Latest progress in development GEM-like detectors with resistive electrodes

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MICROMEGAS, GEM are excellent detectors for tracking and other high position resolution and high rate applications.

However there are plenty of applications which do not require very high position resolution

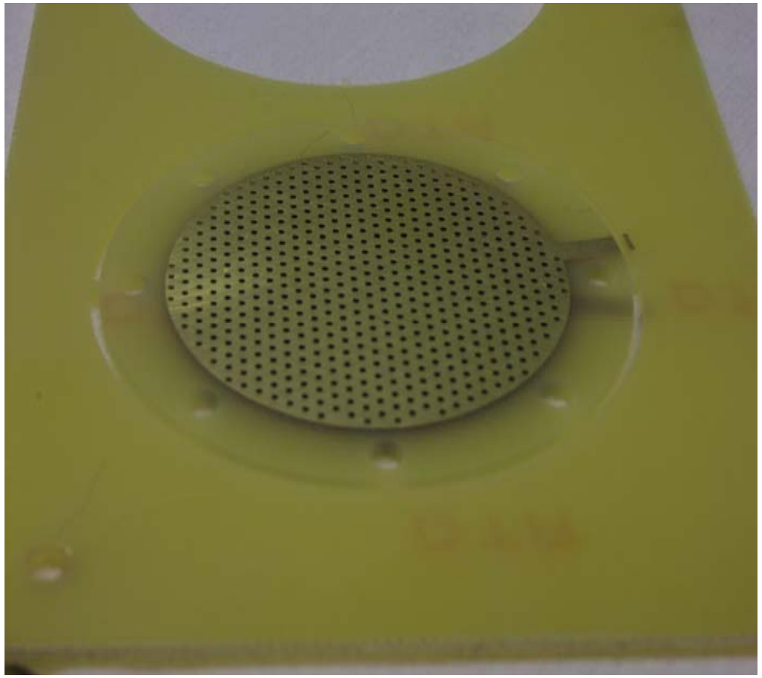
Examples of low position resolution applications: RICH, Noble liquid TPC, some medical and technical applications

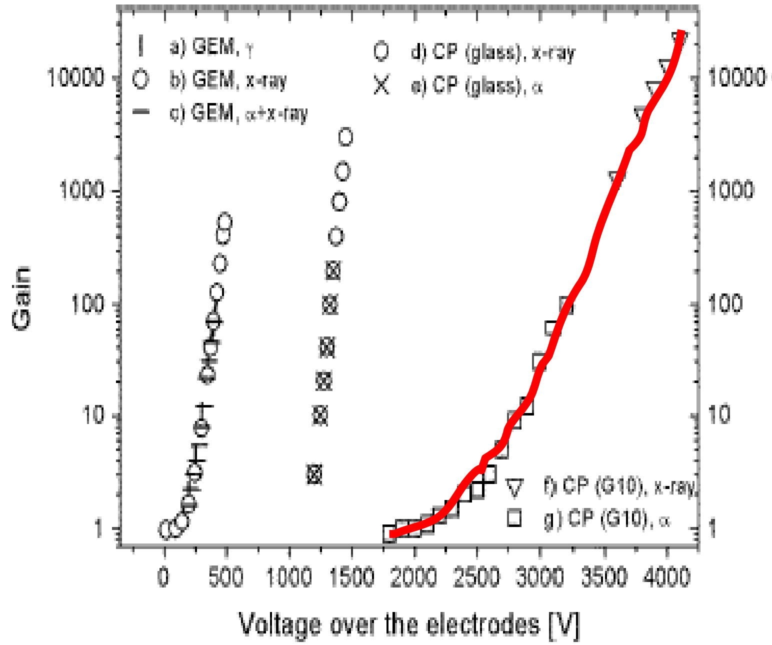
For the last few years we were focused on developing more robust GEM-like detectors for these applications

First attempt-"Optimized"/Thick GEM

Further development of this detector was performed by Breskin group

Photo of one of the “optimized” or “thick GEM” developed by us earlier





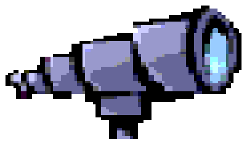
L. Periale et al., NIM A478,2002,377

J. Ostling et al., IEEE Nucl. Sci 50,2003,809

TGEM is manufactured by standard PCB techniques of **precise drilling** in G-10 (+ other materials) and **Cu etching.**

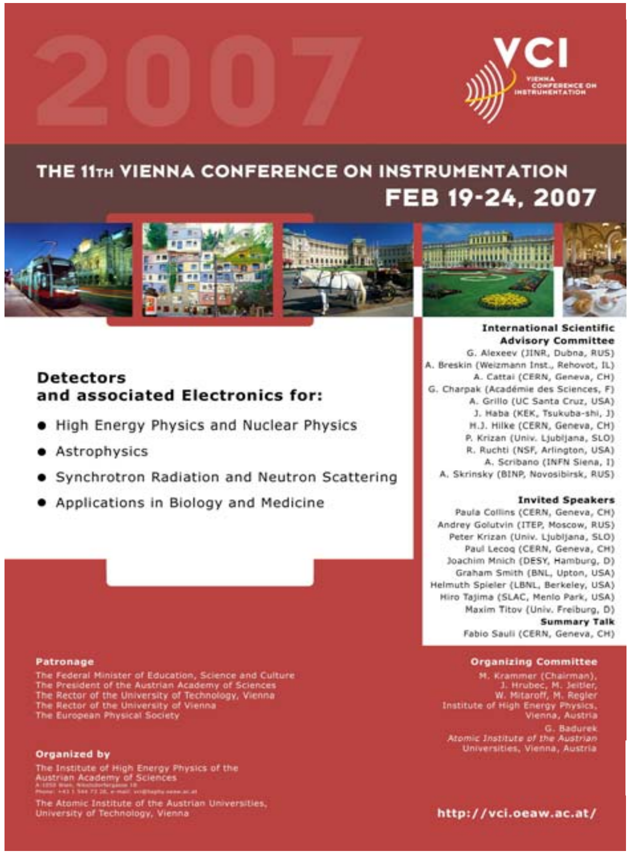
For more info about TGEMs -see the talk of M. Cortesi, this Workshop

We would like present today another promising direction- **resistive electrodes TGEMs**



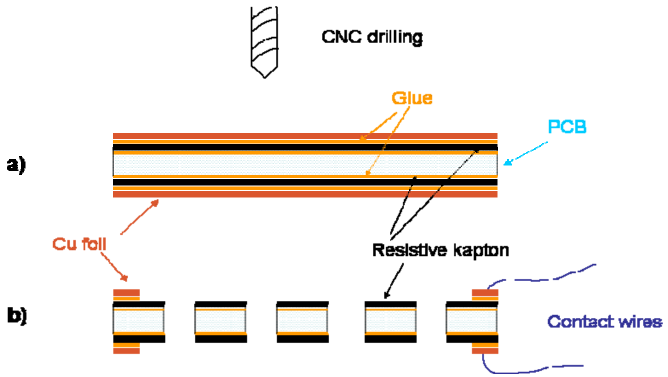
The main advantage of these detectors is that they are fully spark-protected

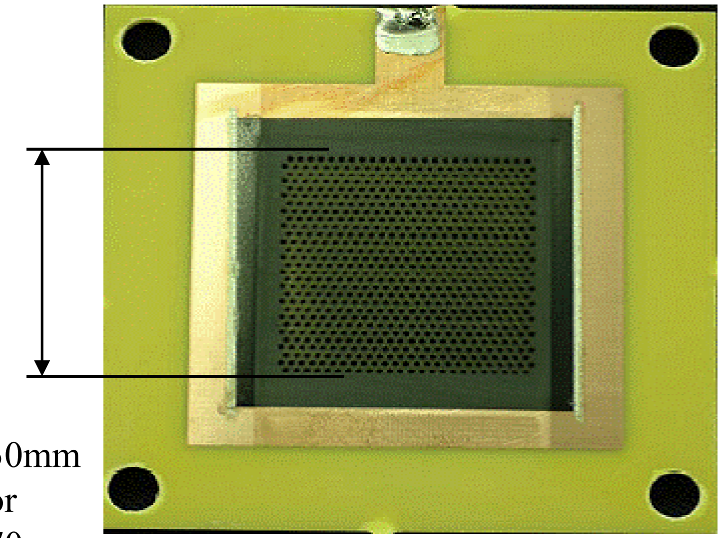
Vienna Conference



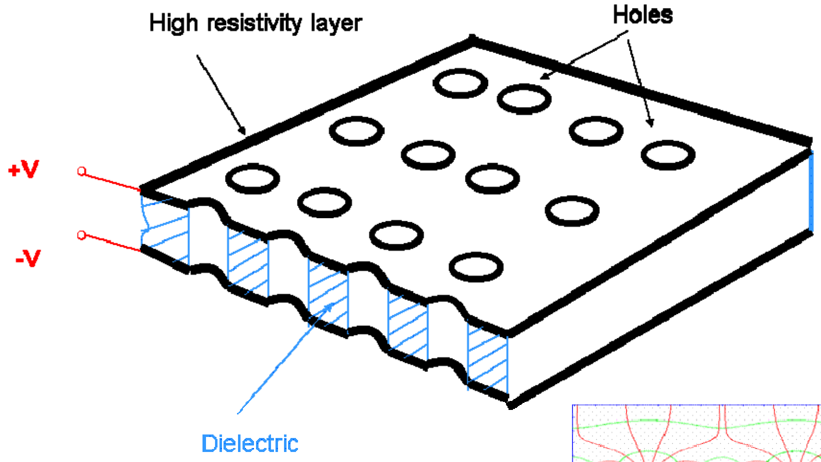
Thick GEM with resistive electrodes (RETGEM)- a fully spark protected detector

A. Di Mauro et al, Presented at the Vienna Conf. on Instrum; to be published in NIM

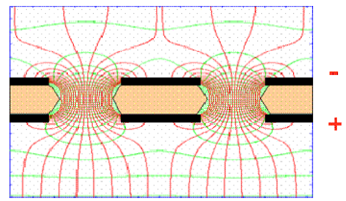




30mm
or
70mm



Principle of operation

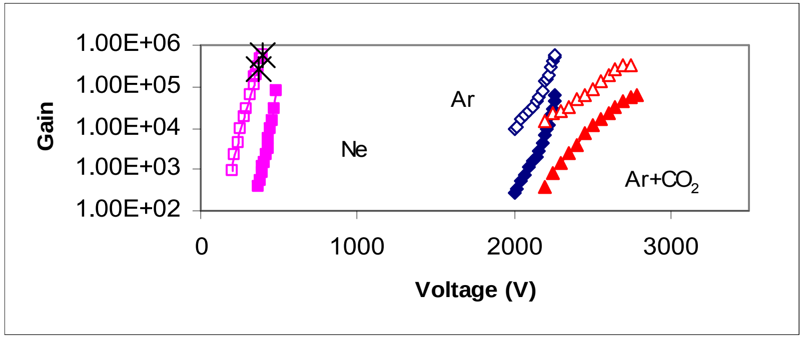


Geometrical and electrical characteristics:
Holes diameter 0.3-0.8 mm, pitch 0.7-1.2 mm, thickness 0.5-2 mm. Resitivity:200-800kΩ/□
Kapton type: 100XC10E

Fully spark-protected

Summary of the main results obtained with kapton RETGEMs

1 mm thick



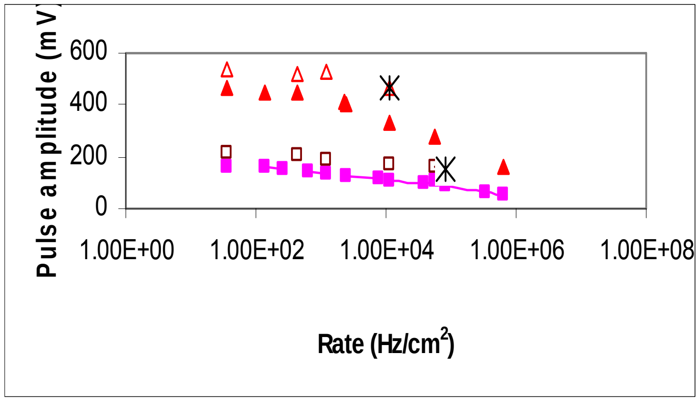
Energy resolution ~30%FWHM
for 6 keV

Discovery:
kapton can be coated with CsI and have after high QE

QE~30% at λ=120nm

Filled symbols-single RETGEM,
open symbols –double RETGEMs
Stars-gain measurements with double RETGEM coated with CsI layer.

15 min continues discharge harm ether the detector or the electronics



With increase of the rate the amplitude drop, but now discharges

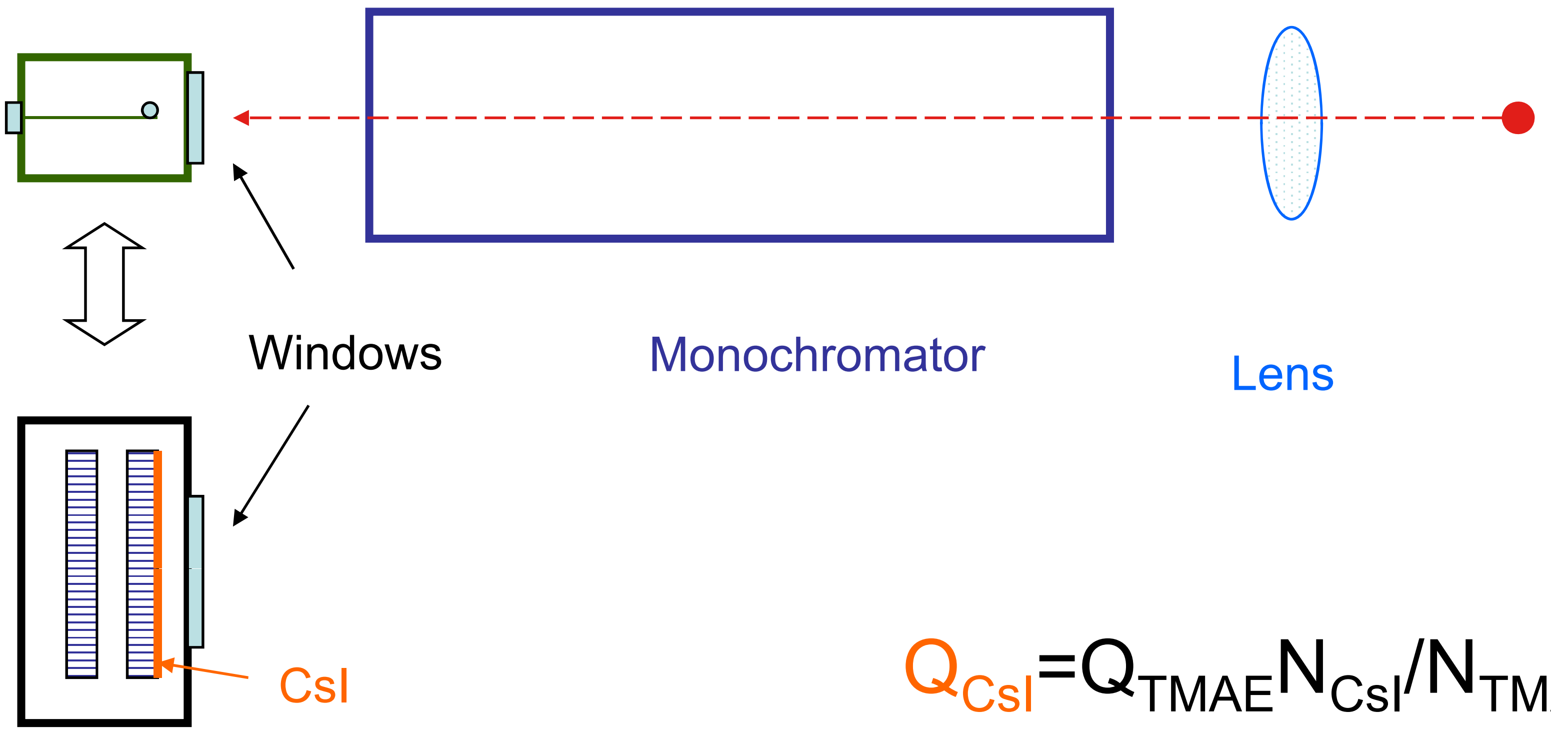
New result

(obtained after Vienne Conference)

Confirmation of high QE

(QE measurements at 185 nm)

QE calibration



$$Q_{CsI} = Q_{TMAE} N_{CsI} / N_{TMAE}$$

Photo of the experimental set up

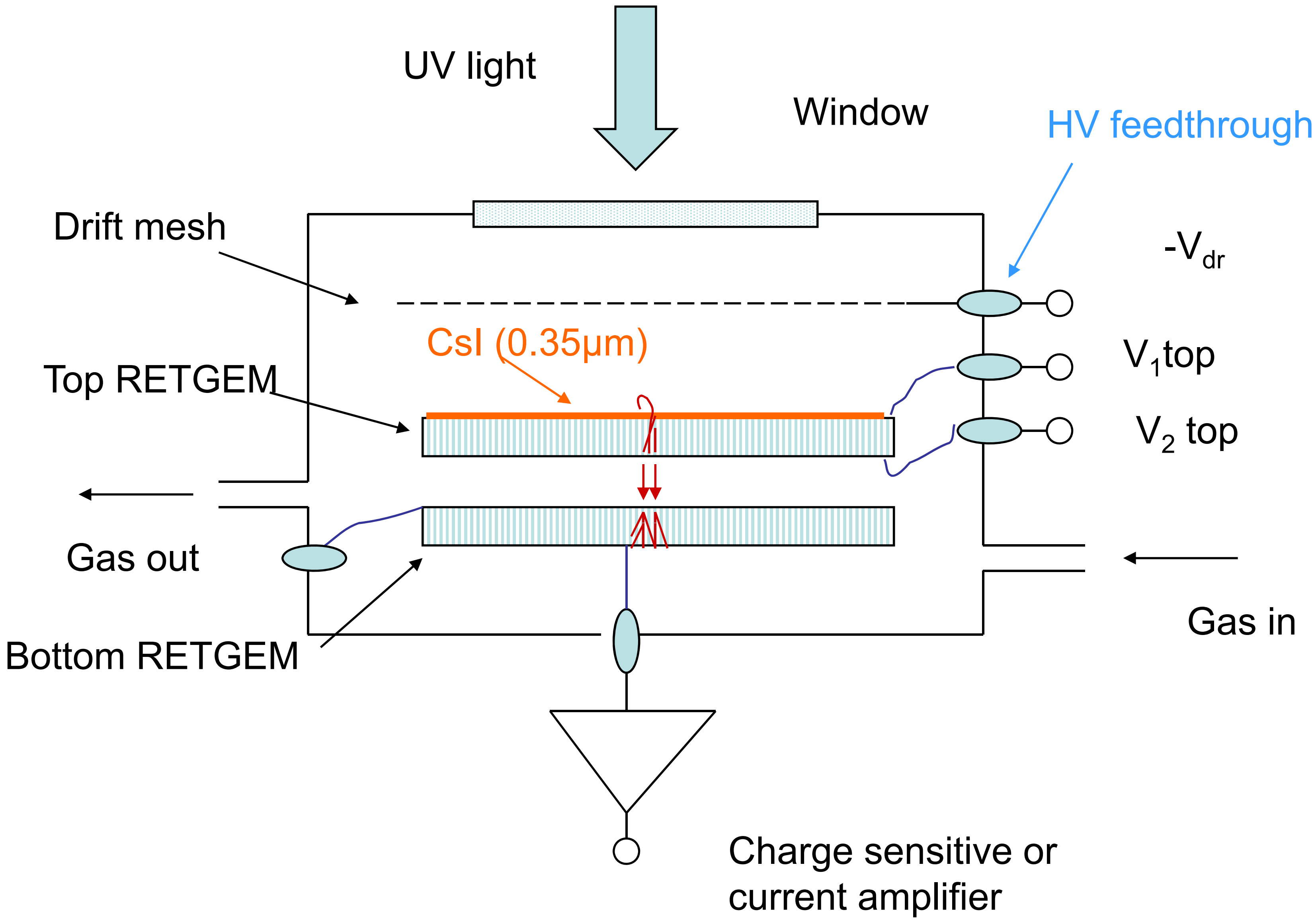
Hg lamp

Lens

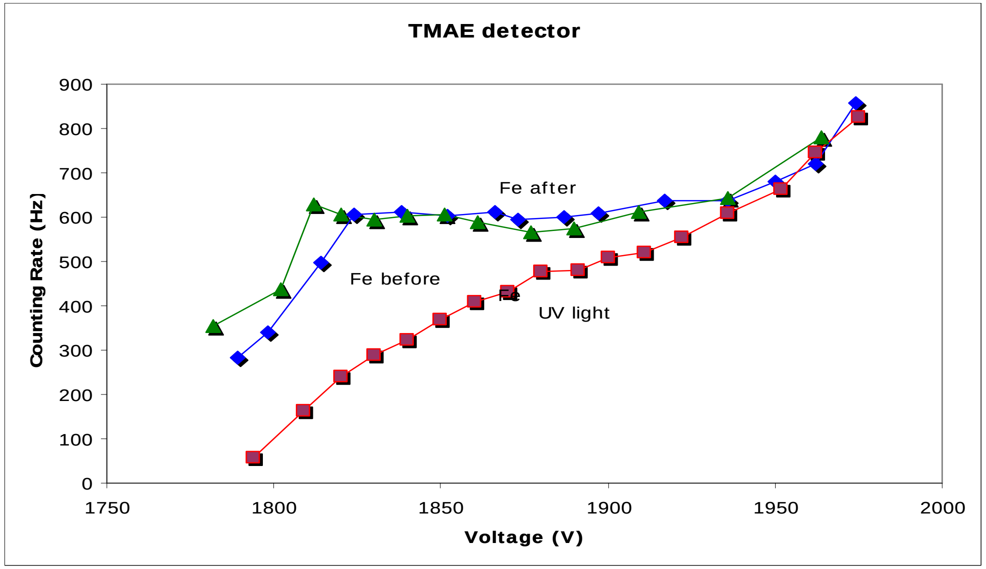
Monochromator

Gas chamber
with RETGEM
coated with CsI

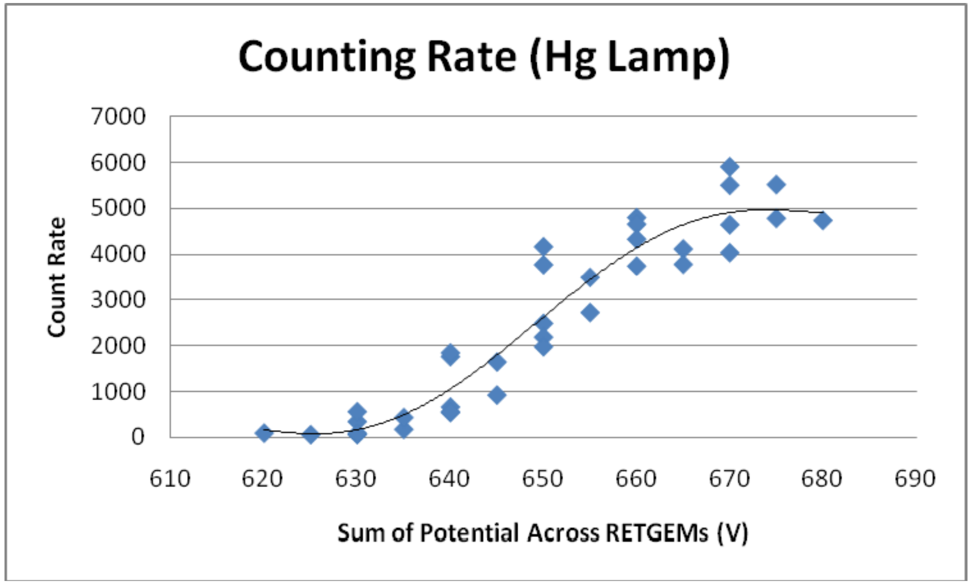
Experimental set up for studies RETGEM with CsI photocathodes



Counting plateau



TMAE detector

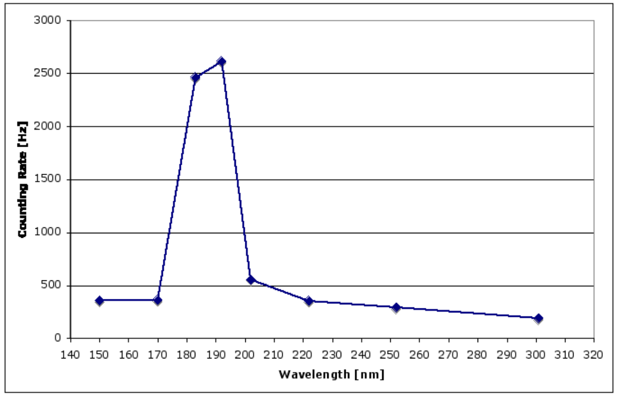


Double RETGEM

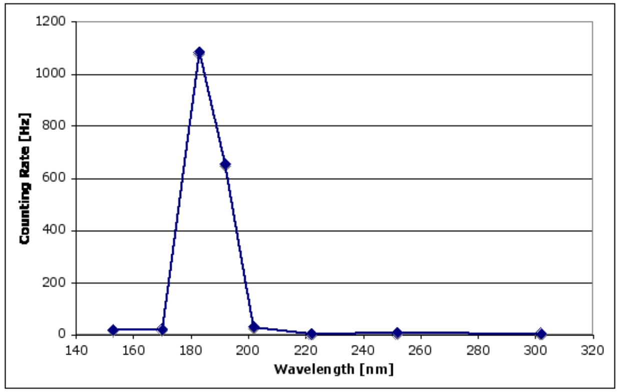
Hg lamp spectra, measured with TMAE (a) detector and RETGEM (b)

TMAE QE vs. wavelength (c)

a)



b)



c)

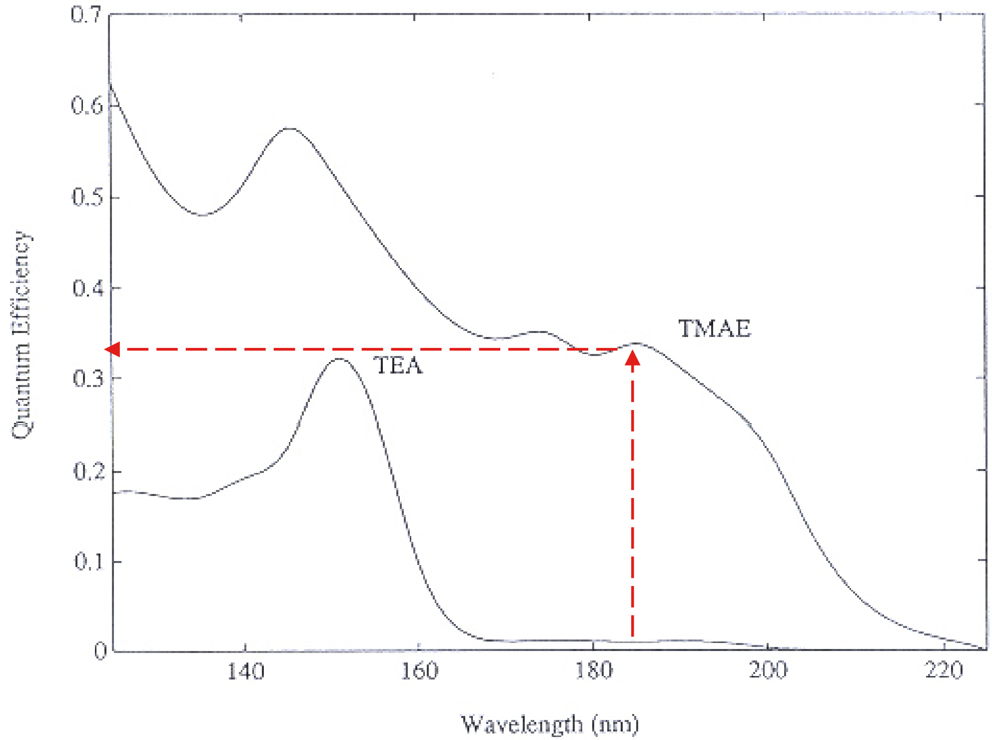
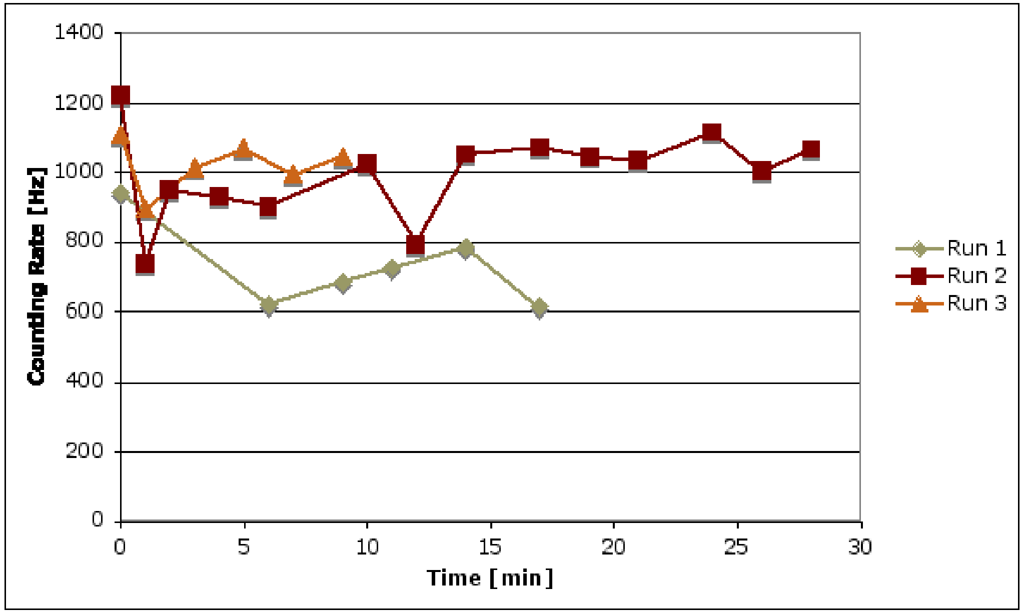


Figure 4.4. Quantum efficiency of TMAE and TEA as a function of wavelength, according to measurements by Holroyd et al [4.6].

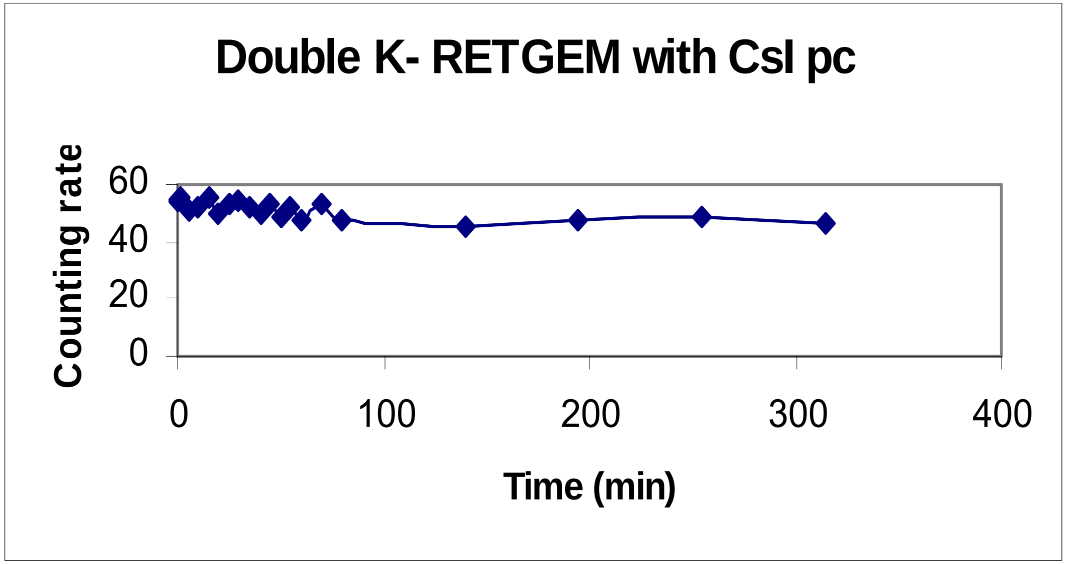
$Q_{CsI}=33\% N_{CsI}/N_{TMAE} \sim$ 10-14.5%



Measurements of the stability of the RETGEM, using Hg as a source, at 185nm. The light is concentrated on a small slit. About 30min without light have passed between each run.

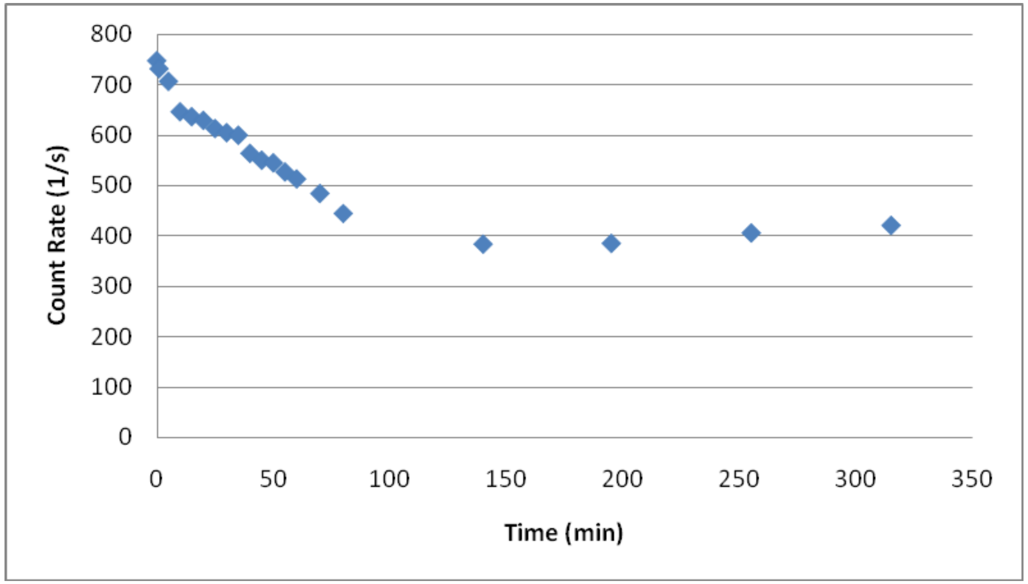
Stability measurements of photosensitive RETGEM

Very low single photoelectron counting rate



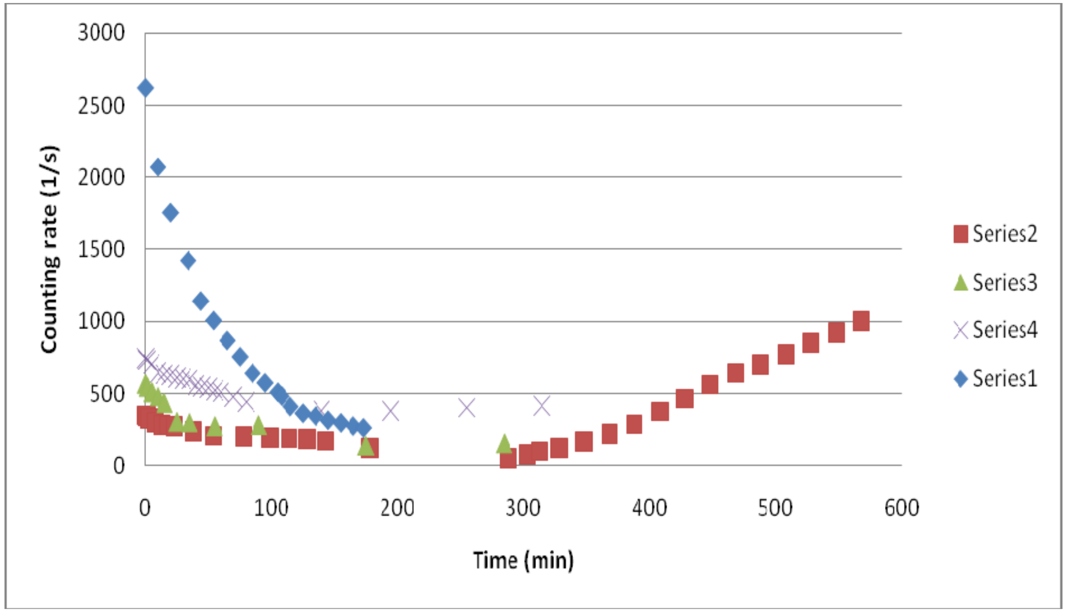
Gas gain~ 10^6

Single –electron (CsI pc) counting rate at a constant threshold

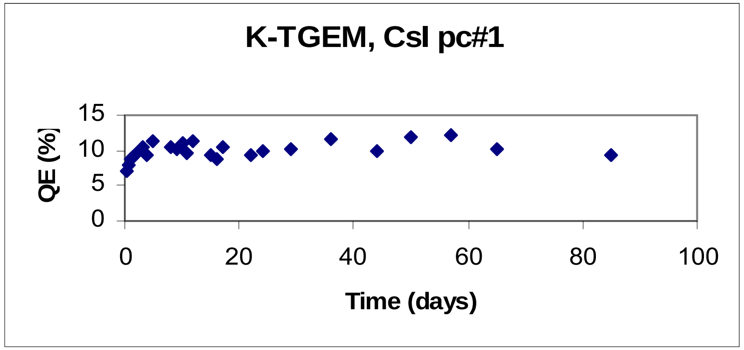


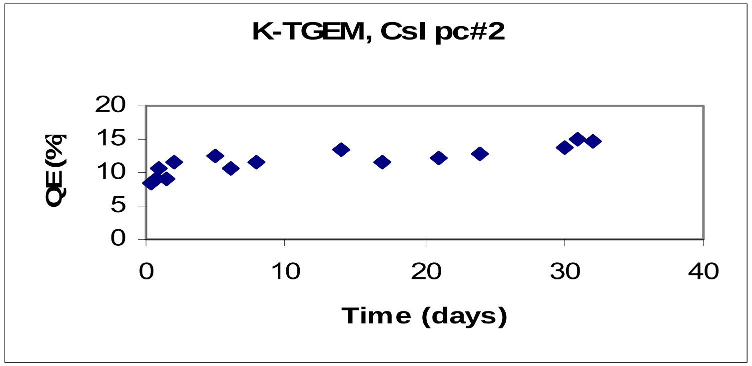
Gas gain~ 10^6

This behavior
is similar to RPC



“Long –term” stability of CsI pcs measures at low counting rate

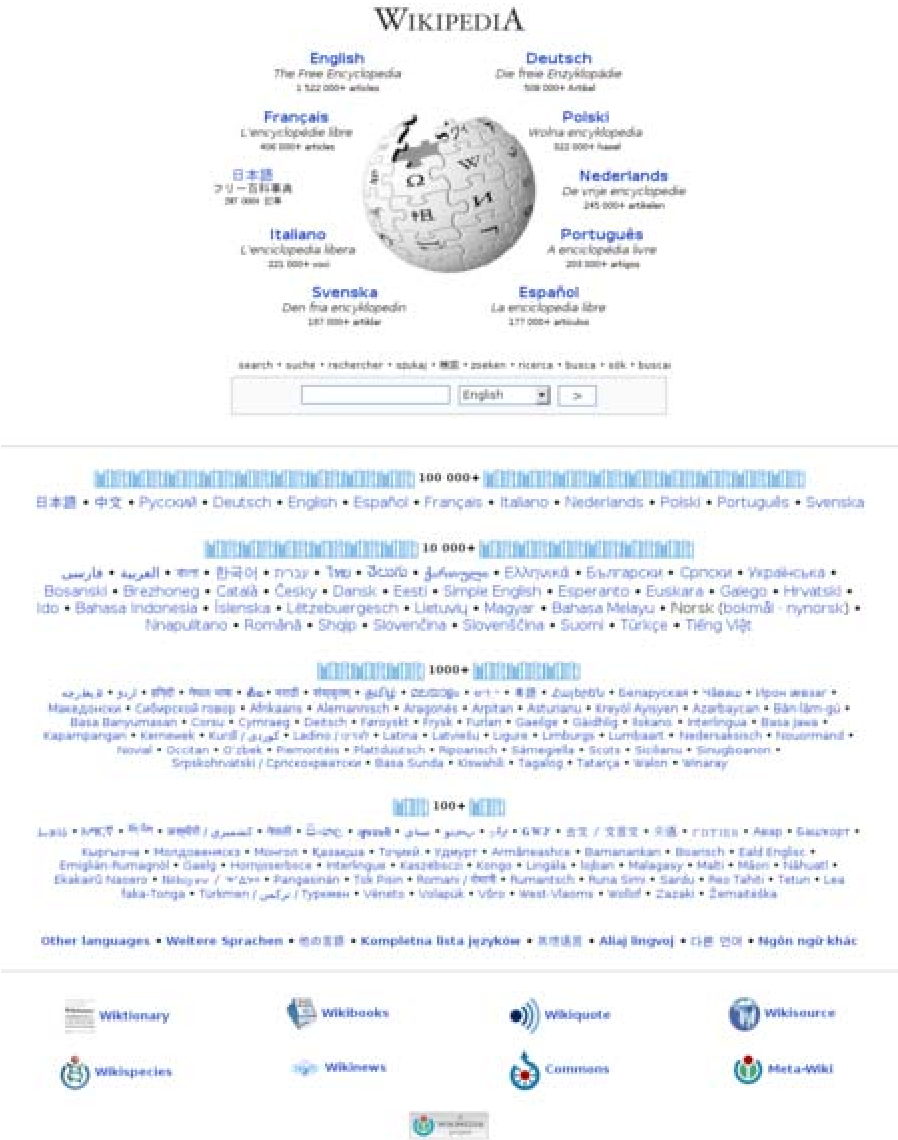




Very new (preliminary) results:

RETGEMs manufactured by screen printing technology

***For more details see**: B. Clark et al., Preprint/Physics/0708.2344, Aug. 2007*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A enciclopédia livre
Svenska
Den fria encyklopedin
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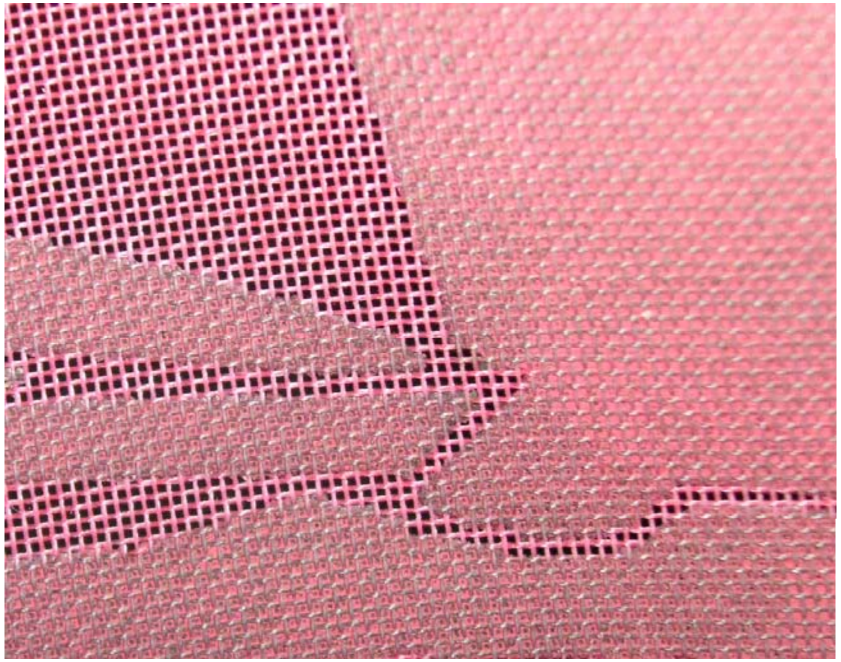


Screen printing is widely used in microelectronics to produce patterns of different shape and resistivity. Therefore, RETGEM technology produced with screen printing techniques offers a convenient and widely available alternative to RETGEMs made of Kapton.

Advantages of the screen printing technology:

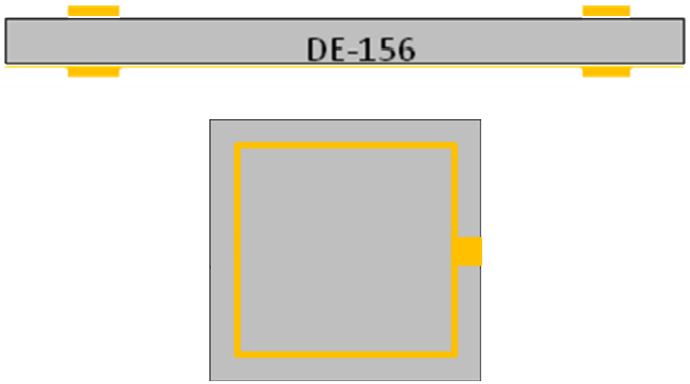
Offers cost-effectiveness, convenience, and easy optimization RETGEMs resistivity and geometry. It is also important to mention that large -area RETGEMs can be produced by this technology.

Consequent steps in RETGEM manufacturing in by screen printing technique (Oliveira Workshop):

a)

DE-156, an Isola product, is used as the base material.

b)

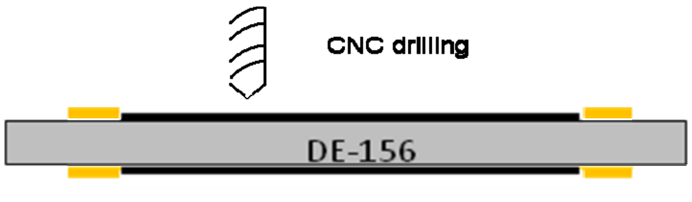


Excess copper is removed from the top and bottom, thereby creating a copper border.

c)

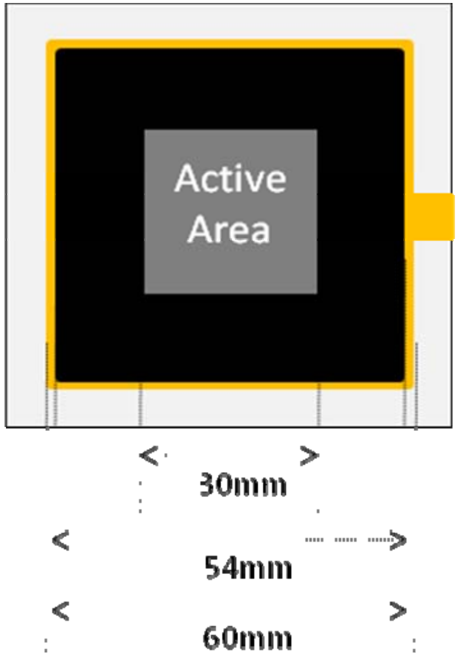
A resistive paste (Encre MINICO) is applied to the top and bottom surfaces using screen printing techniques and technology. The paste is cured in air at 200 C for one hour. After the curing process is complete, the resistive layer is 15μm thick.

d)



Drill consistently sized holes at even intervals in the region enclosed by the copper border.

Two types of RETGEM were manufactured by screen printing technology and tested



RETGEM type 1 Geometrical and Resistive Characteristics

Thickness = 1mm

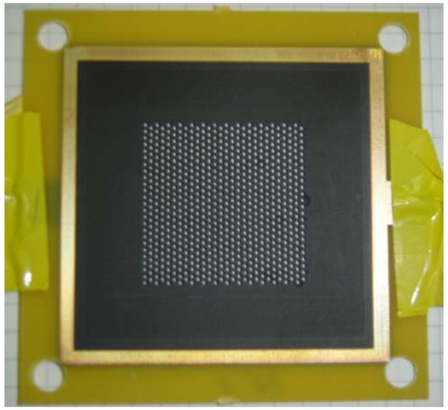
Hole Diameter = 0.5mm

Pitch = 0.8mm

Active Area = 30mm x 30mm

Resistive Layer Thickness = 15µm

Resistivity = 1 MΩ/□ or 0.5 MΩ/□



RETGEM type 2 Geometrical and Resistive Characteristics

Thickness = 0.5mm

Hole Diameter = 0.3mm

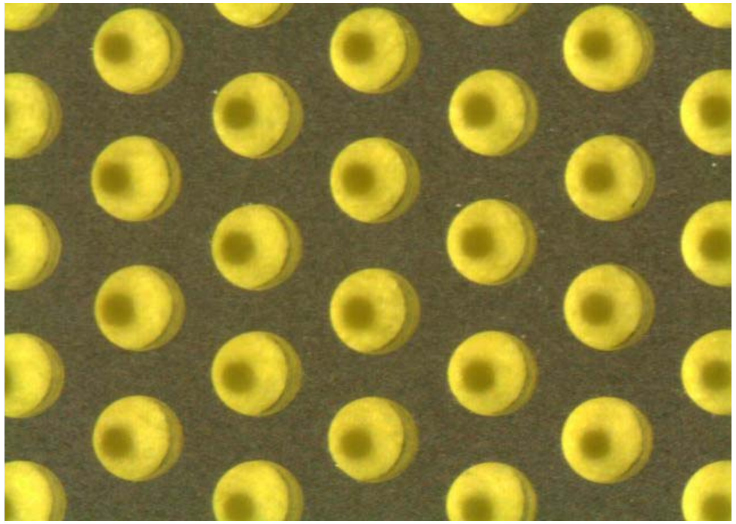
Pitch = 0.7mm

Active Area = 30mm x 30mm

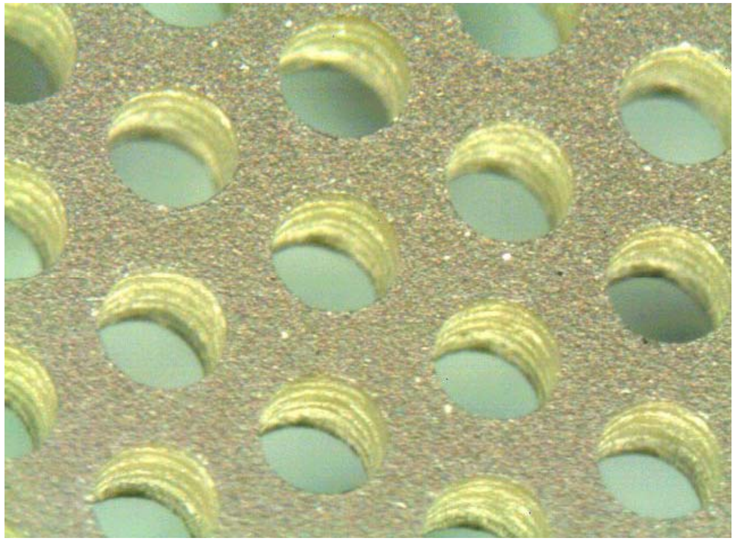
Resistive Layer Thickness = 15µm

Resistivity = 0.5 MΩ/□

Photo of holes at various magnifications:

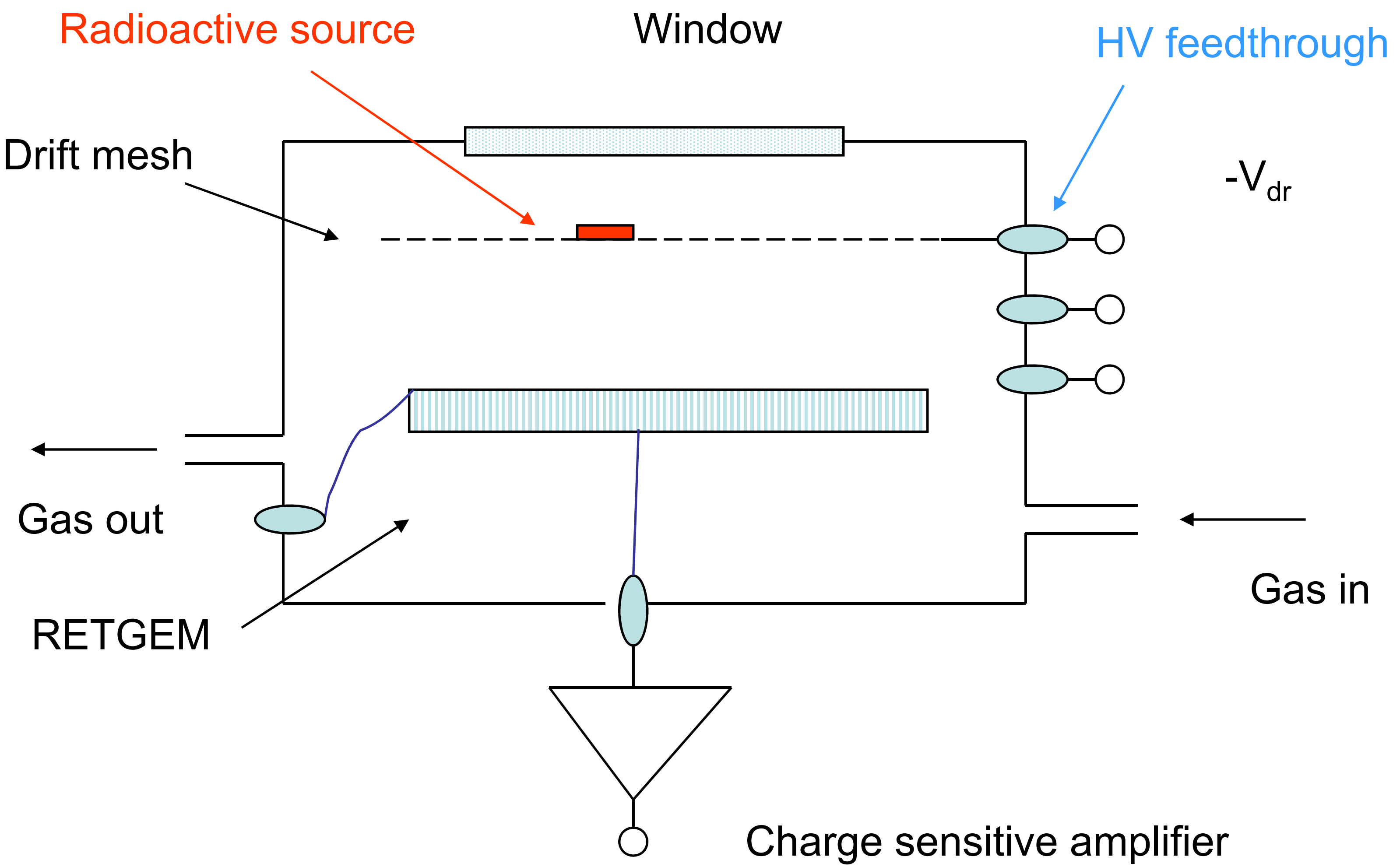


a) medium magnification

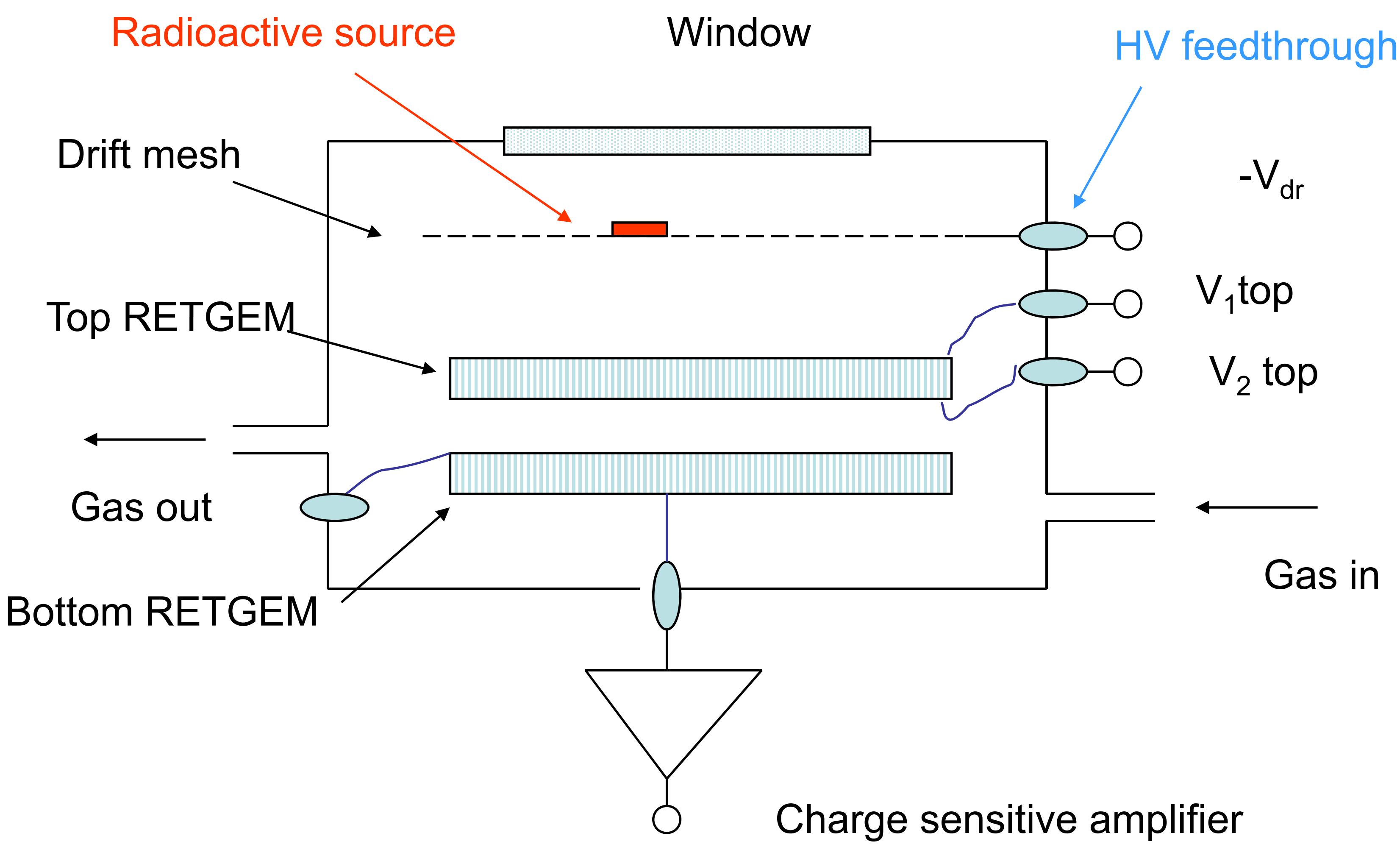


b) higher magnification

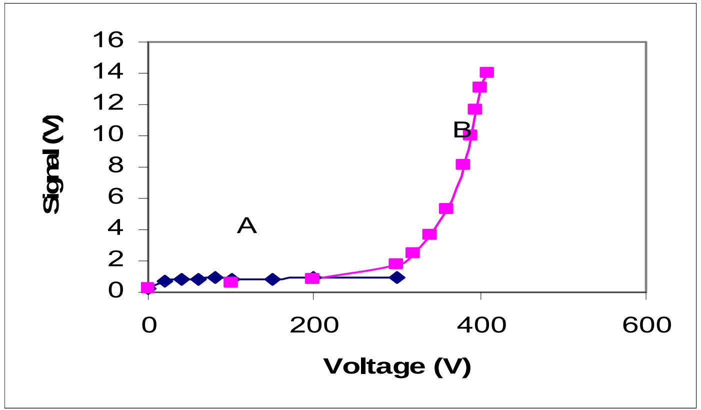
Experimental set up for studies RETGEM manufactured by screen printing technology



Experimental set up for studies RETGEM manufactured by screen printing technology

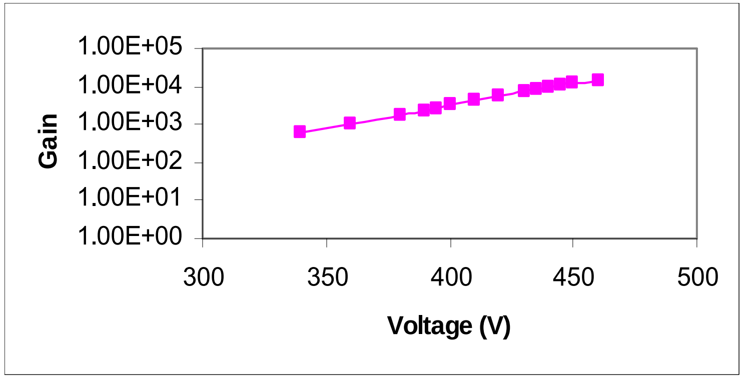


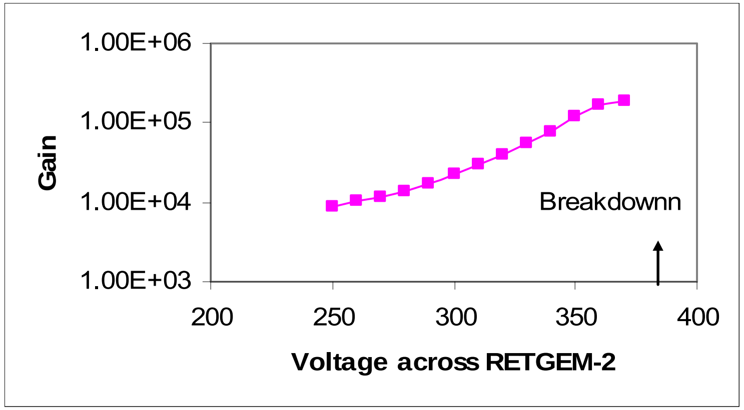
Results of measurements in Ne (SP-RETGEM type 1)



Alpha particles

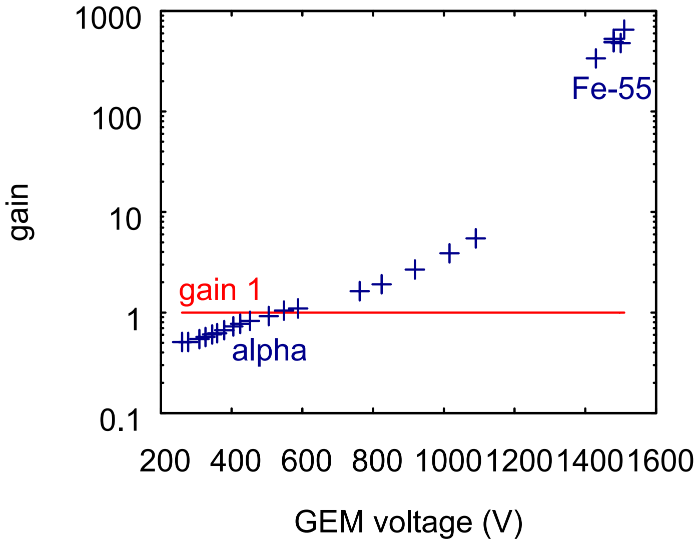
Gain curve measured with single SP-RETGEM (^{55}Fe).





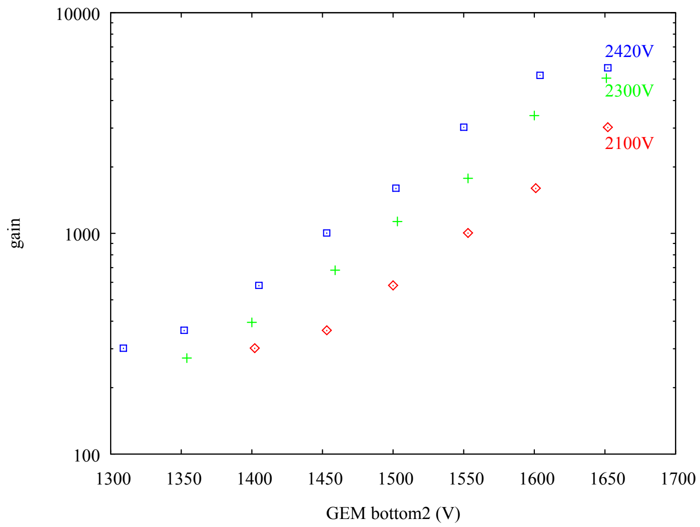
Gain curve measured with double SP-RETGEM operating in Ne (^{55}Fe).

Results obtained in Ar (SP-RETGEM type1)

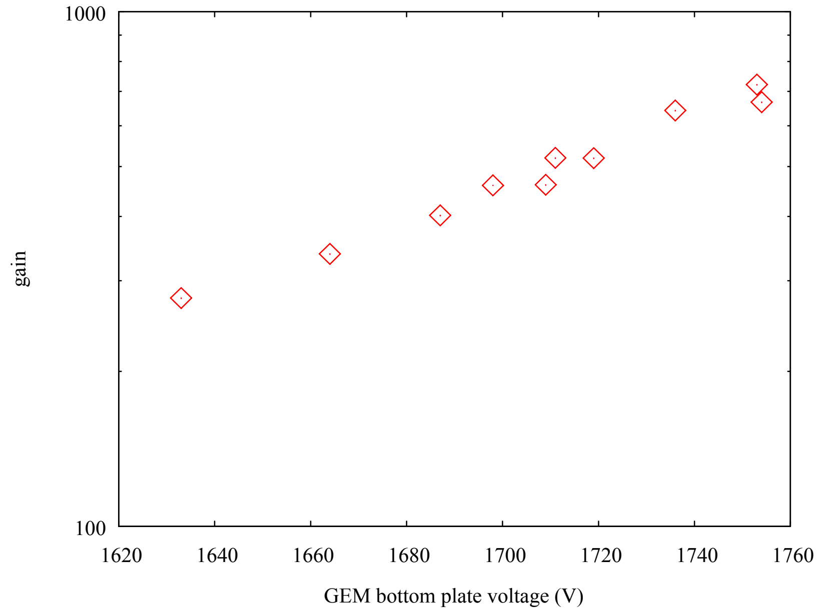


Single step SP-RETGEM

Double SP-RETGEM

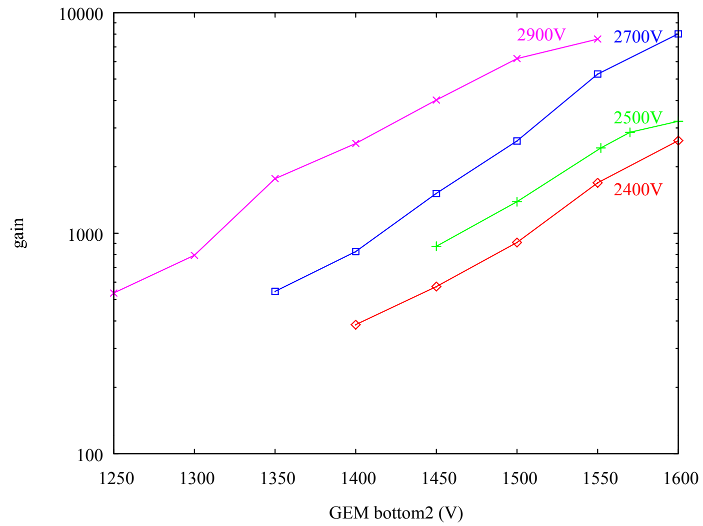


Results obtained in $Ar+CO_2$ (type1)



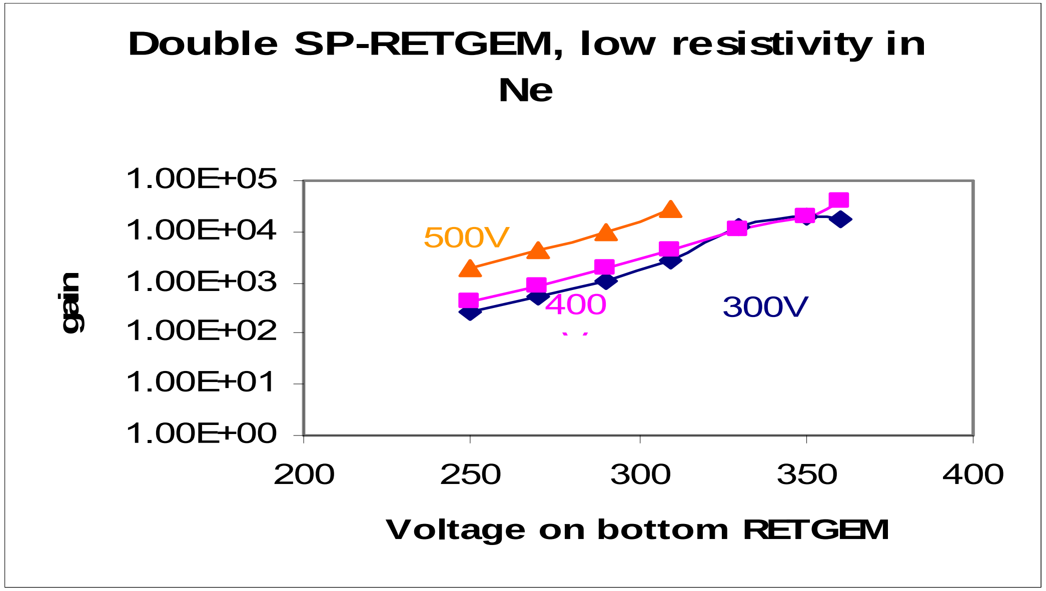
Single step

Double SP-RETGEM

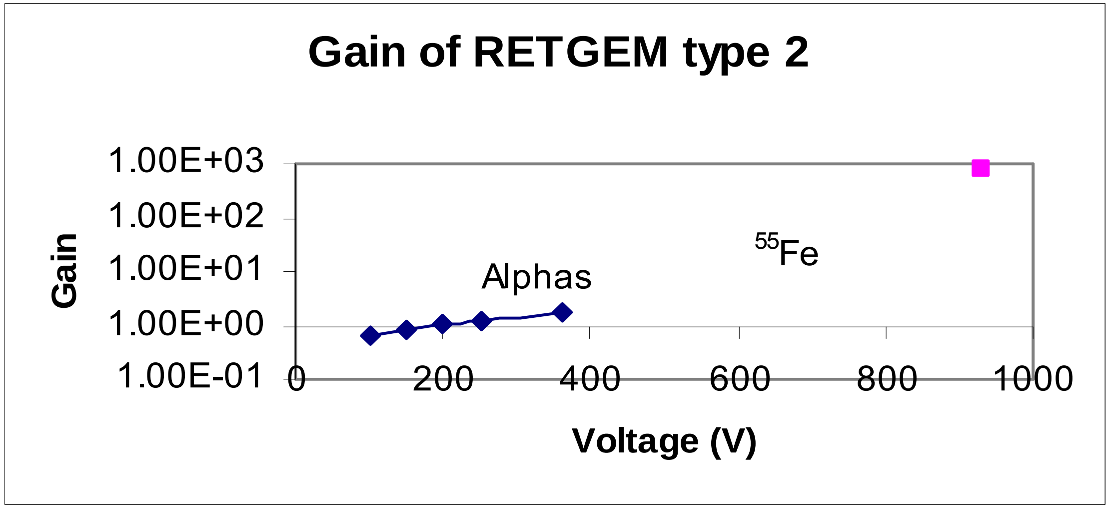


“Low resistivity”(0.5MΩ/□) 1mm thick double step in Ne

(preliminary!)



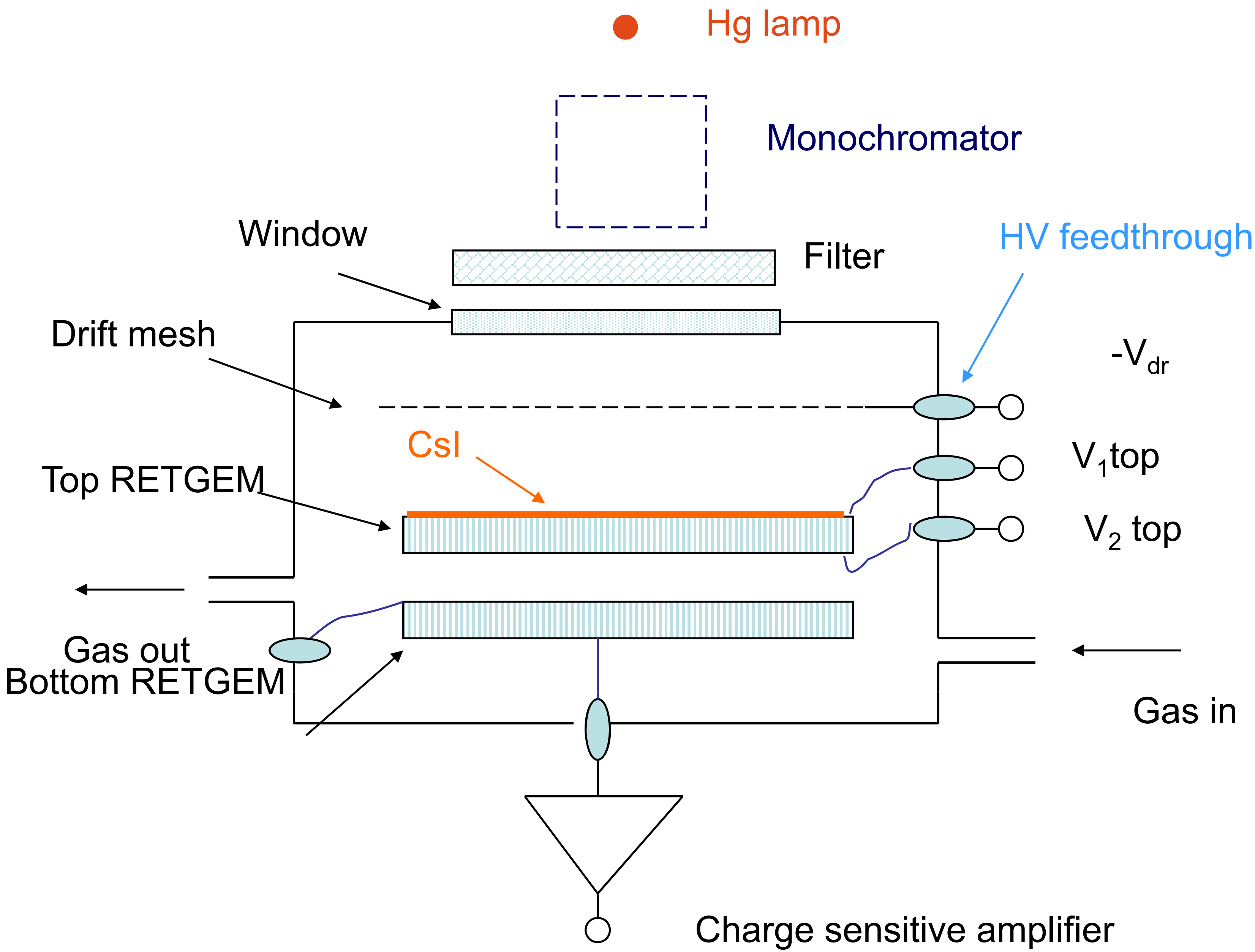
The maximum achievable gain with a 0.5 mm thick SP-RETGEM was the same as in the case of the 1 mm thick, however there voltages were considerably smaller



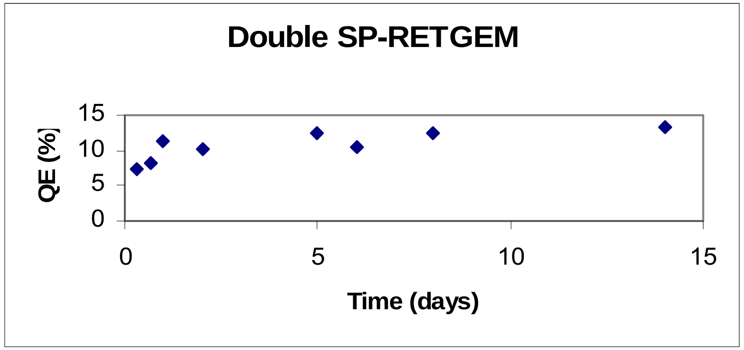
Some samples had excess of high amplitude spurious pulses

Preliminary tests of photosensitive RETGEM manufactured by a screen printing technology

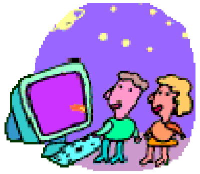
Experimental set up for studies RETGEM with CsI photocathodes manufactured by screen printing technology



Stability with time
(2 weeks observations)



Note: QE ~12.5% at 185 nm was measured



Preliminary comparison of K- RETGEMs with SP-RETGEMs

- In all gases tested K-RETGEMs allow to achieve at least 10 times higher gains than SP-RETGEMs

- Some samples of SP-RETGEM exhibit high amplitude spurious pulses (it is not the case for K-TGEMs!)

- Both detectors are spark-protected, however after 10 min of continuous glow discharge a low resistivity SP-RETGEM can be damage (it is not the case of K-RETGEM!)-the counting rate of spurious pulses increased

- Energy resolution in the case of SP-TGEM was worse

- Photosensitive K-RETGEMS and SP RETGEMS have almost the same QE at 185 nm:10-14.5% at 185 nm -and these values remained stable at least in a month scale

Conclusions:

- RETGEM detectors are fully spark protected (the energy released in sparks is at least 100 times less than in the case of metallic TGEMs)
- At low rate they behave like GEM (and the gas gain is stable with time) and at high rates and high gains RETGEMs are more resembling RPCs (gain reduces with rate)
- Being coated by a CsI layer RETGEMs operate stable at high gains and low rates and their QE is 10-14.5% at 185nm
- "Long term " (few months) stability of RETGEMs with CsI pc was demonstrated

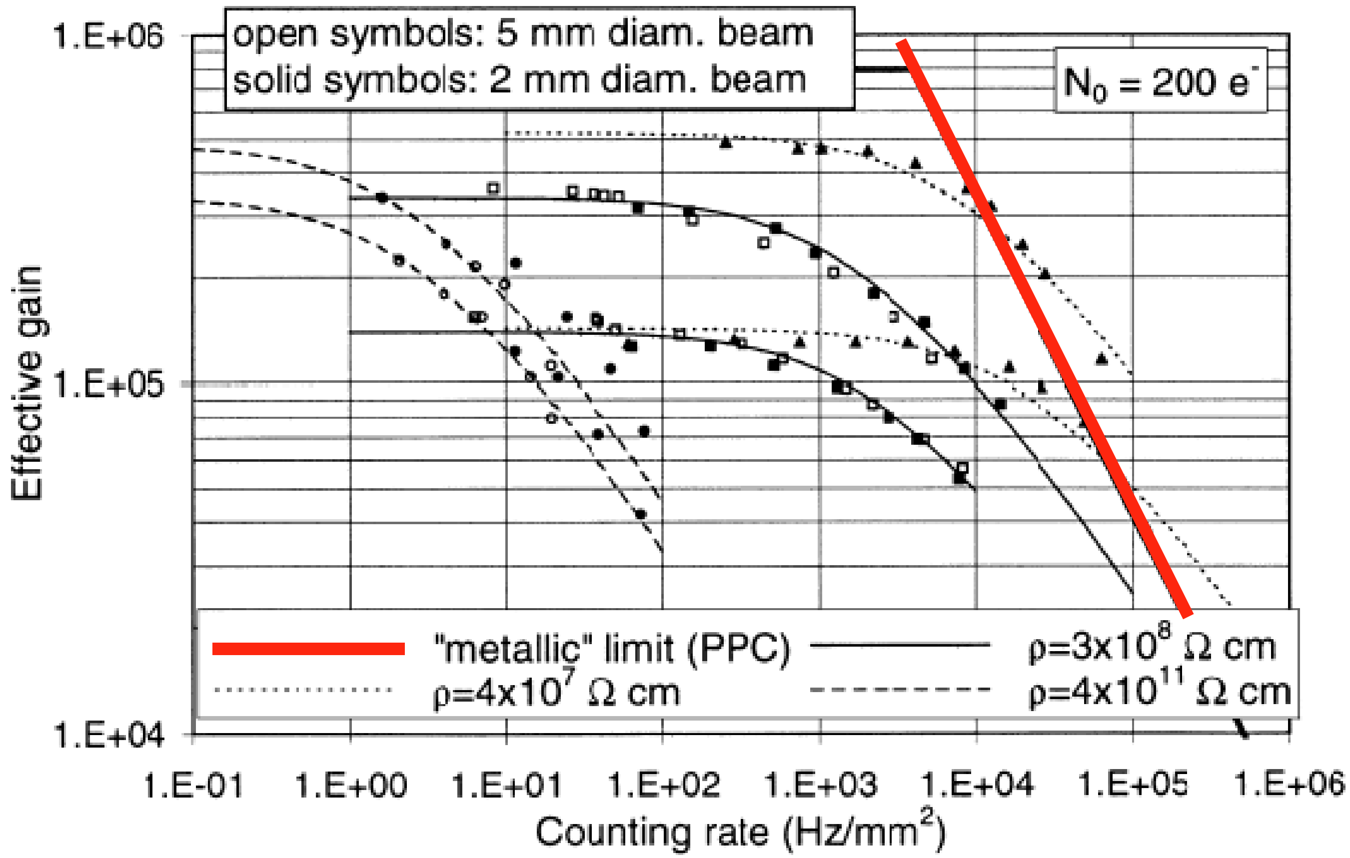
Future tasks:

In contrast to K-TGEMs, SP-RETGEMs require more tuning up:

optimization its resistivity and geometry,

understanding some detail in operation

Optimization of the RPC electrodes resistivity for high rate applications



P. Fonte et al., NIM A413,1999,154

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Spairs