Exercises: Particle Detectors WS 2016/17
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Problem Set No.3

Solutions have to be handed in by Wednesday 3pm, 9.11.2016 in letter box no. 3, in the ground floor of Gustav-Mie building!

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1. Absorption coefficient for gamma rays

In concrete („Beton“ in German) the cross section for photons above 1 MeV is approximately 2 barn per atom. Calculate the absorption length for gamma ray photons in a concrete absorber.

How thick would one need to to make the absorber if not more than 5% of the initial radiation is allowed to penetrate?

Use the web site `http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=144` for the density and the necessary data to calculate the atomic weight. 1 barn, the prevailing unit for cross sections, is defined as $10^{-28}\,\mathrm{m}^2$. [**4 points**]

2. Counting rates

a) What percentage of events have you failed to register when your counter indicates a rate of 10MHz and the pulse length for the counter is 10 ns?

b) In your experiment you expect a true pulse rate of 100 MHz. What is the maximum pulse length in your electronics, if you do not want to loose more than 10% of the signals?
[**4 points**]

3. Drift in gases

The cylindrical „Time Projection Chamber“ (TPC) of the ALEPH detector at the LEP storage ring had a length of 4.4 m and was divided symmetrically into 2 drift volumes. It had been filled with a mixture of Ar (91%) and CH4 (9%) at standard temperature and pressure (20°C and 1 bar). The diffusion constant for electrons in this gas is 140 cm^2/s. In each half i cylinder a voltage of 27 kV was applied to create the drift field parallel to the axis.

a) What is the maximum drift time for the electrons (the TPC is operated with 20ppm water in the gas)? (Use the graph on the next page!)

b) What is the precision for the determination of the z-coordinate parallel to the cylinder axis? How does this precision depend on z?

c) Now an additional magnetic field of 1.5 T is applied in the z-direction. Calculate the Lorentz angle.
[**5 points**]

Please turn over!

N.B: A time projection chamber has an extraordinarily long region as drift space. To obtain a reasonable position resolution this type of chamber is always operated with a magnetic field parallel to the electric field - a trick which we will discuss later in the lecture.