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Temperature Monitoring Systems for Phase-I DUNE Far Detector Modules

The Deep Underground Neutrino Experiment (DUNE) is an international project for neutrino physics and proton decay searches, currently in the design and construction stages. When built, the world's most intense neutrino beam will cross the two detectors composing DUNE. The near detector, placed close to the beginning of the beam line located at Fermilab, will measure the un-oscillated neutrino flux. In the far site, ~1300 km away, a much larger detector, comprising four liquid argon time projection chambers (LArTPCs) of 70Kton, will record the oscillated neutrino flux at a depth of ~1.5 km at the Sanford Underground Research Facility (SURF) in South Dakota. To achieve its scientific goals, DUNE relies heavily on the precise operation of its massive detectors, making temperature control and monitoring critical factors for optimal performance. Two different technologies are approved to be the base of the temperature monitoring systems (TMS) for the first two far detector (FD) modules to be installed during Phase-I. In the FD-I, ~1000 high-precision platinum resistance thermometers (PRTs) distributed across the entire volume are calibrated to record minute fluctuations in temperature of the other of ~2 mK, allowing for real-time monitoring and analysis of the system's thermal behaviour. Due to the vertical configuration of the electric in the FD-II module, around 600 fibre Bragg gratings (FBG) sensors will be vertically monitoring the active volume, providing similar temperature resolution as PRTs in the FD-I. Also, of the order of ~400 PRTs will monitor critical temperature features at strategical points in the FD-II outside the active volume, where electric field is less intense. We discuss ongoing R&D efforts to enhance the temperature monitoring system for even greater precision and efficiency. The potential improvements include the integration of machine learning algorithms for predictive maintenance and adaptive control to temperature fluctuations in real-time.

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