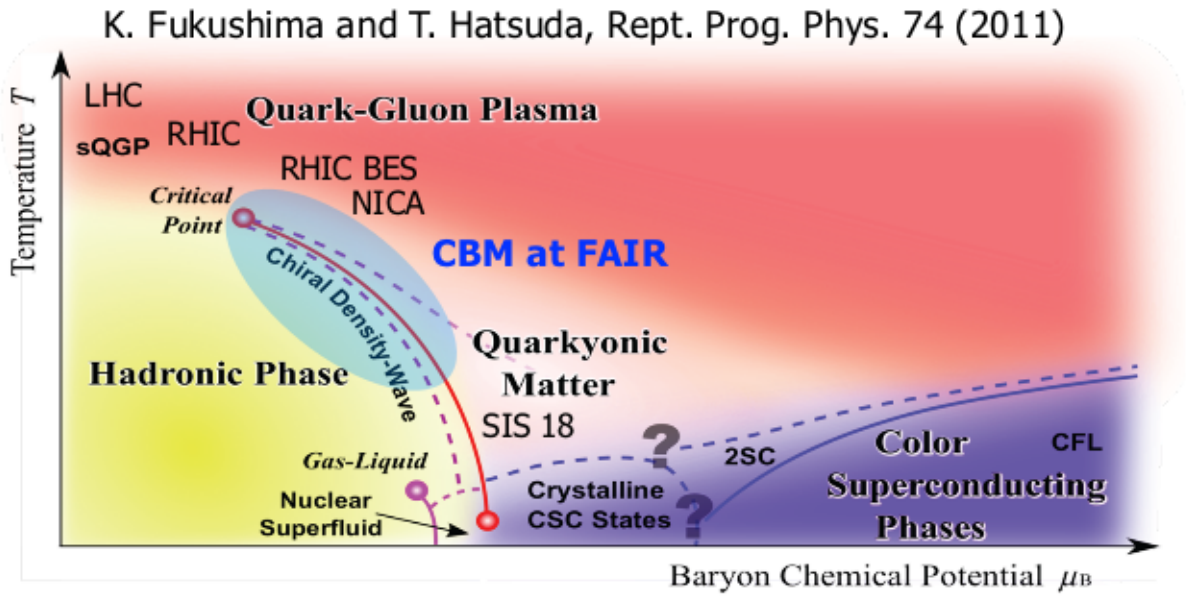
Proiect NUCLEU PN 19 06 01 03

Raport de etapa 2: **Testarea performantei prototipurilor de detectori cu electrozi rezistivi pentru masuratori de timp de zbor MSMGRPC, dezvoltati pentru CBM-TOF, folosind un sistem de achizitie cu electronica auto-trigerata similar cu cel ce va fi utilizat in experimentul CBM (partea II)**

Raport de etapa 3: **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 I)**

Mapping the phase diagram with CBM



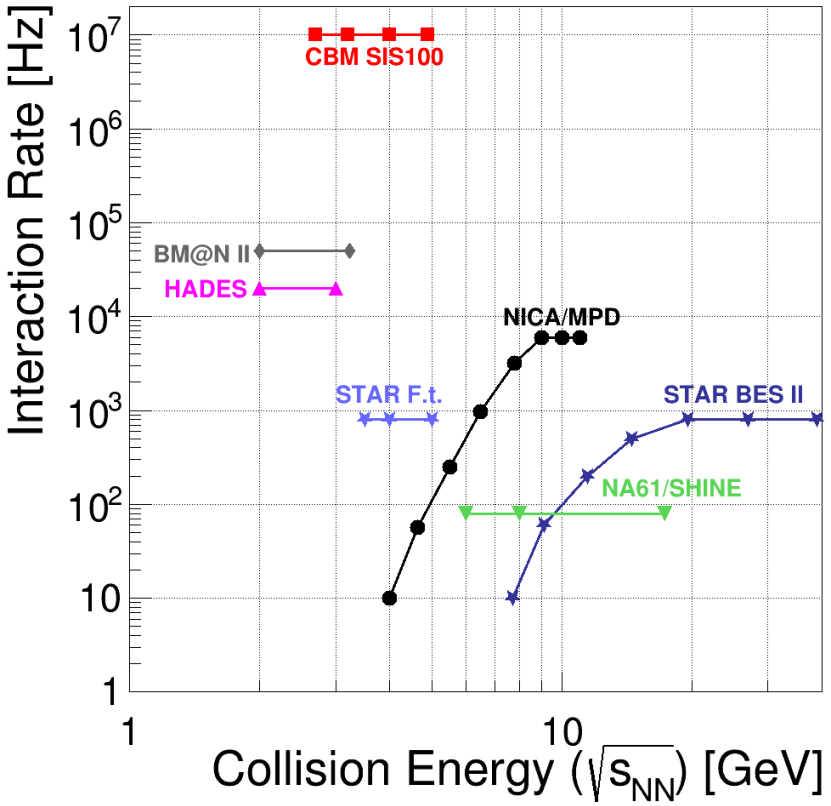
CBM aims to investigate strongly interacting matter in the region of high net baryon densities.

Investigation of:

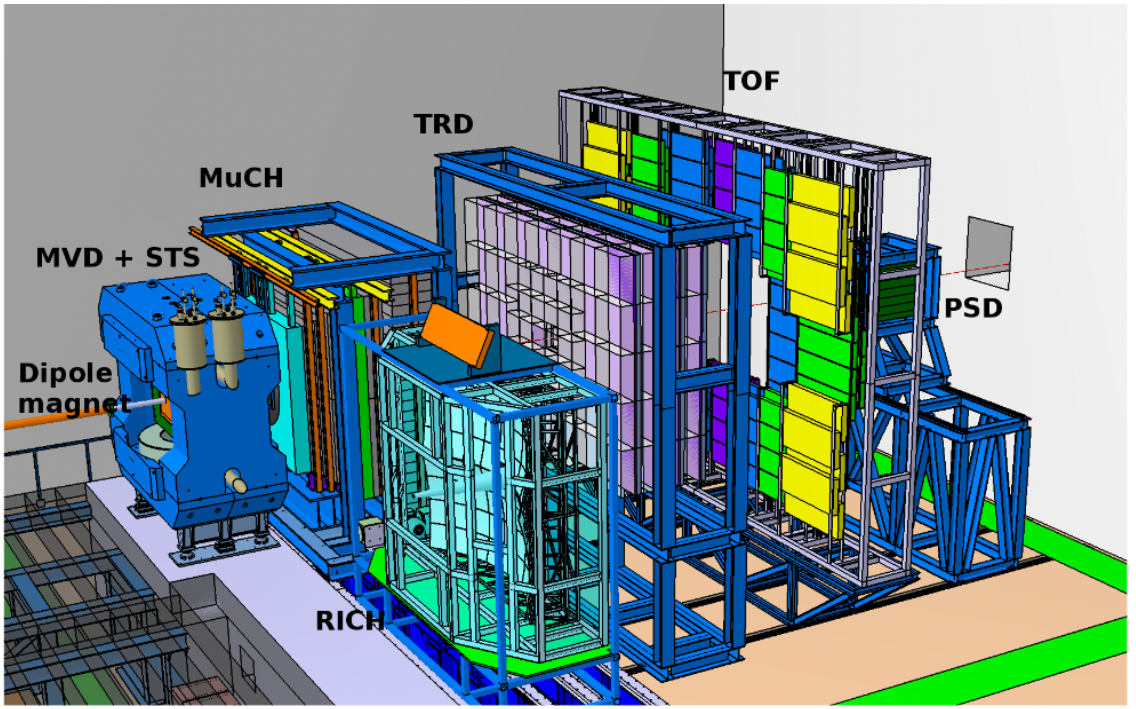
- **hadronic – partonic phase transition and its type**
- **equation of state at high baryonic densities**
- **possible critical point predicted by QCD**

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!

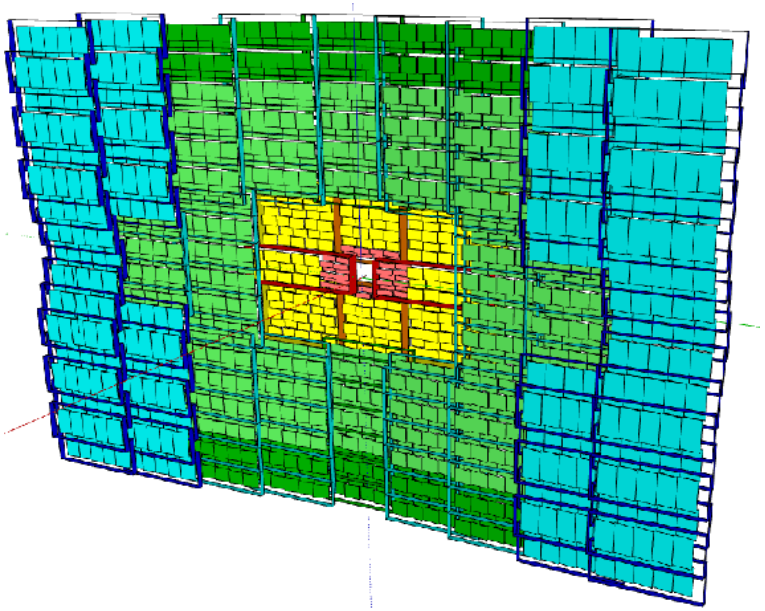
- ✓ **Hadrons in dense baryonic matter and possible modification of their properties;**
- ✓ **Charm production at threshold beam energies and its properties in dense baryonic matter.**

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

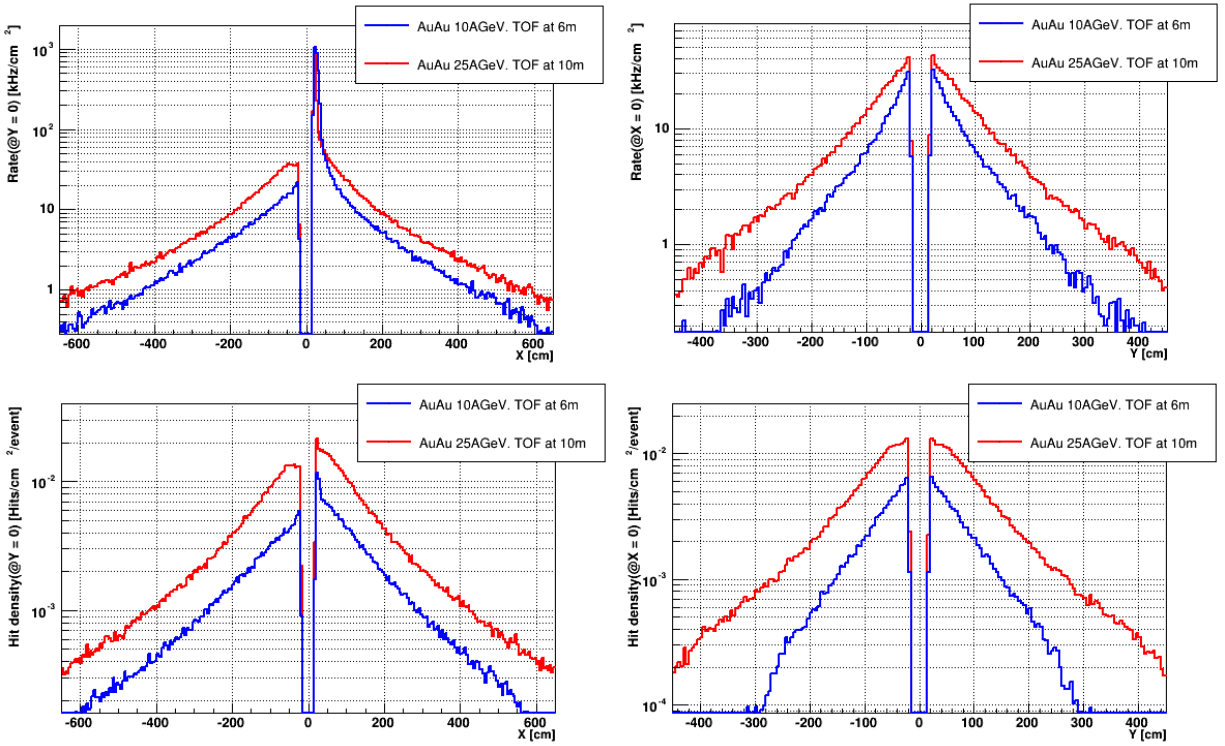
CBM: is a high rate experiment!

- ➢ **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



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



CBM-ToF Requirements:

- **Full system time resolution σ_T ~ 80 ps**
- **Efficiency > 95%**
- **Rate capability ≤ 30 kHz/cm^2**
- **Polar angular range 2.5° – 25°**
- **Active area of 120 m^2**
- **Occupancy < 5%**
- **Low power electronics (~120.000 channels)**
- **Free streaming data acquisition**

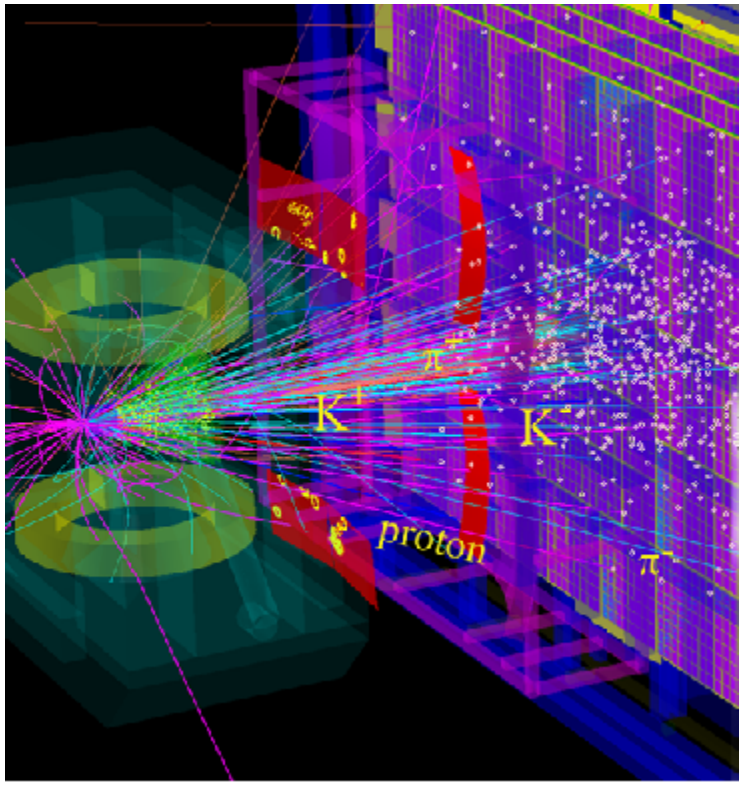
CBM Collaboration, "CBM – TOF Technical Desing Report", October 2014

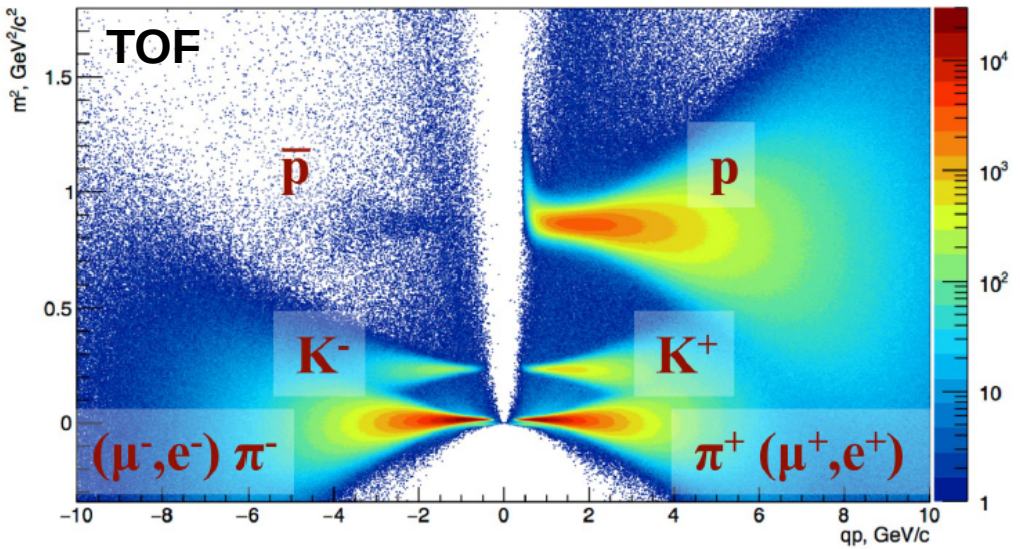
Detectors with different rate capabilities are needed as a function of polar angle

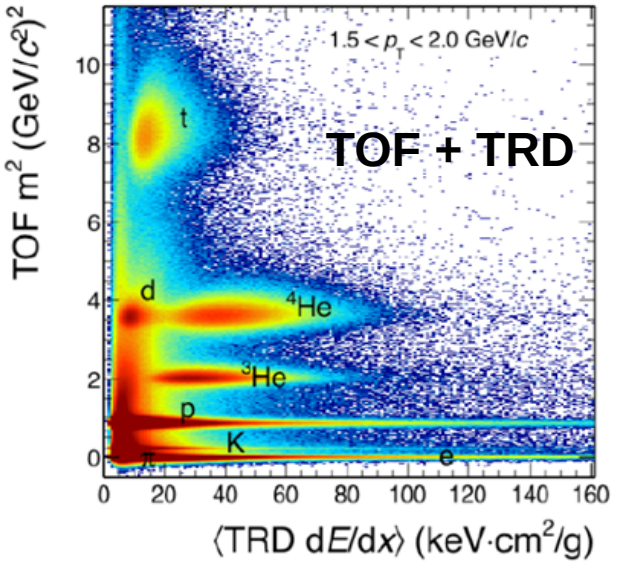
Our R&D activity addresses the CBM-TOF inner wall:

- highest counting rate
- highest granularity
- ~14 m^2 active area

PID with CBM setup





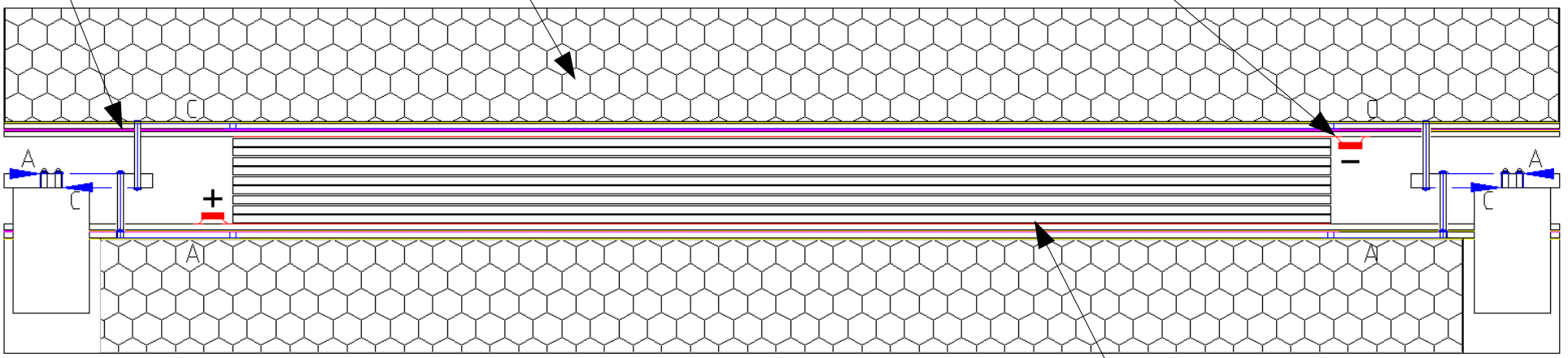


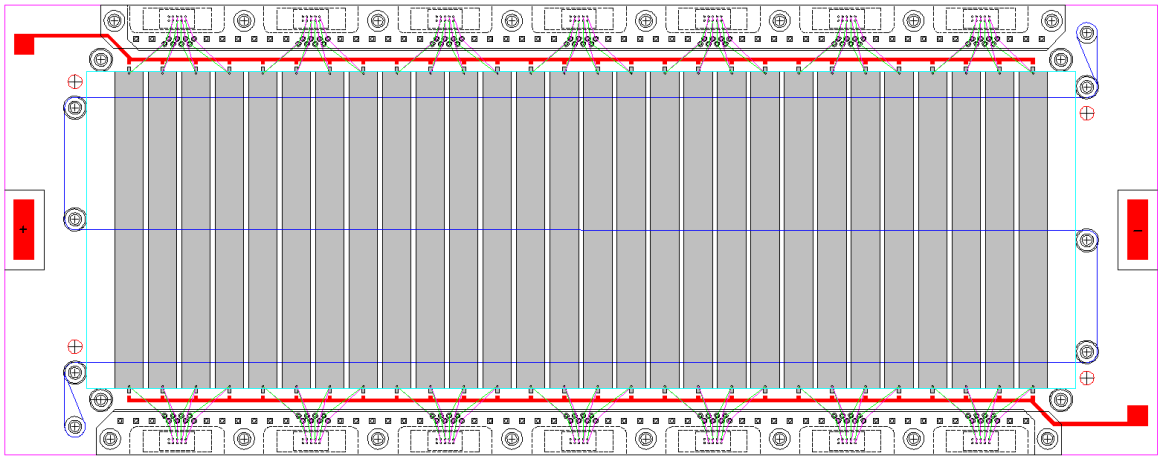
- **Hadron id: TOF (+TRD)**
- **Lepton id: RICH+TRD or MUCH**
- **γ, π0: EMC (or RICH)**

Testarea performantei prototipurilor de detectori cu electrozi rezistivi pentru masuratori de timp de zbor MGMSRPC, dezvoltati pentru CBM-TOF, folosind un sistem de achizitie cu electronica auto-trigerata similar cu cel ce va fi utilizat in experimentul CBM (partea II)

- **Estimarea performantelor detectorului in termeni de dimensiune a clusterului de stripuri cu semnal in conditii de multi-hit**

SS-RPC2015 prototype
100 Ohm transmission line impedance

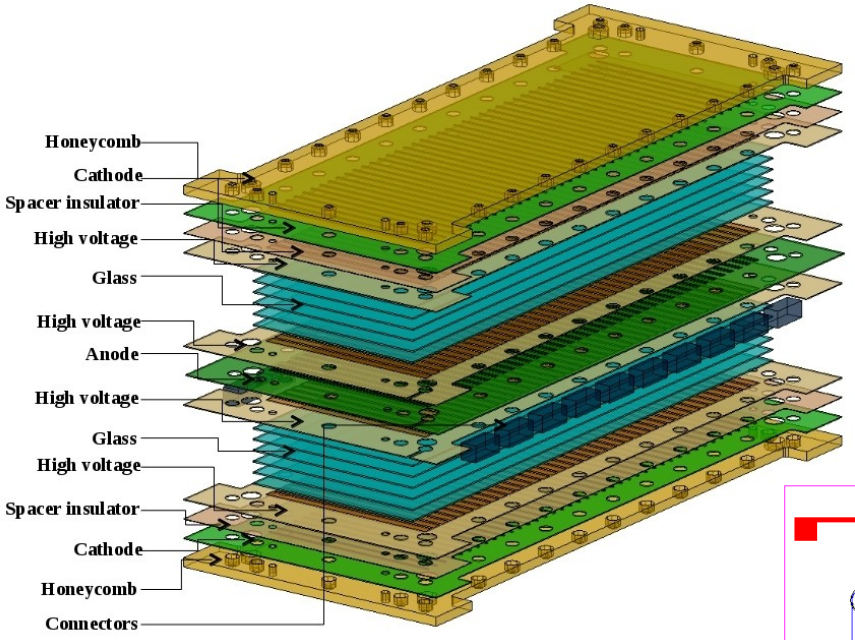




- ✓ Single stack structure: 8 gaps
- ✓ Active area 96 x 300 mm2
- ✓ Gas gap thickness: 140 µm thickness
- ✓ Readout electrode = 28 strips
- ✓ Differential readout = 100 Ohm impedance
- ✓ Resistive electrodes: low resistivity glass

Readout & HV electrode : 10.1 mm pitch= 8.6 mm width + 1.5 mm gap

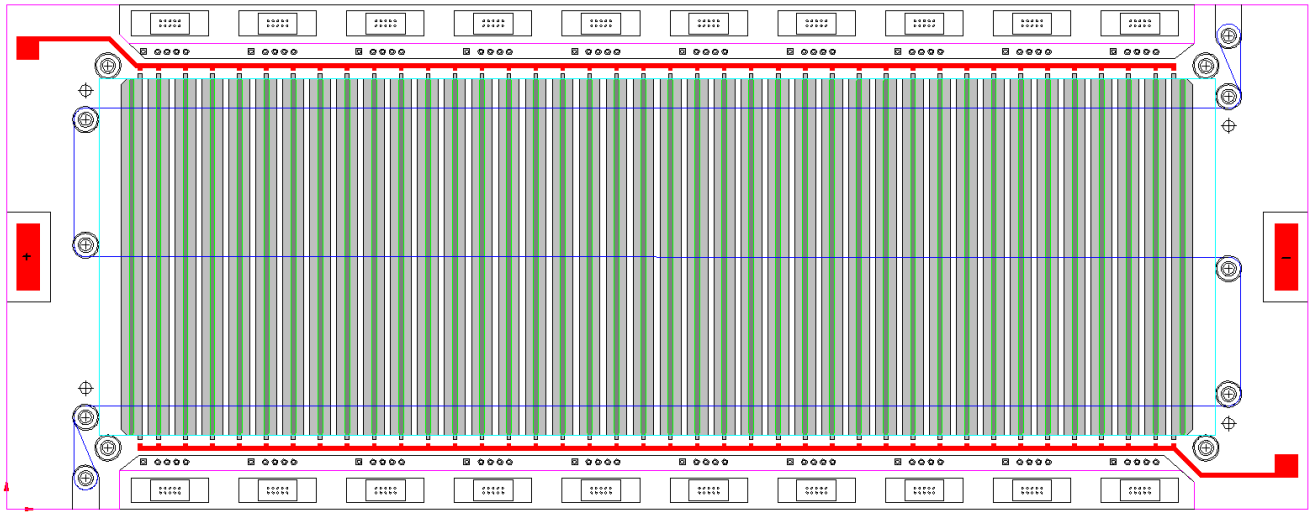
RPC2015DS prototype
strip impedance tuned through the readout strip width

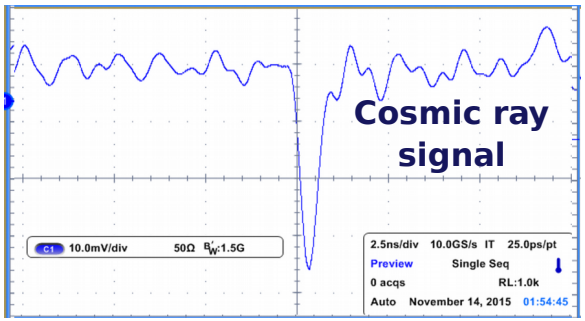


Goal – perfect matching of the impedance of the signal transmission line to the imput impedance of the FEE, in order to reduce the amount of fake information resulted from reflections.

Simulations predicted ~99 Ω impedance for
1.3 mm readout and 5.6 mm high voltage strip widths

- ✓ **Symmetric two stack structure: 2 x 5 gaps**
- ✓ **Active area 96 x 300 mm2**
- ✓ **Gas gap thickness: 140 μm thickness**
- ✓ **Readout electrode = 40 strips**
- ✓ **Differential readout**
- ✓ **Resistive electrodes: low resistivity glass**





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

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

Assembled MSMGRPC2015 prototypes

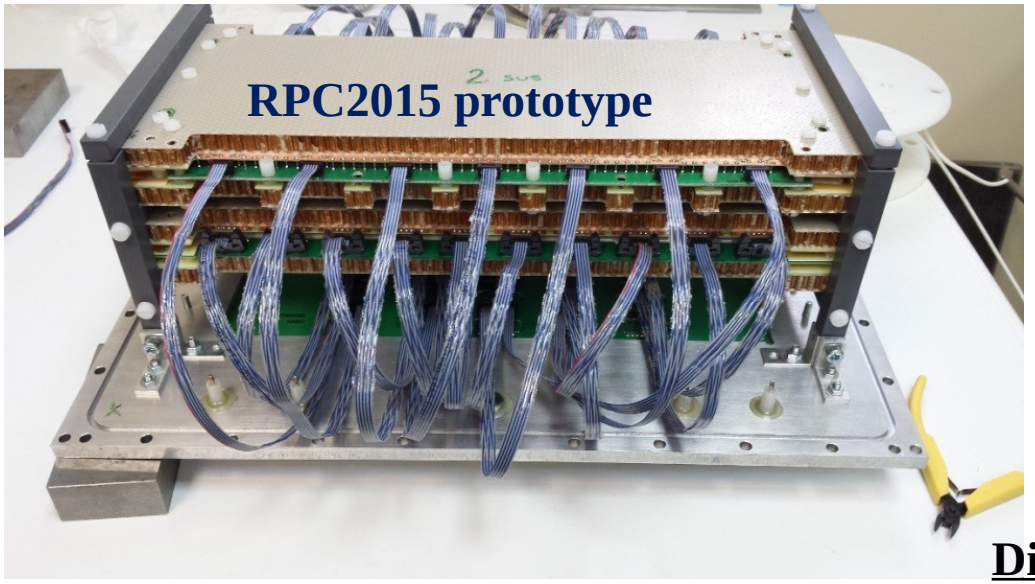
Common in counter architecture:

Electrodes: 0.7 mm low resistivity Chinese glass

Gap size: 140 μm thickness

Differential readout, 100 Ω impedance

Active area: 96 x 300 mm^2



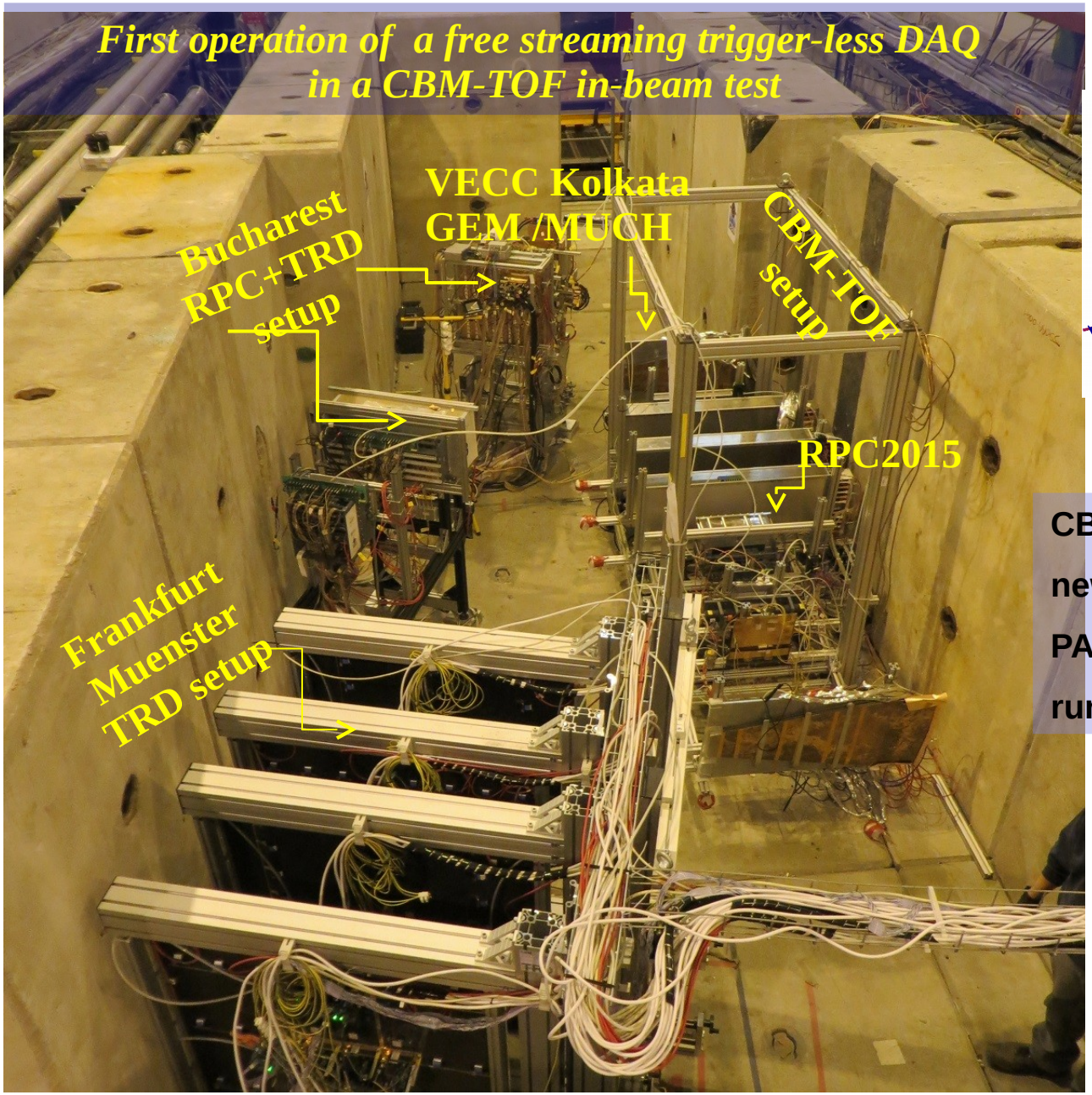
Differences in counter architecture:

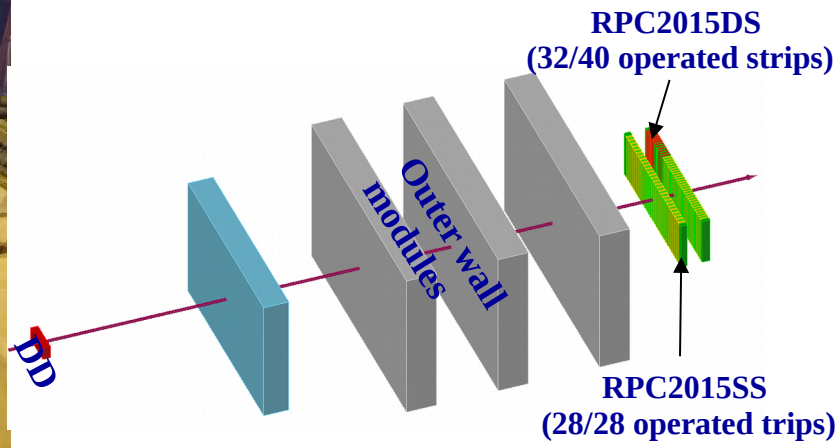
DS: ***Symmetric two stack structure: 2 x 5 gas gaps***

SS: Single stack structure: 1 x 8 gas gaps

Fall 2016 CERN - SPS in-beam tests

Pb beam of 13/30/150 AGeV on a Pb target





CBM-TOF readout ~ 500 Channels with a new readout-chain based on: PADI / GET4 / AFCK / FLIB => DAQ was running stable.

Results of Fall 2016 in-beam test

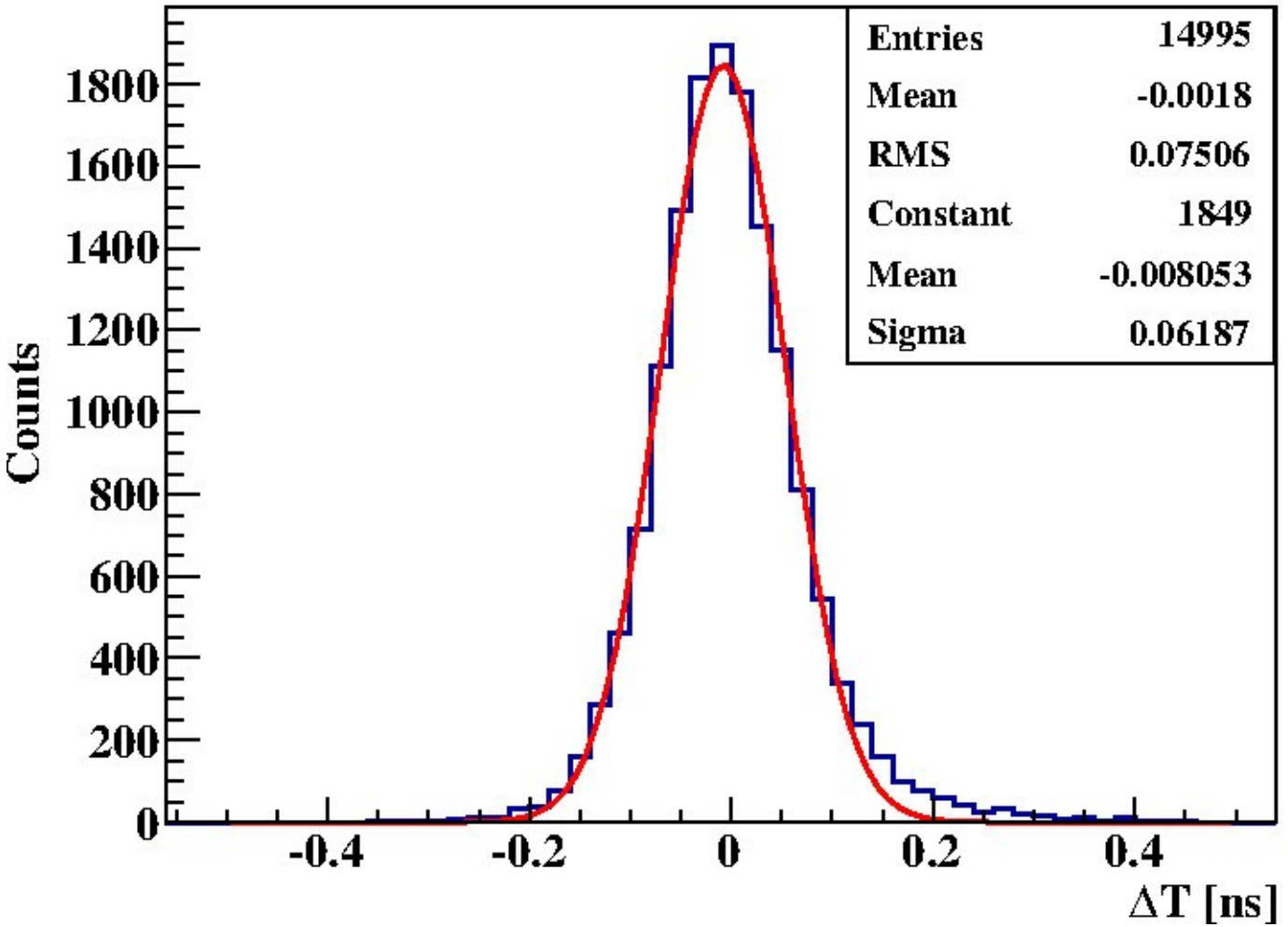
Detector performance in terms of:

- **efficiency (Progress Report 30.07.2019)**
- **time resolution (Progress Report 30.07.2019)**
- **cluster size**

  in a close to real free-streaming signal processing

Time difference spectrum

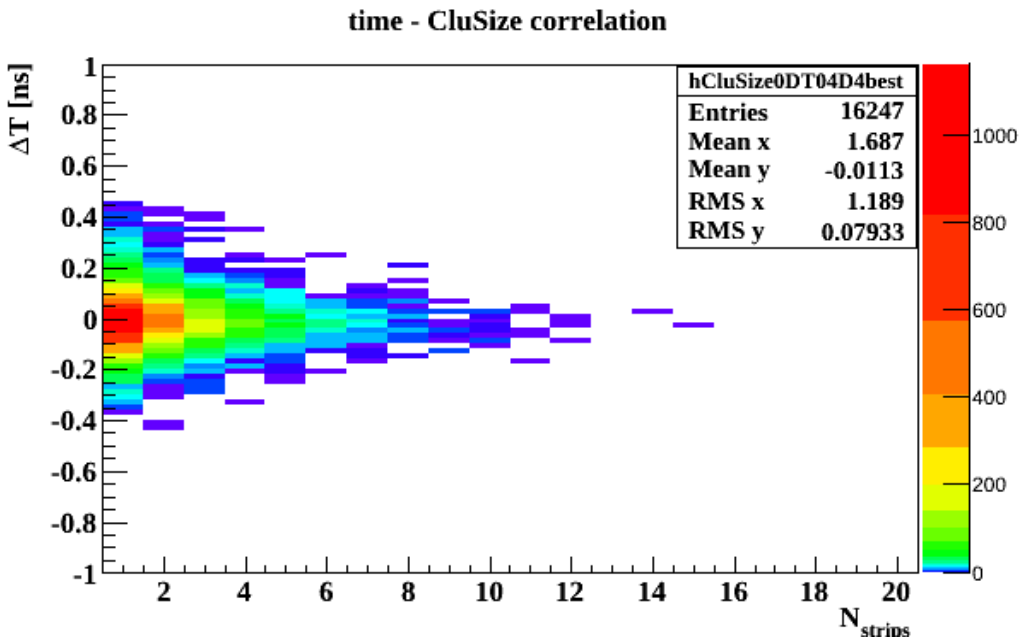
➢ Progress Report 30.07.2019

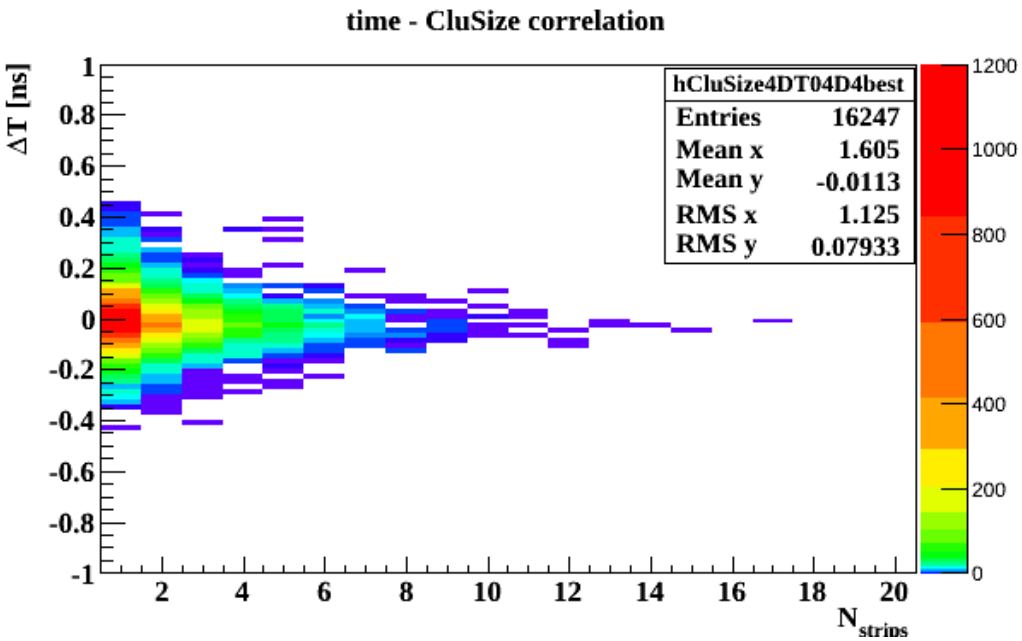


System time resolution = 62 ps

Single counter time resolution = 44 ps

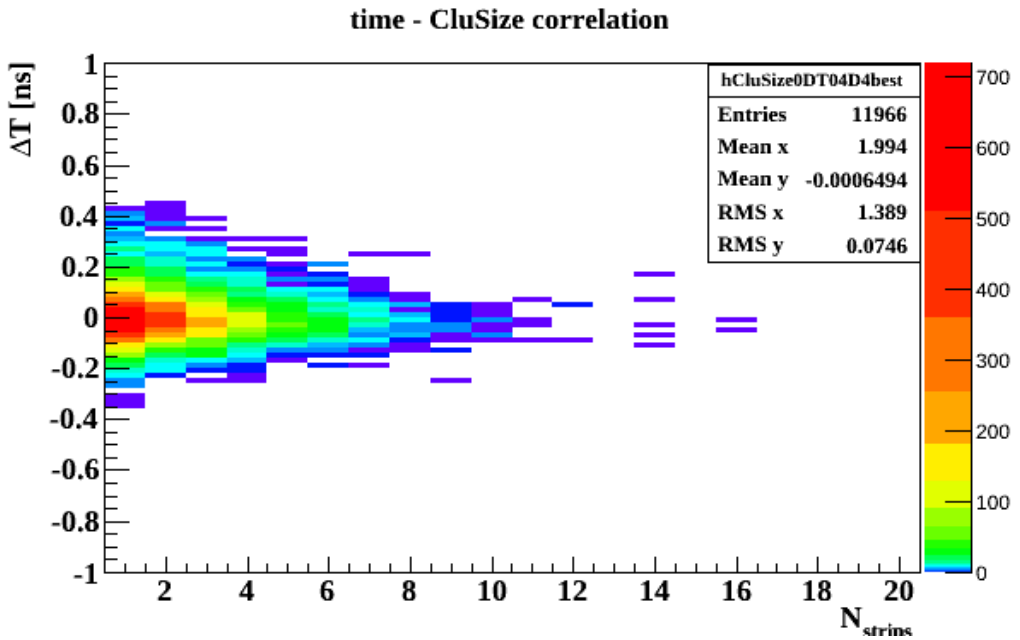
Time – Cluster Size Correlations

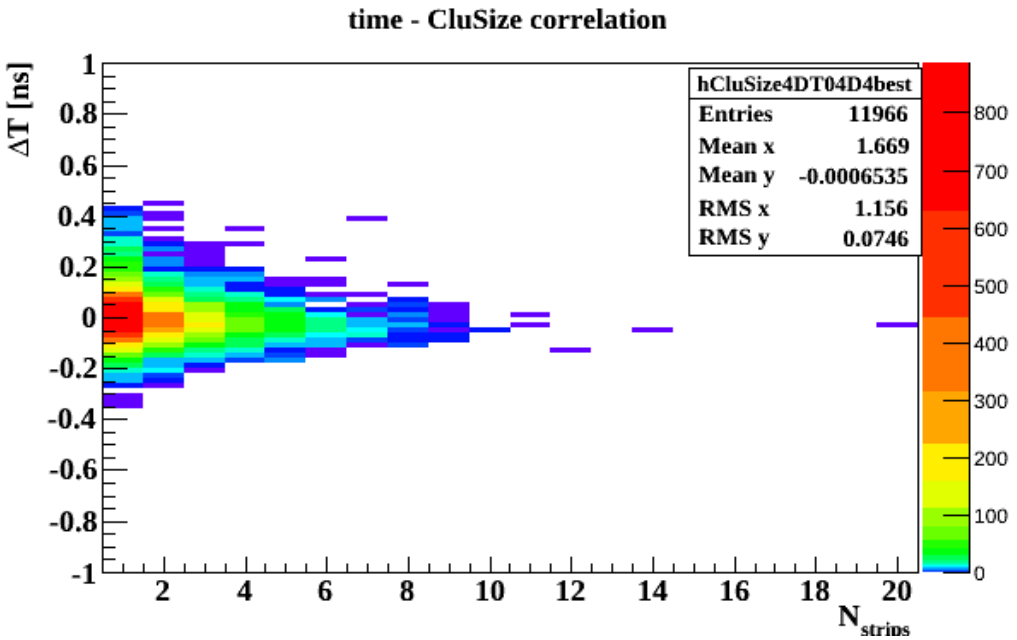




	DUT	REF
HV	±8.8 kV (157 kV/cm)	±5.5 kV (157 kV/cm)
FEE Th	300 mV	300 mV
Cl Size	1.7	1.6

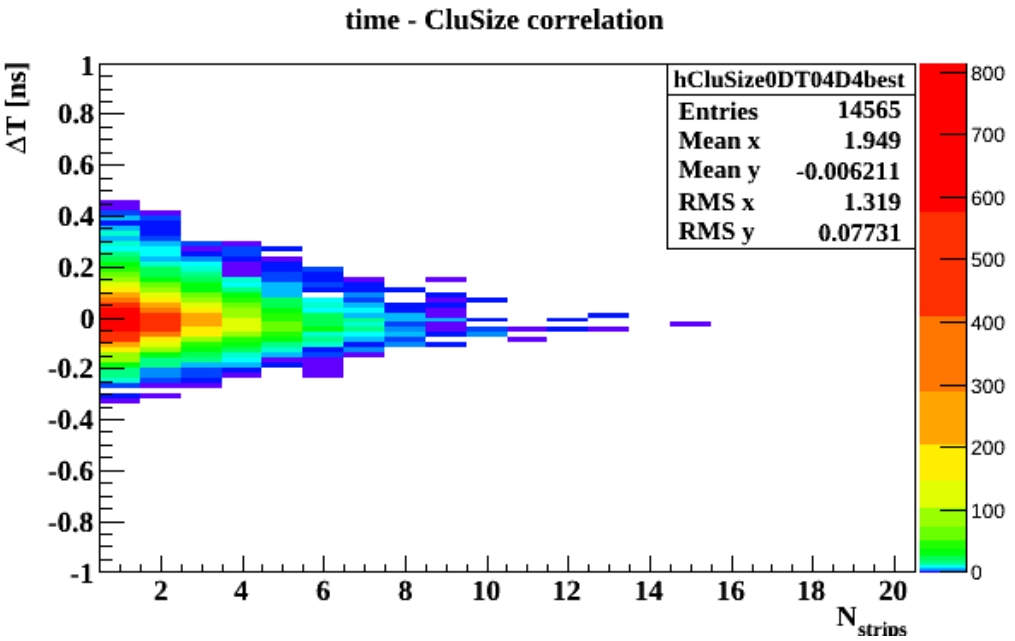
Time – Cluster Size Correlations

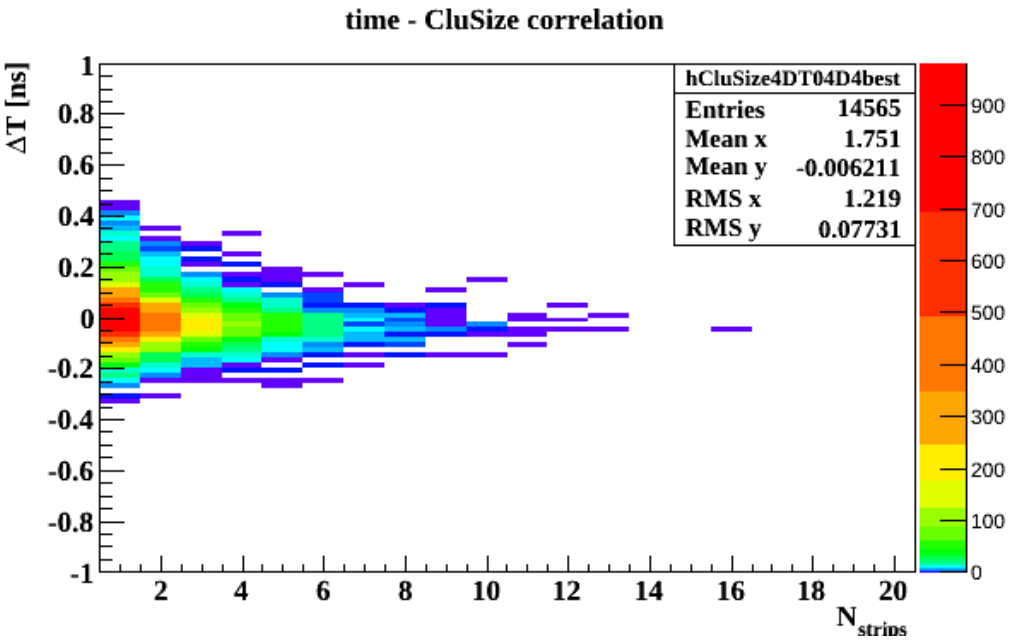




	DUT	REF
HV	±8.8 kV (157 kV/cm)	±5.5 kV (157 kV/cm)
FEE Th	200 mV	300 mV
Cl Size	2	1.7

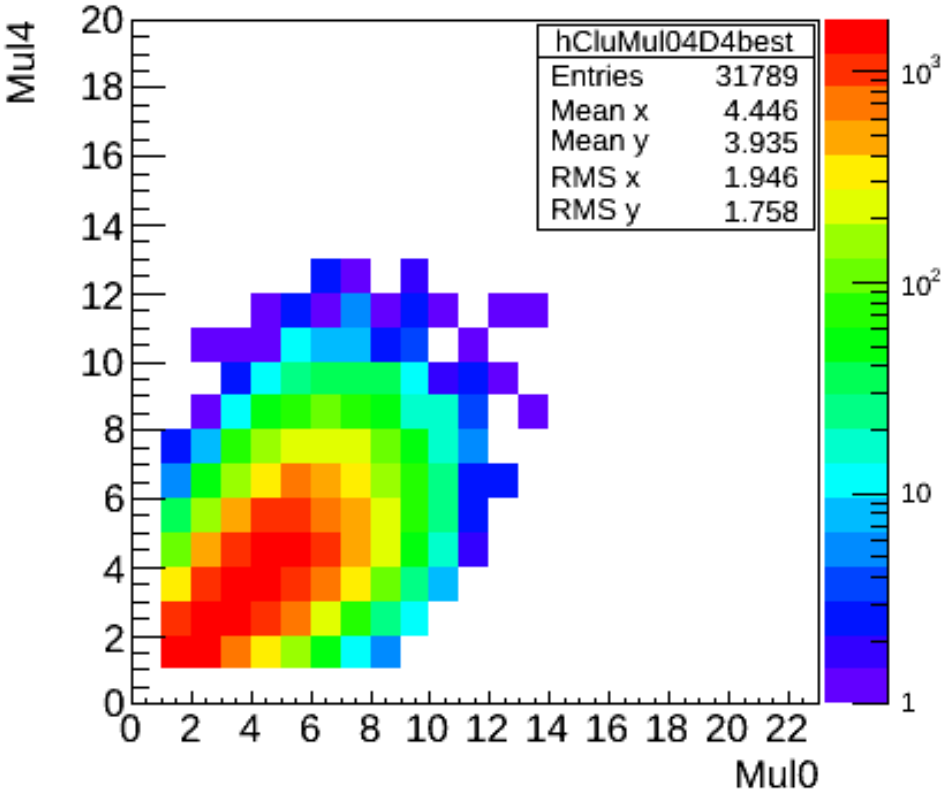
Time – Cluster Size Correlations





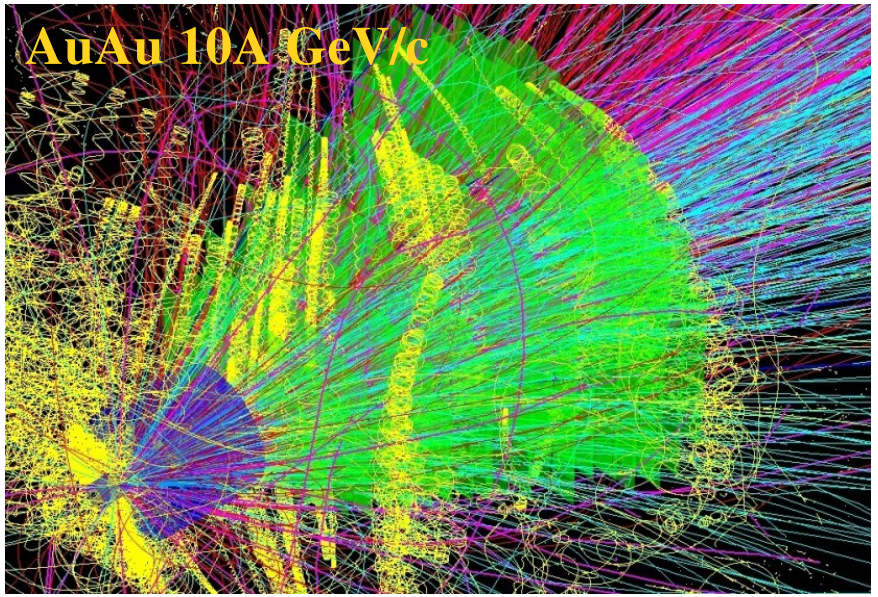
	DUT	REF
HV	±8.9 kV (159 kV/cm)	±5.5 kV (157 kV/cm)
FEE Th	300 mV	300 mV
Cl Size	1.9	1.7

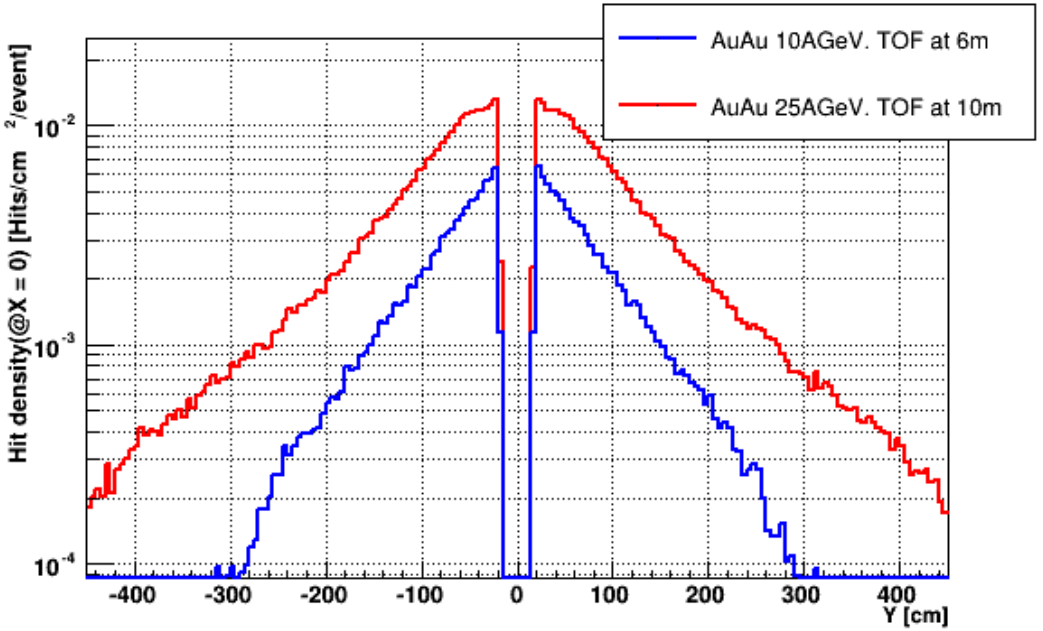
Multiplicity Correlation



Strip length calculation

for the highest granularity of the CBM-TOF wall





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

→ **6 cm strip length**

Proiectarea si realizarea a doua prototipuri de MGMSRPC, 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 I)

- **Desene de poiectare a componentelor mecanice si electronice folosind platformele QCAD si OrCAD**

New RPC2018 prototype design

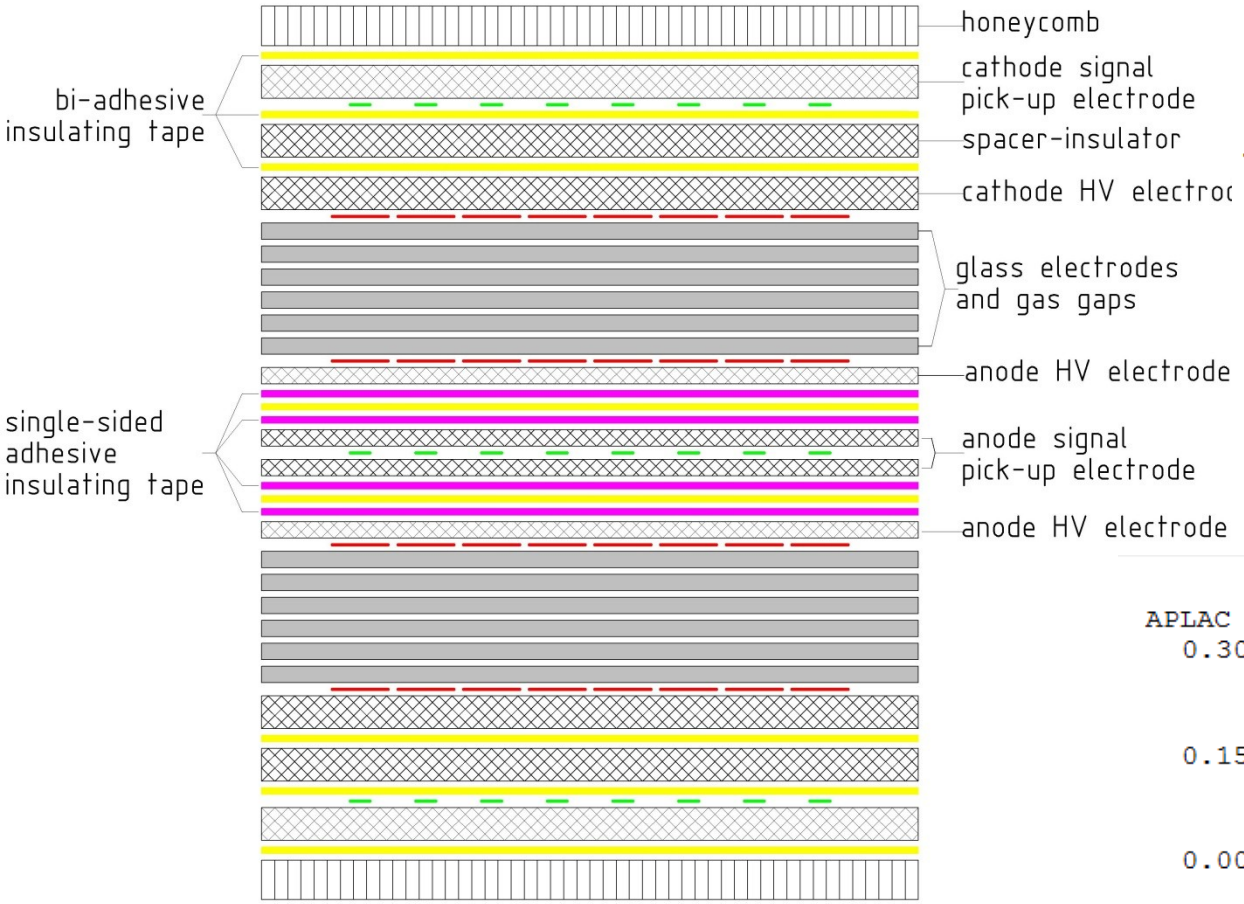
Motivation

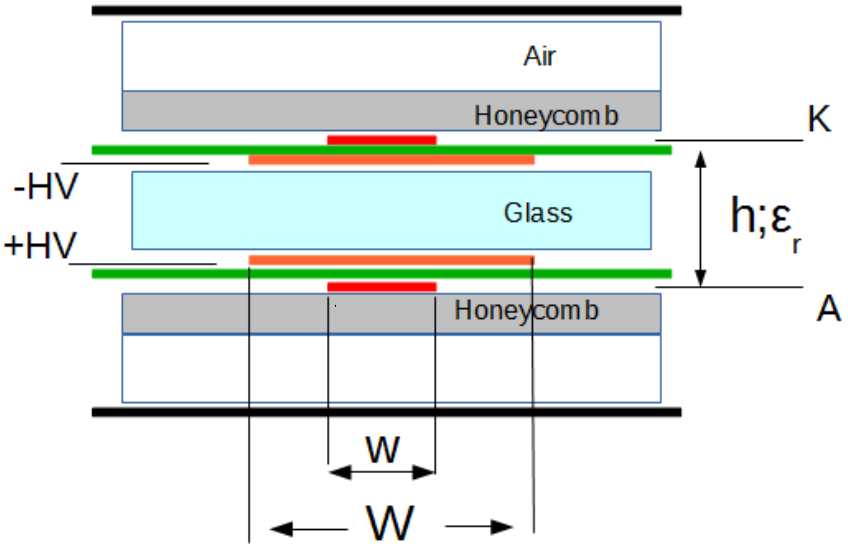
RPC2015 prototypes:

- ***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***

New RPC2018 prototype design



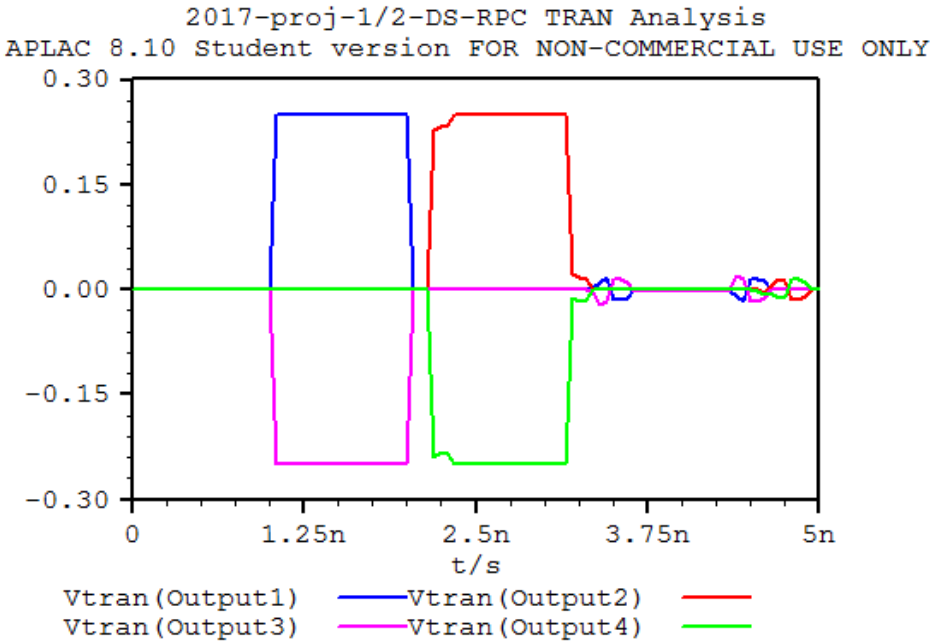


h = equivalent dielectric thickness

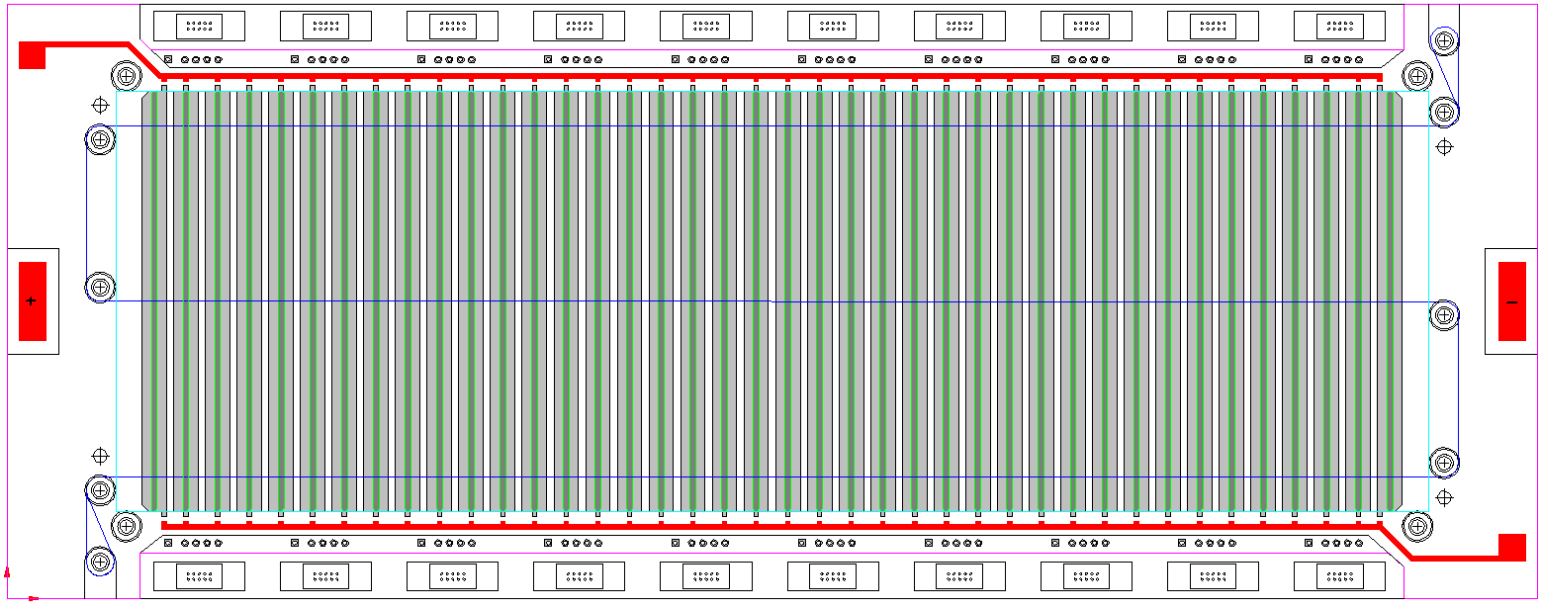
ε = equivalent dielectric constant

APLAC predicted 97 Ω for

1.27/7.4 mm readout/HV strip width



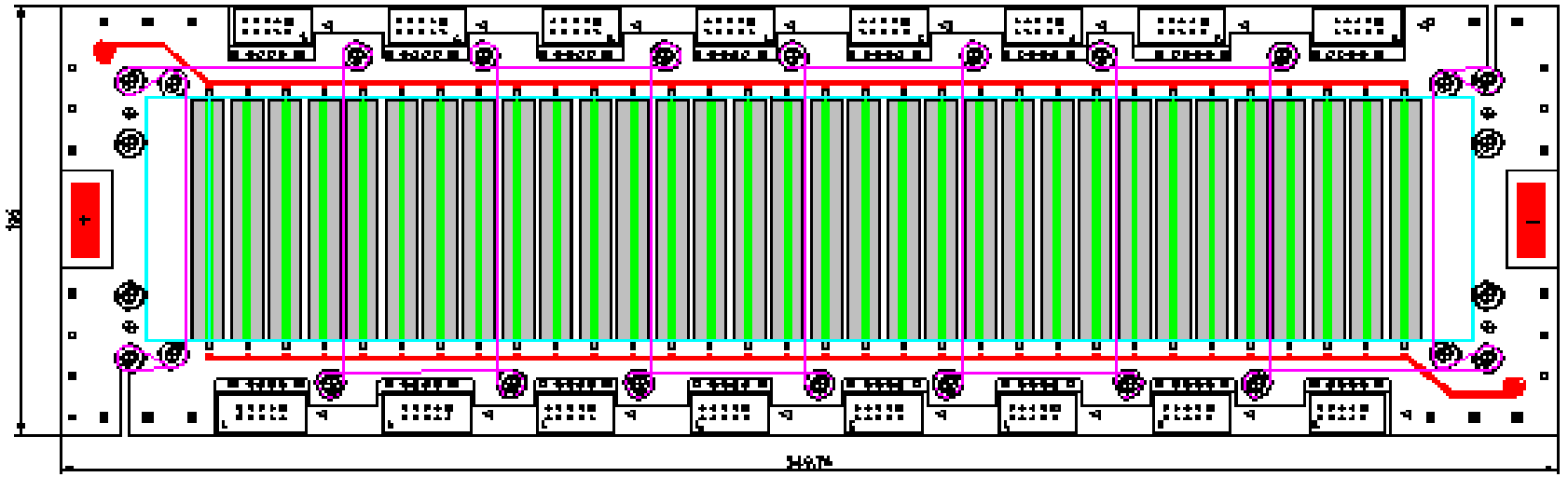
From RPC2015 to RPC2018 prototype



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

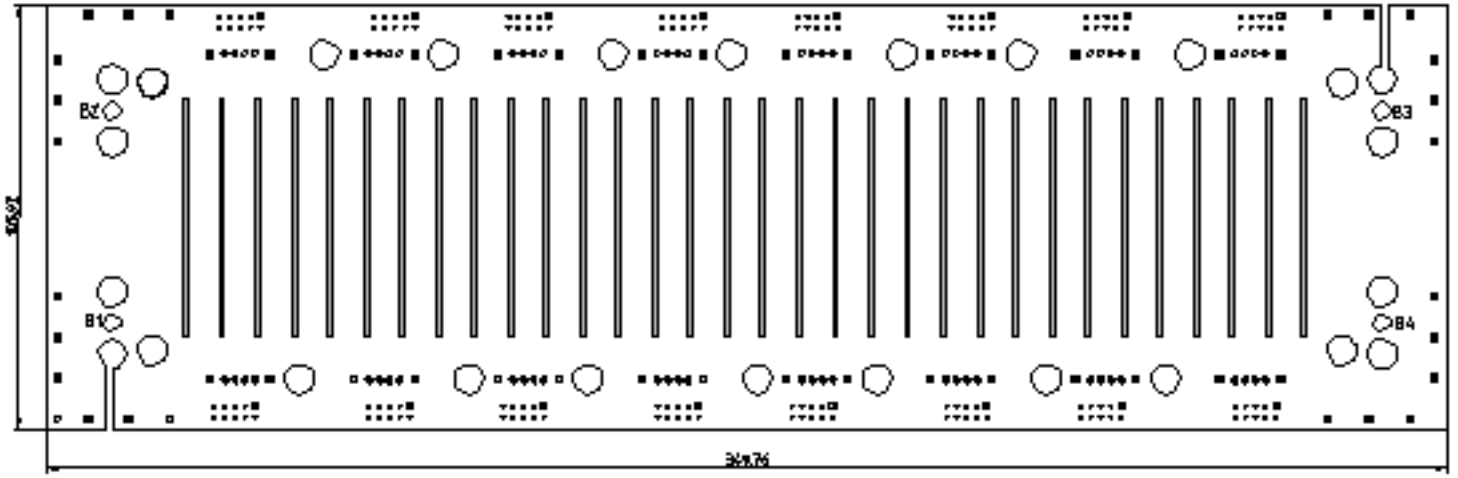
190S60-FAZ1.3

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

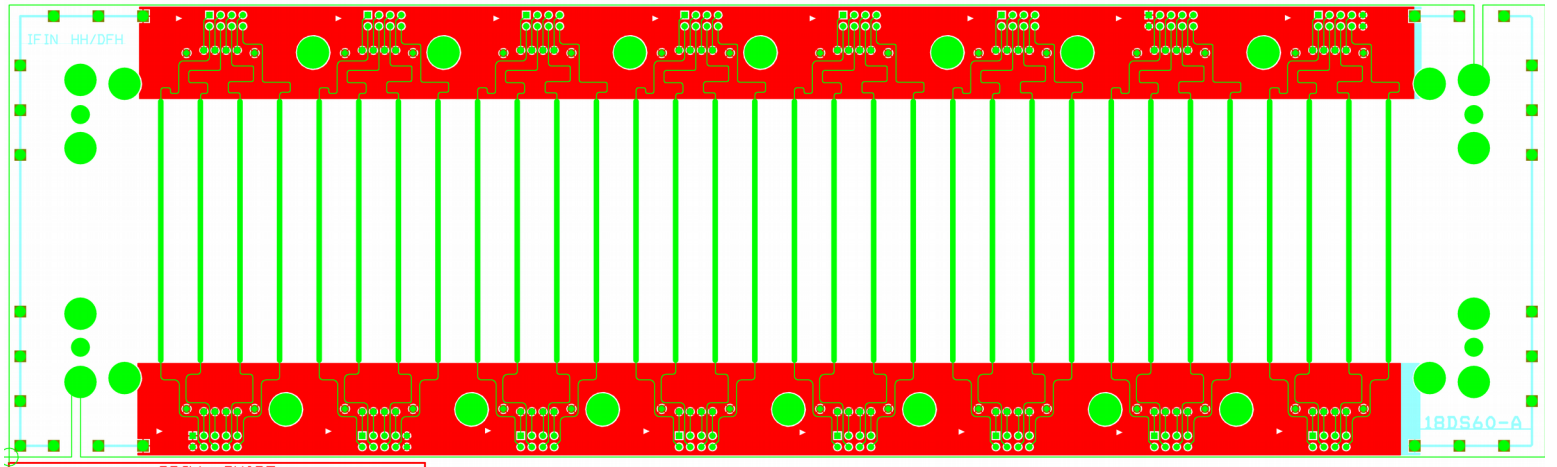
High Voltage electrode: 9.02 mm pitch= 7.37 mm width + 1.65mm gap

Anode readout electrode

QCAD



OrCAD

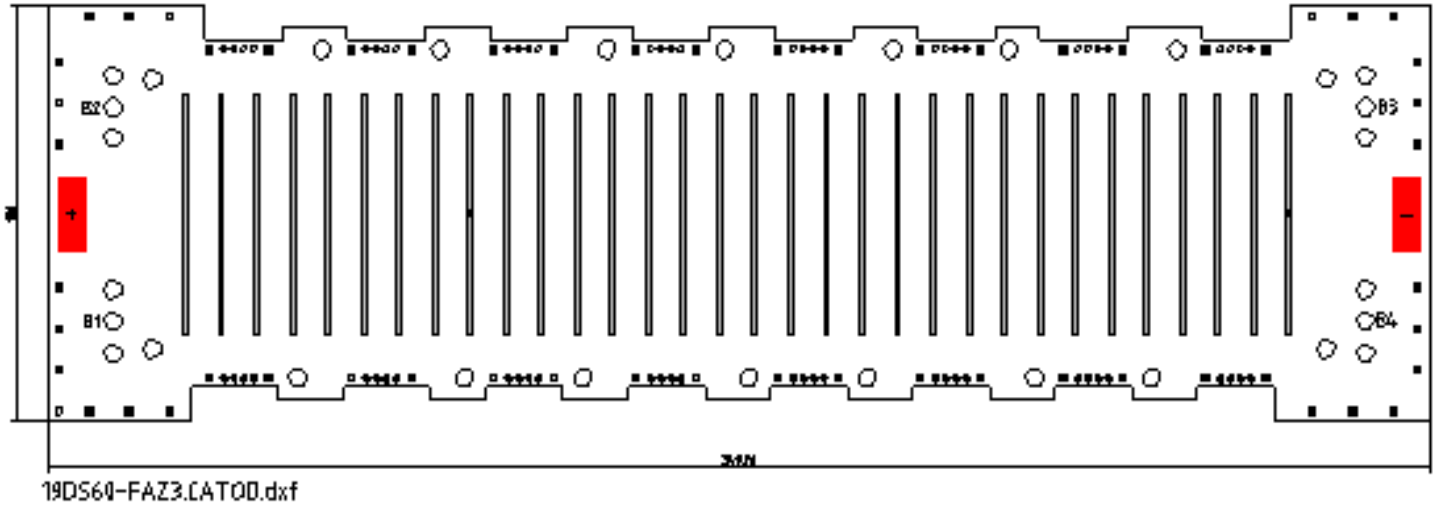


DRILL CHART				
SYM	DIAM	TOL	QTY	NOTE
+	0.037		136	
×	0.038		121	
◇	0.170		4	NON-PLATED
⊠	0.290		26	NON-PLATED
TOTAL			287	

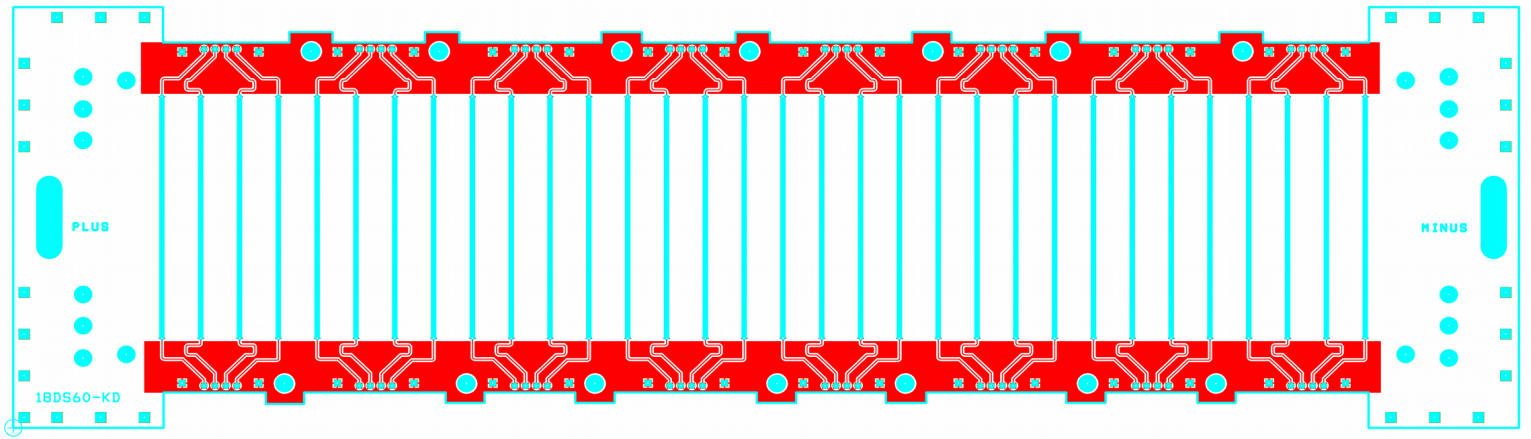
Reper:18DS60-A
3 LAYERS: TOP, INNER & BOTTOM
Material: FR4
Distance between TOP-INNER and INNER-BOTTOM : 12mil (0.3mm)
Copper total thikness on INNER and OUTER layers: 1oz (0.035mm)
Controlled impedance on INNER layer: w=8 mil, total thikness TOP-BOTTOM = 24mil (0.6mm)

Cathode readout electrode

QCAD



OrCAD



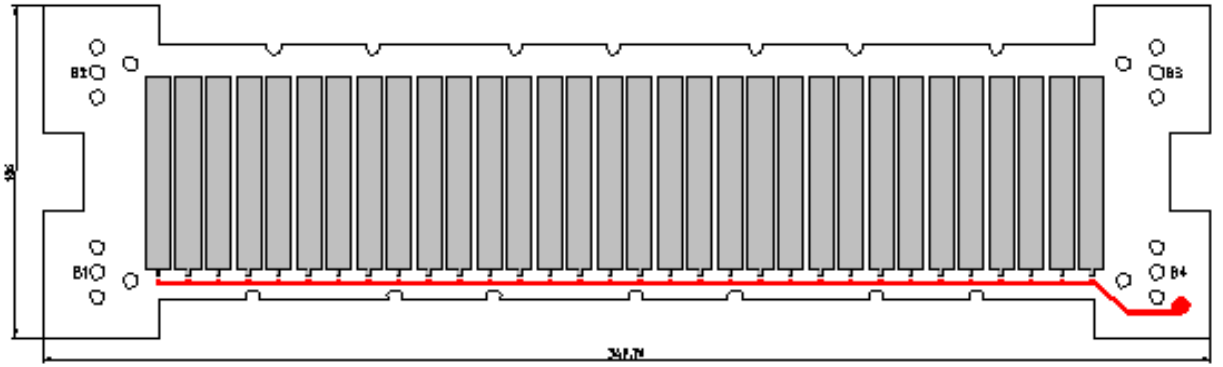
DRILL CHART				
SYM	DIAM	TOL	QTY	NOTE
+	0.012		64	
×	0.038		121	
◇	0.170		30	NON-PLATED
TOTAL			215	

Reper: 18DS60-KD-T

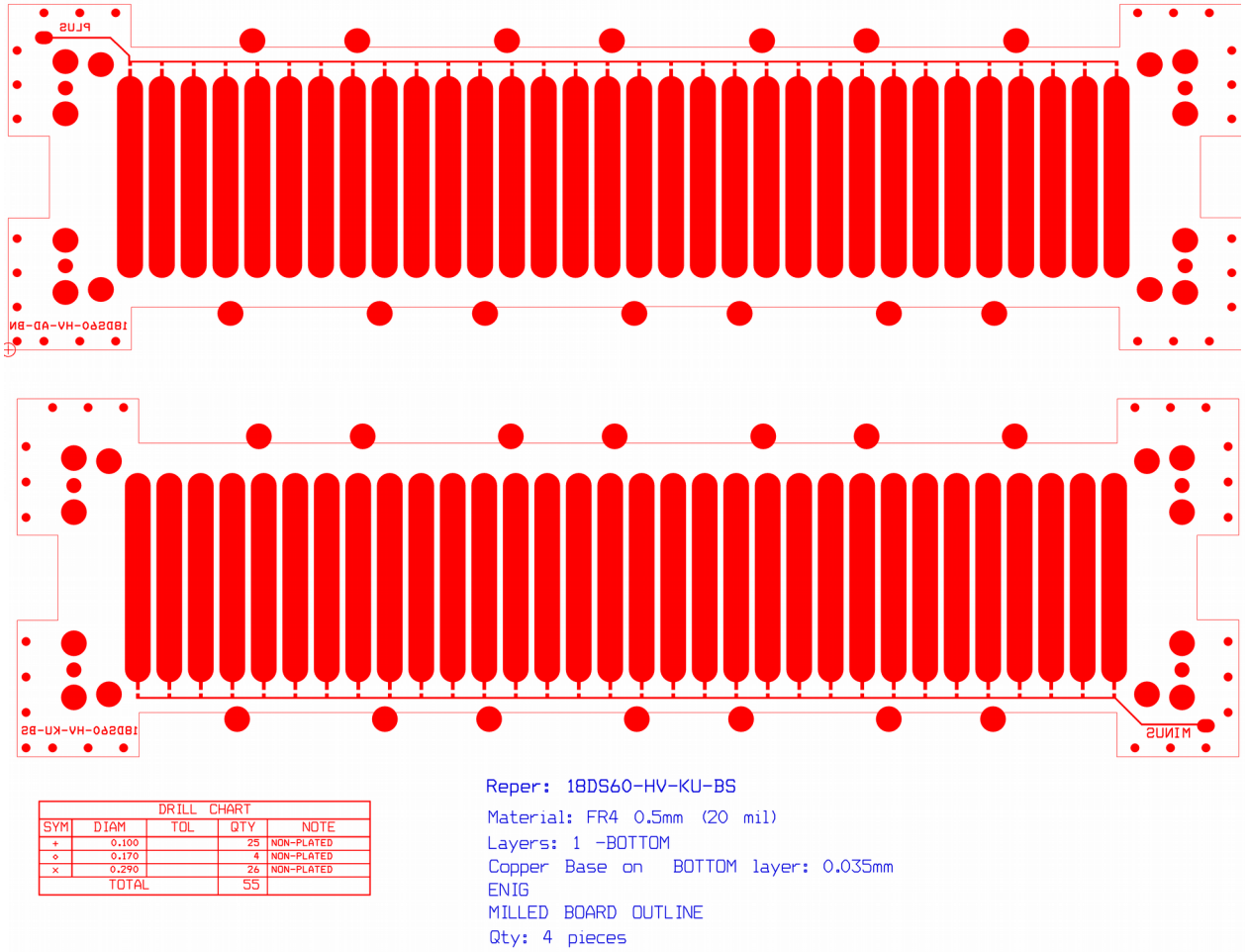
Material: FR4 0.5mm (20 mil)
Layers: 2 TOP , BOTTOM
Controlled impedance on BOTTOM layer: w=8 mil, Copper Pour Clearance = 15mil
Copper Base on TOP and BOTTOM layers: 0.035mm

High voltage electrode

QCAD

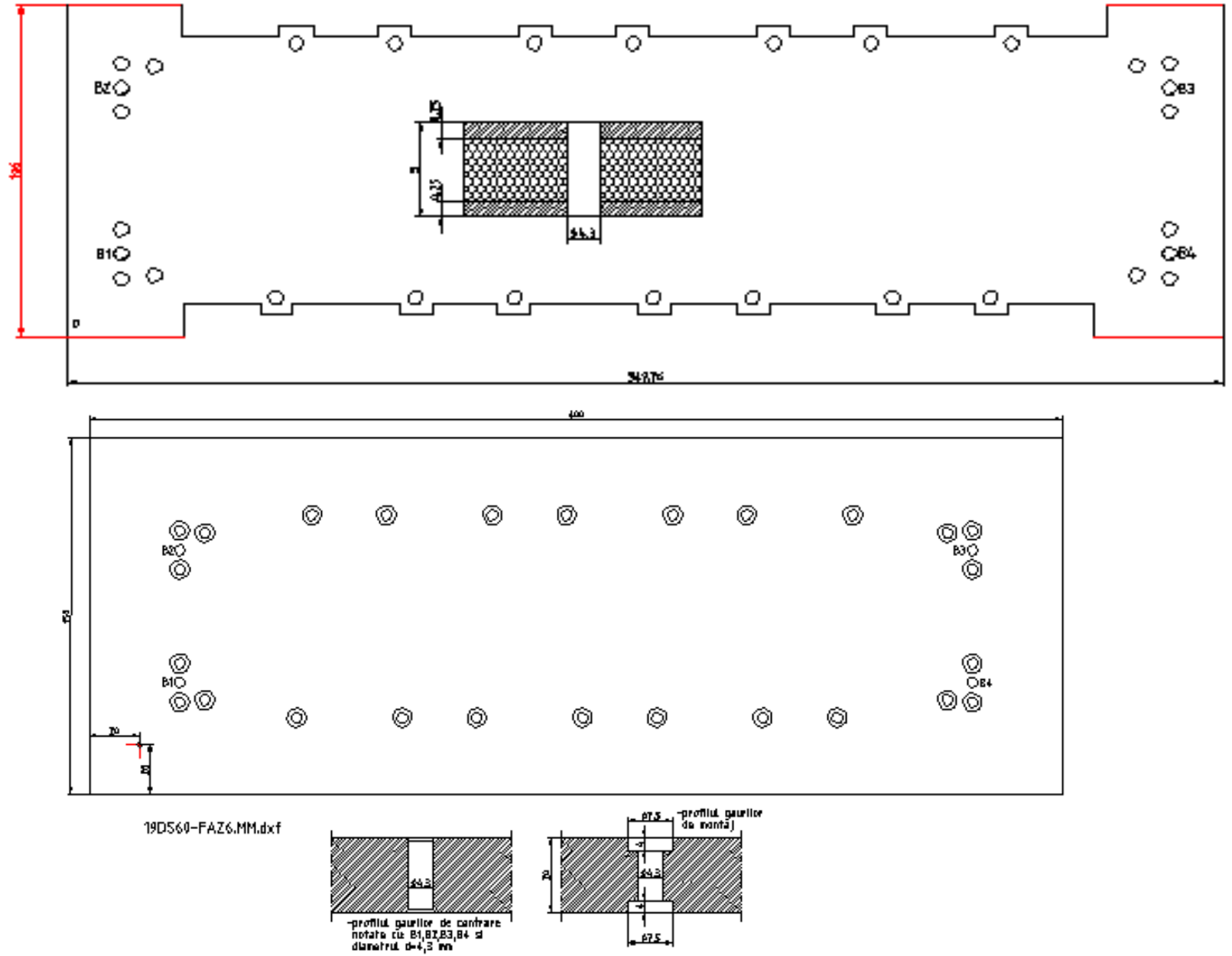


OrCAD



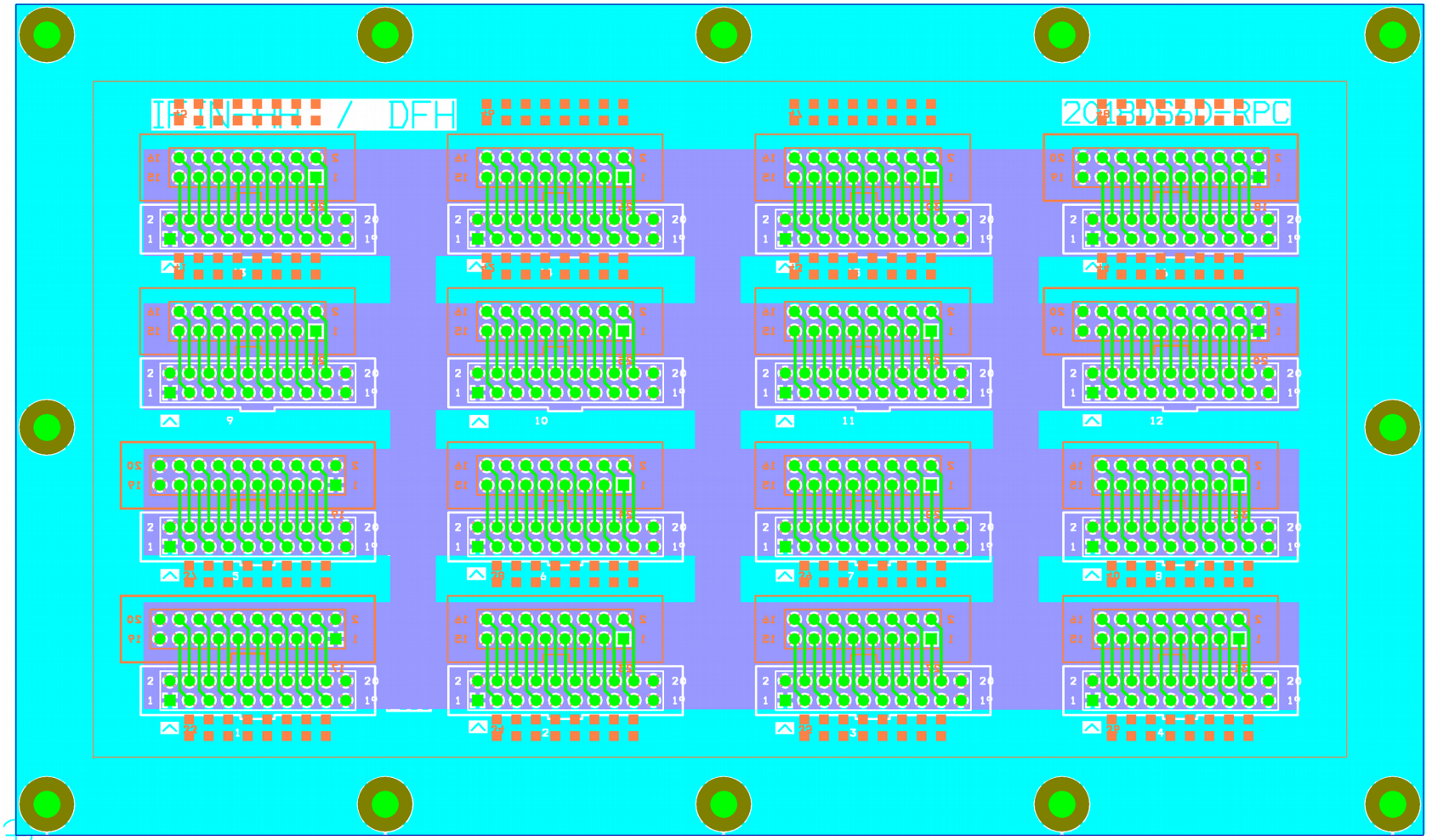
Honeycomb & mechanical support plates

QCAD



Back pannel connector plate

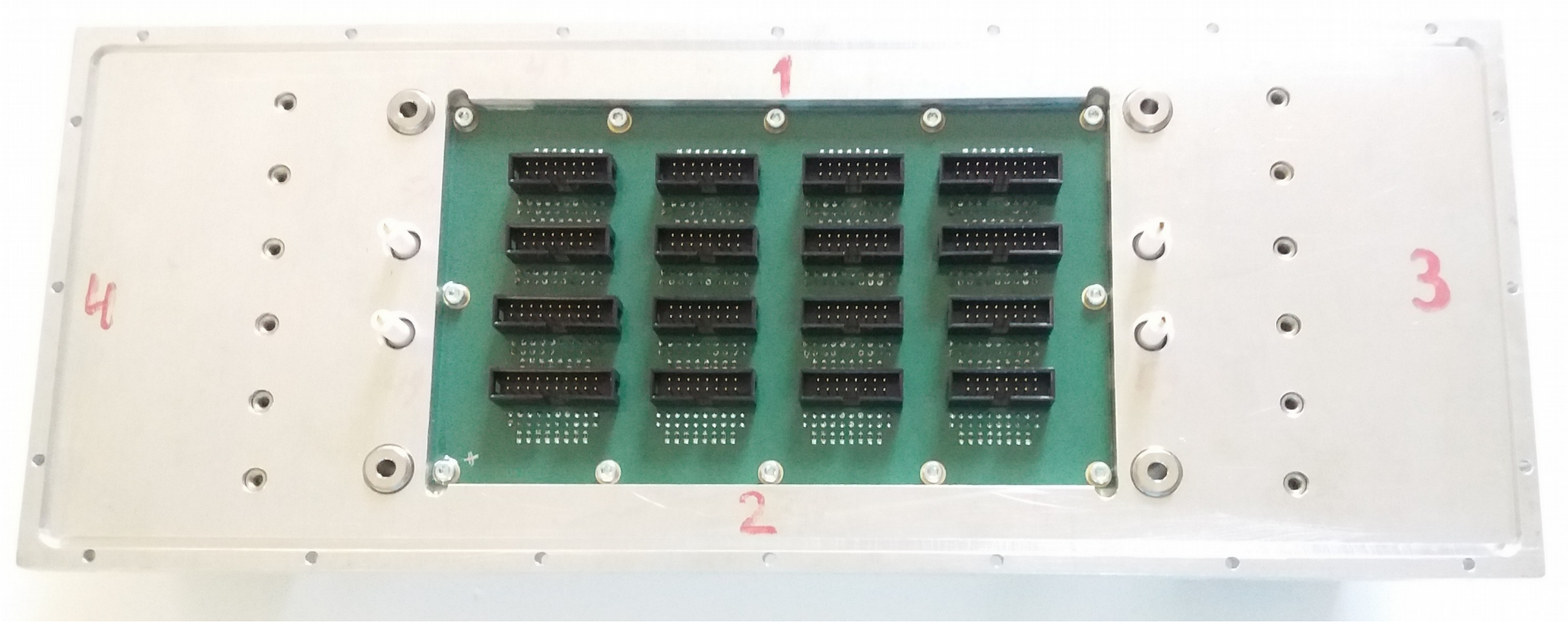
OrCAD



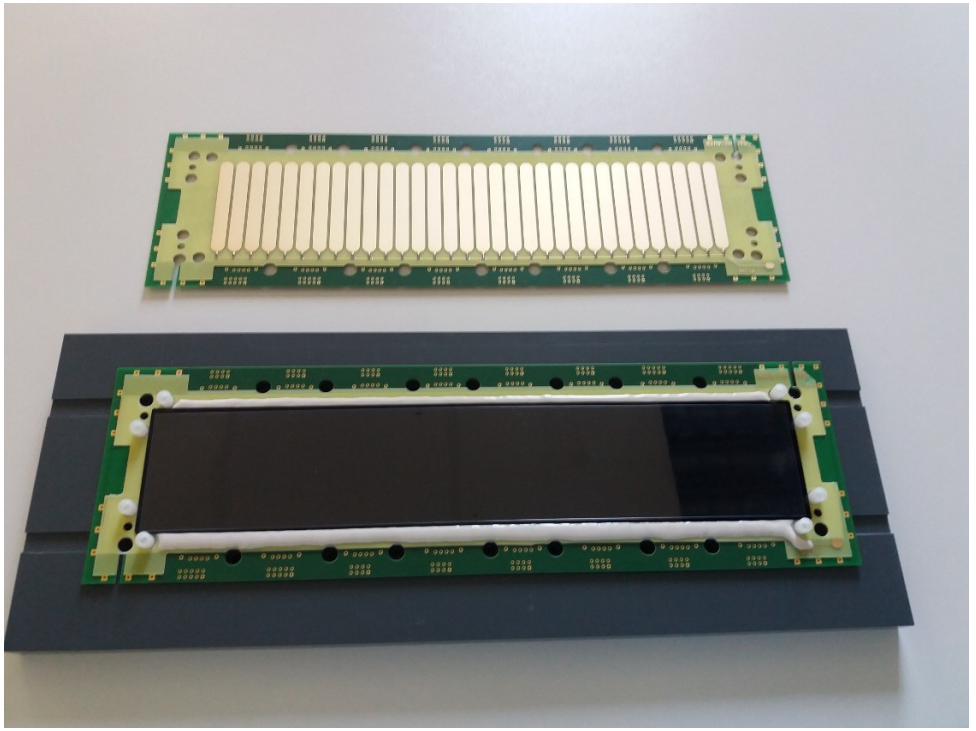
DRILL CHART				
SYM	DIAM	TOL	QTY	NOTE
×	0.940 mm		592	
+	3.200 mm		12	
TOTAL			604	

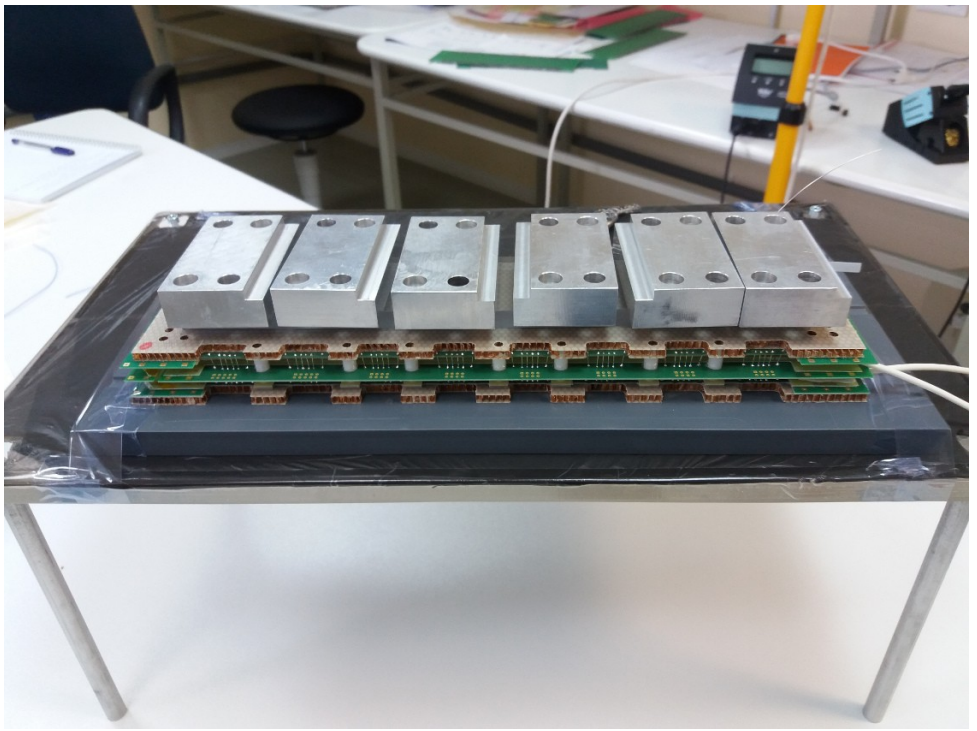
Reper:18DS60-ConPan
Material: FR4
4 LAYERS: TOP, INNER1, INNER2 & BOTTOM
Controlled impedance on INNER1 layer: w=0.35mm
Distance between TOP and INNER1 = 0.5 mm
Distance between INNER1 and INNER2= 0.5 mm
Copper Base: 0.035mm
FINAL THICKNESS = 2mm

Manufactured components



Manufactured components





Conclusions and Outlook

- The obtained results of 2016 SPS in-beam test using a free-streaming signal processing showed the high granularity MSMGRPC performance.

- They demonstrate the possibility to operate MSMGRPCs in a free-streaming readout mode with minimum fake signals produced by reflections, thus becoming a real candidate for high interaction rate experiments.

- The MSMGRPC prototype with the highest granularity of the CBM-TOF wall was designed. The technical drawings of the mechanical and electronic components used for its assembling were made using QCAD and OrCAD software platforms.


Thank you for your attention!