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Study of the energy response for AHCAL

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Samples

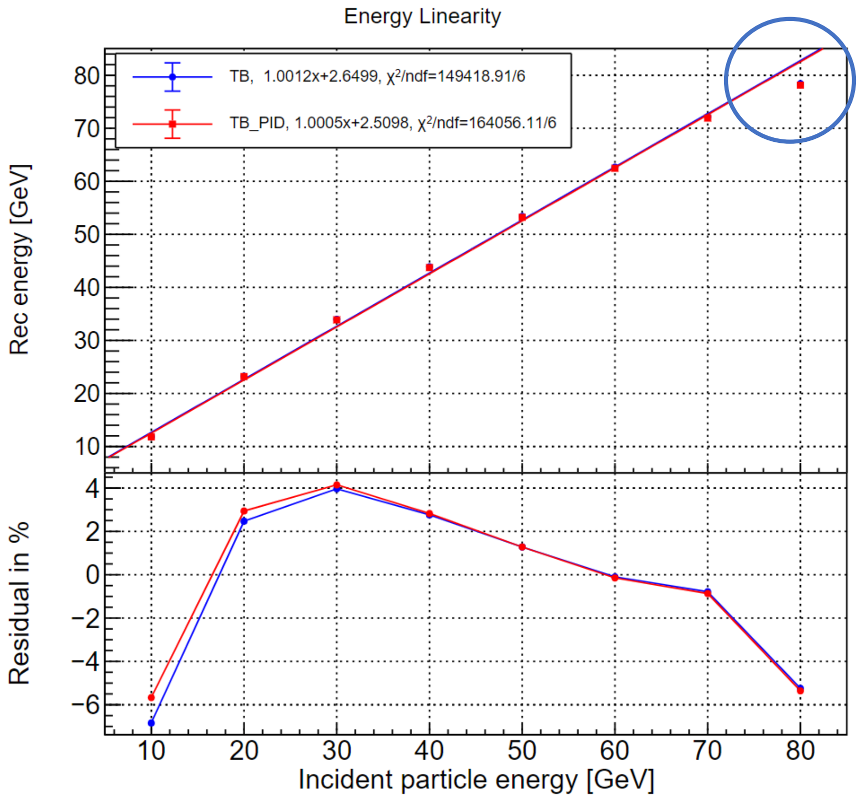
- TB data samples: /cefs/higgs/diaohb/CEPC2023/SPS/recostruction/HCAL_alone (2023 SPS, from Hongbin)
- MC samples: /cefs/higgs/dudejing/Beamtest/2023_CERN_SPS/SimValidation/Sim_data/Digi_DAChb_LG3000_20231210 (after channel by channel digitization)

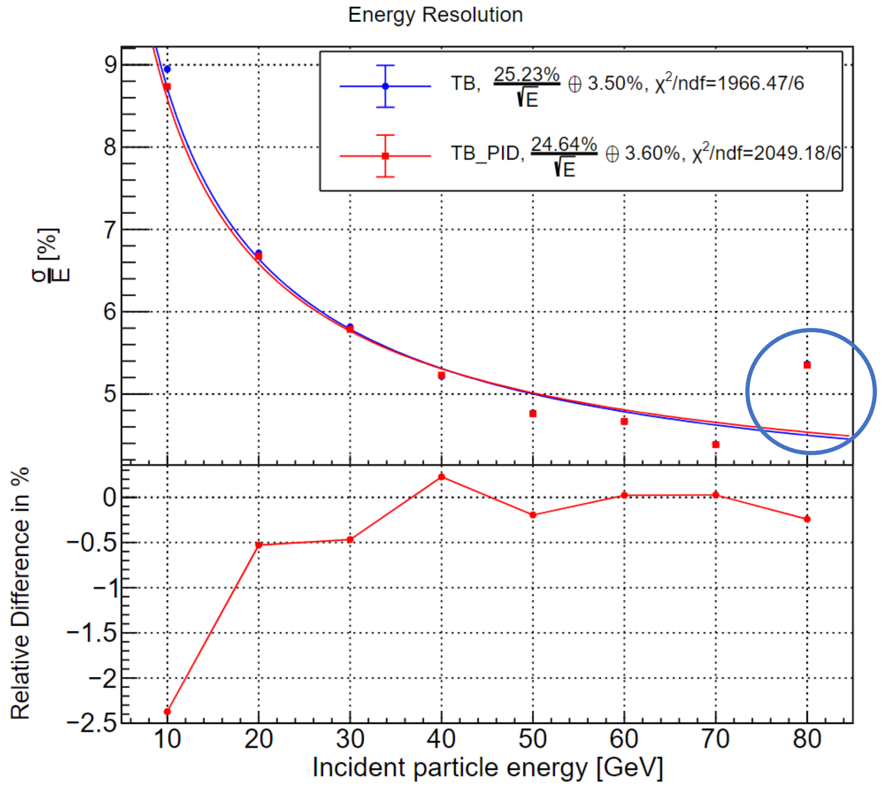
- TB data and MC have 0.5 MIP energy threshold

- PID: TB data are identified by FD (from Xin)

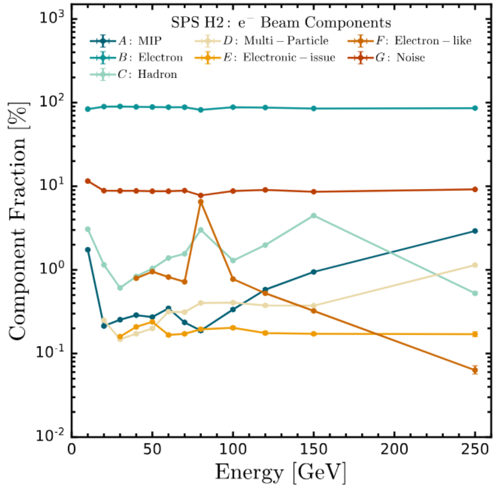
- Fitting by gaussian function, range of $\pm 2\sigma$

Electron energy response: testbeam data



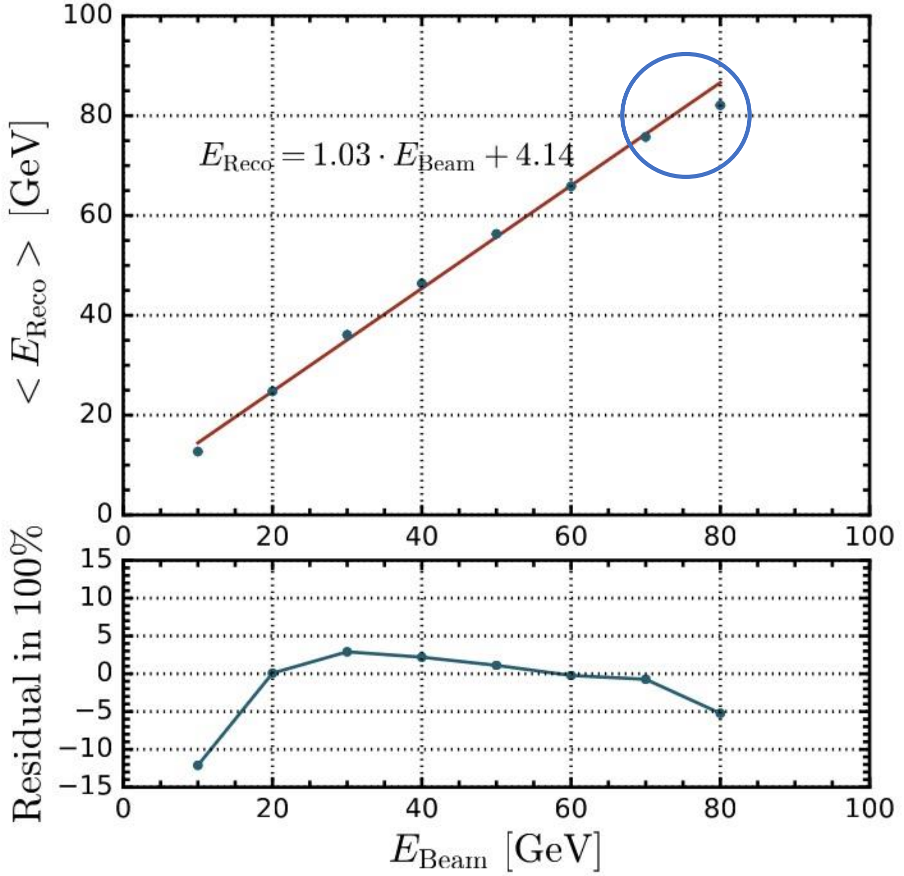


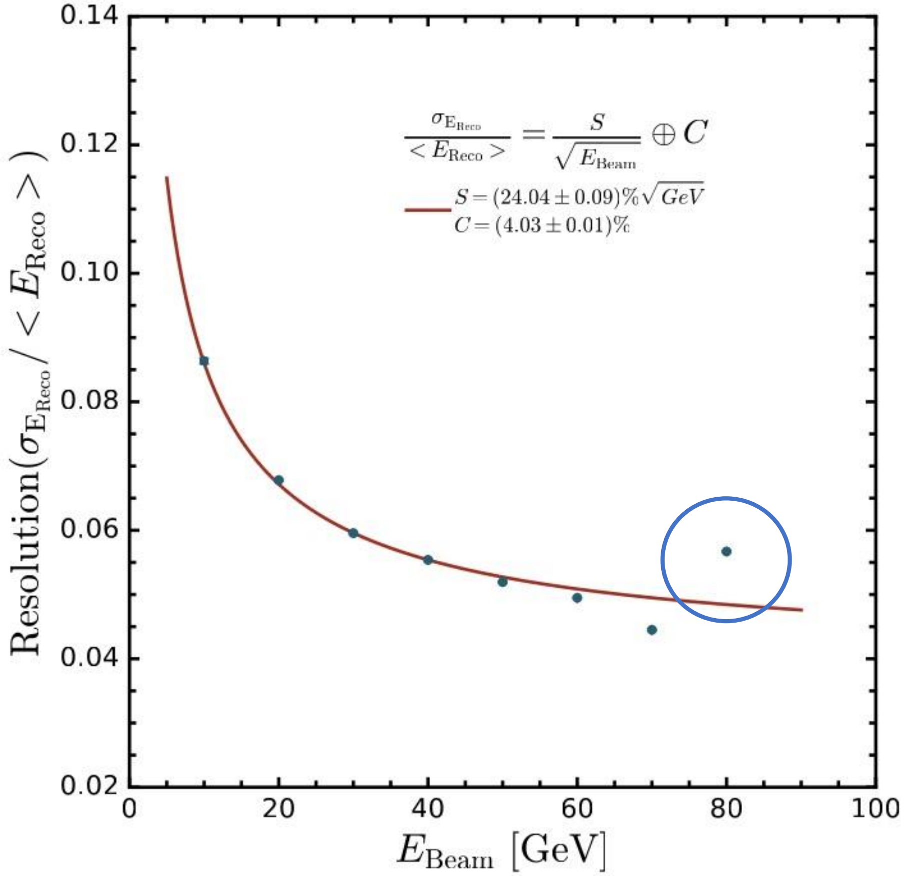
- PID has little effect on the energy response of electrons
- A significant saturation was observed
- SiPM saturation effect was not considered in data calibration ?



The purity of the electron beam remains consistently high, consistently exceeding 80%, and exhibits minimal dependence on the energy.

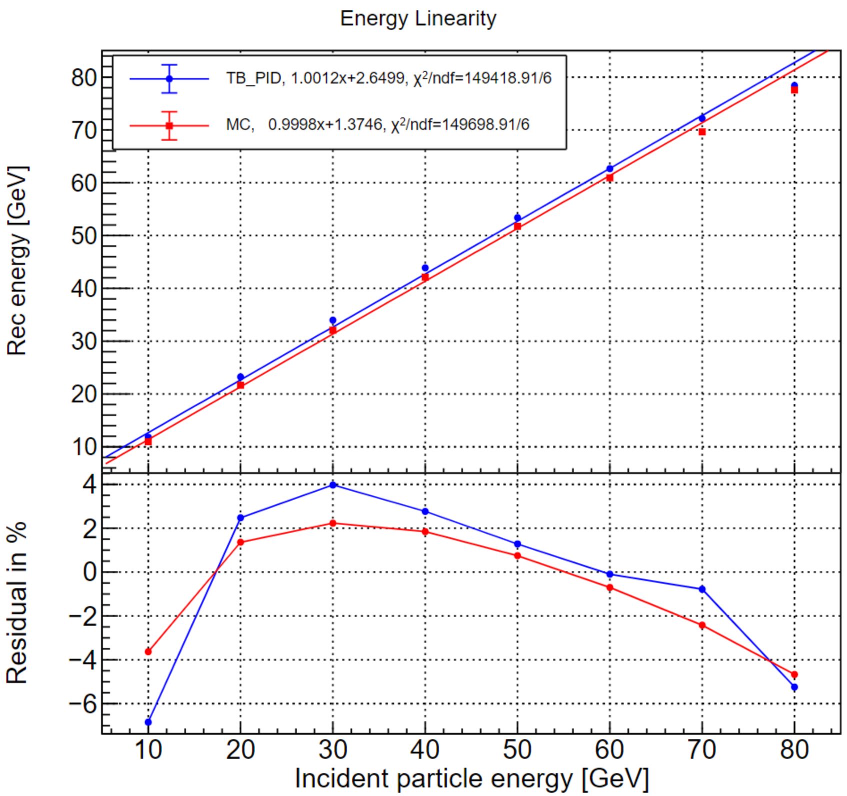
Electron energy response: testbeam data (by Xin Xia)

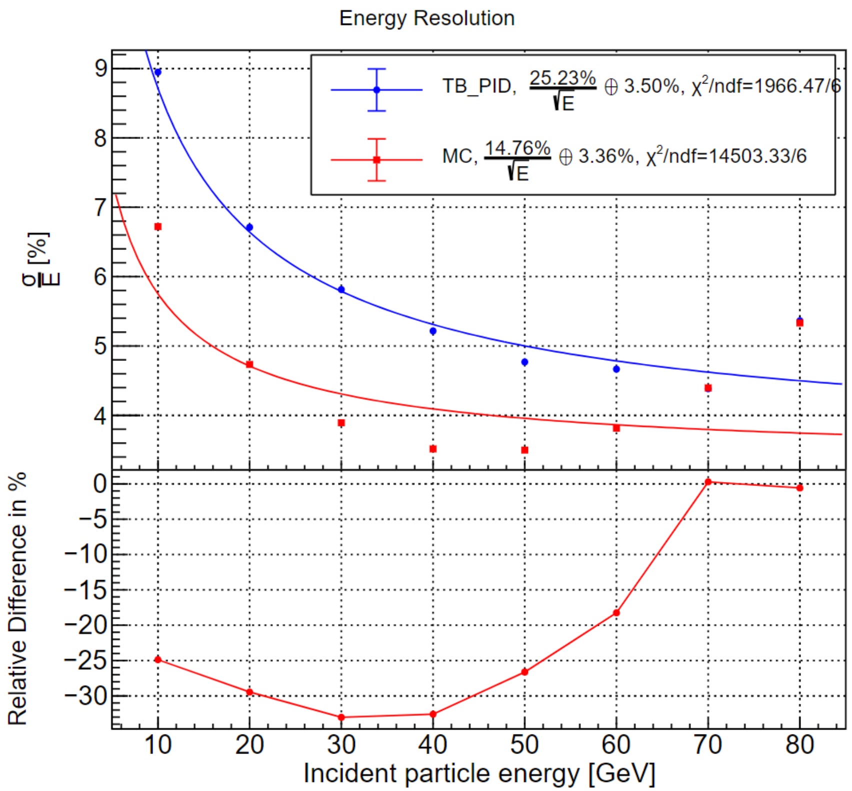




- Cross check
  - The results are generally consistent, and can observe same structure
  - Different: fitting range of energy linearity (10-80 GeV), and the data samples (all runs, calibrated by yukun)

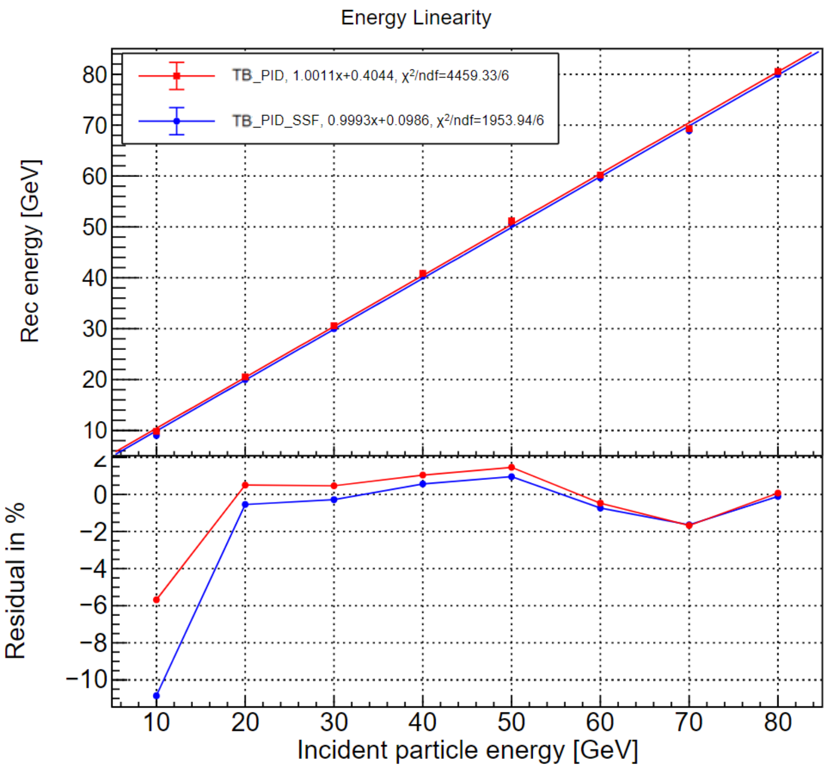
Electron energy response: TB vs. MC

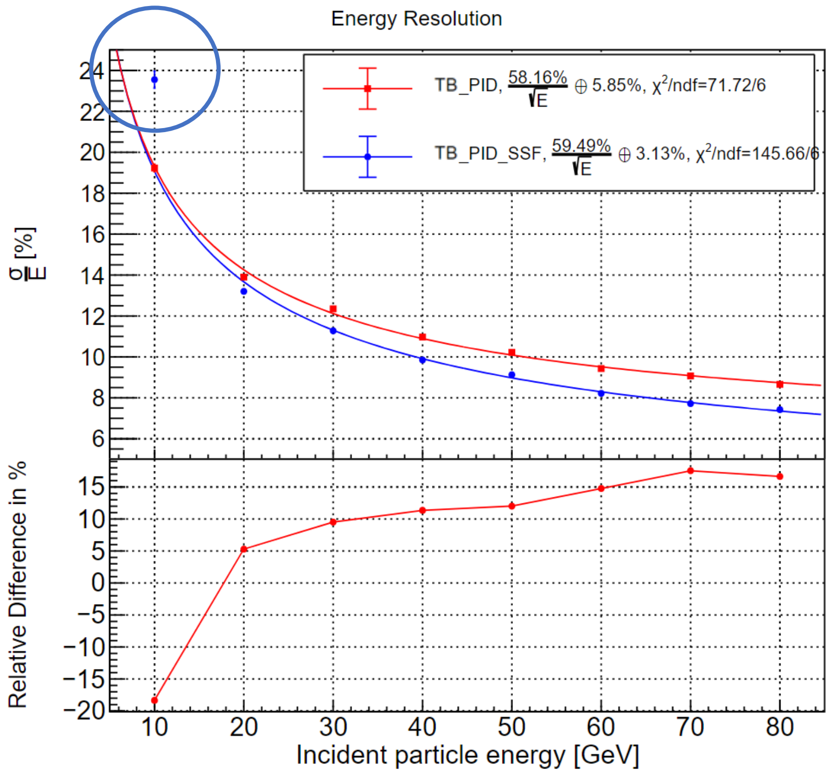


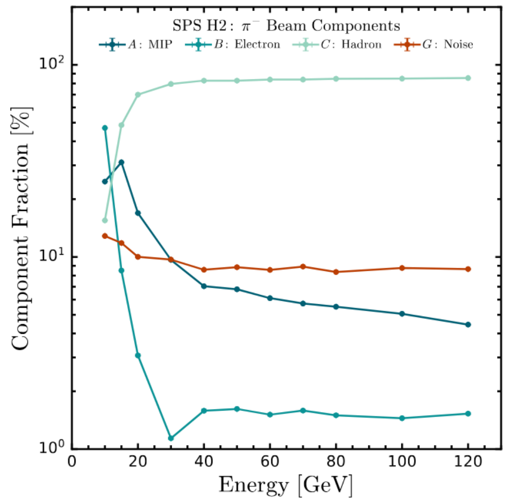


- The energy linearity of MC is slightly better than TB data
- In MC data, the saturation can also be observed
- This saturation has a significant effect on energy resolution and needs to be corrected

Pion energy response: Testbeam data



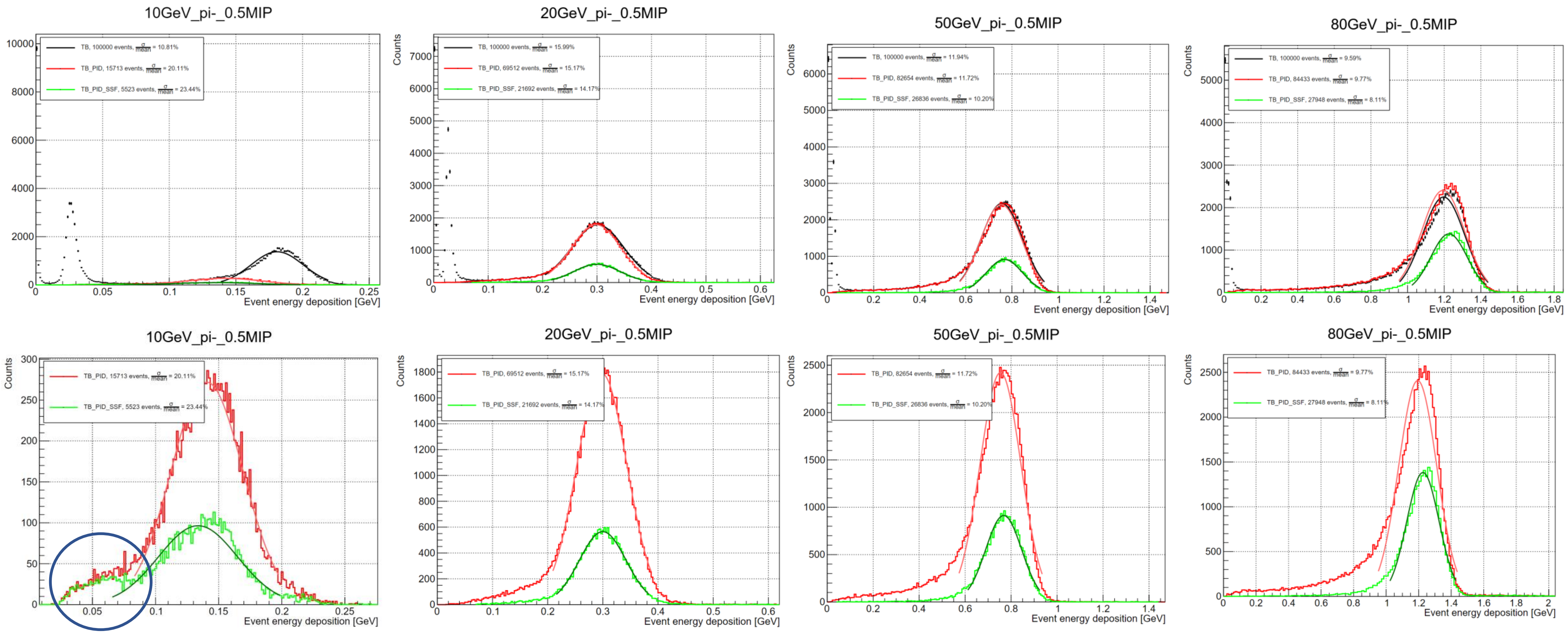




At energies below 30 GeV, the purity of the beam decreases significantly, especially at 10GeV, the purity is only about 15%

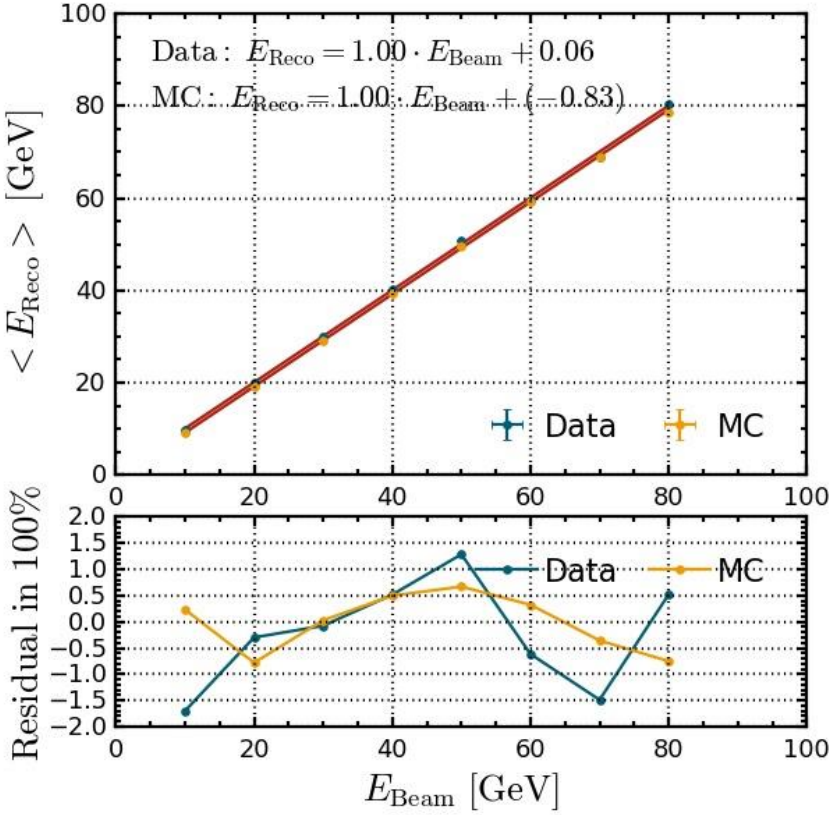
- Due to low pion beam purity, PID is necessary
- The energy leakage is reduced by limiting the shower starting layer <= 5
- Unexpected 10GeV point !

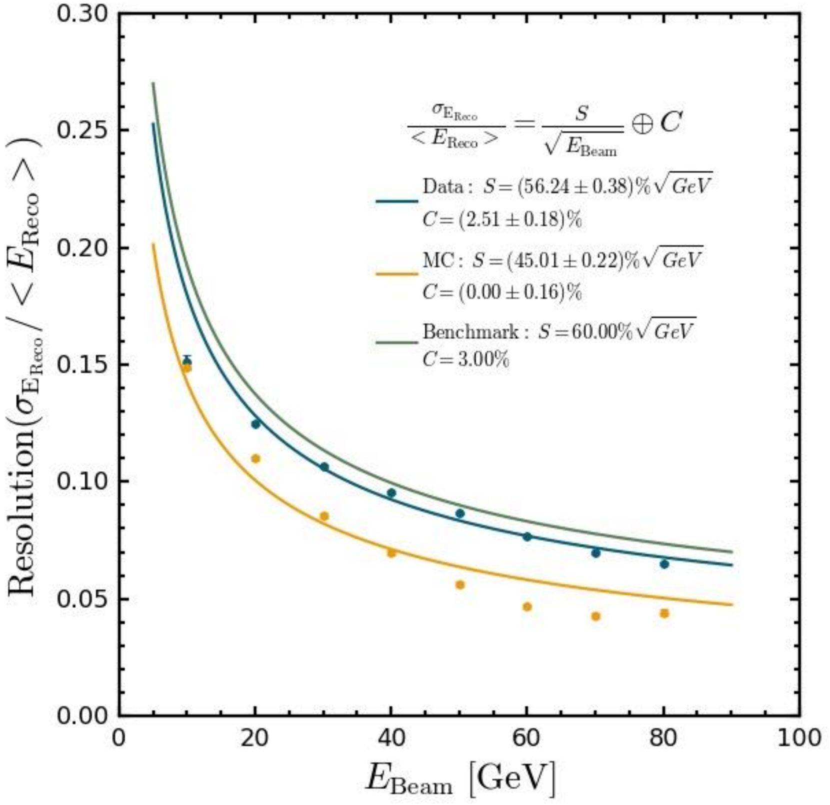
Pion energy response: Testbeam data



- With the exception of 10GeV, limiting the shower starting layer can effectively improve the energy resolution
- The algorithm for finding shower start needs further optimization

Pion energy response: TB vs. MC (by Xin Xia)





➢ **Cut for energy leakage:**
1< Shower_Start < 5 && Shower_End < 38

- **Shower_Start:** The first layer in which the number of hits is larger than or equal to 4 and the RMS of all hits in that layer is less than 50.
- **Shower_End:** The layer following the shower start in which the number of hits is less than or equal to 4.

Linearity: Data: ±1.7%; MC: ±0.8%
Resolution: Data: S=(56.24±0.38)%; C=(2.51±0.18)%
MC: S=(45.01 ± 0.22)%; C=(0.00 ± 0.16)%

Summary

- ➢ The saturation effect has a great influence on the energy response of electrons, and it needs to be corrected in order to obtain reliable results

- ➢ Reducing energy leakage effectively improves pion's energy resolution
  - Energy linearity can be achieved within 2%
  - Energy resolution
    - ➢ TB data: S=(56.24±0.38)%; C=(2.51±0.18)%
    - ➢ MC: S=(45.01 ± 0.22)%; C=(0.00 ± 0.16)%

Backup

Shower Start Finder

- Shower start algorithm:

$$E_{i+1} > E_{thr} = (a \times E + b)\ \mathrm{MIP}$$
$$\Lambda = A_{\mathrm{i}} + A_{\mathrm{i+1}} > c\ \mathrm{MIP}$$
$$\Pi = N_{\mathrm{i}} + N_{\mathrm{i+1}} > \mathrm{n}$$

the energy deposition E_i and the number of hits N_i in layer i, $A_i = \frac{\sum_{k=0}^{i} E_k}{i+1}$

- Parameters: a = 0.25, b = 10, c = 3, n = 6.5 (from references)
- The shower starting layer <= 5