A new design of MPGD: Micro-Mesh Micro Pixel Chamber (M^3-PIC)

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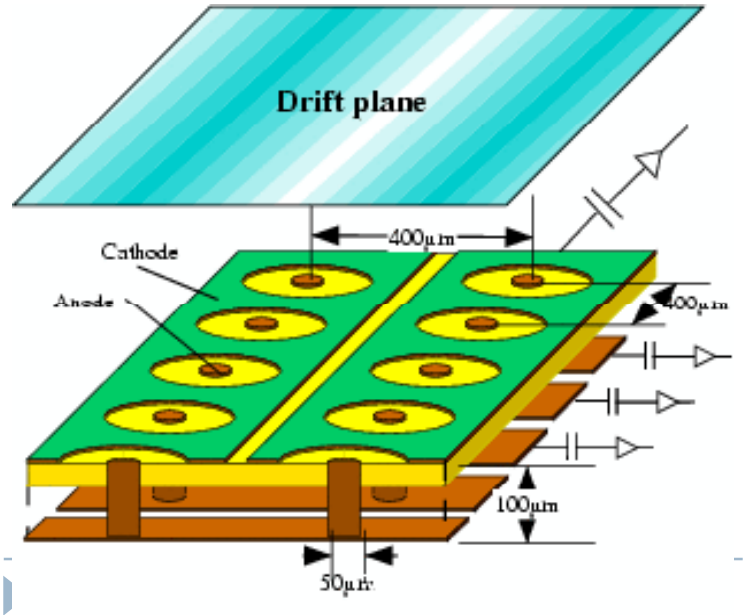
Introduction

- Introduction to μ-PIC
- Design of new M^3-PIC
- Advantages using micro mesh

Introduction to μ-PIC

- M^3-PIC is based on μ-PIC
  - **μ-PIC : micro pixel gas chamber**
  - **Large area with PCB tech.**
  - **pitch :400μm**
  - **high gas gain**
  - **small discharge damage**



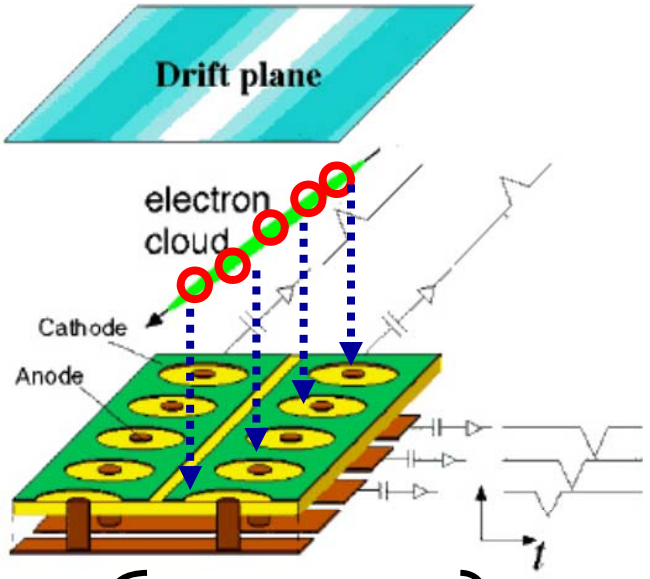
	MSGC	μ-PIC
Maximum gain	1700(with capillary)	15000
Stable Gain	1000	7000
Long time		>30 days
Area	10×10cm²	30×30cm²
Pitch	200μm	400μm (300μm possible)
uniformity (σ)	~35%	4%

- Invented by A.Ochi and T.Tanimori (NIMA 471 (2001) 264)
- Application: X-ray imaging, Gamma camera, Medical RI tracing, etc.

Introduction to μ-PIC (cont'd)

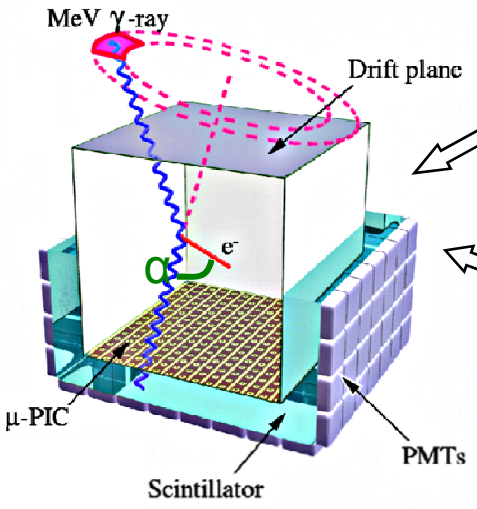
- Applications --- Micro TPC → Gamma ray camera

(ETCC: Electron-Tracking Compton Camera)



X, Y from m-PIC
+
Z from timing

3 D Track



Tanimori, et al, 2004

Gaseous TPC
with micro-electrodes

Recoil Electron :
3D Sequential Track ->Direction, Energy

Scintillation Camera

Less cost than semiconductor
Scattered Gamma-ray :
Energy, Direction

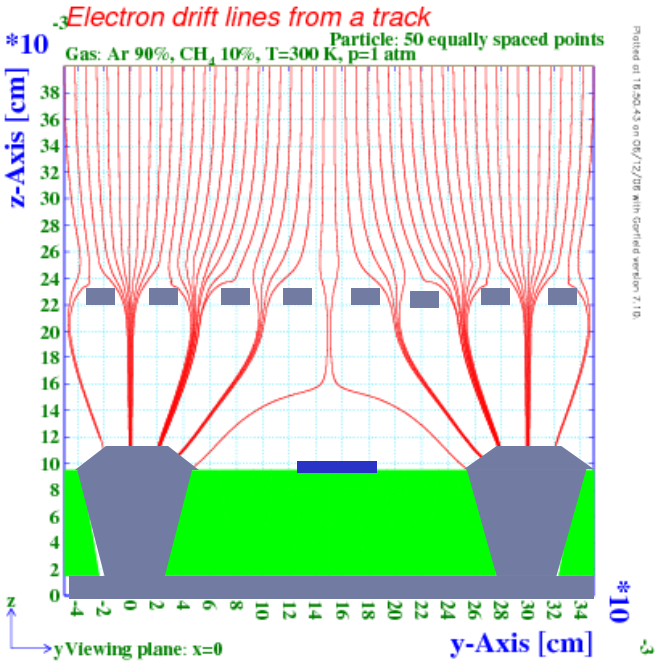
$$\cos\alpha = \left(1 - \frac{m_e c^2}{E_g}\right)\sqrt{\frac{K_e}{K_e + 2m_e c^2}}$$

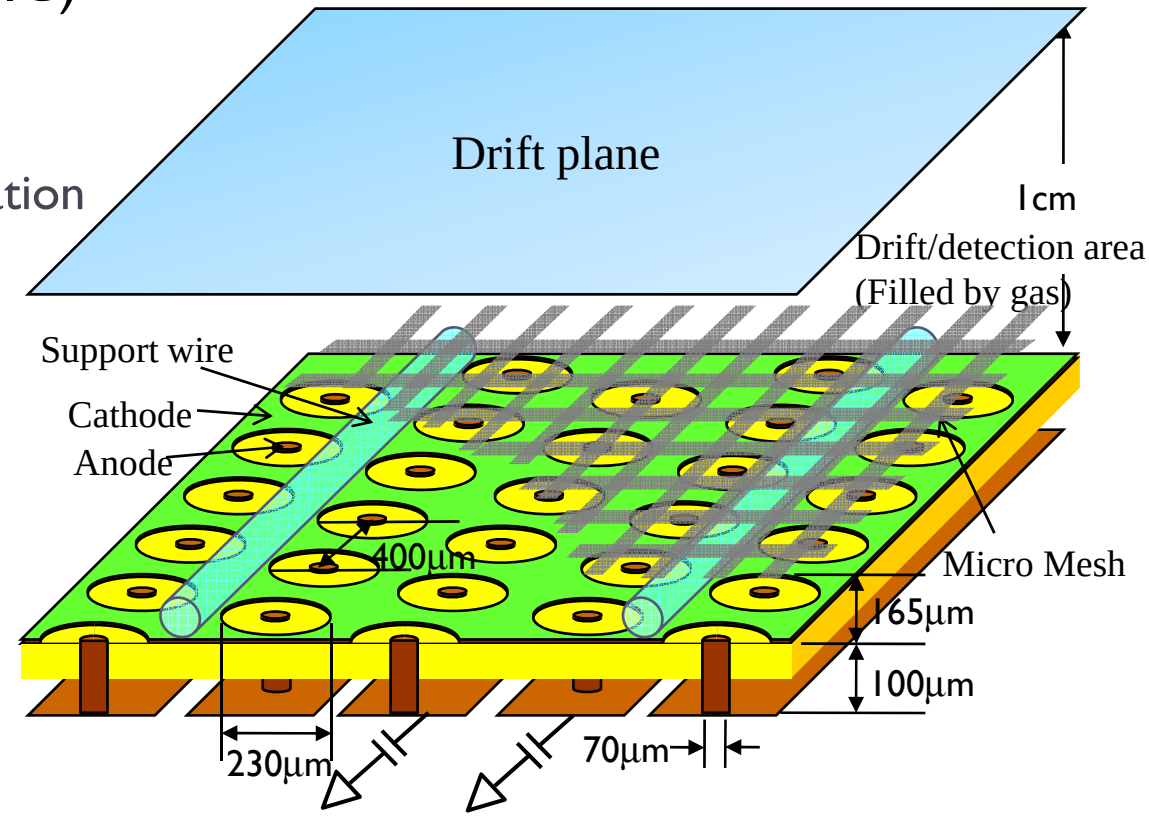
Design of M^3-PIC

- Micro pixel chamber (μ-PIC)

  +

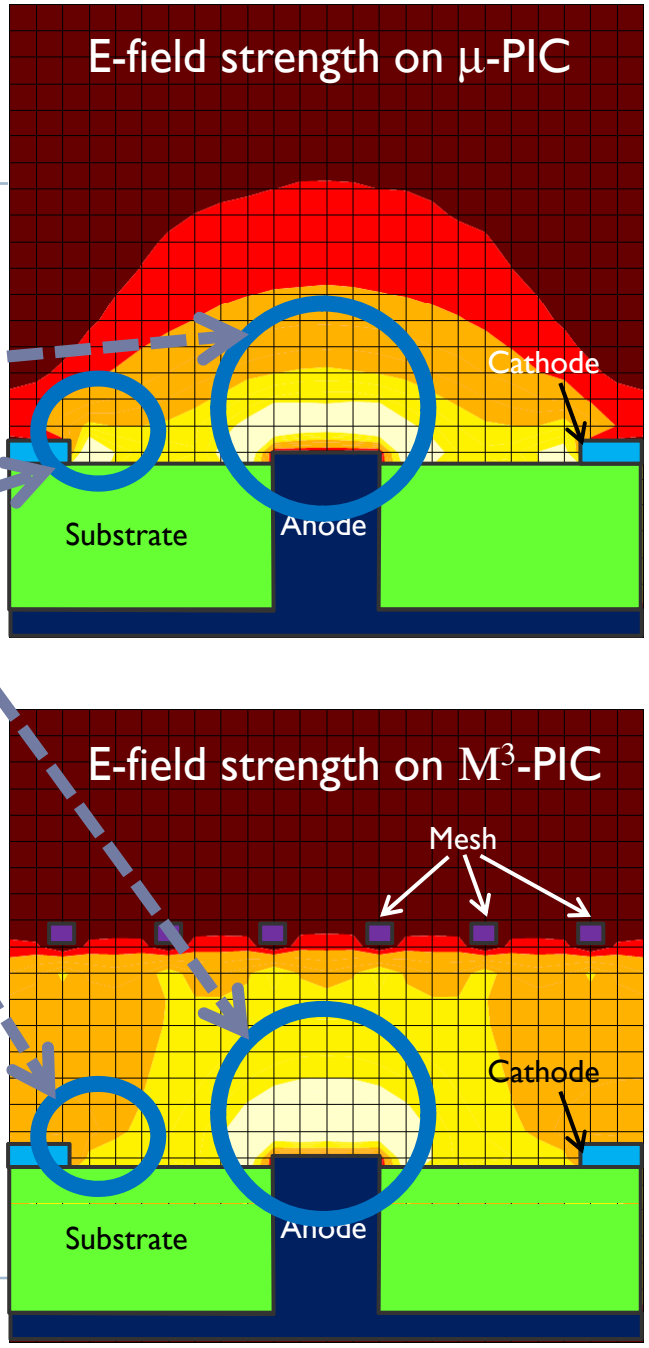
- With micro mesh
  - Higher gain in stable operation (~5x10^4)
  - Low ion backflow (<1%)





Advantages using micro mesh

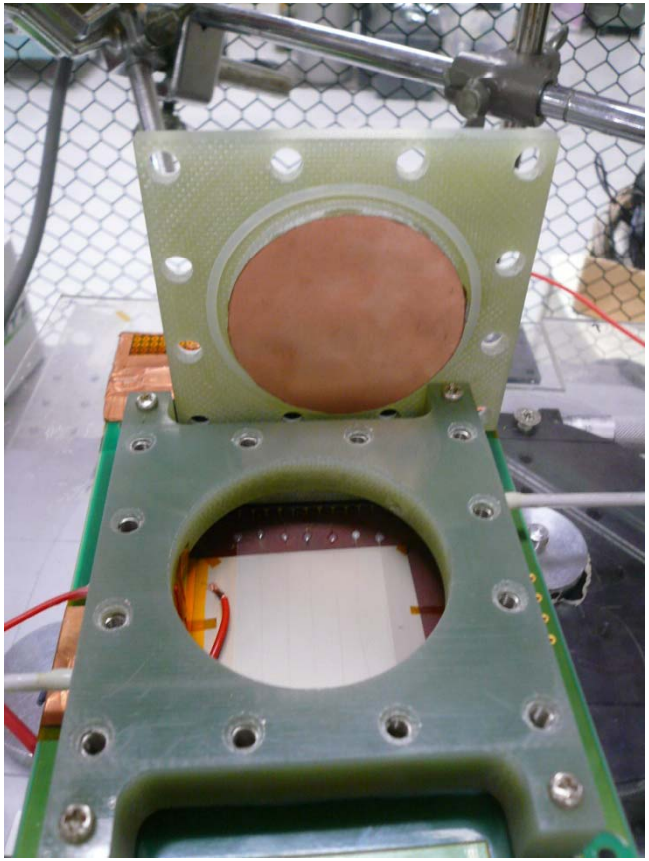
- Higher gas gain will be attained safely ($10^{4\text{-}5}$)
  - High electric field is formed larger area around the anode
  - Without increase of e-field near cathode edge
    - Electron emission from cathode edge is reduced
    - Streamer from anode is quenched
- Reduction of positive ion backflow
  - μ-PIC: ~30%
  - M^3-PIC: < 1%



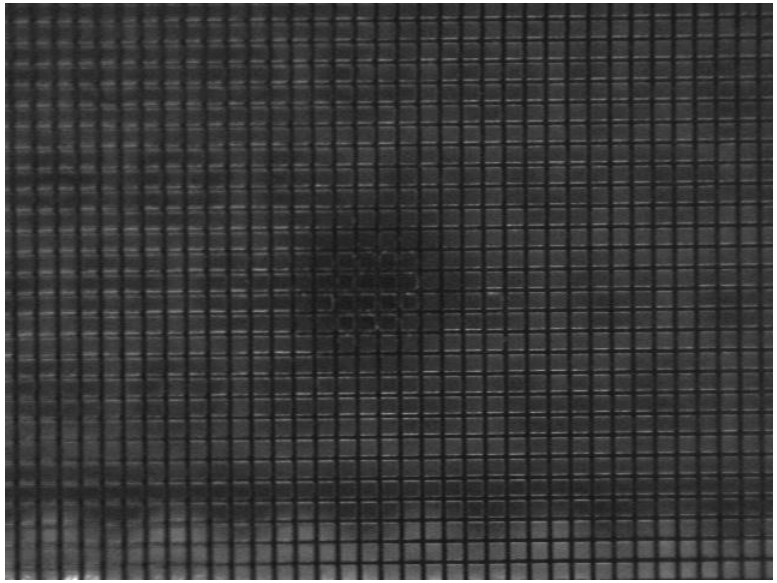
Setup and operation tests

- Setup
- Gas gain measurements
- Ion backflow measurements

Setup

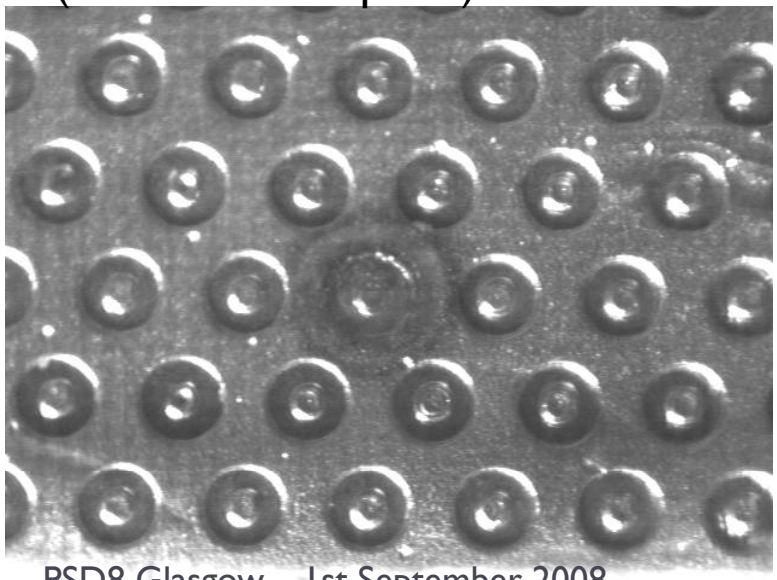


Micro mesh mounted on μ-PIC by hand.
Size of μ-PIC = 3cm x 3cm.



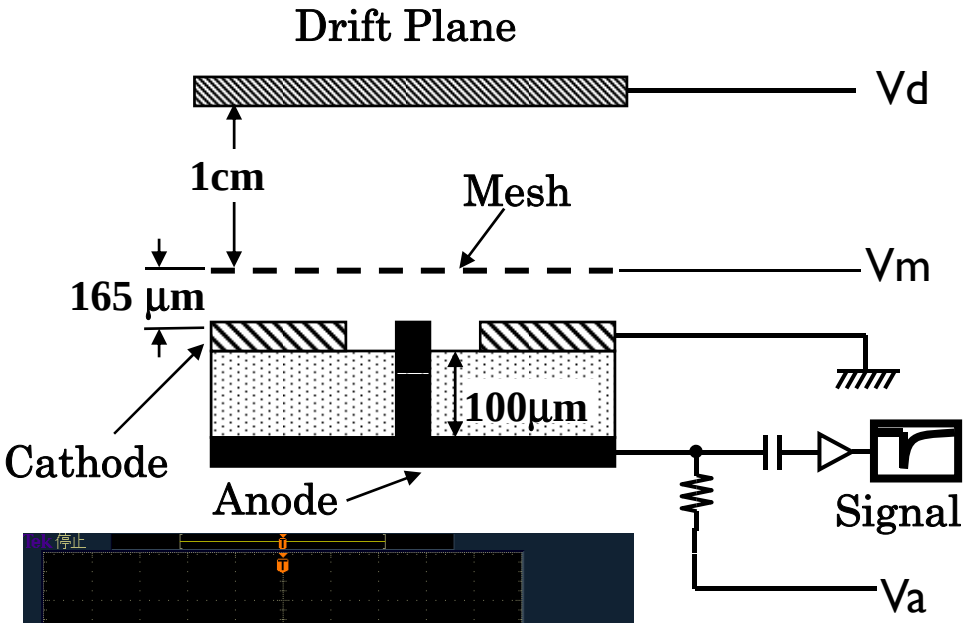
Micro scope pictures
for same place
(different focus point)

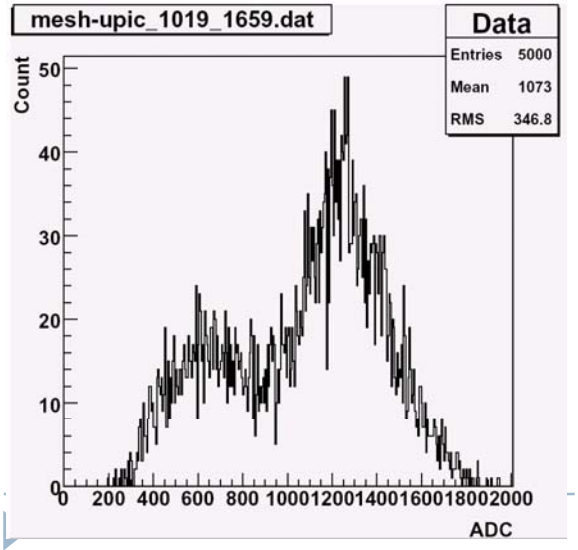
0.5mm

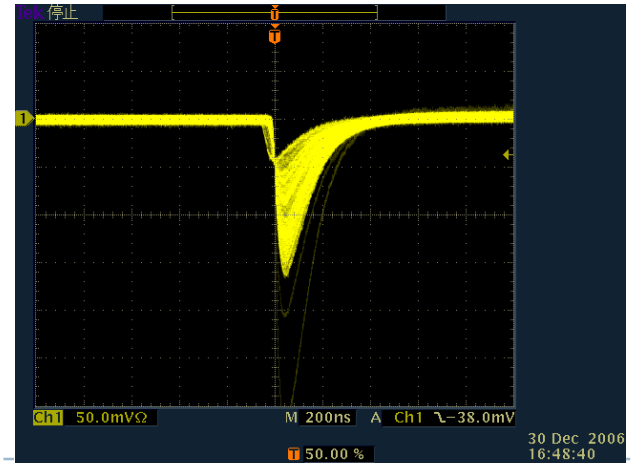


Gas gain measurements

- Gain dependency on
  - Anode voltage (=Va)
  - Mesh voltage (=Vm)
  - Drift field (=(Vd-Vm)/1cm)

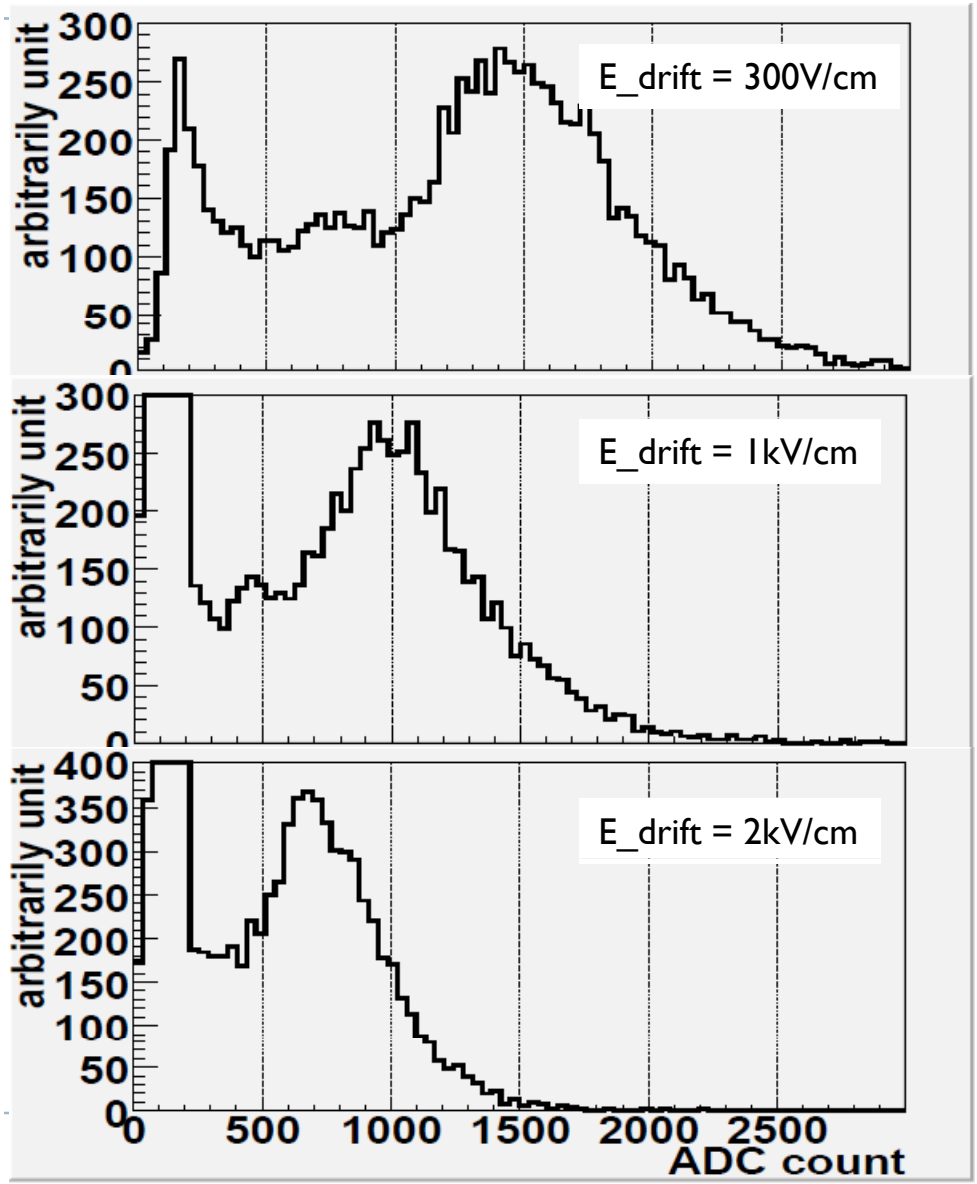






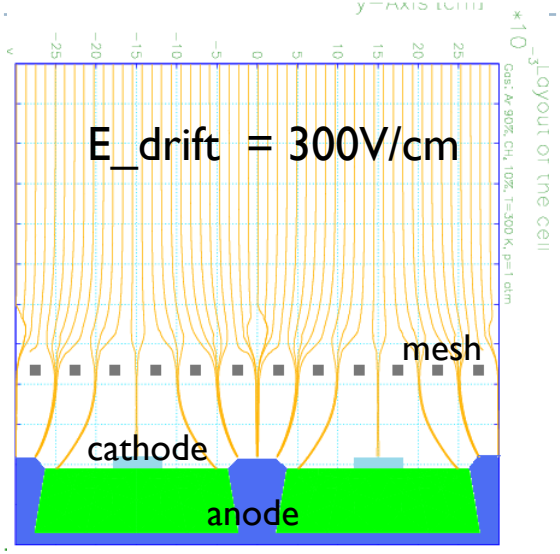
Gain dependence of drift field

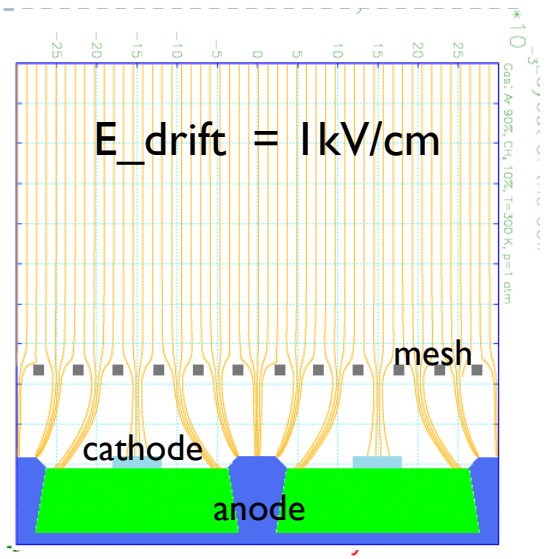
- Higher drift field
  - Lower electron collection efficiency on anode
  - → Gain decrease
  - → Energy resolution worse
    - → No escape peak found in 2kV/cm
- Maximum gain
  - 100V/cm < E_d < 500V/cm
  - E_d below 100V/cm
    - → Ion-electron recombination

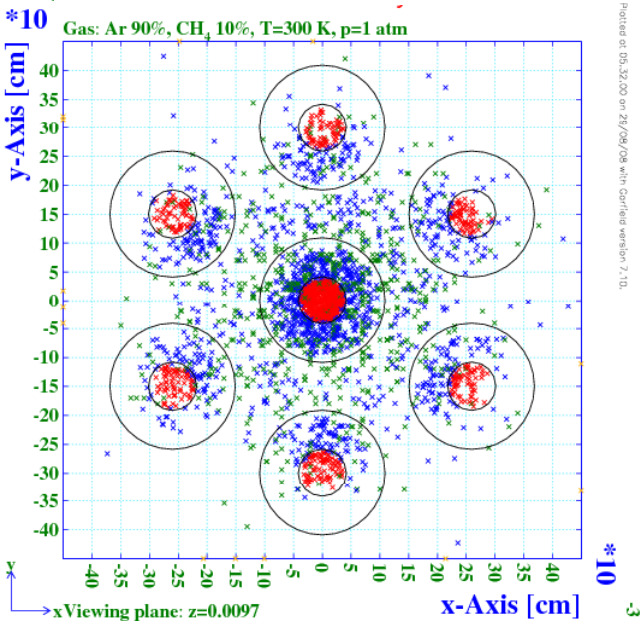


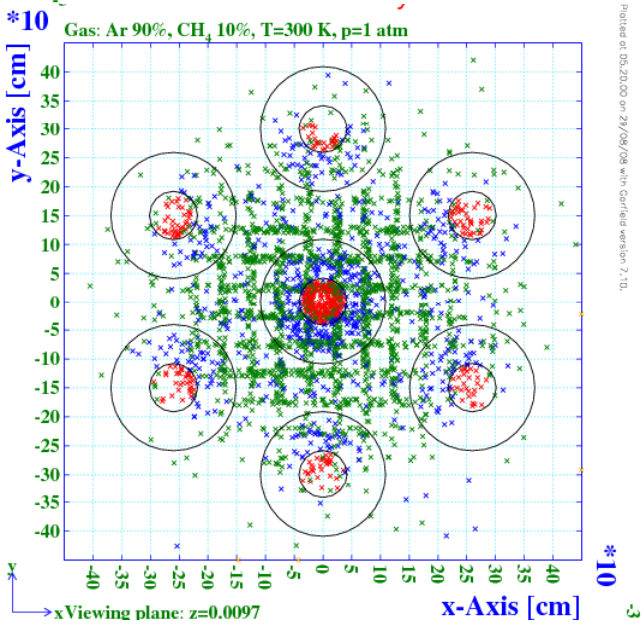
Electron drifts toward anode (simulation)

- Electrons are absorbed in the mesh or cathodes when electric field in drift region is higer.





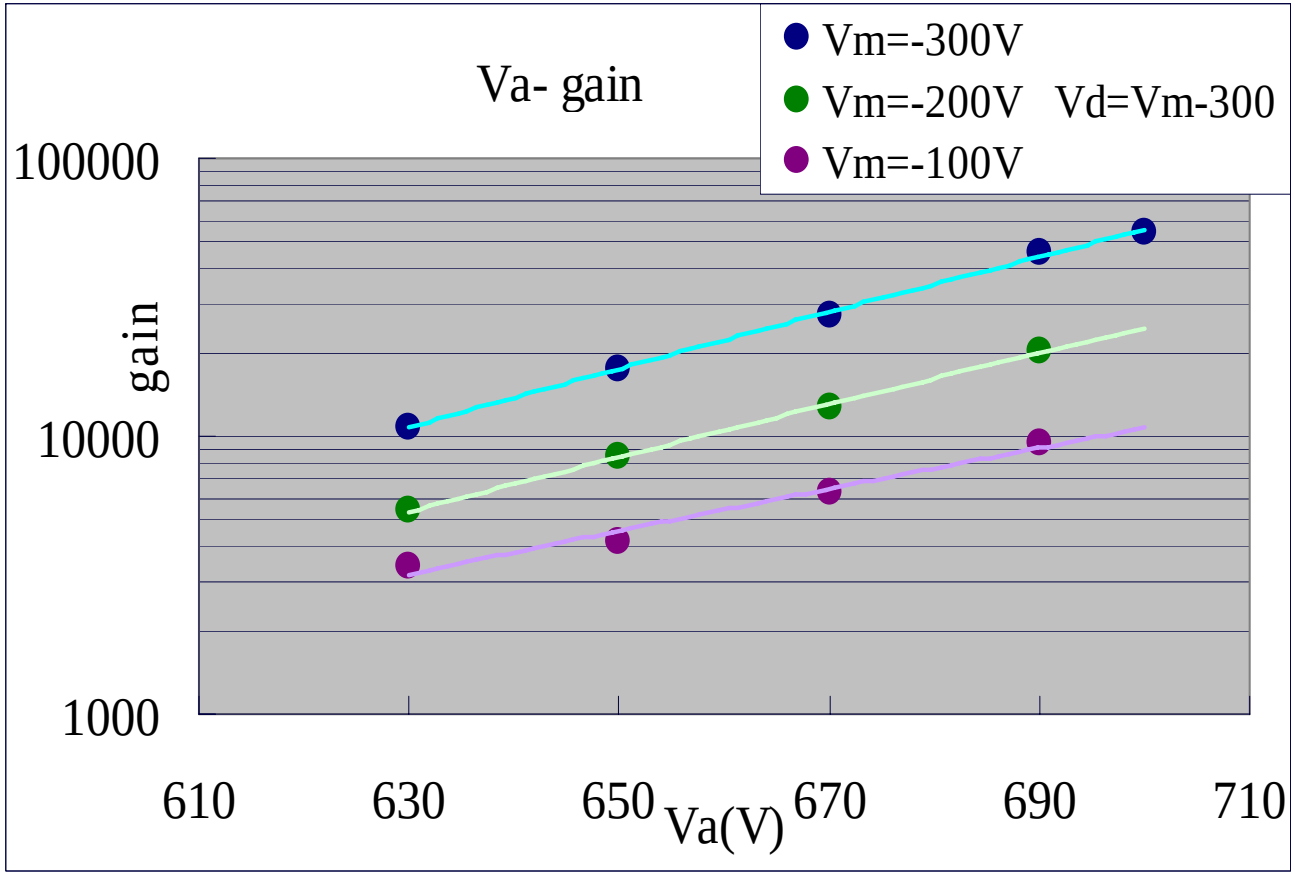




Gain dependence on Vm and Va

- E_drift = 300V/cm
- Maximum gain : 5 x 10^4

Gap of mesh: 165μm
Mesh thickness: 5μm
Gas: Ar:C2H6 = 50:50

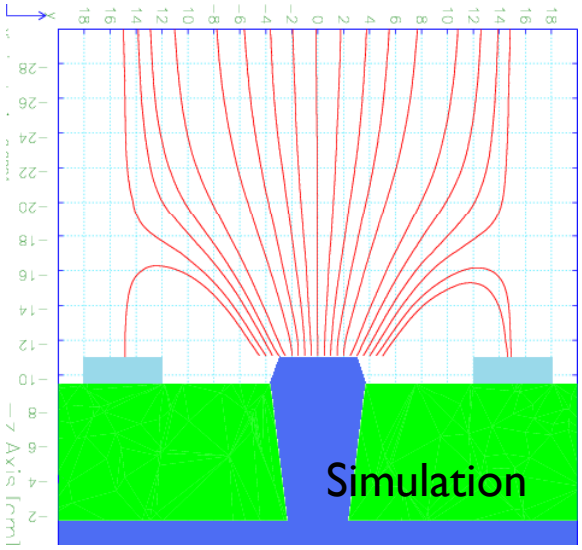


Ion backflow (IBF)

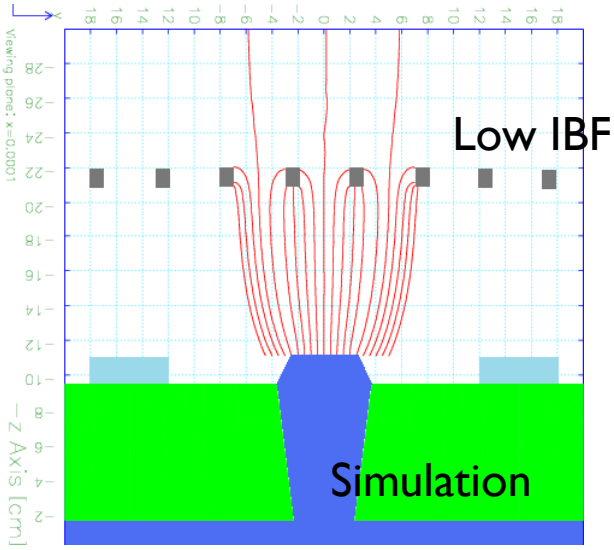
- Ion backflow: The fraction of total avalanche-generated ions reaching to drift region.
- Serious problem for TPC readout

Ion drift lines from anodes

μ-PIC (no mesh)

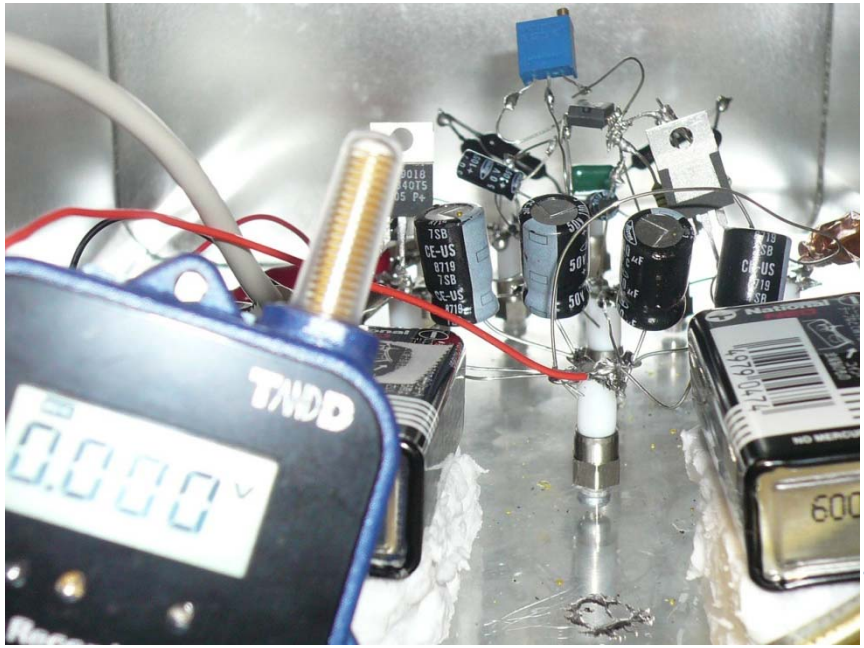


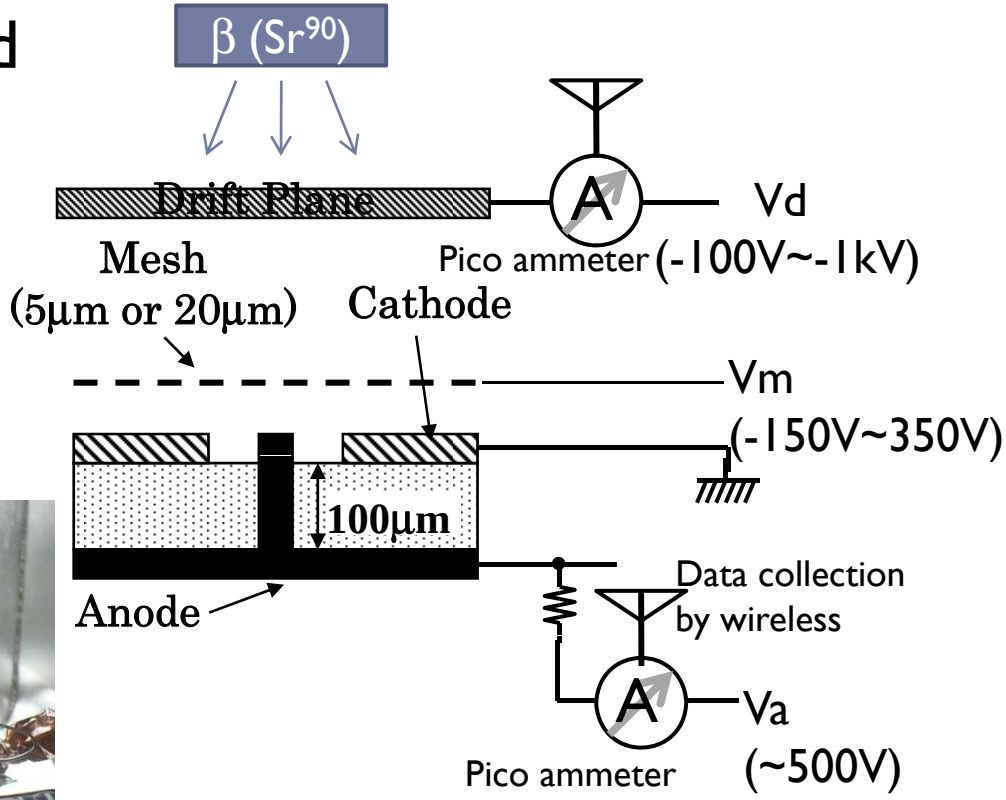
M³-PIC



Setup for ion backflow measurements

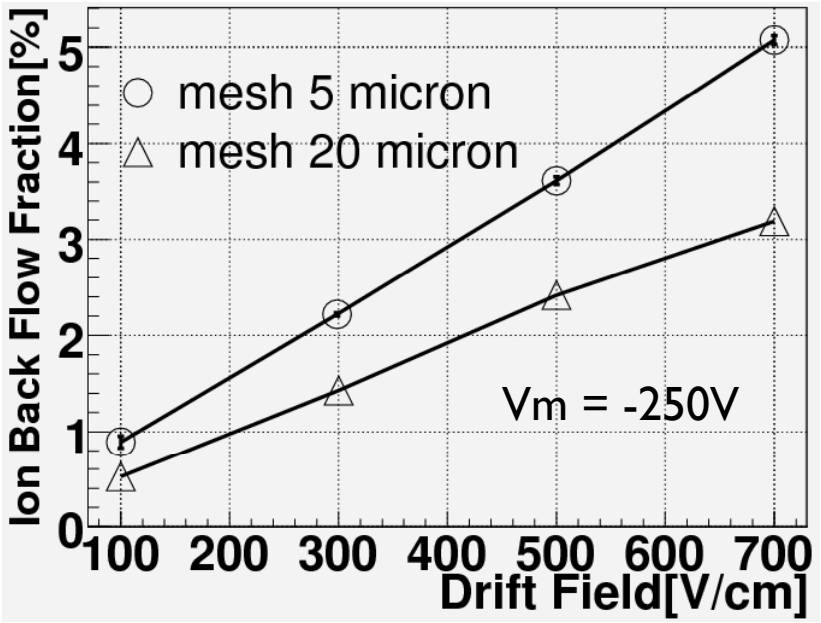
- Pico-ammeter is inserted in Drift and Anode line
- IBF = (I_drift/I_anode)
- Wireless data taking for keeping insulation



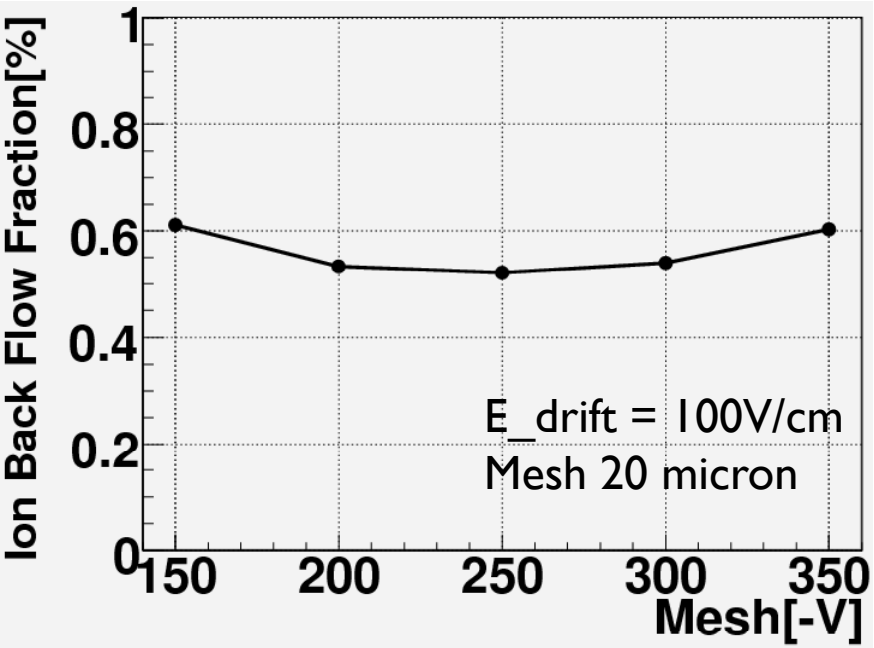


IBF of M^3-PIC

- IBF dependence on drift field and mesh thickness



- IBF dependence on mesh voltage



- Gas: Ar 90% + C_2H_6 10%
- Gain = 10^4 for these tests
- Liner dependence of IBF on drift field
- Small IBF for thicker mesh
- Optimum point of mesh voltage

Minimum IBF = 0.5%

Summary

- New MPGD design: M^3-PIC was developed
  - Combined with μ-PIC and micro mesh
  - Ideal electrical fields are formed around anodes for gas avalanche
- Prototype was manufactured and tested
- Maximum gain of 5×10^4 has been attained at present
  - A few time larger than the gain of simple μ-PIC
- Minimum IBF of 0.5% has been attained at present

Future Prospects

- Optimization of structure parameters (mesh gap, mesh thickness … etc.) and operation parameters (HV, gas etc.)
- Combination with existence large area μ-PIC
  - Testing imaging and tracking capabilities
  - Long term operation test