

Exercises: Particle Detectors WS 2016/17  
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Problem Set No. 1

**Solutions have to be handed in by Wednesday 3pm, 25.10.2016 in letter box  
no. 3, in the ground floor of Gustav-Mie building!**

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**1. Accelerator kinematics**

The LHC accelerator collides two beams of protons, each with an energy of 8 TeV.

- What is the centre-of-mass energy of the collisions?
- If one wanted to achieve the same centre-of-mass energy by shooting one proton beam at a fixed target (also consisting of protons), what beam energy would be required?

**[2 points]**

**2. Time of flight**

- Two particles (masses  $m_1, m_2$ ) with momentum  $p$  traverse the path of length  $L$ . Calculate the difference of the time of flight of the two particles for relativistic momenta. Use the approximation

$$\beta = \sqrt{1 - \frac{1}{\gamma^2}} \approx 1 - \frac{1}{2\gamma^2} \quad (1)$$

**[2 points]**

- Decay of hadrons with heavy quarks occur e.g. for B-Mesons. A typical lifetime of  $B_d^0$ -Mesons is  $\tau(B_d^0) = 1.55$  ps. Determine the mean length of flight assuming a mean momentum of 20 GeV. Missing parameters can be obtained from the Particle Data Group <http://pdg.lbl.gov/> **[2 points]**

**3. Dating of samples**

Explain the  $^{14}\text{C}$  method for dating of organic samples. **[2 points]**

**4. TV sets**

Discuss quantitatively why former television sets were operated with vacuum. Assume a voltage for acceleration of 10 kV. **[2 points]**