Development of Hard X-ray Detector with GEM

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KEK Detector Technology Project

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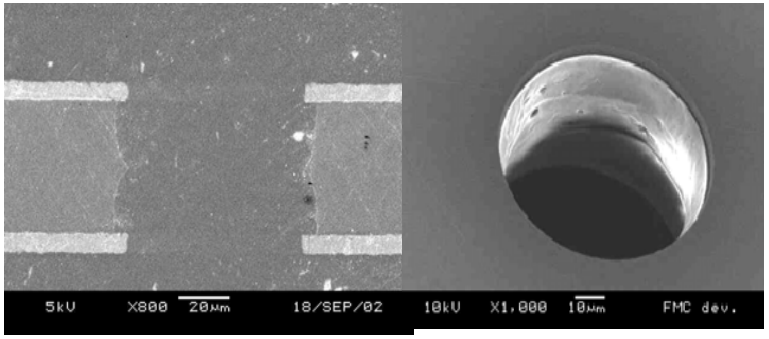
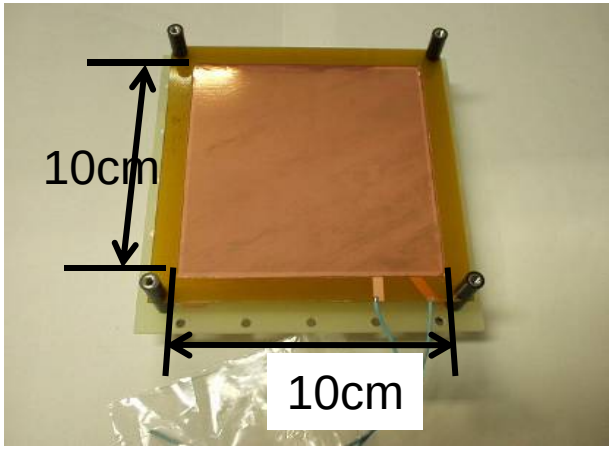
GEM foils made by Japanese company

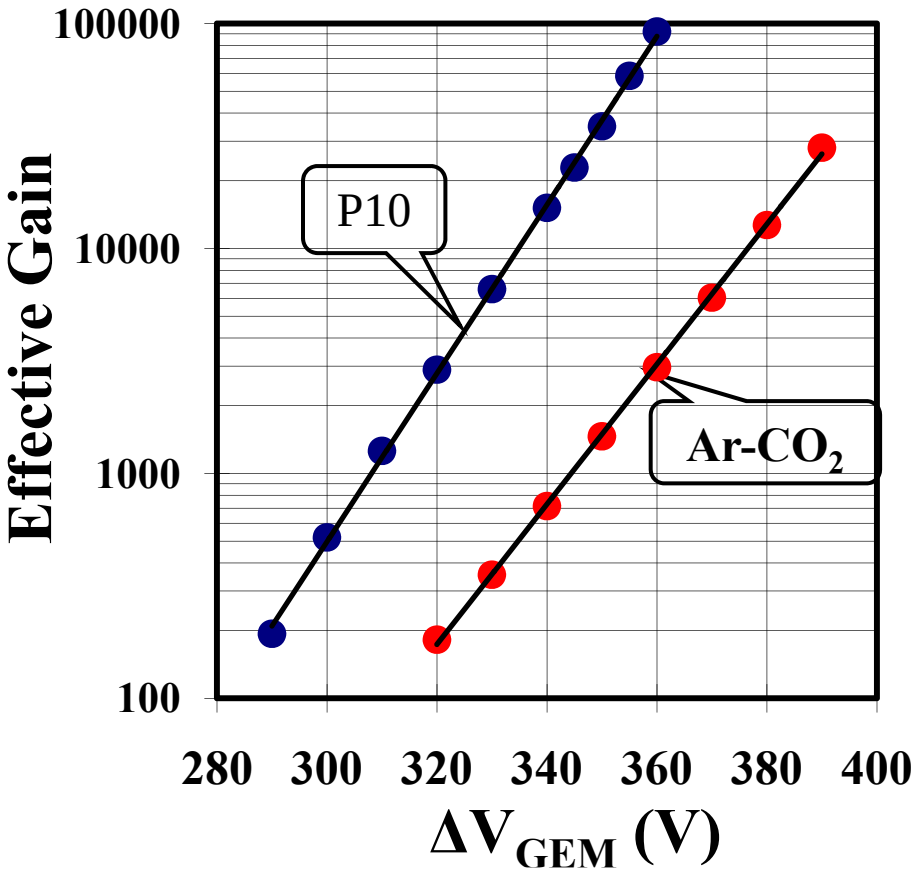
- New method (plasma etching) was tried in several years ago.
  - Not chemical etching (CERN)
  - M. Inuzuka, et al., NIM A 525(2004) 529-534
- **Laser + Plasma**
  - To reduce sparks
  - T.Tamagawa, et al., NIM A560(2006) 418
- It is convenient for us to make new types of GEM foils.
  - Fine pitch/small hole : 50μm/30μm
    - Better resolution → Cosmic X-ray polarimeter
    - RIKEN
  - Thicker/thinner : 100(150)μm/ 25(12)μm
    - Higher gas gain : a part of my talk
      - S.Uno, et al., NIM A581 (2007) 271
    - Higher transparency : Gating grid for TPC
  - Coated GEM
    - Boron : Neutron detection
    - Gold : Hard X-ray ← my talk
    - CsI : Hamamatsu ← Sekiya's talk



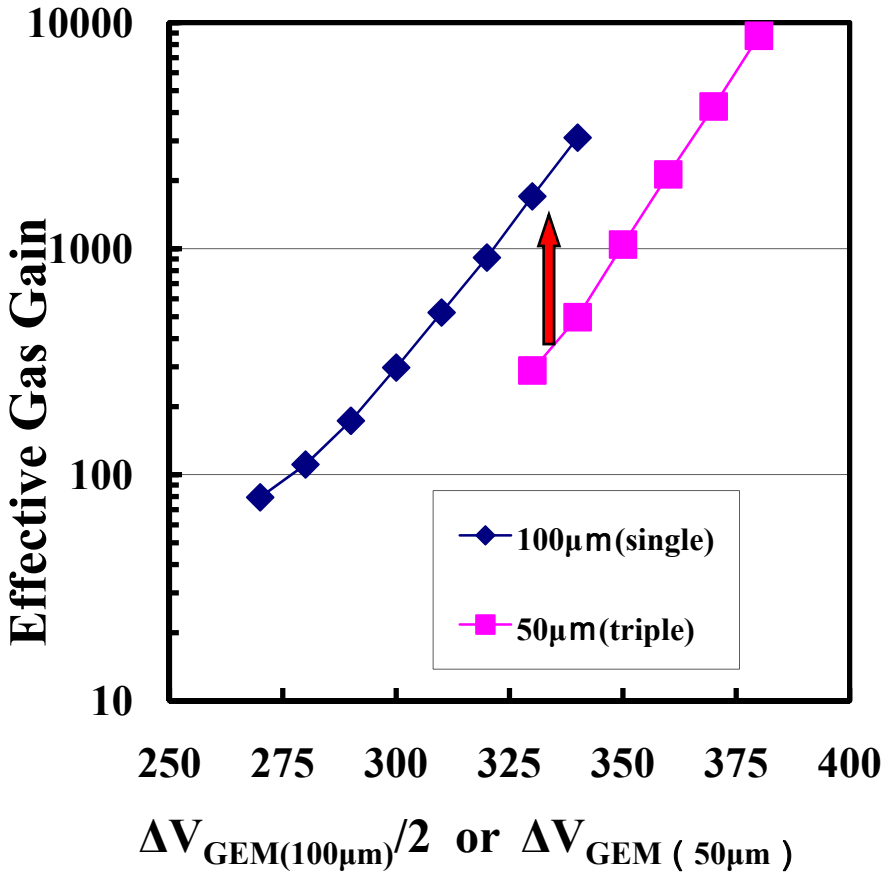


Scienergy Co., Ltd.
(Japanese company)
http://www.scienergy.jp/

Triple GEM
with 50μm^t



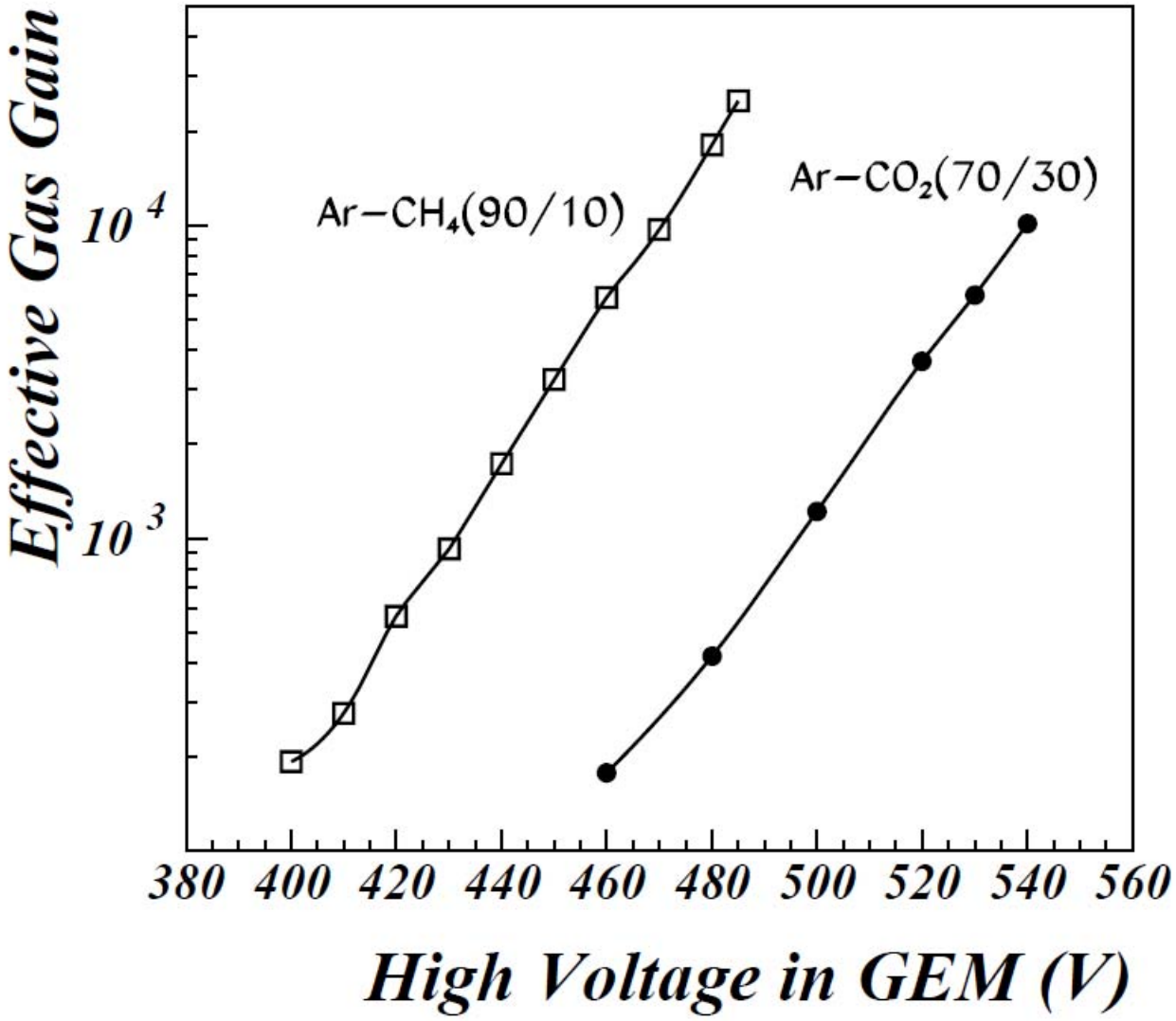
Single GEM
with 100μm^t



100mm^t GEM :
Hole diameter 70μm (90μm)
Pitch 140μm

Double GEM with 100μm^{t} GEM

70μm$^{\phi}$



Combination of different thickness GEM

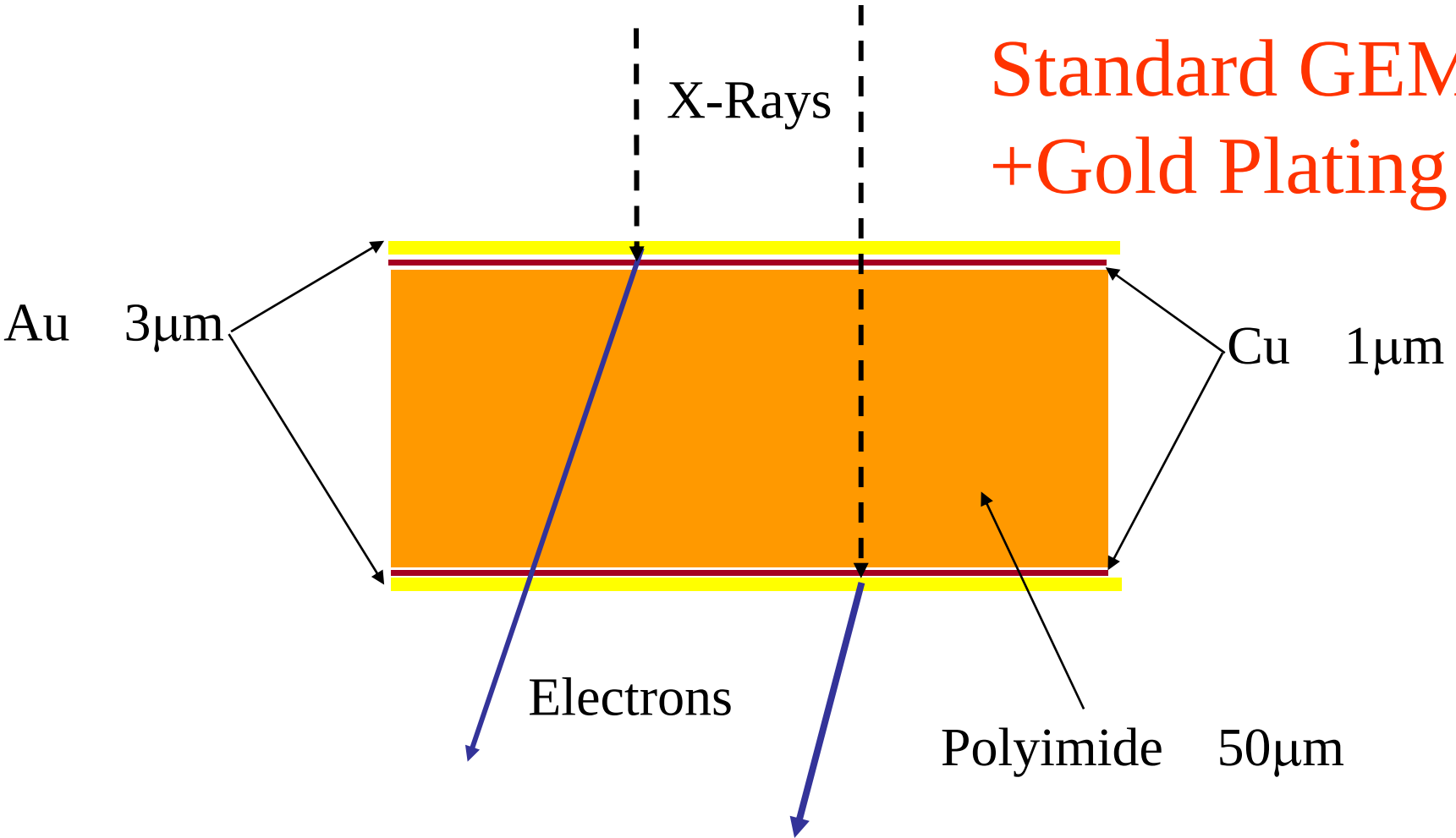
Thickness (μm)	ΔV_{GEM1} (V)	ΔV_{GEM2} (V)	Sum (V)	Gain	Comments
100/100	557	557	1114	1.3×10^4	
100/100	579	579	1158	4.3×10^4	
100/100	651	506	1157	5.4×10^4	
100/50	675	375	1050	4.8×10^4	Stable
100/50	650	400	1050	5.0×10^4	Stable
Triple	390 × 3		1170	3.0×10^4	

Diameter:90μm$^{\phi}$ for 100μm^{t} GEM
:70μm$^{\phi}$ for 50μm^{t} GEM

Hard X-ray detector

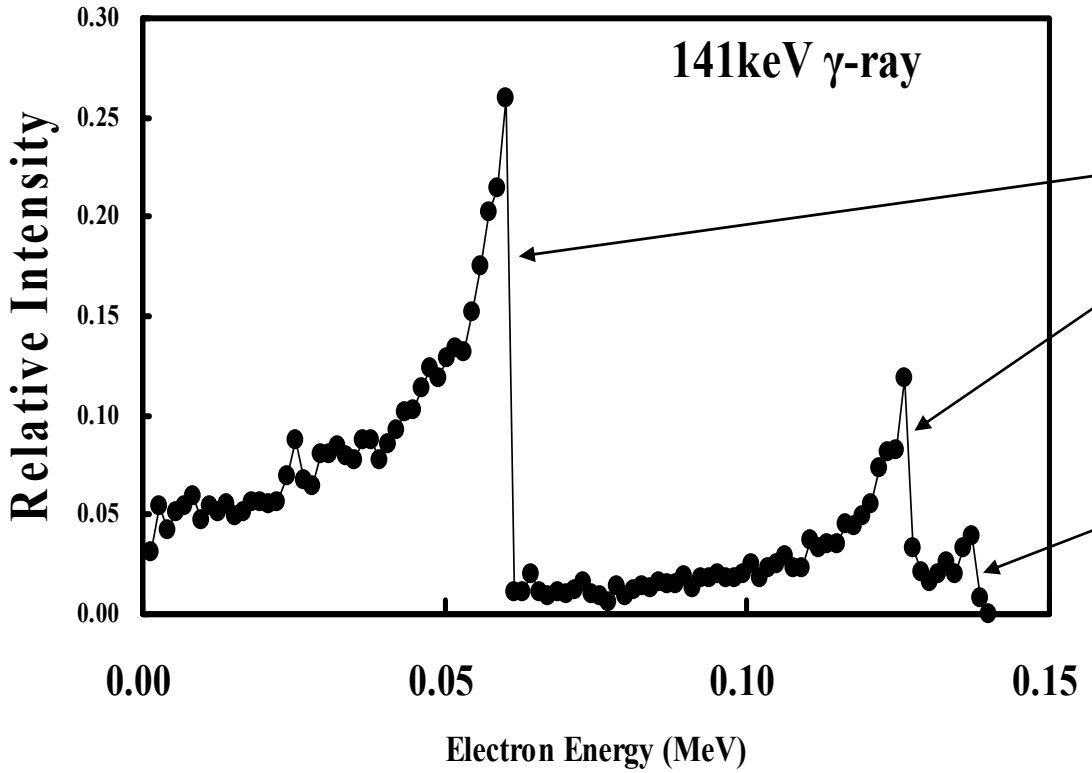
- Hard X-ray can even penetrate a thick iron plate and a concrete block. Therefore, it is useful for non-destructive inspection in industrial purpose.
- Usually, Xenon gas has been used for detection of X-ray.
- But, efficiency is not so high for hard X-ray (>~60keV).
- Solid converter (Gold) is used for detection of hard X-ray.
- Range of produced electron is very short. Gold layer should be thin. Then, many thin gold layers are necessary to get higher efficiency.

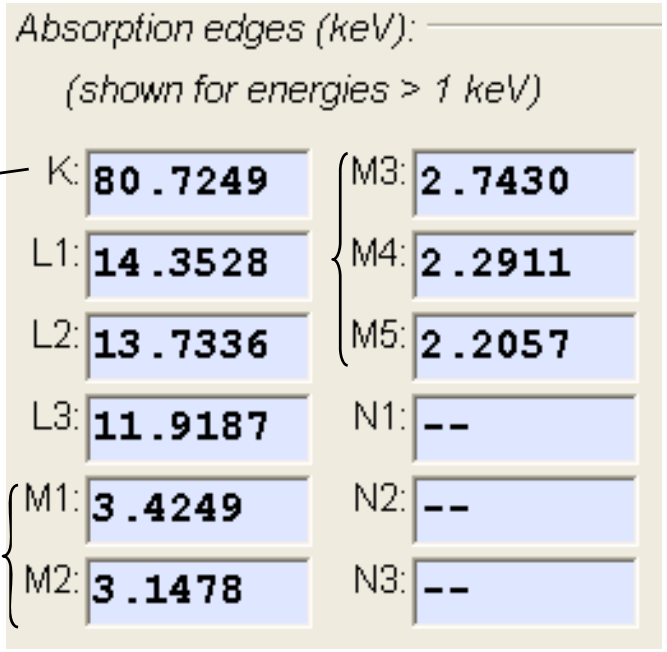
Gold plated GEM
to get higher efficiency
for hard X-ray with higher energy



Simulation Study

Energy spectrum in gas volume
for produced electron in gold layer

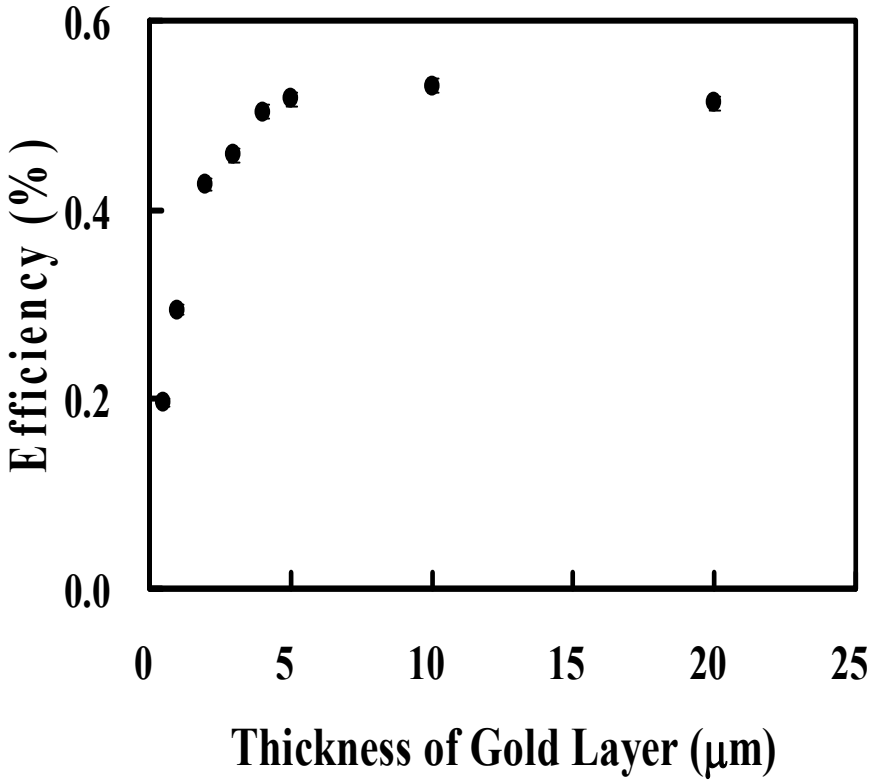


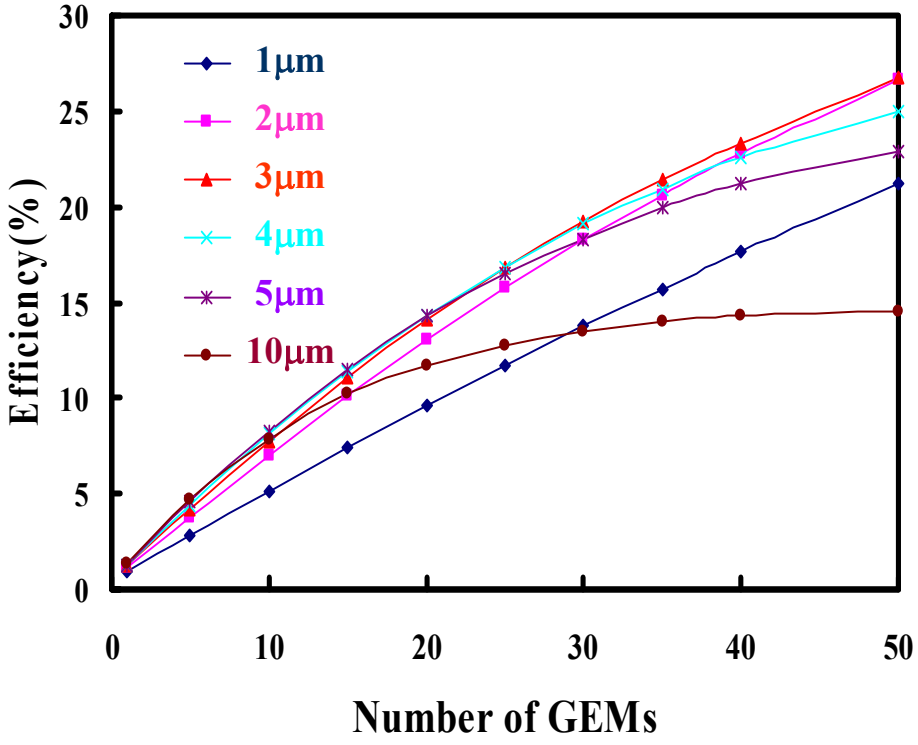


Optimization of Gold thickness

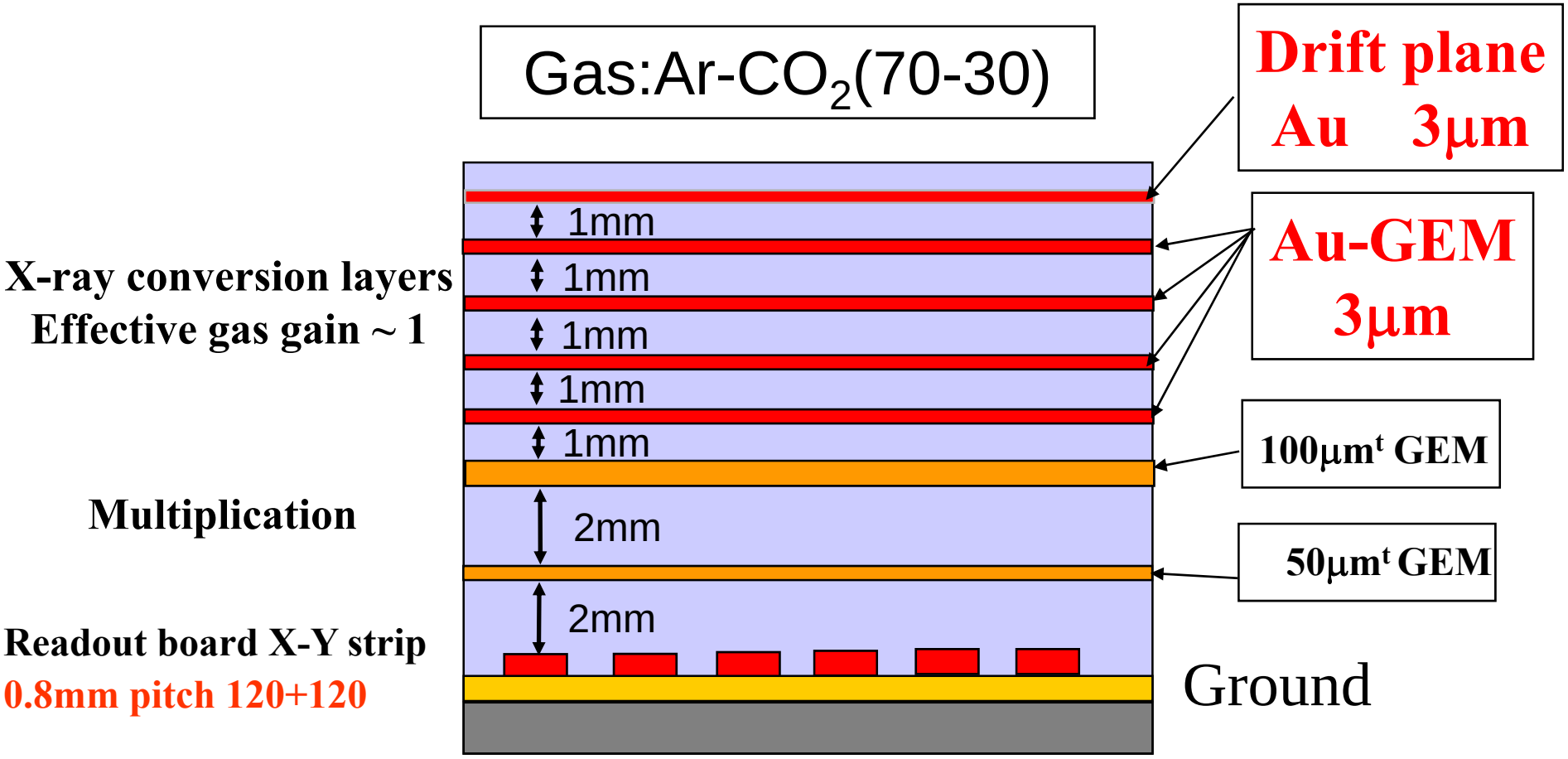
Simulation

Photon Energy: 141keV





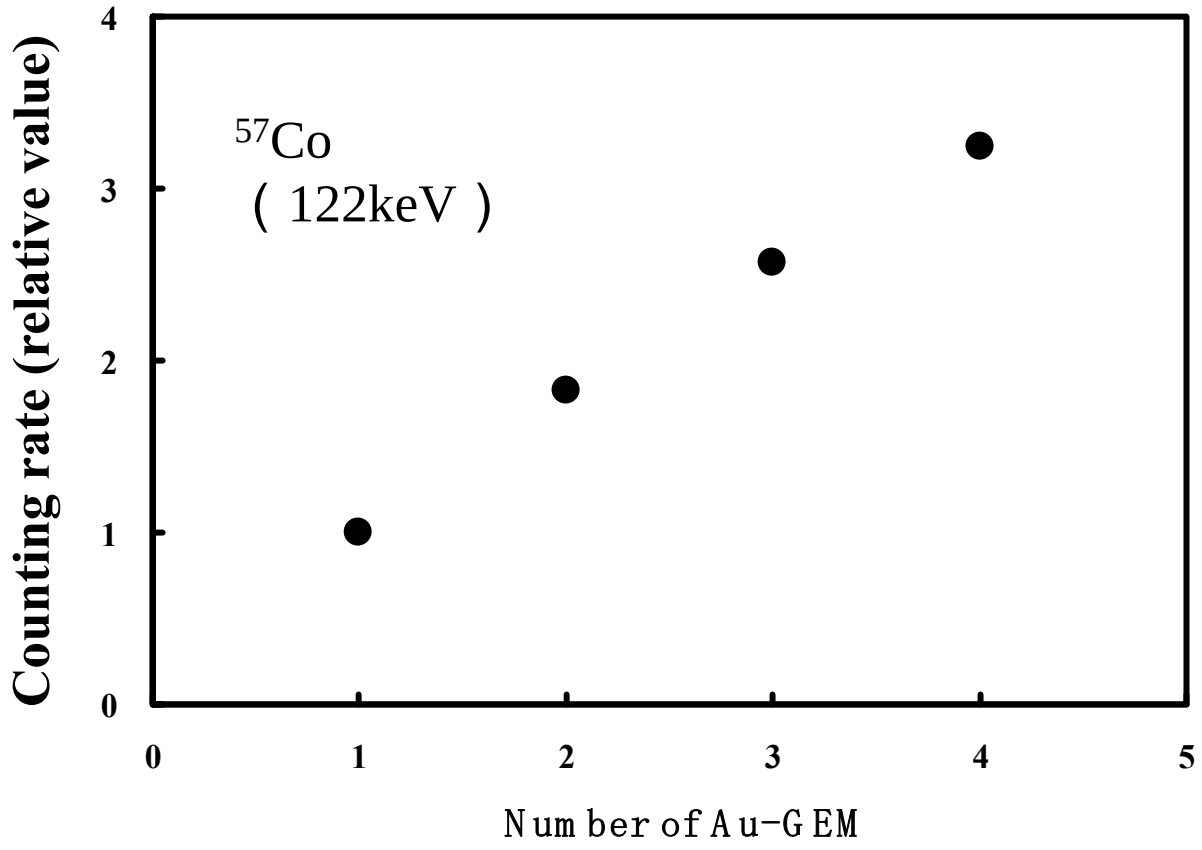
Chamber structure



Experimental result

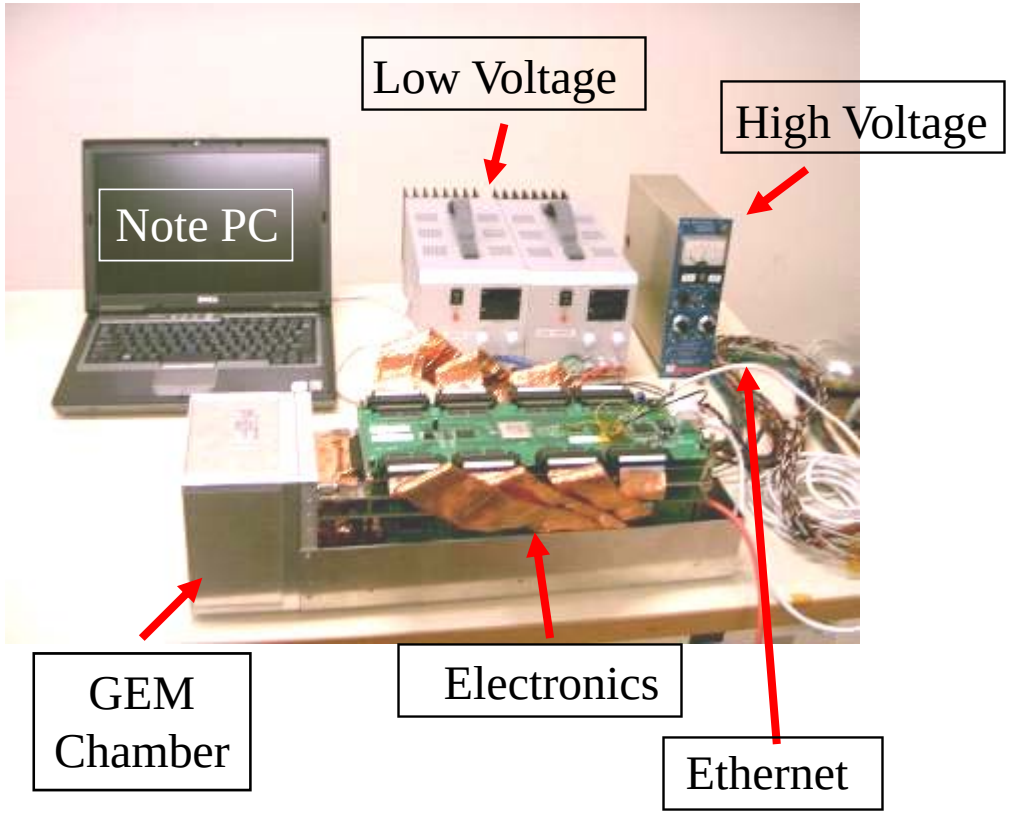
Gold coated GEM

Thickness of Gold Layer: 3μm
on both surfaces



Present Detector System

Detector size 150mm×150mm×510mm



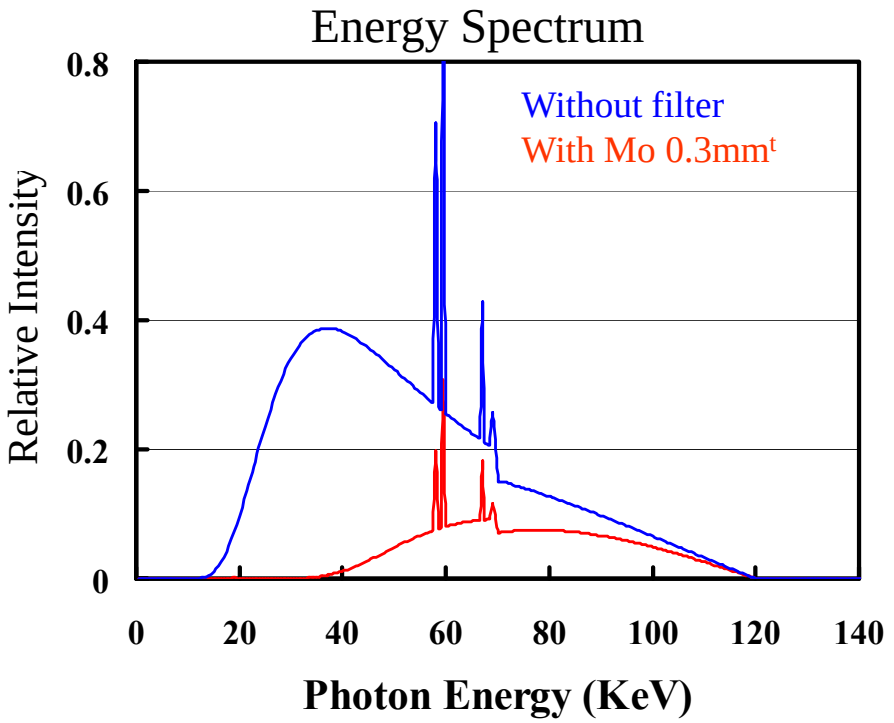
- I/F
  - One HV cable
  - Five LV cables
  - One Ethernet cable
- Electronics
  - Four ASIC boards
  - One FPGA board
- FE2007 ASIC
  - By Y. Fujita (KEK)
- Data transfer and Control through Ethernet
  - SiTCP (by T. Uchida)
  - Using Note-PC

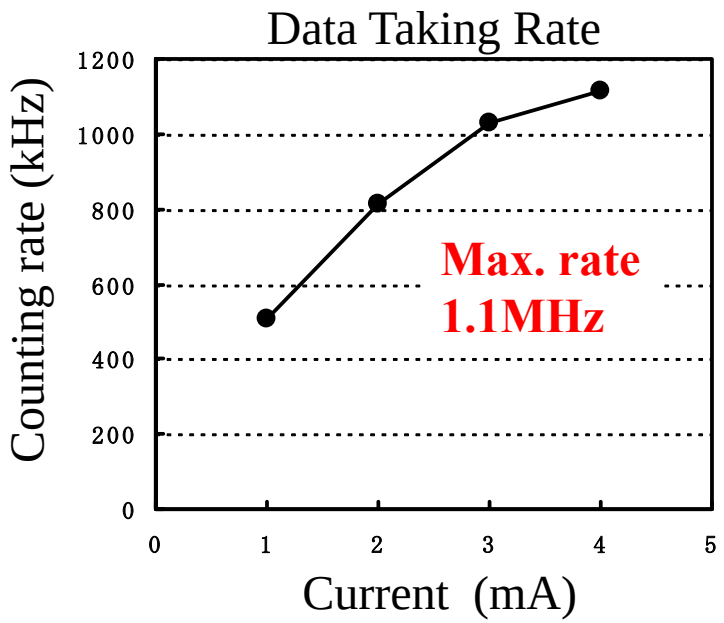
Compact and Portable System

T.Uchida et. al., "Prototype of a Compact Imaging System for GEM detectors," was published on IEEE TNS 55(2008)2698.

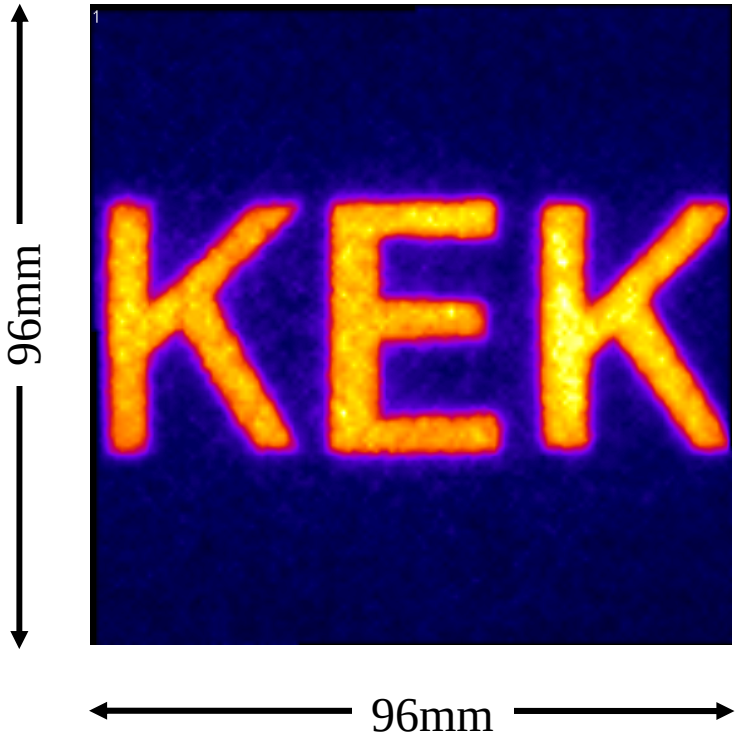
X-ray irradiation test

- Medical X-ray Generator
  - Voltage 120kV
  - Current 1mA





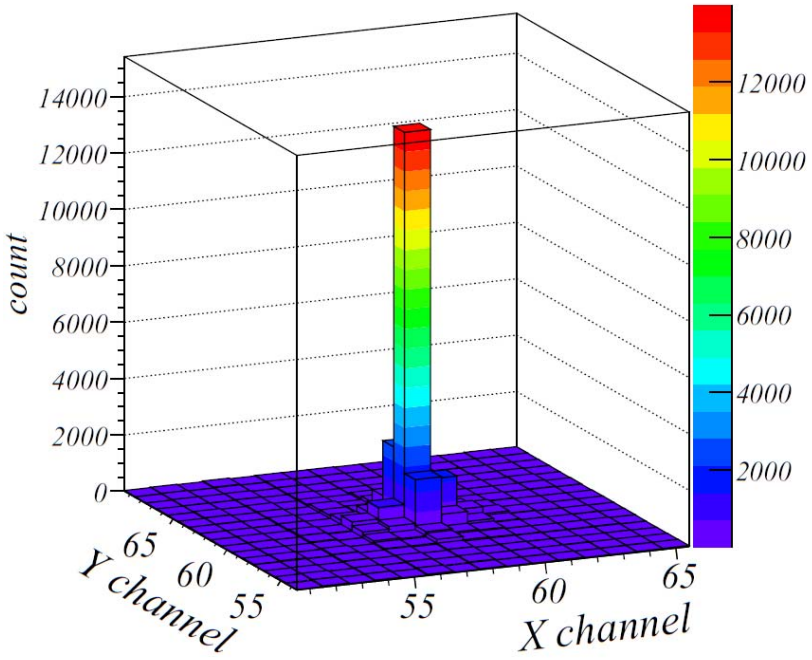
2D Image for Hard X-ray

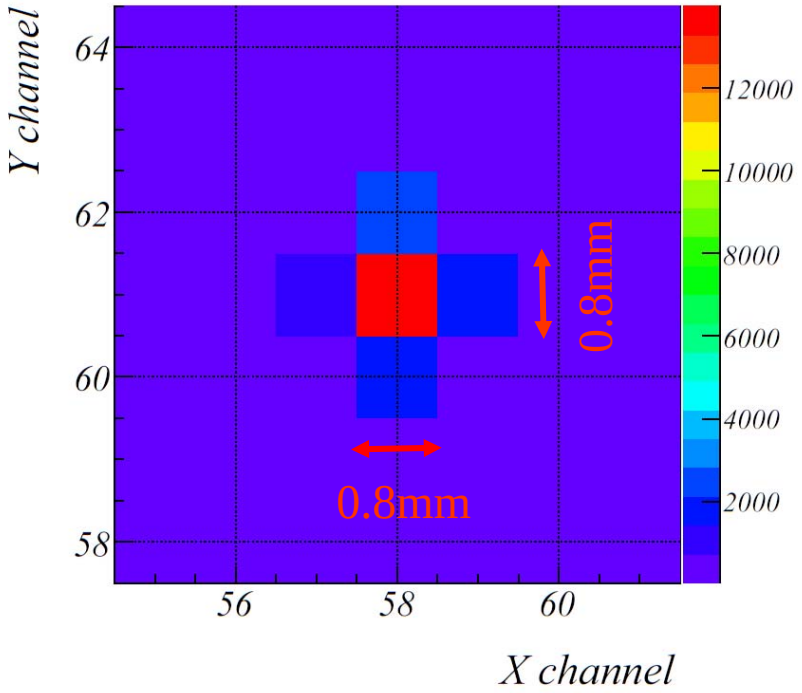


Clear 2D image could be seen.

Pinhole (0.5mm$^{\phi}$)

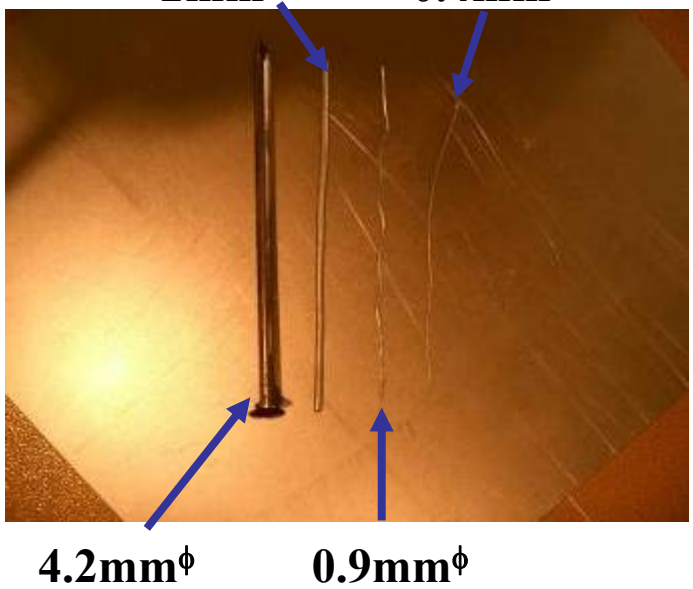
Irradiation time:100sec

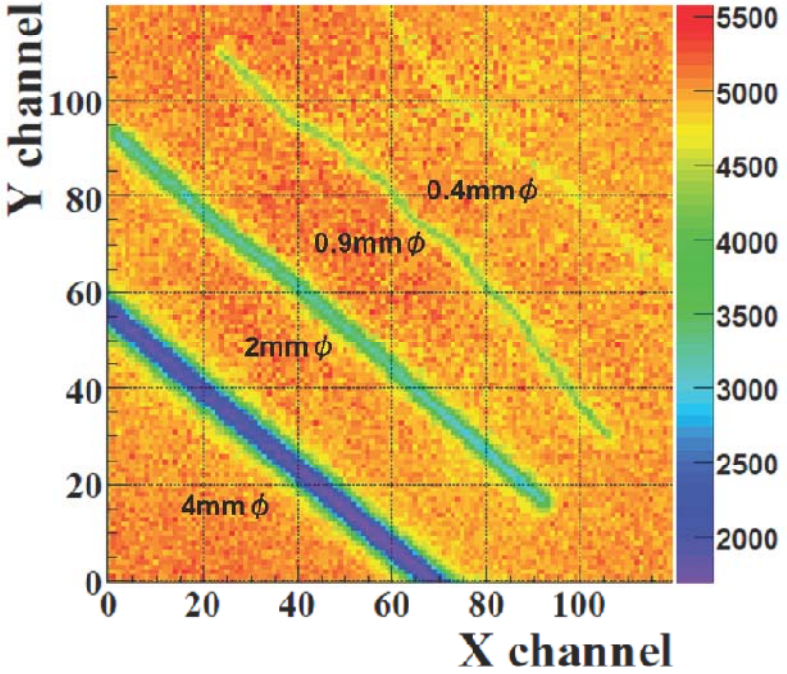




Iron Plate and Bars

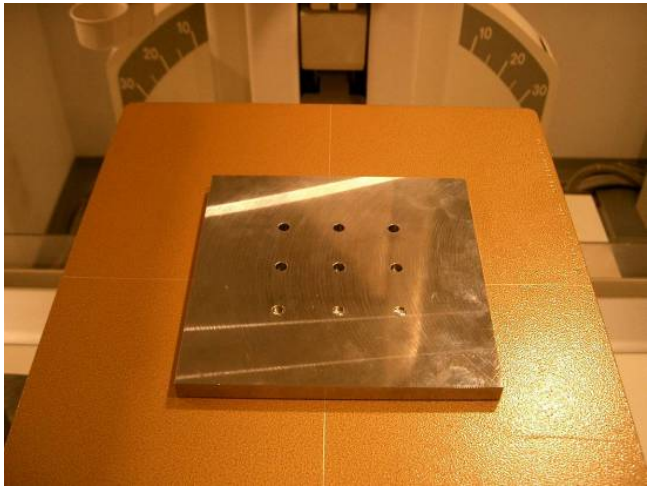
- On the Detector
  1. Grid (Laminate structure of Lead and Aluminum)
     To reduce scattering X-Rays
  2. Iron plate : 10mm thickness
  3. Four bars with different diameter

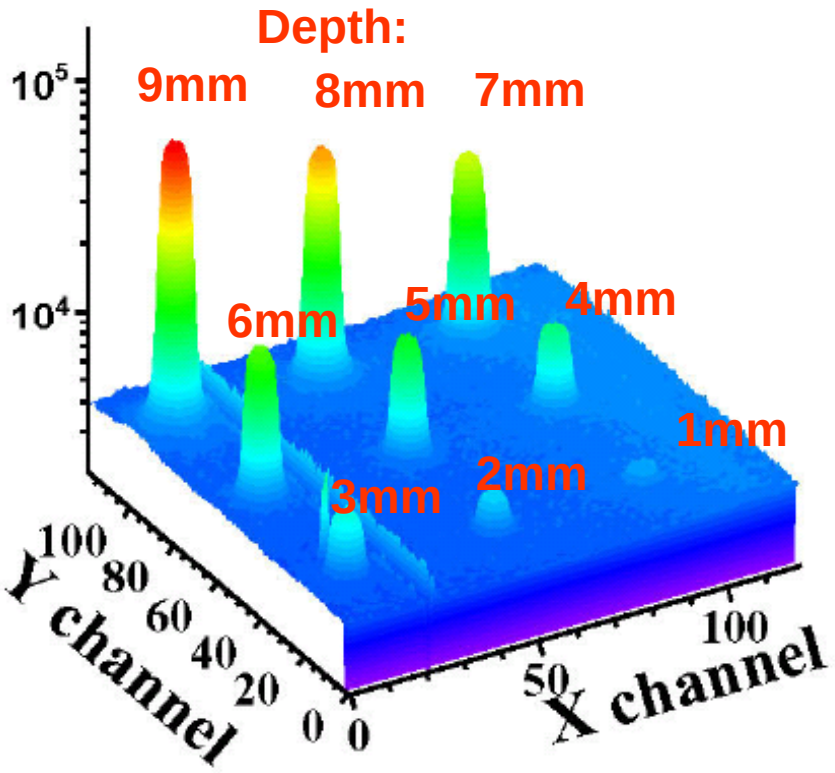




Iron Plate with holes

Iron plate with 10mm thickness
Hole diameter : 6mm

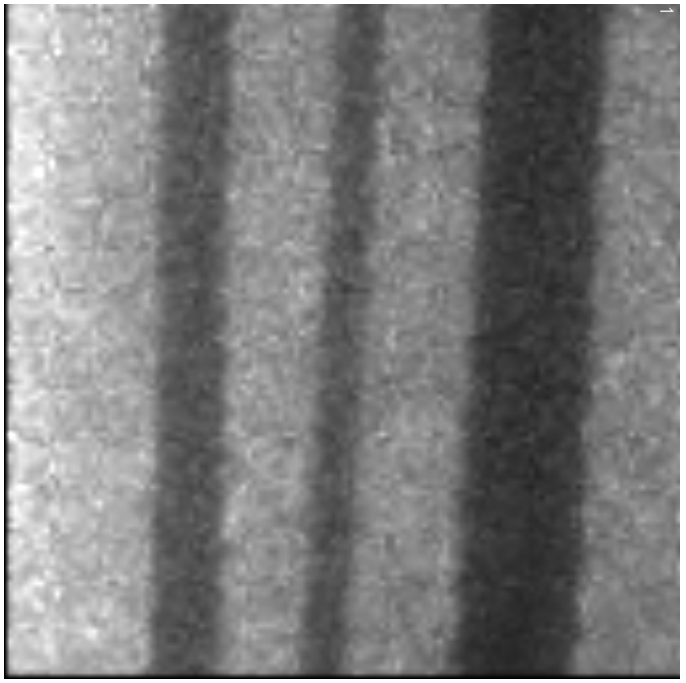




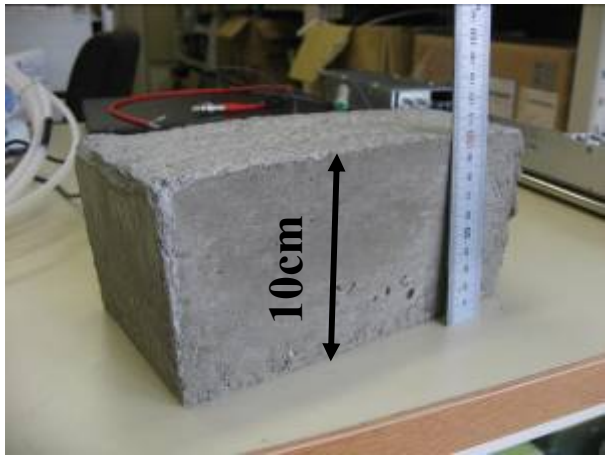
Iron Bars inside Concrete

Four types of Iron Bars
before molding

Thickness of Concrete :10cm
Irradiation Time : 100sec



9~10mm 6mm 15~17mm



Concrete sample with Iron Bars

Summary

- Japanese company (Scienergy Co., Ltd.) can produce various GEM foils.
- Flexible 100μm^t GEM is effective to get higher gas gain for single GEM structure.
- Gold coated GEM foils were manufactured.
  - Higher efficiency was obtained with more GEM foils.
- A prototype of hard X-ray detector with gold coated GEM was constructed.
- Performance study was done with X-ray generator.
  - Clear 2D image could be seen.
  - Hard X-ray could be observed through the thick iron plate with 10mm thickness.
  - Iron bars could be seen inside concrete block.