PH7363 Fall 2025

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Particle detection and detector physics

The Question

A stationary, hypothetical neutral particle, the "Zeta" (ζ^0), decays into two charged particles: a positive muon (μ^+) and a negative pion (π^-).

The rest masses of the particles are given below:

- $m_{\zeta^0} = 450.0$ MeV
- $m_\mu = 105.7$ MeV
- $m_\pi = 139.6$ MeV

The resulting π^- particle immediately enters a gas-filled **proportional counter** positioned adjacent to the decay point.

The proportional counter is filled with Argon gas. The average energy required to create an electron-ion pair in Argon (the W-value) is $W = 26\,\mathrm{eV}$. The detector is set to an operating voltage that provides a gas multiplication factor (Gain, G) of 5×10^3.

Assume the π^- is completely stopped within the active volume of the detector.

Part A: Kinematics and Einstein's Equation

Using Einstein's mass-energy equivalence principle and the laws of conservation of energy and momentum for a two-body decay, calculate the kinetic energy of the π^- particle (K_π) in MeV immediately after the decay.