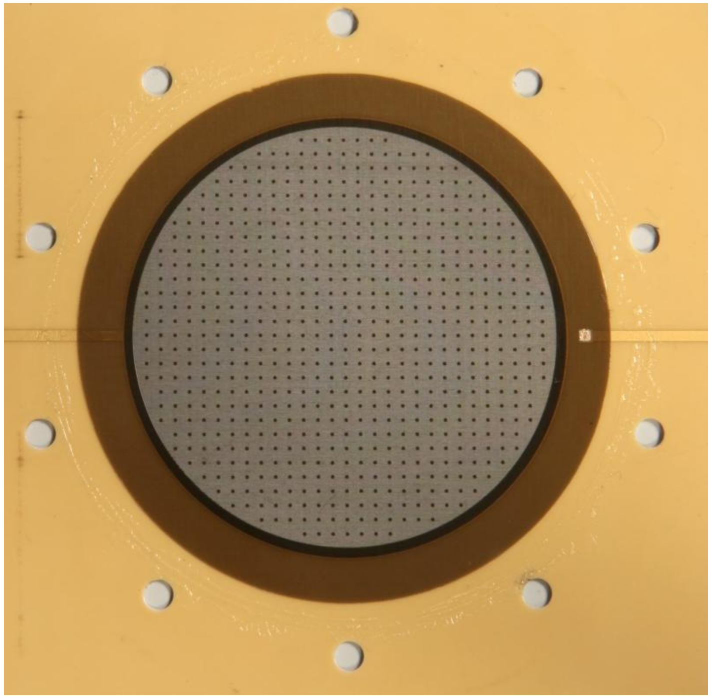
Piggyback resistive Micromegas



D. Attié, A. Chaus, D. Durand, D. Deforges, E. Ferrer Ribas, J. Galán, I.Giomataris, A. Gongadze, F.J. Iguaz, F. Jeanneau, R. De Oliveira, T. Papaevangelou, A. Peyaud, A. Teixeira

CERN and IRFU (CEA-Saclay)

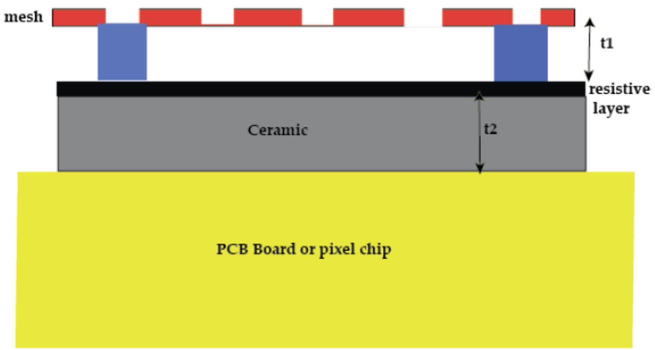
Outline

- Motivation and concept
- First experimental set-up and results
- Towards a sealed detector
- Conclusions and outlook

Motivation

Problem with gas filled proportional chambers ➔ Sparking induced by heavily ionizing particles

- Limitations on rate operation
- Reduction of the detector life time
- Risks of damage of the readout electronics



Possible solutions:

- Resistive foil on top of anode plane
- Resistive strips above readout *à la MAMMA*
- Gridpix: layer of amorphous silicon deposited on the chip

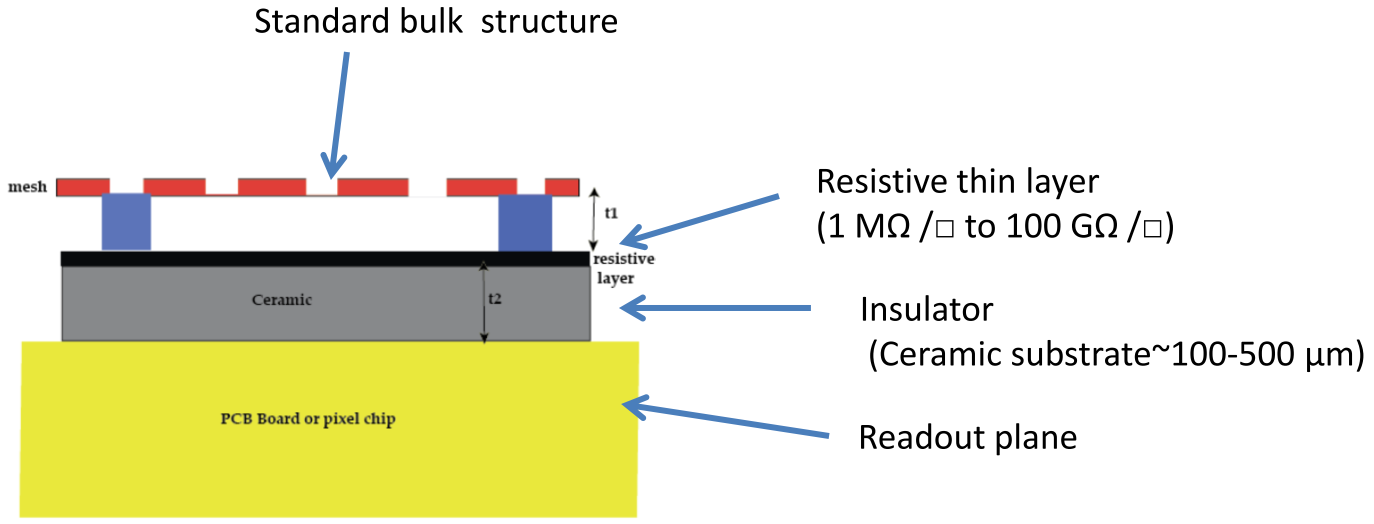
Piggyback resistive Micromegas *Attié et al. , JINST 8 P05019*

inspired by similar work with PPAC by *M. Kocsisa et al., NIMA 563 (2006) 172–176*

new approach where a thin resistive layer is desposited on an adequate insulator

Concept

- Separation of the amplification structure and the readout plane



- Signal is transmitted by capacitive coupling to the readout plane
- Optimisation of the induced signal : $t_{insulator} << t_{gas}\ \varepsilon_{insulator}/\varepsilon_{gas}$
- $\varepsilon_{insulator}$ should be as high as possible (first prototype alumina with ε~10)

Why « Piggyback »?

McGraw-Hill Science & Technology Dictionary:
piggyback board

A small printed circuit board that plugs into another circuit board in order to enhance its capabilities

Piggyback (transportation), something that is riding on the back of something else

piggy-back ['pɪgɪbæk] *nombre* **to give sb a piggy-back ride,** llevar a alguien a caballito/a cuestas

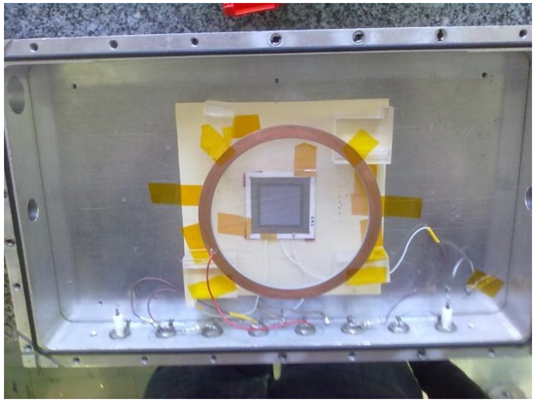
piggyback *adv informal* (riding on sb's back)sur le dos (de qqn) *loc a*

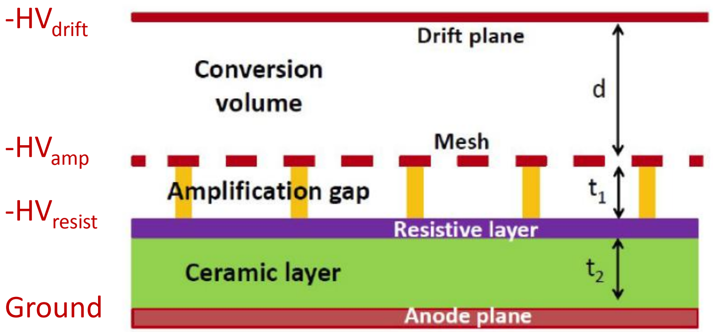
piggyback *n* (ride on sb's back) *στους ώμους*καβάλα *ουσ.ϑηλ.*

piggyback *n* (ride on sb's back)l'andare a cavalcioni di qn, l'andare in spalla a qn

to give sb a piggyback _ jn huckepack nehn

First set-up

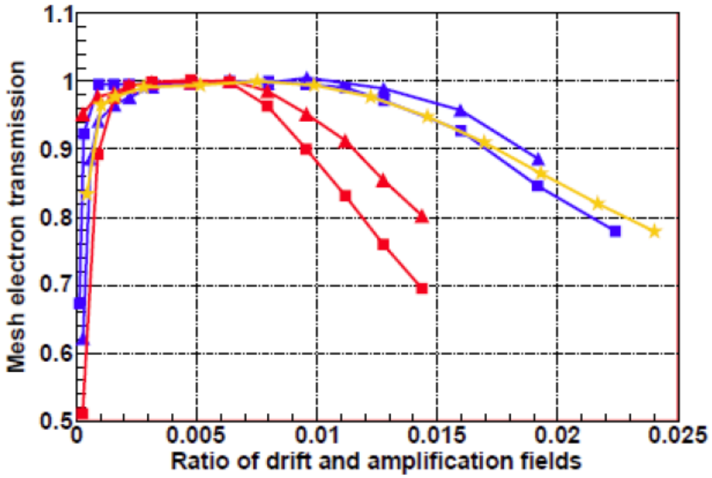


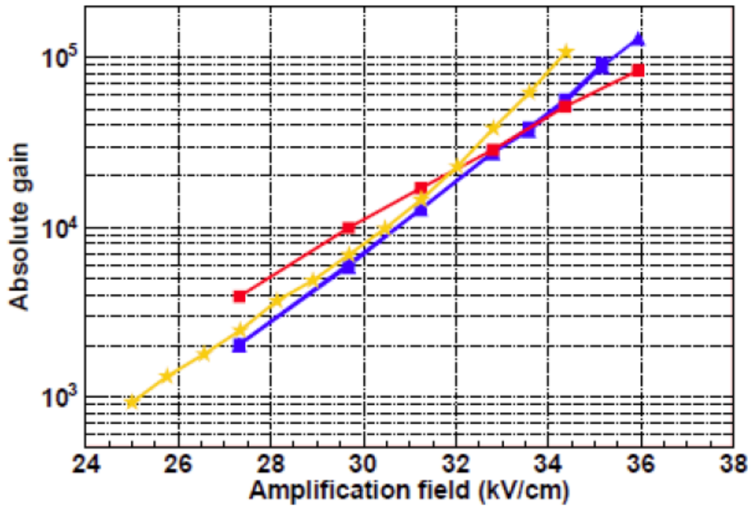


3 detectors with active area: 3×3 cm^2

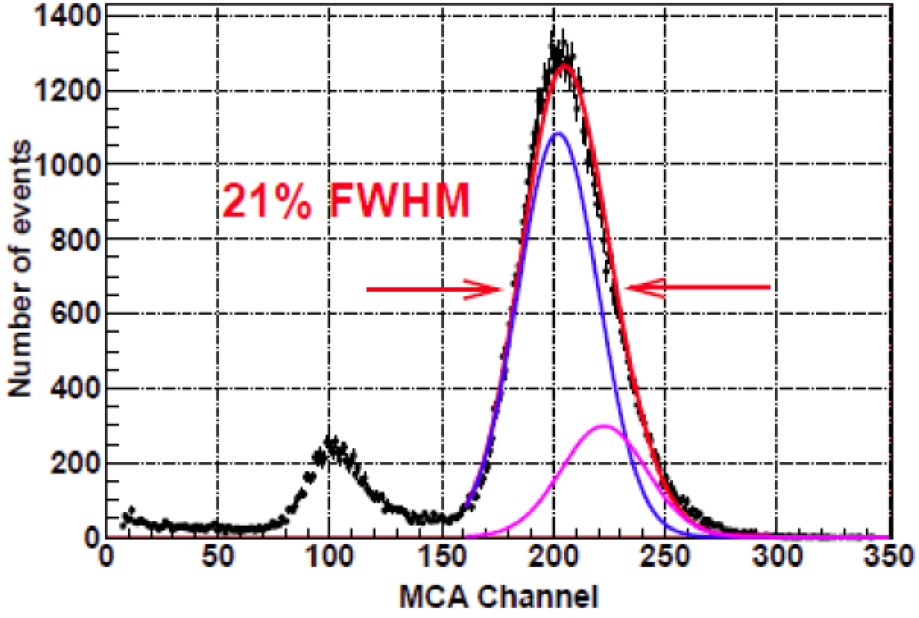
1 cm drift, 128 µm amplification gap, 20 µm of RuO_2 with 100 MΩ/□, ceramic layer 300 µm

Argon + 5%Iso and Ne + 5% Ethane and a standard buk in Argon + 5%Iso

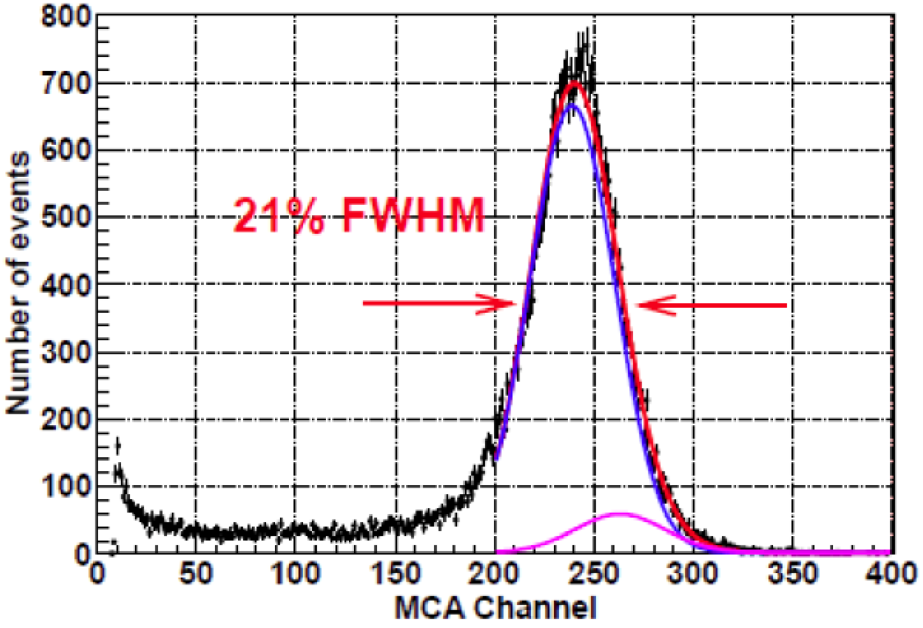




First experimental results



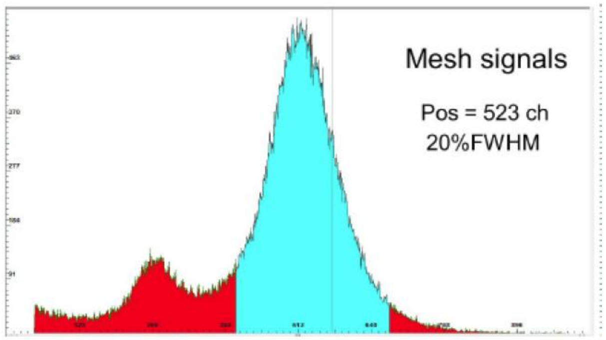
Ar+ 5% Iso

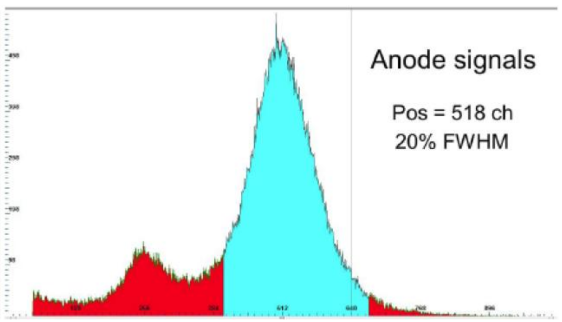


Ne+ 5% Ethane

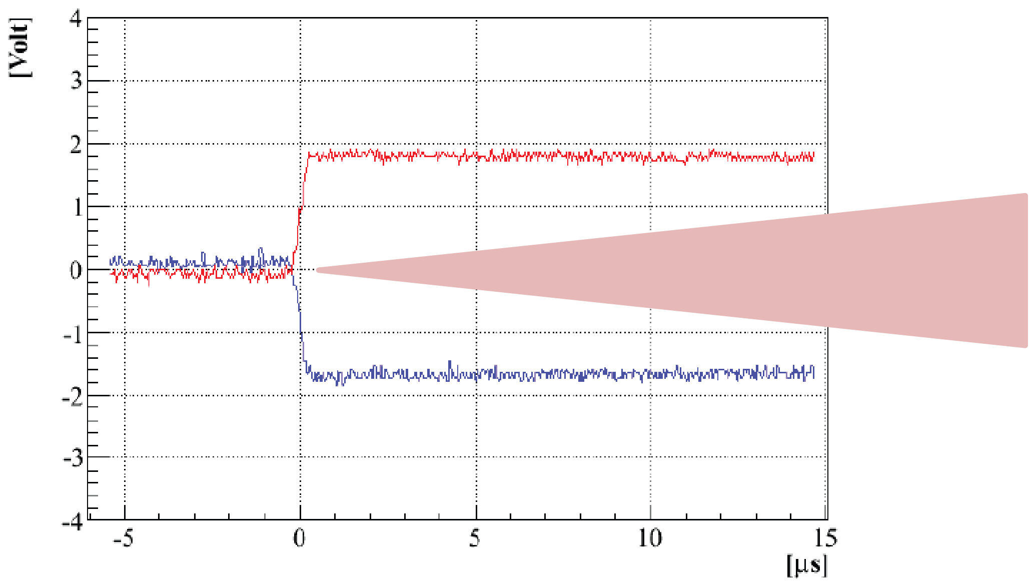
First experimental results

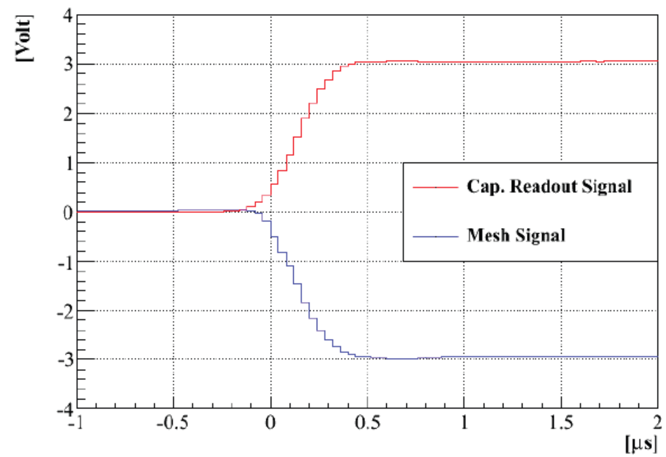
Checking possibles looses by the ceramic layer: signal entirely transmitted





Test with a ^{252}Cf (fission fragments signals) reading simultaneously mesh and anode





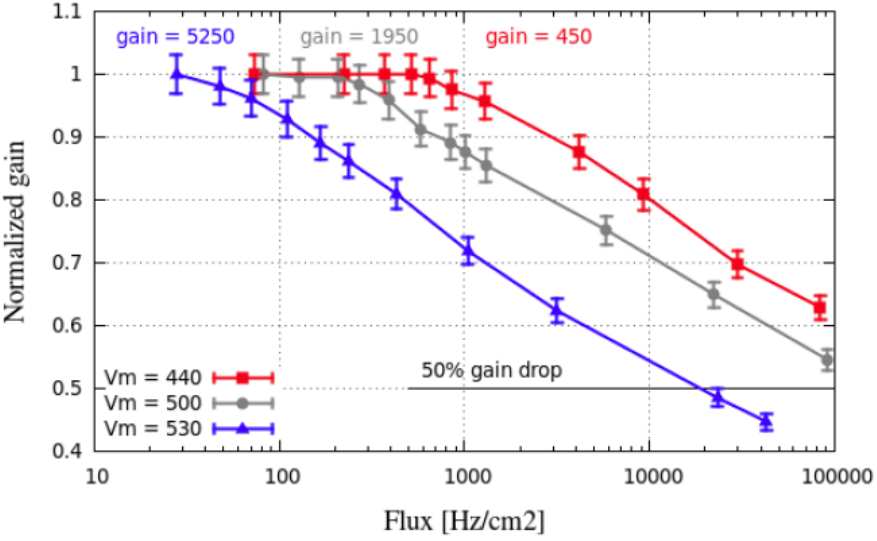
Amplitude within 5%

Same rise time for both polarities

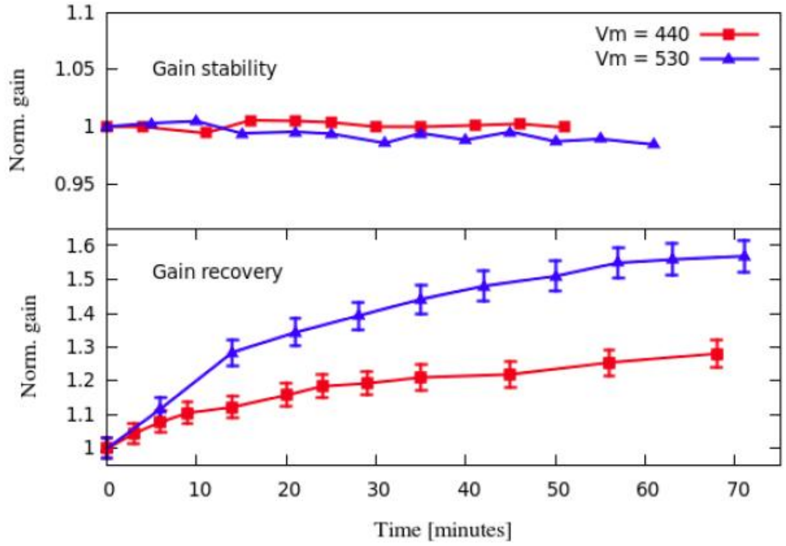
Rate capability

X ray generator tests

Drift 0.5 cm



Gain Stability better than 2%



With higher rates=> the gain drops as a function of flux

Gain dependence with rate depends on the resistivity and the capacitance chosen.

Simulation of charge diffusion over the resistive top plate

Charge diffusion relation for a given charge Q following a Gaussian distribution with width w:

$$\rho(r,t) = \frac{Q}{2\pi(2ht+w^2)}\exp\left[-\frac{r^2}{2(2ht+w^2)}\right] \qquad h = 1/RC$$

M. Dixit NIM A 581 (2007) 254

Extrapolation to the case of a continuos current flow:

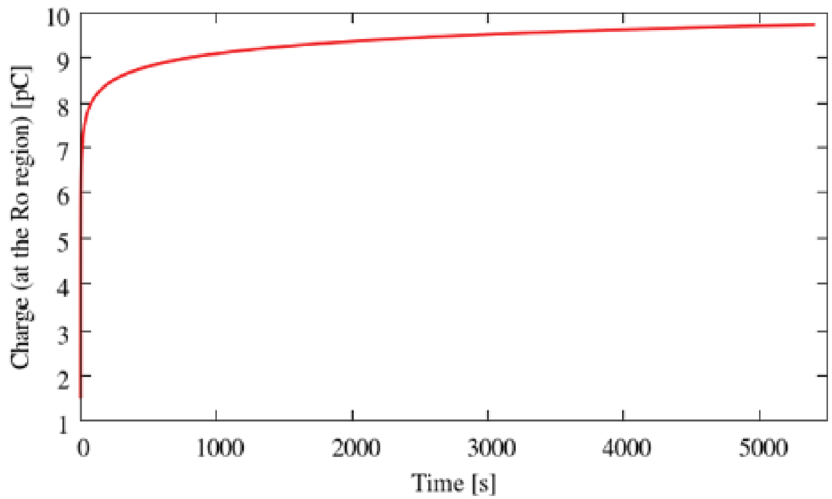
$$Q(R_o,t_o) = \int_0^{t_o} \frac{d\rho(R_o,t)}{dt}dt = \int_0^{t_o}\left[1-\exp\left(-\frac{R_o^2}{2(2h(t_o-t)+w^2)}\right)\right]\left(\frac{dq(V_a)}{dt}\right)dt$$

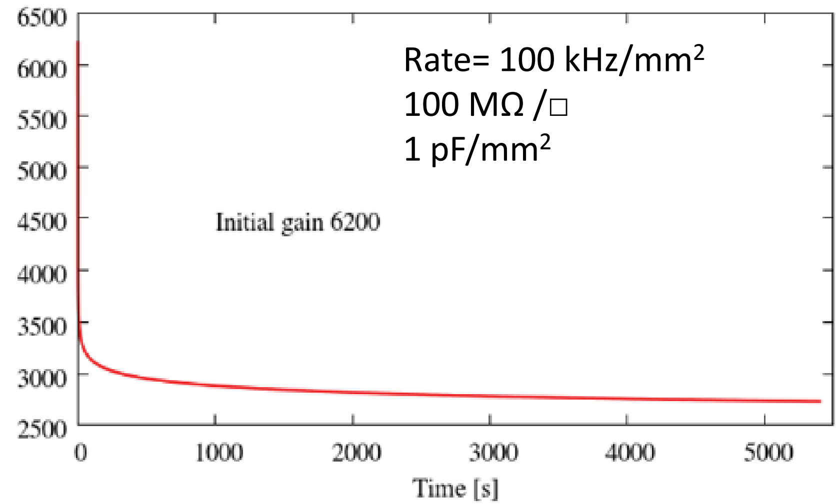
V_a anode potential
R_0 radius of the region

Integral will be calculated by adding charge contributions at each time interval n and describing the gain:

$$\delta q_n = g(V_a(n\delta t))N_e q_e r \qquad V_a(n\delta t) = q_n/\pi R_o^2 C$$

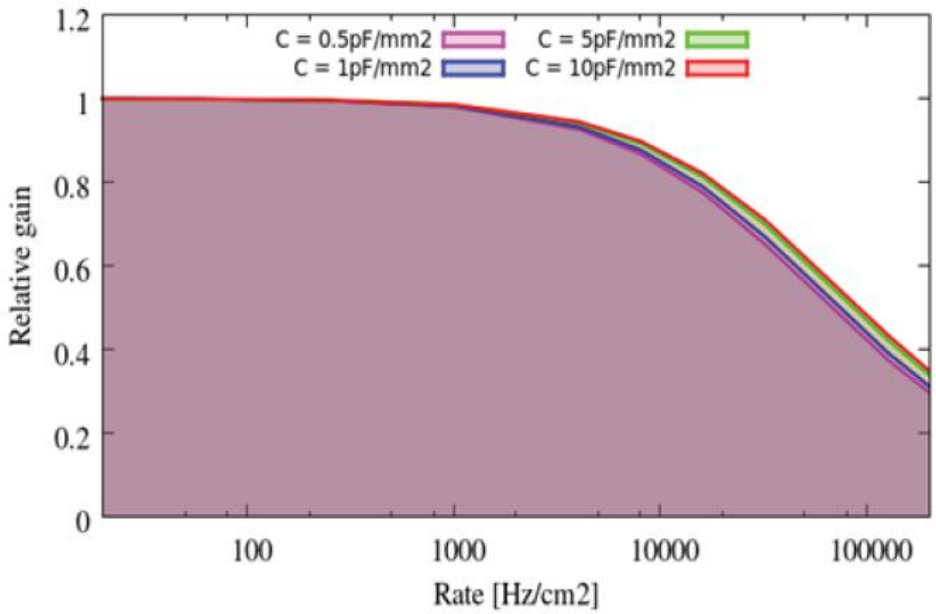
N_e number of electrons
r interaction rate

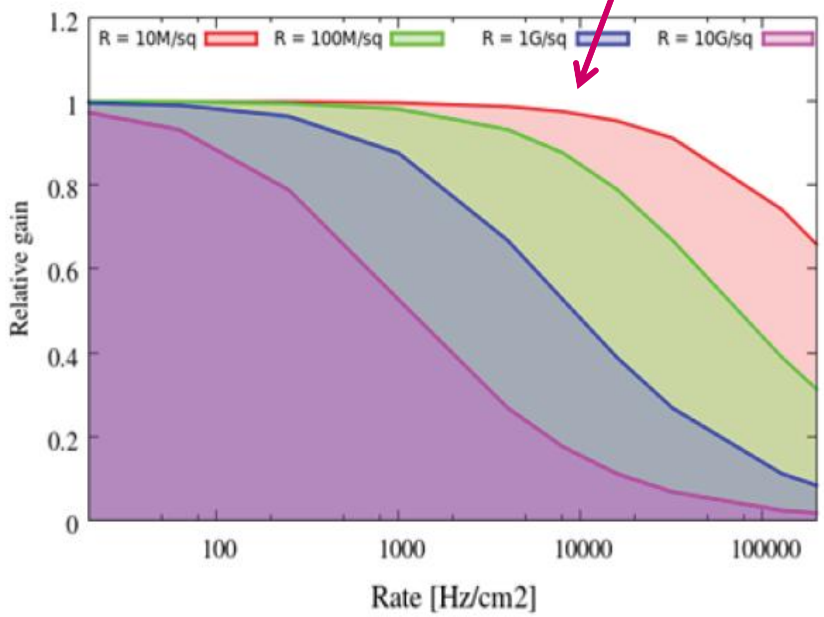




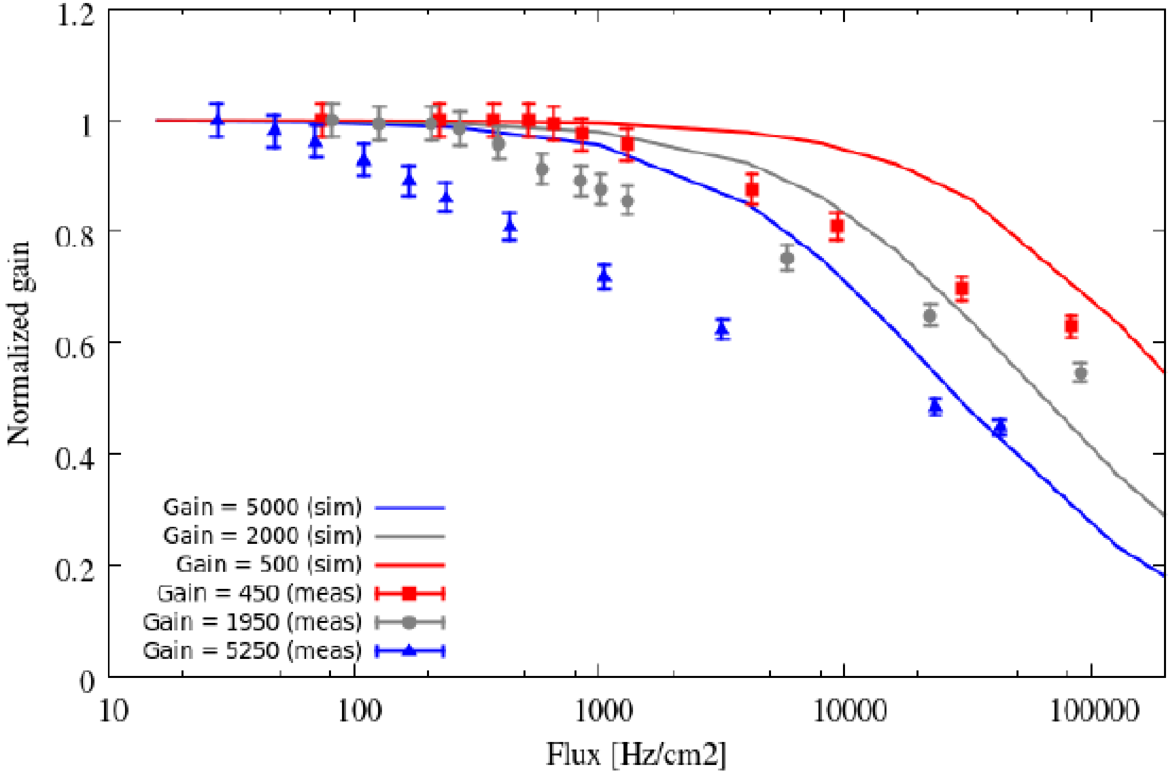
Simulation of charge diffusion over a resistive plate

Lower values of the resistivity extend the plateau behaviour





Simulation of charge diffusion over a resistive plate



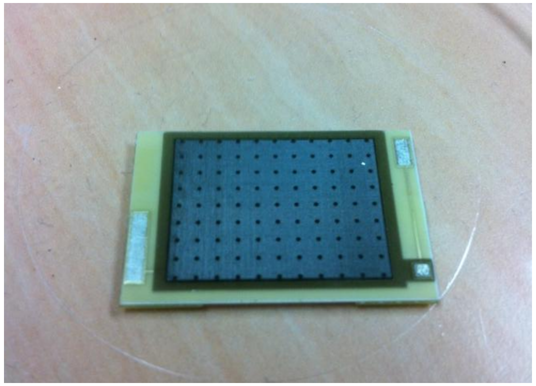
Agreement in the general tendency

Differences could be due to grounding configurations, resistivity values and homogeneity

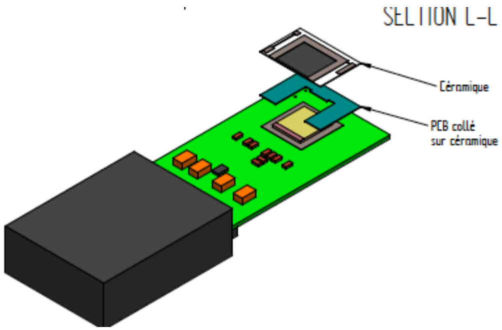
CMOS chip readout

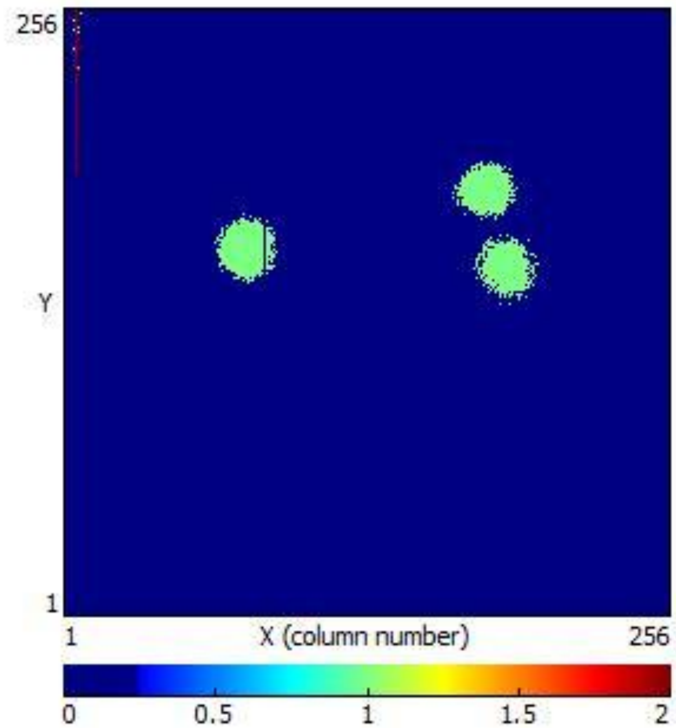
Medipix2/Timepix
CMOS chip
256×256 square pixels of 55 µm side each

To be used with MPGD the MPGD needs to be covered by a layer of high resistivity material (amorphous silicon or silicon-rich nitride)



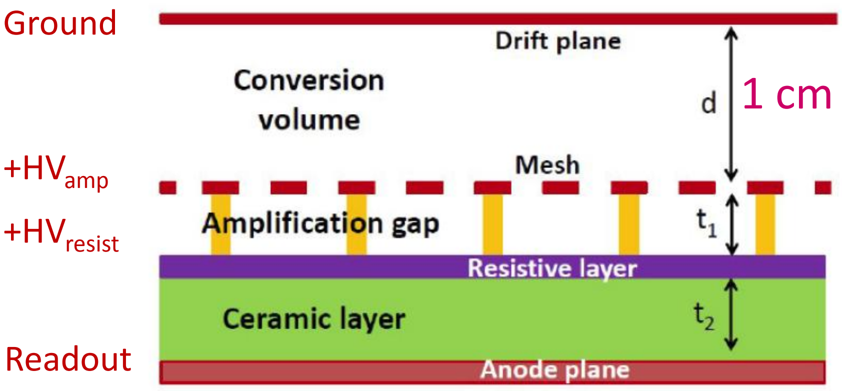
Set-up with Piggyback
30×20 mm^2 bulk
Amplification gap 128 µm
Drift gap 10 mm



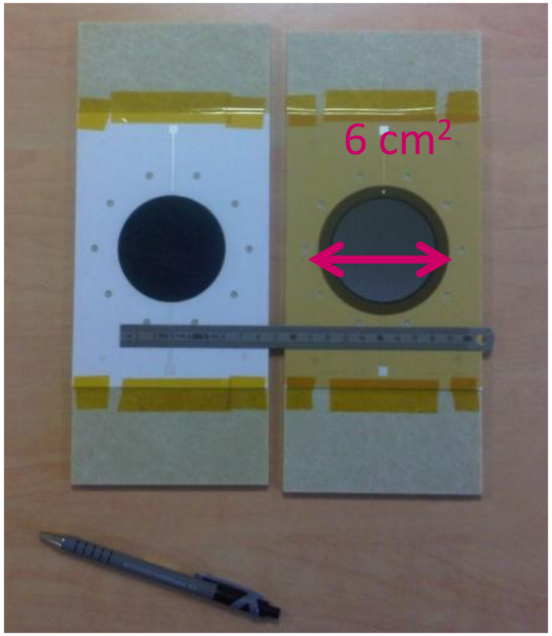


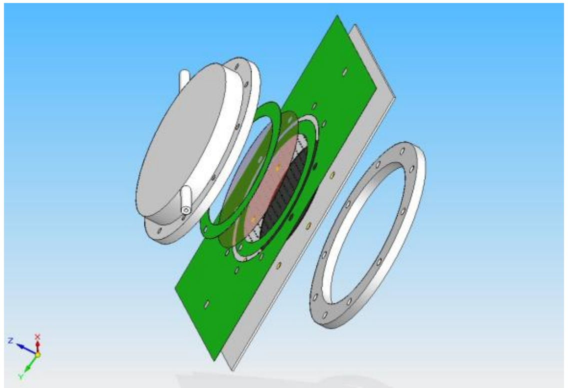
Signal observed on Medipix chip with Ar + 5% Iso
No damage of the chip during operation at high gain 10^5

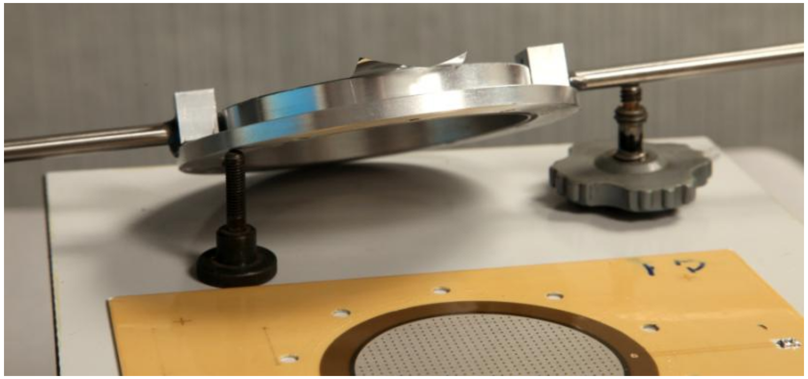
Second set-up



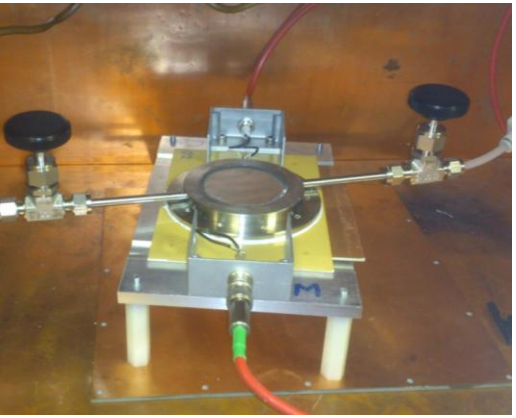
Due to the detector material (ruthenium oxide and ceramic) excellent outgassing properties→ suited for detector operation in sealed mode

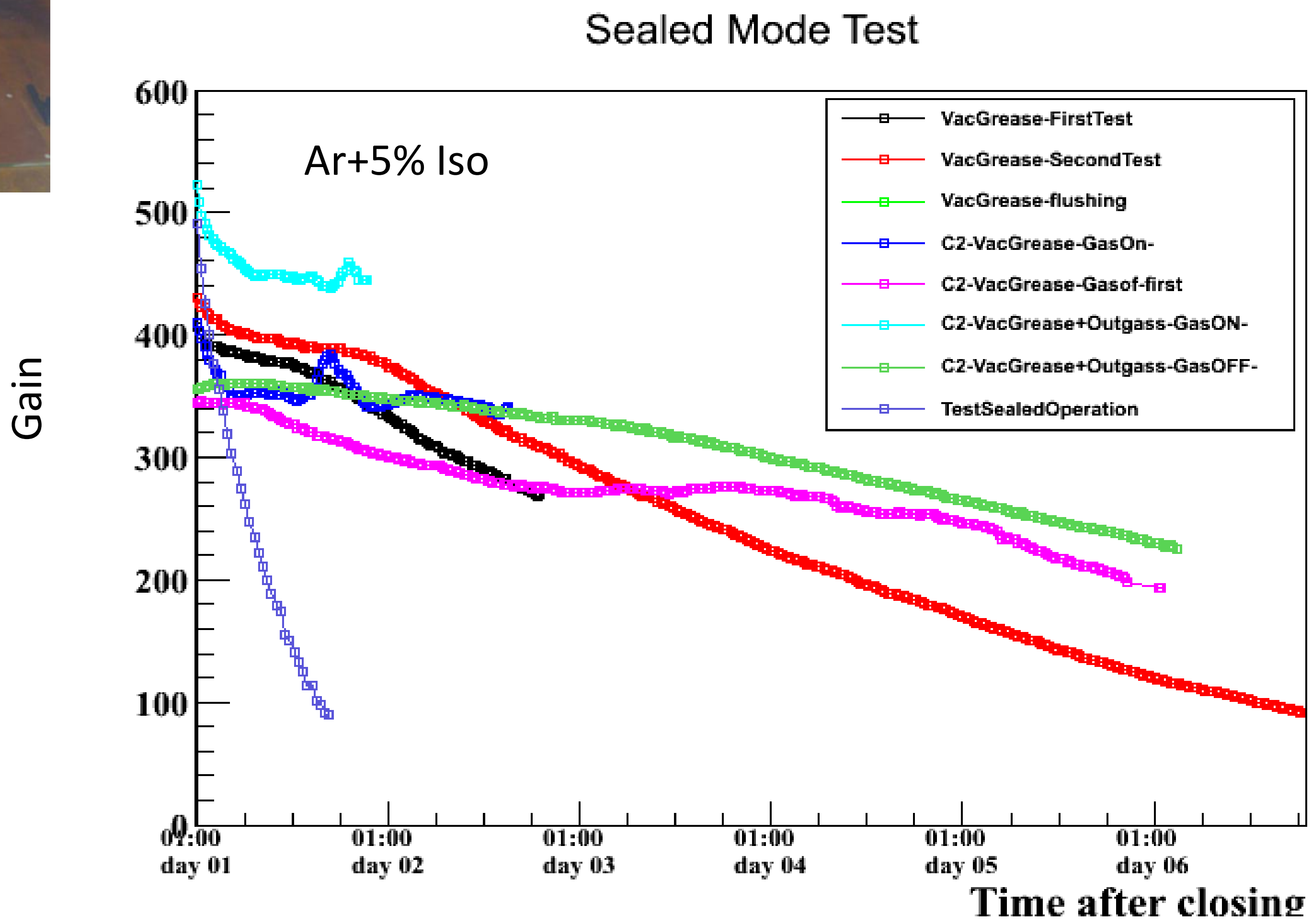




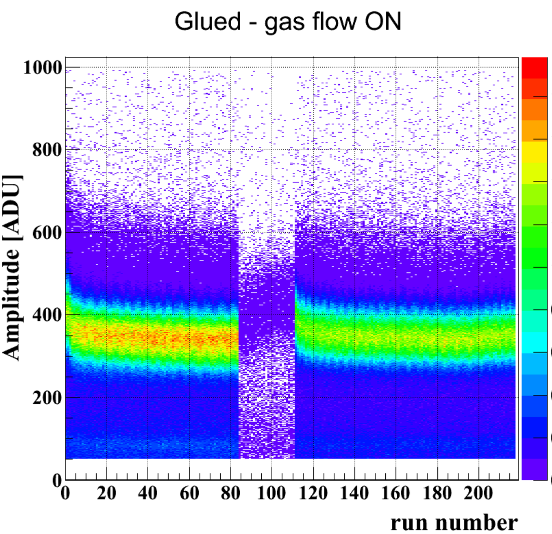


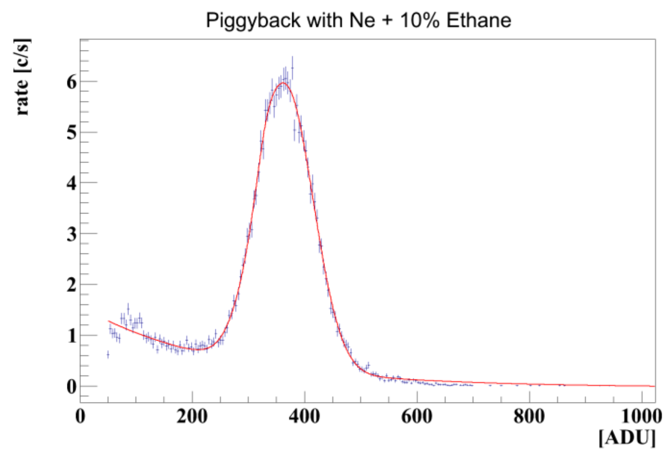
Second set-up: towards a sealed detector

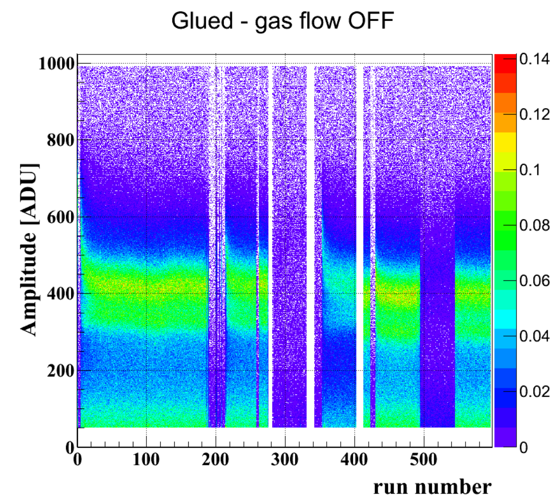


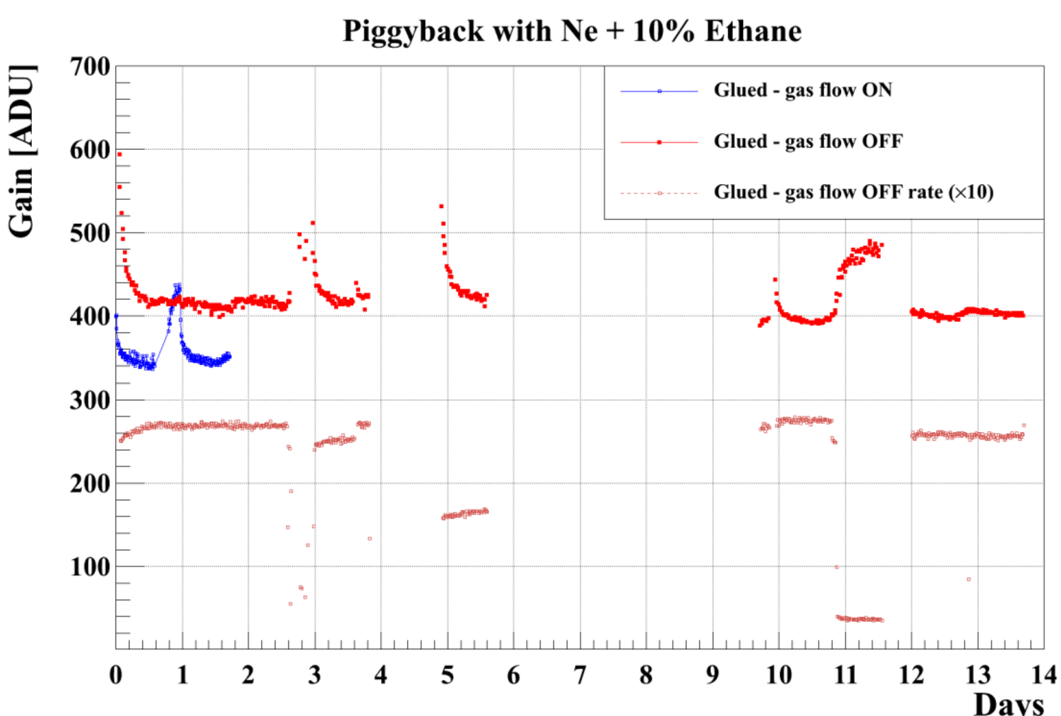


Second set-up: towards a sealed detector





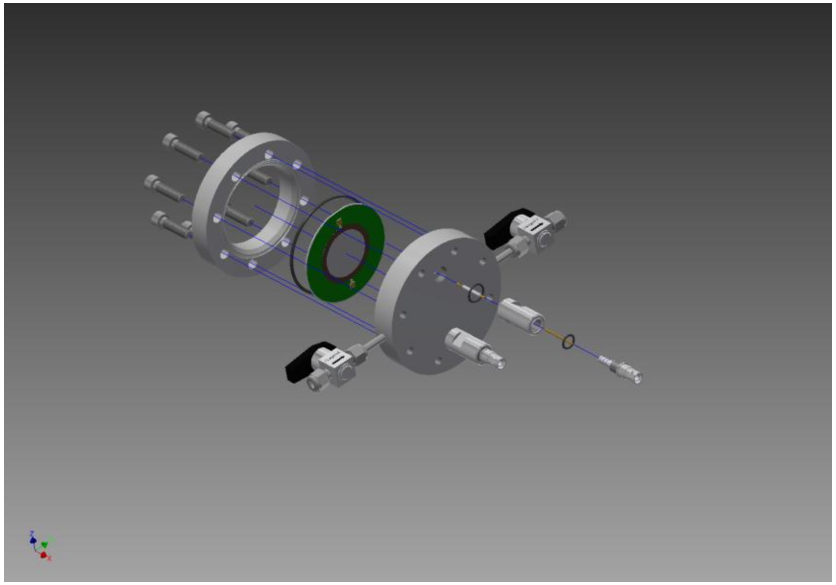




Detector chamber glued
One night oven at 60°C + pumping

Fflushed with gas for only 4 hours
Stability over 14 days

Improved set-up



- New chamber with fitted ceramic inside
- Chamber in Stainless steel
- Ceramic is sandwiched between two gaskets
- More robust mechanics and more versatile

Future tests:

❑Cycles of heating and gas flow to reduce outgazing

❑Stability tests in sealed operation

❑Test with different electronics

Conclusions and outlook

- Floating mesh, Bulk Micromegas, Microbulk, Ingrid and now Piggyback
- Piggyback resistive Micromegas provides spark protection
- Detector dissociated from readout plane
- Can optimise dead space
- High rate vs resistivity has been studied
- Test higher values of resistivity, different thickness of ceramic
- Seal detector is under development