Progress of the Capillary Plate-based Gaseous Detector for high energy photon imaging

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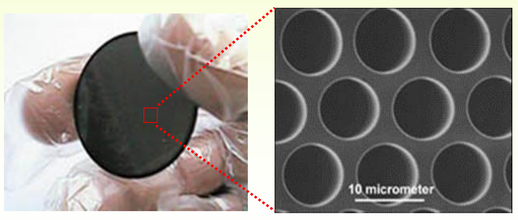
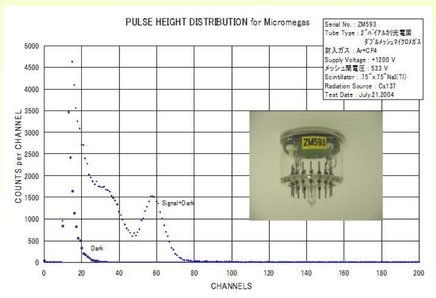
Abstract: A Hole-type MPGD with glass capillary plate (CP) is the most promising detector to provide two-dimensional imaging capability with a good position resolution and highly reliable to discharge. The CP gas detectors can be expected ideal two-dimensional imaging system combined with amplified charges and scintillation light emitted from each hole upon gas excitation. For the realization of the imaging capability, we describe the operation properties and some of the characteristics of the CP with diameter less than 50μm.A basic performance test of the CP gaseous detector was carried out with a gas mixture of Ne (90%) + CF4 (10%). We successfully obtained a gas gain of over 1000, and we have been studying the energy resolution and imaging capability using X-rays.

Introduction

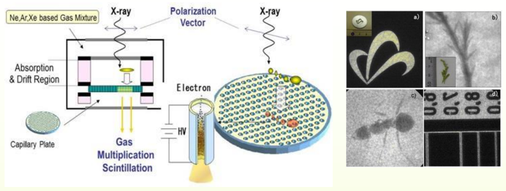
Capillary Plate -based gaseous detectors have been intensively studied for the purposes of X-ray radiography, cosmic X-ray polarimetry, cold neutron imaging and photodetector sensitive light ranging from vacuum ultraviolet to visible wavelength.

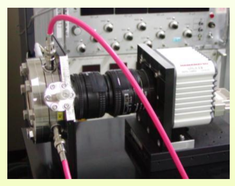


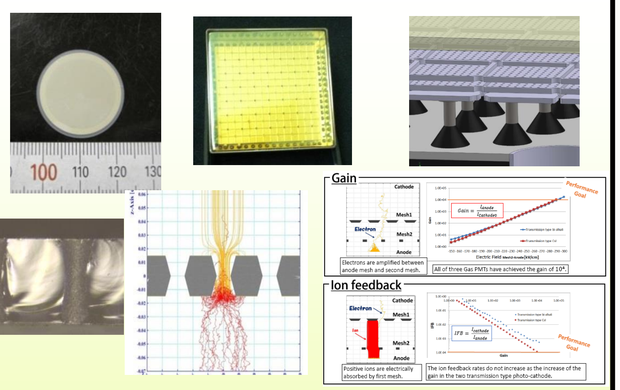
H. Sakurai et al. , NIMA,374(1996)341
F. Tokanai et al. , NIMA,567(2006)376



J. Va'vra and T. Sumiyoshi, NIMA, 535,(2004),334







F. Tokanai et al. , NIMA,610(2009)164
T.Sumiyoshi et.al., NIMA,639 (2011) 121
F.Tokanai et.al., NIMA,766 (2014) 176

Capillary Plate (CP)

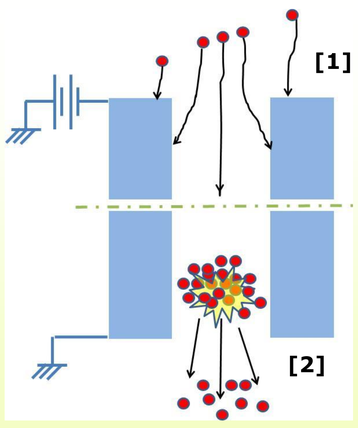
✓Glass plate with fine glass tubing regularly arranged in two-dimensional array.
✓Each capillary hole can be from a few microns to several hundred microns.
✓The electrodes on the surface of both ends of CP were coated with metals.

Merit

- Low outgassing ⇒ suitable for "Sealed" gaseous detectors.
- Less damaged by sparks ⇒ high gain operation.
- High opening ⇒good Spatial resolution (without complex signal processing.)

The use of CP having a small capillary hole is required to improve the gain and the spatial resolution at the same time.

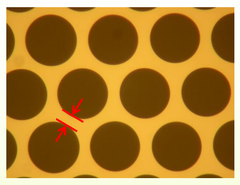
Small capillary hole cause the loss of …..
[1]collection efficiency of incident electron ← not contribute to avalanche
[2]output signals (electron & Scintillation photon) ← "collimator effect"

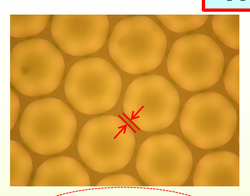


Standard: OAR≒60%

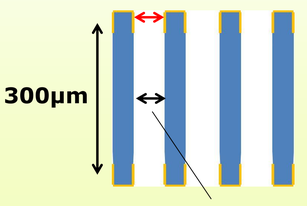
Wide opening OAR≒90%

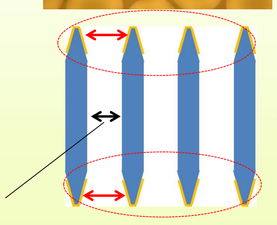
This work





Top view



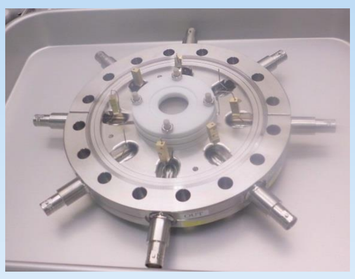


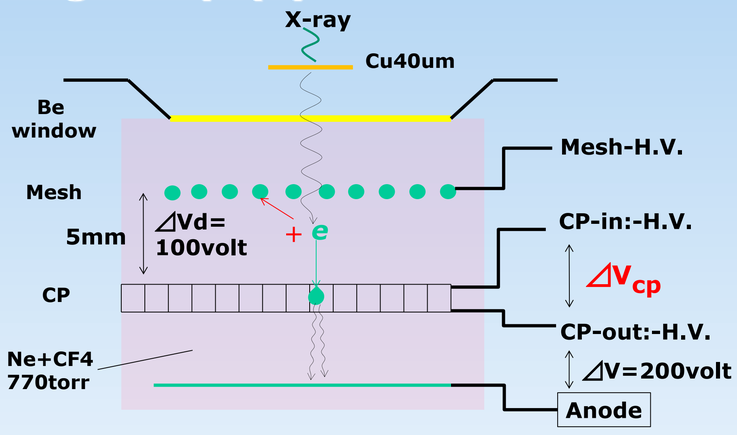
Schematic profile

Diameter:50μm

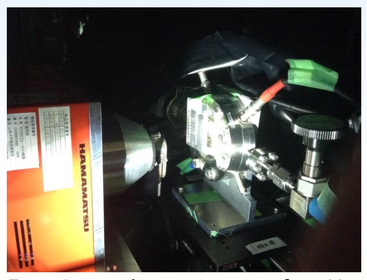
Performance test using X-rays(1)

Experimental setup

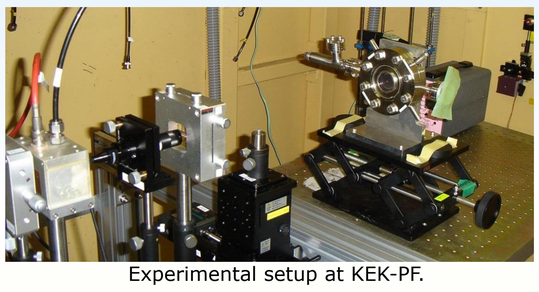




The characteristics of the Capillary Plate -based gaseous detector filled with a Ne (90%) + CF4(10%) gas mixture at 1atm is investigated using X-ray generator and the X-ray beams at the BL14A beamline in KEK-PF.



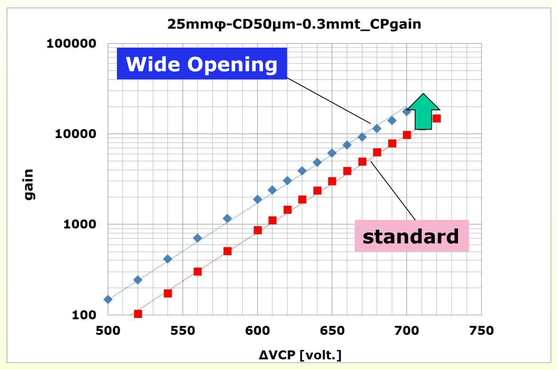
Experimental setup of X-ray generator system at Yamagata Univ.



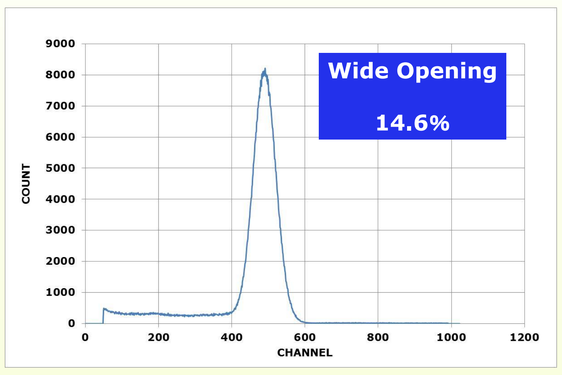
Experimental setup at KEK-PF.

The energies of the incident X-ray beams were fixed at 6 keV by a Si double-crystal monochromator. The incident X-rays were defined by a collimator of 0.1 mm diameter.

Gain and Pulse height



Gain as a function of voltage between the electrodes of CP for Ne (90%) + CF_4 (10%) gas mixture at 1 atm.



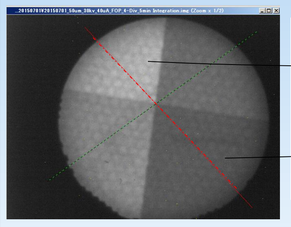
Pulse height distribution of charge signal of CP detector for 6keV X-ray.

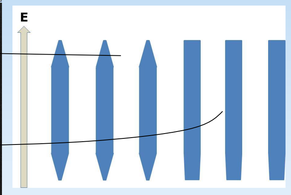
Wide Open type CP

- **Effective Gain of is twice higher than that of standard type CP.**
- **Energy resolution is 14.6% (FWHM) for 6 keV X-rays.**

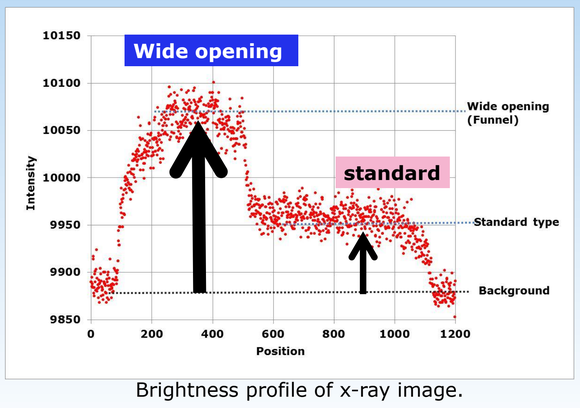
Performance test using X-rays(2)

Comparison of Light Yield





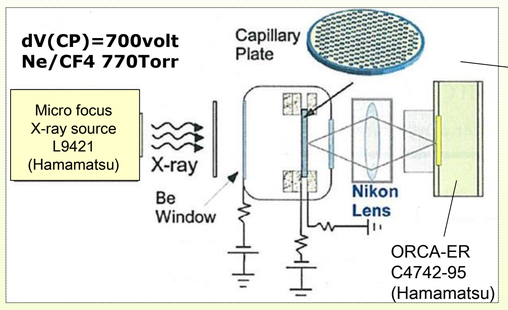
For the comparison of light yield , we prepared the CP with different opening in a single plate, and X-ray image was obtained at a same time.

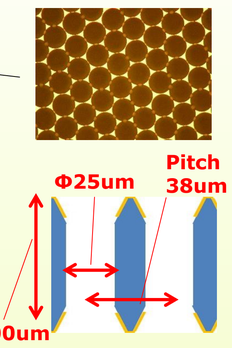


Brightness profile of x-ray image.

Brightness is 2-fold improvement compared with the standard type. This result is consistent with the results of the charge signal.

Imaging test of CP diameter 25um





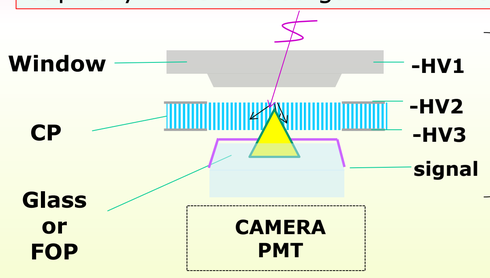
X-ray image obtained using wide opening type CP. Capillary hole diameter is 25μm.

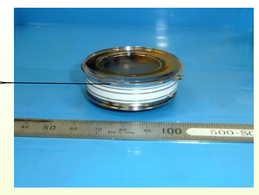
Summary and future works

For improving the characteristics of Capillary Plate -based gaseous detectors .

- Charge signal & scintillation light yield are twice higher.
- X-ray imaging with smaller capillary hole (25μm) is successfully obtained.

We are currently studying the better shape of the CP and developing a sealed Capillary Plate -based gaseous detectors , "GSI".





Concept of a sealed detector, "GSI" (Gas scintillation Imager)

Application

- ✓ **Soft X-ray imaging**
- ✓ **Particle (neutron ,β)**
- ✓ **UV imaging**

etc.

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