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Estimation of Cosmic Muon-Induced Neutron Yields via Muon Spallation in Deep Underground Environments Using (e, e ‘xn) Cross-Section Measurements of 181Ta

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Cosmic muon-induced fast neutrons are one of the main sources of neutron background in deep underground environments. Due to the high energy and low flux of cosmic muons, it is challenging to directly measure the neutron yield. According to the Weizsäcker-Williams virtual photon method, when the energy transfer is less than one-tenth of the kinetic energy of the lepton, the Coulomb excitation process of leptons with the same relativistic factor is analogous. Therefore, by measuring the neutron yield produced by electron Coulomb excitation, we can estimate the cosmic muon-induced neutron yields via muon spallation in detectors and provide an estimate of the lower bound of neutron background in deep underground measurements. In this study, the cross sections of the 181Ta(e, e′xn; x = 1–8)181−xTa reactions induced by electrons with energies ranging from 20 to 110 MeV were measured. Discrepancies between the experimental data and the TALYS code predictions were observed, which were attributed to the nuclear level density model in TALYS not accurately describing the Ta nuclei. Consequently, the model selection and its parameterization were optimized. Based on the measurement results, the neutron yield produced by cosmic muons in detectors—serving as a lower limit for the neutron background in deep underground measurements—was estimated per unit mass of detector material per unit time.

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