

2005

Special Relativity

Proton-antiproton annihilation

Consider an antiproton of mass m moving with initial velocity v and experiencing a collision with a proton which is at rest in the laboratory reference frame (a target). This collision leads to their annihilation, with emission of two photons.

- 1) Explain why annihilation produces two photons rather than one.
- 2) What is the velocity u of each of the particles in the center of mass system?
- 3) In terms of v and m , what is the energy w_{cm} of each of the two photons created in the annihilation process in the center of mass system?
- 4) Assuming the photons are emitted at an angle θ to the direction of motion in the center of mass frame, find the energies of the photons in the laboratory frame, in terms of v , m and θ .
- 5) For $\theta = 0$ (photon emission in the direction of motion of the anti-proton) find the laboratory frame energy of the least energetic photon in the limit $v \rightarrow 0$, and in the limit $v \rightarrow c$.