The Performance of Glass-GEM

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Zaragoza

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  - GEM for sealed gas application
- Glass GEM
  - Fabrication process
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- Experimental Results
  - Fe-55 Source
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- Summary

The Glass GEM

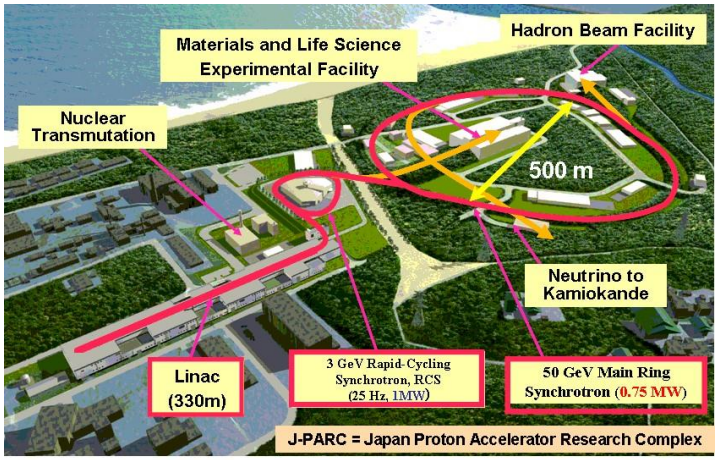
We fabricated a GEM with brand new material,

Photo Etchable Glass

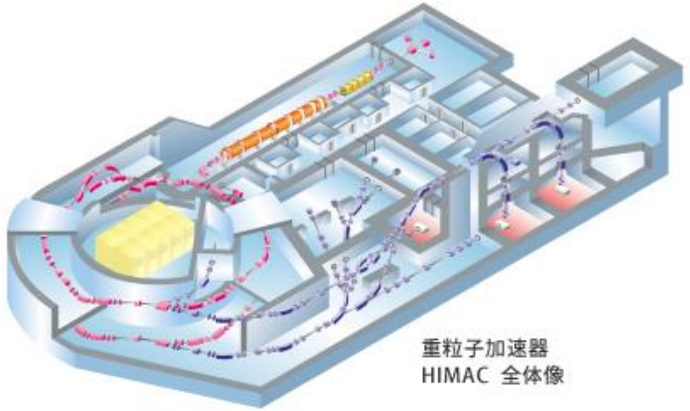
Background

- TOF Neutron Detector
  - For reflectometer
  - High gain
  - Stability
  - Uniformity
  - High count rate
  - **Hydrogen free material**
  - **Sealed gas (He-3)**
- Medical application
  - 2-D dosimeter for Carbon beam (Cancer therapy)
  - **Sealed gas chamber (Hospital)**

Focusing on sealed gas application



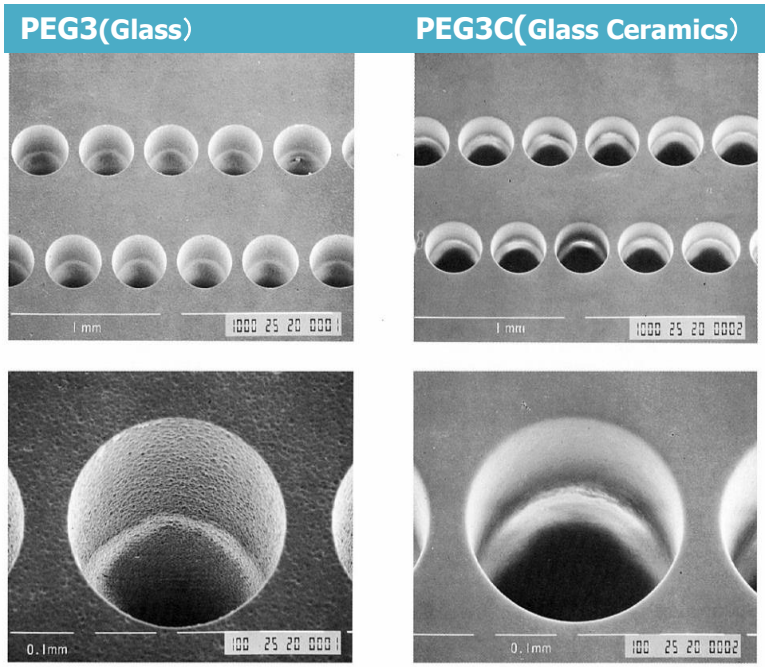
Neutron detector for J-PARC

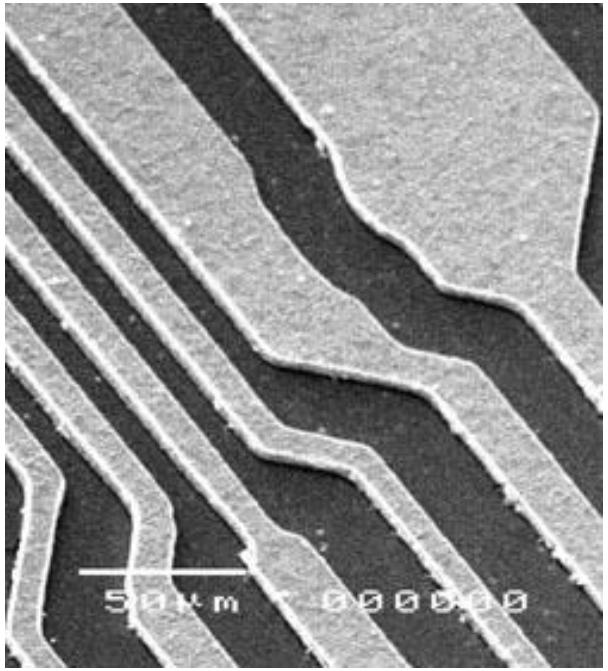


HIMAC (Heavy-Ion Medical Accelerator in Chiba)

HOYA corporation
Innovative Glass Material Developer in Japan

Photo Etchable Glass 3 : PEG3





Features

- Via-Hole and Trench Structure
- High Aspect Ratio
- Small Diameter
- 3-Dimensional Fabrication Process
- Transmits Light (PEG3)
- Smooth and Flat Surface

Application

- Glass Circuit Board
- Ink-Jet Print Head
- MEMS
- Flat Panel Display
- Optical Fiber Guide
- Wire Guide for IC Final Tester

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Comparison PEG3 glass with Polyimide

ITEM	*Units*	**PEG3**	**Polyimide**
Thermal conductivity @25° C	W/m K	0.795	0.3
Young's modulus	GPa	79.7	18.6
Dielectric const. @1GHz		6.28	3.55
Volume resistivity@25° C	W cm	8.5×10^{12}	$\sim 10^{18}$
Thickness	mm	0.1 - 1	
Min. Hole Diameter	μm	10	
Aspect ratio of Via Hole	Thickness/ Via Hole Diameter	30	

HOYA **Photo Etchable Glass 3 : PEG3**

Fabricating Process of Glass GEM

1. Glass Substrate

2. UV exposure (1st_exp)

3. Crystal formation
(1st heat treatment)

4. Via etching
(hydrogen fluoride wet etch)

5. Cu/Cr Plating and Sputtering

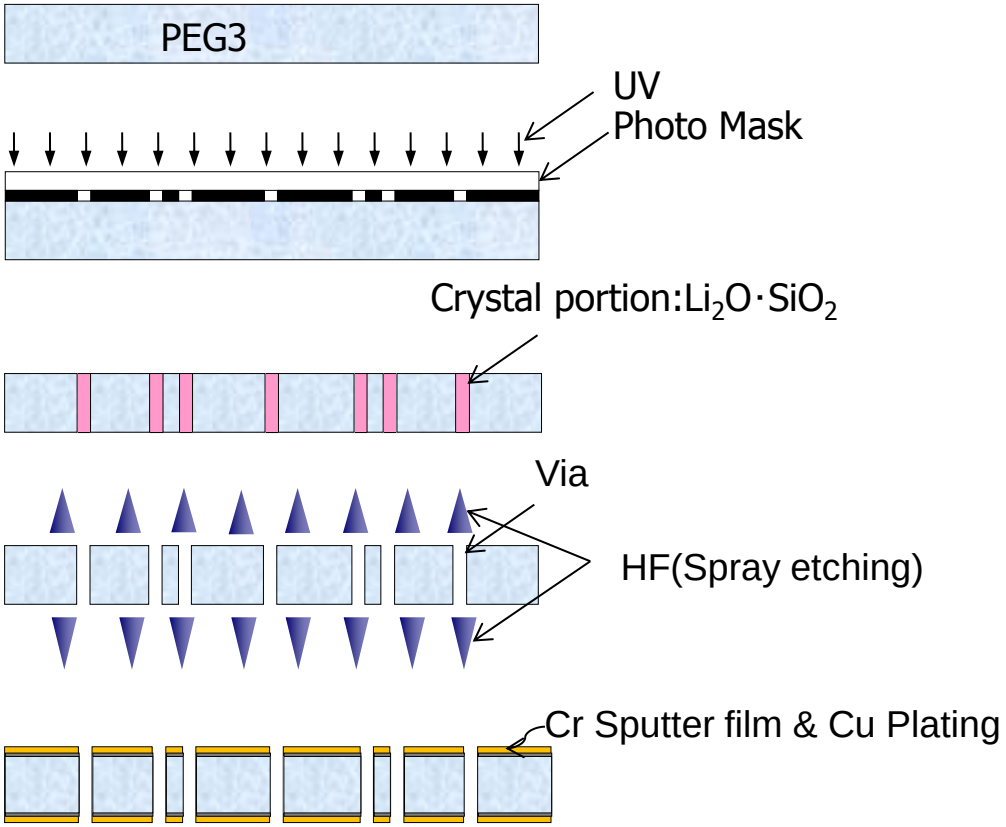

Photo Etchable Glass 3 : PEG3

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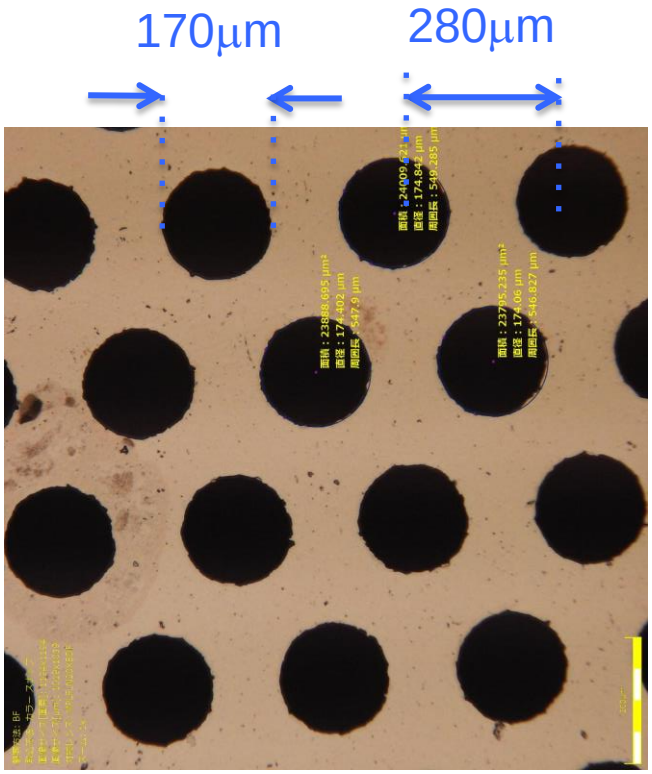
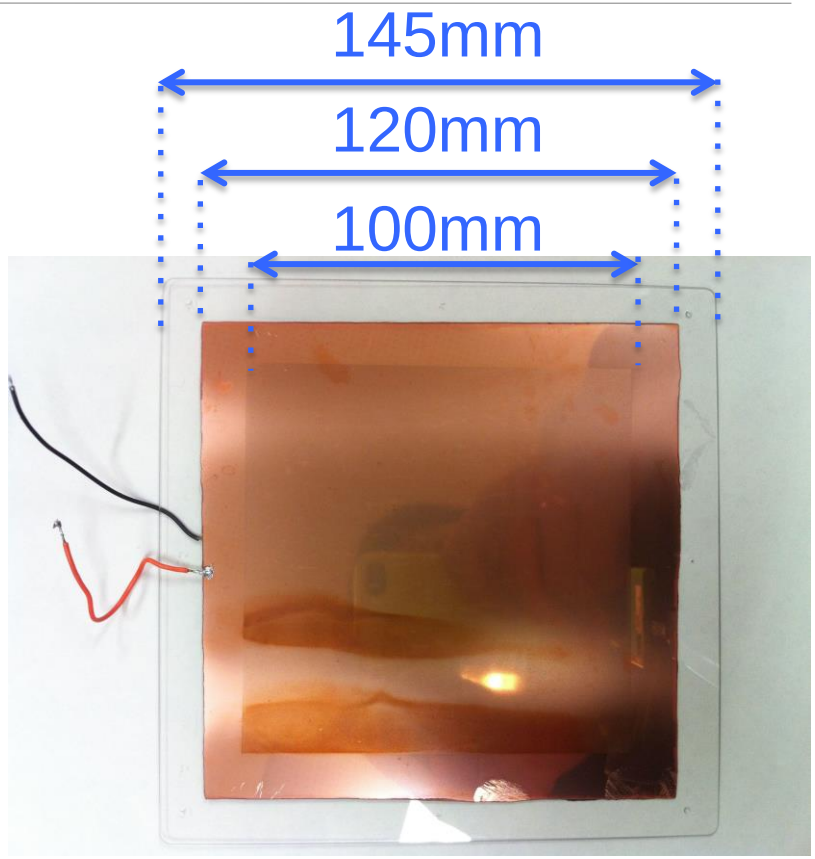
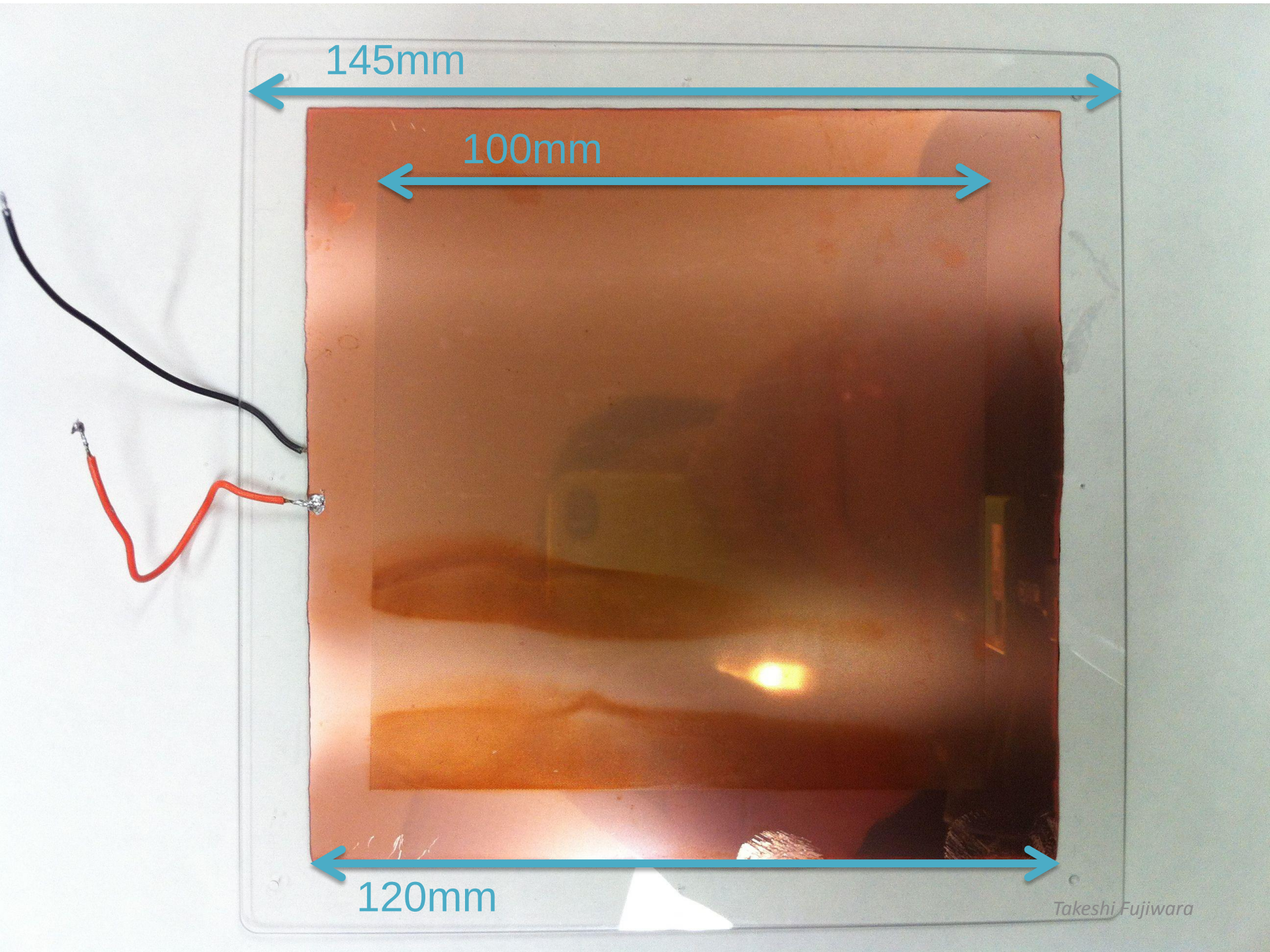
Glass GEM





- Substrate: 145 mm x 145 mm
- Effective area: 100 mm x 100mm
- Thickness: 680μm (410~800μm)
- Electrode: Cu + Cr
- Hole pitch: 280μm
- Hole dia.: 120~190μm


145mm
100mm
120mm
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Advantages of Glass GEM

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Easy to handle

- Needs no support to mount a GlassGEM

No Outgas

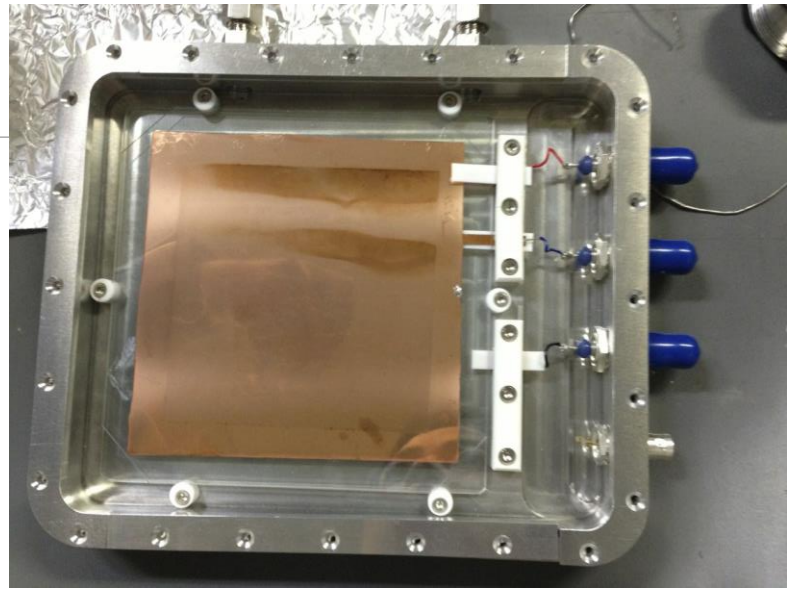
- No outgas from the substrate

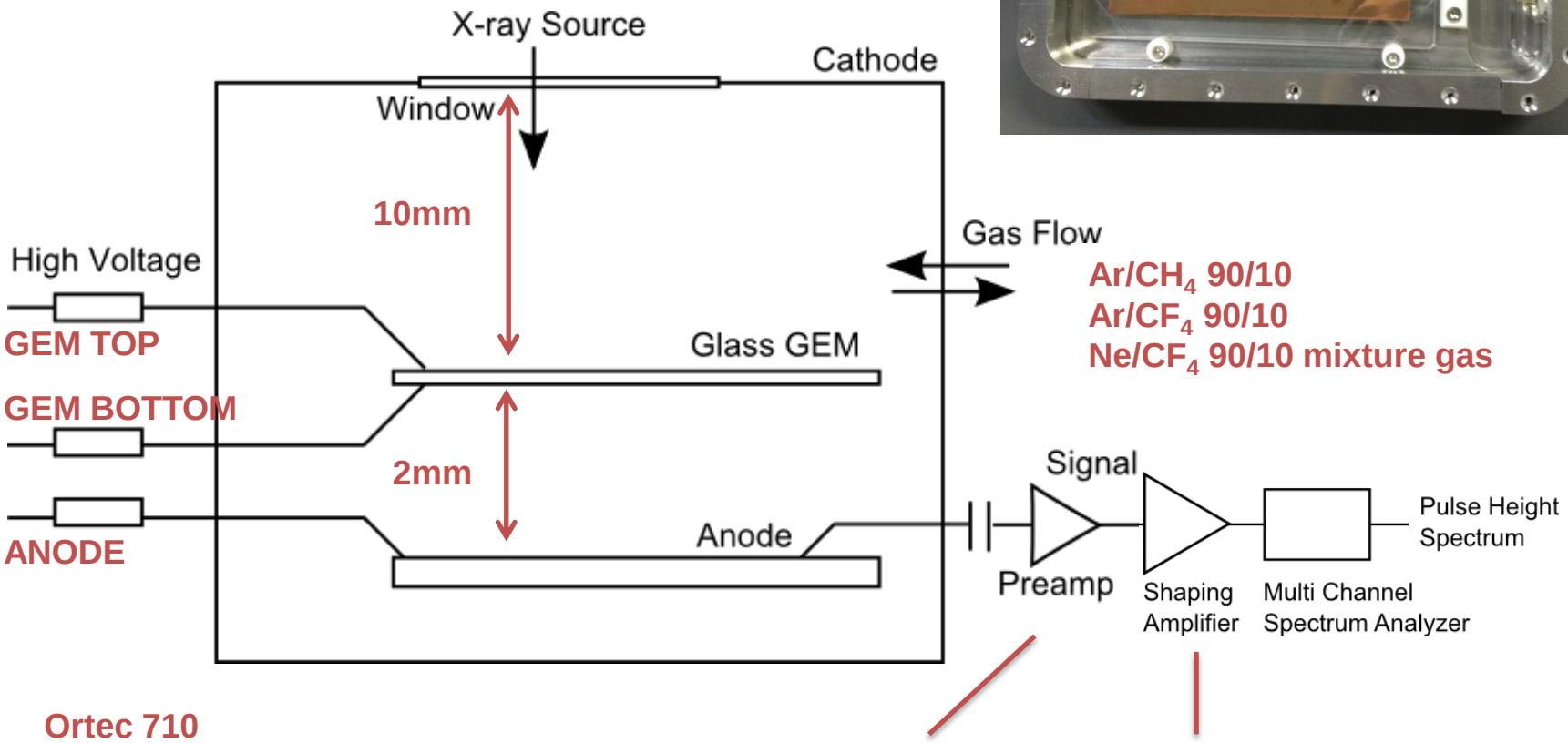
  (since it is inorganic material)

Fabricating Process

- Direct etching -> good uniformity
- Easy to fabricate

Setup





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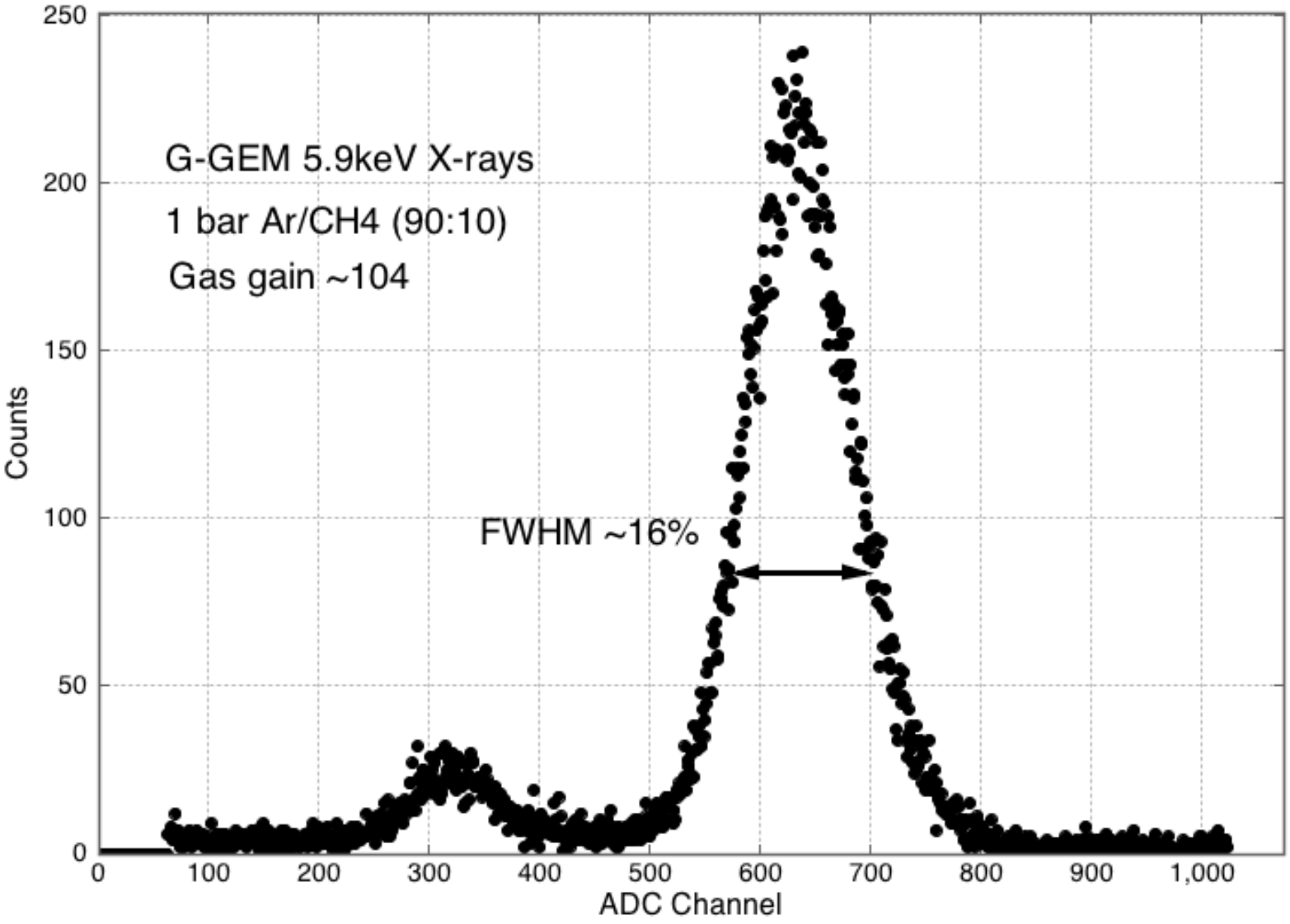
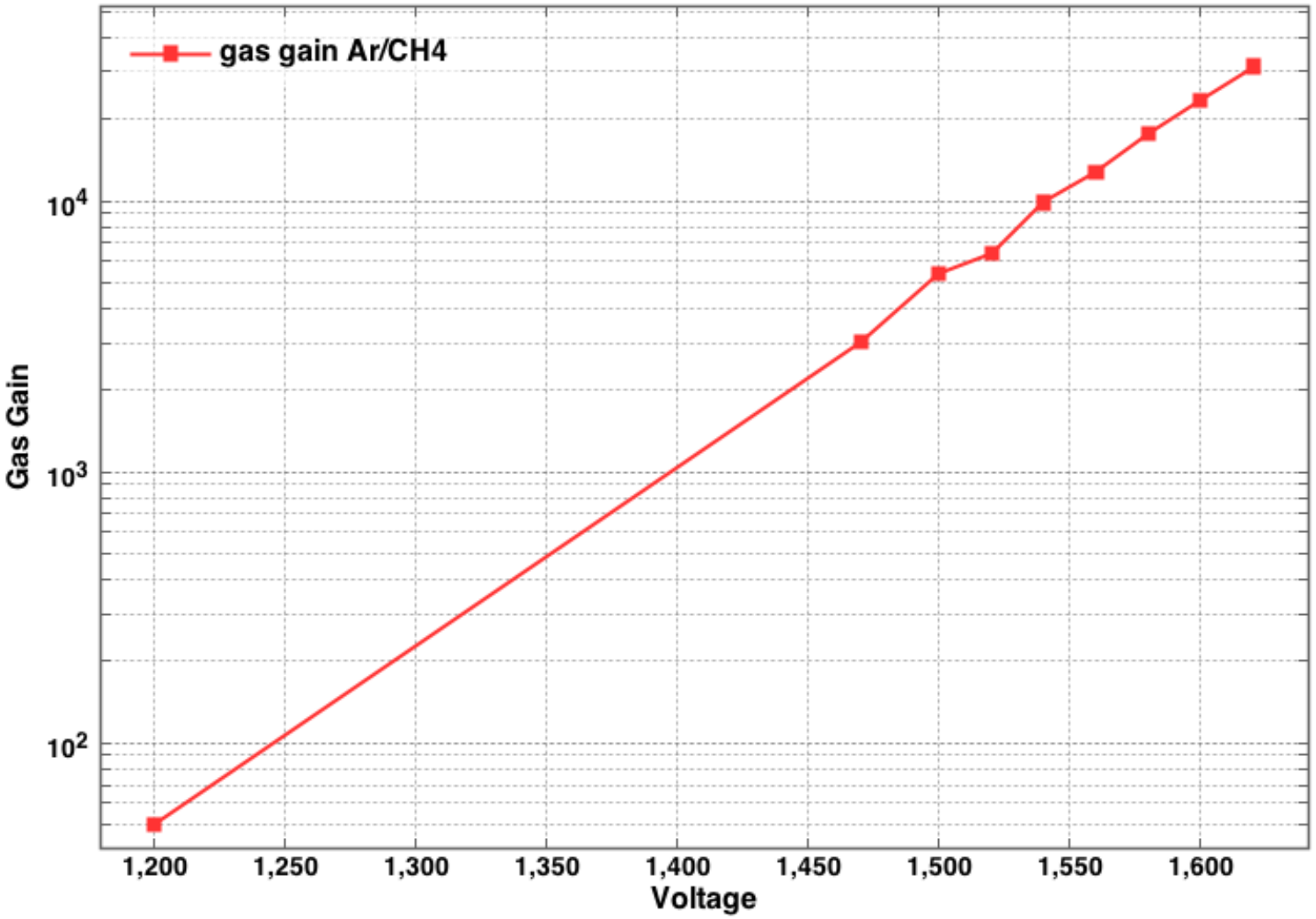
Energy spectra of Glass GEM with ^{55}Fe 5.9 keV X-ray source

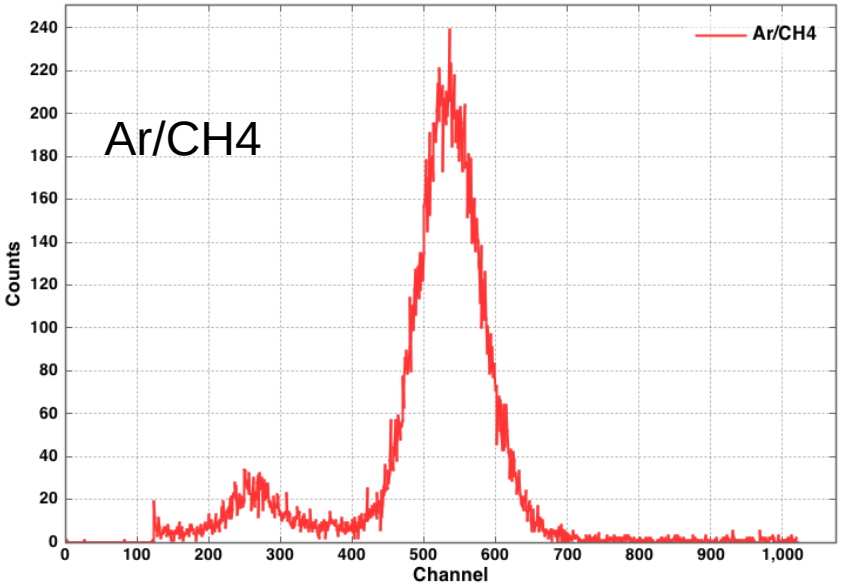


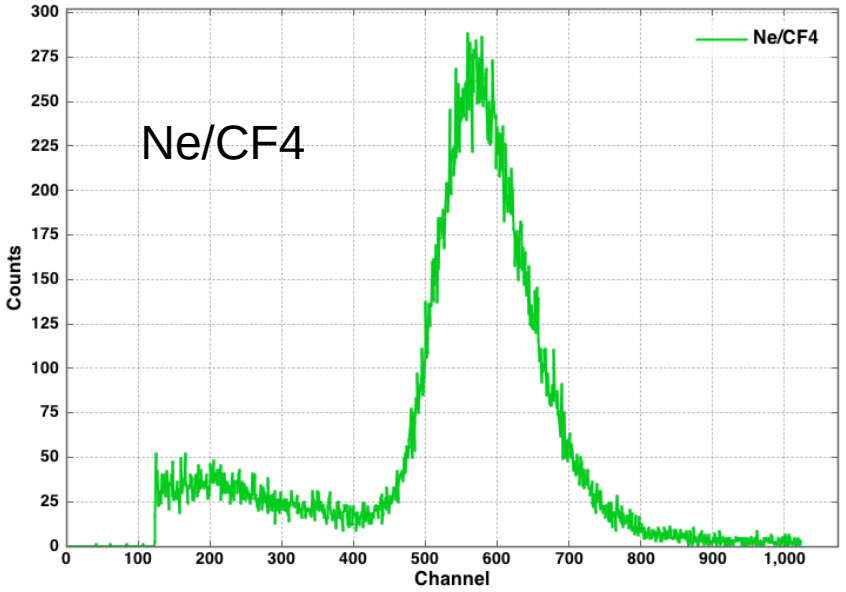
Gain curve

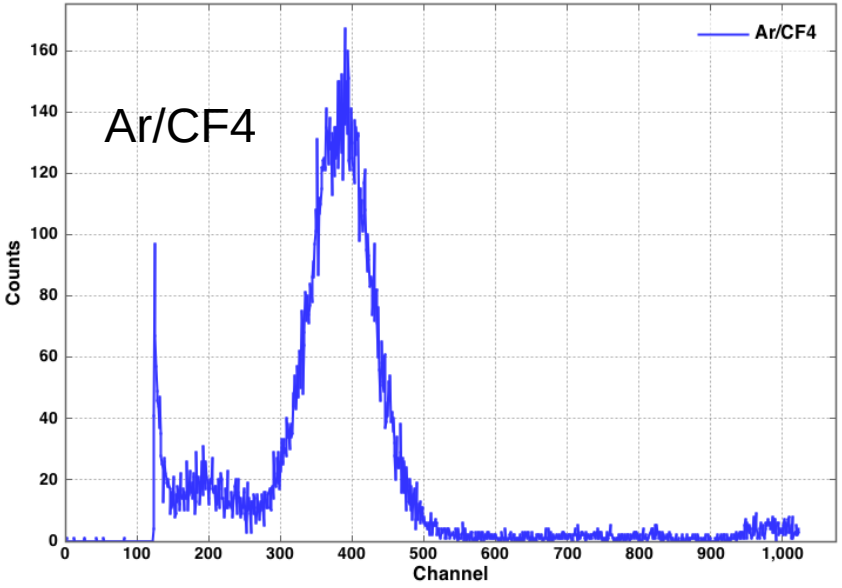


[GlassGEM] Thickness: 680μm, Hole diameter: 170μm

Energy spectrum in various gas (^{55}Fe 5.9 keV X-ray source)



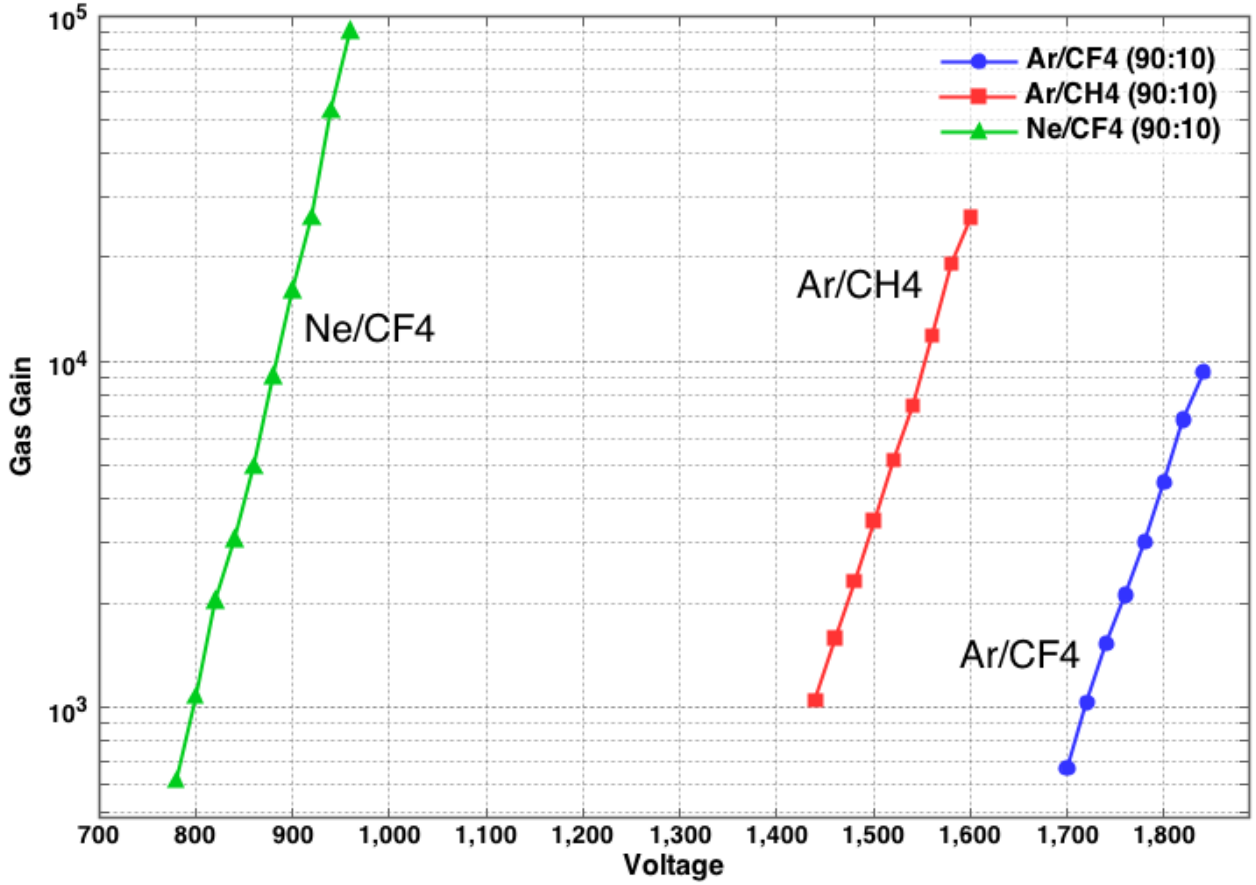




- Operated in Ar/CH4, Ar/CF4, Ne/CF4 gas mixture
- Ar/CH4 (90:10) gain 10,000
- Ne/CF4 (90:10) gain 10,000
- Ar/CF4 (90:10) gain 5,000

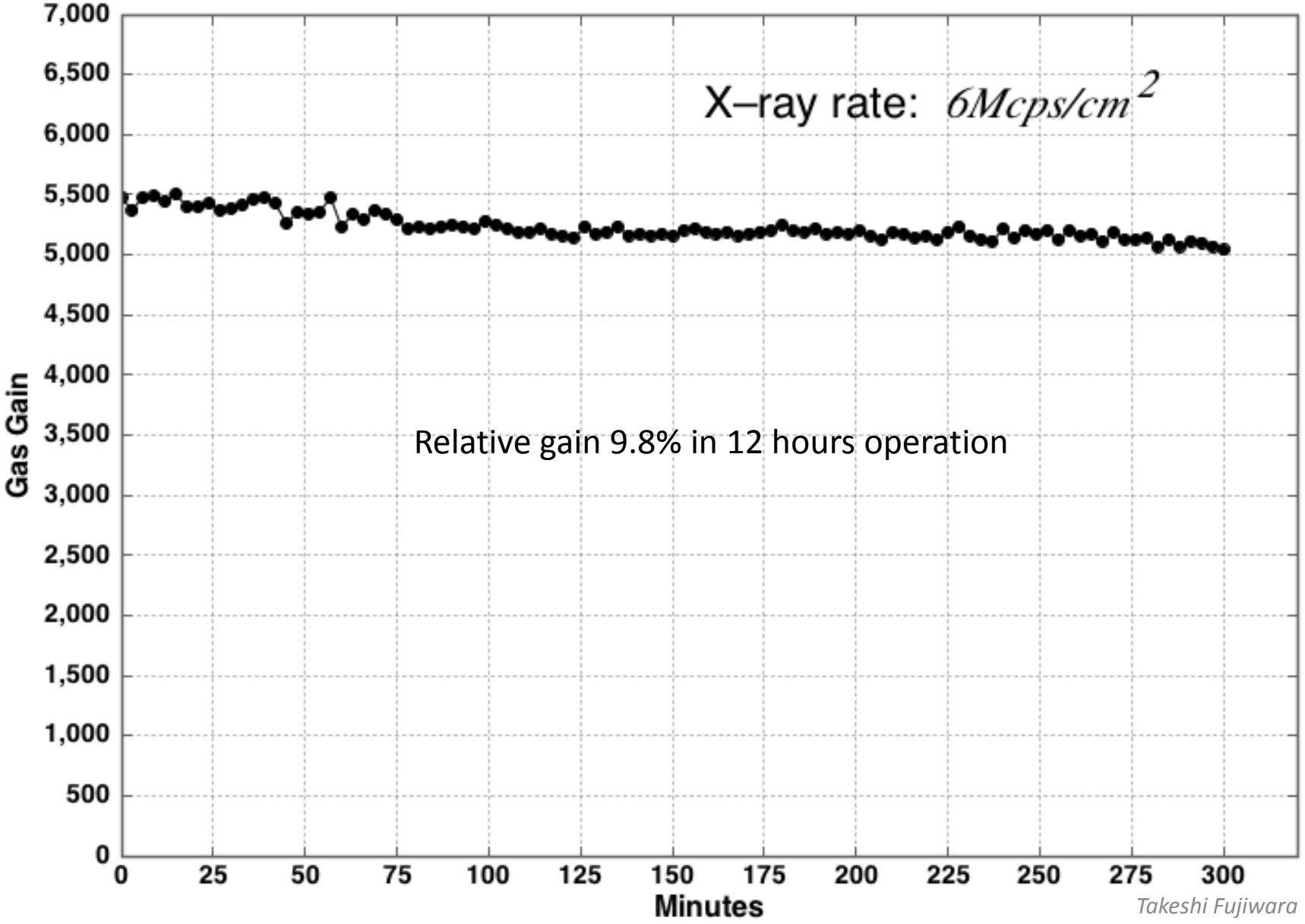
Gas gain

[GlassGEM] Thickness: 680μm, Hole diameter: 170μm

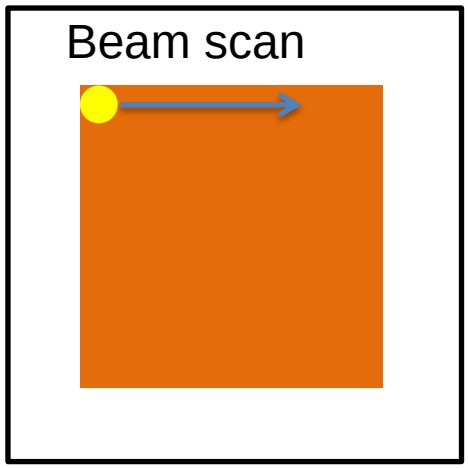


- Maximum gas gain
  - $9.8 * 10^4$ @ Ne/CF4 (90:10)
  - $3.2 * 10^4$ @ Ar/CH4 (90:10)
  - $9.5 * 10^3$ @ Ar/CF4 (90:10)

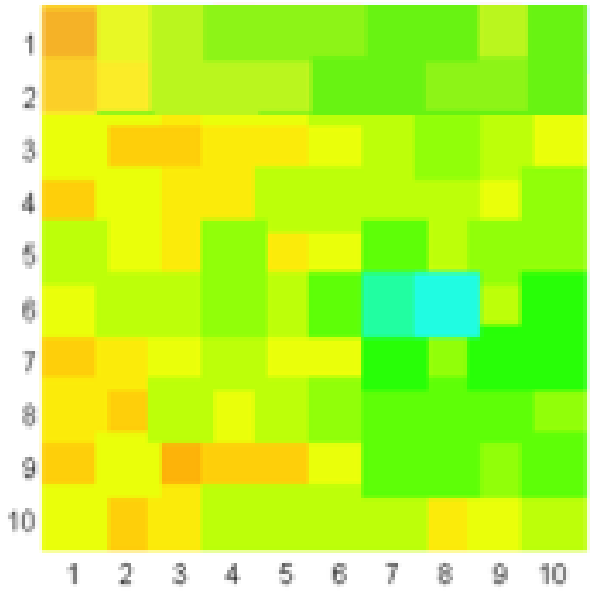
Gas gain stability (1 bar Pr10)



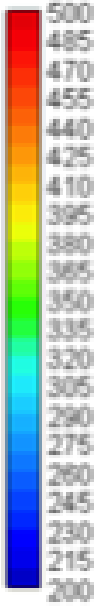
Uniformity of Glass GEM



- Tested at KEK PF (synchrotron radiation facility)
- 6keV 0.2mmΦ collimated beam
- 700kHz/cm^2
- Beam scan 10 * 10



Gas gain map

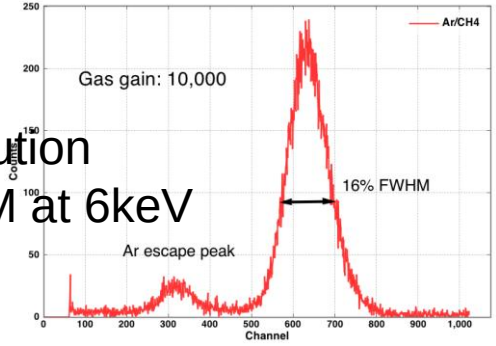


Varies of gas gain

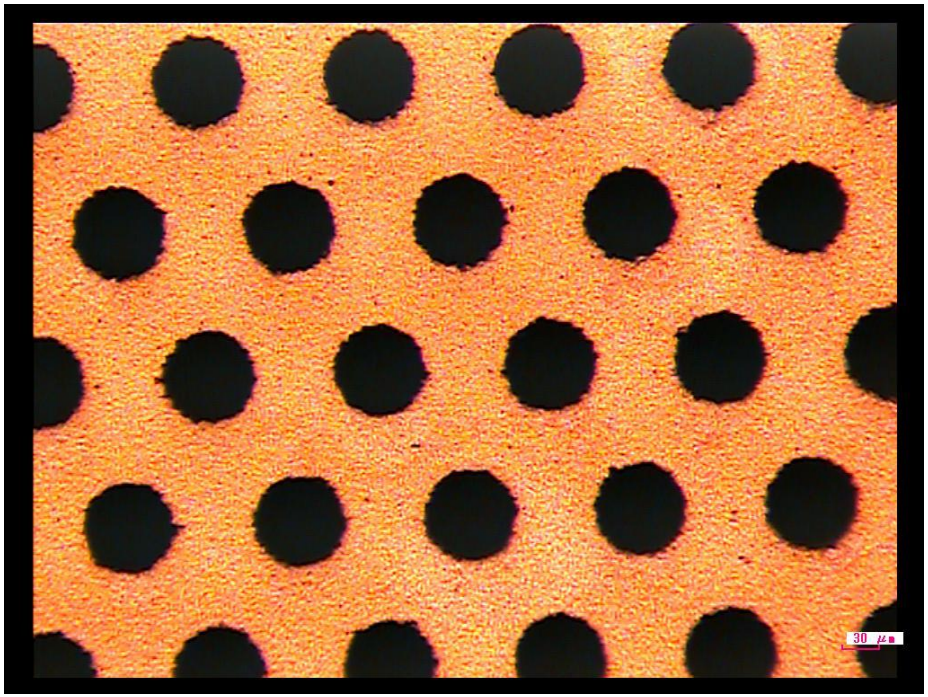
Entire area

Gas gain
min. 9987
max 12306

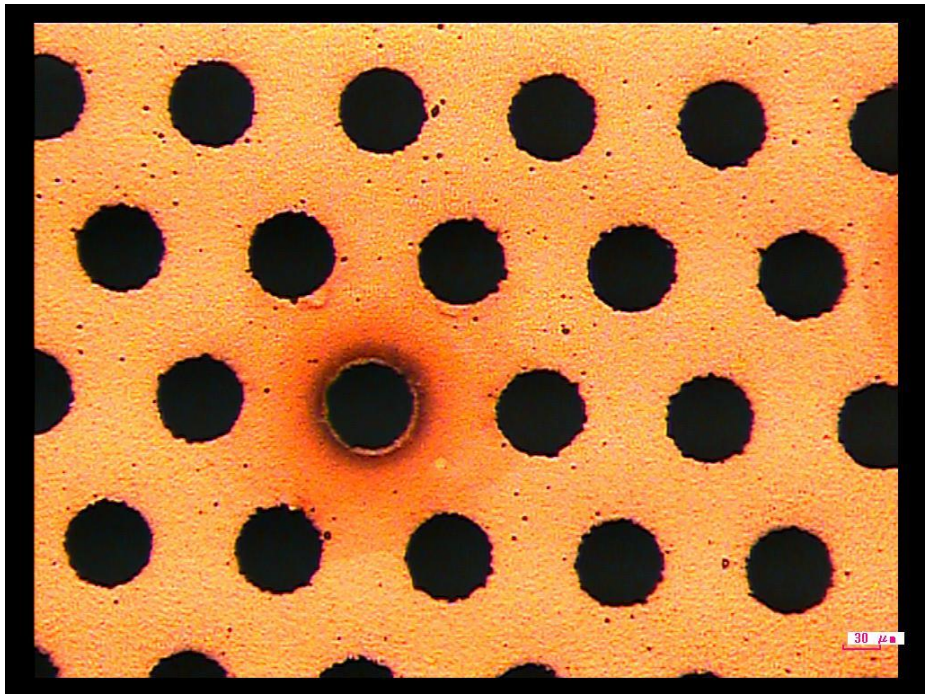
Energy resolution
15.8% FWHM at 6keV



Spark tolerance



Before operation



Discharged part of GlassGEM

- During the operation, several sparks where observed (heard) but nothing to do with the Glass GEM.
- Some burned print where observed around the hole, but no change of gas gain and energy resolution.
- **<u>Glass substrate has a tolerance against sparks.</u>**

GlassGEM for medical application

2-D Carbon Ion Beam Dosimeter

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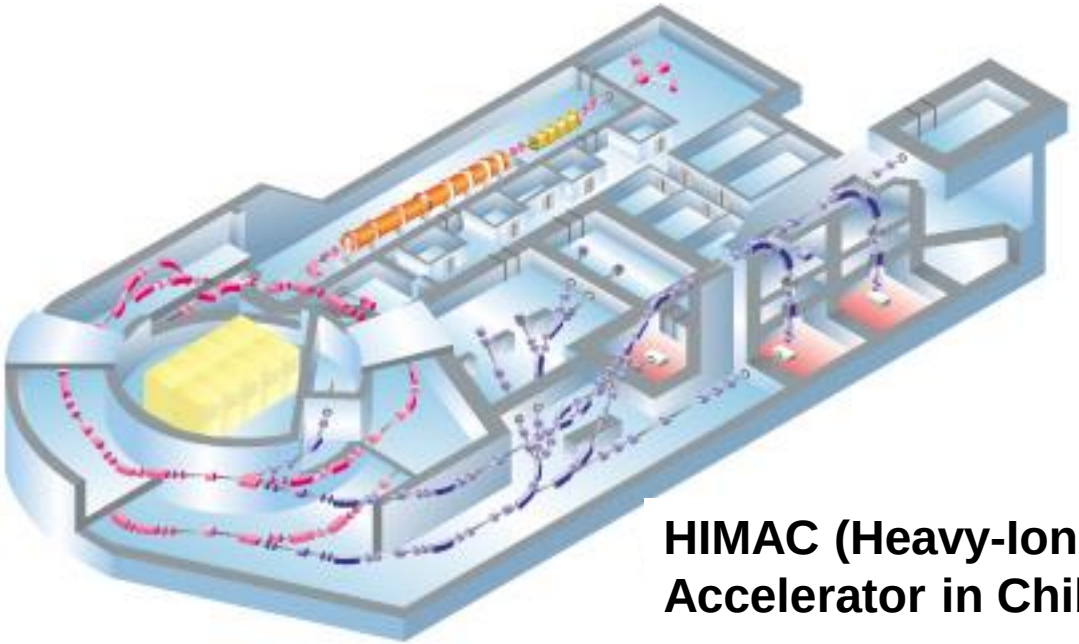
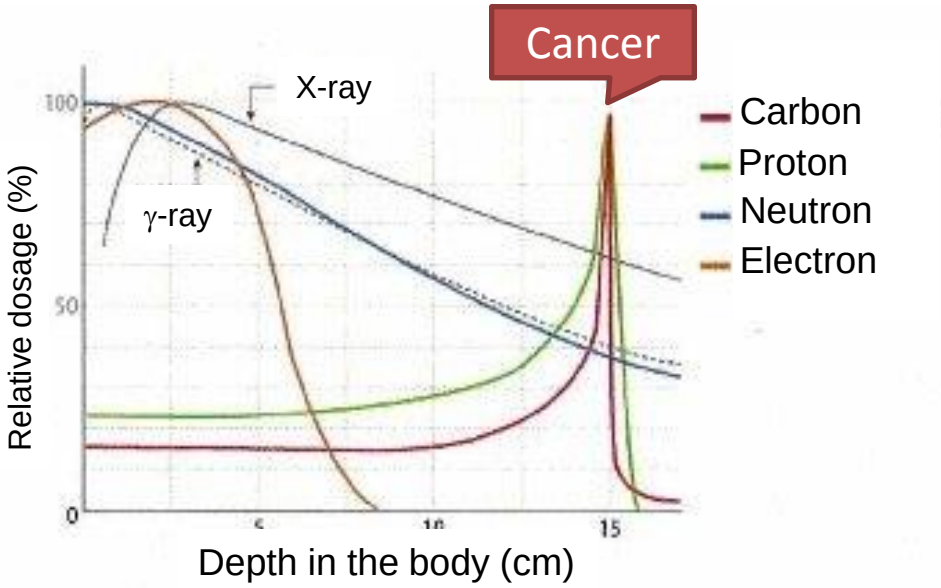
2-D dosimeter for carbon beam cancer therapy



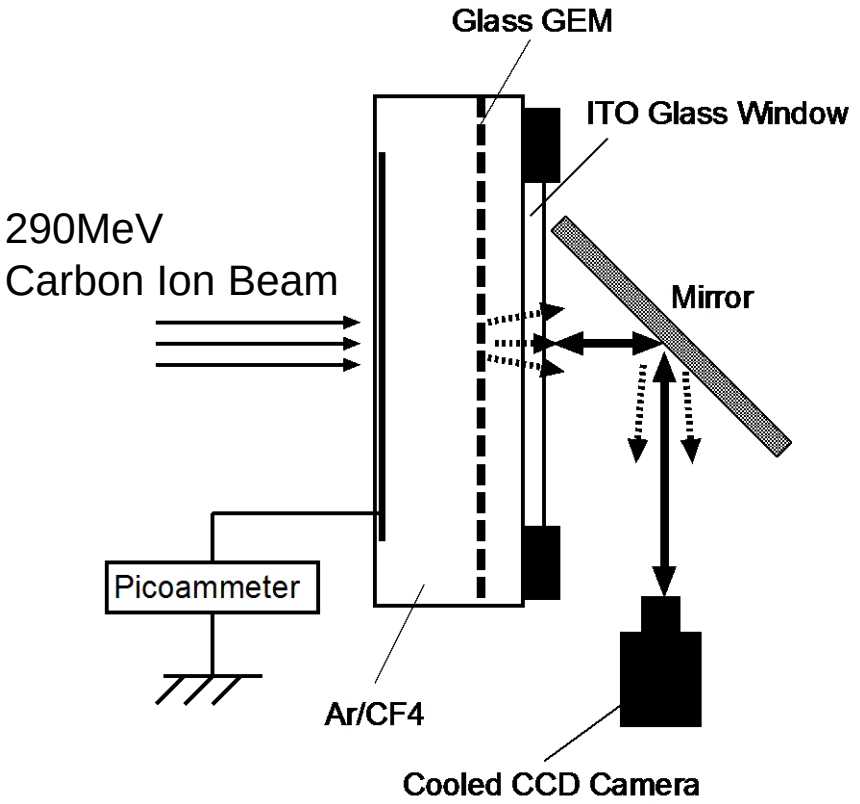
- 290 MeV Carbon ion accelerator for cancer therapy
- Localize the radiation dosage precisely using Bragg peak.
- 2-D dosimeter is required for accurate treatment planning.

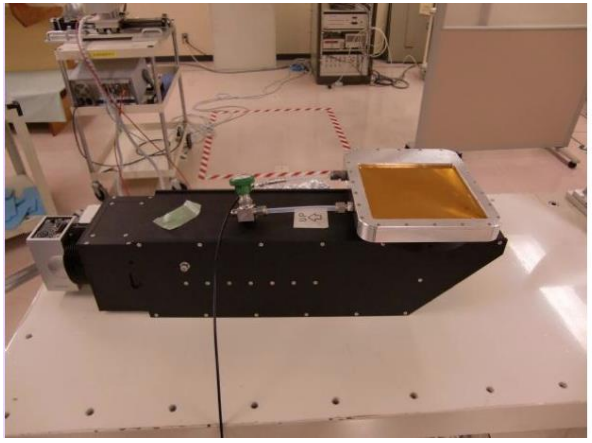
HIMAC (Heavy-Ion Medical Accelerator in Chiba)

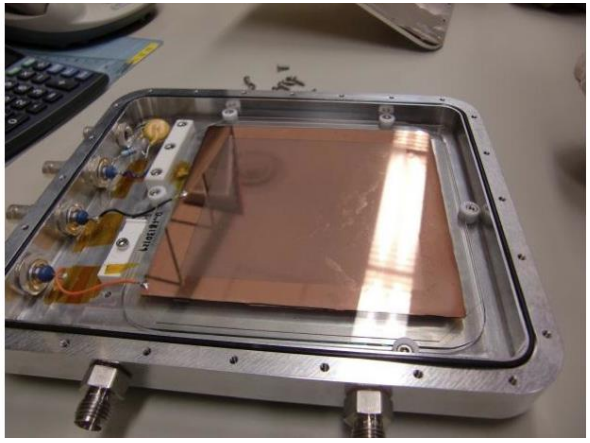


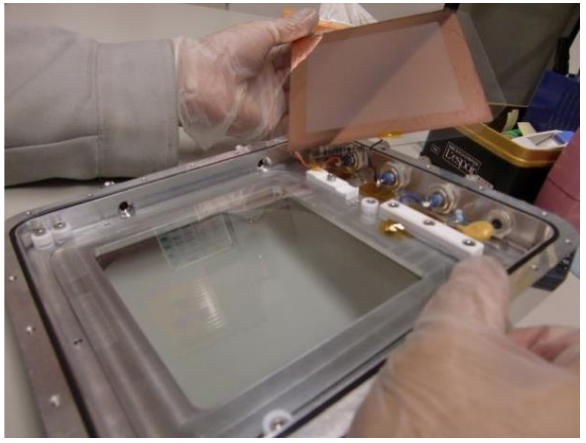
Glass GEM

- Beam
  - 290MeV Carbon Ion Beam
  - 10cmΦ
- Detector
  - GlassGEM + ITO Anode
  - Ar/CF4 for scintillation gas
  - Cooled CCD for imager
  - Mirror to avoid irradiation to CCD



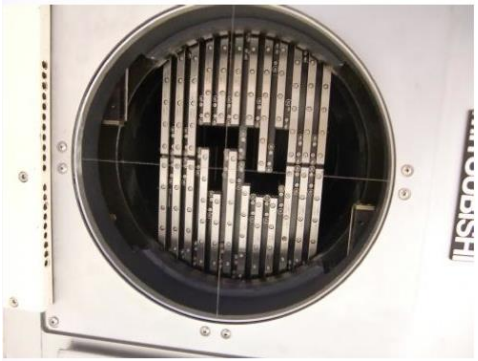






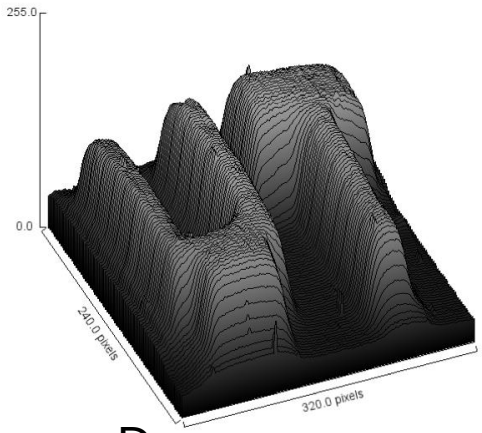
Preliminary result

- “UT” (University of Tokyo)



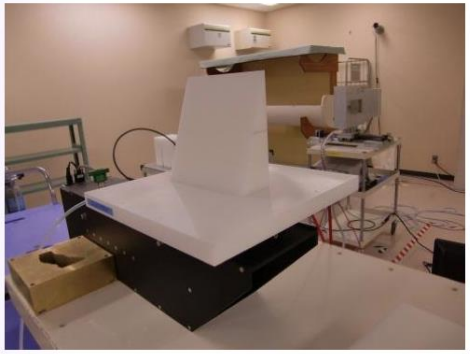
Collimator

Obtained Image

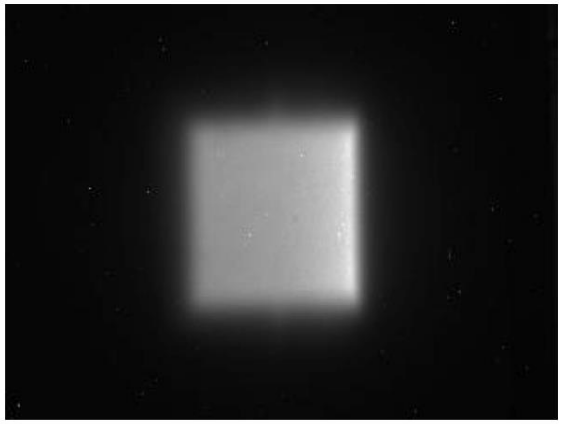


Dosage map

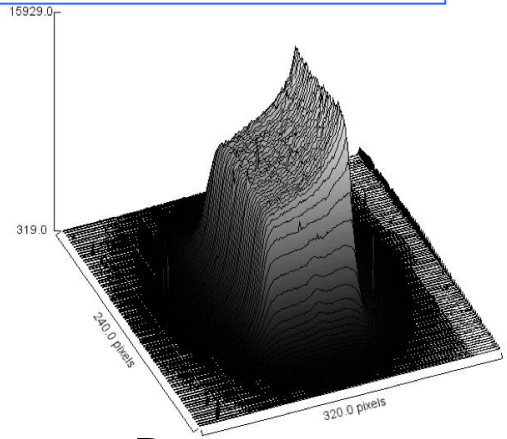
- Bragg peak measurement



Moderator on GEM



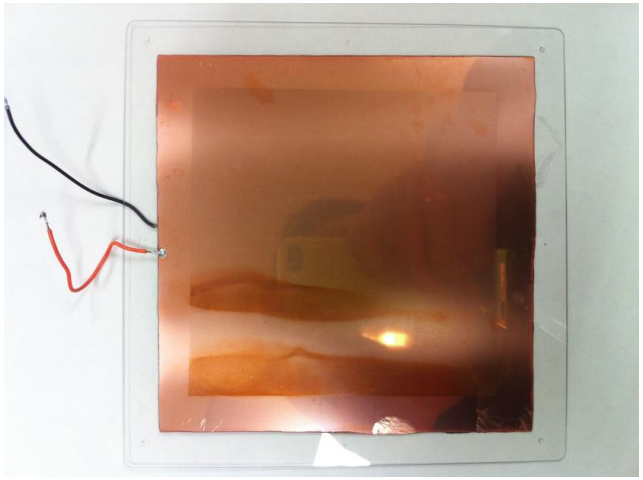
Obtained Image



Dosage map

Summary of **The Glass GEM**

- Succeed in fabricating GEM with new material
  - **photo etchable glass**
- Fabricated with **PEG3 substrate** (HOYA corp.)
- Effective size: 100 * 100mm^2
- High gain with single substrate
  - Gas gain : 3 × 10^4 @Ar/CH4 (90:10, 1bar)
  - Gas gain : 9 × 10^4 @Ne/CF4 (90:10, 1bar)
- Energy resolution: 15 to 18%
- Glass GEM is a **outgas free** material : suitable for sealed gas application
  ex. He-3 neutron detector



Thank you for your attention.