High Risk Maintenance Project

at the LBNL 88-Inch Cyclotron

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88-Inch Cyclotron

Lawrence Berkeley National Laboratory

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The 7th International Workshop on Accelerator Operation

High Risk Maintenance Project

The 88-Inch Cyclotron Operation

- The 88-Inch Cyclotron is a small facility
  - staff of ~ 24 FTE (4 Oper., 10 Techs, 3 Eng, 7 Ops Grp.)
- The Cyclotron runs ~ 93% availability.
- Scheduled operation of ~ 5000 hours a year.
- Operates on a 10-4 cycle, 24 h/day, 2 long shutdowns/ year.
- We support LBNL nuclear science research program (60%) and our applied science program for the Aerospace industry radiation effects testing (40%).
- 88-Inch has managed to survive by continuing to do important nuclear science research and applied science with a steady program of upgrades and by adjusting to our user's needs.

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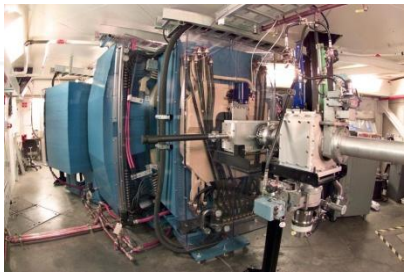
88-Inch Cyclotron Complex Experimental Facilities

Cave 4C GRETINA/GRETA

Heavy Ion Facilities

BASE

Cave 1 BGS



Cave 0, Isotope production
Applied and Nuclear Science
Neutron Facility

88-Inch

Light Ion Facility

Laser Trapping

LIBERACE

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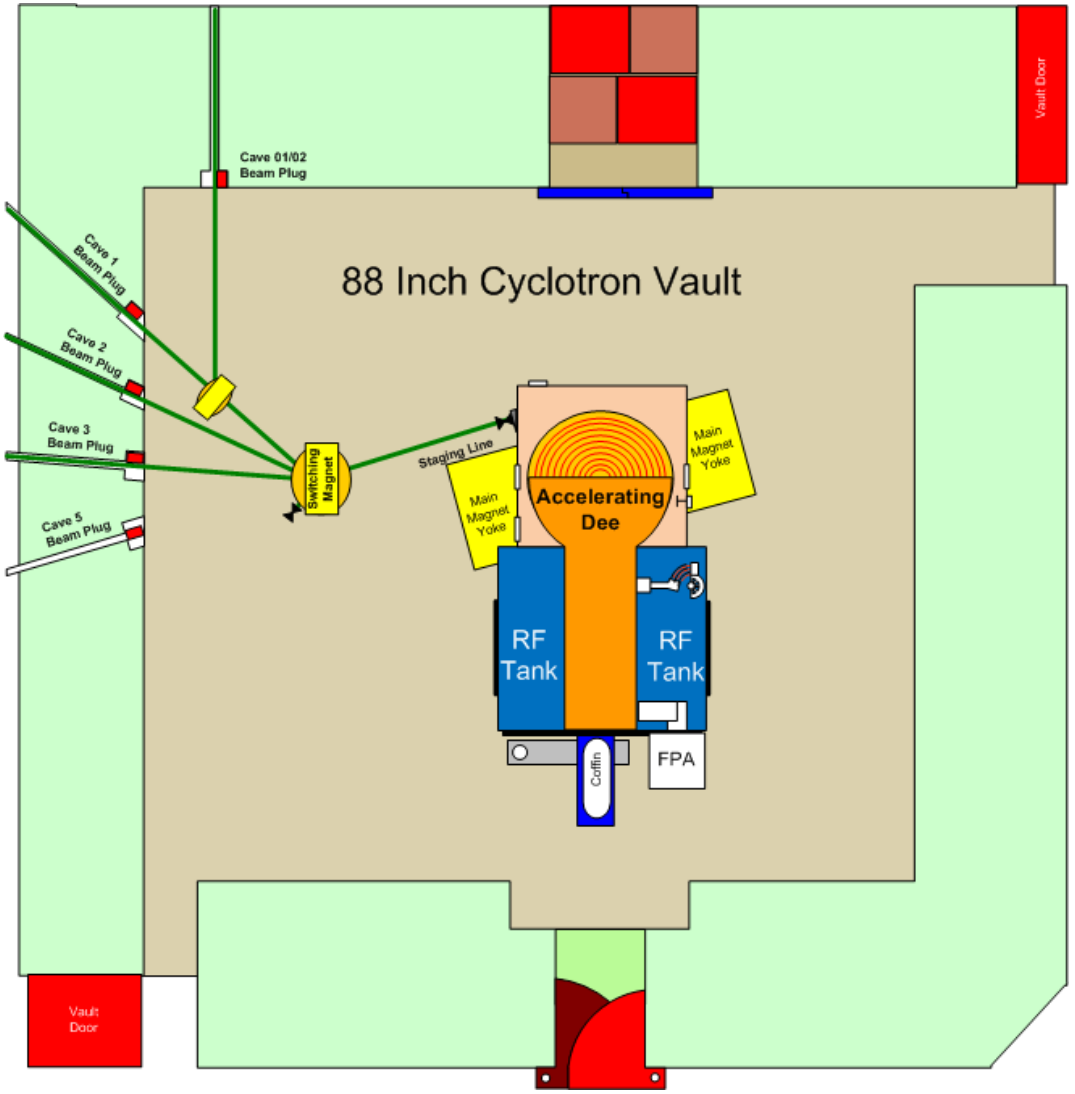
Overview

- The Cyclotron's layout
- Variable frequency RF Tank
- Accelerate every element from Hydrogen to Uranium at various energies

High Intensity Light Ions
Protons to 55 MeV
^{3}He to 135 MeV
Heavy Ions
5 To 32 MeV/nuc
$0.2 \leq Q/M \leq 0.5$
Mass Resolution
1/3000



High Risk Maintenance Project

Maintenance Work on a Mature Accelerator

Maintenance work on the 88-Inch Cyclotron is mostly routine component maintenance and repair.

On occasion projects develop that involve systems that are not typical maintenance work.

This talk is about such a high risk project:

To repair the Accelerating Dee vacuum seal.

- The risk is that this repair project could result in un-repairable damage to the Accelerating Dee.
- The high current RF system might not work after the project.
- No one working at the 88 had ever done this.

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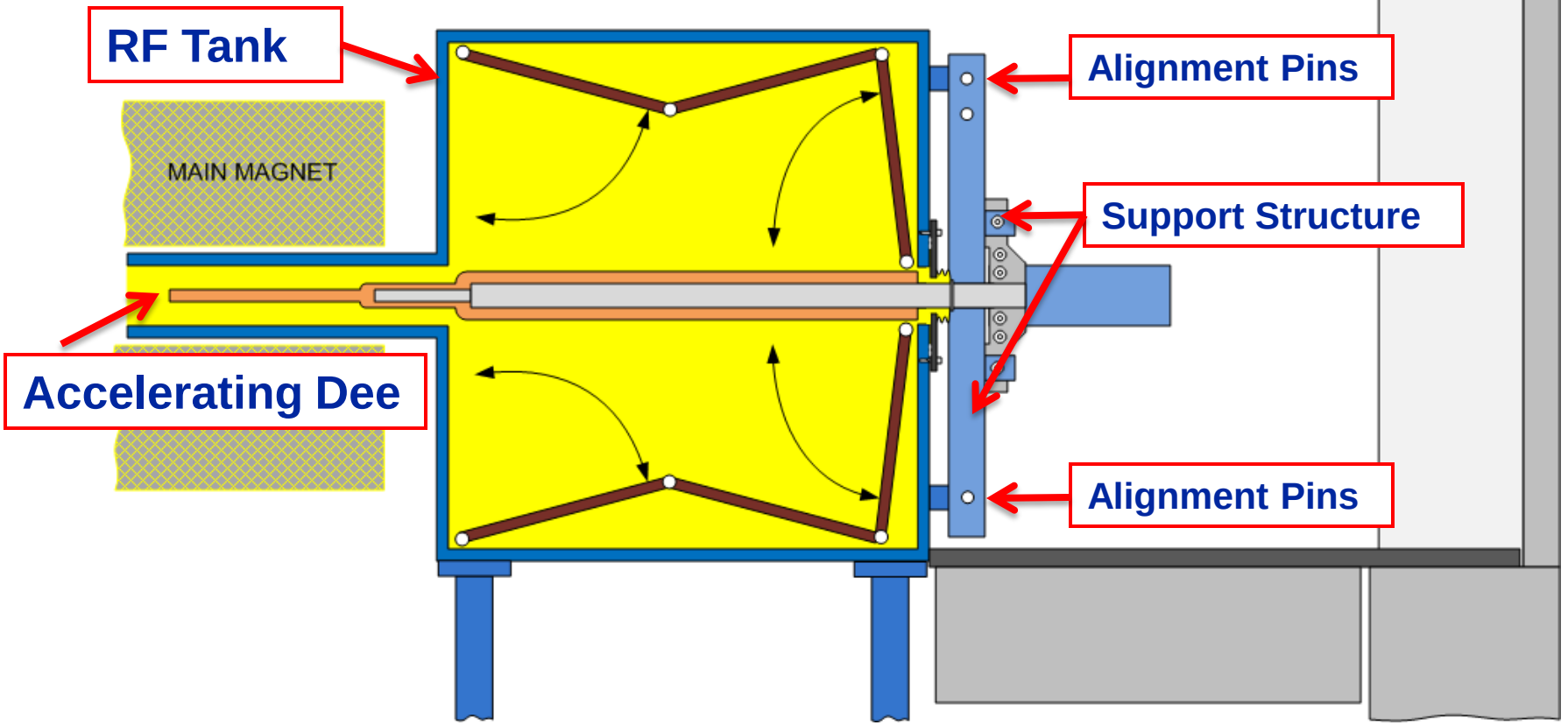
The Sideview

- The Accelerating Dee is a ~14 foot cantilevered structure weighing about 2000 lbs supported by a rigid support structure mounted on the RF tank.



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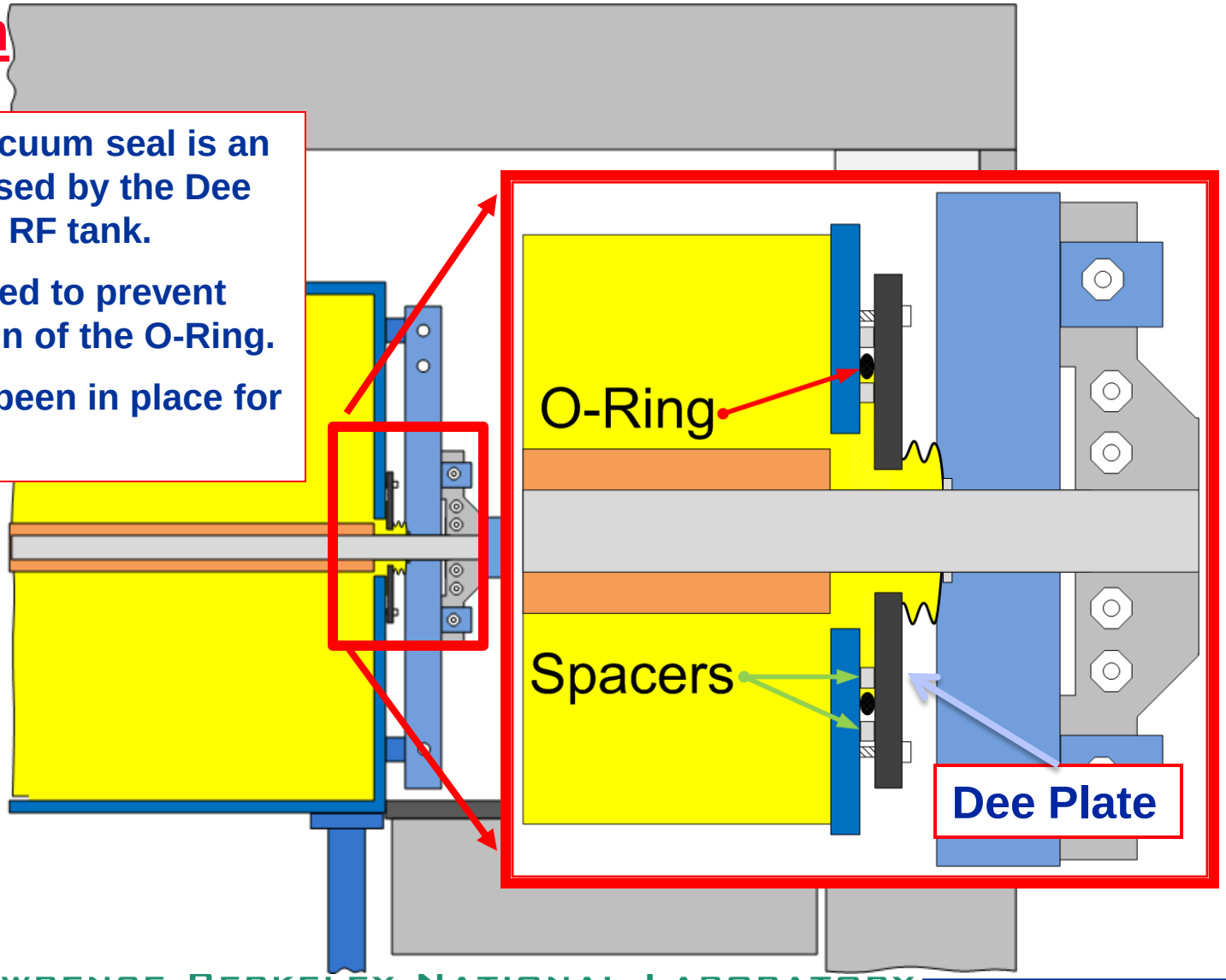
The Problem

- The Dee plate vacuum seal is an O-Ring compressed by the Dee plate against the RF tank.
- Spacers were used to prevent over compression of the O-Ring.
- The O-Ring had been in place for over 30 years.



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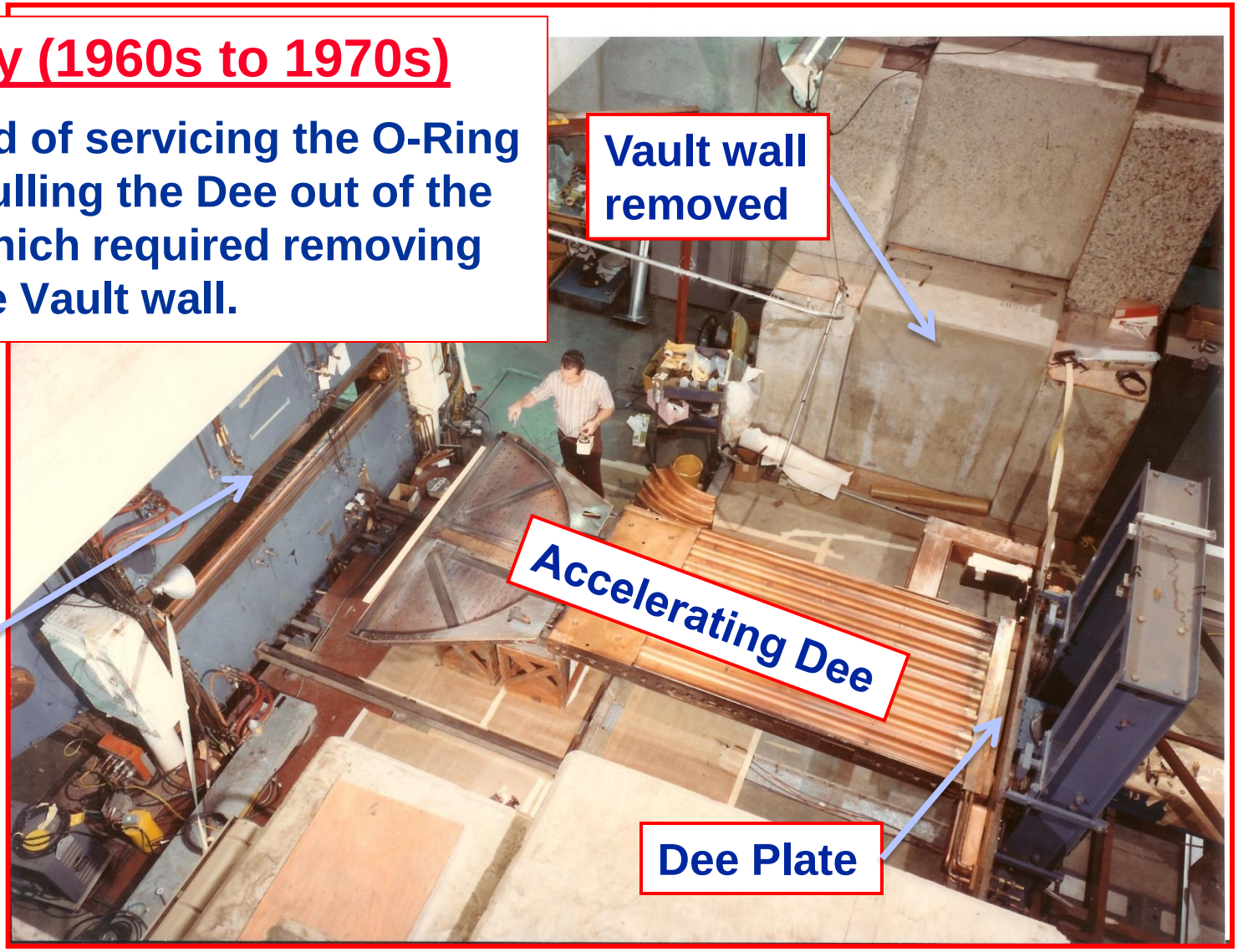
Historically (1960s to 1970s)

- The method of servicing the O-Ring involved pulling the Dee out of the RF tank, which required removing parts of the Vault wall.



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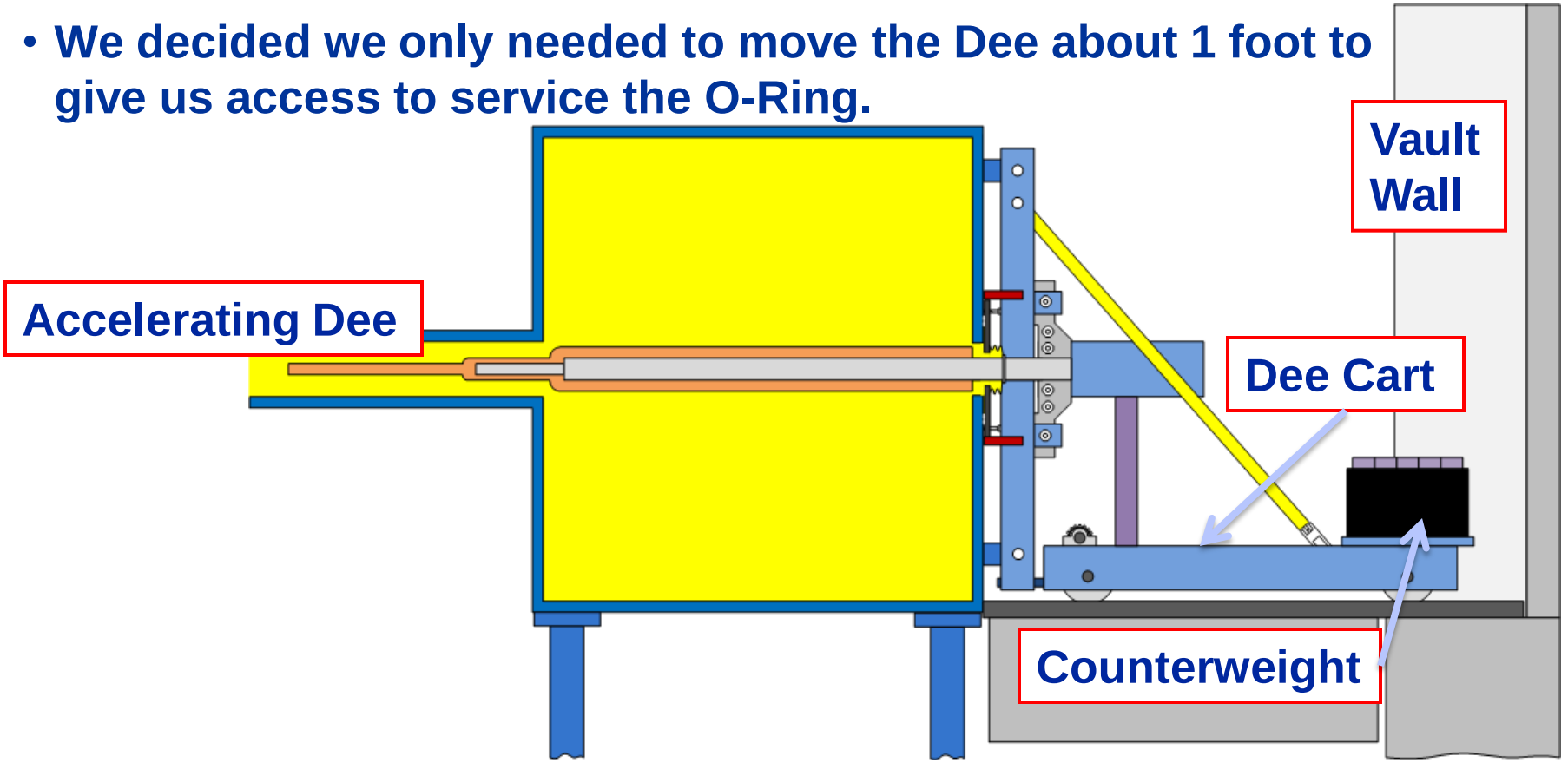
The Project

- The project was to replace the O-ring without removing the Vault wall.
- The project was analyzed to plan the sequence of steps to optimize the efficiency of the work.
- The hazards were analyzed and mitigations were put in place.
- The team was trained on the sequence of the work.
- Each day the days work was discussed and the lessons learned from the previous day were incorporated.
- In lieu of “Dee pulling experience” we would rely on project preparation and the skills of the staff.

The Plan

- To pull the Dee we had to build a Dee cart (~ 1 year to build). with a counterweight to support the Dee.
- We decided we only needed to move the Dee about 1 foot to give us access to service the O-Ring.



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Preparation

- When the repair project was initiated the first step was to get the cart moved into position.

Riggers moved the cart into position.

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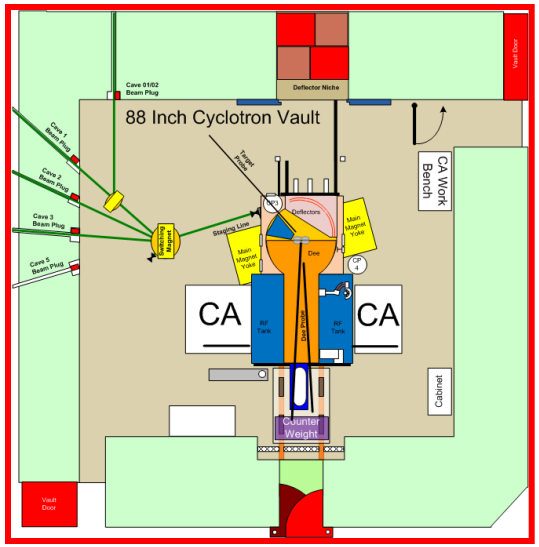
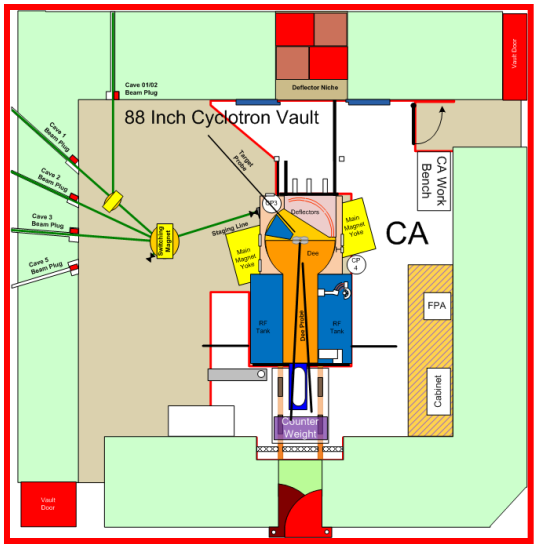
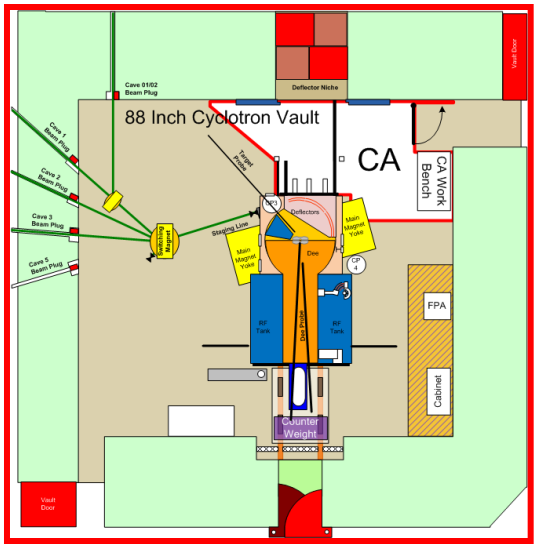
Preparation

- Opening the Cyclotron or RF Tank requires Contaminated Area (CA) controls to limit risk of spreading removable contamination.
- Planning the repair required coordination of effort to manage the limited access resulting from CA's being posted.







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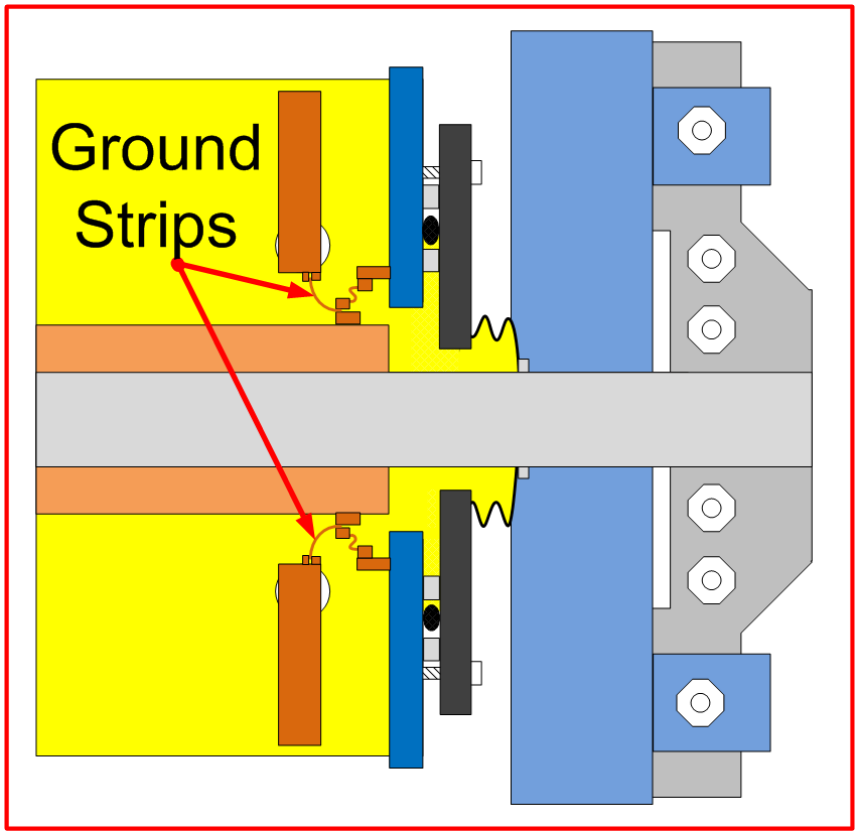
Preparation

- Removing the Dee required removing the grounding strips between the Dee, RF panels and the RF Tank
- Removing the Dee grounding strips was risky.



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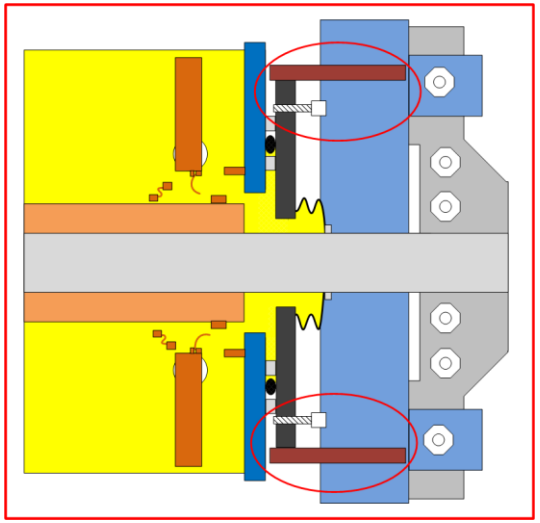
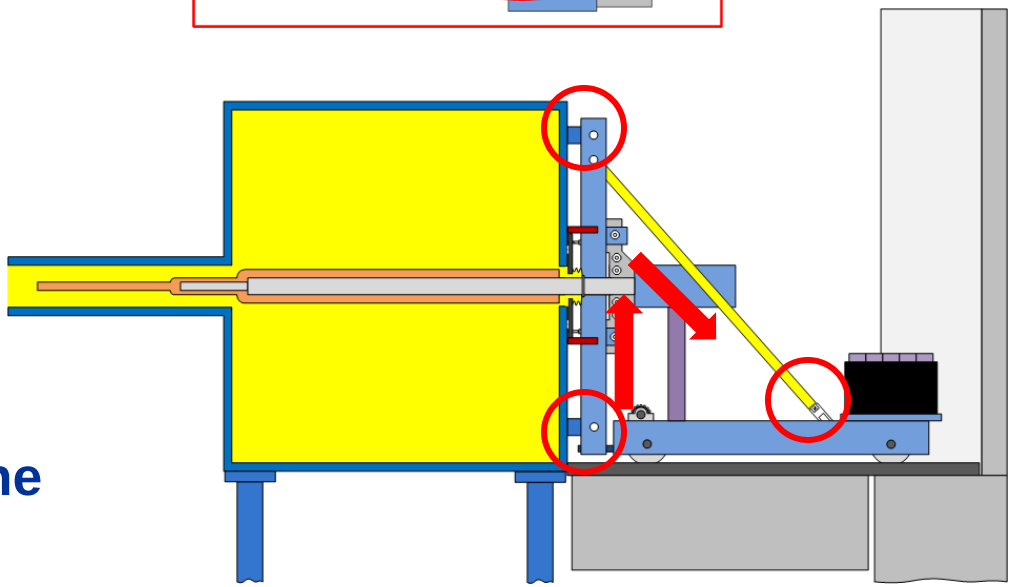
Preparation

- The Dee plate was supported and unbolted from the RF Tank.



Load Shift

- The load of the Dee was shifted to the Dee cart.
- The alignment pins were removed,
- The Dee cart supported the Dee



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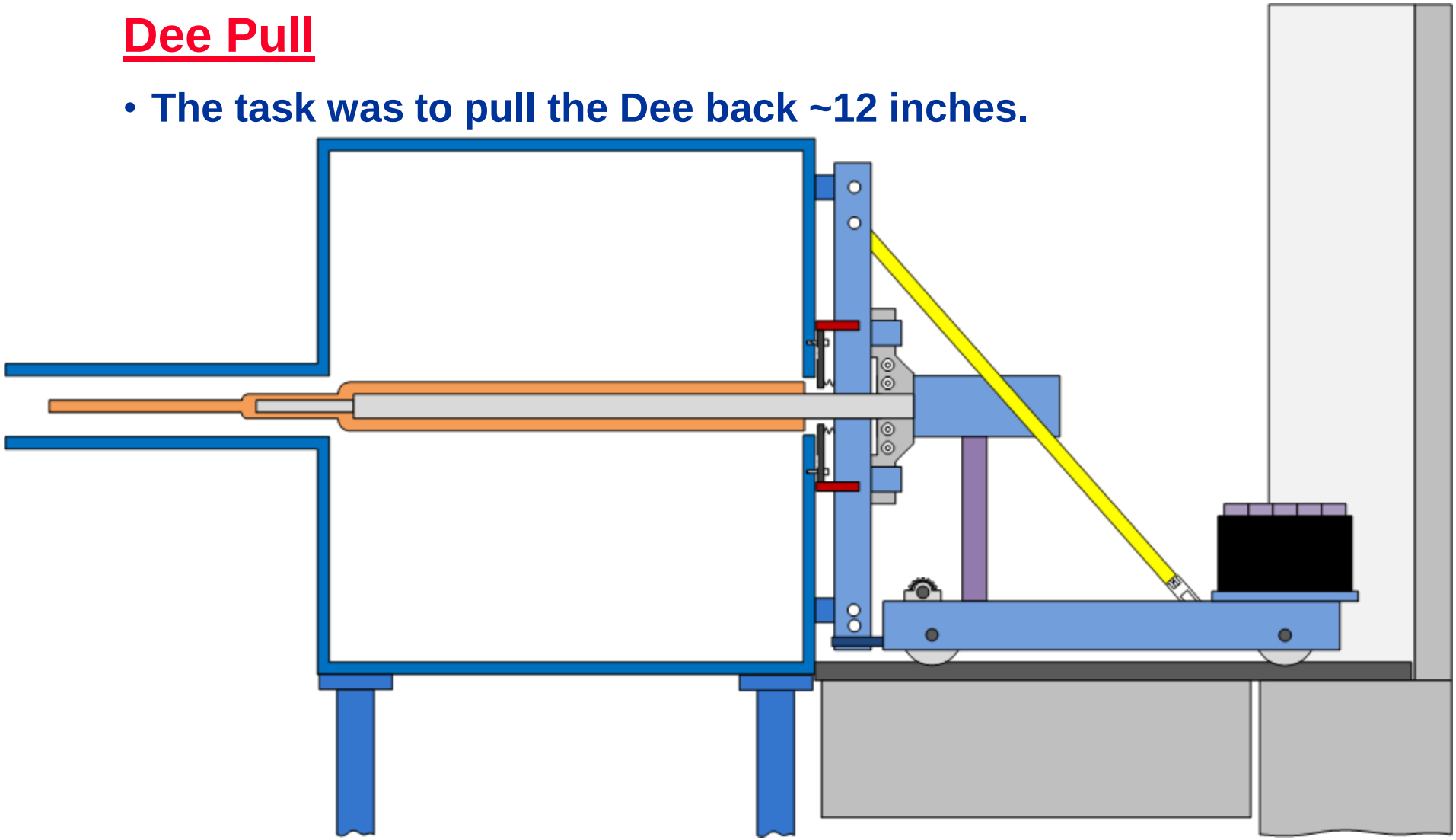
Dee Pull

- When all preparations were completed for the Dee pull

the pull team prepared to enter the CA.

Dee Pull

- The task was to pull the Dee back ~12 inches.



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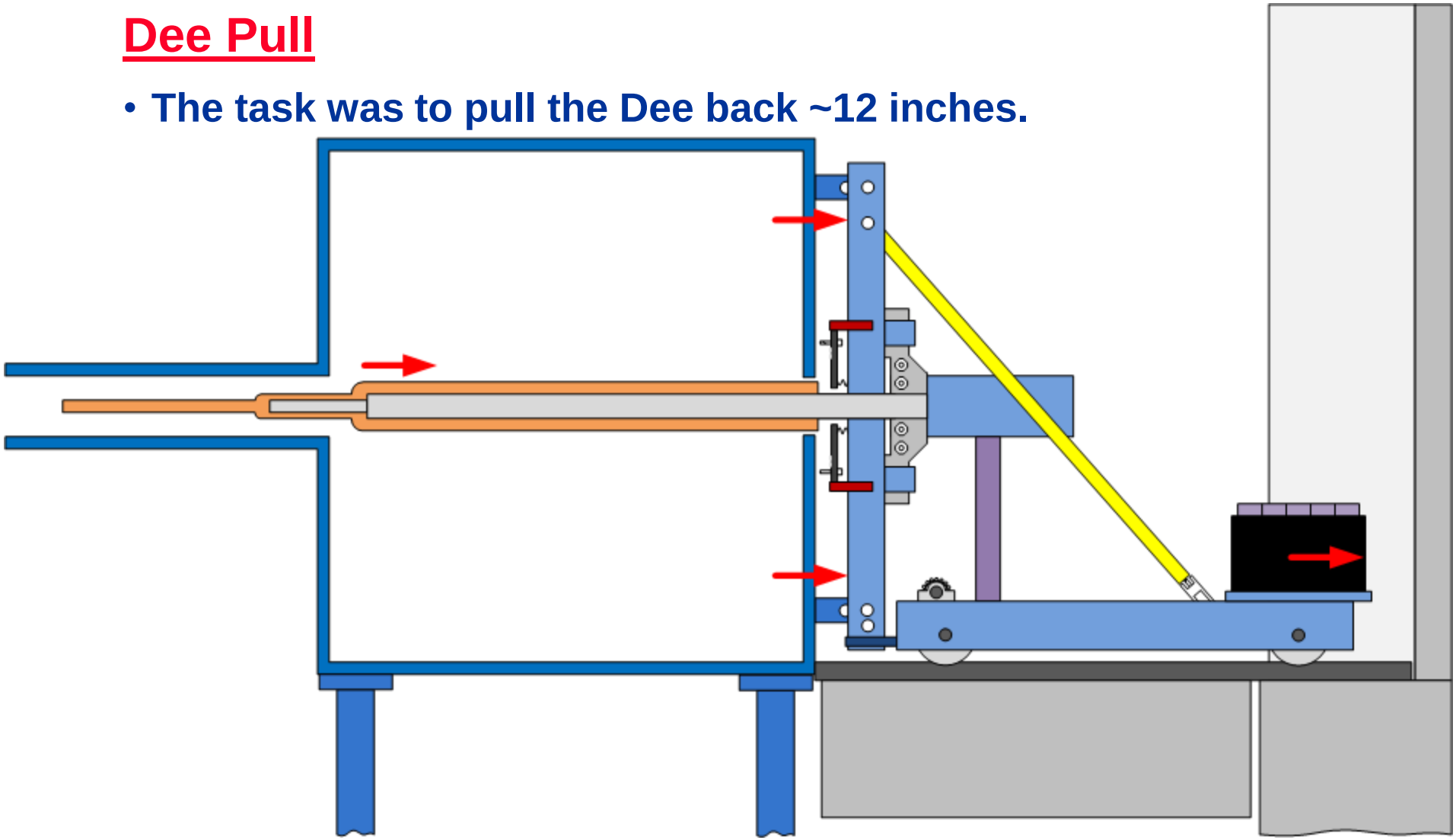

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Dee Pull

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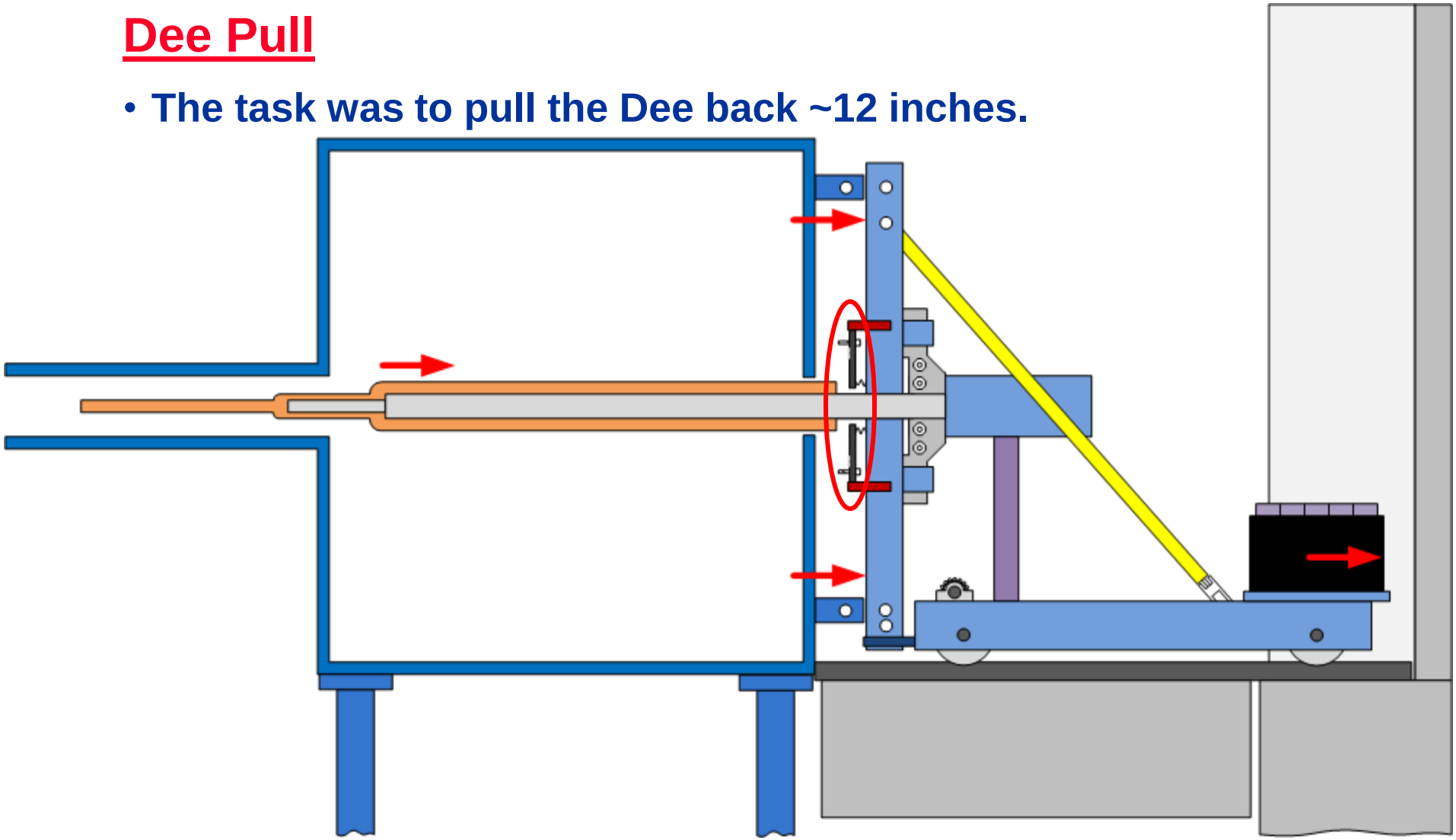

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Dee Pull

- The Dee pull went smoothly.

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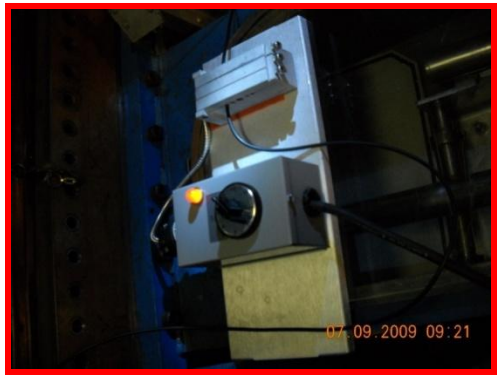
The Repair

- The old O-Ring was removed.
- The sealing surfaces were cleaned and polished (~ 1 week).
- The spacers were cleaned and replaced.
- The new O-Ring was fabricated in place.



- The new O-Ring was greased and installed.

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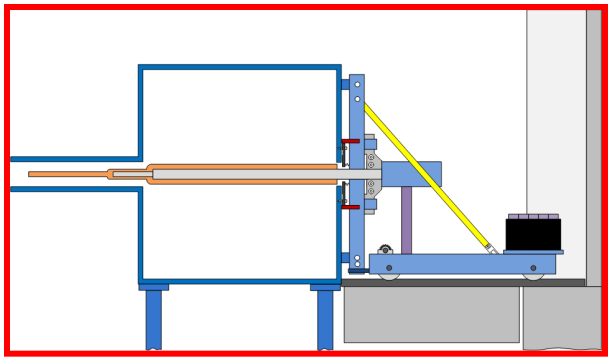
The Recovery



- The Dee was reattached to the RF tank.
- Damaged grounding strips were replaced and all strips were re-attached.

- The alignment of the Dee was verified.
- The infrastructure connections were reinstalled.
- The Cyclotron was sealed and it pumped down easily.
- A standard beam was tuned out of the Cyclotron..we were able to accelerate particles.

- The Dee cart was removed form the Vault.

The Return to Operation

- The RF system had sparking problems and we had vacuum problems associated with high RF power.
  - We investigated and found the grounding strips had not remained attached and were overheated.
  - We also found a screwdriver had been left in the RF tank.
- The grounding strips were re-attached using appropriate material and the screwdriver was removed.

- Lesson Learned
  - How to attach the grounding strips.
  - We needed better management of tools.

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Summary

- The Accelerating Dee's vacuum leak was repaired.
- The Accelerating Dee and RF system were NOT damaged.
- The project was completed despite our lack of experience pulling the Dee and not having complete information at the beginning of the process.
- We made some mistakes but they were not catastrophic, we recovered, we learned useful lessons.

- We now have the experience and a process to use to conduct future repairs of the Accelerating Dee if needed.