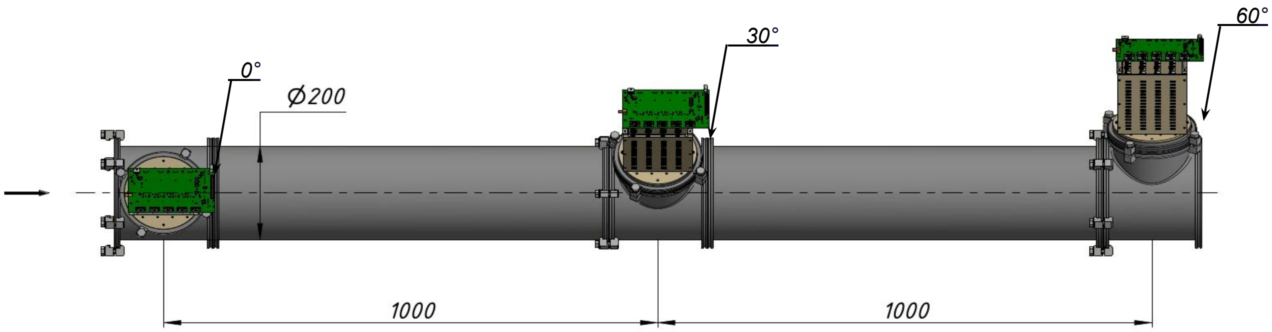
Analysis of the Beam Trackers operation in the Xe run

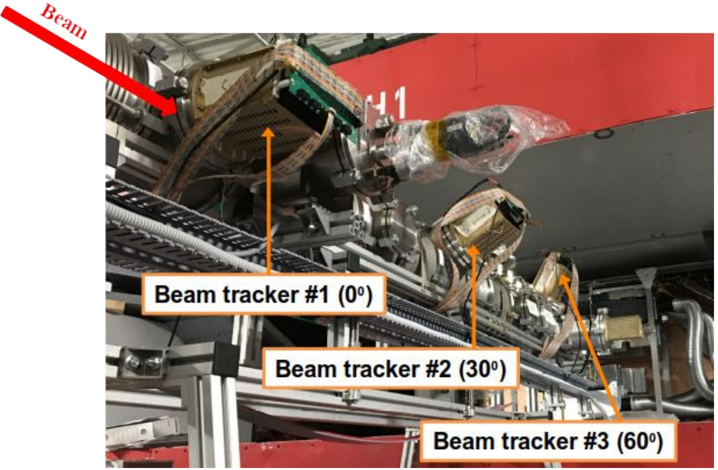
Danil Chemezov on behalf of Forward Silicon Tracker team

10th Collaboration Meeting of the BM@N Experiment at the NICA Facility,
15-19 May 2023

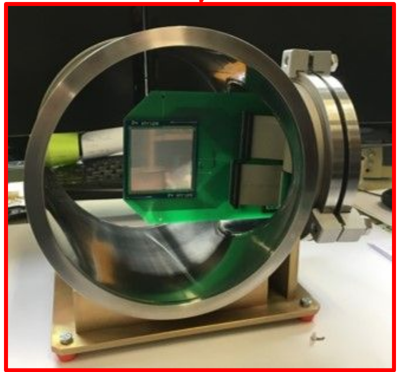
Beam Tracker

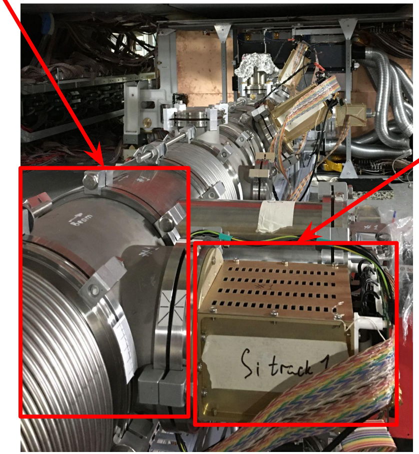


- **Physical purpose**: determination of the reaction plane, refinement of the vertex definition, beam profilometry
- **detector:** DSSD, 128×128 strips, pitch p+ / n+ strips 0.47 mm, thickness 175 μm, active area 61×61 mm^2
- **FEE**: based on VATA64HDR16.2 (64 ch, dynamic range: -20 pC ÷ +50 pC; 50, 100, 150, 300 ns programmable shaping time)



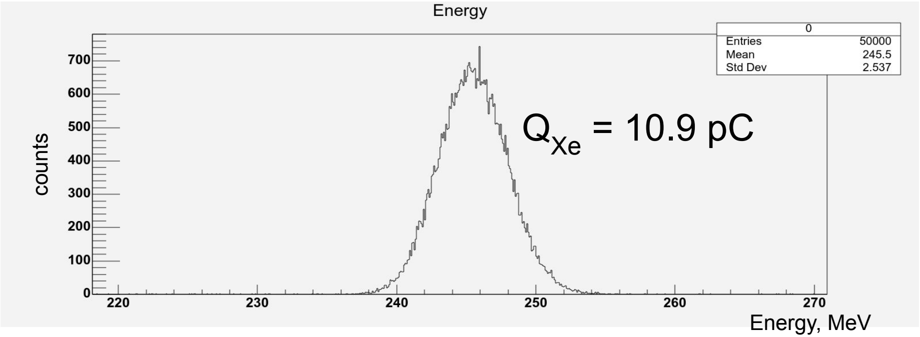
Si detector inside vacuum chamber





FEE

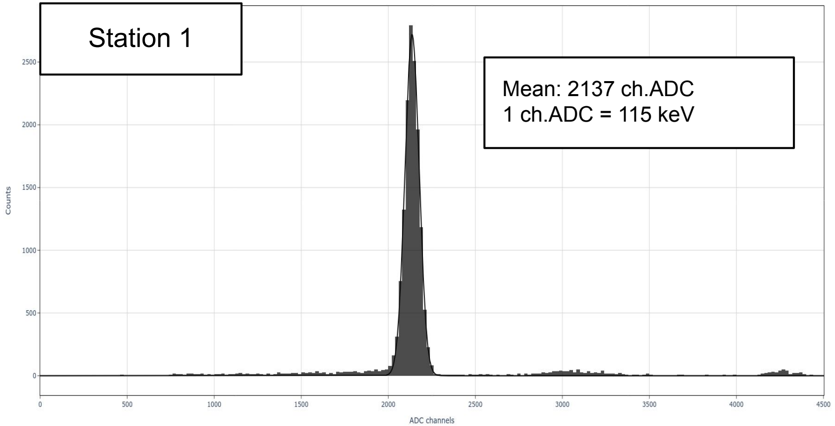
Energy deposition of Xe in 175 μm silicon



Xe 4 AGeV ions deposited energy

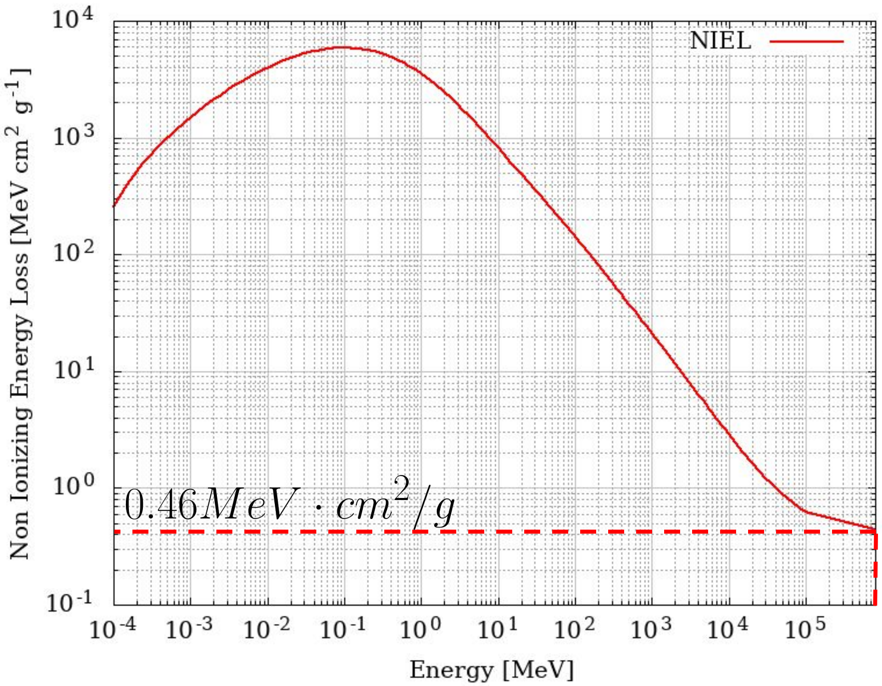
- Using the GEANT4 framework, a simulation of Xenon energy loss of 4 AGeV in 175 μm silicon was performed.
- The **ΔE = 245 MeV/175 μm (Si)**, which corresponds to a charge of **10.9 pC**, which falls within the dynamic range of VATA64HDR16.2
- Remind: ($Q_{m.i.p/175μm\ Si}$=2.33 x 10^{-3} pC)

P+ side cluster amplitude distributions, run 8270



The figure above shows the distribution of cluster amplitudes at station 0 with channels 0-63 (first ASIC). The distribution of cluster amplitudes is well described by the Gaussian function, and the mean value was obtained from the fitting results.

NIEL simulation of ^{124}Xe in 175 μm silicon



NIEL of Xe in 175 μm Si

BT Si detectors were installed in the most severe radiation conditions - in a direct beam of heavy xenon ions. Non-ionizing energy losses (NIEL) are used as a measure of the degree of radiation damage.
Using GEANT4 with the SR-NIEL library, NIEL of Xe in 175 μm Si values were obtained.

NIEL from 1 MeV neutron in Si (ASTM Standard E722-19):

$$NIEL_n = 0.0016 MeV \cdot cm^2/g$$

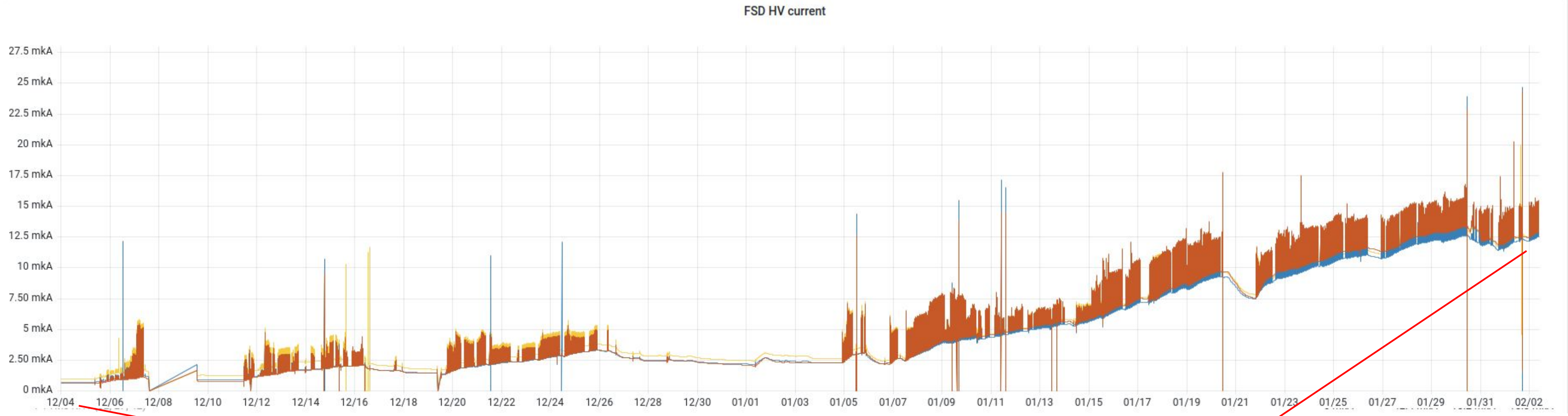
NIEL from 4 A*GeV Xe:

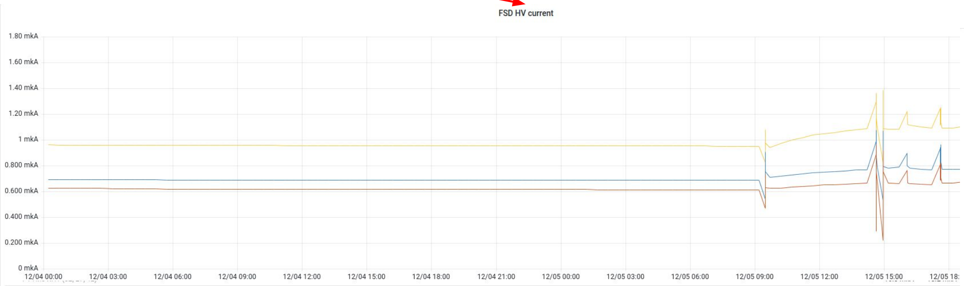
$$NIEL_{Xe} = 0.458 MeV \cdot cm^2/g$$

Hardness factor of 4A*GeV Xe:

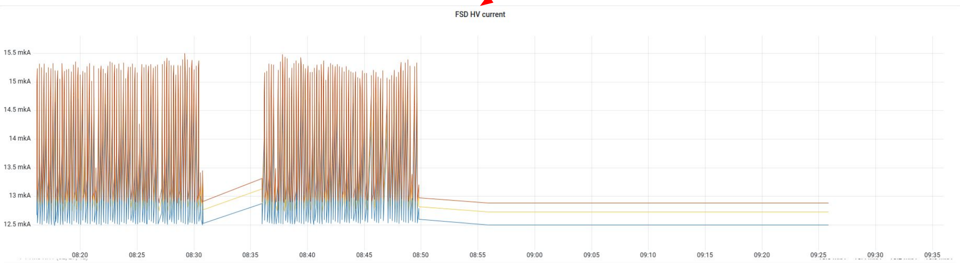
$$NIEL_{Xe}/NIEL_n \approx 276 \Rightarrow \Phi_n = \Phi_{Xe} \cdot 276$$

Increasing the dark current of beam trackers during Xe run





run start, $< I >= 0.761 \mu A; \ t = +22.5^{\circ} C$



run stop, $< I >= 12.7 \mu A; \ t = +26.8^{\circ} C$

Method of measuring the fluence using silicon detectors

	I_{d0}, μA/+20 V/+22.5°C 04.12.2022 (run start)	$I_{d(s)}$, μA/+20 V/+26.8°C 2.02.2023 (run stop)	$\Delta I = I_{d(s)} - I_{d0}$, μA **(at +20 °C)**
BT1	0.965	12.7	6.3
BT2	0.692	12.5	6.4
BT3	0.626	12.9	6.7
Mean	0.761	12.7	6.44

Fluence can be estimated by the empirical formula:

$$\Delta I = \alpha \cdot \Phi_n \cdot V_{det} \;, \alpha = 3 \cdot 10^{-17}\; A \cdot cm^{-1}, V_{det} = 61 \cdot 61 \cdot 0.175\; mm^3$$

, α - bulk radiation damage constant, Φ_n is the equivalent fluence of 1 MeV neutrons, related to the fluence of xenon by the relation:

$$\Phi_n = k \cdot \Phi_{Xe}$$

, k - hardness factor of 4 A*GeV Xe, k =276
Using the calculated hardness factor and experimentally obtained increases of currents we obtain:

	Fluence of 1 MeV neutrons, cm^{-2}	Fluence ^{128}Xe, cm^{-2}	Number of xenon nuclei
BT1	$3.21 \cdot 10^{11}$	$1.16 \cdot 10^{9}$	$4.33 \cdot 10^{10}$
BT2	$3.27 \cdot 10^{11}$	$1.18 \cdot 10^{9}$	$4.41 \cdot 10^{10}$
BT3	$3.41 \cdot 10^{11}$	$1.23 \cdot 10^{9}$	$4.60 \cdot 10^{10}$
Mean	$3.30 \cdot 10^{11}$	$1.19 \cdot 10^{9}$	$4.44 \cdot 10^{10}$

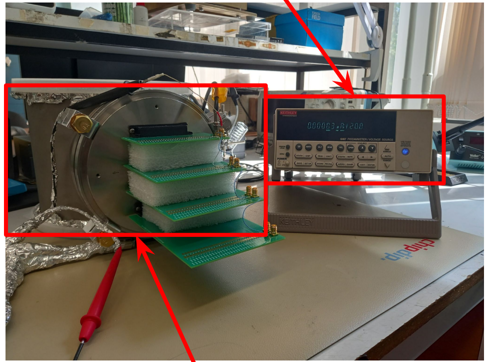
Based on the obtained fluence, we can estimate the number of xenon nuclei that passed through the detectors during the run:

$$N_{Xe} = \Phi_{Xe} \cdot S_{det}$$

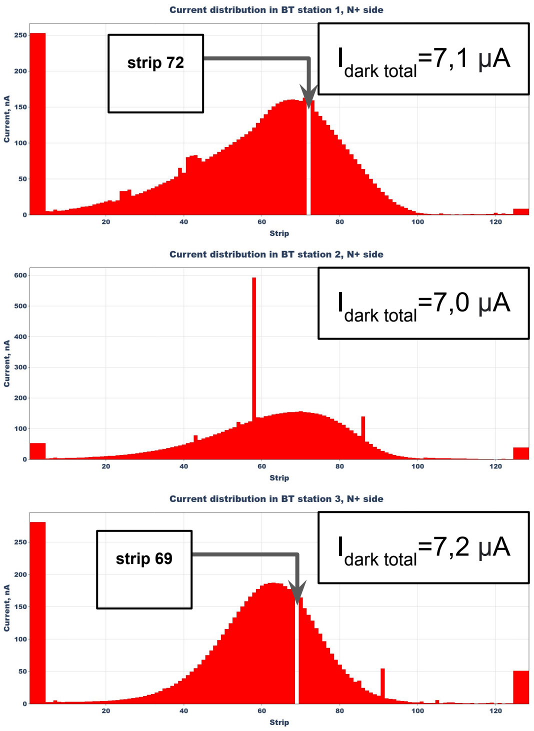
$$S_{det} = 37.2\; cm^2$$

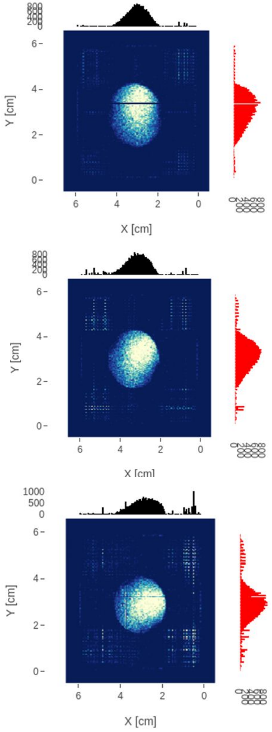
Dark current for each strip after Xe run

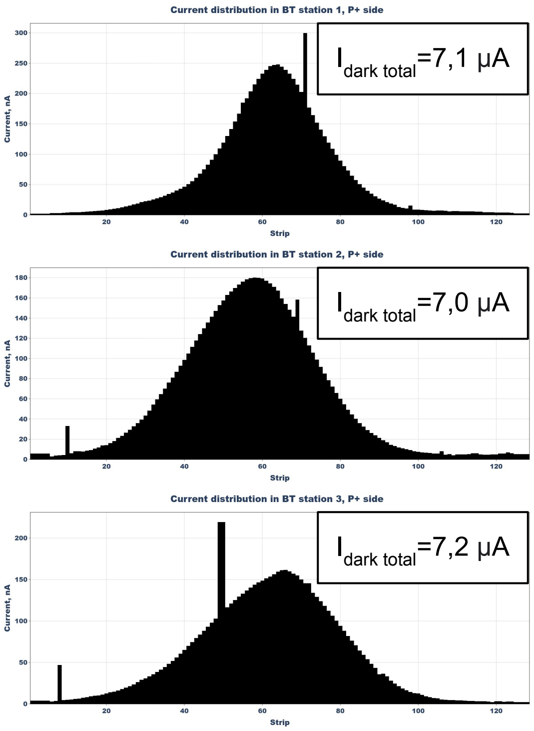
picoammeter/voltage source



beam tracker and boards to read the current from each strip







run 6705,
13.12.2022

Conclusion

Results of work in run 8:

Requires more fine-tuning of ASICs operating modes to reduce the effects of time overlap

Plans

- Adjusting the optimal modes of operation of the ASICs,
- Testing beamzone on detectors on the alpha radiation source (^{226}Ra, E=4.87 MeV) in order to assess the influence of radiation damage on the detectors sensitivity.

Thank you for your attention!

Backup

Energy deposition of Xe in 175 μm silicon

P+ side cluster amplitude distributions, run 8270