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Neutron Beta Decay Measurements with Polarized Neutrons and the Nab Spectrometer

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The polarized neutron beam in conjunction with the Nab spectrometer (pNAB) at the Fundamental Neutron Beam Line (FnPB) at the Spallation Neutron Source (SNS) enables groundbreaking simultaneous measurements of the beta (A) and neutrino (B) asymmetries in free neutron decay. These measurements will complement ongoing Nab experiments utilizing an unpolarized neutron beam and the Nab spectrometer to determine the electron-antineutrino correlation coefficient (a) and the Fierz interference term (b) with high precision. The combined results from the Nab and pNAB measurements of the parameters a , A , and B will facilitate the determination of the ratio of axial-vector to vector coupling constants ($\lambda = g_A/g_V$) in the weak interaction with unprecedented precision, achieving an accuracy on the order of 0.01%. This represents an order-of-magnitude improvement over current experimental limit. Additionally, by integrating these results with precise experimental measurements of the neutron lifetime, the most stringent test of the unitarity of the Cabibbo-Kobayashi-Maskawa (CKM) matrix using free neutron decay will be realized. Furthermore, the determination of the Fierz interference term b will probe physics beyond the Standard Model, providing a unique opportunity to test potential deviations from established theory. This presentation will focus on the pNAB scientific program, detailing the performance capabilities of the Nab spectrometer and outlining strategies for achieving a highly polarized and precisely characterized neutron beam.

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