Exercises: Particle Detectors WS 2016/17
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Problem Set No. 2

Solutions have to be handed in by Wednesday 3pm, 2.11.2016 in letter box no. 3, in the ground floor of Gustav-Mie building!

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1. **Bethe Bloch formula**
   The Bethe-Bloch formula, as described in the lecture, describes the mean rate of energy loss in the region $0.1 < \beta\gamma < 1000$ for intermediate-Z materials with an accuracy of a few %. Write a computer routine that evaluates the formula as a function of the kinematics of the incoming particle. You can ignore the density effect correction (the $\delta(\beta\gamma)$-term). You may want to write utility functions to obtain $\beta\gamma$ to/from momentum and mass. Produce a plot for different particles, illustrating that the minimum of ionization is indeed about constant. **[4 points]**

2. **Cherenkov radiation**

   - Different types of particles can be identified using Cherenkov radiation if the refractive index of the medium is chosen appropriately. What refractive index has to be chosen to separate kaons from pions at a momentum of 10 GeV/c with a threshold Cherenkov counter?
   - The number of photons emitted per unit path length in the wavelength range λ_1 to λ_2 is found to be

$$\frac{dN}{dx} = 2\pi\alpha z^2 \int\limits_{\lambda_1,\ (n(\lambda)>\frac{1}{\beta})}^{\lambda_2} \left(1 - \frac{1}{\beta^2\ n(\lambda)^2}\right)\ \frac{d\lambda}{\lambda^2} \quad ,$$

     where α is the fine structure constant and z the charge of the particle in units if the elementary charge. Calculate the number of photons emitted in the visible spectrum ($\lambda_1 = 400$ nm, $\lambda_2 = 700$ nm), depending on the Cherenkov angle θ_C and neglecting dispersion ($n = const.$).
   - In an experiment pions and kaons traverse two consecutive Cherenkov counters. The first one consists of Aerogel with a refractive index of 1.025. The active medium of the second detector is made of pentane gas (n = 1.0017). What is the range of momenta in which protons, kaons and pions can be distinguished from each other by this arrangement alone?

   [5 points]

3. **ROOT**
   Write small programs on the problem sets below. Please print the code and attach it to the solutions you hand in.

   - Write a program which prints "Hello World" on the screen.
   - Write a program which asks you how often it should print "Hello World" on the screen. Save the requested numbers as the Variable: ntimes. The program should then print ntimes "Hello World" on the screen.
   - Classes: Examples for classes (Student.C and Student.h) you can find on the on the webpage of the lecture in the tab for Problem Set 2. The file .h contains the declaration

of the class. The file .C implements the methods in the class. The class can be loaded in ROOT by .L Student.C.
An object of this class can be produced and is called: Student FRANZ. FRANZ is then an instance of the class student and can do everything the class student can do. I.e. spreak with the command: FRANZ.Speak().
Write your own class Calculator which contains the following methods:
Calculator:Sum(Double_t a, Double_t b);
Calculator:Sqrt(Double_t a, Double_t b);
The method Sum should print the sum of value a and value b on the screen. The method Sqrt should calculate $\sqrt{a^2 + b^2}$ and print it on the screen.

[4 points]