

# Shield Plug-Mounted Hot Cell Manipulator

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- ▲ PaR Systems provided a standard M3000 Manipulator system to Oak Ridge National Laboratory in 1964
- ▲ For use in the Radiochemical Engineering Development Center (REDC) at ORNL
  - One of the missions of REDC is production of radioisotopes for industry and research
  - REDC produces more than 70% of the world's supply of  $^{252}\text{Cf}$
- ▲ Radiation levels require that operations and maintenance performed inside the hot cells must be done remotely

# Typical PaR M3000 Manipulator System

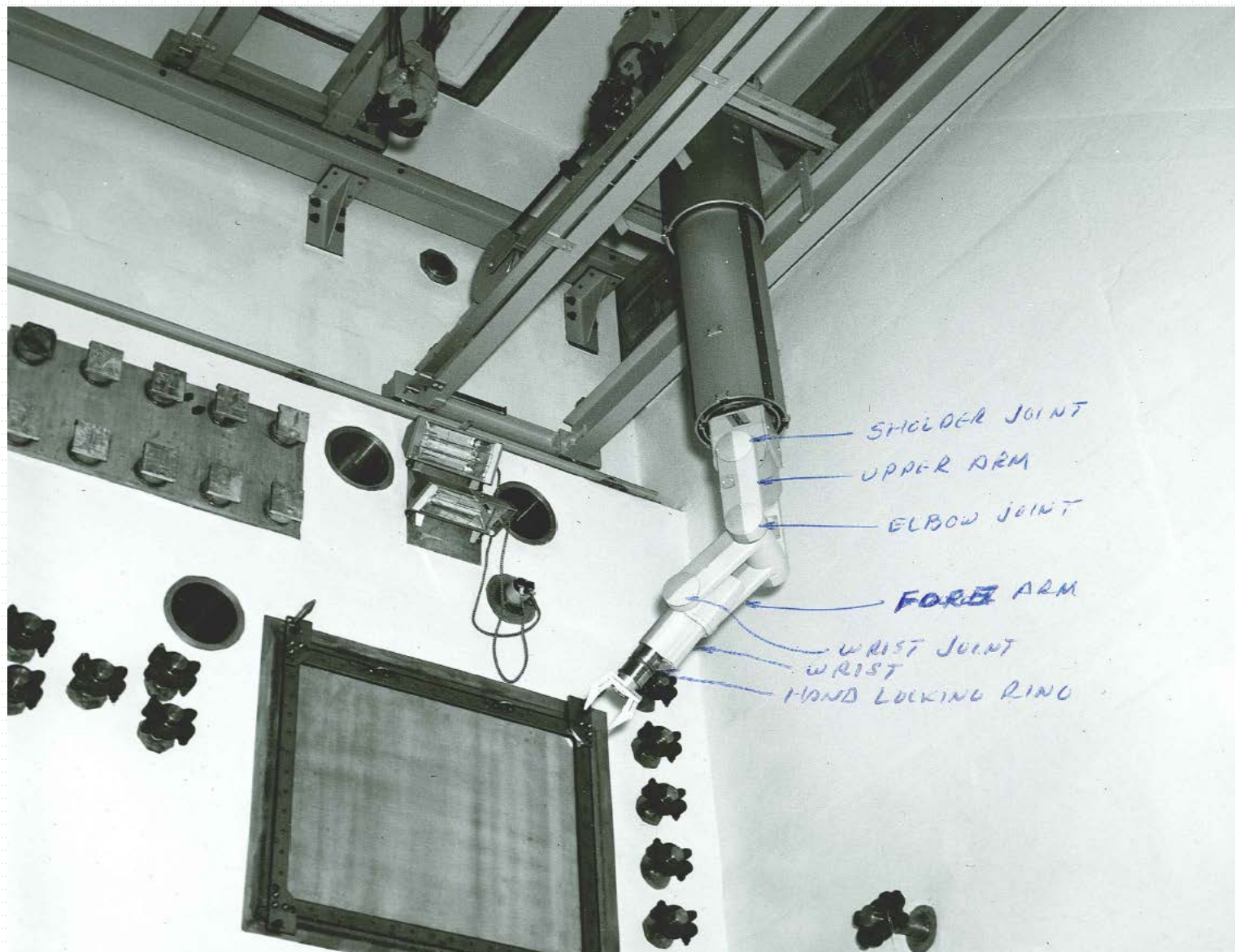


- ▲ Consists of:
  - Bridge (long travel)
  - Trolley (cross travel)
  - Telescoping Mast (vertical travel)
  - Shoulder Rotate
  - Manipulator Arm
  - Interchangeable Grippers
  - Power Center
  - Controller
- ▲ Hundreds of M3000's in service in hot cells worldwide
- ▲ Some in service for 50+ years
- ▲ Manipulator arm design has remained virtually unchanged since its introduction

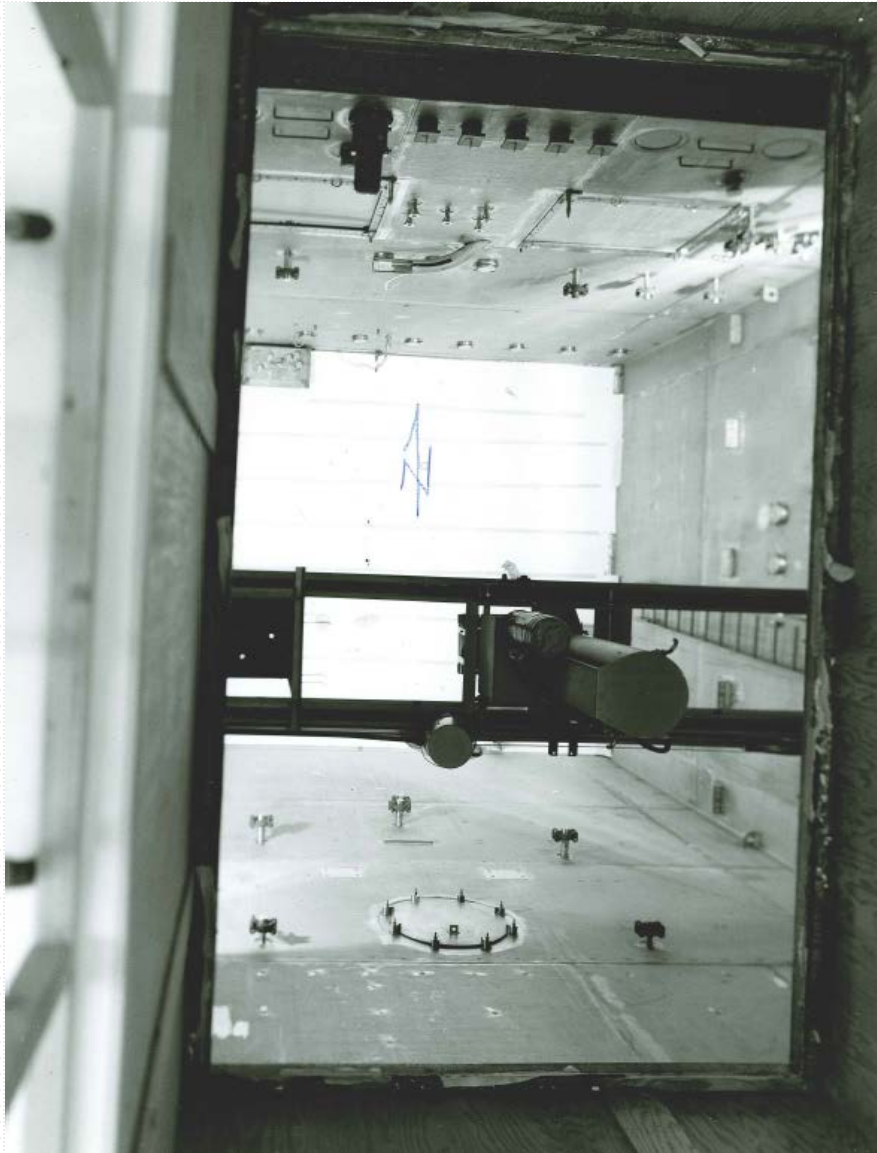
- ▲ Standard bridge and trolley-based system
- ▲ The system that got installed was designed for hands-on maintenance and not intended for use in a hot cell or maintaining remotely
- ▲ A drive failure occurred in 2008 which limited the usage of the system
- ▲ A workable solution (repair or replacement) was not identified in terms of cost, contamination or potential personnel exposure
- ▲ Significant challenges:
  - Installation through shield plug with minimal worker exposure
  - Remote connection of cables once new system is in cell



# Original Manipulator System in Cell



# Original Manipulator System in Cell



- ▲ View of bridge, trolley and mast looking down through the shield plug opening.
- ▲ Photo taken during hot cell construction in 1964.



# Original Manipulator System in Hot Cell



# Ceiling-Mounted Manipulator System?

- ▲ ORNL asked PaR if we could design a ceiling-mounted system that would not require removal of the existing system
- ▲ New system would have equivalent functionality, capacity and in-cell coverage
- ▲ The proposed system would mount to a new 6' x 10' x 5' thick shield plug in the cell ceiling
- ▲ Installation would be accomplished by simply replacing the original shield plug for a new one with the manipulator attached
- ▲ Required ORNL to design a new shield plug with provision for manipulator mounting and cable runs



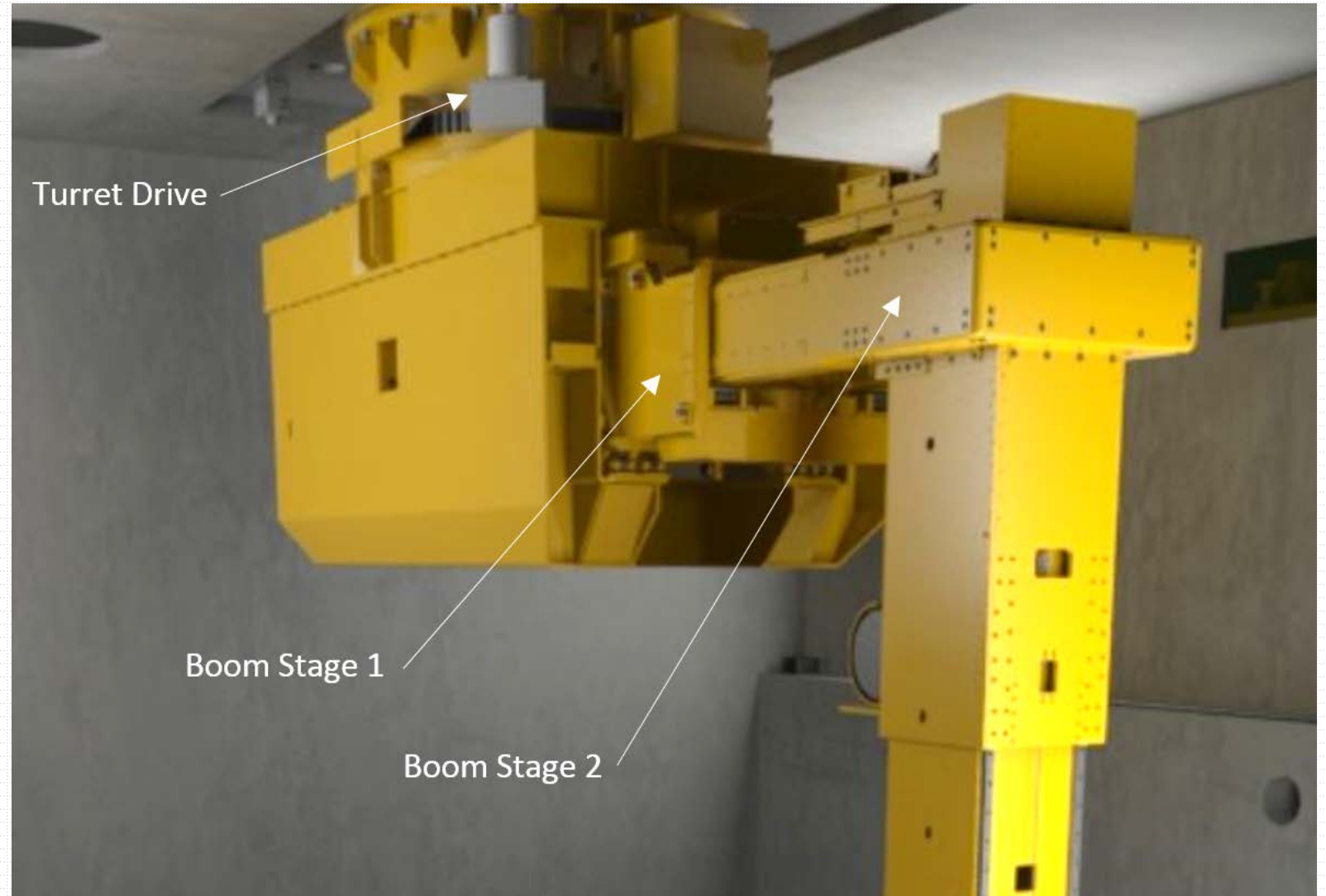
# Shield Plug From Above the Hot Cell



- ▲ ORNL provided PaR with an accurate SolidWorks model of the cell and shield plug
- ▲ ORNL developed a rough concept of the new system along with system requirements
- ▲ PaR, with input from ORNL refined the concept and provided detail design, fabrication and testing
- ▲ Common SolidWorks platform made for effective design evaluation of interfaces

# New Shield Plug-Mounted Design

- ▲ A 360 degree rotating turret attaches to the bottom of the new shield plug
- ▲ A two-stage horizontally extending boom with 8'6" reach is mounted to the rotating turret



# New Shield Plug-Mounted Design

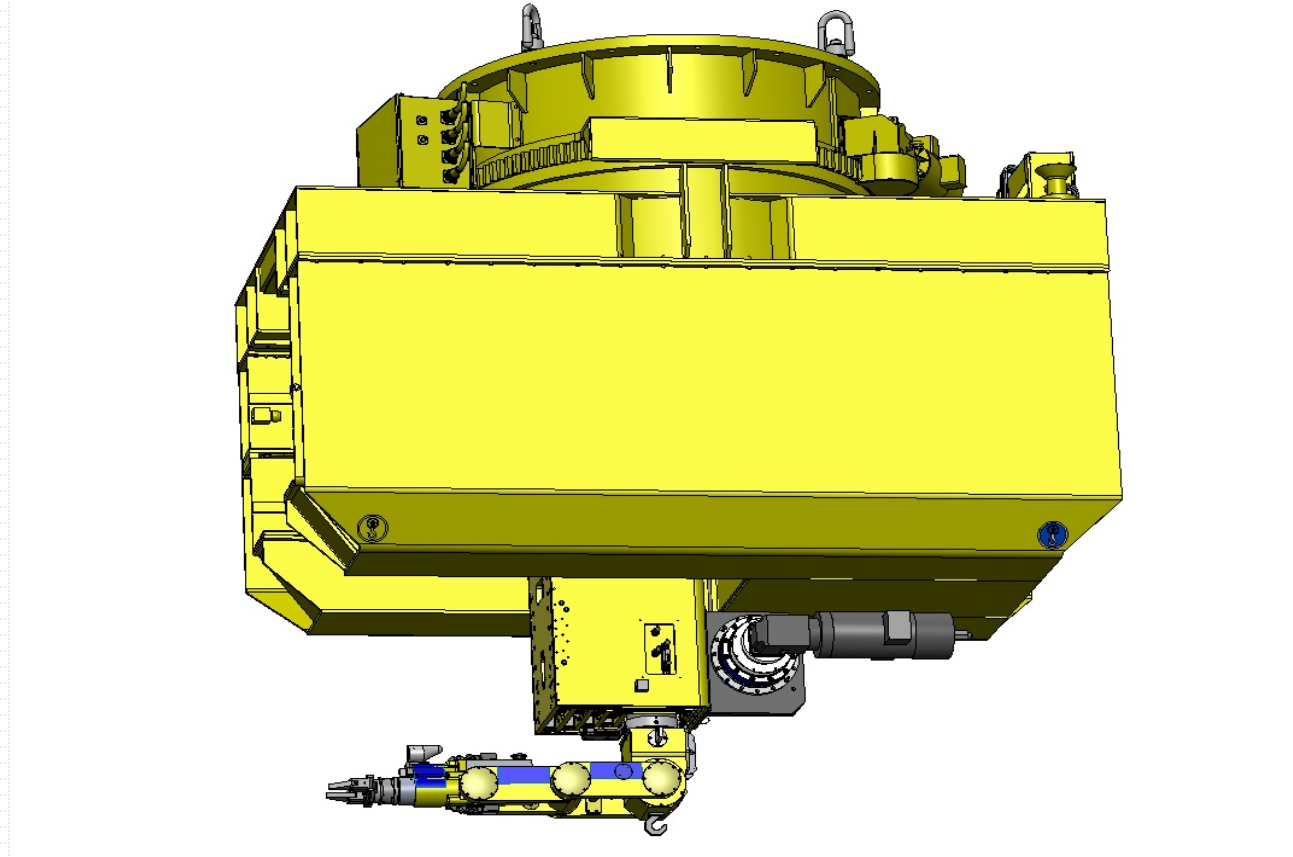


- ▲ A telescoping mast with 14' vertical travel is attached to the boom
- ▲ A PaR M3000 manipulator with seven degrees of freedom is attached to the bottom of the mast



# New Shield Plug-Mounted Design

Manipulator with joints in position for installation and removal



# New ORNL Shield Plug in PaR's Factory



# Completed System in PaR's Factory



- ▲ Shield plug was shipped to PaR for fit-up and testing
- ▲ Successful factory acceptance testing was completed in Fall 2013
- ▲ System is at ORNL and will be installed at a time convenient to REDC operations and production scheduling

# Important System Features

- ▲ Turret rotate, boom extension, mast and manipulator pivot joints have recovery features to allow positioning of axes for retrieval or maintenance
- ▲ The shield plug contains access ports long-handled tools to attach to the recovery hex drives
- ▲ All components radiation hardened to last a minimum of 30 years
- ▲ Provision for CCTV cameras mounted to the manipulator arm
- ▲ Remotely detachable grippers

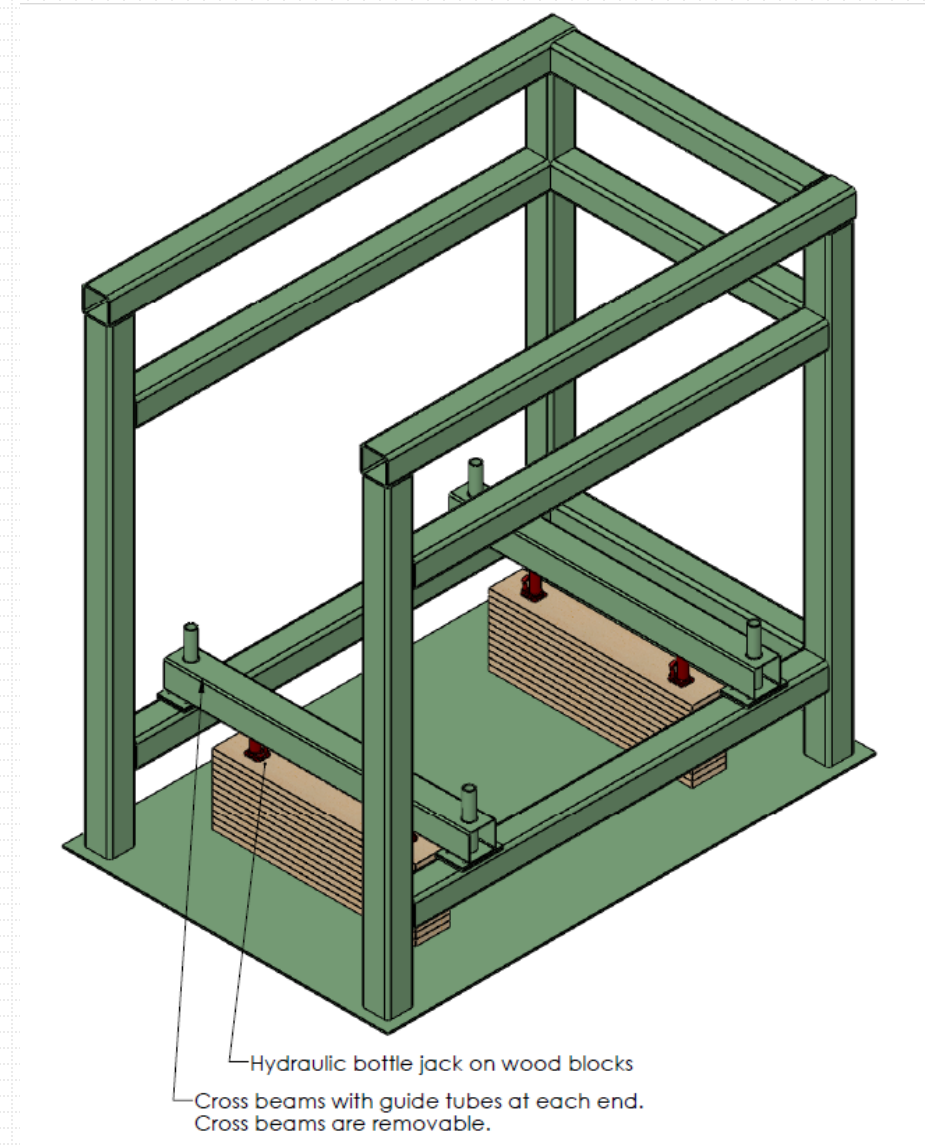


# Manipulator Control Console

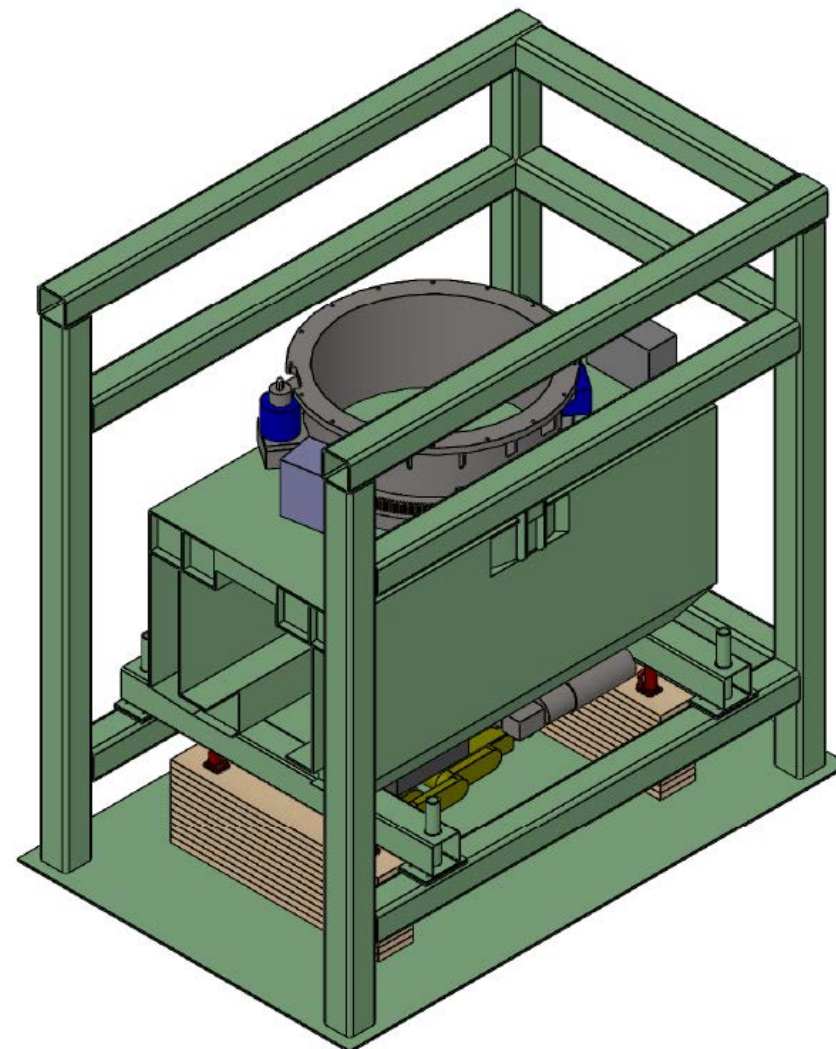
- ▲ Robust, simple and intuitive controls interface
- ▲ All axes are variable speed from 0 – maximum speed
- ▲ Finger switches are spring return
- ▲ Can move one or more axes at a time
- ▲ Portable console – can be moved from window to window



- ▲ The ORNL/PaR team designed a fixture to support the manipulator system and shield plug
- ▲ Manipulator system will be placed on the stand and jacked up to mate with threaded studs on the shield plug

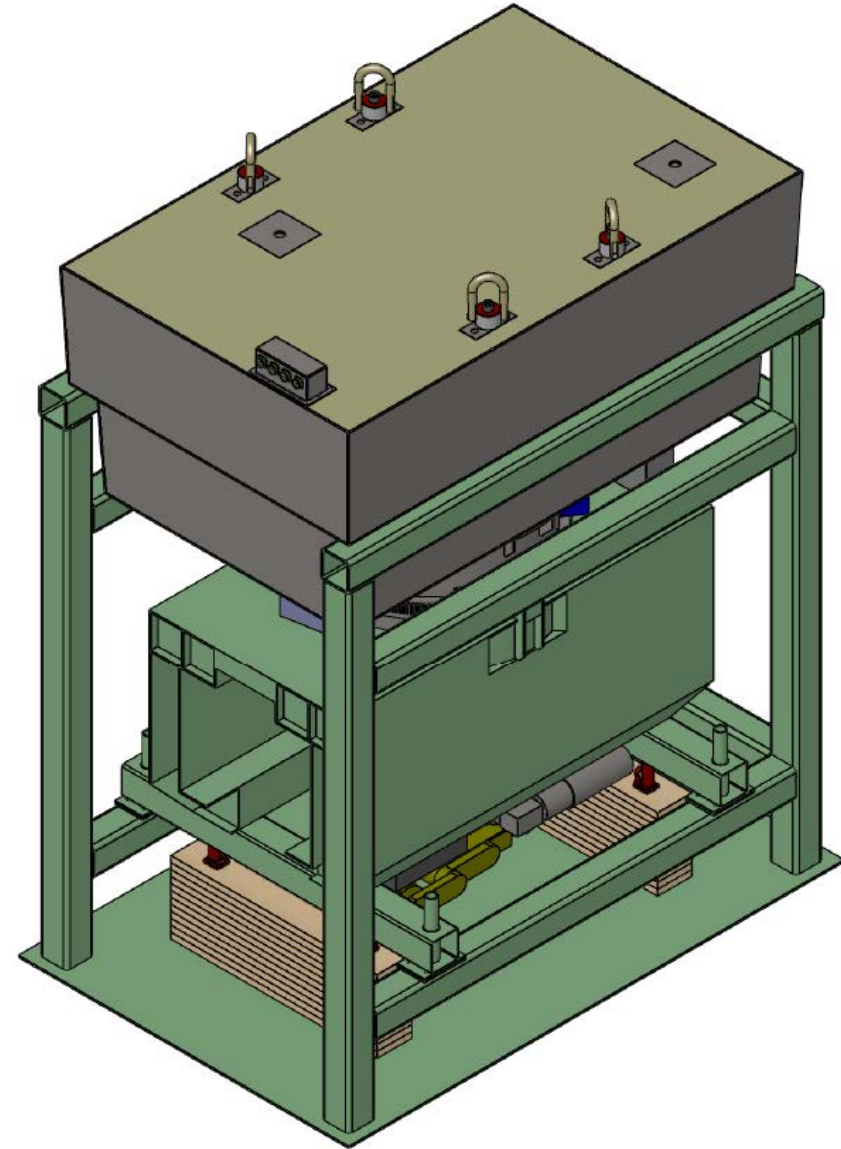


- ▲ Manipulator system will be lowered onto the stand plug using a high capacity building crane above the cell



# Installation Sequence

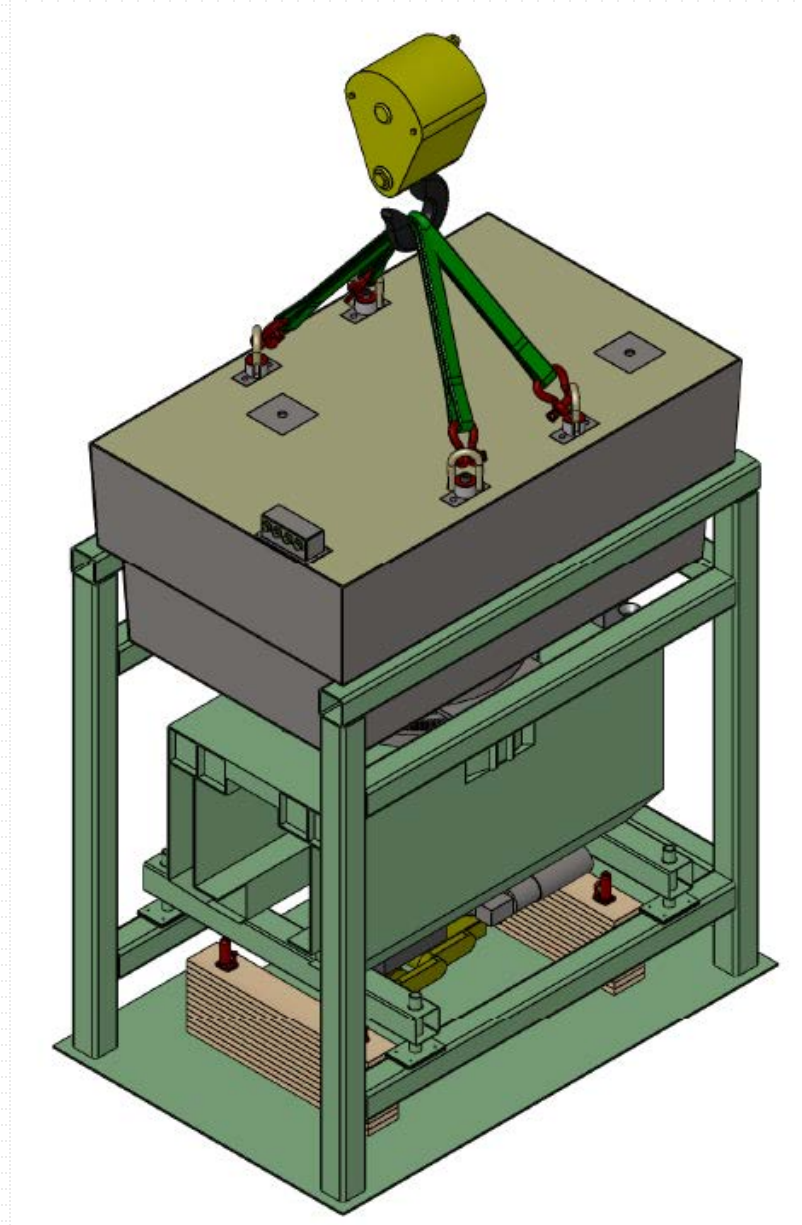
- ▲ Shield plug is lowered onto the stand
- ▲ Gap between plug and turret mounting flange will allow for electrical connections to be made between the manipulator and shield plug





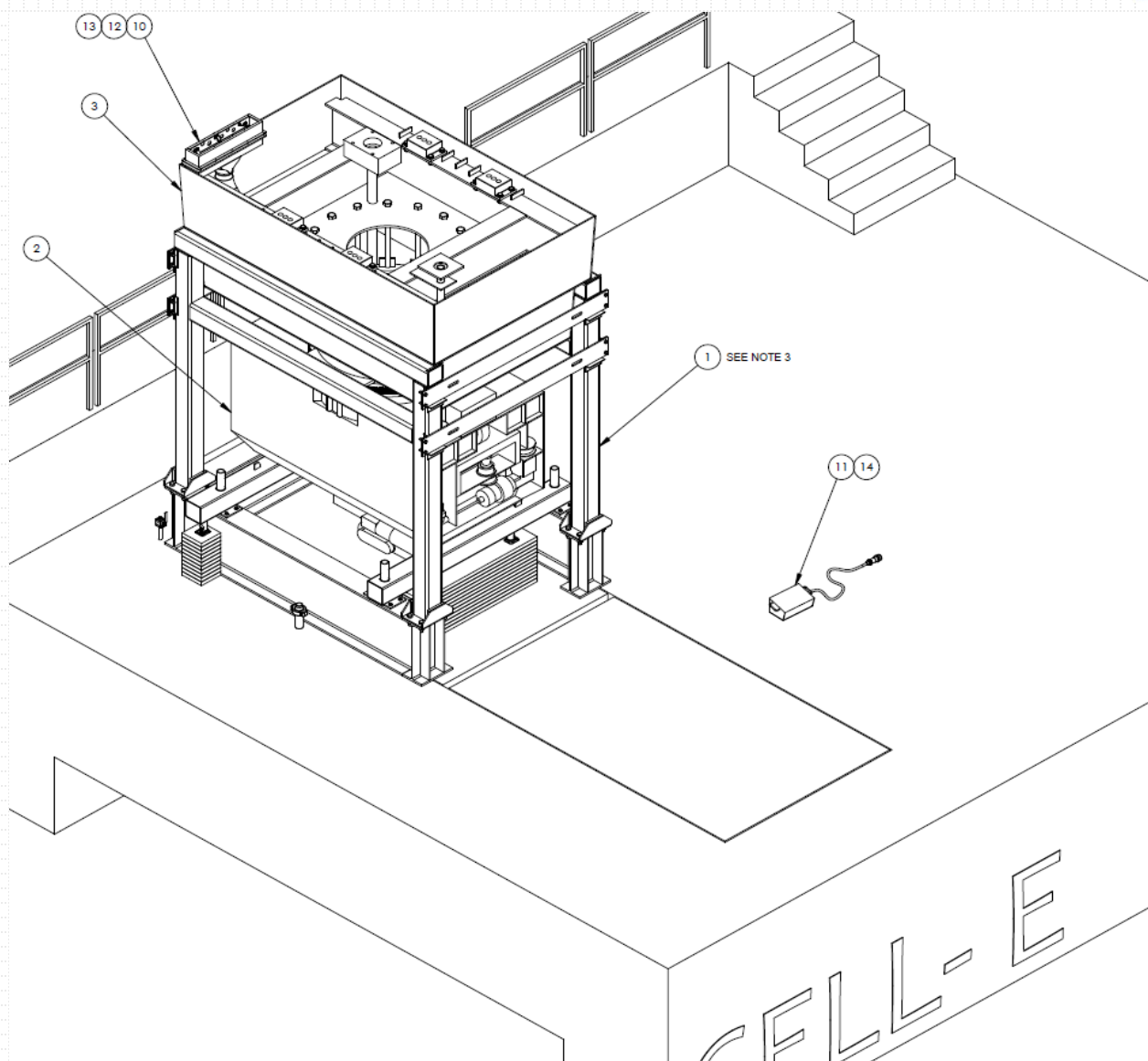
# Installation Sequence

- ▲ Manipulator is raised up to the bottom of the shield plug via hydraulic jacks
- ▲ Mechanical connections are made
- ▲ Shield plug-manipulator assembly is lowered into the opening
- ▲ Out-cell electrical connections are made

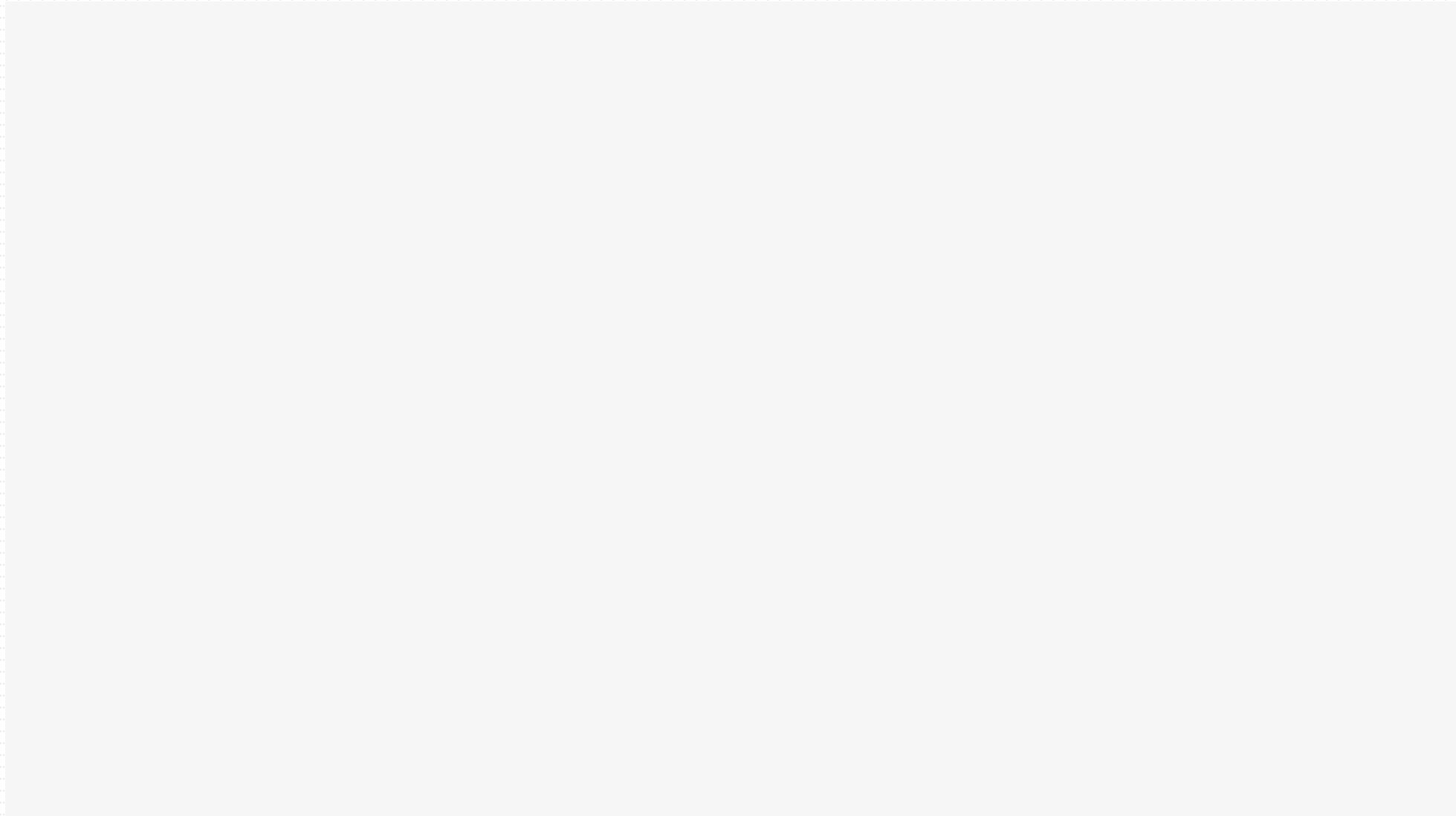


# Installation Sequence

- ▲ Site testing to be performed in a cold cell, Cell E
- ▲ Following complete site testing, system will be installed in Cell G



# Installation Animation



- ▲ Plug-mounted manipulator system solved a challenging replacement problem for ORNL
- ▲ Collaborative effort between ORNL and PaR resulted in no interface issues between shield plug and manipulator mount
- ▲ Similar systems could be implemented in other hot cells with shield plugs where enhanced or replacement remote handling systems are required
- ▲ Free exchange of SolidWorks models was instrumental in the design process



# Acknowledgements

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# Questions

