## References and exercises

## Material

 Brochures published by the Division of Physics of Beams of the American Physical Society (APS/DPB): "Accelerators and Beams: Tools of discovery and Innovation"

http://www.aps.org/units/dpb/upload/accel\_beams\_2013.pdf

Interesting movie, built for the ASP2010, explaining the LHC operation.
See it at:

https://indico.esss.lu.se/event/378/contribution/25/material/video/0.m4v

More materials used for the previous ASP edition are available at:

ASP2010: <a href="http://indico.cern.ch/event/78565/other-view?view=standard">http://indico.cern.ch/event/78565/other-view?view=standard</a>

ASP2012: <a href="http://indico.cern.ch/event/145296/other-view?view=standard">http://indico.cern.ch/event/145296/other-view?view=standard</a>

ASP2014: <a href="https://indico.cern.ch/event/276481/other-view?view=standard">https://indico.cern.ch/event/276481/other-view?view=standard</a>

ASP2016: <a href="https://indico.cern.ch/event/528094/other-view?view=atlas">https://indico.cern.ch/event/528094/other-view?view=atlas</a>

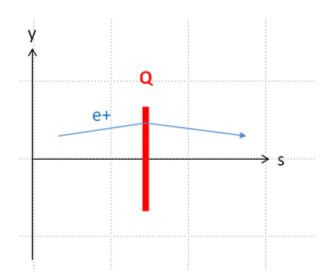
 The link to the Nordic particle Accelerator School and Program: https://npap.eu/

## Homework

- The velocity of a 1 GeV proton with respect to the velocity of a 1 MeV electron is
- A larger
- B the same
- C smaller

A positron is focused in the vertical plane by the quadrupole of the figure. An electron with the same energy enter the quadrupole in the opposite direction with coordinates (x, x', y, y') = (-0.1 mm, 1.2 mrad, 0 mm, 0.0 mrad)

- A is horizontally focused
- B is horizontally defocused



The horizontal emittance in a linac for protons is accelerated from 200 keV to 2 MeV. Its horizontal emittance, disregarding space charge,

- A increases
- B decreases
- C remains constant

A synchrotron for electrons at 3 GeV has a magnetic structure with 36 dipoles. The magnetic field in the dipoles is 1.5 T. The bending radius in the dipoles is sincrotrón para electrones de 3 GeV tiene una estructura magnética con 36 dipolos.

- A less than 10 m
- B equal to 10 m
- C larger than 10 m