



# Status of the Time-of-Flight Identification System of the MPD

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V. Babkin on behalf of the TOF group of the MPD experiment

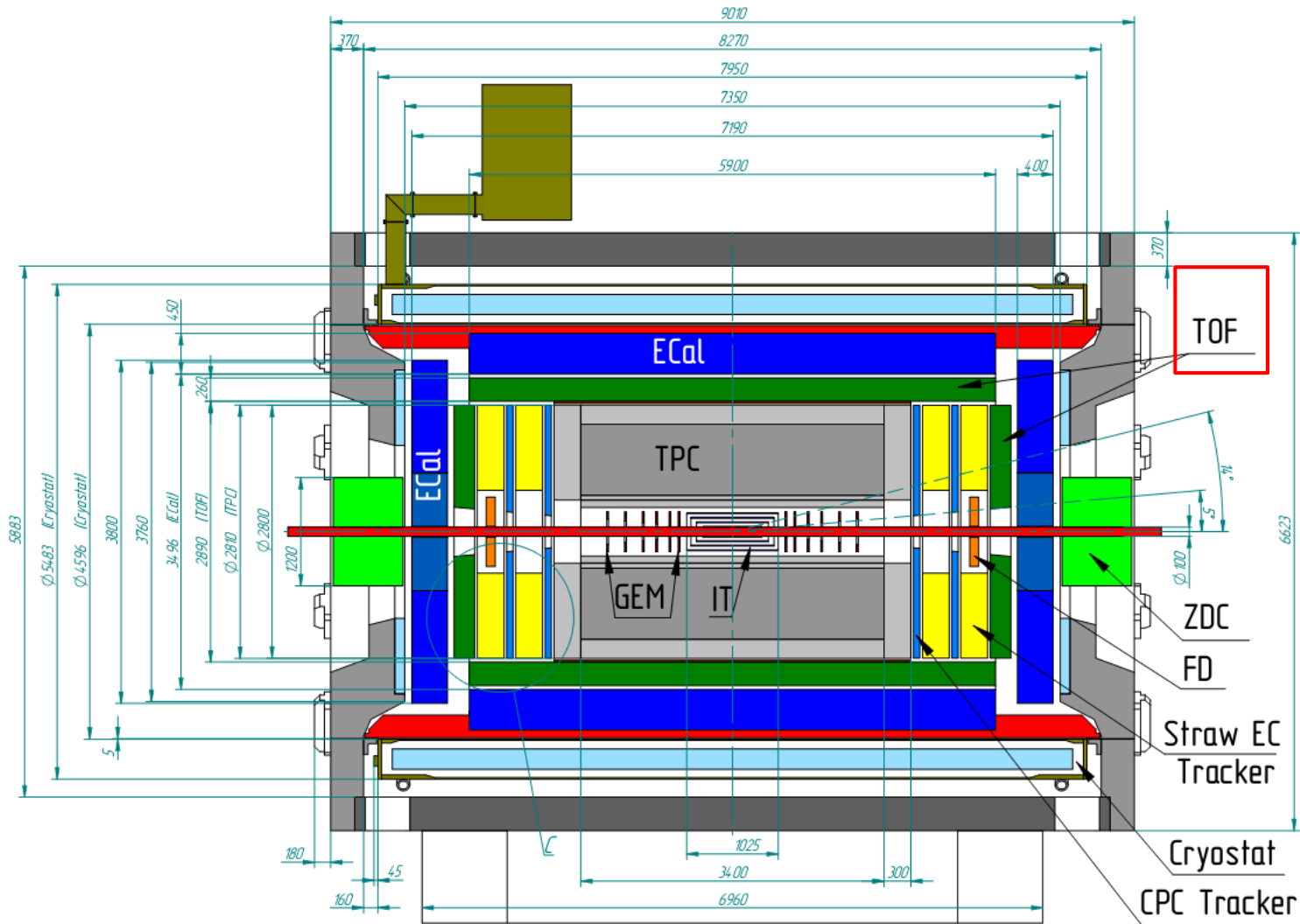
**Abstract:** The identification of hadrons in experiments on the study of hot and dense baryonic matter is an important and complex task. Particles identification in the MPD is performed by a time-of-flight system based on multi-gap RPC. The design of the MPD time-of-flight system is completed and mass production of detectors is now started.

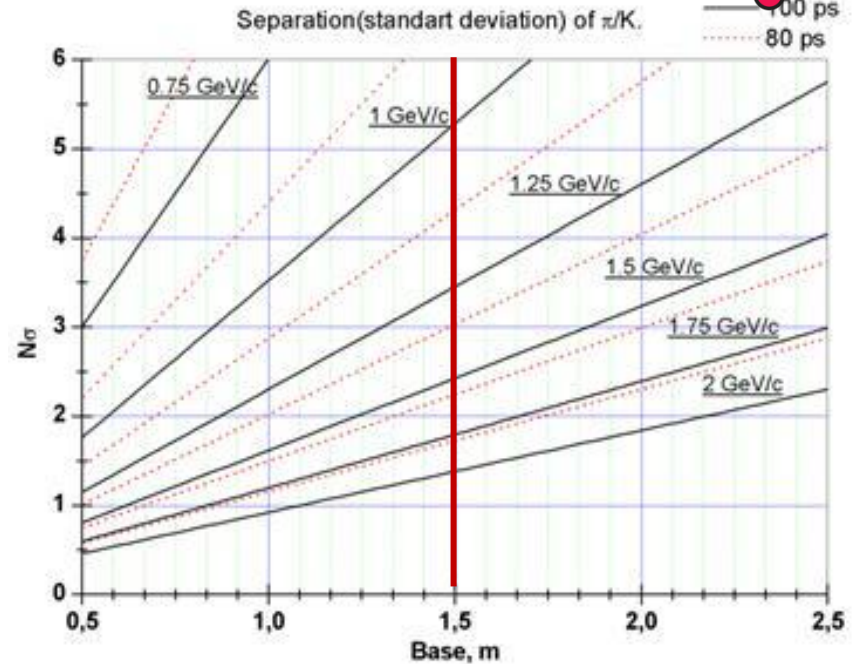
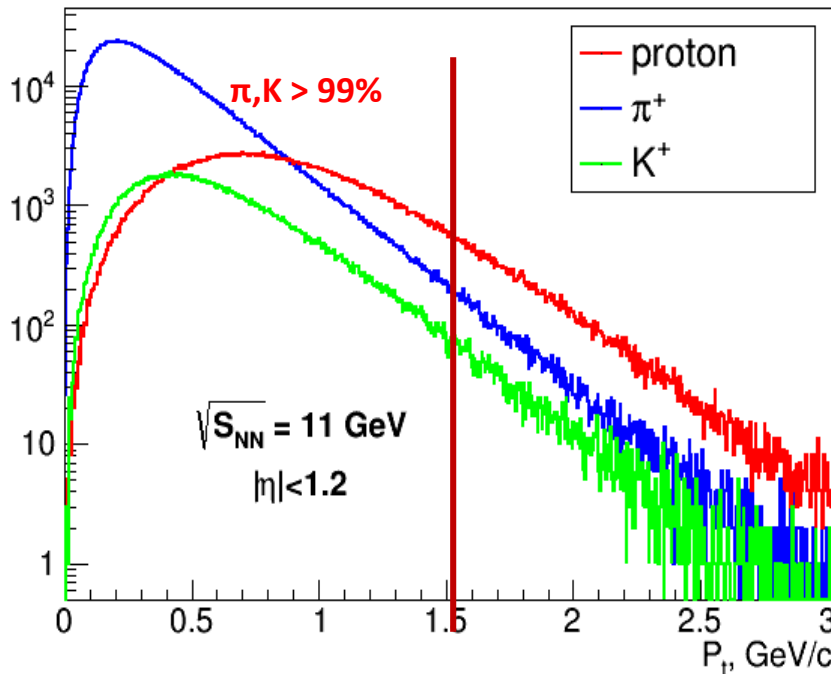
# Outlines

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- The TOF system location in the MPD
- Requirements to the TOF system
- Design of the TOF barrel and MRPC
- Readout electronics
- Integration to the MPD
- Service systems
- Mass production & testing
- Conclusions

# Two stages of the MPD experiment





## The basic requirements to the TOF system are:

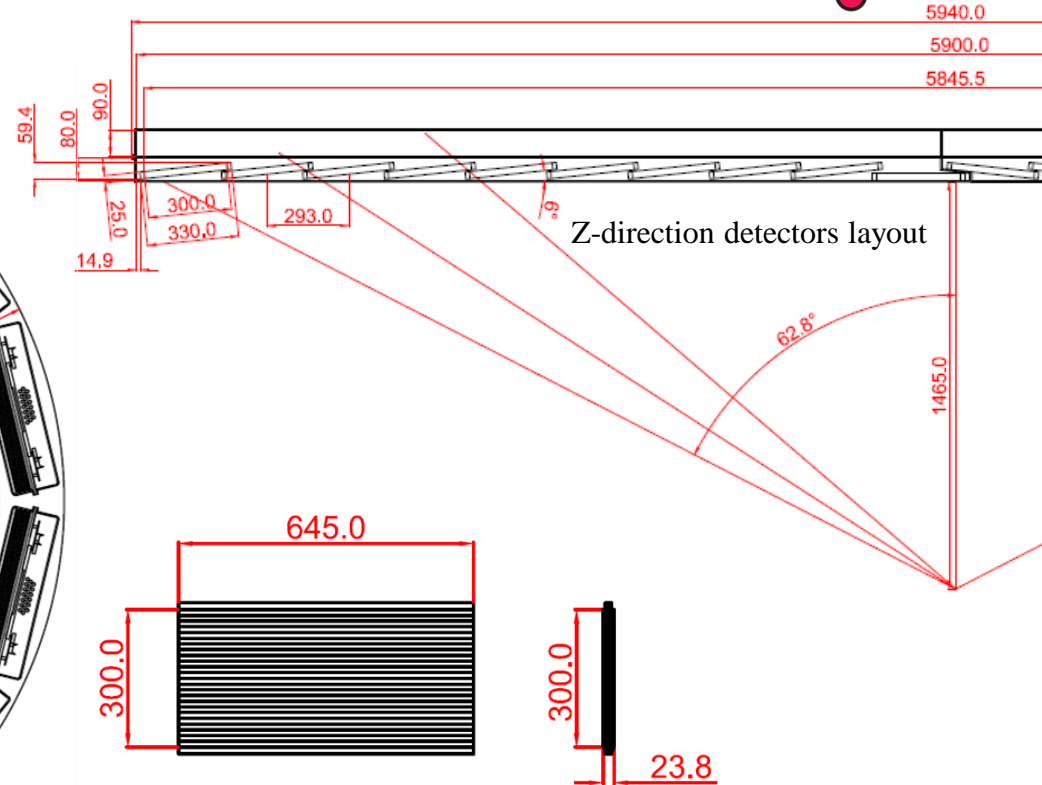
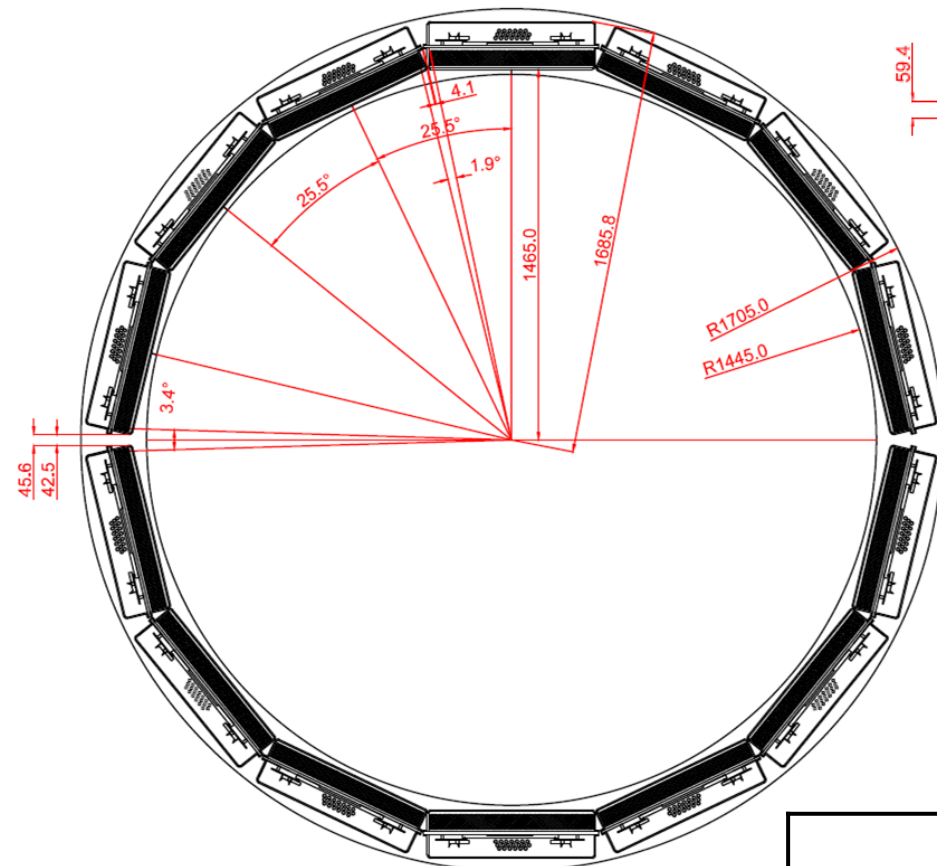
- large phase space coverage  $|\eta| < 2$ ;
- large area coverage  $\sim 50 \text{ m}^2$
- time resolution  $< 100 \text{ ps}$ ;
- high granularity to keep the maximum occupancy  $< 15\%$ ;
- high geometrical efficiency;
- identification of pions and kaons with up to  $p_t < 1.5 \text{ GeV}/c$ ;
- identification of (anti)protons with up to  $p_t < 3 \text{ GeV}/c$ ;

The best choice for this requirements is a Multigap Resistive Plate Chamber (MRPC).

# Mechanical design of the TOF barrel

Estimated occupancy ~14%

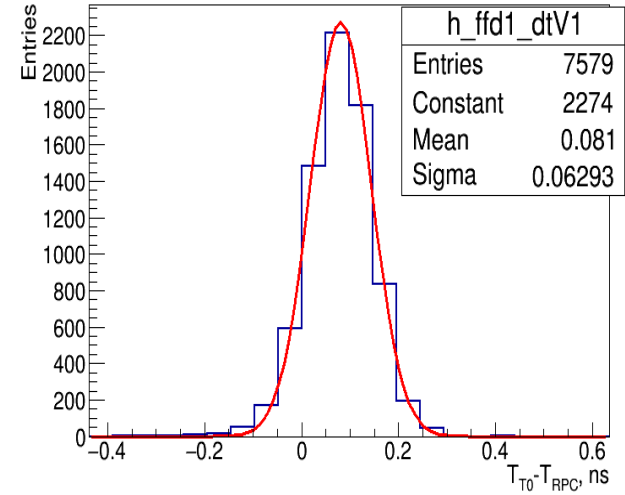
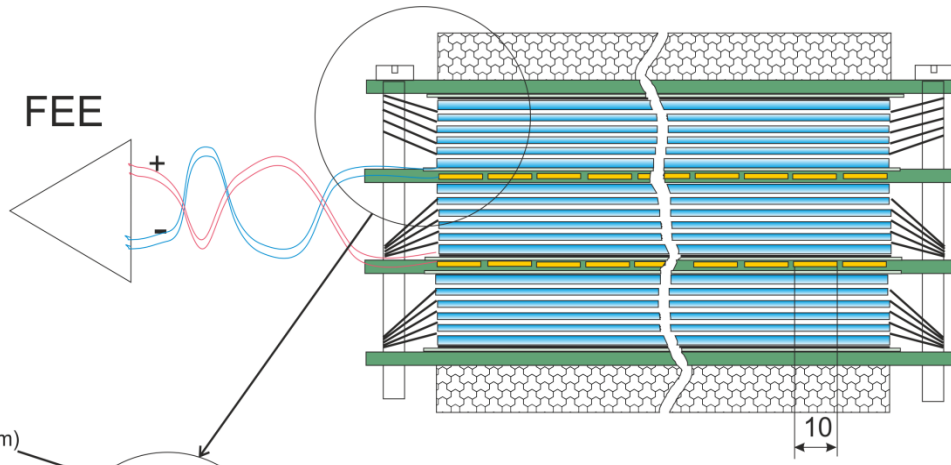
Estimated geometrical efficiency ~94%



	Number of detectors	Number of readout strips	Sensitive area, m <sup>2</sup>	Number of FEE cards	Number of FEE channels
MRPC	1	24	0.2	2	48
Module	10	240	1.85	20	480
Sector	20	480	3.7	40	960
Barrel	280	6720	51.8	560	<b>13440</b> (1680 chips)

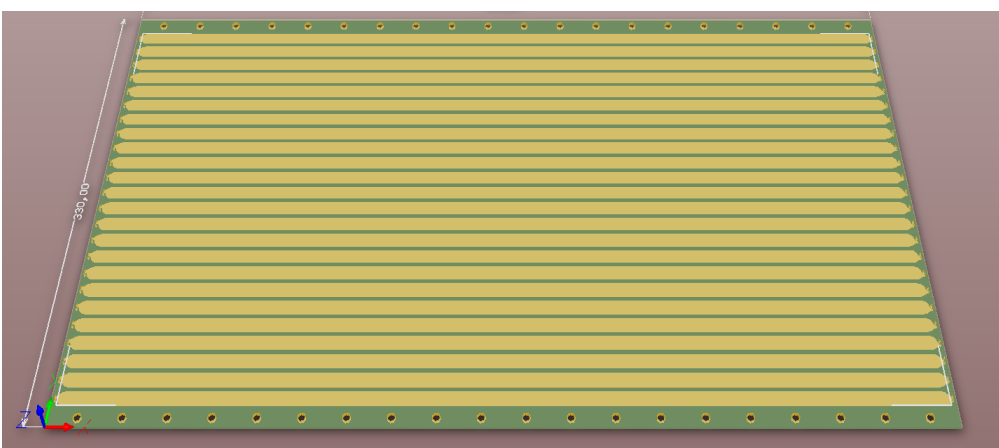
# Triple-stack MRPC

$$\sqrt{63^2 - 48^2} \approx 41 \text{ ps}$$

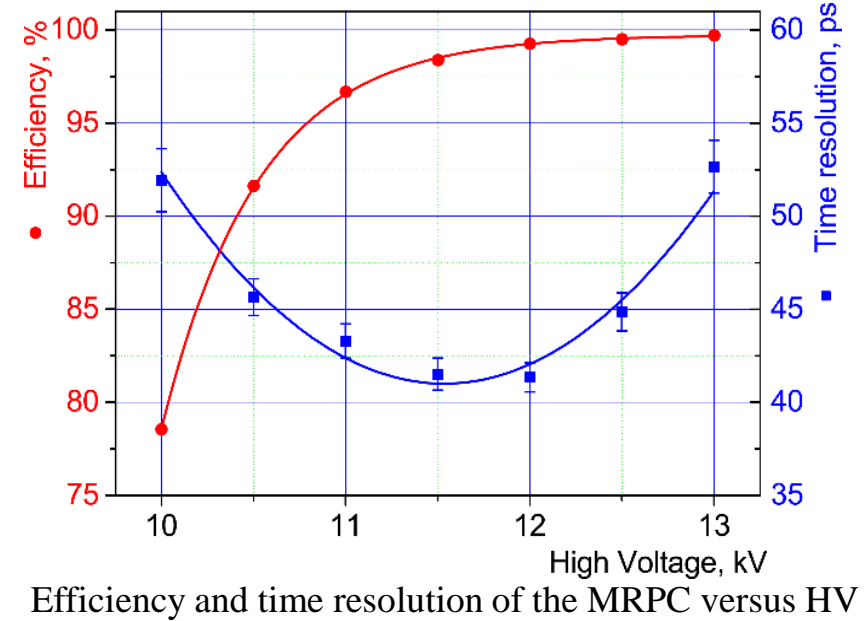


Triple-stack MRPC cut view

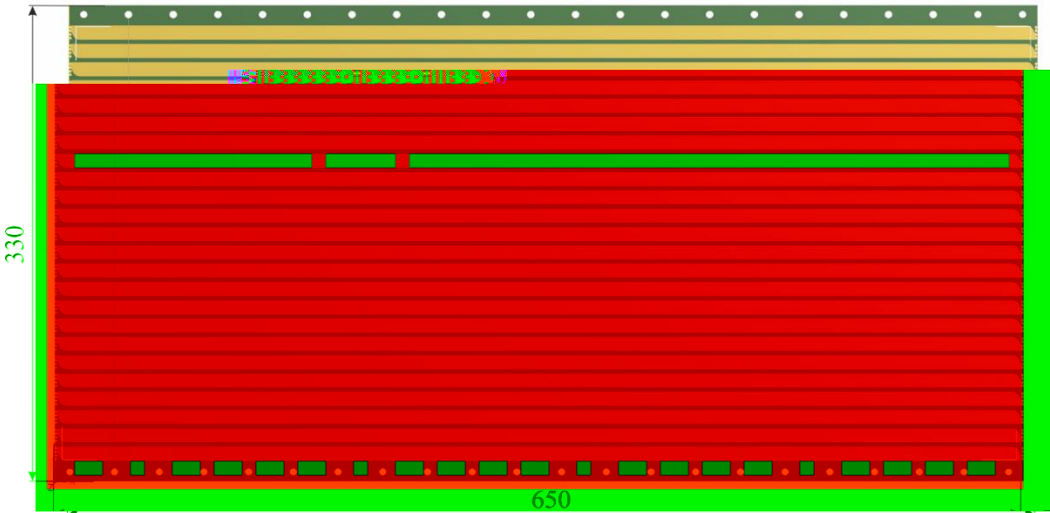
- Honeycomb (5 mm)
- PET Screw
- Outer PCB (1.5 mm)
- Mylar (100mkm)
- Outer HV glass (400 mkm)
- Inner glass (270 mkm)
- Spaser (fishing line 200 mkm)
- PCB with "strips" (1.5 mm)



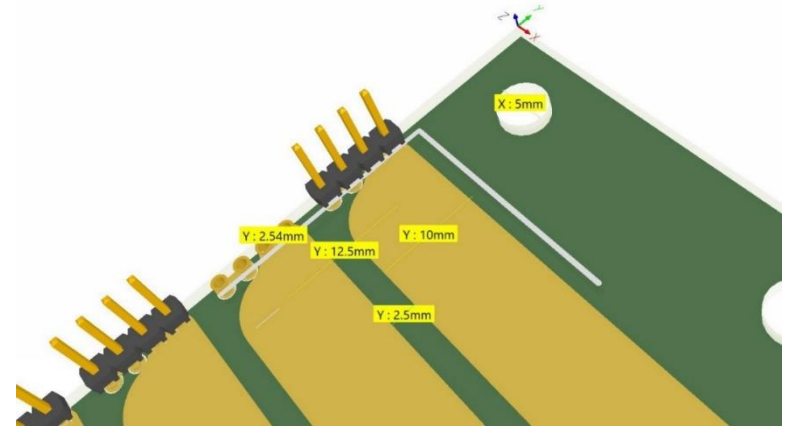
Inner readout board with strips



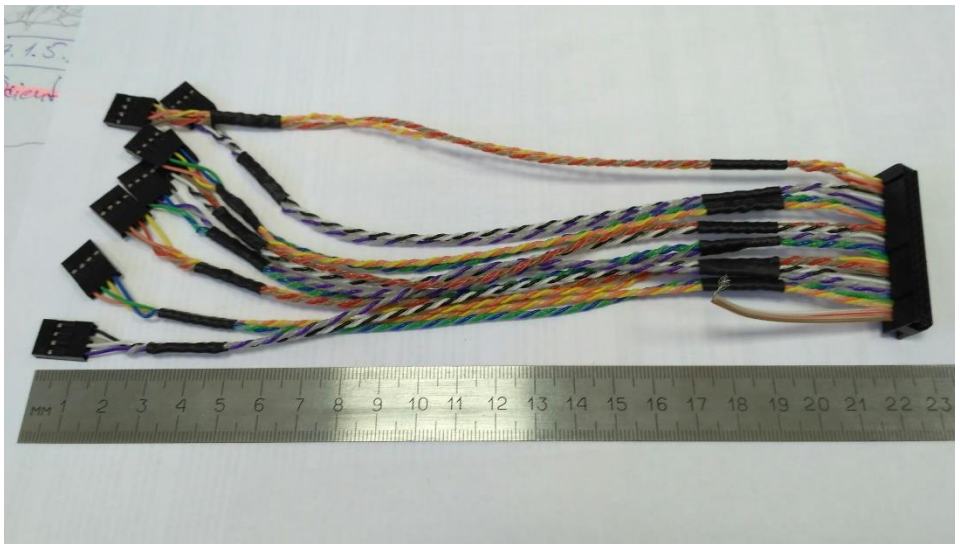
Efficiency and time resolution of the MRPC versus HV



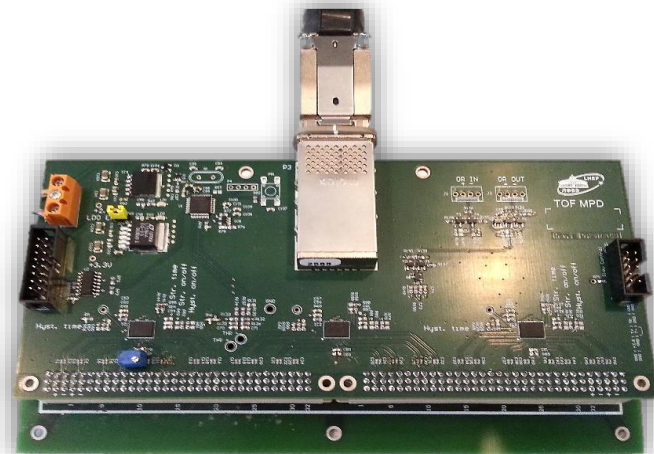
Overall dimensions of the readout board with strips



Signal connectors on the PCB



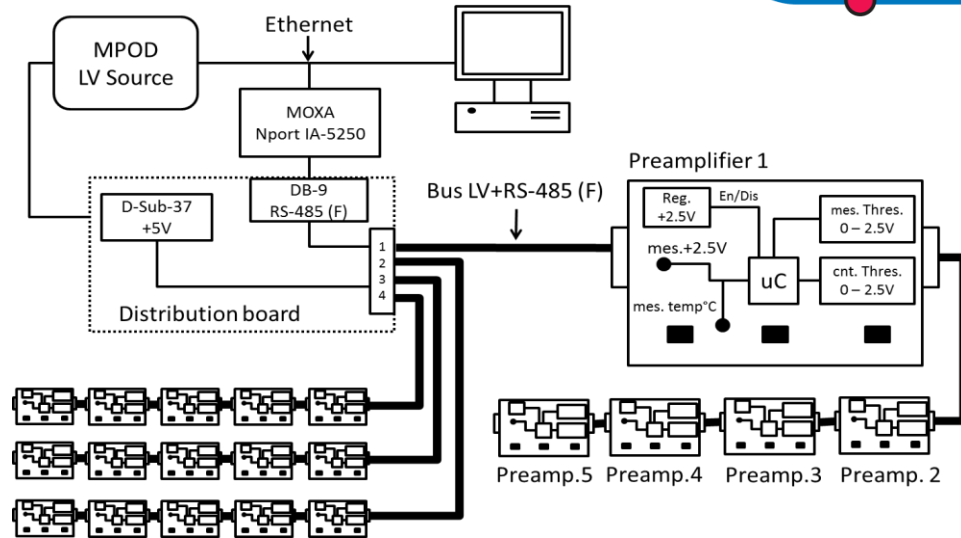
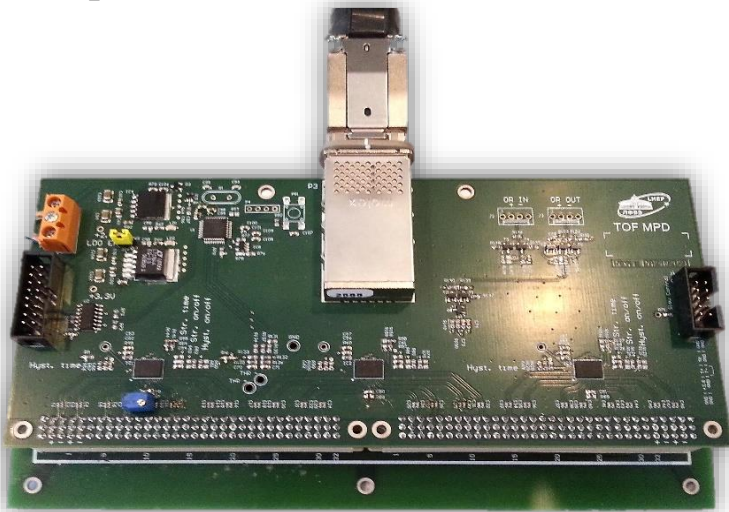
Doubled twisted pair cable for transferring signal to the preamp



NINO based 24-ch preamplifier-discriminator PA24N2V2I with adapter board



## NINO based 24-channels preamplifier-discriminator board PA24N2V2I



Powering preamplifier board and connection scheme.

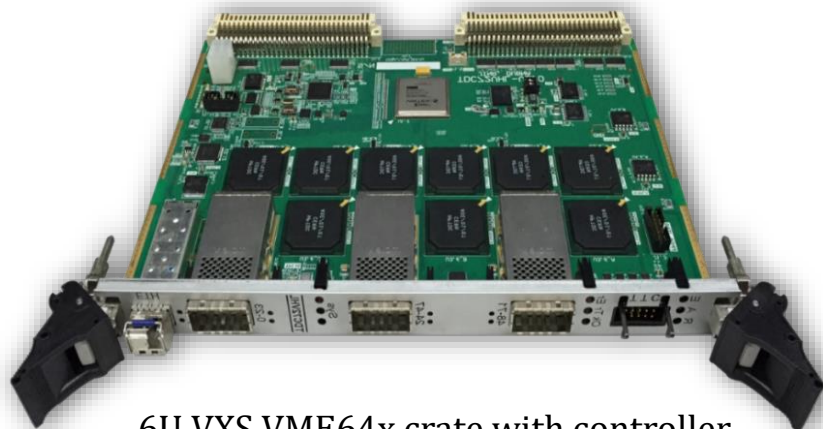
- ✓ Stabilization of the voltage (+2.5V);
- ✓ Differential input (  $Z_{diff} = 55 \text{ Ohm}$ );
- ✓ Inputs capacitors for two-end strip readout;
- ✓ CXP (InfiniBand) 100  $\Omega$  output connector;
- ✓ Series “or” output for 24 channels;
- ✓ Time jitter (RMS) for one channel  $\approx 7 \text{ ps}$ ;
- ✓ “On board” slow control:
  - voltage control & monitoring;
  - preamplifier thresholds control;
  - board temperature monitoring  $\pm 0.5 \text{ }^\circ\text{C}$ ;
  - gas volume temperature monitor.

ch	V+, mV	V-, mV	Vdelta, mV	Vpower, mV	DAC, mV	Tboard, °C	Tgas, °C
1	1946	1741	1624	3248	2775	45	44
2	1993	1637	1544	3287	0	41	38
3	1987	1737	1735	3293	0	43	43
4	1940	1649	1627	3220	0	48	48
5	1914	1588	1615	3265	0	46	38
6	1993	1985	1741	3293	0	50	44
7	1754	1906	1731	3294	0	40	47
8	1777	1836	1980	3272	0	38	48
9	1915	1909	1655	3222	0	37	37
10	1864	1969	1703	3293	0	46	49
11	1855	1378	1841	3268	0	50	48
12	1610	1751	1908	3206	0	49	49
13	1976	1686	1611	3286	0	39	48
14	1993	1898	1787	3250	0	44	47
15	1788	1847	1517	3252	0	49	44
16	1509	1645	1761	3207	0	46	36
17	1711	1785	1990	3268	0	42	35
18	1746	1559	1676	3256	0	38	47
19	1788	1379	1829	3256	0	40	38
20	1514	1566	1641	3296	0	49	48

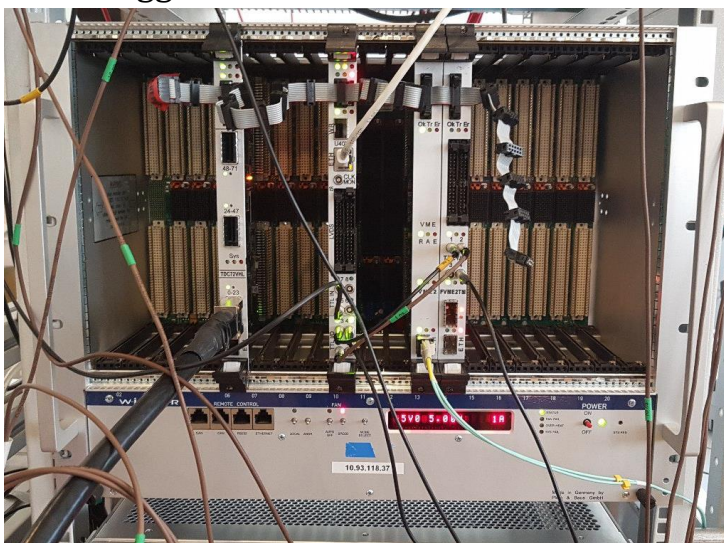
Slow control GUI clients (left side for FEE, right LV source)



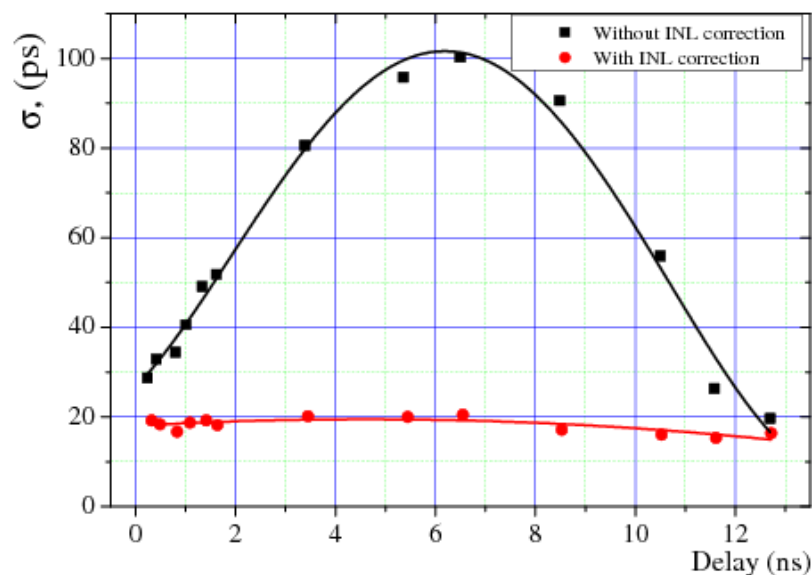
72-channels VME time-to-digital converter TDC72VHL

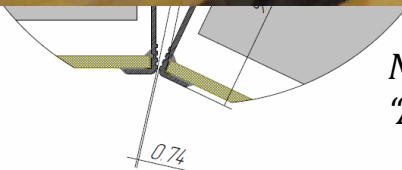
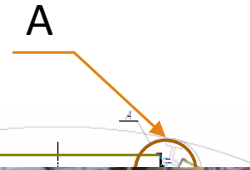
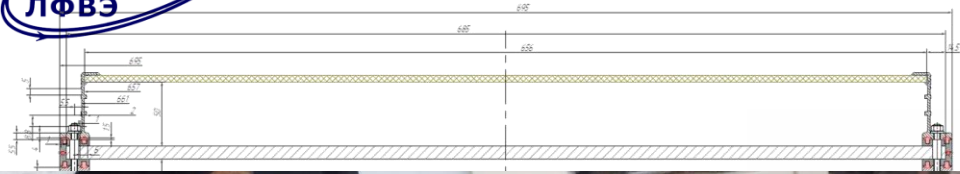


6U VXS VME64x crate with controller, trigger modules and TDC72VHL

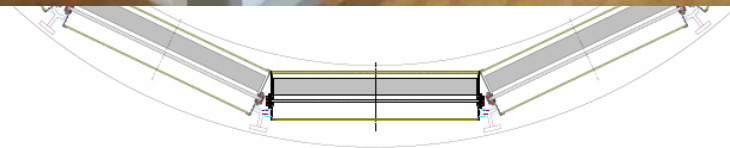


- ✓ VME64x interface with VXS;
  - ✓ TDC type: timestamping HPTDC chip;
  - ✓ Input: differential 100  $\Omega$  (LVDS);
  - ✓ Resolution: 23.4 ps bin size ( $\sigma_t \approx 18$  ps - measured);
  - ✓ Power consumption: +5V/0.13A; +3.3V/5.6A;
- Standalone mode:
- ✓ Ethernet data transfer;
  - ✓ Time synchronization by the White Rabbit.

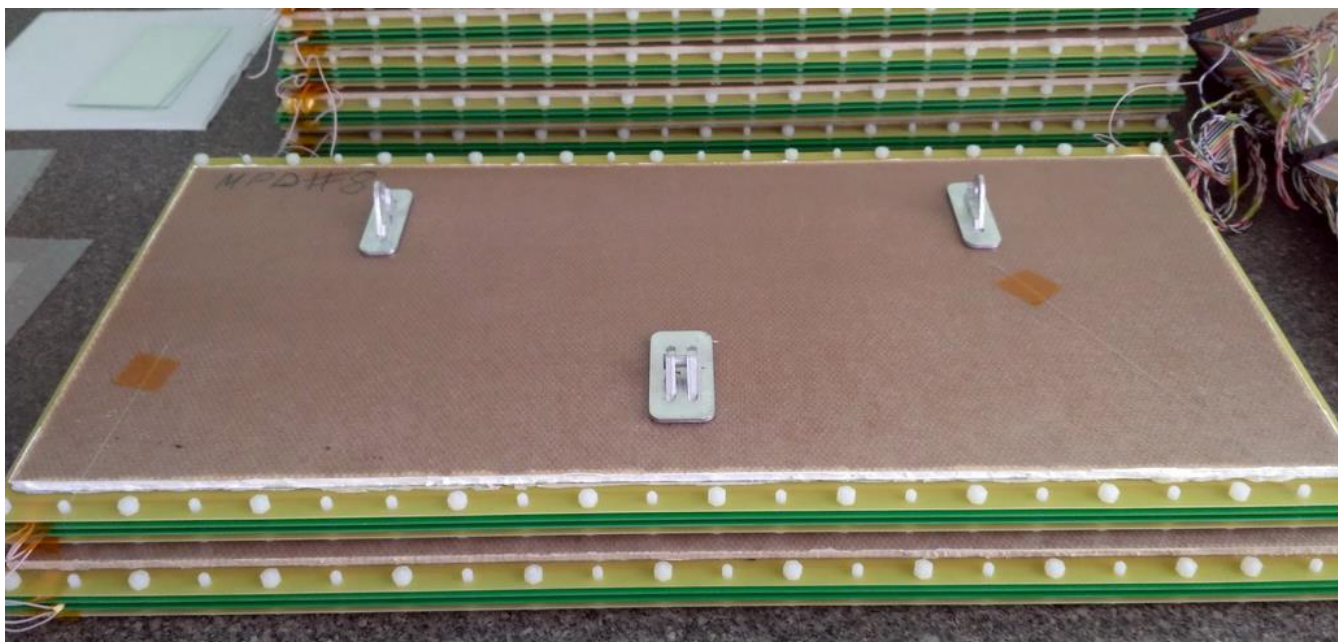
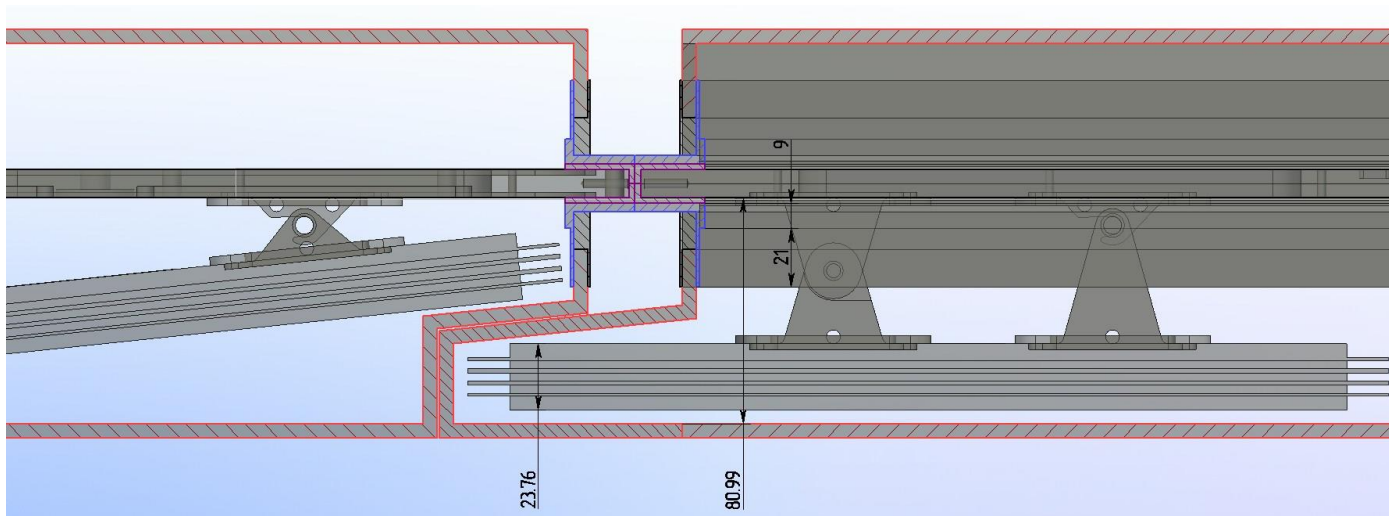


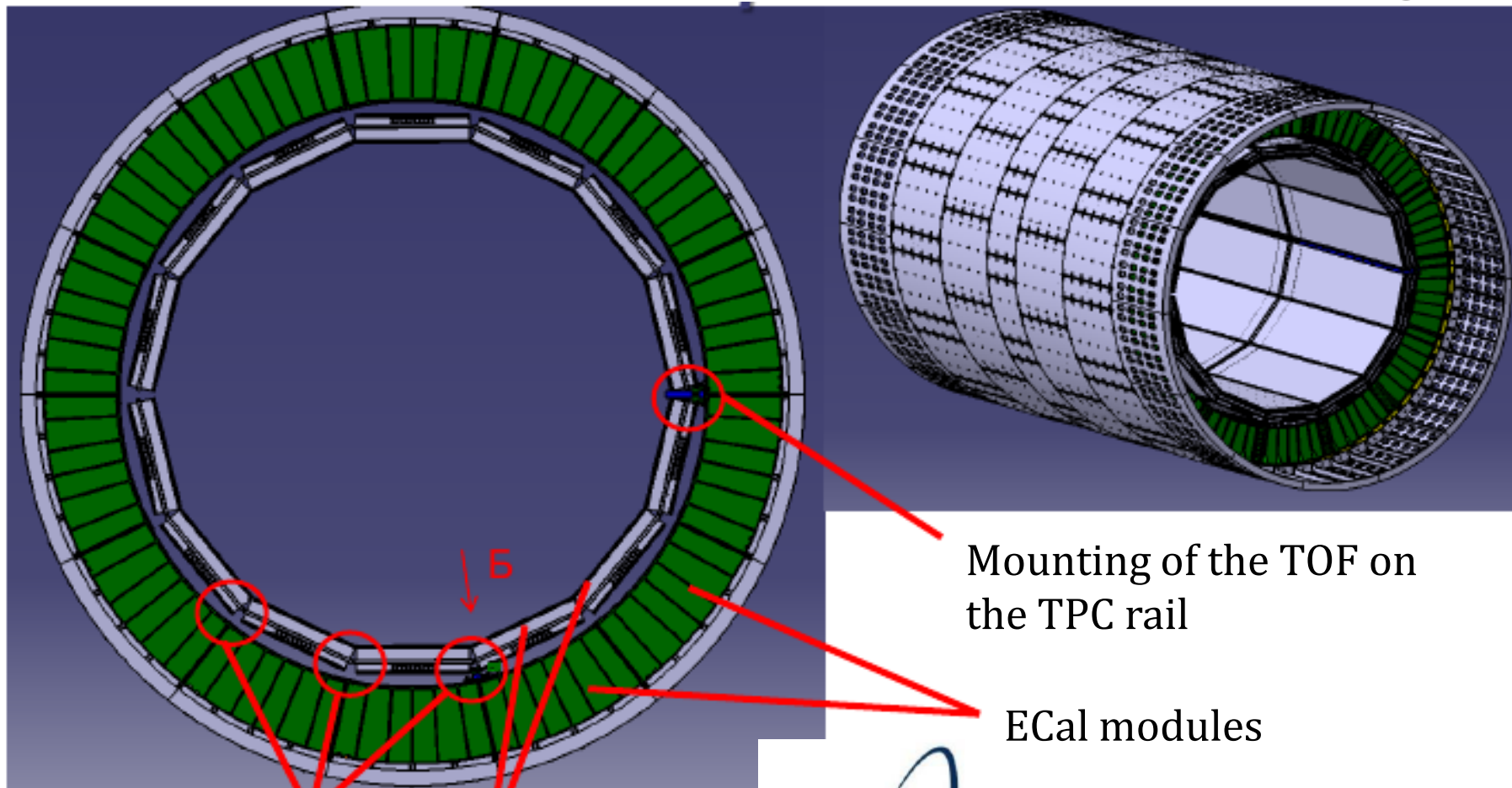


NC PHEP BSU  
"Artmash" (Minsk, Belarus)









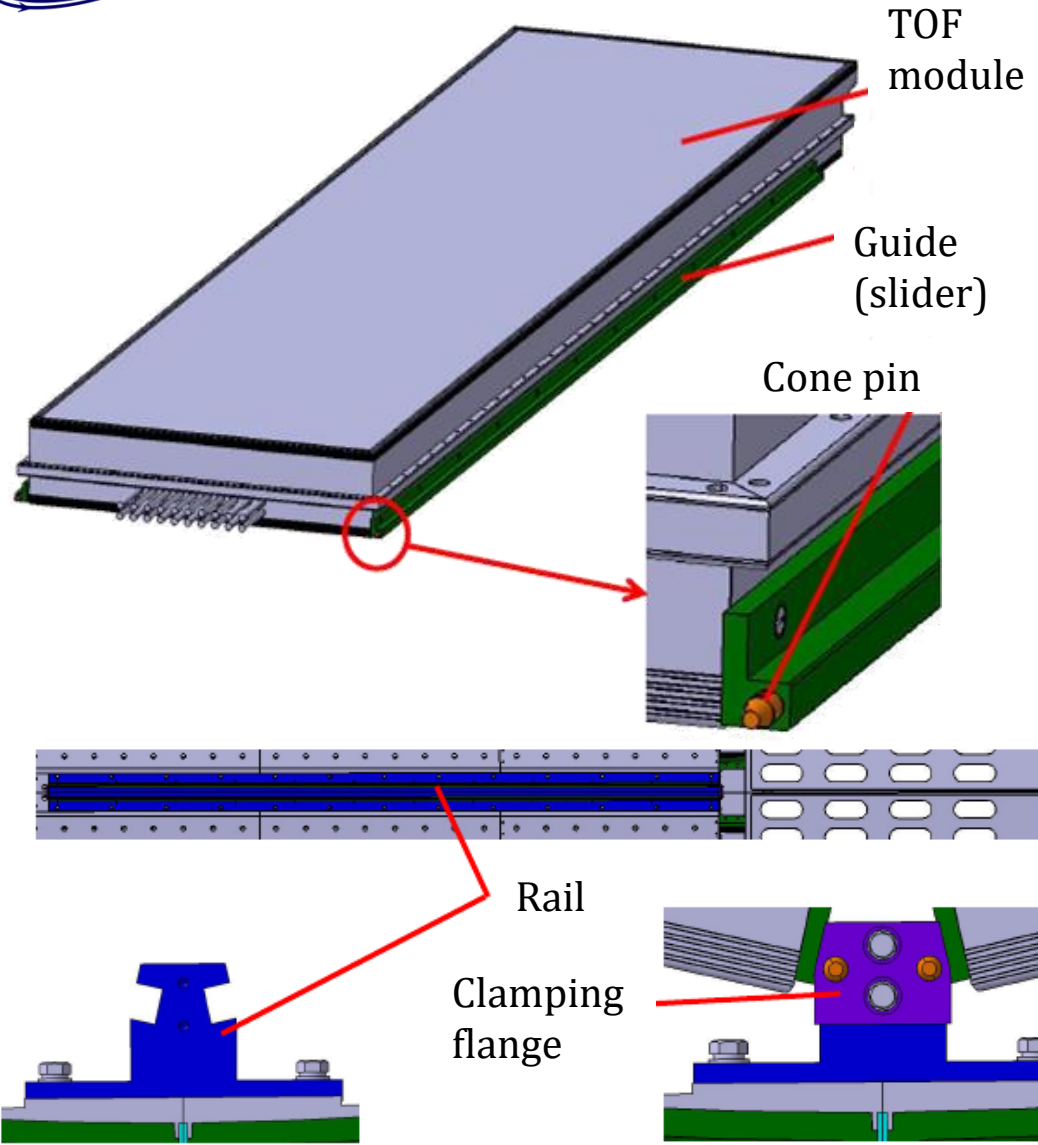
Typical TOF mounting on the Ecal frame

TOF modules

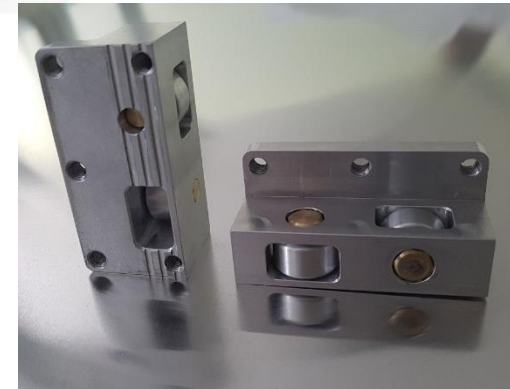
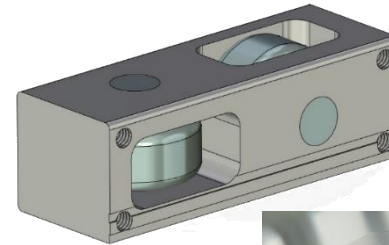
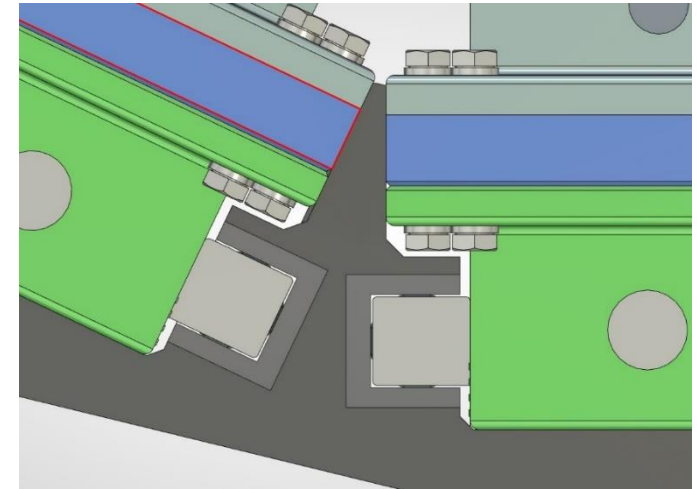
Mounting of the TOF on the TPC rail

Ecal modules



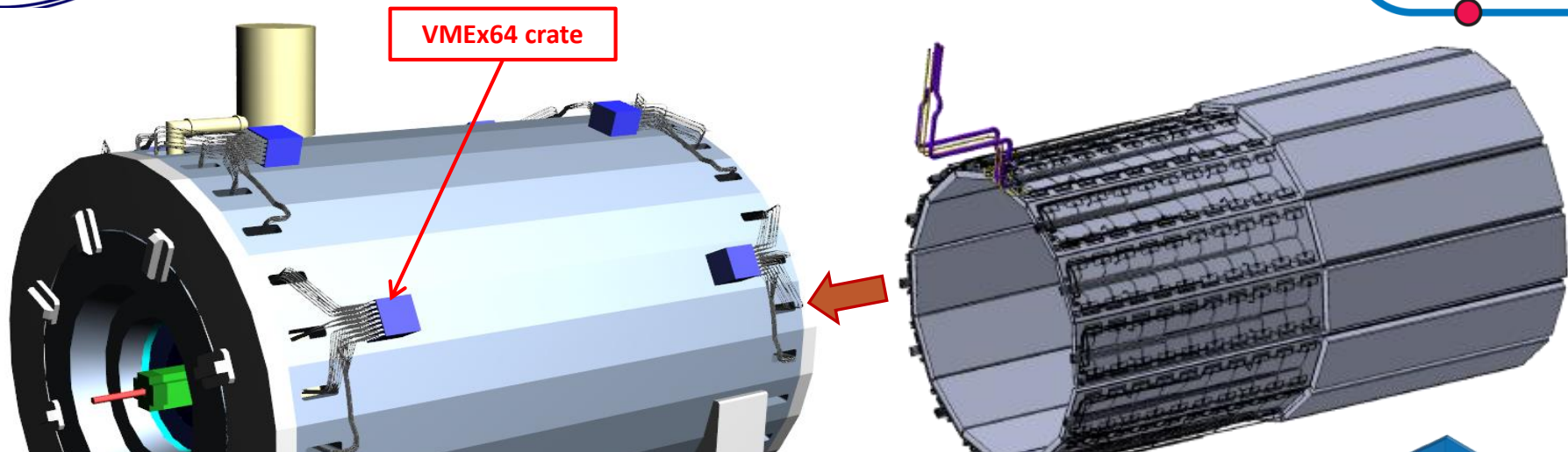


New "Artmash" (Minsk) guides with rollers



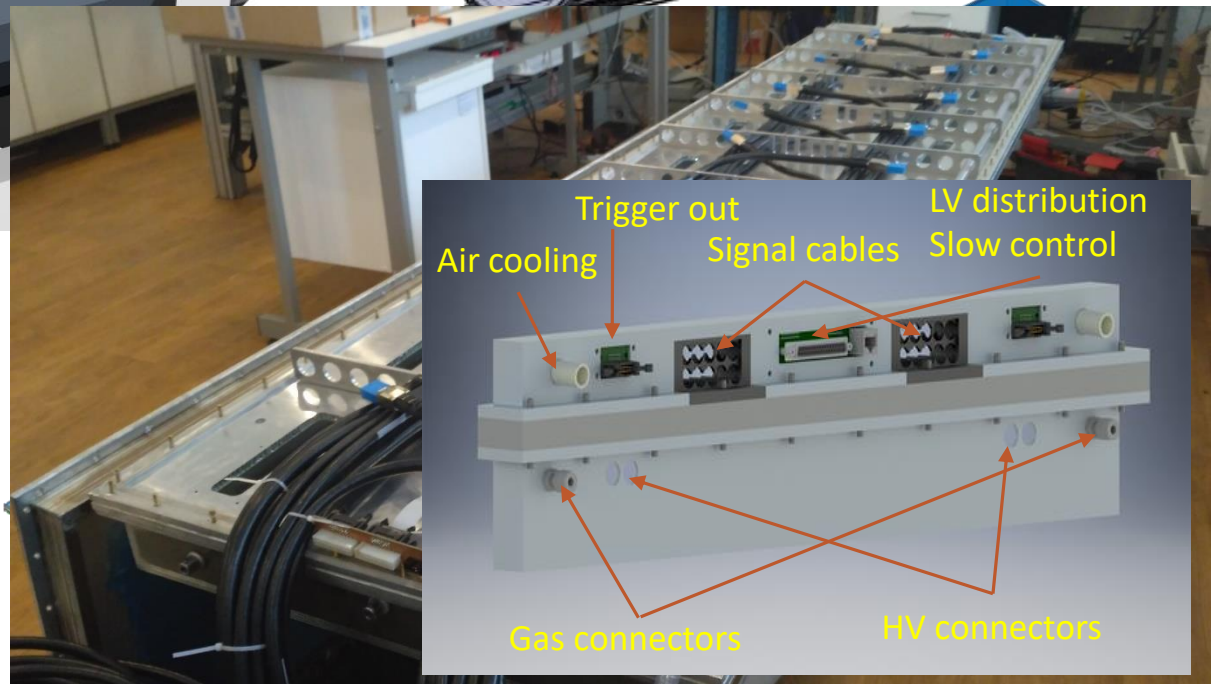


# Cabling and readout electronics location



## Total cabling:

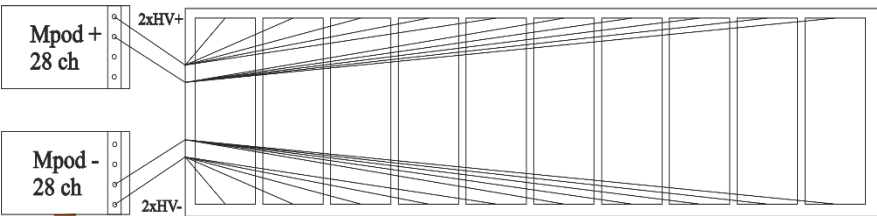
- 14 VME crates
- 196 TDC72VHL => 14 per crate
- 560 cables Molex CXP => 40 per crate
- Cable lengths: 4 - 8 m
- About 70 cm<sup>2</sup> in each technical hole for cables and tubes.
- Low heat dissipation inside the barrel! ~10 W/m<sup>2</sup>





## HV system requirements:

- Minimum number of differential “±” channels: **56 (280)**
- Voltage range (one polarity): **8000 V**
- Total current through the whole system (~150  $\mu$ A)
- Precision of the current monitoring: **~10 nA**
- Multichannel structure
- Remote control



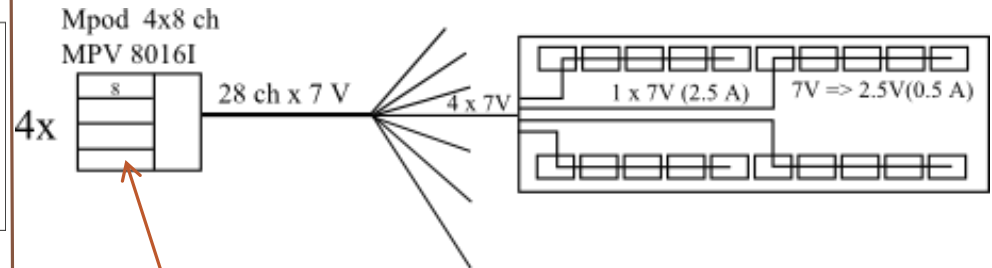
HV distribution scheme



WIENER Mpod system and iSeg EHS 4080p(n) module

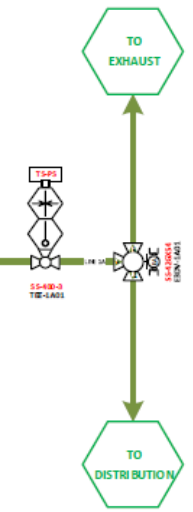
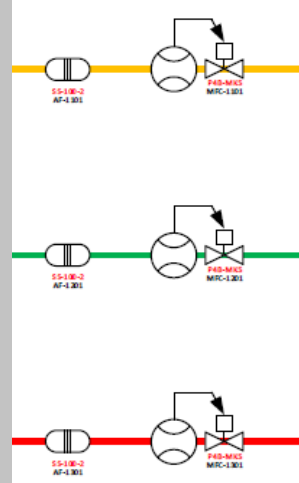
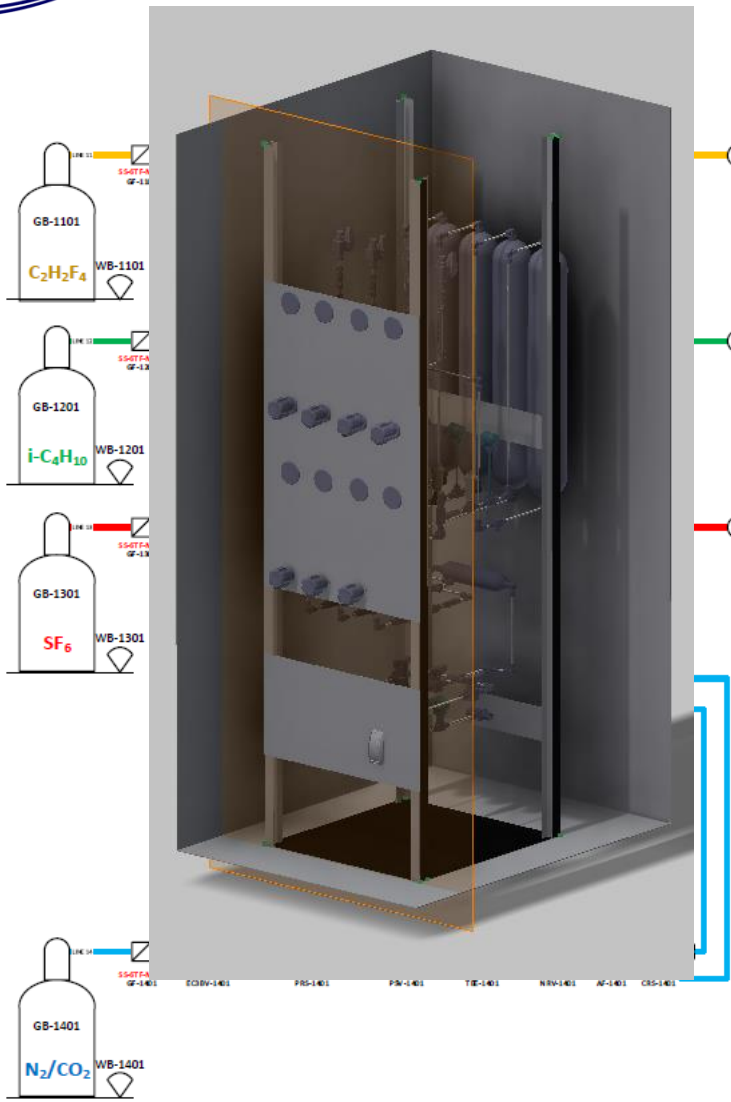
## LV system requirements:

- 560 (1120)** NINO preamplifier-discriminator boards
- Minimum number of LV channels (1 ch per 5 amp): **112**
- Supply voltage: **2.5V & 3.3 V (<0.5 A/board, 2.5 A/LVch)**
- Maximum power consumption **2 kW**
- Multichannel structure
- Remote control



1 LVch per 5 boards (2.5 A)  
560 boards = 112 LVch (280 A)





GSS Gas Supply System			
GMS Gas Mixing System			
Scale: 1:1	Sheet: 1 Z 6	Last modified: 12/03/2018	DATA 07/08/2017
Drawn by: MAREK PERYT; marekperyt@if.pw.edu.pl			
File Name: SC_V_GAS_SYSTEM_MPD_180312.VSDX			
Version: 1.1	Drawing number: 0001	Format: A-4	Log:  NICA-MPD INR VBSLHEP

Mixer | Gas cylinders | Mass Flow Controllers | Pressure | Warnings & Alarms | Logs | System Health & Monitoring

**State**  
 ● **START**  
 Stop enabled  
 ● **STOP**

**Mixer state**  
 Purge  
**State**  
 Stable

**Status**  
 ● cRIO RT Status  
 ● PC UI Status  
 ● Connection PC <-> cRIO

**Limits**

**Alarms**

**Warnings**

**Gas cylinders weight**

Freon R134a	SF6	Isobutane	Nitrogen
4,71 kg	12,42 kg	6,86 kg	45,63 kg
00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY

**MFC Setpoints**

Freon R134a	SF6	Isobutane
0,84	0,04	0,04
00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY

**Composition**

Freon R134a	SF6	Isobutane
90 %	5 %	5 %
00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY

**Flow [ml/min]**

Freon R134a	SF6	Isobutane	Mixer sum
0,84	0,04	0,04	0,92
00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY

**Pressure**

Freon line	SF6 line	Iso-b line
3,41 mb	3,39 mb	3,42 mb
00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY
Mixer line	Atmospheric	
0,49 mb	1008 mb	
00:00:00.0000 DD.MM.YYYY	00:00:00.0000 DD.MM.YYYY	

**Weights:**  
 Freon weight: 0 kg  
 SF6 weight: 0 kg  
 Isobutane weight: 0 kg  
 Nitrogen weight: 0 kg

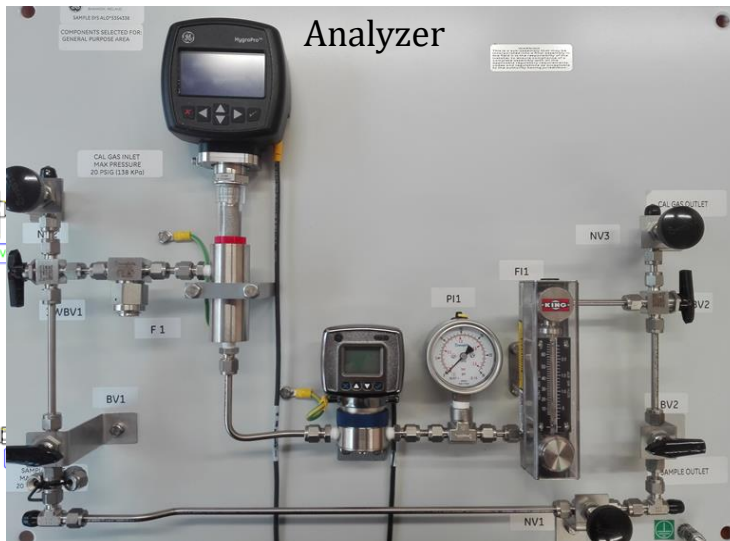
**Key Sensors:**  
 PT-1010: 3,41 bar  
 TT-1009: 21 °C  
 PT-1110: 3,39 bar  
 TT-1109: 21 °C  
 PT-1210: 3,42 bar  
 TT-1209: 21 °C  
 PT-1307: 3,41 bar  
 TT-1306: 21 °C  
 PT-1406: 0,49 bar

**Flow Controllers:**  
 MFC-1013: 0,84  
 MFC-1113: 0,04  
 MFC-1213: 0,04

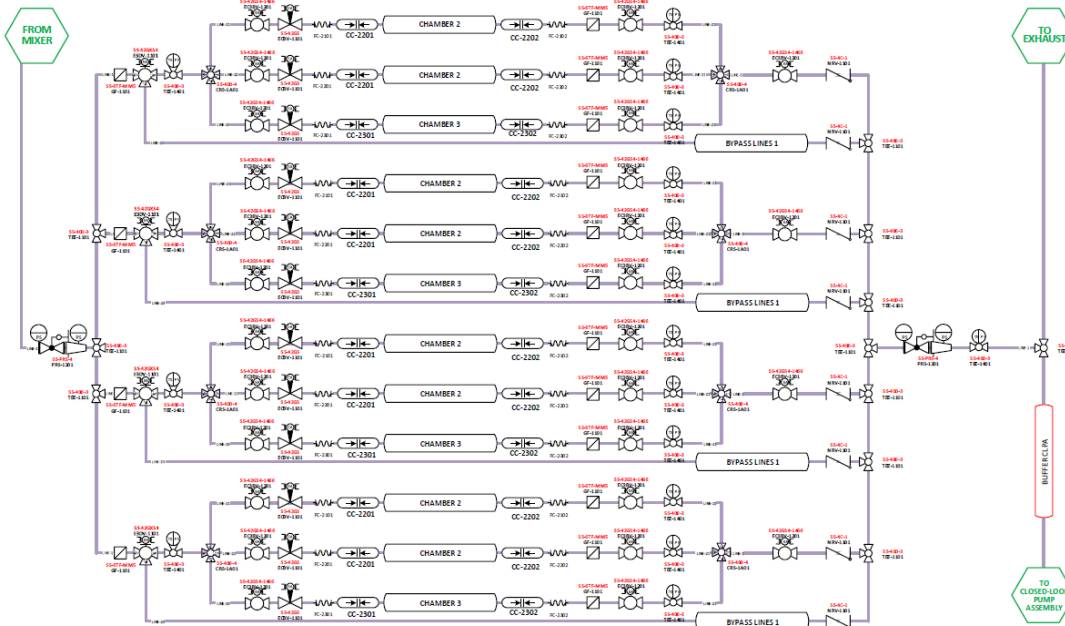
**Valves:**  
 SV-1401, SV-1402, SV-1403, SV-1405, PSV-1408, HV-1409

**Exhaust:** To distribution

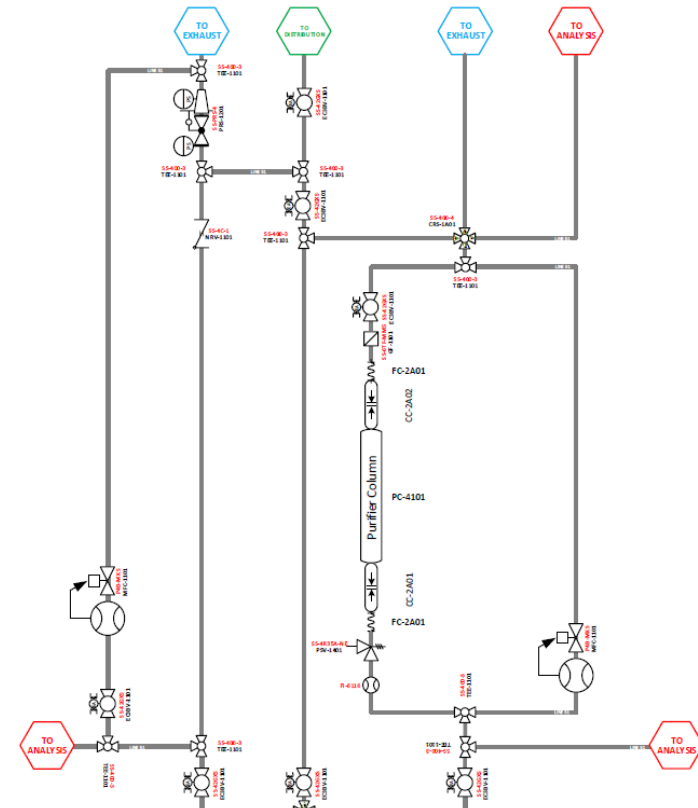




Distribution system



Purification system



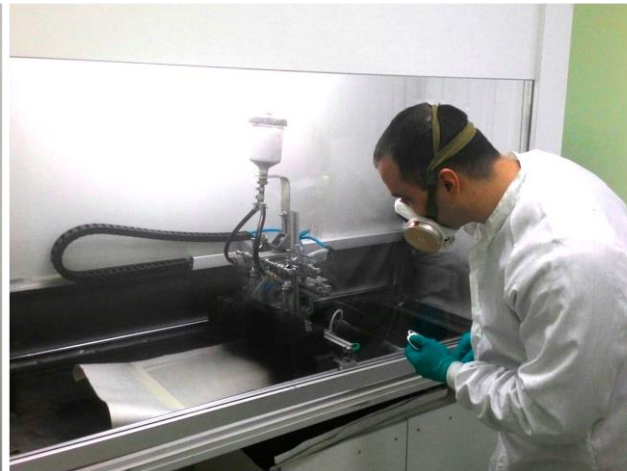


# Mass-production of the TOF modules

Workshop staff: 3 physicists, 4 technicians, 2 electronics engineers  
Productivity: ~ 1 detectors per day (1 module/2 weeks).



Ultrasonic wave glass cleaning



Painting of the HV conductive layer



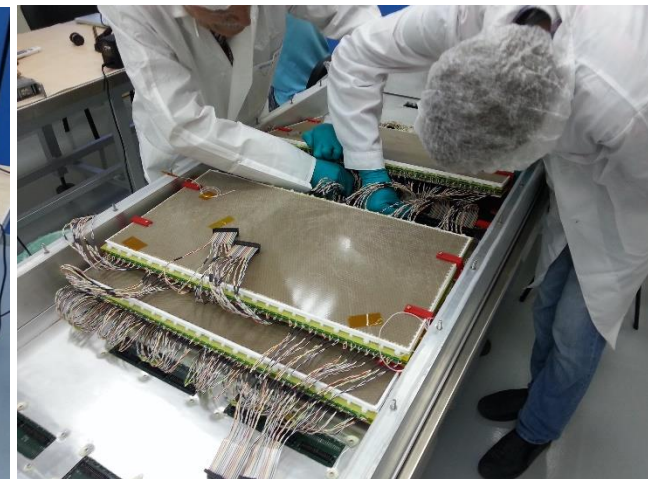
MRPC assembling



Optical quality control

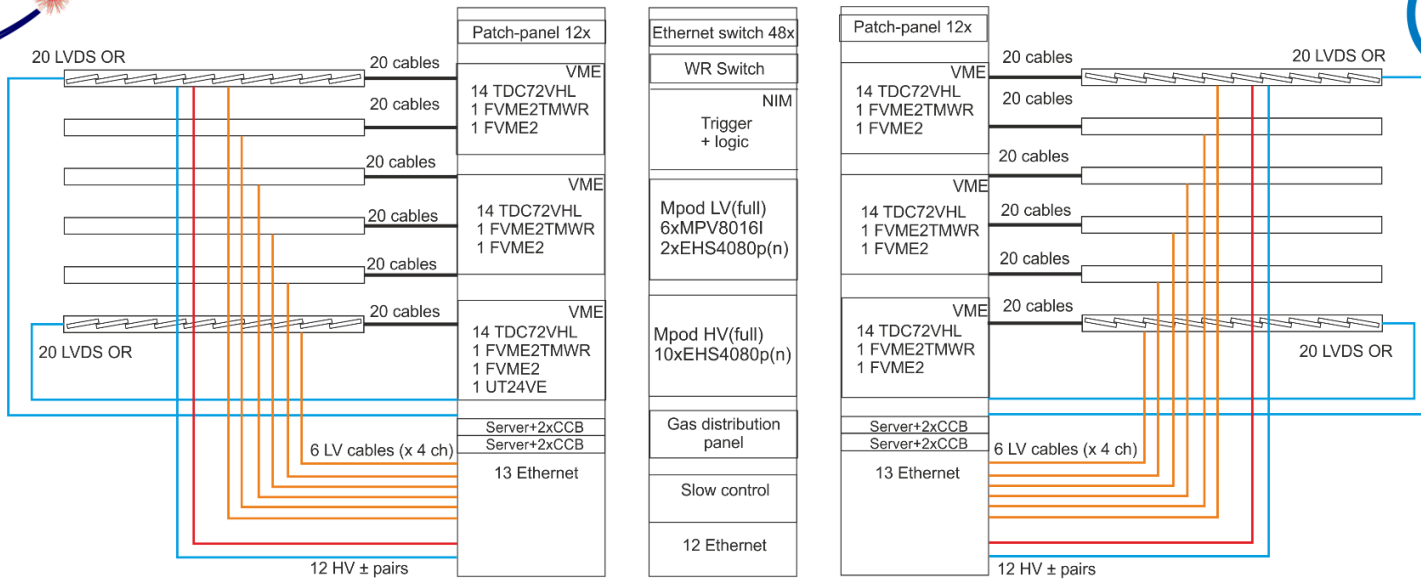


Cables and connectors soldering

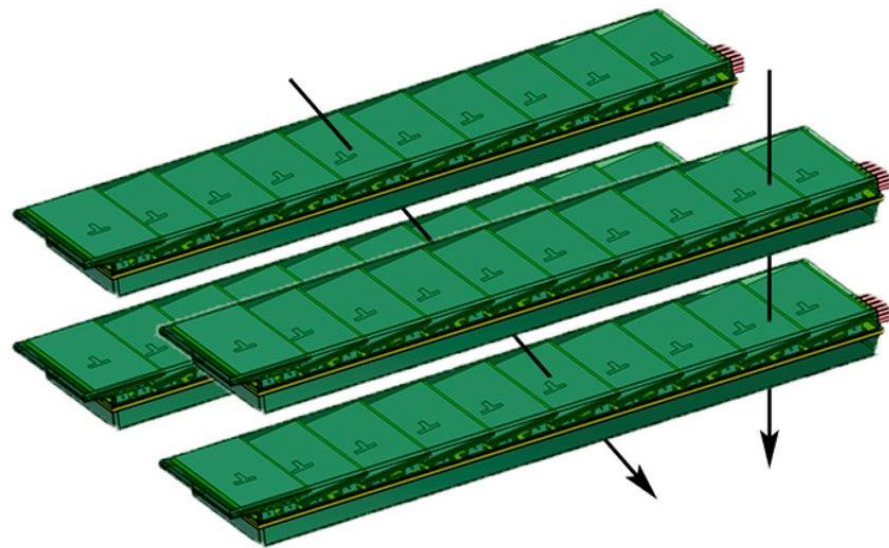


Detectors installation to the TOF box

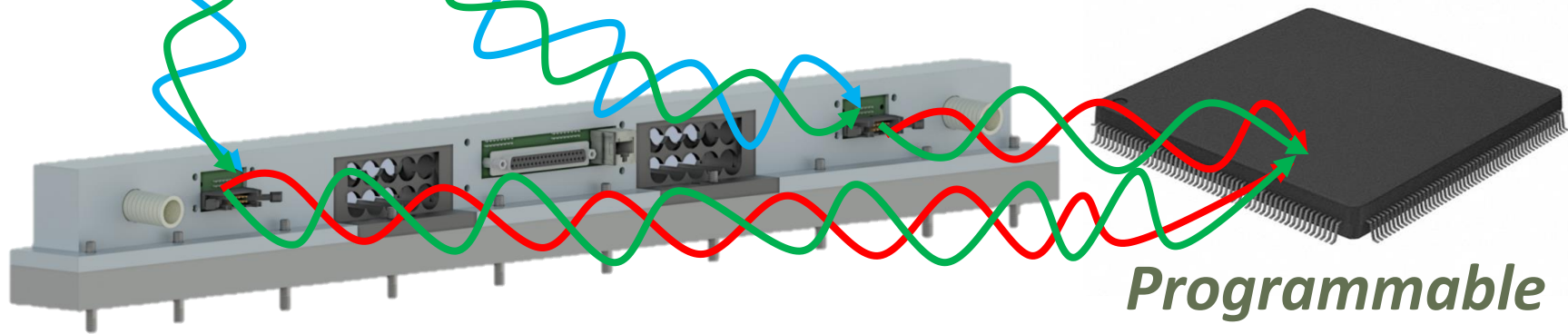
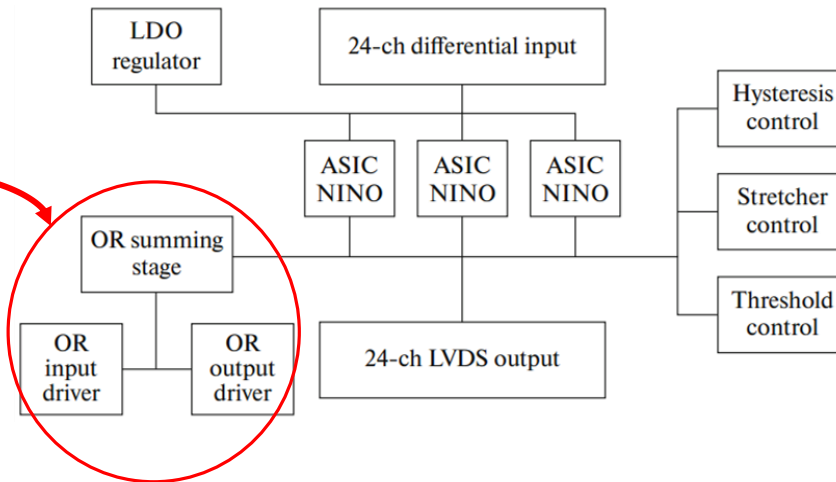
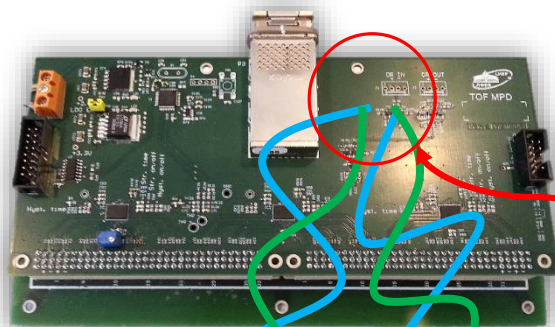
# Cosmic stand for testing of the TOF modules



1 stand = 6 modules = 60 detectors (120 preamps + 40 TDC)







*Programmable logic (FPGA)*

Two operating modes:

- selection of **vertical** tracks;
- selection of **inclined** tracks.

- Technical design of the MPD TOF system is complete.
- Most materials for the TOF production is purchased in full for the entire system in 2017. Everything is ready to start mass-production of detectors.
- Development of the readout electronics is complete now. Mass production began last year. At the moment we already have 30% of preamplifier boards.
- Service systems are in development and purchase state.
- Setup for testing TOF modules with cosmic rays should be commissioned this year.

**Thank you for the attention!**