Nitrogen System VE Status and Other Cryogenics Update

David Montanari

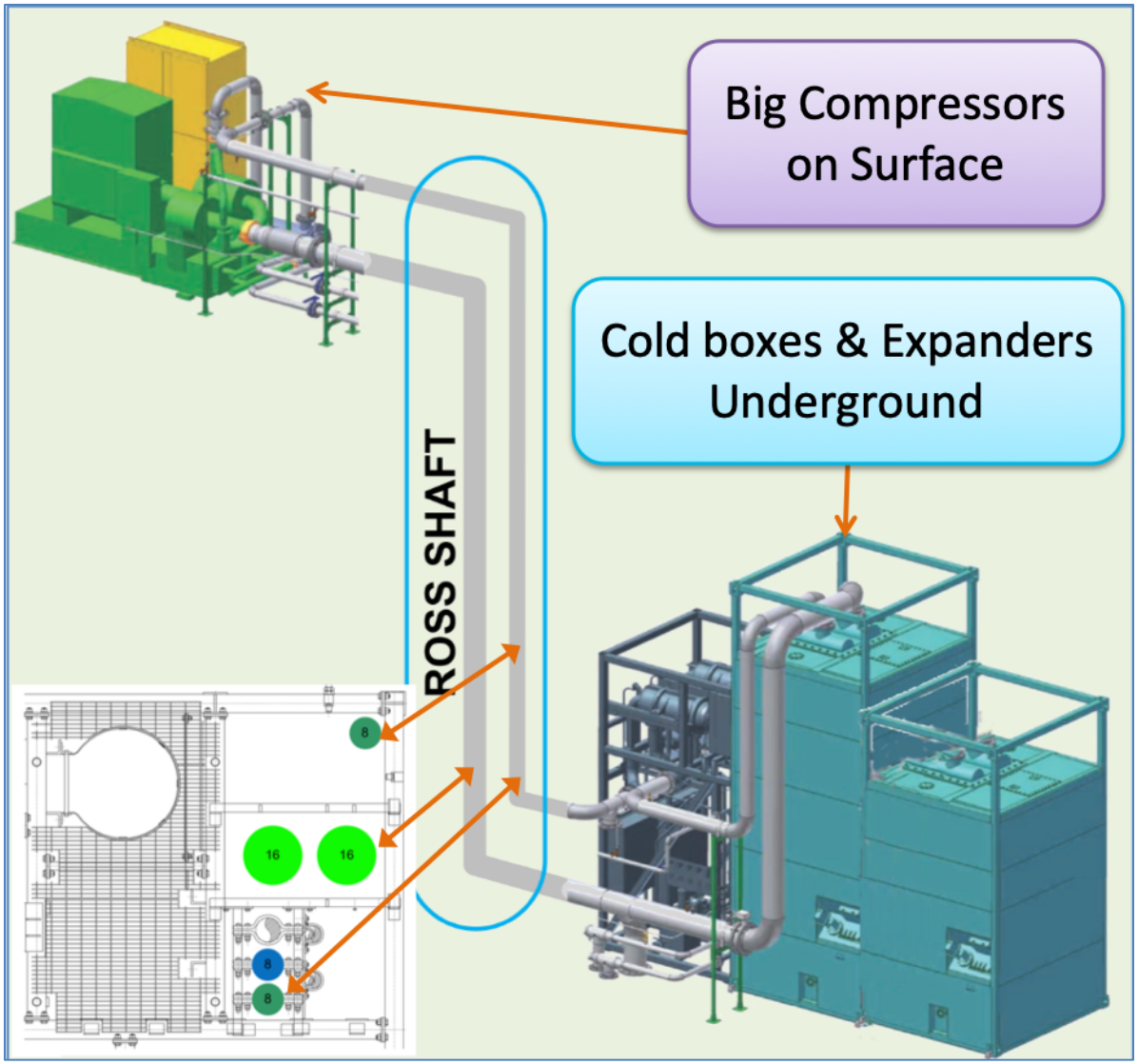
Far Site Integration Meeting

2-4 February 2020

Outline

- Value Engineering Status.
- Ongoing relevant activities.
- Action Items from Aug-2019 FS Integration Meeting.

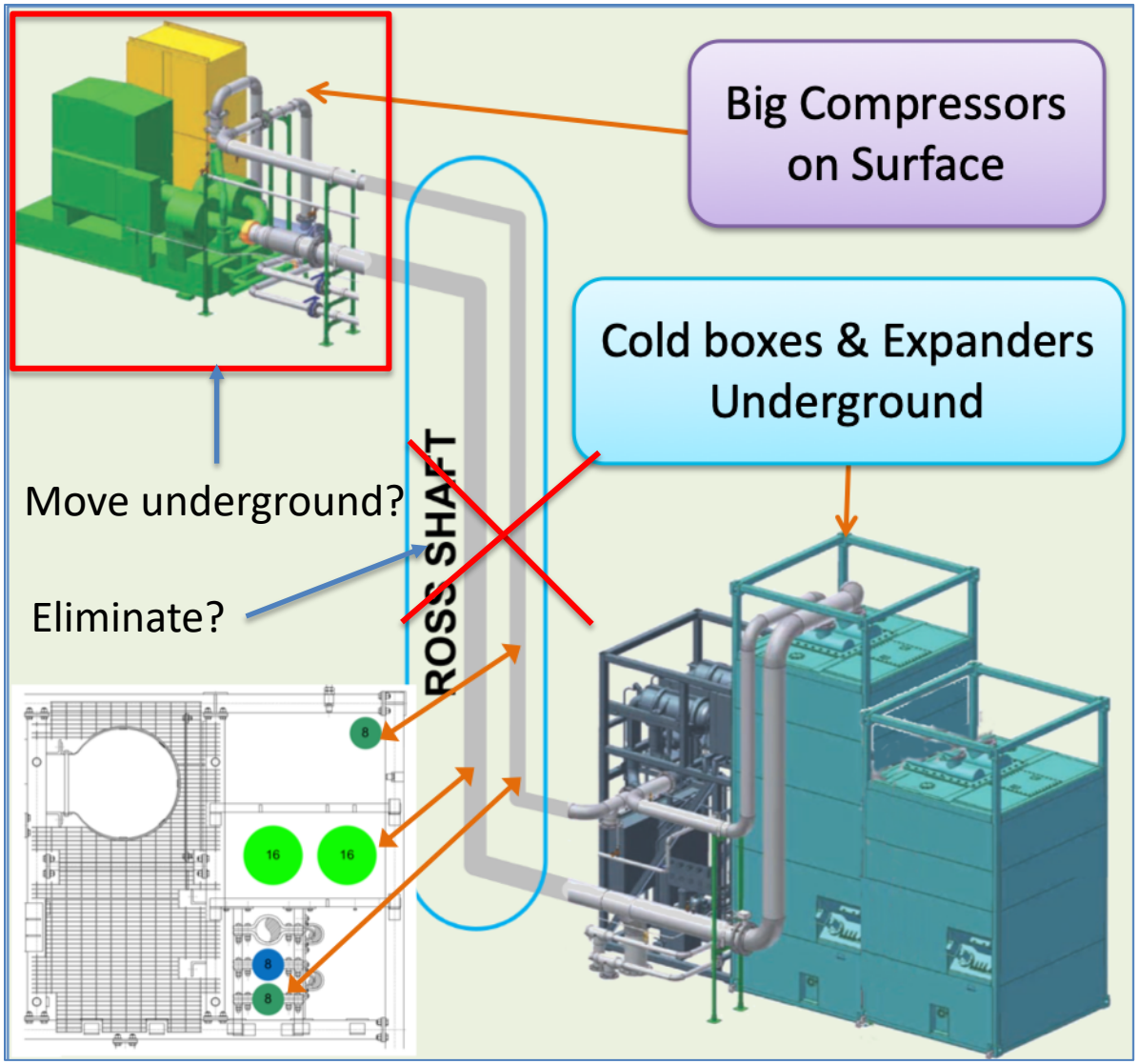
Value Engineering Status



VE Intro

- Can we place complete Nitrogen System at 4850L?
- Can we remove Nitrogen and Argon pipes in Ross Shaft?
- Cryogenics/Conventional Facilities investigation:
  - VE #1 → Placement of Nitrogen System at 4850L. ✓
  - VE #2 → Delivery of LAr to 4850L by portable dewars. ✓
  - VE #3 → Boreholes for Argon/Nitrogen pipes. In progress.
  - VE #4 → Alternate shaft for placement of Argon/Nitrogen pipes. In progress.
- Reached out to industry via Requests For Information to investigate:
  - Feasibility of locating complete Nitrogen System at 4850L and space/utilities needed to support it.
  - Feasibility of transporting LAr/LN2 in portable dewars.

VE #1, #2


Big Compressors on Surface
Cold boxes & Expanders Underground
Move underground?
Eliminate?
ROSS SHAFT
8
16
16
8
8

VE #1 complete Nitrogen System at 4850L – Highlight of industry feedback

- High efficiency, custom made recycle compressors (or permanent magnet) to improve reliability.
- Companders to improve efficiency and reduce size of recycle compressors.
- Using cooling water at 42F would reduce cost, footprint and power.
- Addition of Nitrogen generator underground to charge the system at beginning and replenish periodic losses in seals of rotating equipment.
- Estimated total required electrical power for 4 liquefiers and Nitrogen generation at 4850L: at least 3,000 kW.
- Estimated total required cooling capacity for 4 liquefiers and Nitrogen generation at 4850L: at least 3,000 kW (2,550 kW for first 2 Detectors).
- Conventional Facilities and Systems Engineering investigating how to support this requirement w/ additional cooling/repurposing of existing cooling.
- Alternative of fully integrated system with different refrigerant also possible. Requires paid engineering study to determine feasibility and utilities. **???**

VE #1 complete Nitrogen System at 4850L – Other Considerations

- Removal of GN2 pipes in Ross Shaft (2 x 8 inch + 2 x 16 inch) → Cost/Schedule saving. 👍
- Removal of compressors building on surface → Cost/Schedule saving. 👍
- Removal of Nitrogen receiving station on surface → Cost saving. 👍
- Removal of LN2 dewars/generation for cold box test: Nitrogen System can support needs of cold box test → Cost saving. 👍

VE #2 Delivery of LAr to 4850L by portable dewars – Overview

- Multiple transfers each load:
  - At surface LAr is transferred from receiving facility to portable dewars.
  - Underground LAr is offloaded from dewar into LAr circulation.
- Transport down (via Ross cage or skip):
  - Full dewars down.
  - “Empty” dewars back up (may retain LAr).
- During each transfer (2 per load):
  - Need to purge lines.
  - Potential for Argon contamination.
- Logistics: Dewars need to switch from horizontal to vertical, back to horizontal and rotatable to account for loading/unloading from different sides of skips.
- Safety considerations:
  - No personnel in cage during transport (Dewar full or “Empty”).
  - Dewar inspected for evidence of frost or sweating before loading.
  - Cage usage by personnel during skip dewar transport might be possible w/ risk assessment.

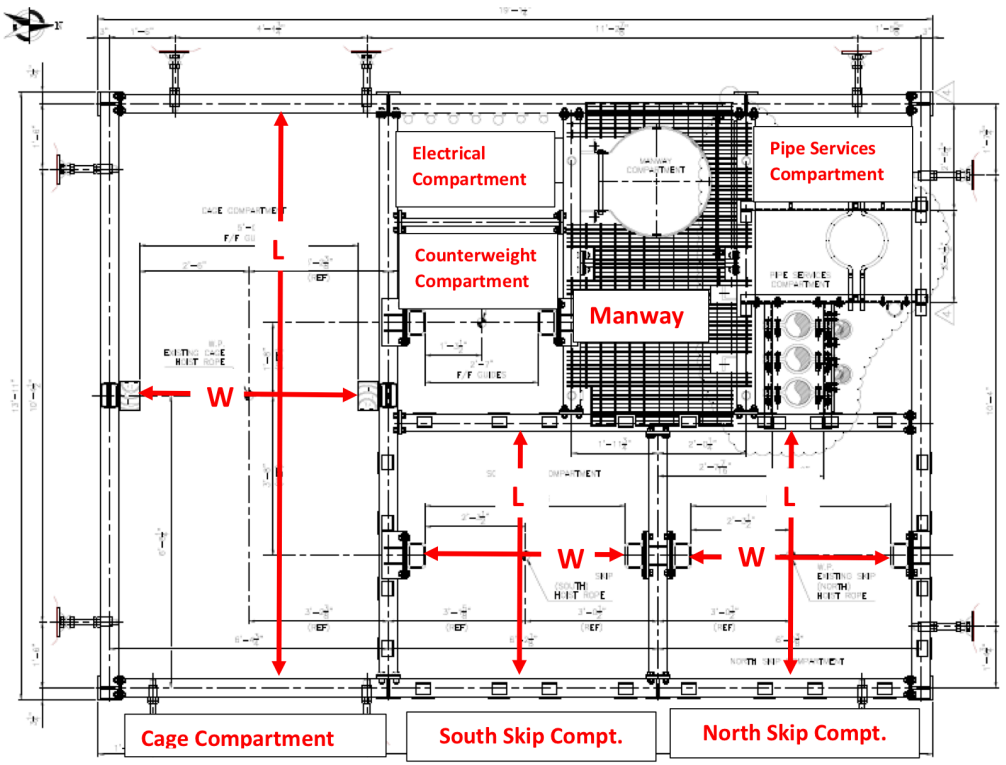
VE #2 LAr loads (per cryostat)

- Estimated to be:
  - As low as **3,700** w/ 4.8 ton loads (15 lds/day) → **7,400 transfers** (per cryostat)
    - 1 m x 5.5 m inner vessel
    - 80% full
  - As high as **5,250** w/ 3.4 ton loads (22 lds/day) → **10,500 transfers** (per cryostat)
    - extra clearance or larger vacuum jacket
    - 70% full
- Limiting skip dimension is: 1.4 m (see next slide).
  - Limits the dewar outer diameter (vacuum jacket)
- Losses:
  - Lines need to be purged prior to each connection.
  - Not all LAr is transferred each time (residual amount inside each time)

Equipment transport requirements

https://edms.cern.ch/file/2215779/1/SURF_Facility_Access_Specifications_Technical_Memorandum_Version_6.0_5-8-2019.pdf

Ross Shaft Typical Set General Arrangement Plan View – New Furnishings



	Length 'L'	Width 'W'
Cage Compartment	12' 10 ½" [3.92m]	5' [1.52m]
South Skip Compt.	5' 7 ¼'' [1.71m]	4' 7" [1.40m]
North Skip Compt.	5' 7 ¼" [1.71m]	4' 7" [1.40m]

VE #2 Delivery of LAr to 4850L by portable dewars – Feedback from industry

- Customized microbulk container:
  - 50 in (1.27 m) diameter x 12.5 ft (3.81 m) tall.
- Weight:
  - Load: 2,400 l each → 3.3 ton.
  - Full weight: 5.5 ton.
- 25 loads/day → 50 transfers/day.
- **6,000** loads per cryostat → **12,000 transfers** (per cryostat).
- Assumed vertical orientation. No rotation/inclination. Need to verify that height is ok everywhere underground.
- Typically stationary application installed with additional safeguards (e.g. relief vent lines).
- Would likely require safe zone around dewars while moving them around underground.

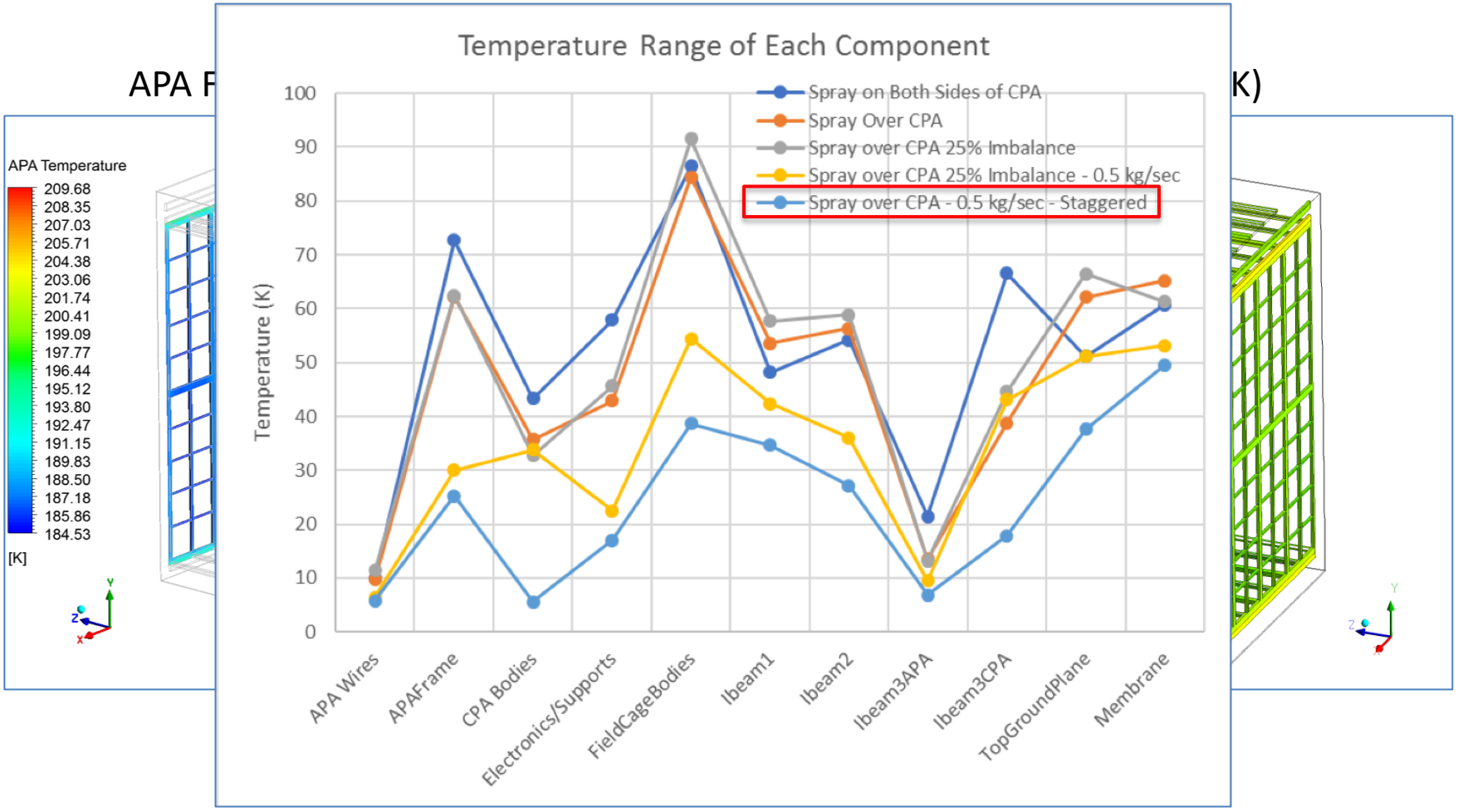
Summary Value Engineering VE #1, #2

- Placement of complete Nitrogen System underground seems feasible:
  - Electrical power (3,000 kW) and footprint (900 m^2) seem to work. More footprint could be useful (from DAQ room?) but may not be necessary.
  - Requires additional cooling (at least 3,000 kW) to match electrical power (2,550 kW for #1, #2).
  - Identified equipment can be transported down the Shaft (tight, but possible).
- Removal of Nitrogen pipes in Ross Shaft is feasible.
- Transfer LAr dewars in Ross Shaft very challenging and requires a lot of resources. No further investigation will be pursued.
- Cryo considers its VE investigation completed:
  - Supports locating complete Nitrogen System at 4850L, providing that additional cooling power is made available.
  - Suggests keeping Argon pipe to transfer Argon to 4850L (in Ross Shaft or other location).
- Conventional Facilities/Systems Engineering still working on providing additional cooling.
- Timeline for Value Engineering completion:
  - Mid Feb → Investigation completed by all parties.
  - End of Feb-2020 → Ready for EFIG discussion.

Ongoing relevant activities

- Updating cryo estimates and P6 schedule in preparation to Director's and DOE CD-2 Reviews.
- Fixed layout of Internal cryogenics to satisfy all stakeholders.
  - No longer passing through APAs.
  - Spraying horizontally over ground plane towards middle of cryostat.
  - Latest CFDs: https://edms.cern.ch/document/2154410/2
- DUNE cold box support:
  - Started working on cryogenics supporting it.
  - Provided feedback on space allocation and penetrations through box to Systems Engineering.
  - Need to restart work to finalize Process & Instrumentation Diagrams and 3D model.

DUNE Cool down plots from CFD Simulations



Action Items from Aug-2019 FS Integration meeting

- **ID 81940**: Update the cooldown sprayers model and internal piping to not interfere with drift volumes (he is aware).
  - CFD simulations done. Results and proposed layout agreed with stakeholders. Need to update 3D model (within weeks).
  - https://edms.cern.ch/document/2154410/2
- **ID 81928**: Evaluate CUC space availability vs requirements for modified DAQ UPS vs. VE GAr/GN2 pipes.
  - Done as part of Nitrogen System VE. Current allocated space should be enough. More space could be useful, but not presently needed.
- **ID 81923**: Define requirements for services needed from SDSD. (1) Power distribution $ responsibility to equipment; (2) compressed air is in BSI at 50' intervals in CUC; (3) final ventilation; (4) consortia?
  - Confirmed compressed air distribution.
  - Power distribution currently unknown. Nitrogen system equipment will be located where it makes the most sense.

Future Activities

- Nitrogen System Acquisition Plan and solicitation (CY2020).
- DUNE cold box support (CY2020).
- Nitrogen System paid preliminary study and award contract for full scope (CY2021).
- Engage with non-DOE partners to deliver In-Kind-Contribution (from CY2020 as they become available).
- Surface Receiving Facilities AP and solicitation (CY2021?).
- Interconnecting piping AP and solicitation (CY2021?).

Thanks

Backup

RFI – Equipment transport requirements

https://edms.cern.ch/file/2215779/1/SURF_Facility_Access_Specifications_Technical_Memorandum_Version_6.0_5-8-2019.pdf

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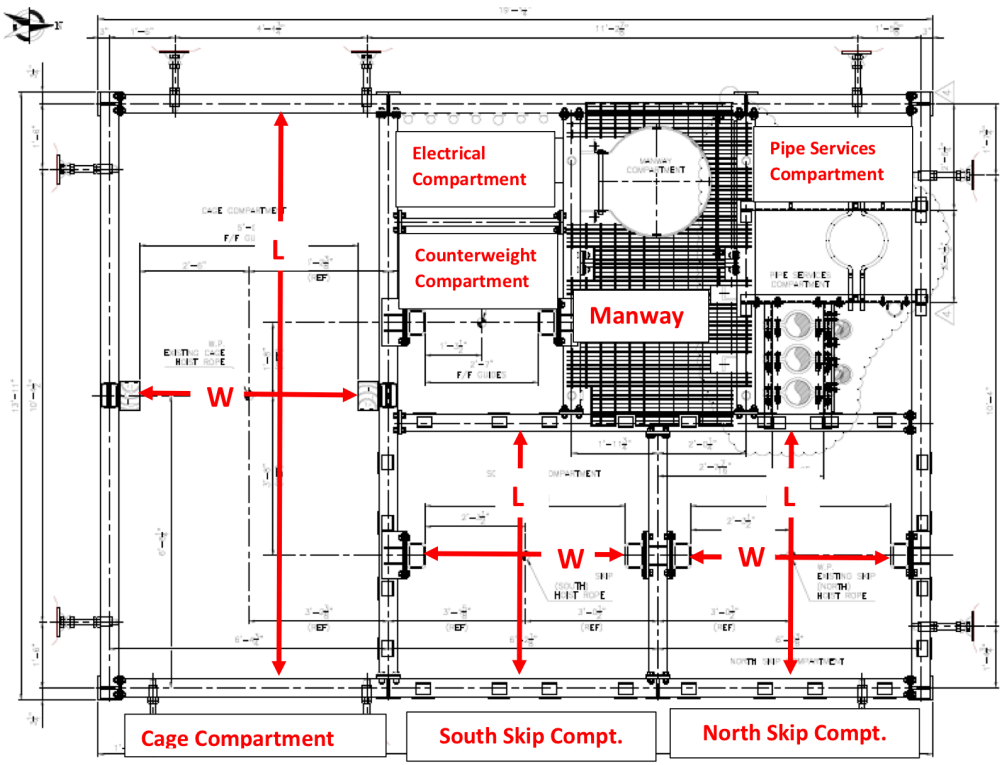

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RFI – Requirements and Utilities (based on current CF design)

System Requirements	Current Configuration (Surface and Underground)	New Configuration Under Consideration (All underground and includes increased cryostat heat leak)
Liquid Nitrogen Backup Storage in CUC	200 m^3	150 m^3
Refrigeration Unit Capacity	100 kw per unit	110 kW per unit
Argon Condensers	Two sets of three condensers	Removed from Nitrogen System scope
Available Utilities & Space		
Cooling Water at Surface	Cooling: 3,600 kW.	None
Cooling Water at 4850L	Cooling: 400 kW.	Cooling: 2,000 kW
Electric Power at Surface	4,500 kW from 4160V transformers	None
Electric Power at 4850L	600 kW from 480V transformer	3,000 kW
Available footprint at Surface (m^2)	191	None
Available footprint at 4850L (m^2) - includes backup LN2 storage	576	796
Additional footprint at 4850L (m^2) - as needed		98
Total footprint at Surface + 4850L (m^2) - w/o additional space	**767**	**796**
Total footprint at Surface + 4850L (m^2) - w/ additional space		**894**

RFI – Available Footprint at 4850L

No additional space, just rearranging of equipment.