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

Problem Set 2: Due on Tuesday, 2-Feb-99 at begin of lecture.
Discussion on Wednesday, 12 – 1 PM in 347 LeConte.

1. Photoelectric absorption is often considered to be a localized interaction. After absorption of the photon energy E_γ, an electron is ejected from the shell with the energy

$$E_{el} = E_\gamma - E_b$$

where E_b is the binding energy of the electron. Using the dE/dx curve in the lecture notes, estimate the range of the ejected electron in Si for photon energies of 20 keV and 100 keV. What are the respective ranges in Ge and NaI? (The range times density is about the same for all materials.)

2. a) The fraction of incident photons that have interacted within a distance x is

$$\frac{N}{N_0} = 1 - e^{-\mu x}$$

Derive this expression.

b) Estimate the required dimensions of a NaI crystal to yield 95% absorption efficiency for 1 MeV photons.

3. An arrangement commonly used to determine the charge number Z of low energy nuclei (1 – 10 MeV/amu) consists of a thin transmission detector and a thick detector to stop the particles. The thin detector measures an incremental energy loss ΔE and the stop detector measures the residual energy. Derive a simple algorithm to determine Z from these measurements.

4. Consider a beam of 5 MeV protons and α particles, i.e. both particle types have the same energy. Describe a simple arrangement that allows discrimination between the two types of particles without requiring an energy measurement.

5. a) What is the required time resolution in a time-of-flight PET system to achieve a position resolution of 1 mm?

b) In a recent press conference Prof. Seren Dipity from the F. Gump Institute of Advanced Studies announced that using scintillation detectors and "state-of-the-art space-age technology" this time resolution has been achieved. The scintillator crystals use a rather standard geometry, i.e. a face of 10 x 10 mm^2 and 30 mm length. Do you believe his claim? Why?