Problem 1 [Knoll Prob. 14.1]

Discuss the feasibility of operatingg BF_3 of ^3He tube in the ionization or Geiger regions rather the as a proportional tube. What practical considerations dictate the latter choice?

Problem 2 [Knoll Prob. 14.10]

The signal current from a typical application of a self-powered neutron detector is seldom more than a nanoaompere. Find the equivalent number of beta particles transferred er second between the emitter and the collector.

Problem 3 [Knoll Prob. 14.11]

Find the fractional decrease in sensitivity (the "burn-up") of a rhodium self-powered detector if used in a neutron flux of $3\times10^{13}/\mathrm{cm}^{-2}\cdot\mathrm{s}$ over a period of 6 moths.

Problem 4 [Knoll Prob. 14.2]

When operated at a gas multiplication factor of 1000, estimate the pulse amplitude produced by the interaction of a thermal neutron in a ^3He tube of 100 pF capacitance.

Problem 5 [Knoll Prob. 14.3]

A $BF-3$ tube using natural boron shows a counting efficency of 1% for 10 eV neutrons in a given application. By what factor can the efficiency be increased by using boron enriched to 95% ^{10}B?

Problem 6 [Knoll Prob. 14.1]

Calculate the detection efficiency of a BF_3 tube (96% enriched in ^{10}B) filled with 600 torr (80 kPa) for incident thermal neutrons if their pathlength through the gas is 10 cm.

Problem 7 [Knoll Prob. 14.5]

In which applications might one prefer to use ^3He tube rather than BF_3 tube for slow neutron counting?

Problem 8 **[Knoll Prob. 14.6]**

In BF_3 tubes of small diameter, the "step" in the pulse height spectrum at 1.47 MeV has a finite positive slope that is much more noticeable than that fro the step at 0.84 MeV. Give a physical explanation for this observation.

Problem 9 **[Knoll Prob. 14.7]**

Sketch the pulse height spectrum expected from a boron-lined proportional tube for thermal neutrons if the boron thickness is small enough so that energy loss of the reaction products in the layer can be neglected.

Problem 10 **[Knoll Prob. 14.8]**

Estimate the number of scitillation photons liberated by the interaction of a thermal neutron in ^{6}Li(Eu) and in a typical Li glass scintillator.

Problem 11 **[Knoll Prob. 14.9]**

Why is not possible to increase the counting efficiency of a fission chamber indefinitely simply by increasing the thickness of the fissionable deposit?

Problem 12 **[Knoll Prob. 15.1]**

Calculate the efficiency of a 4-mm thick ^{6}Li scintillator for incident 1 MeV neutros. Repeat for thermal neutrons.

Problem 13 **[Knoll Prob. 15.10]**

Sketch the differentia pulse height spectrum you would epect from a proton recoil detector if the incident neutron energy spectrum is known to have three very prominent and narrow peaks at 75, 150 and 300 keV.

Problem 14 **[Knoll Prob. 15.11]**

Show that the angle (in the laboratory frame) between a recoil proton and the corresponding scattered neutron is always 90^o.

Problem 15 [Knoll Prob. 15.12]

Estimate the maximum pulse amplitude expected if a methane-filled proportional counter with the following properties is irradiated by 1-MeV neutrons: gas pressure, 0.75 atm; applied voltage, 2000 V; anode radius, 0.005 cm; cathode radius, 2 cm; tube capacitance, 60 pF.

Problem 16 [Knoll Prob. 15.13]

A silicon detector is irradiated by 1 MeV neutrons. Find the minimum and maximum energies expected for the recoil nuclei produced in elastic scattering of the incident neutrons.

Problem 17 [Knoll Prob. 15.14]

What basic physical difference leads to the observation that the recoil energy distribution from 5 MeV neutron scattering from hydrogen is uniform or rectangular shaped while it is highly non uniform fro scattering from helium?

Problem 18 [Knoll Prob. 15.15]

What factor limits increasing the detection efficiency of a proton recoil telescope by simply increasing the thickness of the hydrogenous radiator?

Problem 19 [Knoll Prob. 15.16]

A capture-gated neutron spectrometer is based on the use of a plastic scintillator that is loaded with natural boron to 5% by weight. Assume that an incident neutron is fully moderated at a position near the center of the scintillator, and begins t diffuse as a thermal (0.025 eV) neutron. Calculate the expected mean time from the start of the diffussion process to the time the thermal neutron triggers a capture reaction in the ^{10}B. Offer a justification for why this value is likely to be smaller than the observed pulse pair separation times for capture-gated spectrometers with this compositions.

Problem 20 [Knoll Prob. 15.2]

A thermal neutron detector is placed at the center of a spherical moderator that is exposed to a source of 5-MeV neutrons. If the moderator diameter is varied while holdig all other conditions constant, sketch the corresponding expected variation of the counting rate. Offer physical explanations for the behaviour of this curve at both large and small diameters.

Problem 21 [Knoll Prob. 15.3]

A lithium iodide scintillator is often used as the central detector in the neutron spherical dosimeter. Sketch the expected pulse height spectrum from the scintillator in this application.

Problem 22 [Knoll Prob. 15.4]

An incident fast neutron is moderated and then diffuses a total pathlength of 10 cm before being captured in the BF_3 tube of a long counter. Estimate the time delay between the time of neutron incidence and the leading edge of the output pulse.

Problem 23 [Knoll Prob. 15.5]

Incident 3 MeV neutrons interact in a lithium sandwich spectrometer. Calculate the reaction product energies for the case in which the alpha particle is emitted in the forward direction at 0^o and the triton at 180^o.

Problem 24 [Knoll Prob. 15.6]

Calculate the maximum proton energy from the ^{3}He(n,p) reaction when induced by 1.5 MeV neutrons.

Problem 25 [Knoll Prob. 15.7]

Explain the physical origin of the epithermal peak observed in most pulse height spectra from ^{3}He proportional tubes when used with fast neutron sources.

Problem 26 [Knoll Prob. 15.8]

Calcualte the detection efficiency of a methane-filled proportional counter for incident 100 keV neutrons if the gas pressure is 1 atm and the neutron pathlenght through the gas is 5 cm.

Problem 27 [Knoll Prob. 15.9]

A 1 MeV neutron enters a plastic scintillator and undergoes two sequential scatterings from hydrogen nuclei before scaping. If the first scattering deflects the neutron at an angle of 40^o with respect to its original direction and the scattering sites are 3 cm apart, calculate the time that separates the two events. If the PM anode time constant is 20 ns, will the two events be resolved?

Problem 28 [January 2013]

Consider a ^{3}He filled proportional tube used as a slow neutron detector. What is the amplitude reached by a pulse caused by the passage of a neutron?

Data: $^{3}\mathrm{He} + \mathrm{n} \rightarrow {}^{3}\mathrm{H} + \mathrm{p}$ (Q=0.764 MeV) Gain of ^{3}He = 1000 Capacitance of the anode = 100 pF $w_{^{3}H}$

Problem 29 Slow neutron detection with a ^{3}He proportional chamber [January 2017]

A commonly used detector for thermal neutrons is a proportional tube filled with ^{3}He gas:

a) Calculate the mean free path of thermal neutrons if the gas is a pressure of 5 atm. Consider the cross section of thermal neutrons as 5000 barns

b) If the tube has a diameter of 4 cm, what is the probability that a thermal neutron going through its center will be detected?