MINISTERUL CERCETĂRII ȘI INOVĂRII

Proiect NUCLEU PN 19 06 01 03

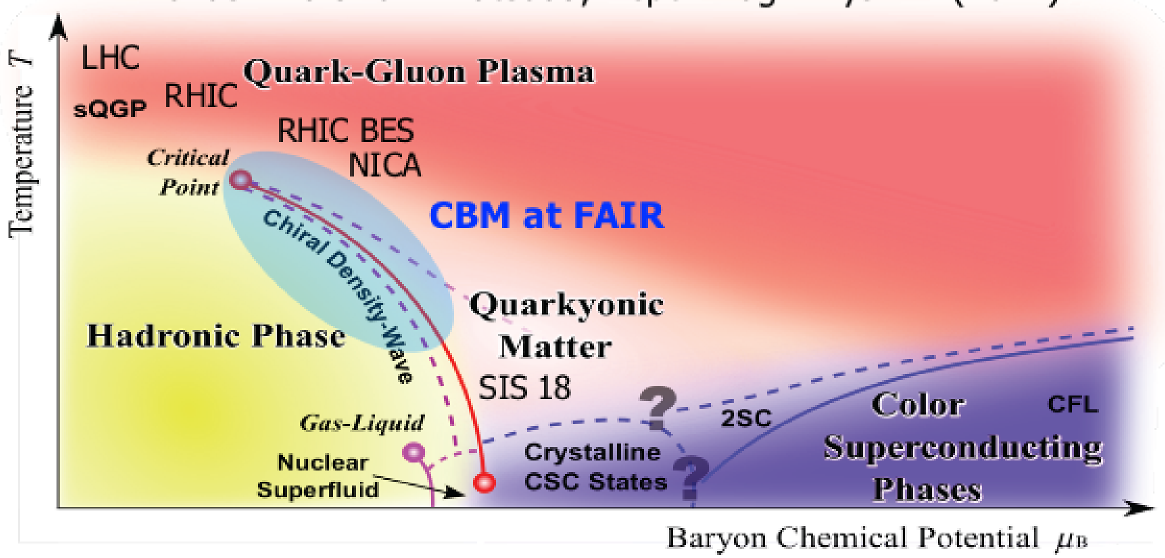
Raport de etapa nr. 4

Proiectarea si realizarea a doua prototipuri de MSMGRPC, simulari APLAC ale impedantei liniei de transmisie, proiectarea zonei interne a subdetectorului de timp de zbor al CBM bazat pe detaliile constructive ale acestora (partea II)

Mariana Petris, DFH Seminar, 04.12.2019

Mapping the phase diagram with CBM

K. Fukushima and T. Hatsuda, Rept. Prog. Phys. 74 (2011)



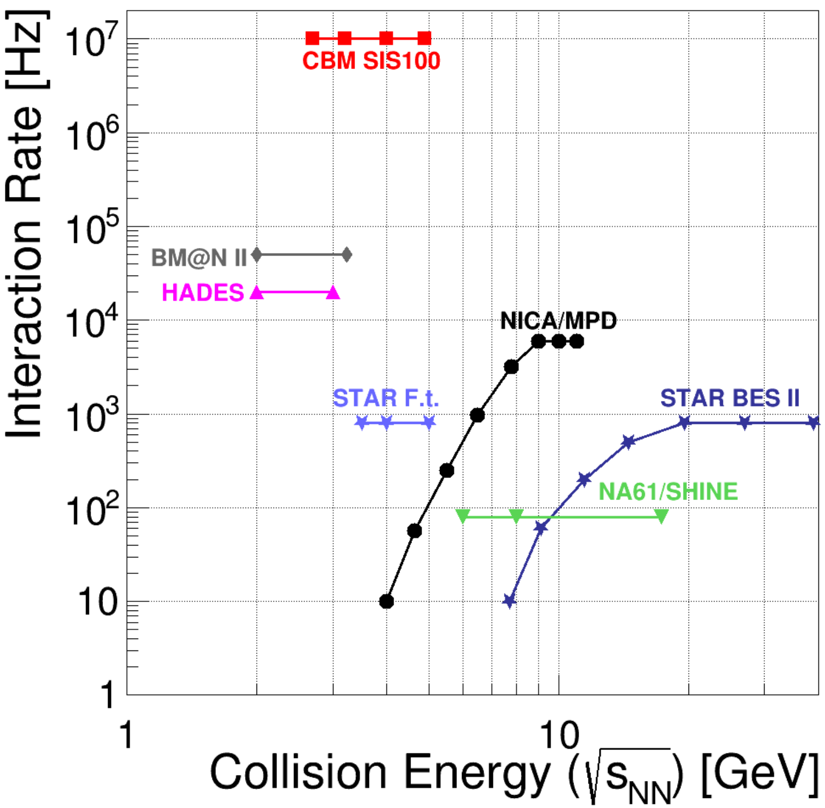
CBM aims to investigate strongly interacting matter in the region of high net baryon densities.

Investigation of:

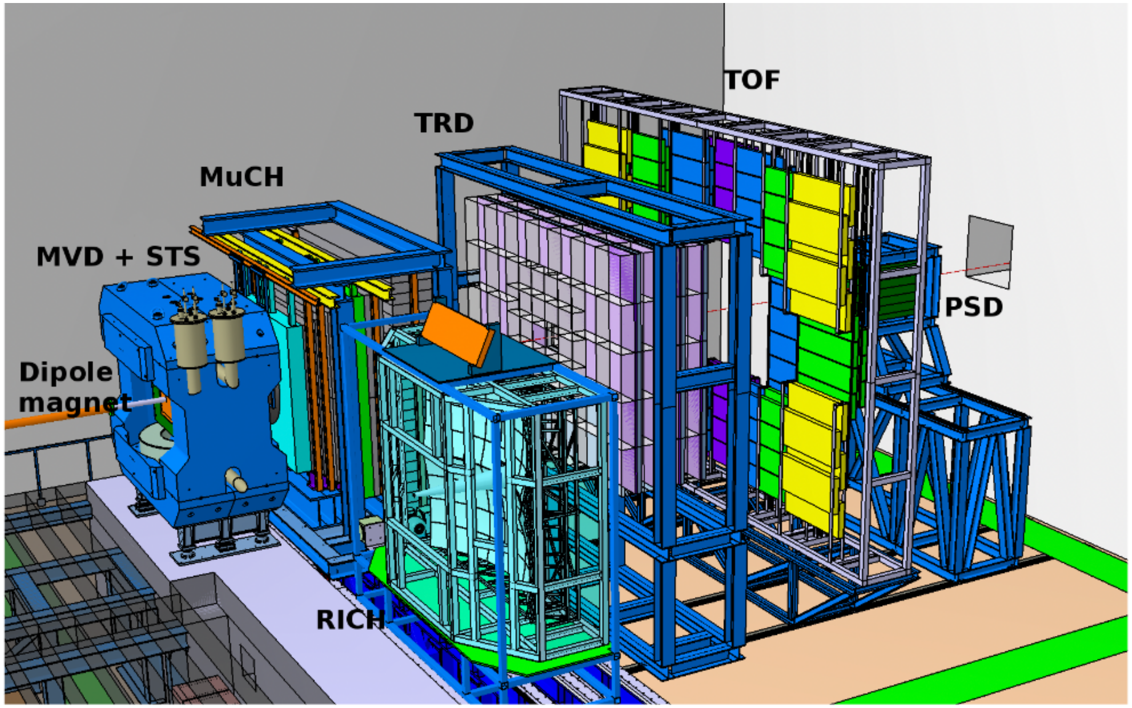
- **equation of state at high baryonic densities (neutron star core densities)**
- **hadronic – partonic phase transition and its type**
- **possible critical point predicted by QCD**

SIS100 Beam	Plab, max	$\sqrt{(s_{NN,max})}$
Heavy ions (Au)	11A GeV	4.7 GeV
Light ions (Z/A=0.5)	14A GeV	5.3 GeV
protons	29 GeV	7.5 GeV

Experiments exploring dense QCD matter



CBM experiment @ SIS100/FAIR



CBM will perform comprehensively high precision measurements of rarely produced observables. Multi-differential studies of rare probes (<1 particle per million events) require unprecedent statistics. Opens up new possibilities!

- ✓ **Hadrons in dense baryonic matter and possible modification of their properties;**
- ✓ **Charm production at threshold beam energies and its properties in dense baryonic matter.**

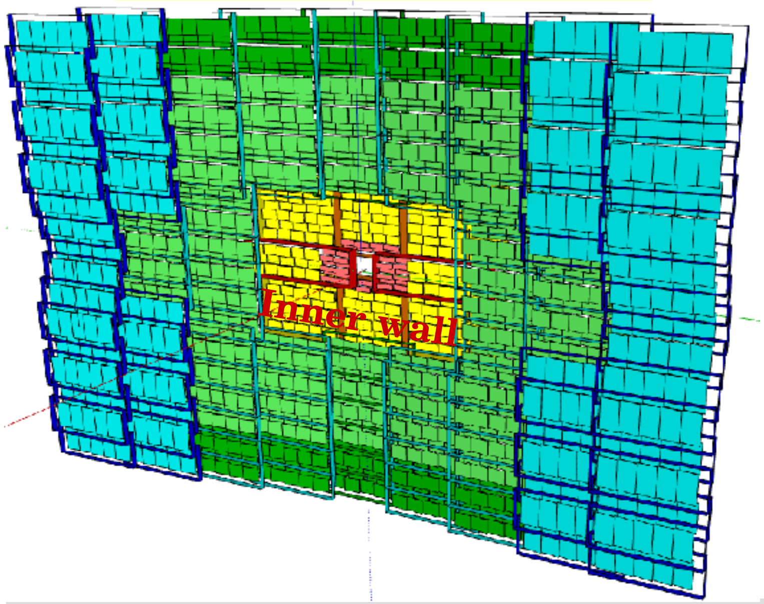
CBM Collaboration, Eur. Phys. J. A (2017) 53: 60

CBM: is a high rate experiment!

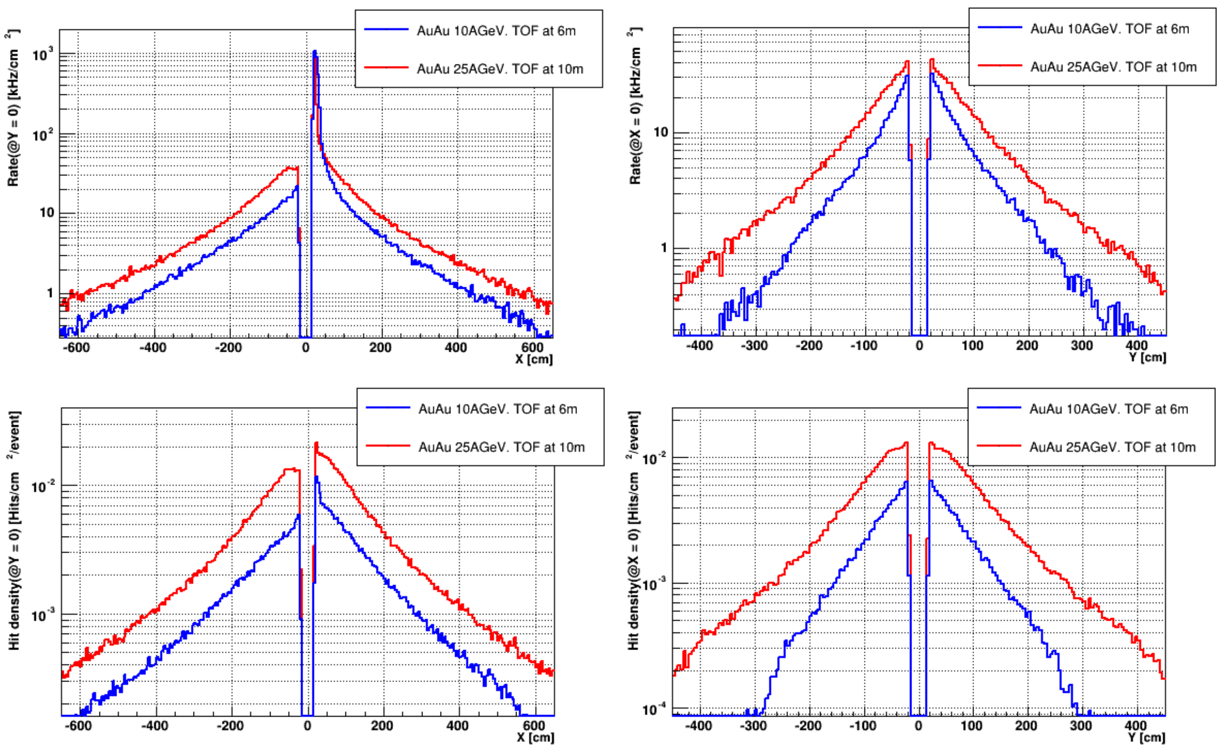
- **Fast, radiation hard detectors and front-end electronics.**
- **Novel readout system:**
  - **Free-streaming readout,**
  - **detector hits with time stamps,**
  - **4-D (space+time) event reconstruction.**
- **High speed data acquisition & performance computing farm for on-line event selection.**

CBM – TOF requirements

CBM-TOF modular structure



URQMD simulated charged particle flux from Au + Au events for an interaction rate of 10 MHz



<u>CBM-ToF Requirements:</u>

- **Full system time resolution σ_T ~ 80 ps**
- **Efficiency > 95%**
- **Rate capability ≤ 30 kHz/cm²**
- **Polar angular range 2.5° – 25°**
- **Active area of 120 m²**
- **Occupancy < 5%**
- **Low power electronics (~120.000 channels)**
- **Free streaming data acquisition**

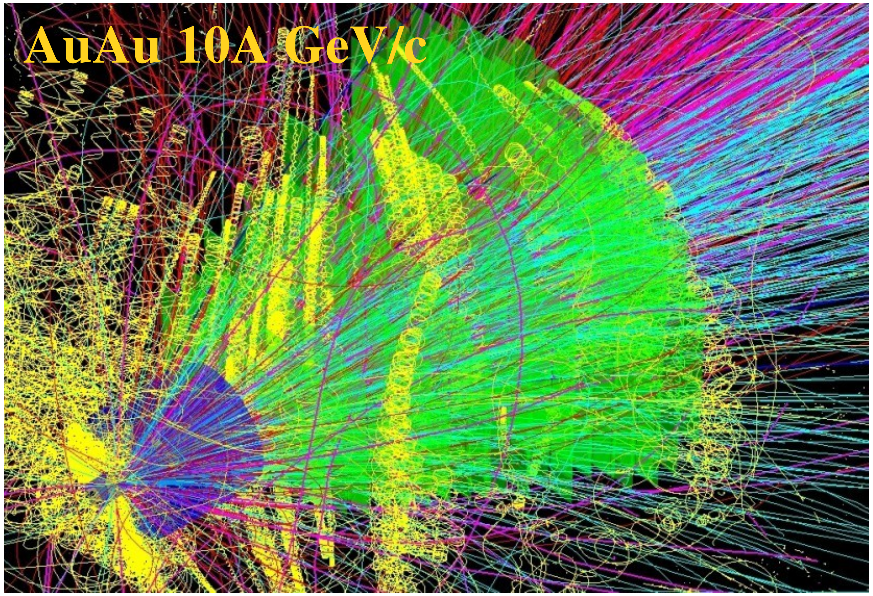
CBM Collaboration, "CBM – TOF Technical Desing Report", October 2014

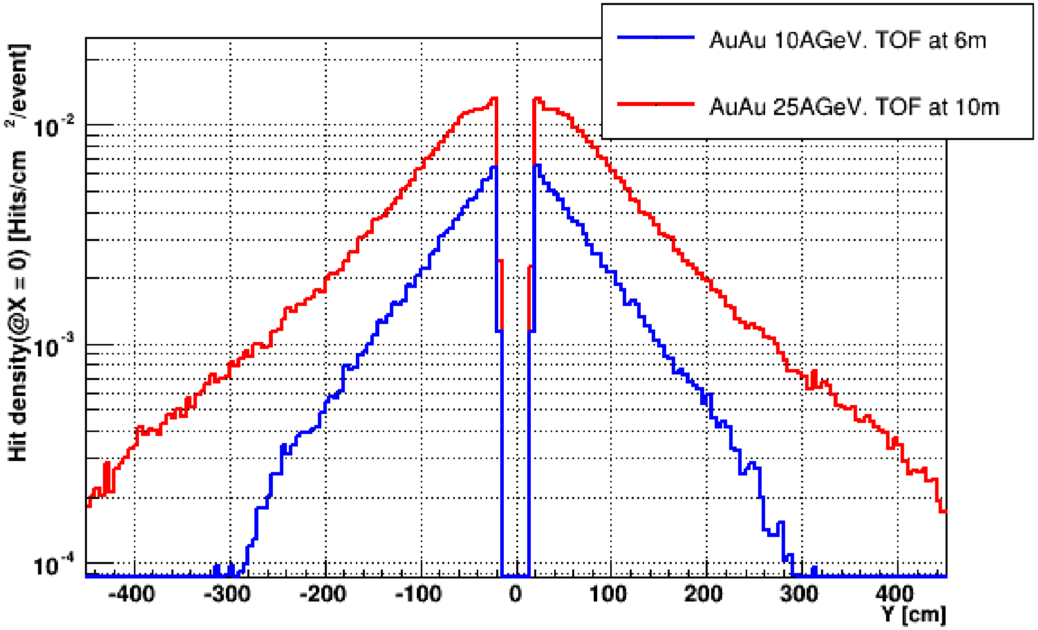
Detectors with different rate capabilities and granularities are needed as a function of polar angle

<u>Our R&D activity addresses the CBM-TOF inner wall:</u>

- highest counting rate
- highest granularity
- ~15 m² active area (2.5^0 – 12^0 polar angle)

Strip length calculation
for the highest granularity of the CBM-TOF wall





- occupancy = 5%
- maximum hit density= 0.6×10^{-2} cm^{-2}
- strip pitch = 0.72 cm
- average cluster size = 1.8 strips

→ **6 cm strip length for the counter with the highest granularity**

- **Calcule pentru o impedanta de 100 Ohm a liniei de transmisie a semnalului pentru 140 µm spatiu intre electrozii rezistivi folosind software-ul APLAC**

New RPC2018 prototype design

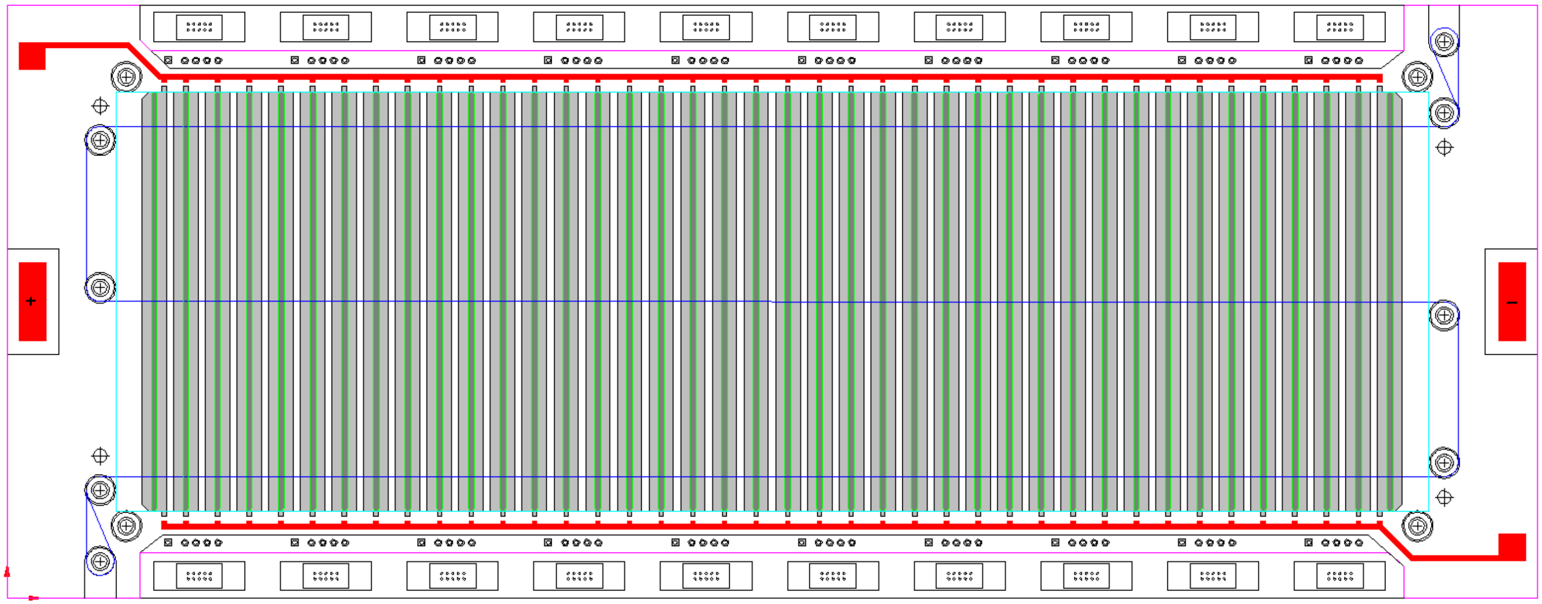
Motivation

RPC2015 prototypes:

- ***SS. 10.1 mm strip pitch – 28 operated strips out of 28 – 100% active area***
- ***DS. 7.2 mm strip pitch – 32 operated strips out of 40 – 80% active area***

✓ ***In order to fulfill the requirement to have modulo 32 readout strips compatible with 32 channels FEE baseboard***

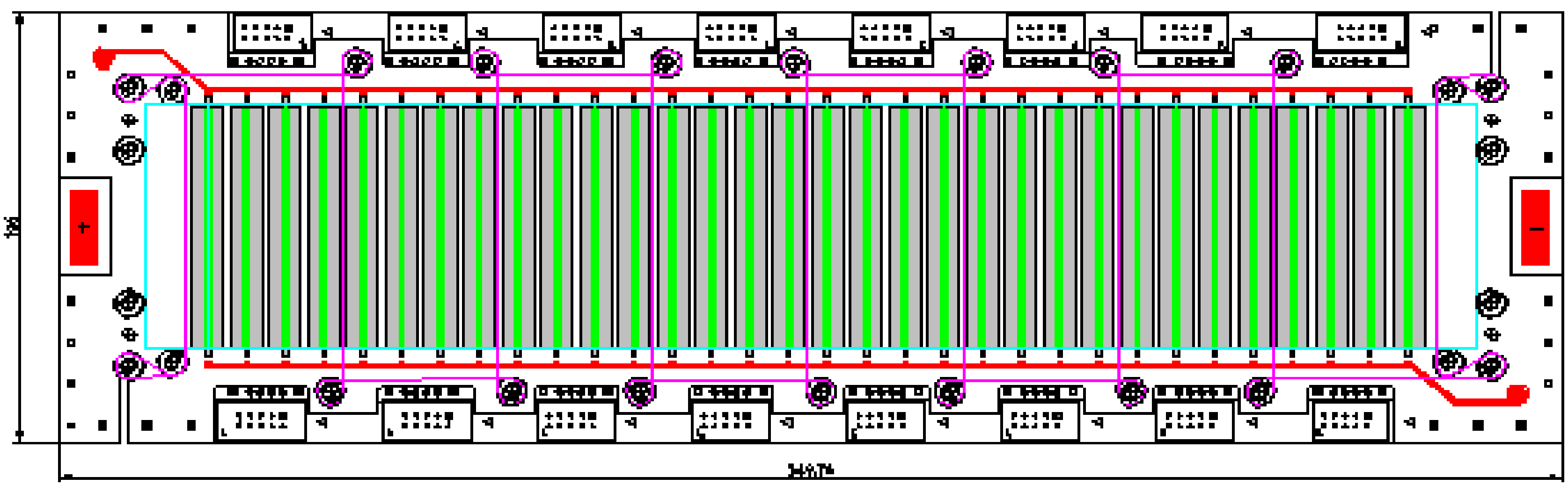
From RPC2015 to RPC2018 prototype



RPC2015

Readout electrode: 7.2 mm pitch= 1.3 mm width + 5.9 mm gap

High Voltage electrode: 7.2 mm pitch= 5.6 mm width + 1.6 mm gap



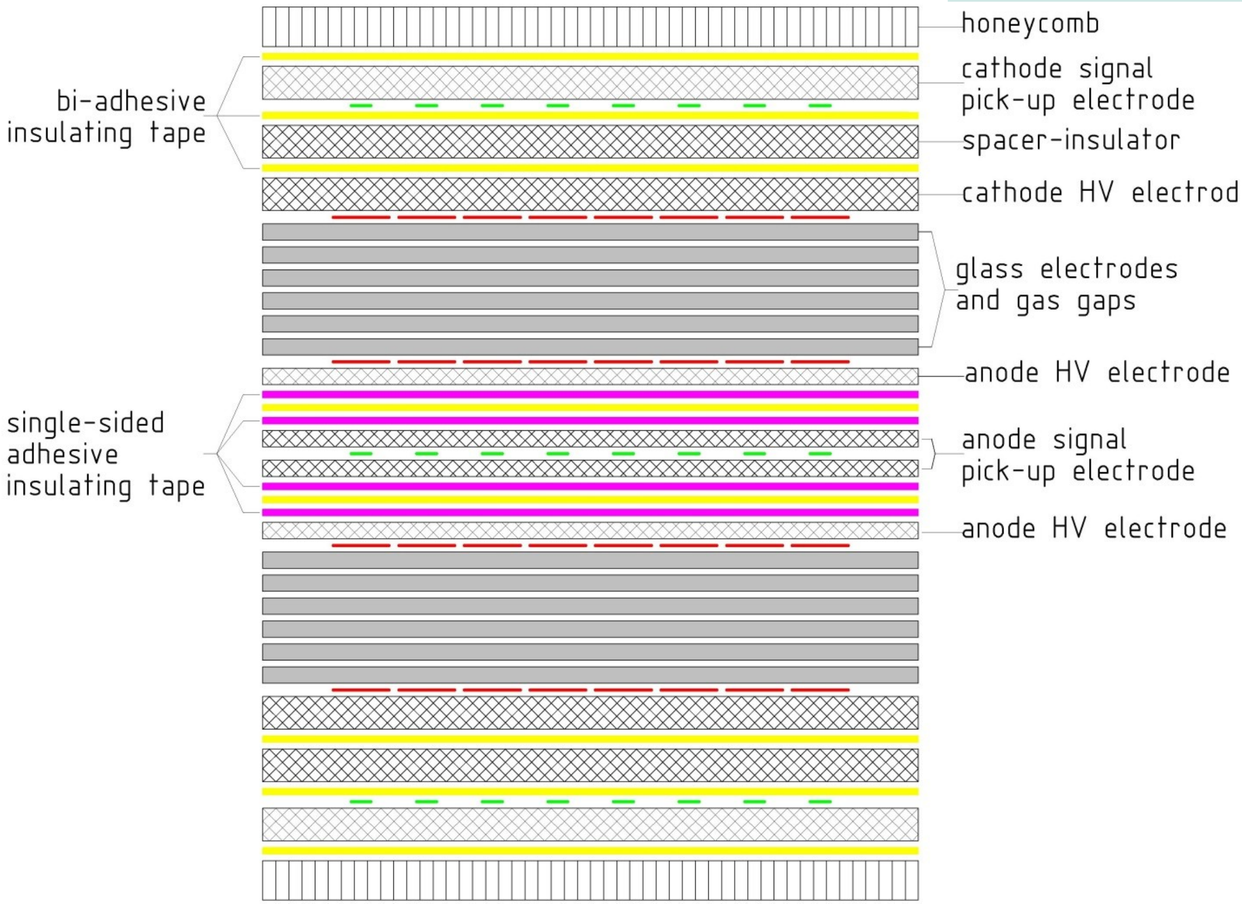
RPC2018

Readout electrode: 9.02 mm pitch= 1.27 mm width + 7.75 mm gap

High Voltage electrode: 9.02 mm pitch= 7.37 mm width + 1.65mm gap

Signal transmission line impedance in MSMGRPCs

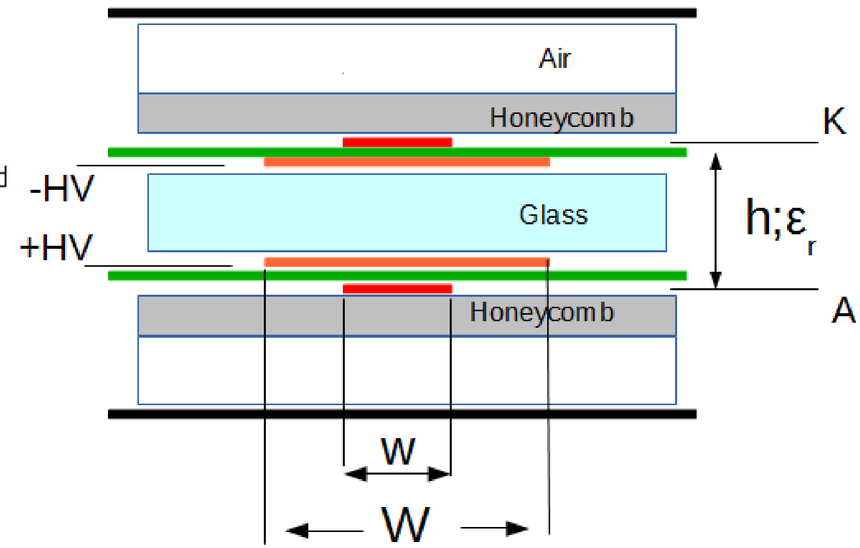
Double stack, strip readout, multigap, timing RPC concept - MSMGRPC



APLAC predicted ~100 Ω for

1.27/7.4 mm readout/HV strip width

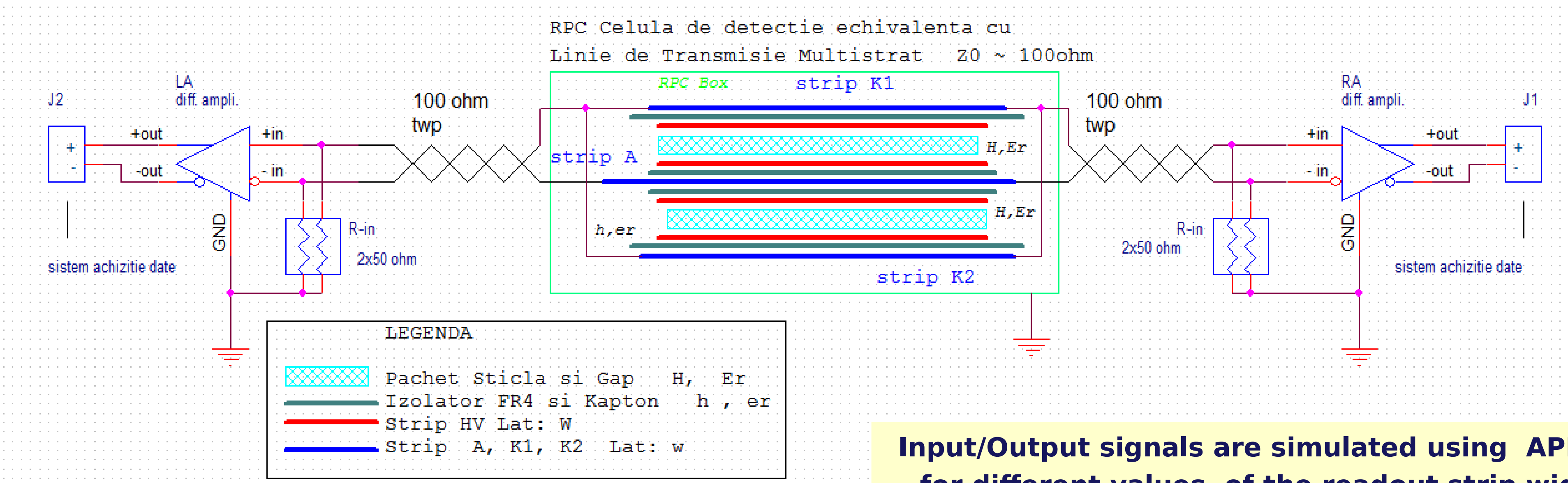
- **The overlapped readout strips and the materials in between define a signal transmission line (STL)**
- **STL impedance Z_0 depends on the readout strip width and the properties of the material layers in between**
- **APLAC software used for impedance estimations**



w = readout strip width
W = high voltage strip width
h = equivalent dielectric thickness
ε = equivalent dielectric constant

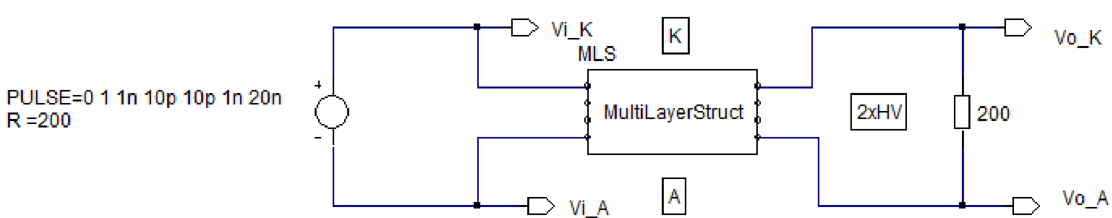
$$Z_0 = \sqrt{\frac{L'}{C'}}$$

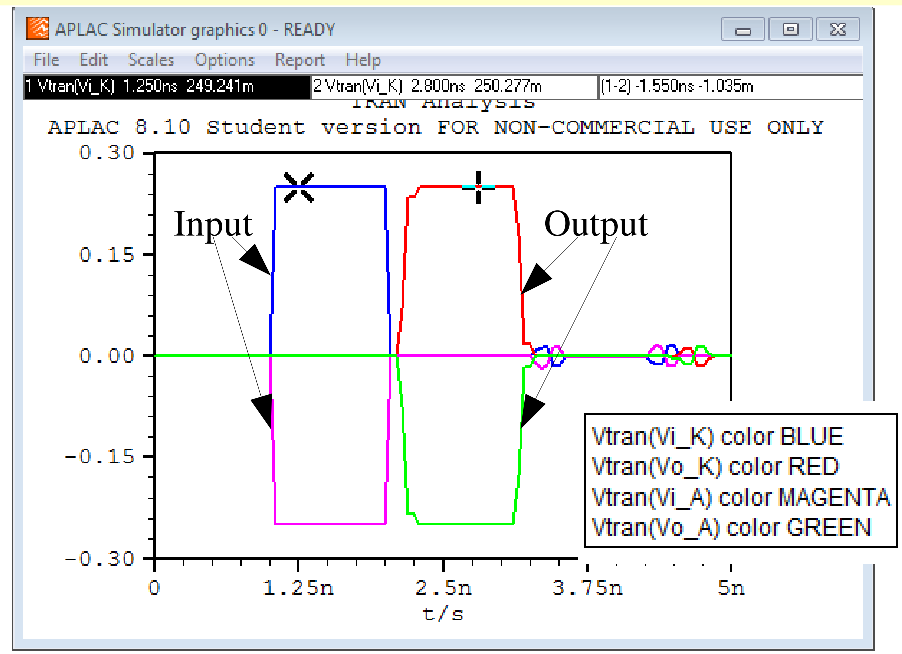
APLAC simulations for the characteristic impedance of the MSMGRPC transmision line impedance



Input/Output signals are simulated using APLAC for different values of the readout strip width

Simulation scheme for one stack





If R = Z_0 = Z_L the transmission line is matched;

Z_0 = characteristic impedance of a transmission line

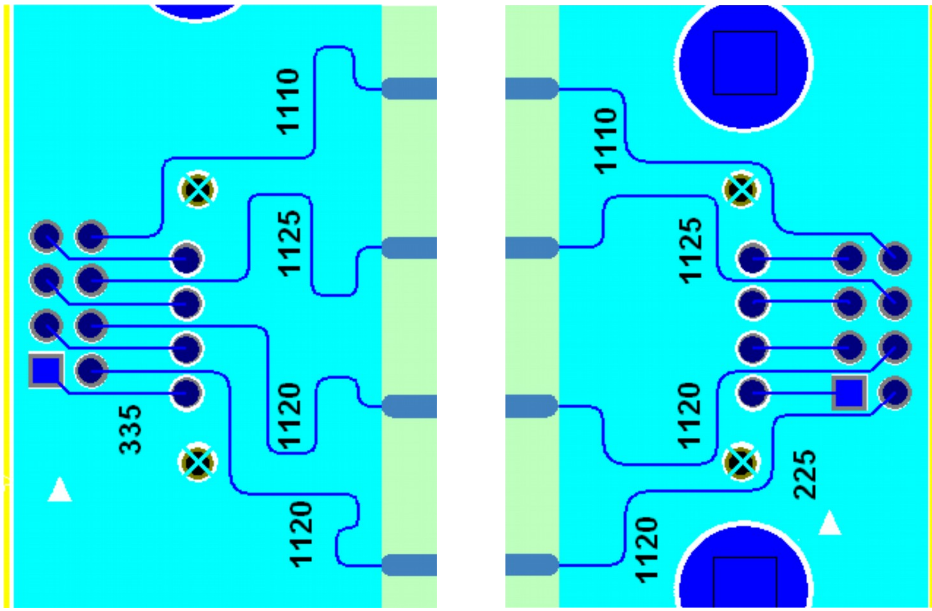
Z_L = load resistor connected to the transmission line

R = internal resistance of the pulse generator

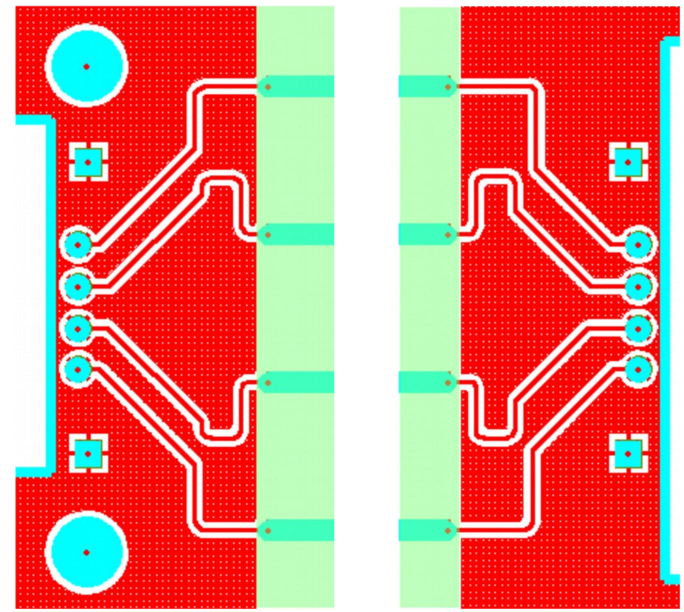
D. Bartos et al. Romanian Journal of Physics 63, 901 (2018)

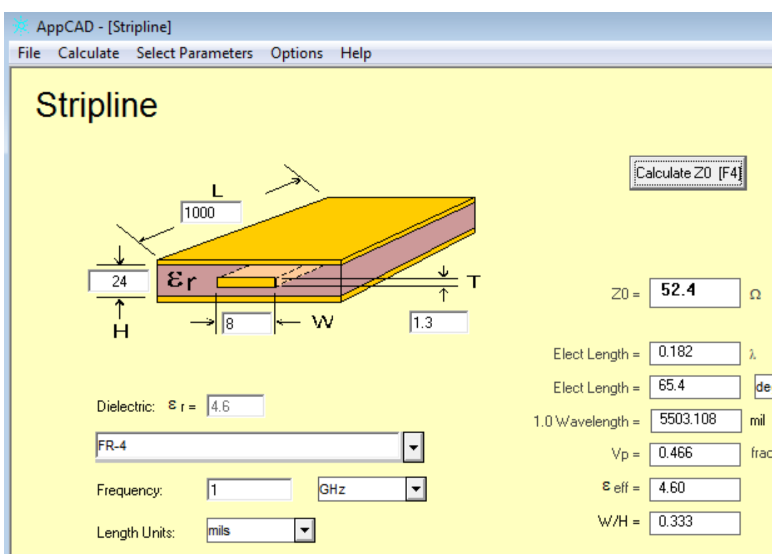
Calculations of the length of the traces for the transmission of the anode and cathode signals to the connectors

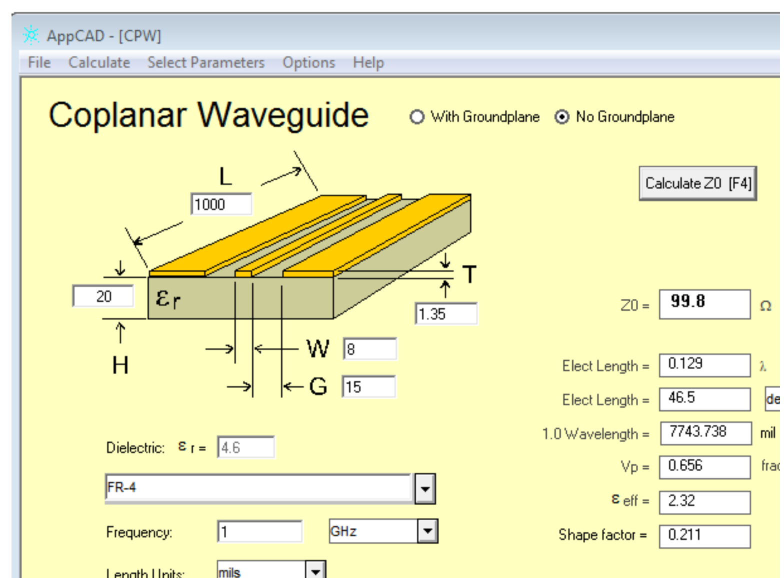
Anode board traces (50 Ω)



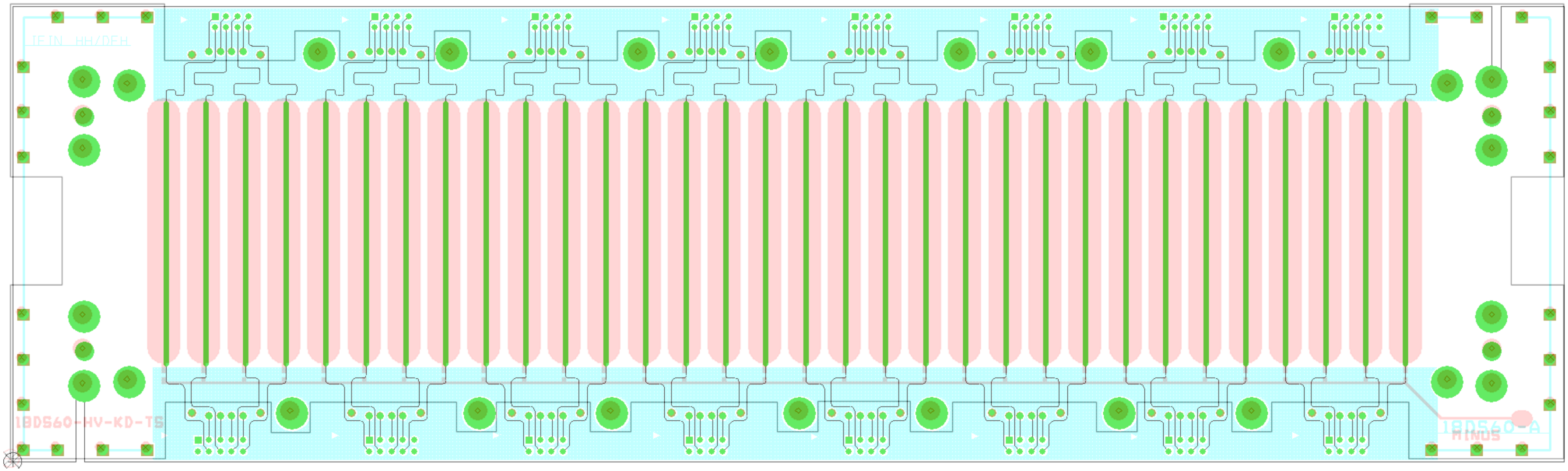
Cathode board traces (100 Ω)

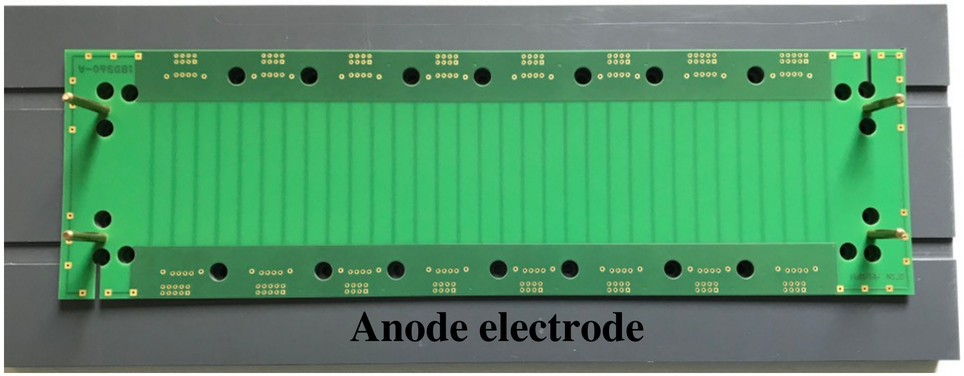


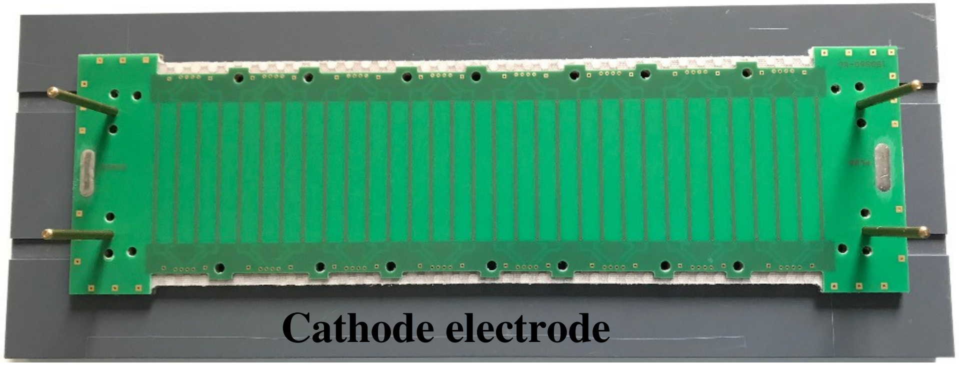




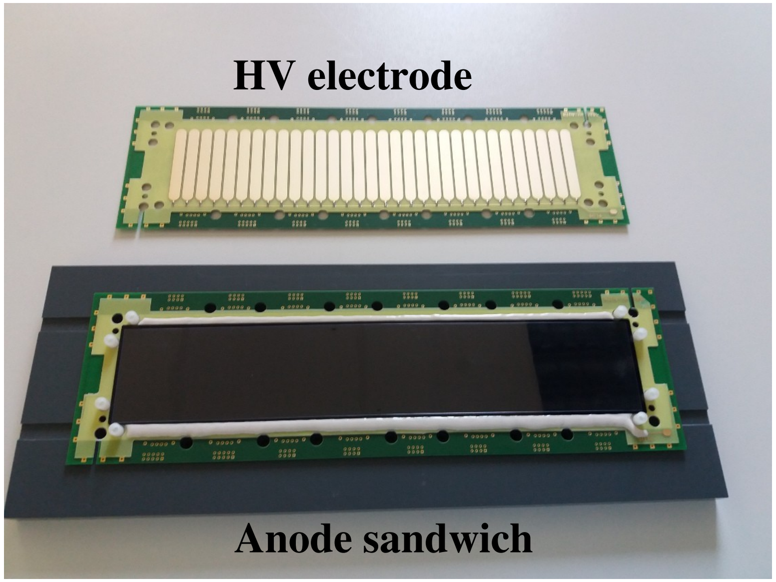
OrCAD design of the readout electrodes and their manufacture



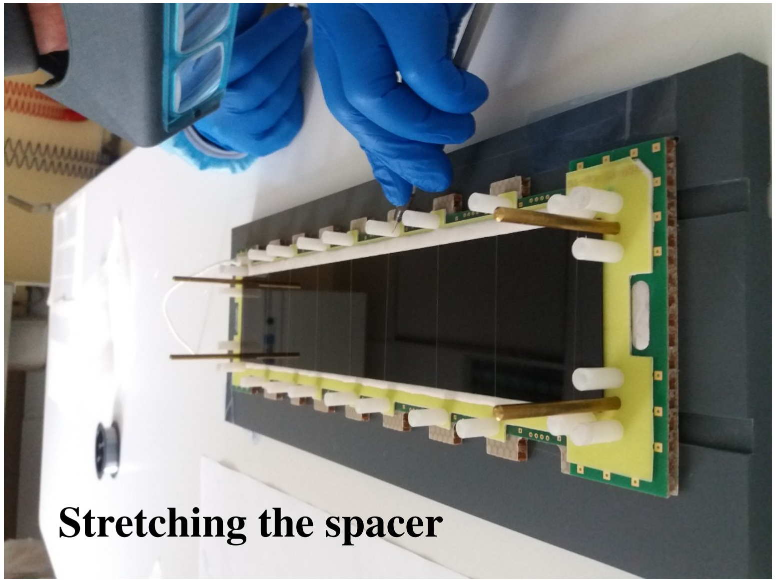

Anode electrode

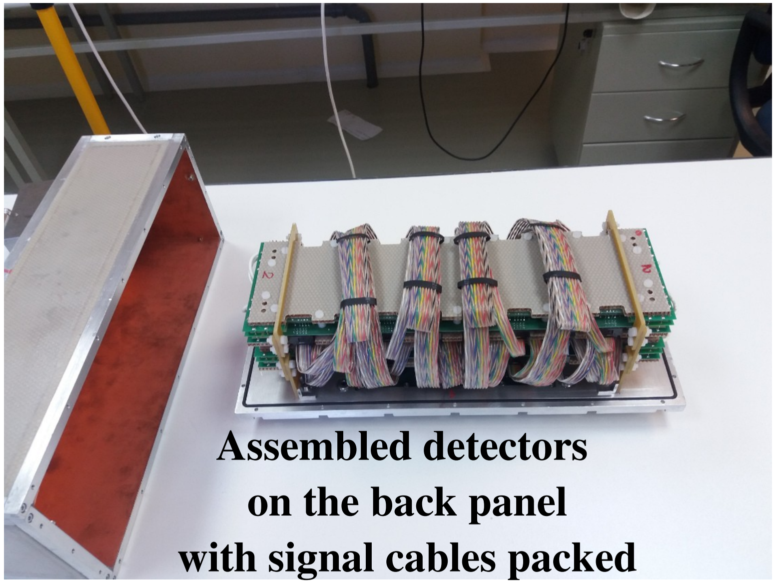

Cathode electrode

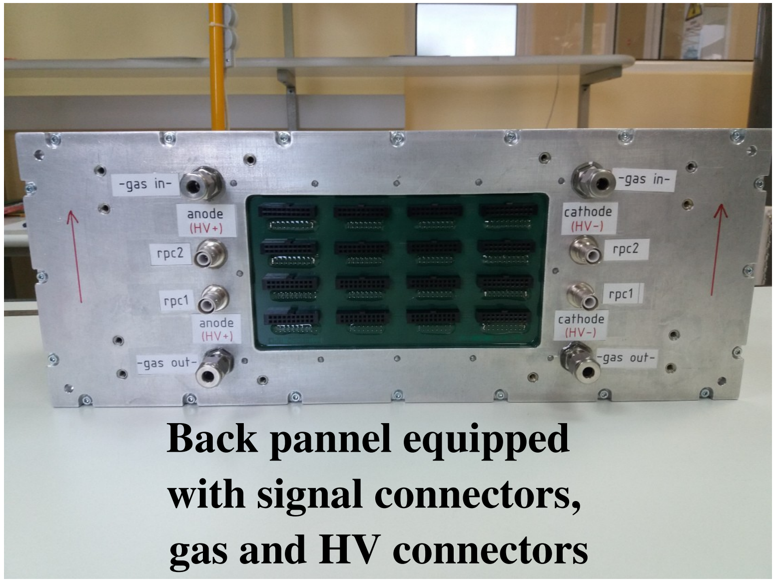
Prototype assembling


HV electrode

Anode sandwich


Stretching the spacer

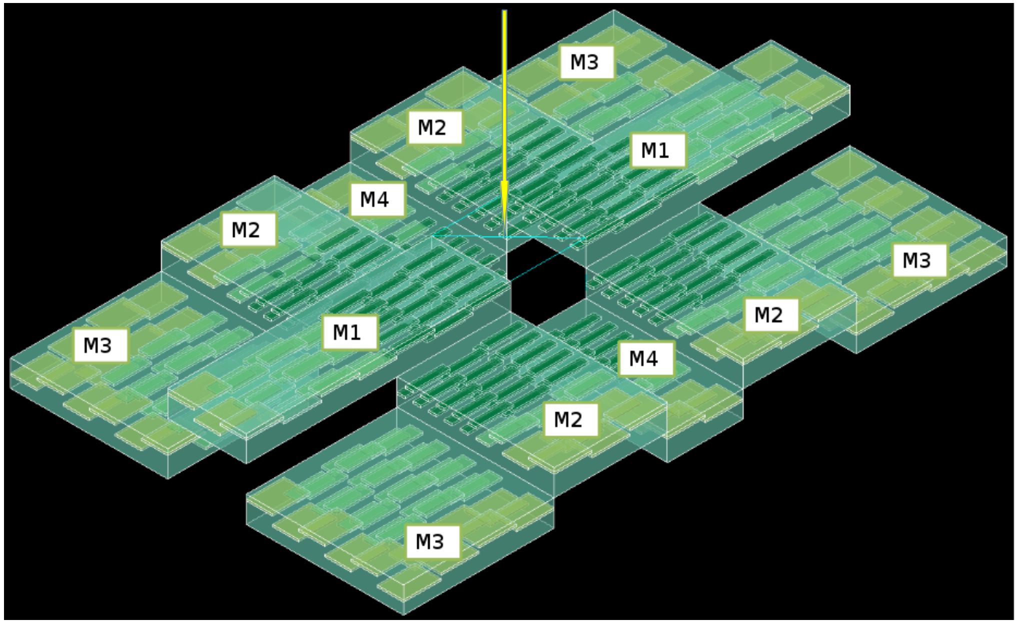

Assembled detectors
on the back panel
with signal cables packed



Back pannel equipped
with signal connectors,
gas and HV connectors

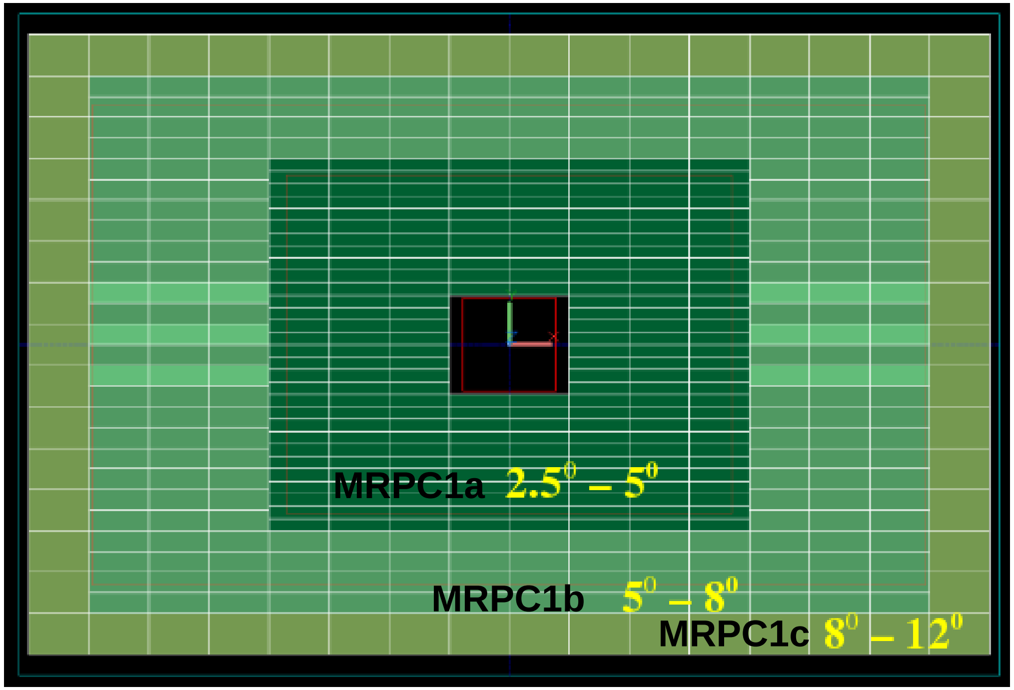
- **Desene de proiectare a zonei unghiurilor polare mici ale CBM-TOF bazat pe detaliile constructive ale acestor prototipuri, integrata constructiv in ansamblul subdetectorului CBM-TOF**

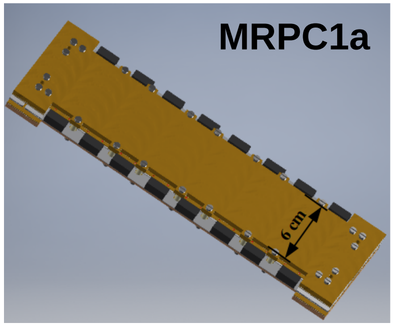
CBM-TOF Inner Wall Design

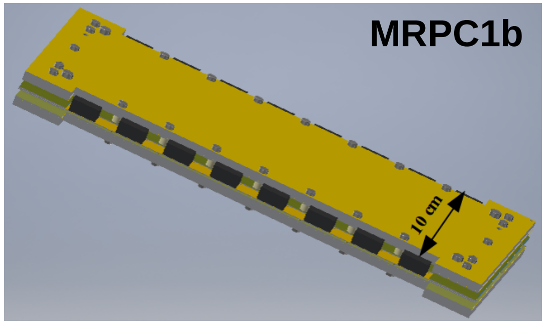


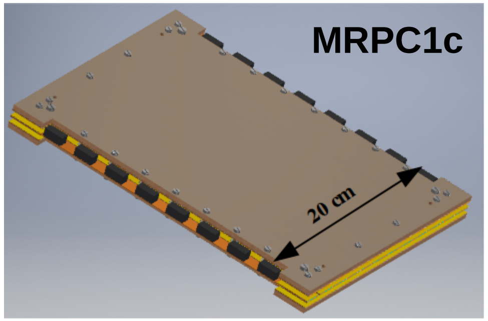
CBM-TOF inner zone – modular design

- *~15 m^2 active area (4.7 m x 3.2 m)*
- *12 modules of 4 types (2M1, 4M2, 4M3, 2M4)*
- *470 MSMGRPCs of 0.9 mm strip pitch,*
- *3 types of MSMGRPCs → differ through the strip length :*
  - *60 mm (MRPC1a) – 220 counters*
  - *100 mm (MRPC1b) – 164 counters*
  - *200 mm (MRPC1c) - 86 counters*
- *30 080 readout channels*



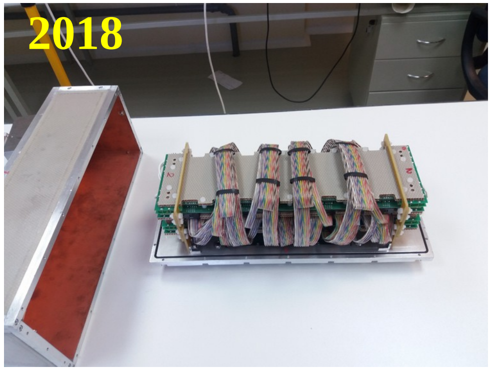




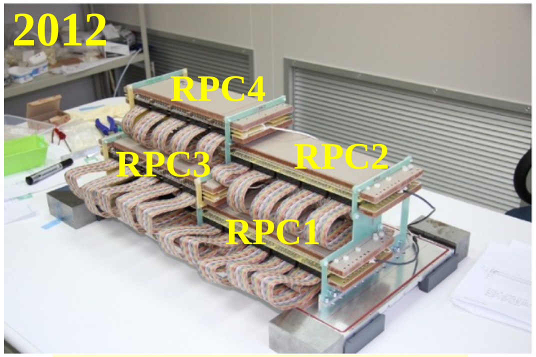


Prototypes for the CBM-TOF Inner Wall

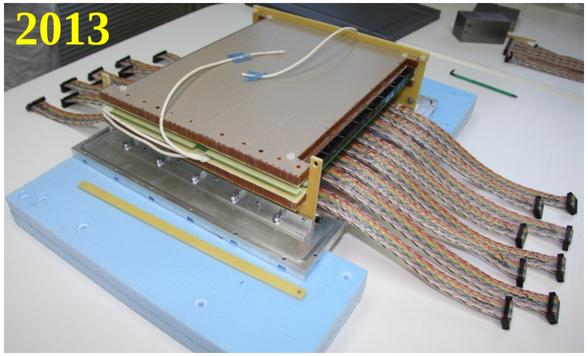
60 mm strip length



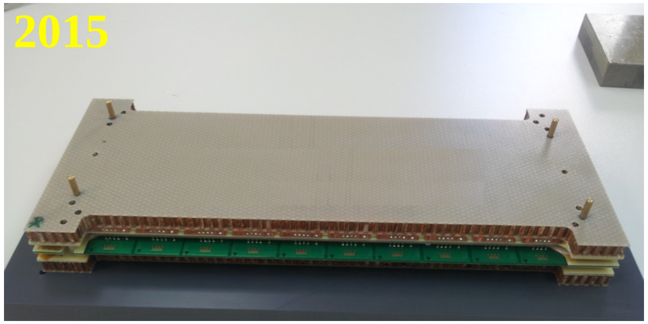
100 mm strip length

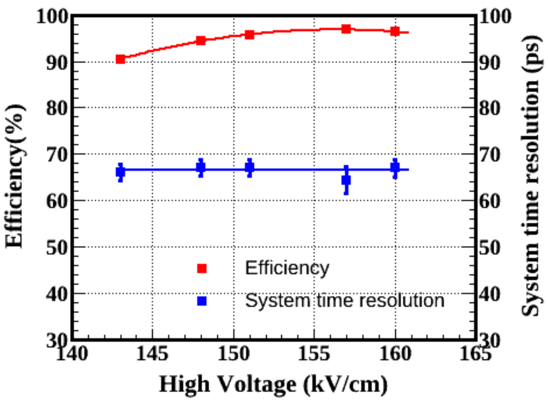


200 mm strip length

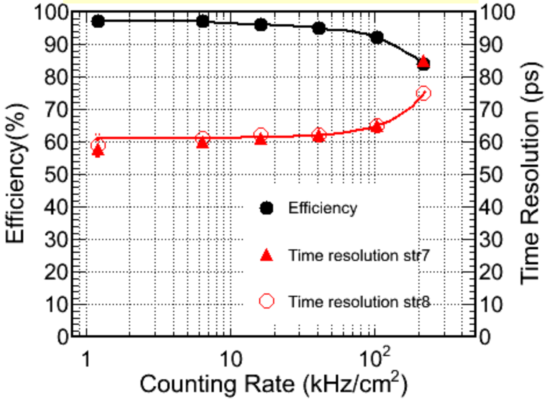


100 mm strip length

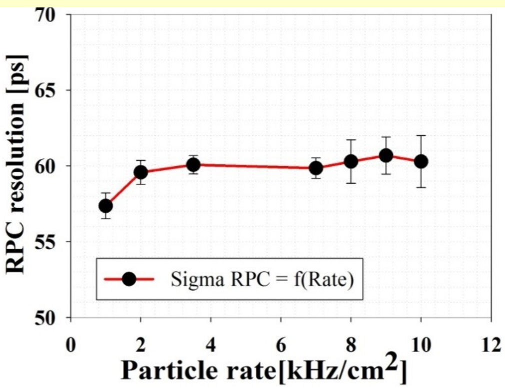




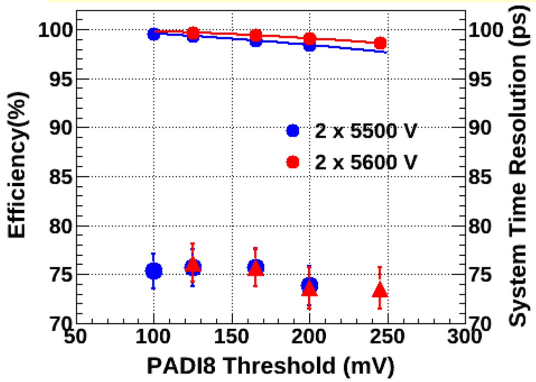
Focused p beam, 2.5 GeV/c @ COSY Julich

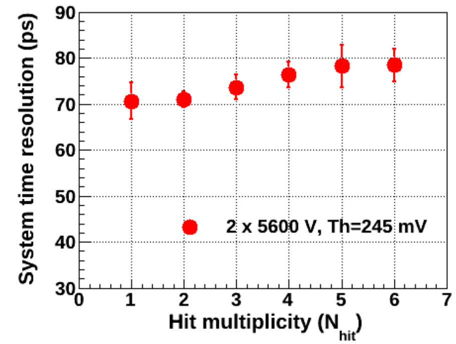


Ni 1.9 GeV/u on Pb target GSI Darmstadt, exposure over whole active area



1.1 GeV/u ^{152}Sm beam on Pb targetGSI Darmstadt



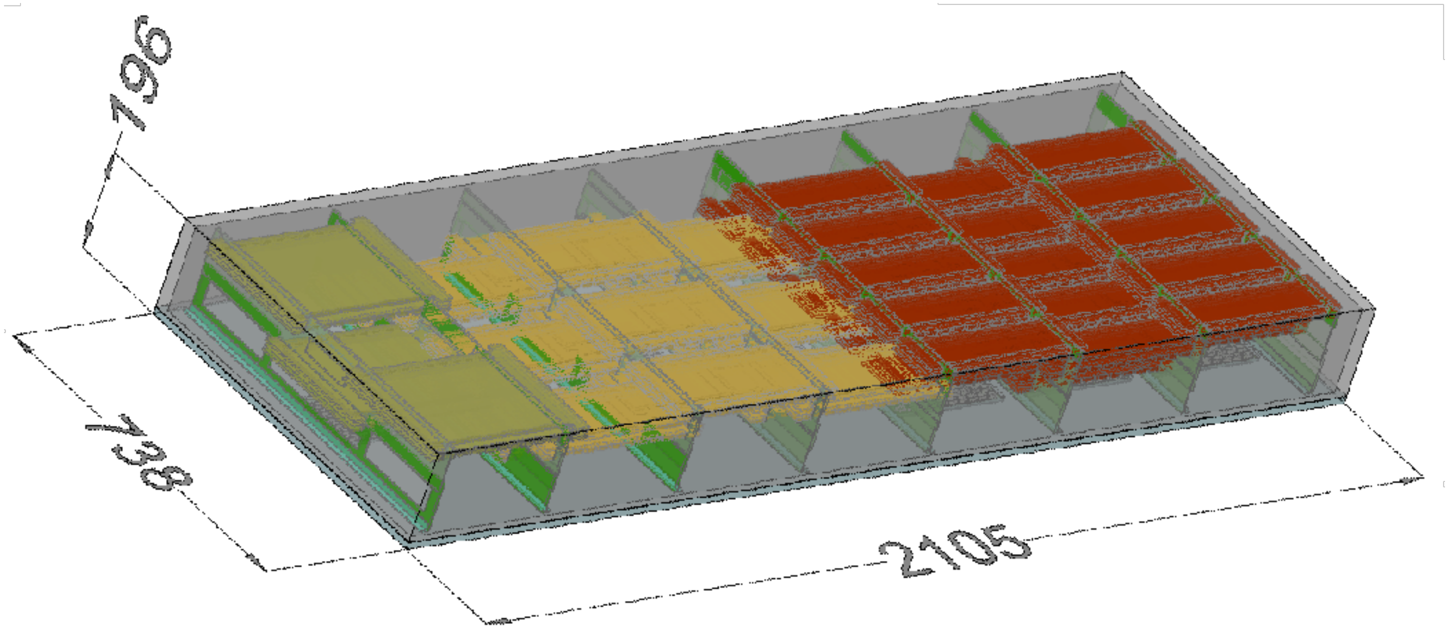


M.Petrovici et al. JINST 7 P11003, 2012

M.Petris et al. JINST 11 C09009, 2016

M. Petris et al., NIMA 920 (2019), 100

Modul M1 Design



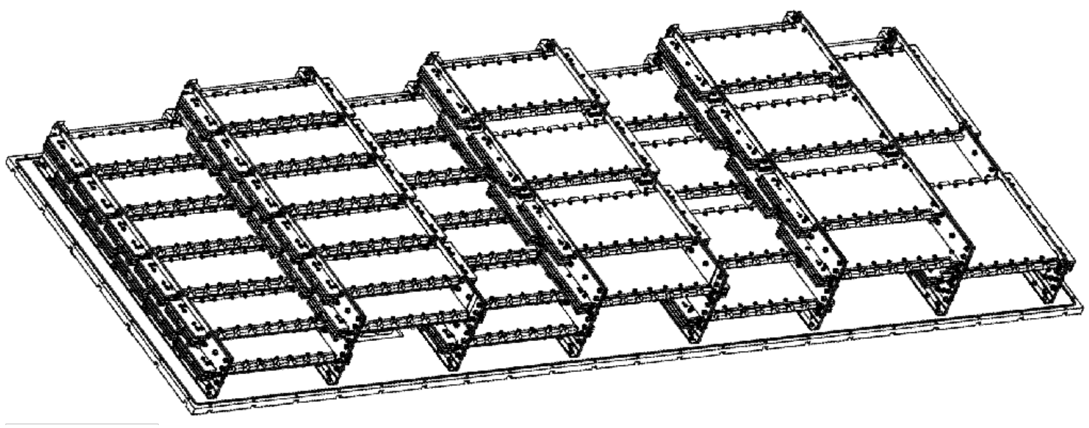
51 MSMGRPCs

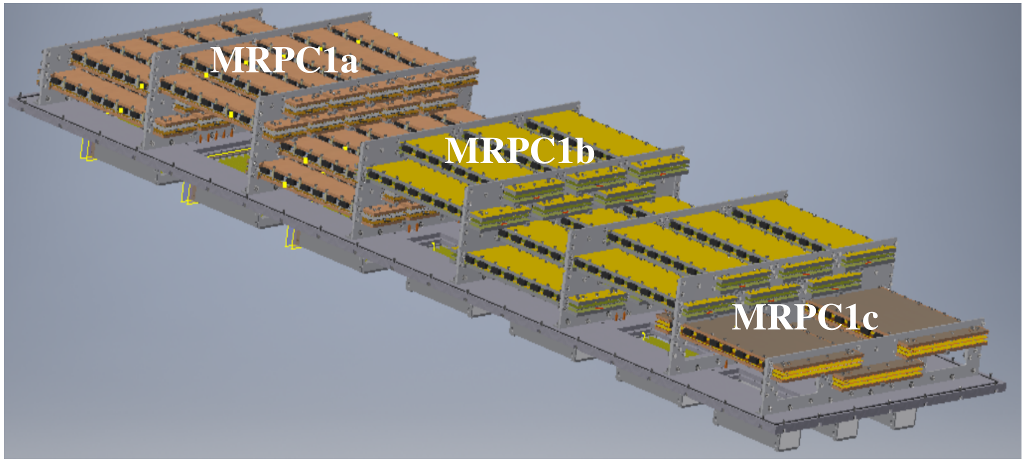
30 x MRPC1a (60 mm)
18 x MRPC1b (100 mm)
3 x MRPC1c (200 mm)

Back panel connectors:

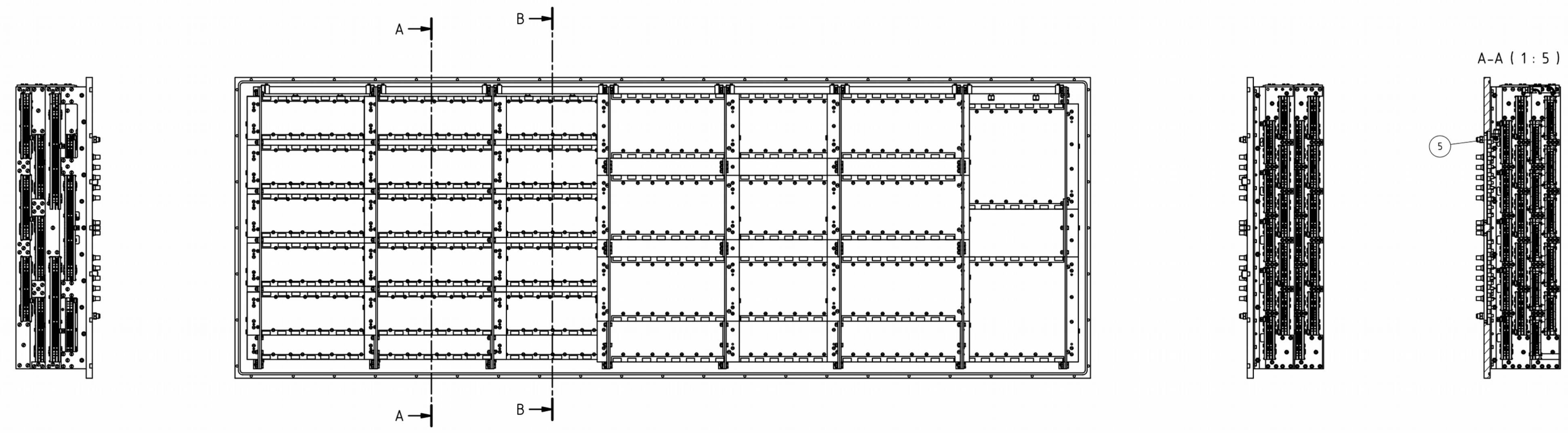
- 408 inside
- 408 outside

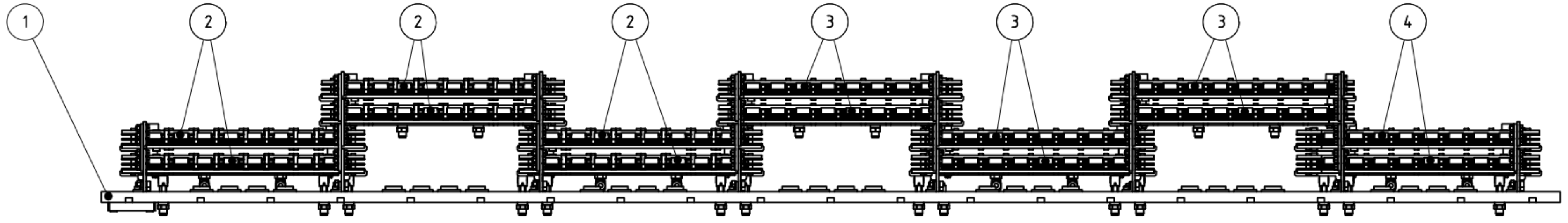
weight: ~ 150kg





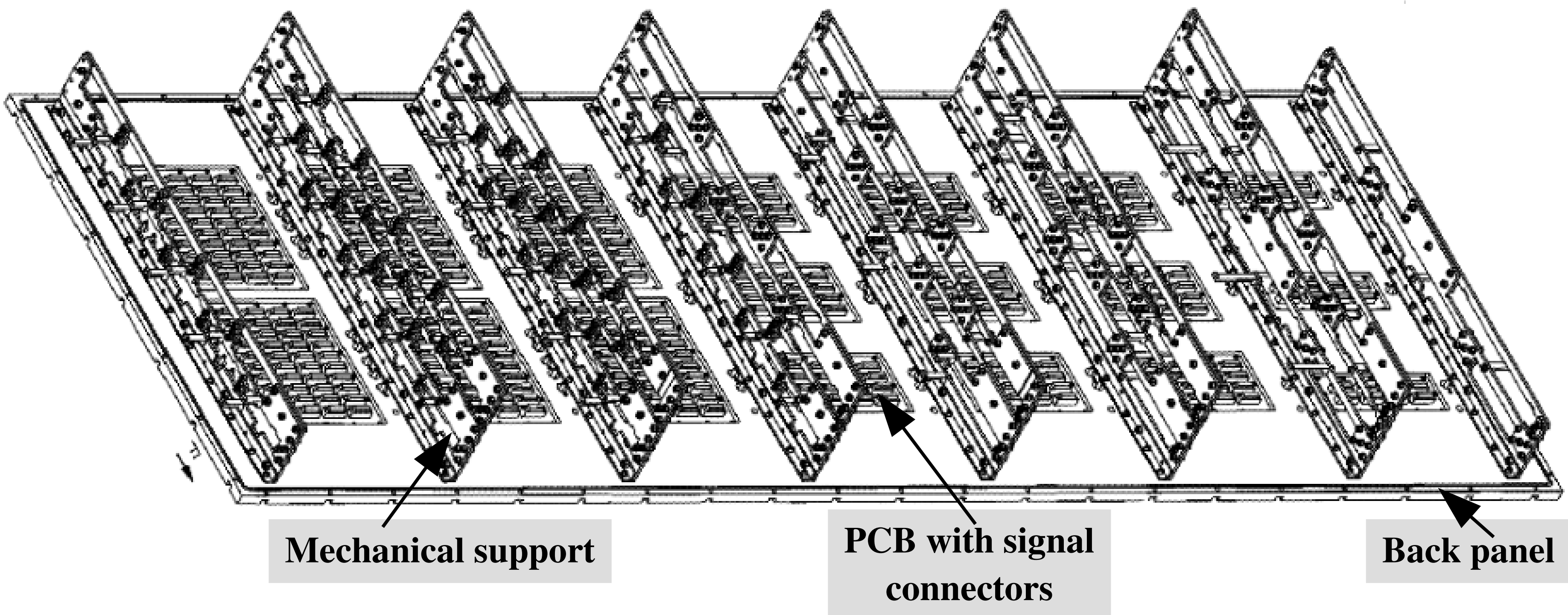
Modul M1 – details of the execution drawings

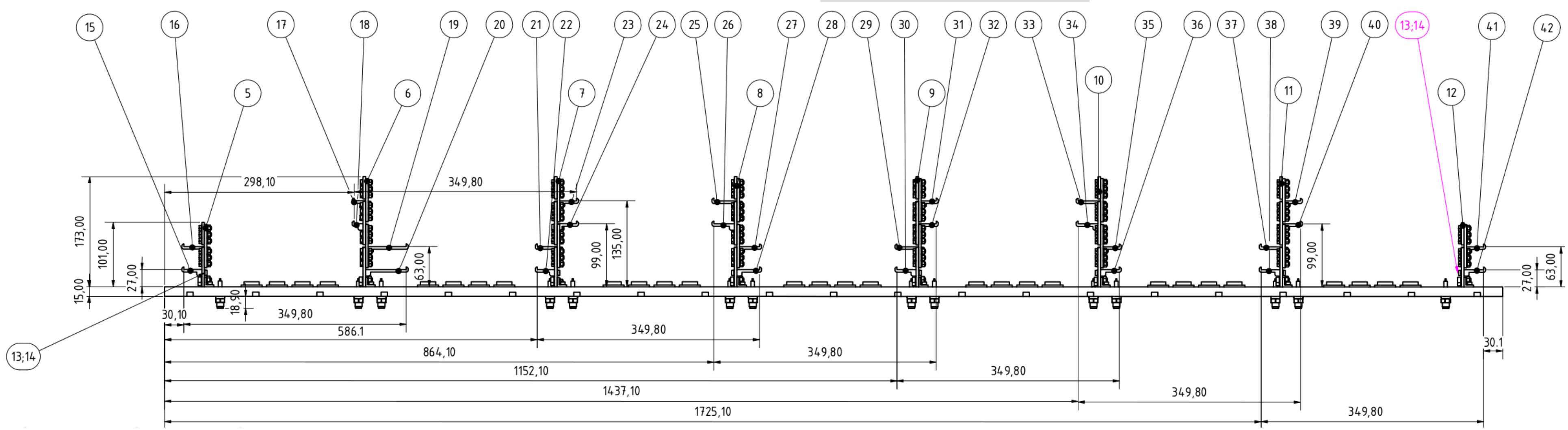




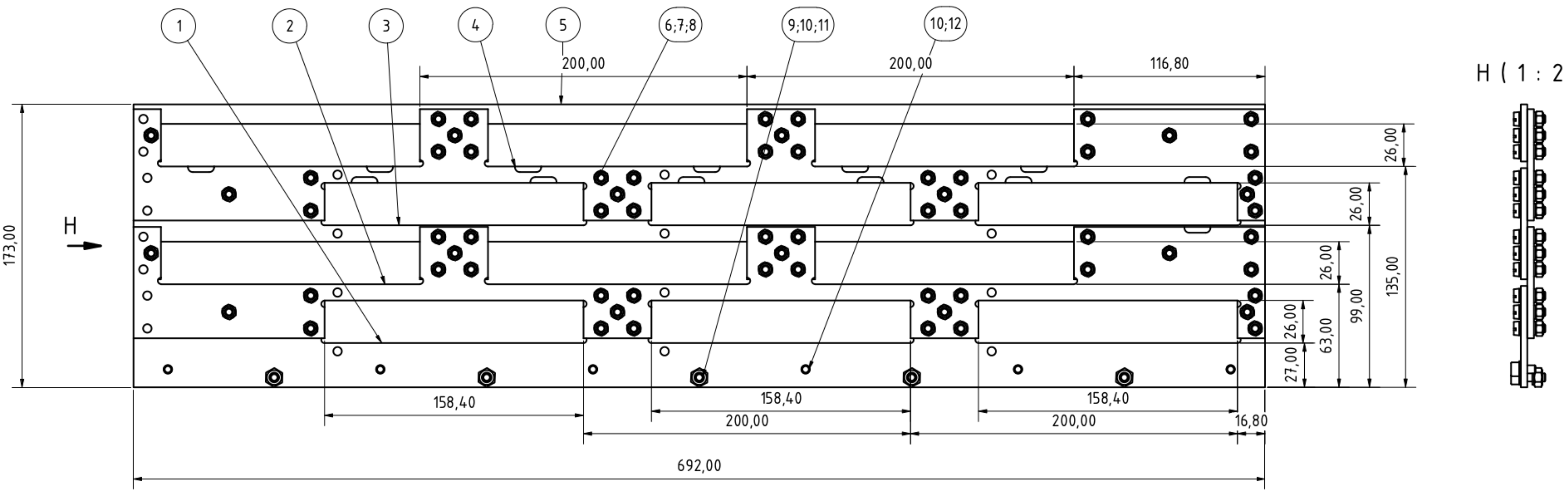
MSMGRPCs are staggered on four layers in order to provide the necessary overlap for a continuous active area.

Modul M1 – details of the execution drawings → mechanical supports

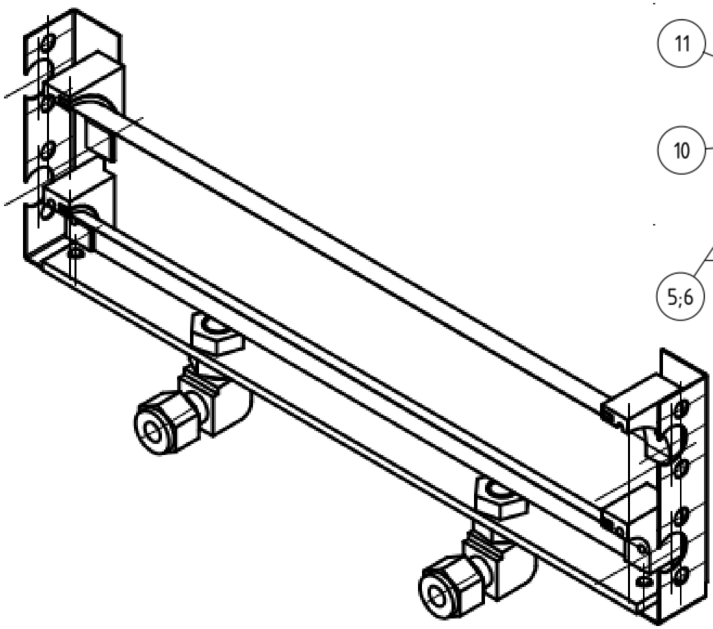


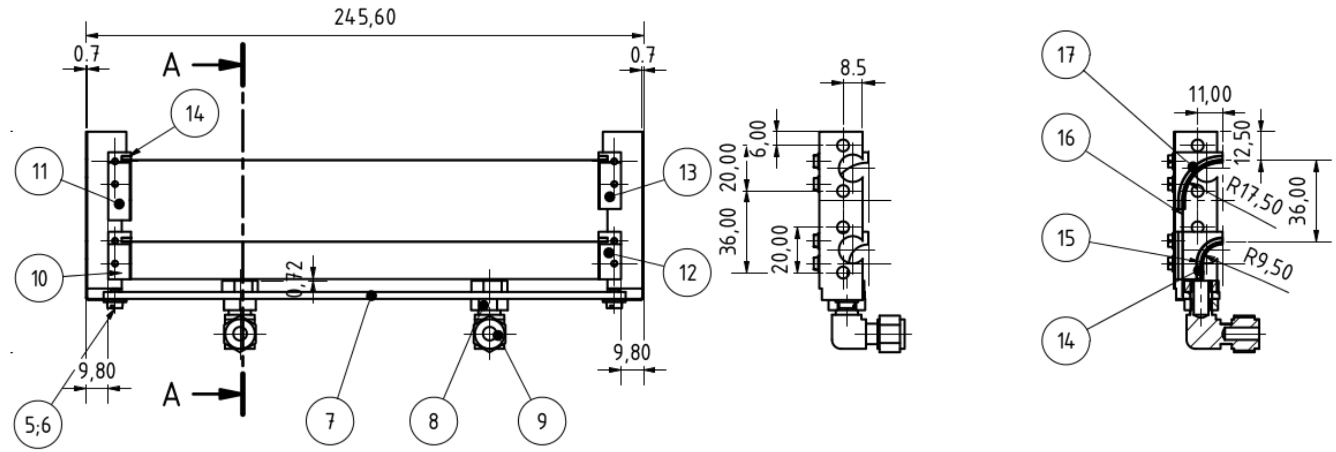


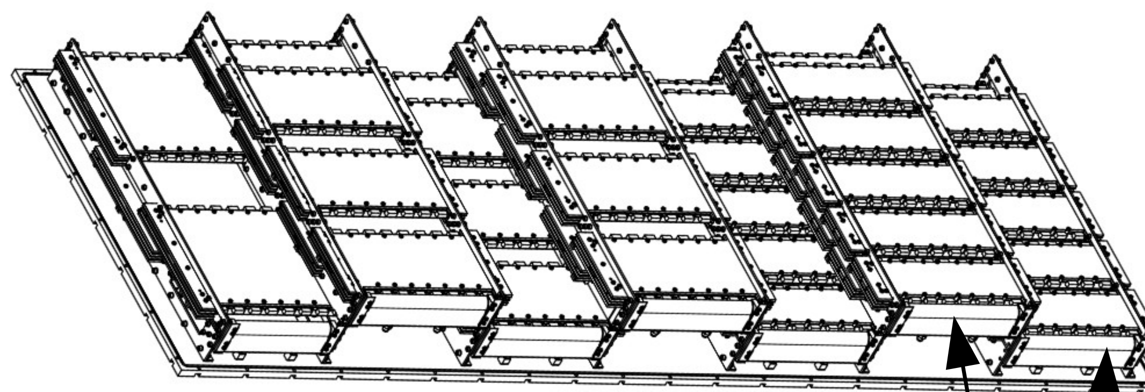
Modul M1 – details of the execution drawings for a mechanical support

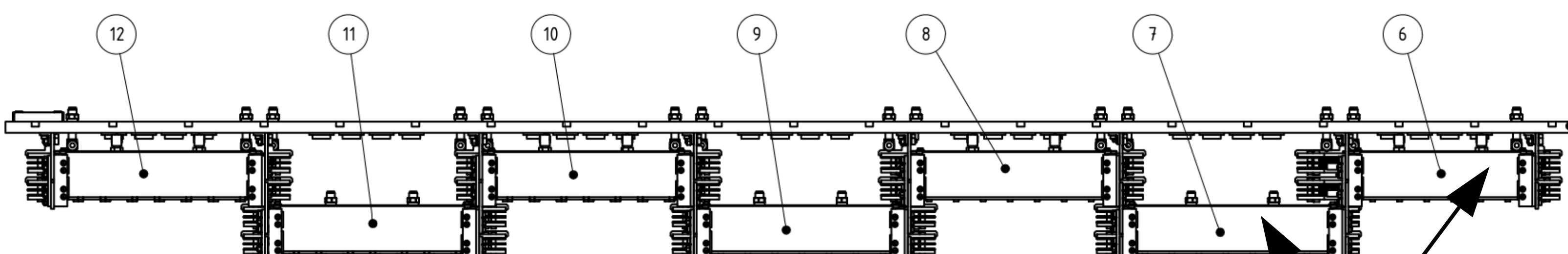


M1 design details – gas deflector



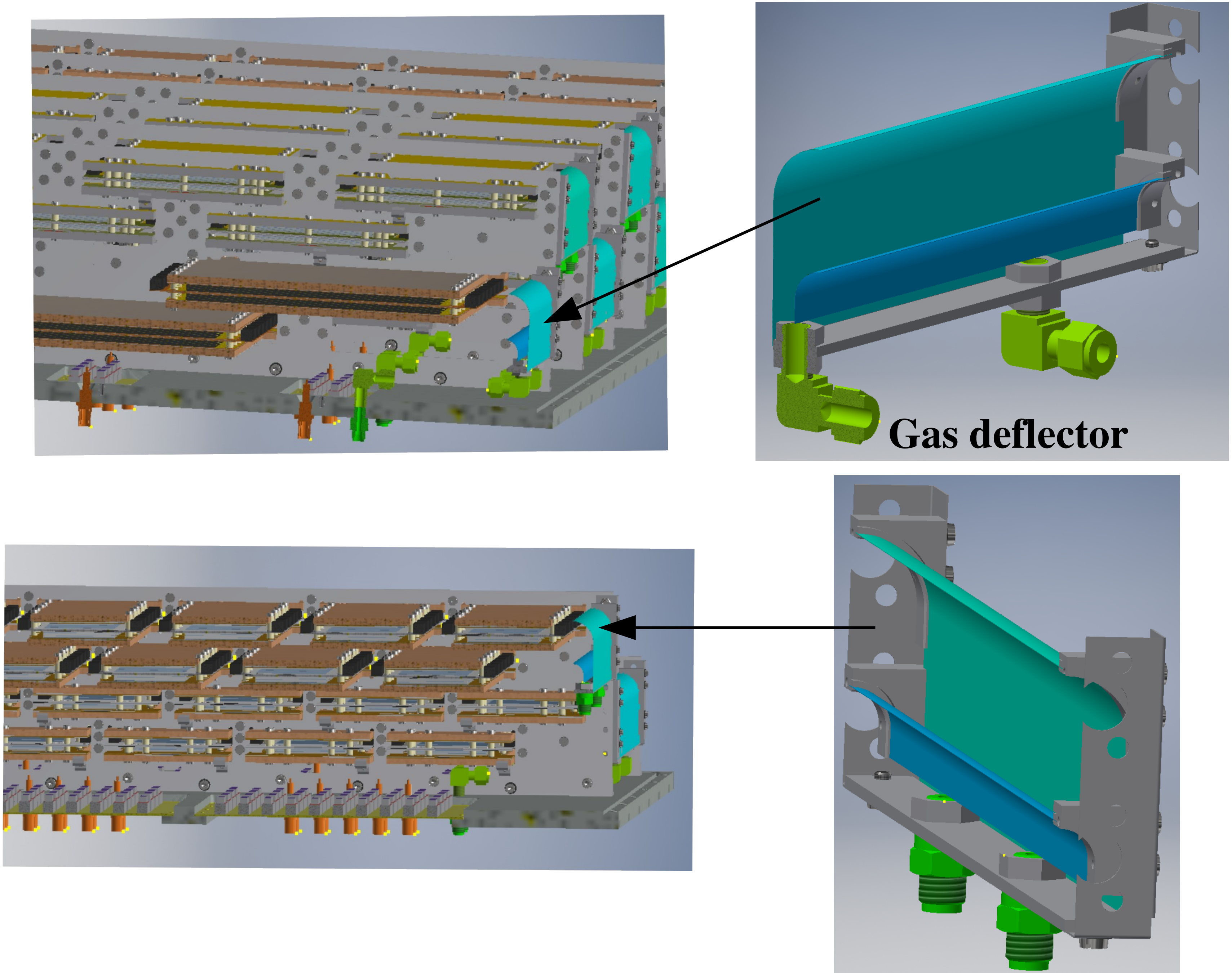




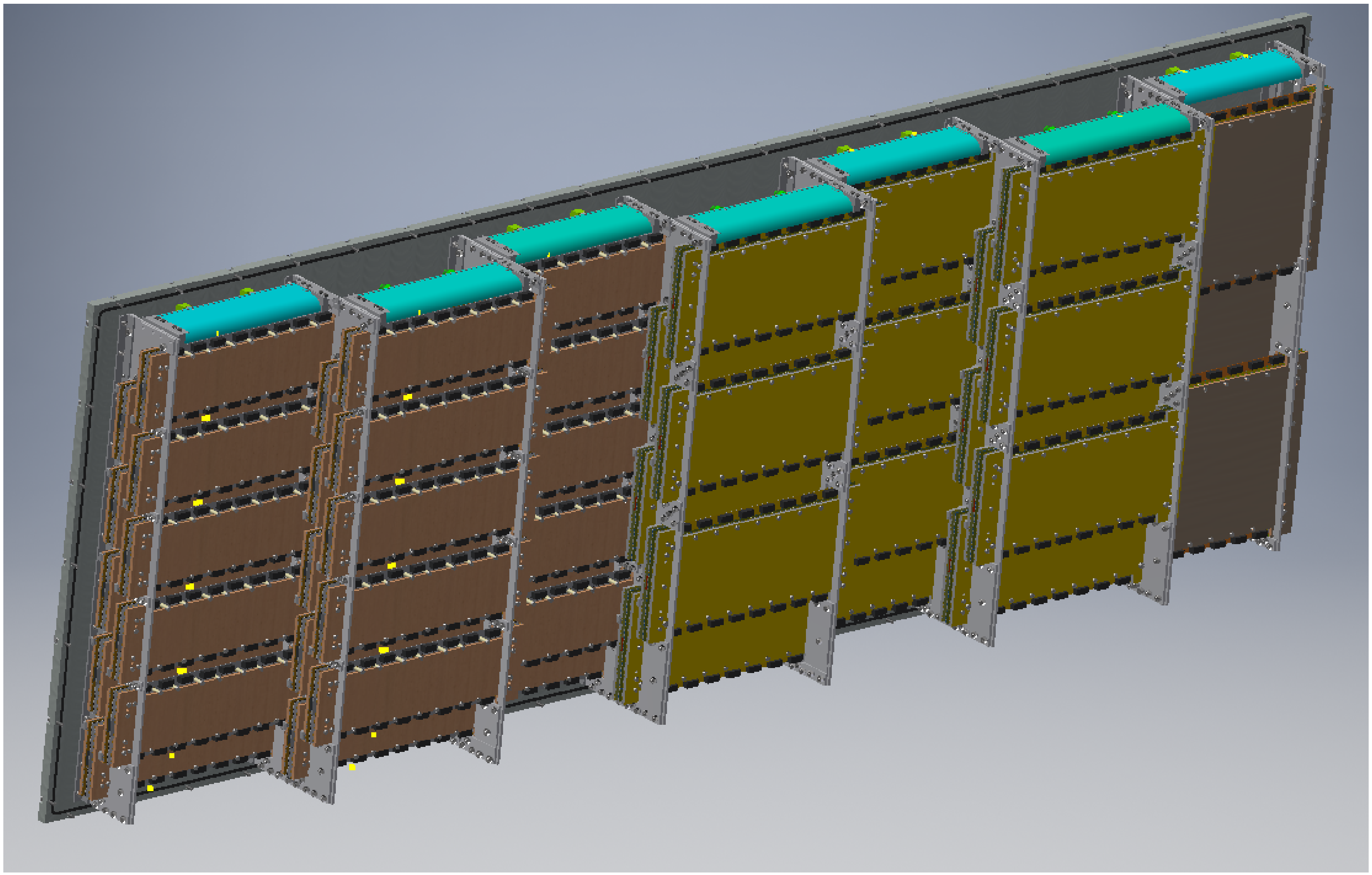


Position of the gas deflector

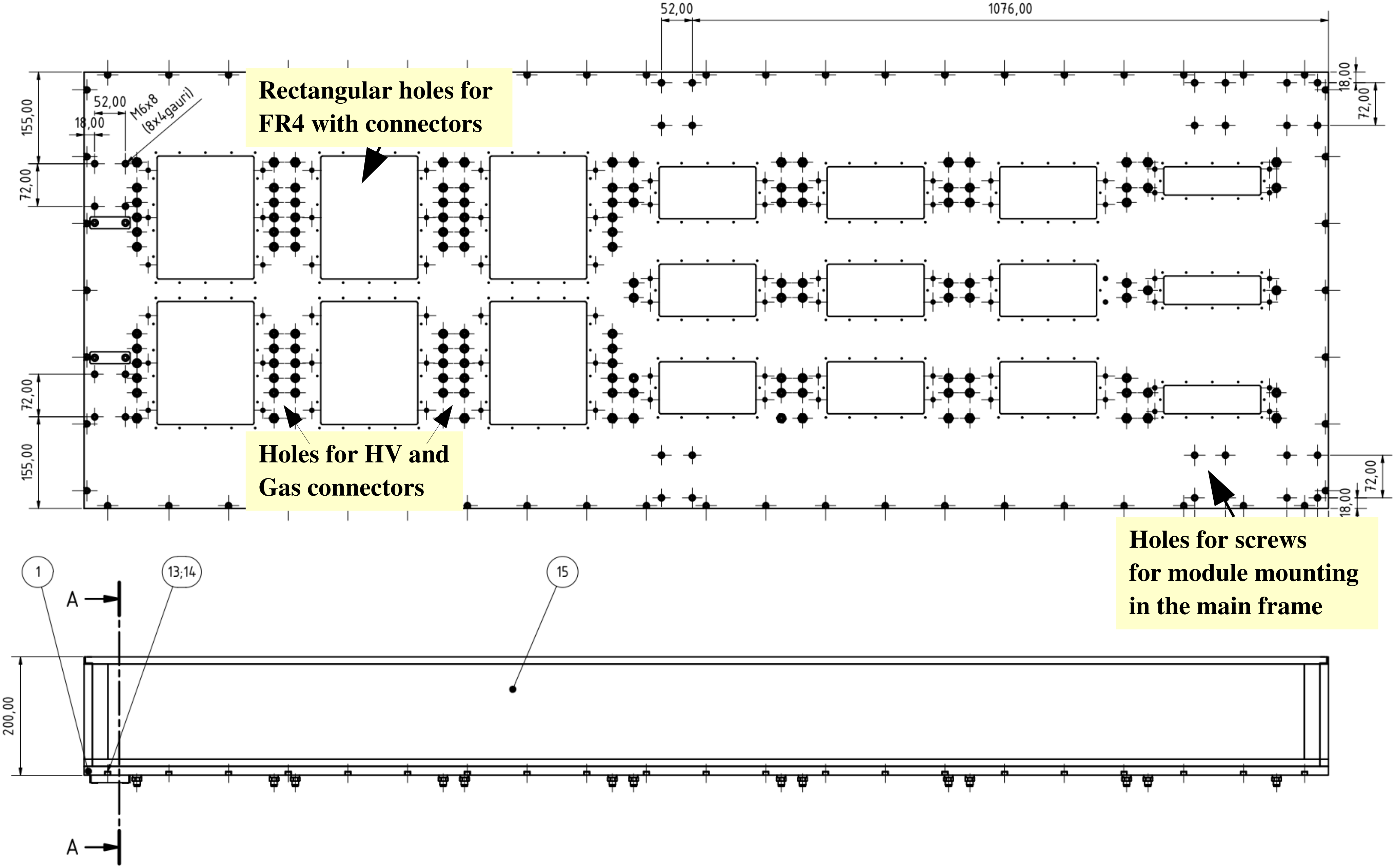
M1 design details – gas deflector 3D view



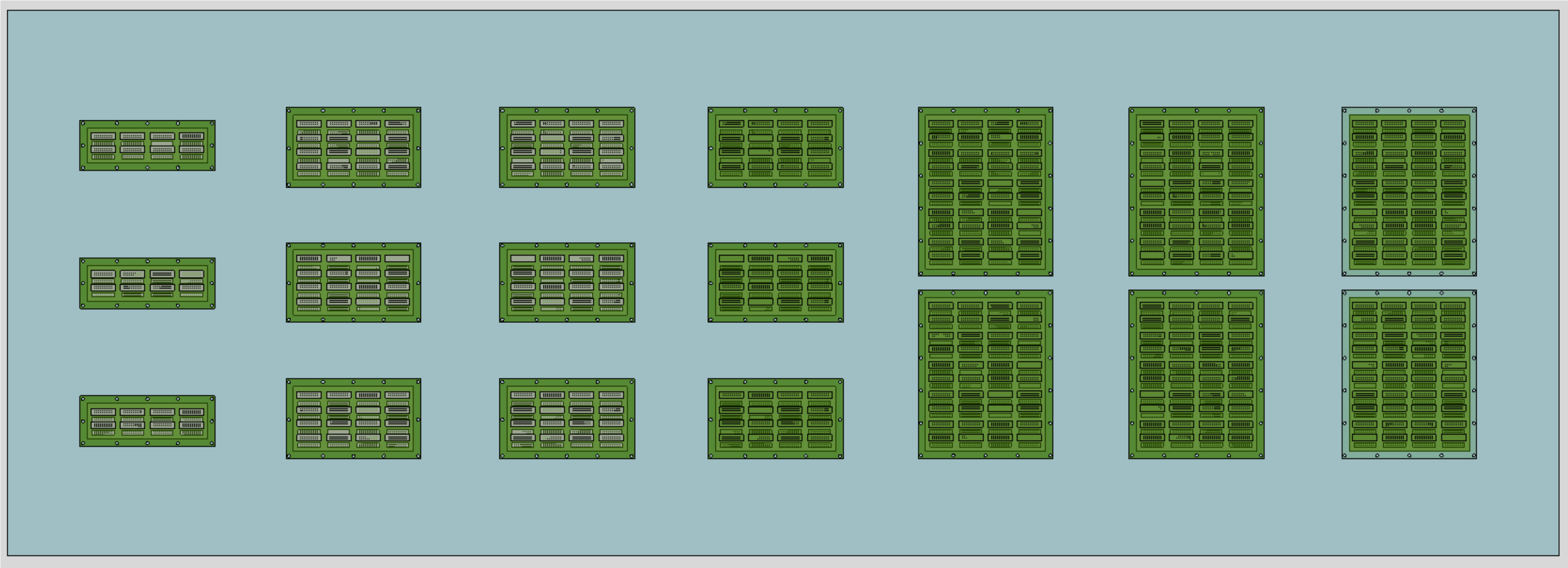
M1 equipped with gas deflectors



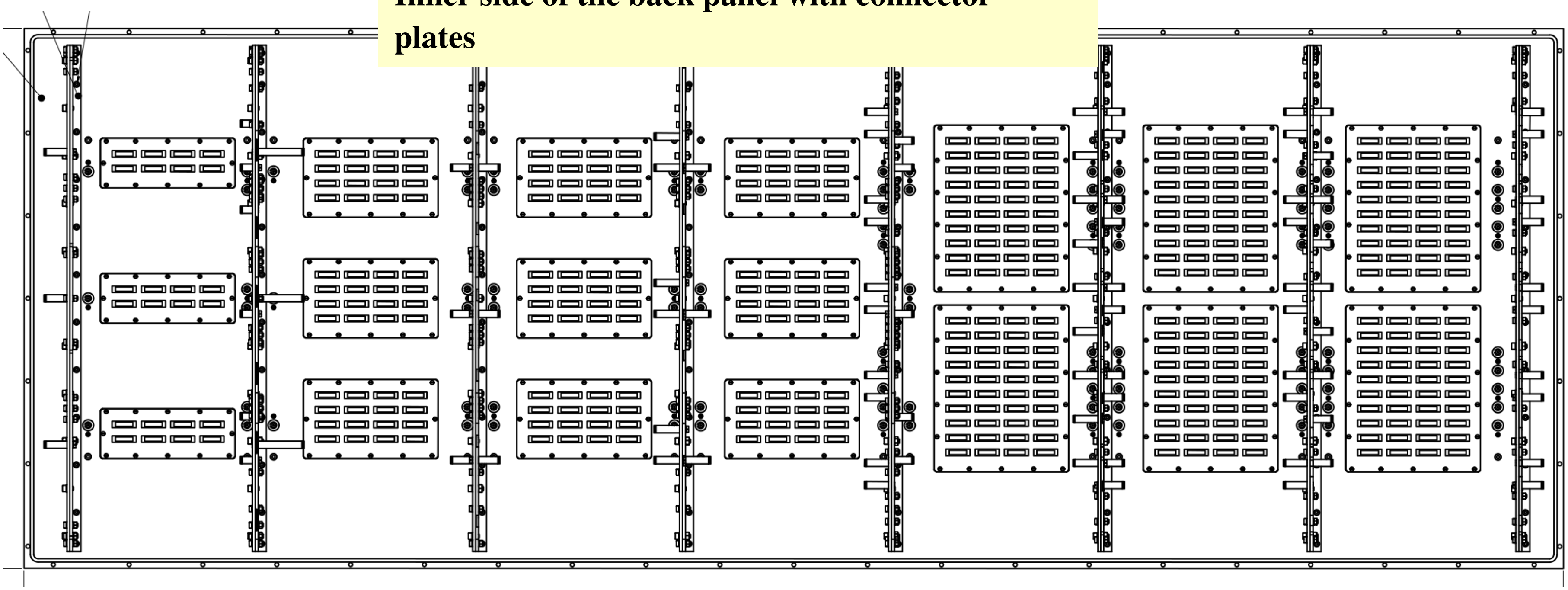
M1 design details – Al backpanel



M1 design details – Al backpanel

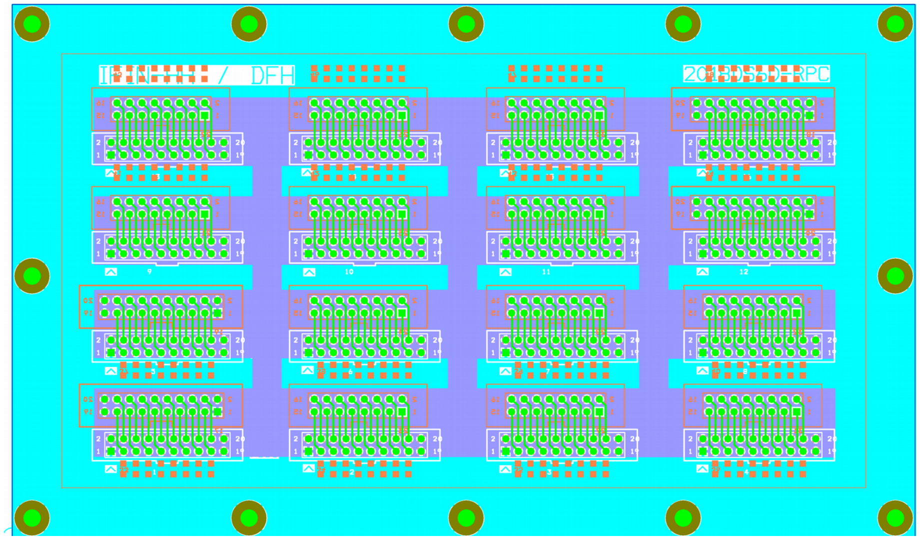


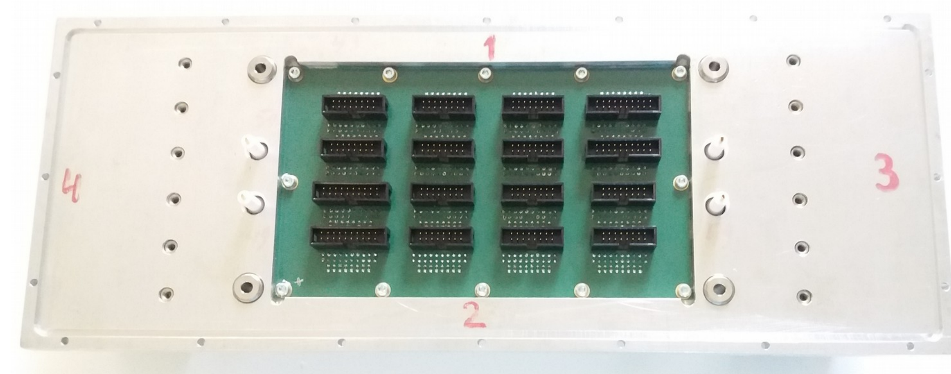
Inner side of the back panel with connector plates

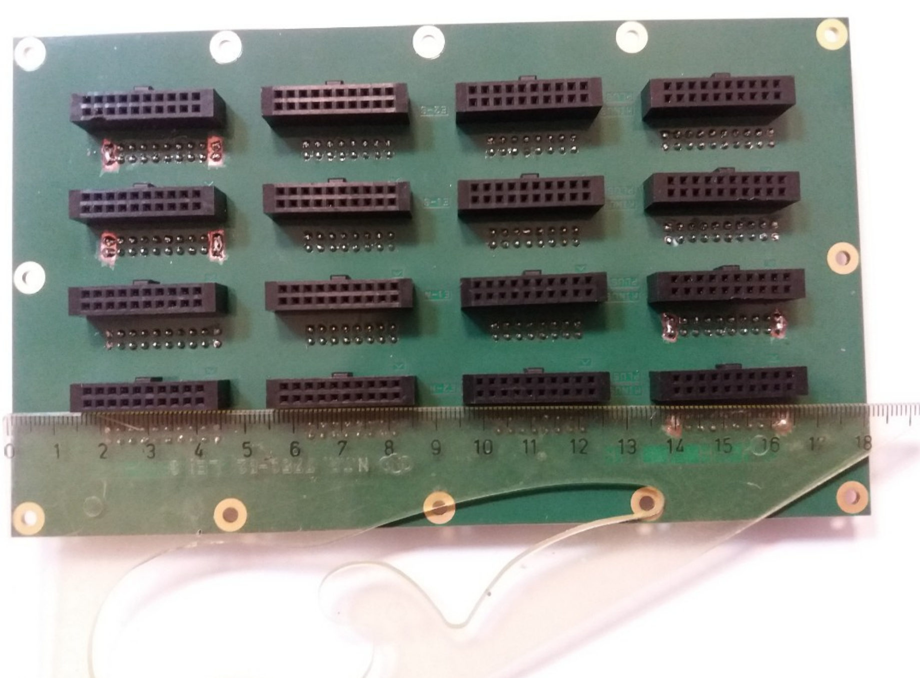


Back pannel connector plate

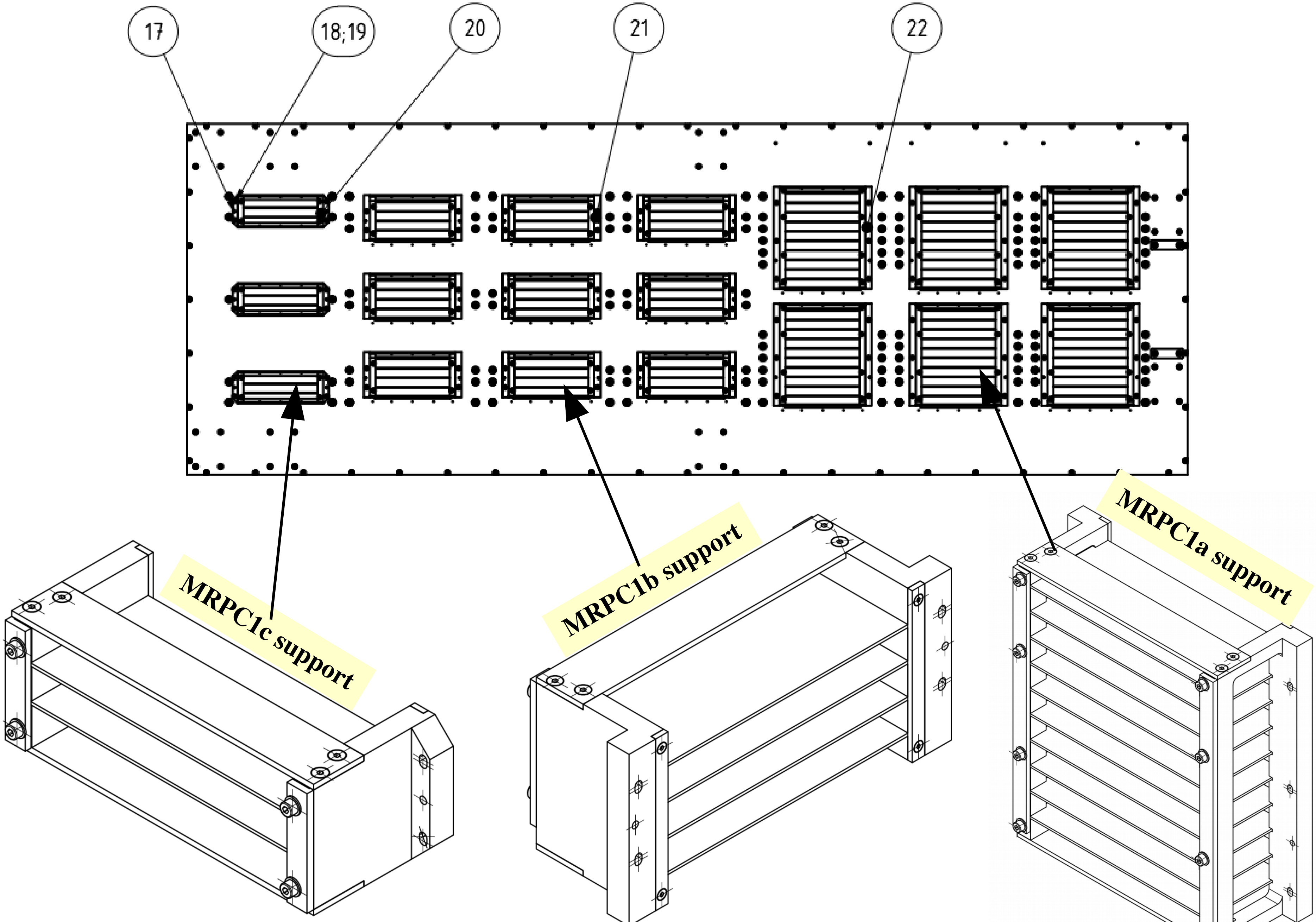
OrCAD



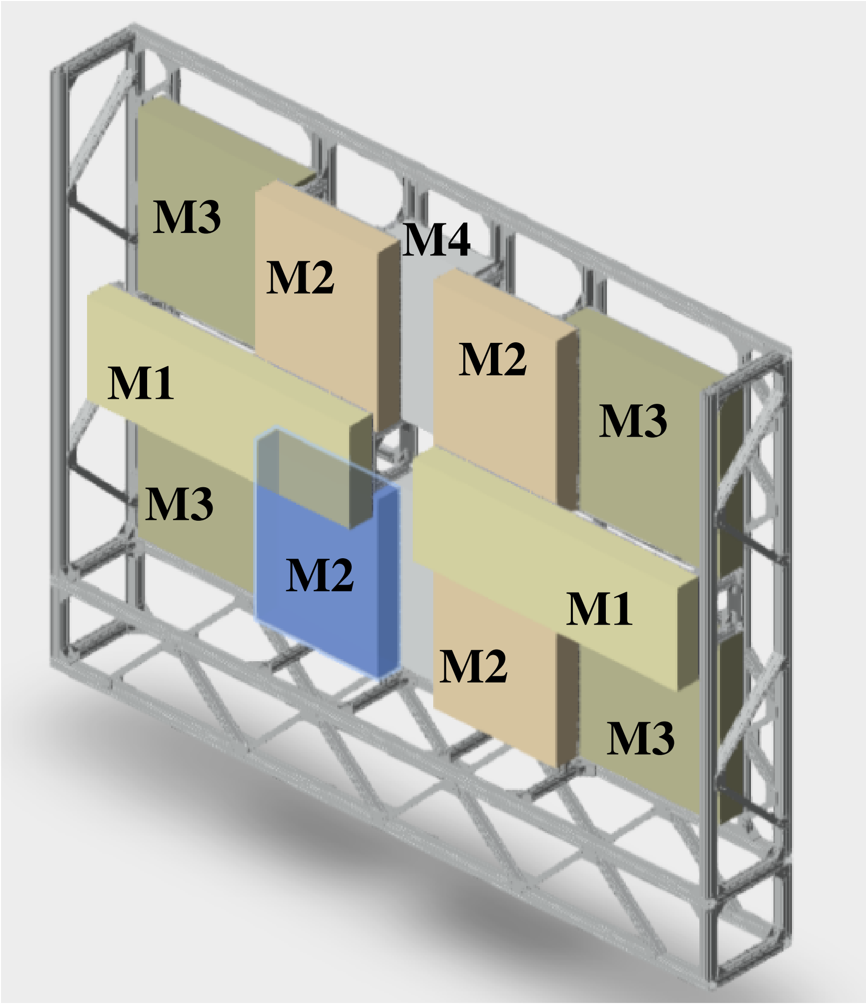


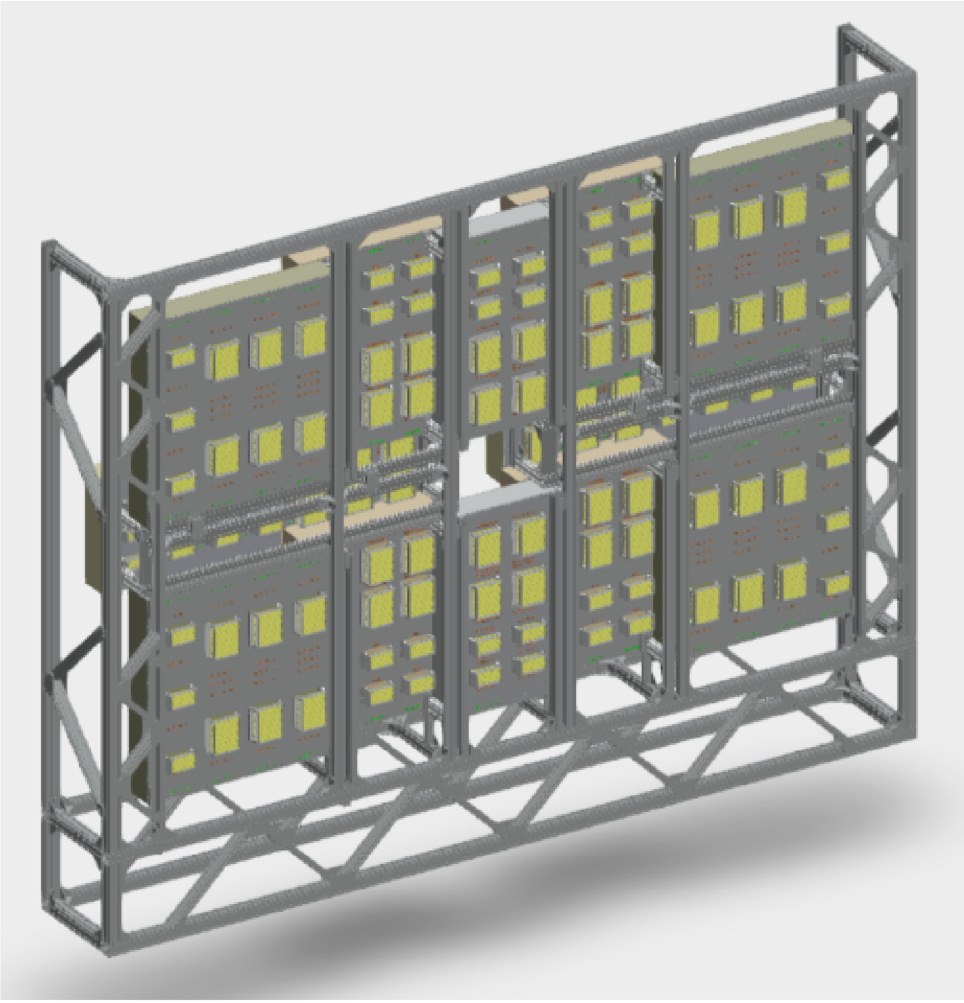


M1 design details – FEE mechanical supports



Space frame design





Conclusions and Outlook

- **The MSMGRPC prototype with the highest granularity of the CBM-TOF wall was designed with 100 Ohm characteristic impedance of the transmission line matched to the input of the front-end electronics, using OrCAD and APLAC software.**

- **Two identical prototypes with the highest granularity of the CBM-TOF wall were assembled based on this design.**

- **A modular design of the inner zone of the CBM-TOF wall, cover the active area with 12 modules of 4 types. The modules are populated with up to three types of MSMGRPCs which differ only by their strip length, having the same inner geometry.**

- **Detailed technical drawings for the design of M1 module have been performed.**

- **Module M1 is going to be assembled in the near future.**

Conclusions and Outlook

The presented activity was reported in:

- ✓ **M. Petris et al.**

  "Status of the activities for the CBM-TOF inner wall"

  34^{th} CBM Collaboration Meeting, 29^{th} September - 3^{rd} October 2019, Kolkata, India

- ✓ **M. Petris et al.**

  "Towards the construction of the CBM-TOF inner zone"

  XXIII International School on Nuclear Physics, Neutron and Applications,

  September 22 – 28, 2019 Varna, Bulgaria


Thank you for your attention!