University of Twente

InGrid: An integrated gaseous detector using wafer post-processing technology

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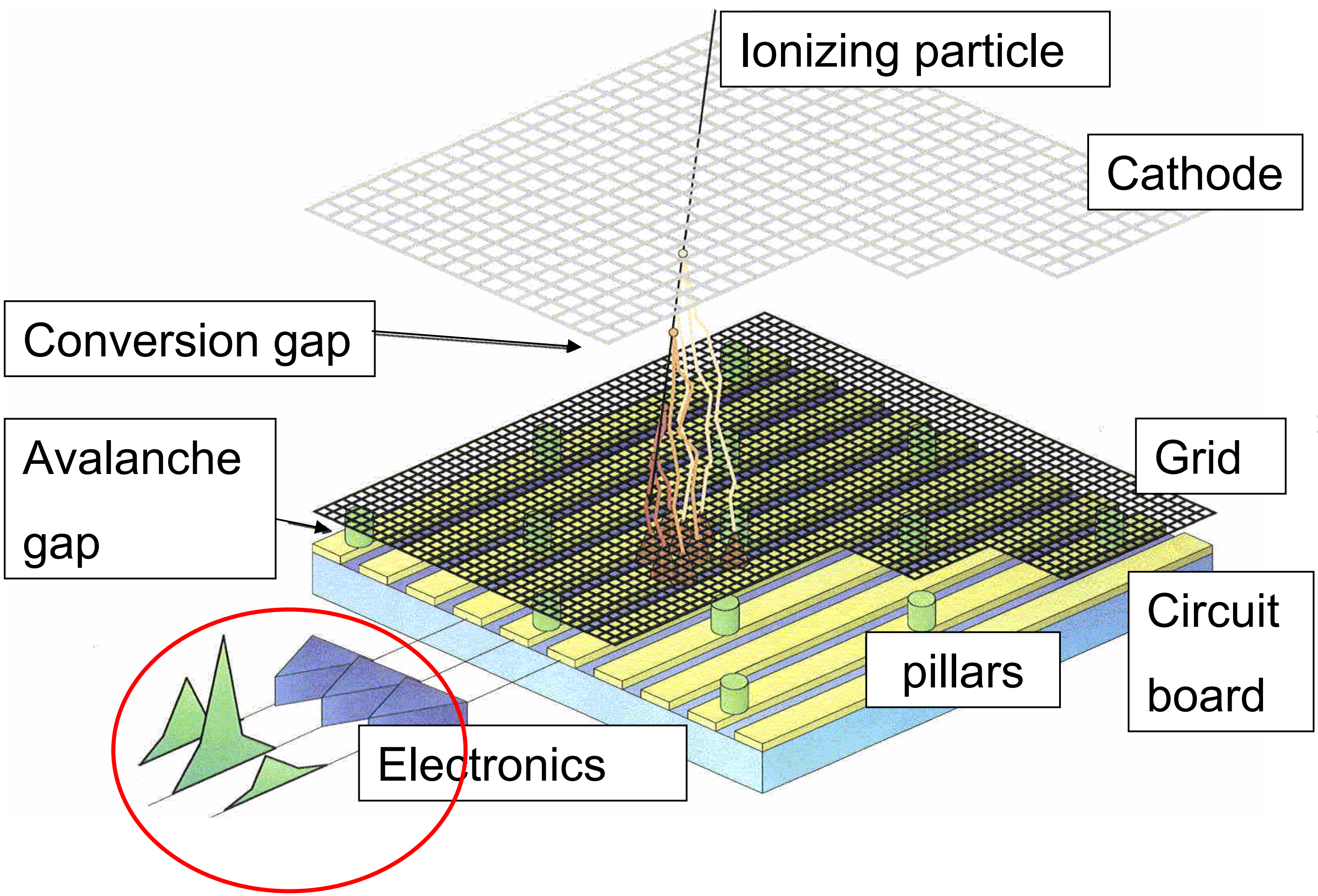
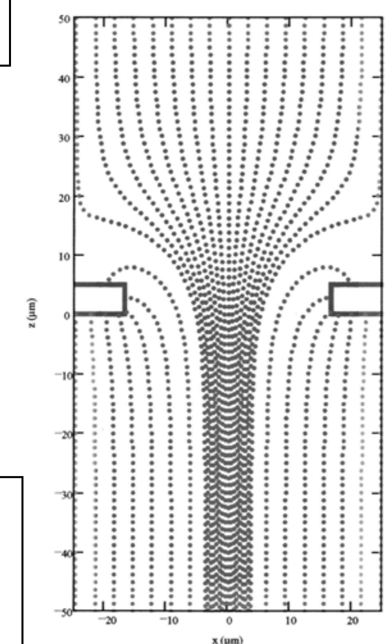
Overview

- Wafer post processing idea
- InGrid:Fabrication
- Experimental results
- Sparking
- Conclusions and future plans

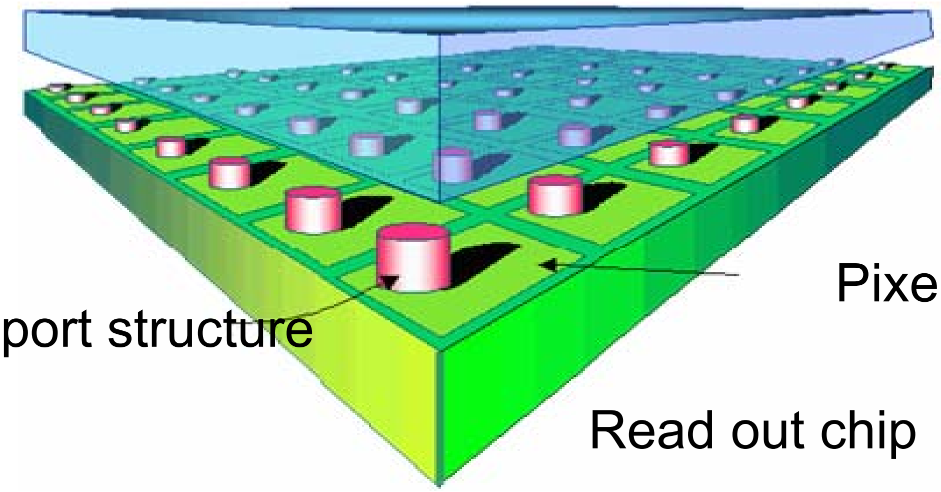
The MICRO MEsh GASeous detector





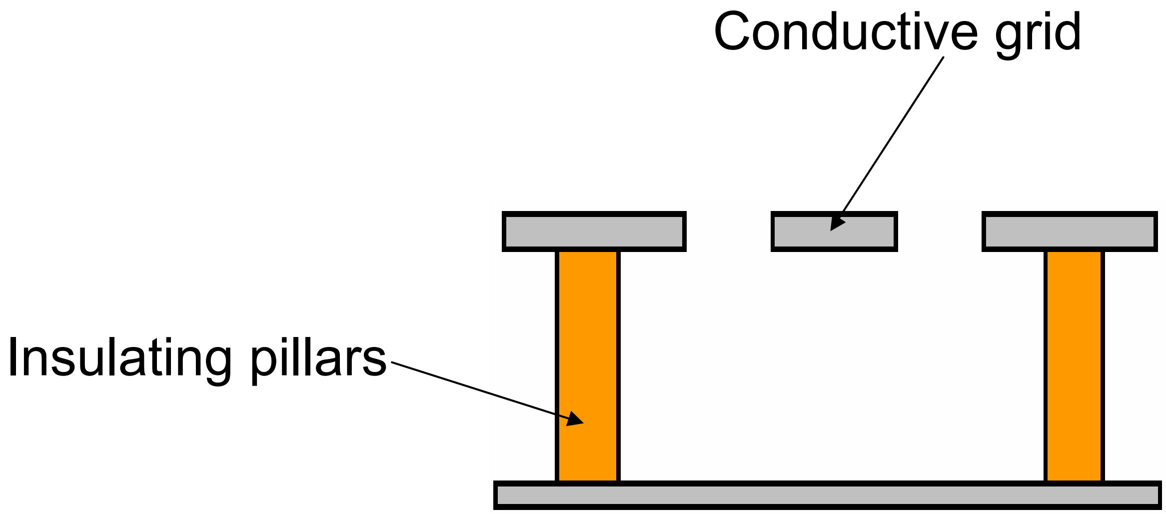
Wafer post processing

- Use microelectronics to add functionalities
- Process must not damage the chip
- Enlarge pixel surface
- Deposition of high resistive layer
- Integration of micromegas
  - Perfect alignment holes/pixels
  - No dead areas
  - No manual manufacturing

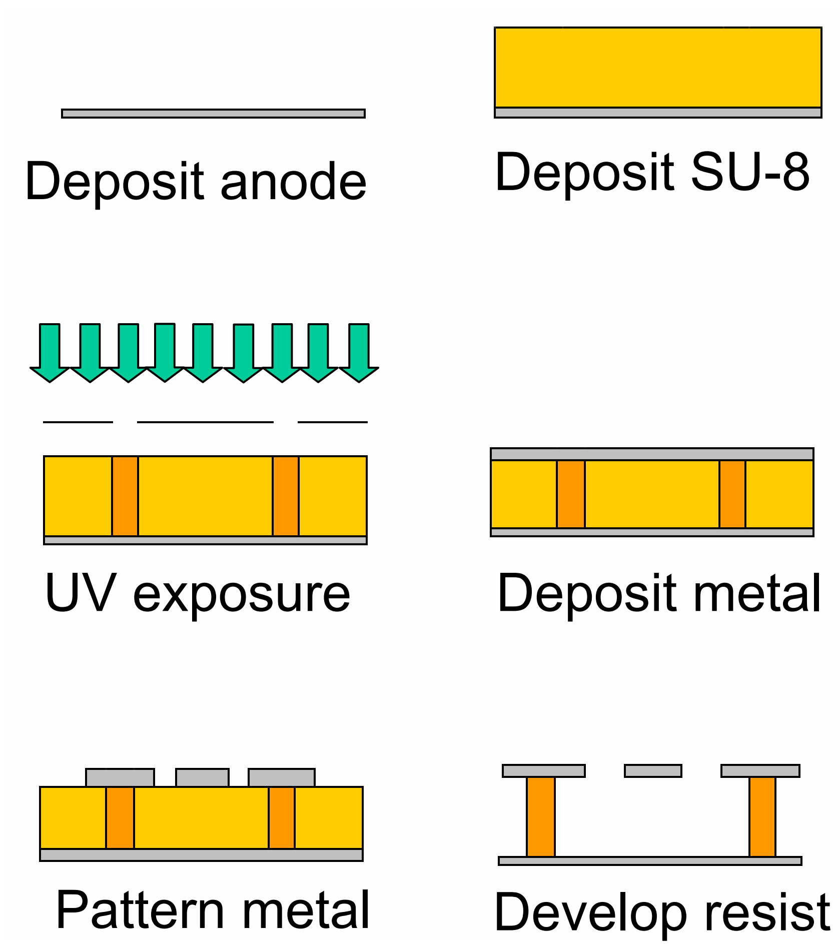


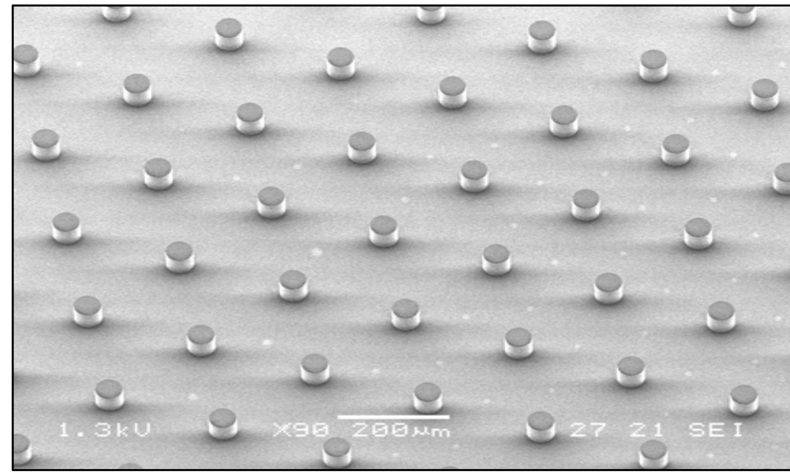
Materials for our structures

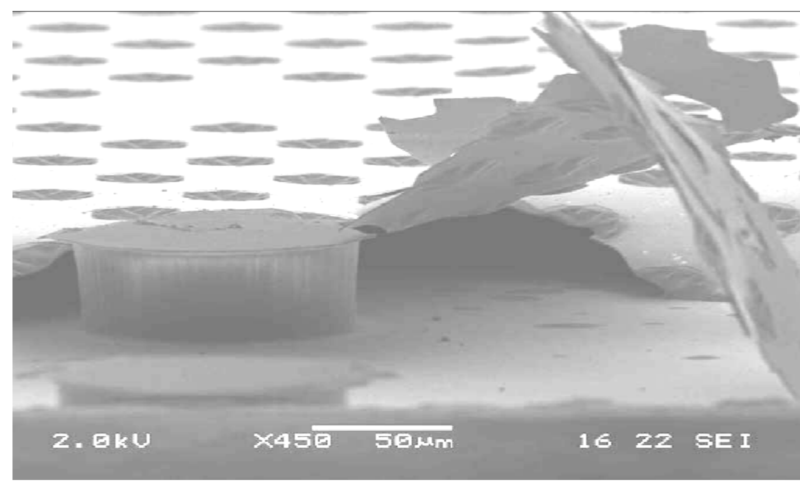
- SU-8 negative resist as insulating pillars
  - Easy to define structures
  - Wide range of thickness (5 µm to 250 µm)
  - High precision
- Aluminum as conductive grid
  - Commonly used in microelectronics
  - Easy to deposit
  - Easy to pattern



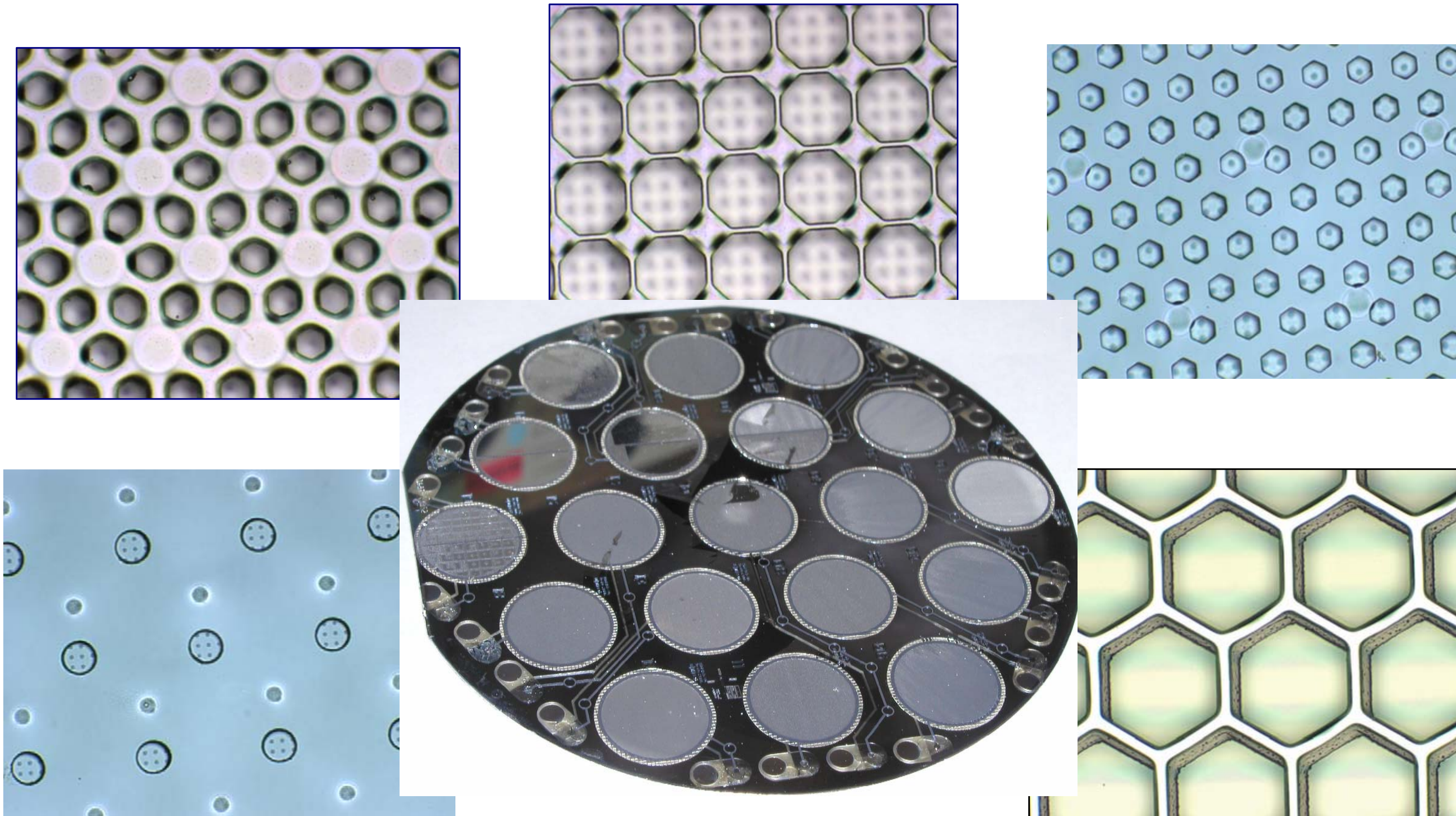
InGrid: Integrated Grid





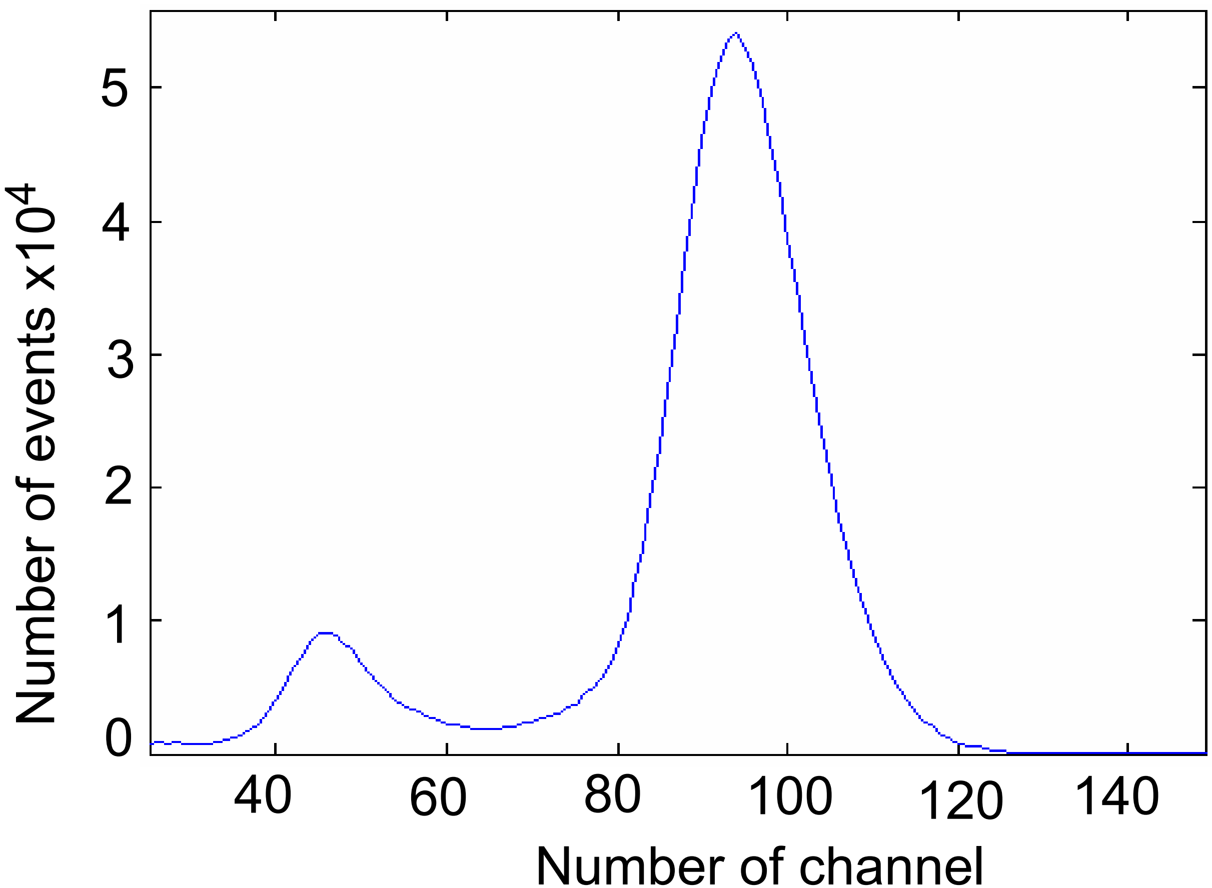


Any field structure feasible



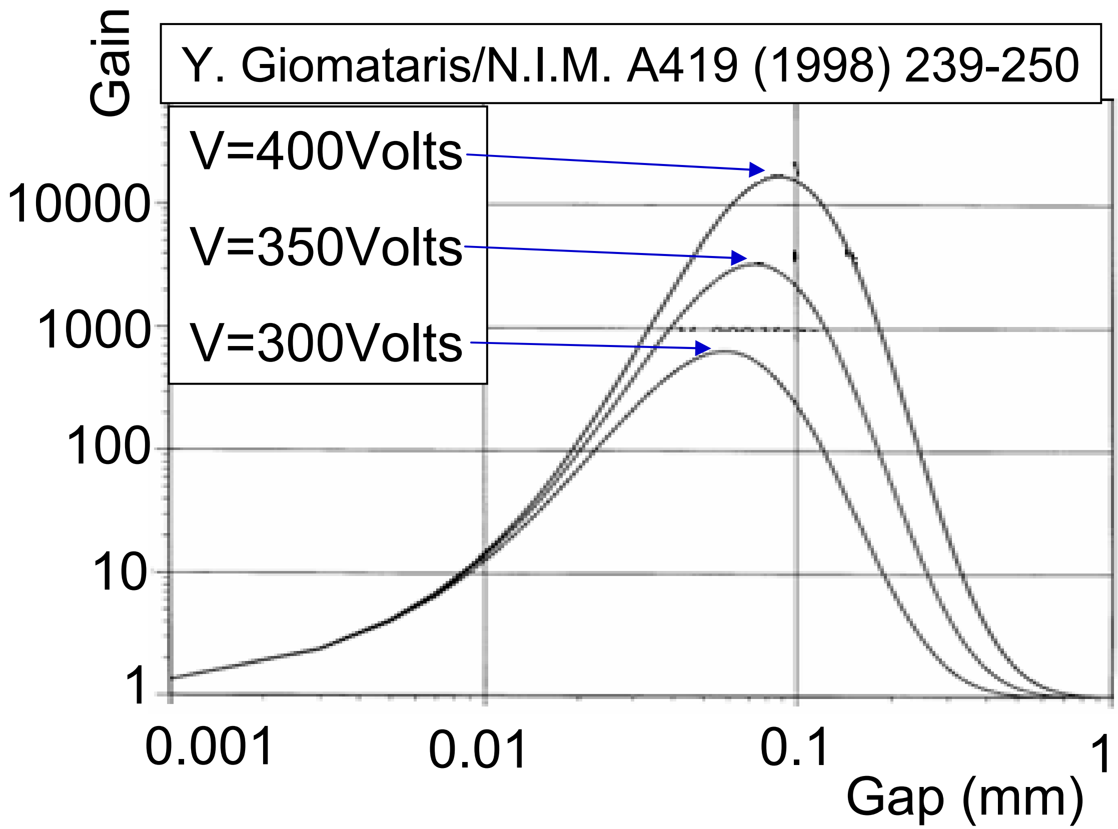
And now we start to record spectra

Histogram of ^{55}Fe source in Ar/Isobutane 80/20



Gain for different gap sizes

Maximum predicted in gain vs gap curve

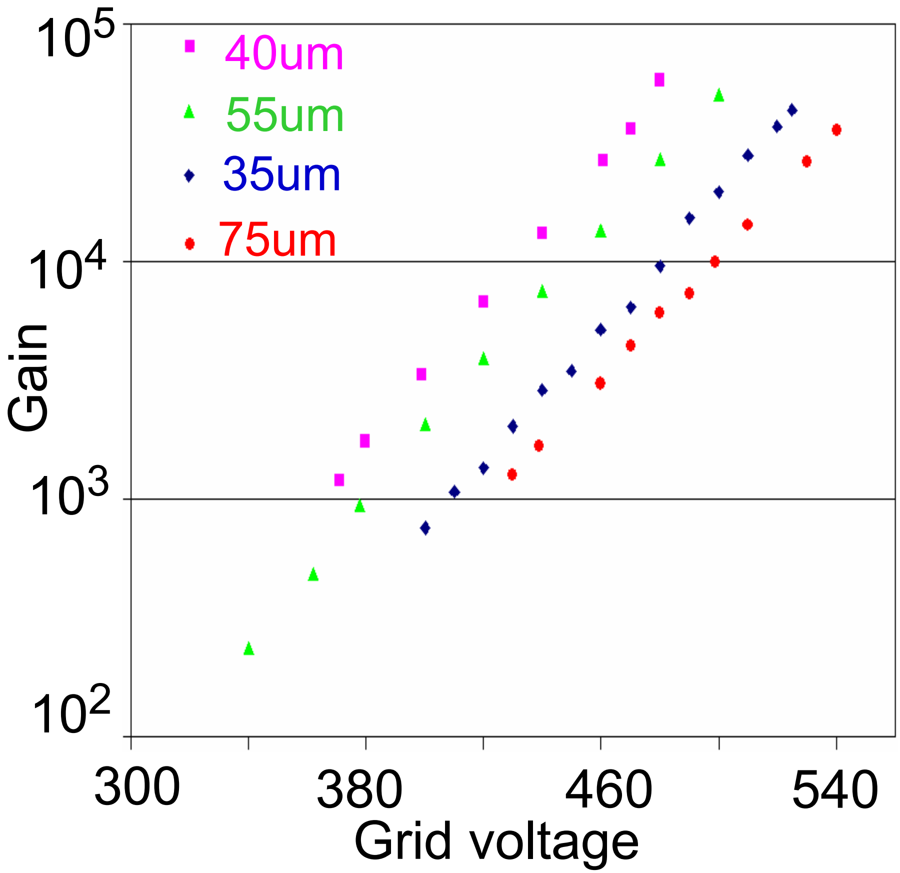


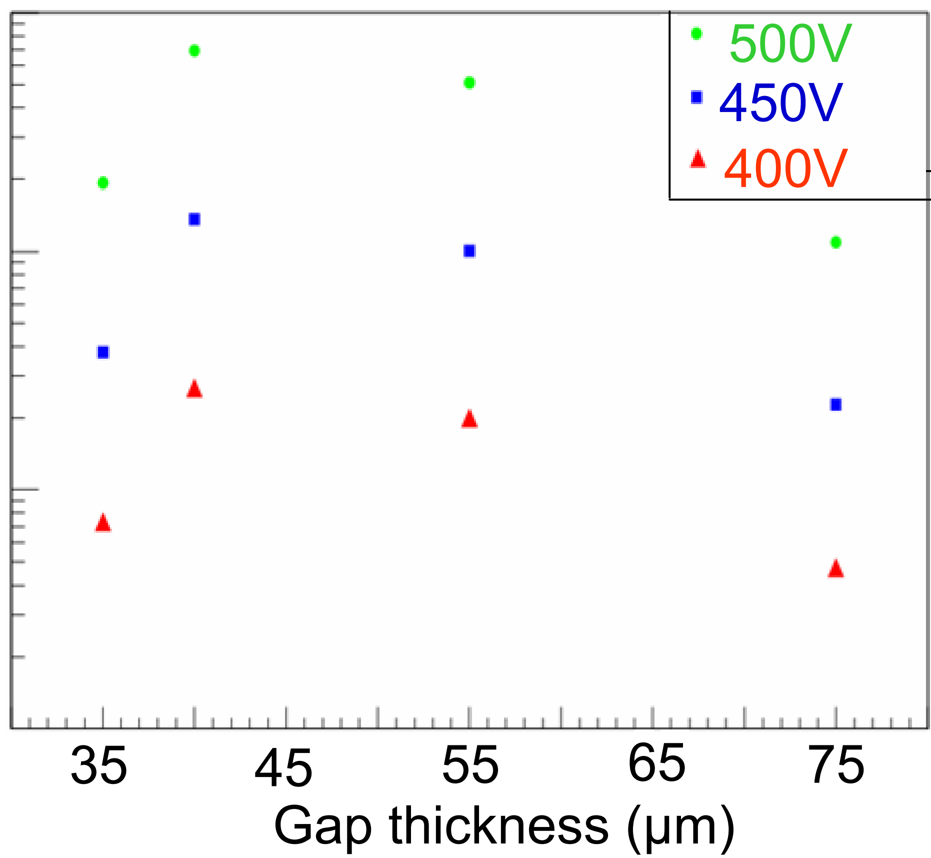
$$\alpha = pAe^{-Bp/E}$$

Rose & Korff

Gain for different gap sizes

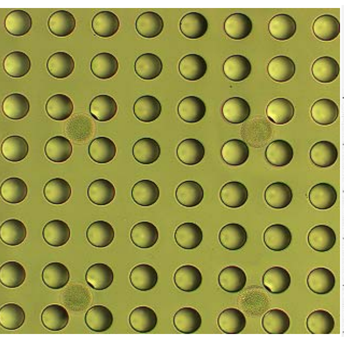
- But now we can make measurements

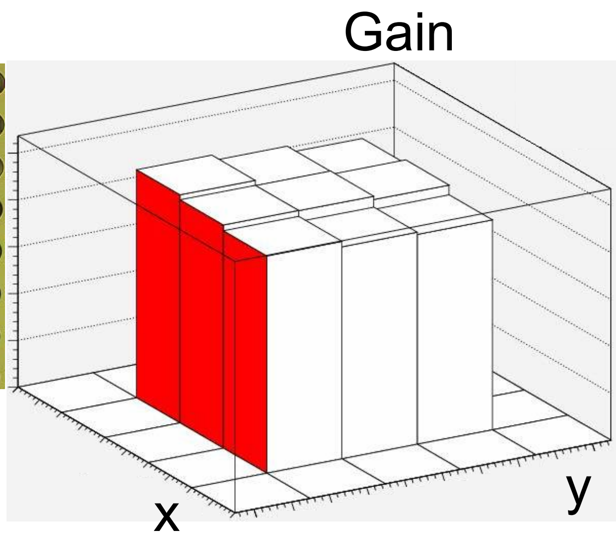




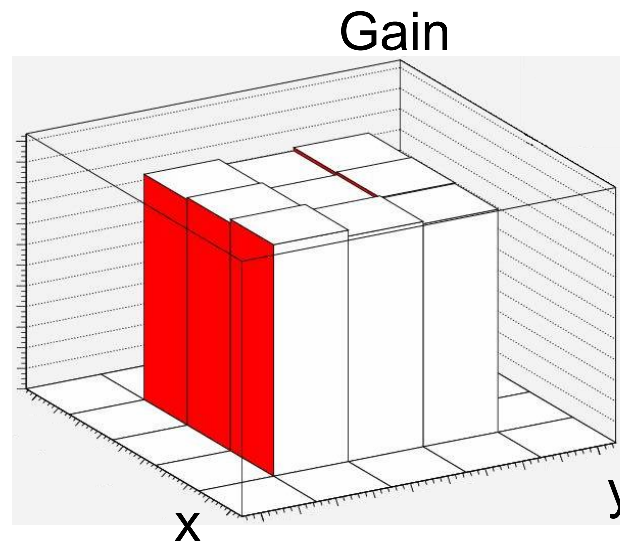
Homogeneity

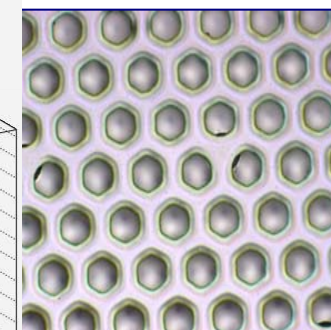
- Gain measurements scanning the surface of the detector
- Homogeneity given by grid quality





2.6 % RMS

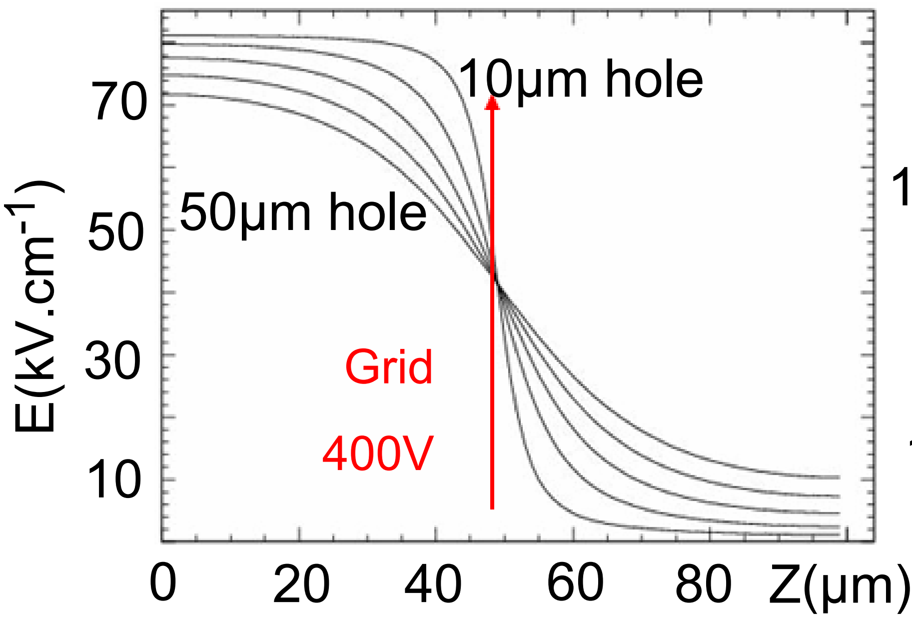


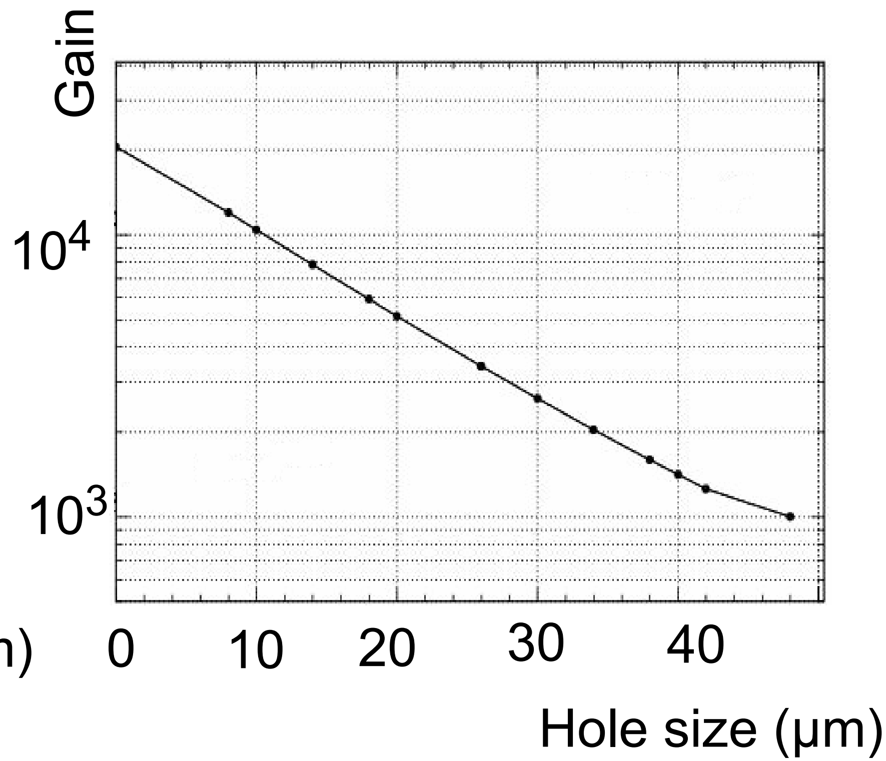


1.6 % RMS

Simulated gain for different hole size

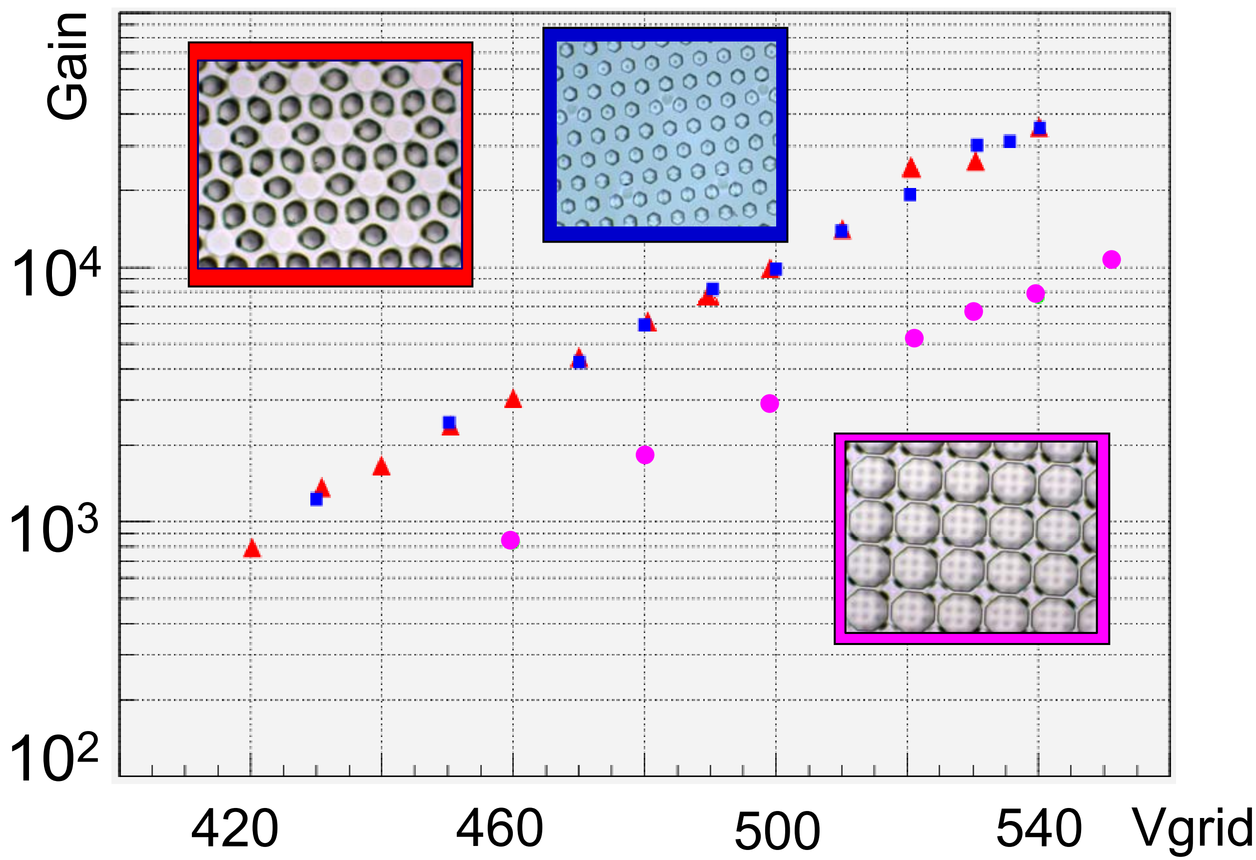
- Electric field along z axis decreases with hole size
- Different gain expected for different hole size





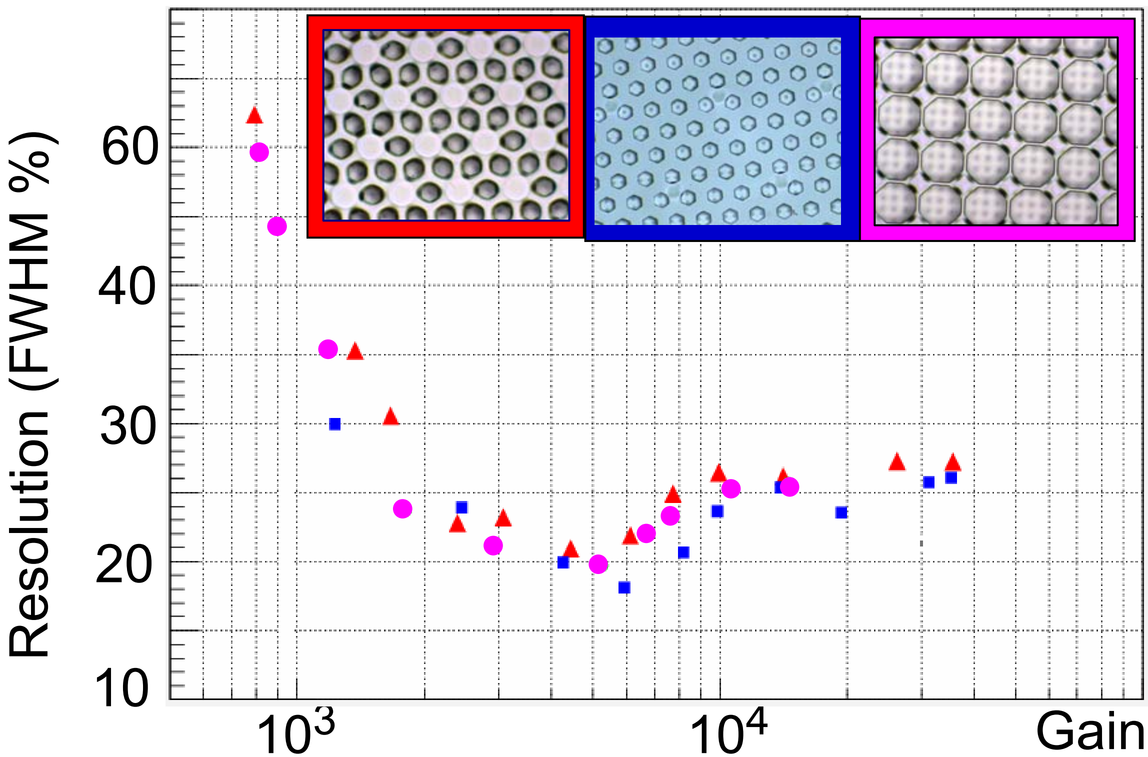
Measured gain for different hole size

And measurements confirm simulations



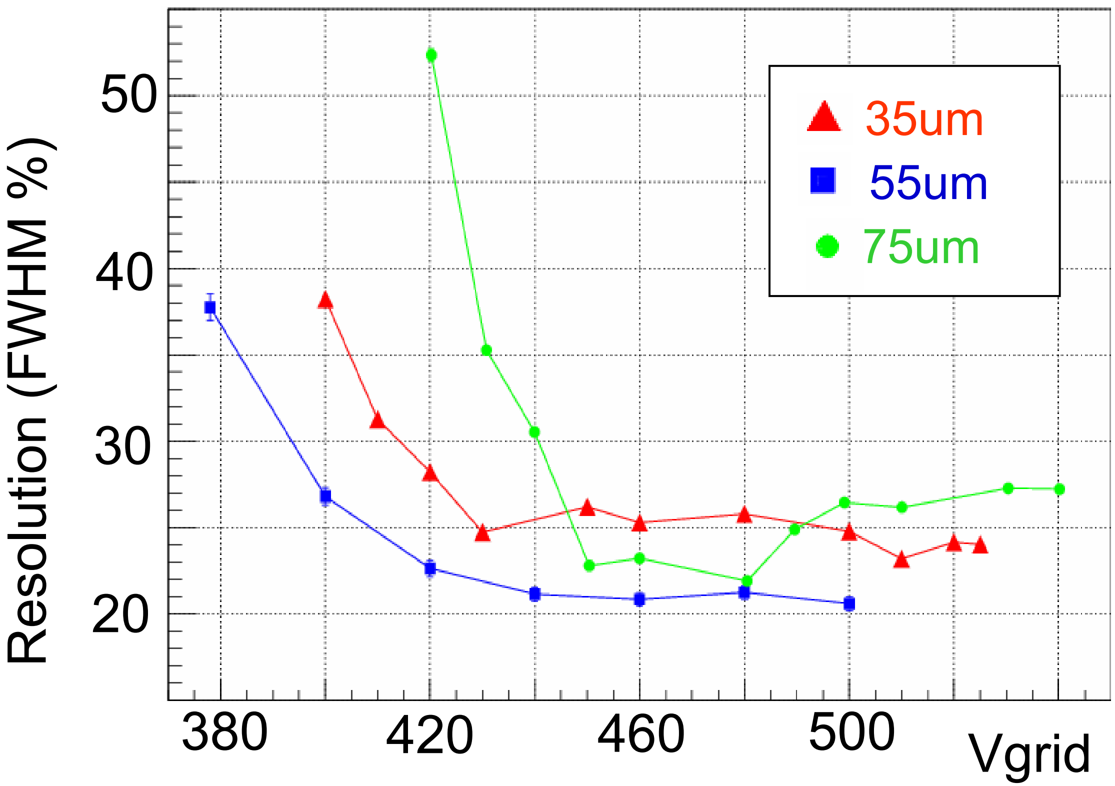
Energy resolution

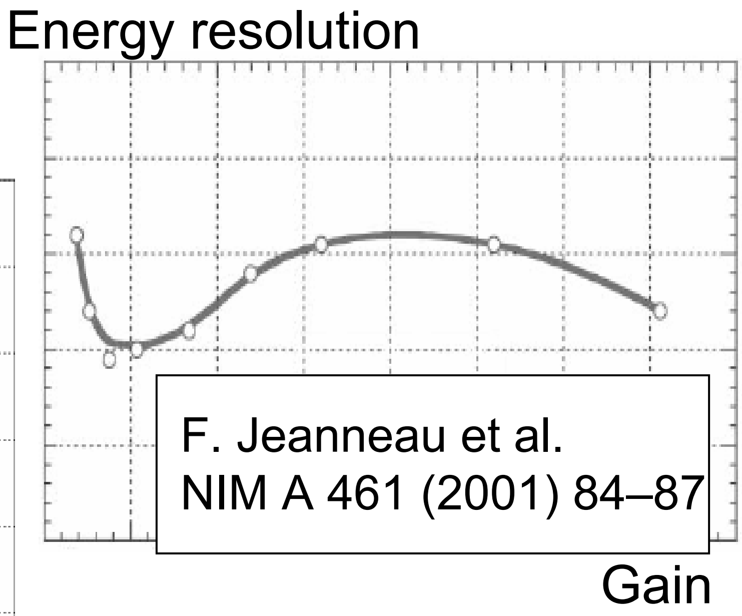
- Resolution depends on
  - Primary,attachment,T,P
  - Collection efficiency (field ratio)
  - Gain homogeneity & transverse diffusion



Energy resolution as function of gap

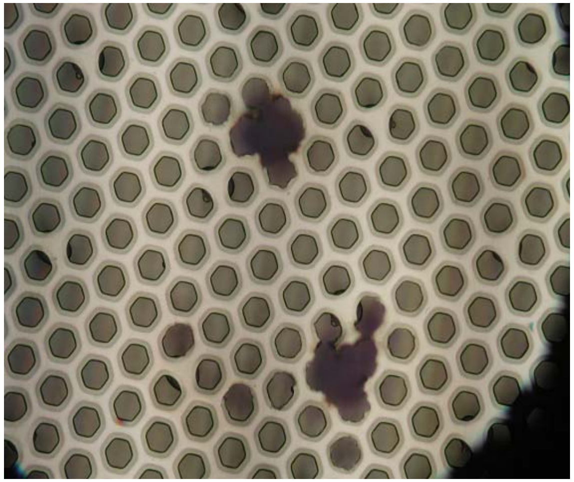
- Why a parabolic behavior ?

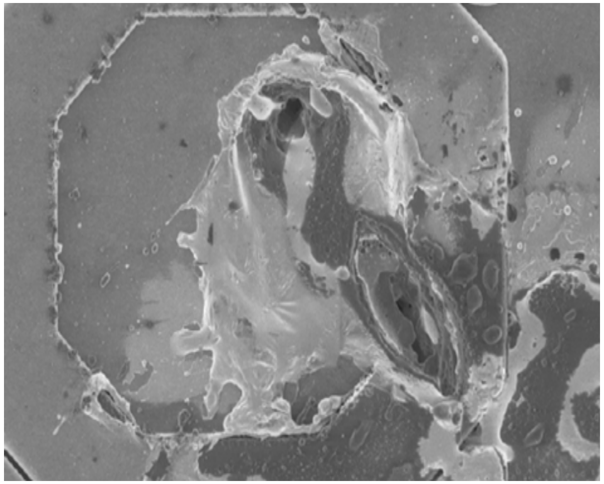




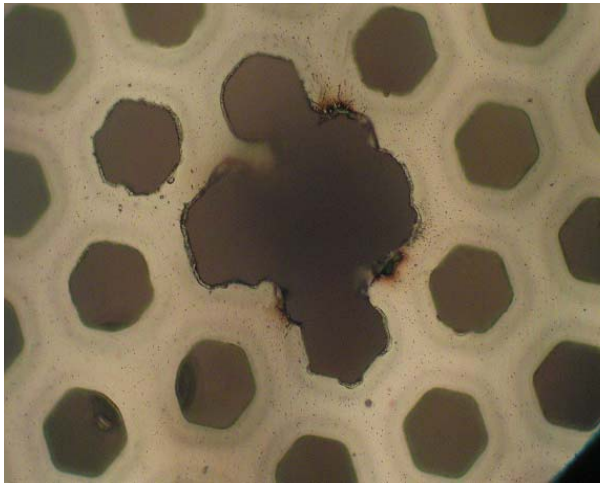
Sparking

- Chip faces 80kV/cm with no protection
- Degradation of the field, or total destruction



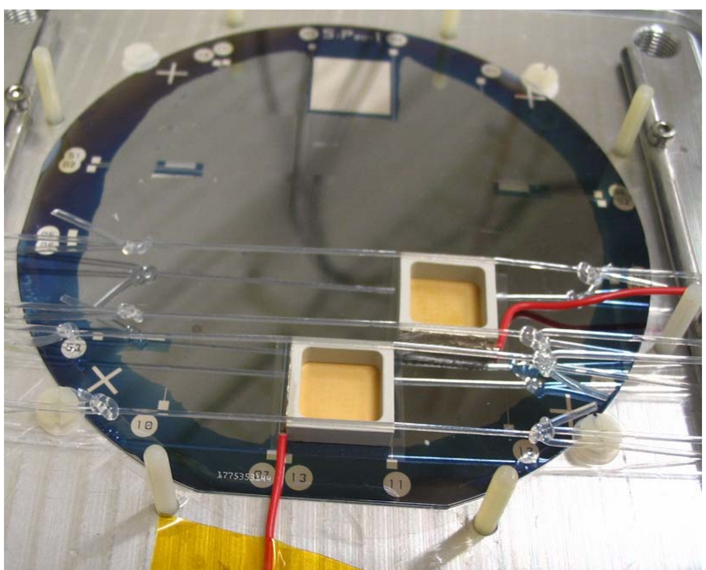


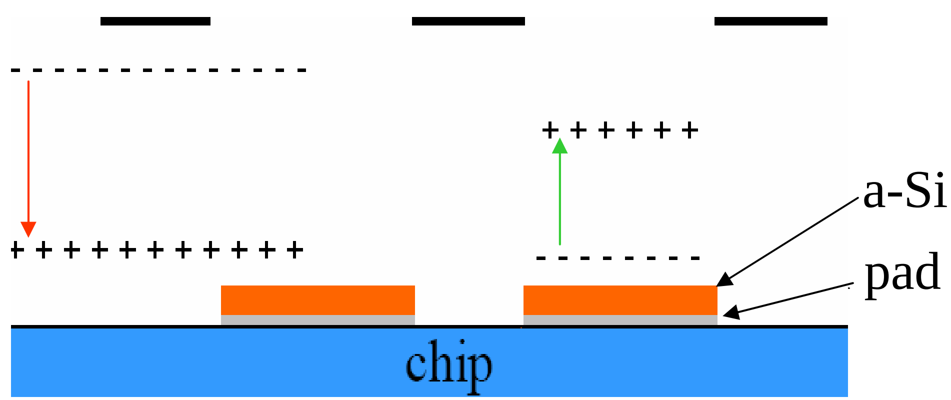
10μm



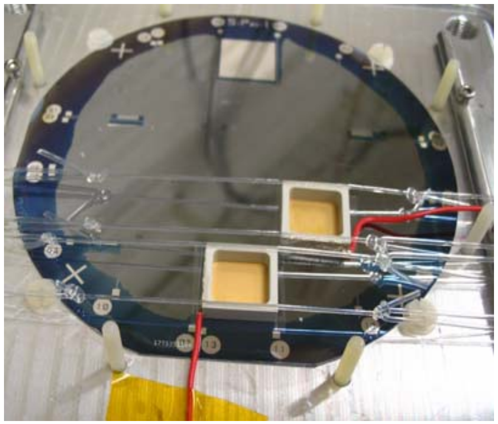
Solution:high resistive layer

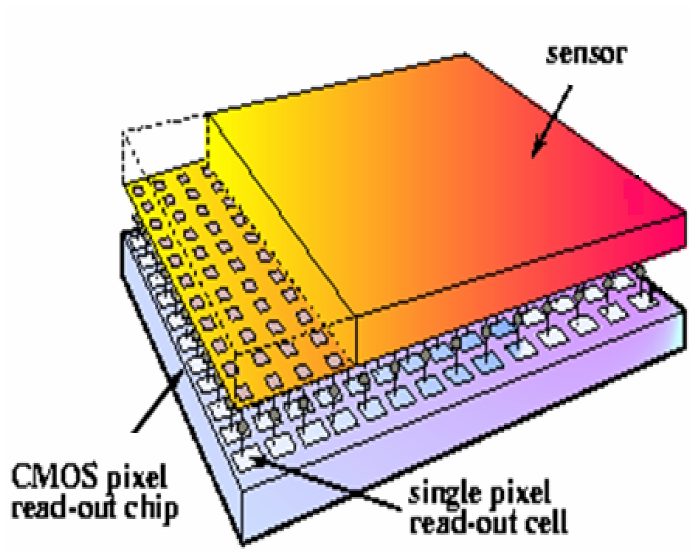
- Resistive plate chamber principle
- Amorphous silicon deposited
  - 4um thickness,resistivity ~$10^{11}\Omega$.cm,temperature~250 ° C
- Signals recorded in first experiments

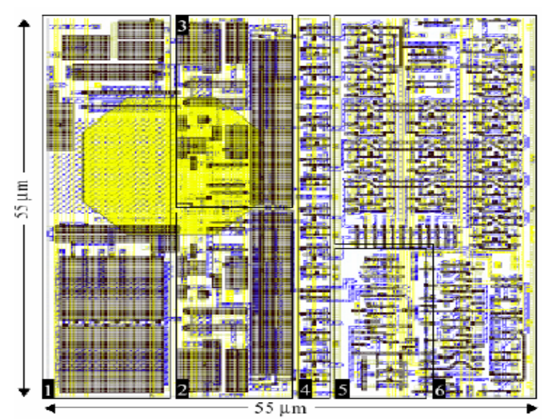




Future plan




sensor
CMOS pixel
read-out chip
single pixel
read-out cell


55 µm
55 µm
1
2
3
4
5
6

Conclusions

- New detector described
- Completely flexible design
- Measurements for different structures
- Sparking solution presented
- On chip integration is coming

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Dominique Altpeter

Tom Aarnink

STW

University of Twente
The Netherlands

BACK UP SLIDES

Advantages of GOSSIP compared to silicon sensors

- **No bias current**, only signal induced currents will be observed
  - < 10 pA/pixel at sLHC
  - => Low current setting in frontend amplifier
- **Very low electrode capacity**(0.5 fFto micromegasfor 60 μm pixel pitch and 50 μm amplification gap)
- **=> minimal cooling requirements or cooling by environmental air for electronics**(1.8 μA/pixel => 0.1 W/cm2)
- **High rate capability observed**
  - Possibly exceeding **3.3 x 109/cm2 mips**
- **Good aging performance observed**
  - Tests suggest **mip operation possible until 1016 /cm2**
  - **No aging for neutrons** expected
  - Almost **insensitive for X rays**
  - **No aging at beam accidents**(tuning)
    - Bias voltage switched off by over-current protection
- **Operation at a wide temperature range (-30 to 50 °C)**
- **Average signal can be kept constant during irradiationup to 1016mips/cm2**
  - by regularly readjustingVgrid
- **Low material budget: X/X0= 0.05%**
  - for GOSSIP + pixel chip thinned to 30 μm

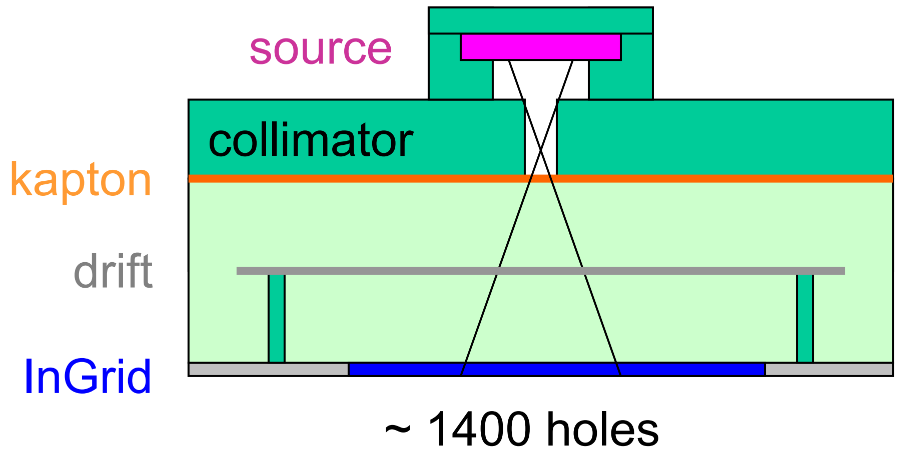
Disadvantages compared to silicon sensors

- **Different technology: gas system required**
- **Gas gain strongly dependent on several parameters**(Vgrid, Pabs, T, distance grid to anode)
  - Better gain uniformity expected for INGRID
- **Occasional spark discharges**
  - Requires resistive protection to avoid damage to pixel chip => **SIPROT**
  - Will be most likely solved
- **Poor statistics of primary ionisation** (2.3 –4.7 clusters/mm)
  - Reduced efficiency: 90-99% (gas dependent)
  - Charge signal has big variance
- **Bigger thickness of detecting medium**(1 mm vs≤300μm)
  - Worse resolution for inclined tracks and systematic deviation (ballistic deficit)
    - Improvement possible by drift time measurement (Timepixchip)
- **High dust sensitivity**
  - Assembly sensors in high class clean room like for semiconductormanufacturing
  - But dust sensitivity is over as soon as the gas volume is closed
- **Aging depending on certain pollutants**
  - Aging of gaseous detectors is never a natural constant but oftendepends on minor traces of pollutants (ppB level) in the chamber gas
  - => aging monitoring (special aging chambers have to be built in)

Radiation source

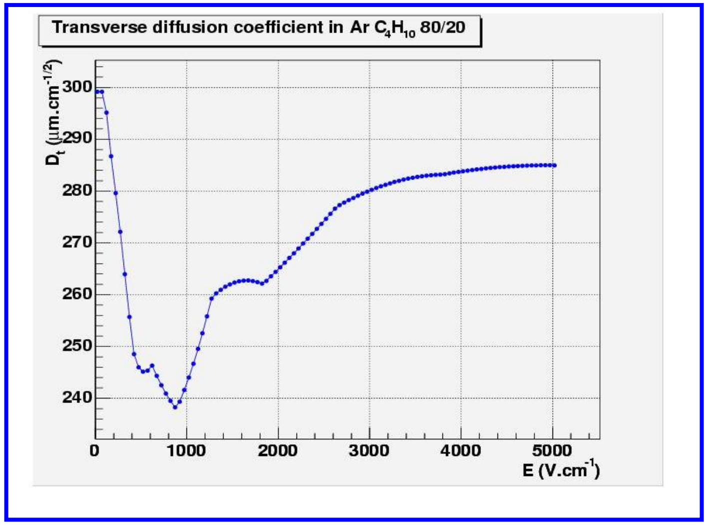
- 55Fe of few MBq
  - 5.9 keV + 6.5 keV lines emitted in ratio 9/1
  - After 2.5 cm of Argon, ratio = 7/1

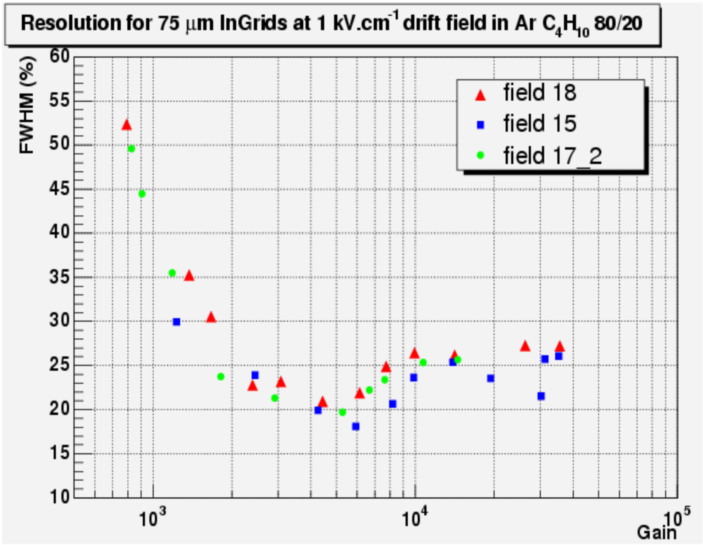
- 0.5 mm Ø collimation
- 3.5 cm above grids
  - ~ 20 mm2 on grid
  - ~ 9 % grid surface

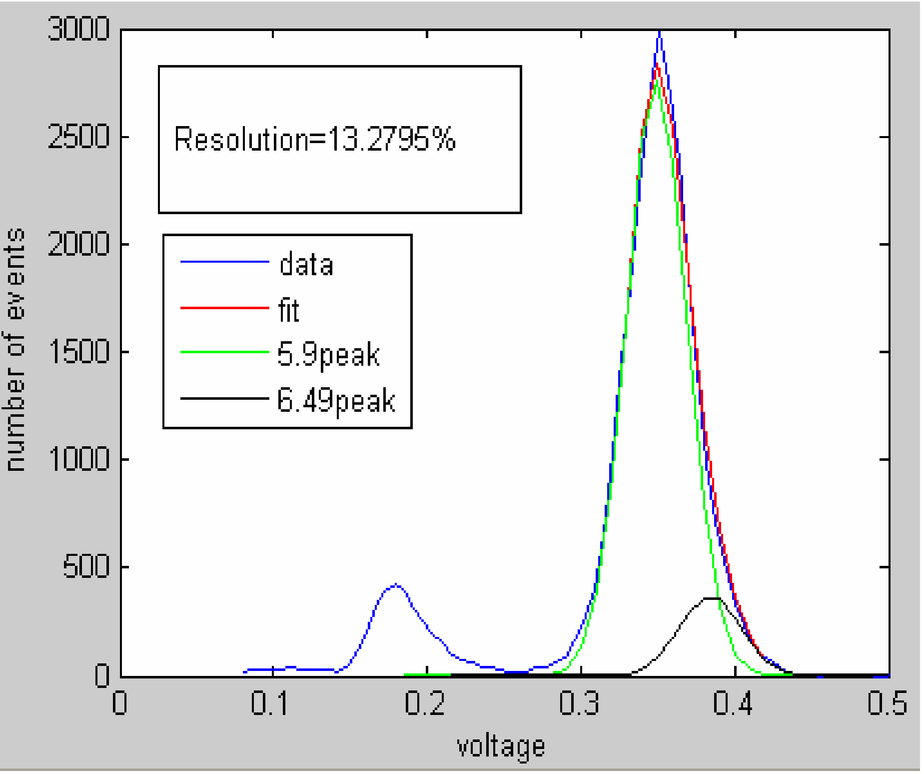


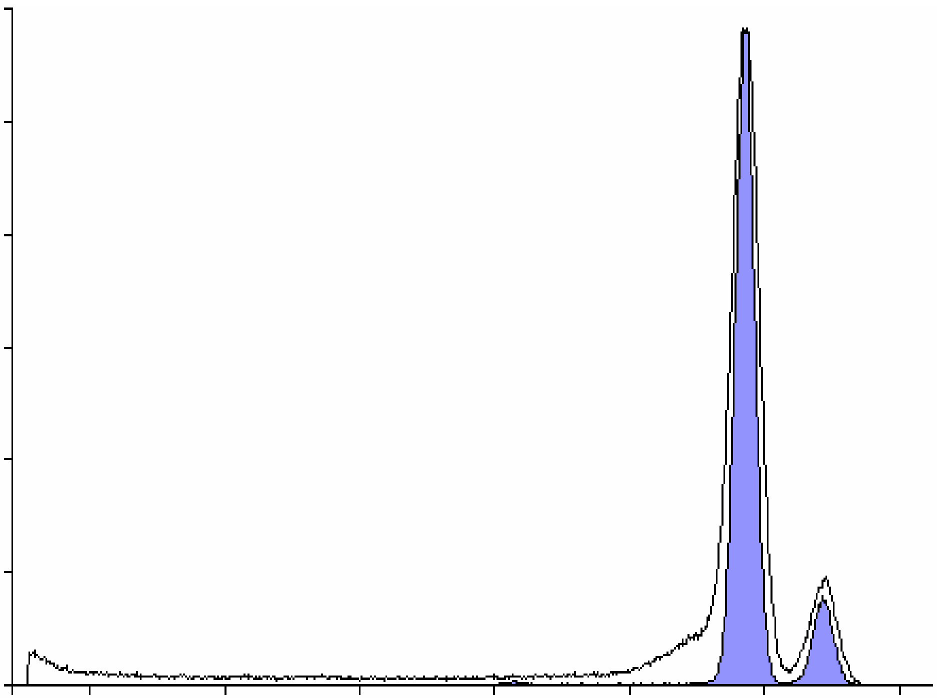
Resolution

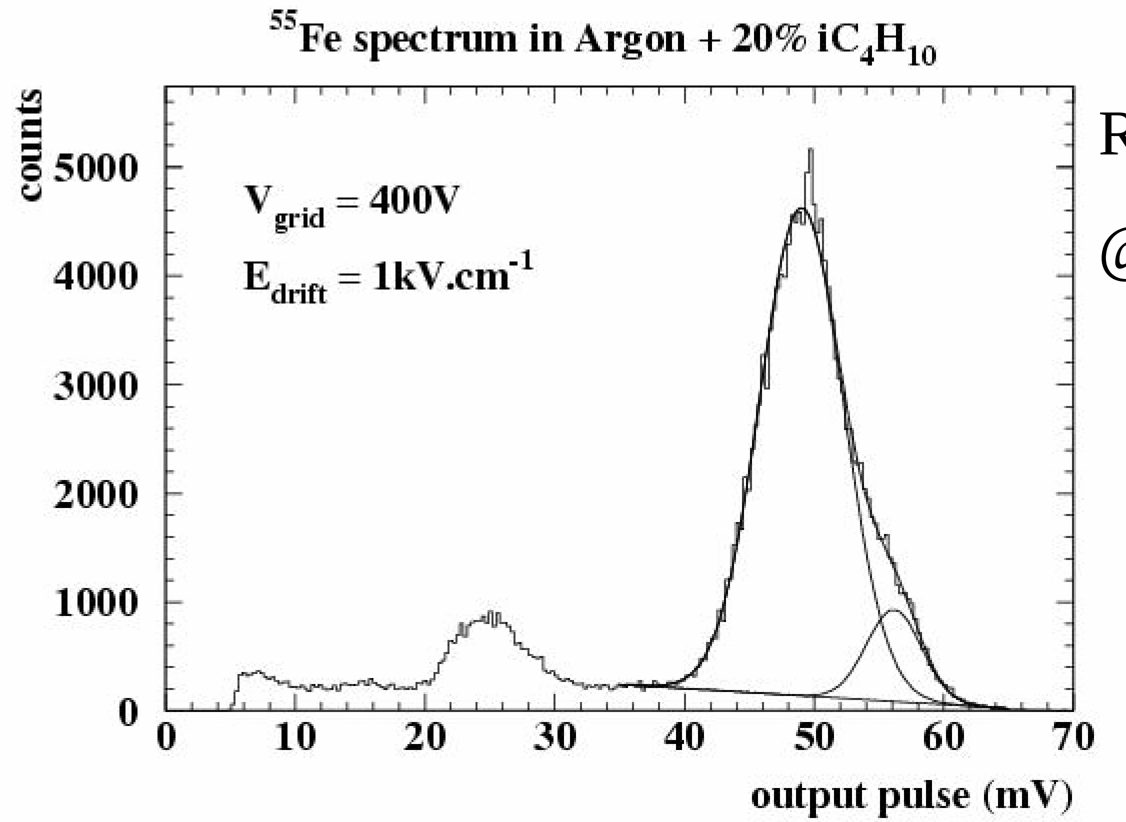
- What does it depend on?
  - Primary & Fano, attachment, T, P
  - Collection efficiency (field ratio)
  - Gain homogeneity & transverse diffusion
- What we measure with 500 V on grid:
  - @ 1310 V/cm α ~ 50
  - σt ~ 260 μm/cm1/2
  - **17 % FWHM**
  - @ 340 V/cm α ~ 200
  - σt ~ 260 μm/cm1/2
  - **21 % FWHM**
- Resolution seems to depend only on gain
- Why a parabolic behavior ?






Resolution=13.2795%
data
fit
5.9peak
6.49peak
number of events
voltage
3000
2500
2000
1500
1000
500
0
0
0.1
0.2
0.3
0.4
0.5



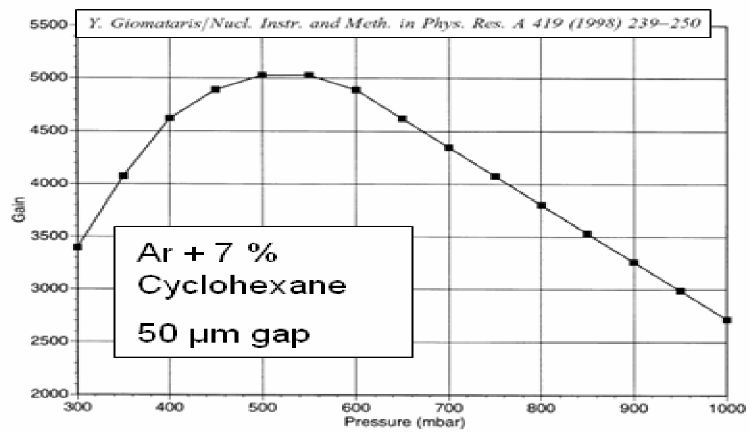


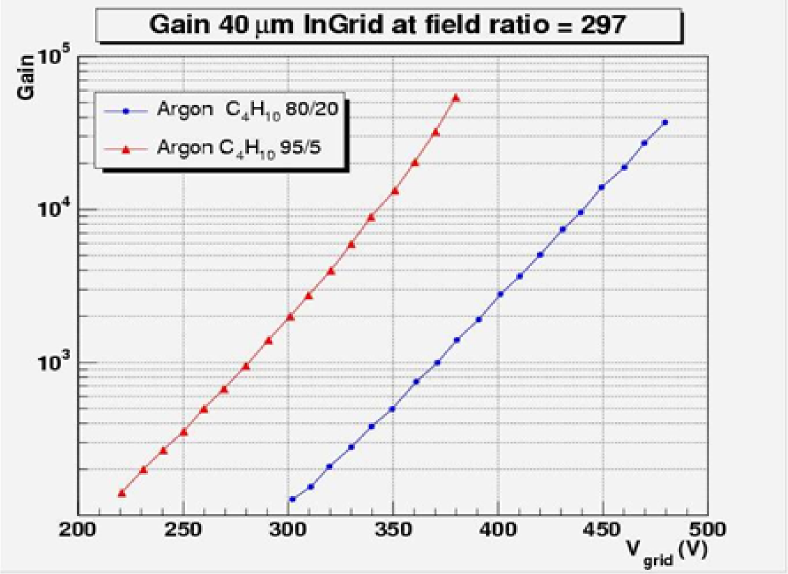
Resolution 14.9% FWHM

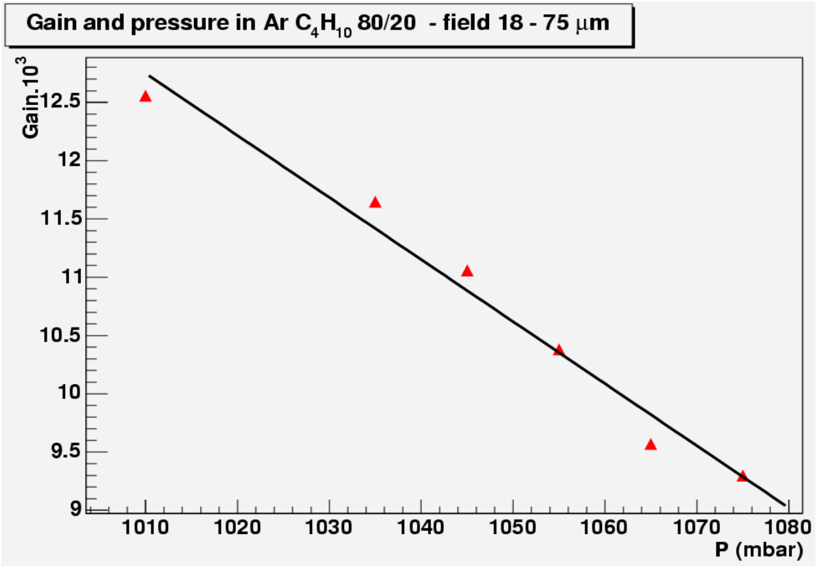
@ 5.9 KeV x-rays

Pressure and gas dependence

- Correction of gain for pressure variations when measuring different fields
- Increment in pressure gives less eficient collisions







Gain decreases of 80 every mbar-1

Resolution different drift field