Status of the new BM@N FHCAL

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on behalf of INR RAS, Moscow

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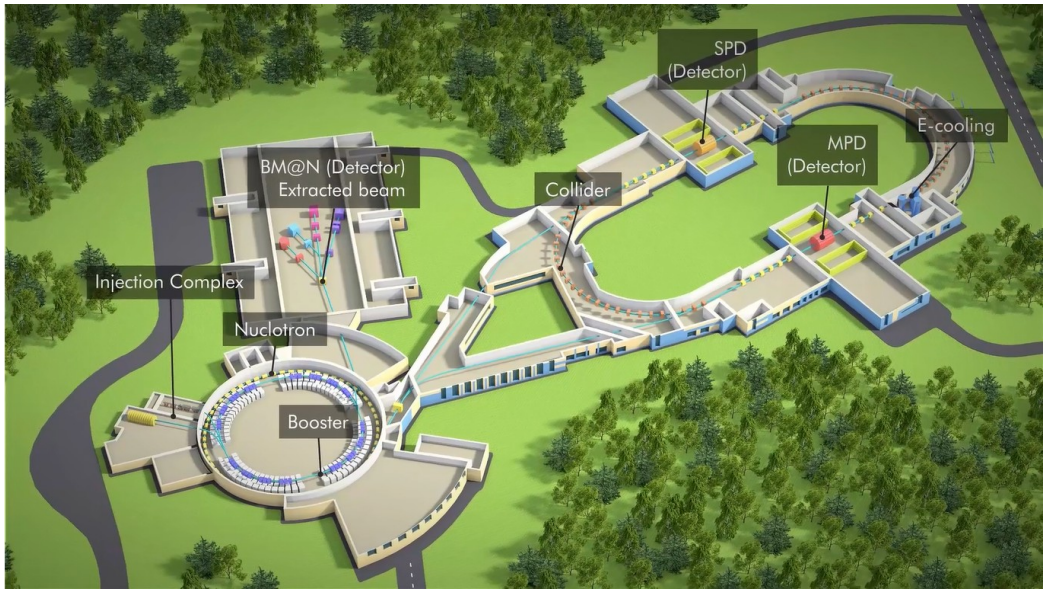
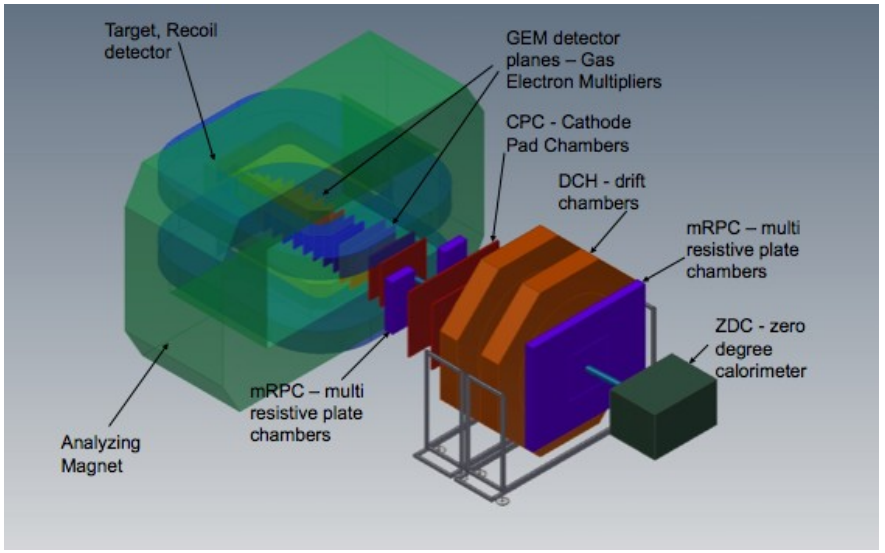
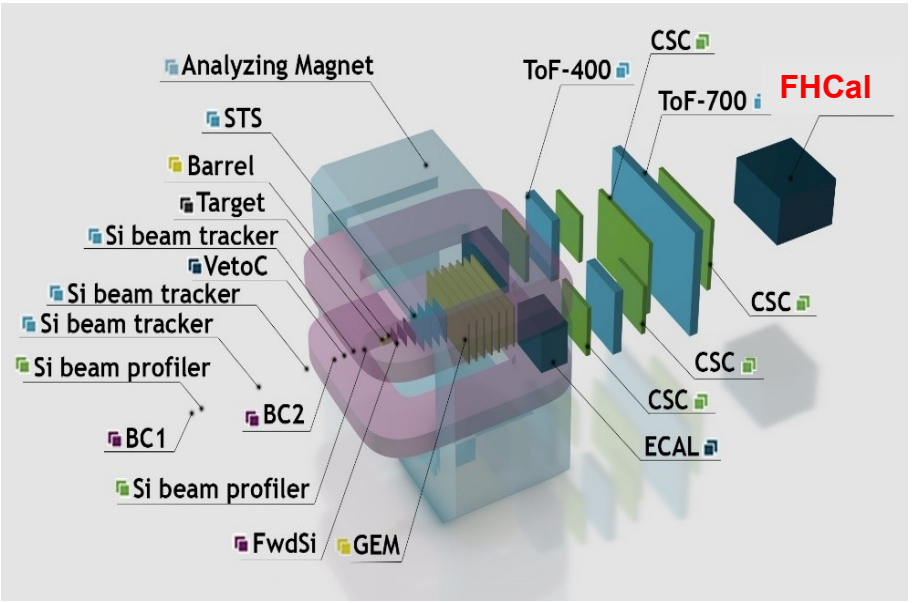


BM@N experiment upgrade at NICA acceleration complex

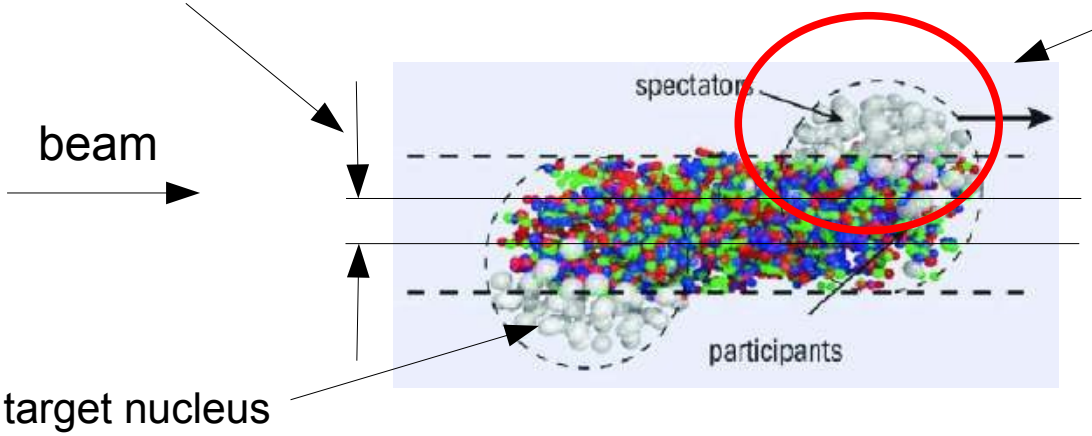




impact parameter "b"
(distance between
nuclei centers)

projectile spectators
(to be detected with FHCal)

Fixed target experiment (ion-ion collision)



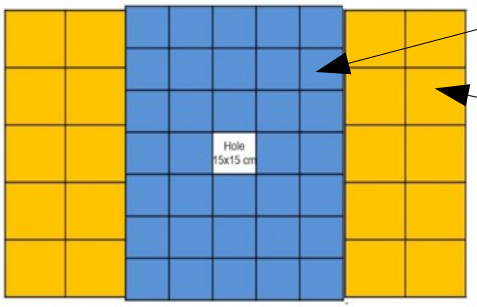
BM@N (upgrade of all detectors):

New FHCal in place of old ZDC:

- high expected dose and activation
- longitudinal segmentation of FHCal
- higher dynamic range
- reliable cosmic muon calibration

New FHCal has been installed
in the BM@N area!

FHCAL@BM@N

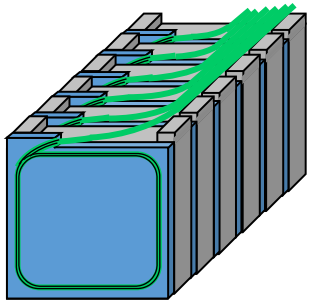


The FHCal consists of:

- 34 MPD FHCAL modules - 42 Pb/scint. samples – (16mm Pb + 4mm Scint)

- 20 CBM PSD modules – 60 Pb/scint. samples. - (16mm Pb + 4mm Scint)

Length of the MPD module ~ 4 λ_{int}
Length of the CBM module ~ 5.6 λ_{int}

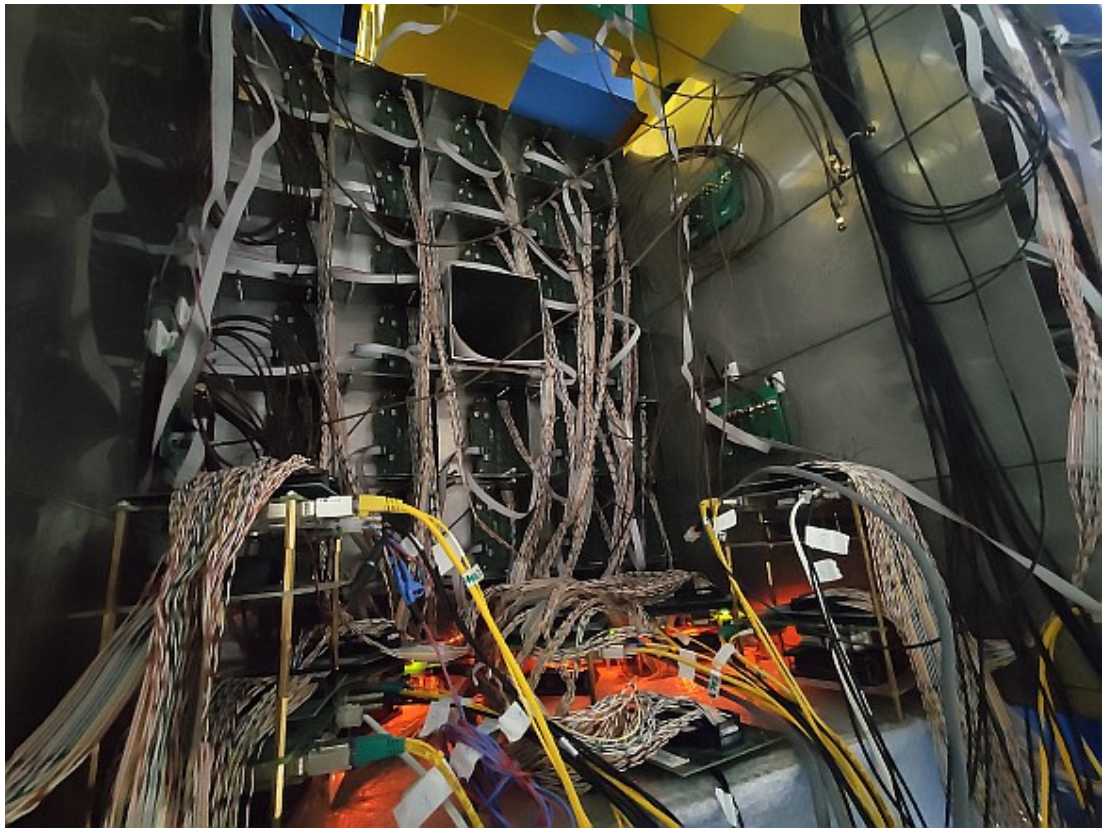


Light collections – 6 WLS fibers from each 6 scint. tiles (one section) - combined to one optical connector at the end of module.

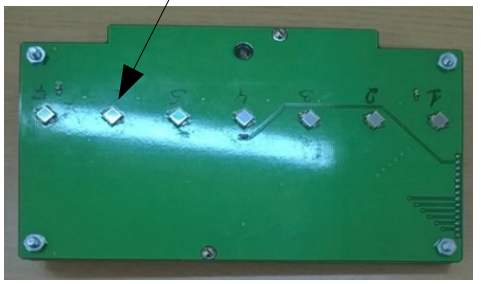
Light readout: 7 MPPC (3x3 mm^2) per MPD module and 10 MPPC per CBM module.

Weight of the MPD FHCAL module – 200 kg.
Weight of the CBM PSD module – 500 kg.

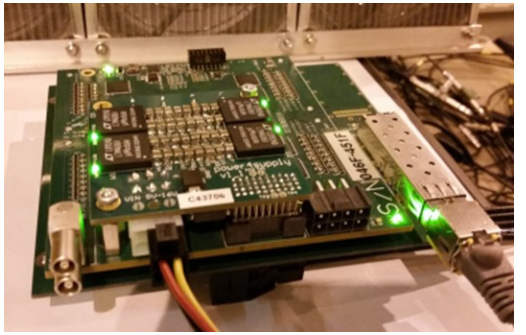
CBM PSD module



Hamamatsu MPPC
pixel -10x10 µm²;
PDE~12%;
G~10⁵.



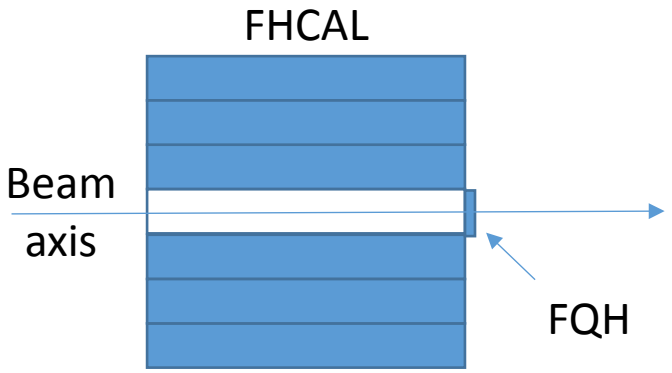
FEE board
(MPPC side)
HVsys, JINR

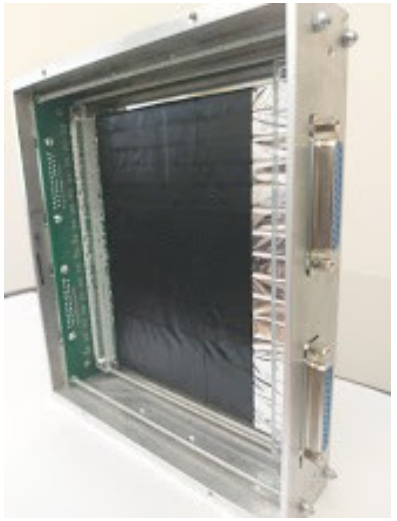


ADC64s2
readout board
AFI, JINR

- 54 FEE boards have been connected and tested
- 8 ADC64s2 board are in places, tested, connected with new cables (yellow on foto) to Rack 6 + WR optical fibers
- 6 analog sum boards are connected to FEEs
- new power supply (WIENER MPOD) is in testing now

The use of the Forward Quartz Hodoscope (FQH) to measure fragments charges in the FHCal beam hole.

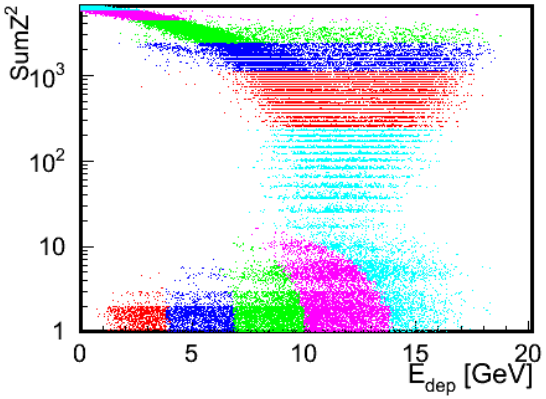


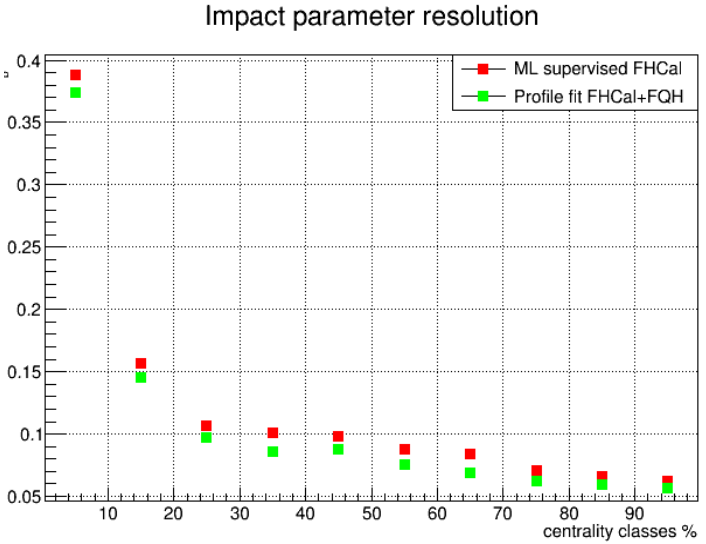


- Forward Quartz Hodoscope (FQH) is ready (2 variations – with scintillator and with quartz plates)

- TQDC board planned to use for read-out is under testing now with new FEE (at INR)

- fragments charge measurements in the FHCal beam hole.
- alignment of the FHCal
- MB and centrality triggers

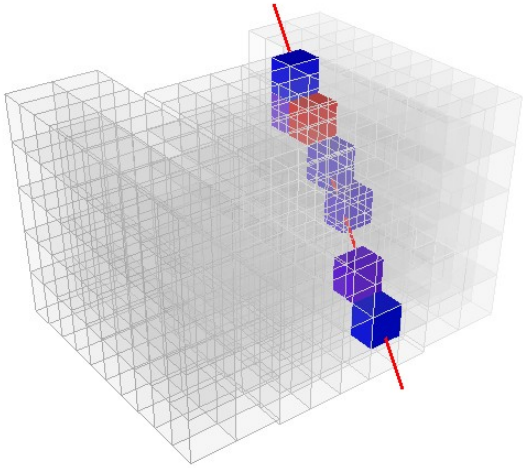


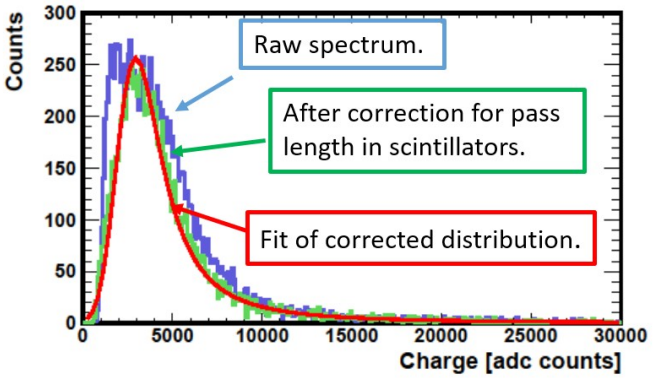


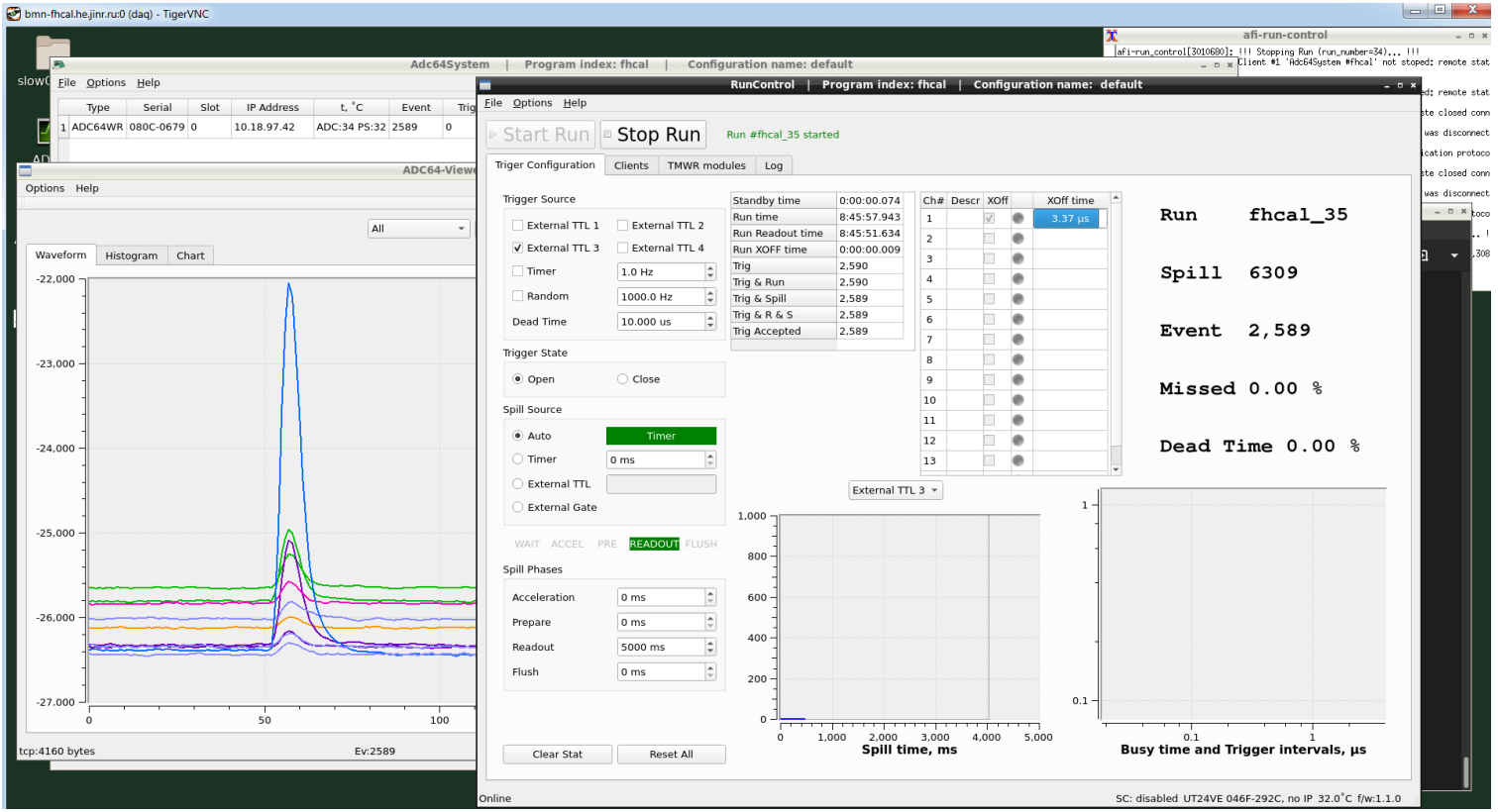
- the impact parameter resolution is slightly better when FQH+FHCal are used

- FQH will allow to measure charge fragments in the FHCal beam FHCal hole:
  - can be useful to tune fragments models in event generators

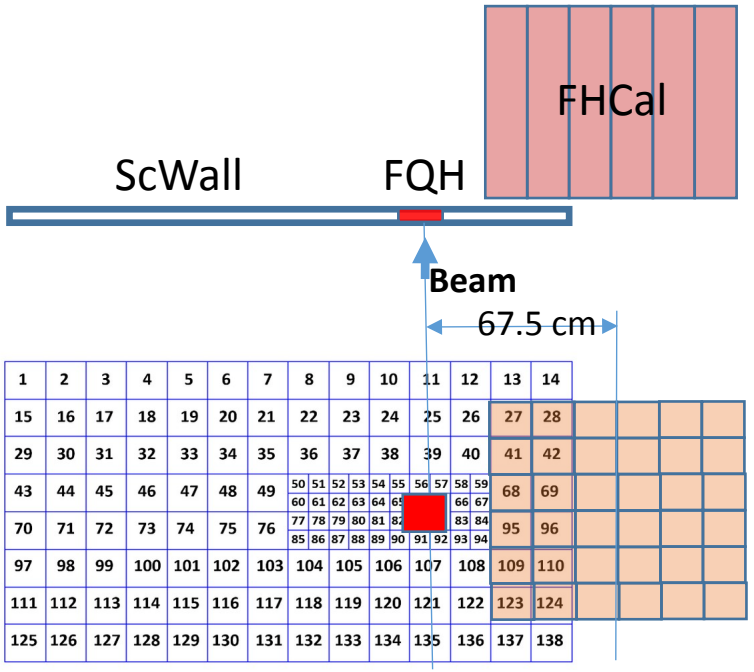
Status of the new BM@N FHCAL







New cosmic muon calibration procedure based on 3D tracking with transverse and longitudinal granulation of FHCal has been developed and is under testing on cosmics with FHCal (remotely from INR)

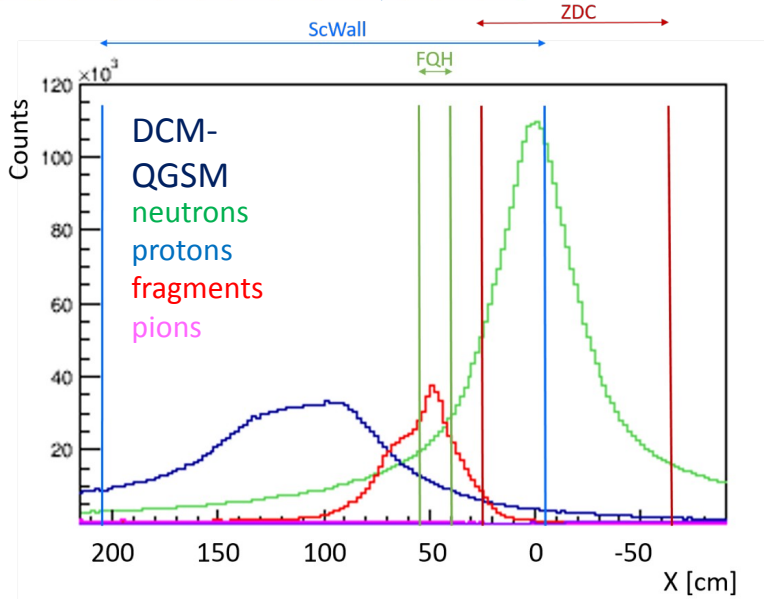


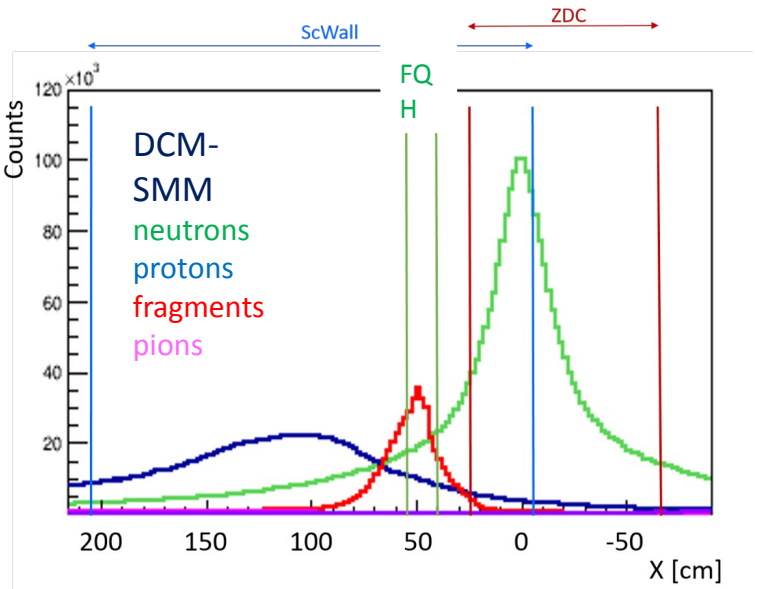
Additional segmented scintillation wall is planned:

- FHCal (36 MPD modules 15 x 15cm^2) to measure neutron spectators

- Scint. Wall (138 cells: 28 cells (75 x 75 x 10 mm^3) + 110 cells (150 x 150 x 10 mm^3) + FQH (16 quartz strips 160 x 10 x 4 mm^3) to measure charged fragments

Separate measurements of the neutron, proton and fragments could be possible with this detector system.

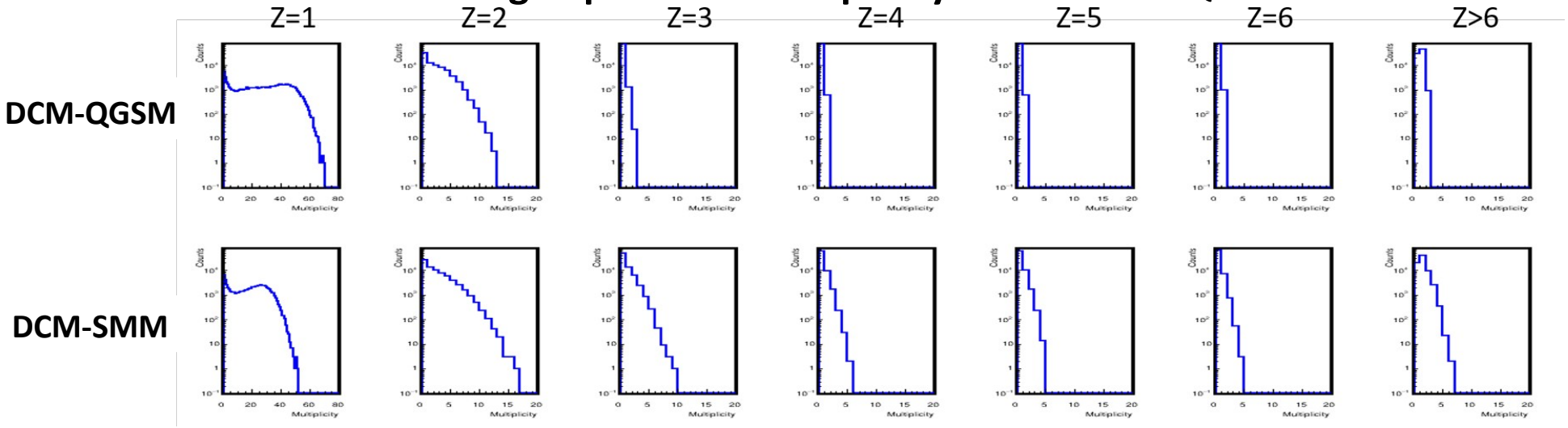




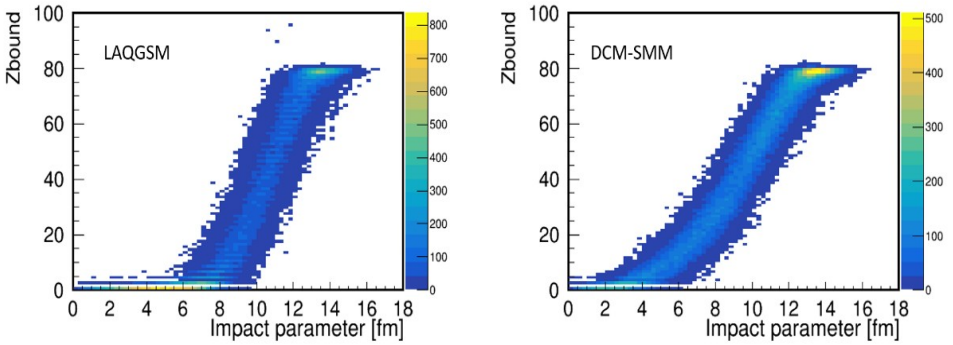
- large spatial separation between the proton and neutron spectators on the plane located at 9m from the target for Au+Au @4.5 AGeV with different event generators.

Comparison of fragments distributions in DCM-QGSM and DCM-SMM models

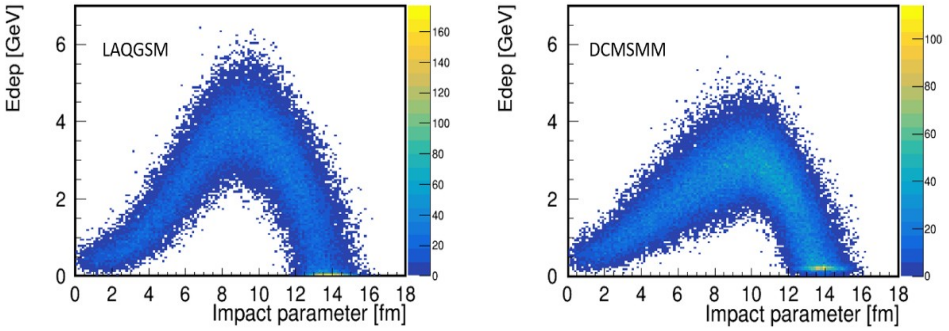
Charged particles multiplicity in ScWall + FQH



Z_{bound} distributions in ScWall+FQH



Neutron energy distributions in ZDC



Conclusions:

- FHCal for BM@N experiment has been installed at the BM@N area
- additional Forward Quartz Hodoscope (FQH) is designed and constructed
- ADC64s2 readout system has been installed and is under tests now
- slowControl system (HV and temperature compensation) is under upgrade

Outlook:

- slowControl integration to the common DCS
- 3D cosmic muon calibration of the FHCal has been developed and is in progress

Thank you for your attention!

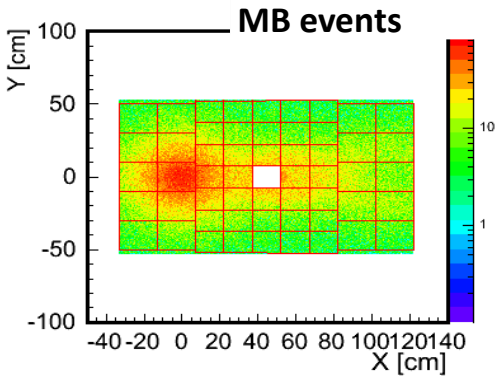
This work was supported by the RFBR 18-02-40081 mega grant

Backup slides

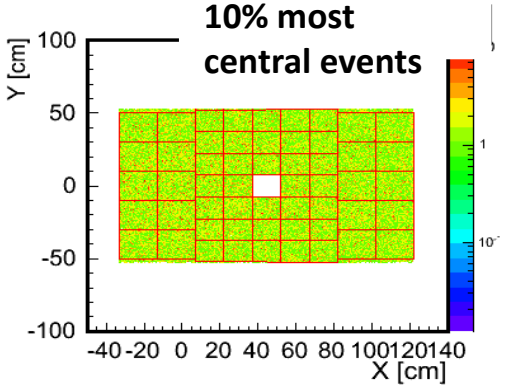
FHCAL BM@N simulation:

Reaction Au+Au@4.5 AGeV

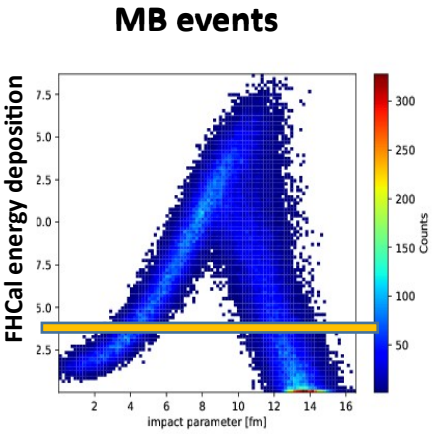
- **Event generators DCM-QGSM**
- **Transport code GEANT4 (FTFP_BERT physics list)**
- **bmnroot framework**



50% of particles energy goes through the hole



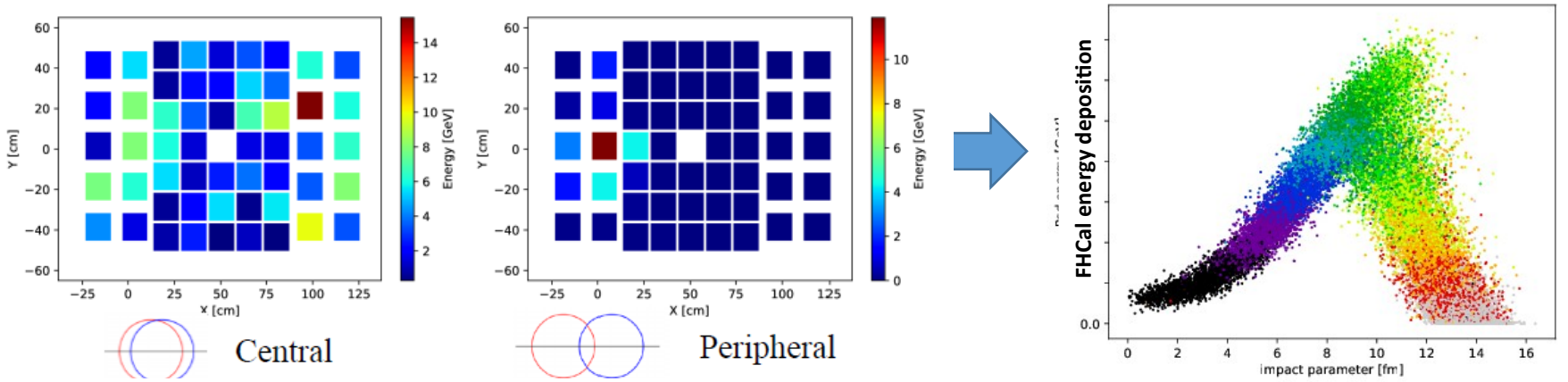
2% of particles energy goes through the hole

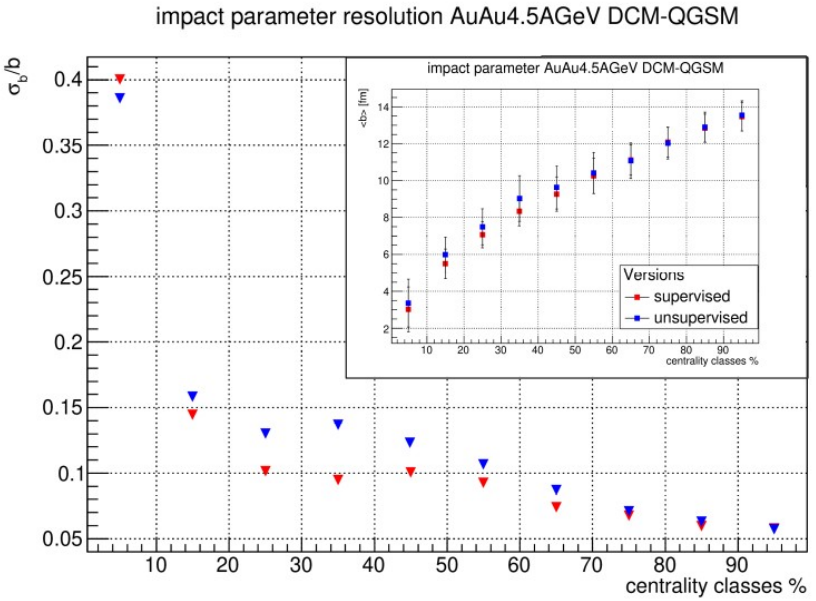


How to resolve the ambiguity in centrality determination?

One of the approaches – machine learning (ML) - use of information about energy deposition in each of 54 FHCal modules.

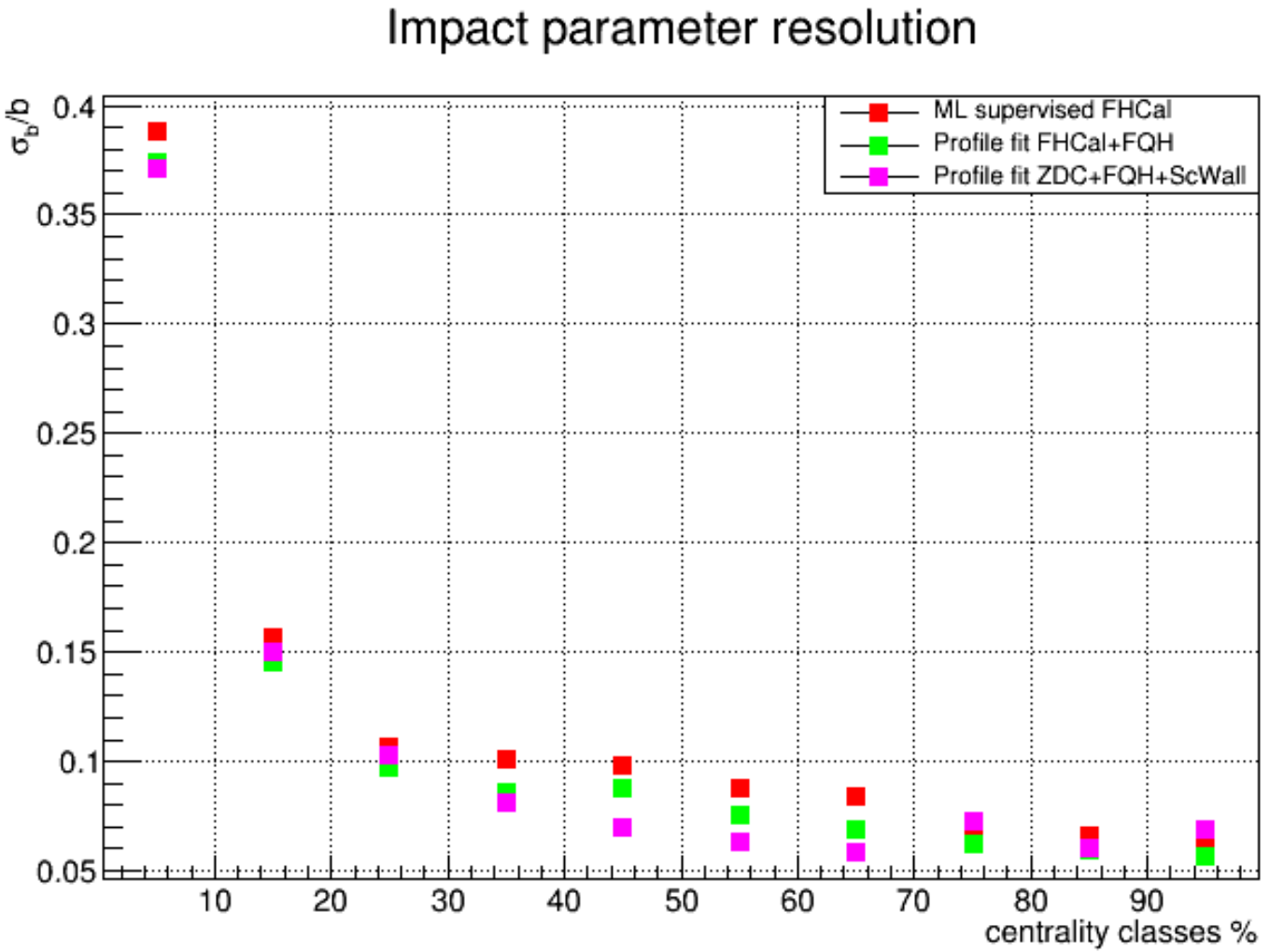
The FHCal transverse granularity and deposited energy in the calorimeter modules are used to determine the centrality classes with ML approach:





- Difference in impact parameter resolution between supervised and unsupervised approaches for semicentral events is essential

- ML method can be modified with taken into account not only energy deposition in modules but also the energy deposition in longitudinal sections of the FHCal modules


Impact parameter resolution
σ_b/b
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
10
20
30
40
50
60
70
80
90
centrality classes %
ML supervised FHCal
Profile fit FHCal+FQH
Profile fit ZDC+FQH+ScWall