# New Readout Scheme of Large detectors

I.Laktineh

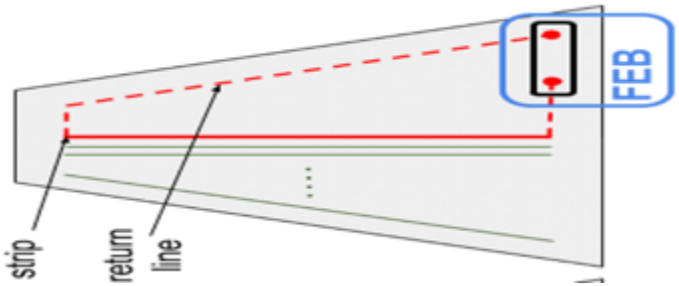
IP2I, Lyon, France

# **RPC** are excellent muon detectors**:**

- ❑ They are fast timing detectors
- ❑ They can be built with large surface, excellent homogeneity and very small dead zone
- ❑ They are cheap.

**Several ways to read out RPC:**

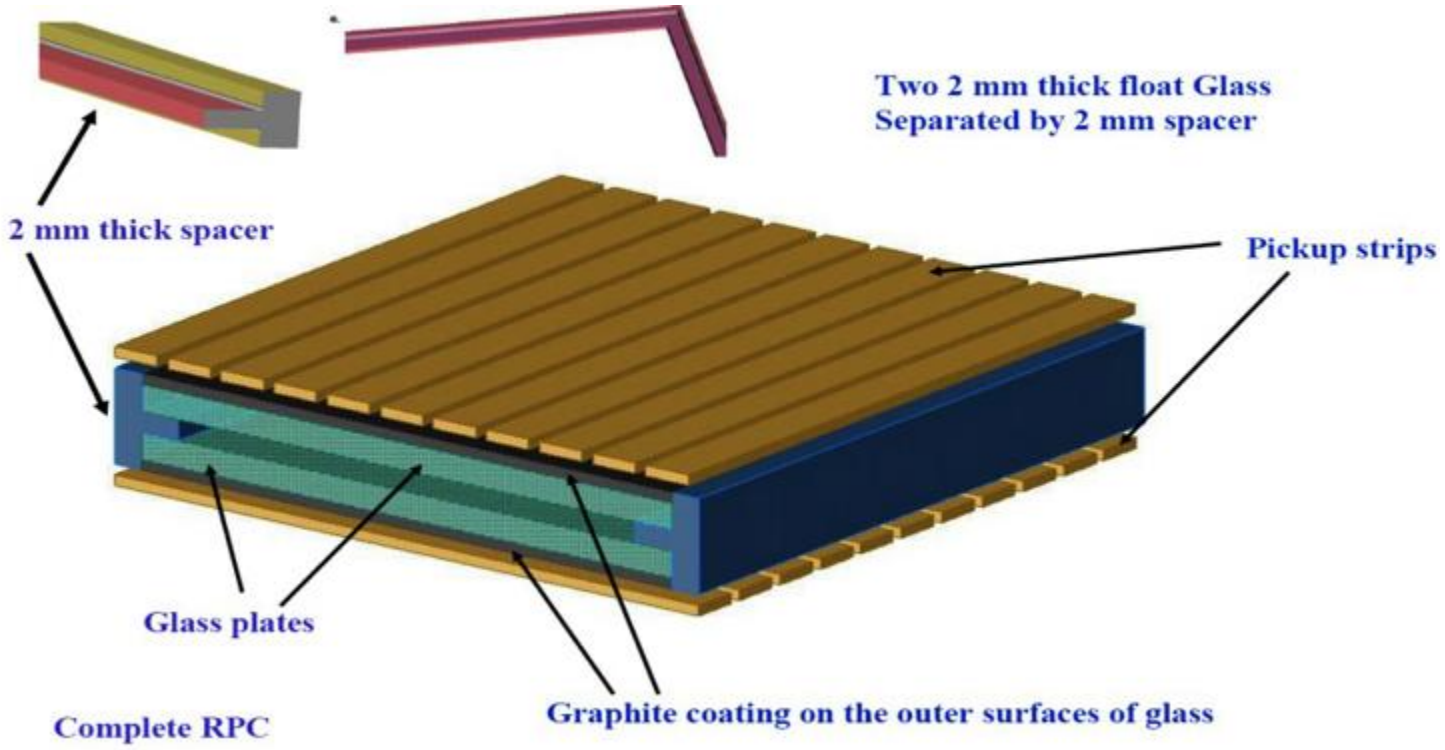
- ◆ Using pick-up strips (either one direction on the anode side as for current CMS RPC or two directions one on the anode and one on the cathode as for ATLAS)
  or **2-D readout** using **excellent time measurement** as the one we propose for CMS iRPC upgrade project (now approved by the CMS collaboration).



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

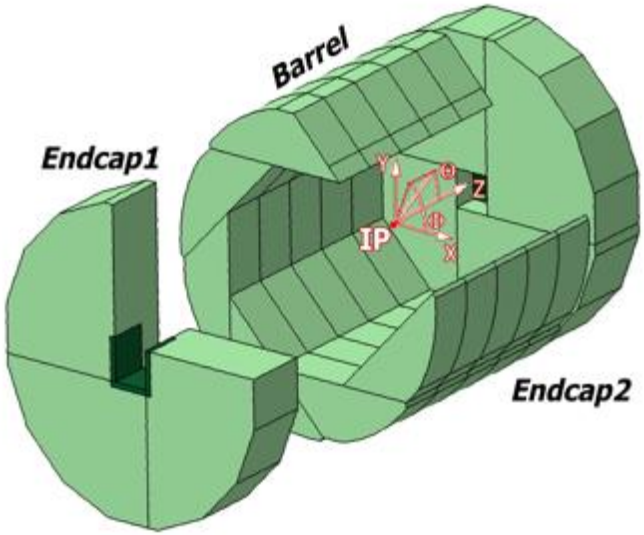
To measure time with excellent precision in particular with the MultiGap version.

# RPC-based Muon system




- ✓ X-Y strips-based readout proposed for the RPC muon system is ok.
- x For tail catcher this may face the problem related to ghost particles.

# ILC, CEPC SDHCAL calorimeter system baseline




The ILC, CECP calorimeter baselines are all **high-granularity** 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 will continue to consume power and to produce heat, necessitating in case of circular collider **active cooling** → **reduced PFA performance**

**This statement applies for all high granular calorimeters other options.**

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

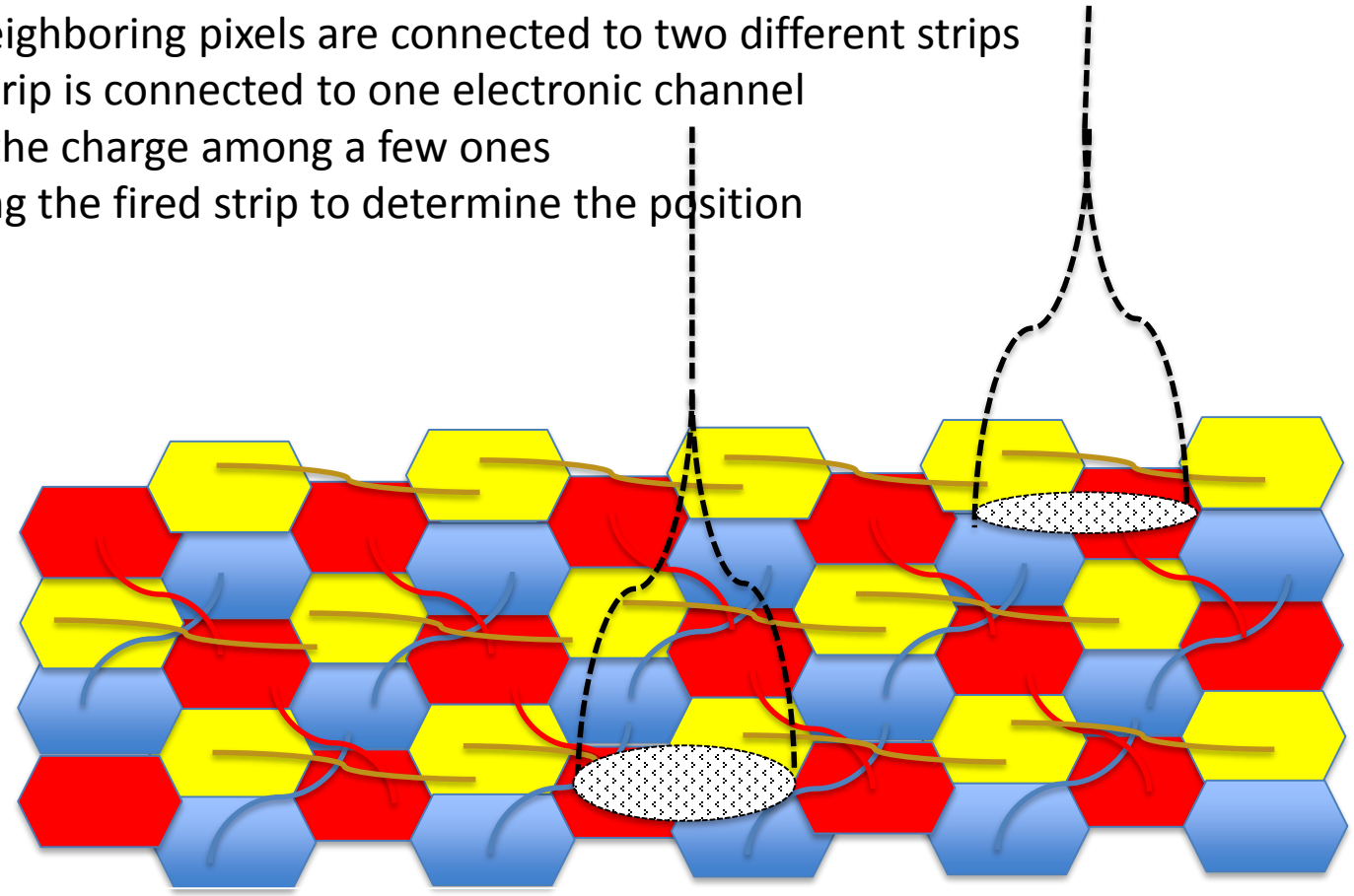
Can we do something to save power and money without impacting the physics

?

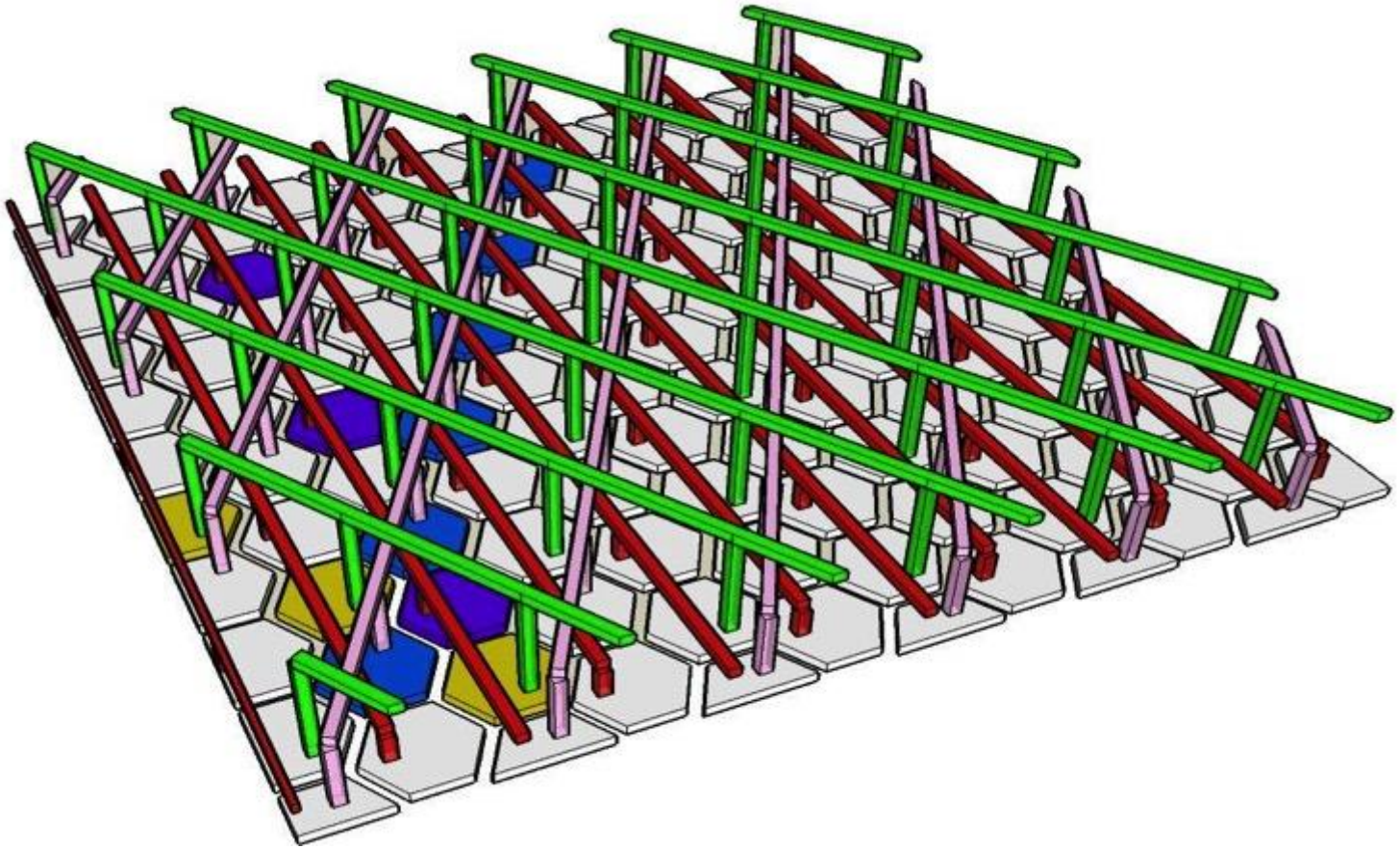
# There is a solution

PCT/EP2018/053561

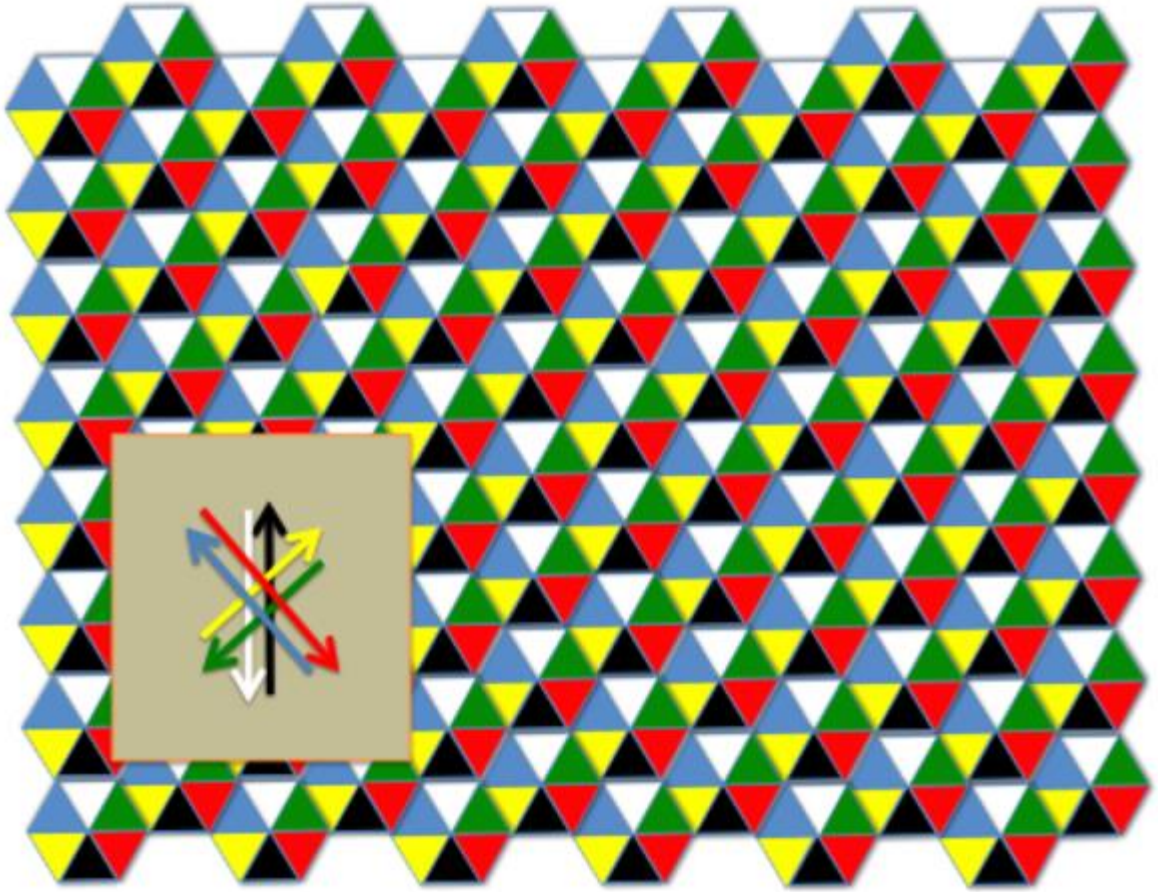
- Connect the pads/pixels in a special way: **woven strips**
- Two neighboring pixels are connected to two different strips
- Each strip is connected to one electronic channel
- Share the charge among a few ones
- Crossing the fired strip to determine the position



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

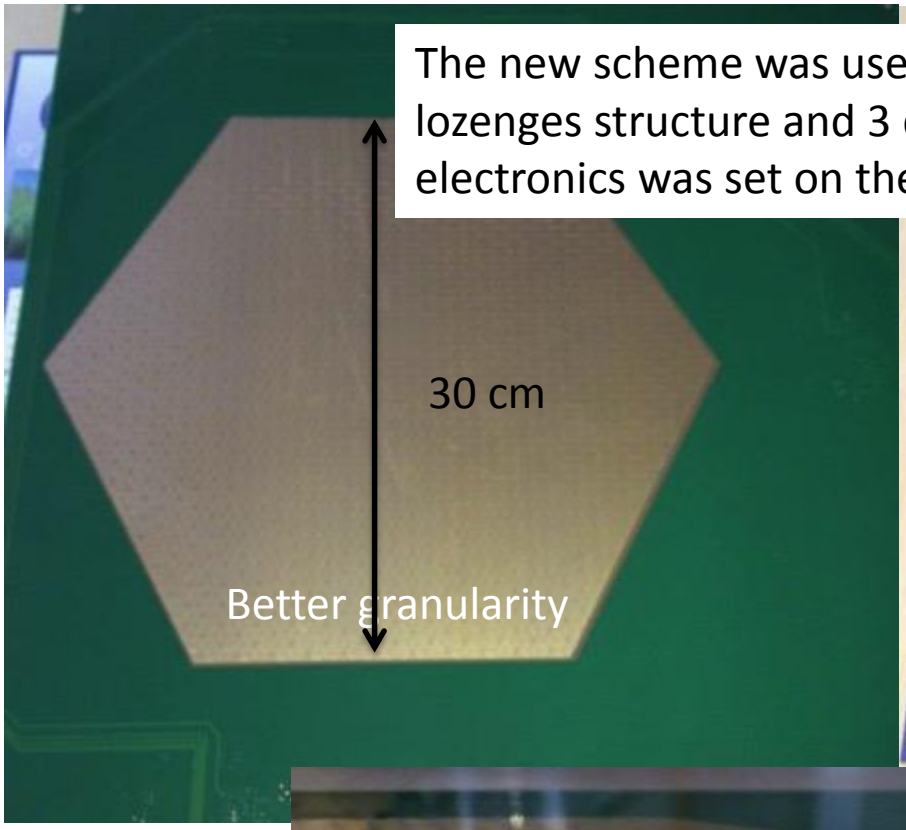


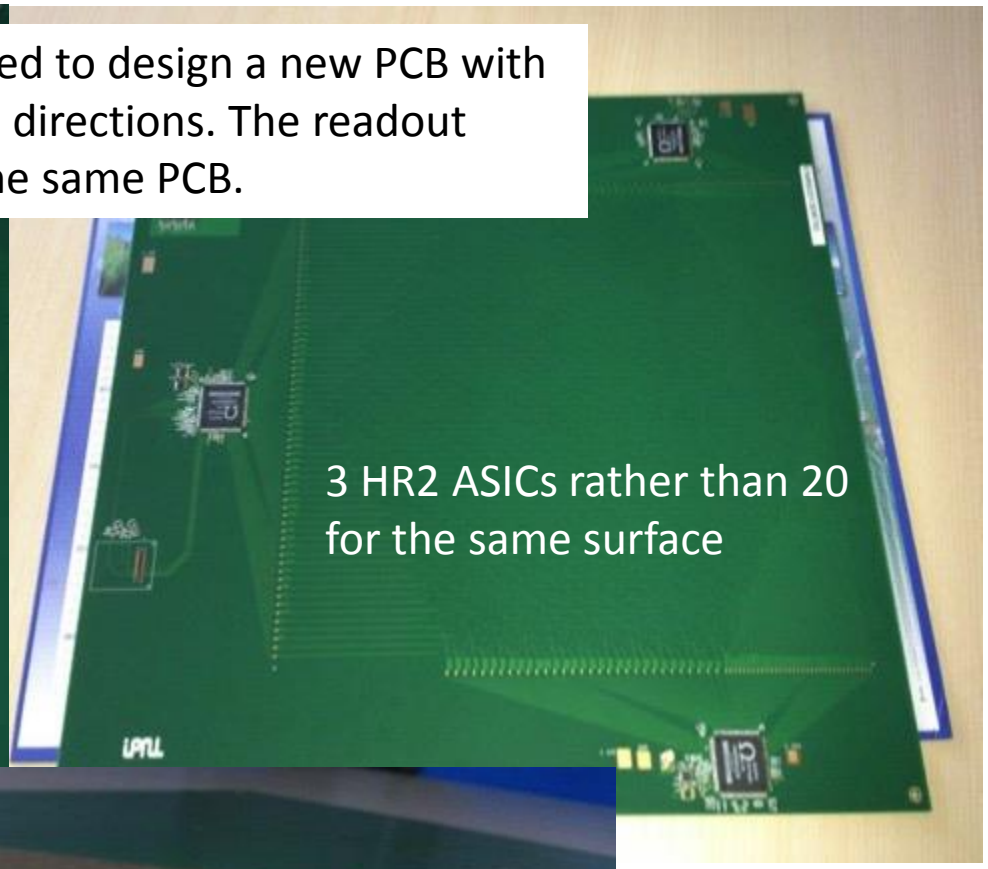
- Several shapes of pads/pixels can be used: triangles, lozenges, pentagons, hexagons the most convenient is the triangular shape
- The pad/pixel size should be a slightly smaller to the charge extension to feed at least two. In gaseous detector this is always possible.
- Having 3 or more directions allows one to eliminate ambiguities (ghost particles)

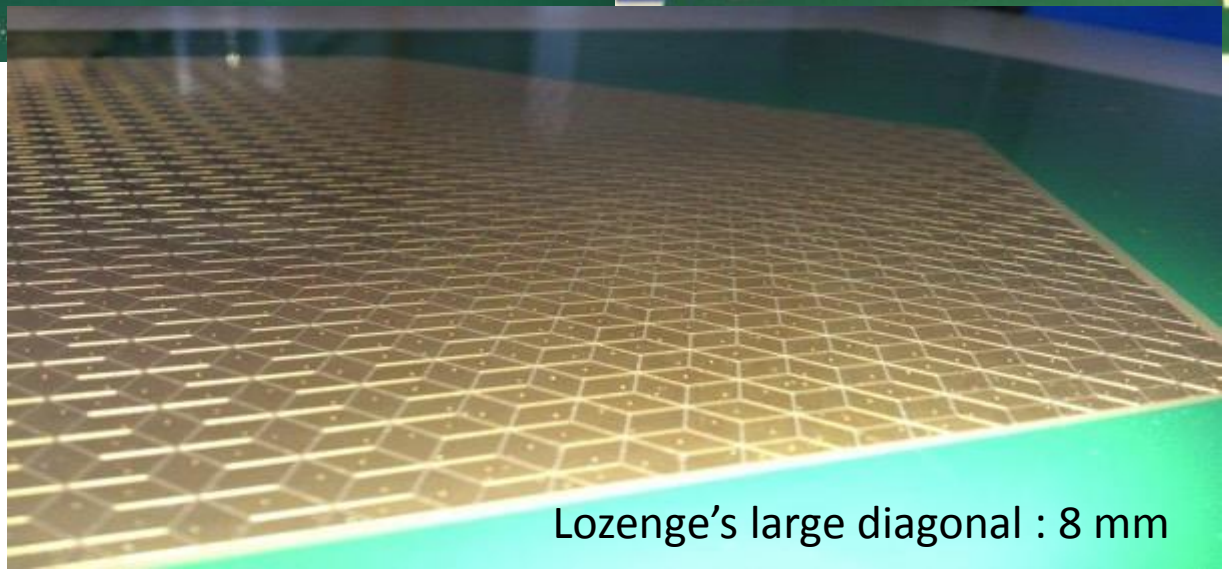


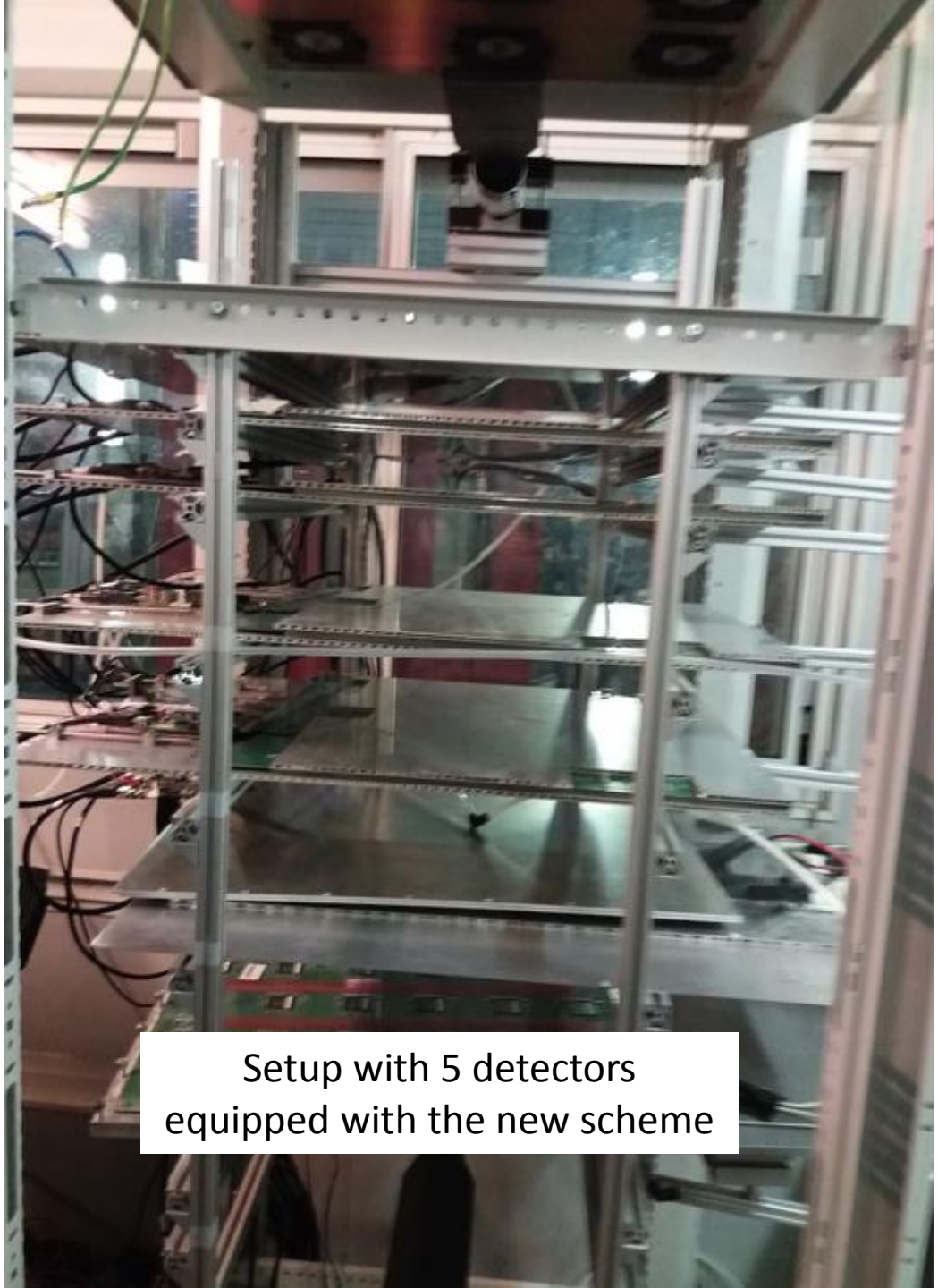
One can read the signal from both sides and get profit of the difference in time arrival to improve the position resolution and get the absolute time as well. For this we need a well matched impedance.

The new scheme was used to design a new PCB with lozenges structure and 3 directions. The readout electronics was set on the same PCB.



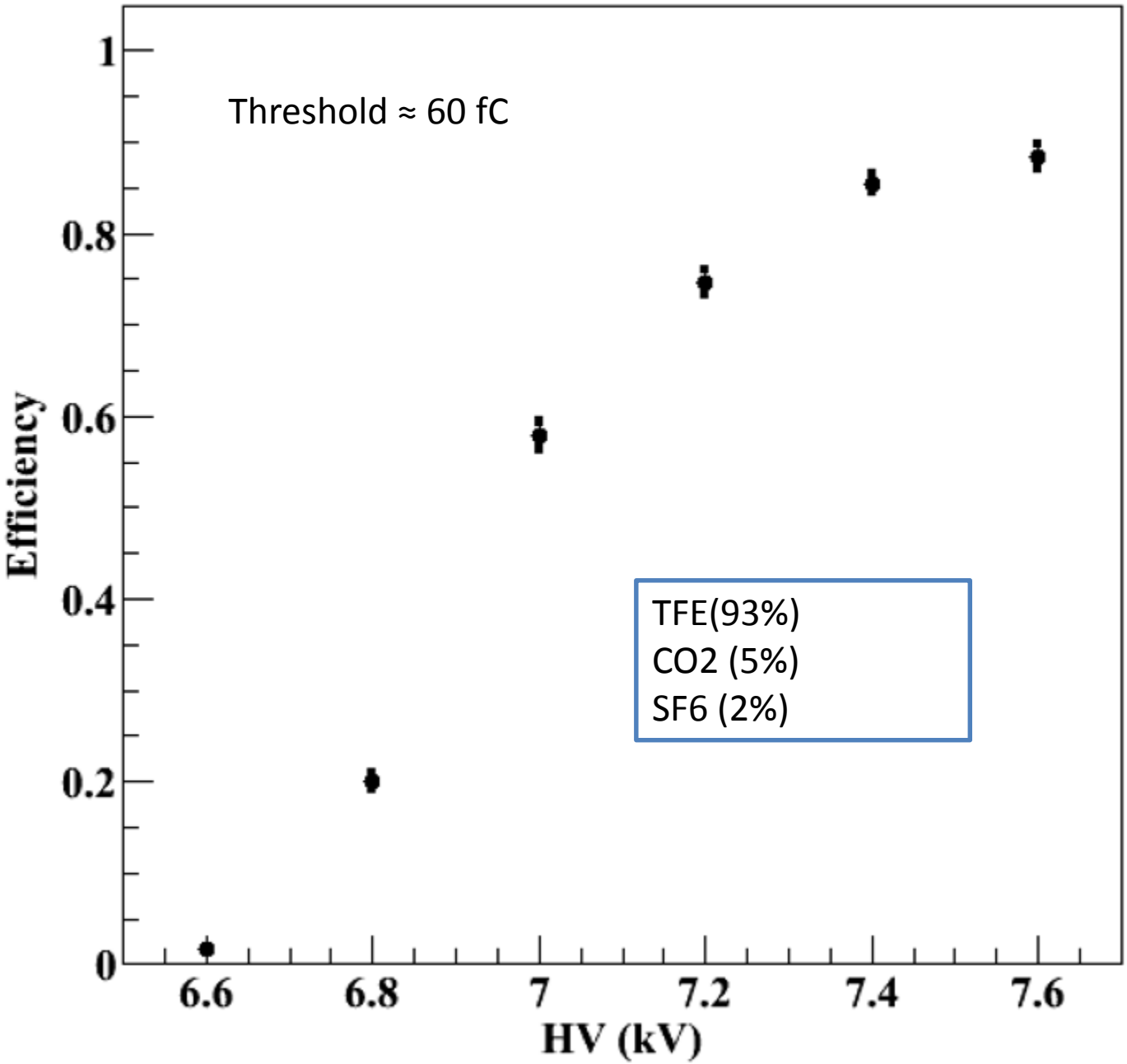





Setup with 5 detectors
equipped with the new scheme

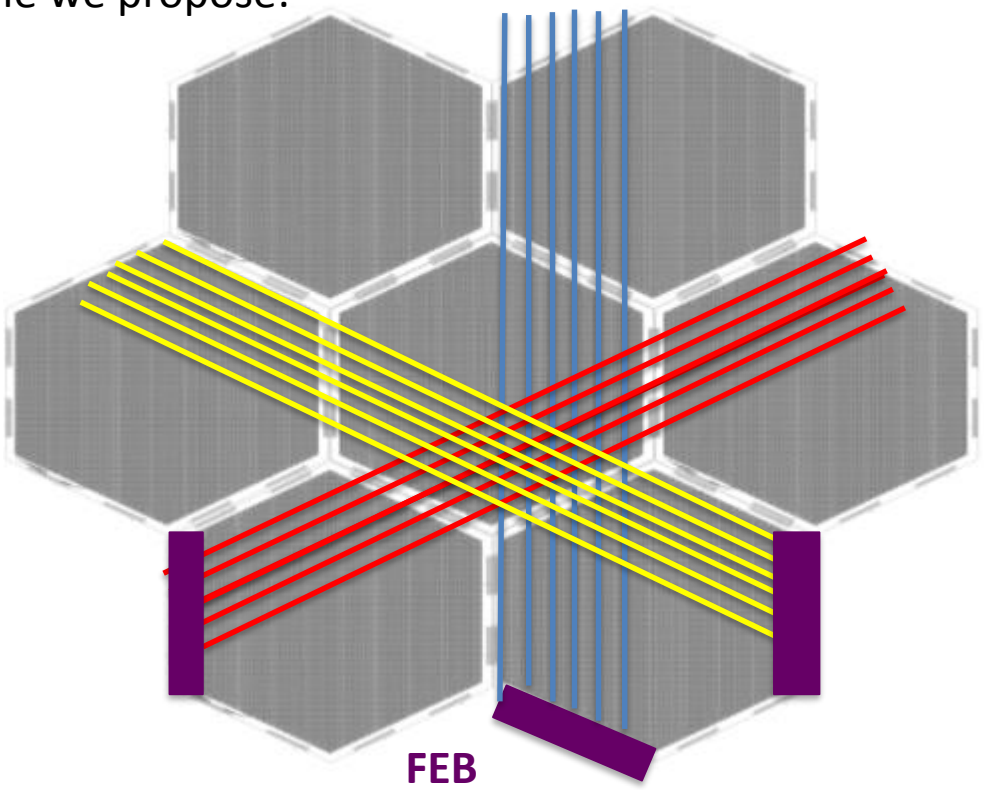
# Efficiency vs HV



# Large surface detectors

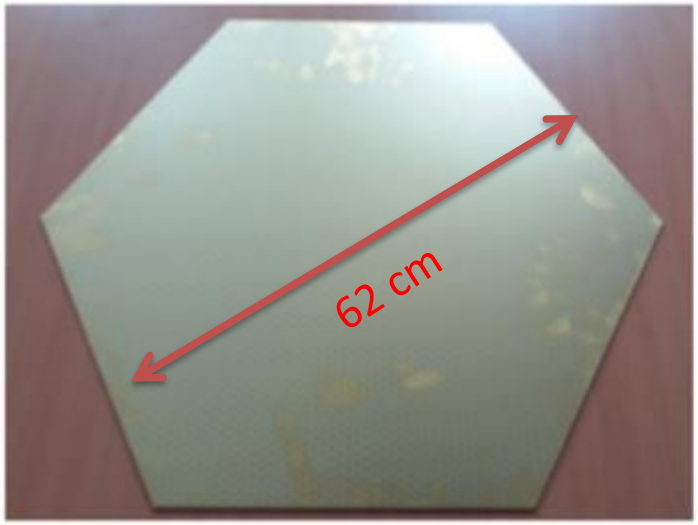
To instrument **very large gaseous detectors** the readout electronics could not be part of the PCB. A solution to separate strips panels from the readout electronics is needed.

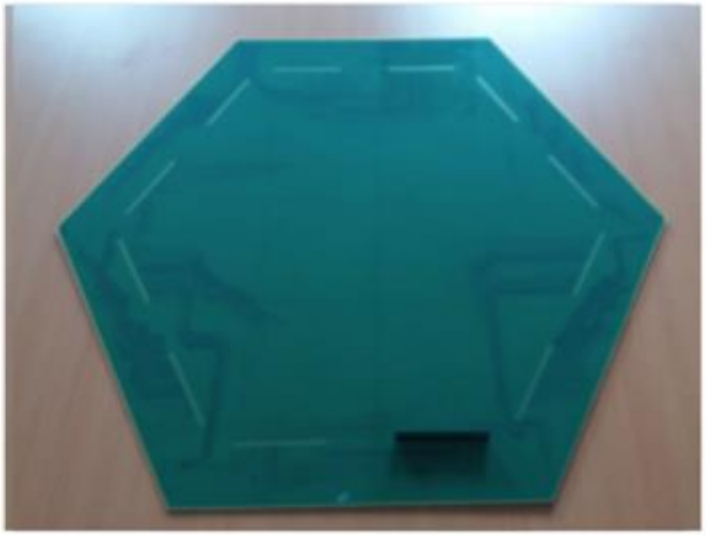
Here is the scheme we propose:

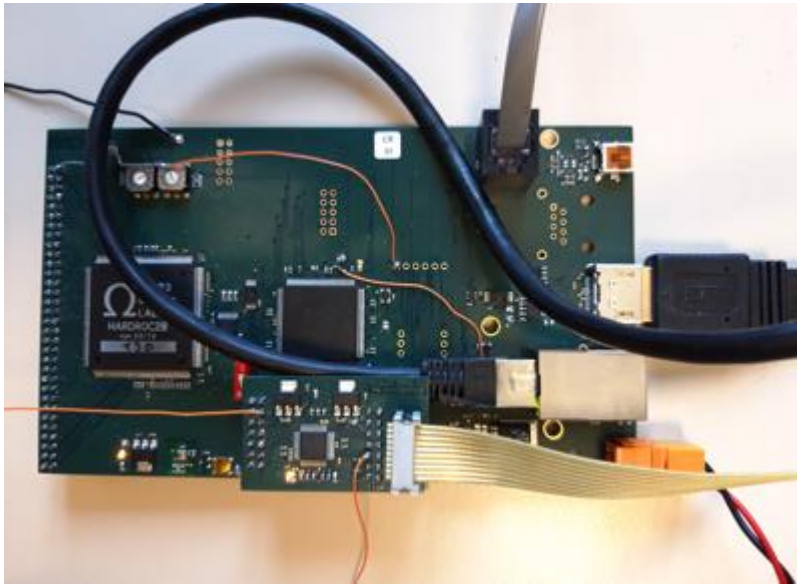



"Well matched impedance will help to keep the signal in good shape for long distances"

# Large surface detectors



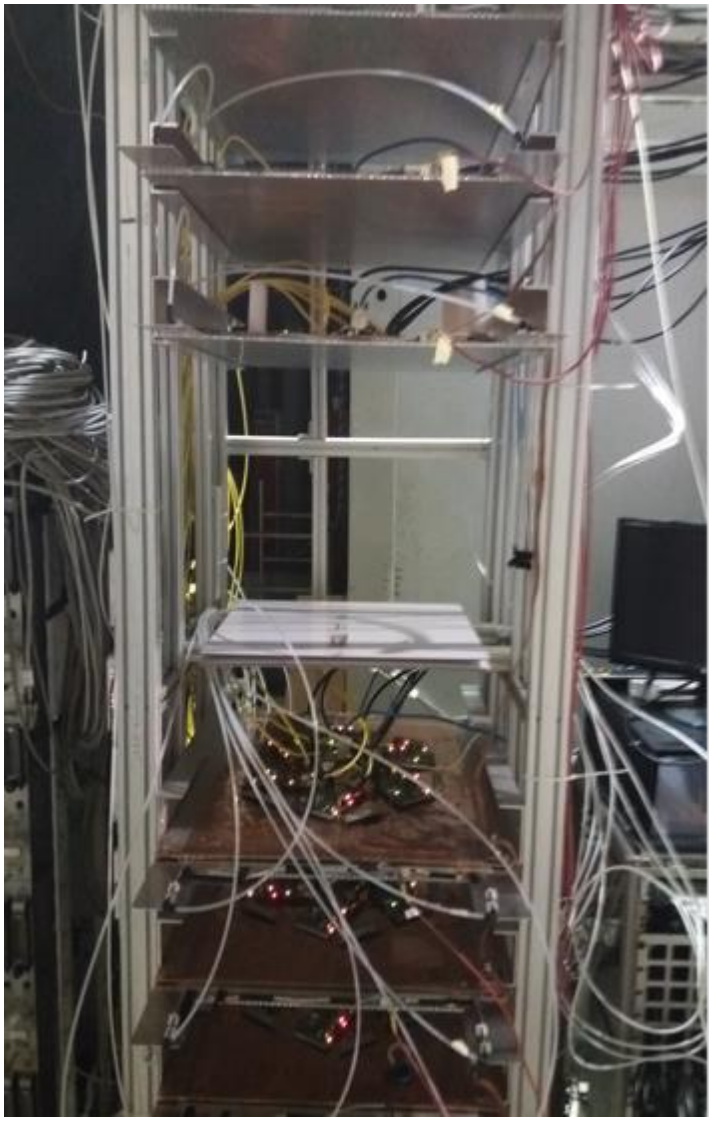


A board hosting
- One Hardroc ASIC
- One Microcontroller

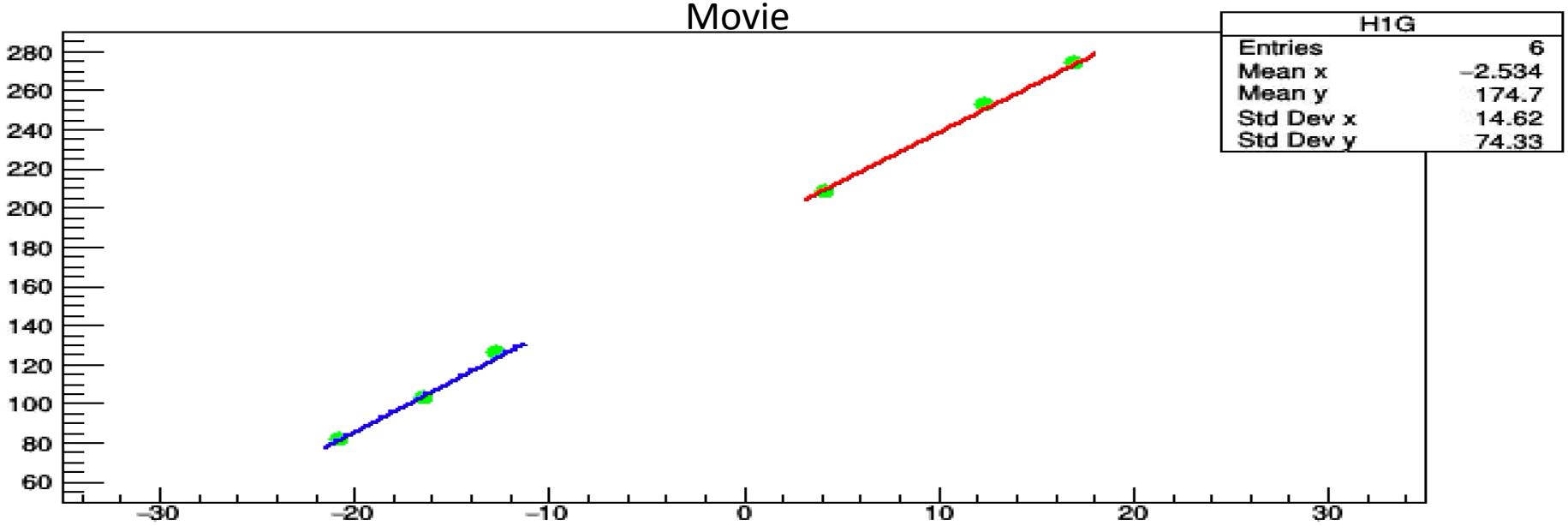
To be plugged directly on the back of the PCB, on the edge to read out 64 woven strips (1 HR2 ASIC).

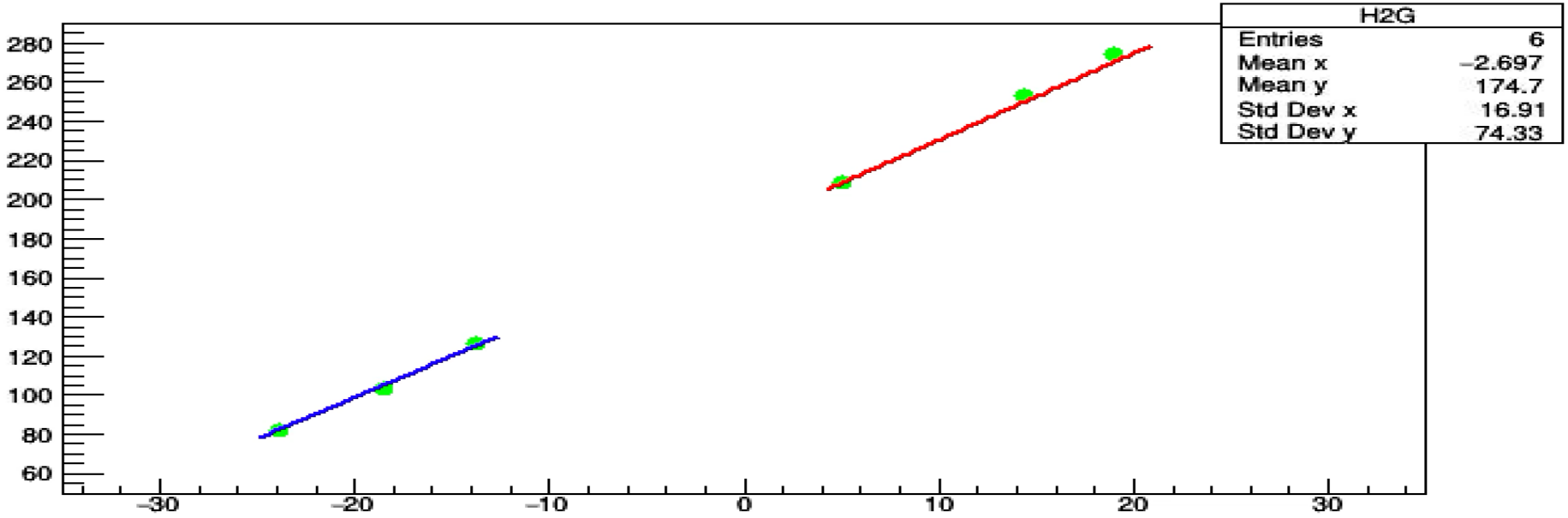
# SETUP

The new readout scheme was tested first using a SC-PMT and in a standalone mode.

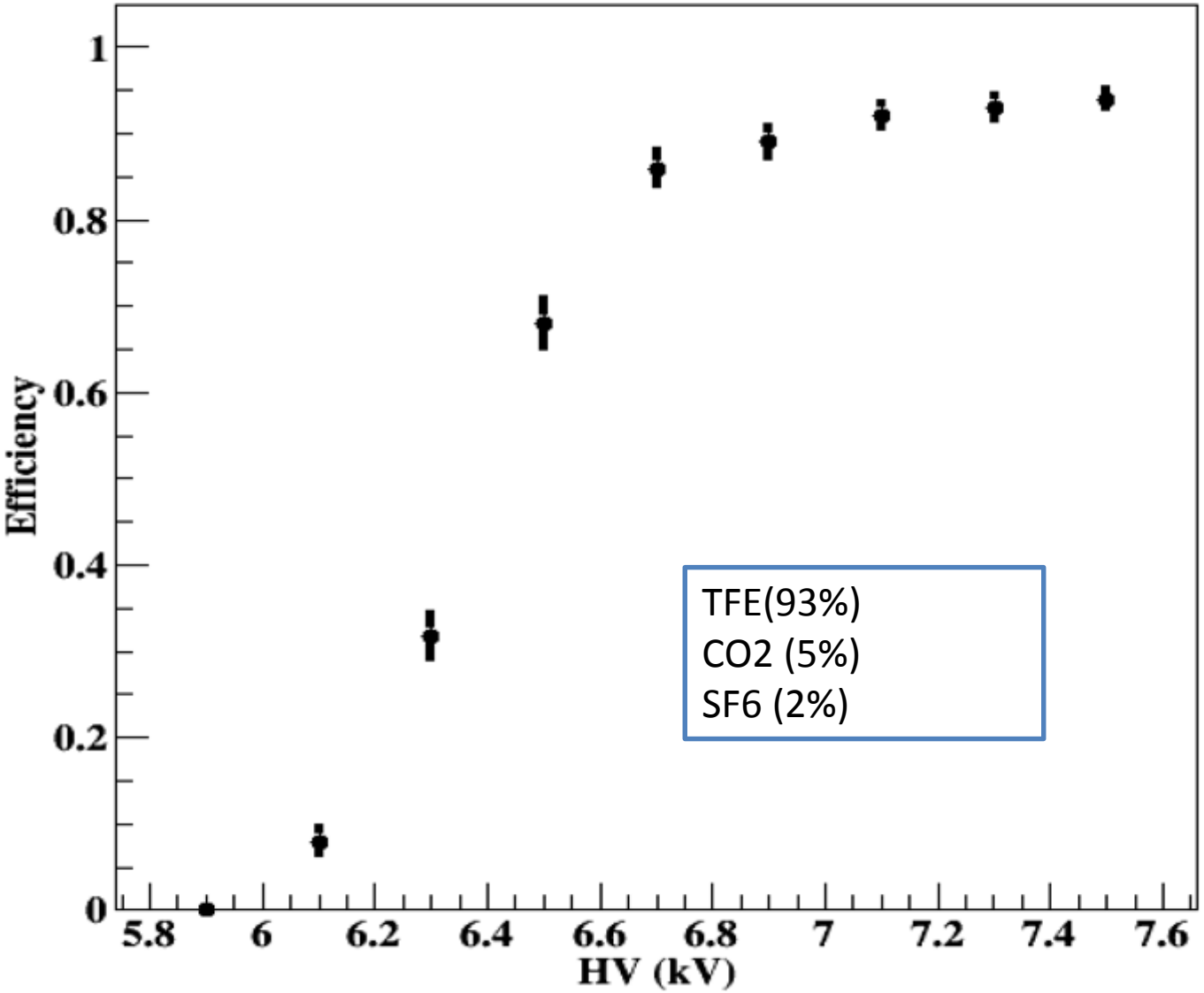


# Movie

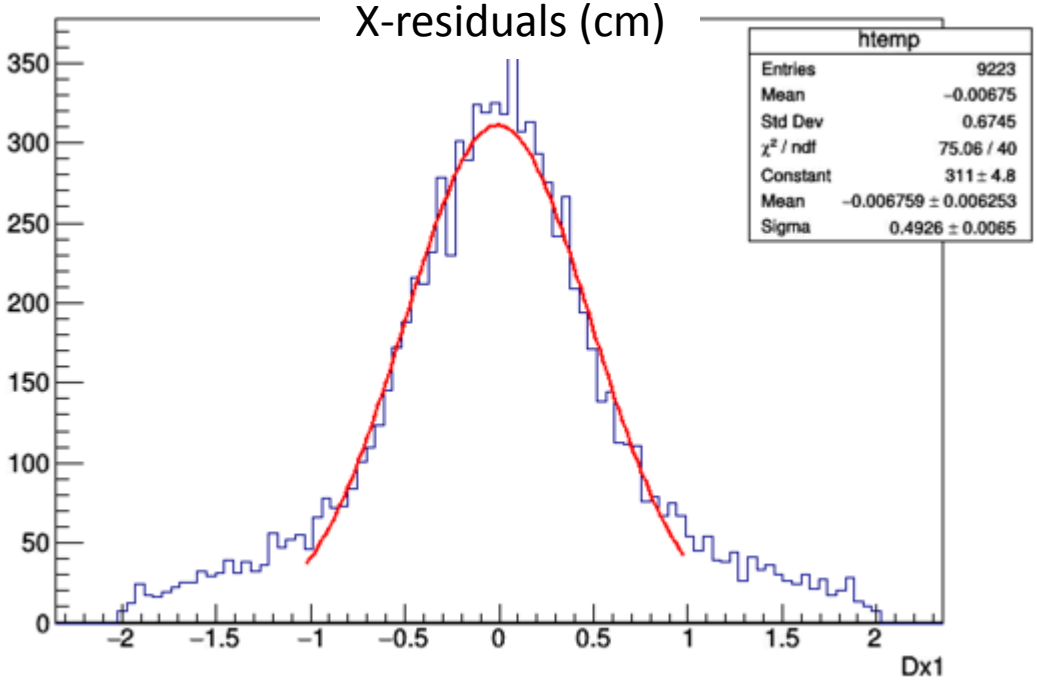

H1G
Entries 6
Mean x −2.534
Mean y 174.7
Std Dev x 14.62
Std Dev y 74.33
280
260
240
220
200
180
160
140
120
100
80
60
−30
−20
−10
0
10
20
30


H2G
Entries 6
Mean x −2.697
Mean y 174.7
Std Dev x 16.91
Std Dev y 74.33
280
260
240
220
200
180
160
140
120
100
80
60
−30
−20
−10
0
10
20
30

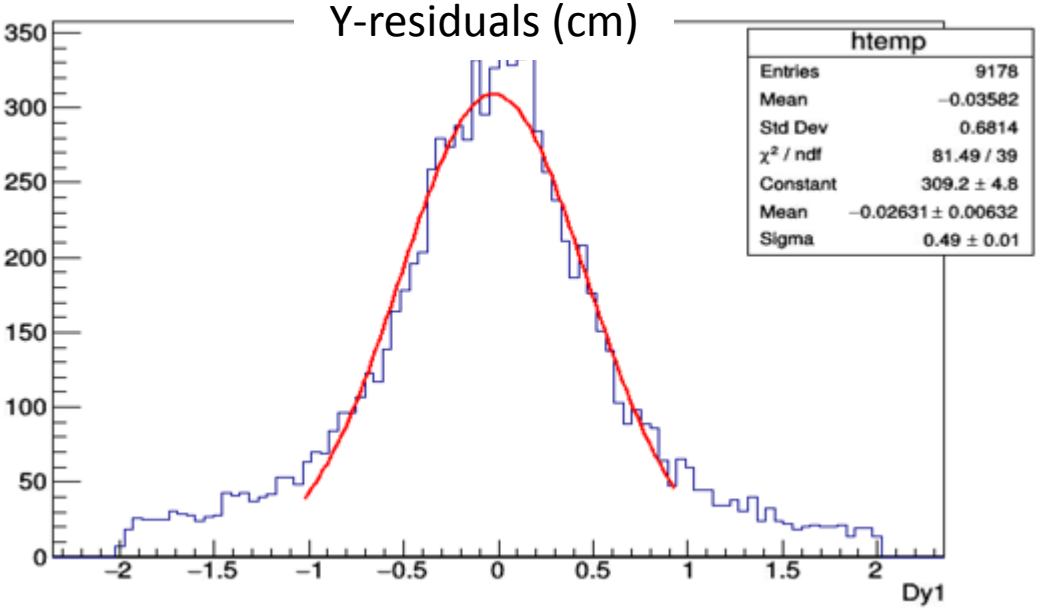
Efficiency with the new scheme



X-residuals (cm)

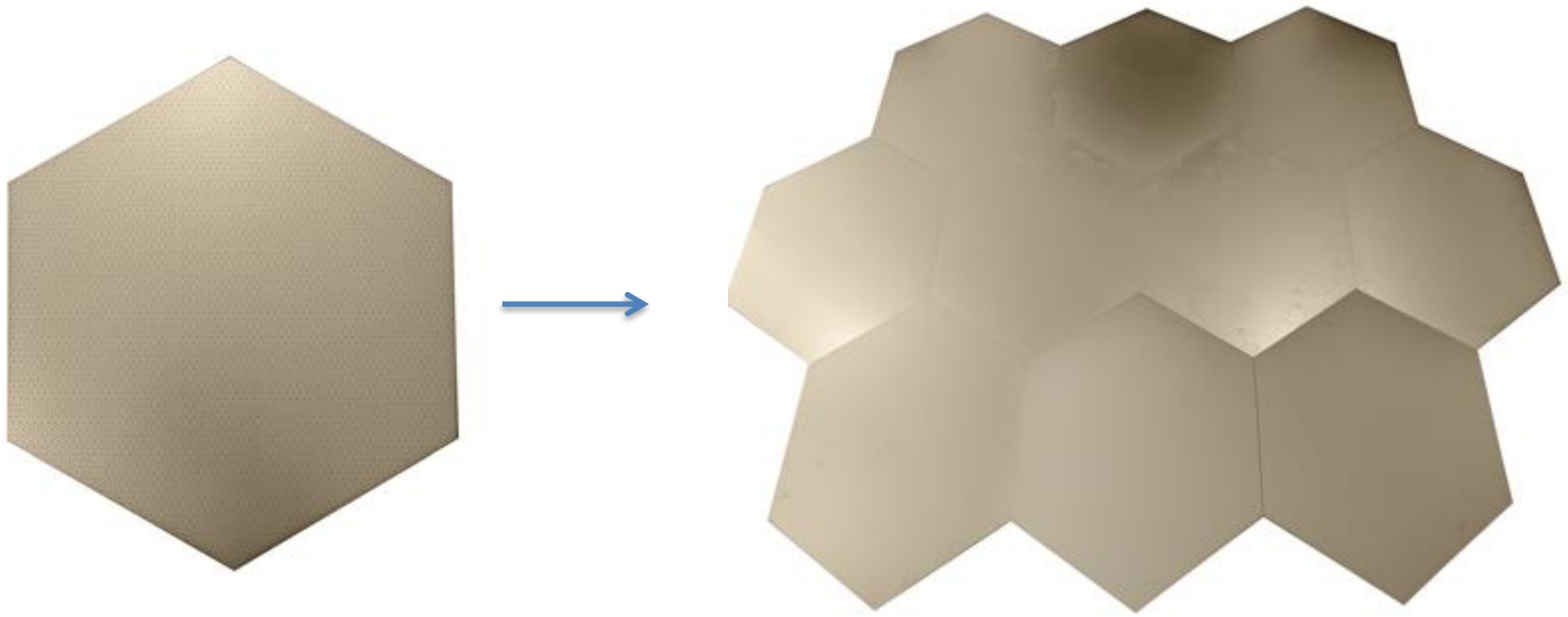



Y-residuals (cm)



# Next Step

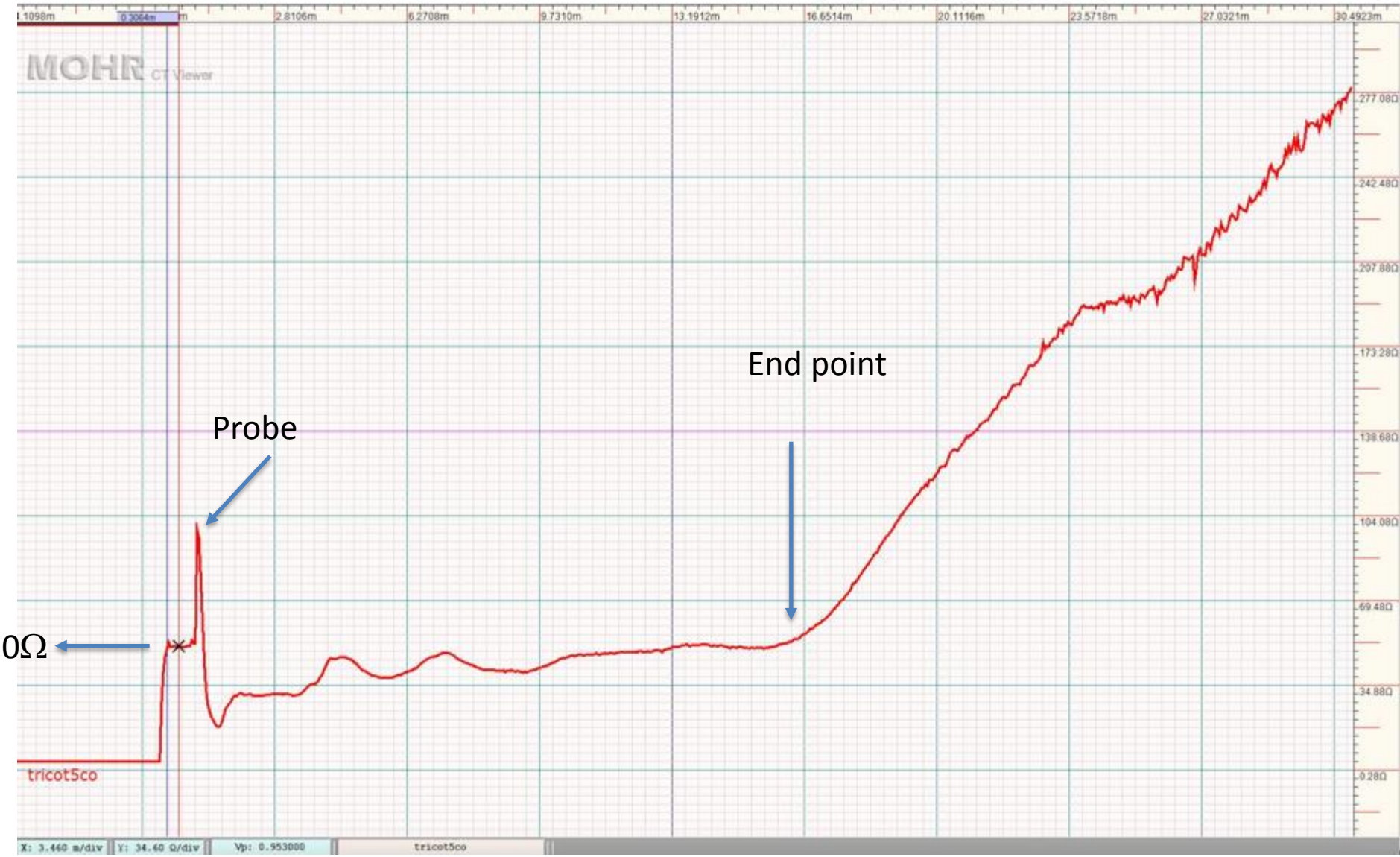
We would like to build large detectors similar to those to be used in the Endcaps of ILC and CEPC muon systems and use the new readout scheme to validate completely the concept. We will then test the new concept within SDHCAL to assess the possibility to use it in future calorimeters.



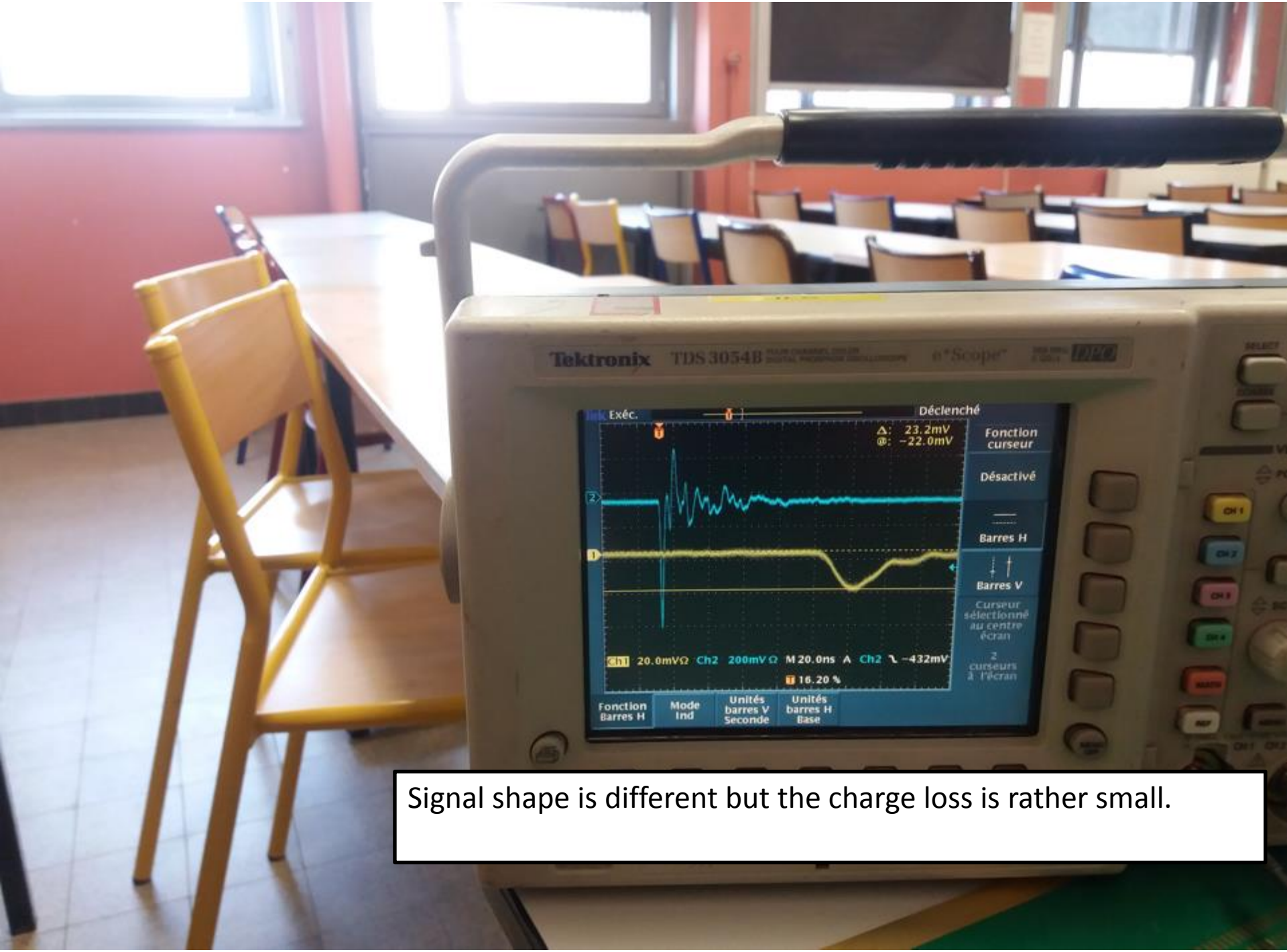
Connecting two neighboring PCBs:

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 secondone.

We add 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
X: 3.460 m/div
Y: 34.60 Ω/div
Vp: 0.953000
tricot5co

We add the ten we have
7m long

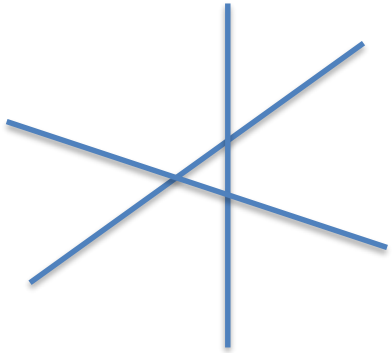



Signal shape is different but the charge loss is rather small.

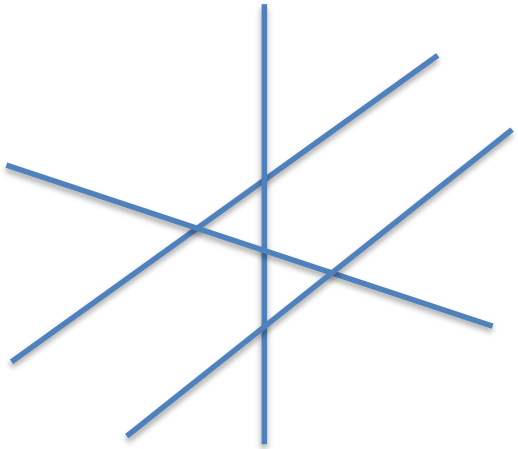
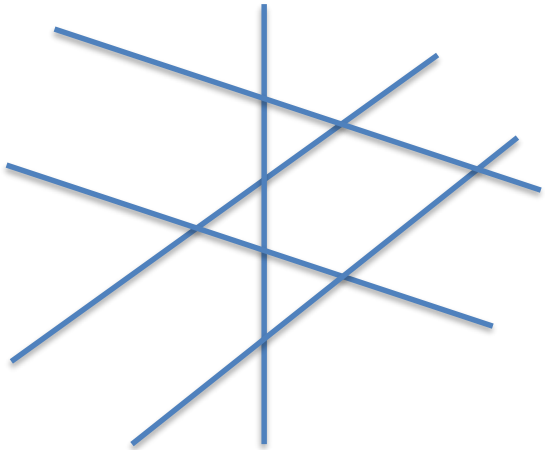
# Conclusion

- A new scheme allowing a reduced cost and reduced power consumption without reducing the granularity is proposed to equip large RPC detectors
- This solution is very useful if one wants to use the muon detectors as a tail catcher
- The scheme could be applied to any MPGD in principle
- Study to assess the possibility to use it in SDHCAL is ongoing.
- Large RPC detectors will be built and equipped with the new scheme soon.

3 crossings



5 crossings



8 crossings