

Subatomic Physics II

Problem set 2

Due on October 14, 11:59:59 PM

Problem 2.1: The LHC accelerator

- The LHC accelerator is installed in the old LEP-tunnel with a circumference of 27 km. The maximum magnetic field in the bending magnets is 8.36 T. The accelerator is not a pure circle, rather it contains a number of straight sections. These house the experimental halls, the accelerating cavities and focussing magnets. Knowing that the maximum proton energy of the LHC is 7.0 TeV, estimate the fraction of straight section in the accelerator. (Hint: consider the bending radius of the protons.) (2pt)
- Particle beams in colliders are not continuous but grouped into bunches. For example, each proton beam circulating in the LHC contains 2808 bunches which collide with each other in each detector.
 - How many collisions of bunches are there in 1 second? (1pt)
 - The time interval between bunches at a detector is 25 ns. How many collisions occur in 1 second? Is this the same answer as in the previous question? Why (not)? (1pt)
 - The current of the proton beam in LHC is 0.58 A. How many particles are there in one bunch? (1pt)
 - How many turns can a proton beam stay vertically in the tube (diameter 18 mm) if there are no focussing magnets? (1pt)In practice the beams stay for up to 12 hours in the tube, thanks to the focussing magnets.

Problem 2.2: Mass of the muon-neutrino

In order to measure the mass of the muon neutrino, you study the two-body decay of the charged pions, $\pi^- \rightarrow \mu^- \bar{\nu}_\mu$ for pions stopped in matter and thus decaying at rest. Your measurements of the muon momentum using a magnetic spectrometer yield the result: $|\vec{p}_\mu| = 29.79 \pm 0.01$ MeV. Calculate the muon-neutrino mass and its uncertainty using world- average values for the pion and muon masses. Give general expressions and insert numerical values at the end of your derivation only!

Note: use relativistic kinematics and discuss central value and uncertainty of the result on the mass of the muon neutrino, where for the uncertainty you need to consider the uncertainty on $|\vec{p}_\mu|$ only (why?).

(4pt)