DEVELOPMENT OF GASEOUS PHOTOMUTIPLIERS WITH MICRO PATTERN GAS DETECTORS

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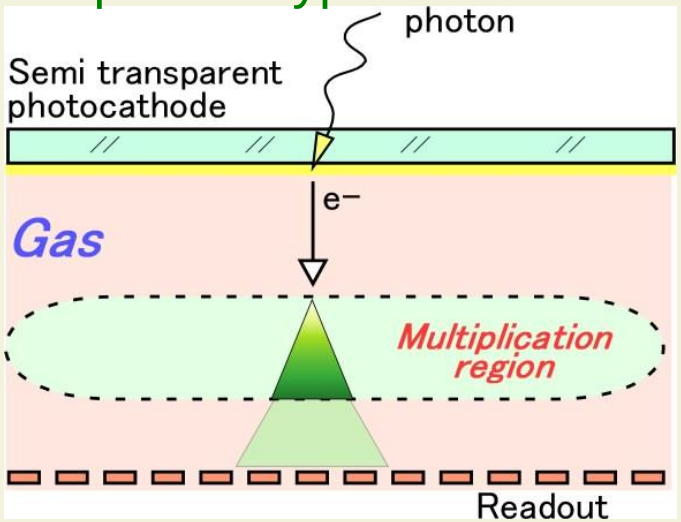
Concept of Gas-PMT

- **Gas-PMT**
  → Photocathode + Micro-Pattern Gas Detectors

Transparent-Type



Photons are converted to electrons by photoelectric effect .

Photoelectrons are multiplied in a high electric field in the gas.

Signals are formed on the anode pads.

- **Glass tubes, electrodes, insulators are same as those used in general vacuum PMTs.**

Advantage of Gas-PMT

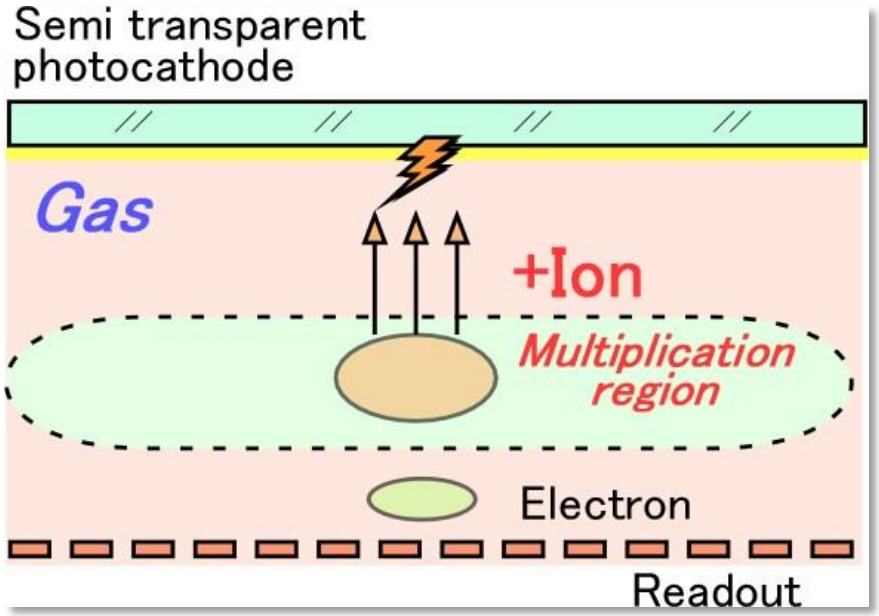
Gas-PMT have many advantages.

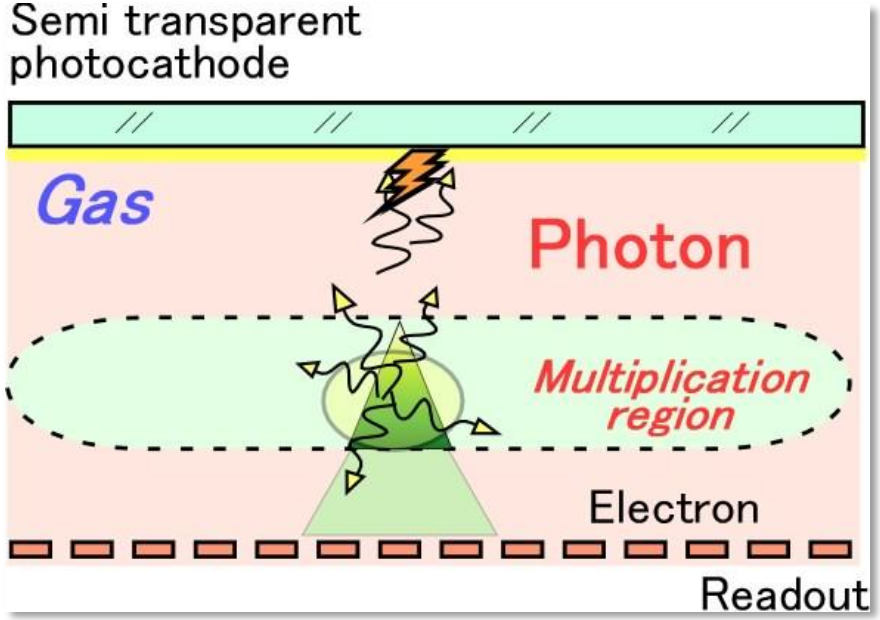
	Q.E.	Δt	B	area	Cost/ch
PMT	○	○	△	△	△
Gaseous PMT	△	△	○	○	○

- Can be operated in a high magnetic field (~1.5T), which enables simultaneous diagnosis with PET and MRI.
- Can achieve a very large effective area with moderate position and timing resolutions.
- Low cost per channel

Ion and Photon feedback issues

There are ion and photon feedback issues.





Can not obtain the expected gains due to these feedback effects.

Maximum obtainable gain by the bi-alikali GasPMT might be less than 1000 due to ion and photon feedbacks.

****goal****

gain : 10^{5}

ion feedback : 10^{-5}

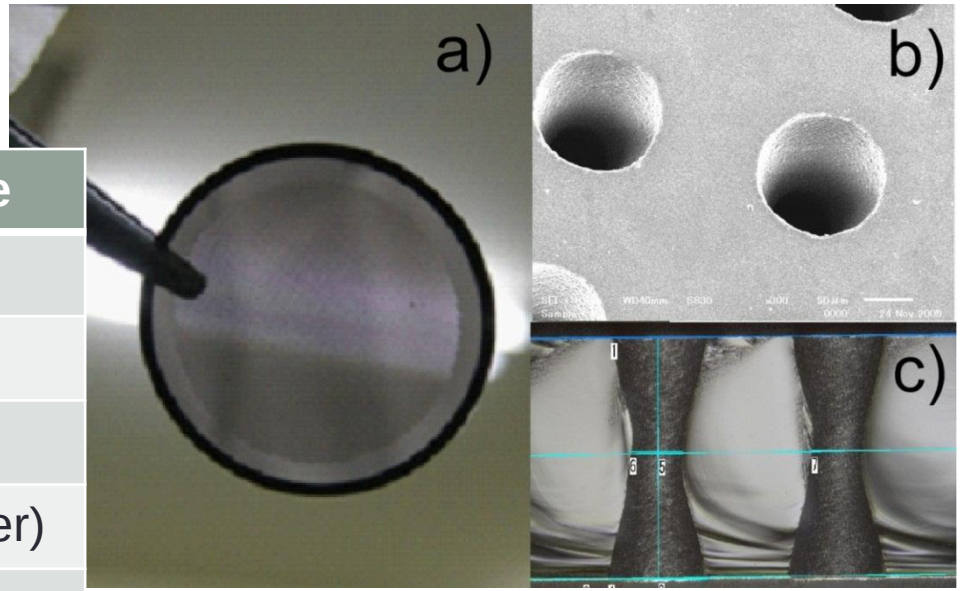
Production of pyrex glass capillary plates

Development of hole type MPGD for Gas-PMT

- **GEM -> glass CP**

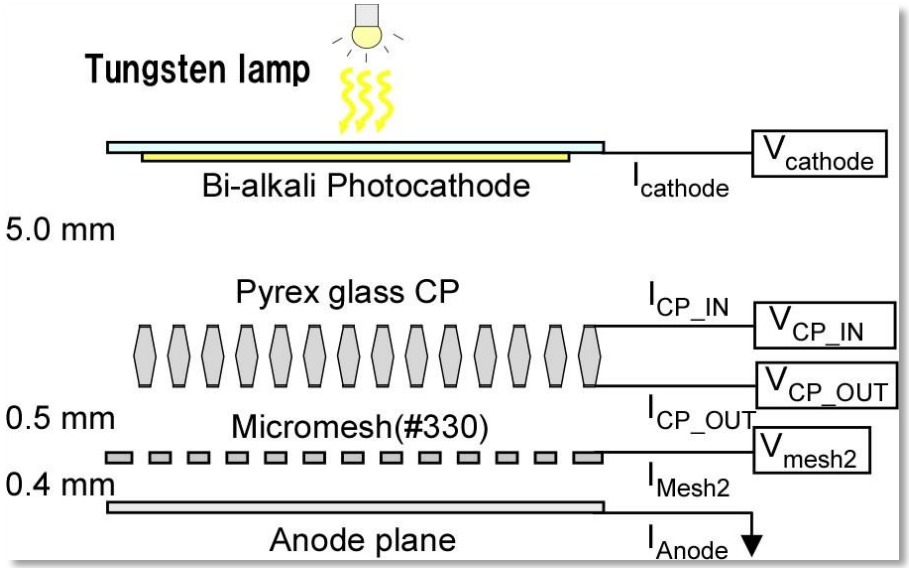
  Material of GEM made chemical reaction with alkali metals used for the photocathode and we could not make a normal photocathode.

Parameter of Microblasted Glass Plate	
Material	Pyrex glass
Size (mm)	26φ~100□
Thickness (mm)	0.3
Channel Diameter (μm)	120/60 (center)
Pitch of channel (μm)	230
Electrode Material	Al (1μm)



Made by a new production Method :
Sandblasting (Microblasting)

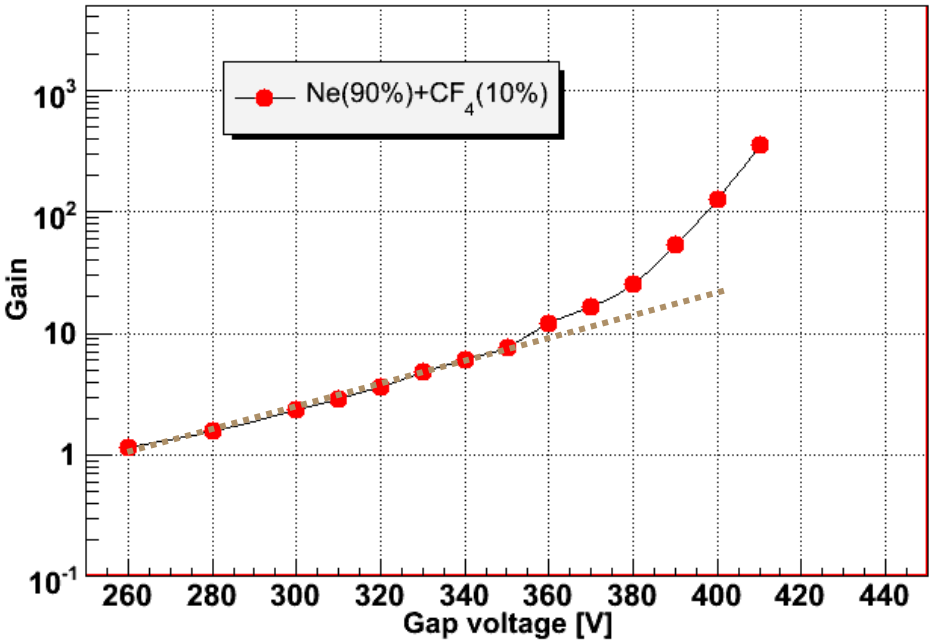
Development of Gas-PMT with bi-alkali photocathode



- **No change in the resistance of CP after the evaporation of bi-alkali metals.**

-> Don’t observe any induction of chemical reaction seen in with Kapton-GEM.

Gain of the Gas-PMT with bi-alkali PC



Clear deviation from exponential line was observed at Gain~10.

As reported by Mörmann et al (2003)

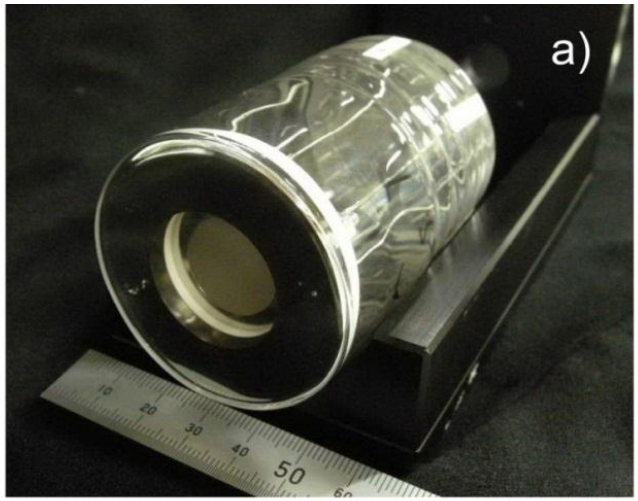
Due to ion and photon feedback.

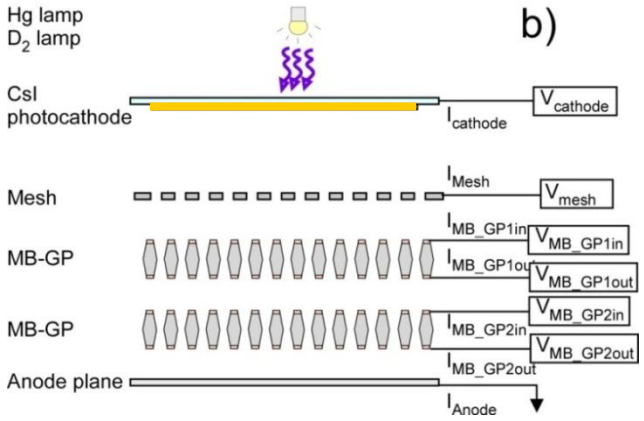
Since work function of bi-alkali photocathode is lower than CsI photocathode,
effects of ion feedback are much severe for bi-alkali case.

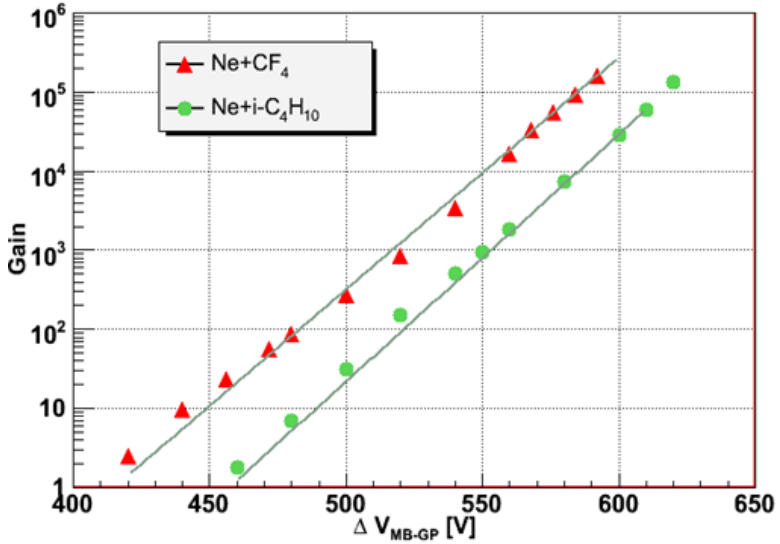
-> More efficient suppression of ion and photon feedback is required for a visible light Gas-PMT.

Development of Gas-PMT with glass CP and CsI photocathode

CsI photocathode is resistant to the photon feedback.
-> Can obtain high-gain and only see ion feedback issue.





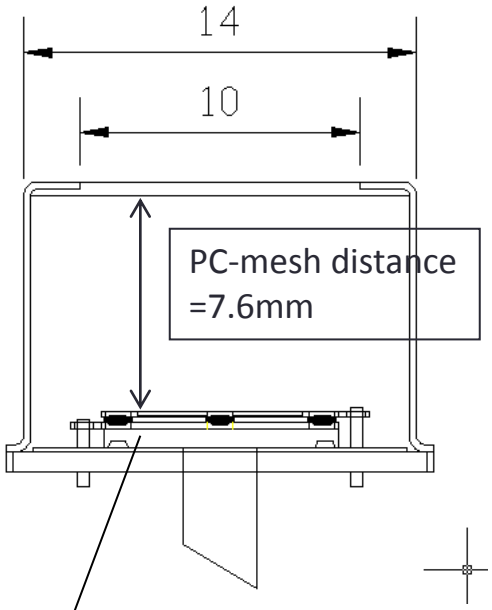


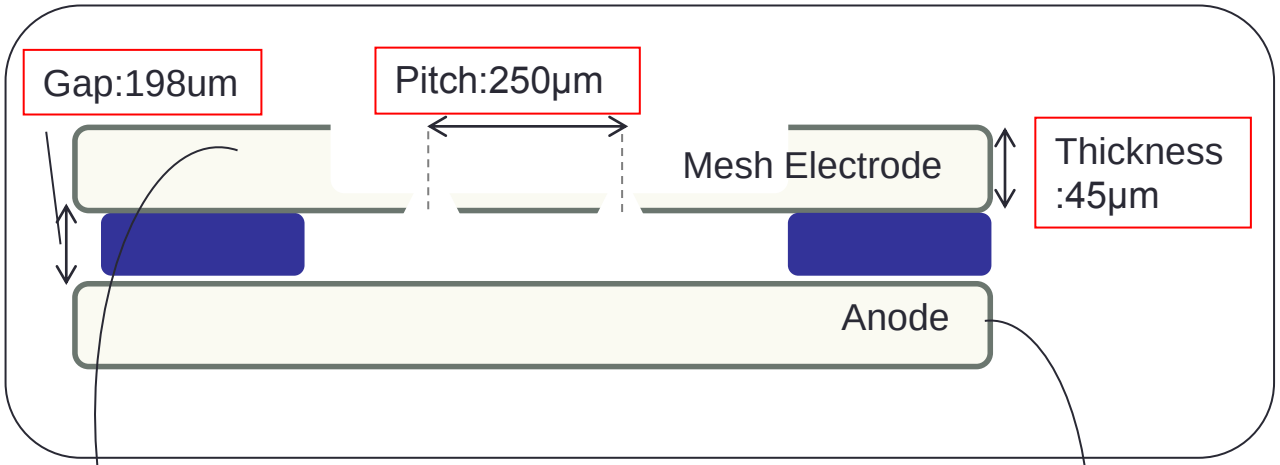
For Ne + CF_4, the gain of 10^5 was obtained at the applied voltage of 590 volts and for Ne + i-C_4H_{10}, at 620 volts

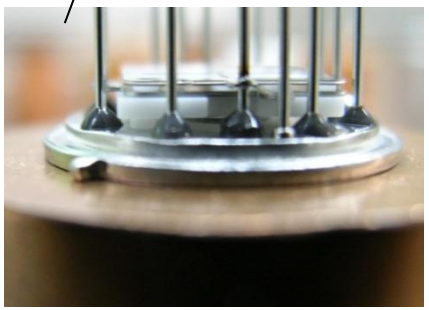
Ni mesh suppresses ion feedback effect.
->ion feedback ~ 7.9%

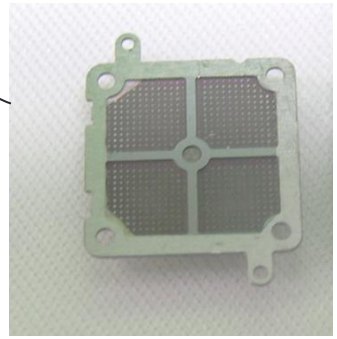
Estimated from current increases at the anode and photocathode as changing the gap voltage.

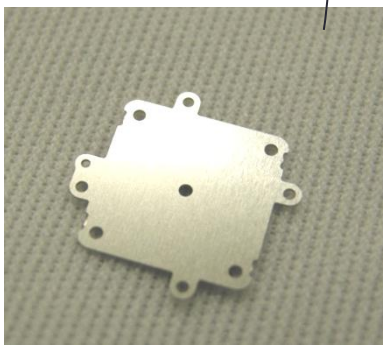
Structure of the Gas-PMT with Micromegas









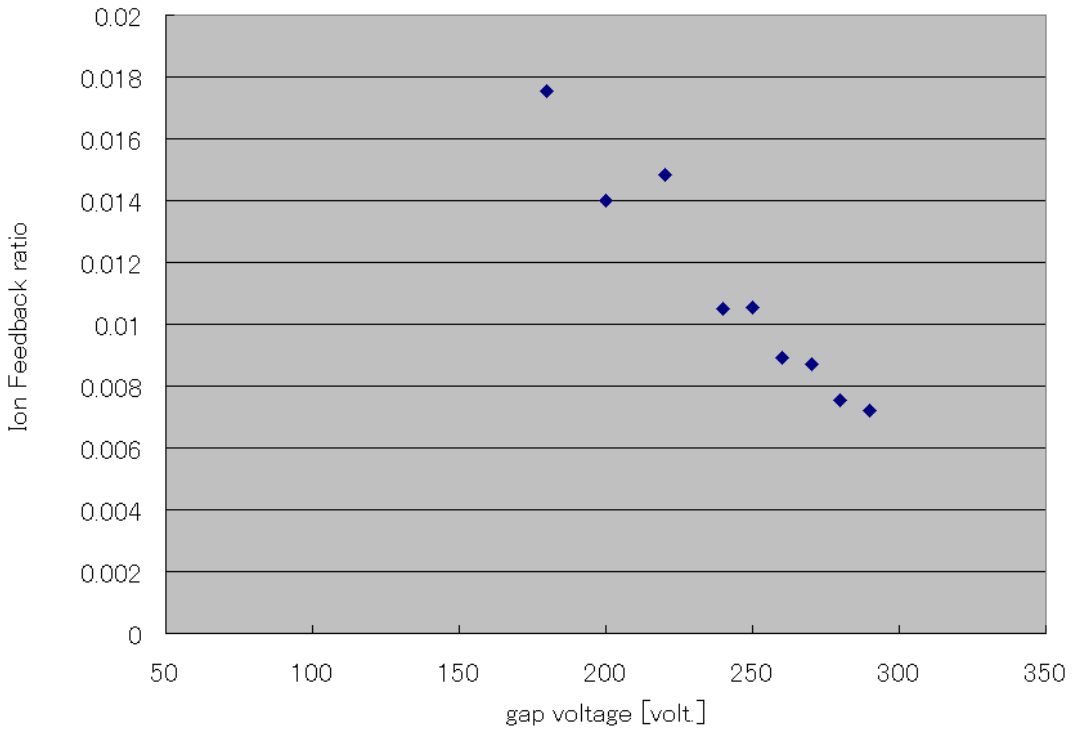


Development of Gas-PMT with Micromegas

- Micromegas that can effectively suppress ion feedback.

Ion feedback of Gas-PMT with Micromegas

- Ion feedback rate ~ 1% - experimental value

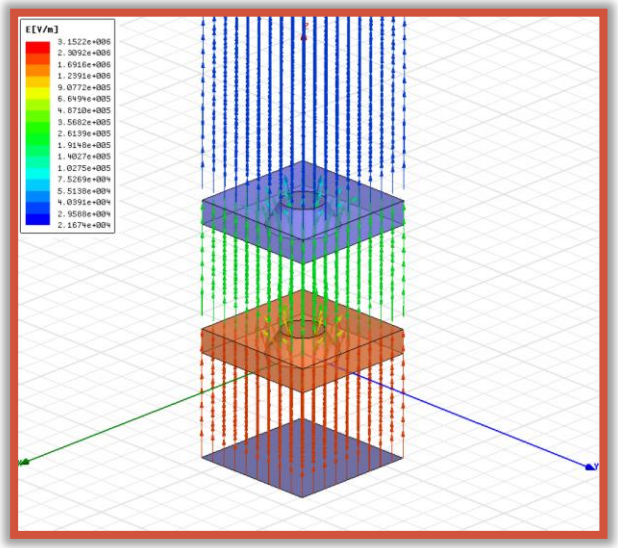


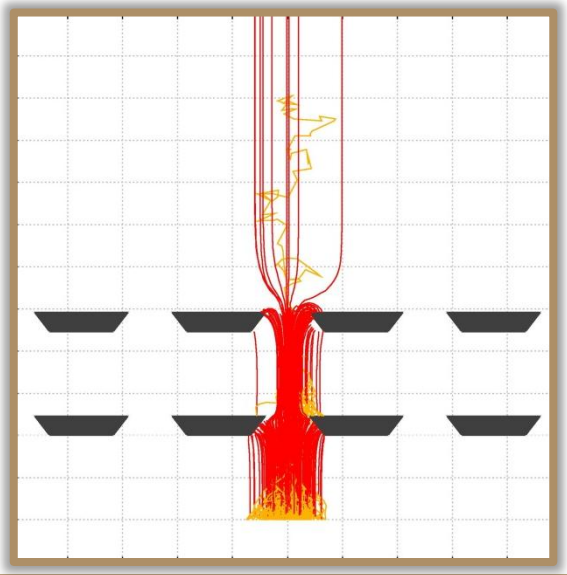
- **Can we further reduce ion feedback rate?**
  - **Research this issue using simulation**

Simulation tools - Maxwell & Garfield

Maxwell

- Maxwell is the electromagnetic field simulation software
- Input the geometry of Micromegas or glass CP, then calculate the electric fields.

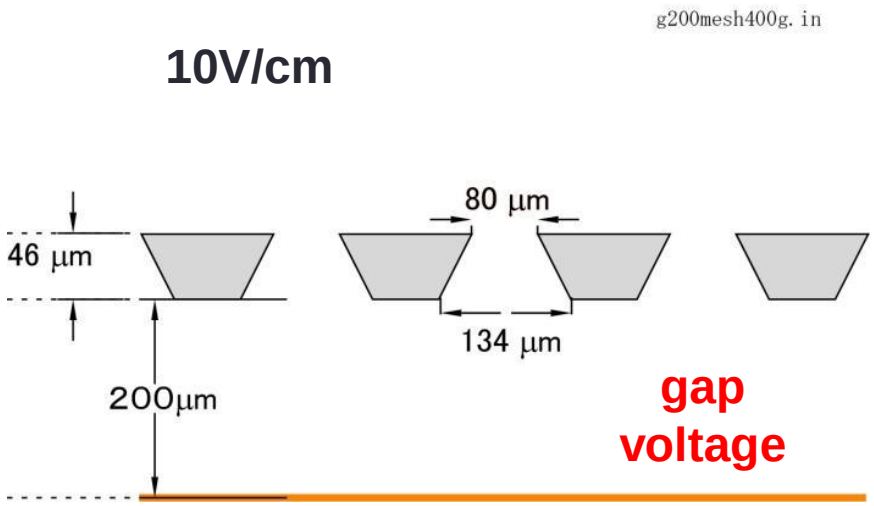


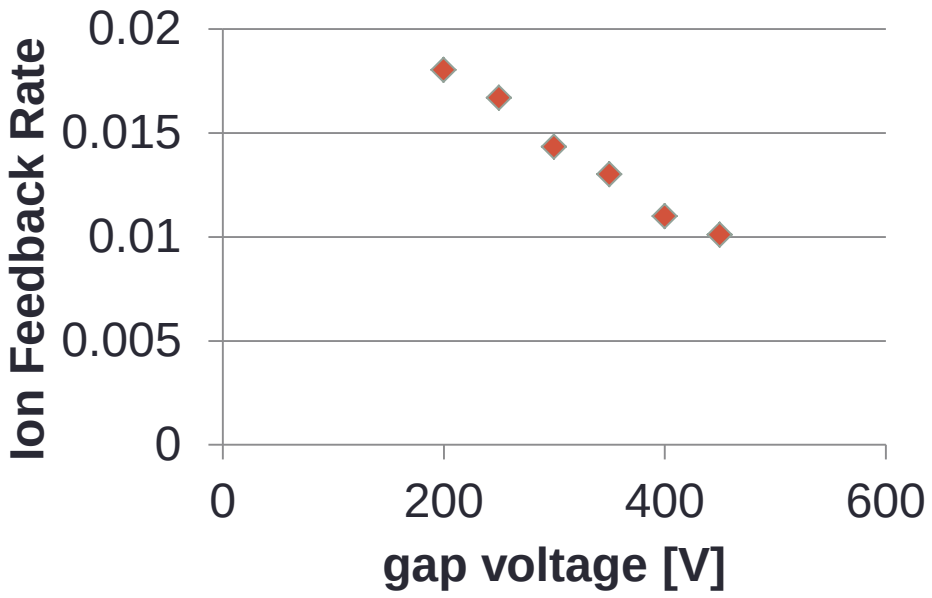


Garfield

- Trace the drift of electrons and ions in the electric field calculated by Maxwell.
  (Gain and rate of ion feedback can be obtained)

Single Micromegas

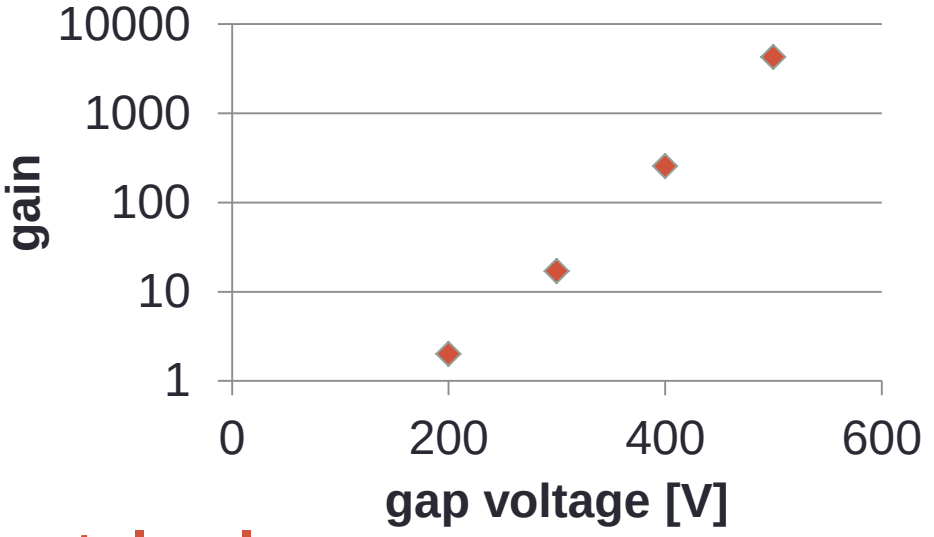




Ion feedback Rate = I_{fb} / I_{tot}

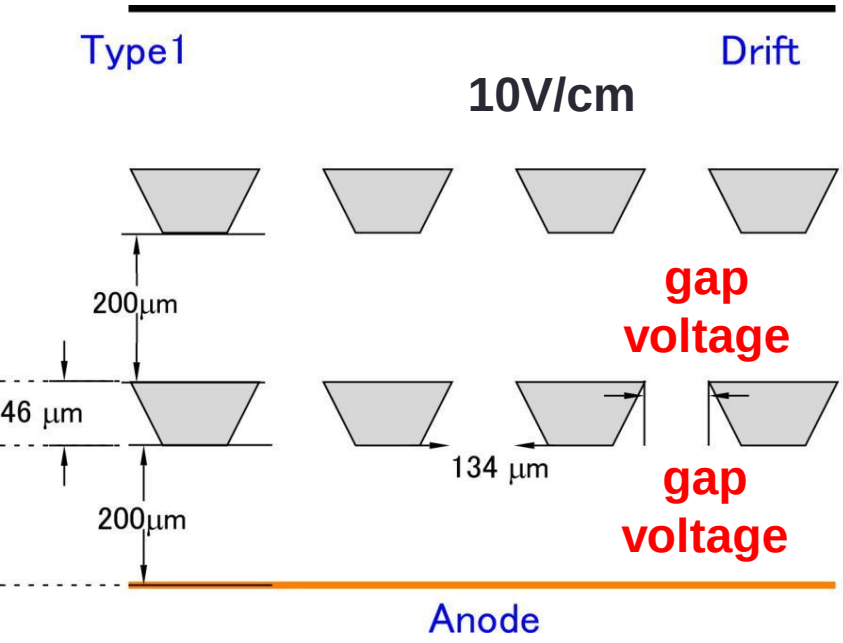
- I_{fb} : Number of ions which reach photocathode
- I_{tot} : Number of ions created

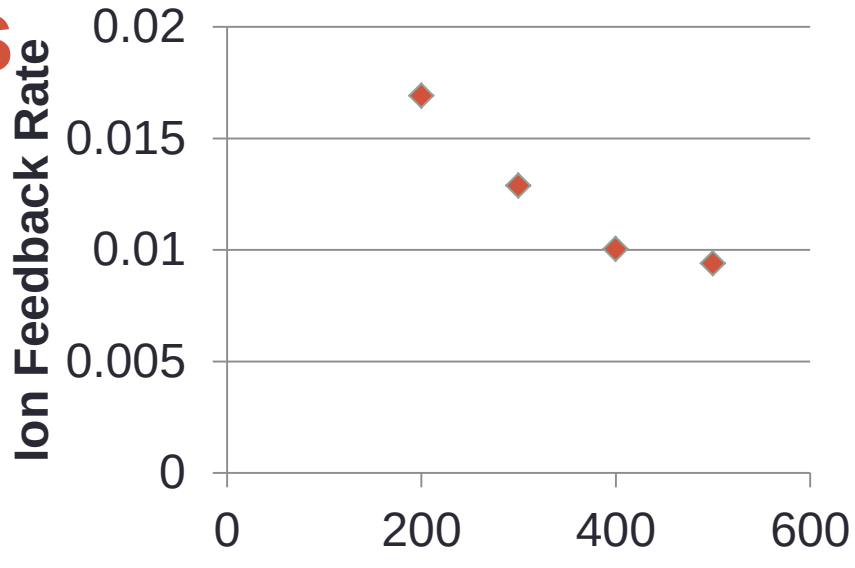
- **ion feedback ~ 1%**
- **gain ~ 10^3**

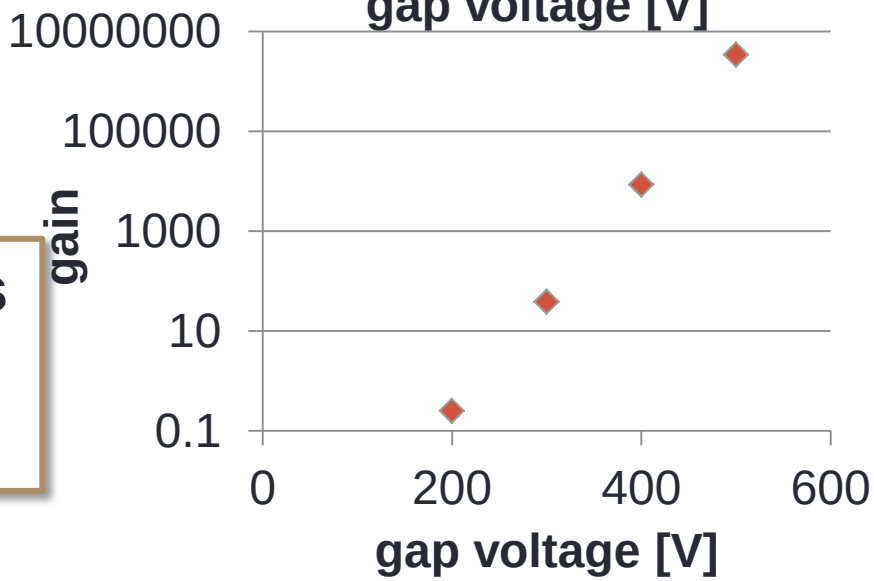


-> Consistent with the experimental value

Double Micromegas





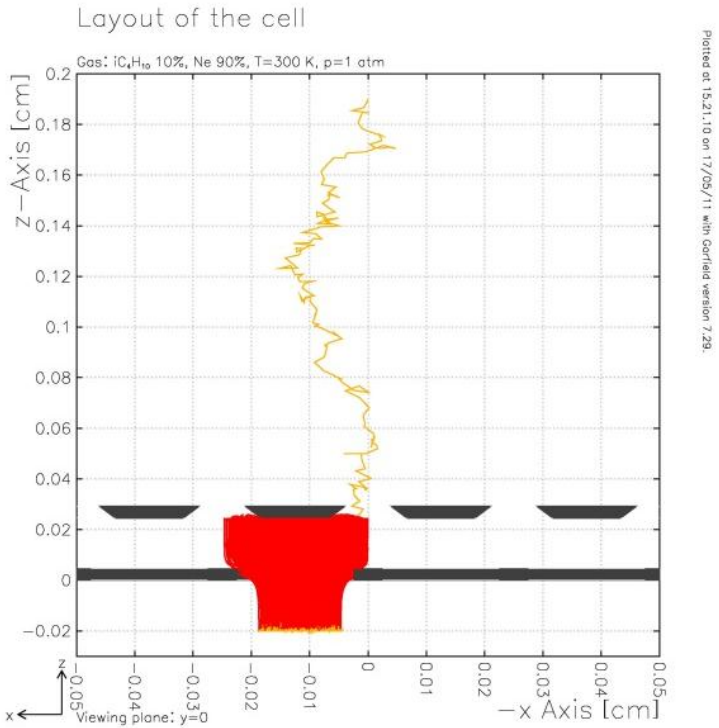


- Ion feedback rate is same as the single Micromegas ~ 1%
- Gain is larger ~ 10^5

-> Need to suppress ion feedback further more

Improved structure of Double Micromegas

Reference : Ion back-flow gating in a micromegas device
NIM A 623 (2010) 94-96



- **ion feedback < ~10^{-5}**
- **gain ~ 10^5**

(Ne:i-C_4H_{10}=9:1, 1atm)

Using this kind of structures, a Gas-PMT with high-gain and well suppressed ion feedback can be developed.

Summary

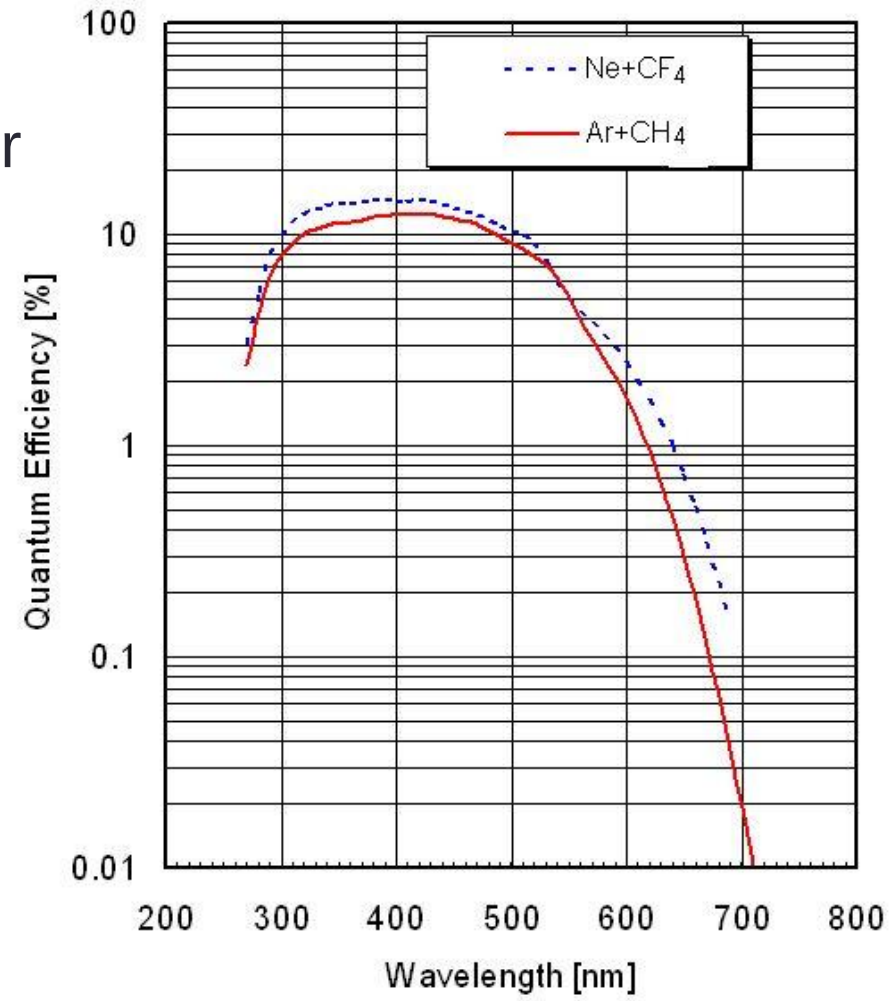
- Gas-PMT with CsI and bi-alkali photocathodes coupled with MPGD is under development.
- Pyrex glass CP produced by microblasting is a good candidate as a hole-type MPGD for a visible light Gas PMT. But Clear deviation from exponential line is observed.
  -> Ion and photon-feedbacks.
- CsI photocathode with glass CP was tested.
  ->10^5 gain was obtained with less feedbacks.
- Micromegas PMT was tested
  ->ion feedback ~ 1%
- Using simulation, a Gas-PMT having a new structure of double Micromegas was tested.
  ->gain~10^5
  ->ion feedback < ~ 10^{-5}

BACK UP

Quantum efficiency in the gas

The measured quantum efficiencies are almost same for Ne gas and Ar gas.

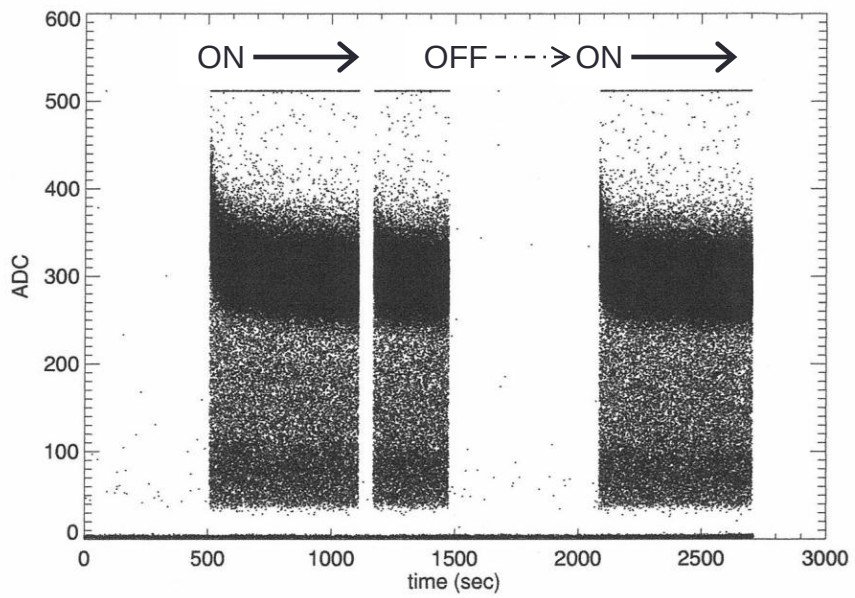
Maximum obtained QE;
In Ne gas 14% （@350nm)
In Ar gas 12% （@420nm)
(in Vaccum 20%)



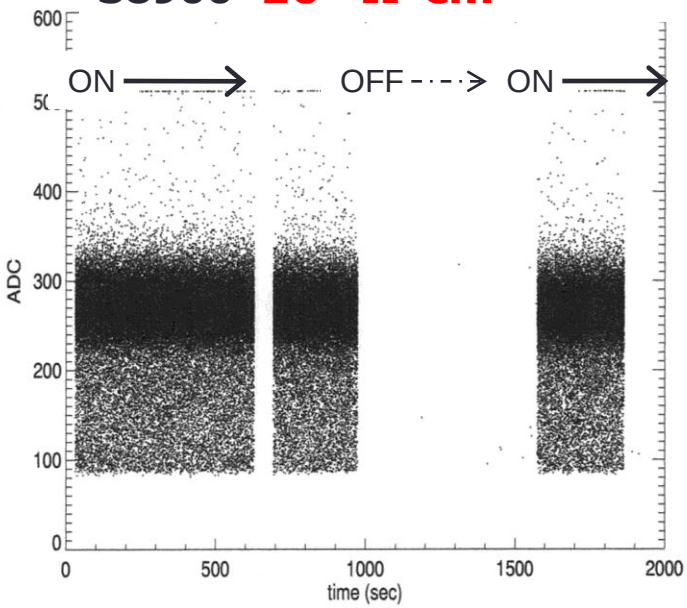
Gain stability of Gas-PMT with pyrex CP

Gain stability of a pyrex glass CP Gas PMT was compared with that of S8900 CP.

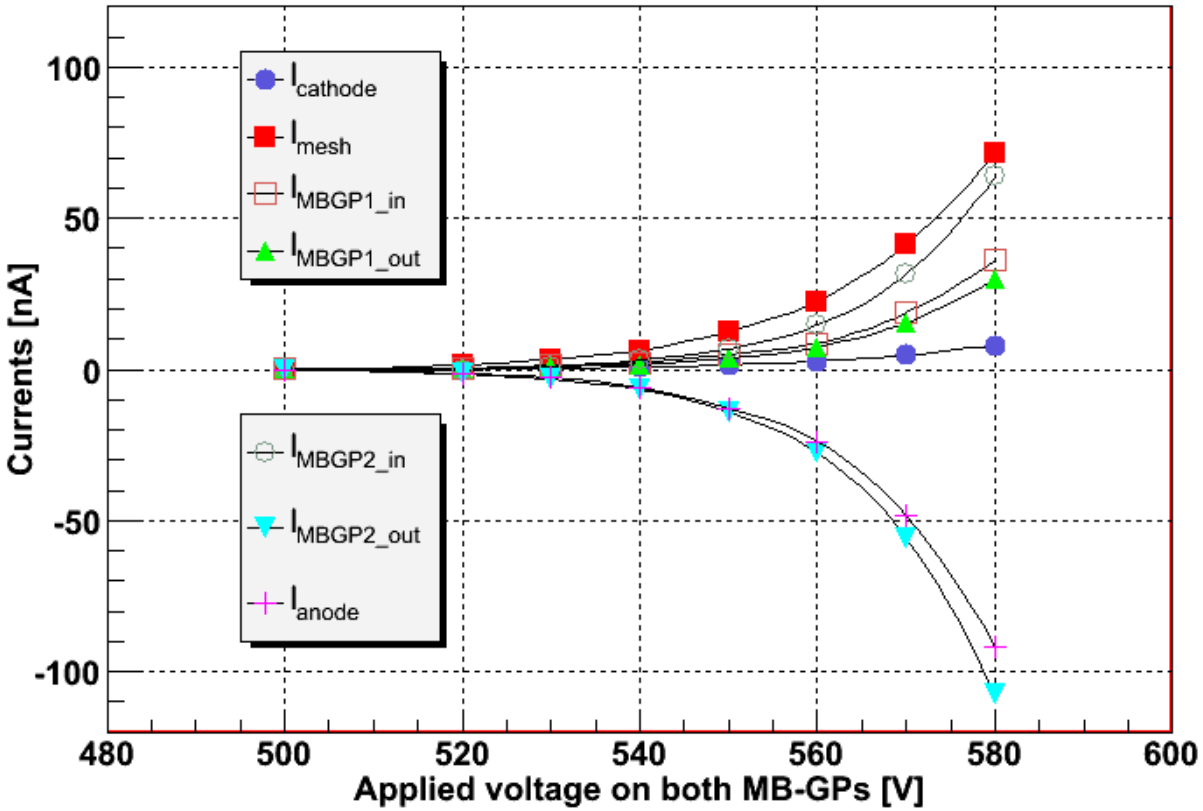
Pyrex glass $10^{14}\Omega\cdot cm$



S8900 $10^{11}\Omega\cdot cm$



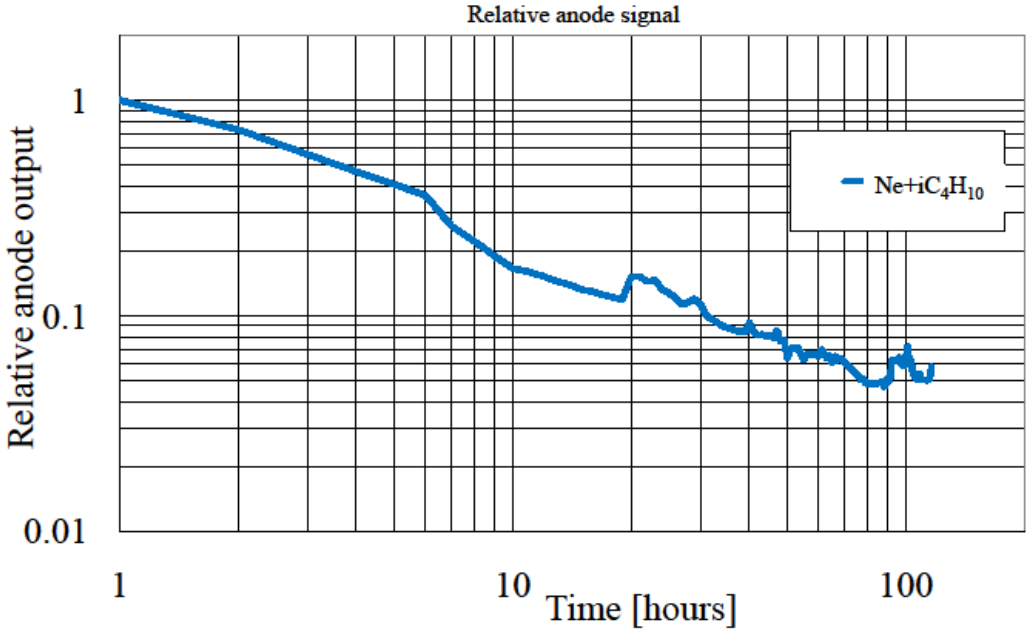
Measurement of ion feedbacks

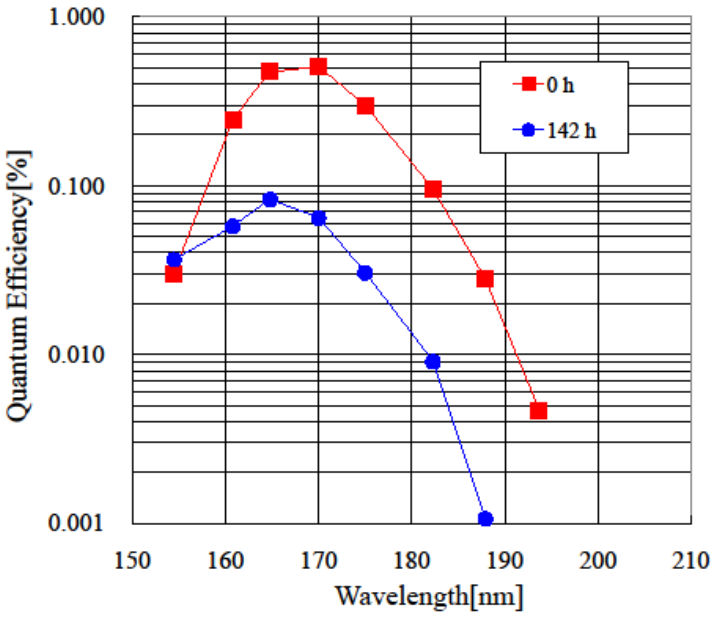


- This value estimated from current increases at the anode and photocathode.

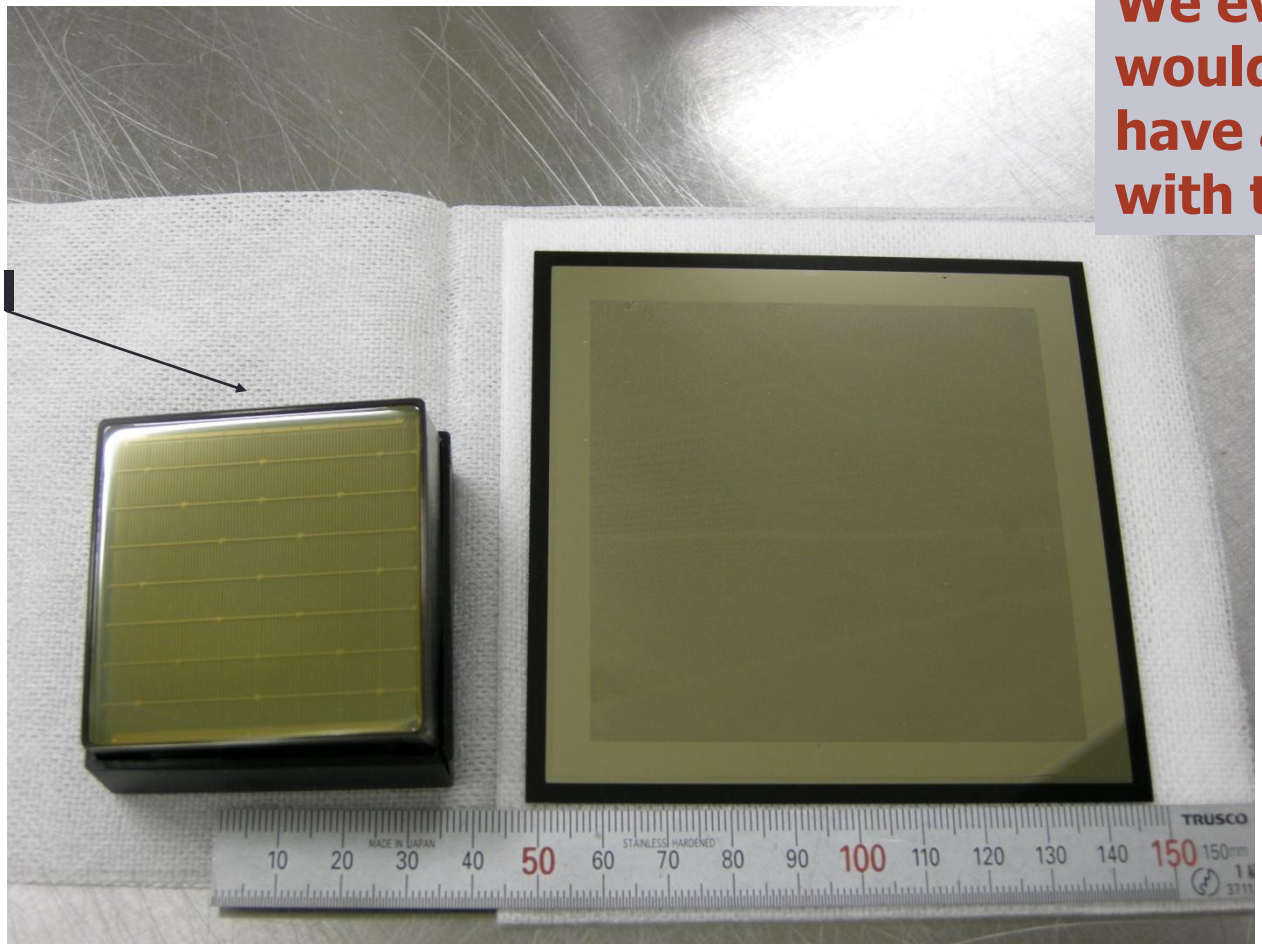
Aging of the CsI photocathode

- After 8 hours of operation:
  accumulated anode charge >110 mC/mm^2
  80% decrease of the signal current
- The accumulated charge on the CsI photocathode:
  estimated to be 9.9 mC/mm^2,
  with ion feedback of 7.9%





H8500D Flat Panel PMT



We eventually would like to have a Gas PMT with this size