

Nuclear Fano factor effect for Dark Matter and CE ν NS detection

Content

Dark matter direct detection and Coherent Elastic Neutrino-Nucleus Scattering (CE ν NS) represent two of the primary frontiers for discovering new particles and exploring physics beyond the Standard Model (SM). Accurately identifying these rare signals requires a precise reconstruction of the ionization signal produced by a recoiling atom. This cascade process partitions the primary nuclear recoil energy into electronic excitation and nuclear motion, a relationship quantified by the ionization efficiency, or quenching factor (QF). While the mean QF is conventionally determined using the first moment of the Lindhard integral equation, this work derives the integral equation for the second moment. By solving the resulting second-order integro-differential equation, we define a “nuclear Fano factor” that characterizes the statistical fluctuations inherent to the ionization efficiency, particularly in the low-energy regime. Finally, we evaluate the impact of these reconstruction effects on event rates and discuss the higher-order statistical implications of nuclear skewness and kurtosis excess.

Summary

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