

高速型HPDの開発

2006年12月8日

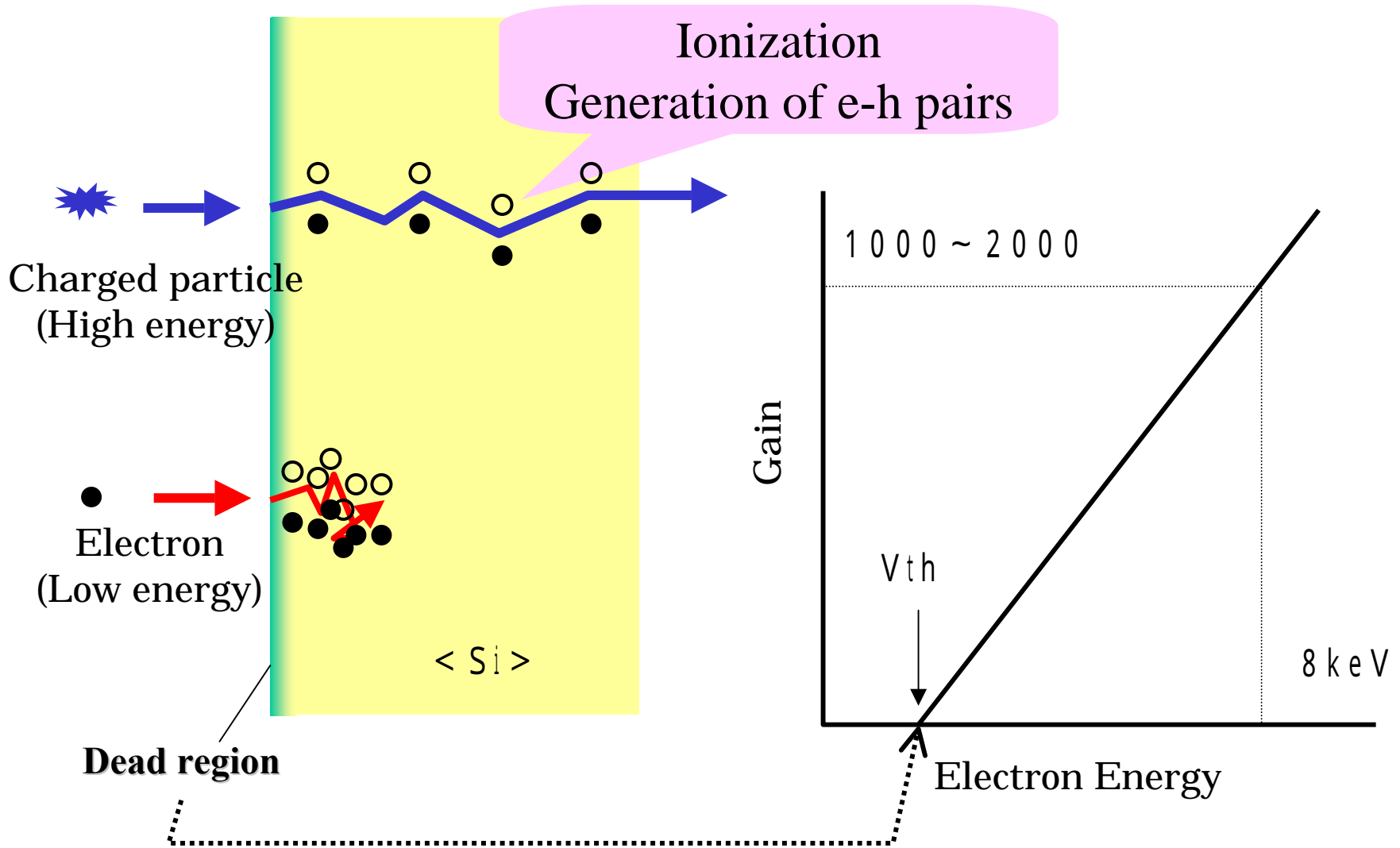
第2回次世代光センサーに関するワークショップ

浜松ホトニクス(株)電子管技術部
須山本比呂

Contents

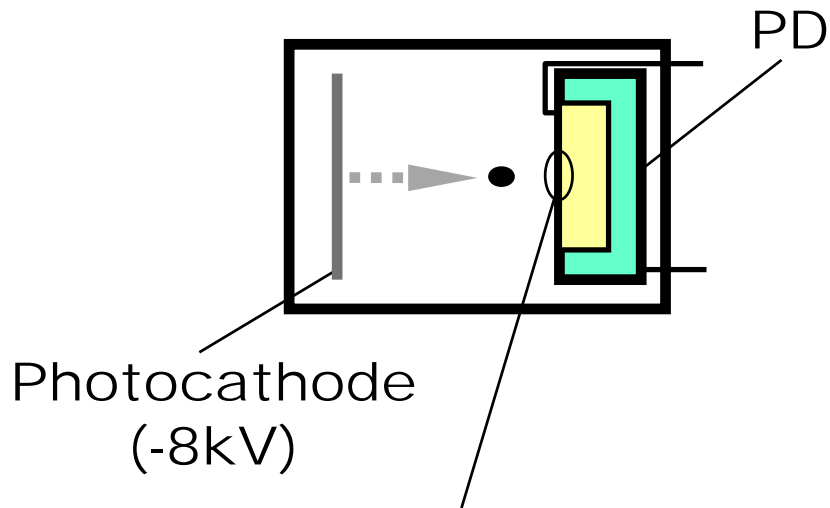
1. What's HPD? (Merit/demerit, potential)
2. Developed sensors
 - High speed HPD
 - Multi-pixel HPD

Electron Bombarded Gain



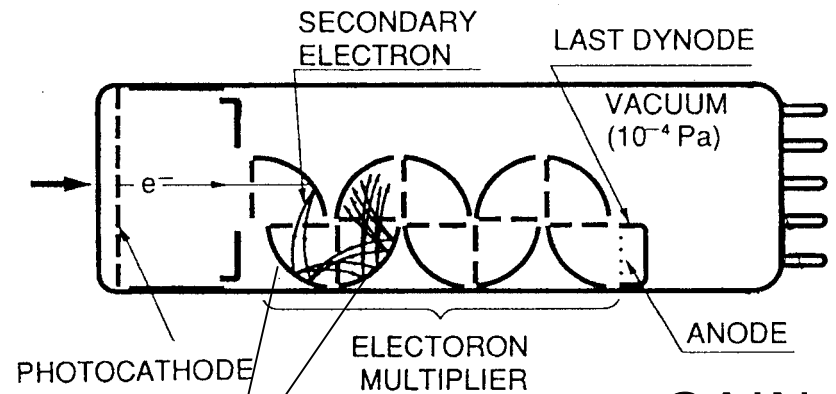
HPD compared with PMT

<Hybrid Photo Detector (HPD)>



EB Gain: 1000 ~ 2000

<PMT>

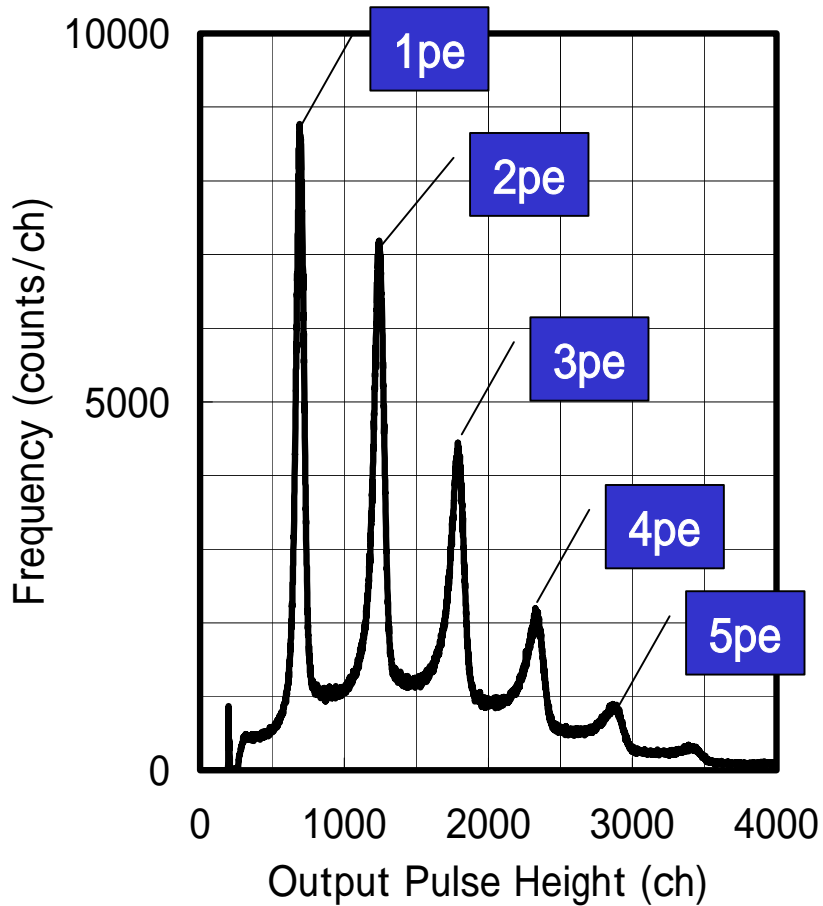


DYNODE: 5 x 5 x 5 ..

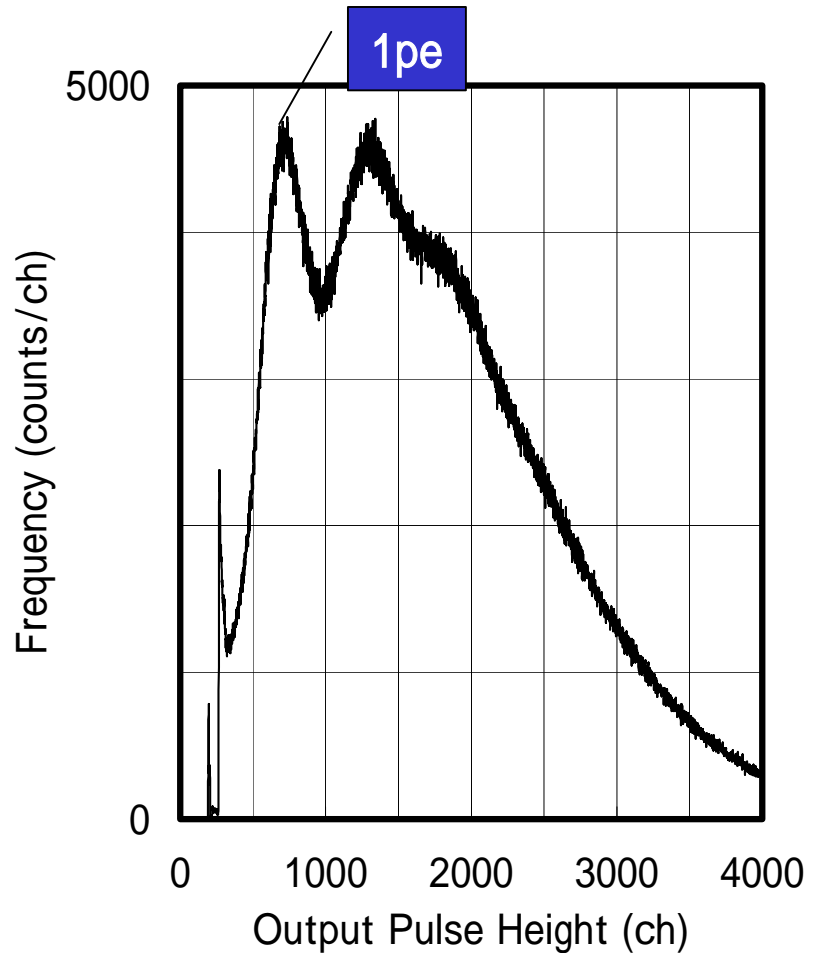
GAIN:
 1×10^6



Pulse Height Distribution



HPD

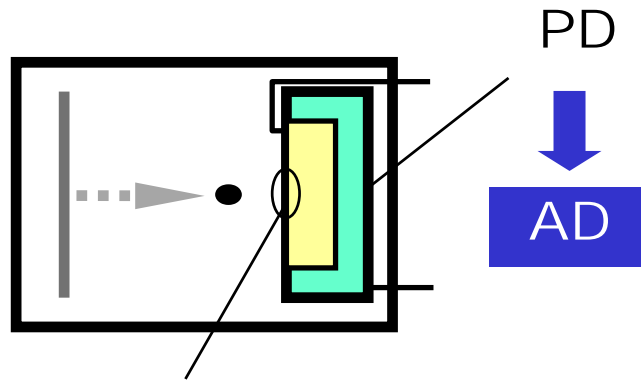


PMT

HPD compared with PMT

<Hybrid Photo Detector (HPD)>

<PMT>

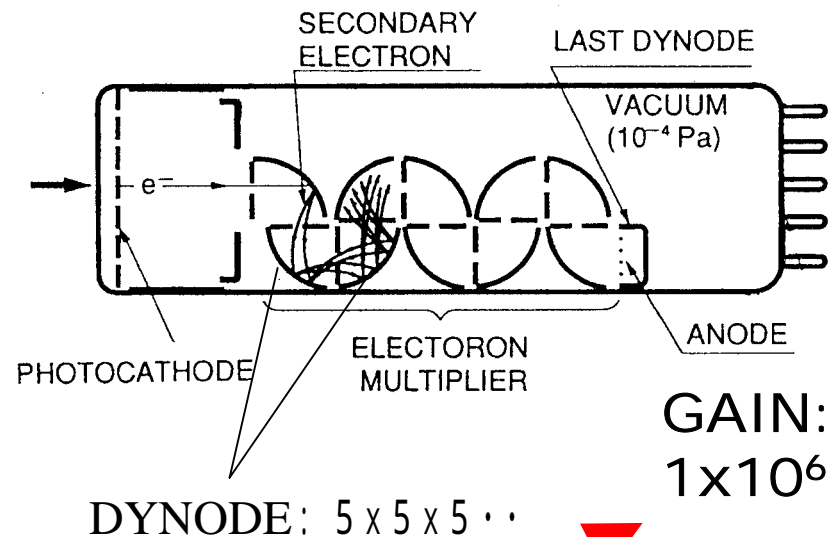


EB Gain: 1000 ~ 2000

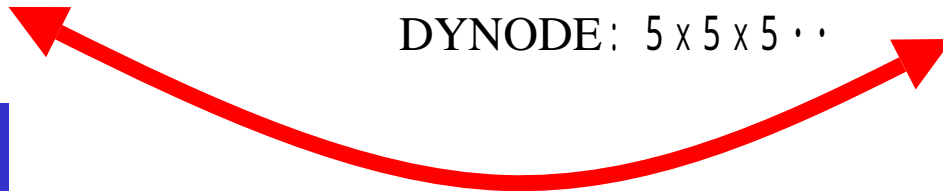


AD Gain: 30 ~ 100

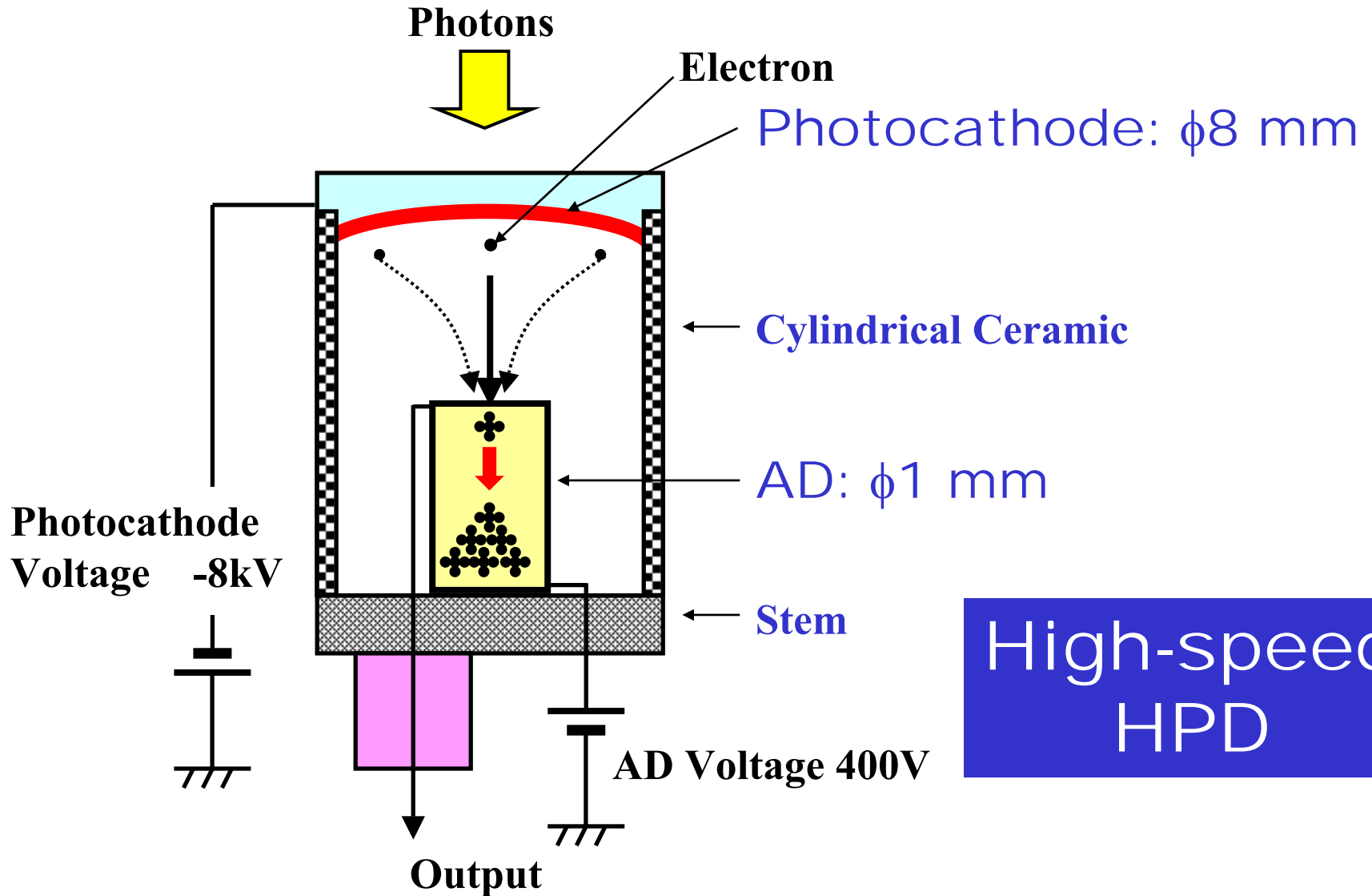
Total gain: $\sim 1 \times 10^5$



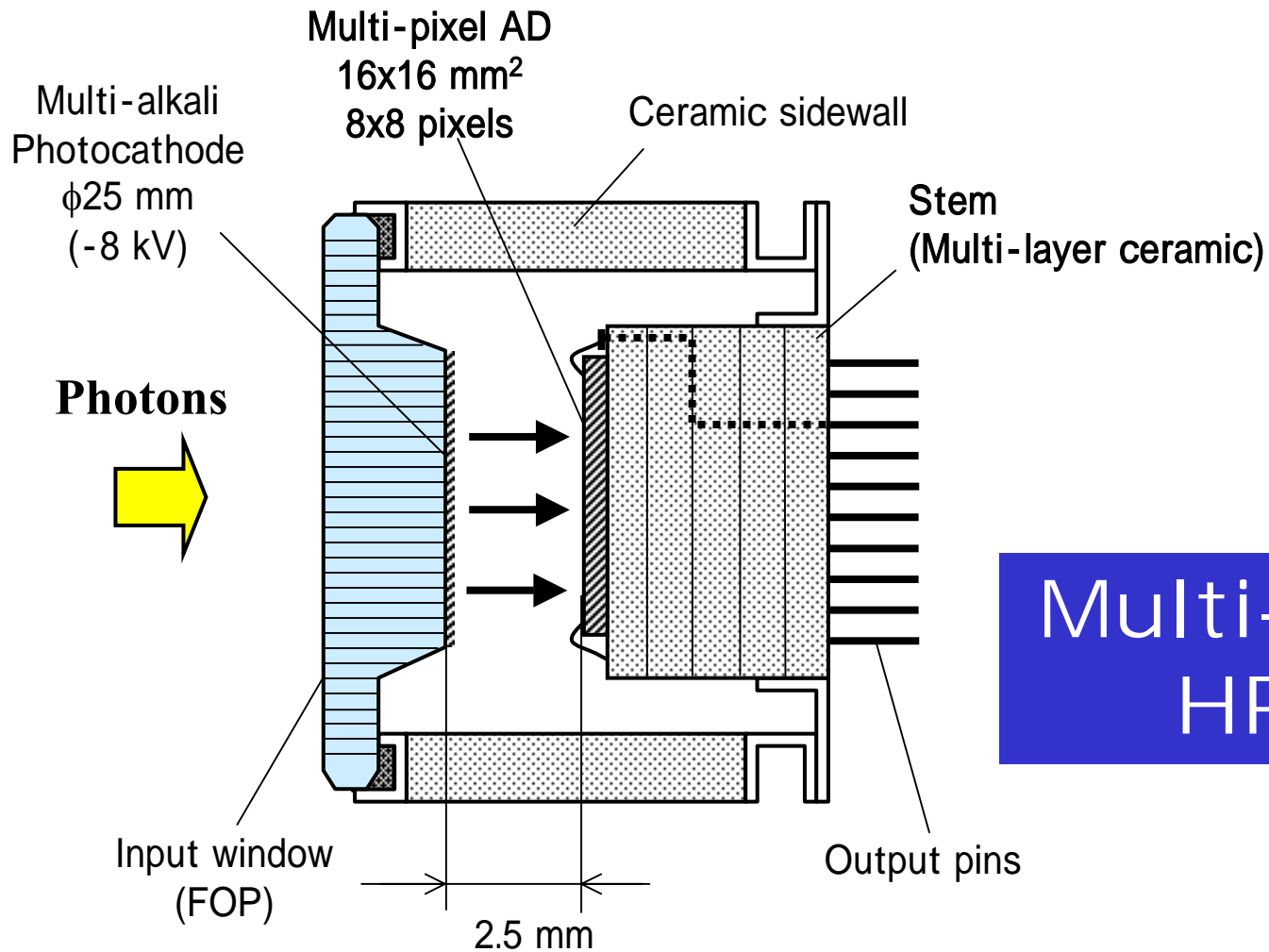
GAIN:
 1×10^6



Electro-static Focusing Type

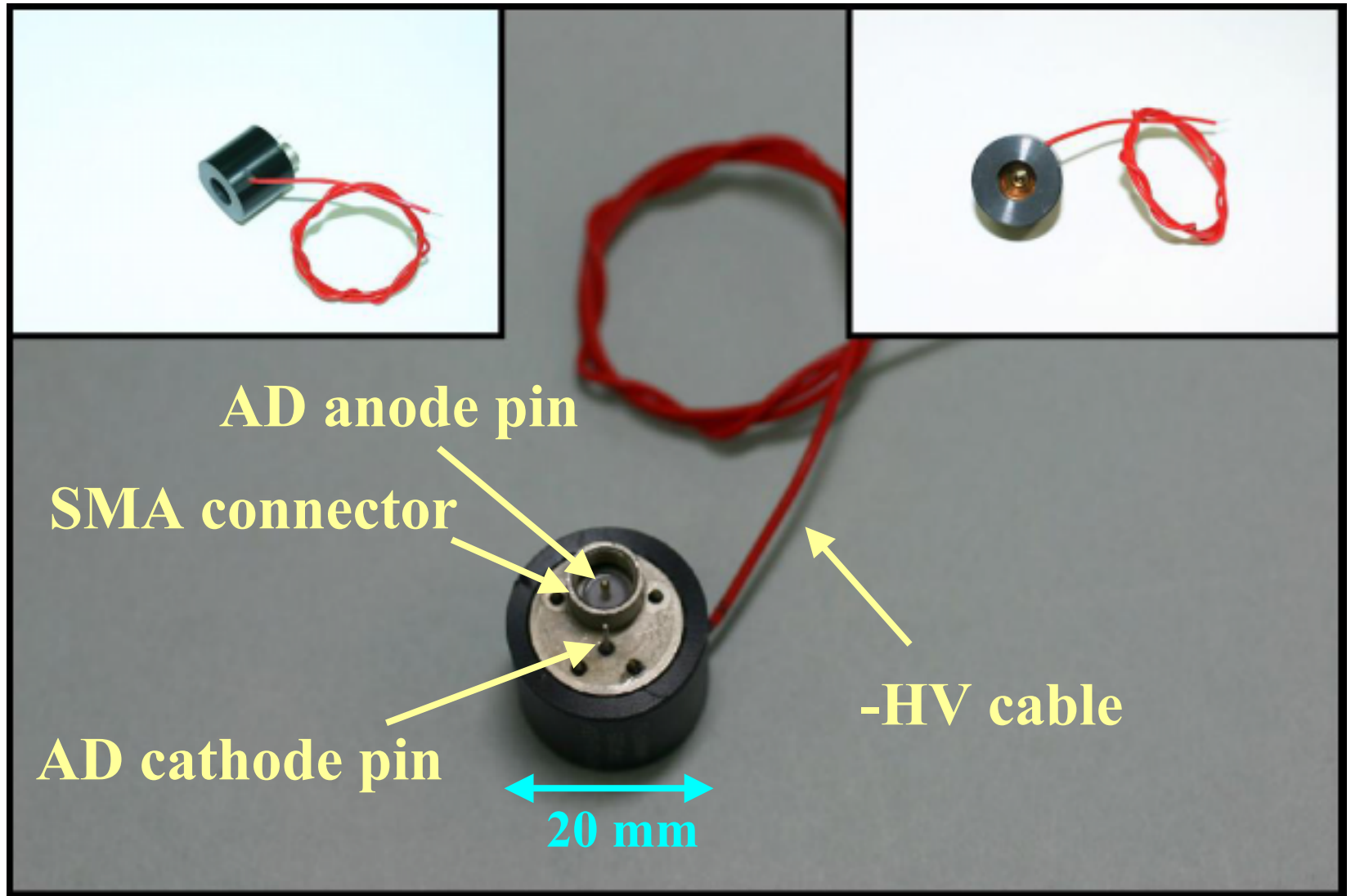


Proximity Focusing

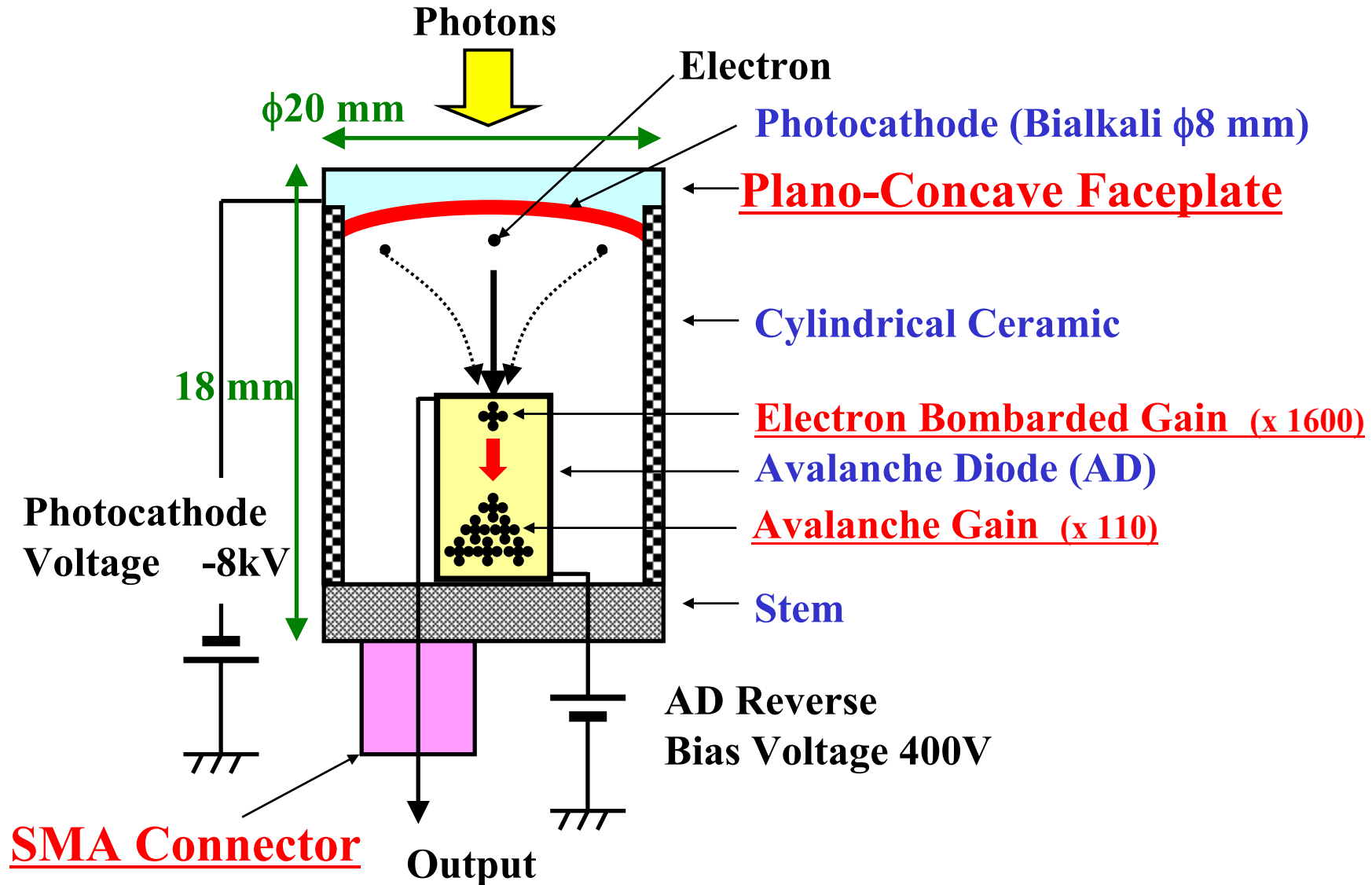


Multi-pixel
HPD

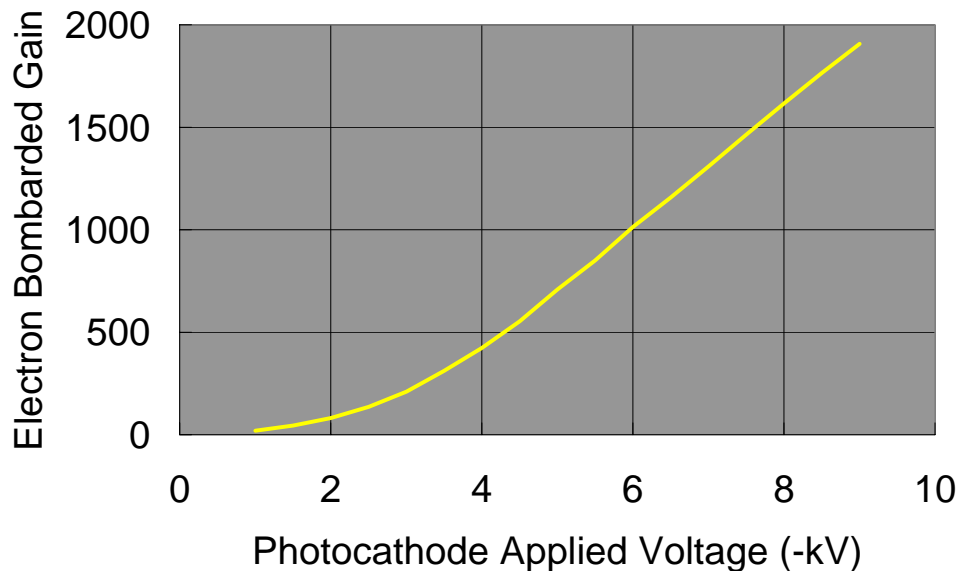
High speed HPD



Structure of High speed HPD



Gain Characteristics



Electron Bombarded Gain

1600 at -8 kV

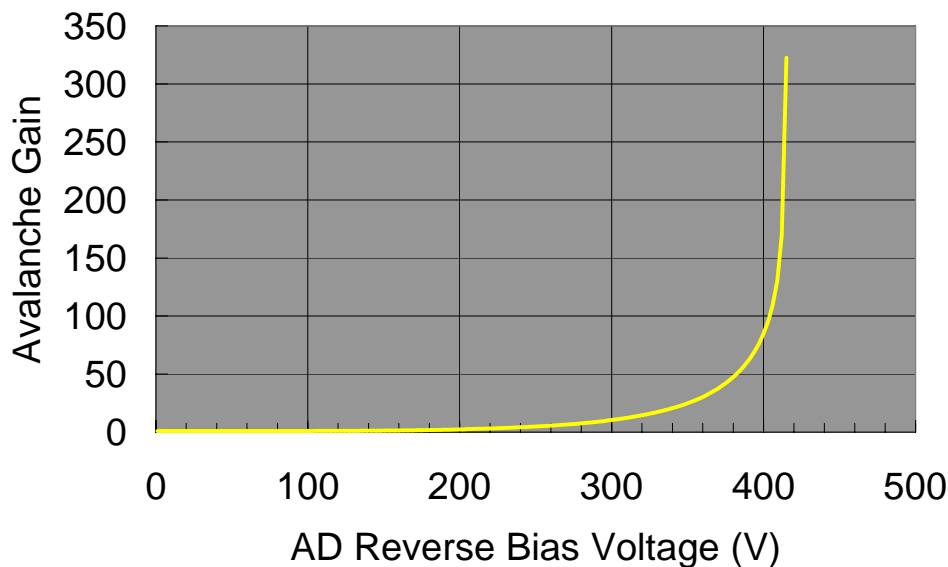
Avalanche Gain

110 at 405 V

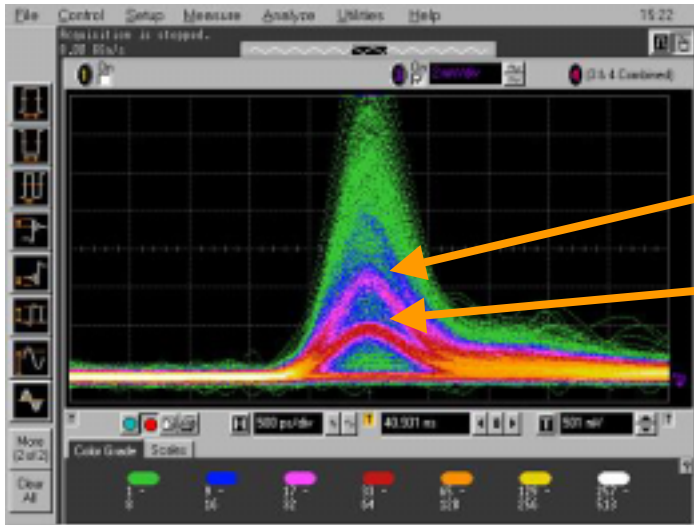


Total Gain

180,000



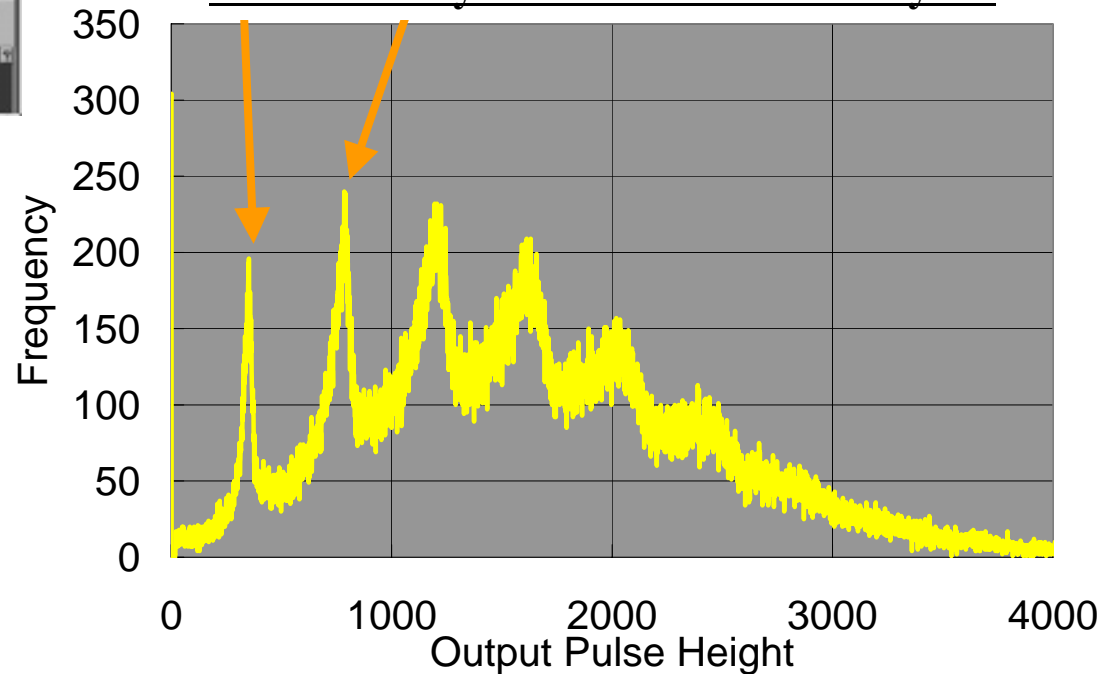
Pulse Height Distribution



2 p.e.

1 p.e.

Measured by Multi-Channel-Analyzer



Measured by Oscilloscope

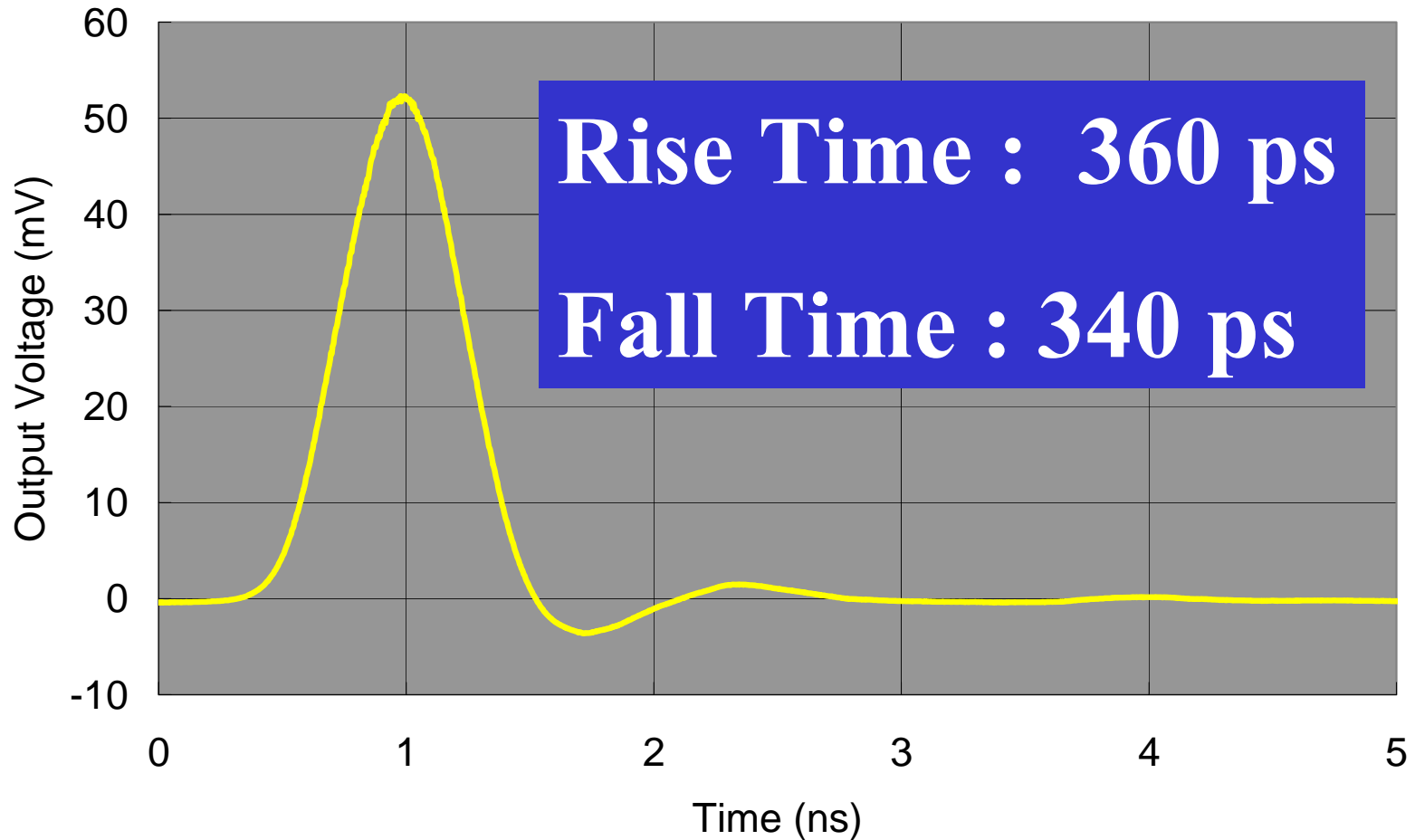
Load Impedance : 50 ohm

-8 kV, 405 V



**Pulse Height of 2 mV
for Single Photon**

Time Response



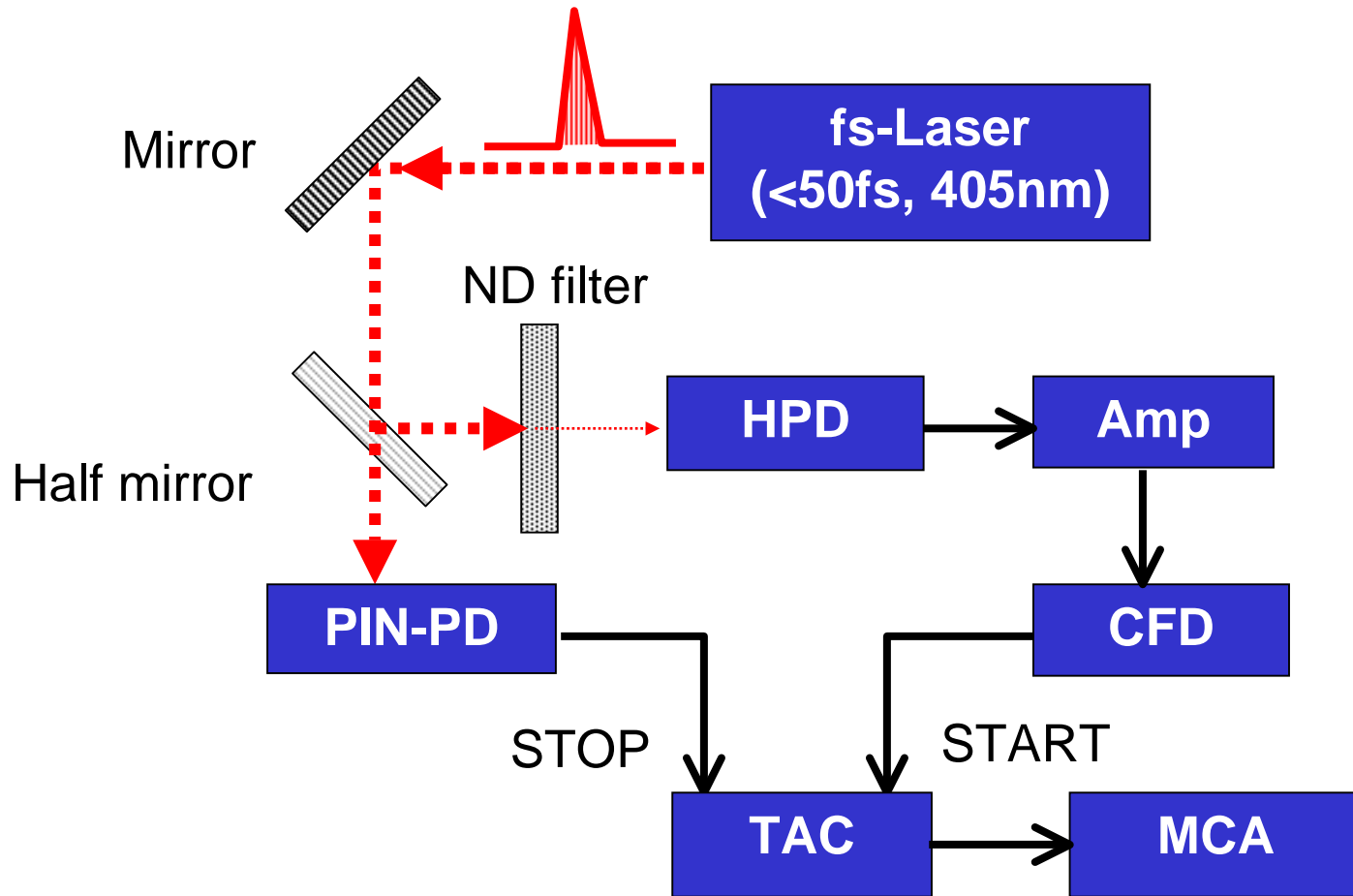
Photocathode Voltage : -8 kV

Oscilloscope : 1.5 GHz Bandwidth

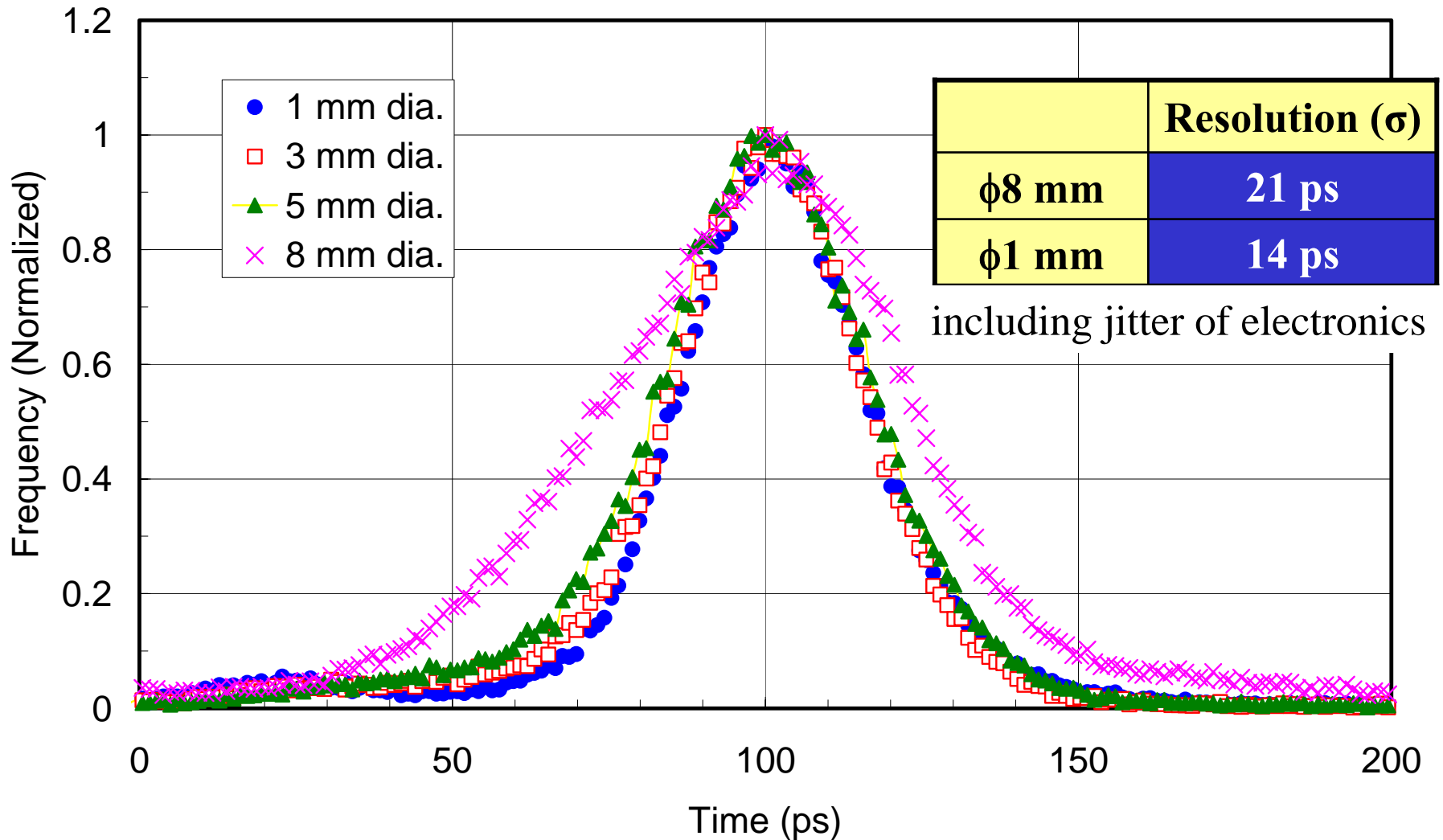
AD bias Voltage : 380 V

Load Impedance 50 ohm

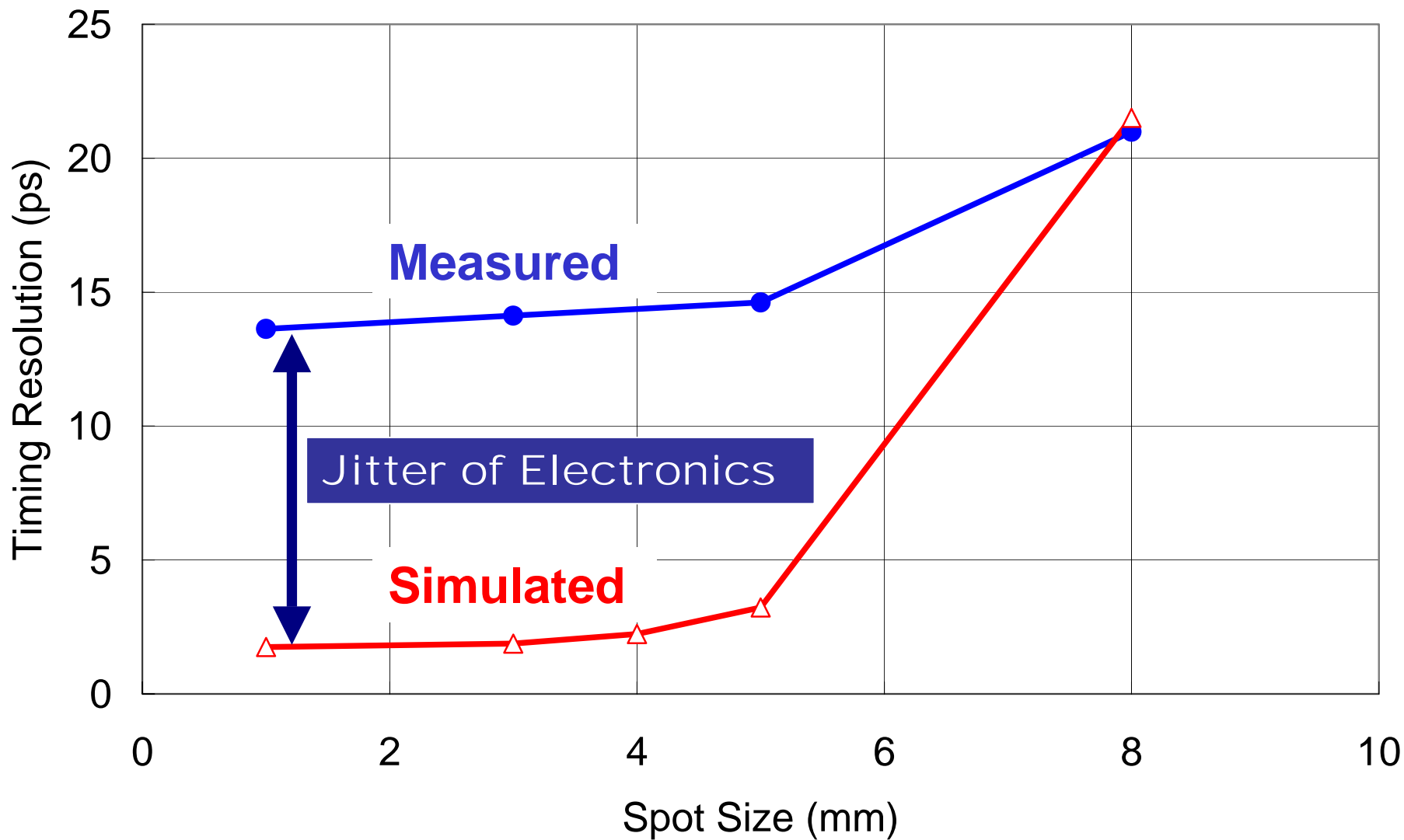
Setup for Timing Resolution



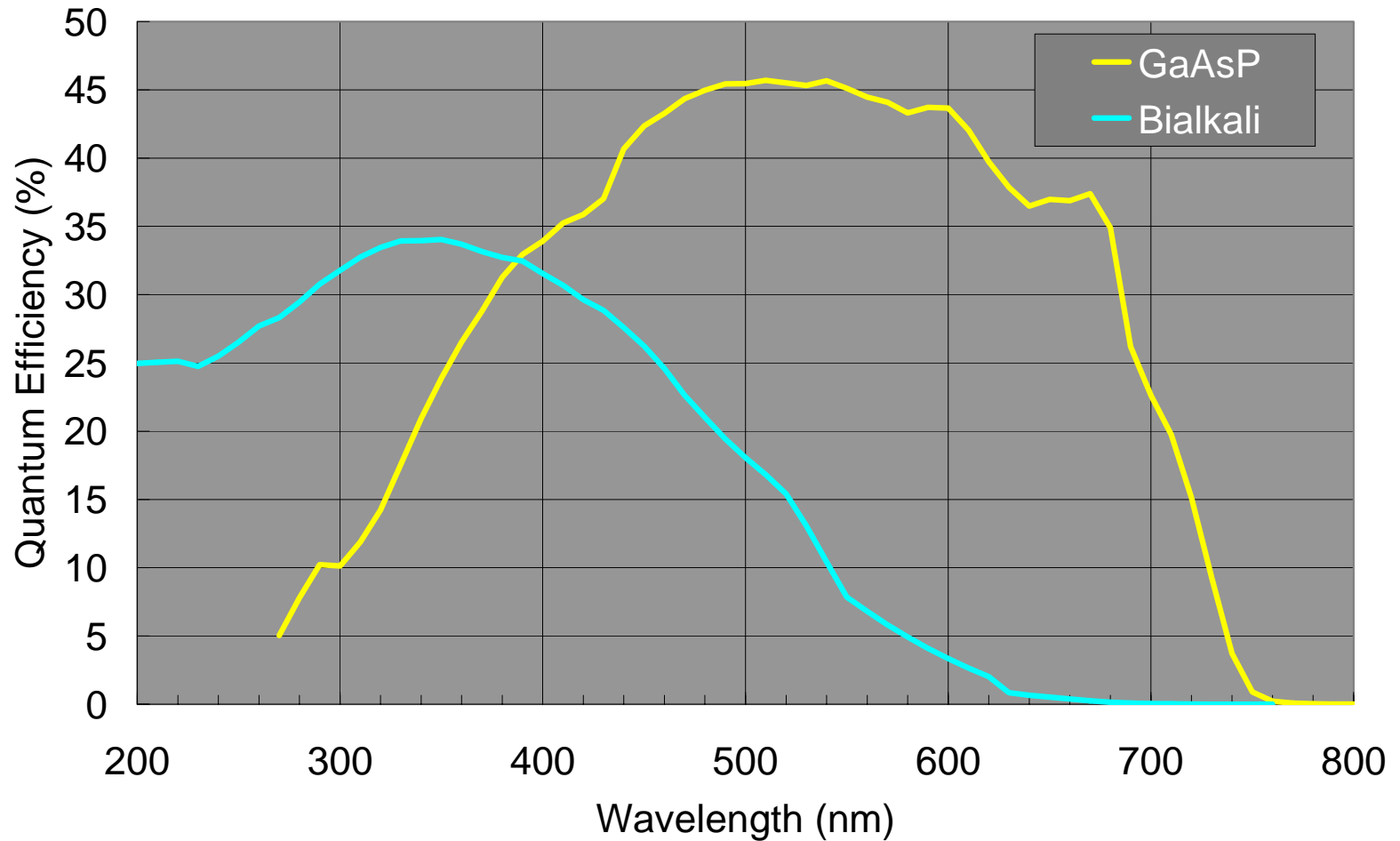
Timing Resolution



Comparison with simulation



Photocathode Sensitivity (QE)



Bialkali: 34 % at 350 nm

GaAsP: 46 % at 500 nm

High speed HPD Summary

	Bialkali		GaAsP	
Photocathode Quantum Efficiency at the peak	34 %		46 %	
Effective Area	ϕ 8 mm		ϕ 3 mm	
Gain	2 x 10 ⁵			
Time Response	Rise Time 360 ps			
	Fall Time 340 ps			
Timing Resolution σ for single photon (Estimated)	ϕ8 mm	ϕ 1mm	ϕ3 mm	ϕ 1mm
	21 ps	14 ps	38 ps	28 ps

The world fastest HPD is realized!!

Collaborators for High speed HPD Development

- **High Energy Accelerator Research Organization (KEK)**

J. Haba, H. Nakazawa

- **Hamamatsu Photonics K.K.**

Solid State Division

K. Yamamoto, Y. Ishikawa, M. Muramatsu

Electron Tube Division

**J. Takeuchi, T. Morita, S. Muramatsu, Y. Negi,
Y. Egawa, K. Shinmura, S. Kimura, M. Suyama,
A. Kageyama**

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