Exploiting the tagging of projectile light fragments at BM@N

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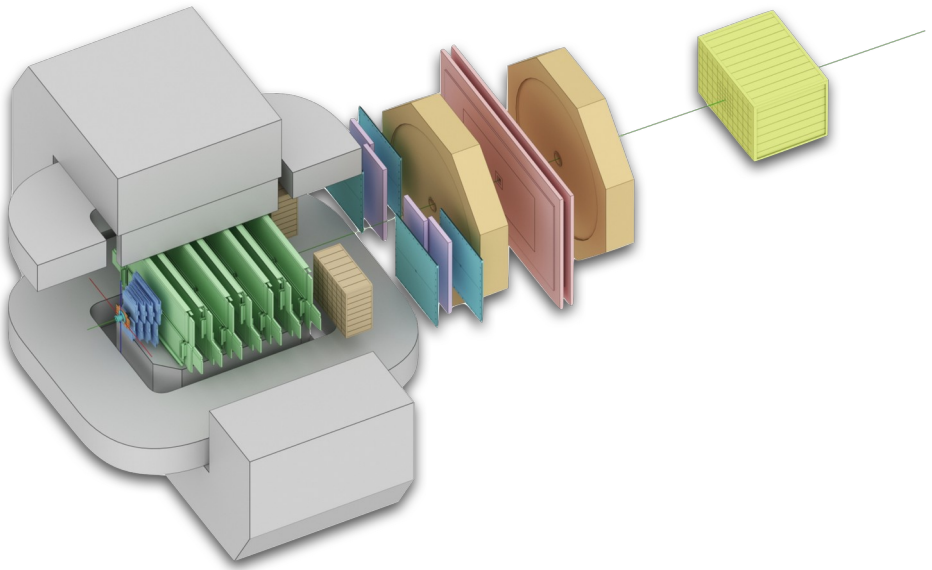
Outline

- Light fragments tagging possibility
- Hodoscope design proposal
- Opportunity to study the global polarization of Lambda baryons
- Detector test station proposal
- Conclusions

Tagging of light nuclear fragments at BM@N

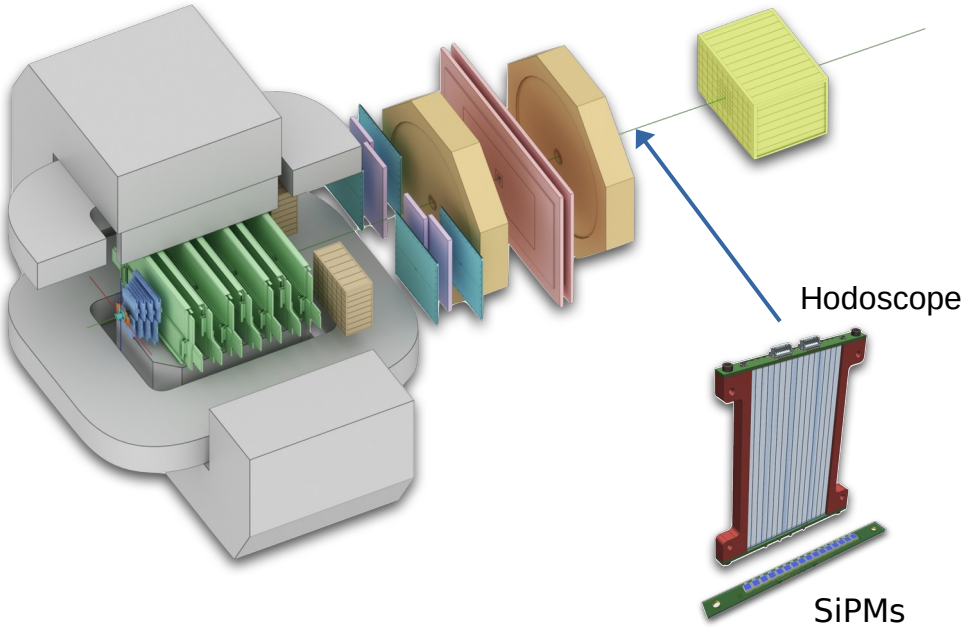


- Fixed-target experiment at Nuclotron hall.
- Research program focused on the production of strange matter in heavy-ion collisions at beam energies between 2.0A and 6.0A GeV
- Large-acceptance dipole magnet with a magnetic field reaching a maximum of 1T, allows separation of nuclides based on their mass to charge ratio.

Magnetic rigidity

$$\frac{p}{q} = B\rho$$

Tagging of light nuclear fragments at BM@N



Bethe-Bloch equation

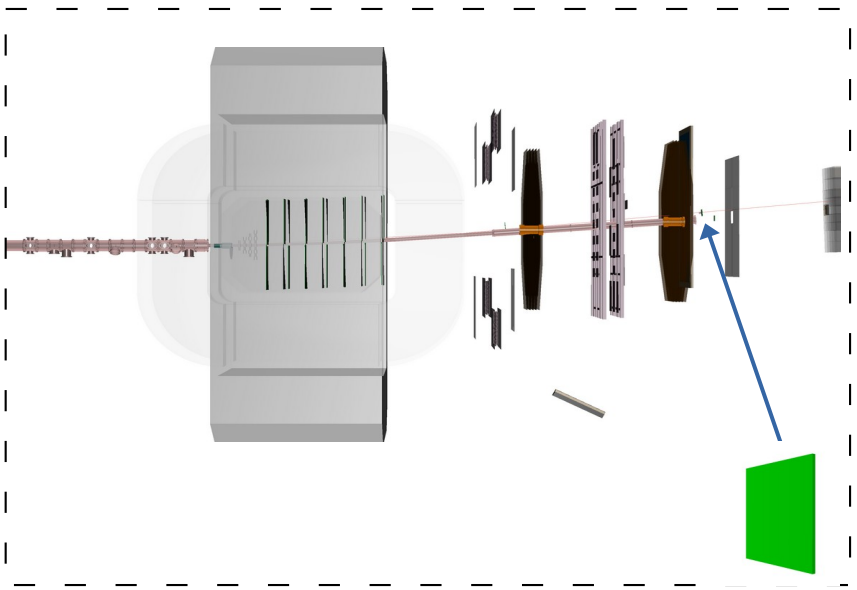
$$\left.\frac{\mathrm{d}E}{\mathrm{d}x}\right|_{Z_i} = kZ_i^2 f(\beta_i)$$

For spectator fragments with the same velocity

$$\frac{\mathrm{d}E/\mathrm{d}x|_{Z_i}}{\mathrm{d}E/\mathrm{d}x|_{Z_j}} = \frac{Z_i^2}{Z_j^2}$$

Plastic Scintillator x 30 elements
120 mm x 4 mm x 4 mm

Tagging of light nuclear fragments at BM@N



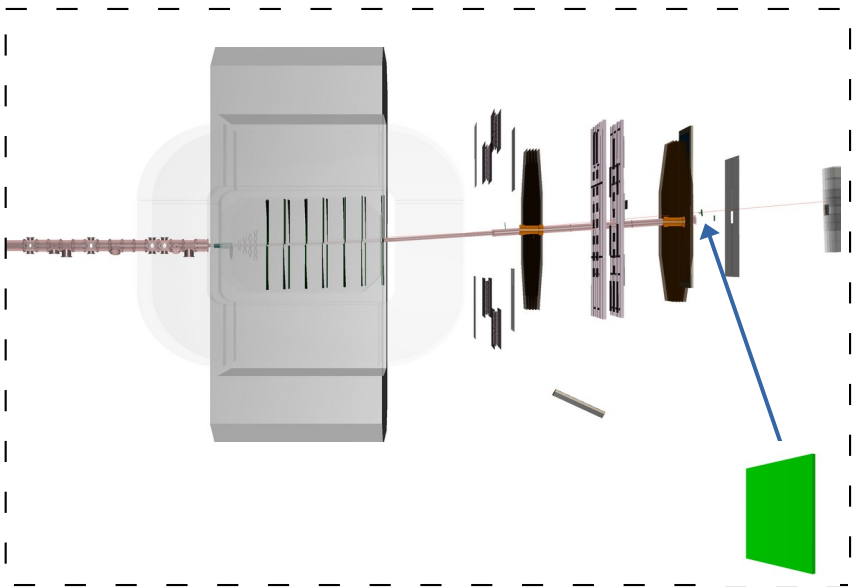
BmnRoot simulations:

- DCM-SMM generator
- $^{124}Xe + ^{124}Sn$
- 2.5A GeV
- 1M mb events

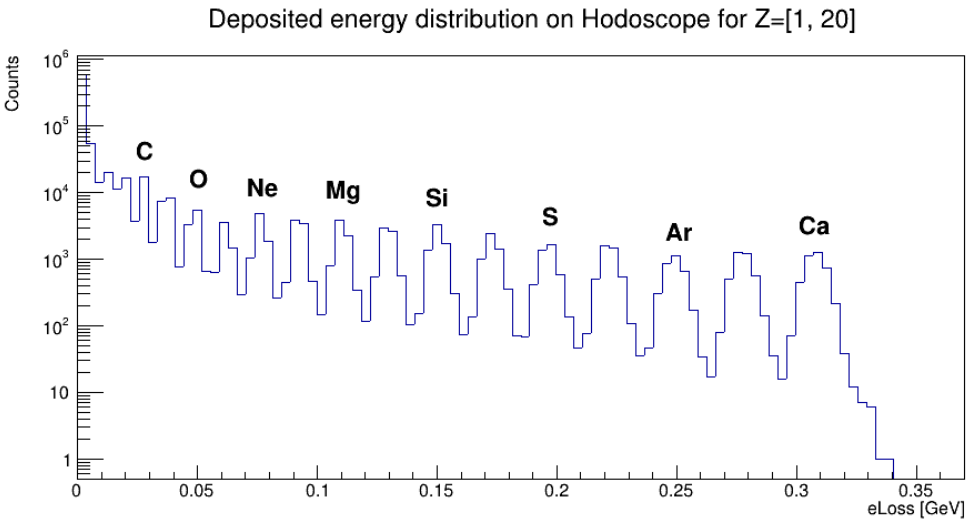
12 x 12 x 0.4 cm^3 polystyrene plane placed at 8 cm from the center of the beam pipe.

Optimized position for A/Z=2 ions

Tagging of light nuclear fragments at BM@N



Deposited energy proportional to Z^2



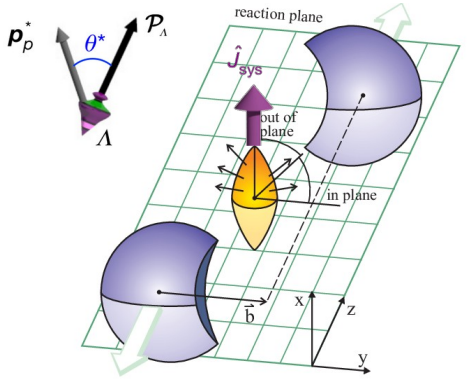
Proposals for exploiting these capabilities:

1) Λ hyperons global polarization studies.

2) Installation of a detector test station.

(1) Λ baryons global polarization

Relativistic heavy ion collisions



state of matter with fluid properties

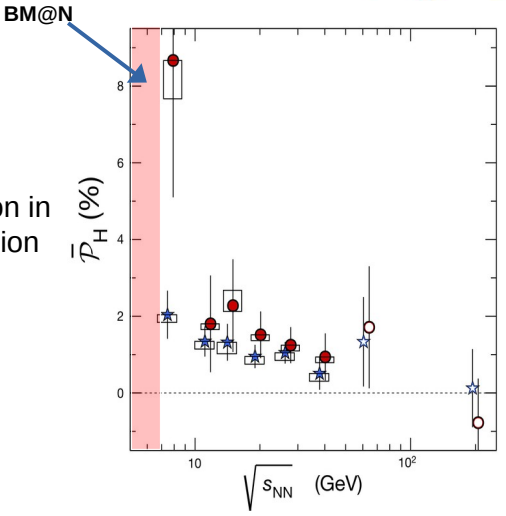
↓

non-central events have a large angular momentum (~ 10^3 h)

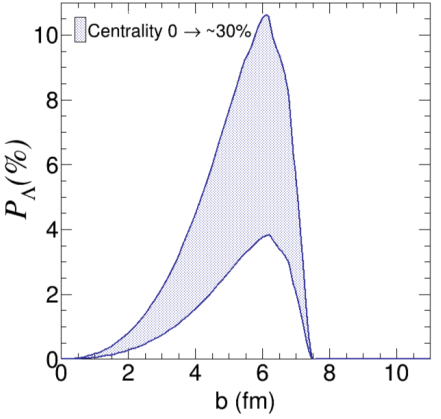
↓

leads to in-medium vorticity ← **Quantitative probe: Λ polarization measurements**

Λ(blue), anti-Λ(red) average polarization in Au + Au collisions as a function of collision energy.(*)



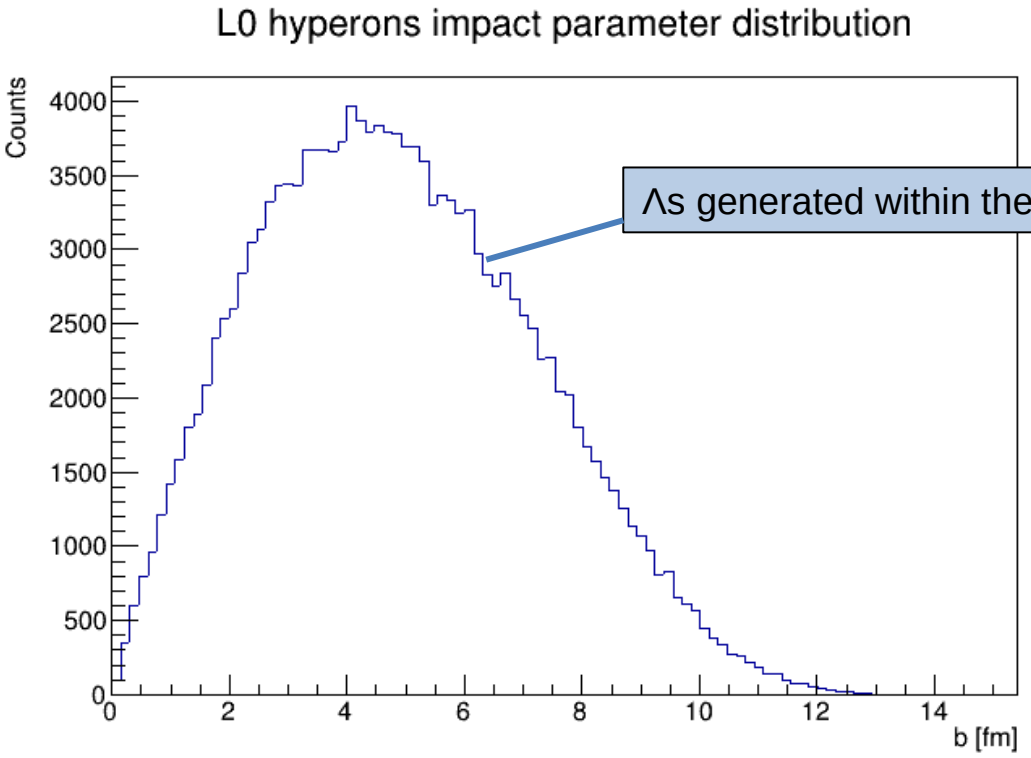
Λ global polarization as a function of impact parameter for Au+Au collisions at 3A GeV.(**)



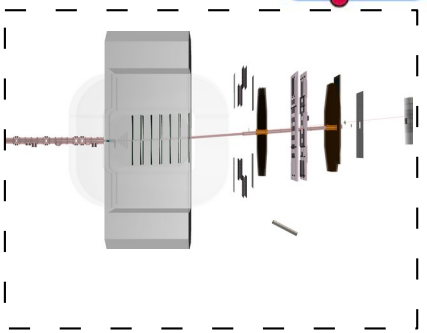
(*)Global Λ hyperon polarization in nuclear collisions. Nature, 2017, vol. 548, no 7665, p. 62-65.
(**)Ayala, A., Domínguez, I., Maldonado, I., & Tejeda-Yeomans, M. E. (2022). Physical Review C, 105(3), 034907

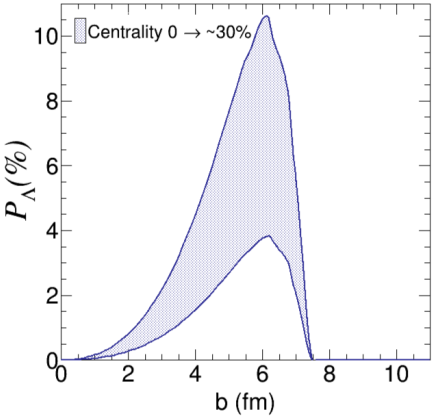
(1) Λ baryons global polarization

Simulations results



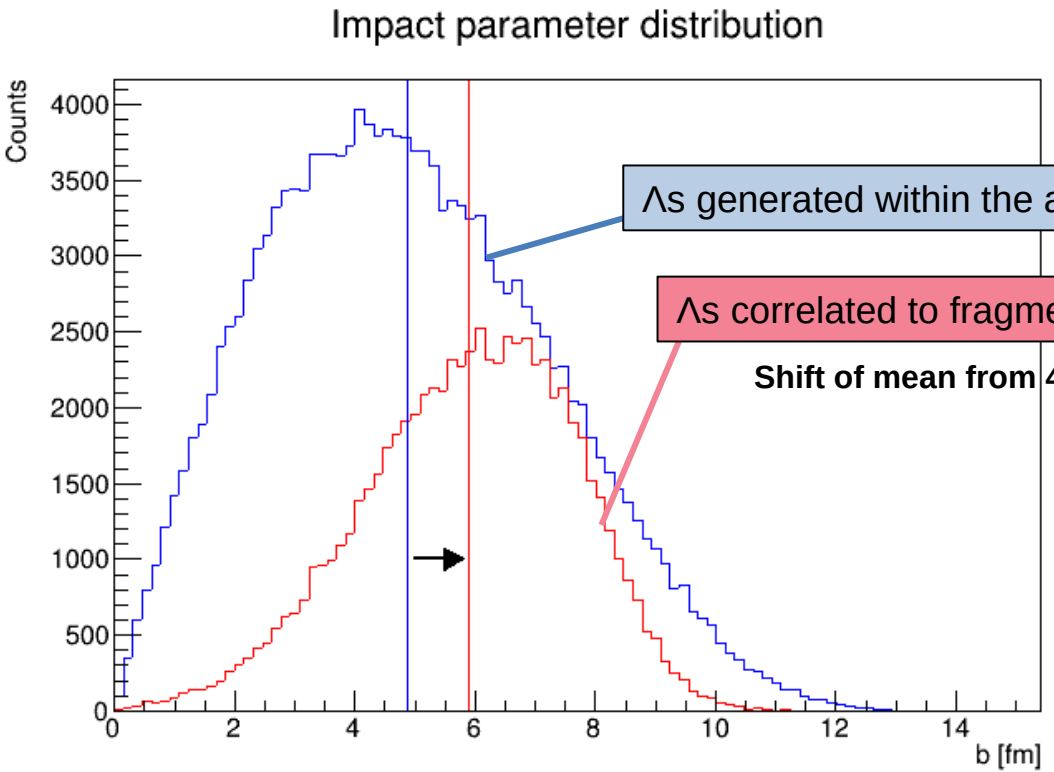
Λs generated within the acceptance of BM@N

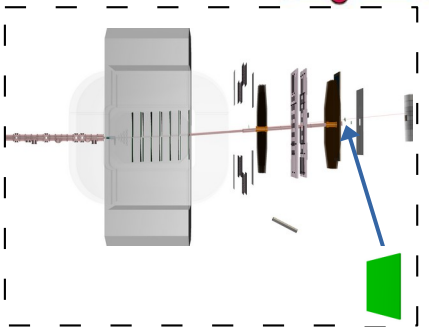




(1) Λ baryons global polarization

Simulations results

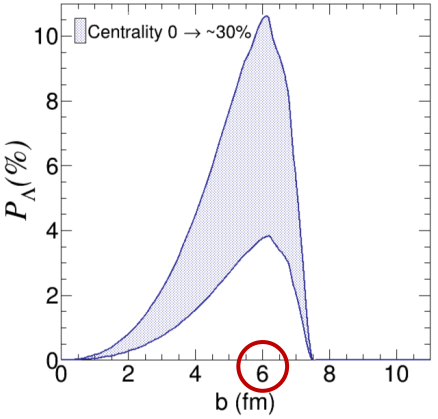




Λs generated within the acceptance of BM@N

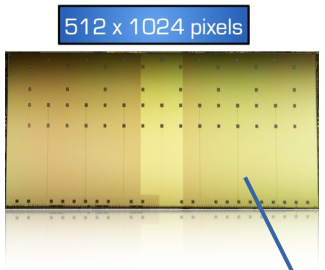
Λs correlated to fragments detected at Hodoscope position

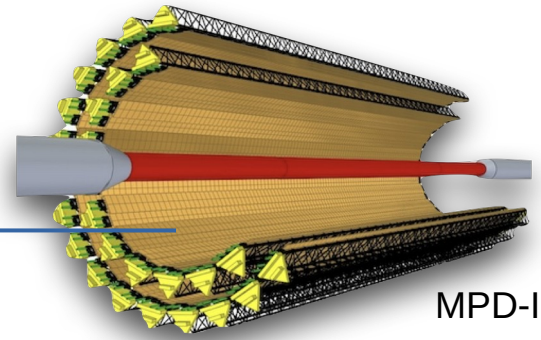
Shift of mean from 4.88 fm to 5.89 fm.



(2) Detector test station

Monolithic **A**ctive **P**ixel **S**ensor (MAPS)

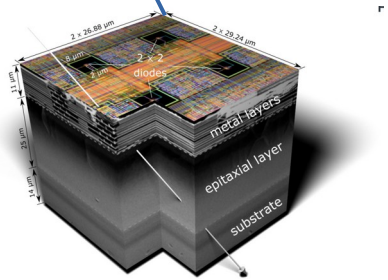




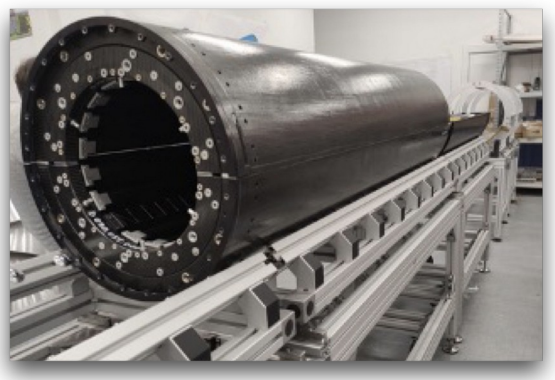
MPD-Inner Tracking System

Sensor architecture

Size: 15mm x 30mm
Pixel pitch: 28µm x 28µm
Event time resolution: < 2µs
Power consumption: 39mW/cm^2
Dead area 1.1mm x 30mm

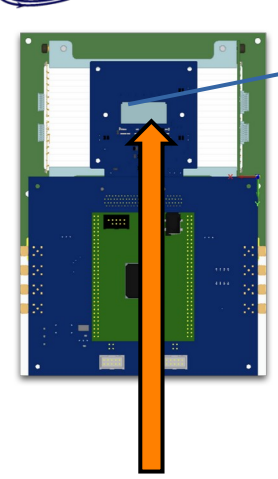


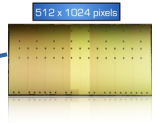
100 µm sensor thickness



Installation Container for MPD-ITS developed in VBLHEP-JINR

(2) Detector test station





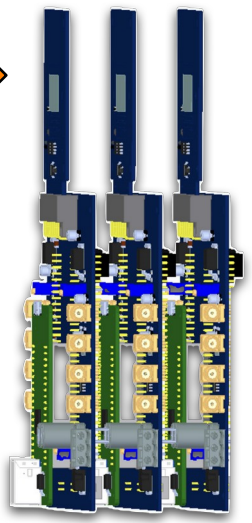
Nuclei fragments

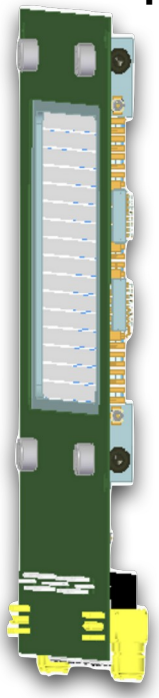
Telescope setup

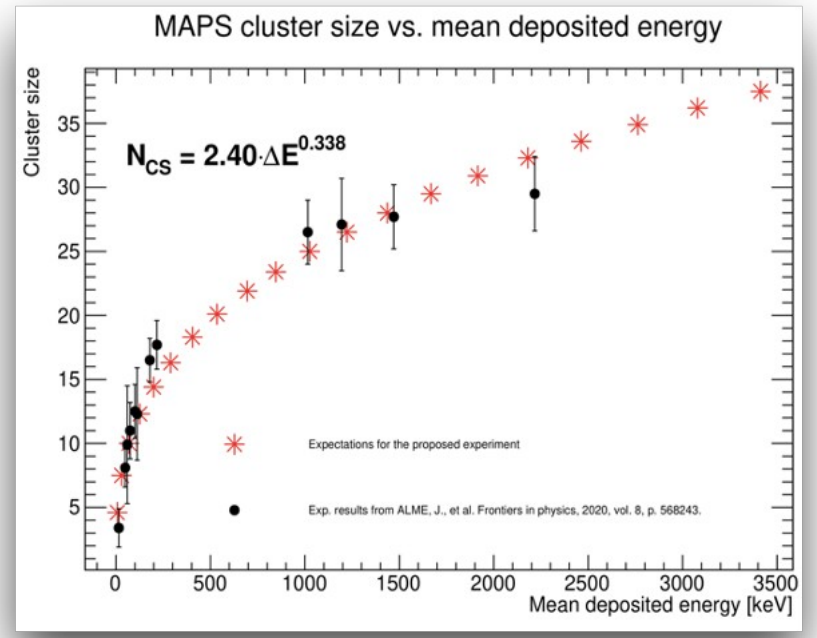
Nuclei fragments

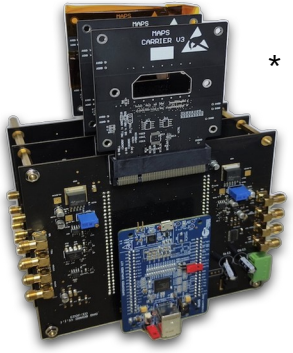
MAPS

Hodoscope









*

DAQ boards and MAPS carrier-plates.
Made in VBLHEP-JINR

*Beam test results by D. Dementev

Conclusions

- The characteristics of the BM@N experiment are suitable for the tagging of light fragments resulting from relativistic heavy ions collisions.

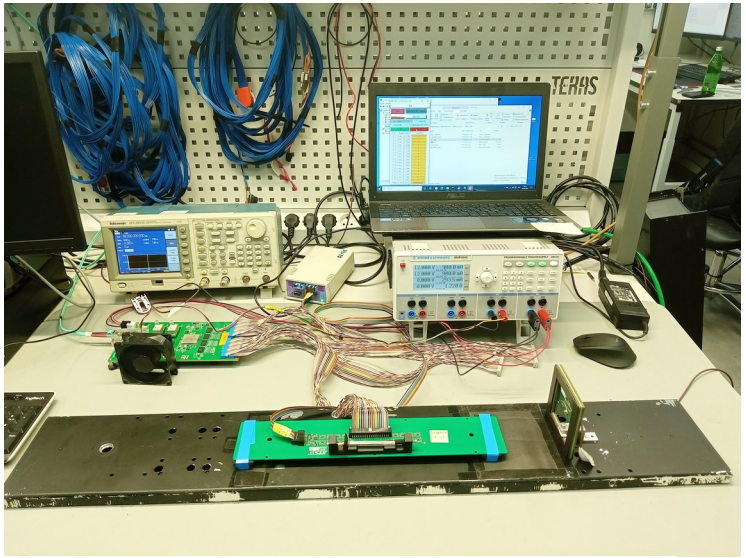
- It is proposed to set up a hodoscope-based tagging station to exploit this capability with two main purposes:

1) Selection of non-central events for studies of global polarization of Λ hyperons.

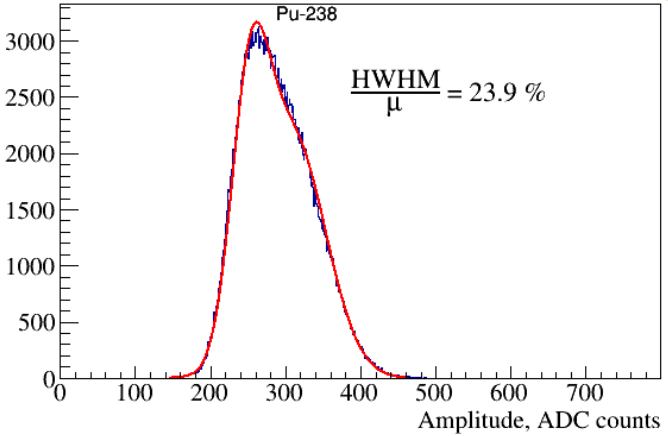
2) Detector testing and characterization.

Thank you.

Back up slide



Test bench for scintillator + SiPM + read out chain*.
*Provided by the MPD-ECal team.



Spectrometric analysis for ^{238}Pu alpha source.