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New gatable MCP-PMTs and their performances in comparison with semiconductor type detectors for SLR applications

Takeshi Taguchi, Masahiro Nakamura
Hamamatsu Photonics K. K.

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Abstract

MCP-PMTs(Microchannel Plate Photomultiplier Tubes) and semiconductor detectors such as APD (Avalanche Photo Diode) are commonly used for SLR applications.

Performance of these detectors are compared on parameters such as sensitivity, noise, temporal response, timing jitter and other characteristics. The MCP-PMTs we have developed show improvements in especially sensitivity and noise induced by gating pulse.

We also focus on signal processing technic to optimize detector performance and introduce other possible detector modules for future applications. Other possible applications using MCP-PMTs are discussed as well for general laser ranging.

Introduction

New Gated MCP-PMTs introduced herein have been improved in their performances. In particular, sensitivity (= detection efficiency in this case) and time jitter（resolution) are superior to the former type, R5916U series.

In comparison with semiconductor type detector, this new gated MCP-PMT unit shows some advantages on its performance.

Improvements in Sensitivity and Time Resolution

Fig. 1 shows structures and operating principles of former type (R5916U series) and new gated MCP-PMT. R5916U has a grid electrode between the photocathode and MCP for gating function but new one does not. In a case of new one, a gate pulse is directly applied to the photocathode instead of the grid electrode.

This results in improvement of detection efficiency (***30% UP!***) because the grid electrode blocks some photoelectrons passing through and also generates some time jitter caused by low potential due to the gate pulse (10 to 50 V but 200 V with the new type) as shown in **Fig. 2**.

In Comparison with Former Types (R5916U Series)【Structures(Sensor Head) & Operating Principles】

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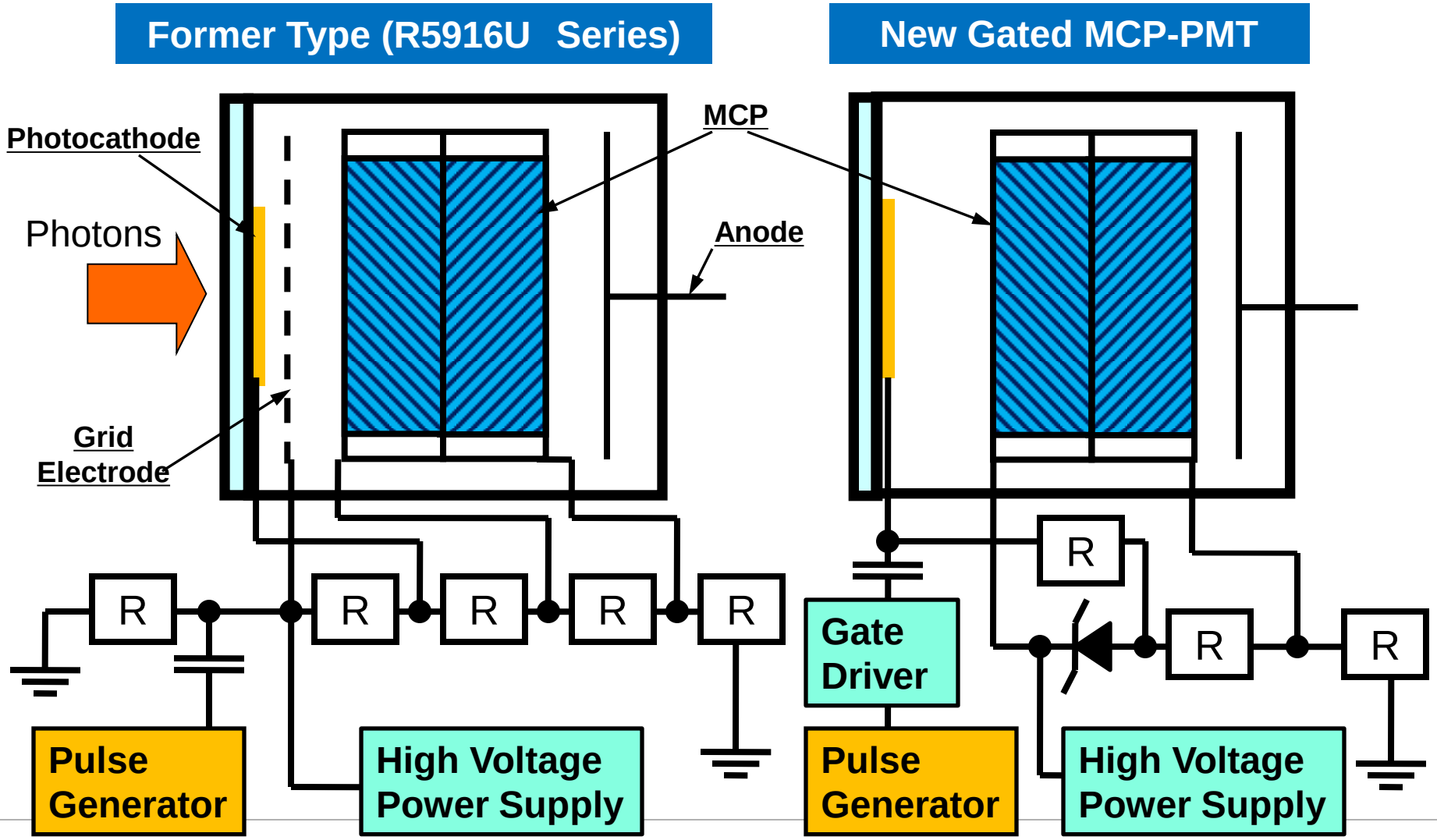
Fig. 1



In Comparison with Former Types (R5916U Series) 【Improved Time Resolution】

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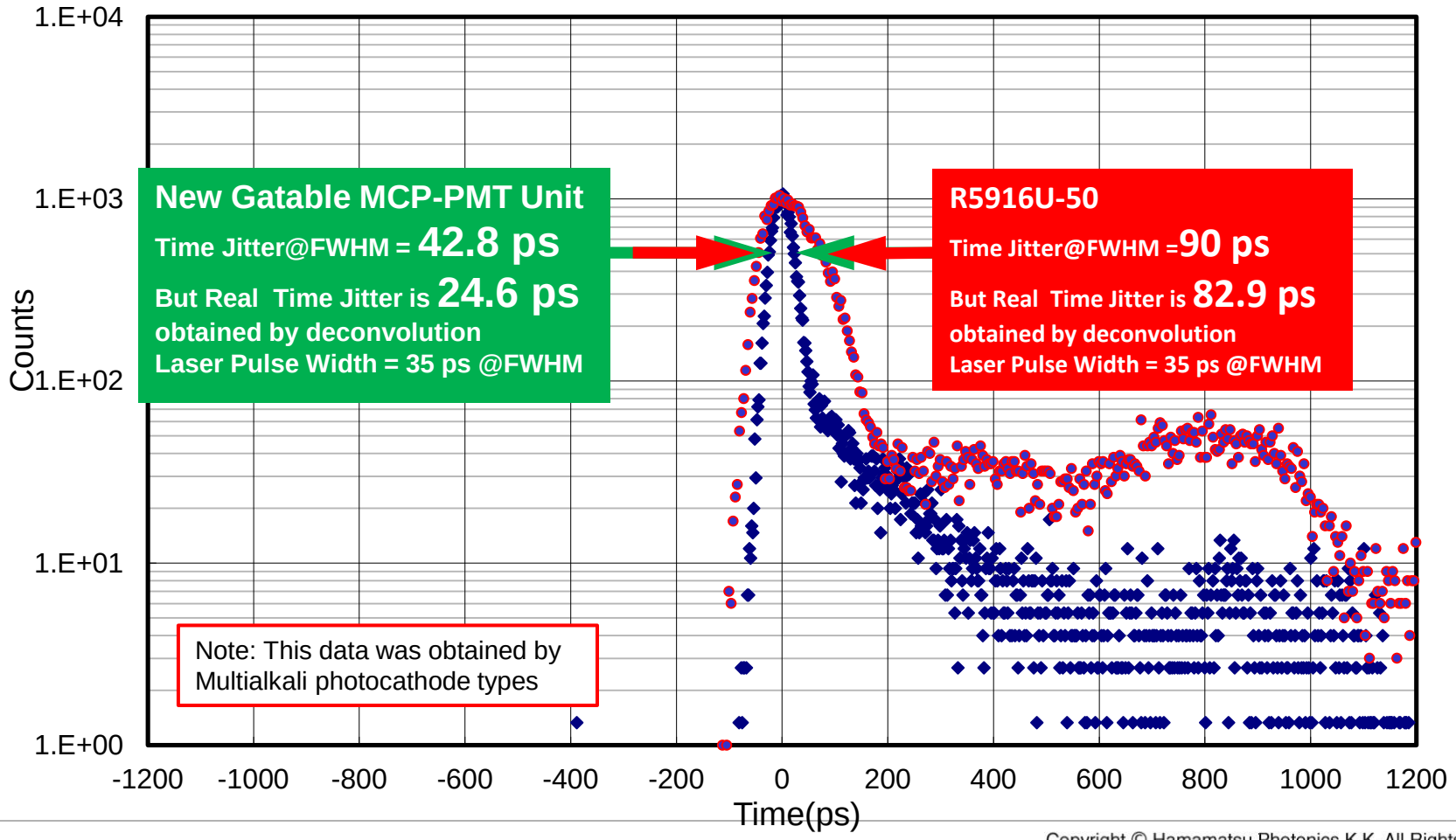
Fig. 2

Time Resolution of New Gated MCP-PMT Unit in comparison with R5916U



Other Characteristics
【Photocathode Sensitivities】

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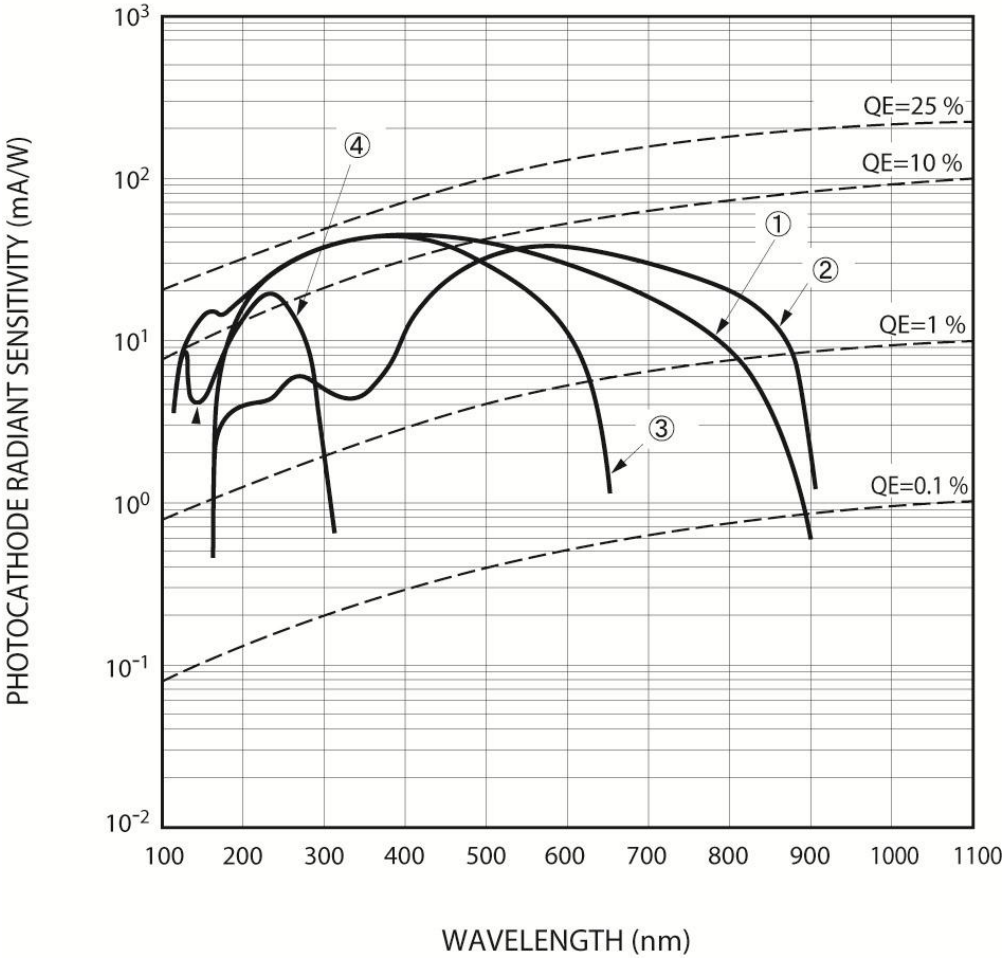
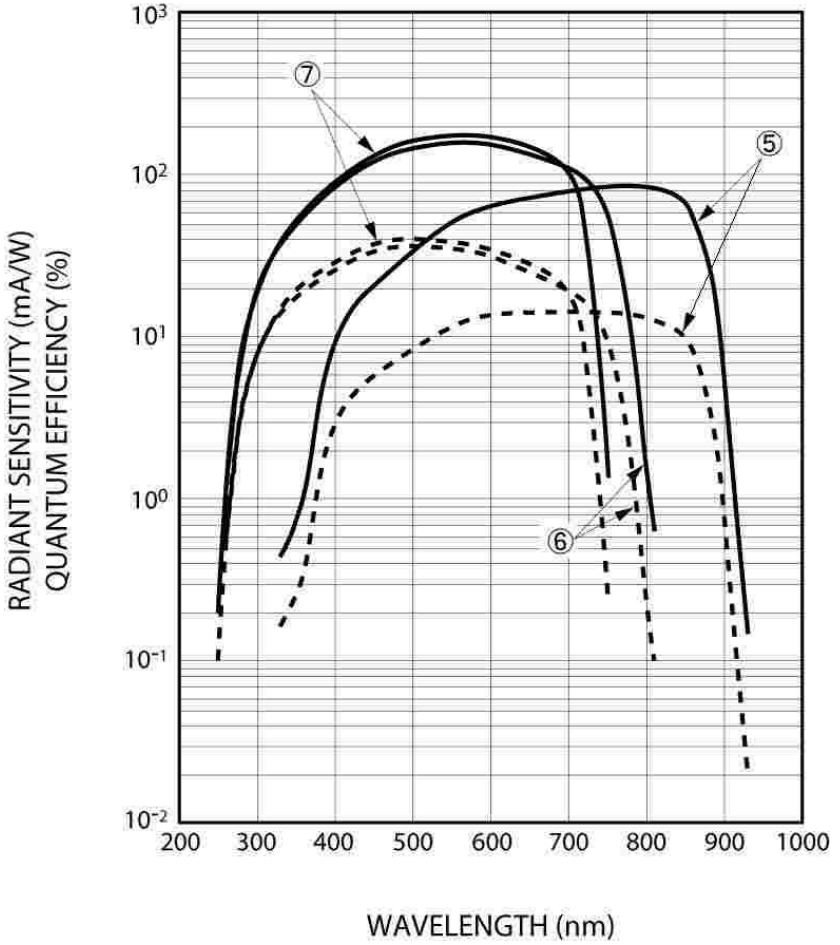
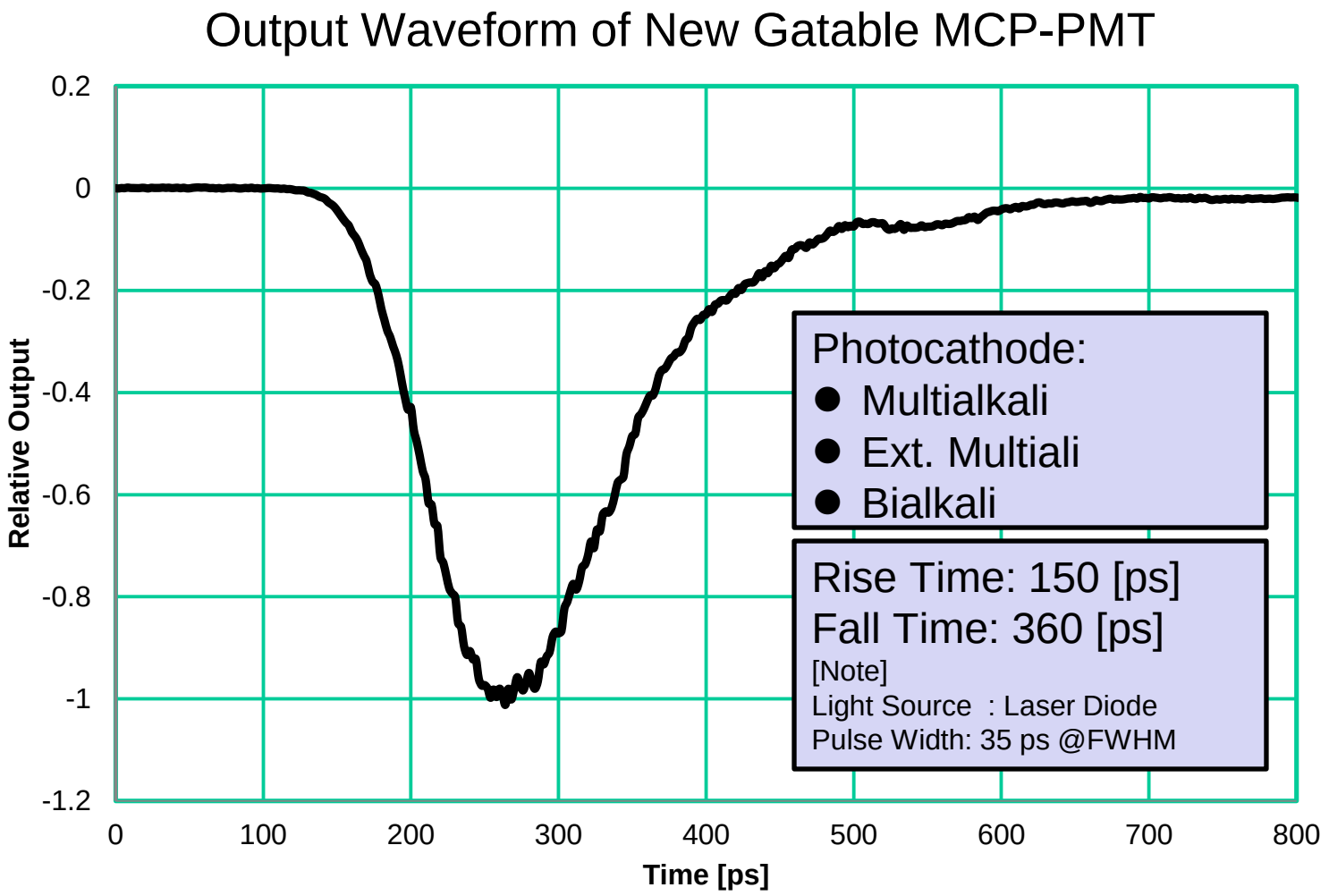
①Multialkali ②Ext. Multialkali ③Bialkali
④CsTe ⑤GaAs ⑥Ext. GaAsP
⑦GaAsP



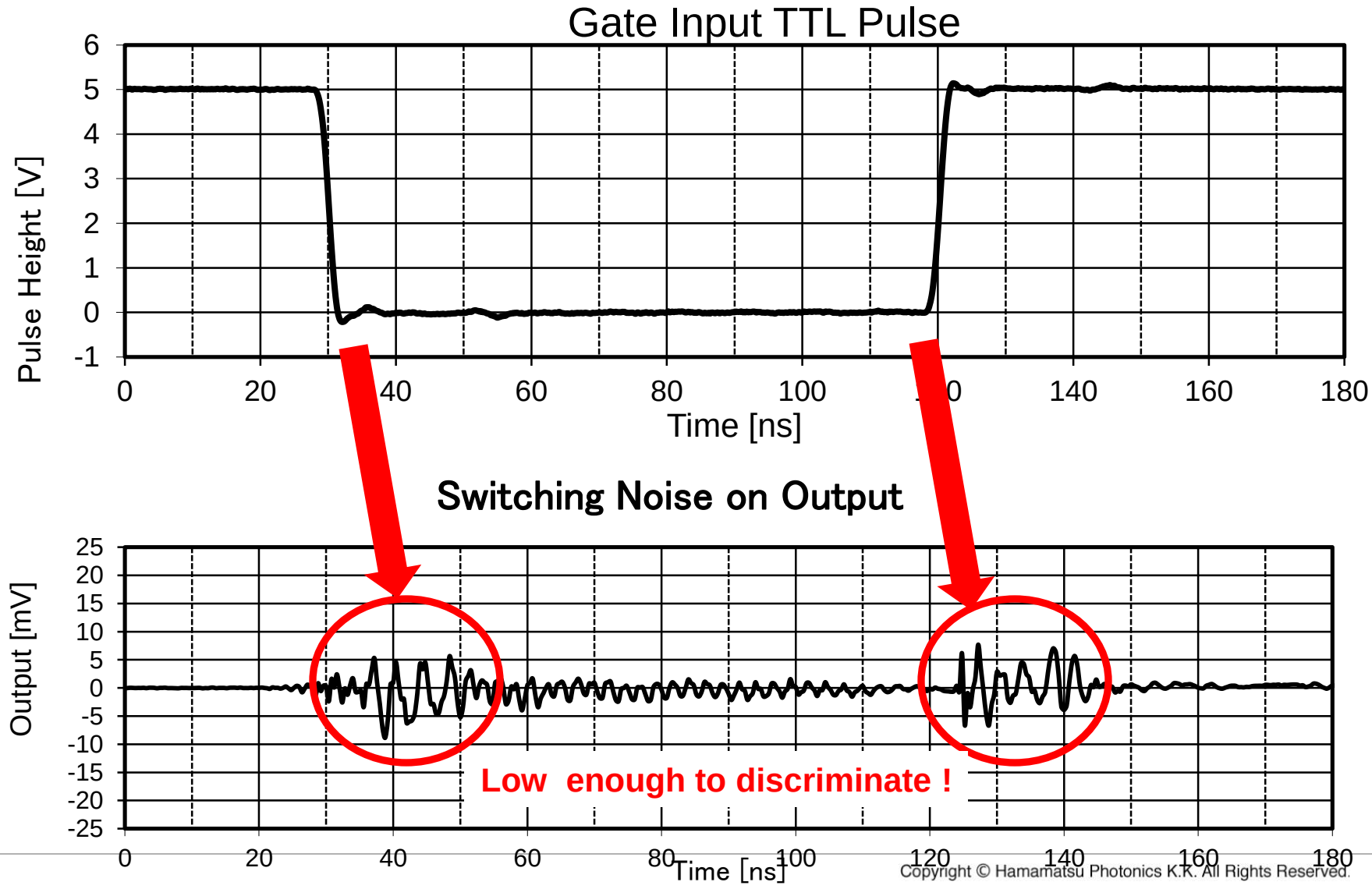


Other Characteristics
【Output Waveform】



Other Characteristics
【Switching Noise Induced by Gate Pulse】

Fig. 7−1



In Comparison with Former Types (R5916U Series)【Photographs】

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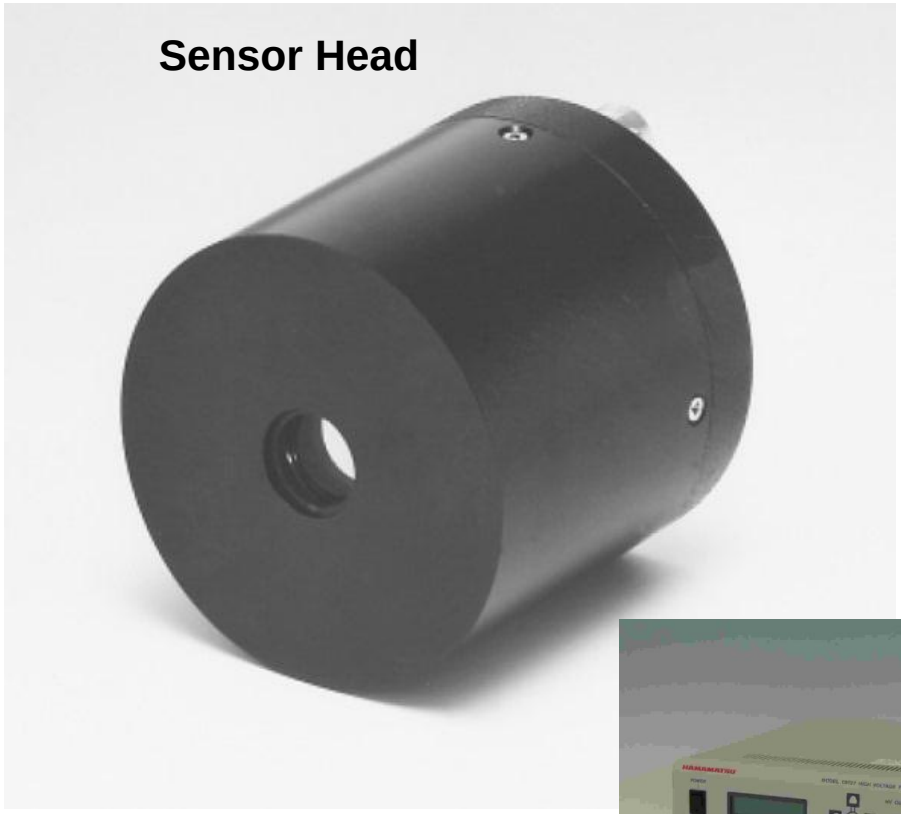
R5916U Series

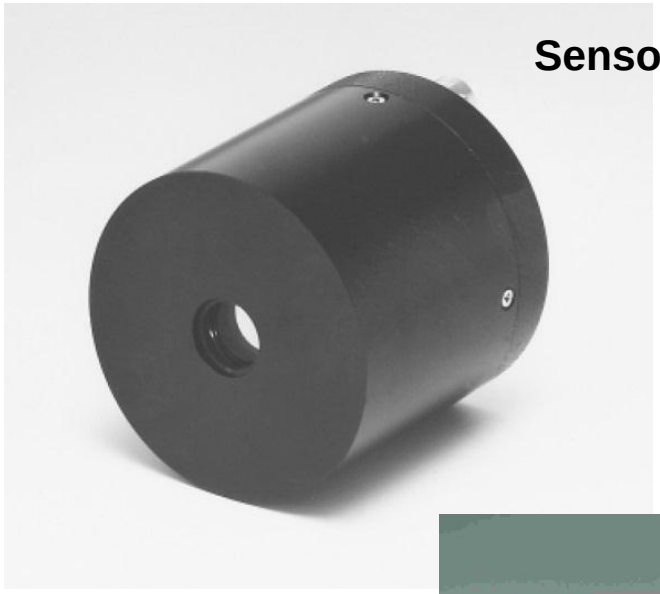
Sensor Head



HVPS(#C9727) Option

New Gated MCP-PMT Unit

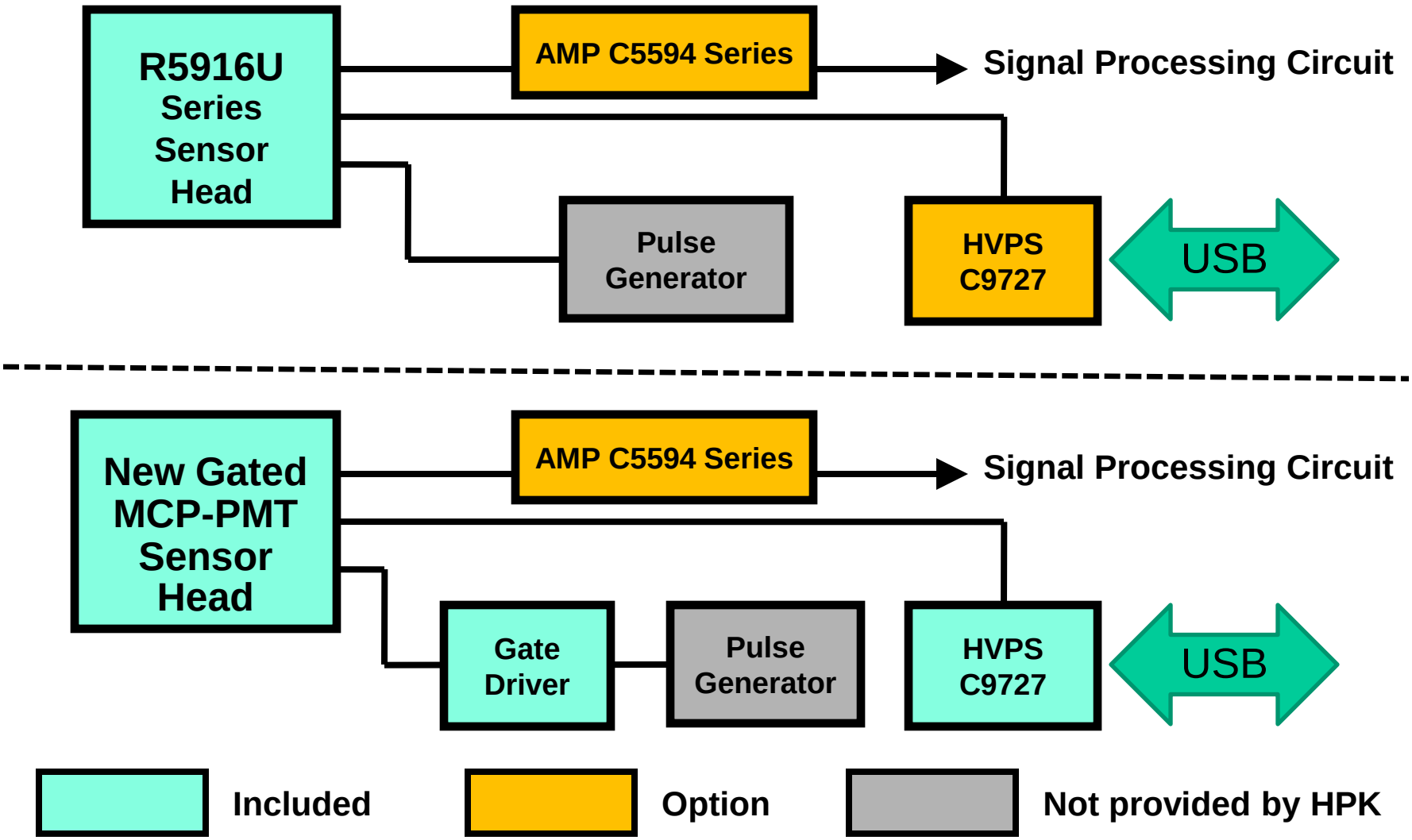
Sensor Head



HVPS (#C9727) Included

Gate Driver Included

In Comparison with Former Types (R5916U Series)【Constructions & Wiring】



In Comparison with Semiconductor Type Detector 【Specifications】

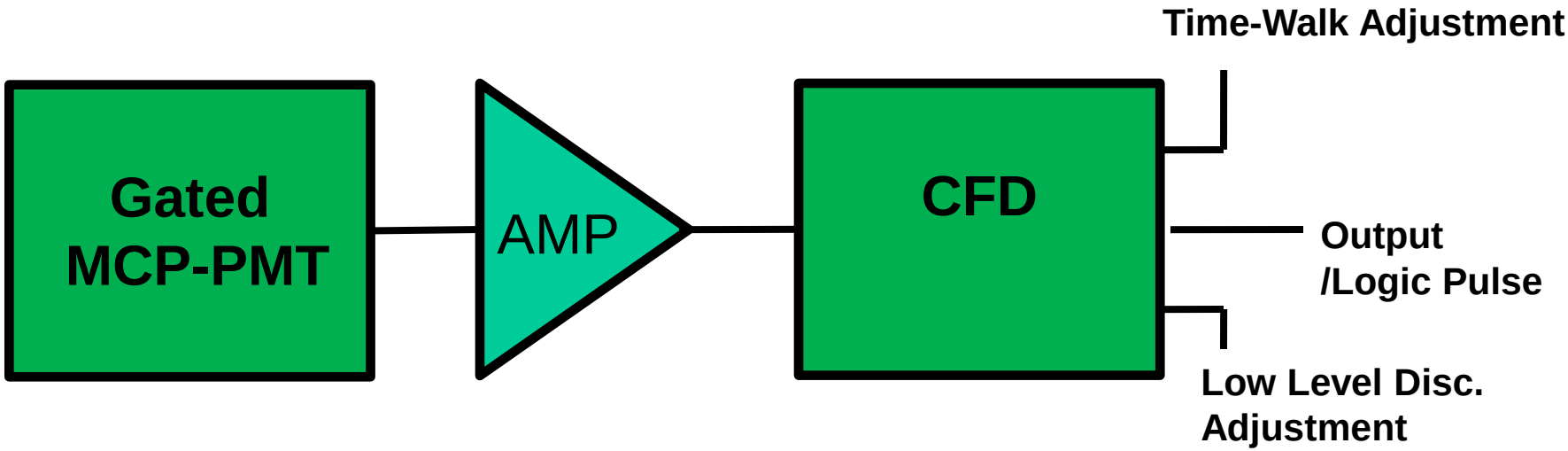
		R5916U-50 (Multialkali)	New Gatable MCP-PMT (Multialkali)	New Gatable MCP-PMT (GaAsP)	Semiconductor Detector
Spectral Response Range [nm]		160 - 850	160 - 850	280 - 720	350 - 1100
Quantum Efficiency(QE) [%] @532 nm (Typ.)		8	8	40	20
Effective Area (mm in diameter)		10	10	10	0.2
Gain (Min.)		1.0×10^5	1.0×10^5	1.0×10^5	-
Time Response [ns] (Typ.)	Rise Time	0.18	0.15	0.18	0.7
	Fall Time	0.7	0.4	0.4	-
Time Resolution (Jitter) @FWHM [ps] (Typ.)		90 1)	≦25 2)	50 2)	＜60
Dark Count Rate [s^{-1}] @25 ℃ (Typ.)		1000	1000	10000	9000
Average Anode Current [nA] (Max.)		100	100	100	-
Gating Time		5 ns -10 μs	100 ns - 50 μs	100 ns - 50 μs	-

1) This value includes a jitter of the electronics and the pulse width (35 ps @FWHM) of the light source.
2) These values are obtained by deconvolution for the laser pulse width.

Signal Processing Technic

To minimize a time jitter;

- Use CFD (Constant Fraction Discriminator)
- Set right level for low discrimination and optimize a time-walk of CFD



Conclusion

- New gated MCP-PMT units are now our standard product.
- They show better performance over the former type, R5916U series. In particular, detection efficiency and time resolution have been improved.
- In comparison with semiconductor detectors, our new gated MCP-PMTs show some advantages over the specifications such as sensitivity (GaAsP), time resolution (Multialkali) and wider photocathode effective area (0.2 mm in diameter for semiconductor type ⇒ 10 for ours)