1. The diagram below illustrates the photoproduction of a particular resonance, in which a photon excites a proton into a state which subsequently decays strongly into a neutron and a pion.

\[ \gamma \rightarrow p \rightarrow Resonance \rightarrow n, \pi^+ \]

In the laboratory, the momentum of the neutron is 500 MeV/c and the momentum of the pion is 450 MeV/c. The opening angle between the neutron and pion is 30.5°.

(a) What is the “mass” you measure for the resonance?
(b) What are the isospin \( I_3 \), baryon number, and strangeness of the resonance?

2. As discussed in class, the process considered in problem #1 is important in astrophysics. It limits the energy at which cosmic rays may traverse a significant part of the universe. Above this energy, the protons will “see” the 2.7 K cosmic microwave background as hard gamma rays, and lose energy through the photoproduction process. At what proton energy will this process occur?