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# Gas TPCs with directional sensitivity to dark matter, neutrinos, and BSM physics

There is an opportunity to develop a long-term, diverse, and cost-effective US experimental program based on directional detection of nuclear recoils in gas TPCs.

Smaller, 1 $m^3$ scale detectors could detect and demonstrate directional sensitivity to Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) at either NuMI or DUNE. This technology is also sensitive to beyond the Standard Model (BSM) physics in the form of low-mass dark matter, heavy sterile neutrinos, and axion-like particles. For every factor ten increase in exposure, new measurements are possible. A 10 $m^3$ detector could produce the strongest SD WIMP-proton cross section limits of any experiment across all WIMP masses. A 1000 $m^3$ detector would detect between 13 and 37 solar CEνNS events over six years. Larger volumes would bring sensitivity to neutrinos from an even wider range of sources, including galactic supernovae, nuclear reactors, and geological processes. An ambitious DUNE-scale detector, but operating at room temperature and atmospheric pressure, would have non-directional WIMP sensitivity comparable to any proposed experiment, and would, in addition, allow us to utilize directionality to penetrate deep into the neutrino floor.

If a dark matter signal is observed, this would mark the beginning of a new era in physics. A large directional detector would then hold the key to first establishing the galactic origin of the signal, and to subsequently map the local WIMP velocity distribution and explore the particle phenomenology of dark matter.

To understand and fully maximize the physics reach of gas TPCs as envisioned here, further phenomenological work on dark matter and neutrinos, improved micro-pattern gaseous detectors (MPGDs), customized front end electronics and novel region-of-interest triggers are needed. We encourage the wider dark matter, neutrino, and instrumentation communities participating in Snowmass to come together and help evaluate and improve this proposal.

## Primary frontier topic

Cosmic Frontier

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