

HAMAMATSU

Latest status of PMTs and related sensors

2007.06.28

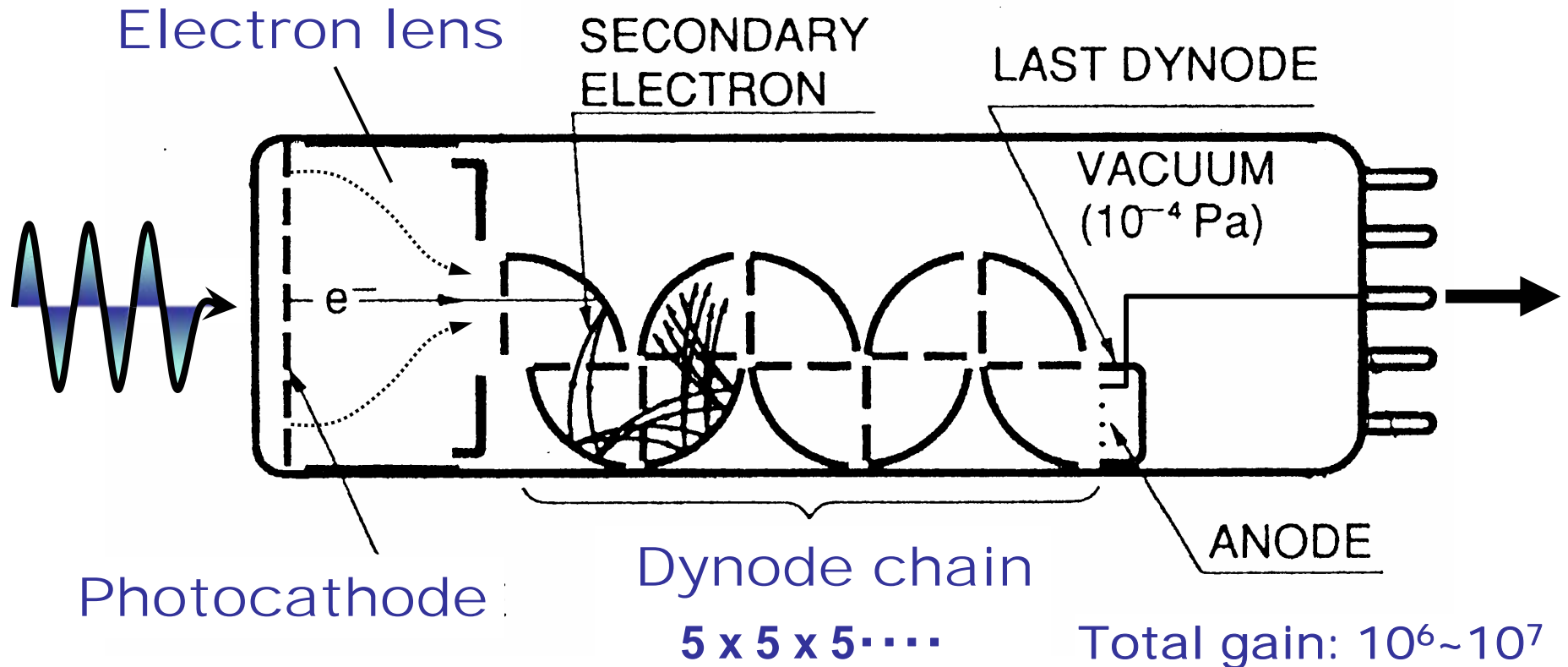
浜松ホトニクス株式会社

Motohiro SUYAMA

Contents

- **Operation of PMTs**
 - Photocathode / Electrostatic focusing lens / Dynodes
(Designing to meet your requirements)
- **Recent progresses**
 - High efficiency photocathode
 - Hybrid photo-detector (HPD)

Operation of PMT



Features of PMT

- **Photocathode**

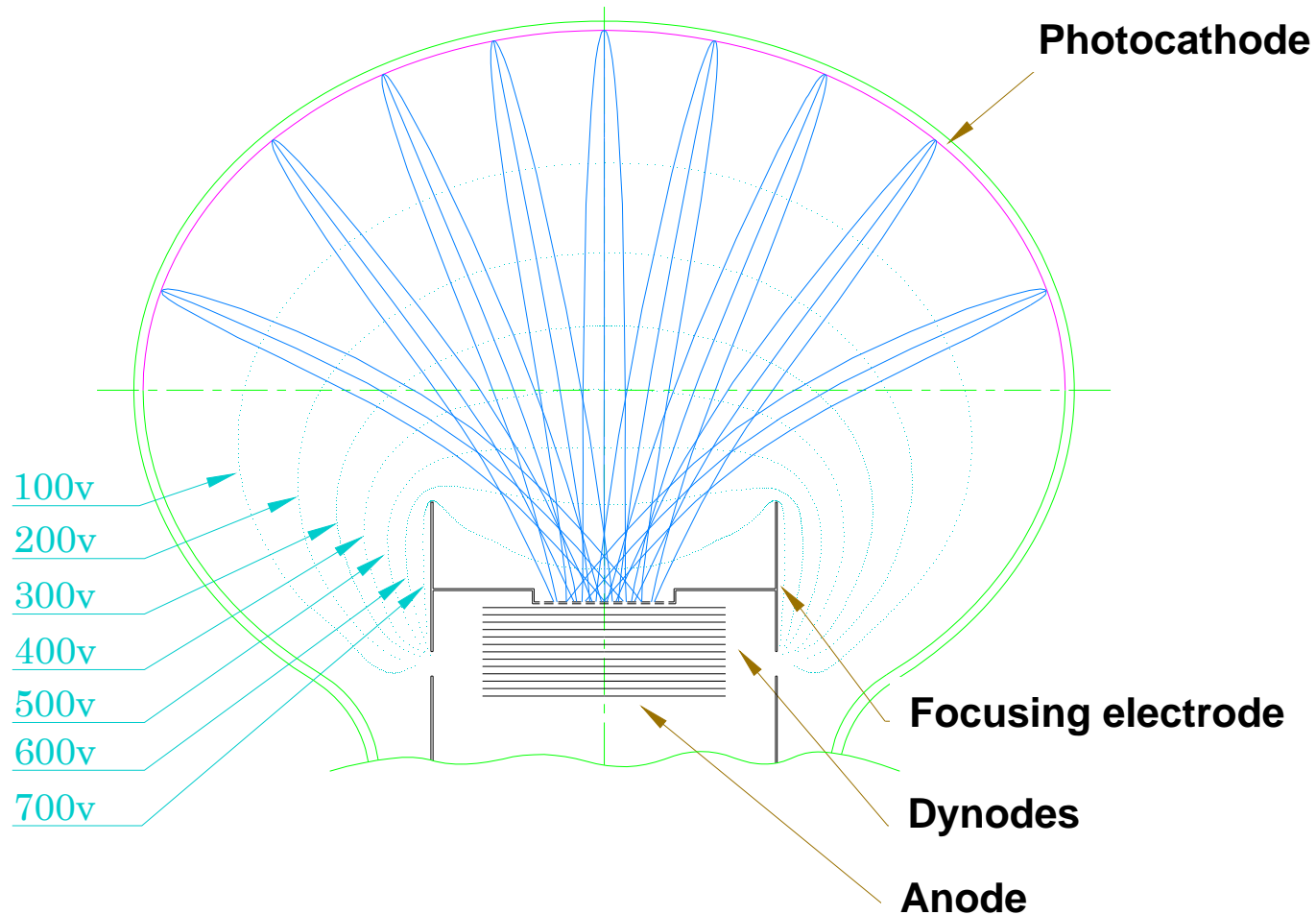
- Large effective area: up to $\phi 500\text{mm}$
- Low QE: 30% (or higher)
- Low dark current: $0.01 \sim 300\text{Hz/mm}^2$
- Low cost per area

- **Dynodes**

- High gain: up to 10^7
- High speed: $\sim \text{ns}$

If large aperture is necessary,

Electrostatic focusing lens

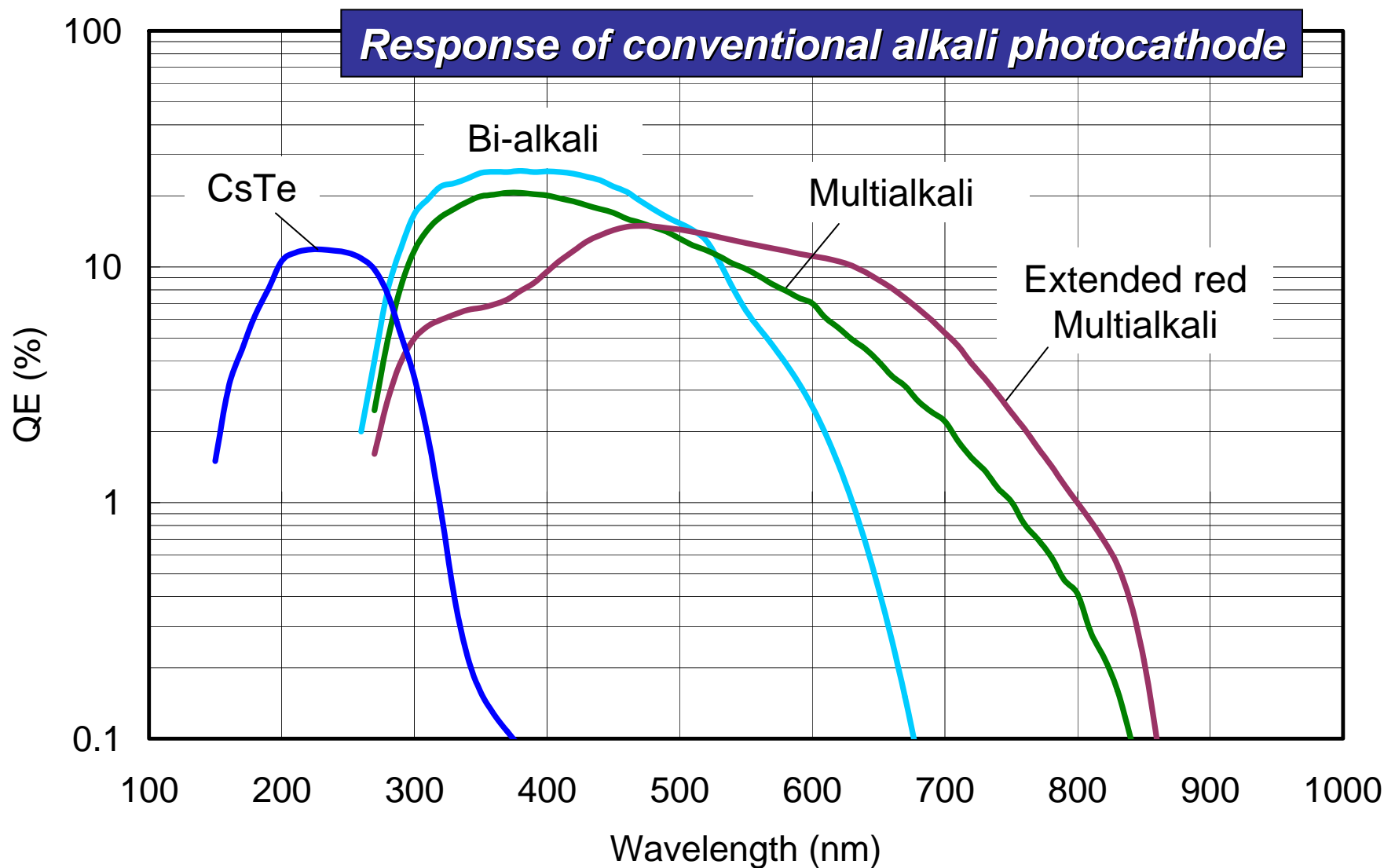


Large Format PMTs



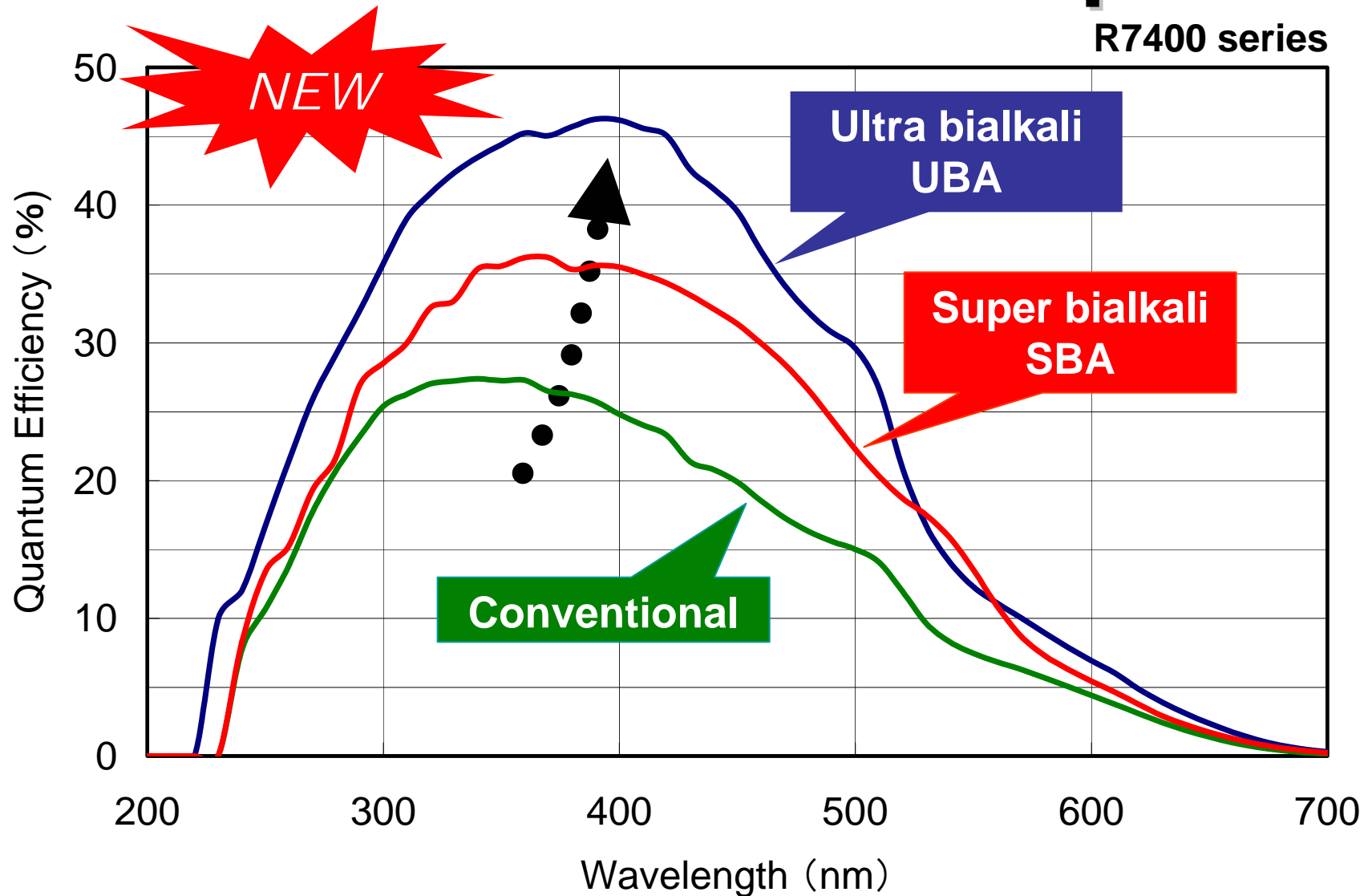
Large aperture with reasonable cost

If wavelength is specified,



Ultra Bialkali is developed

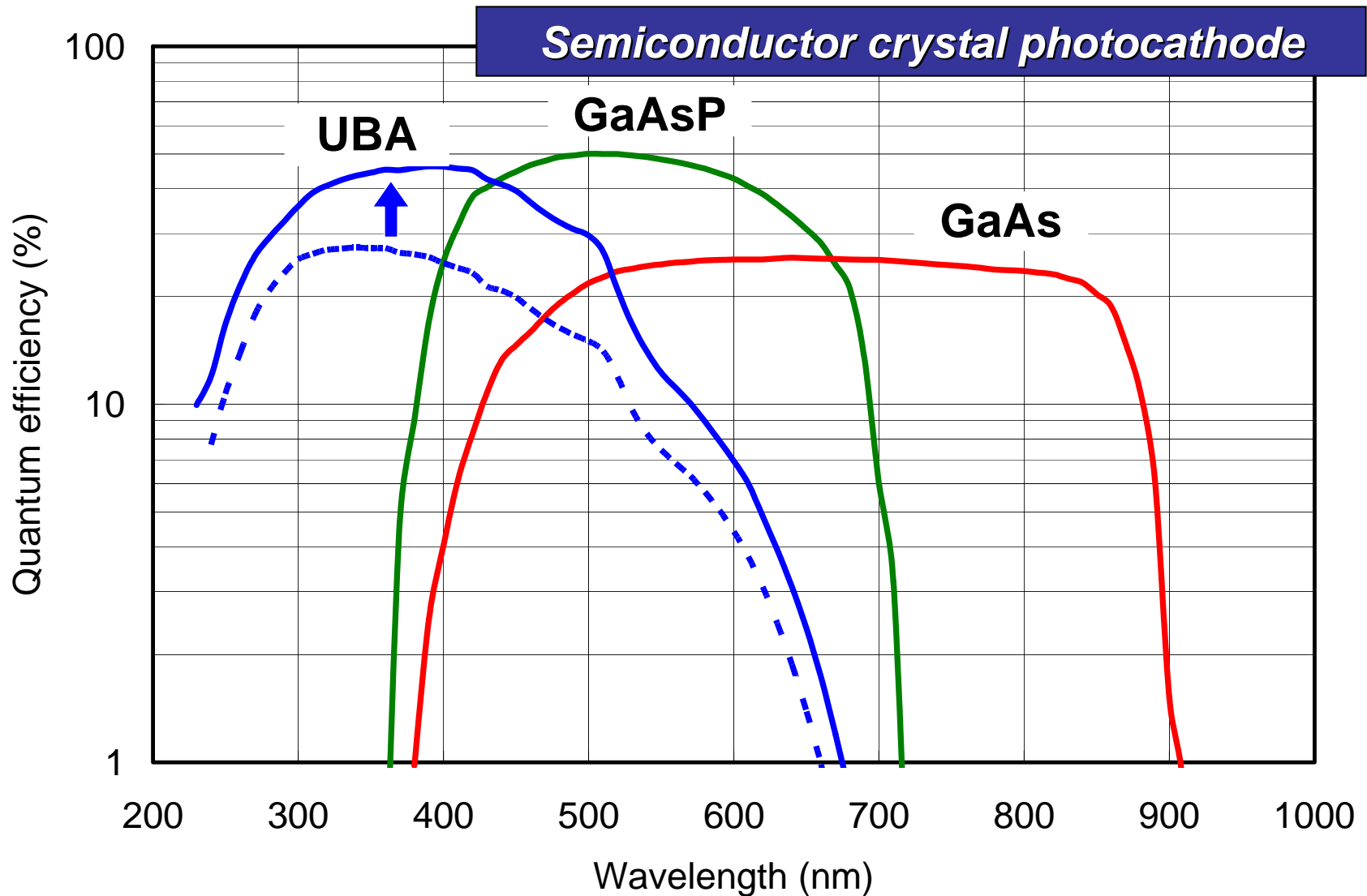
R7400 series



Availability of UBA/SBA

Photocathode	QE at peak wavelength		Type Availability
	Min.	Typ.	
Ultra Bialkali (UBA)	38%	43%	R7400/ R7600 (Metal Package PMT)
Super Bialkali (SBA)	32%	35%	R7400/ R7600 (Metal Package PMT) 1"-3"Glass Bulb type

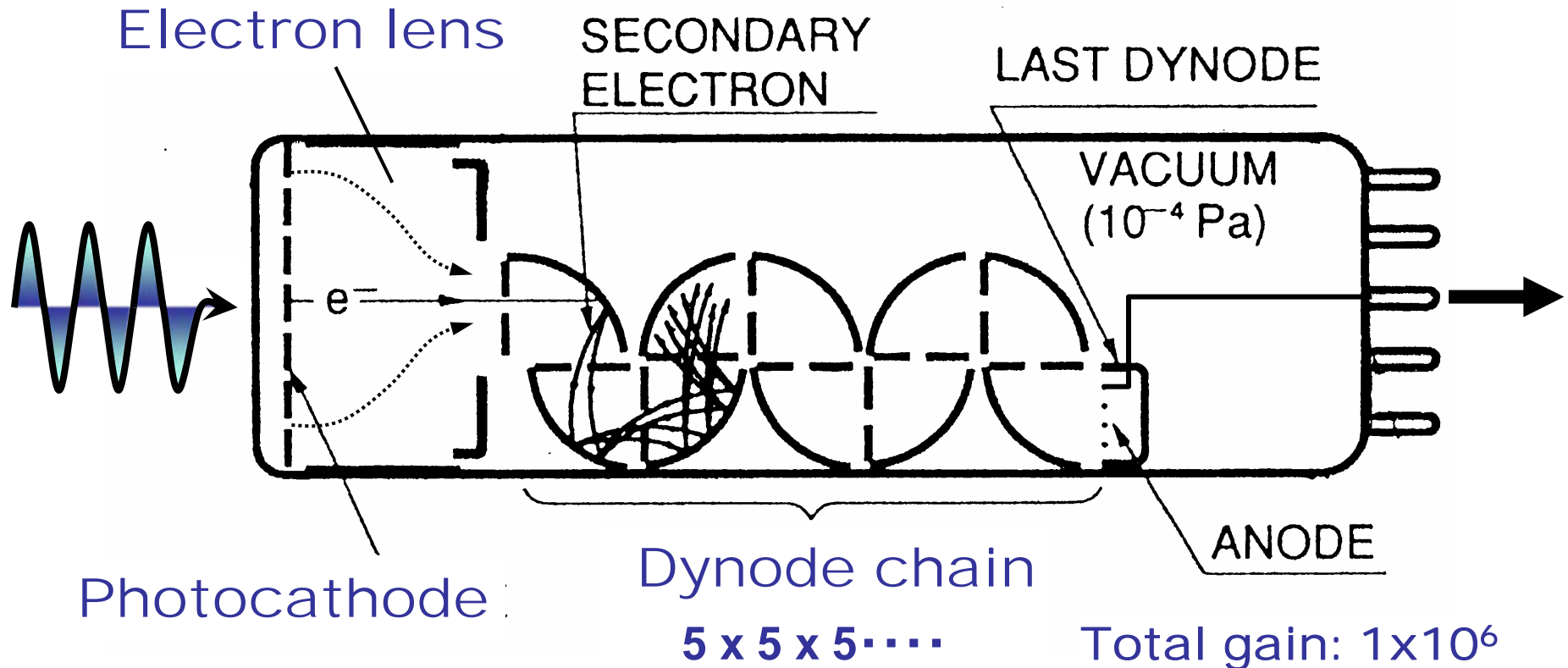
If high QE is demanded in visible,



Availability of GaAsP

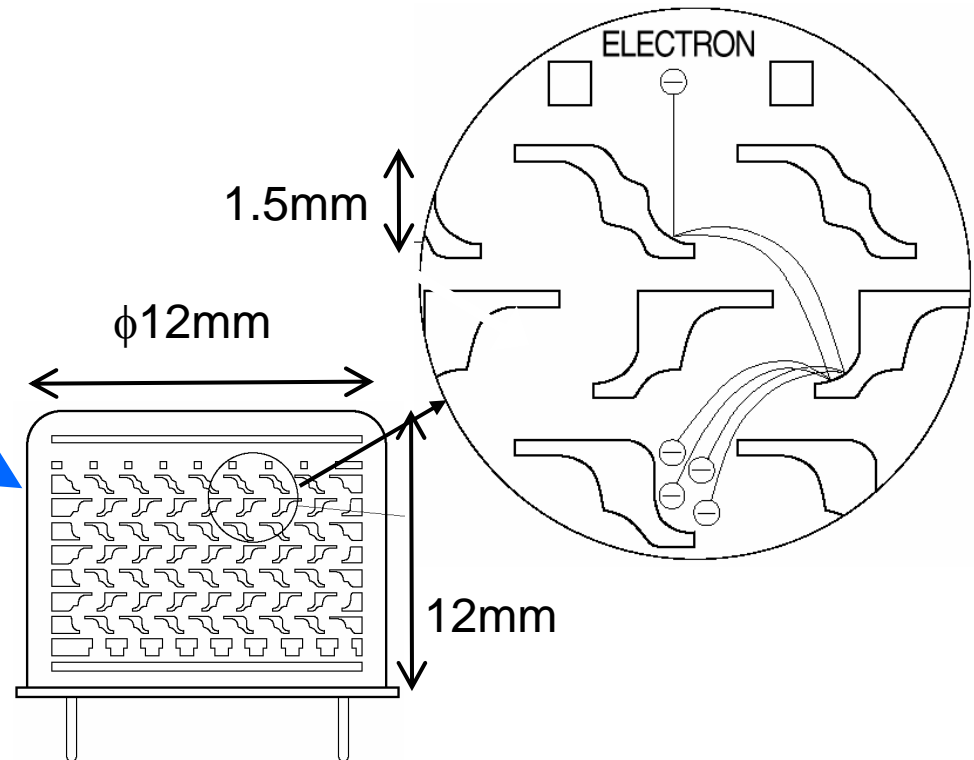
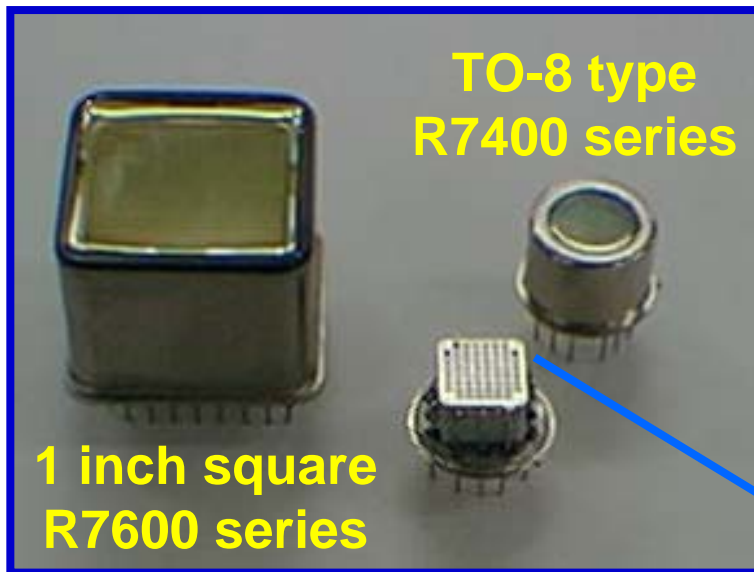
H7422	ϕ 5mm	PMT
R3809-61	ϕ 10mm	MCP-PMT
R7110U-40	ϕ 5~8mm	HPD
R10467	ϕ 3mm	HPD
V8070U-64	ϕ 18mm	Proximity II
V9501U-74	ϕ 25mm	Proximity II

Operation of PMT



If low profile is demanded,

Metal Channel Dynodes



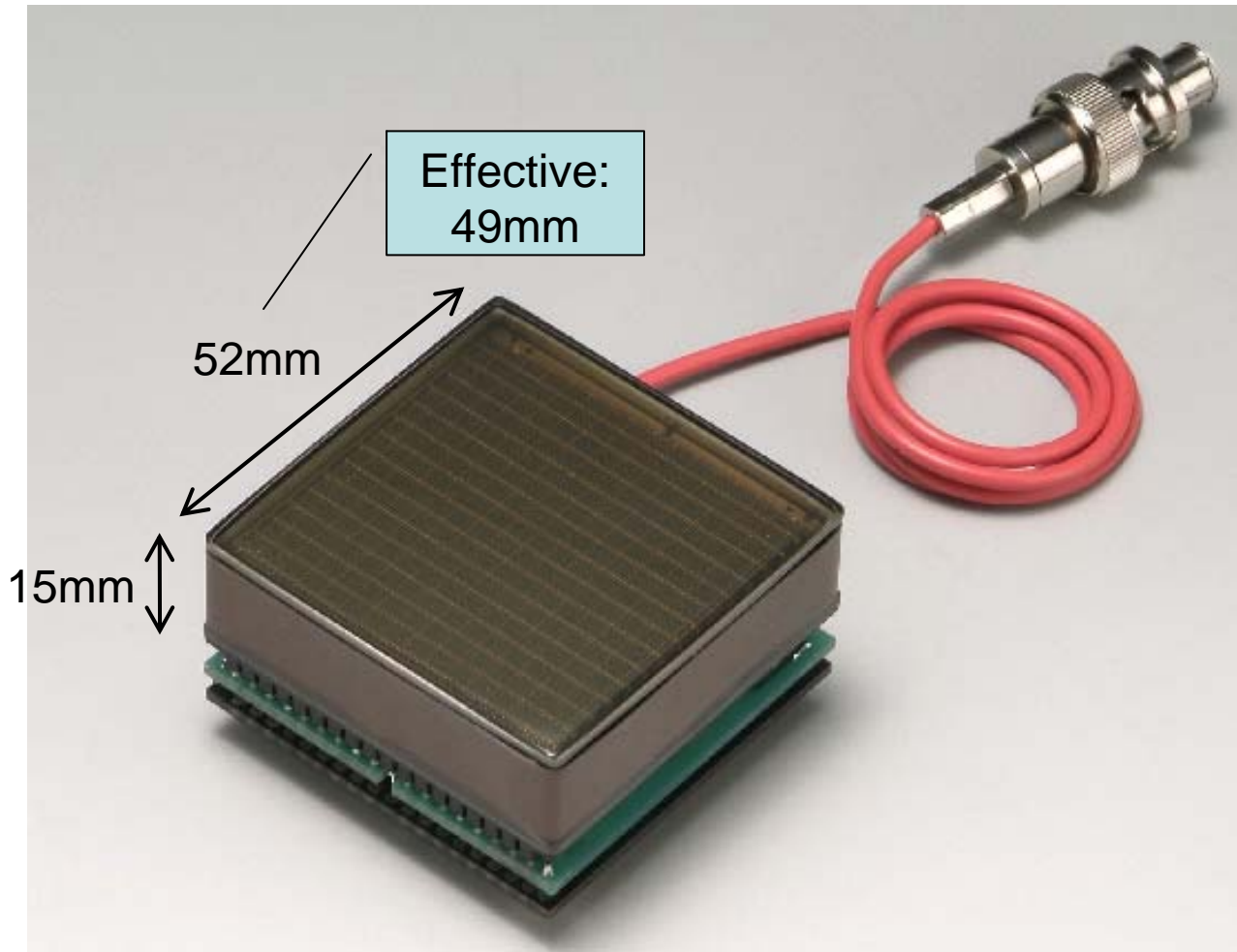
Features

Compact

Fast Time Response

Position Sensitive

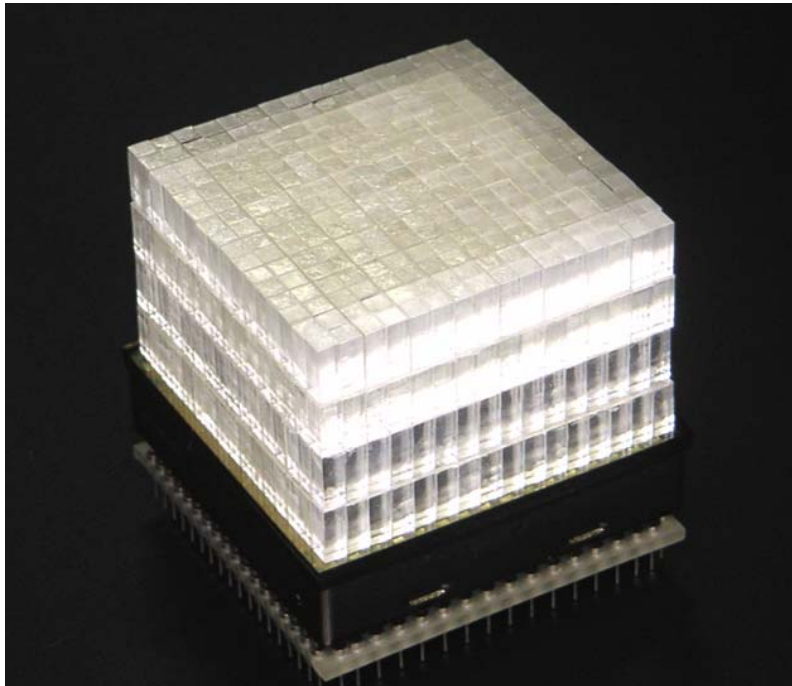
Flat panel PMT (H8500/H9500)



H8500 (64ch)
H9500 (256ch)

DOI (Depth of Interaction) detector (H9500 + 4 layers GSO)

- DOI detectors used for jPET-D4(Brain dedicated PET) developed by NIRS (National Institute of Radiological Sciences)



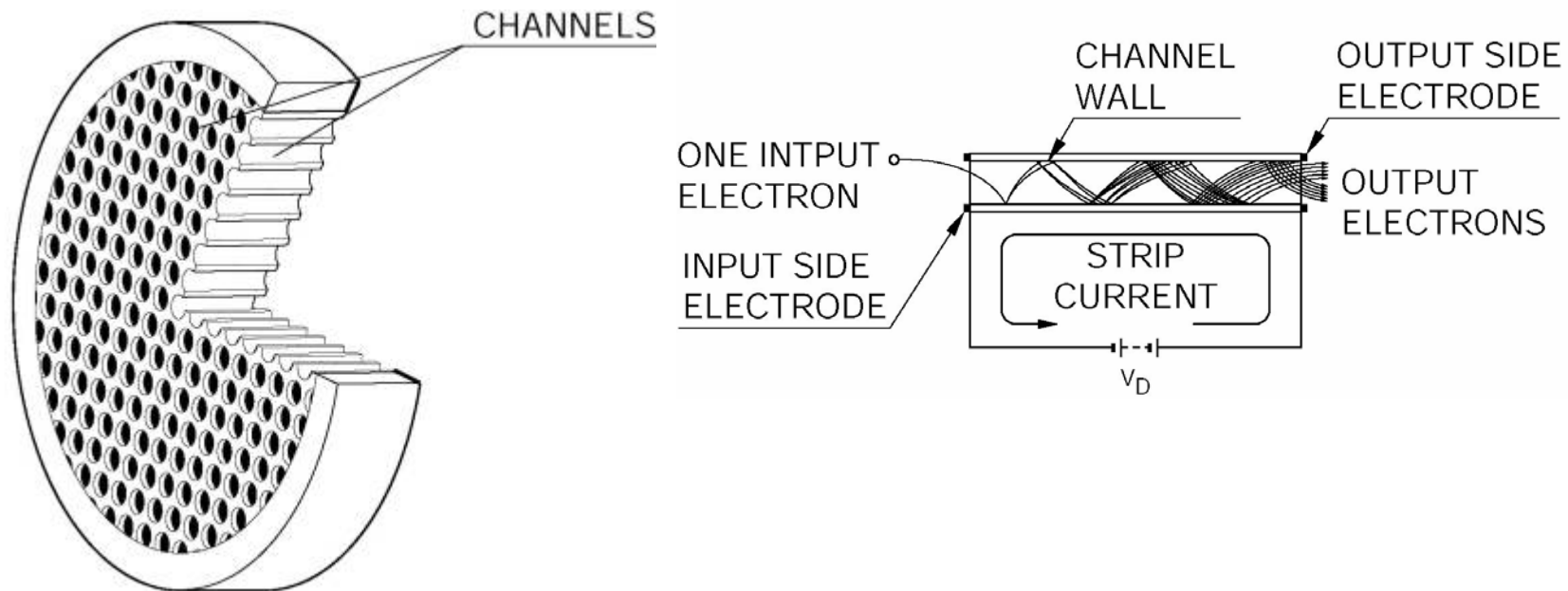
Improvement Plan for H8500

Item	Catalog Value	Catalog Value from Oct 06		unit
Cathode Sens	45	50	min.	μA/lm
	55	60	typ.	
Cathode Blue Index	6.5	8	min.	-
	8	9.5	typ.	
QE at 420nm	20	24	typ.	%
Uniformity	1:3	1:2	typ.	-
	1:5	1:4	max.	

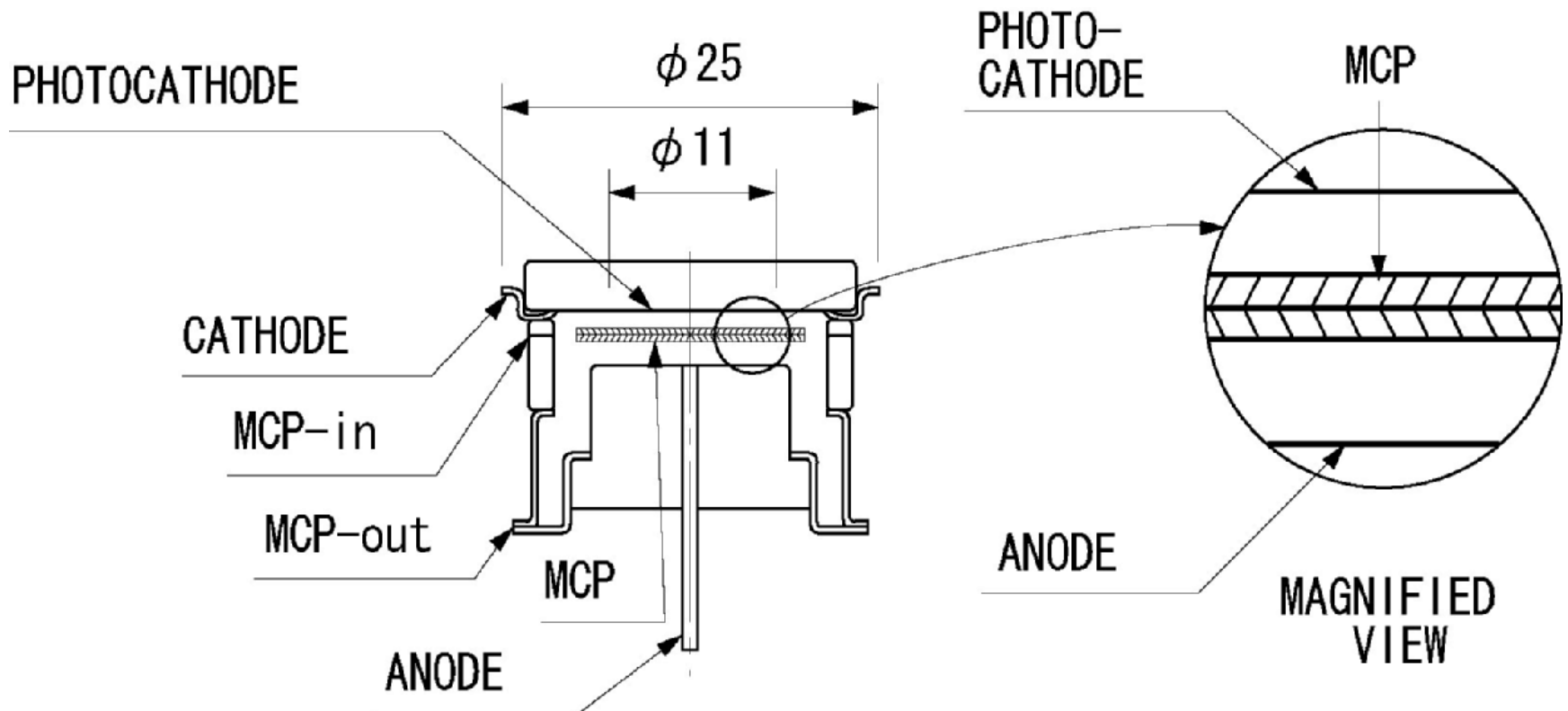
If fast response is required,

Fastest dynode: MCP

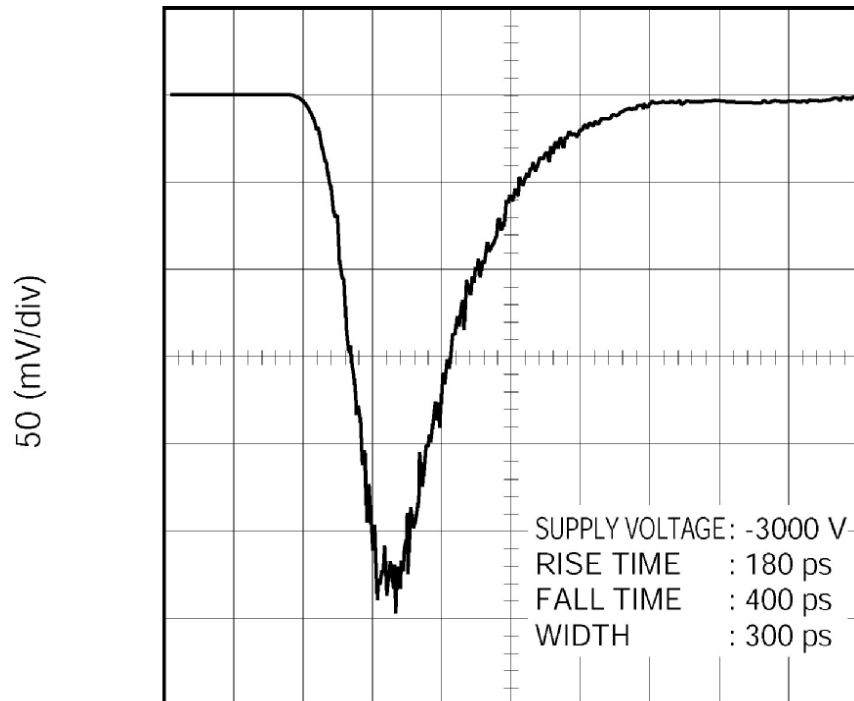
- Transit time of dynodes is greatly reduced.



MCP-PMT

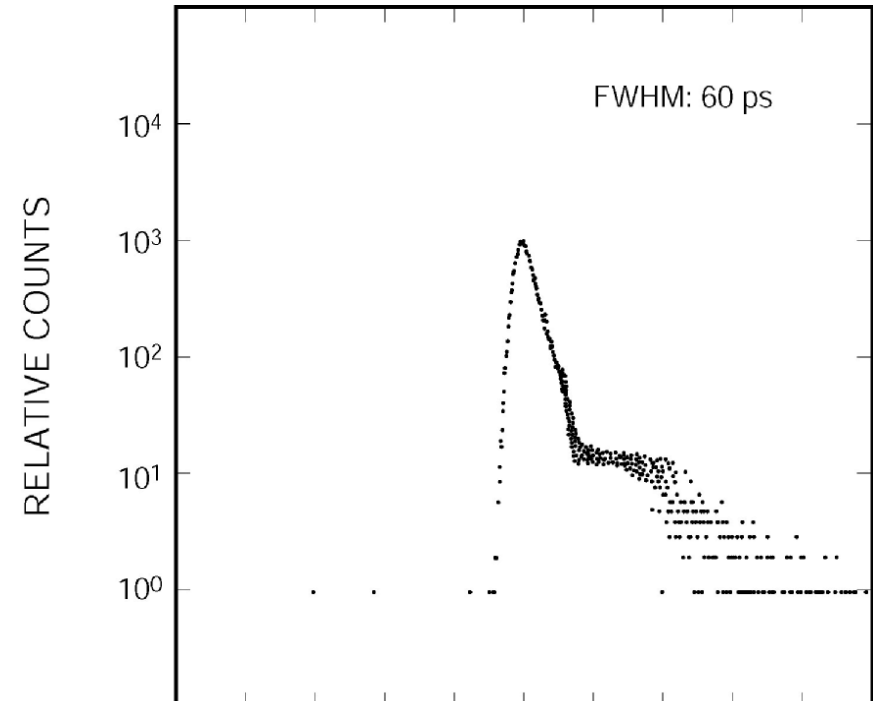


Temporal performance



0.2 (ns/div)

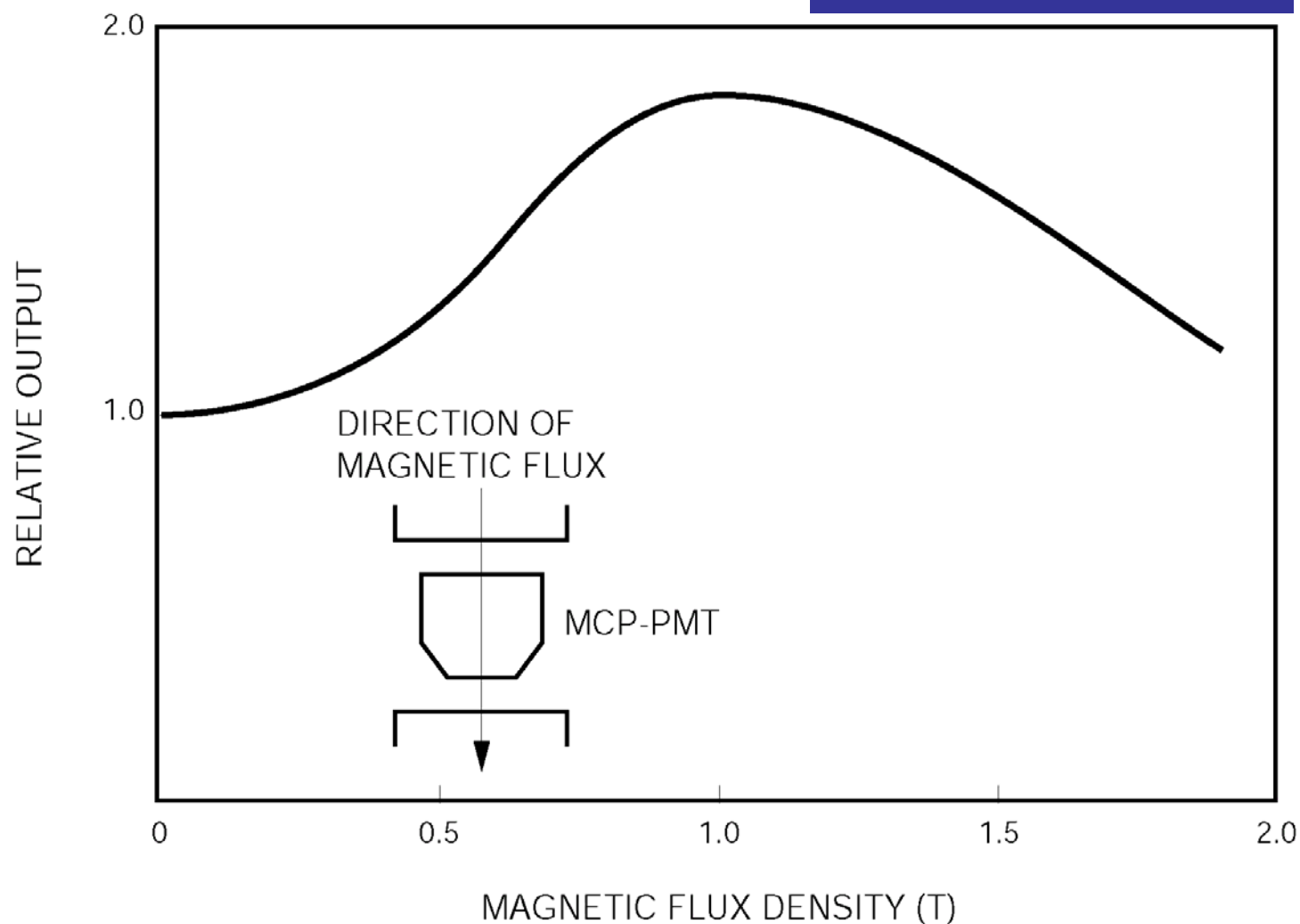
GaAsP photocathode



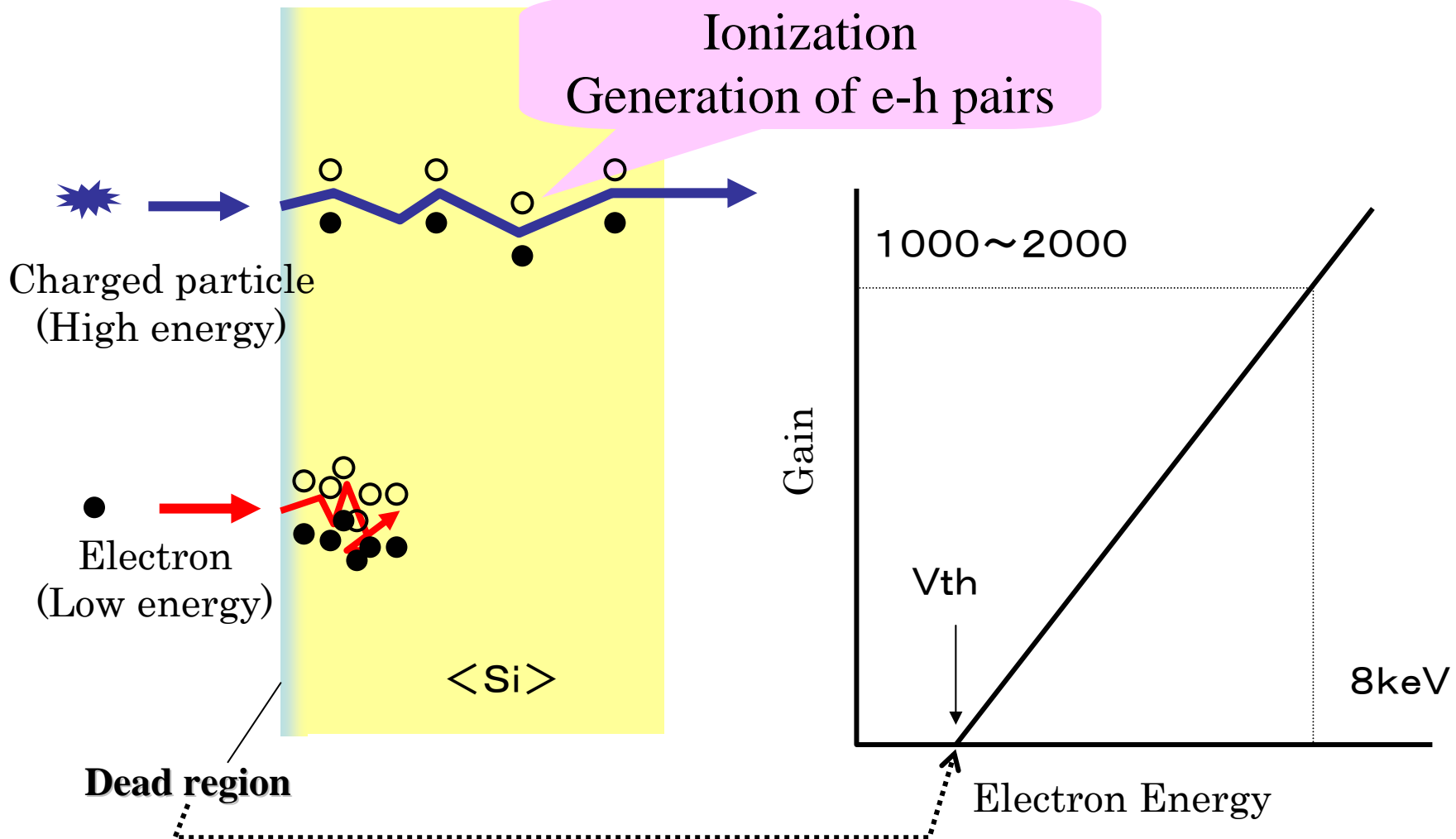
0.2 (ns/div)

If operated in magnetic field,

MCP-PMT

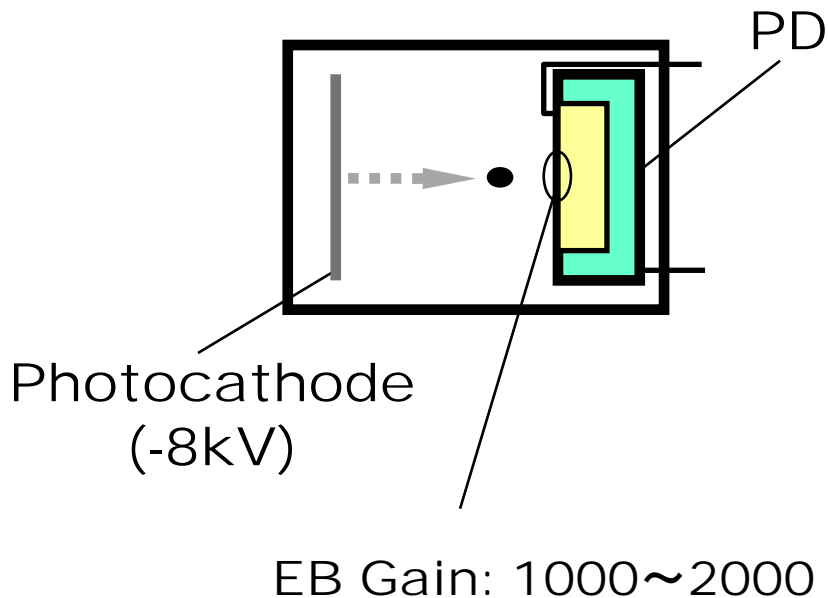


If number of photons should be counted, *High first gain: EB multiplication*

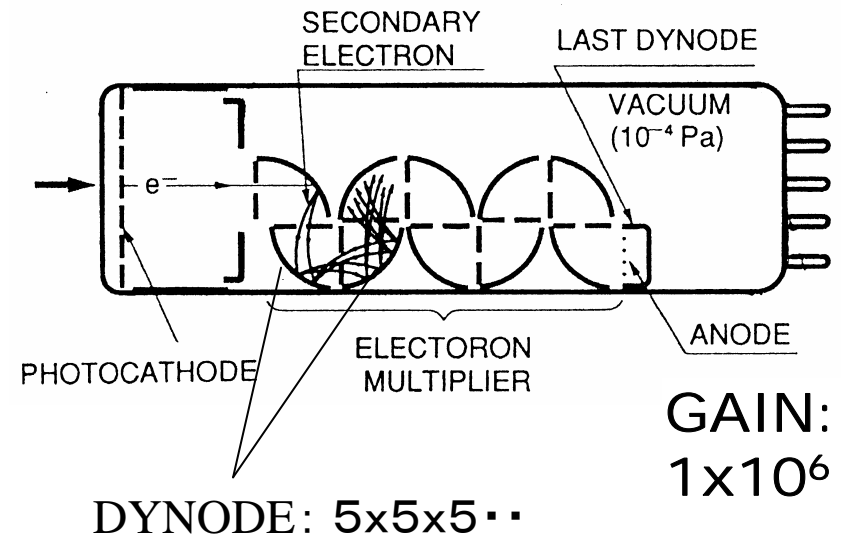


HPD compared with PMT

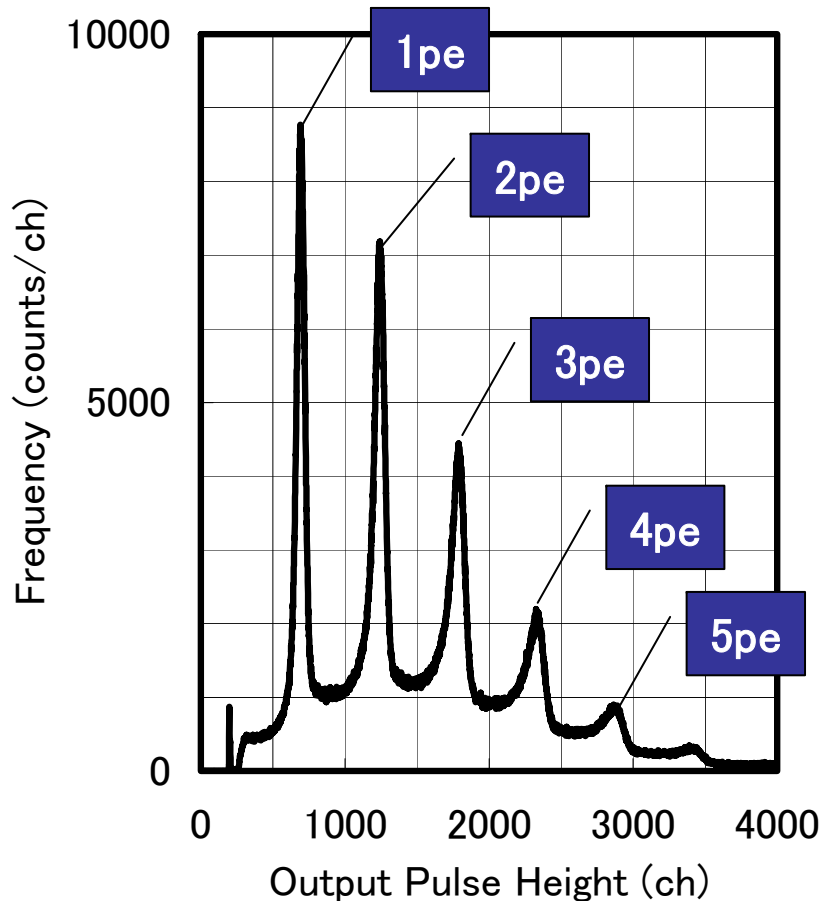
<Hybrid Photo Detector (HPD)>



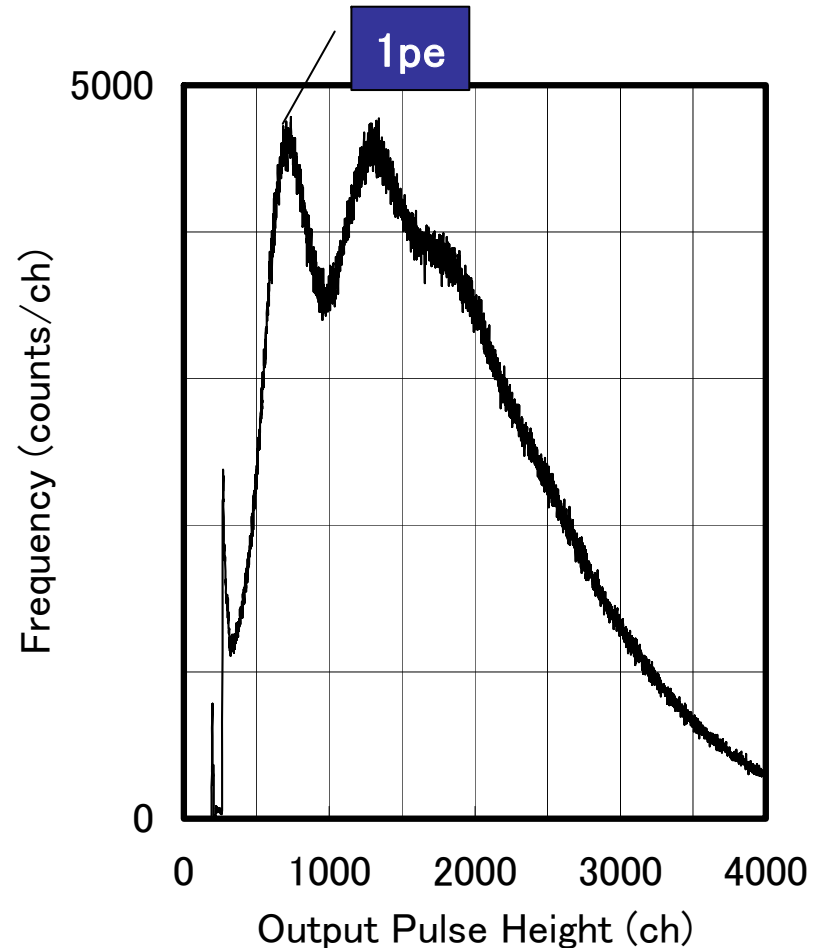
<PMT>



Pulse Height Distribution



HPD

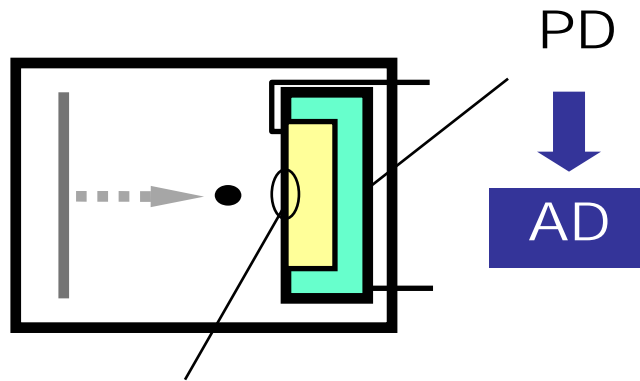


PMT

HPD compared with PMT

<Hybrid Photo Detector (HPD)>

<PMT>

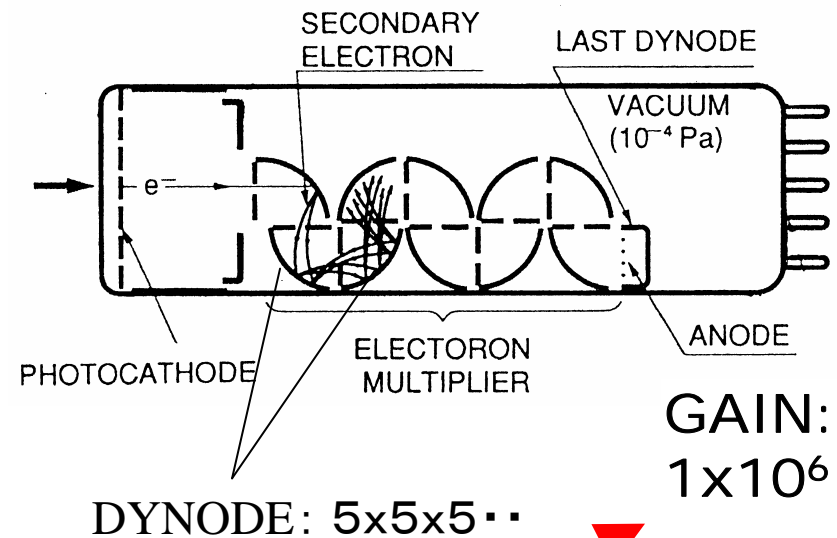


EB Gain: 1000~2000



AD Gain: 30~100

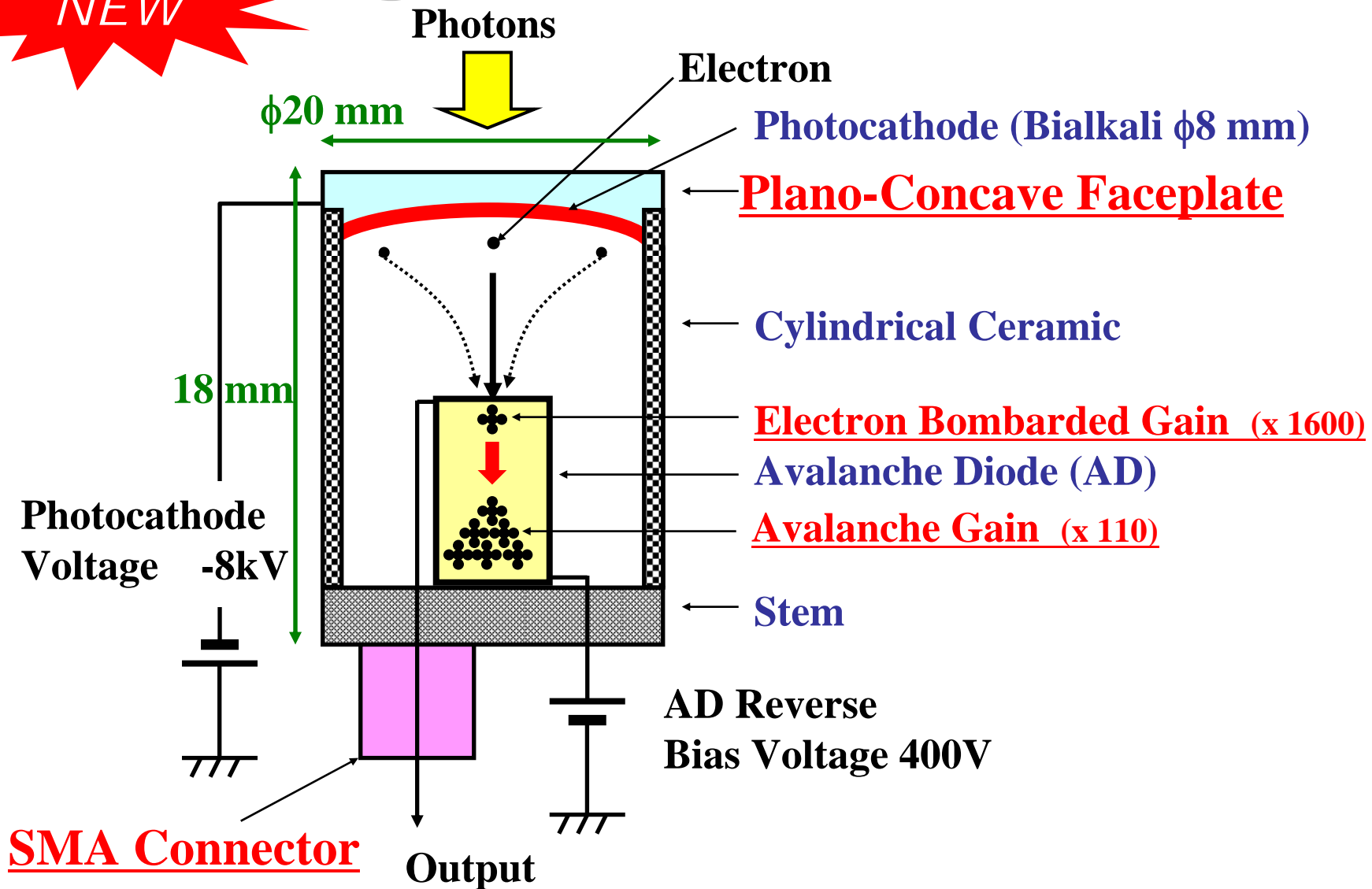
Total gain: $\sim 1 \times 10^5$



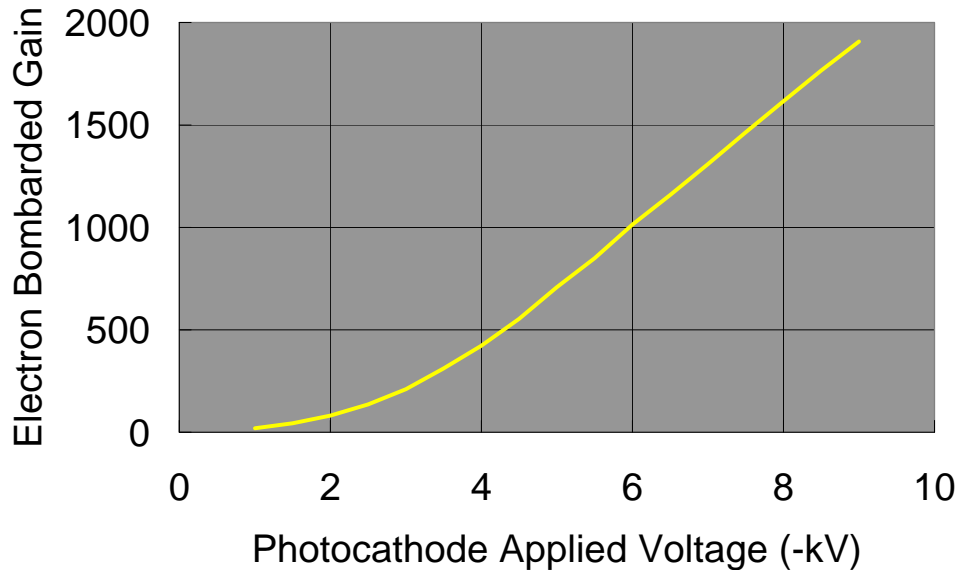
GAIN:
 1×10^6

High speed HPD

NEW



Gain Characteristics



Electron Bombarded Gain

1600 at -8 kV

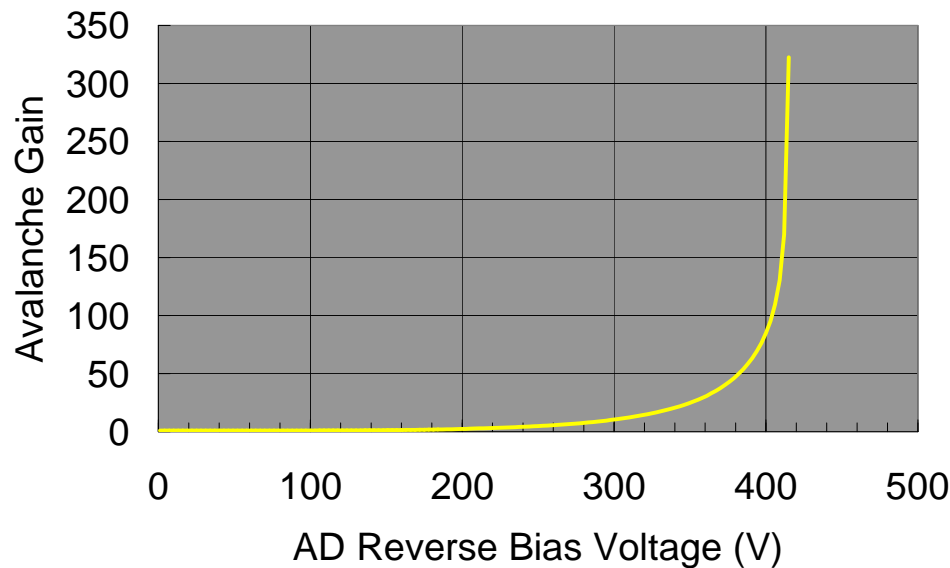
Avalanche Gain

110 at 405 V

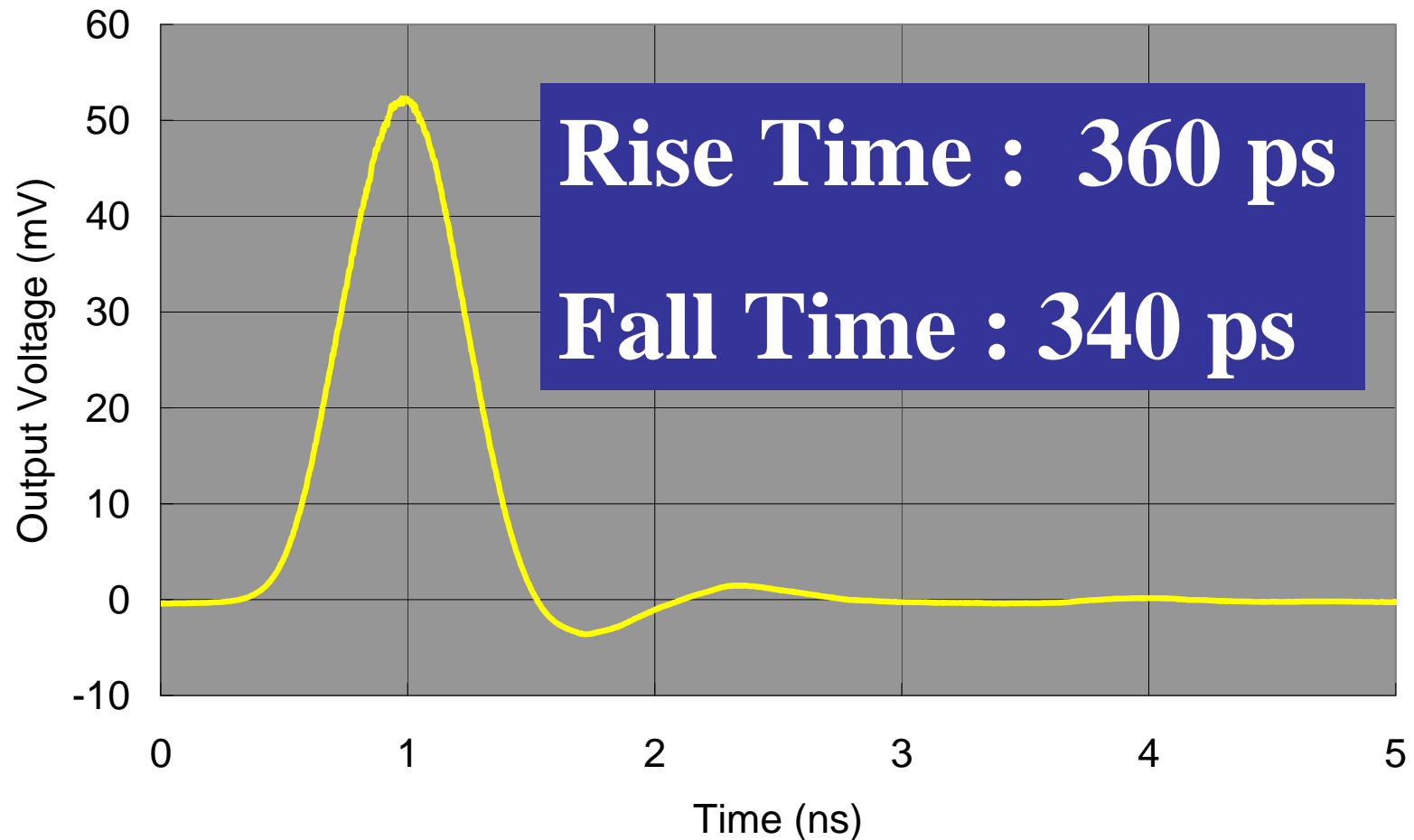


Total Gain

180,000



Time Response



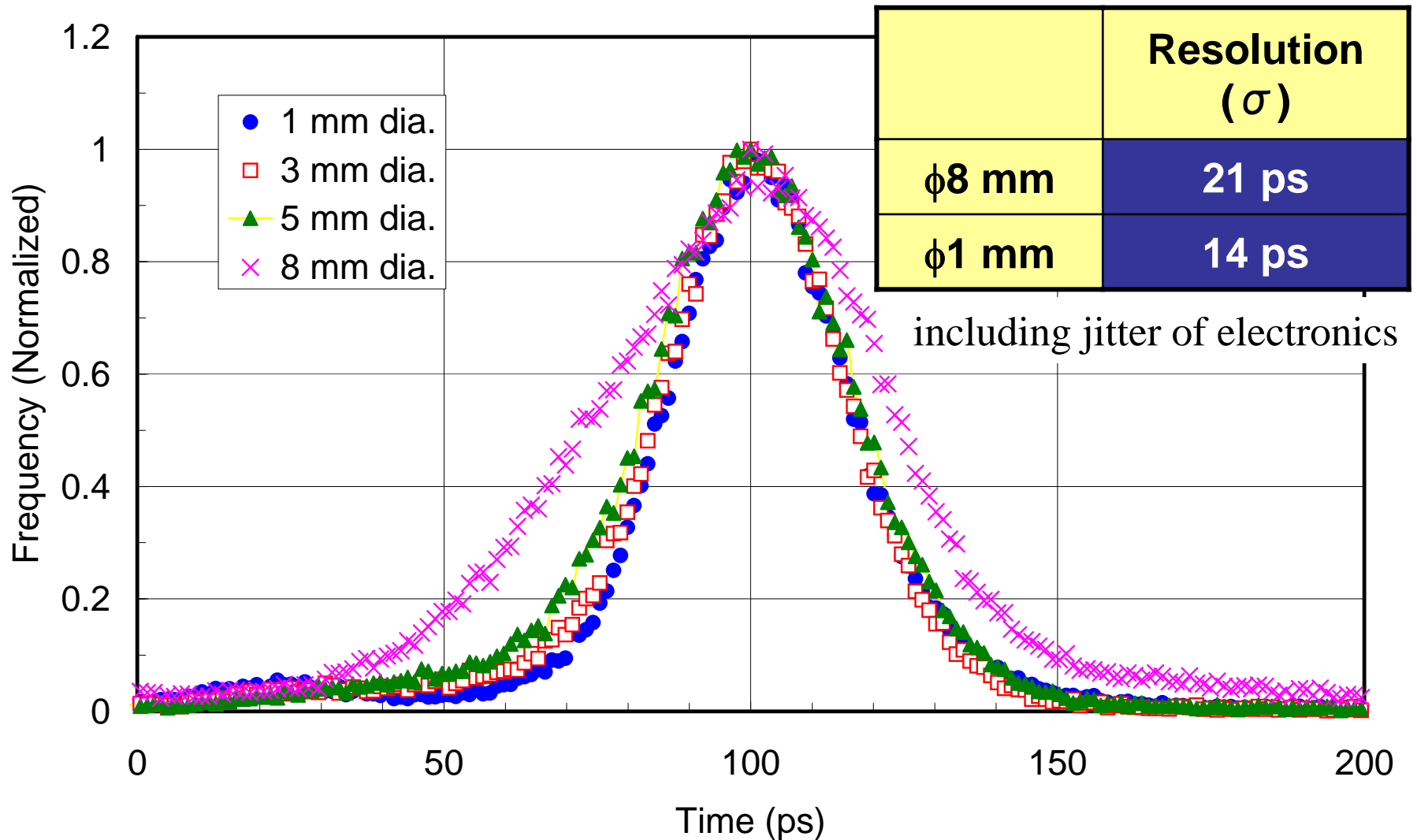
Photocathode Voltage : -8 kV

Oscilloscope : 1.5 GHz Bandwidth

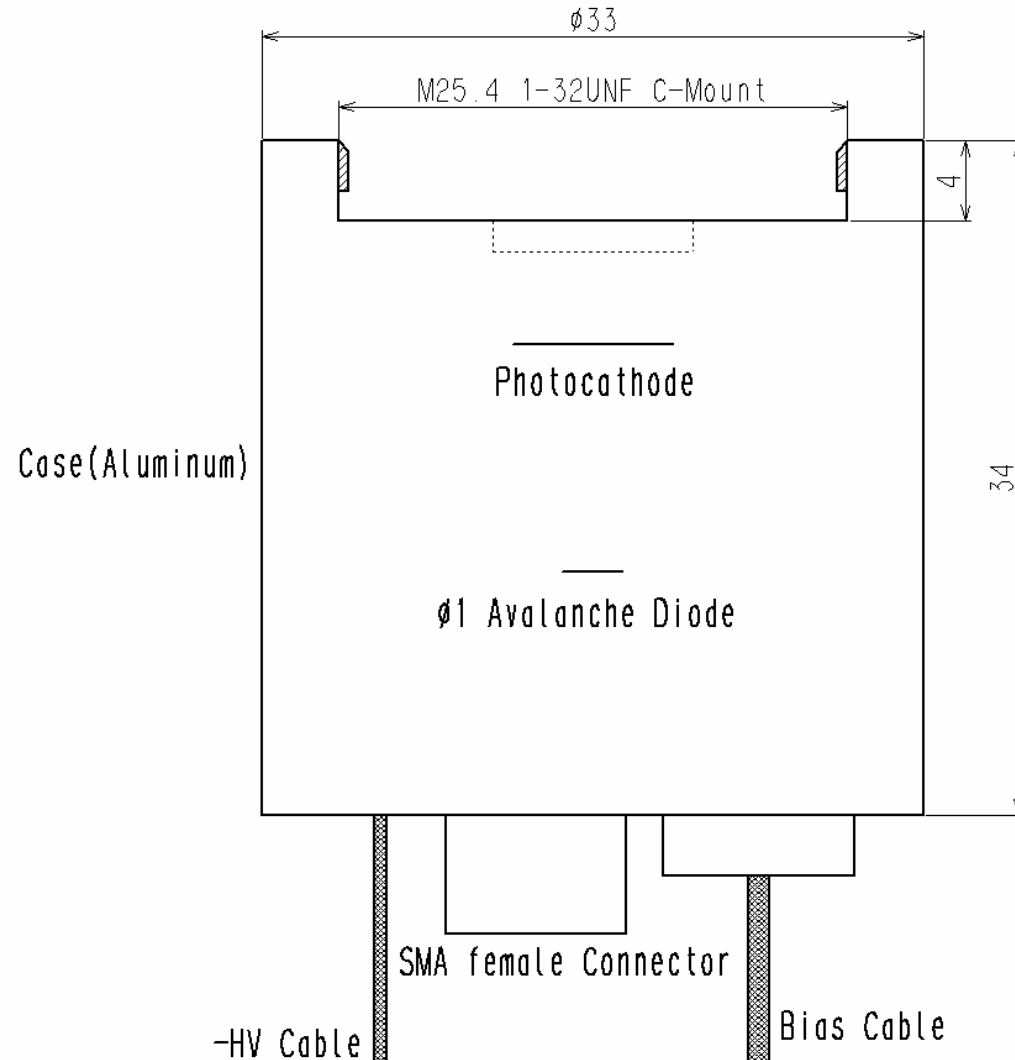
AD bias Voltage : 380 V

Load Impedance 50 ohm

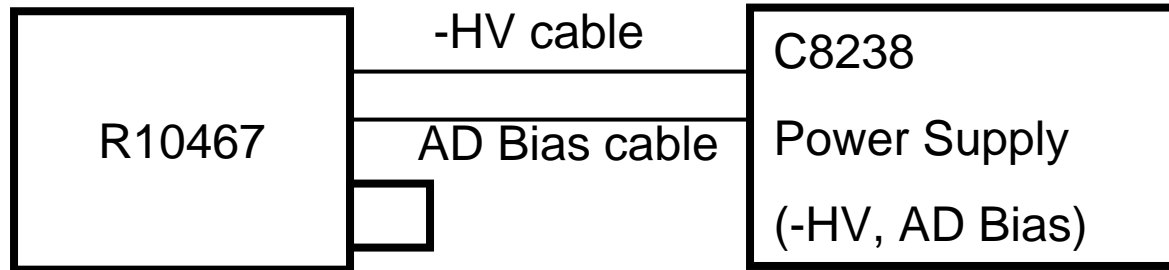
Timing Resolution



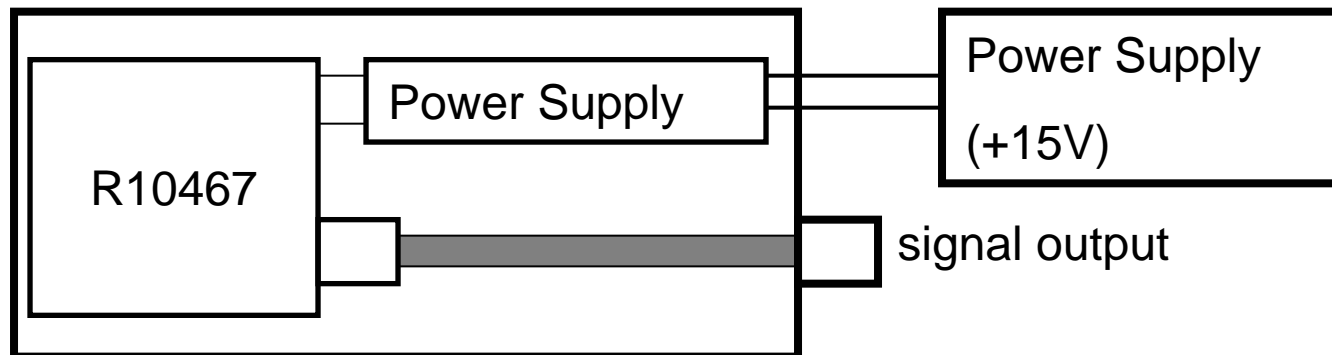
R10467 Assy (tentative)



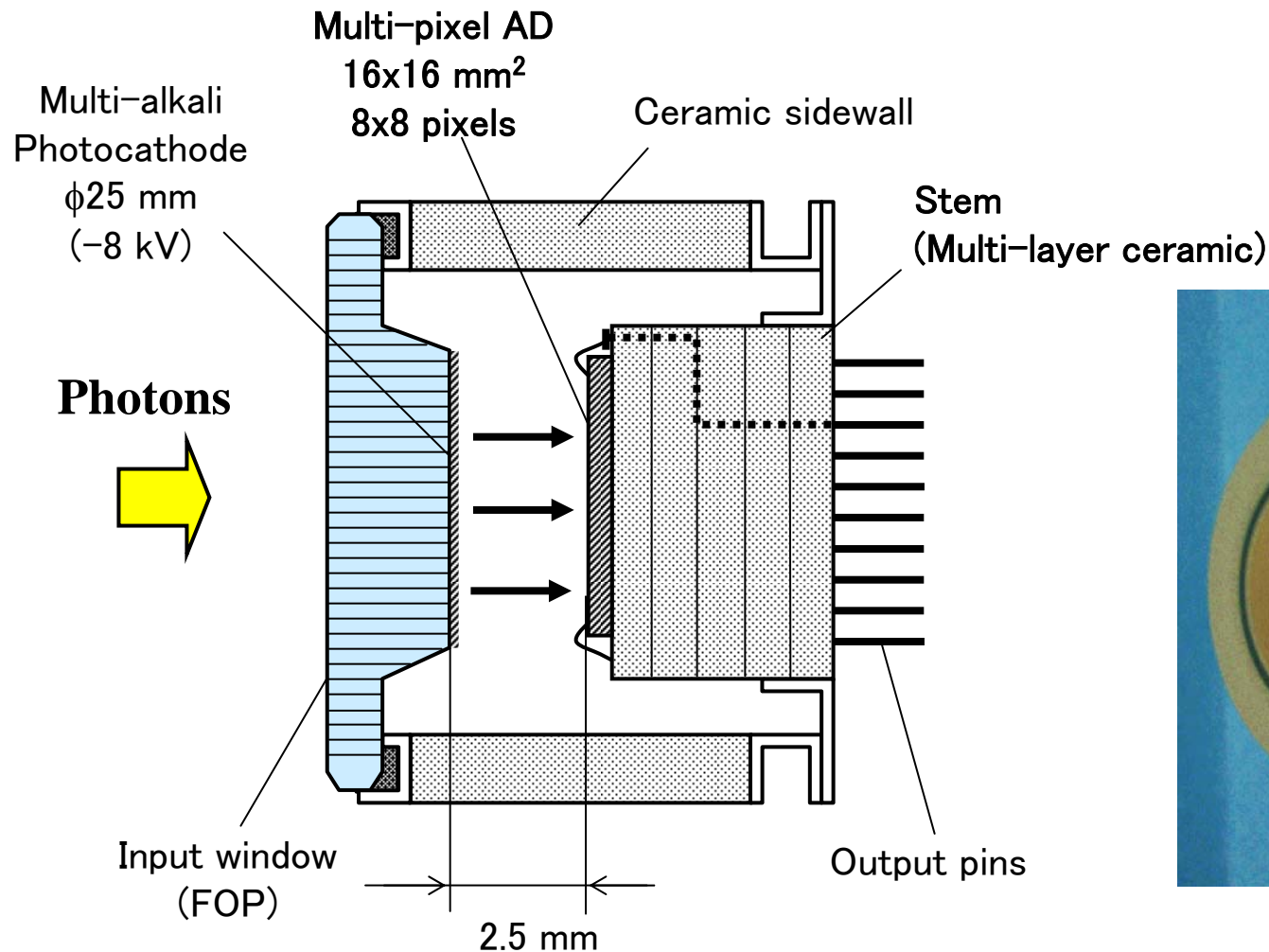
Module



High Speed HPD Module



Proximity focused HPD

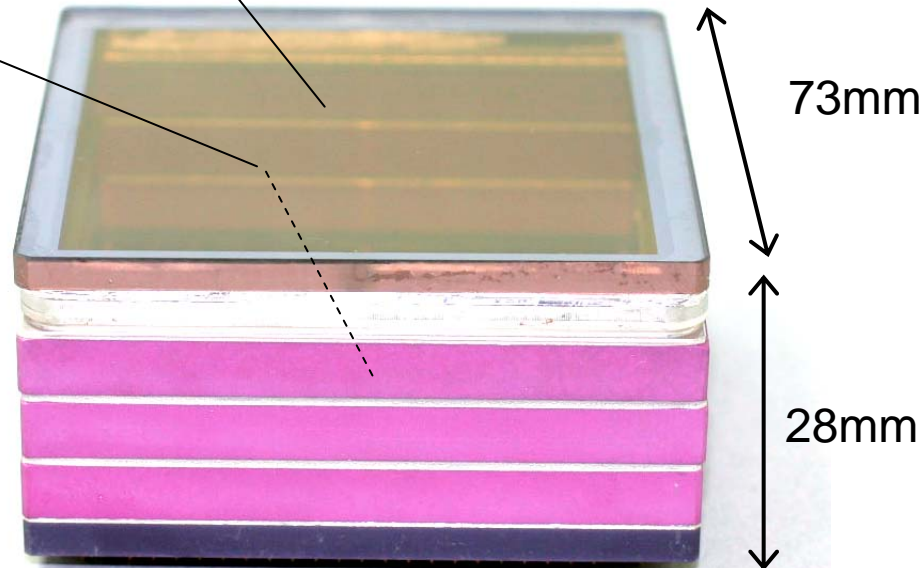


144 multi-anode HPD

*Nagoya Univ., KEK,
Tokyo metropolitan Univ.*

Bialkali
Effective area:
60x60mm

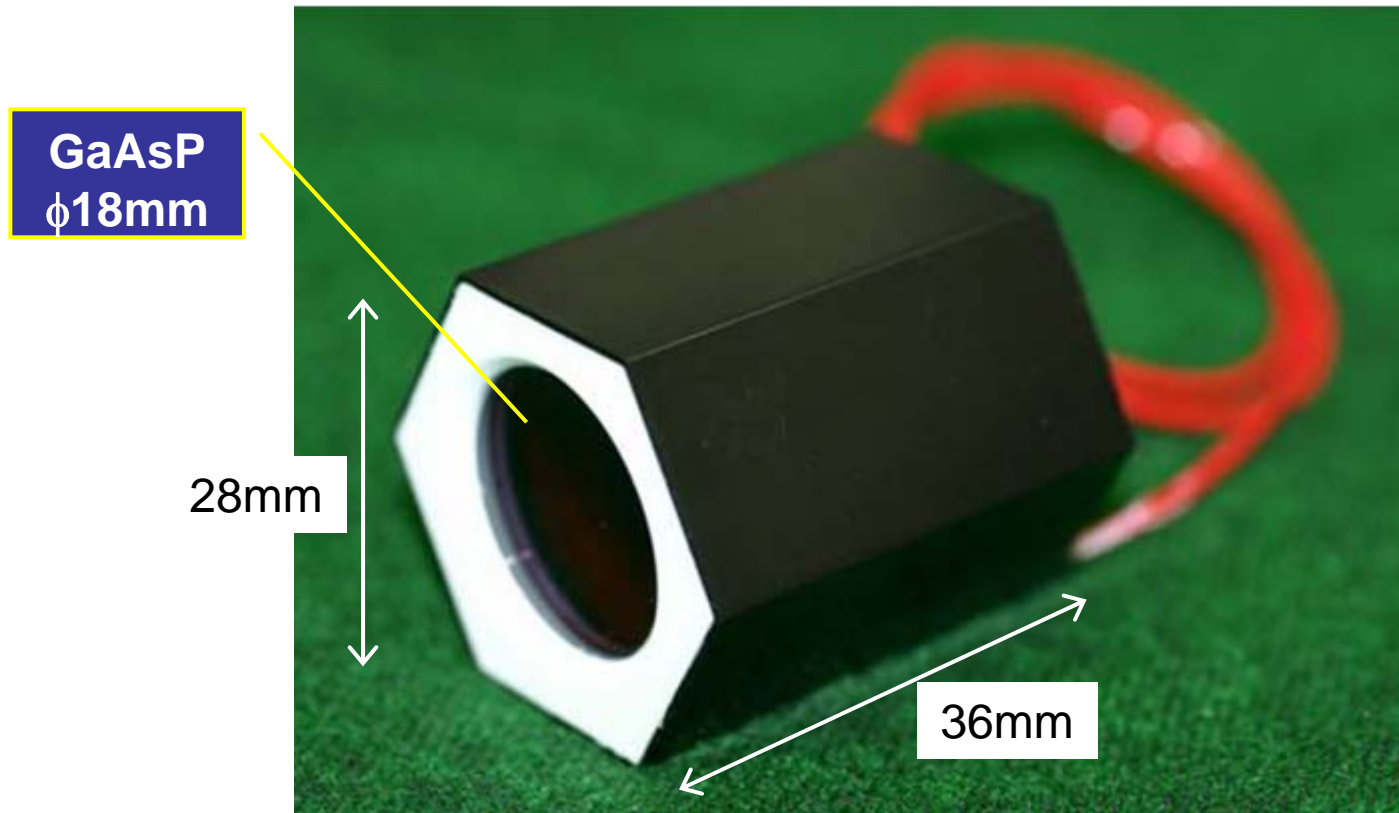
AD
5x5mm pixel
12x12 pixels



Please refer to Adachi-sensei's presentation

$\phi 18\text{mm}$ -GaAsP HPD

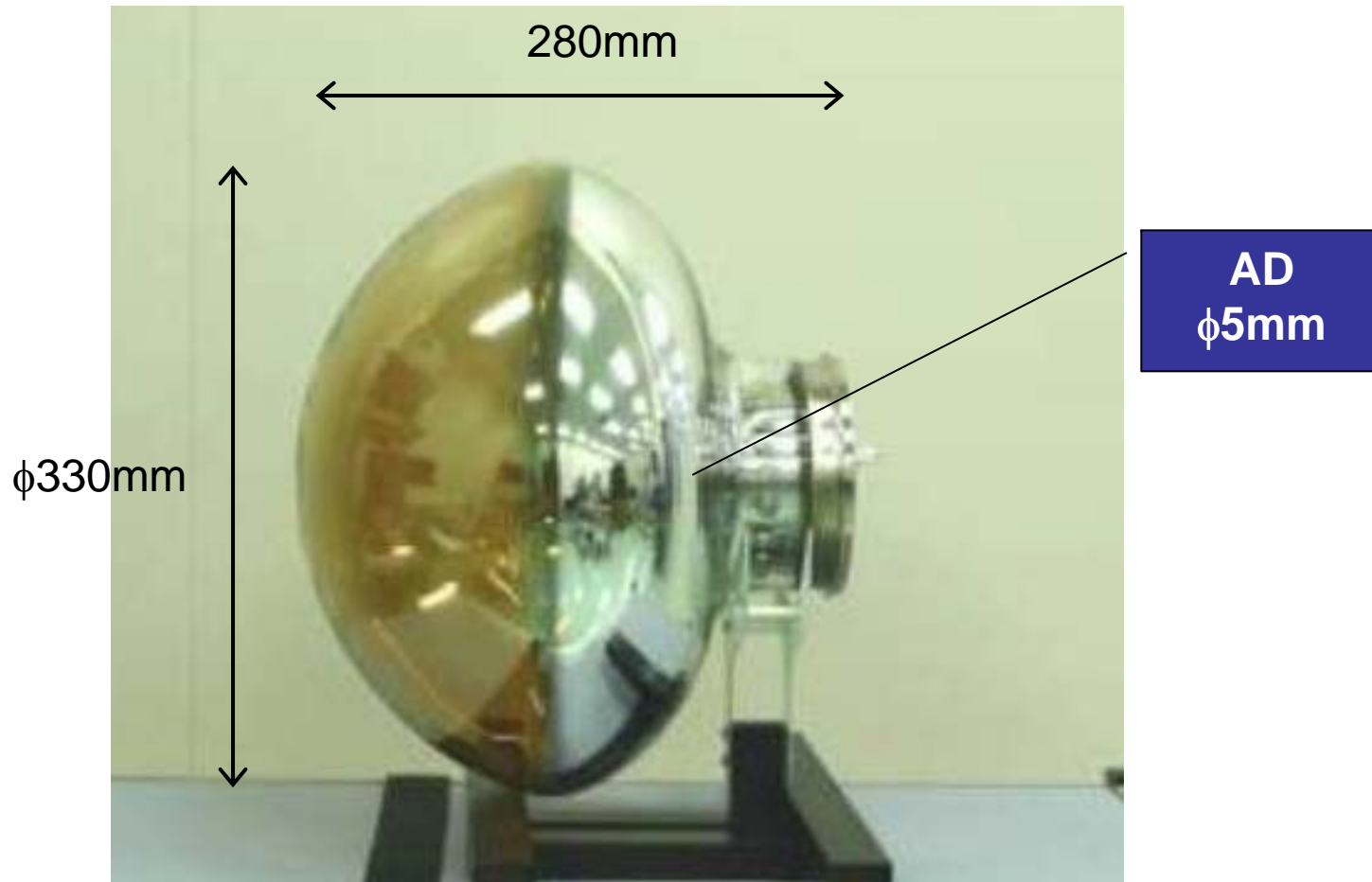
MPI



Please refer to Saito-san's presentation

Large format HPD

Tokyo Univ.



Summary

- **PMTs getting improved continuously**
 - High QE photocathode
 - Low profile metal channel dynode, MCP, etc.
- **Instead of dynodes, Si-device is used in HPD. Application field gradually expanding.**
 - High speed / Proximity focused / Large format / ϕ 18mm-GaAsP / 144 multi-anode

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