PID with beta and rigidity

The independent measurements of particle velocity (β=v/c) and particle rigidity (R=p/Zc with p particle momentum, Z particle charge and c speed of light) are often used to identify particles, i.e. determine their mass and/or charge.

Relativistic momentum can be written as p = mvγ ($\gamma^2 = 1/(1-\beta^2)$). Hence the two following relations can be derived:

1) $$\beta = \frac{Z}{m} \frac{R}{\sqrt{1 + R^2 \left(\frac{Z}{m}\right)^2}}$$

2) $$\frac{Z}{m} = \frac{\beta}{R \sqrt{1 - \beta^2}}$$

Goal of these exercises

The aim of these exercises is to plot the beta versus rigidity distribution and determine Z/M in a given situation.

Basic informations: you will work on a set of events coming out from a PAMELA experiment simulation. The given file

`/home/mocchiut/pamela/data/pamsimu2015.root`

contains the TTree pamcalotree, storing data with the PamCalo class, header file:

`/home/mocchiut/pamela/PamCalo/inc/PamCalo.h`

so library:

`/home/mocchiut/pamela/PamCalo/lib/Linux/libPamCalo.so` .

The ROOT file contains a mixture of different particles: protons, antiprotons, electrons and positrons in an energy range from about 1 to about 20 GeV.

In these exercises, we will select particles from the sample having pID==0 and we will construct and save three variables on a different file. Then we will use a script to plot the distributions of the observables in given rigidity and beta intervals. In the next step we will determine Z/M by fitting the distribution and we will plot the theoretical curve on the distribution.

Exercise 1

Write an an executable compiled program which reads the input file

`/home/mocchiut/pamela/data/pamsimu2015.root`

and gives as output a new ROOT file containing a TTree with three variables (a TBranch for each one):

- beta
- energy (this is actually the rigidity, save it as “R”)
- ZoverM (defined, event by event, as in equation 2.)

Save into the new file the events for which the following condition is satisfied:

1. for each event “pID” is equal to 0.

Hints:

- to compile, remember to add also the compilation flags:

```
-I/home/mocchiut/pamela/PamCalo/inc
-L/home/mocchiut/pamela/PamCalo/lib/Linux/
-lPamCalo
```

- to run, remember to export LD_LIBRARY_PATH:

```
export LD_LIBRARY_PATH=/home/mocchiut/pamela/PamCalo/lib/Linux/:$LD_LIBRARY_PATH
```

Exercise 2

Write a ROOT-CINT script which reads the output file of exercise 2 (should be similar to this one: `/home/mocchiut/scripts/EM_output_090916.root` use this file if you are unable to complete or run exercise 1) and gives as output on the screen and on the disk (pdf format) a TCanvas, divided into two pads (one column, two rows – hint: `TCanvas::Divide`), which contains from top to bottom:

1. the distribution of beta versus rigidity (`TH2D`, X range [0.,8.] Y range [0.5,1.6], number of bins: 500 for both X and Y).
2. the distribution of ZoverM for events having rigidity in the interval [1.,1.2] (`TH1D`, X range [0.,10.], number of bins: 500).

Exercise 3

Update the script of exercise 2 in order to:

1. Fit the ZoverM distribution with a Gaussian function in a proper interval (draw on the plot the result).
2. Using the mean of the Gaussian obtained in point 1, create e TF1 function that represents beta as function of R (equation 1) and draw this function on the TH2D distribution. Does it represent correctly the distribution of data points?
3. If the particle had four times the mass but the same charge, how would behave the function of point 2? Draw this new function (dashed line) on the TH2D distribution.

Save the canvas on the disk as pdf file.

Preparing the output

- create a directory and put inside this directory ALL the files you want me to correct and look at.
- create a README text file, inside the file write:
  - **your name and surname**
  - a list of the files you are submitting
  - **in details** how to compile and run the programs
  - any other comment and answer to question(s)

Timing and rules

- You have four hours time to do your work.
- You can search the web, look at manuals, look at any note you wrote during the course, etc.
- We will discuss what you have written at the oral examination on 2015/07/17, until that (if needed) you can change and improve your programs. In that case prepare an electronic version we can look at during the oral examination, we will compare it to the one handed in today and we will discuss any change and/or correction.