FRONT-END ELECTRONICS FOR TPC MPD/NICA

A.Averyanov, S.Chernenko, G.Cheremukhina, F.Levchanovskiy, S.Movchan, S.Vereschagin, Yu.Zanevsky and S.Zaporozhets

TPC/MPD Collaboration

Laboratory of High Energy Physics, JINR, Dubna

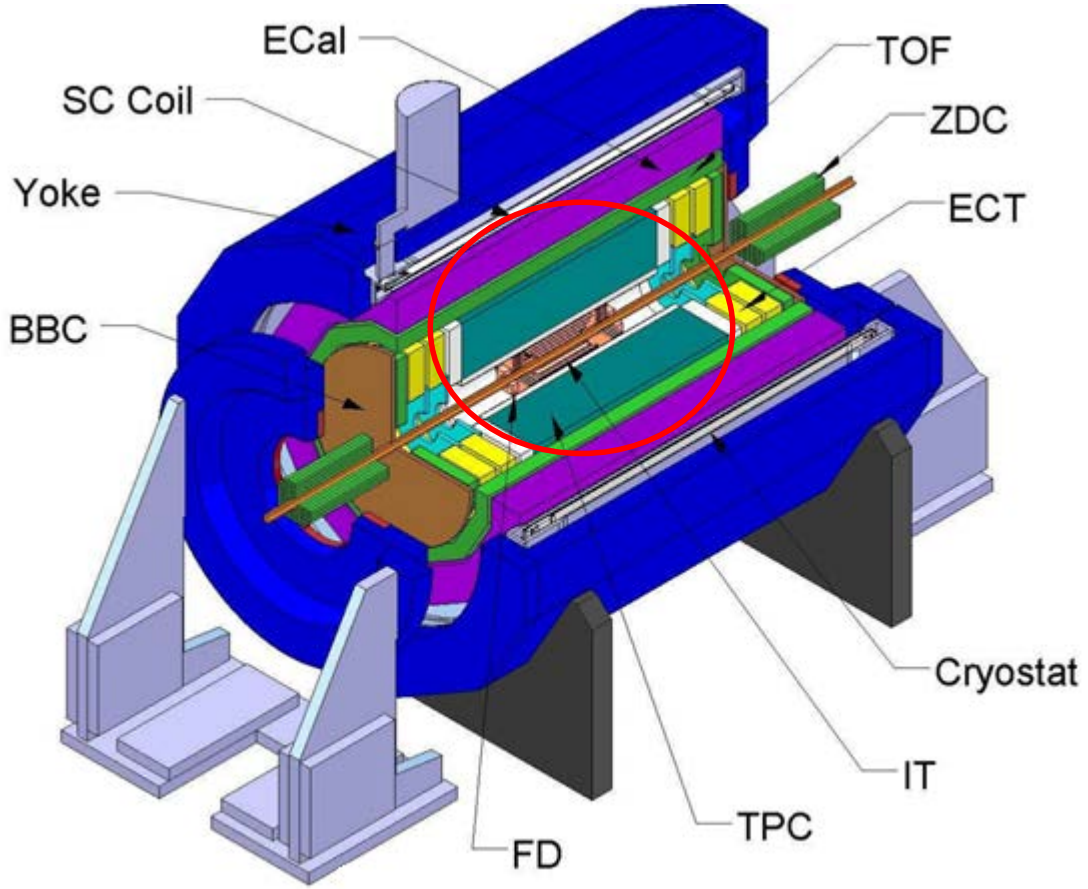
Alushta, June 11, 2015

CONTENS

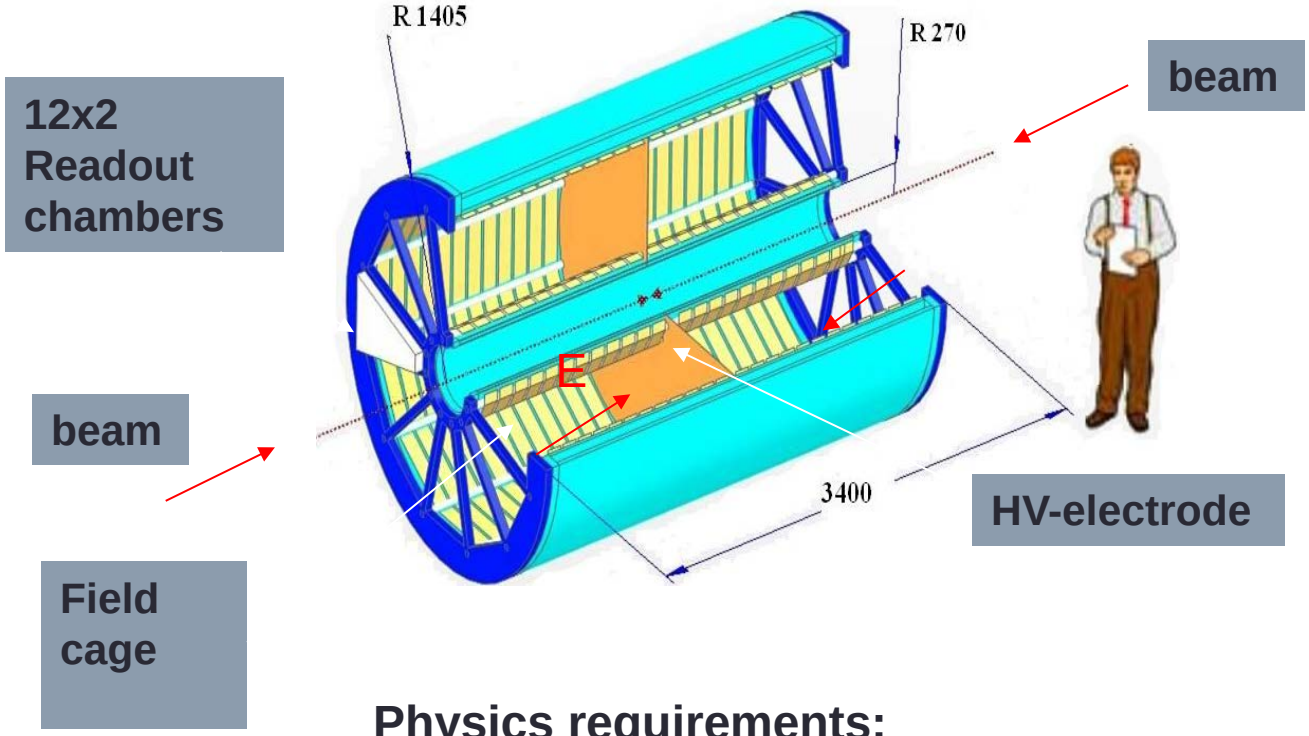
- Introduction (MPD setup, TPC design overview and general characteristics)
- Main parameters and base of the FEE TPC
- FEE prototype
- Testing of FEE
- FEE for one readout chamber
- Conclusions

General view of the MultiPurpose Detector (MPD) NICA project

- SC Coil - superconductor solenoid
- IT - inner detector
- ECT - straw-tube tracker
- TPC - time-projection chamber
- TOF - time-of-flight stop counters
- FD - The fast forward detectors
- ZDC - zero degree calorimeter
- BBC - beam-beam counter



TPC design overview



Physics requirements:

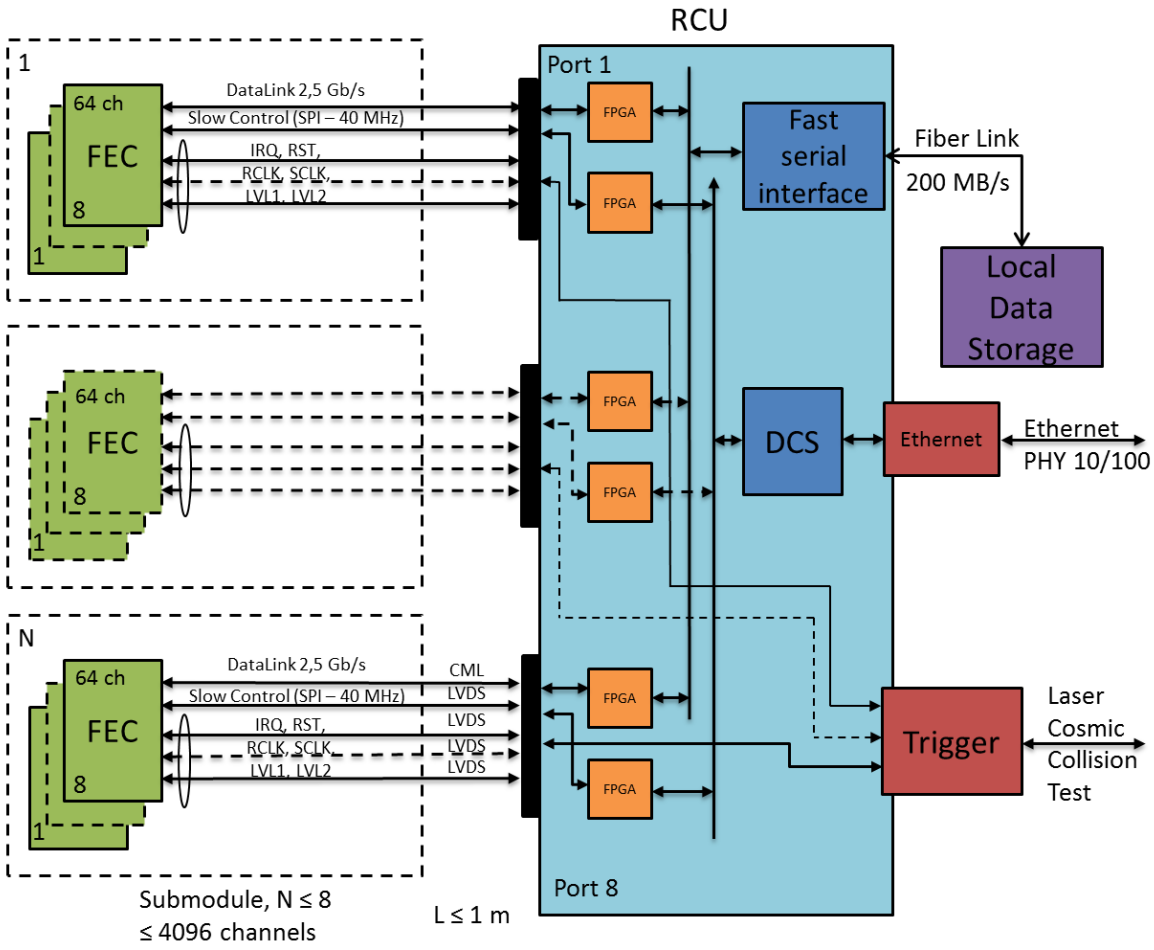
The overall acceptance on $|\eta| \sim 1.2$
The momentum resolution ~ 3% in p_t interval from 0.1 to 1 GeV/c
Two-track resolution ~ 1 cm.
Charged particle multiplicity ~ 1000 in a central collisions
Hadron and lepton identification by dE/dx measurements with resolution better than 8%

Main parameters of the FEE TPC

Significant data volume makes a special demands to the FEE. Electronics is designed with a modern technologies.

- ✓ Total number of channels - 95 232
- ✓ Mean data stream from whole TPC – 10 GB/s
- ✓ Low power consumption – less then 100 mW/ch
- ✓ Fast optical transfer interface
- ✓ Based on ASIC and FPGA

Block diagram of FEE base



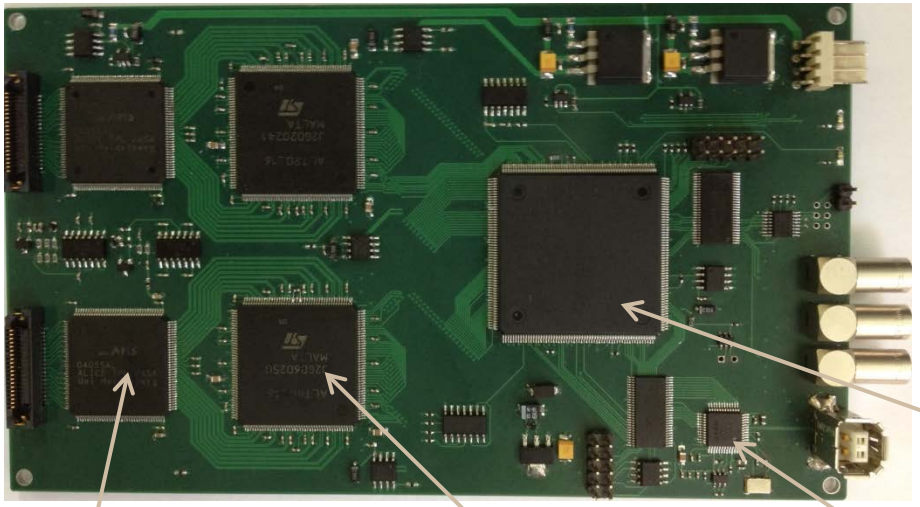
Total number of ch.- 95 232

Total number of FECs - 1488

Total number of RCU - 24

Front-End Electronics prototype

FEC-64 channels



- Signal to noise ratio, S/N - 30
- $\sigma_{NOISE} < 1000e^-$ (C=10-20 pF)
- Dynamic Range - 1000
- Zero suppression
- Buffer (4 / 8 events)

4 PASA chip
16 channels ASIC
(low noise amplification of the signal)

4 ALTRO chip
16 channels ASIC
(digitization and signal processing)

ALTERA FPGA - board control

FTDI USB2.0
(prototype only)

FECs stress tests and debugging FPGA firmware

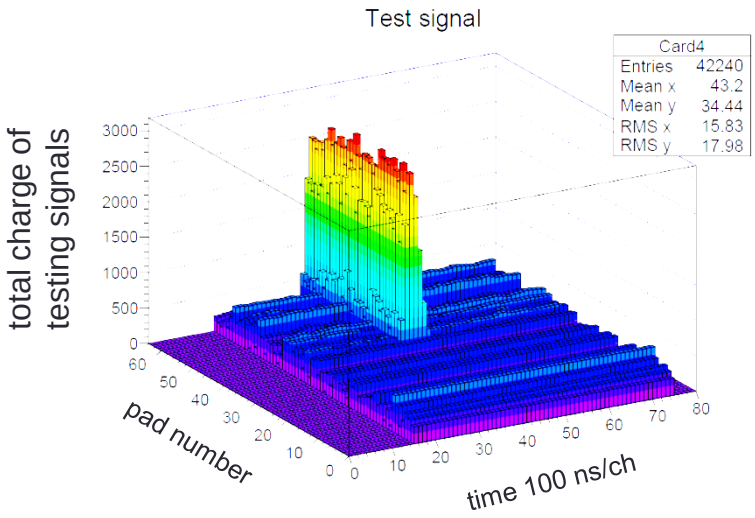
Main functionality tests were performed during 3 months at 8 hours per day.

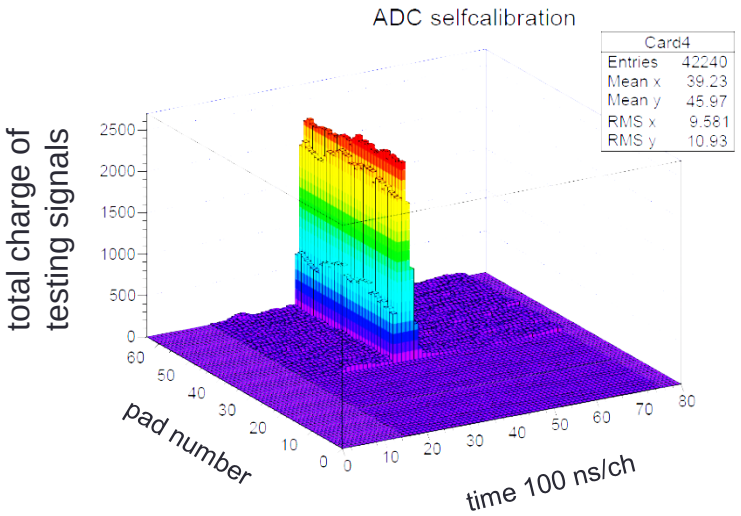
The following operation conditions are tested:

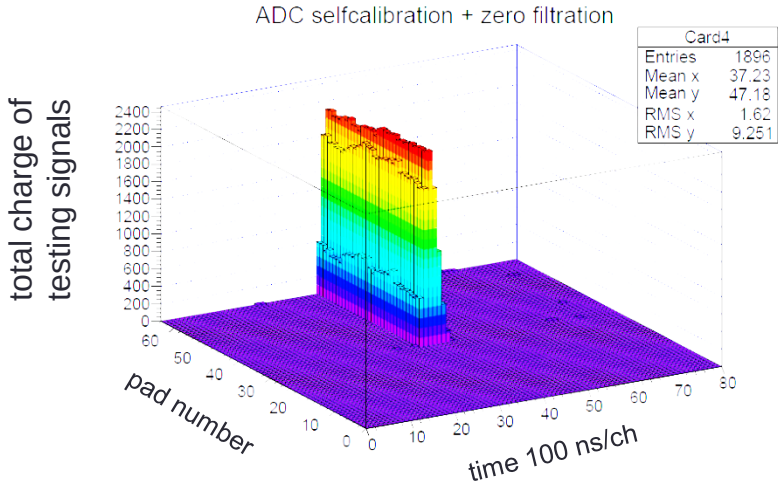
- «With baseline correction»;
- «Without zero suppression» (big event volume);
- Trigger rate variate from 10 Hz to 3 kHz;
- With number of ALTRO buffers from 1 to 8;
- «Stream mode»;
- «Receive event after event»;

Event real-time checking (less then 0.3 % of errors);

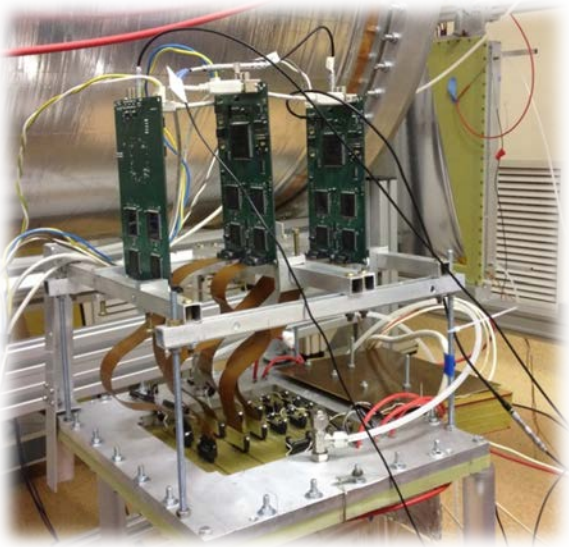
Testing FECs on the test bench with signal generator







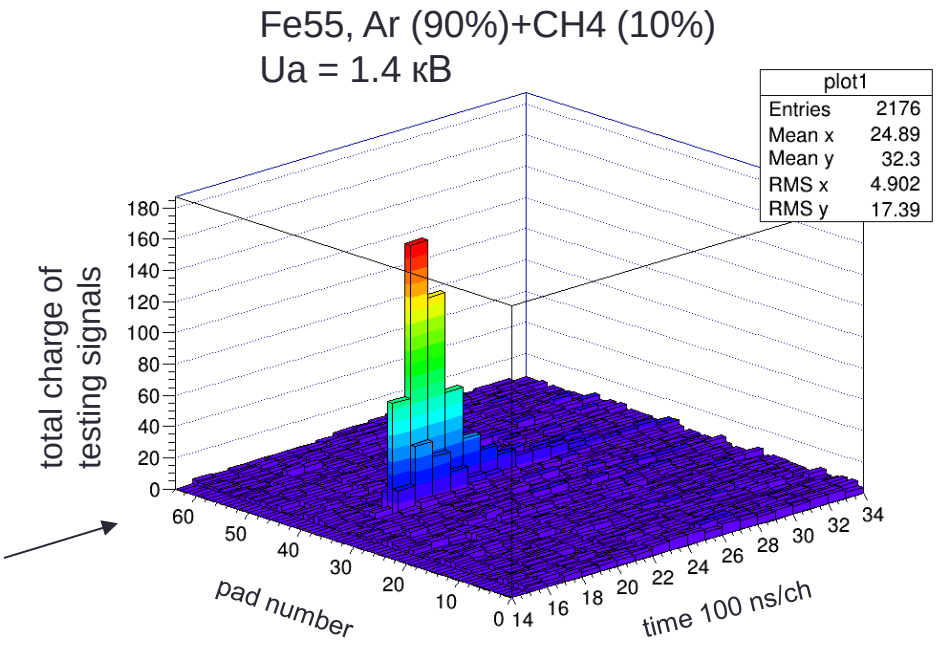
Testing of 3 FECs on readout chamber prototype



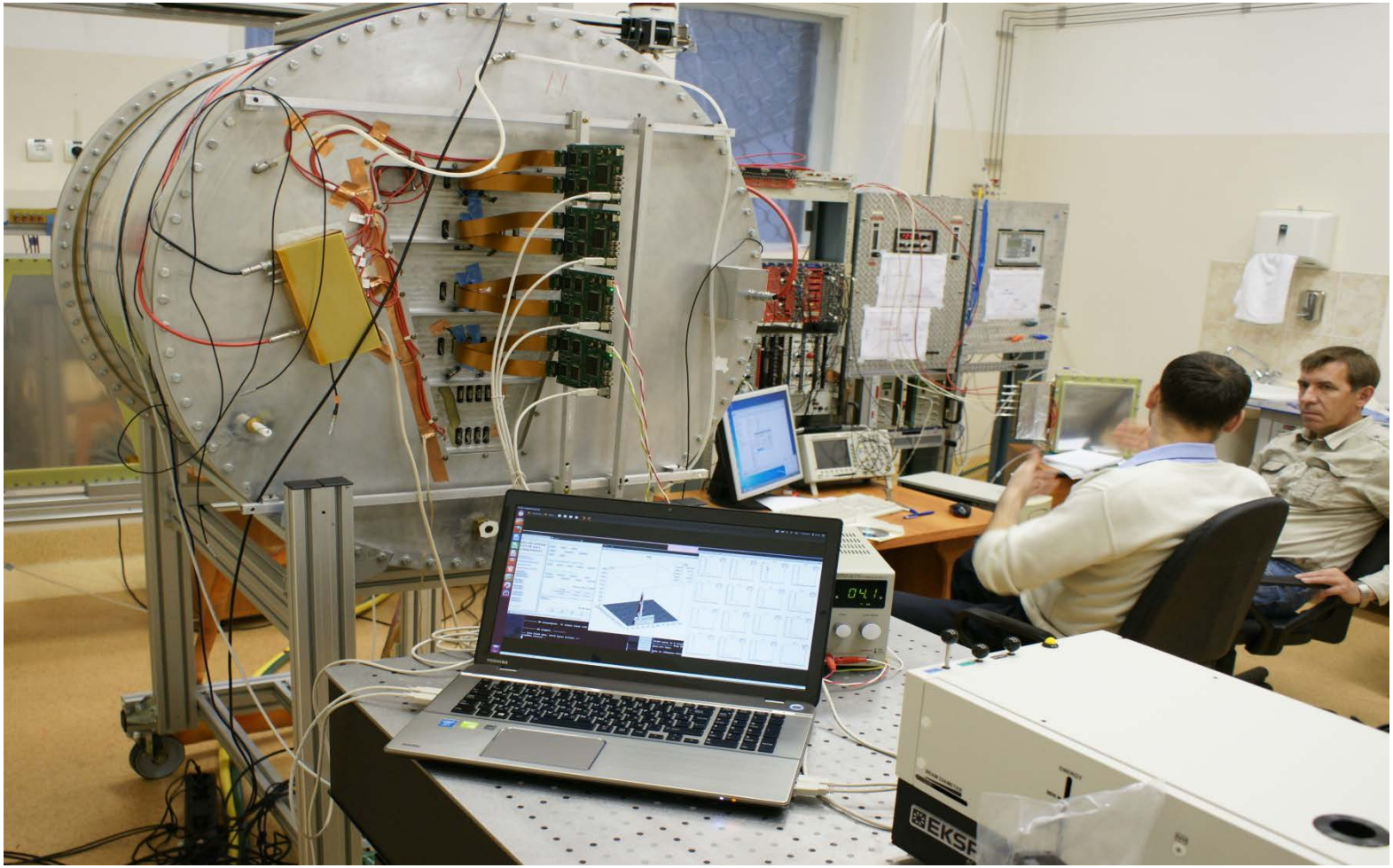
Readout chamber prototype

- Trigger from anode wires
- γ quantum ~ 400 Hz
- Total number of channels 64x3
- Event collection with different collimators

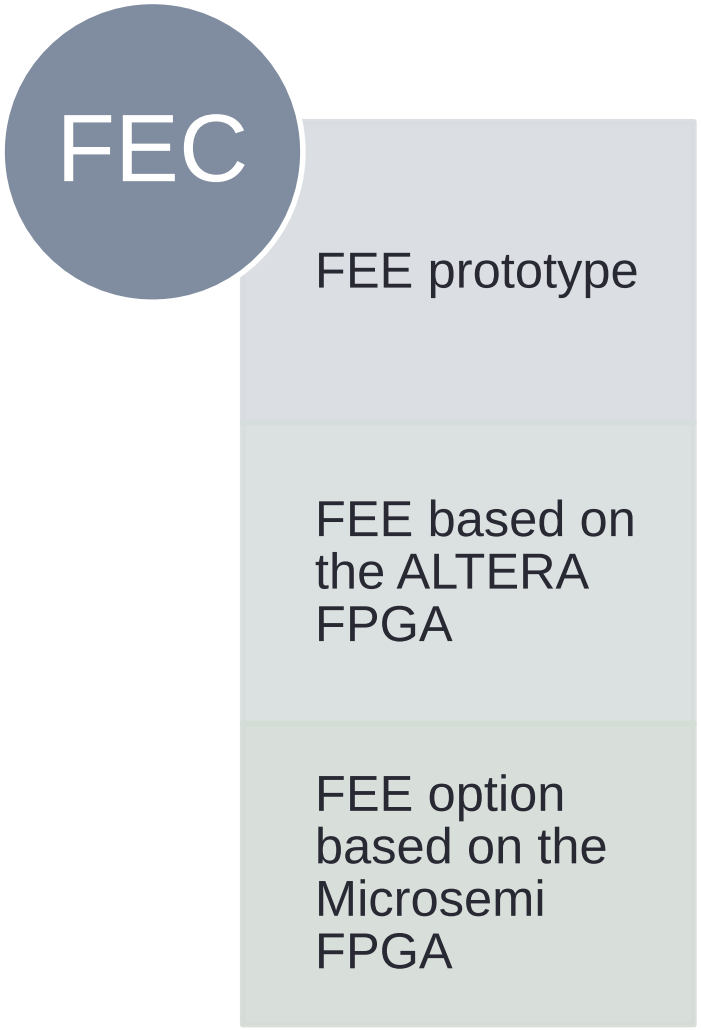
γ quantum value with energy E= 6 kEv which fell on the middle of pad 36

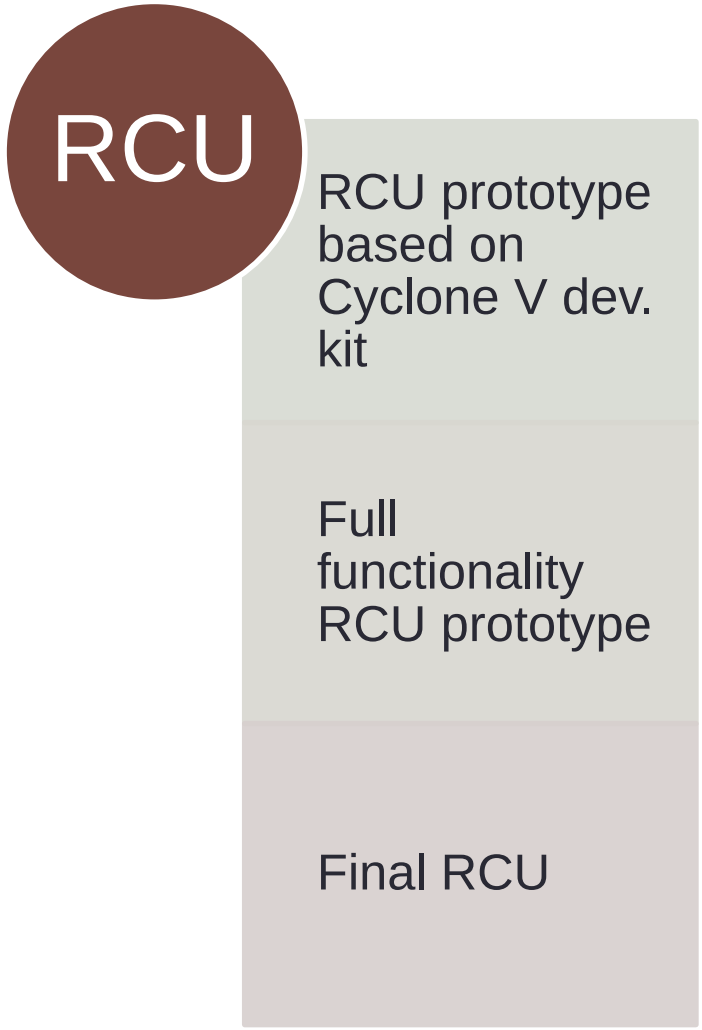


FEE Testing



Status of FEE design





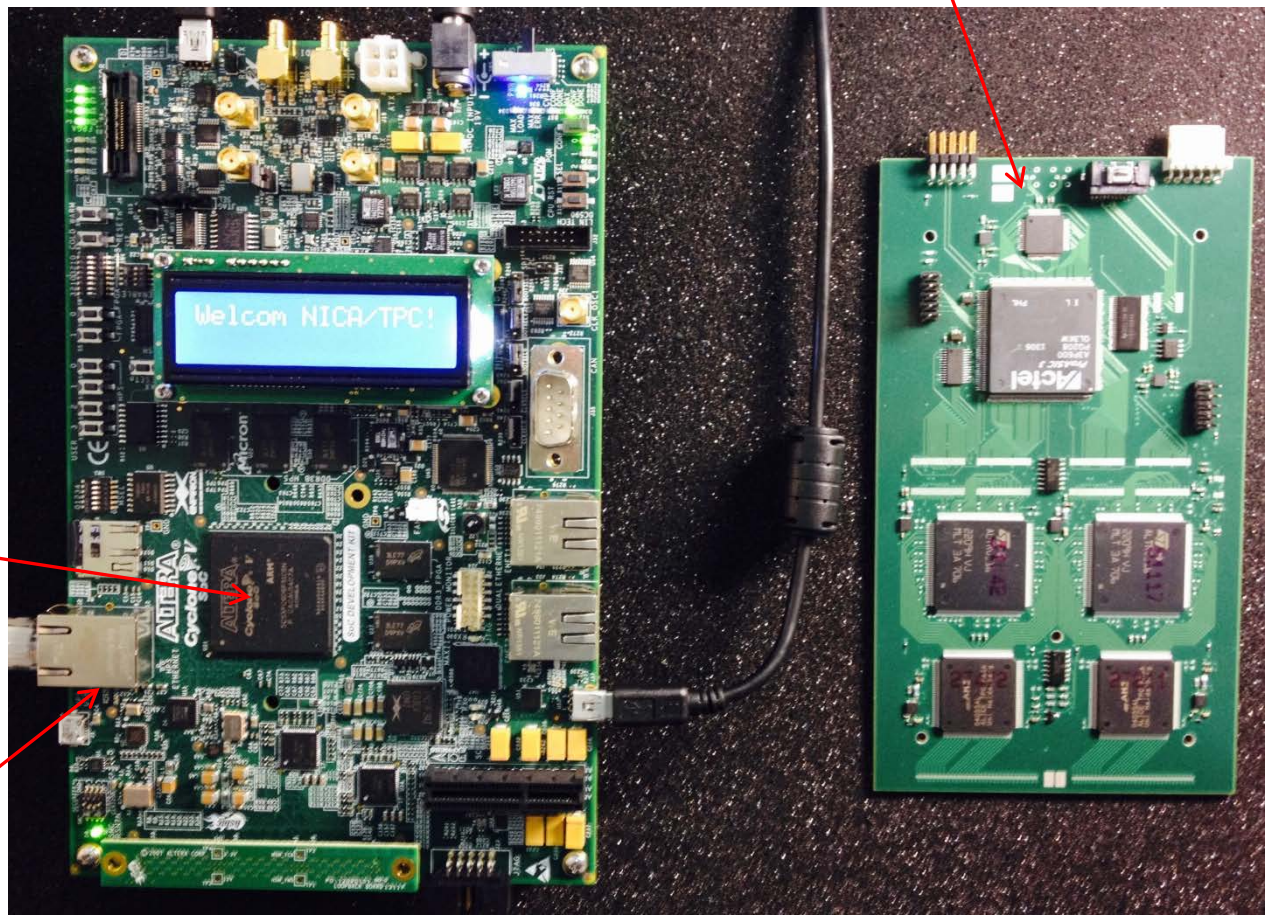
FEE for one readout chamber

High-speed transceiver 2.5 Gb/s

Readout control unit prototype based on the ALTERA Cyclone V SX SoC Development Board

Cyclone V 5CSXFC6D6F31C6N Chip with high-speed transceivers and embedded HPS

1Gb/s Ethernet



Future possible improvement

- New ASIC chip is under development in CERN
- ALICE and STAR have FEE upgrade projects based on that ASIC
- Dubna team is participating in chip testing to understand its feasibility for NICA TPC FEE

Conclusion

- ✓ Base FEE concept was developed
- ✓ 6 Prototype cards have been designed, produced & tested
- ✓ New FECs was designed
- ✓ Testing and debugging of new cards is ongoing
- ✓ RCU prototype based on ALTERA Cyclone V dev. board is almost finished
- ✓ We consider deferent ways to improve our system

I’d like to thanks for help:

Alexander Moskovsky (JINR)
Alexander Pilyar (JINR)

Thank you for your attention!

Main parameters of the TPC

Length of the TPC	**340 cm**
Outer radius of cylinder	**140 cm**
Inner radius of cylinder	**27 cm**
Length of the drift volume	**170cm (of each half)**
Magnetic field strength	**0.5 Tesla**
Drift gas	**90% Ar+10% CH_4**
Temperature stability	**0.5°C**
Gas amplification factor	**~ 10^4**
Number of readout chambers	**24 (12 per end plate)**
Pad size	**5x12mm^2 and 5x18mm^2**
Number of pads	**95 232**
Pad raw numbers	**53**
Maximal trigger rate	**~5 kHz**
dE/dx	**better than 8%**
Δp/p	**~ 3% in 0.1< p_t<1 GeV/c**