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Recent R&D results on the double phase LAr LEM TPC

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The Liquid Argon (LAr) Time Projection Chamber (TPC) is the state-of-the-art technology for neutrino detection thanks to its superb 3 dimensional (3D) charge imaging and calorimetry performance. Based on this technology, a giant (10-40 kt) LAr TPC has been proposed as the detector for an underground observatory for the study of neutrino oscillations, neutrino astrophysics and proton decay.
Unlike the single phase LAr TPC which collects the electrons by means of wire planes inside the liquid argon, the double phase LAr TPC takes the advantage of charge multiplication in the gas phase. Electrons produced in the liquid argon are efficiently extracted into the gas phase where they're multiplied by the Large Electron Multiplier (LEM) before being collected on the 2 dimensional (2D) anode. This novel technology offers various benefits in terms of signal-to- noise ratio, signal waveform, sensitivity to low energy interactions, long drift path and mm-scale channel pitch, etc.
In order to cope with the large strip capacitance with the increased detector size, a novel design of a low capacitance 2D anode has been proven meeting all the requirements on energy resolution, charge sharing symmetry and uniformity. This anode offers a capacitance per unit length as low as 150 pF/m, and thus keeps the electronic noise within 1000 e– for a readout length of 2 m. The design parameters of the LEM have been optimised in real double phase operations of a smaller setup with a readout area of 10 × 10 cm2. The optimised LEM could be operated with a stable gain over 20 in absence of discharge for weeks. This notable gain offers a large signal-to-noise ratio of over 100 for minimal ionising particles (MIPs). Based on these R&D outcomes, 50×50 cm2 anode and LEM panels have been successfully manufactured for the double phase LAr LEM TPC demonstrator – the LBNO-DEMO (WA105) experiment. Results of validation and performance tests of the large area anode and LEM will be presented.
As a demonstrator of the large double phase LAr LEM TPC, LBNO-DEMO (WA105) has a 6 × 6 × 6 m3 (appr. 300 t) active volume. Its construction and operation aim to test scalable solutions for the crucial aspects of this detector: ultra high argon purity in non-evacuable tank, long electron drift path, very high voltage generation and feedthrough, large area Micro Pattern Gas Detectors (MPGD), and cold front-end electronics. WA105 will implement a total area of 6 × 6 m2 LEM consisting of 144 independent 50 × 50 cm2 LEM panels. Operation of these LEMs will provide a vital feedback for the future design of the long baseline neutrino experiment following the double phase LAr LEM TPC concept.

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