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Measurements of low energy nuclear recoil quenching factors for NaI(Tl) scintillating crystal

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Understanding nuclear recoil quenching factors, the ratio of the scintillation light yield produced by nuclear and electron recoils of the same energy, is critical for rare event searches, such as dark matter and neutrino experiments. Because NaI(Tl) crystals are widely used for dark matter direct detection and neutrino-nucleus elastic scattering measurements, the low-energy quenching factor of the NaI(Tl) crystals is substantially important. The quenching factor for NaI(Tl) scintillating crystals has been measured by several experimental groups for energies above 5 keVnr for Sodium and 10 keVnr for Iodine. We have developed a NaI(Tl) detector with a high light yield of approximately 25 photoelectrons per keVee and an event-selection and analysis method based on waveform simulations that are specialized for studies of events with energies as low as a sub keVee region. As part of these efforts, we have measured quenching factors for nuclear recoil energies below 5 keVnr and 10 keVnr for Na and I, respectively. Furthermore, a reevaluation of previously reported QF results is conducted, incorporating enhancements in low energy events based on waveform simulation. The outcomes are generally consistent with various recent QF measurements for sodium and iodine.

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