Update on digitization procedure of MC simulation of LUXE ECAL

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Plan of the study

- Implement a procedure of converting energy deposits from Geant4 simulation into ADC units,
- Adjust calibration parameters to obtain agreement between TB results and MC simulation,
- Apply the procedure to MC with tungsten absorber in front of the sensor and check the agreement with TB results.

Files used in the analysis

- TB_FIRE_4533.pickle: TB data with Si sensor (500µm) without tungsten layer, 1M events,
- TB_FIRE_4749.pickle: TB data with Si sensor (500µm) with tungsten layer, 500k events,
- Si-e-5GeV-500um-ev500k.root: Geant4 simulation, 500k events, 500µm silicon sensor, generated by Mihai Potlog,
- ~~mc21.singlePositron_50GeV_ECALP_run2.G4gun.SIM.se0003.root: Geant4 simulation, 20k events, 320µm silicon sensor~~, generated by Shan Huang,
- Si-500um-e-5GeV-1W-ev1M.root: Geant4 simulation, 1M events, 500µm silicon sensor, generated by Mihai Potlog,

Setup of the Langaus function fit

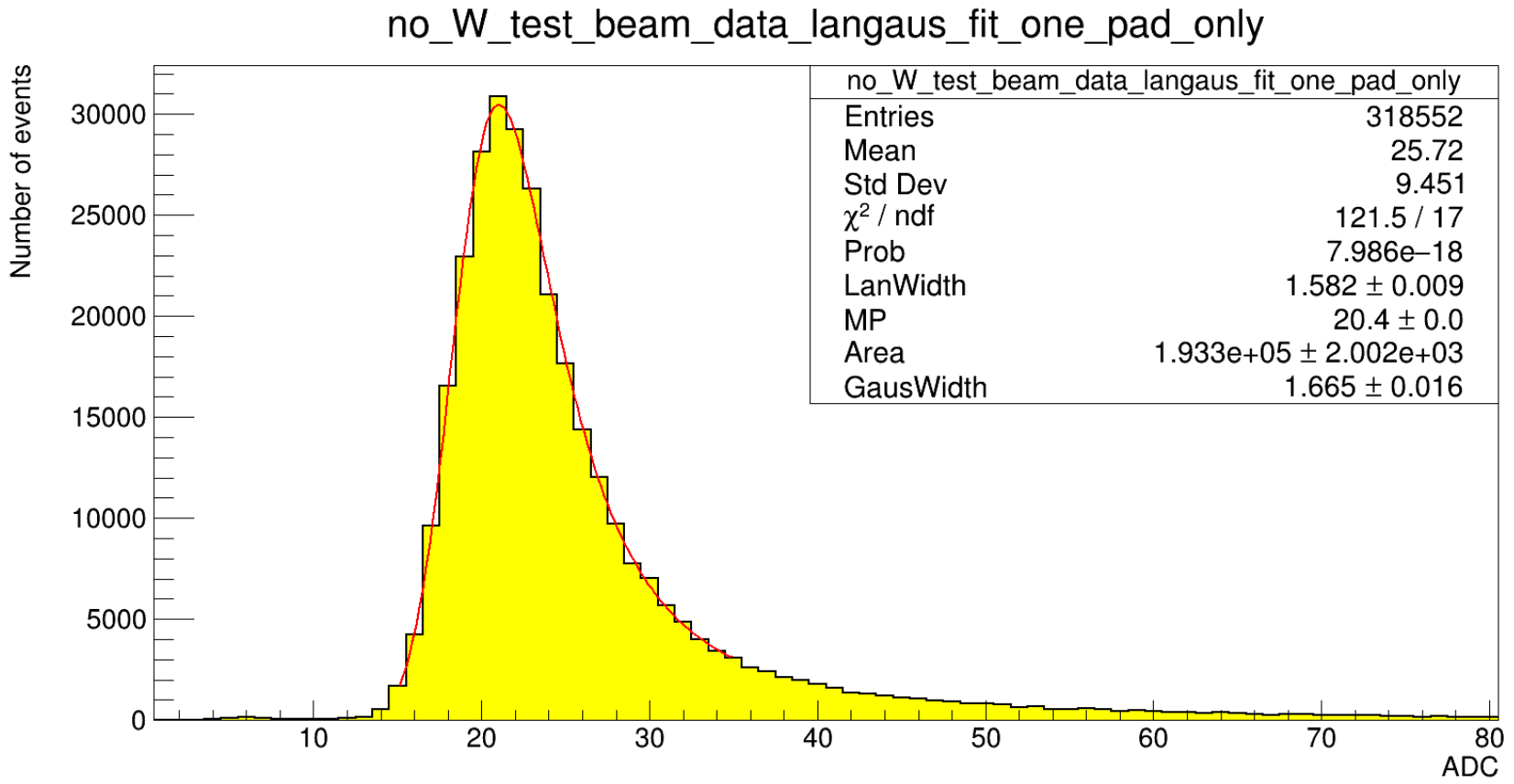
- Histogram of single-particle signal distribution (both from MC and test-beam data) is fitted with Langaus function (Landau & Gauss)
- Langaus function has four parameters:
  - LanWidth: scale parameter of the Landau distribution
  - MP: MPV of the Landau distribution
  - Area: total area, normalization constant
  - GausWidth: width of the convoluted Gaussian function
- Files without tungsten: only events with one hit were selected, to minimize effects caused by secondary particles
- Files with tungsten: only cells with non-zero deposits were considered in conversion procedure

Conversion procedure

Conversion procedure from MeV to ADC:

1) Conversion from MeV to fC using conversion factor:
   a*3.6 eV/electron-hole, where a is an calibration parameter,
2) Conversion from fC to ADC using gain factor for high-gain:
   4.07 ADC/fC, assume saturation at 200 fC,
3) Additional Gaussian variation with sigma equal to noise parameter (taken from pedestal measurements),
4) Additional smearing from Landau distribution (with mean equal to zero and adjustable scale parameter, LanPar).

Langaus fit to TB data, without tungsten absorber

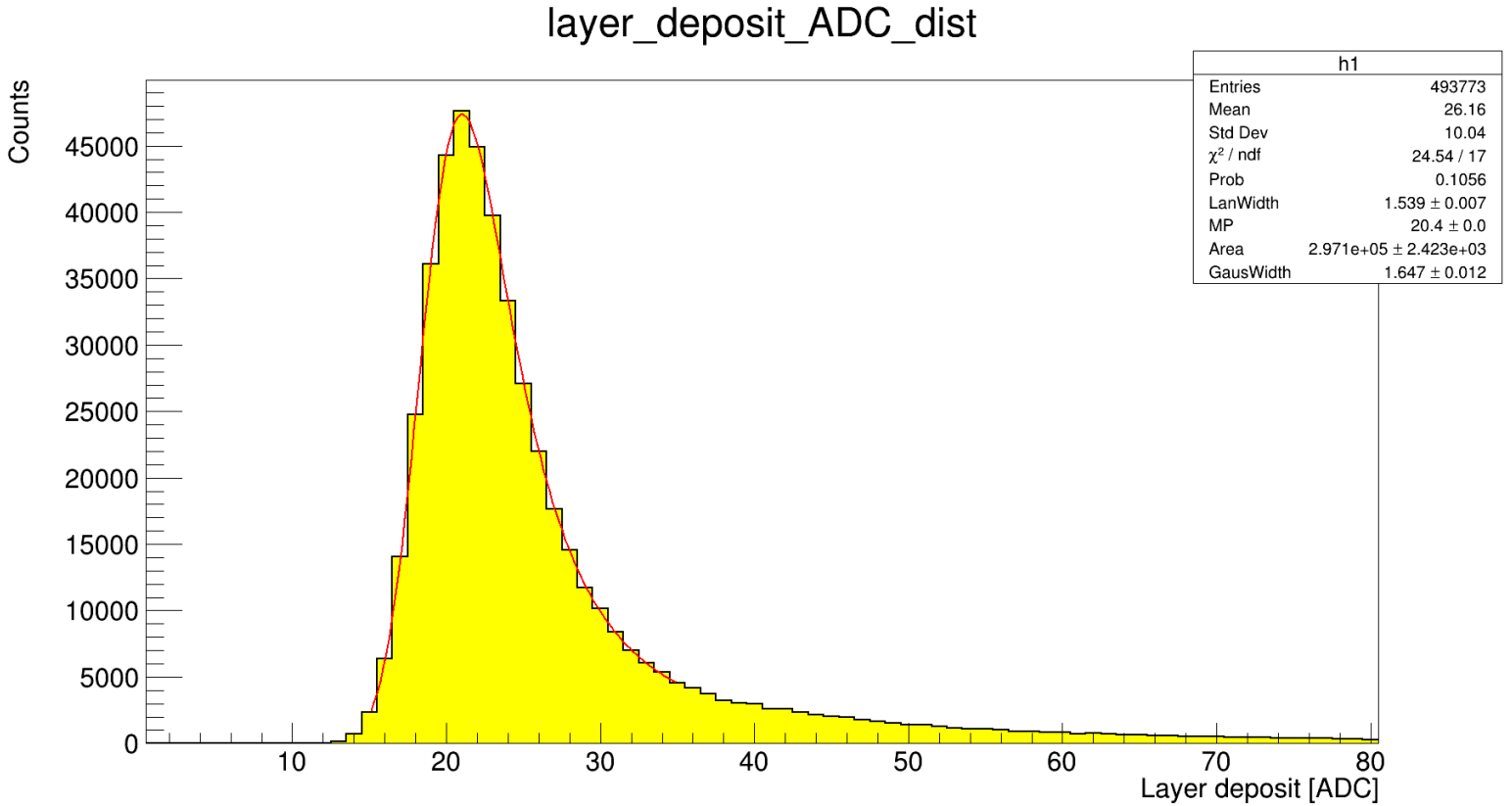


Result of the conversion procedure

- noise = 1.371 ADC
- a = 1.315
- LanPar = 0.212

All parameters are in go agreement with test-beam.

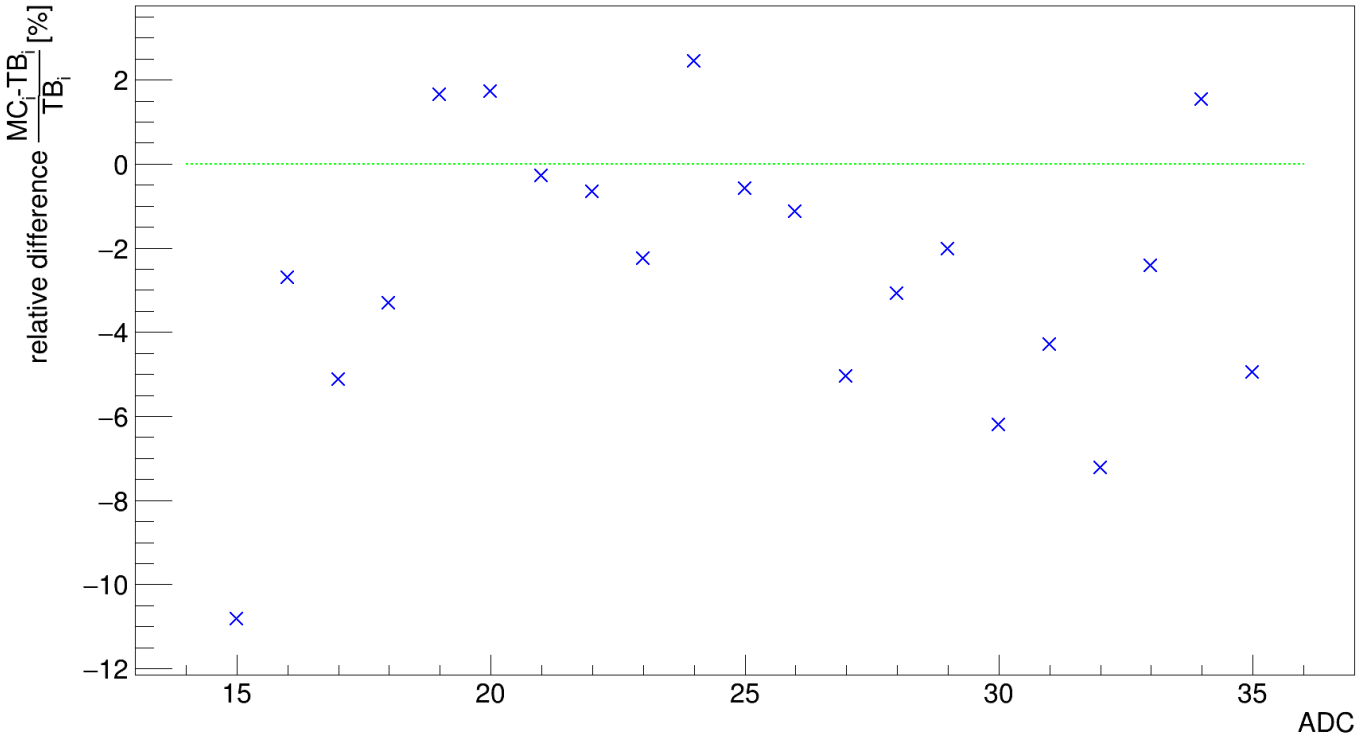
Parameters from fit to test-beam data:
LanWidth = 1.582
MP = 20.4
GausWidth = 1.665



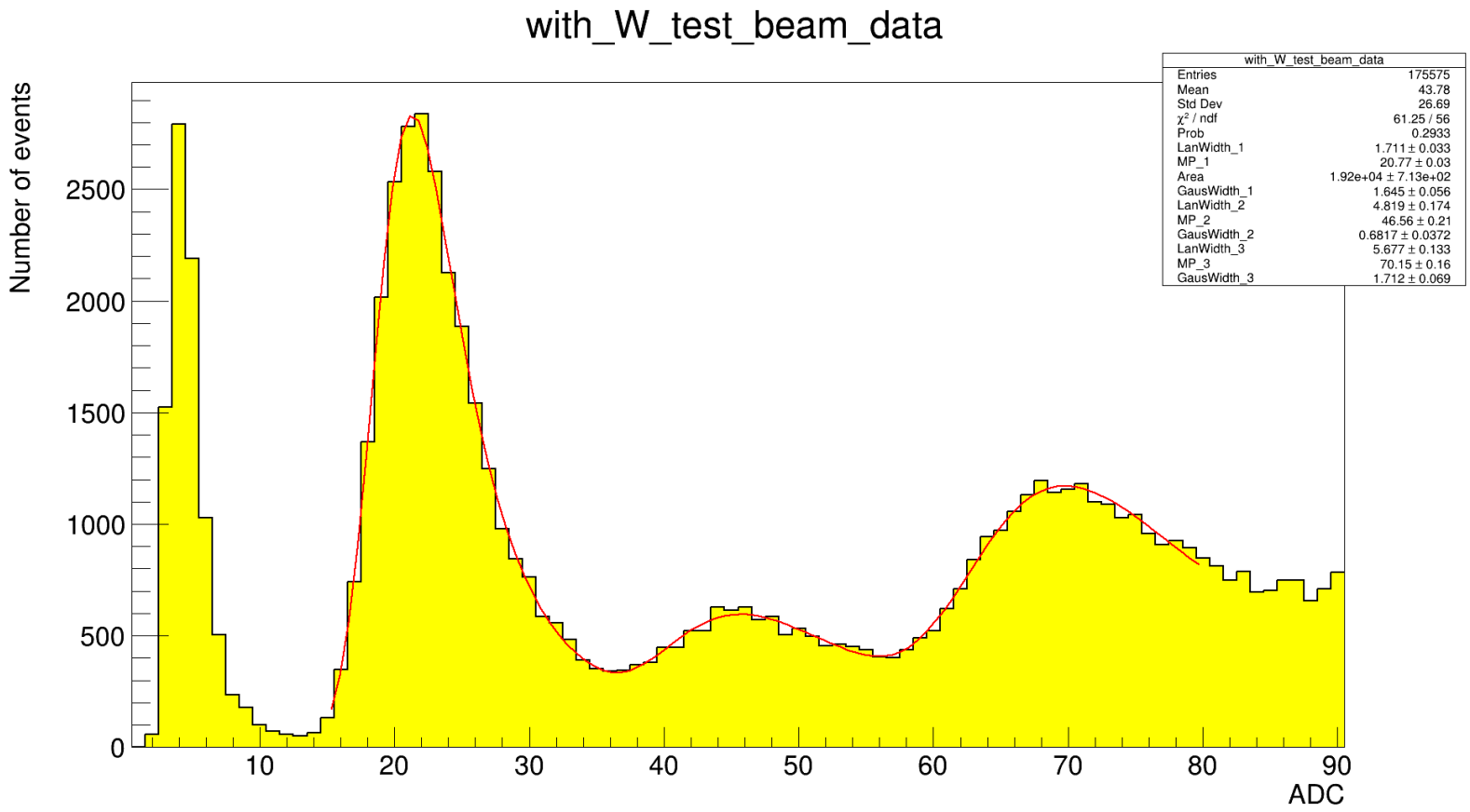
Result of the conversion procedure

- noise = 1.371 ADC
- a = 1.315
- LanPar = 0.212

- relative difference between MC sample and test-beam data is presented



Langaus fit to TB data, with $1X_0$ tungsten absorber

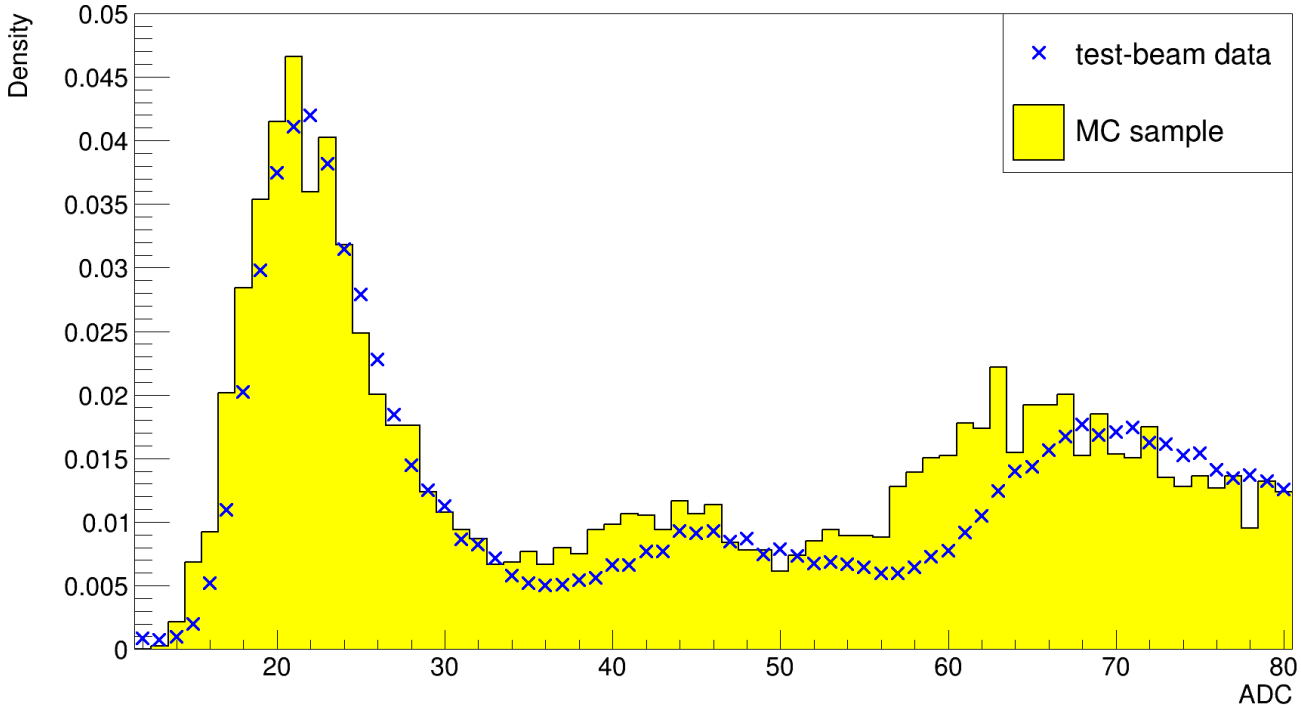


Previous result

- noise = 1.371 ADC
- a = 1.315
- LanPar = 0.212

- distributions of signal from test-beam are presented together with MC sample

- In MC with tungsten absorber the sensor is 320µm thick
- Need for scaling every deposit by the factor 500/320 to get proper MPV
- Larger Landau fluctuations expected for thinner sensor, no way to correct for that →larger Landau width expected

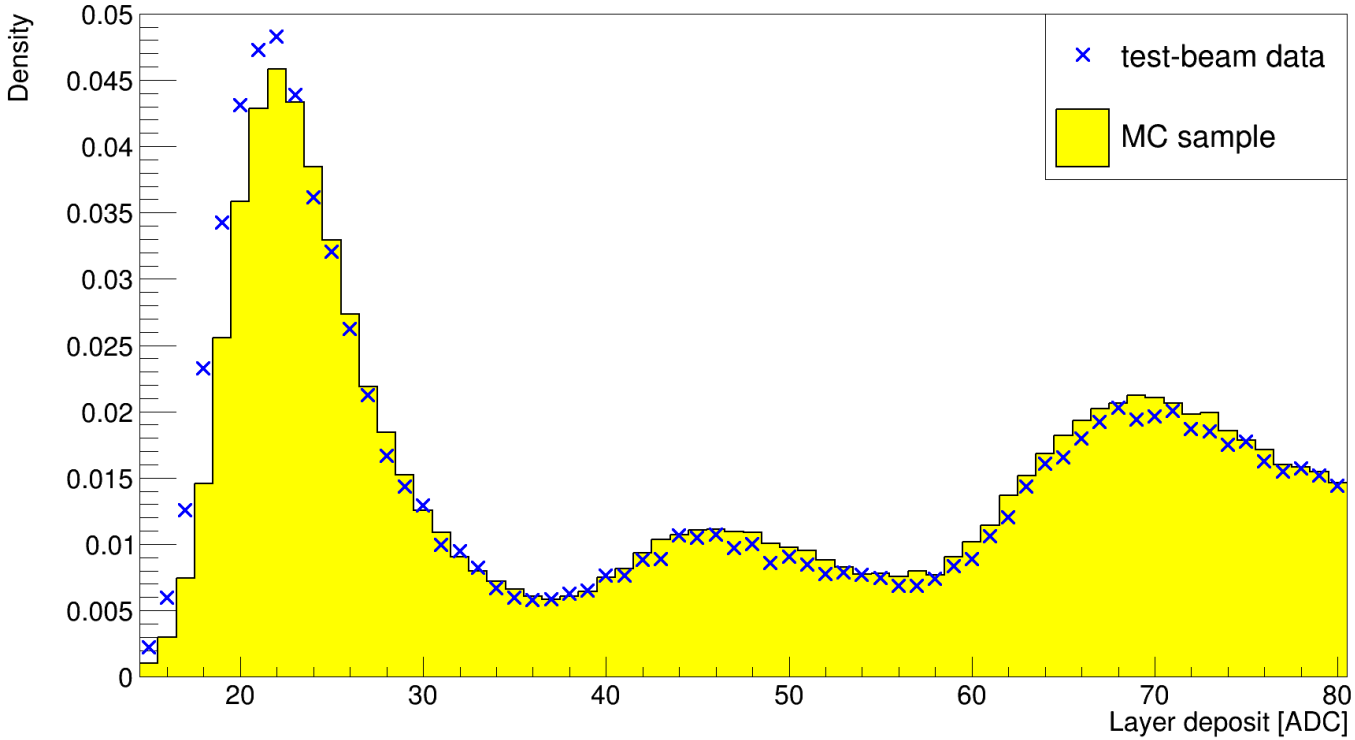


Applying procedure to MC sample with tungsten absorber

- noise = 1.371 ADC
- a = 1.256
- LanPar = 0.212

- distributions of signal from test-beam are presented together with MC sample

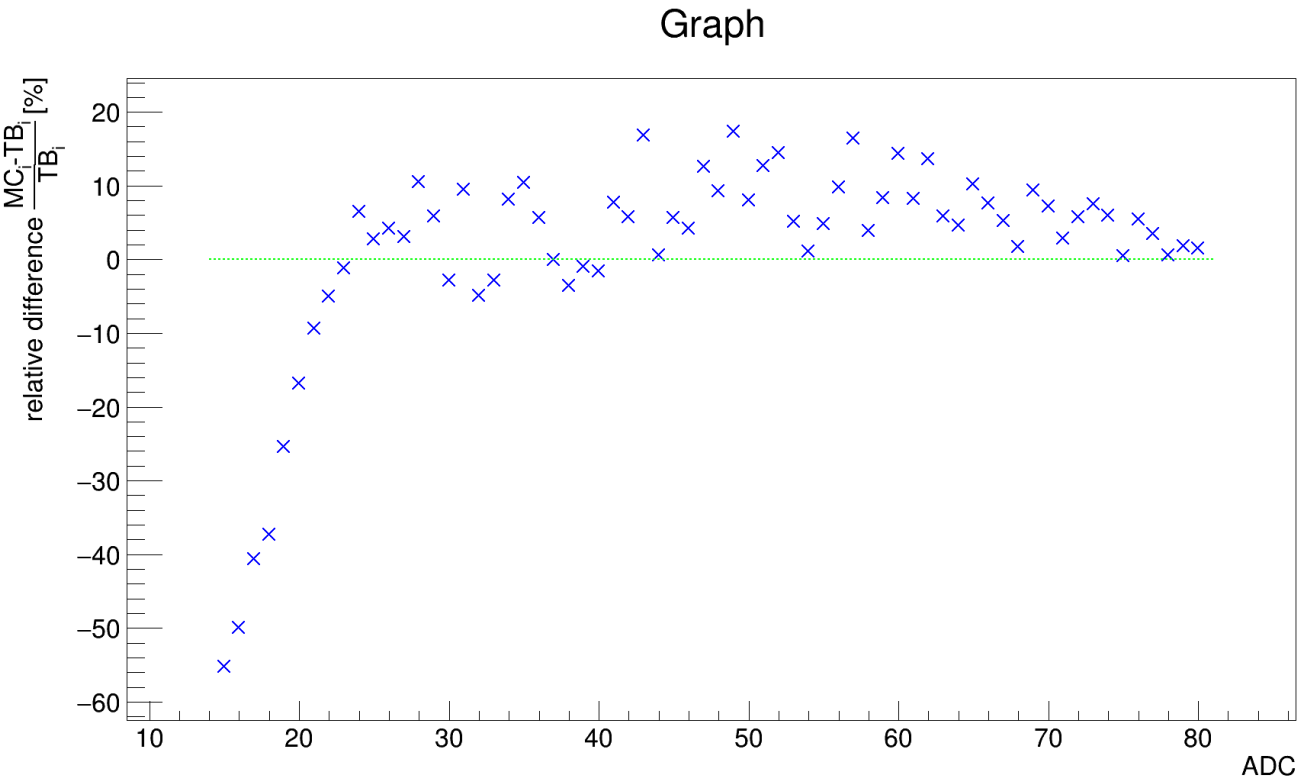
MC distribution obtained from files with 500μm sensor



Applying procedure to MC sample with tungsten absorber

- noise = 1.371 ADC
- a = 1.256
- LanPar = 0.212

- relative difference between MC sample and test-beam data is presented



References

1)Jakub Moroń, FLAME SoC readout ASIC for electromagnetic calorimeter, TWEPP 2022,

2)Marek Idzik, The FLAME and FLAXE ASICs, XII Front-End Electronics Workshop 2023,

3)Wikipedia – properties of Landau distribution.

Conclusion

1)Parameters of conversion procedure (noise, calibration factor, LanPar) can be adjusted to reproduce the shape of deposits distribution from TB.

2)Why the width of Landau distribution doesn’t agree between TB and MC?

3)MC samples with conversion procedure applied does reproduce data (after correcting for different thickness of sensor in TB and MC).