Snowmass ILC meeting

InGrid, an integrated Micromegas made in Silicon wafer post-processing technology

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- Motivation
- Process
- First results
- Future

Reminder : Micromegas + pixels

MICROMEsh GASeous detector :

Amplification region : 50-100 micron gap

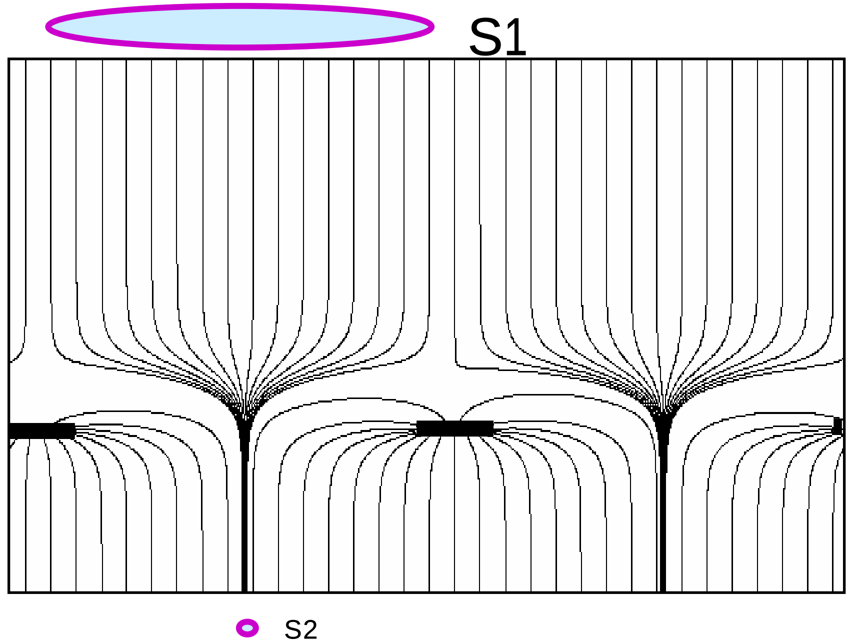
Amplification field >> drift field => efficient collection

Gap small => fast signals

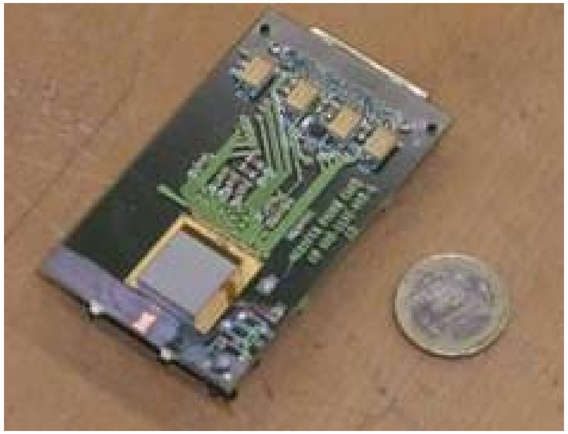
Optimally, anode pad size can be = hole pitch

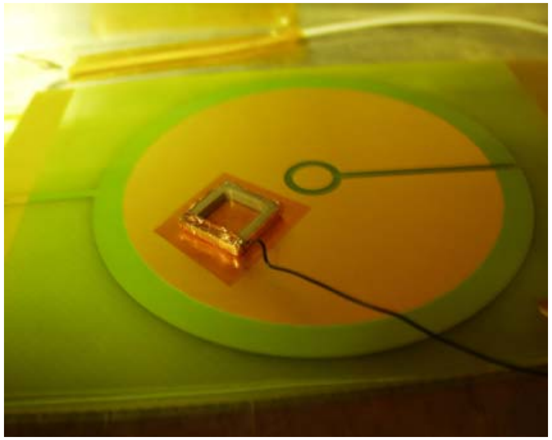
->**VLSI (CMOS) electronics** (Medipix2)

65000 pixels on 2cm^2



NIKHEF-Saclay CERN Twente Collaboration since early 2004

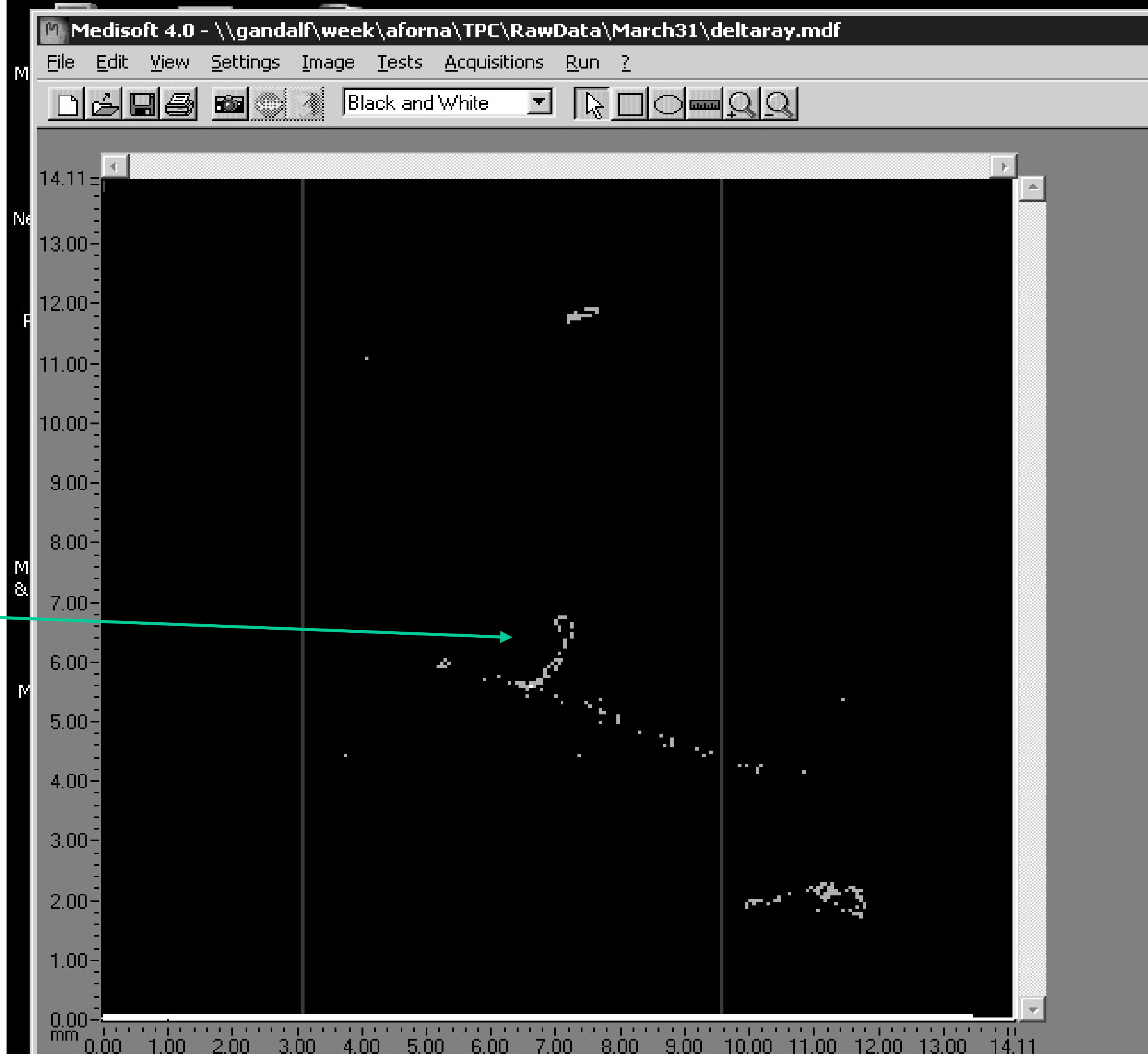




He/Isobutane 80/20
Modified MediPix (80% of the pixel is conductive, instead of 20%)

Cluster by cluster MIP detection

δ-ray?

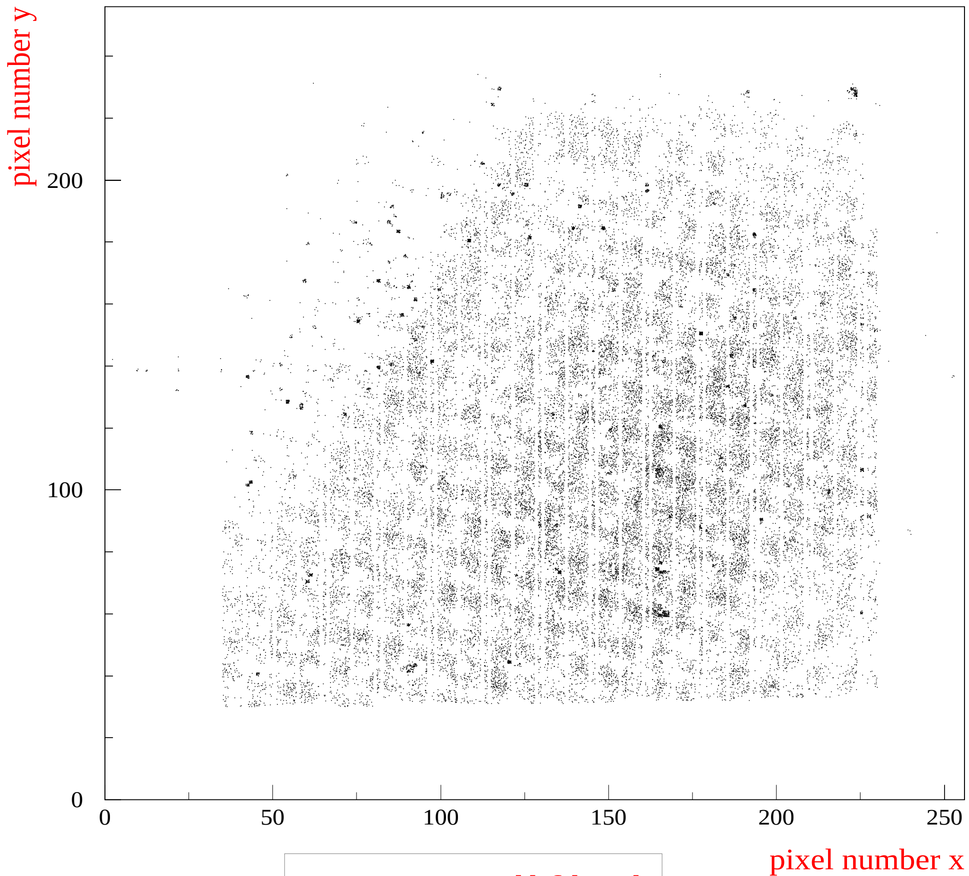


Very successful, but…

But…

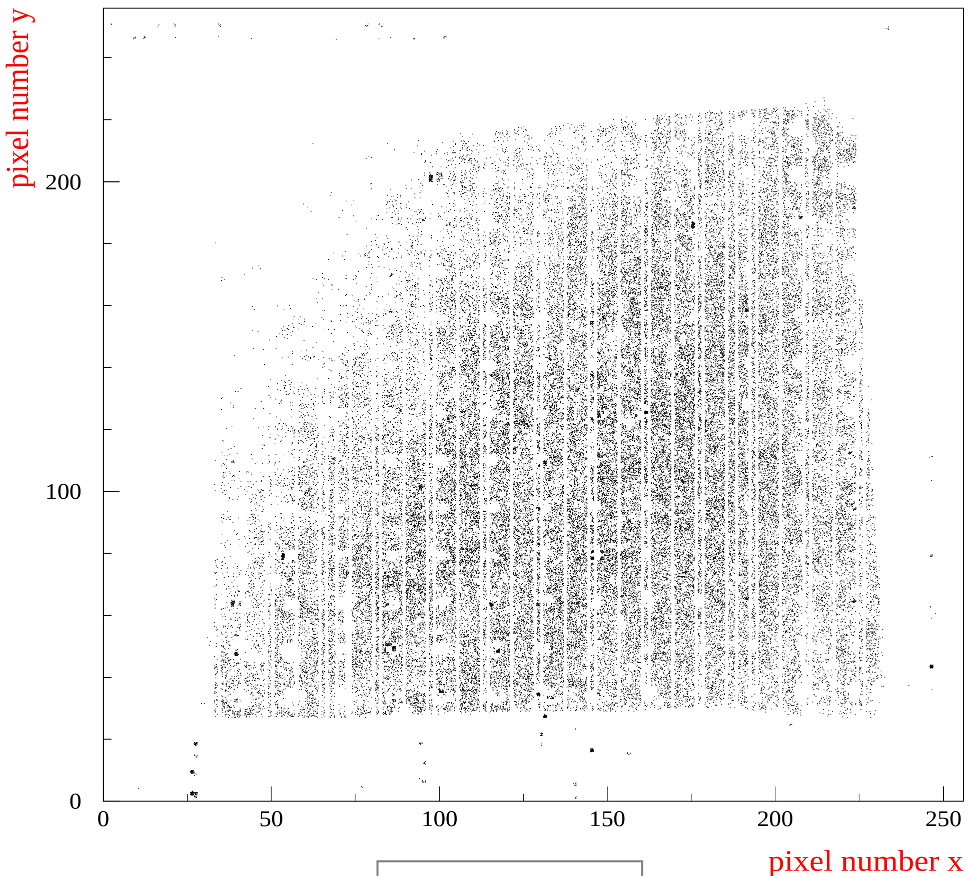
- Moiré effect: pitch Micromegas holes: 60 µm pitch MediPix pixels: 55 µm
  Periodic position of hole w.r.t. pixel: repeats after 12 pixels
- The frame has a finite thickness
- Difficult to reach a perfect adhesion of the frame to the surface

Timepix cosmics



Non Modified

Timepix cosmics



Modified

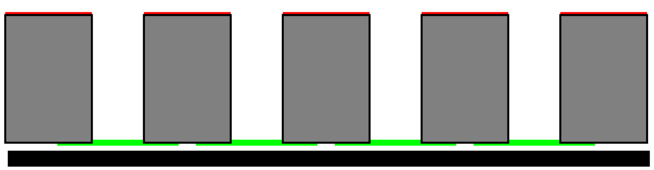
InGrid

Integrate GEM/Micromegas and pixel sensor by 'wafer post-processing' :

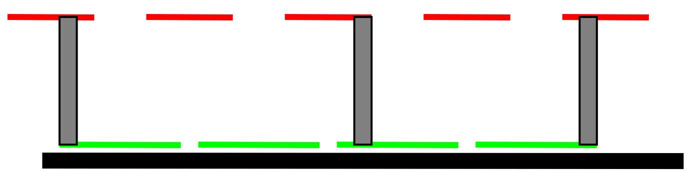
- thinness and robustness of the grid
- accuracy of the gap (provides excellent resolution and uniformity)
- no frame (no loss of active surface)
- possibility to fragment the mesh (provides noise reduction and additional localisation usable for zero-suppression)

First step : try the process on bare Si wafers (without CMOS circuit)

'GEM'

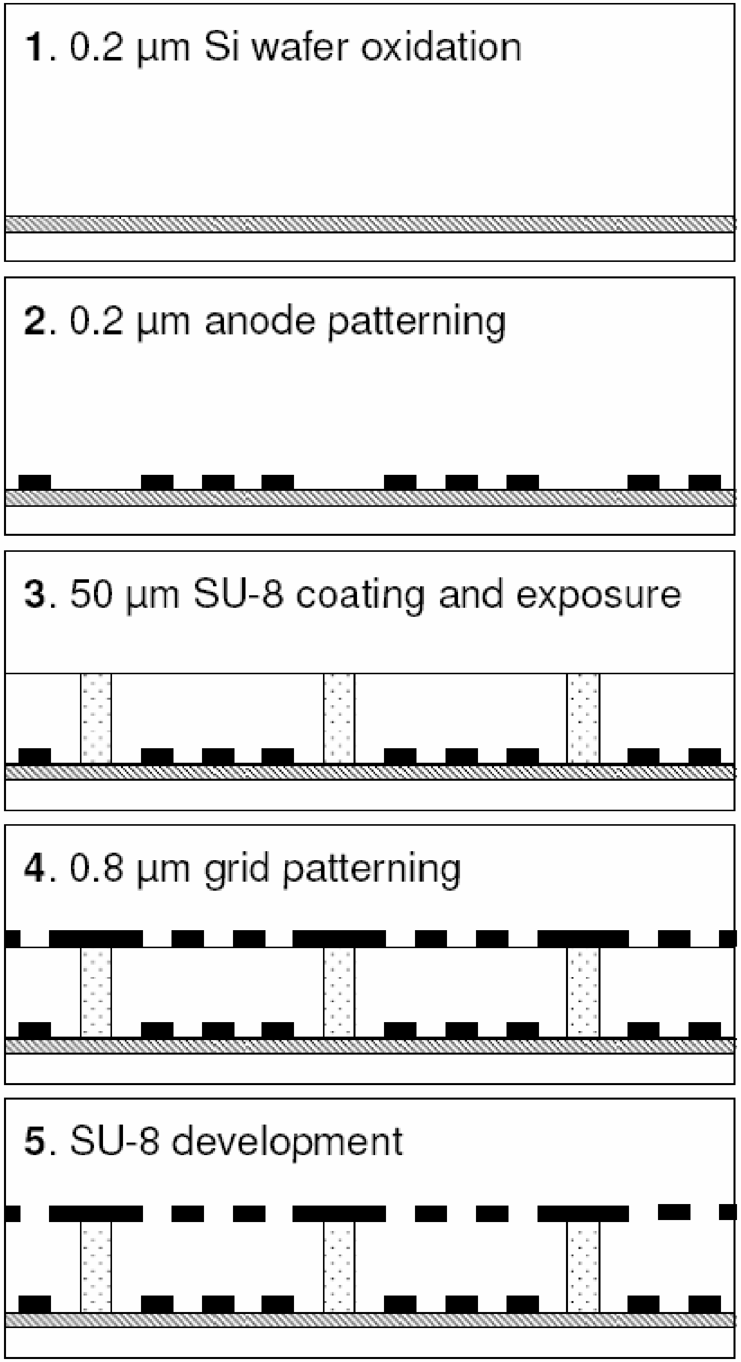


'Micromegas'



InGrid process

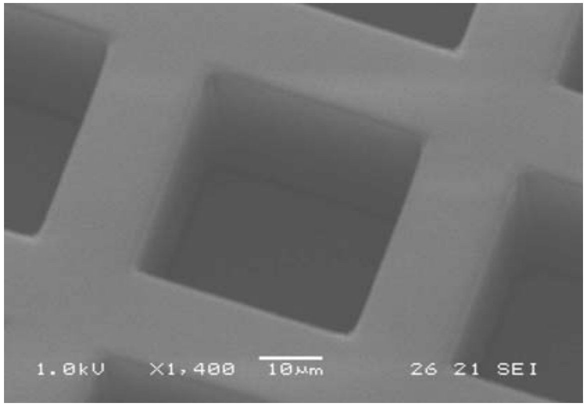
1) Oxide the Si wafer, insulating SiO_2 layer on top
2) Deposition of 0.2 μm of Al for anode, and patterning
3) Deposition of 50 μm photo-resist and UV exposure
4) Deposition and patterning of the grid: 0.8 μm of pure Al
5) Removal of the exposed photoresist

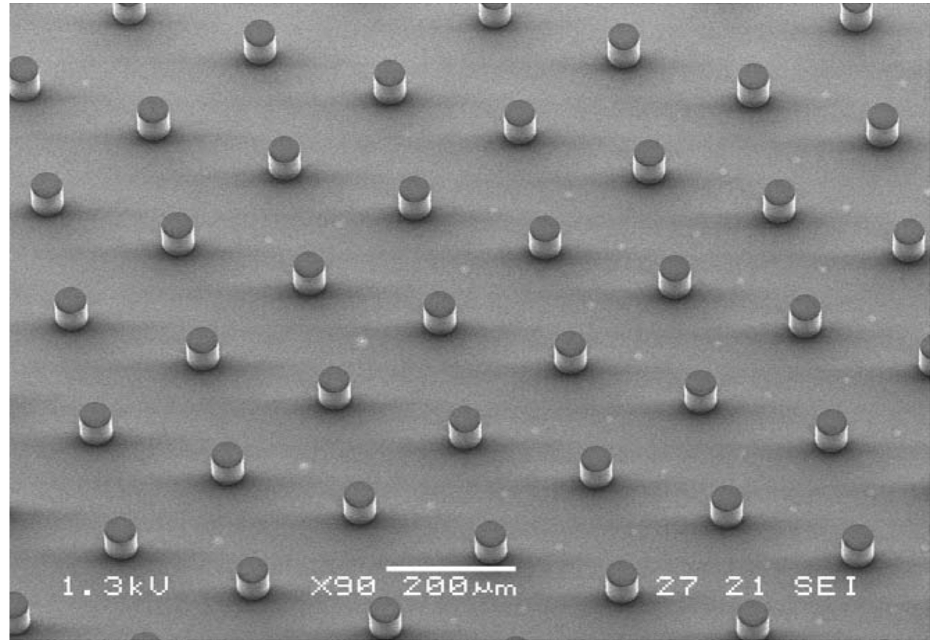


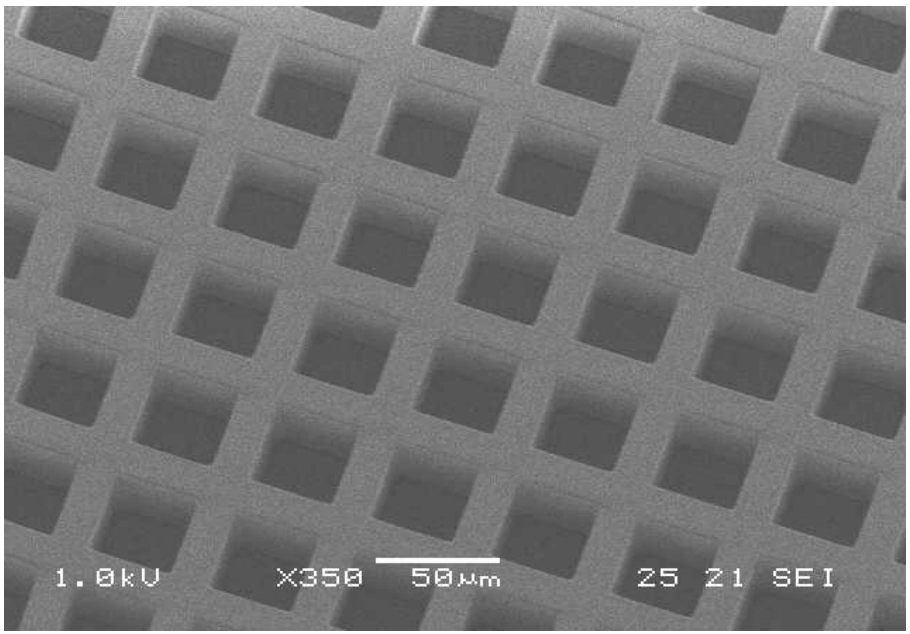
RESULT : a thin mesh (0.8 μm compared to 3-5 μm with best standard techniques), sustained at an accurate 50 μm from the anode.

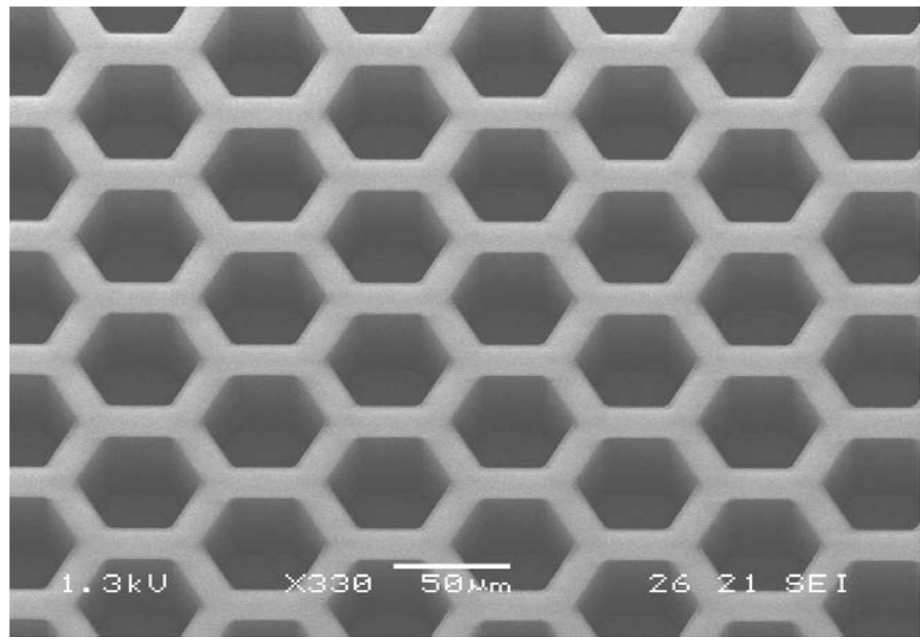
INGRID: some first trials

Various pitches, shapes









Test setup

^{55}Fe source

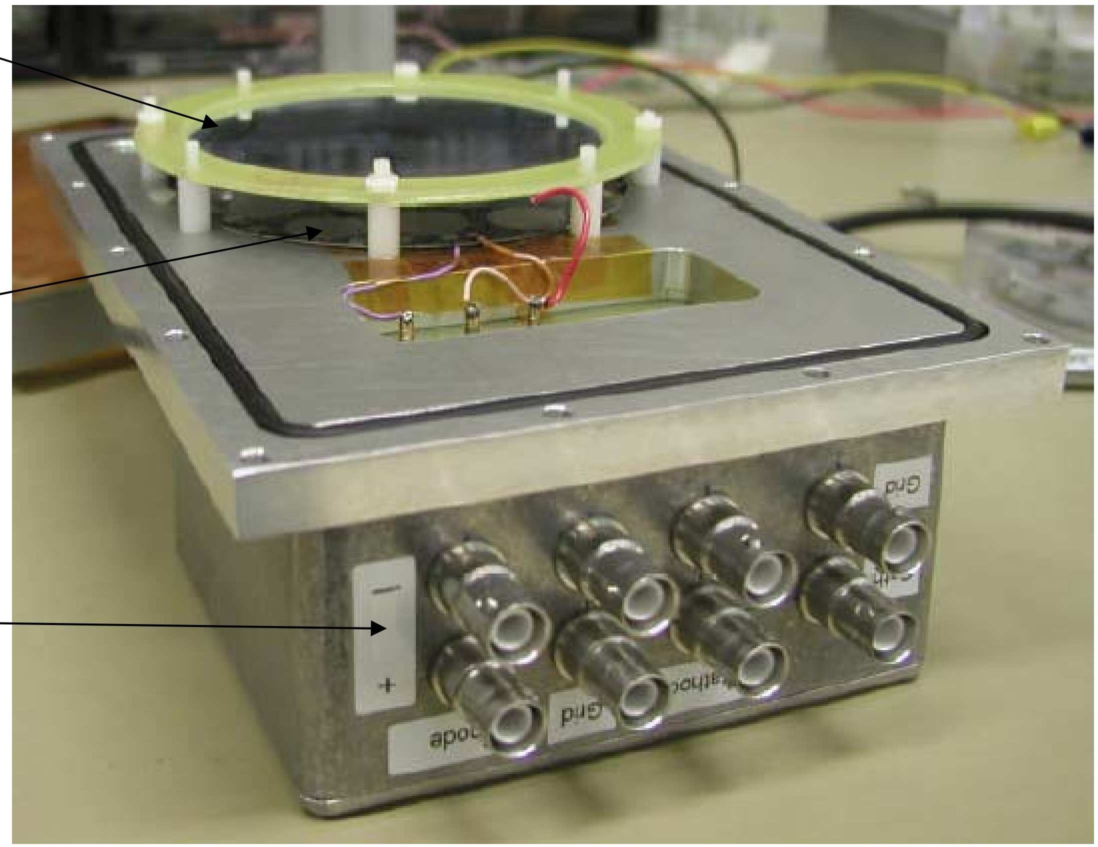
740 MBq

Collimated on 1mm diameter

Drift cathode

InGrid wafer

HV connectors to measure mesh, cathode and anode currents, and mesh signal

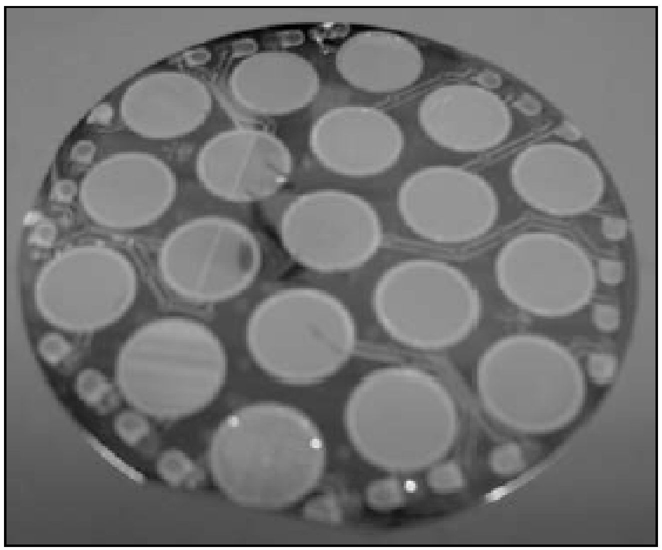


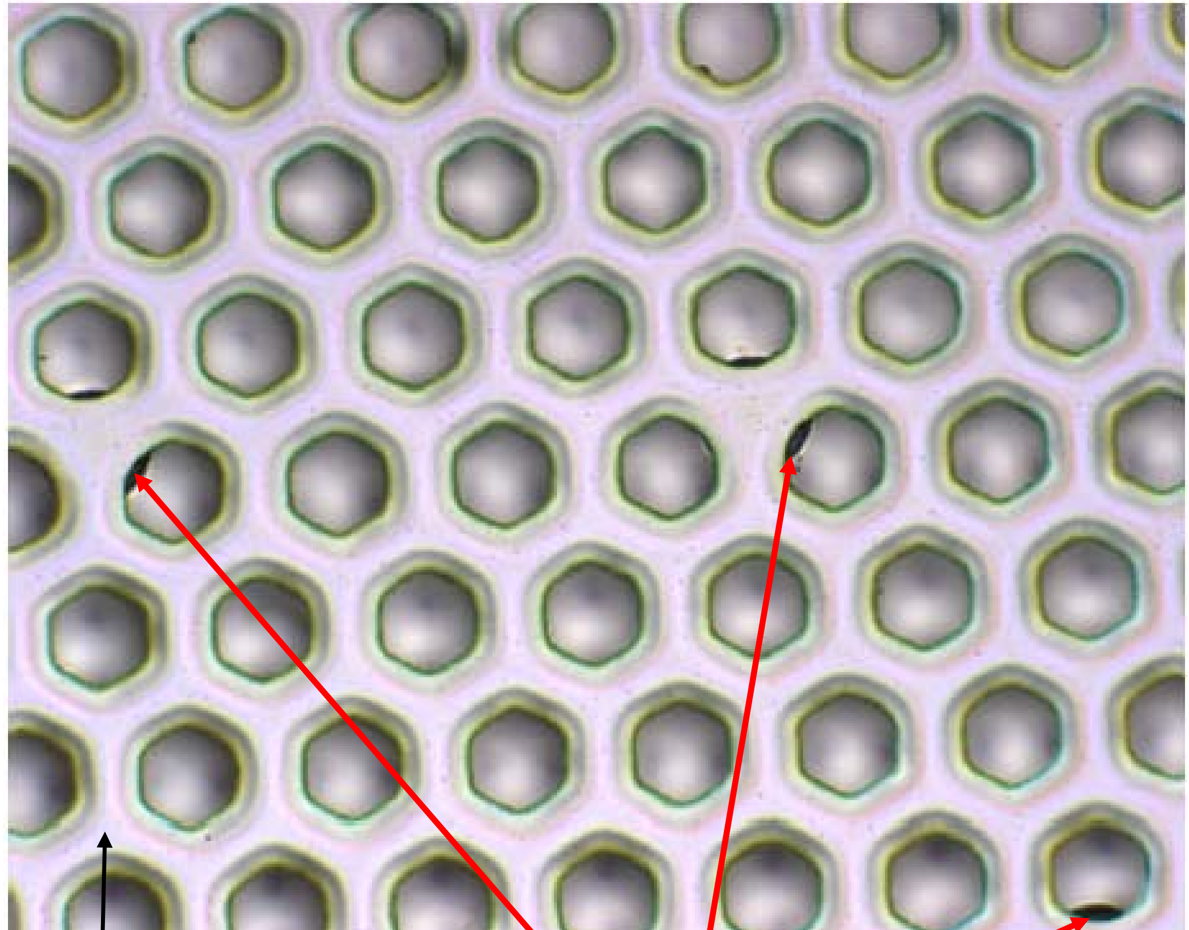
Result of the process

After 1 year of trials and improvements, a satisfactory InGrid holds the voltage.

Pitch 60 μm

4 '' wafer with 19 InGrids





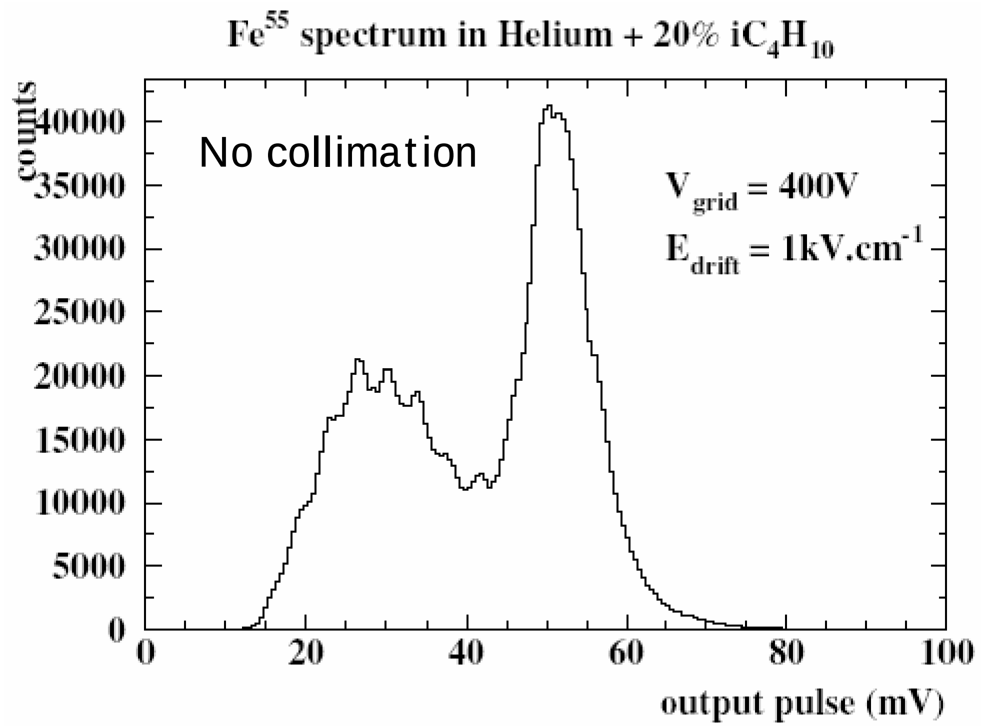
Al grid

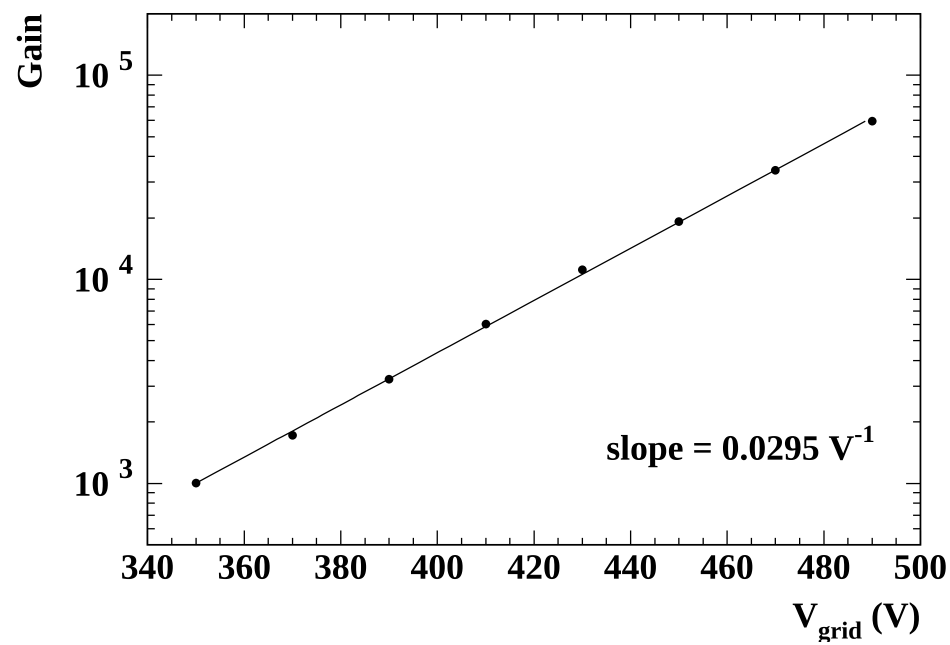
Pillars, 40 μm diameter

No inefficiency

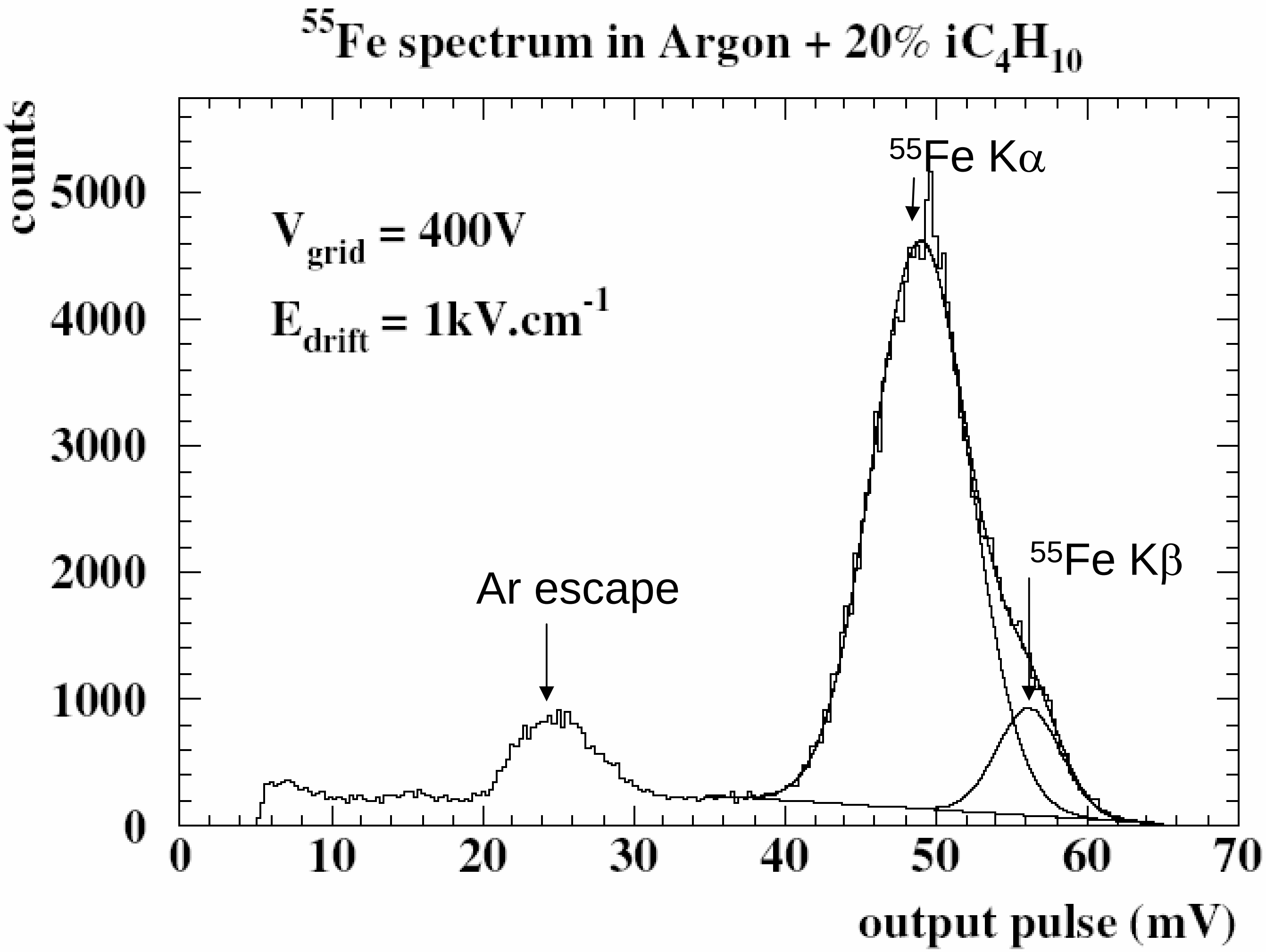
July 2005, first successful test

After 1 year of trials and improvements: first ^{55}Fe signal in an Ingrid detector with He+20%isobutane.





Results with Argon + 20% isobutane



^{55}Fe 5.9 keV line and escape line in Ar clearly visible.

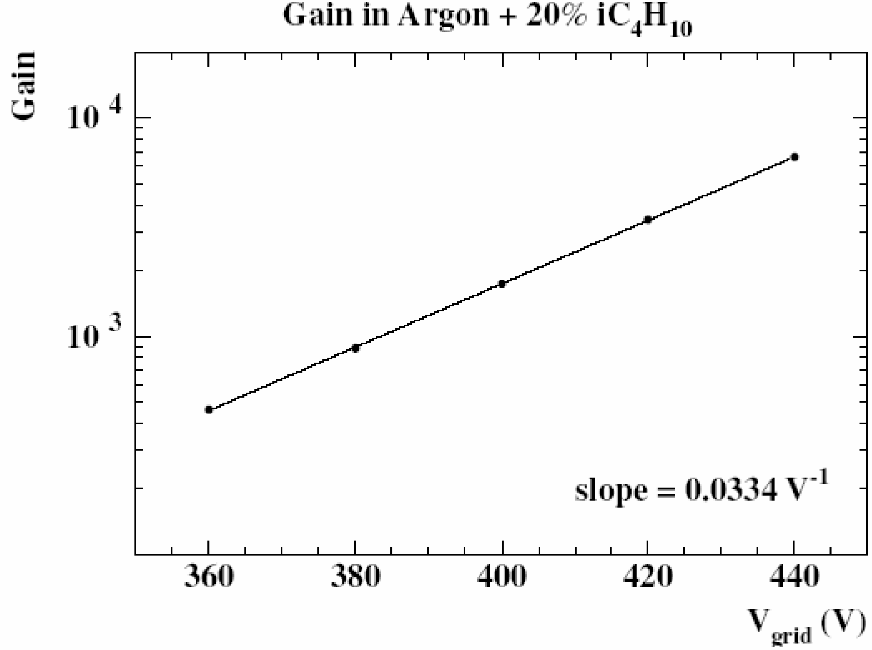
Unprecedented resolution: **σ_E/E = 6.5%.**

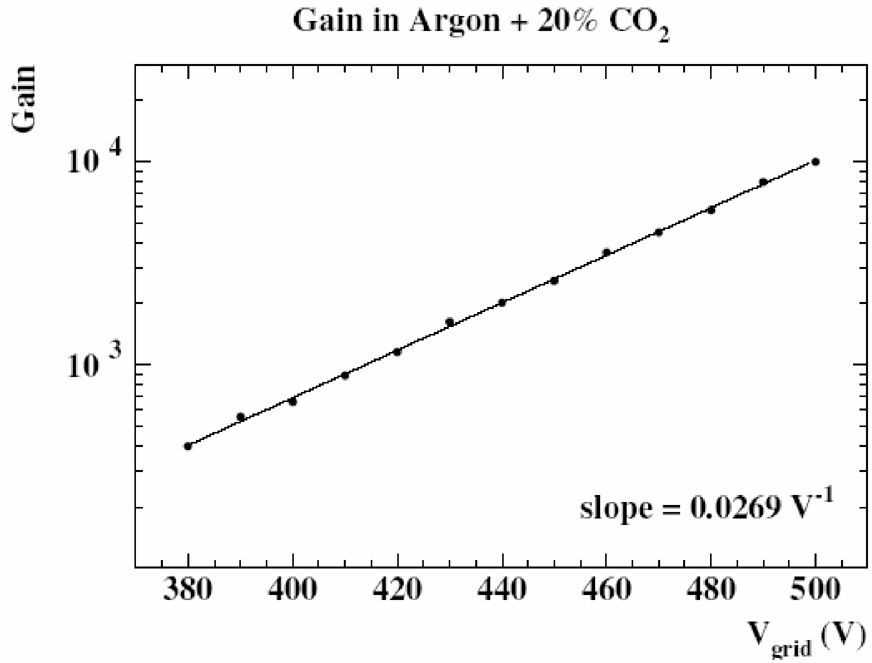
(FWHM=15.3%)

Kα and Kβ (6.5 keV) lines are separated by the fit.

Gain curves

Gains up to $O(10^4)$ are reached with this first InGrid

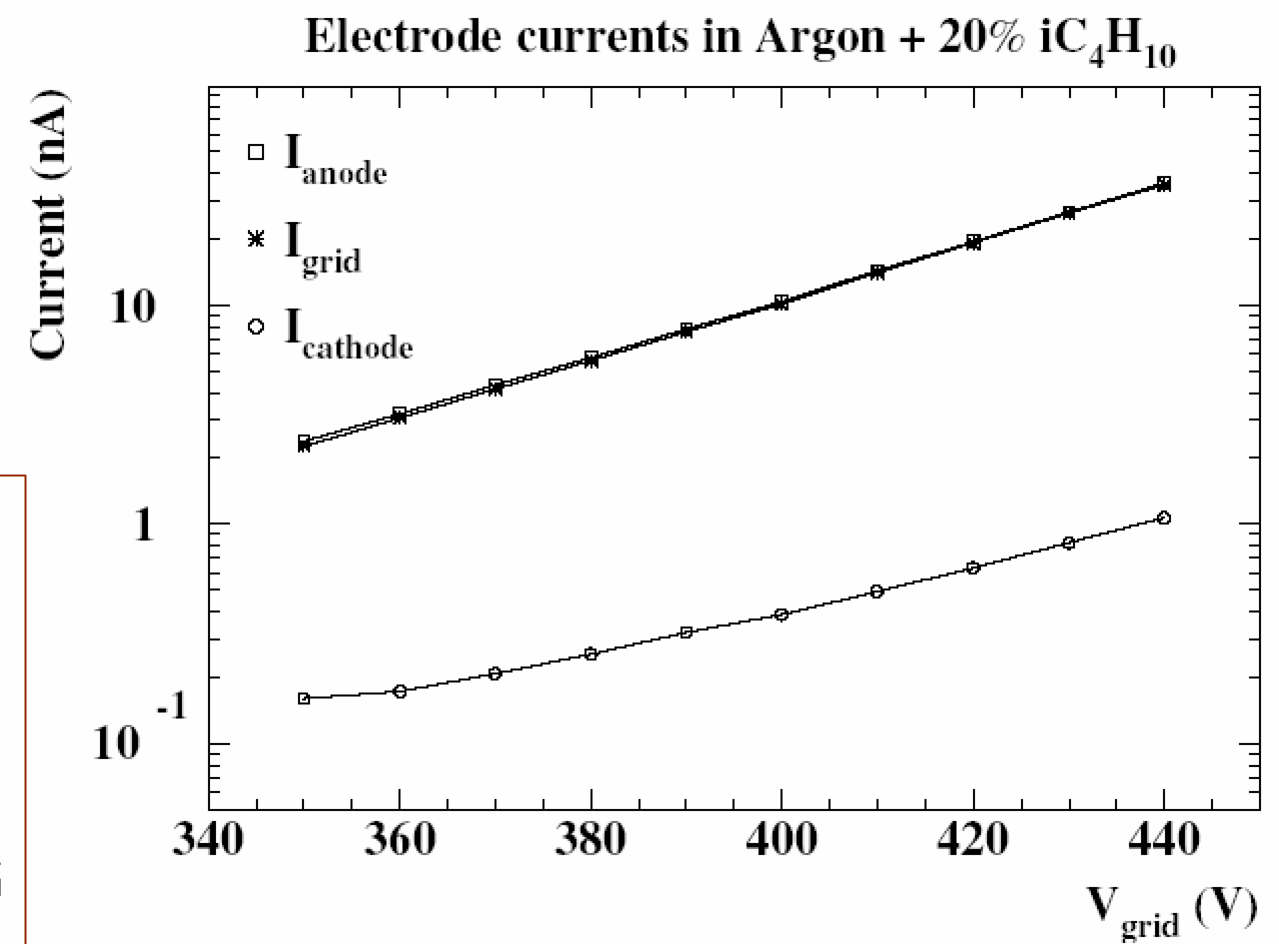


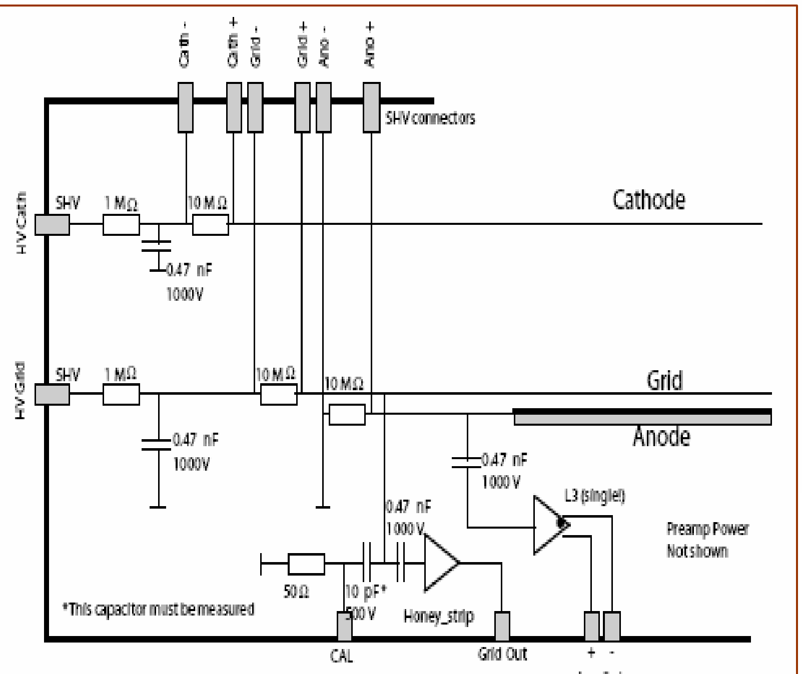


Currents

The currents through the cathode, the grid and the anode are measured

This allows a measurement of the ion backflow fraction : O(1%), consistent with the field ratio.





Future

Try various hole size and pitch (19 already available), thinner gaps.

In parallel develop the chip to provide it with time measurement capability (TimePix, Si TPC)

The work on the Si TPC will receive funding from European Community (EUDET project).

~780 k€, plus a commitment of ~1300 k€ from NIKHEF, Saclay and Freiburg in 2006-2009.

Others are welcome to join, even not from Europe.

Conclusion

The first InGrid shows unprecedented performances

Excellent energy resolution

No need for a frame: the mesh is sustained everywhere.

Easy to segment the mesh (thus lowering the capacitance) and to align mesh and pads

Once the process will be fully stabilized, post-processing onto Medipix2 and Timepix will give a cluster-resolving TPC, very interesting to

- understand further gas ionization and study how Micromegas works

- make a digital TPC