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Analysis of deflection angle for muon energy categorization in muon scattering tomography by means of GEANT4 simulations

In muon scattering tomography, the target materials are distinguished in accordance with the scattering angle through the process chain followed by the incoming muons within the investigated volume, and this scattering angle mainly depends on the atomic number, the density, and the thickness of the medium at a given energy value. The distinct values obtained for the scattering angle at different initial energies also provide the opportunity to classify the incoming muons into a number of energy groups. In this study, we employ the Monte Carlo simulations by using the GEANT4 code and we register the hit locations at the detector layers in order to determine as well as to analyse the deflection angles due to the detector layers present in the studied hodoscope and the possible muon tomography systems. We start with our current hodoscope setup that consists of three top and three bottom plastic scintillators made of polyvinyltoluene with the thickness of 0.4 cm. We show that the deflection angle exponentially declines with respect to the energy increase, and the numerical values for the current configuration are below the detector accuracy except the initial energy bins owing to the low-Z, low density, and low thickness of the current plastic scintillators. This indicates the requirement of auxiliary components that induce the muon scattering. Therefore, we insert stainless steel surfaces into the top and bottom sections in order to augment the deflection angle as well as to diminish the uncertainty, thereby ameliorating the detector performance.

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