PROBLEM 1 (c = 1) UNITS = MeV

$P^\mu_{\gamma_1} = (|\vec{P}_{\gamma_1}|, \vec{P}_{\gamma_1}) = (108.2, 43.5, 75.1, 64.7)$

$P^\mu_{\gamma_2} = (|\vec{P}_{\gamma_2}|, \vec{P}_{\gamma_2}) = (65.2, -43.1, 30.5, -38.2)$

(So that $P^\mu_{\gamma_1} P_{\gamma_1 \mu} = P^\mu_{\gamma_2} P_{\gamma_2 \mu} = 0$, massless)

$P^\mu_{\pi^0} = P^\mu_{\gamma_1} + P^\mu_{\gamma_2} = (173.4, 0.4, 105.6, 26.5)$

$m^2_{\pi^0} = P^\mu_{\pi^0} P_{\pi^0 \mu} = (173.4)^2 - (0.4)^2 - (105.6)^2 - (26.5)^2$

$\Rightarrow m_{\pi^0} = 135.$

$P^\mu_\omega = P^\mu_{\pi^0} + P^\mu_{\pi^+} + P^\mu_{\pi^-} = (1377.7, -30.2, 73.4, 1130.7)$

$m^2_\omega = P^\mu_\omega P_{\omega \mu} \Rightarrow m_\omega = 783.$

$v_{\pi^0} = \dfrac{\vec{P}_{\pi^0}}{E_{\pi^0}} = \dfrac{(0.4, 105.6, 26.5)}{173.4} =$

$= (0.0023, 0.609, 0.153)$

Similarly

$v_\omega = \dfrac{\vec{P}_\omega}{E_\omega} = (-0.0219, 0.0533, 0.821)$

PROBLEM 2 (c = 1)

$\gamma = \frac{E}{m} = \frac{5}{4} \Rightarrow u = \sqrt{\frac{9}{25}} = \frac{3}{5}$ (×c) speed.

$t = \frac{d}{u} = 1.67 \cdot 10^6$ yr. time.

$N = N_0 e^{-d/u\gamma\tau} = N_0 e^{-\frac{10^6}{\frac{3}{5}\cdot\frac{5}{4}\cdot 4\cdot 10^5}} =$

$= N_0 e^{-10/3} = 0.035\, N_0$

$\Rightarrow$ about 3.5 %.

PROBLEM 3.

The rod has a contracted length of $L = \frac{1\,m}{\gamma} = \sqrt{1-v^2}\cdot 1\,m$

$= 0.71\,m$

The time is $t = \frac{L}{\Delta v}$,

$\frac{0.71\,m}{0.8c - 0.7c} = 7.1\,m/c = 2.4\cdot 10^{-8}\,s$.

Problem 4

$$\frac{cp}{MeV} = 300 \cdot \frac{B}{Tesla} \cdot \frac{R}{meters}$$

$$p = 300 \cdot 2 \cdot 0.4 \ MeV/c = 240 \frac{MeV}{c}$$

$$E = \sqrt{p^2 c^2 + m^2 c^4} = \sqrt{240^2 + 69.4^2} \ MeV$$

$$= 54.9 \ MeV$$