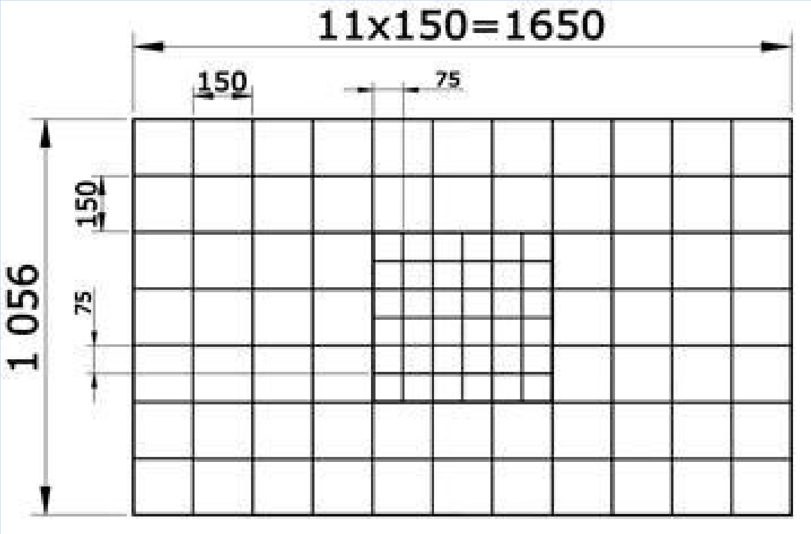
Study of ZDC response in CC@4AGeV (Run6)

Elizaveta Zherebtsova
INR RAS

BM@N Collaboration Meeting,
19/04/21

ZDC calorimeter at the BM@N experiment

- In run 6 was collected data with carbon beam at 4AGeV .
- ZDC calorimeter measure spectator energy.



Central part with 36 modules 7.5 x 7.5cm^2
Outer part with 68 modules 15 x 15cm^2

- Some features of the ZDC experimental data for CC@4AGeV will be presented.

Event selection

Experimental data:

- nHitsBC2 = 1, nHitsT0 = 1
- no fake trigger: nHitsVETO = 0
- hits BD >=2 (in trigger)

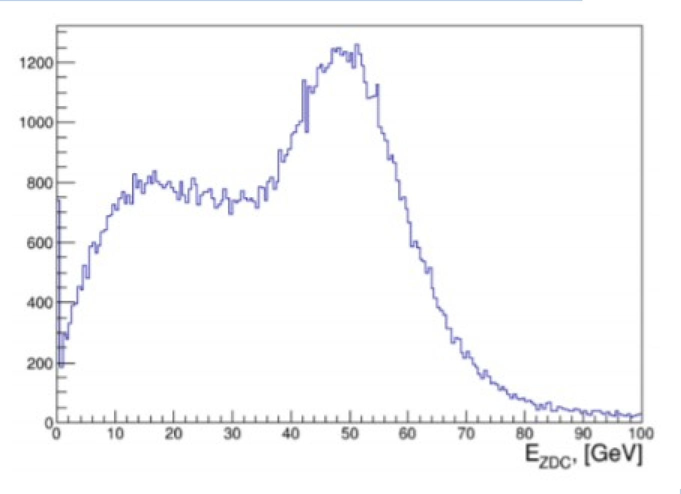
Simulation in GEANT4:

- all BM@N detectors
- DCM-QGSM model, C+C@4 AGeV
- event selection with BD detector (nHitsBD >= 2)

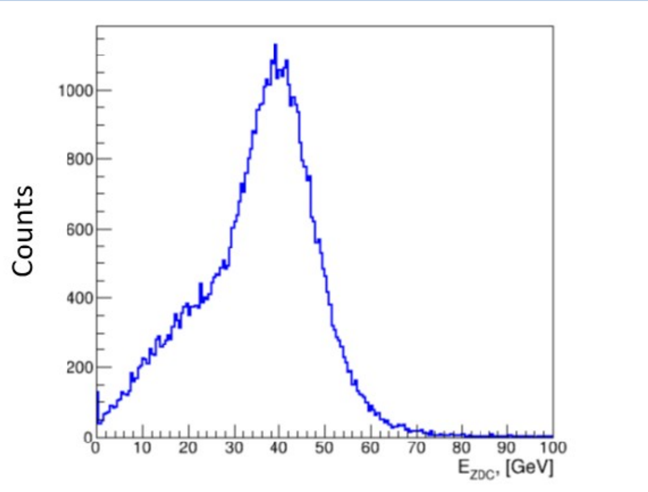
Features of the ZDC data for C+C reaction at 4.0 AGeV

Experimental data

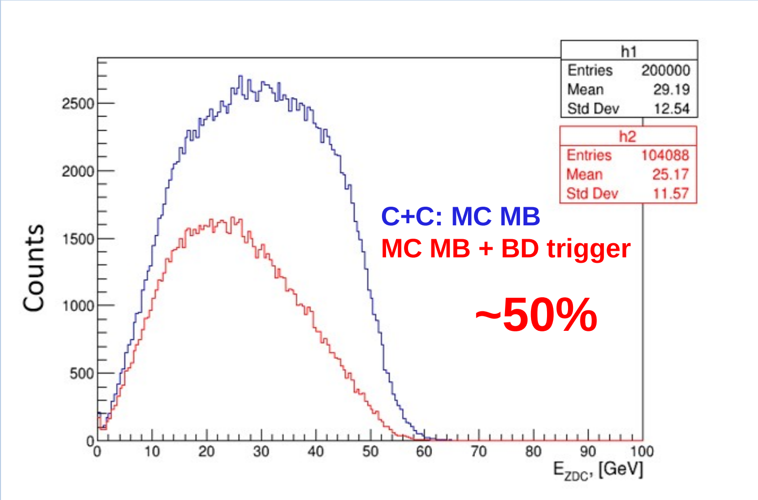
Carbon target



Empty target



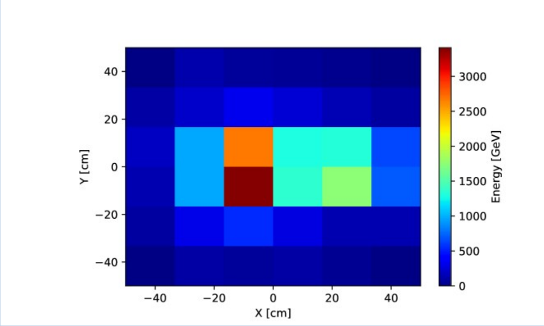
Simulation



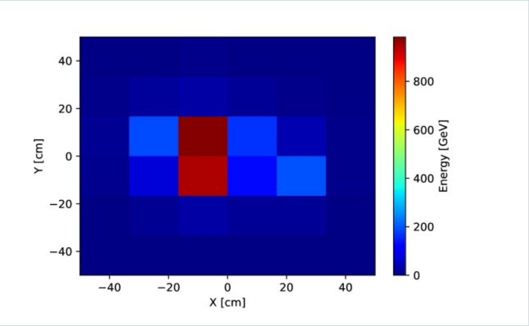
- **Significant fraction of events corresponds to carbon ions.**
- **How to reject these beam events?**

- **At given trigger there are only 50% of the most central events**

Application of ML approach to select the events in reaction CC@4.0 AGeV



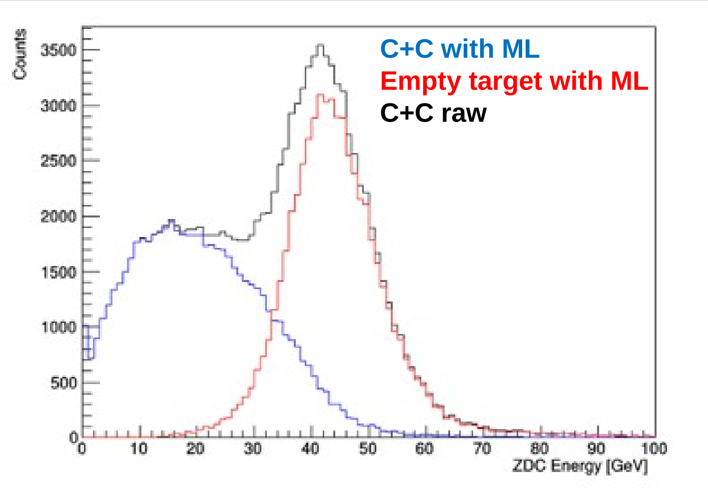
E_{dep} distribution in ZDC modules with target

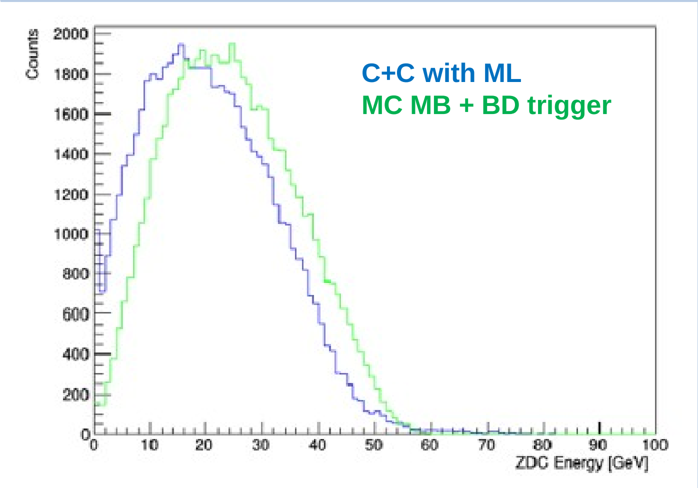


E_{dep} distribution in ZDC modules without target

Train ML to recognize empty target events and then apply to experimental data.

ZDC energy in experimental data:





Experimental data:
ML approach is able to recognize and reject beam carbon events in ZDC energy spectra.

Simulation:
The energy distribution of events measured in ZDC is shifted relative the data obtained MC MinBias. →
The calibration should be checked.

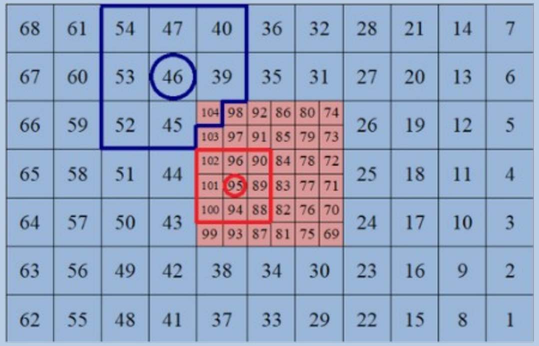
One-nucleon cluster calibration method for the ZDC calorimeter

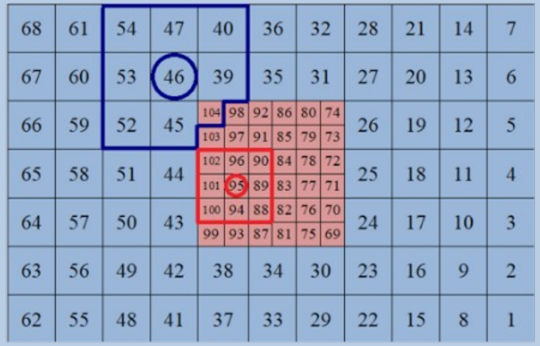
- ➔ Calibration of ZDC modules was based on using cosmic muons
- ➔ To obtain a more uniform response of the calorimeter, a method was proposed for the reconstruction of single-nucleon clusters
- ➔ Single-nucleon clusters events: one spectator nucleon arrives at a given calorimeter module, with an energy equal to the beam energy

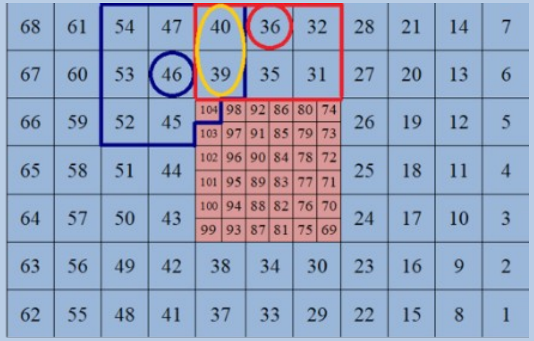
$$E_{cluster} = E_{central\ module\ N} + E_{N\ cluster\ modules}$$

$$E_{cluster} = E_{beam}$$

Cluster types:







Cluster identification algorithm

1. For each module in the event, a cluster is built and the mutual arrangement of all clusters is considered.

2. The energy is redistributed (if the clusters have common, non-central modules).

3. 2 conditions are checked:

- for small modules:

$$E_{\text{central module N}} > 0.8 * E_{\text{cluster}} \ \& \ E_{\text{N cluster modules}} > 0.$$

- for large modules:

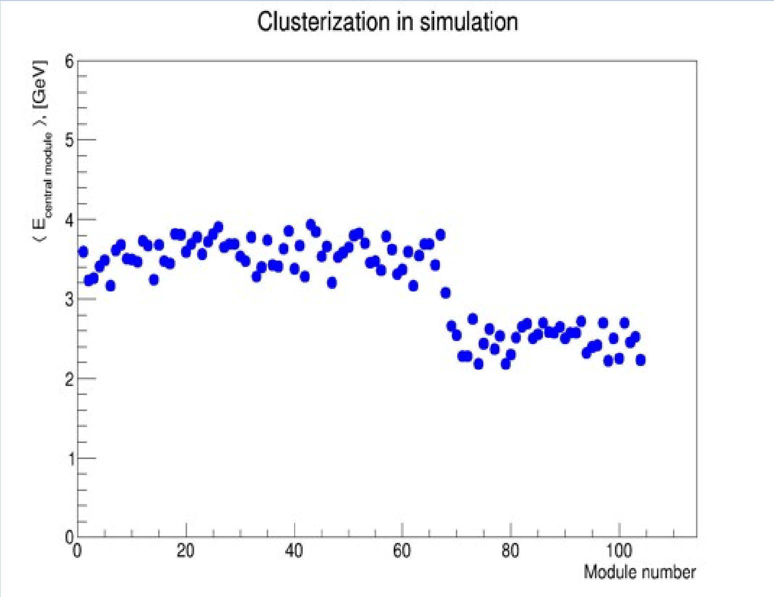
$$E_{\text{central module N}} > 0.7 * E_{\text{cluster}} \ \& \ E_{\text{N cluster modules}} > 0.$$

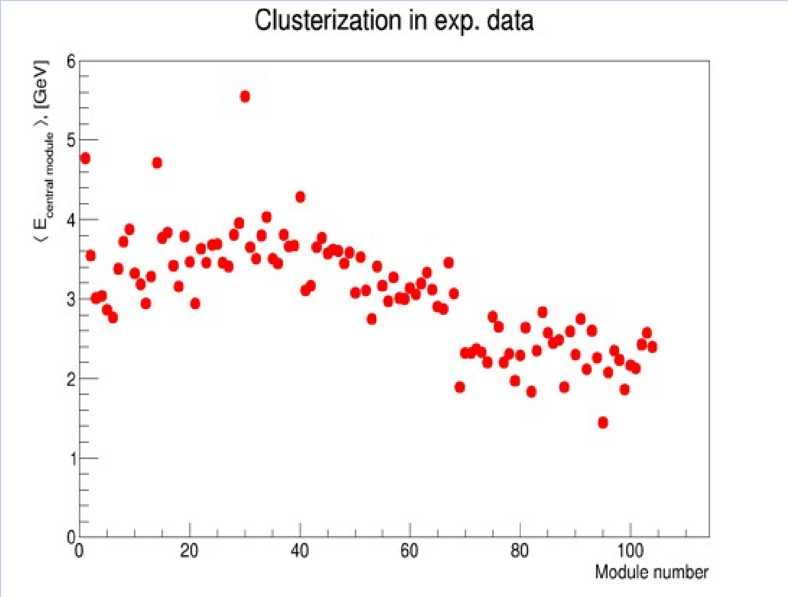
If both conditions are met simultaneously, the cluster is identified.

$$Calibration\,coefficient = \frac{\langle E_{central\,module}(simulation)\rangle}{\langle E_{central\,module}(\exp.data)\rangle}$$

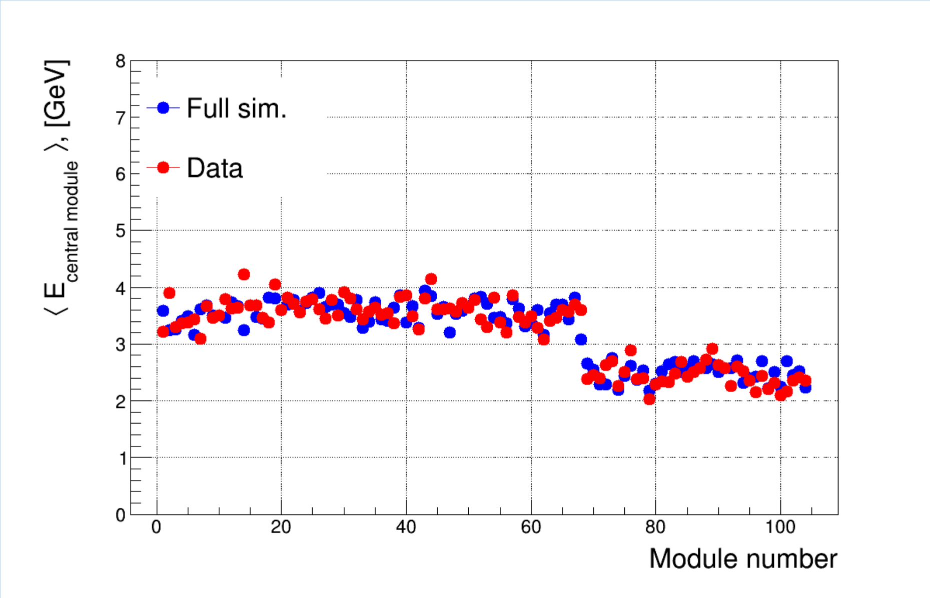
Results of single nucleon cluster calibration

Before application of the one-nucleon cluster calibration:



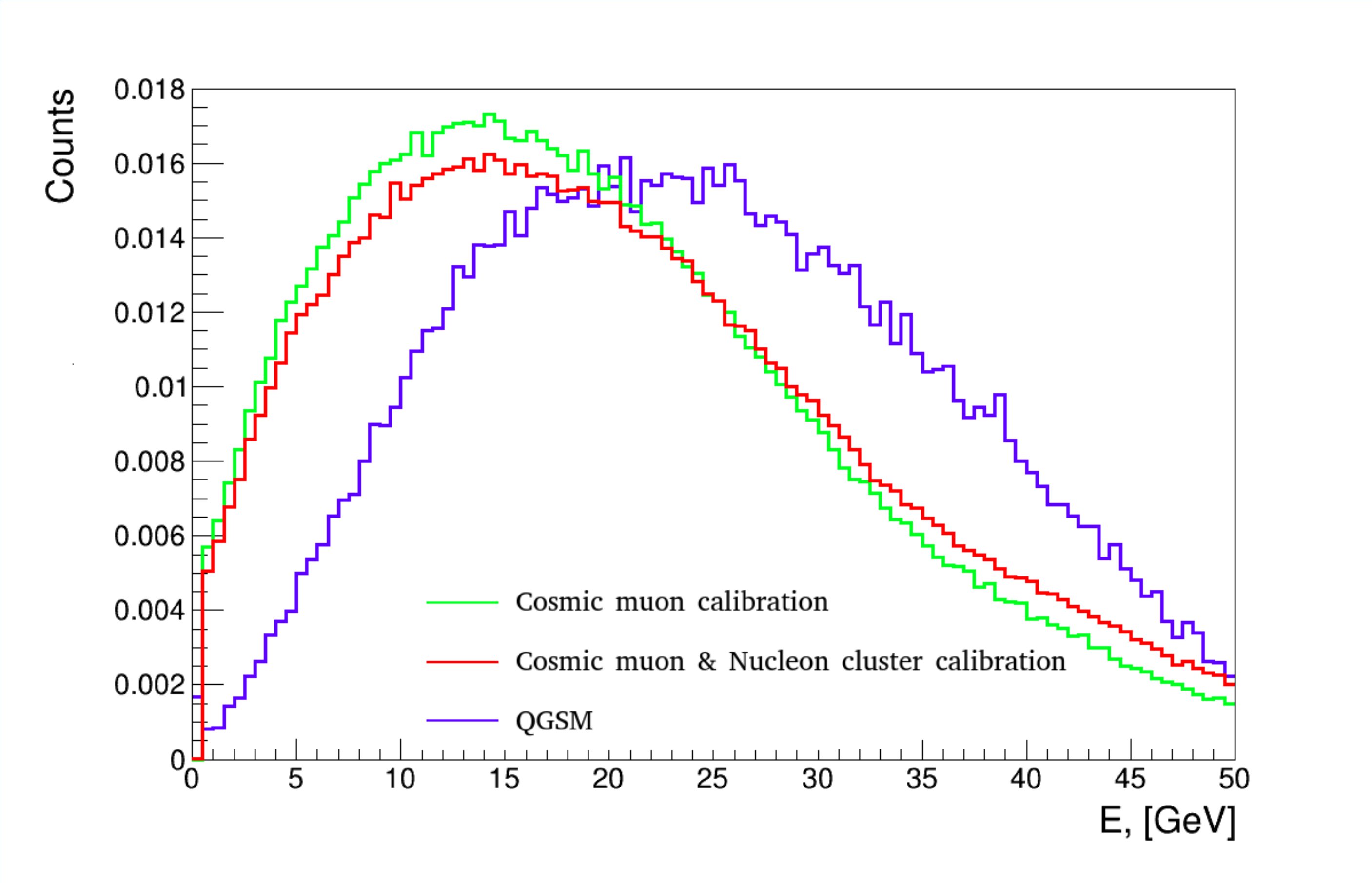


With application one-nucleon cluster calibration:



Results of application single nucleon cluster calibration

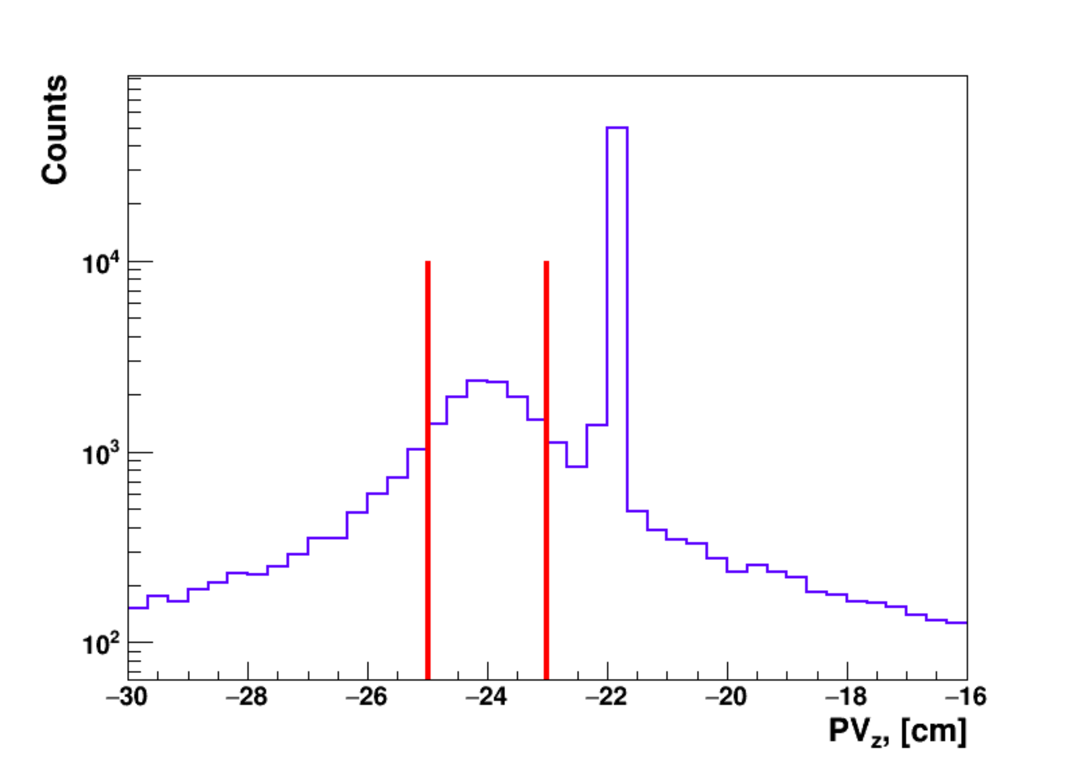
Distribution of the total reconstructed energy in the calorimeter in modeling and in experimental data



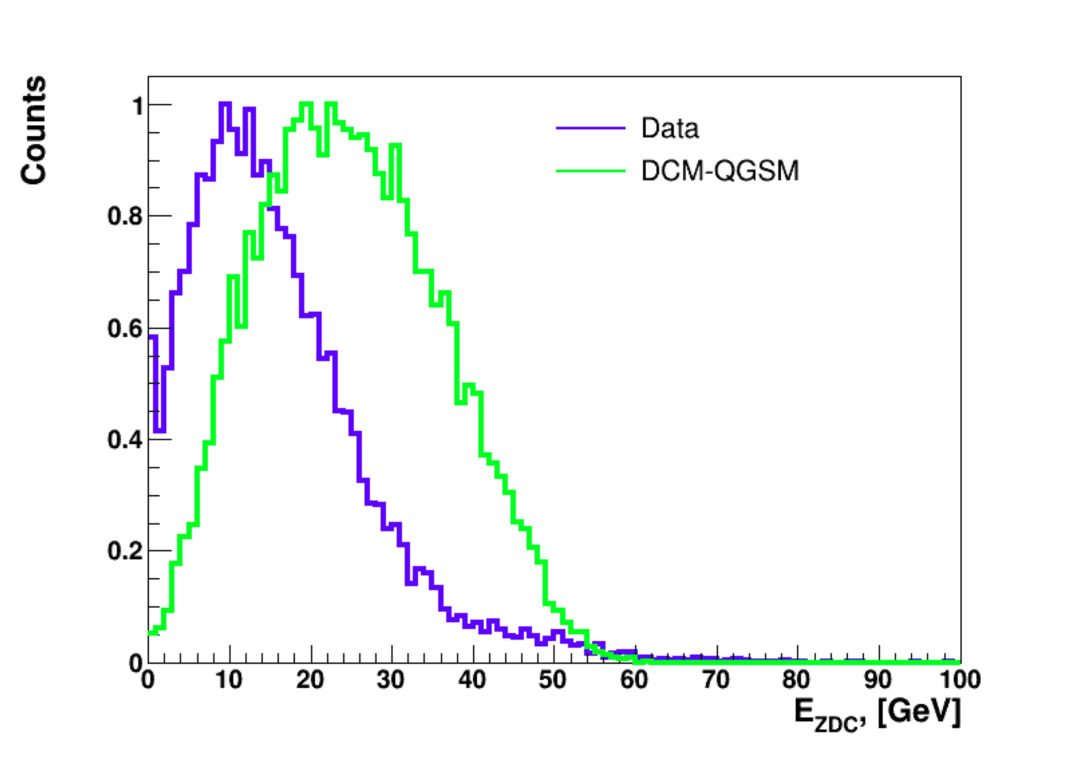
Application of the one-nucleon cluster calibration shows a **slighly difference** in energy spectra from cosmic muon calibration → the calibration was done correctly.

Selection of events for ZDC with primary vertex cut

Z coordinate of primary vertex (PVz):



Reconstructed energy in ZDC
with cut on PVz:
-25cm <PVz < -23cm



Conclusion

- Rejection of carbon events was made by machine learning approach and cut on primary vertex.
- Cosmic muon calibration was checked with one-nucleon cluster calibration algorithm, calibration is correct.
- Cutting out beam events by different methods, the energy spectrum in the calorimeter does not match the simulation.

Future plans:

- Make the same procedures for Cu and Al target runs at 4 AGeV.