Improvements on the Mu2e Remote Handling System

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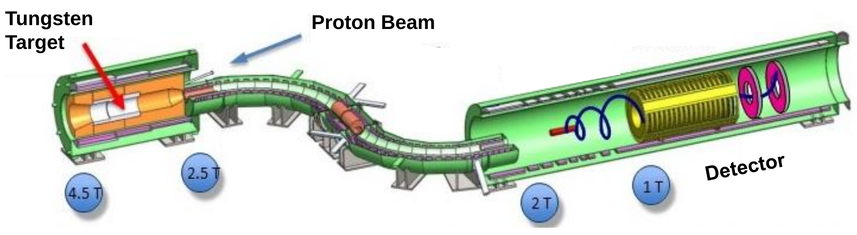
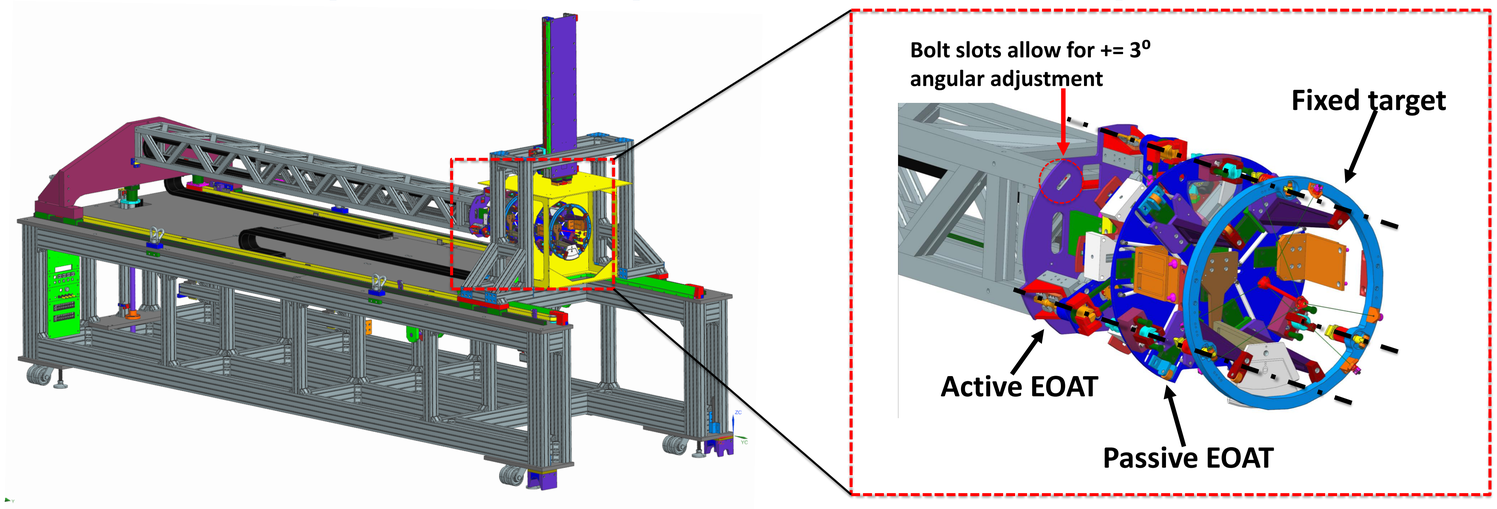
Mu2e seeks to uncover new physics

- **The goal of mu2e is to search for evidence of the neutrino-less conversion of muons into electrons**
- Muons in this experiment are produced by firing high-energy protons from the accelerator into a static tungsten target

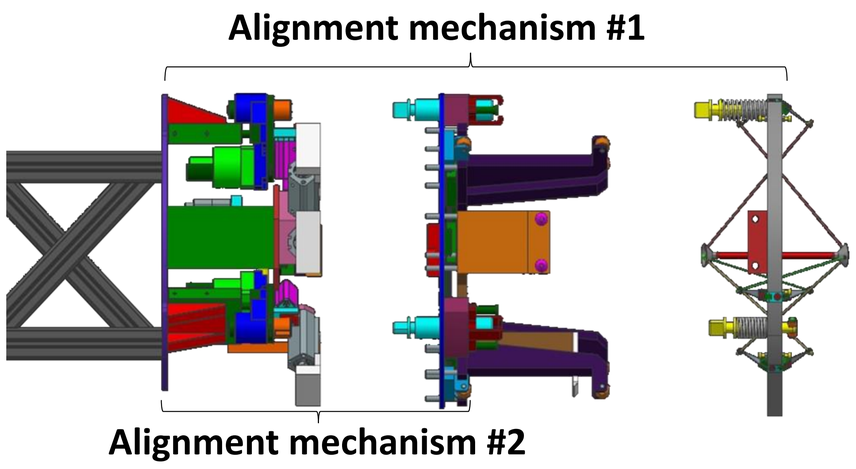


Robots are required to run parts of the mu2e experiment



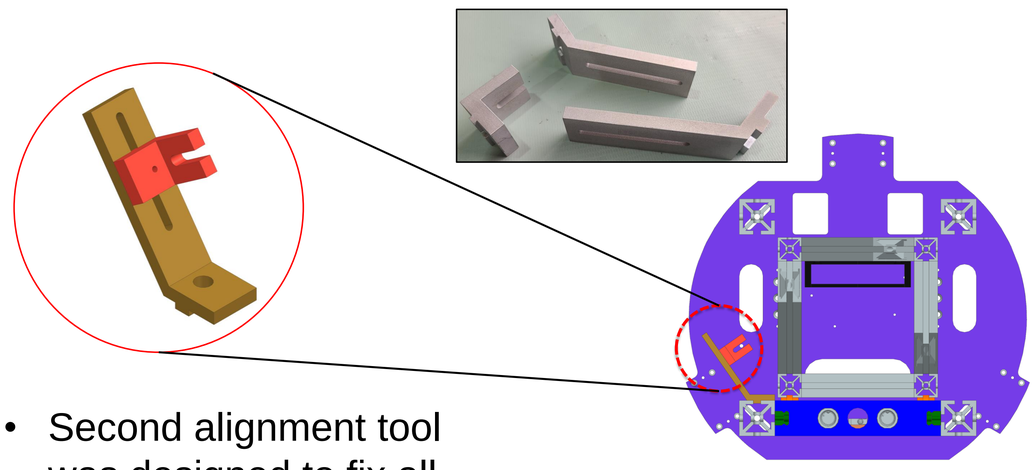
- Tungsten target becomes highly irradiated over time and **must be replaced once/year**
- 2 remote handling systems were designed, built, and validated for this task
- End-of-arm-tooling (EOAT) consists of 2 parts: (purple) active portion bolted to the frame and (navy blue) passive portion for grabbing the target fixture bolted to vacuum vessel

Modularity allows flexibility but can compromise reliability

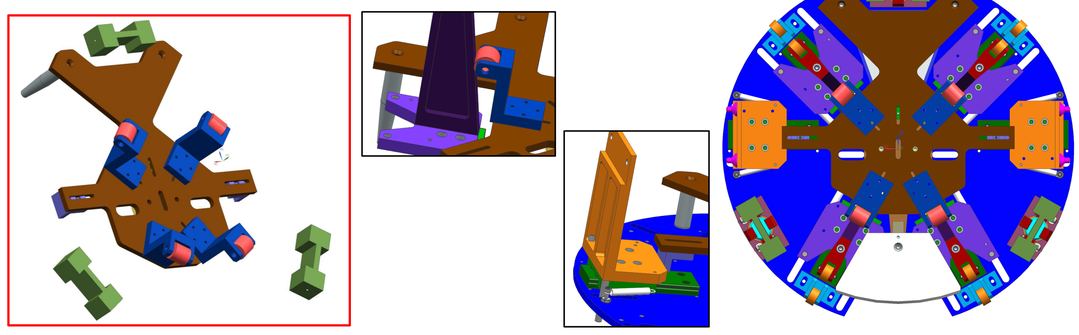


- Left assembly allows for angular adjustment of active EOAT
- **Active EOAT must return to the angular setpoint every time it is removed and re-installed**
- **Attaching passive EOAT is tedious and dangerous** because the purple rollers are free to slide and have features that slot into the active EOAT that are difficult to line up

Design of precision alignment tooling for improving repeatability

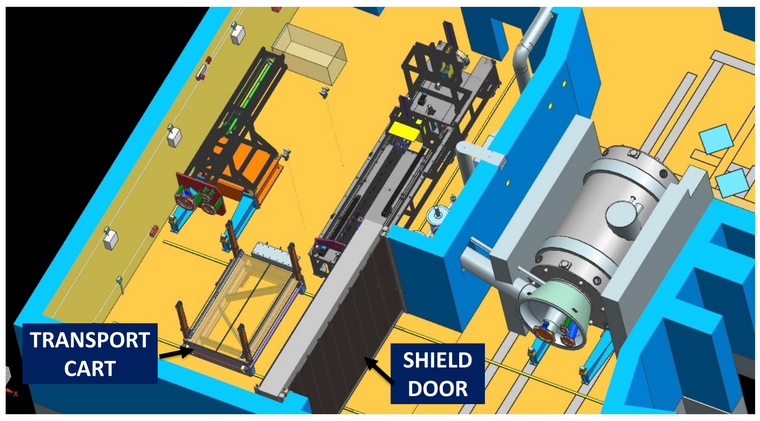


- Second alignment tool was designed to fix all moving parts on the passive EOAT while it is installed onto the active EOAT
- Assembly consists of several positioning features to facilitate installation, and all parts are either aluminum or PLA



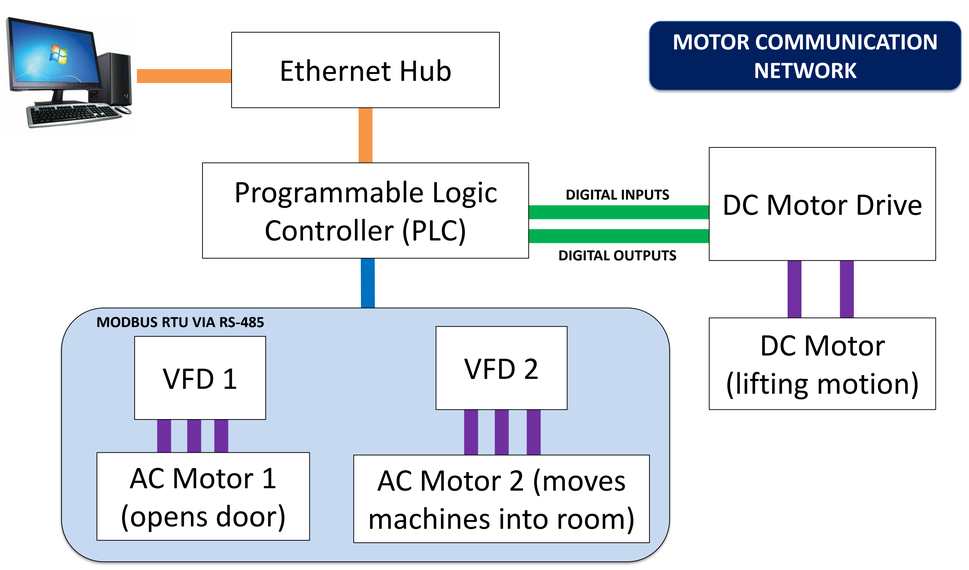
- Aluminum angled u-bracket design constrains the rotation of EOAT
- Tool mounts onto aluminum extrusion via T-slot nuts
- Detailed CAD models and drawings are finished, and both parts have been made

Robots are kept behind a radiation-shielding door

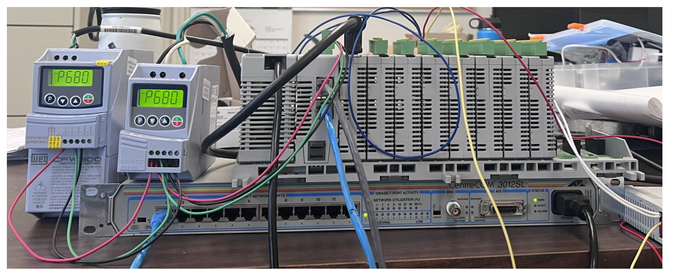


- Remote handling robots live in a containment room on the left
- They need to be transported into target hall on the right during target exchanges

Motion control system for door and cart requires complex communication



Benchtop setup was used to validate control system



- Proved that Modbus RTU can be used for the AC motor comms since it can both command the drives and receive status messages seamlessly
- DC drive only supports Modbus ASCII and has no reversing switch, therefore simple digital signals were deemed best for their control

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