

## MPD/NICA TPC status (16.04.2019)

- clean room and tooling for TPC assembly
- TPC main components
- ROC chambers
- front end electronics
- gas, cooling and laser systems
- integration TPC to MPD
- time schedule

Presented by Sergey Movchan

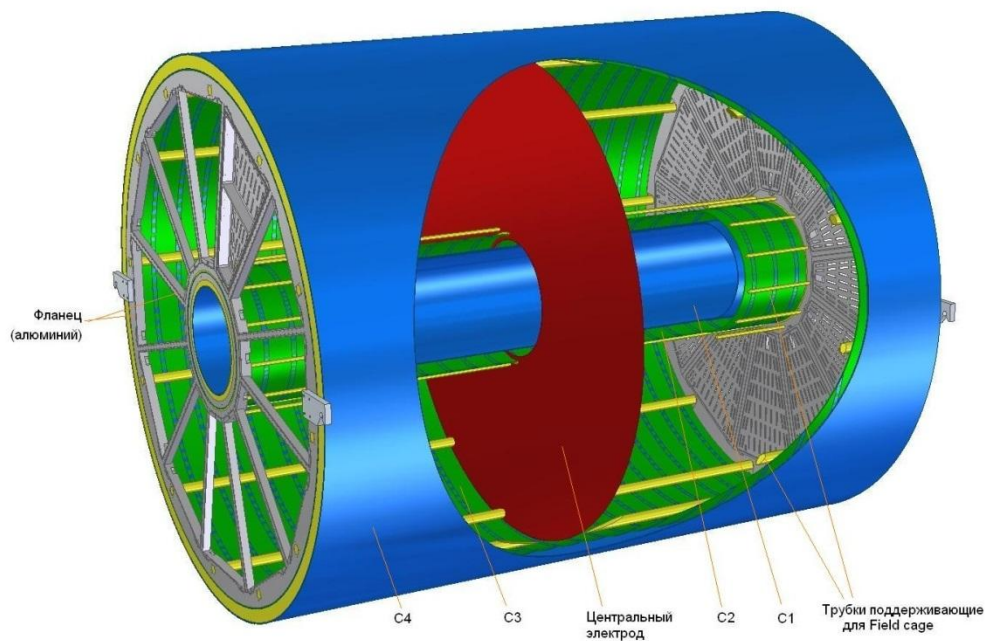
**JINR team: 23 persons**

**Belarus: 5 persons**

*(INP BSU- ARTMASH: A.Litomin, V.Tchekhovskiy, S.Savitskiy, V.Baev, K.Afanasiev)*

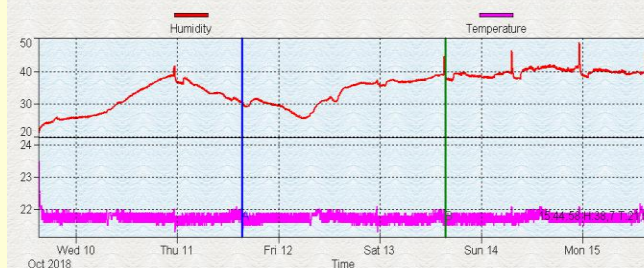
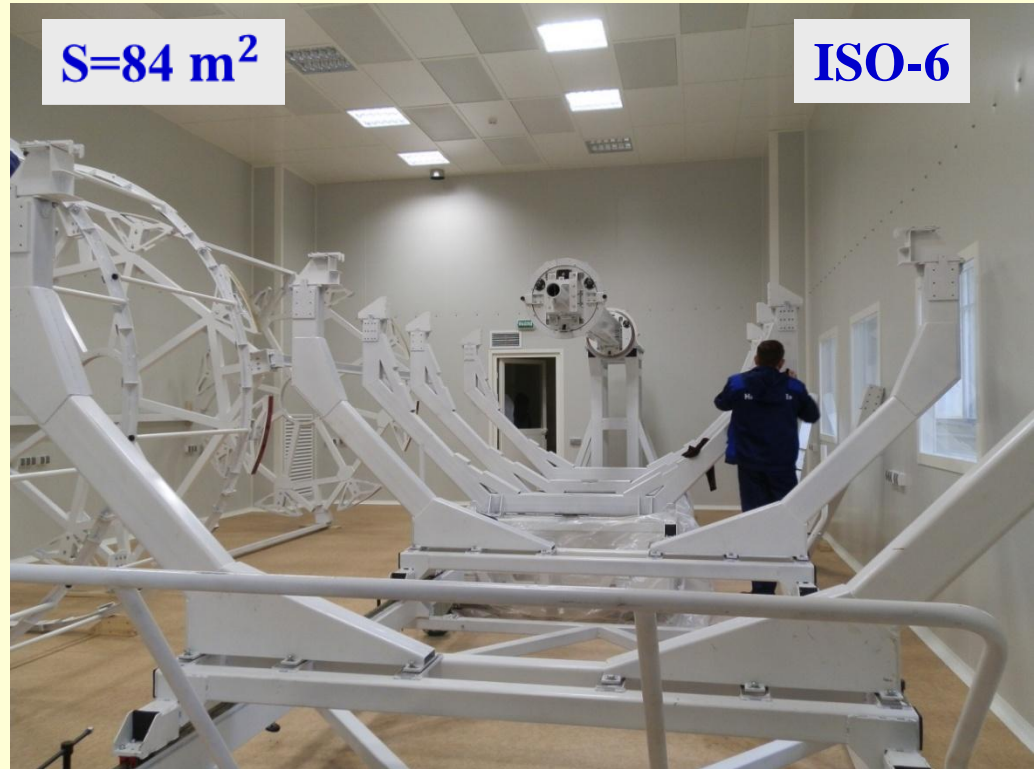
# MPD TPC parameters

Корпус TPC/MPD



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 <sup>4</sup>
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 <sup>2</sup> and 5x18mm <sup>2</sup>
Number of pads	95232
Pad raw numbers	53
Pad numbers after zero suppression	< 10%
Maximal event rate	< 7 kHz ( Lum. 10 <sup>27</sup> )
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

TPC clean room (LHEP, bld.217) – common view



**$H \leq 40\%$**   
 **$T = (21.75 \pm 0.25^\circ\text{C})$**

# TPC cylinders: C1-C4

C1

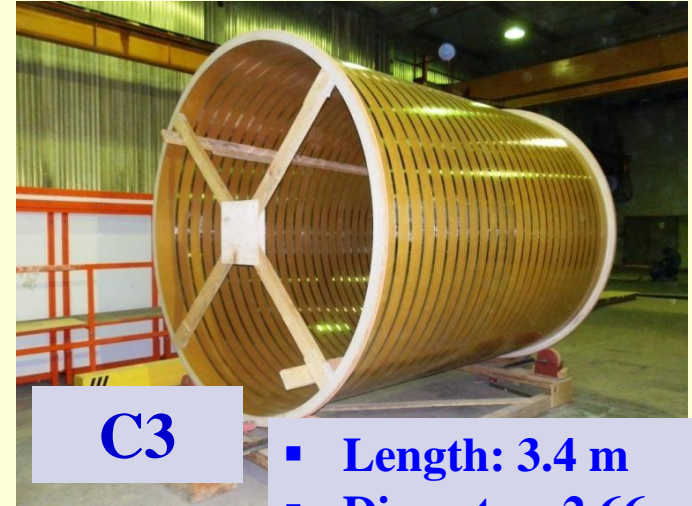


- Length: 3.4 m
- Diameter: 0.54 m

C2

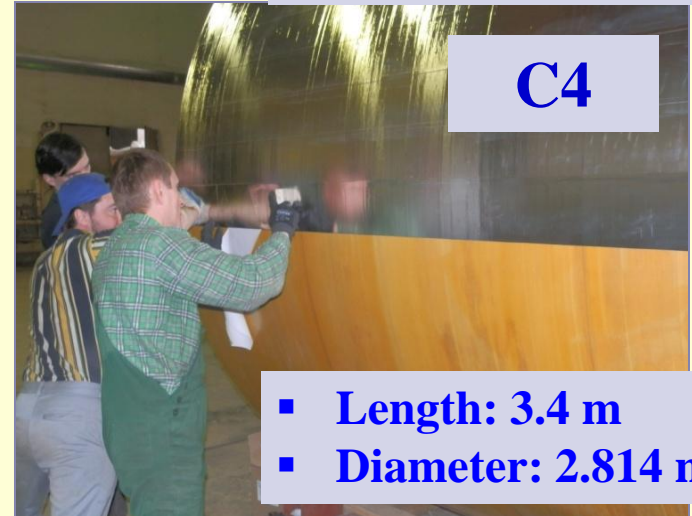


- Length: 3.4 m
- Diameter: 0.676 m



C3

- Length: 3.4 m
- Diameter: 2.66 m



C4

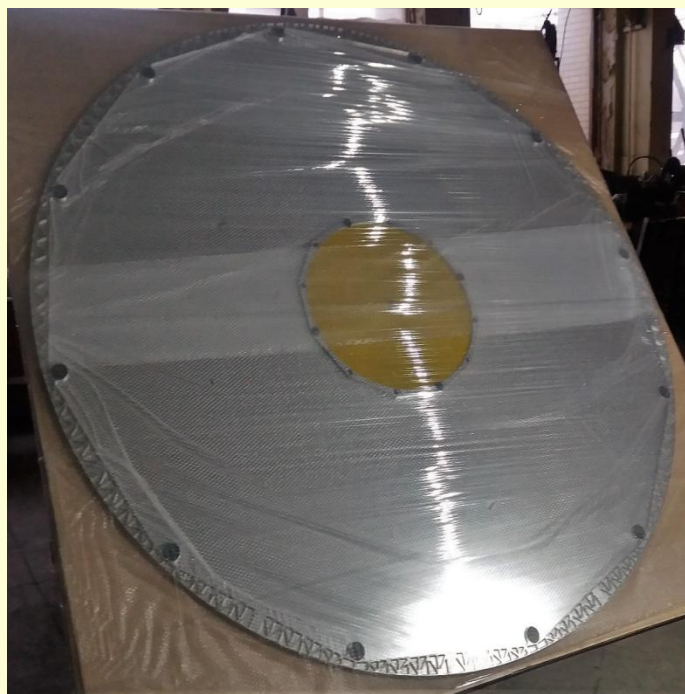
- Length: 3.4 m
- Diameter: 2.814 m

# TPC status: delivered to JINR

## Tooling for HV rods and strips assembly



## Serial HV electrode



## TPC flanges

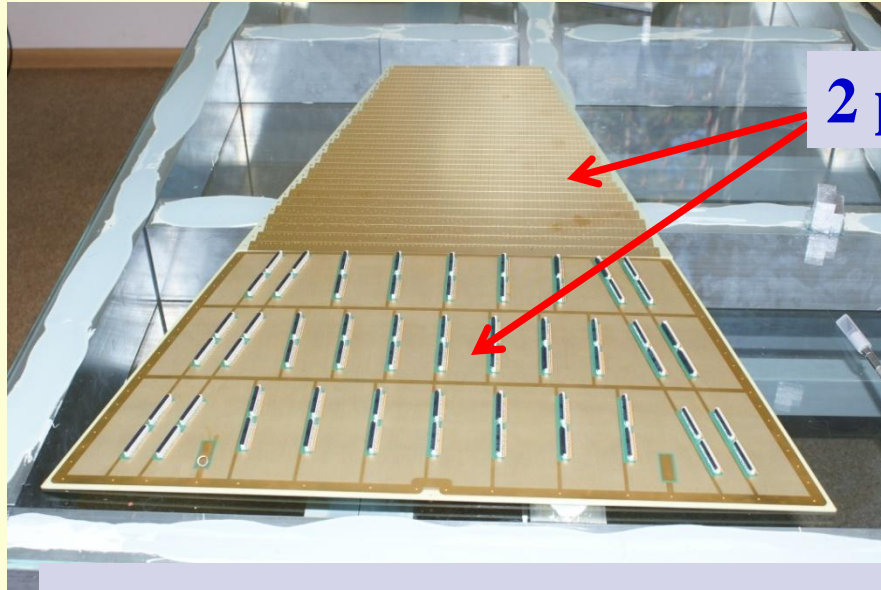


16-Apr-19

S.Movchan MPD/NICA TPC status

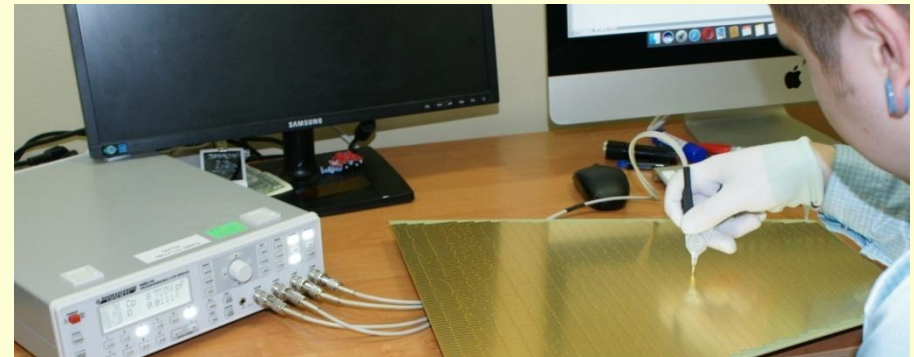
5

## ROC chamber: pad plane from 2 parts



2 parts

Pads capacitor measurement



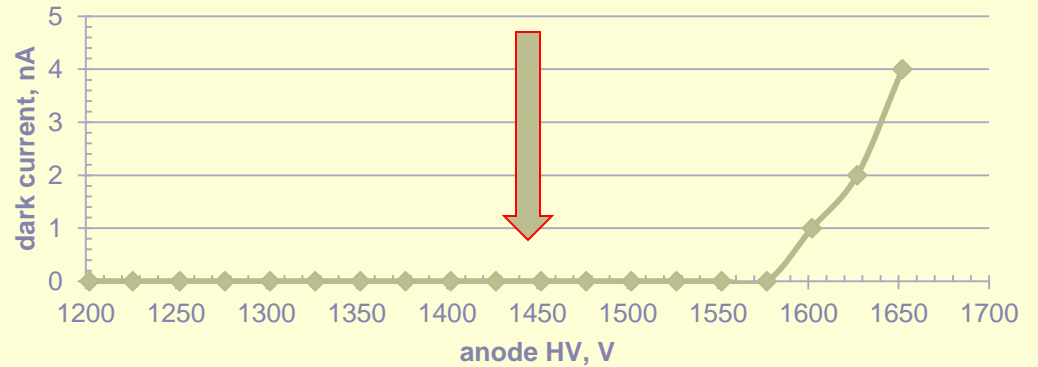
Chamber with 2 sections pad plane - **manufactured and under tested**

New pad plane from Italy - **tested**

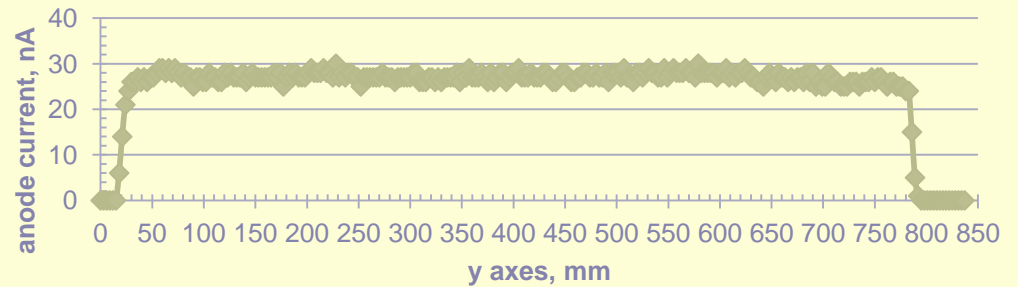
# ROC chamber: test results



ROC-14, Ar/CH4 (90/10), dark current



ROC-14, Xray line scan, step 3 mm, Ar/CH4 (90/10),  $U_a = 1,45$  kV,  $U_{dr} = -1120$ V, **uniformity 18,4%**



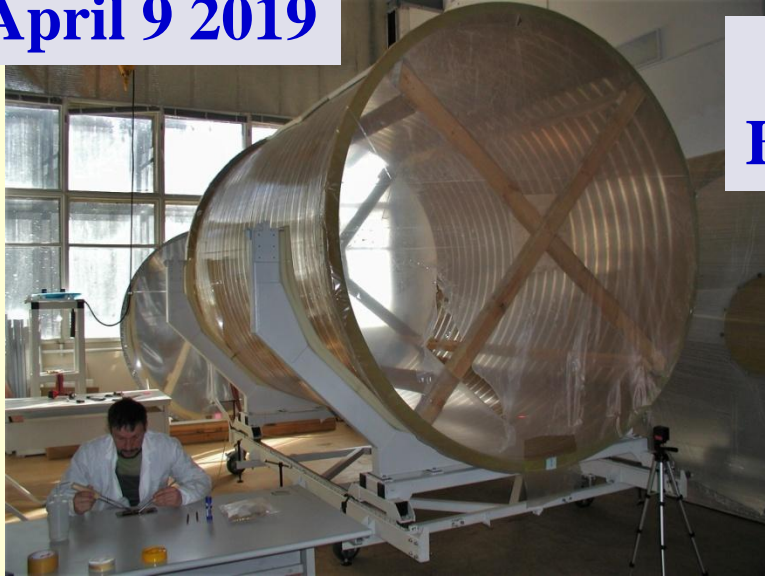
**Fe-55: FWHM ~ 20%**

## Test procedure:

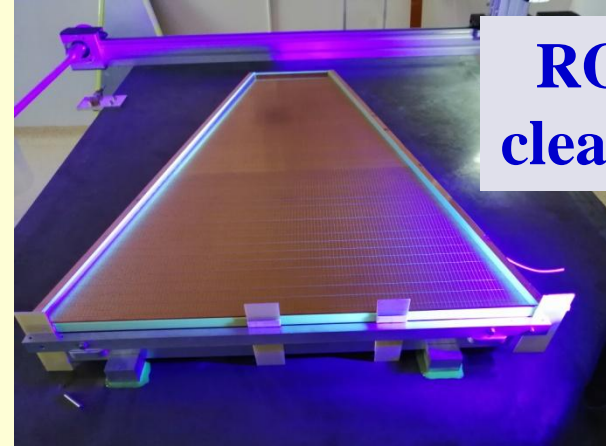
- counting plateau
- dark current
- energy resolution (Fe-55)
- uniformity of gas gain
  - ✓ linear scan
  - ✓ area scan

# TPC and ROCs: status

April 9 2019



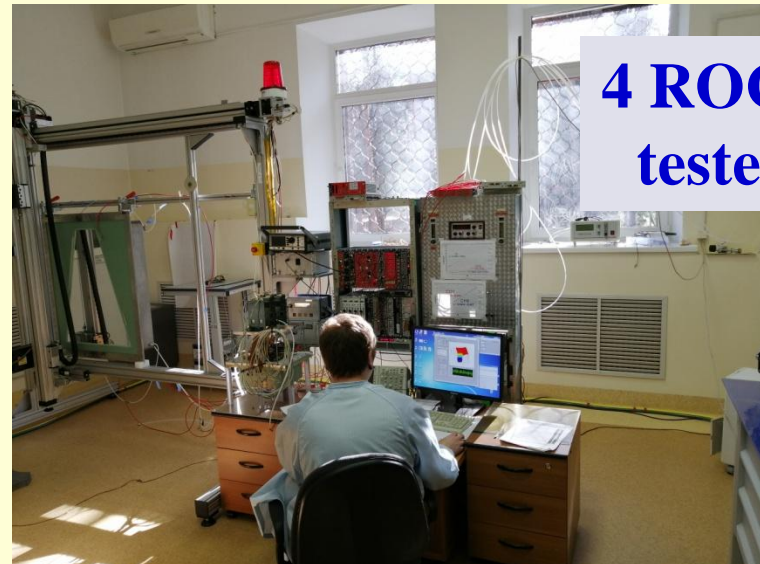
C3 at  
Bld.217



ROC  
cleaning



ROCs  
26 pc



4 ROCs  
tested



## TPC and ROCs: summary

### TPC assembly:

clean room	– ready
C1-C4 cylinders	– ready
flanges (2pc)	- ready
serial HV electrode	- ready
adjust. and align. TPC assembly tooling	– Feb 2019 -> May 2019
field cage rods (30 pc + 30 pc)	– March 2019 -> May 2019
field cage mylar strips manufacture	– April 2019 -> June 2019
start of TPC assembly (C3+C4)	- <b>April 10 2019</b>
flanges + HV electrode + field cage	- Aug 2019
HV test and leak test	- end of 2019

### ROC chambers:

frames (26 pc)	- ready
serial pad planes (30 pc)	– postponed, ordered only 6 pc
HV for ROC gate electrode	– design started
test chamber with 512 ch r/o system	– Aug 2019
serial ROC chambers manufacture	- 2019-2020

# 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 (very preliminary):

- neutrons + protons –  **$2.5 \times 10^{10}$**  p/cm<sup>2</sup> per year
- e- & e+ -  **$1 \times 10^{10}$**  p/cm<sup>2</sup> per year
- ions -  **$0.5 \times 10^5$**  p/cm<sup>2</sup> per year

## Dose:

Expected dose - **1 kRad** per 10 years

## *SAMPA v3/v4* tested at:

*proton fluence* - up to  $N=10^{12}$  per cm<sup>2</sup>

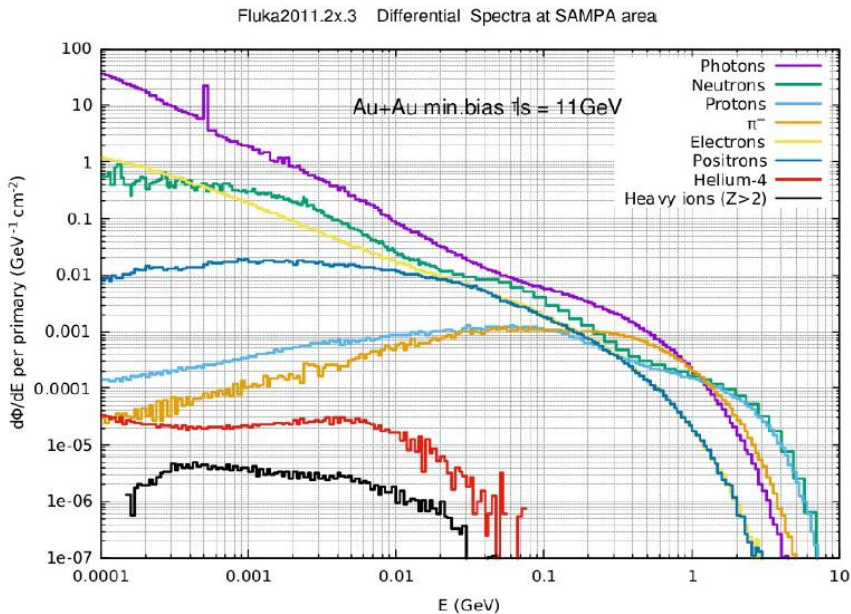
*ion fluence* - up to  $N=10^7$  per cm<sup>2</sup> &  $LET=(3-125)$  MeV cm<sup>2</sup>/mg

*T chip=(45-85) degree* =>  **$SEL=1 \times 10^{-7}$  cm<sup>2</sup> for  $LET=16$  MeV cm<sup>2</sup>/mg**

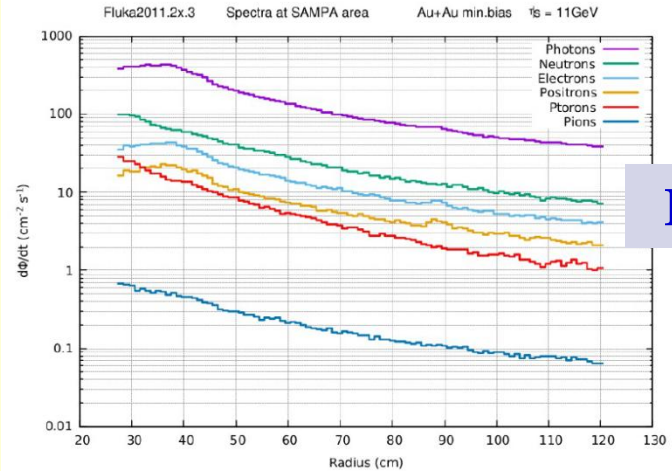
# TPC electronics (FLUKA): fluences and dose

I.Semenova, Au-Au min. bias  $\sqrt{s}=11$  GeV, Si h=100  $\mu\text{m}$ , PRELIMINARY:

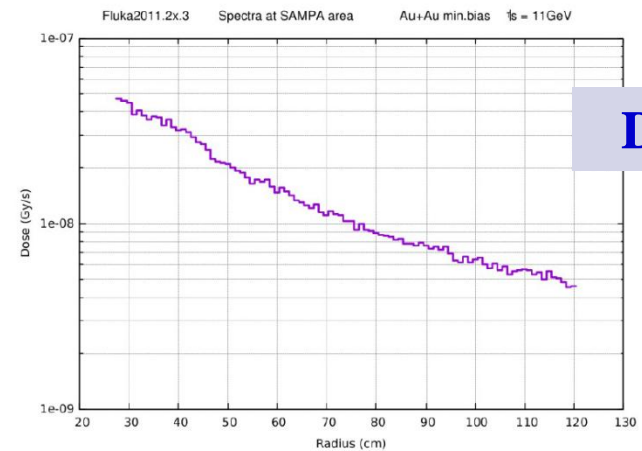
## Differential spectra for SAMPA



Status: in progress



Fluence



Dose

## TPC electronics (FLUKA): fluences and dose

**I.Semenova**, Au-Au min. bias  $\sqrt{s}=11$  Gev (**PRELIMINARY**):

### Fluence:

- all charge particles – **600** particles/cm<sup>2</sup>\*sec (**100** - for E>20 MeV)
- 1 MeV neutron equivalent – **150** n/cm<sup>2</sup>\*sec
  
- gamma - **500** gamma/cm<sup>2</sup> \*sec -> **1x10\*\*11** p/cm<sup>2</sup> per 10 year
- neutron - **100** neutrons/cm<sup>2</sup> \*sec-> **2x10\*\*10** p/cm<sup>2</sup> per 10 year
- proton - **25** protons/cm<sup>2</sup> \*sec -> **0.5x10\*\*10** p/cm<sup>2</sup> per 10 year
- e- & e+ - **60** electrons/cm<sup>2</sup> \*sec -> **1x10\*\*10** p/cm<sup>2</sup> per 10 year
- pions - **0.6** pions/cm<sup>2</sup> \*sec -> **1x10\*\*8** p/cm<sup>2</sup> per 10 year
- ions - **0.01** ions/cm<sup>2</sup> \*sec -> **0.5x10\*\*5** p/cm<sup>2</sup> per 10 year  
(1 year =2x10\*\*7 sec)

**Dose:**  $D=4 \times 10^{-8}$  Gy/s,

per 10 years Dose is about 10 Gy = **1 kRad**

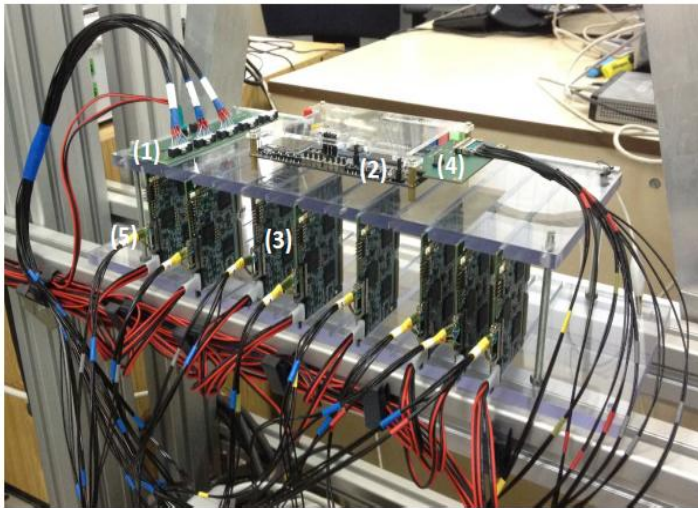
(for Apollo and Shuttle space flights,  $D=2$  Rad/year)

# TPC electronics: status

**SAMPA chips (4500 pc): expected delivery date - June 2019**

## Pilot system – 512 ch

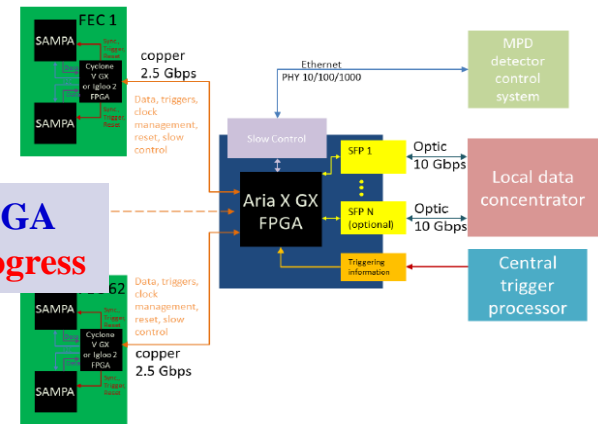
Eight cards pilot system



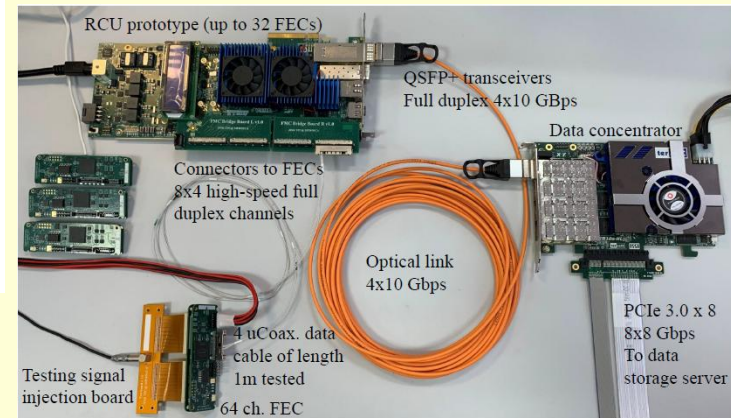
- 1) Trigger, clock, reset distr. board .
- 2) System controller.
- 3) 64-ch SAMPA- FEC.
- 4) HSSI (up to 2.5 GBps; up to 8 FECs).
- 5) Data/conf. full duplex HSSI port; clock 40 MHz, trigger, reset.

**Status: tested**

Block diagram of one chamber readout

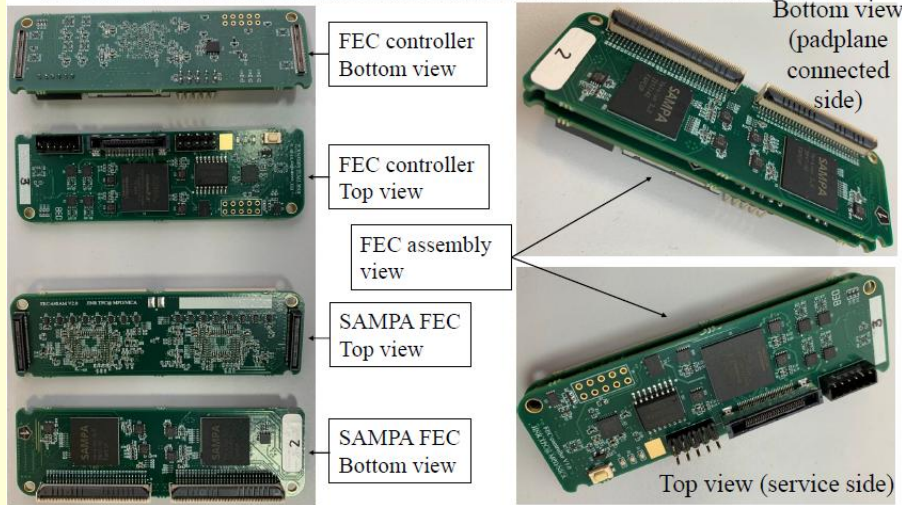


**tests with FPGA  
Aria X – in progress**

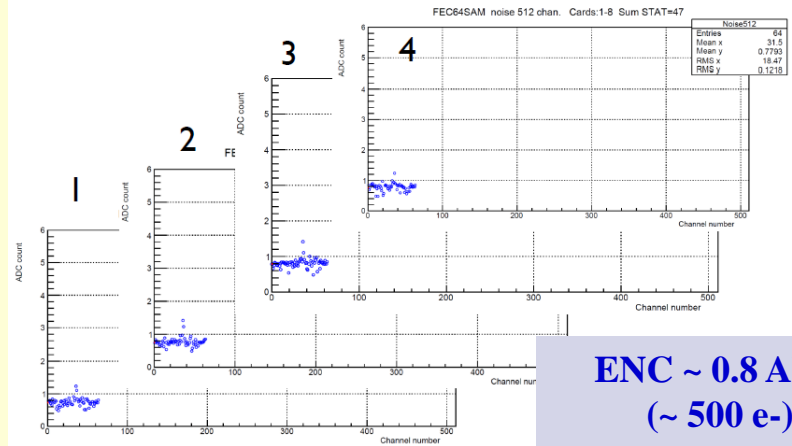


**Pilot readout system for few ROCs – proposal**

# TPC electronics: FE cards

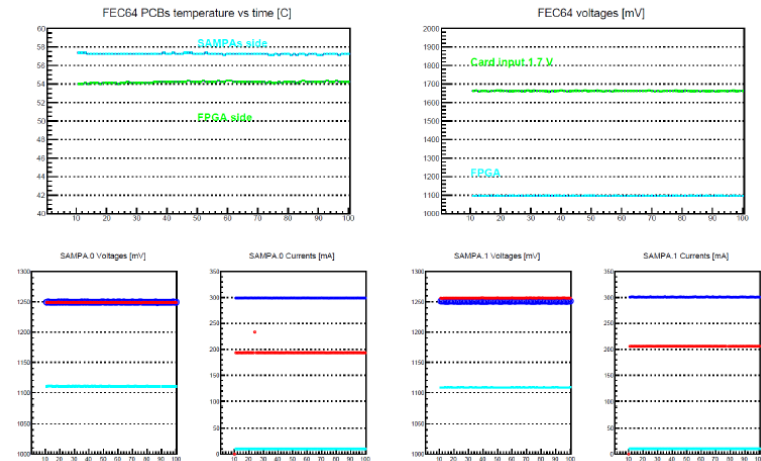


## FEC noise estimate for cards 1,2,3,4



**ENC ~ 0.8 ADC**  
(~ 500 e-)

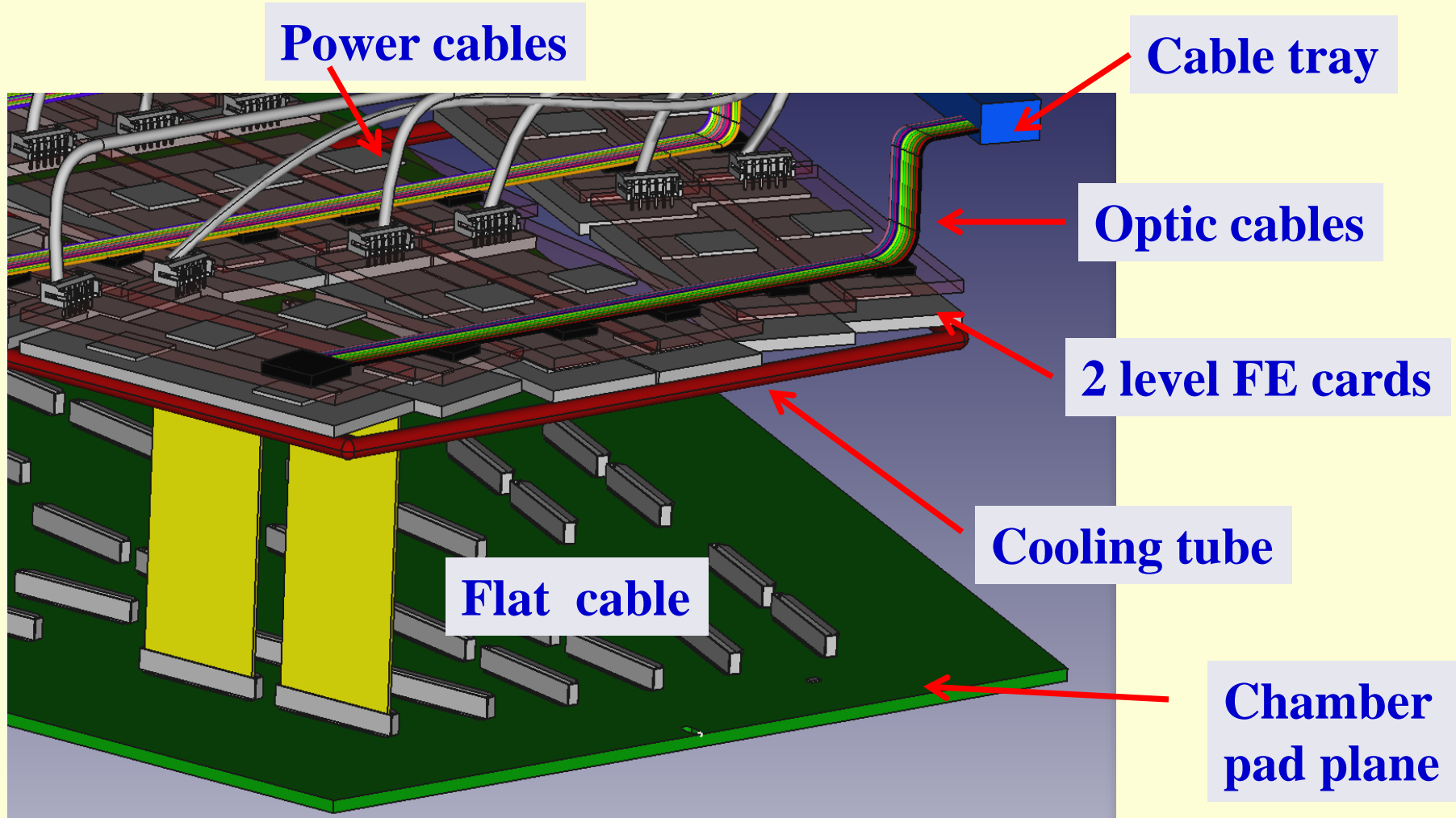
## FEC slow control data



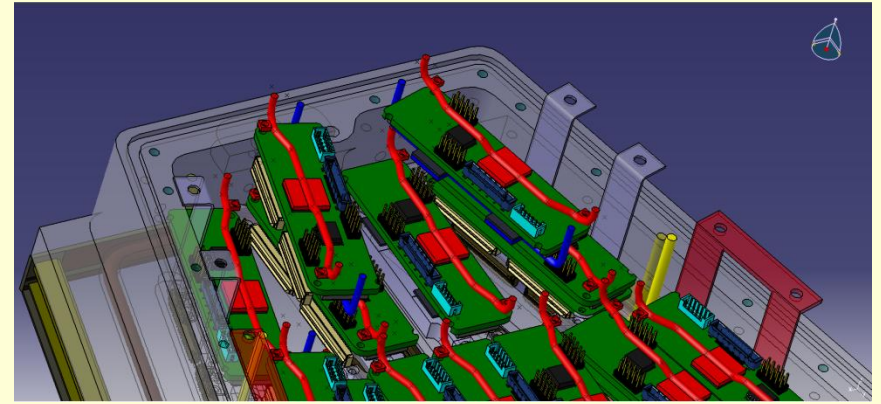
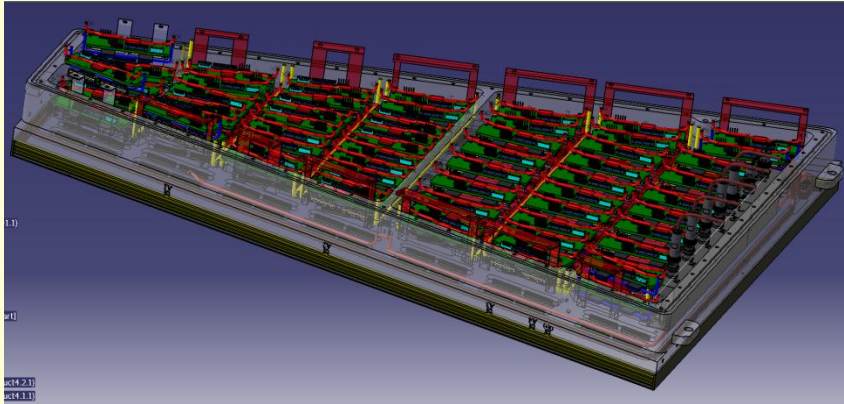
**T<sub>SAMPA</sub> = 57 degree**  
**T<sub>FPGA</sub> = 54 degree**  
**Board LV: 1.7V & 1.1V**  
**SAMPA (2 pc): 1.25V/500 mA**  
**FPGA: 1.1V/10 mA (stand by mode)**

**Status: in progress**

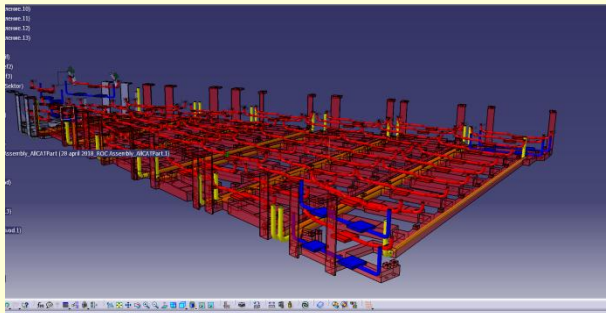
# ROC chamber + electronics integration: **concept**



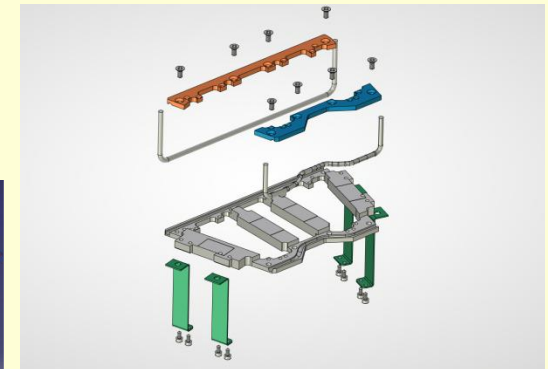
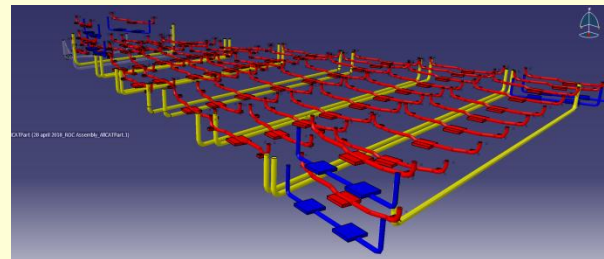
# TPC electronics: FE cards integration



**radiators +  
tubes**



**tubes**

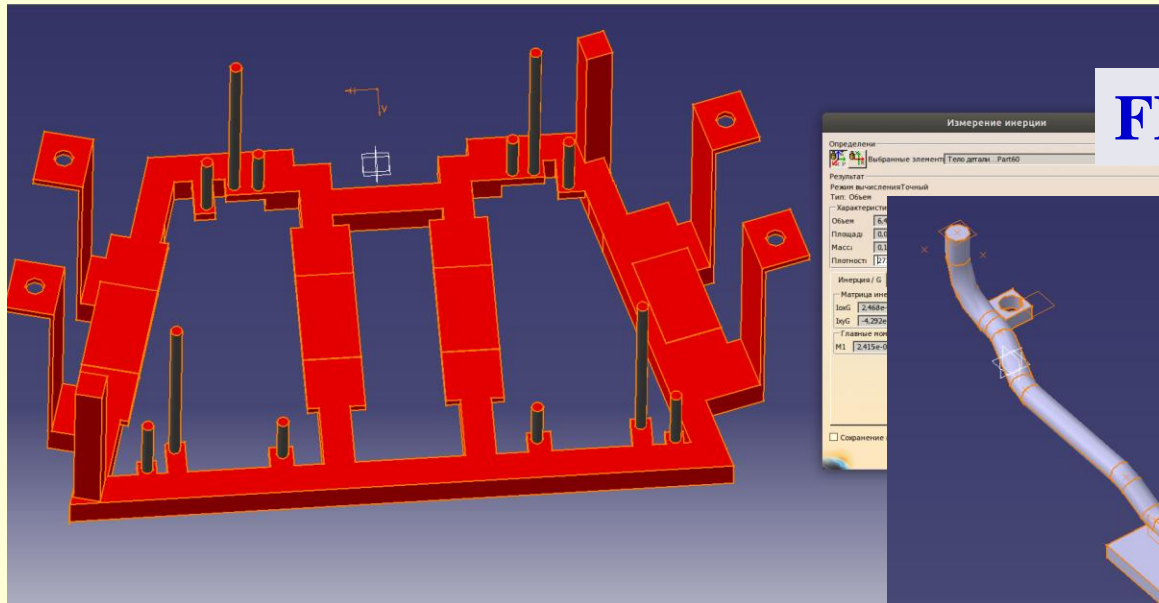


**Status: in progress**

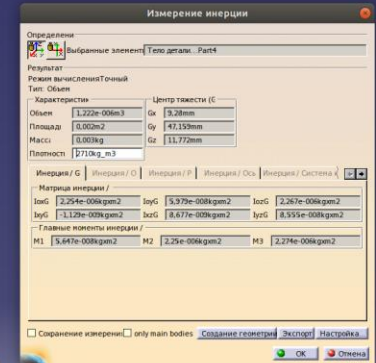
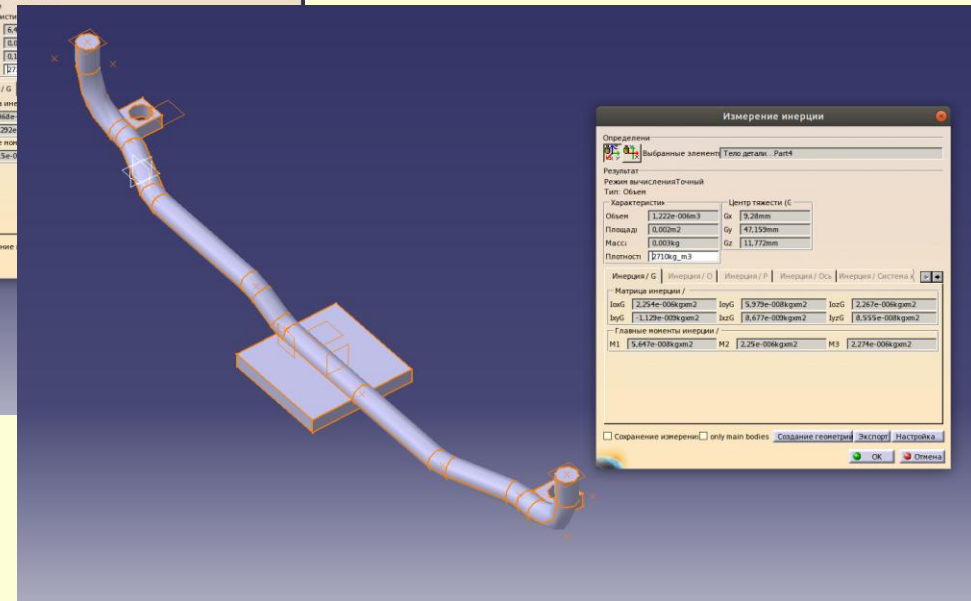
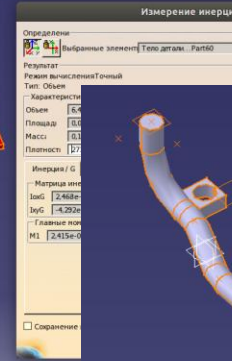


# ROC chamber + electronics integration: design

## SAMPA cooling radiator



## FPGA cooling radiator



# TPC electronics: summary

## FE electronics:

- 512 ch system FEC v1.0 – tested
- test with ROC chamber – Aug 2019
- SAMPA chips (4500 pc) – payment done, **delivery-June 2019**
- Aria 10 GX FPGA for controller (16 pc) - delivered to JINR
- Data concentrator chip (NRNU MEPHI) - design in progress
- FEC64SAM v.2 (10 pc) – delivered
- FE cards integration with ROC chamber - in progress
- FE cards cooling design – in progress, mock up – done
- FE card temperature distribution – calculations and meas. started  
(*T board ~ 40 degree, SAMPAs and FPGA ~ 60 degree*)
- ROC+FE cards temperature distribution – in progress (calculations)
- controller based on commercial kit - in progress

Electronics radiation environment (**preliminary**, per 10 years):

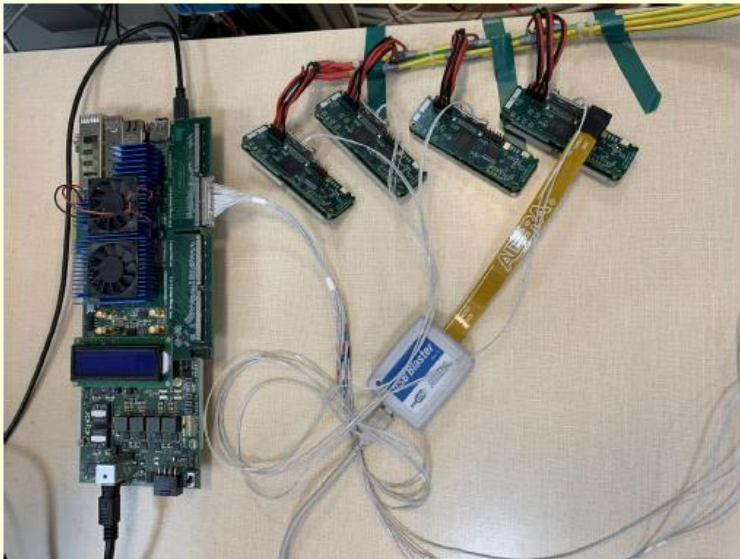
**Dose** – about **1 kRad** (sor Apollo and Shuttle space flights, D=2 Rad/year)

### Data rates:

- trigger mode - **20 GByte/sec** (*N=1000 tracks*)
- continuous readout mode - **300 GByte/sec**

# TPC electronics: status and schedule

**Test bench  
based on commercial kit  
(ARIA-10 FPGA)**



Item	Date
Testing FEC v1.0 finished	Feb. 2019 ✓
Preproduction version FEC v2.1 PCBs ready	June 2019
Delivery of SAMPA v4 chips to Dubna	June 2019
Assembly FEC v2.1 boards (32pc)	July 2019
Installation of FEC v2.1 boards (32pc) to ROC chamber	Aug. 2019
Start tests of ROC chamber in Bld.40	Sept. 2019
Finish tests of ROC chamber in Bld.40	Oct. 2019
Production version FEC v2.2 PCBs ready	Dec. 2019
Assembly FECs v2.2 boards (62pc, 1-st ROC, total 1)	Feb. 2020
Instrumented and test ROC-1 in Bld.40	Apr. 2020
Assembly FEC v2.2 boards (186pc) (3 ROCs, total 4)	May 2020
Instrumented and test ROC-2, 3 & 4 in Bld.40	June 2020
Assembly prod. ver. FECs (620pc, 10 ROCs, total 14)	July 2020
Assembly prod. ver. FECs (620pc, 10 ROCs, total 24)	Aug. 2020

## INP BSU (Minsk): TPC LV system

- |                                 |                |
|---------------------------------|----------------|
| Pre-serial LVDB prototype       | – manufactured |
| cooling plate                   | – manufactured |
| Pre-serial LVDB prototype tests | – done         |
| LVDB mass-production (60 pc)    | - done         |



### LV system (2 options):

- Wiener Marathon (Type AL (300G) MDC 02/07)  
**up to 300 Gauss and 30 Rad**
- CAEN EASY3000 LV system (module type A3100B 2÷7V/100A)  
**up to 5000 Gauss and 200 Rad**

[https://indico.cern.ch/event/699390/contributions/2868537/attachments/1593340/2522493/Neolite\\_RandD\\_effortSummary.pdf](https://indico.cern.ch/event/699390/contributions/2868537/attachments/1593340/2522493/Neolite_RandD_effortSummary.pdf)

### Status for CAEN option:

- invoice for LV test system – OK! delivery time – (3÷4) months
- invoice for HV system – OK! delivery time – (90÷150) days

# TPC gas system

Gas supply



Status - **commissioning**  
in progress

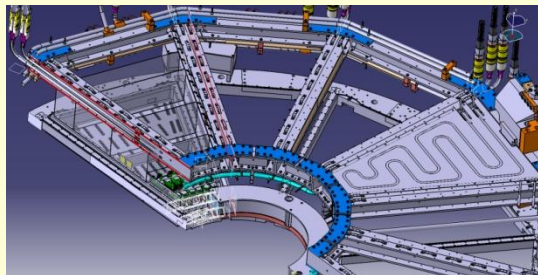
Racks

TPC volume imitator

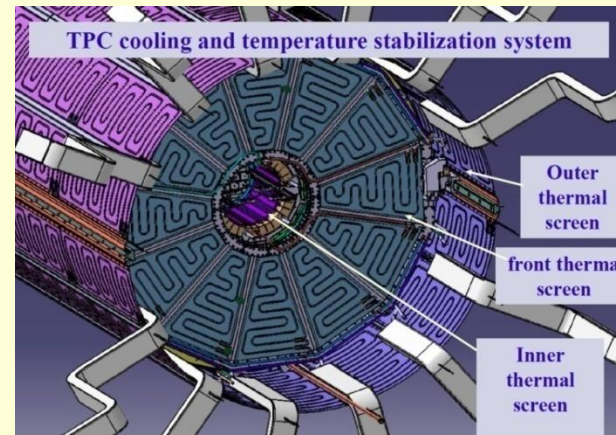


Status - **commissioned** (Bld.217)

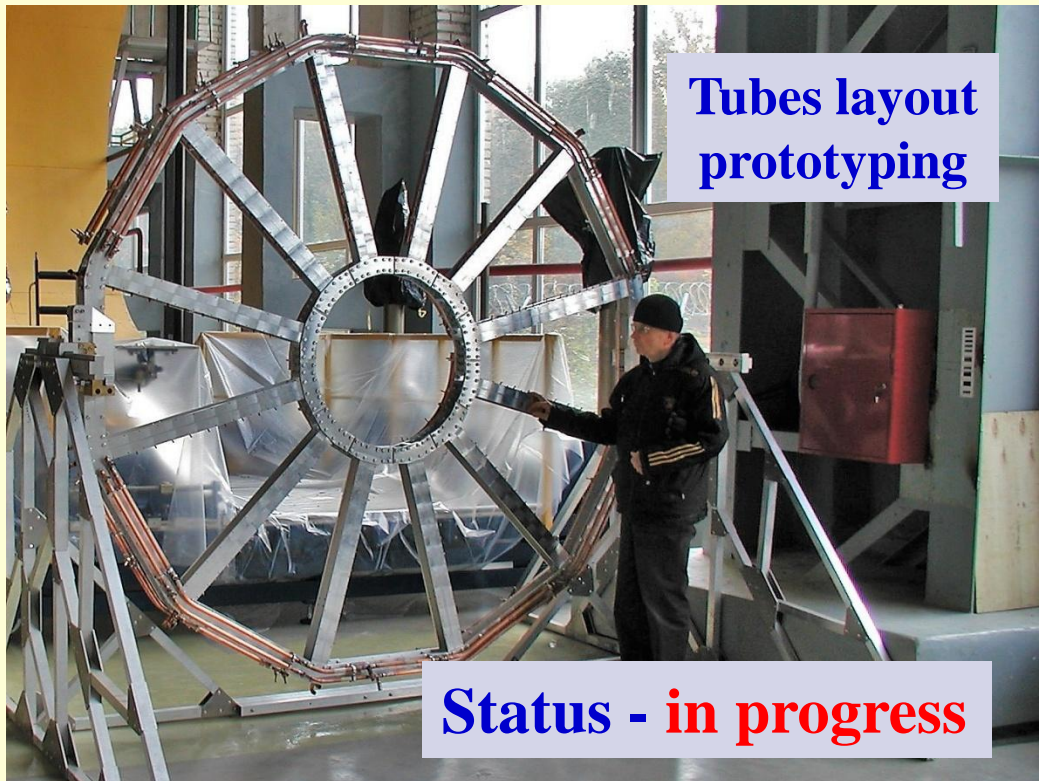
# TPC cooling system: tubes layout and set of thermal panel prototypes



Service wheel



Tubes layout prototyping

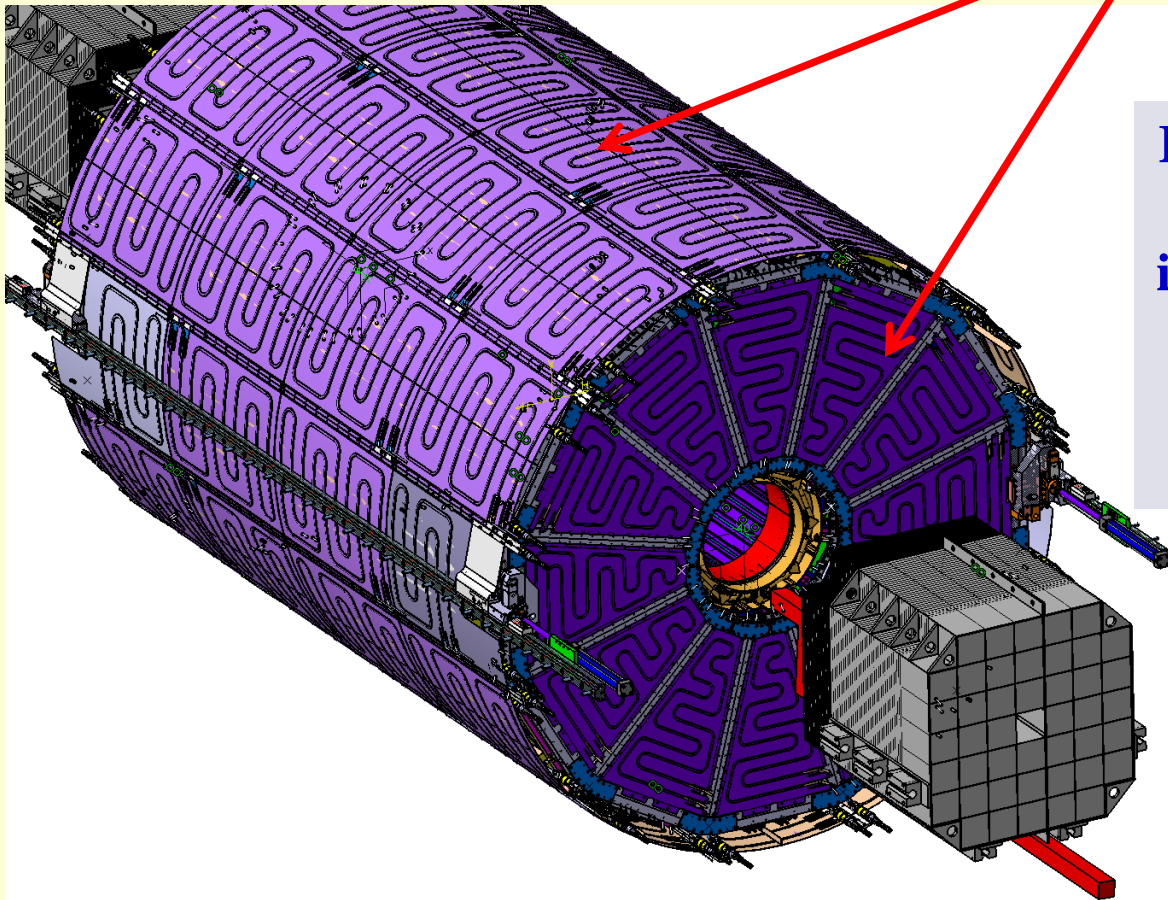


Status - in progress



Al plate – 0.5 mm  
Al tube - D=8/6 mm

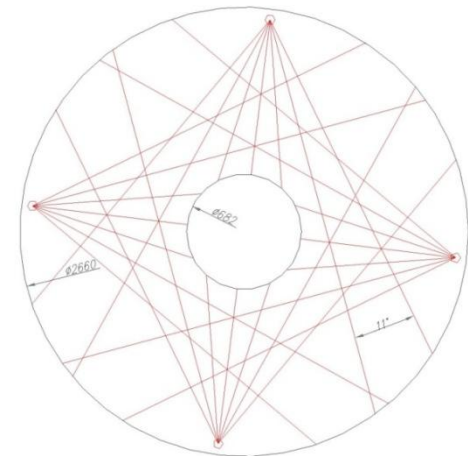
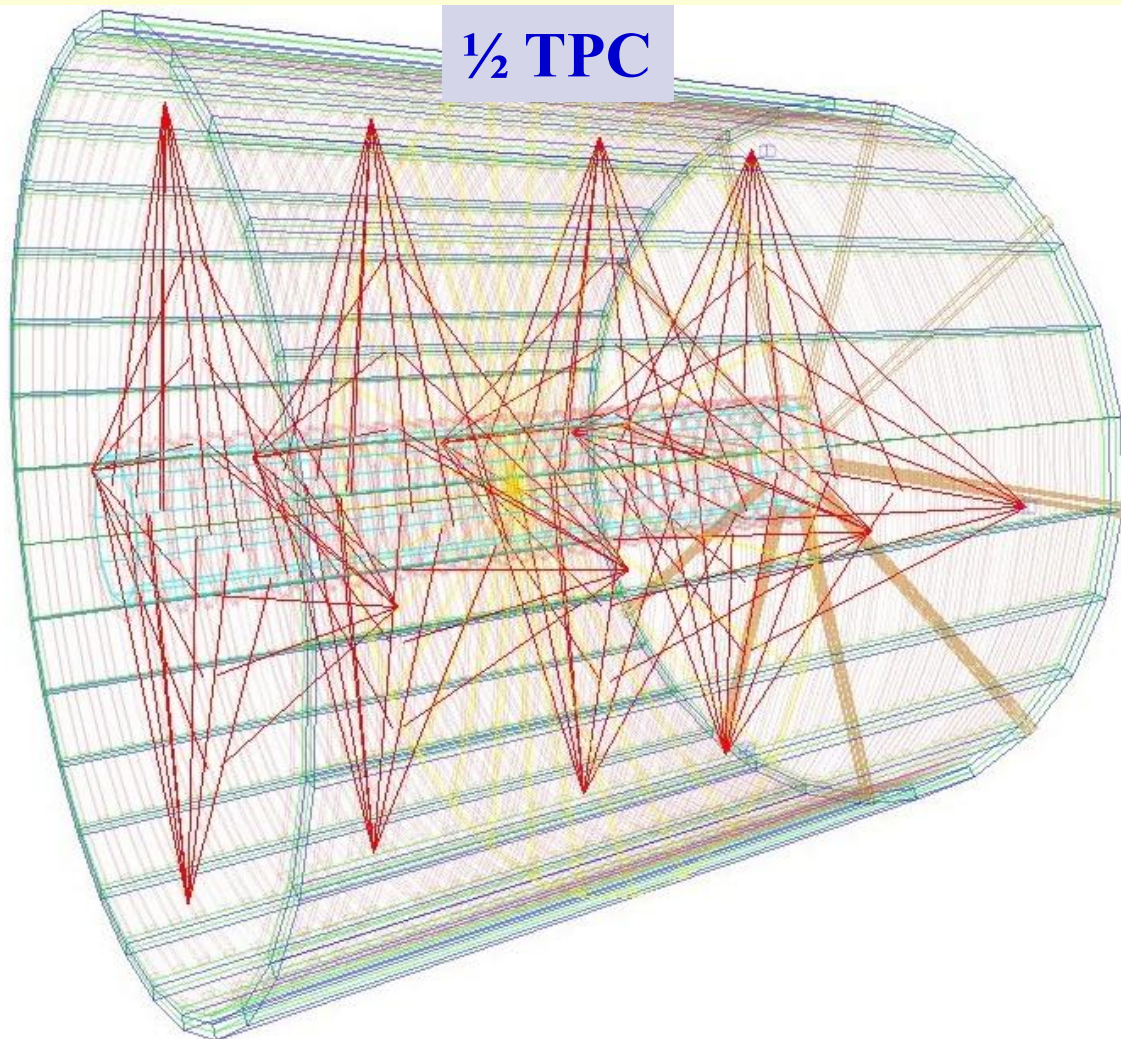
## TPC cooling system: new thermal screens concept



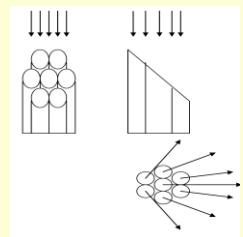
Barrel part – shorter and fixed to TPC instead fixation to ECAL structure

**under discussion !!!!**

# TPC laser calibration system



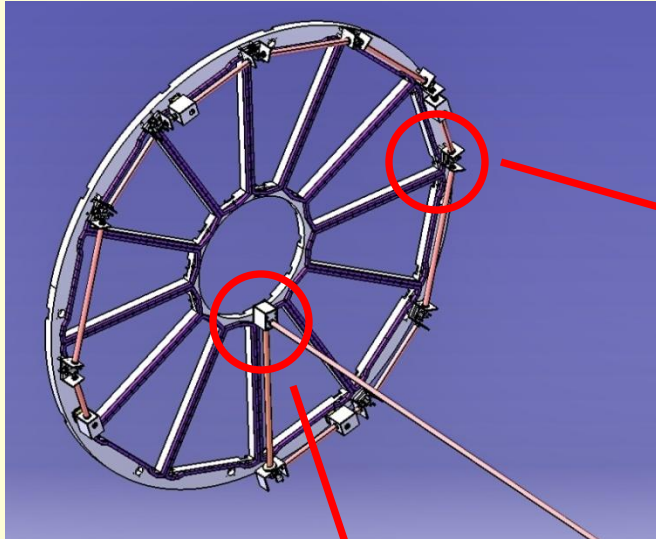
micro-mirror bundles



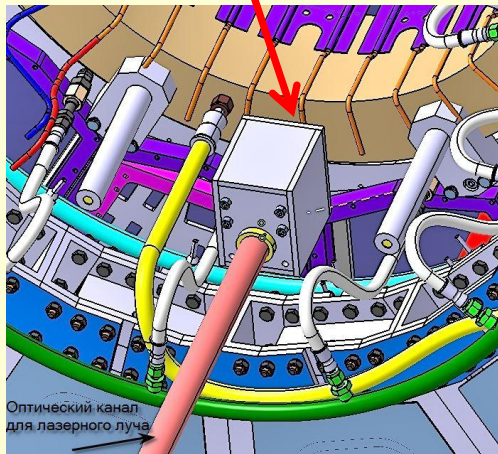
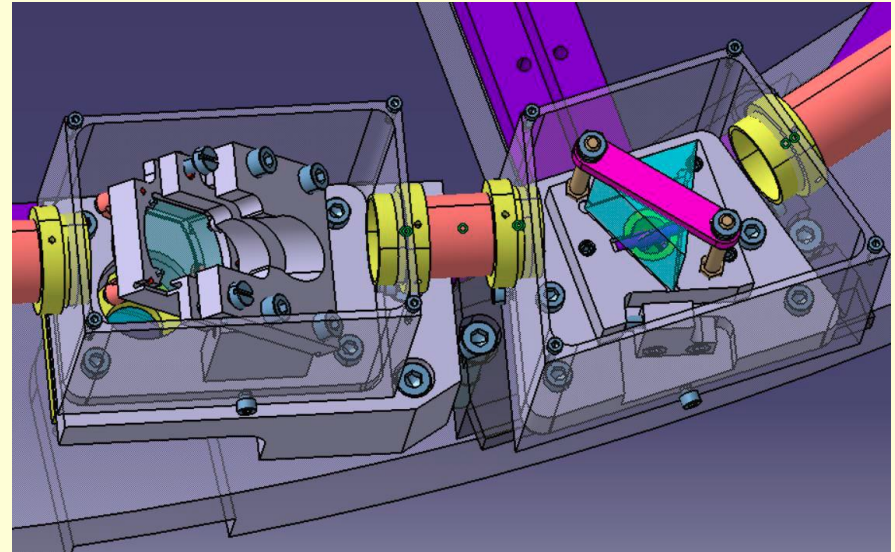
Laser “planes” - 4+4  
 Points per plane - 4  
 Beams per point - 7  
 Laser “tracks”, **N - 224**



# TPC laser calibration system

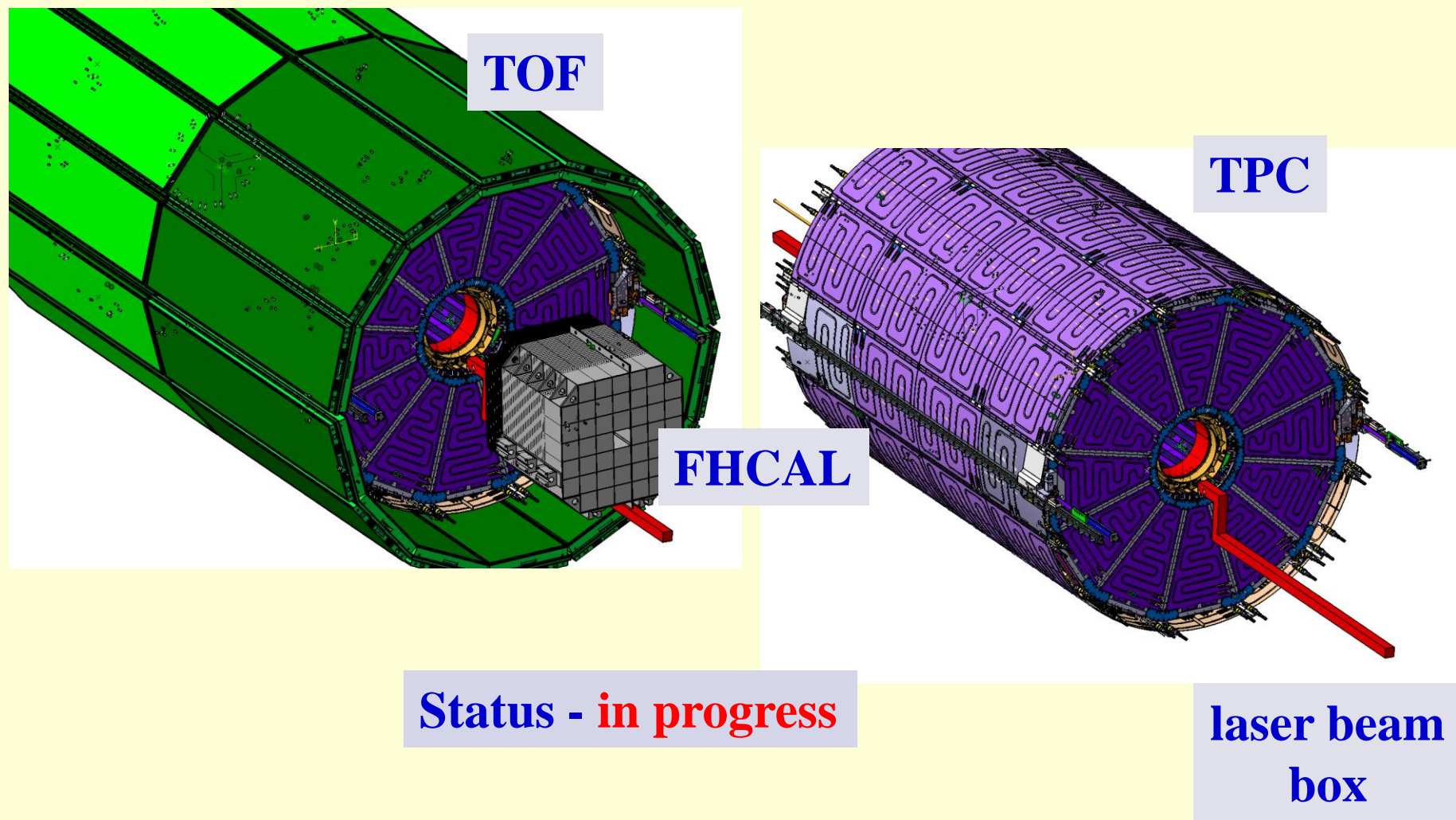


Semi transparency mirror & prism

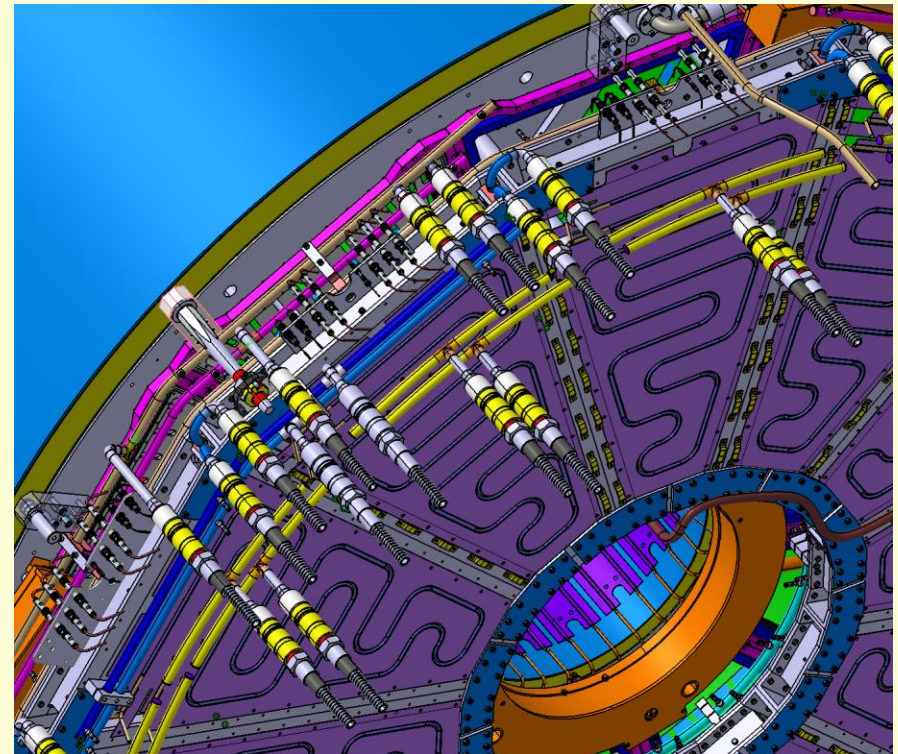
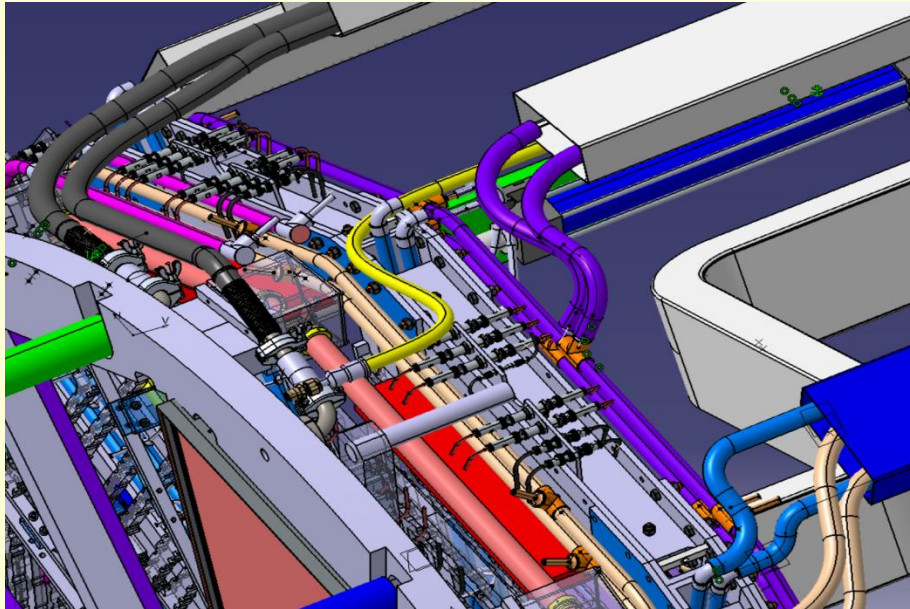


- full set of micro-mirror bundles - **assembled**
- 2 lasers (special option) – **commissioned**
- laser beam splitter and transport system - **in production**
- laser beam monitors - **ordered**

# TPC laser calibration system: laser beam layout (proposal)



## TPC: cables and tubes integration



Optimization - in progress

# TPC services: summary

## LV system:

- pre-serial LVDB + cooling plate (4 pc) – ready, tested
- serial LVDB (60 pc) – assembled, tested
- serial cooling plate – designed and ordered
- CAEN EASY3000 LV test system - invoice got
- CAEN HV system - invoice got
- Wiener Marathon - under discussion

## HV system:

- CAEN HV system (crate + modules) - invoice got

## Gas system:

- commissioned

## Cooling system:

- prototype – ready
- measurements with prototype – done
- barrel and end cap thermal panels – new prototypes ordered
- service wheel cooling tubes routine – prototyping done, optimization in progress

## TPC services: summary (continue)



### Laser calibration system:

lasers (2 pc)

- commissioned

laser beam splitter and transport system - in production, will be delivered

May 2019

beam monitors (WEB cameras + optics )

- ordered

channel for laser beam inside MPD

- new layout proposed

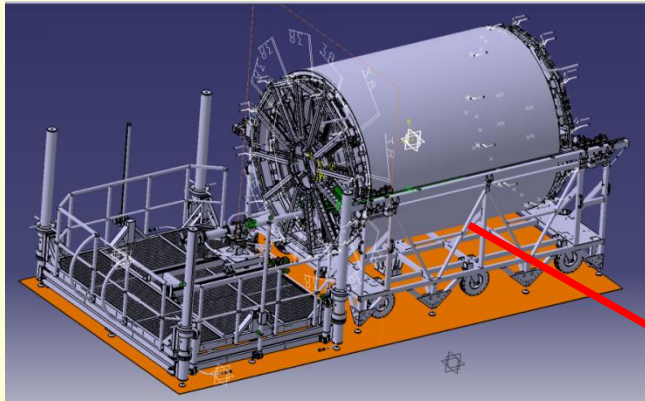
### INTEGRATION:

TPC sub-systems integration - in good shape

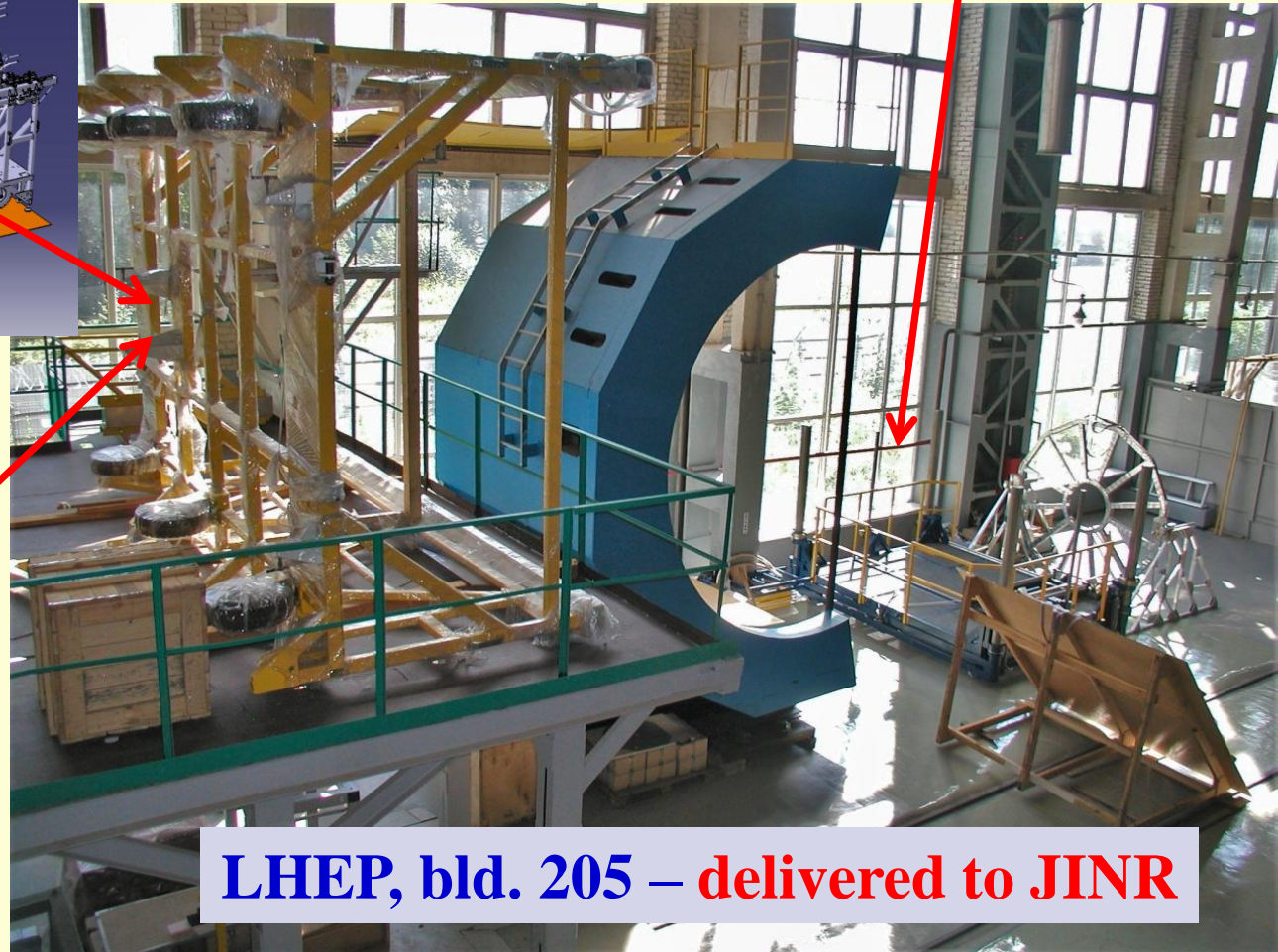
list of TPC cables and tubes – updated

Integration TPC into MPD - **not started yet** (waiting for ECAL design and its integration to MPD)

# TPC: transportation platform and ROC manipulator



at Briansk:

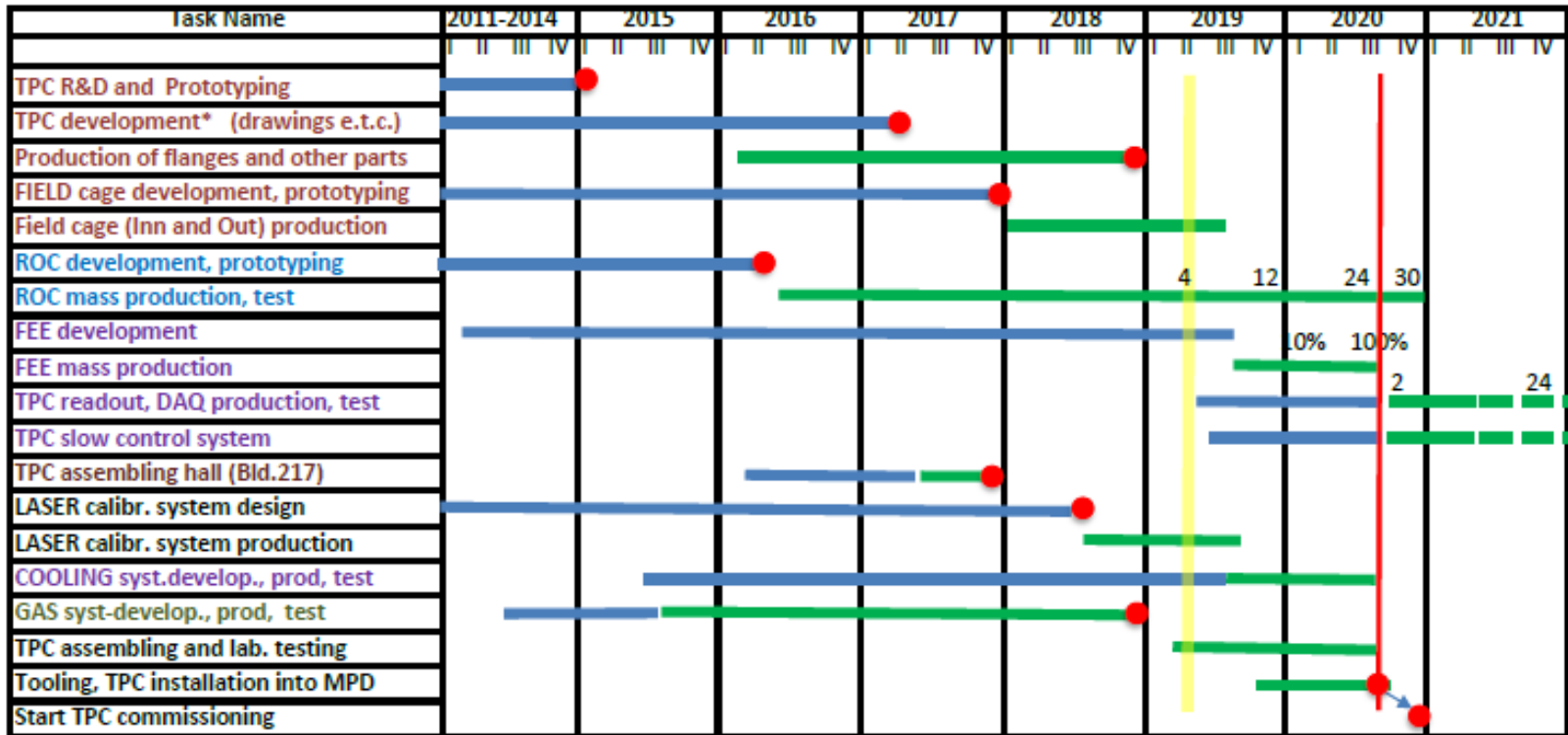


LHEP, bld. 205 – delivered to JINR

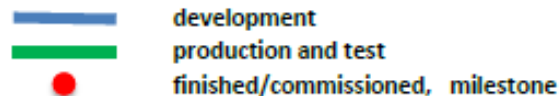
# Time schedule

update - 15.04.2019

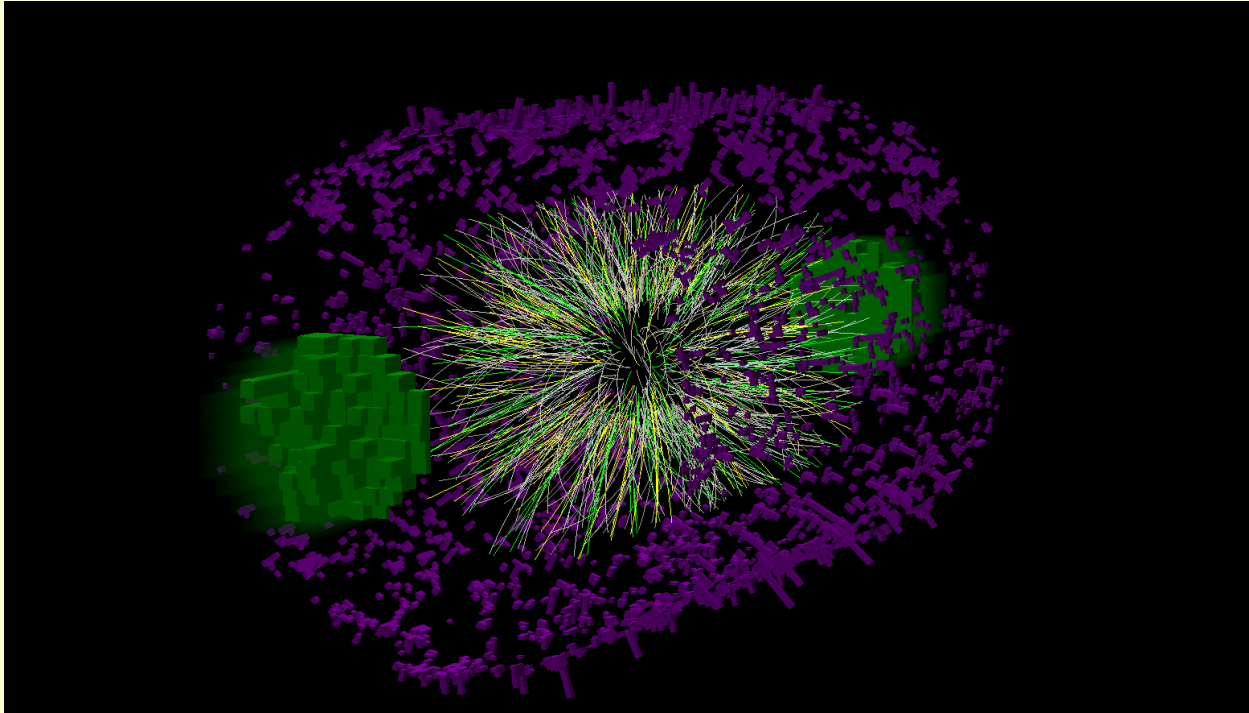
TPC time schedule



\* Current version of TPC dimensions was approved of 31.01.2013



**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>**