

**HOMEWORK 4**

*Homework should be handed in to F10 by 4:00 p.m., Friday, 8<sup>th</sup> December 2017.*

1. The particle physics studies are carried out in fixed target experiments and at colliders, in particular at  $pp$  and  $e^+e^-$  colliders. Explain the advantages and disadvantages of the fixed target versus collider experiments, and  $pp$  versus  $e^+e^-$  colliders. [10]
2. Describe the sphericity parameter and how it was used to prove the existence of two-jet and three-jet events in the MARK I and TASSO experiments. [5]
3. At an electron-proton collider a 30.0 GeV electron beam collides with a 200.0 GeV proton beam at a crossing angle of 20.0 degrees. Calculate the total collision energy in the centre of mass. Calculate the energy of electrons in a beam that would be required in a fixed-target experiment (fixed target made of protons) to achieve the same total energy in the centre of mass. You can neglect electron and proton masses when compared to the beam energies. [5]