Problem 1 [Grupen Prob. 2.1]

The thickness of an aluminium plate, x, is to be determined by the absorption of ^{137}Cs γ rays. The count rate N in the presence of the aluminum plate is 400 per 10 seconds, and without absorber it is 576 in 10 seconds. The mass attenuation coefficient for Al is $\mu/\rho = (0.07 \pm 0.01)$ $(\text{g/cm}^2)^{-1}$. Calculate the thckness of the foil and the total error.

Problem 2 [Grupen Prob. 2.3]

A pointlike radioactive γ-ray source leads to a count rate of $R_1 = 90000$ counts per second in a G-M counter at a distance of $d_1 = 10$ cm. At $d_2 = 30$ cm one gets $R_2 = 50000$ counts per second. What is the dead time of the GM counter, if the absorption effects in the air can be neglected?

Problem 3 [Knoll Prob. 4.1]

Calculate the amplitude of the voltage pulse produced by collecting a charge equal to that carried by 10^6 electrons on a capacitance of 100 pF.

Problem 4 [Knoll Prob. 4.3]

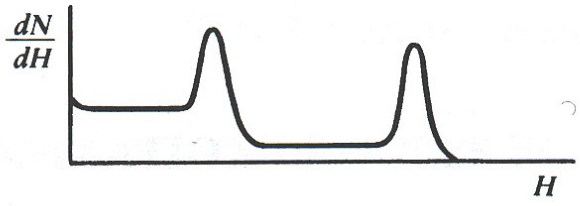
Explain how it works a detector in Mean Square Voltage mode.

Problem 5 [Knoll Prob. 4.4]

A detector with a charge collection time of 150 ns is used with a preamplifier whose input circuit can be represented by a parallel combination of 300 pF and 10 kΩ. Does this situation fall in the category of small or large collection circuit time? Please, sketch the voltage shape expected.

Problem 6 [Knoll Prob. 4.5]

A scintillation counter operated at a given voltage produces a differential pulse height spectrum as sketched below:



(a) Draw the corresponding integral pulse height spectrum

(b) Sketch the expected counting curve obtained by varying the voltage to the detector while counting above a fixed threshold.

Problem 7 [Knoll Prob. 4.6]

Sketch both the differential and integral pulse height spectra (using the same horizontal scale) for the following cases:

(a) Pulses with single amplitud of 1 V

(b) Pulses uniformly distributed in amplitude between 0 and 1 V

(c) Pulses distributed around an average amplitude of 1.5 V with a pulse height resolution of 8%

Problem 8 [Knoll Prob. 4.7]

A gamma ray spectrometer records peaks corresponding to two different gamma-ray energies of 435 and 490 keV. What must be the energy resolution of the system in order just to distinguish these two peaks?

Problem 9 [Knoll Prob. 4.8]

In a detector with a Fano factor of 0.1 what should be the minimum number of charge carriers per pulse to achieve a statistical energy resolution limit of 0.5%?

Problem 10 [Knoll Prob. 4.9]

A pulse processing system operated over a long period of time shows a typical drift that broadens single-amplitude pulses into a distribution with pulse height resolution of 2%. If this system is used with a detector with an intrinsic pulse height resolution of 4%, what will be the expected overall pulse height resolution?

Problem 11 [Knoll Prob. 4.10,4.12]

Find the solid angle subtended by the circular end surface of a cylindrical detector (diameter of 10 cm) for a point source located 20 cm from the surface along the cylindrical axis.

This detector has an intrinsic peak efficiency at 1 MeV of 12%. The point source emits a 1 MeV gamma ray in 80% of its decays and has an activity of 20 kBq. Neglecting attenuation between the source and detector, calculate the number of counts that will appear under the 1-MeV full-energy peak in the pulse height spectra from the detector over a 100 s count.

Problem 12 [Knoll Prob. 4.11]

The diameter of the moon as seen from earth subtends an angle of about 0.5^o. Find the probability that a laser beam aimed in a random direction from the earth's surface will stike the moon.

Problem 13 [Knoll Prob. 4.13]

A source of ^{116m}In (half-life = 54 min) is counted using a G-M tube. Successive 1-min observations gave 131340 coutns at 12:00 and 93384 counts at 12:40. Neglecting background and using a reasonable model for dead time losses, calculate the true iteraction rate in the G-M tube at 12h00.

Problem 14 [Knoll Prob. 4.14]

Counters A and B are nonparalyzable with dead time of 30 and 100 μs, respectively. At what true event rate will dead time losses in counter B be twice as great as those for counter A?

Problem 15 [Knoll Prob. 4.15]

A counter with negligible background gives exactly 10000 counts in a 1-s period when a standard source is in place. An identical source is placed beside the first,a nad the counter now records 19000 counts in 1 s. What is the counter dead time?

Problem 16 [Knoll Prob. 4.16]

A paralyzable detector system has a dead time of 1.5 μs. If a counting rate of 10^5 per second is recorded, find the possible values for the true interaction rate.

Problem 17 **[Knoll Prob. 4.17]**

As a source is brought progressively closer to a paralyzable detector, the measured counting rate rises to a maximum and then decreases. If a maximum counting rate of 50000 counts per second is reached, find the dead time of the detector.

Problem 18 **[Poston Prob. 1.12]**

Calculate the solid angle subtended by a 5 cm diameter cylindrical detector facing a point source 10 cm away.

Problem 19 **[Poston Prob. 1.14]**

A small liquid vial can be placed on top of a 5 cm cylindrical detector of inside a 1.5 cm well, 3.5cm deep in the same size detector. If the detection sensitivity is proportional to the amount of detection material, compare the geometries involved and the operational efficiencies.

Problem 20 **[Poston Prob. 1.15]**

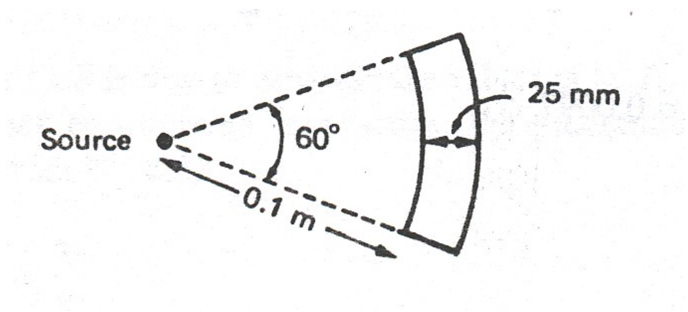
A thin beta emitter is in the form of a 2.5 cm diameter plate, 2 mm thick and has a specific activity of $50\mu\text{Ci/cm}^3$. The half-value layer for that beta energy is equivalent to 6mm of the source material. Calculate the approximative count rate if the source is mounted in a proportional counter in a 4π geometry. Assume a 30% detection efficiency and that the activity is concentrated:

(a) in the center line of the source;

(b) uniformly throughout it

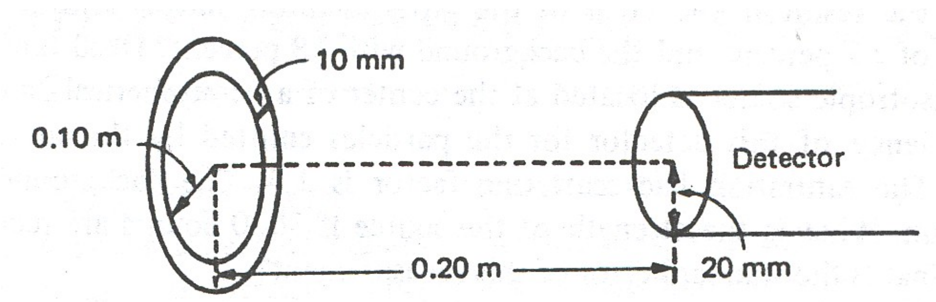
Problem 21 **[Tsoulfanidis Prob. 8.4]**

A 1 mCi point isotropic gamma source is located 0.10 m away from a 60^o spherical shell of a NaI detector, as shown in the figure below. Assuming that all the pulses at the ouptput of the photomultiplier tube are counted, what is the counting rate of the scaler? The gamma energy is 1.25 MeV



Problem 22 [Tsoulfanidis Prob. 8.5]

Calculate the counting rate in particules/s for the case shown in the figure below. The source has the shape of a ring and emits 10^6 particles/s isotropically. The background is zero. The detector efficiency is 80%, and F=1.



Problem 23 [Tsoulfanidis Prob. 8.6]

Calculate the self-absorption factor for a ^{14}C source which has a thickness of 10 μg/cm^2. E_{max}=156 keV.

Problem 24 [Tsoulfanidis Prob. 8.7]

An attempt was made to measure the backscattering factor by placing foils of continuously increasing thickness behind the source and observing the change in the counting rate. The foils were of the same material as the source backing. The results of the measurements are given in the table below. Calculate the saturation backscattering factor and the source backscatterting factor.

Thickness behind source (mm)	Counting rate (c/min)
0.10 (Source backing only)	3015
0.15	3155
0.20	3365
0.25	3400
0.30	3420
0.35	3430
0.40	3430

Problem 25 [Tsoulfanidis Prob. 8.8]

What is te counting rate in a detector with a rectangular aperture measuring 1 mm $\times$ 40 mm, if a 1-mCi gamma ray point isotropic source is 0.10 m away? The efficiency of the detector for these gammas is 65%.

Problem 26 [Tsoulfanidis Prob. 8.9,8.10]

A radioactive source emits electrons isotropically at the rate of 10^4 electrons/s/ A plastic scintillator having the shape of a cylindrical disk with a 25-mm radius is located 120 mm away from the source. The efficiency of the detector for these electrons is 95 percent. The backscattering factor is 1.02, and the source self-absorption factor is 0.98. Dead time of the counting system is 5 μs. How long should one count, under these conditions, to obtain the strenght of the source with a standard error or 5%? Background is negligible. The only error involved is that due to counting statistics.

How would the result change if the backscattering factor was known with an error of $\pm1\%$, the efficiency with an errpr of $\pm0.5\%$, and the source self-absorption factor with an error of $\pm1\%$.?

Problem 27 [Tsoulfanidis Prob. 8.11]

Calculate the strength of a point isotropic radioactive source it it is given that the gross counting rate is 200 counts/min, the background counting rate is 25 counts/min, the counter efficiency is 0.90, the source detector distance 0.15 m and the detector aperture has a radius of 20 mm (F=1). WHat is the standard error of the result if the error of the gross counting rate is known with an accuracy of $\pm5\%$ and the bacground with $\pm3\%$? Dead time is 1 μs.

Problem 28 [Tsoulfanidis Prob. 8.12]

A point isotropic source is located at the center of a hemispherical 2π counter. The efficiency of this detector for the particles emitted by the source is 85%. The saturation backscattering factor is 1.5. The background 25±1 counts/min. What is the strength of the source if 3000 counts are recorded in 1 min? What is the standard error of this measurement?

Problem 29 [Tsoulfanidis Example 8.2]

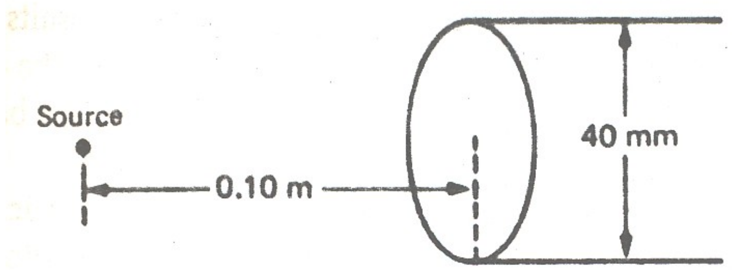
Assume that ^{137} Cs is deposited on a backing material. The thickness of the deposit os t=0.1mm. ^{137}Cs emits betas with E_{max}=0.661 MeV. What is the value of self-absorption factor (f_a) for such a source?. The density of cesium is 1.6×10^{-3} kg/m^3

Problem 30 [Tsoulfanidis Example 8.3]

What is the efficiency of a 50-mmm long NaI(Tl) crystal for a parallel beam of (a) 2-MeV gammas, (b) 0.5 MeV gammas? Use NIST tables to obtain the total linear attenuation coefficients in NaI for the two energies demaded.

Problem 31 [Tsoulfanidis Example 8.4]

The geometric setup shown in the figure below was used for the measurement of the strength of a radiactive source.



The following data were obtained:

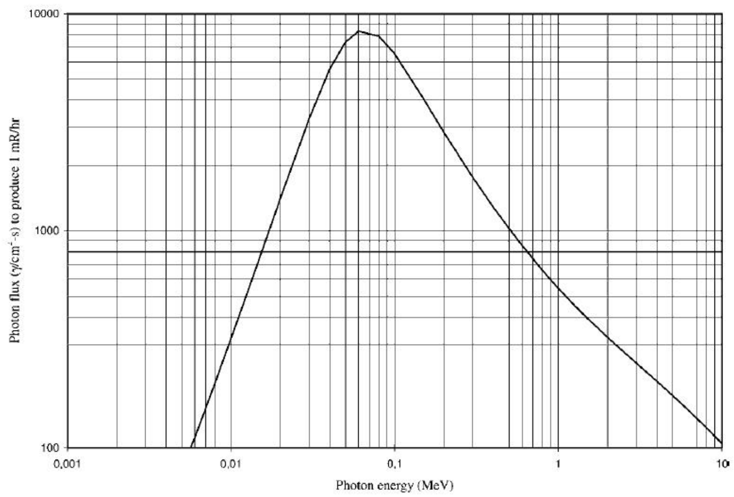
- Gross counts: $G = 6000$ in $t_G = 10$min.
- Background: $B = 400$ in $t_B = 10$ min.
- Dead time: τ =100μs.
- Fano factor: F=1.0±0.001

- Intrinsic efficiency: ϵ=0.600±0.005

What is the strength of the source and its standard error?

Problem 32 [June 2010]

The relationship between dose and photon flux is represented in the following graph:



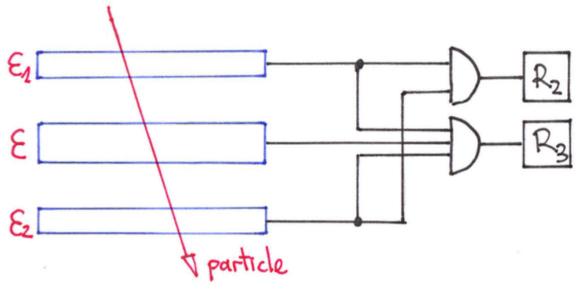
A beam of *gamma* rays of 2 MeV is intercepted by a Geiger detector with an area of 5 cm^2. The efficiency of the counter for this type of radiation is 1.5 radiation is 1.5%. Estimate the counts per minute detected by the detector if the intensity of the radiation is 3.5 mR/hr.

Problem 33 [January 2013]

let's consider a point-like gamma radiation source. With a detector we measure a counting rate R_1=90000 cps at a distance of d_1=10cm. At a distance d_2=30cm the counting rate is R_2=50000 cps. If we neglect the effects of absorption in the air, calculate the dead time of the detector.

Problem 34 Efficiency calculation [January 2015]

The efficiency of a detector can be measured in a simple experiment as showed in the figure:



The detector whose unknown efficiency ε is placed between two trigger counters with efficiencies ε_1 and ε_2. We will measure the two-fold coincidence between both trigger counters (R_2) and the three-fold coincidence among all three detectors (R_3). Let's consider also that all particles which fulfil the two-fold coincidence also pass through the sensitive volume of the detector under investigation. Let's send a total of N particles in a total time T

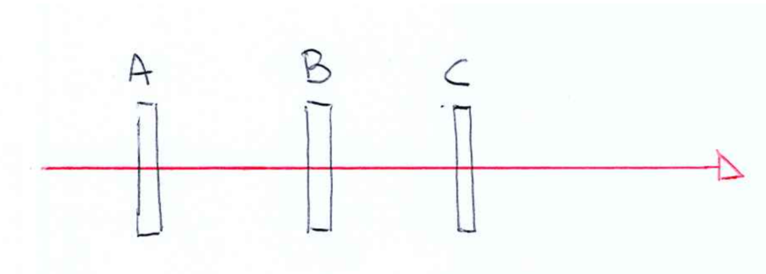
a) What is the total number of particles with two-fold and three-fold coincidence?

b) What is the efficiency ϵ in terms of the two-fold and three-fold measurements?

c) What is the error of this efficiency?

Problem 35 Efficiency [January 2018]

In an experiment we place three scintillator detectors that, all of them, intercept all particles of a beam. In all cases, the particle cannot be stopped by any of the three detectors. We assume also that the detectors have no background, and that the detection for all detectors are independent.



We define that a particle has passed if two of the scintillators have seen the particle. In a data taking period, we have counted the obtained the following values for the coincidences for the three pairs of combination of two detectors and for the coincidence of the three detectors.

N_{AB}	8169099
N_{AC}	8645689
N_{BC}	7825429
N_{ABC}	7434325

a) Compute the detection efficiency of each of the three detectors

b) Bonus: associate an error to each of these efficiencies