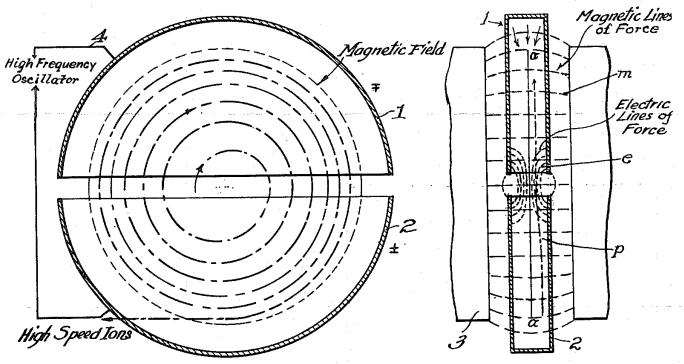
Particle Physics Phenomenology I

HS 10, Series 9

Due date: 03.12.2010, 1 pm

Exercise 1

In 1939, E.O. Lawrence won the Nobel prize for the development of the first cyclotron. It had a radius of $R = 12.5$ cm and a magnetic field of $B = 1.3$ T. The figure below was used to illustrate the principles of a cyclotron in his U.S. Patent 1948384.



(i) What is the maximal momentum to which protons can be accelerated with this cyclotron?

(ii) What should be the frequency of the AC voltage applied to this cyclotron?

(iii) Do relativistic effects impose any limitation to this kind of circular accelerators? How can we modify a cyclotron and overcome these limitations?

(iv) What should be the radial shape of a magnetic field B in order to maintain the synchronisation between the cyclotron and orbital movement of accelerated particles (so called isochronism) at constant frequency ω? Relativistic effects should not be neglected.

(v) How should the cyclotron frequency ω_n change with each turn n, so that we can maintain the isochronism in the case of a uniform magnetic field B? In this case assume that the energy gain turn is tuned to be equal to the rest mass of the accelerated particle.

Exercise 2

The graph below shows how the cross-section for various processes depends on the center of mass energy at a proton-proton collider.

(i) Fill a table with the (approximate) values of the cross-section for all processes shown, at 7, 10 and 14 TeV. For each process, evaluate the ratio of cross-sections at 7 and 14 TeV.

(ii) Assuming that the LHC collected 200 pb^{-1} at a center of mass energy of 7 TeV in the last year, calculate the number of events it should have produced for each process.