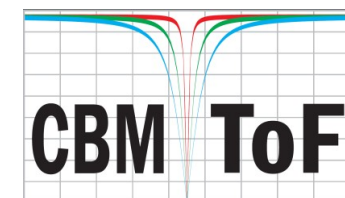
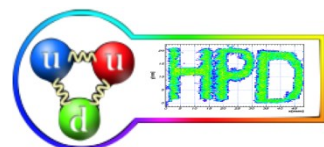


Next generation MSMGRPCs for high interaction rate experiments

Mariana Petris

Hadron Physics Department

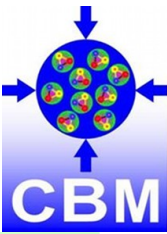
National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH), Bucharest, Romania



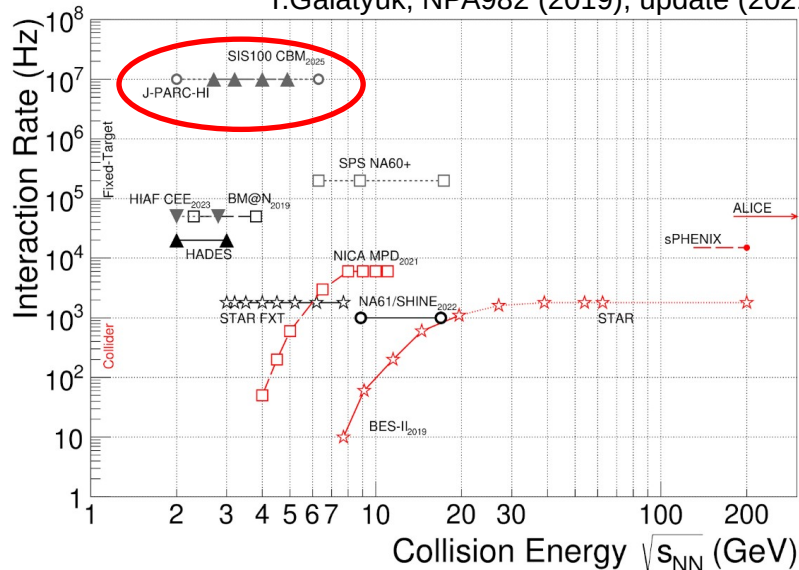
Outline

- **Motivation – next generation of high interaction rate experiments
(e.g. CBM/FAIR, Darmstadt ->TOF inner wall)**
- **MSMGRPC: design considerations & high counting rate performance**
- **Aging studies of MSMGRPC prototypes**
- **Cosmic rays & in-beam tests**
- **Implementation in the CBM-TOF inner wall modules**
- **Summary and Outlook**

High interaction rate experiments



CBM Collaboration, EPJA 53 3 (2017) 60
T.Galatyuk, NPA982 (2019), update (2021)

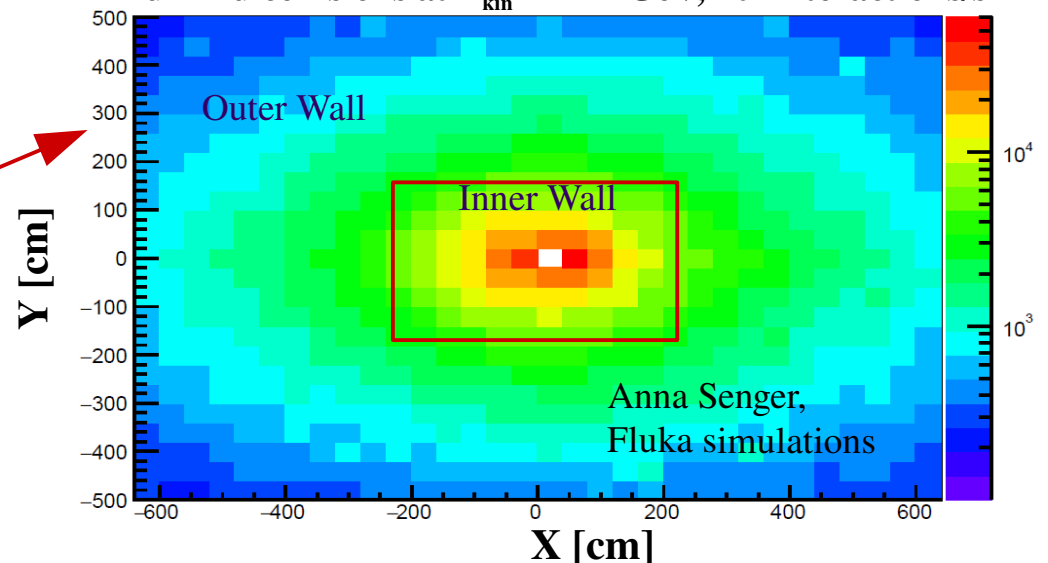


CBM experiment at FAIR/SIS100:

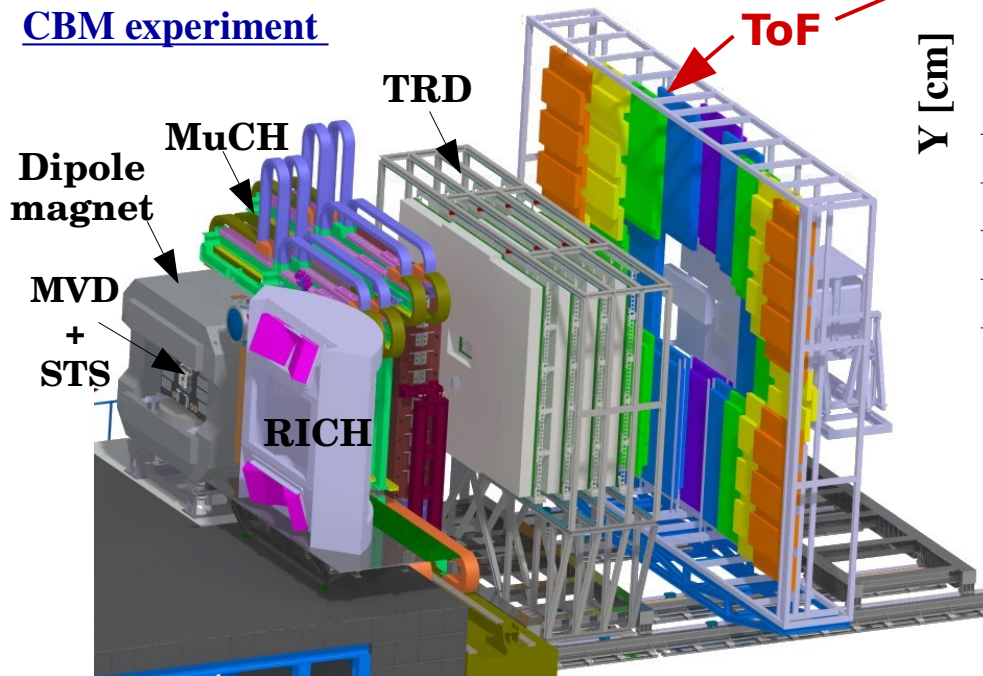
- A+A collisions, $E_{\text{kin}} = 2.5A - 11A$ GeV,
- Systematically explore QCD matter at large baryon densities with high accuracy and rare probes

CBM-TOF → based on MRPCs with strip readout

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

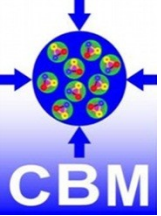


CBM experiment

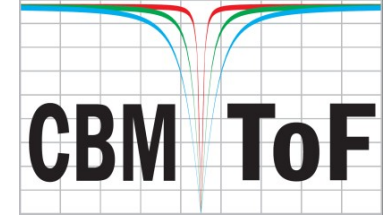


Our R&D activity → CBM-TOF Inner Wall :

- highest counting rate
- highest granularity
- ~14 m² active area (up to ~11° polar angle)



Inner wall of the CBM- ToF system Challenges



Outer wall

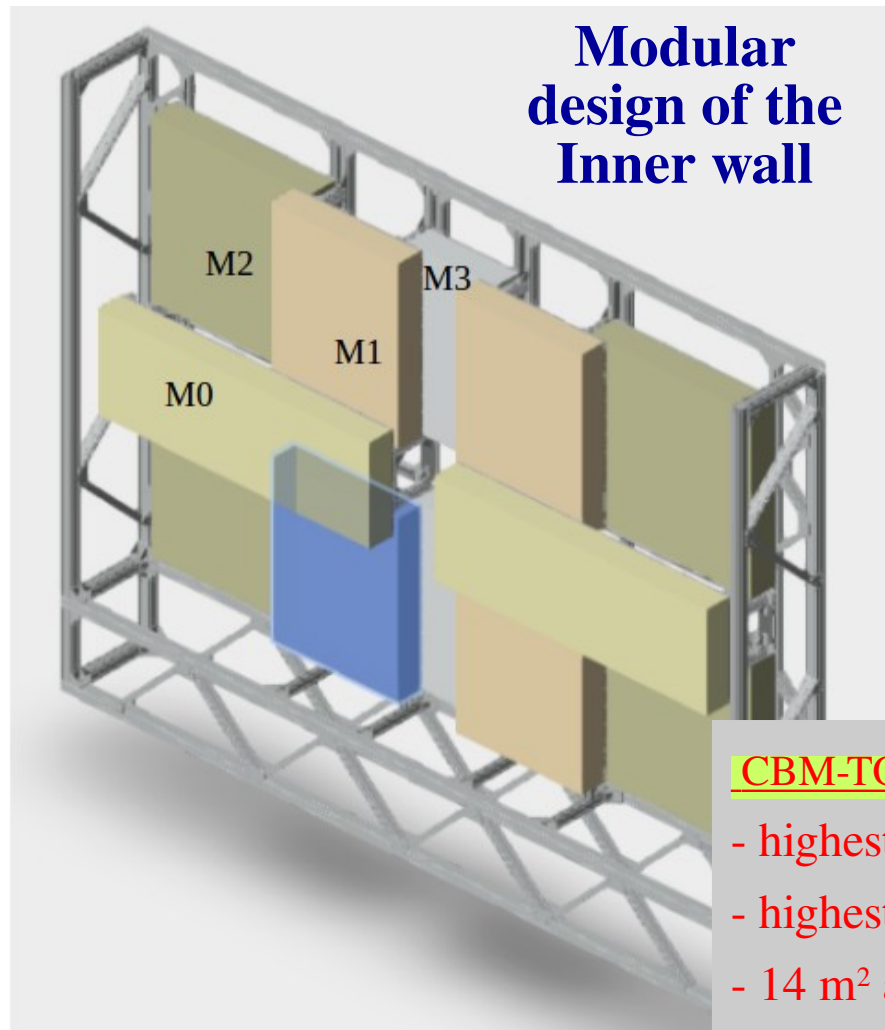
Inner wall

CBM-ToF Requirements

- Full system time resolution $\sigma_T \sim 80$ ps
- Efficiency $> 95\%$
- Rate capability ≤ 50 kHz/cm²
- Polar angular range $2.5^\circ - 25^\circ$
- Active area of 120 m²
- Occupancy $< 5\%$
- Low power electronics ($\sim 120,000$ channels)
- Free streaming data acquisition

CBM Collaboration, "CBM – TOF Technical Design Report", October 2014

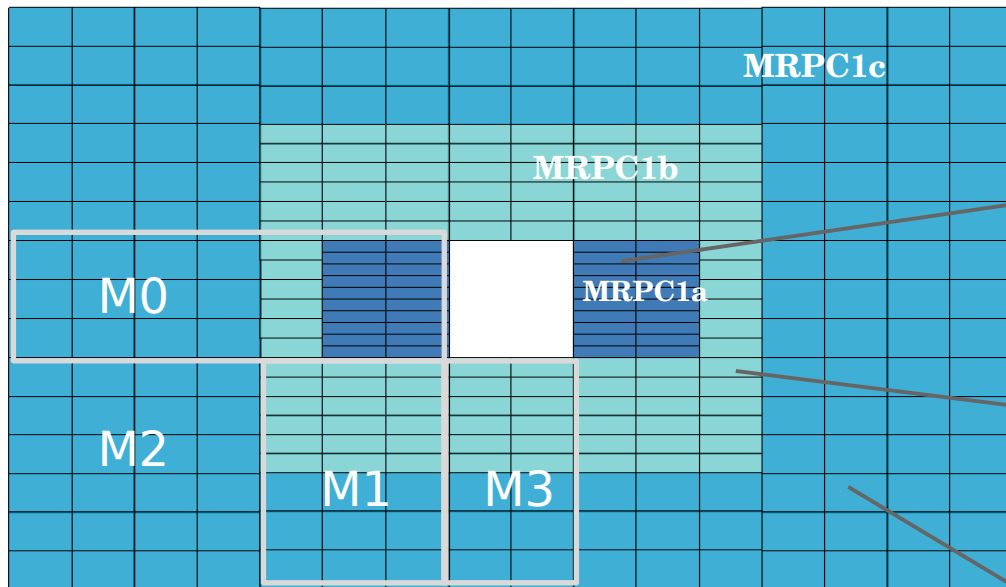
Modular design of the Inner wall



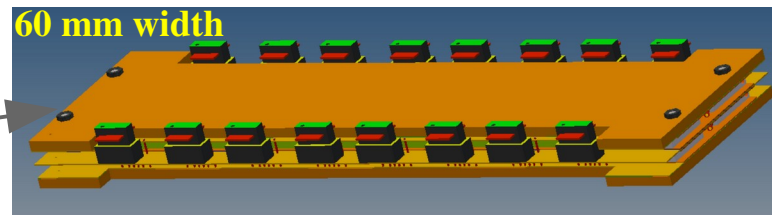
CBM-TOF inner wall:

- highest counting rate
- highest granularity
- 14 m² active area
- 12 modules of 4 types: M0, M1, M2, M3

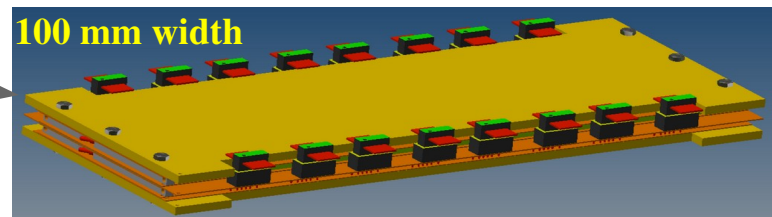
Design of the CBM – TOF inner wall



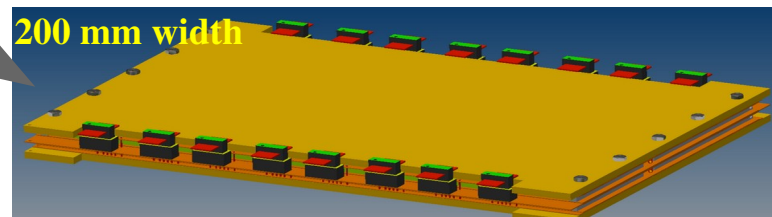
Counters with different granularities - as a function of polar angle



MRPC1a



MRPC1b



MRPC1c

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

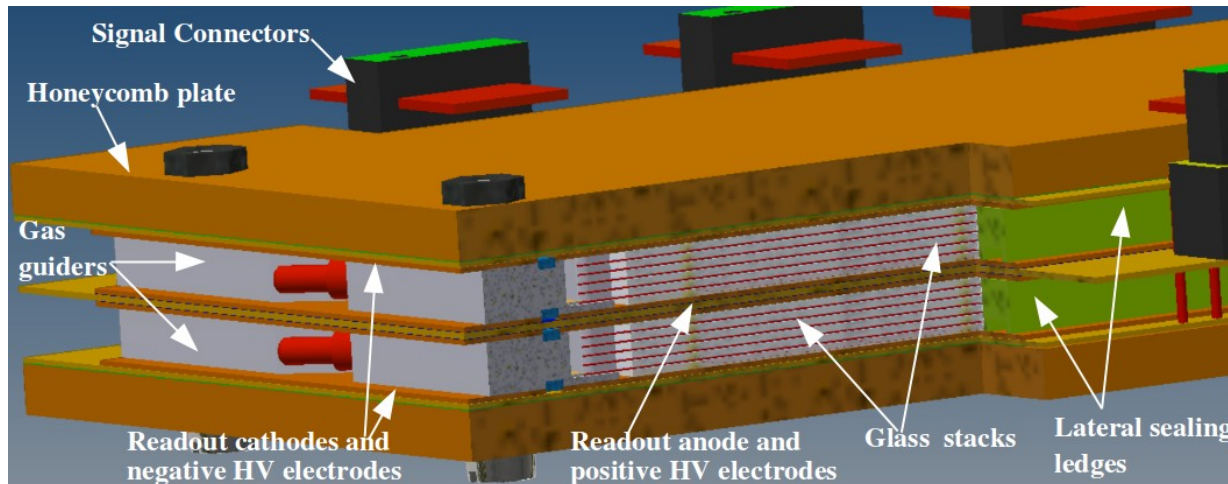
		MRPC1a	MRPC1b	MRPC1c
Glass	Type	Low Resistivity ($\sim 10^{10} \Omega\text{cm}$)		
	Size (mm)	60 x 310 x 0.7	100 x 310 x 0.7	200 x 310 x 0.7
Gaps	Size (μm)	200		
	Number	2 x 5		
Readout strips	Width + gap (mm)	1.27 + 7.75		
HV strips	Width + gap (mm)	8.62 + 0.4		
Impedance		100 Ω differential, double - end strip readout		
Active area (mm^2)		289 x 56	289 x 96	289 x 196
Outer sizes (mm^2)		350 x 103	350 x 144	350 x 246
Weight (Kg)		0.9	1.4	2.4
Thickness (mm)		25.5		

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

~23% from the total number of CBM-TOF chambers/readout channels

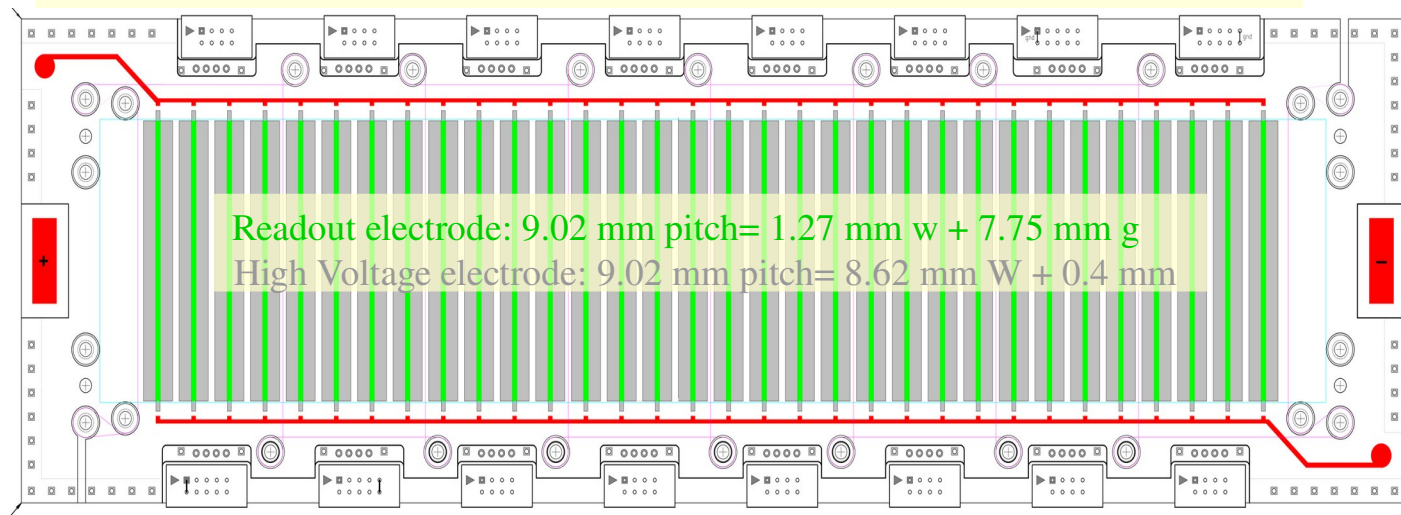
Chamber design considerations

Multistrip Multigap Resistive Plate Chamber - MSMGRPC



matched signal transmission line impedance to the input of the FEE

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



Inner Configuration

Honeycomb

Readout Cathode

Insulator

HV Electrode

Glass *6

HV Electrode

Insulator

Readout Anode

Insulator

HV Electrode

Glass *6

HV Electrode

Insulator

Readout Cathode

Honeycomb

Gas guiders *4

Ledges *4

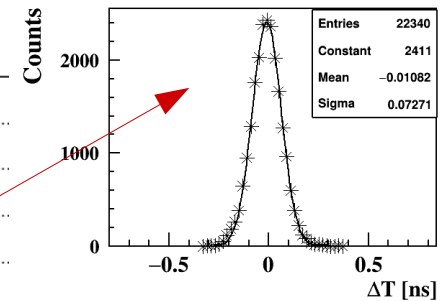
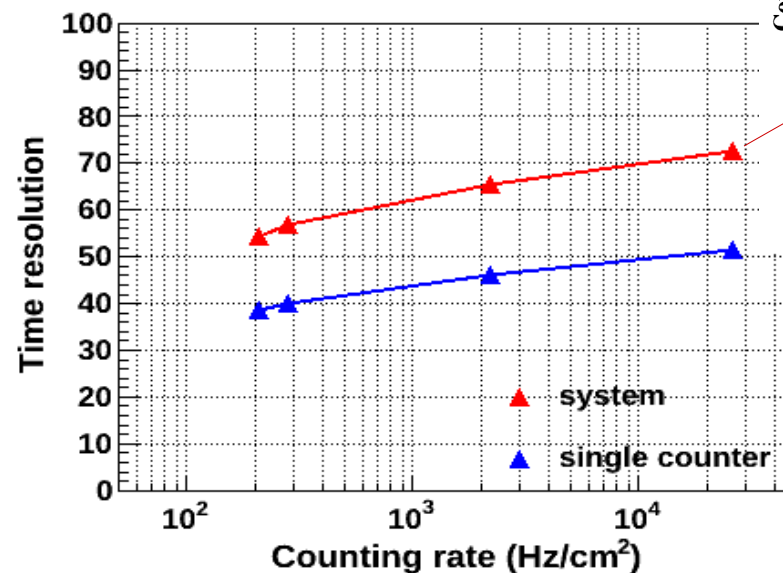
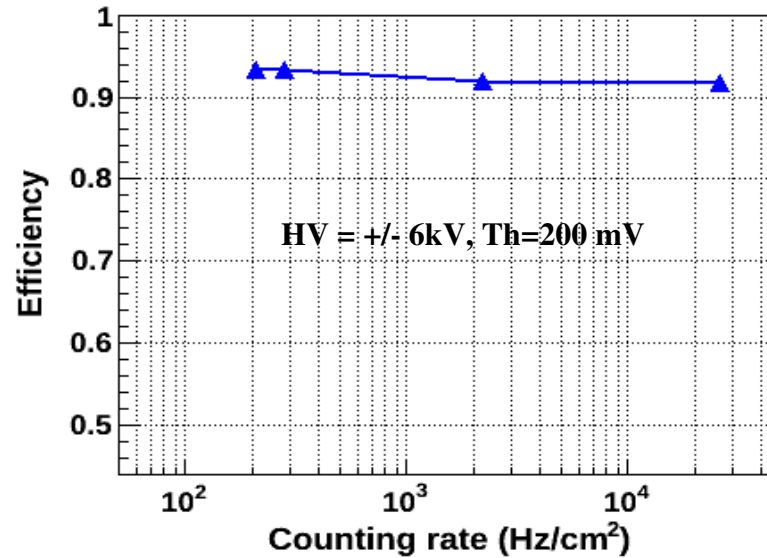
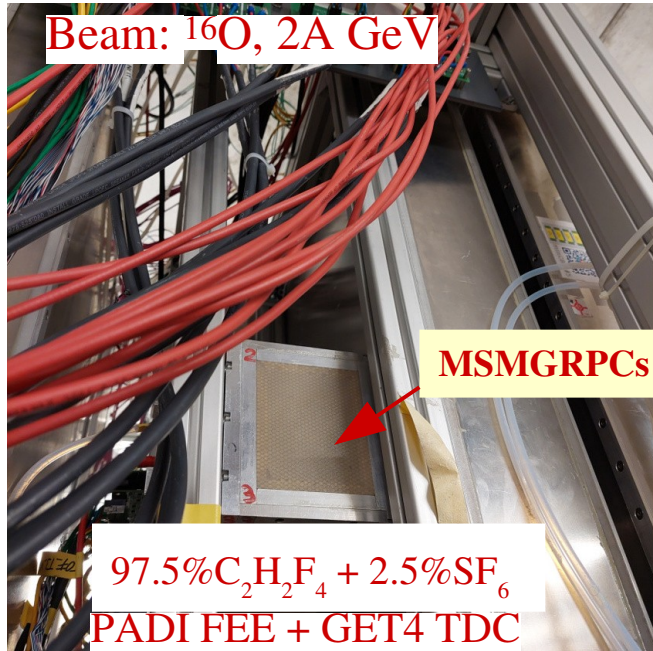
Signal Connectors *16

Direct flow

Chamber performance in high counting rate

MSMGRPC prototype with gas exchange via diffusion

mCBM/SIS18/GSI Darmstadt



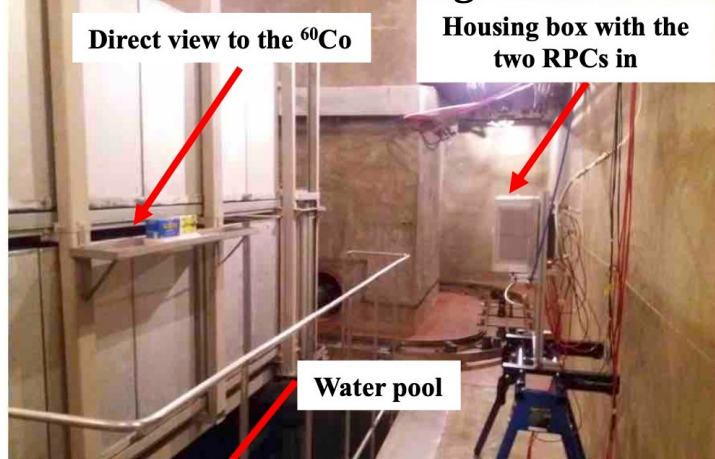
M. Petris et al., Nucl. Inst. and Methods A 1045 (2023) 167621

Aging investigations of MSMGRPCs with gas exchange via diffusion

- IRASM/IFIN-HH multipurpose irradiation center

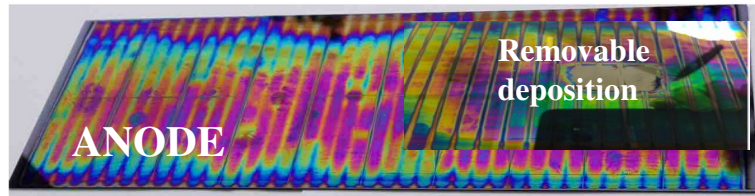
- ^{60}Co source: 360 kCi;

- Total accumulated charge: $130\text{mC}/\text{cm}^2$



Gas mixture: 90% $\text{C}_2\text{H}_2\text{F}_4$ + +5% $\text{i-C}_4\text{H}_{10}$ + 5% SF_6

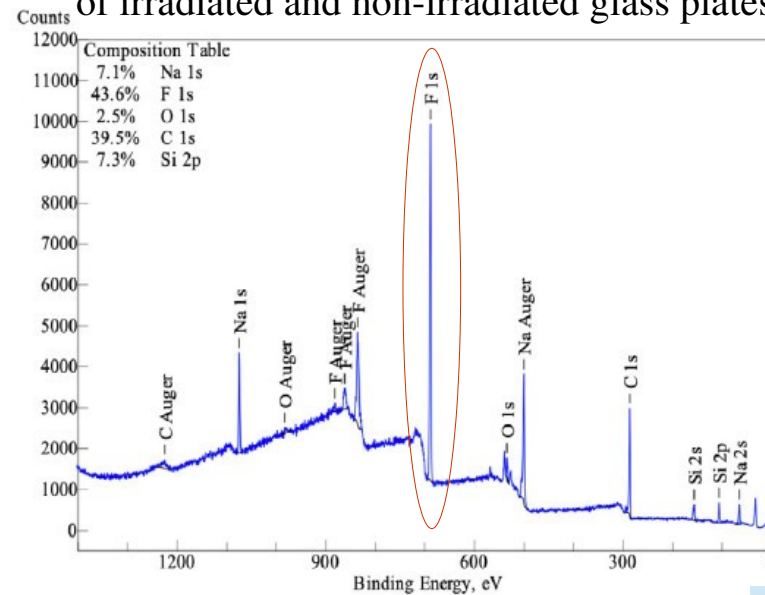
Glass inspections performed with various methods:
(SEM, XPS, AFM RBS)



Glass resistivity remains unchanged

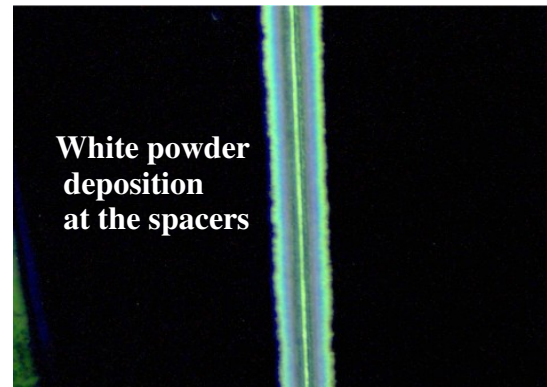


(XPS) analysis of the chemical composition
of irradiated and non-irradiated glass plates



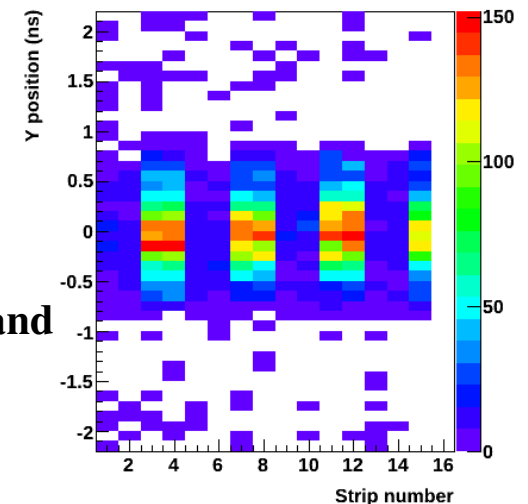
The fluorine percentage
on the surface of the
glass electrodes exposed
in high irradiation
dose is significant.

Non exposed
glass does not
contain fluorine.



Dark rate generated
around the spacers

Effects: increase of the dark current and
dark counting rate.

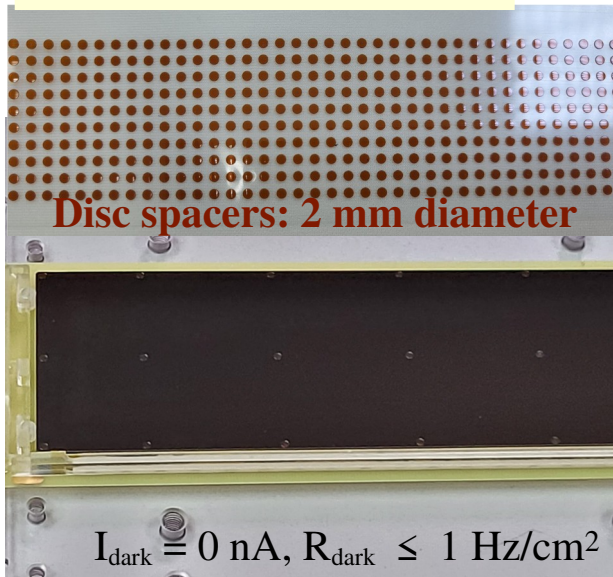


D. Bartos et al., Nucl. Inst. and Methods A 1024 (2022) 166122

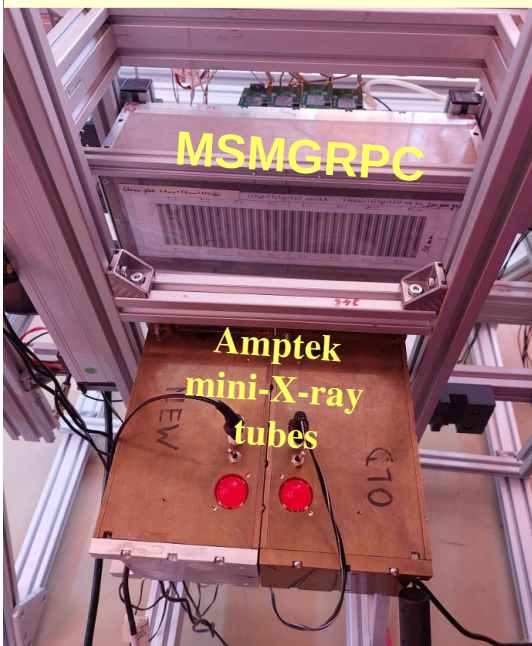
XVIII Workshop on Resistive Plate Chambers and Related Detectors, Rio de Janeiro, Brazil, 14 – 18 September 2020

Mitigation solution - direct flow & discrete polyimide spacers

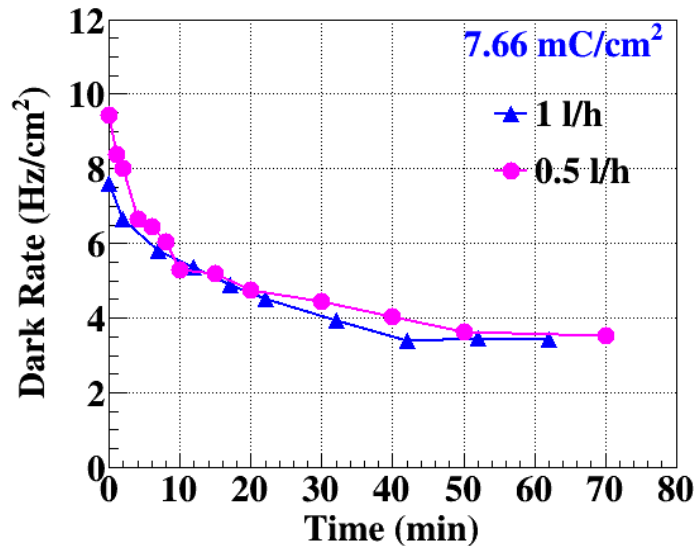
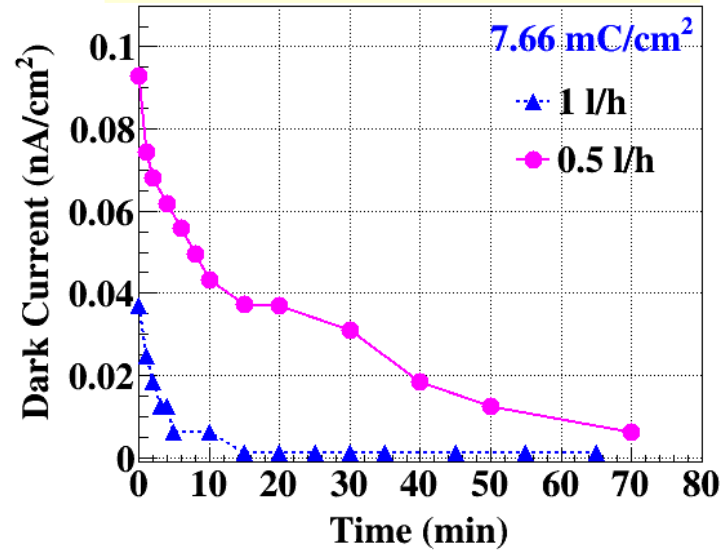
1. Assemble prototypes



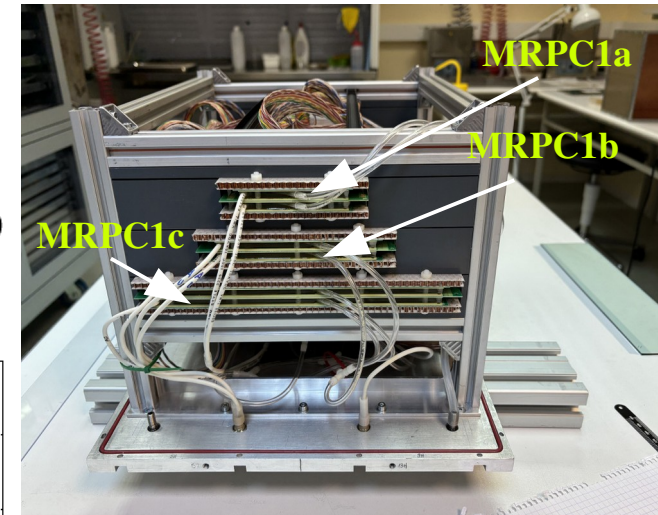
2. High X-ray flux aging test



3. Very good aging test results



4. Assemble MRPC1a, MRPC1b, MRPC1c prototypes for in-beam and cosmic ray tests



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

MRPC1(a,b,c) chambers of the CBM-TOF inner wall based on 100+100 μm polyimide discrete spacers and direct flow

mCBM@SIS18 in - beam test, May 2025

^{56}Fe run

$E_{\text{kin}} = 1.7\text{A GeV}$

Target: Ni 10%

HV Scan

^{209}Bi run

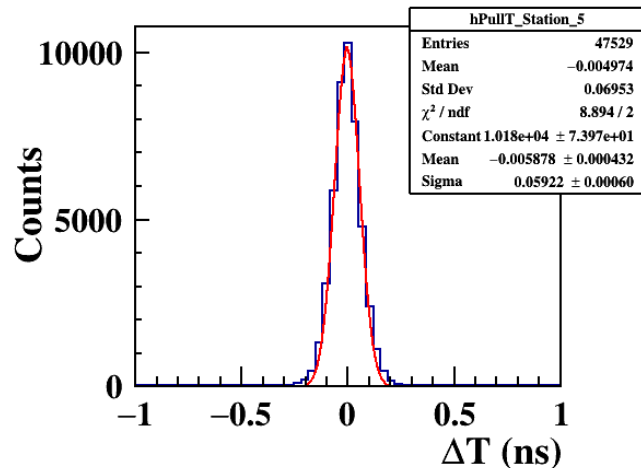
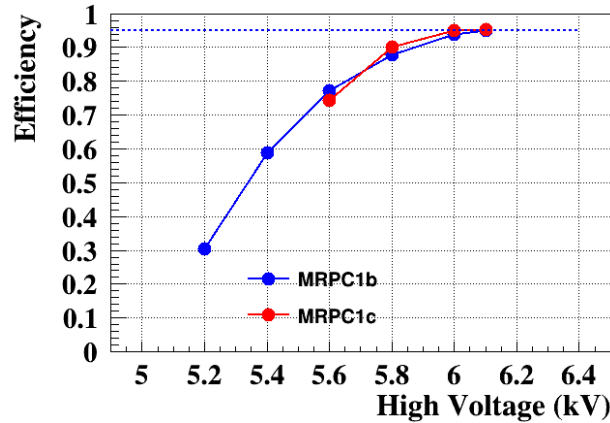
$E_{\text{kin}} = 1.1\text{A GeV}$

Target: Au 10%

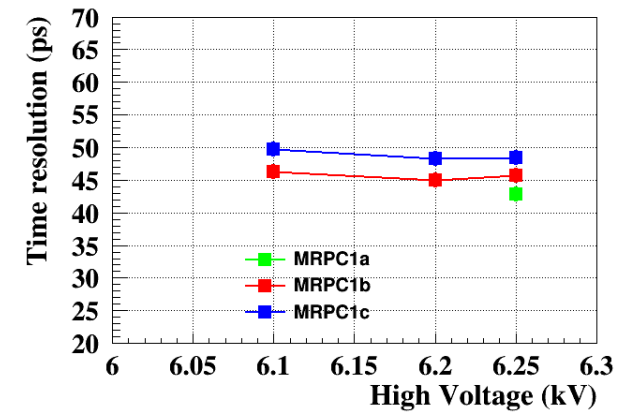
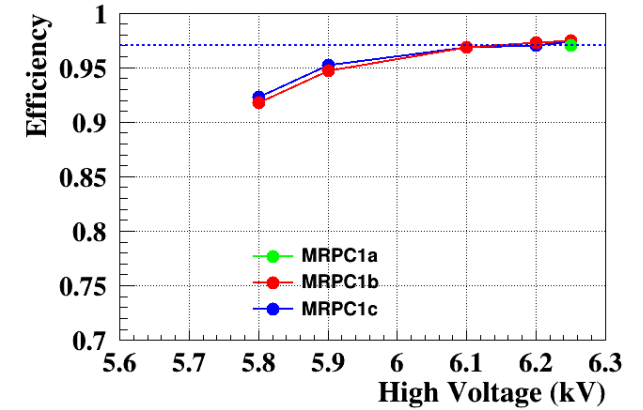
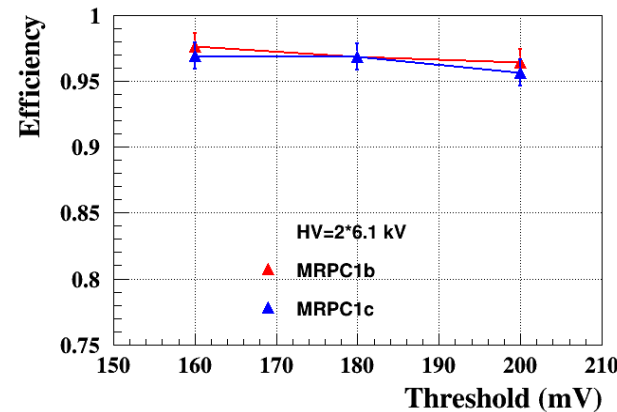
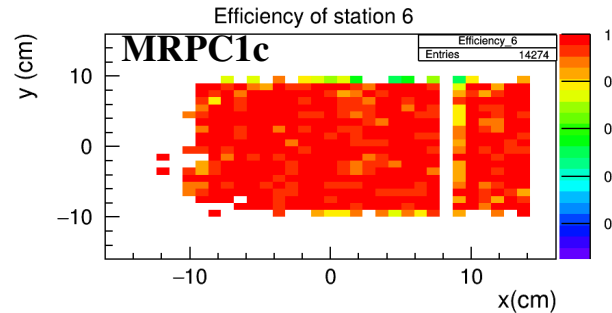
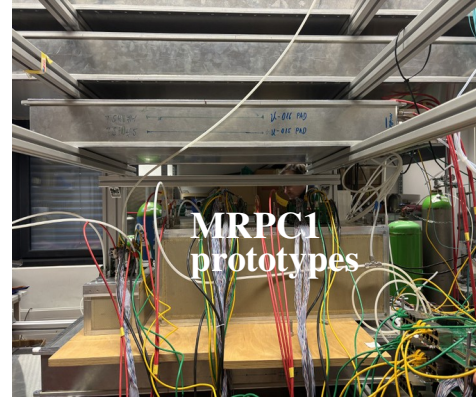
High Rate Scan

Data analysis in progress.

^{56}Fe run

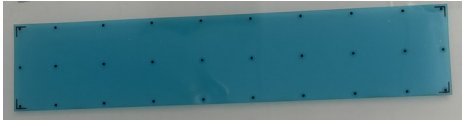


Tests in the CBM-TOF cosmic ray setup installed at Heidelberg University, 2025

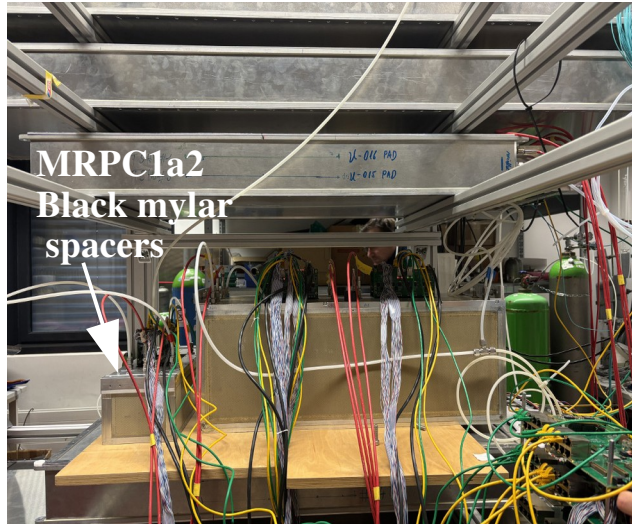


MSMGRPCs with discrete spacers and direct flow, operated with the FEE designed for the CBM-TOF inner zone, showed very good results in the in-beam and cosmic rays tests.

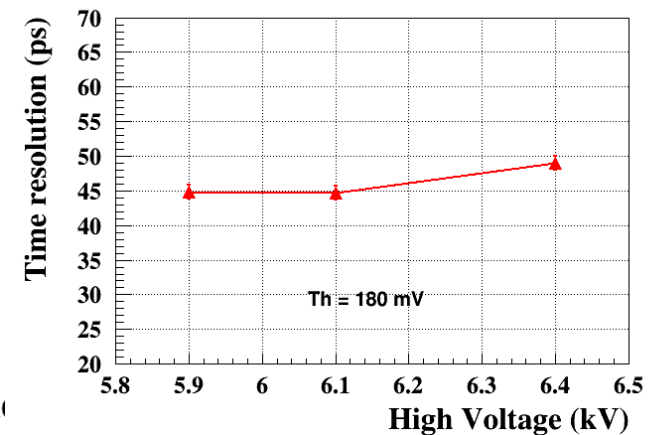
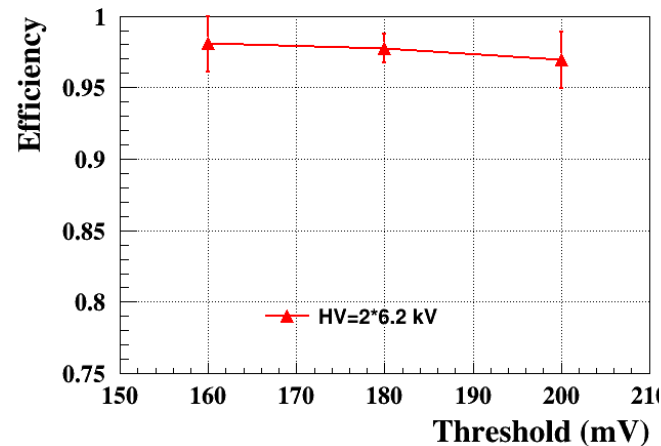
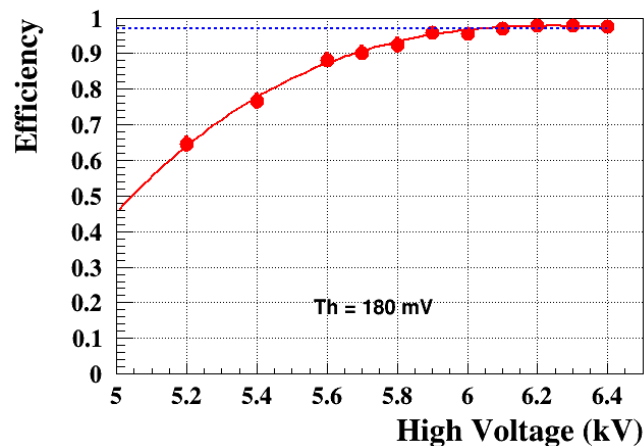
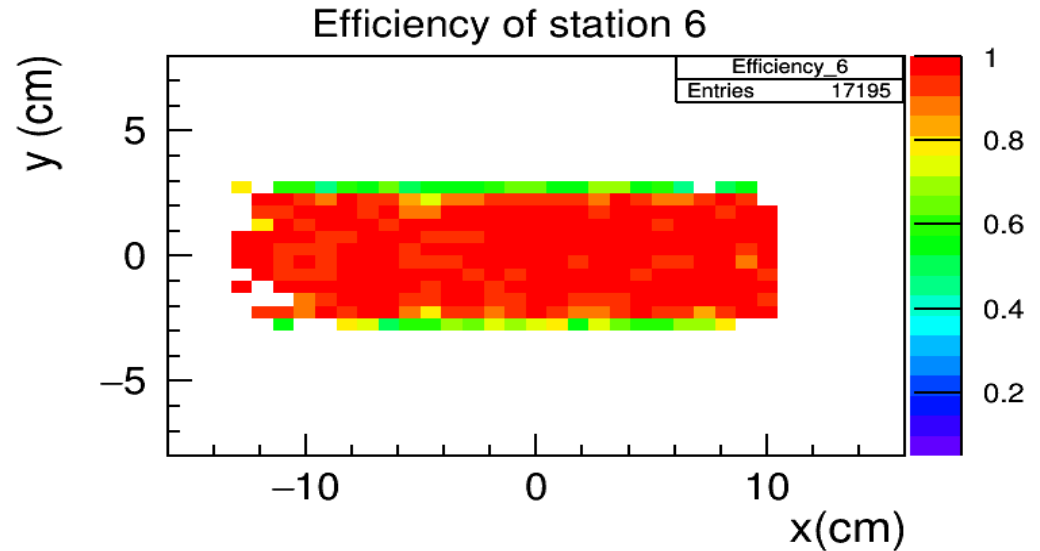
MRPC1a chamber with polycarbonat spacers



2 mm diameter, 200 μm thickness PC,
samples received from Panel Group, Taiwan

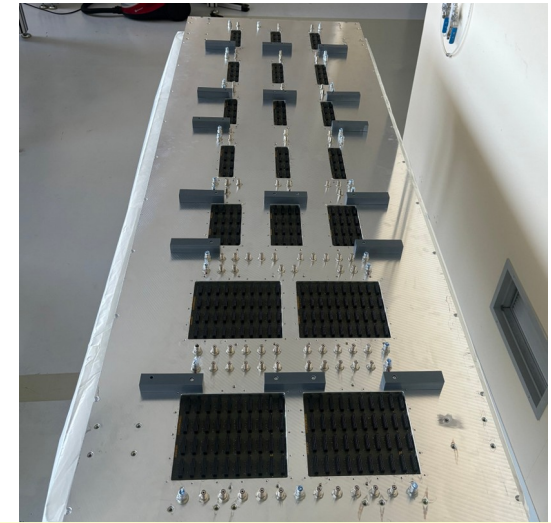
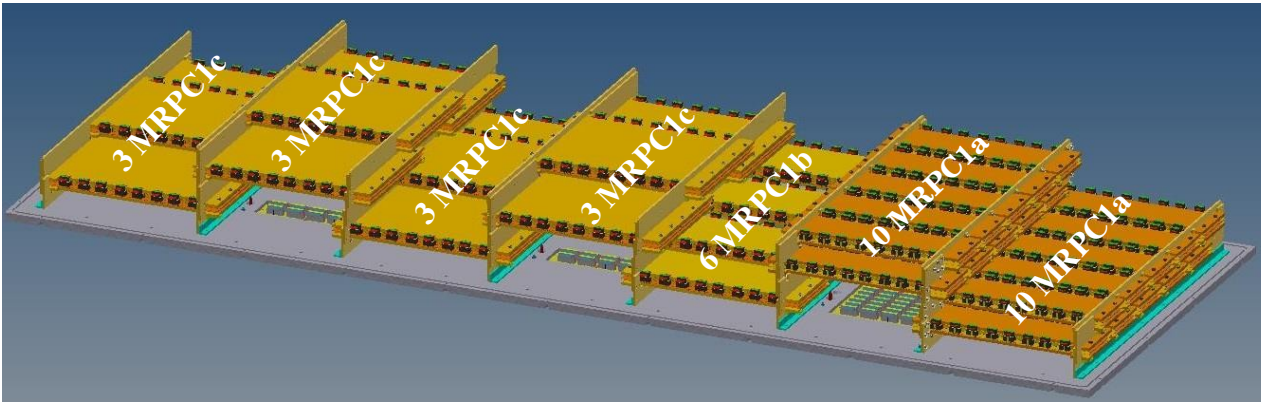


MRPC1a chamber operated with Inner Wall
FEE in the Heidelberg cosmic rays setup



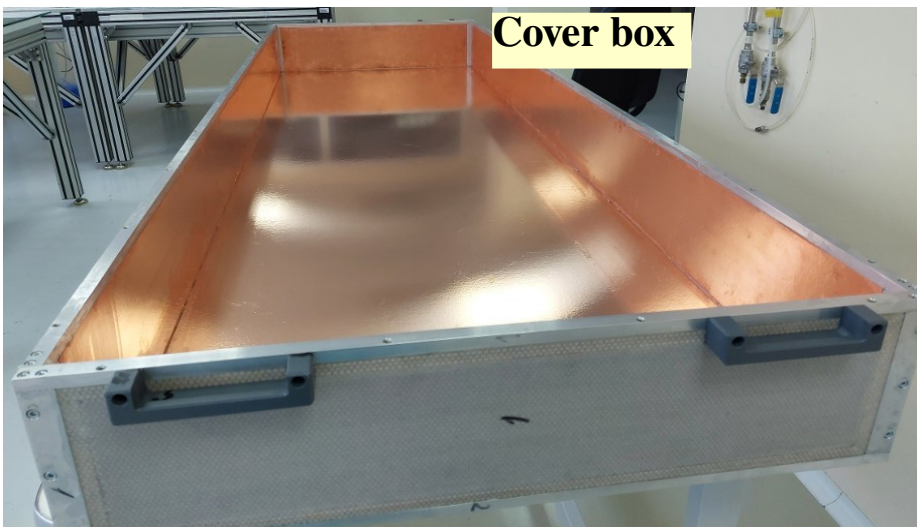
First module (M01) of the CBM-TOF inner wall

0. Module design

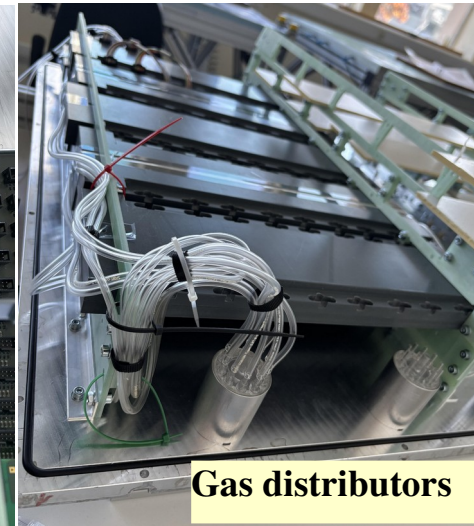
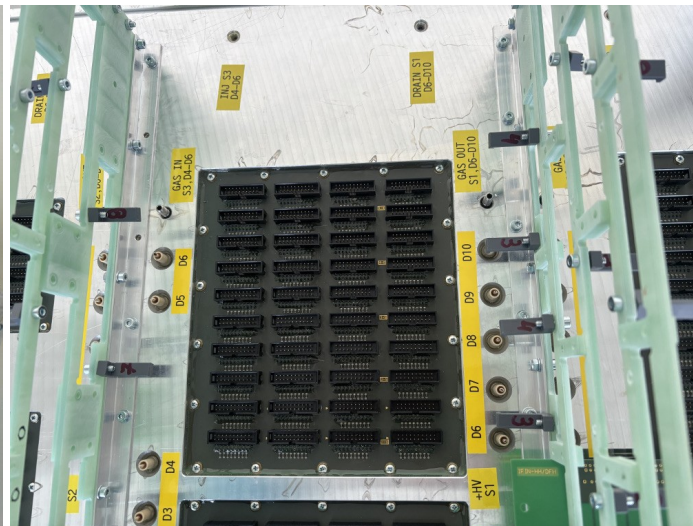


Backpanel outside with HV, gas and PCB signal connectors

1. Housing box: cover, backpanel, connector PCBs, mechanical supports



Cover box



Gas distributors

Assembling of the chambers of the M01 module

2. Chamber components: HV & Readout PCBs, glass plates, spacers, gas guides, signal cables

HV PCBs



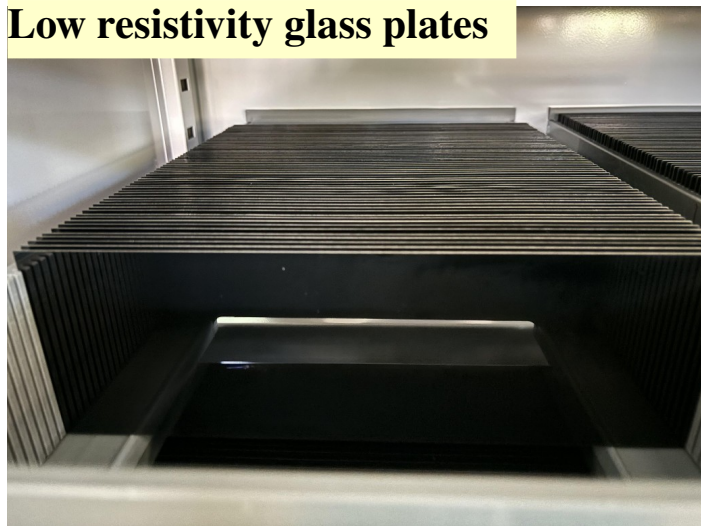
Readout PCBs



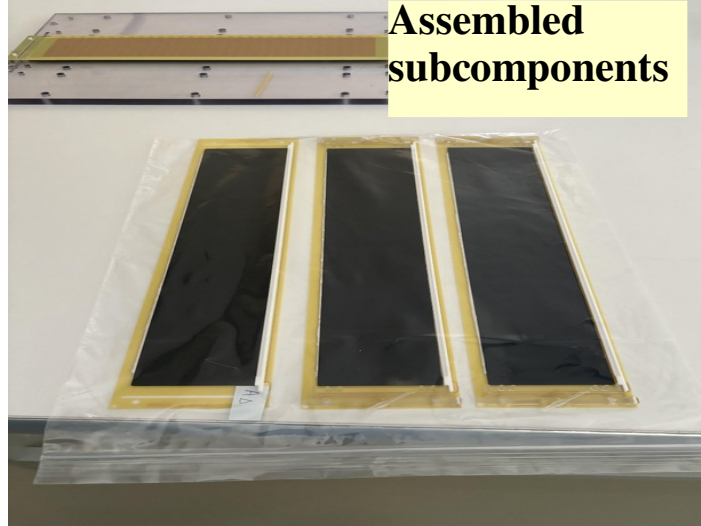
Signal cables



Low resistivity glass plates



Assembled subcomponents



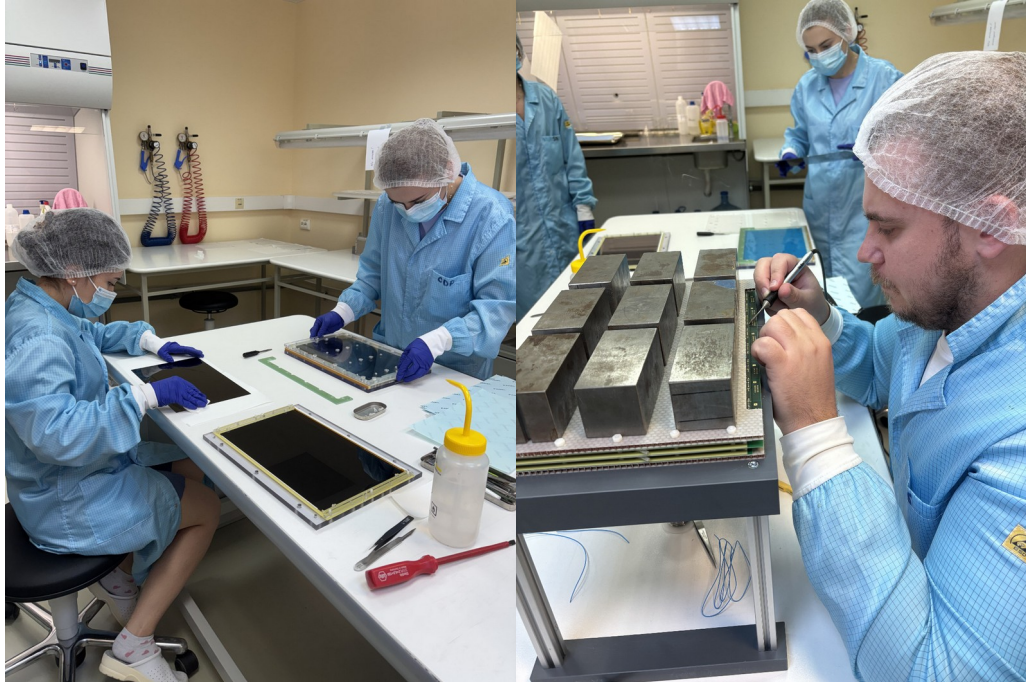
Gas guides



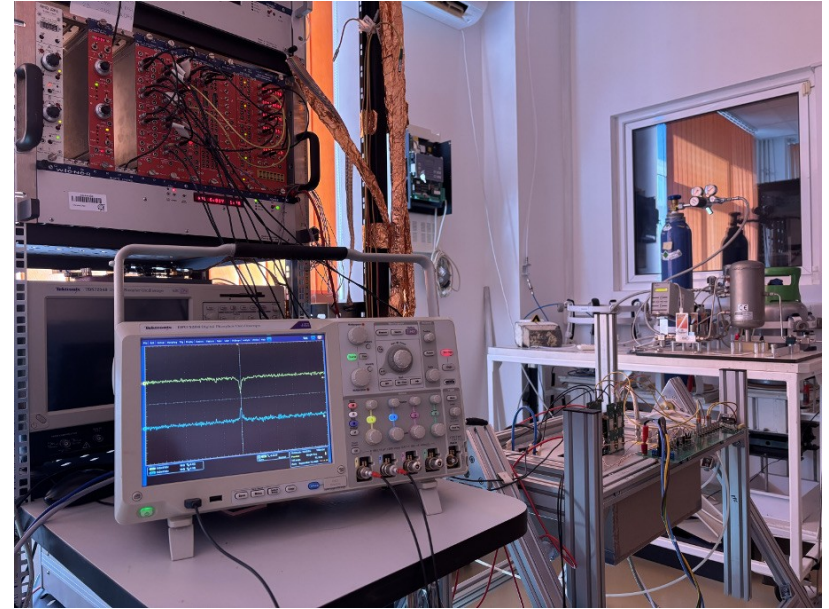
Spacers: 2 mm diameter, 200 μ m thickness PC

3. chamber assembling and testing

Clean room laboratory (10000 part/ft²)

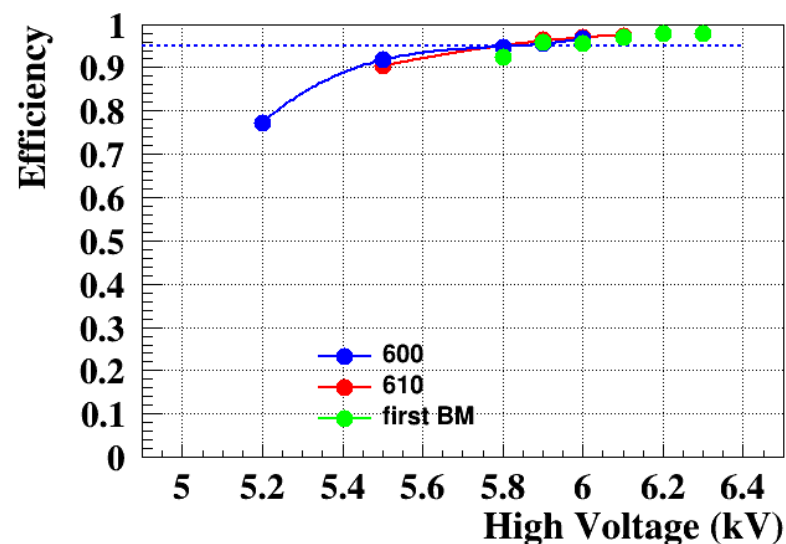
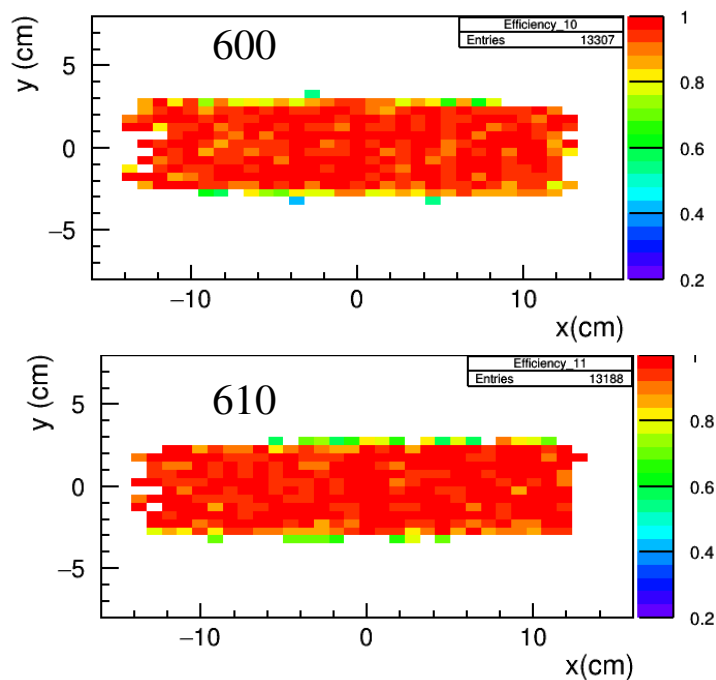
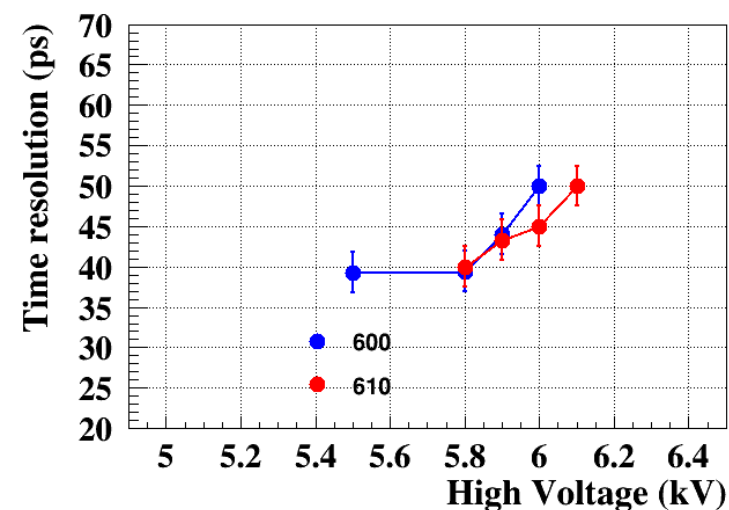
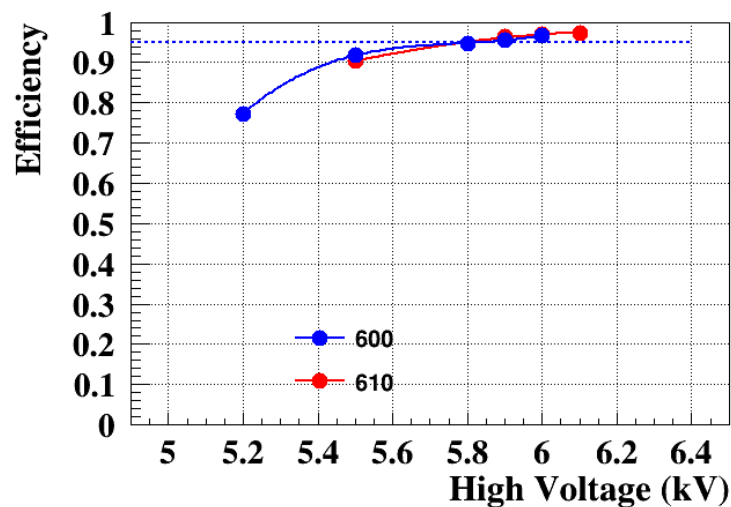


Test laboratory



Detectors	Number	Gas tightness	Dark Current (nA) @ 2x 6 kV	Dark rate (Hz/cm ²) @ 2 x 6 kV
MRPC1a	16/20	99%	0 – 7	0.4 -1.2
MRPC1b	6/6	99%	0 – 7	0.4 – 0.9
MRPC1c	9/12	99%	1 - 9	0.5 – 1.2

4. Test of pre-series MRPC1 chambers in the CBM-TOF cosmic setup

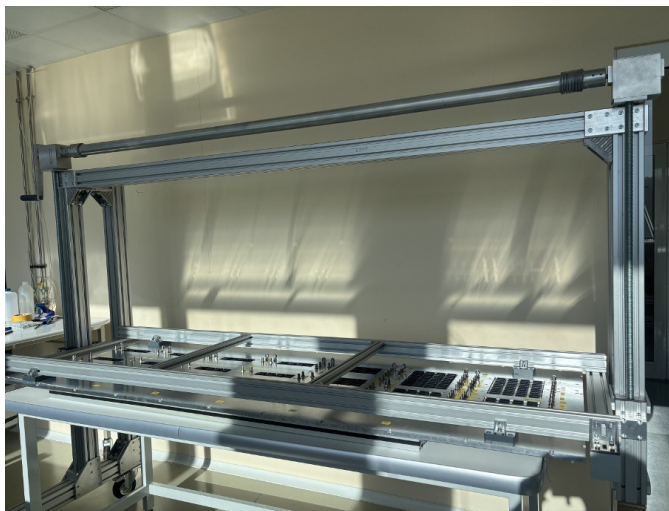


Chamber integration in the (M01) module

First steps:
- manuals



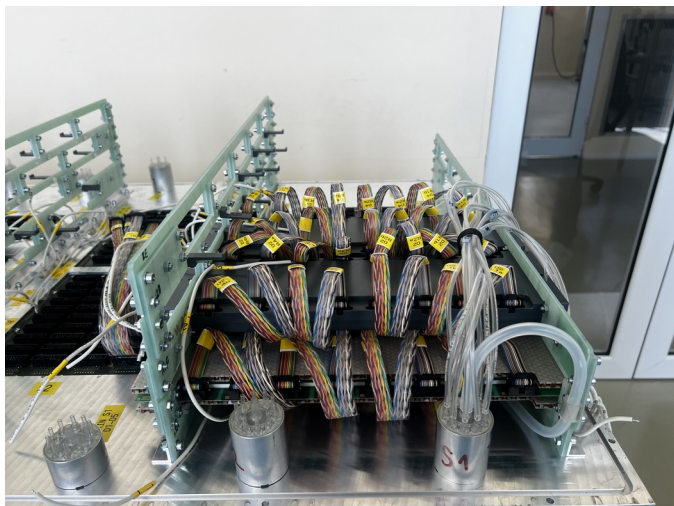
Install in a mobile mechanical support



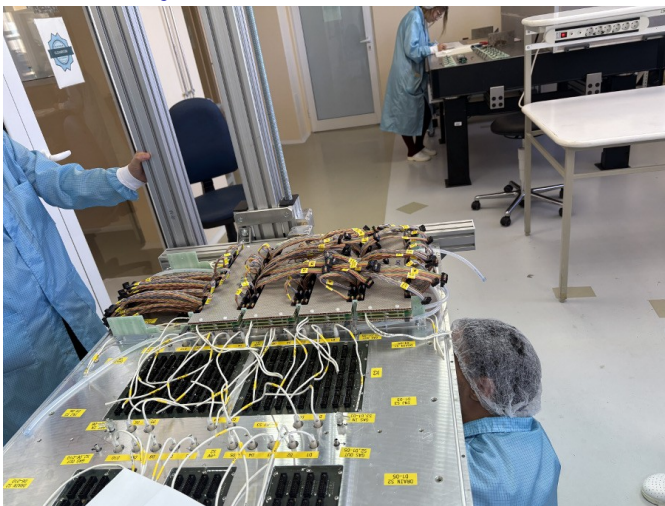
10 MRPC1a chambers



- practice with dummy chambers



First layer of MRPC1a chambers



10 MRPC1a & 3 MRPC1b chambers



Checked signal connectivity

Summary & Outlook

- The MSMGRPC architecture with discrete spacers and direct flow for the CBM-TOF inner zone fulfills the CBM – TOF requirements and provides aging effects mitigation for long term exposure in high counting rate environment.
- The results obtained in the in-beam tests @ mCBM/SIS18, GSI Darmstadt as well as in the cosmic ray CBM-TOF setup in Heidelberg, confirmed the performance of the new architecture in real experimental conditions.
- The assembling of the chambers for the M01 module of the CBM-TOF inner zone is almost ready. Their integration in the first module (M01) is on-going.
- Once finished, it will be transported to GSI Darmstadt for being equipped with CBM-TOF inner wall FEE and tested, first with cosmic rays and later on in-beam.

People involved in the presented activities:

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M. Petris

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D. Bartos

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GSI Darmstadt

Ingo Deppner

Jochen Frühauf

Universität Heidelberg

Esteban Rubio

Norbert Herrmann

Universidad Complutense de Madrid

Cayetano Soneira Landin



XVIII Conference on Resistive Plate
Chambers and Related Detectors

September 14-18, 2026
Rio de Janeiro, Brazil

Thank you for your attention!