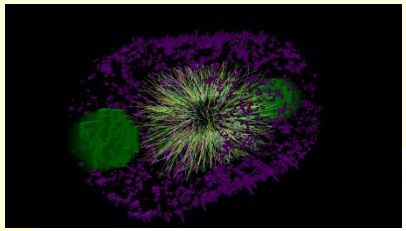
MPD/NICA TPC status (30.01.2020)

- TPC parameters
- TPC cylinders
- ROC chambers
- front end electronics
- gas, cooling, laser and SC systems
- cabling and tubing
- integration TPC to MPD
- time schedule

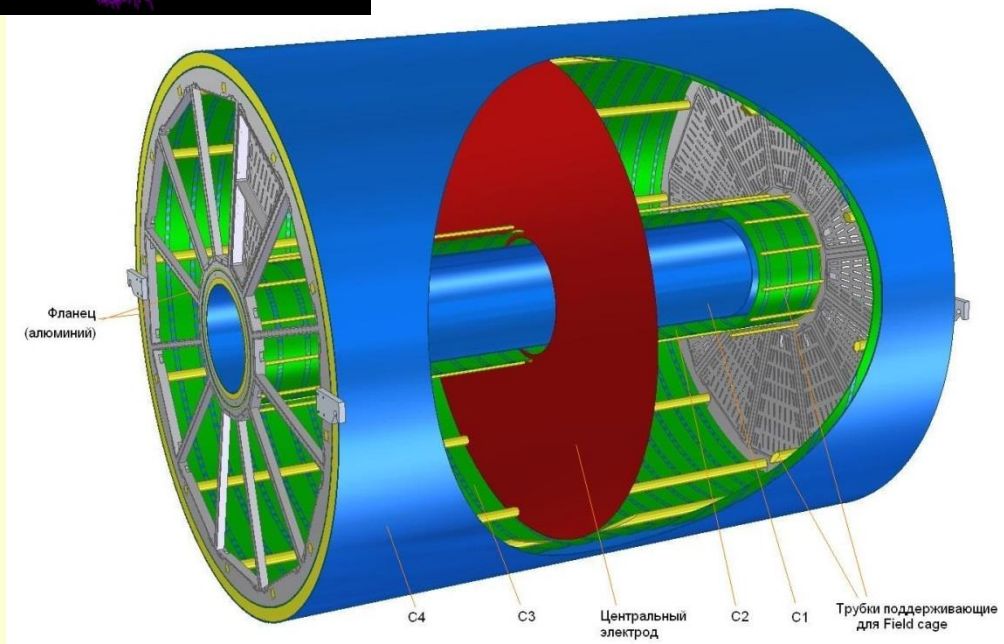
Presented by Sergey Movchan

JINR team: 24 persons
Belarus: 6 persons
(INP BSU- ARTMASH: K.Afanasiev, V.Baev, Yu.Fedotova A.Litomin, S.Savitskiy, V.Tchekhovskiy)

MPD TPC parameters



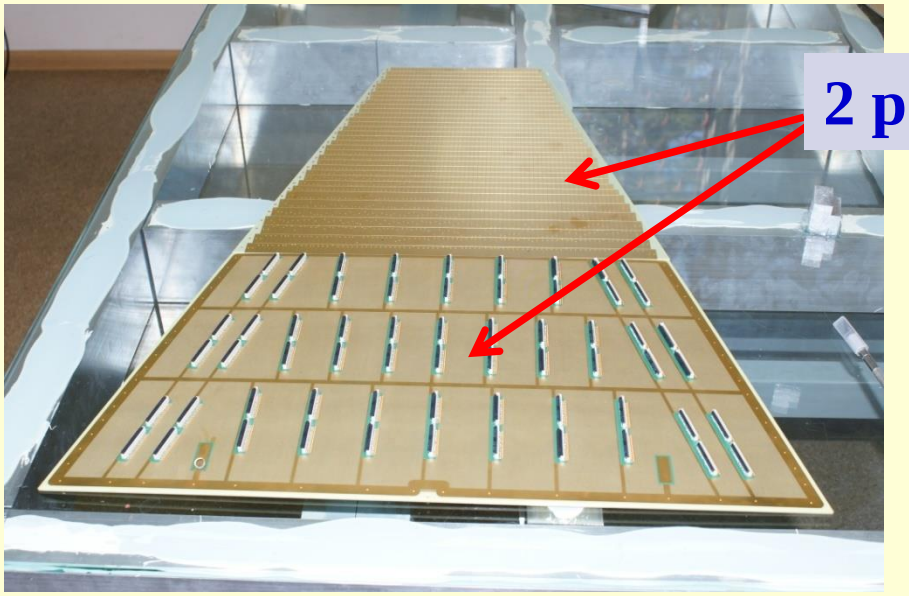
Корпус TPC/ MPD



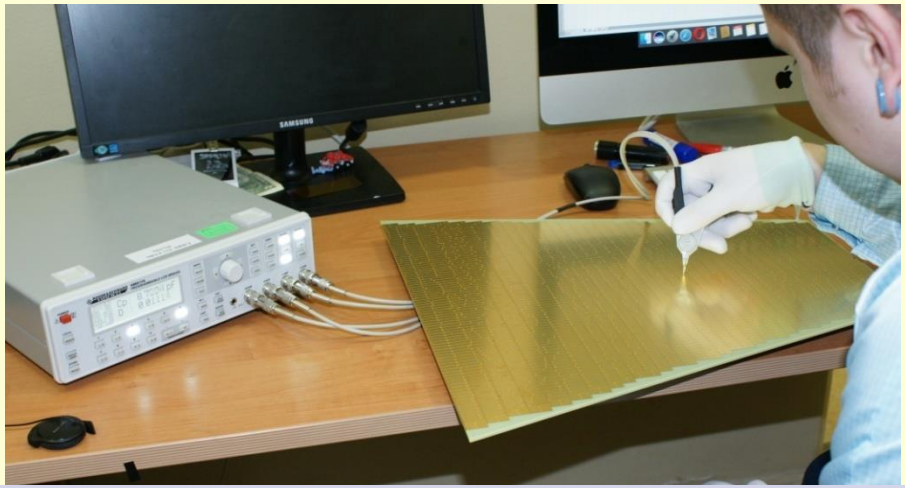
TPC TDR – http://mpd.jinr.ru/wp-content/uploads/2019/01/TpcTdr-v07.pdf

Item	Dimension
Length of the TPC	340cm
Outer radius of vessel	140cm
Inner radius of vessel	27 cm
Outer radius of the drift volume	133cm
Inner radius of the drift volume	34cm
Length of the drift volume	170cm (of each half)
HV electrode	Membrane at the center of the TPC
Electric field strength	~140V/cm;
Magnetic field strength	0.5 Tesla
Drift gas	90% Ar+10% Methane, Atmospheric pres. + 2 mbar
Gas amplification factor	~ 10^4
Drift velocity	5.45 cm/μs;
Drift time	< 30μs;
Temperature stability	< 0.5°C
Number of readout chambers	24 (12 per each end-plate)
Segmentation in φ	30°
Pad size	5x12mm^2 and 5x18mm^2
Number of pads	95232
Pad raw numbers	53
Pad numbers after zero suppression	< 10%
Maximal event rate	< 7 kHz (Lum. 10^{27})
Electronics shaping time	~180 ns (FWHM)
Signal-to-noise ratio	30:1
Signal dynamical range	10 bits
Sampling rate	10 MHz
Sampling depth	310 time buckets

ROC chamber: pad plane



Pads capacitor measurement



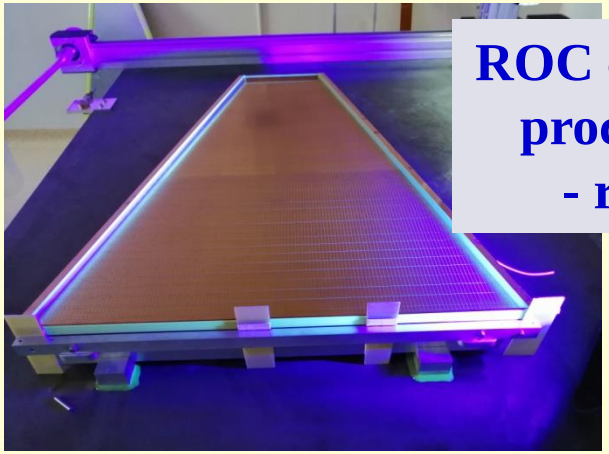
10 serial sets with soldered connectors - delivered Jan 2020

(connectivity test - in progress)

Next (last) 15pc serial pad planes - ordered

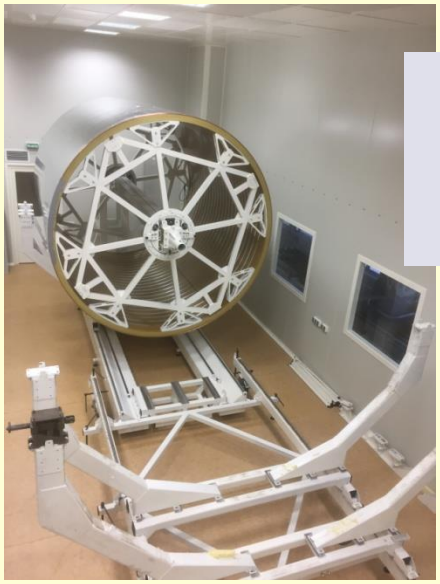
TPC and ROCs: status

26 pc
ROC frames
- in stock



ROC cleaning
procedure
- ready

10pc ROCs -
tested



C3-C4 gluing
– will be finished
Feb 07 2020

TPC and ROCs: summary

TPC assembly:

field cage rods (30 pc + 30 pc)	- in manufacture
field cage mylar strips manufacture	- Feb 2020
flanges finishing (add holes and grooves)	- Feb 2020
C3- C4 gluing	- will be finished Feb 07 2020
C1- C2 gluing	- Feb 2020
start of TPC internal structure ass.	- Dec 2019 -> Jan 2020 -> March 2020

ROC chambers:

serial ROC chambers manufacture	- in schedule (10 pc tested)
frames (26 pc)	- ready
serial pad planes (20 pc ready)	– last 15pc ordered
HV for ROC gate electrode	– design started, in progress
test chamber with 2048ch r/o system	– Sept 2019 -> Nov 2019 -> Feb 2020

TPC transportation platform and manipulator for ROC chamber installation - ready

TPC electronics requirements

Data rates:

- trigger mode – 20 GByte/sec *(N=1000 tracks)*

- continuous readout mode - 300 GByte/sec

Particle fluence *for R=35 cm & 10 years (Oct 2019 update)*:

neutrons + protons – 1011 p/cm2 per year**

e- & e+ - 2x1010 p/cm2 per year**

ions - 10 5 p/cm2 per year**

Dose:

Expected dose - 2 kRad per 10 years

SAMPA v3/v4 tested at:
*proton fluence - up to N=10**12 per cm2*
*ion fluence - up to N=10** 7 per cm2 & LET=(3-125) MeV cm2/mg*
T chip=(45-85) degree =>
SEL =1x10-7 cm2 for LET=16 MeV cm2/mg

TID and SEL - ok!

FPGA Cyclon V (technology -130 nm): 28 nm):
TID – up to 100 kRad, SEL < 0.5 sec for LET=26.6 MeV cm2/mg

TID – ok!, SEL – no so good

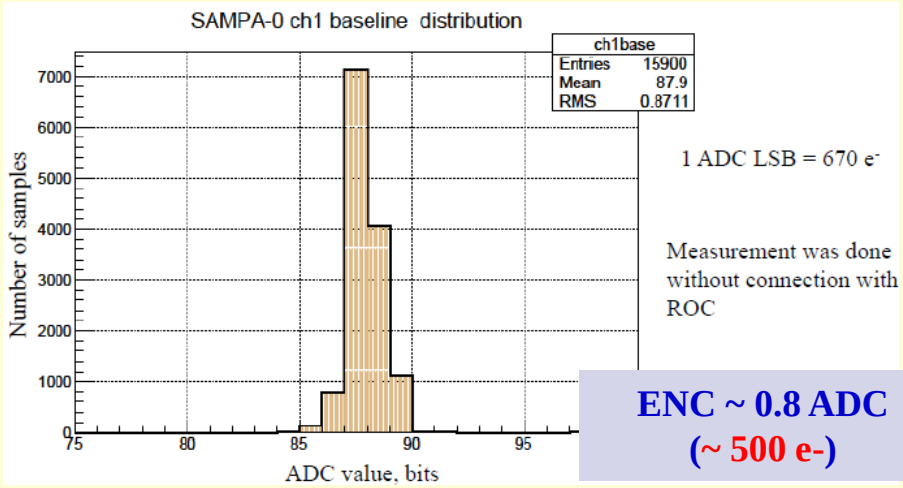
TPC electronics: FE cards

Top view (service side)

- The total number of registration channels: 64
- Input signal dynam. range: 100 fC
- ADC resolution: 10 bit
- ENC: less than 1000e$^-$
- SAMPA chips configured and controlled via FPGA
- Readout serial interface: up to 2.5 Gbps

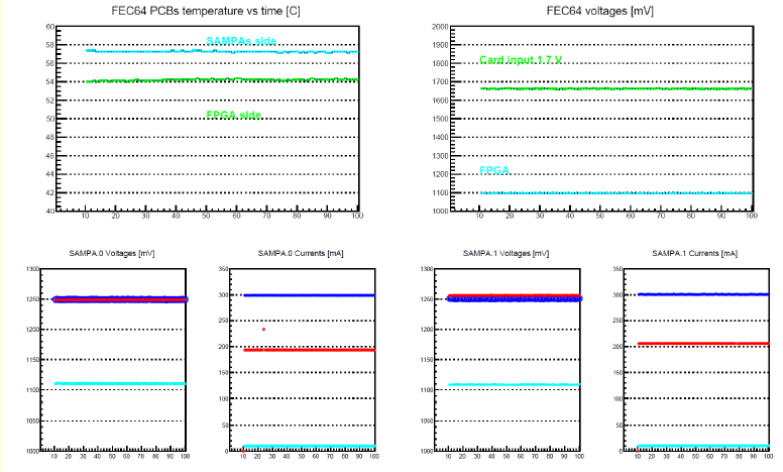
➢Double-board FEC provides opportunities for possible upgrade of the card readout.
➢Transfer of data and trigger signals was realized with the same high-speed serial interface.
➢16 values of currents, voltages and board temperatures are controlled with ADC.
➢External circuit and embedded protection functionality against SEU are provided.
➢Remote system update for FEC firmware was provided.

Bottom view (ROC side)



ENC ~ 0.8 ADC (~ 500 e-)

FEC slow control data



T SAMPA = 57 degree
T FPGA = 54 degree
Board LV: 1.7V & 1.1V
SAMPA (2 pc): 1.25V/500 mA
FPGA: 1.1V/10 mA (stand by mode)

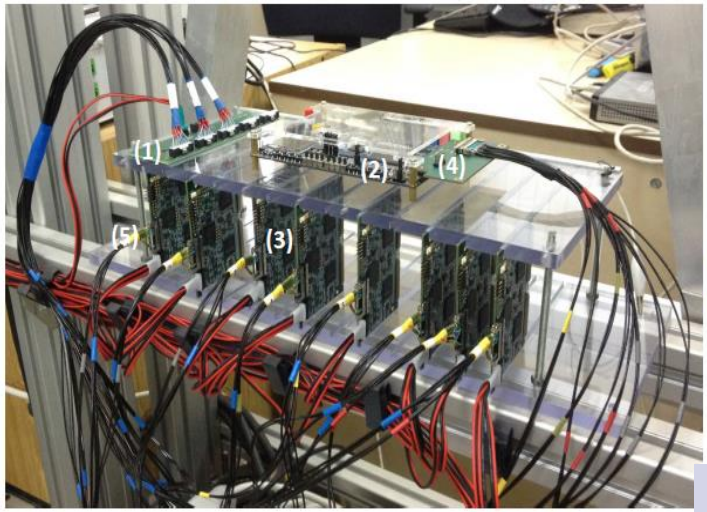
Status: in progress

TPC electronics: status

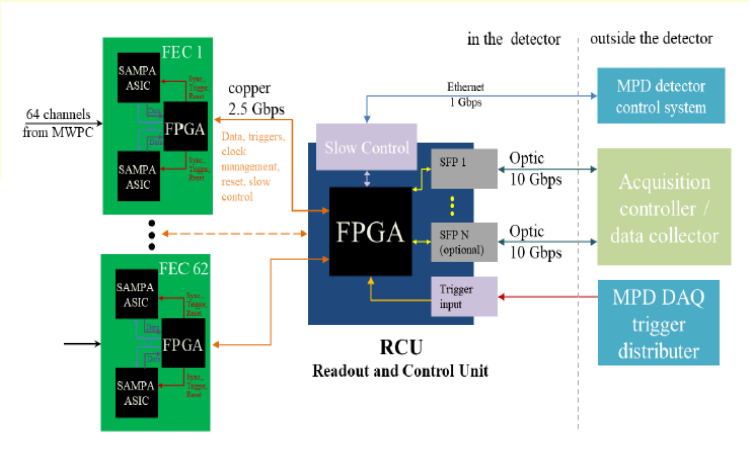
SAMPA chips (4500 pc) delivered to JINR - June 2019

Pilot system – 512 ch

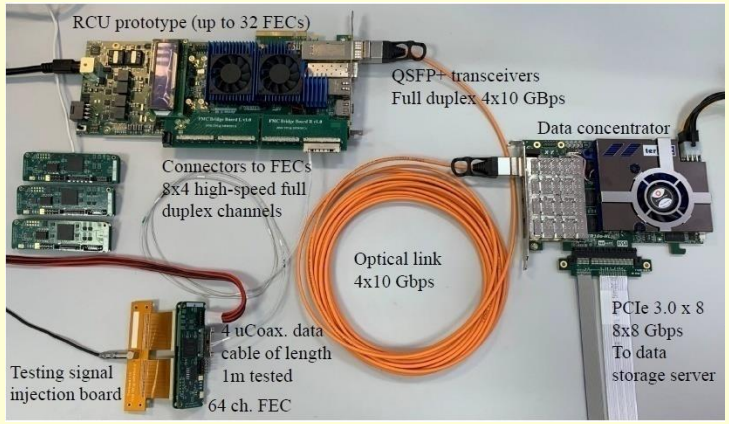
Eight cards pilot system



1) Trigger, clock, reset distr. board .
2) System controller.
3) 64-ch SAMPA- FEC.
4) HSSI (up to 2.5 GBps; up to 8 FECs).
5)Data/conf. full duplex HSSI port; clock 40 MHz, trigger, reset.



tests with FPGA Arria 10 – in progress

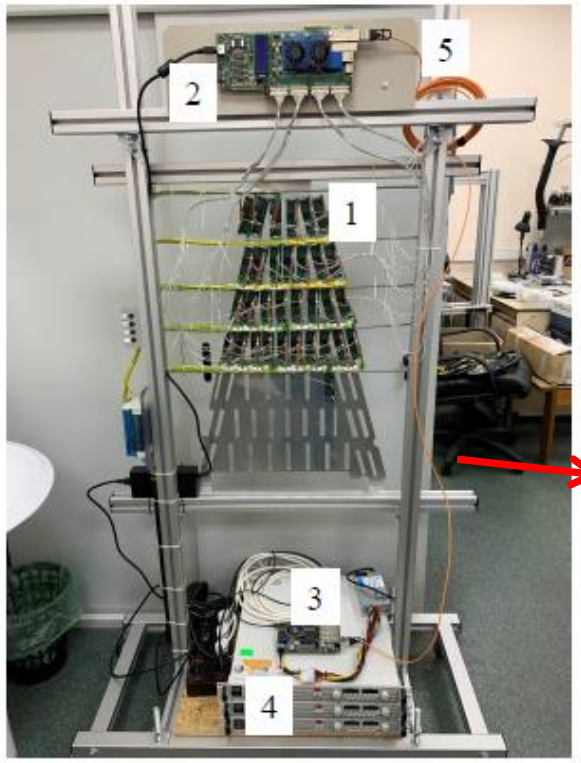


Status: tested

Readout system based on commercial kits

TPC electronics: status and schedule

Test bench

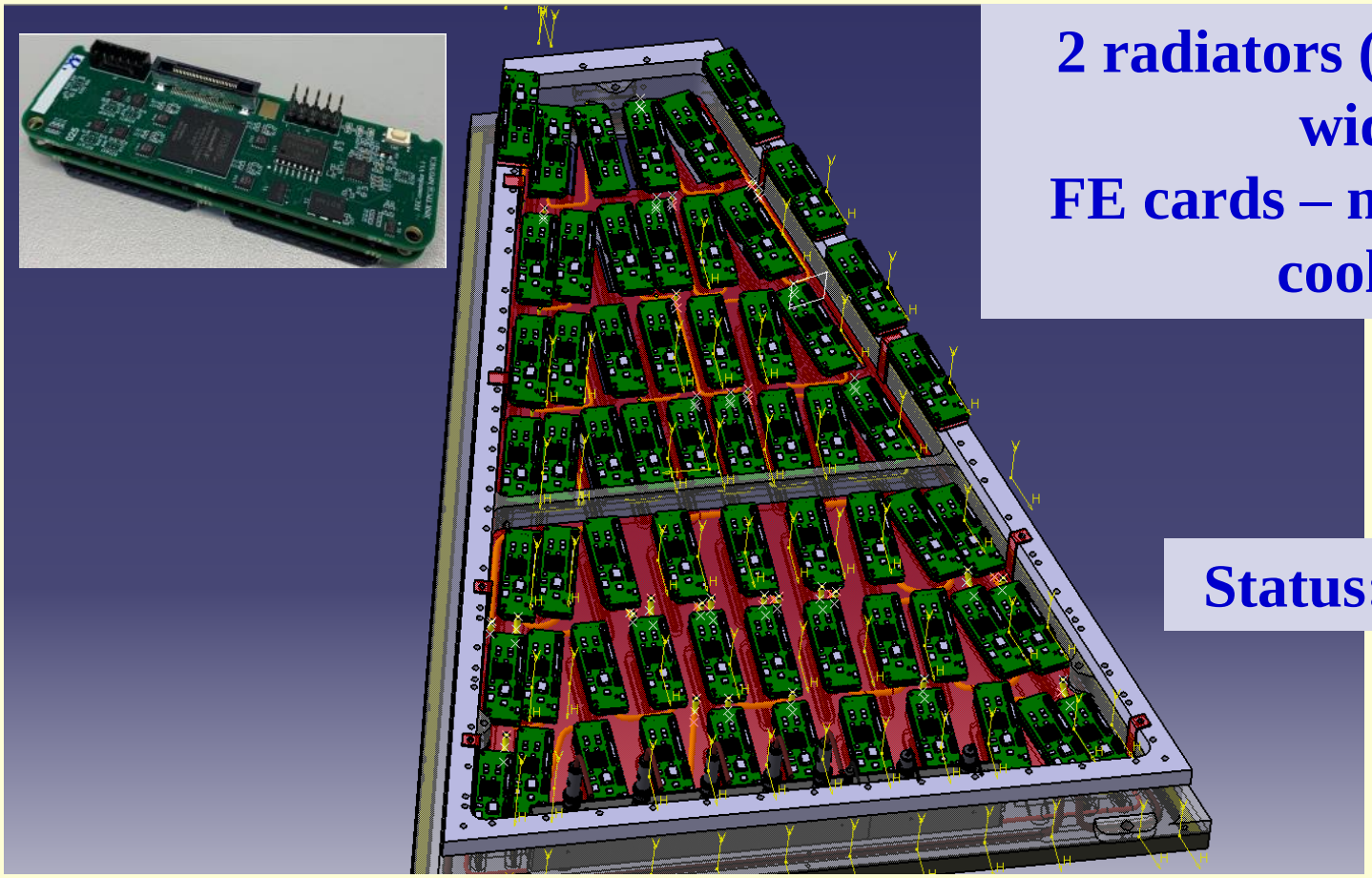


Front view

1) 32 FECs; 2) RCU prototype; 3) DCU module; 4) LV power supply; 5) Optical link.

Item	Date	
Testing 512-channel system (FEC v1.0) finished	Jan. 2019	✓
Testing 256-channel system (FEC v2.0) finished	Feb. 2019	✓
Preproduction vervion FEC PCBs sent for fabrication	Mar. 2019	✓
Half-ROC readout system base design finished	Mar. 2019	✓
Receive SAMPA V4 chips at Dubna	Jul. 2019	✓
34 preproduction version FEC assembled and tested	Nov. 2019	✓
32 preprod. version FEC installed on Pilot 2048 ch. Syst.	Dec. 2019	✓
Instrumented Half ROC system testing	Feb. 2020	
Testing instrumented ROC finished	Apr. 2020	
Production vervion FEC PCBs ready	May 2020	
1st batch of prod.ver FEC (130 pcs) fabricated	Jul. 2020	
2nd batch of prod.ver FEC (800 pcs) fabricated	Sept. 2020	
3rd batch of prod.ver FEC (800 pcs) fabricated	Dec. 2020	

TPC electronics: FE cards integration and cooling



2 radiators (narrow and wide)
FE cards – no individual cooling

Status: in progress

INP BSU (Minsk): TPC LV system

LVDB mass-production (60 pc) - done **Ok!**

LV system based on CAEN rad. hard design:
(up to 2000 Gauss and 15 kRad)
- **power converters A3486 AC/DC (380 V -> 48 V)**
- **CAEN EASY3000 system**
- **LV module - A3100B (2÷7V/100A)**

Status:
- **test system – ordered, delivery time – May 2020**
- **invoice for full system - got, delivery time – (270÷300) days**

LV cables (halogen free, low smoke):
S=50 mm2 – delivered to JINR Dec 2019
S=120 mm2 – delivered to JINR Dec 2019

in progress …

Team for cabling – looking …

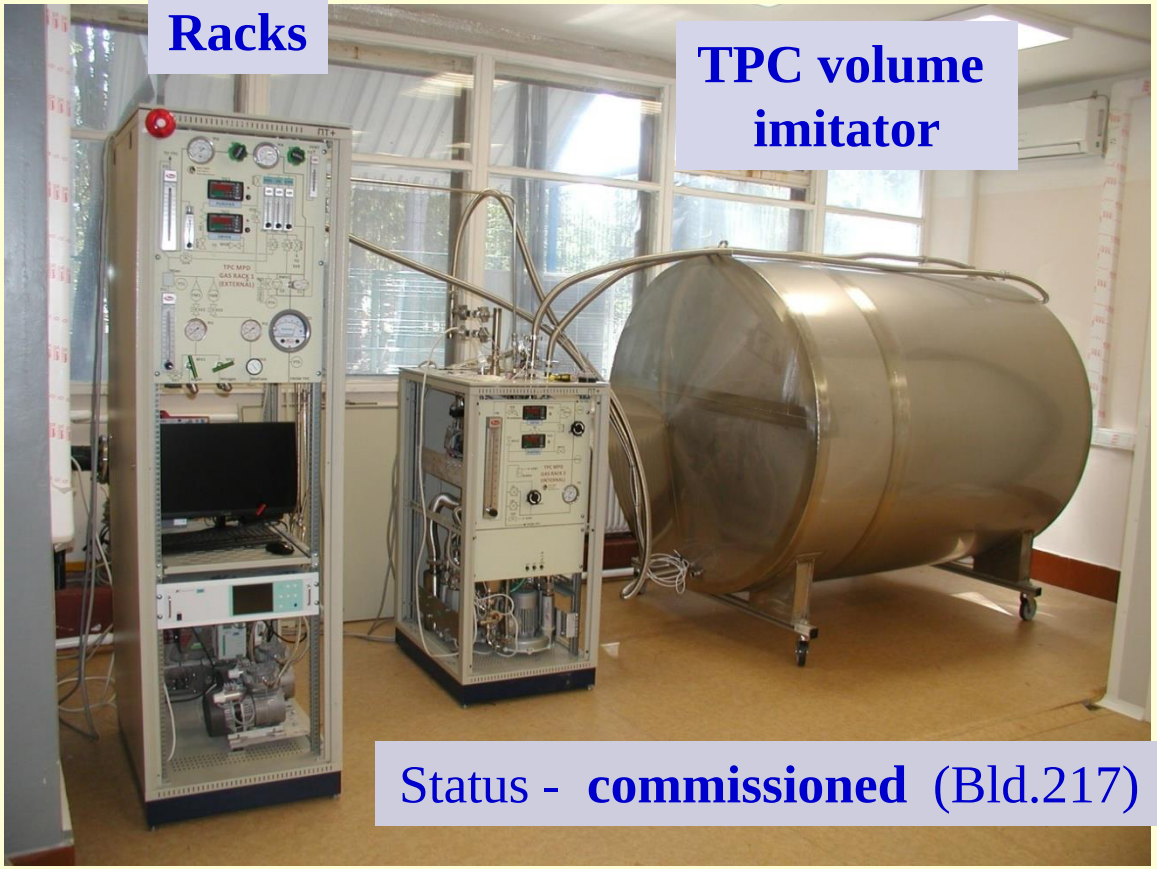
TPC gas system

Gas supply

Status - **commissioning in progress**

Racks

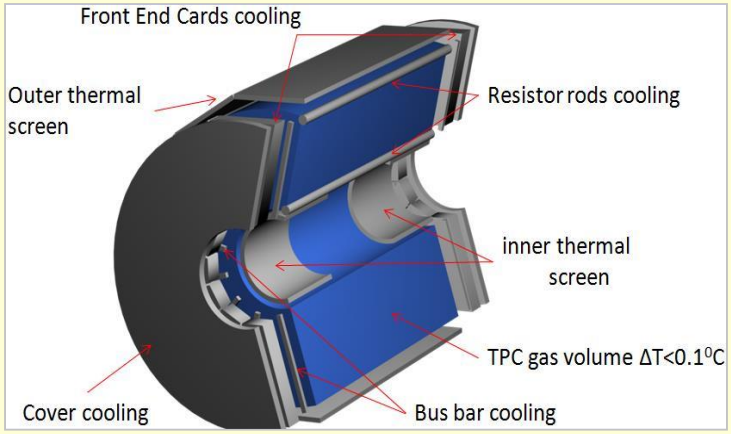
TPC volume imitator

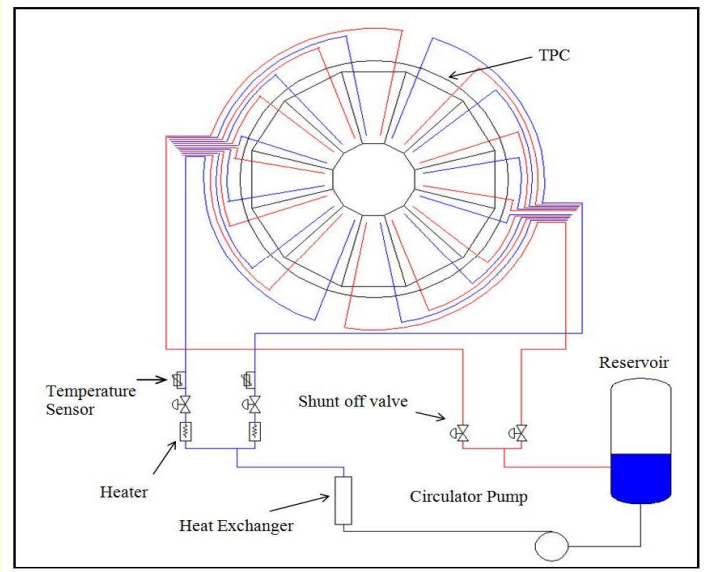


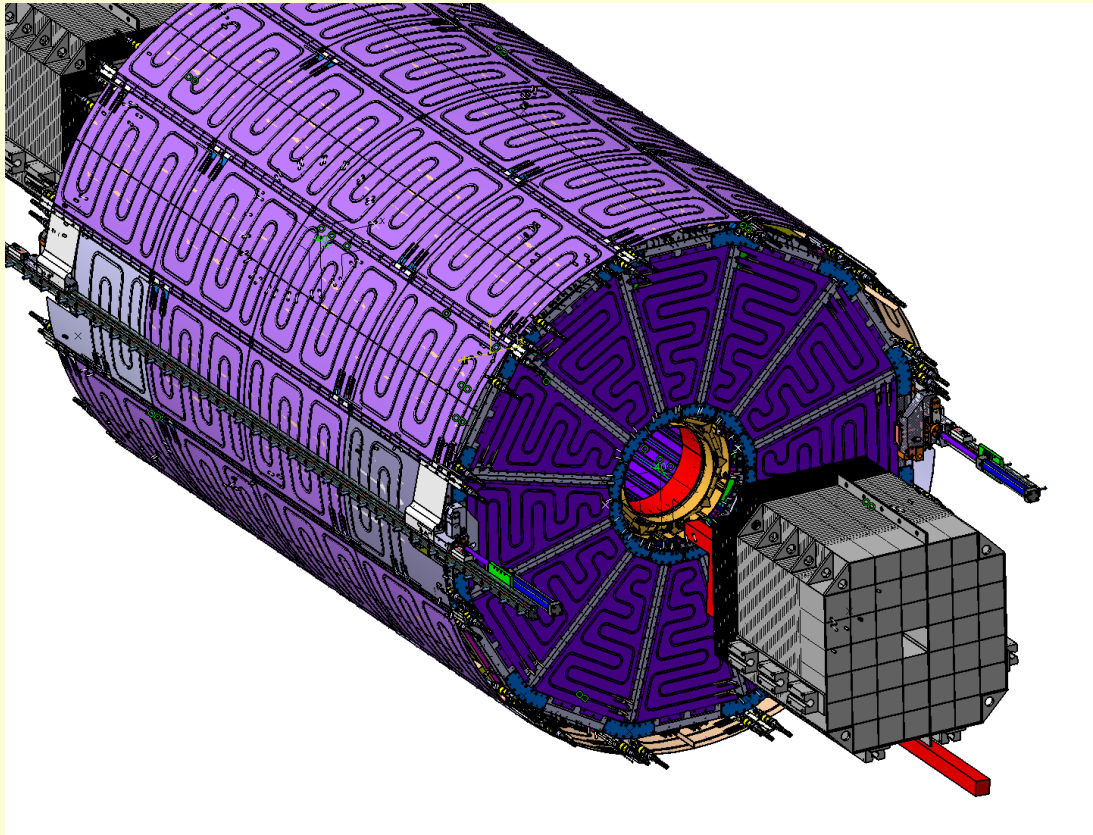
Status - **commissioned** (Bld.217)

paper flow - in progress …

TPC cooling system

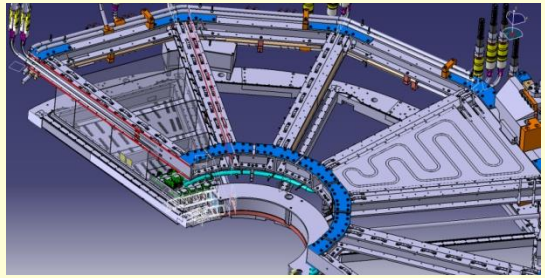




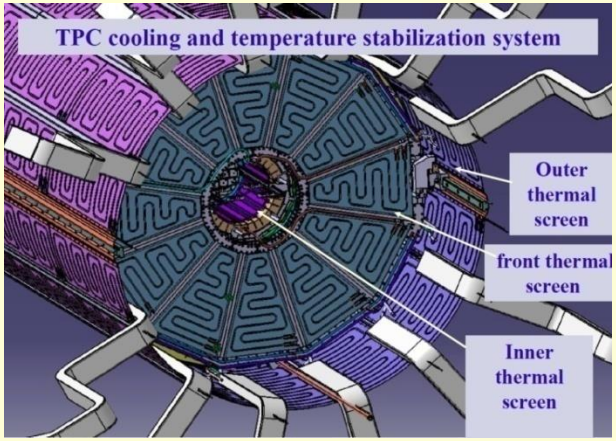


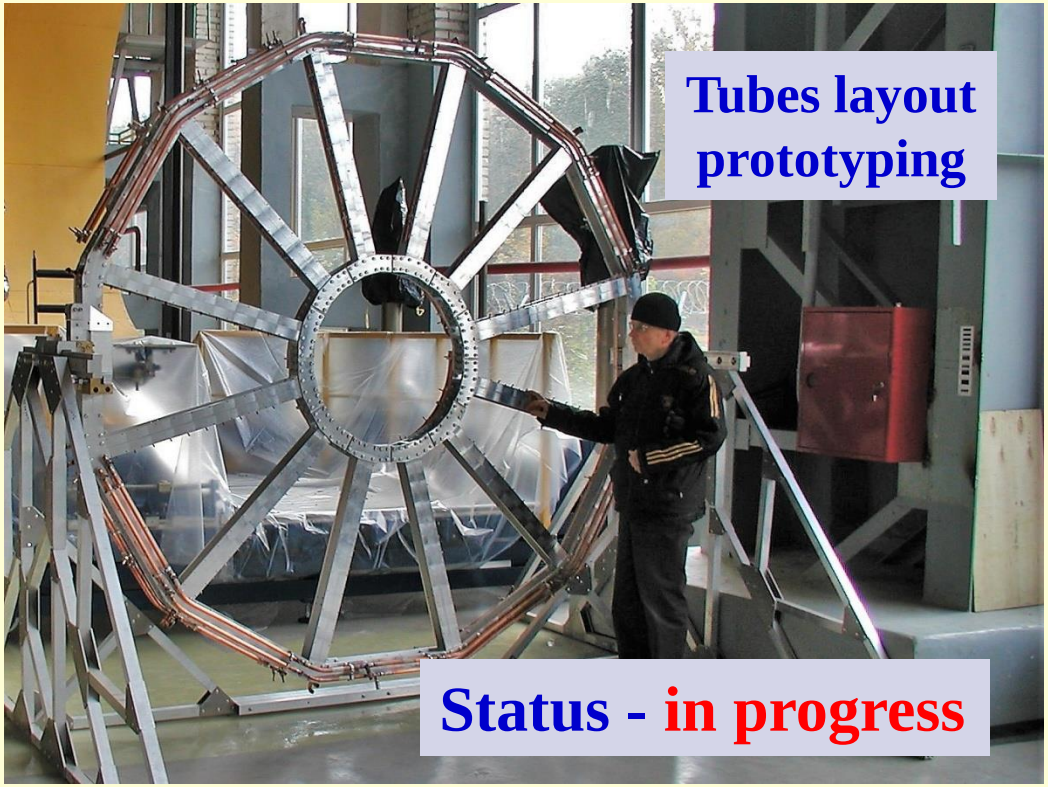
Barrel part – shorter and fixed to TPC

TPC cooling system: tubes layout and set of thermal panel prototypes



Service wheel



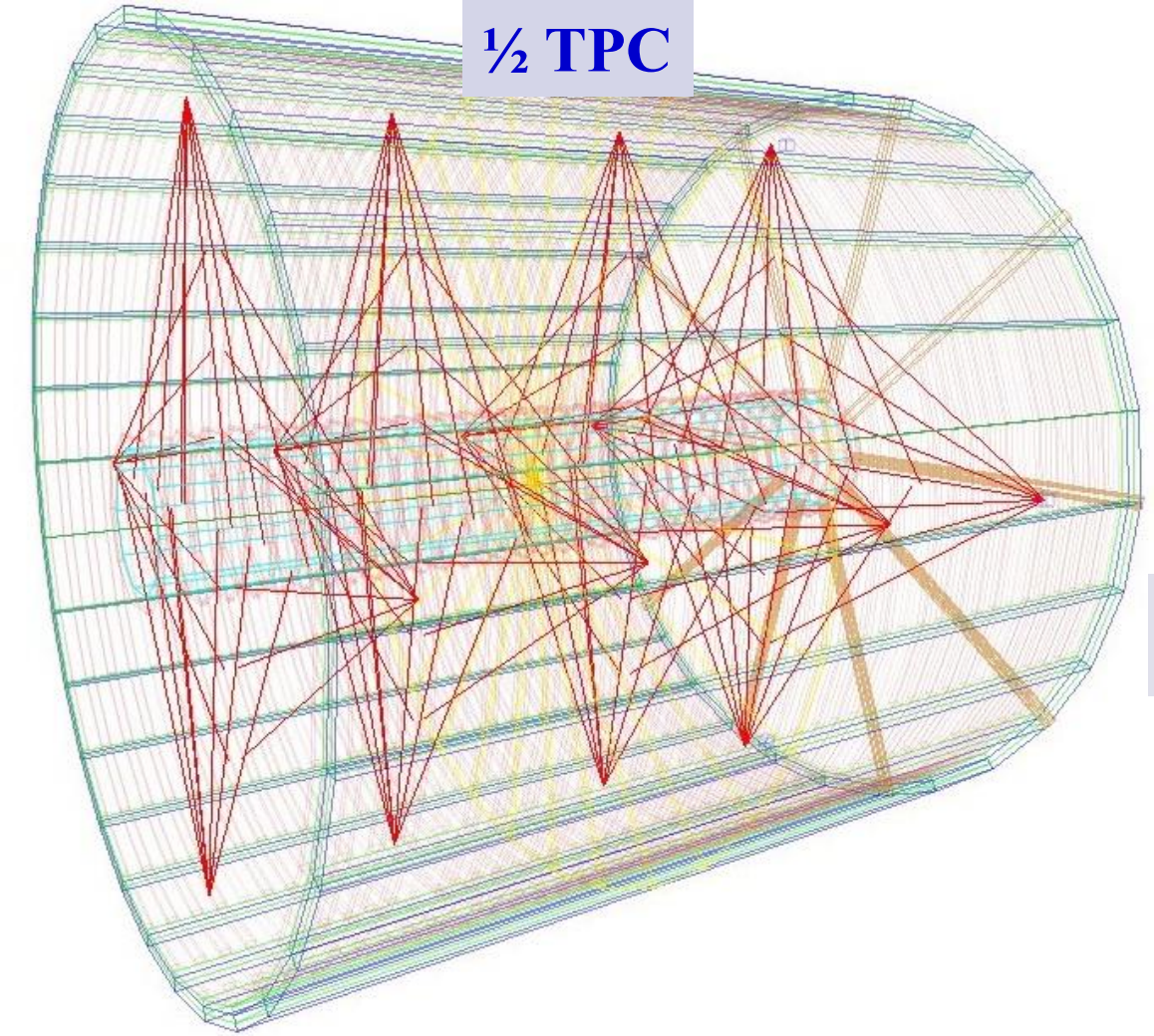


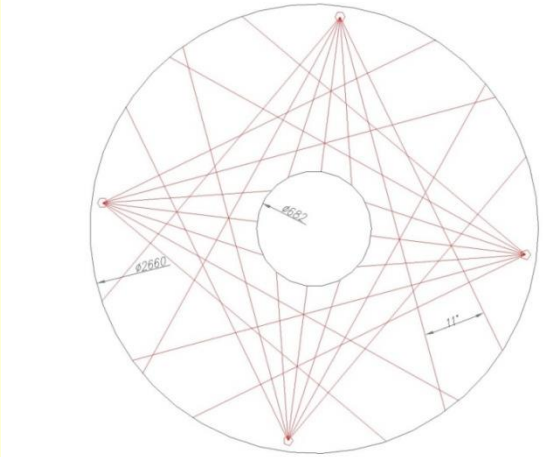
Tubes layout prototyping

Status - in progress

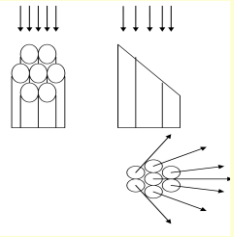
Al plate – 2x1 mm
Al tube - D=8/6 mm

TPC laser calibration system



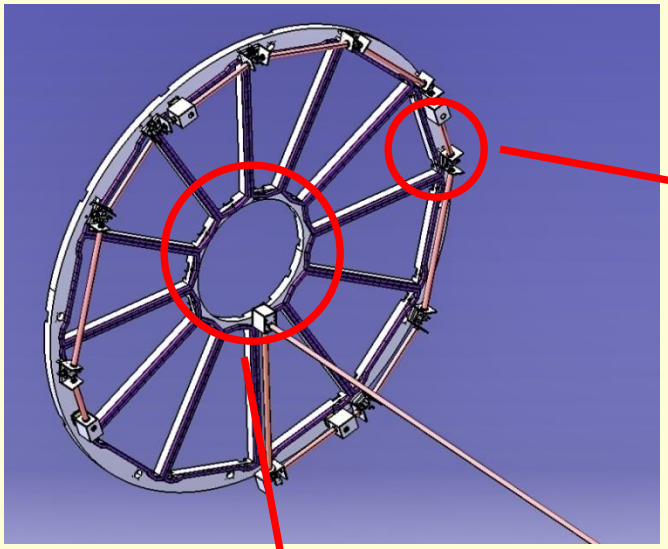


micro-mirror bundles

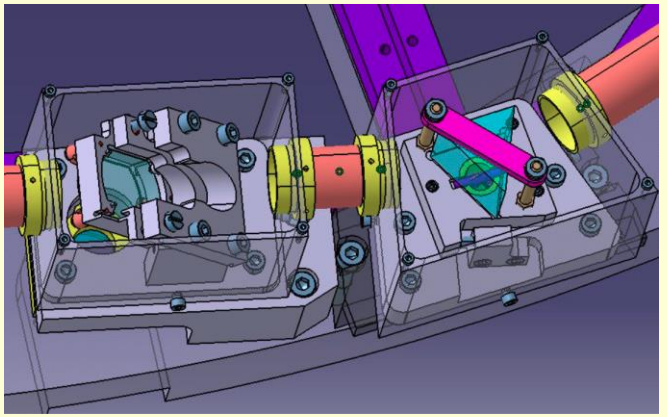


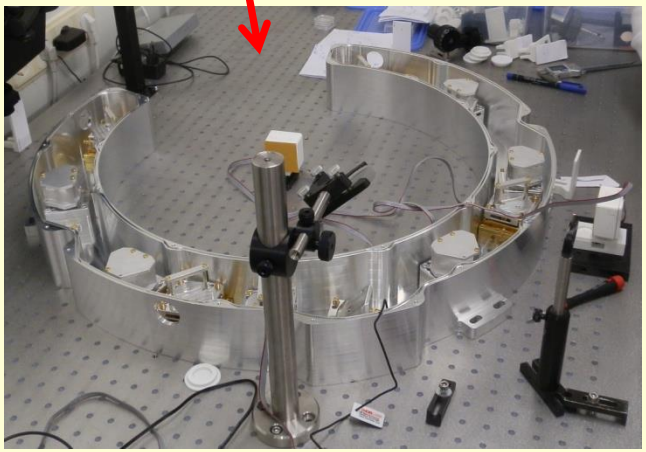
Laser "planes" – 4+4
Points per plane - 4
Beams per point – 7
Laser "tracks", N - 224

TPC laser calibration system



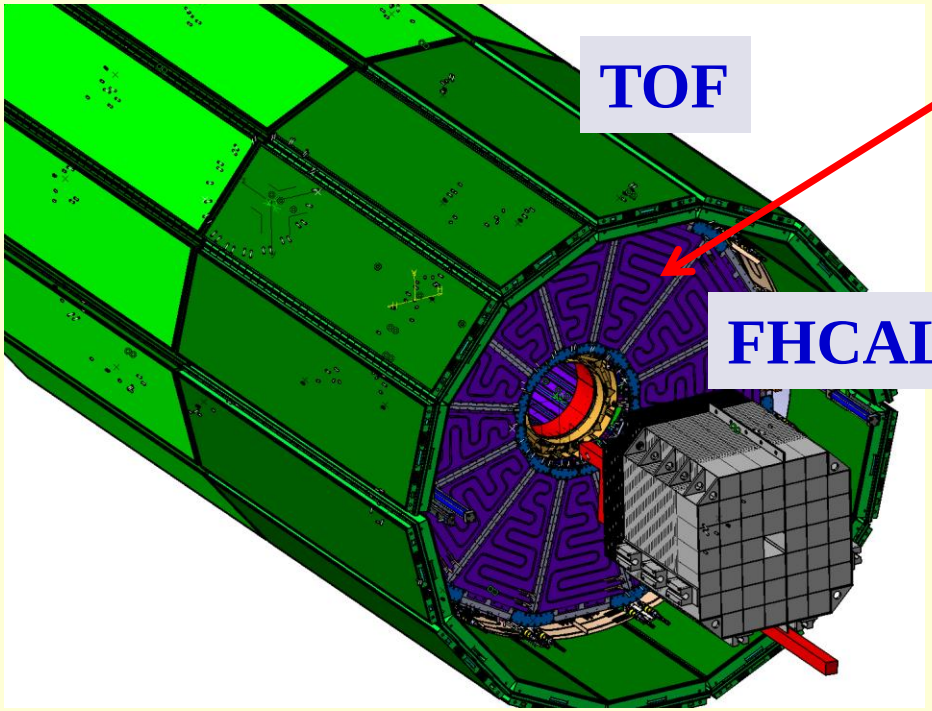
Semi transparency mirror & prism

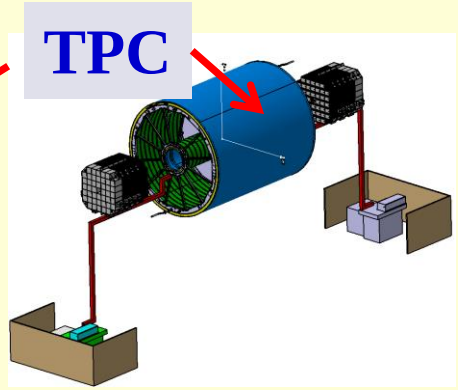


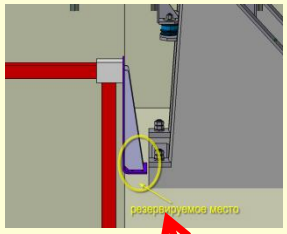


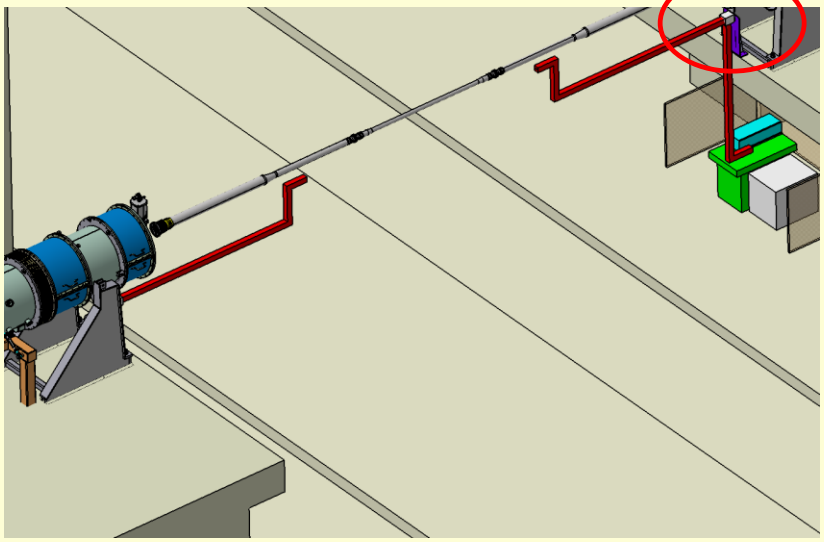
- full set of micro-mirror bundles - assembled
- 2 lasers (special option) – commissioned
- laser beam splitter - delivered to JINR
- laser beam monitors - prototype under tests

TPC laser calibration system: laser beams layout









laser beam layout – under finalization

TPC slow control : sub-systems status

LV system:

1) CAEN EASY3000 (crate SY4527 (2pc), crate EASY3000 (12pc), module A3486 AC/DC (400V) converter (13pc), module PS A3100B (55pc) **+ software GECO 2020 - ok!**

2) Custom made stabilizers (module LVN9 (48pc-ok)) **+** crate 6U (1pc), custom control units (12pc) + crate controller (1pc)+ PC) + **custom software – prototype tests in progress**

HV system:

1) MWPC: CAEN (crate SY4527-2pc + modules A7236DN -3.5kV/1.5mA, A7236DP +3.5kV/1.5mA, A1542HDN -500V/1mA **) + software GECO 2020 - ok!**

2) TPC HV electrode (- 30 kV): Iseg HV PS + Iseg software – ordering

3) HV for ROC gate: custom made system (crate – 2pc, modules –24pc, crate controller- 2pc) + **custom software - NO**

DAQ:

Hardware: FEC64 (1488pc), ROC controller (24pc), data server (24pc) **+ TPC team firmware and software – in progress**

Trigger ???…

Synchronization ??? …

Clock ??? …

TPC slow control : SC

Gas system:

Hardware: DAQ32 module + custom software + PC (PNPI, Gatchina) – **ok!**

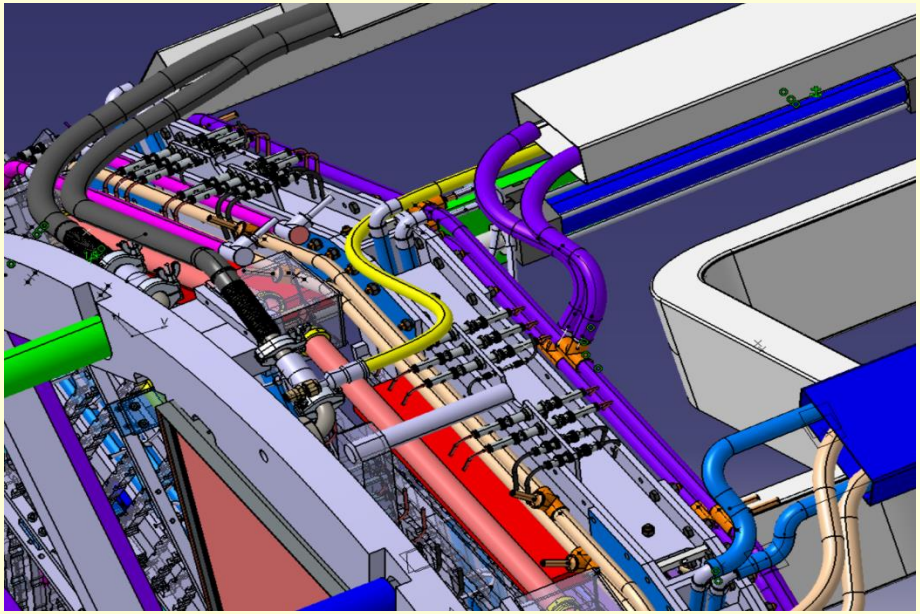
Cooling system:

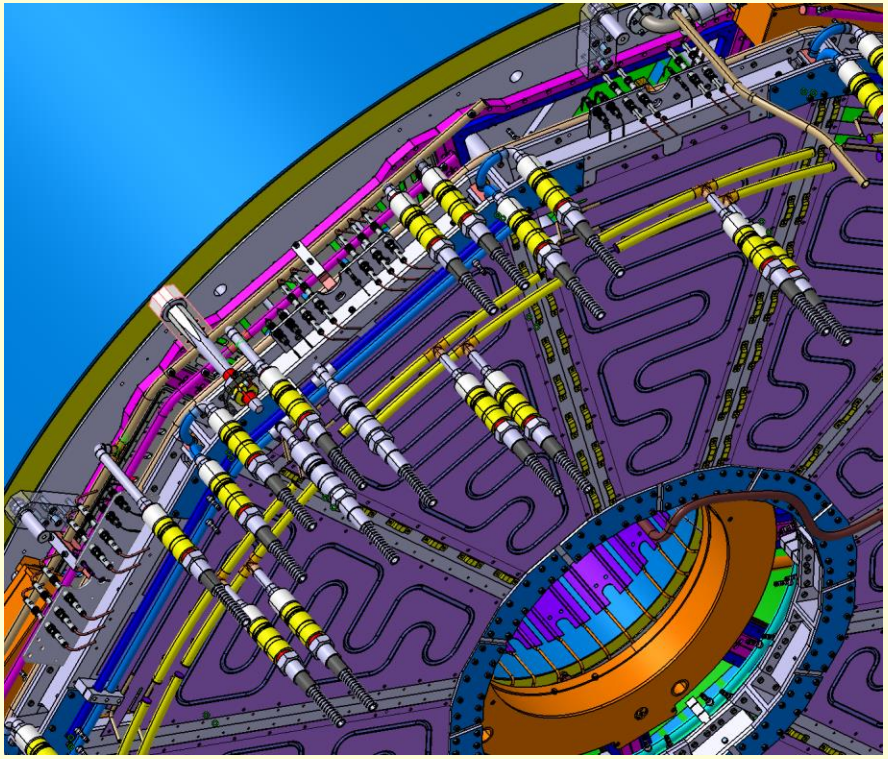
Hardware: NI (national instruments (crate + ADCs) + 75 channels for hitters control + thermo sensors (100pc)) + **custom software - started**

Laser system:

Hardware: PC (1pc), industrial PC (2pc), controllers (2pc), cooling system (2pc), UV laser (2pc), synchronization module (1pc) **+ laser producer software – not started yet**

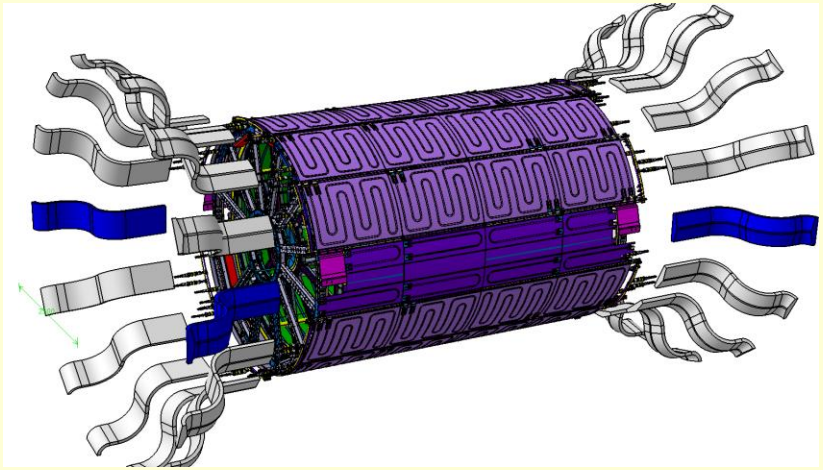
TPC: cables and tubes integration

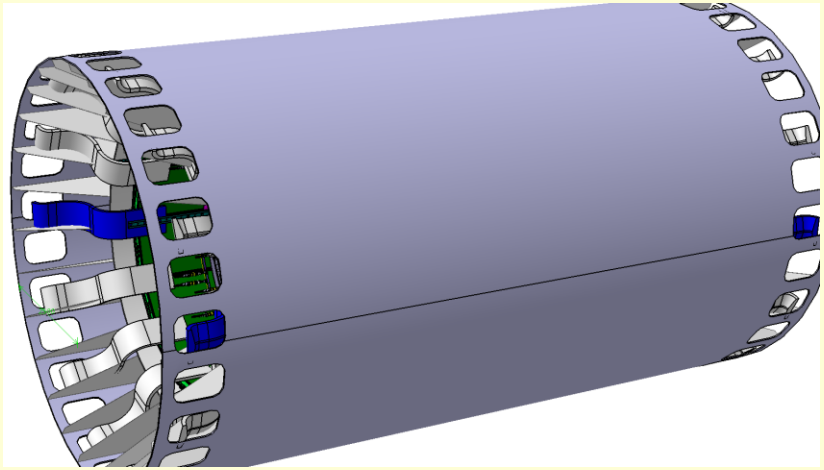


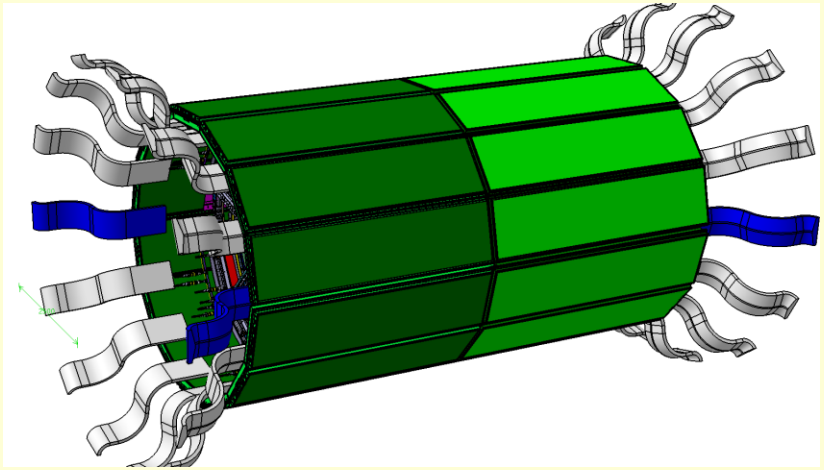


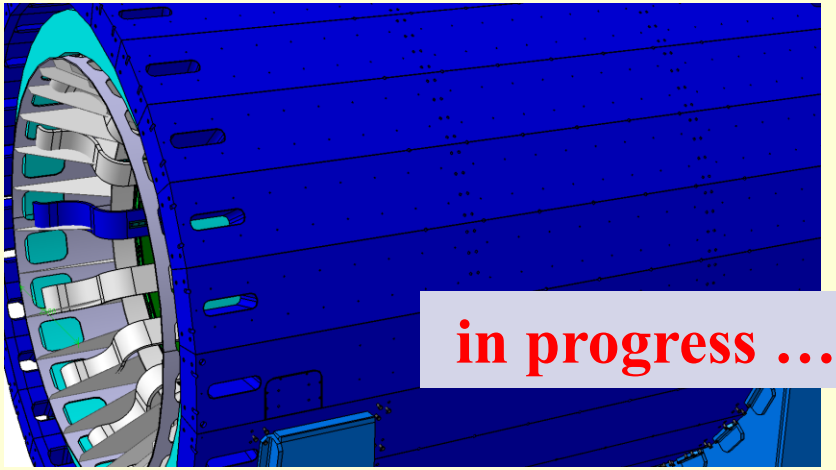
Optimization - in progress

TPC: trays









TPC services: status

LV system:

serial LVDB (60 pc)	– delivered to JINR
serial LVDB cooling plate	– delivered to JINR
CAEN EASY3000 LV system	- test system ordered, full system - invoice got
LV power cables	– delivered to JINR
patch-panels	- under discussion

HV system:

CAEN EASY3000 HV system	- invoice got
HV cables	- will be ordered, delivery June 2020

Gas system:

- equipment	- commissioned
- commissioning of cryogenic vessels for Ar and N2	- paper flow in progress

Cooling system:

FE cooling prototypes	– ordered, one manufactured
testes and measurements with prototype	– in progress
barrel and end cap thermal panels (full set)	– delivered
service wheel cooling tubes routine optimization	- in progress
FE cooling radiators mass-production	- Sept 2020

TPC services: status (continue)

Laser calibration system:

lasers (2 pc)	- commissioned
laser beam splitter	- delivered
beam monitors (WEB cameras + optics)	- prototype tests, design in progress
channels for laser beams inside MPD	– under finalization

Slow control system (software):

- LV system – more less ok!
- HV system – more less ok!
- HV for ROC gate – on critical path
- DAQ – in progress
- Gas system – ok!
- Cooling system – started
- Laser system – not started yet

TPC services: status (continue)

INTEGRATION:

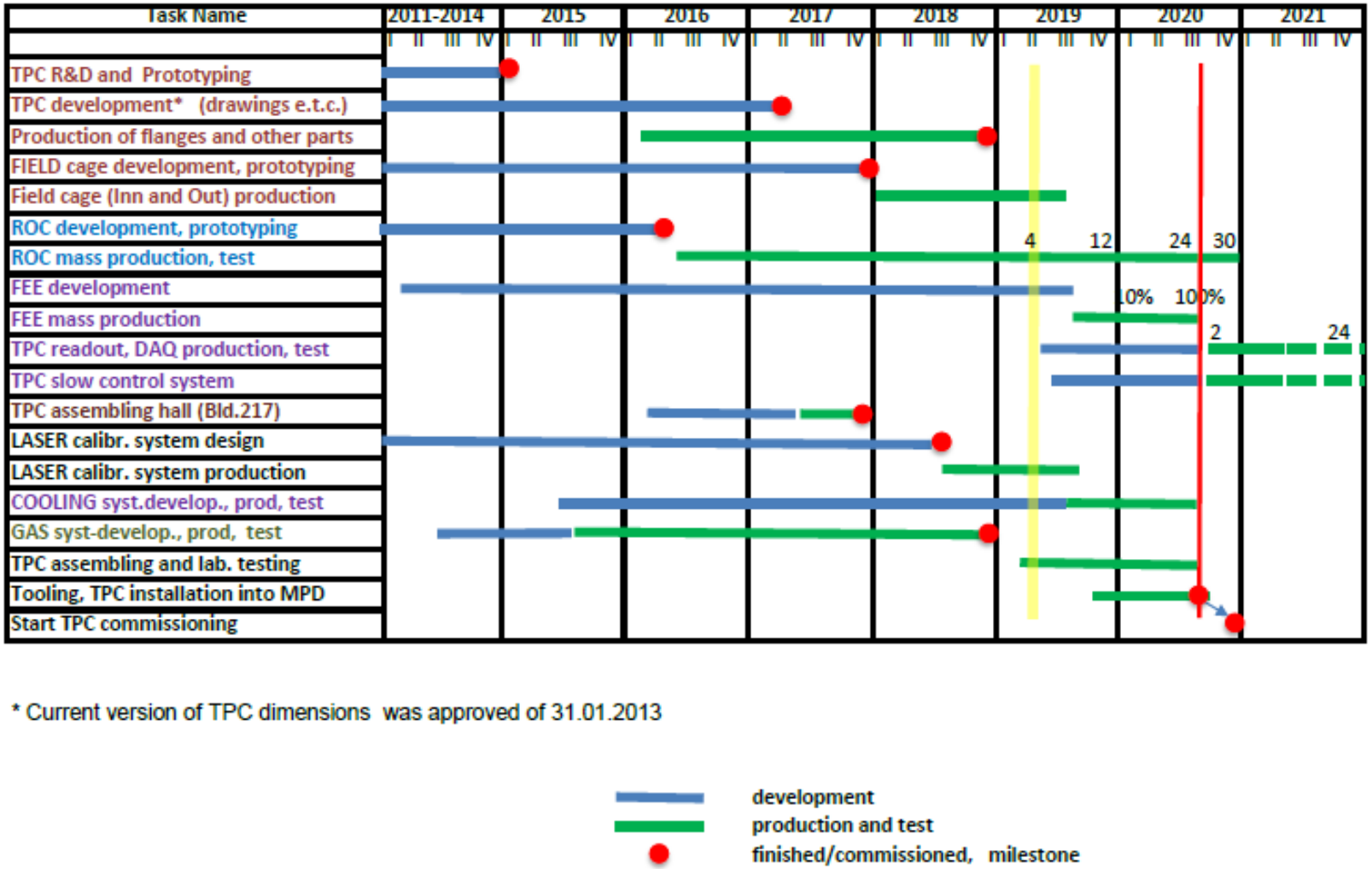
TPC sub-systems integration - in good shape
list of TPC cables and pipes – updated
electronics platform (TPC racks) - started
trays (cables and pipes) - started

Integration TPC into MPD – not started yet
(waiting for final ECAL design and start sub-detectors integration to MPD)

Tooling for installation TPC into MPD - not started yet

Time schedule

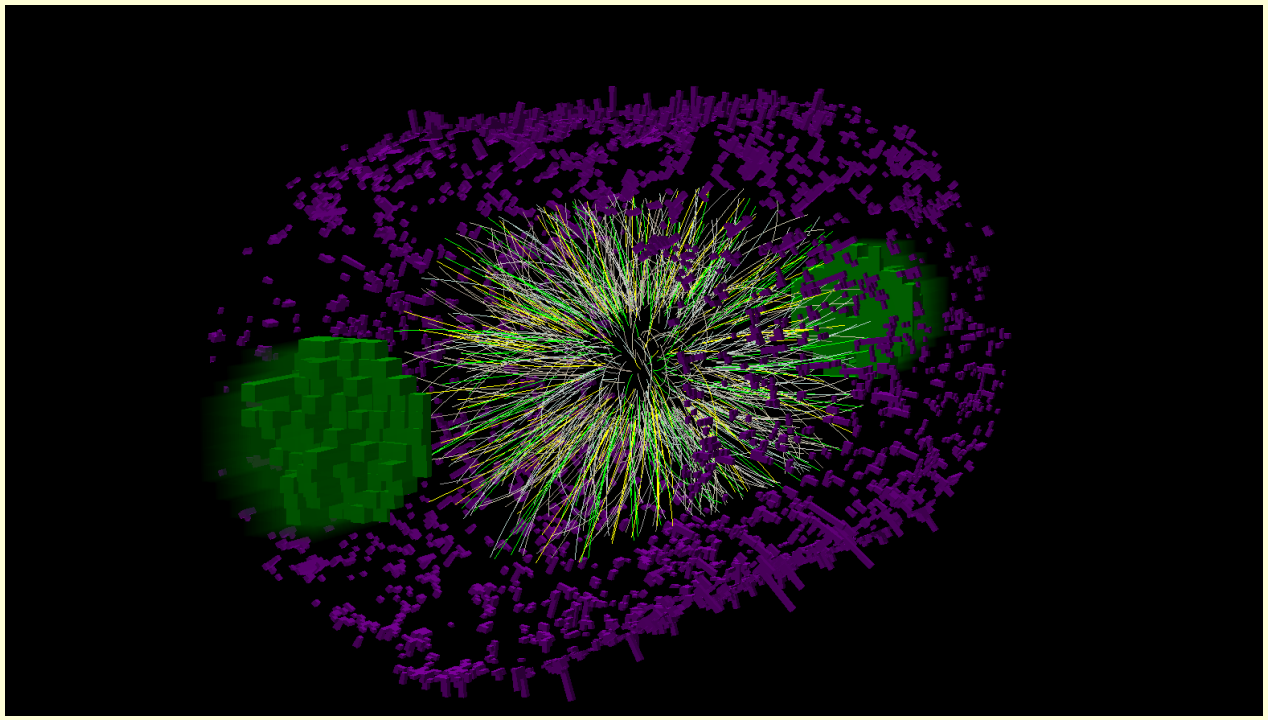
update - 15.04.2019 TPC time schedule



* Current version of TPC dimensions was approved of 31.01.2013

development
production and test
finished/commissioned, milestone

Thank you for attention!

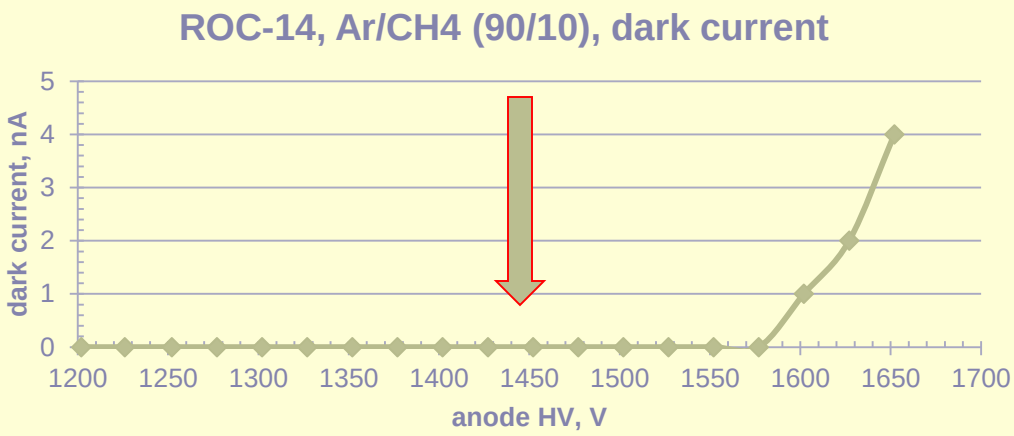


http://nica.jinr.ru/
http://mpd.jinr.ru/

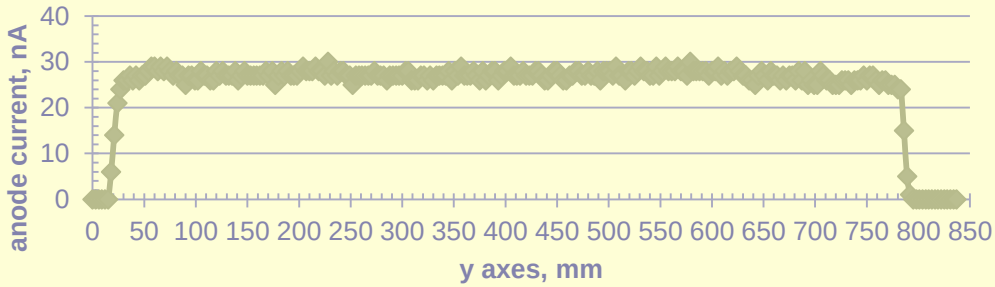
TDR TPC – http://mpd.jinr.ru/wp-content/uploads/2019/01/TpcTdr-v07.pdf

SPARE

ROC chamber: test results



ROC-14, X-ray line scan, step 3 mm,
Ar/CH4 (90/10), Ua = 1,45 kV, Udrift = -1120V,
uniformity 18,4%

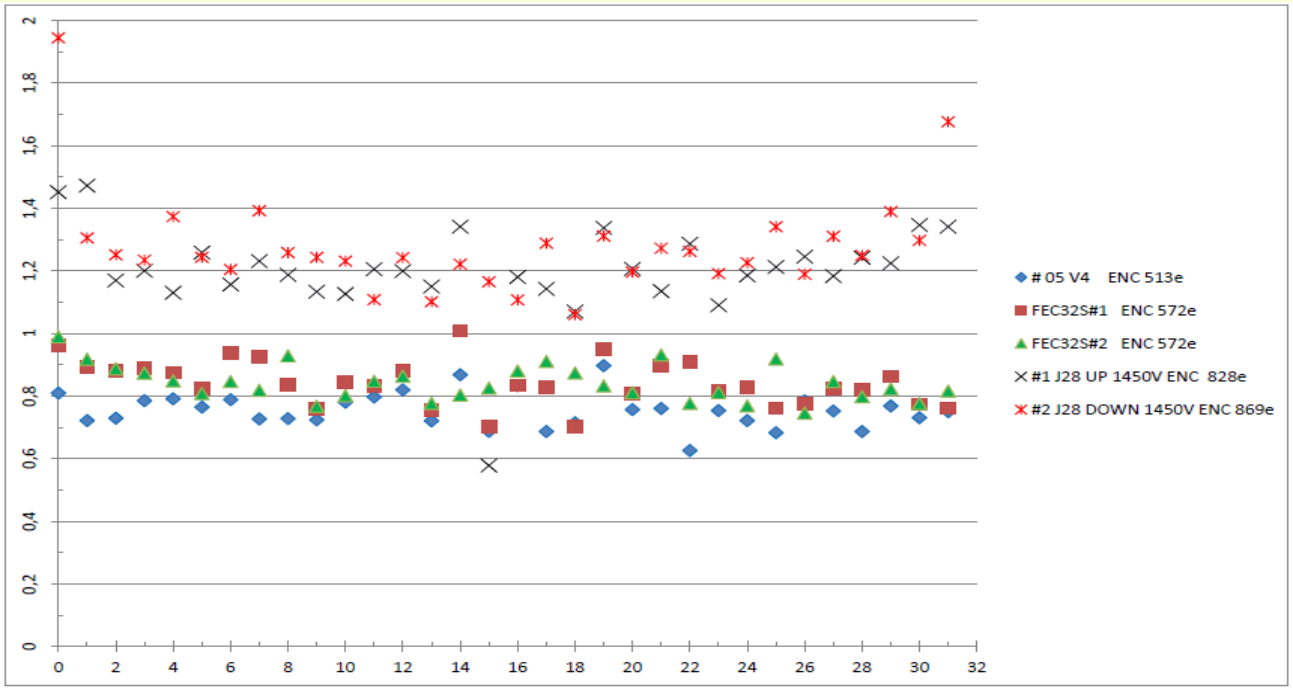


Test procedure:

- **counting plateau**
- **dark current**
- **energy resolution (Fe-55)**
- **uniformity of gas gain**
  - ✓ **linear scan**
  - ✓ **area scan**

Fe-55: FWHM ~ 20%

ROC chamber: test SAMPA chip with ROC chamber

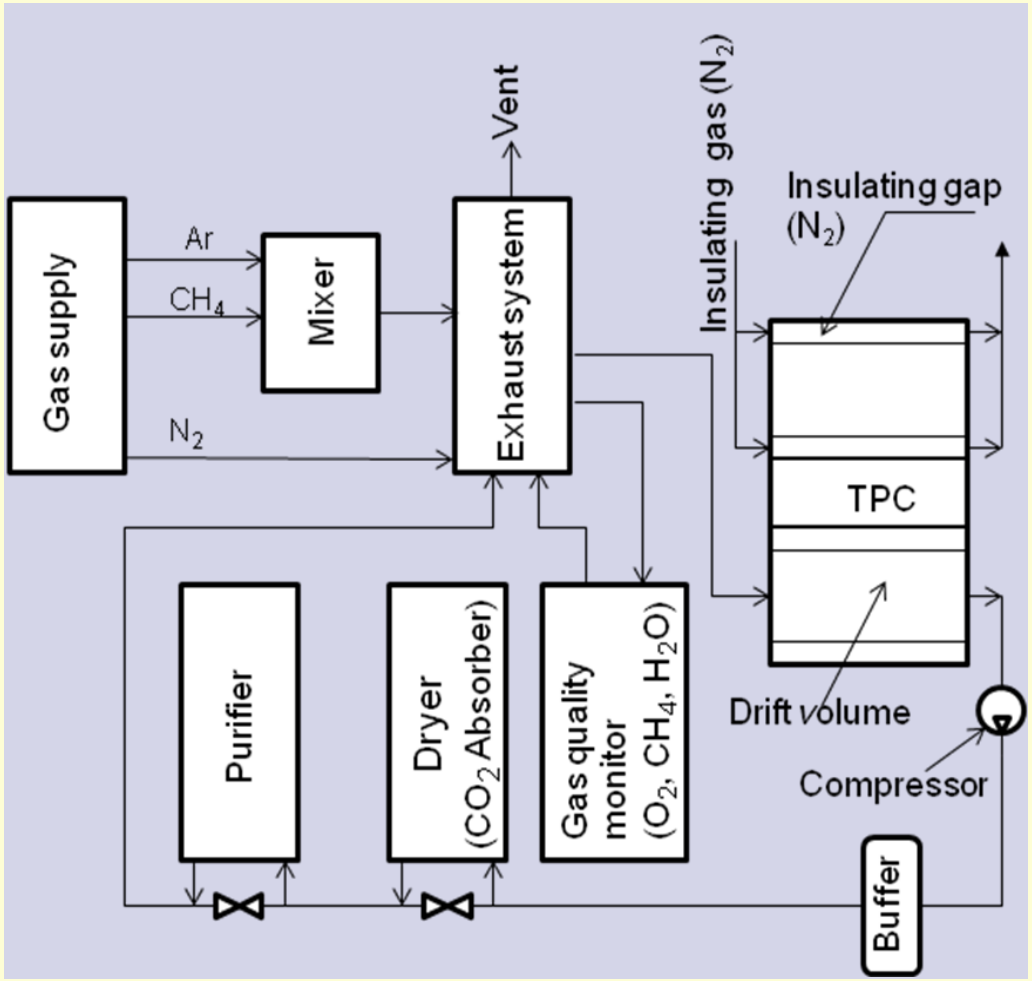


ROC-chamber tested with SAMPA chip (HV=+1450 V):

ENC = 828 e- (for small pads), ENC = 869 e- (for big pads)
(20% more than expected due to digital noise)

Waiting for 30 FE boards with read out system for tests with ROC

TPC gas system



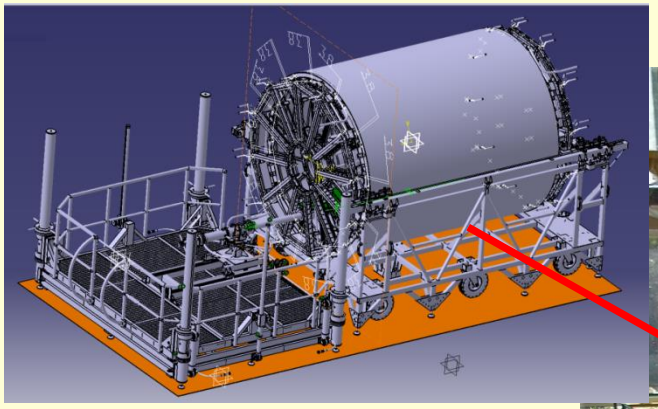
Gas mixture	Ar + 10%CH_4
TPC gas flow, nominal	200 l/min
TPC overpressure	(2.0 ± 0.1)mBar
O_2 admixture	20 ppm
H_2O admixture	10 ppm
External loop, refresh gas rate	30 l/min
Fresh part of gas mixture add to external loop, range	(0-50) l/min
TPC isolating gas	N_2
N_2 gas flow	(5-20) l/min

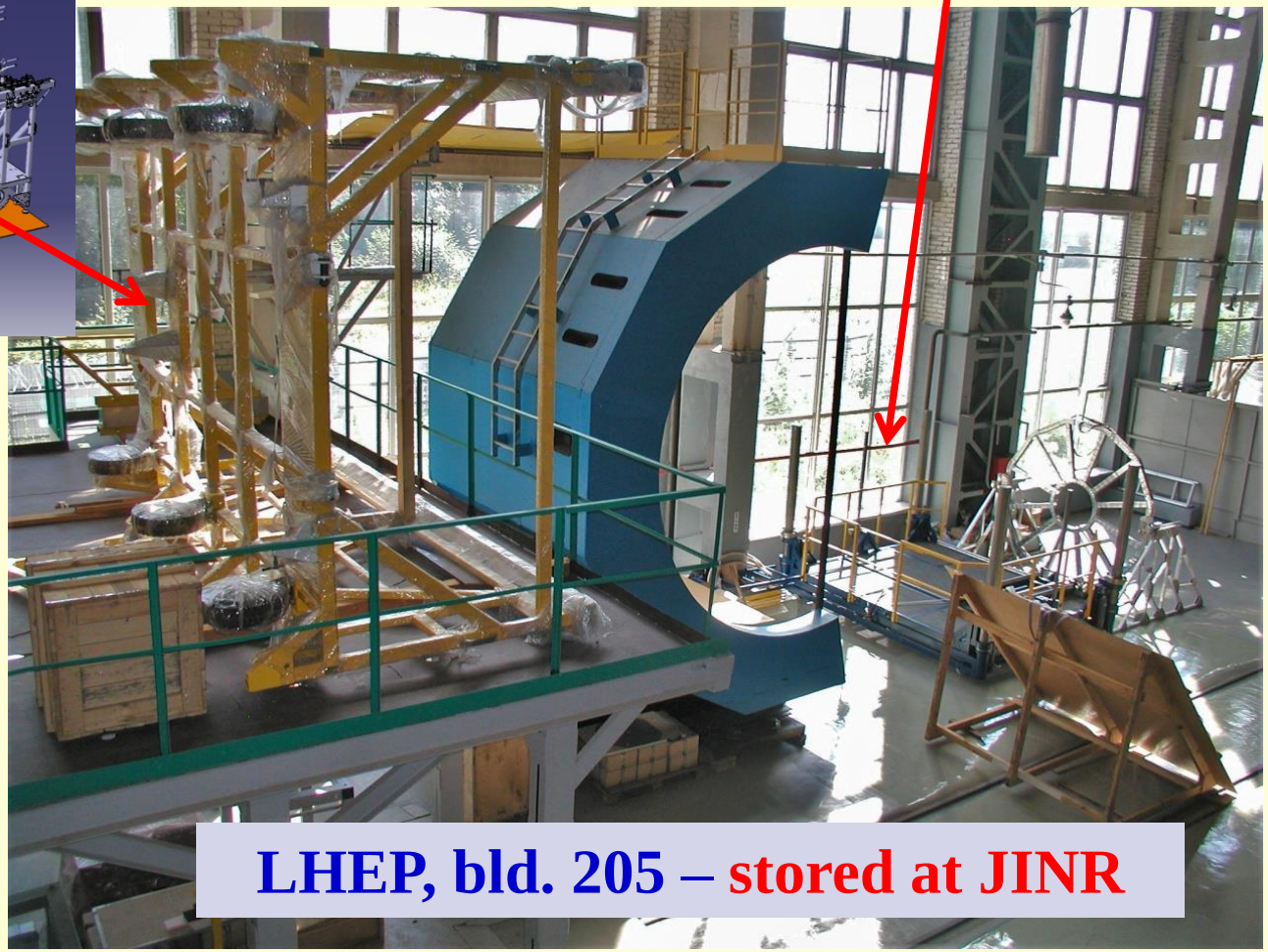
Delivery to JINR:

gas supply system - 2015

purification system - 2017

TPC: transportation platform and ROC manipulator





LHEP, bld. 205 – stored at JINR