B-5

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Consider the reaction, $n + p \rightarrow d + \pi^0$, in which a neutron interacts with a target proton to produce a deuteron and a π^o. Assume that the target proton is at rest in the lab frame. For this problem use: $m_n = m_p = M$, $m_d = 2M$, and $m_\pi = m$.

(a) The neutron threshold momentum is the minimum neutron momentum needed for the reaction to occur. Derive an expression for the neutron threshold momentum, p_n, in terms of M and m.

(b) Derive expressions for the momentum of the π^o, and of the d, at threshold. Leave your expression in terms of p_n, the neutron threshold momentum that you found in part a).

(c) Assume that the π^o created at threshold now decays immediately after its production into two γ rays, $\pi^0 \rightarrow \gamma + \gamma$ (see diagram below). By considering conservation of momentum, derive an expression for the minimum possible angle θ between the γ-rays in the lab frame, in terms of p_π and E_π.