Recent progress in gaseous PMT

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Merits of Gas PMT

Sensor type	Sensitivity	Position Resolution	Timing Resolution	Uniformity	Price	Magnetic Field	Effective Area
Vacuum PMT	Ø	Δ	0	Δ	0	Δ	0
CCD / CMOS	Δ	0	×	0	Δ	0	×
Gaseous PMT	0	0	0	0	0	0	0



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QE in gas mixtures

Bi-alkali Photocathode in Ar(90%) + CH₄(10%) 0.9 atm



Stability of PC in Ar+CH₄ gas



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

Not continuously illuminated.

Collection efficiency of photoelectrons in various gas mixtures



Photoelectron collection efficiency in gases



Collection efficiency for Ar+CH₄ gas



Collection efficiency for Ne+CF₄ 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.







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Suppress ion feedback

Mesh electrode (Micromegas) absorbs ions efficiently.





Gap voltage [volt.]

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

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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/mm²





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.

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A new type of double mesh structures

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



Development of a flat pixel detector







Mesh 1 (100 µmø)

Mesh 2 (190 µm)

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Measured current at each electrode



Gain and IBF

 Gain of 10⁴ and IBF of 10⁻³ was obtained with this staggered structure.



Performance test of flat panel Gas PMT









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



2D readout of flat panel Gas PMT

Pattern of the mask

	chip C					chip D					
C1	C2	C3	C4	C5	C6	D31	D25	D19	D13	D7	D1
C7	C8	C9	C10	C11	C12	D32	D26	D20	D14	D8	D2
C13	C14	C15	C16	C17	C18	D33	D27	D21	D15	D9	D3
C19	C20	C21	C22	C23	C24	D34	D28	D22	D16	D10	D4
C25	C26	C27	C28	C29	C30	D35	D29	D23	D17	D11	D5
C31	C32	C33	C34	C35	C36	D36	D30	D24	D18	D12	D6
B6	B12	B18	B24	B30	B36	A36	A35	A34	A33	A32	A31
B5	B11	B17	B23	B29	B35	A30	A29	A28	A27	A26	A25
В4	B10	B16	B22	B28	B34	A24	A23	A22	A21	A20	A19
B3	B9	B15	B21	B27	B33	A18	A17	A16	A15	A14	A13
B2	B8	B14	B20	B26	B32	A12	A11	A10	A9	A8	A7
B1	B7	B13	B19	B25	B31	A6	A5	A4	AЗ	A2	A1
	chip B chip A										
HAPD通し番号(A~D、1~36)											



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





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



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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

unnnnnnnnnnnnnnn									
	解析条例	4	(A)(細孔)+ (Mesh)	(B)Meshタンデム型					
	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 92%	ଽ⋽−反射	率	17,992	31,945					
	細孔型: Mesh1:								
	開口Ф120)um,pitch3	300µm,t=300µm	開口Φ100μm,pitch250μm					
	Mesh型:			Mesh2:					
	開口Ф100	um ,pitch	250um	開口 $\Phi190$ um ,pitch 250 um					
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