Performance of the Scintillation Wall in the the first physics run at the BM@N Experiment

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on behalf of INR RAS group

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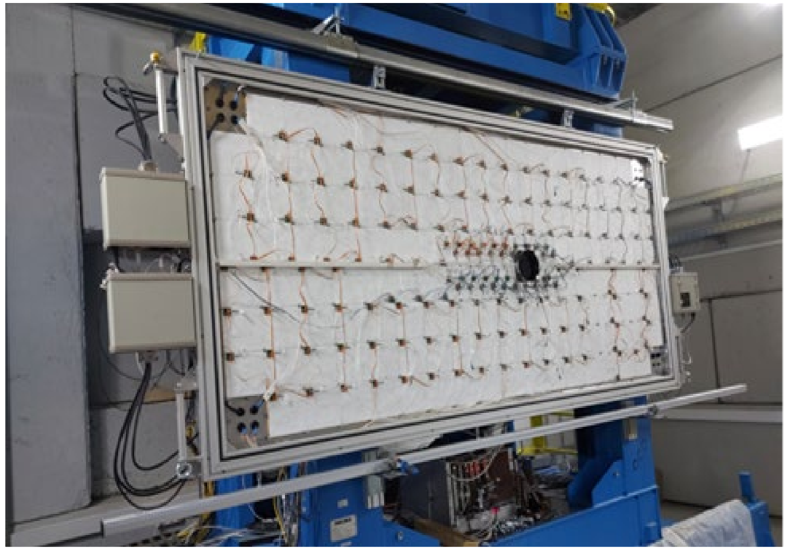
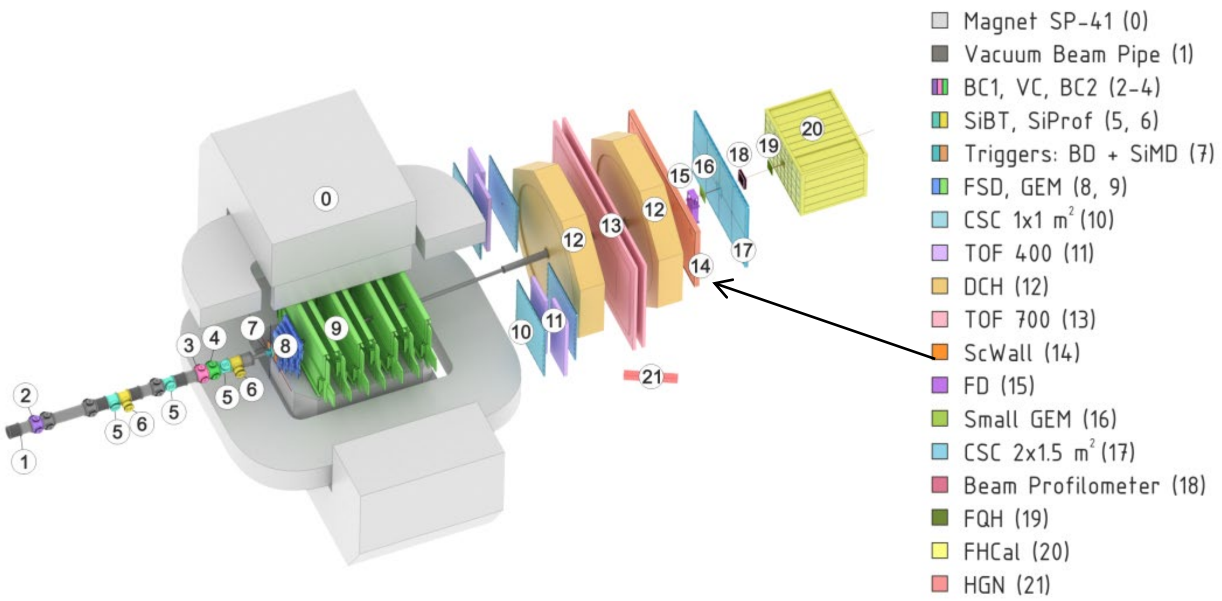
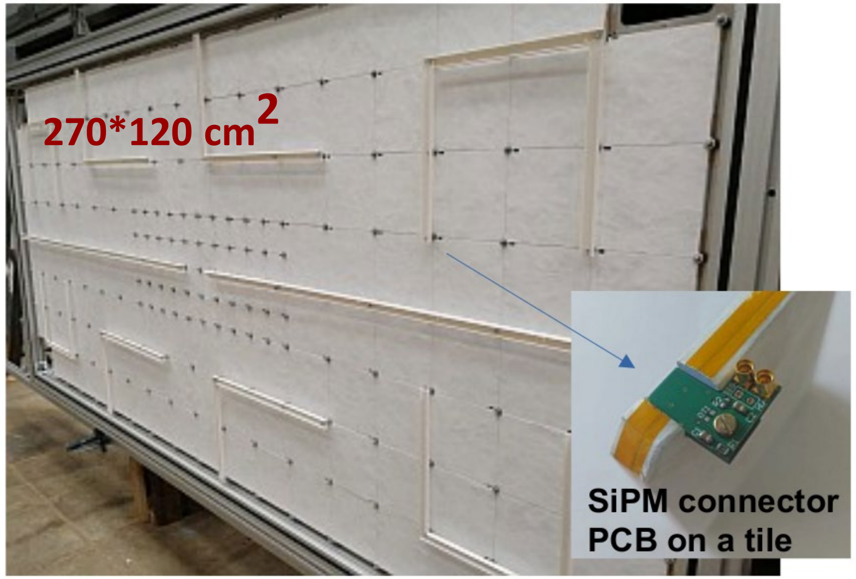
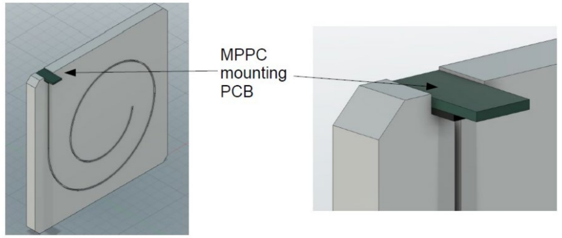
Scintillation Wall for fragments charge measurements and reaction plane estimation





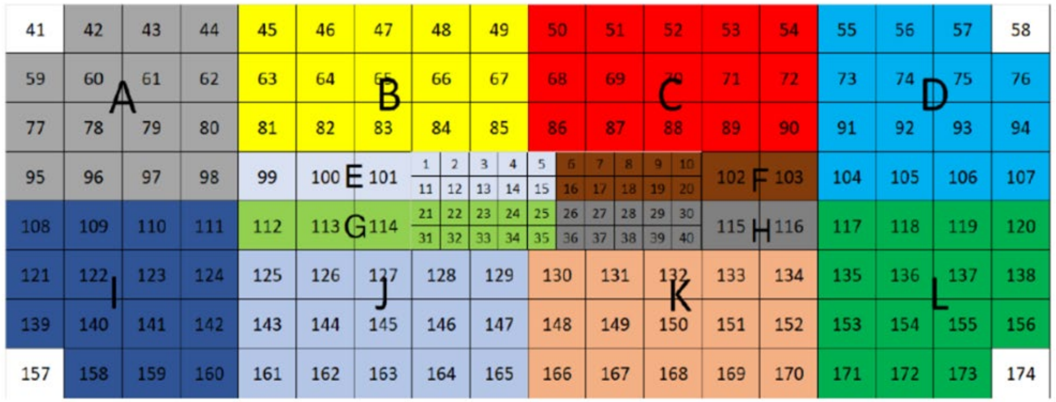


- **36 small inner cells** 7.5×7.5×1 cm^3 + **138 big outer cells** 15×15×1 cm^3
- light yield for MIP signal – small cells 55 p.e.±2.4%; big cells 32 p.e.± 6%.
- beam hole
- covered with a light-shielding aluminum plate
- light collection by WLS fibers
- light readout with SiPM (Hamamatsu MPPC S14160-1310PS) mounted on the PCB at each scint. cell



light collection from tiles

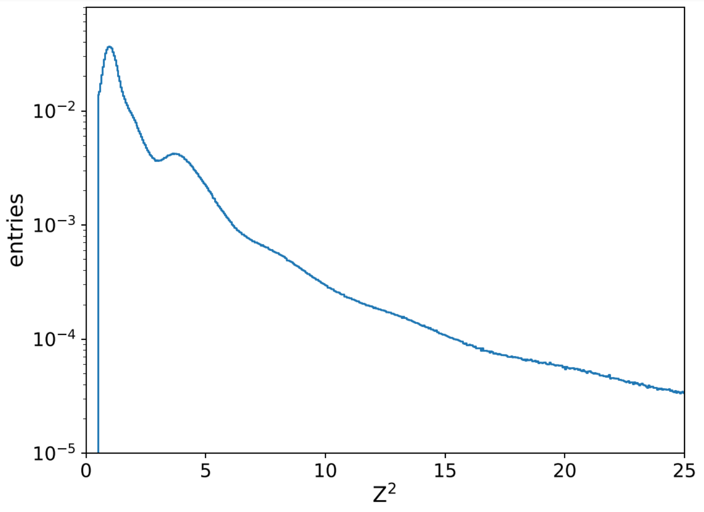
ScWall: design



41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
59	60 A	61	62	63	64	65 B	66	67	68	69	70 C	71	72	73	74 D	75	76
77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
95	96	97	98	99	100 E	101	1 2 11 12	3 4 13 14	5 6 15 16	7 8 17 18	9 10 19 20	102 F	103	104	105	106	107
108	109	110	111	112	113 G	114	21 22 31 32	23 24 33 34	25 26 35 36	27 28 37 38	29 30 39 40	115 H	116	117	118	119	120
121	122 I	123	124	125	126	127 J	128	129	130	131	132 K	133	134	135	136	137 L	138
139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174

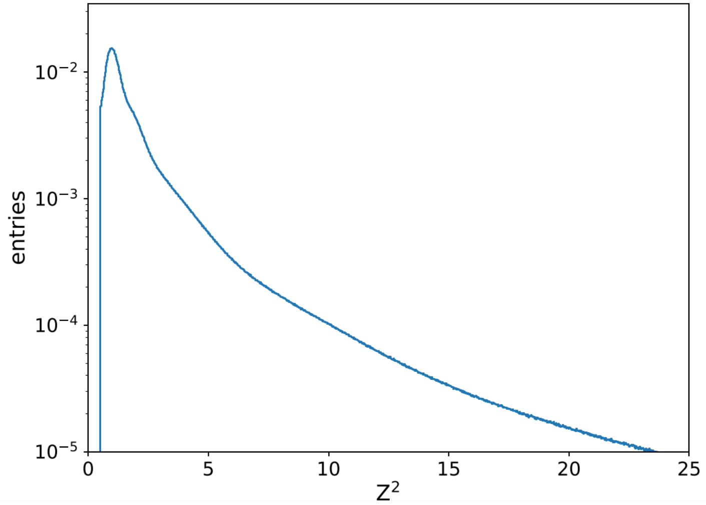
3.8 GeV

- 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



Spectra of charges for small scintillator detectors after calibration

The fragments with Z = 3 and beyond mainly pass through the beam hole and are not detected by most of the scintillator detectors.



Spectra of charges for large scintillator detectors after calibration

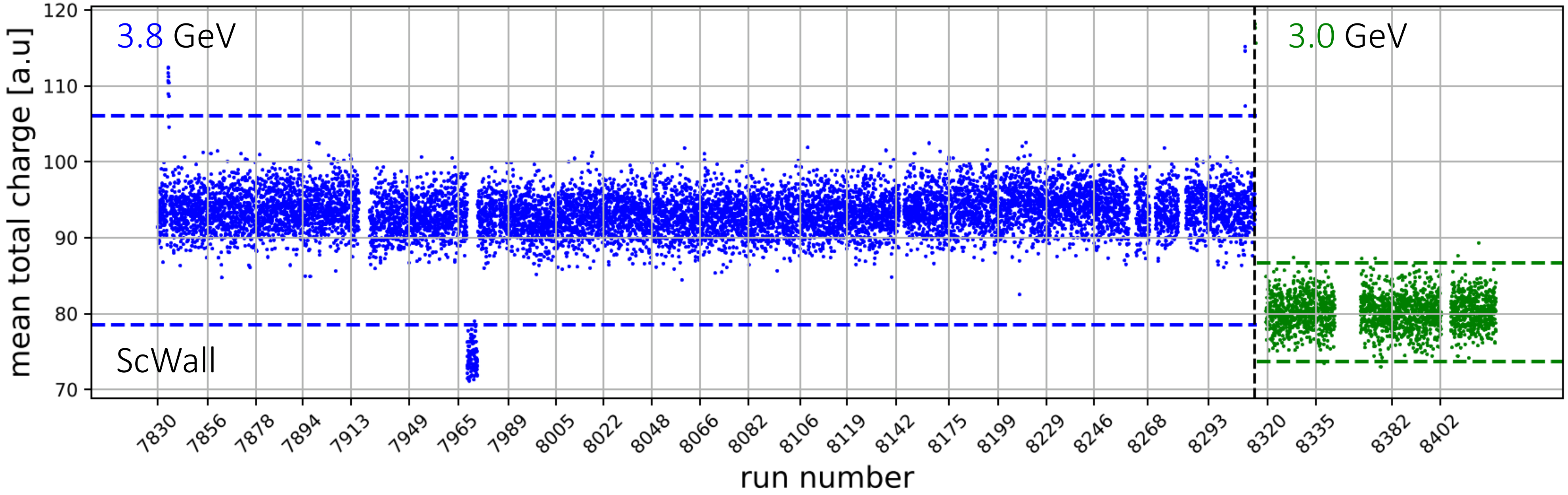
In the large outer scintillation detectors only the Z = 1 peak being clearly visible.

Data for run8.

ScWall stability during the run8

Data for Xe+CsI are presented for all data on a file-by-file basis for energies of 3.0 and 3.8 GeV for ScWall

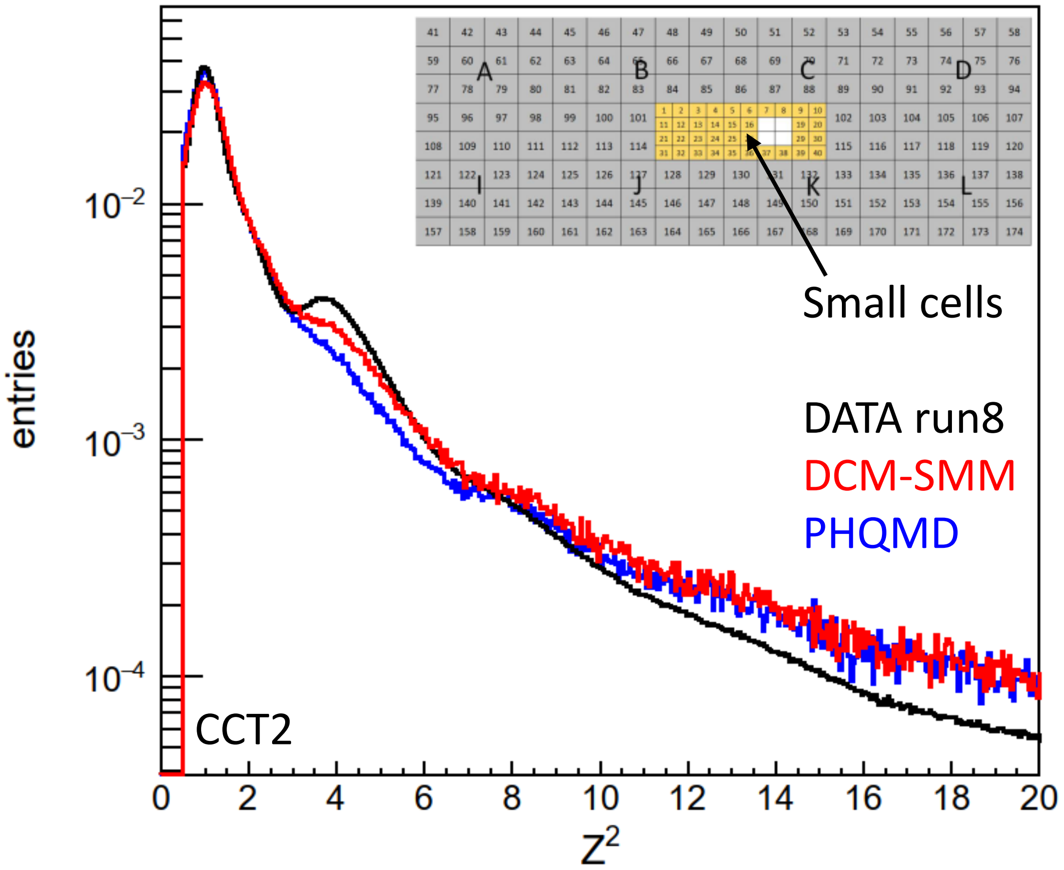
+− 5σ dashed lines are shown

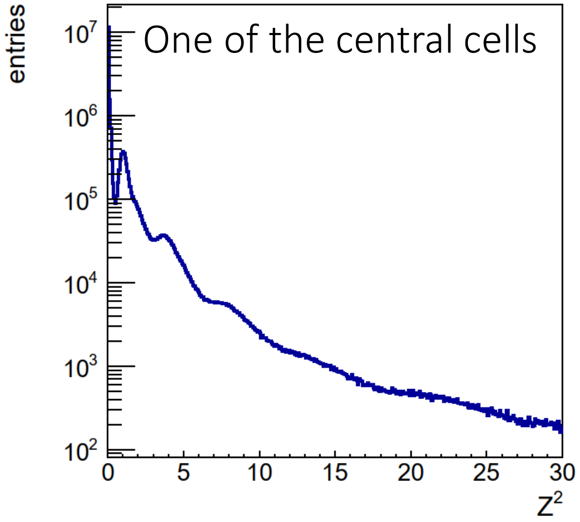


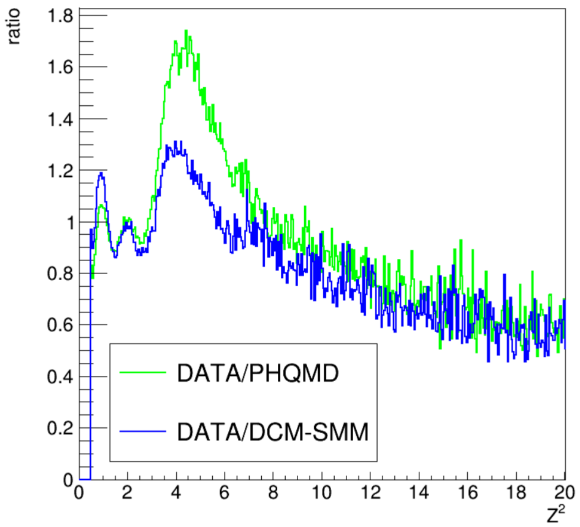
The mean total charge values for ScWall for each file are presented.

Applied cuts: Single Xe, vertex Z (-1.5 cm < Z <1.5 cm), ≥2 tracks in vertex reconstruction

Charges spectra







The charge spectrum on the ScWall is in the range up to Z = 2 (small cells).

Large charges leak out into the hole.

In the cells around the hole, charges up to Z = 4 can be detected.

The shift of the peaks is due to the Birks effect.

The charge yields in the experiment and in the simulation data for Z = 2 are significantly different.

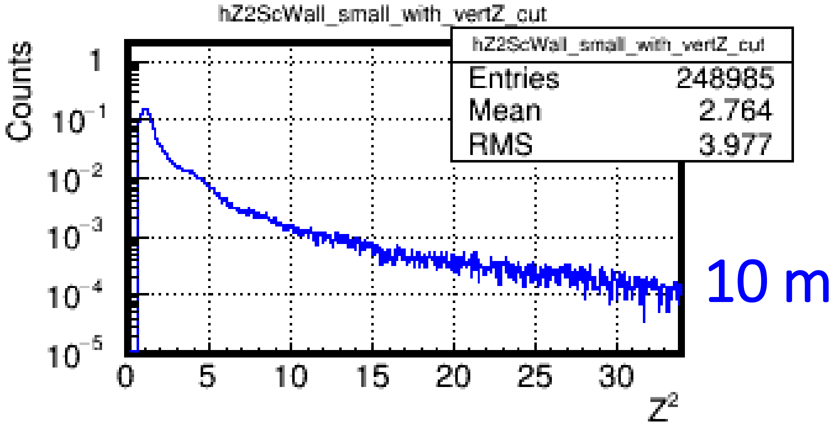
Particle yield difference in the models and data is related to the angular distribution of the particles.

Future upgrade of ScWall

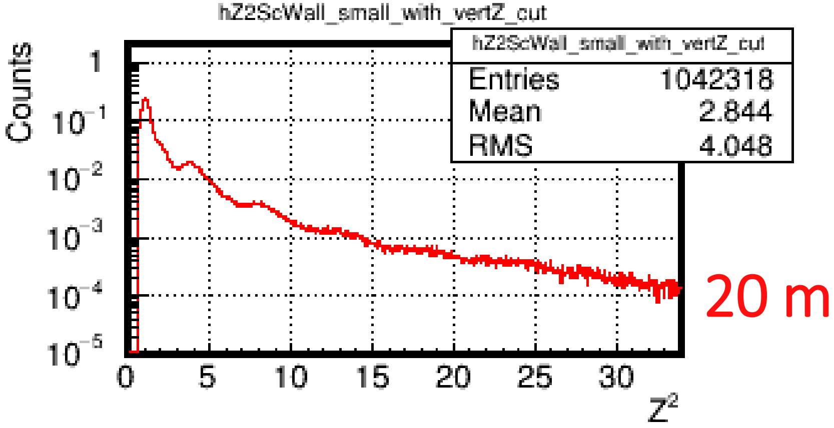
Simulation

ScWall Z^2 distributions XeCs@3.26AGeV

DCM-QGSM-SMM



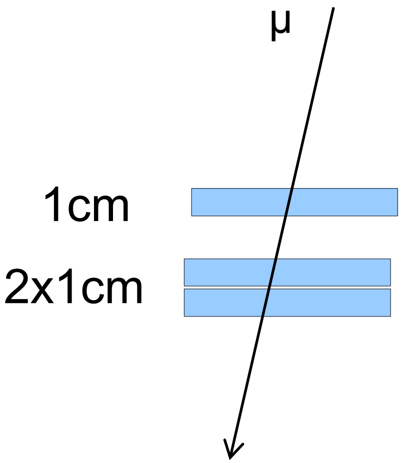
10 mm

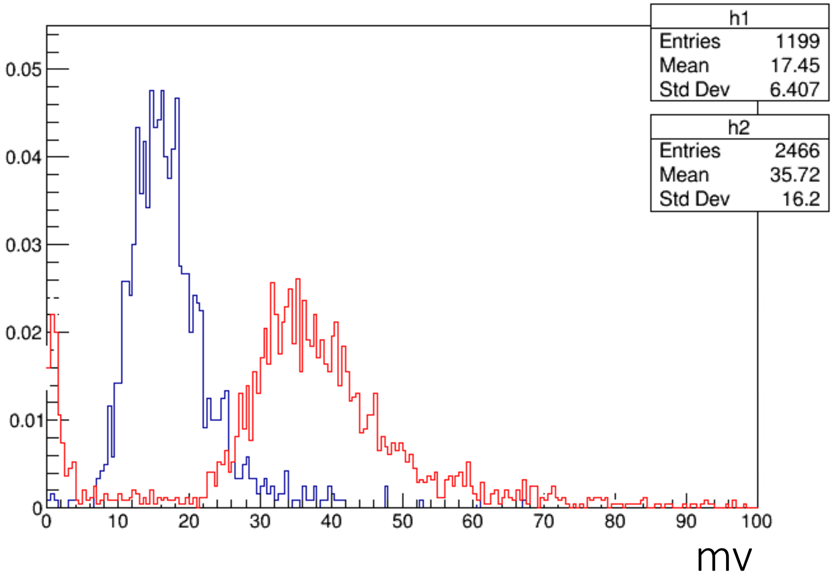


20 mm

The **range** of charges detected on the ScWall is much **greater** (up to Z = 5) in small cells when **thicker cells (20 mm)** are used according to the DCM-QGSM-SMM simulation.

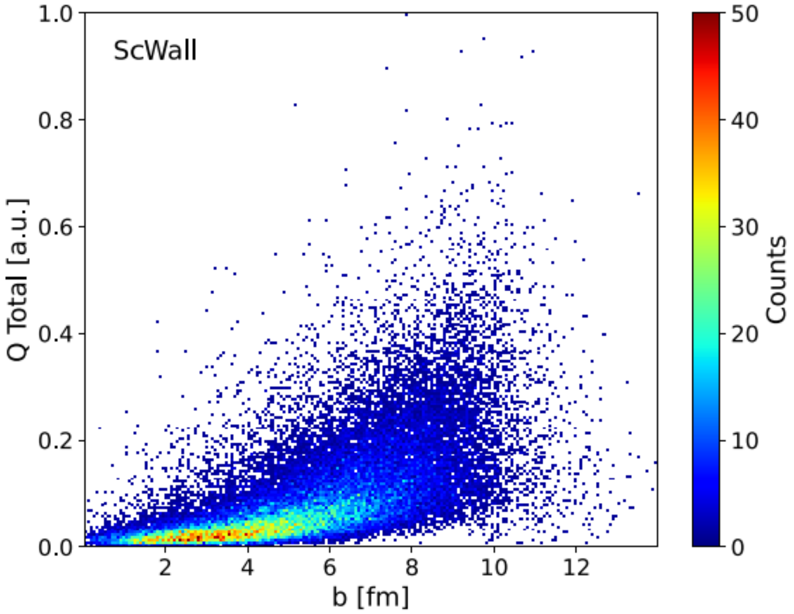
Cosmic tests



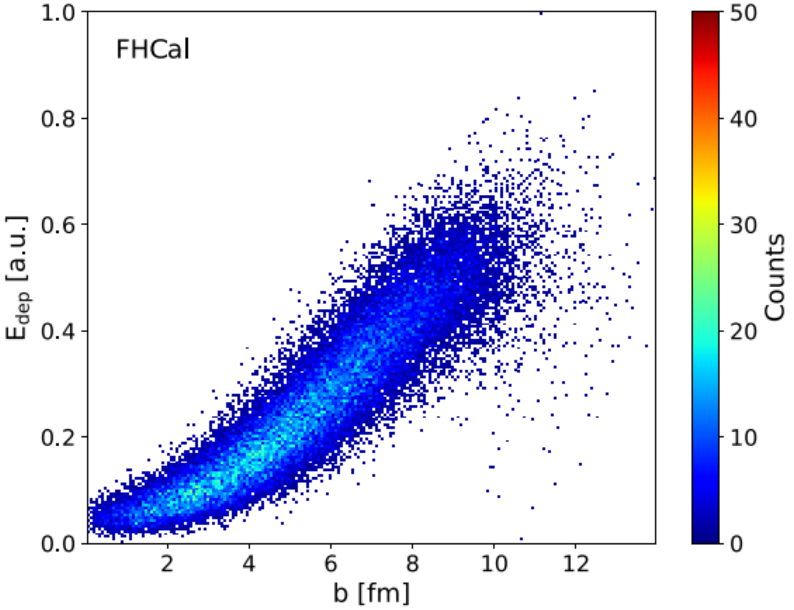


Research on the cosmic shows two times greater amplitude for 2x10 mm cells.

Centrality estimators



(a)



(b)

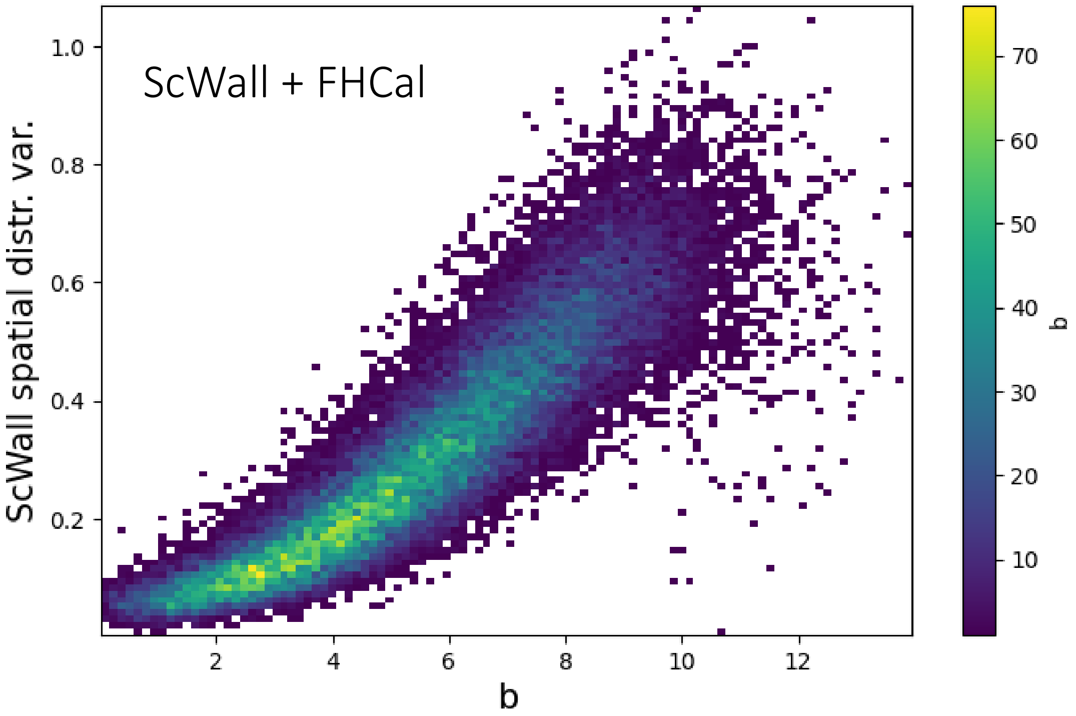
As an estimator of centrality, FHCal E_{dep} performs best (b) (similar to the number of tracks).

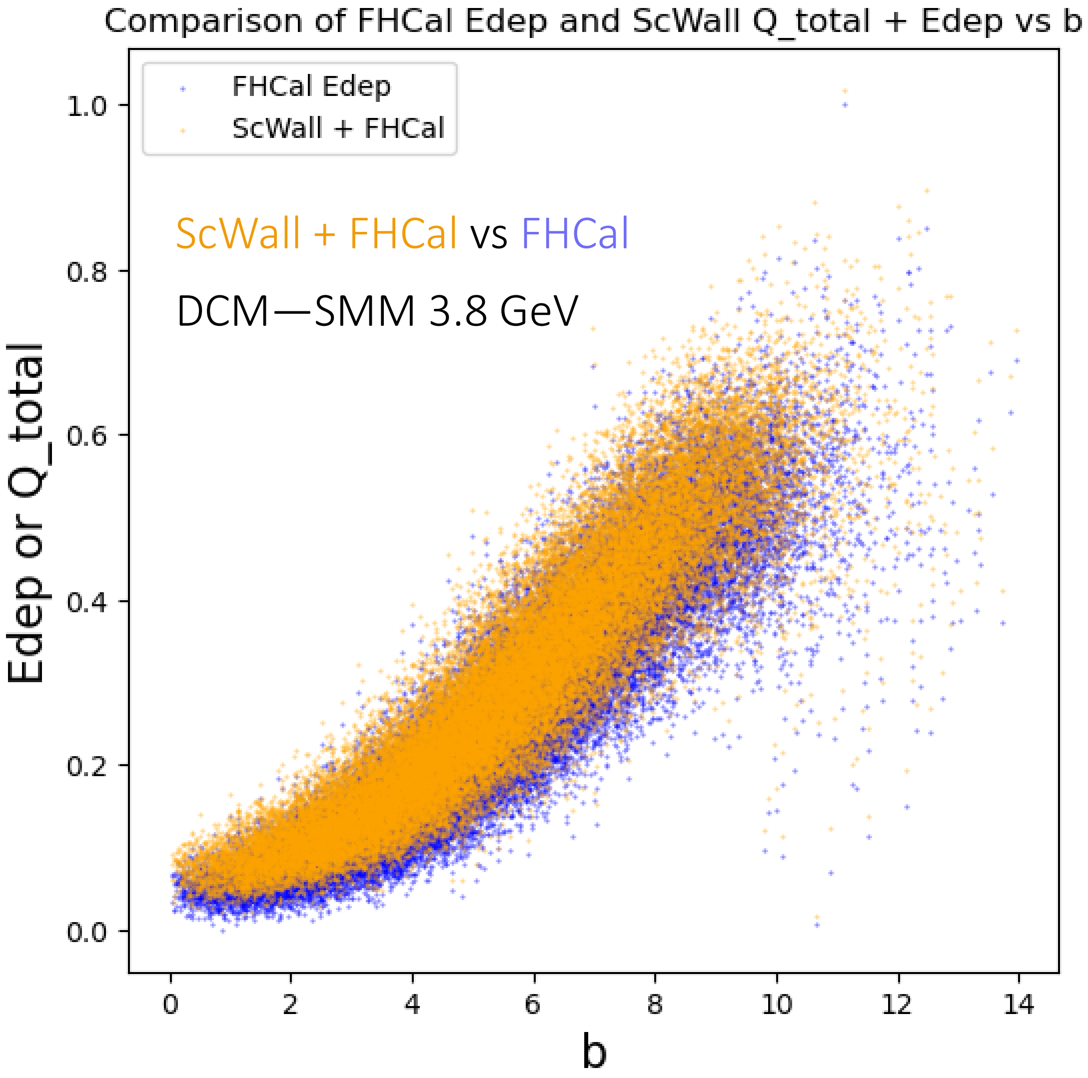
The scintillation wall (a) can sense centrality, but much worse.

It is possible to use the combined observable of these quantities to determine centrality.

DCM—SMM 3.8 GeV

Centrality estimators and combination of observables



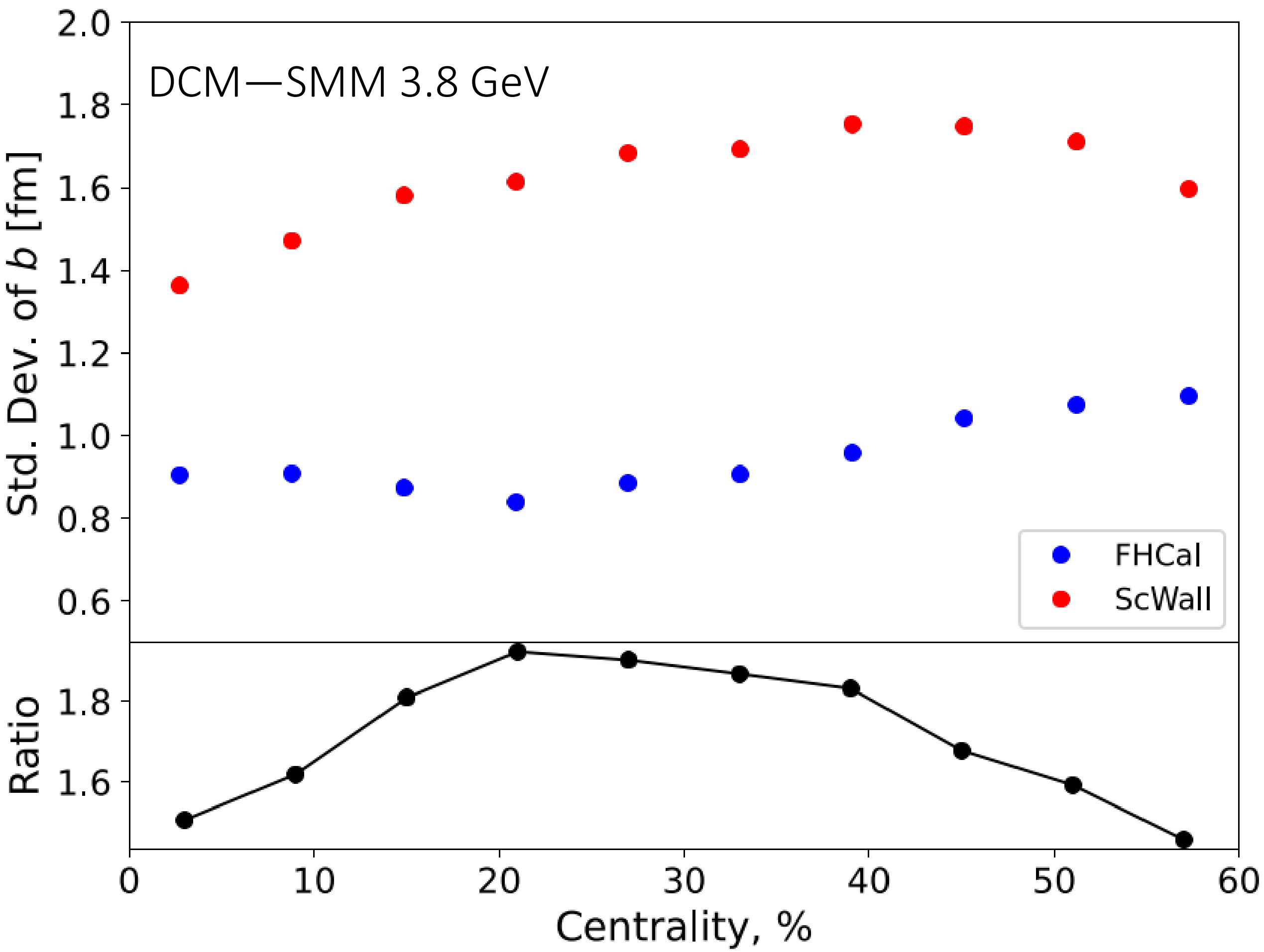


The combined usage of the energy deposition in the FHCal and the total charge on the ScWall gives a narrower distribution.

The centrality accuracy improves only within 1%.

Need to consider autocorrelations with FHCal.

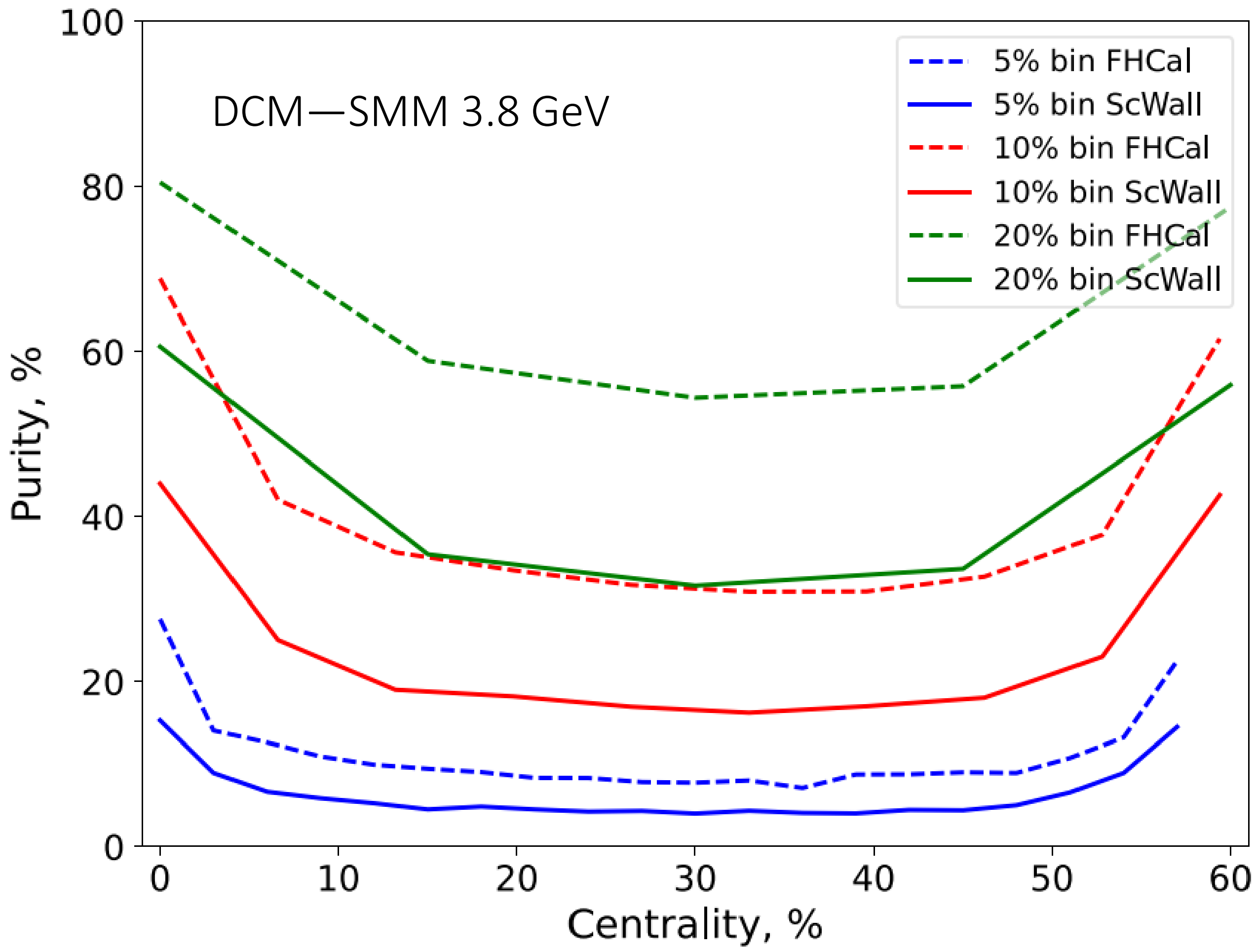
Centrality estimators: ScWall vs FHCal



The width of the distributions of the presented observables as a dependence of the impact factor shows that the ScWall is significantly inferior to the FHCal.

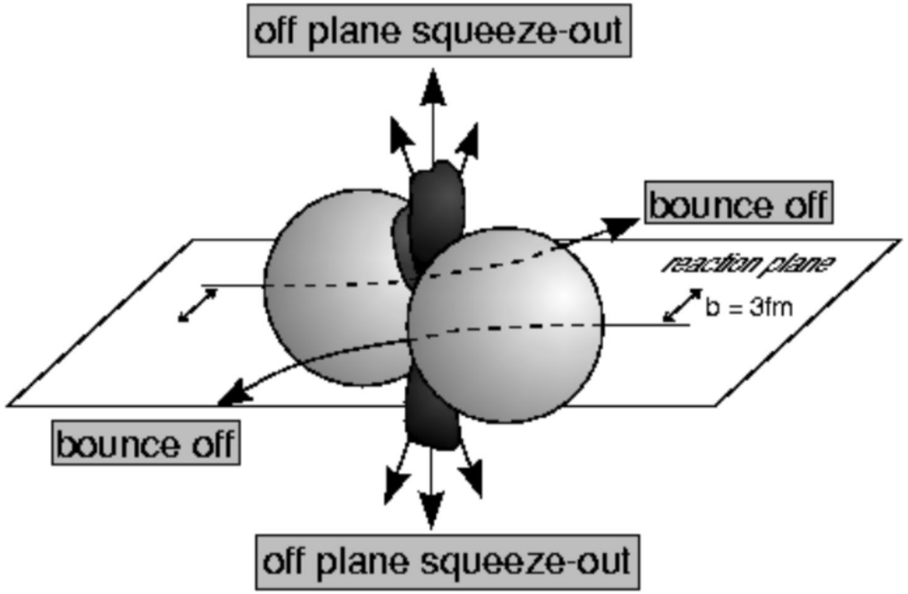
The difference for the most central events in standard deviation units is about 2 times.

Purity and centrality for FHCal and ScWall



To obtain the required purity of 80% for the most central class, it is necessary to take classes size of at least 20%.

Flow measurements theory



The azimuthal angle distribution is decomposed in a Fourier series relative to reaction plane angle:

$$\rho(\varphi - \Psi_{RP}) = \frac{1}{2\pi}(1 + 2\sum_{n=1}^{\infty} v_n \cos n(\varphi - \Psi_{RP}))$$

Anisotropic flow: $v_n = \langle \cos[n(\varphi - \Psi_{RP})] \rangle$

Reaction plane is not experimentally measured, we define the symmetry plane (SP) from spectators:

$$Q_1 = \sum_{k=1}^{N} w_k(\cos\phi_k, \sin\phi_k) = |Q_1|(\cos\Psi_{SP}, \sin\Psi_{SP})$$

Directed flow is measured

$$v_1 = \frac{\langle \cos(\phi - \Psi_{SP}) \rangle}{R_1}$$

Resolution correction factor

$$R_1 = \langle \cos(\Psi_{SP} - \Psi_{RP}) \rangle$$

These results were obtained by Mikhail Mamaev.

Comparison of RP resolution from FHCal and ScWall

Scalar product (SP) method:

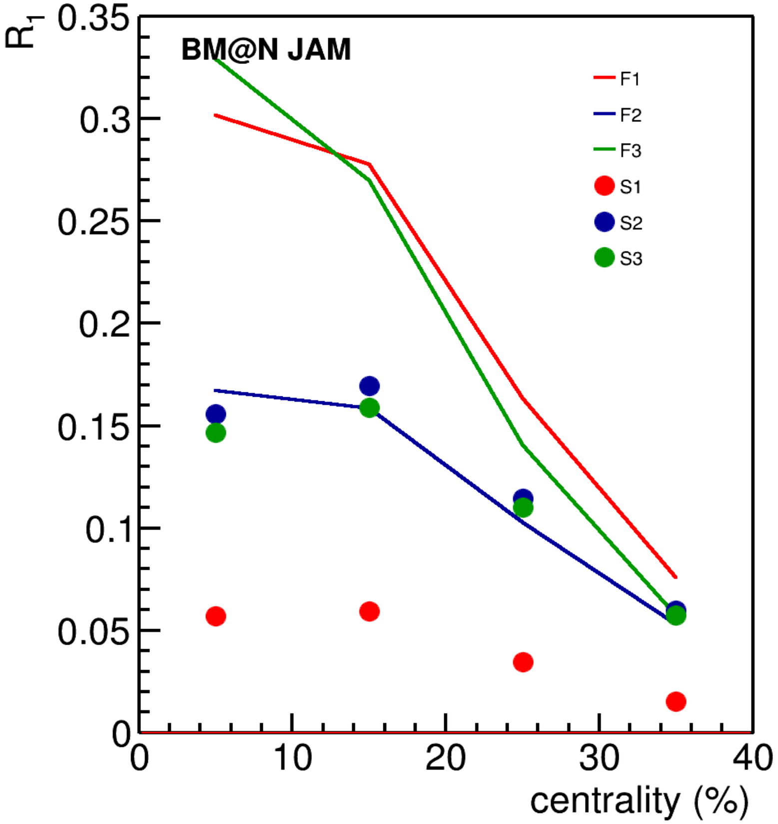
$$v_1 = \frac{\langle u_1 Q_1^{F1}\rangle}{R_1^{F1}} \qquad v_2 = \frac{\langle u_2 Q_1^{F1} Q_1^{F3}\rangle}{R_1^{F1} R_1^{F3}}$$

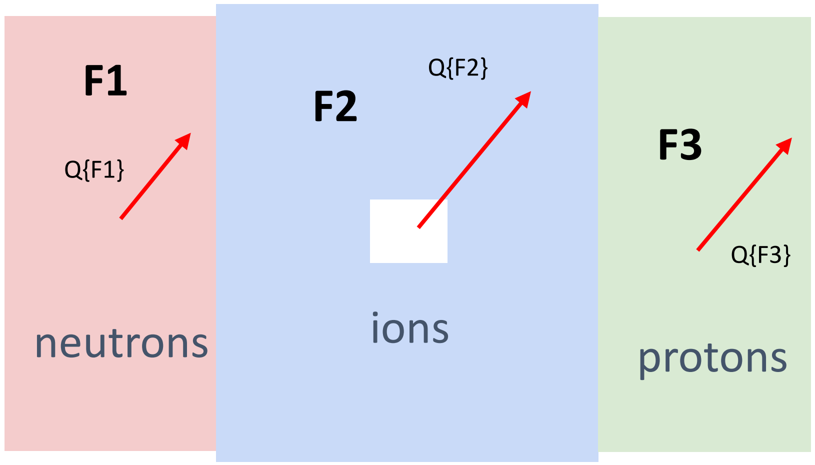
Where R_1 is the resolution correction factor

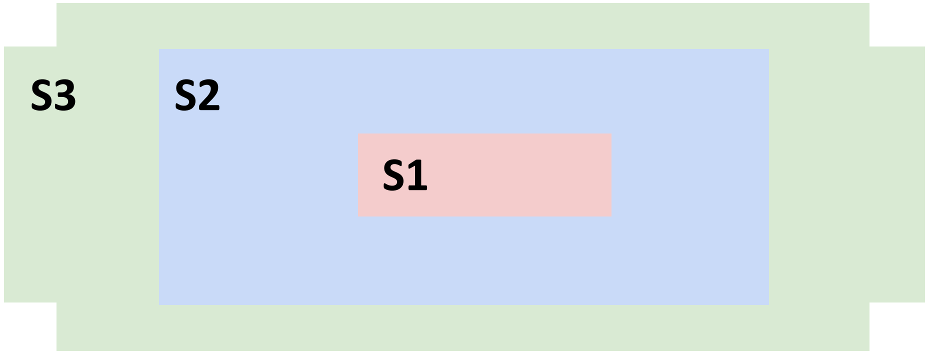
$$R_1^{F1} = \langle \cos(\Psi_1^{F1} - \Psi_1^{RP})\rangle$$

Symbol "F2(F1,F3)" means R_1 calculated via (3S resolution):

$$R_1^{F2(F1,F3)} = \frac{\sqrt{\langle Q_1^{F2} Q_1^{F1}\rangle\langle Q_1^{F2} Q_1^{F3}\rangle}}{\sqrt{\langle Q_1^{F1} Q_1^{F3}\rangle}}$$







3 vectors (F1, F2, F3 and S1, S2, S3) each from FHCal and ScWall were selected and the resolutions were compared.

The ScWall symmetry plane is more fluctuating. Hence SP has lower resolution, and requires more statistics for flow calculations.

These results were obtained by Mikhail Mamaev.

Conclusion

- The ScWall performance during run8 was demonstrated
  - ScWall was stable during run8
  - Charge spectra up to Z = 2, in central small cells up to Z = 4
  - Upgrade (20 mm cells) can significantly improve charge separation

- ScWall centrality and RP are compared with FHCal, Hodoscope and other variables
  - ScWall is weakly correlated with centrality
  - ScWall has worse capability for RP determination

- The ScWall can be used to measure the charged fragment-spectator yields. Such data are important for further constraints on the models.

Thank you for your attention!