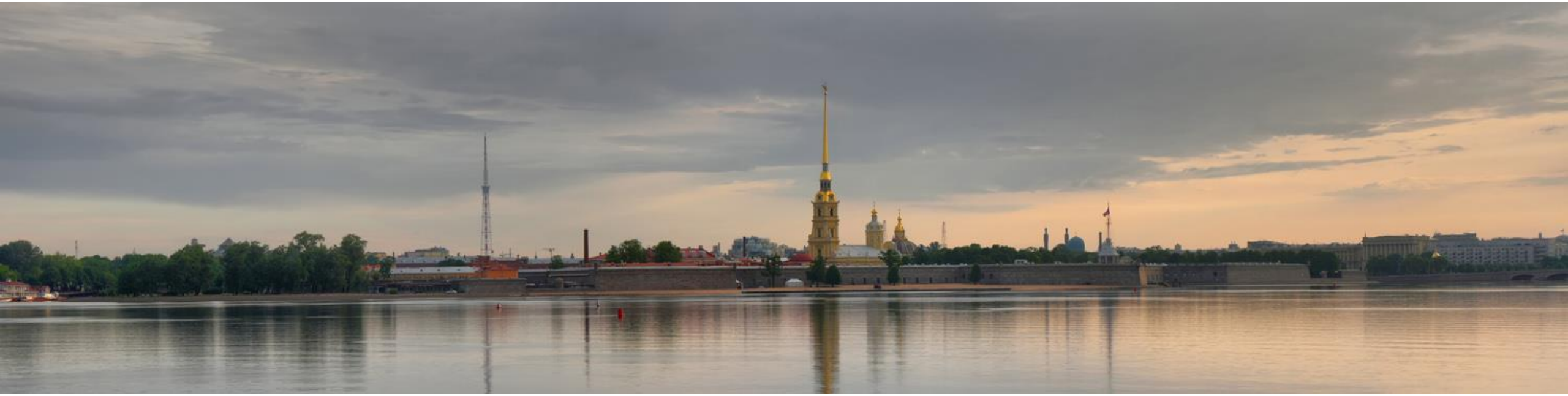
Results of the in-beam tests of STS modules and readout chain at PNPI

Dmitrii Dementev, Shitenkow Mihail, Sheremev Aleksei, Leontyev Vladimir & Igor Rufanov for STS team



10th Collaboration Meeting of the BM@N Experiment at the NICA Facility,

St. Petersburg

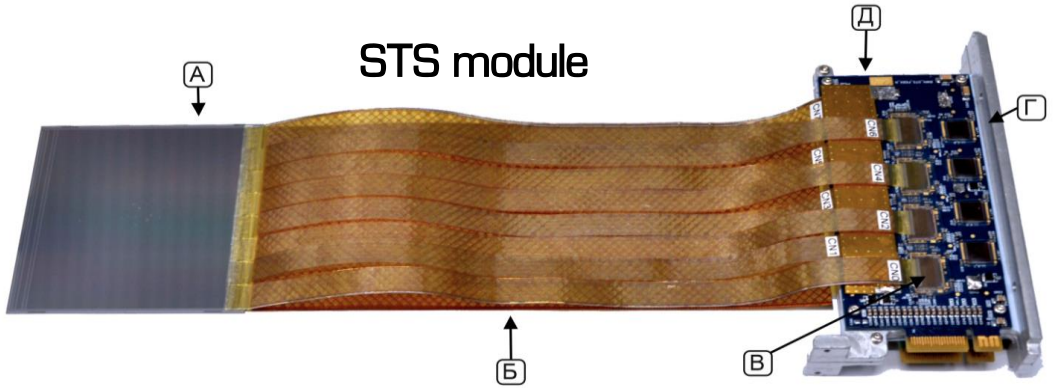
Main goals of the in-beam tests at PNPI

Main goals of the beam-time campaign:

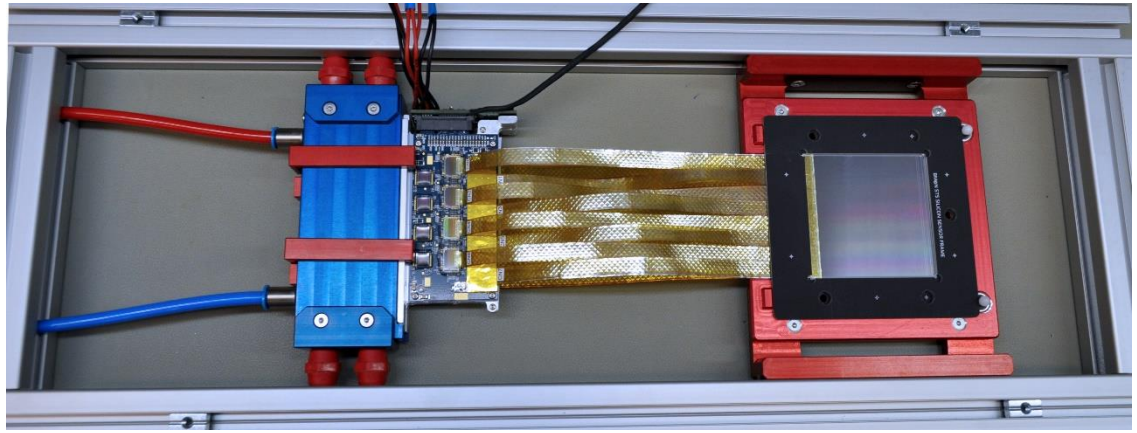
- Test of the full chain of readout electronics and operation of the data-driven readout in triggered mode;
- Tests of the pre-serial STS modules;
- Synchronous data collection from DSSD and MAPS based telescopes and track reconstruction based on both systems (together with SPbU team)
- Tests of the SEU rate of the Gbtx Emulator board based on FPGA

Accelerator machine: SC-1000 @ PNPI

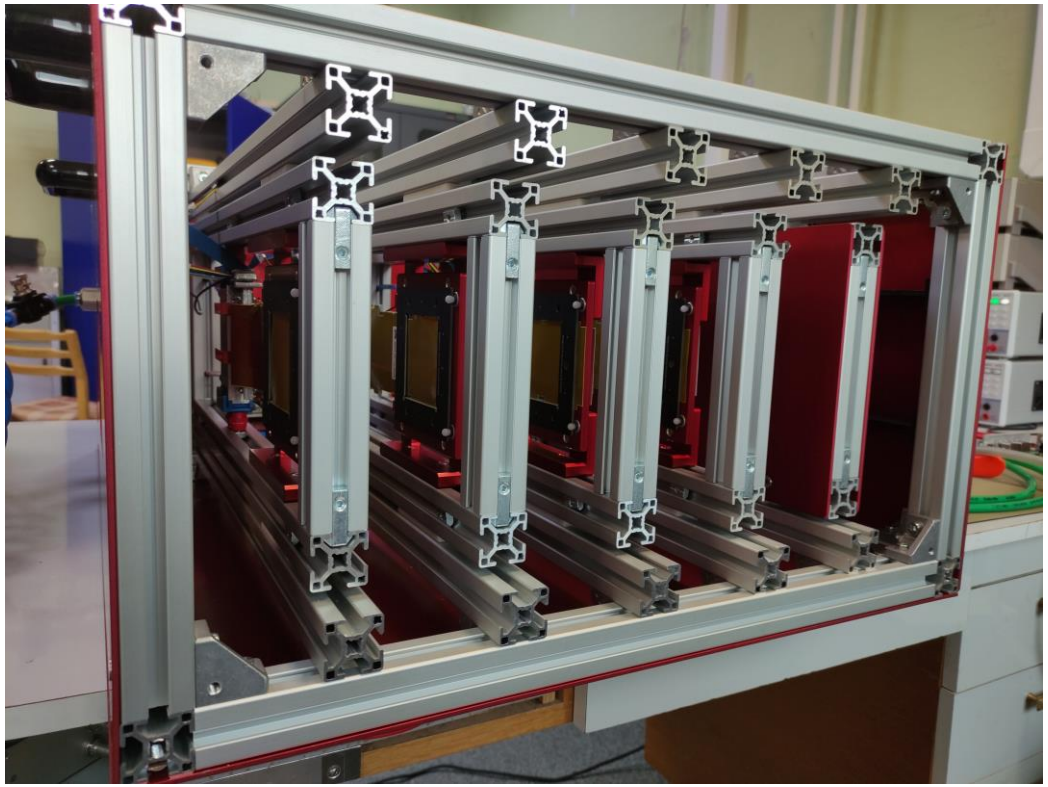
DSSD based STS module



- 1024 strips per side;
- 58 um pitch;
- 7.5° stereo angle



Test frame with STS module

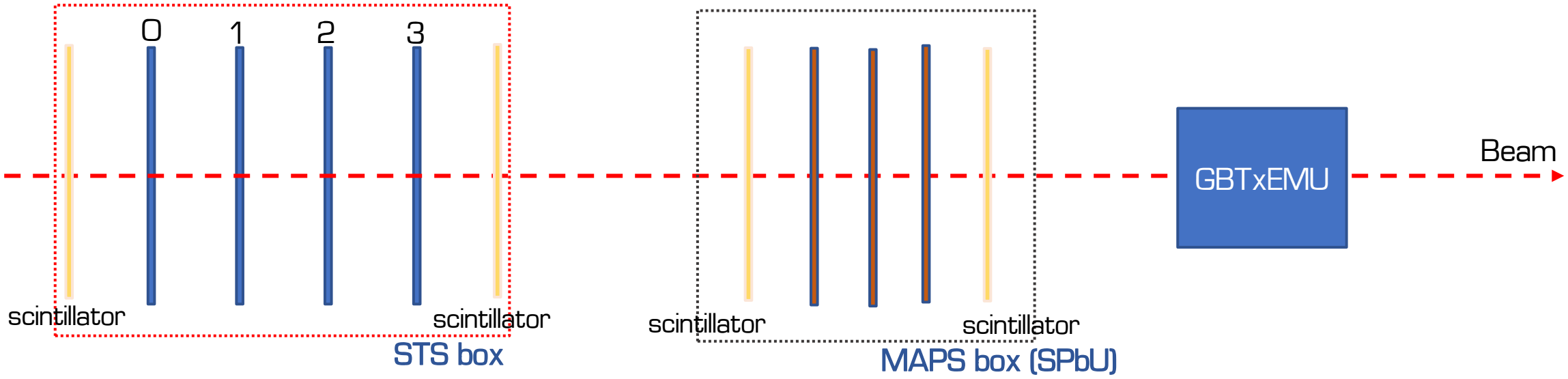


Telescope with 4 modules

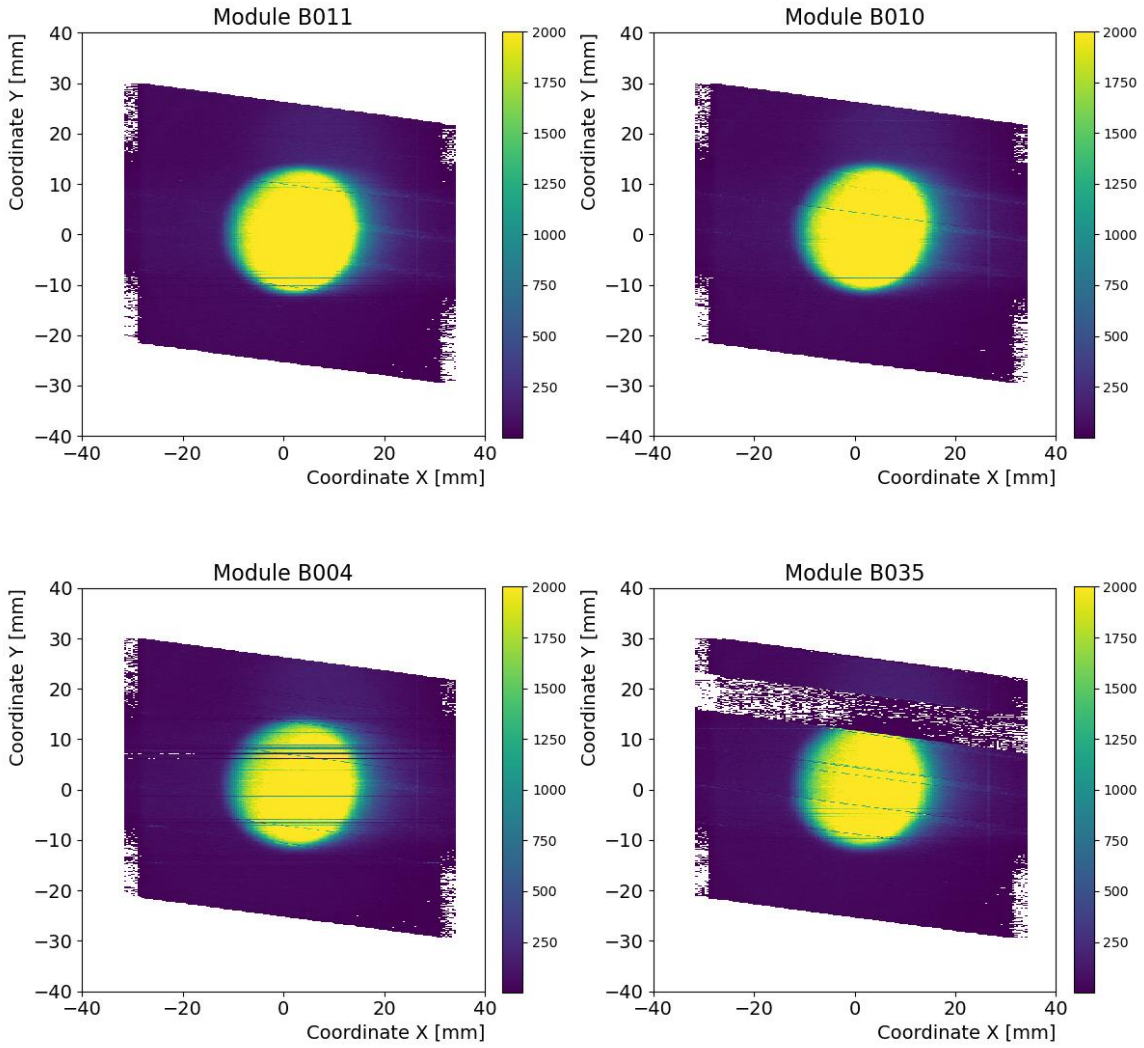
- 4 modules;
- 64 ASICs;
- 8096 readout channels;

A. Sheremetev

Beam test setup



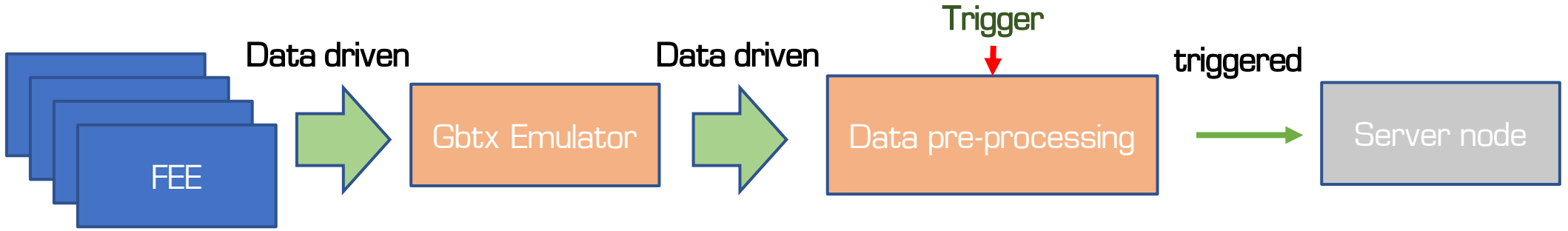
Beam parameters



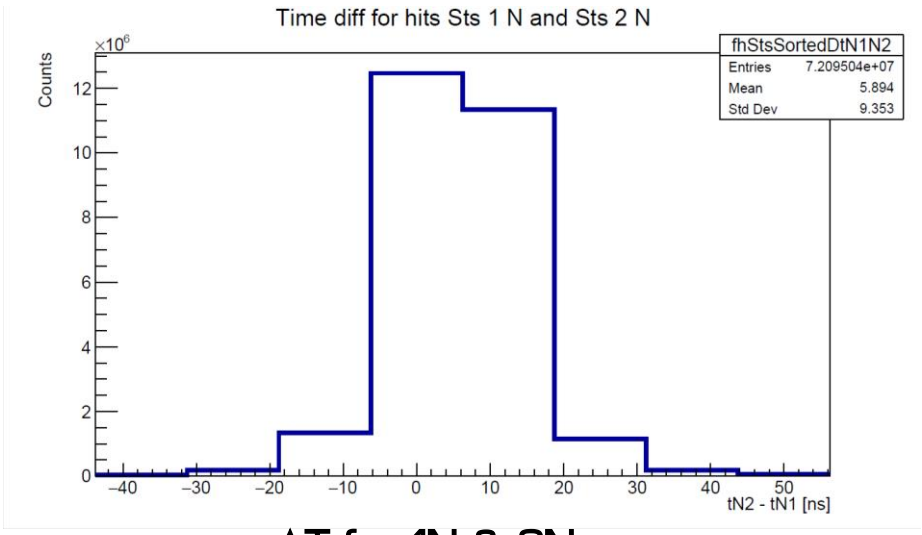
Beam profiles in STS modules

- 1 GeV Proton beam;
- Intensity: $10^4 - 10^6 \frac{p}{cm^2 s}$;
- Beam diameter ~25 mm;
- 250M triggered events

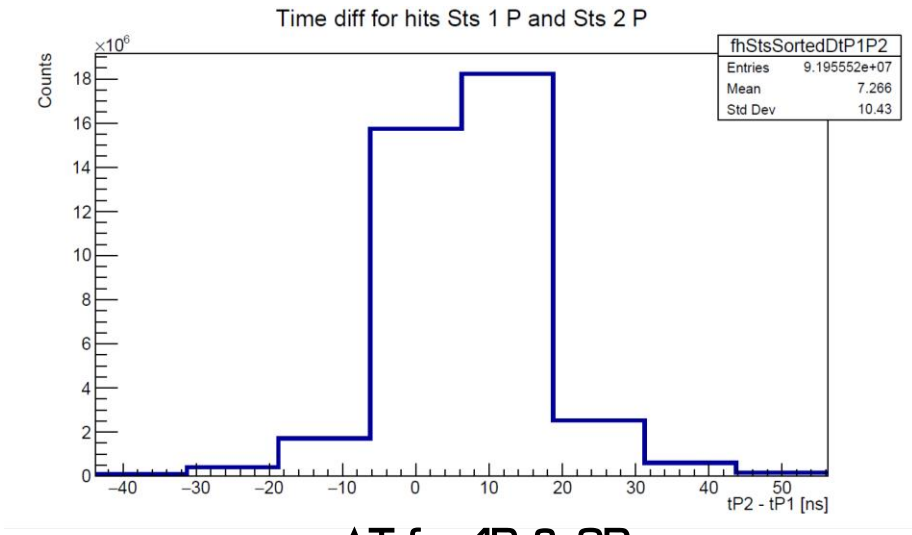
Readout electronics



- Trigger rate tested: 2-50 kHz;
- Synch quality of FEE: 25 ns (2 TS);
- Stable synchronization during 48 h of data taking

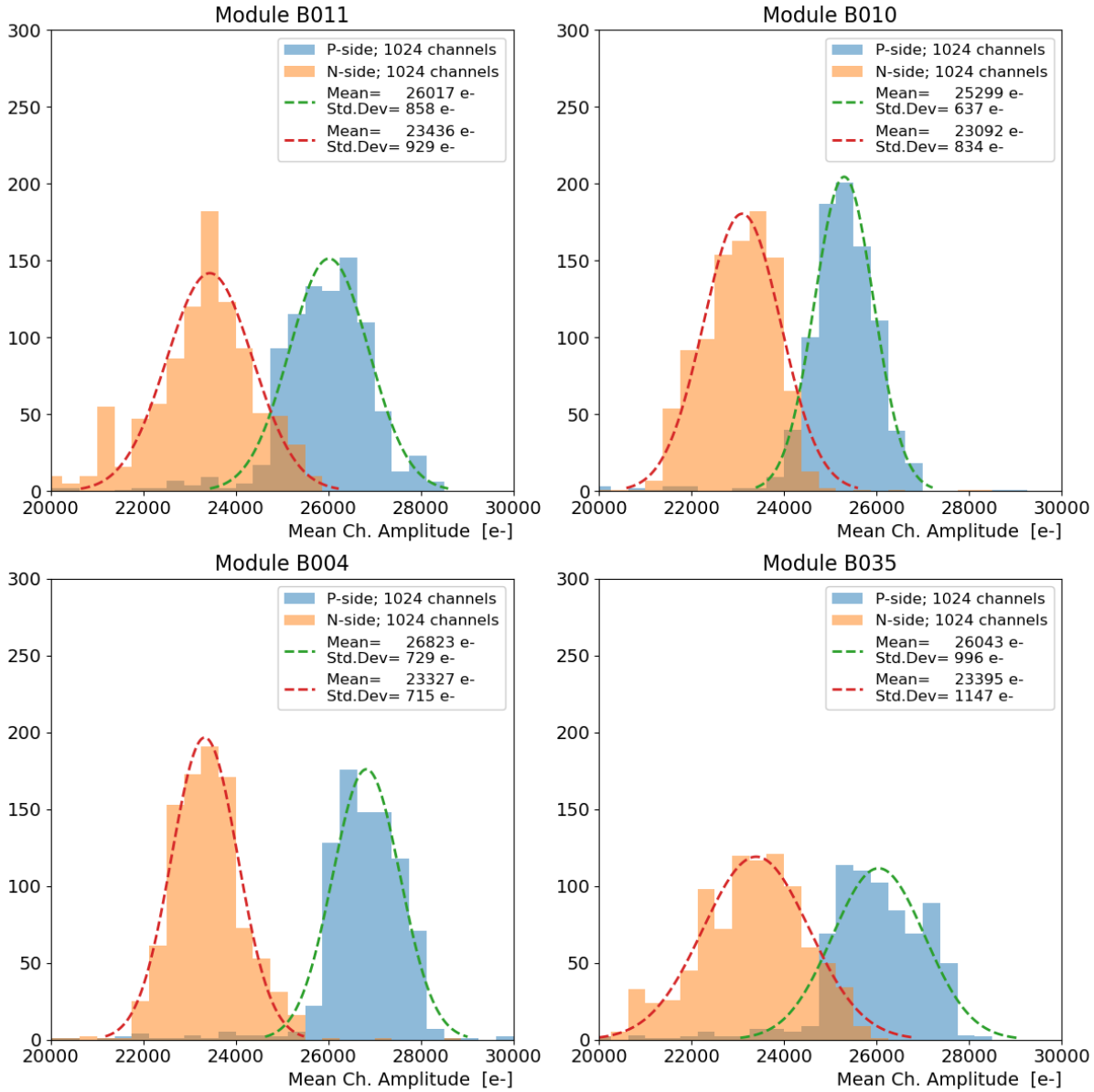


ΔT for 1N & 2N

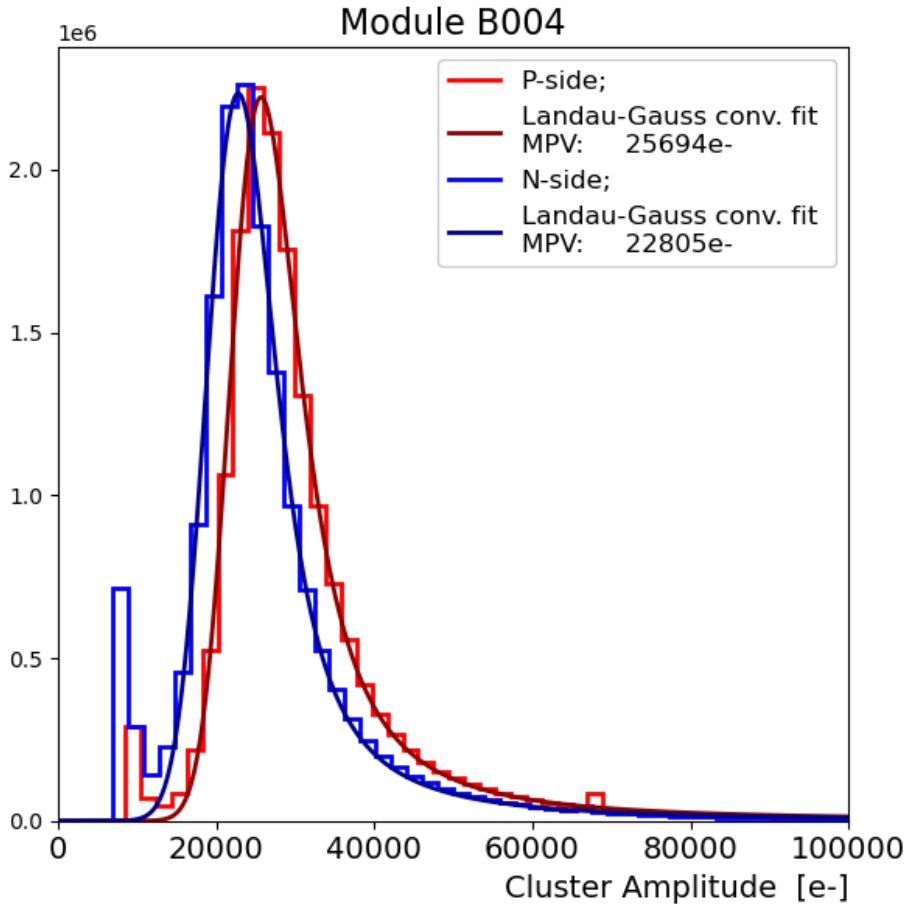


ΔT for 1P & 2P

Gain per channel distribution



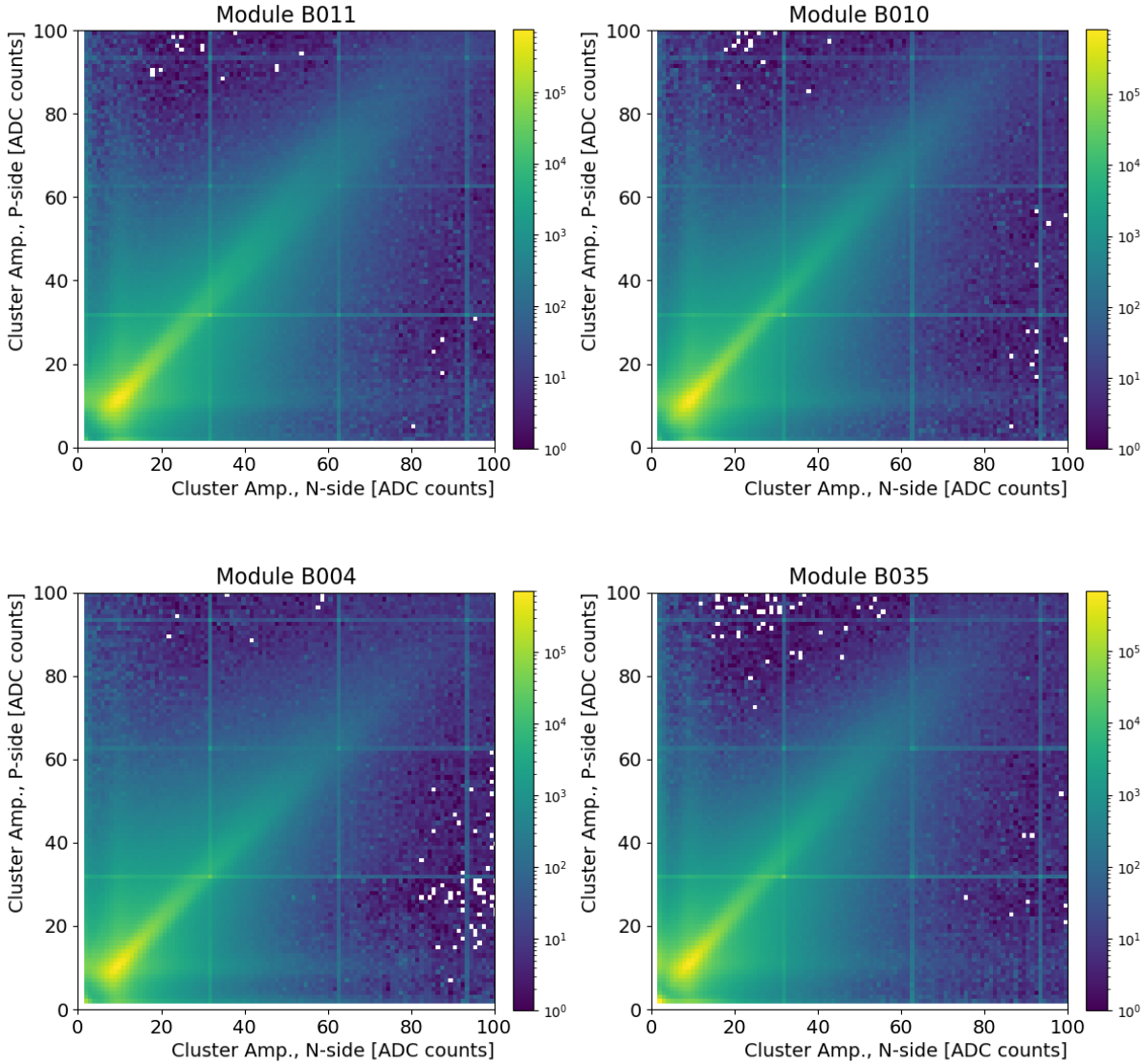
Gain per ch disstribution



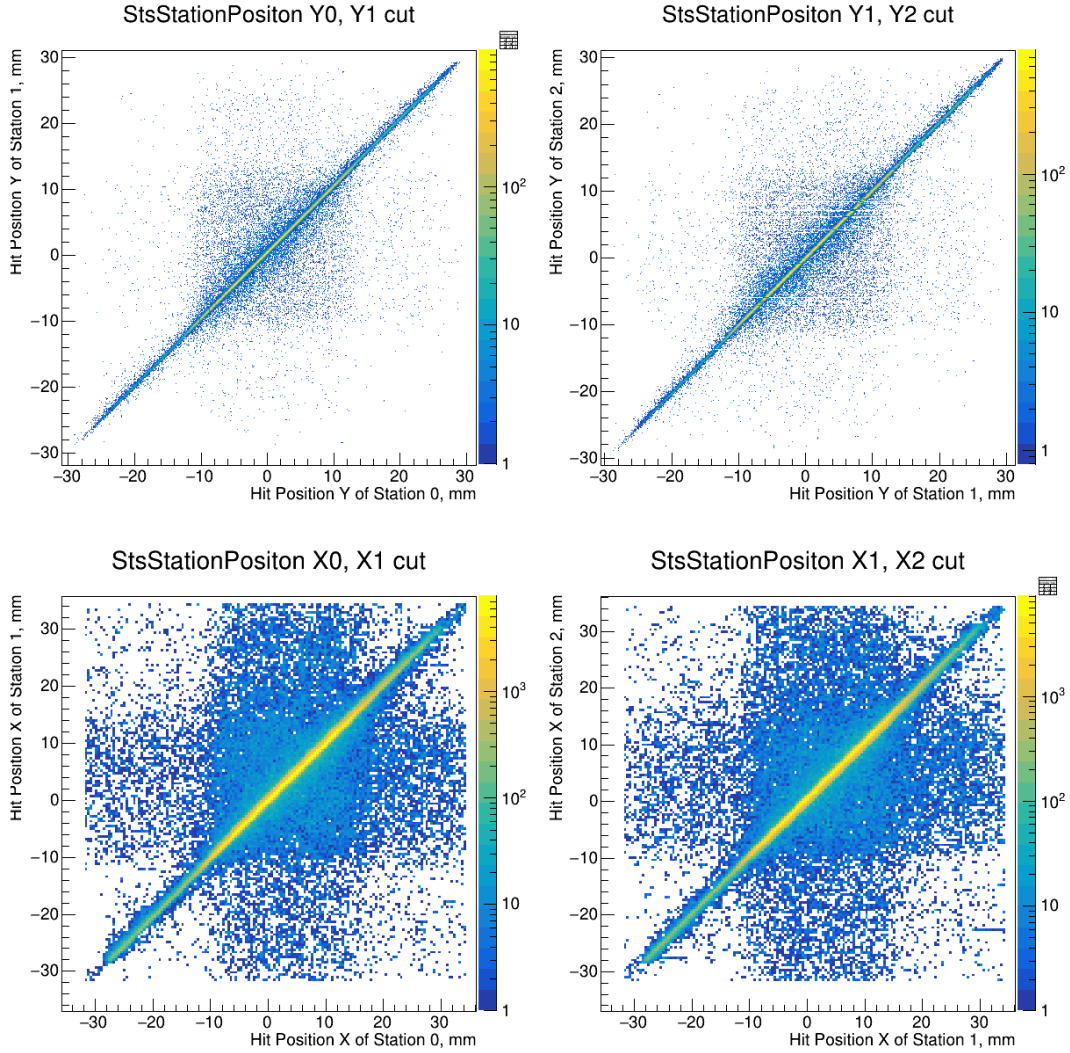
Cluster amplitudes

- Gain per channel discrepancy is less than 15%
- S/N, N-side > 18.5
- S/N, P-side > 20 (Mod. #0,1,3) ~17 (Mod. #2)

Space & Charge Correlations

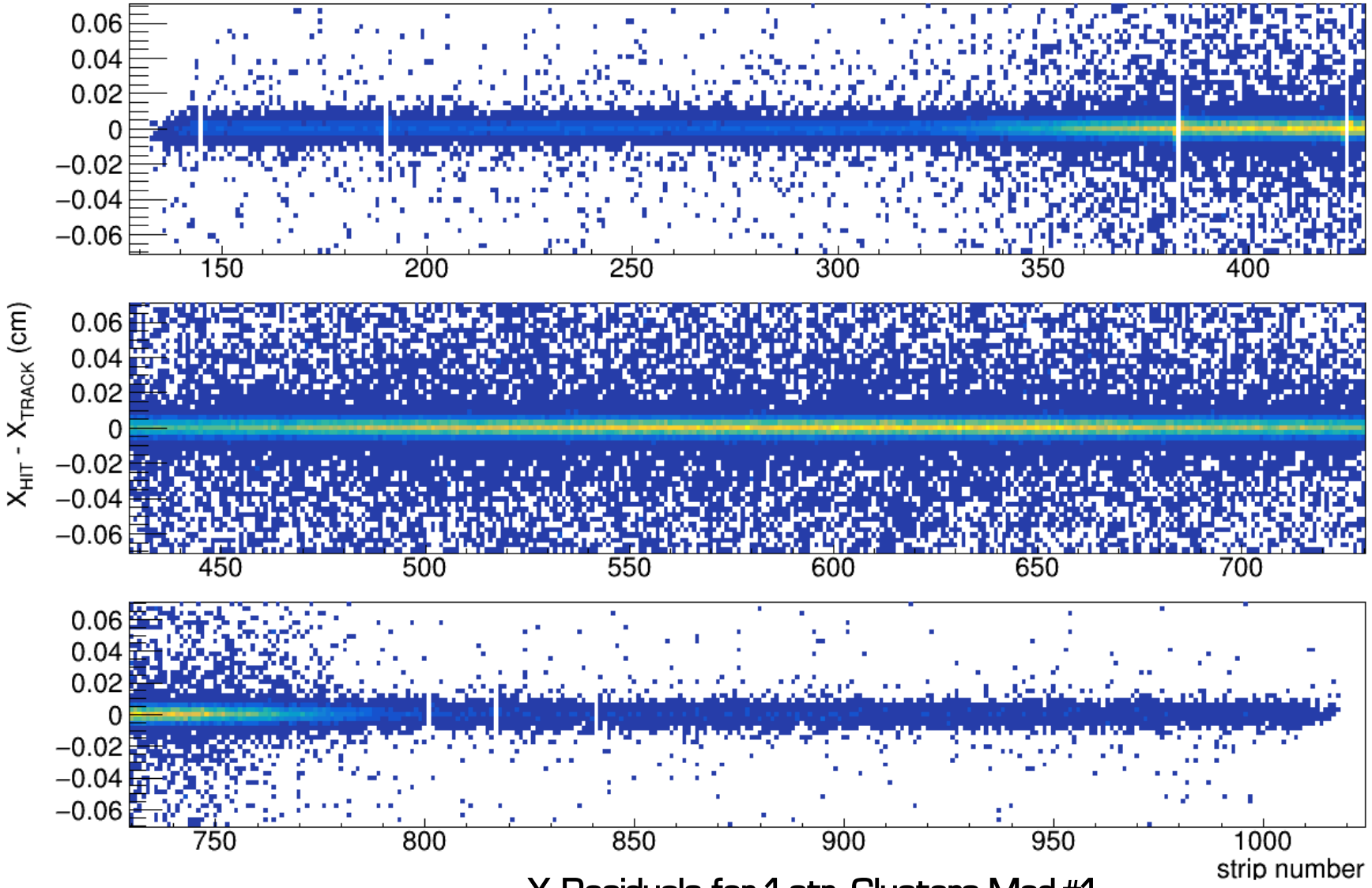


Cluster Amplitudes for P and N sides



XX & YY correlations between #1 & #2

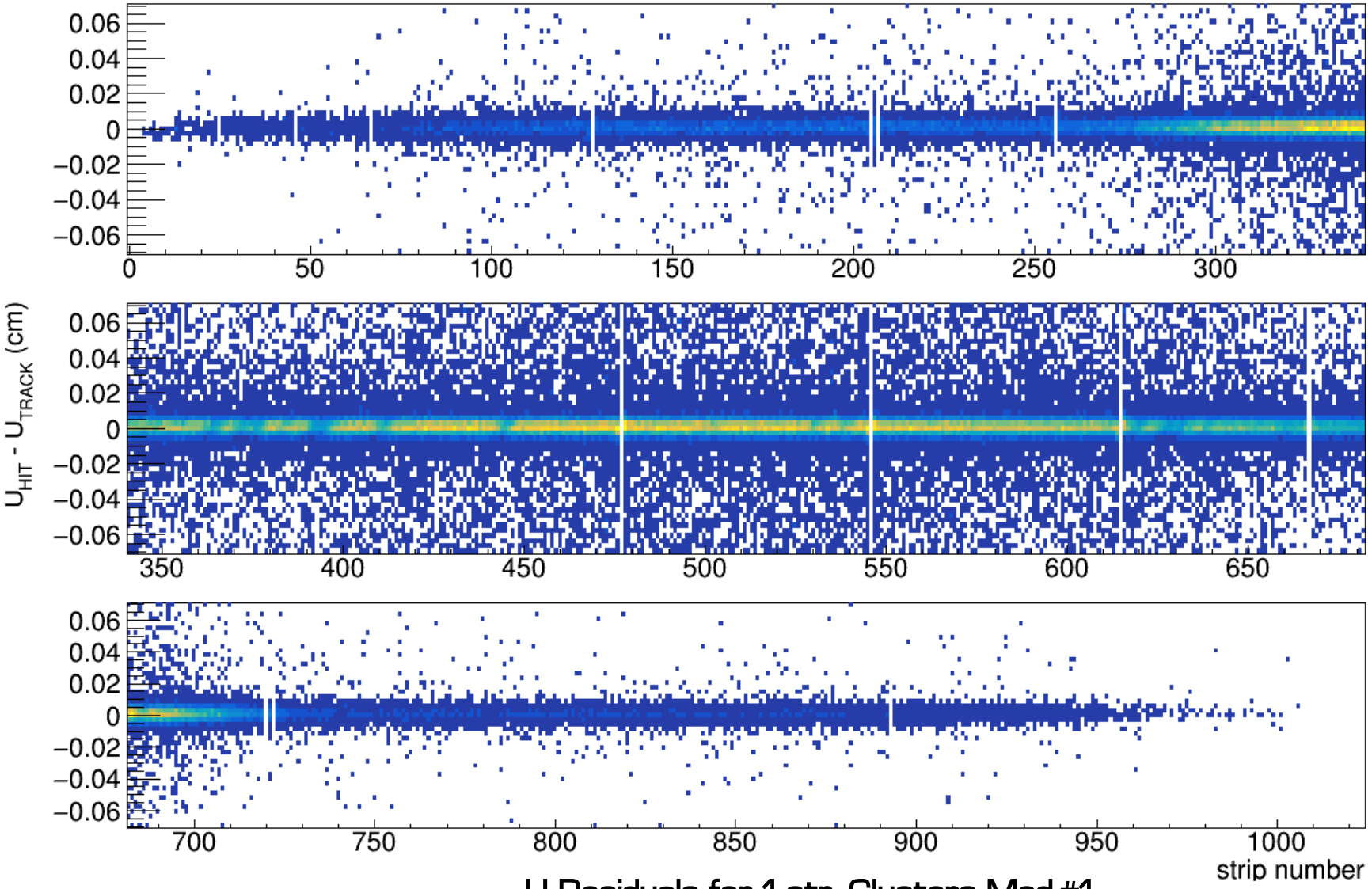
Residuals distribution for 1-strip clusters



X Residuals for 1-str. Clusters Mod.#1

I. Rufanov

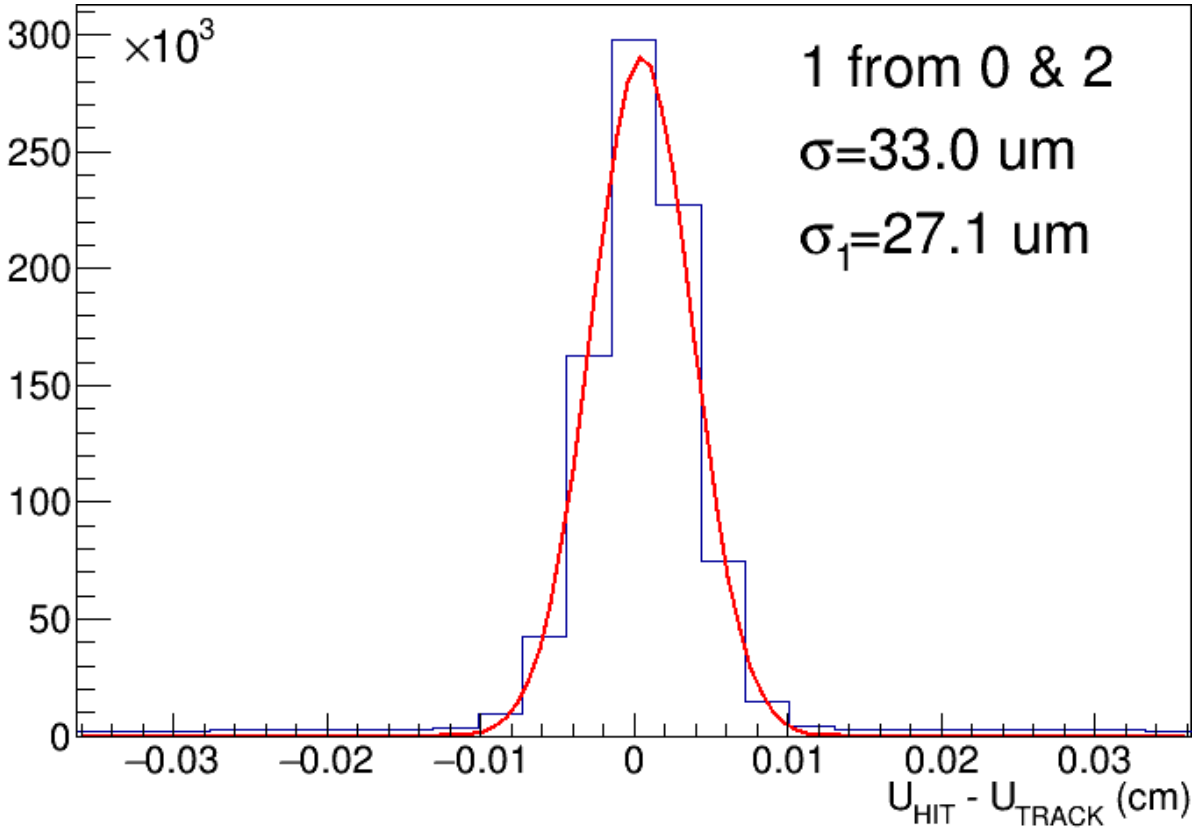
Residuals distribution for 1-strip clusters



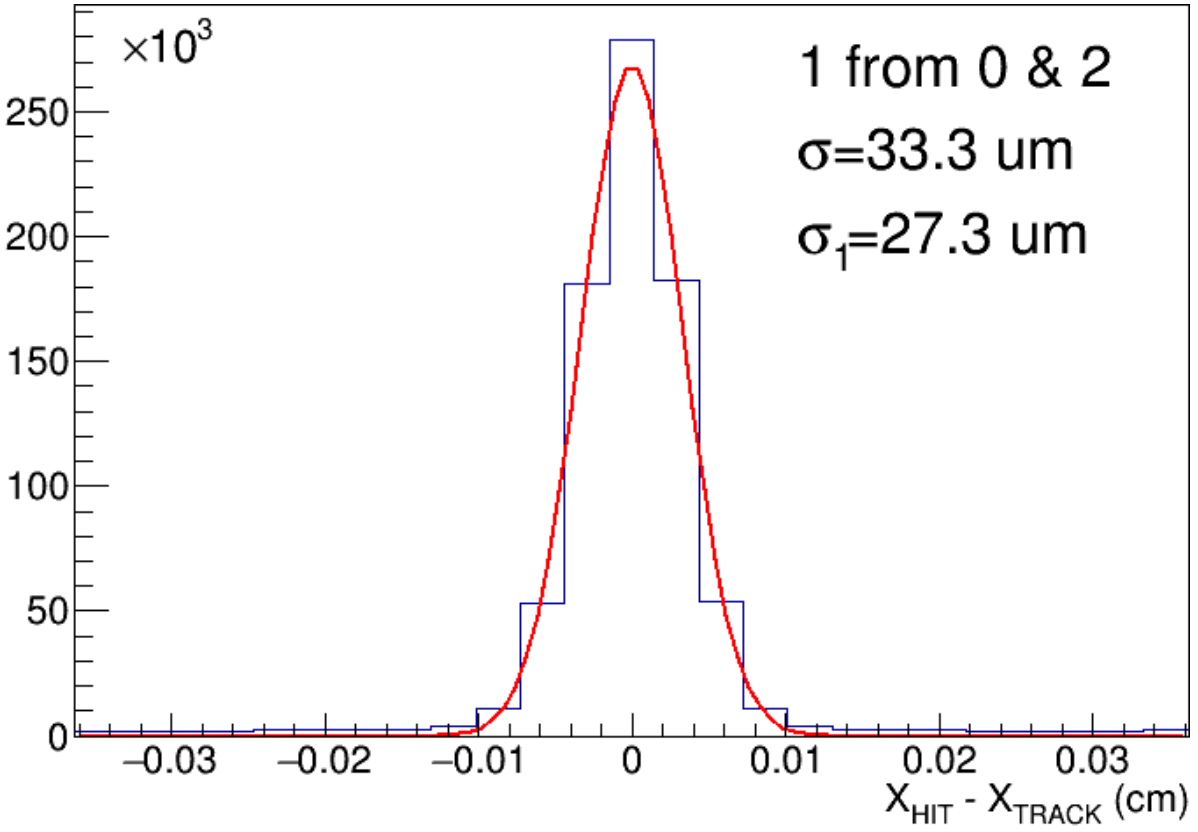
U Residuals for 1-str. Clusters Mod.#1

I. Rufanov

Spatial resolution



U Residuals for Mod.#1



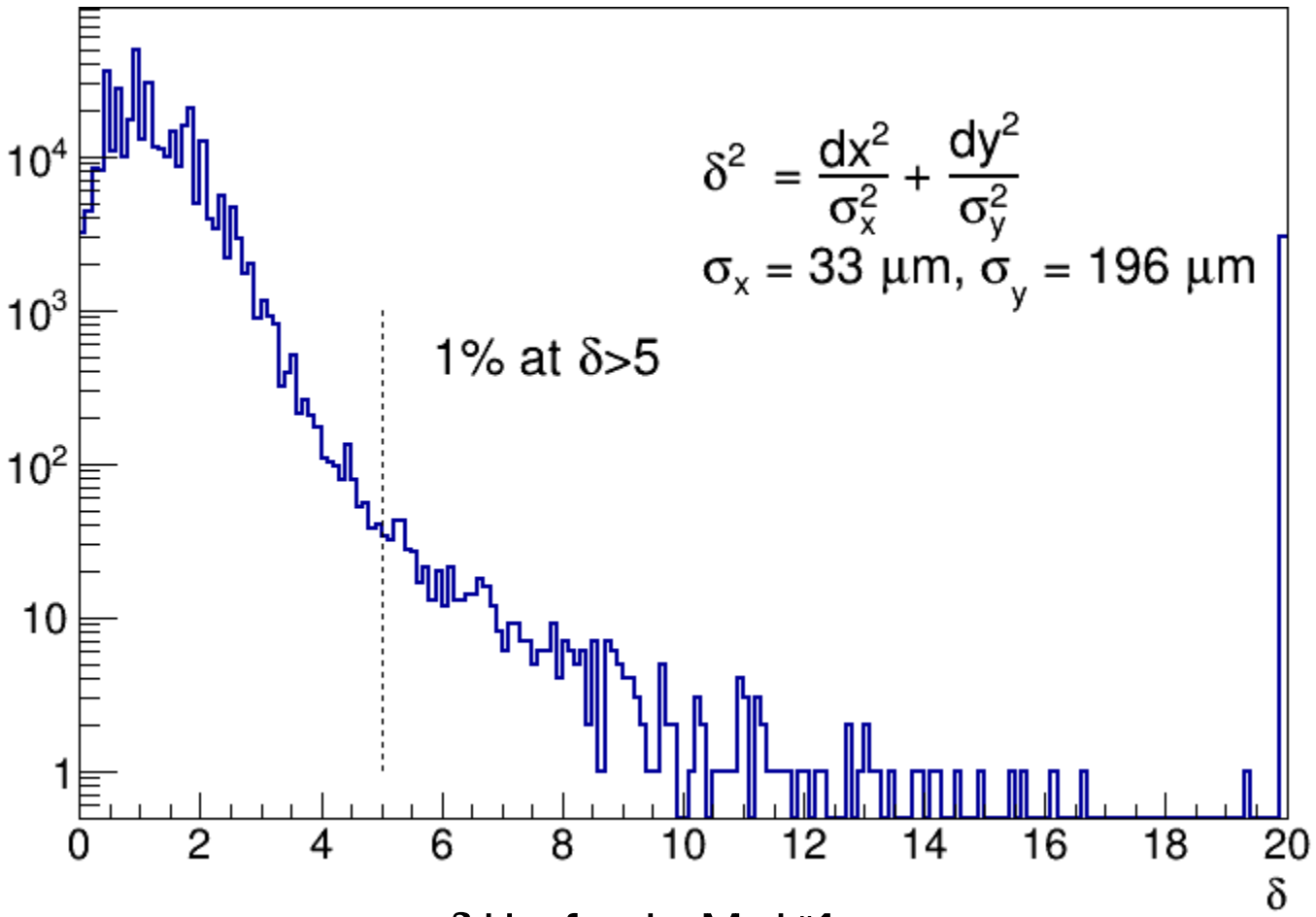
X Residuals for Mod.#1

Dead and 3 neighboring channels were excluded from the analysis

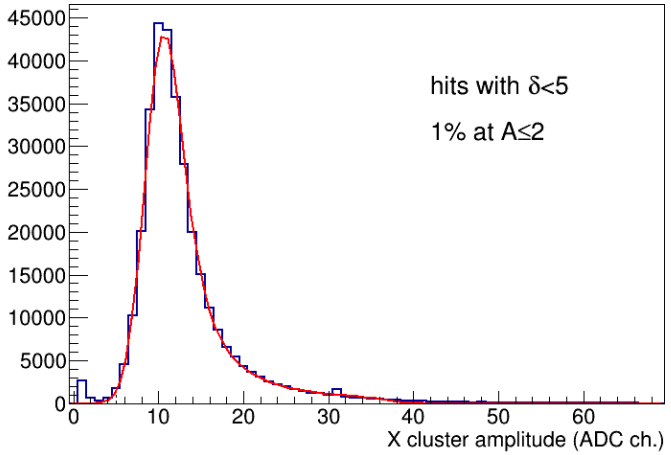
MODULE#	0	1	2	3
σ_X	27.2	27.3	27.2	35.5
σ_U	27.0	27.1	27.0	35.3

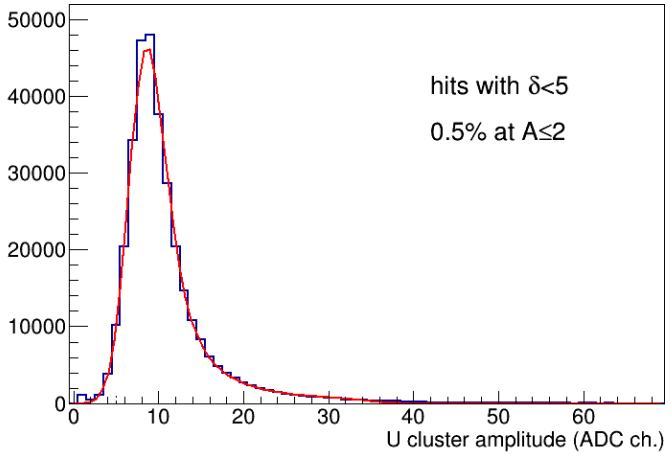
I. Rufanov

Hit Registration Efficiency



δ hits for the Mod.#1





Amp. distr. for hits with δ<5 (Mod.#1)

Dead and 3 neighboring channels were excluded from the analysis
Efficiency ~99%

I. Rufanov

GbtxEmu SEU test

FPGA based interface between the Front-End Electronics and the Data Processing board:

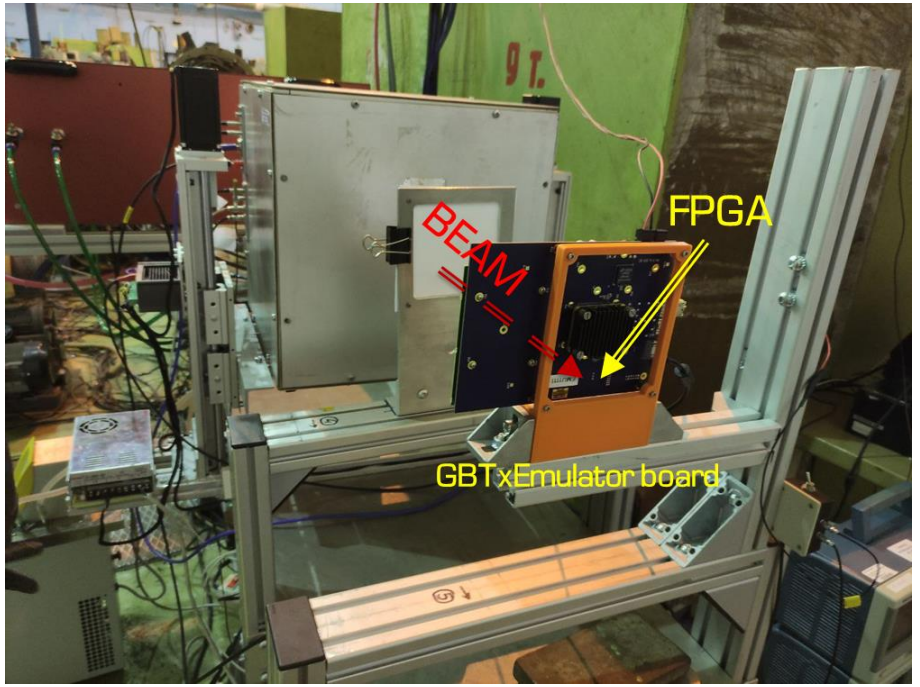
- Provides GBTx ASIC functionality;
- Fast time deterministic transport of downlink massages;
- high-speed transmission of hit data in the uplink direction;

Artix7 FPGA

Detection and correction of SEUs in CRAM was performed with the help of SEM IP-core.

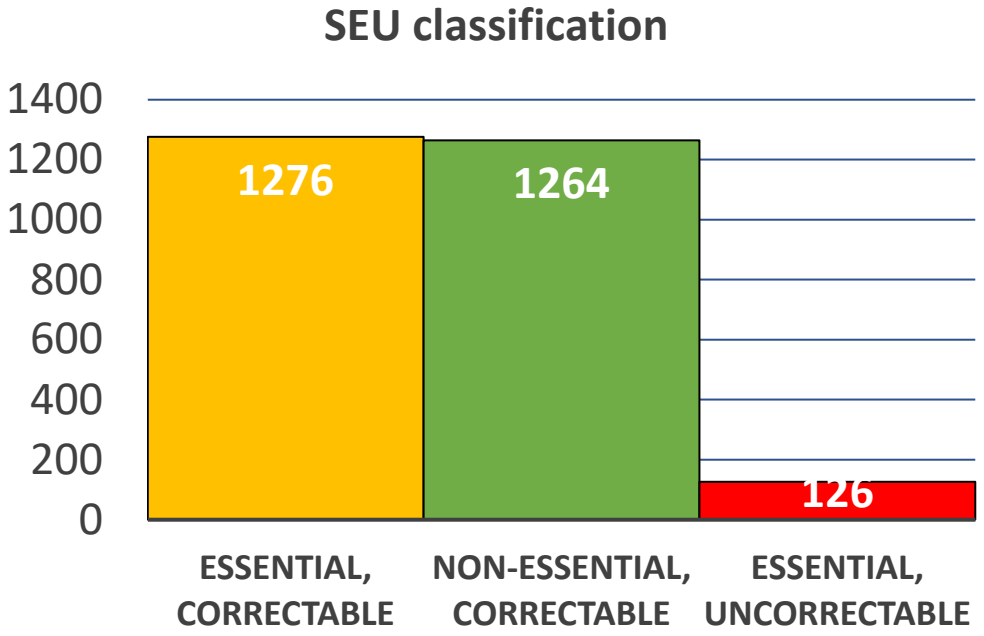
Controlled parameters:

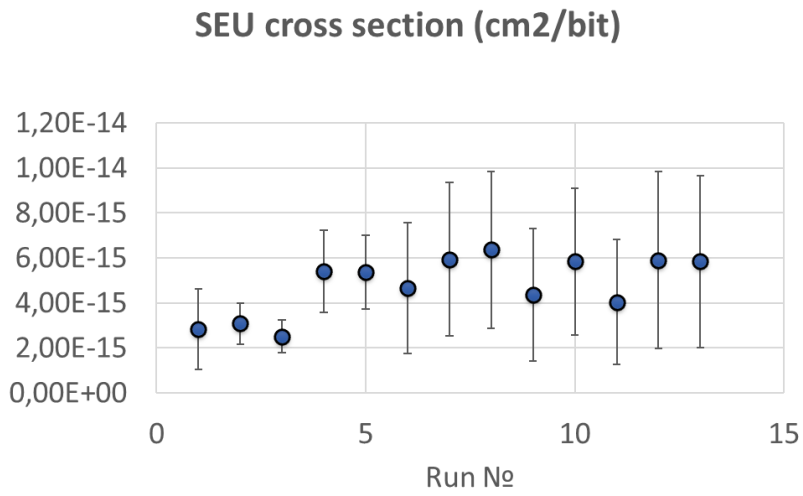
- SEU CRAM rate;
- Error classification;
- Power supply current;
- Flux

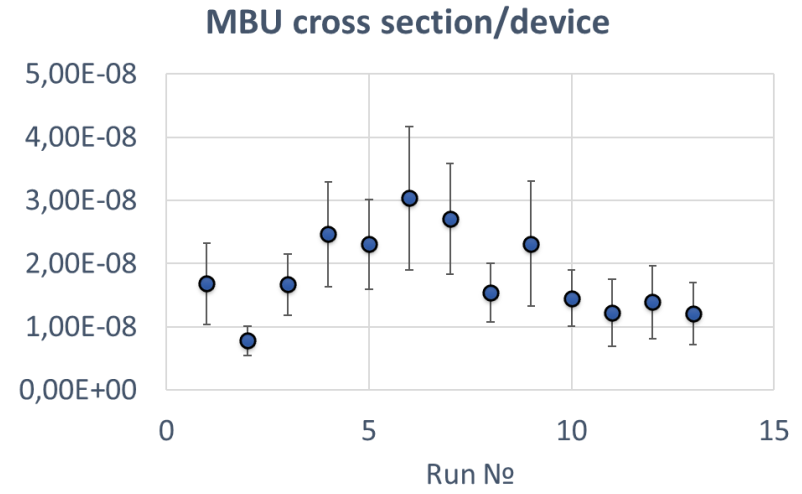


M. Shitenkov

SEU & MBU Cross Sections







- Total: 2666 SEU; 126 MBU;
- Fluence (per die): $5,7*10^{10}$
- TID: 1,18 kRad

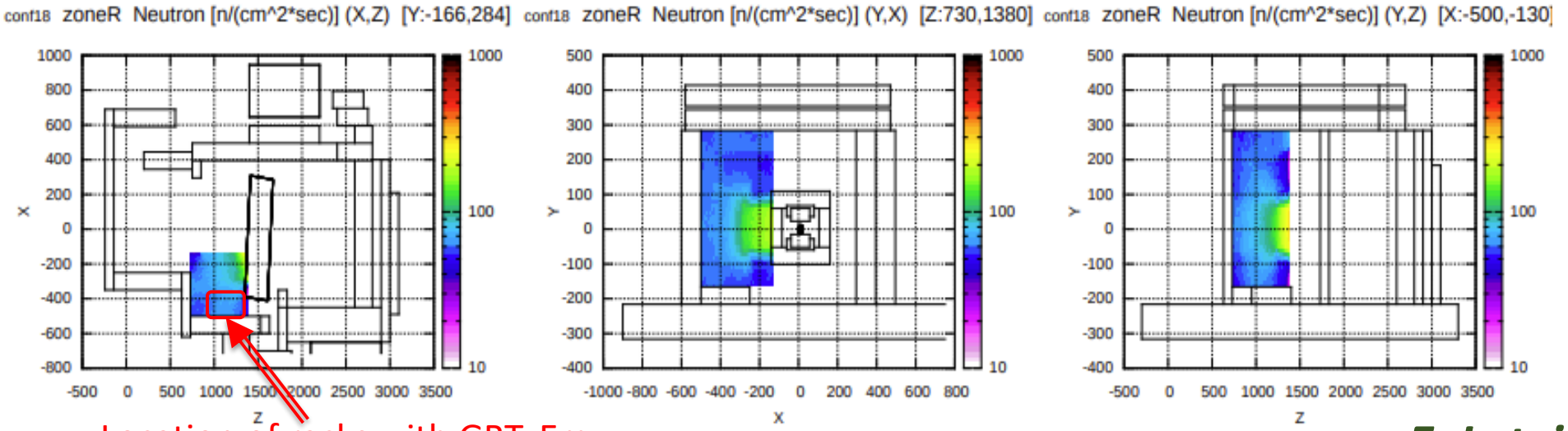
SEU Cross Section: (3,94 ± 2) E-15 cm^2/bit
MBU Cross Section: (2,58 ± 1.3) E-16 cm^2/bit

M. Shitenkov

SEU rate in BM@N environment

Time: 5 years with 3 months beam time each

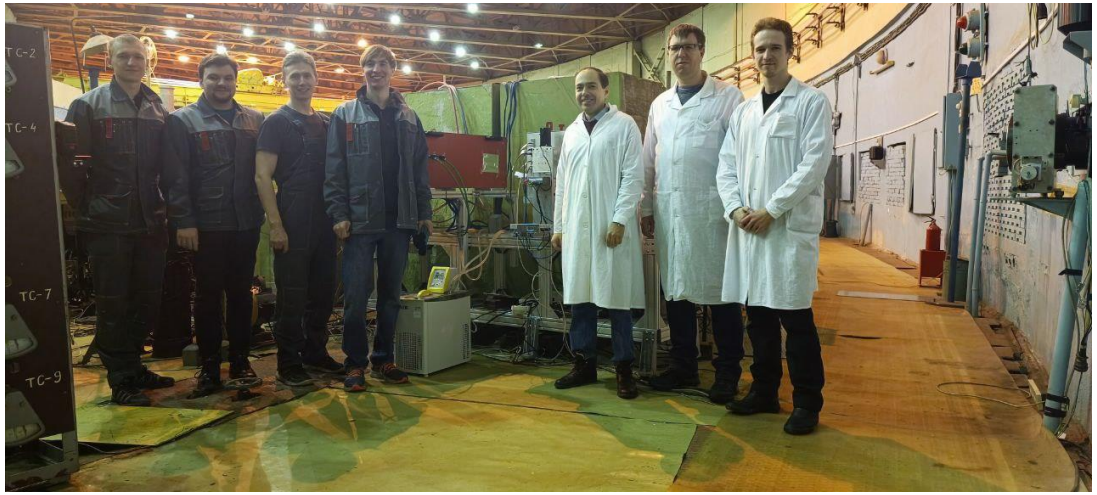
- **TID:** 40 Rad;
- **NIEL:** $4*10^9$ n/cm ;
- **Neutron flux:** 100 $cm^{-2}s^{-1}$
- **Hadron flux (>20 MeV): 1** $cm^{-2}s^{-1}$
- **MTBF** (mean time between failures): **8**h (recoverable), **126** h (unrecoverable)



E. Letvinenko

Conclusion

- First in-beam test at PNPI finished successfully: 48h of data taking, 250M events collected;
- Four STS modules based on DSSD operated stable;
- Data driven readout electronics of STS was operated and tested in the beam in the triggered mode for the first time;
- Synchronous data collection with MAPS detectors was performed for the first time. Tracking analysis is undergoing;
- Operation of the FPGA based GBTx Emulator board in the radiation environment was tested. Usage of the board with existing firmware in BM@N environment was proved;



Thank you for your attention