Centrality determination in carbon beam data for BM@N experiment with Zero Degree Calorimeter (ZDC)

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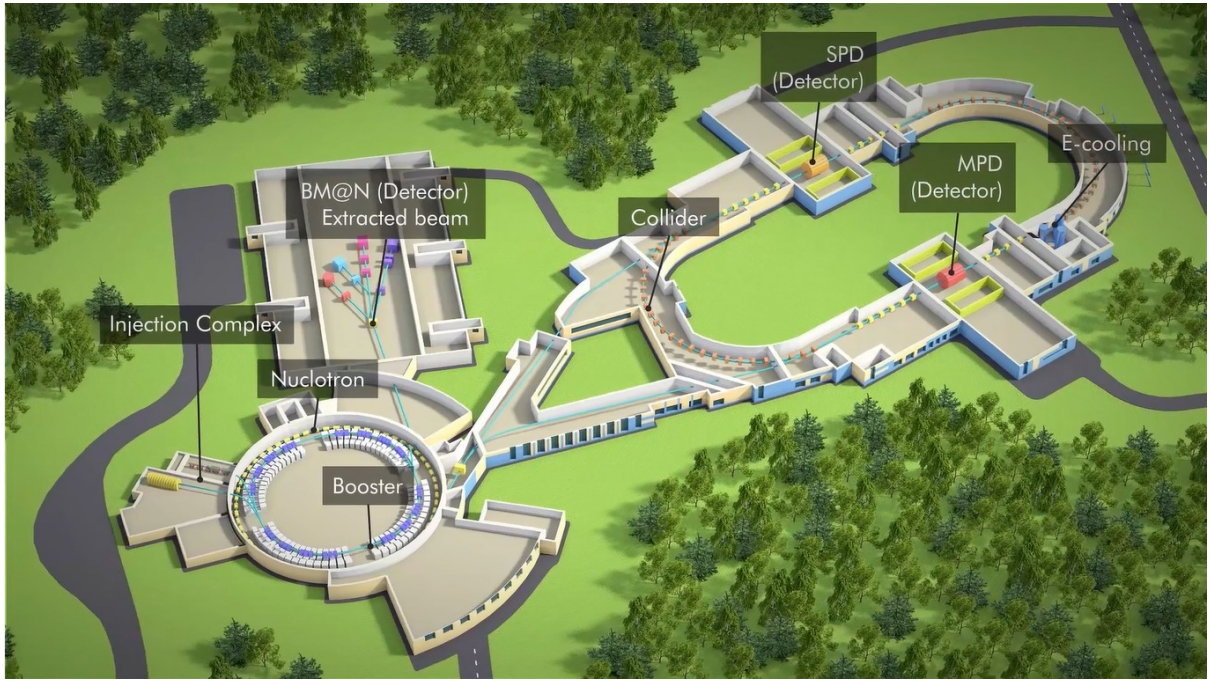
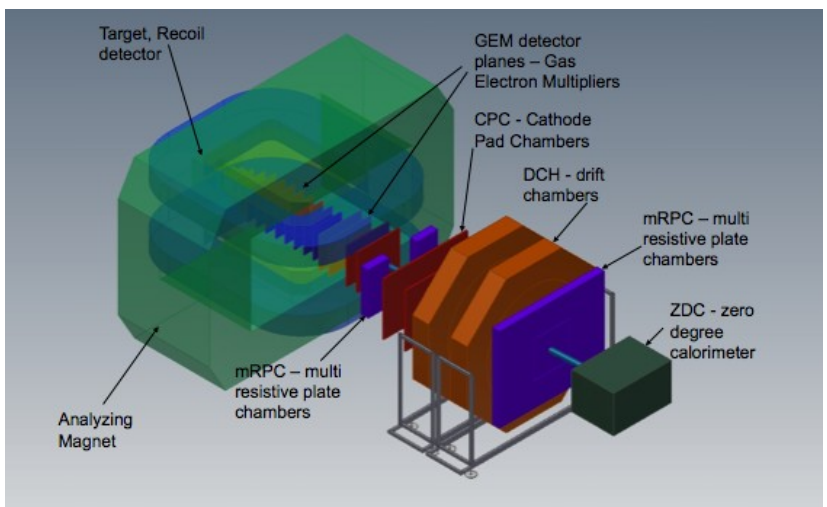
BM@N experiment at NICA acceleration complex

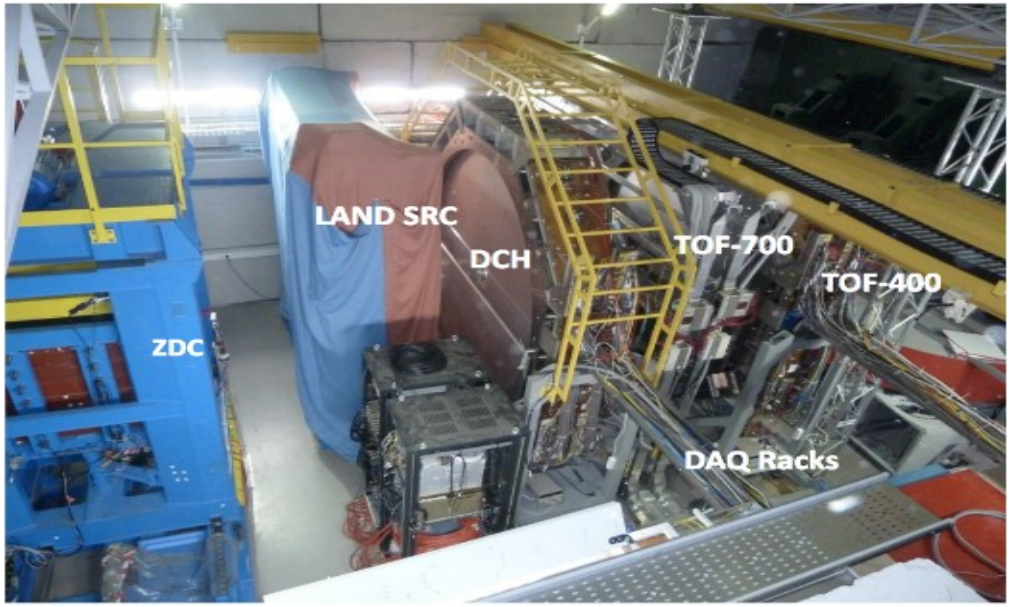




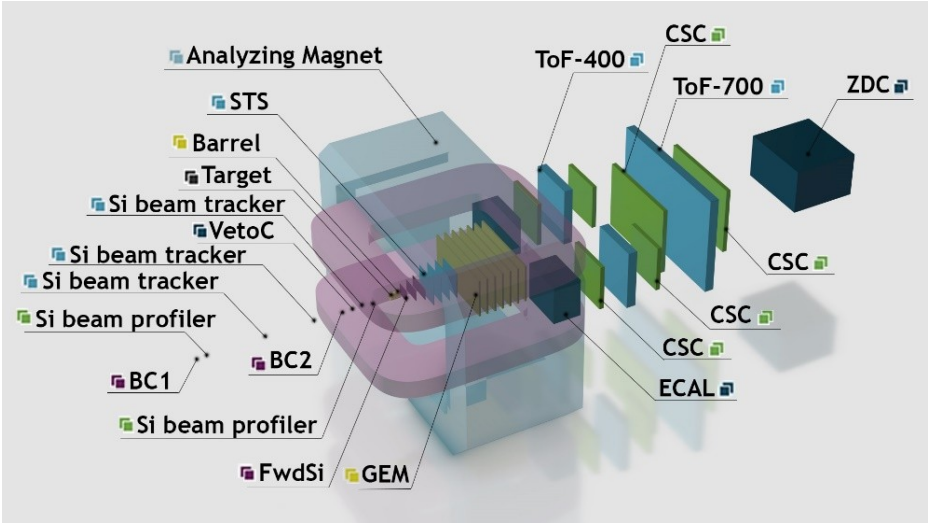
Year	2016	2017 spring	2018 spring	2021	2022 and later
Beam	d(↑)	C	Ar,Kr, C(SRC)	Kr,Xe	up to Au
Max.intensity, Hz	0.5M	0.5M	0.5M	0.5M	2-5M
Trigger rate, Hz	5k	5k	10k	10k	20k→50k

C+C @ 4AGeV

BM@N setup



BM@N experiment schematic view



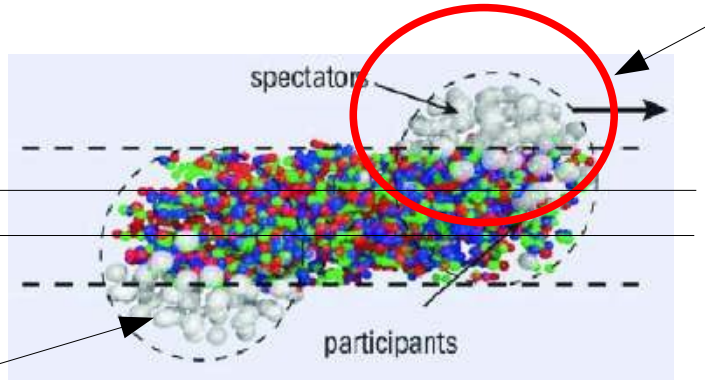
impact parameter "b"
(distance between nuclei centers)

Fixed target experiment (ion-ion collision)

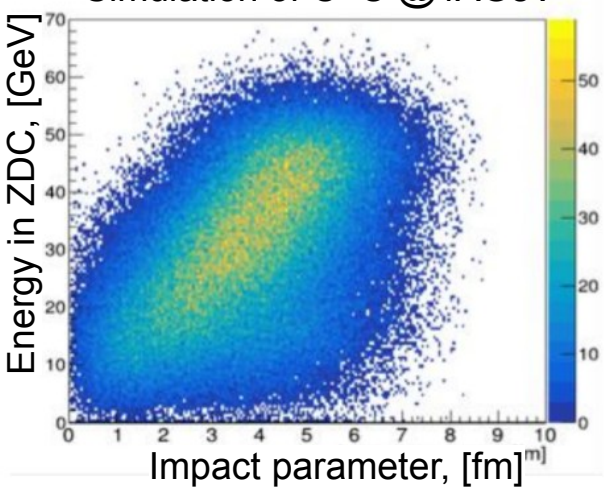
projectile spectators
(to be detected with ZDC)

beam

target nucleus



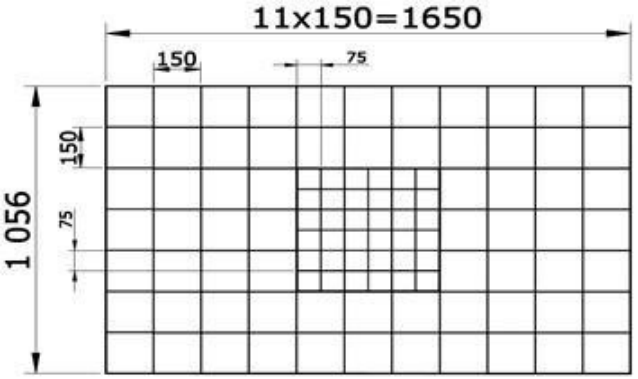
Simulation of C+C @4AGeV



Centrality determination for BM@N with ZDC

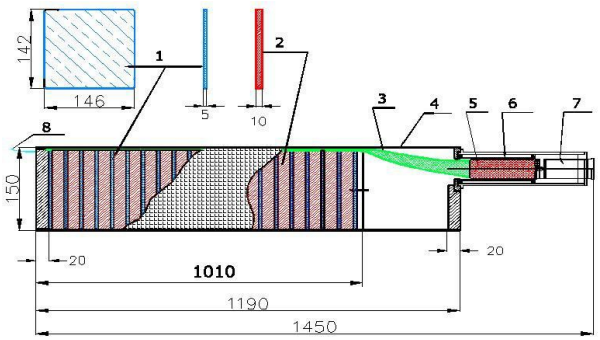
Zero Degree Calorimeter (ZDC) at BM@N

ZDC modules



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

ZDC module structure



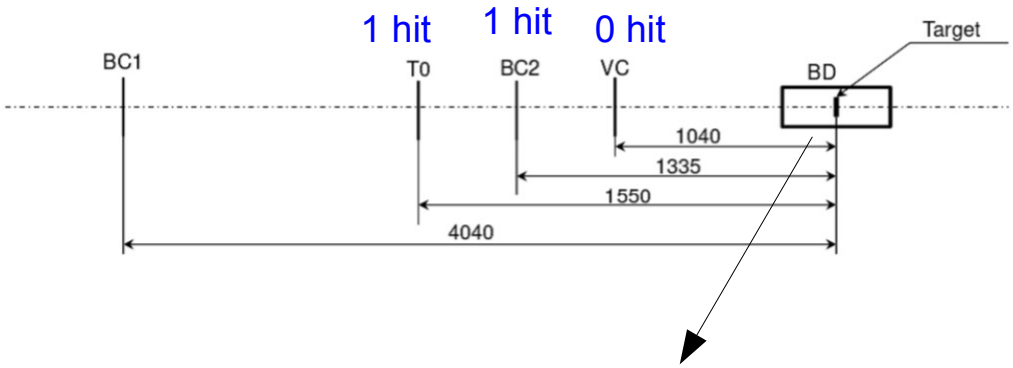
64 layers of 5mm scint. + 10mm Pb

- ZDC modules with light collection by WLS plate and does not have a longitudinal segmentation.

- calibration: on cosmics only

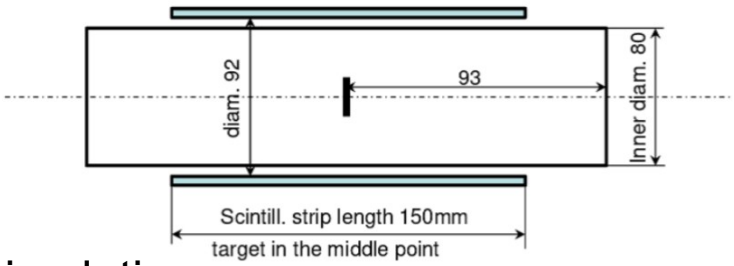
Centrality determination for BM@N with ZDC

Experimental data:
- single ion selection:
  1) nHits in BC2 = 1, nHits in T0 = 1
  2) no fake trigger: nHits in VETO = 0
  3) nHits in BD >=2 (in trigger)



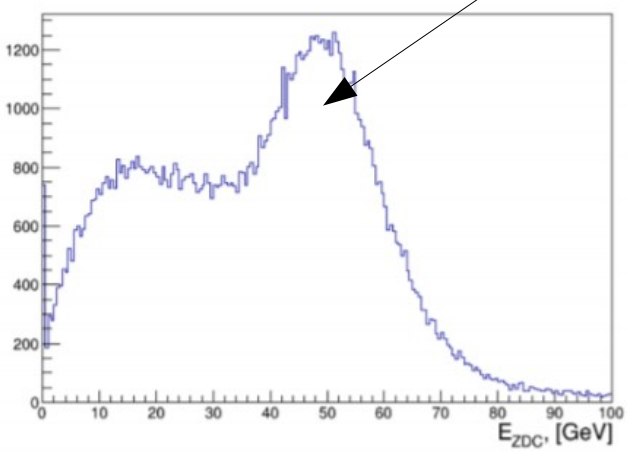
Simulation in GEANT4 (MB – min. biased):
- all detectors in place (TOF + DCH)
- DCM-QGSM model, C+C@4 AGeV reaction
- event selection with BD detector (nHitsBD >= 2)

BD – barrel detector

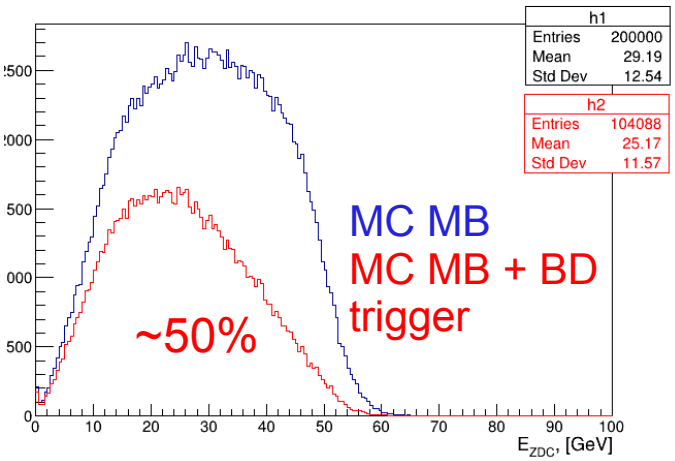


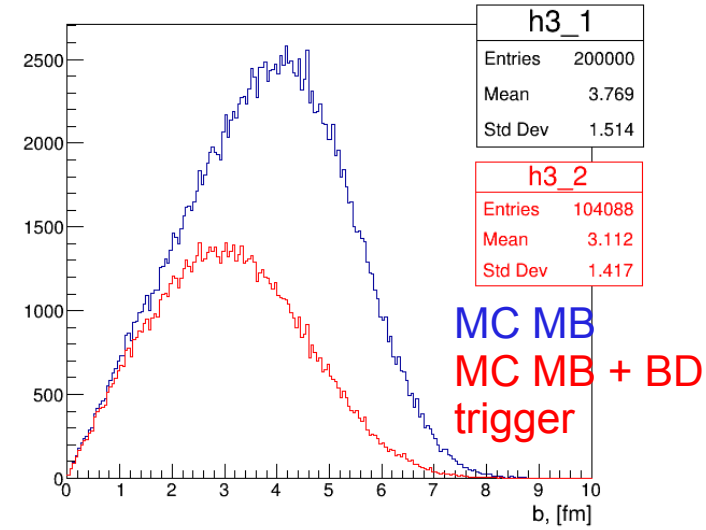
C beam contamination

experimental data



simulation





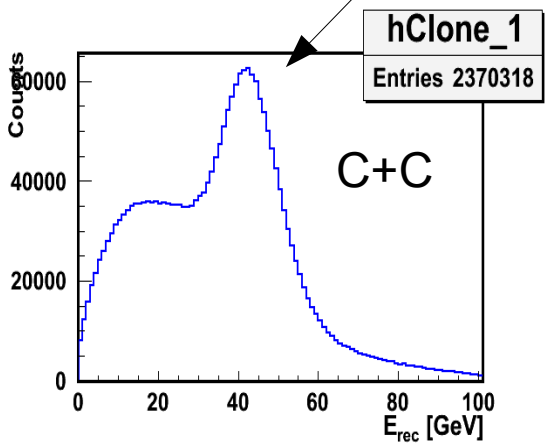
Exp. (multiplicity) trigger BD>=2 affects MB and selects ~ 50% most central events

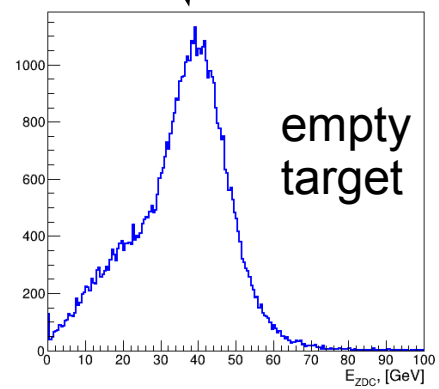
Centrality determination for BM@N with ZDC

Experimental data from C+C @ 4AGeV

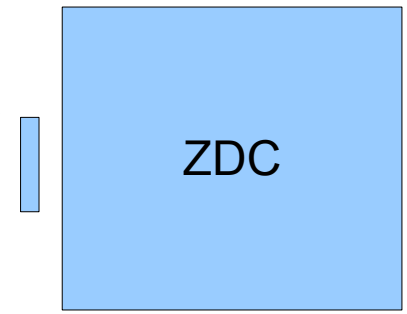
Carbon from beam

Total energy in ZDC



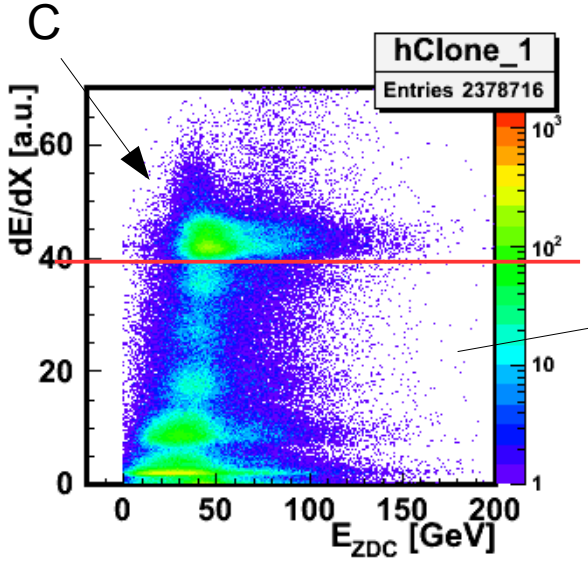


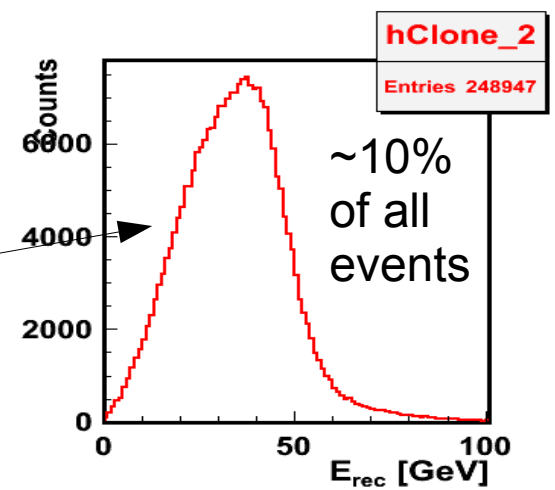
dE/dx
counter



Trying to reject the C ions..

C

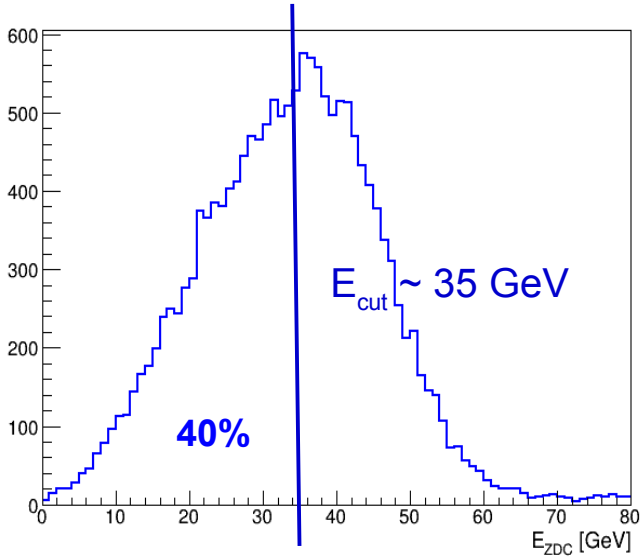




Centrality with energy in ZDC

C+C @ 4AGeV

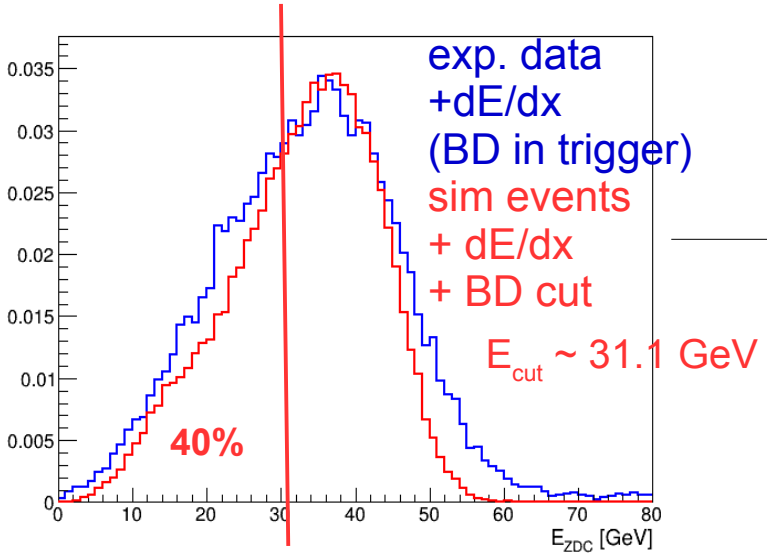
1) Exp. data (events selected with dE/dx counter)



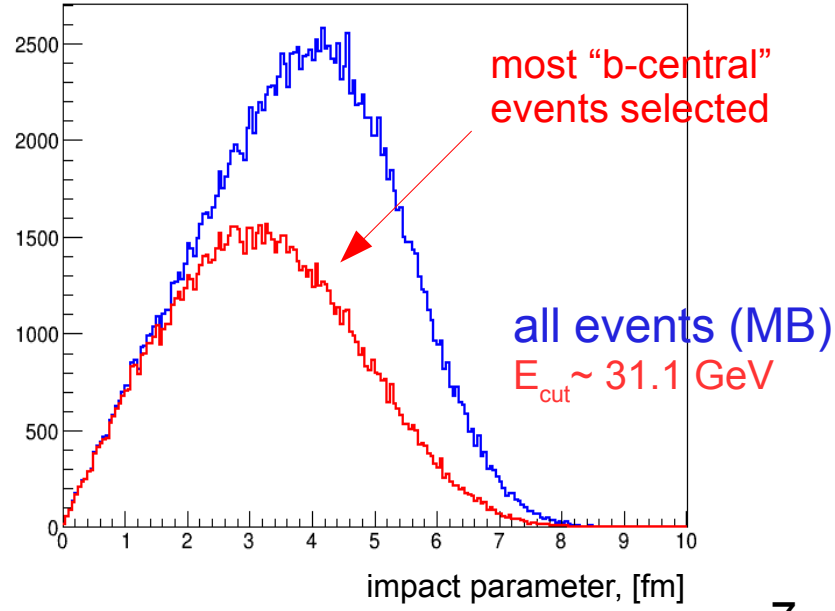
"Centrality" 0 - 40% → E_{cut} ~ 35 GeV

(NOTE: this is not true centrality of all MB events! This is 0-40% of centrality for specially selected events)

2) Comparison with simulation



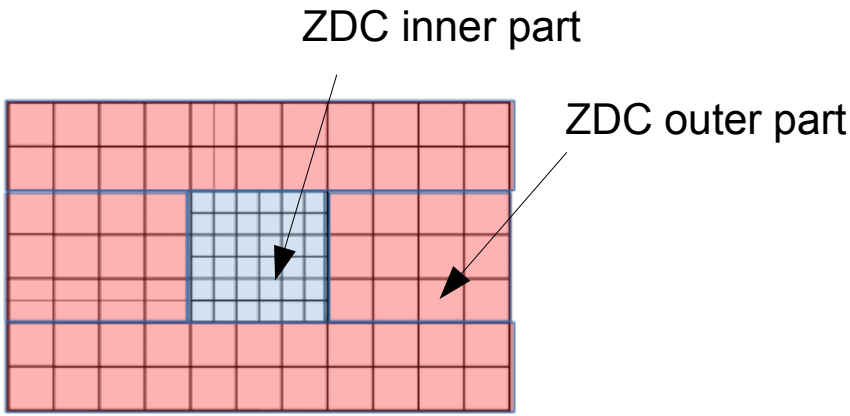
Impact parameter spectra



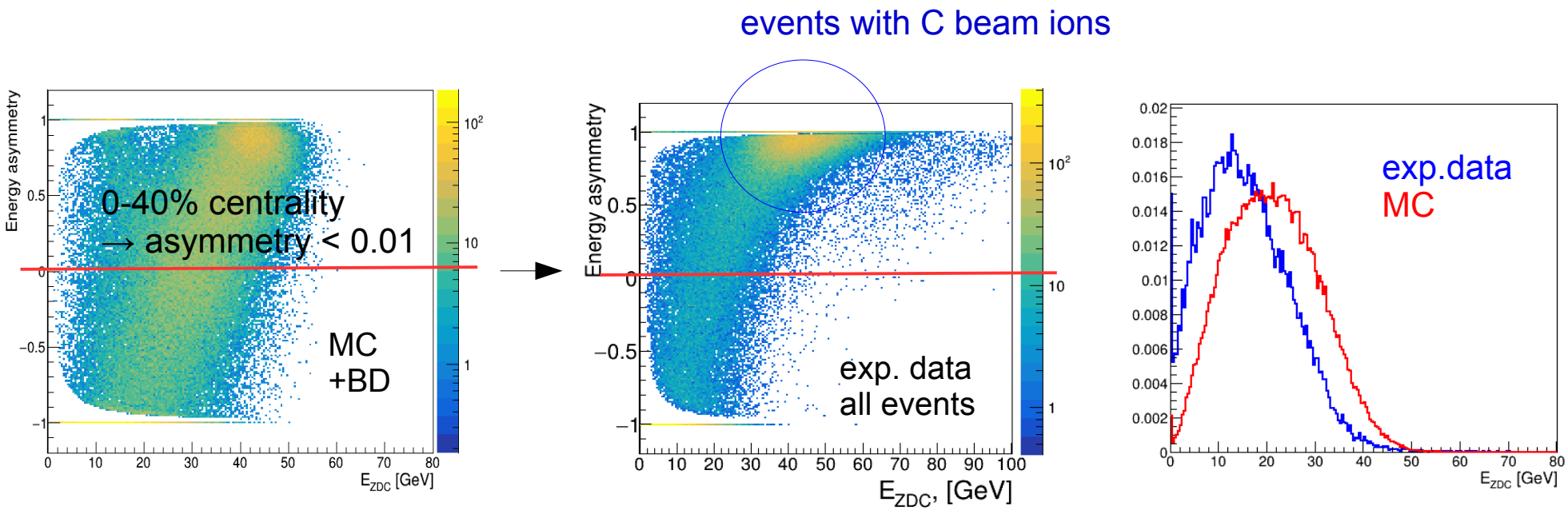
C+C @ 4AGeV

Centrality selection for all experimental data with C beam contamination :

→ energy asymmetry method



$$Energy\ asymmetry = \frac{E_{ZDC\,inner} - E_{ZDC\,outer}}{E_{ZDC\,inner} + E_{ZDC\,outer}}$$



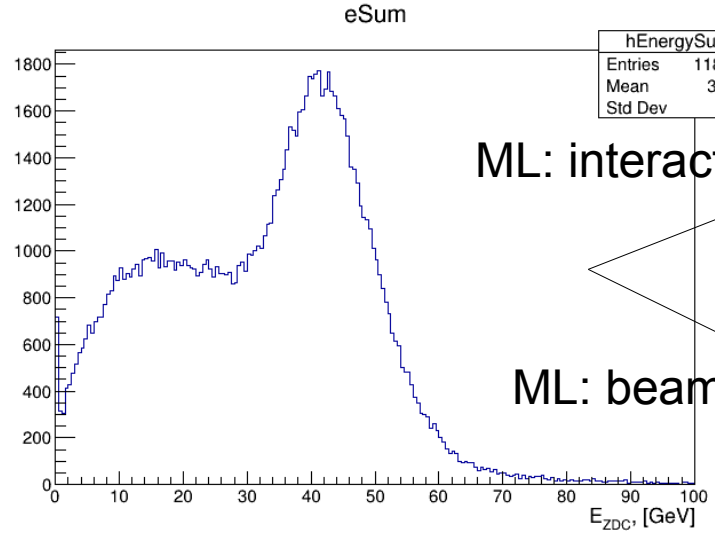
C+C @ 4AGeV

Machine Learning technique

NEW method:

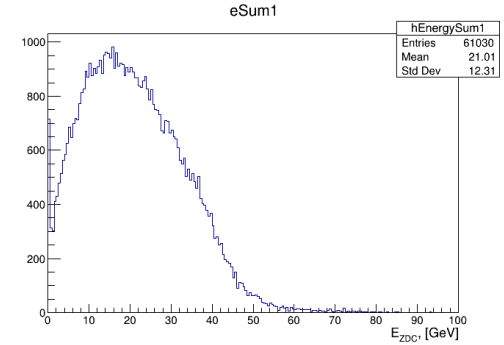
ML technique for event selection

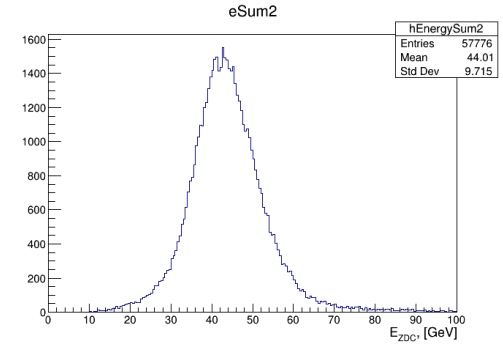
- train on empty target

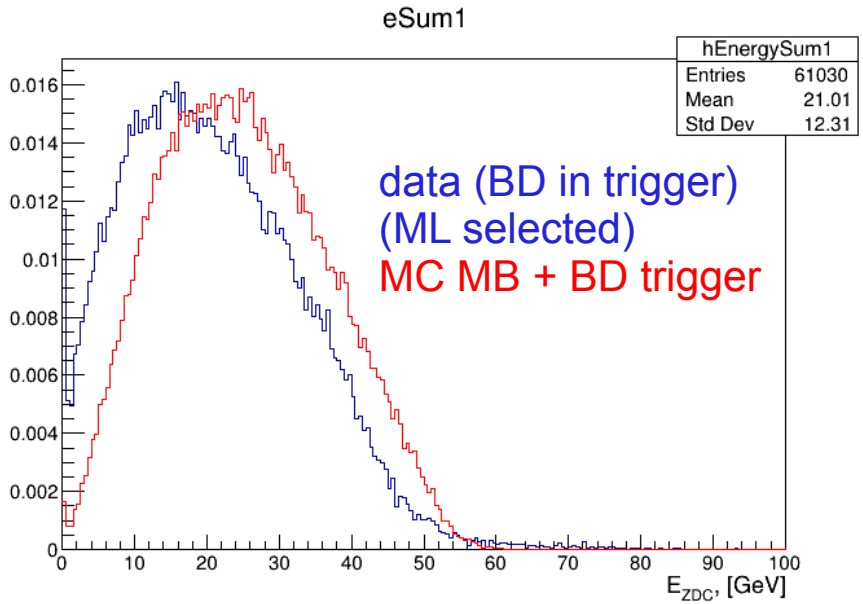


ML: interaction

ML: beam







- significant difference in data and MC

(probably the calibration of ZDC needs to be improved) → the work is in progress..

Conclusions:

- centrality estimation was done for C+C @ 4AGeV in BM@N experiment
- several methods for centrality determination have been tested:
    1) full energy in forward hadron calorimeter (ZDC)
    2) energy asymmetry in ZDC
- ML technique has been tested for carbon beam event rejection

Thank you for your attention!

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