



Beam test data analysis and simulation validation for the CEPC AHCAL prototype



Dejing Du, Yong Liu, Baohua Qi
Institute of High Energy Physics, Chinese Academy of Sciences
On behalf of the CEPC calorimeter team



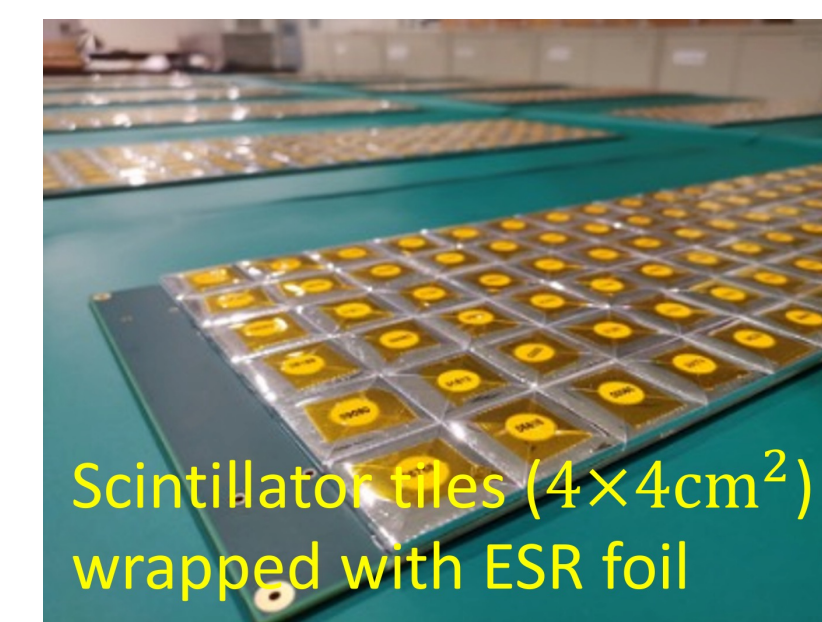
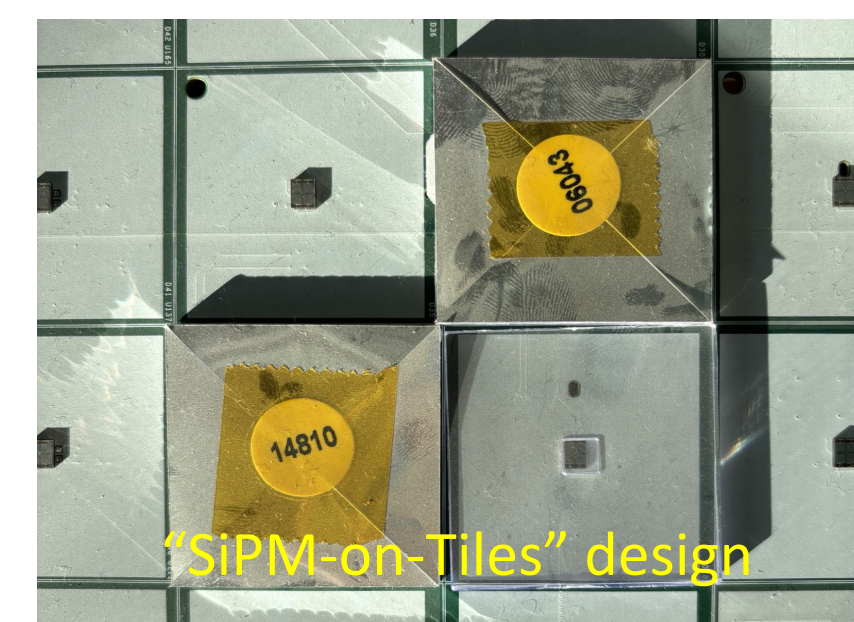
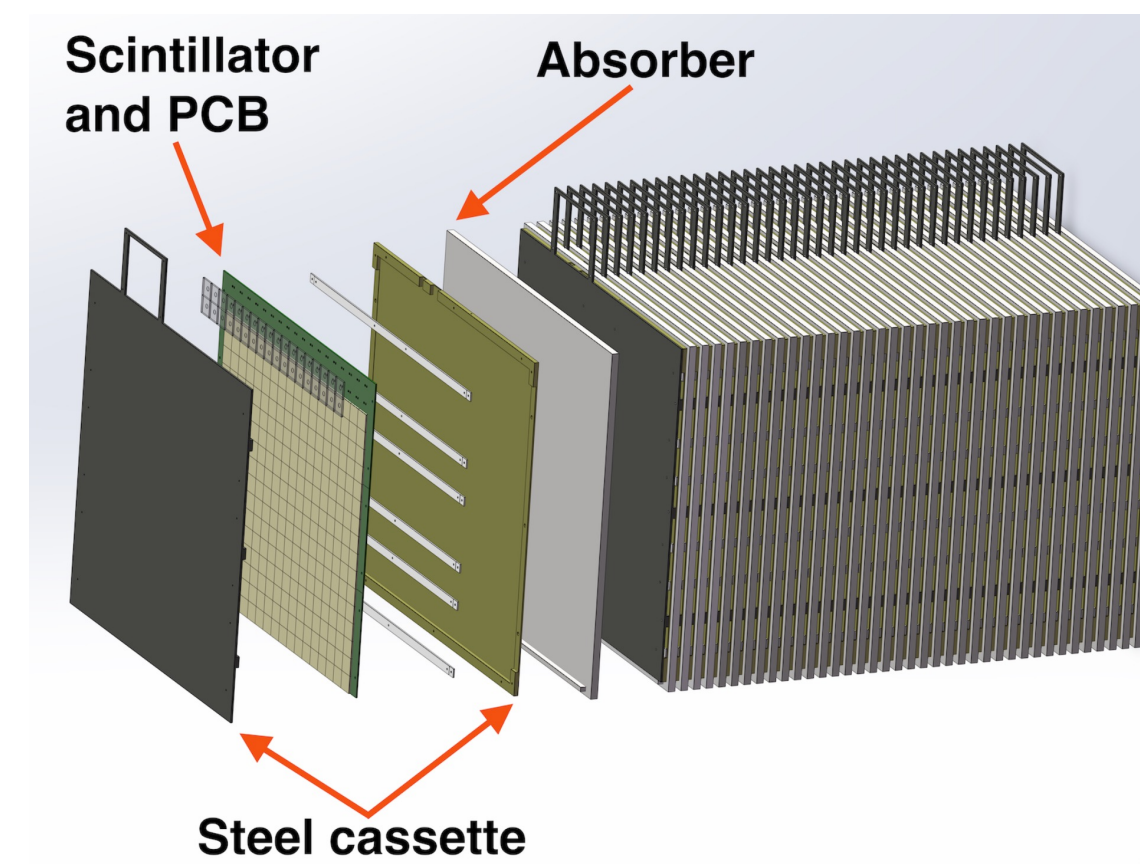
Introduction

CEPC Scintillator-Steel HCAL (AHCAL) prototype

- 40 longitudinal layers, transverse sensitive size $72 \times 72 \text{ cm}^2$
- Each layer: plastic scintillator tiles ($40 \times 40 \times 3 \text{ mm}^2$) + steel absorber plate (2 cm) + SiPMs (HPK S14160-1315 and NDL-22-1515)
- 12960 readout channels, 360 SPIROC2E chips, ~5 ton in weight
- Developed during 2018-2022

Three beam test campaigns and data samples collection

- Conducted at CERN (SPS-H8, SPS-H2, PS-T9) during 2022-2023
- Collected ~60M of beam test data samples
 - Muons: 160 GeV (H8), 100 GeV (H2), 10 GeV (T9)
 - Electrons/positrons: 20-120 GeV, 10-250 GeV, 0.5-5 GeV
 - Pions: 10-120 GeV, 10-350 GeV, 1-15 GeV

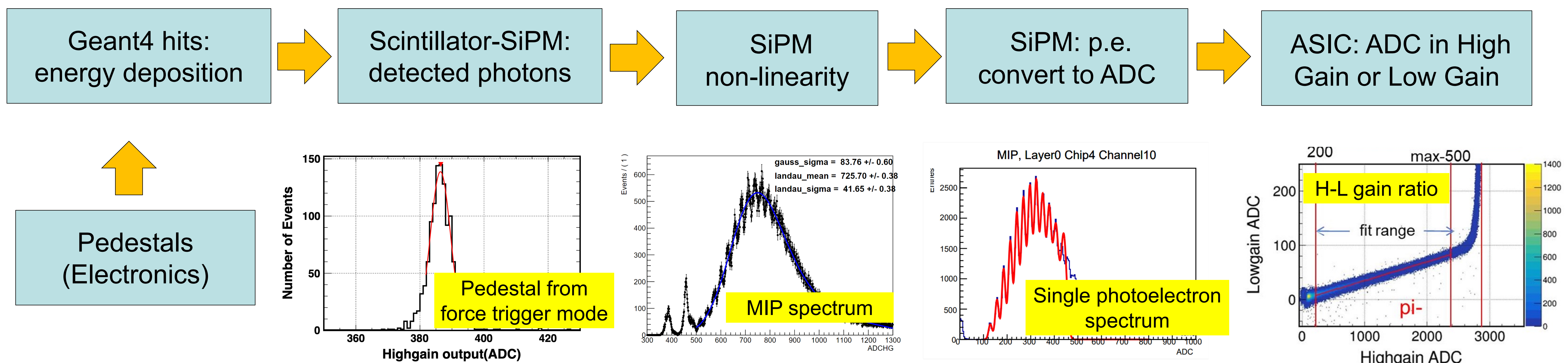


Simulation and Digitisation

Geant4 simulation including detailed geometry AHCAL prototype

Digitisation: energy depositions (Geant4) → digits in ADC (for each readout channel)

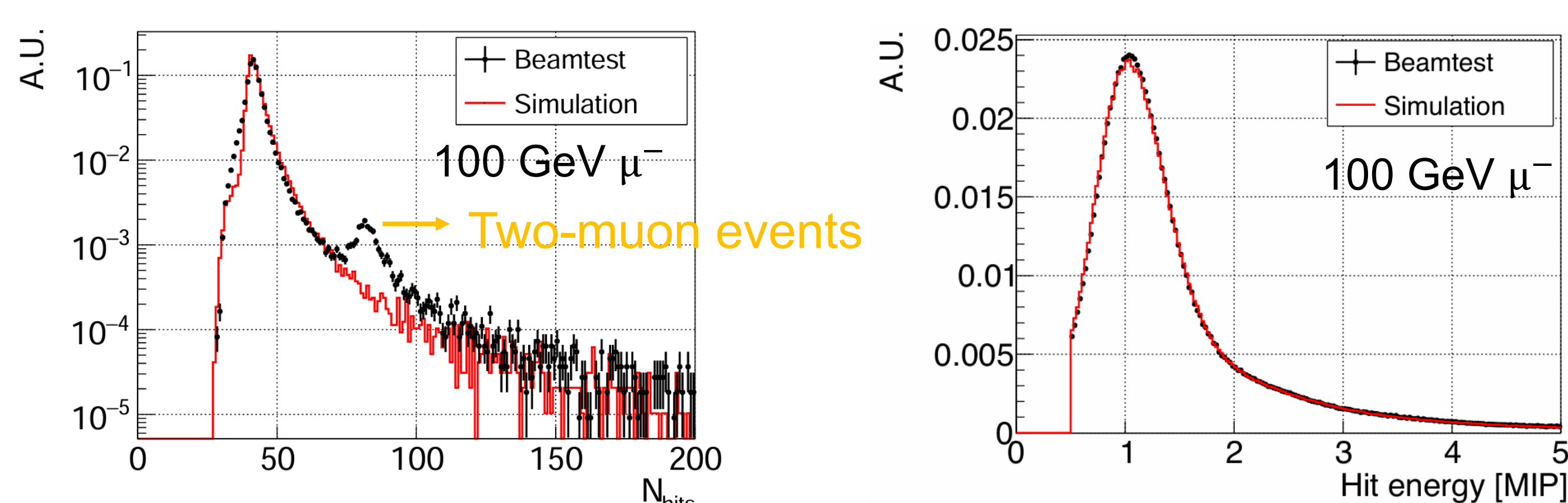
All parameters of digitisation extracted from test data



Simulation Validation Studies

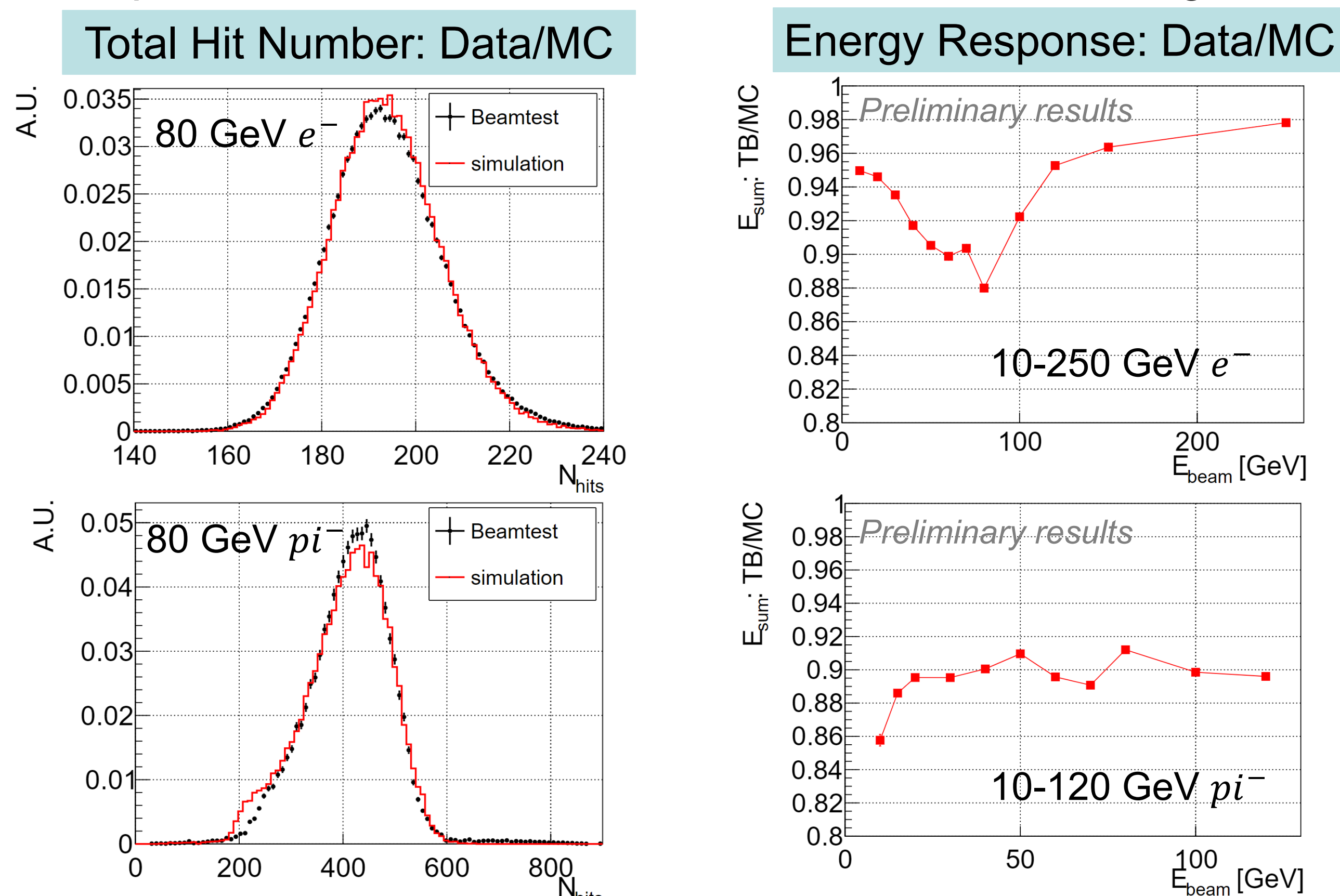
Muon data: good consistency

- MIP calibration: provide energy scale for each channel
- Crucial inputs for energy reconstruction of electrons and pions



Electron and pion data: ongoing studies

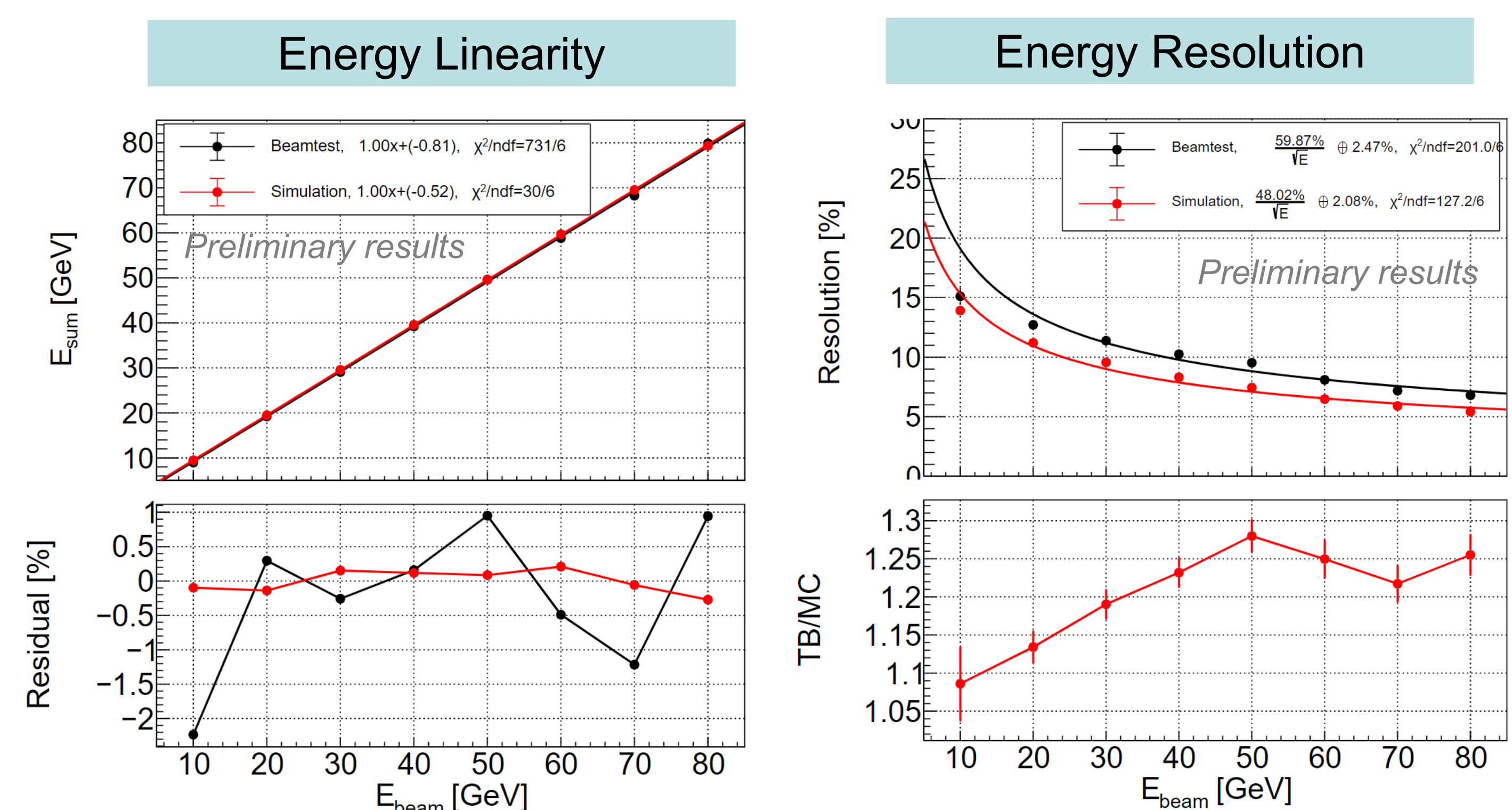
- Data/MC discrepancy: below 12% (e^-) and 14% (π^-)
- Critical issue:** non-linearity effects (saturation in SiPM and ASIC with large signals)
- Requires a better model for saturation effects in digitisation



Performance

AHCAL prototype using pion data sets after PID selections

- Energy linearity: within $\pm 2\%$
- Energy resolution: $\frac{59.9\%}{\sqrt{E(\text{GeV})}} \oplus 2.5\%$



Summary

- Successful beam test campaigns at CERN PS/SPS during 2022-2023 collected decent statistics of data samples in the wide energy range
- Validation of the prototype simulation and digitisation using beam test data
- Ongoing efforts to improve data/MC consistency via better digitization models for non-linearity effects (SiPM and ASIC with large signals)