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Development of a portable monitor for cosmic ray neutron observations

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Measurements of high-energy cosmic-ray neutrons are typically carried out using neutron monitors located around the world. These measurements have a wide range of applications, including space weather observation, solar cycle analysis, and radiation protection at flight altitudes. The flux of cosmic-ray neutrons is also responsible for inelastic reactions that produce isotopes such as ^{26}Al in rocks—used to date the age of rocks and minerals that have been exposed to these neutrons over extended periods.
However, several aspects of cosmic-ray neutron measurements remain under investigation, including the spatial heterogeneity of the particle flux across the Earth and its relationship with other secondary cosmic-ray particles, such as muons. On the one hand, studies in this field would greatly benefit from widespread measurements of secondary cosmic rays at the Earth's surface; on the other hand, neutron monitors are generally heavy, non-portable systems. Additionally, environmental factors such as snow cover can significantly affect neutron flux intensity at ground level, especially for low-energy neutrons (below 10 MeV). As a result, cosmic-ray observations typically achieve high sensitivity only for neutron energies above 20 MeV.
For these reasons, Politecnico di Milano and INFN are developing a portable neutron monitor for ground-level cosmic-ray neutron measurements. The system is based on a commercial thermal neutron counter with high sensitivity, housed within a modular moderator made of polyethylene and lead. This work presents the characterization of the neutron detector in a mixed neutron/gamma radiation field and the Monte Carlo simulations used to determine the optimal moderator dimensions. These efforts are preparatory steps toward the device's calibration in quasi-monoenergetic neutron fields at iThemba LABS.
Calibration of moderator-based detectors is typically performed using the shadow-cone technique in monoenergetic fields to suppress the background from scattered neutrons. According to ISO 8529, this technique is a standard for neutron energies up to 20 MeV; however, its application becomes more complex at higher neutron energies. That said, the low sensitivity of neutron monitors to neutrons below 10 MeV may allow for a relaxation of the stringent requirements for background suppression. This work includes Monte Carlo simulations evaluating the effectiveness of the shadow-cone technique for high-energy neutron measurements.

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