Micro Pixel Chamber Operation with Gas Electron Multiplier

Kyoto University dept. of physics

Cosmic-ray group

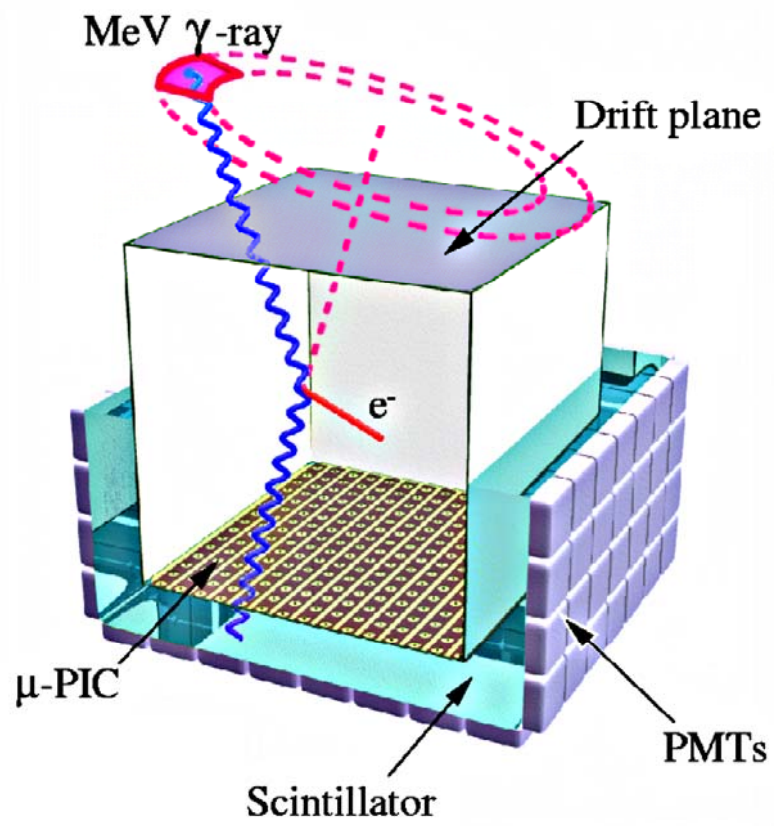
K. Hattori

Contents

1. μ-PIC (Micro Pixel Chamber),
   micro-TPC (Time Projection Chamber based on μ-PIC)
2. For detection of MIPs
   μ-PIC + GEM (gas electron multiplier)
3. Performance of GEM + μ-PIC TPC
4. Summary

Advanced Compton Camera

based on **Micro Pixel Chamber(μ-PIC)**



sub MeV ~ MeV gamma-ray
Compton scattering is dominant

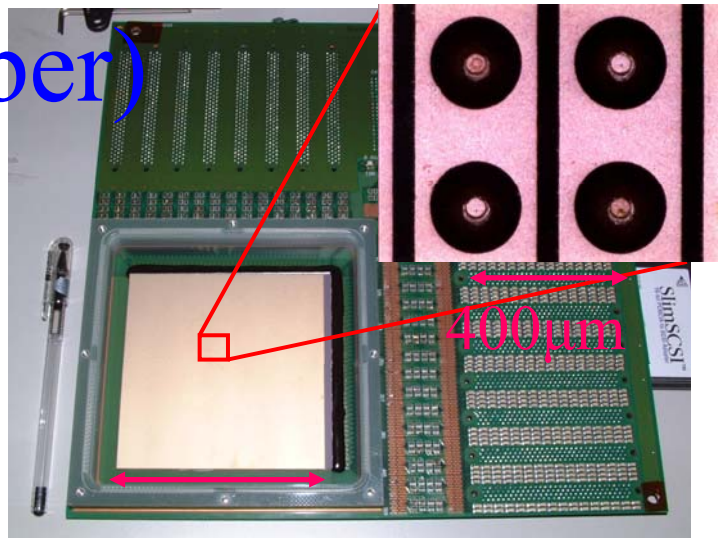
micro-TPC
energy and track of a recoil electron

scintillator(surrounding micro-TPC)
energy and position of
a scattered gamma-ray

1photon : reconstruct completely
energy & direction

low background images
Improvement of micro-TPC

μ –PIC(Micro Pixel Chamber) & micro - TPC

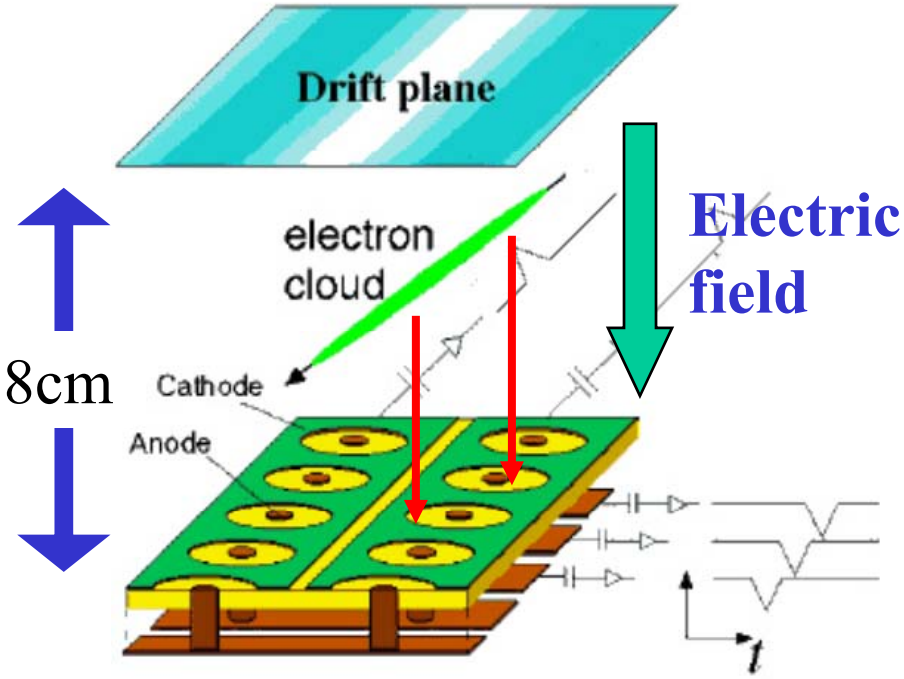


2-dimensional imaging gaseous detector
(pitch 400μm, size 10cm × 10cm)
larger one: Takada's poster

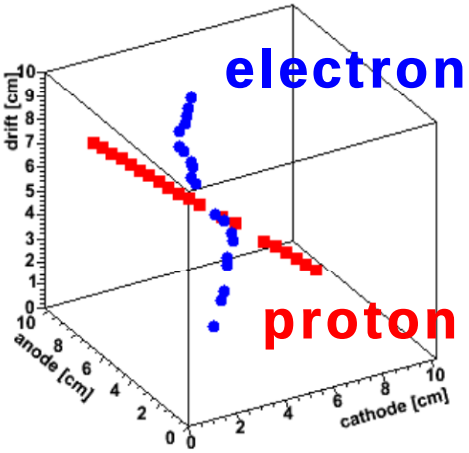
Max gas gain ~ 15000

Stable operation
@gas gain ~ 6000

position resolution
~ 120μm



micro -TPC
Time Projection Chamber based on μ-PIC



Position Sensitive Detec

For MIP(Minimum Ionizing Particle) detection…

Compton camera · · · · · detection of **recoil electron**
by micro-TPC

Recoil electron dE/dx ～ 2 ~ 3 × MIP

μ-PIC ⇨ **stable operation**
@ gas gain 6,000

⇩

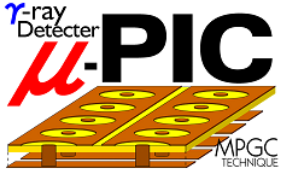
Stable gas gain > 2×10^4

(We haven't achieved because of discharge)

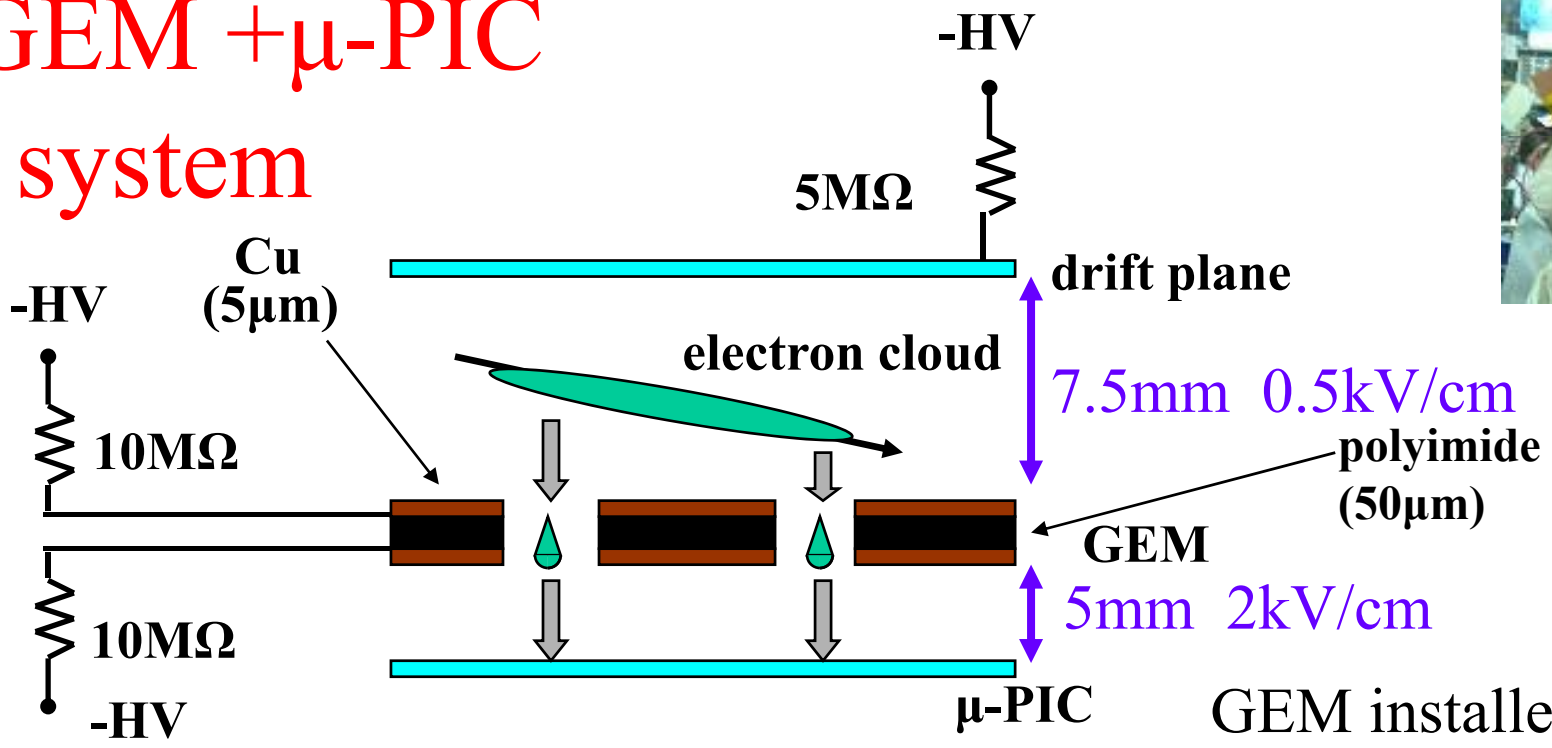
⇨ **sub amplification device**

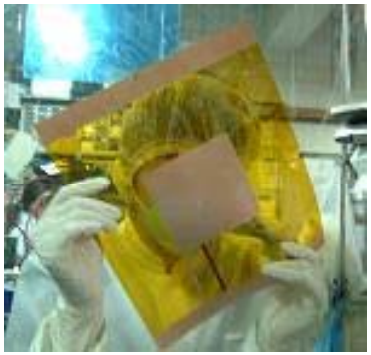
GEM(Gas Electron Multiplier) F.Sauli(1997)

Operated @ low gas gain(< 50)

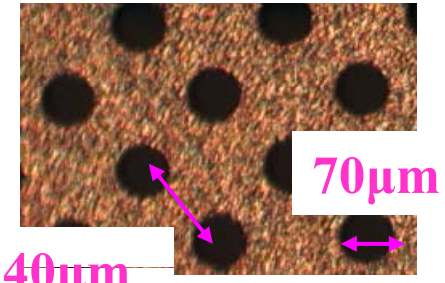


GEM +μ-PIC system



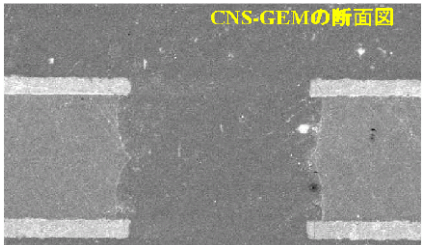


GEM installed just above μ-PIC



Standard GEM design

Mask developed by Hamagaki Lab. @ CNS Univ. of Tokyo



CNS University of Tokyo

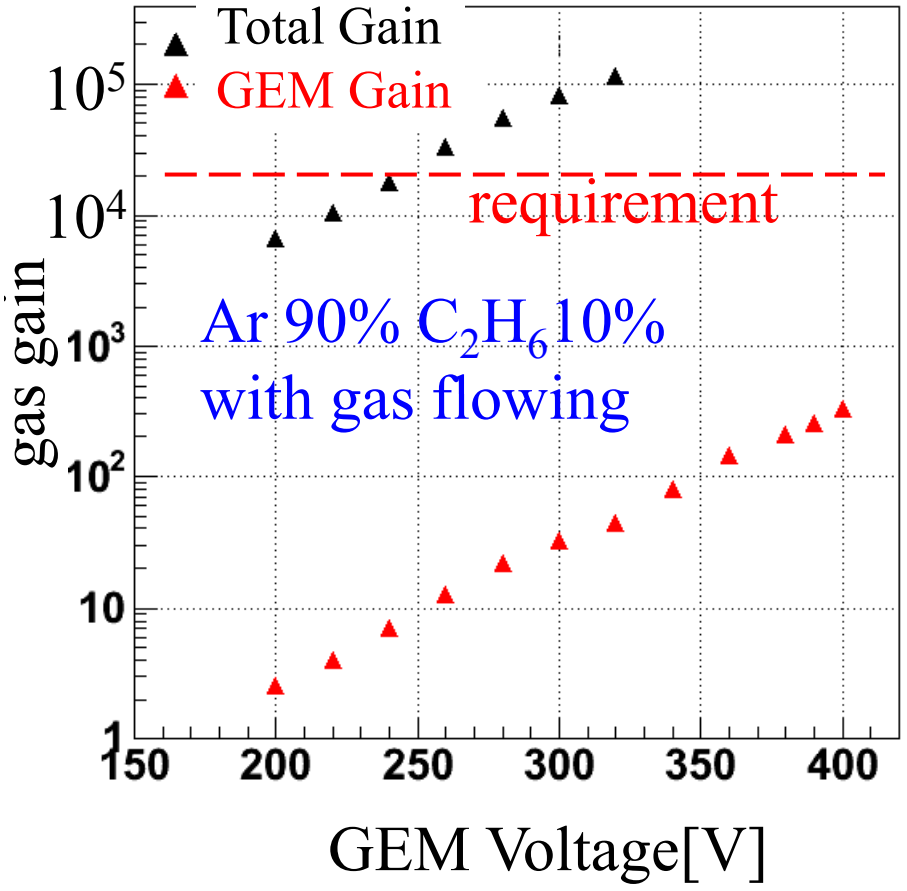
Plasma etching method

@Fuchigami Micro Co., Ltd.

Holes with cylindrical shape

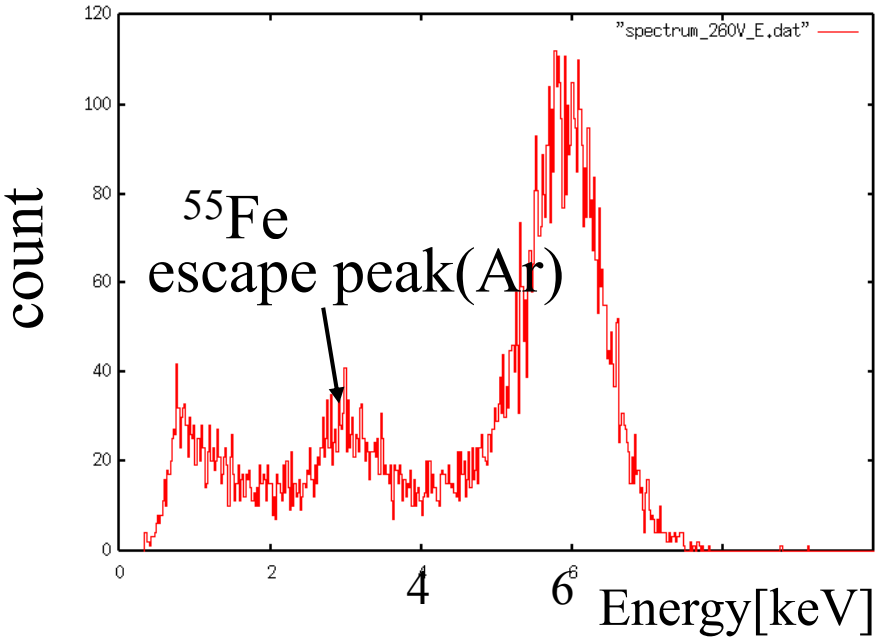
γ-ray Detecter μ-PIC MPGC TECHNIQUE

gas gain



μ-PIC gain fixed 2.6×10^3

spectrum



20%(FWHM) @ 5.9keV
gain 1.3×10^4 ($1.6cm^2$)

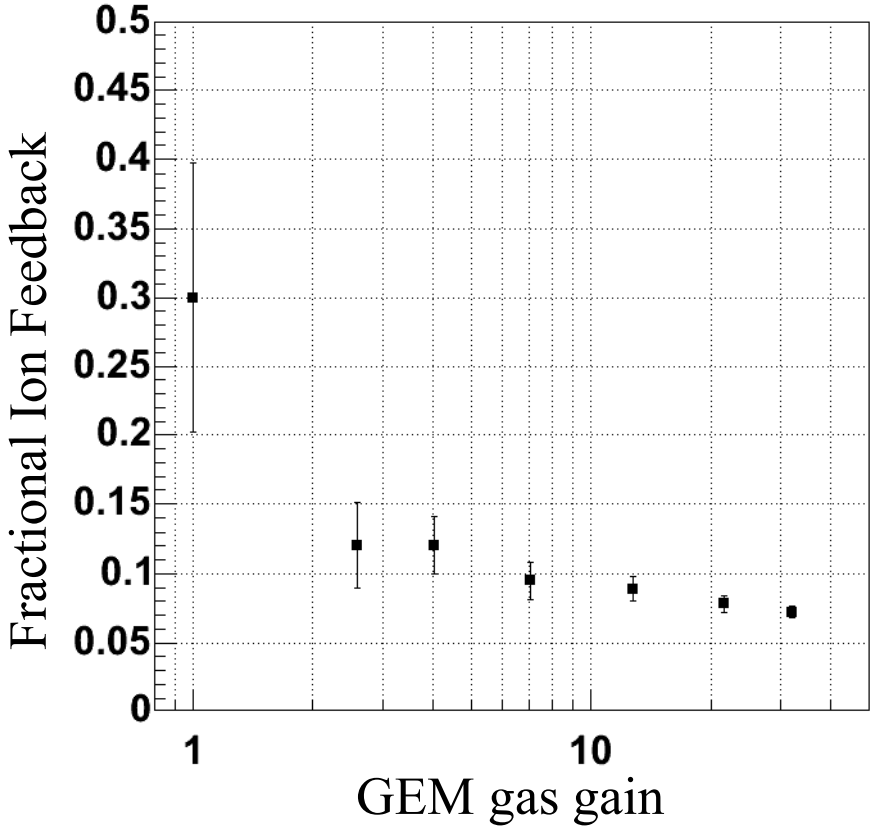
Total Max Gain ～10^5

GEM Max Gain ～300

enough to detect tracks of MIPs ！

ensitive Detectors

Positive ion feedback



Fractional ion current I_D/I_A

I_D : the ion current on the drift plane

I_A : the electron current on anodes of μ-PIC

the dependence of the fractional ion current on the gain of the GEM

Ion feedback **less than 10%** **@ gas gain > 10**

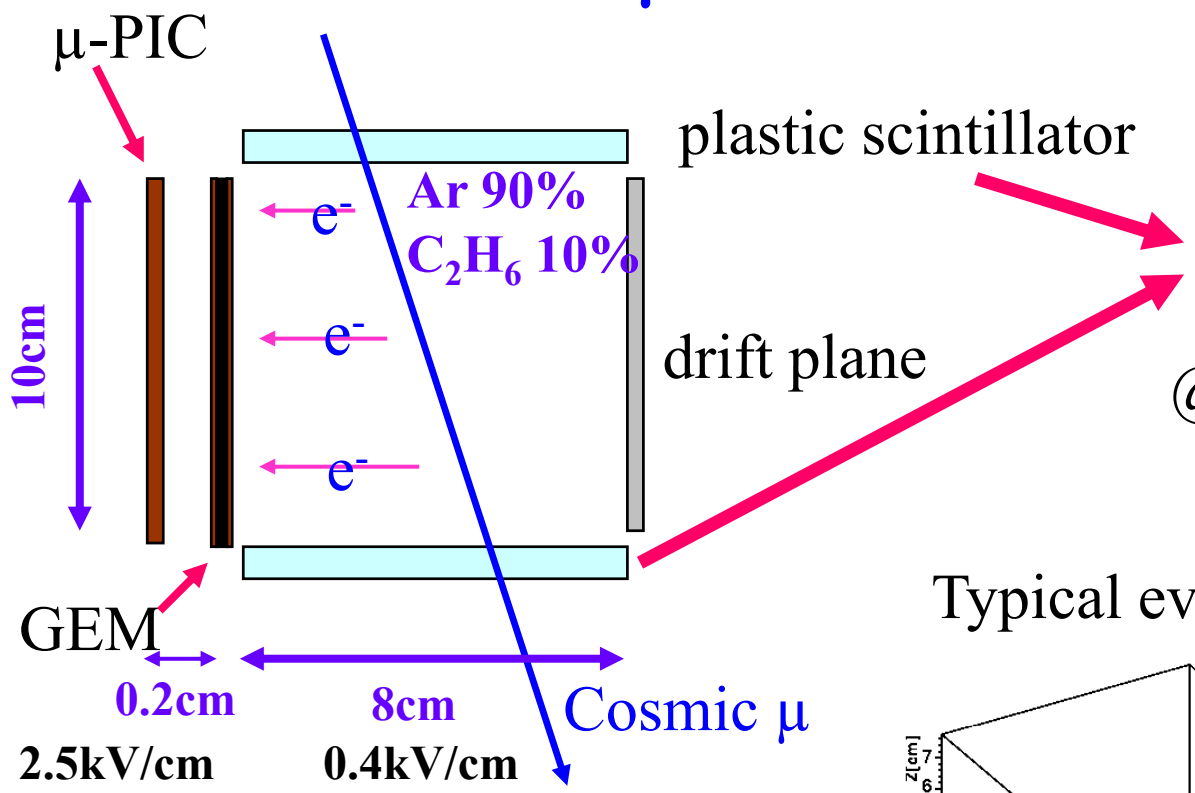
without GEM 30%

μ-PIC 30% × GEM 30% → total 10%

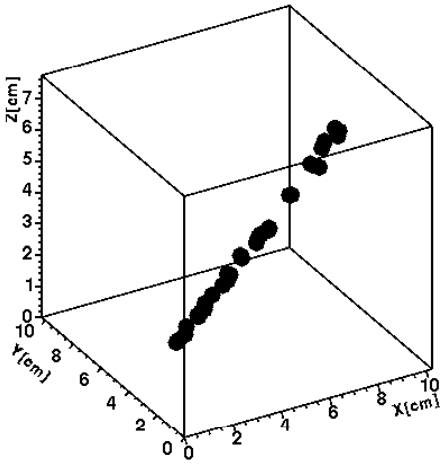
→ GEM suppresses the positive ion feedback in a drift region

Potential of μ-PIC + GEM system for high-rate condition operation

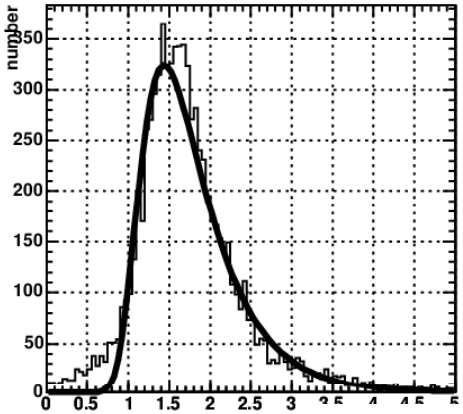
A GEM + μ-PIC TPC -muon track-



Typical event



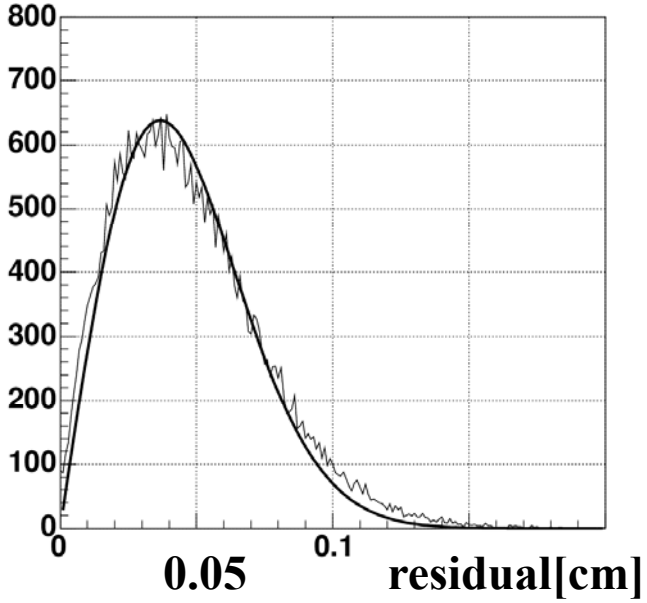
Landau Distribution



track efficiency
(hit point > 3) / (trigger) **97%**

Position resolution

Difference between hit points
and tracks obtained from fitting



2-dimensional Gauss distribution
(the position resolution in the direction
of a track is unknown)

$$\frac{\sqrt{2\pi}}{\sigma} r \exp(-\frac{r^2}{2\sigma^2}) \mathrm{d}r$$

→ σ ~ 370μm

transverse diffusion 460μm
Z-pitch (DAQ clock) ~ 400μm
→ reasonable

Summary & Future Works

μ-PIC + GEM

⇒ **stable gas gain of 2×10^4, ion feedback < 10%**

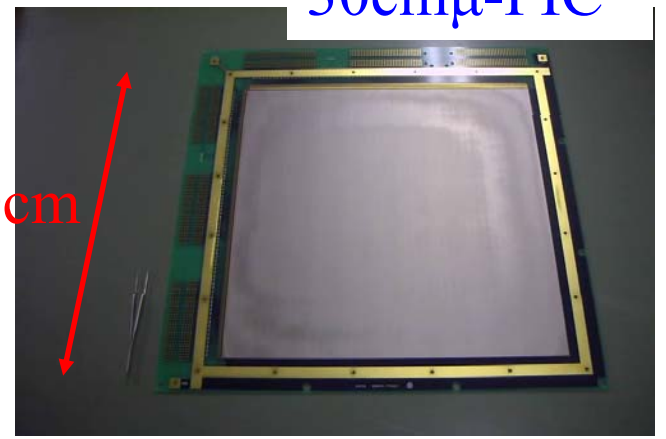
μ-PIC + GEM TPC

⇒ **Fine tracks of MIPs were obtained.**

track efficiency 97%

⇒ **position resolution 370μm**

30cmμ-PIC

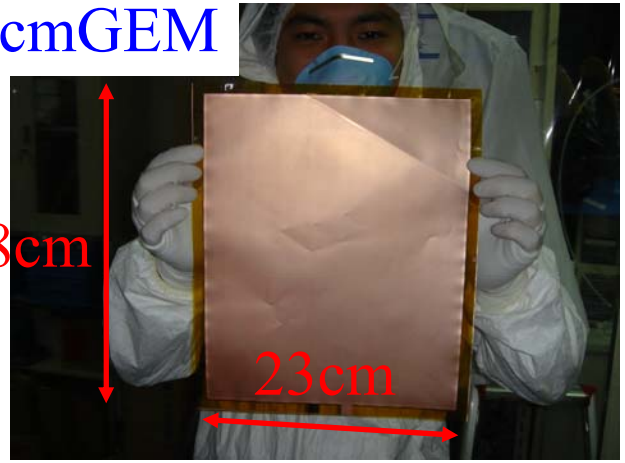


Future Works

μ-PIC & GEM with a larger detection area

about 30cm × 30cm(takada's poster)

30cmGEM



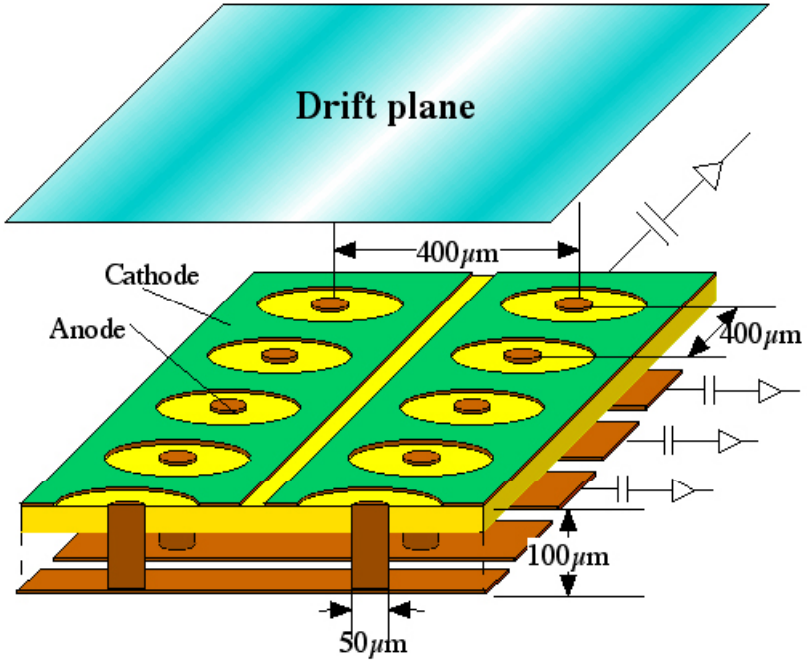
φ70μm
pitch 140μm
standard
design

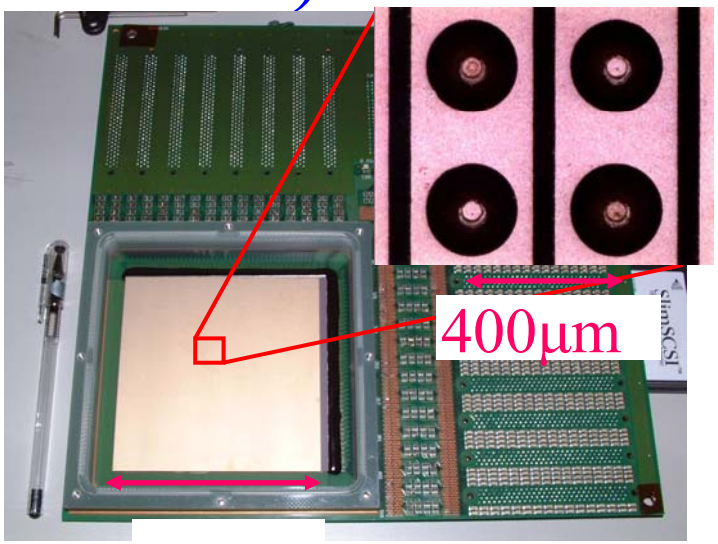
Performance of μ –PIC (Micro Pixel Chamber)

2-dimensional imaging gaseous detector

anode 256 × cathode 256
~ 65000pixels

Max gas gain ~ 15000



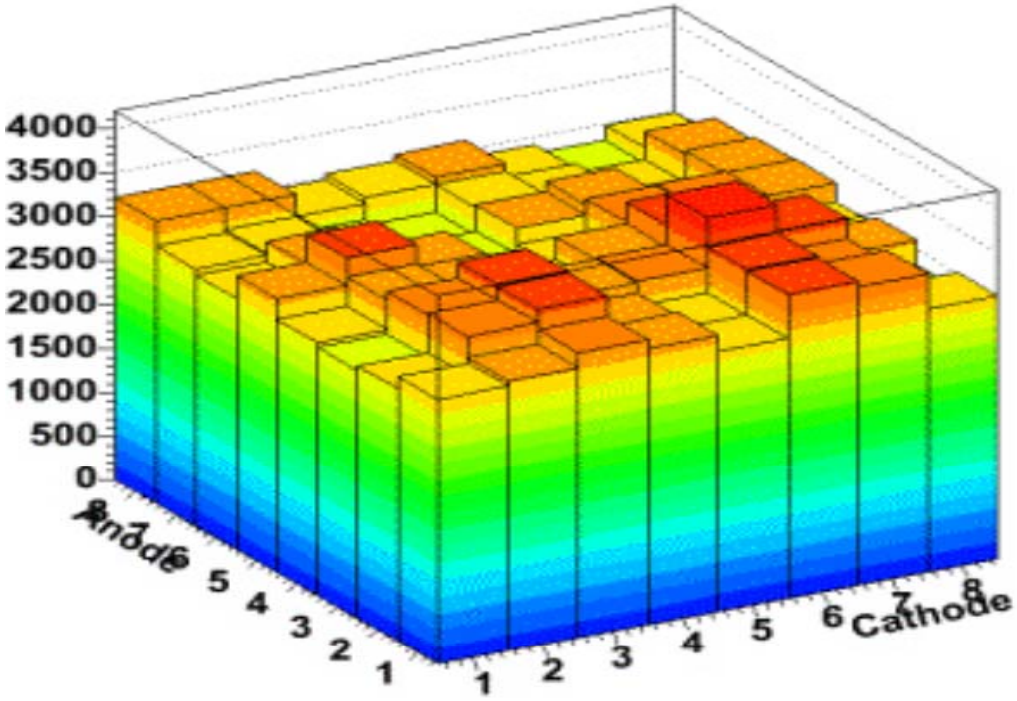


10cm

Stable operation for 1000h
(gas gain ~ 6000)
Energy Resolution
30%(FWHM)@5.9keV(100cm^2)
position resolution
~ 120μm

Performance of μ –PIC
- uniformity -

σ ~ 7%



γ-ray Detecter μ-PIC MPGC TECHNIQUE

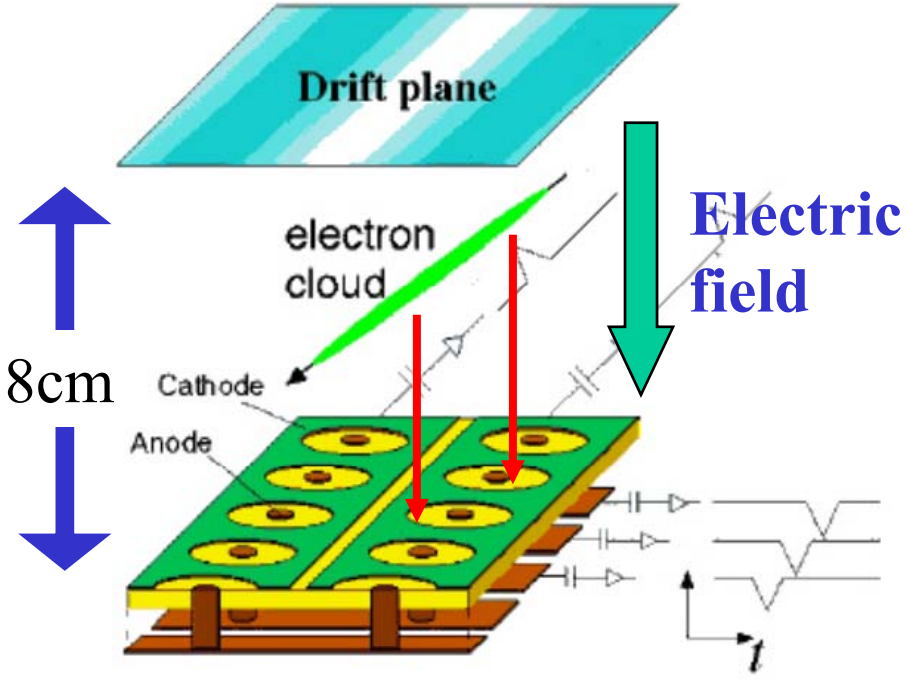
μ-TPC

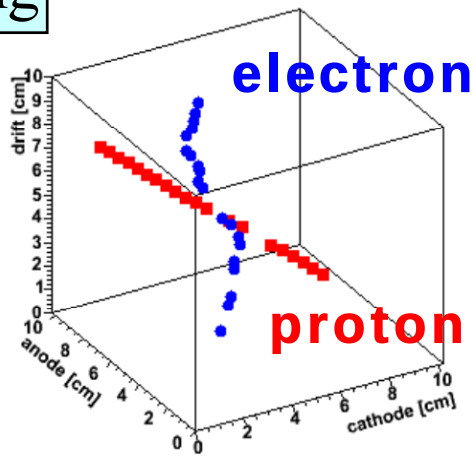
(Time Projection Chamber based on μ-PIC)

Electron cloud → Electric field → 10cm × 10cm μ-PIC
2-D hit position
(Analog & digital)

time → drift distance

100MHz encoder → 3-D tracking





Applications

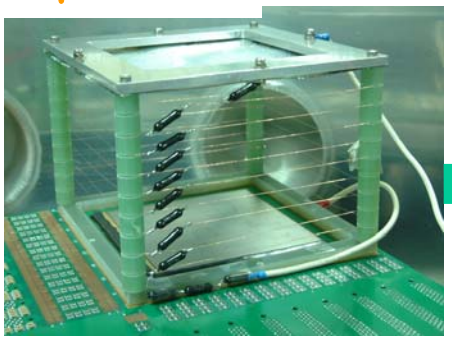
Compton camera

(recoil electron)

Dark Matter search

• DAQ system

μ-TPC



512ch

ASD

512ch digital

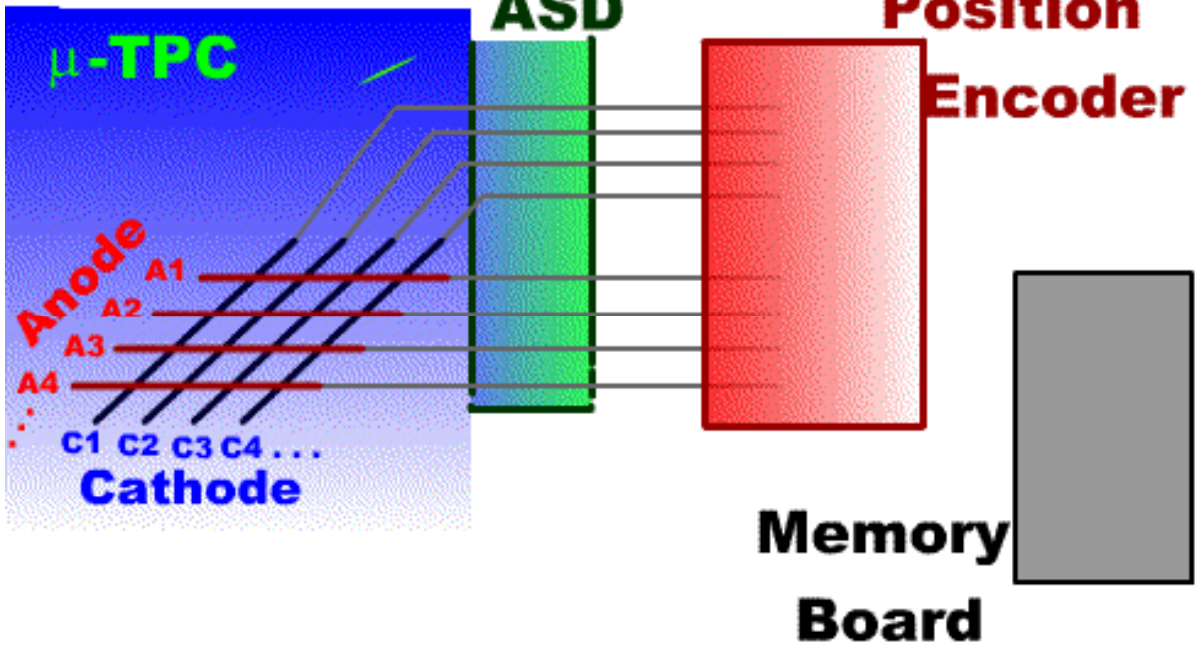
Encoder

32bit

VME Memory Board

summed analog (8ch)

VME FADC 100MHz 8ch



ve Detectors

γ-ray Detecter μ-PIC MPGC TECHNIQUE

GEM

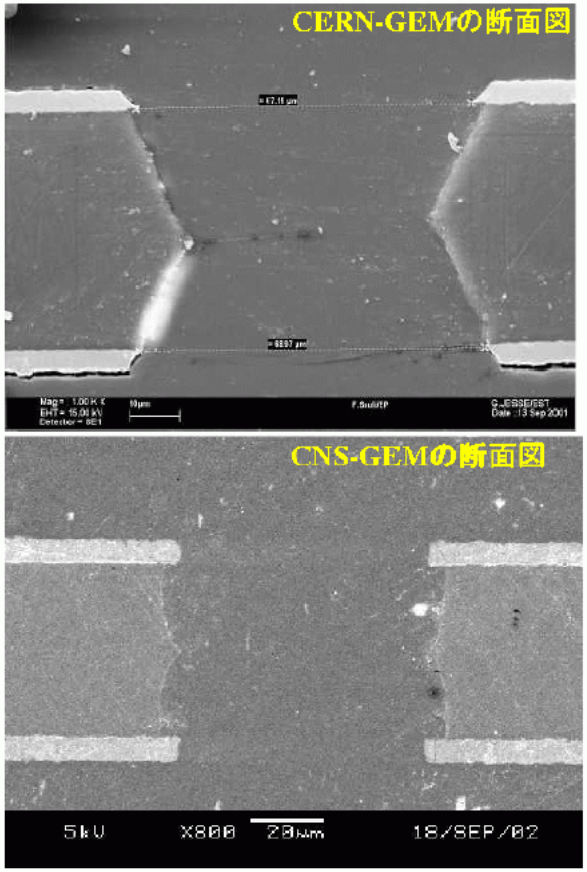
Mask by Hamagaki Lab.
@ CNS Univ. of Tokyo

Plasma etching method
@Fuchigami Micro Co., Ltd.

Holes with cylindrical shape

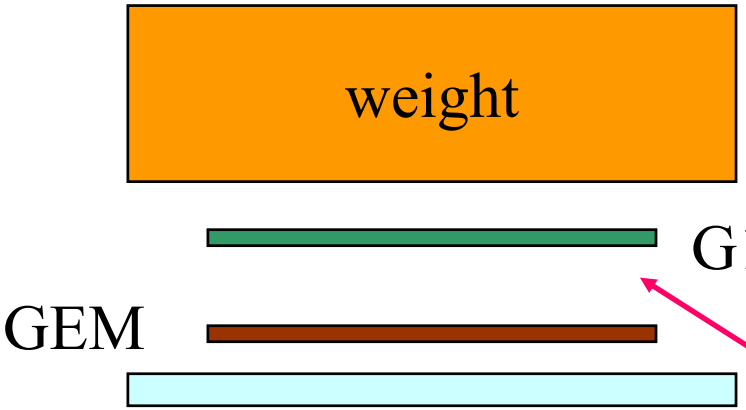
CERN :
holes with a double-conical shape

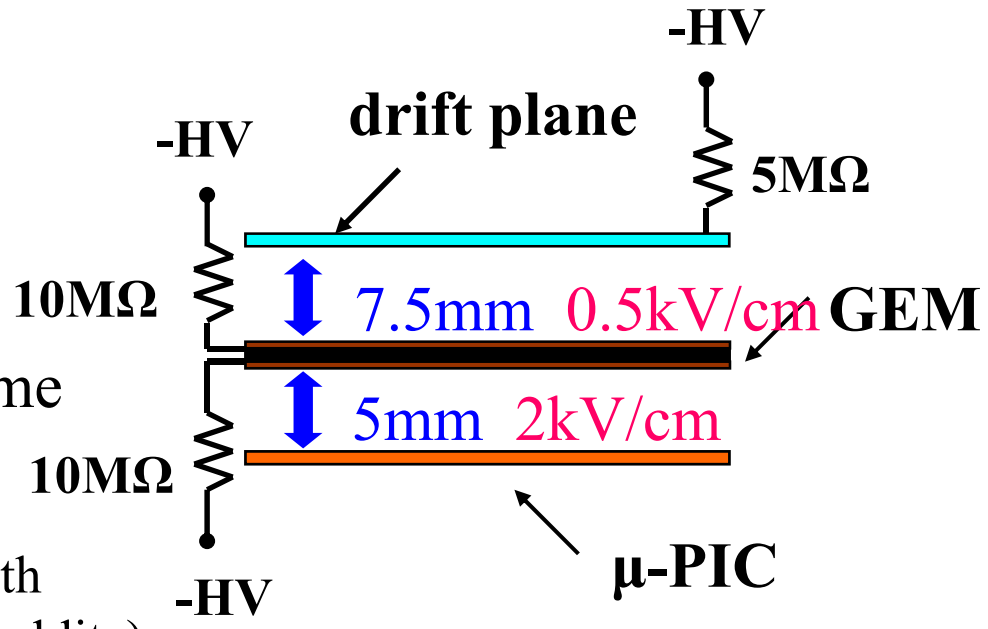
CNS-GEM

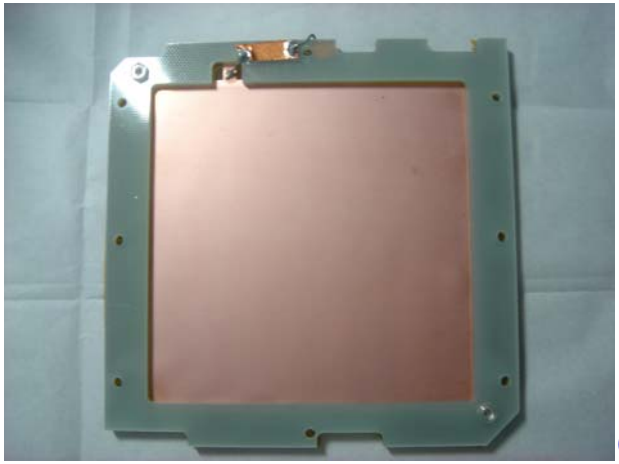


Setup

How to glue a GEM







aging

In dry nitrogen gas

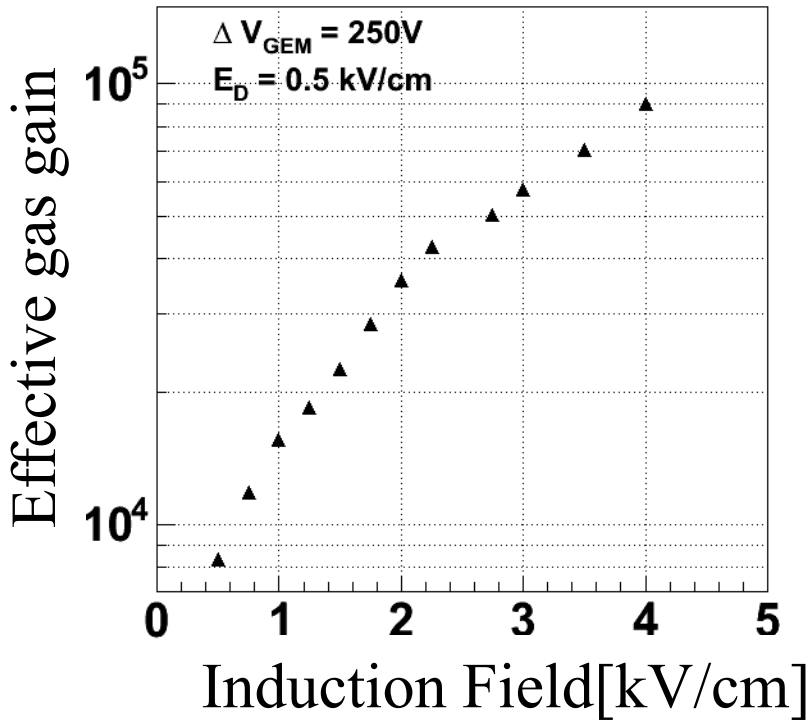
$\Delta V_{GEM} \sim 500V$

Dependence of total gain on induction field

ΔV_{GEM} = 250V(gain 10)
E_D = 0.5kV/cm

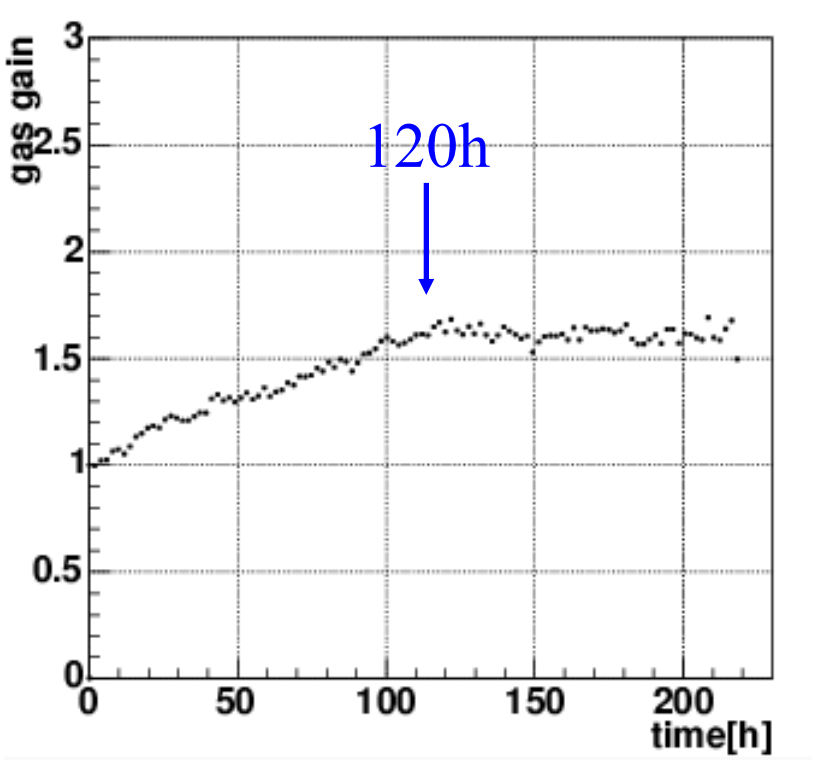
plateau wasn't observed

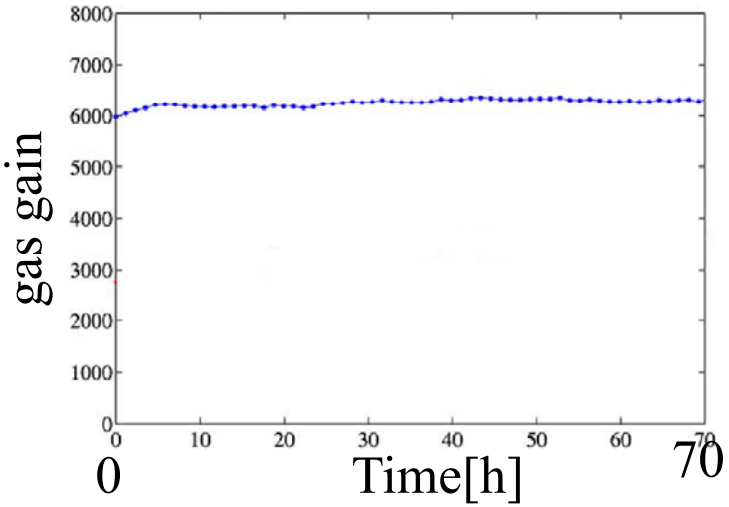
the system unstable
@ gas gain of ~ 10^5



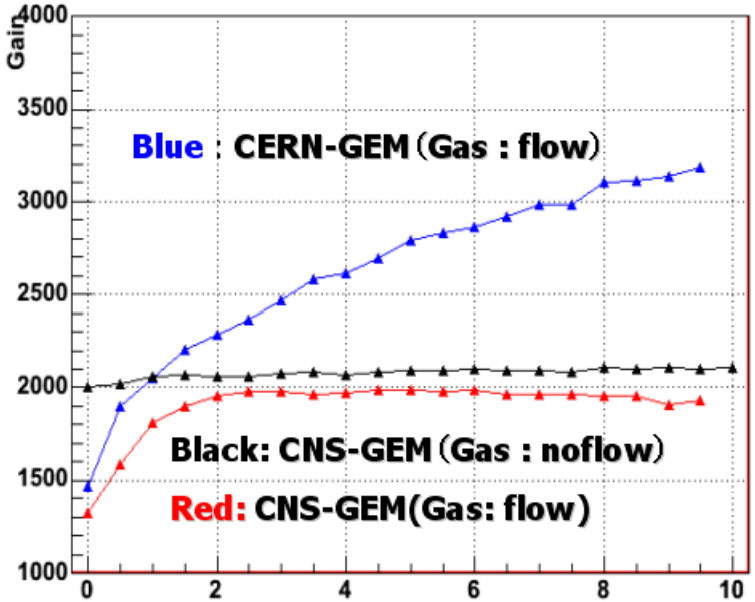
Long-term gas gain stability

μ-PIC **6%** for **70h**

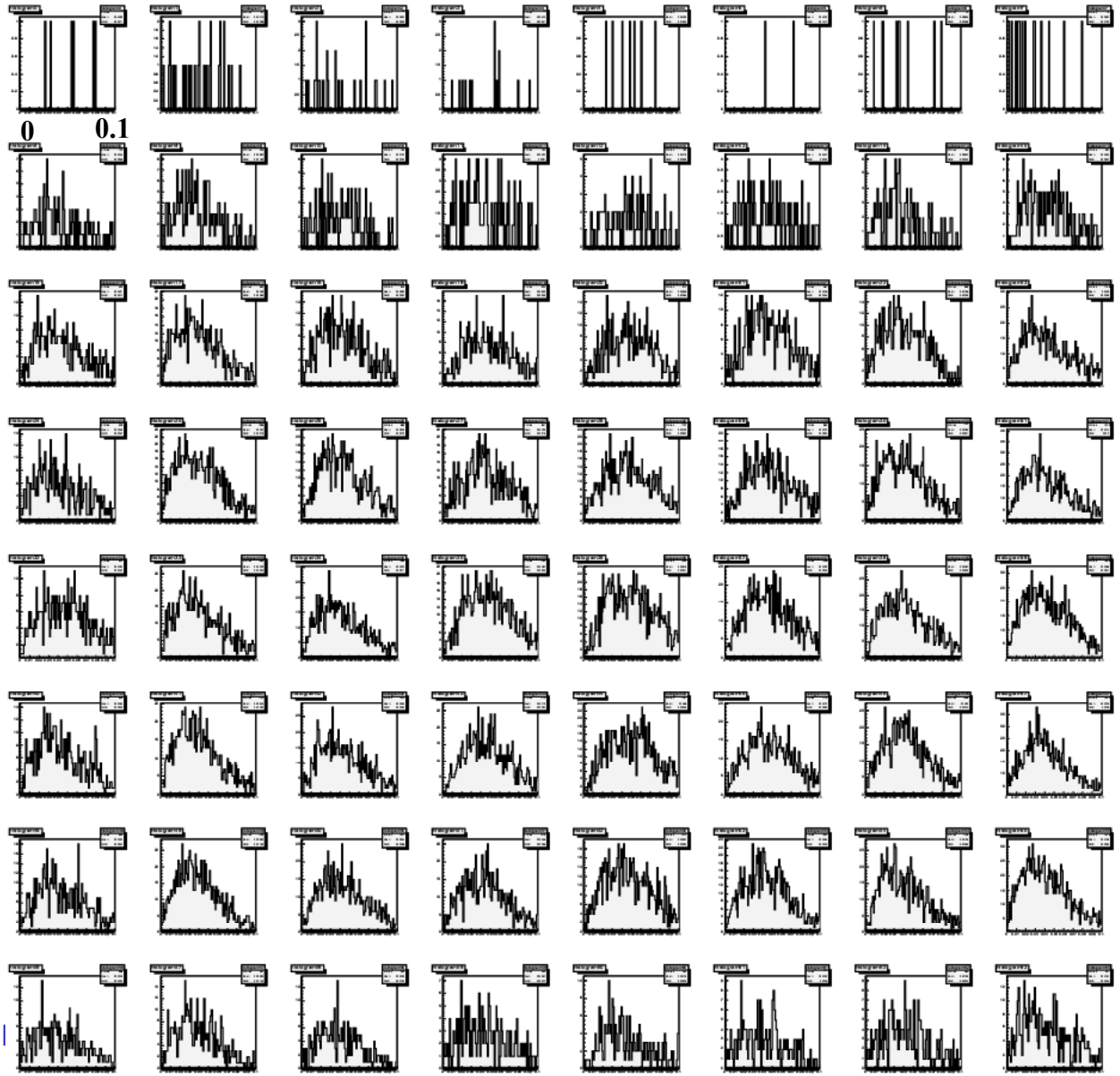




The gain increased **50%** for **120h**

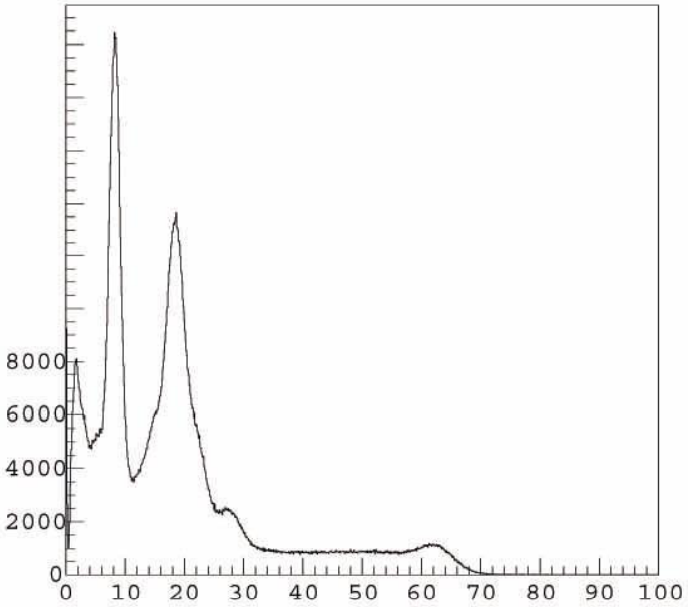


Performance of micro-TPC
- uniformity -



Performance of Hybrid micro-TPC
- gamma – ray -

micro -TPC energy
13%`20keV(FWHM)



μTPC mumber of sampling
Points for one electron track

X-ray from Cu
electrode in μPIC