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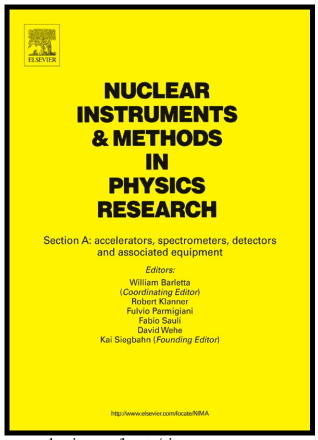

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FLUKA Monte Carlo assessment of the terrestrial muon flux at low energies and comparison against experimental measurements

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Abstract

In recent years, there has been an increasing interest in the assessment and modelling of Galactic Cosmic Rays (GCR) particularly regarding the evaluation of the radiation effects on airline crew and passengers, interplanetary missions and on-board microelectronics. In the latter field, today the problem is not just limited to Single Event Effects (SEE) as used in avionics, but is more and more observed at ground level. Galactic cosmic muons, coming from the interaction of primary cosmic rays in the Earth's atmosphere, represent the most numerous species at ground level. In this work, we used the Monte Carlo code FLUKA to assess the atmospheric and terrestrial neutron and muon differential fluxes at various altitudes and specific examples such as the geographic coordinates corresponding to New York City and Vancouver. In this context, particle energy spectra were compared with references available in literature, calculation results obtained by both the QARM and EXPACS codes, as well as recently performed measurements. In addition, the zenith angular distribution, at ground level, was assessed for both neutrons and muons and compared with available references. Differential particle fluxes assessed for Vancouver were used as a primary source to simulate a muon detector currently taking data at TRIUMF to evaluate the passing and stopping terrestrial muon rate under different conditions. Finally, simulations were compared with the experimental measurements made at TRIUMF. Results show an excellent agreement between the FLUKA simulations and both references and the experimental measurements made at TRIUMF.

Keywords: Monte Carlo; FLUKA; Galactic Cosmic Rays; terrestrial muon; plastic scintillator detector

1. Introduction

Primary cosmic rays are galactic particles (protons, helium ions and heavier ions) with energies up to 10^{19} eV. Primary cosmic rays are assumed to be isotropic; penetrating the Earth's atmosphere and interacting with the atoms of the atmosphere causing a shower of particles, which we call cosmic rays. [1]. The composition of terrestrial ionizing radiation is largely due to this cosmic-ray shower in the Earth's atmosphere: the incident ions create secondary particles during the interaction with the atmosphere and, after several generations of interactions, determine the sea-level environment consisting of a mixture of neutrons, protons, pions, muons and other particle species [2]. Due to the specific interaction mechanisms to which the various particle types are subjected, the attenuation of