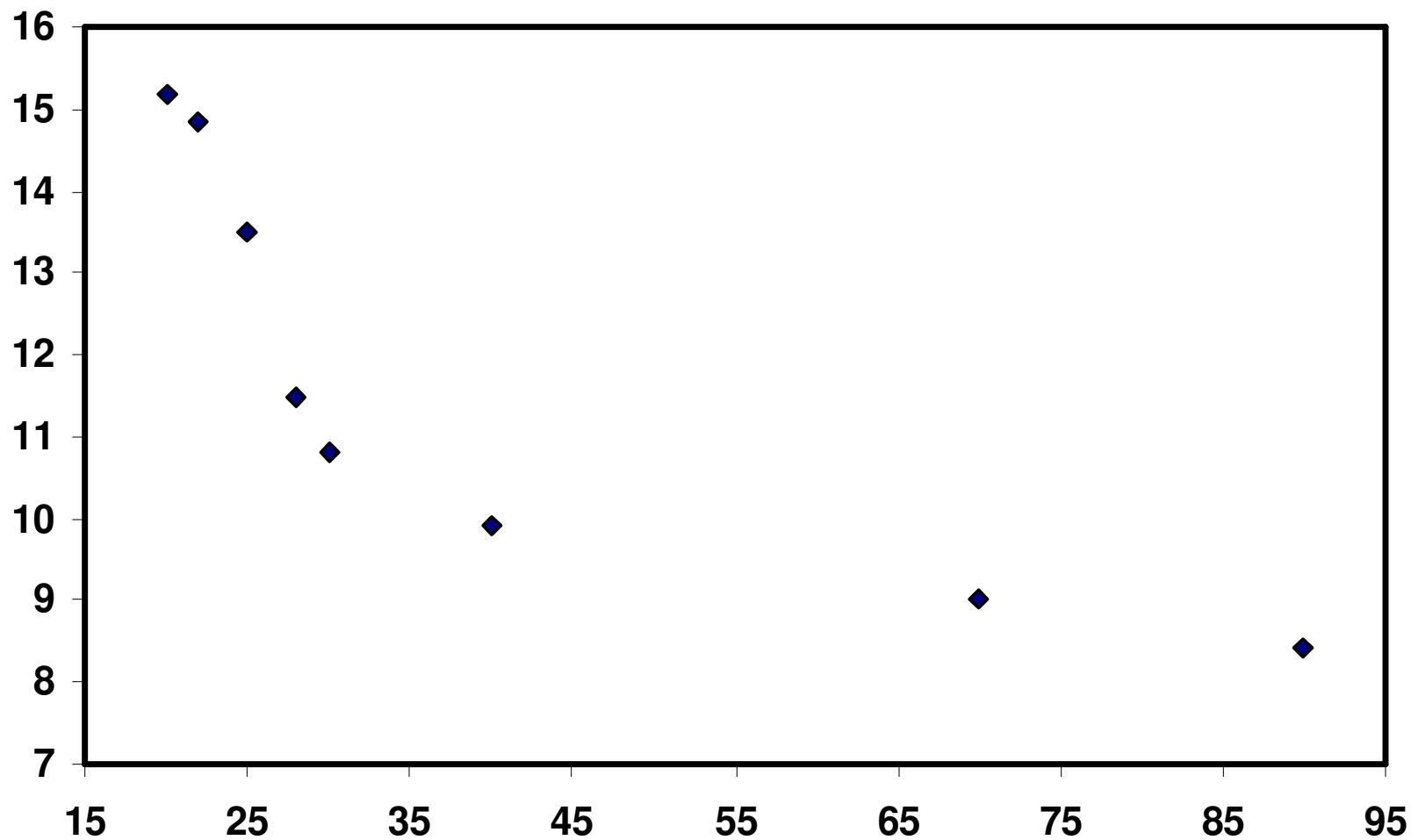- 20 GeV
- 22 GeV
- 25 GeV
- 28 GeV
- 30 GeV
- 40 GeV
- 70 GeV
- 90 GeV

Linearity Vs Beam Energy: Semi-Digital (0.2,5,10MIP)
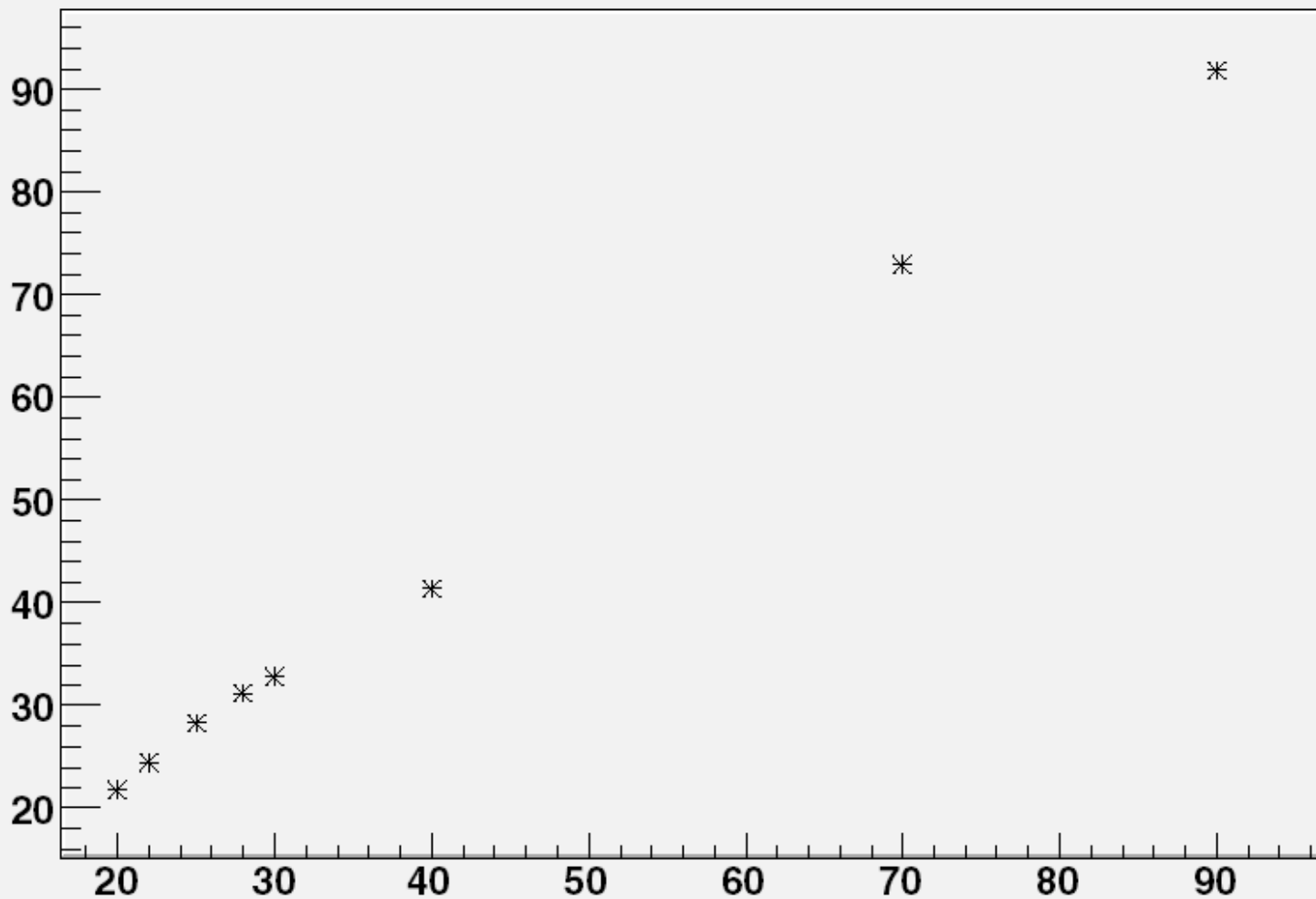
Resolution Vs Beam Energy: Semi-Digital (0.2,5,10MIP)

Conclusion

- Full simulation of realistic HCAL-RPC prototype was performed

- Both digital and semi-digital solution were studied

- Semi-digital seems to provide better linearity and better resolution for a convenient set of thresholds

- The study was based on the dE/dX information. This will be reperformed using the the charge accumulated (work developped by Manqi)

- Neural network can e very helpful. New variables related to the hadronic showers characteristics will be added