A New Readout Scheme for RPC

and Other Gaseous Detectors

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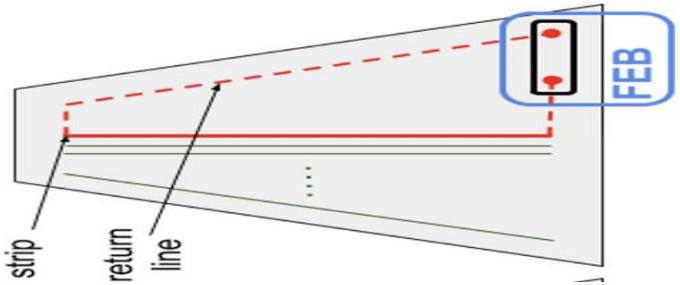
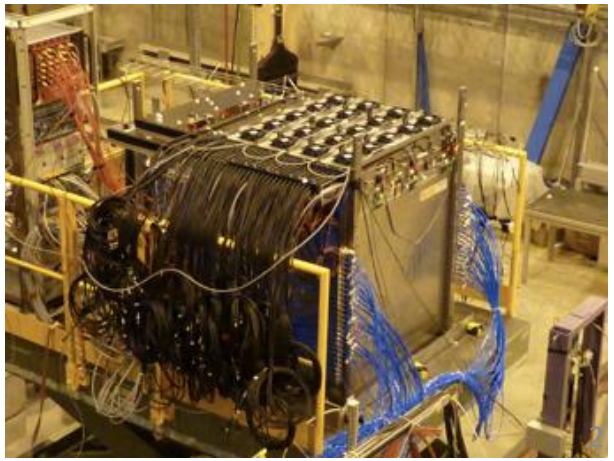
Readout of RPC

There are several ways to read out RPC:

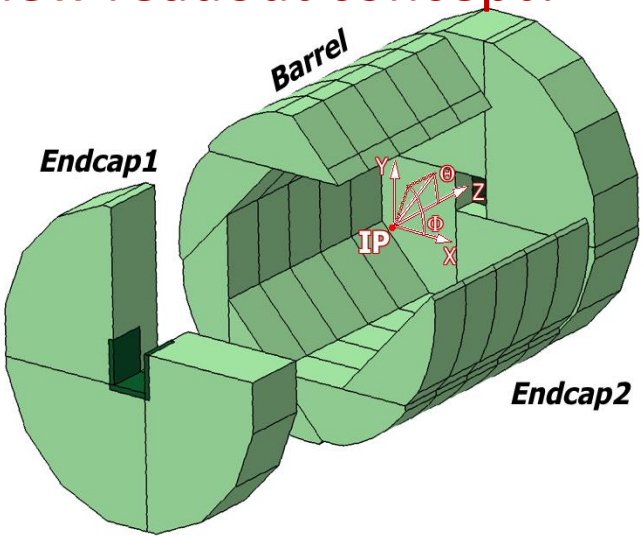
- Using **one-end readout pick-up strips** (either one direction on the anode side as for current CMS RPC or two direction one on the anode and one on the cathode as for ATLAS)
  or **two-end readout** using **excellent time measurement** as the one proposed for **CMS iRPC** upgrade project



- Using **pick-up PADs** as for SDHCAL (CALICE)



Why we need a new readout concept?



ILD SDHCAL concept

ILC, CECP calorimeters baselines are all **high-granularity PFA-**based.

- **SDHCAL** is one of the HCAL baselines for both with **tens of millions of channels**
- Only about 10^3 will be fired for each collision. So the channels are idle almost all of the time but continue to consume power and to produce heat, necessitating in the case of circular colliders **active cooling** → **reduced PFA performance**

This statement applies for all high granular calorimeters other options.

Why we need a new readout concept?

Reducing the number of pads/pixels is not an option since this leads to less granularity → inefficient PFA.

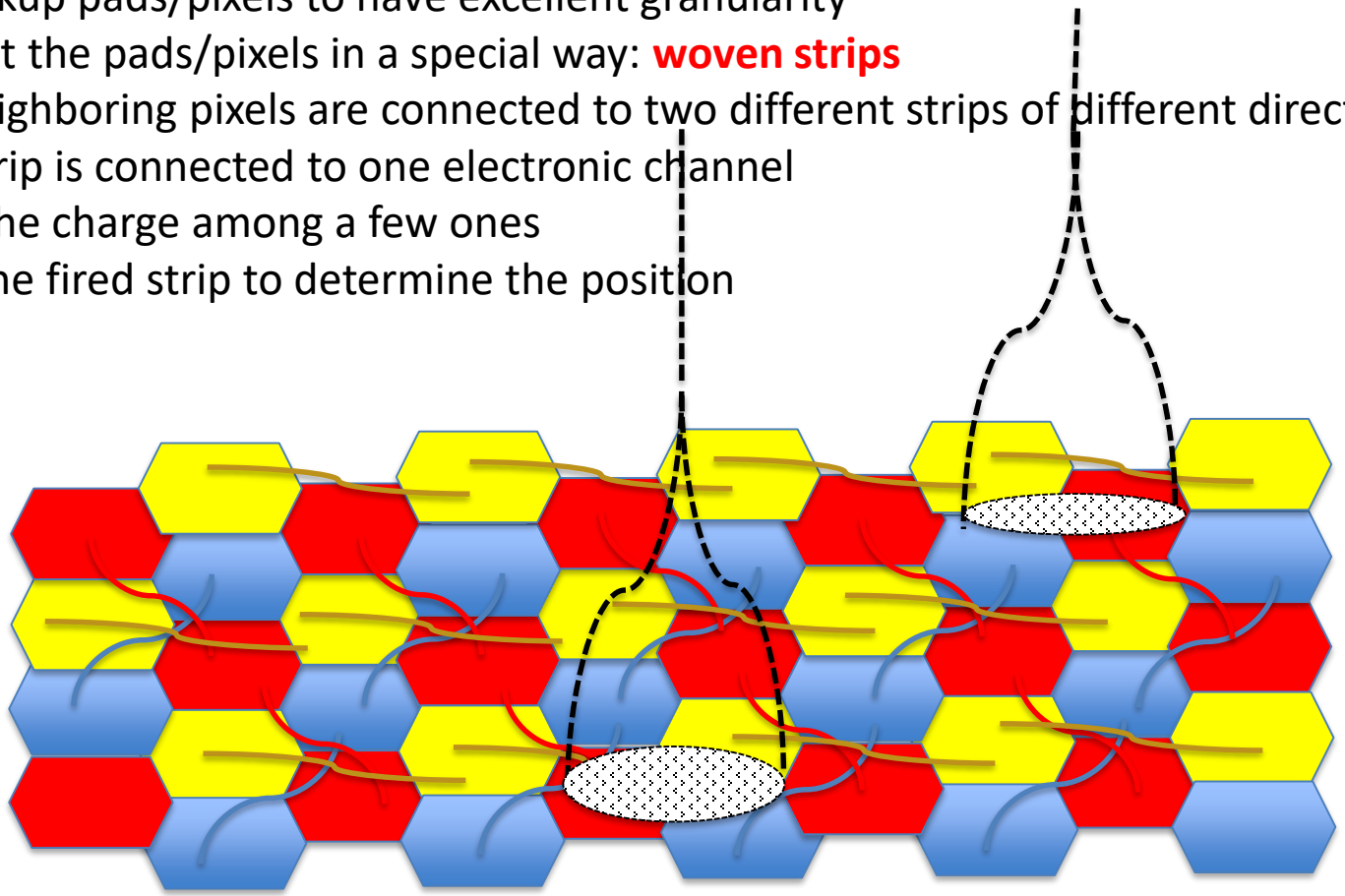
Can we do something to save power and money without impacting the physics

?

There is a solution

PCT/EP2018/053561

- Use pickup pads/pixels to have excellent granularity
- Connect the pads/pixels in a special way: **woven strips**
- Two neighboring pixels are connected to two different strips of different directions
- Each strip is connected to one electronic channel
- Share the charge among a few ones
- Cross the fired strip to determine the position



NXN → 3N : Reduction of electronic channels, power consumption and occupancy

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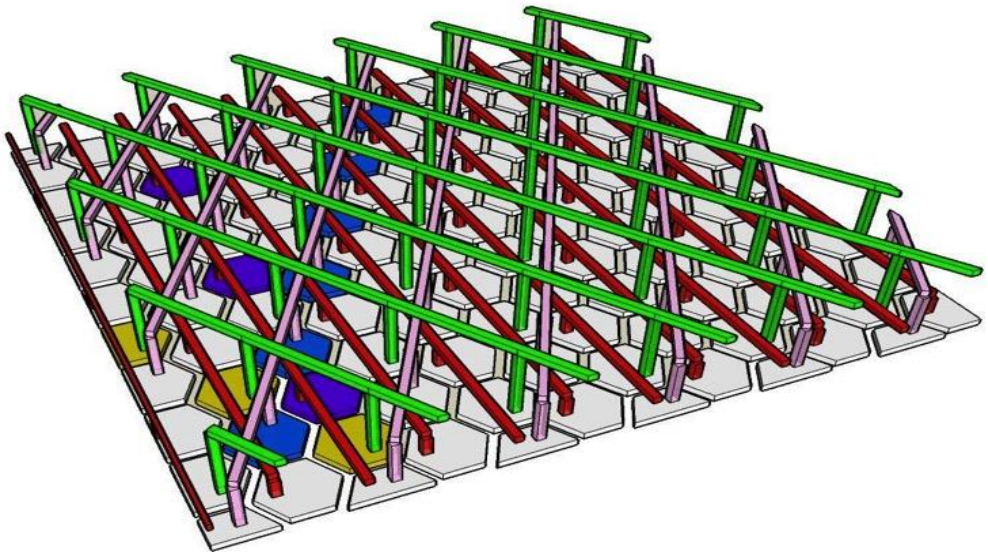
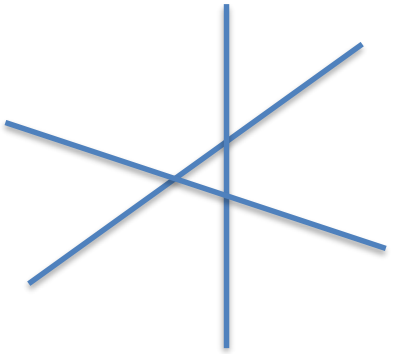
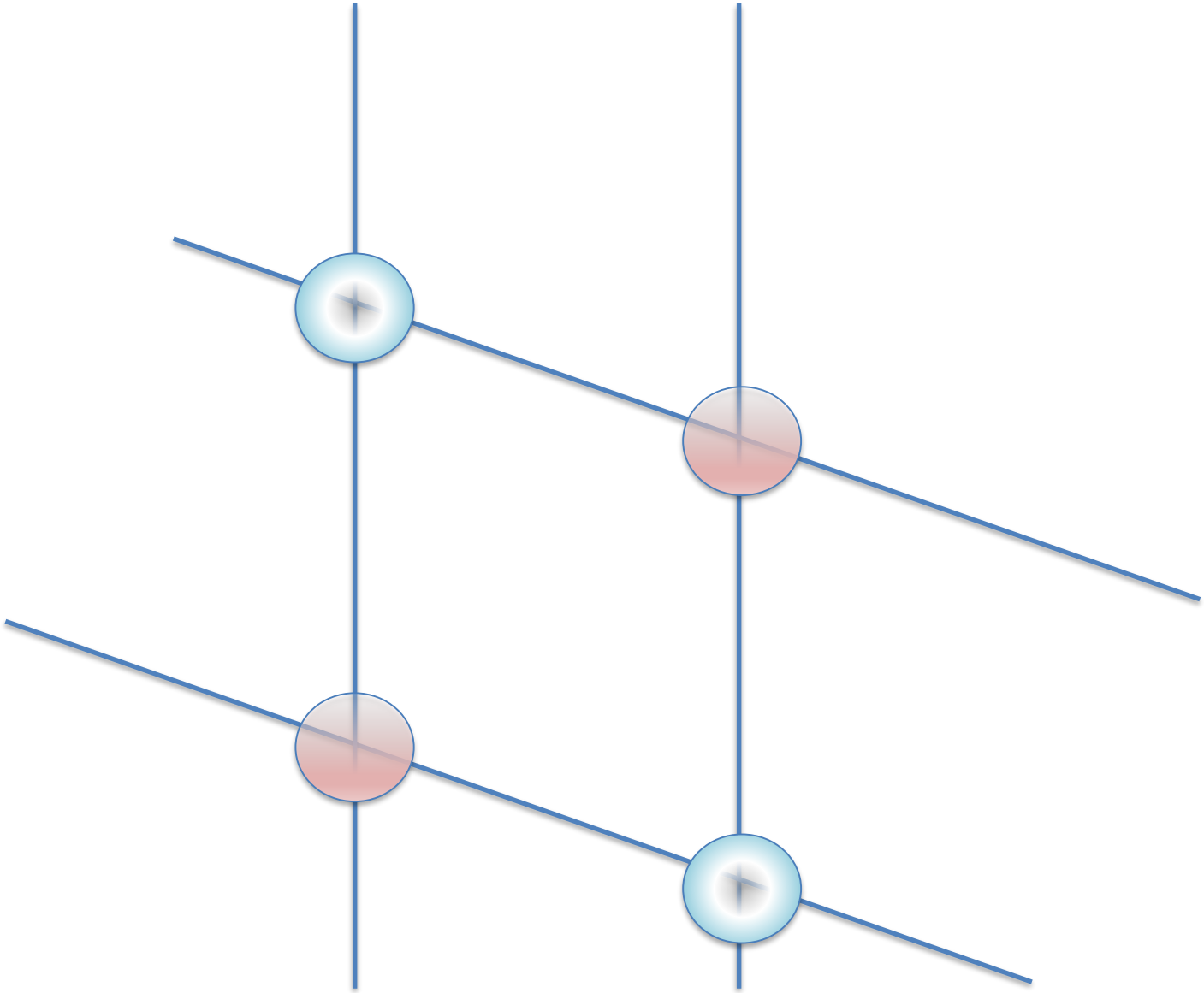
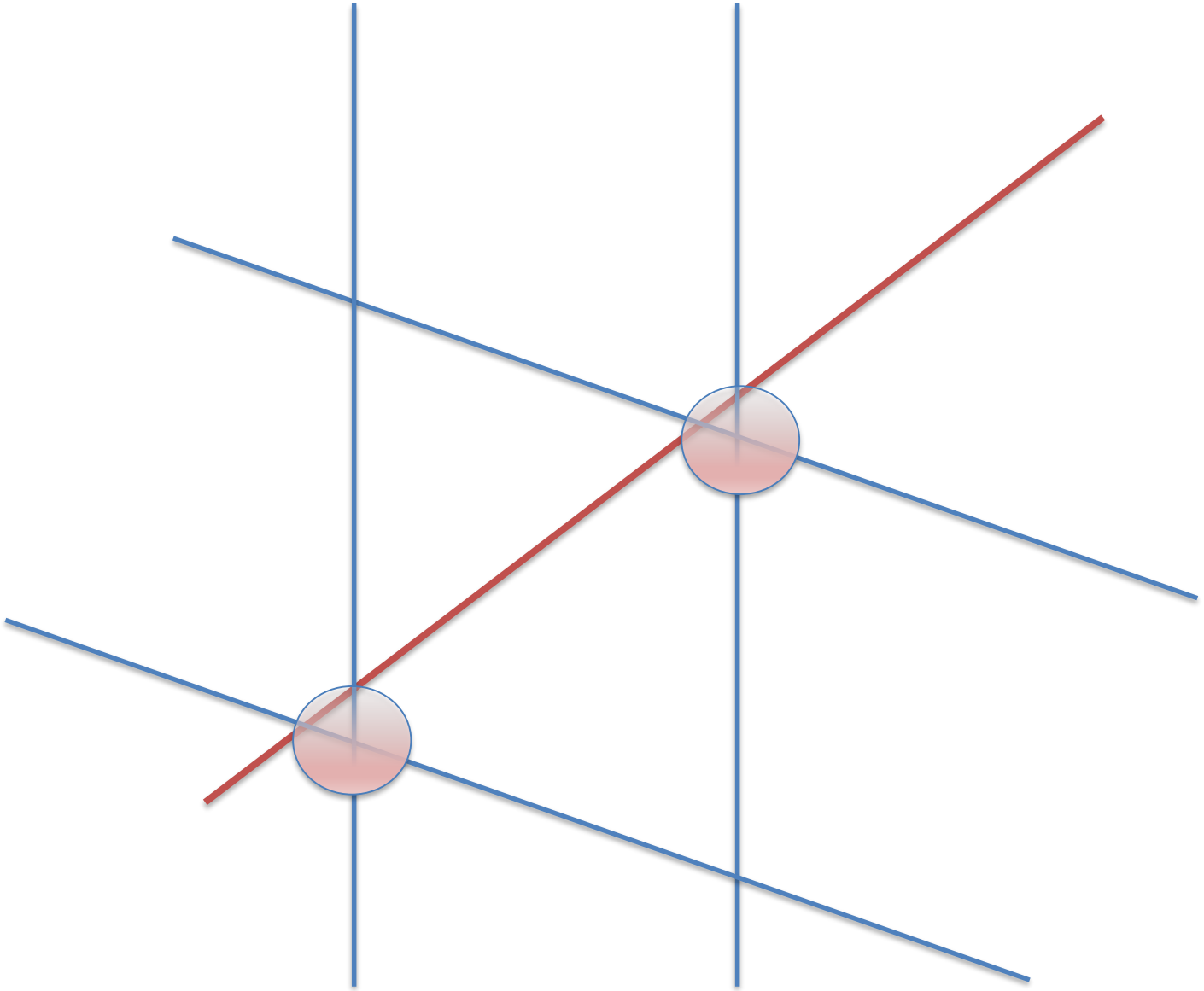




1 intersection
=
1 “Hit”

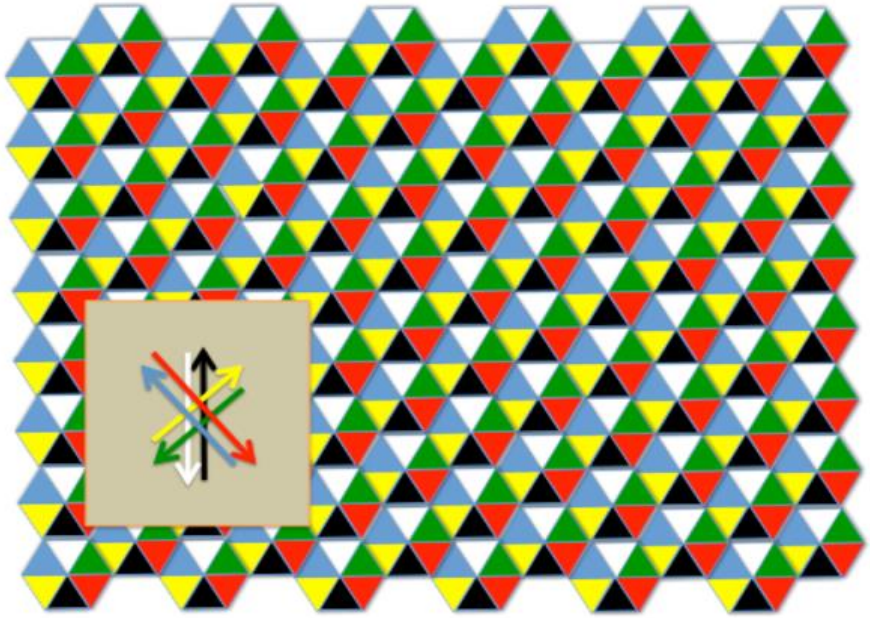
NXN → 3N : Reduction of electronic channels, power consumption and occupancy





Important features:

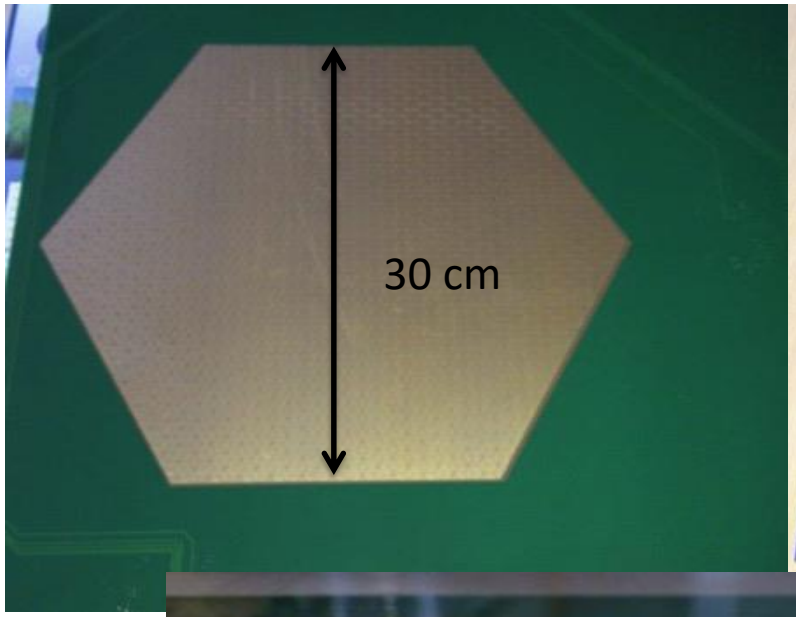
- The pad/pixel size should be slightly smaller than the charge extension to feed at least two pads/pixels. In gaseous detector this is always possible (RPC or resistive MPGD).
- Having 3 or more directions allows one to eliminate ambiguities (ghost particles)

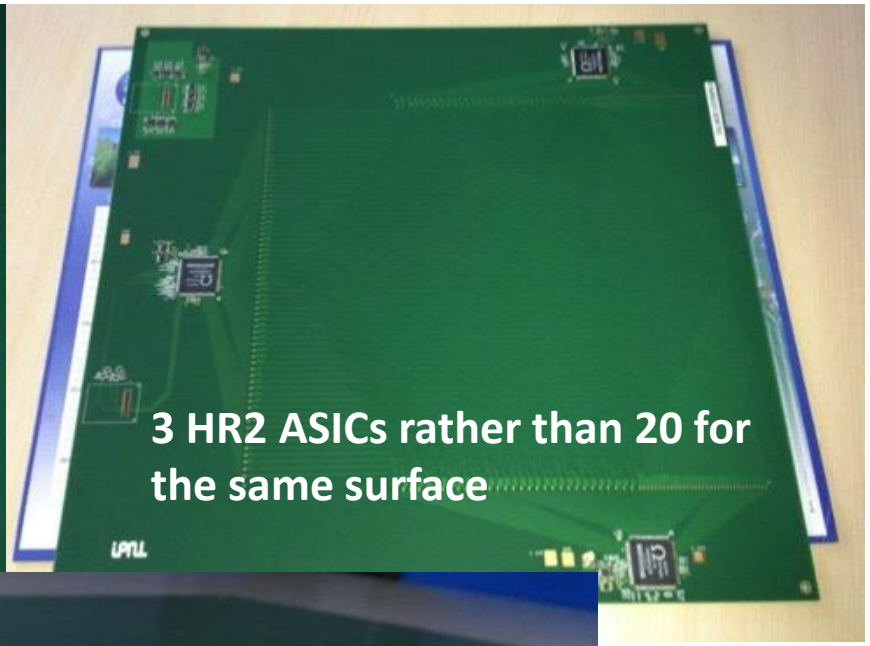


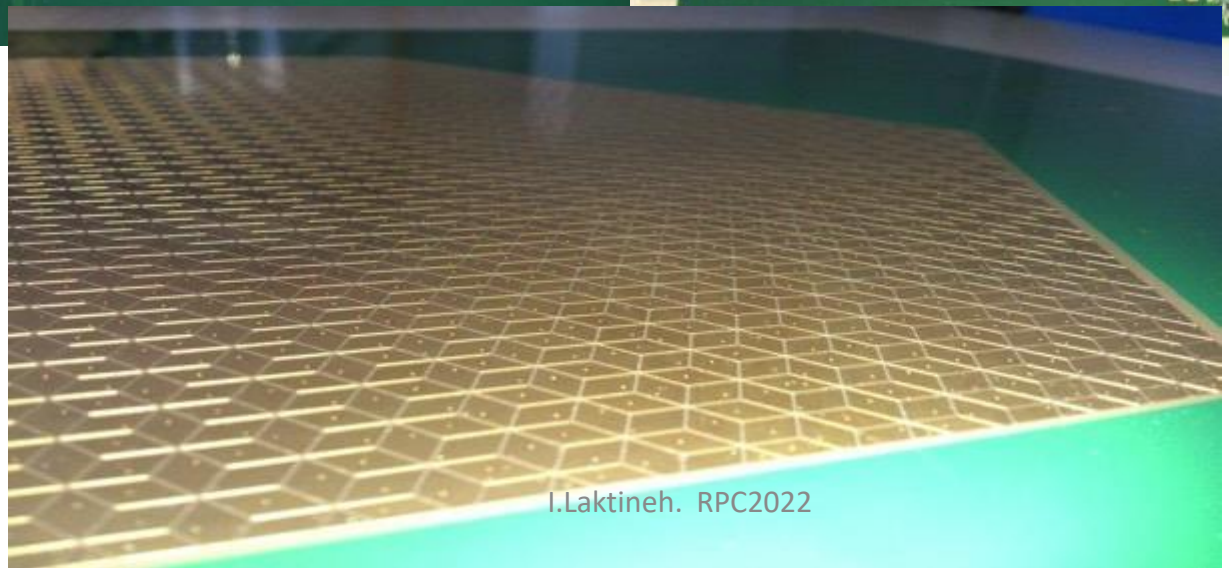
One can read the signal from both sides and get profit of the difference in **time of signal arrival** to confirm the position resolution and get the absolute time as well.

Realization

The new scheme was used to design a PCB with lozenges-based structure and 3 directions. The readout electronics was set on the same PCB. HARDROC2 ASICs (64-ch, 2-bit) conceived for SDHCAL are used.



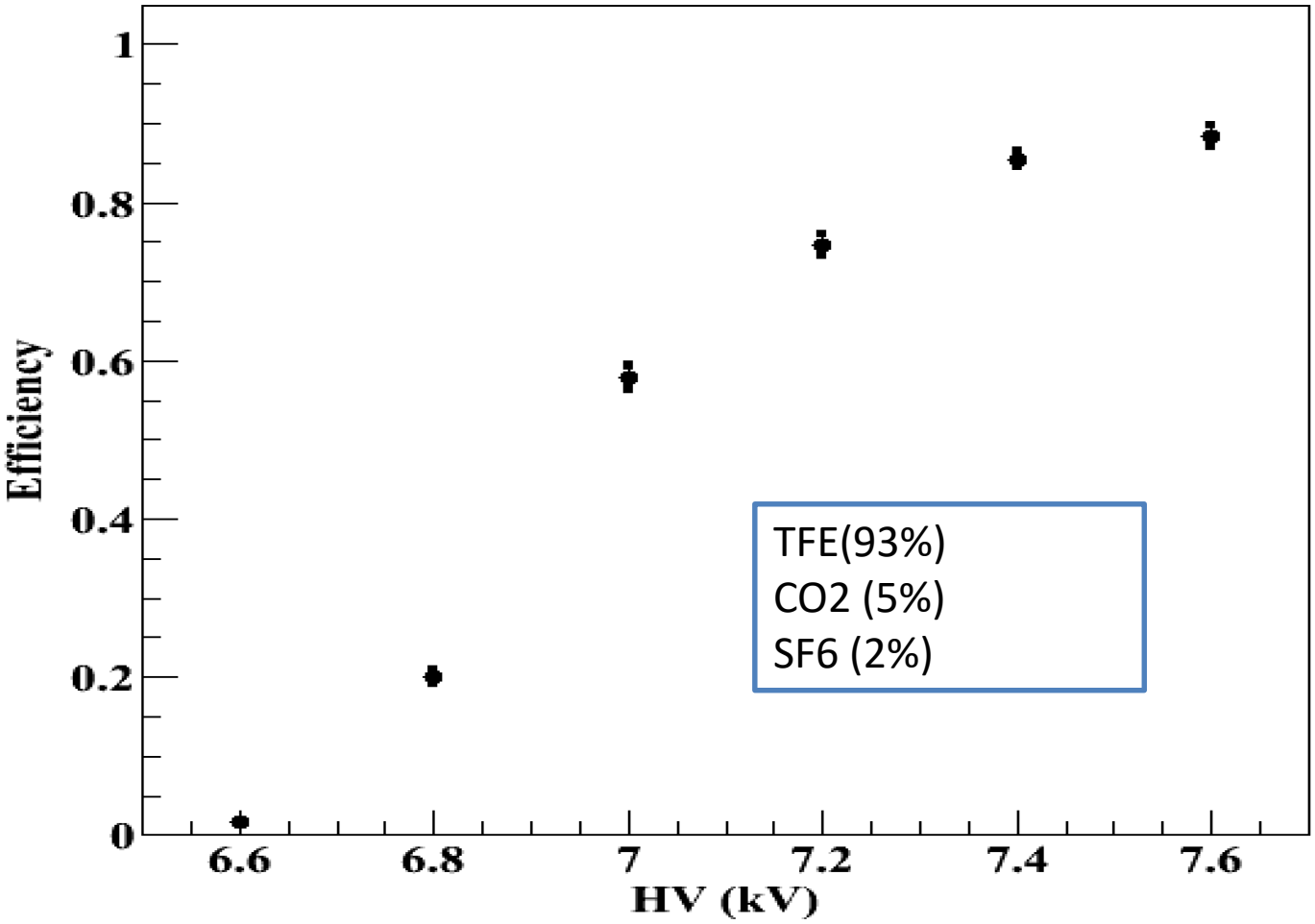




Setup with 5 detectors equipped with the new readout scheme

Efficiency vs HV

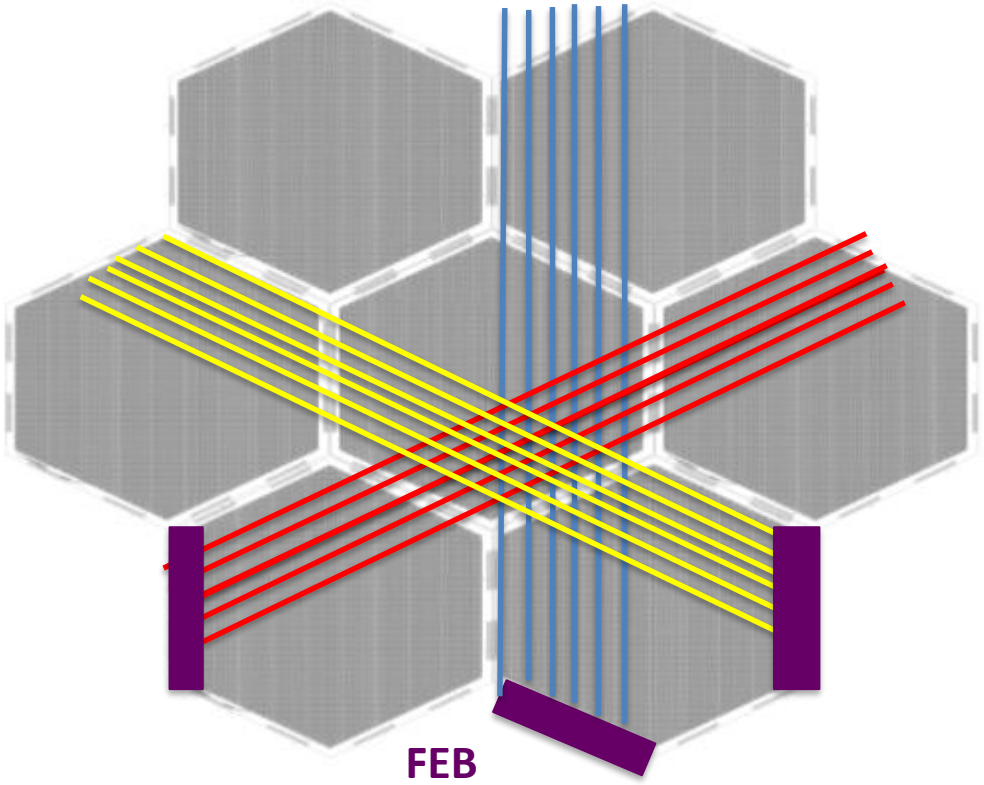
Threshold ≈ 80 fC Triggerless mode



Large surface detectors

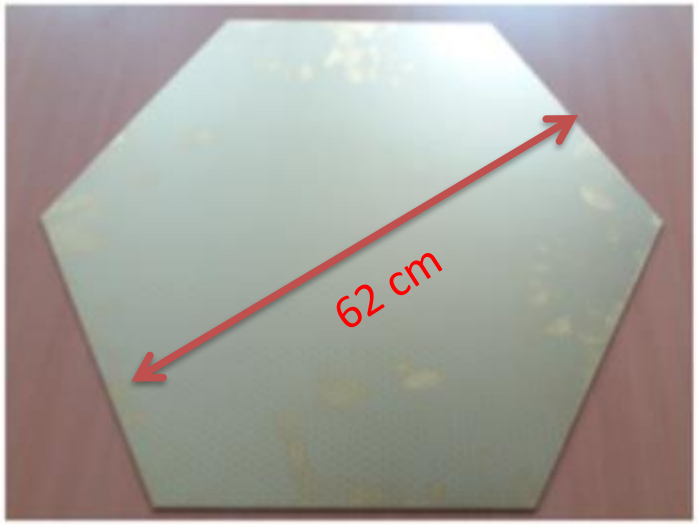
To instrument **(very) large gaseous detectors** the readout electronics could not be part of the PCB. It is therefore mandatory to separate strip panels from the readout electronics.

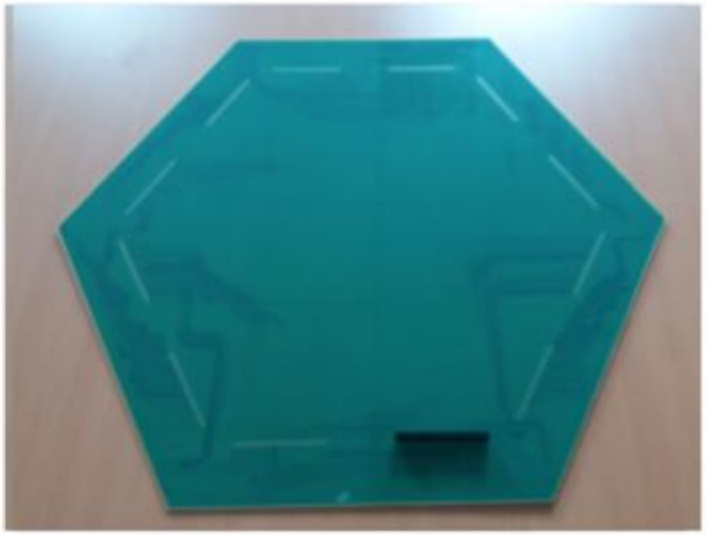
A simple scheme is proposed:

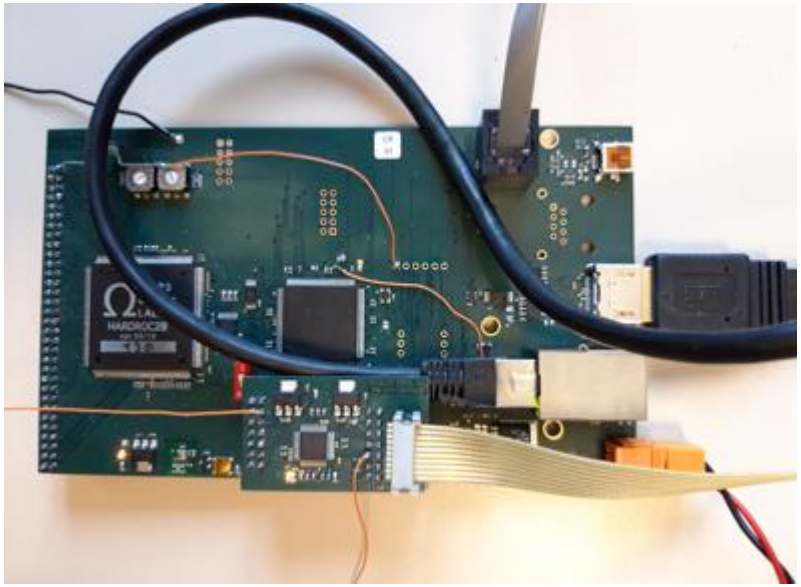


"Well matched impedance will help to keep the signal in good shape for long distances"

Large surface detectors







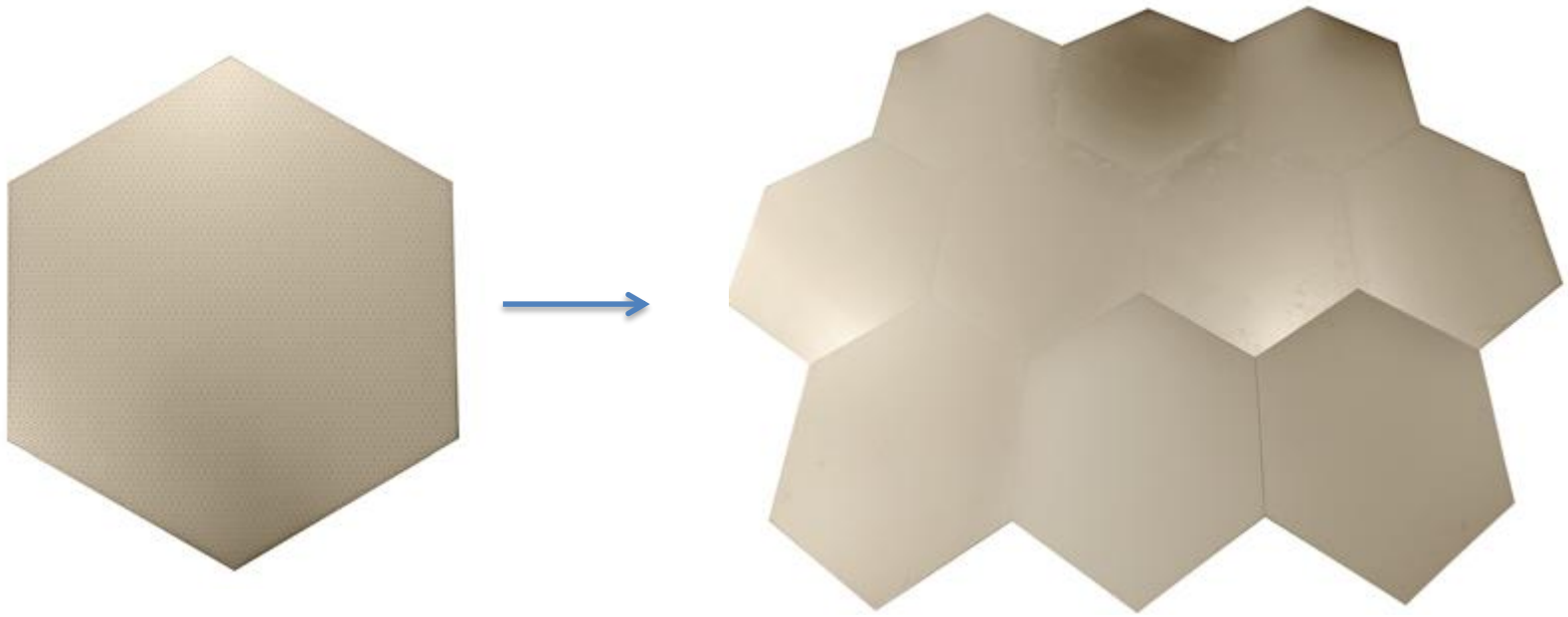
A board hosting
- One Hardroc2 ASIC
- One Microcontroller

To be plugged directly on the back of the PCB, on the edge to read out 64 woven strips (1 HR2 ASIC).

Large surface detectors

We need to build large detectors to be used as muon system in future experiments (ILC, CEPC, FCC, Mathusla…) but also in the SDHCAL calorimetry concept and we propose to instrument them with the new concept.

For this we need to associate several PCB with no dead zone in-between.



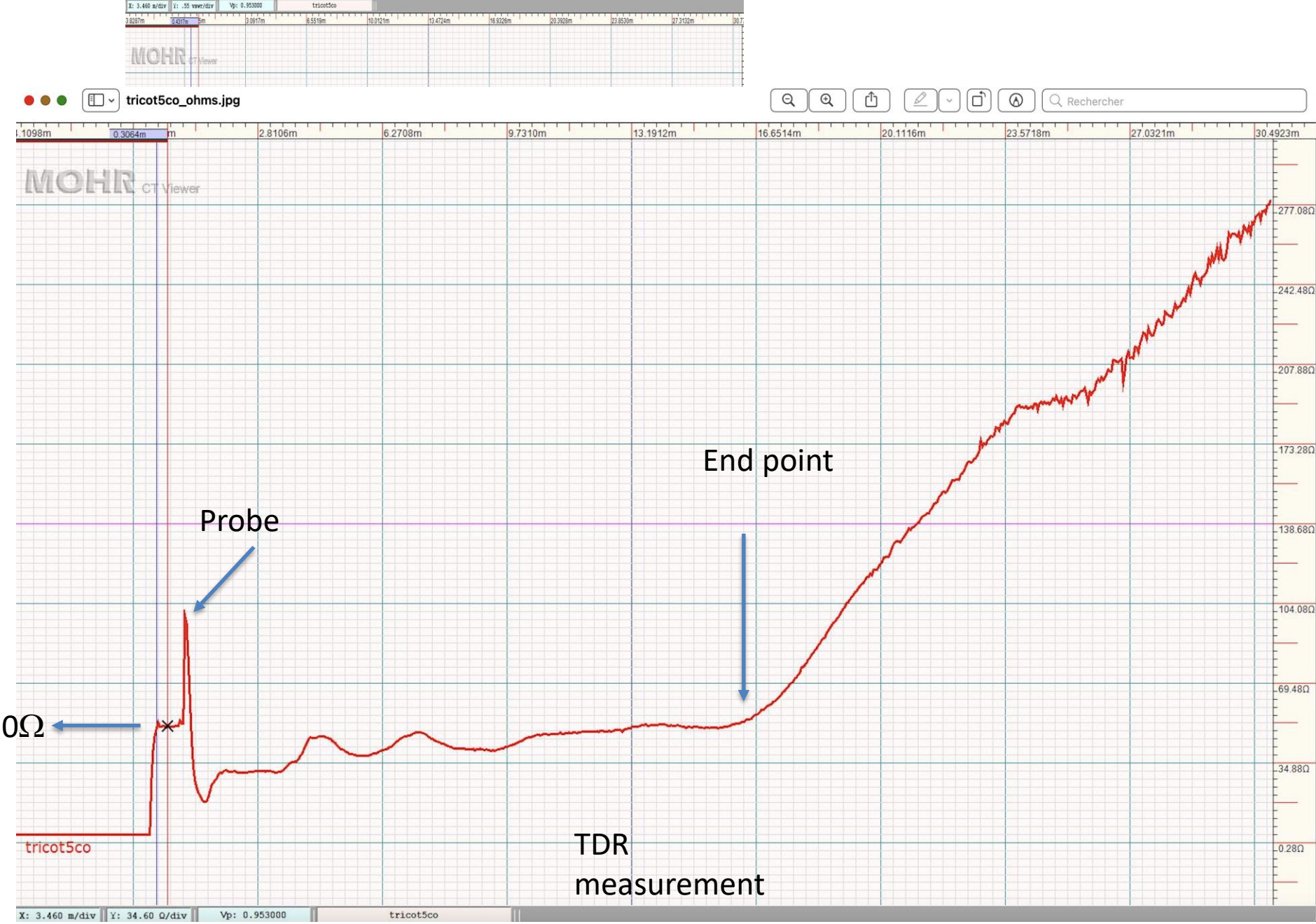
Large detection area can be instrumented by assembling easily many PCB.

Large surface detectors

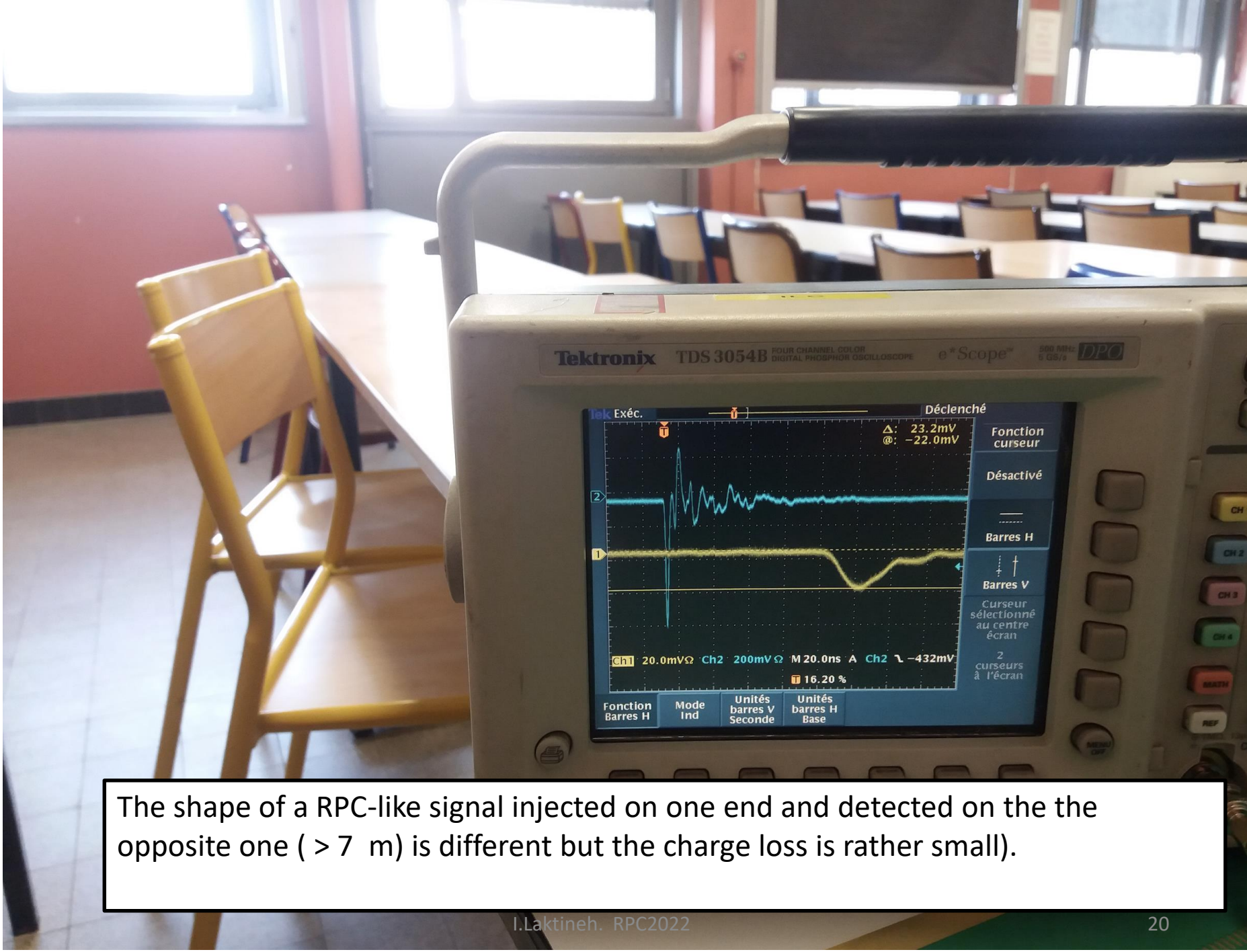
Connection of two neighboring PCBs is made through the connectors on the backside of the PCB.

No signal loss was observed by injecting a signal on the furthest end of the first PCB and detecting it on the opposite side of the second one.

We added five of them


tricot5co_ohms.jpg
MOHR CT Viewer
1.1098m
0.3064m
2.8106m
6.2708m
9.7310m
13.1912m
16.6514m
20.1116m
23.5718m
27.0321m
30.4923m
277.08Ω
242.48Ω
207.88Ω
173.28Ω
138.68Ω
104.08Ω
69.48Ω
34.88Ω
0.28Ω
End point
Probe
50Ω
tricot5co
TDR
measurement
X: 3.460 m/div
Y: 34.60 Ω/div
Vp: 0.953000
tricot5co

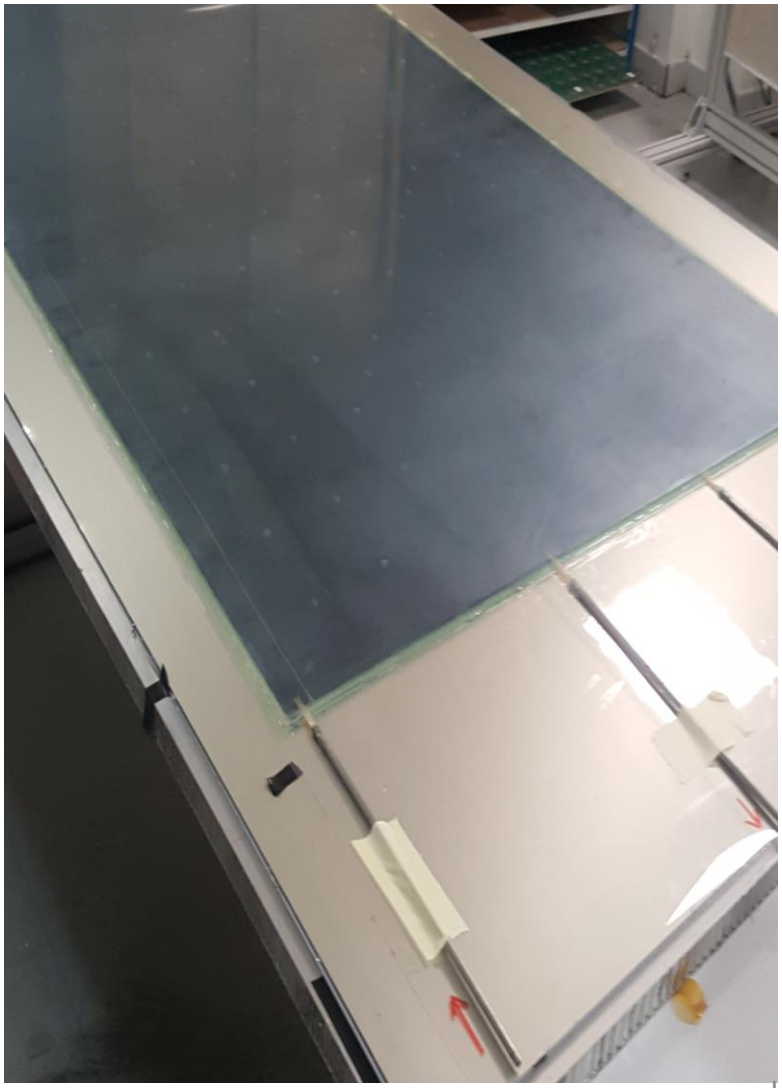

We added 10 of them

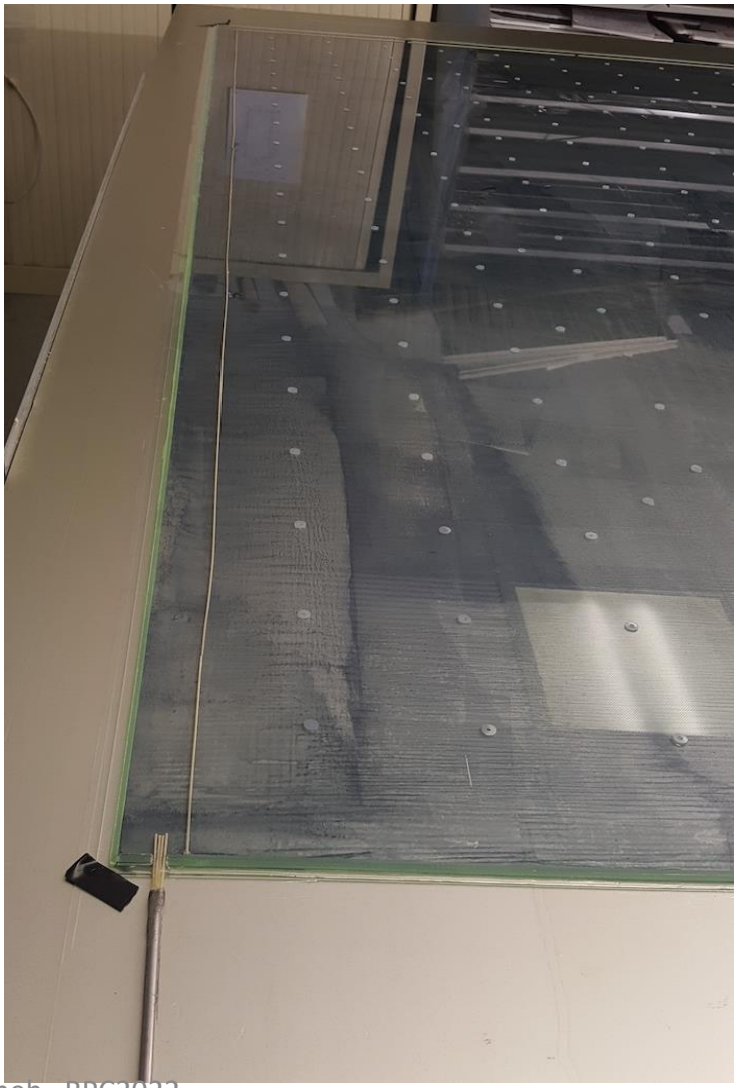


The shape of a RPC-like signal injected on one end and detected on the the opposite one (> 7 m) is different but the charge loss is rather small).

Large surface detectors

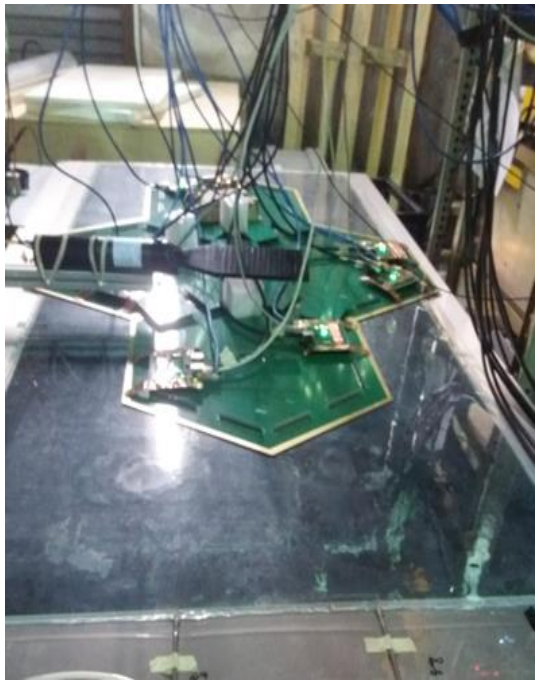
We built several large detectors (1 m x 2 m) to test the new concept

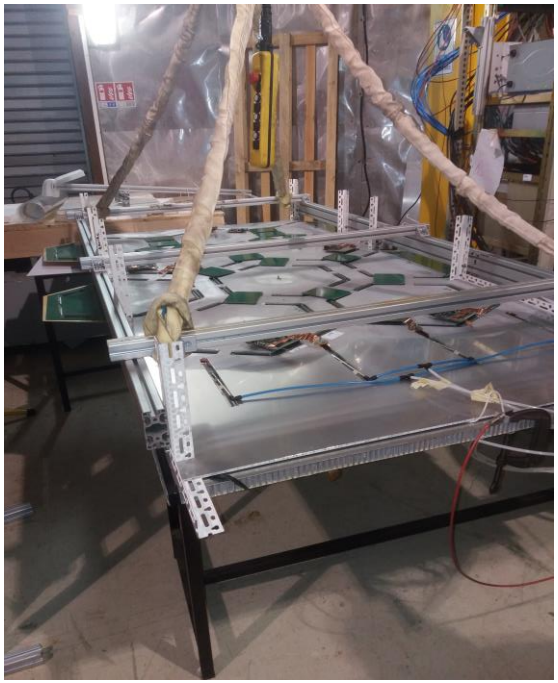


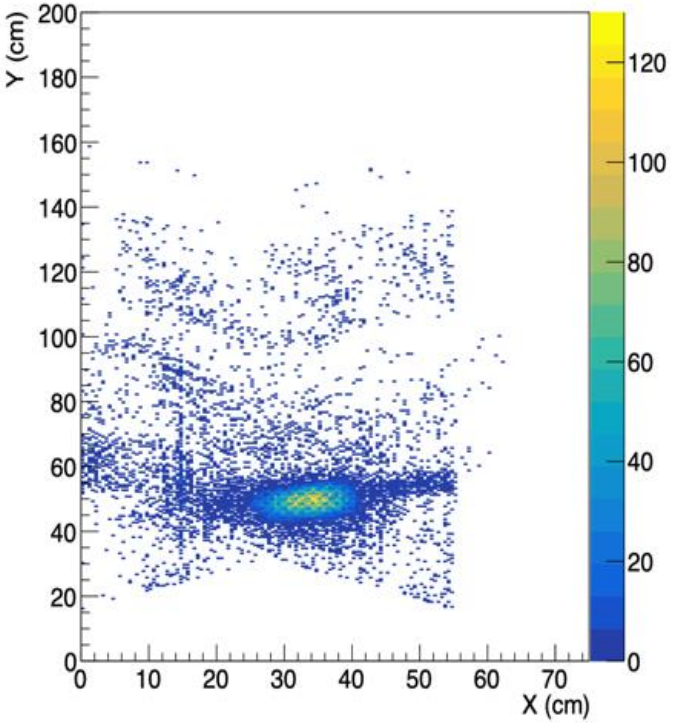


Large surface detectors

The new scheme is being tested on a large GRPC (2m x 1 m) with several PCBs
Reconstruction efficiency (1 direction efficiency is not included) is around 90%.

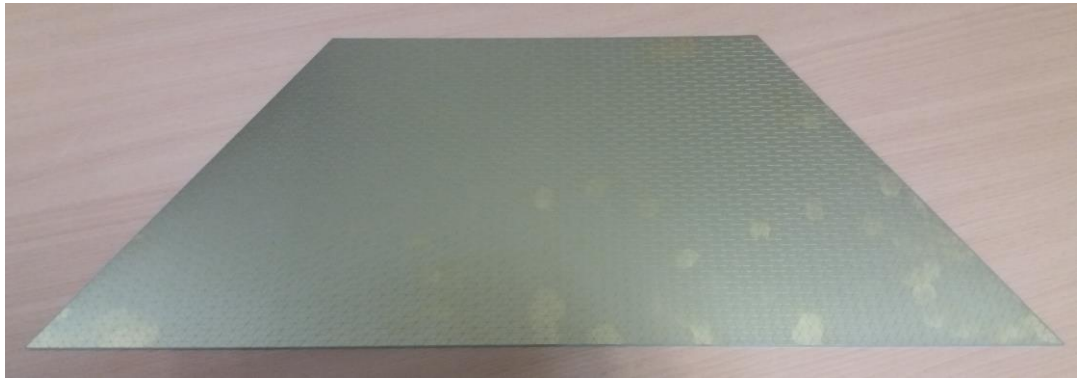


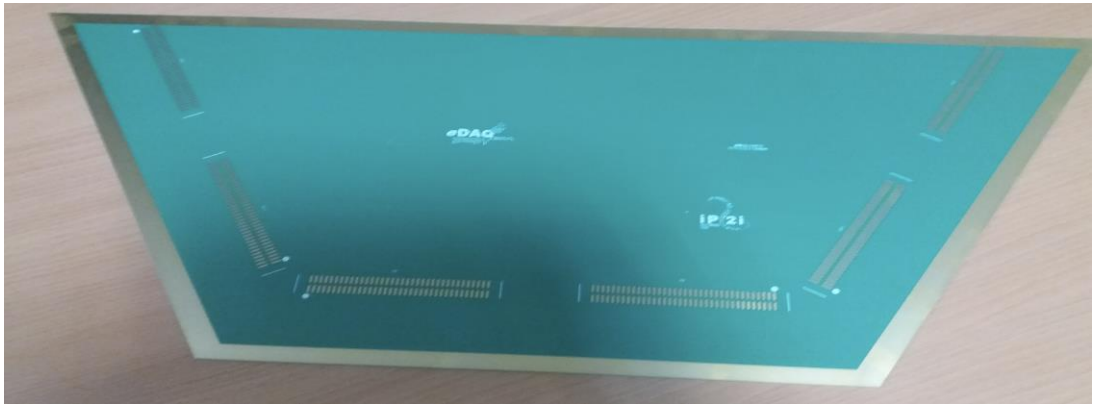




Large surface detectors

Half-hexagon PCBs were also designed and recently produced. Triangular PCB using the same concept were also designed.
Rectangular detectors could be efficiently covered.





Conclusion

- A new scheme allowing a reduced cost and reduced power consumption without reducing the granularity is proposed to equip large RPC detectors
- The scheme could be applied to resistive MPGD in principle. Two resistive MicroMegas were built in collaboration with CERN Technical Staff with this new scheme and will be soon tested.
- Study to assess the possibility to use it in SDHCAL and SDHCAL tail catcher is to come soon