Hybrid Multi Micro-Pattern Gaseous Photomultiplier for detection of liquid xenon scintillation

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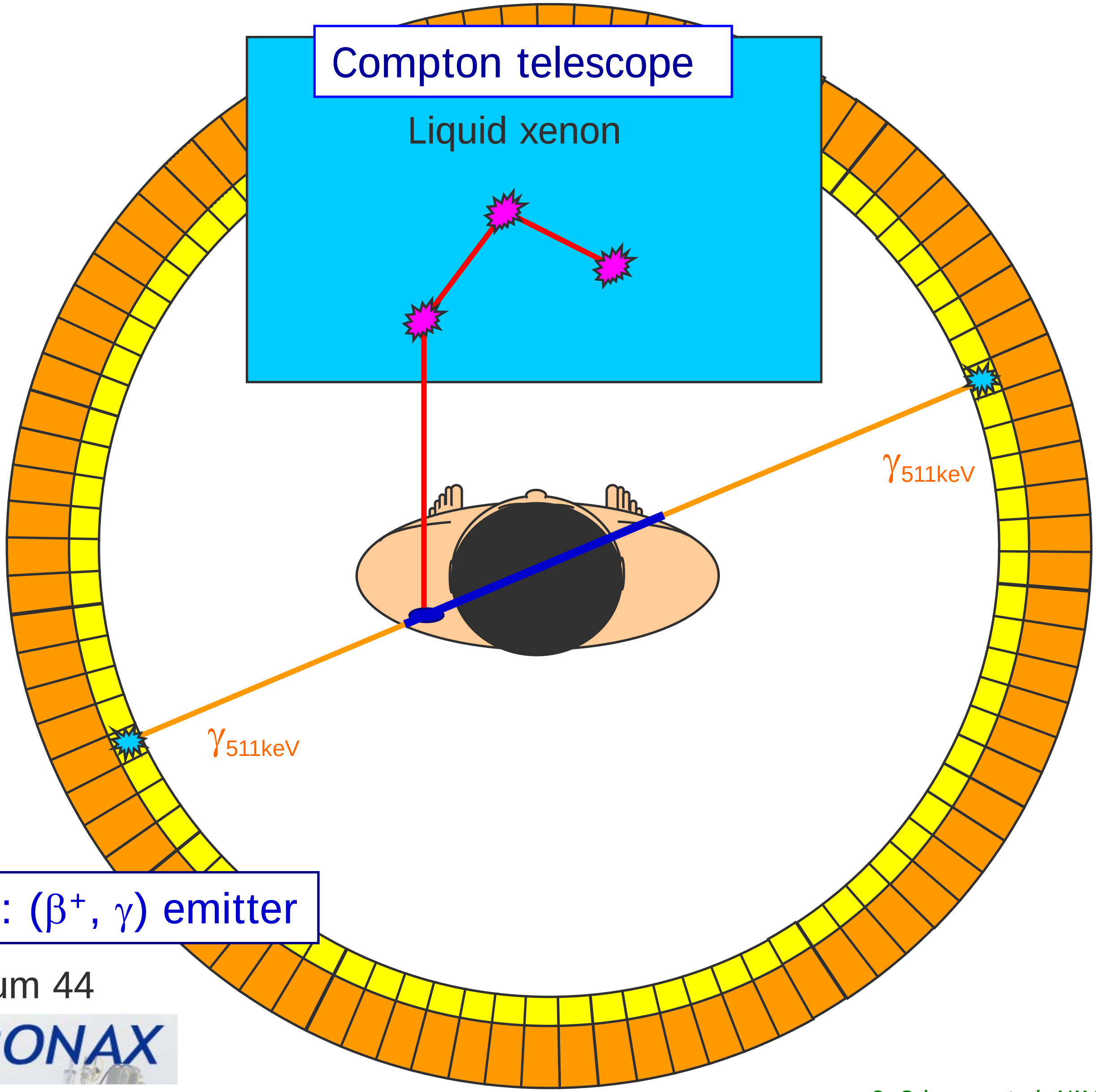
Context: 3γ imaging

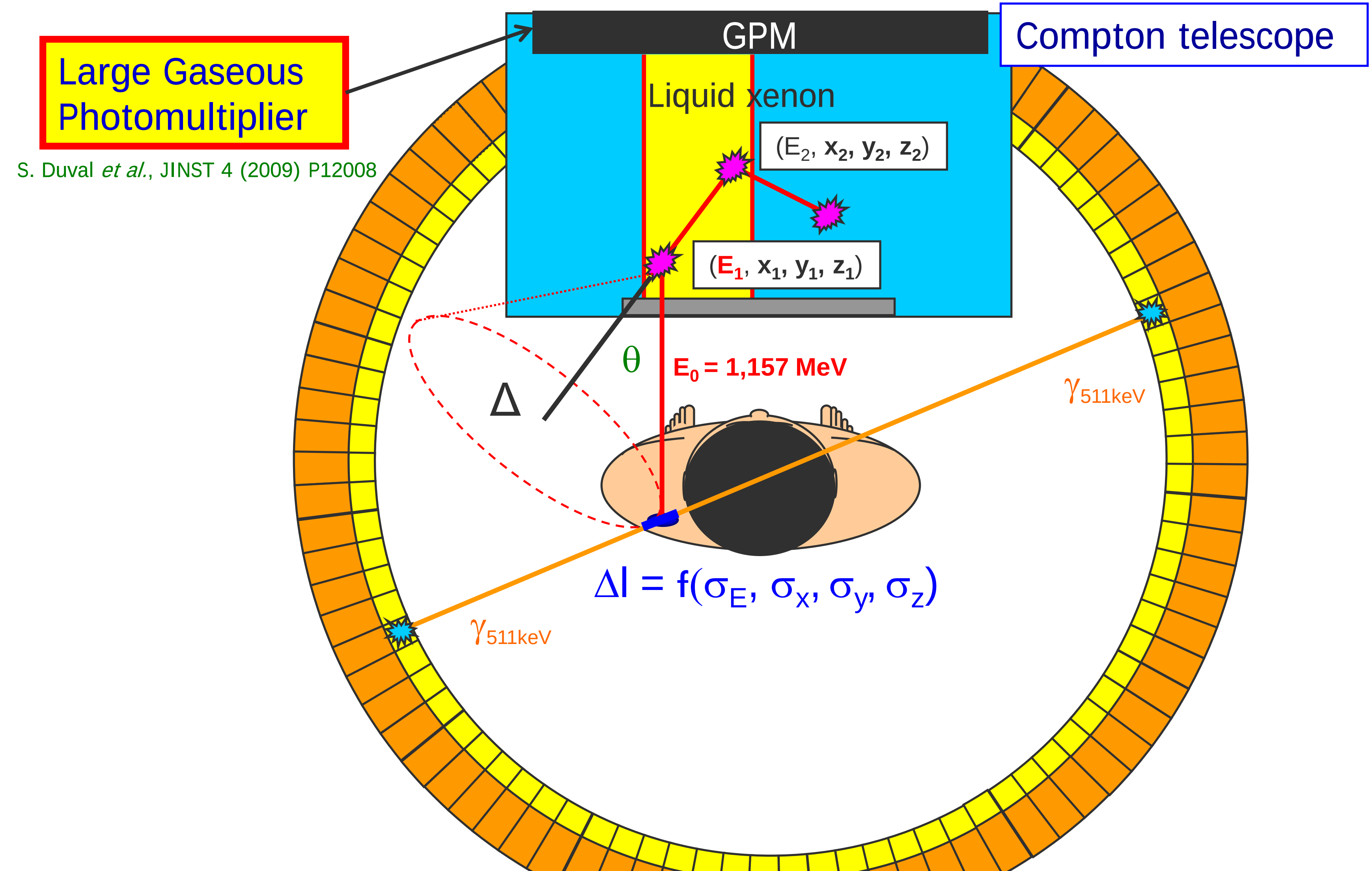


Radioisotope : (β^+, γ) emitter

Scandium 44

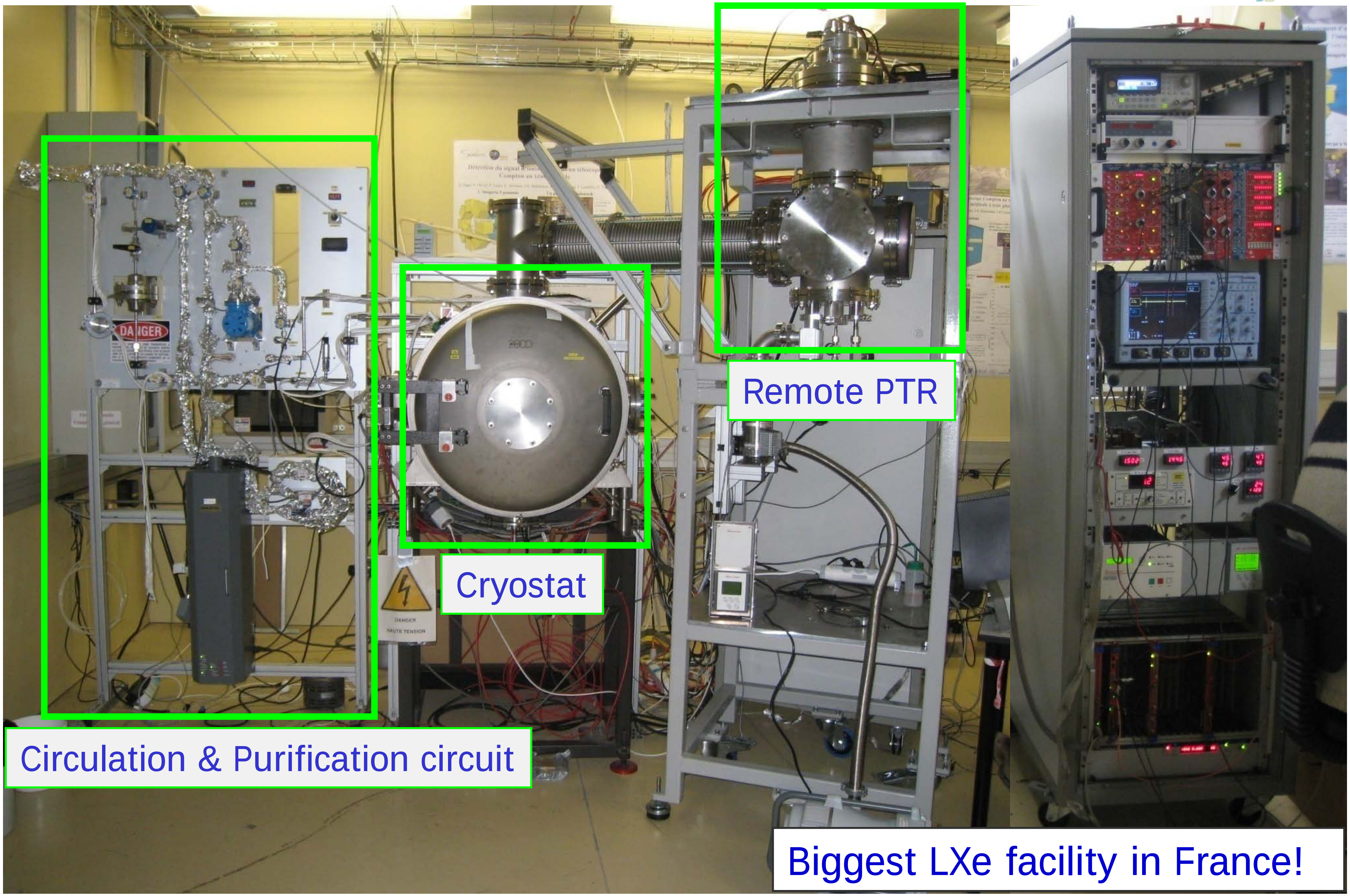
C. Grignon *et al.*, NIM A 571 (2007) 142

Context: 3γ imaging

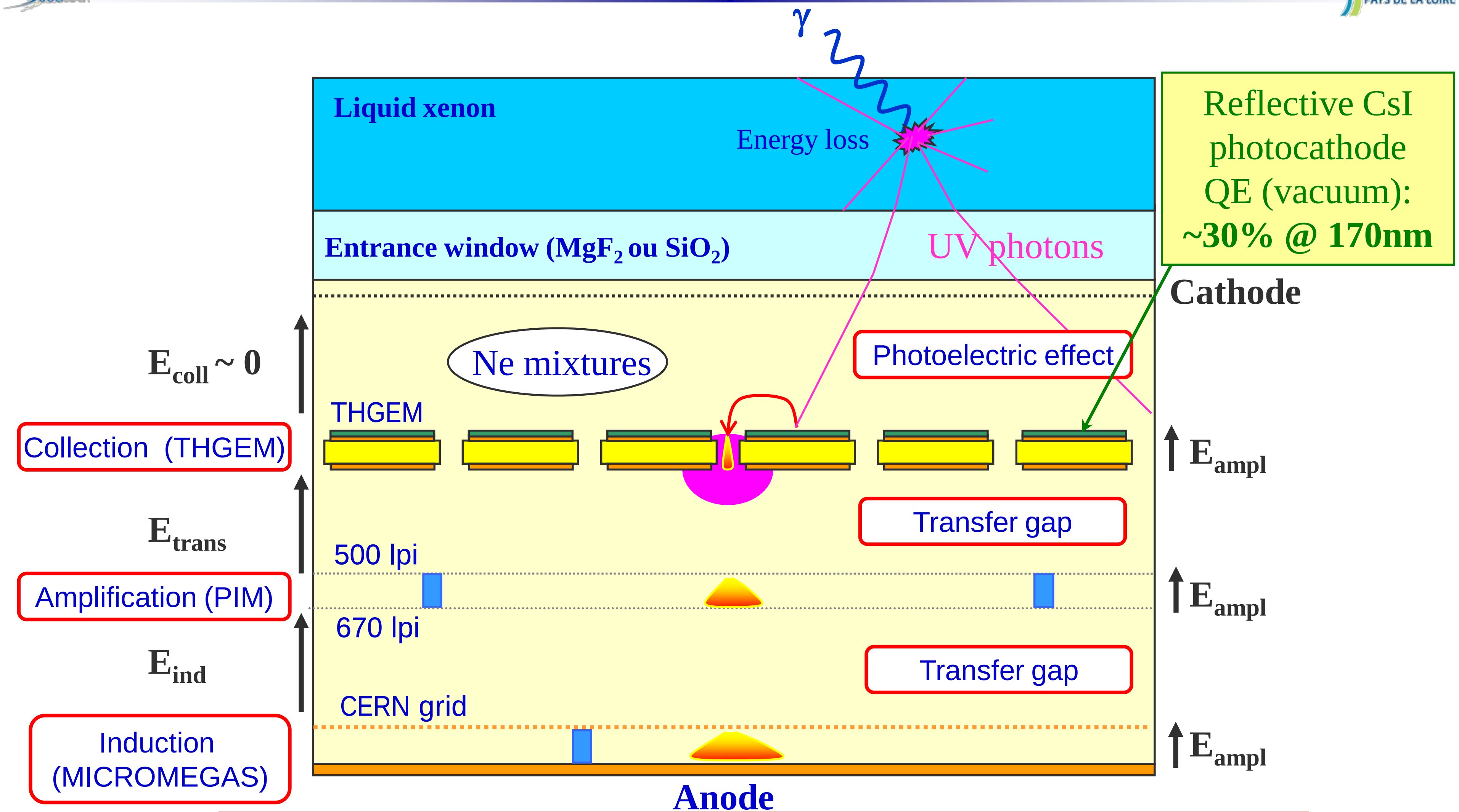


Cryo-GPM: of interest for Next Generation Dark Matter Experiments!

XEnon Medical Imaging System



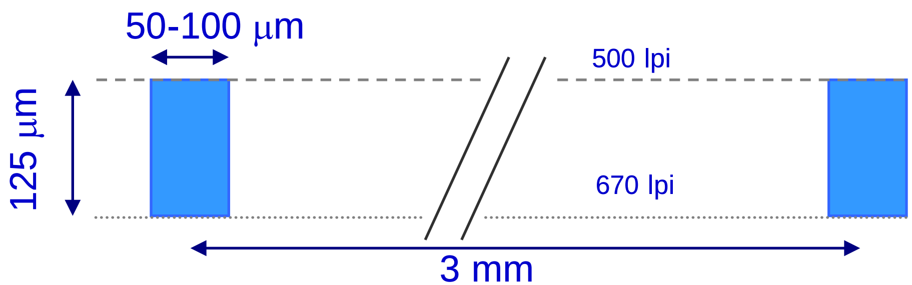
Cryogenic GPM prototype principle

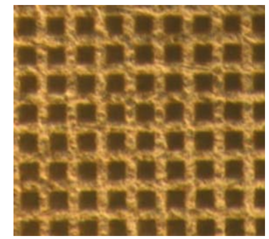


THGEM: Efficient photoelectron collection + low gain
PIM/MICROMEGAS: ion blocking (less CsI damage) & gain

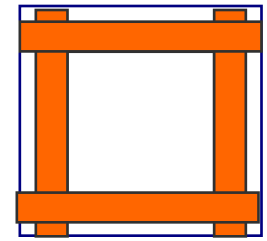
Ion blocking with micromeshes

Avalanche-ions blocking ➔ reduced damage to CsI photocathode



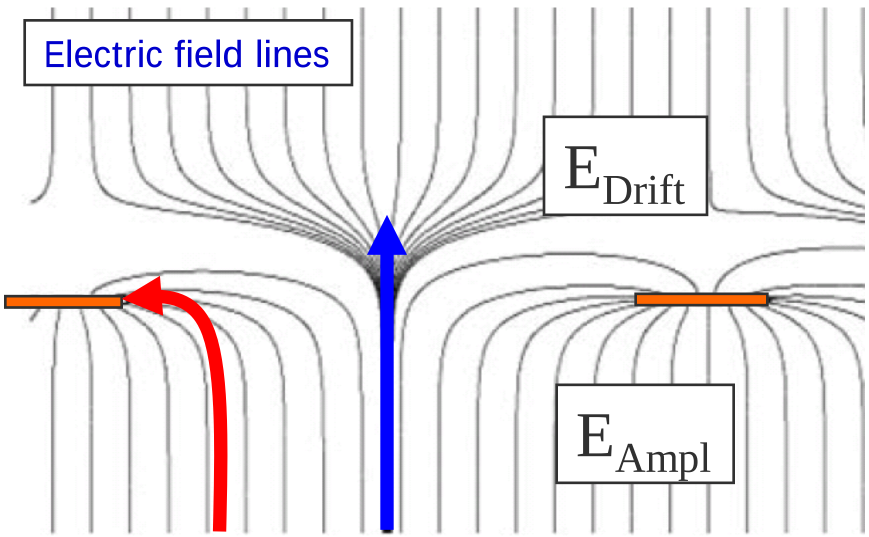


Zoom

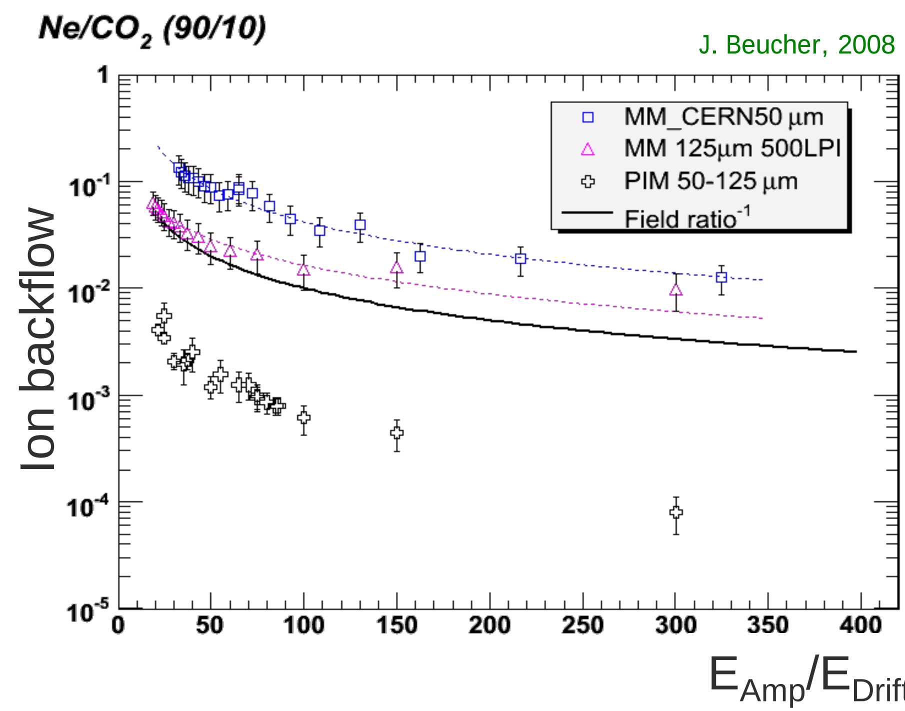


Elementary mesh

Ion blocking

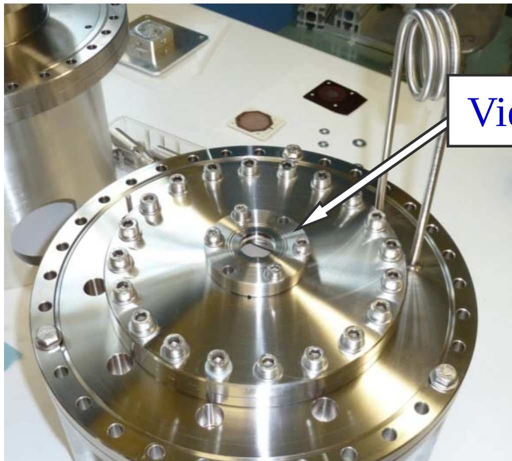


Colas *et al.*, NIM A 235 (2004) 226

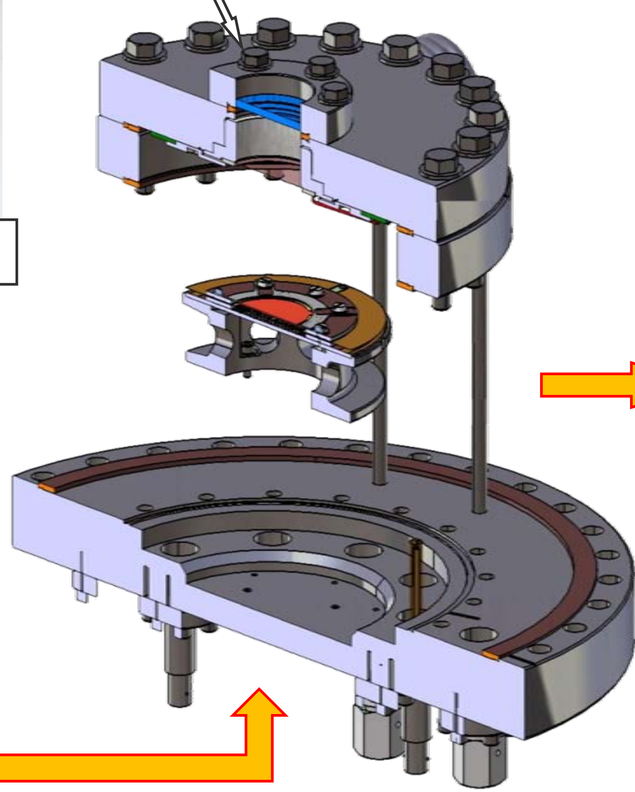


Studies in Ne-mixtures in course

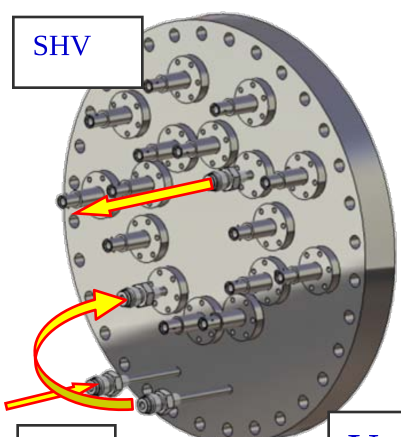
Cryogenic GPM prototype structure



LXe GPM prototype (LXe side)



THGEM / PIM / MICROMEGAS
Internal structure

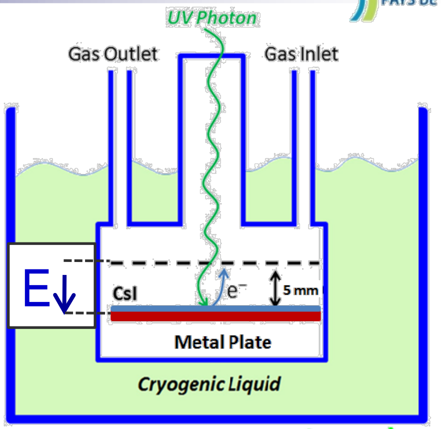


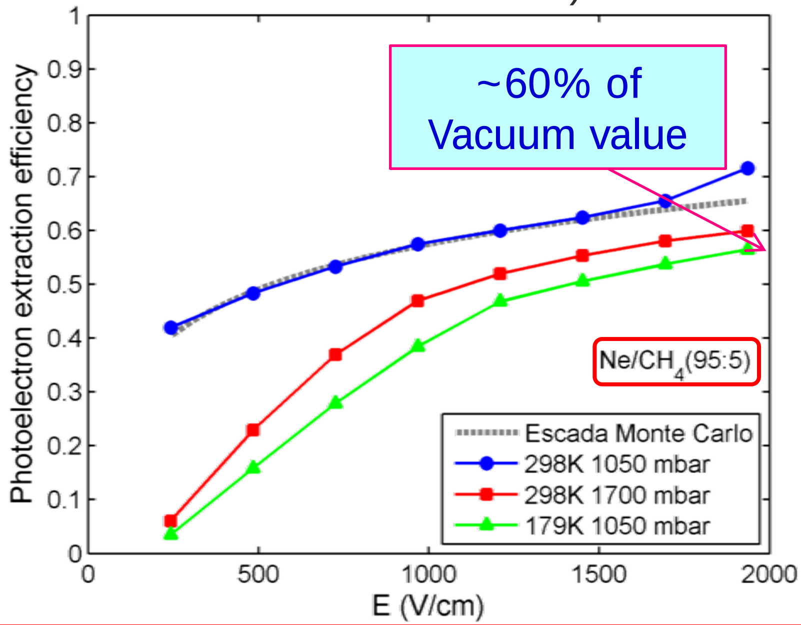
Vacuum side

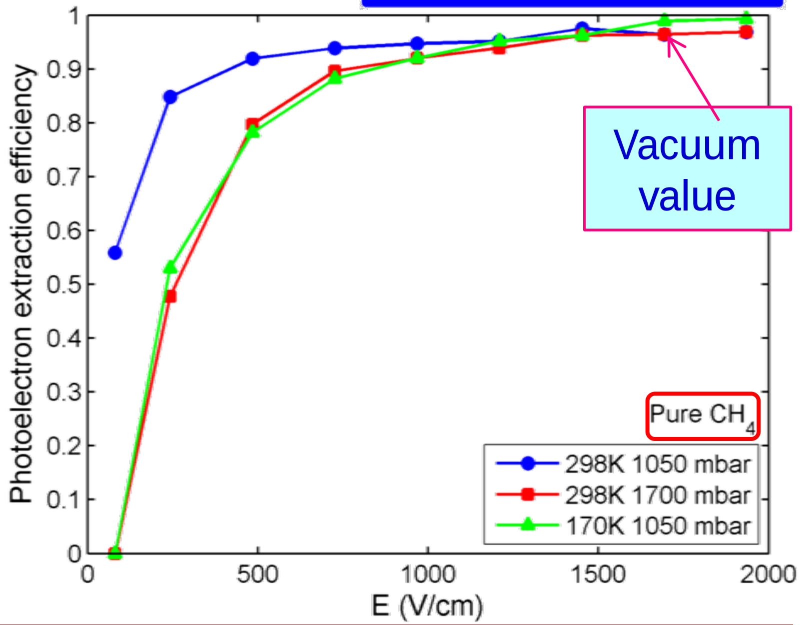
*Precision EForming .LLC

CsI photoemission in cryogenic conditions

- Ne/CH_4 (95:5):
  - Leading effect at LXe temp: backscattering due to 1.7 fold higher density
  - Water condensation on CsI suspected for further ~10% efficiency loss
- Pure CH_4:
  - Nearly no backscattering (>90% above ~1 kV/cm)
  - Essentially no difference between LXeT and RT at same density (possibly less water in this measurement)

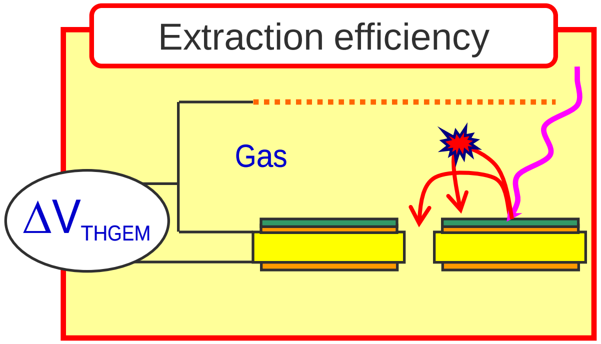


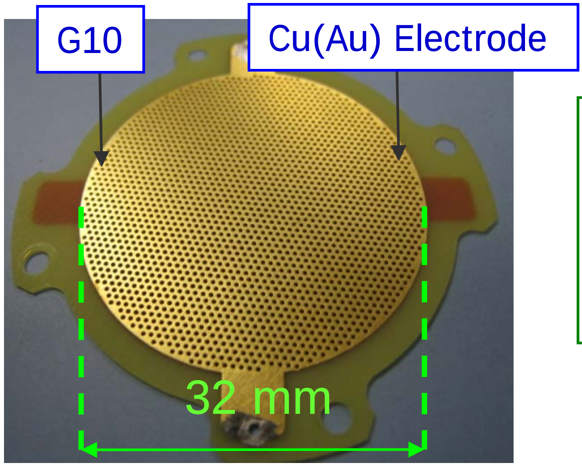




Ne-mixtures ➔ lower operation HV but lower efficiency (~60% of vacuum value)
CH_4 ➔ high operation HV, but high extraction efficiency (close to vacuum)
Other gases investigated

THick Gaseous Electron Multiplier



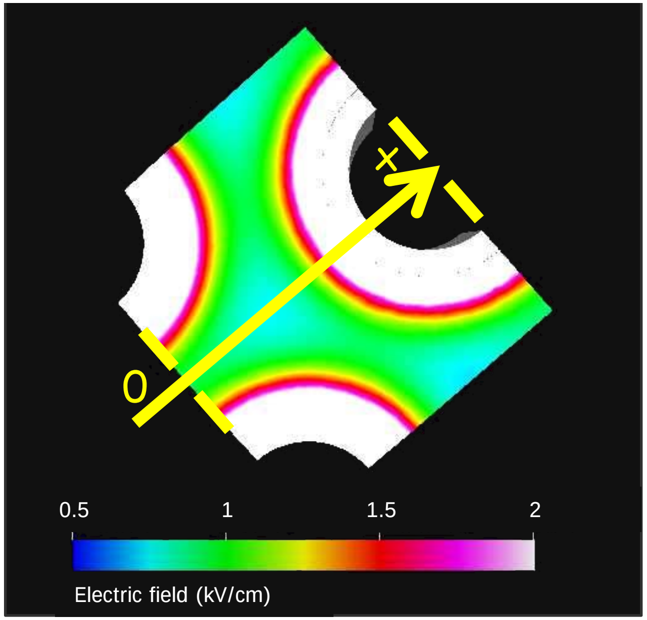


A. Breskin *et al.*, NIM A 598 (2009) 107

Geometric characteristics:

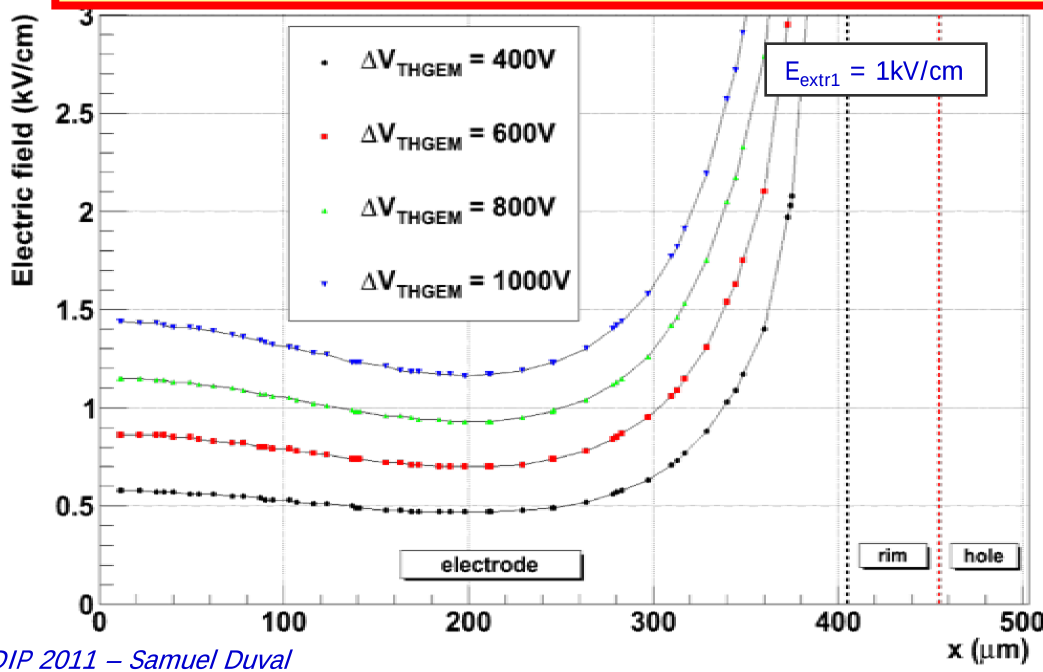
- Ø holes «d» = 300 μm
- pitch «m» = 700 μm
- thickness «e» = 400 μm
- rims «c» = 50 μm

(E_{coll} = 0 kV/cm; ΔV_{THGEM} = 600V; E_{extr1} = 1kV/cm)

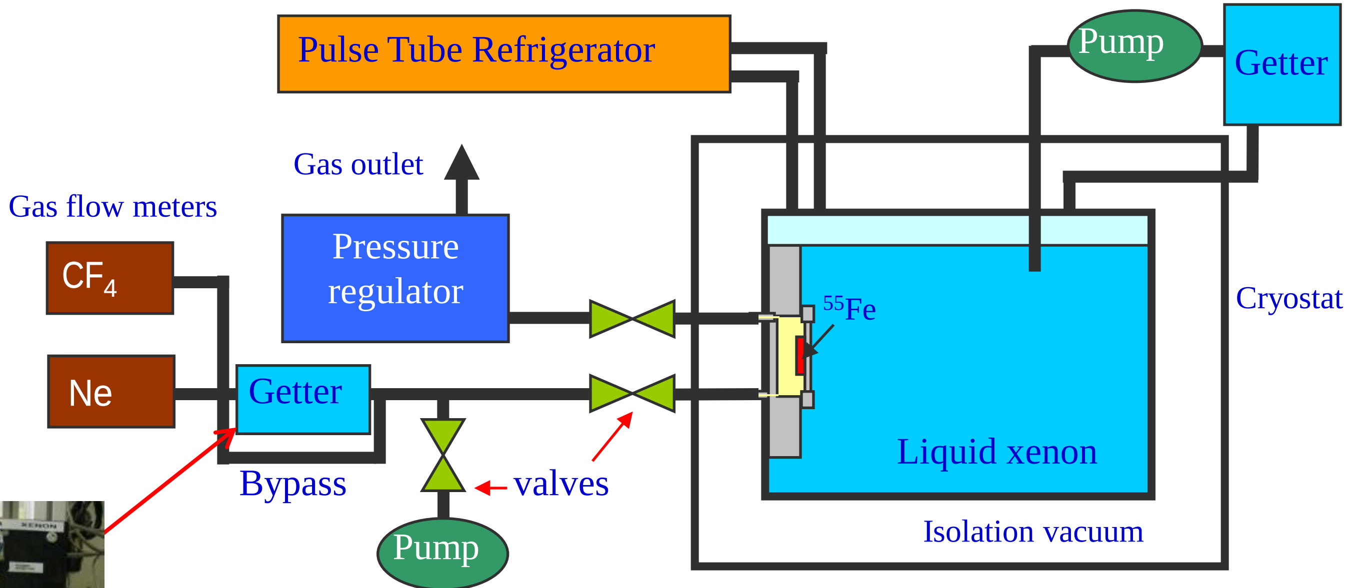


using Elmer software

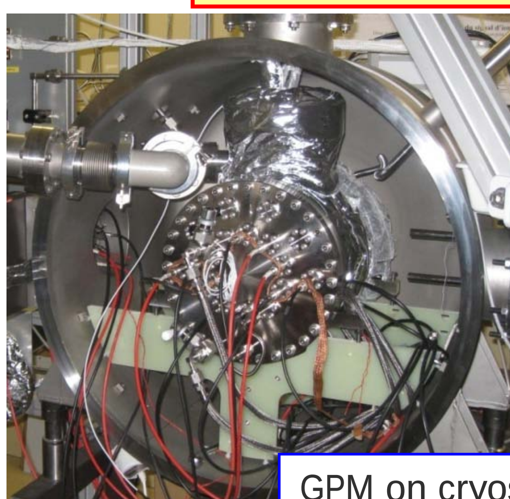
High surface electric field ➔ good photoextraction

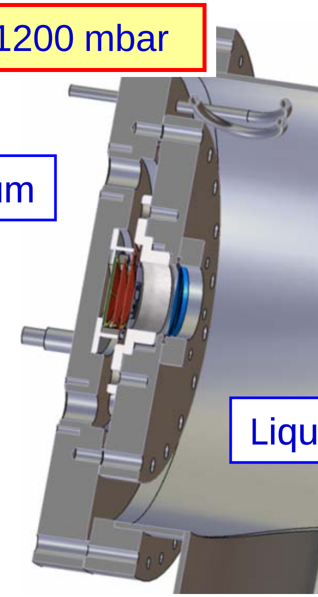


Cryogenic tests bench



P_{GPM} = 1100 mbar, T = 171 K, P_{Xe} = 1200 mbar



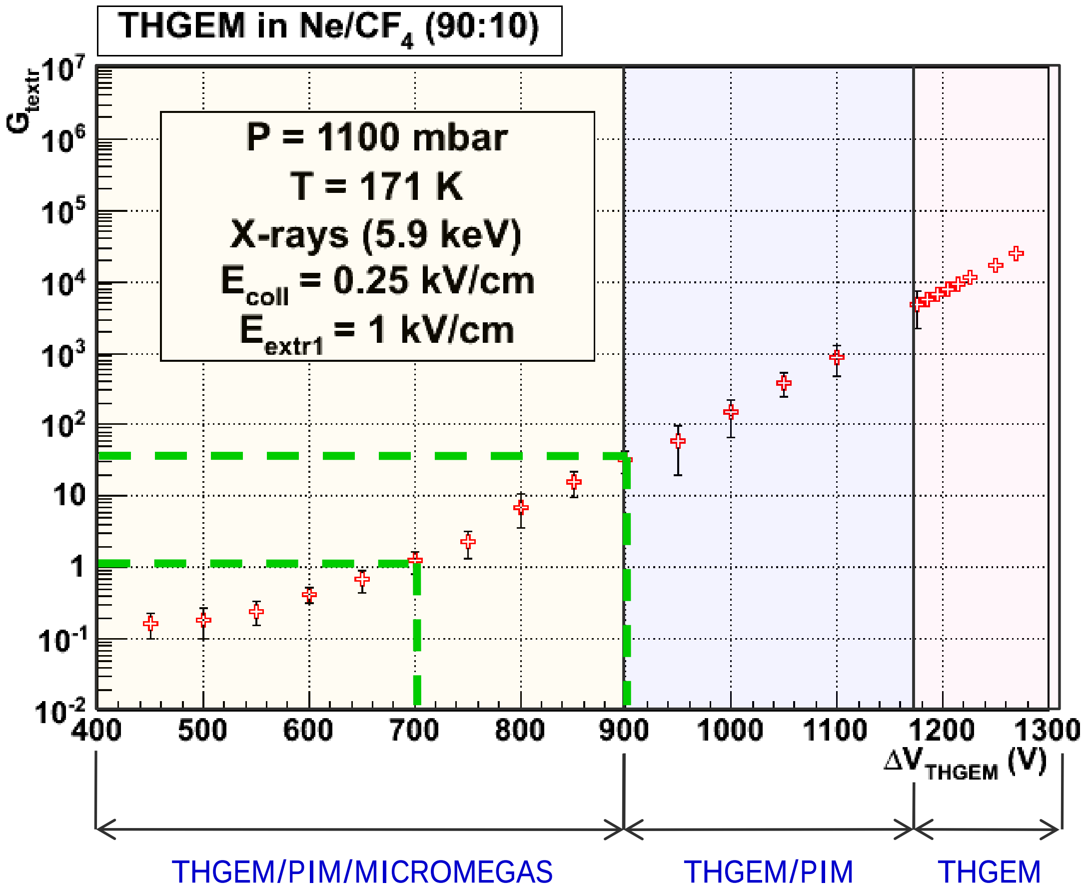


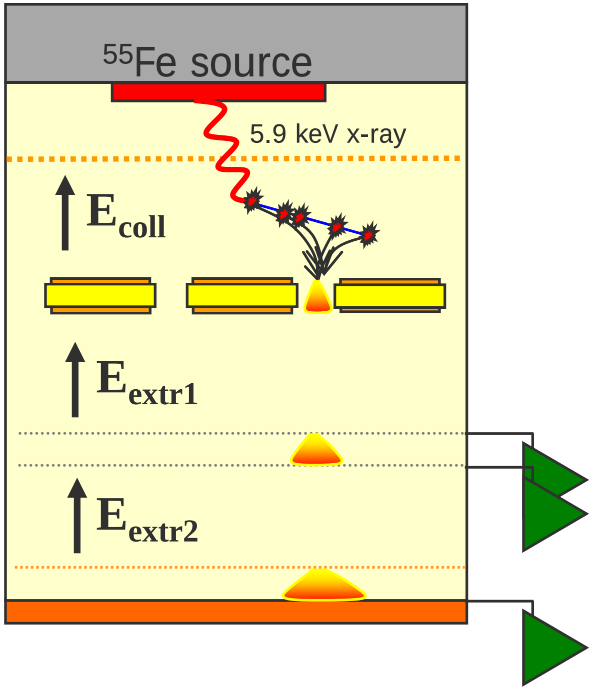
$\Delta T_{in/out}$ ~ 2K

Rate < 2 ln/h

Gain measurements in pulse-mode with ^{55}Fe source

THGEM gain with extraction in Ne/CF_4 (90:10) at 171K (E_{extr1} = 1kV/cm)

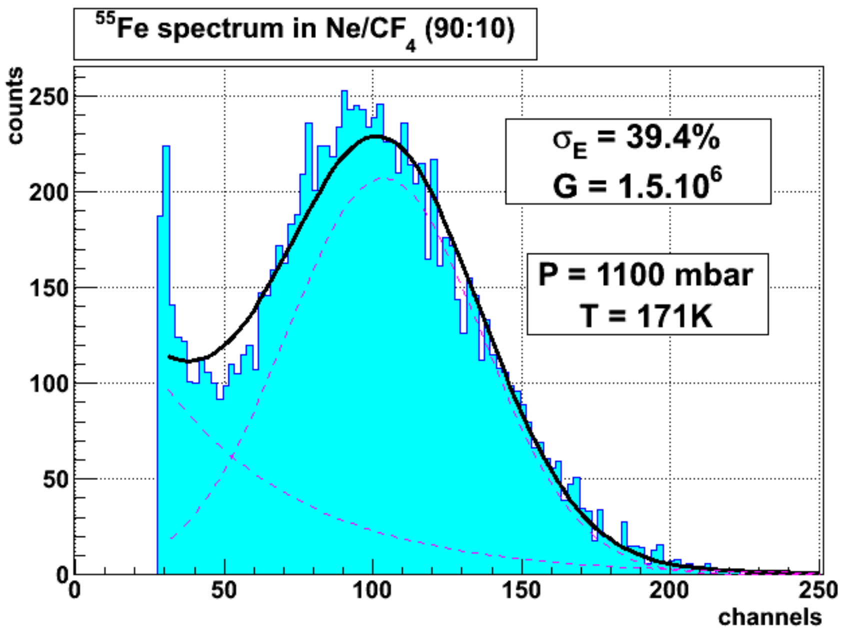


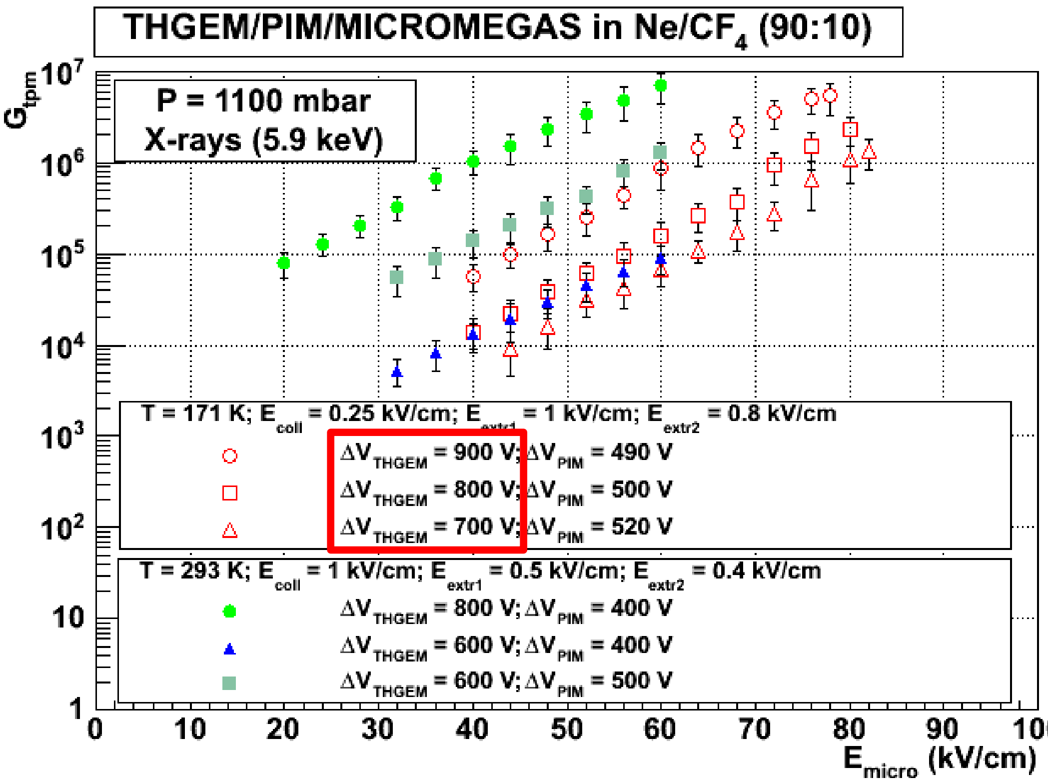


ΔV_{THGEM} > 700V = E > 1kV/cm
ΔV_{THGEM} < 900V = G_{textr} < 100

Gain measurements in pulse-mode with ^{55}Fe source

Hybrid GPM : THGEM/PIM/MICROMEGAS





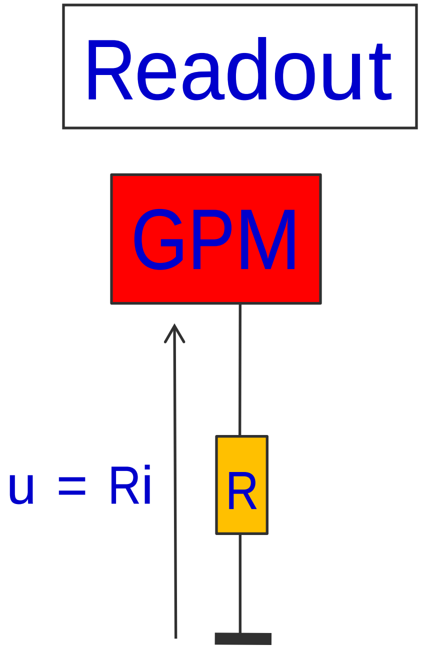
Polarization voltages:

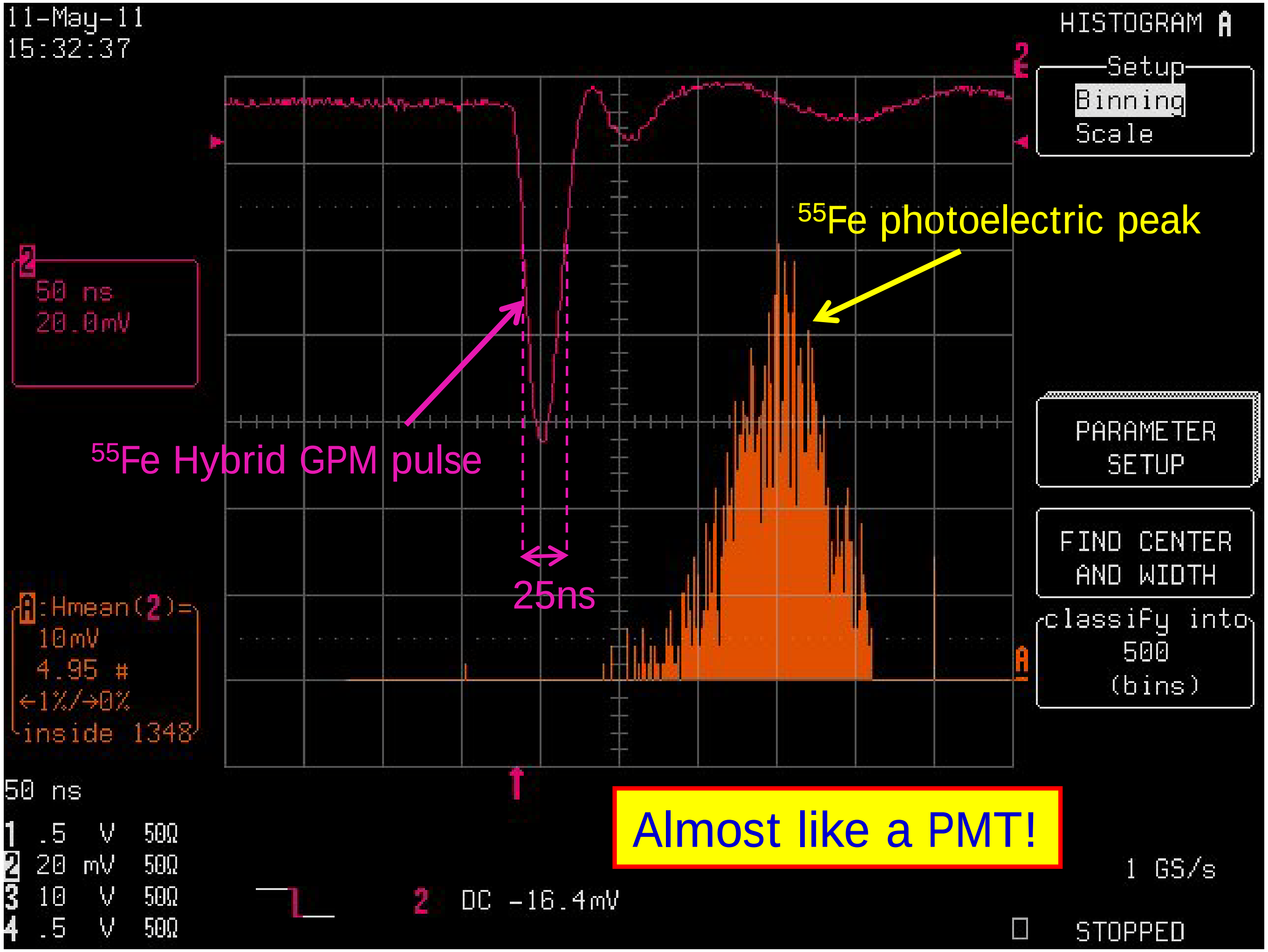
E_{coll} = 0.25kV/cm ΔV_{PIM} = 490V
ΔV_{THGEM} = 900V E_{extr2} = 0.8kV/cm
E_{extr1} = 1kV/cm ΔV_{micro} = 330V

High total gain!
With low THGEM gain

Fast 50Ω signal readout

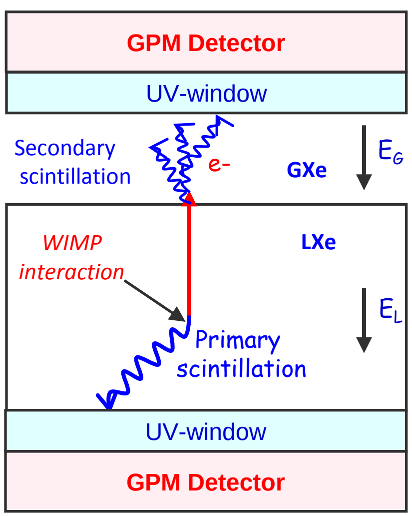
Oscilloscope snapshot : T = 173K; Ne/CF_4 (90:10); Gain ~10^6



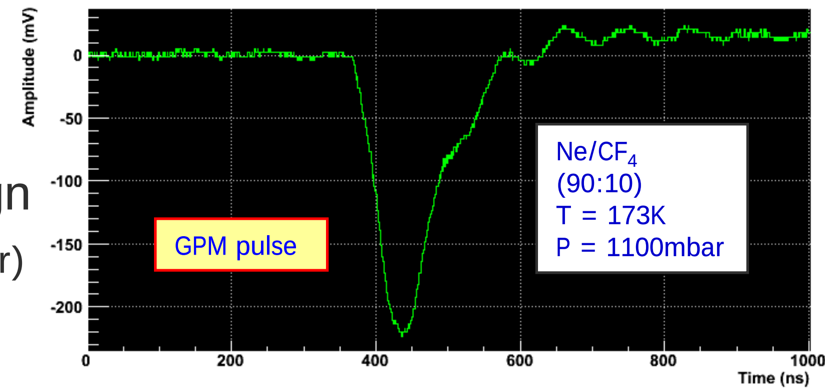


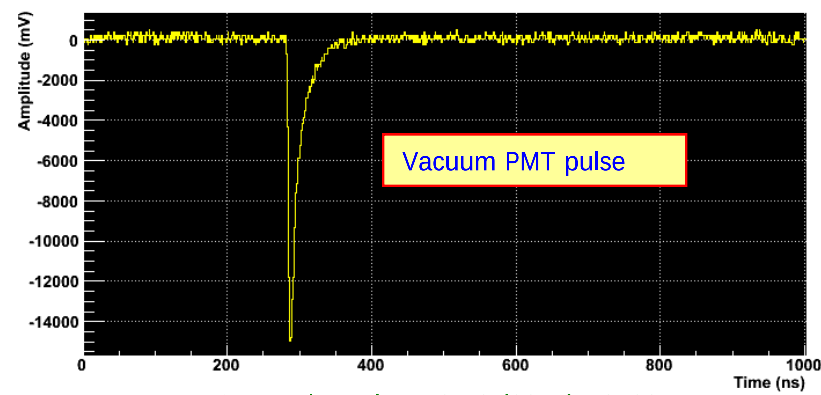
Conclusions

- High gains at LXe T ~10^6
- Efficient ion blocking expected also in Ne-mixtures
- CsI photocathode studies in progress
- Large-size prototype for Medical Imaging in design for a LXe Compton Telescope (target: 20 inch diameter)
- GPM for LXe/LAr Dark Matter detectors: in course



Hybrid MPGD GPM:
^{238}Pu scintillation pulse from LXe





S. Duval *et al.*, JINST 6 (2011) P04007

Thank you !