**KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS**

**DEPARTMENT OF PHYSICS**

**PHYS 441-221 Particle Physics**

**Major Exam-1 Solutions**

**12/10/2022**

**NAME**

**ID #**

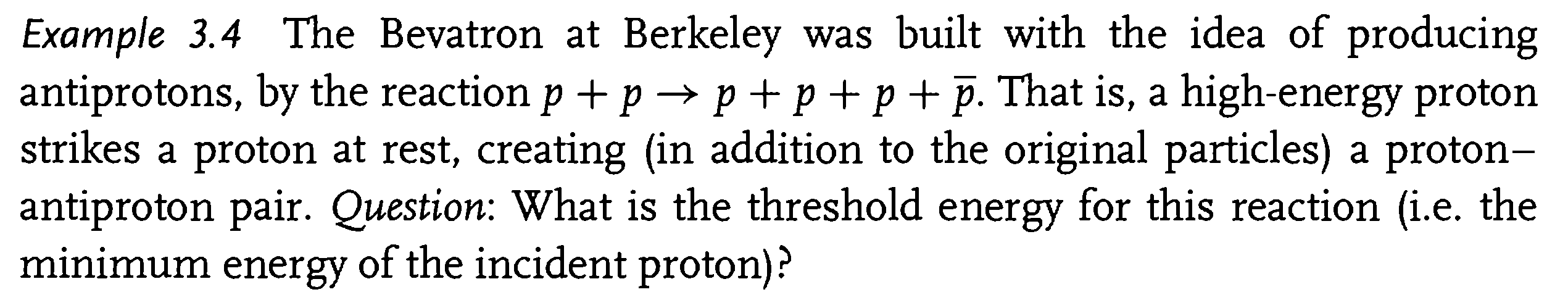
**Q1. (5 points)**

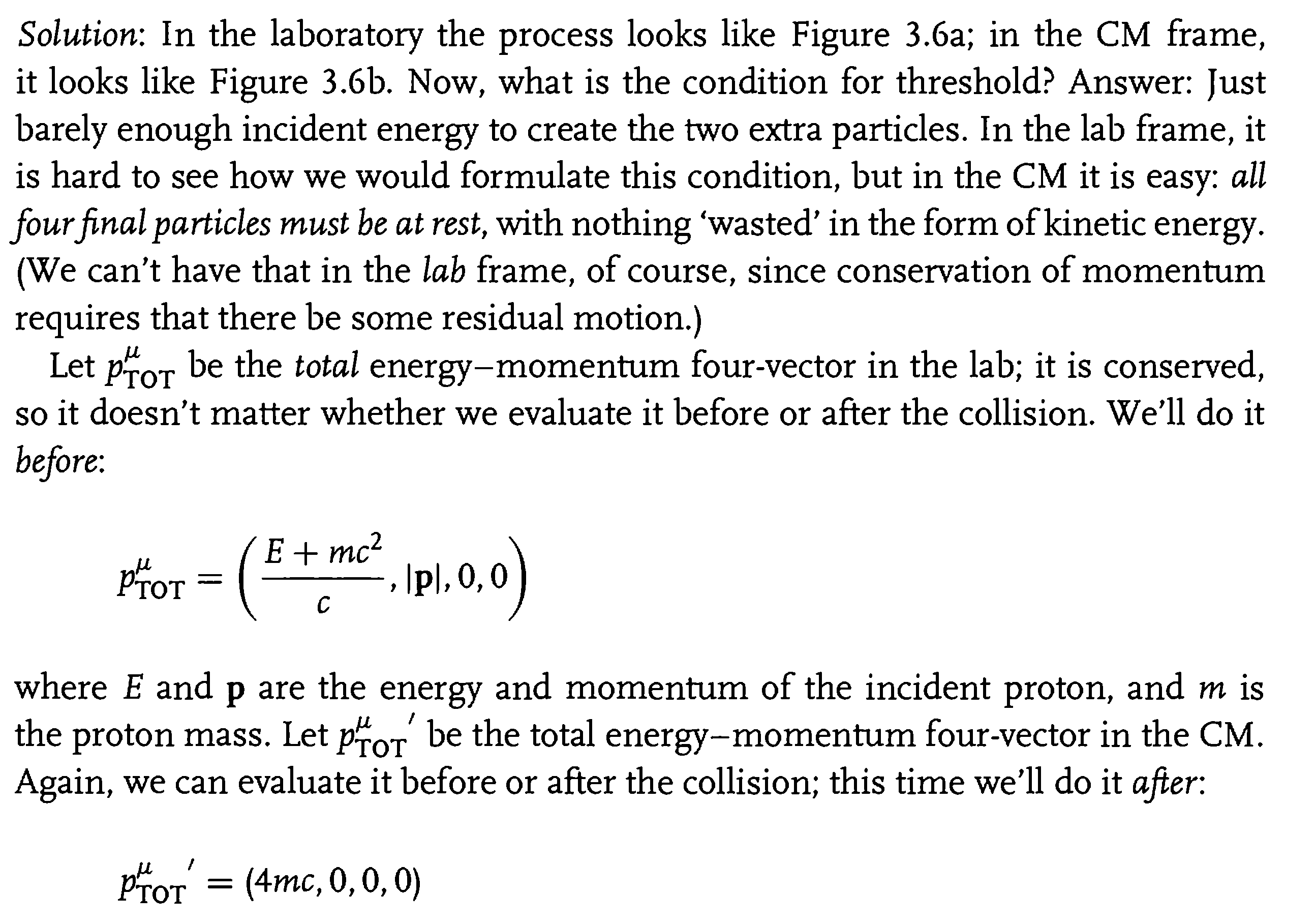
An electron of total energy *E* hits an electron at rest producing three electrons and one positron in the reaction

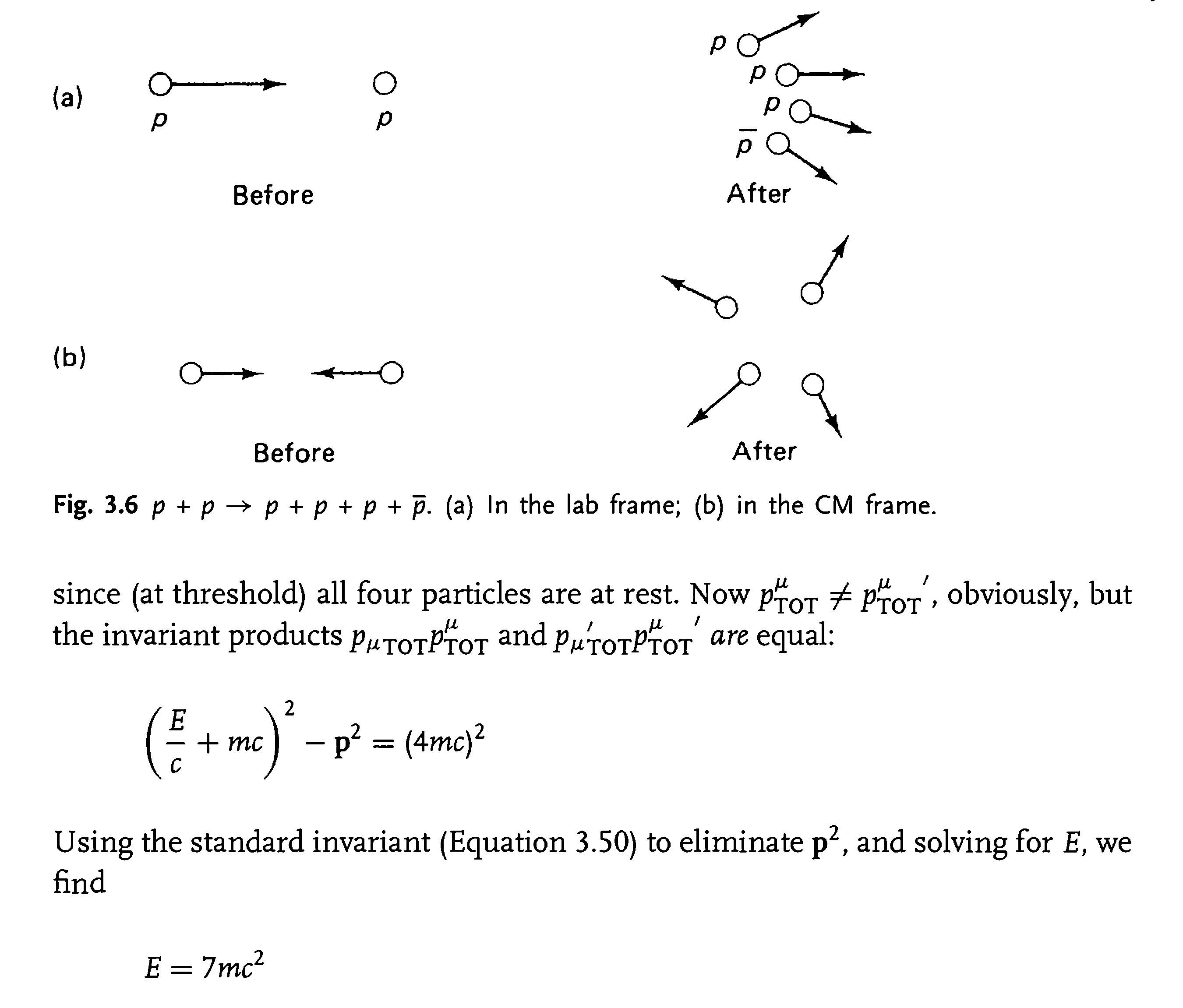
Calculate the threshold kinetic energy (minimum KE) of the incident electron for this reaction in terms of the electron mass m.

**Solution**

This problem is essentially the same as the one treated in Example 3.4 on page 106 of textbook using protons instead of electrons.







**Q2. (5 points)**

Consider the Feynman diagram shown below for in the ABC toy model:



Using the Feynman rules for this model, find the scattering amplitude *M* for this diagram, assuming . Leave your answer in the form of an integral over one remaining 4-momentum q.

**ADHERE TO THE MOMENTUM CONVENTION IN THE ABOVE FIGURE**

**Solution**

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**Q3. (5 points)**

**(a)**Determine the lowest-order scattering amplitude for the process . (There are two diagrams)

**(b)**Find the scattering amplitude for this process in the CM frame, assuming Express your answer in terms of the incident energy (of particle ) and the scattering angle (of particle ).

**Solution**









