Annex 3

To the In-Kind Contract

Between the FAIR GmbH, the Shareholder National Research Authority (ANC) and the Provider IFIN-HH

About the design, prototyping, production, delivery, assembly and commissioning of the chambers of the CBM TOF inner zone
as part of the Work Package PSP 1.1.1.5.3

for the CBM experiment

This Annex is an integral part of the said In-Kind Contract between the FAIR GmbH, NIT and IFIN-HH.

Technical Specifications

The technical specifications for the Provider's Component for Delivery are specified in the:

1. *General Technical Specifications for Experiments at FAIR*
2. *Specific Technical Specifications*

and attached to this document.

In case of discrepancies between the documents listed above, the statements of the *Specific Technical Specification* prevail.

Established in Darmstadt in four originals.

Specific Technical Specifications

Table of Contents

- **Purpose and classification of the document**

The purpose of this document is to specify the detailed technical requirements of all parts of IFIN-HH-HPD to the CBM Time of Flight (ToF). Wherever requirements are specified in the General Specifications and Technical Guidelines they are only referenced in this document. This document belongs to the Technical part of the contract. All commercial and management conditions are not treated here. General regulations and requirements are specified in the General specification and the Technical guidelines. They are only referenced here.

- **Abbreviations, Terms and Definitions**

Abb. Term	Definition
GSI	Helmholtzzentrum für Schwerionenforschung
FAIR	Facility for Antiproton and Ion Research in Europe GmbH
CBM	Compressed Baryon Matter
ToF	Time of Flight System
FAT	Factory Acceptance Test
SAT	Site Acceptance Test
TDR	Technical Design Report
CDR	Conceptual Design Review
PDR	Preliminary Design Review
FDR	Final Design Review

- **Scope of the Technical System**

- **System Overview**

CBM-ToF concept tries to accommodate the different requirements caused by the large range of incident beam energies that need to be covered. The TOF wall has to be operational at beam energies ranging from E_{beam}=2A GeV to E_{beam}=45A GeV. For a forward spectrometer like CBM a planar geometry is advantageous, offering the possibility to adjust to the different beam energies by placing it at different distances to the target. The number of different module types should be kept as low as possible in order to allow for easy exchange and minimal number of spares. In addition keeping the number of different counter sizes small reduces the overall production costs.

The solution is a modular ToF wall consisting of 6 different modules position in x - direction (the deflection plane of the dipole magnet) and that can be adjusted in vertical (y) direction according to the actual distance of the wall in order to minimize dead areas. The schematic design of the CBM - TOF wall as implemented in the simulation environment is shown in Fig.1 projected on a plane orthogonal; to the beam axis and in Fig.2 in a 3D representation, respectively.

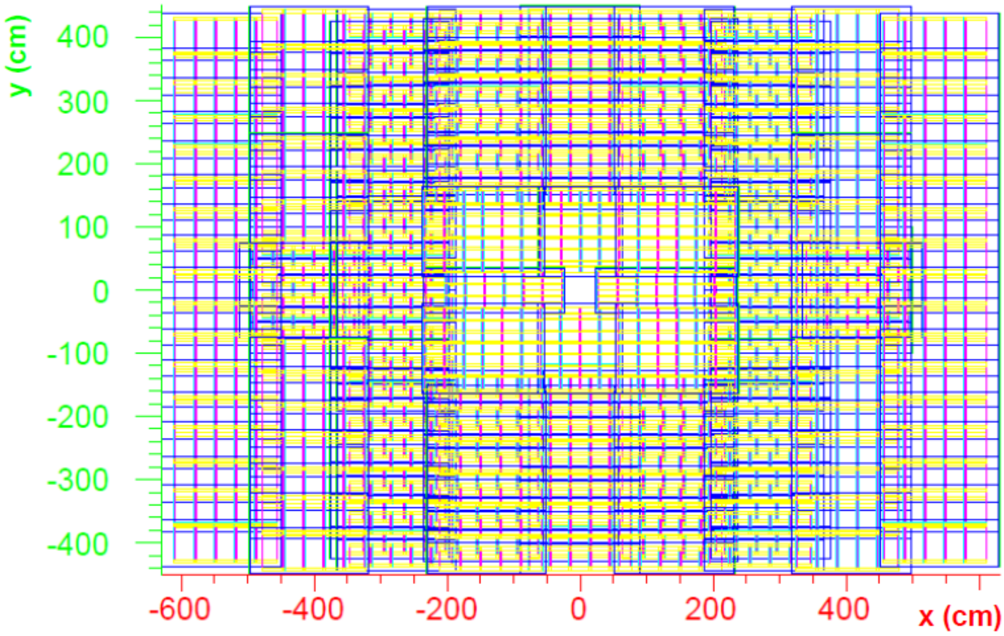


Figure 1: Planar projection of the ToF wall in the xy plane

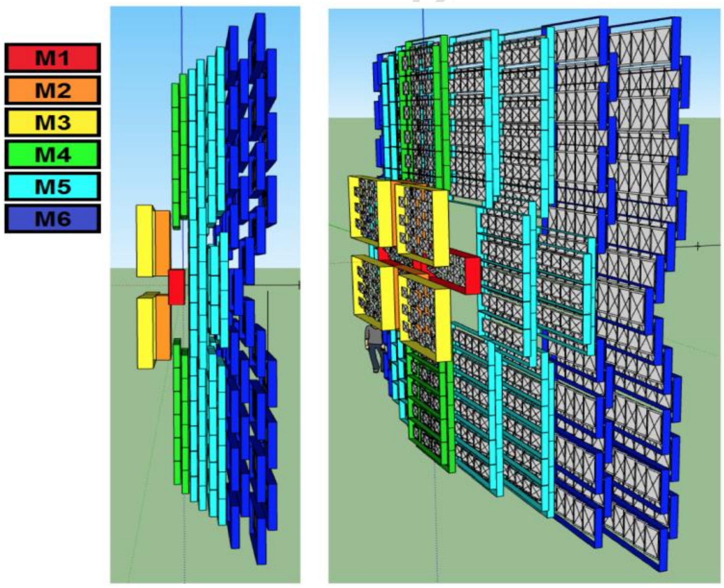
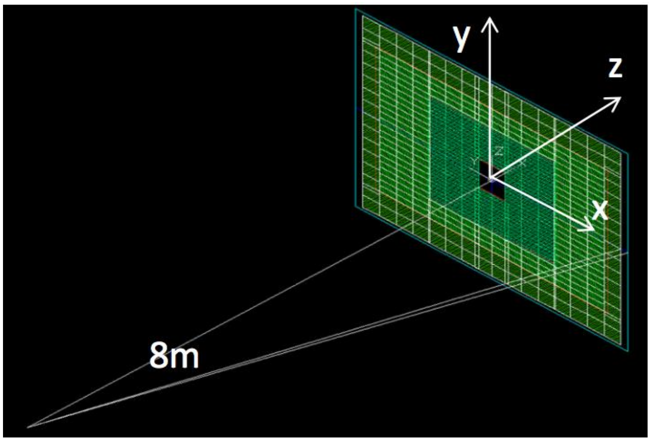


Figure 2: 3D representation of the TofF wall

In the proposed scenario the full wall consists of only 4 different types of MRPC counters that are arranged into 6 different types of modules. These modules are described in detail in Chapter 3 of the CBM-ToF TDR. The inner zone of the CBM-ToF, the subject of the present Contract is presented in Fig3a at 8 m from the target position and Fig.3b is a qualitative representation of the distribution of different type of RPCs within the Inner Wall.



a)

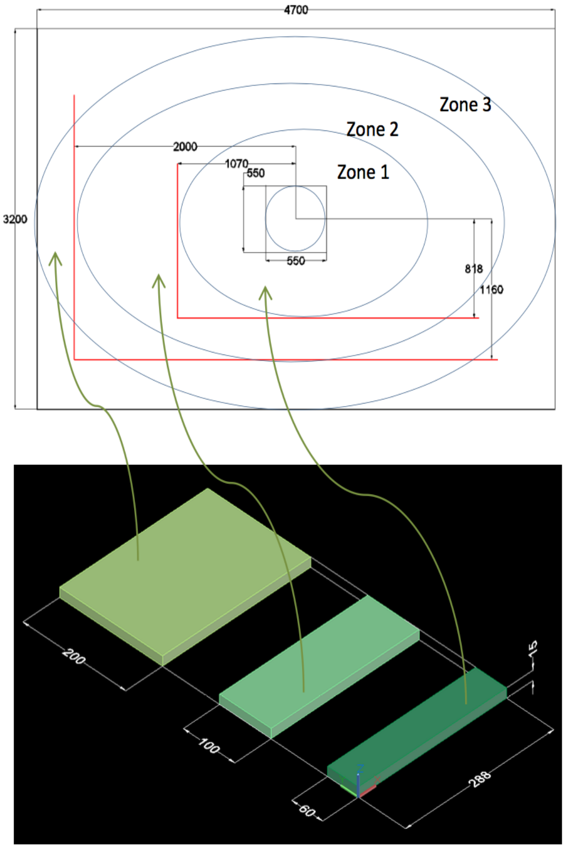


Figure 3: a) The CBM-ToF Inner Wall structure at 8m from the target position

b) A qualitative representation of the distribution of different type of RPCs

within the Inner Wall

The Inner Wall covers the most forward polar angles and is based on 4 type of modules arranged in a geometry which guarantees a continuous coverage of the most forward region with no dead region and minimum overlap of the efficient zones, see Fig.4.

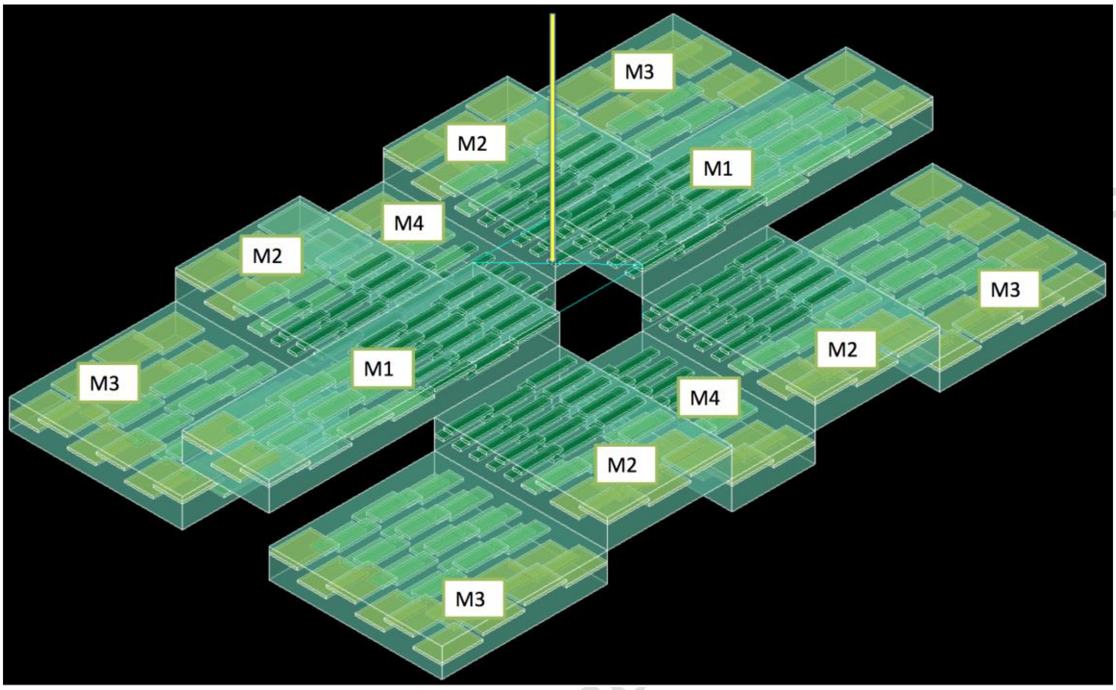


Figure 4: 3D representation of the CBM-ToF Inner zone structure

The structure and contents of the 4 individual modules, the number of the RPC, their type, supports, signal cables and connectors in each type of module can be followed in Fig.5 and Fig.6.

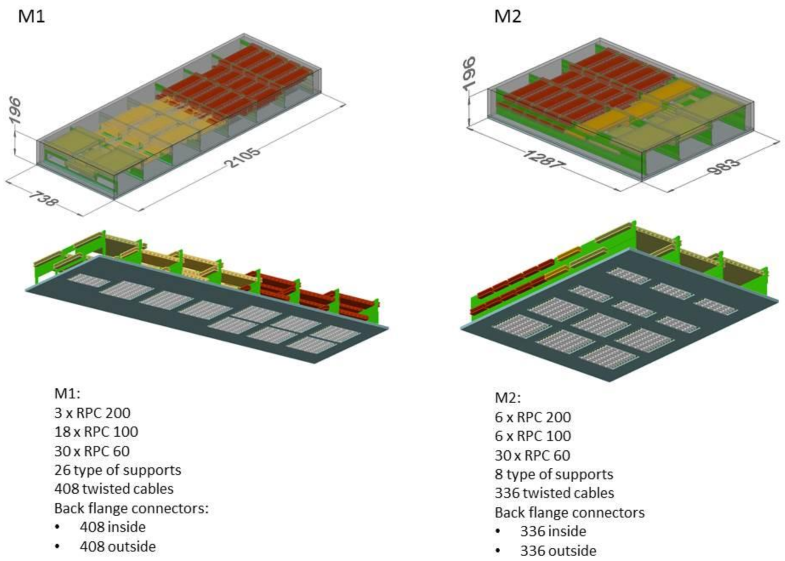


Figure 5: 3D representation of the internal structure of M1 and M2 modules

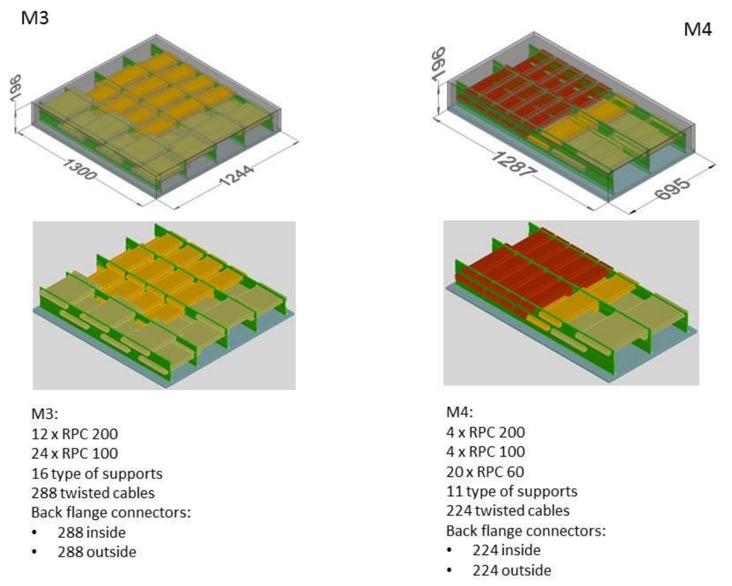


Figure 6: 3D representation of the internal structure of M3 and M4 modules

The breakdown of an RPC components is depicted in Figure 7.

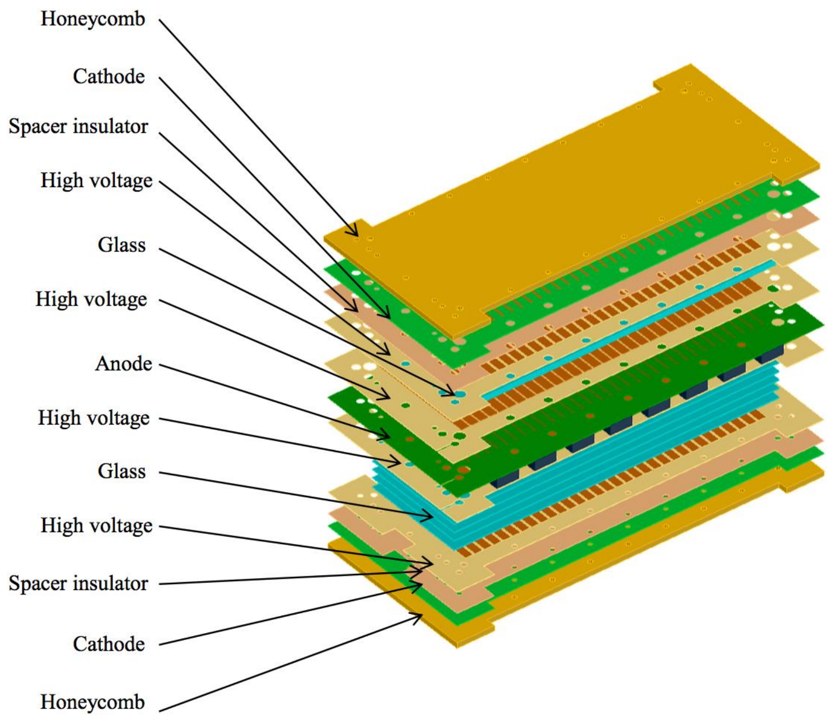


Figure 7: The main components of an RPC

As could be seen in Fig.5 and Fig.6, the RPCs are mounted on an Aluminum back flange using special supports from stesalit. An example on how these supports are mounted on the back flange can be followed in Fig.8.

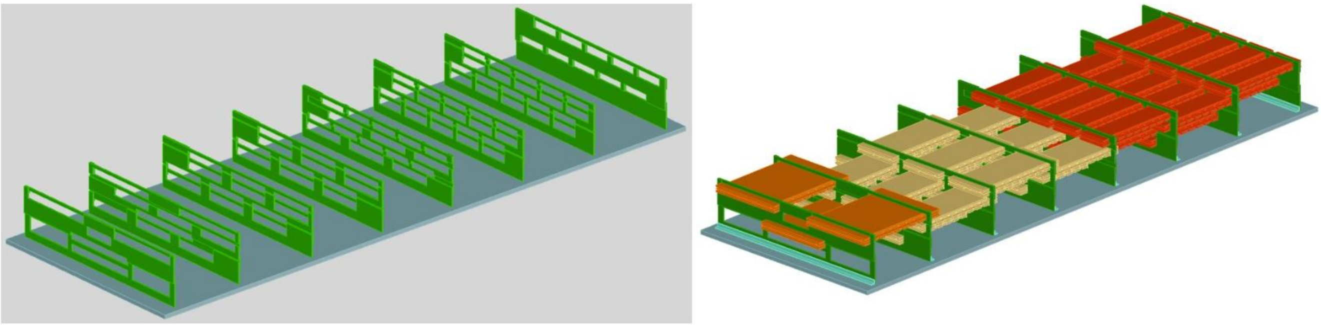
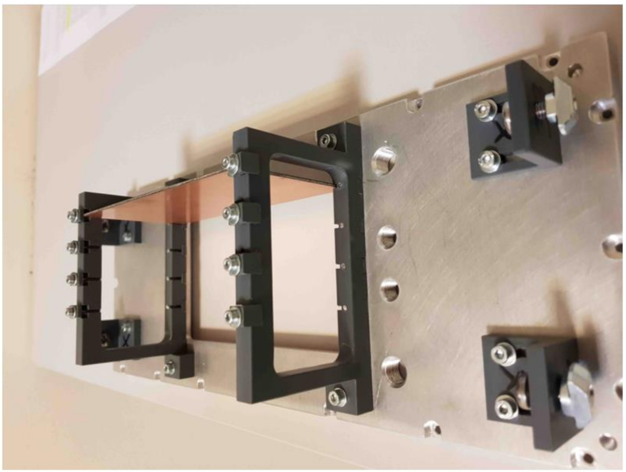


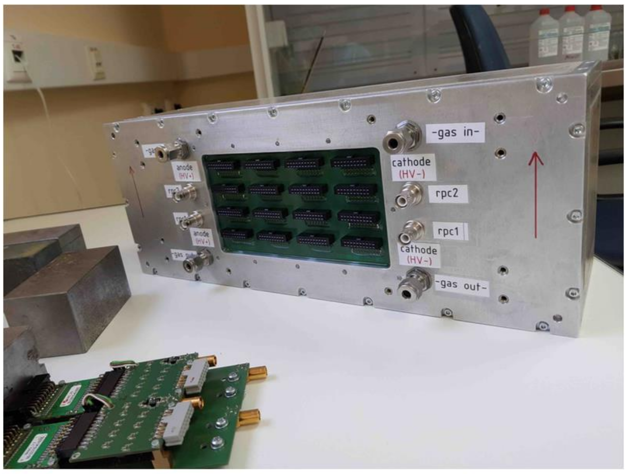
Figure 8: Left: RPC stesalit supports (green) mounted on the Aluminum back-flange (grey); Right: An example how the RPCs are mounted in a module using such supports.

a)



b)

c)



d)

Figure 9: Prototypes of: a) housing box; b) back flange with FEE mechanical supports; c) housing box mounted on the back flange; d) RPC mounted in the housing box with the signal transmission PCB and HV, gas feed through on the back flange.

The housing boxes of the modules are made from honey comb structure in order to reduce at minimum the energy loss of the incoming reaction products and secondary interactions.

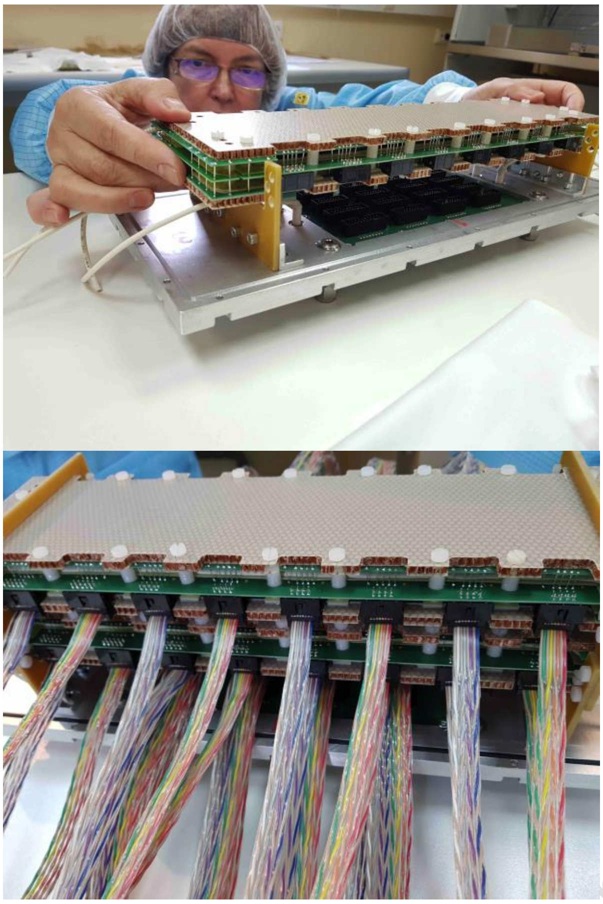
The honey com sheets are sandwiched between two layers of 200 µm stesalit layers the inner side being covered by a Cupper layer for electromagnetic screening of the inner RPC structure. An assembled housing box of the final version of a RPC prototype is presented in Fig. 9a. The tightness relative to the Aluminum back flange (right side of Fig.9a) is made using an O-ring placed in a groove machined at the edge of the Aluminum back flange. On the back side of the Aluminum back flange is mounted the mechanics supporting the FEE (Fig.9b). In Fig.9c is presented the housing box mounted on the Aluminum back flange, before assembling the signals transmission PCB. On the special machined openings of the back flange is glued the PCB with the signal connectors for transmitting the signals fro the inside RPCs to the FEE (Fig.9d).

The low resistivity glass plates upon arrival pass a preliminary optical quality acceptance and are stored in special boxes which placed in a super dray cabinet in the clean area of the HPD DetLab, see Fig.10.

Fig.10. Left: Special boxes used to store the glass plates passing a preliminary optical QA upon arrival from producer; Right: Boxes with the glass plates in are stored in a super dry cabinet in the clean DetLab where the RPC assembling with take place.

a) b) c)

Fig.11: a) optical inspection; b) last cleaning before assembling using a N_2 jet; c) distribution of
The spacer along the strips direction



a) b)

Fig.12: a) mounting the RPC on the Aluminum back flange using the stesalit supports.
b) cabling the RPC signals and HV

The main steps of assembling activities are summarized in Fig 11 and Fig.12. Before assembling, a careful optical inspection is performed (Fi.11a) and the glass plates are cleaned once more using a spray of pure and dry N_2 (Fig.11b). All the details of assembling will be presented in a dedicated assembling manual. The distribution of the spacers for a given gas gap cen bi followed in Fig.11c.

Once the whole RPC is assembled, it becomes a standalone object and will be mounted on the back flange using the special stesalit supports presented above (Fig.12a). After that are cabled the special signal flat cables between the connectors mounted on the RPC electrodes and the connectors placed on the PCB glued on the Aluminum back flange (Fig.12b). The preliminary tests after mounting each RPC will be described in a dedicated manual.

Fig.13: a) Special device for transporting the modules from the assembling site (clean area) to the TestLab; b) an example of the mechanical structure assembled on a 2D scanning table for the final tests on the HPD site.

Once the RPCs are mounted in the moduls and the modules are closed, they will be transported using a dedicated device (Fig.13a) from the clean area to a dedicated TestLab (Fig.13b and Fig.14)

Deliverable Quantity (to be completed - Mariana, Victor, Laura)

Deliverable	**Quantity**	**Comment**
RPC	**470 RPCs**	**220 RPC60, 164 RPC100, 86 RPC200**
Honeycomb plates of 5 mm thickness	940 pieces	
High voltage electrodes	1880 pieces	
Cathode readout electrodes	940 pieces	
Anode readout electrodes	470 pieces	
Signal connectors mounted on RPCs	7520 pieces	
Signal cables (twisted pair)	3760 pices	
Modules	**12 boxes**	
Back panels	12 plates	
Connectors	7520 pieces	

PCB plates for connectors	148 plates	
Mechanical supports for RPCs assembling in modules	170 pieces	
Mechanical support of Inner Wall		
Tools for the Inner Wall assembling in the CBM experiment		

- **Functional and Technical Specification**

IFIN-HH will contribute to the CBM-ToF Inner zone detector with the following components and tasks.

- **CBM-ToF Inner zone components**

- **Assembly and tests on IFIN-HH-HPD site of CBM-ToF Inner Wall modules**

- **Mechanical structures and cabling, unit assembly, high voltage powering, gas distribution**

Excellent clean-room and test facilities, highly skilled personnel, previous successful contribution at large scale experiments as ALICE and last but not least essential contribution in developing high counting rate MGMSRPCs make HPD of IFIN-HH the natural place for producing and testing of the Inner Wall of the CBM ToF detector. A general view of the HPD DetLab infrastructure with the location of present or foreseen activities related to CBM is presented in Fig. 14.

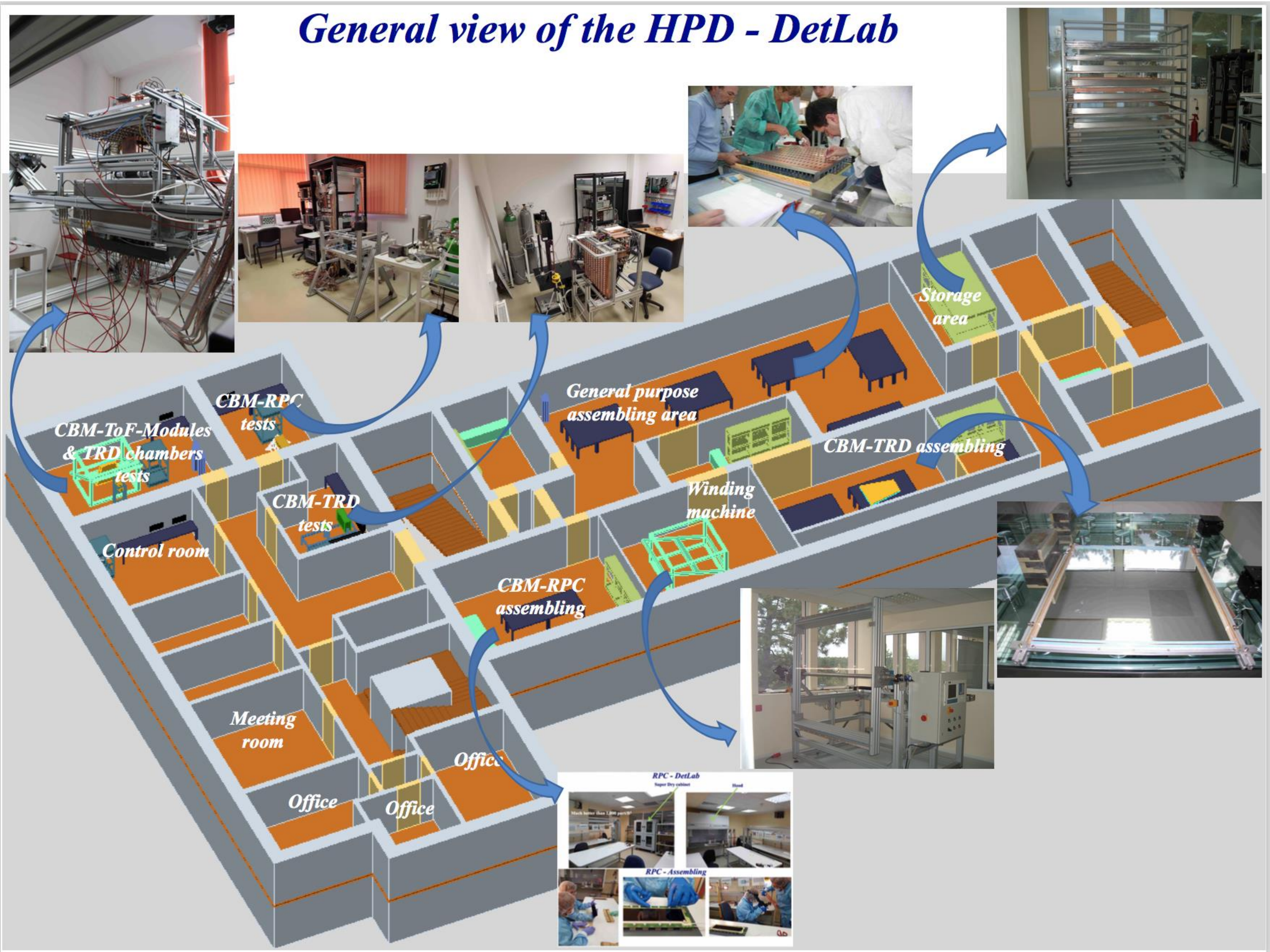


Fig.14 A general view of the HPD DetLab infrastructure with the location of present or foreseen activities related to CBM

- **References**

[1] Multistrip,Multigap,Symetric RPC
M.Petrovici
VI Workshop on Resistive Plate Chambers and Related Detectors, Coimbra, Portugal, 26-27 November, 2001

[2] Large - area glass-resistive plate chamber with multistrip readout
M. Petrovici, N. Herrmann, K.D. Hildenbrand, G. Augustinski, M. Ciobanu, I.Cruceru, M. Duma, O. Hartmann, P. Koczon, T. Kress, M. Marquardt, D. Moisa, M. Petris, C. Schroeder, V. Simion, G. Stoicea, J. Weinert
Nuclear Instruments and Methods in Physics Research A 487(3):337-345, (Jul 21 2002)

[3] Multistrip Multigap Symmetric RPC
M. Petrovici, N. Herrmann, K.D. Hildenbrand, G. Augustinski, M. Ciobanu, I.Cruceru, M. Duma, O.
Hartmann, P. Koczon, T. Kress, M. Marquardt, D. Moisa, M. Petris, C. Schroeder, V. Simion, G.
Stoicea, J. Weinert
Nuclear Instruments and Methods in Physics Research A 508 (1-2):75-78(Aug 2003
[4] Time Resolution of Radiation Hard Resistive Plate Chambers for the CBM Experiment at FAIR
D.Bartos, G.Caragheorgheopol, F.Dohrmann, K.D.Hildenbrand, B.Kampfer, R.Kotte, L.Naumann,
M.Petris, M.Petrovici, V.Simion, M.C.S.Williams, J.Wustenfeld
IEEE Dresden 19-25 October 2008
[5] Strip Readout RPC Based on Low Resistivity Glass Electrodes
M.Petris, M.Petrovici, V.Simion, D.Bartos, G. Caragheorgheopol, F. Dorhmann, K.D. Hildenbrand,
B. Kaempfer, R. Kotte, L. Naumann, D. Stach, M.C.S. Williams, J. Wuenstenfeld
Rom. Journ. Phys.56:349-358, 2011
[6] A Multi-strip Multi-gap RPC Barrel for Time-of-Flight Measurements
M.Kis, M.Ciobanu, I.Deppner, K.D.Hildenbrand, N.Herrmann, T.I.Kang, Y.J.Kim, P.Koczon,
Y.Leifels, M.Marquardt, M.Petrovici, K.Piasecki, M.S.Ryu, A.Scuttauf, V.Simion, J.Weinert,
X.Zhang, Nucl.Instr. and Meth. in Phys.Res. A646(2011)27
[7] Toward a high granularity and high counting rate, differential readout timing MRPC
M. Petris, M. Petrovici, V. Simion, D. Bartos, G. Caragheorgheopol, I. Deppner, K. Doroud, N.
Herrmann, M. Kiss, P. Loizeau, Y. Zhang, M.C.S. Williams
Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers,
Detectors and Associated Equipment, Vol. 661, Suppl.1, 1 January 2012, S129-S133
[8] The CBM time-of-flight wall
I. Deppner, N. Herrmann, D. Gonzalez-Diaz, V. Ammosov, J. Cheng, M. Ciobanu, V. Gapienko,
K.D. Hildenbrand, A. Kiseleva, M. KiÅ¡, D. Kresan, R. Kotte, C. Huangshan, Y. Leifels, J.
Fruehauf, C. Li,Y. Li, P.-A. Loizeau, L. Naumann, M. Petrovici, M. Petris, A. Semak, V. Simion,
D. Stach, Y. Sun, Yu. Sviridov, Z. Tang, E. Usenko, J. Wang, Y. Wang, K. Wisniewski, J.
Wuenstenfeld, L. Xu, V. Zaets, Y. Zhang, X.Zhu
Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers,
Detectors and Associated Equipment, Vol. 661, Suppl.1, 1 January 2012, S121-S124, 2012
[9] High counting rate, two-dimensional position sensitive timing RPC
M.Petrovici, M.Petris et al. Journal of Instrumentation Volume 7 Nov. 2012 (JINST 7 P11003)

[10] Multi-Strip RPC for high counting rate experiment
M. Petris and M. Petrovici, Journal of Physics: Conference Series, Volume 533, 012009, 2014
[11] The CBM Time-of-Flight wall — a conceptual design
I. Deppner, N Herrmann, A Akindinov, D Bartos, A Balaceanu, S Belogurov, P Cao, G Caragheorgheopol, H Chen, J Cheng, M Ciobanu, F Constantin, Z Deng, H Deppe, V Duta, H Fan,
H Flemming, J Frühauf, J Gebelein, K Heidel, K Hildenbrand, U Kebschull, M Kiš, S Kiselev, K
Koch, P Koczon, R Kotte, A Laso Garcia, J Lehrbach, C Li, Y Li, P -A Loizeau, P Lv, D
Malkevich, S Manz, L Naumann, A Nedosekin, W Niebur, A Oancea, M Petris, M Petrovici, V
Plotnikov, M. Prokudi, L Radulescu, M Shao, V Simion, C Simon, R Sultanov, Y Sun, Z Tang, Y
Wang, J, Wüstenfeld, C Xiang, N Xu, Y Zhang, D Zhou and X Zhu
2014 JINST 9 C1001 2014
[12] Technical Design Report for the CBM Time-of-Flight System (TOF),
CBM-TOF Collaboration, Report No.: GSI-2015-01999, 2015
[13] Prototype with the basic architecture for the CBM-TOF inner wall tested in close to real conditions
M. Petris, D. Bartos¸, G. Caragheorgheopol, F. Constantin, M. Petrovici, L. Radulescu, V. Simion ,
I. Deppner, N. Herrmann, C. Simon , J. Fruhauf, M. Kis, P-A. Loizeau
Journal of Physics: Conference Series 724 (2016) 012037
[14] A Method to Adjust the Impedance of the Signal Transmission Line in a Multi-Strip Multi-Gap
Resistive Plate Counter
D. Bartos¸ M. Petris¸ M. Petrovici, L. Rădulescu, V. Simion
Romanian Journal of Physics 63, 901 (2018)

Authorised to sign on behalf of the FAIR GmbH

Name: Prof. Dr. Thomas Nilsson
Position: Chairman of the Management Board/Scientific Managing Director
Date:
Signature:

Name: Dr. Katharina Stummeyer
Position: Administrative Managing Director
Date:
Signature:

Authorised to sign on behalf of the Shareholder (National Research Authority) Institute of Atomic Physics (IFA)

Name: Dr. Florin-Dorian BUZATU
Position: Director
Date:

Signature:

Authorised to sign on behalf of Horia Hulubei National Institute of Physics and Nuclear Engineering (IFIN-HH)

Name:
Position: Director
Date:

Signature:

Name:
Position: Director
Date:

Signature:

Authorised to sign on behalf of the CBM Collaboration,
To certify that the CBM Collaboration agrees with this In-Kind Contract
Name: Prof. Dr. Tetyana Galatyuk
Position: CBM Spokesperson
Date:
Signature: