大面積Micro Pixel Chamberの開発 3

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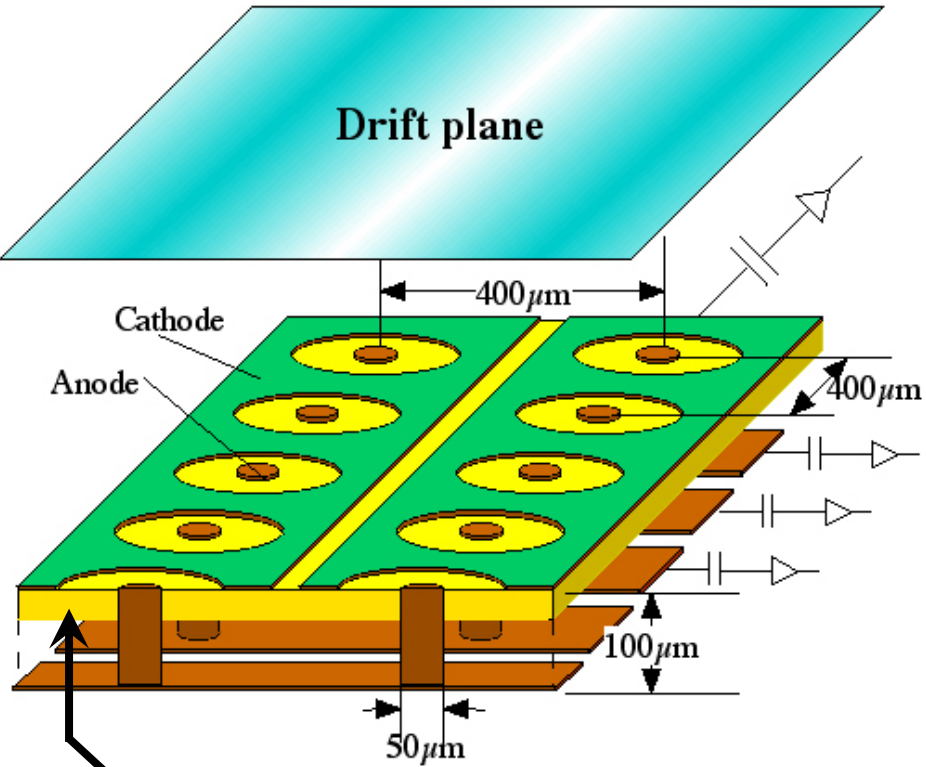
1.1 Micro Pixel Chamber (μ-PIC)

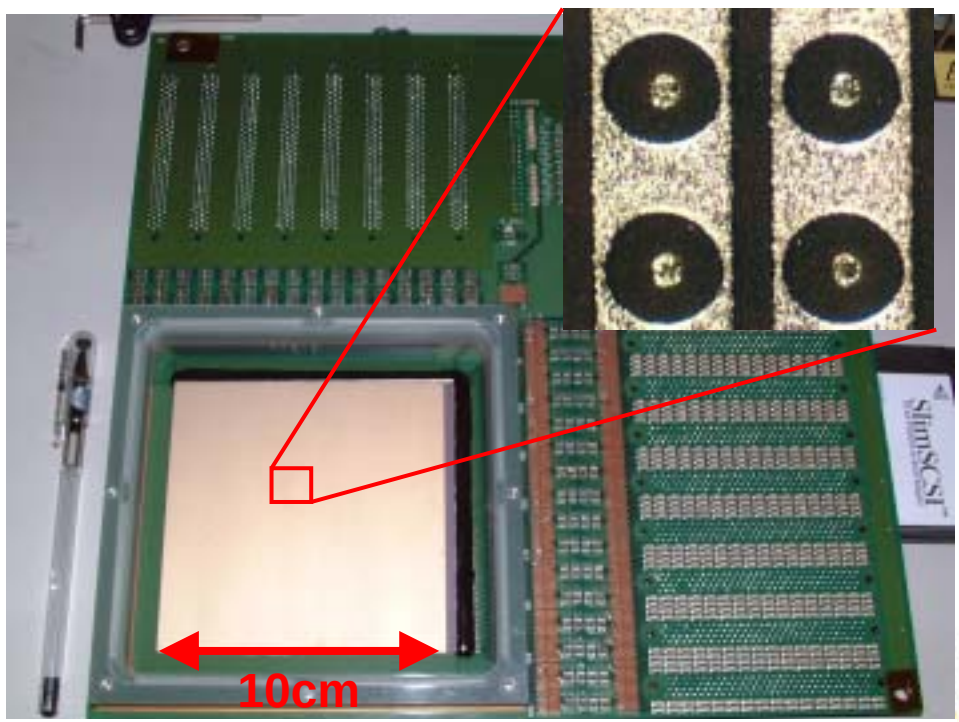


polyimide substrate (prepreg)

- 400μm pitch electrodes
- 256 anodes and
  256 cathodes

Printed Circuit Board (PCB) technology

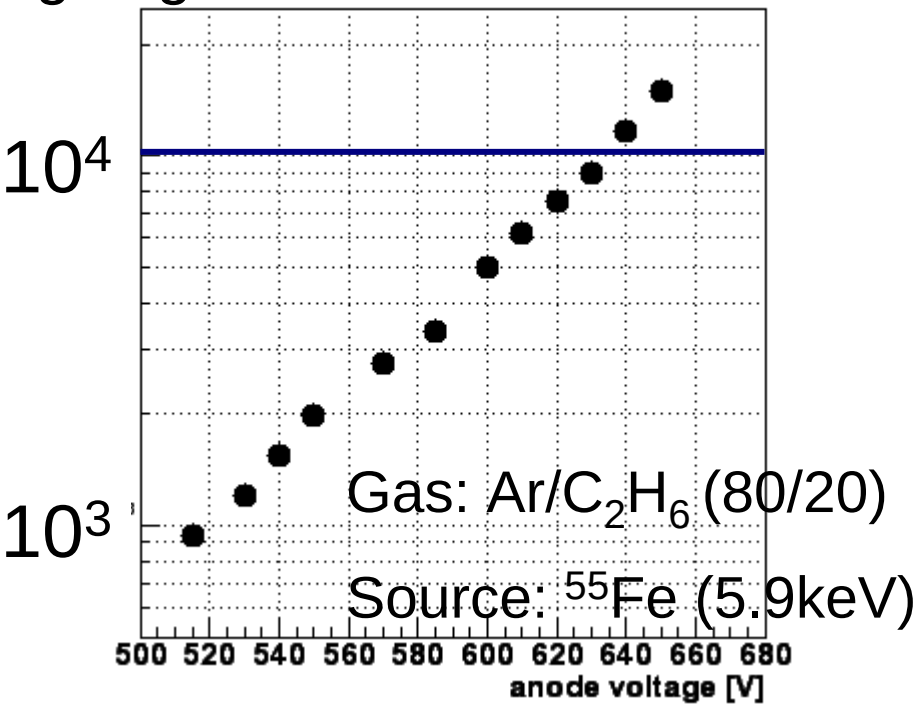
- Large area
- Low cost



Detection area = 100cm^2

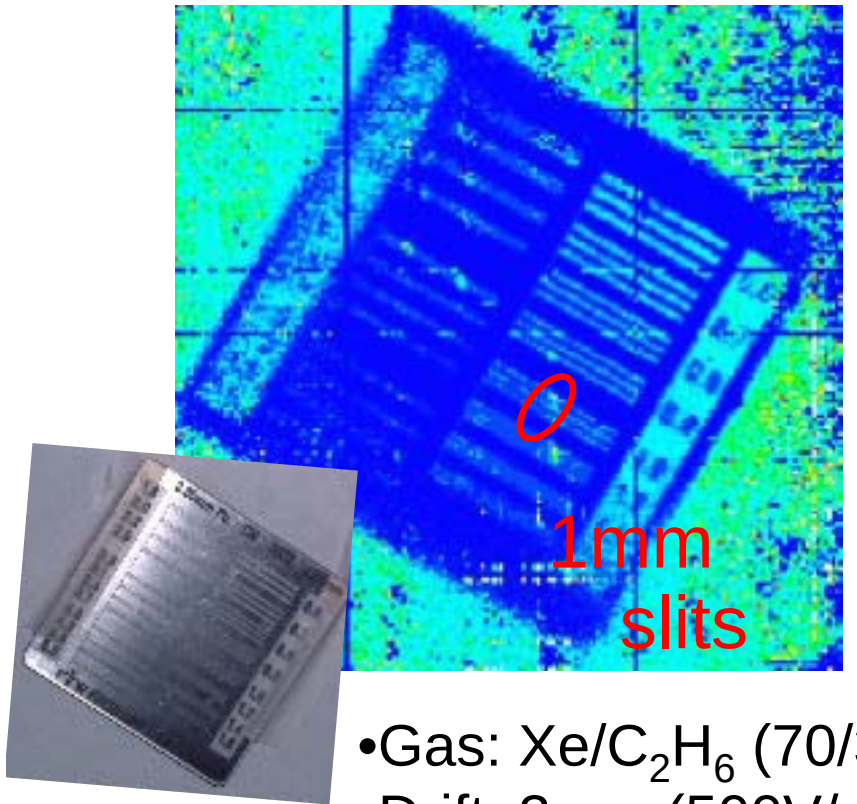
1.2 Performances

gas gain



- Gas gain ~ 15,000 (max)
- Stable operation (>1000h) @ gas gain ~ 5000

X-ray imaging



- Gas: Xe/C_2H_6 (70/30)
- Drift: 3mm (500V/cm)

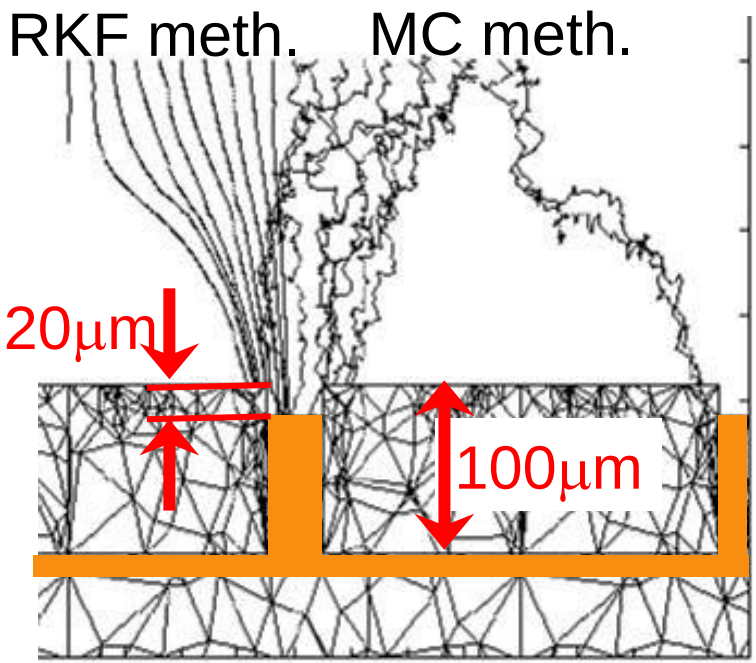
Position resolution

σ ~ 160 μm

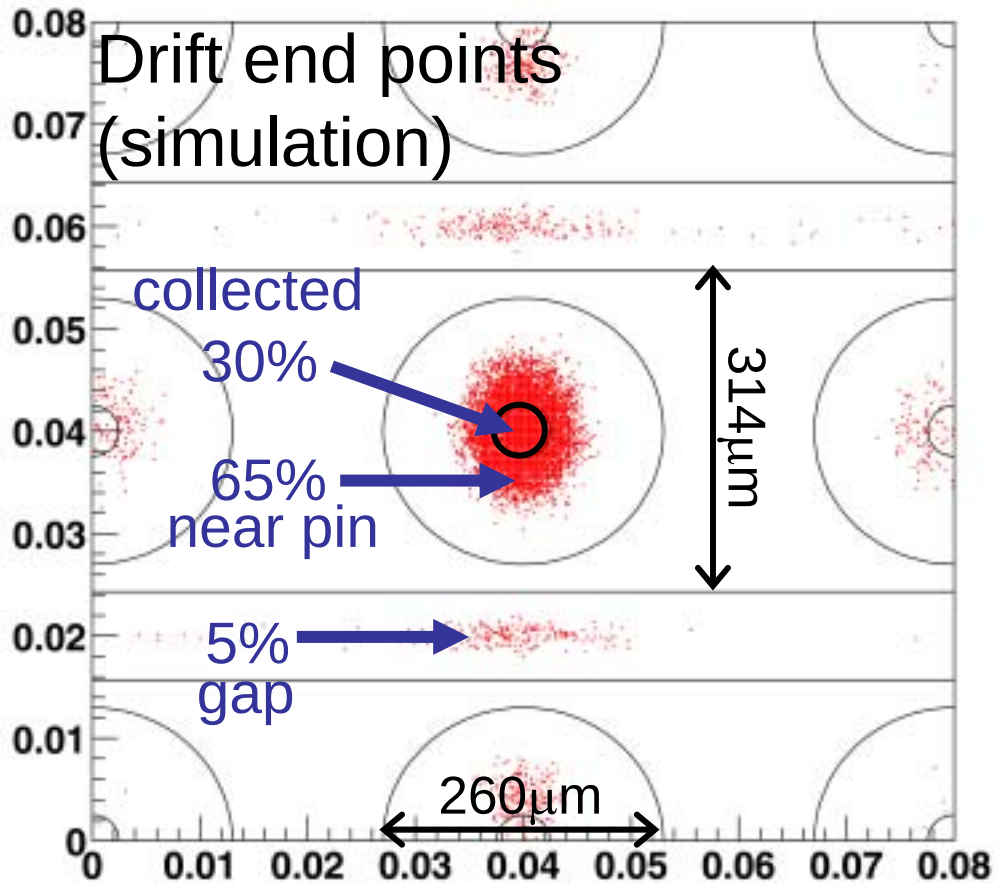
(knife edge test)

2.1 Drift simulation ~ For the best electrode ~

3D simulation
(Maxwell + Garfield)



Drift paths of electrons



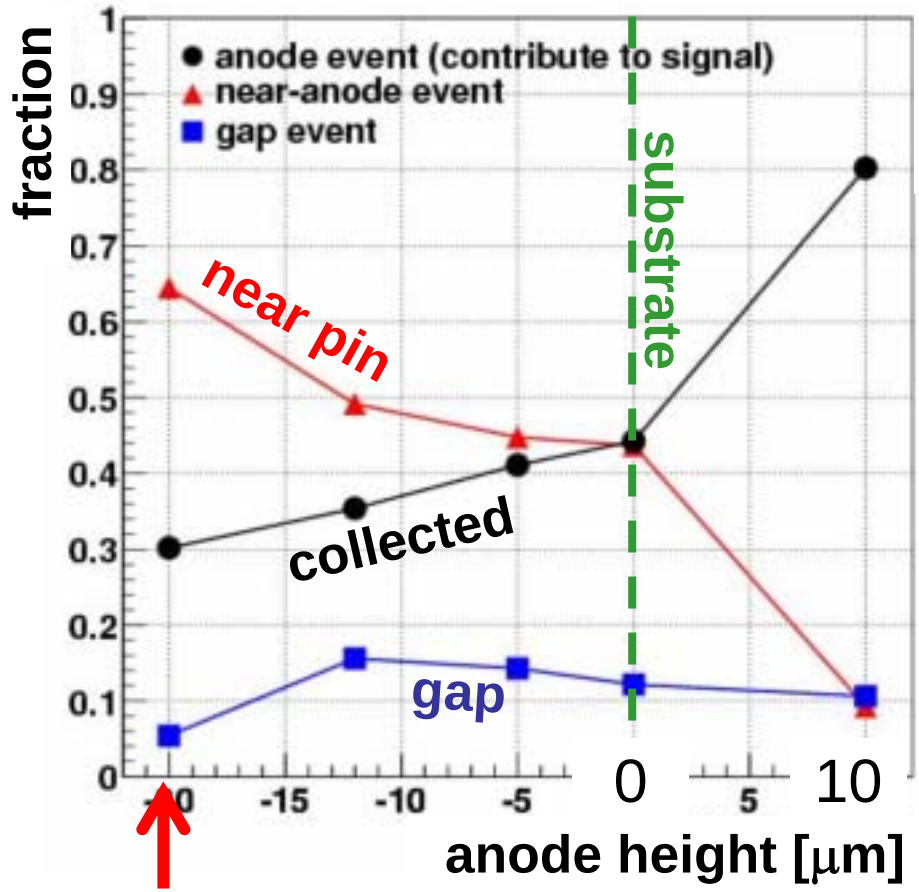
Top of anode electrodes are below substrate.

Collection efficiency ~ 30%

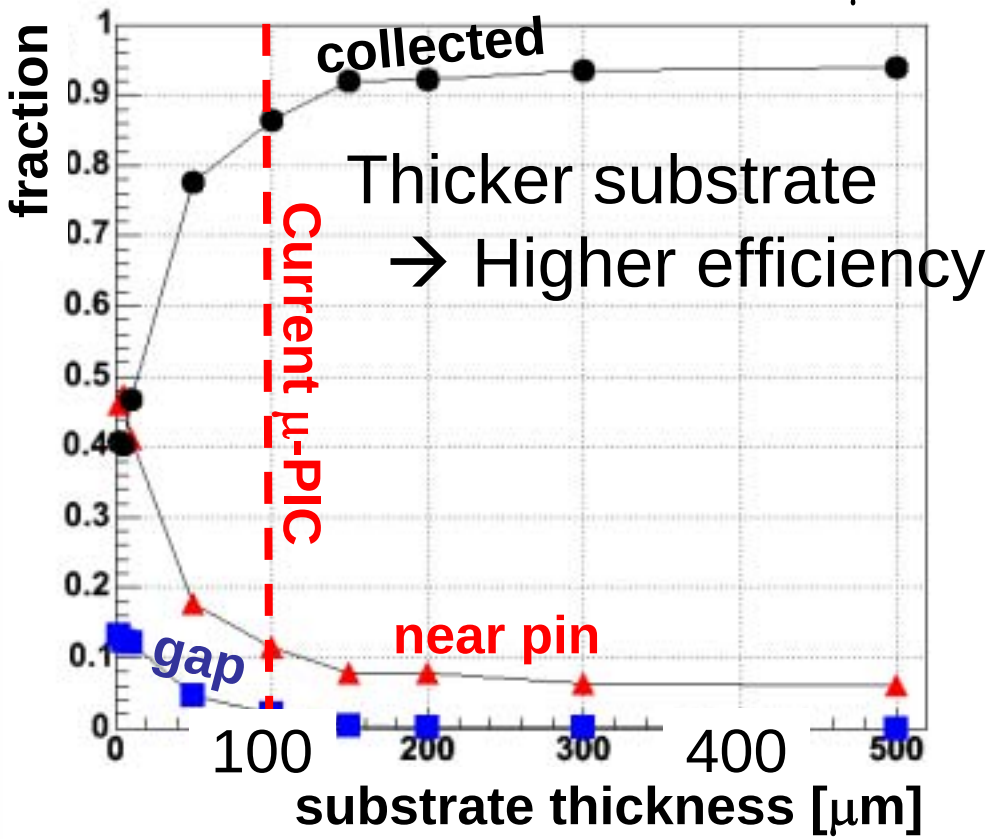
2.2 Drift simulation

Anode height = +10μm
Anode diameter = 50μm
Cathode width = 314μm
Cathode diameter = 260μm

Higher anode
→ Higher efficiency



Current μ-PIC
(-20μm)



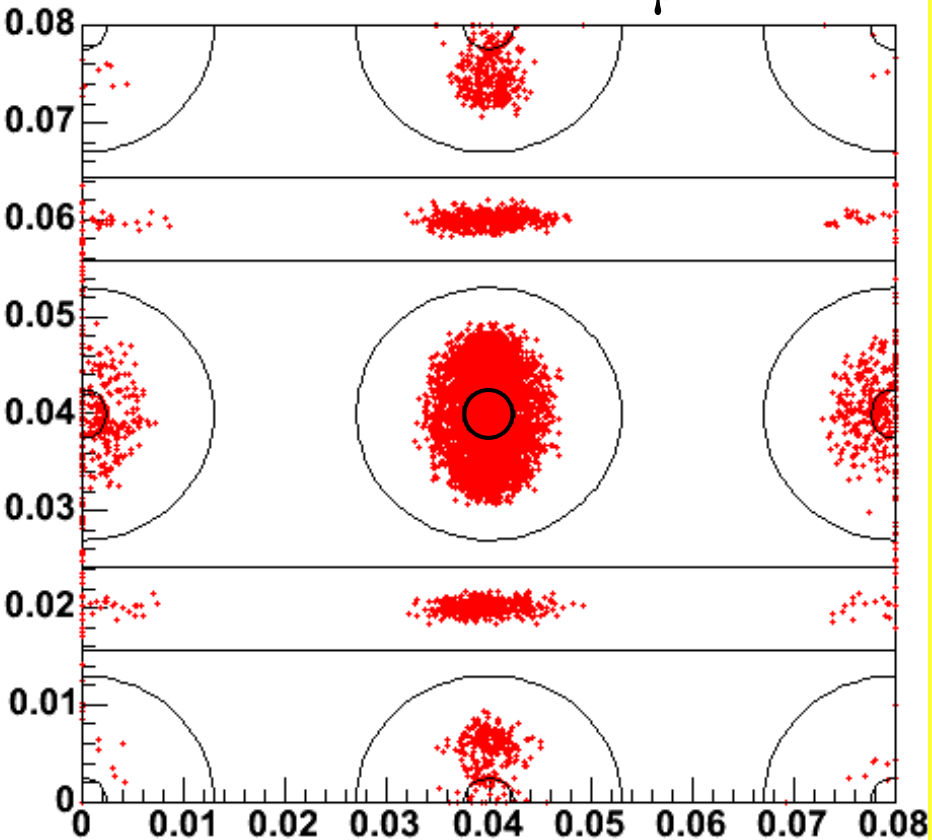
Thicker substrate
→ Higher efficiency

Substrate > 200μm … difficult

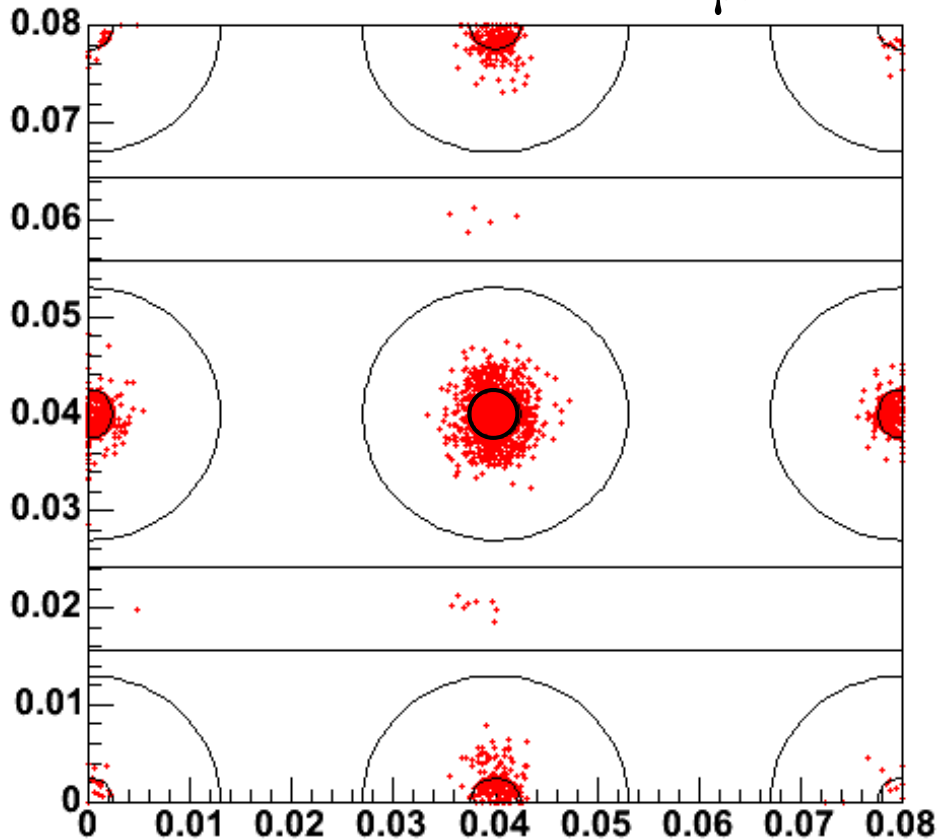
Anode = 10μm … possible!!

Drift end points

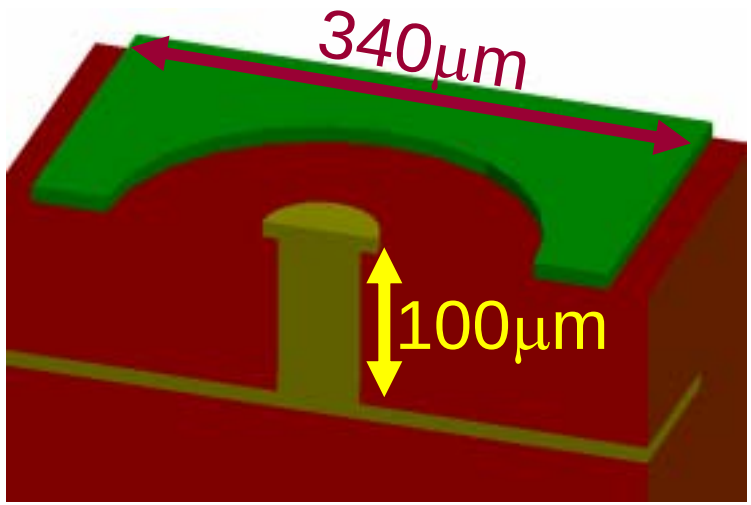
Substrate = 5μm



Substrate = 200μm



2.3.1 New μ-PIC



Electrode formation process

- Current type
  … normal plating *("bottom-up")*
- New type
  … plating and etching *("top-down")*

Coming soon!!

Detection area
30cm × 30cm

1. Electroless plating

3. Surface etching

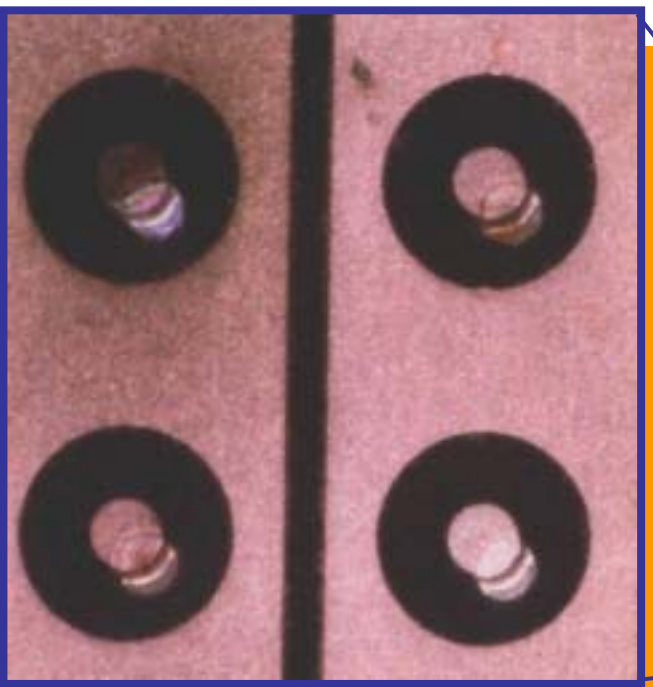
2. Via-fill plating

4. Electrode etching

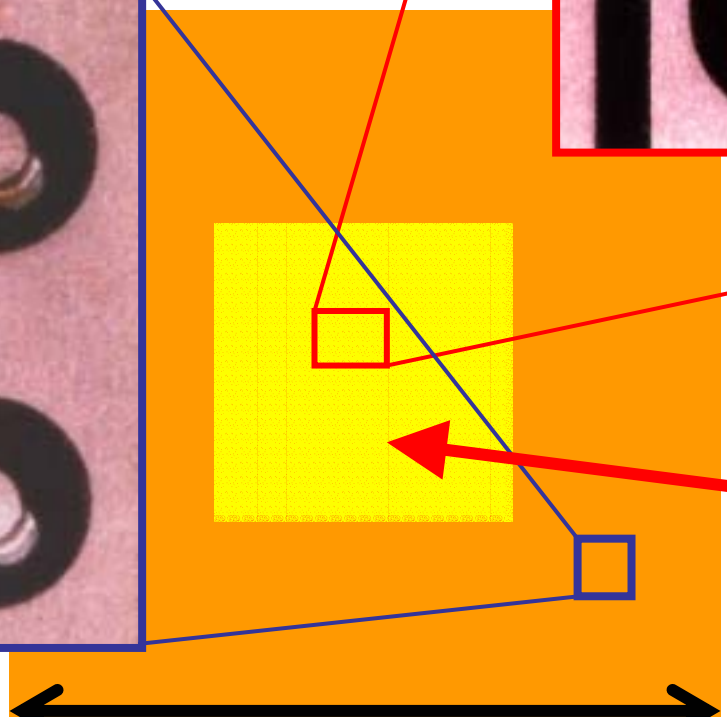
2.3.2 New μ-PIC

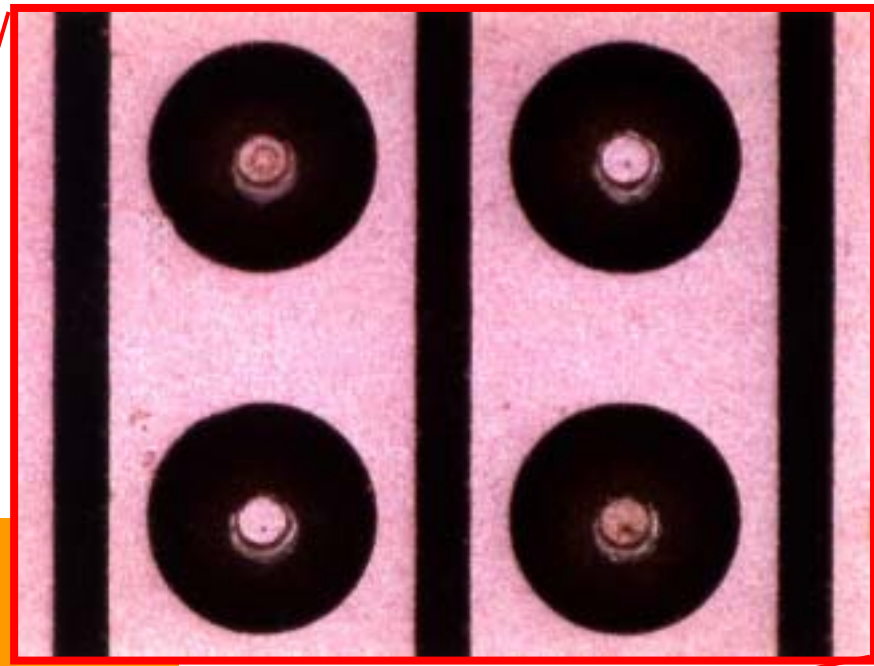
30×30 cm^2 detector

Edge region



some offset …





Center region

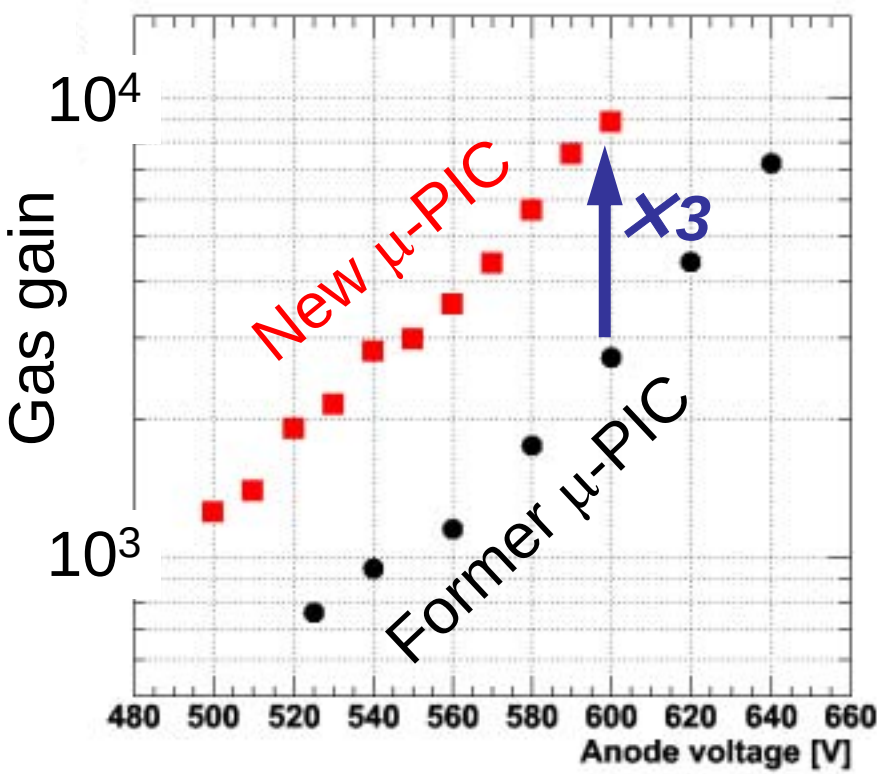
Beautiful!

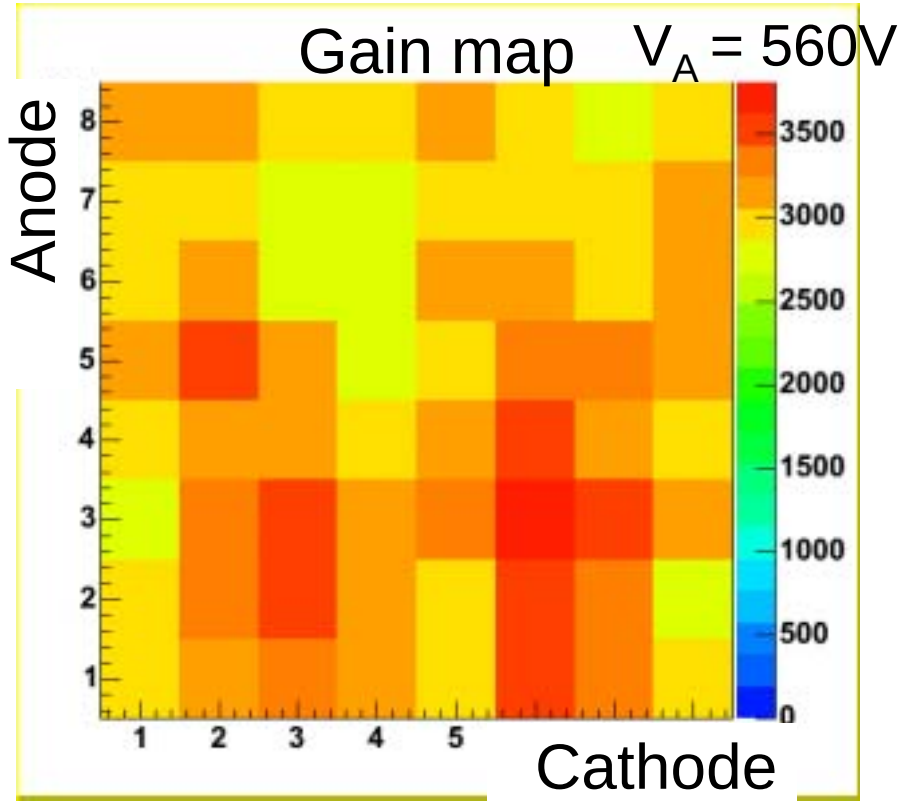
10×10 cm^2 :

Available for performance test

2.3.3 New μ-PIC

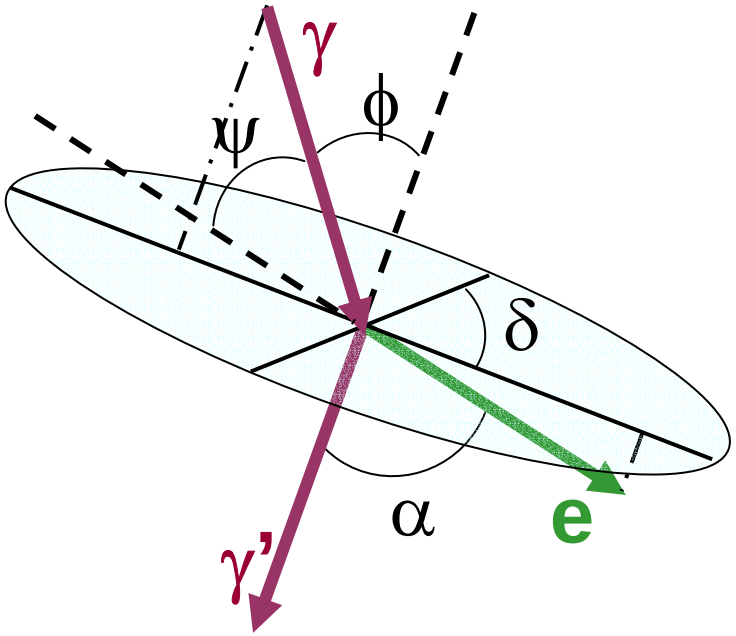
- 10×10cm^2 detection area
- Bad electrode < 0.1%
- Leakage current
  < 2nA @800V (in air)

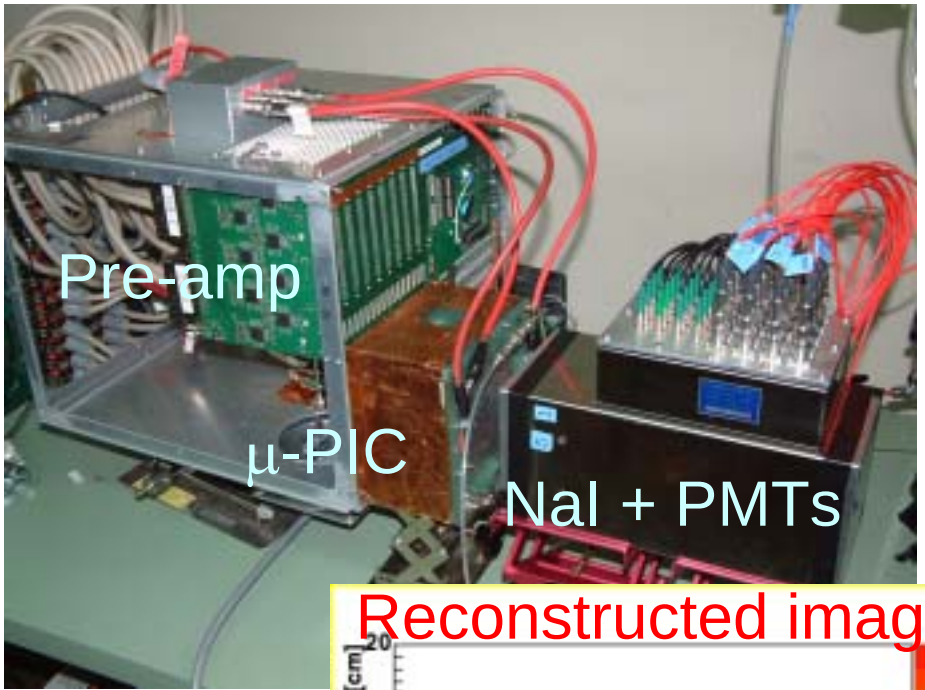


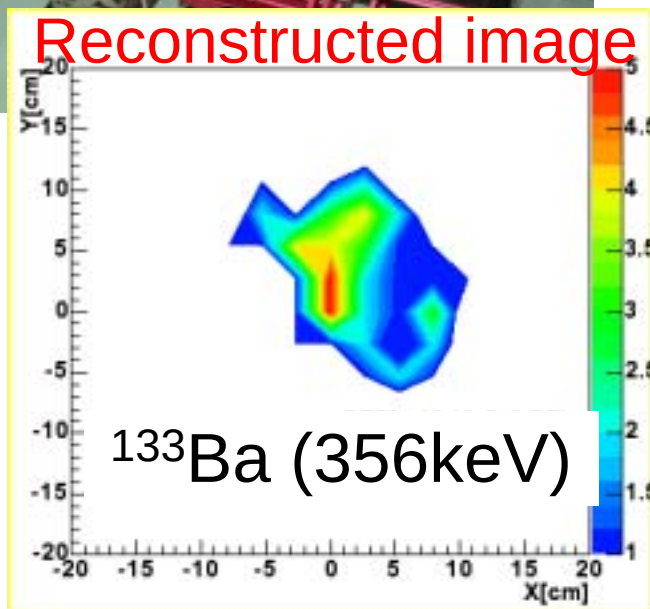


- uniform anodes
- anode height
  = cathode thickness
- gas gain ~ 9000 @V_A = 600V
- gain uniformity (σ)
  ~ 7%

3.1 Gamma-ray imaging







Compton scattering

- Electron tracking → Full reconstruction
- Cross section $\sigma \propto$ number of electrons

Balloon experiment in 2006

3.2.1 Gas study ~ Ar vs. CF_4 ~

Ar

- Number of electrons = 18
- W value = 26 eV/pair
- $(dE/dx)_{min}$ = 2.44 keV/cm

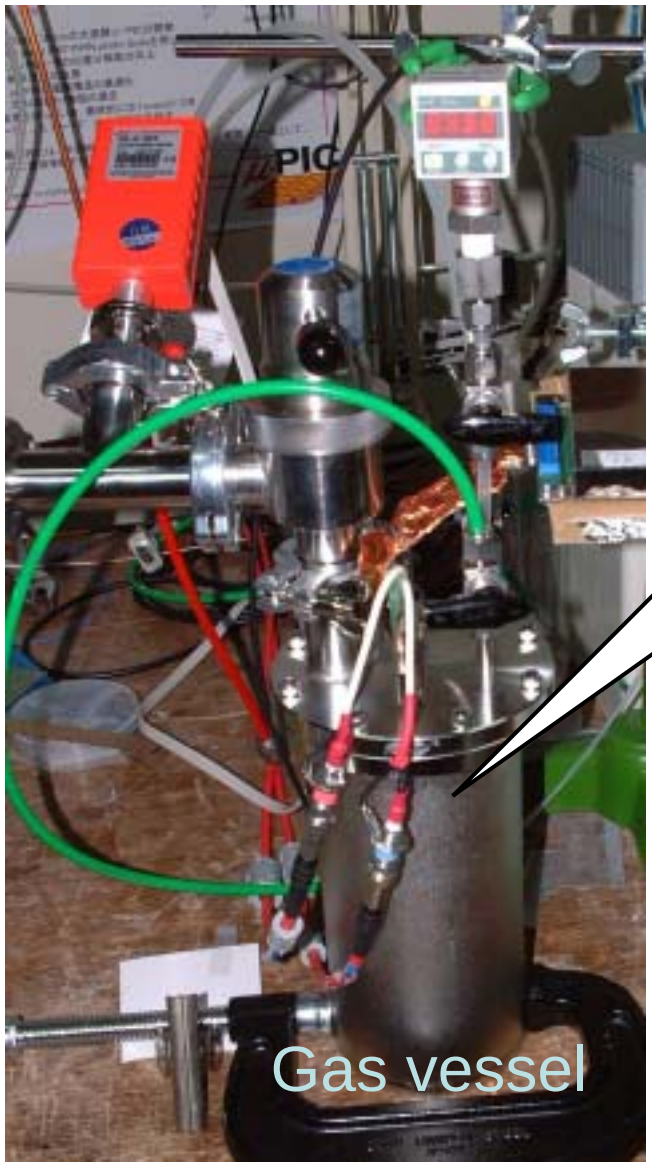
Standard gas for gas detectors

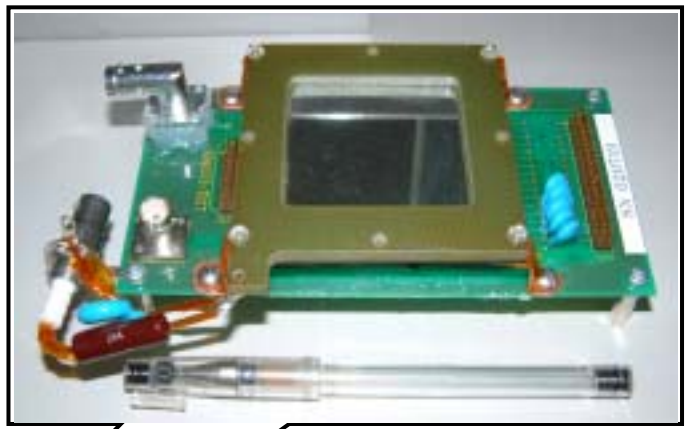
CF_4

- Number of electrons = 42
- W value = 54 eV/pair
- $(dE/dx)_{min}$ = 7 keV/cm
- Fast drift (~9cm/μs), small diffusion

Good properties for MIPs!

3.2.2 Operation test





3×3cm^2 μ-PIC

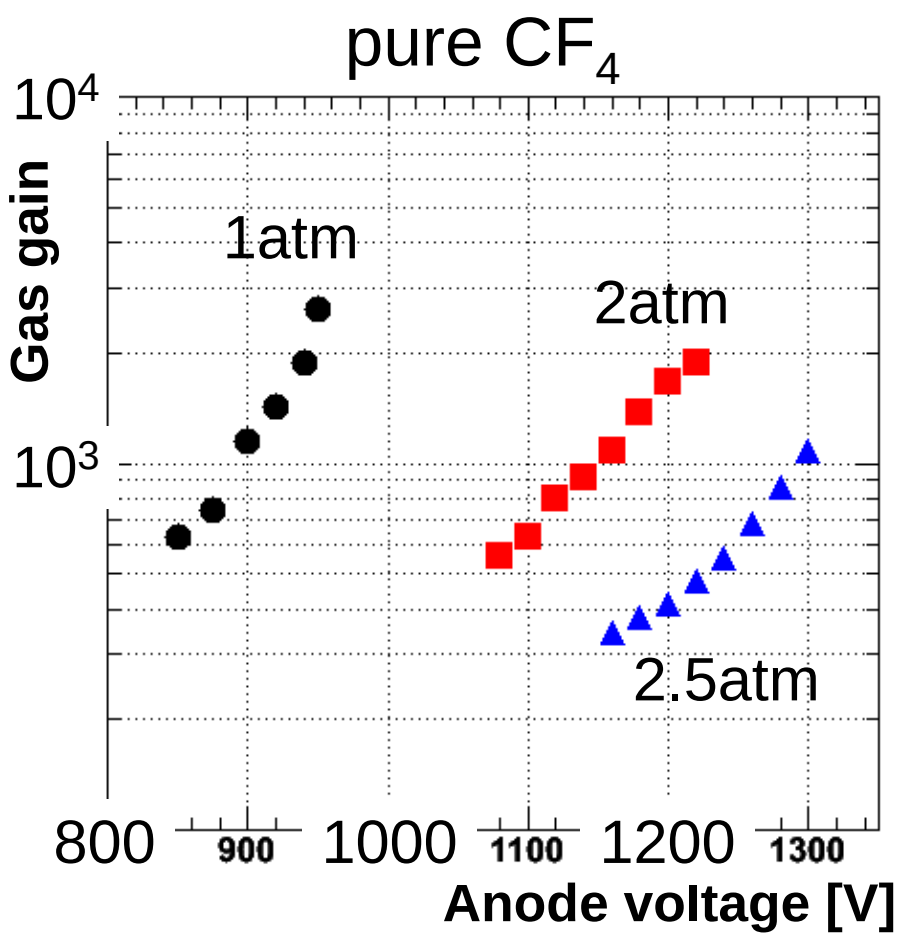
Operation test with CF_4 gas

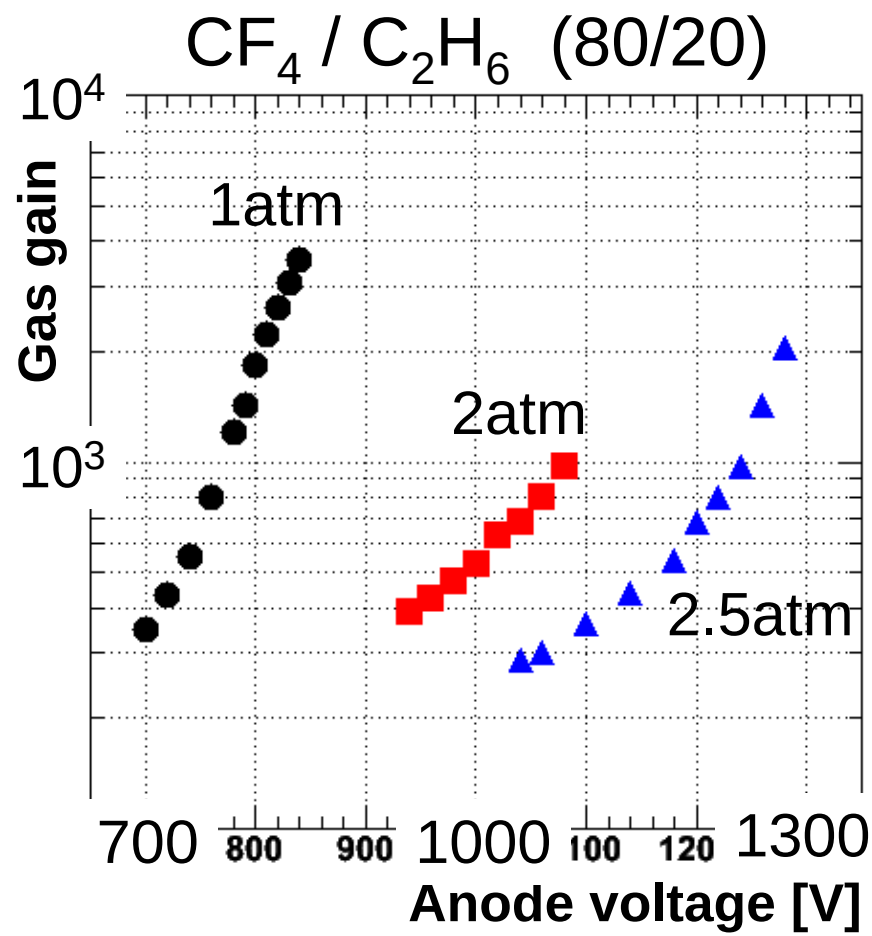
Dependence on …

- Mixture ratio (C_2H_6)
- Pressure (1 – 2.5atm)

Source: ^{55}Fe (5.9keV)

3.2.3 Operation test

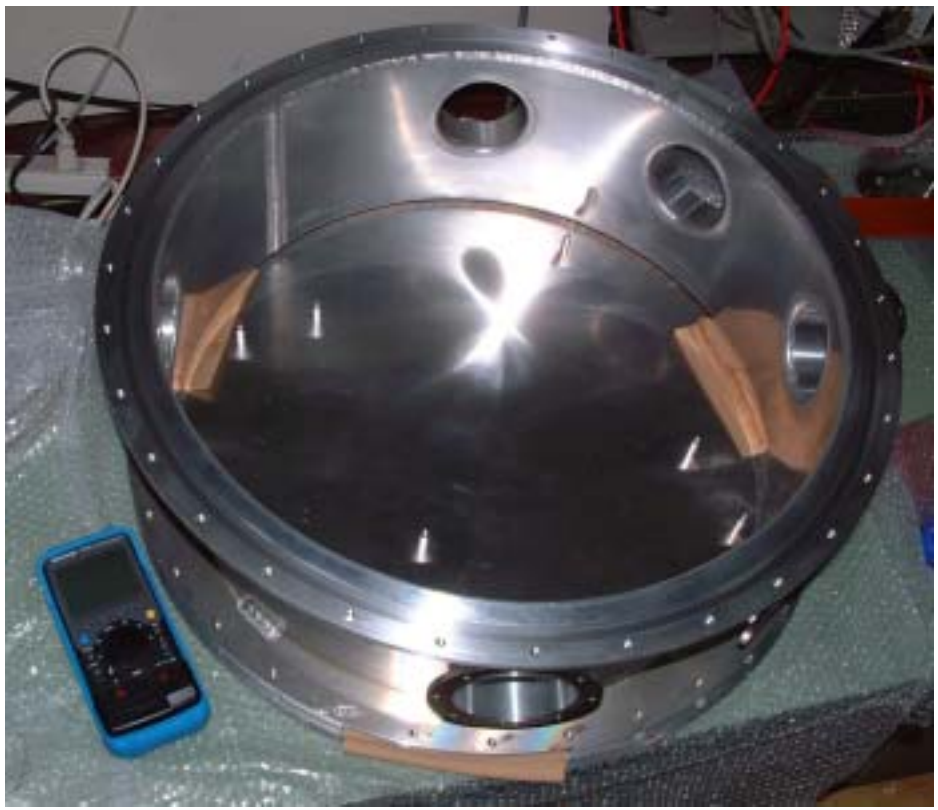




- Maximum gas gain ~ 3500 (80/20 mixture)
- Gas gain > 10^3 @ 2.5atm

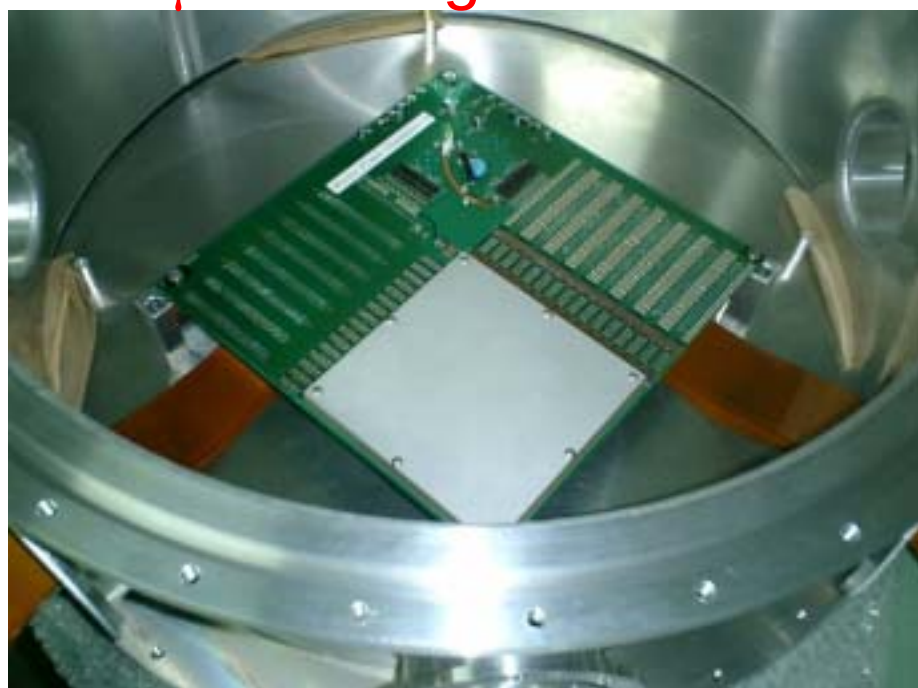
3.3 Gas vessel

- Available for 30×30 cm^2 detector
- Vacuum ~ 4atm (?)



Flexible boards for read-out

μ-PIC in gas vessel

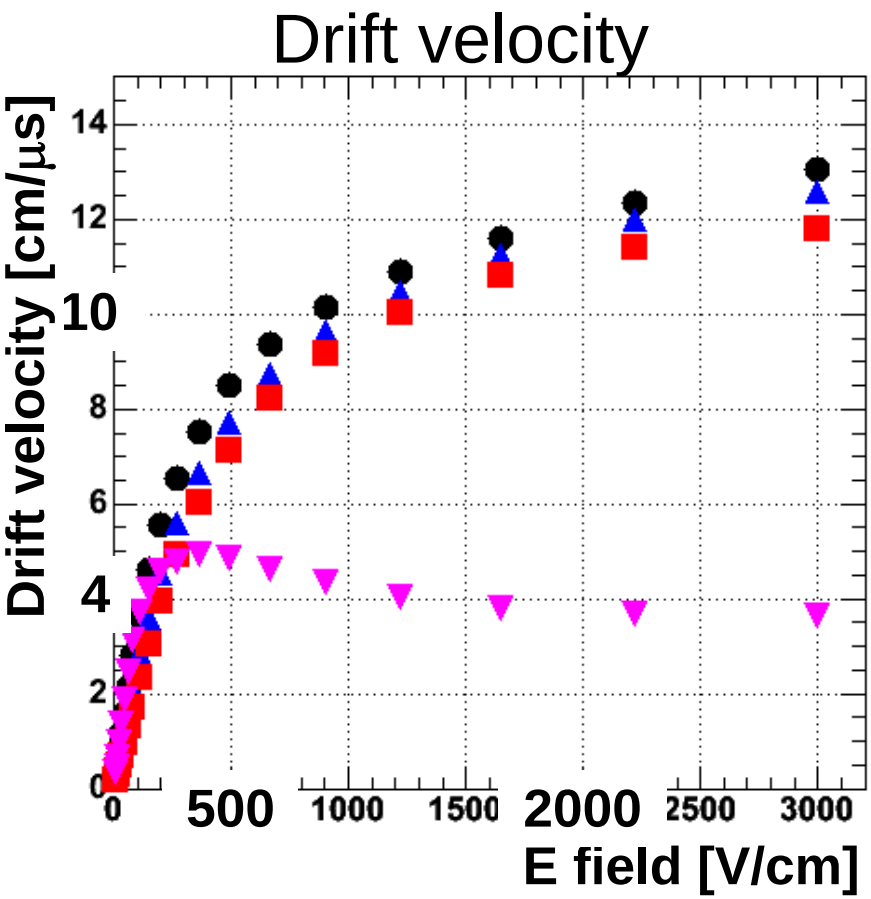


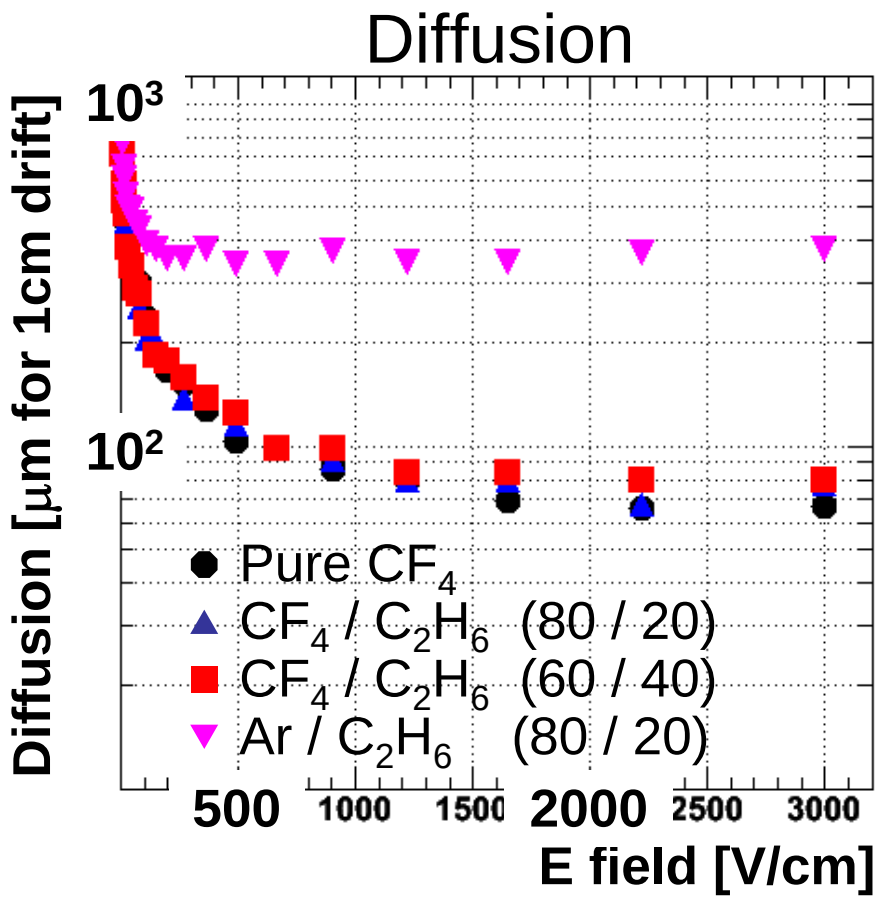
4 Summary

- 3D simulation of μ-PIC
  - Higher anode → high efficiency (> 90%)
- A new manufacture technology
  - Anode height = cathode thickness
  - Gas gain ~ 9000
  - Uniformity: σ ~ 7%
- CF_4 gas
  - Stable operation @ gas gain > 1000
- Gas vessel for 30×30cm^2 detector
  - Pressure-resistant test is in progress

3.2.1 Drift and diffusion

~ Simulation by Magboltz ~





- Drift: ×2 faster than Ar
- Diffusion: 1/4 smaller than Ar