Design of Cryogenic System for SBN Near Detector

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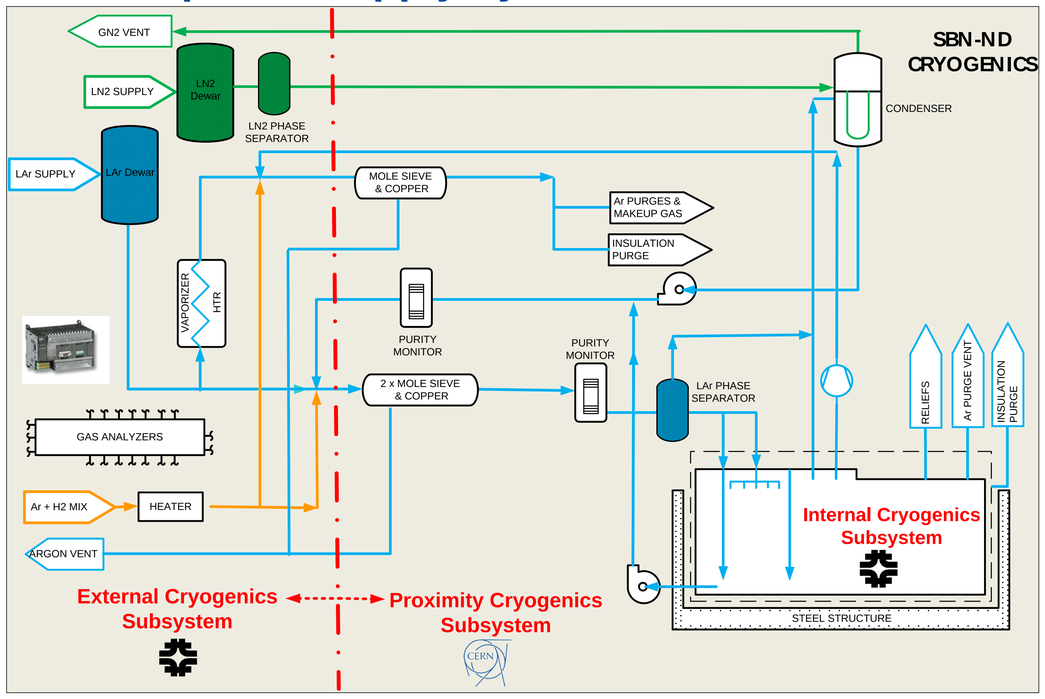
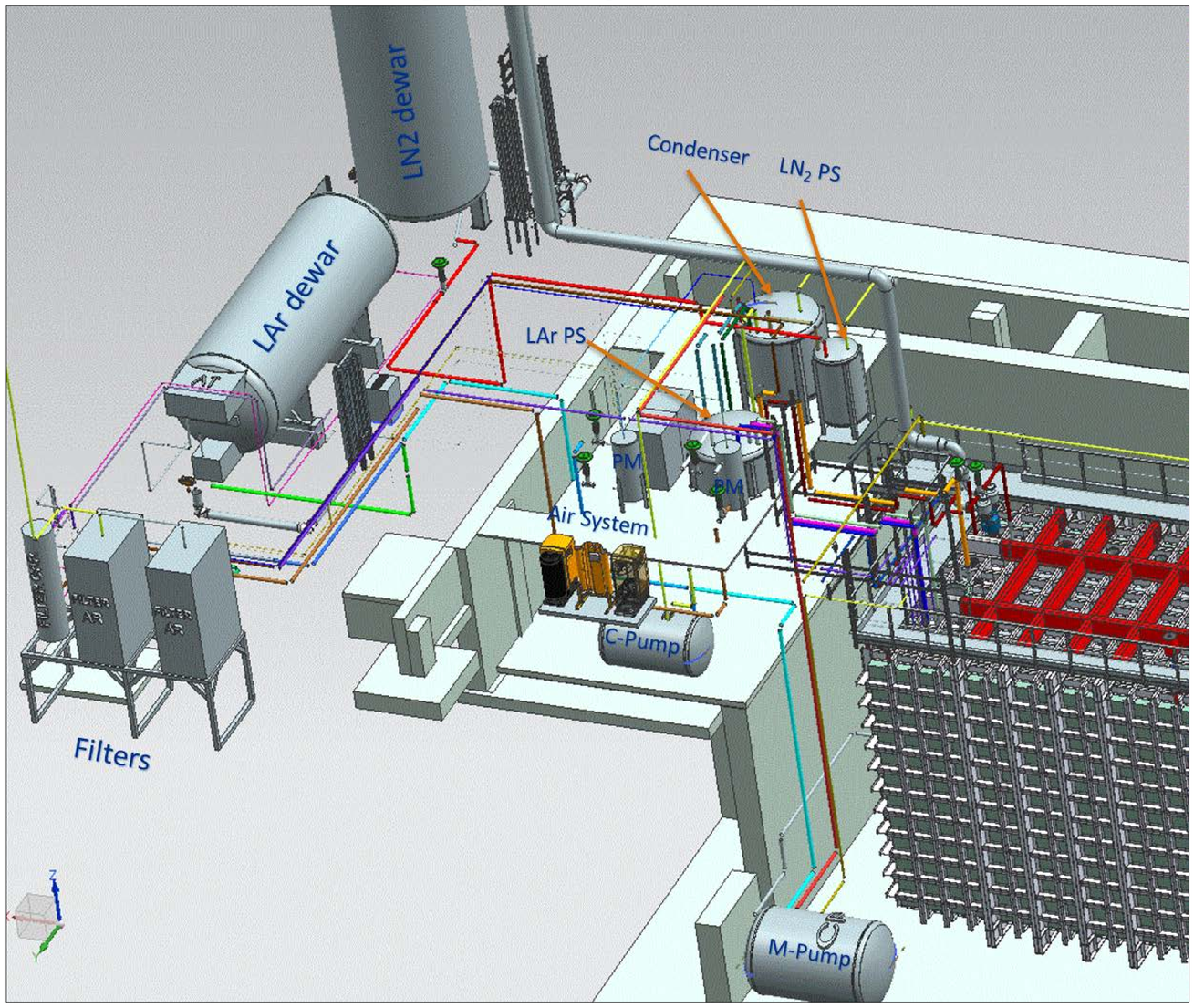
Scopes of Supply by CERN and Fermilab



Cryogenic System Layout

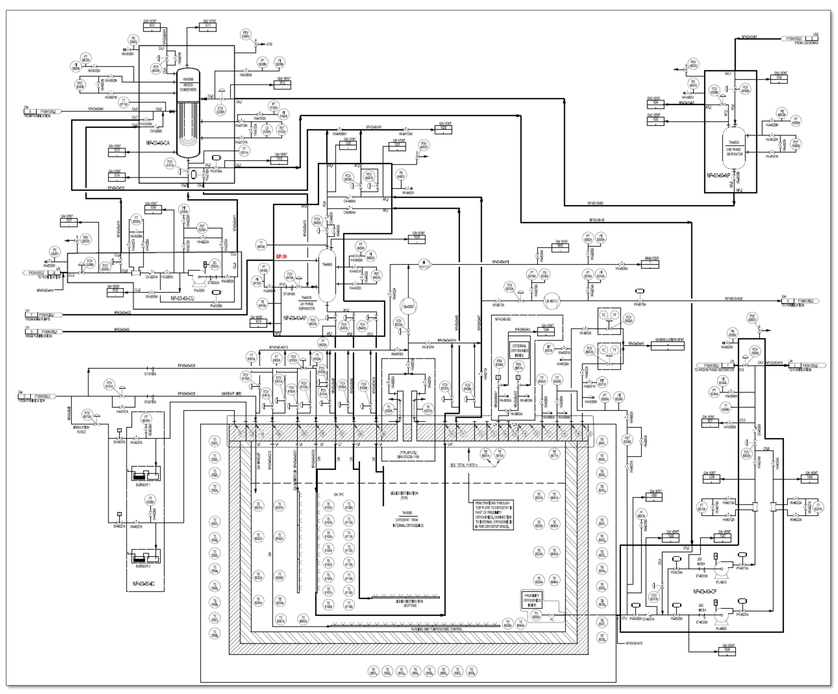


Design Requirements

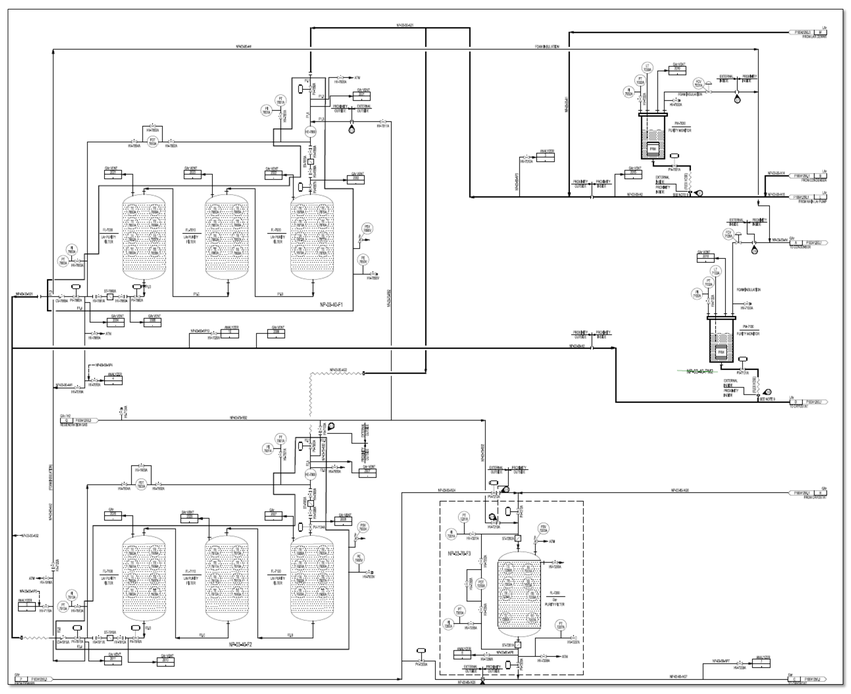
Required Parameter for Cryogenics	Value
LAr purity in cryostat	3 ms electron lifetime (100 ppt O2 equivalent)
Nitrogen contamination	Less than 2 ppm (to coincide with T600)
Design Pressure	Internal: 345 mbarg External: 50 mbarg
Operating gas pressure	70 mbar with +/- 5%
GAr Piston purge rate of rise	1.2 m/hr
Membrane cool-down rate	From manufacturer (most likely < 10-15 K/hr)
TPCs cool-down rate	< 40 K/hr < 10 K/m (vertically)
Mechanical load on TPC	The LAr or the gas jet pressure shall not apply a mechanical load to the TPC greater than 200 Pascal
Nominal LAr purification flow rate (filling/ops)	10 - 35 gpm
All surfaces in the ullage during operations	< 100 K
Convective currents inside cryostat	< 10 cm/s
GAr purge within insulation (From LBNF)	1 volume change/day of the open space between insulation panels
Condenser cooling power	Based on fill with LAr (~25 kW)
Grounding and noise requirement	Electrical isolation from cryostat. Approval by SBND committee supervising detector and building grounding

Requirements for Cryogenics	Rationale
Include systems for: • receipt of LAr and LN2 • LAr acceptance • LAr transport to cryostat • GAr recovery to LAr • LAr recirculation	The scope of the cryogenics system should include all sub-systems necessary to receive, transfer, store and purify the LaAr
Verifiable contamination levels for LAr delivery	O2 < 1 ppm, H2O < 1 ppm, N2 < 2 ppm (to coincide with T600)
Cooldown rate	The detector cool-down rate shall be chosen to ensure that temperature induced differential stresses in the detector do not exceed the yield stress of the detector components
LAr recirculation rate	The system shall allow recirculation and purification of the liquid argon inventory to achieve the needed Lar purity to meet the scientific requirements
Cryogenic System Noise Control	The cryogenics system shall be designed so as not to introduce unwanted noise into the electronics
Piston-Purge technique	The cryostat and cryogenic systems shall be designed for using the piston-purge technique (introducing heavy gas at the bottom and taking out exhaust from the top) for removing initial electronegative impurities
LAr flow speeds	The liquid argon shall have local flow speeds low enough to prevent distortion of the electron drift trajectories

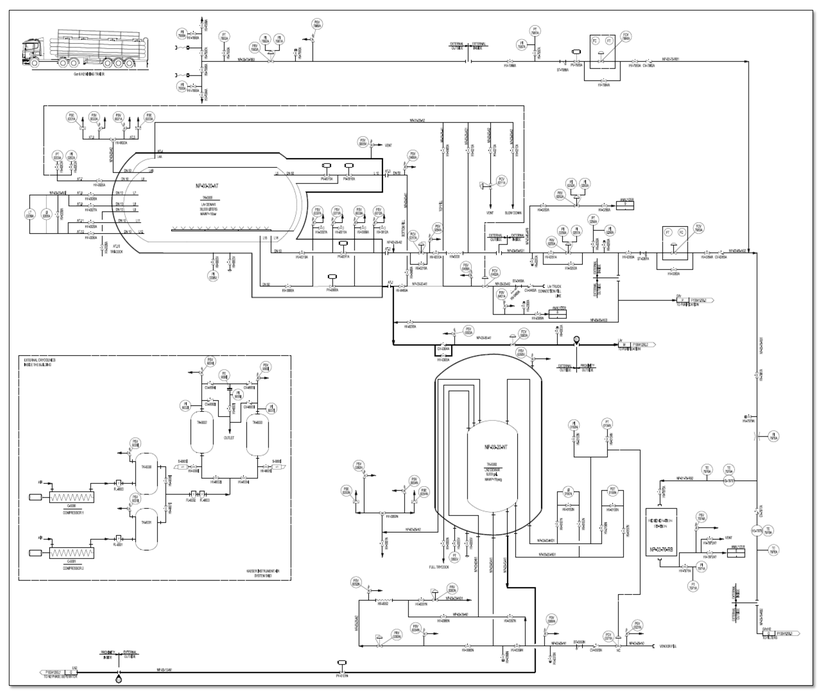
Design Concepts



Proximity: Cryostat – Condenser – Recirculation

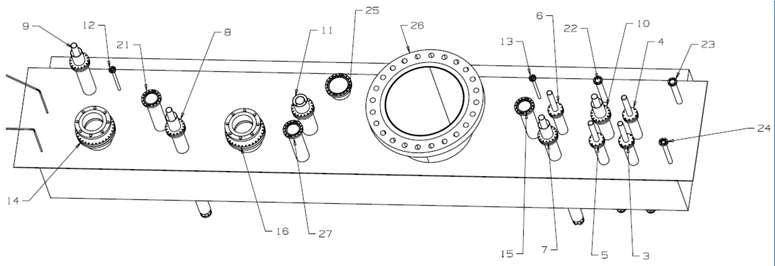


Proximity and External: Recirculation – Filtration



External: Cryogens Supply (additionally, venting,

Top Plate



Design Highlights

- Used 36 k-liter LN2 and 30,000 k-liter LAr dewars
- Re-usable and movable LAr filters (mol. sieve + Cu)
- Regeneration gas supply systems using Ar/H2
- Vacuum-jacketed cryo vessels, piping, valve boxes
- Condenser: Ar (shell) – LN2 (tubes) with condenser pump
- Electrical isolation between detector and building ground for all cryogenic equipment
- Collection and venting of cryo gases outside building
- External purity monitors before and after filters
- Continuous analysis of gases for O_2, N_2 and H_2O