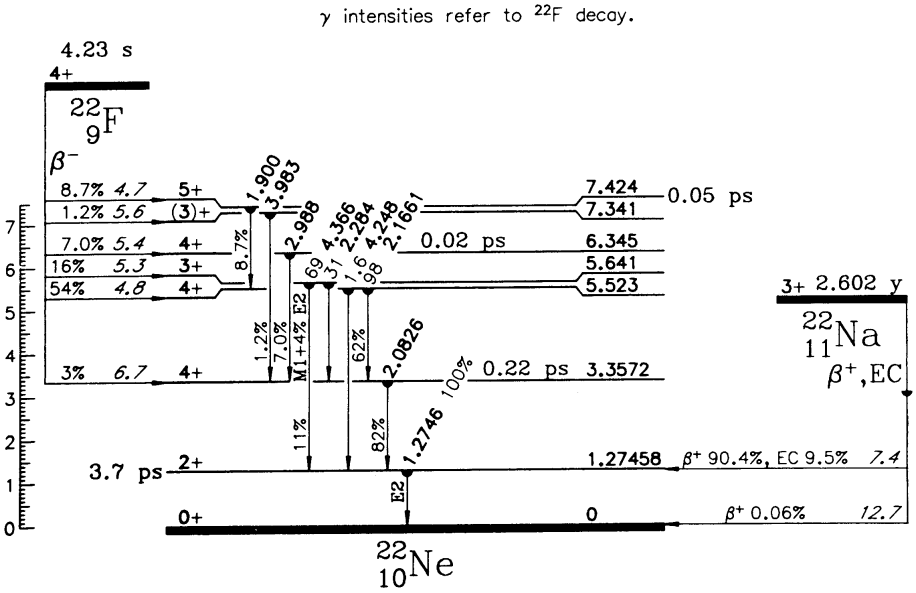
Problems for Physics 198, Spring Semester 1999 Helmuth Spieler
Introduction to Radiation Detectors and Electronics

Homework due on Tuesday, 26-Jan-99 at begin of lecture.

1. ^{22}Na is commonly used as a calibration source. The level scheme from the *Table of Isotopes* is shown below.



   a) Sketch the emission spectrum, showing the relative intensities.

   b) Assuming a source strength of 0.1 μCi, what are the counting rates of the individual spectral lines in a detector with 5 cm diameter placed 50 and 100 cm from the source? Assume an ideal detector with 100% efficiency.

2. A detector system with a 10-bit digitizer is calibrated with ^{60}Co and ^{137}Cs sources. The ^{60}Co lines at 1173 and 1332 keV are centered at channels 797 and 906 (the numbering starts with 0). The 662 keV line from the Cs source is at channel 447.

   a) Determine the calibration function that relates channels to energy. What are the minimum and maximum energies that can be measured without readjusting the system?

   b) Where would the peaks from a ^{22}Na source appear?

   c) A second system shows the ^{60}Co and ^{137}Cs lines at channels 869, 677 and 299. What do you conclude from this result?

3. The LBNL supernova search group has determined that in a ground-based 4 m telescope their system has a sensitivity of 1 photon/s for a magnitude 26.7 object. The magnitude describes the faintness of a star and is defined as

$$\Delta magnitude = -2.5 \cdot {}_{10}\log \frac{\Phi_1}{\Phi_2},$$

i.e. the magnitude increases with decreasing photon flux Φ. Five units of magnitude correspond to a flux ratio of 100.

a) Humans can recognize stars of magnitude 5 to 6 with the naked eye (assume 6 for young folks). What is the photon flux captured by the eye?

b) The eye + brain system integrates over about 0.1 s. What is the statistical fluctuation of photons sensed during this integration time?