1 (a) Gain $= \delta^N$; $5^{10} = 9.77 \times 10^6$

(b) one e^-/dynode $\frac{\sigma}{N} = \frac{\sqrt{5}}{5} = 0.447$

(c) amplified signal from one e^- $\left(\frac{\sigma_N}{N}\right)^2 \sim \frac{1}{\delta - 1}$ (EQ 9.4)

$\sigma_N/N = \left(\frac{1}{4}\right)^{1/2} = \frac{1}{2}$

(d) amplified signal from 100 e^-'s ... we could imagine that we are taking 100 samples (if there is no interaction during cascade) ... thus the error would be reduced by $\frac{1}{\sqrt{100}} = \frac{1}{10}$

$(\sigma_N/N) \sim \frac{1}{2} \times \frac{1}{10} = 0.05$

2 (a) $\ln M = \frac{V}{\ln(b/a)} \frac{\ln 2}{\Delta V} \left\{ \ln \frac{V}{p\, a \ln(b/a)\, K} \right\}$ (eq 6.8)

P-10 $\Delta V = 23.6$ V , $K = 4.8 \times 10^4$ V/cm atm Table 6.1

$\ln M = \frac{2000}{\ln(5/.005)} \frac{\ln 2}{23.6} \left\{ \ln \frac{2000}{1(.005) \ln\left(\frac{5}{.005}\right) 4.8 \times 10^4} \right\}$

$\ln M = 1.595 \rightarrow M = 4.93$

(b) $V = \frac{Q}{C} M = \frac{5.0 \times 10^6 \text{ eV} \times 1.602 \times 10^{-19} \times 4.93 \text{ coul}}{26 \text{ eV/IP} \quad 100 \times 10^{-12} \text{ farad}}$ w from Table 6.2

$V = 1.5 \times 10^{-3}$ Volts

3 (a) Resolution (following Eq 4-15 or 12-13)

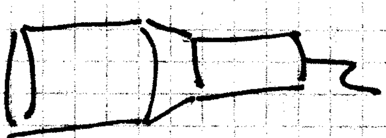
$$\text{Resolution} = 2.354\,(FWE)^{1/2} = 2.354\,(0.08\,[7.68\text{ eV}]\,10^{6}\text{ eV})^{1/2}$$

(7) Resolution $= 1.8$ keV

(b) $Z_{Ge} = 32 < (Z_{Pb} = 82\ ,\ Z_{I} = 53)$

(3) thus because photoelectric σ depends on Z^5 or so most counts should be in photopeak for PbI_2

4



$$\tau_{elec} = RC = (10^{2} \times 10^{-12})\ 50$$
$$RC = 5 \times 10^{-9}\text{ sec}$$

$$1\text{ MeV} \times 38000 \times 0.80 \times 0.20 \times \times 10^{4} = N_0$$
$$6.08 \times 10^{7} = N_0$$

$$Q = N_0 e = 608 \times 10^{7} \times 1.602 \times 10^{-19}\text{ coul} = 9.74 \times 10^{-12}\text{ coul}$$

(6) $V_R = \dfrac{Q}{C} = \dfrac{9.74 \times 10^{-12}}{10^{2} \times 10^{-12}} = 9.7 \times 10^{-2}$ V ✓ limit for $\underline{\underline{\text{large}}}$ RC

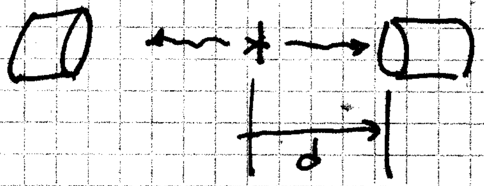
τ electronics ~~ef~~ is fast compared to $\tau_{light} \sim 0.23\ \mu s$

max $\tau_{radiation} \sim \dfrac{10\text{ cm}}{3 \times 10^{8}\text{ cm/sec}} \simeq 33$ ns

for small time constant $V = \dfrac{\tau}{\theta}\dfrac{Q}{C}$ [eq 9.17a]

(4) $V_R = \left(\dfrac{\tau_{NaI}}{\tau_{elec}}\right)^{-1}\dfrac{Q}{C} = \dfrac{0.005\ \mu s}{0.230\ \mu s}\,[9.7 \times 10^{-2}\text{ V}] = 2.1 \times 10^{-3}$ ✓

5



$A_{\gamma\gamma} = 10\,\mu Ci \times 3.7\times 10^{10}/sec \times 10^{-6}\ \frac{Ci}{\mu Ci}$

$A_{\gamma\gamma} = 3.7\times 10^{5}$ into 4π

(a) photopeak effic. ~ @ 1.1 or 1.3 MeV for ^{60}Co ~ $0.3 = \epsilon_{INT}$
fig 10.25

(b) want $R_1 = R_2 = 10^2/sec = A\,\epsilon_{INT}\,\epsilon_{Geo}\,W(\theta)$

if there is no angular correlation .. low rate ignore summing

$$\epsilon_{Geo} = \frac{10^2/sec}{3.7\times 10^{5}/sec\,(0.3)} = 9.0\times 10^{-4}$$

[eq 4.22] and $\epsilon_{Geo} \sim \frac{\pi a^2}{4\pi d^2} \rightarrow d = \left[\frac{\pi(7.6/2)^2}{4\pi(9.0\times 10^{-4})}\right]^{1/2}$ cm

$$d = \left[4.0\times 10^{3}\,cm^2\right] = 63.\ cm$$

"separate" by 2d or 126 cm

(c) $R_{12} = (A\,\epsilon_{Geo})(A\,\epsilon_{Geo})\,2\tau$ [Eq 10.13]

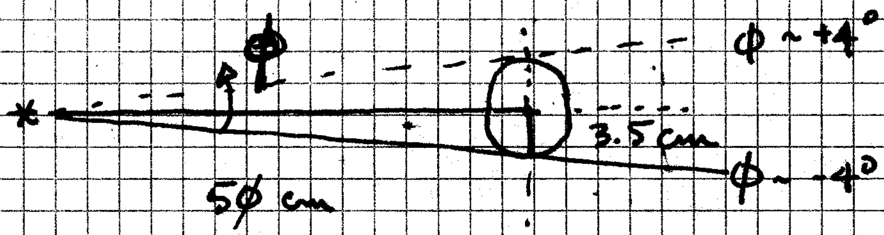
[use total ϵ not photopeak]

$$R_{12} = \left(3.7\times 10^{5}/sec \times 9.0\times 10^{-4}\right)^2\ 4\times 10^{-6}\,sec$$

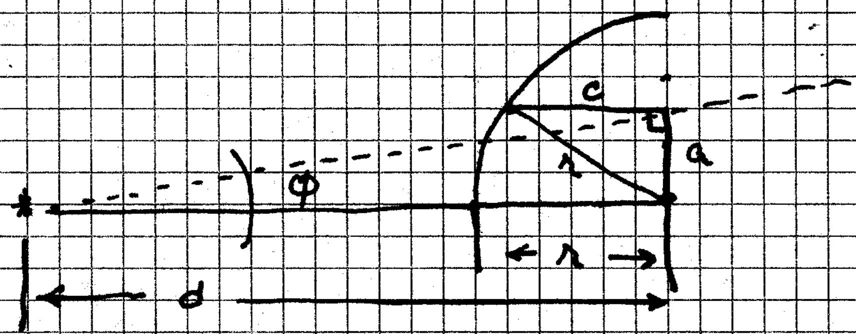
$$= (333/sec)^2\ 4\times 10^{-6}\,sec = 0.44/sec$$

[or 1 in 250 is rand]

6



$$\phi/2 \sim \tan^{-1}\left(\frac{3.5}{50}\right) \sim 4^{0}$$



approximate the path across the detector by the "cord" of the circle

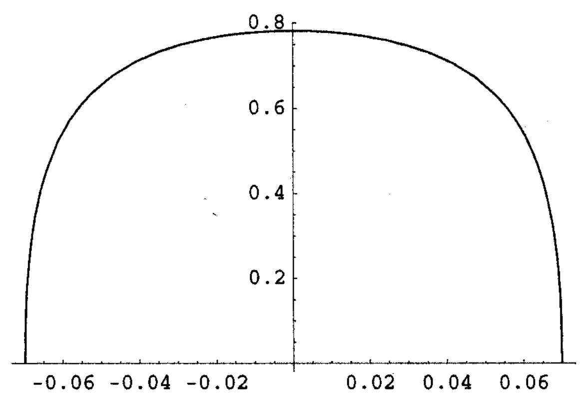
$$c^2 = r^2 - a^2 \qquad \tan\phi = a/d \rightarrow c = \left[r^2 - (d\tan\phi)^2\right]^{1/2}$$

frac. attenuation $= 1 - \frac{I}{I_0} = 1 - e^{-\mu(2c)}$

from NIST website $\mu/\rho = 0.04086\ \frac{\mathrm{cm}^2}{\mathrm{g}}$ for Ge @ 2 MeV

$\rho = 5.323\ \mathrm{g/cm^3}$


```
In[51]:= Plot[
          {1 - Exp[-0.04086 5.323 * 2 cord[3.5, 50, phi] ]},
          {phi, -phiMax[3.5, 50], phiMax[3.5, 50]}
         ]
```




```
Out[51]= - Graphics -
```

7
- should be sensitive to fast neutrons (only)
- Cd sheet absorbs thermal neutrons
- parafin $(CH_2)_N$ thermalizes neuts that pass through the Cd sheet due to high energy
- BF_3 proportional counter absorbs thermal neuts and gives an ionization pulse $^{10}B + n \to {}^7Li + {}^4He + Q$
  $\searrow {}^7Li^* + {}^4He + Q'$
- pulse height distribution contains little information, only the presence of a neutron reaction when above a noise threshold or Bkg pulses from γ's

8 (a) $\text{deadtime per event} = \begin{pmatrix}\text{time to}\\ \text{digitize}\end{pmatrix} + \begin{pmatrix}\text{time to}\\ \text{store}\end{pmatrix}$

$= 10\ \mu s + n(3\mu s)$ where n is # of words

$= 10 + 10(3)\ \mu s/\text{event}$ opposite case to that in textbook

$\tau = 40\ \mu s/\text{event}$

nonparal.

(b) $R_{OBS} = R_{TRUE} / 1 + R_{TRUE}\tau = \dfrac{200}{1 + 200(40 \times 10^{-6})}$

$R_{OBS} = 198./\text{sec}$

$\text{fraction dead} = R_{OBS}\tau = 198 \times 40. \times 10^{-6} = 7.9 \times 10^{-3}$

(c) $0.50 = R_{OBS}\tau \rightsquigarrow R_{OBS} = \dfrac{0.50}{4 \times 10^{-5}} = 12{,}500/\text{sec}$

$12500 = \dfrac{R_T}{1 + R_T\tau}$

$12500(1 + R_T\tau) = R_T$

$12500 + 0.5R_T = R_T$

$12500 = 0.5R_T$

$25000 = R_T$ [obviously]