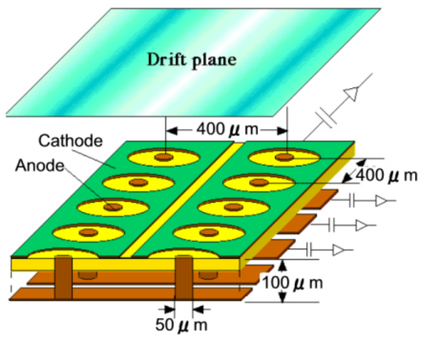
A very large area Micro Pixel Chamber

A. Takada, K. Hattori, S. Kabuki, H. Kubo, K. Miuchi, T. Nagayoshi[1], H. Nishimura
Y. Okada, R. Orito[2], H. Sekiya, A. Takeda[3], T. Tanimori and K. Ueno
Kyoto University, [1]Waseda University, [2]Kobe University, [3]ICRR University of Tokyo

1. μ-PIC (Micro Pixel Chamber)

➢ Previous μ-PIC [1]

- A gaseous 2D imaging detector with strip read out
- Cu electrodes and polyimide substrate
- 65,536 pixels with a pitch of 400μm
- based on the Print Circuit Board technology
- max gas gain ~15,000
- fine position resolution (RMS ~120μm)
- large detection area ~105 cm^2
- good gas gain uniformity (RMS ~5%) at the whole area
- stable operation for ~1000 hours with gas gain ~6,000



➢ The applications of μ-PIC…

- MeV gamma-ray Compton Camera [2]
  H. Nishimura's talk (S5) and K. Hattori's talk (S7)
- Dark Matter search (NEWAGE) [3]
  H. Sekiya's talk (S11)
- X-ray crystallography [4]

} Not large enough for these applications!

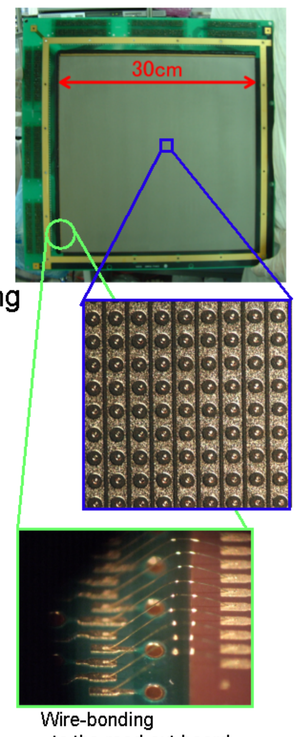
Development of a new μ-PIC having a more large detection area!!

2. A very large area μ-PIC

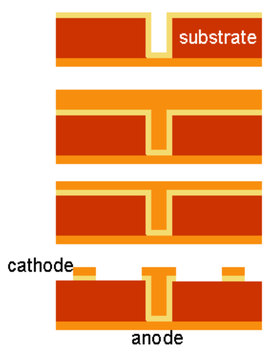
➢ The design parameters

- The structure of the pixel is same as that of previous μ-PIC
- 768×768 (=589,824) pixels
- The pitch of pixels 400μm
- detection area ~944 cm^2
- Anode/Cathode strips connect to read-out board with wire-bonding

⇒ the 9 times detection area
the 3 times read out



➢ Manufacturing process



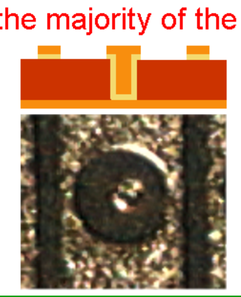
1. Electroless plating :
   creating the seeds for the Via-fill plating
2. Via-fill plating :
   filling up the holes and coating the substrate
3. Surface etching :
   making the surface flat
4. Electrode etching :
   creating the structure of pixel

⇒ The yield of the first production : ~50%

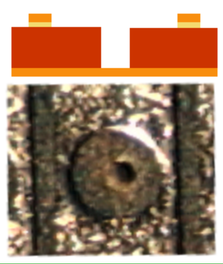
➢ The results of the first production

✓ The types of the pixels' structure

I. Good pixels
- ideal structure
- functional pixels
- the majority of the pixels



II. Dead pixels
- miss of the plating
- no signal
- ~1% in the whole area

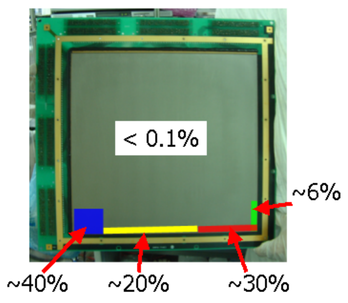


III. Bad pixels
- miss-etching
- causing the discharge
- ~0.02% in the whole area

✓ The distribution of the dead pixels and the bad pixels

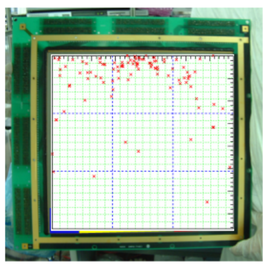
◆ Dead pixels

The right figure shows the distribution of the dead pixels. In the much of the detection area, the existence ratio of the dead pixels is less than 0.1 %. But the ratio is much higher at the edge area, and that of the worst area is ~40 %.In the whole area, the average of the existence ratio is about 1%, and it is not a large problem for the detection and the imaging of the X-rays.



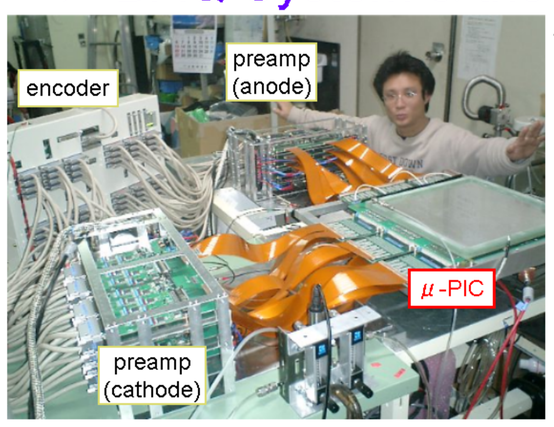
◆ Bad pixels

The position of the bad pixels are shown by the red-cross in the right figure. The bad pixels concentrate at the opposite side of the dead pixel area. In comparison to the distribution of the dead pixels, the bad pixels exist in the whole area, although the number is very little. For the stable operation in the future, we need to decrease the number of the bad pixels causing the discharge.



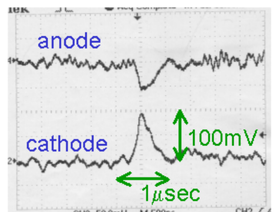
3. Performance for X-rays

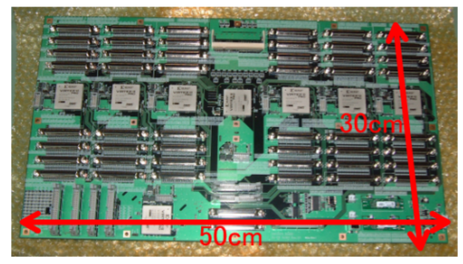
➢ DAQ System & the first signal



← DAQ system
- μ-PIC has 1536 channel signal read out
- each strip read out by ASD chip [5]
- the digital output (LVDS) into the position encoder
- the sum of 32 channel preamp output as an analog signal

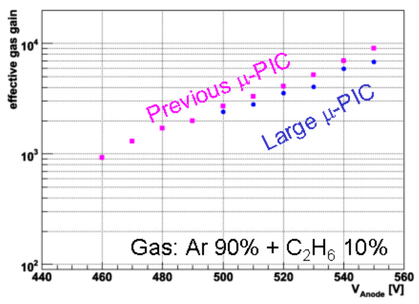
First signal →
- Gas : Ar 90% + C_2H_6 10%
- signal of β-ray from ^{90}Sr/Y
- V_{anode}=500V

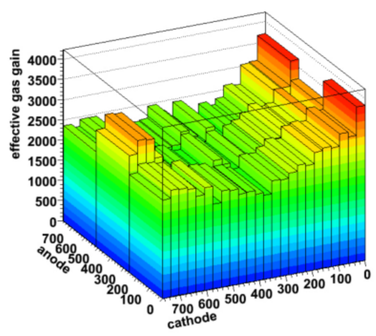




← Position Encoder
- 1536 channel LVDS input
- operation with 100MHz clock
- pipeline encoding process with 8 FPGAs
- output the 32-bit encoded information to VME memory board

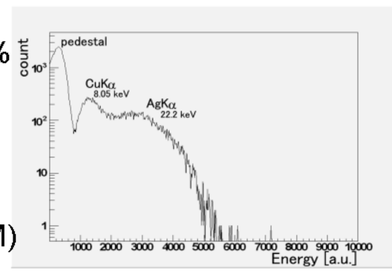
➢ The gas gain & the spectrum





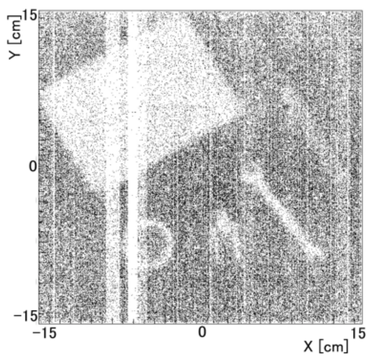
← Gain curve
- stable gain of ~3500 and maximum gain of ~7000
- gain of new μ-PIC is nearly equal to the gain of previous

Spectrum →
- Gas : Ar 90% + C_2H_6 10%
- source : ^{109}Cd (22.2keV)
- V_{anode} = 530V
- the area of 6mm×30cm at the center
- energy resolution (FWHM) ~50% @ 8.05 keV



← Gain map
- Minimum : Maximum = 1 : 2.2
- RMS / Mean = 16.7%
- The gas gain of the edge is higher than the center
- Gas : Ar 90% + C_2H_6 10%
- V_{anode} = 500V

➢ The X-ray imaging



- Gas : Ar 90% + C_2H_6 10%
- gas depth : ~1cm
- source : ^{109}Cd (22.2keV)

Successful in taking the X-ray image!!!

4. Summary & Prospects

- We have developed a very large μ-PIC with a detection area of 30×30 cm^2.
- The structure of the new μ-PIC's electrode is as same as that of the previous μ-PIC, and a new μ-PIC has 768×768 pixels with a pitch of 400μm.
- The yield of the first production was ~50%, and there are only ~1% dead pixels in the whole area.
  → It is a prospect to the mass production of the large area μ-PIC.
- The bad pixels are made by the miss of the etching, and they cause the discharge.
- A data acquisition system of a very large μ-PIC was already constructed.
- We could operate the new μ-PIC, and the β-ray was detected as the first signal.
- The effective gas gain of the new μ-PIC is nearly equal to the gain of the previous one.
- The energy resolution (FWHM) is ~50% at 8.05 keV.
- The ratio of the gas gain was 2.2 between the minimum and the maximum gain area.
- It was successful to take the X-ray image by irradiating the X-rays from ^{109}Cd.

For the near future…
- ➢ development of the Time Projection Chamber with a volume of 30×30×30 cm^3
- ➢ the higher yield of the production

References

[1] A. Ochi, et al., *NIM A*, **478** (2002) 196; T. Nagayoshi, et al., *NIM A*, **525** (2004) 20.
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[3] T. Tanimori, et al., *Phys. Lett. B*, **578** (2004) 241.
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[5] R. Orito, et al., *IEEE Trans. Nucl. Sci.*, **51** (2004) 1337.

http://www-cr.scphys.kyoto-u.ac.jp/research/mu-PIC/index.html