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Neutronics Studies for the Nab Experiment

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The Nab experiment aims to measure the neutron beta decay electron-neutrino correlation coefficient "a" and the Fierz interference term "b". Measurement of "a" to a relative uncertainty of 10^{-3} provides λ, the ratio of axial to vector coupling constant, at roughly the same precision level as the vector coupling determined from the superallowed decays. A measurement of "b" with an uncertainty of 10^{-3} would reach physics beyond standard model. In Nab, the parameter "a" is extracted from the proton momentum and electron energy using an asymmetric magnetic spectrometer and two large-area highly pixilated Si detectors . To achieve 10^{-3} accuracy, there must be comparatively low background rates to our signal. Background is primarily reduced by using coincidence detection for our signal. However, further reduction is still necessary. Neutron and gamma radiation produce a reaction rate in the Si detectors, which can cause false coincidences. Proper shielding is also needed to reduce dose levels in worker accessible areas. The majority of this background and dose can be reduced by properly collimating the beam such that neutrons primarily see materials that do not produce penetrating radiation upon capture, such as ^6Li. However, collimation using ^6Li creates additional sources of fast neutrons from secondary reactions that must be considered when designing the shielding. The shielding is modeled using MCNP6 (Monte Carlo N-Particle 6). Lead and stainless steel are used to shield gammas, while neutrons are shielded using ^6Li and borated polyethylene. I will present a design that optimizes the use of shielding materials to reduce gamma, cold and fast neutron background and dose.

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