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P2.1: GEANT4 simulation study of low-Z material identification using muon tomography

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Traditional X-ray scanning systems for cargo use ionising radiation which can be harmful to operators and the environment and requires shielding. Fully passive muon tomography is a promising alternative or a complementary approach to X-ray scanners. Muon tomography is a non-invasive technique that uses naturally occurring cosmic-ray muons and their scattering in various materials to create images of cargo in trucks or containers without applying ionising radiation. Muons are high-energy particles that are produced when primary cosmic rays collide with the Earth's atmosphere. These muons can penetrate through thick materials, such as concrete or metal, and are therefore useful for detecting hidden objects, including contraband. Muon tomography is expected to be used for detection of a wide range of materials, including metals, plastics, and organic materials like drugs or cigarettes, as well as weapons and explosives. In this work we have used the GEANT4 toolkit to simulate the performance of muon tomography in identifying the contraband cigarettes hidden inside the legal low-Z materials in a truck trailer. We have used the Point of Closest Approach (PoCA) reconstruction algorithm to reconstruct the three-dimensional image of a loaded truck. As an example we have considered cigarettes hidden among wood pellets, plasterboards and wood planks. In all investigated scenarios cigarettes were detected and localised. We have applied CRY and MUSIBO muon generators to sample cosmic-ray muons at the surface of the Earth. The CRY software package generates muons on a horizontal plane while MUSIBO, based on a well-known Gaisser's parameterisation of the muon spectrum and angular distribution, modified to account for muon decay and Earth surface curvature, generates muons on the surfaces of a box (rectangular parallelepiped) which is more appropriate for simulation of inclined muons. This simulation study using GEANT4 and relatively simple but reliable PoCA reconstruction algorithm demonstrates the potential of muon tomography for detecting hidden materials in cargo. We conclude that muon tomography is capable of producing detailed images of various objects and can become a powerful tool for detecting contraband cigarettes and other goods in a non-invasive and harmless way.

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