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118. LBNF/DUNE Nitrogen Refrigeration System Update

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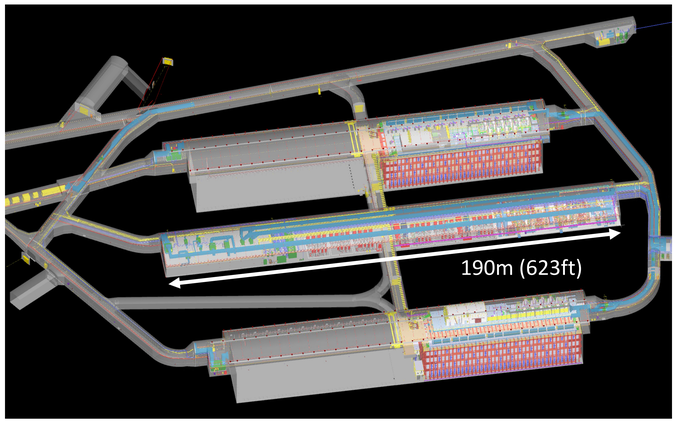
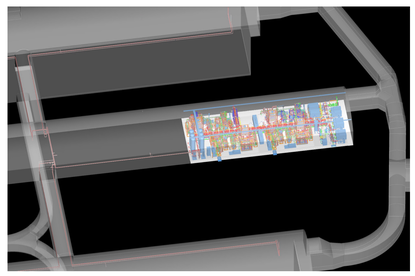
LBNF/DUNE Overview



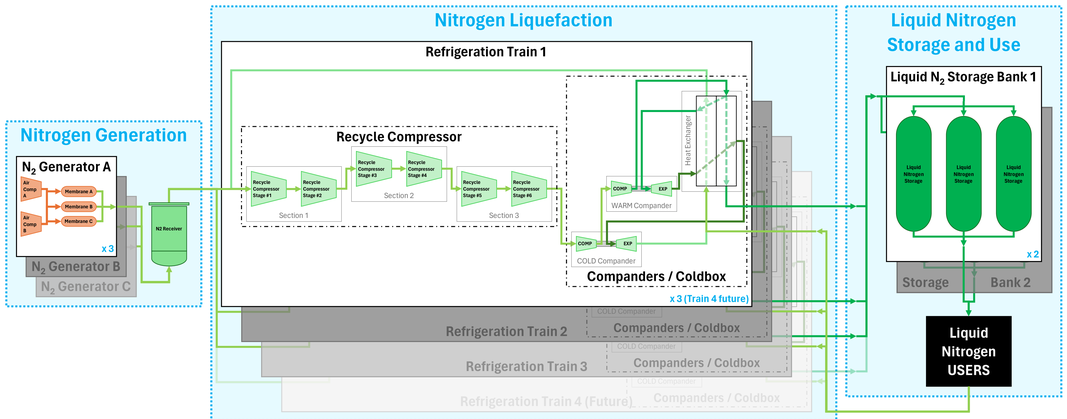
The Deep Underground Neutrino Experiment (DUNE) is supported by the infrastructure of the Long Baseline Neutrino Facility (LBNF). The central feature of DUNE is the liquid argon filled cryostats, which house the neutrino detector components. To maintain the argon in a liquid state, heat must be removed continuously. Argon condensers 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. All of this will be installed nearly 1.5km (1mi) underground on the 4850 level of the Sanford Underground Research Facility (SURF). The final DUNE vision requires 400kW (2.07kg/s or 226kscfh) of liquid nitrogen cooling.



Left: LBNF/DUNE Caverns overlayed on the surface in Lead, South Dakota, USA
Right: Nitrogen Refrigeration System in the Central Utility Cavern. Distribution piping shown extending to the North and South detector caverns

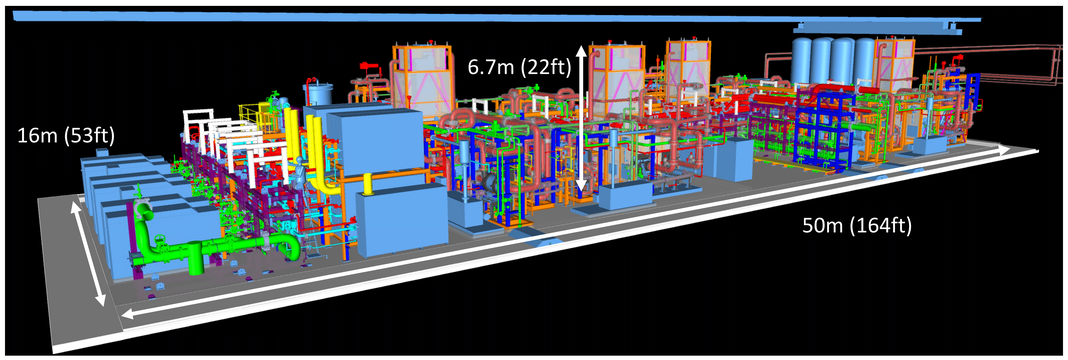
Nitrogen Refrigeration System Overview

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 make up for losses. 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 (0.52kg/s or 56kscfh).



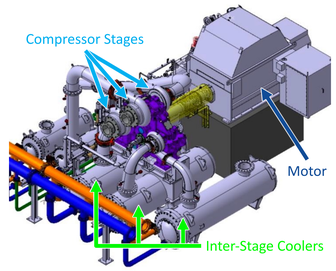
Process Flow Diagram of the Nitrogen Liquefaction System

Nitrogen Refrigeration System Model

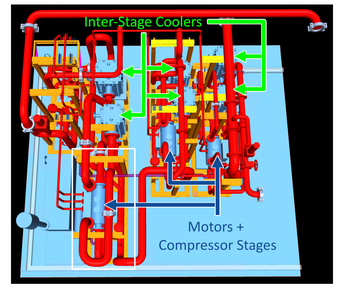


The nitrogen equipment is packed very closely together, and some pieces are even stacked to fit everything in the allowed space.

Compression Equipment

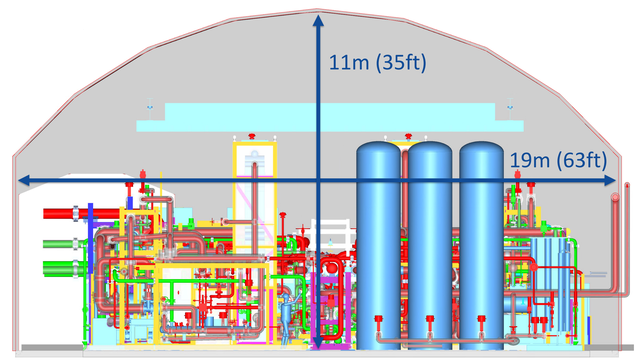


Typical Integrally Geared Centrifugal Compressor



LBNF/DUNE Compression Scheme with Transport Module size shown (white box)

A typical industrial nitrogen liquefaction unit uses a 6-stage compressor in conjunction with 2 combination compressor-expander units. From a process perspective this is the same as what will be employed in this project. However, from an equipment perspective there are significant differences. All equipment in this system must be able to be transported down the mine shaft, which has a width limit of 1.4m (4ft 8in). Typical systems utilize a 6-stage integrally geared centrifugal compressor, which use a large bull gear and a single motor to drive 3 rotors. The size of the motor, and compressor gear box make this an infeasible compressor to use underground. In this project there are still 3 rotors however, each rotor will be powered by a motor which sits around the shaft between the compression stages. This arrangement reduces the motor size, eliminates the bull gear, and permits disassembly of the compressor system into modules that fit underground.



Profile view of the Central Utility Cavern (CUC) with the Nitrogen Equipment shown inside.

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