Recent progress in gaseous PMT

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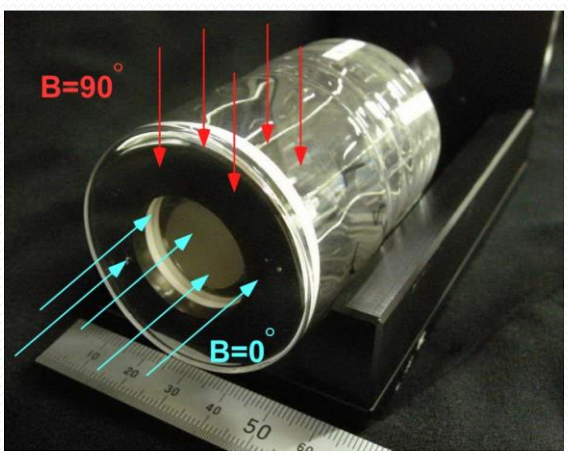
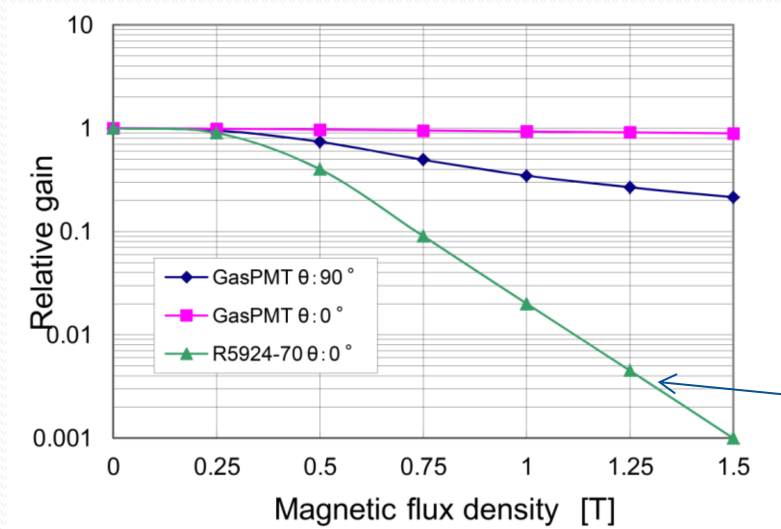
- **Contents**
  - Merits of Gas PMT
  - Quantum efficiency in gas mixtures
  - Ion and Photon Feedbacks
  - Long time operation of the Gas PMT
  - A new type of double mesh structures
  - Development of a flat pixel detector
  - Summary

Merits of Gas PMT

Sensor type	Sensitivity	Position Resolution	Timing Resolution	Uniformity	Price	Magnetic Field	Effective Area
Vacuum PMT	◎	△	◎	△	○	△	○
CCD / CMOS	△	◎	×	◎	△	◎	×
Gaseous PMT	○	○	○	○	◎	◎	◎



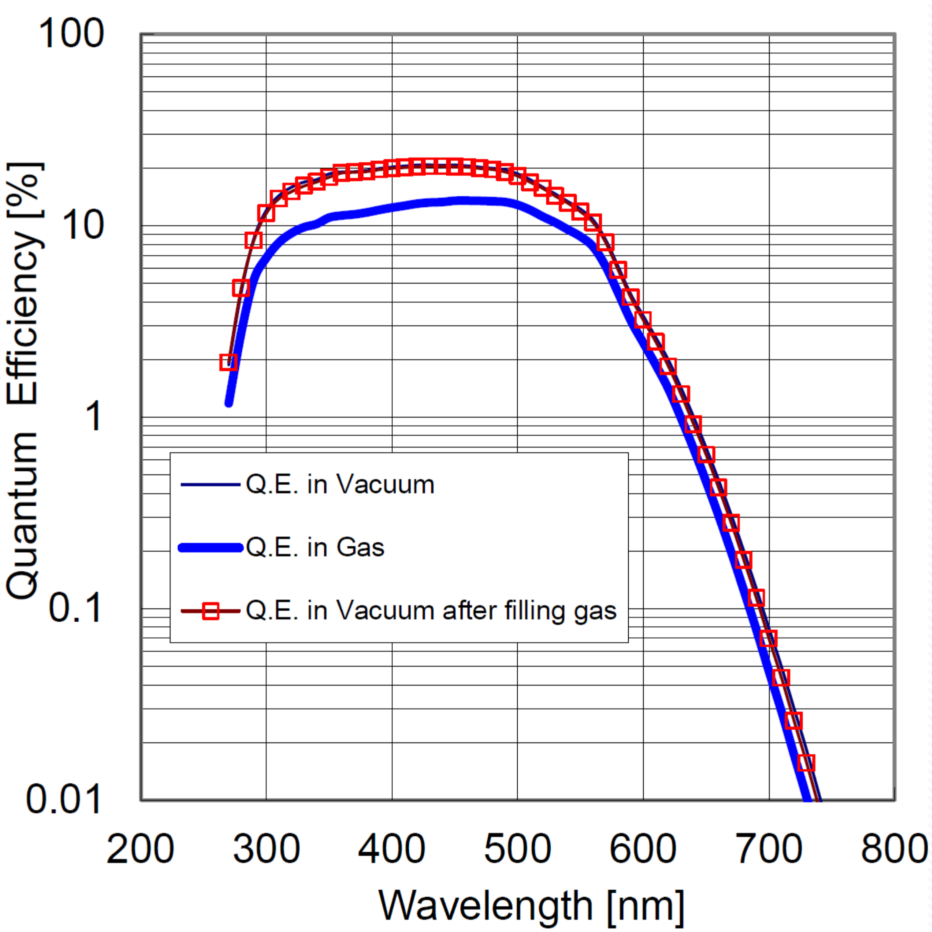


Almost immune to magnetic field

Fine-mesh Dynodes PMT

QE in gas mixtures

Bi-alkali Photocathode in Ar(90%) + CH_4(10%) 0.9 atm

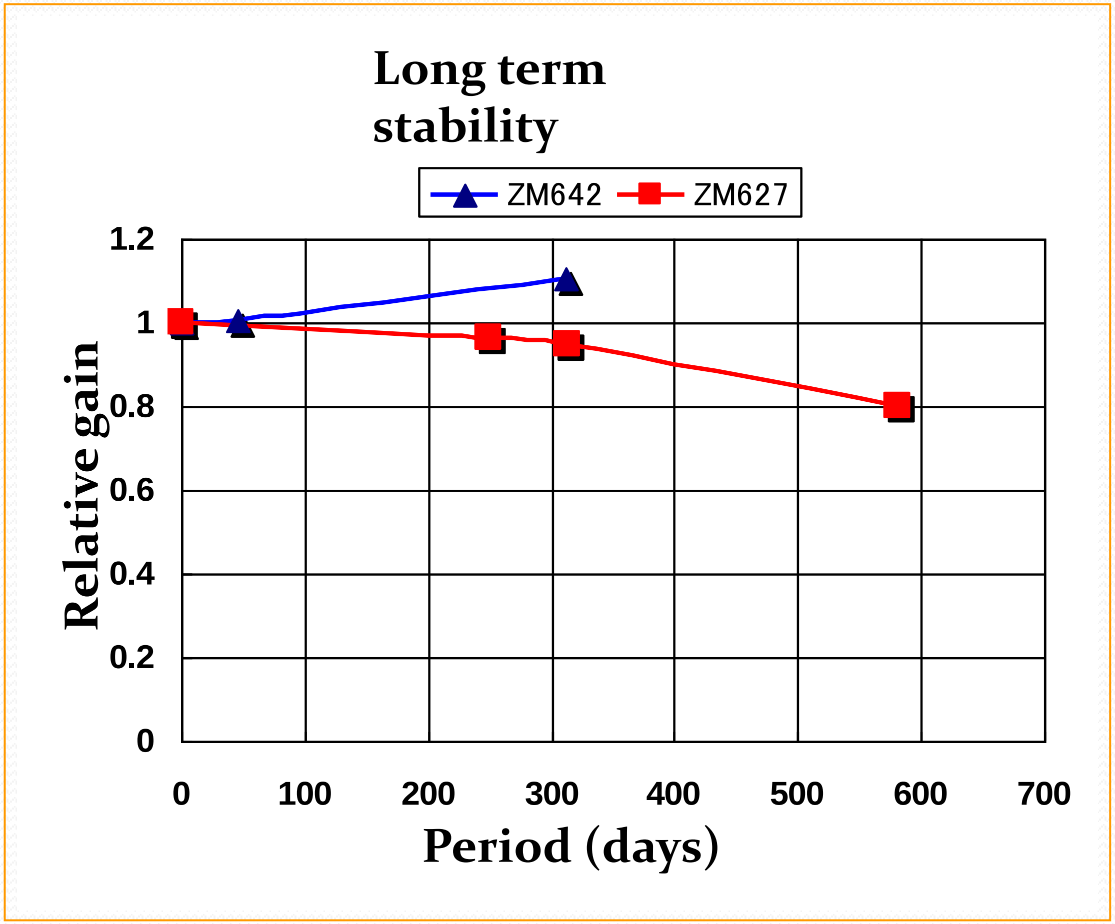


QE in vacuum ~20%

QE in the gas ~12%

After evacuation QE recovered to ~20%.

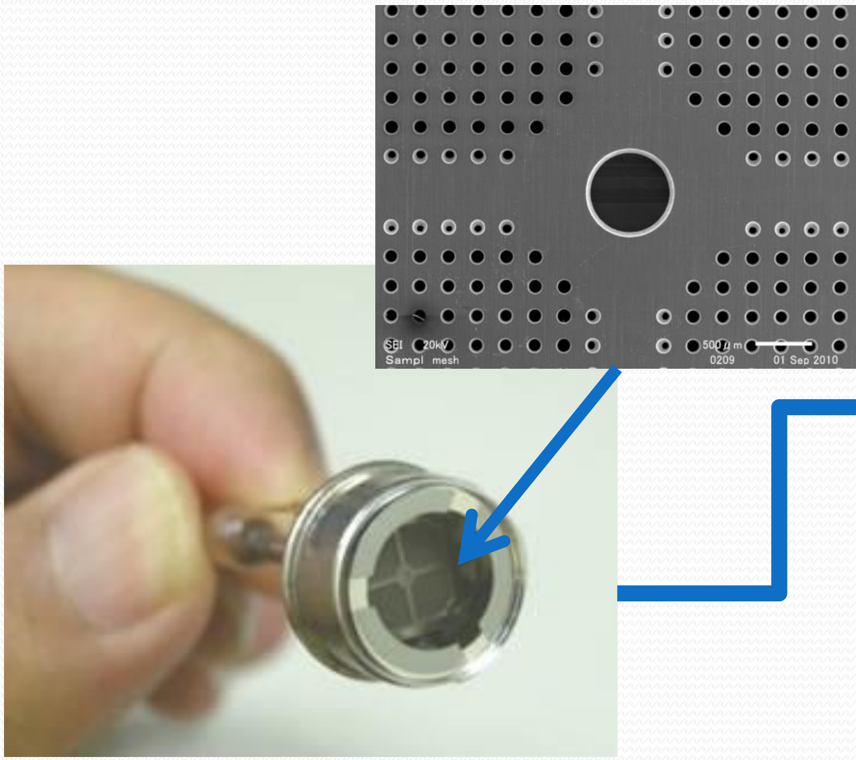
Stability of PC in Ar+CH_4 gas

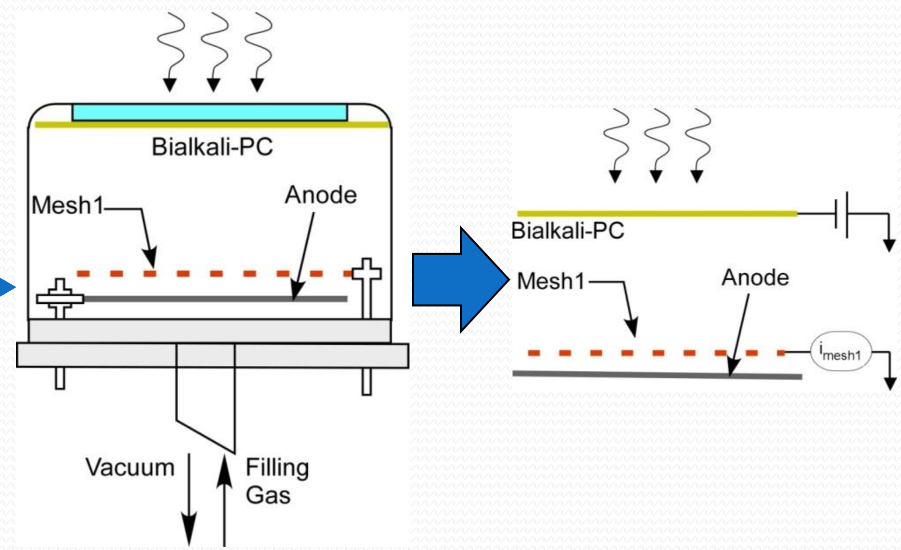


QE maintains almost the same value after 581 days in gas.

Not continuously illuminated.

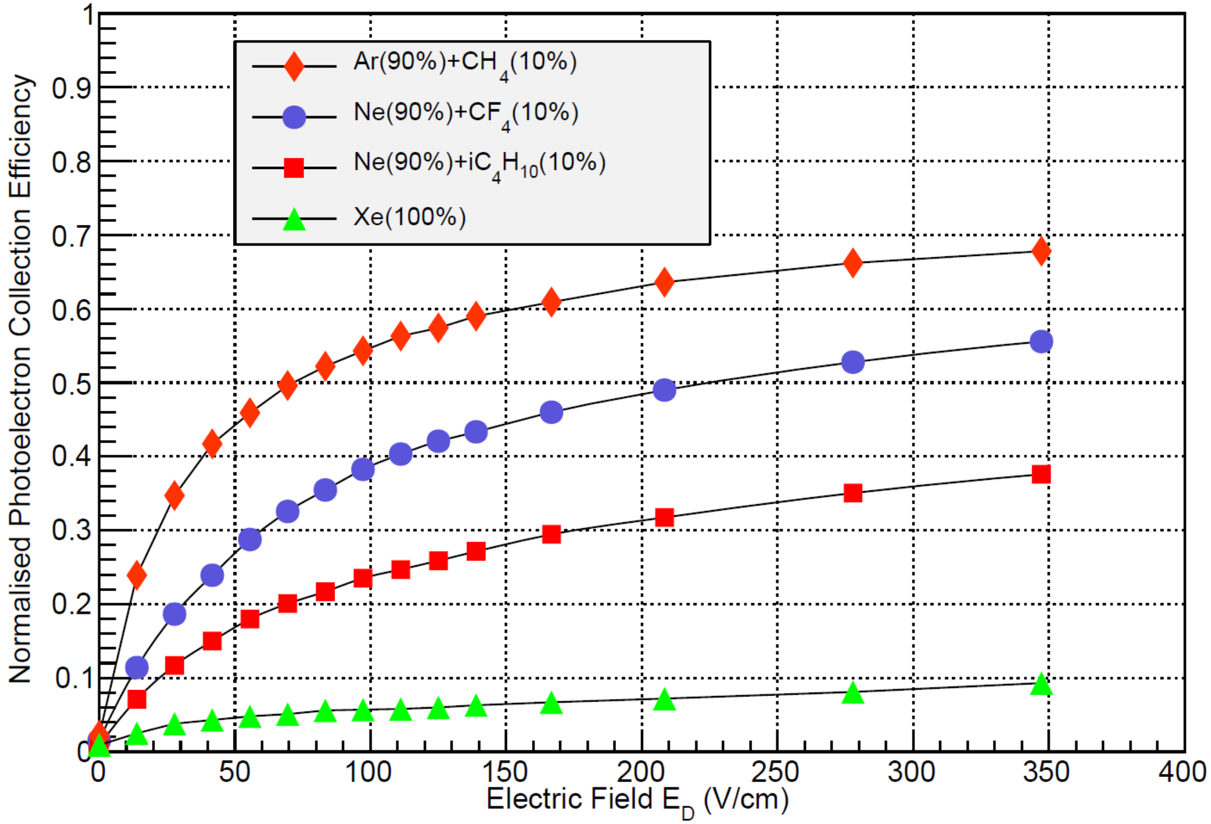
Collection efficiency of photoelectrons in various gas mixtures



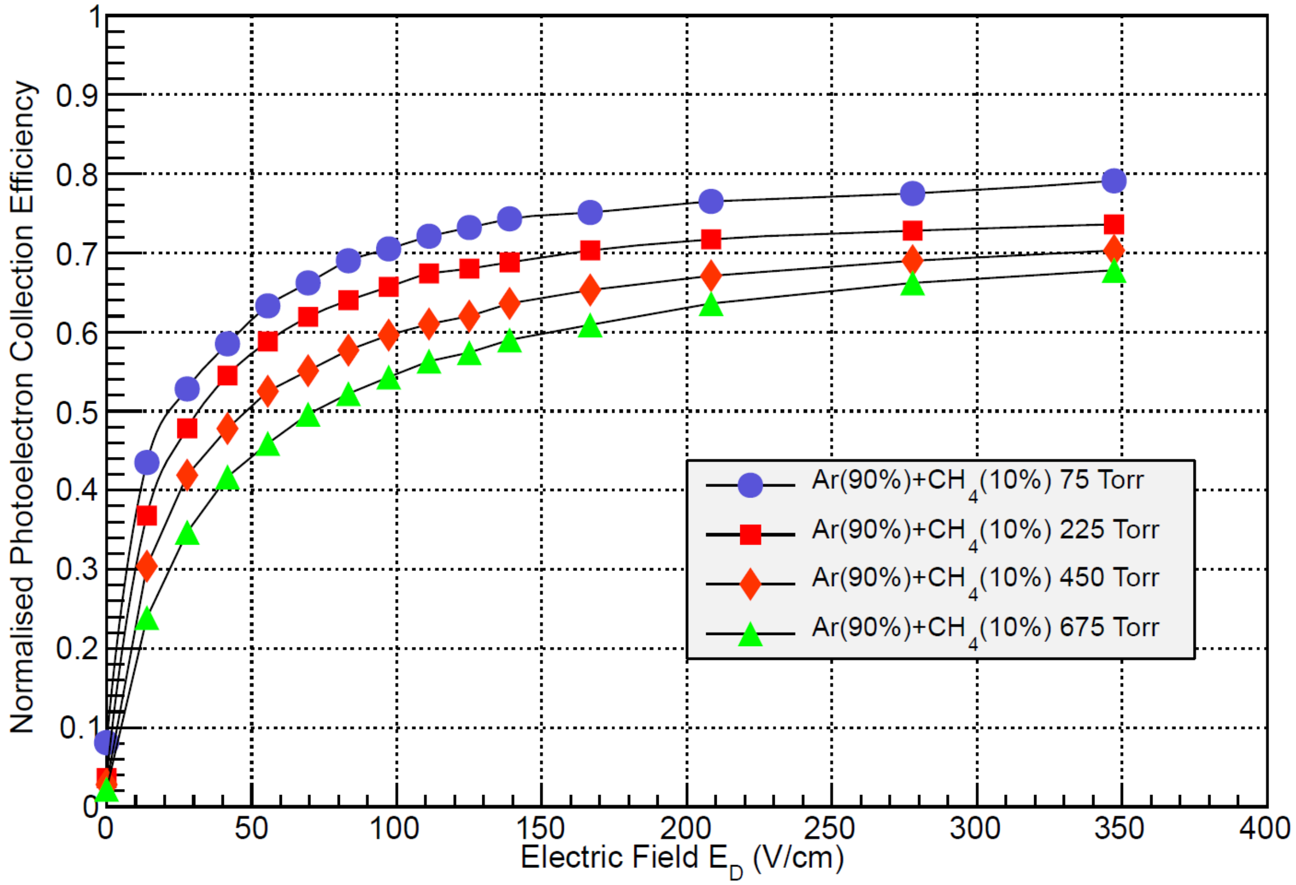


$$Collection\ Efficiency = \frac{Mesh1\ Current(gas\ mixture)}{Mesh1\ Current(vacuum)}$$

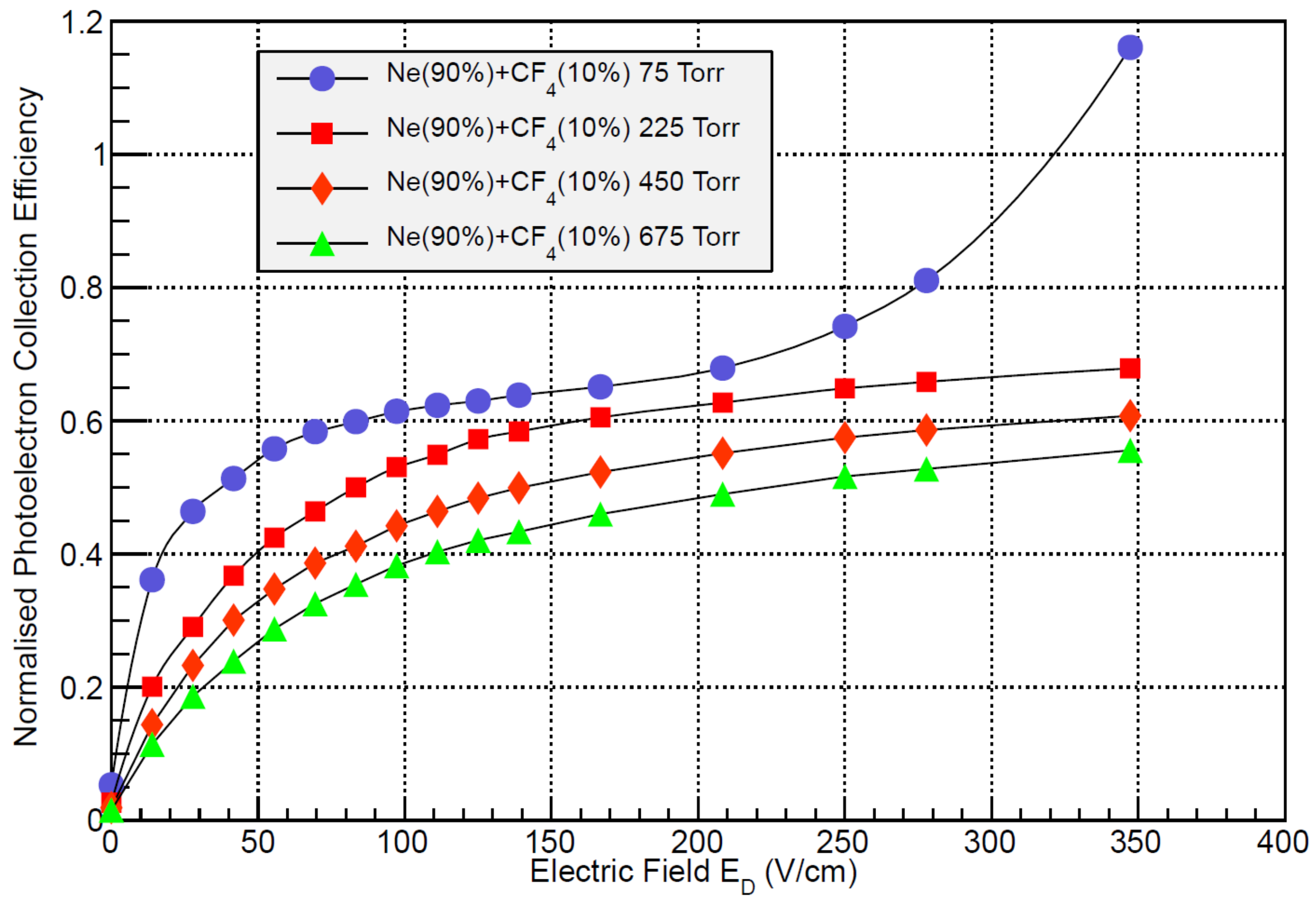
Photoelectron collection efficiency in gases



Collection efficiency for Ar+CH_4 gas

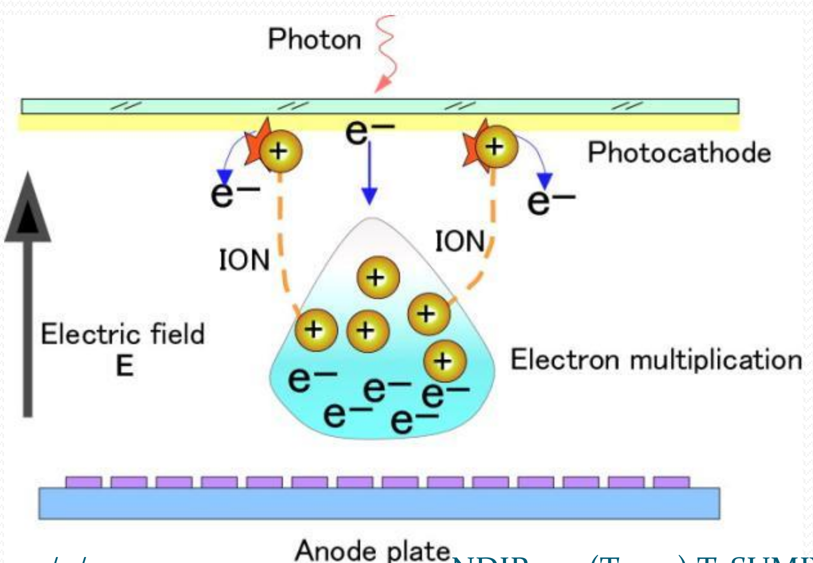


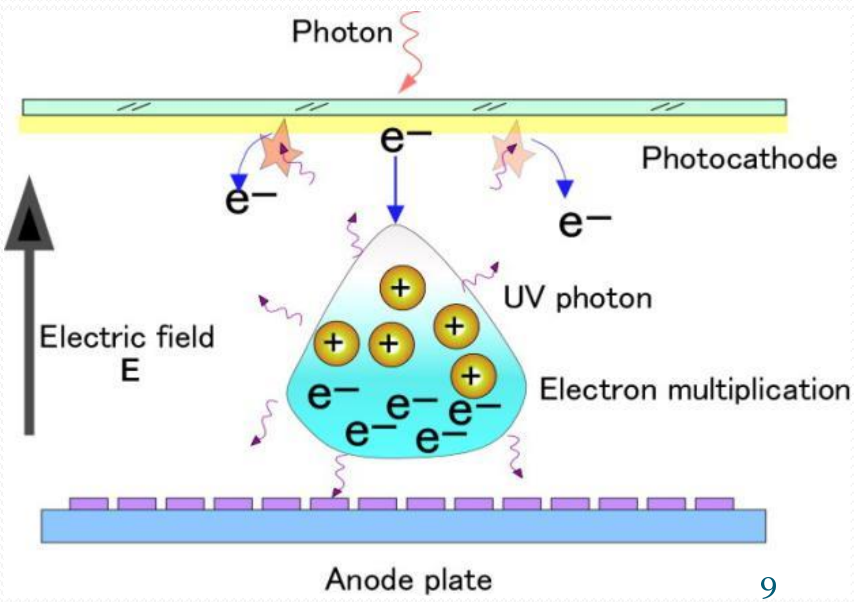
Collection efficiency for Ne+CF_4 gas



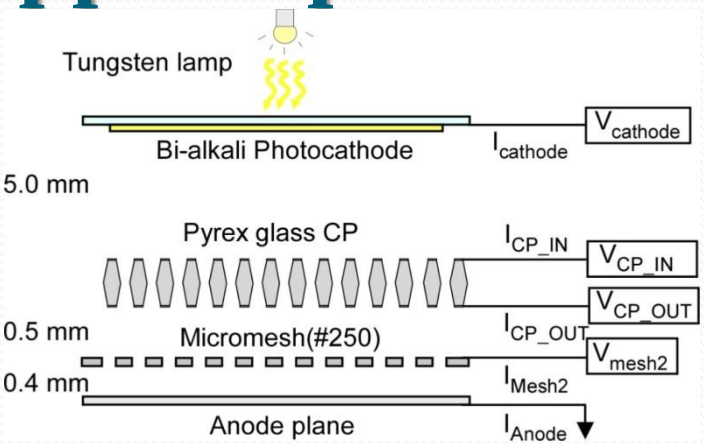
Possible problems: Ion and Photon Feedbacks

- During amplification process in avalanche, a lot of electrons and ions are produced together with many UV photons.
- Ions and UV photons can hit photocathode.

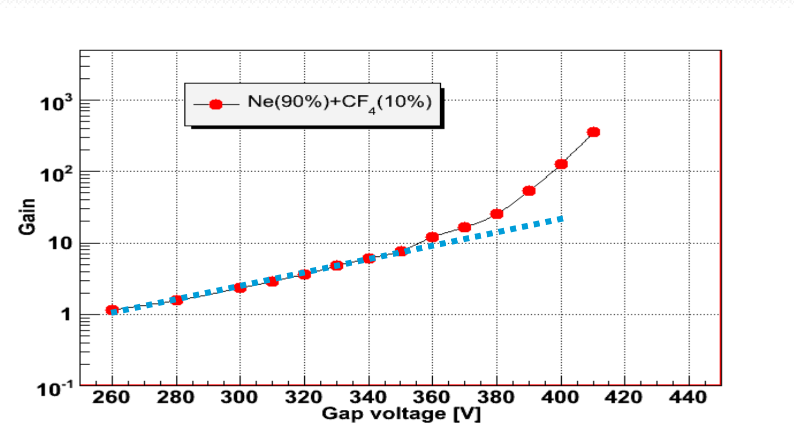


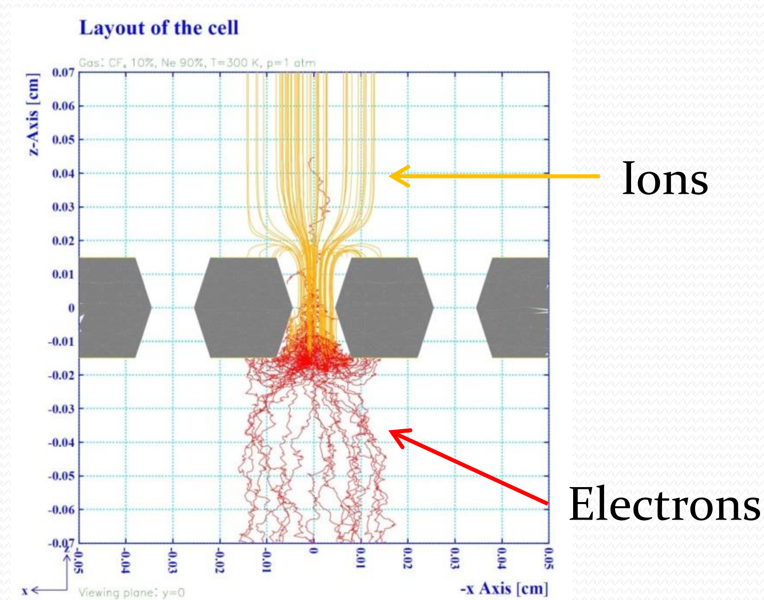


Suppress photon feedback



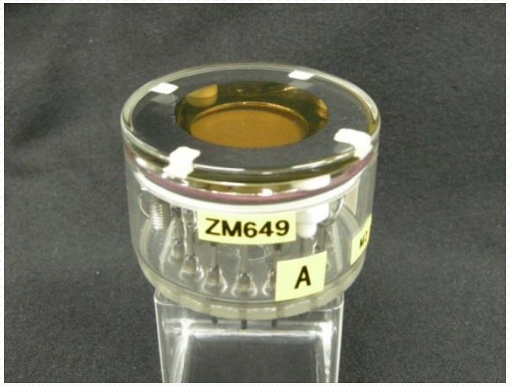
Glass CP may reduce Photon Feedback.
But ion back flow rate is 0.3 in this case.

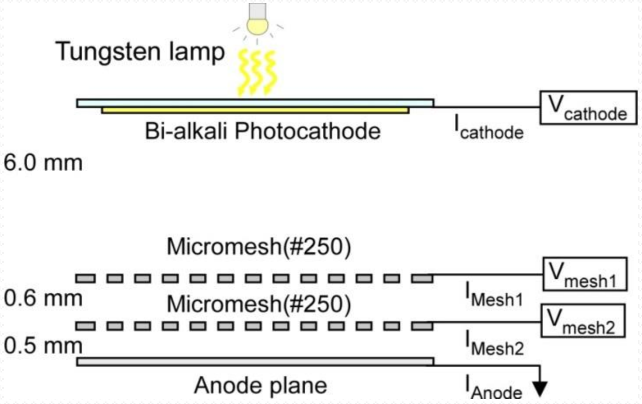


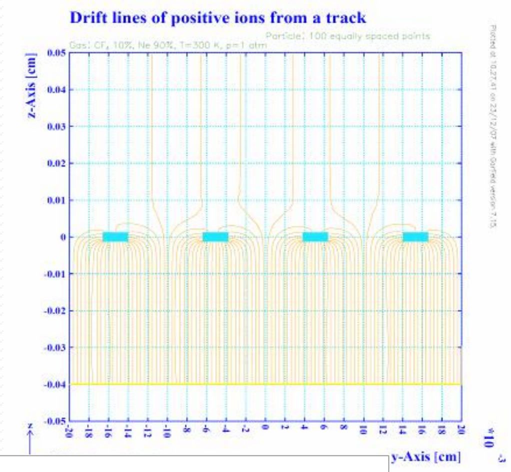


Suppress ion feedback

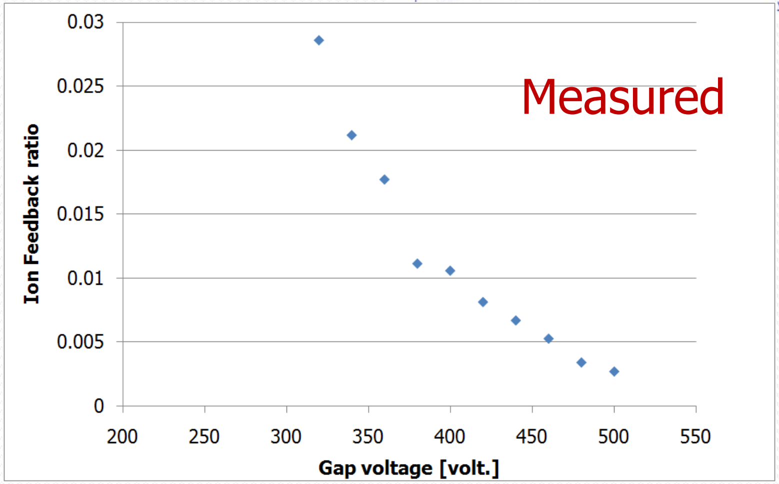
- Mesh electrode (Micromegas) absorbs ions efficiently.



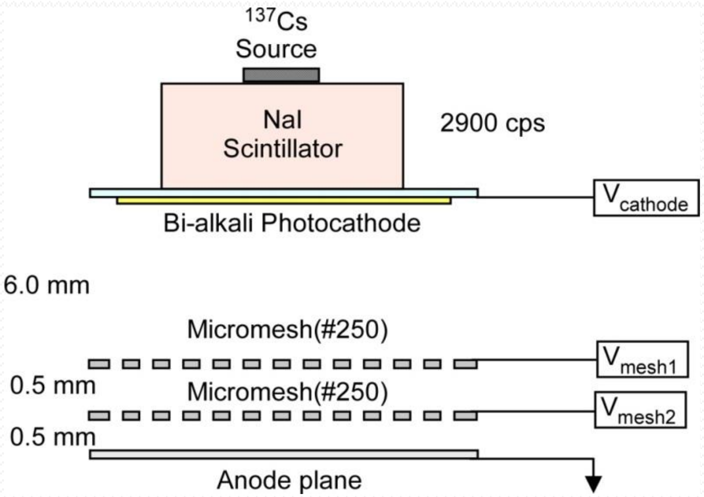




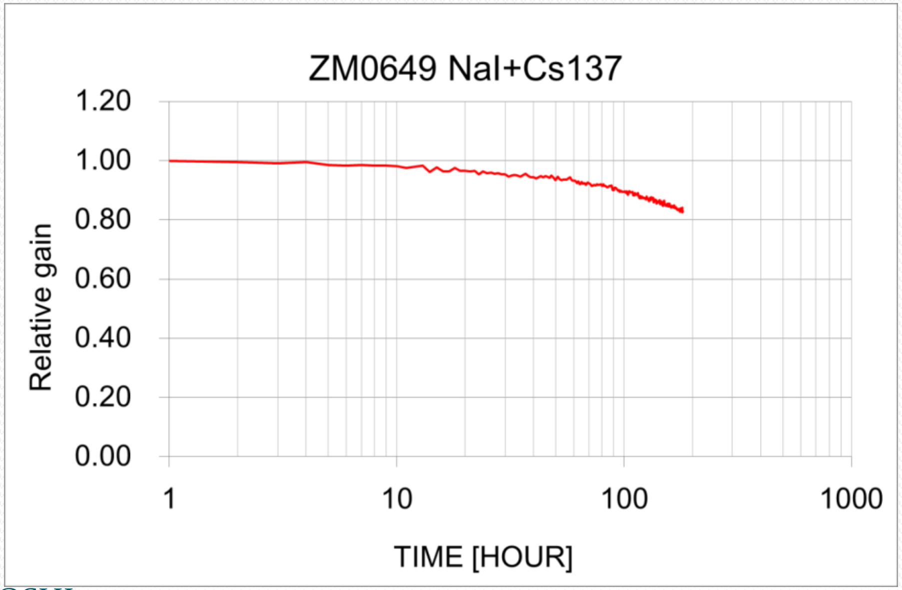
Ion back flow rate is less than 0.01 for this case.



Long time operation of the Gas PMT

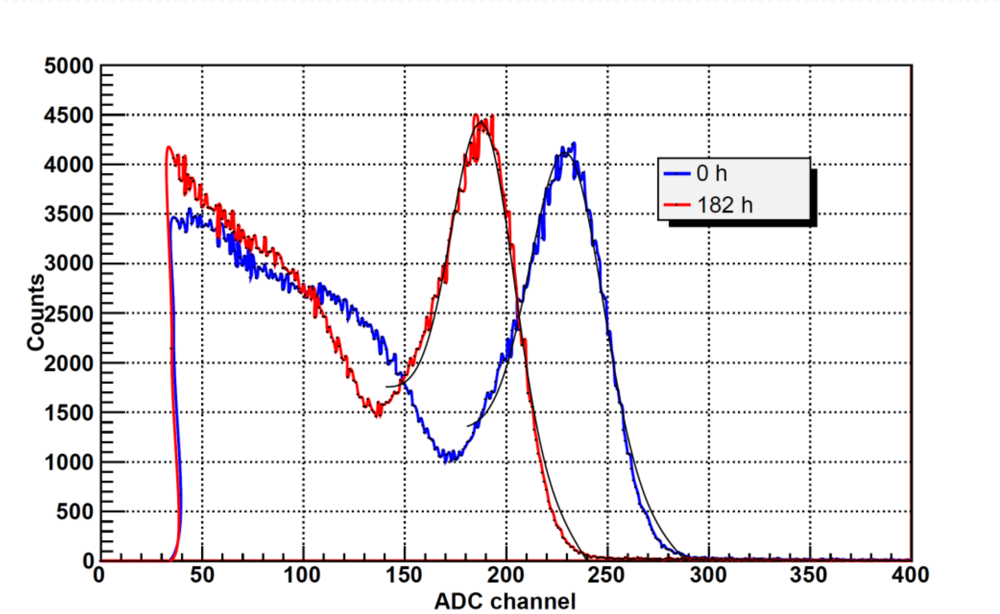


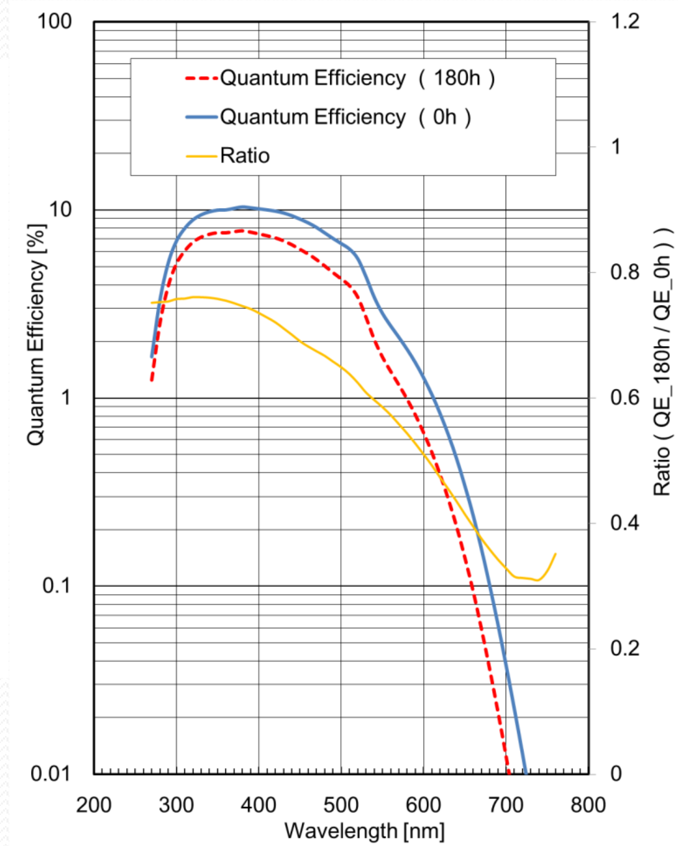
- After **180 hours** of operation, **20% decrease** of the signal output was observed.
  - Gain: 670
  - IBF: 0.32%



Long time operation of the Gas PMT

- Gain: 670
- IBF: 0.32%
- Accumulated ion on PC : 1.5 nC/mm^2

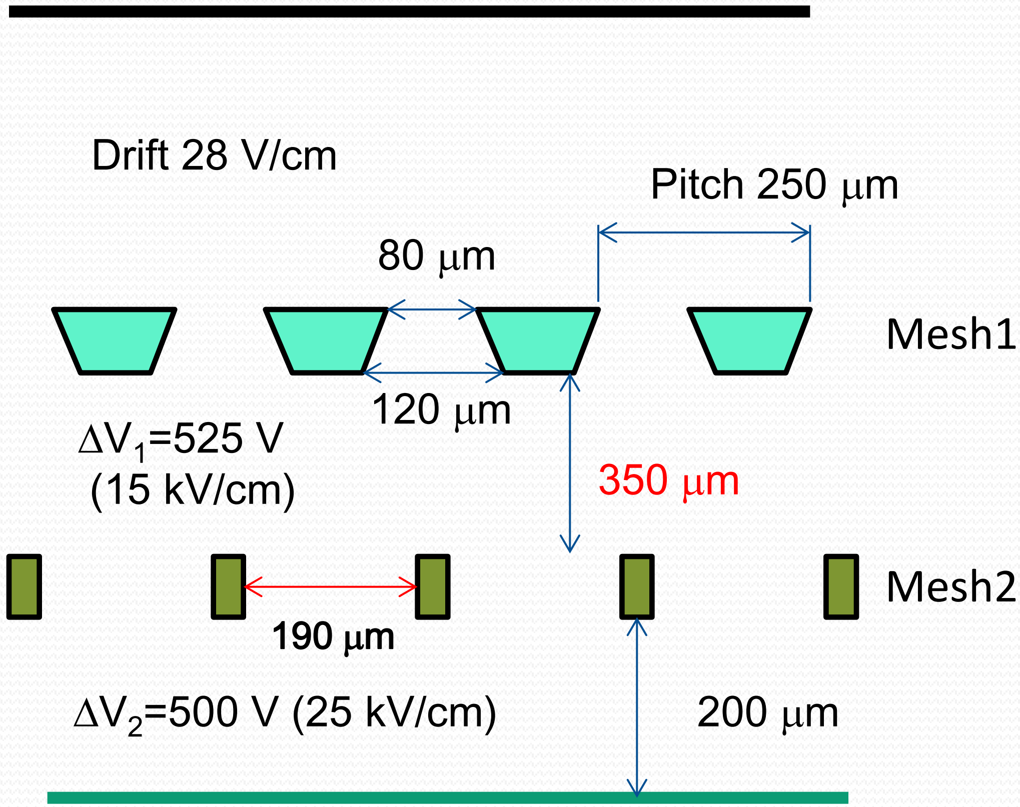




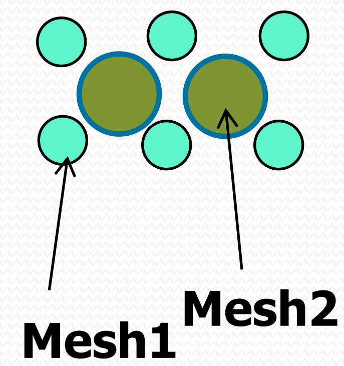
- The peak channel was shifted to lower channel (about **20%**) than that obtained at 0 h.
- The energy resolution were 18.2% (FWHM) and 19.0% (FWHM), respectively, for 0 h and 180 h after operation.

A new type of double mesh structures

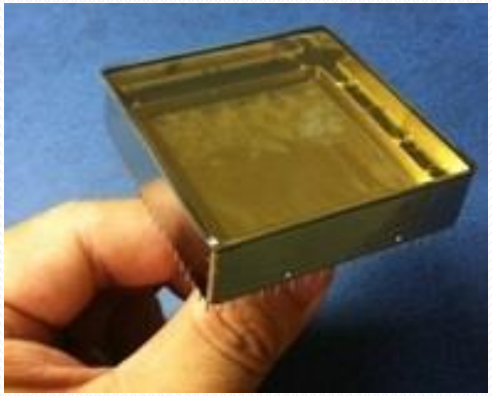
- For further reduction of ion back flow a new type of double mesh structure was tried.

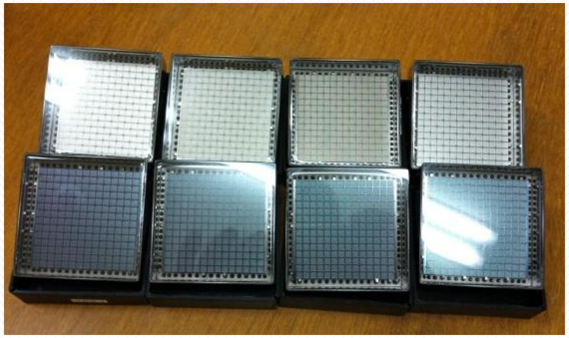


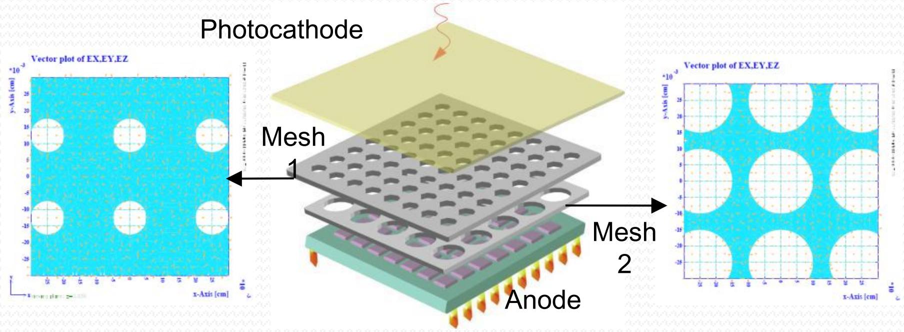
A new structure (top view)

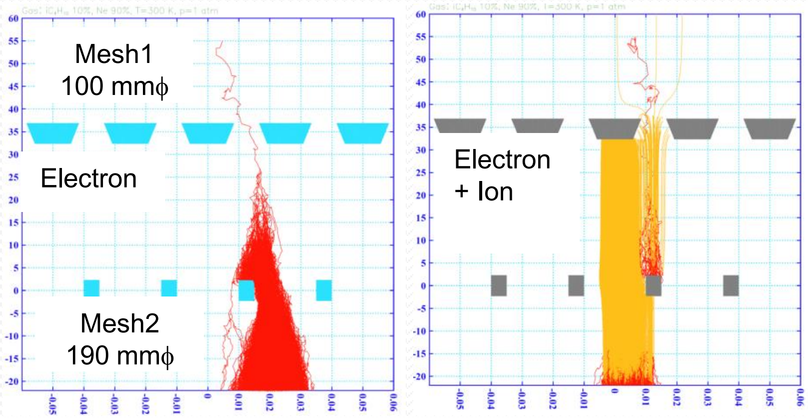


Development of a flat pixel detector

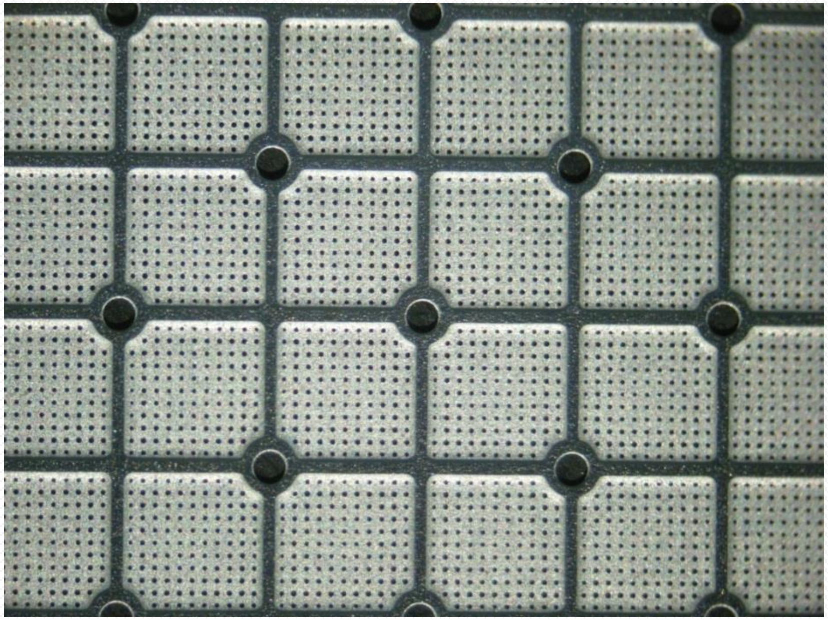




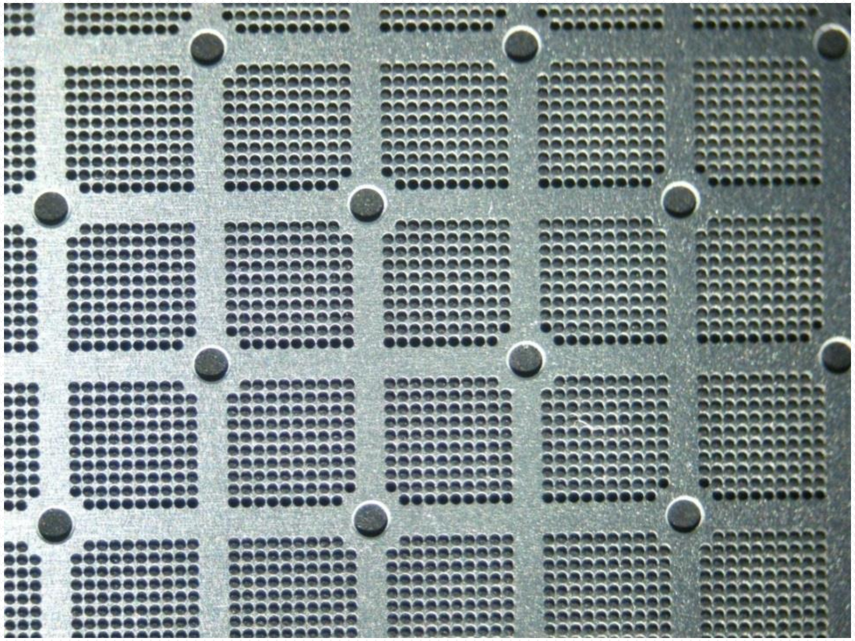




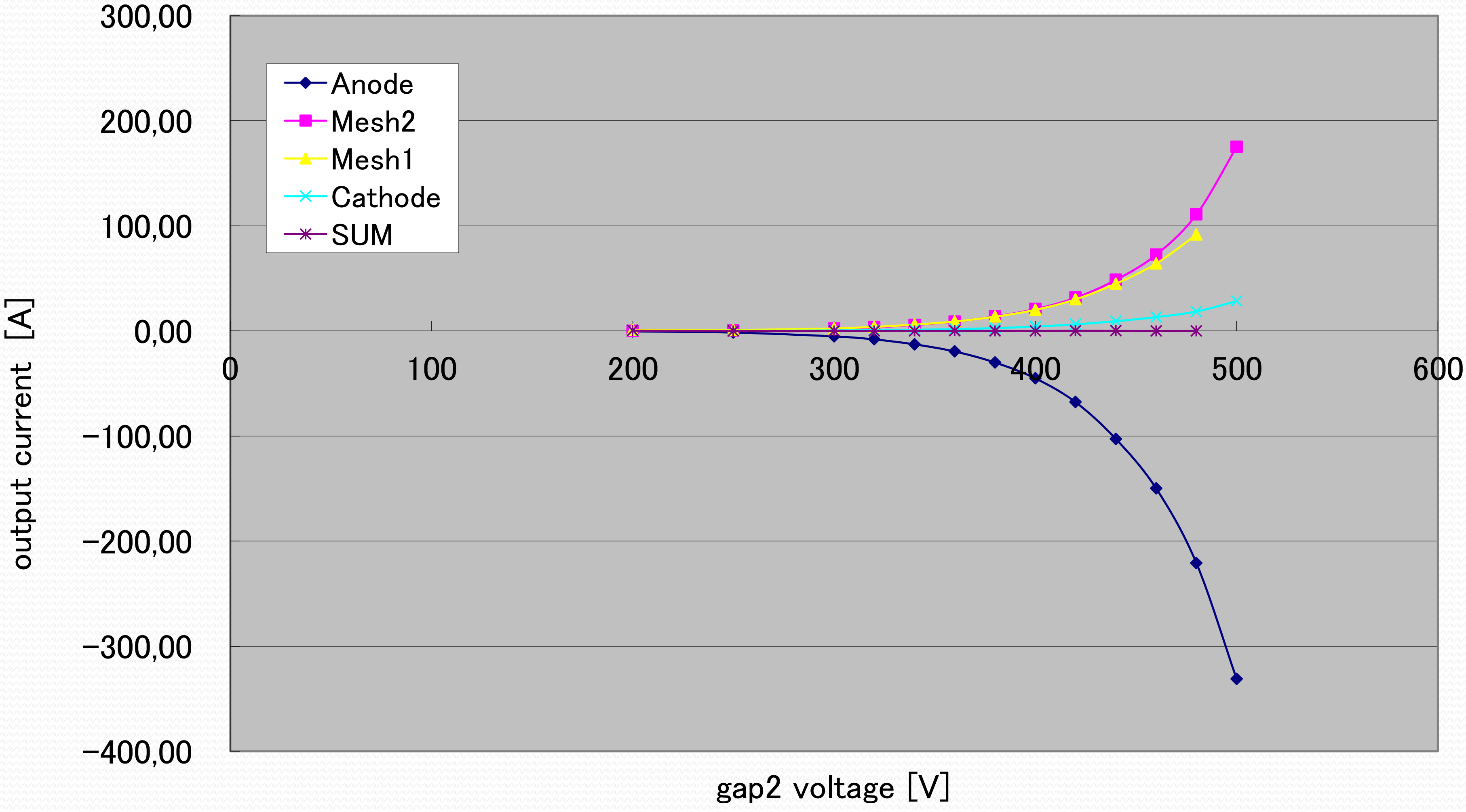
Mesh 1 (100 μmϕ)



Mesh 2 (190 μmϕ)

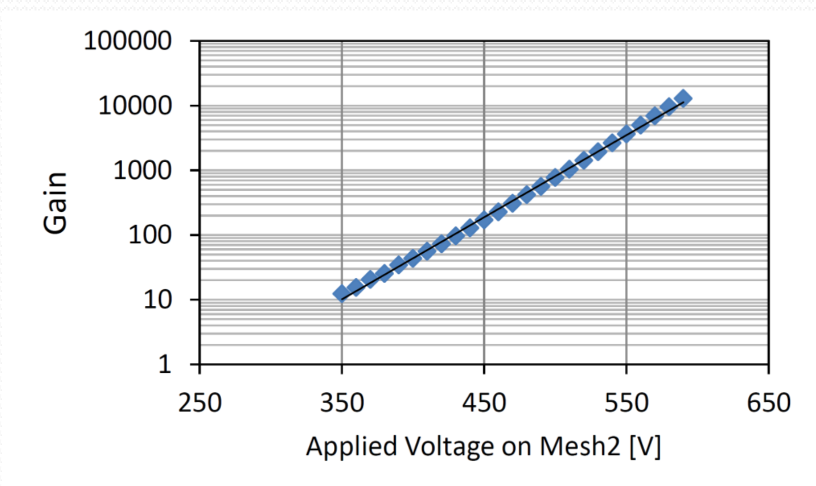


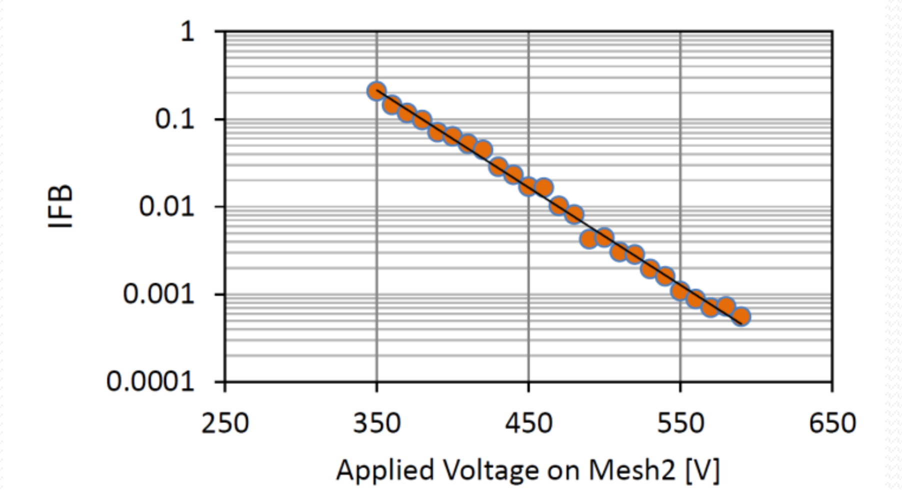
Measured current at each electrode



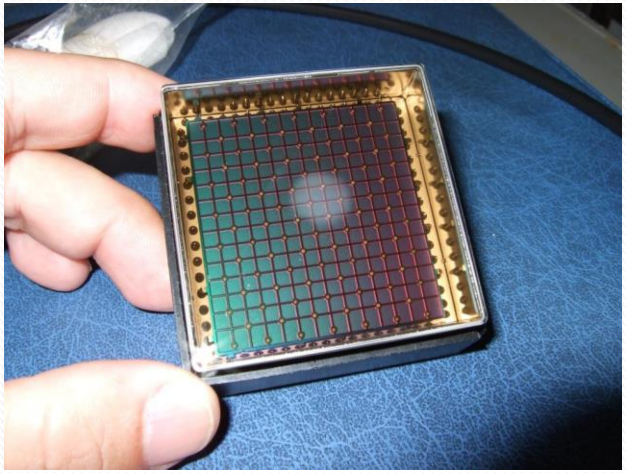
Gain and IBF

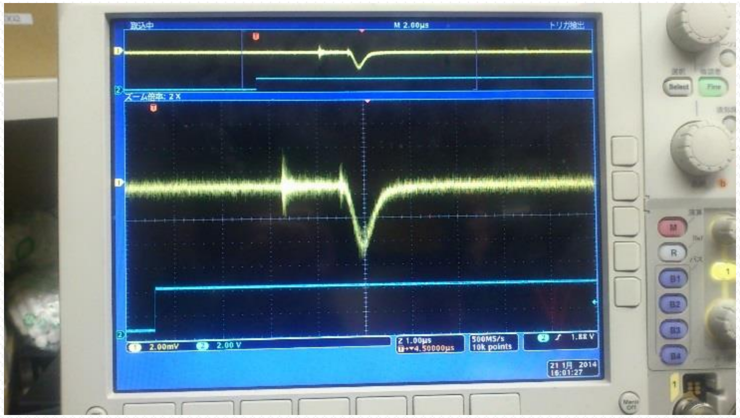
- Gain of 10^4 and IBF of 10^{-3} was obtained with this staggered structure.

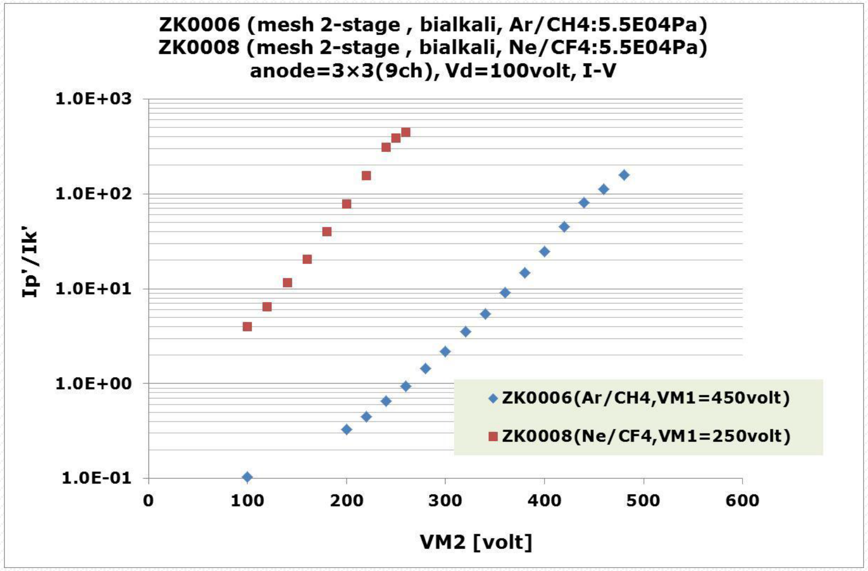


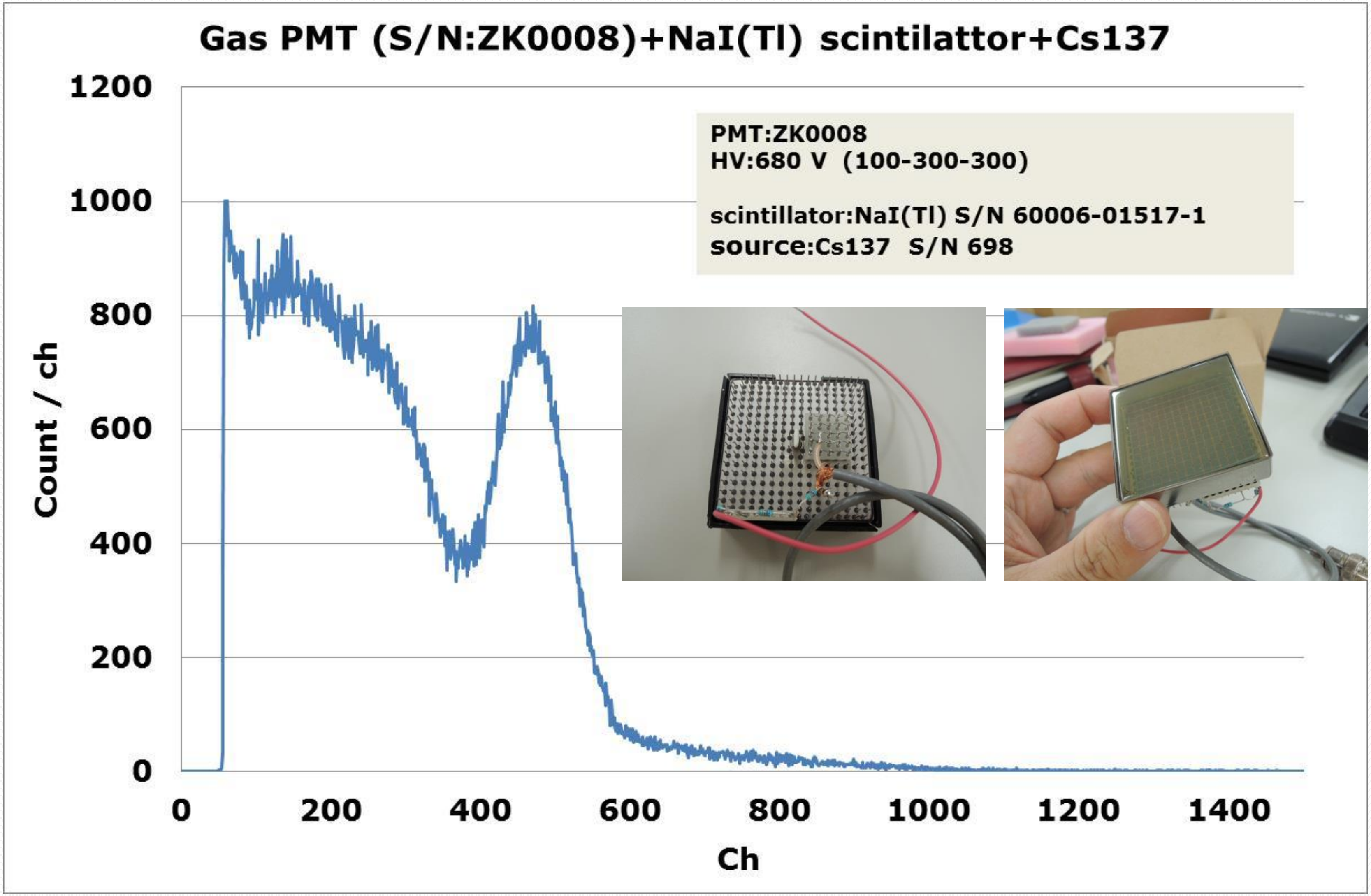


Performance test of flat panel Gas PMT

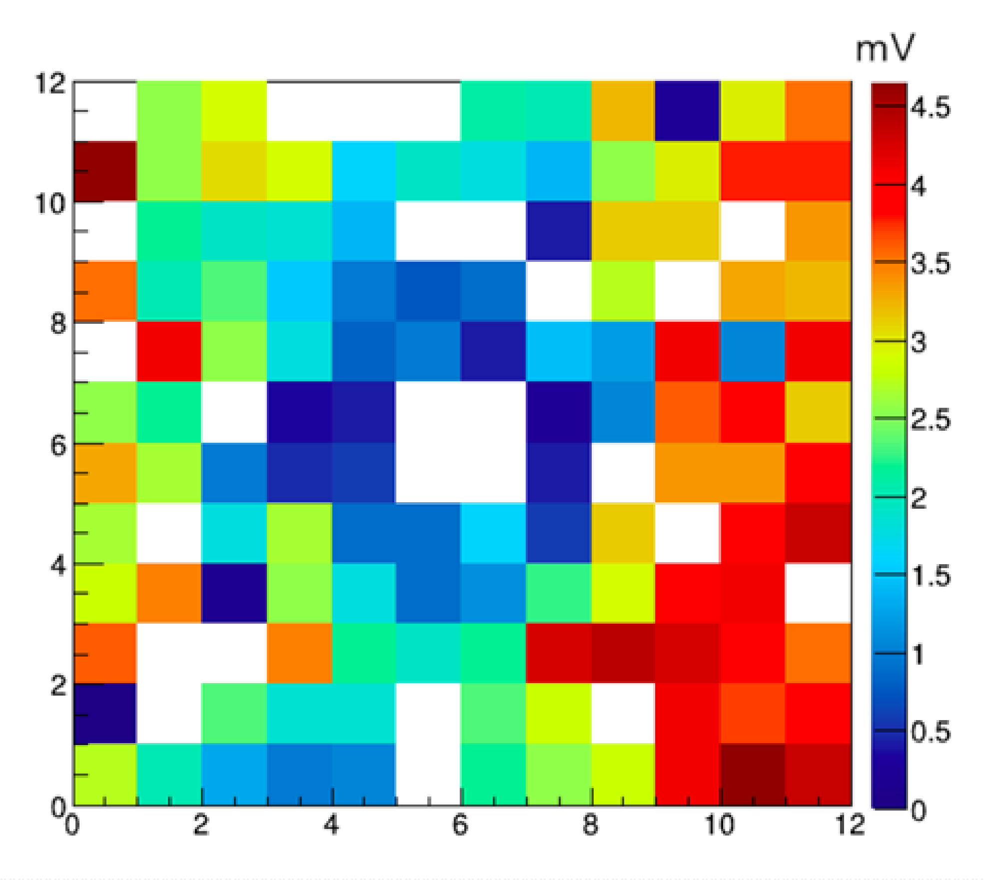






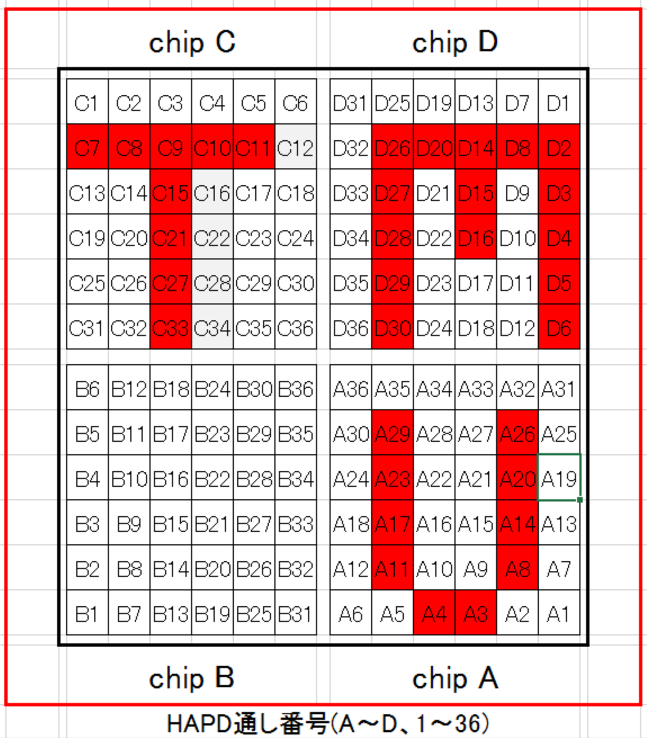

Gas PMT (S/N:ZK0008)+NaI(Tl) scintilattor+Cs137
PMT:ZK0008
HV:680 V (100-300-300)
scintillator:NaI(Tl) S/N 60006-01517-1
source:Cs137 S/N 698
Count / ch
Ch
0
200
400
600
800
1000
1200
1400

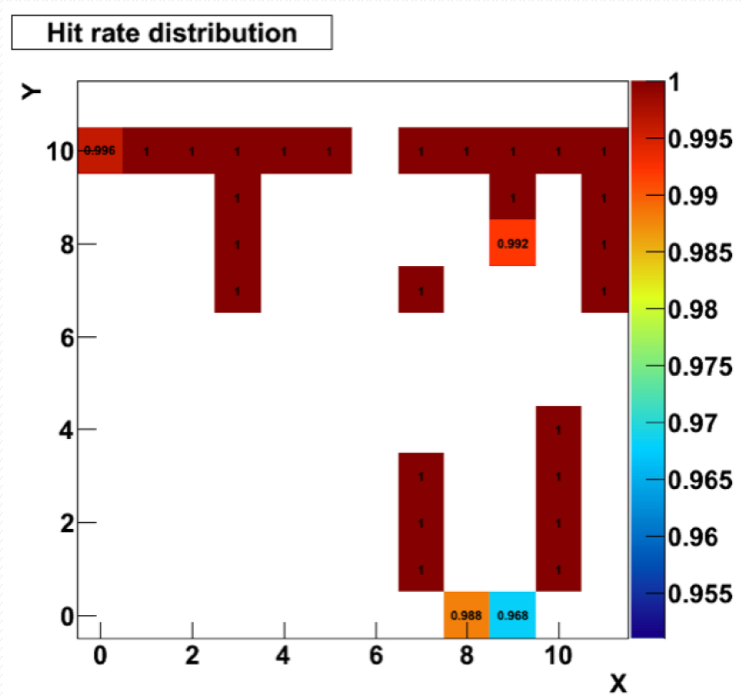
- Nonuniformity was observed.
- Inefficiency ch: due to micro discharge?



2D readout of flat panel Gas PMT

Pattern of the mask





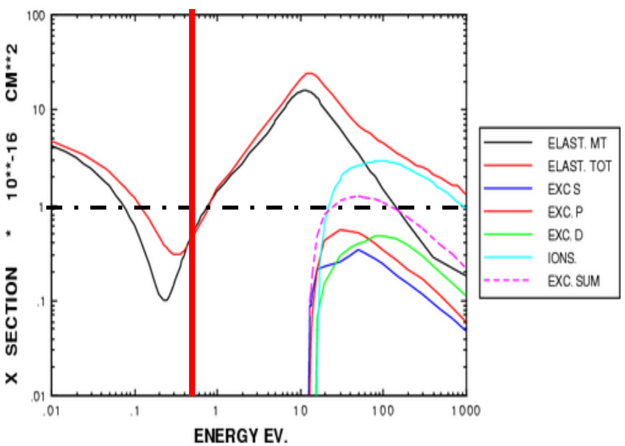
Summary

- Gas PMT has merits compared with vacuum type PMTs:
  immune to high magnetic field (~1.5 Tesla)
  simple dynode structure -> large size with less money
- Long term stability: need to suppress ion feedback
  Staggered hole structure with double meshes may work.
- 2 D imaging was tried with a pixel anode Gas PMT.
  Nonuniformity was observed: under investigation.

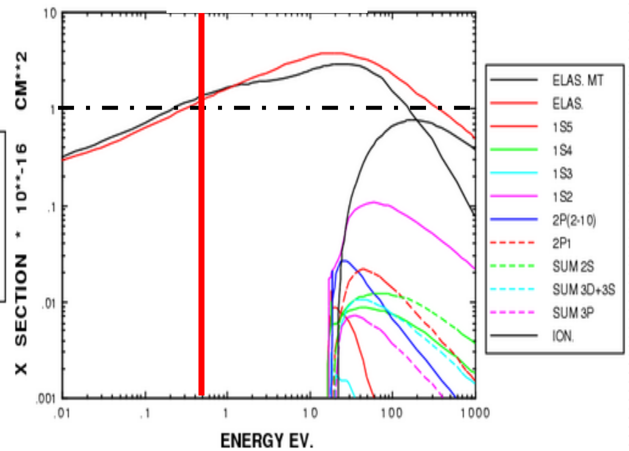
- **Backup Slides**

Cross section of electron with gases

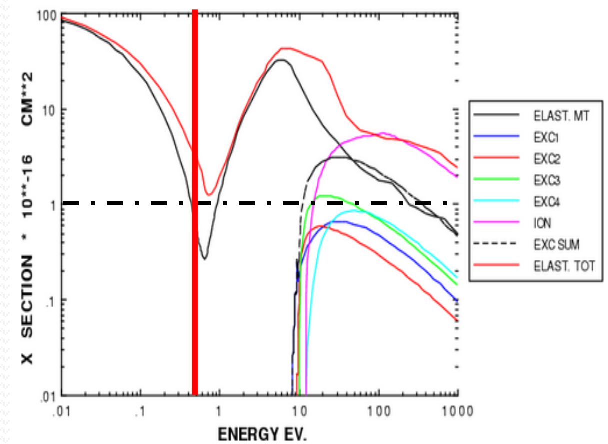
Ar



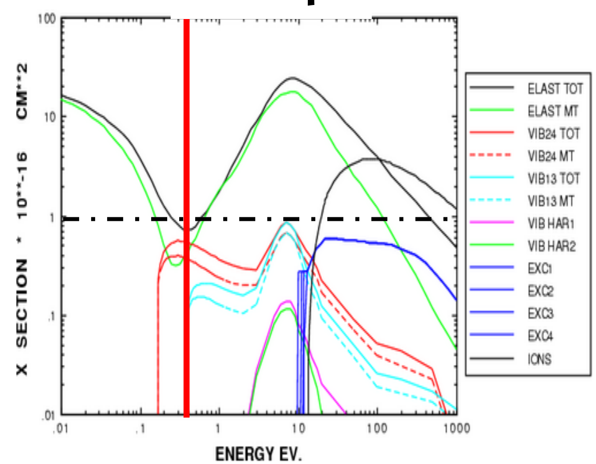
Ne



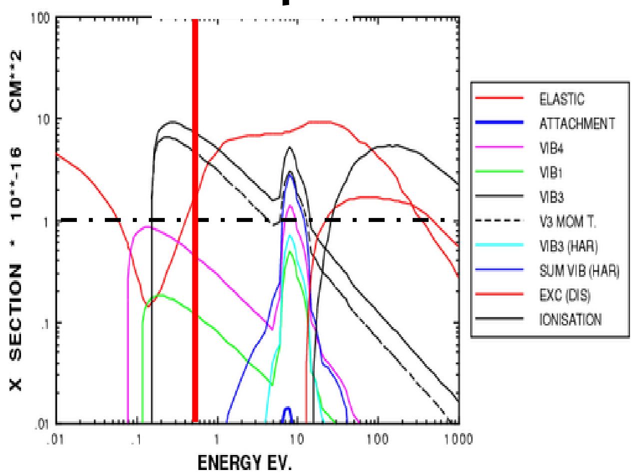
Xe



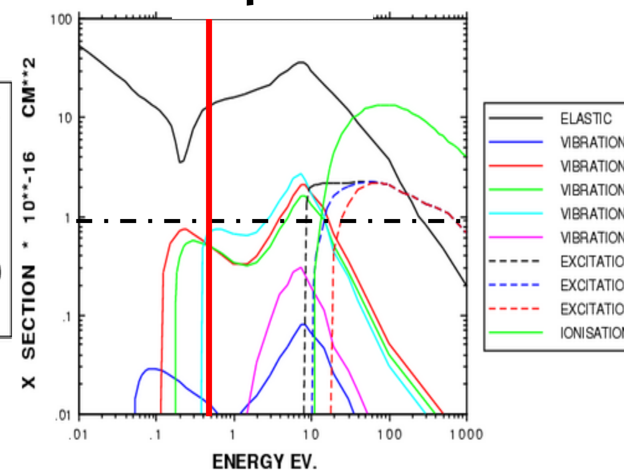
CH_4



CF_4

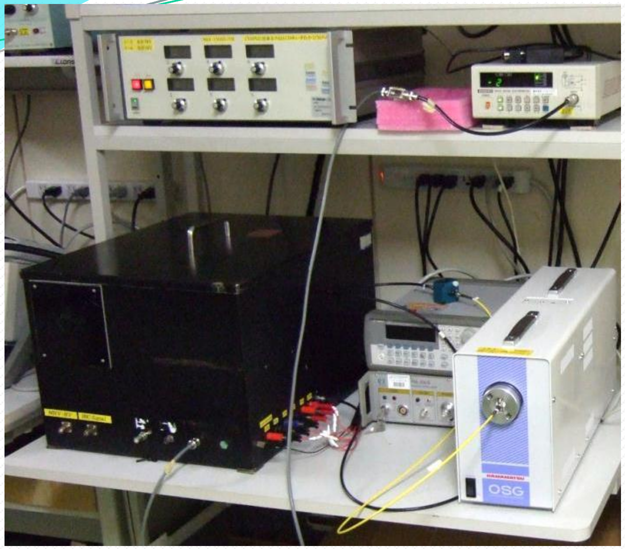


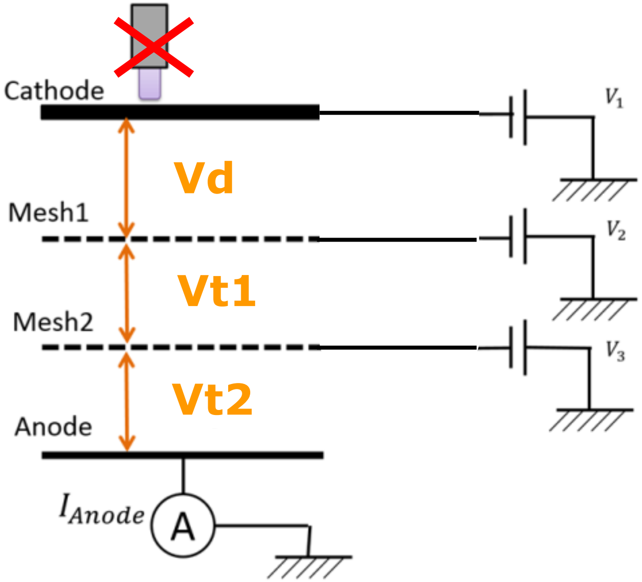
C_4H_{10}

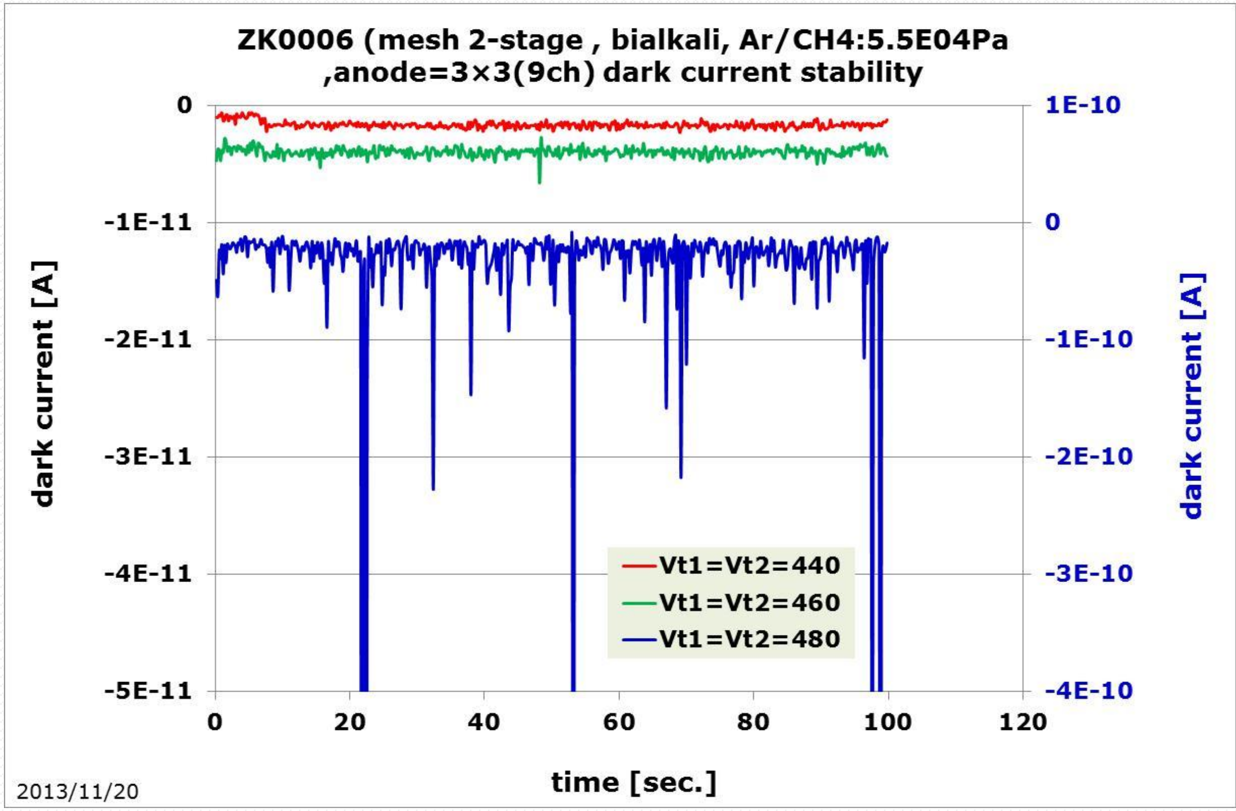


http://rjd.web.cern.ch/rjd/cgi-bin/cross?update

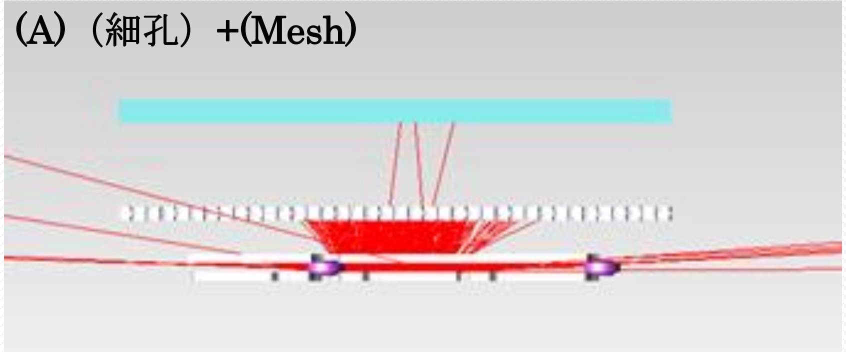
Dark Current

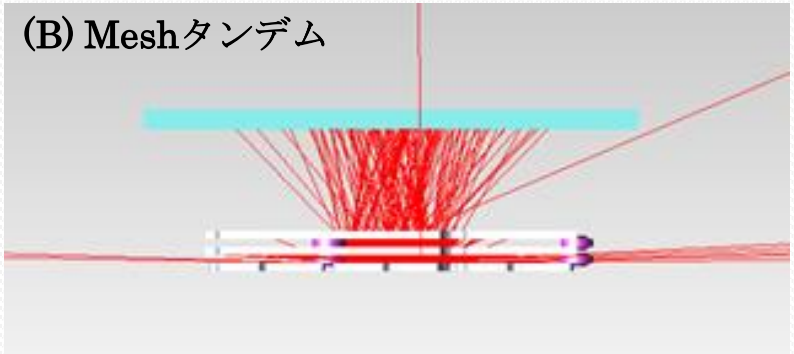






Photon Feedback





アノード表面からの出射した 光子数100,000 に対するカソード面への到達flux数

解析条件	（A）（細孔）+（Mesh）	（B）Meshタンデム型
① 吸収率 100%	58	1,310
② 反射率 50%	1,617	8,219
③ 反射率 70%	5,028	14,313
④ ﾐﾗｰ反射率 92%	17,992	31,945

細孔型：
開口Φ120μm,pitch300μm,t=300μm
Mesh型:
開口Φ100um ,pitch250um

Mesh1：
開口Φ100μm,pitch250μm
Mesh2:
開口Φ190um ,pitch250um