MPD/NICA TPC status (25.02.2020)

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

Presented by Sergey Movchan
on behalf of the MPD collaboration

JINR team: 24 persons
Belarus: 6 persons
## MPD TPC parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the TPC</td>
<td>340 cm</td>
</tr>
<tr>
<td>Outer radius of vessel</td>
<td>140 cm</td>
</tr>
<tr>
<td>Inner radius of vessel</td>
<td>27 cm</td>
</tr>
<tr>
<td>Outer radius of the drift volume</td>
<td>133 cm</td>
</tr>
<tr>
<td>Inner radius of the drift volume</td>
<td>34 cm</td>
</tr>
<tr>
<td>Length of the drift volume</td>
<td>170 cm (of each half)</td>
</tr>
<tr>
<td>HV electrode</td>
<td>Membrane at the center of the TPC</td>
</tr>
<tr>
<td>Electric field strength</td>
<td>~140 V/cm;</td>
</tr>
<tr>
<td>Magnetic field strength</td>
<td>0.5 Tesla</td>
</tr>
<tr>
<td>Drift gas</td>
<td>90% Ar+10% Methane, Atmospheric pres. + 2 mbar</td>
</tr>
<tr>
<td>Gas amplification factor</td>
<td>~ $10^4$</td>
</tr>
<tr>
<td>Drift velocity</td>
<td>5.45 cm/μs;</td>
</tr>
<tr>
<td>Drift time</td>
<td>&lt; 30 μs;</td>
</tr>
<tr>
<td>Temperature stability</td>
<td>&lt; 0.5°C</td>
</tr>
<tr>
<td>Number of readout chambers</td>
<td>24 (12 per each end-plate)</td>
</tr>
<tr>
<td>Segmentation in φ</td>
<td>30°</td>
</tr>
<tr>
<td>Pad size</td>
<td>5x12 mm$^2$ and 5x18 mm$^2$</td>
</tr>
<tr>
<td>Number of pads</td>
<td>95232</td>
</tr>
<tr>
<td>Pad raw numbers</td>
<td>53</td>
</tr>
<tr>
<td>Pad numbers after zero suppression</td>
<td>&lt; 10%</td>
</tr>
<tr>
<td>Maximal event rate</td>
<td>&lt; 7 kHz (Lum. $10^{27}$)</td>
</tr>
<tr>
<td>Electronics shaping time</td>
<td>~180 ns (FWHM)</td>
</tr>
<tr>
<td>Signal-to-noise ratio</td>
<td>30:1</td>
</tr>
<tr>
<td>Signal dynamical range</td>
<td>10 bits</td>
</tr>
<tr>
<td>Sampling rate</td>
<td>10 MHz</td>
</tr>
<tr>
<td>Sampling depth</td>
<td>310 time buckets</td>
</tr>
</tbody>
</table>
ROC chamber assembly hall (Bld.40)

Gluing

Wiring

Test set up

Soldering
Read out chamber (ROC): based on MWPC

Structure of Readout Chamber:
- three wire planes
- pad plane
- insulation plate
- trapezoidal aluminum frame

Wire structure:
- anode wire (Ø=25 µm) pitch - 3 mm
- cathode wire (Ø=75 µm) pitch - 1.5 mm
- gate wire (Ø=75 µm) pitch - 1 mm
- wires gap - 3 mm

Pads:
- rectangular shape
- 27 rows of pad with size 5x12 mm² at inner area
- 26 rows of pad with size 5x18 mm² at outer area
ROC chamber: pad plane

2 parts

Pads capacitor measurement

Connectivity test

Next 10 serial pad planes with soldered connectors: delivered - Jan 2020 connectivity test - ok!

Next (last) 15pc serial pad planes - ordered
ROC chambers status

- 26 pc ROC frames - in stock
- 10 pc ROCs - tested
- ROC cleaning procedure
- Wire pitch check set up
TPC assembly (Bld.217) – common view

C3-C4 glued (Feb 18 2020)

S=84 m²

ISO-6
TPC and ROCs: summary

ROC chambers:
- serial ROC chambers manufacture - in schedule (10 pc tested)
- frames (26 pc) - ready
- serial pad planes (20 pc ready) – last 15 pc ordered, ok!
- HV for ROC gate mesh – design started … on critical path
- test chamber with 2048ch r/o system – Nov 2019 -> Feb-March 2020

TPC assembly:
- C3- C4 gluing - done (Feb 18  2020)
- C1- C2 gluing - Feb-Mach 2020
- field cage rods (30 pc + 30 pc) - in manufacture
- field cage mylar strips manufacture - March 2020
- flanges finishing (add holes and grooves) - March 2020
- start of TPC internal structure ass. - Jan 2020 -> March 2020

TPC transportation platform and manipulator for ROC chamber installation - ready
Data rates:
- trigger mode – 20 GByte/sec (N=1000 tracks)
- continuous readout mode - 300 GByte/sec

Particle fluence for R=35 cm & 10 years (October 2019 update):
neutrons + protons – 10**11 p/cm2 per year
e- & e+ - 2x10**10 p/cm2 per year
ions - 10** 5 p/cm2 per year

Dose:
Expected dose - 2 kRad per 10 years

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

- The total number of registration channels: 64
- Input signal dynamic range: 100 fC
- ADC resolution: 10 bit
- ENC: less than 1000 e-
- 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.

ENC \approx 0.8 \text{ ADC } (\approx 500 \text{ e-})

FEC slow control data

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

for more details - see S. Vereschagin talk

SAMPA-0 ch1 baseline distribution

Measurement was done without connection with ROC

1 ADC LSB = 670 e-

ENC ~ 0.8 ADC
(\approx 500 \text{ e-})

S.Movchan MPD/NICA TPC status, INSTR-2020, Novosibirsk, Russia, Feb 24-28 2020
# TPC electronics: status and schedule

## Bench test

![Bench test](image_url)

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

Front view

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

LV&HV system based on CAEN rad. hard design:

(\textit{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)

\textbf{Status:}

- test system – ordered
- quotation for full TPC LV+HV system got, procurement – in progress

LV cables (halogen free, low smoke):

\begin{itemize}
  \item S=50 mm² – delivered to JINR Dec 2019
  \item S=120 mm² – delivered to JINR Dec 2019
\end{itemize}

HV cables - will be delivered July 2020

LVDB boards (60 pc) - delivered

\begin{itemize}
  \item \textit{INP BSU (Minsk)}
\end{itemize}

Team for cabling and piping – looking …
TPC gas system

Gas supply

Commissioning - in progress

Racks

TPC volume imitator

Status - commissioned (Bld.217)
**TPC cooling system**

Barrel part – shorter and fixed to TPC instead TOF structure
TPC cooling system: pipes layout and thermal panels

Service wheels - manufactured

Pipes layout optimization

in progress ...

Prototypes:

All thermal panels – manufactured
TPC laser calibration system: laser beams layout

for ½ TPC

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

TPC

micro-mirror bundles

laser beams layout – under finalization
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 slow control system: 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 - 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 + software - ???
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 (6pc) + TPC team firmware and software – in progress

Trigger and synchronization - NO
TPC slow control system: sub-systems status

Gas system:
**Hardware:** DAQ32 module + PC (PNPI, Gatchina) + custom software – 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) – ok! synchronization module (1pc) – design not started yet, custom software – NO

Integration SC sub-systems to common TPC slow control system – not started yet
TPC: cables and pipes integration

Trays layout concept

Optimization - in progress
Status:

**TPC:**
- vessel (C3-C4 cylinders) - assembled
- TPC internal structure - start assembly March 2020

**ROC chambers**
- 10 pc tested, 12 pc in manufacture
  - next 15 pc pad planes - ordered

**Electronics:**
- FE electronics (2048ch set up) - testing in progress
- RCU prototype - testing in progress
- FE (32 cards) + ROC tests - Feb-March 2020
- FE cooling prototype - designed, manufactured, tests in progress
- FE cards mass-production and tests - July-Dec 2020
- FE radiators mass-production - Sept 2020

**Sub-systems:**
- local TPC DAQ - in progress
- gas system - commissioned, integration to MPD started
- cooling system - thermal screen panels are delivered, FE cooling radiator tests - in progress
- HV+LV systems - procurement started (CAEN)
- laser calibration system - UV lasers and laser beam distrib. systems are delivered, rest - ordered
- slow control system - sub-systems more less ok, integration to common system not started yet

**Cabling and piping:**
- TPC cabling and piping - started, in progress
- MPD TPC trays design - started, in progress

**Integration TPC to MPD**
- TPC racks (~ 10 pc) - racks layout on electronics platform - in progress
- tooling for installation TPC to MPD - not started yet (a waiting ECAL design)

**TPC schedule**
- start TPC commissioning - end of 2020
Thank you for attention!

MPD event display - http://db-nica2.jinr.ru/ (V.Krilov) running on smart phone too …

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


Example for TPC