CALO Simulation for previous beam tests

9th HERD Workshop

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Status of CALO simulation for beam test

- Geant4.10.5;
- Geometry: 5×5×10(5×5×20) LYSO crystals, 1mm carbon fiber for honeycomb structure, (5mm,2mm,3mm) gap size;
- Digitization algorithms: based on ICCD/IsCMOS readout;

Already implemented:

✓ A simplified parameterization method which converting energy deposition to facula grayscale (gray value, digital number) with gaussian smearing;

✓ Each channel has different parameters used by the algorithms.

Parameters using by digitization

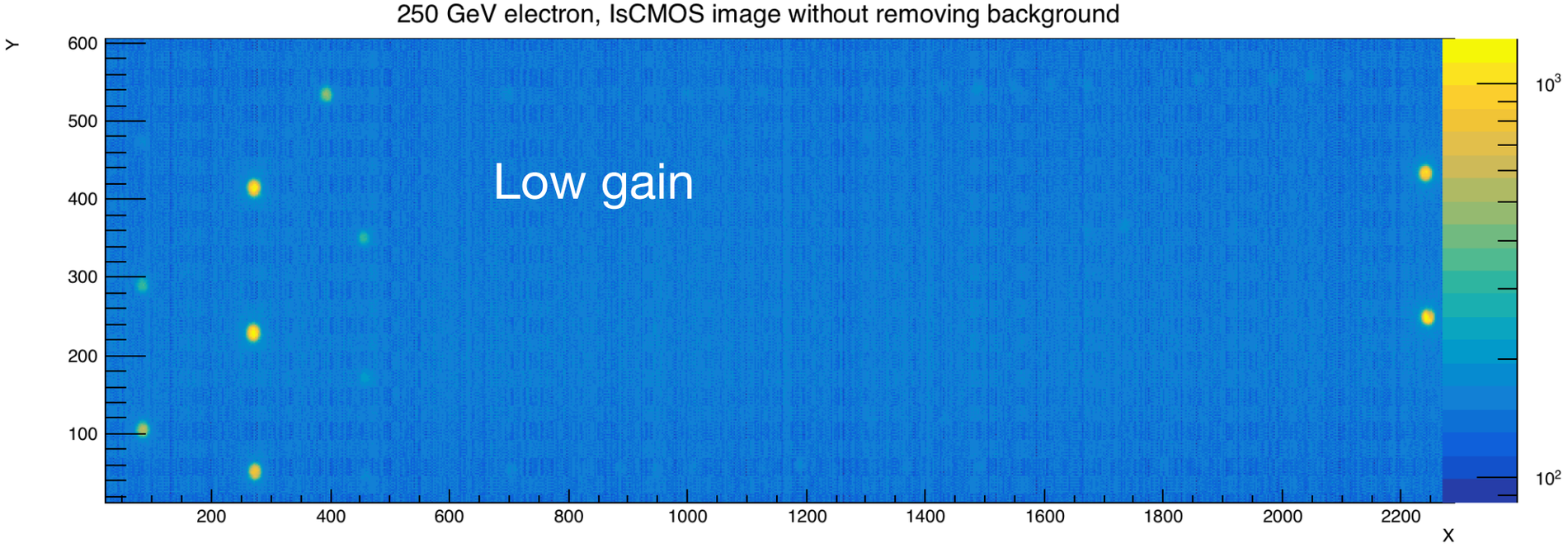
Based on beam test data:

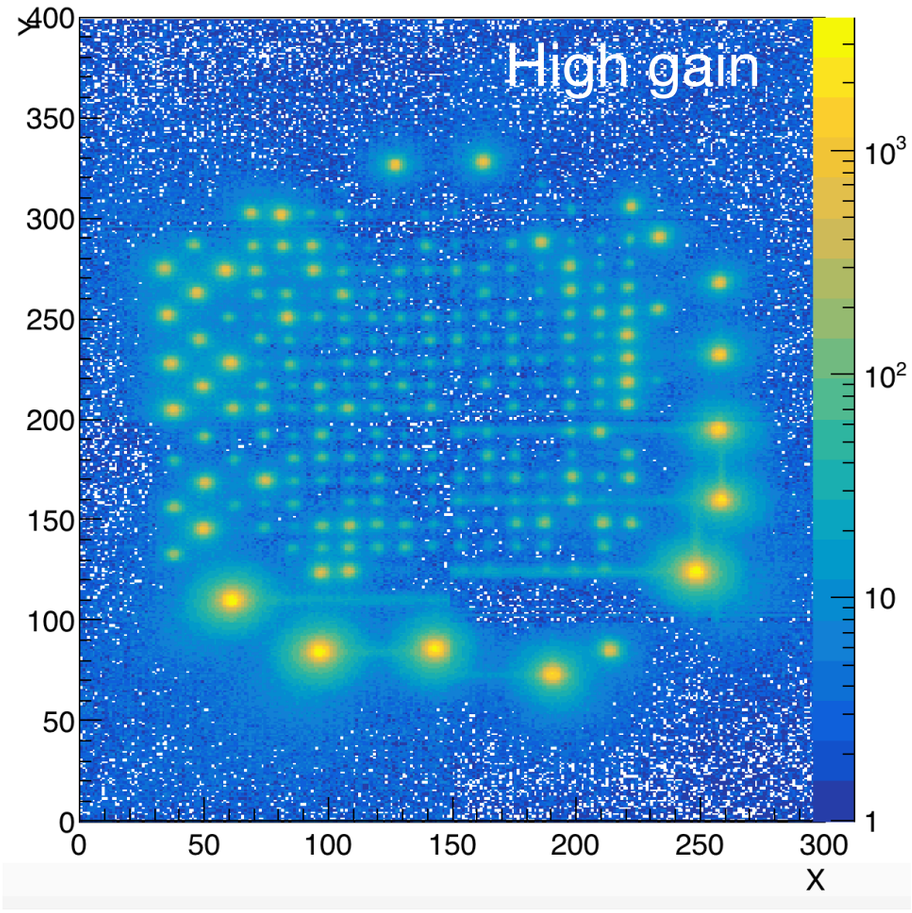
- std::vector<float> PedValueLG; //pedestal for low gain
- std::vector<float> PedValueHG; //pedestal for high gain
- std::vector<float> MIPValue; //MIP for each channel
- std::vector<float> LHRatio; //ratio between high gain and low gain;

Based on LED test data:

- ROOT::MATH::Interpolator ResponseLG;//response for low gain
- ROOT::MATH::Interpolator ResponseHG;//response for high gain
- TF1* LGSigma;//using by gaussian smearing for low gain
- TF1* HGSigma;//using by gaussian smearing for high gain

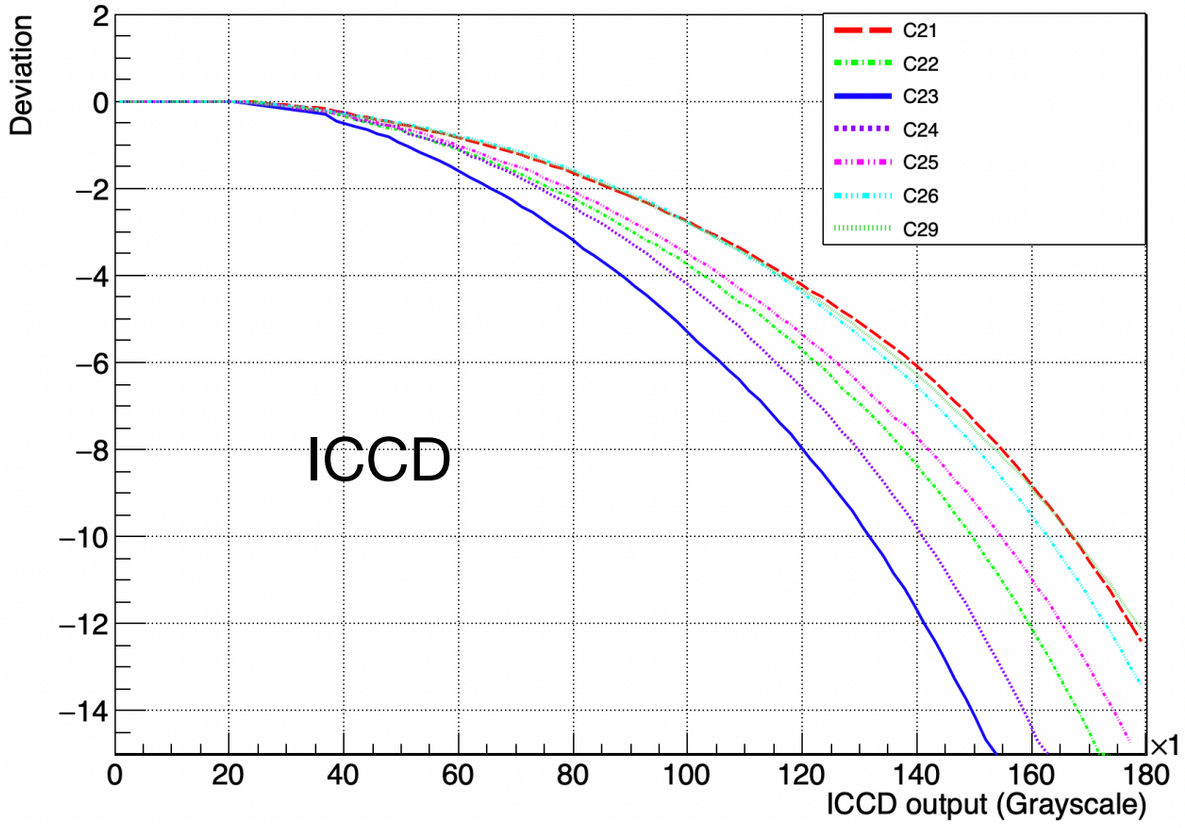
ICCD/IsCMOS output

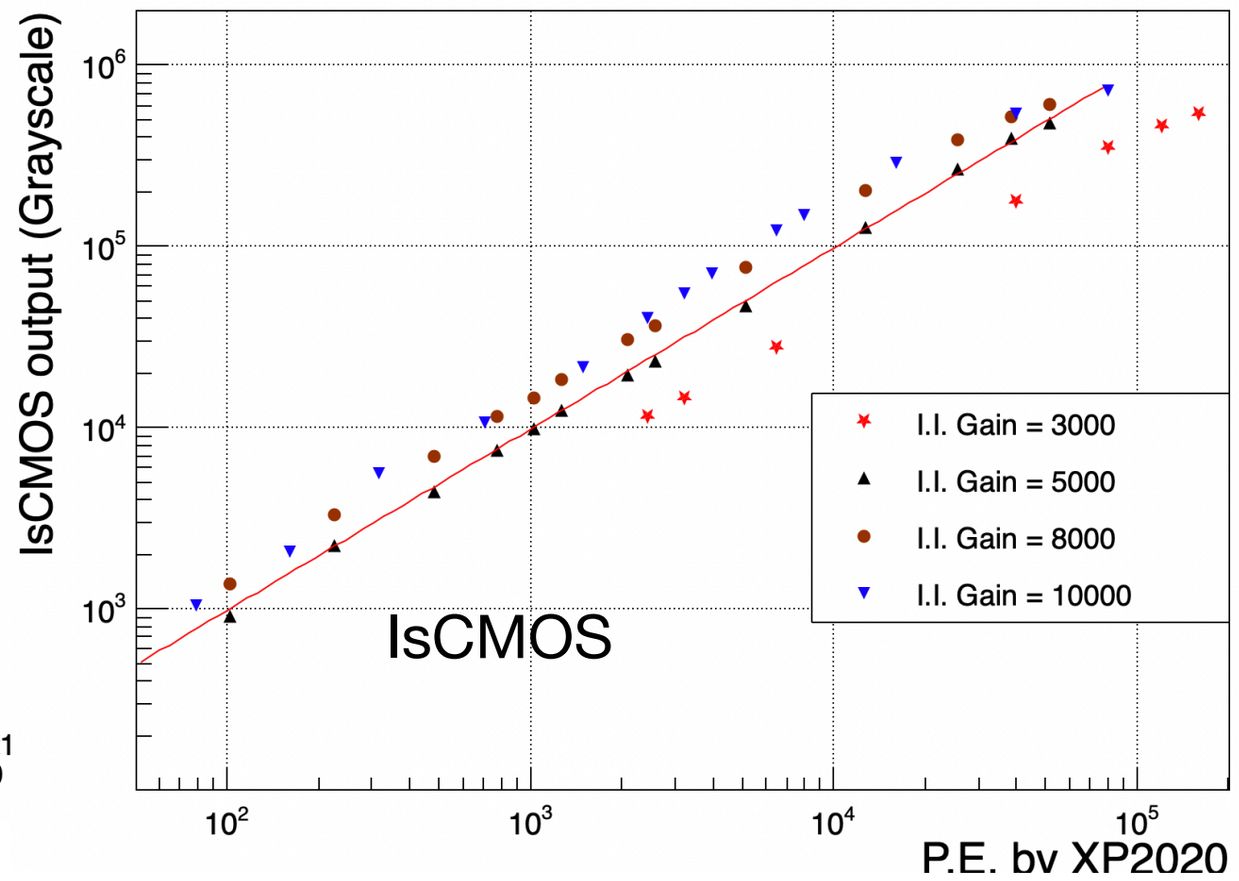




- ICCD (high gain): take R= 5 pixels circle as facula area, pixel size = 26μm;
- IsCMOS (low gain): take R= 30 pixels circle as facula area, pixel size = 5.5μm.

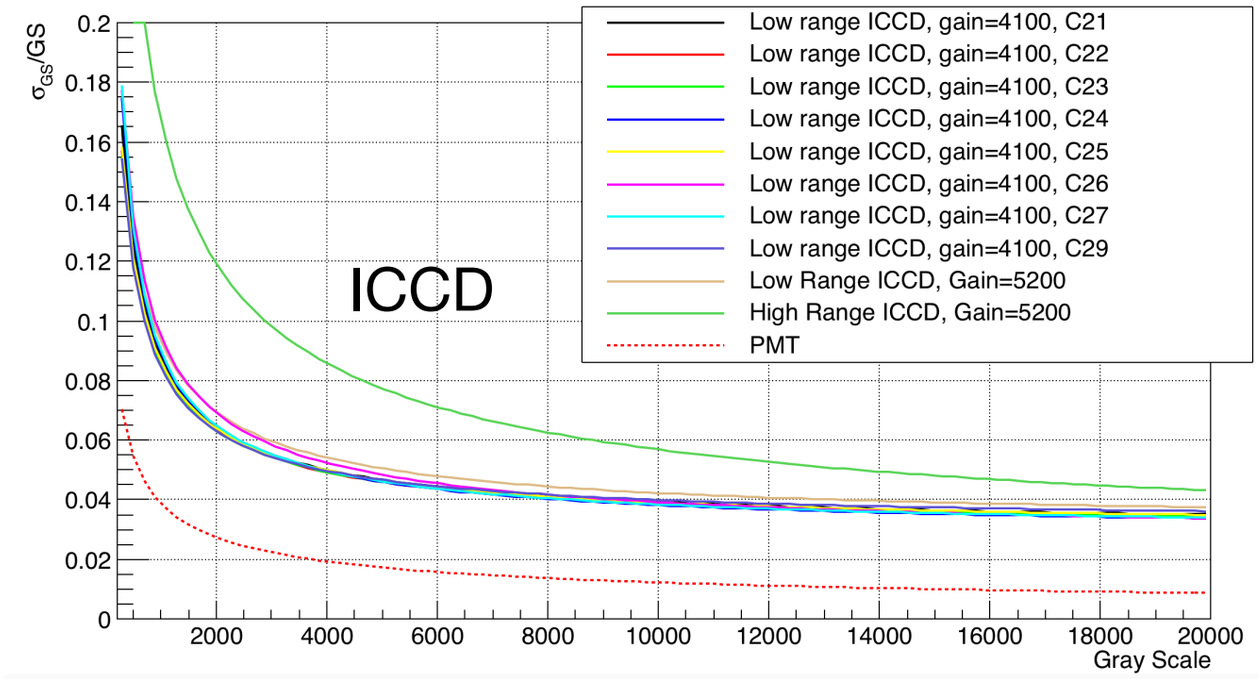
ICCD/IsCMOS Linearity test

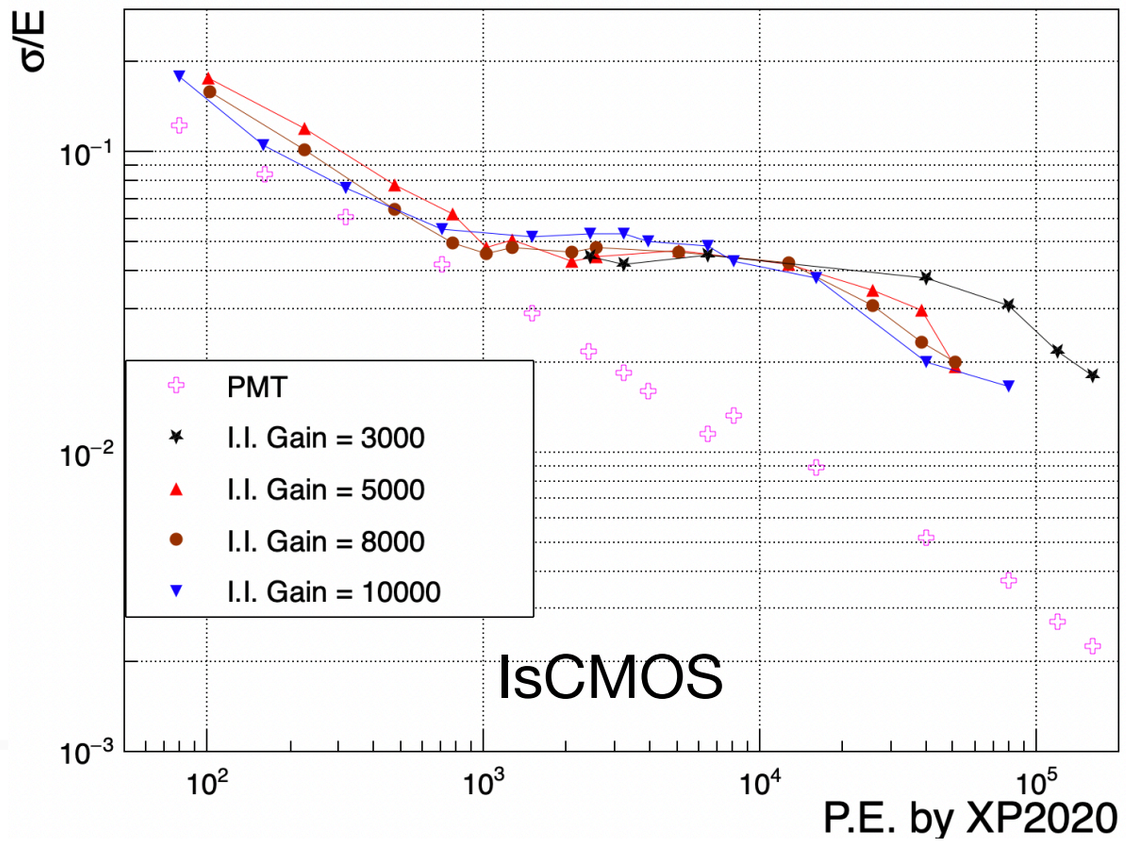




- Testing with LED and PMT;
- Measurement of linearity : typically from 50P.E. ~ 30000P.E. @ 1e4 gain;
- Measurement of the relationship between ICCD/IsCMOS output and input when it’s saturated.

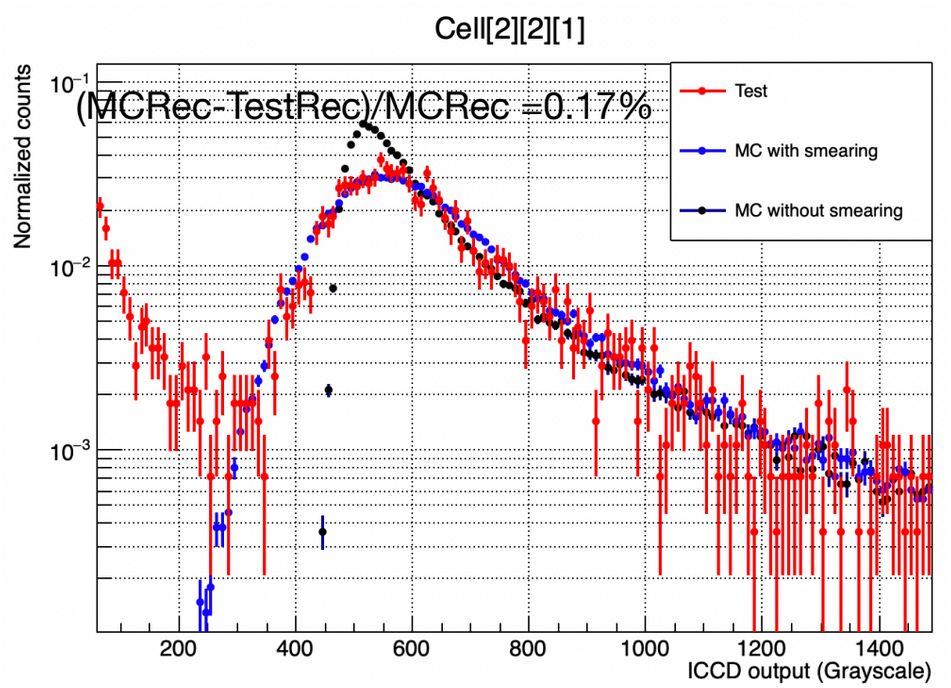
ICCD/IsCMOS fluctuation

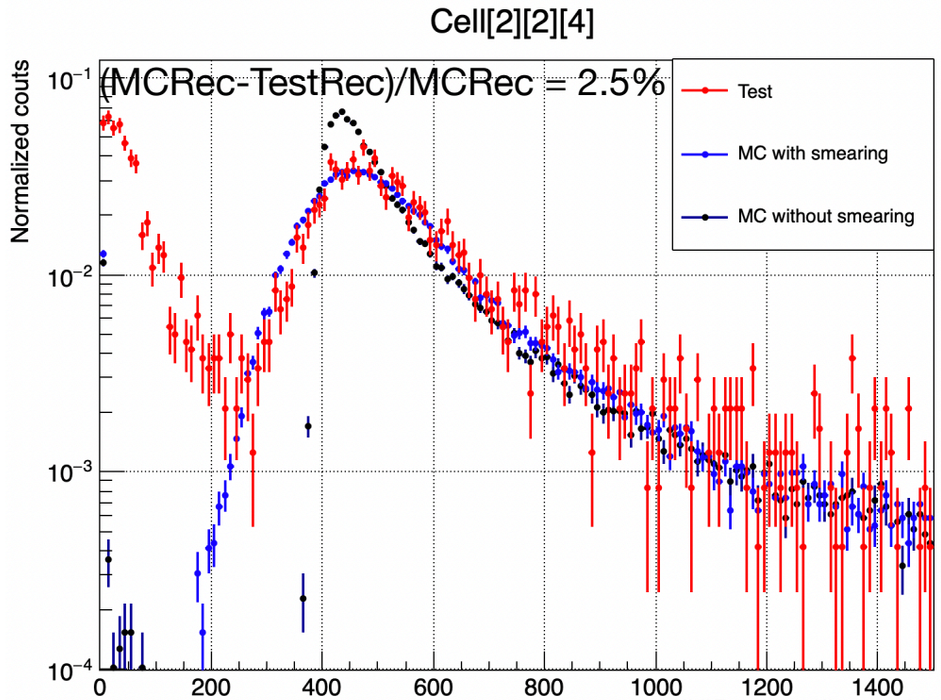


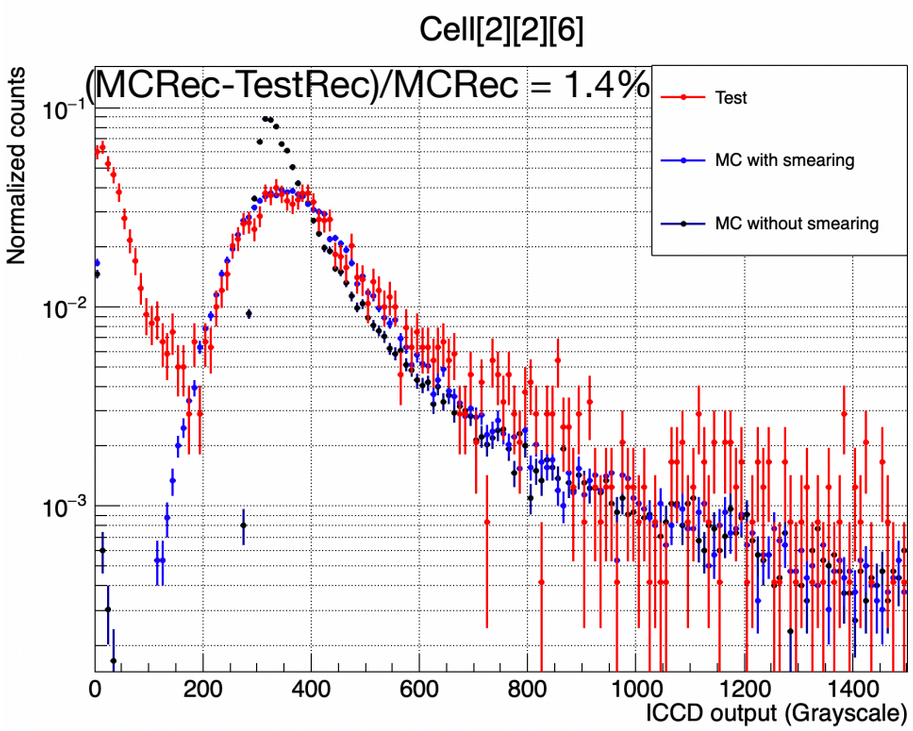


- Testing with LED and PMT;
- σ/E measurement: parameters used by digitization for gaussian smearing.

Testing with MIP

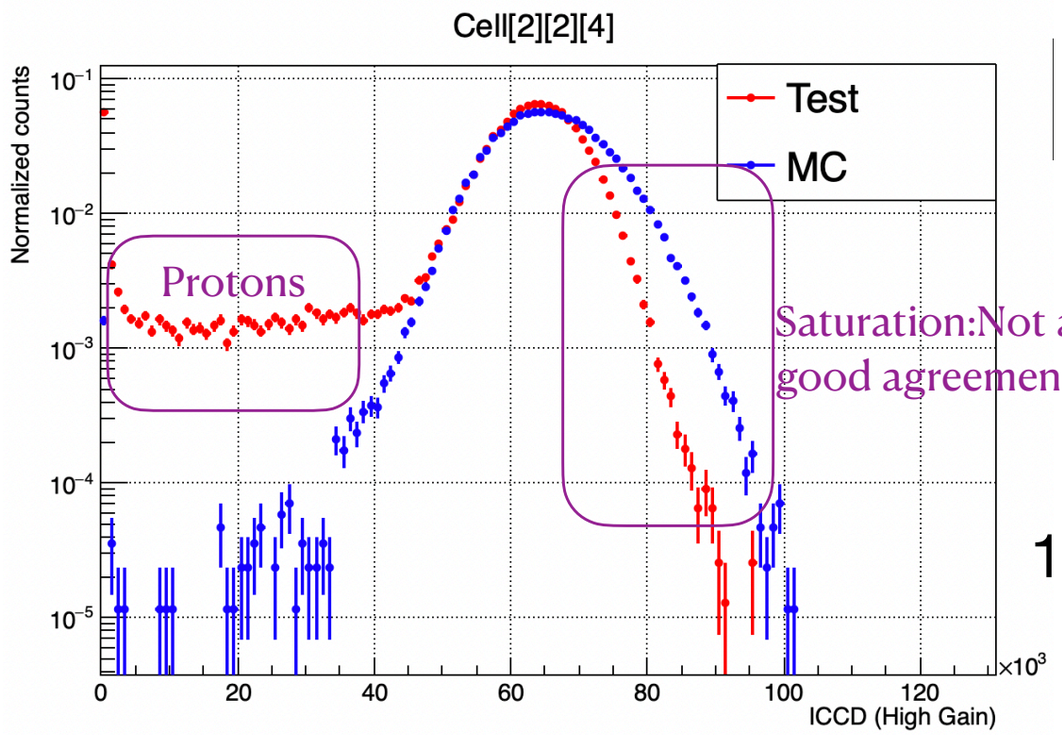




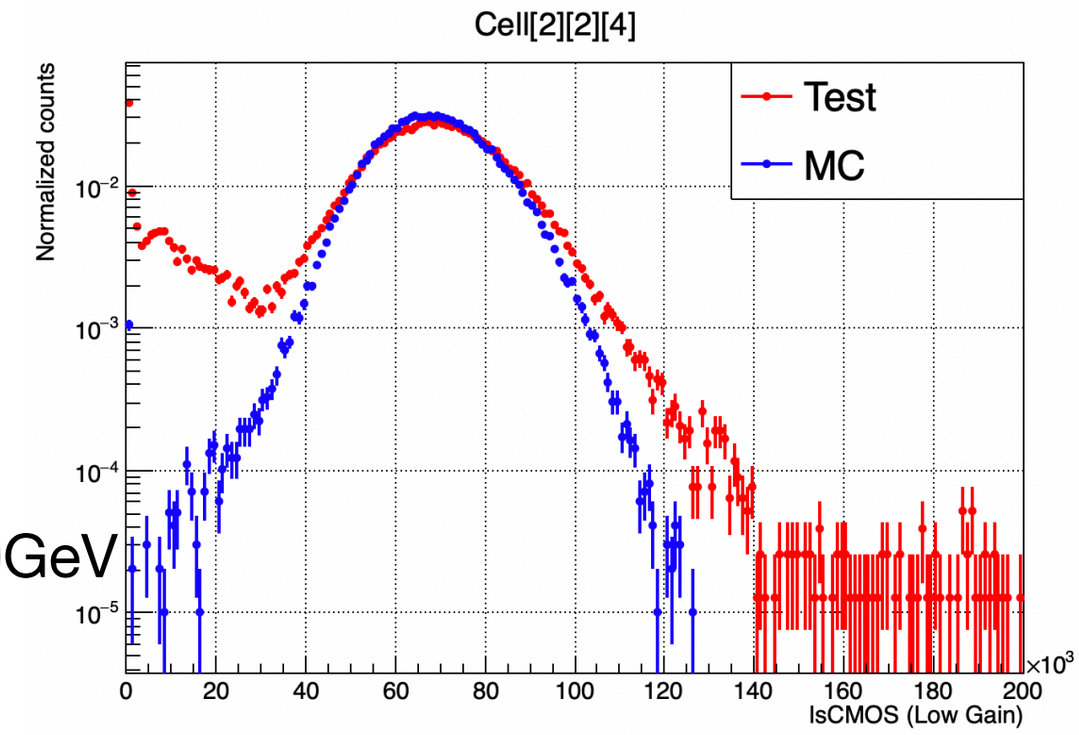


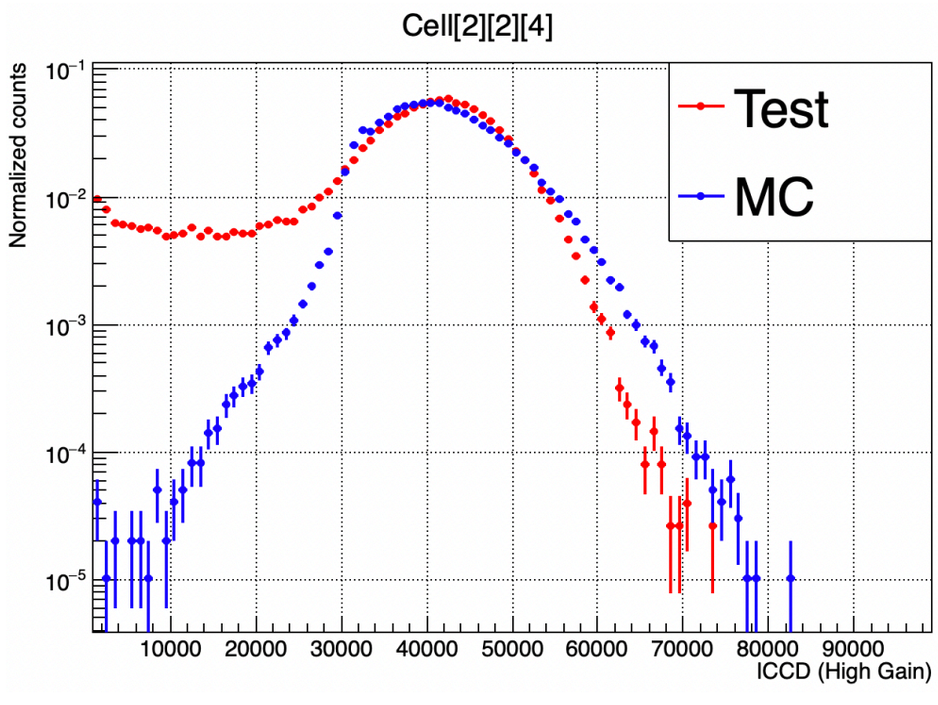
- Testing the digitization with MIP signals from 400GeV protons;
- Pedestals are subtracted;
- Energy resolution: 16%~21%;
- Deviations between MC_MIP and Test_MIP are lower than 2.5%;
- Mis-triggered events are found in test data, pedestal can be observed.
- Cell[2][2][x] means the central crystal at the $(x+1)^{th}$ layer.

Testing with high energy(50GeV/100GeV electrons), Position distribution is based on AMS tracker results

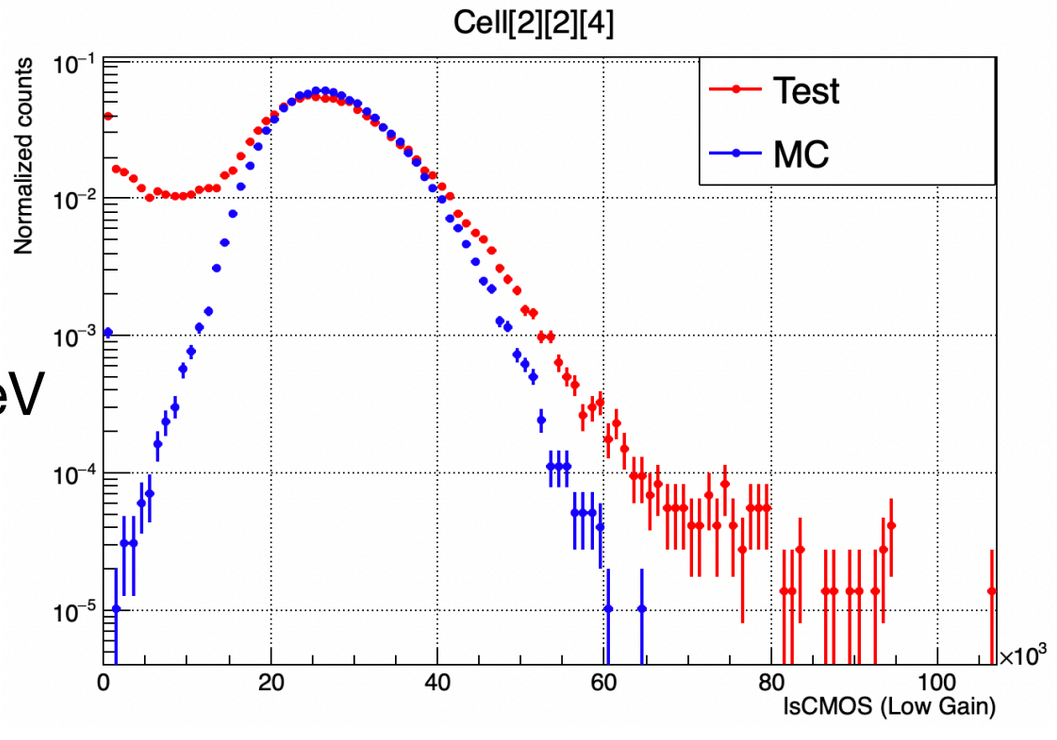


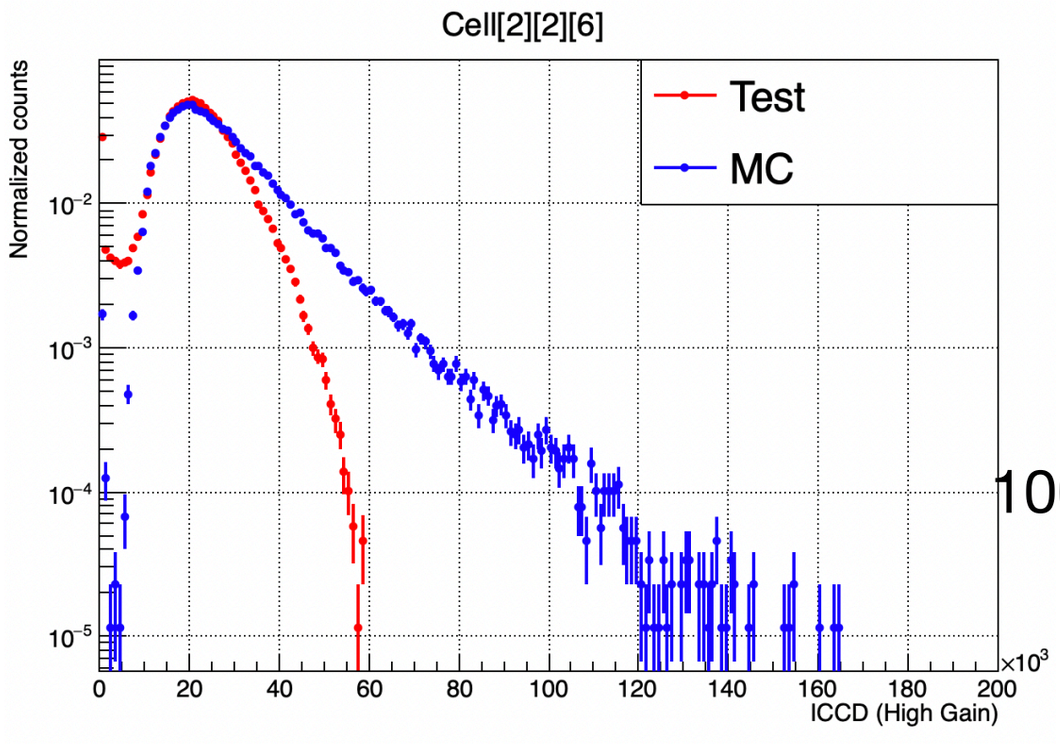
100GeV



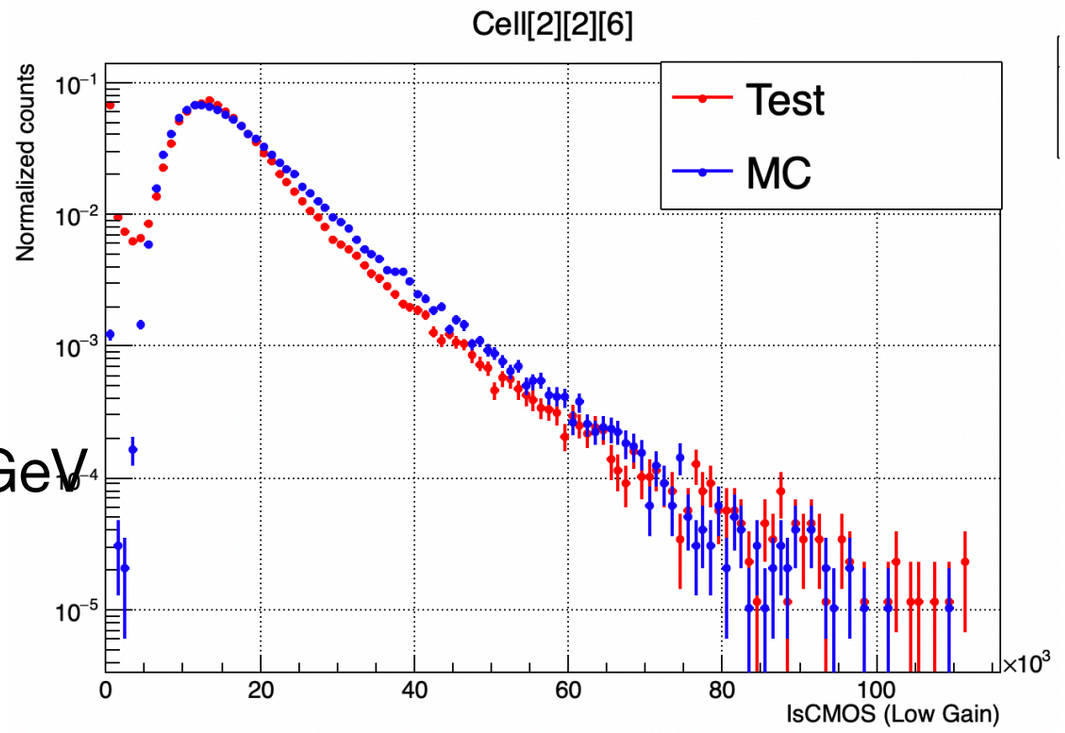


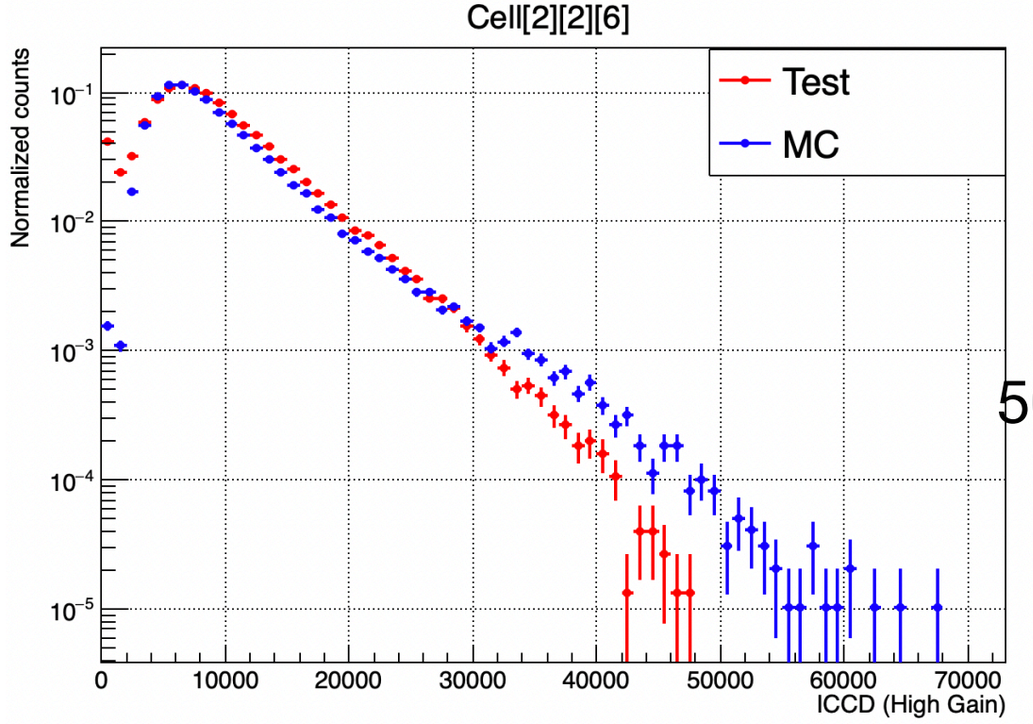
50GeV



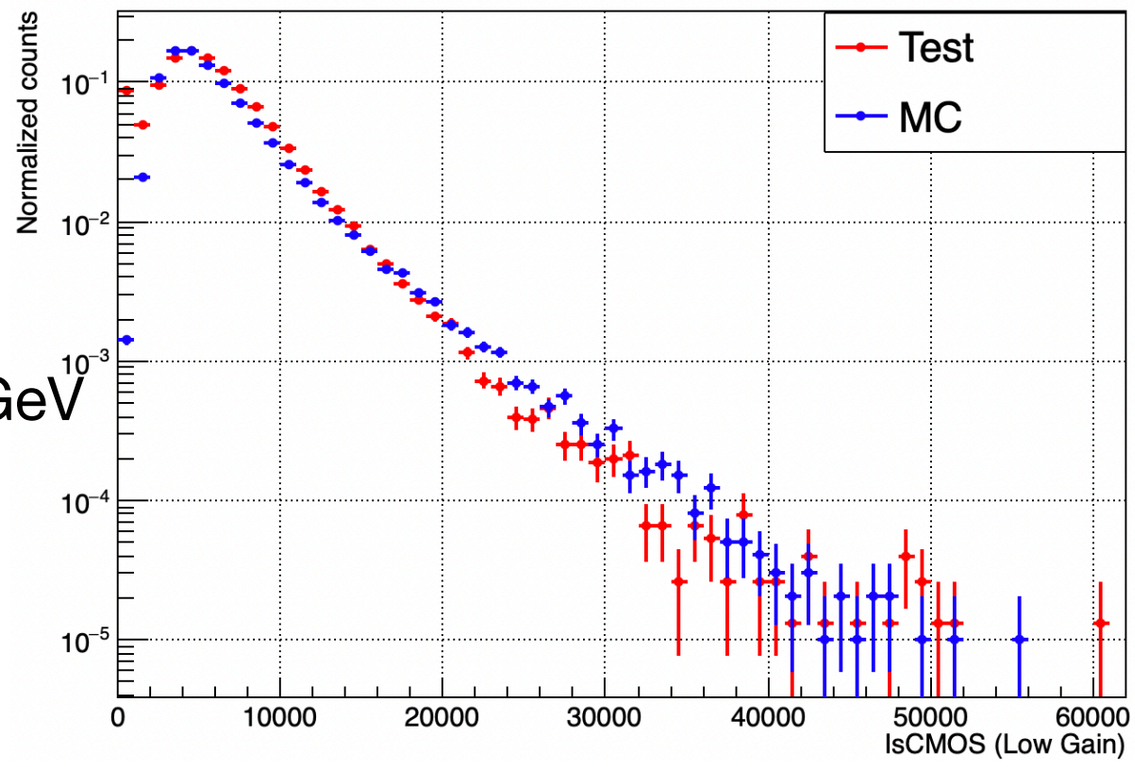


100GeV

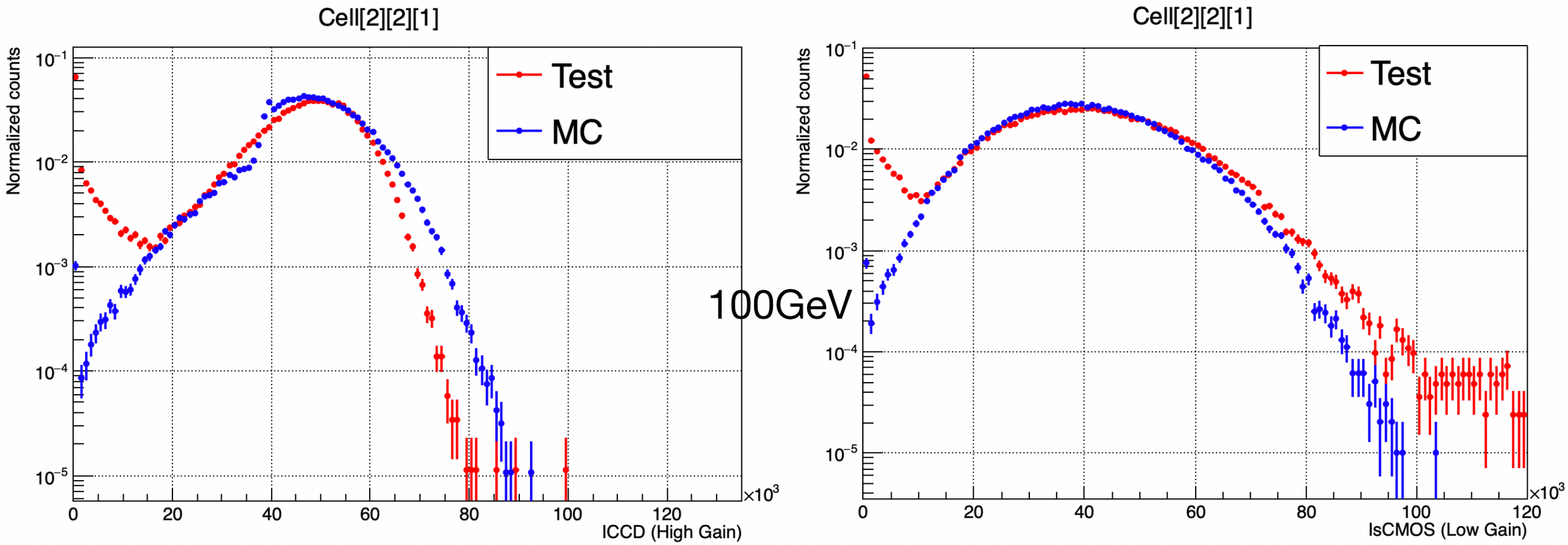




50GeV



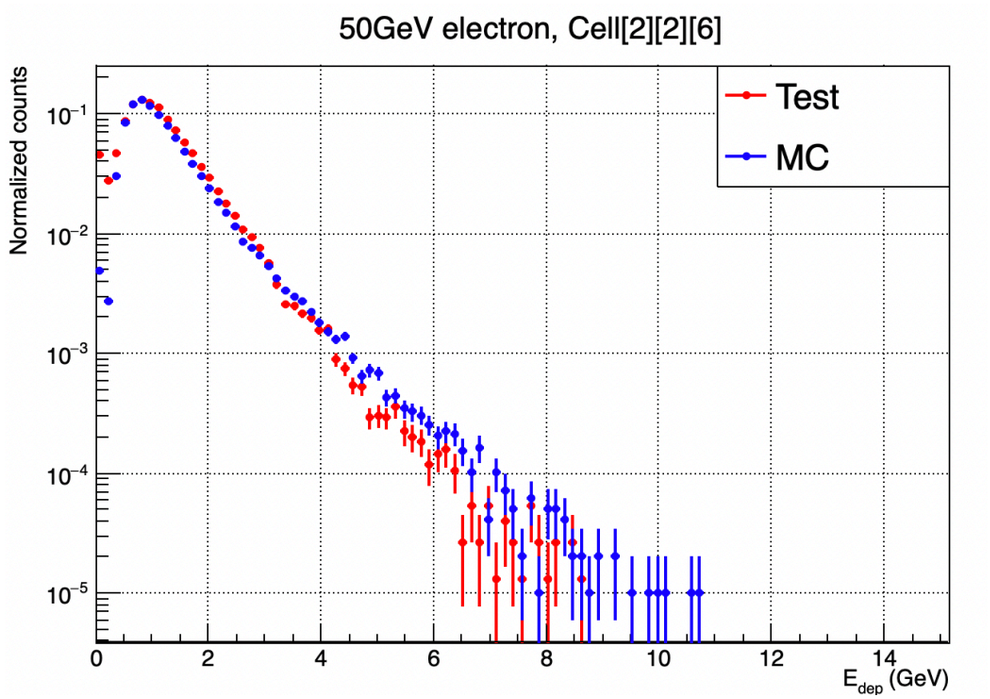
Testing with high energy(100GeV electrons)

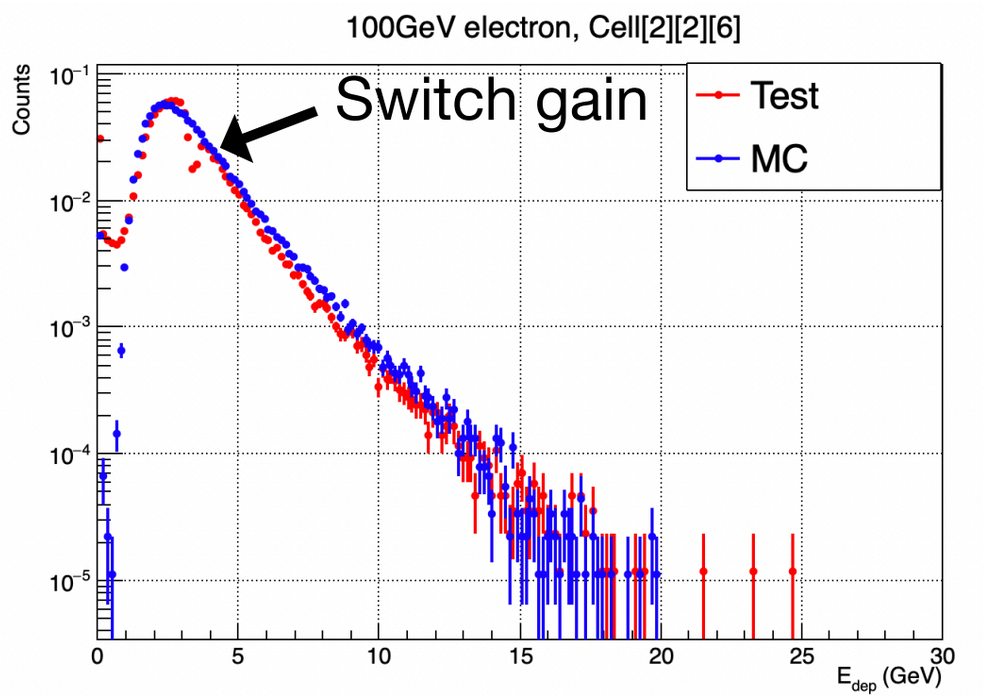


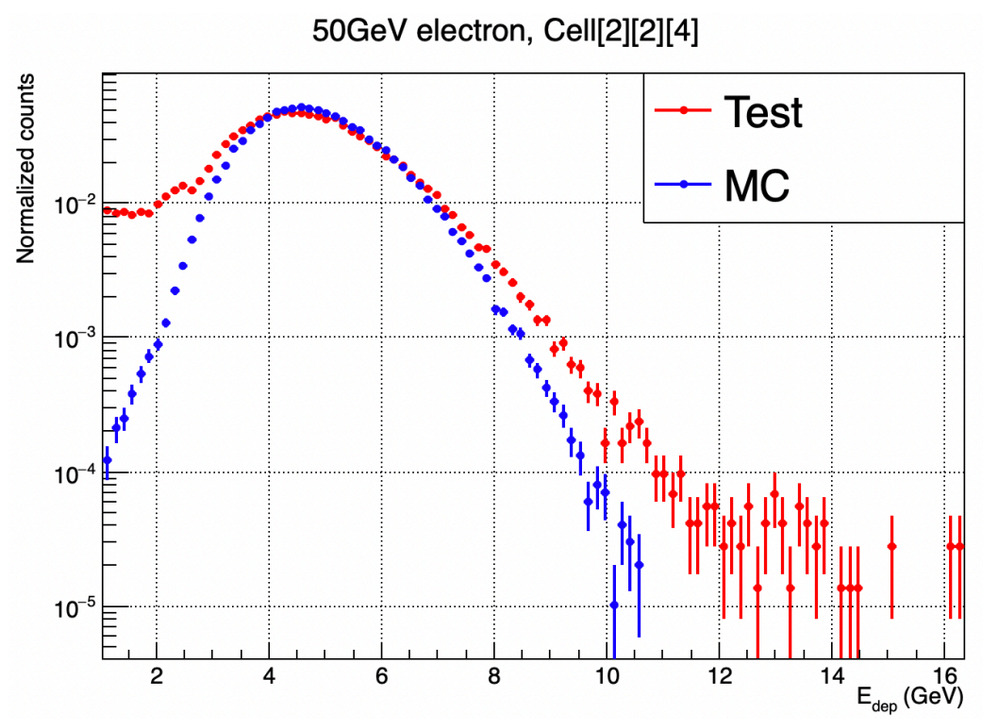
100GeV

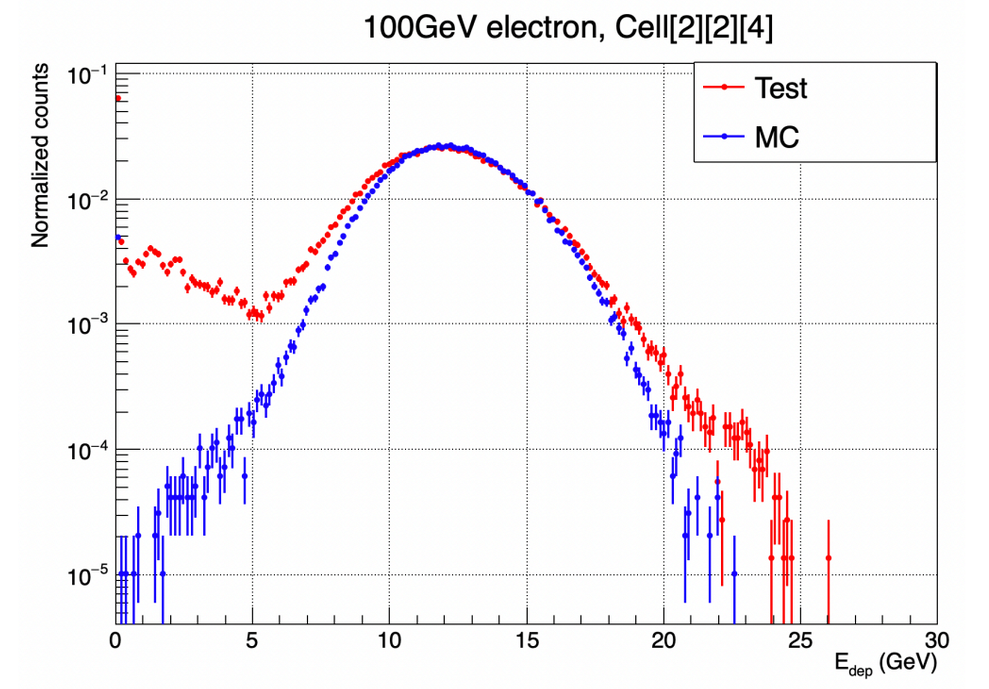
- Comparison between test data and digitized MC using 100GeV electrons;
- Parameters using by saturation effect should be re-checked;
- This digitization can give a correct result even if the saturation simulation is not accurate, because in most cases low gain data is used and saturation data is avoided.

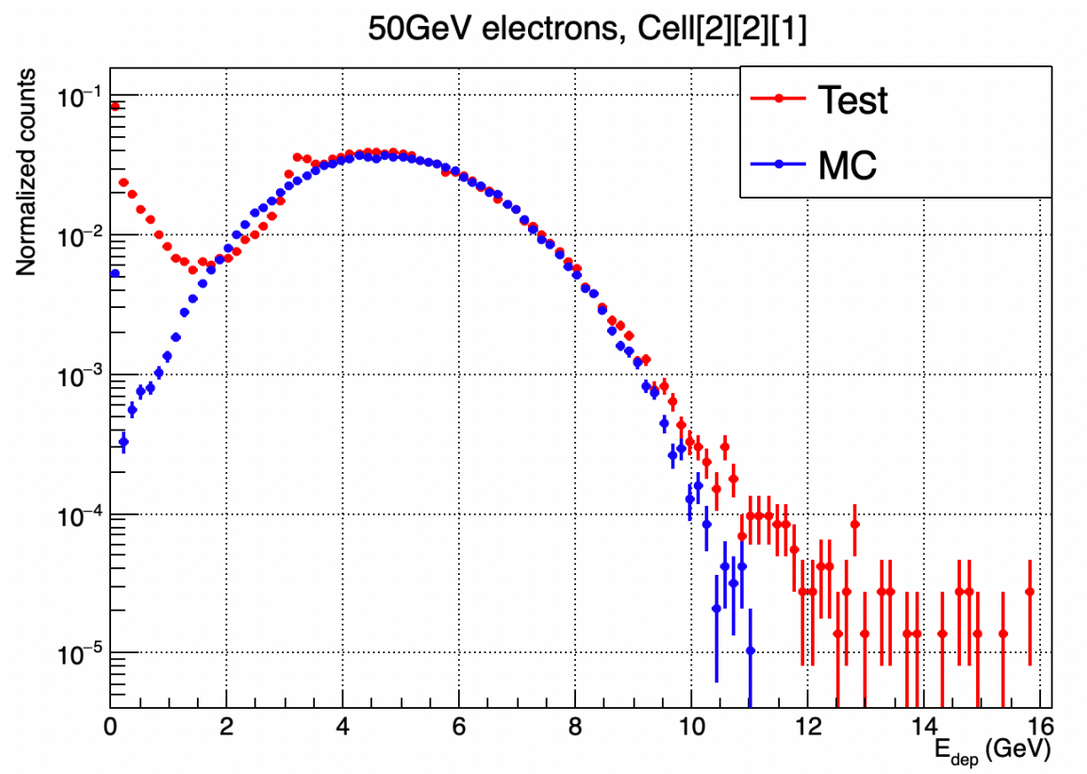
Energy reconstruction for single cell

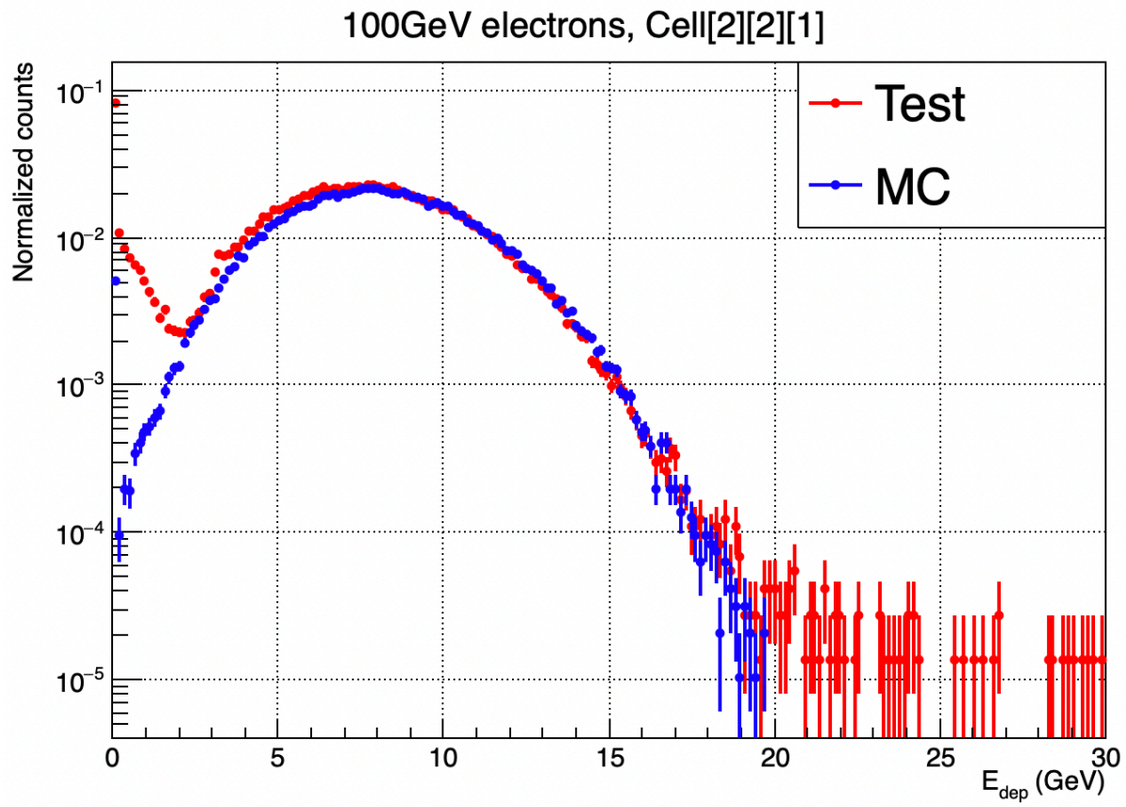






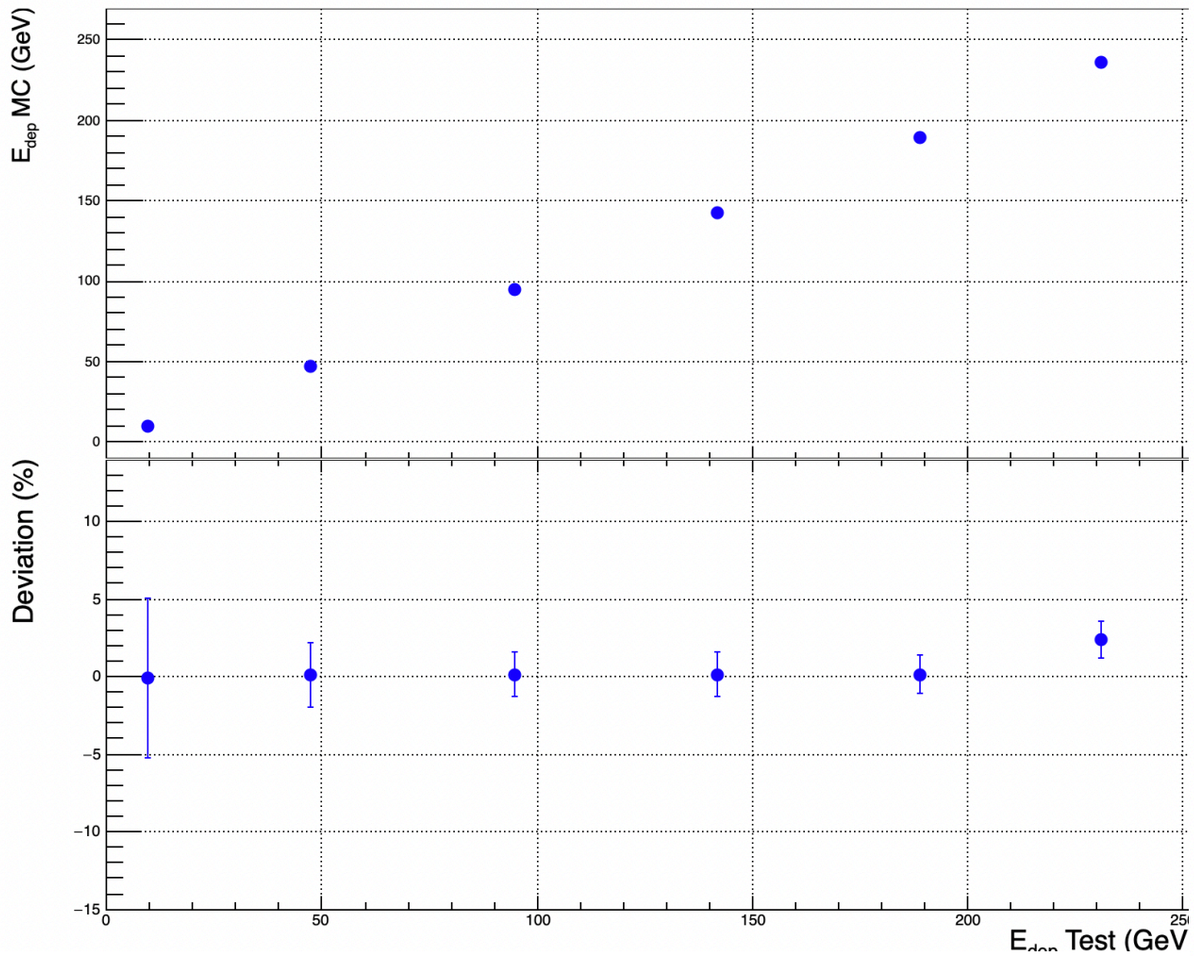


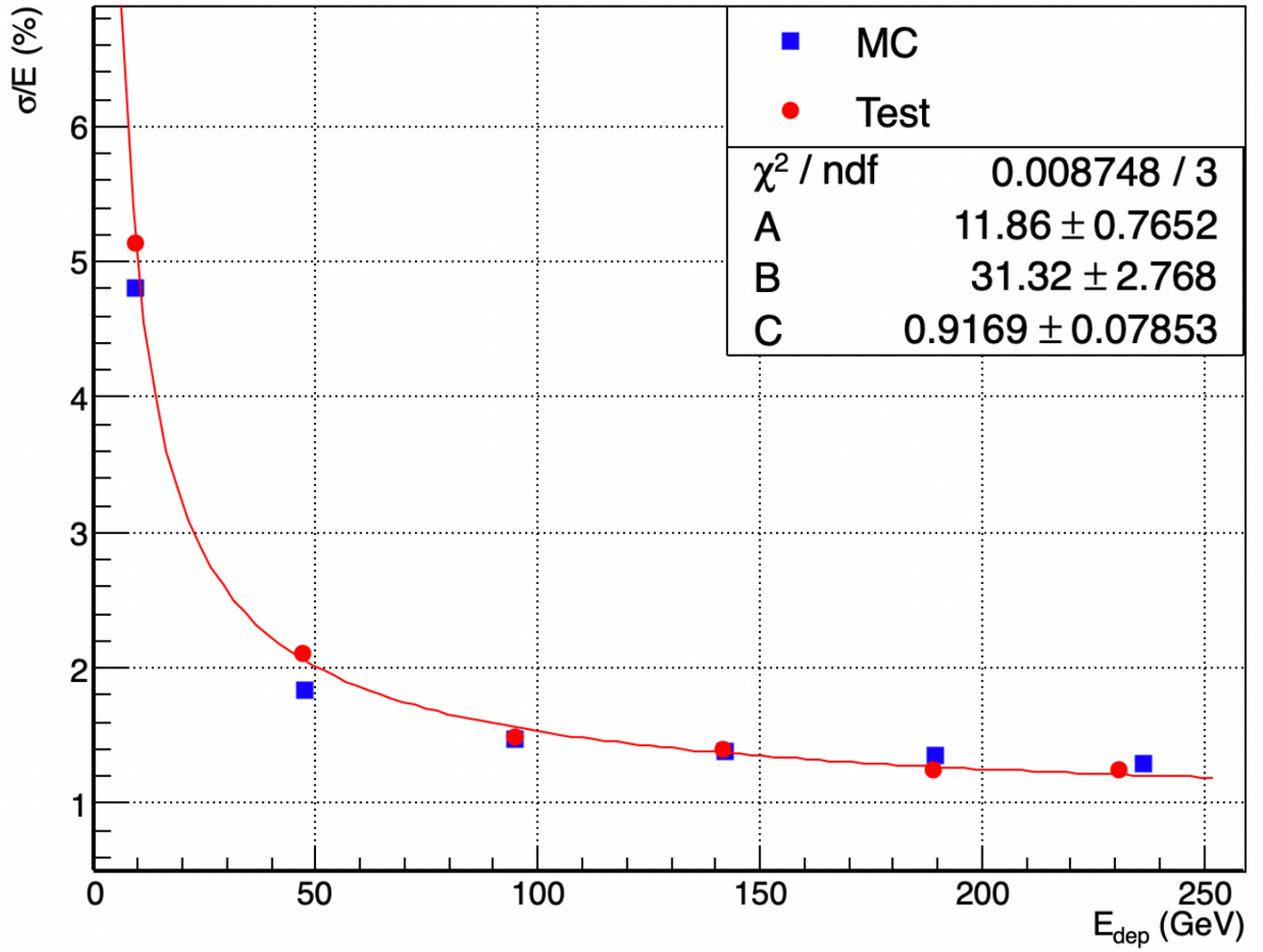




- Energy depositions of single cells reconstructed from digitized MC and test data are slightly different at some energies;
- The parameters used in gaussian smearing should be optimized.

Linearity and Energy resolution, Threshold = 2*Ped_sigma





Summary

- A preliminary version of CALO simulation for ICCD/IsCMOS readout is implemented;
- The digitization algorithm can convert energy deposition to ICCD/IsCMOS output with fluctuation.
- Using the same reconstruction method as beamtest data analysis to convert ICCD/IsCMOS output to energy deposition.
- According to the MC result and test result, the digitization algorithms work well basically but still needs to be improved.

TODO:

- Optimize digitization algorithms, re-check calibration;
- Testing re-designed IsCMOS hardware for 2021 CALO prototype, update parameters;
- Study of facula crosstalk, this should be added to digitization algorithms;
- Study of low-level reconstruction using more detailed information of faculae to improve IsCMOS linearity;
- Study of pileup effect in-orbit (insignificant at laboratory).