Performance of BM@N scintillation wall in Xe+CsI@3.8 AGeV run

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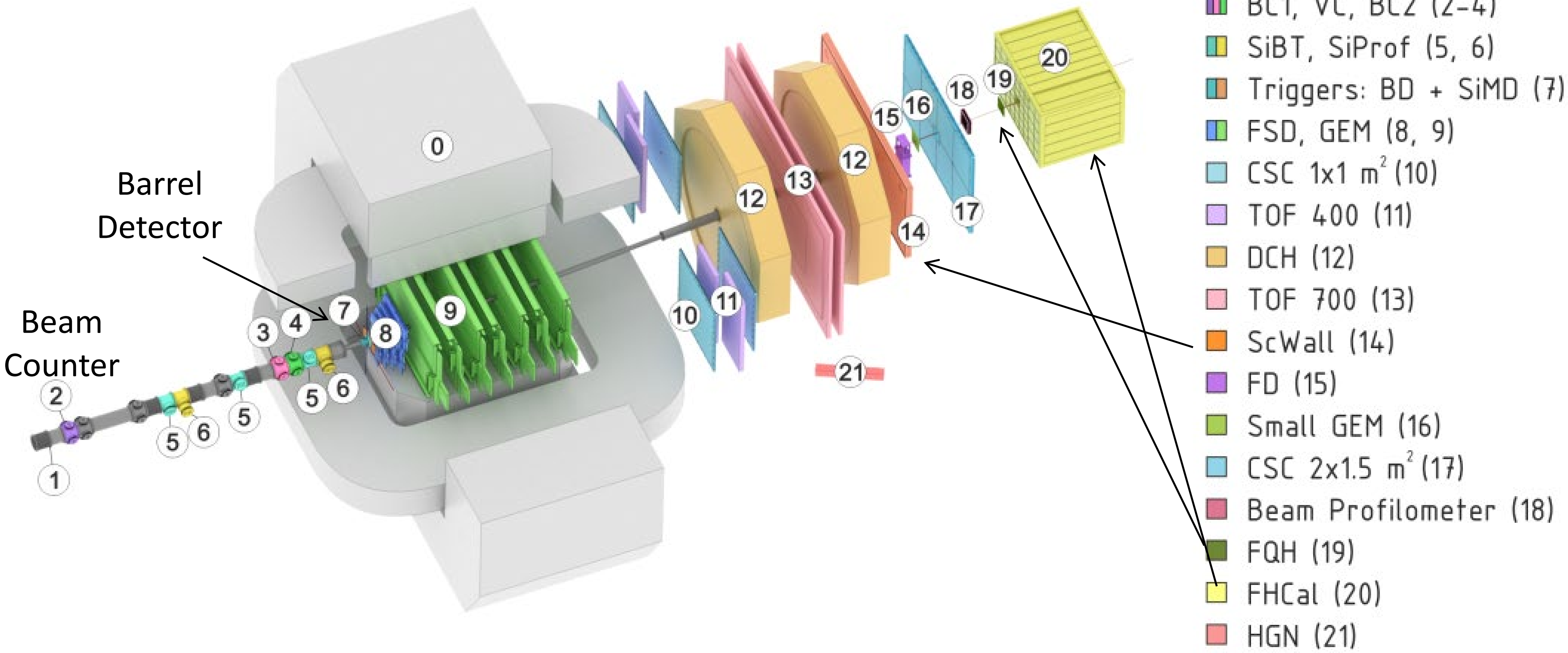
Outline

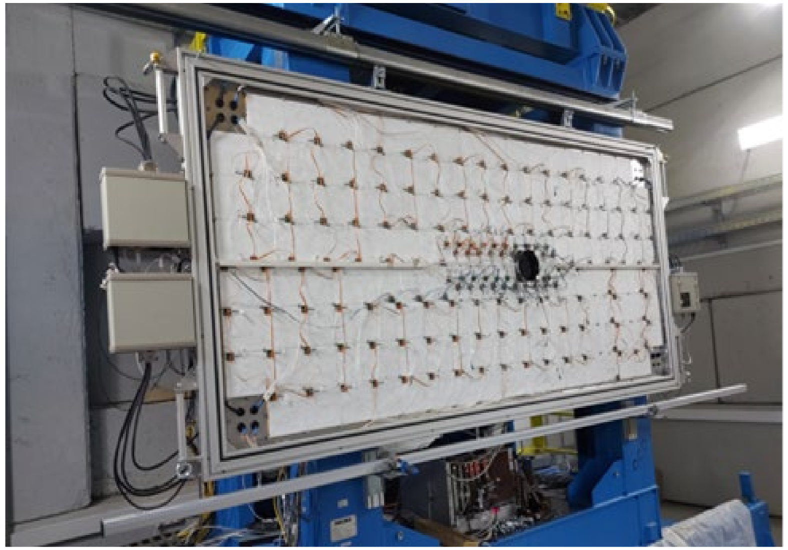
- The general structure and tasks of the scintillation wall
- The ScWall performance examples for different charges
- ScWall calibration
- The charges range detected in the last BMN runs
- The sensitivity of the ScWall to centrality according to multiplicity
- Correlations of ScWall multiplicity with the calorimeter deposited energy and barrel detector multiplicity
- Multiplicity distributions as a function of the charge deposited on the ScWall

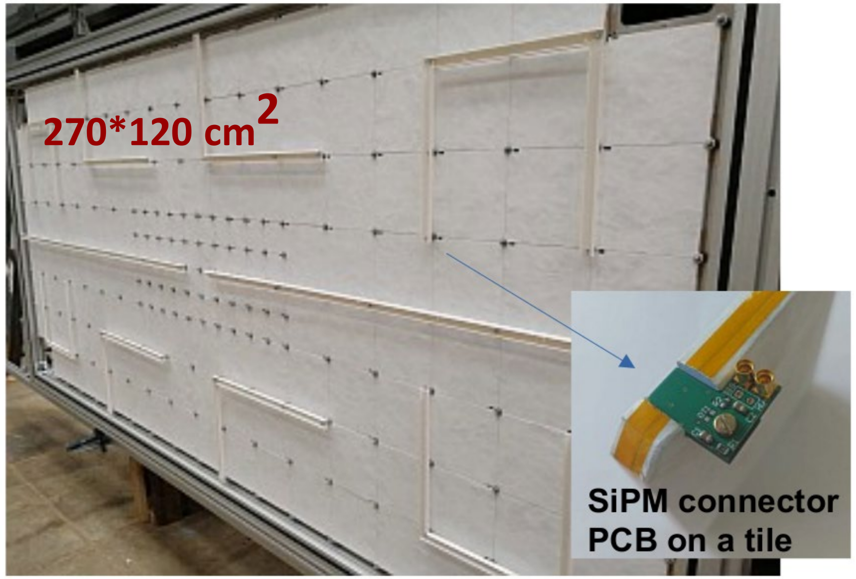
Event selection

≥2 tracks in vertex reconstruction
Single Xe ion selected with Beam Counter BC1S
With cuts on vertex Z (-1.5cm < Z <1.5cm)

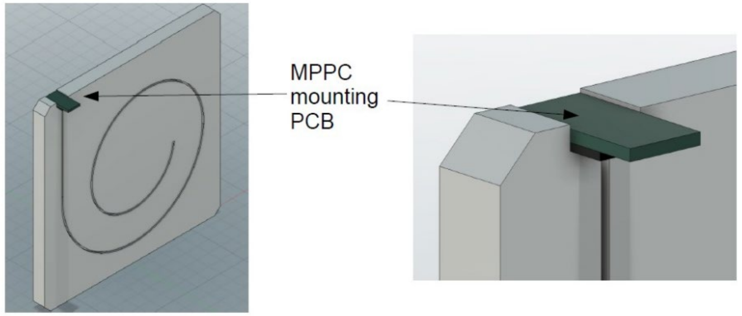


Scintillation Wall for fragments charge measurements and reaction plane estimation

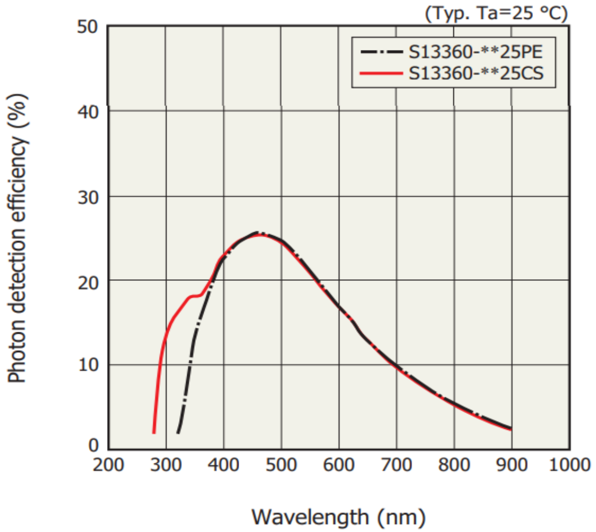




- 36 small inner cells 7.5×7.5×1 cm^3 + 138 big outer cells 15×15×1 cm^3
- light yield for MIP signal – small cells 55 p.e.±2.4%; big cells 32 p.e.± 6%.
- optional beam hole (covered with 4 small cells for the SRC run)
- covered with a light-shielding aluminum plate
- light collection by WLS fibers
- light readout with SiPM mounted on the PCB at each scint. cell

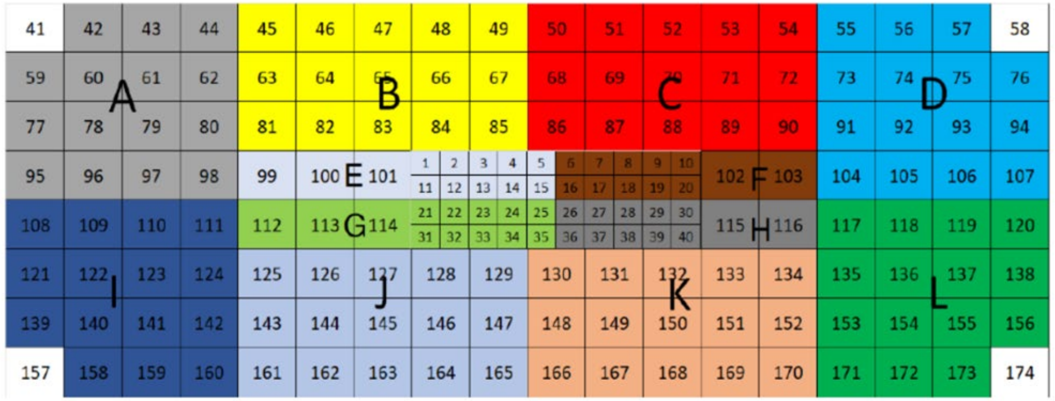


light collection from tiles



- Hamamatsu MPPC S13360-1325CS 1.3*1.3mm^2
- Number of pixels: 2668
- Gain: $7*10^5$
- PDE: 25%

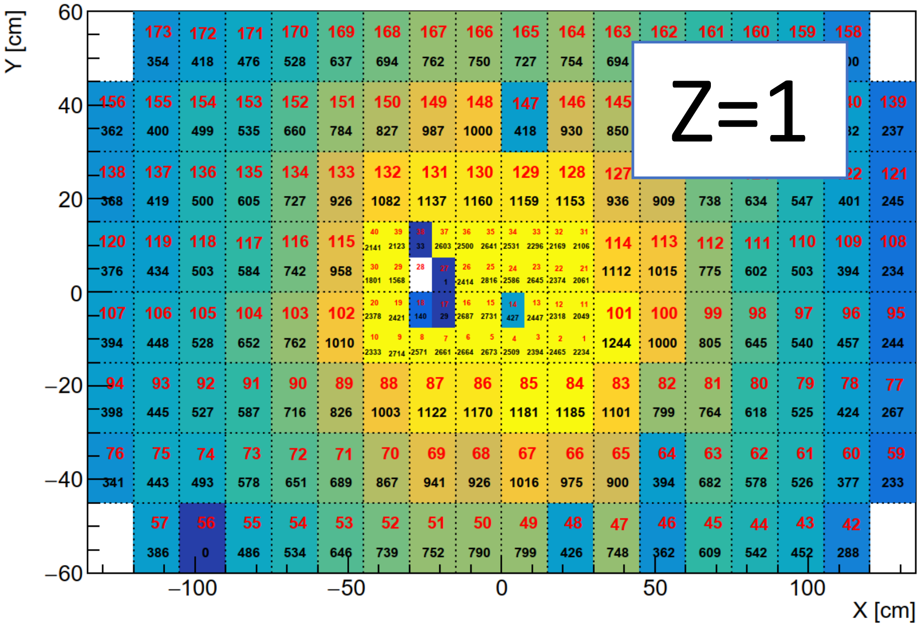
ScWall: design

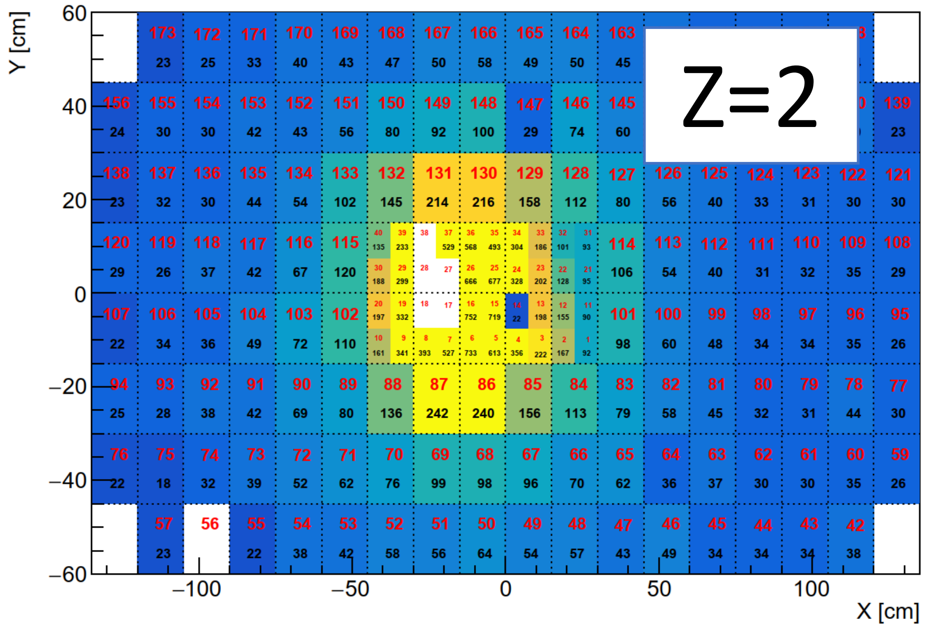


- readout divided into 12 sectors each one equipped with single temperature sensor
- each 4 sectors are read by combined electronics unit:
  - One ADC64s2 board
  - Four 16-channels FEE boards
  - Voltage control unit

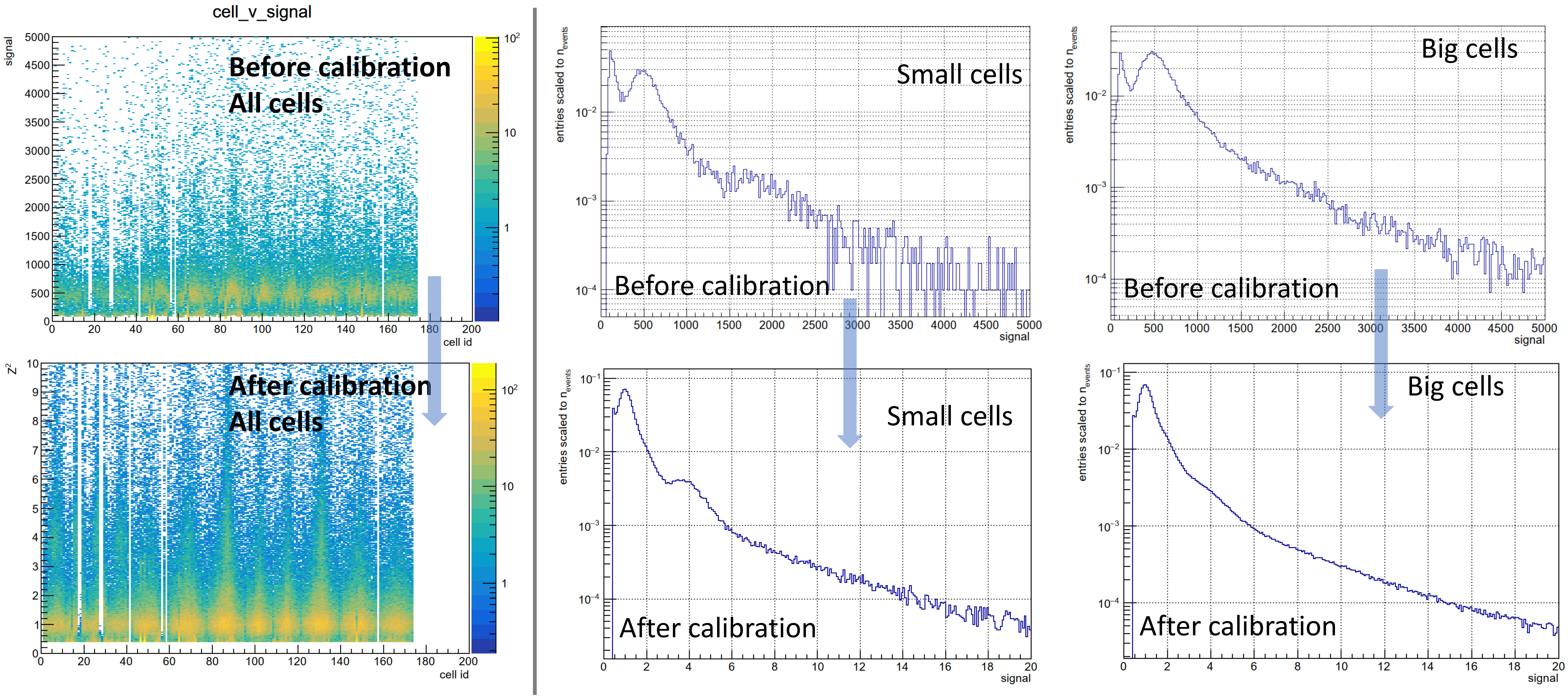
ScWall average Z^2 distribution with CsI (2%) target, Xe, CCT2

3.8 GeV



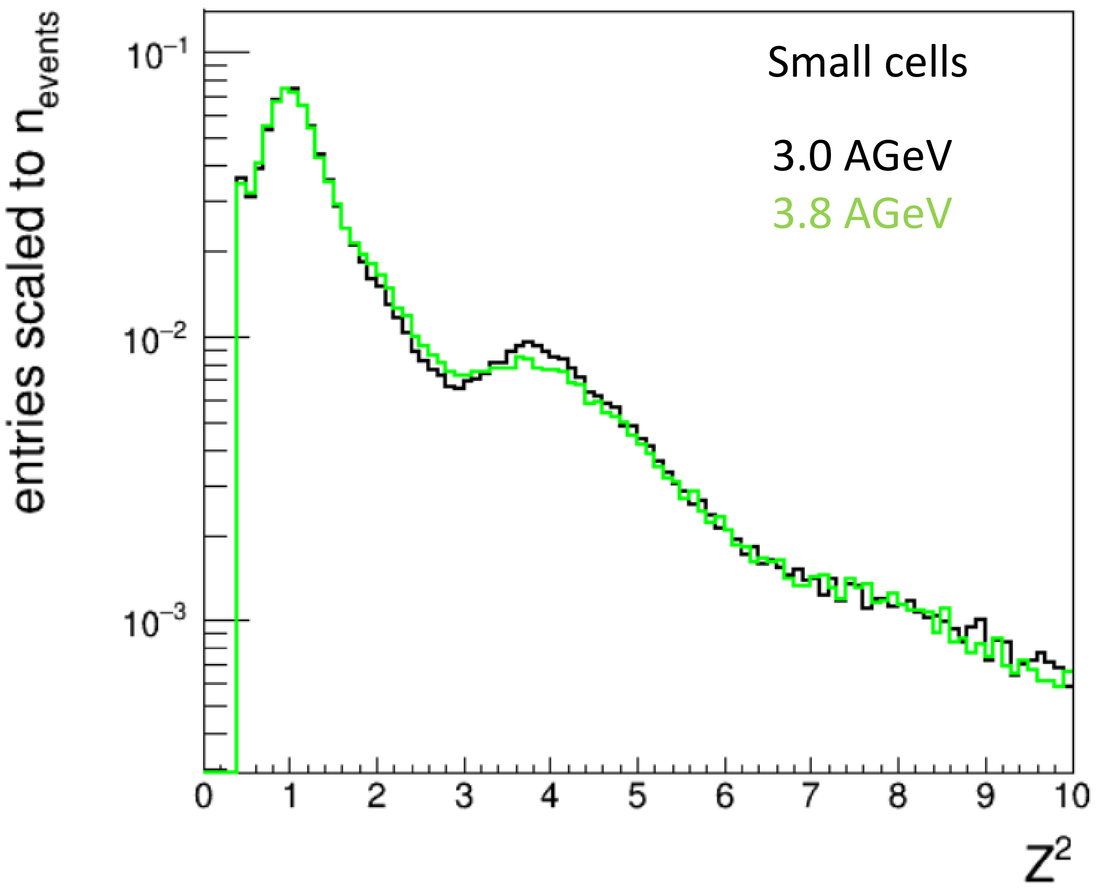


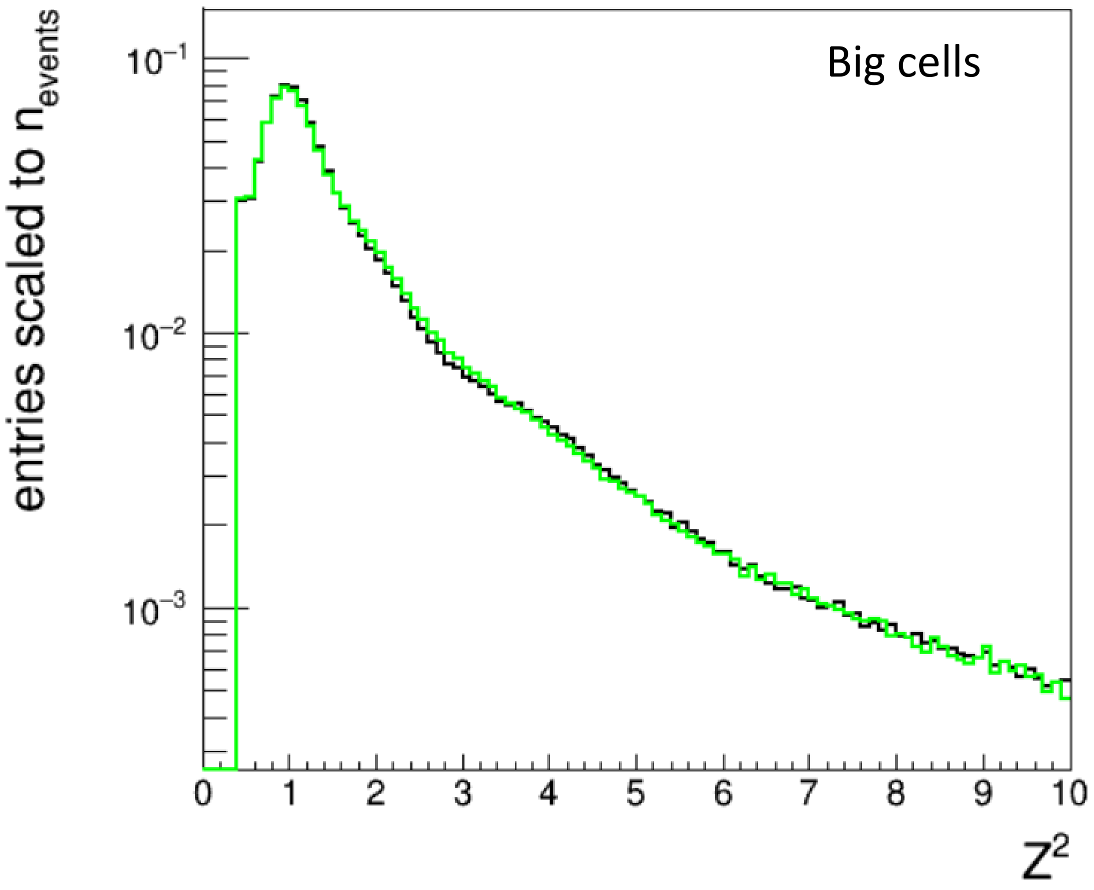
Charge distribution in ScWall cells (CCT2)



Charge distribution over the scintillation wall. A peaks corresponding to charges Z = 1, 2 can be clearly seen.

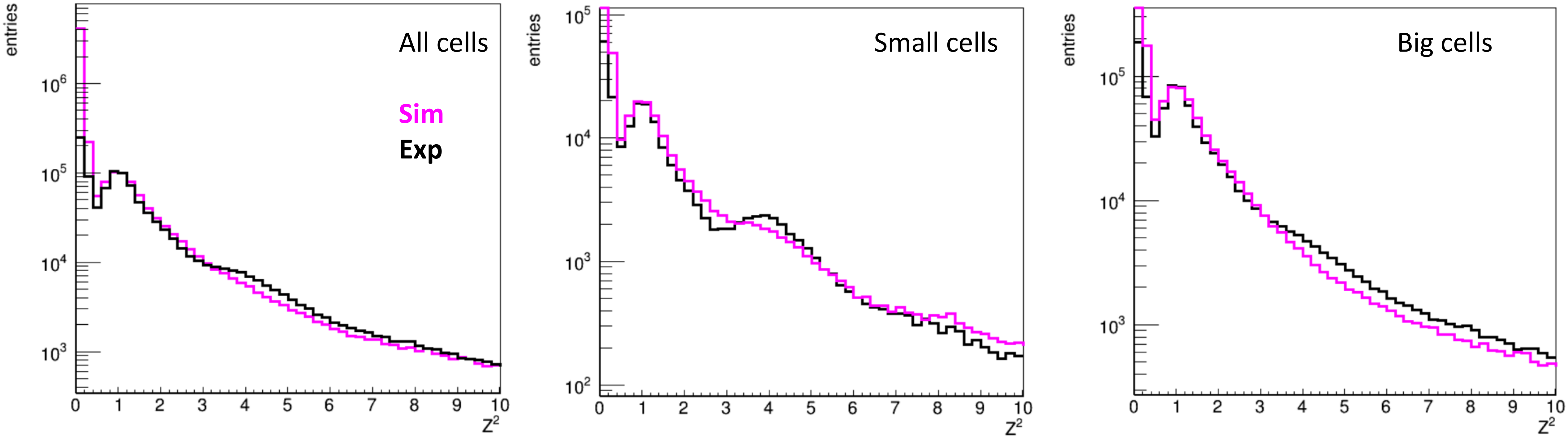
Charge distribution in ScWall cells





- Comparison of the charge distributions over the scintillation wall for the two energies at 3.0 and 3.8 GeV for the CCT2 trigger.
- The two cell types (small and big) are presented separately.
- It can be seen that the distributions are very similar, with a slight difference in the second peak.

Charge distribution in ScWall cells: comparison with DCM-QGSM-SMM

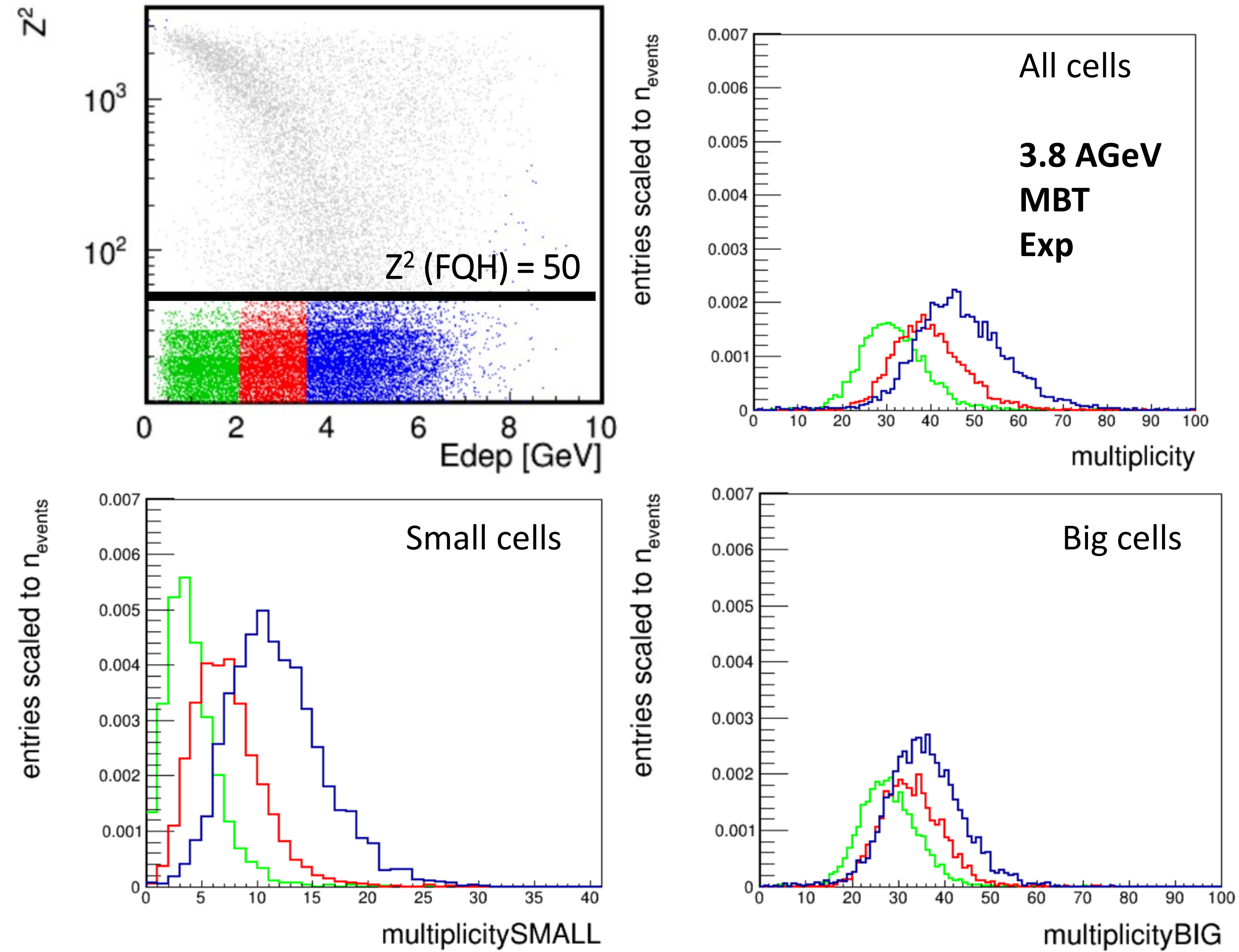


- The spectra of the distributions are matched in shape, and the number of events is normalised for illustration.

MBT

- Comparison of the charge distributions over the scintillation wall for Sim and Experimental data.
- The 3 cell types (all, small and big) are presented separately.
- It can be seen that the distributions are very similar, with a slight difference in the second peak for small cells.
- Both data – experimental and simulated show that the **maximum charge Z^2** that can be distinguished on the wall is **4**.

ScWall multiplicity distributions of charged particles for different centrality classes



ScWall multiplicity refers to the number of fired cells in the wall.

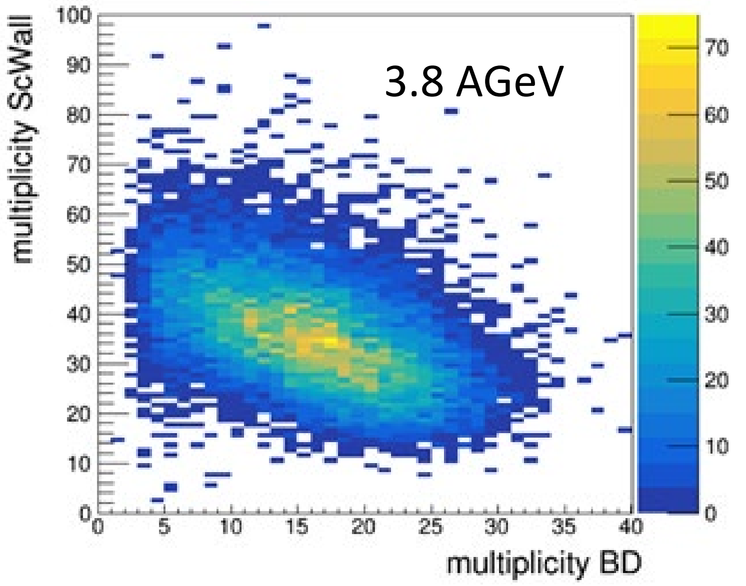
Multiplicity is sensitive to centrality -> can be used as estimator. Green, red and blue reflect the most central, semi-central and semi-peripheral arbitrary classes of events.

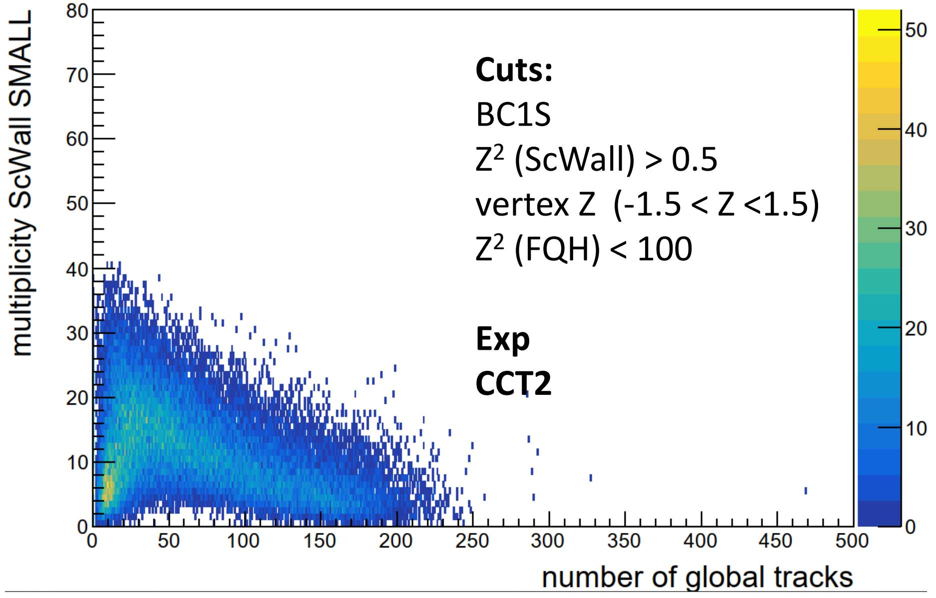
~50% of minbias events, need to be checked with sim (b<10 fm).

Cuts:
BC1S (1 Xe)
Z^2 (ScWall) > 0.4
vertex Z (-1.5 < Z <1.5)
Z^2 (FQH) < 50

MBT

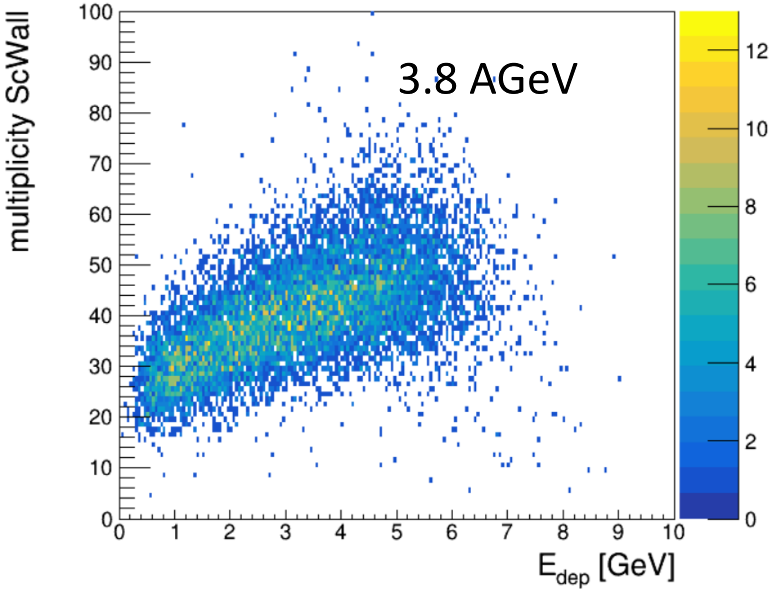
Multiplicity in ScWall / multiplicity in BD

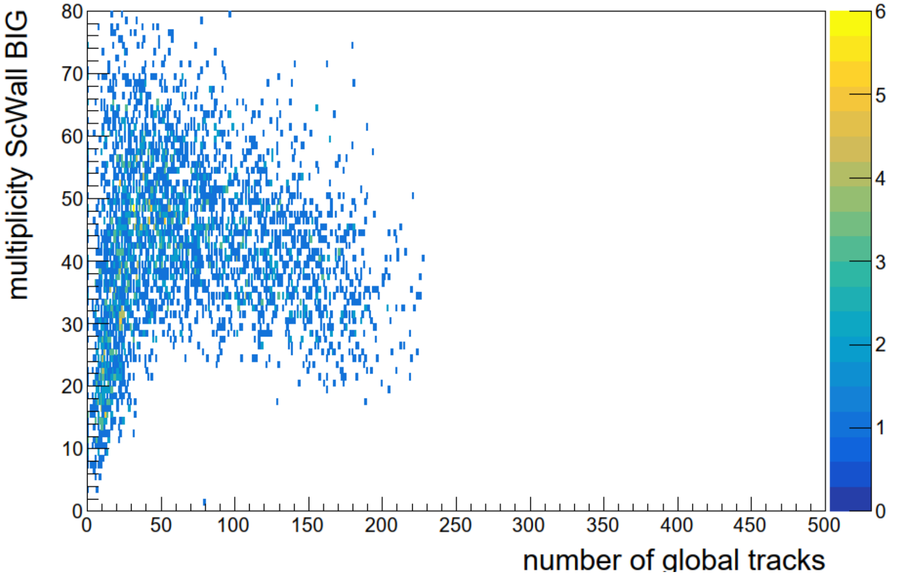


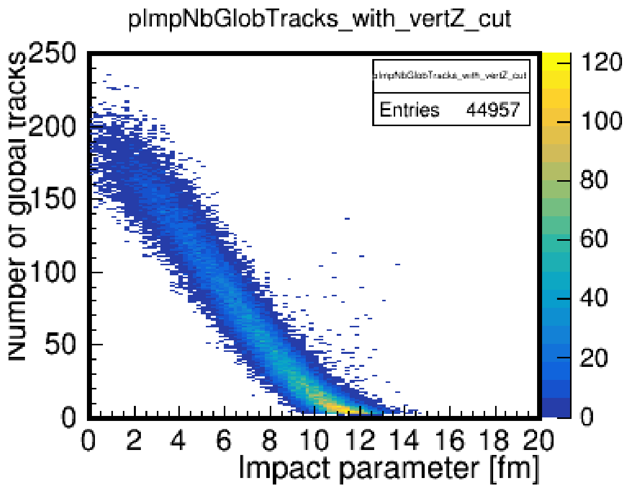


Multiplicity correlates with energy deposition in the calorimeter, and anticorrelates with multiplicity in BD.

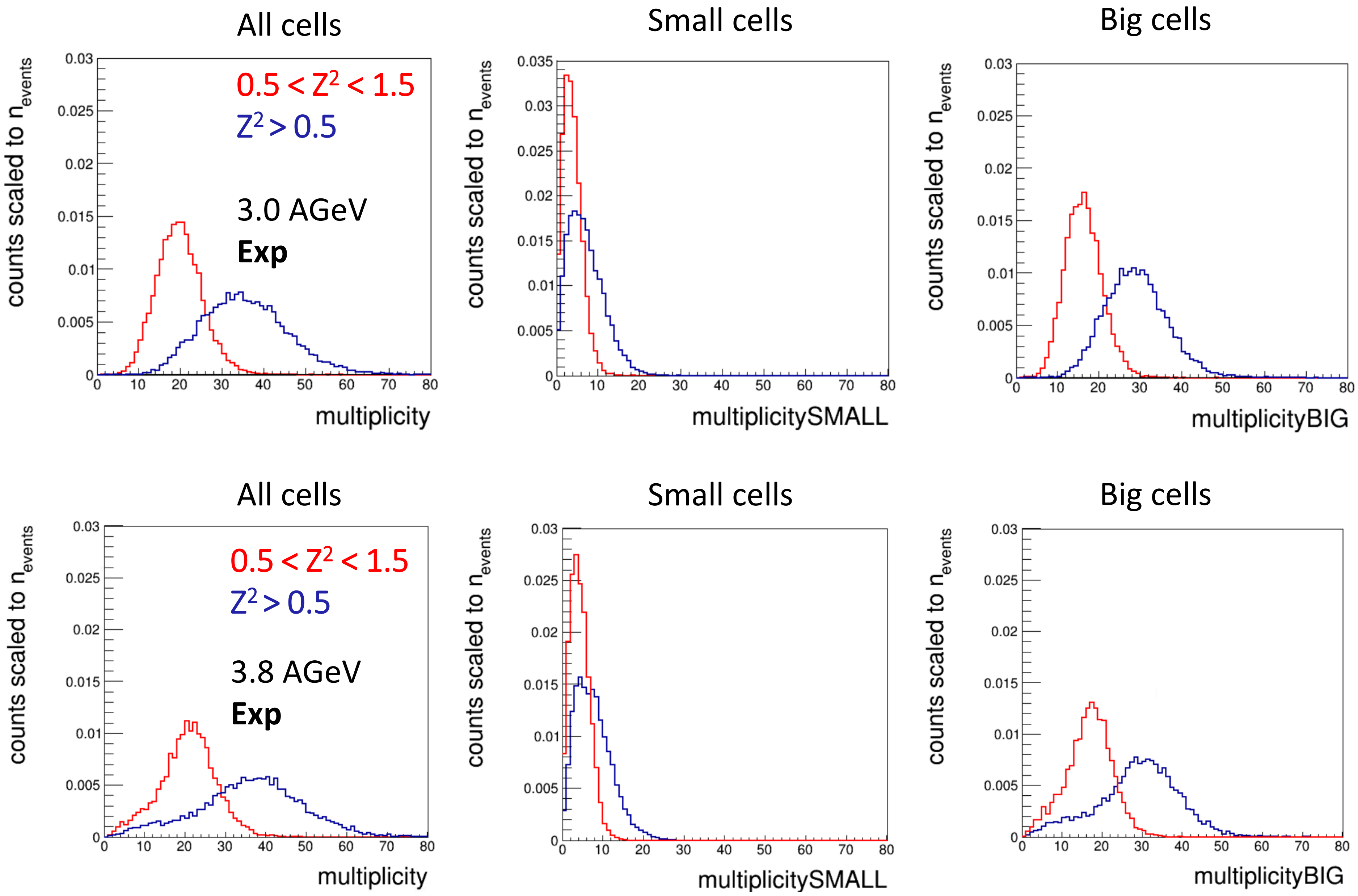
Ambiguity in multiplicity vs number of global tracks







Multiplicity distribution of charged particles in ScWall



Multiplicity is sensitive to charges on the wall for both energies. The peak corresponding to the single charge is clearly prominent.

This dependency can be used for comparison with Monte Carlo models (DCM-QGSM-SMM etc.)

Conclusion

- The general structure and tasks of the scintillation wall have been presented.
- The ScWall performance examples at different energies were demonstrated.
- ScWall calibration results were shown.
- The charges range detected in the BMN run 8 are shown.
- Comparison of charge spectra from simulation data (DCM-QGSM-SMM) and experimental data shows agreement.
- The sensitivity of the ScWall to centrality according to hit multiplicity is shown.
- Correlations of ScWall multiplicity with the calorimeter deposited energy and barrel detector multiplicity are presented.
- ScWall hit multiplicity distributions for different spectator charges are shown.

Thank you for your attention!

ScWall Z^2 distributions (Z^2 > 0.5)

Simulation
after RECO, with reconstructed
vertexZ cut
-1.5cm – 1.5 cm
no trigger
With / without
impact parameter < 10 fm
Normalized to number of events

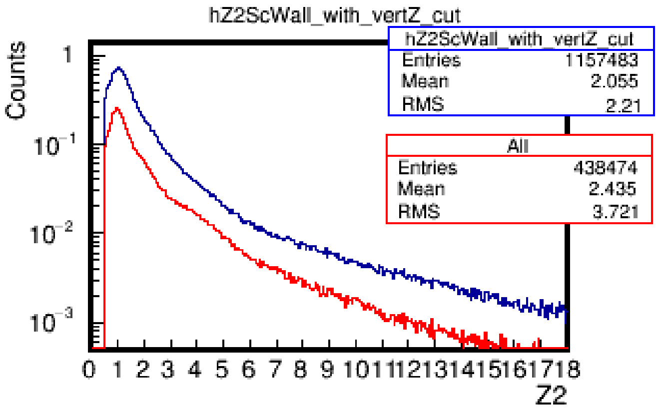
Experiment
run 8
XeCsI@3.8 AGeV,
Normalized to
number of triggers,
Vadim

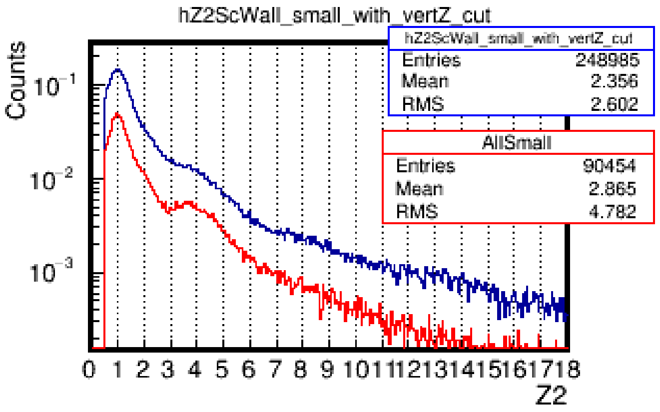
XeCs@3.26A GeV, DCM-QGSM-SMM, UNIGEN
Scale 0.929
FHCal 977.8 cm, Xsh=65.3 cm,Ysh=-0.8cm, rotY 1.6 deg
Hodo 970.2 cm, Xsh=64.9 cm, Ysh=-1cm, rotY 1.6 deg
ScWall hole 741.5 cm, Xsh=68.7cm
air in cave, Magnet, **all BMN detectors**
VacZdcWall 200x200cm before nDet 12x12cm 27.3deg
Simul - 58992 ev, RECO – 58804 ev

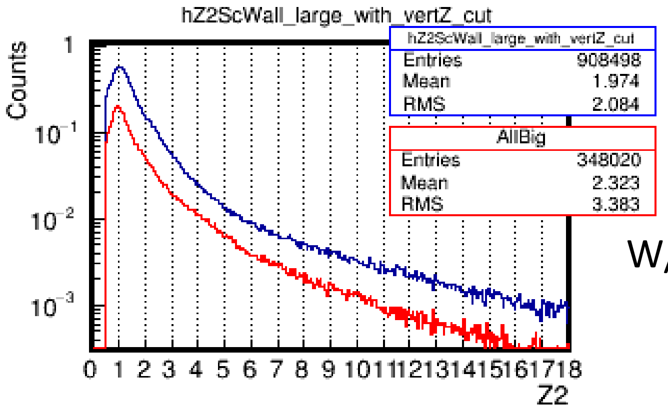
Simulation
Experiment

All cells | Small cells | Large cells

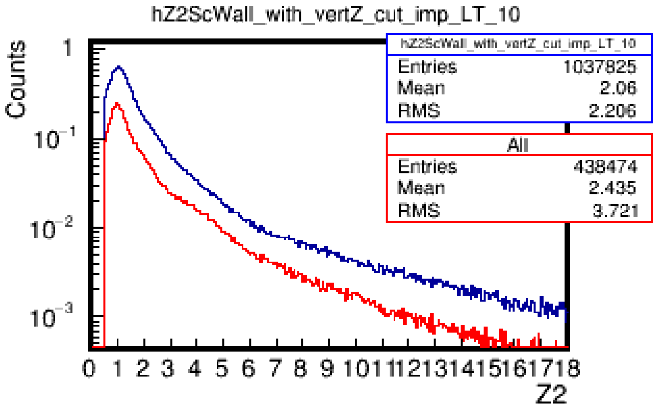
W/o impact parameter cut

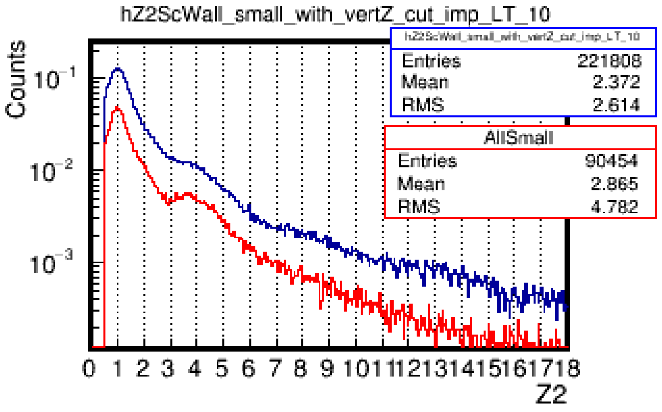


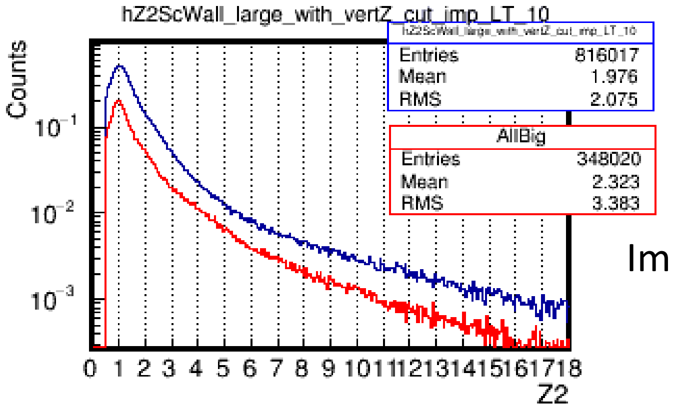


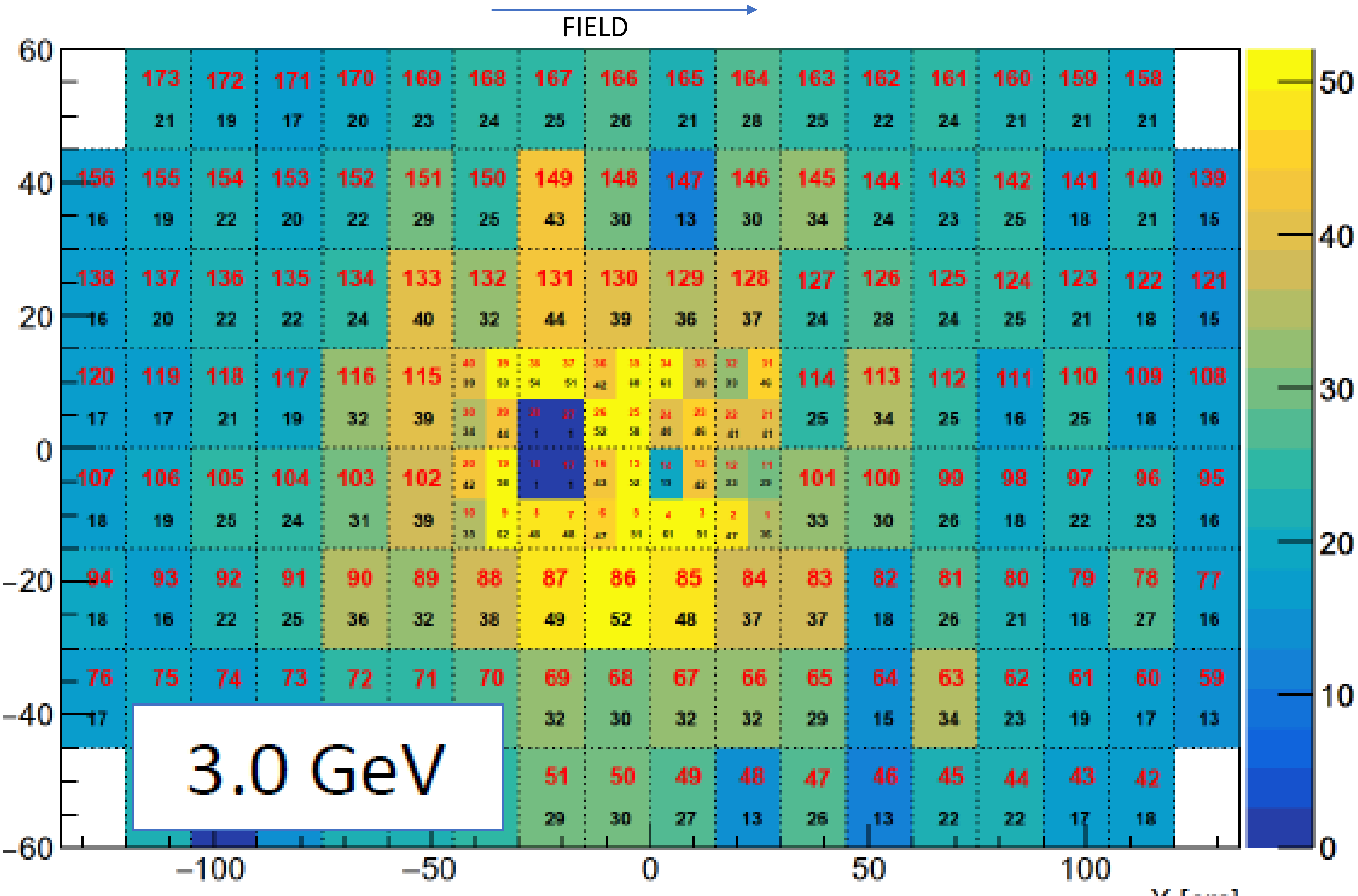


Impact parameter < 10 fm



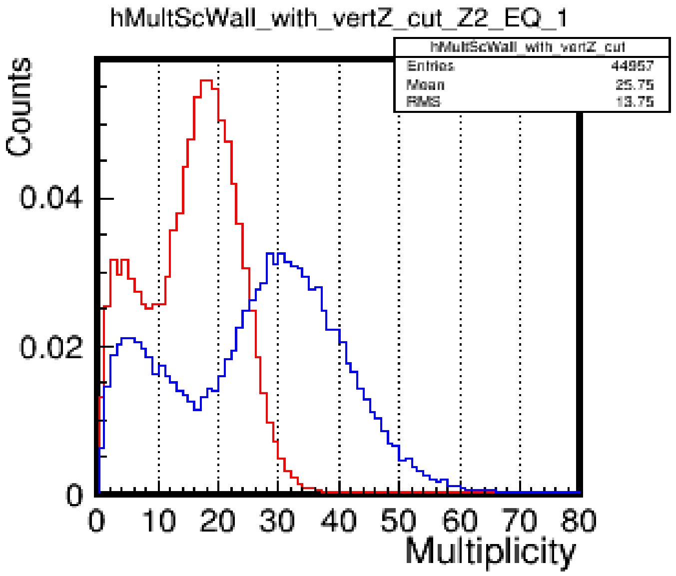


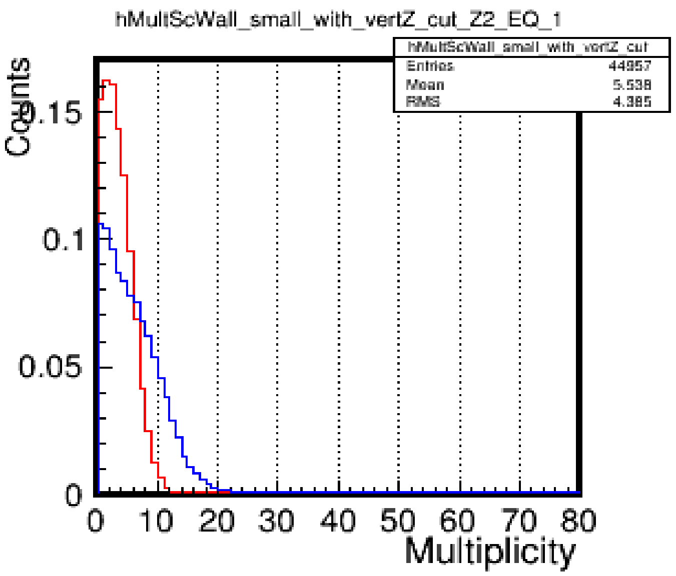


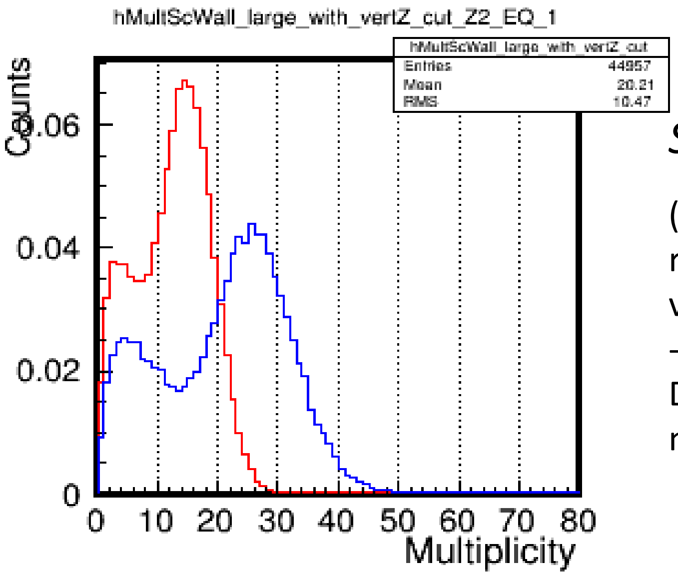

FIELD
3.0 GeV

Simulation and experiment comparison (ScWall multiplicity)

XeCs@3.26A GeV, DCM-QGSM-SMM, UNIGEN
Scale 0.929
FHCal 977.8 cm, Xsh=65.3 cm,Ysh=-0.8cm, rotY 1.6 deg
Hodo 970.2 cm, Xsh=64.9 cm, Ysh=-1cm, rotY 1.6 deg
ScWall hole 741.5 cm, Xsh=68.7cm
air in cave, Magnet, **all BMN detectors**
VacZdcWall 200x200cm before nDet 12x12cm 27.3deg
Simul - 58992 ev, RECO – 58804 ev



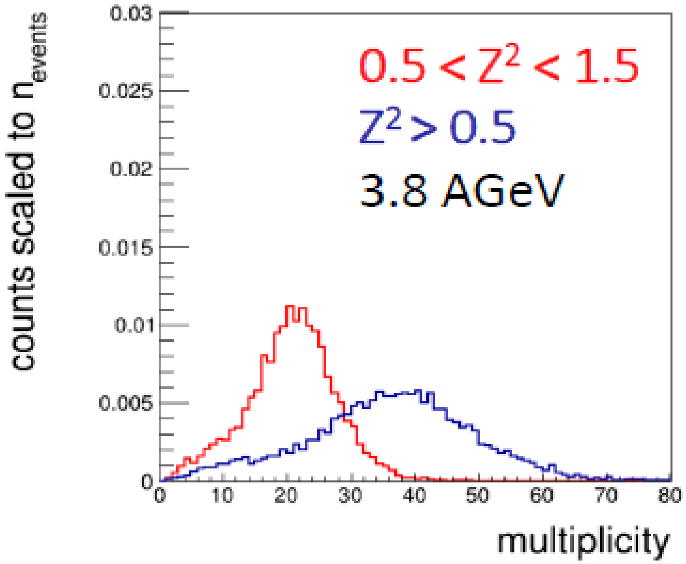




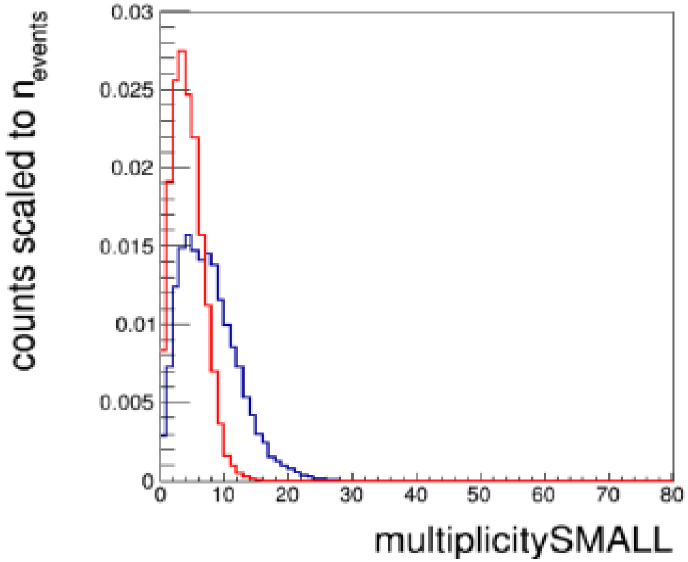
Simulation

(after RECO, with reconstructed vertexZ cut -1.5cm – 1.5 cm DrawNormalized() no trigger)

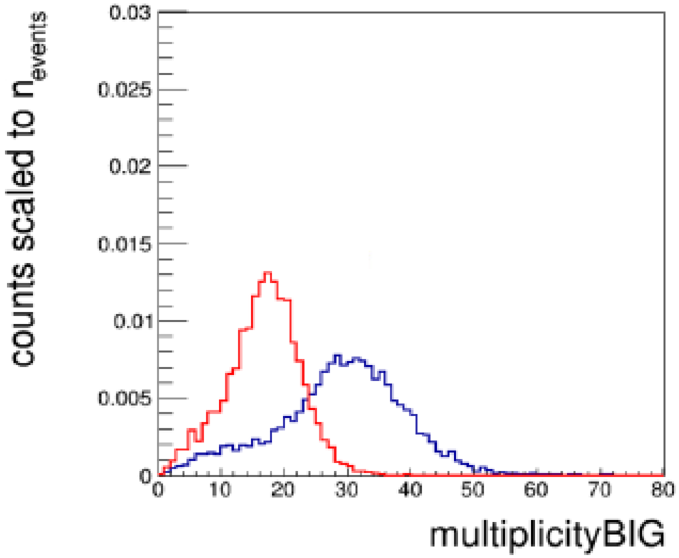
All cells



Small cells



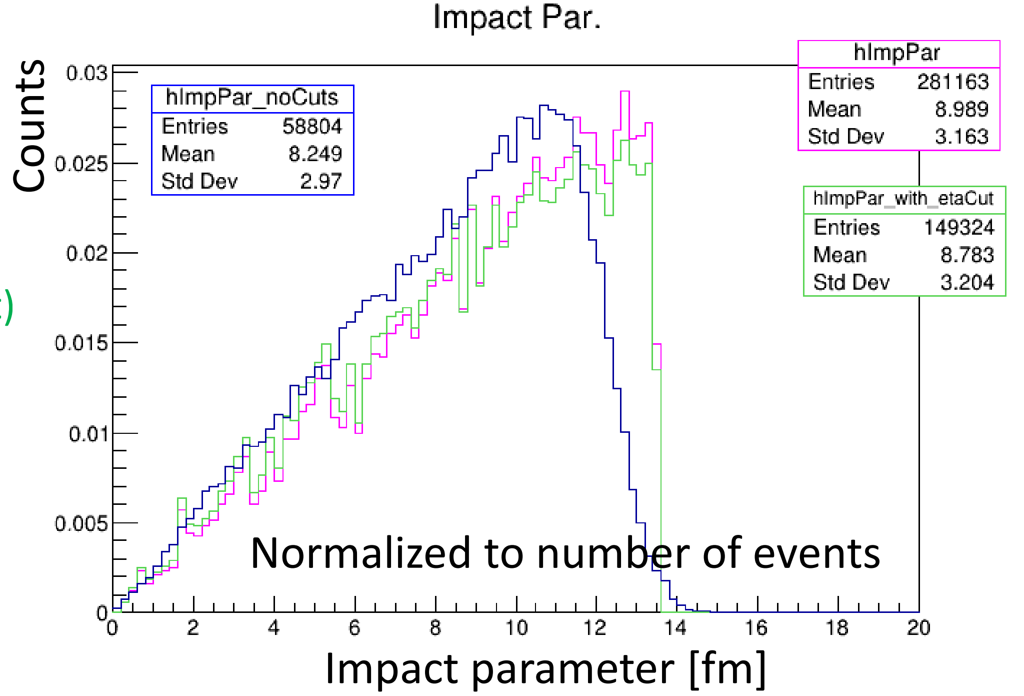
Big cells



Experiment
(run 8 XeCsI@3.8 AGeV, Vadim)

Impact parameter comparison (DCMSMM vs PHQMD)

BMN
DCMSMM XeCs@3.8AGeV (after RECO)
PHQMD XeCs@3.8AGeV (SIM no etaCut)
PHQMD XeCs@3.8AGeV (SIM with etaCut)

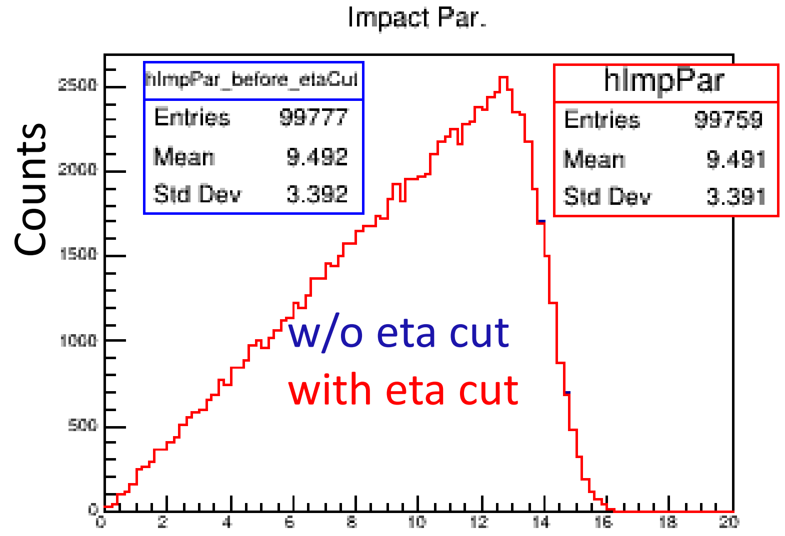


NA61 PSD simulations: Pb+Pb@30 AGeV, no field
Distributions are done ***w/o and with eta cut*** on primary particles:

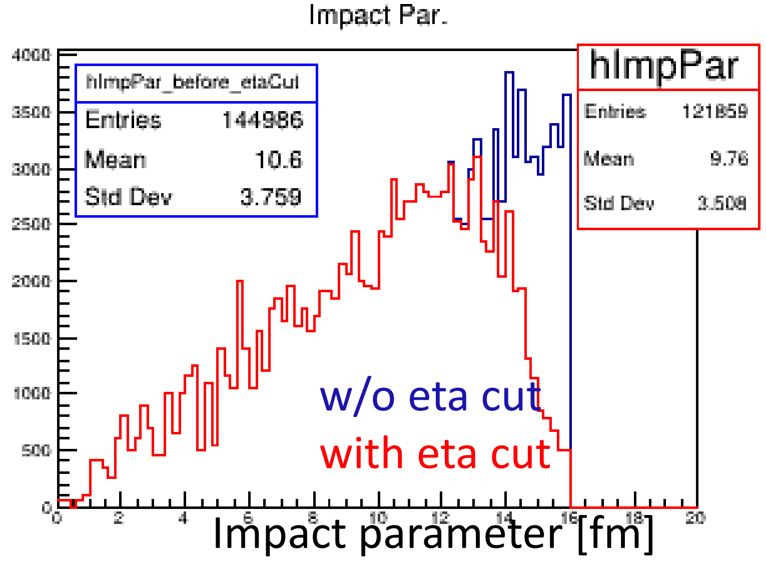
- events with at least one primary particle with |eta| < 1 are selected (eta - pseudorapidity)

Impact parameter distributions

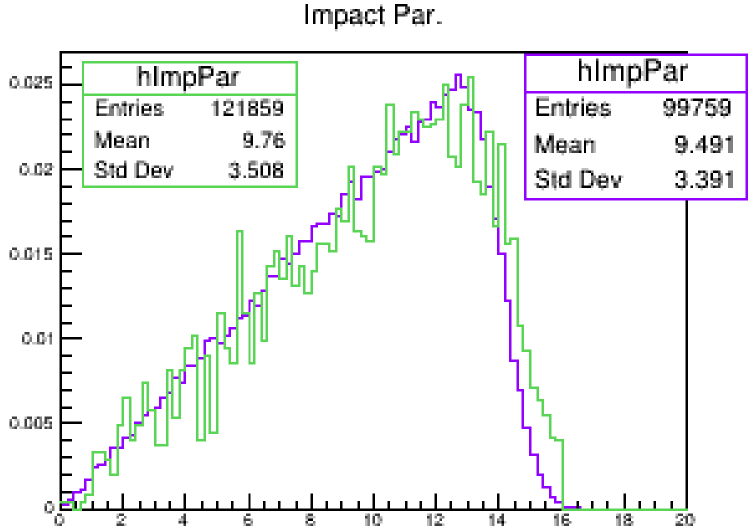
DCMSMM



PHQMD



DCMSMM vs PHQMD
(with eta cut)



XeCs@3.26A GeV, DCM-QGSM-SMM, UNIGEN
Scale 0.929
FHCal 977.8 cm, Xsh=65.3 cm,Ysh=-0.8cm, rotY 1.6 deg
Hodo 970.2 cm, Xsh=64.9 cm, Ysh=-1cm, rotY 1.6 deg
ScWall hole 741.5 cm, Xsh=68.7cm
air in cave, Magnet, **all BMN detectors**
VacZdcWall 200x200cm before nDet 12x12cm 27.3deg
Simul - 58992 ev, RECO – 58804 ev

ScWall Z^2 distributions ($\mathbf{Z^2 > 0.5}$)

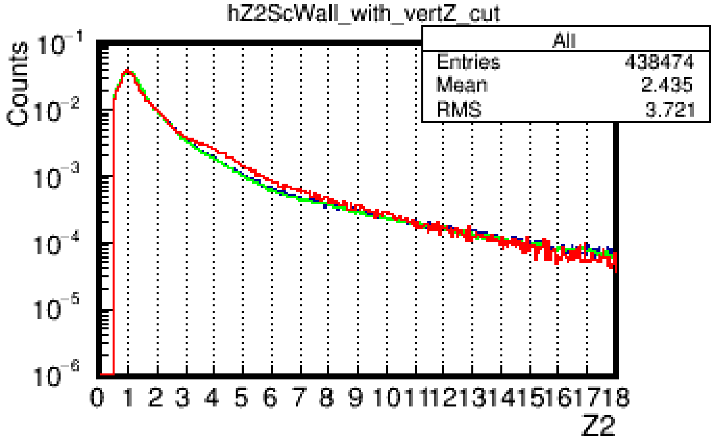
Simulation
after RECO, with reconstructed
vertexZ cut
-1.5cm – 1.5 cm
no trigger
DrawNormalized()

Experiment
run 8
XeCsI@3.8 AGeV,
DrawNormalized()
Vadim

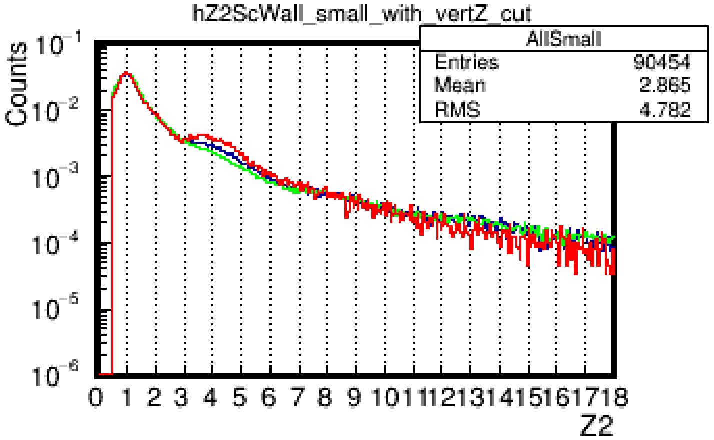
XeCs@3.8A GeV, PHQMD, UNIGEN
Scale 0.929
FHCal 977.8 cm, Xsh=65.3 cm,Ysh=-0.8cm, rotY 1.6 deg
Hodo 970.2 cm, Xsh=64.9 cm, Ysh=-1cm, rotY 1.6 deg
ScWall hole 741.5 cm, Xsh=68.7cm
air in cave, Magnet, **all BMN detectors**
VacZdcWall 200x200cm before nDet 12x12cm 27.3deg
Simul - 281163 ev, RECO – 279140 ev, no etaCut

DCMSMM
PHQMD
Experiment

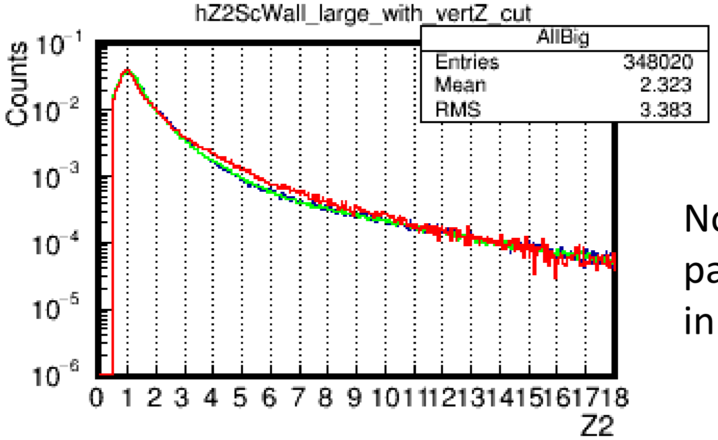
All cells



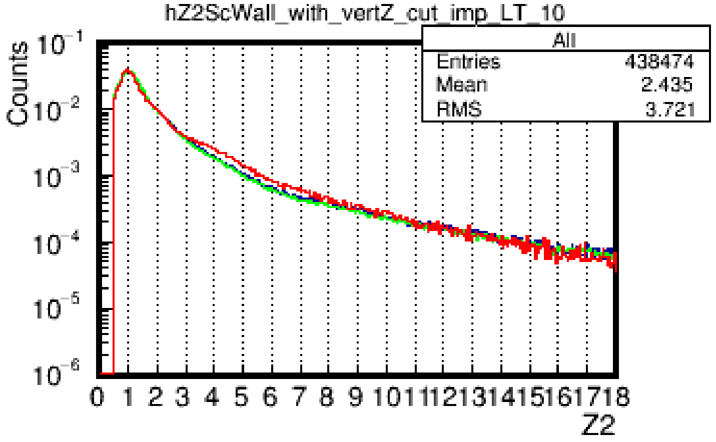
Small cells

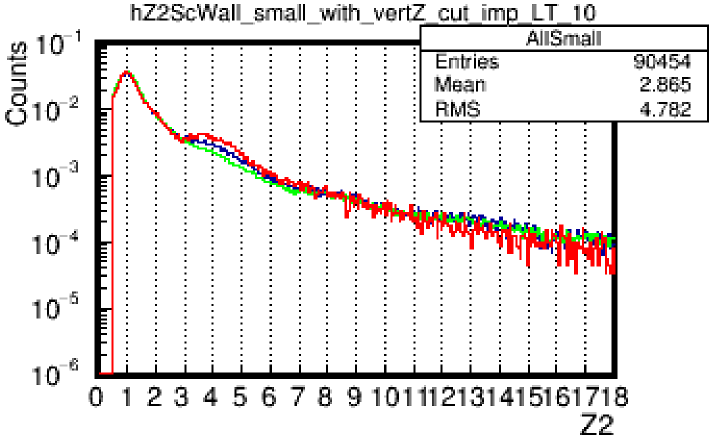


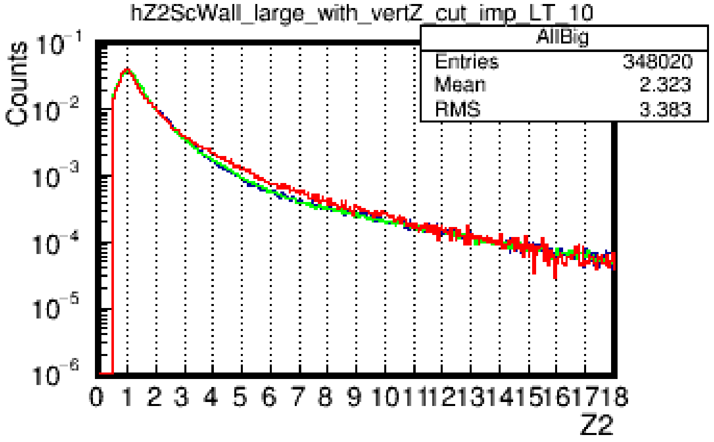
Large cells



No cuts on impact parameter in simulations







b < 10 fm
b < 9 fm

XeCs@3.26A GeV, DCM-QGSM-SMM, UNIGEN
Scale 0.929
FHCal 977.8 cm, Xsh=65.3 cm,Ysh=-0.8cm, rotY 1.6 deg
Hodo 970.2 cm, Xsh=64.9 cm, Ysh=-1cm, rotY 1.6 deg
ScWall hole 741.5 cm, Xsh=68.7cm
air in cave, Magnet, **all BMN detectors**
VacZdcWall 200x200cm before nDet 12x12cm 27.3deg
Simul - 58992 ev, RECO – 58804 ev

Simulation and experiment comparison (ScWall multiplicity)

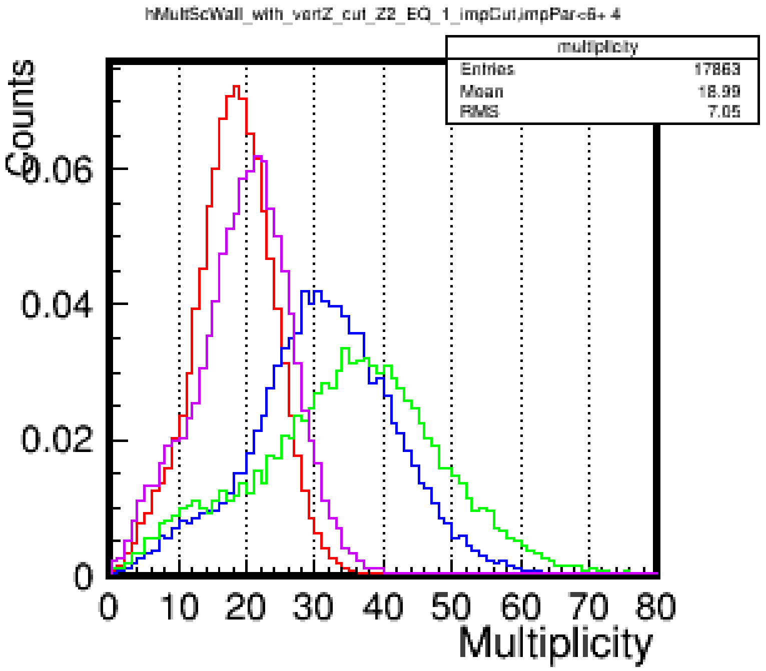
Simulation
(after RECO, with reconstructed vertexZ cut
-1.5cm – 1.5 cm
no trigger cut, MB
DrawNormalized()
With impact parameter < 10 fm

ScWall $Z^2 > 0.5$
ScWall $0.5 < Z^2 < 1.5$

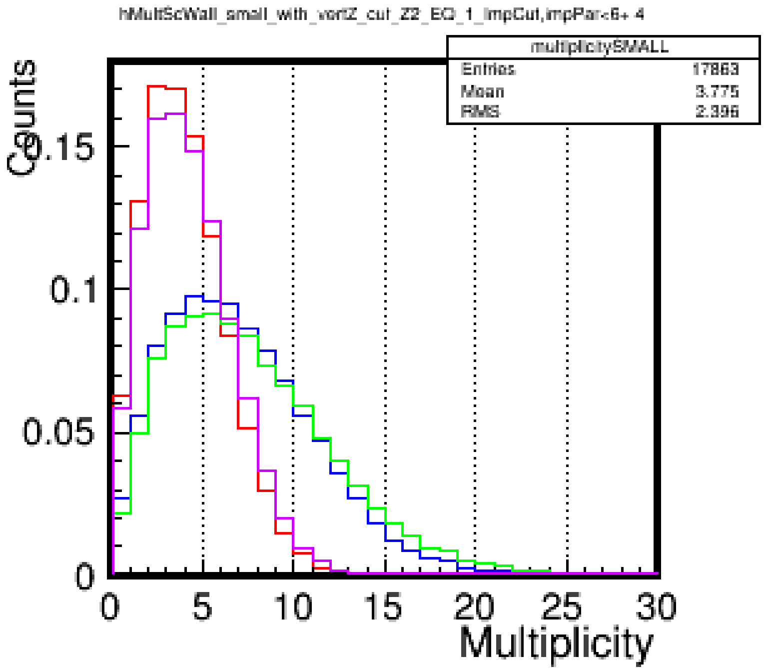
Experiment
(run 8
XeCsI@3.8 AGeV,
MBT trigger
DrawNormalized()
Vadim)

ScWall $Z^2 > 0.5$
ScWall $0.5 < Z^2 < 1.5$

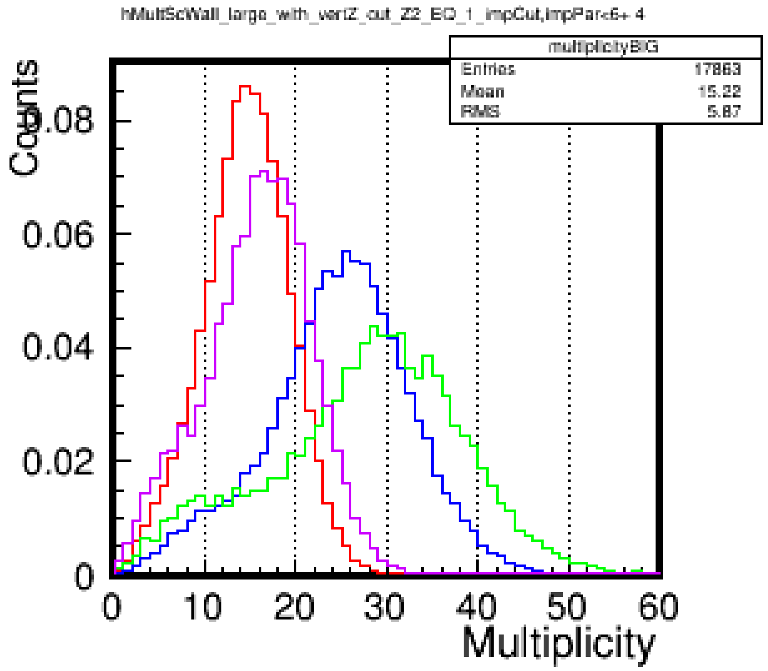
All cells



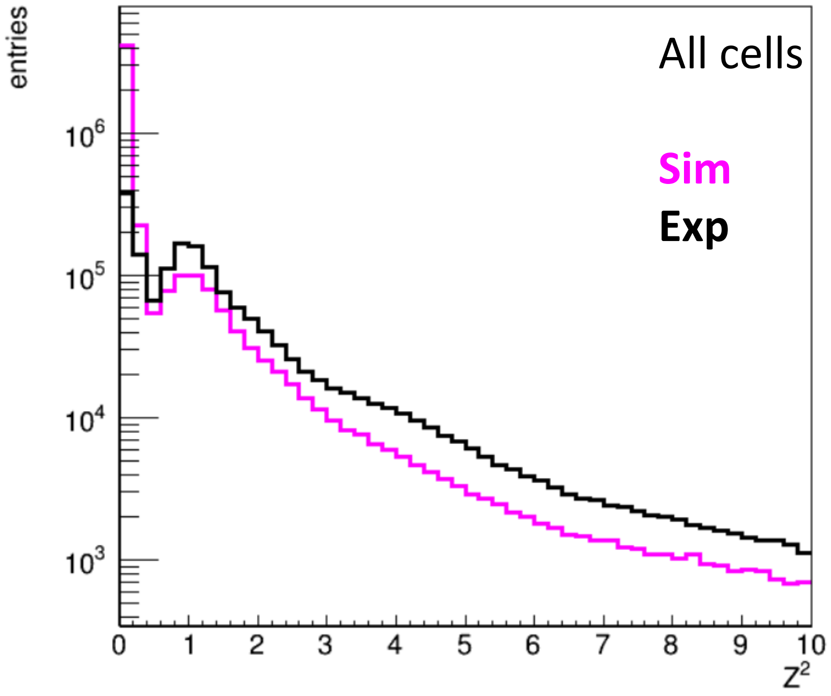
Small cells

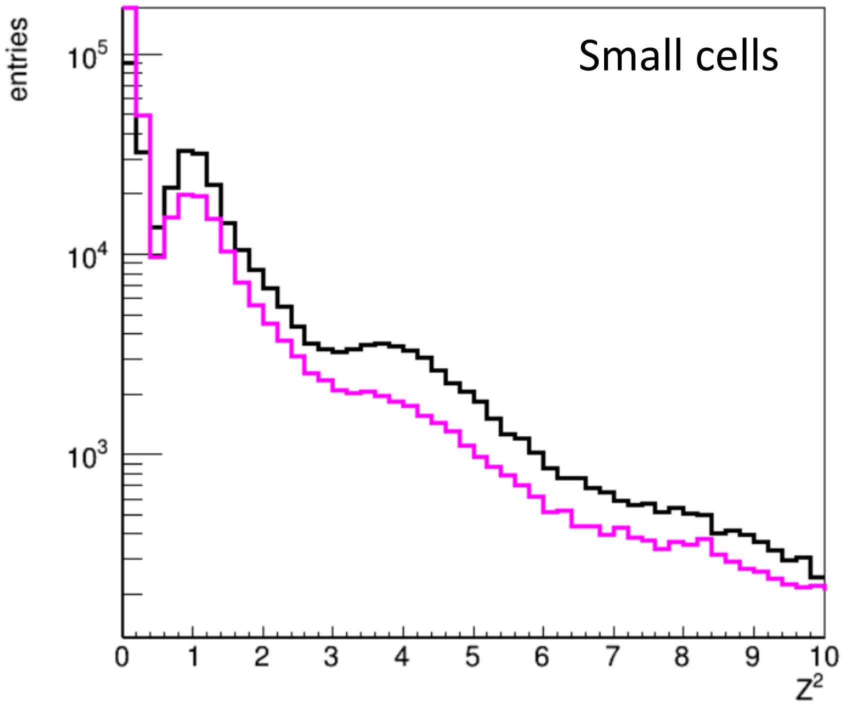


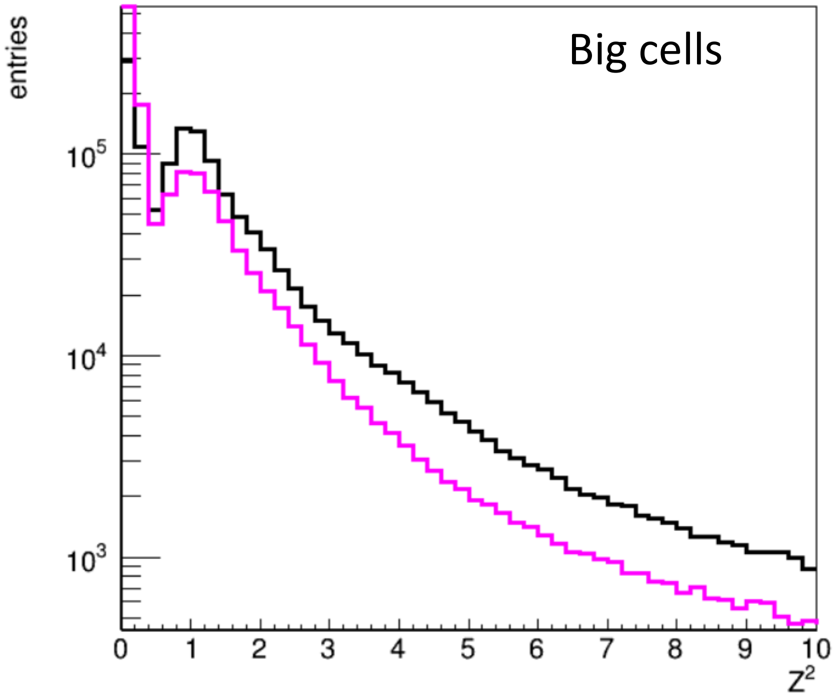
Large cells



Charge distribution in ScWall cells: comparison with DCM-QGSM-SMM





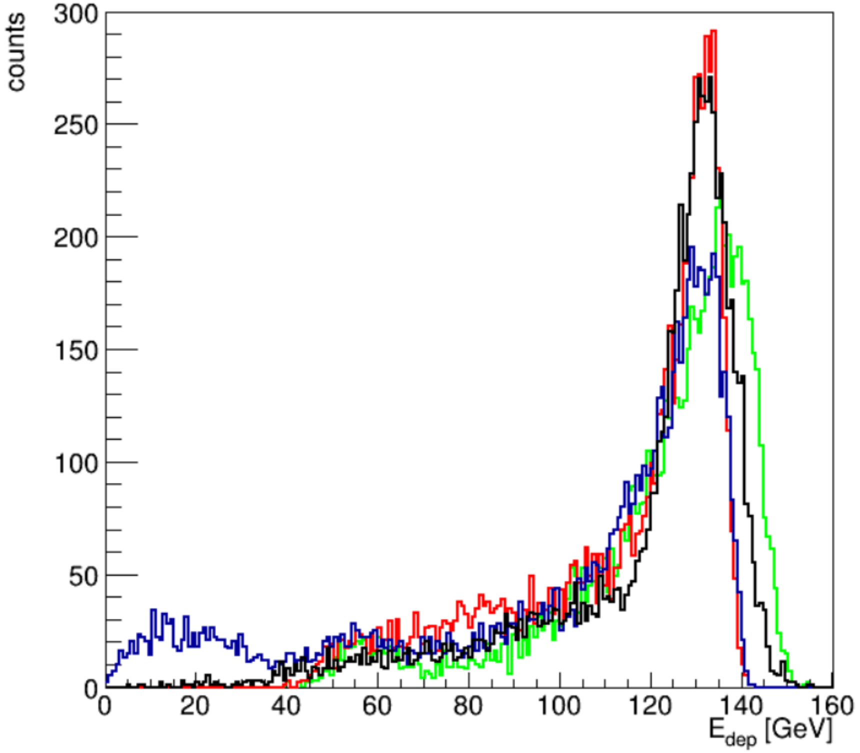


- The spectra of the distributions are matched in shape, and the number of events is normalised for illustration.

CCT2

- Comparison of the charge distributions over the scintillation wall for Sim and Experimental data.
- The 3 cell types (all, small and big) are presented separately.
- It can be seen that the distributions are very similar, with a slight difference in the second peak for small cells.
- Both data – experimental and simulated show that the **maximum charge Z^2** that can be distinguished on the wall is **4**.

DCM-SMM ?



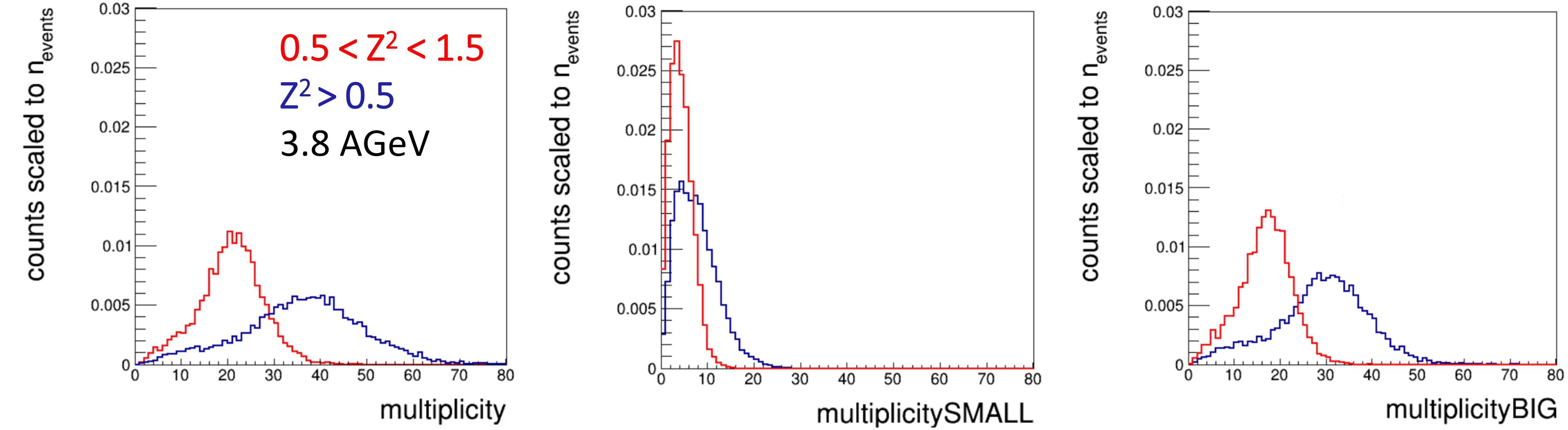
- It is obvious from the comparison results that the **DCM-SMM model is closer to the experimental data** in the case of a calorimeter without a hole.
- In the case of a hole, the **DCM-SMM model is significantly superior** to both PHQMD versions.

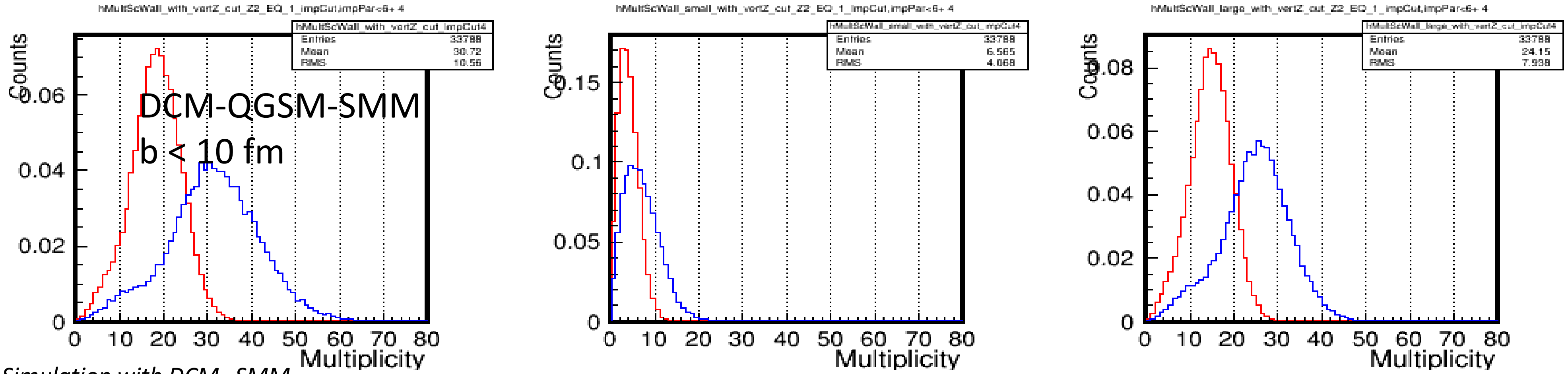
$$\chi^2 = \sum_{i=1}^{n} \frac{(MC_i - Oi)^2}{\sigma_{MC_i}^2 + \sigma_{O_i}^2}$$

NO HOLE	E_{dep}	"Mean" r-v	Radius	E_{max}
DCM-SMM	6.37	4.33	3.55	4.43
PHQMD MST	7.61	11.88	5.58	13.87
PHQMD SACA	5.71	28.27	13.19	>100
HOLE	E_{dep}	"Mean" r-v	Radius	E_{max}
DCM-SMM	4.32	5.85	5.47	10.55
PHQMD MST	49.21	11.75	10.09	>100
PHQMD SACA	>100	48.09	36.26	>100

Multiplicity distribution of charged particles in ScWall

All cells | Small cells | Big cells





Simulation with DCM--SMM

(after RECO, with reconstructed vertexZ cut -1.5cm – 1.5 cm

DrawNormalized()

no trigger)

Multiplicity is sensitive to charges on the wall for both energies. The peak corresponding to the single charge is clearly prominent.

This dependency can be used for comparison with Monte Carlo models (DCM-QGSM-SMM etc.)

Comparison with models, to do: adjust sim to data.

XeCs@3.26A GeV, DCM-QGSM-SMM, UNIGEN
Scale 0.929
FHCal 977.8 cm, Xsh=65.3 cm,Ysh=-0.8cm, rotY 1.6 deg
Hodo 970.2 cm, Xsh=64.9 cm, Ysh=-1cm, rotY 1.6 deg
ScWall hole 741.5 cm, Xsh=68.7cm
air in cave, Magnet, **all BMN detectors**
VacZdcWall 200x200cm before nDet 12x12cm 27.3deg
Simul - 58992 ev, RECO – 58804 ev

Simulation and experiment comparison (ScWall multiplicity)

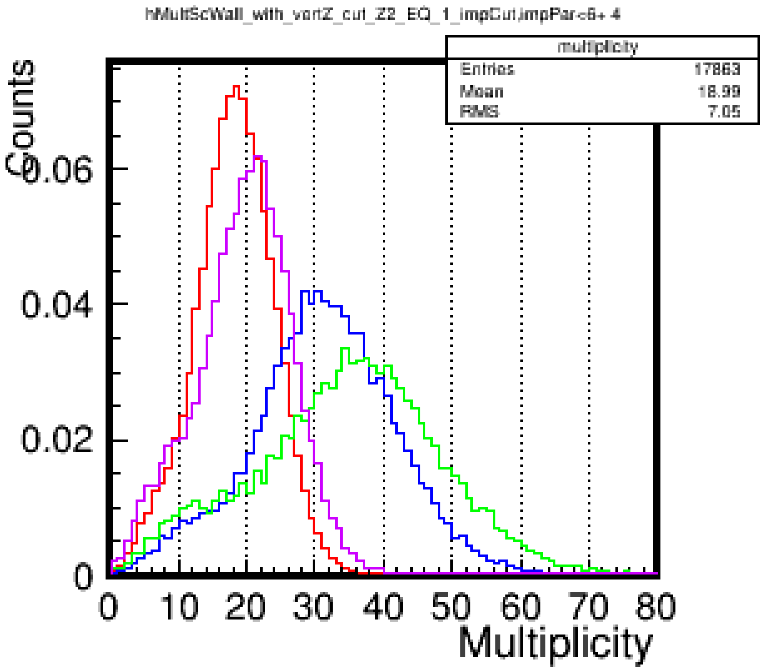
Simulation
(after RECO, with reconstructed vertexZ cut
-1.5cm – 1.5 cm
no trigger cut, MB
DrawNormalized()
With impact parameter < 10 fm

Experiment
(run 8
XeCsI@3.8 AGeV,
MBT trigger
DrawNormalized()
Vadim)

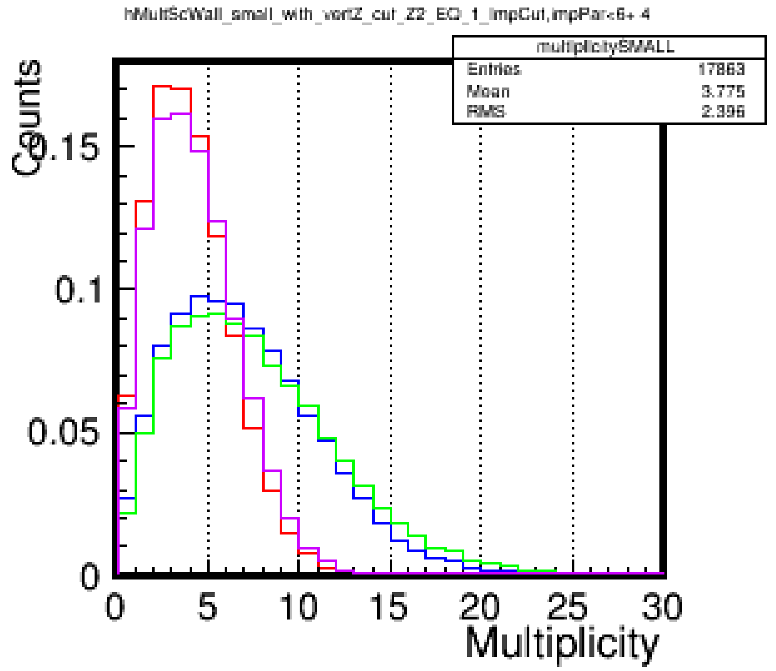
ScWall $Z^2 > 0.5$
ScWall $0.5 < Z^2 < 1.5$

ScWall $Z^2 > 0.5$
ScWall $0.5 < Z^2 < 1.5$

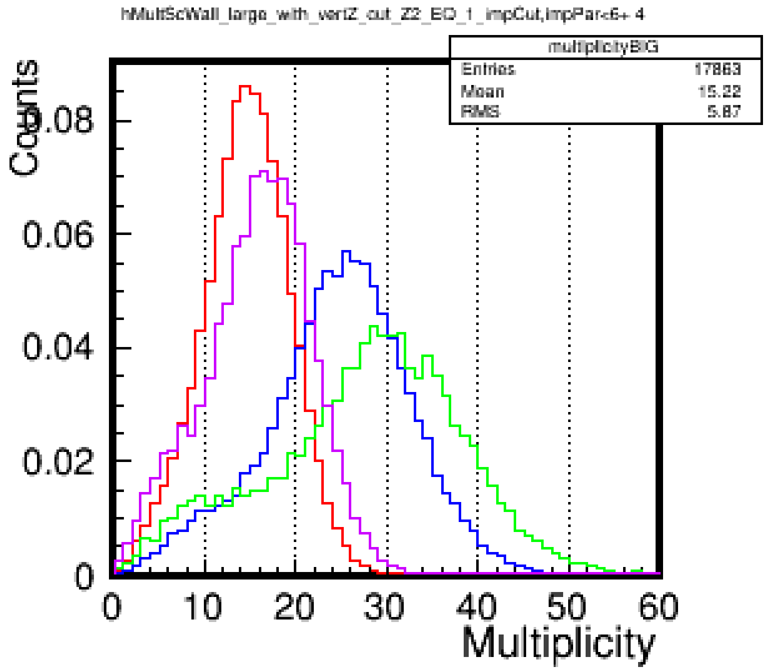
All cells

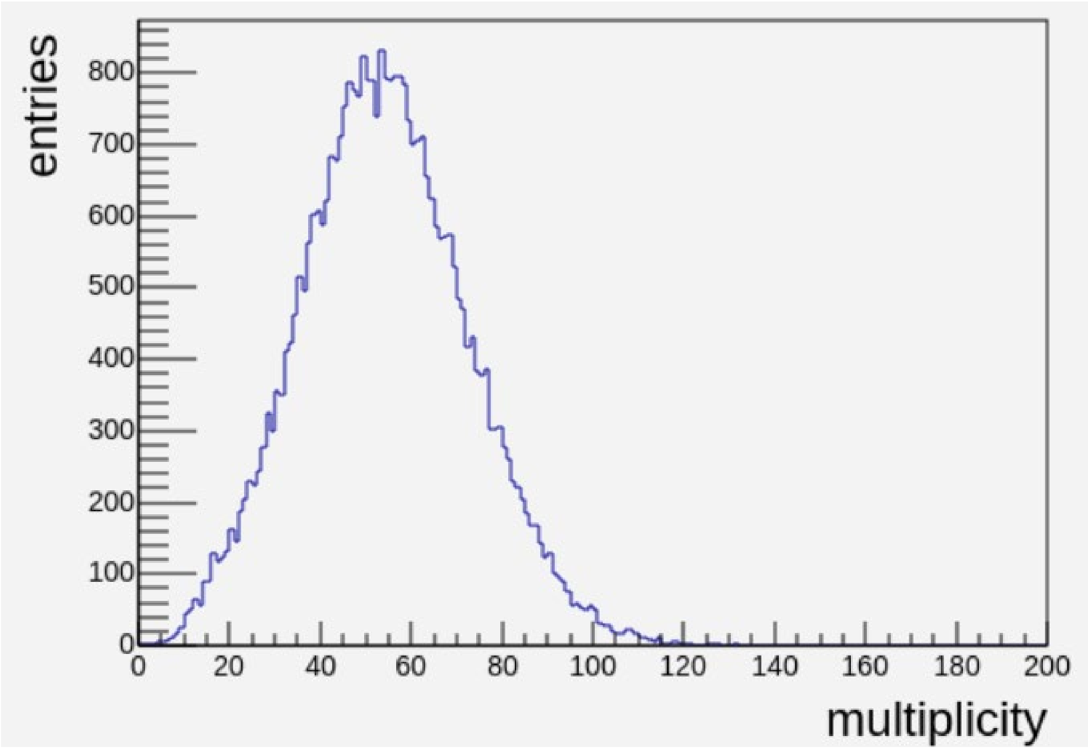


Small cells



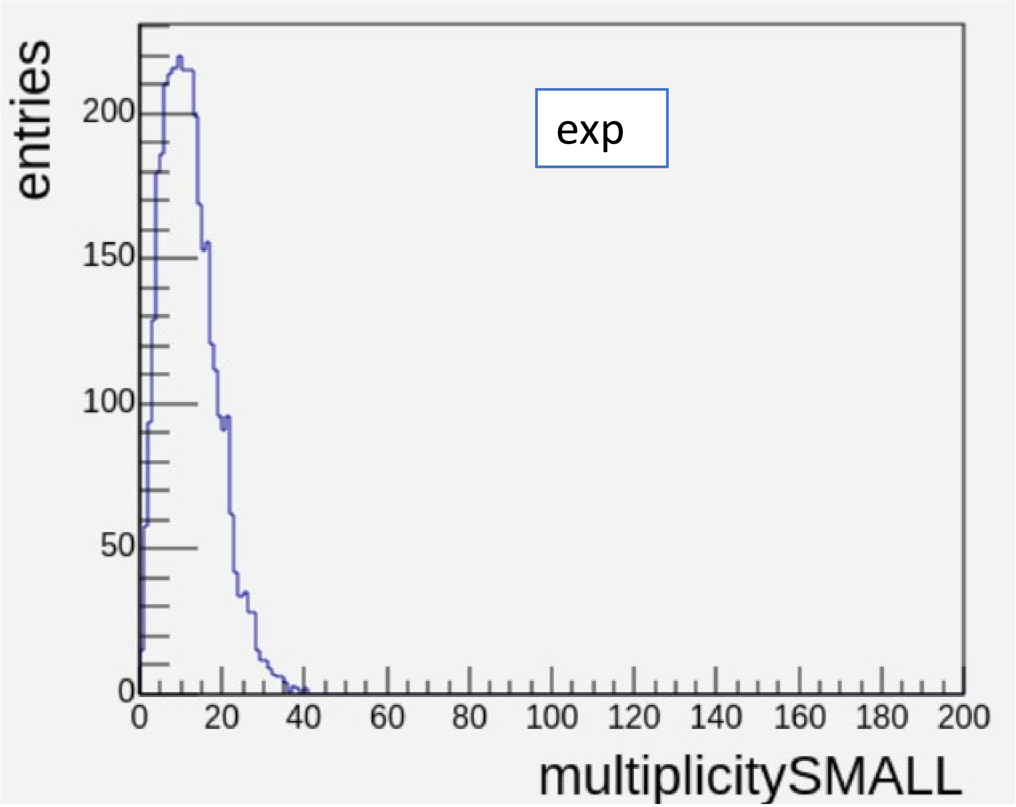
Large cells

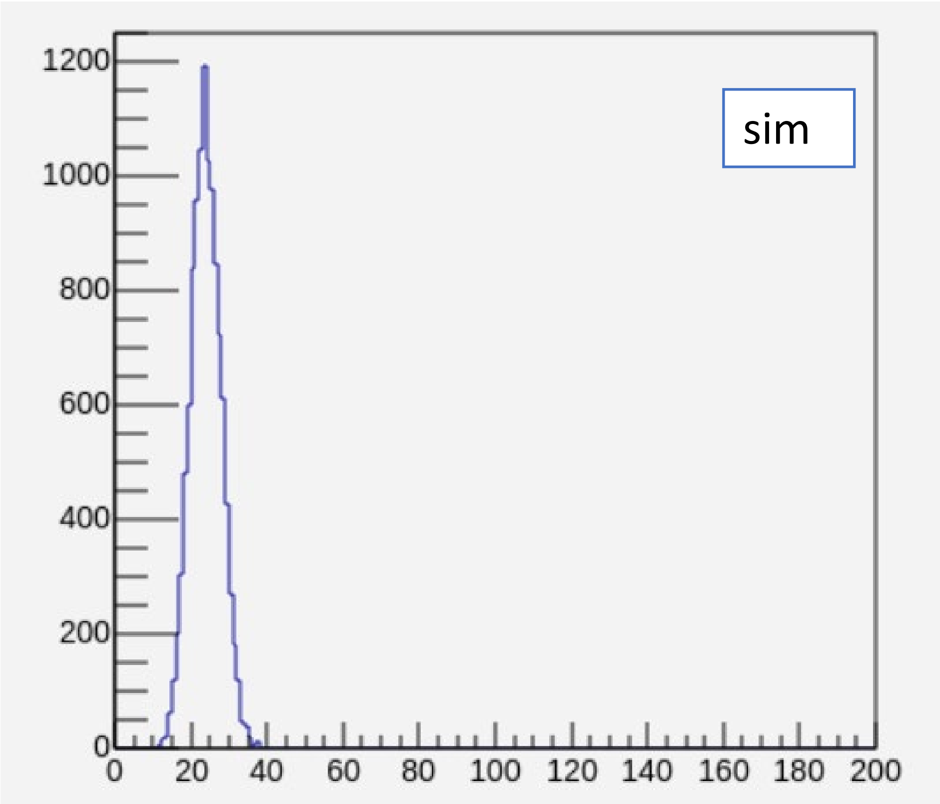



entries
0
100
200
300
400
500
600
700
800
0 20 40 60 80 100 120 140 160 180 200
multiplicity

New sim

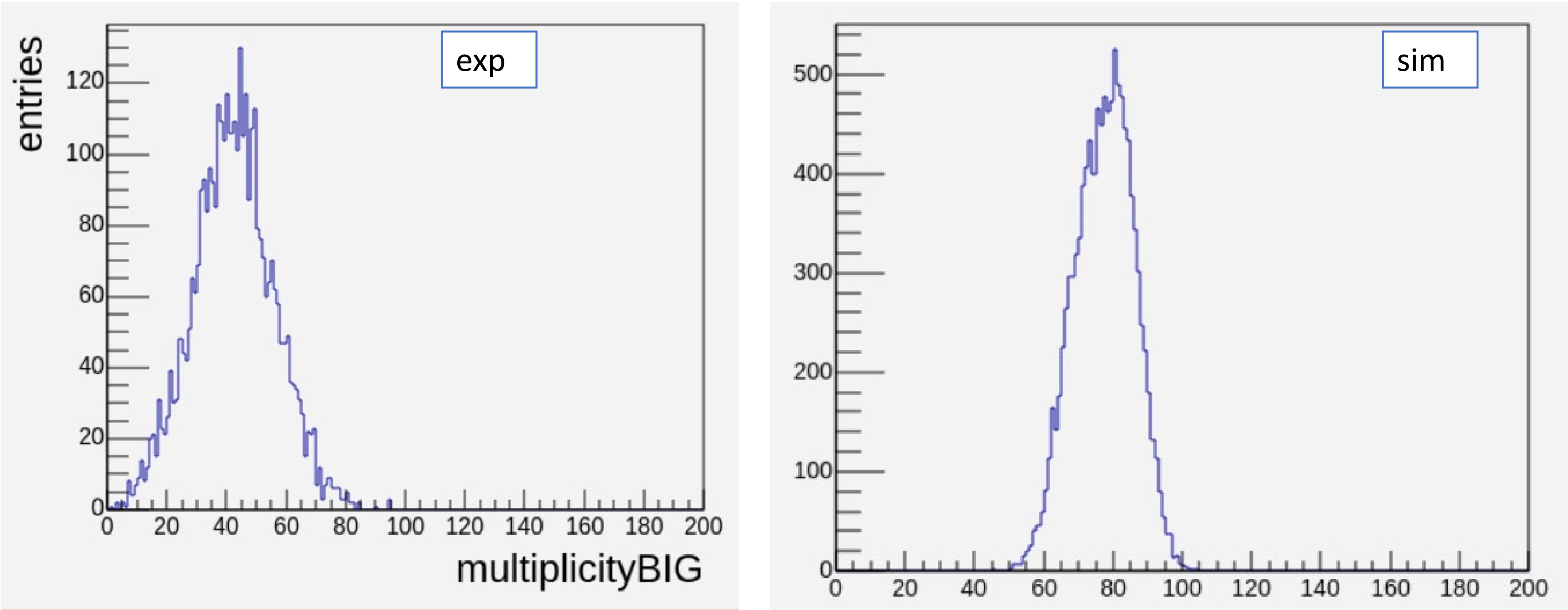
- Small cells exp cct2 vs sim
- No fhcal cut

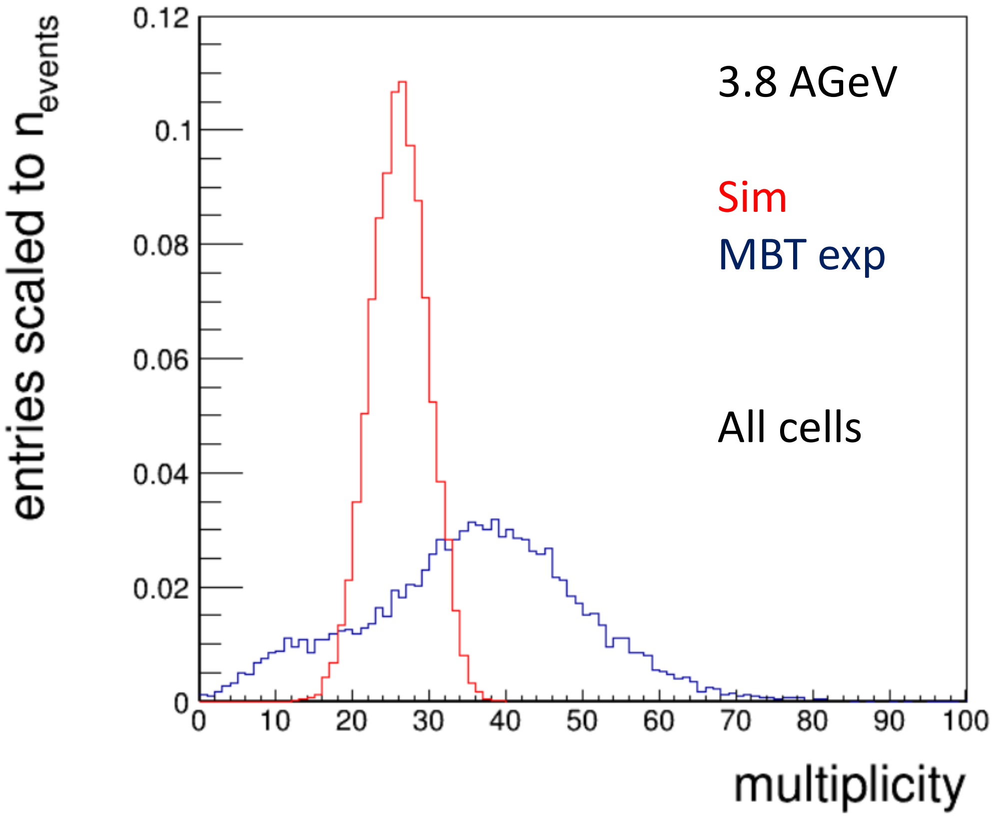


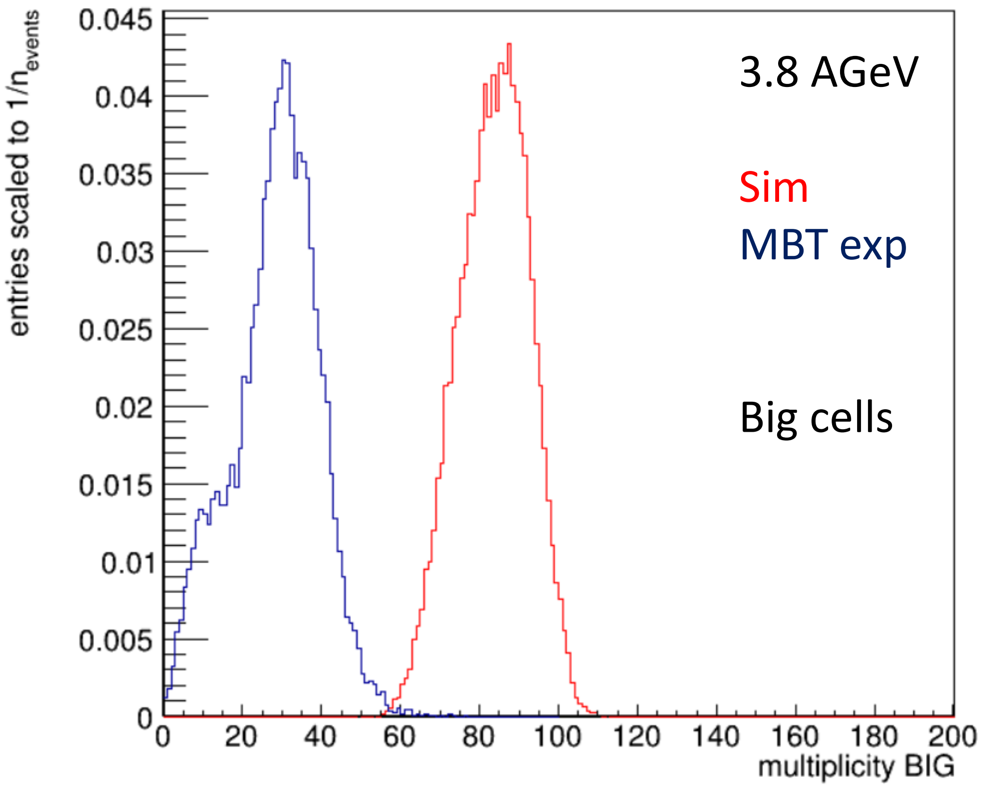


New sim

- big cells exp cct2 vs sim
- No fhcal cut

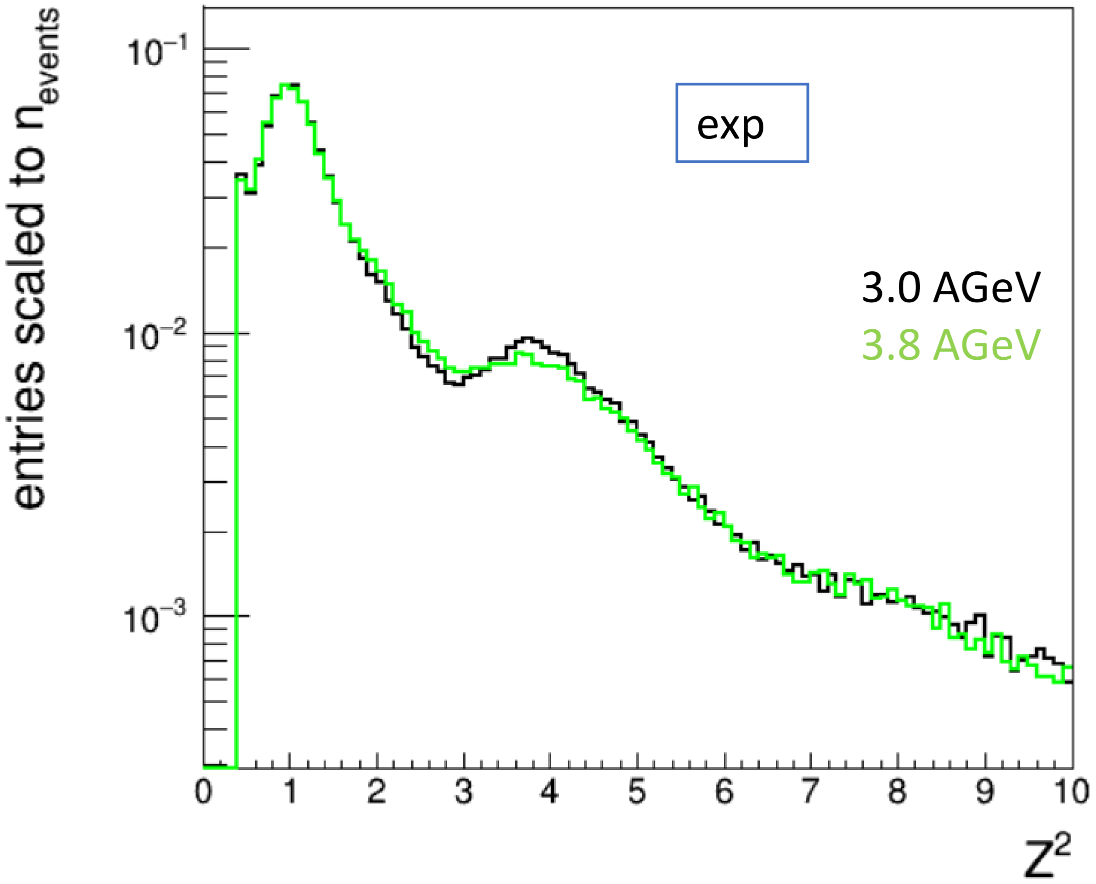


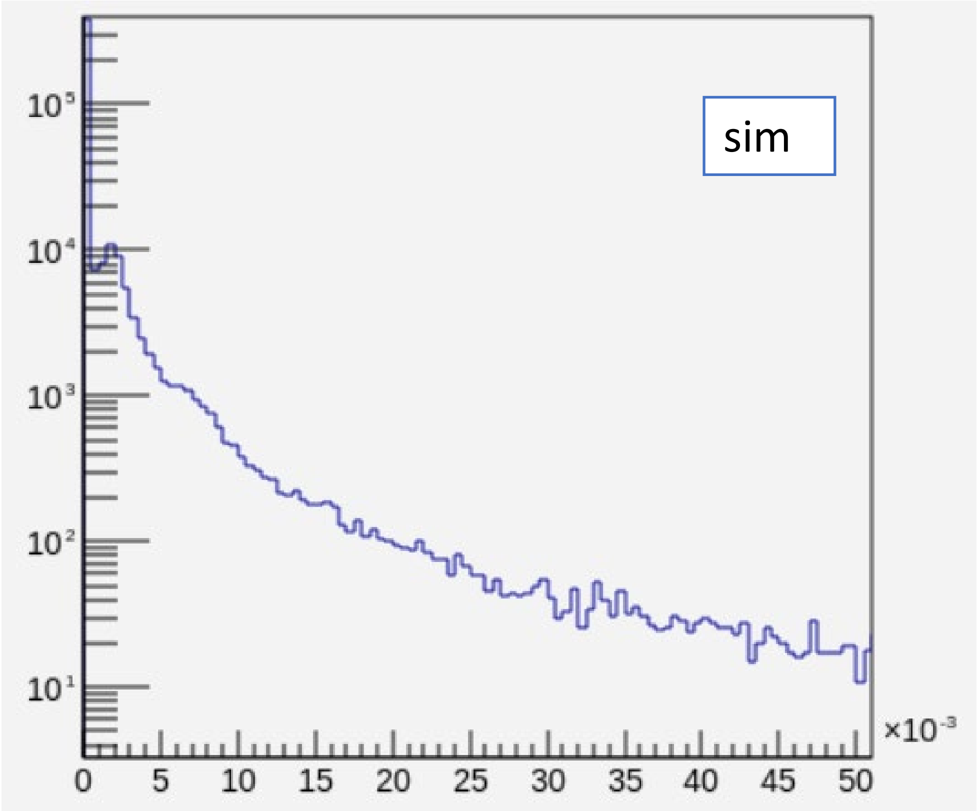

entries scaled to n_{events}
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
70
80
90
100
multiplicity
3.8 AGeV
Sim
MBT exp
All cells


entries scaled to $1/n_{events}$
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
20
40
60
80
100
120
140
160
180
200
multiplicity BIG
3.8 AGeV
Sim
MBT exp
Big cells

New sim

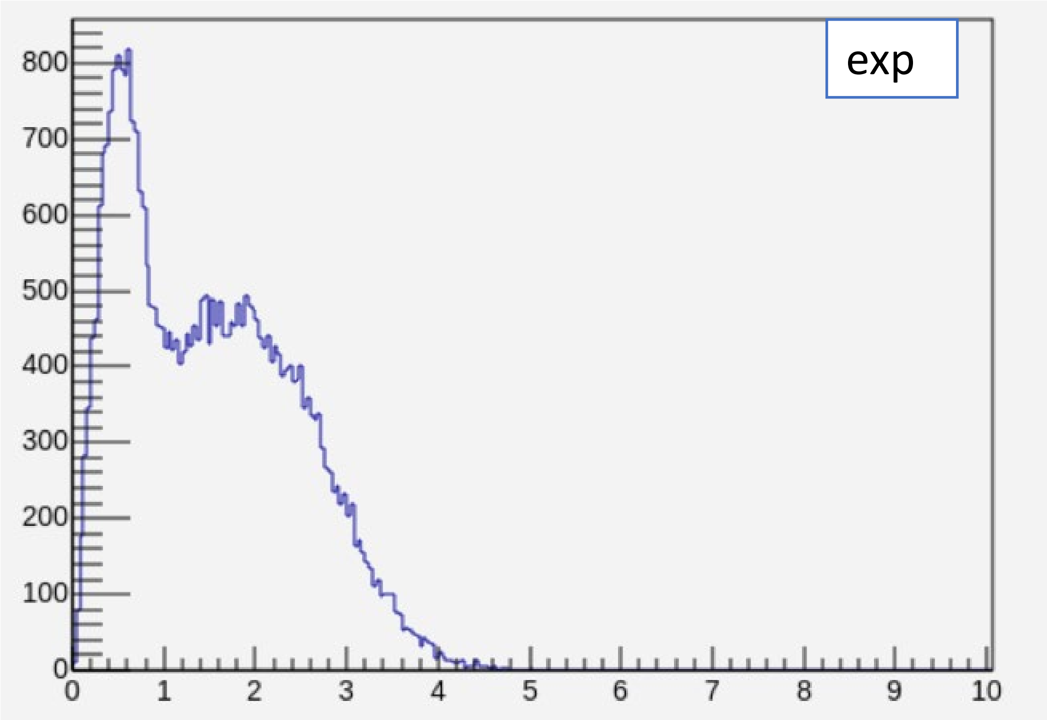
- ScWall charge

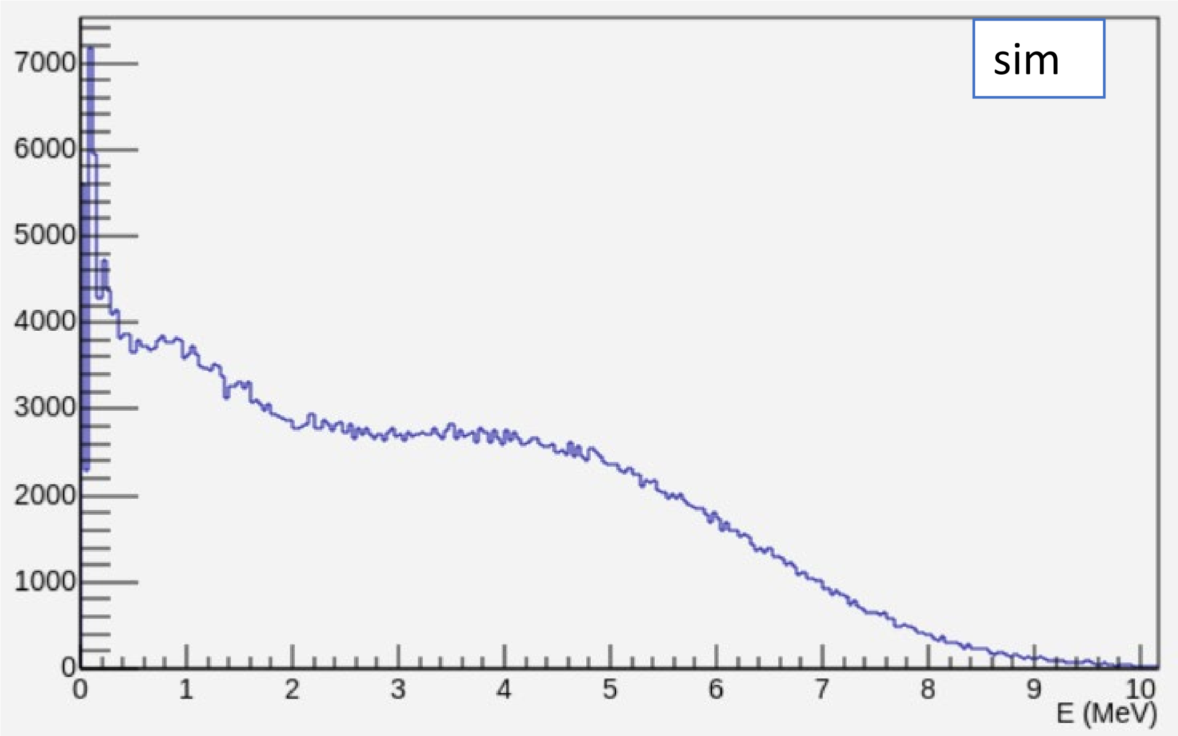




New sim

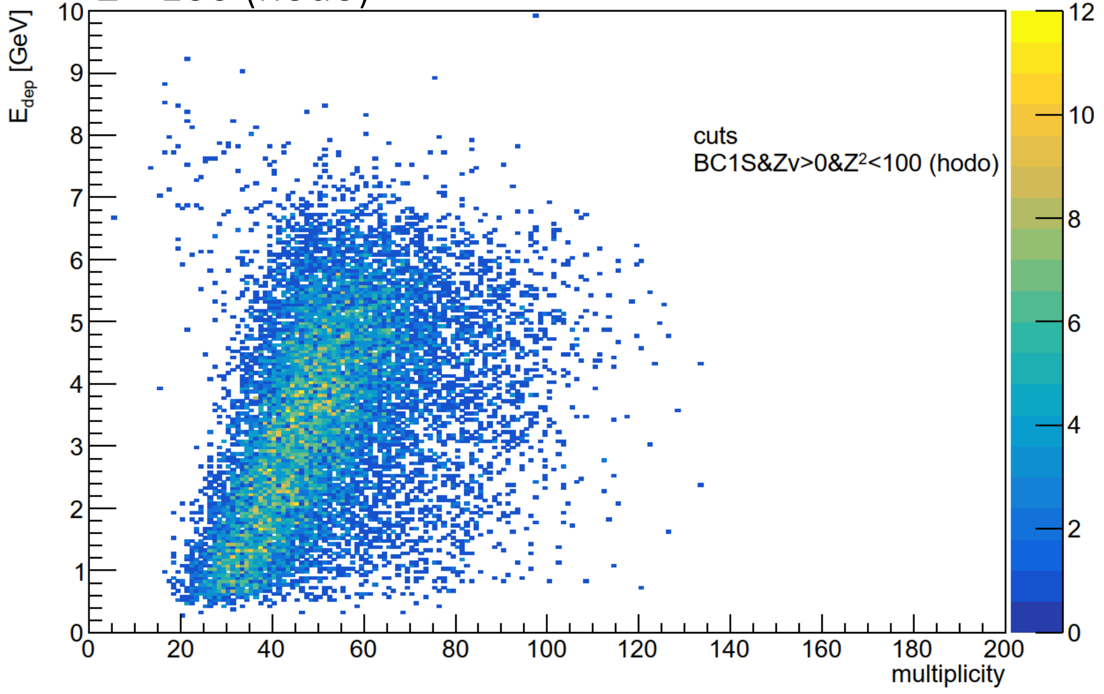
- FHCal Edep



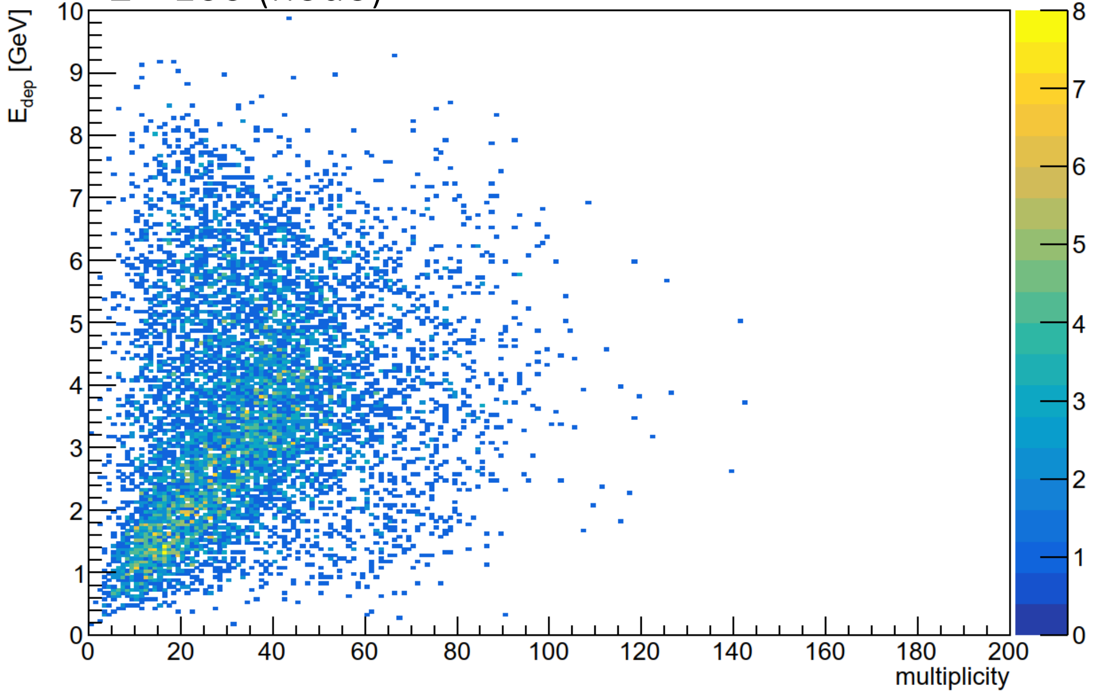


Edep vs multiplicity (scwall) CCT2 (MBT is equal)

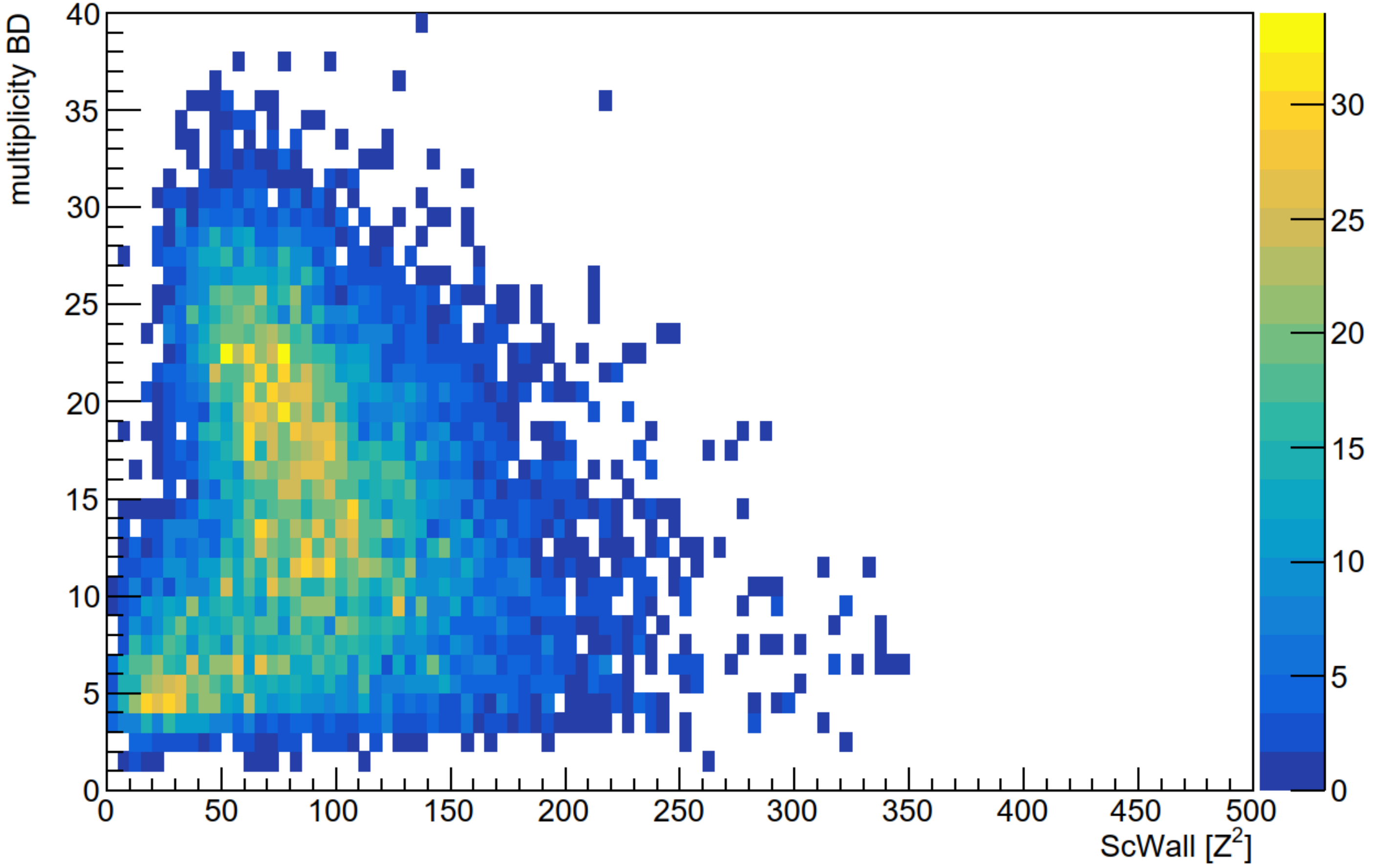
Cut (BC1S)
Cut (vertex & BC1S)
Cut (vertex (|z| > 0) & BC1S)
Z^2<100 (hodo)



Cut (BC1S)
Cut (vertex & BC1S)
Cut (vertex (|z| > 0) & BC1S)
Z^2>100 (hodo)



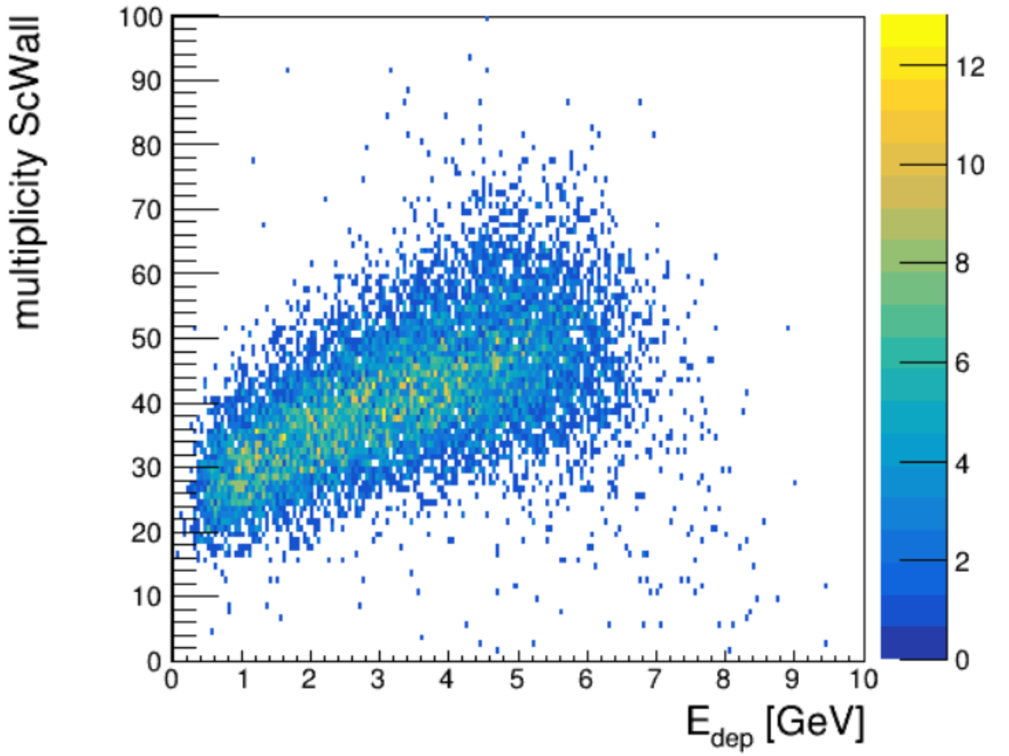
BD mult vs ScWall charge

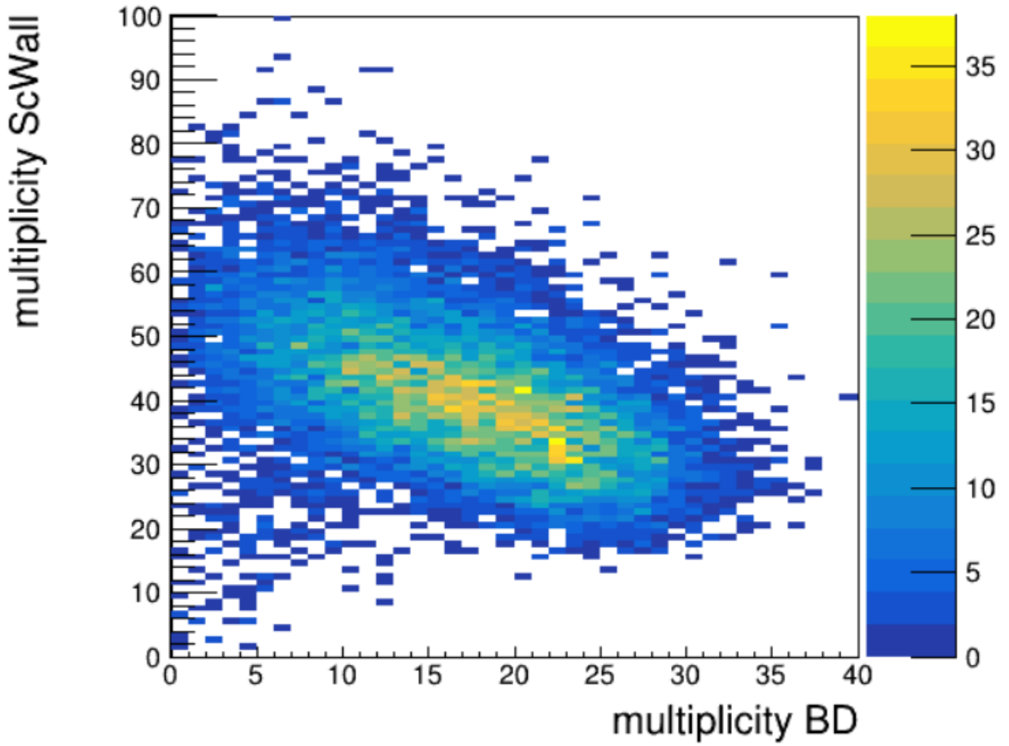


MBT 3.8

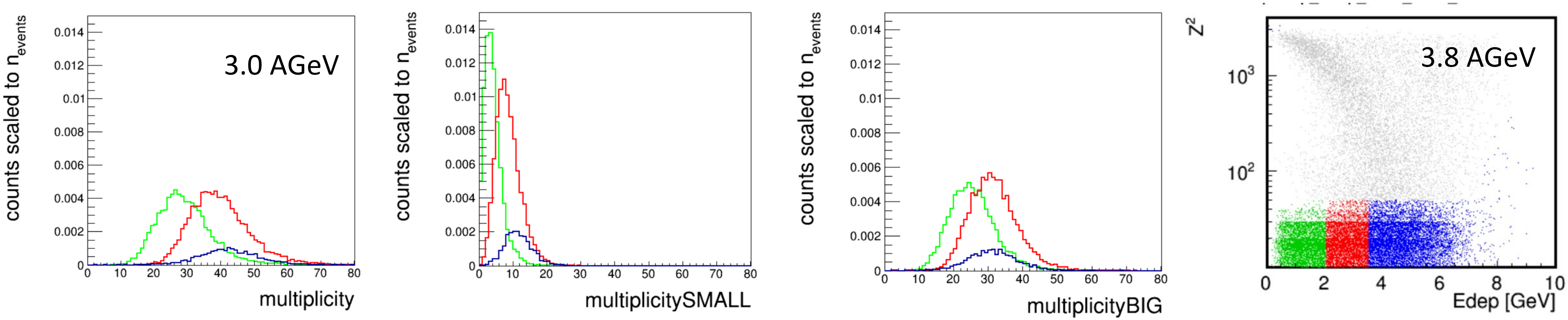
Cuts:
BC1S
Z^2 (ScWall) > 0.4
vertex Z (-1.5 < Z <1.5)
Z^2 (FQH) < 50

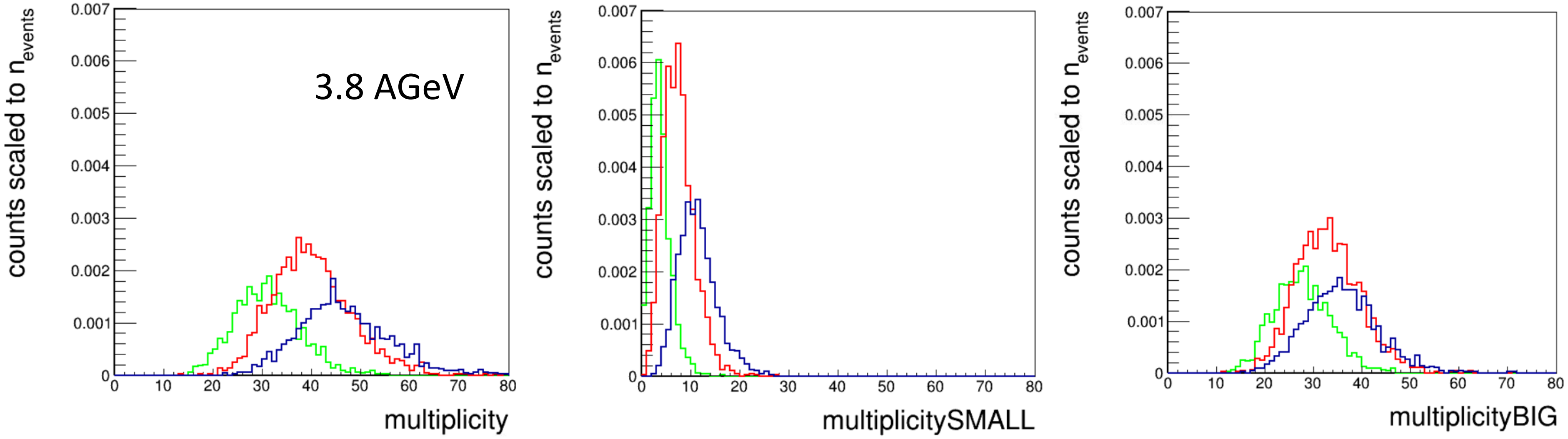
MBT



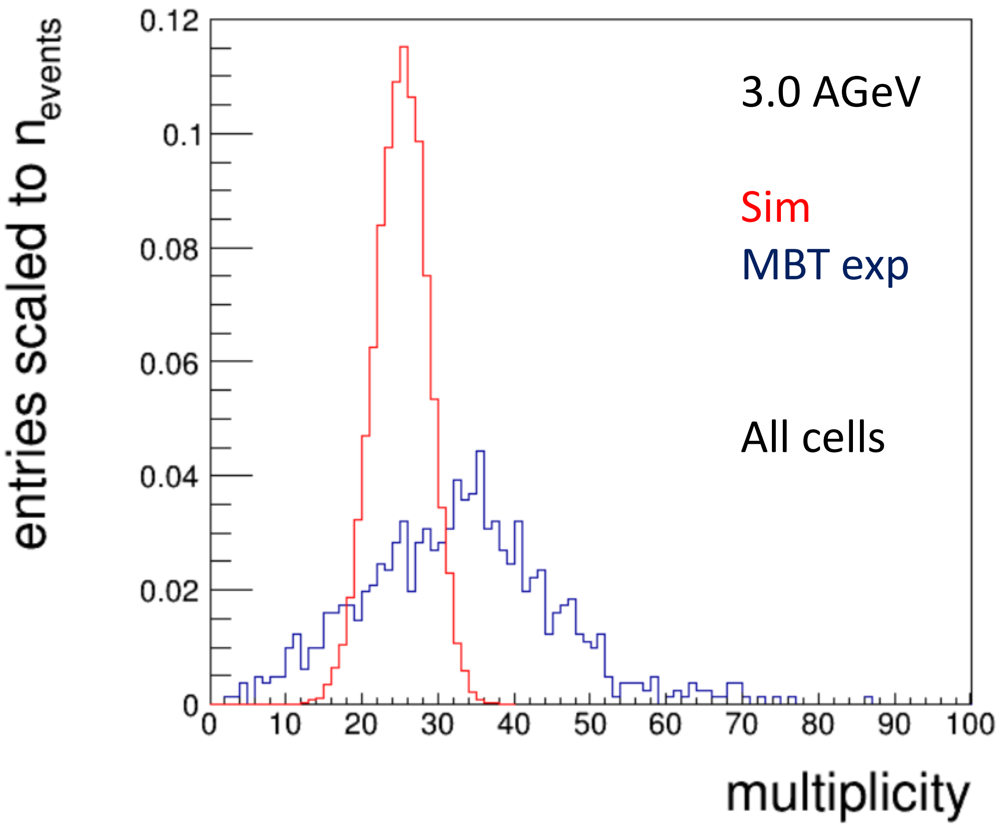


ScWall multiplicity distributions of charged particles for different centrality classes

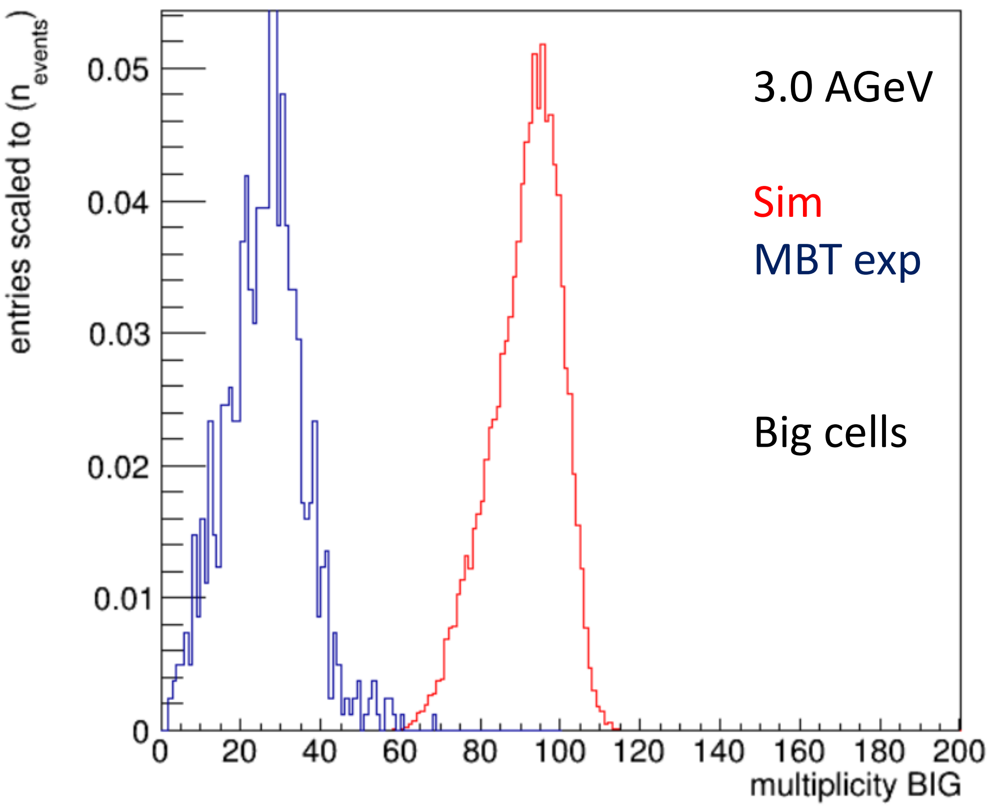




Multiplicity is sensitive to centrality. Green, red and blue reflect the most central, semi-peripheral and peripheral classes of events.

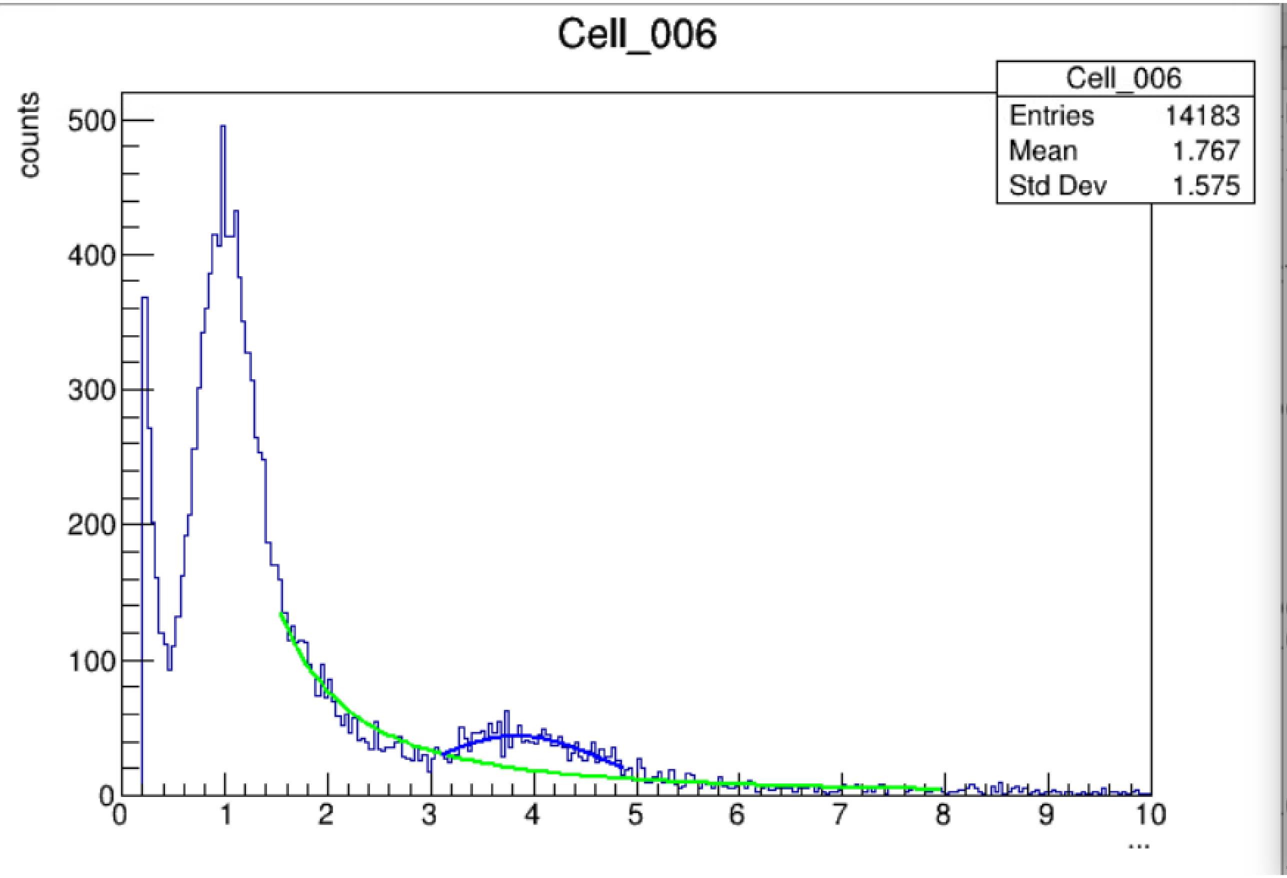


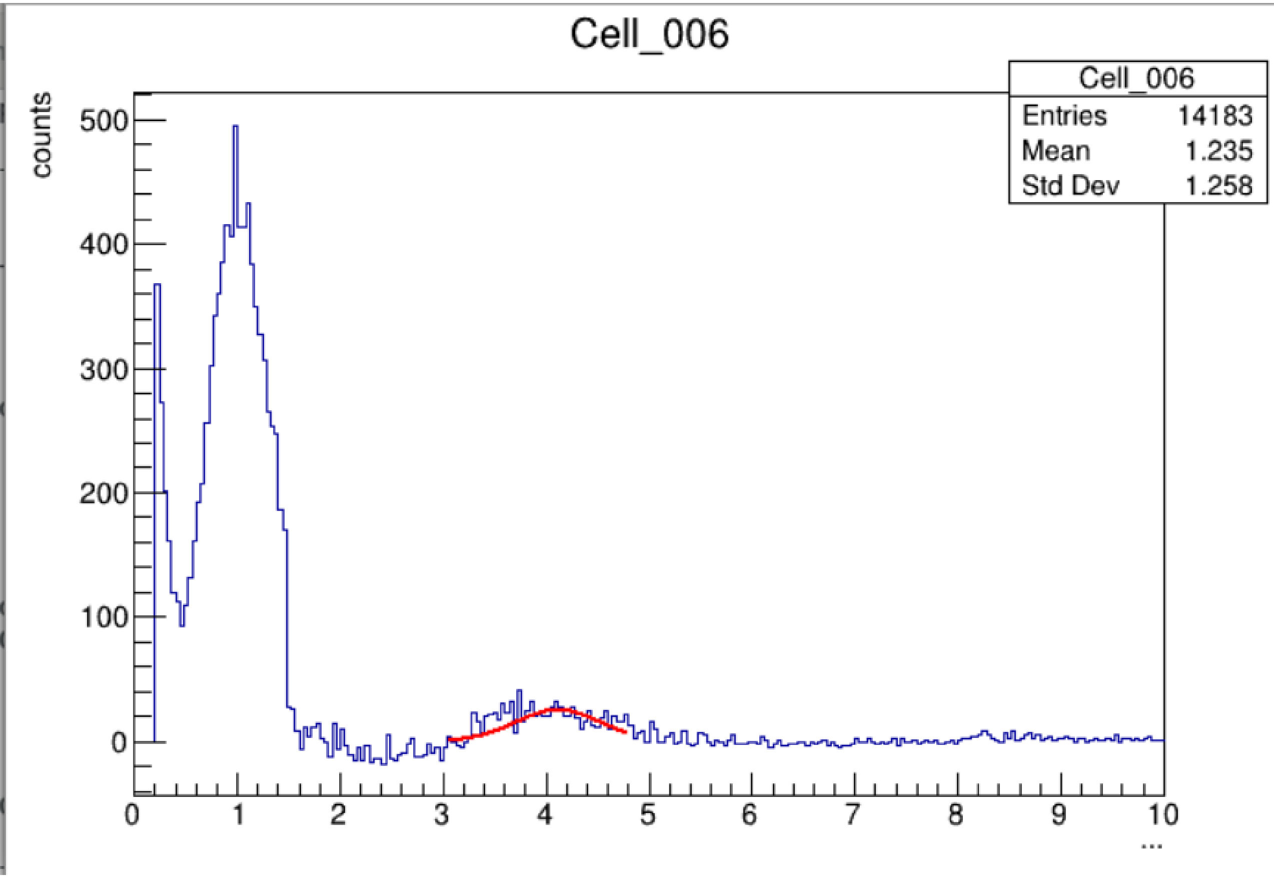
entries scaled to n_{events}
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
70
80
90
100
multiplicity
3.0 AGeV
Sim
MBT exp
All cells



entries scaled to (n_{events})
0.05
0.04
0.03
0.02
0.01
0
0
20
40
60
80
100
120
140
160
180
200
multiplicity BIG
3.0 AGeV
Sim
MBT exp
Big cells

Background subtr.
Before / after

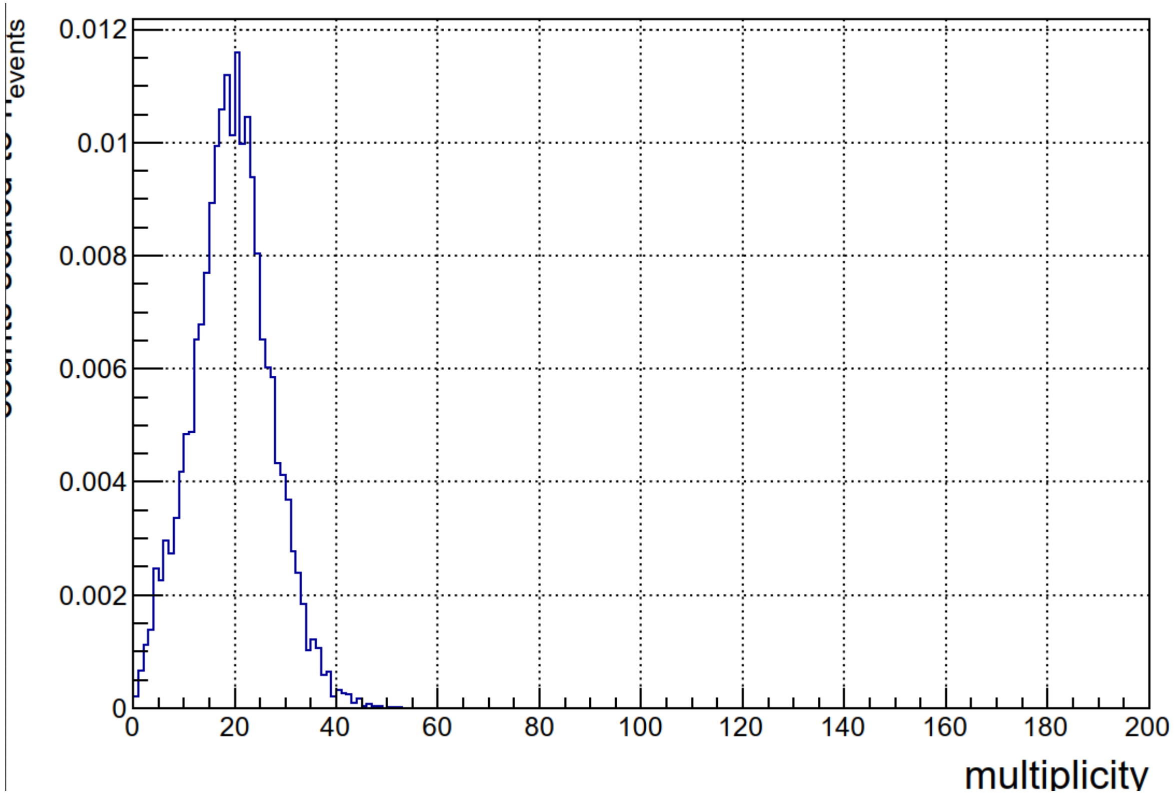


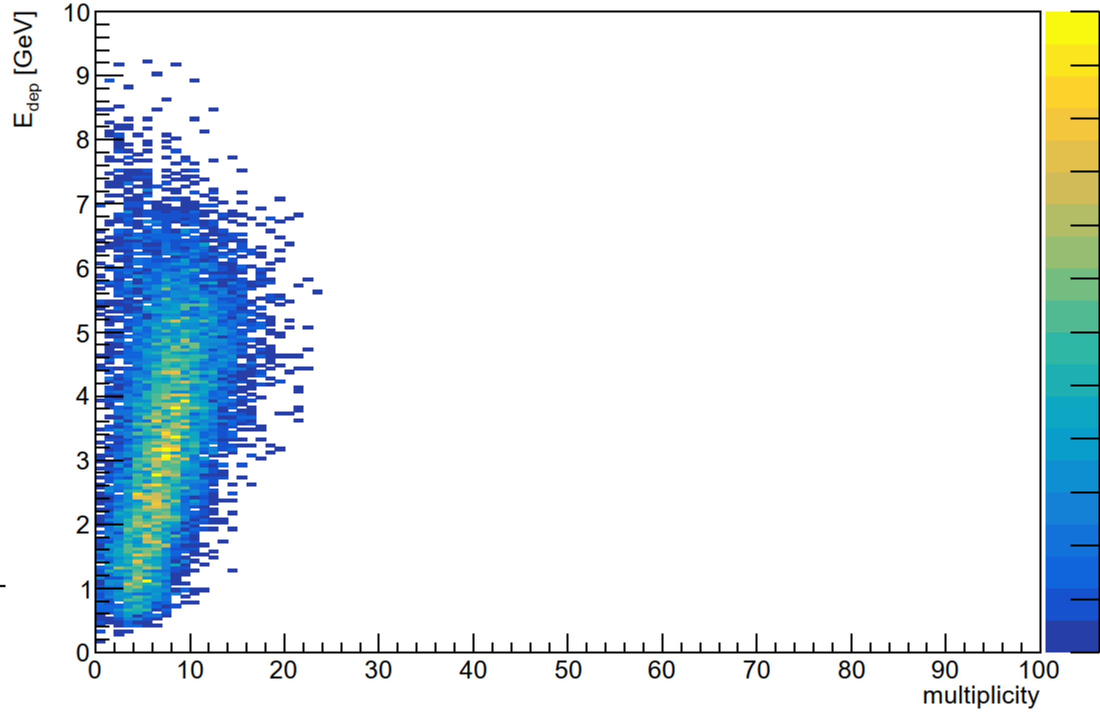


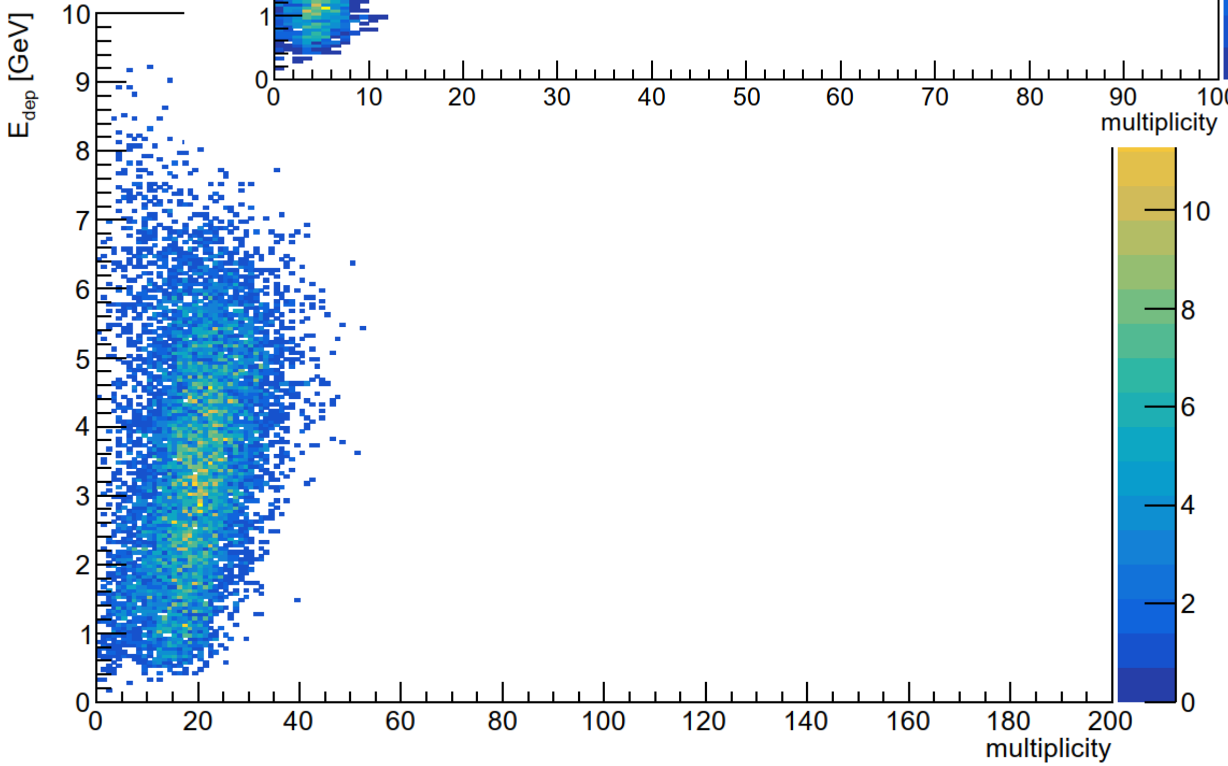
New dst

multiplicity (ScWall) CCT2 all cells

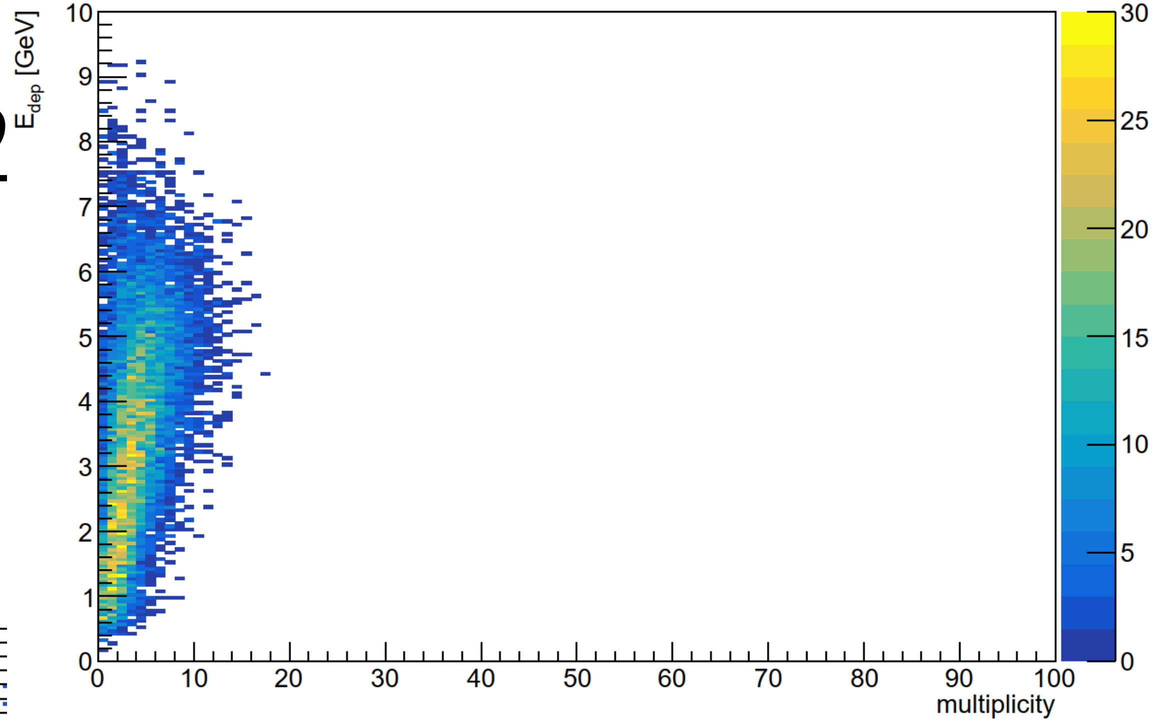
Cut (vertex (|z| > 0) & BC1S)
0.5> Z^2 < 1.5 ScWall



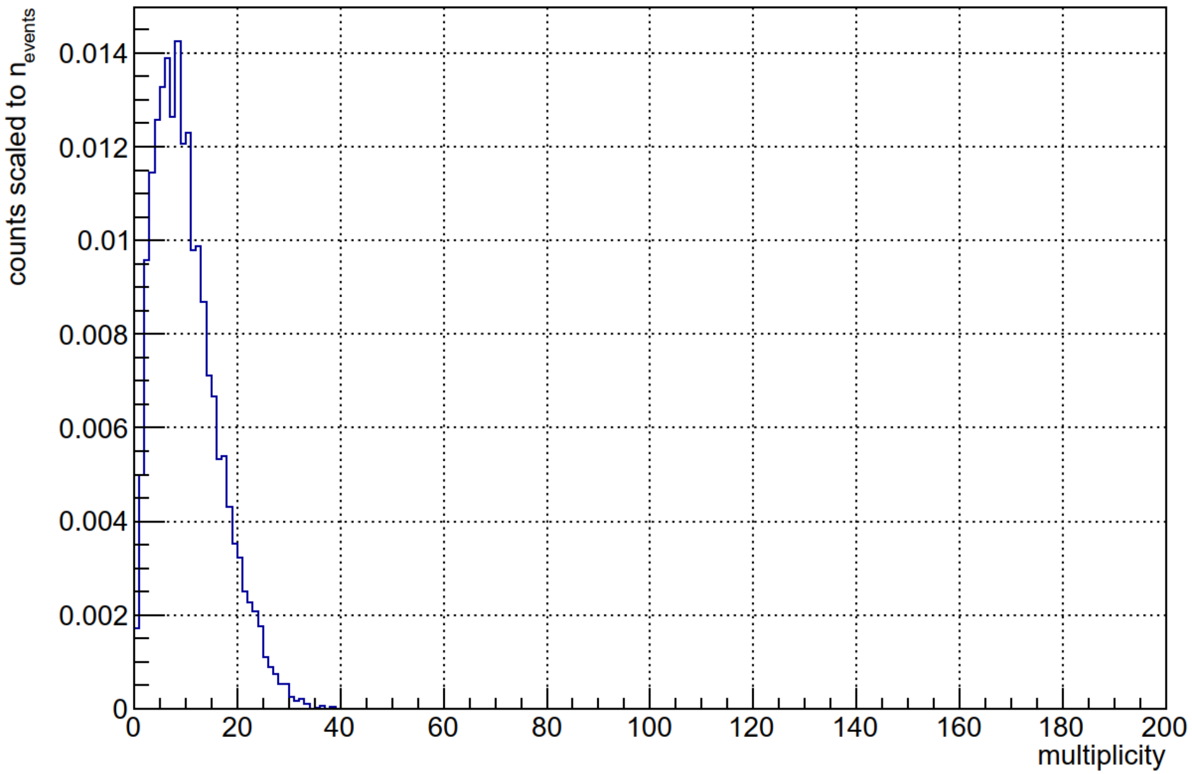


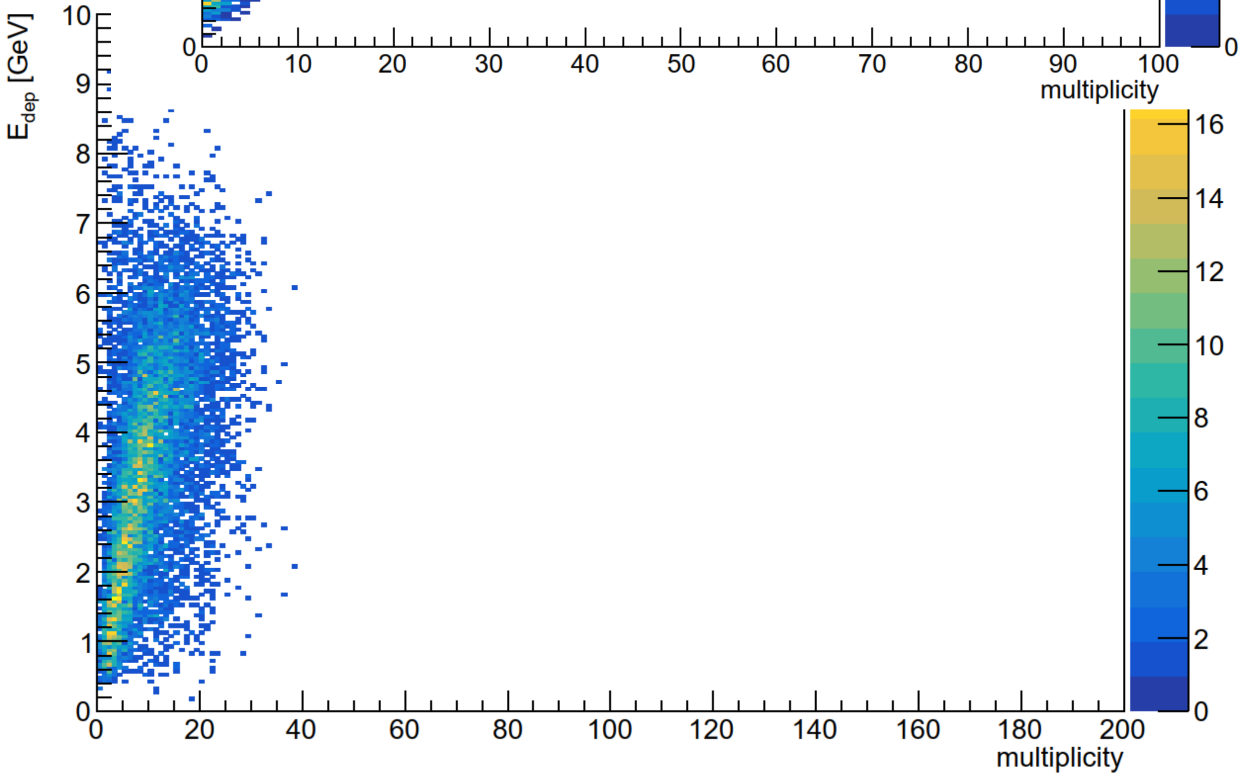


multiplicity (ScWall) CCT2 small cells



Cut (vertex (|z| > 0) & BC1S)
0.5> Z^2 < 1.5 ScWall





multiplicity (ScWall) CCT2 big cells

Cut (vertex (|z| > 0) & BC
0.5> Z^2 < 1.5 ScWall