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Novel Neutron Detector Design for Accurate Measurement in Ultra-Iron Nucleosynthesis Study

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The current polyethylene-moderated 3He neutron detector suffers from low detection efficiency and a dependence on the neutron energy and emission angle, which hinders the accurate measurement of critical data for astrophysical modeling, such as (α, n), (γ, n) cross sections, and β-delayed neutron emission probabilities. To address this, a novel detector design was proposed, using a large spherical heavy water tank, and a layer of "3He+CF4" gases coupled with surrounding photomultiplier tubes. We used the MCNPX code to calculate detection efficiency dependencies with the neutron energy and emission angle under the different configurations, and obtained an optimal configuration (6 cm thick 11B + 0.2 cm thick Be + 70 cm thick D2O) that can offer a high detection efficiency (76%), a relatively good efficiency flatness (1.02) up to 10 MeV, and a broad scope of emission angle independency with efficiency. Such a leap in fast neutron detector would advance nuclear astrophysics with more accurate measurements.

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