Hint sheet for numerical exercise of
problem set 5 for the lecture
Particle Detectors, WS 2015/16

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Some useful ROOT objects and functions to complete the first numerical exercise are:

- The main program can be very simple, e.g. just creating a file mscattering.c with the following content:
  - `void mscattering() {`
  - `  *all the code*`
  - `}`

  and for example calling it by `root -l mscattering.c`.
- To define the Rutherford cross-section use a TF1 object, e.g.
  - `TF1* rutherford = new TF1("(1/E-30)*sin(x*acos(-1)/180)* ....", 0.1, 180);`
  - `double probability = rutherford->Integral(0.1,0.2) * ...;`
  - you can also define it in radian of course
- For histograms, class TH1F should be fine, examples of use are
  - `TH1F* h_probabilities = new TH1F("h_probabilities","",1800,0,180);`
  - `h_probabilities->SetBinContent(1, some_value);` bin numbering in ROOT starts with 1!
  - `double theta = h_probabilities->GetRandom();` get a random number distributed according to the contents of the histogram
  - `h_phi->Fill(some_angle);`
  - `h_phi->Draw();`
  - `h_phi->Fit("gaus");`
- For the simplified case of planar geometry it is useful to keep track of both muon position and velocity using TVector2, some examples of use:
  - `TVector2 v_position, v_velocity;`
  - `v_position.Set(0.,0.);`
  - `v_velocity = v_velocity.Rotate(some_angle);`
  - `v_position += v_velocity;`

  - `double some_angle = v_velocity.DeltaPhi(v_original)*180/acos(-1);`
  - `cout<<"Direction "<<v_velocity.Phi()<<" at "<<v_position.X()<<endl;` debug output is very useful, but keep in mind that if you do that for every step and muon, the program will be slowed down significantly by writing to the screen
- For simple random numbers you can use predefined pointer to a TRandom3 object, called gRandom
  - `if (gRandom->Integer(2)==0) ....;` making a 50/50 decision

If there is interest in "playing" a bit with the toy model once fully implemented, up to one bonus point can be earned by trying to get and documenting some deeper understanding of its viability, looking into the dependency of the result on the cut-off angle, length defined, the fraction of particles leaving the lead on the wrong end, muon energy dependency, ...

More information on the use of ROOT can e.g. be found at `https://root.cern.ch/guides/users-guide`.