Study of the Response of the Forward Hadron Calorimeter in Xe+CsI Reactions at 3.8 AGeV at the BM@N

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Outline

1. FHCal of the BM@N Experiment

2. Simulation

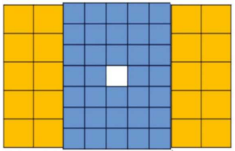
3. Calibration

4. Event Selection

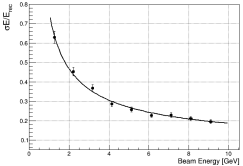
5. Experiment & Simulation comparison

6. Conclusions

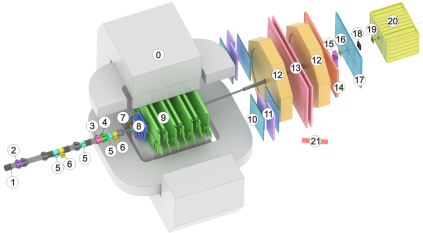
FHCal of the BM@N Experiment at NICA



Energy Resolution

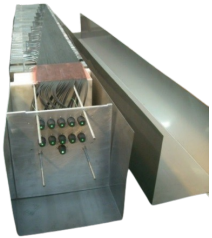


- Forward Hadron Calorimeter (FHCal)
  - Modular hadronic calorimeter for spectators and forward particles
- Key physics tasks:
  - Event centrality determination
  - Reaction plane orientation



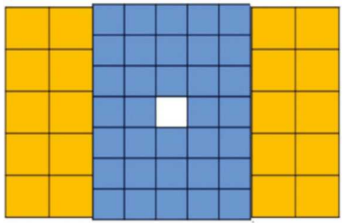
- Magnet SP-41 (0)
- Vacuum Beam Pipe (1)
- BC1, VC, BC2 (2-4)
- SiBT, SiProf (5, 6)
- Triggers: BD + SiMD (7)
- FSD, GEM (8, 9)
- CSC 1x1 m^2 (10)
- TOF 400 (11)
- DCH (12)
- TOF 700 (13)
- ScWall (14)
- FD (15)
- Small GEM (16)
- CSC 2x1.5 m^2 (17)
- Beam Profilometer (18)
- FQH (19)
- FHCal (20)
- HGN (21)

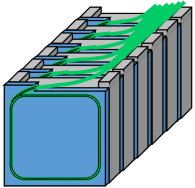
FHCal: Forward Hadron Calorimeter

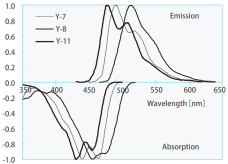


Module Assembly

- **34 inner modules** (15x15 cm^2): 42 Pb/scint layers
- **20 outer modules** (20x20 cm^2): 60 Pb/scint layers
- Length: Small: ~4 λ_{int} ; Large: ~5.6 λ_{int}
- Light collection: 6 WLS fibers per 6 tiles → combined to one optical connector at the end of module
- Light readout:
  - 7 MPPCs (small), 10 MPPCs (large)
- Module weight:
  - 200 kg (small), 500 kg (large)

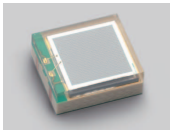


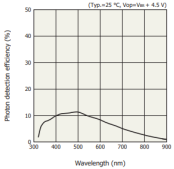




MPPC (SiPM): Hamamatsu S12572-010P

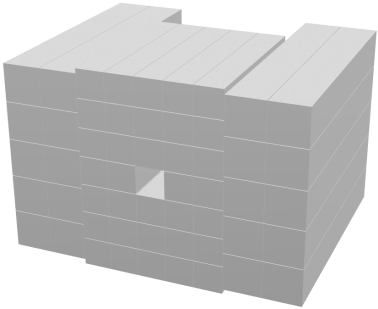
- Active area: 3x3 mm^2
- 90,000 pixels
- Gain: $1.35 \cdot 10^5$
- PDE: 12% @ 450 nm





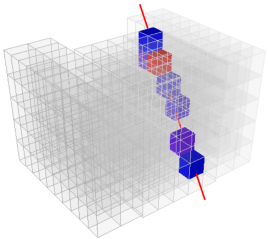
Realistic FHCal Simulation

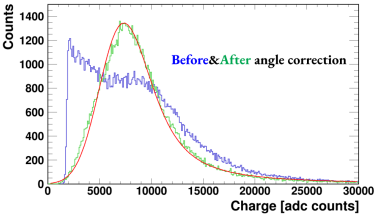
- **Detailed detector geometry**
  - All passive and active materials included in ROOT-based geometry
- **Birks' saturation effect**
  - Non-linear scintillator response for highly ionizing particles
  - $dL/dx \propto \frac{dE/dx}{1+k_B \cdot dE/dx}$
- **Photon statistics and sensor response**
  - Poisson sampling of the number of detected photons
  - MPPC saturation taken into account:
    - Finite number of pixels: 90,000
    - Smooth saturation at high light yields



Calibration with Cosmic Muons

- Detector is calibrated using cosmic muons:
  - Denoise raw data
  - Reconstruct muon tracks as straight lines
  - Perform angular correction and extract MIP peak





Event Selection

Event selection:

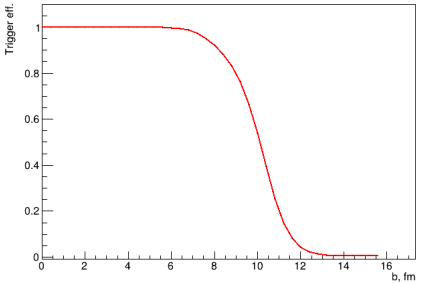
- Vertex
  - At least 2 tracks in primary vertex
  - $(X^2 + Y^2) < 1$

Experiment

- Trigger selection: Central Trigger
- Single Xe ion in 3.6 μs by Beam Counter 1

Simulation

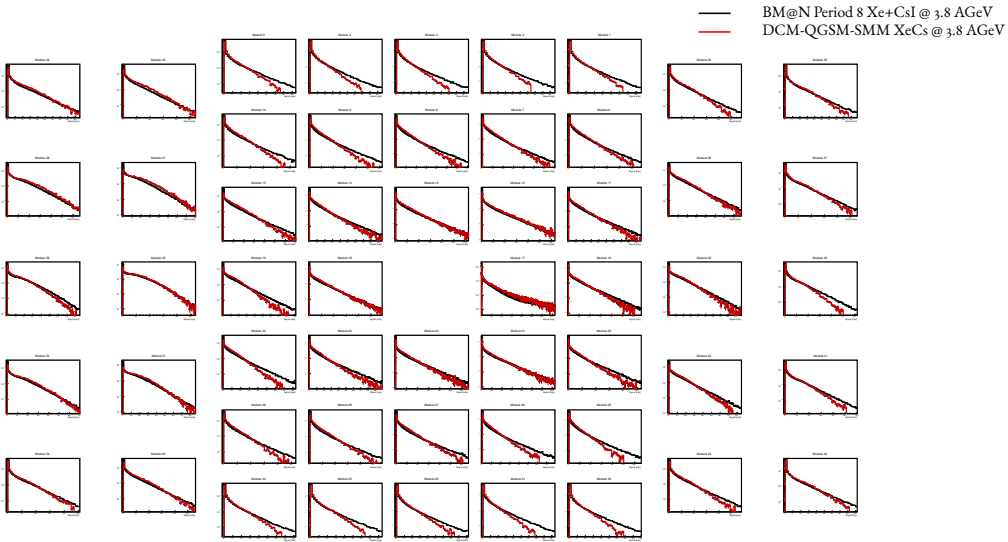
- Central Trigger efficiency → *see talk by D.Idrisov*



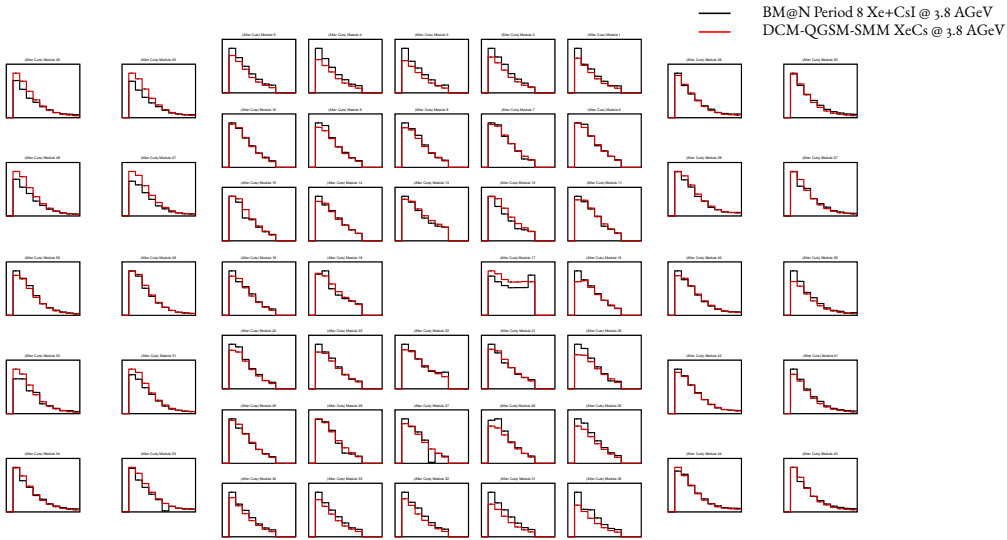
FHCal signals selection:

- FHCal noise threshold in section 0.5 MIP

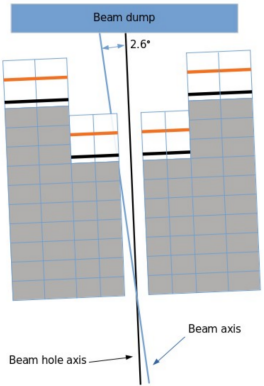
Experimental & Simulated Responses



Experimental & Simulated Responses

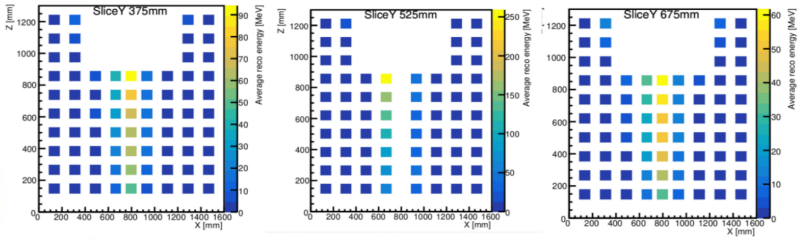


FHCal position correction



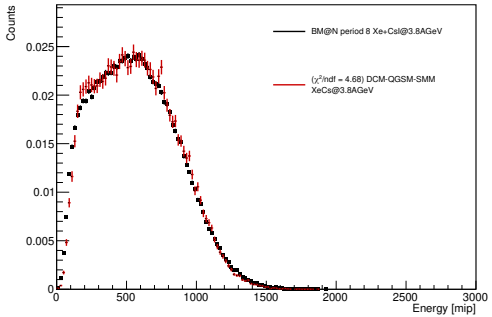
after period 8 FHCal was rotated
and is now aligned to beam axis

Energy distribution in calorimeter sections. Beam trigger



Conclusions

- **FHCal simulation (DCM-QGSM-SMM) aligns well with Run 8 data**
  - MIP-based scaling
  - Refactored simulation and digitization code
  - Signal charge as a measure of deposited energy
  - Significant reduction in experiment–MC discrepancies
- **Future plans**
  - Perform a dedicated analysis of the most forward detectors
  - Test alternative MC models (URQMD-AMC, URQMD-SMM)
  - Refactoring of the other forward detectors (e.g. Forward Quarz Hodoscope)



Thank You!