U.S. DEPARTMENT OF ENERGY | Office of Science

Brookhaven National Laboratory

Muon Telescope Detector and Quarkonia

Rongrong Ma (BNL)

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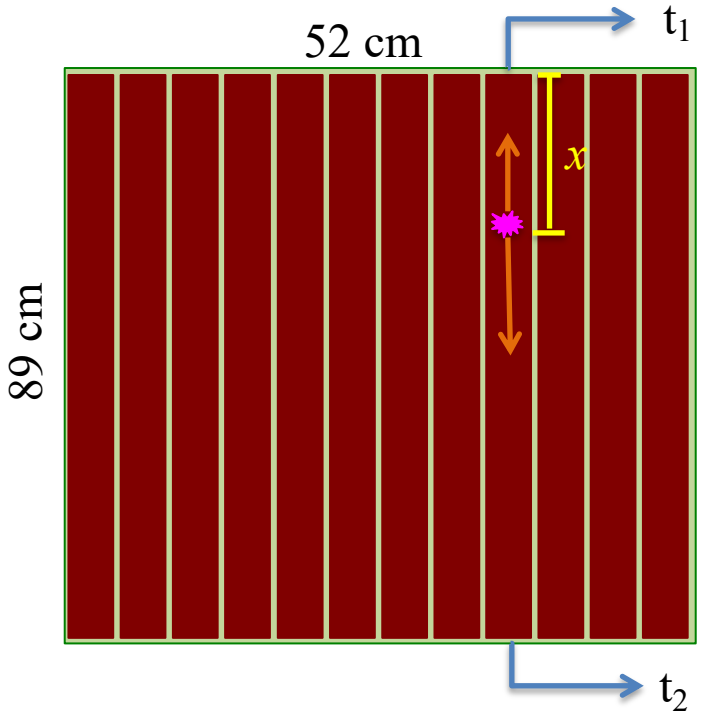
Lecture for NuSTEAM Program

Question 1



HW: given that the time signals for a particle hitting a strip of length L are t_1 and t_2, and the signal travel velocity in the strip is v, what is the time and position of the hit?

Assuming the particle hits the strip at position x and time t:

$t_1 = t + x/v$

$t_2 = t + (L-x)/v$

$t = (t_1+t_2-L/v)/2$

$x = (t_1-t_2)v/2+L/2$

Question 2

HW: what is the interaction length? Why is it important for MTD analysis?

Nuclear interaction length is the mean free path of a particle between two inelastic scatterings with material. The smaller the interaction length, the more inelastic scatterings the incident particle undergoes, and more likely to be stopped.

MTD analysis relies on the absorber to stop background particles other than muons, and therefore thicker material is preferred.

Question 3

HW: what is fraction of runs excluded with 4σ cut due to statistical fluctuations?

Random variable of large statistics follows Gaussian distribution. Fraction of a Gaussian distribution outside of 4σ range due to fluctuation is 0.006%.

Question 4

HW: how to calculate the invariant mass from decay muons' momenta?

The four-momenta of the two decayed muons are:

$p_1 = (E_1, p_{x1}, p_{y1}, p_{z1})$, $p_2 = (E_2, p_{x2}, p_{y2}, p_{z2})$

$p = p_1 + p_2$

$m^2 = p^2 = (p_1 + p_2)^2$

$= (p_1)^2 + (p_2)^2 + 2p_1p_2$

$= 2m_\mu^2 + 2[E_1 E_2 - (p_{x1} p_{x2} + p_{y1} p_{y2} + p_{z1} p_{z2})]$

$E_1^2 = m_\mu^2 + p_{x1}^2 + p_{y1}^2 + p_{z1}^2$

$E_2^2 = m_\mu^2 + p_{x2}^2 + p_{y2}^2 + p_{z2}^2$