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LBNF/DUNE nitrogen refrigeration system update

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The Deep Underground Neutrino Experiment (DUNE) is supported by the infrastructure of the Long Baseline Neutrino Facility (LBNF). The central feature of DUNE is the liquid argon filled cryostats, which house the neutrino detector components. In order to maintain the argon in a liquid state, heat must be continuously removed. Argon condensers will remove this heat, and liquefy the argon, through the evaporation of liquid nitrogen. The supply of liquid nitrogen relies heavily on a near-industrial scale nitrogen refrigeration/liquefaction system. The nitrogen system will be a closed loop, in which the liquid nitrogen is supplied to users and, after being vaporized, is recycled to the nitrogen liquefaction units to be liquefied again. The system will also include nitrogen generation, to increase inventory in the closed loop, as well as to make up for losses. All of this will be installed nearly one mile underground (1.5km) on the 4850 level of the Sanford Underground Research Facility (SURF). The final DUNE vision requires 400kW of liquid nitrogen cooling capacity. Based on the operation modes and phased installation of the experiment, modularity of this cooling capacity is required. Nitrogen liquefaction will occur in four units which will afford a wide operational range of production (nominally 100kW each). Due to the experiment's location deep underground in an inactive gold mine, there are unique and challenging constraints. These include limited access, footprint, and utilities. This contribution will provide a description of the engineering effort, an overview of the refrigeration system, and how the constraints are being addressed. The design includes a unique compressor arrangement which will be covered in detail. Pictures and models will be included where possible to help visualize the system, and how the constraints referenced above were managed.

Submitters Country

United States of America (USA)

Author: GRAF, Markus (Fermilab)

Co-authors: MONTANARI, David (Fermilab); ADAMOWSKI, Mark (Fermilab)

Presenter: GRAF, Markus (Fermilab)

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