CBM-TOF inner wall status overview

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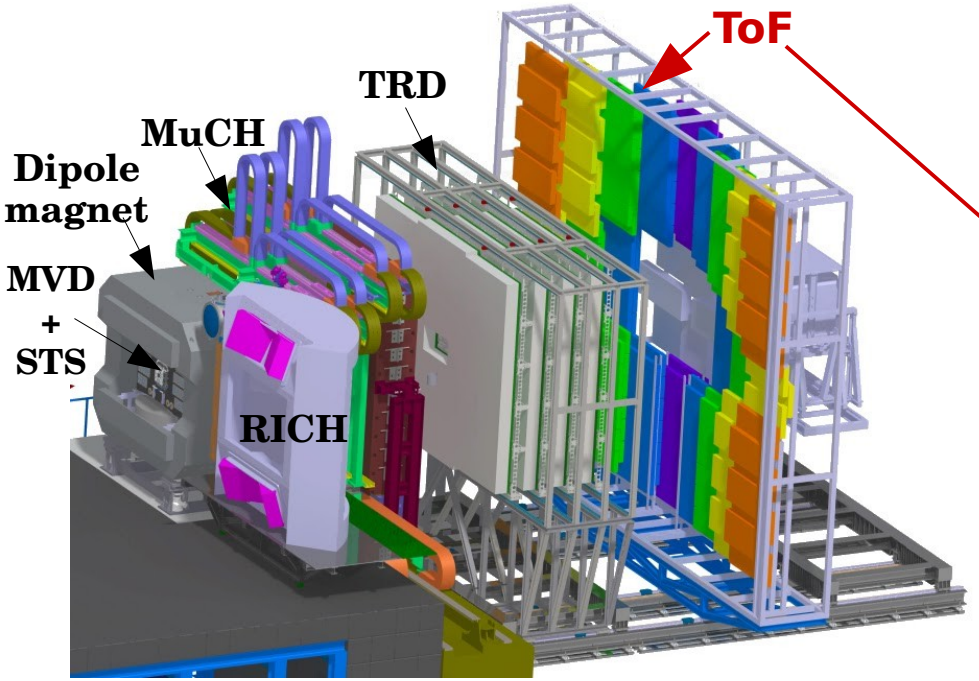
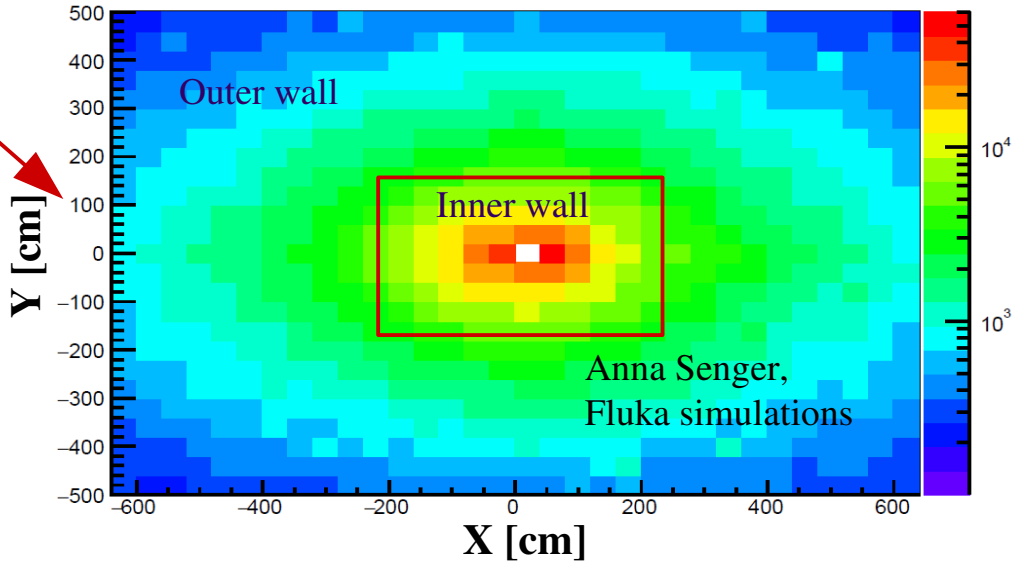
46th CBM Collaboration Meeting, Lanzhou, China, 19 – 24 October, 2025

CBM - TOF subsystem

CBM experiment :
- A+A collisions, E_{kin} = 2.5A – 11A GeV, 10^7 interactions/s



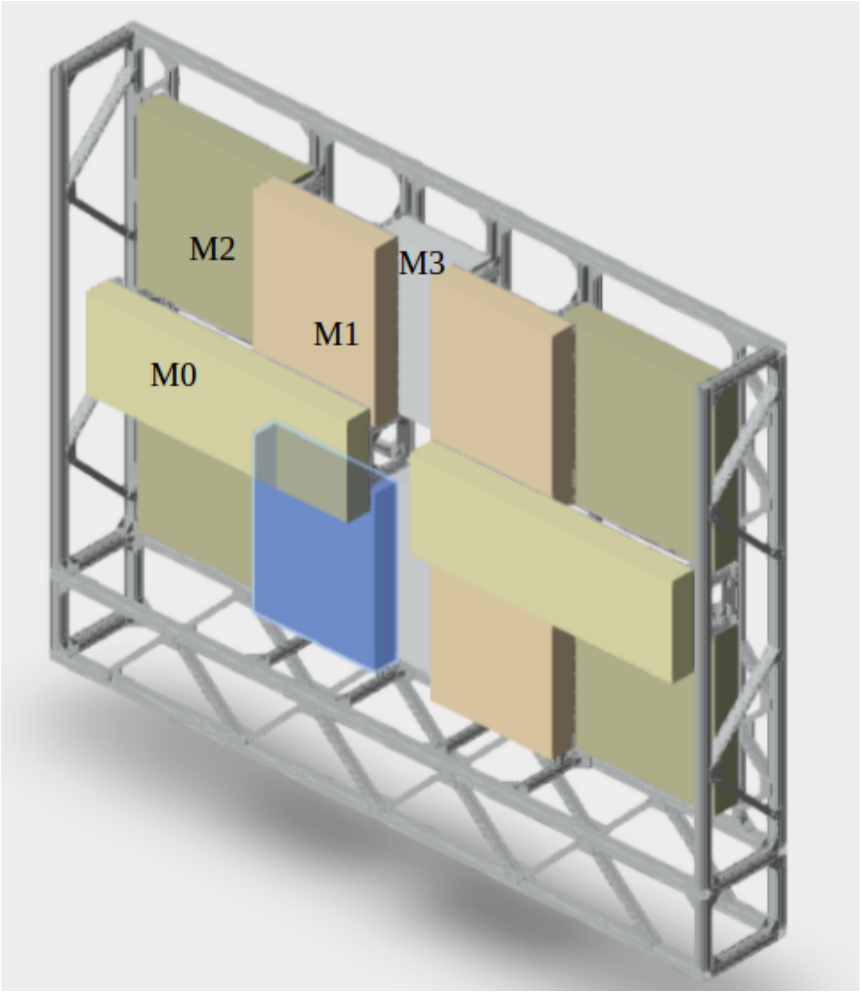
Charged particle flux on TOF wall @ 8 m from the target, Au + Au collisions at E_{kin} = 11A GeV, 10^7 interactions/s



CBM-TOF Requirements
- Full system time resolution ~ 80 ps
- Efficiency > 95 %
- Rate capability up to 50 kHz/cm^2
- Active area of 120 m^2
- Occupancy < 5 %

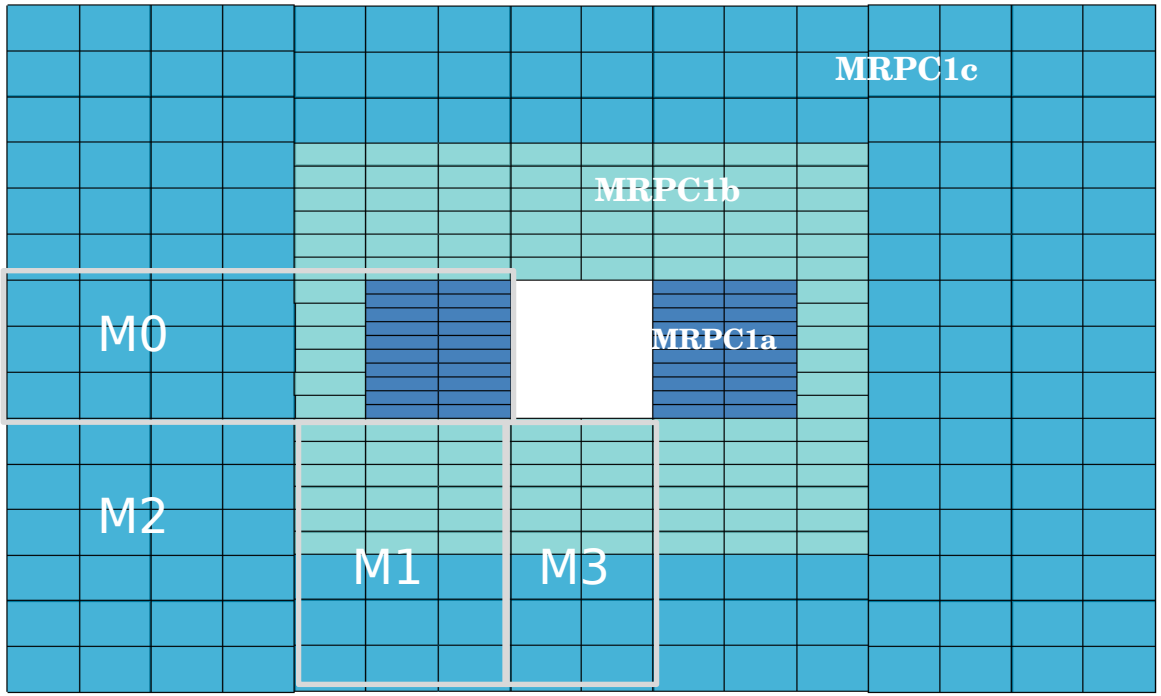
MSMGRPCs for the inner wall :
- highest counting rate → low resistivity glass
- highest granularity
- ~15 m^2 active area (up to ~ 11° polar angle)

Design of the CBM – TOF inner wall



CBM-TOF inner zone

- *~15 m^2 active area, modular architecture:*
  - *12 modules*
  - *4 types (M0, M1, M2, M3)*



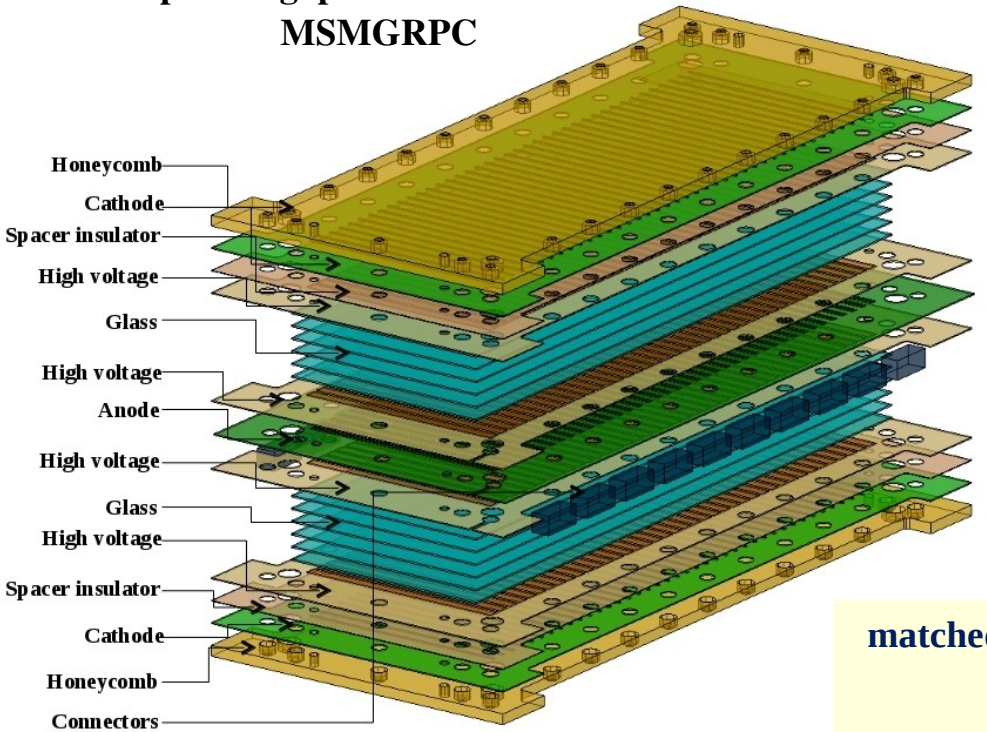
	MRPC1c (196 mm)	MRPC1b (96 mm)	MRPC1a (56 mm)	Total
No. MRPCs	168	108	40	316
No. channels	10752	6912	2560	20224

Counters with different granularities are used.

3 chamber types: 56/96/196 mm (strip length) x 300 mm

Chamber design considerations

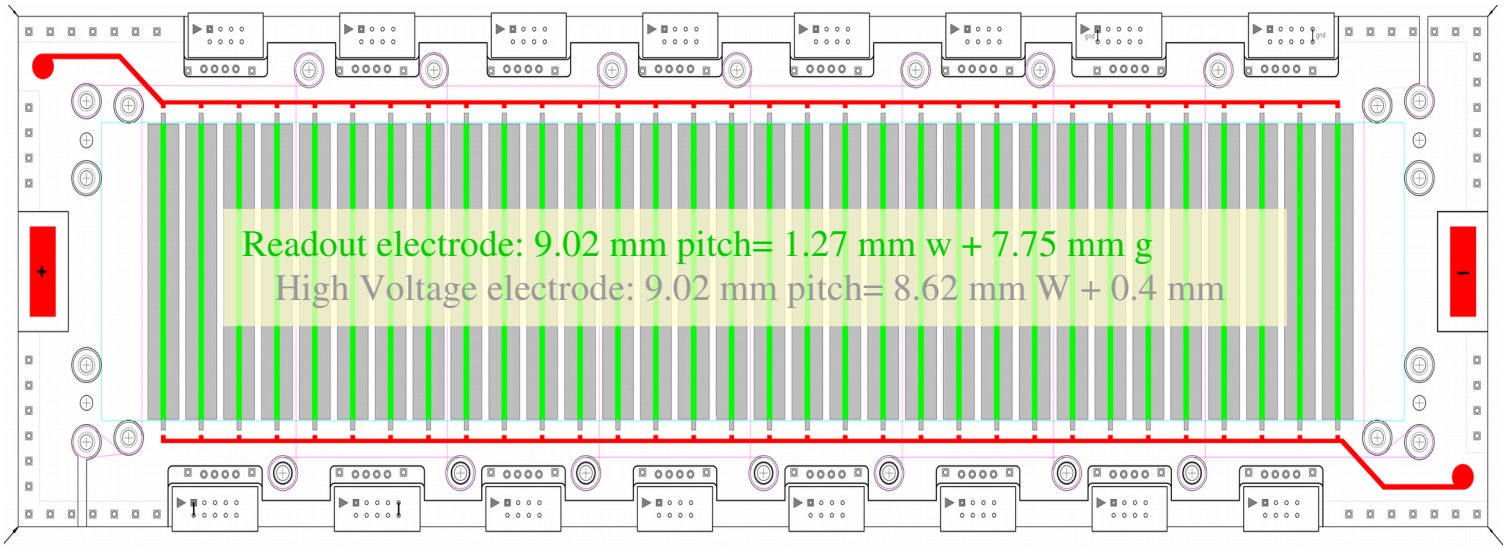
Multistrip Multigap Resistive Plate Chamber
MSMGRPC

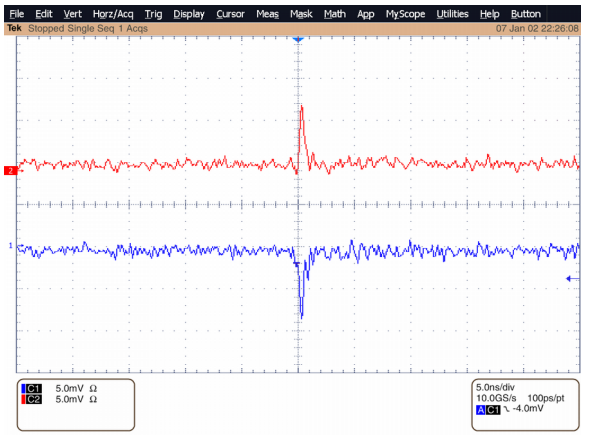


- ✓ **Symmetric structure: 5 gaps x 2 stacks**
- ✓ **Gas gap thickness: 200 µm**
- ✓ **Active area: strip length x 9 mm pitch x 32 strips**
- ✓ **Strip length:56/96/196 mm (MRPC1a/MRPC1b/MRPC1c)**
- ✓ **Resistive electrodes: ~10^{10} Ωcm, 0.7 mm (Chinese glass)**
- ✓ **Strip structure for Readout & HV electrodes**
- ✓ **Differential readout**
- ✓ **Direct flow through the gas gaps**

matched signal transmission line impedance to the input of the FEE

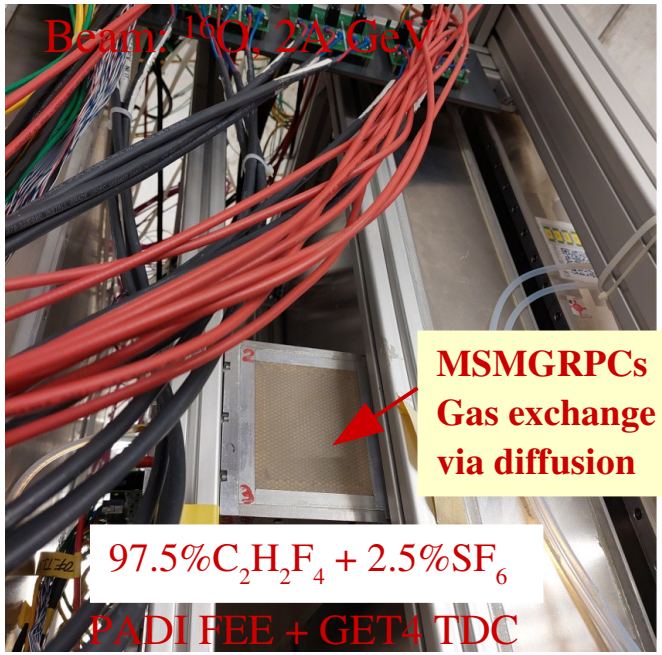
D. Bartos et al., Romanian Journal of Physics 63, 901 (2018)

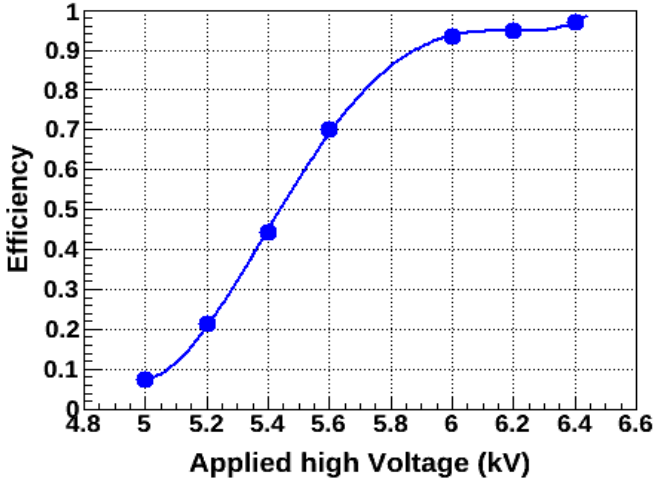


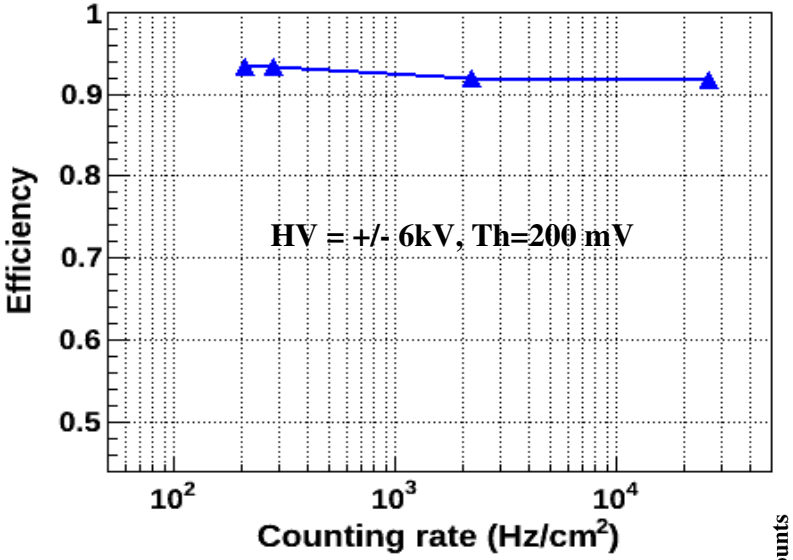


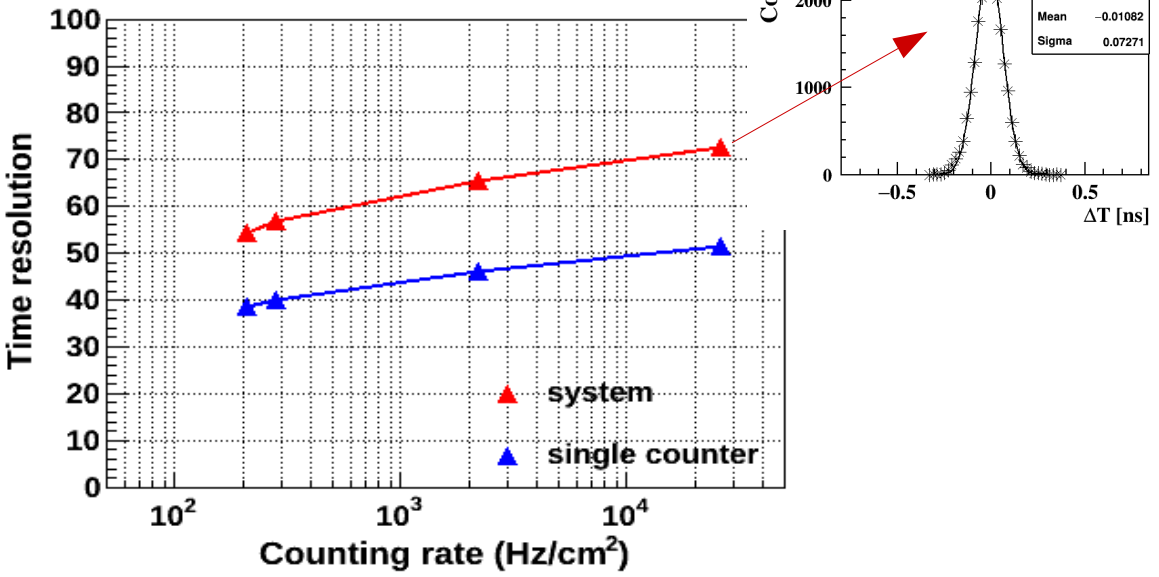
High counting rate test of a MSMGRPC prototype

mCBM/SIS18/GSI Darmstadt





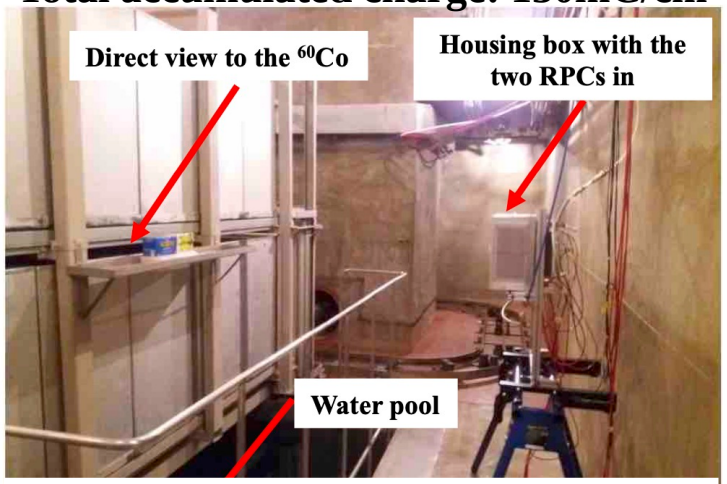




M. Petris et al., Nucl. Inst. and Methods A 1045 (2023) 167621

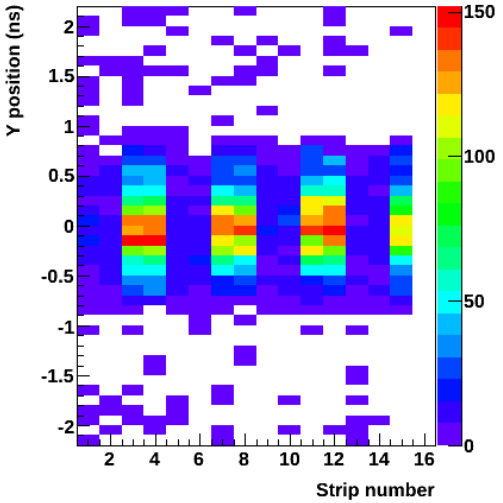
Aging investigations of MSMGRPC with gas exchange via diffusion

- **IRASM/IFIN-HH multipurpose irradiation center**
- **^{60}Co source: 360 kCi;**
- **Total accumulated charge: 130mC/cm^2**

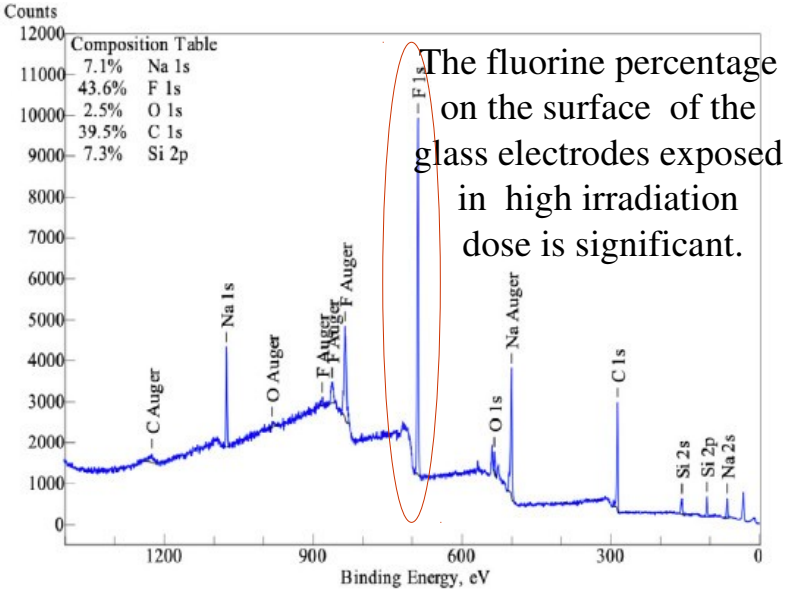


Gas mixture: 90% $C_2H_2F_4$ + +5%i-C_4H_{10}+5% SF_6

Dark rate generated around the spacers

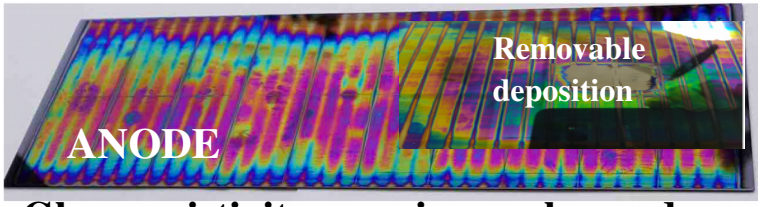


(XPS) analysis of the chemical composition of irradiated and non-irradiated glass plates

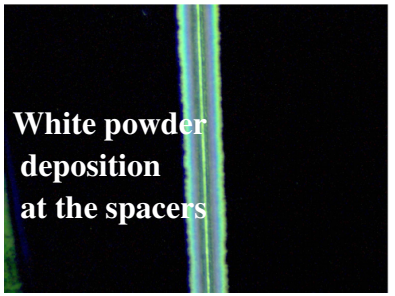


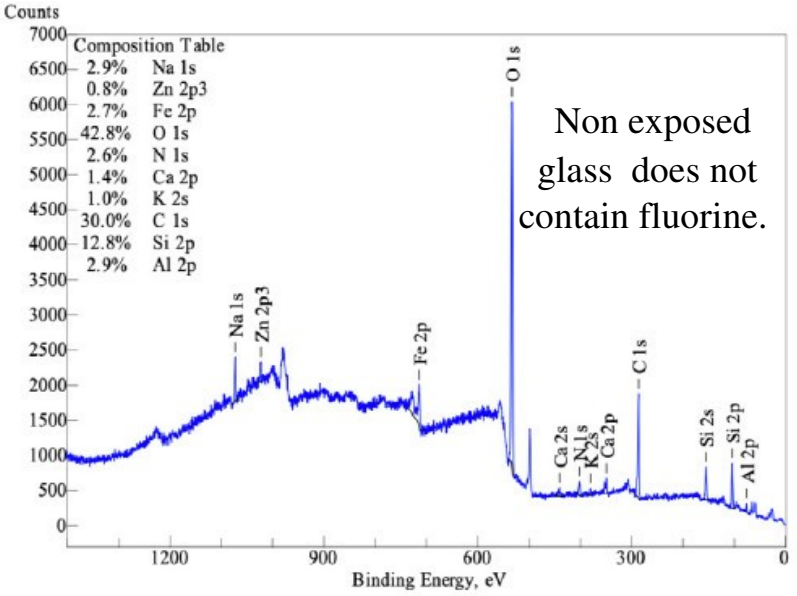
The fluorine percentage on the surface of the glass electrodes exposed in high irradiation dose is significant.

Glass inspections performed with various methods:
(SEM, XPS, AFM RBS, non-RBS, THz-TDS)



Glass resistivity remains unchanged





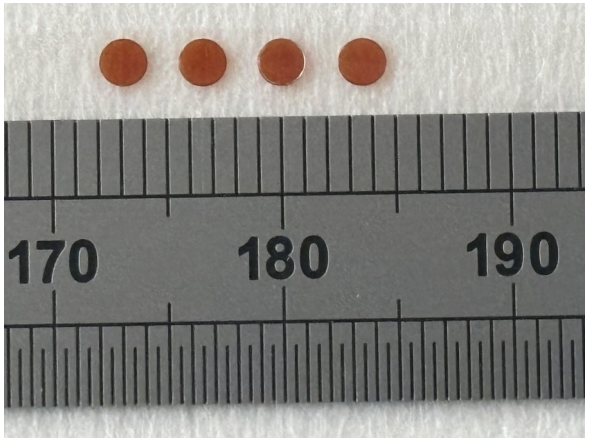
Non exposed glass does not contain fluorine.

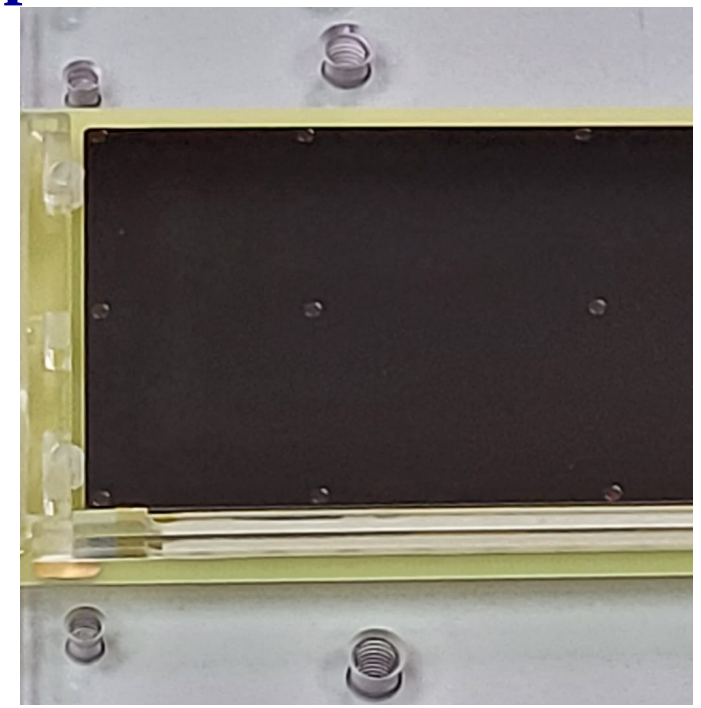
D. Bartos et al., Nucl. Inst. and Methods A 1024 (2022) 166122

Direct flow MSMGRPC prototype based on polyimide (Kapton) spacers

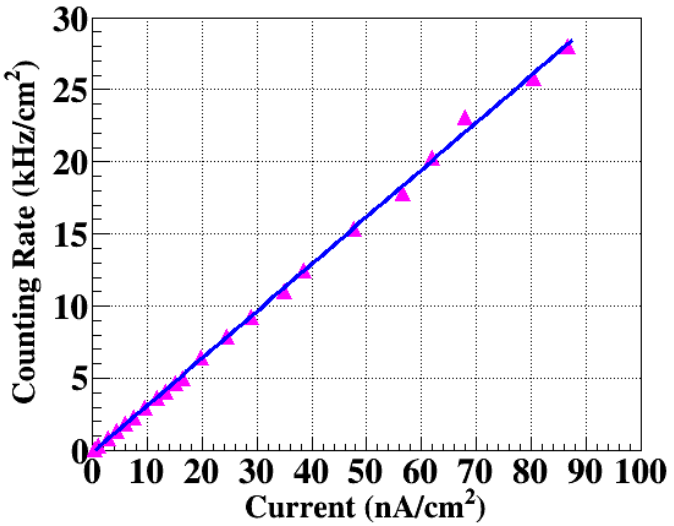
Home made rectangular spacers:
2 mm x 2 mm, 200 µm

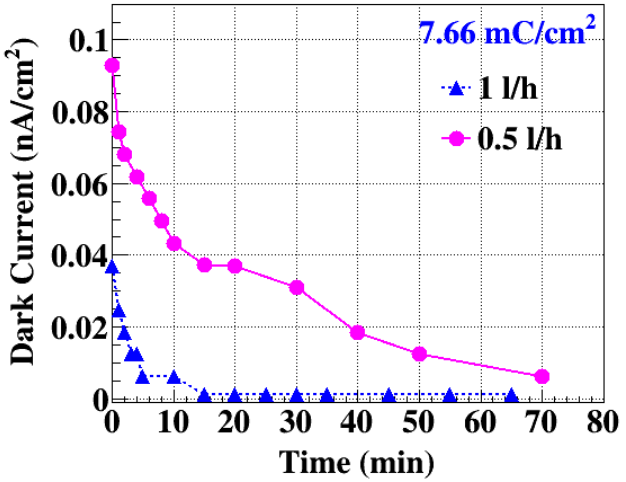
Commercial disc spacers:
2 mm diameter, 170 µm thickness

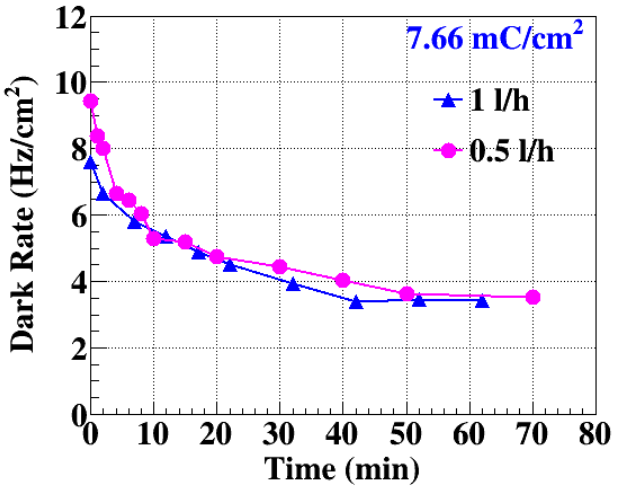




Gas mixture: 97.5% $C_2H_2F_4$ + 2.5% SF_6

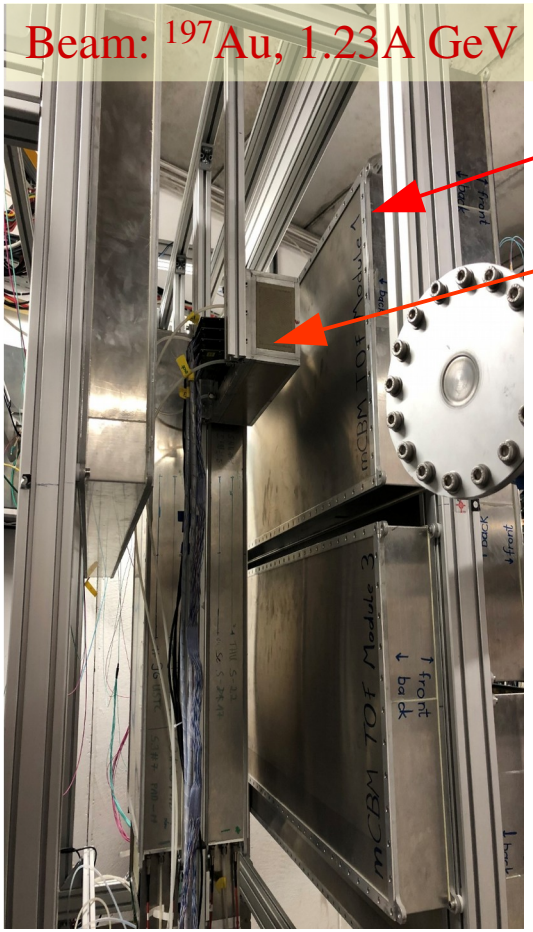


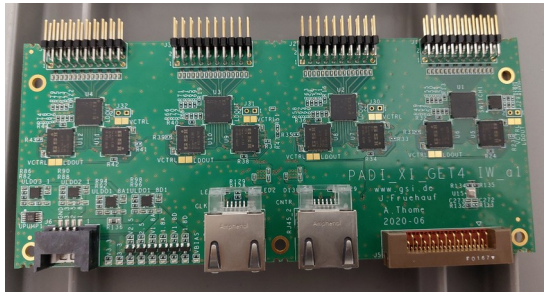


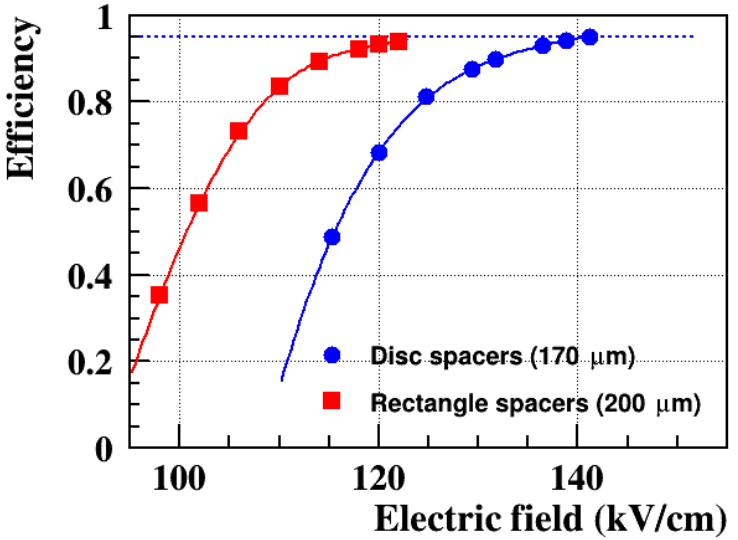


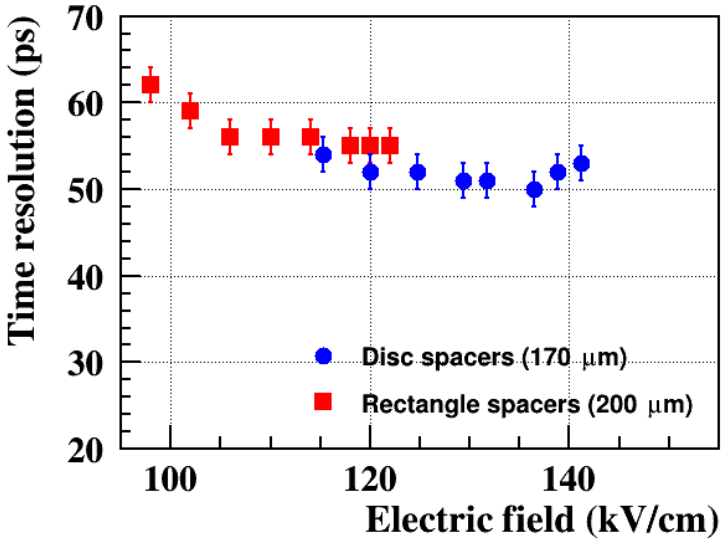
M. Petris et al., Nucl. Inst. and Methods A 1066 (2024) 169584

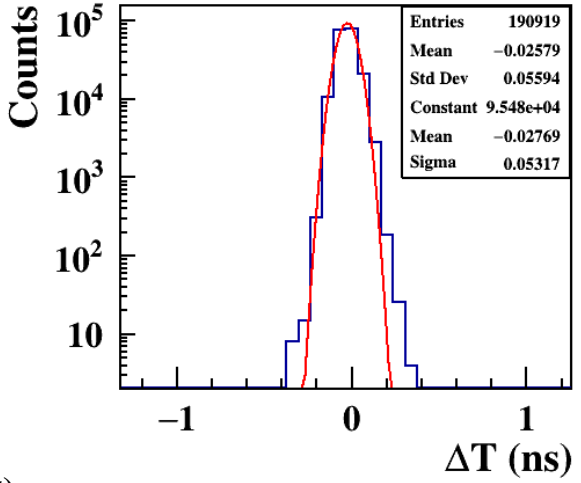
In-beam test in mCBM @ SIS18/GSI









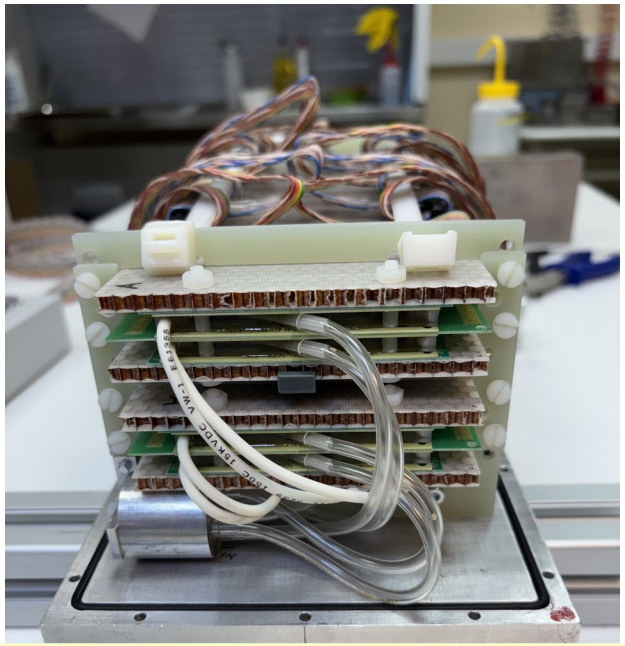


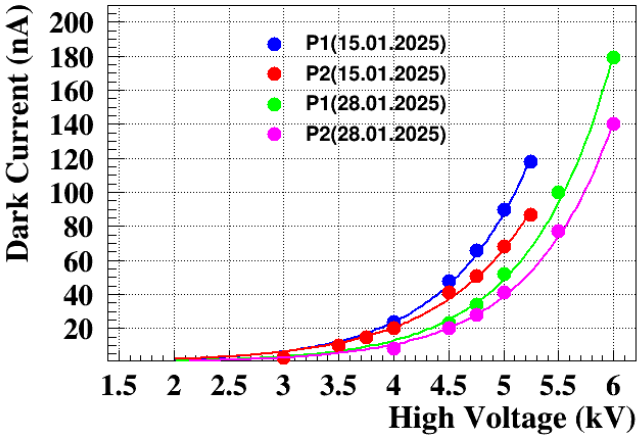
Inner TOF FEE board(J. Frünhauf)

PADI XI (IEEE Trans. Nucl. Sci., vol. 68, no. 6, p. 1325)
+ GET4 (IEEE Nucl. Sci. Sym. Conf. Rec. (2009) 295)

M. Petris et al., Nucl. Inst. and Methods A 1078 (2025) 170580

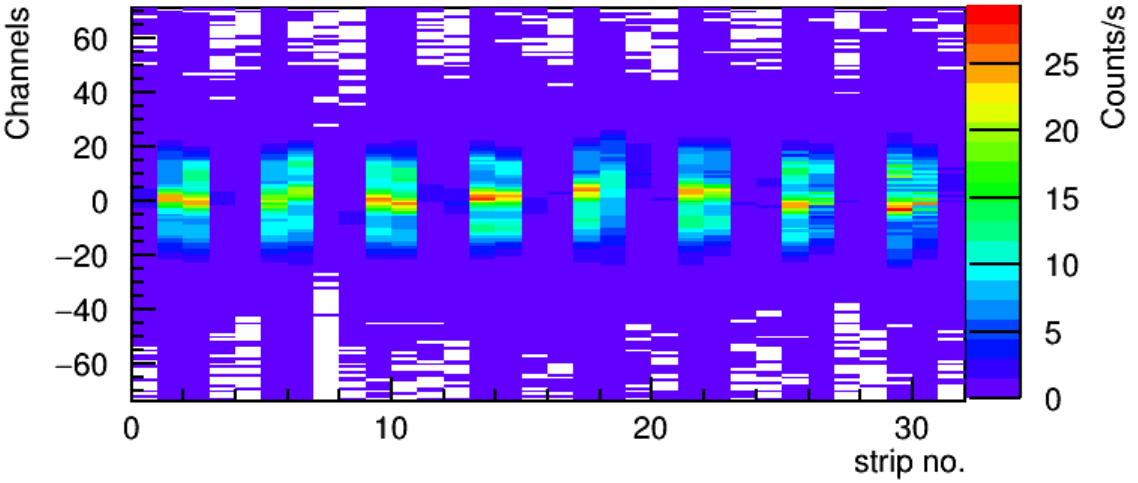
MRPC1a with 200 µm thickness discrete spacers from Panel Group/Taiwan

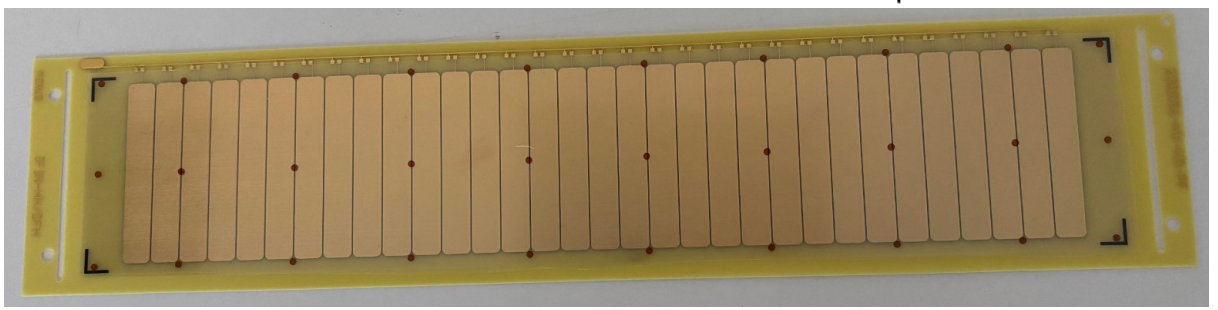




- average dark rate
  P2 ~55 Hz/cm^2
  P1 ~30 Hz/cm^2

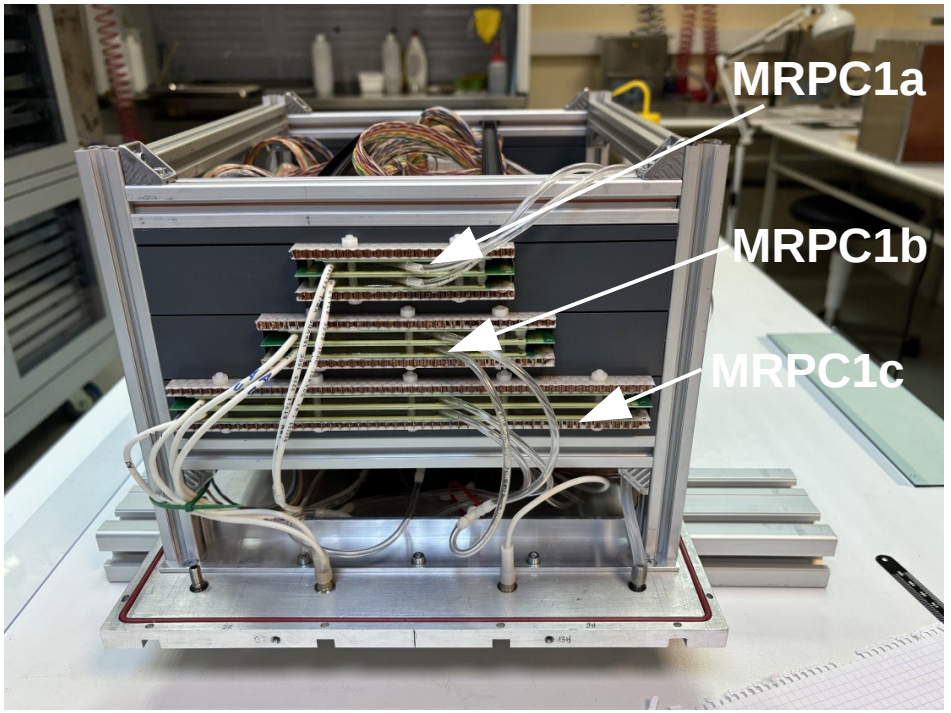
- Polyimide (Kapton like) spacers/Panel Group/Taiwan
- Advertised within DRD1 Collaboration:
  Chia – Yu Hsieh, DRD1 meeting on June 7th, 2024.





MRPC1 chambers of the CBM-TOF inner wall based on 100+100 µm polyimide discrete spacers and direct flow

We participated in the mCBM May 2025 beam time

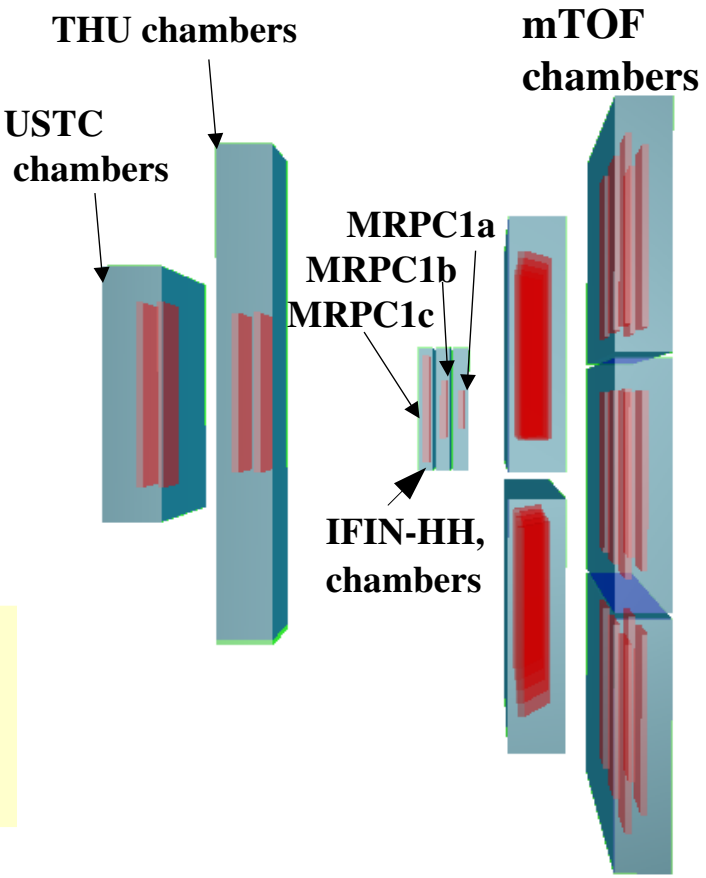


Test counter	Strip length	Granularity	Spacer disc	Glass	Max rate in CBM
MRPC1a	5.6 cm	5.05 cm^2	200 µm	Low res.	50 kHz/cm^2
MRPC1b	9.6 cm	8.66 cm^2	200 µm	Low res.	15 kHz/cm^2
MRPC1c	19.6 cm	17.68 cm^2	200 µm	Low res.	7 kHz/cm^2

mCBM in - beam test May 2025

^{56}Fe run
E_{kin} = 1.7A GeV
Target: Ni 10%
HV Scan

^{209}Bi run
E_{kin} = 1.1A GeV
Target: Au 10%
Rate Scan

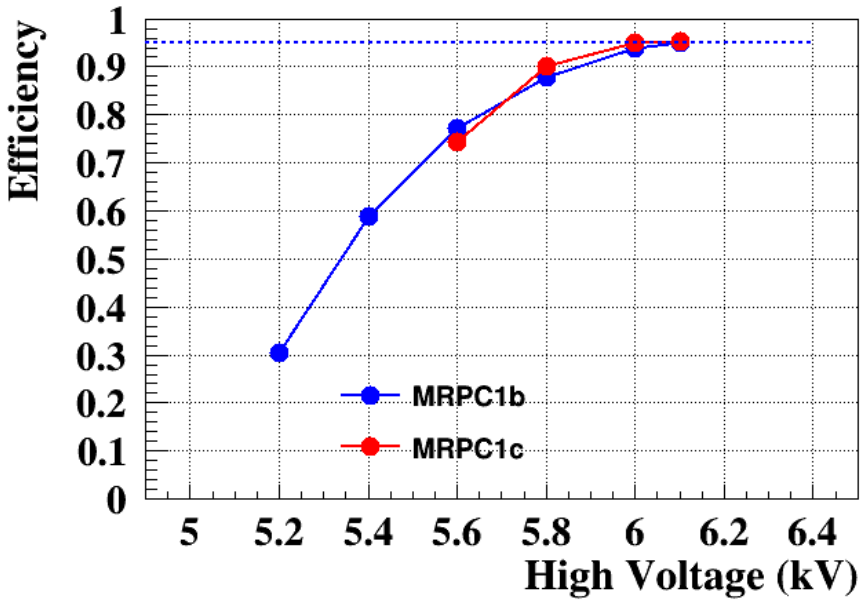


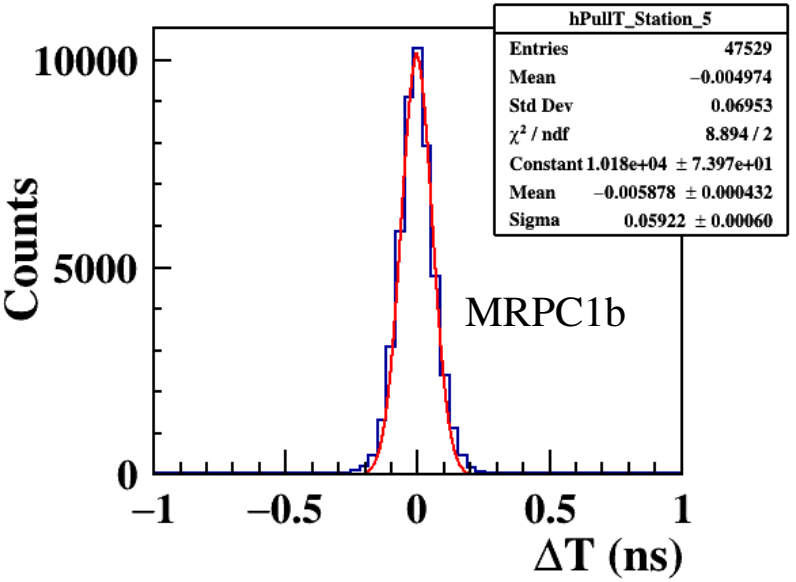
Setup and Tracking:

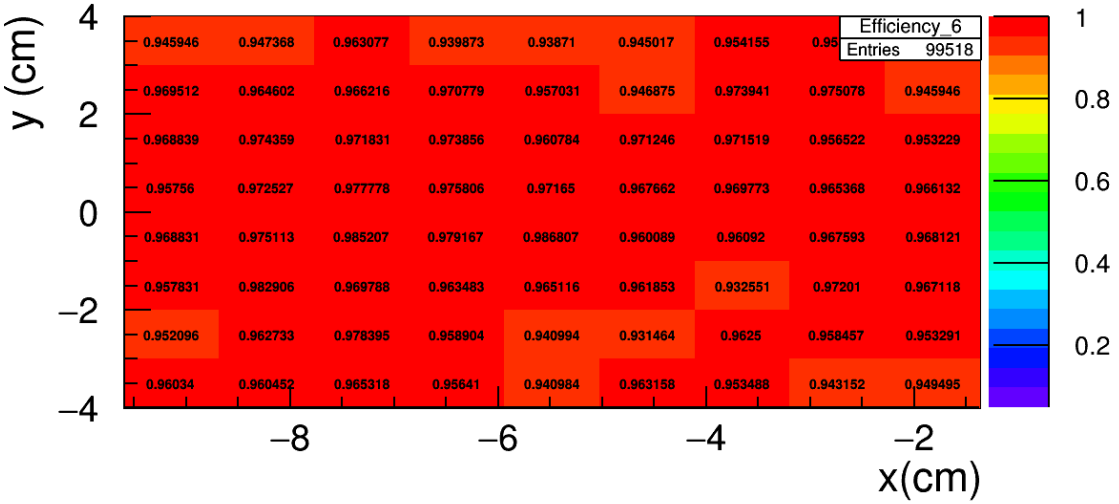
- **Dia + 7 chambers = 8 tracking stations**
- **Analysis → 1 DUT and 7 reference stations**

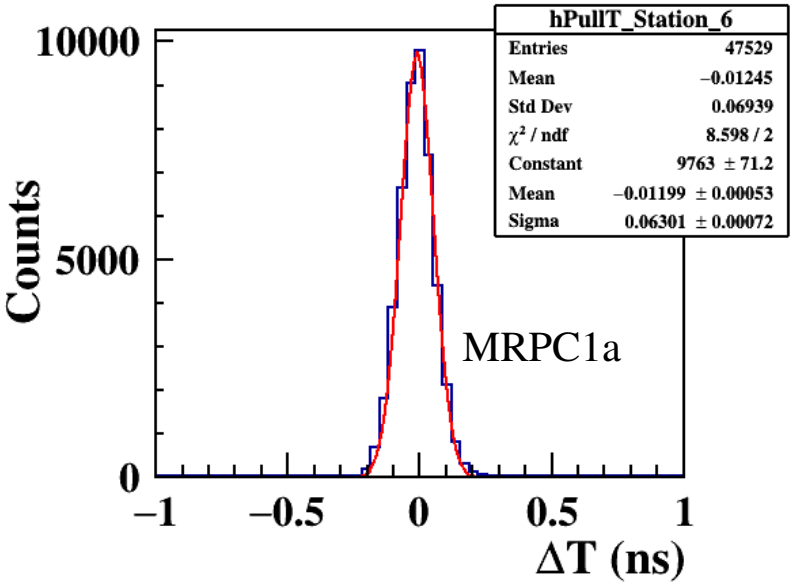
Data analysis is in progress.

Preliminary results of the in-beam test of MRPC1 chambers of the CBM-TOF inner wall



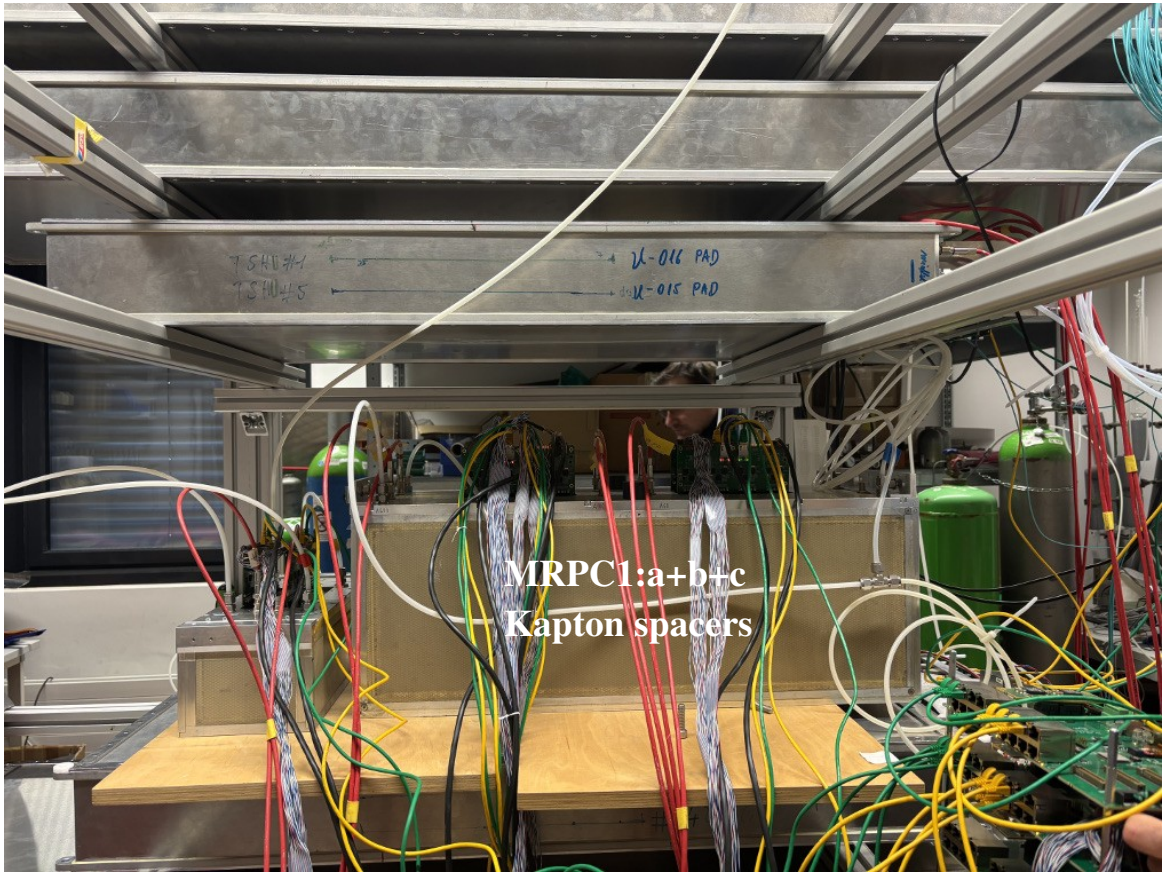




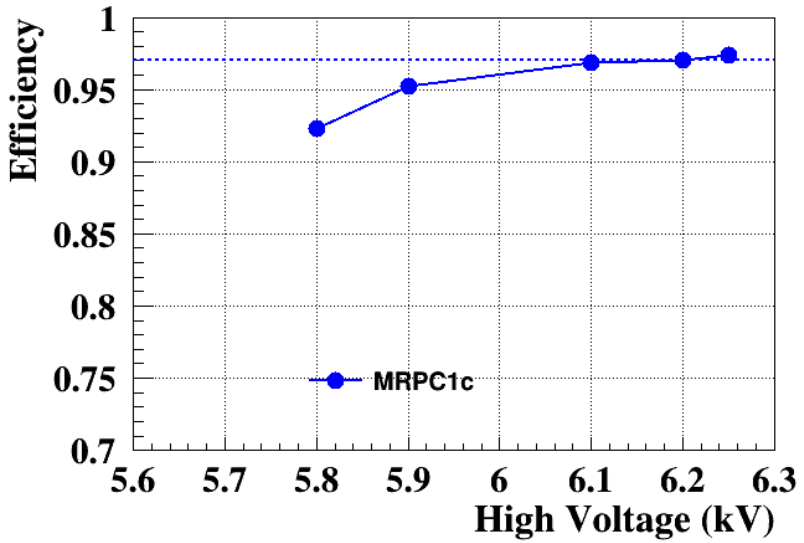


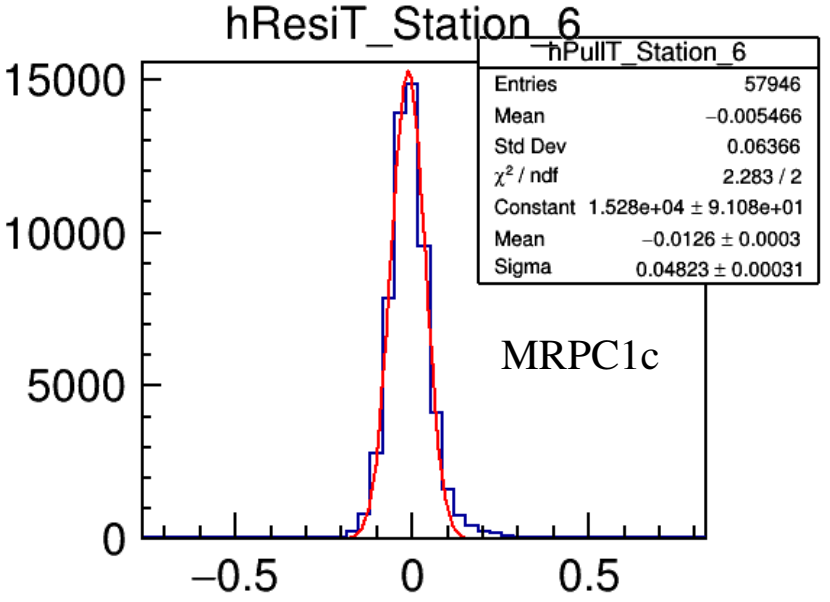
Talk at the EuNPC2025 (22 – 26 September, France)

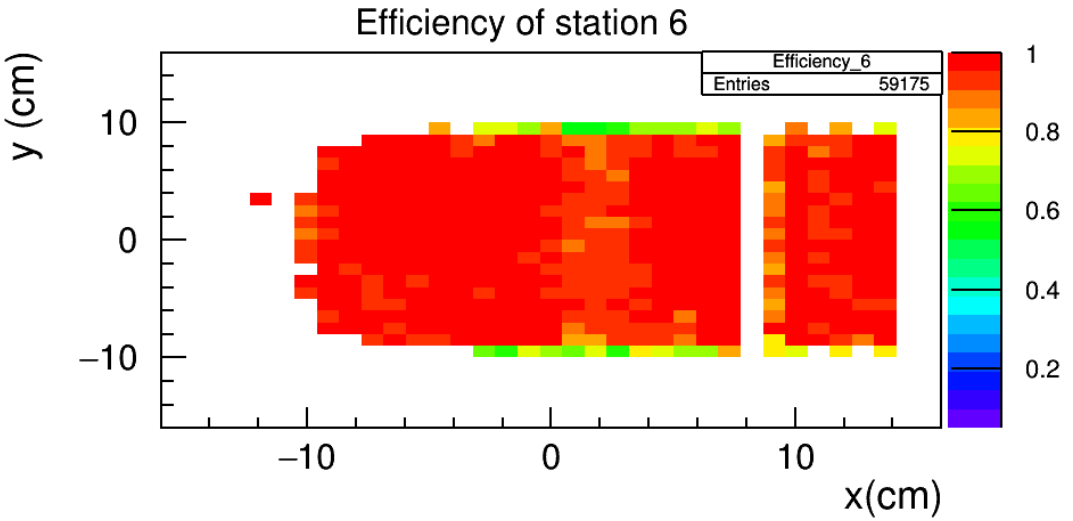
MRPC1 chambers in the Heidelberg cosmic setup

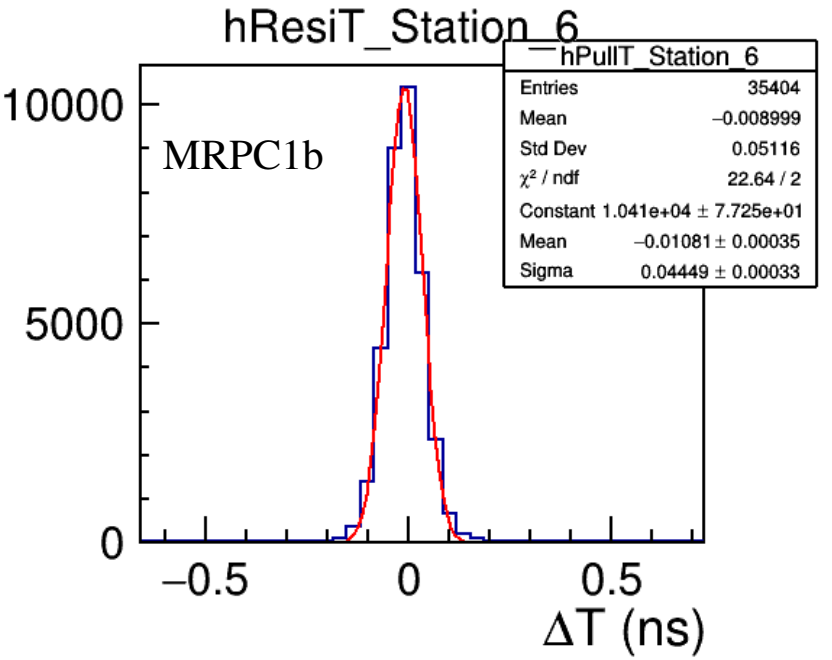


MRPC1b + MRPC1c

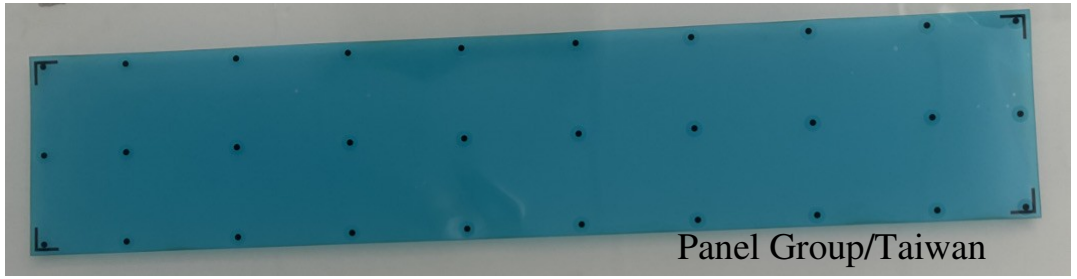


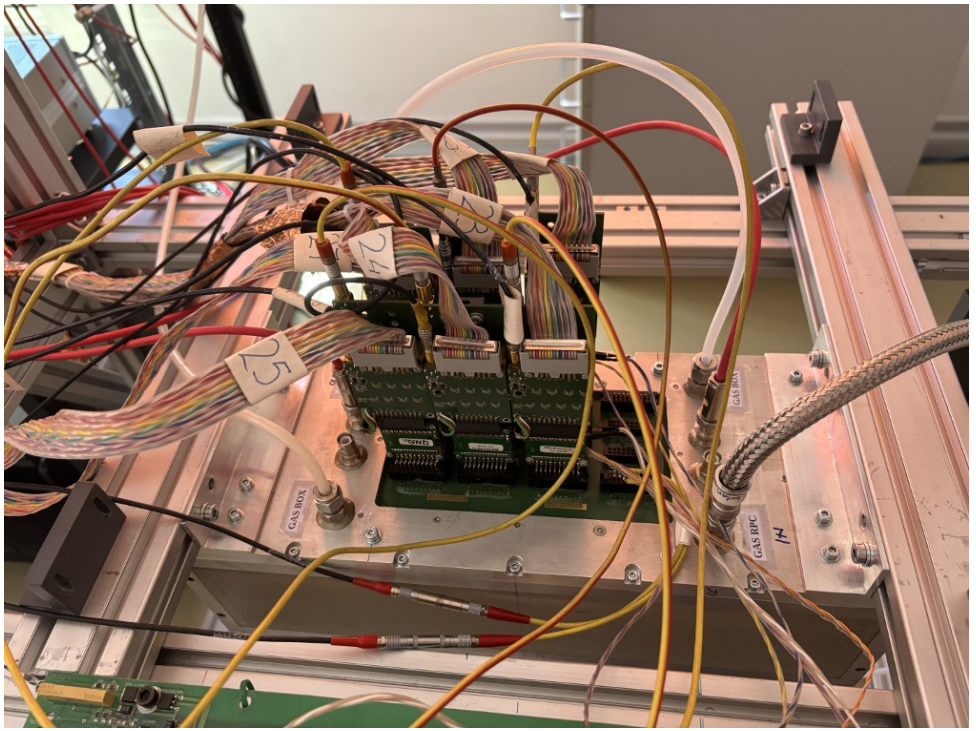


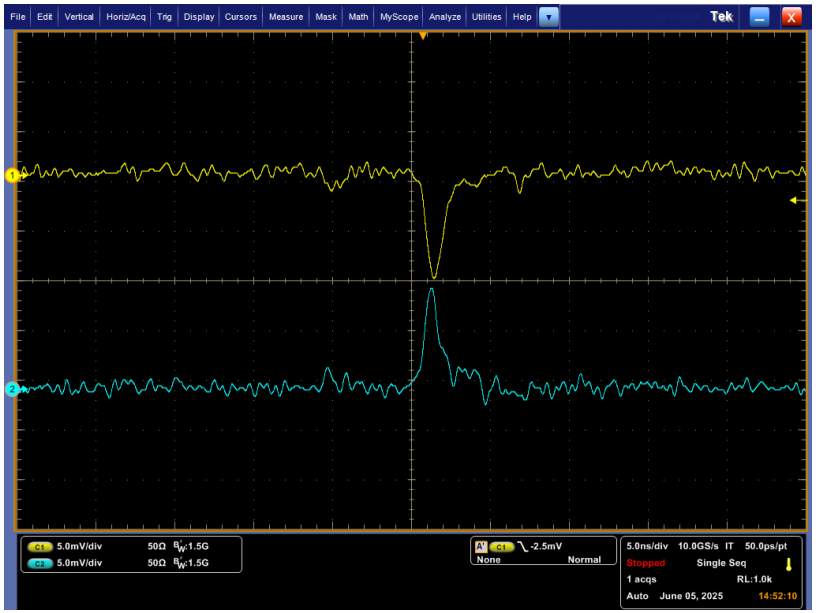


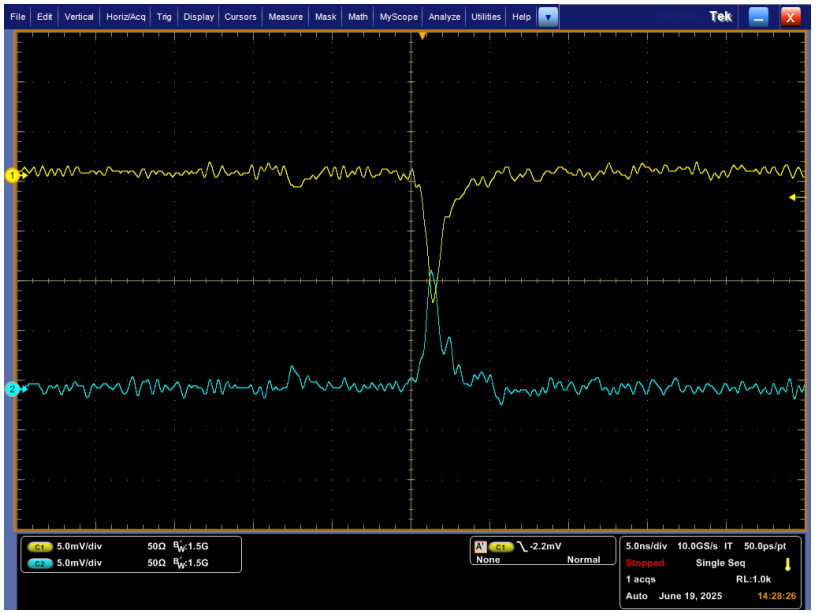


MRPC1a chamber with 200 μm polycarbonat spacers









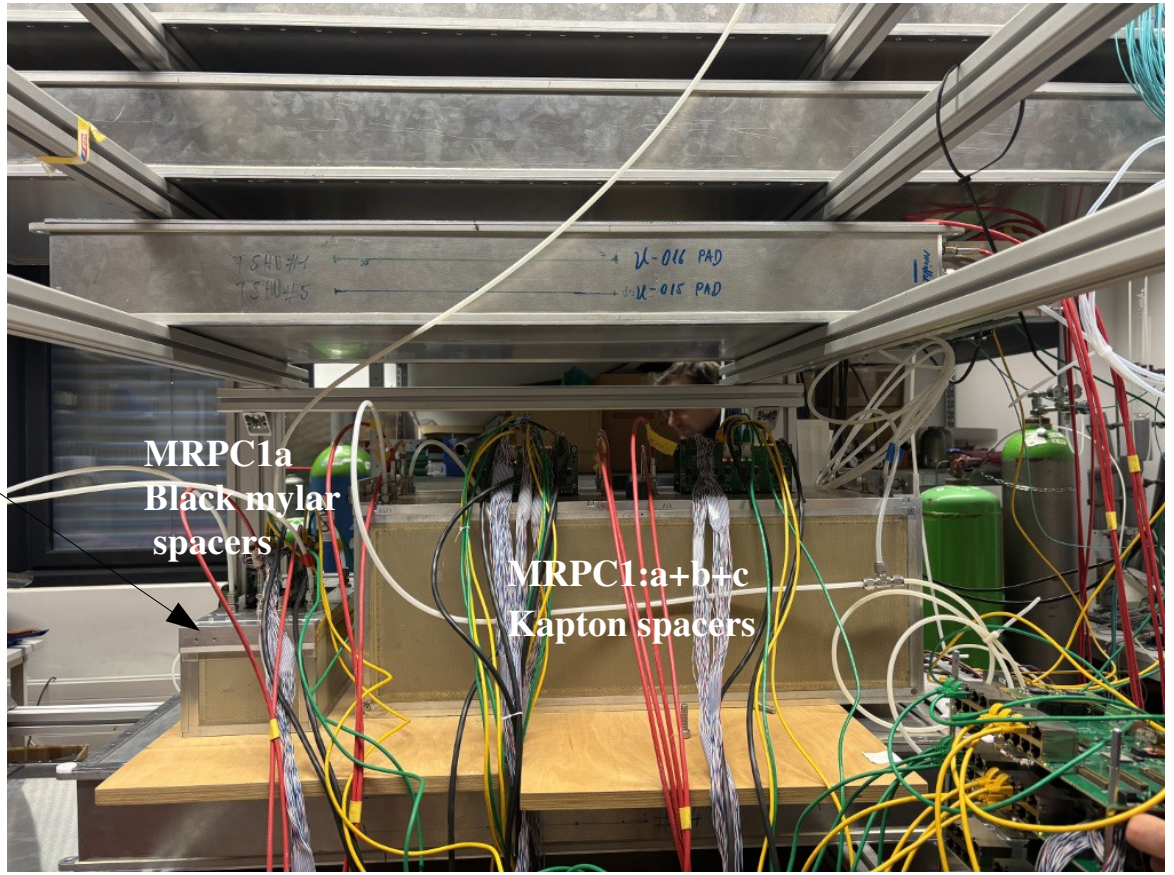
19.06.2025

Dark current @ +/-6 kV = 1-2 nA

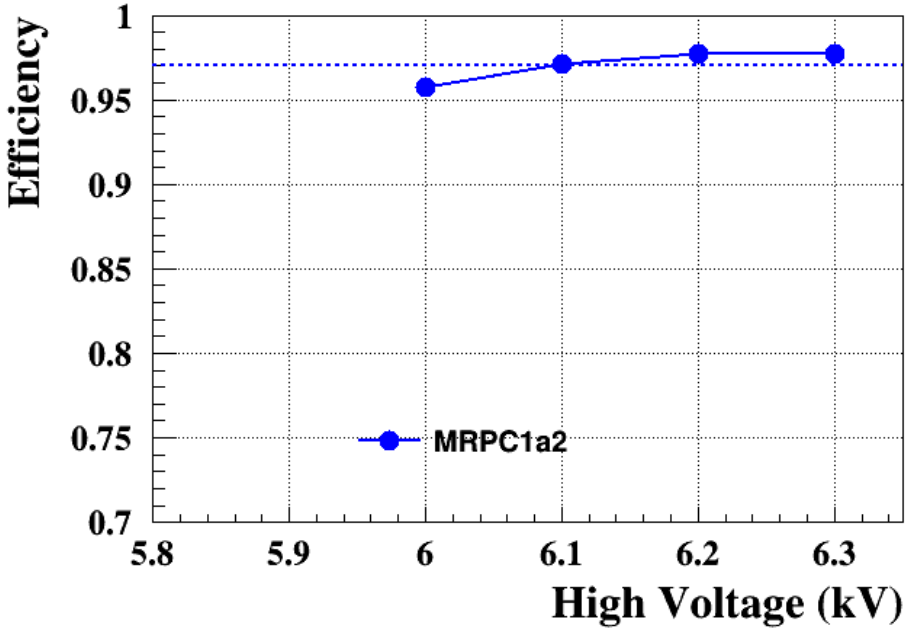
Dark rate @ +/-6 kV ≈ 1 Hz/cm^2

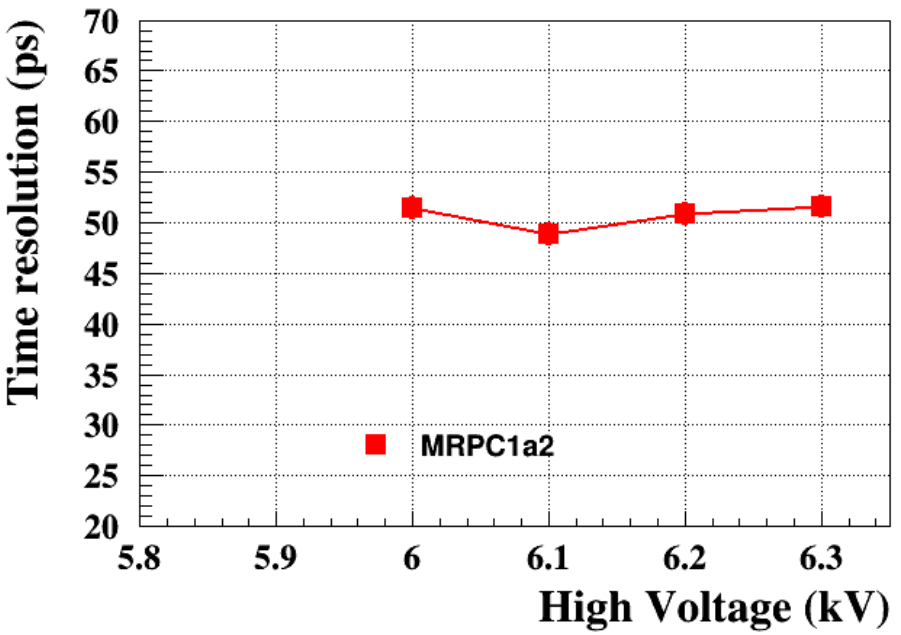
MRPC1 chambers in the Heidelberg cosmic setup

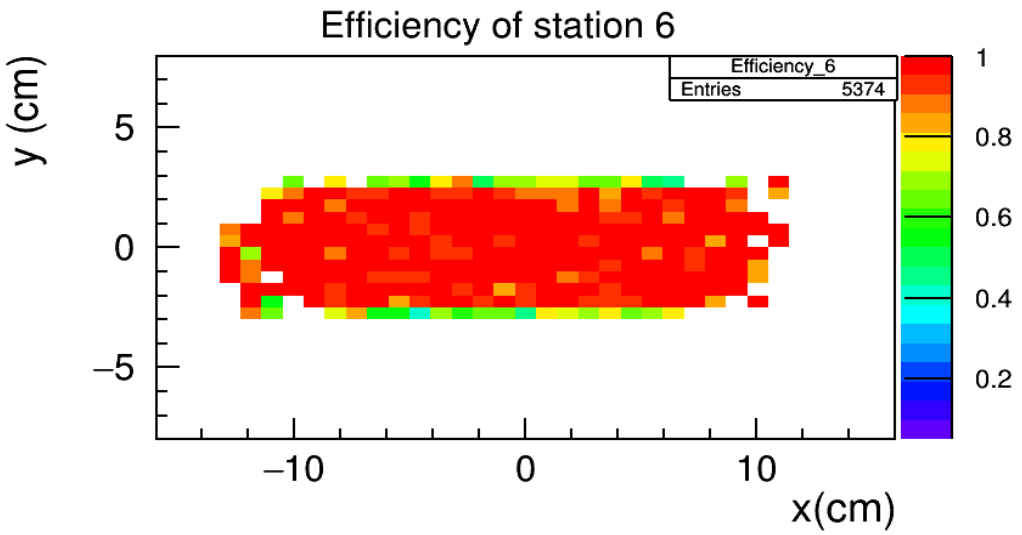
09.09.2025

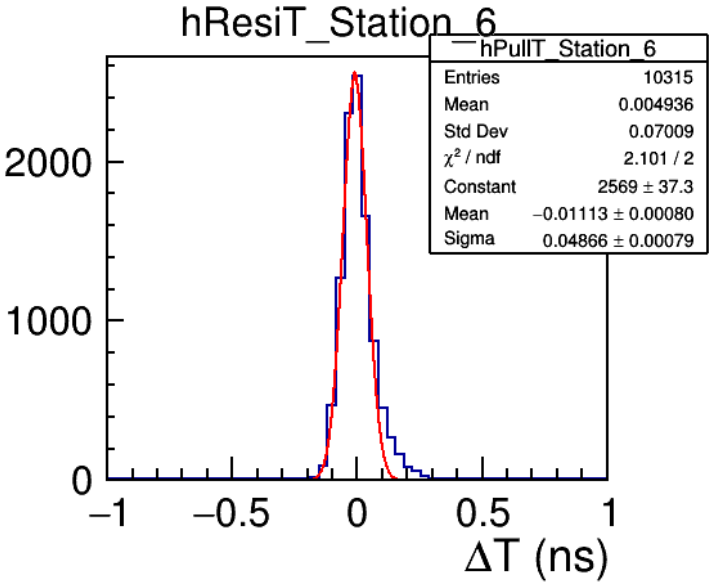


MRPC1a chamber with polycarbonat spacers
Cosmic rays test results





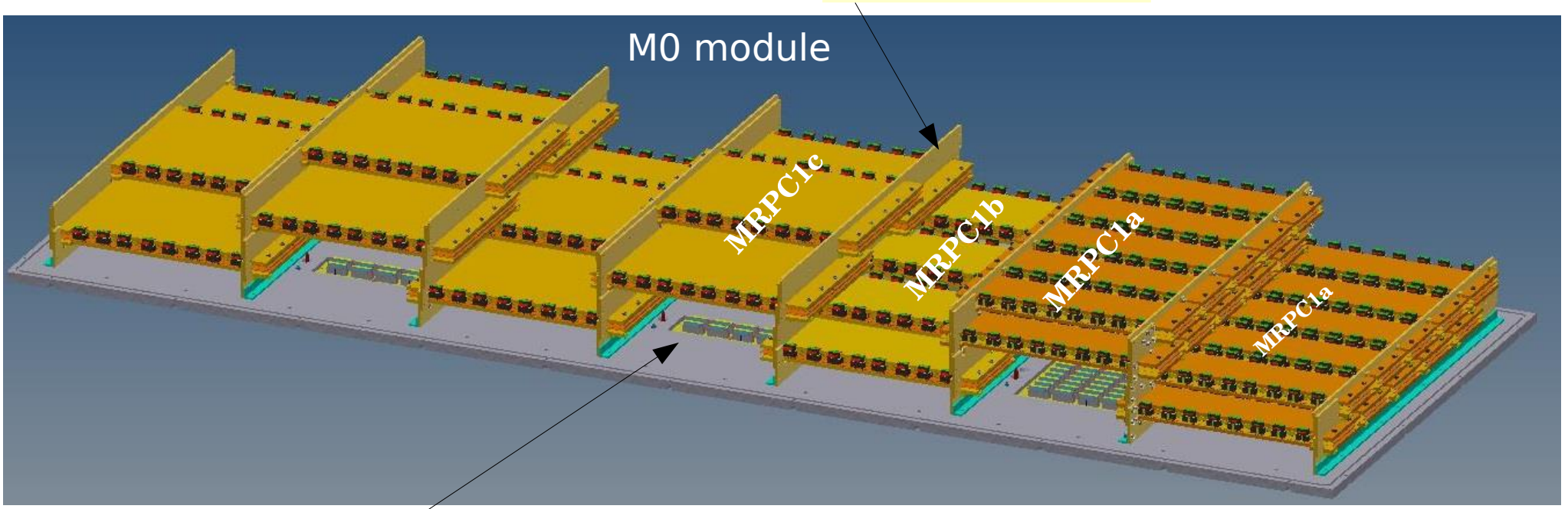




First module (M0) of the CBM-TOF inner wall

Chamber type	Strip length	No.
MRPC1a	56 mm	20
MRPC1b	96 mm	6
MRPC1c	196 mm	12

→ 2432 readout channels = 12% of inner wall channels



Assembling of the first module (M0) of the CBM-TOF inner wall

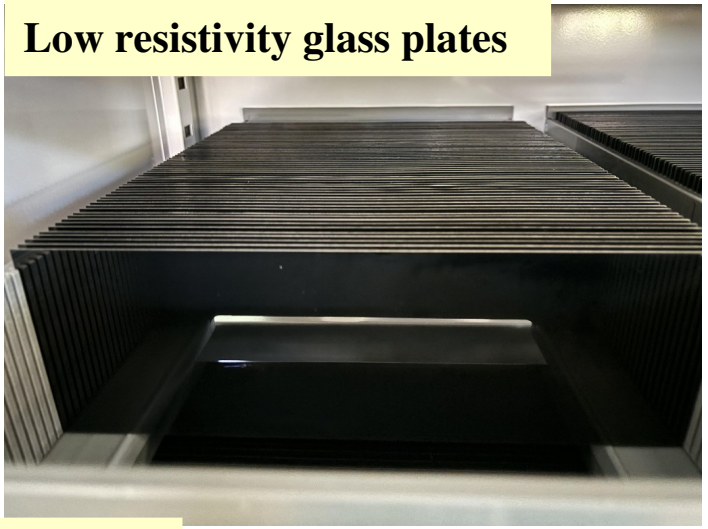
Chambers: main components – already manufactured and procured

HV PCBs

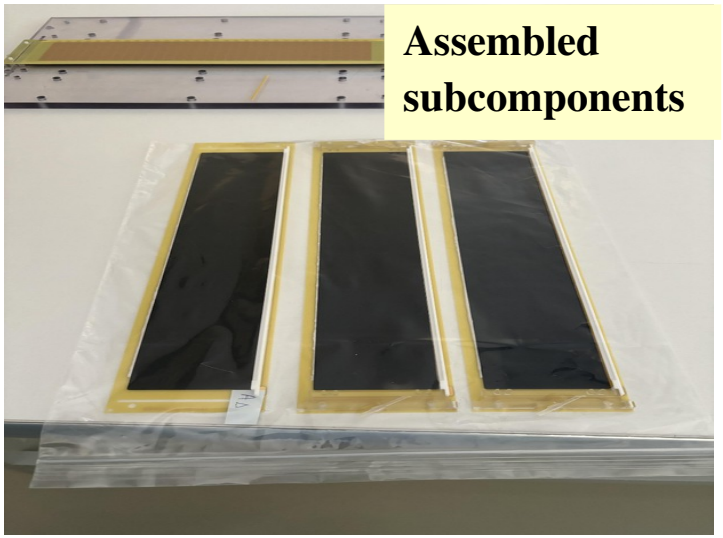
Readout PCBs

Signal cables

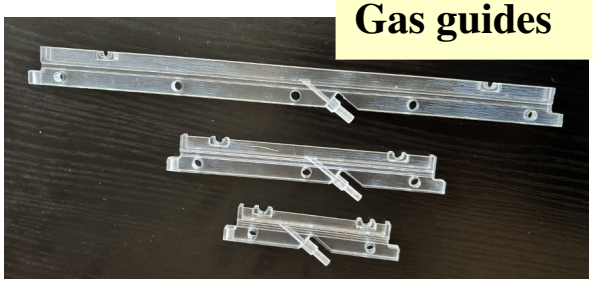
Low resistivity glass plates



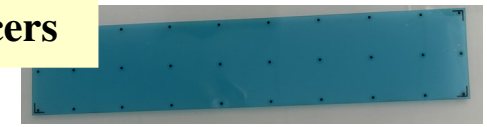
Assembled subcomponents



Gas guides



Spacers

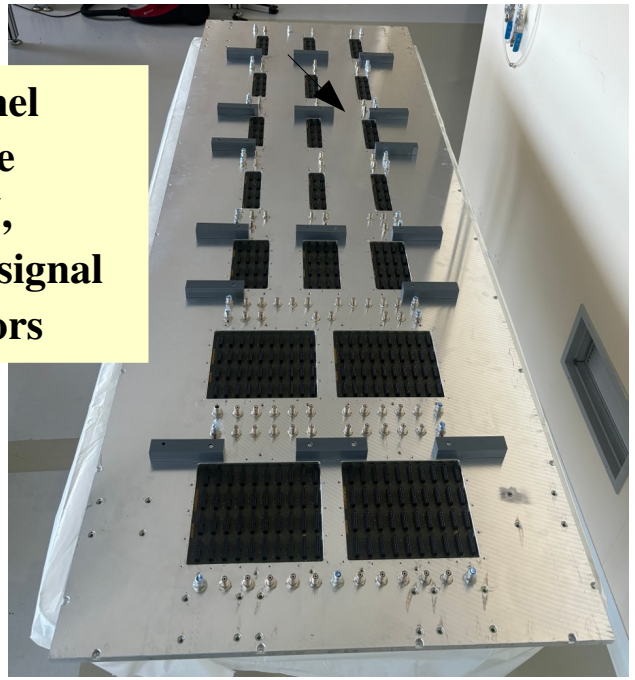


Spacers to be used: 2 mm diameter, 200 µm thickness PC, samples received from Panel Group, Taiwan

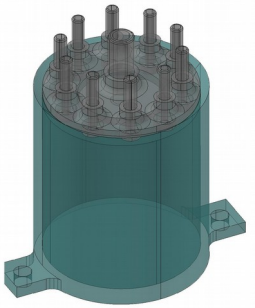
Assembling of the first module (M0) of the CBM-TOF inner wall

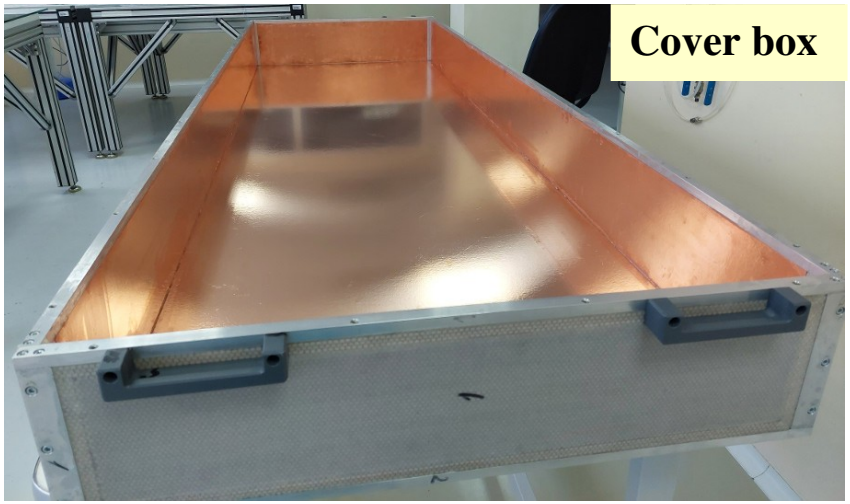
Housing box: cover, backpanel, mechanical supports

Backpanel outerside with HV, gas and signal connectors

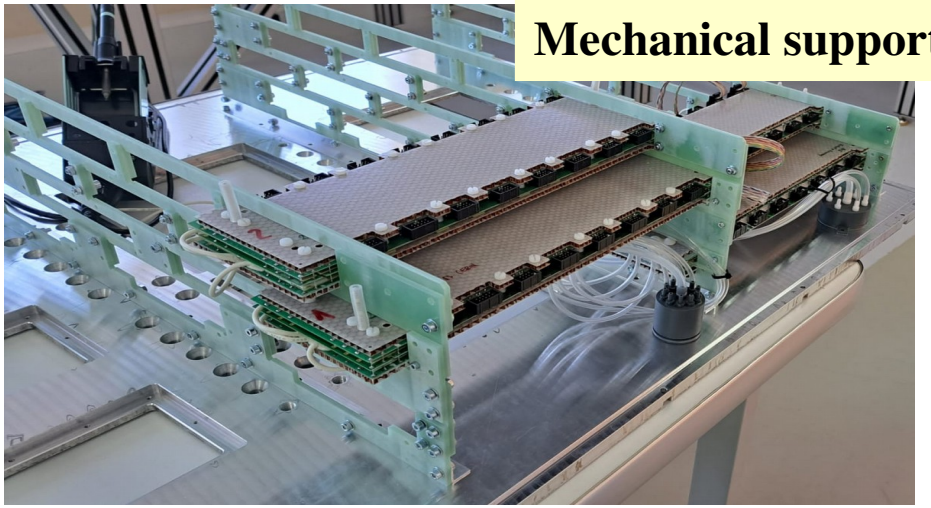


Gas distributors





Cover box



Mechanical supports

Assembling of the first module (M0) of the CBM-TOF inner wall

Summary & Outlook

- **The performance of the MSMGRPC architecture with discrete spacers and direct flow, operated with the FEE designed for the CBM-TOF inner zone, showed very good results in the in-beam and cosmic rays tests. Data analysis is still on-going.**
- **The assembling of the first module (M01) of the CBM-TOF inner zone based on direct flow MSMGRPCs with discrete spacers is in progress.**
- **Spacers procurement is started.**
- **Manual for signal cables routing is ready, manual for detector assembly and manual for the gas pipe distribution are in progress.**
- **Assembling of the housing box of the second module (M02) is in progress.**
- **The backplane for the second M0, backplanes for the M3 modules and components for their housing box are already procured.**
- **The HV and readout electrodes for M02 module are procured.**
- **We had a kik-off meeting for starting the preparation of the in-kind contract.**

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