MPD/NICA TPC status (24.10.2019)

• TPC parameters
• TPC cylinders
• ROC chambers
• front end electronics
• gas, cooling, laser and SC systems
• cabling and tubing
• integration TPC to MPD
• time schedule

Presented by Sergey Movchan

JINR team: 24 persons
Belarus: 6 persons

MPD detectors and TPC

TPC

FFD

ITS

TOF

ECAL
**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>

S. Movchan  MPD/NICA TPC status  IVth MPD Collab meeting, Warsaw, October 21-25  2019
TPC TDR status

TPC cylinders: C1-C4 at JINR

- **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 HV electrode and flanges: delivered to JINR

Tooling for HV rods and field cage strips assembly

Serial HV electrode

TPC flanges – 2 pc
MWPC and pad plane
ROC chamber cross-section

- Gate: 75 mkm Cu-Be, 80 g
- Cathode: 75 mkm Cu-Be, 80 g
- Anode: 20 mkm W-Re, 50 g
ROC chamber Al frame

Sealing frame
Stiffening rib
Al frame
Isolated plate
Pad plane

~ 25 µm
**ROC chamber: pad plane from 2 parts**

10 serial sets will be delivery to Dubna – Oct-Nov 2019

After inspection - next 10 serial sets will be ordered
ROC chamber: test results

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

ROC-14, X-ray line scan, step 3 mm, Ar/CH4 (90/10), Ua = 1.45 kV, Udrift = -1120 V, uniformity 18.4%

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

Fe-55: FWHM ~ 20%
TPC clean room (LHEP, bld.217) common view: ready

S=84 m²

ISO-6

H ≤ 40% - ok!
T=(21.75 ± 0.25°C) – ok!
Tooling for TPC assembly -> ready

TPC deformation:
Max = 32 µm
TPC cylinders: C3-C4 assembly status

**Status:**
C3-C4 technology of gluing – prototype + tests
(glue type will be chosen and ordered)

C3 - preparation for cleaning
  - gas inlets gluing - done
  - decrease of flanges diameter - done

C4 - preparation for cleaning

**Plans:**
C3-C4 glued - Nov-Dec 2019

Start of TPC internal structure ass. – Jan 2020
(flanges, HV electrode, field cage, …)
TPC and ROCs: **status**

- **26 pc ROC frames** - in stock
- **ROC cleaning procedure** - ready
- **8pc ROCs** - tested
- **C3-C4 gluing** – in preparation
TPC: transportation platform and ROC manipulator

at Briansk:

LHEP, bld. 205 – delivered to JINR
# 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** - done
- **field cage rods (30 pc + 30 pc)** - ready
- **field cage mylar strips manufacture** - June 2019 -> Nov 2019
- **C3- C4 gluing** - June 2019 - > Nov-Dec 2019
- **flanges + HV electrode + HV rods** - ready
- **start of TPC internal structure ass.** - Dec 2019 -> Jan 2020

**ROC chambers:**

- **frames (26 pc)** - ready
- **serial pad planes (30 pc)** – ordering 10 pc –> delivery end of Oct
- **HV for ROC gate electrode** – design started, **in progress**
- **test chamber with 512 ch r/o system** – Sept 2019 - > Nov 2019
- **serial ROC chambers manufacture** - 2019-2020, in schedule (8pc tested)

**TPC transportation platform and manipulator for ROC installation** - ready
TPC electronics requirements

Data rates:
- trigger mode – 20 GByte/sec \((N=1000\ tracks)\)
- continuous readout mode - 300 GByte/sec

Particle fluence \(\text{for } R=35\ \text{cm} \& \ 10\ \text{years (very preliminary, Dec 2018)}:\)
- neutrons + protons – \(2.5 \times 10^{10}\ \text{p/cm}^2\ \text{per year}\)
- e- & e+ - \(1 \times 10^{10}\ \text{p/cm}^2\ \text{per year}\)
- ions - \(0.5 \times 10^{10}\ \text{p/cm}^2\ \text{per year}\)

Dose:
Expected dose - 1 kRad per 10 years
\(\text{(for Apollo and Shuttle space flights, } D=2\ \text{Rad/year)}\)

After re-simulation (Oct 2019, FLUKA) – factor \(\times 2\) more
**TPC electronics: requirements and status**

*SAMPA v3/v4 tested at:*

- **proton fluence** - up to $N=10^{12}$ per cm$^2$
- **ion fluence** - up to $N=10^7$ per cm$^2$ & LET=$(3-125)$ MeV cm$^2$/mg

*Chip angle* $(45-85)$ degree $\Rightarrow$

SEL = $1 \times 10^{-7}$ cm$^2$ for LET = 16 MeV cm$^2$/mg

**TID and SEL - ok!**

*FPGA Cyclon V (technology -130 nm):*

- **TID** – up to 100 kRad, SEL < 0.5 sec for LET = 26.6 MeV cm$^2$/mg

**TID – ok!, SEL – no so good**
**TPC electronics: FE cards**

- **FEC controller**
  - Bottom view
  - Top view
- **FEC assembly view**
- **SAMPA FEC**
  - Top view
  - Bottom view

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

ENC ~ 0.8 ADC (~ 500 e-)

**FEC slow control data**

- **T_{SAMPA} = 57 degree**
- **T_{FPGA} = 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**

23-Oct-19  S. Movchan  MPD/NICA TPC status  IVth MPD Collab meeting, Warsaw, October 21-25 2019
ROC chamber: test SAMPA chip with ROC chamber

ROC-chamber tested with SAMPA chip (HV=+1450 V):

ENC = 828 e- (for small pads), ENC = 869 e- (for big pads)
(20% more than expected due to digital noise)

Waiting for 30 FE boards with read out system for tests with ROC
TPC electronics: status

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

Pilot system – 512 ch

Status: tested

Readout system based on commercial kits

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TPC electronics: status and schedule

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

Tests – in progress

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

- Power cables
- Cable tray
- Optic cables
- 2 level FE cards
- Cooling tube
- Chamber pad plane
- Flat cable

S.Movchan  MPD/NICA TPC status  IVth MPD Collab meeting, Warsaw, October 21-25 2019
TPC electronics: FE cards integration and cooling

2 radiators (narrow and wide)
FE cards – no individual cooling

Status: in progress
INP BSU (Minsk): TPC LV system

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 15 kRad

https://indico.cern.ch/event/699390/contributions/2868537/attachments/1593340/2522493/Neolite_RandD_effortSummary.pdf

Status of CAEN option:
- invoice for LV system – got, delivery time – (270-300) days
- invoice for HV system - got, delivery time – (90÷150) days

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

Team for cabling – looking …
TPC gas system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas mixture</td>
<td>Ar + 10% CH₄</td>
</tr>
<tr>
<td>TPC gas flow, nominal</td>
<td>200 l/min</td>
</tr>
<tr>
<td>TPC overpressure</td>
<td>(2.0 ± 0.1)mBar</td>
</tr>
<tr>
<td>O₂ admixture</td>
<td>20 ppm</td>
</tr>
<tr>
<td>H₂O admixture</td>
<td>10 ppm</td>
</tr>
<tr>
<td>External loop, refresh gas rate</td>
<td>30 l/min</td>
</tr>
<tr>
<td>Fresh part of gas mixture add to external loop, range</td>
<td>(0-50) l/min</td>
</tr>
<tr>
<td>TPC isolating gas</td>
<td>N₂</td>
</tr>
<tr>
<td>N₂ gas flow</td>
<td>(5-20) l/min</td>
</tr>
</tbody>
</table>

Delivery to JINR:
- gas supply system - 2015
- purification system - 2017
TPC gas system

Gas supply

Status - commissioning in progress

Racks

TPC volume imitator

Status - commissioned (Bld.217)

in progress ...
TPC cooling system

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

Diagram showing the TPC cooling system with components such as:
- Temperature Sensor
- Shunt off valve
- Heater
- Heat Exchanger
- Circulator Pump
- Reservoir
TPC cooling system: thermal screens

Barrel part – shorter and fixed to TPC

2 thermal panel prototypes - testing
TPC cooling system: tubes layout and set of thermal panel prototypes

Service wheel

Tubes layout prototyping

Status - in progress

TPC cooling and temperature stabilization system

Al plate – 2x1 mm
Al tube - D=8/6 mm
TPC laser calibration system

½ TPC

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

micro-mirror bundles
TPC laser calibration system

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

Semi transparency mirror & prism
TPC laser calibration system: laser beam layout (proposal)

Status - in progress

TPC

TOF

FHCAL

laser beam layout
TPC slow control: SC

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 (2pc), control units (24pc) + crate controller (2pc)+ PC) + custom software - started

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 + Iseg software – not ordered
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 (24pc) + TPC team firmware and software – in progress
   Trigger ???…
   Synchronization ??? …
   Clock ??? …
**Gas system:**
**Hardware:** DAQ32 module + custom software + PC (PNPI, Gatchina) – **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), synchronization module (1pc) + **laser producer software** – **not started yet**
TPC: cables and tubes integration

Optimization - in progress
TPC: trays

in progress …
## TPC services: summary and status

### LV system:
- serial LVDB (60 pc) – delivered to JINR
- serial LVDB cooling plate – in manufacture
- CAEN EASY3000 LV system - invoice got, under discussion …
- LV cables and patch-panels - ordered, June 2020

### HV system:
- CAEN standard HV system (crate + modules) - invoice got
- CAEN EASY3000 HV system - under discussion …
- HV cables - June 2020

### Gas system:
- system - commissioned
- commissioning of cryo. vessels for Ar and N2 - in progress

### Cooling system:
- FE cooling prototypes – ordered
- testes and measurements with prototype – in progress
- barrel and end cap thermal panels delivery – end of 2019
- service wheel cooling tubes routine optimization - in progress
- FE cooling radiators mass-production - Sept 2020
Laser calibration system:
- lasers (2 pc) - commissioned
- laser beam splitter and transport system - in production, will be delivered July 2019 -> Nov 2019
- beam monitors (WEB cameras + optics) - ordered, design in progress
- channels for laser beams inside MPD – under discussion

Slow control system:
- LV system – more less ok
- HV system – more less ok, but HV for ROC gate – on critical path
- DAQ – in progress
- Gas system – ok!
- Cooling system – started
- Laser system – not started yet
TPC services: summary (continue)

INTEGRATION:

TPC sub-systems integration - in good shape
list of TPC cables and tubes – updated
trays filing - not started yet

Integration TPC into MPD – not started yet
(nevertheless waiting for final ECAL design and sub-system integration to MPD)

Tooling for installation TPC into MPD - not started yet
Time schedule

TPC R&D and Prototyping
TPC development* (drawings e.t.c.)
Production of flanges and other parts
FIELD cage development, prototyping
Field cage (Inn and Out) production
ROC development, prototyping
ROC mass production, test
FEE development
FEE mass production
TPC readout, DAQ production, test
TPC slow control system
TPC assembling hall (Bld.217)
LASER calibr. system design
LASER calibr. system production
COOLING syst.develop., prod, test
GAS syst-develop., prod, test
TPC assembling and lab. testing
Tooling, TPC installation into MPD
Start TPC commissioning

* Current version of TPC dimensions was approved of 31.01.2013
Thank you for attention!


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