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Improving the Optics and Fiducial Volume of the PICO Bubble Chamber Dark Matter Detector (student talk)

Friday, 16 February 2018 21:00 (15 minutes)

PICO is an ongoing experiment at SNOLAB, the underground laboratory at Vale's Creighton mine near Sudbury, Ontario. The purpose of PICO is to detect dark matter in the form of Weakly Interacting Massive Particles using superheated C3F8 in which bubbles form when sufficient energy is added in the form of a nuclear recoil. The active fluid is contained in a quartz jar within a larger pressure vessel filled with mineral oil. Cameras at the pressure vessel viewports are used for optical triggering. LED rings positioned around the cameras illuminate the pressure vessel and a retroreflector ensures adequate light returns to the cameras. PICO-60, the previous phase of the experiment, used bellows above a water interface to control the pressure of the active fluid. At the water interface and around the edges of the chamber, many background events were observed, limiting the fiducial volume of the detector. Poor optics due to the retroreflector geometry similarly limited the fiducial volume, in addition to the optical triggering efficiency. In PICO-40L, the next phase of the experiment, the collaboration aims to improve many of these issues by using a new retroreflector design. To this end, ray tracing was used to produce simulated images for a variety of retroreflector designs, and it was found that successive cone stages above the detection chamber resulted in the most uniform light intensity at the cameras. Experiments to measure the reflected light intensity with respect to the incident angle for various retroreflective materials showed that 3M 3290 retroreflective sheeting produced the highest image quality in the conditions under which PICO-40L will operate. A new retroreflector design based on these findings will be implemented in PICO-40L in mid-February. Once PICO-40L is operational, the new retroreflector design will serve as a proof-of-concept for PICO-500, the planned tonne-scale detector.

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