Physics 56400 Assignment #3 – Due October 24th

1. Suppose a beam of protons has a Gaussian distribution of intensity of the form

$$I(r) = I_0 \frac{1}{2\pi\sigma^2} e^{-r^2/2\sigma^2}$$

where $I_0 = 10^6\ \mathrm{s}^{-1}$ and $\sigma = 1\ \mathrm{mm}$. Suppose this beam were incident at right-angles to a target foil made of a $100\ \mu\mathrm{m}$ thick sheet of pure ^{7}Li. If the cross section for $p + {}^7Li \rightarrow {}^7Be + n$ is 10 mb, calculate the rate at which neutrons are produced.

2. Calculate the relative cross sections for inclusive Σ^+ and Σ^- production from
   (a) A beam of K^- incident on a hydrogen target,
   (b) A beam of K^- incident on a deuterium target.

3. Using the empirical mass formula for the baryons:

$$M_{q_1q_2q_3} = m_{q_1} + m_{q_2} + m_{q_3} + \kappa \frac{\vec{s}_1 \cdot \vec{s}_2}{m_{q_1} m_{q_2}} + \kappa \frac{\vec{s}_2 \cdot \vec{s}_3}{m_{q_2} m_{q_3}} + \kappa \frac{\vec{s}_1 \cdot \vec{s}_3}{m_{q_1} m_{q_3}}$$

with parameters

$$m_u = m_d = 364\ MeV,$$
$$m_s = 535\ MeV$$
$$\kappa = 0.0259 \times 10^9\ MeV^3$$

Calculate the masses of the spin 1/2 and spin 3/2 baryons and compare your results with their measured values. Show, as an example, the calculation for the Σ^{*+} baryon, but use a spreadsheet to perform similar calculations for the other baryons.