# Time Projection Chamber Assembling

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### NICA Complex





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

# MPD experimental setup





Charged multiplicity distributions in central Au + Au collisions (b < 3 fm) calculated by UrQMD.



MPD Stage II



MPD stage I detectors:

- ECal: Electromagnetic Calorimeter
- FFD: Fast Forward Detector
- TOF: Time of Flight system
- FHCal: Forward Hadron Calorimeter
- **TPC**: Time Projection Chamber

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### Magnet assembly in the MPD Hall





### TPC operational principle





# TPC design requirements and main parameters





#### The TPC/MPD design requirements:

- The overall acceptance:  $\eta < 1.2$
- The momentum resolution for charged particles is under 3% in the transverse momentum range 0.1 < pt < 1 GeV/c
- Two-track resolution is of about 1 cm
- Hadron and lepton identification by dE/dx measurements: with a resolution better than 8%
- Operation trigger rate: 7 KHz

#### TPC main parameters:

ltem	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	~ 104
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 $\phi$	30°
Pad size	5x12mm <sup>2</sup> and 5x18mm <sup>2</sup>
Number of pads	95232
Pad raw numbers	53
Pad numbers after zero	< 10%
suppression	< 10/0
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 cylinders**



Al foil rings  $t = 50 \, \mu \kappa$ 

Tedlar  $t = 50 \,\mu\kappa$ 

Kevlar t = 4 mm

Tedlar  $t = 50 \,\mu\kappa$ 

Al foil rings t = 50 µK

ring width = 25 mm, step 125 mm

ring width = 25 mm, step 125 mm



### C1 cylinder

Wall structure



```
D<sub>in</sub> = 540 mm, L = 3400 mm
```



### C2 cylinder

### D<sub>in</sub> = 676 mm, L = 3400 mm



### C4 cylinder

D<sub>in</sub> = 2660 mm, L = 3400 mm



D<sub>in</sub> = 2802 mm, L = 3400 mm

### TPC cylinders assembly









# TPC body was assembled with test rods to check TPC geometry by laser tracker AT-402

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 $S = 84 m^2$ 

### TPC vessel assembling





# Field cage and high-voltage electrode





# Potential degrader rods and HV membrane connector MAPS



### Field cage assembly





Inner field cage rods installation 20% installed



# Read-Out chambers (ROC)









Finite element calculation of the chamber deformation caused by the wire tension (F = 800 N) and overpressure 5 mBar. The maximum deformation is **27 µm** 

### Pad Response Function





### PadPlane overview

Pads layer





PadPlane structure pad raw number: 53 rectangle shape - small pads 5×12 mm<sup>2</sup> - large pads 5×18 mm<sup>2</sup>

Total number of signal pads per one ROC: 3968

### PadPlane PCB structure

Layer Name	Туре	Material	Thickness (mm)
Top Overlay	Overlay		
Top Solder	Solder Mask/Co	Surface Material	0.01016
Top Layer	Signal	Copper	0.018
Dielectric1	Dielectric	Core	1
Signal Layer 1	Signal	Copper	0.035
Dielectric2	Dielectric	Prepreg	1
Signal Layer 2	Signal	Copper	0.035
Dielectric3	Dielectric	Core	1
Bottom Layer	Signal	Copper	0.018



### **ROCs production status**







Test procedure:

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



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### ROC chamber installation









### Gating grid system





### Gating grid system test setup









Pulse rise time - 500 ns: OK

Mass-production: in progress Delivery to JINR: Dec. 2023

### Low voltage and High voltage power supply





LV&HV system based on CAEN rad. hard desig	n:
(up to 2000 Gauss and 15 kRad)	
- power converters A3486 AC/DC (380 V -> 4	l8 V): 15+3 pc
- EASY3000 crates:	14+2 рс
- LV module - A3100B (8V/100A):	48+8 pc
- LV module - A3100HBP (14V/50A):	6+2 рс
- HV modules –A3540P (+4kV/1mA):	8+3 pc
- HV modules –A3540N (- 4kV/1mA):	2+2 рс
Status:	
LV+HV system: JINR-CAEN contract was sign	ed
Expected delivery date to JINR: was delivered	ed
test system: testing is ongoing	
LV cables (halogen free, low smoke), S=50 mm	2: was delivered
HV cables: was ordered	





Low voltage distribution board. Designed in INP BSU (Minsk)

### Gas system scheme

#### Gas system main features:

- Drift gas mixture: 90%Ar + 10%CH<sub>4</sub> (P10);
- Insulating gas: N<sub>2</sub>;
- Operating pressure: atmospheric + 2.0 ± 0.03 mbar;
- Drift volume: 17640 liters;
- Insulating gaps volume: 2380 liters;
- Oxygen content: 5 ppm;
- Moisture content: 10 ppm;
- Recirculation rate of outer loop: 30 L/min;
- Recirculation rate of inner loop: 20 L/min

#### Gases consumption:

		<b>_</b>	
Mode	Argon, $m^3$	Methan, $m^3$	$Nitrogen, m^3$
TPC purging	84	5.4	36
Experiment:			
Per day	7.8	0.86	8.6
Per month	234	25.9	259



Drift vólume

Compressor

Buffer

Purifier

Ar

CH4

 $N_2$ 

Mixer

Gas quality monitor (O<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>O)

CO<sub>2</sub> Absorber)

Dryer

Gas supply

### Gas system





### Cooling system





### Cooling plates



### FEE cooling plates



### Cooling system position



NEW cooling system position -> 2-nd floor of a additional platform - design and optimization in progress



cooling system equipment arrangement

### Serial cooling system calculations





#### TPC system pressure with water column height



### Test setup measurement results



Comparation of experimental and calculated test results



Design pressure drop of the panel  $\Delta P = 0.12$ bar at coolant flow Q = 0.36 l/min

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pressure in the tank  $P_{tank}$  {0.89, 0.75, 0.55} bar

### Laser calibration system





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X 

### Laser calibration system





# TPC/MPD data acquisition system main parts



Front-End-Cards (FEC): 1488 pc., 95 232 10bit ADCs in total



### 1488 ×

# Data Concentrator Units (DCU): 6 pc. in total



Readout and Control Units (RCU): 24 pc. in total



Local Data Concentrator (LDC) servers: 6 pc. in total



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6 ×

# TPC/MPD DAQ conceptual scheme





### Front-End Card



Double-desk FEC formfactor: a) SAMPA board; b) Controller board;



- The total number of registration channels: 64 ٠
- Maximum input charge in a linear range: 100 fC ٠
- ADC resolution: 10 bit .
- ENC: les than 1000 e<sup>-</sup> ٠
- Readout serial interface: up to 2.5 Gbps ٠
- The total number of monitored values of current, voltage, and temperature: 16 ٠
- SAMPA chips management via FPGA high speed interface
- > Double-PCB 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.
- >Onboard circuit and embedded protection functionality against SEU are provided.
- Remote system update for FEC firmware was provided.



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### **Readout and Control Unit**





- 1. PS connector (+12 V)
- 2. 16-ch. ADC (health monitoring)
- 3. RJ45 connector (NIOS Ethernet 1Gbps)
- 4. SFP+ connector (optical trigger up to 10 Gbps)
- 5. QSFP connector (data transfer interface up to 40 Gbps)
- 6. SFP+ connector (spare optical channel up to 10 Gbps)
- 7. JTAG connector (FPGA programming end debugging + spare management channel)
- 8. Arria 10 GX FPGA
- 9. FECs XCVR connectors 64 full duplex channels
- 10. Multifunctional connector with GPIO pins and 2 spare XCVR

#### Main **RCU** functionality:

- Receiving data packets from 62 FECs;
- Buffering data with subsequent transmission to the DCU via optical channel;
- Organizing high-speed management channel to the FECs;
- Organizing FECs synchronization;

# Data Concentrator Unit and Local Data Concentrator server







#### DELL R740XD rack unit

Receiving data via PCIe of the DCU card and after transmitting it to the MPD DAQ via 100G Ethernet

**DCU** card based on commercial development board

- 1) USB connector for onboard usb-blaster;
- 2) PS connector +12 V;
- 3) PCIe gen 3 x16 connector (double x8);
- 4) 4 QSFP connectors for data taking and management;
- 5) Arria 10 GX FPGA;

### **DCU functionality**:

- Receiving data packets from four RCUs;
- Organizing high-speed management channel via PCIe;
- Managing of all downstream devices (RCUs, FECs);
- Buffering data with subsequent transmission to the server memory via PCIe ;

#### ReadOut Chamber DAQ test setups RCU64 (left) and RCU32 (right) Test setup in bld. 40 1. Test setup in bld. 201 FECs on the ROC (62 pc) 2. LVDB modules 3. Clock fanout 4. Sector cards mean RMSs (ev.4) carsRMS Entries 62 6.002 Mean x Mean y 4.57 bins] RMS x 2.789 2.4 RMS y 1.919 2.2-■ **I D D D I I**.8-1 FEC noise 16 14 1.2 10 FECrow FEC position in row Vital element of the ROC Channel noise [ADC bins] data acquisition system is microcoaxial cable assembly based on $\mu$ coax 36 AWG cables and Hirose FX15, FX16 series connectors.

ADC channel

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### Tooling for Installation TPC to MPD















### NICA-MPD-Platform (NMP)



**Common view** 





### MPD electronic platform



### TPC equipment racks composition (4<sup>th</sup> floor)

F4-R1 means		F4-82 LV		F4-R3 LV		F4-R4		F4-85		F4-R5 (LV)	_	F4-87 (LV)		F4-RB (npassui)
47	- 1	Cable annualizer	4	Cable secondary	42	Cable annualizer	47	Cable exception	40	Cable sensitive	47	Cable arrestor	43	Cable secondary
the second second		Cathrogener		Caterorgander		Cater organise		Cable organizer		Cathering incom		Constantian and a second se		Cable organise
45 Patch Panel Fiber	4	S Patch Panel Fiber	- 43	Patch Panel Riber	45	Patch Panel Fiber	45	Patch Panel Riber	45	Patch Panel Riber	-45	Patch Panel Fiber	45	Patch Panel Fiber
44 Aruba 3810M 24G (146W) 6 43	Gg 4	Aruba 3810M 24G (146W) 6kg	4	Aruba 3810M 24G (146W) 6kg	44	Aruba 3810M 24G (146W) 6kg	44	Aruba 3810M 24G (146W) 6kg	44	Aruba 3810M 24G (146W) 6kg	44	Aruba 3810M 24G (146W) 6kg	44	Aruba 3810M 24G (146W) 6kg
42 Corney GATE	4	A SHEE MAY (SERVICE STUDIE)	4	ADJES NOT DROVAC-ROUDCI	4	ADARK IN/7 (DRIVING-40V/DC)	42	ADJES ME DROVAC-ADVDC)	47	ADARS MAR (DRIVAC-ADVIDC)	42	ADARS NOT TRANSCORPTC	43	ADARG NUIS (DRIVING-ROUTIC)
41 40W x 12 xawep * 500W	4	3kW, max, 4kW 380k/15A	41	3kW, max.4kW 380V/15A	43	Retaine SC gas aces speitros EASY	41	3kW, max.4kW 380v/15A 30kg	43	3kW, max-4kW 380W/15A	41	3kW, max.4kW 380V/15A	41	max,15kW 38DV/15A
								Retainer-68V 2x speiltos ERSY						
40 220V/10A		0 30xg	40	301g	40	380-y15A, 3 kW (max 4 kW), 30kg	40	3000(0%)	40	30g	- 40	10 <sub>1</sub> g	40	304
10 100					- 1									
34	1	Crate EASY 2000 Net	3	Crate EASY 3000 Ne4	34	Crate EASY 2000 Nella (HV)	38	Crate EASY 3000 Nedla (HV)	38	Crate EASY 3000 Neg	31	Crate EASY 2000 Net2	36	Crate EASY 2000 NetS
17 Current GATE		The stress of the factors of \$1486		Particular & ARM Generation on A 1485	11	Refaxue + 48V Separch of A3485	17	numarius + 48V Seperce of A3485	12	Particular a ARV Generation of A 2485	1.1	Partness a ARV Factories on A3485	11	Participant a diffi francesso on 13485
36 40W x 12 xawep = 500W	1		3		36		36		14	Contraction of the Comparison of Provide	34		10	
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34 20xg	3	4 42.5kg	3	42.5kg	34	42.5kg	34	42.5kg	34	42.5kg	34	42.5kg	34	42.5kg
13	1	·	1		30		- 11		10		1		11	
11 8445 8448	- 1	Bard Barbar	1	AND ADDA	1	Bart Barth	32	and annual	30	and another	11	And Division	30	Mark Relation
30			30		30		30				- 30		30	
			-											
29 CHOTHERA SPECTRA	2	A SHEE NH2 (280VAC-40VDC)	21	ASHES NIS (280VAC-40VDC)	25	Crate SC day LVN9	29	Crate SN627 (HV)	25	AMES NITE (BROVAC-40VDC)	25	ASKIE NILI (BOVAC-40VDC)	25	CHICTHANA GATE
27 220/05A	2	10x	27	2018	27	220v/30A	27	220//104	27	204	27	No.	27	220W10A
					-			8 wogyne x 13ch#96ch+3.5kV/1mA	-				-	
26 50kg	2	<u>د</u>	24		26	62	26	•	26		24		26	20kg
25	2	S Crate EASY 2000 No2	25	Crate EASY 3000 NeS	25	(система недленного контроля	25	avogyne x 13ch + 24ch-500v/1mA)	25	Crate EASY 2000 Nr 30	25	Crate EASY 2000 Net2	25	
24	2	A metanese + 48V Separce or A3486	24	nenawae + 48V Sepance on A3485	24	marawa LVN9 - 48 un.)	24	45kg	24	nutawar + 48V Seperce of A3486	24	natawae - 48V Separce of A3485	34	Cecteurs GATE
23	2	1	21		23		23		23		21		23	40W x 12 xawep = \$30W
22 8945, 524656	2	2	22		22	Crate VME8100/11	22	BENT, BANKAL	22		22		22	220V/10A
21	2	1 42.5kg	21	42.5kg	21	1.1kW, max. 2.5kW	21		21	42.5kg	21	42.5kg	21	20kg
20 Maguas teamonitary N	4 2	0	20		20	220x/15A	20	Crate VME8300/11	20		20		20	,
19 20DW	2		15		15	30kg	19	1.1kW, max.2.5W	15		19		15	
18 23DV	1	BENT, REMAN	1	BHR. DOWN	11		18	220v/15A	15	BANK, REMORE	11	BINT. REPORTS	11	BANK, RUNNIN
17 Skg	1	7	17		17		17	30kg	13		17		17	·
16	2	A A A A A A A A A A A A A A A A A A A	14	A3486 N=6 (380VAC-80VDC)	16		16		16	A3486 Nr11 (380VAC-40VDC)	16	A3486 Nr14 (389/AC-40/DC)	16	Spare: Cectema SPECTRA
15	1	5 3kW, max.4kW 380k/15A	12	3kW, max.4kW 380V/15A	15	BENT, RENEW	15		15	3kW, max.4kW 380V/15A	15	3kW, max.4kW 380V/15A	15	SODW
14TPC Laser system synchronizatio	ion 1	4 30x	14	101	14		14		14	101	14	201	14	220M/15A
13 200W, 220V	1	1	11		11	Crate NIM	13	BENT, BANKAL	11		11		11	50g
13 814		Come FACE TOTAL VICE		Contra FACE MAD IN F		1100 mm 1 1000				Contra Calify 2008 Martin		Contra CARTA DAMA MARIA		
12 34g	1	Durtanee + 48/ Separat at A3486	11	Detterne + 48/ Secretce of A3485	11	220//30A	11	Crate NIM	11	Entrance - 48V Secence of A3485	11	Turtaware - 45V Securica of A3485	11	
									-					
10 TPC HV membrane - 30ks	V 2	0	10		- 10	30/g	10	61DW, max. 1.15kW	10		10		10	
220/		42.5kg		42.50				Die		42.5kg		42.5kg		
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5		BEAL BANKS		800.020A			5	HALL BARRAN		BING, GAMAGA		BRIT, DAVIDA		2201
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											_			

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**Structure design - in progress** 



**TPC+TOF+ECAL cabling is in progres Piping is not started yet** 

### Time schedule

NICA	
	<b>D</b>

TPC assembling:	
Field cage assembly:	July 2023 $\rightarrow$ Nov 2023
HV tests:	August 10 2023 $\rightarrow$ Nov 2023
TPC vessel ready (glue by epoxy):	August 30 2023 $\rightarrow$ Dec 2023
Laser beams position measurements:	Sept 2023 → Jan 2024
<b>TPC</b> vessel tightness measurements:	$\overrightarrow{\text{Oct 2023}} \rightarrow \text{Jan 2024}$
24 ROC chambers installation:	Nov-Dec 2023 $\rightarrow$ Feb 2024
TPC tests: laser tracks and cosmic test:	Jan-Sept 2024 → March - Sep 2024
Integration TPC to MPD:	
TPC racks (8pc) + cabling:	Oct – Dec 2024
<b>TPC rails (2pc manufacture and delivery):</b>	Dec 30 2023
<b>Rails installation to ECAL support structure:</b>	May 2024
Tooling for installation TPC to MPD:	
<b>Design optimization + prototype 1:5:</b>	Done
<b>Tooling manufacture (9 month):</b>	Aug 2024
Delivery to JINR:	Aug 30 2024
TPC+ECAL cooling systems:	
systems delivery:	Apr 2024
commissioning:	Sept 30 2024
TPC installation to MPD:	Oct 1-Nov 30 2024
MPD commissioning	Ion 10 Fab 2025

# Thank you for your attention!