MicroHole & Strip Plate Based Photosensor Operating at HpXe

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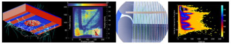
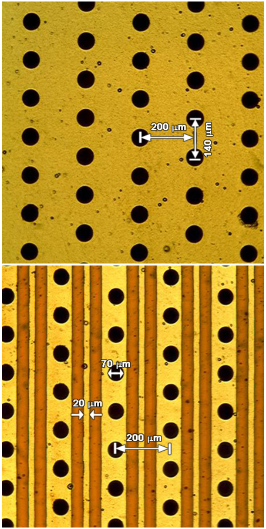


Motivation

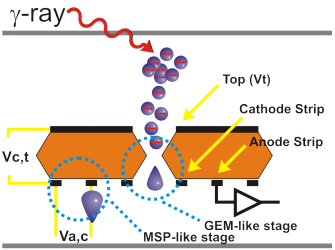
- Microstructures operating at high pressure in gaseous detectors
  - Hard x- and γ-rays detection
  - Good position and energy resolutions
  - Large areas detectors
  - Low cost per detector
- Possible applications:
  - Dual phase detectors
  - Dark matter search
  - High pressure TPC
  - Nuclear Medical detectors
  - Other applications needing
    - High position resolution
    - High energy resolutions

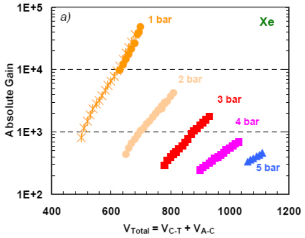
MicroHole & Strip Plate (MHSP)



- 2 Amplifications stages (GEM and MSP-like)
- High gains – $\sim 10^4 - 10^5$
- Fair energy resolution – 13.5% @ 5.9keV X-rays in Xe atmosphere
- High rate capability – $> 0.5MHz/mm^2$
- High pressure operation capability
- Position detection capability – $\sigma \sim 130\mu m$ (with resistive line)

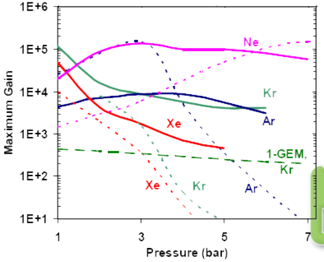
MicroHole & Strip Plate (MHSP)
Operation principle





[1]

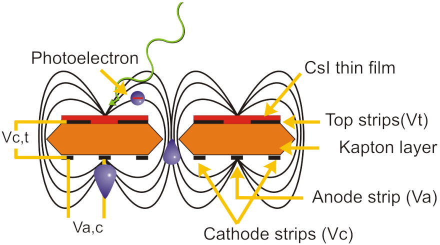
- Radiation absorption and gas ionisation
- Electron drift to the MHSP - V_t
- Hole focus and 1^{st} multiplication stage (GEM-like) - $V_{c,t}$
- Anode recoil and 2^{nd} multiplication stage (MSP-like) - $V_{a,c}$
- Maximum Gain decrease with the pressure slower than in Triple-GEM (dashed line)

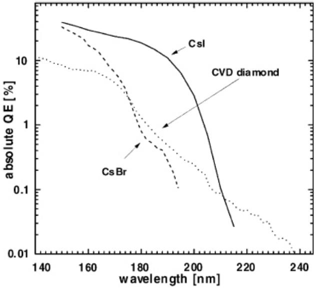


[1]

[1] -F. D. Amaro, et al.,JINST, 2006.

MicroHole & Strip Plate-CsI Photosensor



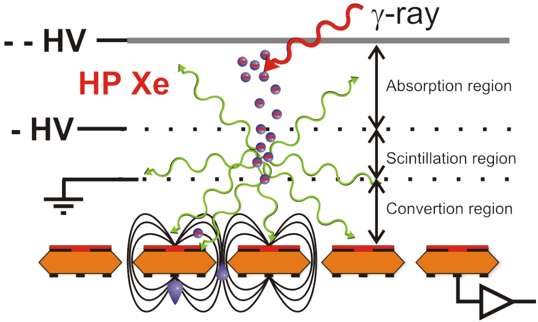


[2]

- CsI - Highest QE
  - $QE_{(175\ nm)} \approx 30\%$
  - Easy to deposit (Thermal evaporation)
- Reflective photocathode
  - Higher QE when comparated to semi-transparents
  - Photolectrons extracted near to the holes
  - Decrease of drift time and photoelectron losses

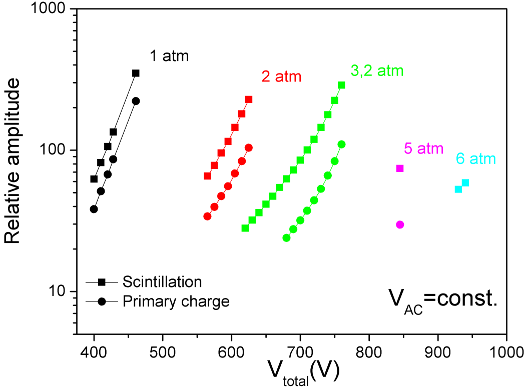
[2] - A. Breskin, et al.,Nucl.Instr.andMeth.A(2000)

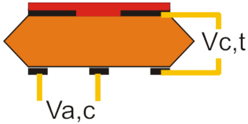
Detector Operation Principles



- γ photon absorption and primary electron cloud production
- Electron drift to the scintillation region
- Gas secondary scintillation and light amplification
- Light detection and photoelectron conversion
- Electron multiplication and recoil

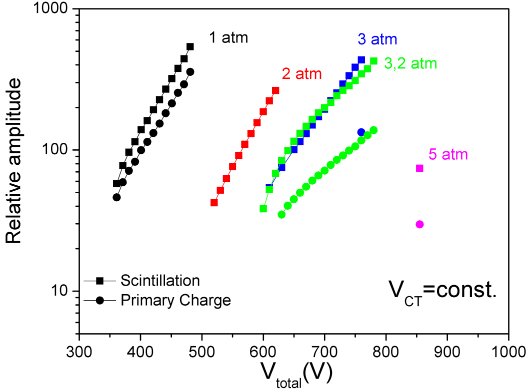
Light gain and primary charge amplification
Varying $V_{c,t}$

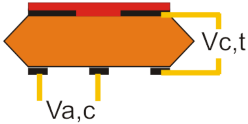




- Presence of a light gain
- The light gain increases with the pressure
- Almost the same total gain for different pressures (except 5 and 6 atm)

Light gain and primary charge amplification
Varying $V_{a,c}$





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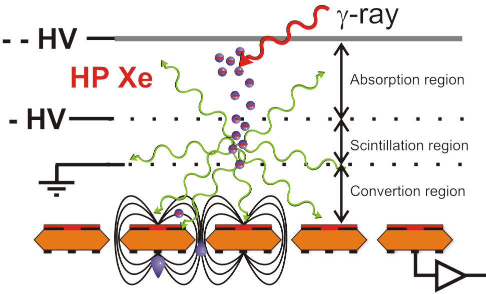
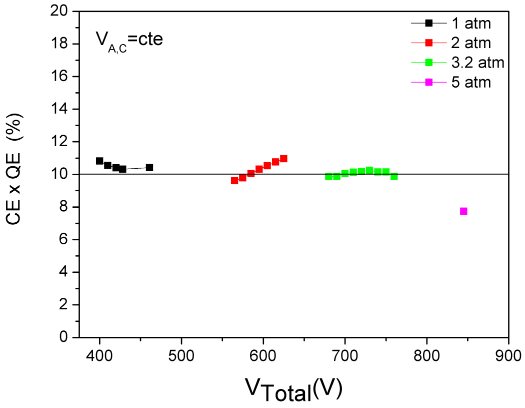
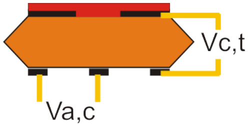
Photoelectron collection efficiency
Method

- *Backscattering* at Hp
- $CE = \frac{Detected\ Photoelectrons}{Extracted\ Photoelectrons}$
- $QE \times CE = \frac{Detected\ Photoelectrons\ (N_{fe})}{UV\ photons\ reaching\ photocathode\ (N_{fUV})}$
- $N_{TfUV} = \frac{\Delta V.e}{\epsilon_{UV}.Q_c}$
- $N_{fUV} = \Omega.A_{eff}.N_{TfUV}$
- $N_{feeje} = N_{fUV}.QE$
- $L = \frac{Detected\ photoelectrons\ (N_{fe})}{Primary\ electron\ (N_{ep})} = \frac{A_{Scintillation}}{A_{Charge}}$
- $CE = \frac{L}{N_{feeje}}$
- $QE \times CE = \frac{L}{N_{fUV}}$



Photoelectron collection efficiency
Varying $V_{c,t}$

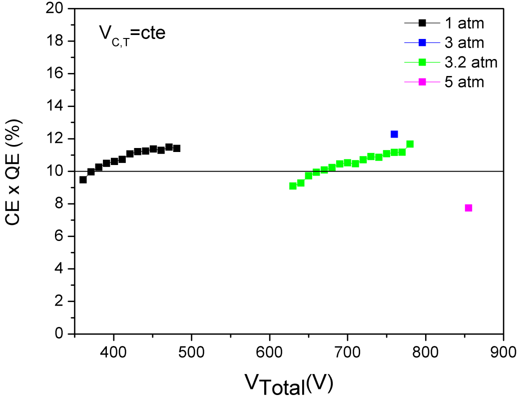


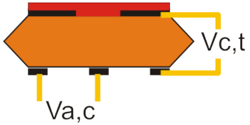


- $CE \times QE$ almost constant with the pressure
  - Possibility to operate at high pressures

Photoelectron collection efficiency

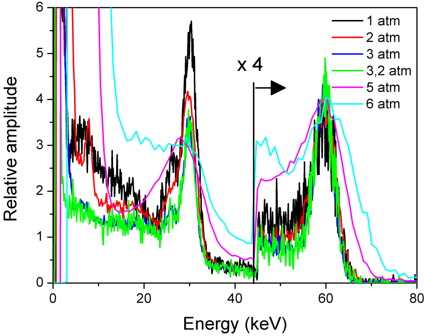
Varying $V_{a,c}$





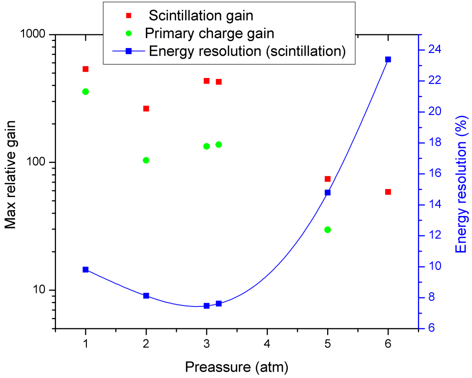
- Slight $CE \times QE$ increase with V_{Total}
- $CE \times QE$ almost constant with the pressure
  - Possibility to operate at high pressures

Spectra



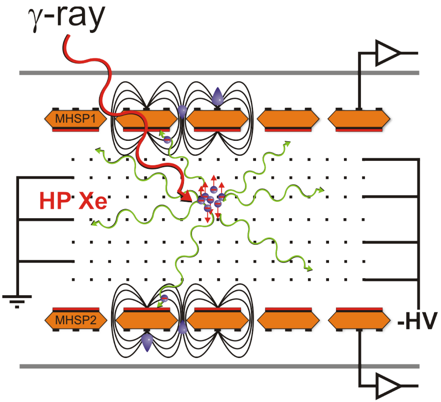
- Pulse-height distribution of 59.6 *keV* from the ^{241}Am
- Low signal-noise ratio for 5 and 6 *atm*

Energy resolution



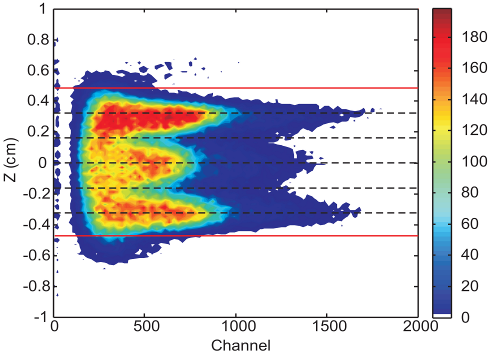
- 7.2% energy resolution at 3.2 *atm* for 59.6 *keV* γ-photons
  - Energy resolution degrades for $p > 3.2$ *atm* due to MHSP defects
- Energy resolution increases until $p < 3.2$ *atm*
  - Due to the increase of the number of UV photons

Detector Operation Principles



- Increase the detected photon number
- Possibility to sum two signals amplitude for the same event
  - Increase the total gain
- Interaction position detection (orthogonal to the photosensors)
  - Implementation of correction algorithms

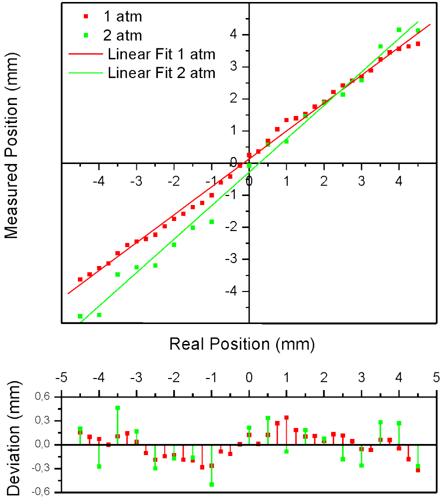
Position detection



- $z = k\frac{A1 - A2}{A1 + A2}$
- Mesh position well defined
- Measured position almost independent of the detected energy
- Background reduction

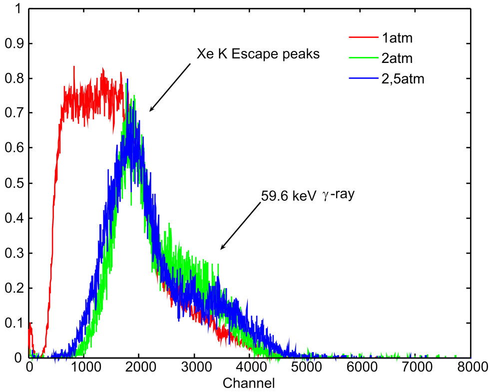
Position detection

Detector with $0.5 \times 12\,\mathrm{mm}$ slit - All events



- 1 atm
  - $\mathrm{R}^2 = 0,99556$
  - Max deviation: 341 μm
- 2 atm
  - $\mathrm{R}^2 = 0,99123$
  - Max deviation: 498 μm

Energy resolution

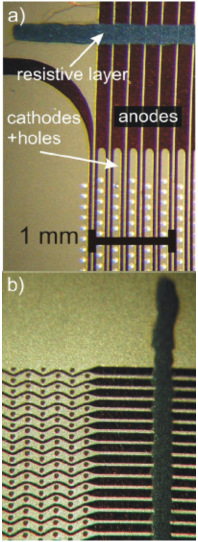


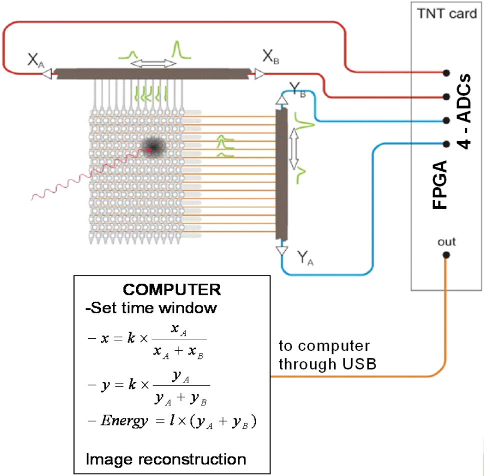
- Marginal energy resolution
- Increase of the energy resolution with the preassure
- Spatial dimension of the primary electron cloud

Conclusions

- Preliminary results shows good MHSP capabilities to operate at high pressure
  - $CE \times QE$ constant with the pressure
  - The high UV-photon production gives the possibility to operate at different pressures maintaining the same total gain.
- Photosensors operating face-to-face
  - Good linearity between measured and actual photon interaction position (deviations below 300 and 500 μm for 1 and 2 *atm*, respectively)
  - The achieved energy resolution is marginal, improves with higher Xe pressure

Charge readout and position detection





Future improvements and work

- Continuing with the increasing of the *Xe* pressure
- Use of $Xe - CH_4$ in order to improve the photoelectrons extraction
- Study of the scintillation light and collections efficiencies on $Xe - CH_4$ mixtures
- Study of the transport and electron multiplication for the 2D-MHSP at high pressure
- First image and study of the position resolution as function as the pressure

Thanks for your attention