End Station Refrigerator 2 Cryoplant at JLAB

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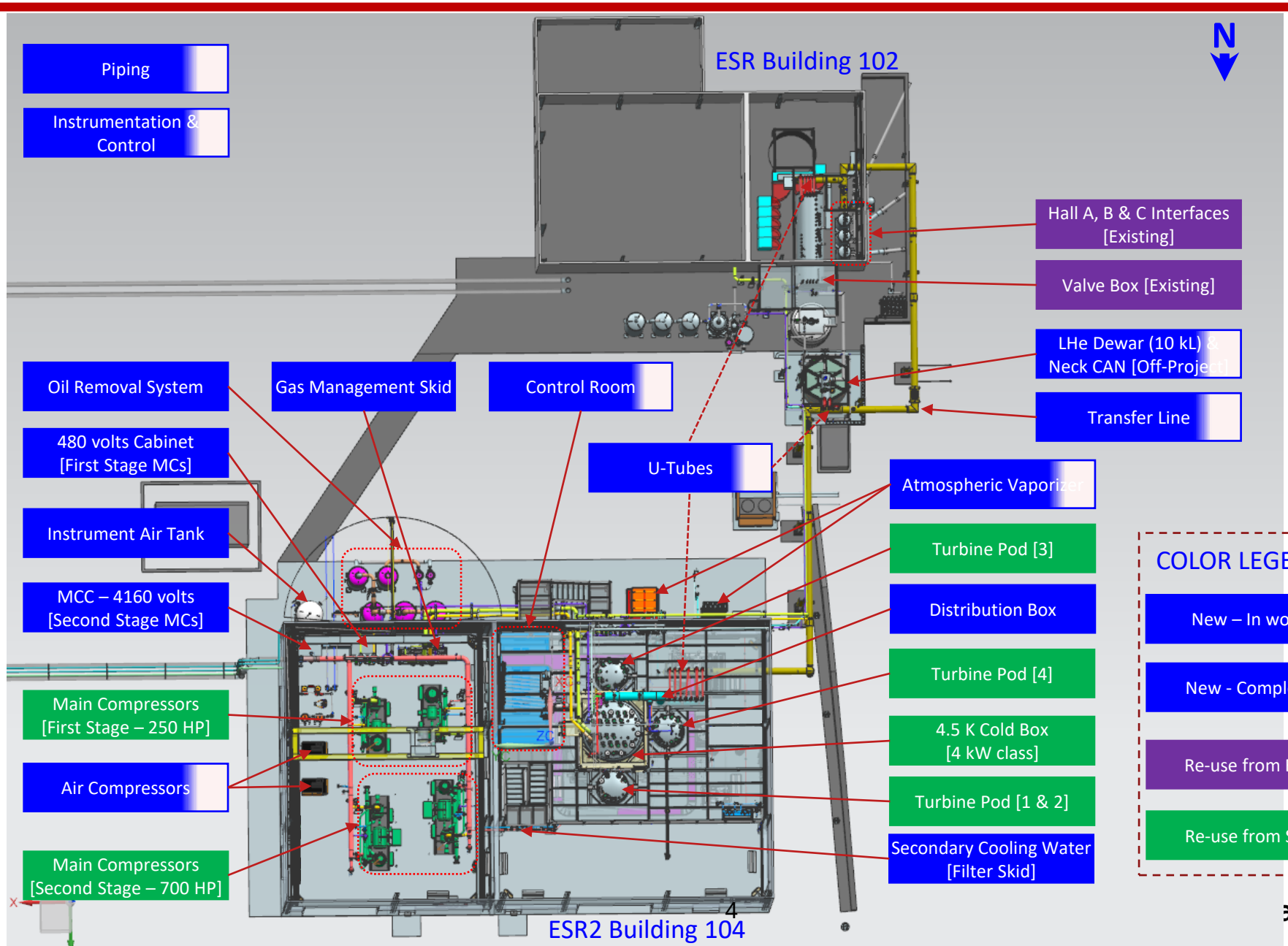
Introduction

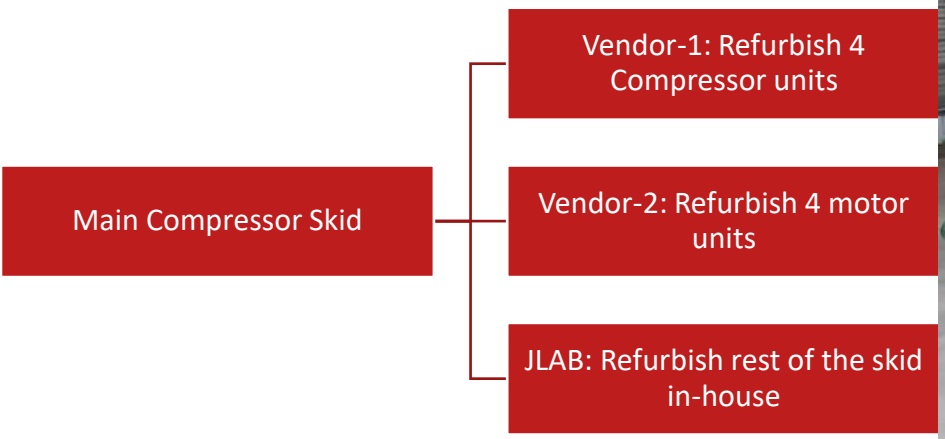
- Cryogenic cooling for the 4.5 K temperature spectrometer magnets, magnet current lead and 15 K temperature targets located at the experimental Halls A, B and C is currently provided by the End Station Refrigerator (ESR) 1.
- The 1500 W at 4.5K temperature capacity of the ESR1 cryogenic plant is boosted using JLAB's Central Helium Liquefier (CHL) by providing 10 g/s liquid helium at 4.5K, 3 bara to support the experimental loads.
- The existing ESR1 is 45+ years old and has insufficient capacity and reliability challenges due to the lack of critical spare parts that are no longer manufactured or available.
- End Station Refrigerator 2 cryogenic plant with 4 kW at 4.5K capacity is projected to replace the operating End Station Refrigerator by June 2024.
- JLAB received the cryogenic system from the Superconducting Super Collider Laboratory (SSCL) and ASST-A refrigeration system is currently under refurbishment to be used as ESR2 cryogenic plant.

ESR2 Cryogenic System



Refurbishment of Main Compressor System

- Main helium compressor system consists of Sullair made two 186 kW [250 hp], 460 V first stage and two 522 kW [700 hp], 4160 V second stage units in a skid including oil cooler, after cooler and bulk oil separator.
- The challenge was establishing a sub-contract for refurbishing the entire main compressor skid within the budgeted cost during the global pandemic.
- The following execution strategy was re-planned and implemented successfully as a cost and schedule control measure.



Refurbishment of Main Compressor System

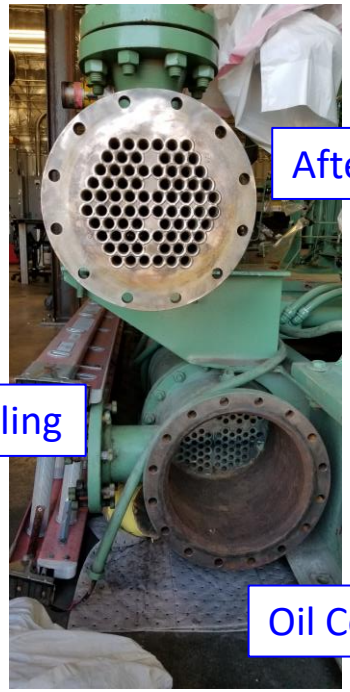
- Vendor-1 struggled to procure OEM parts for the Sullair compressor unit refurbishment. The schedule was impacted due to the longest lead oil pump and shaft seal kit.
- The original oil pump was obsolete and was replaced with a new one. JLAB supplied spare shaft seal kit to the vendor-1 to finish the work scope.
- Visible damage marked was observed at the inboard thrust bearing case, and replaced with new bearing kit.

Inboard Thrust Bearing Case

Refurbishment of Main Compressor System

- The main compressor skid was dismantled for cleaning and changing out soft seals. Internal rusting was discovered at the water stream side of the oil cooler and helium after the cooler.
- The affected areas were cleaned and descaled, maintaining the required thickness, measured with a laser tool, and verified after cleaning.
- Part of the affected piping sections were replaced with new ones.

Cleaning and descaling



Oil Removal System

- The oil removal system [ORS] comprises three oil coalescers, a charcoal-bed adsorber, and a final filter unit. ORS includes two charcoal-bed adsorbers and two final filter units for redundancy and quick changeover for regeneration purposes.
- Sub-contractors fabricated oil coalescers, absorbers, and final filters based on JLAB's built-to-print design.

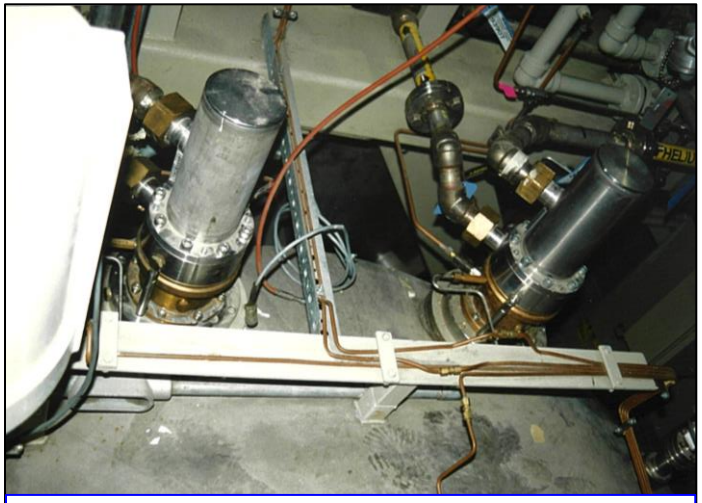
Oil Removal System.
NOTE: Picture from SSCL

ESR2 Oil Removal System

Jefferson Lab

Turbine and Break Cooler

- Linde Kryotechnik AG refurbished eight Sulzer-made turbines for ESR2.
- Design optimization was implemented using a Linde-style break cooler mounted directly on top of the Turbine cartridge.
- Original Sulzer-made Turbine was designed and installed at SSCL using an external Helium-Water heat exchanger as a Turbine break cooler, including intermediate piping.
- The new break coolers were designed and built by Linde Kryotechnik AG.



Turbine – 1 and 2 with separate break Cooler [Cooler not shown].
NOTE: Picture from SSCL

ESR2 Turbine – 1 and 2
Linde style break cooler

Regeneration System

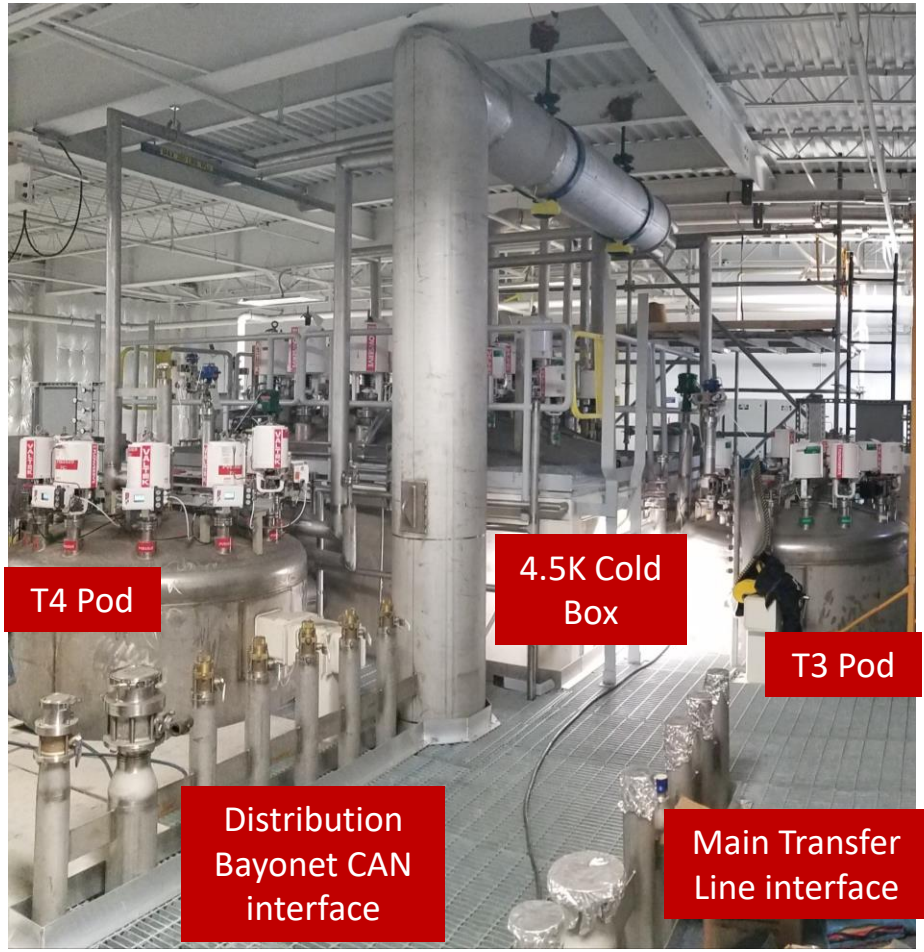
- SSCL regeneration system was very complex, with many more functions than the ESR2 project required.
- The electrical regeneration heater from SSCL is reused for the ESR2 regeneration system with simple and manual control to regenerate 80K and 20K adsorber beds. A simple and optimized design helped reduce the design, fabrication, and installation set of warm piping around the 4.5K cold box.

Regeneration System for the 80 K and 20 K adsorbers at 4.5K cold box.
NOTE: Picture from SSCL

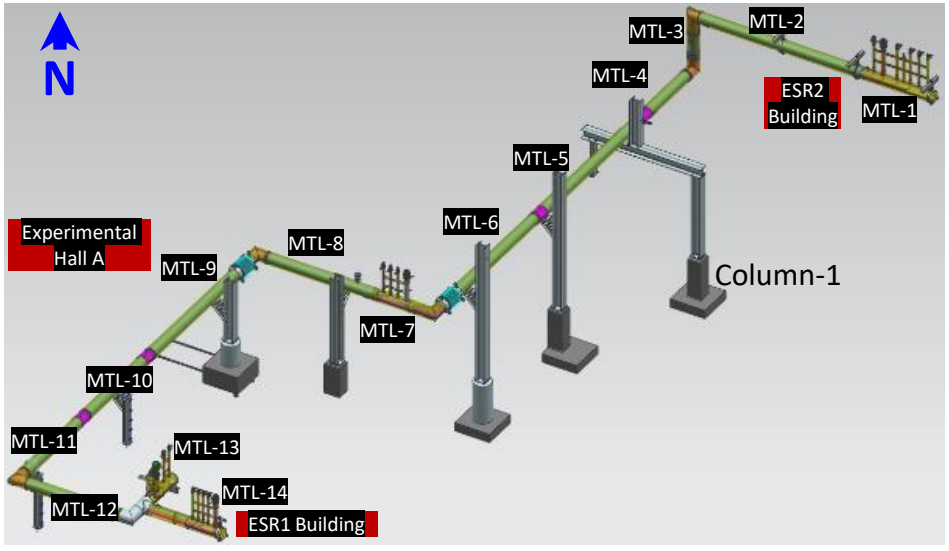
ESR2 Regeneration System for the 80 K and 20 K adsorbers at 4.5K cold box.

ESR2 Distribution Bayonet CAN

- ESR2 distribution bayonet CAN consists of 4.5K primary supply/return, 15K, 12K, and 8K target supply and common return, and liquid nitrogen piping distribution from the 4.5K cold box to the main transfer line.
- ESR2 distribution bayonet CAN was designed, fabricated, and installed in-house with seven interfacing female bayonets to connect with the main transfer line.
- The interfaces of distribution CAN are seven individual jacketed process pipes connecting to dedicated ports of 4.5K cold box, Turbine #3 Pod, and Turbine #4 Pod.



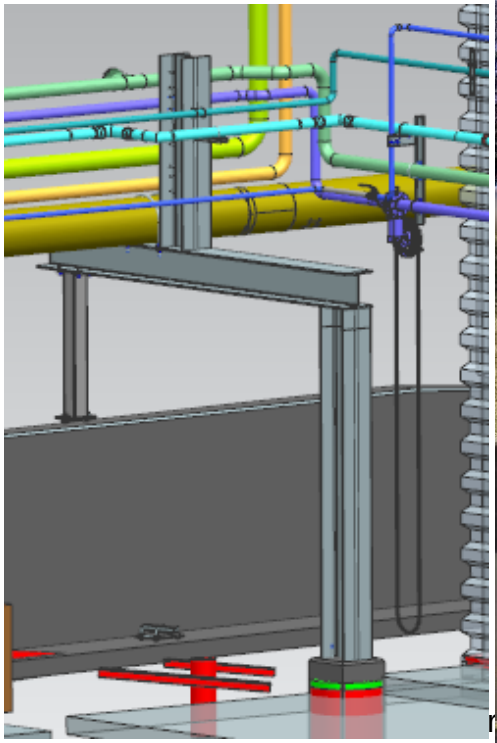
ESR2 Main Transfer Line [MTL]



- ESR2 50m+ length main transfer line was designed and fabricated in-house. Currently, the last field joint work is ongoing.
- Fourteen segments were fabricated, including four bayonet segments for interfacing with distribution bayonet CAN, liquid helium Dewar, ESR1 valve box, and Hall A, B, and C CANs.
- Several installation challenges were faced, including being the schedule critical path item for the ESR2 project.

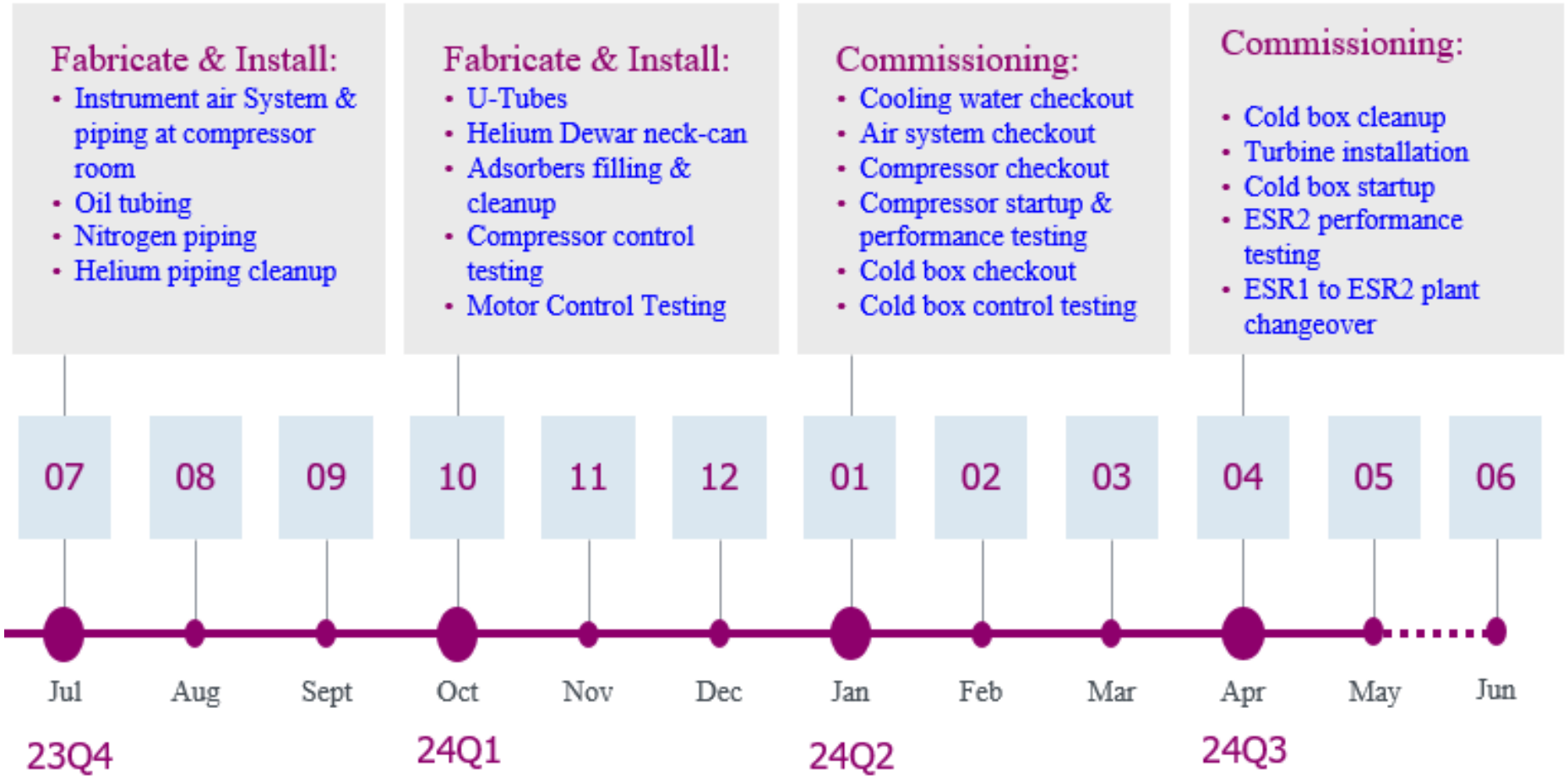
ESR2 Main Transfer Line Challenges

Conflict: Existing water piping and valve at the column -1



- Utility water piping and equipment incursion was detected after the ground excavation for the MLT support column-1 foundation work.
- Column-1 design was modified, and the base foundation was relocated – thanks to 100% in-house work with quick resolution.
- A detailed site survey of all transfer line foundations revealed that elevations are about 152 mm [average] lower than expected due to the error in old facility drawings.
- All concrete transfer line support foundations were reworked to fulfill the required elevation.
- As most of the transfer line is routed outdoors, weather [winter, rain, wind, and summer] has impacted the installation work.

Project Schedule Look Ahead



Conclusion

- Design is complete during the global pandemic.
- Fabrication and installation challenges are summarized in the current talk.
- Fabrication and installation of the main compressor and cooling water systems are complete.
- Refurbishment of 4.5K cold box and distribution bayonet CAN are complete.
- Installation of the main transfer line will be complete by July 2023 end.

Please visit our POSTER on Jul 11, 2023, 9:15 AM :

“Design and refurbishment of End Station Refrigerator 2 at Jlab”

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Question?

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