Electroluminescence yields in MicroMegas, THGEM and GEM

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Outline

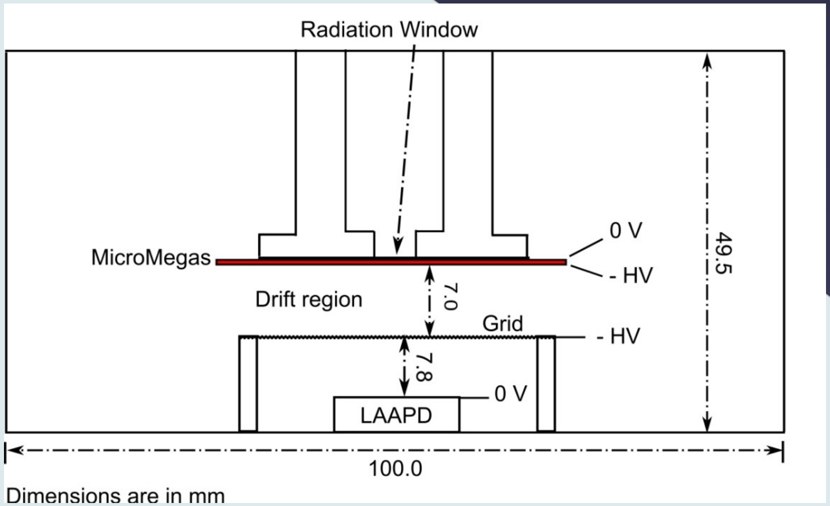
- Motivation;
- Experimental setups with different MPGDs and UV sensitive LAAPDs;
- Methods for determination of Electro-luminescence yields;
- Results;
- Conclusions.

Motivation

- Rare event experiments (eg.: dark matter search, neutrinoless double beta decay) can take advantages of reading charge and scintillation light produced by MPGDs;
- Decoupling of electronic noise;
- Usually much better SNR.

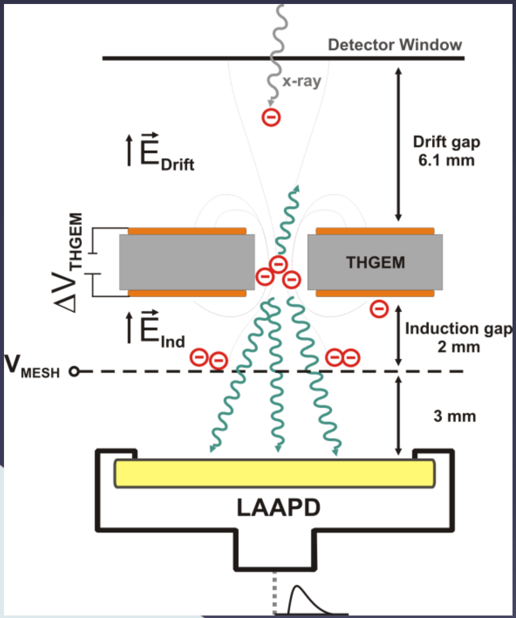
MPGD scintillation vs. charge readout

MicroMegas



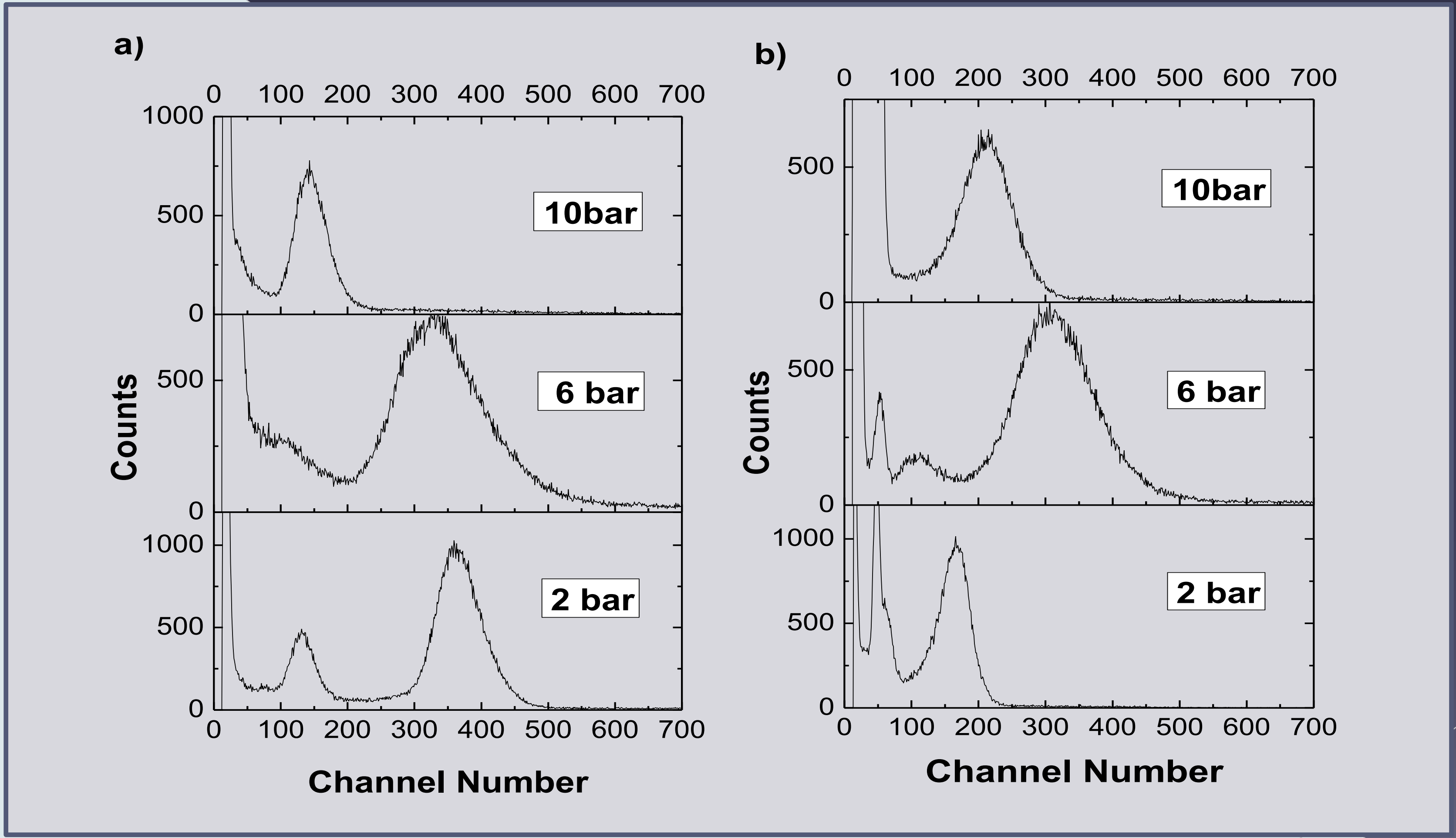
Gap: 50 μm
Hole diameter: 25 μm

THGEM/GEM



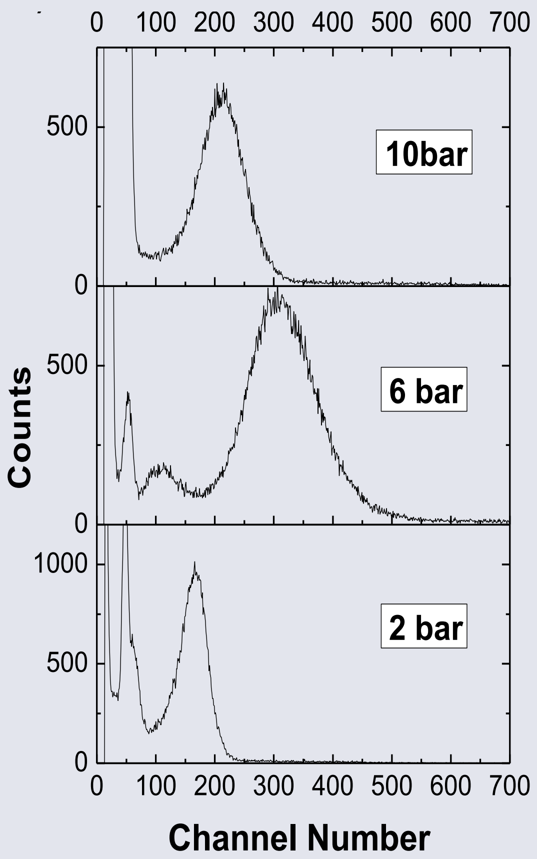
Thickness: 0.4 mm
Hole diameter: 0.4 mm
Rim: 0.1 mm

Charge (a) and scintillation (b) pulse-height distributions in MM



LAAPD gain ~ 30

MM EL Yield



$$N_{e,XR} = \frac{22100\ \text{eV}}{3.62\ \text{eV}} = 6.1 \times 10^{3}$$

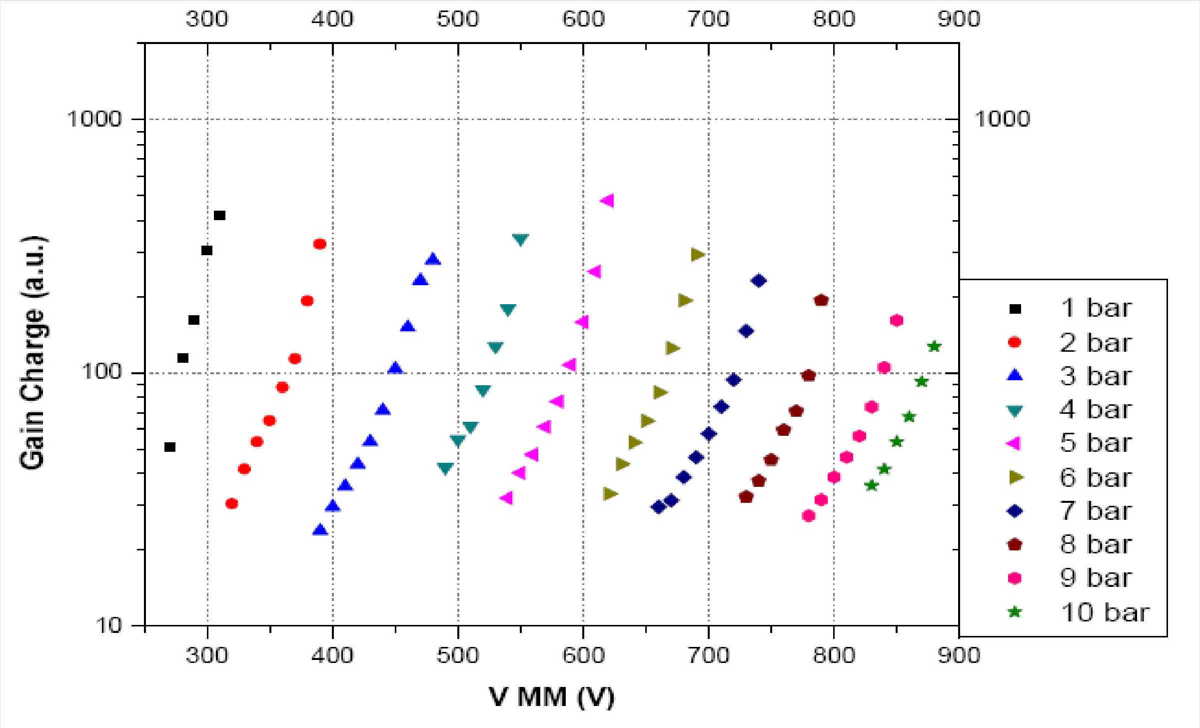
$$N_{UV} = \frac{A_{Sc}}{A_{X}} \times \frac{N_{e,XR}}{QE}$$

$$Y_{eff} = N_{UV} \times \frac{2\pi}{\Omega_{Sc}} \times \left(\frac{E_{x}}{w_{E_{x}}} \right)^{-1}$$

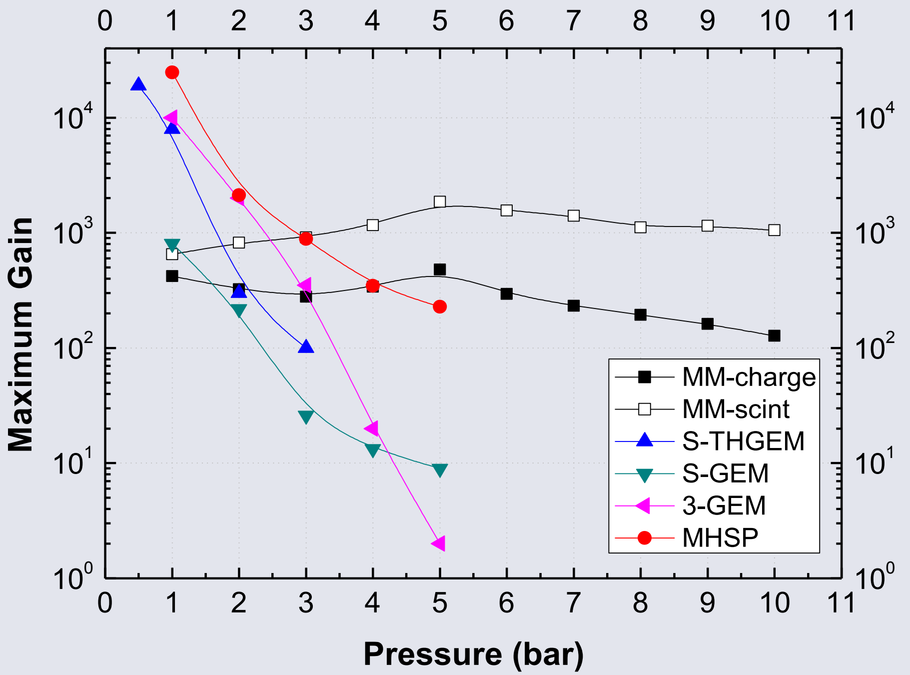
$$N_{UV,e} = QE^{-1} \times \frac{G_{tot}}{G_{APD}}$$

$$Y_{eff} = N_{UV} \times \frac{2\pi}{\Omega_{Sc}}$$

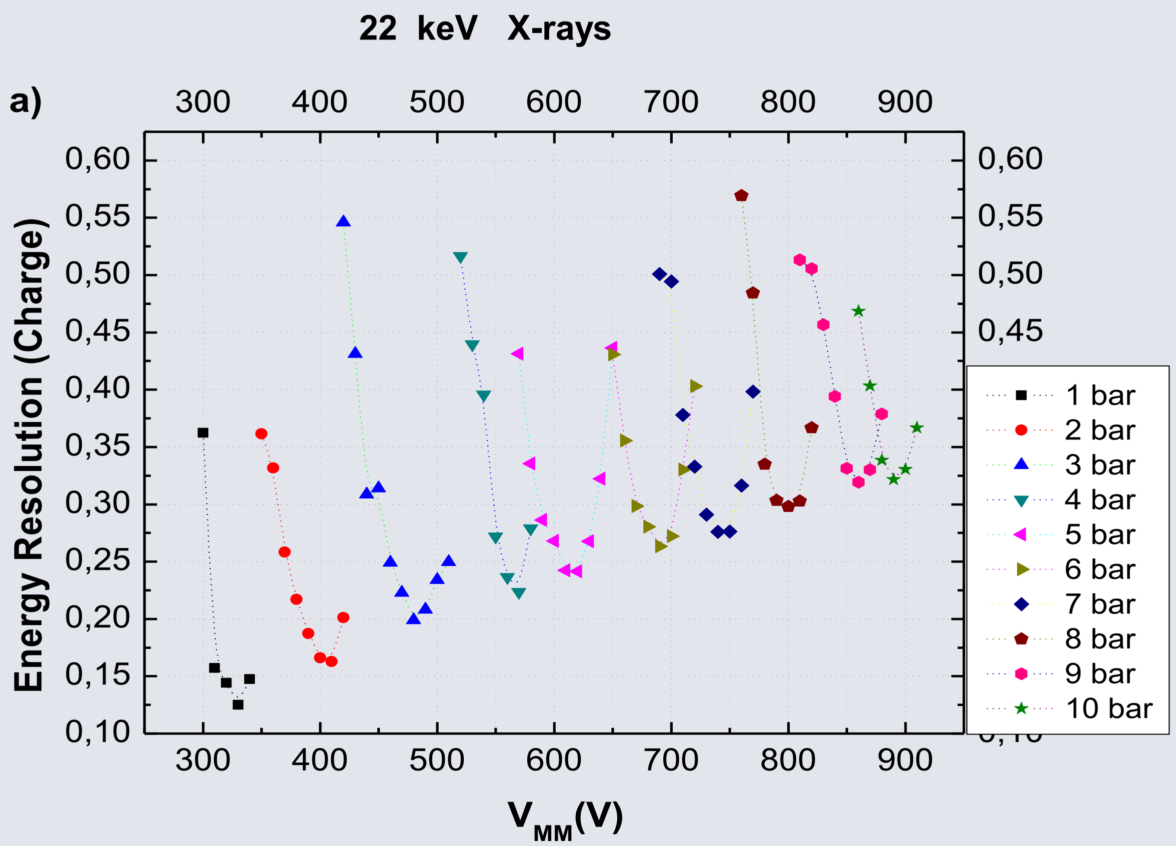
MM charge gain in Xe



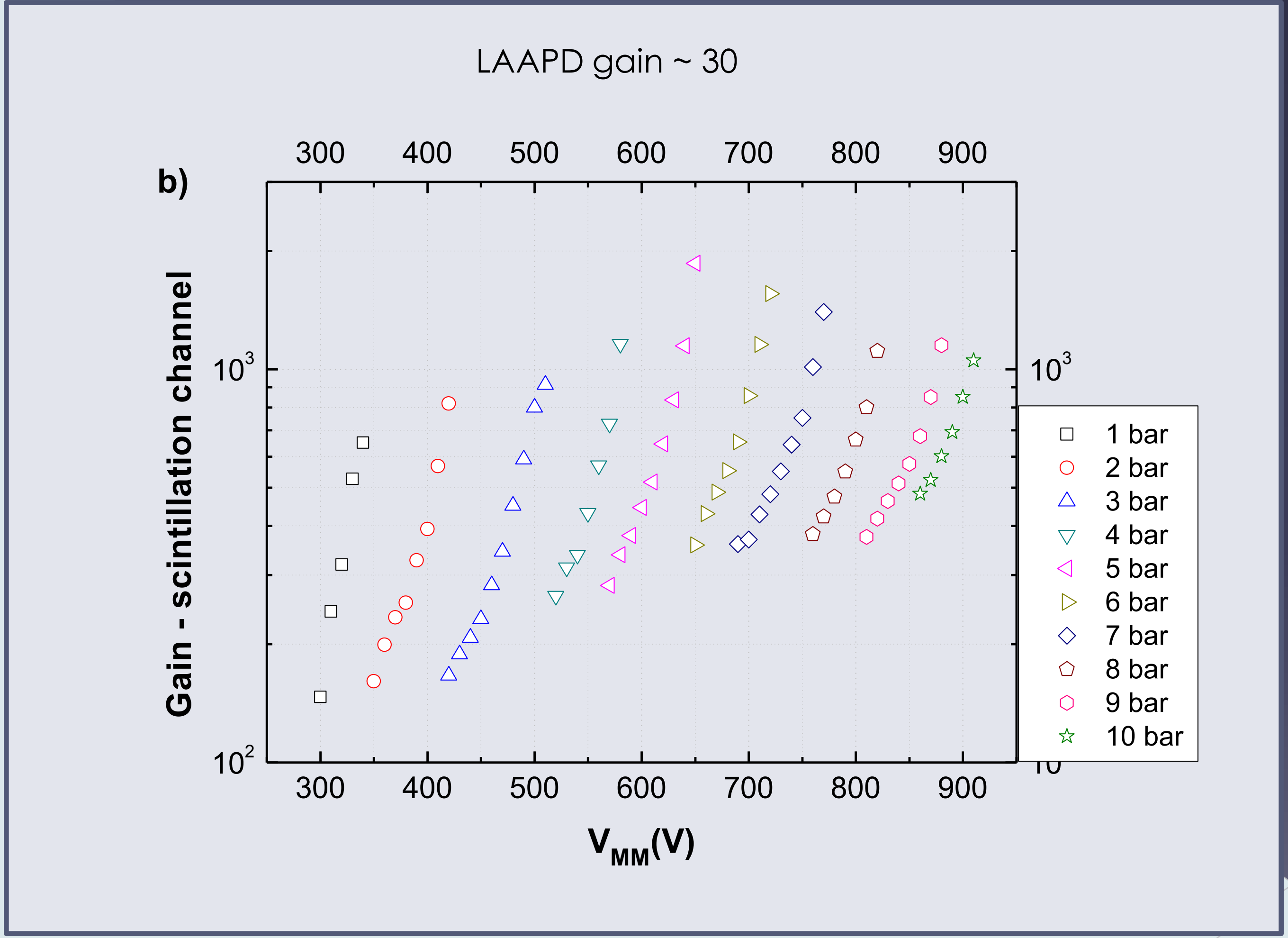
Maximum charge gain Vs pressure (Xe)



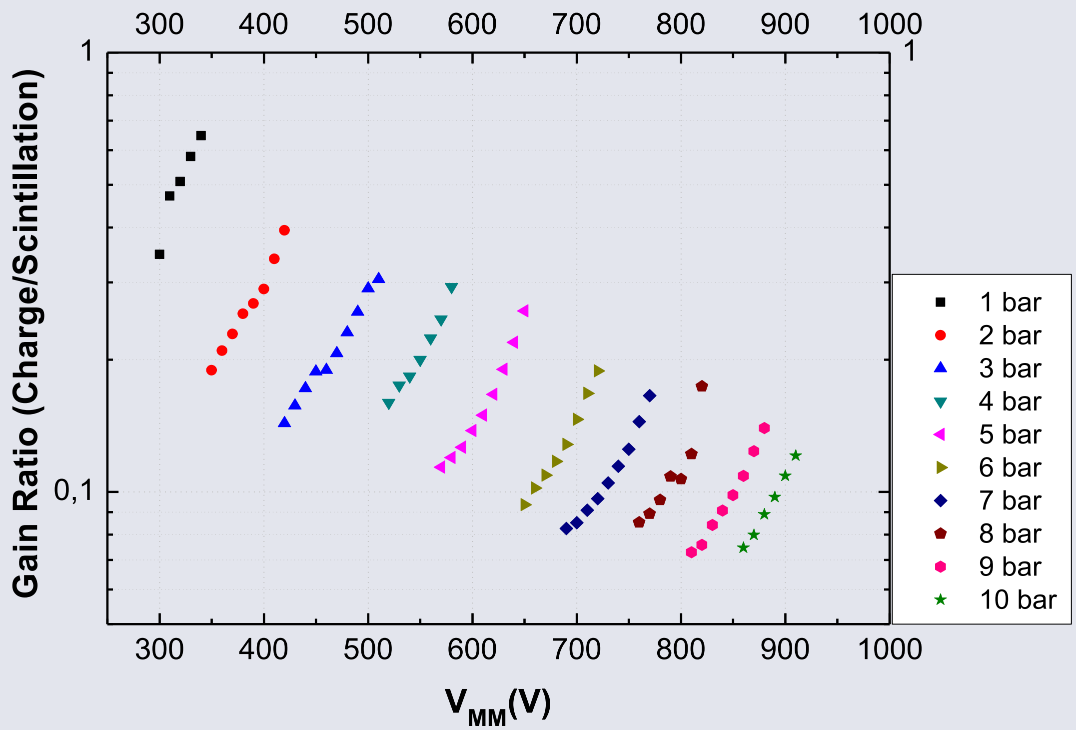
MM Charge gain fluctuations (Xe)



MM gain in scintillation-readout
(G_{tot} = primary charge/charge out from LAAPD)

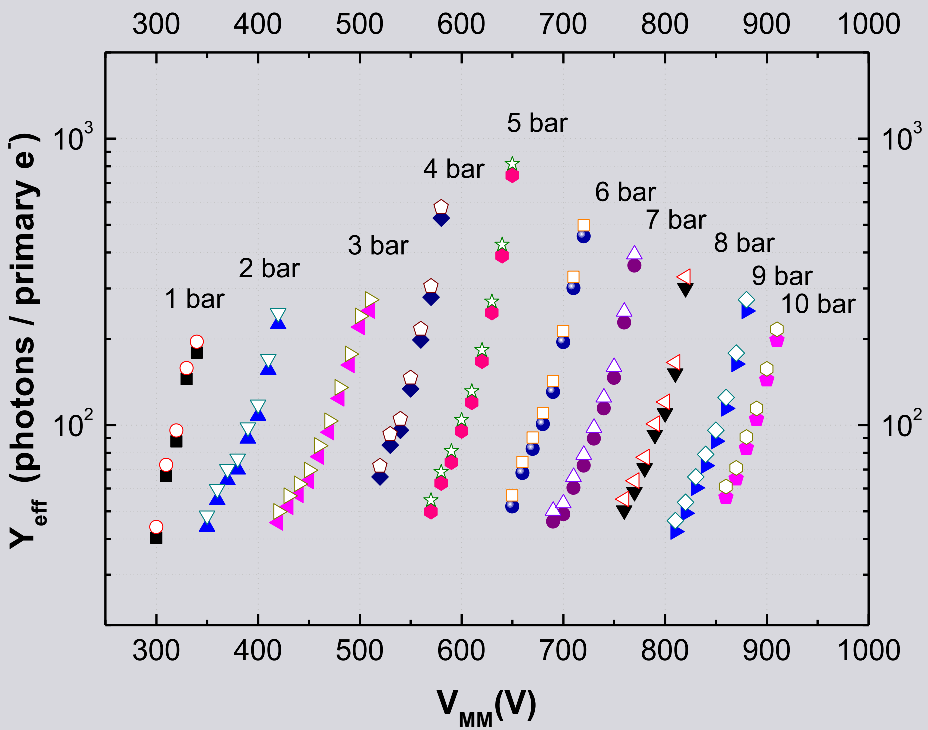


Charge-to-scintillation gain ratio



Lower E/p favours excitations

Absolute EL Yield "out" of MM (Xe)

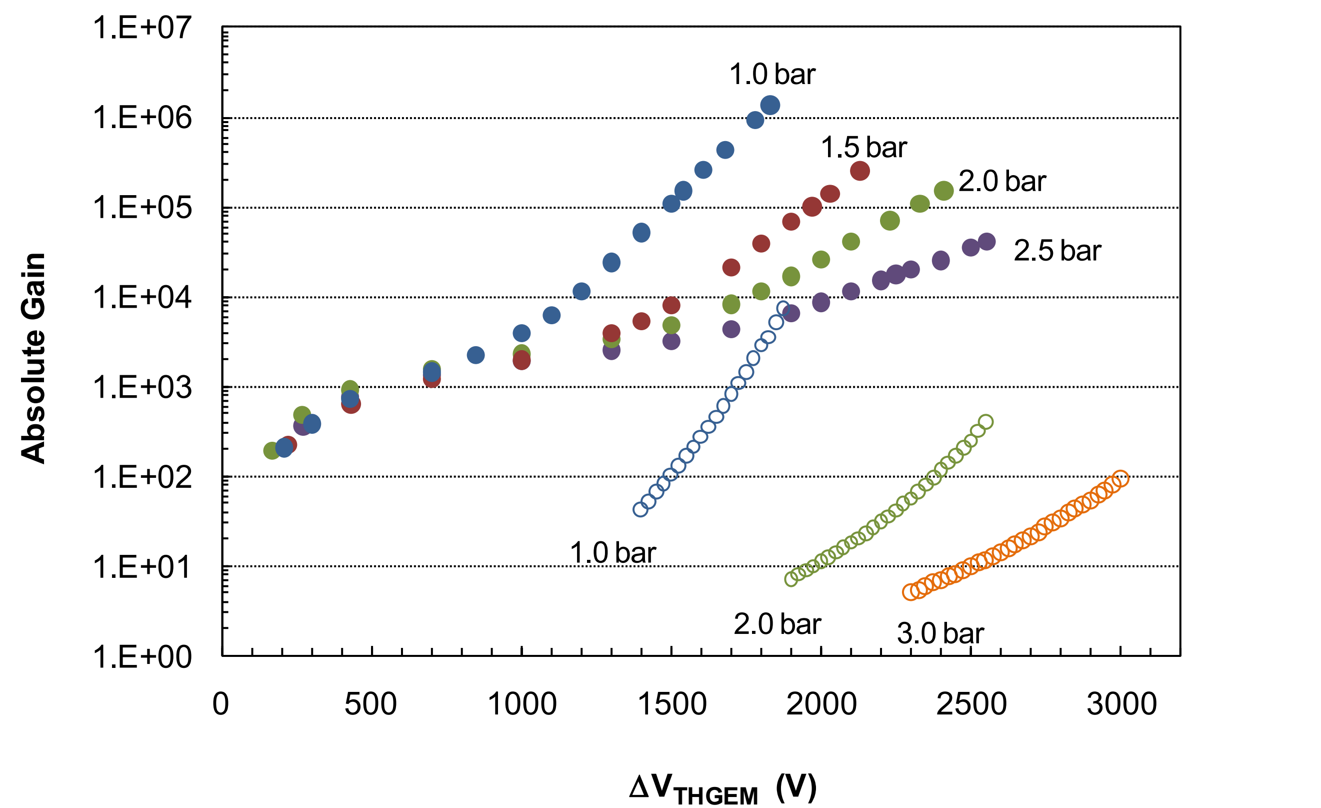


- **Double mesh, uniform field scintillation gap yields**

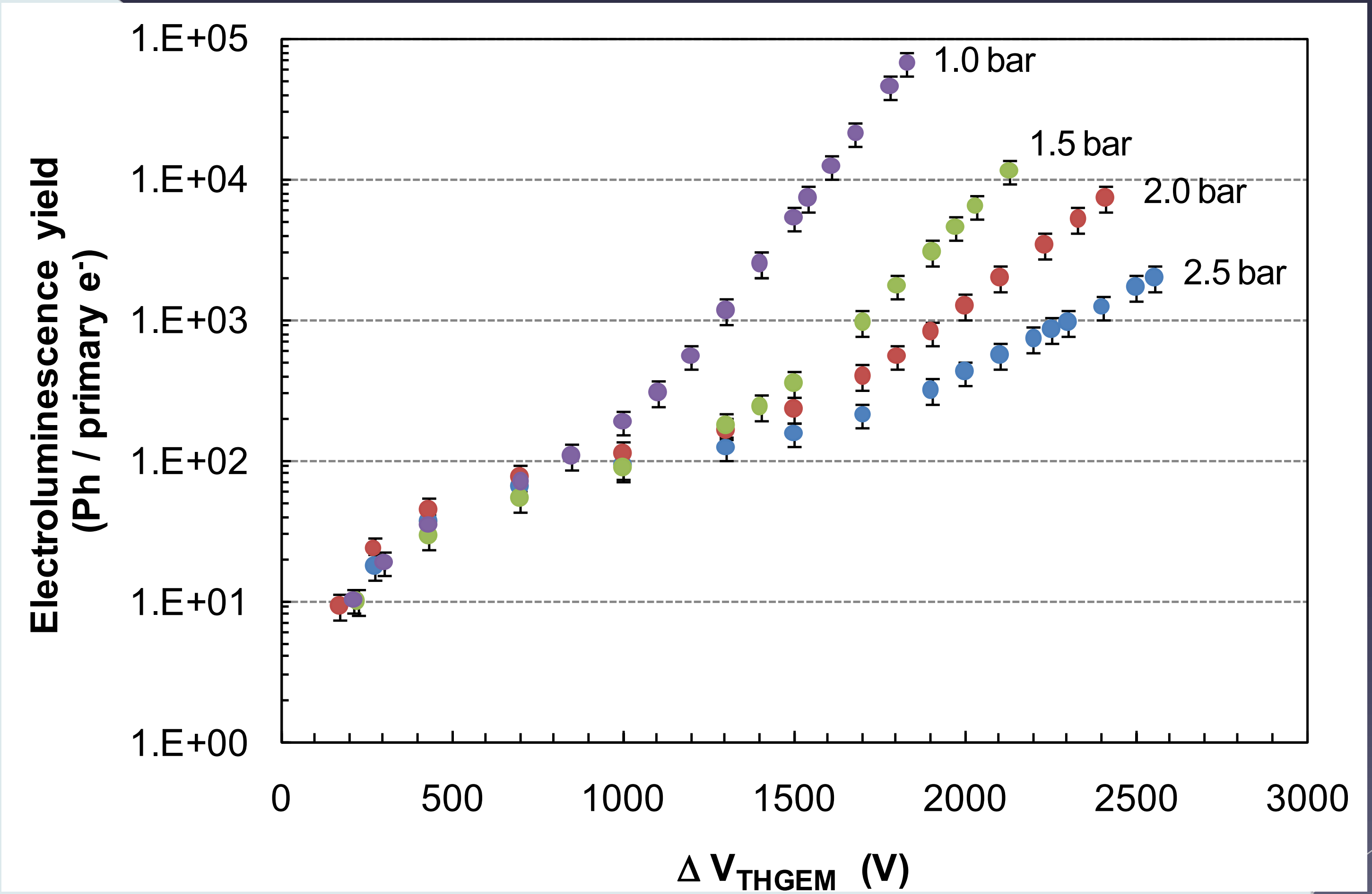
466 photons/e⁻/cm @ 4.1 kV/cm/bar

THGEM Gains in Xe

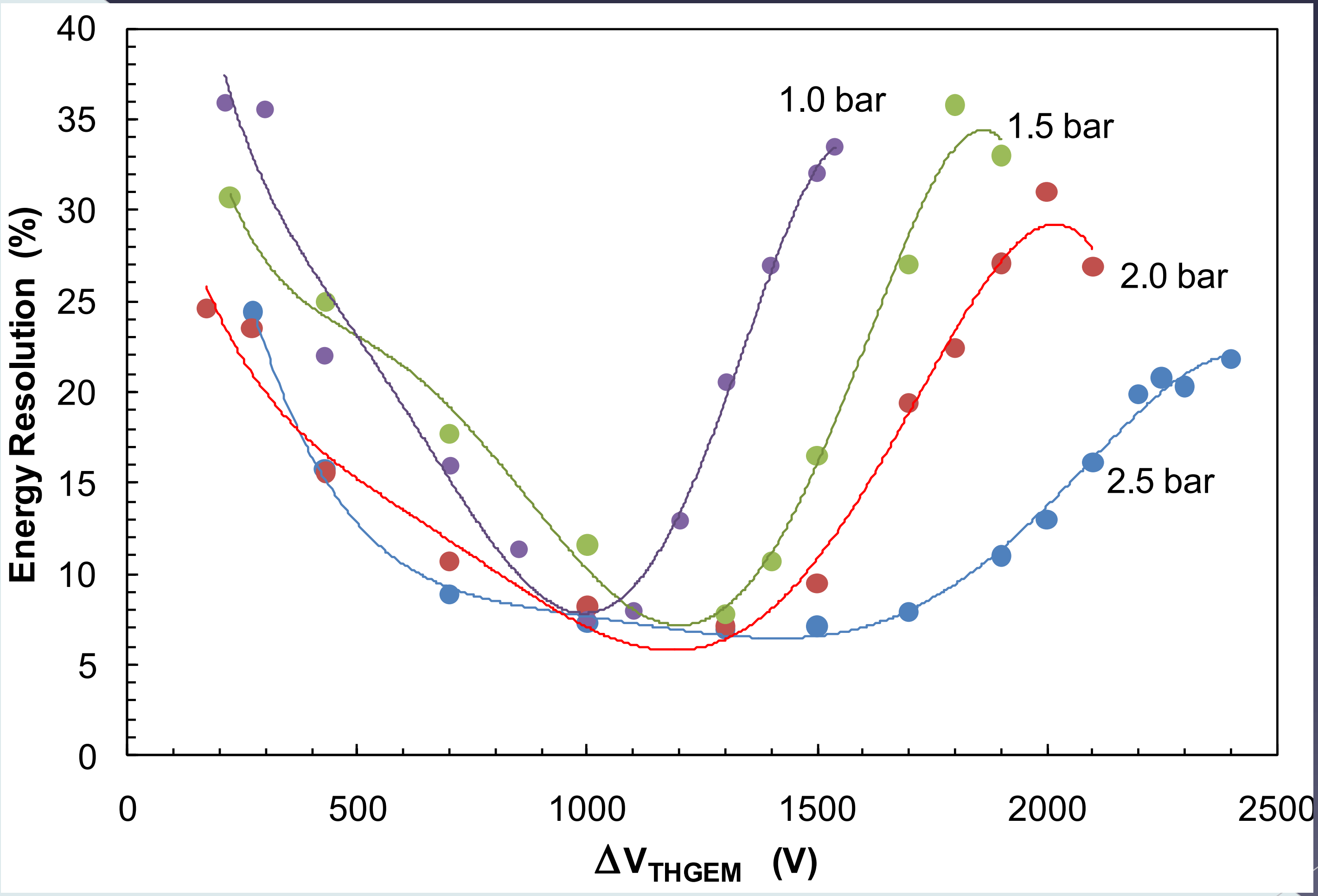
APD gain ~150



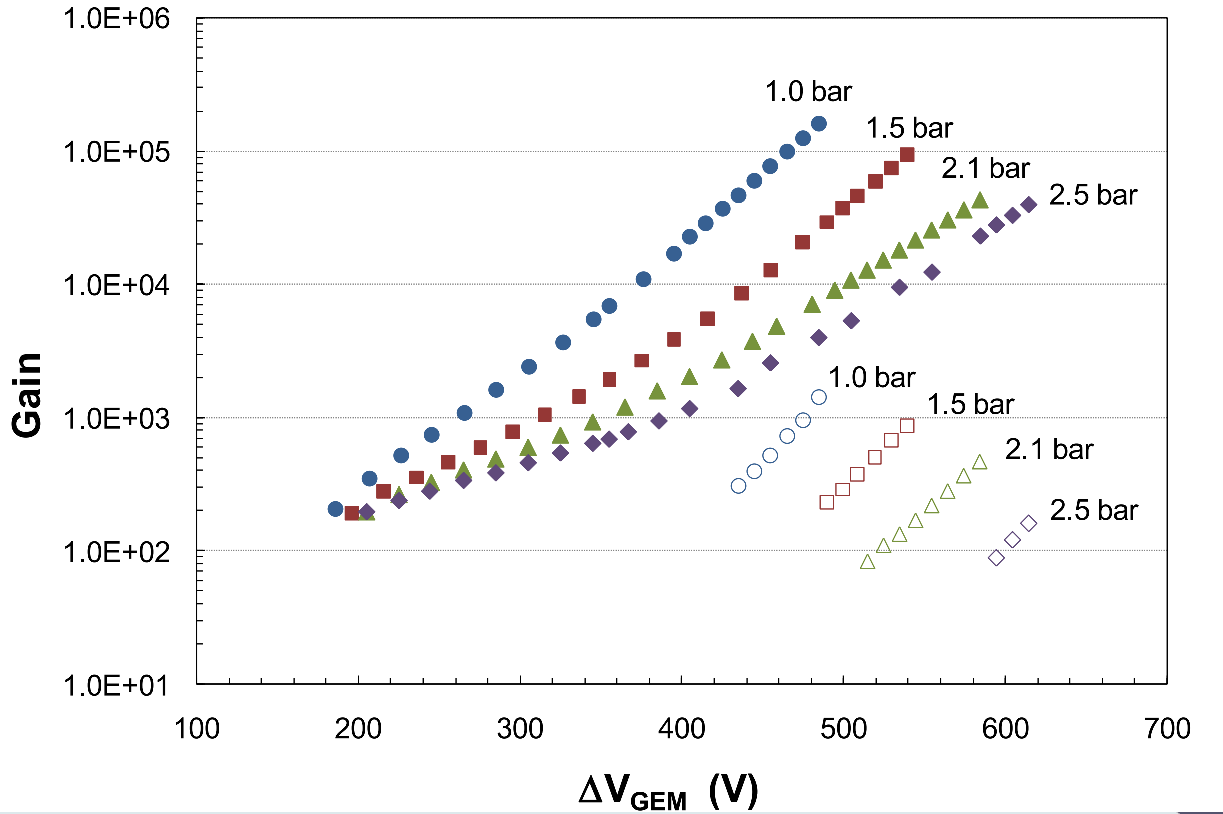
THGEM EL yield in Xe



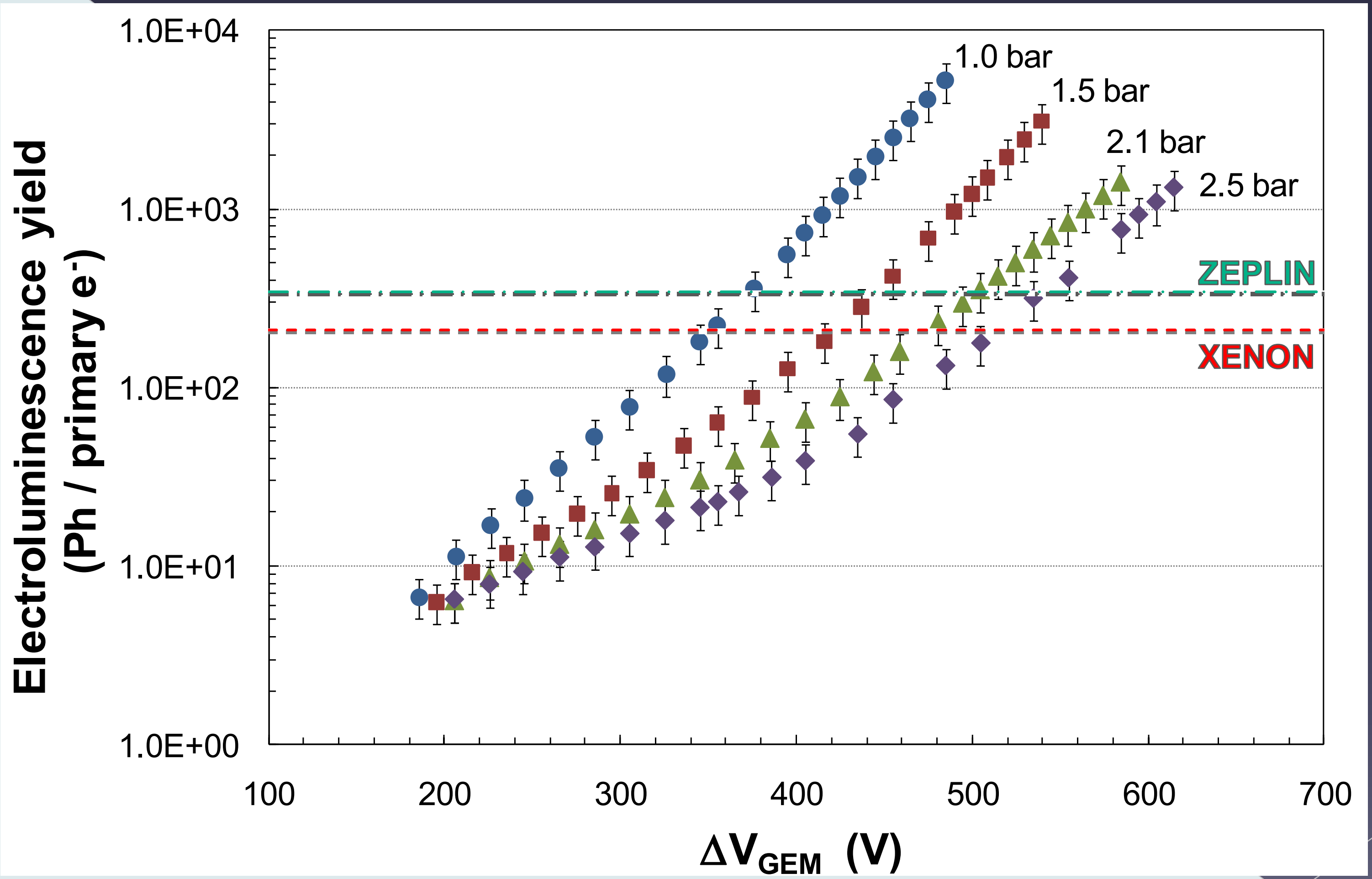
Statistical fluctuations in THGEM



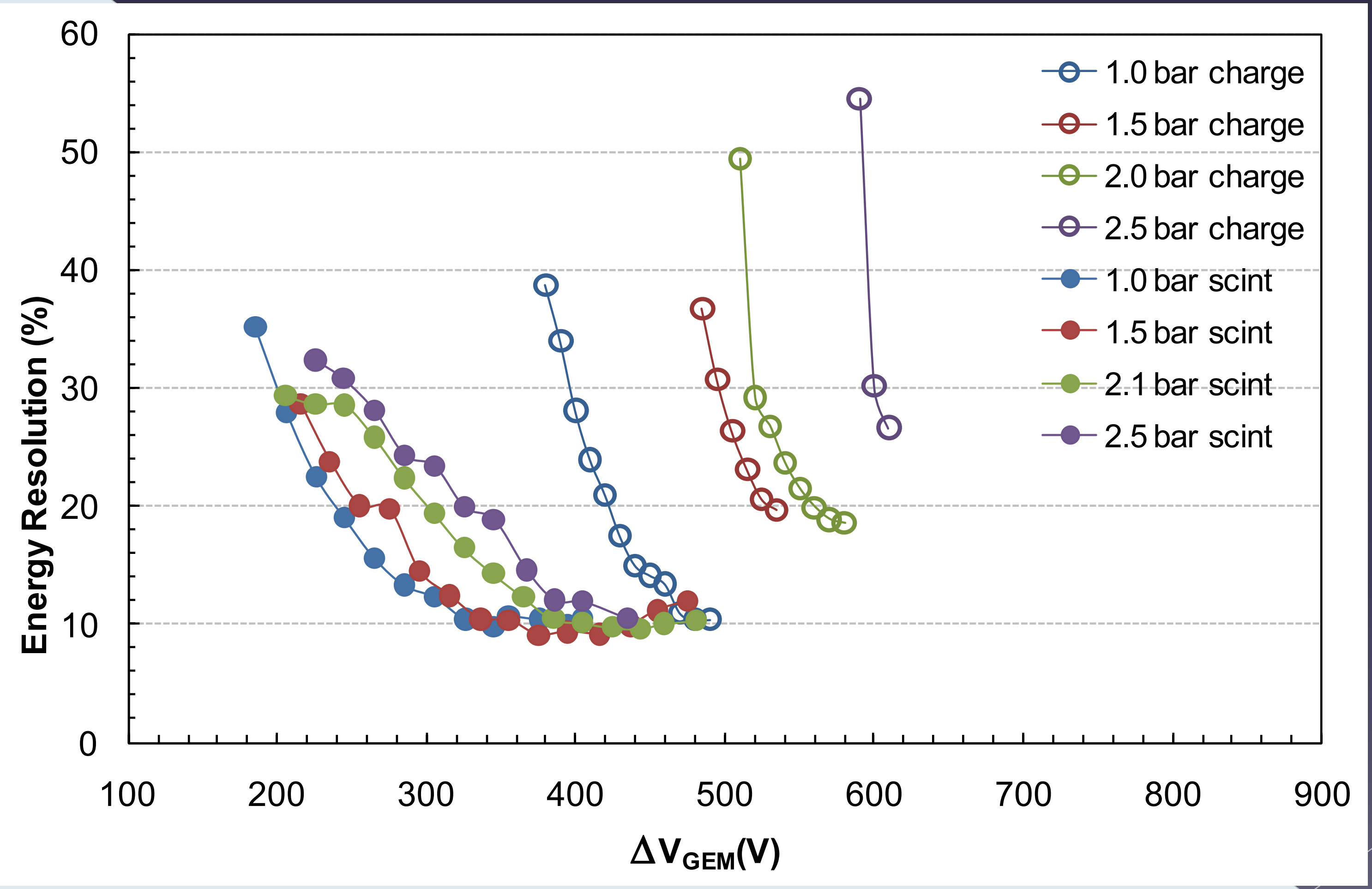
GEM gain in Xe



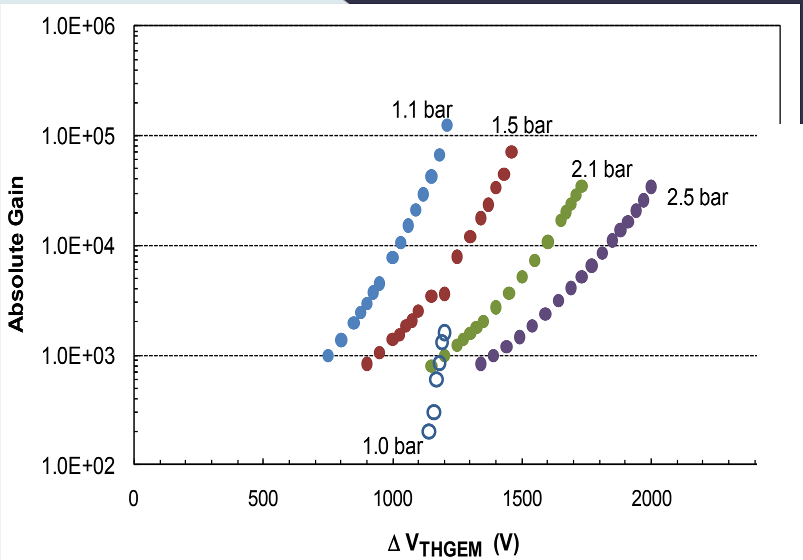
GEM EL yield (Xe)



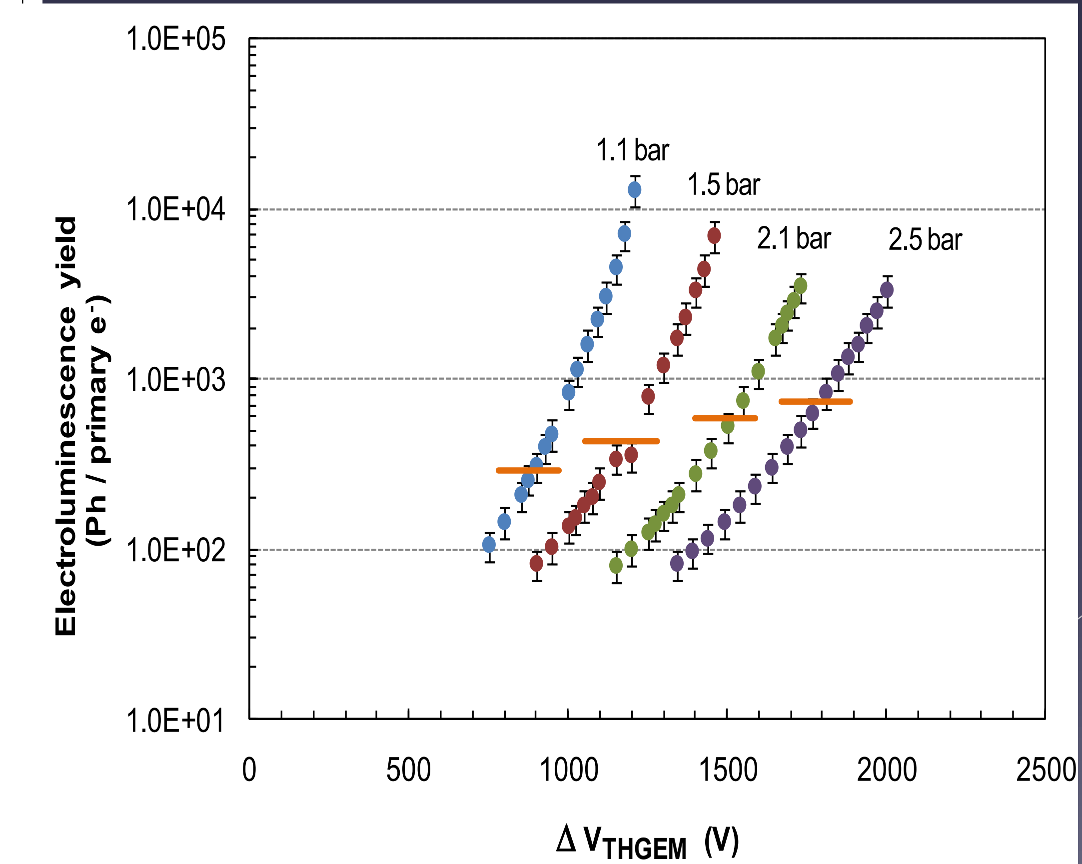
GEM statistical fluctuations



THGEM in Ar

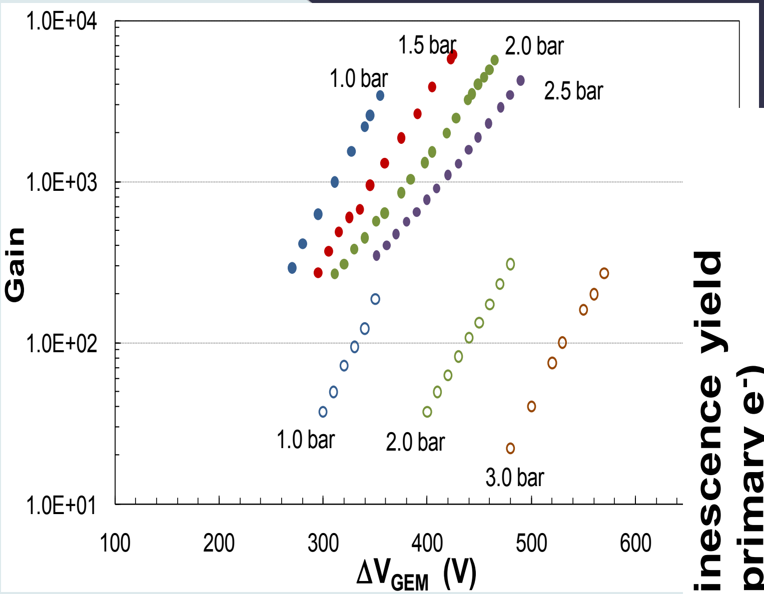


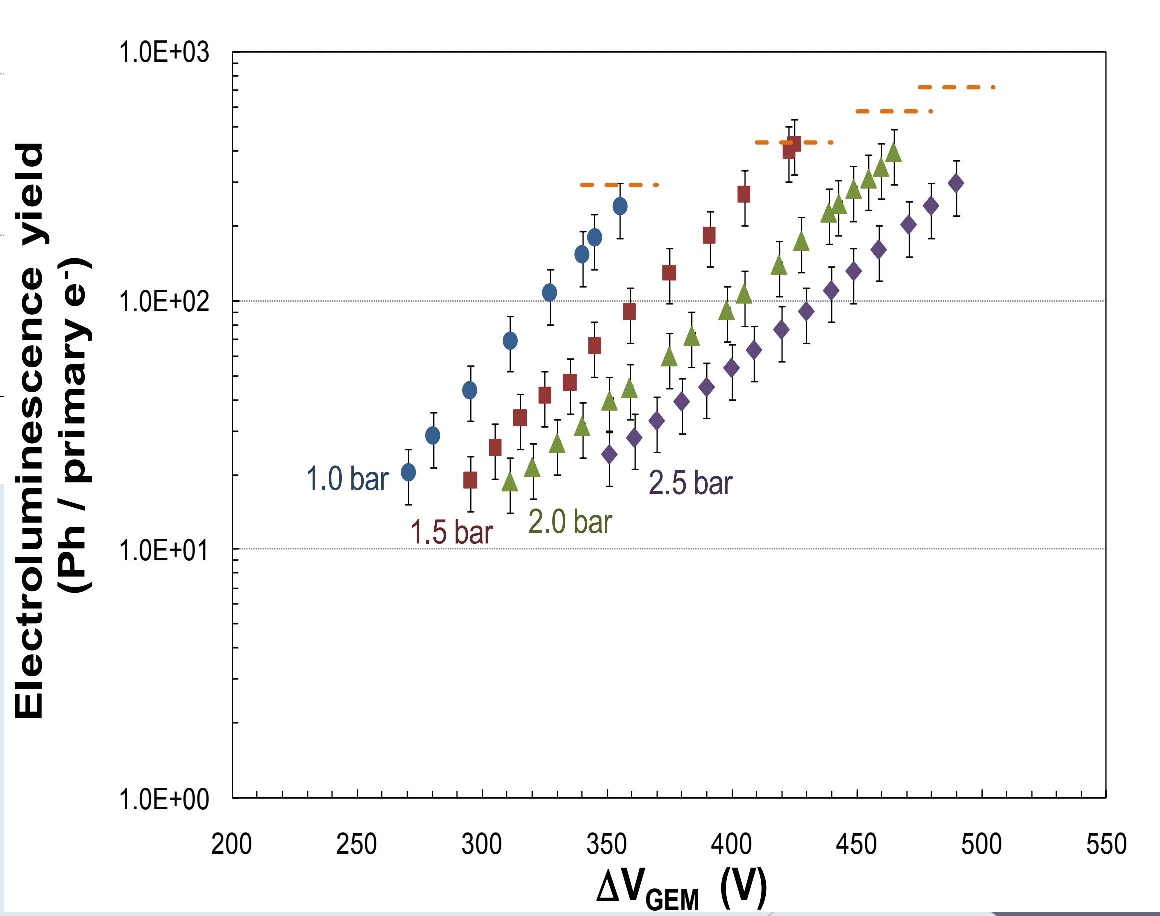
Absolute Gain
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.1 bar
1.5 bar
2.1 bar
2.5 bar
1.0 bar
0
500
1000
1500
2000
Δ V$_{THGEM}$ (V)



Electroluminescence yield (Ph / primary e-)
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.1 bar
1.5 bar
2.1 bar
2.5 bar
0
500
1000
1500
2000
2500
Δ V$_{THGEM}$ (V)

GEM in Ar


1.0E+04
1.0E+03
1.0E+02
1.0E+01
Gain
1.5 bar
2.0 bar
1.0 bar
2.5 bar
1.0 bar
2.0 bar
3.0 bar
100
200
300
400
500
600
ΔV_GEM (V)


1.0E+03
1.0E+02
1.0E+01
1.0E+00
Electroluminescence yield
(Ph / primary e⁻)
1.0 bar
1.5 bar
2.0 bar
2.5 bar
200
250
300
350
400
450
500
550
ΔV_GEM (V)

Conclusions

Table I – Maximum gain and scintillation yield for GEMs and THGEMs operating in argon and xenon at 1 bar and 2.5 bar.

		Xenon		Argon	
		1 bar	2.5 bar	1 bar	2.5 bar
GEM	Gain	1.5×10^5	4×10^4	5×10^3	5×10^3
	Yield	6×10^3	1.5×10^3	3×10^2	3×10^2
THGEM	Gain	1.2×10^6	4×10^4	1.2×10^5	3×10^4
	Yield	7×10^4	2×10^3	1.5×10^4	4×10^3

- **Double mesh, uniform field scintillation gap yields**

  466 photons/e^-/cm @ 4.1 kV/cm/bar