JOINT INSTITUTE FOR NUCLEAR RESEARCH

Development of a New Silicon Tracking Station for the BM@N Central Tracker

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XXVI INTERNATIONAL BALDIN SEMINAR ON HIGH ENERGY PHYSICS PROBLEMS

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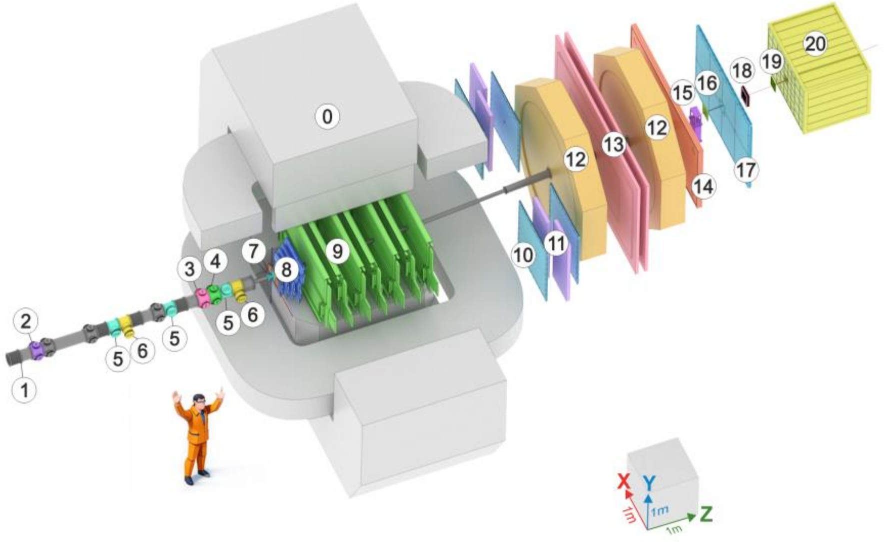
Outline

- BM@N Experiment at NICA;
- Central Tracking System of BM@N Experiment;
- New silicon tracking station (STS);
- STS module;
- Results of the in-beam tests of the module;
- Integration of the readout electronics and mechanics;

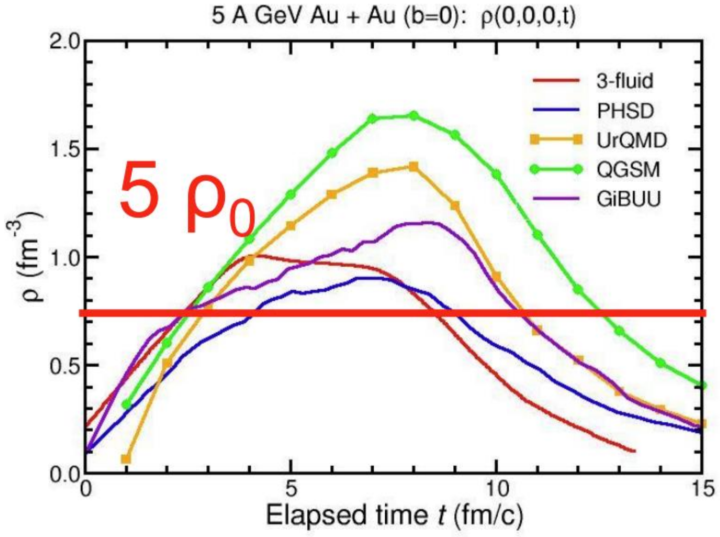
Baryonic Matter at Nuclotron (BM@N)

BM@N is the first experiment put into operation at NICA, aimed at studying dense nuclear matter in heavy-ion collisions within the energy range of 1 – 4.65 AGeV.

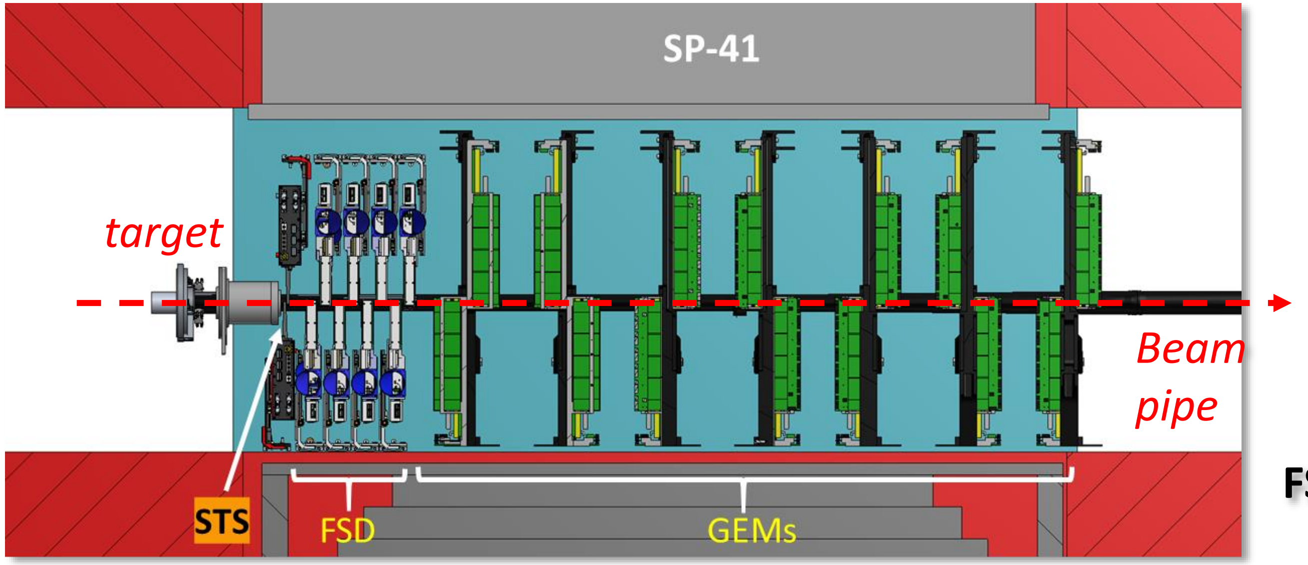


The research program of BM@N includes:

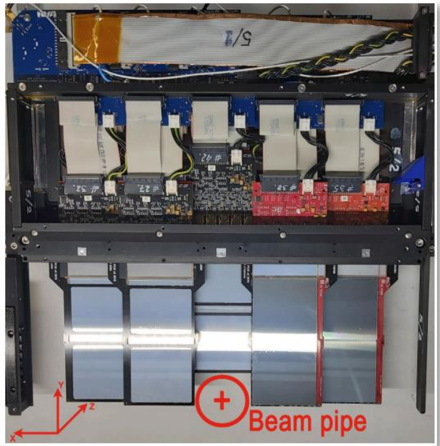
- ❑ Scouting the location of transition between hadronic and partonic dominated matter;
- ❑ Probing the EoS at neutron star core densities;
- ❑ Searching the critical endpoint of a possible 1st order phase transition at Nuclotron energies;
- ❑ Study of the ΛN, ΛNN, and ΛΛN interactions



Central Tracking System of BM@N Experiment

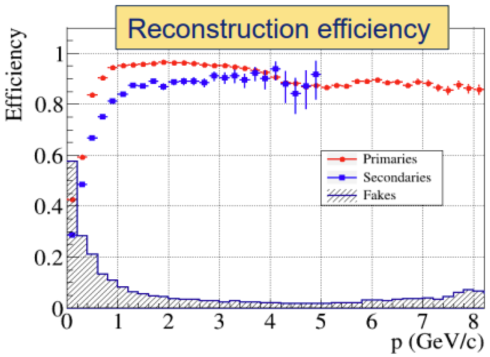


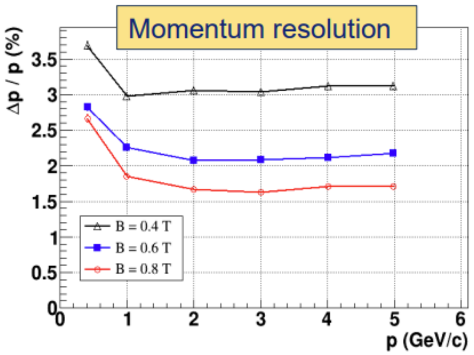
Central Tracking system of BM@N

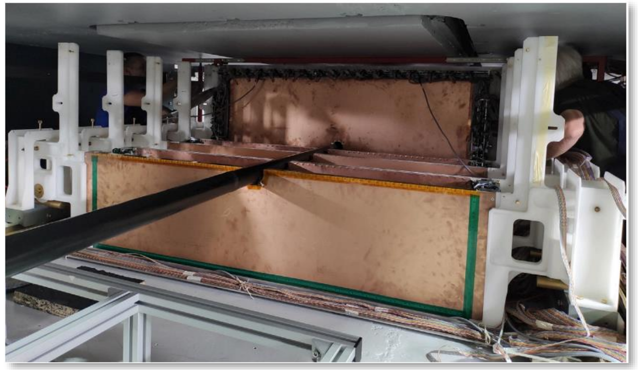


FSD half-plane without shielding

- Strip pitch p^{+}/n^{+}: 95/103 μm;
- Stereo angle: 2.5°;
- Total area: 0.3 m^2;
- Number of channels: ~54k.



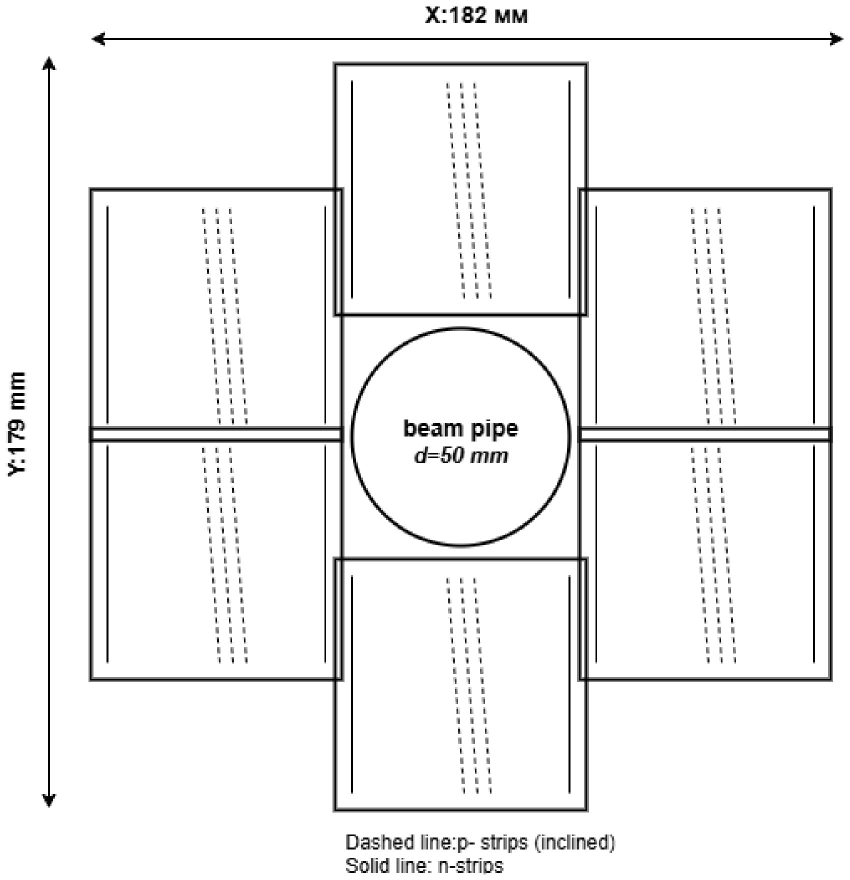



GEM planes

- Strip pitch: 800 μm;
- Stereo angle: 15 °;
- Total area: 9.6 m^2;
- Number of channels: ~12.5k.

- Reconstruction eff. > 90% for primaries
- Δp/p < 2% for p>0.5 Gev/c

New Silicon Tracking station



Layout of the station

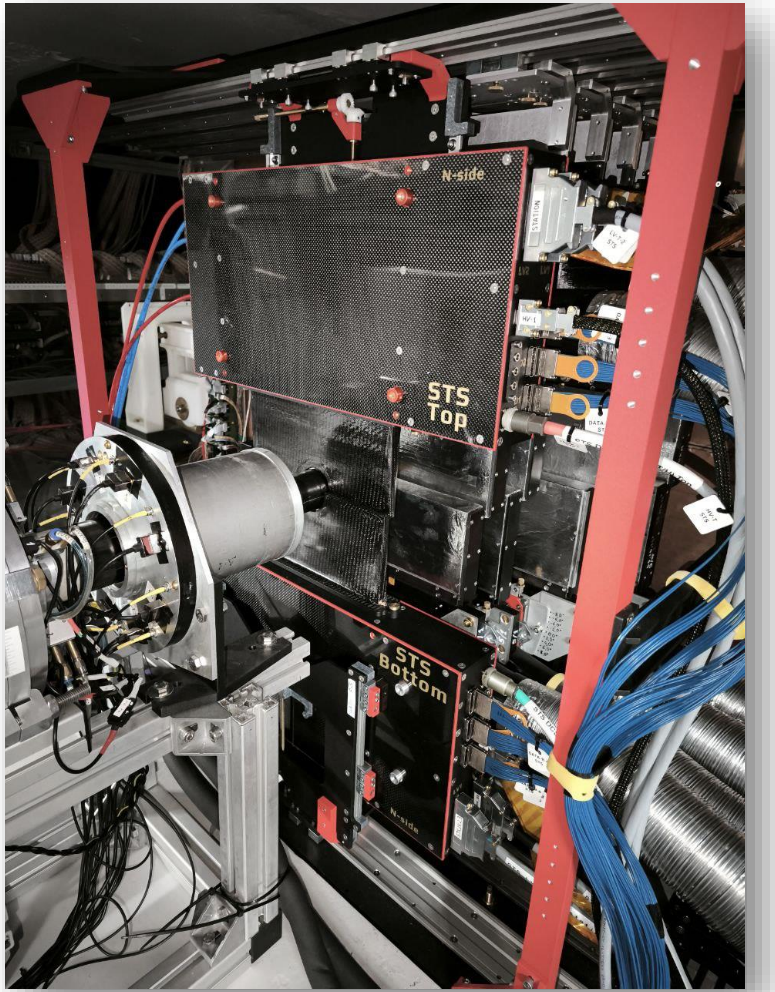
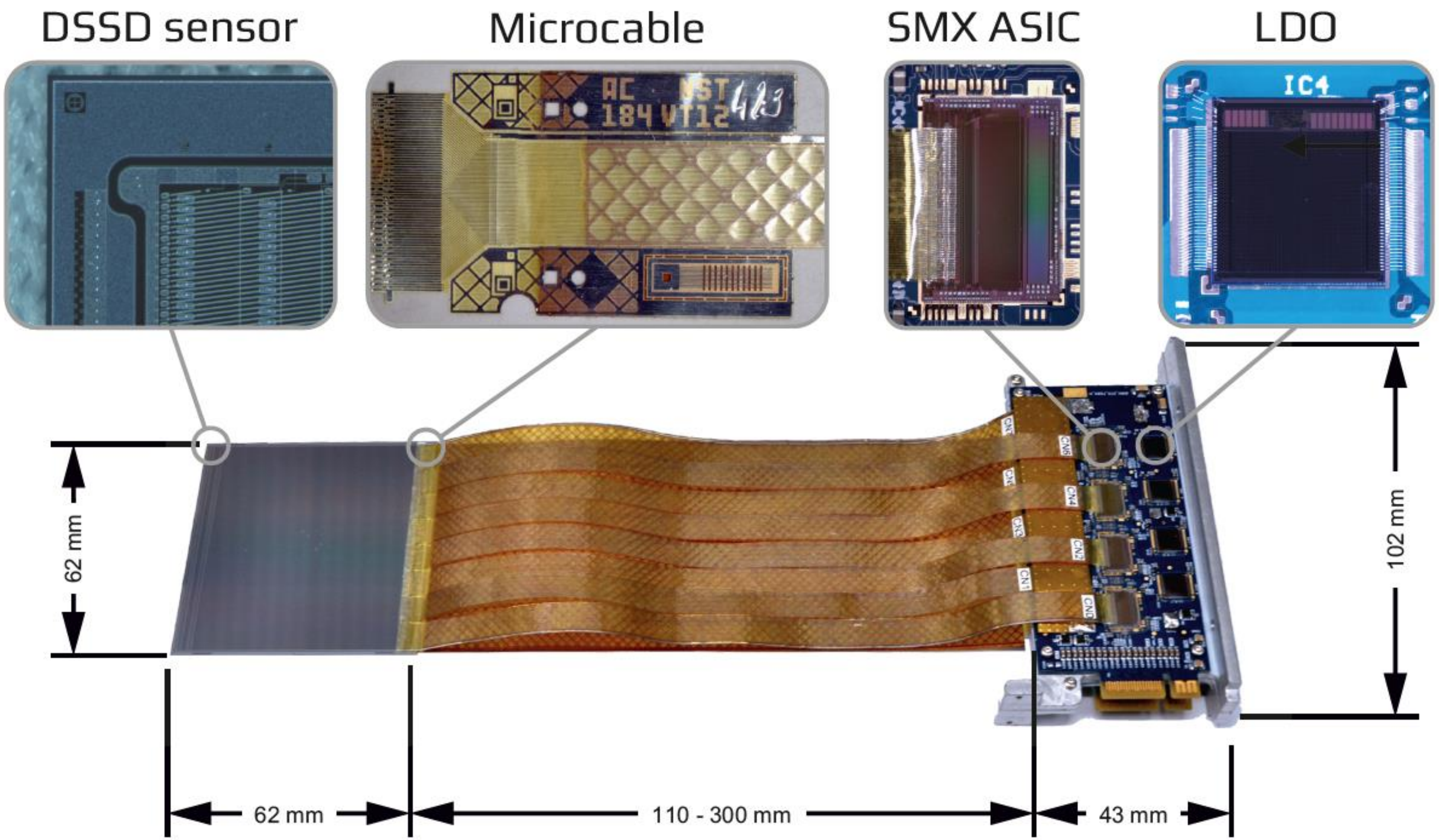


Photo of the station installed inside SP-41 Magnet

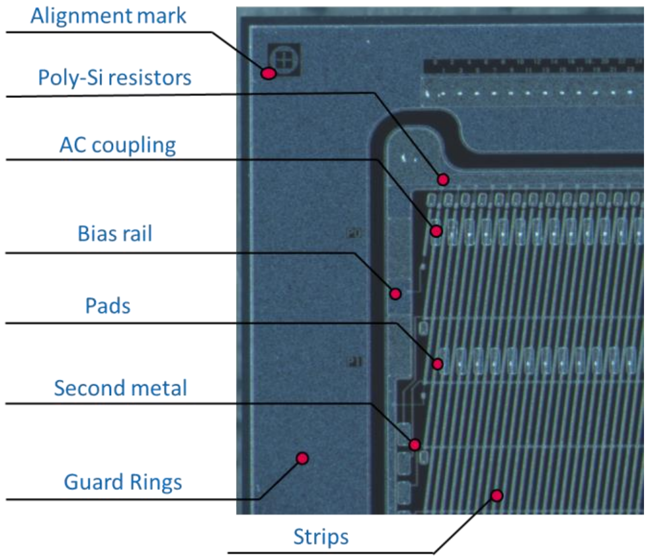
- Midrapidity tracking
- Reconstruction of Ξ^- decay

- Strip pitch: 58 μm;
- Stereo angle: 7.5 °;
- Number of channels: ~12k.

STS Tracking module

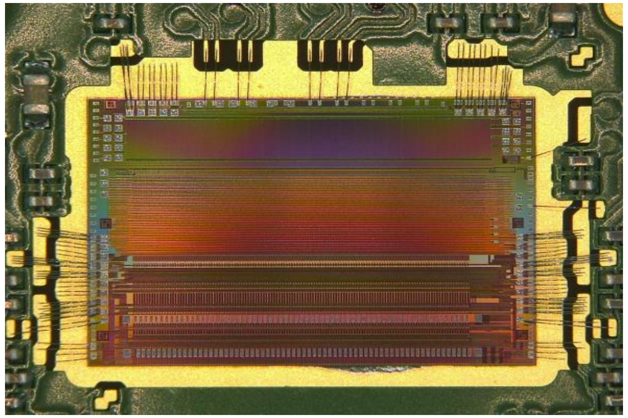


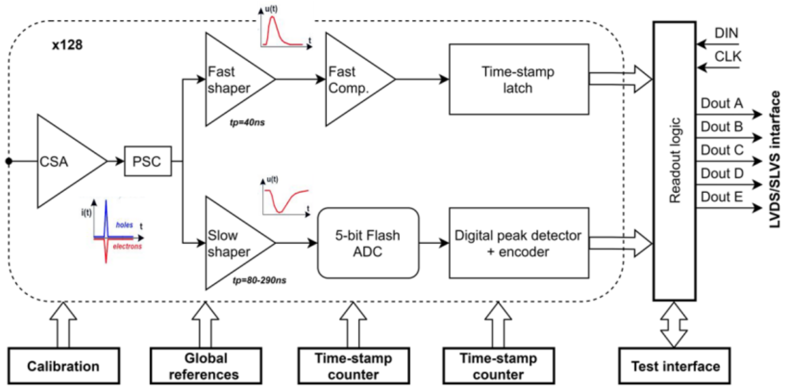
Features of the module



Sensor parameters:

- ❑ Size: 6.2×6.2 cm^2;
- ❑ Thickness: 320 µm;
- ❑ Num. of Strips: 1024
- ❑ Pitch: 58 µm;
- ❑ Stereo angle: 7.5 deg;
- ❑ In-build AC-coupling;
- ❑ Sec. metal layer at p-side



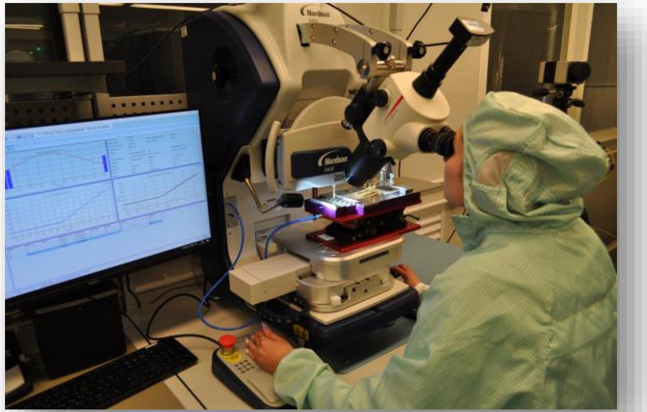


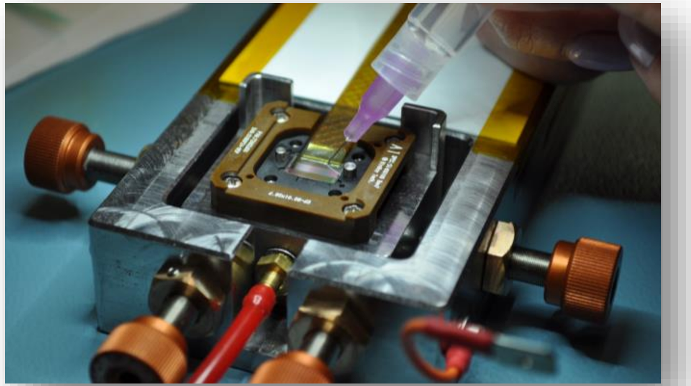
STS-XYTER ASIC

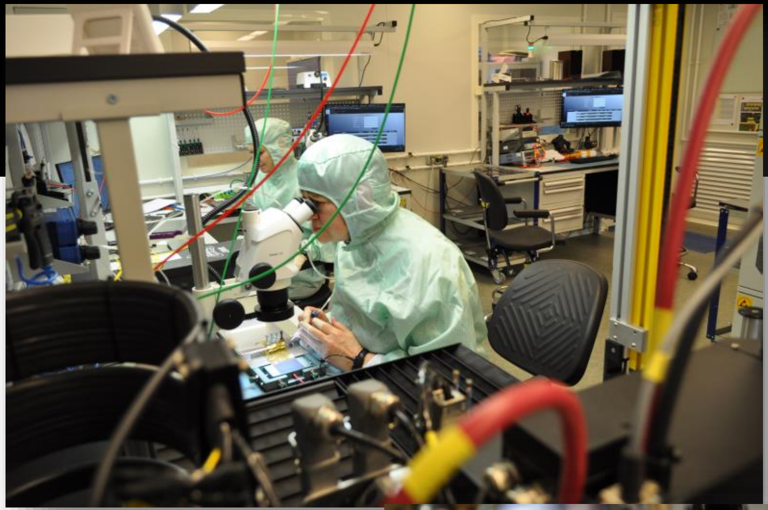
STS-XYTER v.2.2 ASIC

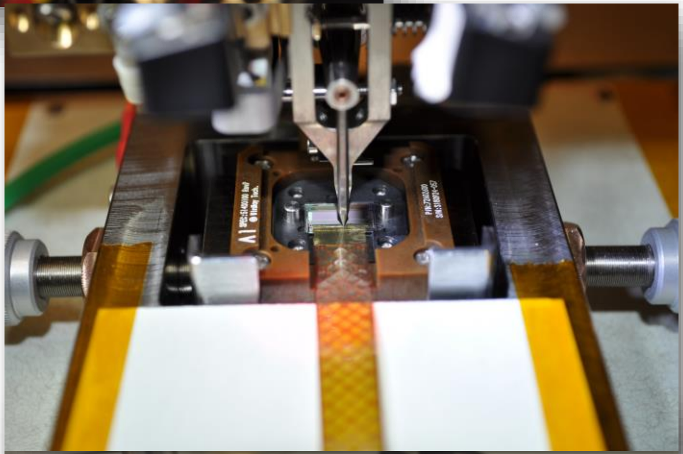
- ❑ 128 channels;
- ❑ Data driven architecture;
- ❑ 5 bit ADC, TDC < 10 ns;
- ❑ Shaping time 80-120 ns (Slow Shaper for Amp.);
- ❑ Back-end interface : 5 e-link per ASIC with AC coupling.
- ❑ Up to 47 Mhit/s/ASIC @ 320 Mbps/link

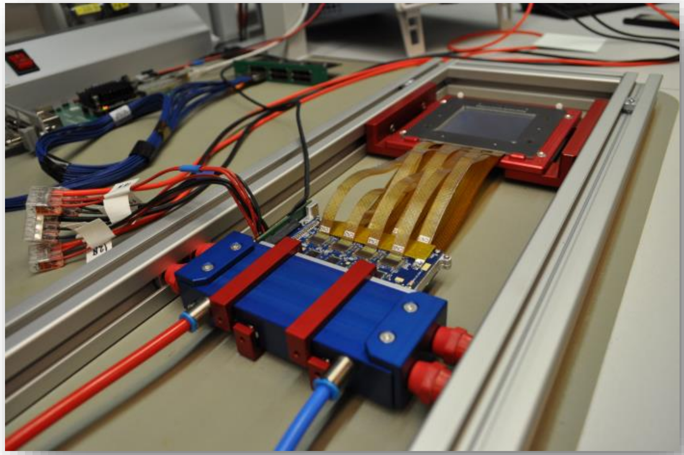
Module assembly

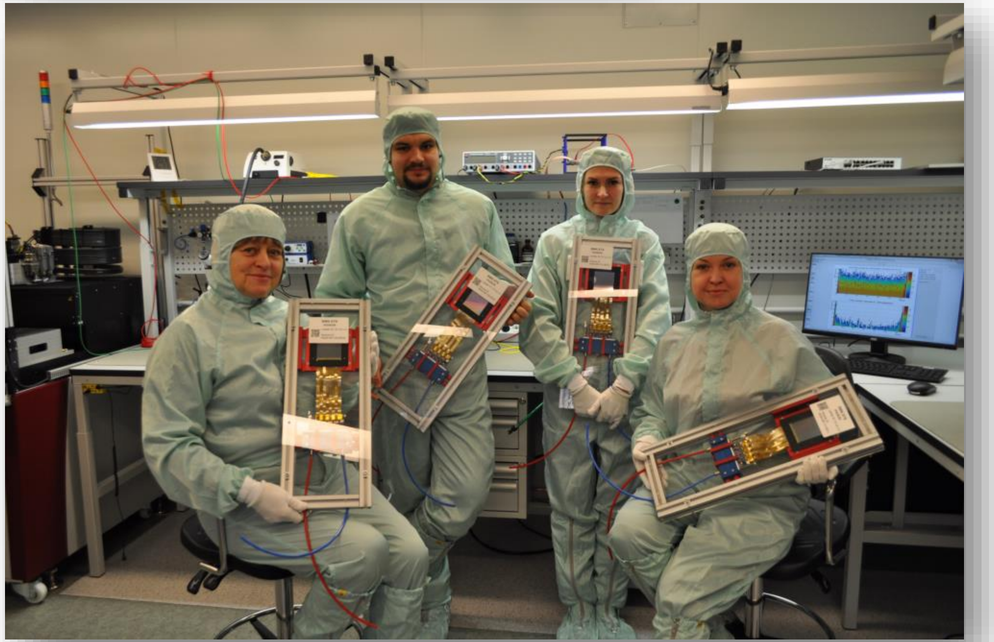


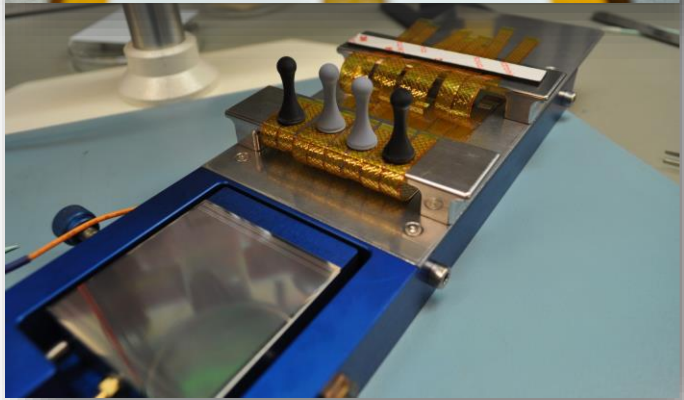






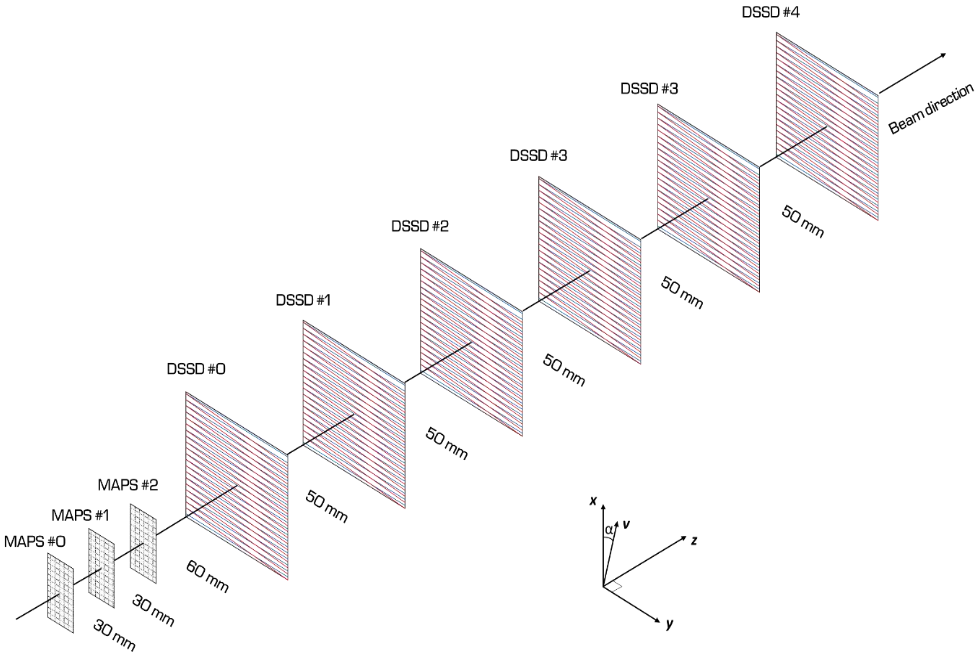


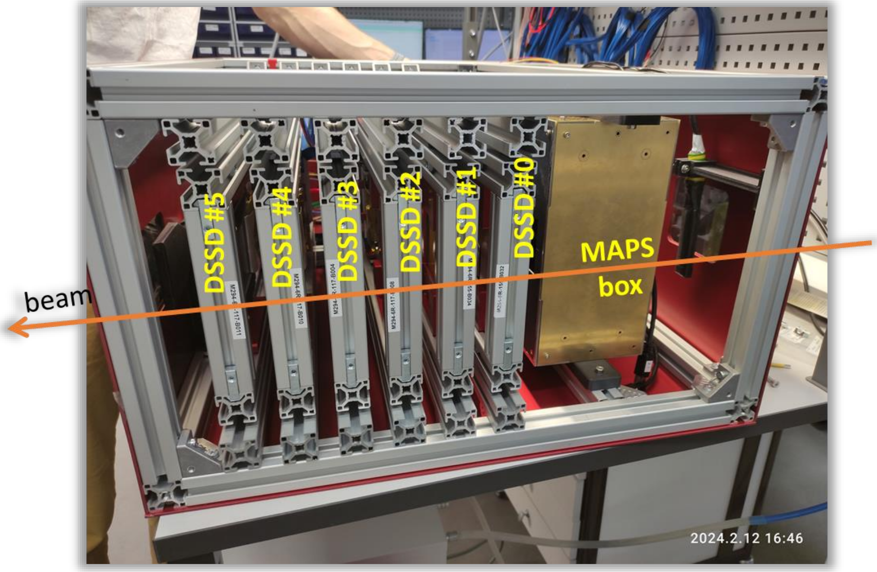




A. Sheremetev, PhD Thesis

In-beam tests at PNPI

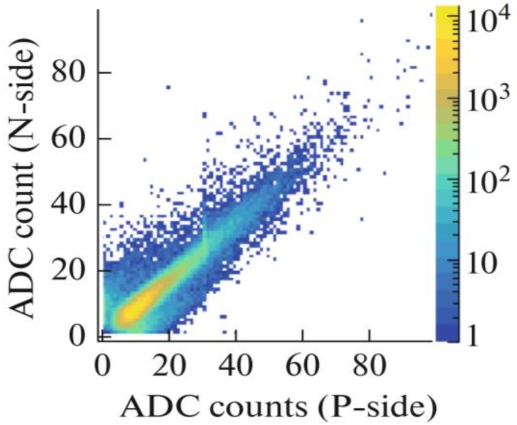




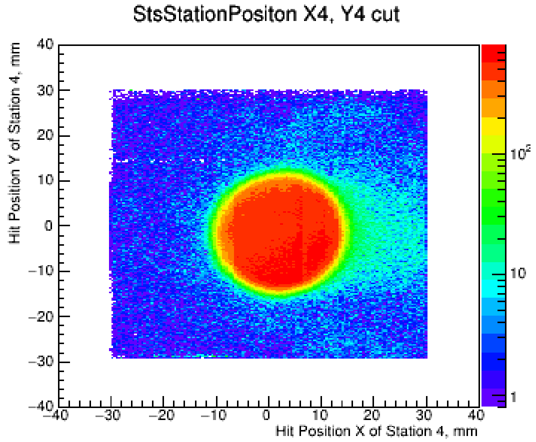
Beam telescope

Tests with 1 GeV & 200 MeV proton beams at SC-1000:

- Study of the tracking performance of DSSD sensors;
- Merging of the data from two different subsystems

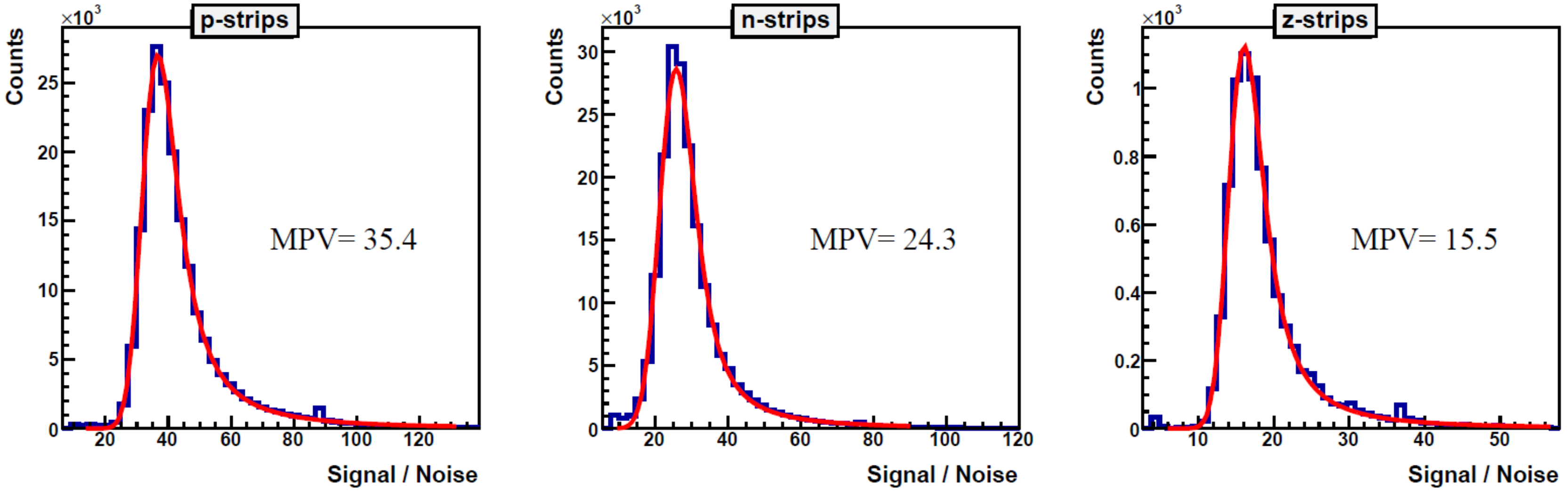


Signal Amplitude (p & n)



Beam profile

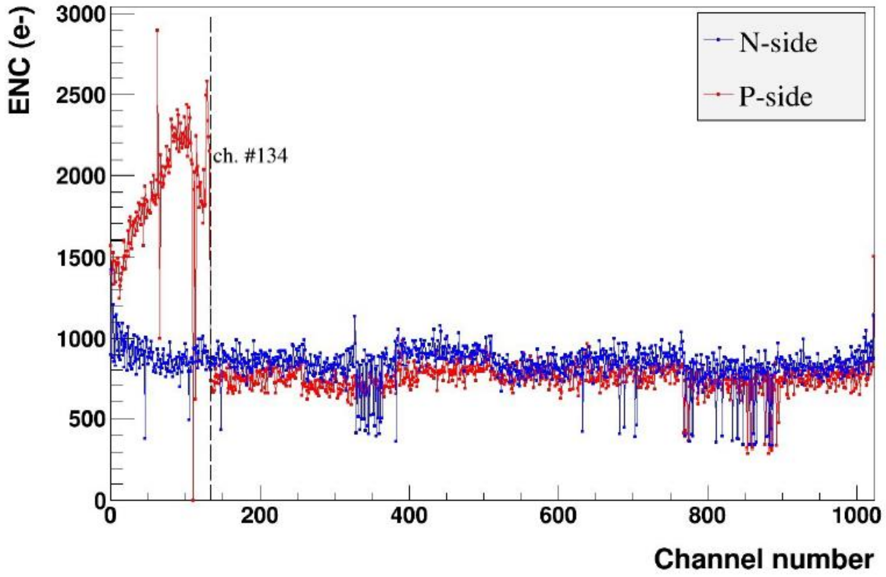
Signal-to-Noise Ratio



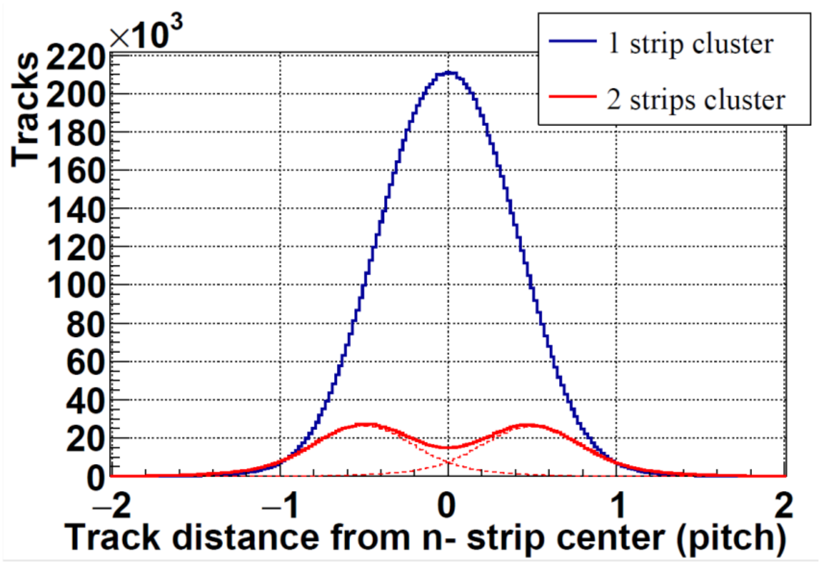
Signal/Noise distribution for 1GeV protons

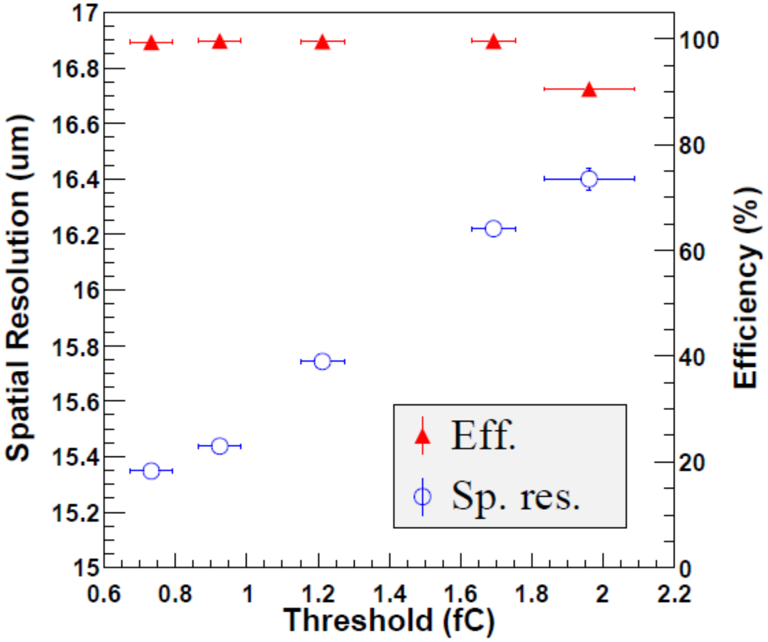
SRIM: $Signal_{MIP} = 0.92 \times Signal_{1\ GeV\ protons}$

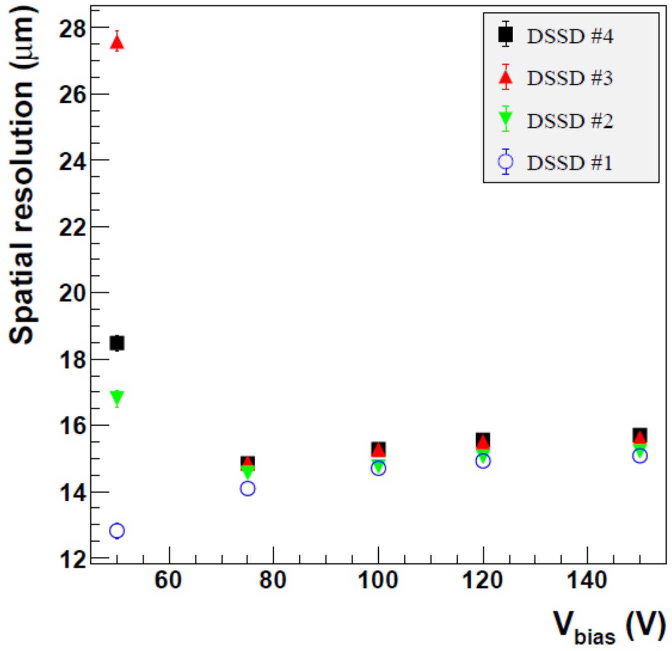
- ***p*-strips SNR_{MIP}: 28 - 30.5;**
- ***n*-strips SNR_{MIP}: 21 - 24.5;**
- ***z*-strips SNR_{MIP}: 8 – 13;**



Spatial Resolution and Efficiency







$\sigma_{X,U}$ = 15.4 ± 0.4 μm

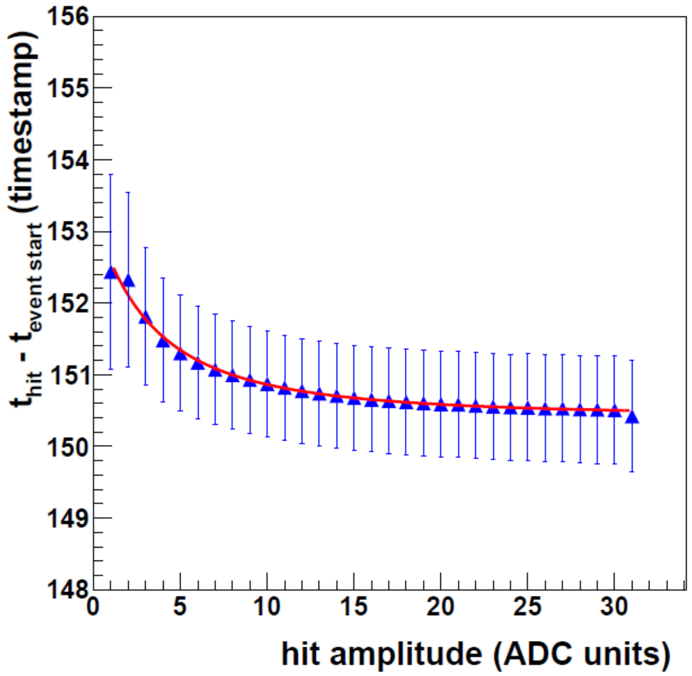
σ_{Y} = 170 ± 4μm

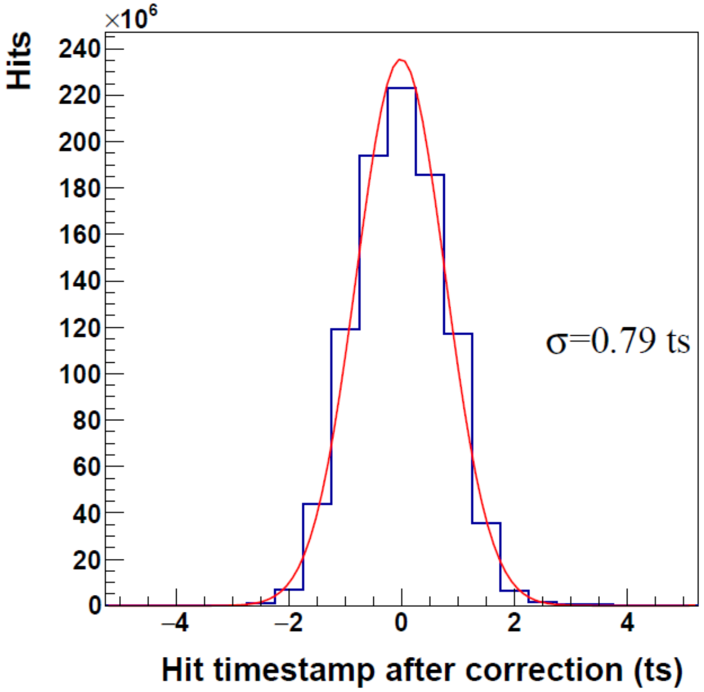
eff. > 99%

Time resolution

$$\sigma_{tot} = \sigma_{Jitter} \oplus \sigma_{TDC} \oplus \sigma_{Time\,Walk}$$

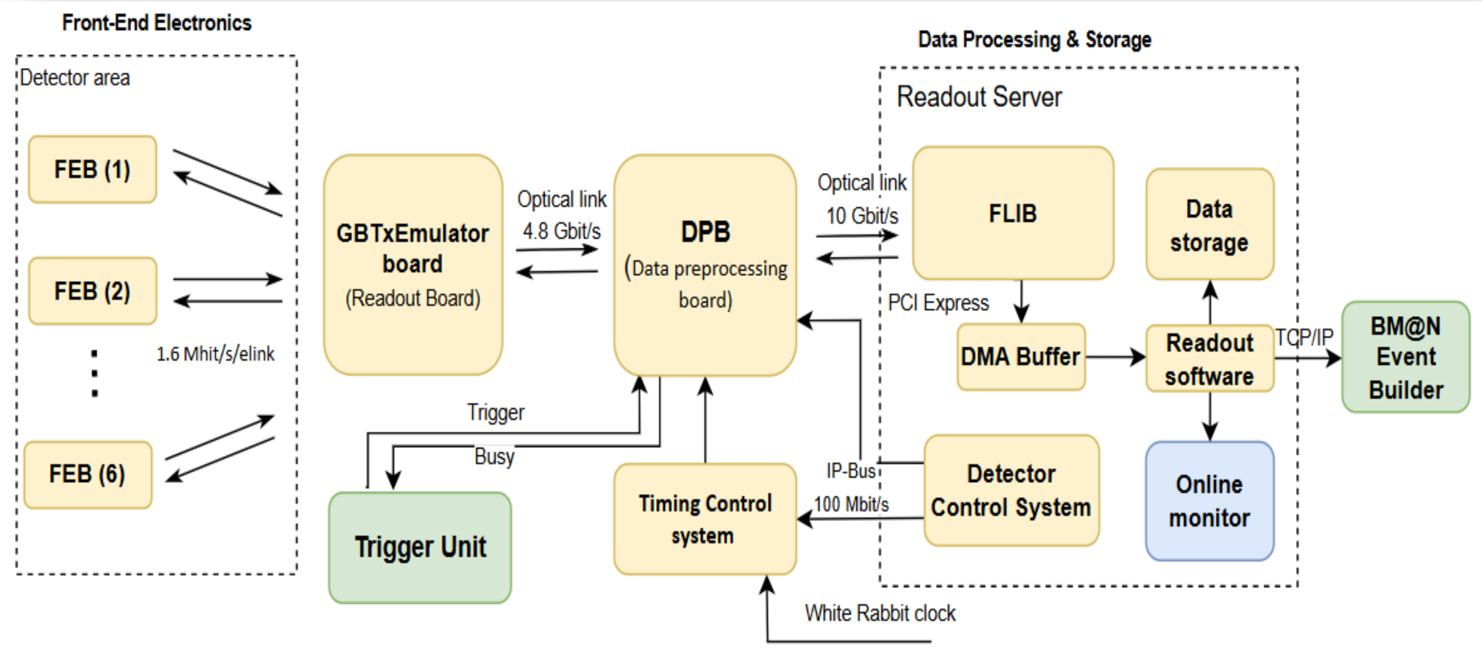
Time walk correction





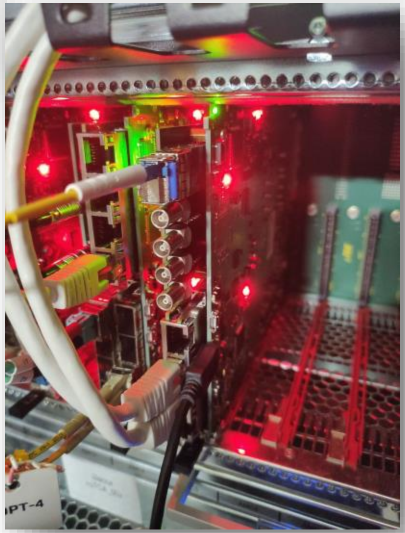
$$\sigma_{tot} = 9.9 \text{ ns}$$

Readout electronics



Scheme of the Data Acquisition System

STS server node in the BM@N data center



DPB

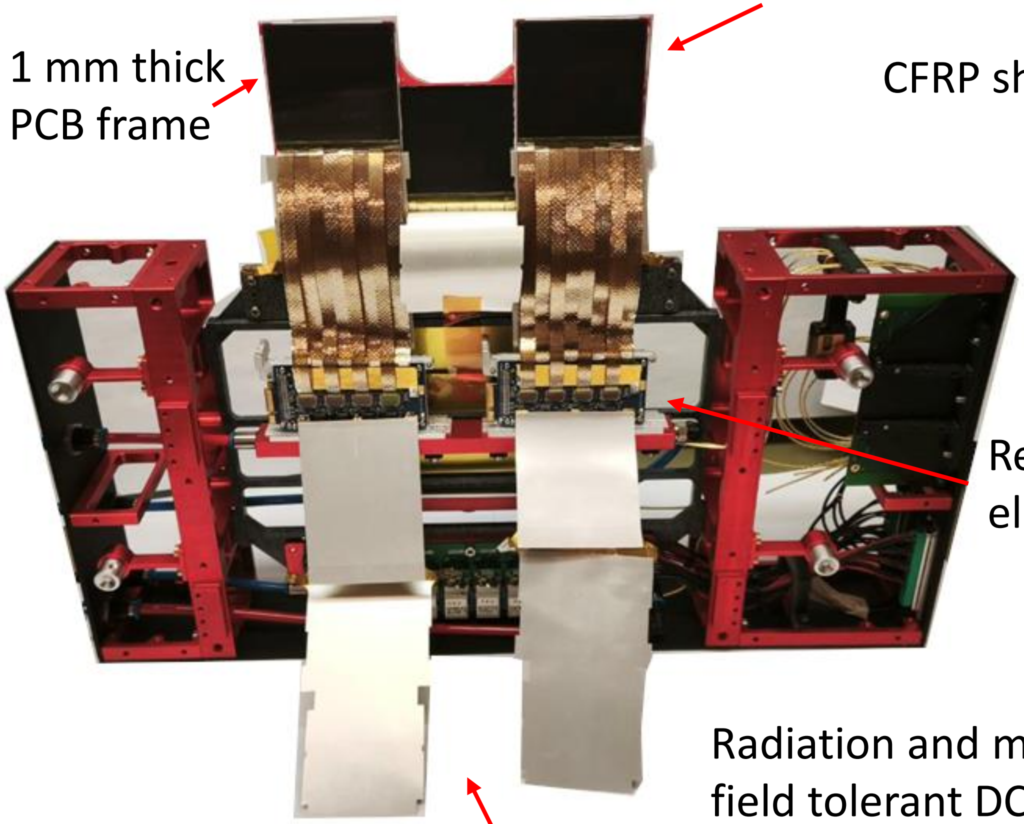
STS rack

- Trigger rates up to 78 kHz;
- Hit rates of 3.6×10^5 hits s^{-1} cm^{-2}

STS half-planes

Sensors

1 mm thick
PCB frame

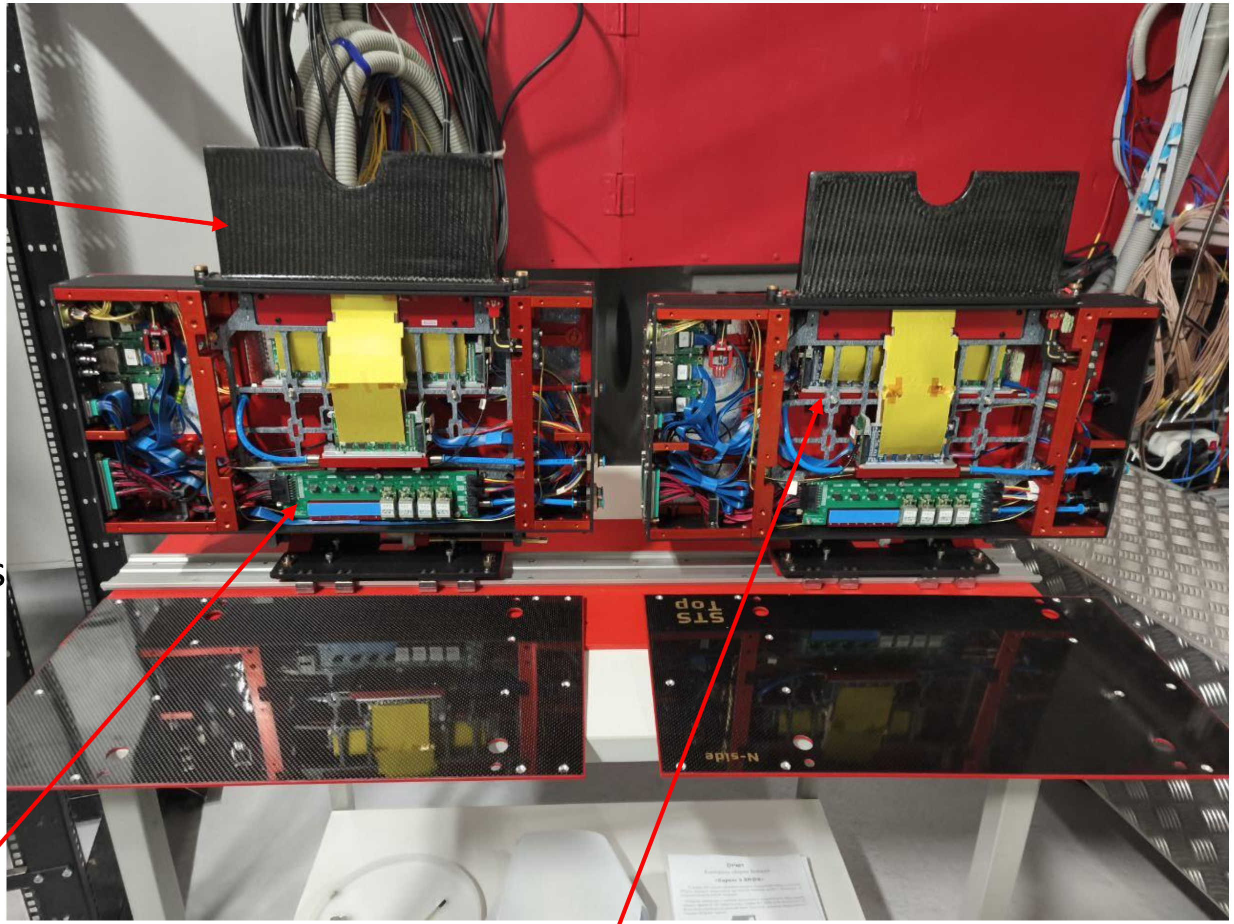


Cable shielding

Readout
electronics

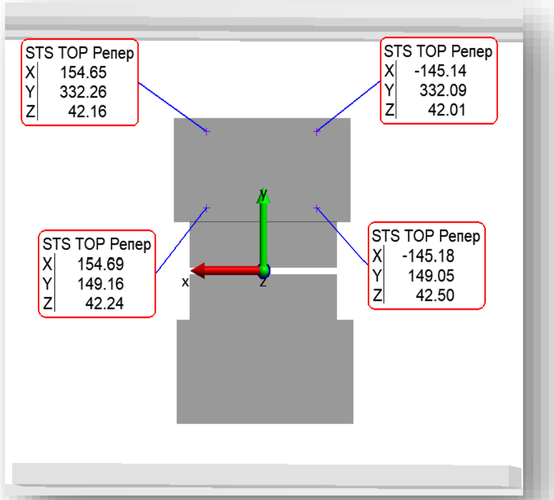
Radiation and magnetic
field tolerant DC/DC
converters

CFRP shielding

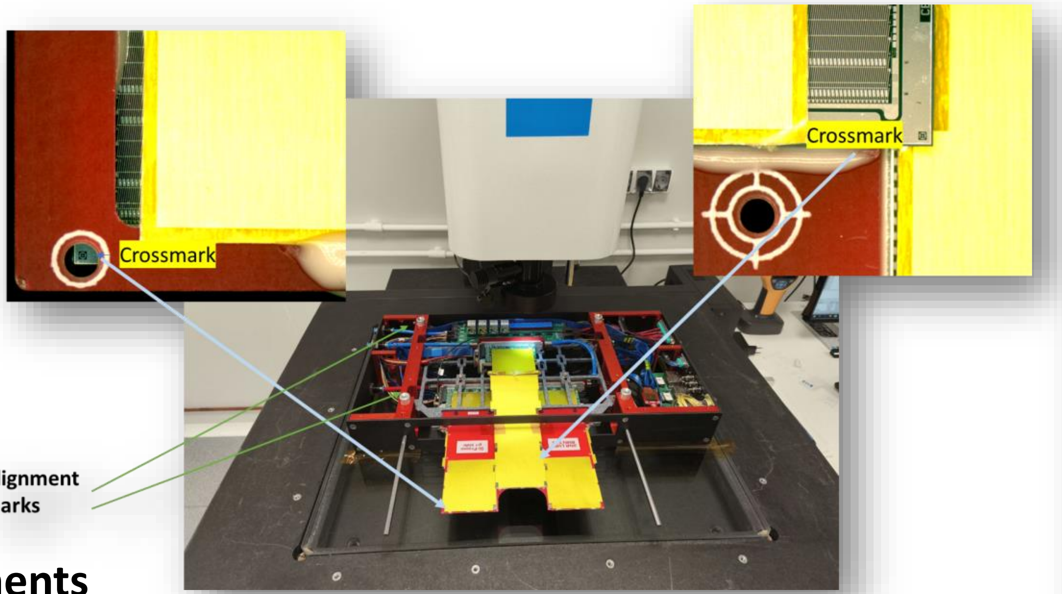


Water cooling
(tot. power dissipation ~150 W)

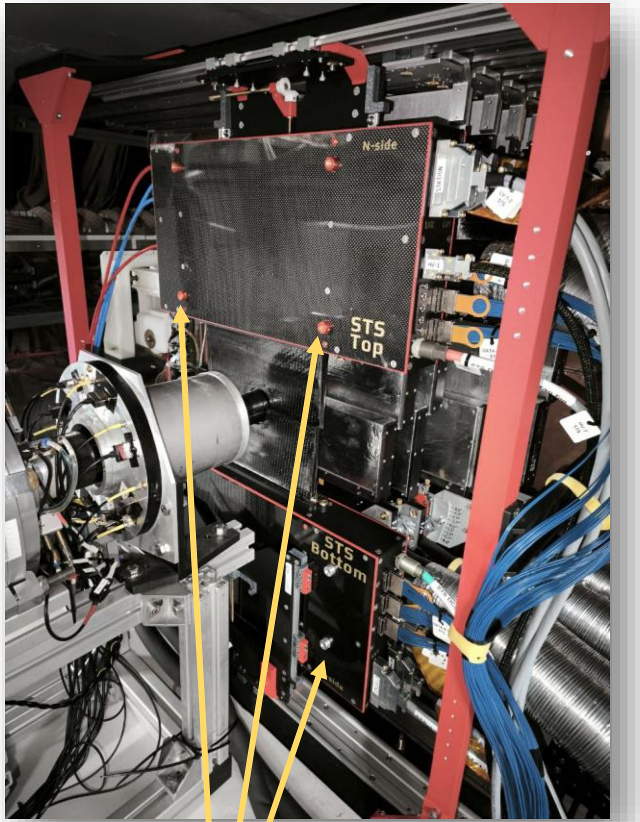
Integration and Allignment



Results of the metrology measurements



Measuring of the sensor's positions



4x alignment marks per half-station

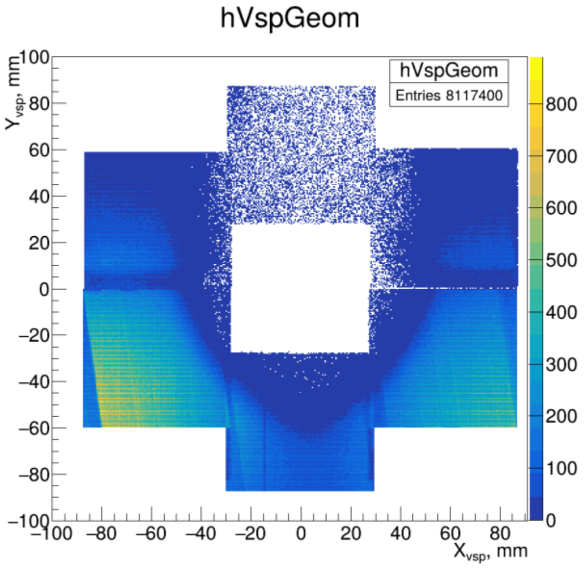
Measuring of the station position

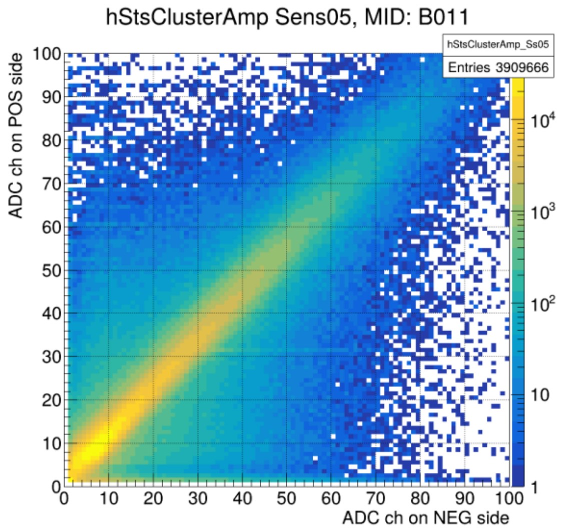
Station was installed and aligned with an accuracy of 0.3 mm;

Position of the sensors was measured with an accuracy of 0.1 mm

Conclusion

- The modules demonstrated stable operation, high signal-to-noise ratios, spatial resolution of ~15 µm, and registration efficiency above 99% for regular strips.
- Integration of the data-driven readout system of the BM@N silicon tracking station with the global BM@N DAQ has been successfully achieved, supporting trigger rates up to 78 kHz in the triggered configuration and handling hit rates of $3.6 \times 10^{5}\ s^{-1}\ cm^{-2}$
- A new Silicon tracking station was installed and aligned with a precision of 0.3 mm.





Ru-106 source, positions are below the STS-plane

Thank you for your attention!