

# A New Readout Scheme for RPC and Other Gaseous Detectors

*Imad Laktineh*

IP2I, Lyon, France

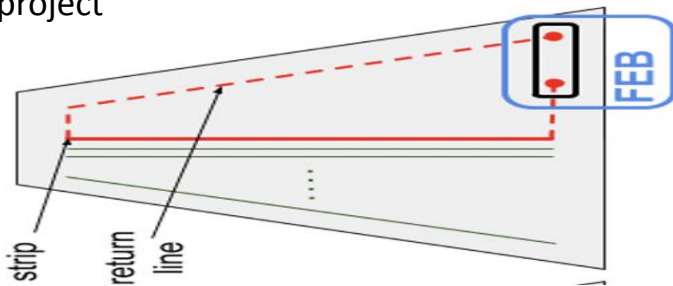


# Resistive Plate Chambers (RPC):

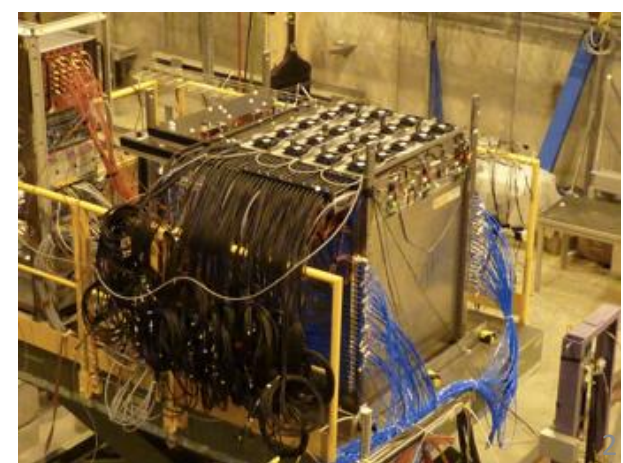
- ❑ Are fast timing detectors
- ❑ Can be built with large surface, excellent homogeneity and very small dead zone
- ❑ Are robust and cheap.

## Several ways to read out RPC:

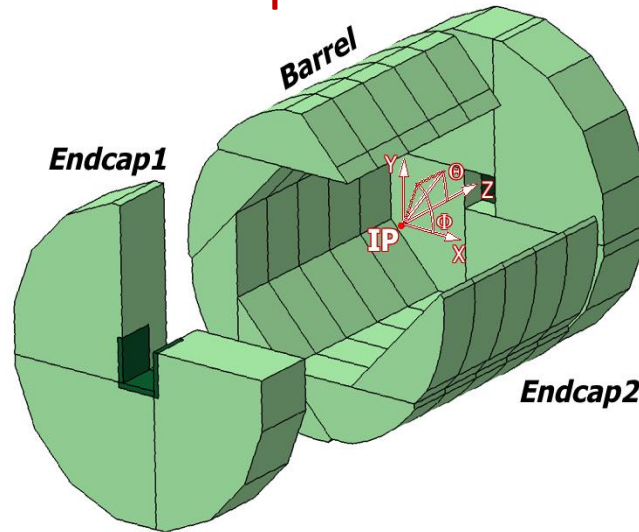
- ◆ Using **one-end readout pick-up strips** (either one direction on the anode side as for current CMS RPC or two directions: one on the anode and one on the cathode as for ATLAS) or **two-end readout** using **excellent time measurement** as the one proposed for **CMS iRPC** upgrade project



- ◆ Using **pick-up PADS** as for SDHCAL (CALICE)



# Why we need a new 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 case of circular colliders **active cooling** → **reduced PFA performance**

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

# Why we need a new concept?

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

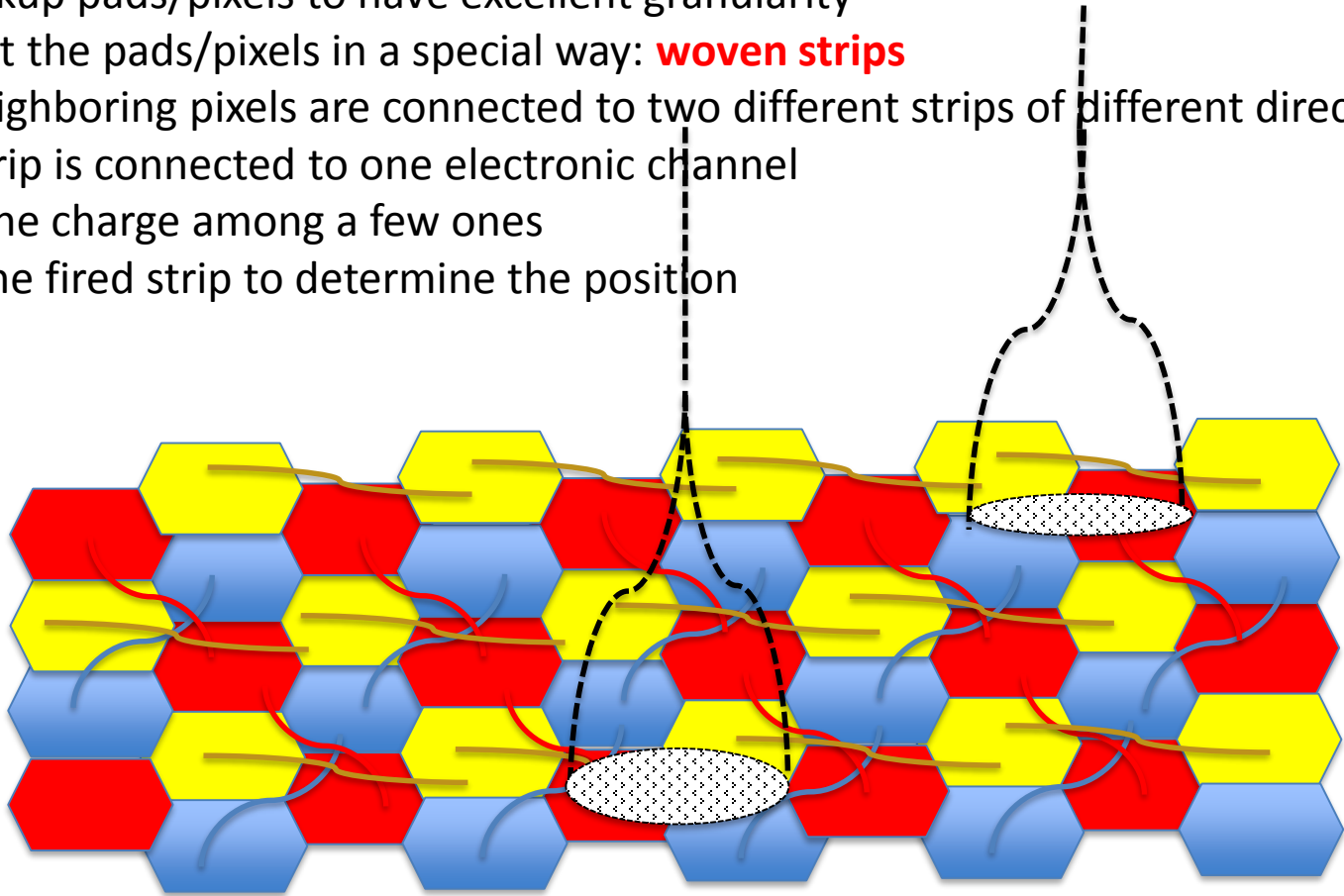
Can we do something to save power and money without impacting the physics

?

## 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

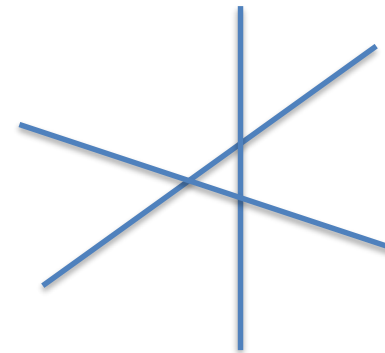
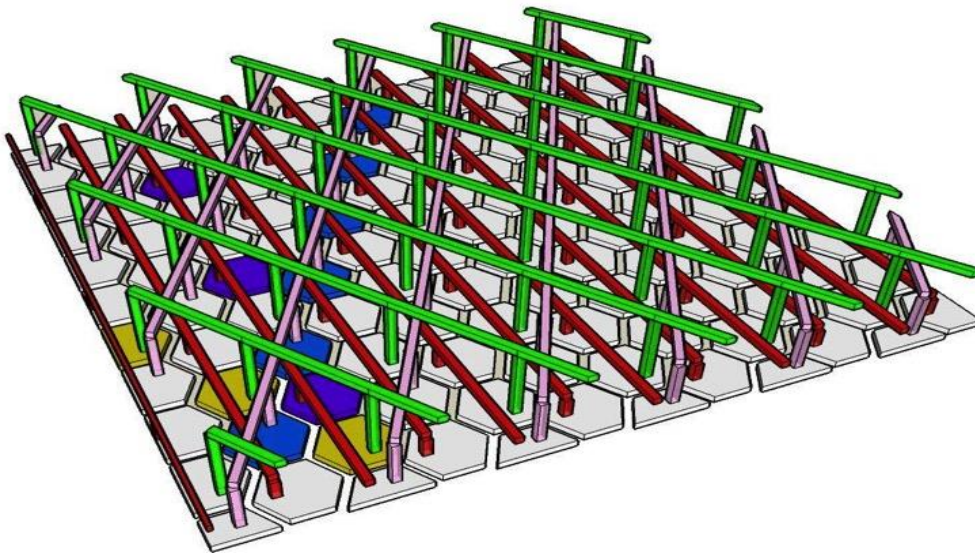


$N \times N \rightarrow 3N$  : Reduction of electronic channels, power consumption and occupancy

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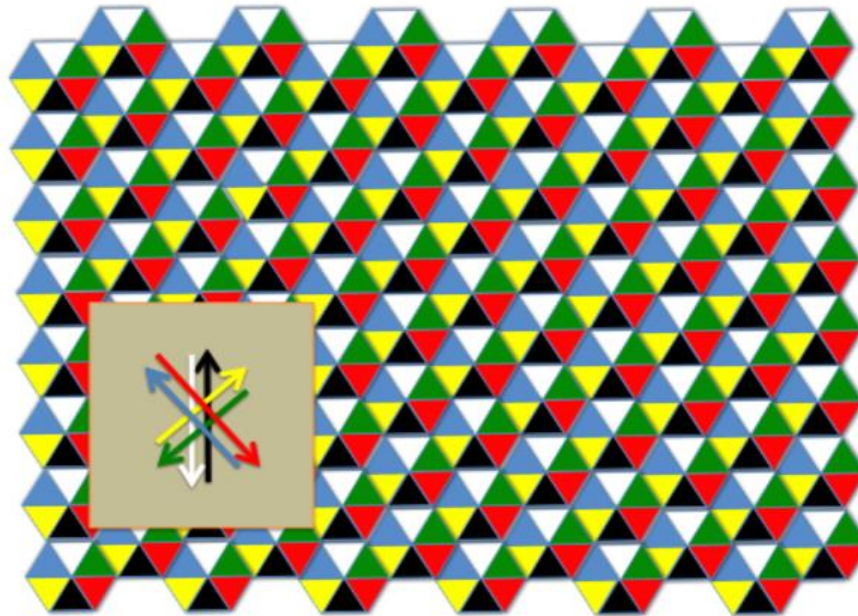
1 intersection  
=  
1 "Hit"

$N \times N \rightarrow 3N$  : Reduction of electronic channels, power consumption and occupancy



## Important features:

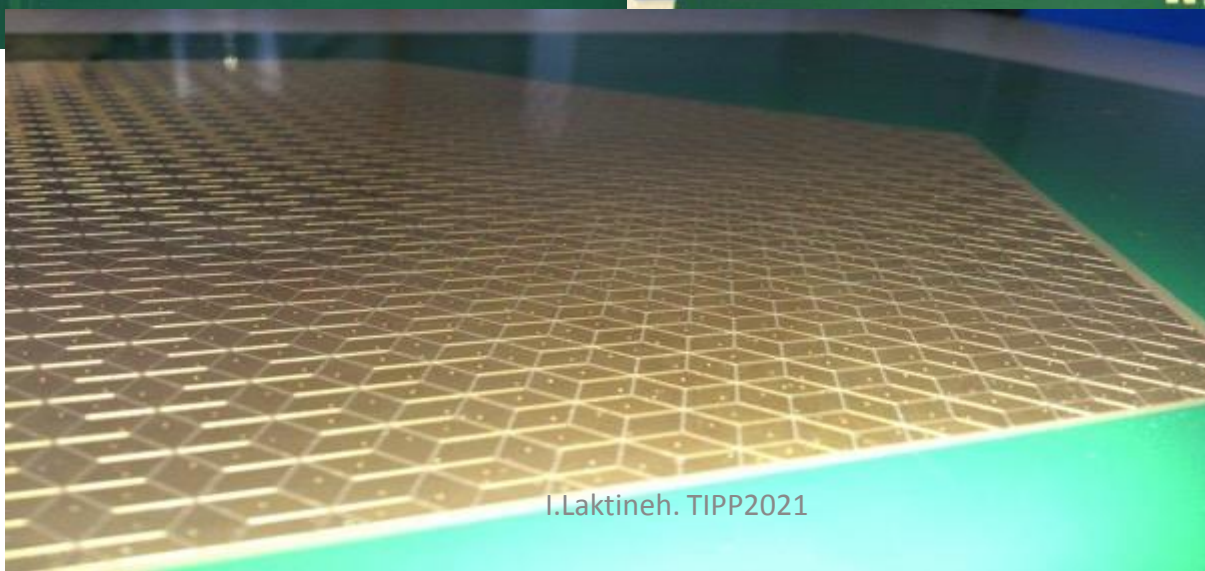
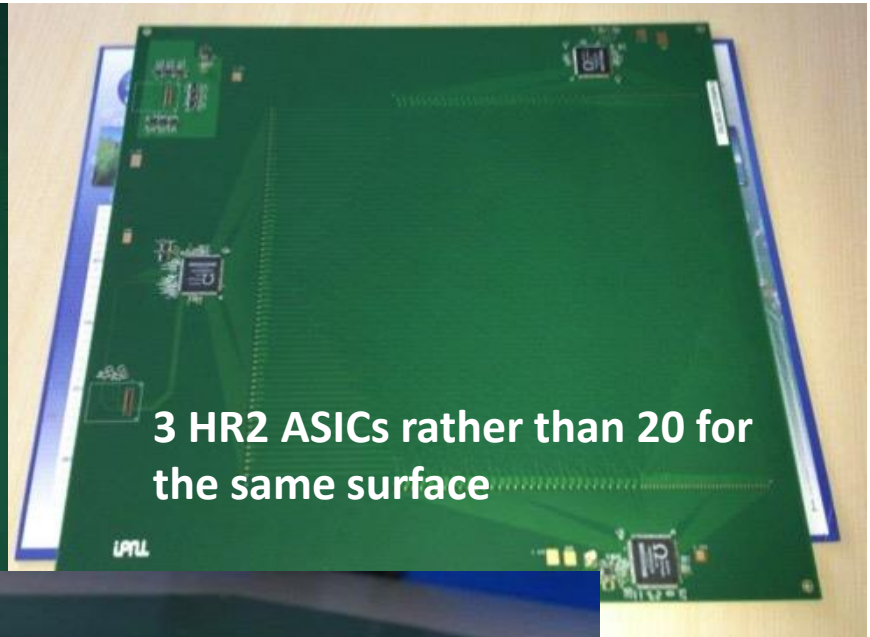
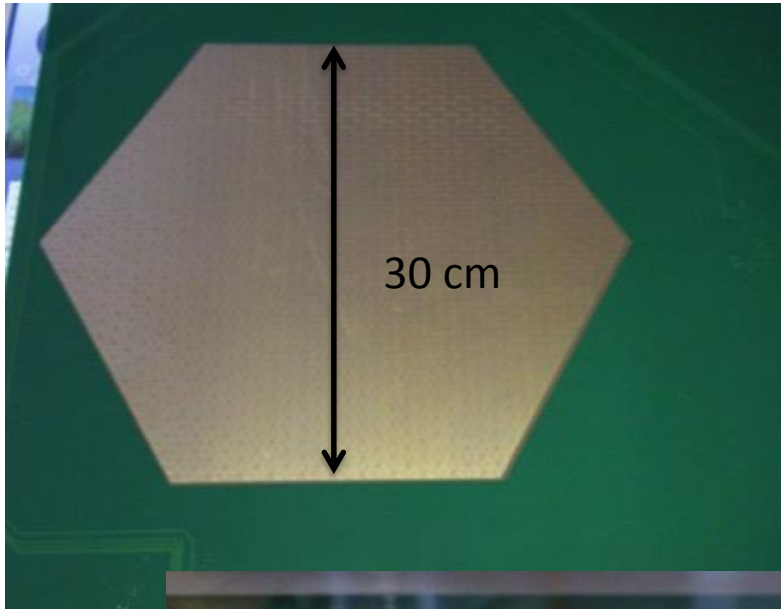
- ❑ The pad/pixel size should be slightly smaller than the charge extension to feed at least two pads/pixels. In gaseous detector this is always possible (RPC or resistive MPGD).
- ❑ Having 3 or more directions allows one to eliminate ambiguities (ghost particles)



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.





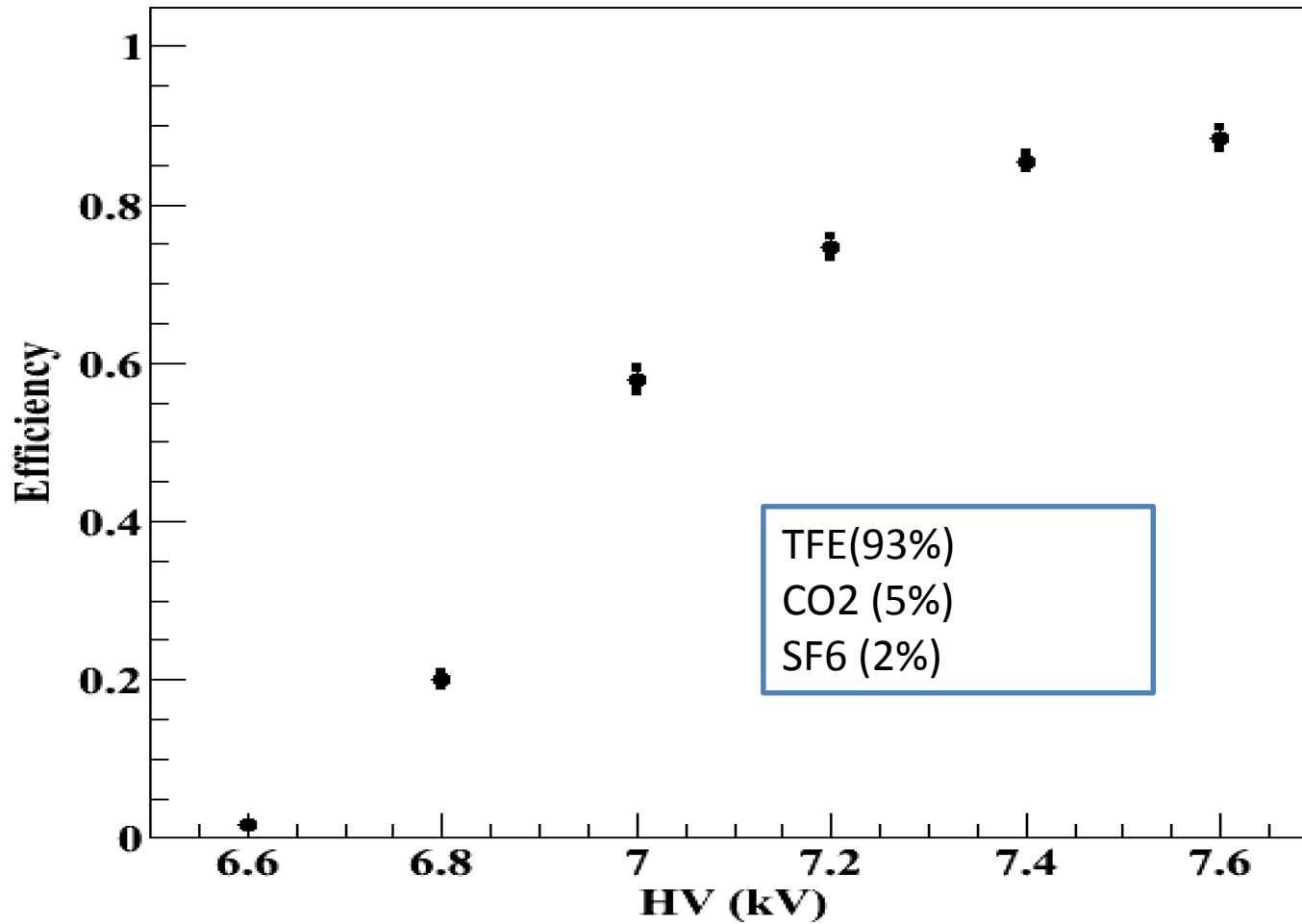


Setup with 5 detectors equipped  
with the new readout scheme

# Efficiency vs HV

Threshold  $\approx 80$  fC

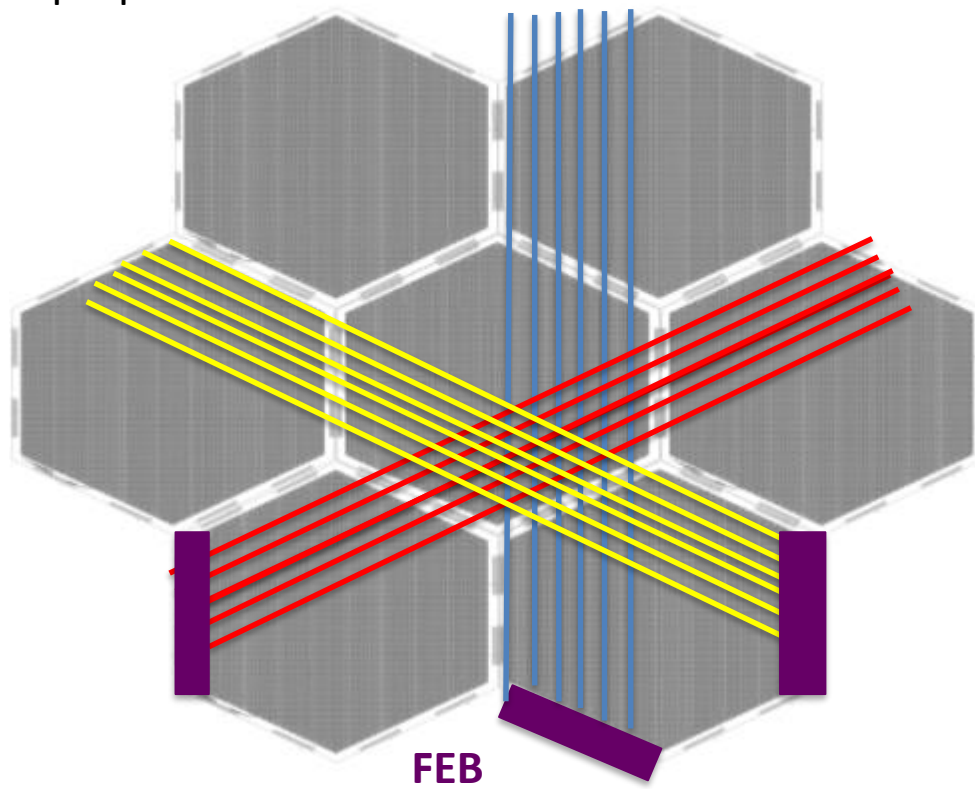
Triggerless mode



# Large surface detectors

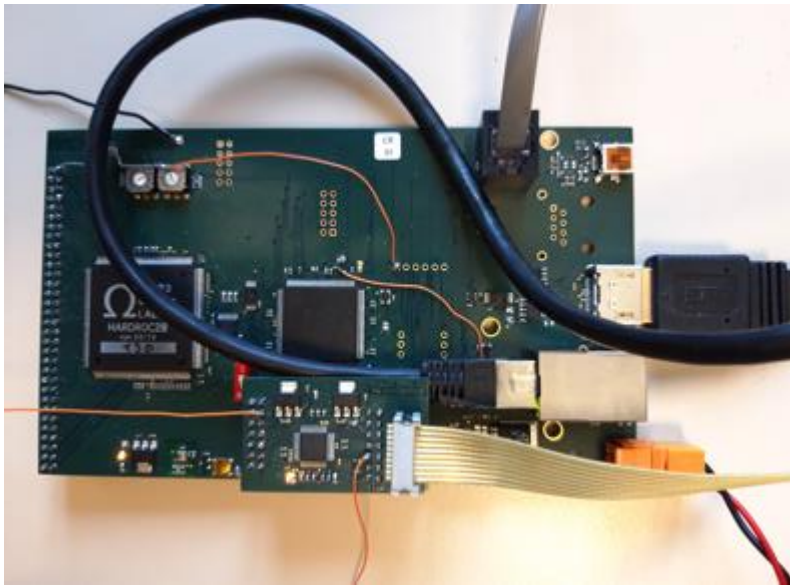
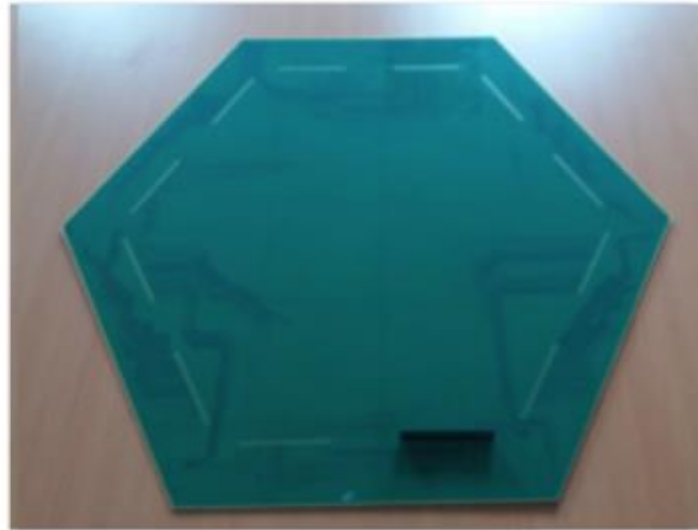
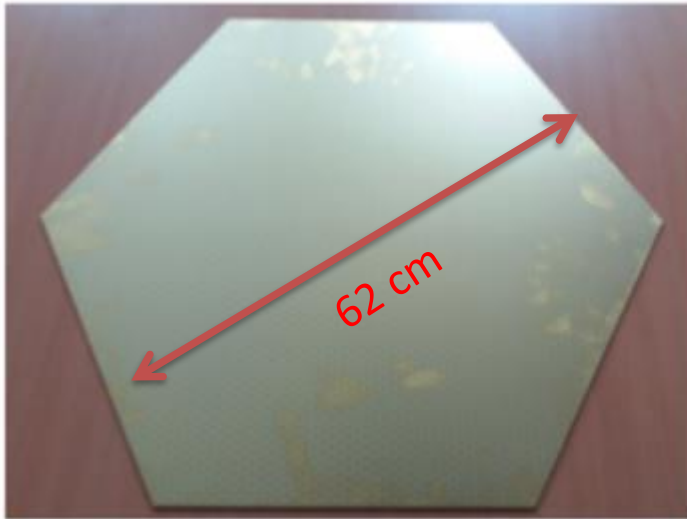
To instrument **very large gaseous detectors** the readout electronics could not be part of the PCB. It is therefore mandatory to separate strip panels from the readout electronics.

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).



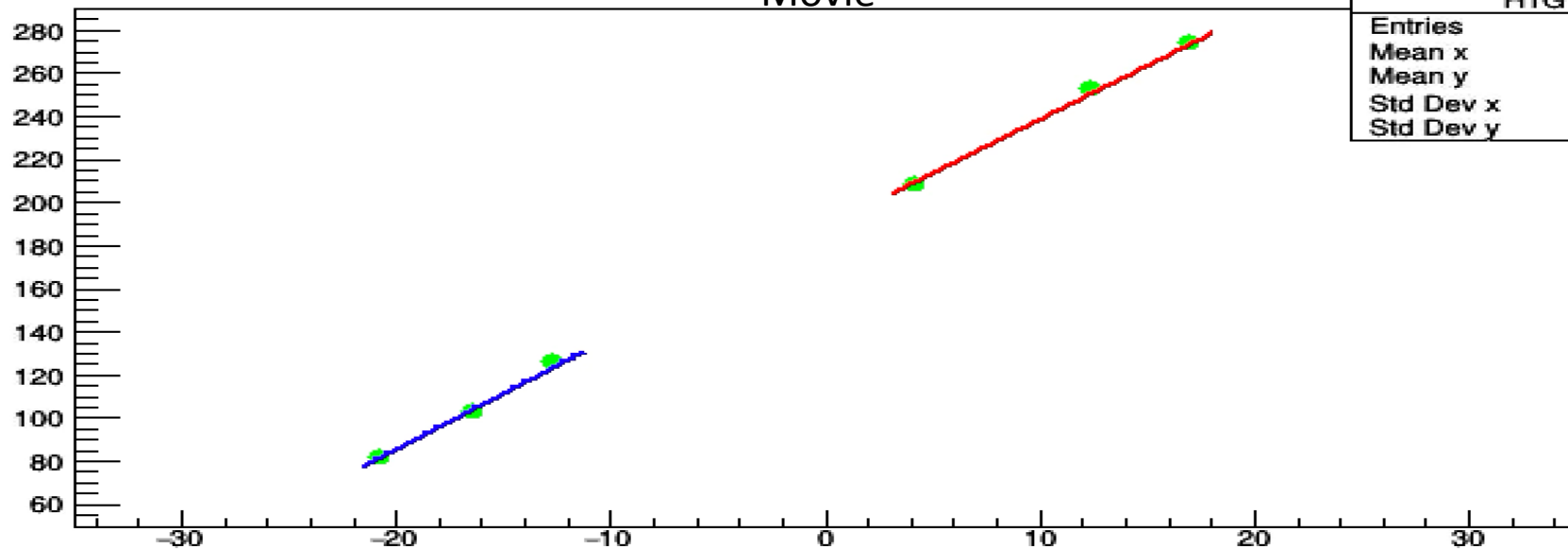
# SETUP

The new readout scheme was tested first using a SC-PMT (trigger mode) and then in a triggerless mode.

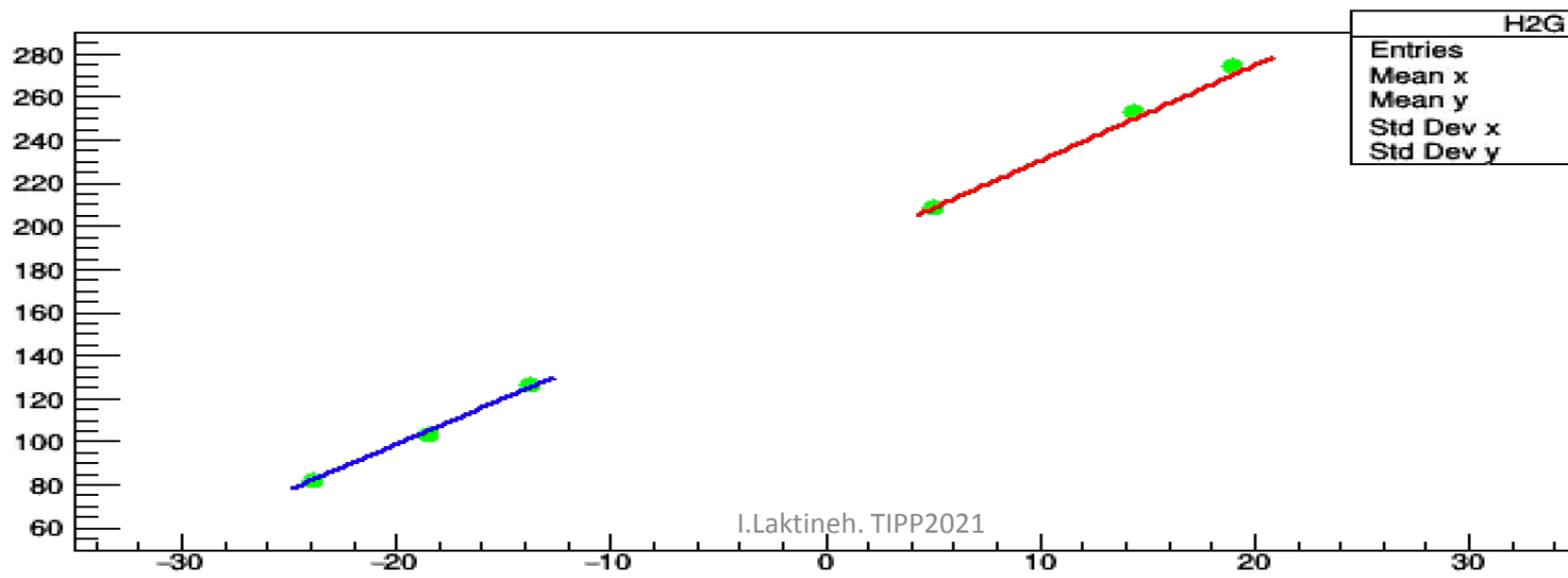




# Movie

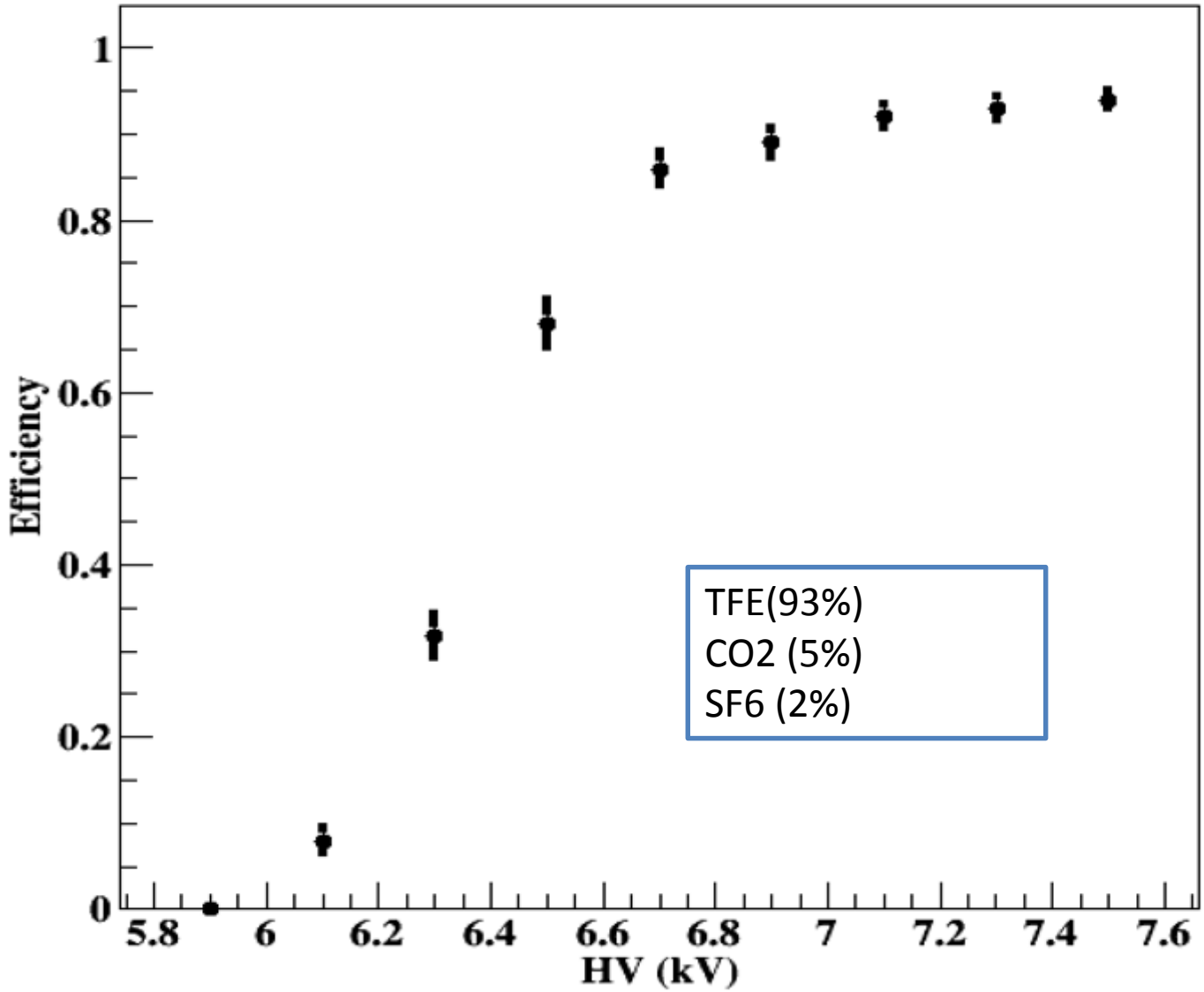


H1G	
Entries	6
Mean x	-2.534
Mean y	174.7
Std Dev x	14.62
Std Dev y	74.33

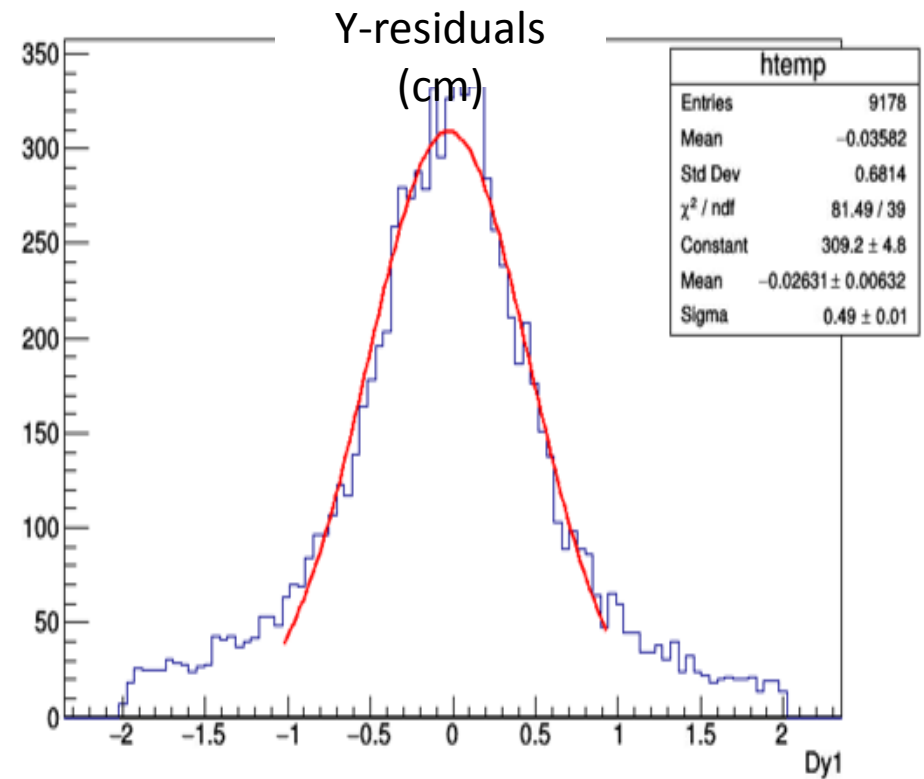
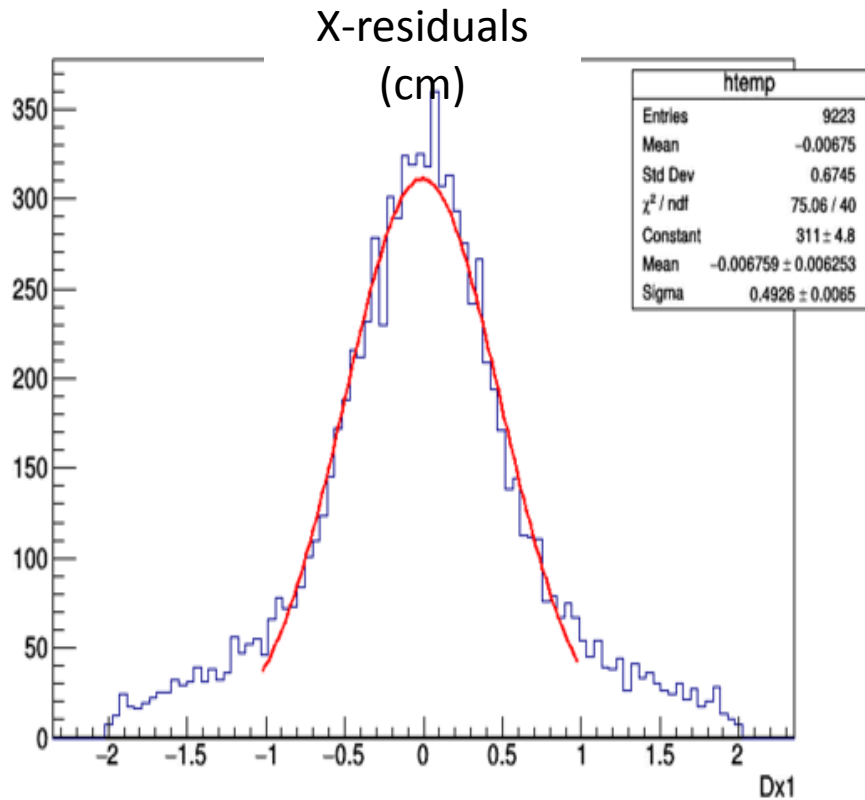


H2G	
Entries	6
Mean x	-2.697
Mean y	174.7
Std Dev x	16.91
Std Dev y	74.33

# Efficiency



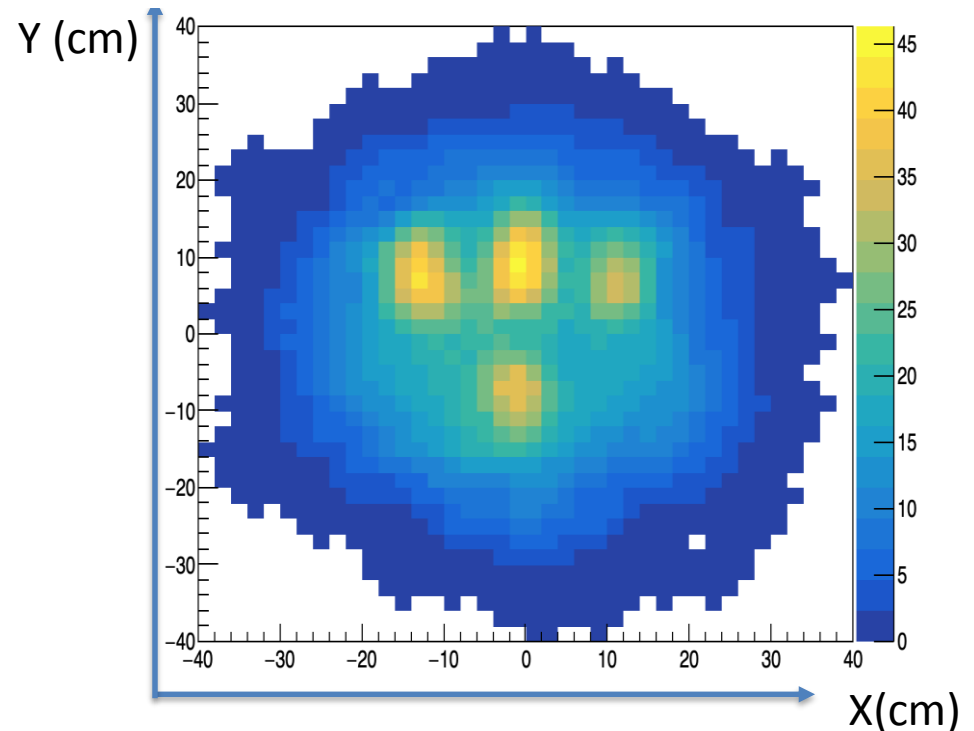
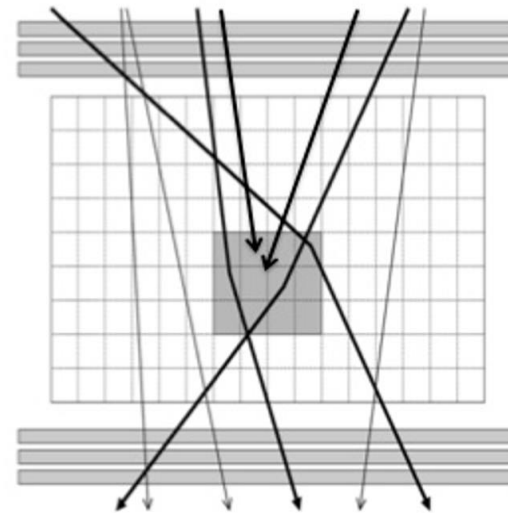
# Spatial resolution

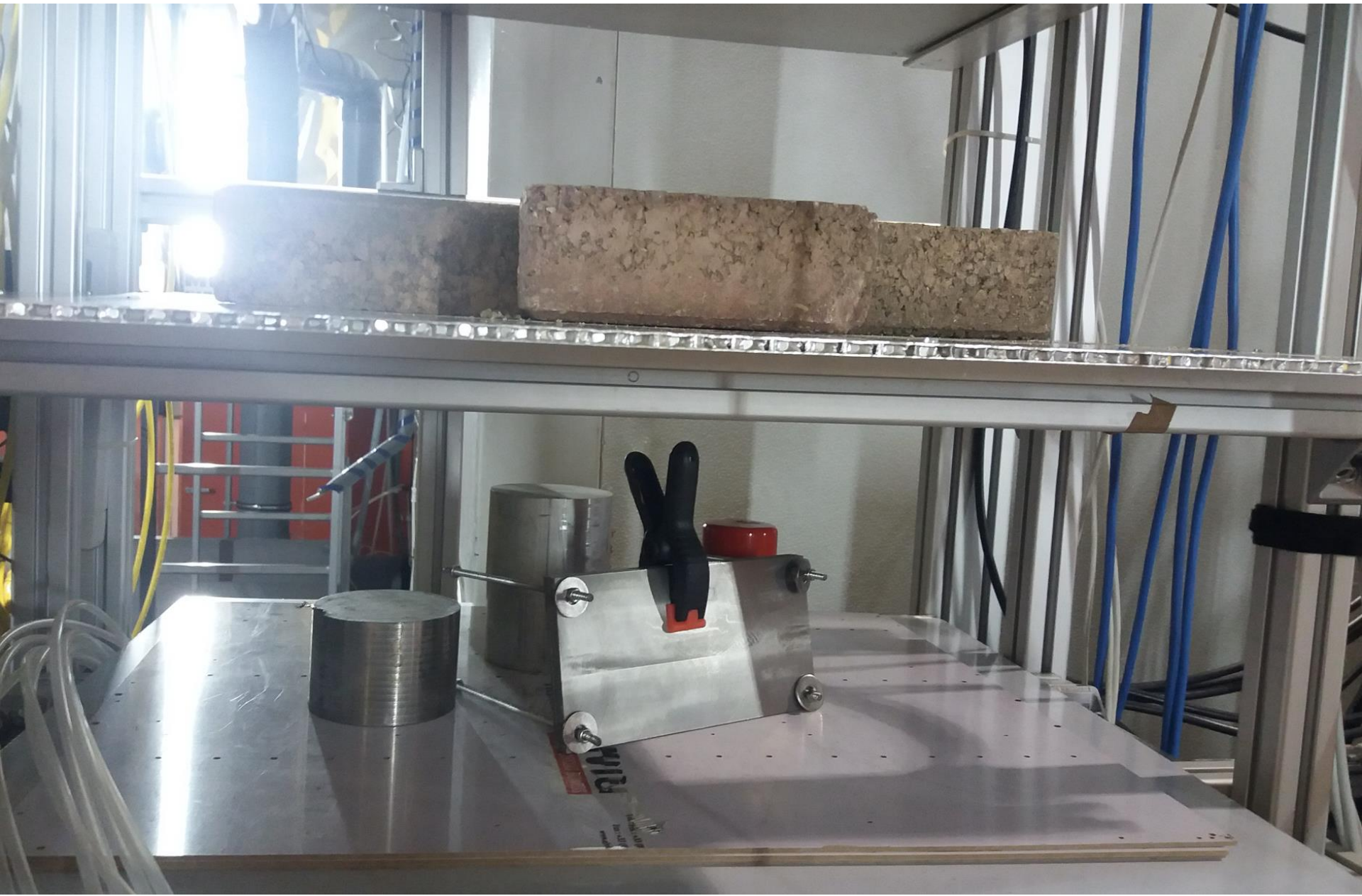


Similar to the one obtained with 1cm X 1cm pickup pads of the SDHCAL RPC.

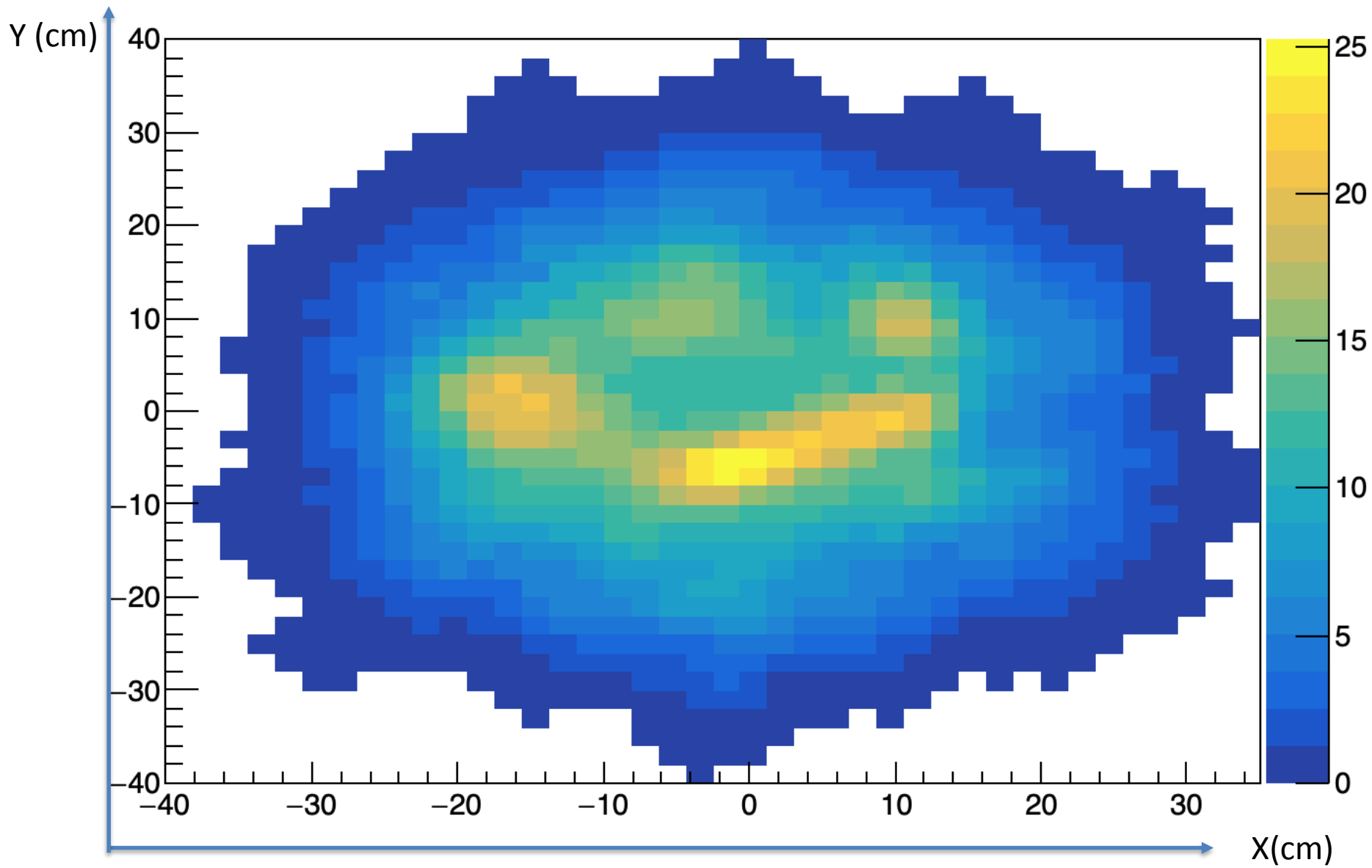
An attempt to use the new scheme in home security application is being attempted. Hidden blocks of different dense materials were found using multiple scattering techniques.

This is only possible with a precise angular measurement of the two segments.







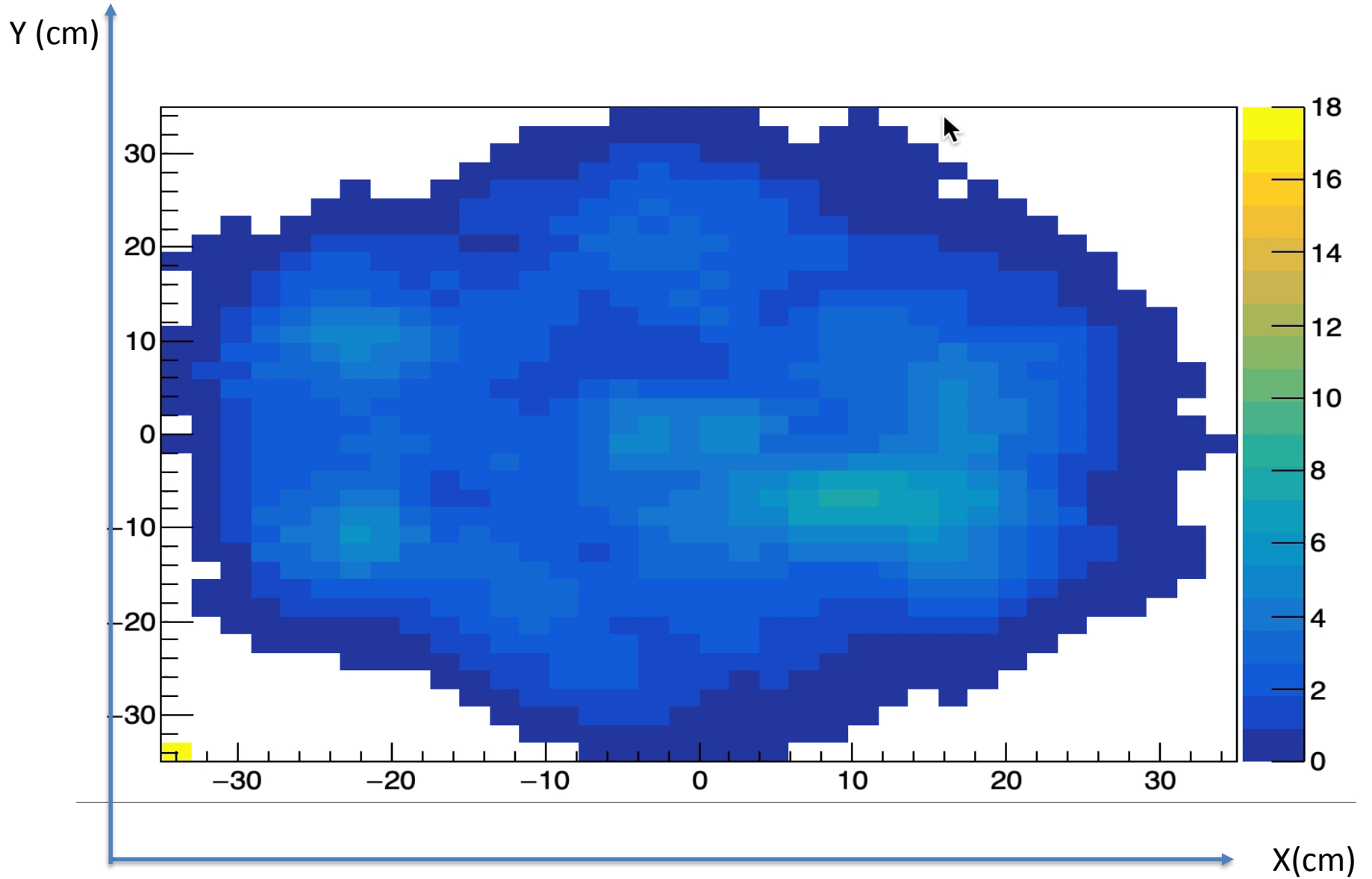




First floor

Seond floor

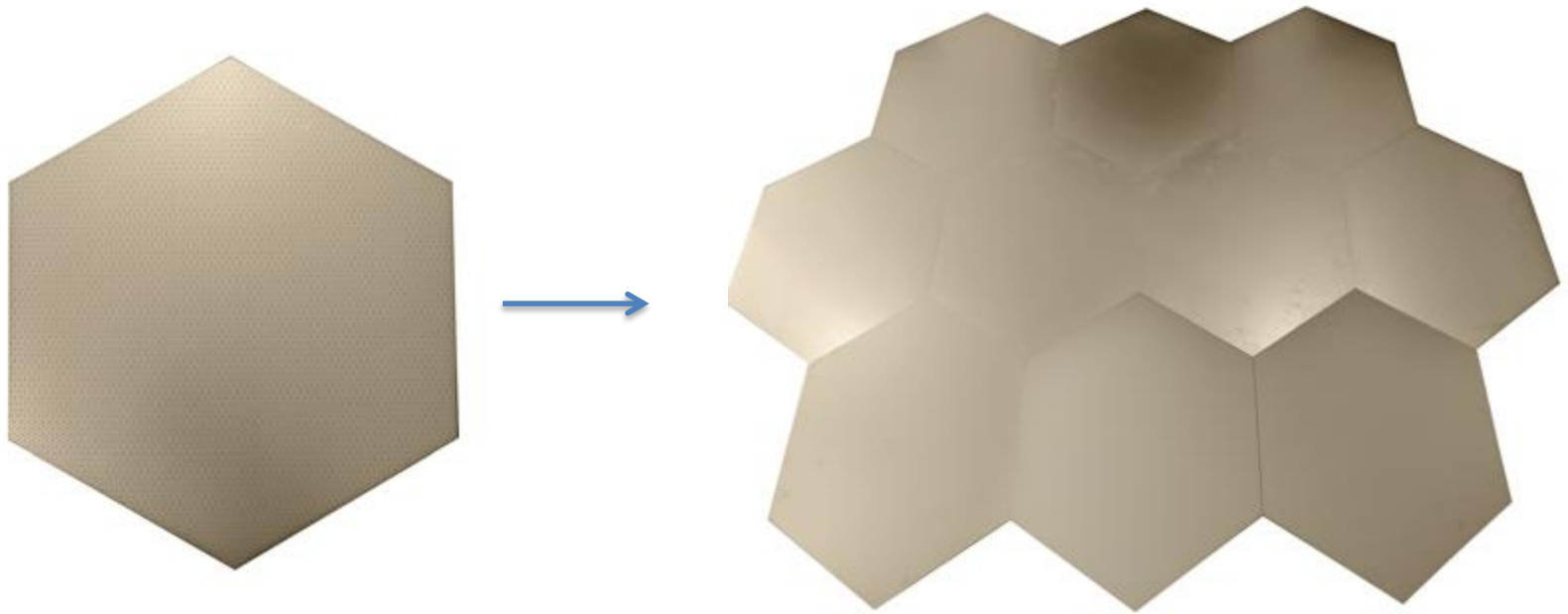
# Movie-Zscan



## Next Step

We are building large detectors similar to those to be used in muon system in future experiments ( ILC, CEPC, FCC, MATHUSLA...) but also in the SDHCAL calorimetry concept and will 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.

# Next Step

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.



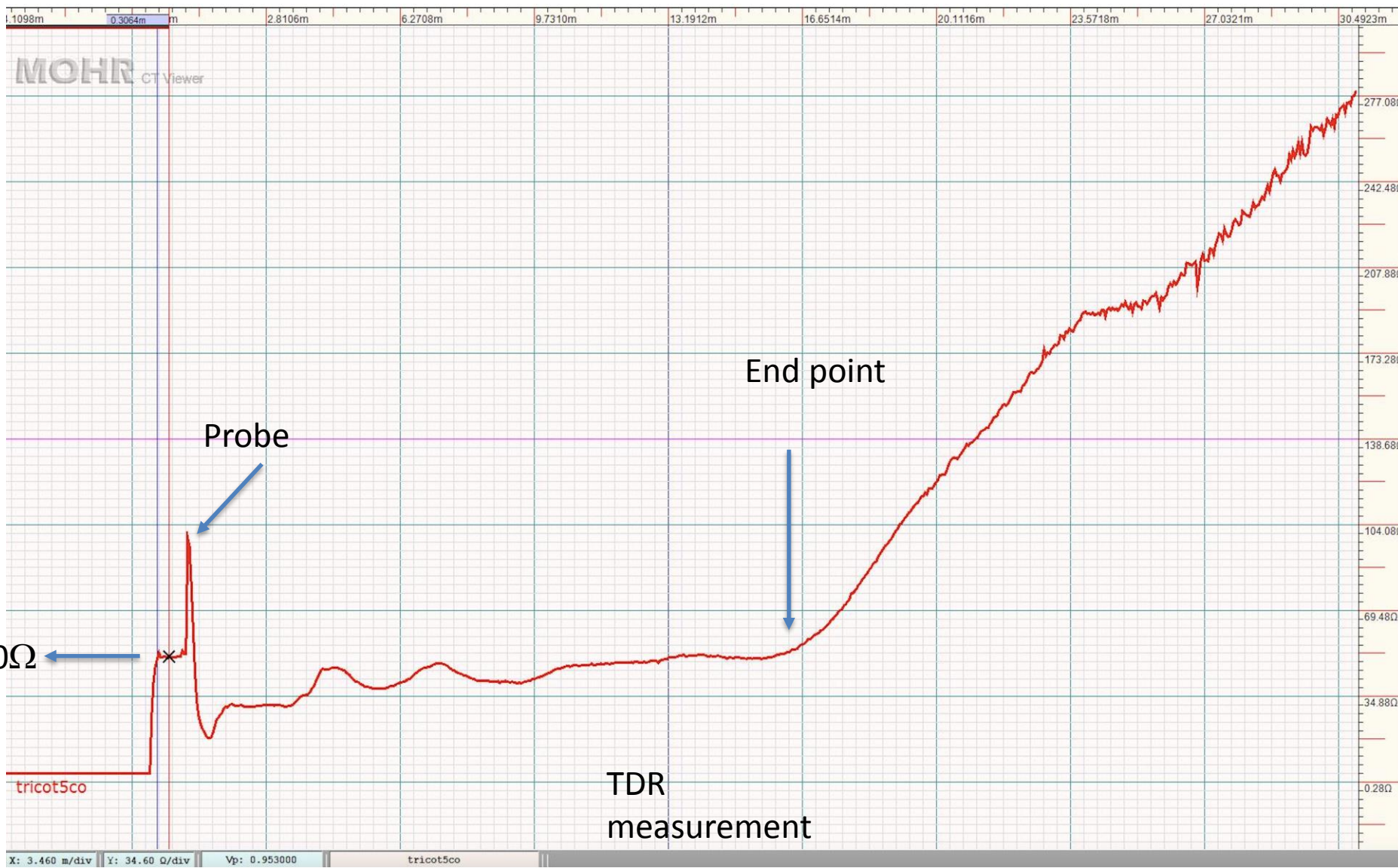


We added five of them



tricot5co\_ohms.jpg

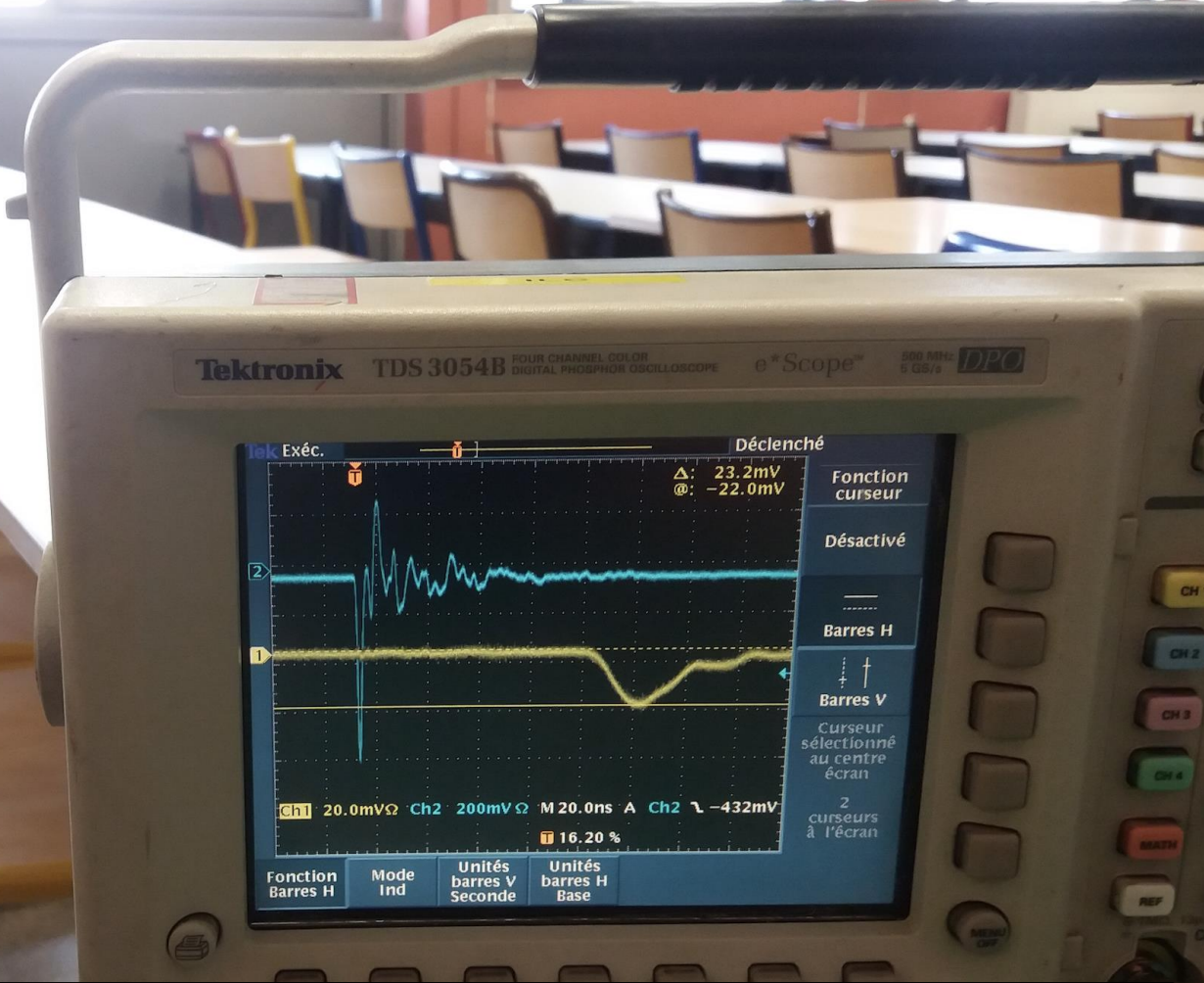
Rechercher





We added 10 of them

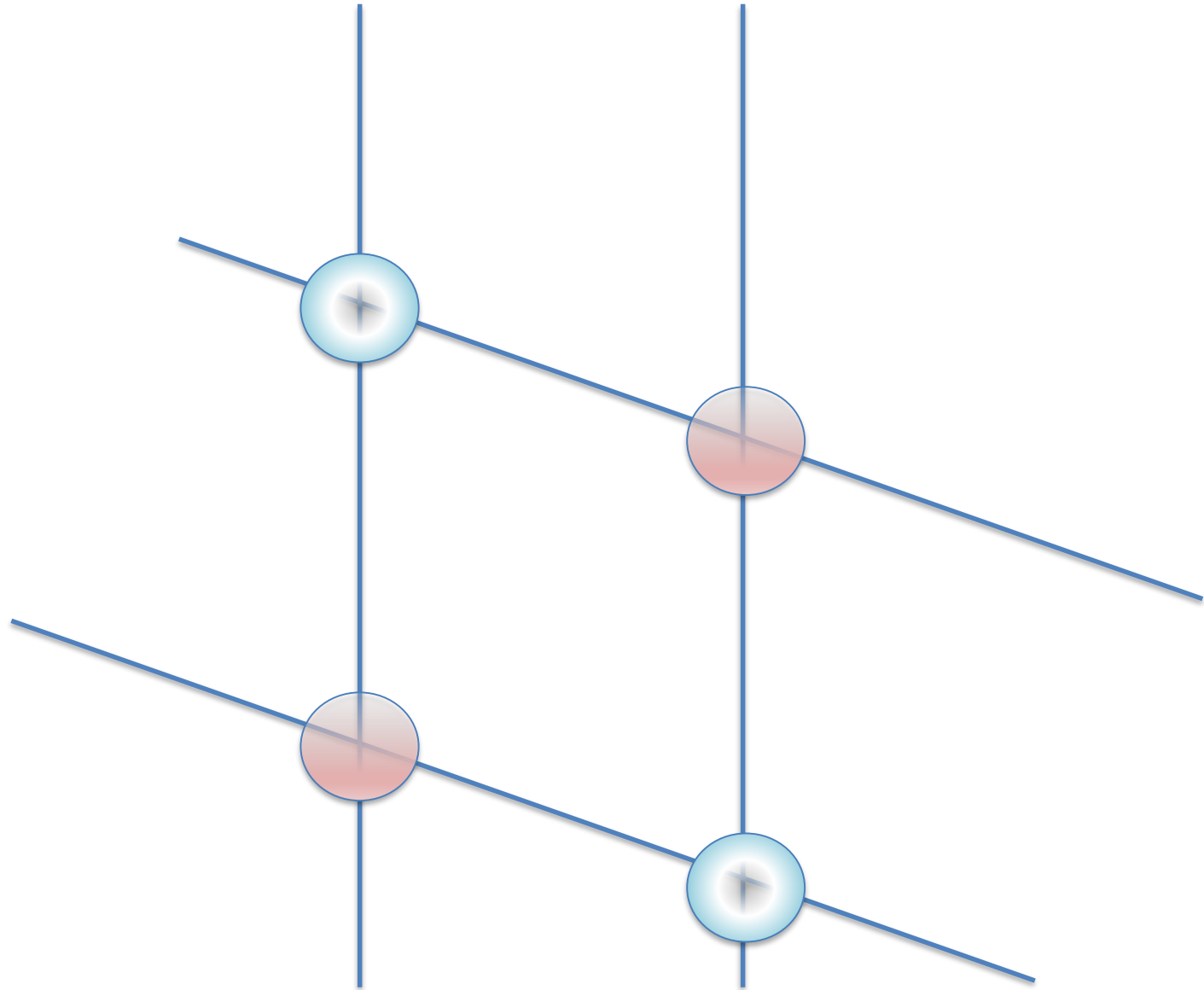




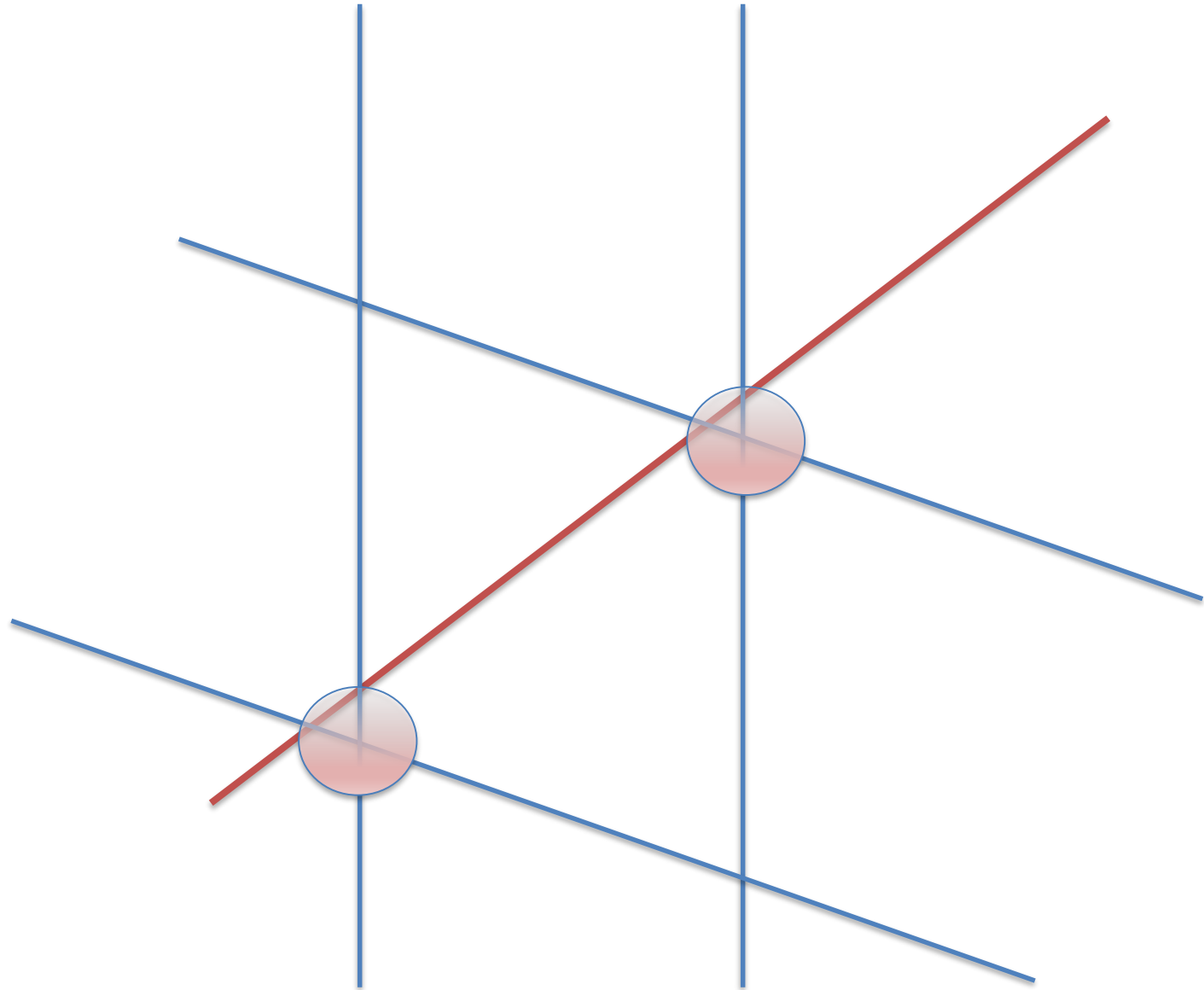
The shape of a RPC-like signal injected on one end and detected on the the opposite one ( $> 7$  m) is different but the charge loss is rather small).

# 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. Indeed, the 3 direction idea was already attempted in Wire Chamber and GEM (Hexaboard) detectors but in different manner.
- ❑ Study to assess the possibility to use it in SDHCAL concept is ongoing.
- ❑ Large RPC detectors are being built and will be equipped with the new scheme .







# Large RPC

