COMPUTING METHODS FOR PHYSICS
18 NOVEMBER 2020

You must submit your exam by **Wednesday Nov 18 at 13:30** following the instruction at http://www.roma1.infn.it/people/rahatlou/cmp/

Spectrum of Compton Scattering

Cesium-137 is a radioactive isotope which decays via beta emission (half life of 30.2 years) to a an excited metastable state of Barium ^{137m}Ba. This state decays with a half-life of 153 seconds to the ground state ^{137}Ba emitting a photon with energy E_0 = 662 keV. We want to study the spectrum of ^{137}Cs and the effect of Compton scattering.

1. Generate 10^5 photons with energy E_0.

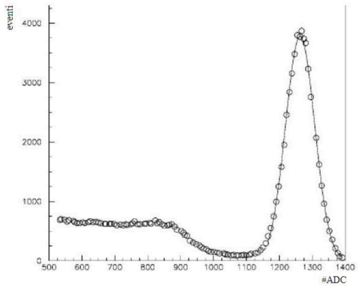
2. Each photon is detected with a NaI crystal which has a resolution of 5%. Use a Gaussian convolution and plot the distribution of detected energy E_i of all photons. Make sure reasonable binning are used for the histogram and labels and units are added. The expected distribution should be a Gaussian entered at E_0.

3. Assume that each photon has a 70% probability of undergoing Compton scattering in the crystal.

4. The energy E_f of the photon after the scattering is given by where me is the mass of the electron (511 keV) and θ is the angle of the photon after scattering as shown in the figure.
$$E_f = \frac{E_i}{1 + (E_i/m_e)(1 - cos\theta)}$$

5. Generate a random angle θ for each photon according to the angular distribution
$$1 + cos^2\theta$$
If you do not know how to do this, you can generate a flat distribution for θ (with a penalty).

6. Plot the distribution of energy E_f after scattering for all photons. You should still see a peak around E_0 and a continuous distribution (a Fermi-Dirac shape) for E_f<E_0. (See the figure as an example)



Save a PDF file for each of the above 2 plots. You can use C++ or python. Define a function `Compton` (with proper arguments and return values) to simulate the scattering of a photon of energy E. If you choose python, use comprehensions and dictionaries to implement the simulation and plotting the required plots.