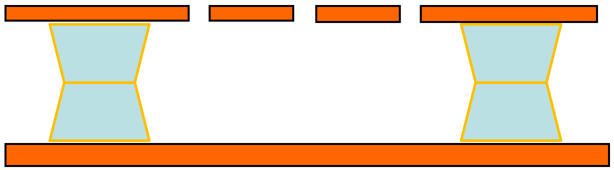
MicroBulk and results in high pressure noble gases

I. Giomataris, CEA-Irfu

New fabrication technology

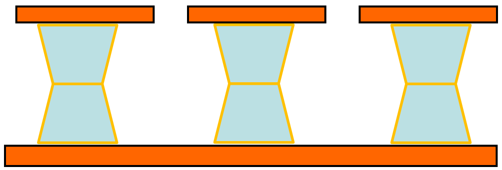
Micro-Bulk

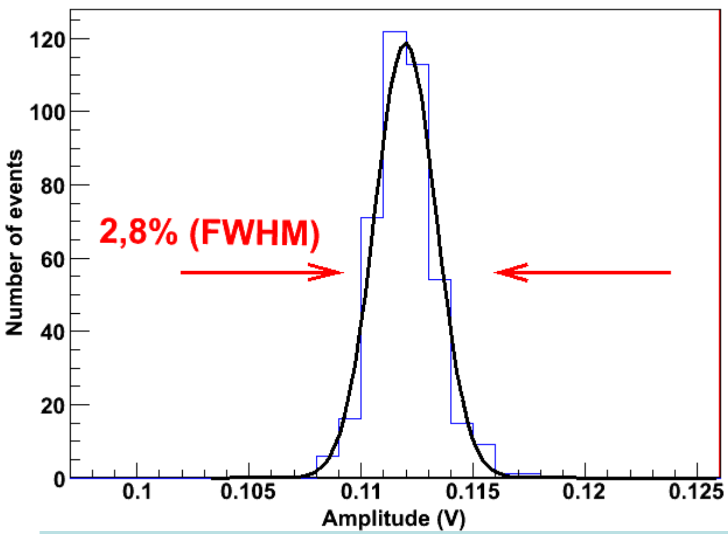
Type1



An I. Giomataris and R. De Oliveira patented idea

Type2





Xe @ 2 bar
Neutrinoless Double Beta (0nbb) using ^{136}Xe target

50 μm and 25 μm gaps fabricated

Very good energy resolution
- -11% at 5.9 keV
- 5.5% at 22 keV
- <1.5% with Am alpha source

Other advantages
- Flexible structure (cylinder)
- Good uniformity
- Low material
- Low radioactivity

Long term stability ?

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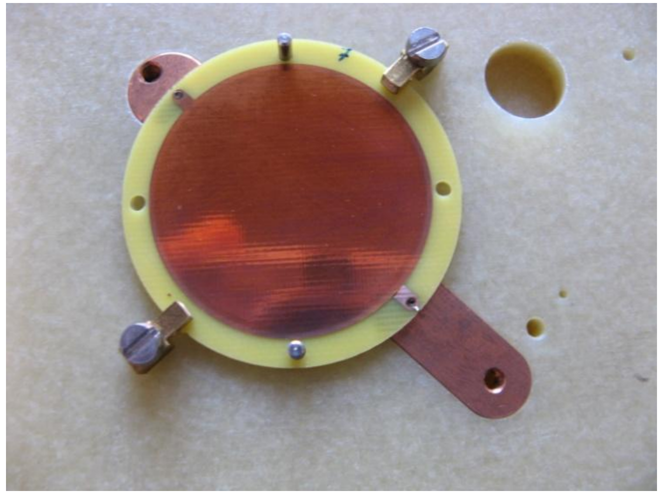
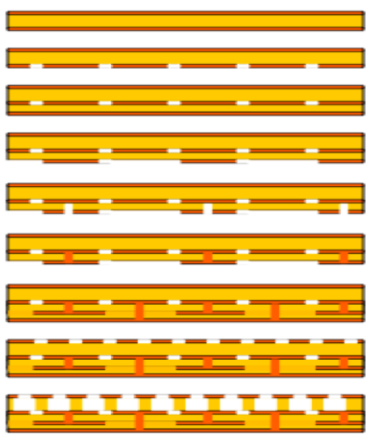
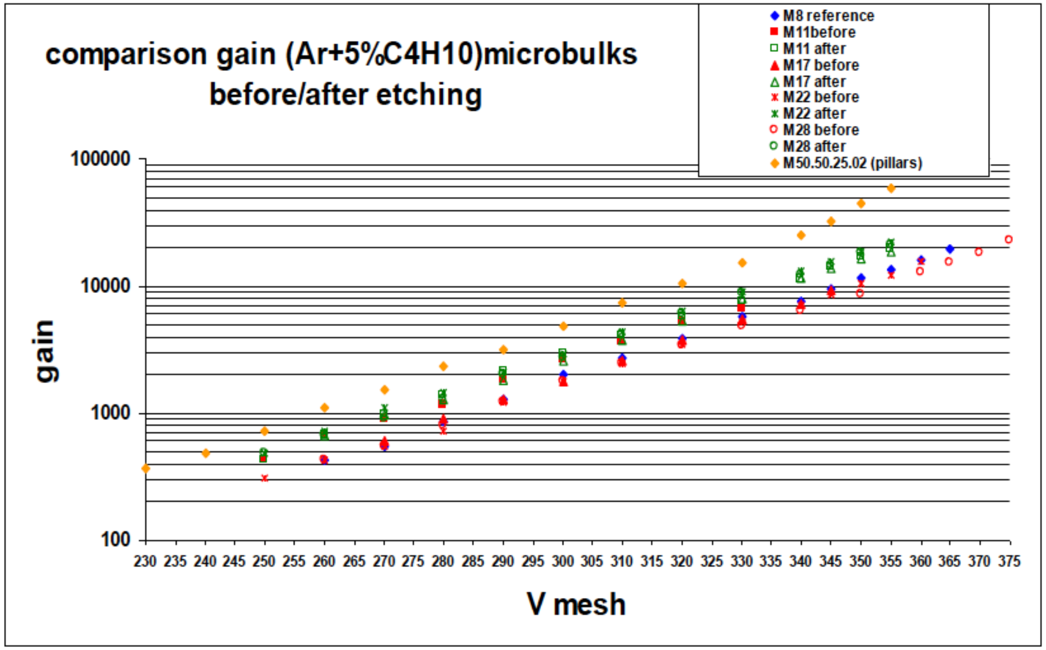
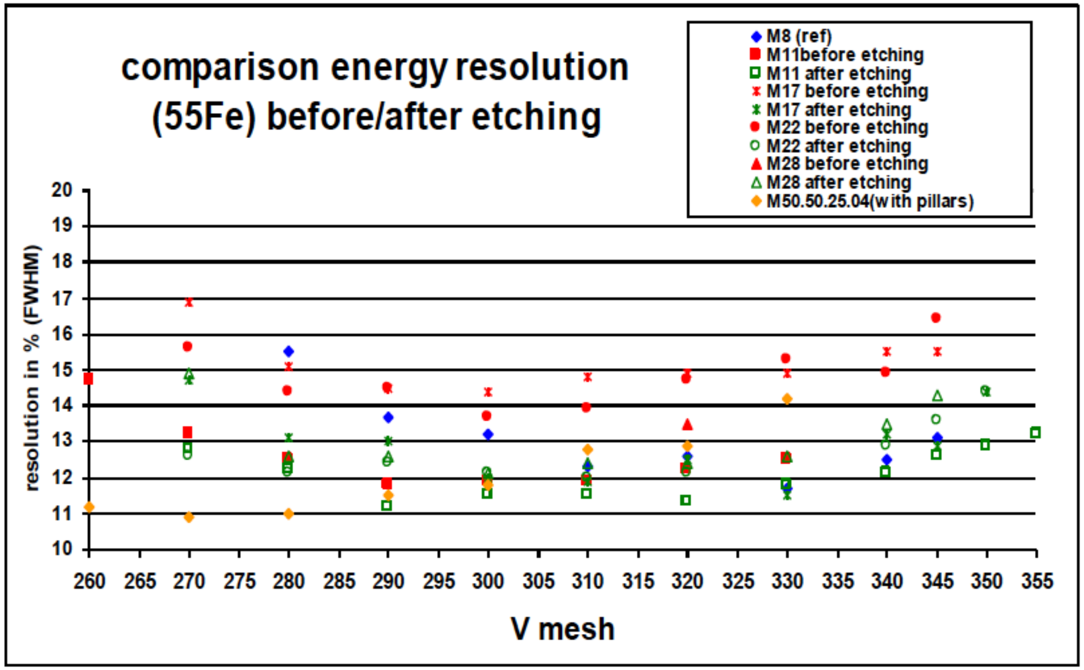




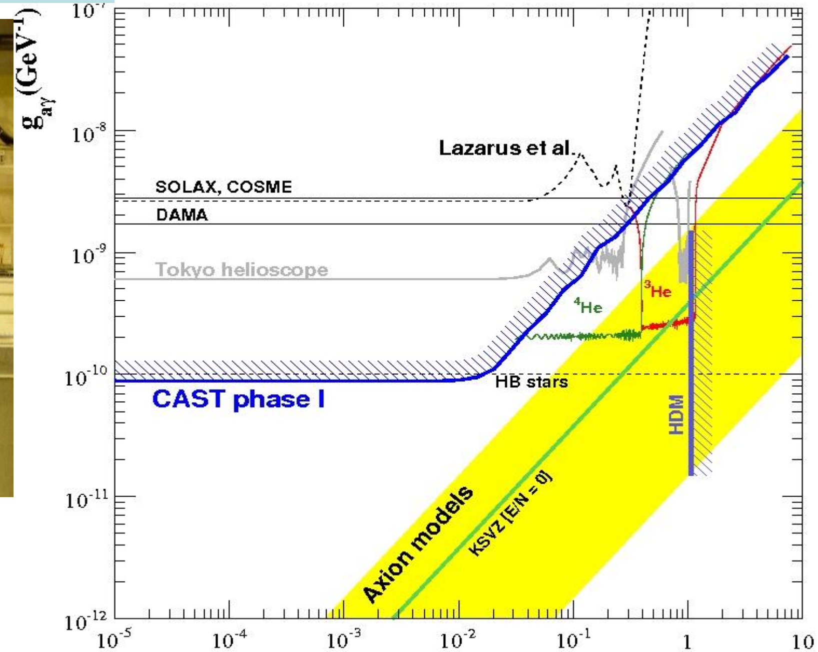
Double side Cu-coated (5 μm) Kapton foil (50 μm),
Construction of readout strips/pads (photolithography)
Attachment of a single-side Cu-coated kapton foil (25/5 μm)
Construction of readout lines
Etching of kapton
Vias construction
2nd Layer of Cu-coated kapton
Photochemical production of mesh holes
Kapton etching / Cleaning

Systematic study with additional etching

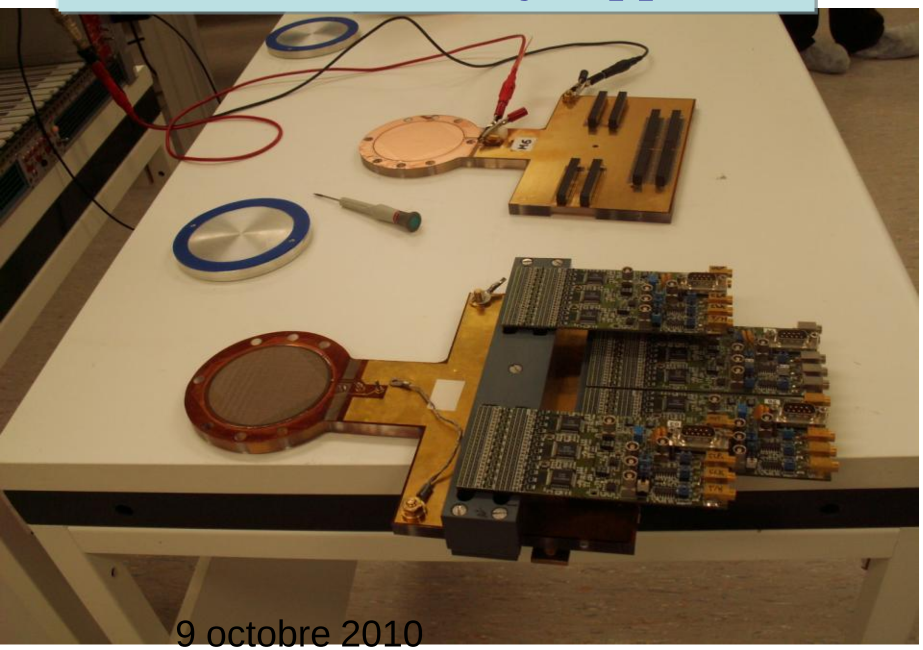


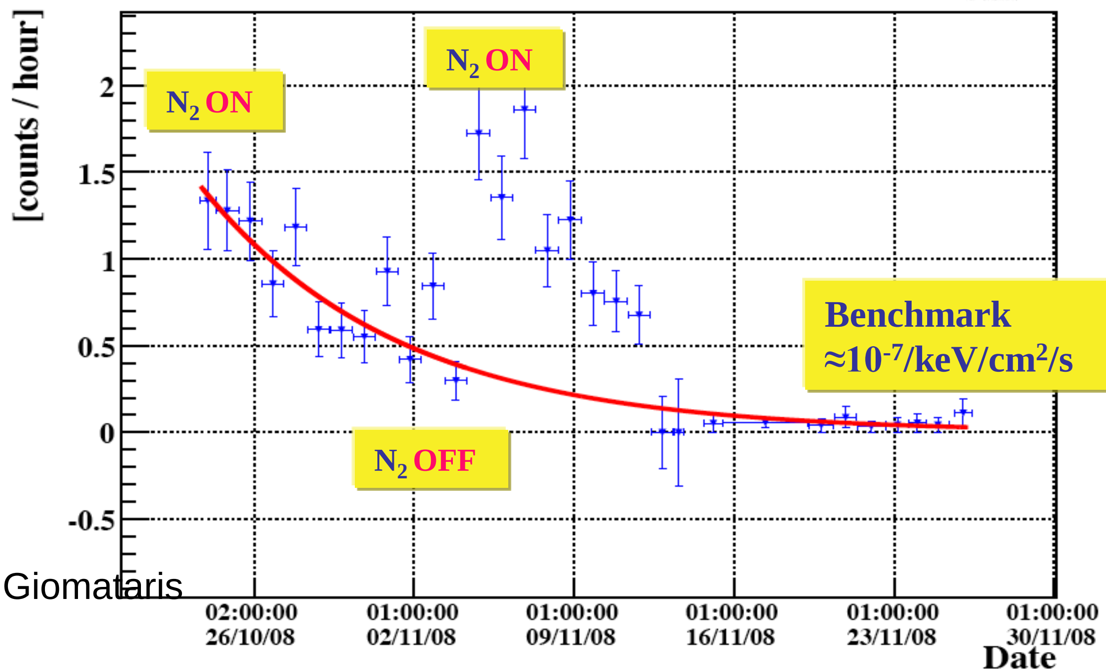


Micro-bulk in CAST - high performance

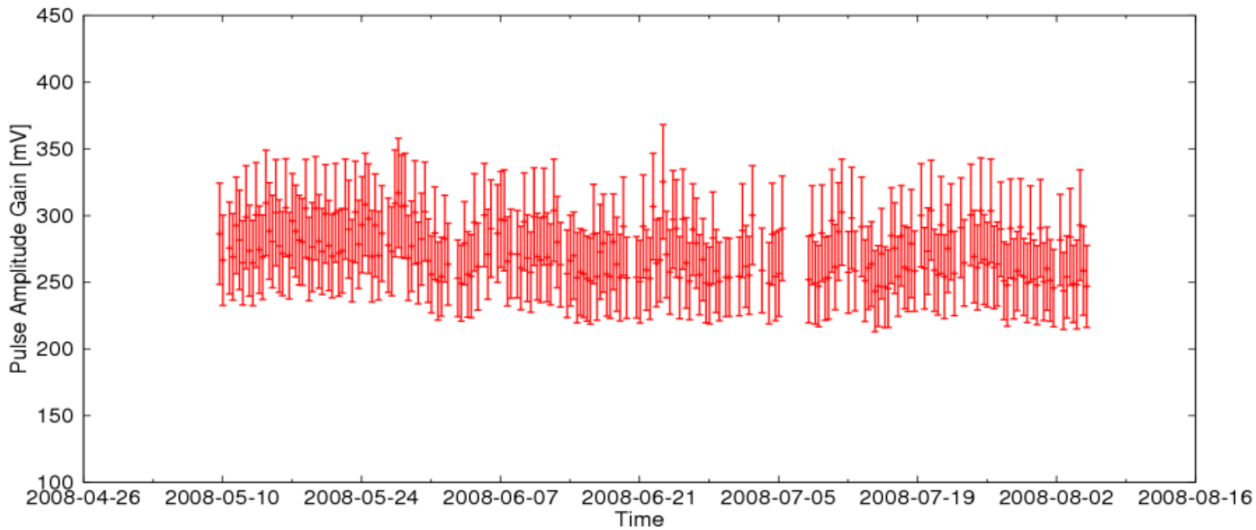


On low radioactivity support



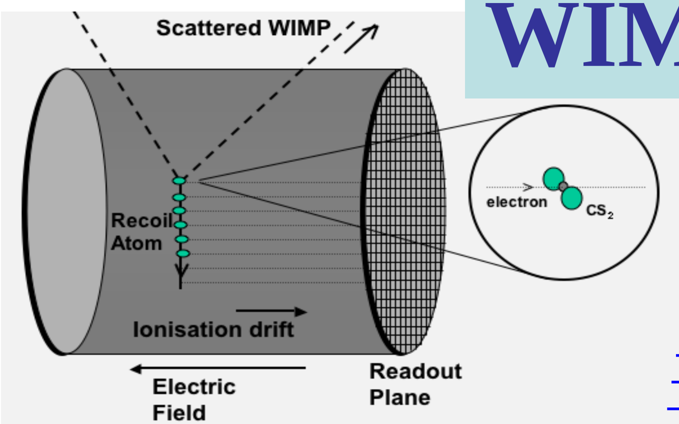


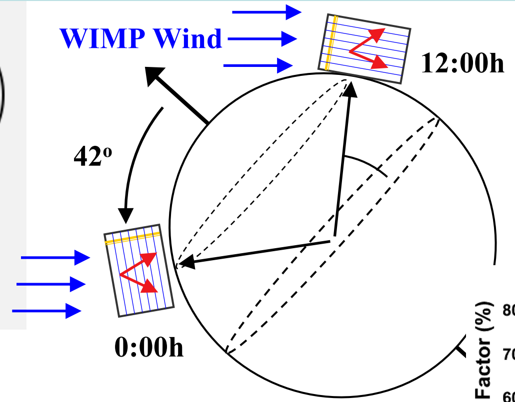
Stability of CAST detector

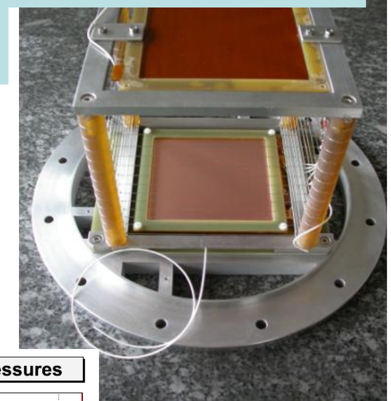


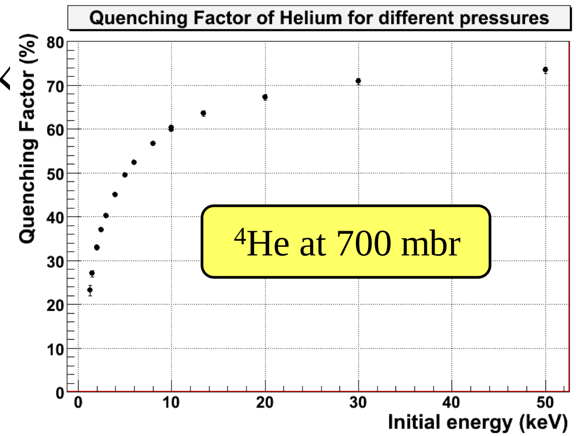
WIMP directional TPCs

Micromegas:µTPC chamber



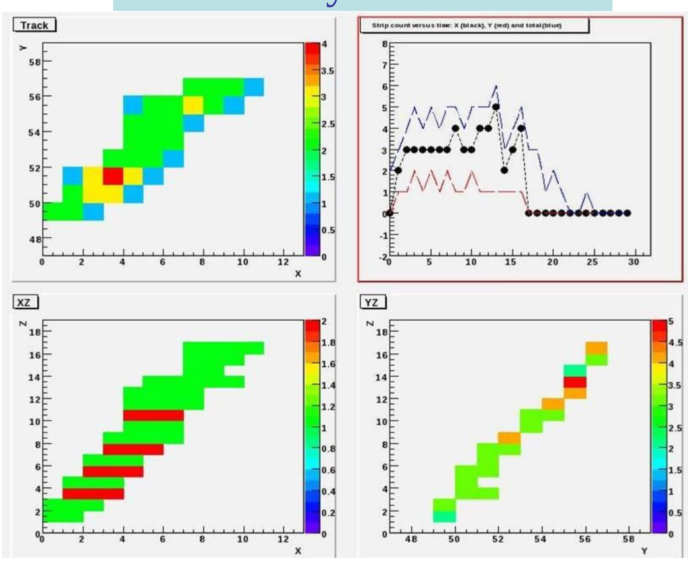




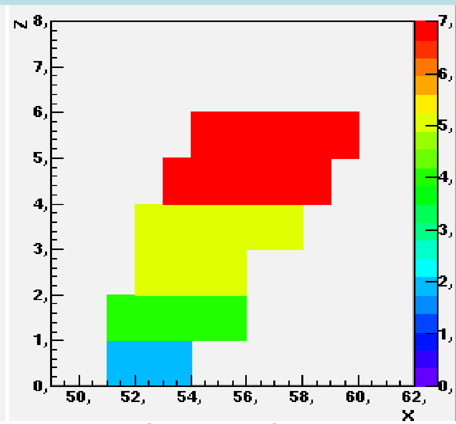


MIMAC-He3 MIcro-tpc Matrix of Chambers of He3
On-baryonic dark matter search, **Micromegas read-out**,
Grenoble – Saclay, Cadarache collaboration

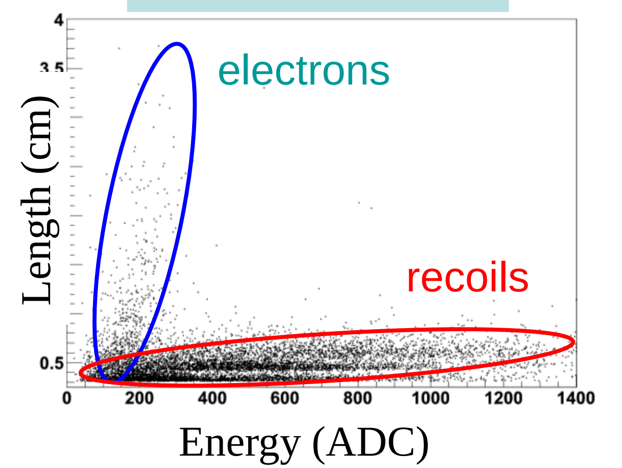
Electrons by 5.9 keV ^{55}Fe



Recoil from 144 keV neutrons



100 mbar Isobutane



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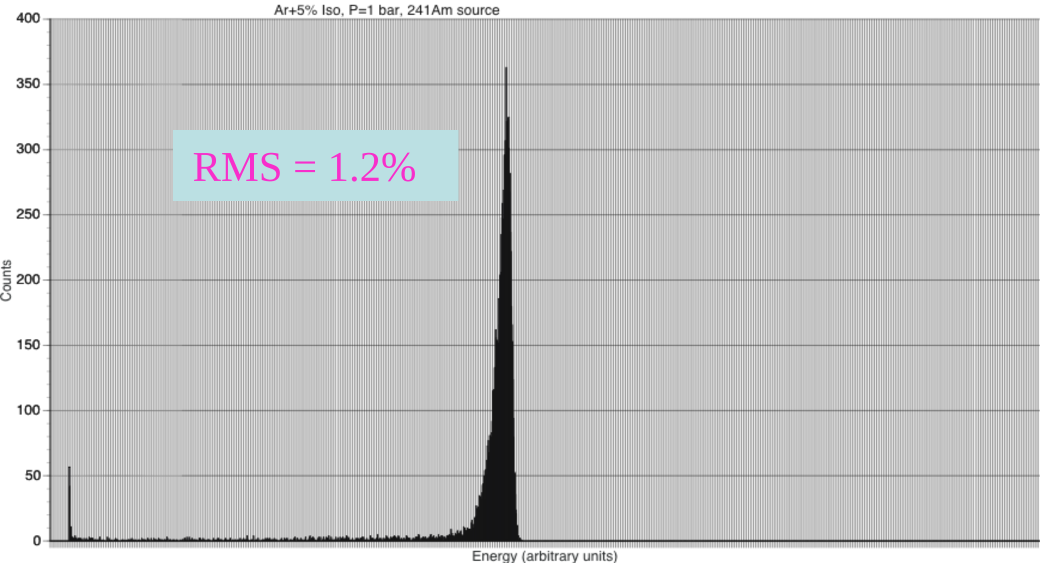
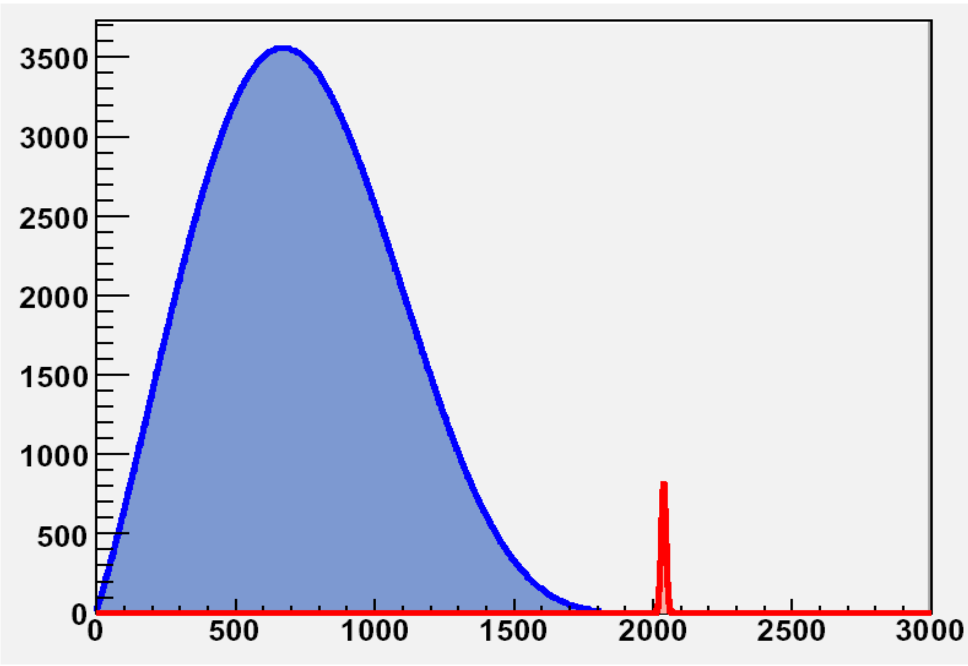
^{241}Am resolution in a small TPC with Micromegas read-out

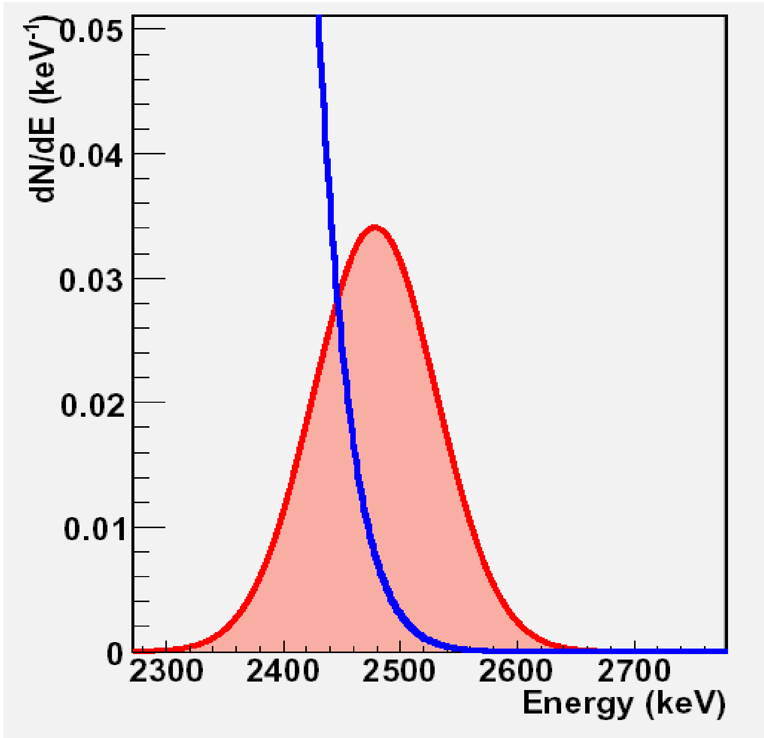
Saclay, Saragoza,Ottawa collaboration



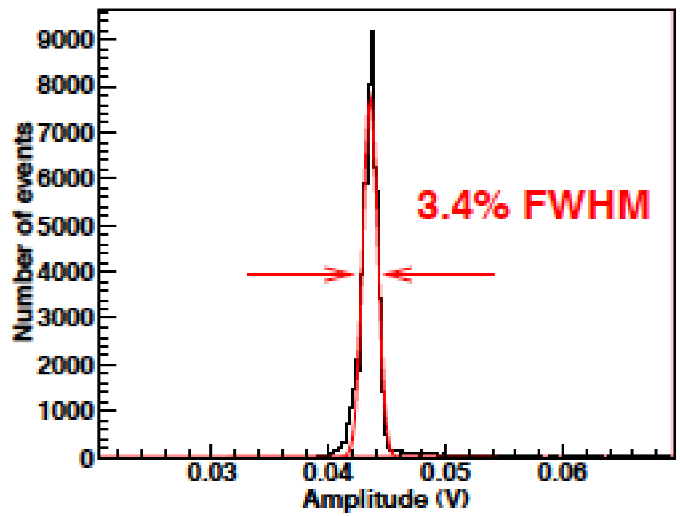
- In Argon energy resolution was constant (RMS=1.2%) up to 4 bar
- We must measure it at higher pressure and in Xenon mixtures
- Neutrinoless Double Beta (0nbb) using ^{136}Xe target

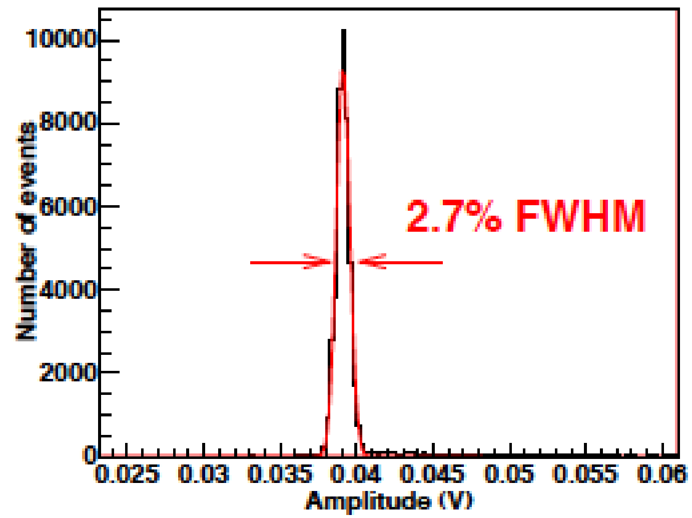


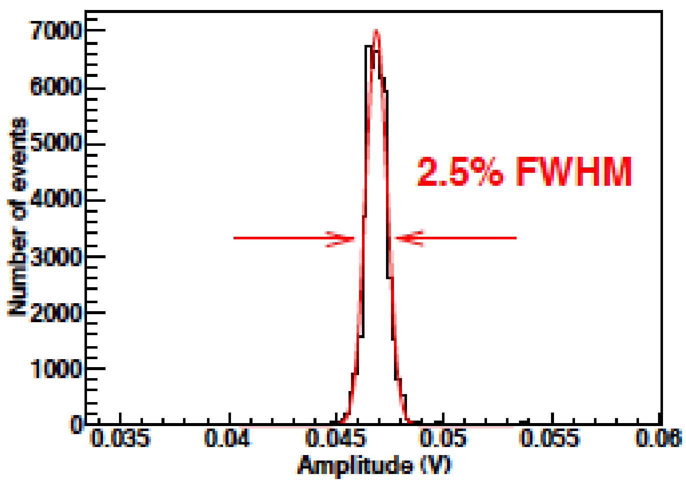
mataris

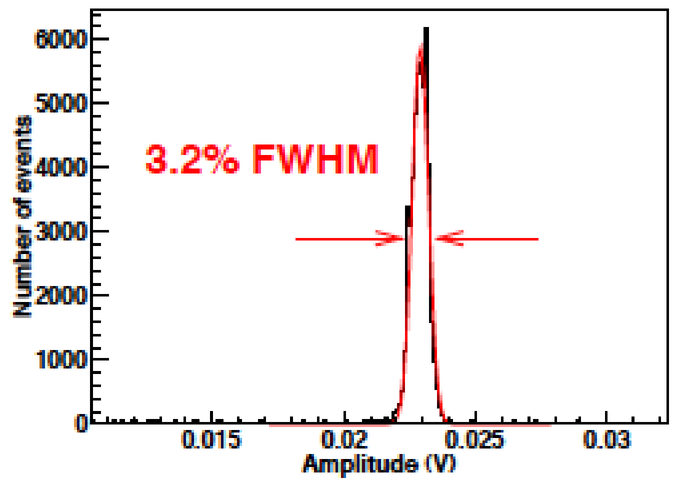


Energy resolution in Xenon 2,3,4,5 bars









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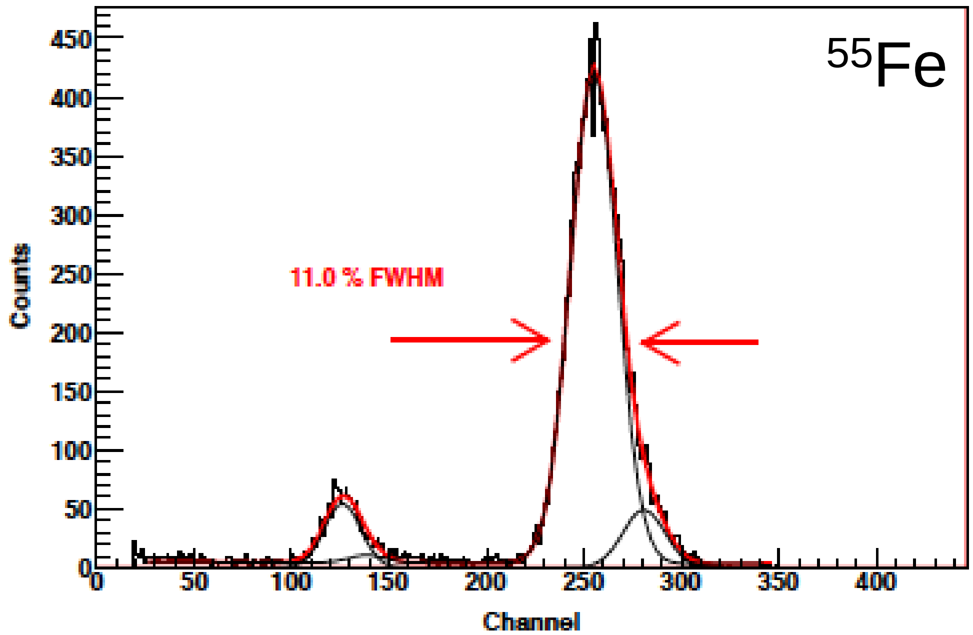
Energy resolution in Argon



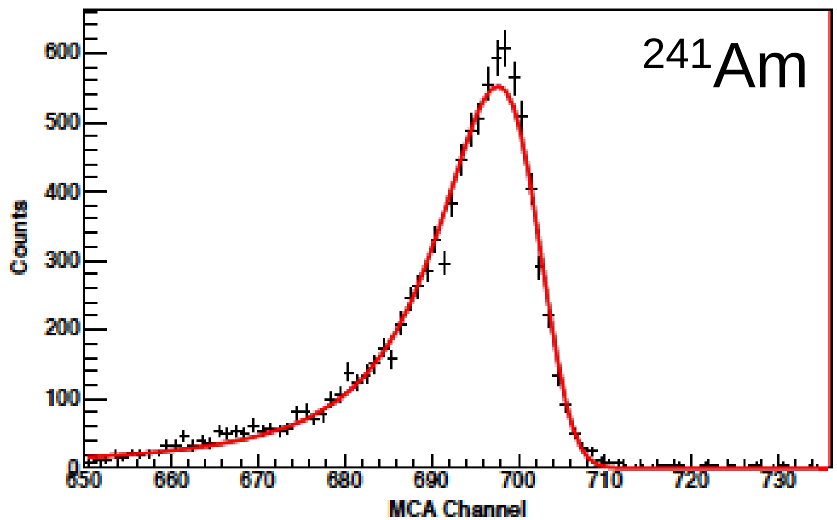
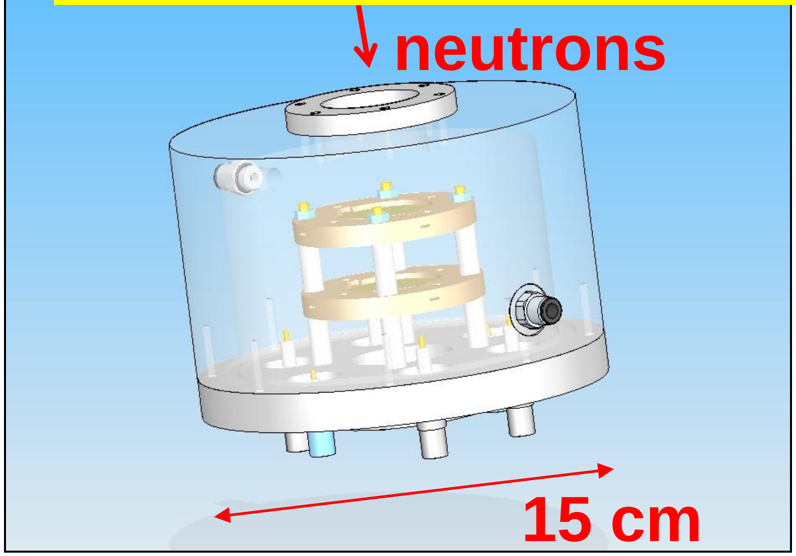
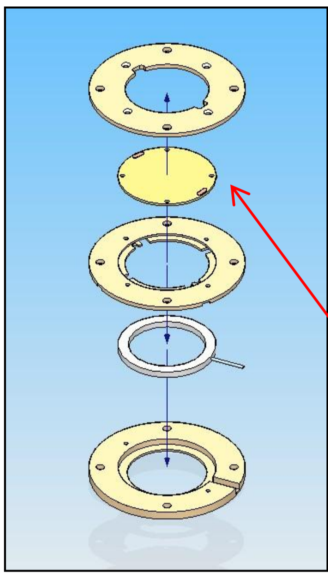
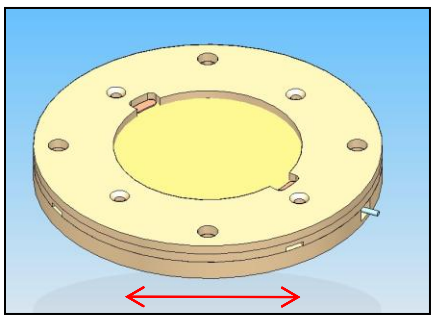


Figure 2. Example of an alpha peak measured in [17], with the fit to a Landau function convoluted with a gaussian. The best fit values for the FWHM of the gaussian component is 0.7%.

MicroMegas neutron flux monitor
World record on low material budged

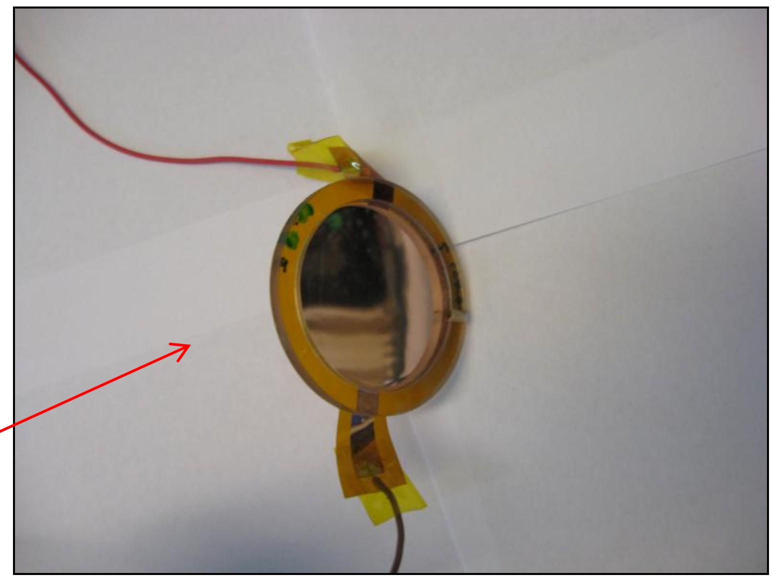


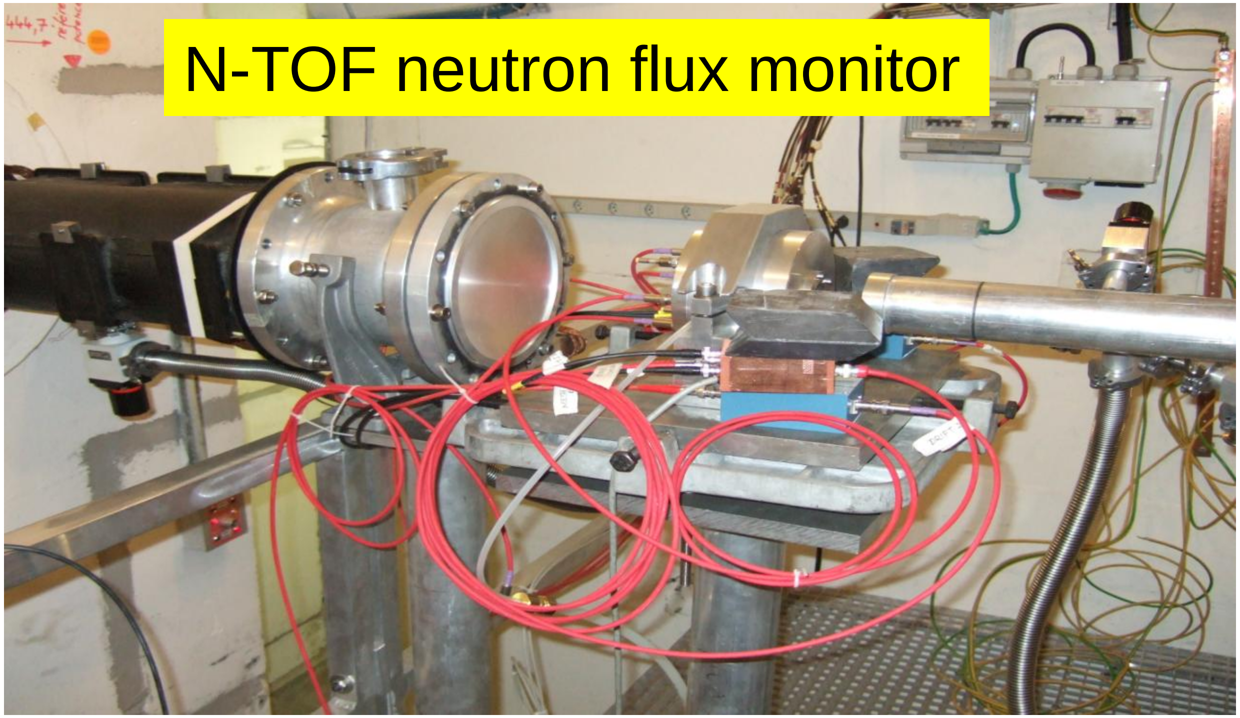


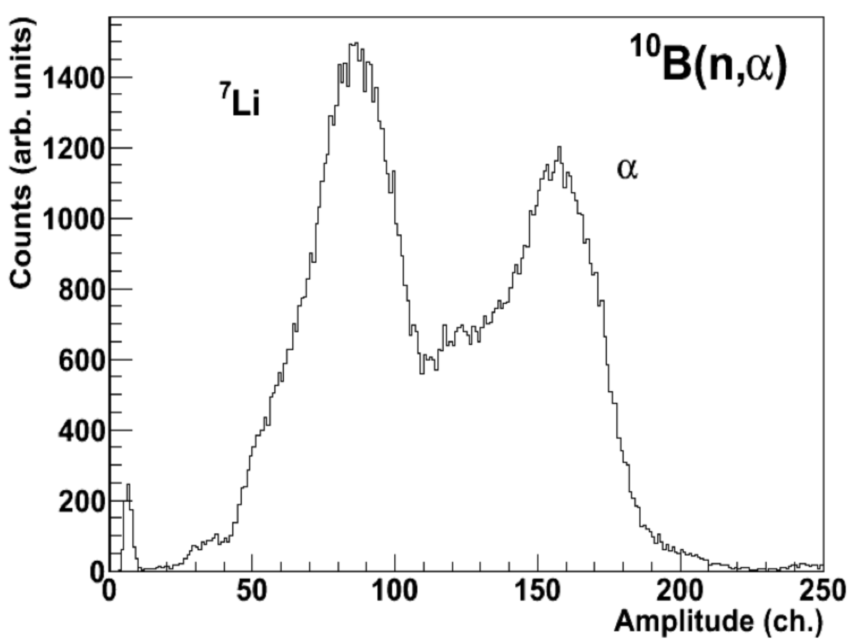


3.5 cm beam interception

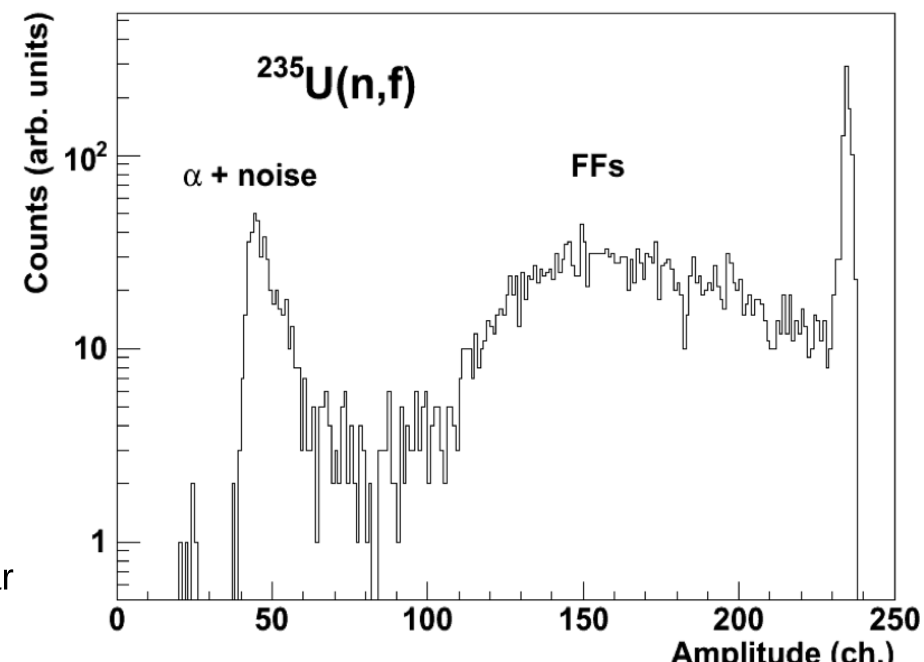
MicroBulk



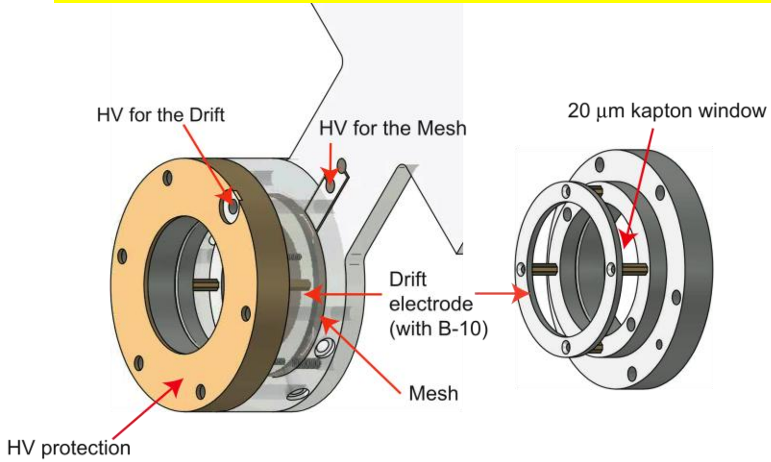

N-TOF neutron flux monitor

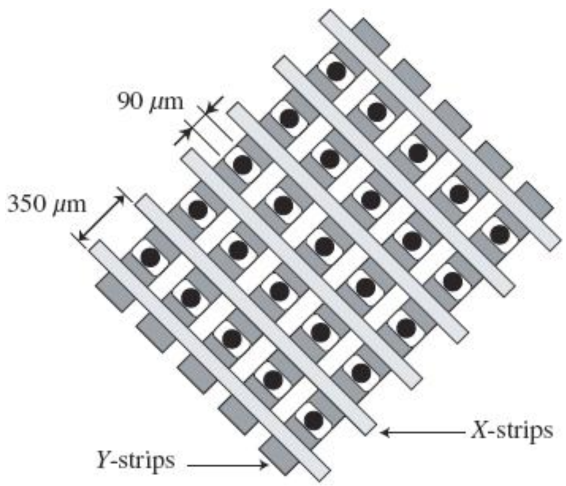

10B(n,α)
7Li
α
Counts (arb. units)
Amplitude (ch.)
0
200
400
600
800
1000
1200
1400
50
100
150
200
250

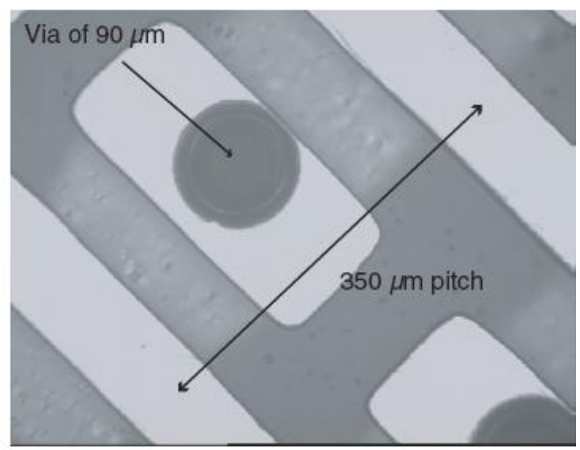
I. Giomatar

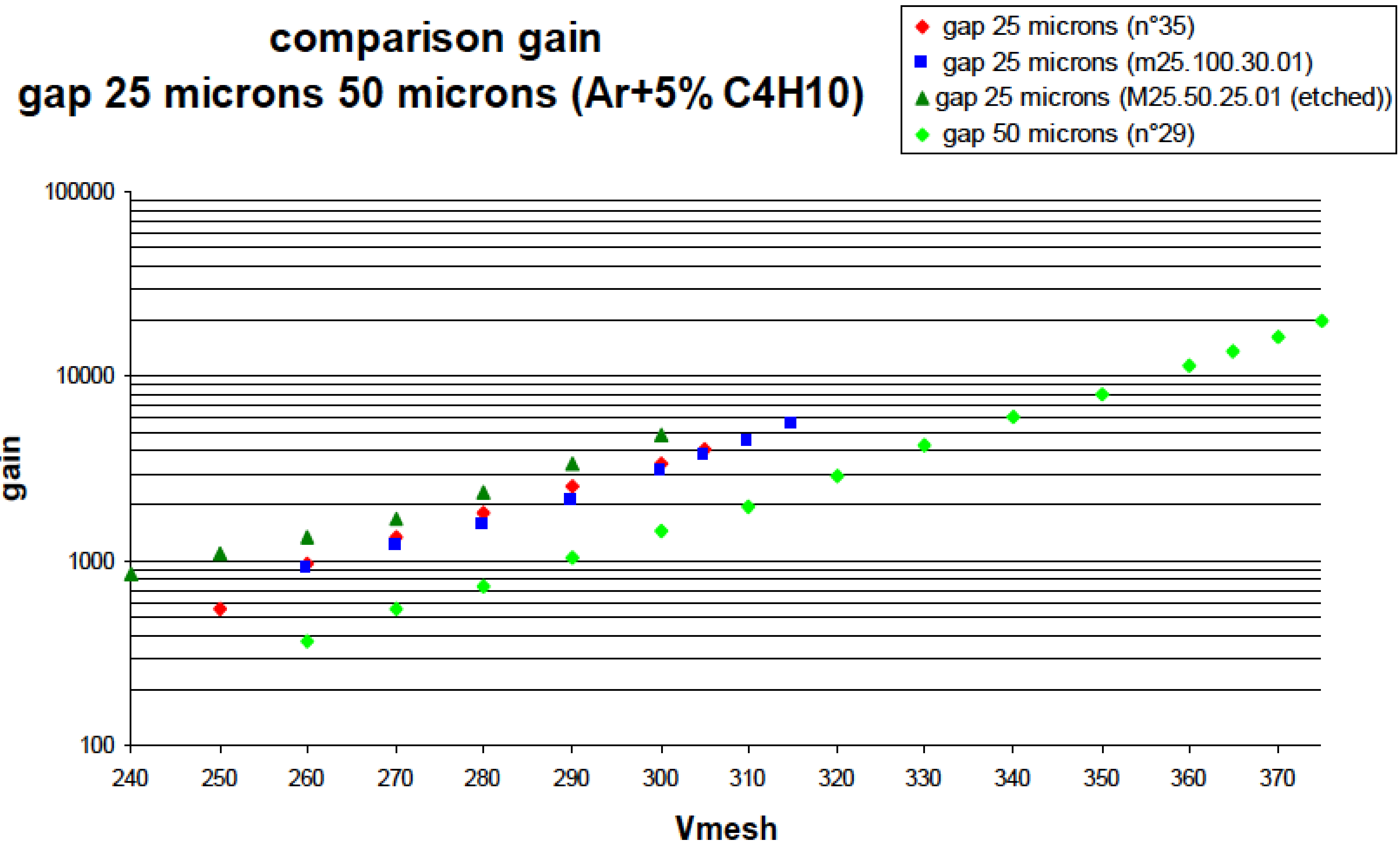

235U(n,f)
α + noise
FFs
Counts (arb. units)
Amplitude (ch.)
1
10
10²
0
50
100
150
200
250

N-TOF neutron profile detector









comparison gain
gap 25 microns 50 microns (Ar+5% C4H10)
gap 25 microns (n°35)
gap 25 microns (m25.100.30.01)
gap 25 microns (M25.50.25.01 (etched))
gap 50 microns (n°29)
gain
100000
10000
1000
100
240
250
260
270
280
290
300
310
320
330
340
350
360
370
Vmesh

Micromegas operation in high pressure xenon: charge and scintillation readout

C. Balan[1], E.D.C. Freitas[1], T. papaevangelou[2], I. Giomataris[2], H. Natal da Luz[1], C.M.B. Monteiro[1], J.M.F. dos Santos[1]

[1]Instrumentation Centre, Physics Department, University of Coimbra, 3004-516 COIMBRA, Portugal

[2]Saclay…..

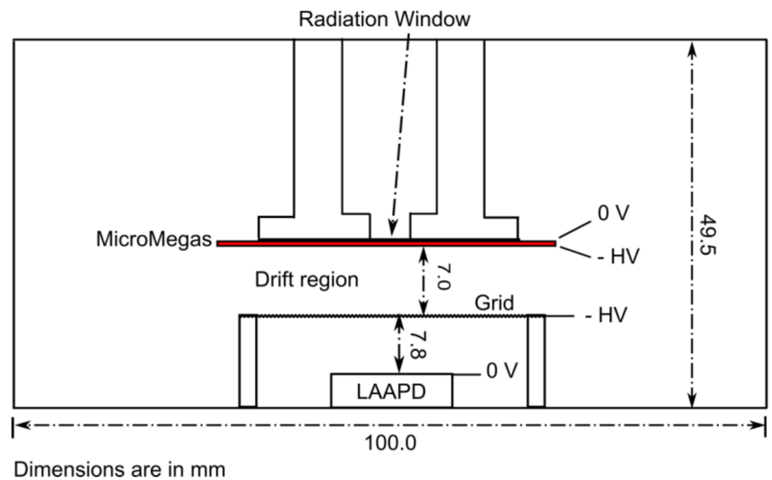


Figure 2- Typical pulse-height distributions obtained for the ^{109}Cd X-ray source; a) for the charge readout channel and b) for the scintillation readout channel.

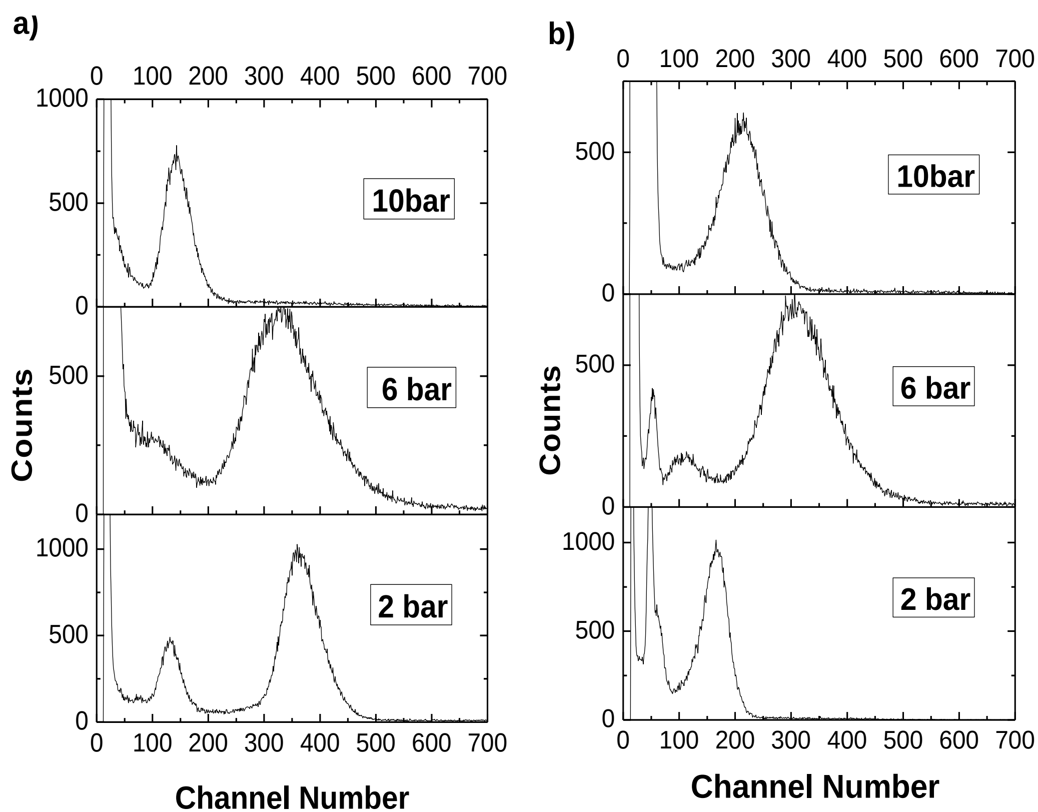
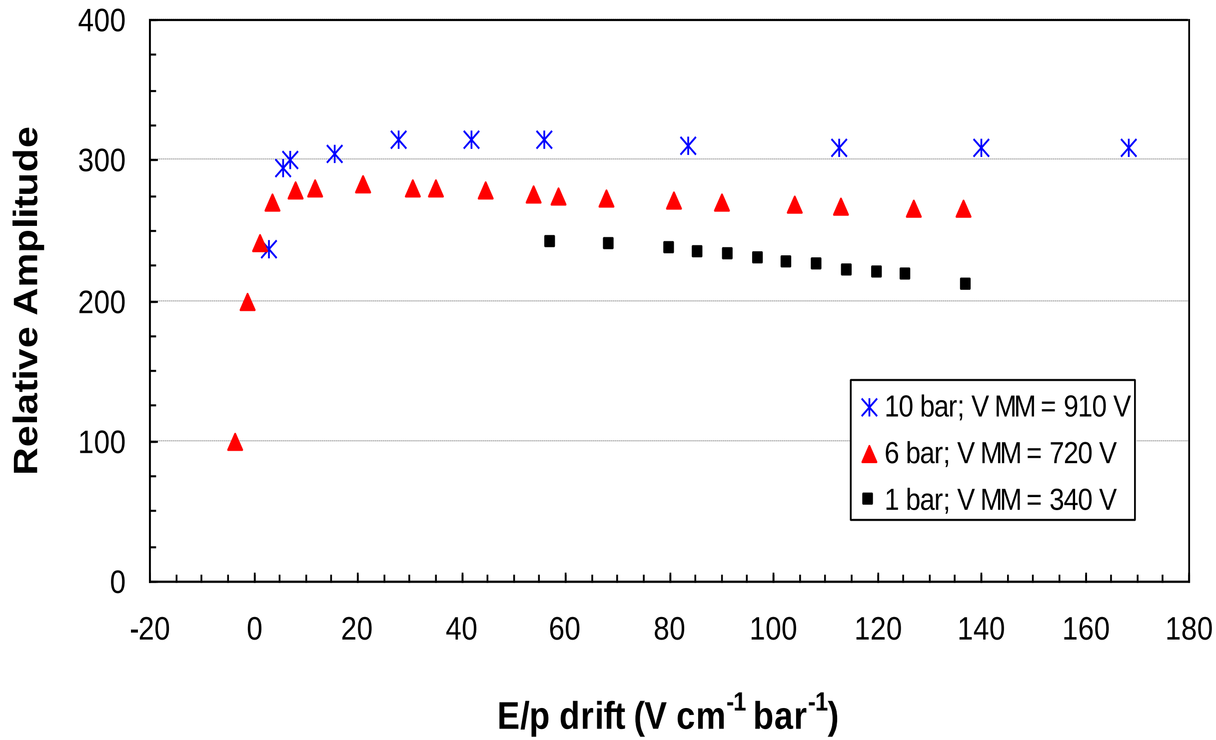


Figure 3- MM relative amplitude as a function of reduced electric field in the drift region



The maximum gain achieved in the scintillation readout channel presents an even smaller dependence with pressure, increasing by a factor of 3 up to 5 bar and, then, decreasing within a factor of two up to 10 bar, as shown in Fig.4b) and Fig.5.

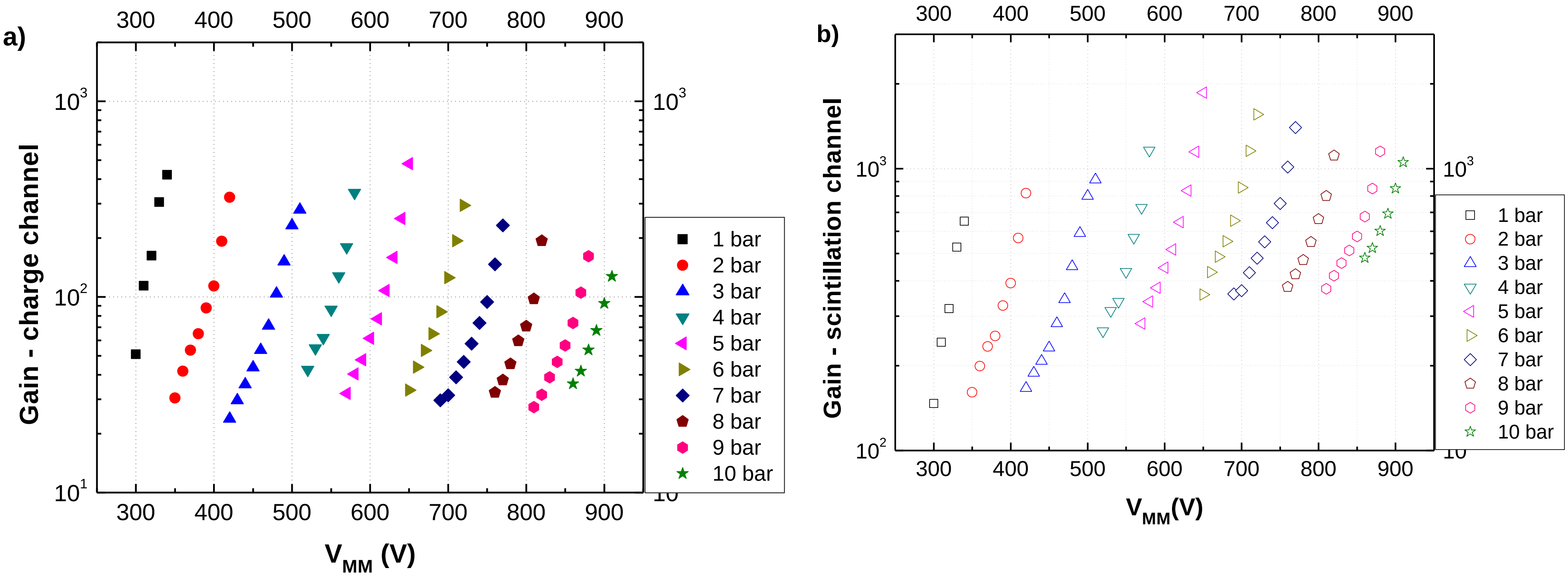
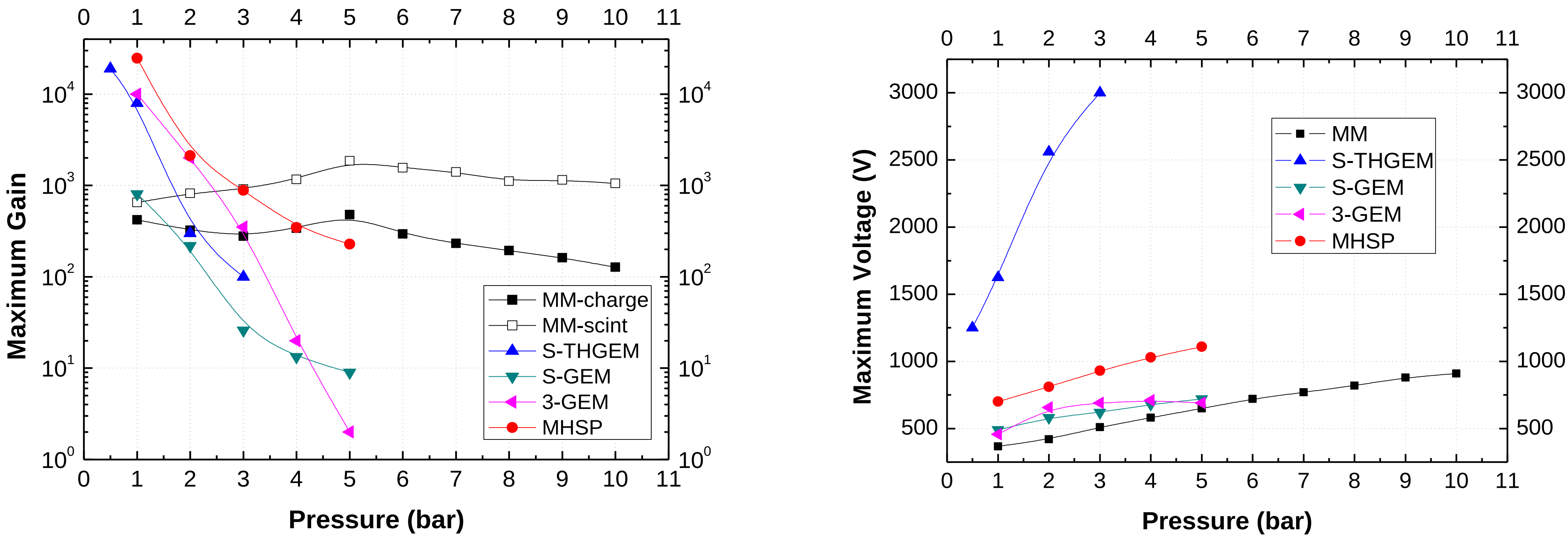


Figure 5 – Maximum gains obtained with the MM for both charge and scintillation readout channels as a function of pressure in the 1 to 10 bar range. For comparison the maximum gains obtained with other micropattern gas electron multipliers are also depicted as a function of pressure: triple-GEM [9], MHSP [10], GEM [11], THGEM [12].



[9] V. Aulchenko et al., *Further studies of GEM performance in dense noble gases*, Nucl. Instr. Meth. A 513 (2003) 256 and references therein.

[10] F.D. Amaro et al., *Operation of MHSP multipliers in high pressure pure noble-gas*, J. Inst. 1 (2006) P04003.

[11] A.S. Conceição, et al., *Operation of a single-GEM in noble gases at high pressures*, 2007 J. Inst. 2 P09010.

[12] R. Alon et al., *Operation of a Thick Gas Electron Multiplier (THGEM) in Ar, Xe and Ar-Xe*, J. Inst. 3 (2008) P01005.

Figure 9 – Detector energy resolution for the 22.1 keV as function of MM biasing voltage and for the different xenon pressures: a) charge readout channel, b) scintillation readout channel.

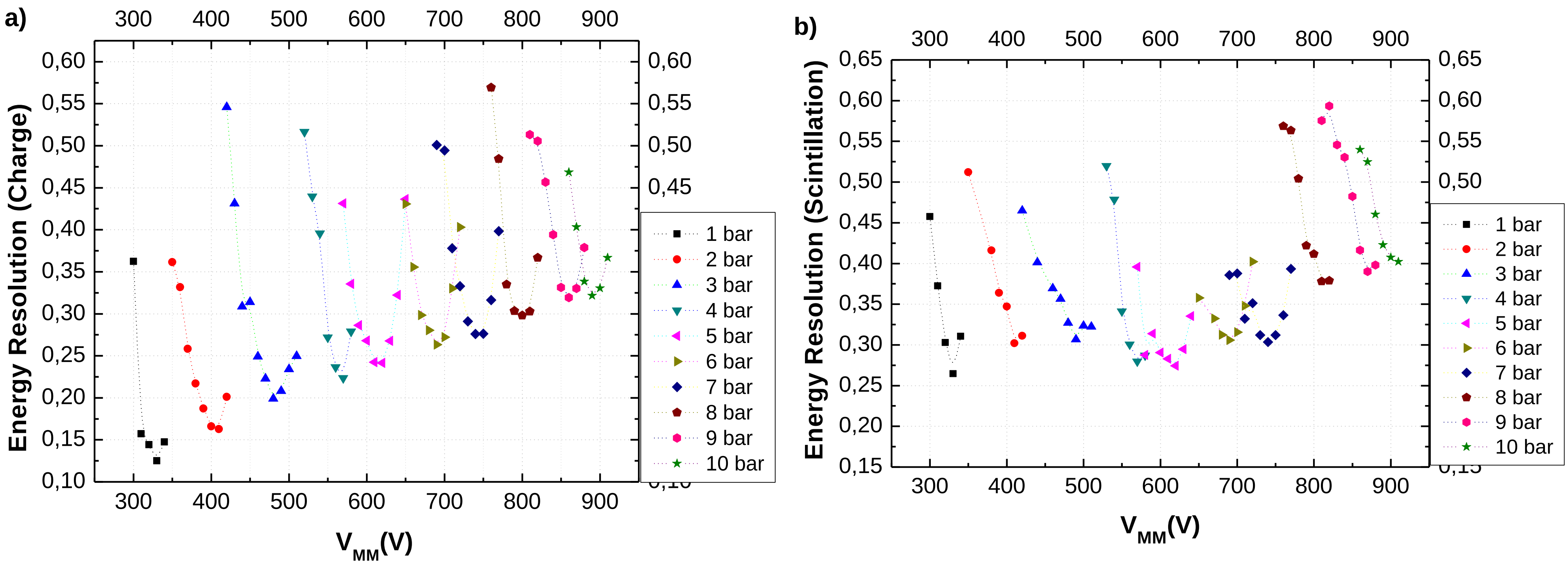
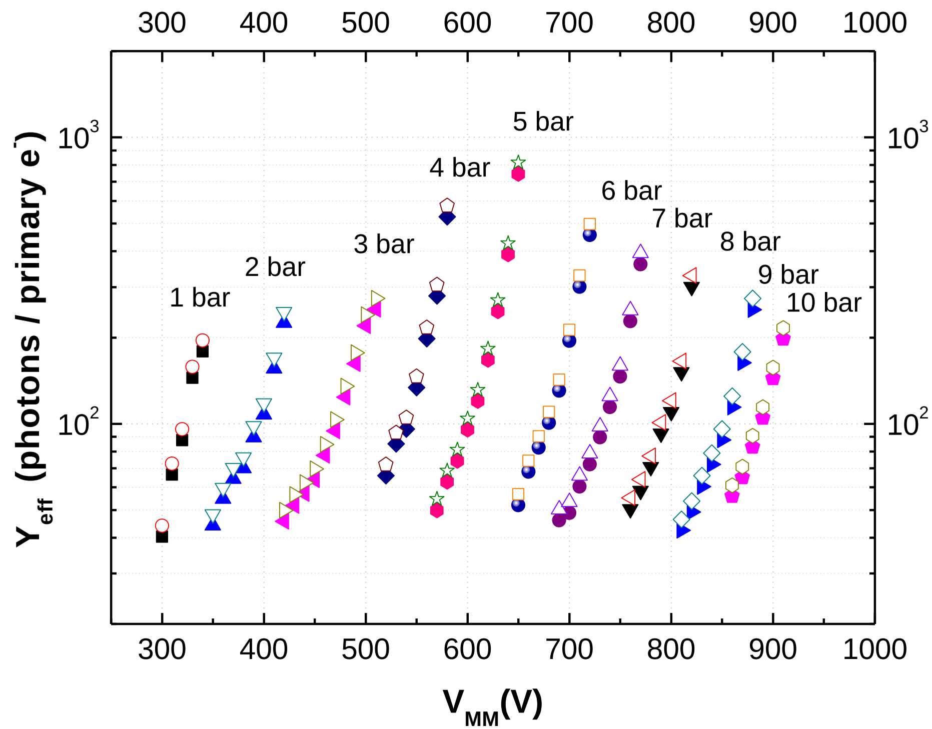


Figure 11 – Effective scintillation Yield, i.e. number of photons emitted from the MM per primary electron produced in the drift region, as a function of MM biasing voltage. Solid symbols: using direct X-ray interactions in the LAAPD as a reference; open symbols: using the gain calibration of the electronic chain and an LAAPD gain of about 30.



Future developments of micro-Bulks
Very high priority of our group

- Improve robustness
- Larger surfaces
- Further decrease material (<10% of a silicon detector)
- Decrease capacity
- Increase optical transparency
- Push mesh technology (1000-2000 LPI?)
- Smaller amplification gaps (<10microns?)
- Spark protection
- Segmentation for spark protection
- Novel X-Y structure
- Light emission study, photodetection, …….