

Hamamatsu PMTs

Latest developmental status



TIPP in May, 2017

Yuji Hotta

Electron Tube Division

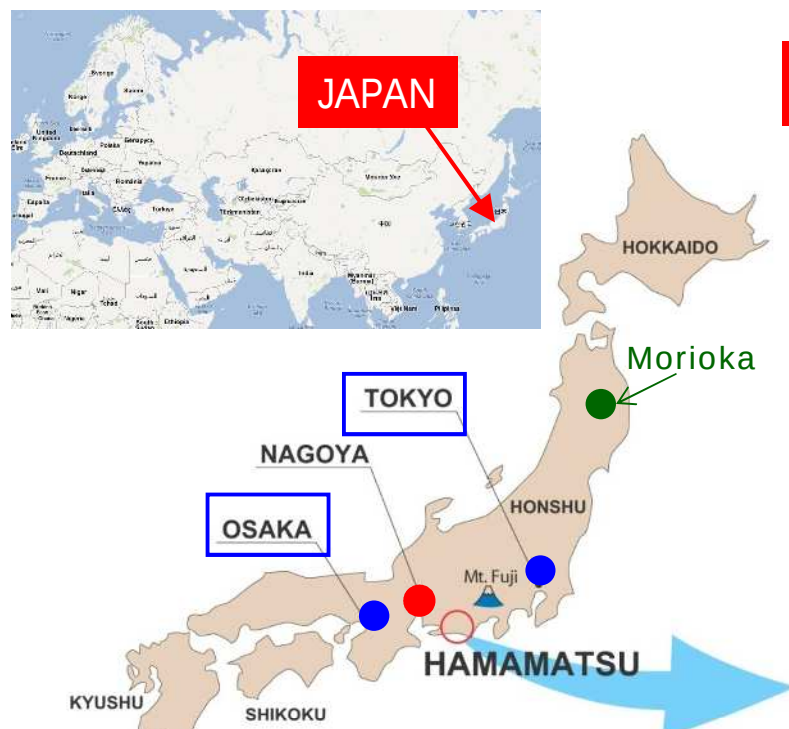
Hamamatsu Photonics K.K.

Contents

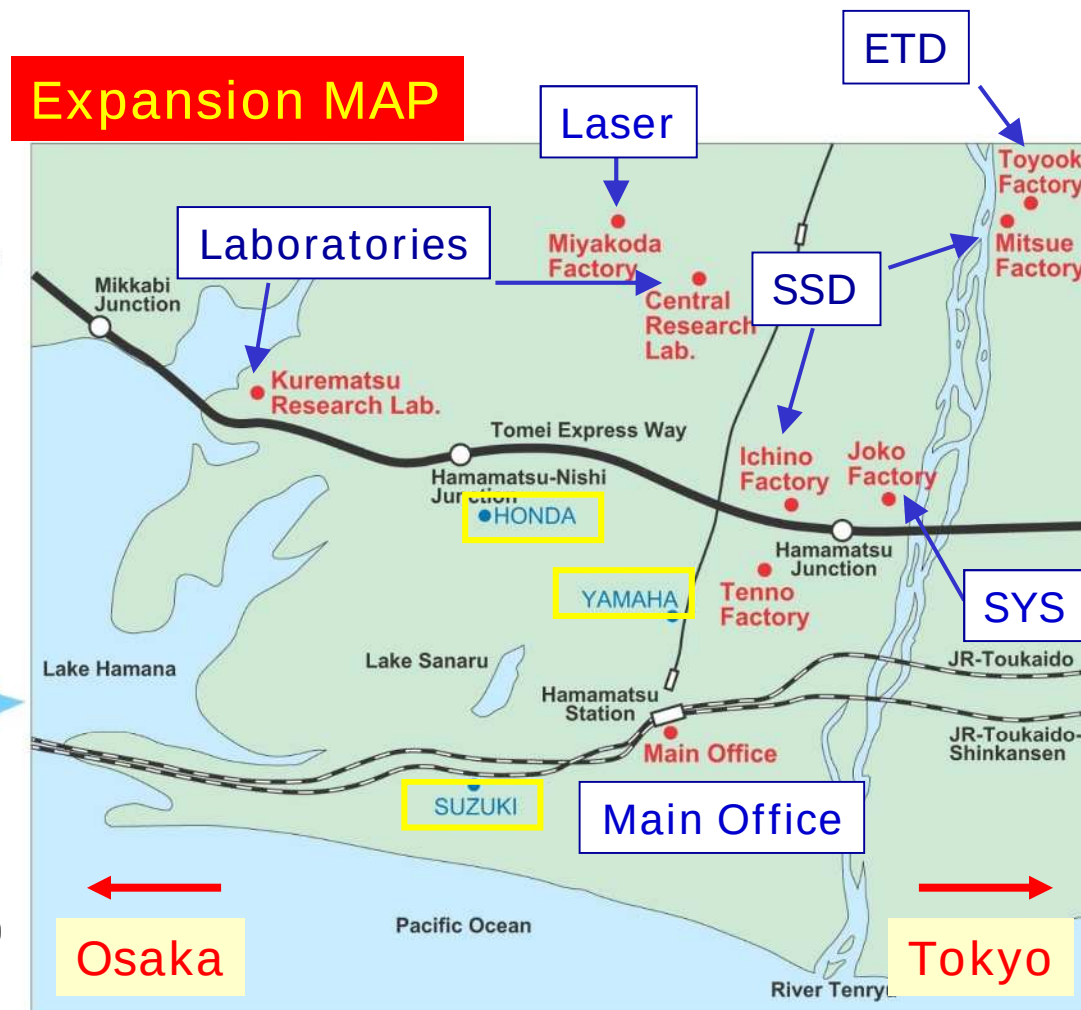
- 
1. About Hamamatsu
 2. Latest developmental status
 - (1) New $\Phi 80$ mm PMT
 - (2) New 8 inch PMT

1. About Hamamatsu

Where is Hamamatsu located ?



Hamamatsu City
Population: 809K
(As of March 1st, 2016)



HONDA, YAMAHA and SUZUKI are located in the same area.

Hamamatsu Photonics K.K.

Solid State Division



Electron Tube Division



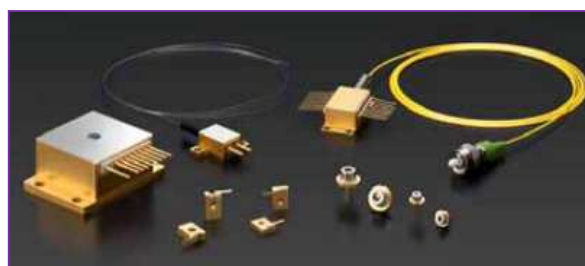
Research Laboratories



Systems Division



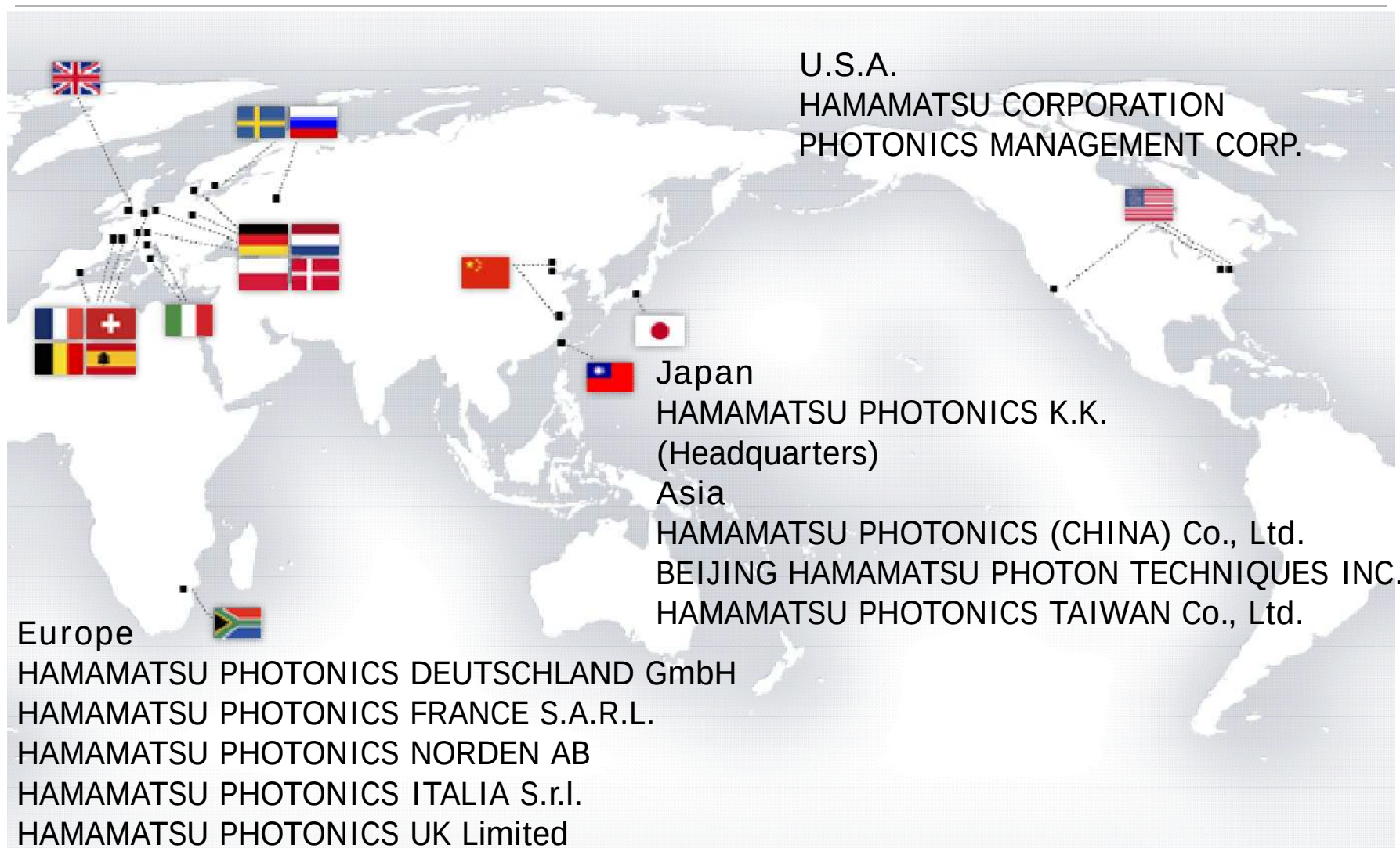
Laser Group



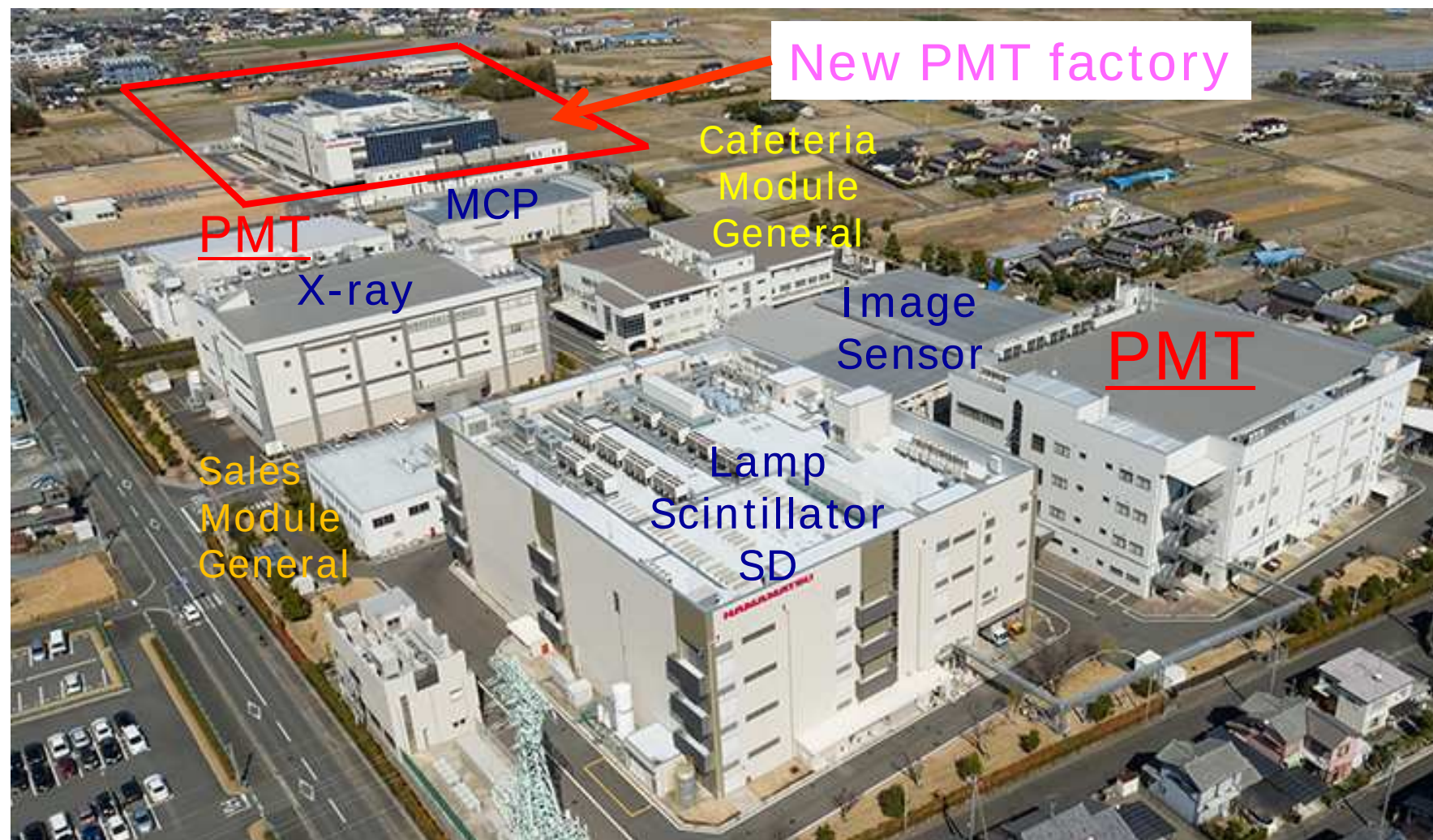
Established : Sept.29.1953 (63 years old)
Net Sales : (FY2016) Yen 122B (\$1.1B / €1.0B)
Employees : 4,482 (Group) (As of Sept.2015)

Exc. Rate
¥110/\$
¥120/€

Global subsidiaries



Electron Tube Division



Electron Tube Division / New Factory

New PMT factory



IEEE Milestone for 20-inch PMT

20-inch PMT, which was used for KAMIOKANDE Neutrino Experiment, was authorized as IEEE Milestone on Oct.15.2014.

Milestones Program (established in 1983) recognizes a significant technical achievement that occurred at least 25 years ago in an area of technology represented in IEEE and having at least a regional impact on community and industry.



IEEE : The Institute of Electrical and Electronics Engineers

Location of IEEE Milestone Plaque

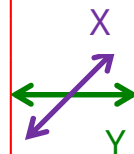


2. Latest developmental status

(1) New $\Phi 80$ mm PMT

R12199 Current Type

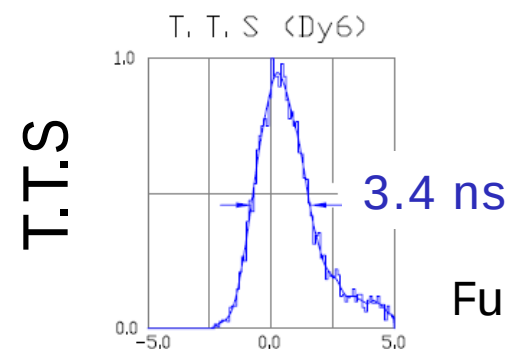
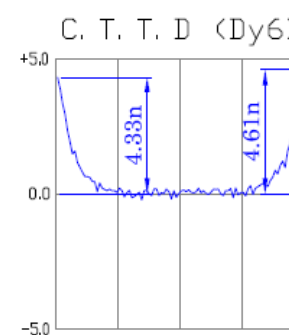
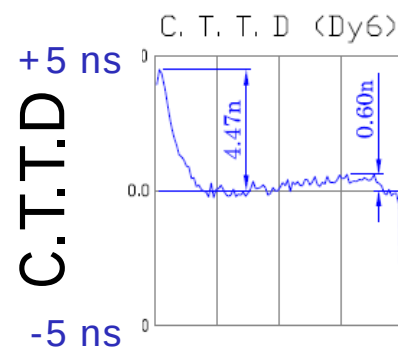
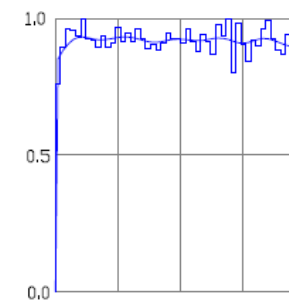
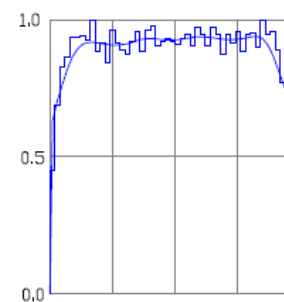
CONFIDENTIAL



Uniformity

Y-Axis

X-Axis



CE : 96.3%
(Dy6 Full)

Full Illumination

R12199 Current Type vs. New Type

CONFIDENTIAL

Ratio 3:1:1...

Disk : 288.5V

Dy1 : 288.5V

Dy2 : 384.6V

Dy3 : 480.8V

Dy4 : 576.9V

Dy5 : 673.1V

Dy6 : 769.2V

Dy7 : 865.4V

Dy8 : 961.5V

Dy9 : 1057.7V

Dy10 : 1153.8V

Anode : 1250V

2↓

Ratio 3:2:1...

Disk : 267.9V

Dy1 : 267.9V

Dy2 : 466.4V

Dy3 : 535.7V

Dy4 : 625.0V

Dy5 : 714.3V

Dy6 : 803.6V

Dy7 : 892.9V

Dy8 : 982.1V

Dy9 : 1057.7V

Dy10 : 1160.7V

Anode : 1250V

Red: New Type

1. Bulb Shape

- Change in curvature
- Add straight portion

2. Voltage Divider Ratio

3-1---1 => 3-2-1---1

3. Disk Shape4. Dy1 Shape5. Length

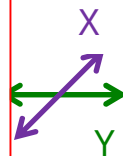
- Focus: +1 mm (42 mm => 43 mm)
- Dynode: +5 mm (26 mm => 31 mm)

We could keep the length, but it would be not possible to reduce the length.

CONFIDENTIAL

R12199 New Type

CONFIDENTIAL



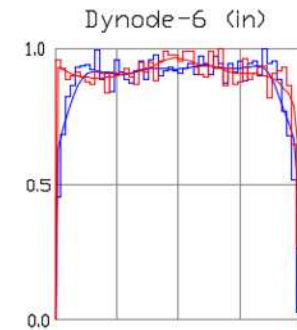
Blue: Current Type
Red: New Type

HAMAMATSU
PHOTON IS OUR BUSINESS

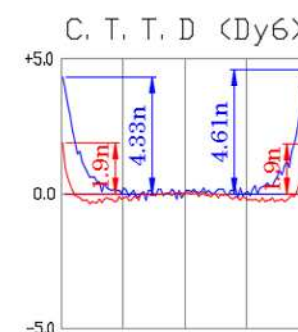
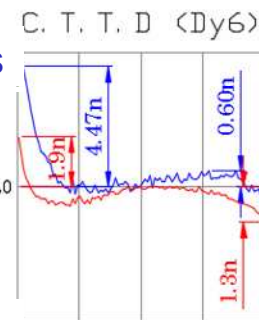
Y-Axis

X-Axis

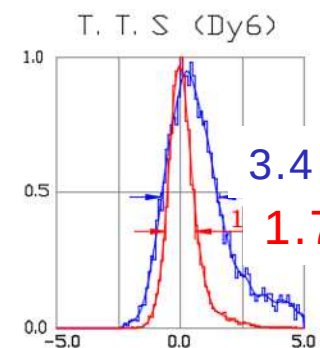
Uniformity



C.T.T.D
+5 ns
-5 ns



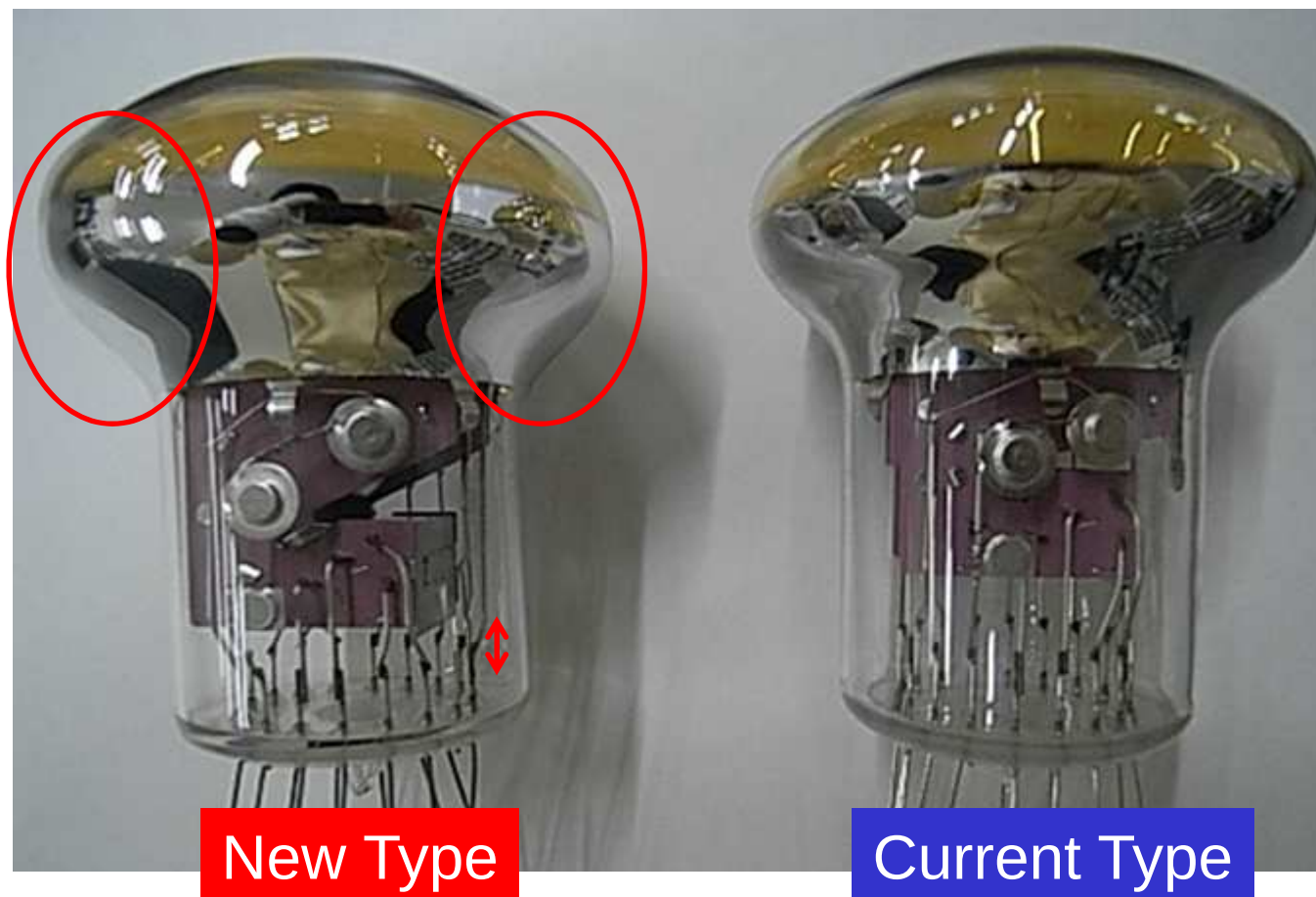
T.T.S



CE : 96.8%
(Dy6 Full)

Full Illumination

R12199 Current type vs. New Type



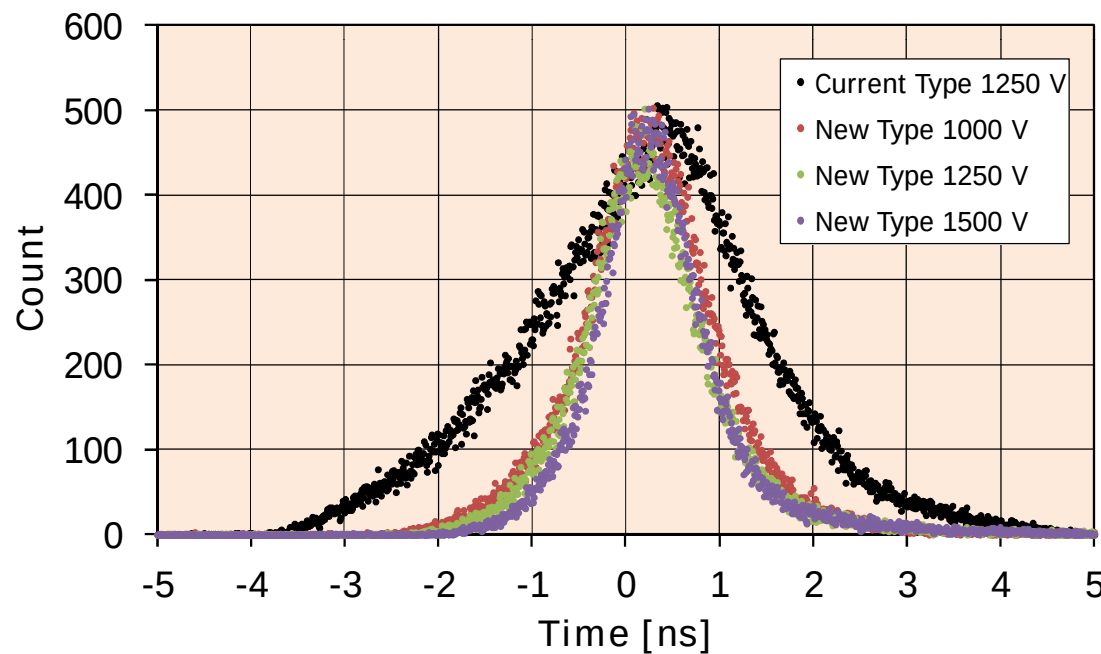
R12199 Transit Time Spread (TTS)

Supply Voltage	1000 V	1250 V	1500 V	
Current Type	3.4	2.8	2.5	N = 10
New Type	1.5	1.3	1.1	N = 5

Single pe. FWHM

Unit : ns

R12199 Transit Time Spread



New R12199 Electrical characteristics

	SK [uA/lm]	SKb	SP 1250 V [A/lm]	IDB 1250 V [nA]	Gain 1250 V [x 1E+06]	Ebb Gain 3E+06 [V]	$\delta 1$	Dark count [s-1]	AP [%]	P/V Ratio
Sample 1	96	10.4	460	8	4.8	1170	12.5	1600	5.2	2.9
Sample 2	84	9.9	430	24	5.1	1160	13.2	1600	5.4	2.5
Sample 3	90	10.1	559	17	6.2	1130	13.0	1050	6.1	2.7
Sample 4	77	9.7	221	2	2.9	1260	13.2	423	5.7	2.7
Sample 5	82	9.8	237	3	2.9	1260	12.9	2143	6.7	2.9
New Type Average (N = 5)	86	10.0	381	11	4.4	1196	13.0	1363	5.8	2.7
Current Type Average (N = 312)	96	10.4	1386	16	14	1029	12.3	831	8.0	2.7

2. Latest developmental status

(2) New 8 inch PMT

Large Format PMT Lineup



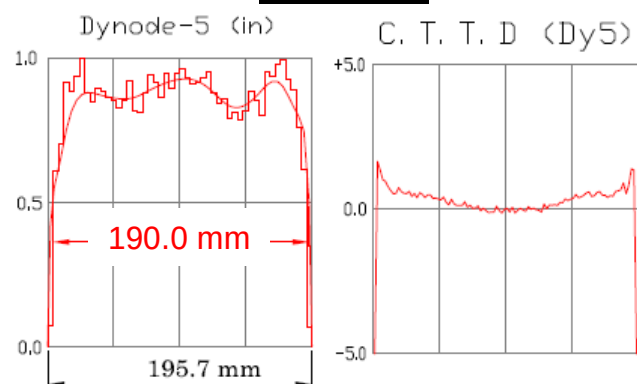
R5912 (8 inch PMT)



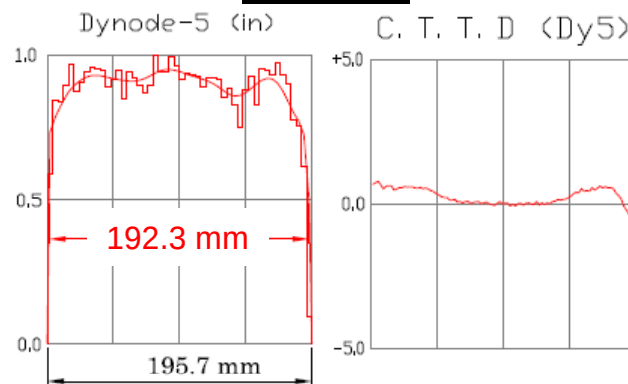
Items	R5912 8-inch PMT
Diameter	202 mm
Effective Area	190 mm min.
Tube Length	220 mm
Collection Efficiency	85 %
Dynodes	B&L / 10-stage
GAIN	1.0E+07 at 1500 V
T.T.S. (FWHM)	2.4 ns
P/V Ratio	2.8
Pressure Resistance	0.7 MPa

New 8 inch PMT / 1st Simulation Result

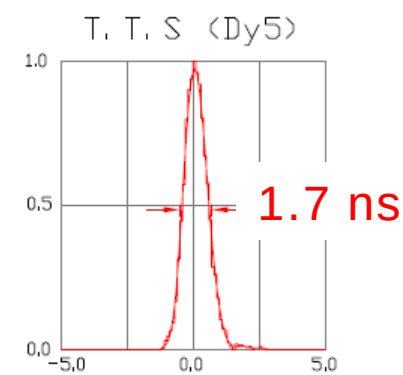
X-Axis



Y-Axis



Full Illumination



Bleeder:

11.5-1-3.5-4-2-2-1....

Dy1= 575V

Disk= 625V

Dy2 = 800V

Dy3= 1000V

Dy4= 1100V

Dy5= 1200V

Dy6= 1250V

Dy7= 1300V(Acc)

Dy8= 1350V

Dy9= 1400V

Dy10= 1450V

Anode= 1500V

CONFIDENTIAL

CONFIDENTIAL

CE = 92.2 %
(Dy5 Full)

Efficiency

K-Dy1 = 95.4%

Dy1-Dy2 = 85.9%

Dy2-Dy3 = 71.2%

Dy3-Dy4 = 93.4%

Dy4-Dy5 = 73.8%

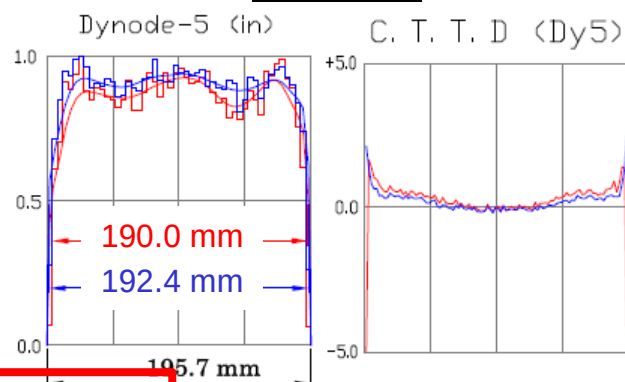
HV
1500 V

85 mm

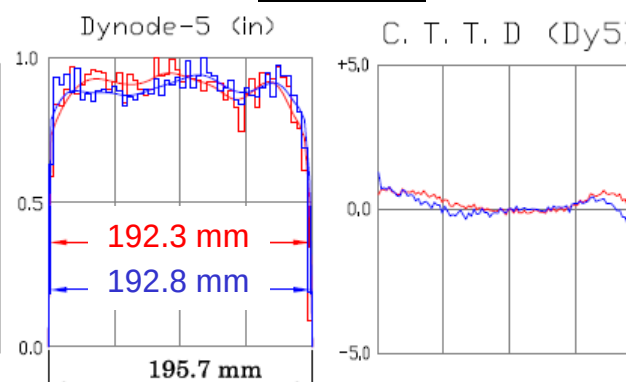
85 mm

New 8 inch PMT / 2nd Simulation Result

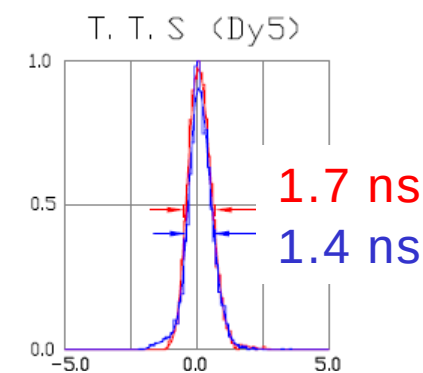
X-Axis



Y-Axis



Full Illumination



CE = 92.2 %

CE = 95.7 %

(Dy5 Full)

Efficiency

K-Dy1 = 97.3%

Dy1-Dy2 = 90.3%

Dy2-Dy3 = 89.3%

Dy3-Dy4 = 83.2%

Dy4-Dy5 = 73.8%

Bleeder:
11.5-1-3.5-5-1.5-1.5-1...

Dy1= 575V
Disk= 625V
Dy2 = 800V
Dy3= 1050V
Dy4= 1125V
Dy5= 1200V
Dy6= 1250V
Dy7= 1300V(Acc)
Dy8= 1350V
Dy9= 1400V
Dy10= 1450V
Anode= 1500V

CONFIDENTIAL

CONFIDENTIAL

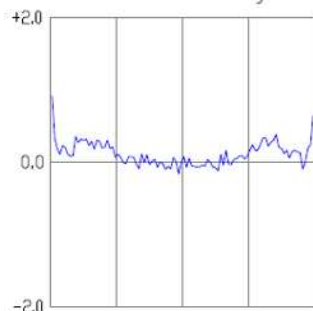
HV
1500 V

New 8 inch PMT / 3rd Simulation Result

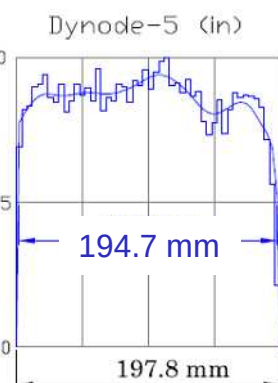
X-Axis



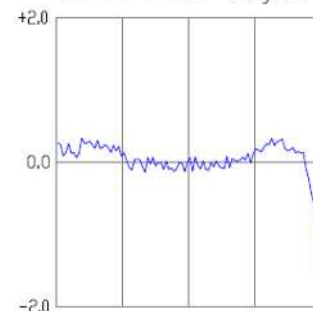
C. T. T. D (Dy5)



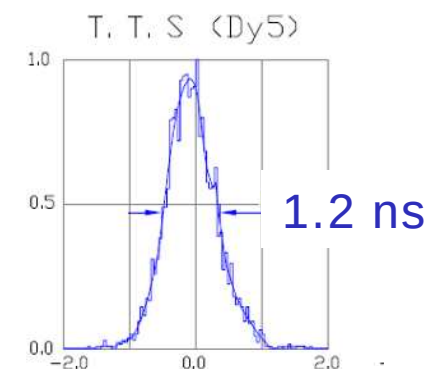
Y-Axis



C. T. T. D (Dy5)



Full Illumination



Bleeder:

11.5-1-3.5-4-2-2-1

Dy1= 575V

Disk= 625V

Dy2 = 800V

Dy3= 1000V

Dy4= 1100V

Dy5= 1200V

Dy6= 1250V

Dy7= 1300V(Ac)

Dy8= 1350V

Dy9= 1400V

Dy10= 1450V

Anode= 1500V

CONFIDENTIAL

CONFIDENTIAL

CE = 96.3 %
(Dy5 Full)

Efficiency

K-Dy1 = 98.4%

Dy1-Dy2 = 88.6%

Dy2-Dy3 = 82.3%

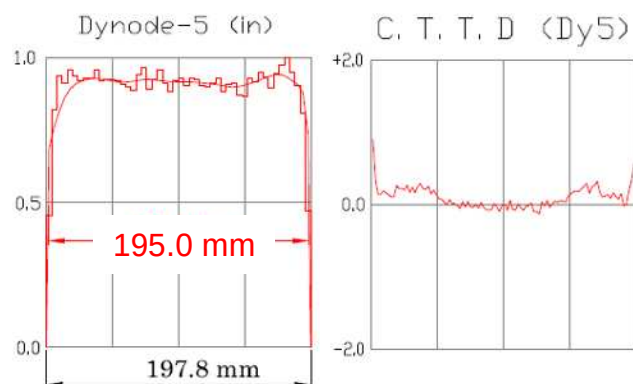
Dy3-Dy4 = 92.8%

Dy4-Dy5 = 71.2%

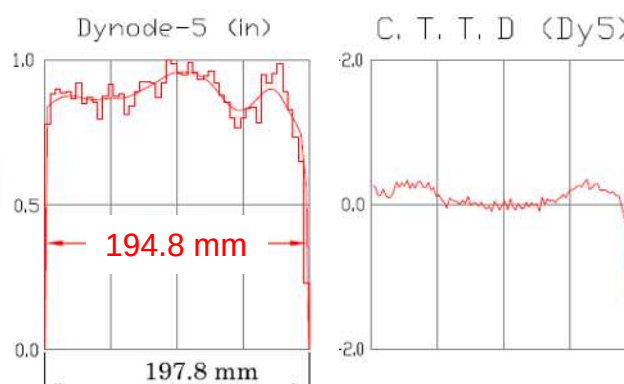
HV
1500

New 8 inch PMT / 3rd Simulation Result

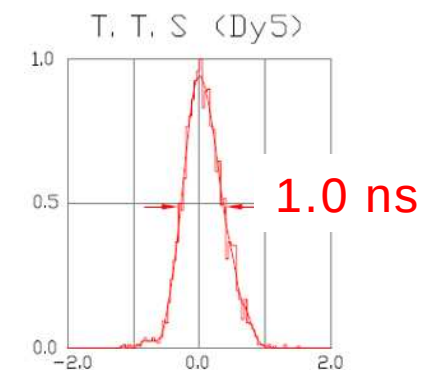
X-Axis



Y-Axis



Full Illumination



Bleeder:

11.5-1-3.5-4-2-2-1

Dy1= 766.7V

Disk= 833.3V

Dy2 = 1066.7V

Dy3= 1333.3V

Dy4= 1466.7V

Dy5= 1600.0V

Dy6= 1666.7V

Dy7= 1733.3V

Dy8= 1800.0V

Dy9= 1866.7V

Dy10= 1933.3V

Anode= 2000V

CONFIDENTIAL

CONFIDENTIAL

HV
2000

CE = 97.2 %
(Dy5 Full)

Efficiency

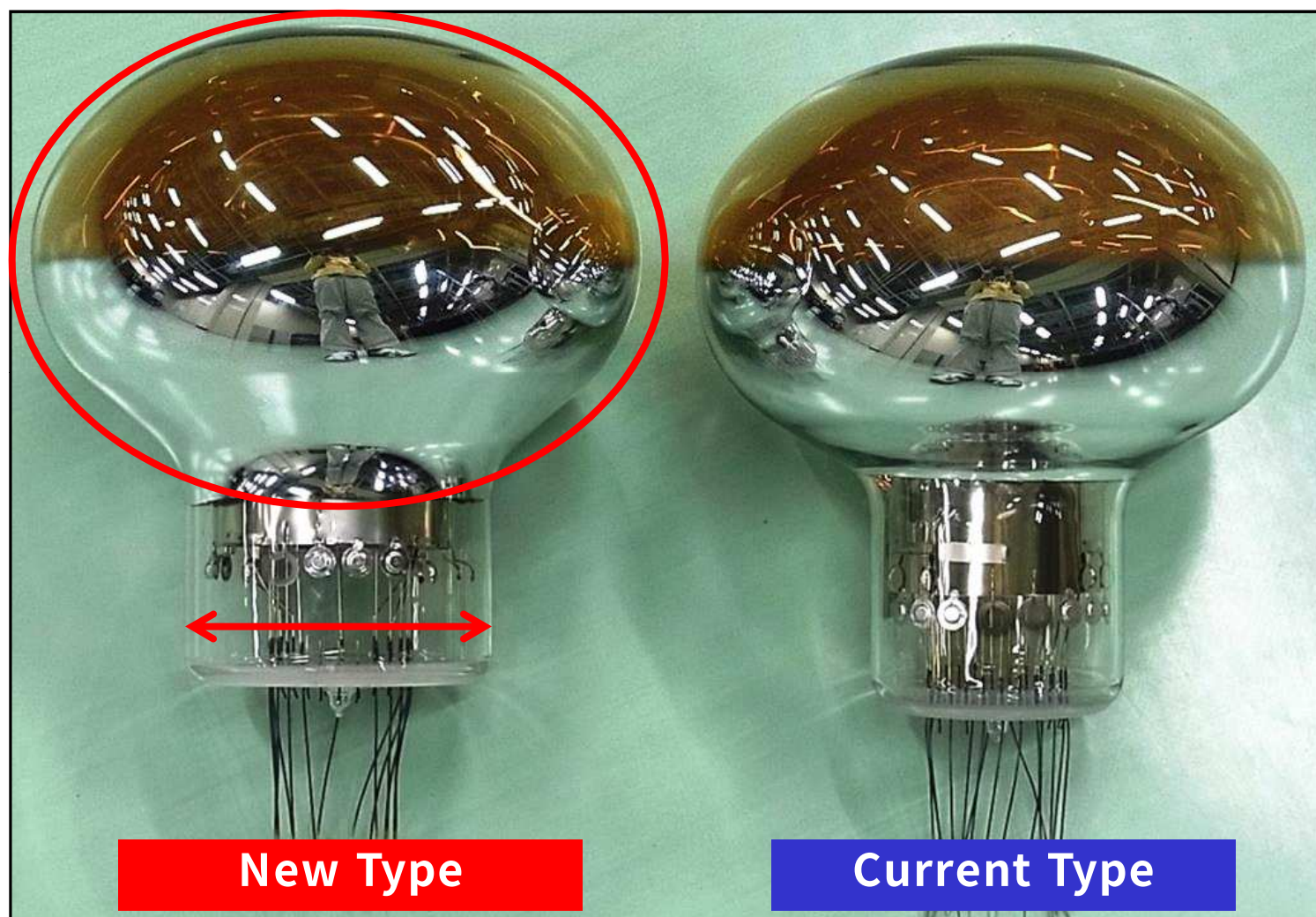
K-Dy1 = 98.5%
Dy1-Dy2 = 92.9%
Dy2-Dy3 = 87.0%
Dy3-Dy4 = 94.9%
Dy4-Dy5 = 76.8%

New 8 inch PMT / Simulation Result

Simulation	Applied Voltage	Effective Area	T.T.S.	Collection Efficiency*
1st	1500 V	190 mm	1.7 ns	89.4%
2nd	1500 V	192 mm	1.4 ns	92.8%
3rd	1500 V	195 mm	1.2 ns	93.4%
	2000 V	195 mm	1.0 ns	94.3%
R5912	1500 V	190 mm	2.4 ns	85%

* The transmittance (97%) of the mesh in front of the first dynode is included.

New Type vs. Current Type



New 8 inch PMT Trial Production Result

Serial Number	Test Date	DC Measurement				PHD Measurement						Judge ment
		SK [uA/lm]	SKb	1×10^7 Ebb [V]	1×10^7 Idb [nA]	P/V	TTS [ns]	Dark Counts [kcps]	TTS (1500V) [ns]	Rise Time (1500V) [ns]	Fall Time (1500V) [ns]	
Max.				2000	1000			8				
Typ.		80	10.0	1500	100	2.8	2.4	4				
Min.		40	6.0			1.5						
ZC2711	2017/1/18	89	9.5	1470	-	1.40	1.849	19.8	1.832	2.93	3.58	NG
ZC2712	2017/1/25	72	8.4	1750	1268			268				
ZC2713	2017/1/30	69	8.2	1840	1659							
ZC2714	2017/2/14	87	9.2	1600	700							

Because dark current/count was larger, TTS could not be measured correctly.

A photograph of two men in business suits shaking hands over a desk. The desk is cluttered with various office items, including two laptops, papers, a camera, and other small objects. The background is a simple office setting with a white wall and a window.

HAMAMATSU

PHOTOGRAPHY IS OUR BUSINESS