A couple of ideas to enhance spatial resolution

Different anodic readout configurations

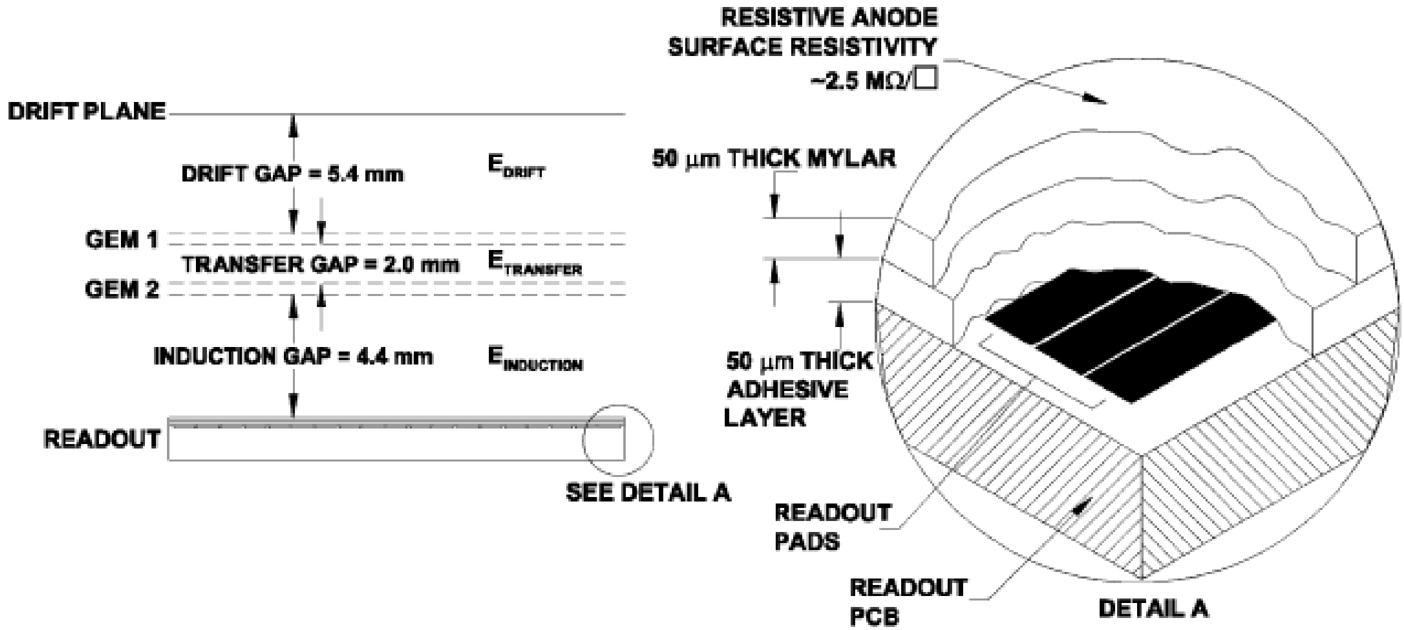
Thanks to the work of Dixit (1) and Holhmann (2)

(1) *Development of high resolution Micro-Pattern Gas Detectors with wide readout pads*, 1st International Conference on MPGD, June 12-15, 2009, Kolimpari, Crete Greece

(2) *CMS Forward Muon System Upgrade,* CERN 2/18/2013

Spatial resolution improvements

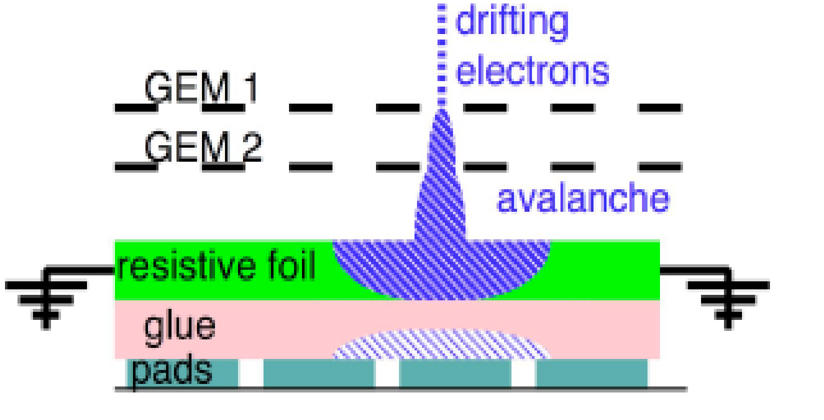
- How to improve spatial resolution without to increase significantly the electronic channels number?
- Analog readout with "*centre of gravity*" method
- New anodic readout by using "*charge dispersion*" method with resistive anode
- useful in case we are not interested in timing measurements



Space-time charge evolution

$$\frac{\partial \rho}{\partial t} = \frac{1}{\tau}\frac{\partial^2 \rho}{\partial x^2} \qquad \tau = RC$$

per unit-length (1)



$$\frac{\partial \rho}{\partial t} = \frac{1}{\tau}\left[\frac{\partial^2 \rho}{\partial r^2} + \frac{1}{r}\frac{\partial \rho}{\partial r}\right]$$

2-dimensional equation for charge density on the resistive surface (Telegraph-equation) where
R: anode surface resistivity,
C: capacity density per unit area,
τ: *system time constant per unit area*

$$\rho(r,t) = \frac{\tau}{2t}\exp\left(-\frac{r^2\tau}{4t}\right)$$

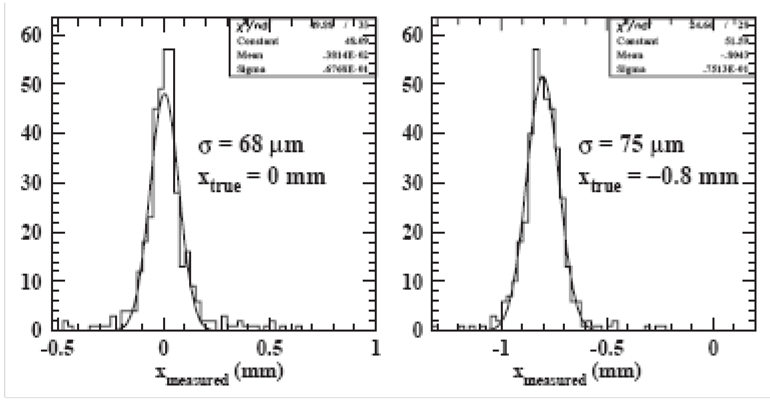
ρ solution for a resistive anode of finite size (infinite Fourier series)

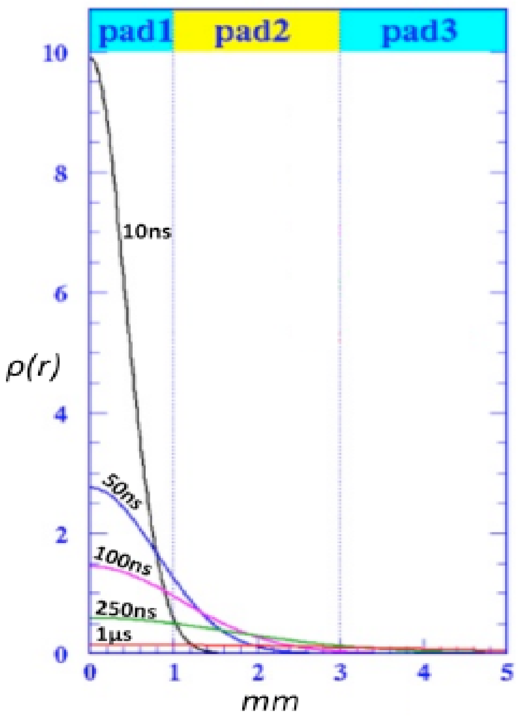
1. V. Radeka and P. Reak,*Charge dividing mechanism on resistive electrode in position sensitive detectors,* IEEE Trans. Nucl.Sci. 26 (1979) 225

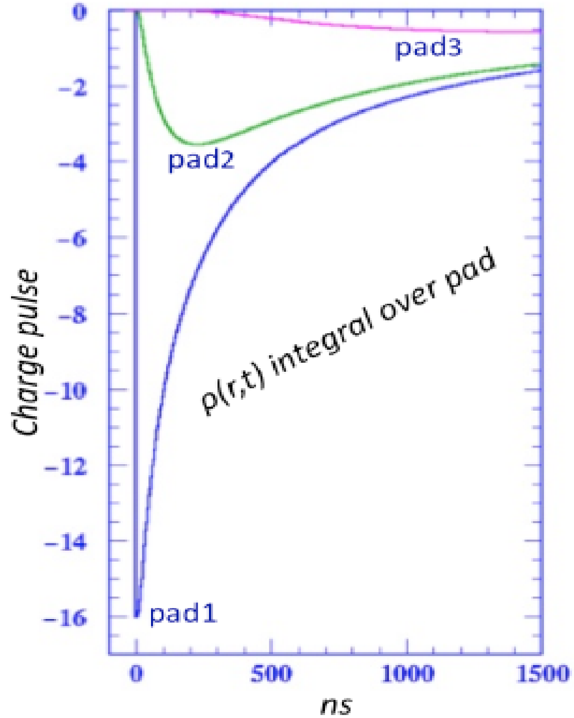
Charge dispersion method

- the charge density function is function of time and pad/strip position wrt charge development
- Its shape depends on the pad/strip geometry
- …on the location of pad readout wrt the initial charge
- …and the RC time constant of the system
- The signal on the readout pad/strip can be computed by:
  - integrating the charge density function
- The shape and pulse eight depends on:
  - pad geometry
  - pad localization wrt initial charge
  - *RC* time constant of the system

$$\rho(r,t) = \frac{\tau}{2t} \exp\left(-\frac{r^2\tau}{4t}\right)$$



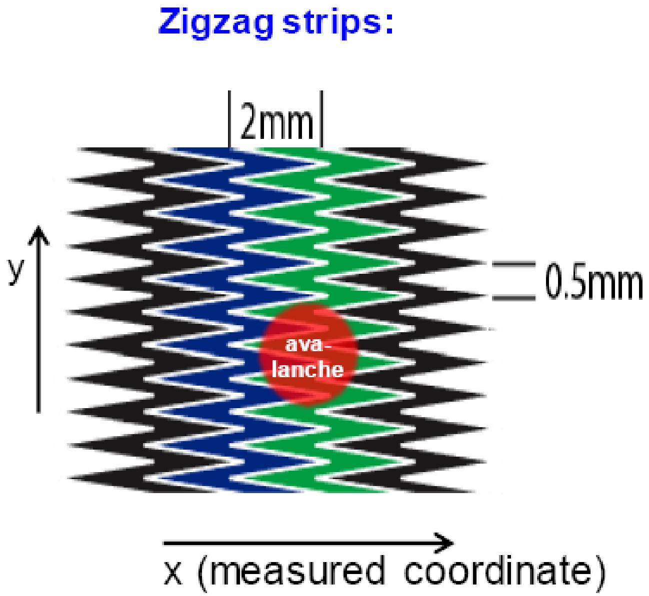




M.Dixit et.al. NIM A 518 (2004) 721-727

Zigzag readout strips structure

M. Holhmann CMS Forward Muon System Upgrade Review

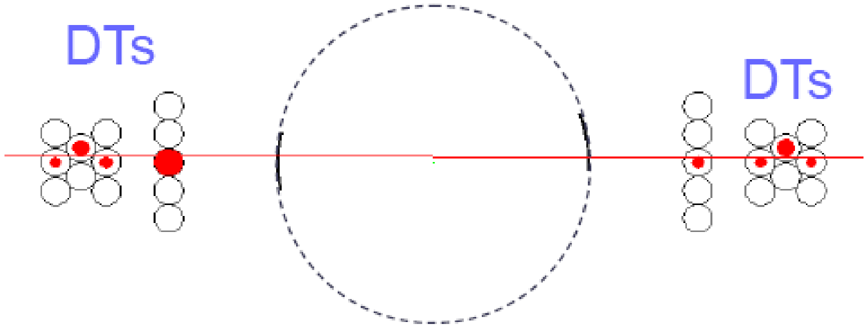


	Pitch [mm]	Typical Resolution [µm]
Zigzag strips & analog r/o	2.0	80
Straight strips & VFAT (baseline design, short end)	0.6	300
Improvement factor w/ zigzag strips	3.33	3.75

Concept:

- Charge sharing among adjacent strips allows quite sensitive **position-interpolation** in x-direction
- We are sacrificing the measurement of the 2^{nd} coord. (y) to gain precision in the 1^{st} coord. (x)

The test beam on the CGEM prototype (2008)



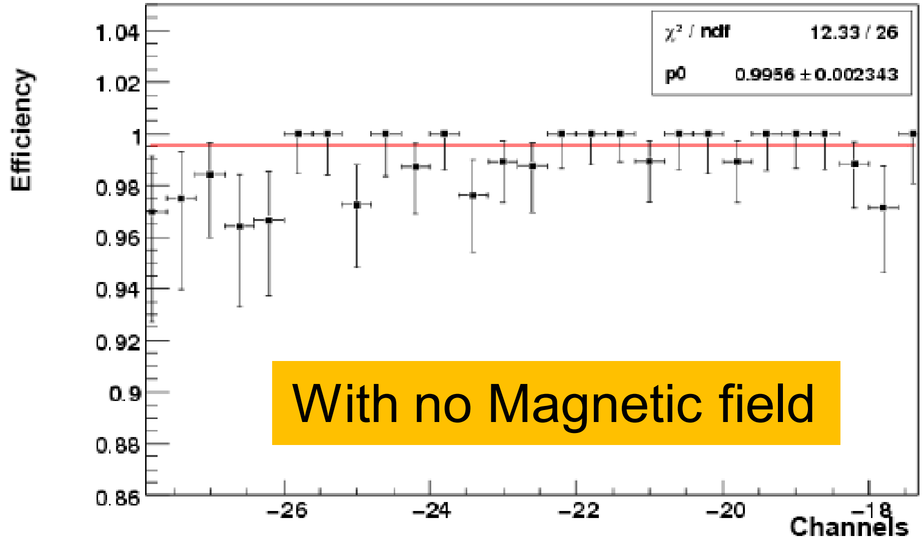
10 GeV pions beam CERN-PS T9 area

- GAS MIXTURE: Ar/CO_2 70/30
- GAIN: 2×10^4
- FEE: 16-channels GASTONE [NIMA 604 (2009)]
- Axial strips, 650 µm pitch
- External tracking: 2 DT stations operating in streamer mode with $Ar{:}iC_4H_{10}$ 60:40

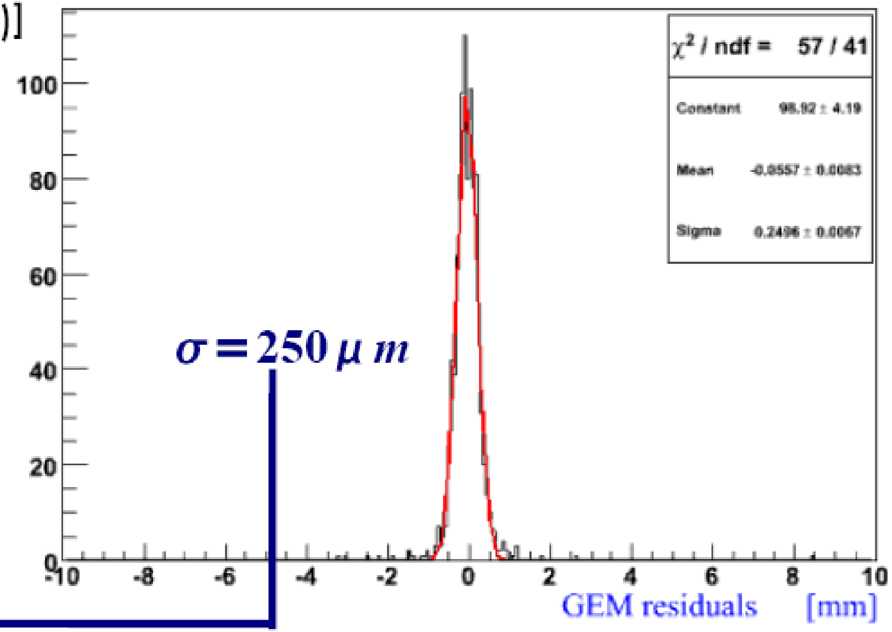
$$\sigma_{GEM} = \sqrt{(250\,\mu m)^2 - (140\,\mu m)^2} \simeq 200\,\mu m$$

$650\,\mu m/\sqrt{12}$

DT spatial resolution

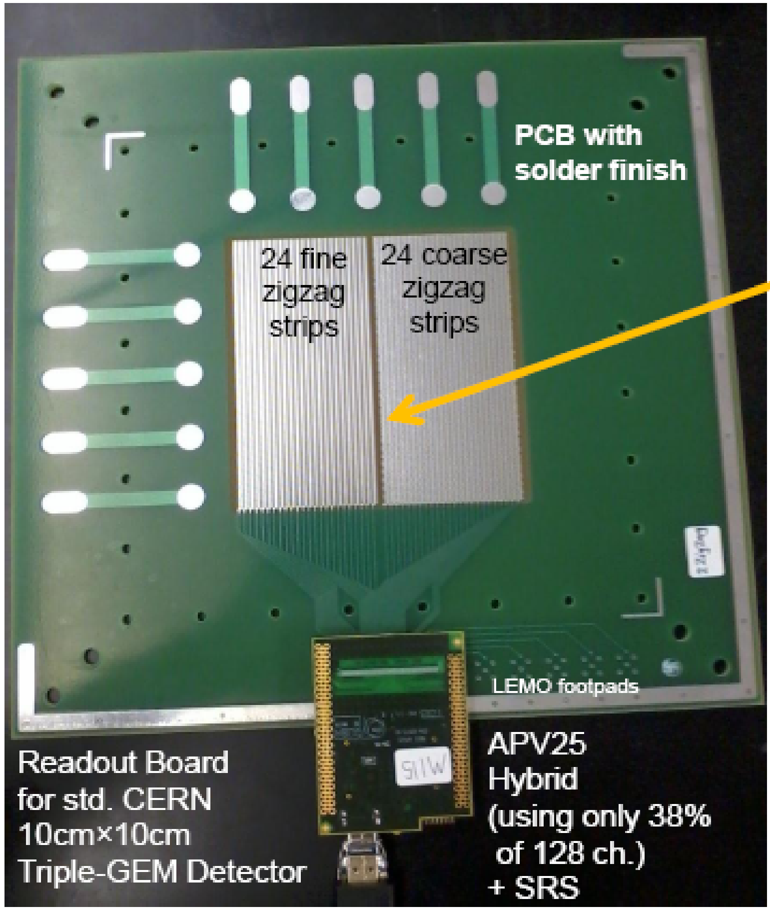


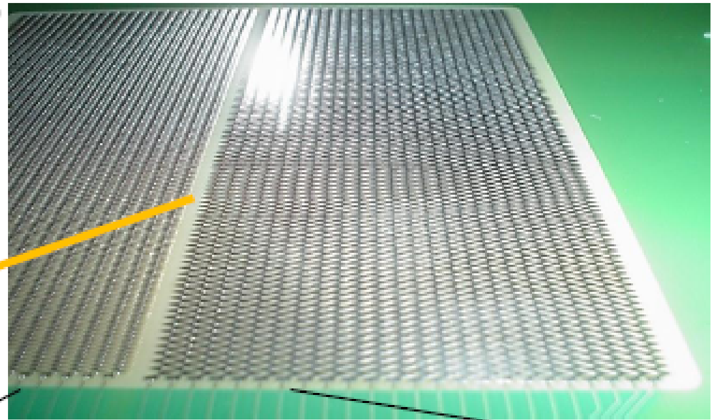
Detection efficiency ε = 99.6%

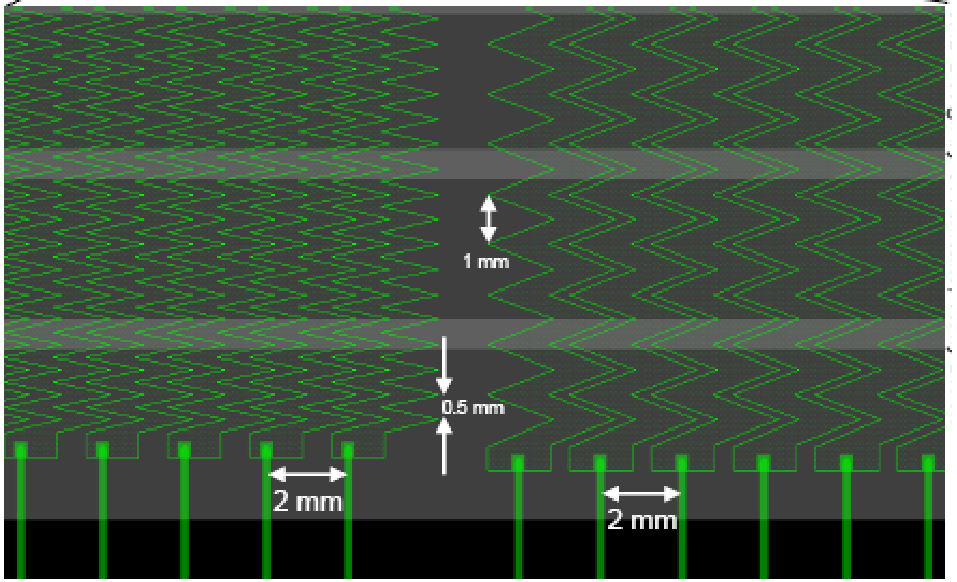


R&D on resolution: the zigzag strips

2 sets of 10cm zigzag strips with different zigzag pitch (along strip)



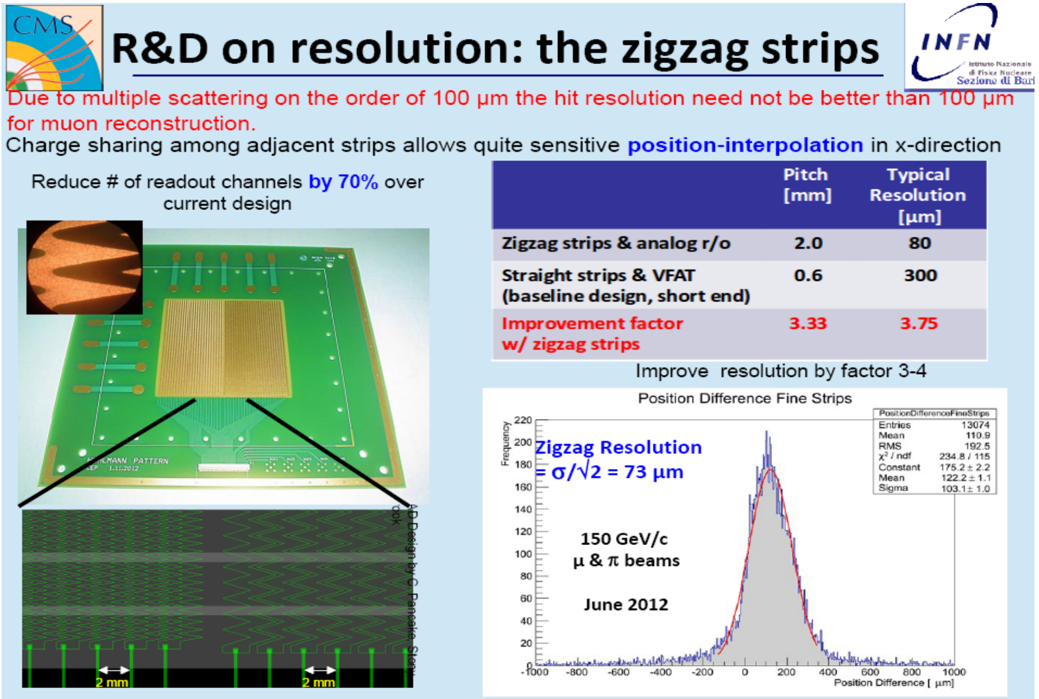




BNL/FIT/Stony Brook Collaboration

Solid ground plane on the back side.

R&D on resolution: the zigzag strips



What about multiple scattering? If of the order of 100 um the hit resolution not better than 100 um

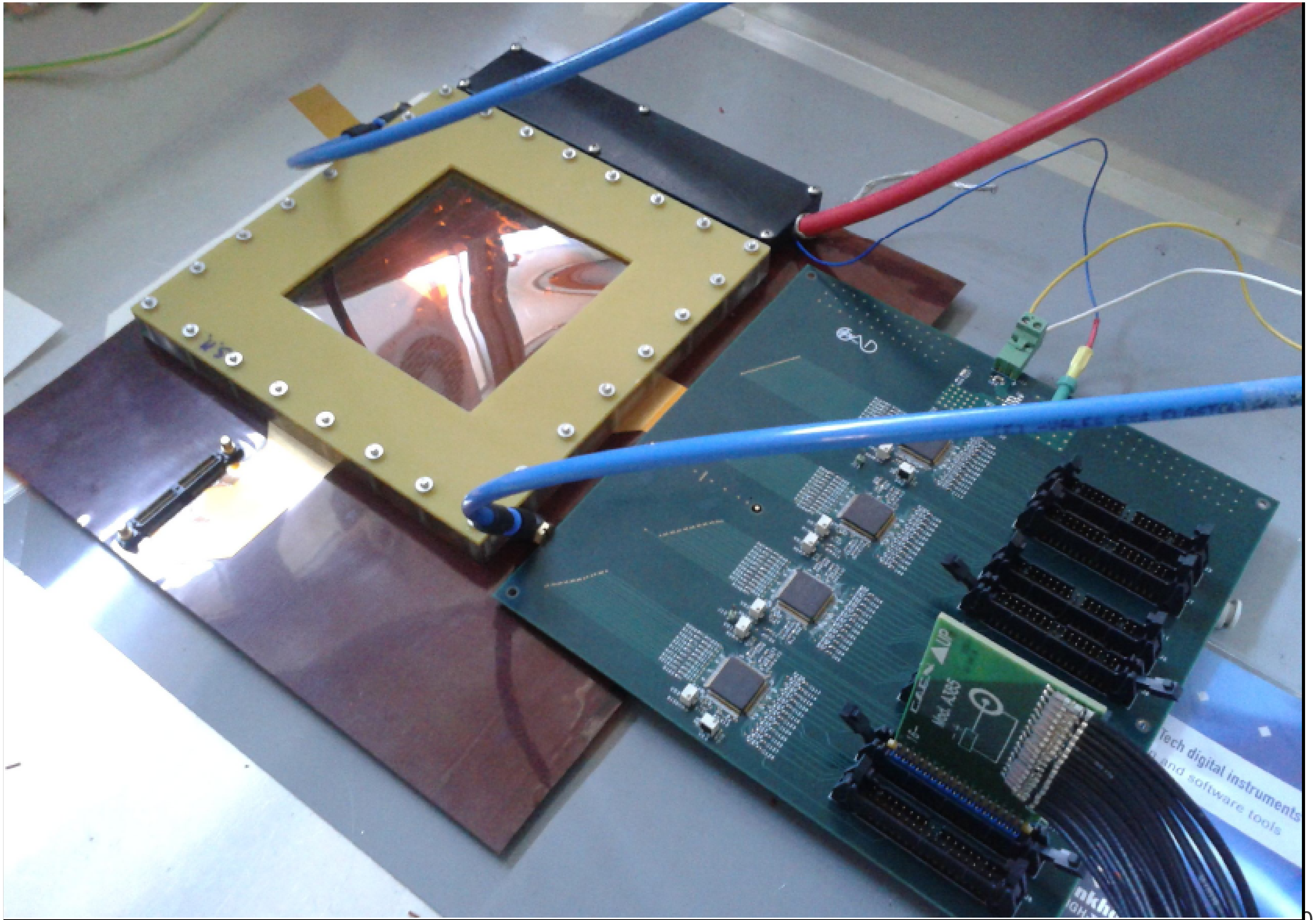
- Can reduce # of readout channels & electronics costs
- Improve resolution by factor 3-4

Idea to be investigated

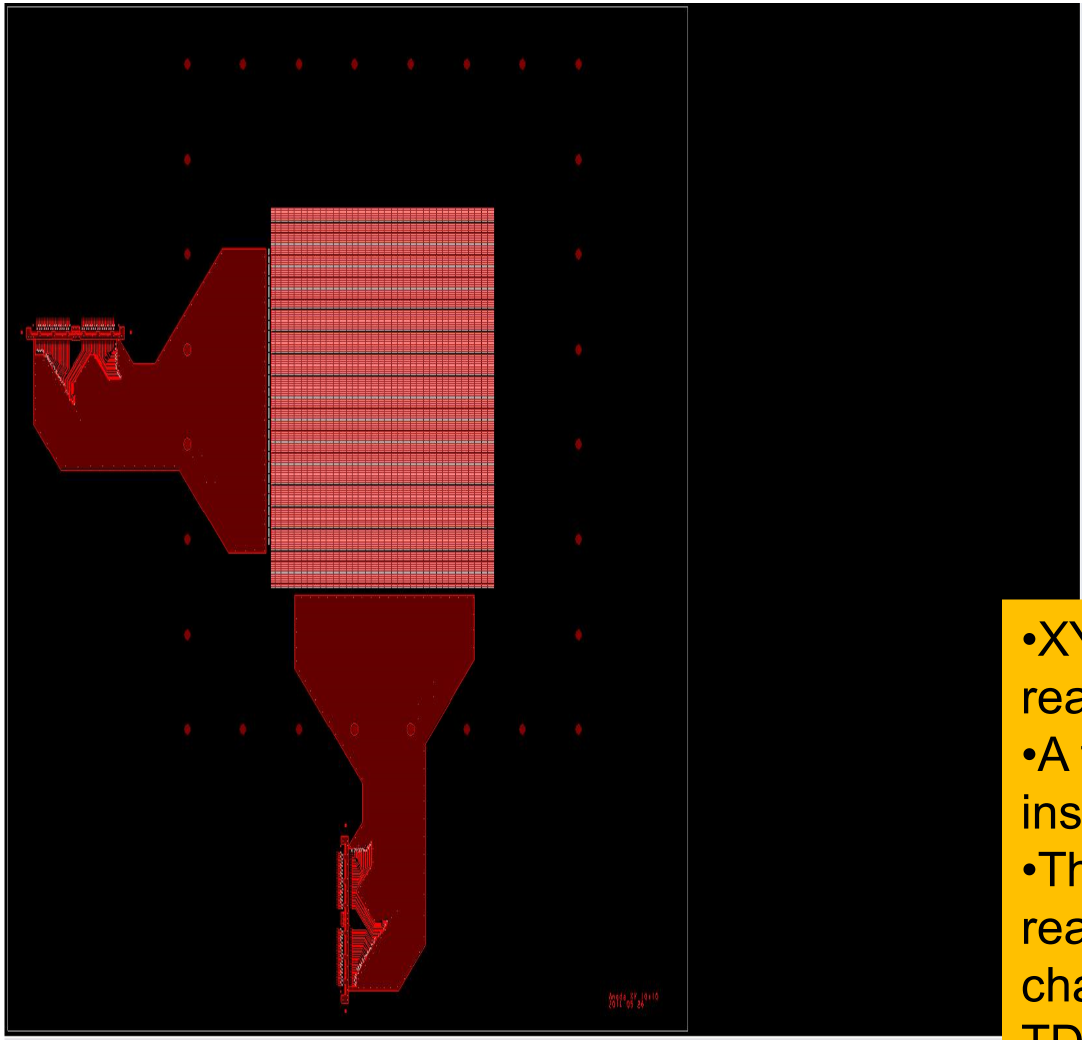
Two detector layers with *back-to-back* anode planes:

- to reduce the number of readout channels by a factor 3 and hence electronics cost while maintaining a spatial resolution of ≈ 100μm with a zigzag strip shape and an analog pulse height readout

GEM 10x10 detector with GASTONE_32



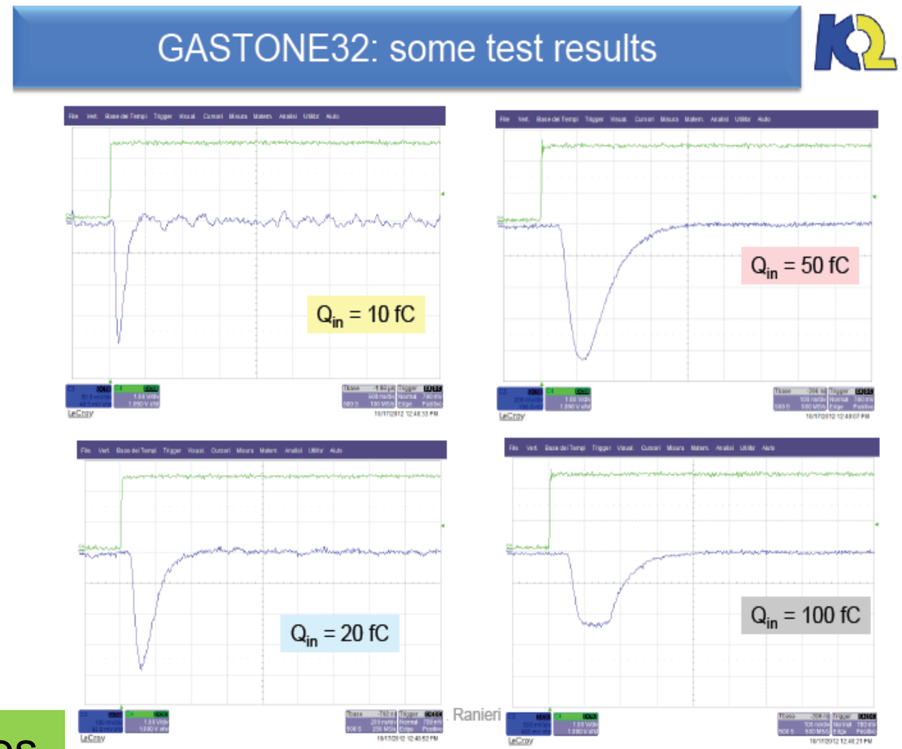
XY readout plane



- XY readout with the same KLOE readout parameters
- A total of 128 channels completely instrumented
- The analog output are indifferently read by a “peak-sensing” ADC for charge distribution study or by a TDC for timing study

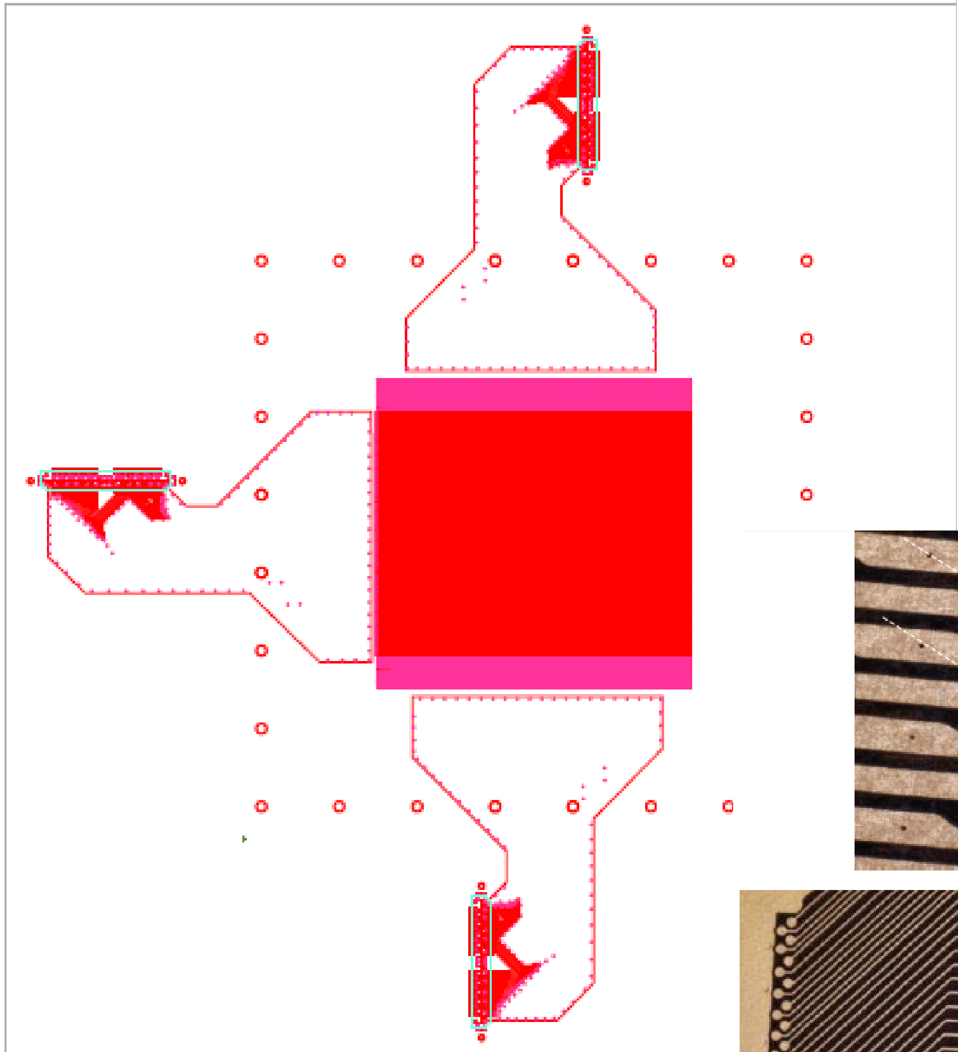
First look to signals from GASTONE_32

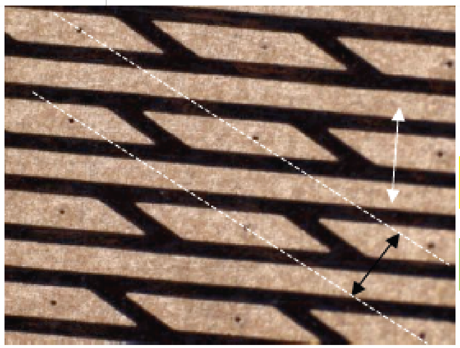
Signal from a ^{90}Sr (1.2 MBq)



Laboratory test with injected test pulses

KLOE XV readout plane structure

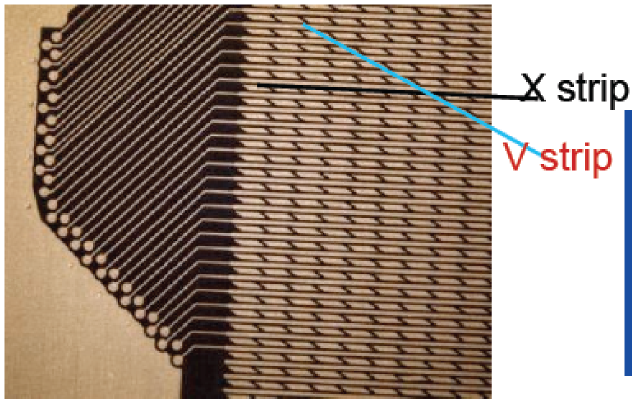




2-dimensional readout with XV strips on the same plane

X pitch 650µm → X res 190µm

V pitch 650µm → Y res 350µm



Multilayer Kapton circuit realized at CERN