Physics 627, YK
March 11, 2008

Home Work #8

(due Tuesday March 25, 2008)

1. Liquid Scintillator in KamLAND spherical detector is made of 80% dodecane + 20% pseudocumene + 1.5 g/l PPO (trimethyloxazol). Its light yield is 70% of anthracene (for anthracene ~ 61 eV of energy loss is required to produce one optical photon). The average attenuation length for optical photons is 20 m. Distance from the center of KamLAND sphere to the photocathode of photomultiplier tubes is 8.25 m. 35% of area of radius 8.25 m is uniformly covered with PMT photocathode. Assume that photon → photoelectron conversion efficiency of the photocathode is 20%. (a) Estimate the number of photoelectrons produced in the KamLAND Liquid Scintillator per MeV of deposited energy if the source is in the center of the sphere. (b) predict the energy resolution as function of energy in MeV; (c) Calculate dependence of light yield vs radius in the radii range 0 – 6.5 m.

2. Trigger threshold of Double Chooz liquid scintillator neutrino detector expressed in MeV is 0.7. Assuming that light yield of liquid scintillator is 180 single photoelectrons per MeV calculate the dependence of efficiency of this trigger vs deposited energy. Find this efficiency at energy 1.022 MeV – threshold of the detection of positron in the reaction

$$\overline{\nu}_e + p \rightarrow e^+ + n$$

3. Estimate energy resolution (statistical part) at 1 MeV for BGO scintillator crystal for ^{137}Cs gamma source with energy 0.667 MeV. Assume that crystal (dia. 1”, length 1”) is coated (on five sides) with diffusive white TiO_2 paint and 85% of photons are collected to the photocathode of the PMT. Find from PDG relative light yield of BGO in comparison with NaI(Tl) scintillator and assume that in the latter one detectable photon is produced per 100 eV of energy deposition. Quantum efficiency of photocathode is 20%.

4. Assume that you have to detect minimum ionizing particles with a plastic organic scintillator with efficiency 65% of anthracene. The scintillator is a slab with dimensions 60 cm × 45.72 cm × 1.27 cm which is readout (on 45.72 × 1.27 cm^2 side) by twisted light guides and matching "optical cone" (with large diameter that should accommodate the light guides combined in the square and small diameter should fit the photocathode of 2" PMT). Estimate expected light yield in s.p.e./m.i.p. (single photoelectron per minimum ionizing particle) in the middle of scintillator slab assuming refractive index of plastic scintillator is 1.42. Assume that scintillator is wrapped in the black paper which makes no optical contact with the scintillator surface and the side of scintillator opposite to readout side is mirrored with mirror reflection coefficient 0.8. Assume the light attenuation length in the scintillator of 4.5 m and the quantum efficiency of the photocathode is 20%.

5. Small scintillator "beam counter" has a size 2 cm × 2 cm × 0.2 cm and has to detect beam of protons with momentum 0.6 GeV/c. Suppose the scintillator is suspended symmetrically from the top by two needles inside the cylinder with diameter 3 cm and height 4 cm. The cylinder is painted inside with highly reflected coat (90% reflectivity). Bottom part of the cylinder is open and rests on the photocathode of PMT with diameter 1.5" and QE = 20%. What is the average number of photoelectrons produced in PMT per one passing proton?