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Directionality for nuclear recoils in a liquid argon Time Projection Chamber

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The Recoil Directionality project (ReD) within the Global Argon Dark Matter Collaboration aims to characterize the light and charge response of liquid argon (LAr) dual-phase Time Projection Chamber (TPC) to neutron-induced nuclear recoils. The main goal of the project is to probe for the possible directional dependence suggested by the SCENE experiment. Furthermore, ReD is also designed to study the response of a LAr TPC to very low-energy nuclear recoils. Sensitivity to directionality and low-energy recoils are both key assets for future argon-based experiments looking for Dark Matter in the form of WIMPs. Furthermore, the ReD TPC uses all the innovative features of the design of the DarkSide-20k experiment: in particular the optoelectronic readout based on SiPM and the cryogenic electronics. It is thus a valuable test bench of the technology which is being developed for DarkSide-20k and the future project Argo.

The first measurement of ReD consisted of the irradiation of a miniaturized LAr TPC with a neutron beam at the INFN, Laboratori Nazionali del Sud (LNS), Catania. The correlation of the ionisation and scintillation signals, which is a possible handle to measure the recoil direction of nuclei was studied in detail for 70 keV nuclear recoils, using a neutron beam produced via the reaction p(7Li,7Be)n from a primary 7Li beam delivered by the TANDEM accelerator of LNS. A model based on directional modulation in charge recombination was developed to describe the correlation. In addition, a dedicated measurement tailored to characterize the response of the TPC to very low-energy nuclear recoils (< 10 keV) is being currently performed at INFN Sezione di Catania, using neutrons produced by an intense Cf252 fission source.

In this contribution, we describe the experimental setup, the theoretical model, and the preliminary results from data analysis.

In-person participation

Yes

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