

Update on THGEM project for RICH application

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On behalf of an Alessandria-CERN-Freiburg-Liberec-
Prague-Torino-Trieste Collaboration

Outline

- Short introduction;

In order to detect the single photon, we investigated many aspects:

- Multilayer detector;
 - Spectra and gains;
 - Time resolution;
 - Photoelectron extraction efficiency.
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- Conclusions

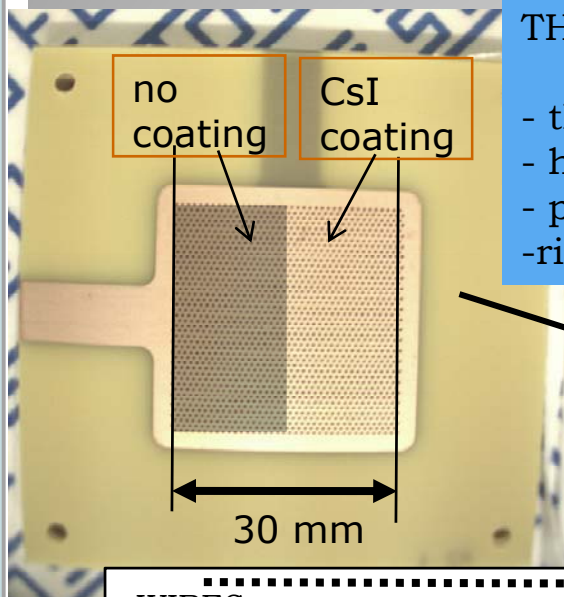
Short Introduction (1/2):

- From the systematic characterisation studies over 30 THGEMs we learned the following:
 1. Use the smaller rim possible (i.e. 10 μm) for limiting the gain instabilities vs time;
 2. Maximum gain variation of 20% over a range of several MHz/mm²;
 3. The production aspect is not negligible and to fix as important geometrical parameter as well.

Short Introduction (2/2):

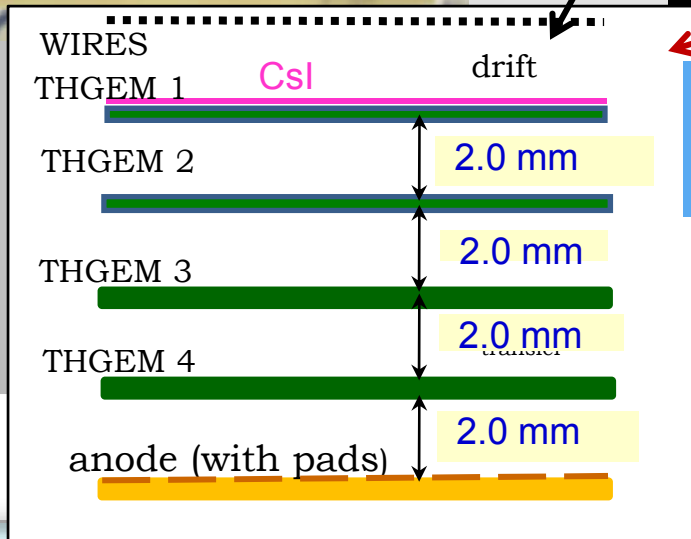
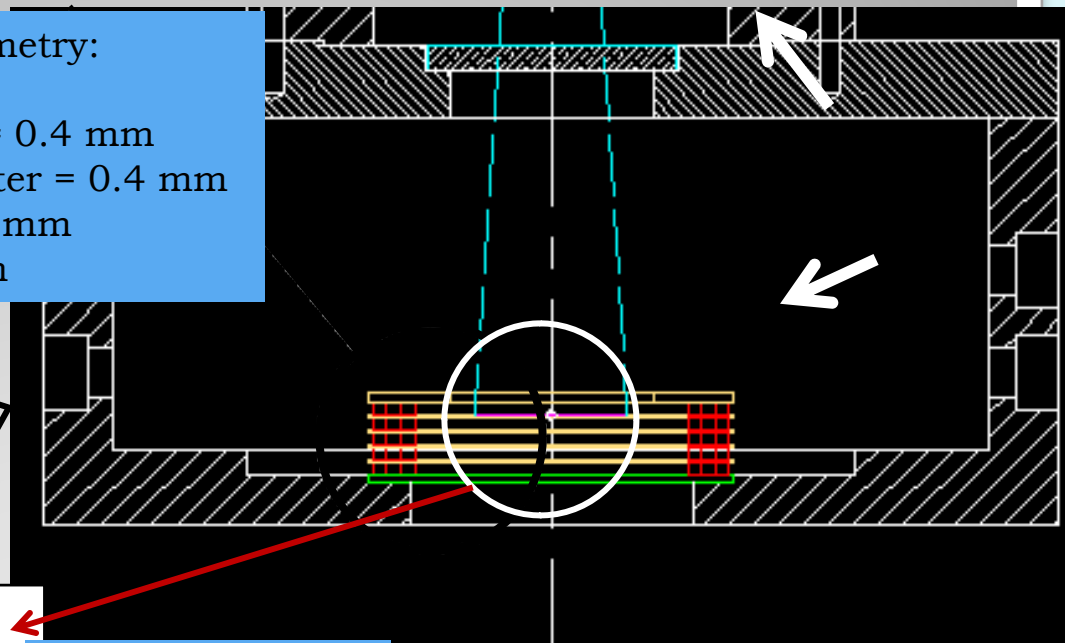
Up to now we tested the THGEMs as detector for ionizing particle and now we are verifying the THGEMs as photon detector.

Multilayer detector for single photon detection



THGEM geometry:

- thickness = 0.4 mm
- hole diameter = 0.4 mm
- pitch = 0.8 mm
- rim = 10 μm



NOTE:
reflective
photocathode



UV light Pulse Source

1. Model UV LED-255

by Seoul Optodevice Co., Ltd, Seoul, Korea (South)

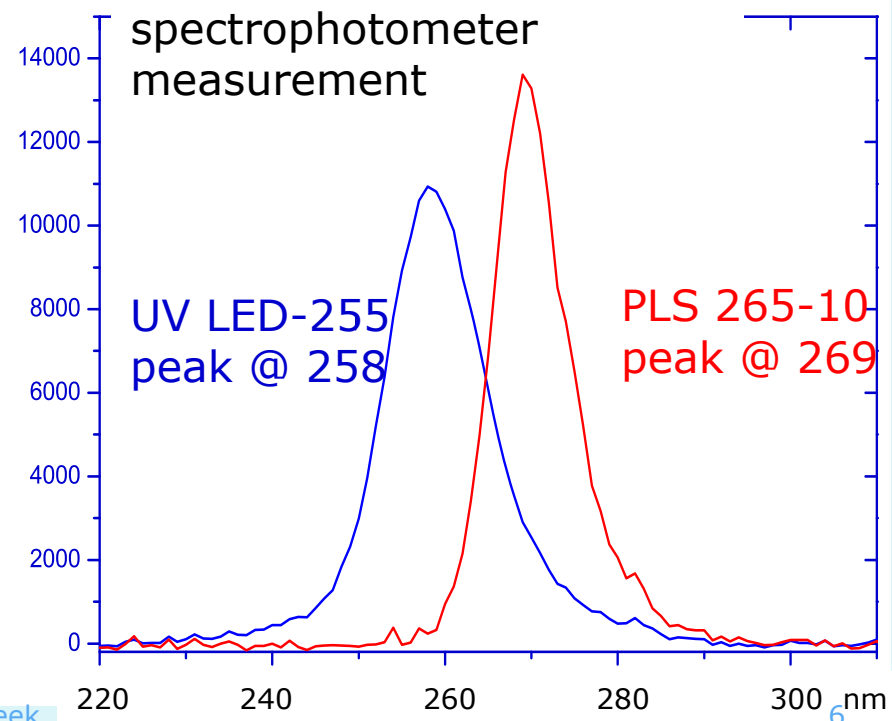
- Central wavelength: $255 \pm 10 \text{ nm}$
- Spectral line width: $<20 \text{ nm FWHM}$
 - also called germicidal ray (disinfection)
 - Applications: Water/Surface purification, Laboratory testing



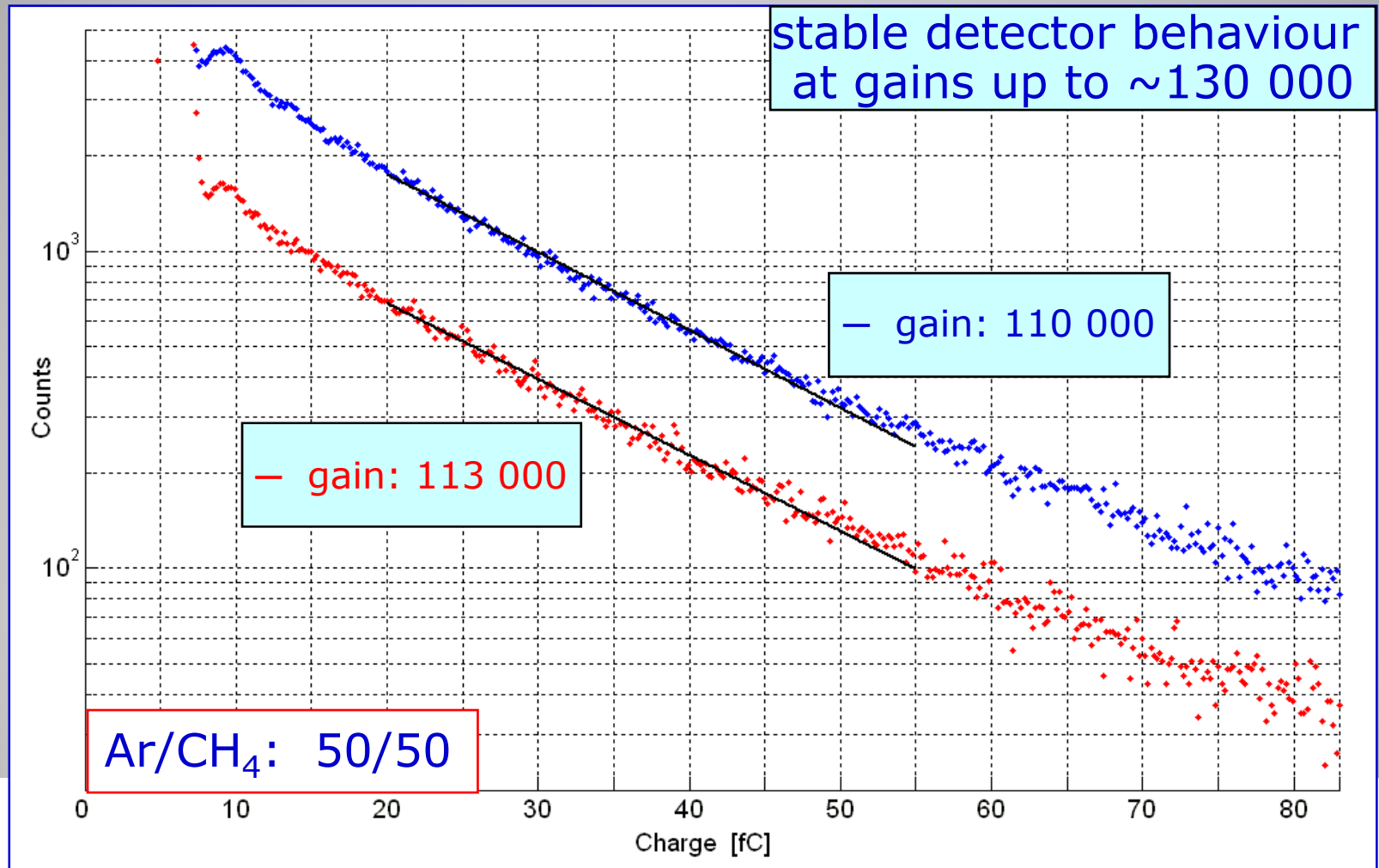
2. PLS 265-10 (pulsed LED) and controller

by PicoQuant GmbH, Berlin, Germany

- 600 ps long pulses
- up to 40 MHz



Single photon detection: amplitude spectra



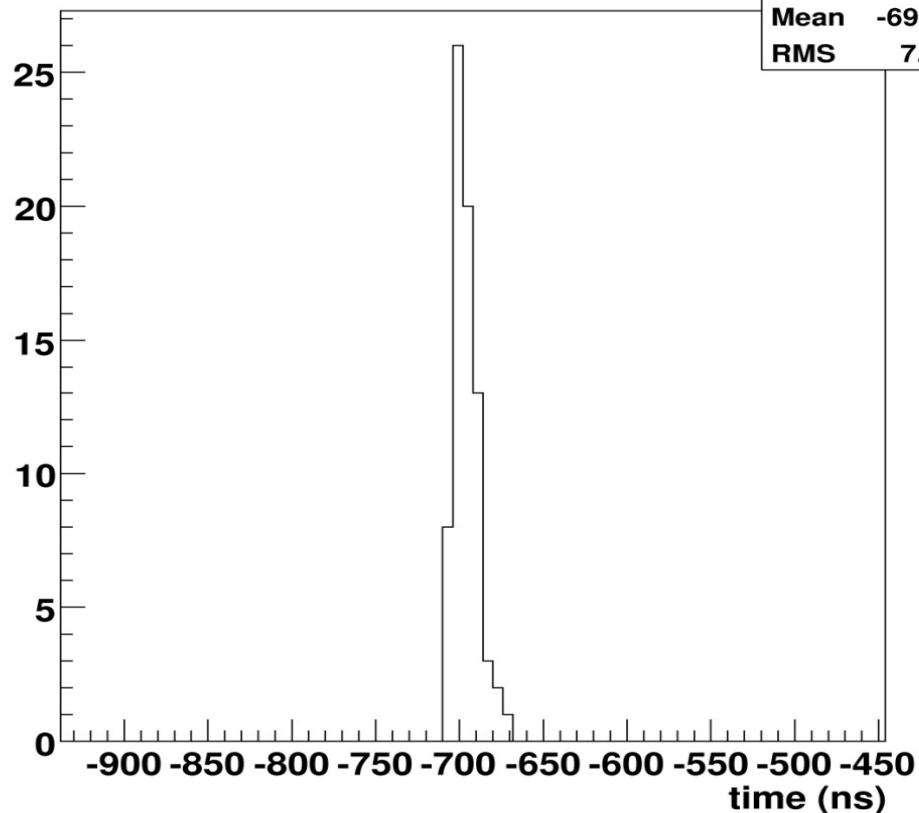
Single photon detection: time resolution

Recall:

TDC bin size: 108 ps
pulse width: 600 ps

No detector optimisation
for time response
performed so far

RT01P10_times

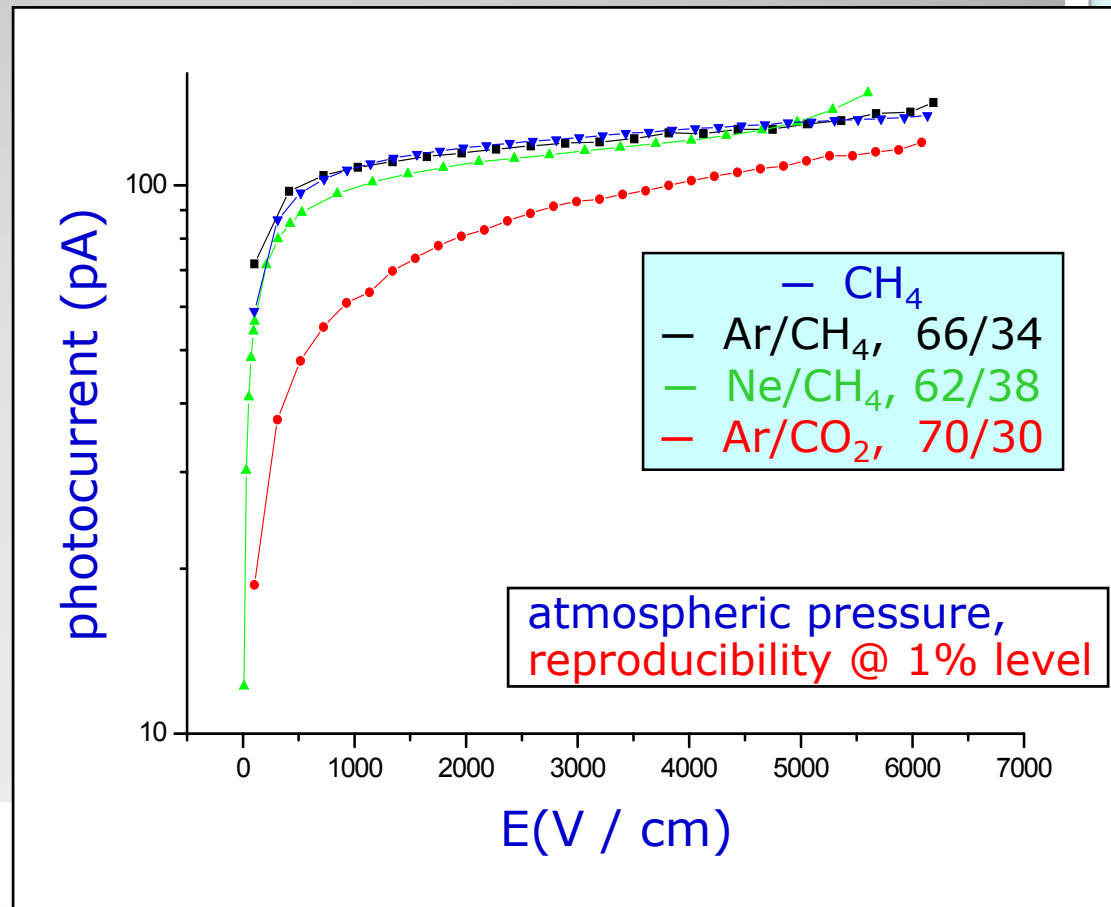
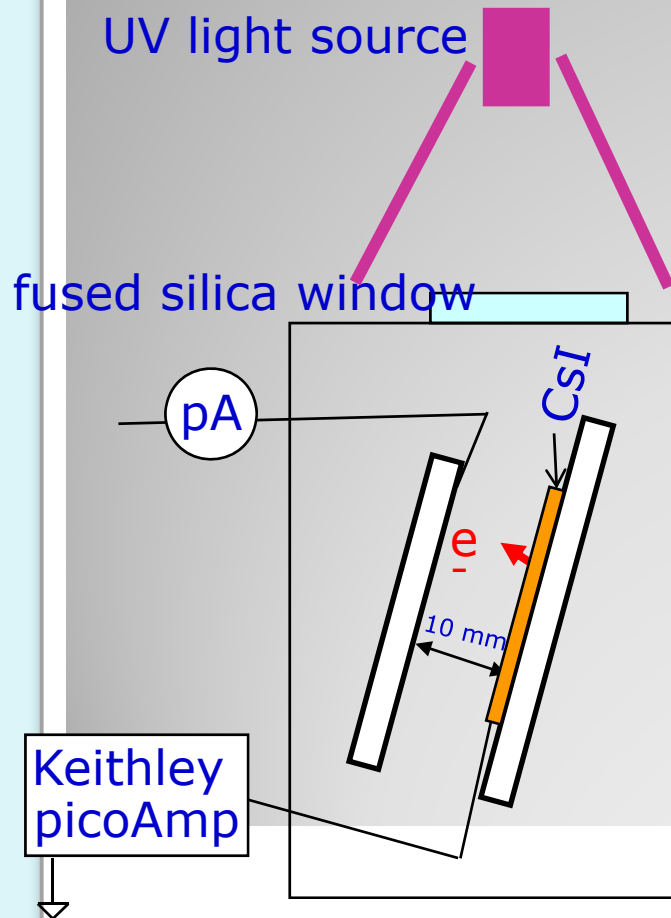


RT01P10_times

Entries	81
Mean	-696.1
RMS	7.52

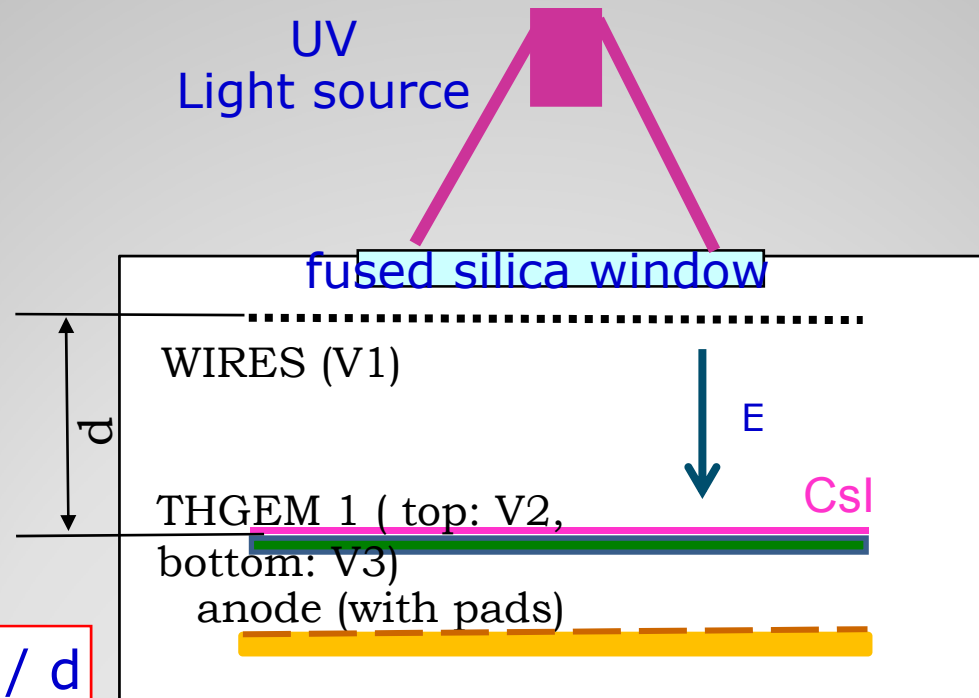
Photoelectron extraction (1/6)

Photocurrent measurements in various gas atmospheres

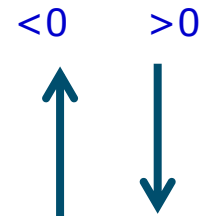


Photoelectron extraction (2/6)

Photoelectron extraction vs ΔV and E , simulations and measurements



E field, sign
convention

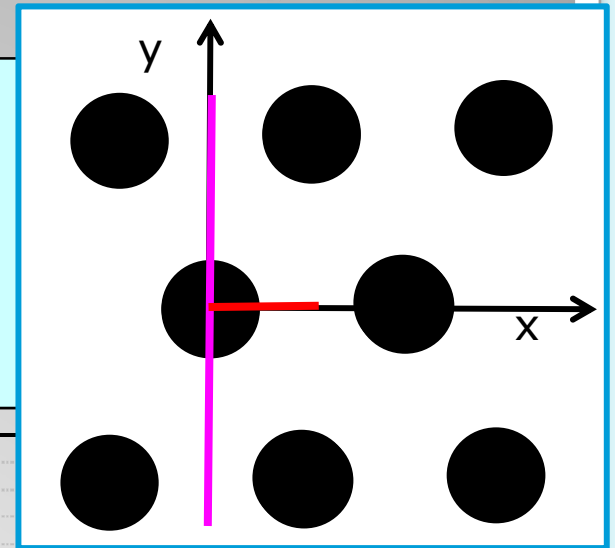


$$E = (V2 - V1) / d$$
$$\Delta V = V3 - V2$$

Photoelectron extraction (3/6)

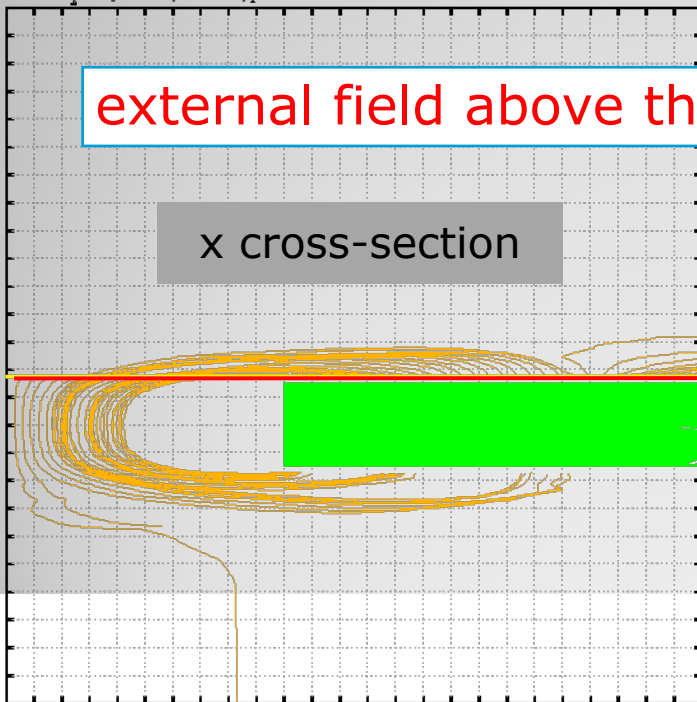
photoelectron trajectories from
a THGEM photocathode, simulation,
multiplication switched off

thickness 0.6 mm, diam. 0.4 mm, pitch: 0.8 mm, $\Delta V = 1500$ V

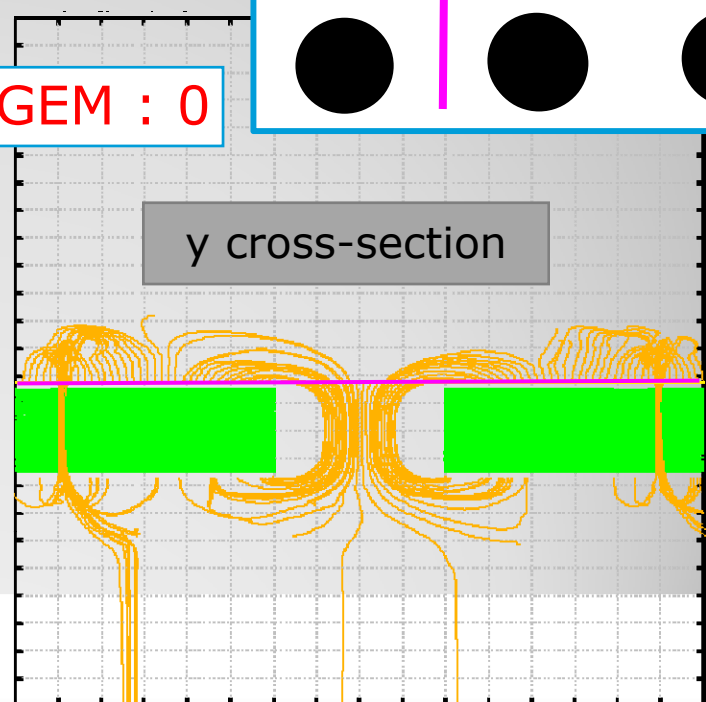


external field above the THGEM : 0

x cross-section



y cross-section

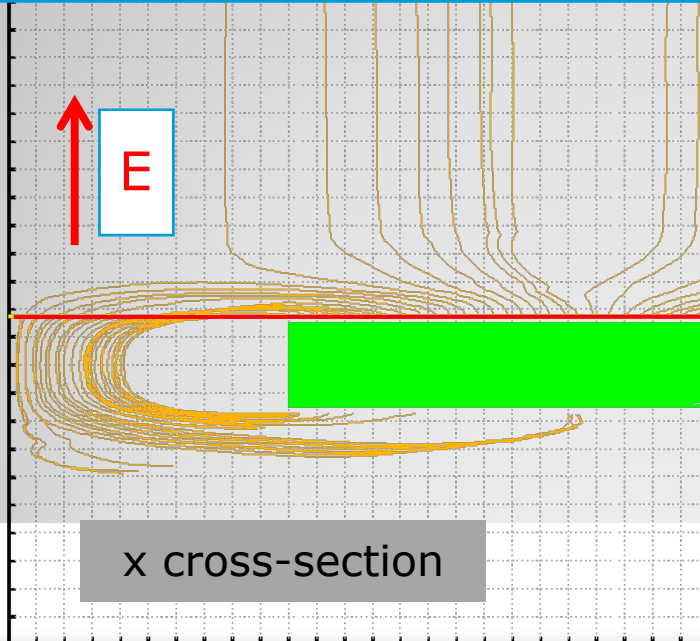
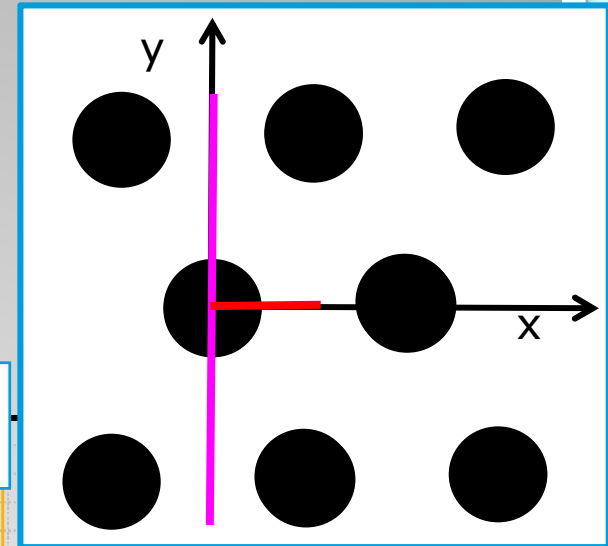


Photoelectron extraction (4/6)

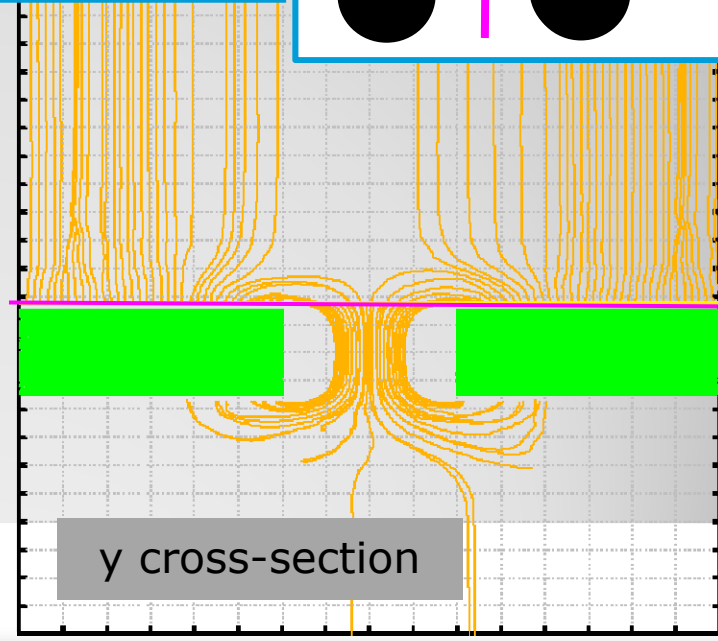
photoelectron trajectories from
a THGEM photocathode, simulation,
multiplication switched off

thickness 0.6 mm, diam. 0.4 mm, pitch: 0.8 mm, $\Delta V = 1500$ V

external field above the THGEM : - 500 V /cm:
photoelectron lost (not entering the holes)



x cross-section



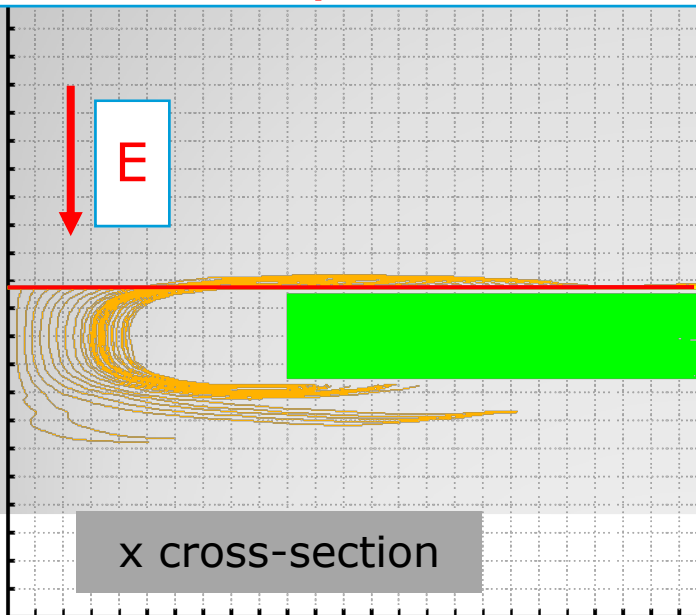
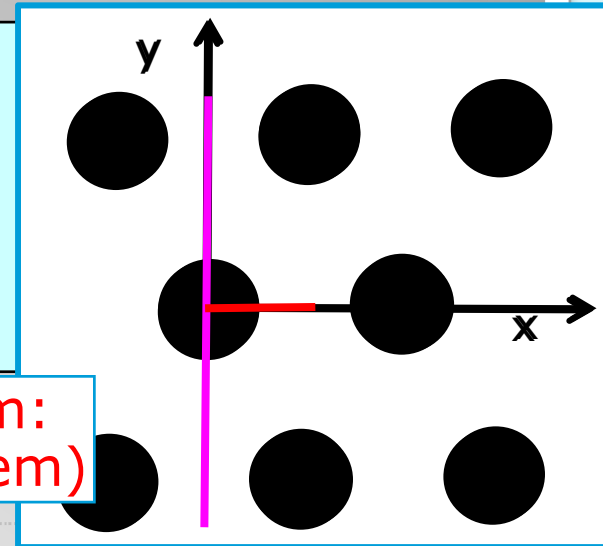
y cross-section

Photoelectron extraction (5/6)

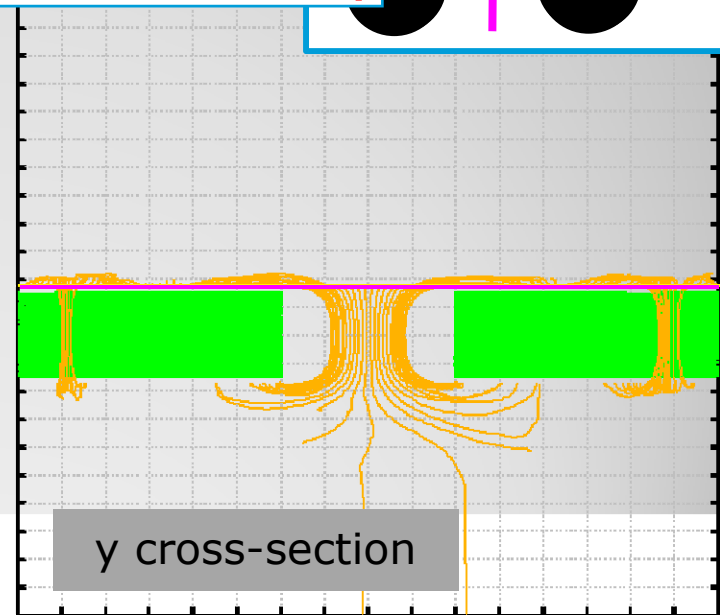
photoelectron trajectories from
a THGEM photocathode, simulation,
multiplication switched off

thickness 0.6 mm, diam. 0.4 mm, pitch: 0.8 mm, $\Delta V = 1500$ V

external field above the THGEM : + 500 V /cm:
photoelectron lost (too low field to extract them)



x cross-section

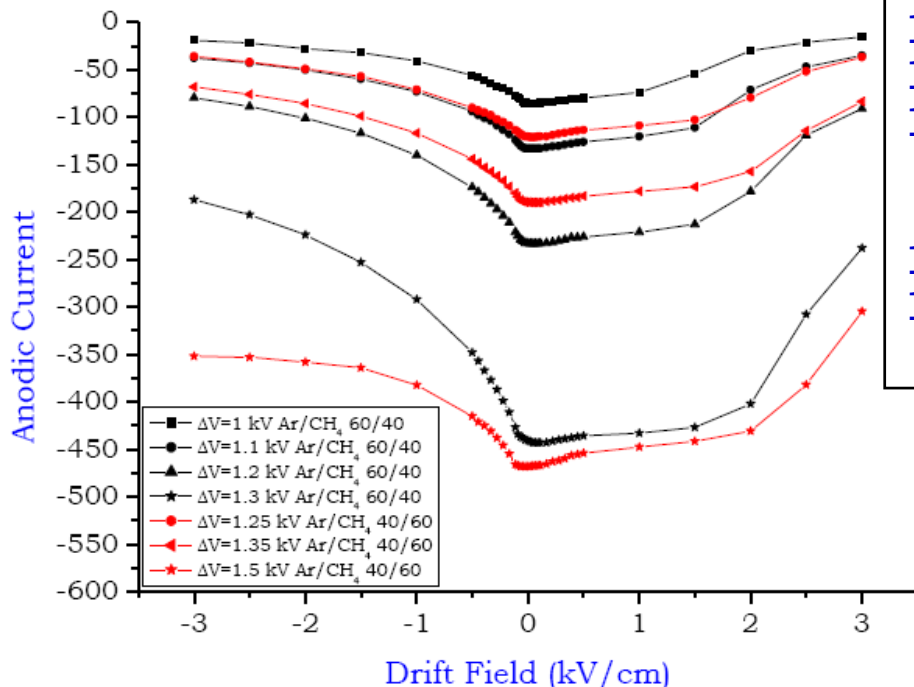


y cross-section

Photoelectron extraction (6/6)

Anodic current in a THGEM detector versus the external electric field applied, a measurement

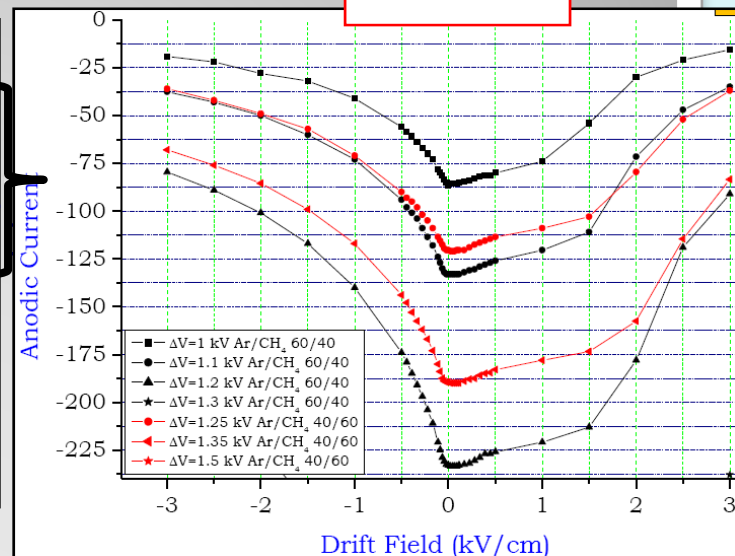
Ar/CH₄: 40/60; 60/40



ΔV =
1kV
1.1, 1.2
1.25, 1.3

1.35
1.5

ZOOM



The behaviour predicted by the simulation is confirmed!
→ A clear suggestion to optimise the detector design

Conclusions

- Intense R&D activity towards THGEM based photon detectors
 - In parallel and in close contact with Weizmann, Coimbra, Bari, ST.Etienne in the context of RD51 – the MPGD R&D Collaboration.
- Detection of single photons:
 - Gains $> 10^5$ in electrically stable detectors with $\leq 10 \mu\text{m}$ rim and a 4-layer structure;
 - time resolution $\sim 7 \text{ ns}$;
 - effective photoelectron extraction possible in CH_4 mixtures.
- NO STOPPING POINTS DETECTED, even if still a long way to go...