Accelerator Physics short option
Problem set 1.

Nicolas Delerue

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1 Rutherford scattering

a) What is the resolution of an α particle ($m = 6.7 \times 10^{27}$ kg; q=2e) with a velocity of 2×10^7 m/s probing a gold nucleus (Z=79)? (hint: what is the distance at which the kinetic energy of the incoming particles is equal to the potential energy due to the Coulomb interaction?

b) What is the maximal velocity at which α particles can probe a gold nucleus ($r = 7.3fm$)?

c) What would be the energy required for an electron to have the same resolution (ie wavelength)?

2 Cockroft-Walton generator

Let's consider a Cockroft-Walton generator made of 6 diodes and 6 capacitors which is discharged at t=0. A square wave with period 1 and amplitude 1 is used to load the generator. Sketch the voltage as a function of time on each of the capacitors until the generator is fully loaded.

3 Tandem Van de Graaff

What is the maximal energy that can be reached in a Tandem Van de Graaff with a 15 MV field for the following ions (the negative ion state is given in brackets).

a) $H^+(H^-)$
b) $C^{2+}(C^-)$
c) $Pb^{4+}(Pb^-)$
d) $Au^{2+}(Au^-)$
e) $U^{10+}(U^-)$

4 LHC as a fixed target collider

a) What would be the center of mass energy of an experiment in which one of the 7 TeV LHC beams would be sent onto a fixed Hydrogen target?

b) What would have to be the energy of this beam to reach 14 TeV in the center of mass?

5 Luminosity

In a circular collider two beams with the same ellipsoidal shape collide. The vertical (σ_y^0) to horizontal (σ_x^0) size ratio is 10 and the luminosity of the collisions is L.

a) What would be the luminosity (expressed as a function of L) of this collider of the beam had the same horizontal size ($\sigma_x^a = \sigma_x^0$) but a round shape?

b) And what would be this luminosity of the beams had a vertical to horizontal size ratio of 100 (still with $\sigma_x^b = \sigma_x^0$)? Could you suggest one issue related to this mode of operation?