

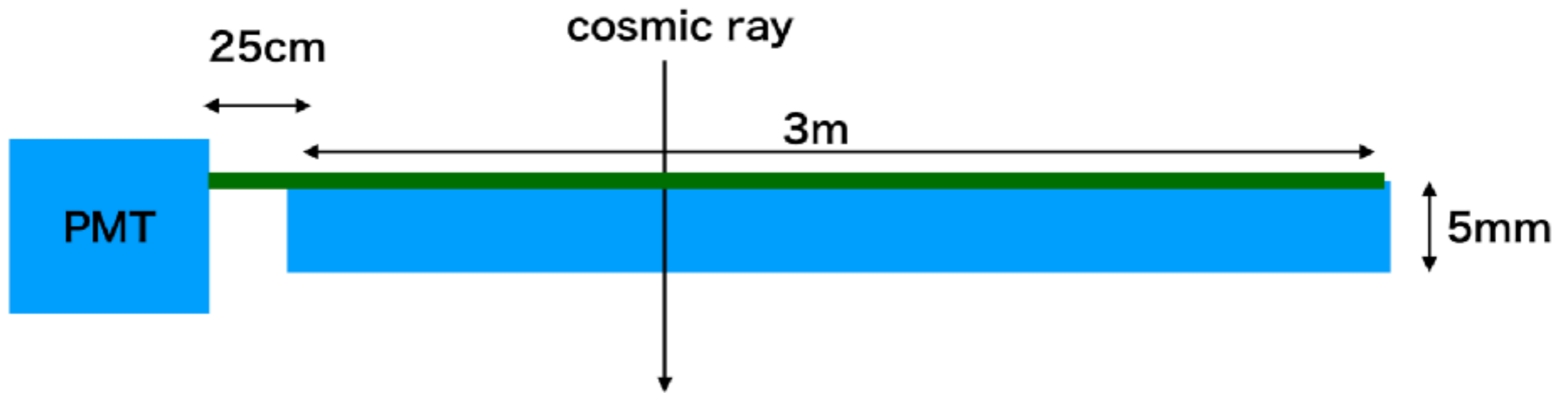
Calculate Light Yield

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Calculate Light Yield



How many photo electrons we will obtain when cosmic ray passing through the 5mm-thick and 3m-long plastic scintillator ?
(6 points (0.5m, 1m, 1.5m, 2m, 2.5m, 3m from the PMT))

Needed input : Light yield of plastic scintillator

Trapping efficiency (1mm diameter WSF)

Absorption wave length of selected WLS Fiber

Attenuation length of the WLS finger

Quantum efficiency of the PMT

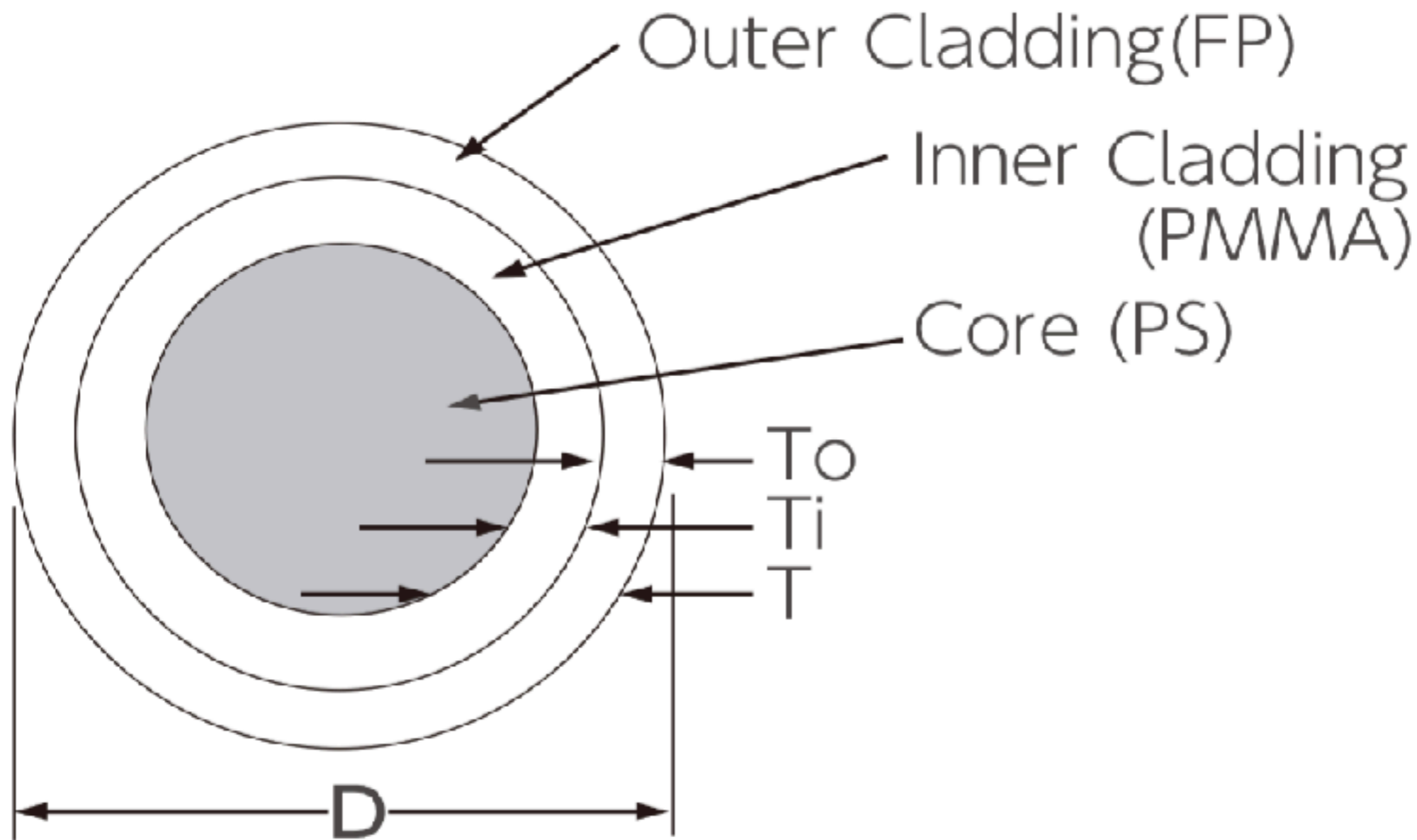
Properties of Plastic Scintillator(EJ-200, Eljen technology)

PROPERTIES	EJ-200	EJ-204	EJ-208	EJ-212
Light Output (% Anthracene)	64	68	60	65
Scintillation Efficiency (photons/1 MeV e ⁻)	10,000	10,400	9,200	10,000
Wavelength of Maximum Emission (nm)	425	408	435	423
Light Attenuation Length (cm)	380	160	400	250
Rise Time (ns)	0.9	0.7	1.0	0.9
Decay Time (ns)	2.1	1.8	3.3	2.4
Pulse Width, FWHM (ns)	2.5	2.2	4.2	2.7
No. of H Atoms per cm ³ (x10 ²²)	5.17	5.15	5.17	5.17
No. of C Atoms per cm ³ (x10 ²²)	4.69	4.68	4.69	4.69
No. of Electrons per cm ³ (x10 ²³)	3.33	3.33	3.33	3.33
Density (g/cm ³)	1.023	1.023	1.023	1.023
Polymer Base	Polyvinyltoluene			
Refractive Index	1.58			
Softening Point	75°C			
Vapor Pressure	Vacuum-compatible			
Coefficient of Linear Expansion	7.8 x 10 ⁻⁵ below 67°C			
Light Output vs. Temperature	At 60°C, L.O. = 95% of that at 20°C No change from 20°C to -60°			
Temperature Range	-20°C to 60°C			

Properties of Plastic Wavelength Shifter Fiber(Y11, Kuraray)

		Material	Refractive index	Density (g/cm ³)	No. of atom per cm ³
Core		Polystyrene (PS)	$n_D=1.59$	1.05	C: 4.9×10^{22} H: 4.9×10^{22}
Cladding	for single cladding inner for multi cladding	Polymethylmethacrylate (PMMA)	$n_D=1.49$	1.19	C: 3.6×10^{22} H: 5.7×10^{22} O: 1.4×10^{22}
	outer for multi cladding	Fluorinated polymer (FP)	$n_D=1.42$	1.43	

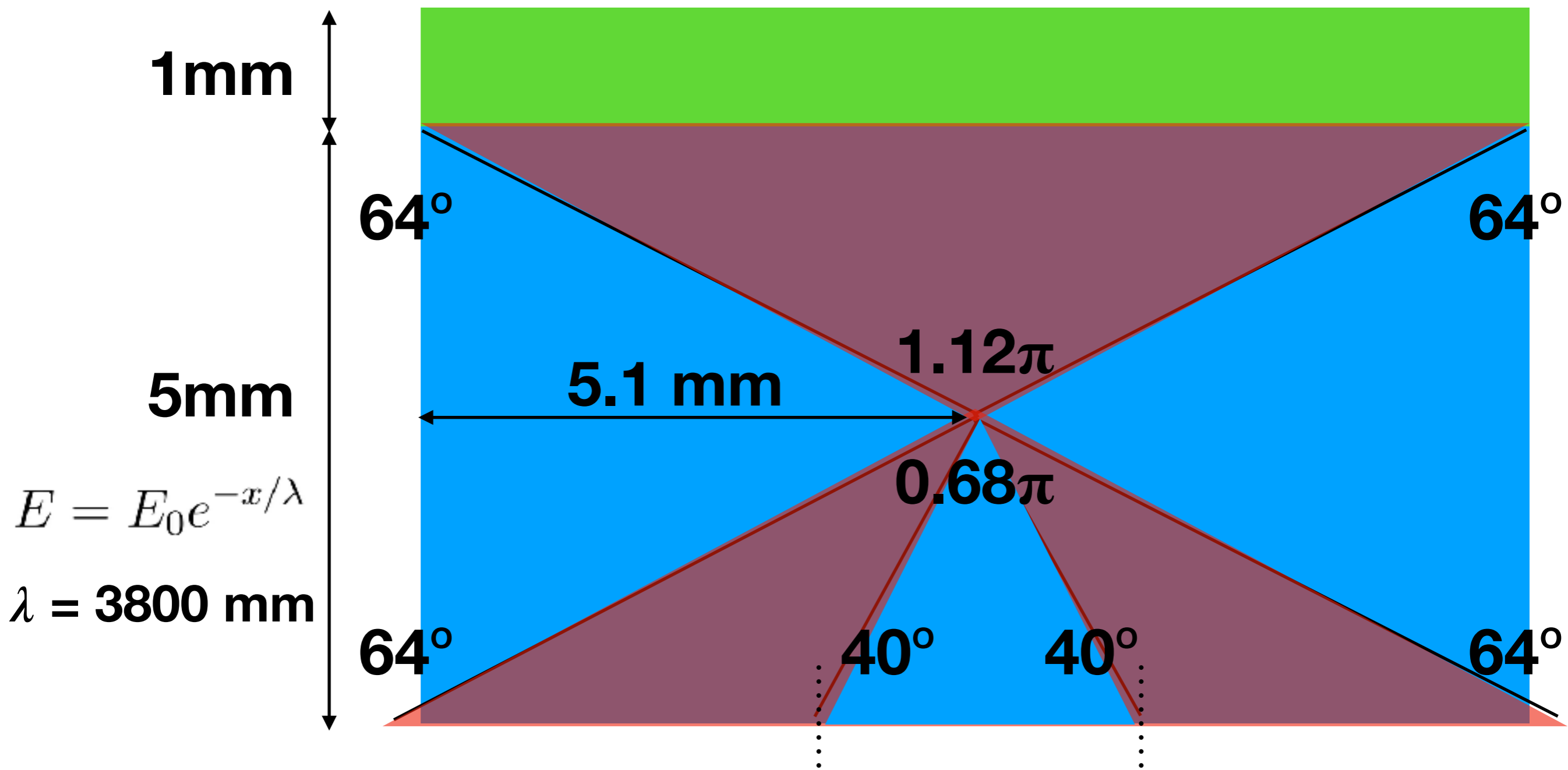
Description	Emission			Absorption Peak[nm]	Att. Leng. ²⁾ [m]	Characteristics
	Color	Spectra	Peak[nm]			
Y-7(100)	green	See the following figure	490	439	>2.8	Blue to Green Shifter
Y-8(100)	green		511	455	>3.0	Blue to Green Shifter
Y-11(200)	green		476	430	>3.5	Blue to Green Shifter (K-27 formulation) Long Attenuation Length and High Light Yield
B-2(200)	blue		437	375	>3.5	UV to Blue shifter
B-3(200)	blue		450	351	>4.0	UV to Blue shifter
O-2(100)	orange		550	535	>1.5	Green to orange shifter
R-3(100)	red		610	577	>2.0	Green to red shifter



Cladding Thickness²⁾ : $T = 2\%(T_o) + 2\%(T_i)$
 $= 4\%$ of D

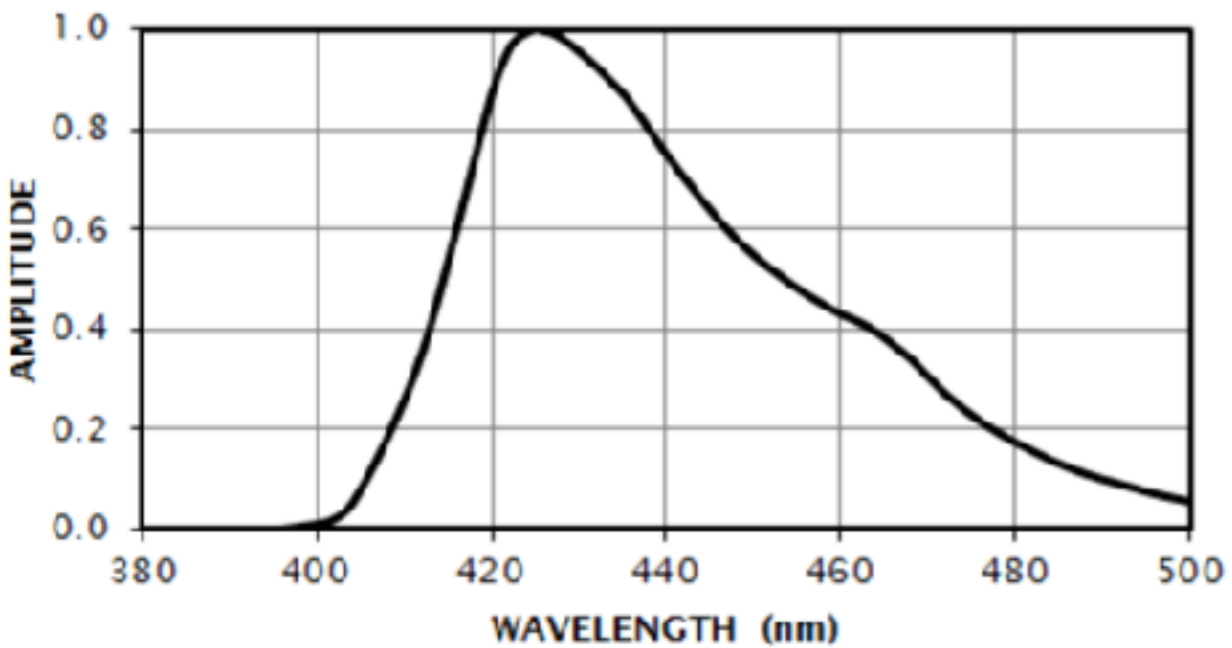
Numerical Aperture : $NA = 0.72$

Trapping Efficiency : 5.4%

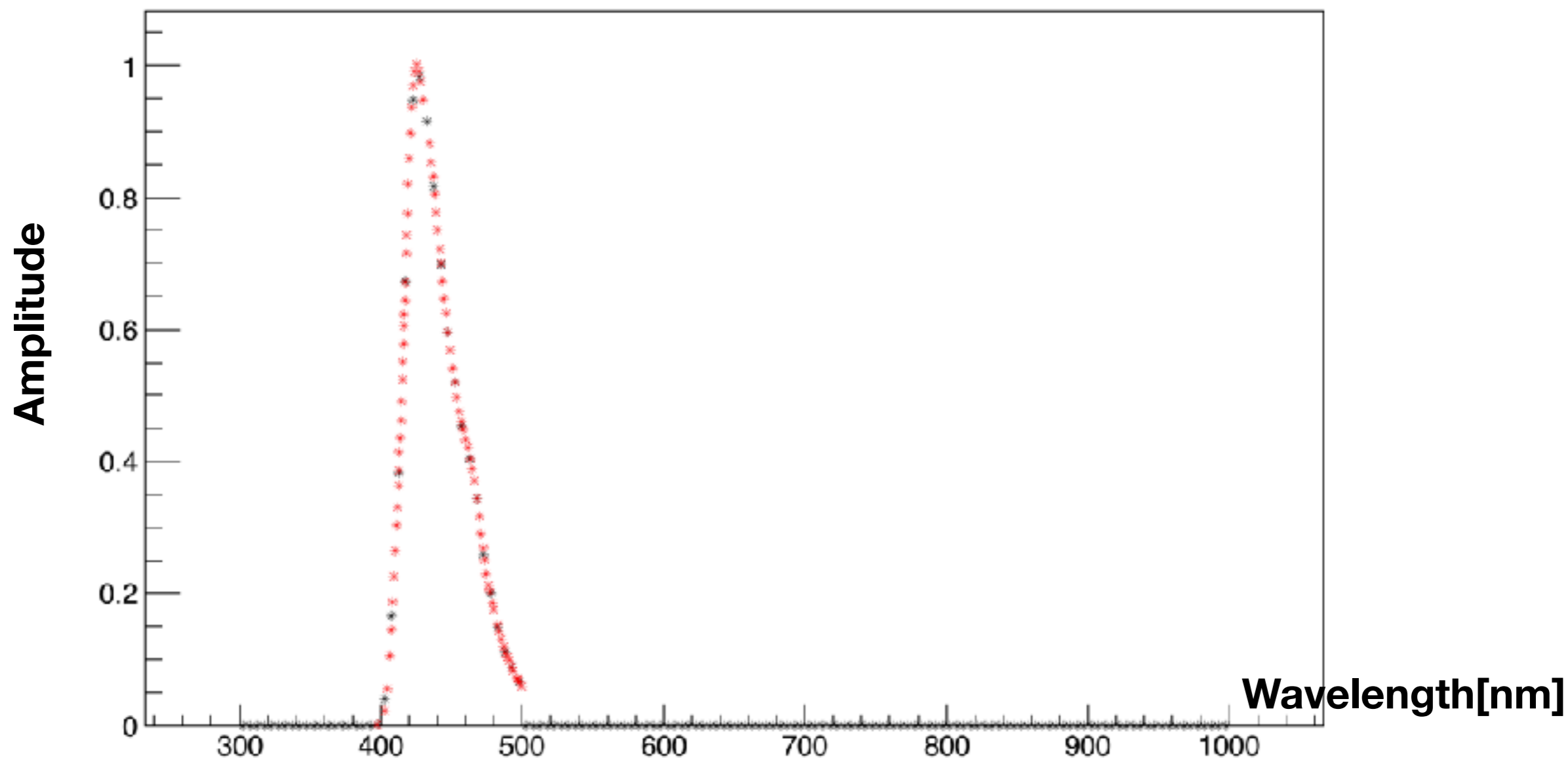
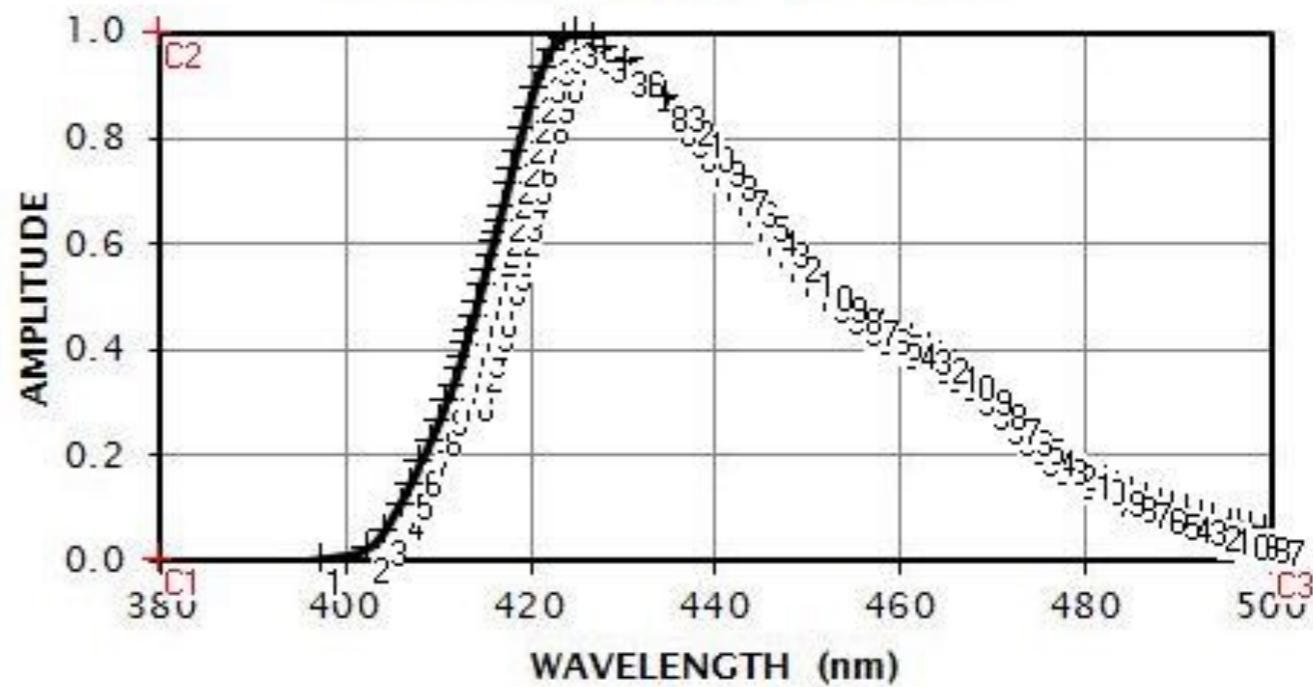


$$\frac{1.80\pi}{4\pi} = \frac{4500 \text{ photons}}{10000 \text{ photons}}$$

EJ-200 EMISSION SPECTRUM

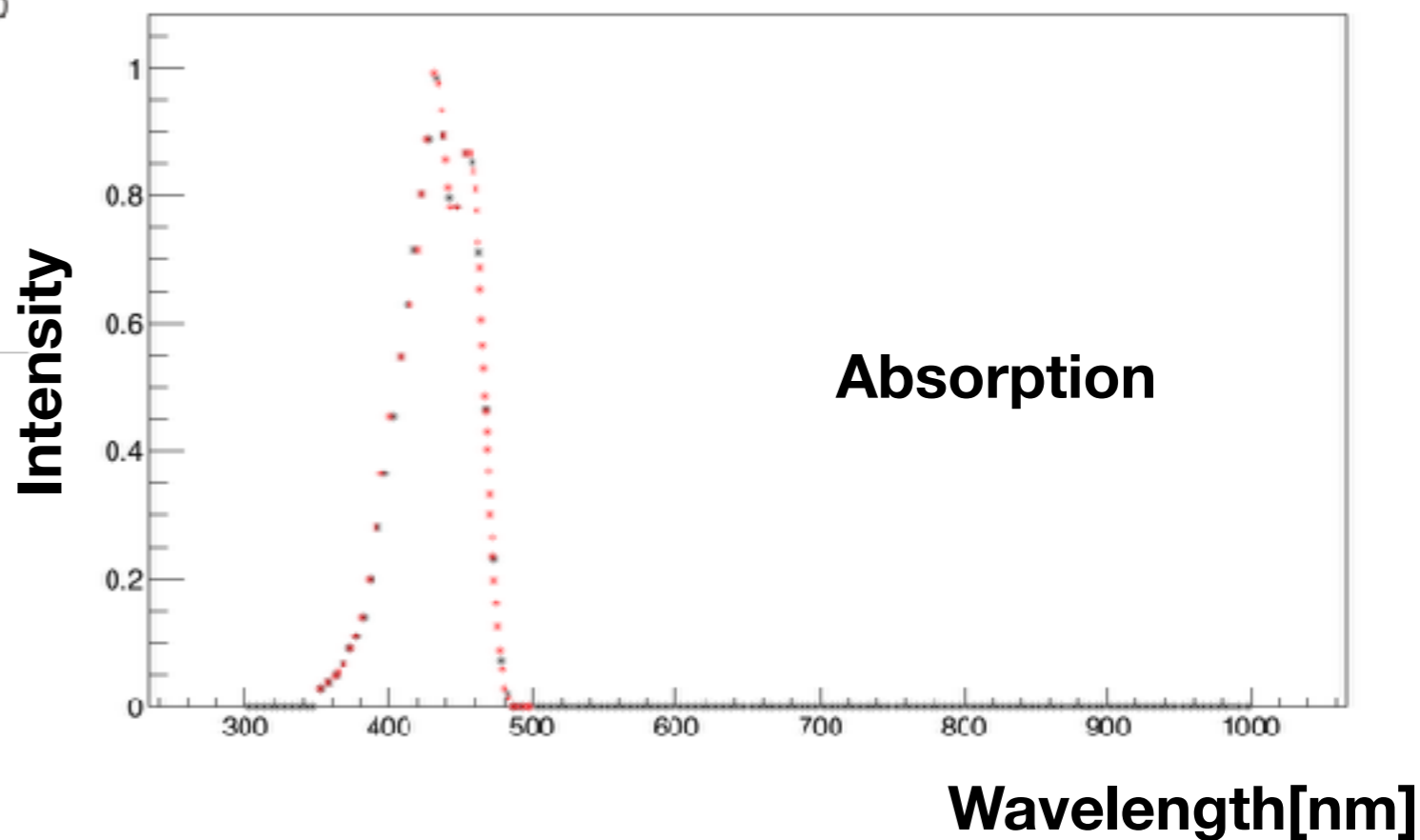
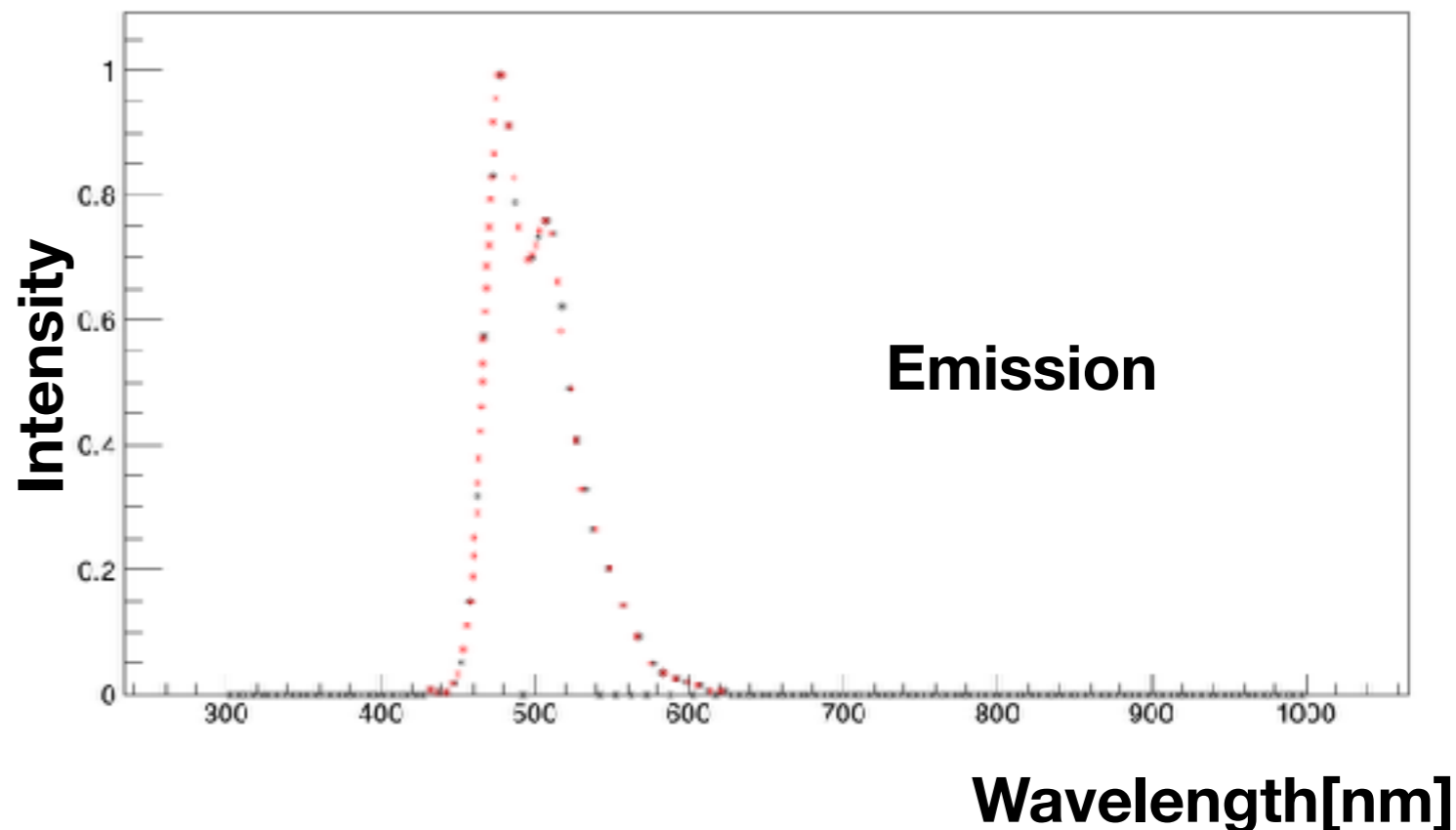
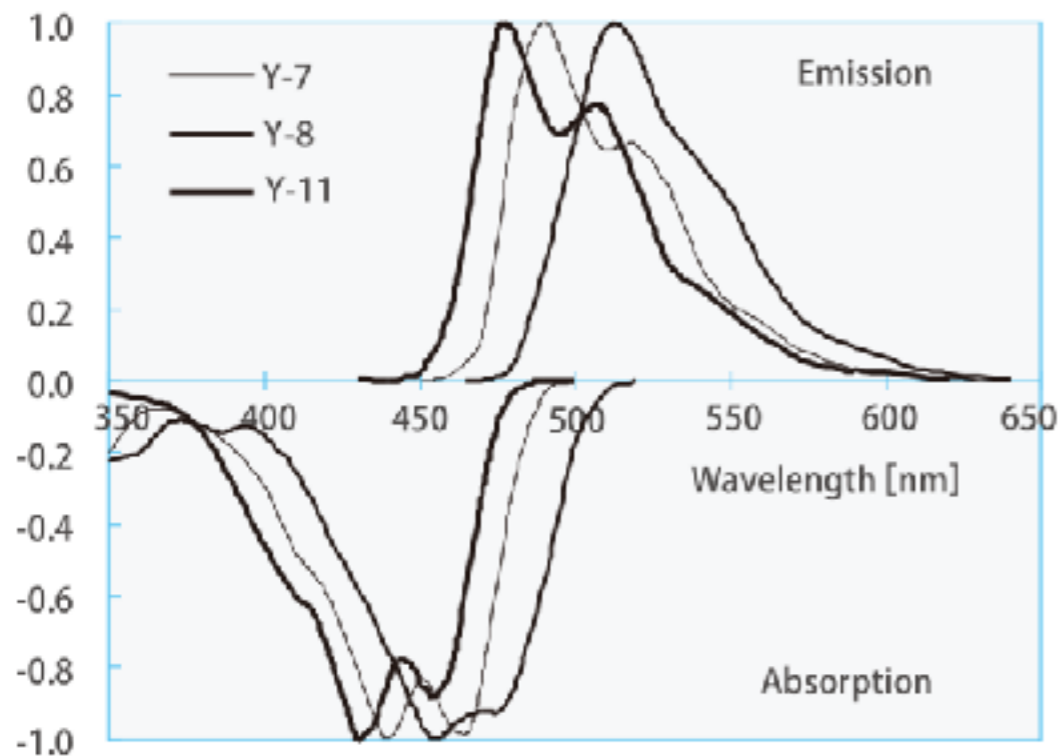


EJ-200 EMISSION SPECTRUM



Absorption and Emission Spectra

Y-7, Y-8, Y-11



3305 photons

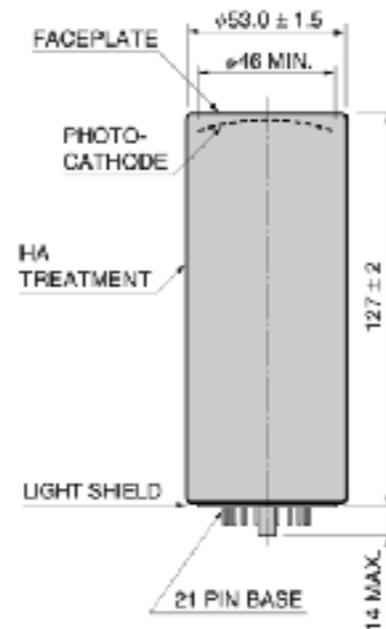
Trapping Efficiency : 5.4%

$$E = E_0 e^{-x/\lambda} \quad \lambda = 350 \text{ cm}$$

x	50cm	100cm	150cm	200cm	250cm	300cm
Trapping Efficiency 고려	178	178	178	178	178	178
Attenuation Length 고려	154	133	115	100	87	75

Properties of Photomultiplier Tube

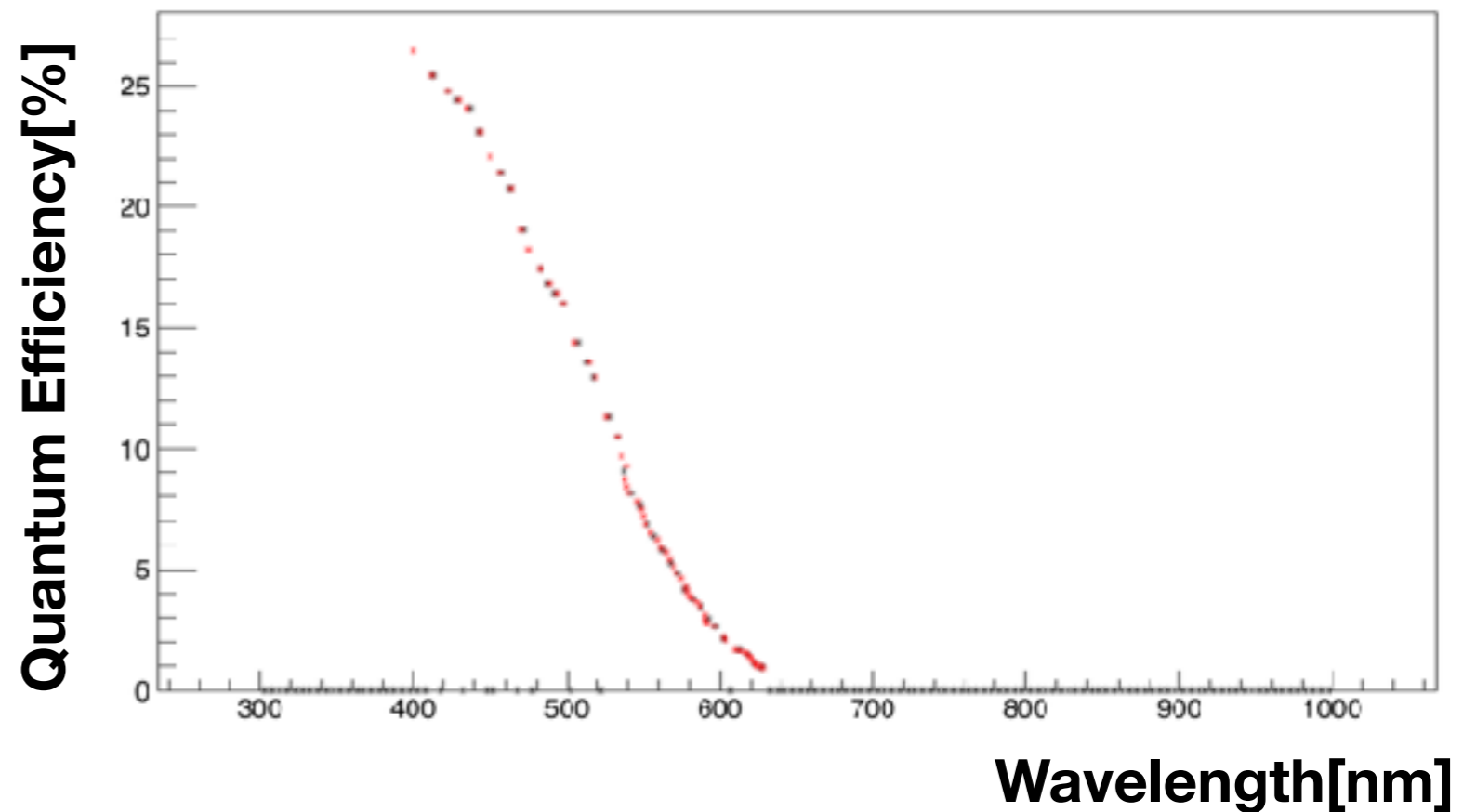
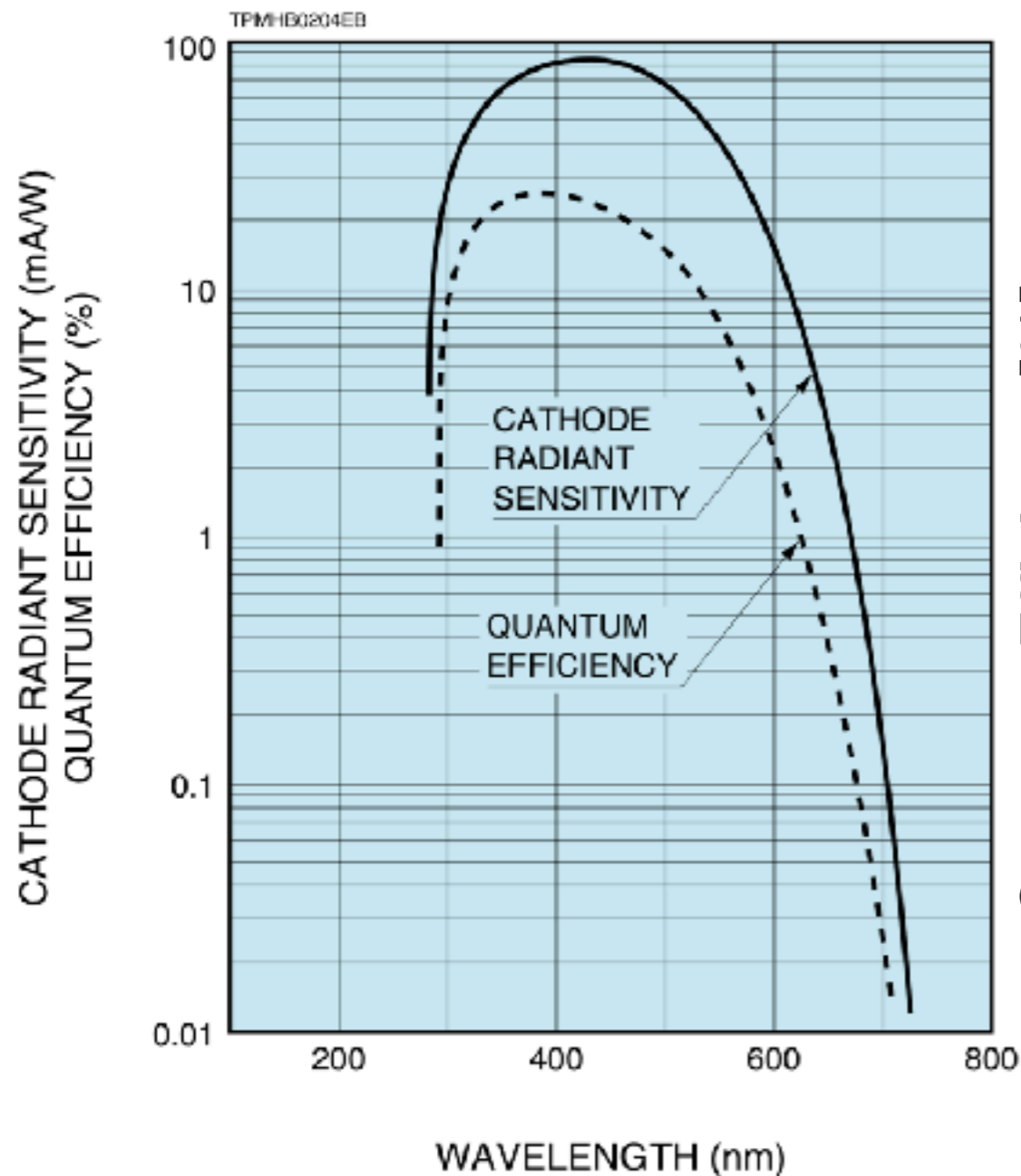
Hamamatsu R329-02



Parameter		Description / Value	Unit
Spectral response		300 to 650	nm
Wavelength of maximum response		420	nm
Photocathode	Material	Bialkali	—
	Minimum effective area	$\phi 46$	mm
Window material		Borosilicate glass	—
Dynode	Structure	Linear focused	—
	Number of stages	12	—
Operating ambient temperature		-30 to +50	$^{\circ}\text{C}$
Storage temperature		-30 to +50	$^{\circ}\text{C}$
Base		21-pin glass base	—
Suitable socket		E678-21C (supplied)	—

Quantum Efficiency

$$Q.E. = \frac{\text{Number of Photoelectrons}}{\text{Number of incident photons}}$$



Result

x	50cm	300cm
Number of photoelectron	16	7