GRAIN status report

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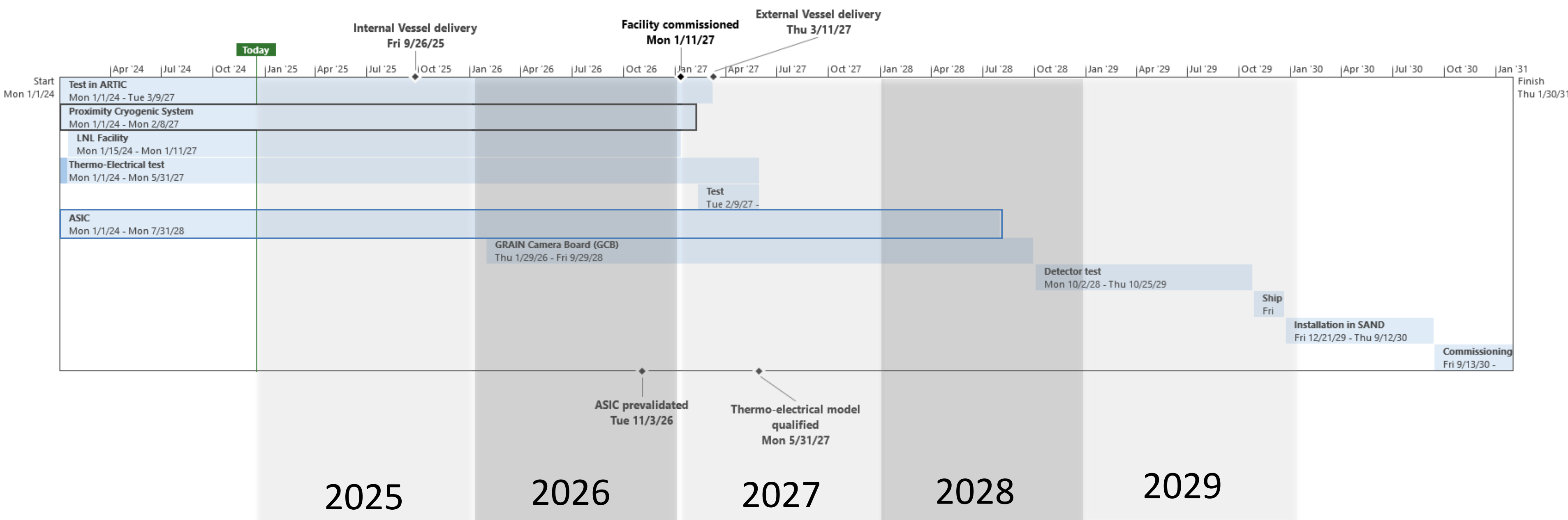
for
GRAIN Working Group

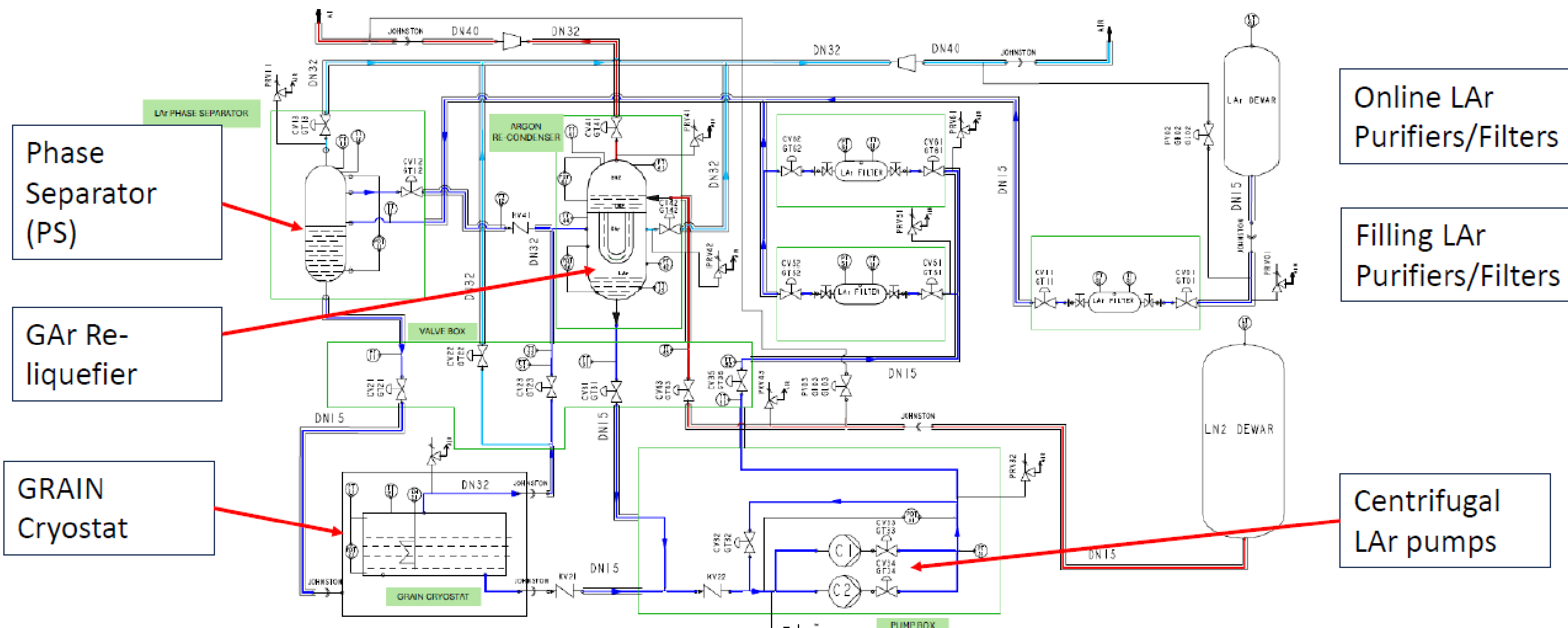
Where we are ?

- Proximity Criogenic System and the new ASIC are on the critical part



Proximity Criogenic System

- In order to start the Tender procedure we need a quotation to set the base price:
  - We are still waiting quotations by: Cryotec, Demaco, Simic...they have been solicited!



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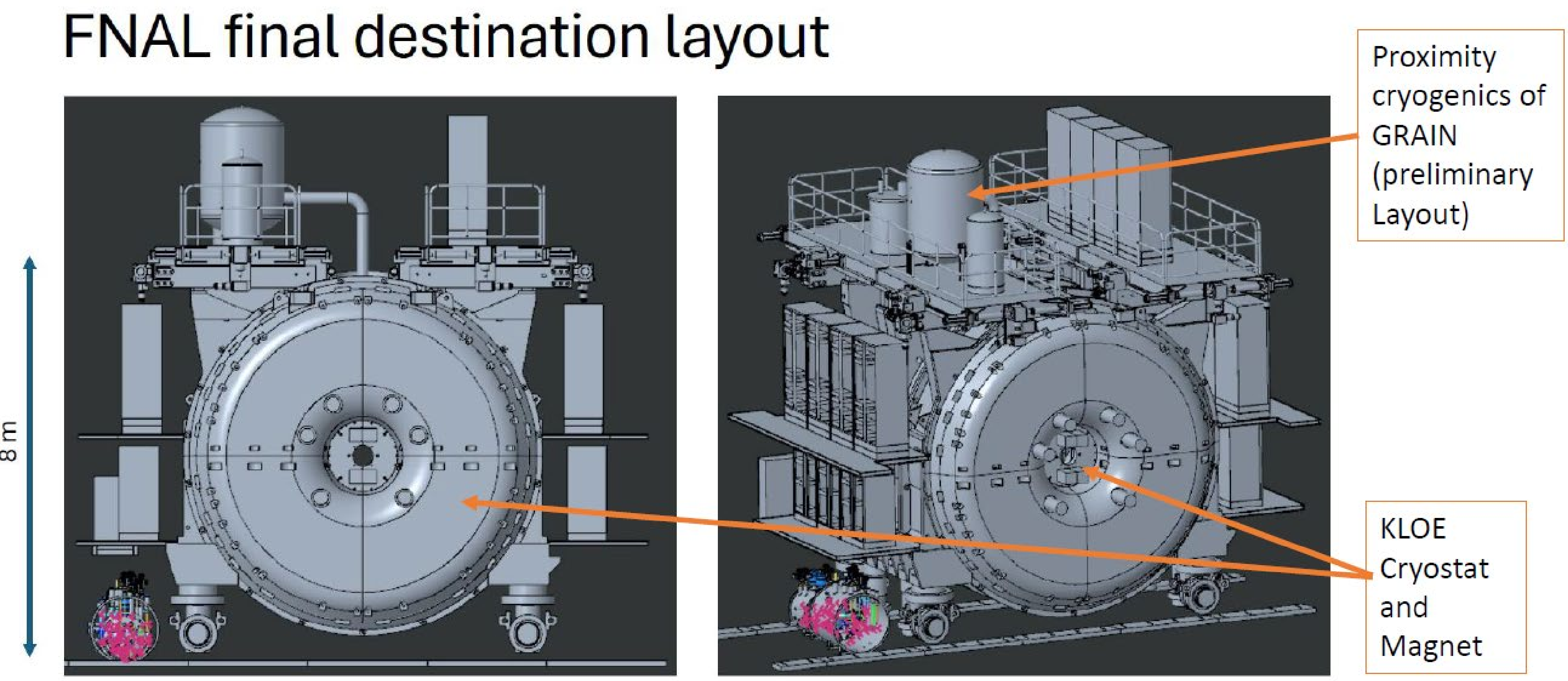
MAIN COMPONENTS

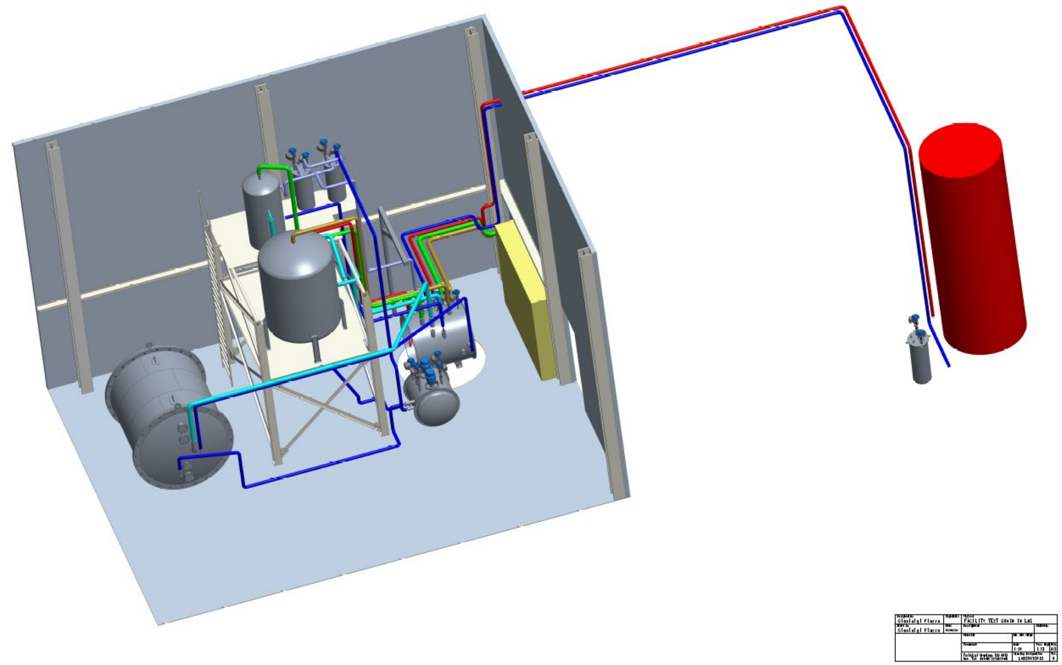
Proximity Criogenic System

- Some revision was necessary to take into account the position of the Phase Separator



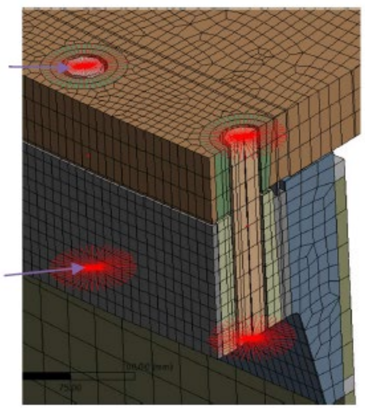
Test Facility in Legnaro (LNL)

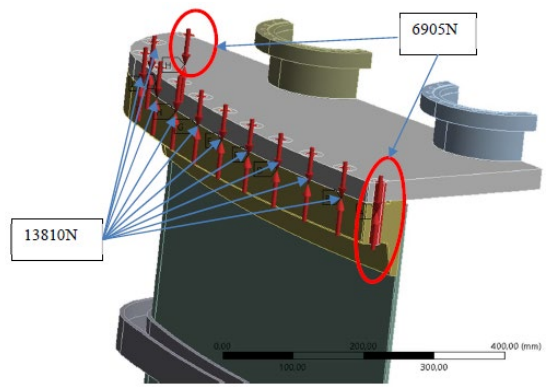
- Four new lines have been installed: IN/OUT for LAr/GAr and LN2/GN2
- Space has been cleared and obsolete stuff removed
- Some maintenance of the floor is under way (asbestos removal)
- Control panel components for cryogenic system have been purchased

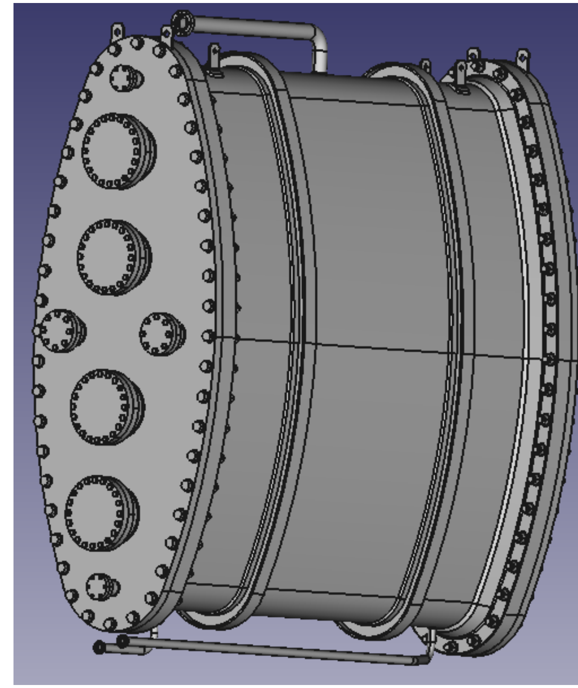


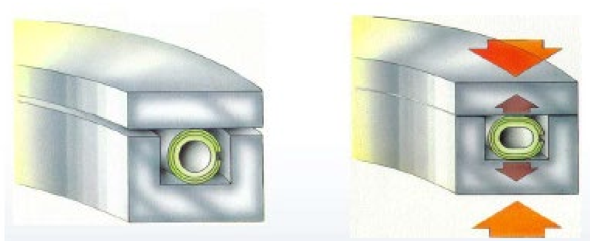
Cryostat Inner Vessel

- Few flanges were added for future versatility
- Cryo Service engineer met at LNL to discuss details of the project: they would be happy to build it.
- We will start Tender procedure beginning of January

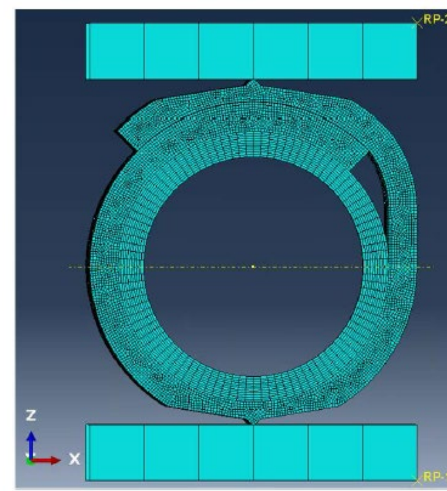




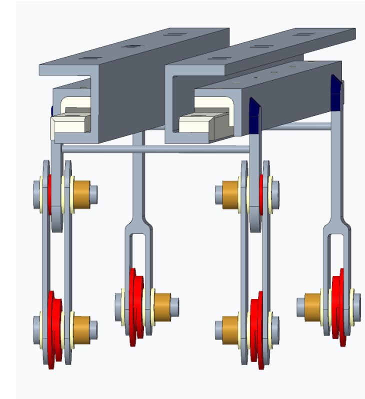




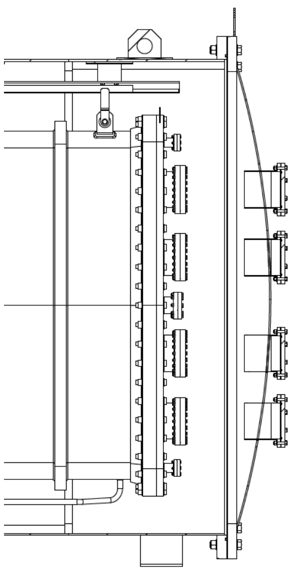
Before tightening After tightening

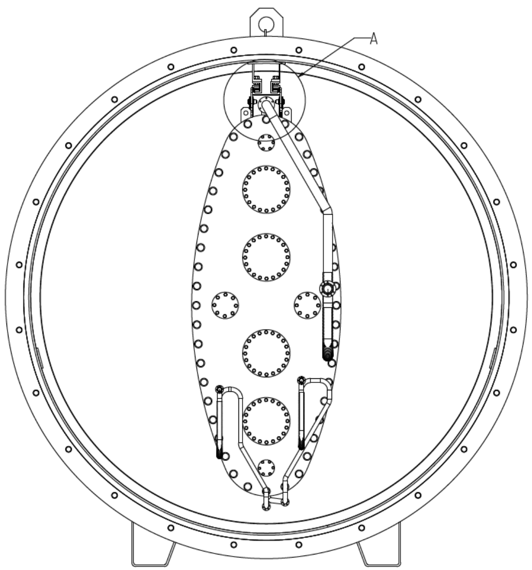


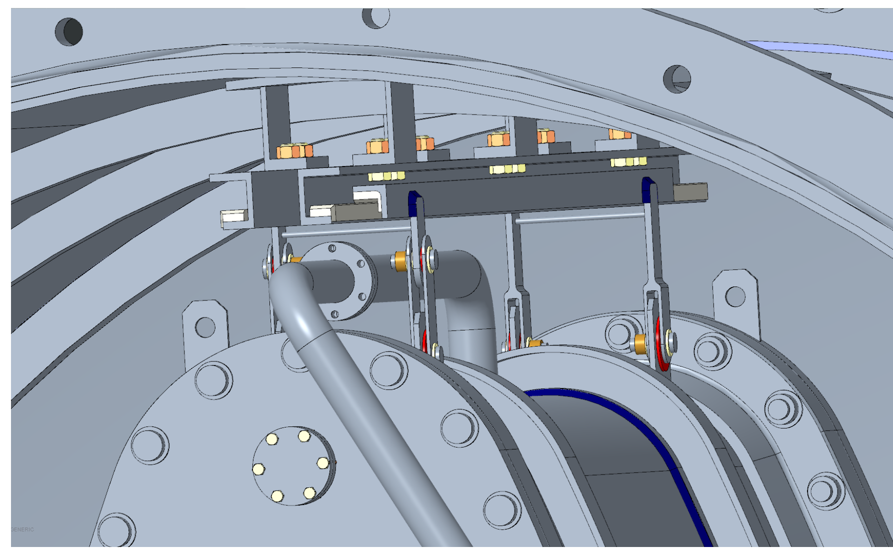
Vacuum Tank



- Order to Cryo Service was already sent
- Discussion with company representative was held in Legnaro:
  - Suspension system
  - Installation in final External Vessel
- Some upgrade to the original quotation is needed for the new sliding system
- Expected delivery to LNL in June2025





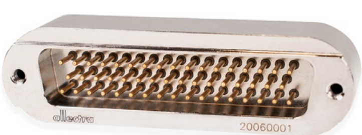


Electrical tests on Interconnections

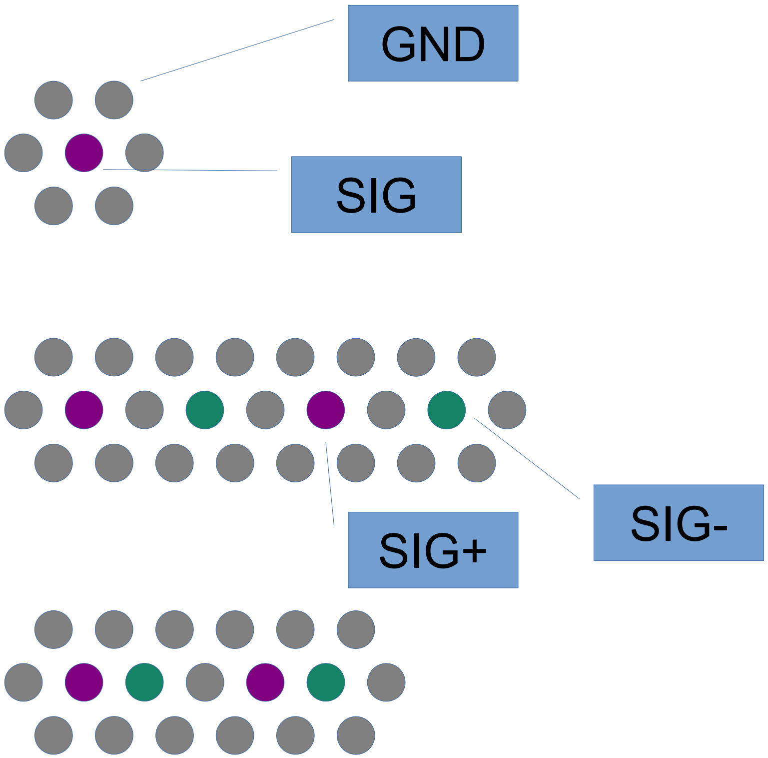
- Feedthrough vendors only offer:
  - Plain D-SUB
    (up to 50 pins)
  - Individual SMA
  - D-SUB with coax
    (up to 8 coax)
  - High density D-SUB
    (up to 78 pins)

- Neither SMA nor D-SUB with embedded coaxial offer enough density
  - There is no workaround except larger flanges

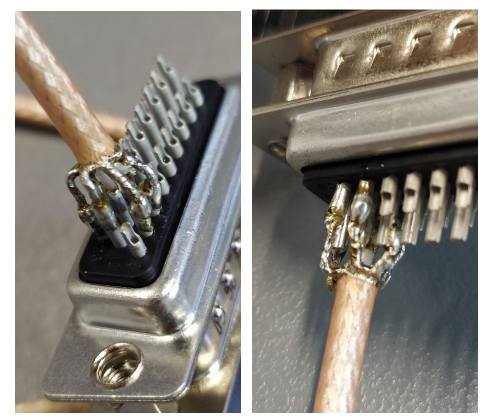
- Neither plain D-SUB nor HD D-SUB offer controlled impedance for LVDS
  - Partial workaround by “smart” pin layout



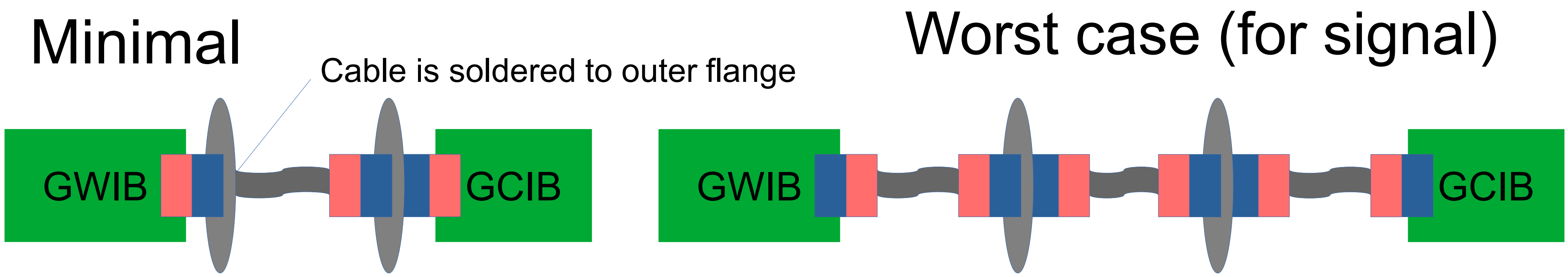
Electrical tests on Interconnections



- Some possible layouts
- Currently testing the first (single ended 50Ω)



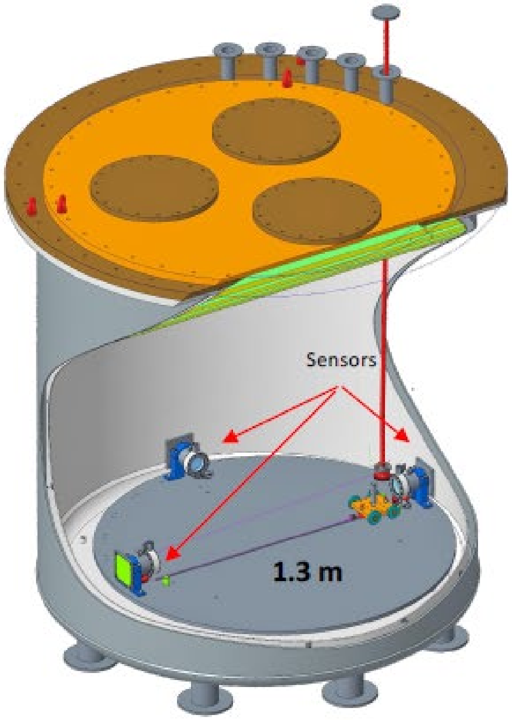
Electrical tests on Interconnections



- Must plug GWIB and GCIB on the flanges
- GWIB and GCIB become multiple PCBs for mechanical reasons

- 6 connections
- More cable
- More flexibility for board design and placement

Plan for camera optimzation



- Cosmic ray detection in LAr (+Xe) triggered by an external cosmic ray system
- In ARTIC we have to install a LAr recirculation (+ Xe doping system) for collecting scintillation light (by end 2024)
- An external CRT will be mounted on the top and on the bottom
- We plan to use 2 - 3 cameras for reconstructing the muon tracks

These tests:
- will validate the possibility to use the new detectors in GRAIN
- will allow us to design and test the final detectors and electronics
- will provide additional measurement of LAr properties

TDR: GRAIN chapter

- Mechanics and Cryogenics system updated

1.1.2 Mechanical Design

As depicted in Figure 1.1, the GRAIN cryostat consists of an Internal Vessel hc Vacuum Vessel, both with elliptical transverse shape. The Internal Vessel, made of (AISI 316L), has elliptical transverse base with axes measuring 49 cm and 148 cm anc length of 150 cm. It is designed to store 1 t of LAr and withstand an internal press

The Internal Vessel includes the main body with a 6 mm thick shell, reinforced by ribs, each 6 mm thick, to ensure structural rigidity while minimizing the material bu

DUNE Near Detector Prelimin

Chapter 1: SAND

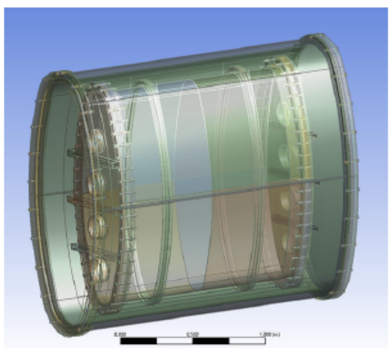


Figure 1.1: GRAIN cryostat

to the beam axis. The two open bases are closed by two endcaps 30 mm thick, each instrumentation flanges: 4 CF-DN160, 2 CF-DN63 and 2 CF-DN40, fitted with fe signals and detector power. The thickness of the endcap was chosen to ensure sufficient rigidity to avoid deformations that would compromise the sealing of the 'Helicoflex' seal. The imaging detectors (based on lenses or masks) are mounted on frames attached to the endcaps. There are three pipes welded to the Internal Vessel, two on the bottom for the filling and circulation for purification of LAr and one on the top for the boil off of GAr. The thermal insulation of the Internal Vessel relies on the vacuum created by the Vacuum Vessel, the minimized thermal conduction through the suspension and the multi layer insulation loosely wrapped around the

1.1.3 Cryogenic System

Since a large number of active electrical component will be immersed in LAr, resulting in a significant amount of heat being injected, a phase separator is positioned with a 4 m elevation difference from the GRAIN cryostat. In this way, the hydrostatic level is utilized to achieve subcooling of the LAr, providing a gain of approximately 4 K on the boiling temperature of argon. This help to avoid the formation of bubbles, which could deteriorate optical transparency, generate microphonic noise, and create large thermal gradients. The phase separator consist of a tall and narrow dewar with a capacity of approximately 200 l of LAr in which the liquid phase is separated from the gaseous phase by gravity.

The required LAr purity for optical transparency is $O_2 \leq 0.03$ ppb, $N_2 \leq 0.03$ ppb and $H_2O < 5$ ppm. To maintain this level of purity during detector operation, a recirculation and purification system is required. One purification filter is utilized during the filling operation of the entire system to pre-purify the LAr. Additionally, two redundant purification filters installed in parallel ensure continuous purification. Each purification filter has its own vacuum jacket, ensuring independence. This design allows one filter to be dismounted for regeneration without affecting the other, as each has its own vacuum, preventing the need for heating the remaining filter and so without interrupting the operation of the system, ensuring a constant purity of argon. Since the purification process occurs in the liquid phase, a cryogenic pump is required. Two centrifugal pumps are installed in a redundant parallel configuration inside a single vacuum container for thermal insulation, each capable of providing a mass flow of 14 g/s (0.6 l/min) and magnetically coupled machines to maintain the purity of Argon. The total heat load (the static heat load of the cryostat plus the heat load from the detector) must be be limited at 1500 W, resulting in a boil-off mass flow of approximately 9 g/s within the cryostat, which need to be recondensed. The generated GAr is delivered to the Re-condenser, where liquid nitrogen is used as cooling power in a U-tube configuration heat exchanger. The nitrogen operates in a loss configuration, so it is not recovered, while the LAr feeds by gravity the inlet of the pump. In Figure 1.4 are shown all temperature and pressure sensors, flow meters and valves required to control and monitor the system. A facility test in INFN-LNL laboratories is scheduled to verify the functionality of all proximity cryogenics prior to shipment to FNAL.

DUNE Near Detector Preliminary Design Report

Support frame

- Old preliminary studies