



Status and Prospects of the MPD Time-of-Flight Identification System at NICA

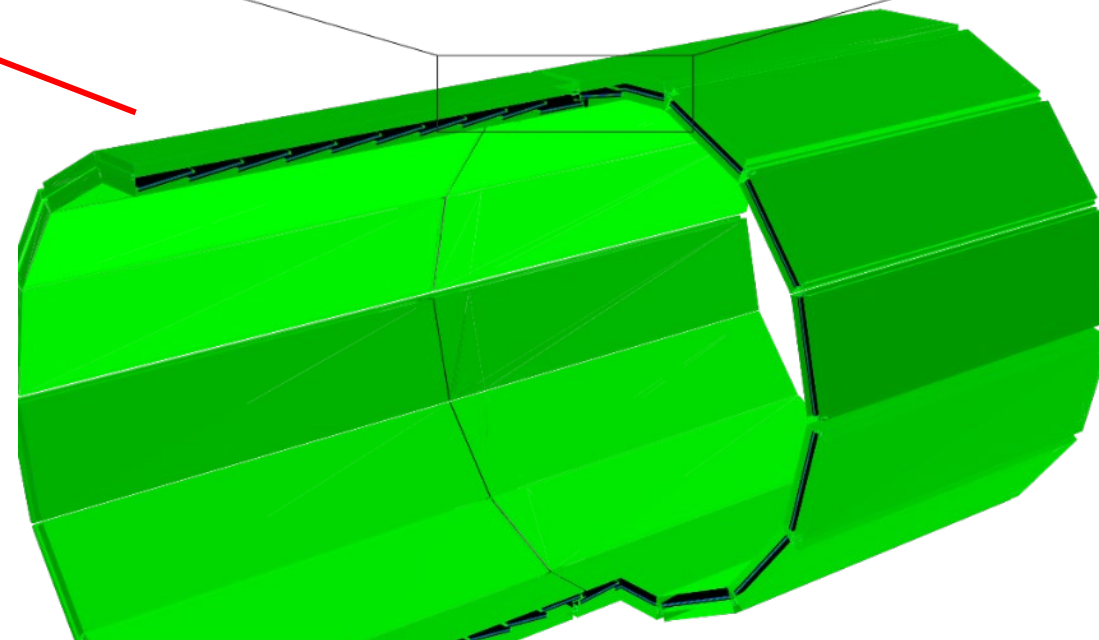
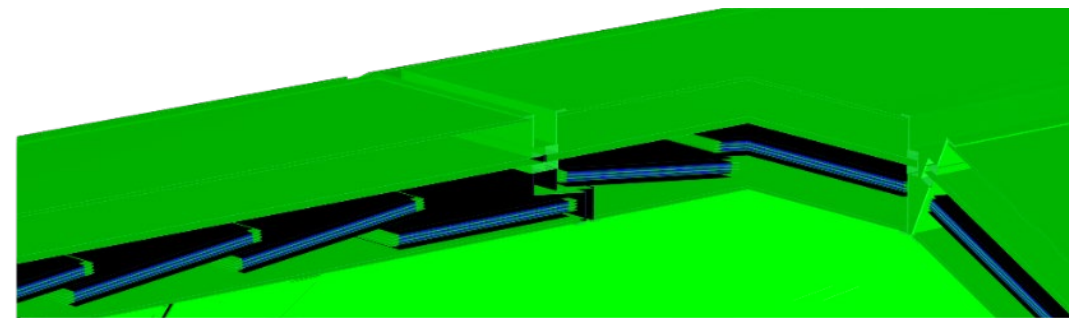
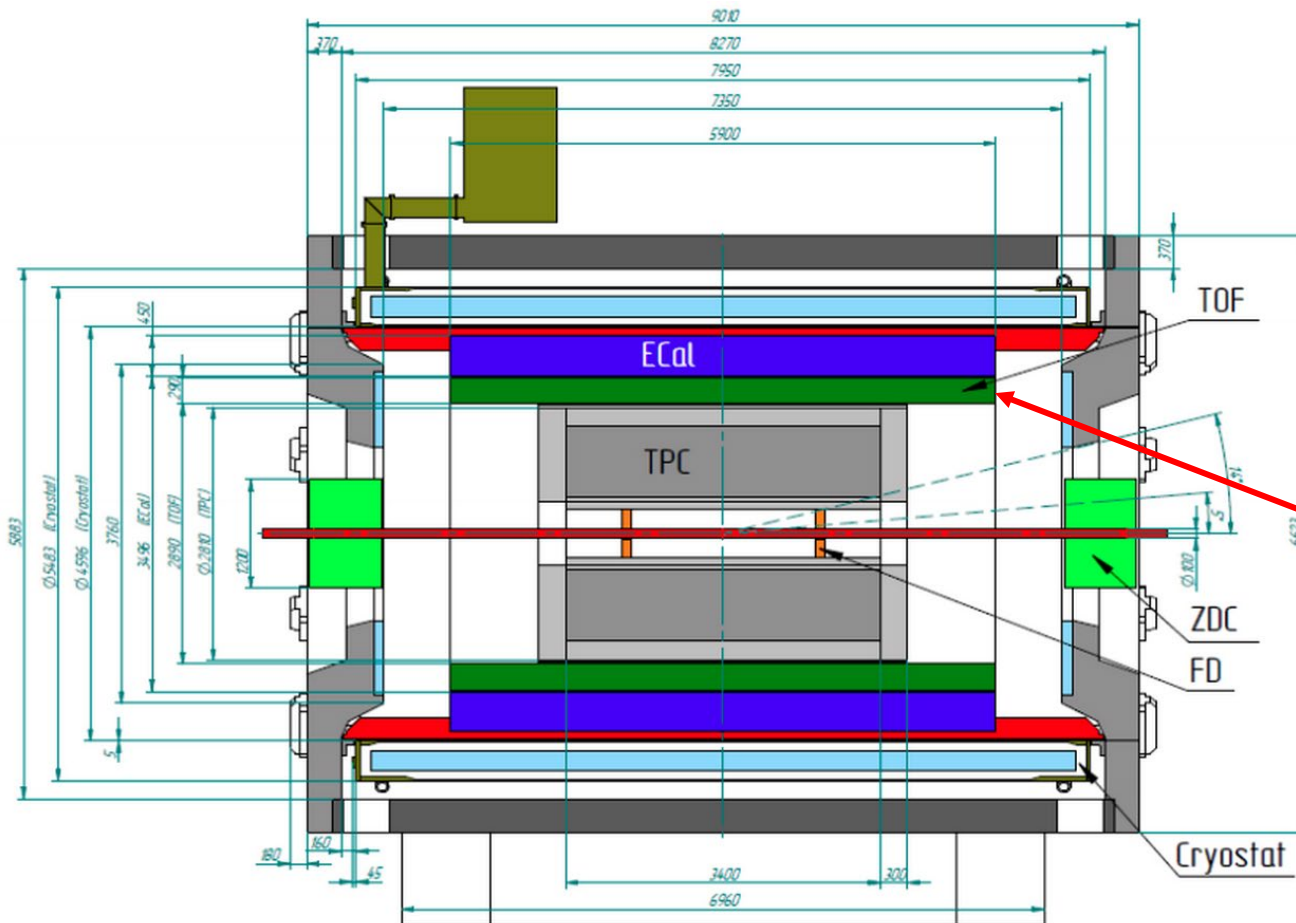


Contents

- 1) First stage of the TOF system of MPD
- 2) Current situation of TOF production in JINR
- 3) TOF installation into the MPD solenoid
- 4) TOF service and sub-systems status
- 5) Development of the End-cup TOF rings
- 6) New electronics for TOF readout
- 7) MPD test beam facility

Time-of-Flight system in the basic configuration of MPD

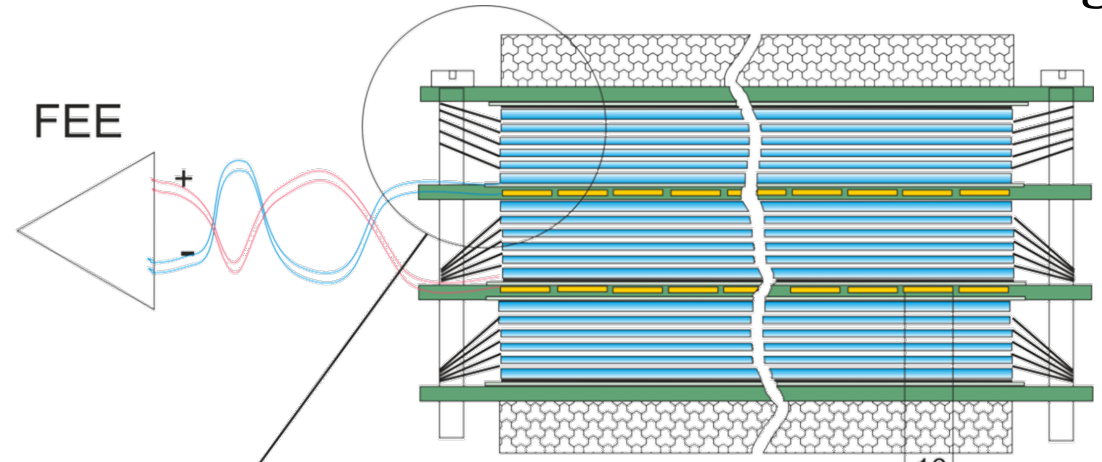
$L \approx 6 \text{ m}$, $d \approx 3 \text{ m}$, $|\eta| < 1.44$



TOF Barrel (MPDRoot geometry)

	Number of detectors	Number of readout strips	Sensitive area, m ²	Number of FEE cards	Number of FEE channels
MRPC	1	24	0.192	2	48
Module	10	240	1.848	20	480
Barrel (28 modules)	280	6720	51.8	560	13440

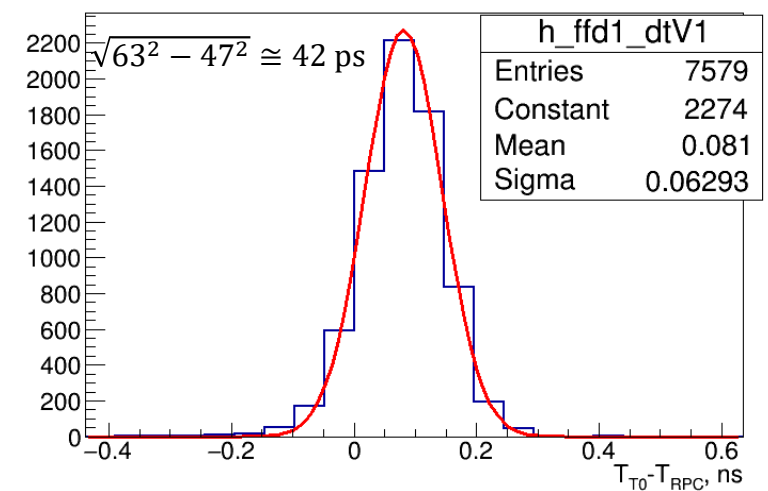
MPD TOF MRPC design



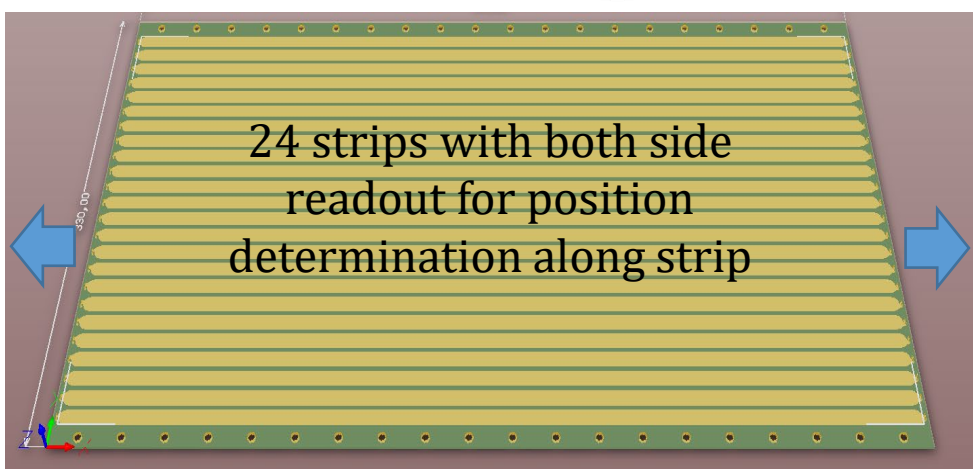
3-stack 15-gaps MRPC

- Honeycomb (5 mm)
- PET Screw
- Outer PCB (1.5 mm)
- Mylar (100mkm)
- Outer HV glass (400 mkm)
- Inner glass (270 mkm)
- Spaser (fishing line 200 mkm)
- PCB with "strips" (1.5 mm)

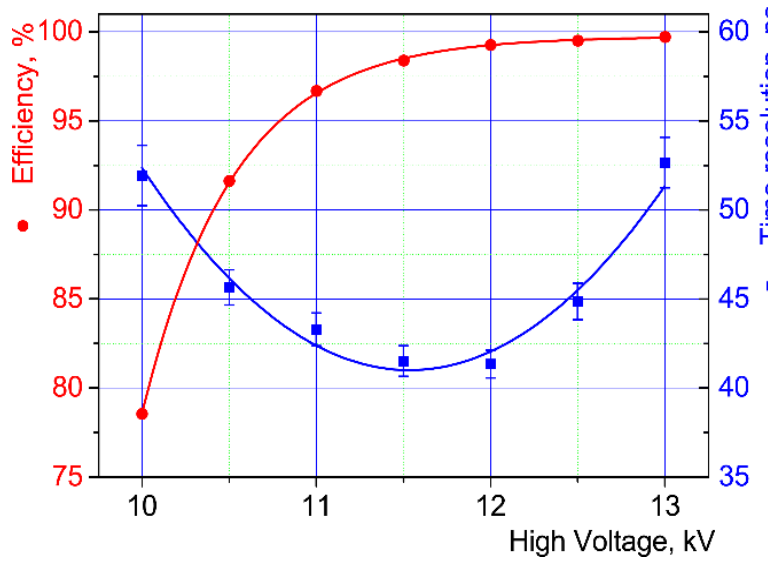
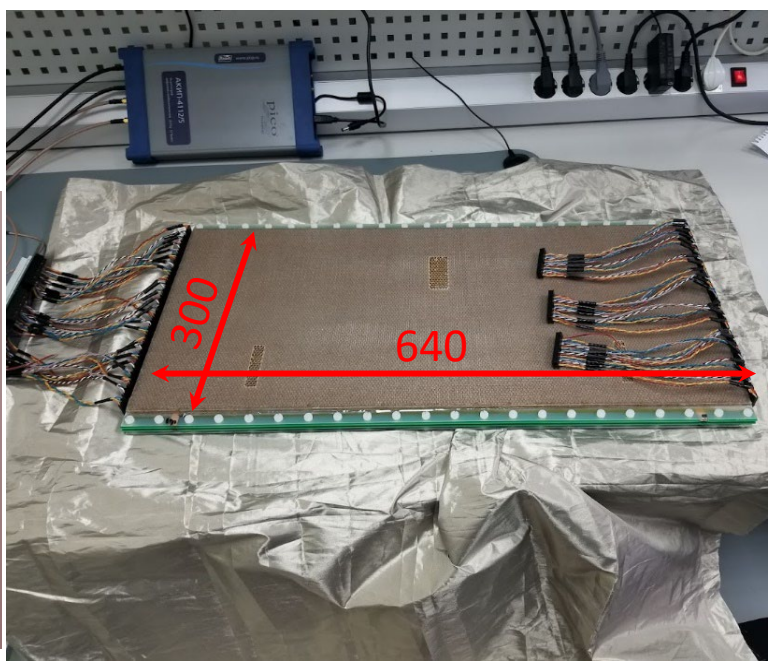
Gas mixture: $C_2H_2F_4/SF_6/iC_4H_{10}$ (90/5/5)



The best measured time resolution

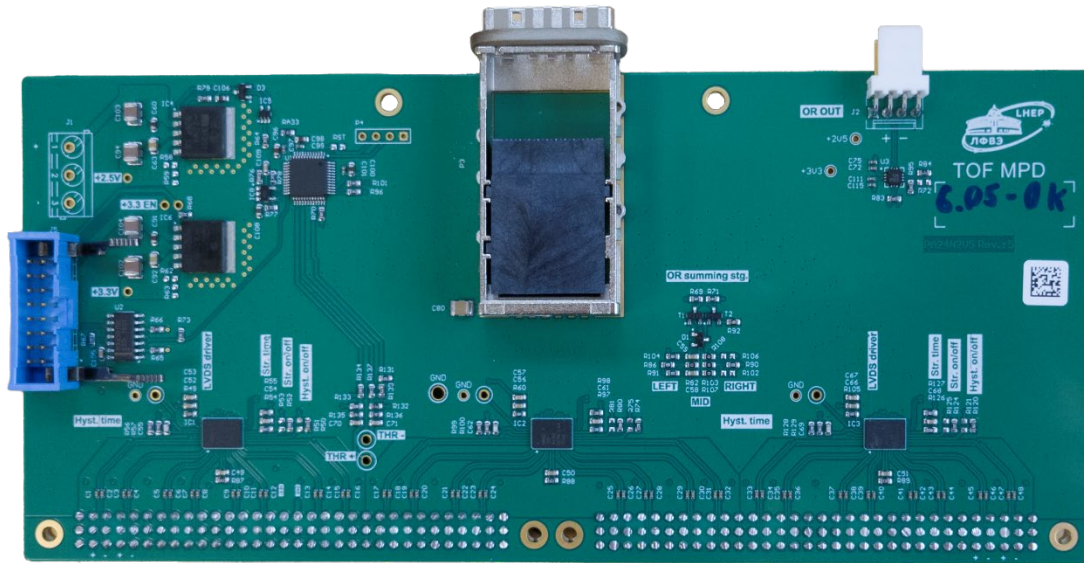


MRPC readout strips



Efficiency vs applied HV

Readout electronics of the MPD TOF system



MPD TOF amplifier-discriminator PA2402V(4)5

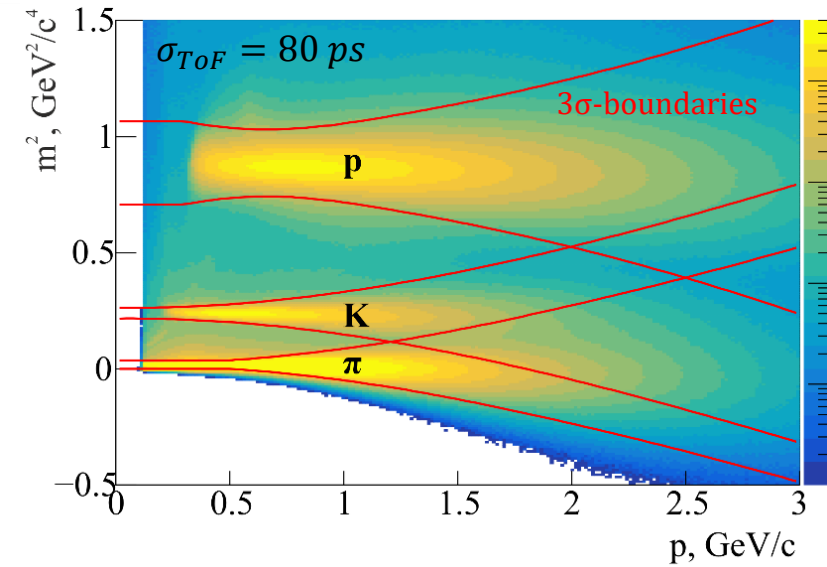
- Time jitter (RMS) for one channel ≈ 7 ps;
- Stabilization of **NINO** and MC voltages (+2.5V/+3.3V)
- Differential inputs ($Z_{\text{diff}} = 55$ Ohm)
- Inputs overload protection by 1 MOhm resistors
- Capacitors on the inputs for double-end strip readout
- CXP (InfiniBand) 100 Ω output connector
- The possibility to use for triggering (series “or” output)
- “On board” slow control:
 - supply voltage control
 - preamplifier thresholds (0-500 mV) control
 - board and gas volume temperature monitoring ± 0.5 °C



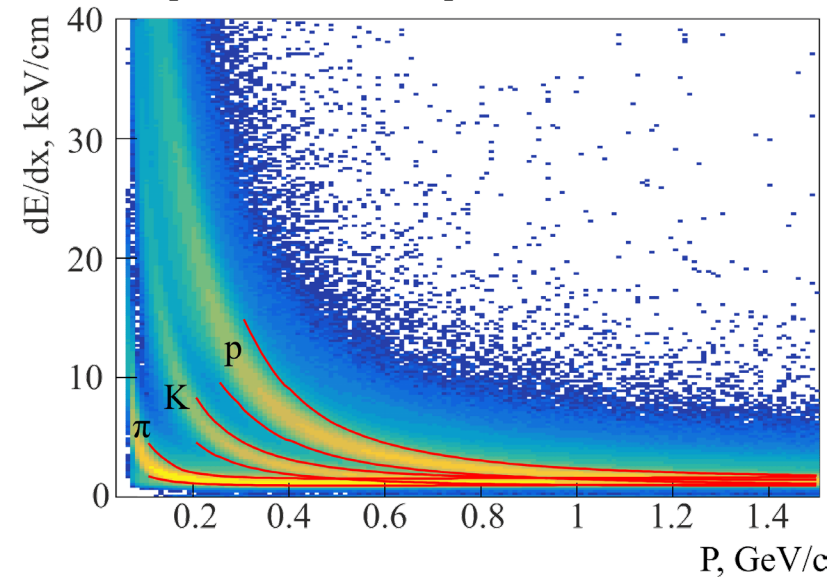
72-channels time-to-digital converter TDC72VHL-V4(VXS)

- VME64x interface with VXS
- TDC type: timestamping **HPTDC** chip
- Input: differential 100 Ω (LVDS)
- Channel resolution: 24 ps bin size ($\sigma_t \approx 20$ ps – average measured)
- Power consumption: +5V/0.13A; +3.3V/5.6A;
- Standalone mode
- Ethernet or VXS data transfer
- Time synchronization by the White Rabbit

Charged particles identification in MPD

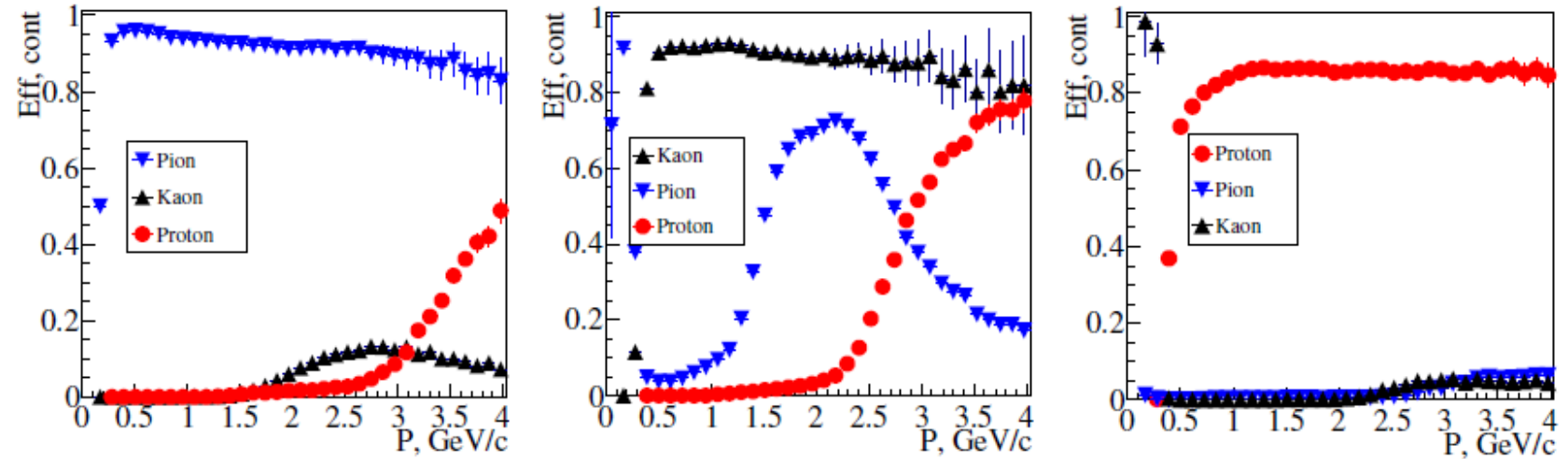


Squared mass of particles from TOF

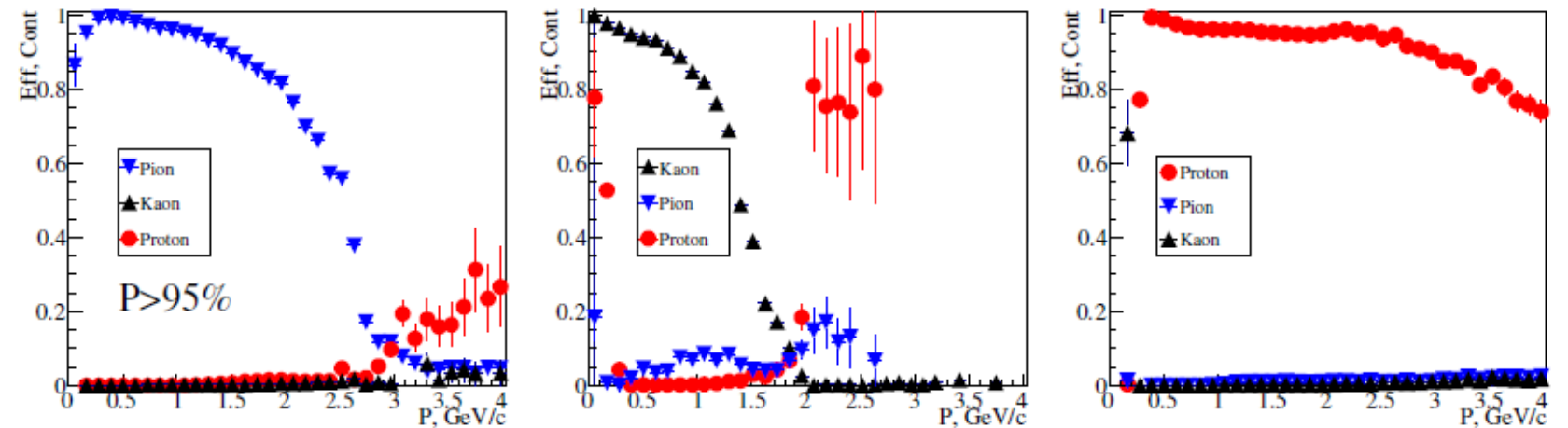


Energy deposition of particles in TPC

Efficiency and contamination of "3 σ -method" PID



Bayesian approach for particles identification





Mass production and quality control

Mass production staff: 4 physicists, 4 technicians, 2 electronics engineers

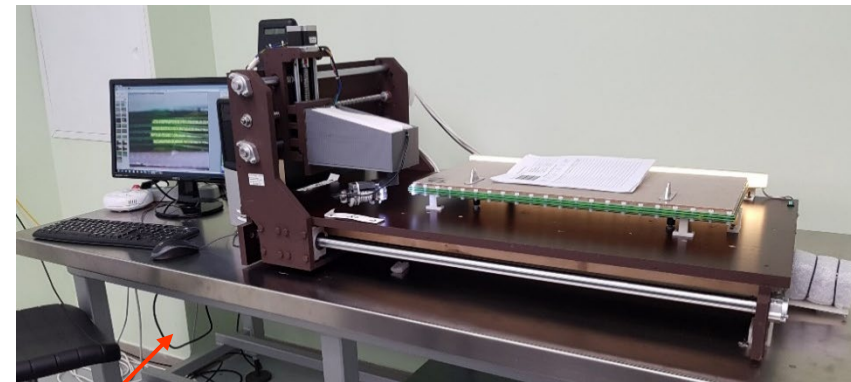
All procedure of detector assembling and optical control is performed in a clean rooms ISO class



Glass cleaning with ultrasonic wave & deionized water



Automatic painting the conductive layer on glass



Check list

- 1) Optical control (gap uniformity, cracks in glass)
- 2) Primary HV testing (without gas) - up to 6 kV
- 3) Readout pins and cables break, short-circuit and reversed polarity control
- 4) Full HV testing (after fast pumping and filling with working gas mixture) - up to 12 kV
- 5) Transmission line impedance (reflection) control



MRPC assembling



TOF modules assembling



Cosmic rays test of TOF modules

Laboratory stand for testing TOF modules on cosmic rays operate since beginning of August 2021



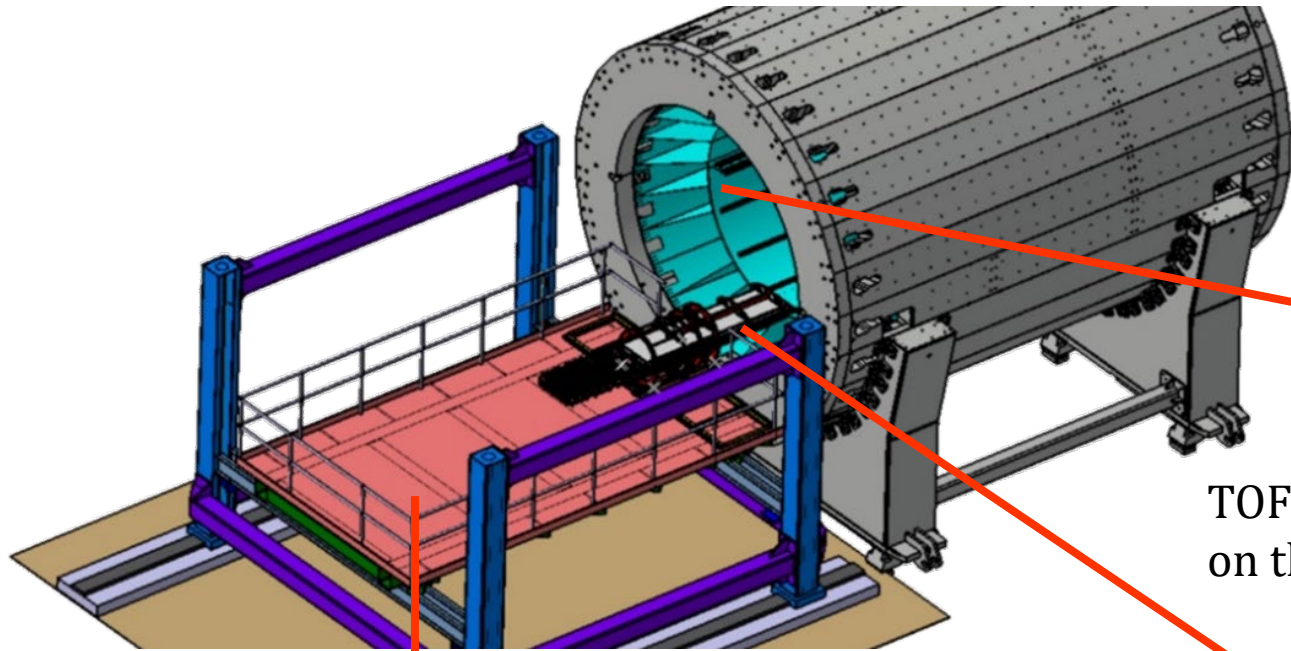
Progress of the TOF detectors and modules assembling

The production of MRPC detectors has been completed. Totally, to date, **300 (107%)** MRPC detectors were produced. All **28 (100%)** TOF MPD modules are already assembled, tested and stored.



We are ready for TOF installation into the MPD power frame

TOF installation



TOF module
on the rails

MPD Power Frame



Lifting platform



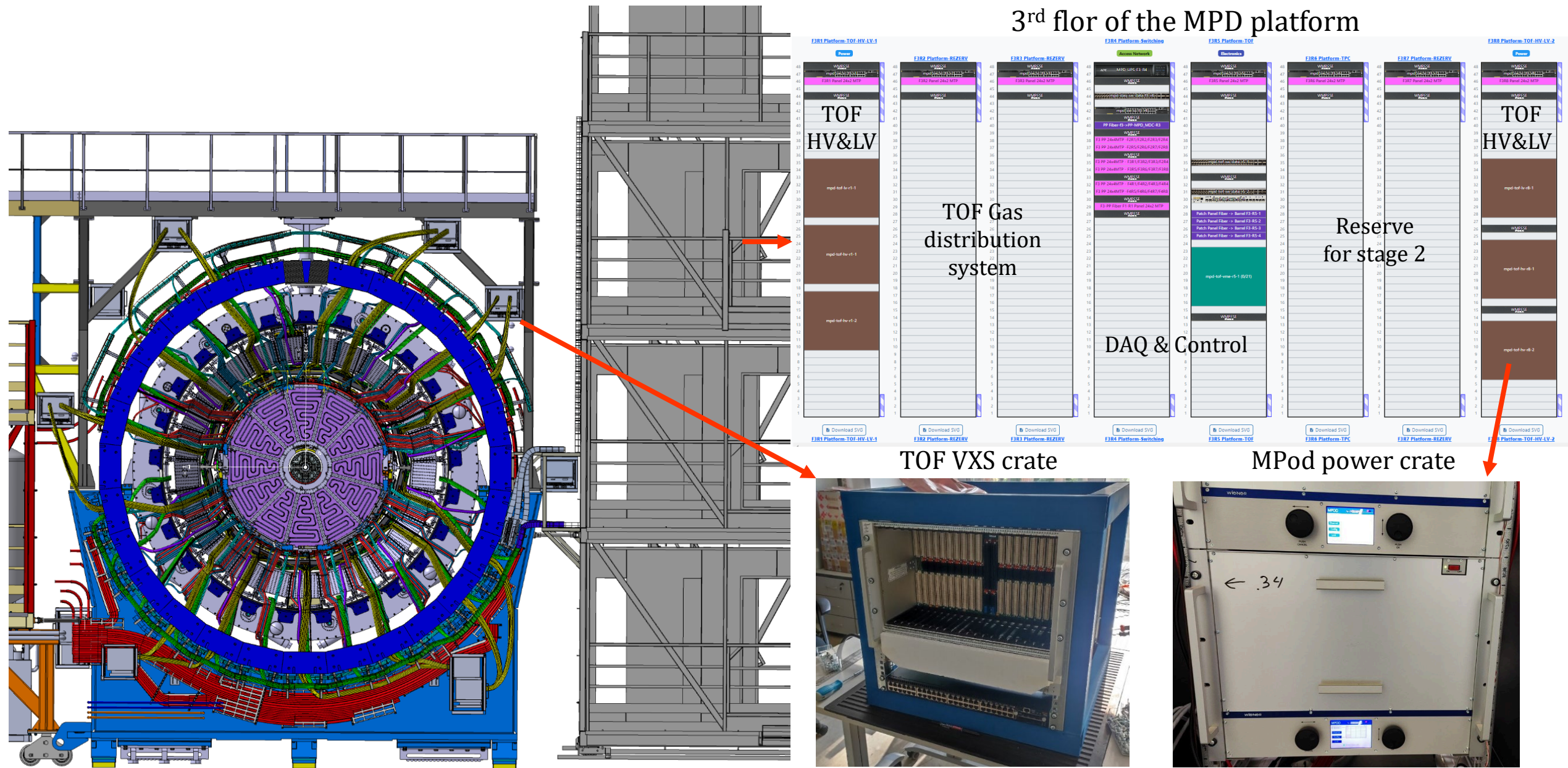
The TOF installation bench is fully assembled and tested in the VBLHEP



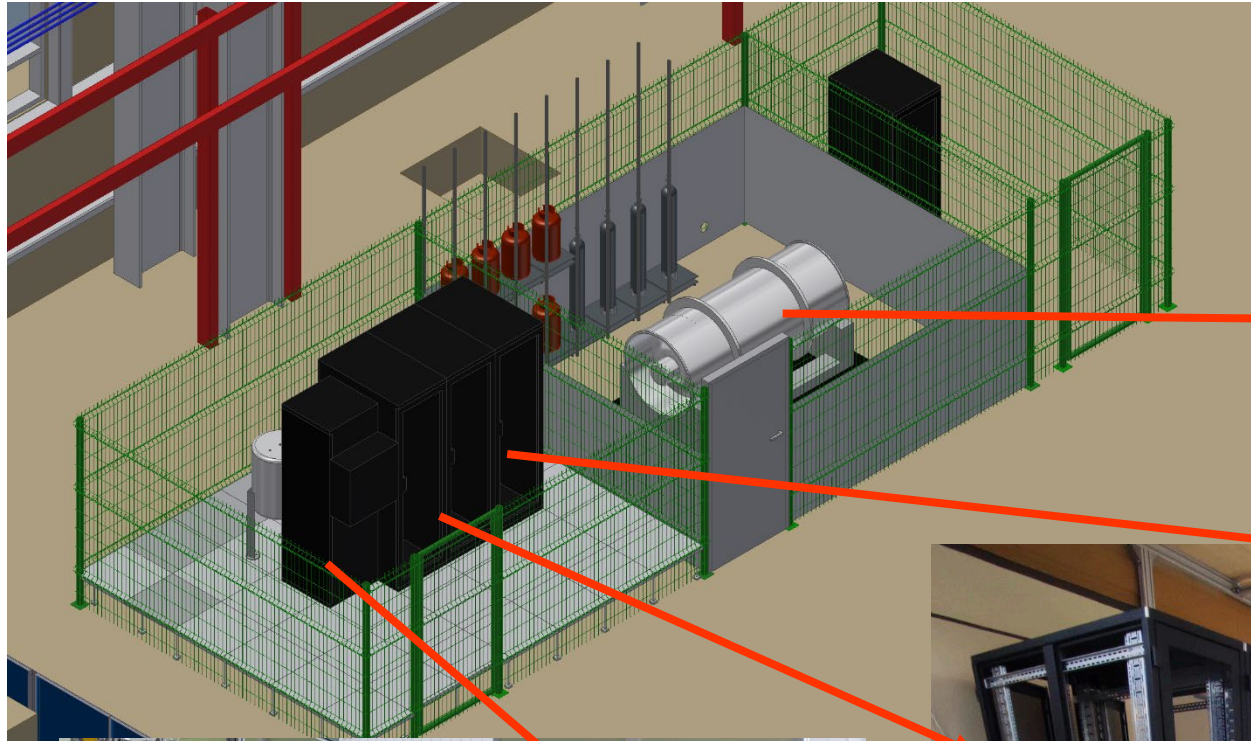
Vadim Babkin, MPD TOF status and prospects,
The 2nd China-Russia Joint Workshop on NICA Facility, Qingdao

TOF readout and power crates

3rd floor of the MPD platform



Gas system for the TOF in the MPD hall



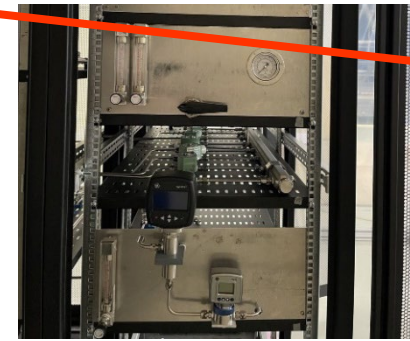
Freon cylinder (1000 kg)



Gas mixture purifier (rack #4)



Mixer and analyzer (racks #2, 3)



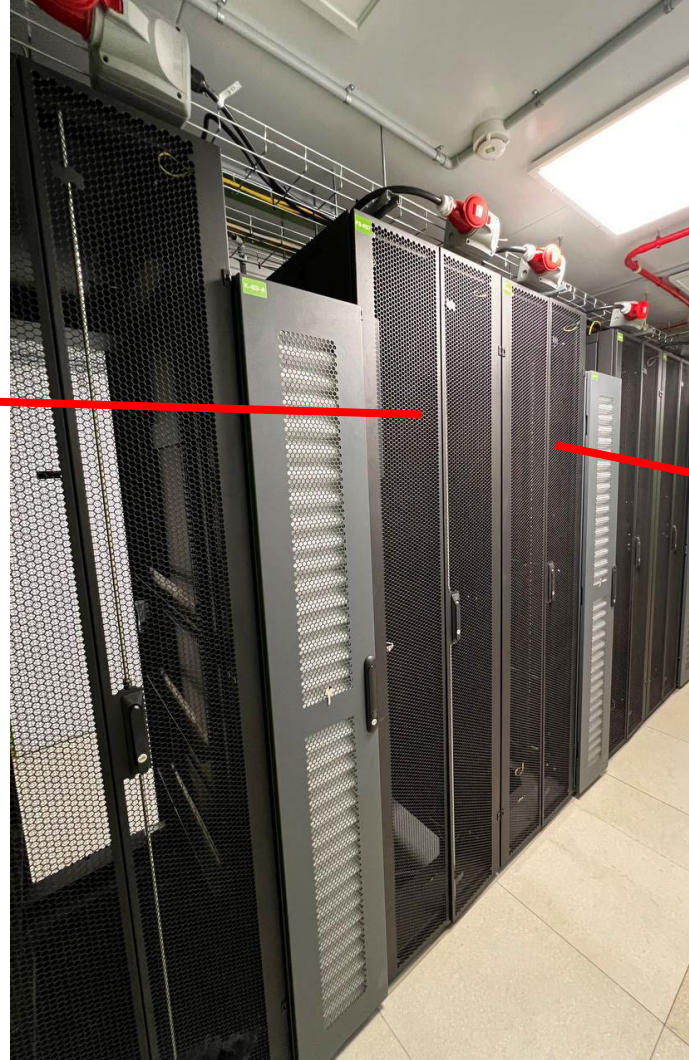
Automatic and control (rack #1)

Gas distribution system for the TOF in the MPD Electronics Platform

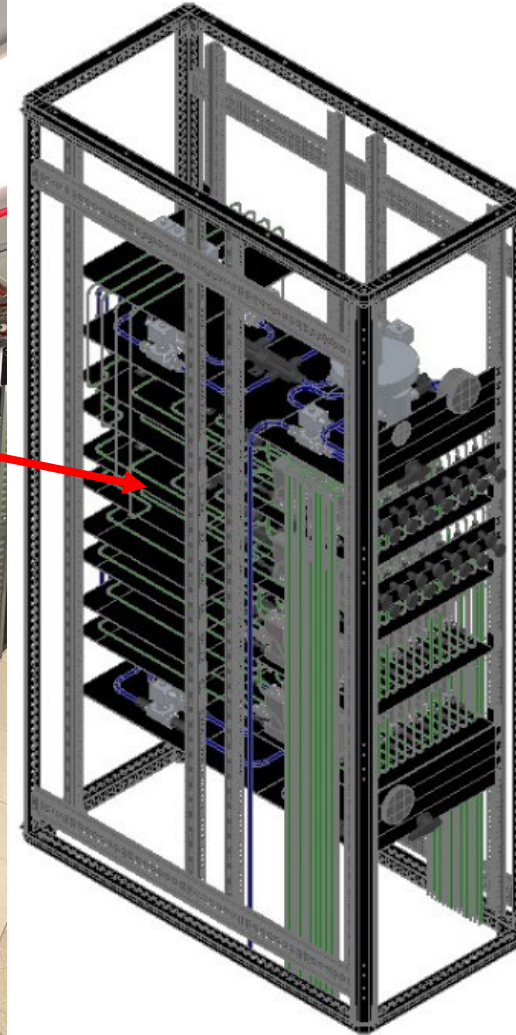
Distribution control rack



3-rd floor (rack #2, 3)



Gas distribution rack



TOF integration schedule

- 1) Mass production of MRPCs – 300 of 280 are ready (~107%)
- 2) Mass production of TOF modules – 28 of 28 are ready (~100%)
- 3) Integration equipment – completed
- 4) TOF slow control – in development
- 5) VME crates, cables, and HV distributors on the MPD yoke – in development
- 6) Gas supply and storage for the gas system in building 17 – in the assembly

TOF plans in accordance of the MPD assembling milestones

June-Sept 2024 – upgrade of existed TOF modules (remove any leakages, update FEE, etc.)

July-Sept 2024 – building of TOF gas system area in the MPD hall

Aug-Oct 2024 – assembling of the TOF gas system

Nov-Dec 2024 – commissioning of the TOF gas system

January 2025 – organizing of the TOF modules installation area and assembling of equipment

Febr-March 2025 – TOF modules installation into the MPD power frame

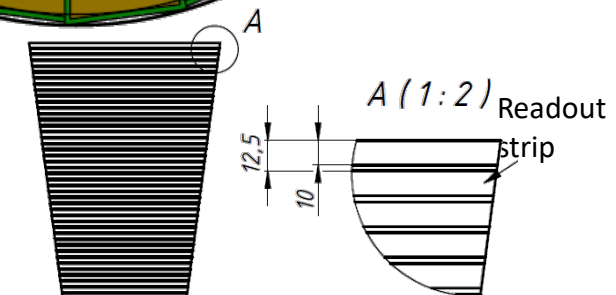
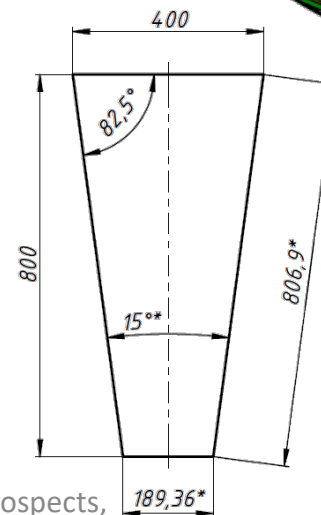
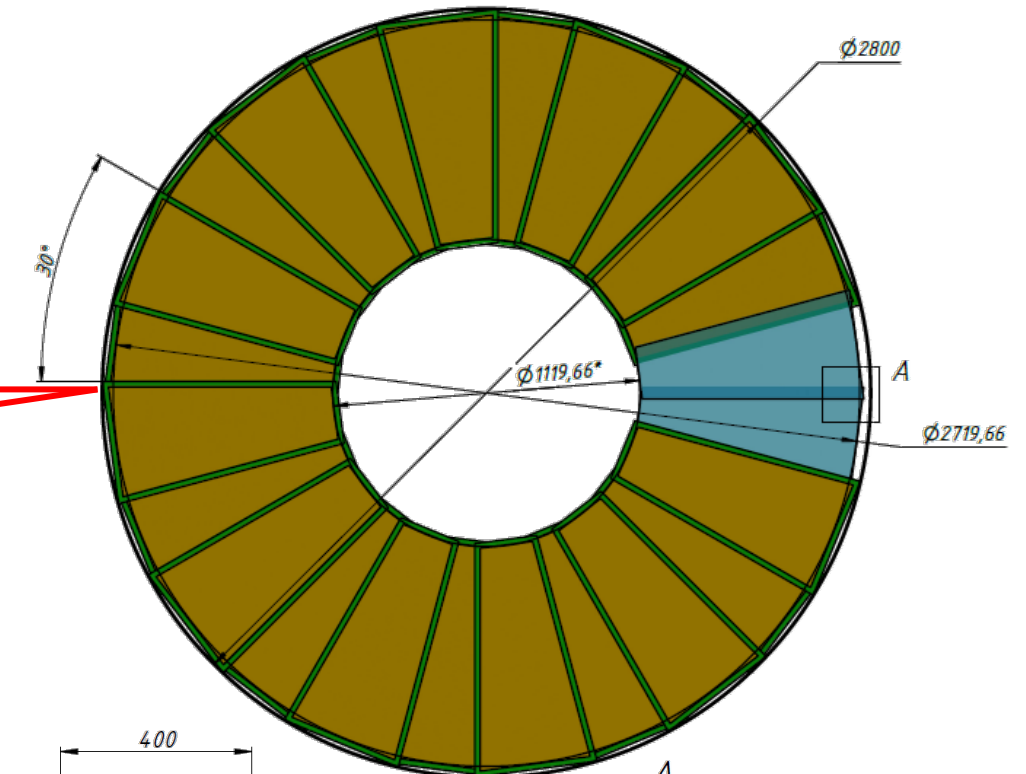
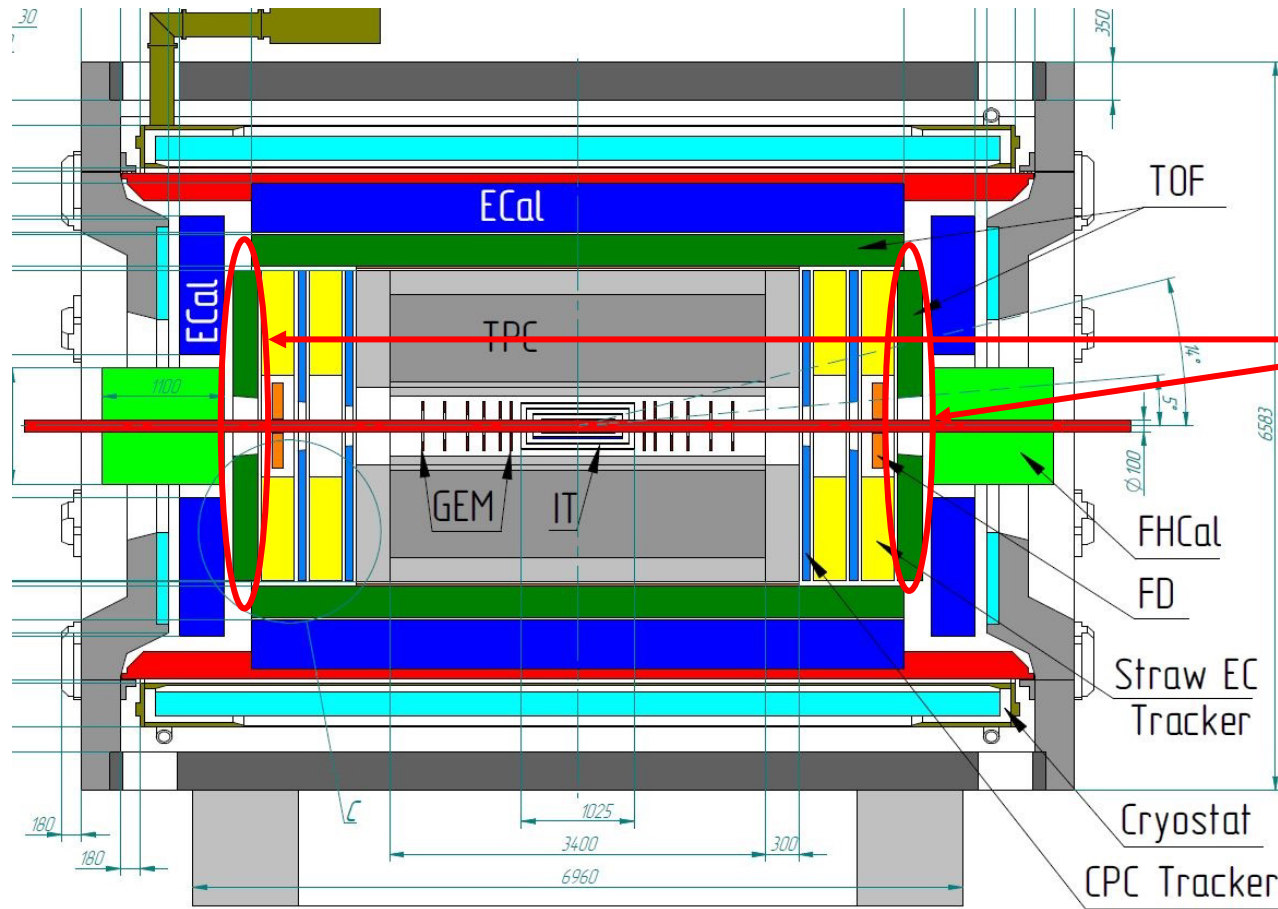


Prospects and possible upgrades of the MPD TOF system

- End-cup TOF rings
- New readout electronics
- Eco-friendly gas mixture

End-cup TOF rings conception

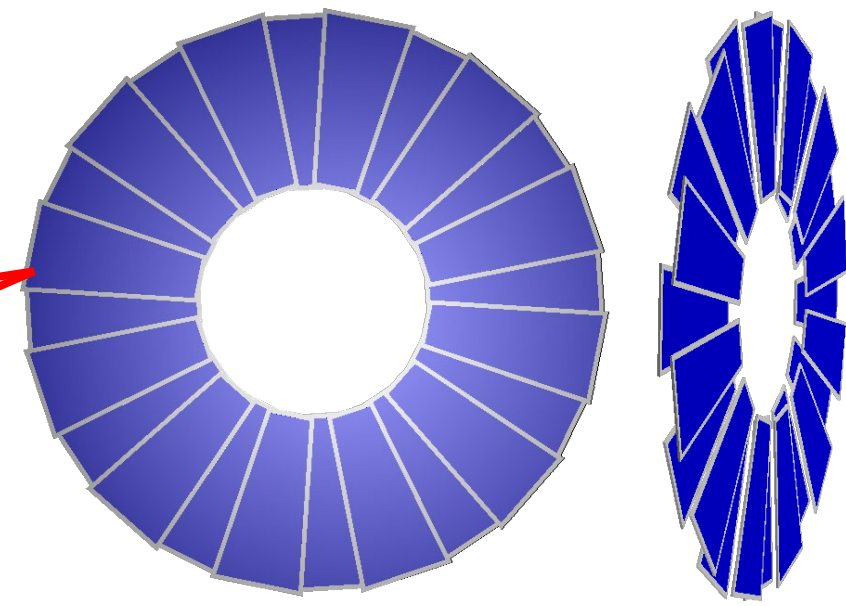
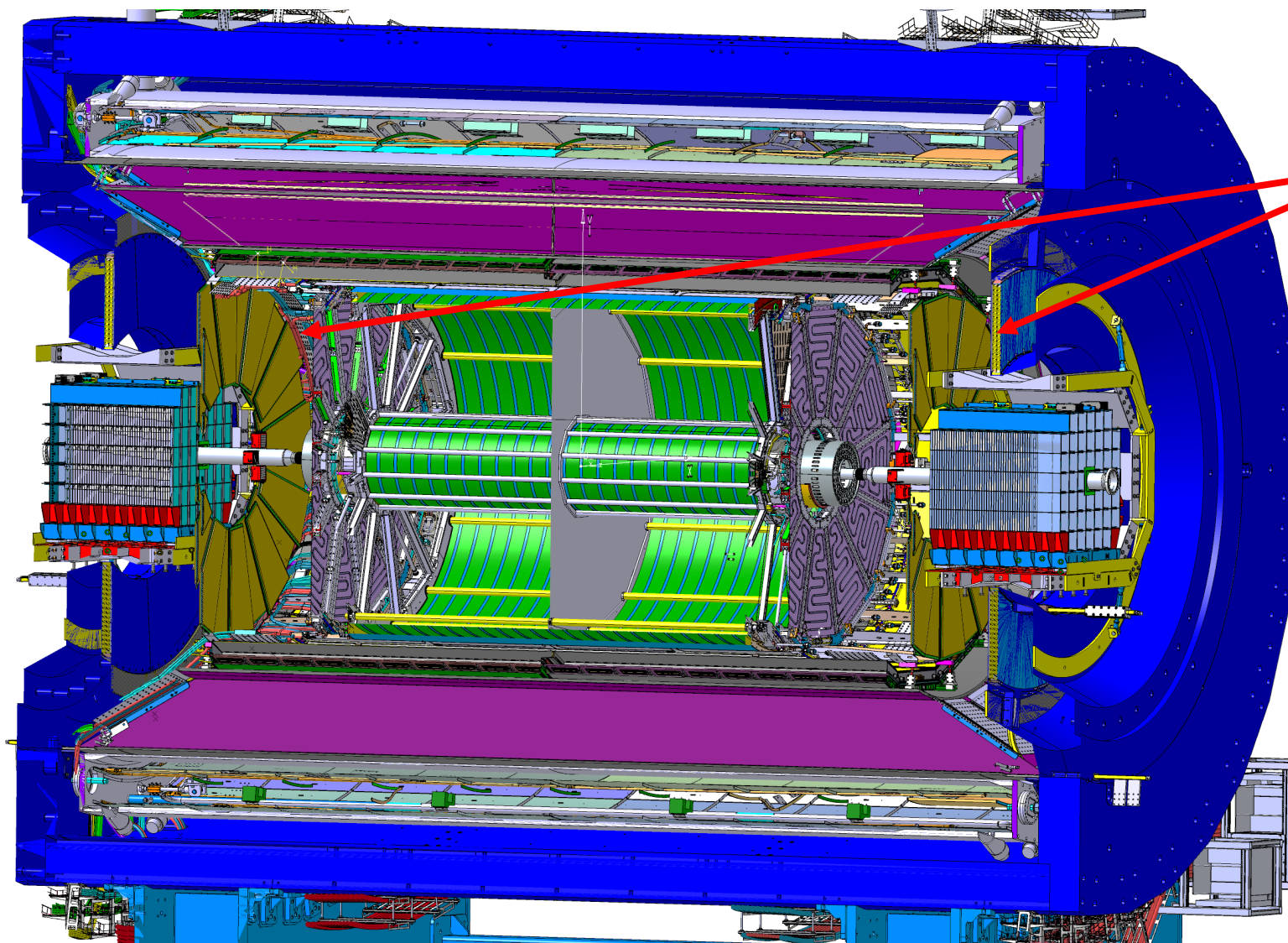
$$Z = \pm 3 \text{ m}, d_{\text{out}} \approx 2.7 \text{ m}, d_{\text{in}} \approx 1.1 \text{ m}, 1.5 < |\eta| < 2.4$$



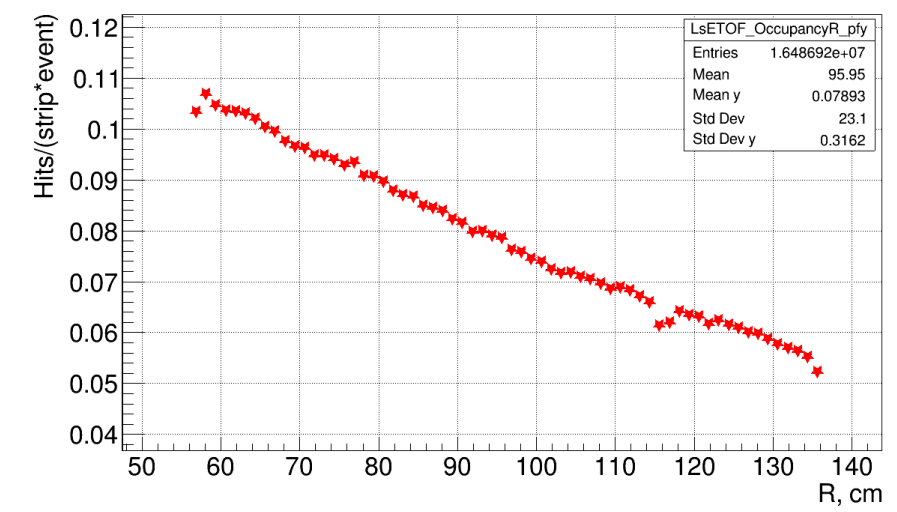
MRPC with 64 strips

ETOF: 2 rings \Rightarrow MRPCs: $2 \times 24 = 48 \Rightarrow$ Strips: $48 \times 64 = 3072 \Rightarrow$ FEE chan: $3072 \times 2 = 6144$

End-cup TOF rings conception



MPDRoot ETOF geometry

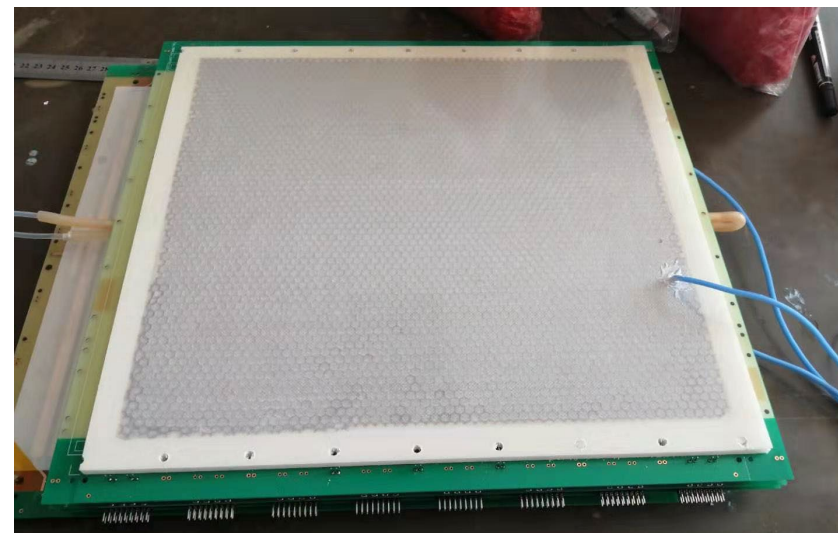
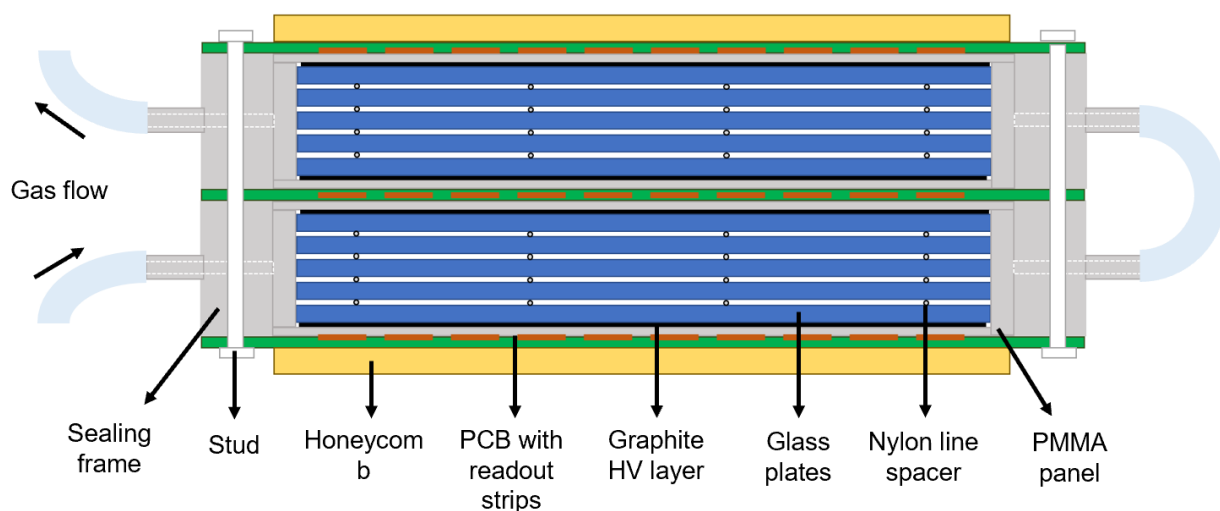


Hits by channel per event (occupancy) Au+Au 11 GeV LAQGSM

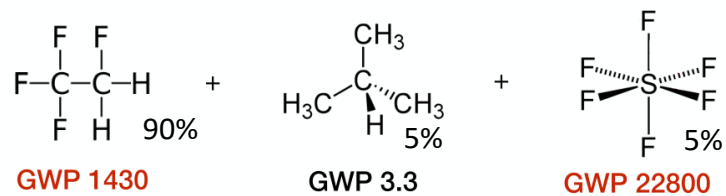
End-cup TOF detectors

Sealed MRPC from Tsinghua University (China)

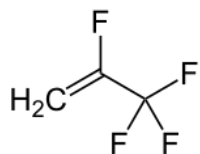
(B.Wang et AL, *jinst* 15 (2020) 08, C08022)



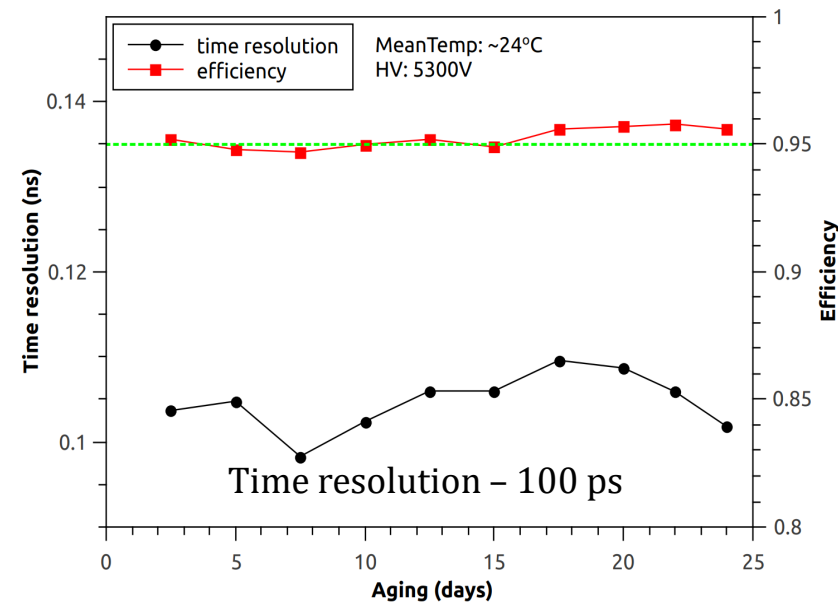
Gas saving: 20 sccm/m² gas flow with common practice! It provides us the possibility for usage of new gas mixture based on R1234yf. This freon has a very low GWP index, but costs 10 times more than R134a.



Total GWP - 2430



GWP < 1 (Honeywell specification)

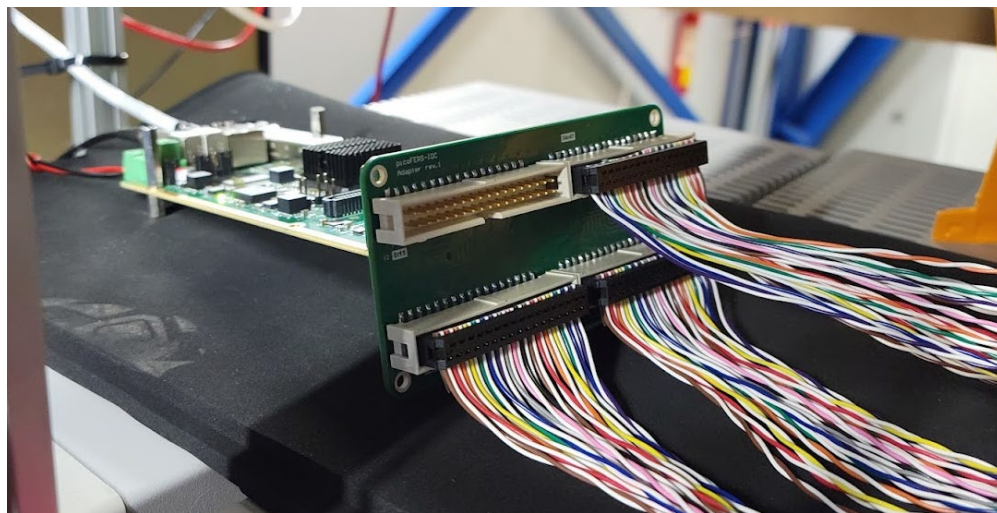


Electronics for TOF&ETOF MPD

Precise ToF measurement by PicoTDC



CAEN A5203 PicoTDC FERS board with cable adaptor



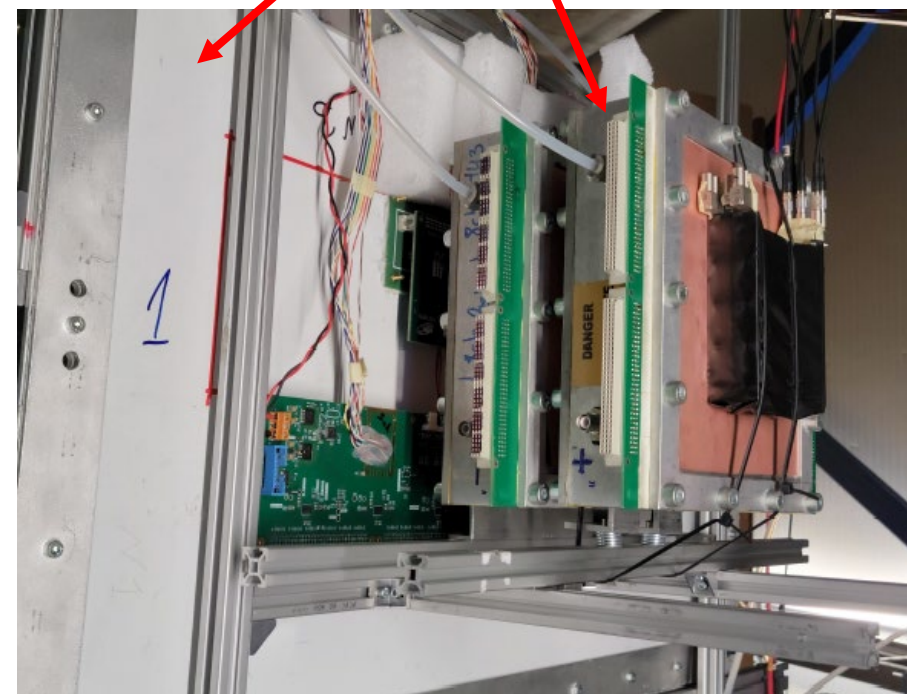
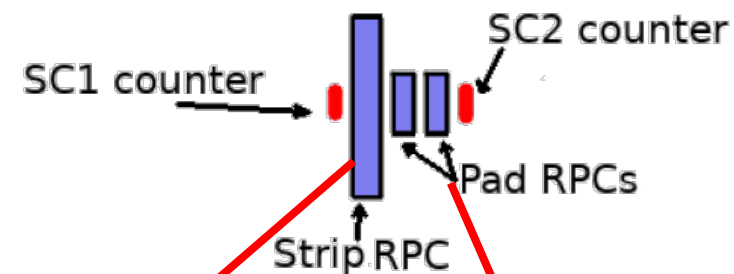
PicoTDC specification:

LSB: 3.25 ps

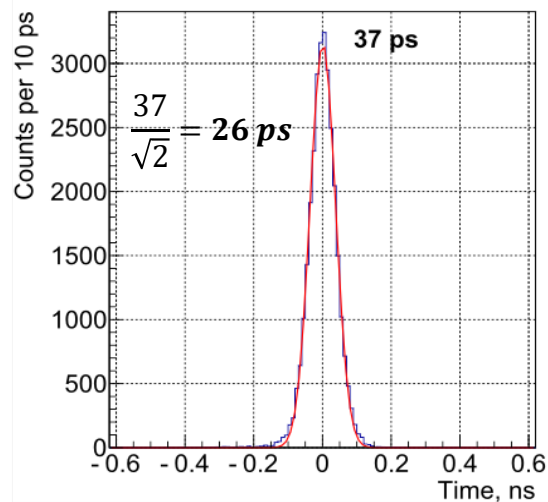
Channels: 64/128

Dynamic range = 56 bit

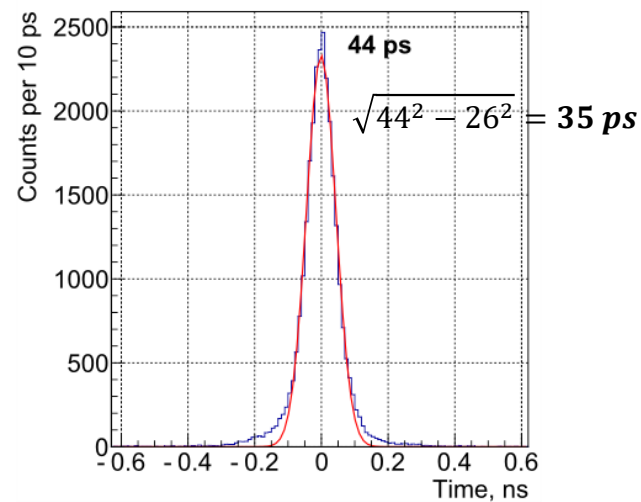
NA61 test of NINO+PicoTDC with MRPCs (150 AGeV Pb-Pb collisions)



dT between two Pad MRPCs

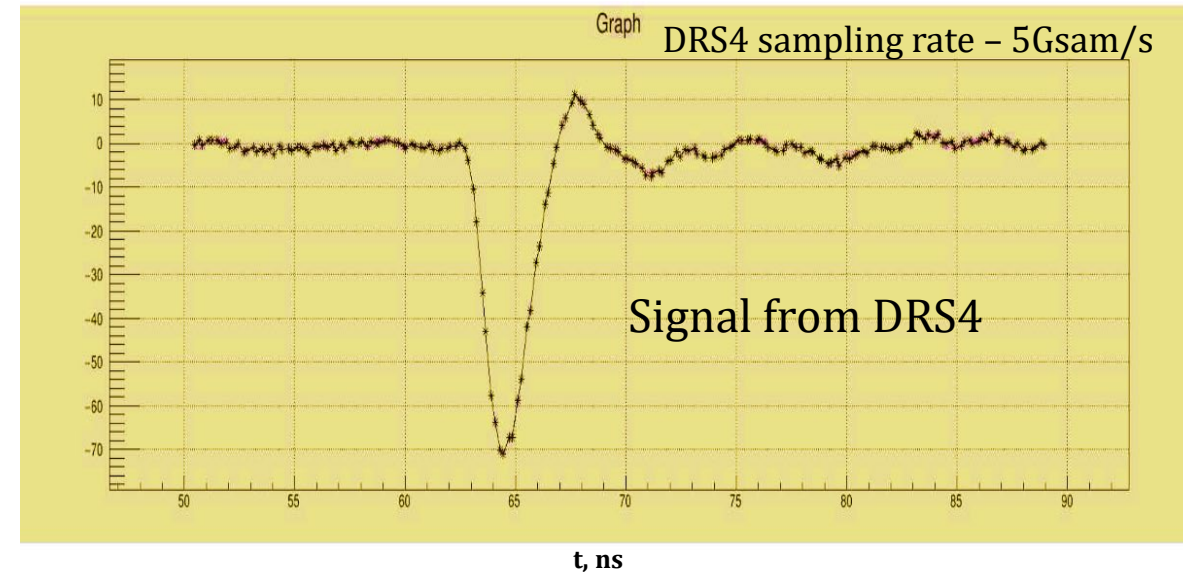
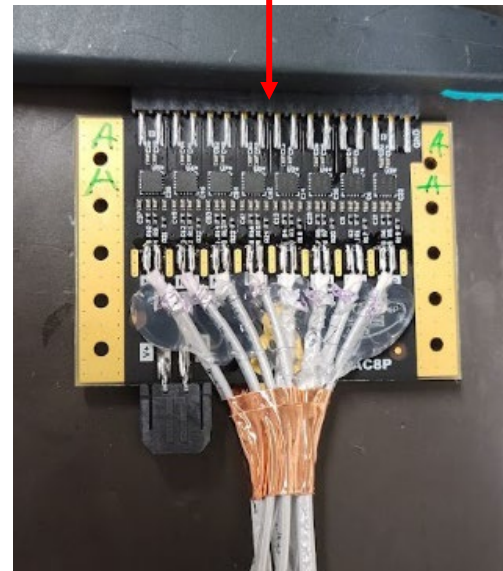
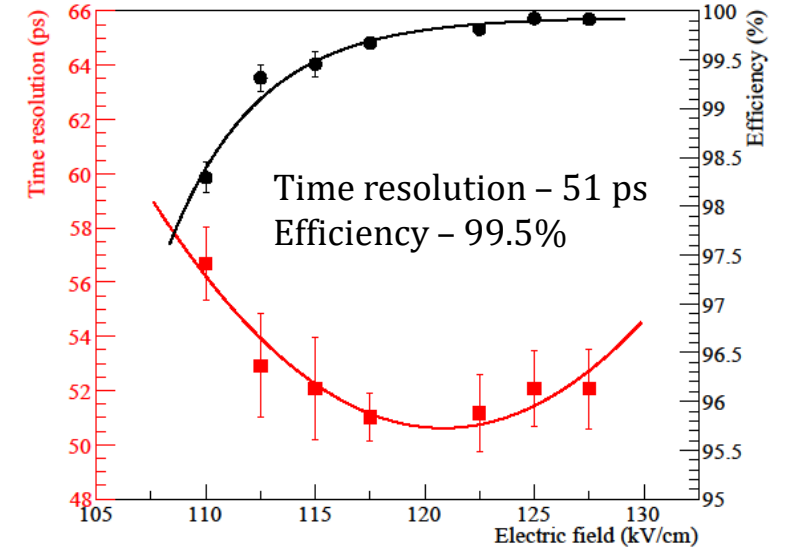
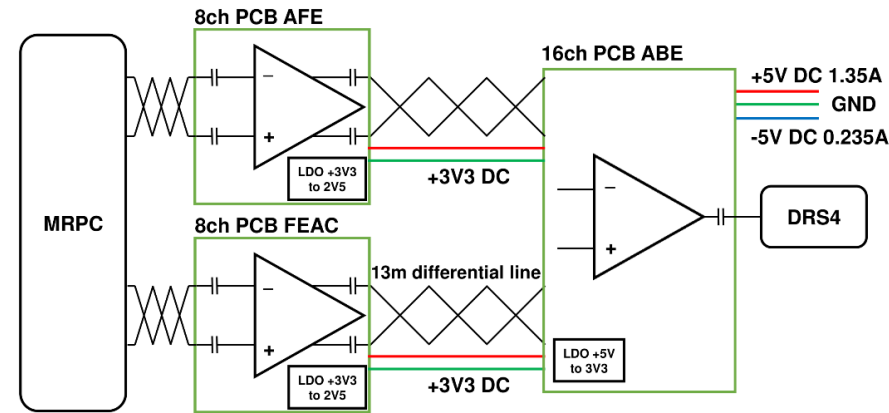


dT between Pad&Strip MRPCs



Electronics for TOF&ETOF MPD

Digitizing shape of MRPC signal by DRS4

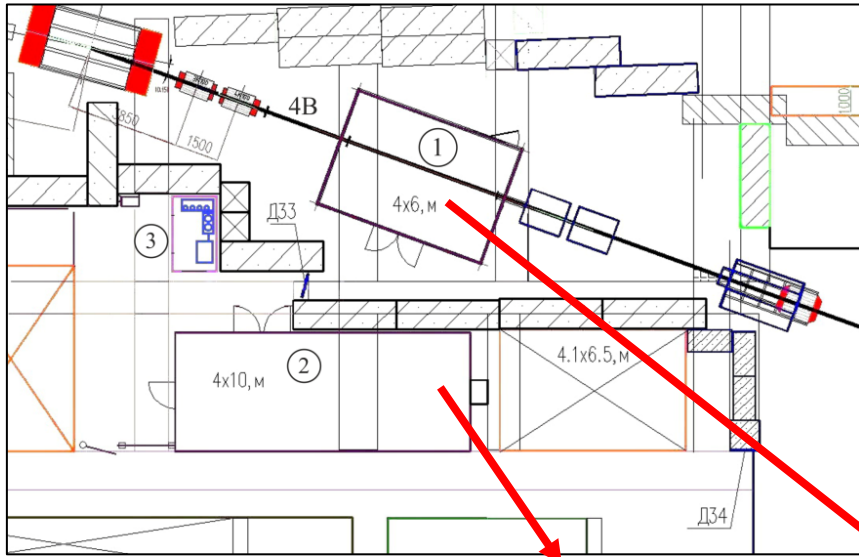


New L-ToF of NA61(SHINE) at SPS
(already commissioned)

12.09.2024

8 ch analog front-end preamplifier

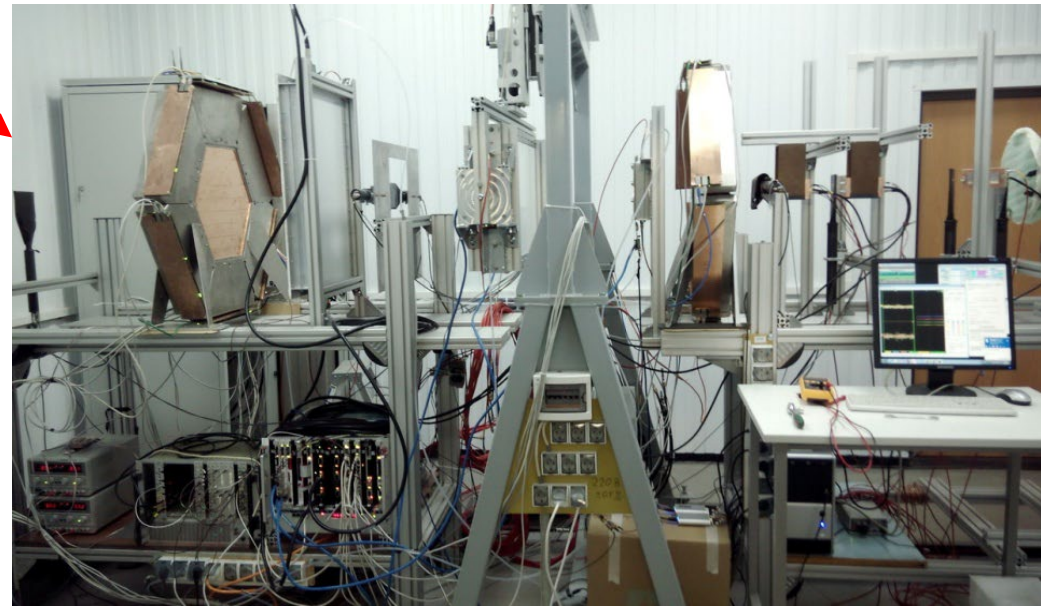
MPD test beam facility at the VBLHEP Nuclotron



Particles	Energy, GeV/u	Maximum intensity, c^{-1}
p	0.2 - 4.5	$\sim 10^8$
d	0.2 - 4.5	$\sim 10^7$
^{12}C ...	1 - 3.5	$\sim 10^6$

Main parts of the MPD test beam setup:

- two platforms made of aluminum profile (total length - 5 m);
- the precision positioning device for detectors movement remotely;
- three multiwire proportional chambers with position resolution ~ 0.5 mm;
- two independent gas system with different gas mixtures (freons and inert gases);
- data acquisition system (DAQ) based on the VME and Ethernet.



Should be available in 2026 due to installation work at the NICA collider

We invite you to cooperate in the field of hardware and software development

E-mail: babkin@jinr.ru
vbabkin@cern.ch

Thank you for the attention!