

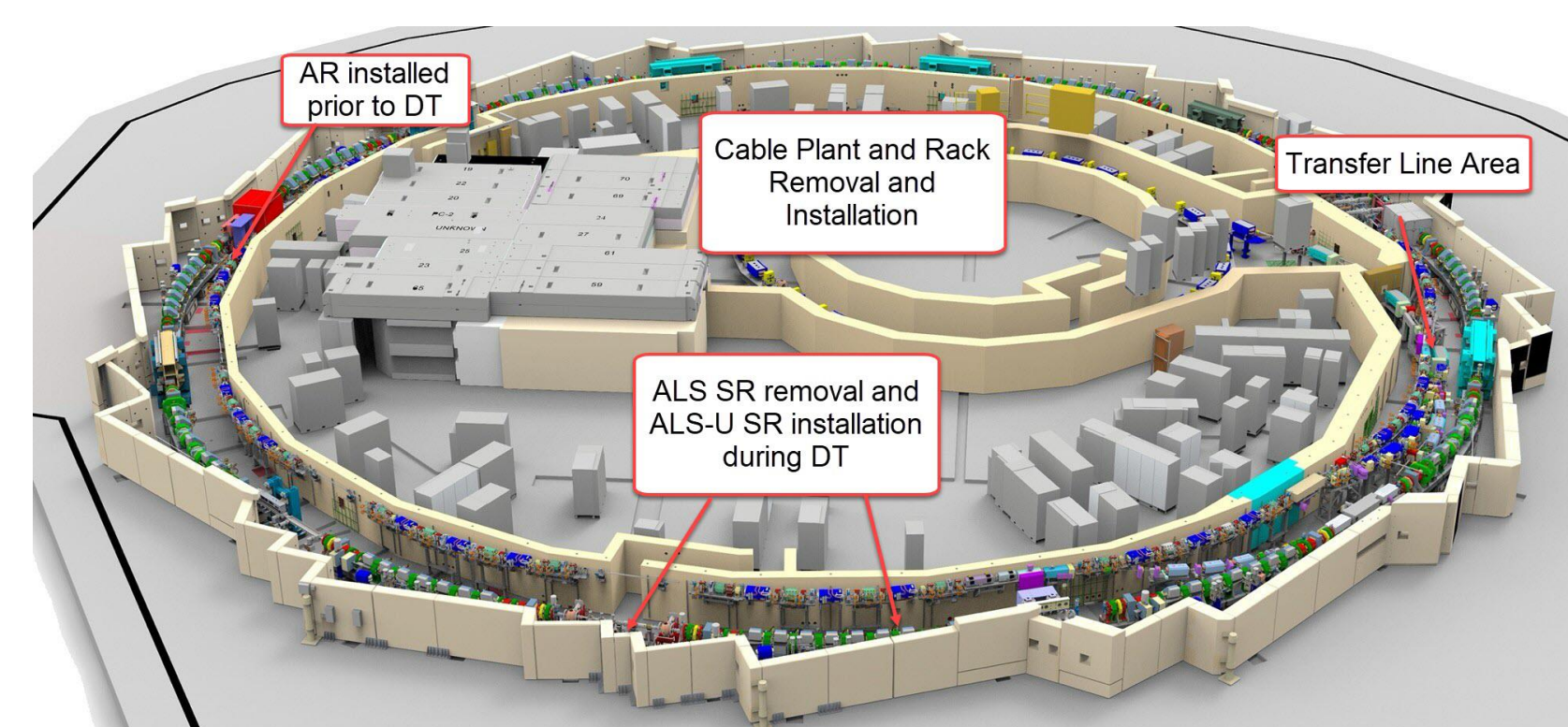


# ALS-U Accumulator Ring installation progress and lessons learned

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## Abstract

The ALS-U project is an upgrade to the Advanced Light Source (ALS) at the Lawrence Berkeley National Laboratory that aims to deliver diffraction-limited x-ray beams with an increased beam brightness two orders of magnitude for soft x-rays compared to the current ALS facility. The new storage ring (SR) design utilizes a nine-bend achromat lattice with reverse bending magnets and on-axis swap-out injection from an accumulator ring (AR).

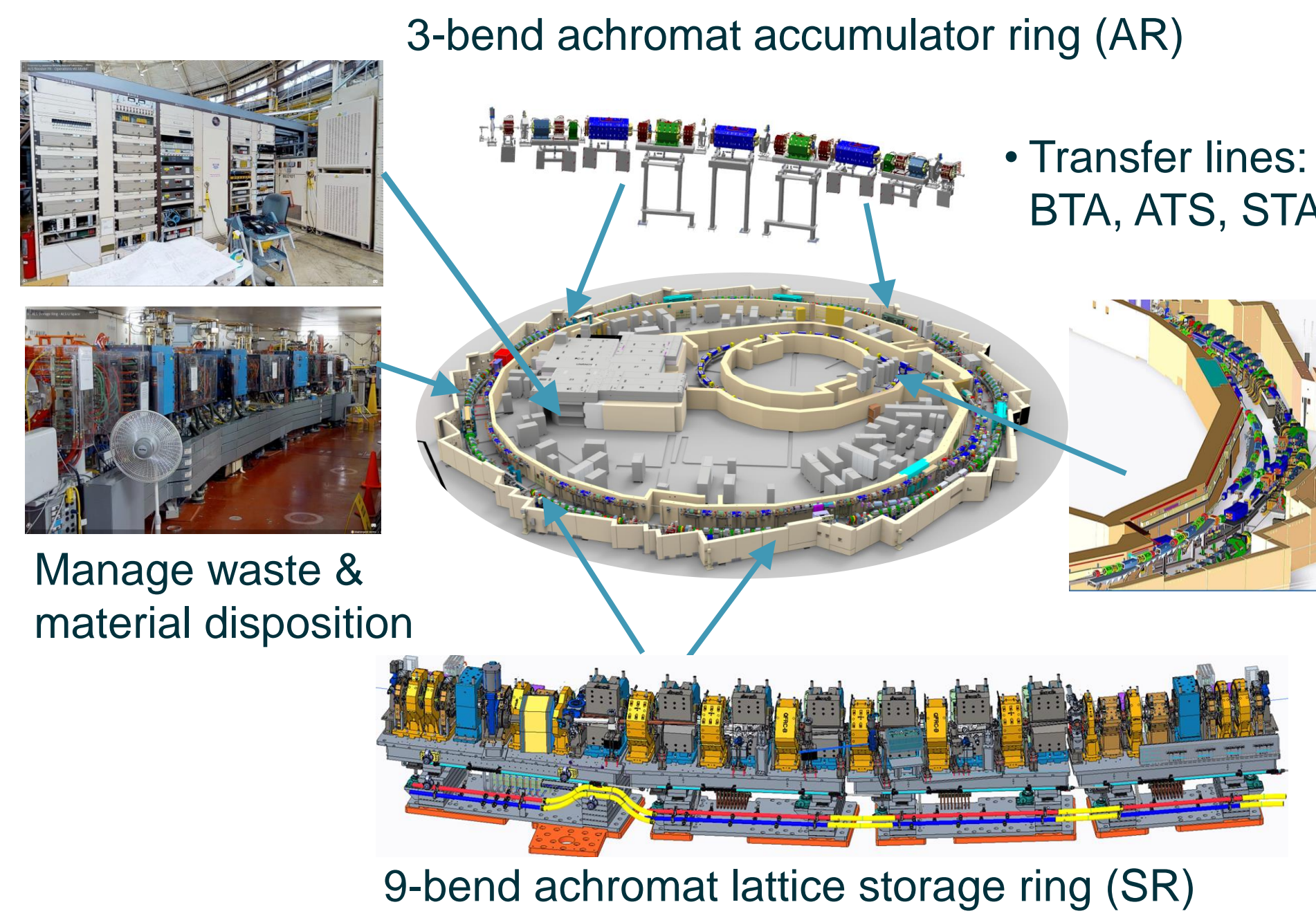


The AR is installed on the inner wall of the tunnel. Ground based bottom-up lifting and overhead crane installation methods are utilized. Preparation activities are performed before the main installations. Installation processes are guided and documented by QA procedures.

## Removal and installation scope for the ALS-U

### Removal and Installation Phases

- Site Preparation of the existing tunnel for the accumulator ring installation
- The installation of the accumulator ring prior to Dark Time with the ALS continuing to operate
- Preserve Injection booster synchrotron and upgrade injection energy from 1.9 GeV to 2 GeV
- 12 month DT: Replace the existing storage ring and commission the ALS-U



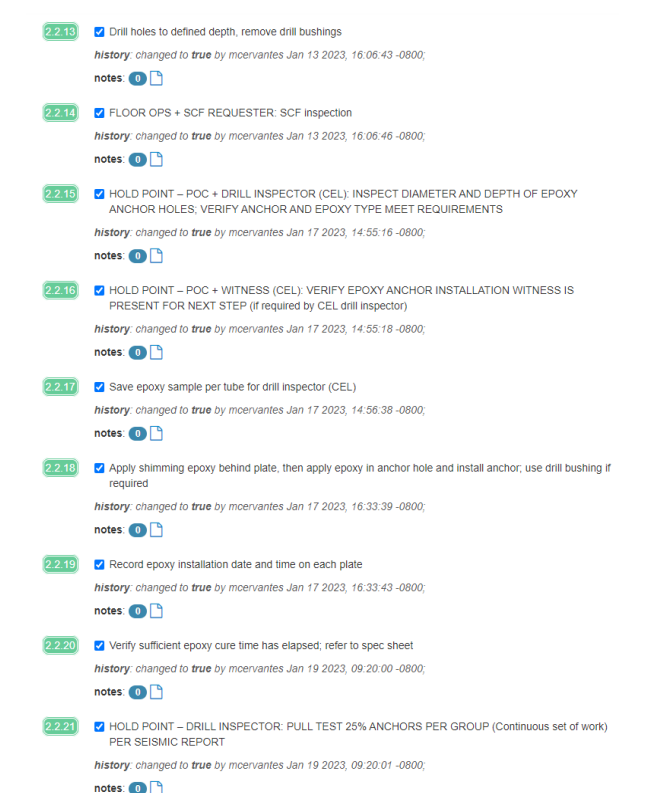
**Accumulator ring: CD-3A**  
Installation: 2020-2025  
~ 70 metric tons  
~ 61,500 hours  
~ 2,500+ cables  
~ 40+ months

**Storage ring: ~9 months**  
Dark Time: 10/1/2025-9/30/2026  
~ 500 metric tons (in/out)  
~ 124,400 hours  
~ 10,000+ cables  
~ 9 months

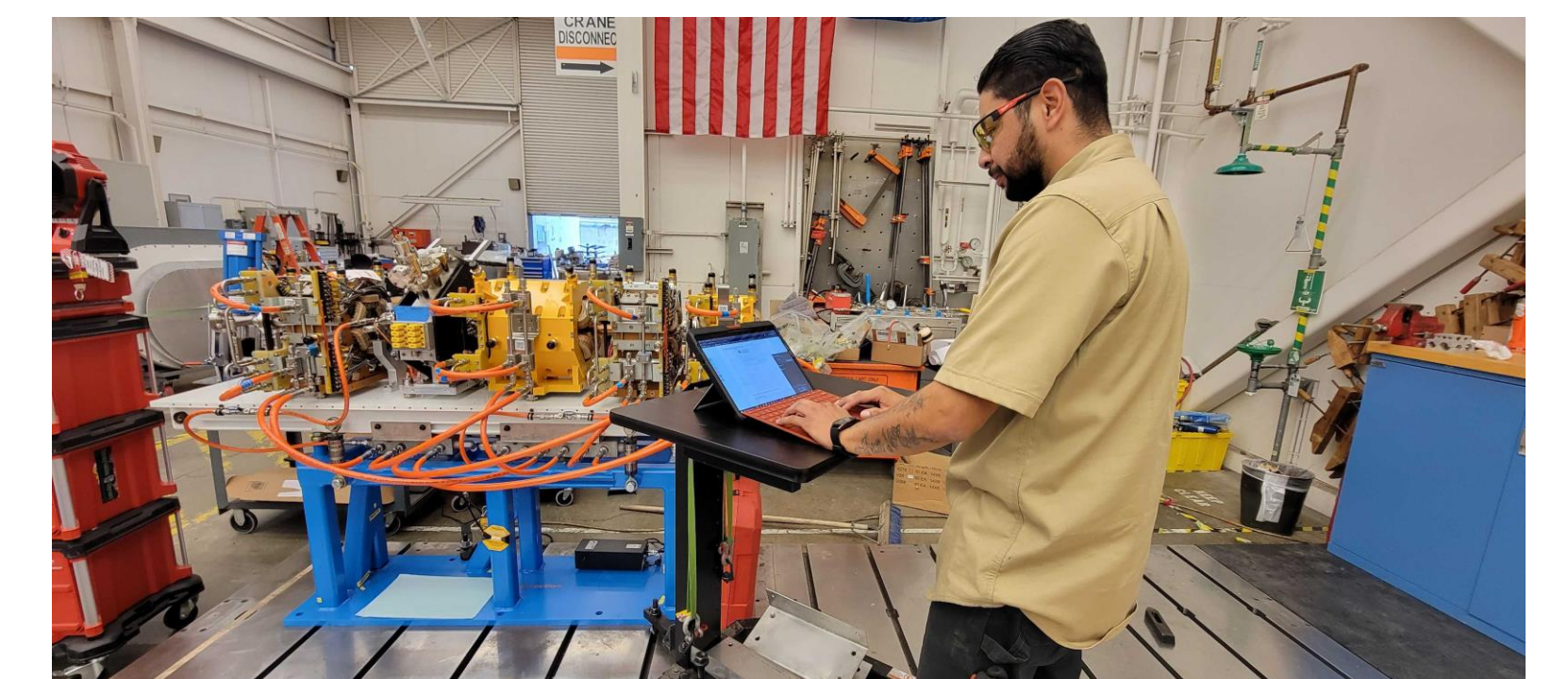
## Installation checklists

All AR installation activities are guided and documented through digital eTravelers. Each member of the installation team has the ability to view, edit and complete the eTraveler steps. Completed eTravelers are stored in Windchill.

Snapshot of eTraveler system



ALS-U Mech Tech working with the eTraveler checklist

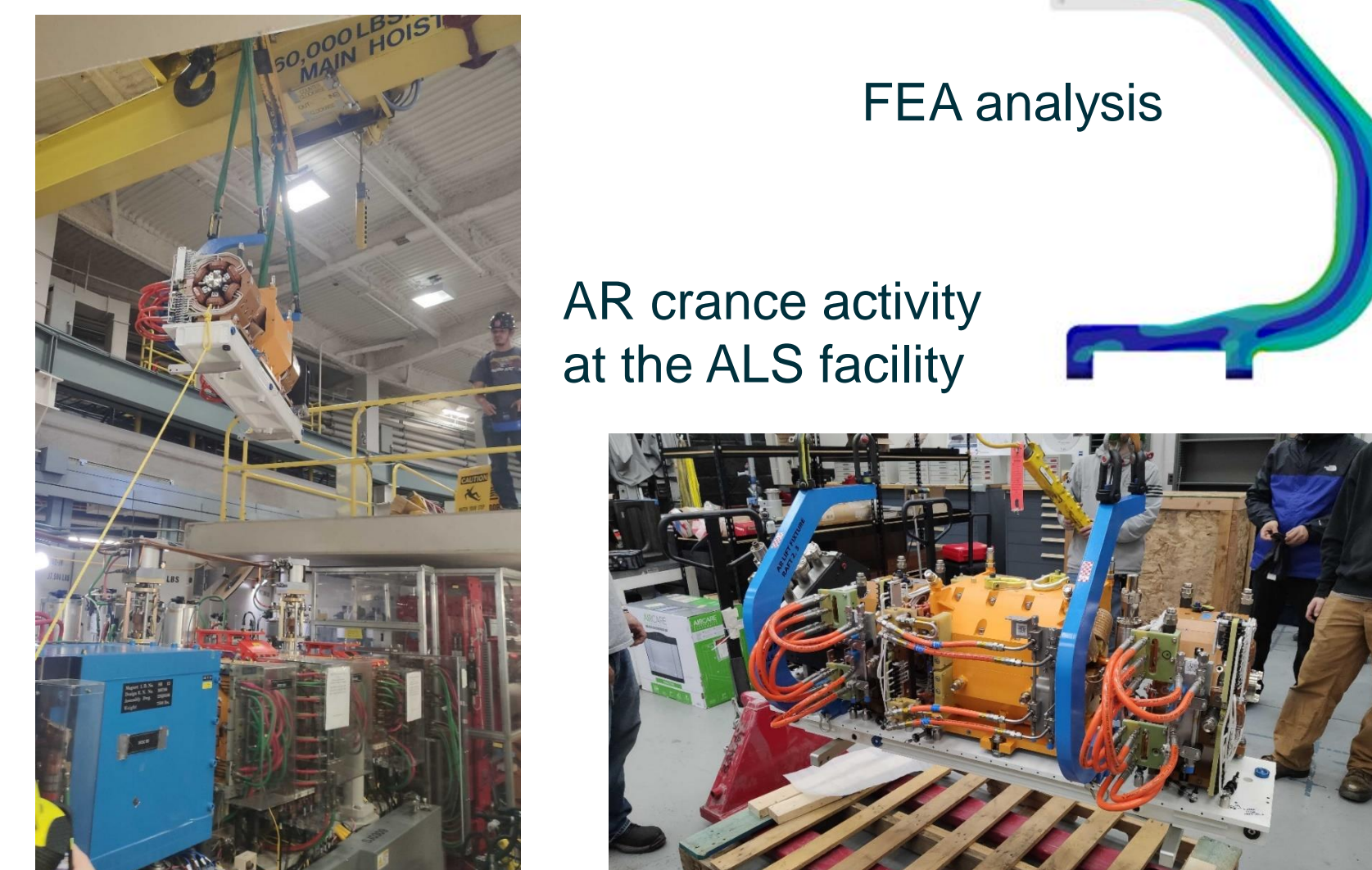


## AR overhead crane installation

Overhead crane installation of the AR requires removing roof blocks at the installation locations. Custom lifting frames were designed for the specific lifting requirements.



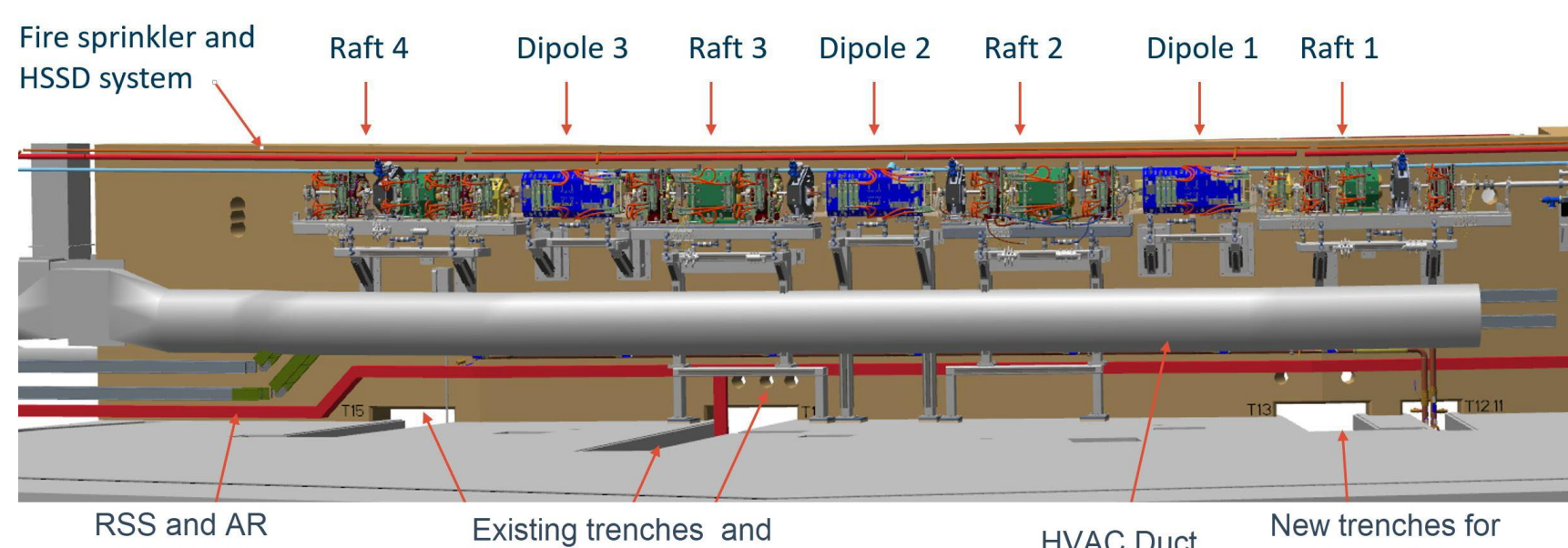
Roof block lift  
Lift Plan



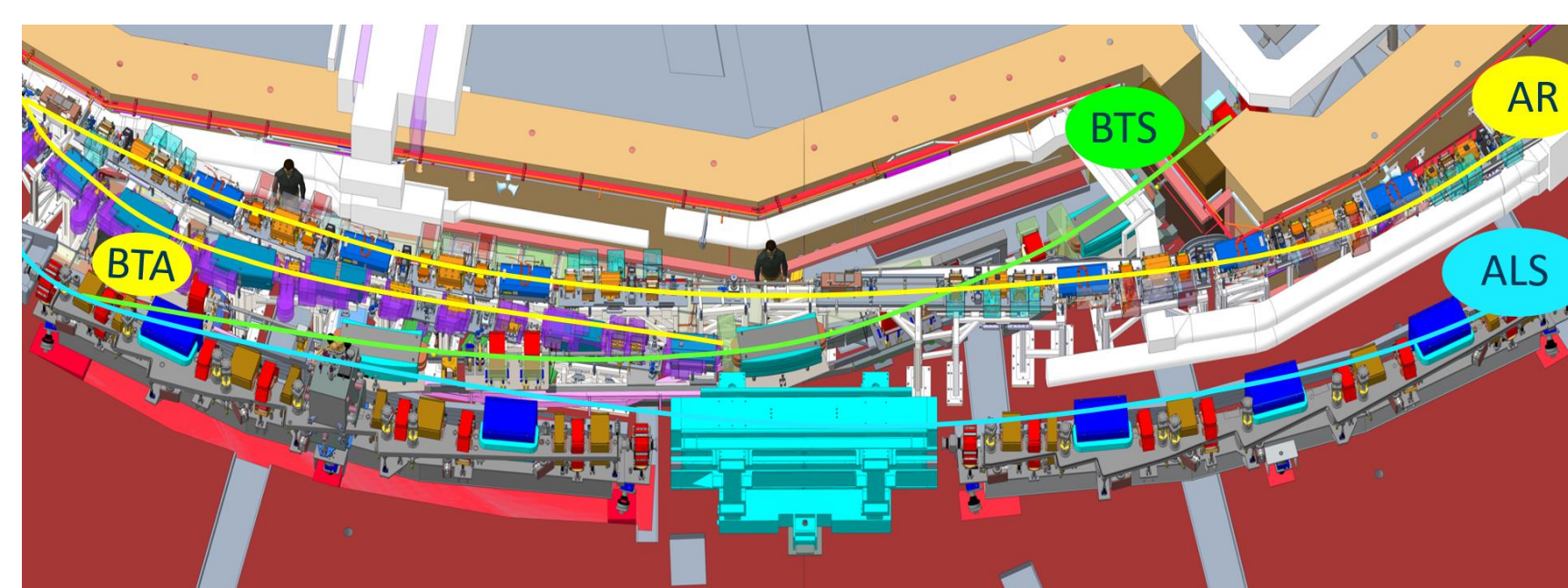
FEA analysis  
AR crane activity at the ALS facility

## AR installation in the tunnel

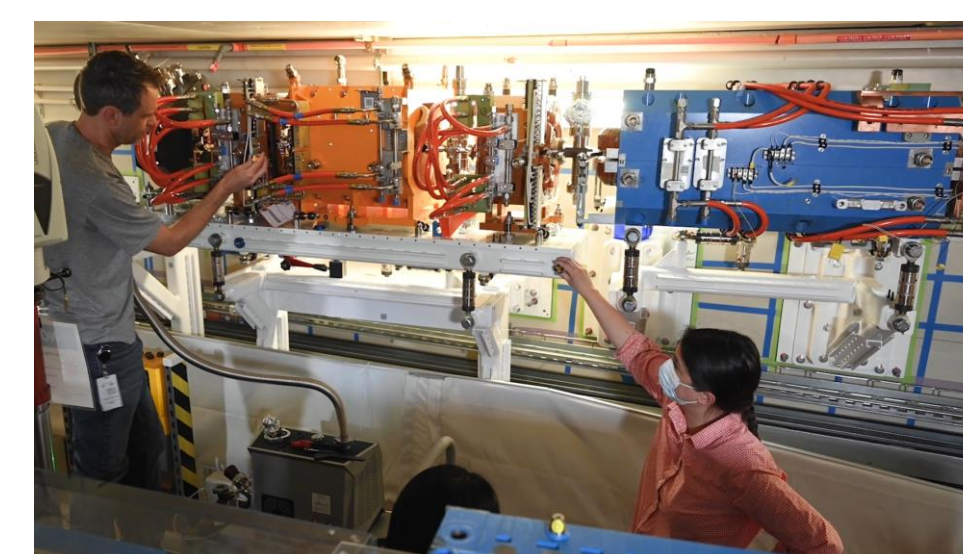
The accumulator ring is added to the inner wall of the existing ALS tunnel. Major challenges for the project are the space constraints inside the tunnel and the limited access to the tunnel. To minimize the assembly effort inside the tunnel, pre-aligned raft assemblies have been developed that integrate magnets, vacuum chambers, and diagnostics devices as well as localized cooling and cabling routing.



One of the 12 ARC sections of the 3-bend achromat AR



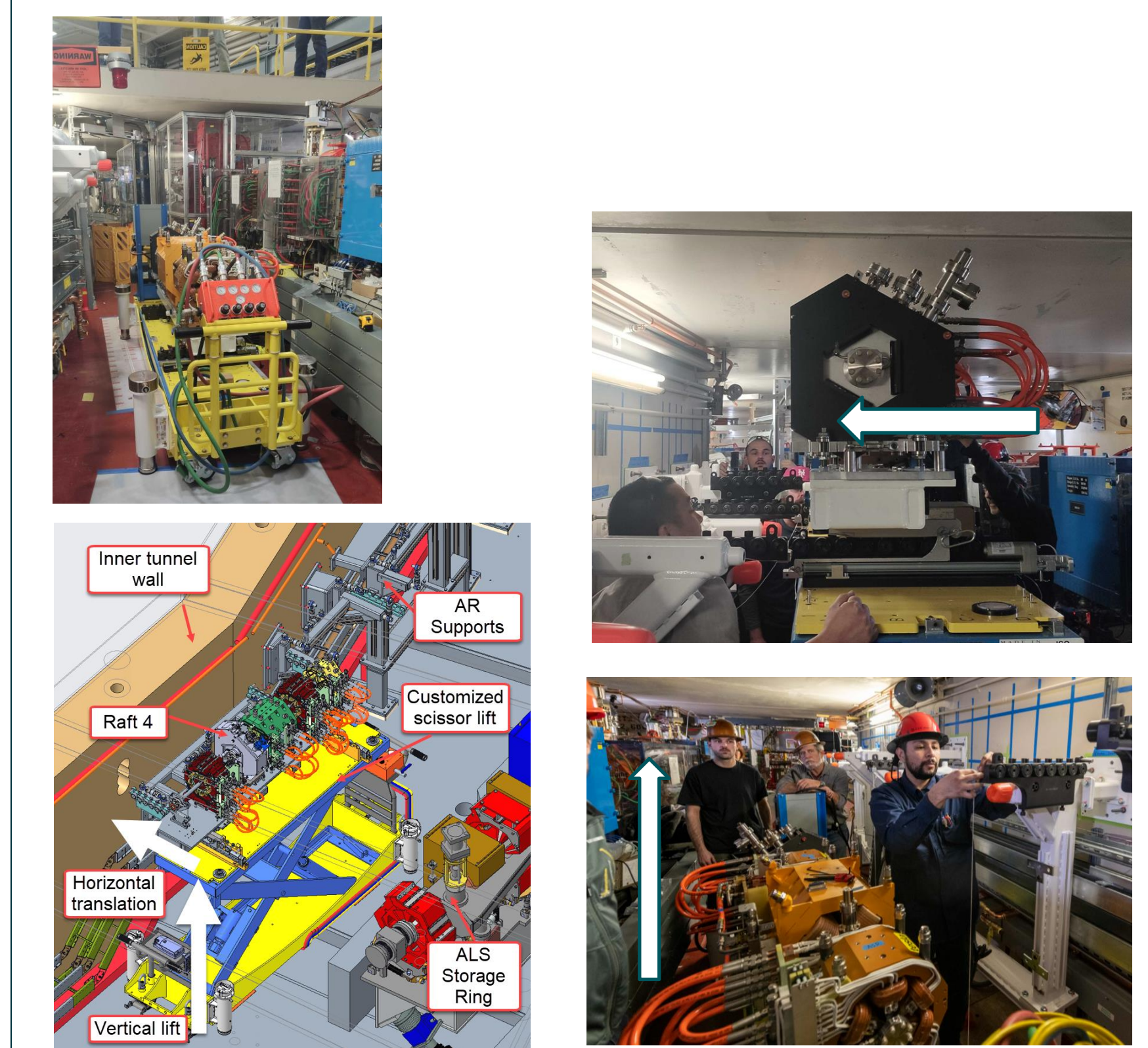
The ALS transfer line (TL) area with the Booster-to-Accumulator branching off the existing Booster-to-Storage ring TL



- Total 48 Rafts and 36 Dipoles
- RF Straight
- 7 standard straights
- 1 Diagnostics straight
- 3 Injection and extractions straights
- BTA Transfer line

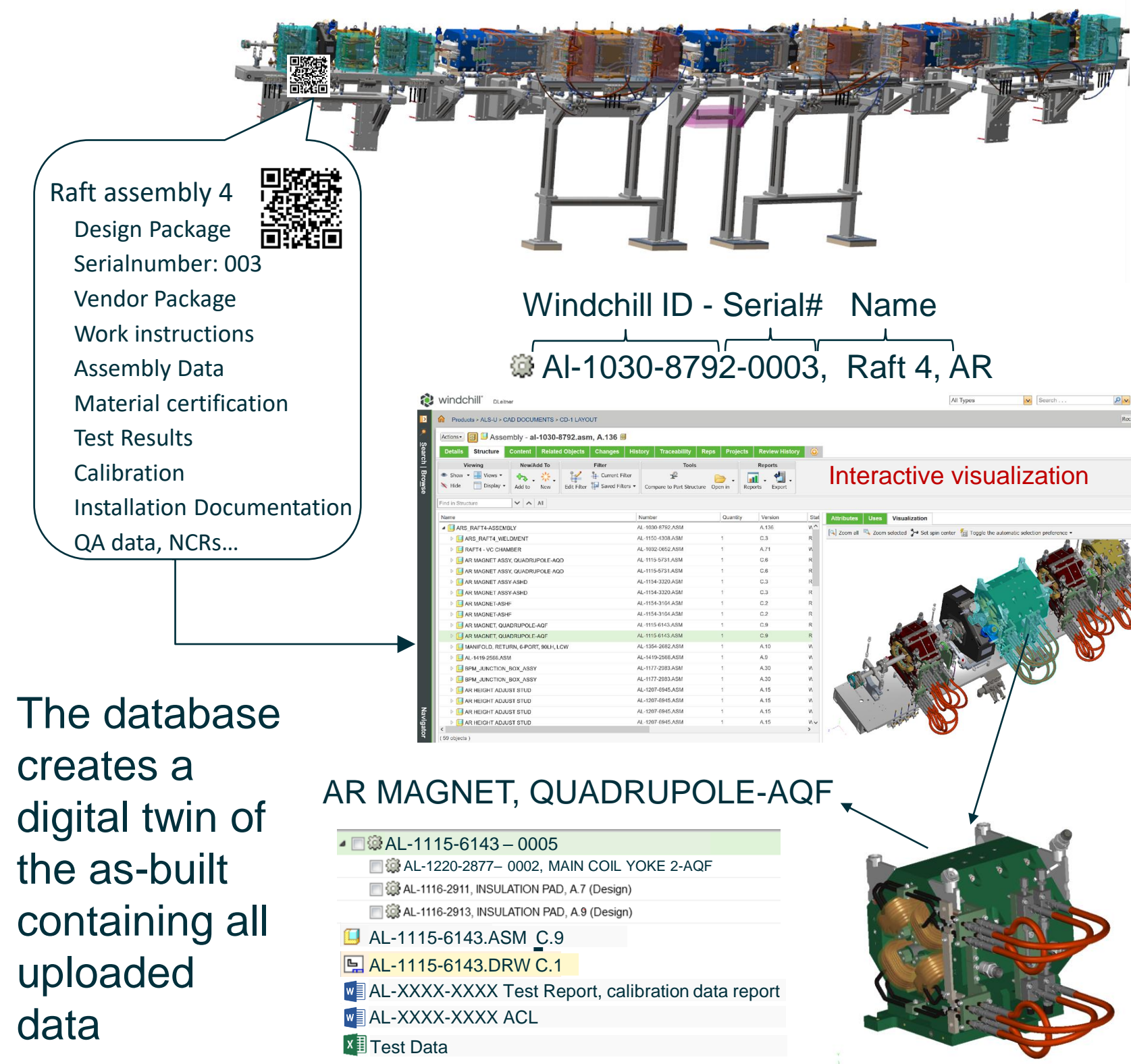
## AR bottom-up installation

The bottom-up AR installation is based on a custom built lifting cart. It allows the installation of AR rafts and dipoles with adjacent roof blocks in place. The lifting cart has an integrated scissor lift for vertical lifts and a roller system for horizontal translations.



## QA Database

An assembly QR code links each component to the Windchill database for drilldown of the as-built and serial number configuration.



The database creates a digital twin of the as-built containing all uploaded data

## AR installation activities – Lessons learned

The accumulator ring installation activities during our previous shutdown periods provided valuable lessons learned for the project. The R&I and installation team documented these lessons and improved the overall efficiency and quality of the installation activities.

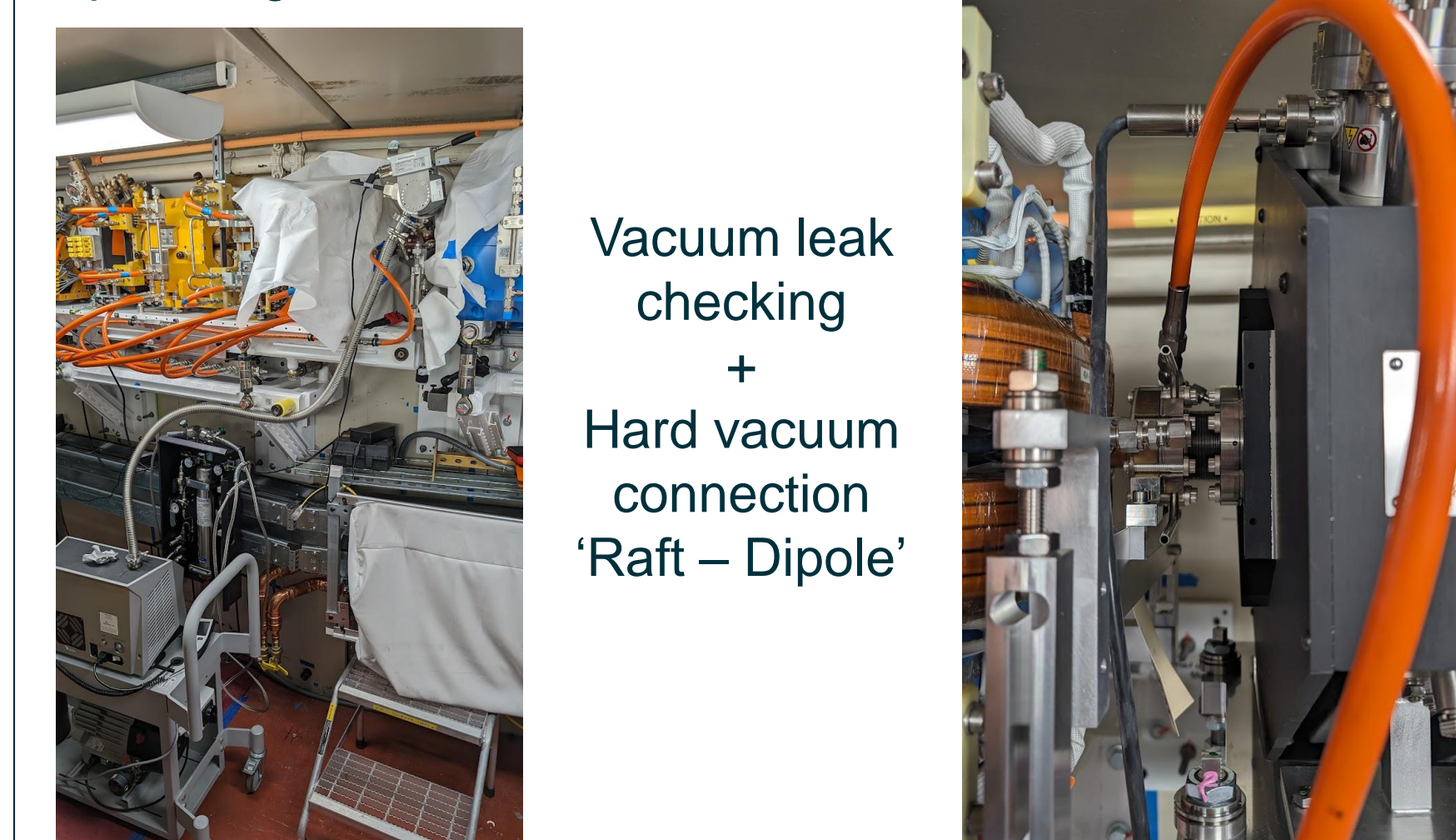


Prototyping pays off!

- Lifting operations and ground conveyance processes worked excellently.
- Thorough prototype testing paid off and allowed the installation processes to become very reliable.
- Ground transportation combined with bottom-up lifting is clearly the most efficient installation process.
- The modular nature of the rafts and dipole allows the installation of AR sector components in any sequence.
- Pre-qualifying several AR rafts before the shutdown streamlines the installation process.
- Installation hardware has to be precisely tracked during hand-offs.
- As-built conditions need to be thoroughly analyzed and understood to avoid potential 'showstoppers'.

## AR integration activities – WS24

AR integration activities have started during the winter shutdown 2024 on a sector level basis. After fully installing and aligning sector 6 in the ALS tunnel, including the neighboring straights sections, 3 'hard vacuum' connections and 5 bellow connections have been established. However, the integration process consists of many more steps, e.g. vacuum qualification, electrical connections, controls systems, diagnostics hardware, etc. These steps are planned for the next upcoming shutdowns.



Vacuum leak checking + Hard vacuum connection 'Raft – Dipole'

