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Iron filter designs for portable, monoenergetic 24 keV neutron calibration sources

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Searches for light (<1 GeV) dark matter are mainly limited by detector sensitivity to low energy deposits. Accurately characterizing dark matter detector thresholds calls for calibration sources that produce well-understood low energy neutron spectra and that are convenient to use. For low energy nuclear recoils, two existing strategies to produce monoenergetic neutrons are photoneutron sources and filtered neutron sources. Photoneutron sources are generally compact and transportable. However, the low cross section for neutron production introduces a large population of background gammas that requires extra shielding material to mitigate. An alternative is the use of a filter material with a notch in its cross section–a narrow region in neutron energy where the material has a decreased scattering cross section. Combined with a broadband neutron source, typically from a reactor, the filter preferentially transmits neutrons with energies in the notch. We present two source designs that leverage these concepts, using a long rod of natural iron as a filter for portable, monoenergetic neutron calibration sources. Neutrons produced by the SbBe photoneutron reaction have an energy of 24.5 keV, which coincidentally overlaps almost perfectly with a notch in the cross section of ^{56}Fe at a neutron energy of 24 keV. The source provides a relatively high total flux of about 10^5 neutrons per second with a GBq-scale ^{124}Sb source, while the background gamma rate can be controlled with a combination of the iron filter technique and traditional gamma shielding materials such as lead and tungsten. We also present a filtered source design based on the deuterium-tritium fusion neutron process, where the 14.2 MeV neutrons are moderated using fluental and eventually filtered with natural iron. Simulations for both source designs suggest they yield excellent neutron purity and serve as directional sources of 24 keV neutrons. In both cases, it is possible to turn the neutron flux on and off, improving their practicality for detector calibrations. The design, simulation analysis, and current status of both source concepts will be discussed.

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