Introduction to Particle Accelerators

Homeworks I

1 Magnetic rigidity

Derive the expression of the magnetic rigidity $B\rho$ as a function of the particle relativistic momentum and charge:

$$B\rho = \frac{p}{q}. \tag{1}$$

Express it numerically for protons and for electrons with B in Tesla, ρ in meter and p in GeV/c.

2 Relativistic kinematics

Compute the following quantities for protons at injection energies of the CERN PB Booster (PBS) (injection kinetic energy of 50 MeV), PS (injection kinetic energy of 1.4 GeV), SPS (injection kinetic energy of 26 GeV) and LHC (injection kinetic energy of 450 GeV):

- Momentum;
- Kinetic energy, total energy;
- Relativistic β and γ;
- Magnetic rigidity (see problem 1).

3 Ion beams for the LHC

Assuming the same magnetic fields as for problem 2, compute the injection energies for Xenon and Lead ion beams[1] (total, per nucleon and per charge).

4 Betatron 2-in-1 rule

Derive the 2-in-1 rule for constant orbit in a betatron (Wideroe's condition). Why is it important to consider the radial dependence of the magnetic field.

[1] See `https://home.cern/cern-people/updates/2017/10/lhc-report-xenon-action`.