THGEM: Introduction to discussion on UV-detector parameters for RICH

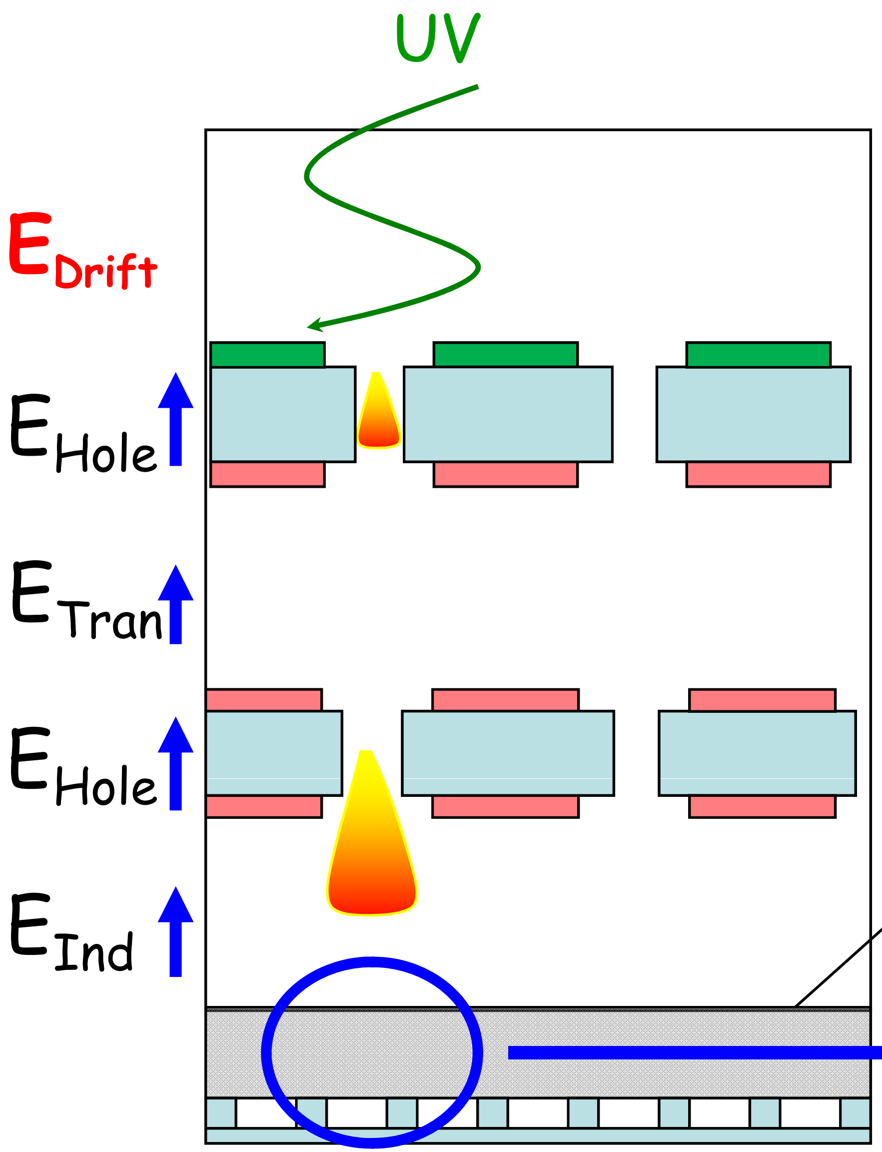
Amos Breskin
Weizmann

Discussion topics:

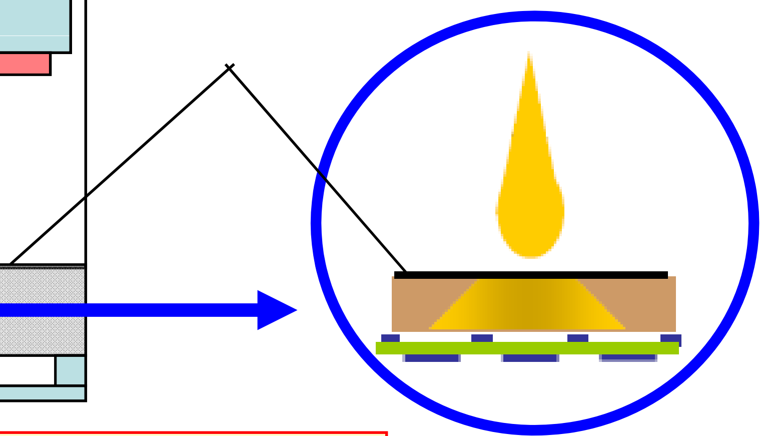
THGEM: hole-layout geometry?
THGEM : rim or no rim?
THGEM gain: single or double?
Gas?
Fields?
Readout?
Stability of gain?
Rates? ➔ CsI aging?
RTHGEM?

RD51 meeting, Paris, October 2008

Double-THGEM photon-imaging detector



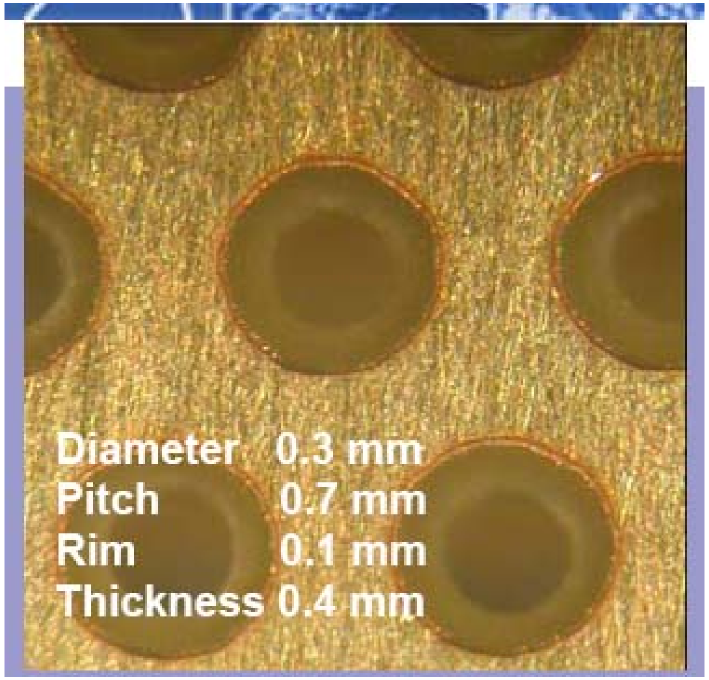
Single-photons:
Robust
Single-photon sensitivity
Effective single-photon detection
8ns RMS time resolution
Sub-mm position resolution
>MHz/mm2 rate capability
Cryogenic operation: OK

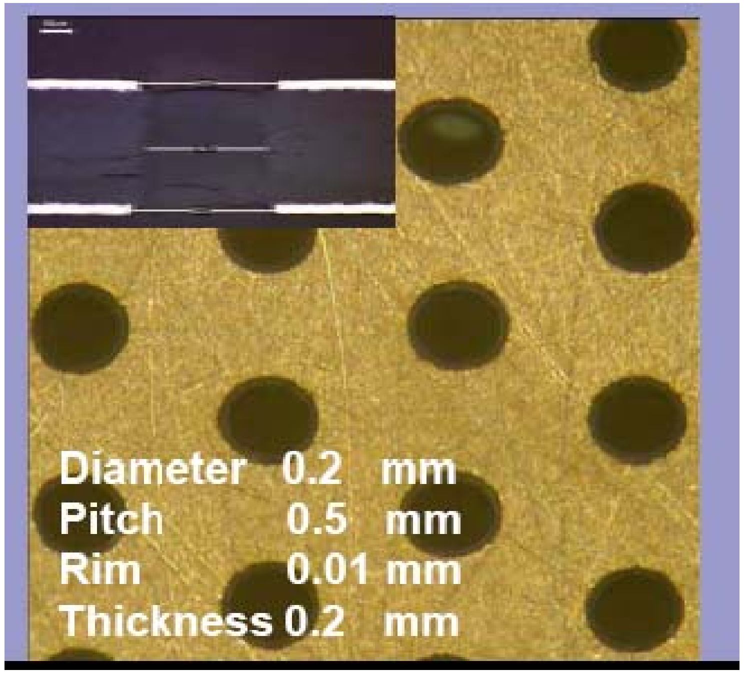


Induced-signal width matched to readout-pixel size.

One readout solution:
Resistive anode

TO RIM OR NOT TO RIM…?





Higher gain but:
- Higher charge-up
- Studied extensively

Lower gain but:
- Low charge-up
- Higher effective CsI surface
- Need further studies
  (e.g. e-collection into holes)

geometrical parameters of THGEMs studied at Weizmann

THGEM #	Thicknes s t [mm]	Drilled hole diameter d [mm]	Etched Cu diameter [mm]	Pitch a [mm]	*Ref* PC area [%]	Low (L) or Atm (A) pressure
1	1.6	1	1 (no etching)	7	98	L*
2	1.6	1	1 (no etching)	4	94	L*
3	1.6	1	1.2	4	92	L*
4, 6	1.6	1	1.2	1.5	42	L*+A
5	3.2	1	1.2	1.5	42	L*
7	0.4	0.5	0.7	1	56	A
8	0.8	0.5	0.7	1	56	A
9	0.4	0.3	0.5	0.7	**54**	1 atm
10	0.4	0.3	0.5	1.0	**77**	1 atm
11	2.2	1	1.2	1.5	42	L*
Standard GEM	0.05	0.055	.07	.14	77	

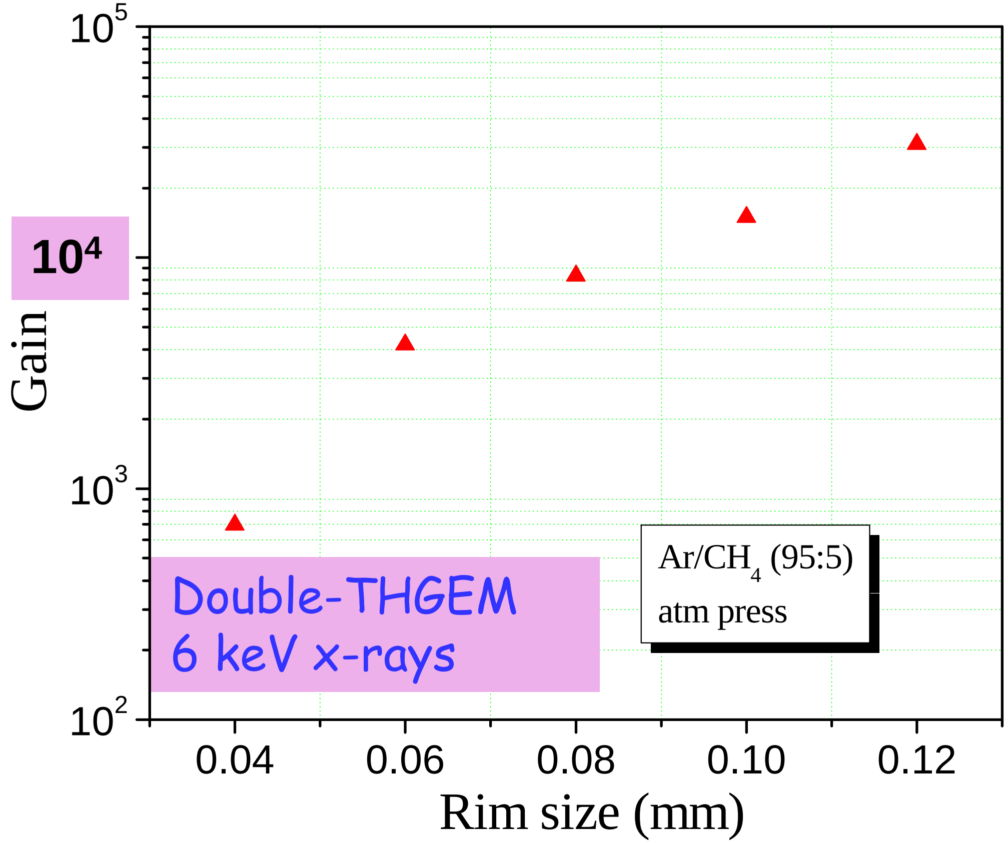
83%

92%

UV: Gain did not vary much with geometry

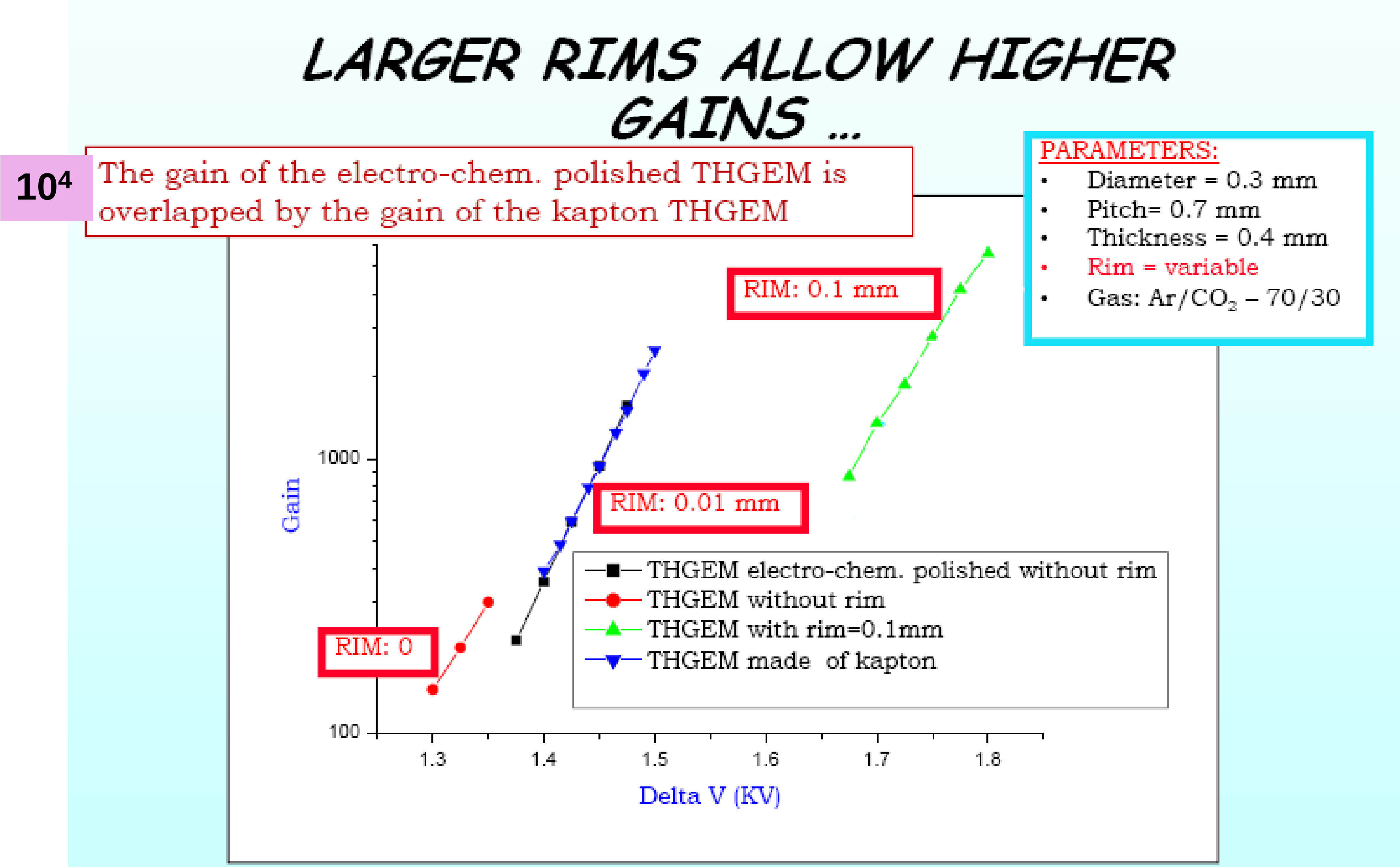
Active CsI area ➔ larger with no rim

THGEM - Gain vs rim size: Ar/5%CH_4



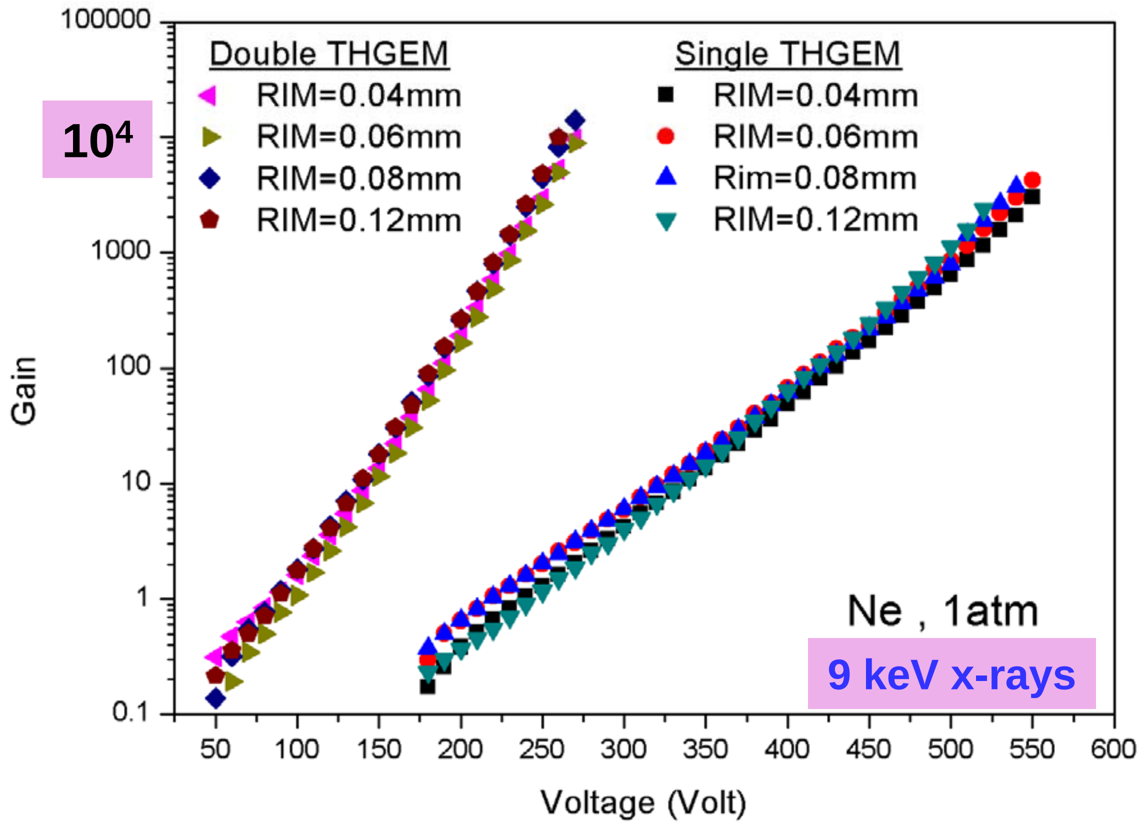
pitch *= 1 mm;* ***diameter*** *= 0.5 mm;*
rim*=40; 60; 80; 100; 120 µm*

GAIN vs RIM size: TRIESTE results: Ar/30%CO2



VERY NEW!

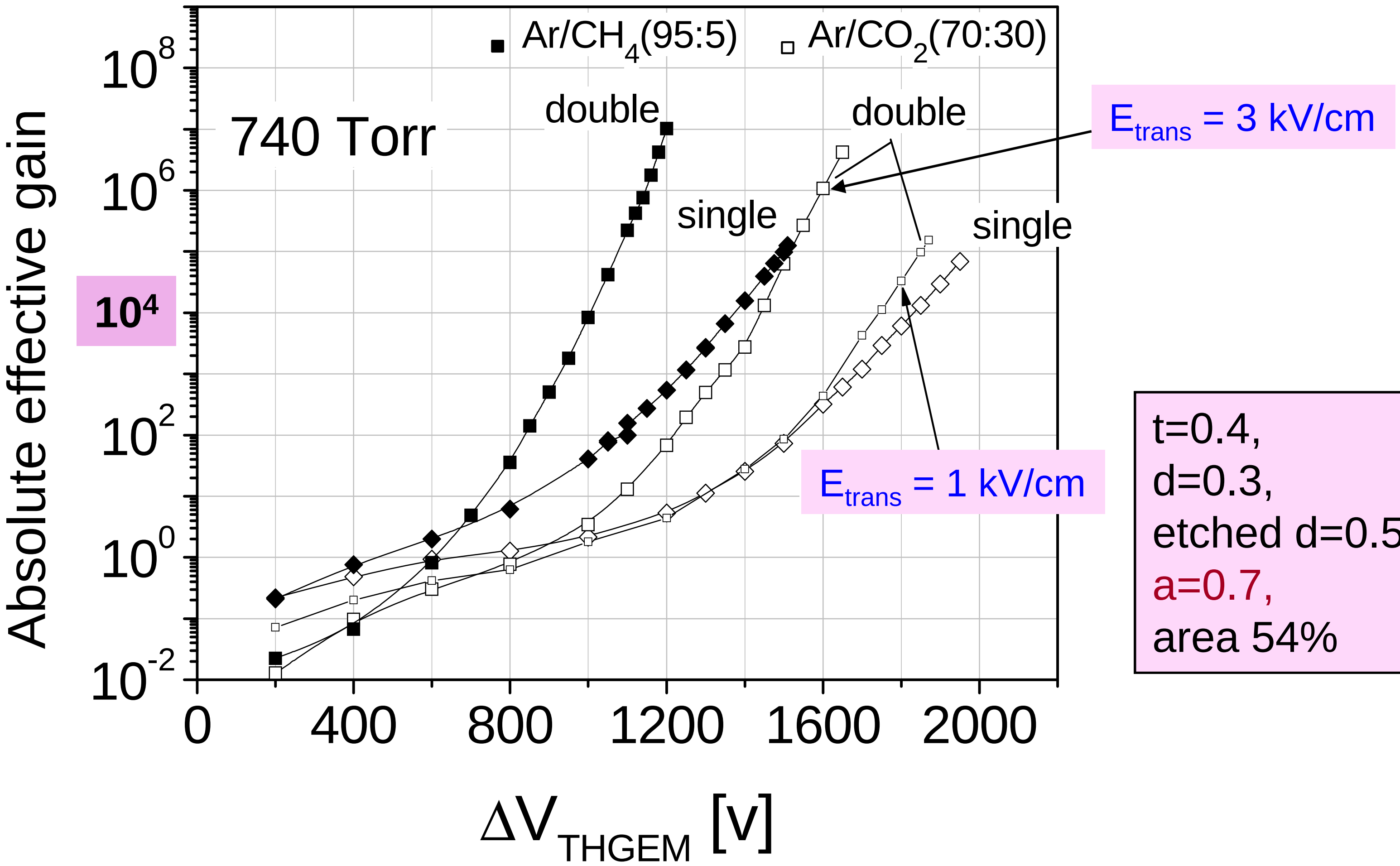
GAIN vs RIM-size in pure Ne



pitch *= 1 mm*
diameter *= 0.5 mm*
thickness *= 0.4 mm*
rim*=40-120 microns*

SIMILAR GAIN LIMIT WITH X-RAYS for RIM: 40-120 microns:
Single-THGEM: gain ~ 5,000
Double-THGEM: gain ~20,000

GAIN single- & double-THGEM: UV (recall)

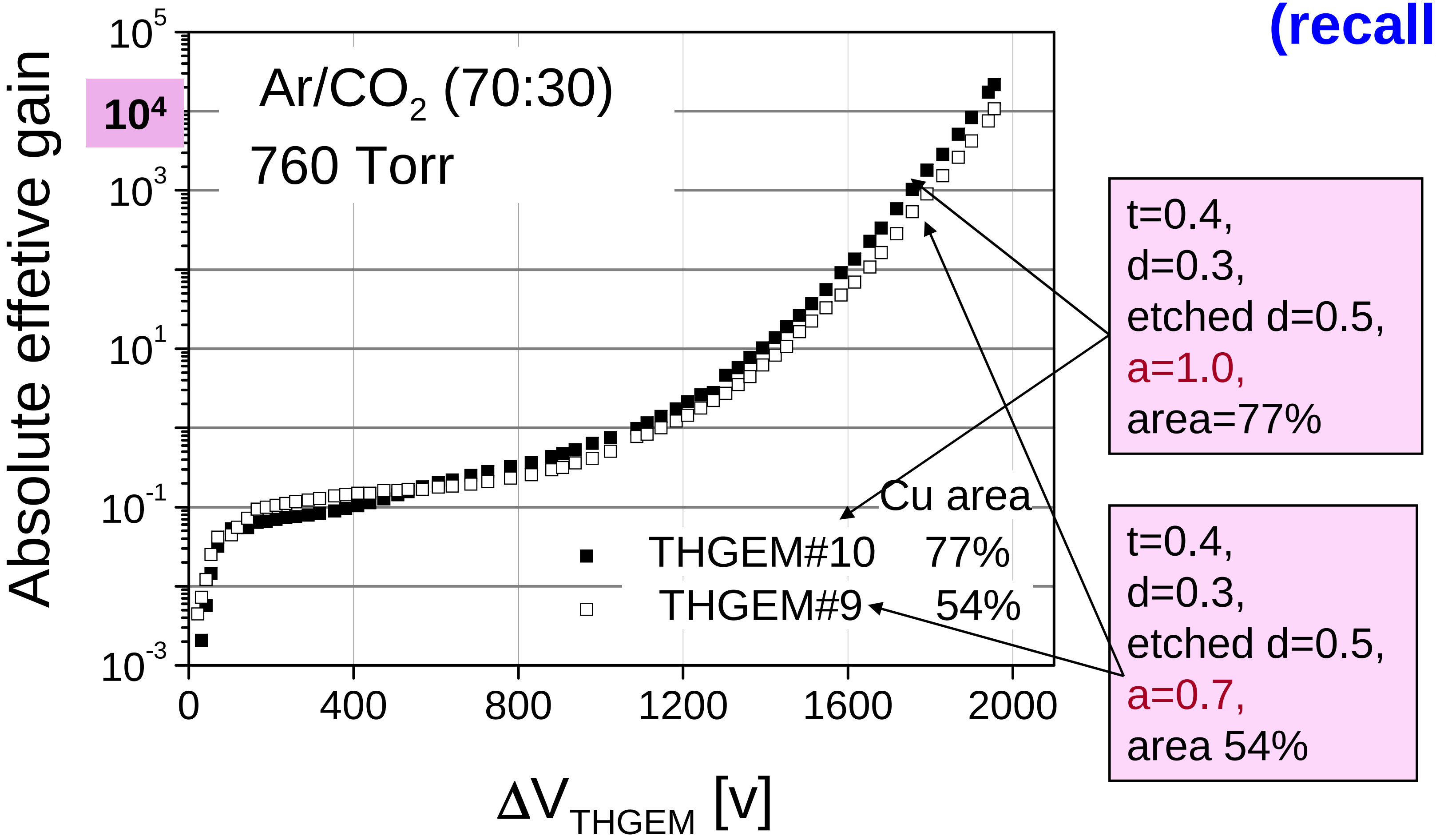


t=0.4,
d=0.3,
etched d=0.5,
a=0.7,
area 54%

2-THGEM: 100 higher gain & lower HV. Etrans➔ affects total gain

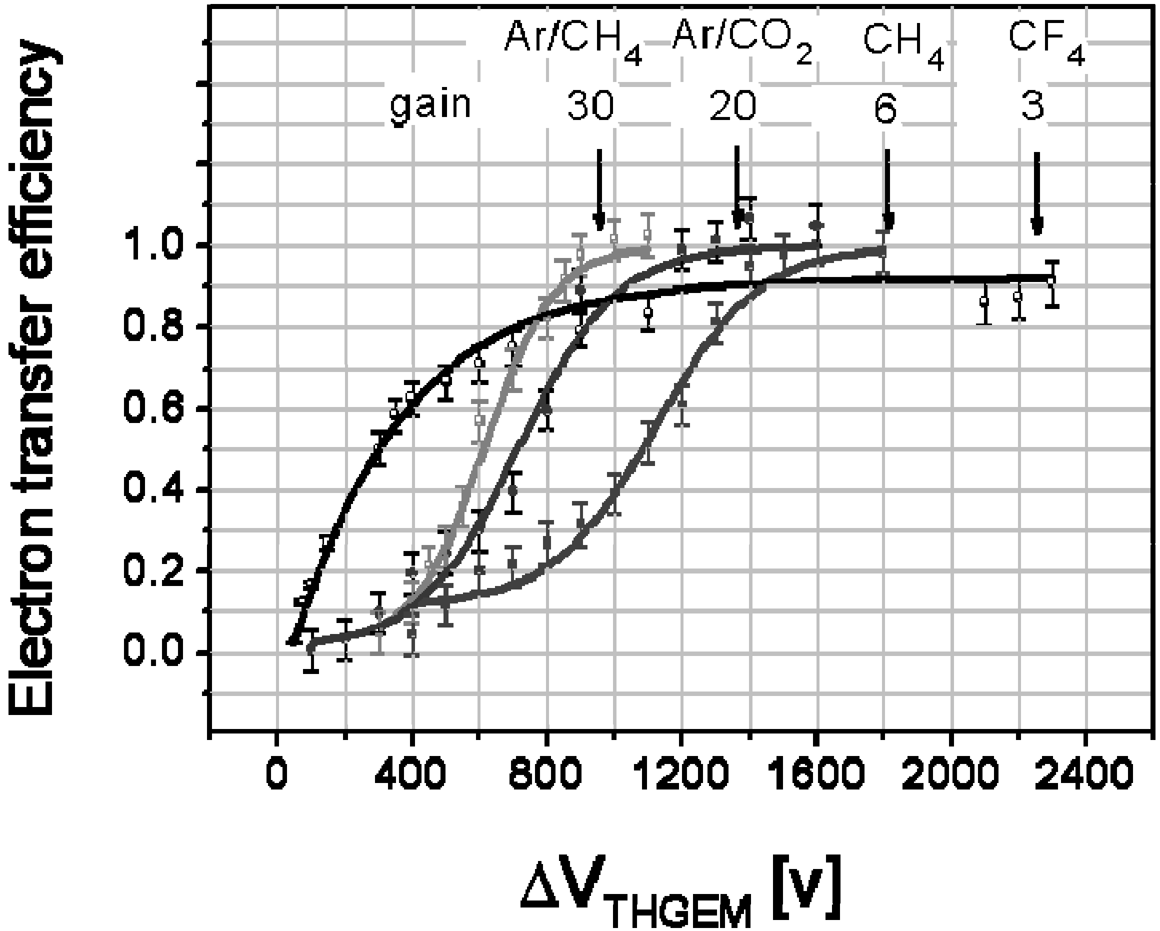
SINGLE-THGEM: EFFECT OF HOLE-PITCH: UV

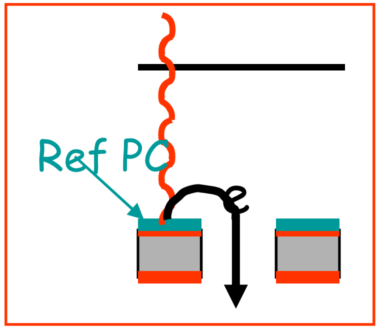
(recall)



Single-THGEM: Varying the hole pitch from 0.7 to 1 mm: minor effect on gain

e- collection efficiency into holes (recall)

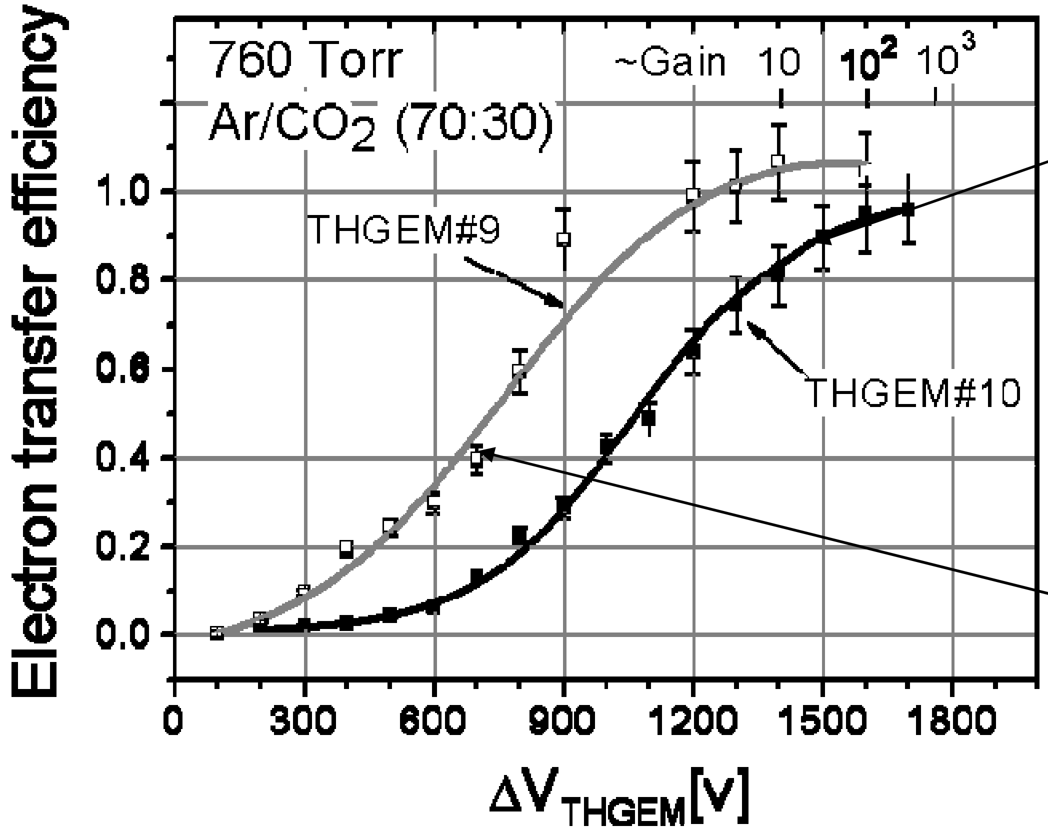




t=0.4,
d=0.3,
etched d=0.5,
a=0.7,
area 54%

DEPENDS ON DIFFUSION ➔ GAS & FIELDS
Large hole➔ smaller diffusion effects ➔ full collection at very low gains compared to standard GEM.

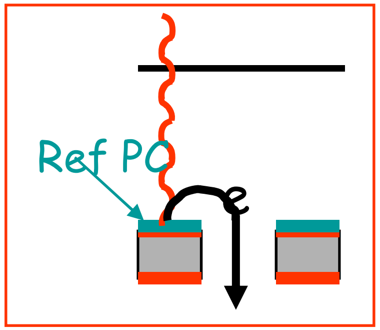
e- collection efficiency vs hole-pitch (recall)



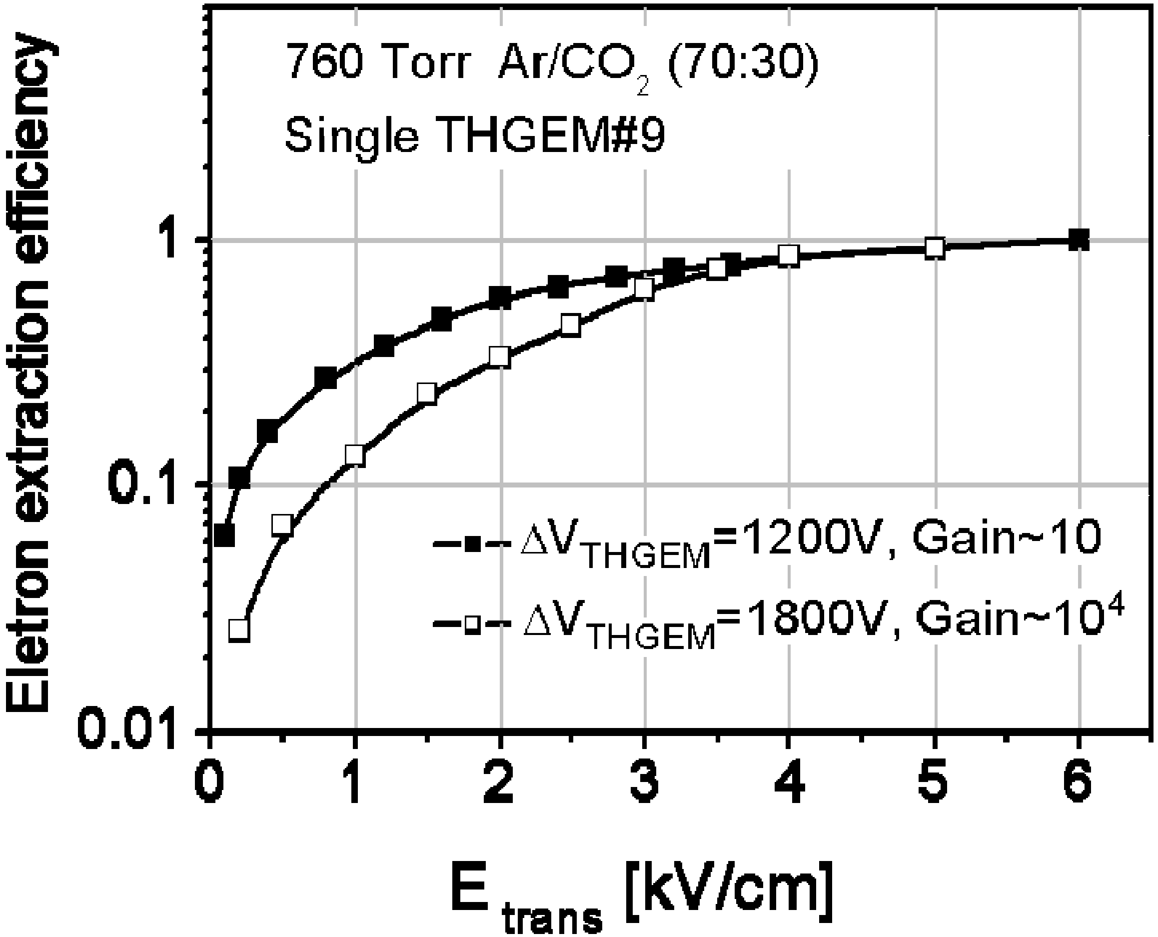
t=0.4,
d=0.3,
etched d=0.5,
a=1.0,
area=77%

t=0.4,
d=0.3,
etched d=0.5,
a=0.7,
area 54%

Larger pitch➔ need higher ΔV_{THGEM} & higher gain



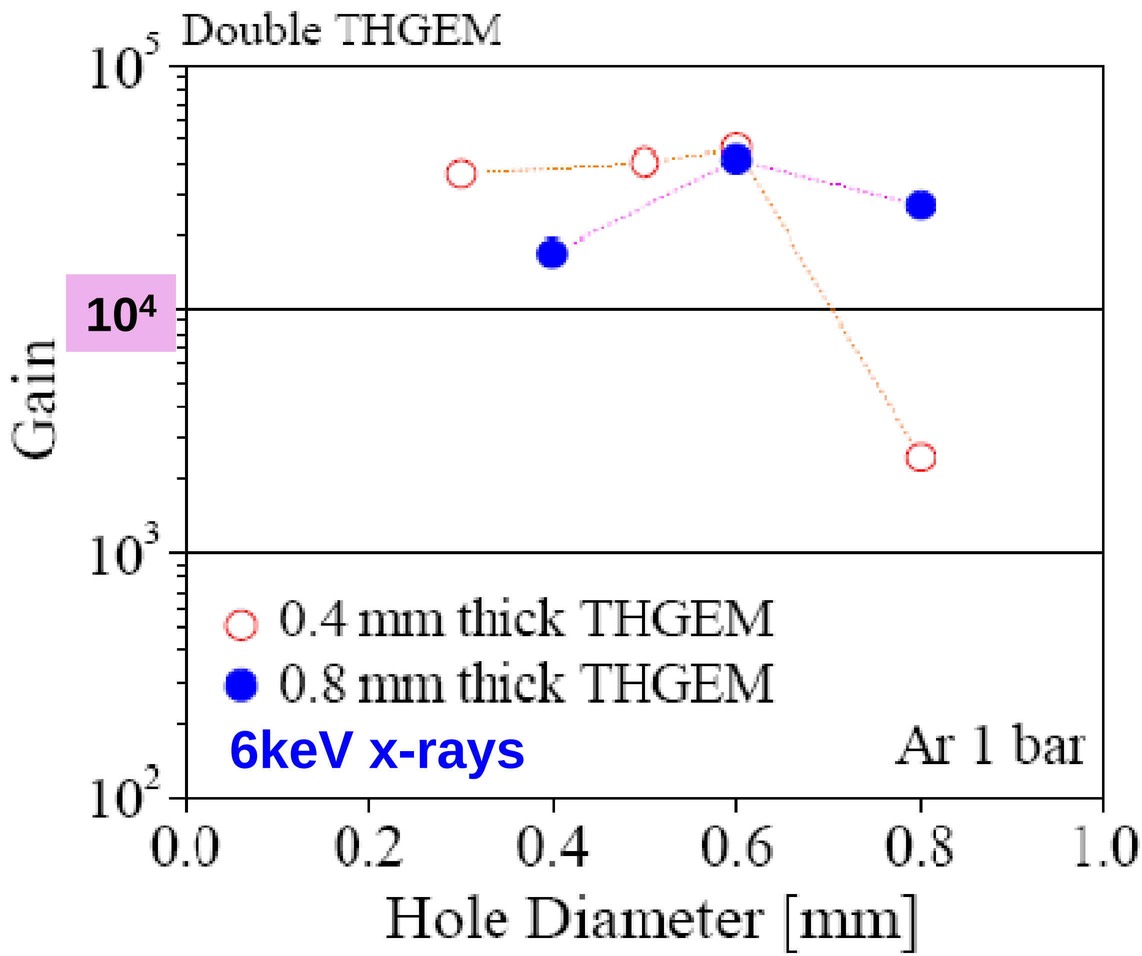
e- extraction efficiency from holes vs E $_{trans}$ (recall)



t=0.4,
d=0.3,
etched d=0.5,
a=0.7,
area 54%

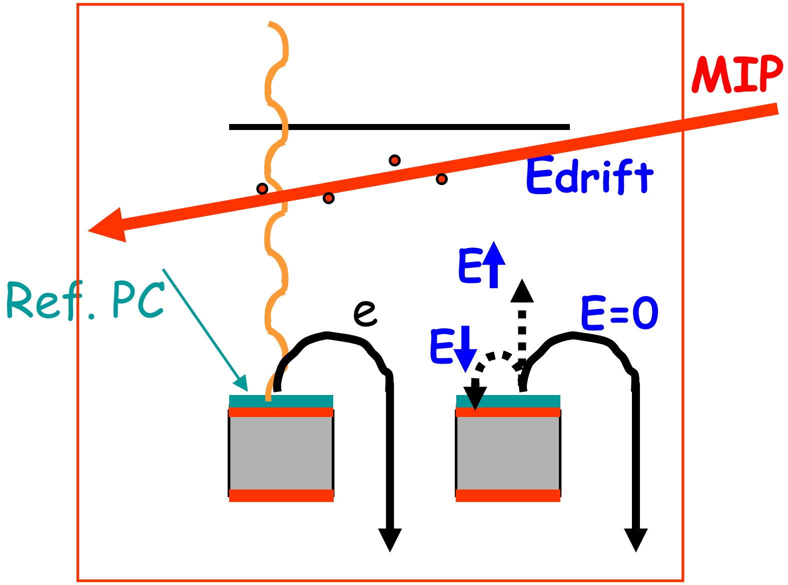
VARIES WITH GAS & THGEM PARAMETERS

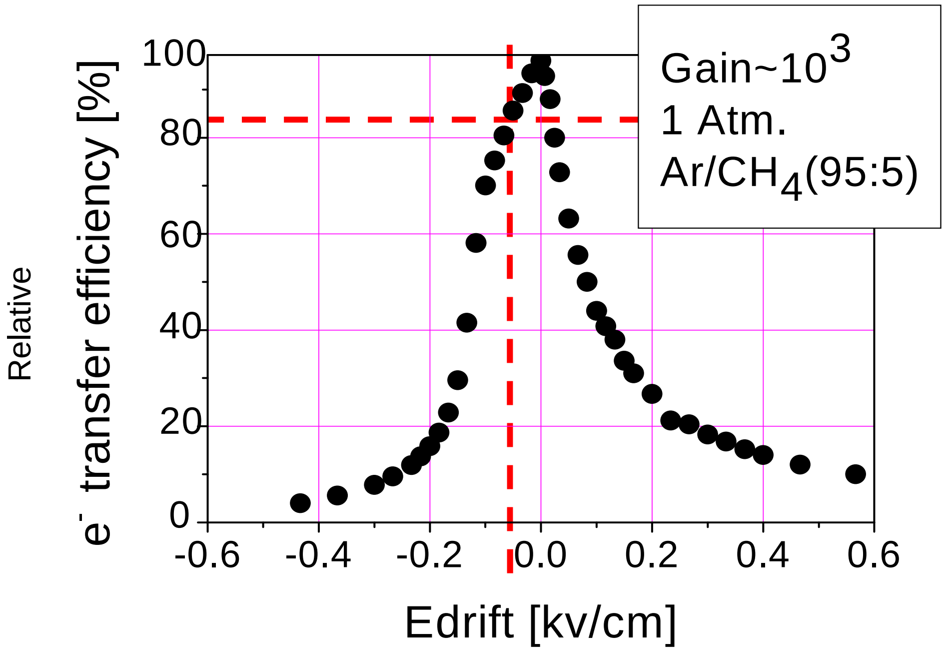
GAIN vs HOLE DIAMETER/THICKNESS



MAX GAIN ➔ hole diameter ~ thickness

Reversed Drift-field





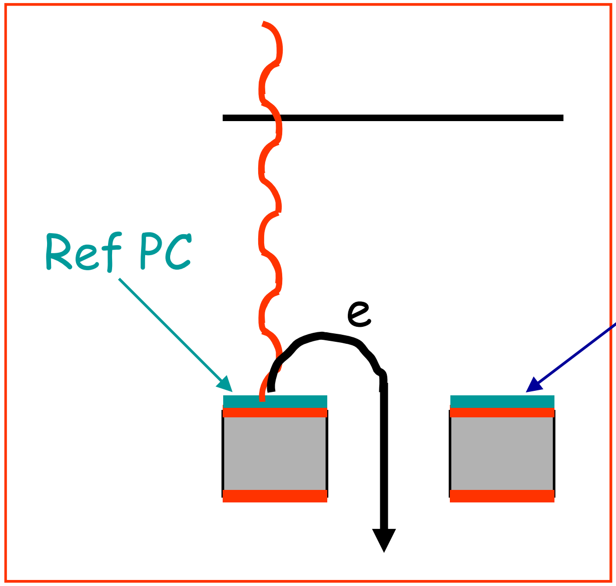
Focusing is done by hole dipole field.

- **Maximum efficiency at E_{drift} =0 (like in GEM).**
- **Slightly reversed E_{drift} (50-100V/cm)**
  good photoelectron collection & low sensitivity to MIPS (~5-10%) !

Attention: gas and field dependent!

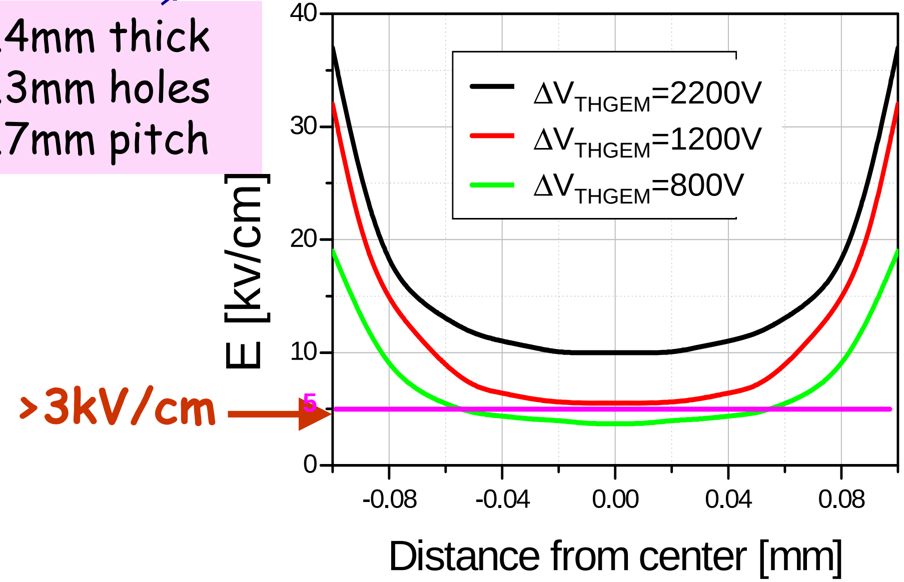
Photoelectron extraction: effective QE

FIELD AT THE THGEM CsI SURFACE



0.4mm thick
0.3mm holes
0.7mm pitch

Electric field on photocathode surface created by the hole dipole field



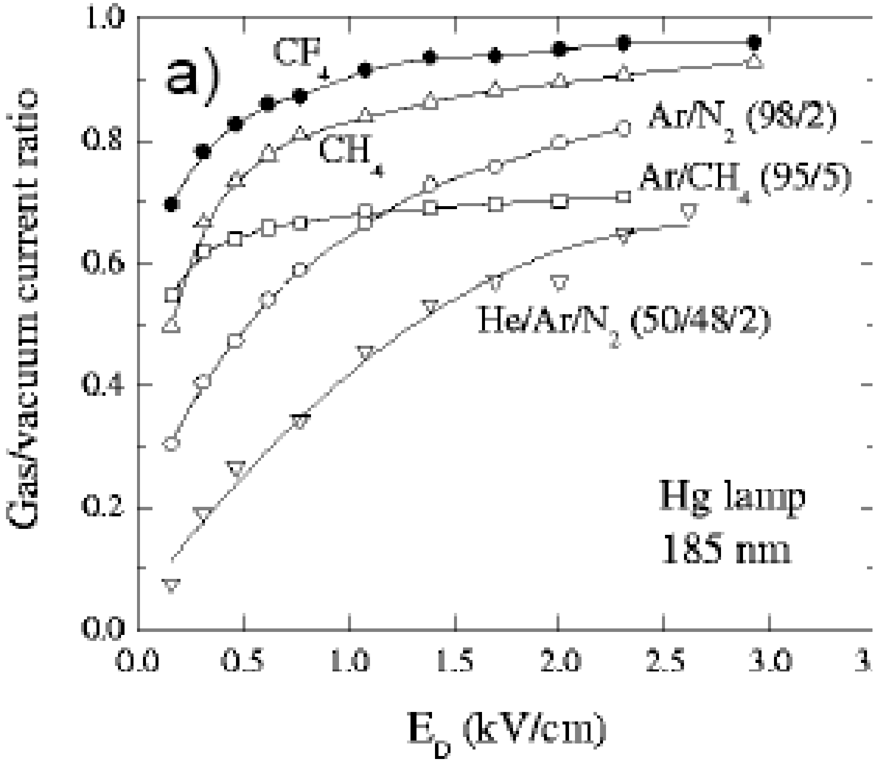
High field on the PC surface (high effective QE)
Also at low THGEM voltages (e.g. in Ne mixtures!)

Attention: varies with hole-pitch & hole-voltage

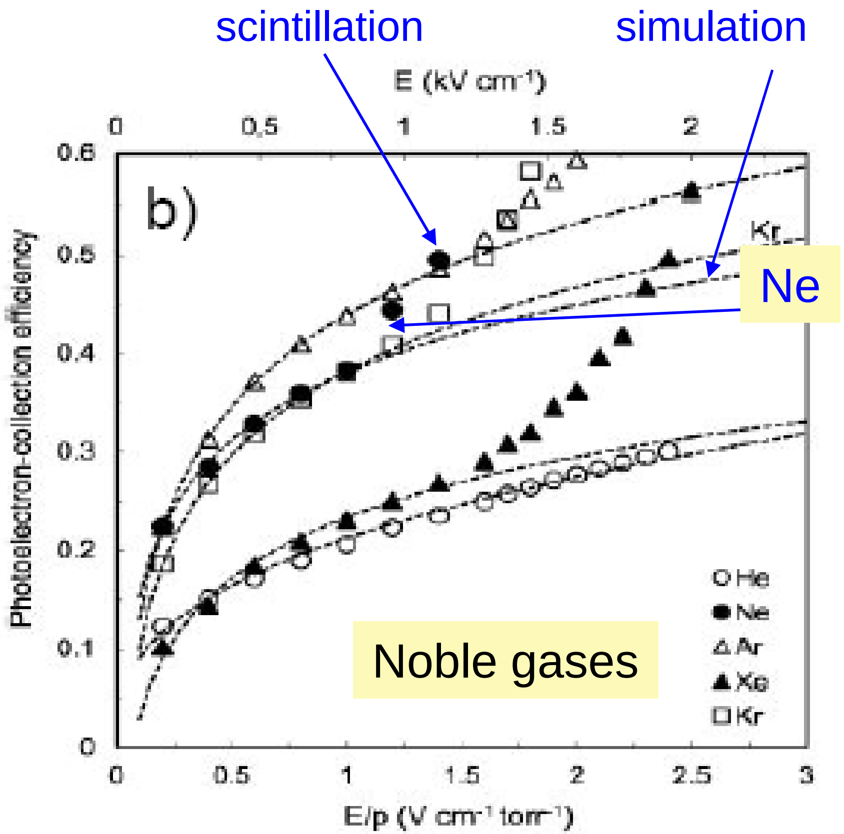
C. Shalem et al. NIM A558 (2006) 468

BACKSCATTERING ON GAS: EFFECTIVE QE

No data for Ar/CO_2 & Ne/CH_4



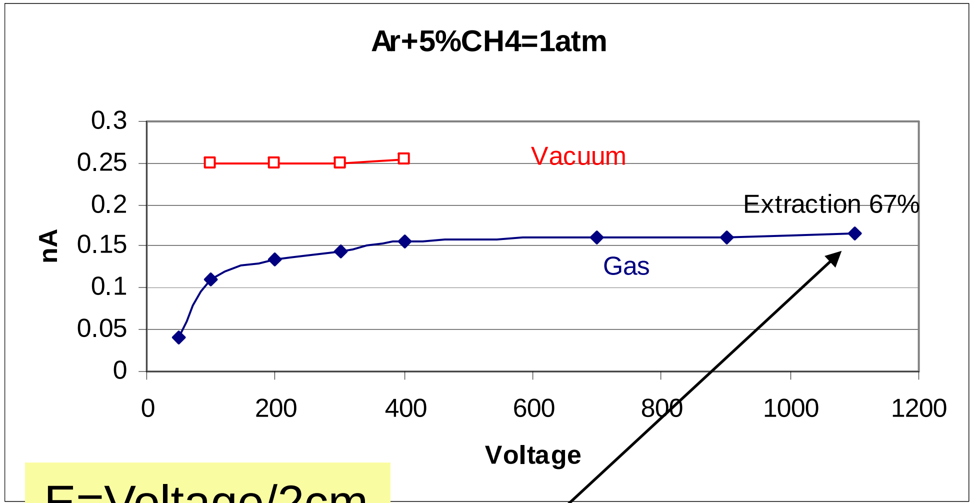
Breskin et al. NIM A483 (2002) 670



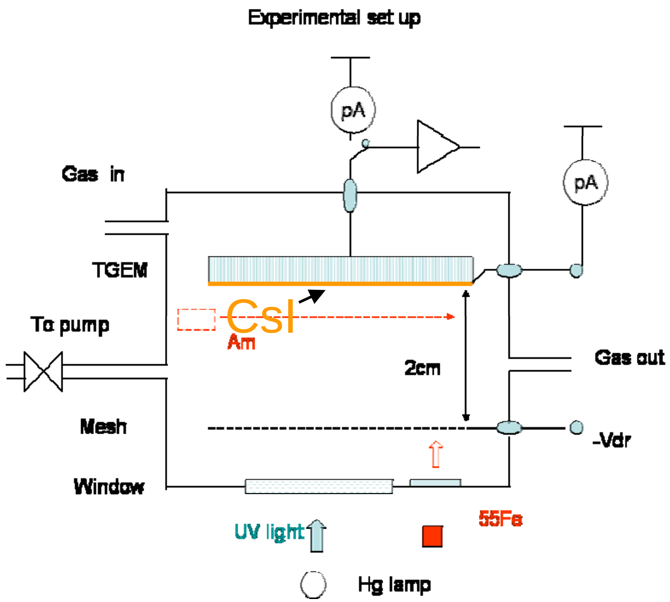
Coelho et al NIMA 581(2007)190

Repeated: extraction from CsI pc: Ar+5%CH4

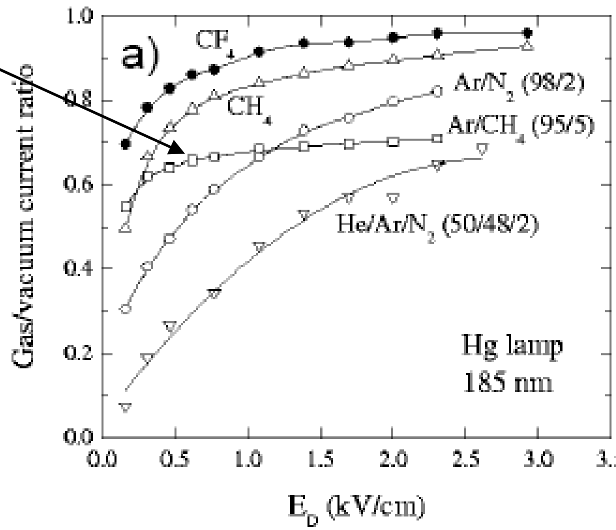
This work



E=Voltage/2cm

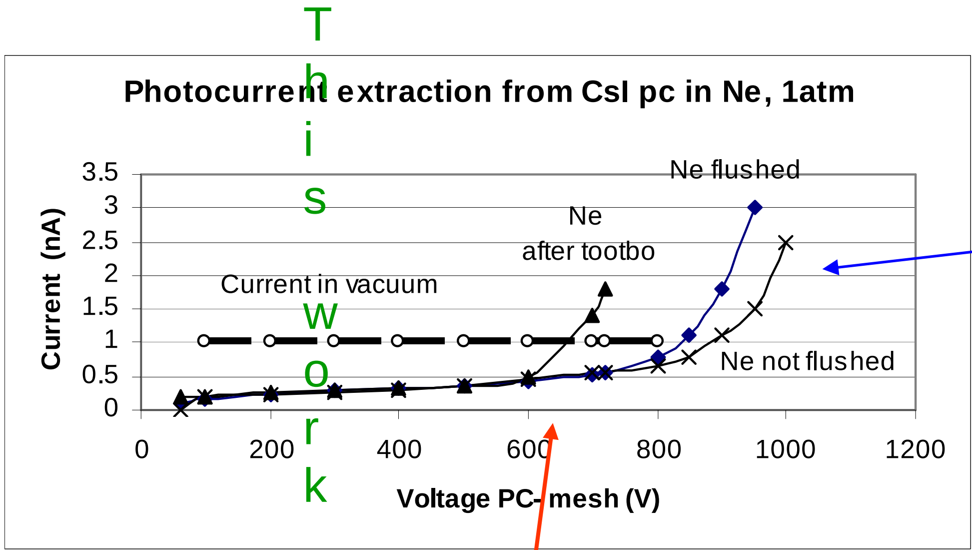


Extraction efficiency:
Ar/5%CH4: **67%**@550V/cm
➔ Same in both works

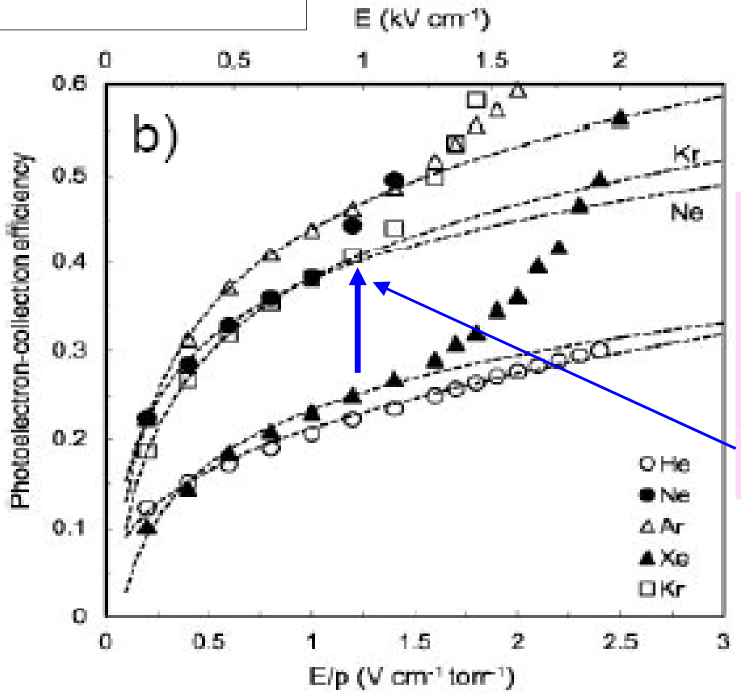


Breskin et al. NIM A483 (2002) 670

Repeated: extraction from CsI pc: Ne



scintillation



Extraction efficiency:
Depends on Ne purity!
After turbo: ~50% @ 300V/cm
Flushed: ~60% @ 380V/cm
"Static": ~70% @ 420V/cm

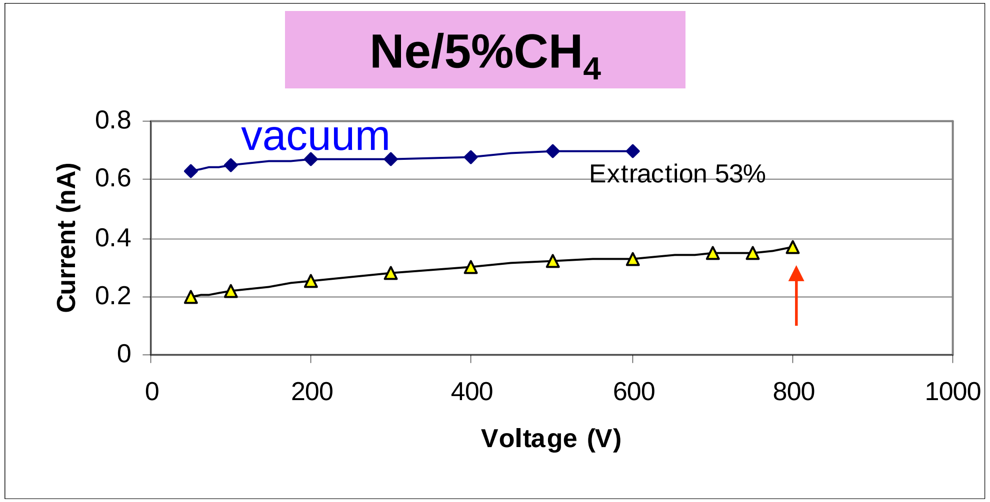
Extr. Efficiency
In ultra-pure Ne
(with getter):
~40% @ 900V/cm
Scintillation limit!

Need to add a "quencher"

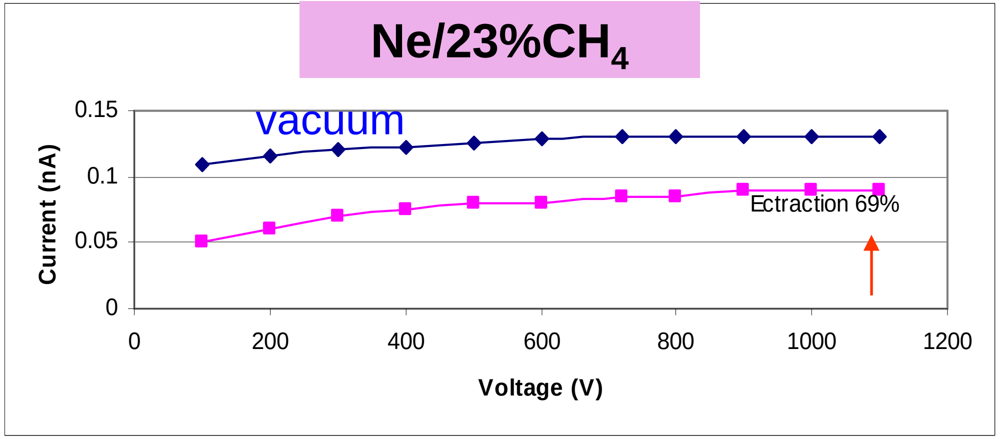
Coelho et al NIMA 581(2007)190

Extraction from the CsI pc in: Ne+CH4

This work



This work



$Ne/5\%CH_4$: ~53% @ 400V/cm
$Ne/23\%CH_4$: ~**69%** @ 550V/cm
NO SCINTILLATION!

Similar to $Ar/5\%CH_4$

Gain stability

- Discussed yesterday
- Depend on gas, THGEM-parameters, gain, rate. To determine in “real conditions” with CsI/UV.
- Seems better with no rim (TRIESTE) @ $6x10^4$
- To check with Ne-mixtures and high-rate UV

Gain comparison for UV:

- **WIS:** $Ar/5\%CH_4$ & $Ar/30\%CO_2$, with 0.1mm rim:
  1-THGEM 10^5 & 2-THGEMs **10^7**
  Ne, Ne/CH_4 1-THGEM 10^5 -10^6

- **TRIESTE:** $Ar/30\%CO_2$, with 0 rim:
  2-THGEMs **$6x10^4$**

Summary - considerations for a RICH w CsI

1. Gain ➔ Single- vs double-THGEMs
   Lower voltage per THGEM
   Larger dynamic range – less sensitive to heavily ionizing BGND
   Optimize transfer field! (gas-dependent)
2. Gas
   Diffusion: affects e- collection eff. into the holes
   V_{hole}: affects effective-QE (photoelectron extraction from CsI)
3. Photon detection efficiency ➔ Effective-QE + e-collection + gain
   Effective-QE➔ Hole layout & field at CsI surface
   Extraction fields should be calculated vs hole-layout & rim-size & gas
   e- collection efficiency should be measured in pulse-counting mode with no-rim THGEMs in the selected gas (not simple but method known)
4. Gain-stability ➔ rim vs no-rim
5. Induction field ➔ defined by readout type
6. Drift field above CsI➔ slightly reversed to reduce MIPs sensitivity
7. RTHGEM? If in Ne: low HV, stable operation…
8. Max gain in LARGE AREA THGEM (defects limit)
9. RICH tests: how? Who? When?

Ne or Ne/CH_4

- **Attractive low voltages**
- **Similar e-extraction efficiency to Ar/CH4**
- **High gain for x rays & UV ➔ dynamic range**

But still to verify:

- Calculate fields on PC surface to estimate e- extraction eff. in real conditions
- large diffusion ➔ e- collection efficiency into holes should be measured.
  ➔ optimize transfer field
  ➔ Maybe need to increase hole size (loss eff. surface)
  ➔ Max gain in rimless THGEM
- Raether limit ➔
  verify if lower sensitivity to heavily ionizing BGND