Exercises: Particle Detectors WS 2016/17
Prof. Dr. Ulrich Landgraf, Dr. Susanne Kühn
Problem Set No.4

Solutions have to be handed in by Wednesday 3pm, 16.11.2016 in letter box no. 3, in the ground floor of Gustav-Mie building!

---

1. Introduction to ROOT histograms

In physics or statistics analyses so called histograms are often used to display results or as input for subsequent calculations. A histogram is a bar diagram where the horizontal axis is divided into a finite number of sections, each corresponding to one specific range of values of a variable. On the vertical axis is indicated how often the a value in this range has occurred. To learn the usage of histograms in ROOT, please start from the small C++ program `MyHisto.C` supplied with this exercise sheet.

There you fill find a construct that is called array (or data field) which allows to store several numbers under a common name (here: `data`). To demonstrate how one can access individual elements of the array the contents are printed to the computer screen in a loop.

Please complete this ROOT program by creating a one-dimensional histogram with the methods of class `TH1`, filling it with the elements of array `data` and displaying the result on the computer screen. Choose a histogram of the subclass `TH1F` with 10 channels and a range from 0.5 to 10.5. [**4 points**]

2. Random numbers in ROOT

To generate random numbers, ROOT provides several different methods that are implemented as classes `TRandom`, `TRandom1`, `TRandom2` and `TRandom3`. As all other ROOT classes they are documented in
`http://root.cern.ch/root/html534/ClassIndex.html`. `TRandom3` is the best of the generators; however the class `TRandom3` is derived from the base class `TRandom` (this is called inheritance). For this reason only additional methods are documented under `TRandom3`; most methods of this class you will find already under the heading `TRandom`.

Create an object of the class `TRandom3` and use the method `BreitWigner` to generate 20 random numbers that are distributed according to a Breit-Wigner distribution with mean value $mean = 25.0$ and width $gamma = 10.0$. Fill a histogram with 50 channels between -20 and 100 with these 20 random numbers. Note that the mean value and standard deviation of this histogram are automatically displayed in a box; the standard deviation is called RMS (root mean square) here, because it is calculated by squaring the deviations from the mean, taking the average of these squared numbers and finally drawing the square root.

If you run this program several times you will always get the same histogram. The reason for this is that `Random3` generates only pseudo random numbers with a deterministic algorithm (as do all random generators on computers). If you want to obtain a different

sequence of random numbers you have to use the method `SetSeed(i)` to change the „seed“, where `i` is some integer. `SetSeed(0)` uses the computer clock to initialise the seed, i.e. in this case you will always get a different sequence of random numbers. [**4 points**]

3. Geometrical acceptance of a rectangular detector

A particle source generates particles that are emitted uniformly in all space directions.

At a distance of 1 m from the source a particle detector of 0.8 m height and 1.2, m width is positioned symmetrically with respect to the particle source.

Calculate the acceptance of the detector by using the random generator of ROOT to generate particles at the source, trace them individually to the detector plane and decide if they hit the active area or not.

Now vary the distance between source and detector in the range 0.5 m and 3 m and plot the acceptance as a function of the distance. [**4 points**]