MPD/NICA TPC status (23.04.2020)

- 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

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>340cm</td>
</tr>
<tr>
<td>Outer radius of vessel</td>
<td>140cm</td>
</tr>
<tr>
<td>Inner radius of vessel</td>
<td>27 cm</td>
</tr>
<tr>
<td>Outer radius of the drift volume</td>
<td>133cm</td>
</tr>
<tr>
<td>Inner radius of the drift volume</td>
<td>34cm</td>
</tr>
<tr>
<td>Length of the drift volume</td>
<td>170cm (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>~140V/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; 30µs;</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 $\phi$</td>
<td>30°</td>
</tr>
<tr>
<td>Pad size</td>
<td>5x12mm$^2$ and 5x18mm$^2$</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>


S. Movchan  MPD TPC status, Dubna, Russia, April 23 2020
ROC chamber: pad plane

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

- **14 pc ROCs**
  - tested

- **ROC cleaning procedure**

- **Wire pitch check set up**
TPC assembly (Bld.217) – common view

C3-C4 glued
(Feb 18 2020)

ISO-6

S=84 m²
TPC and ROCs: summary

ROC chambers:
- serial ROC chambers manufacture - in schedule (14 pc tested)
- frames (26 pc) - ready
- serial pad planes - last 15 pc ordered, ok!
- HV for ROC gate mesh - design started … on critical path
- test chamber with 2048ch r/o system - ready for tests

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

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

Particle fluence for \(R=35 \text{ cm} \& 10 \text{ years} \) (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

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
\(T\ chip=45-85 \text{ degree} \Rightarrow\)
\(SEL=1x10^{-7} \text{ cm}^2\) for LET=16 MeV cm²/mg

TID and SEL - ok!

FPGA Cyclon V (technology 130 nm): 28 nm:
\(TID\ – \text{ up to 100 kRad, } SEL < 0.5 \text{ sec for } LET=26.6 \text{ MeV cm}^2/\text{mg}\)

\(TID\ – \text{ ok!}, \ SEL\ – \text{ no so good}\)
TPC electronics: block diagram of one chamber readout

RCU and data concentrator based on commercial kits

SAMPA chip
TPC electronics: FE cards

- The total number of registration channels: 64
- Input signal dynam. 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

Top view (service side)

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-)

1 ADC LSB = 670 e-
Measurement was done without connection with ROC

FEC slow control data

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

<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>

Test ROC with FE (2048ch) – > **May 2020** ?
Data concentrator ASIC (NRNU MEPHI)

65 nm CMOS process, Mixed-Signal, Low Power

Bi-directional interface, readout from 2 SAMPA chips (2.56 Gb/s speed, trigger mode, rad-tolerant)

Status:
Size - 2*2 mm2
N of prototypes – 100 pcs
Packaging - CPGA120 case
Delivery – 4-5 months
Europractice
(deadline on 13/05/20)
TPC LV+HV system

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

(up to 2000 Gauss and 15 kRad)
- power converters A3486 AC/DC (380 V -> 48 V) – 13 pc
- EASY3000 crates – 12 pc
- LV module - A3100B (2÷7V/100A) – 55 pc

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

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

HV cables - will be delivered July 2020

LVDB boards (60 pc) - delivered

INP BSU (Minsk)

Team for cabling and piping – looking …
TPC gas system

Gas supply

Commissioning - in progress

Racks

TPC volume imitator

Status - commissioned (Bld.217)

22-Apr-20  S.Movchan  MPD TPC status, Dubna, Russia, April 23 2020
**TPC cooling system**

- Front End Cards cooling
- Outer thermal screen
- Resistor rods cooling
- Inner thermal screen
- Cover cooling
- Bus bar cooling
- TPC gas volume $\Delta T < 0.1^\circ C$

**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 serial thermal panels – manufactured
TPC: FE cooling - prototype 1, INP BSU Minsk

Set up

FE power stabilization board

ROC + FE

Water - +17 degree
Al tube, Din - 6 mm
Flow - 6 l/min
CAEN - 177 W
(+3.5V/28.2A, +4/2V/22.0A)

FE power (31pc) - 134.9 W
Thermal pad - 0.8 W/m*K
Al plates thickness –(11+11) мм

Results:
SAMPA chips - (22-25) deg
FPGA chips - (28-33) deg
FE PS cables - 5.1 W

Disadvantages:
Radiation length - 25%
Impossible to do replacement of FE cards

=> New prototype (№2)
TPC: FE cooling - prototype 2, INP BSU Minsk

Set up

Test sample

Results:
FPGA chip - 28 deg (6 l/min)
- 40 deg (0.3 l/min)
- 70 deg (no water flow)

Advantages:
Radiation length - 9%
Easy FE cards replacement

Water - +15 degree
Cu tube Din - 3.36 mm
Flow - (0.3-6) l/min
FE power (1pc) - 5.2 W
Thermal glue - 6 W/m*K
Plates thickness - (4+4) мм

=> Prototype №3
TPC: FE cooling - prototype 3, INP BSU Minsk
combination of proto 1+ proto 2

Bottom cooling plates

Set of top cooling plates

Cu tube Din - 3.36 mm
Plates thickness - (4+4) мм

Tests – May 2020?
TPC laser calibration system: laser beams layout

½ TPC

Laser “planes”  - 4
Micro-mirrors bundles per plane  - 4
Beams from micro-mirrors bundle  - 7
Laser “tracks”, N  - 224

laser beams layout – under finalization
TPC laser calibration system

Optical table schemes

- optical table with components (2pc) – ordering
- short periscope (2pc) – ordering
TPC laser calibration system

- Full set of micro-mirror bundles - assembled
- 2 lasers – commissioned
- Laser beam splitter – ready to install
- Laser beam monitors – prototype under tests

Semi transparent mirror & prism

ordered

S. Movchan  MPD TPC status, Dubna, Russia, April 23 2020
TPC slow control system: sub-systems status

LV system:
1) **CAEN EASY3000** (crate SY5527 (1pc), crate EASY3000 (12pc), module A3486 AC/DC (400V) converter (13pc), module PS A3100B (55pc) + software **GECO 2020 - ok!**
2) **Custom made power stabilizers** (module LVN9 (60pc-ok)) + crate 6U (1pc), custom control units (12pc) + crate controller (1pc)+ PC + custom software) - **in progress**

HV system:
1) **MWPC ->** CAEN crate EASY3000 + modules A3535P/N 3.2kV/0.5mA – 6pc - **ok!**
   **Spare option:** 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** - ask quotation
3) HV for ROC gate: **custom made system** (crate – 2pc, modules –24pc, crate controller- 2pc + custom software) – **on critical path**

**DAQ:**
**Hardware:** FEC64 (1488pc), ROC controller (24pc), data server (6pc) + **TPC team firmware and software – in progress**
## 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 + thermal sensors (100pc)) – **ok!**, **custom software** - **started**

### Laser system:
**Hardware:** PC (1pc), industrial PC (2pc), controllers (2pc), cooling system (2pc), UV laser (2pc) – **ok!**
synchronization module (1pc) and **custom software** – **design and software not started yet**

### Trigger and synchronization – **no info**

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

Trays layout concept

Optimization - in progress
ITS+FFD integration to TPC

Concept – done, design - in progress
MPD TPC status 2020: summary

Status:

• **TPC:**
  - vessel (C3-C4 cylinders) - assembled
  - TPC internal structure assembly - March 2020 -> start of June 2020
• **ROC chambers (24pc):**
  - 14 pc tested, 2 pc in manufacture
  - next 15 pc pad planes - ordered
• **Electronics:**
  - FE electronics (next 32 cards) - ordered
  - RCU controller - design in progress
  - FE (32 cards) + ROC tests - March 2020 -> May 2020 ?
  - FE cooling prototype 1 - designed, manufactured, tested -> re-design done (prototype 2)
  - FE cards mass-production and tests - July-Dec 2020 -> 2021
  - FE radiators mass-production - Sept 2020
• **Sub-systems:**
  - local TPC DAQ - in progress
  - Gas system - commissioned, integration to MPD started
  - Cooling system: full set of thermal screen panels - delivered, FE cooling and system design - in progress
  - HV+LV systems - procurement started (CAEN)
  - Laser calibration system: UV lasers and laser beam distrib. systems - delivered, rest parts - ordered
  - Slow control system - sub-systems more less ok, integration to common SC system not started yet
• **Cabling and piping:**
  - TPC cabling and piping - in progress
  - MPD TPC trays filling - in progress
• **Integration TPC to MPD:**
  - TPC racks (5 pc) layout - in progress
  - tooling for installation TPC to MPD - in progress
• **TPC schedule:**
  - start of TPC commissioning - beginning of 2021
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