Geant4, Gain

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Shot Muon into scintillator with 2 GeV/c

- Determine the volume of the scintillator at $1cm^3$
- Energy unit is MeV
- Length unit is cm
- Use table 2.1 in Techniques for Nuclear and Particle Physics Experiments

Bethe-Bloch formula

- $-\frac{dE}{dx} = 2\pi N_a r_e^2 m_e c^2 \rho \frac{Z}{A} \frac{z^2}{\beta^2} \left[\ln\left(\frac{2 m_e \gamma^2 v^2 W_{max}}{I^2} \right) - 2\beta^2 - \delta - 2\frac{C}{Z} \right]$
- r_e : $classical\ electron$
- m_e : $electron\ mass$
- N_a : $Avogadro's\ number$
- I : $mean\ excitation\ potential$
- Z : $atomic\ number\ of\ absorbing\ material$
- A : $atomic\ weight\ of\ absorbing\ material$
- ρ : $density\ of\ absorbing\ material$

- z : $charge\ of\ incident\ particle\ in\ units\ of\ e$
- $\beta = \frac{v}{c}$ $of\ the\ incident\ particle$
- $\gamma = \frac{1}{\sqrt{1-\beta^2}}$
- δ : $density\ corrention$
- C : $shell\ correnction$
- W_{max} : $maximum\ energy\ transfer\ in\ a\ single\ collision$
- $I = 64.7 * 10^{-6}$
- $C_0 = -3.2$
- $a = 0.1610$
- $X_1 = 2.49,\ X_0 = 0.1464$
- $m = 3.24$
- $\eta = \beta\gamma$

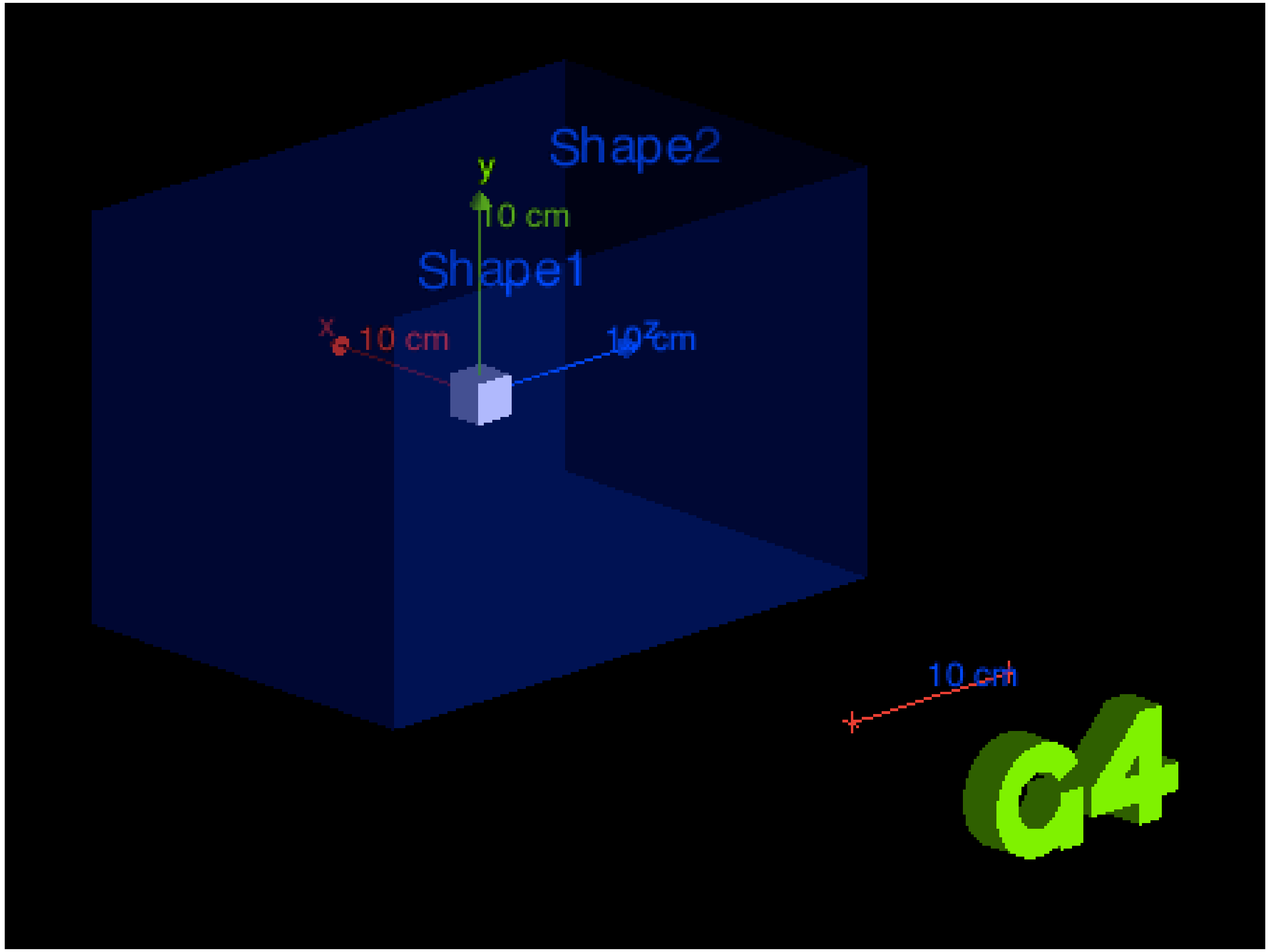
- $W_{max} \cong 2m_e c^2 \eta^2 \quad (\because M >> m_e) \quad = 364.234$
- $\delta = 4.6052X + C_0 + a(X_1 - X)^m \quad (\because X_0 < X < X_1), \; X = 1.27596$
- $p = \frac{mv}{\sqrt{1 - \frac{v^2}{c}}} \qquad \therefore v = 0.9986c$
- $Z_{eff} = \sum a_i Z_i \; = 33.1$
- $A_{eff} = \sum a_i A_i = 61.5429$

- $-\frac{dE}{dx}$ =2.22579

Scintillator

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	7.8×10^{-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			

Scintillator(1cm*1cm*1cm)



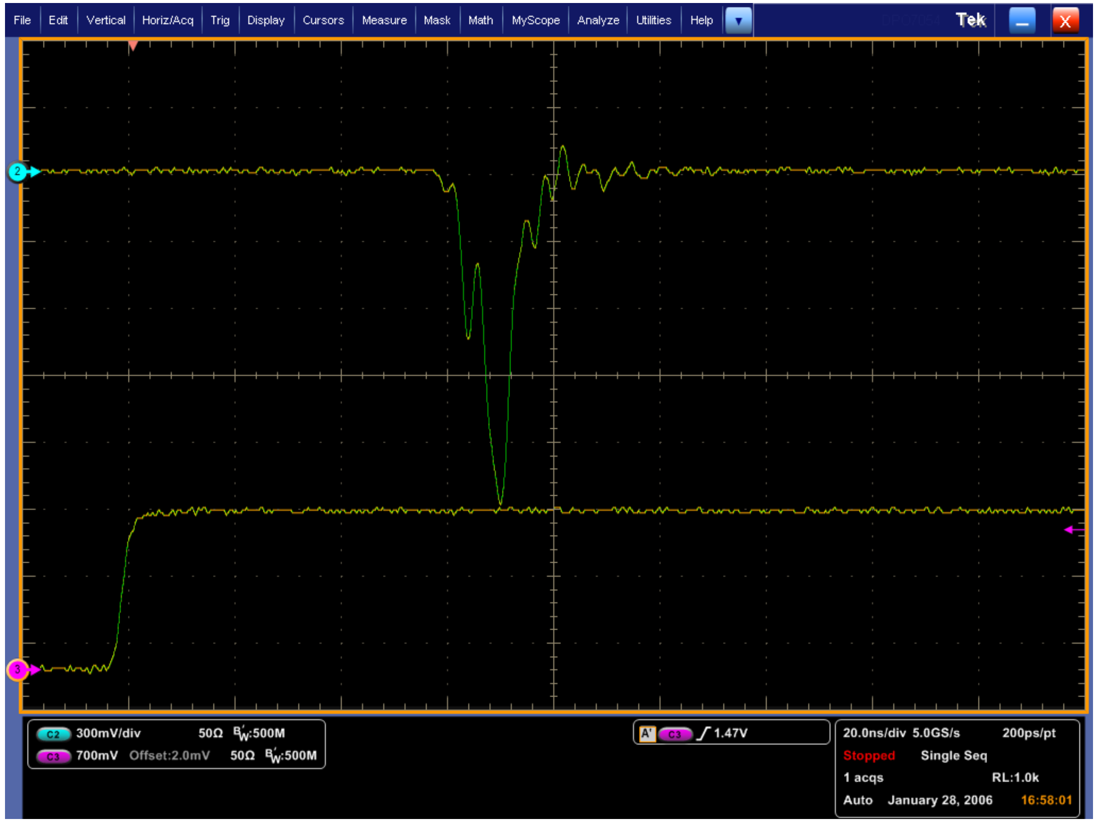
of Photons

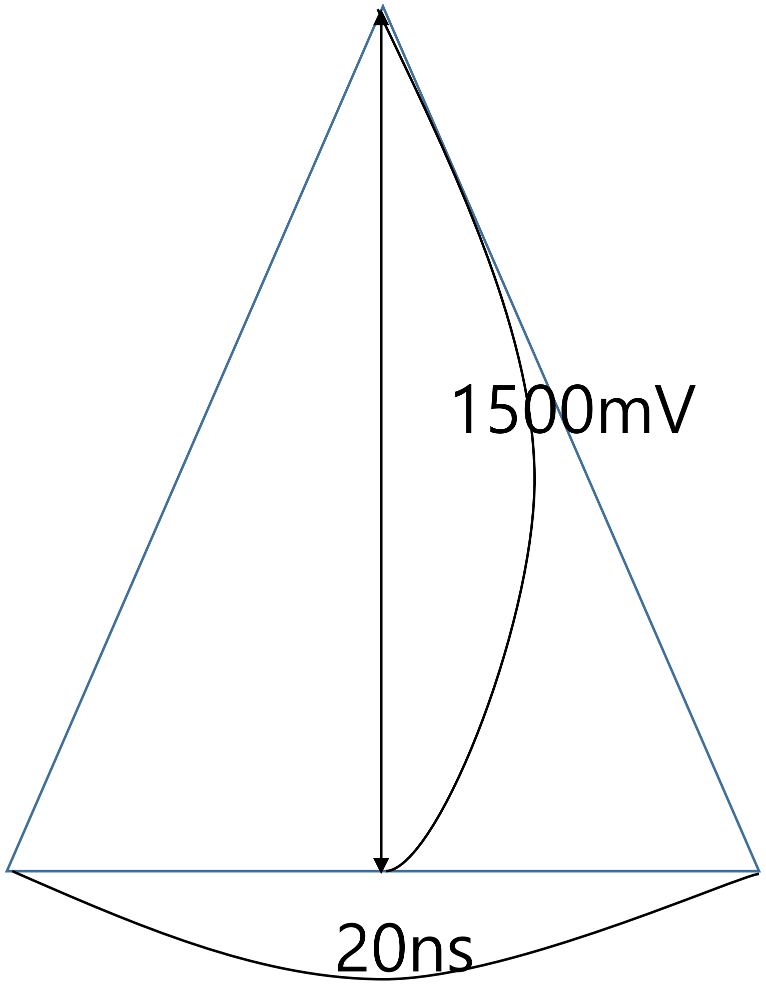
- QE $= \frac{\# \, of \, photoelectrons}{\# \, of \, photons}$
- # of photons $= \frac{\# \, of \, photoelectrons}{QE}$
- Gain $= \frac{I_p}{I_k} = \frac{e_{p/t}}{e_k/t} \frac{\# \, of \, e_p}{\# \, of \, photoelectrons}$
- $\# \, of \, photons = \frac{\# \, of \, e_p}{QE * gain}$
- I_p : $anode \, current$
- I_k : $cathode \, to \, 1st \, dynode \, current$

PMT

photon
photo
electron
cathode
1st dynode
2nd dynode
4V
1.1V
1V
1V
anode

Number of photon entering PMT





Charge

- I=q/t
- V=IR

- q= $\frac{V*t}{R}$
- q= $\frac{1}{2}*\frac{1500mV*20ns}{50\Omega}=3*10^{-10}C$ $e=-1.602176634*10^{-19}$C
- $\#\ of\ e_p\ =1.87*10^9$

QE

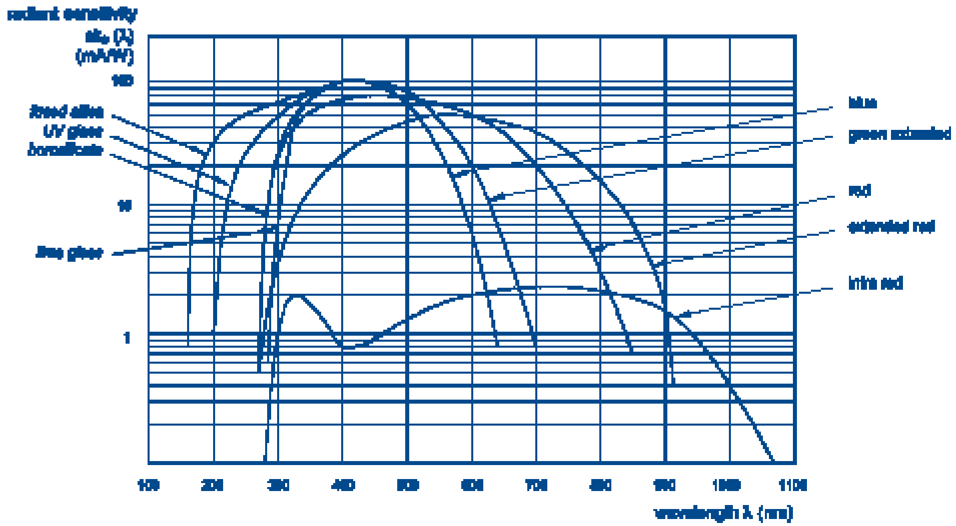


Fig.2 Typical spectral sensitivity characteristics of standard photocathodes with associated window materials.

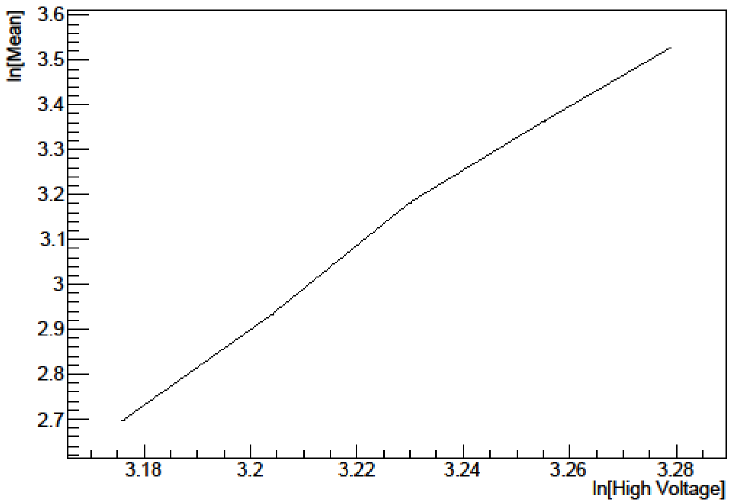
- QE(%) $= \frac{124}{\lambda} \times$ $radiant\ sensivity\ (\frac{mA}{W})$
- $radiant\ sensivity = 90\ \left(\frac{mA}{W}\right)$
- $\lambda = 400nm$
- QE=27.9%

of Photons

- $\# \, of \, photons = \frac{\# \, of \, e_p}{QE * gain}$
- $\# \, of \, photons = \frac{1.87 \times 10^9}{27.9\% * 3 \times 10^7} = 2.23 * 10^2$

Gain(μ)측정

- $\mu = A * V^{kn}$
- $V: supply\ voltage \quad n: \#\ of\ dynodes \quad A: const$
- $\frac{\mu_1}{\mu_2} = (\frac{V_1}{V_2})^{kn} \quad kn: slope\ of\ the\ straight\ line,$ graph of $\ln(mean) - \ln(V)$



To do list

- Need to draw and fit histogram : ln(mean)-ln(V) for get kn
- Draw graph of gain ratio
- Study bethe-bloch formula
- Study of Geant4 and simulate