



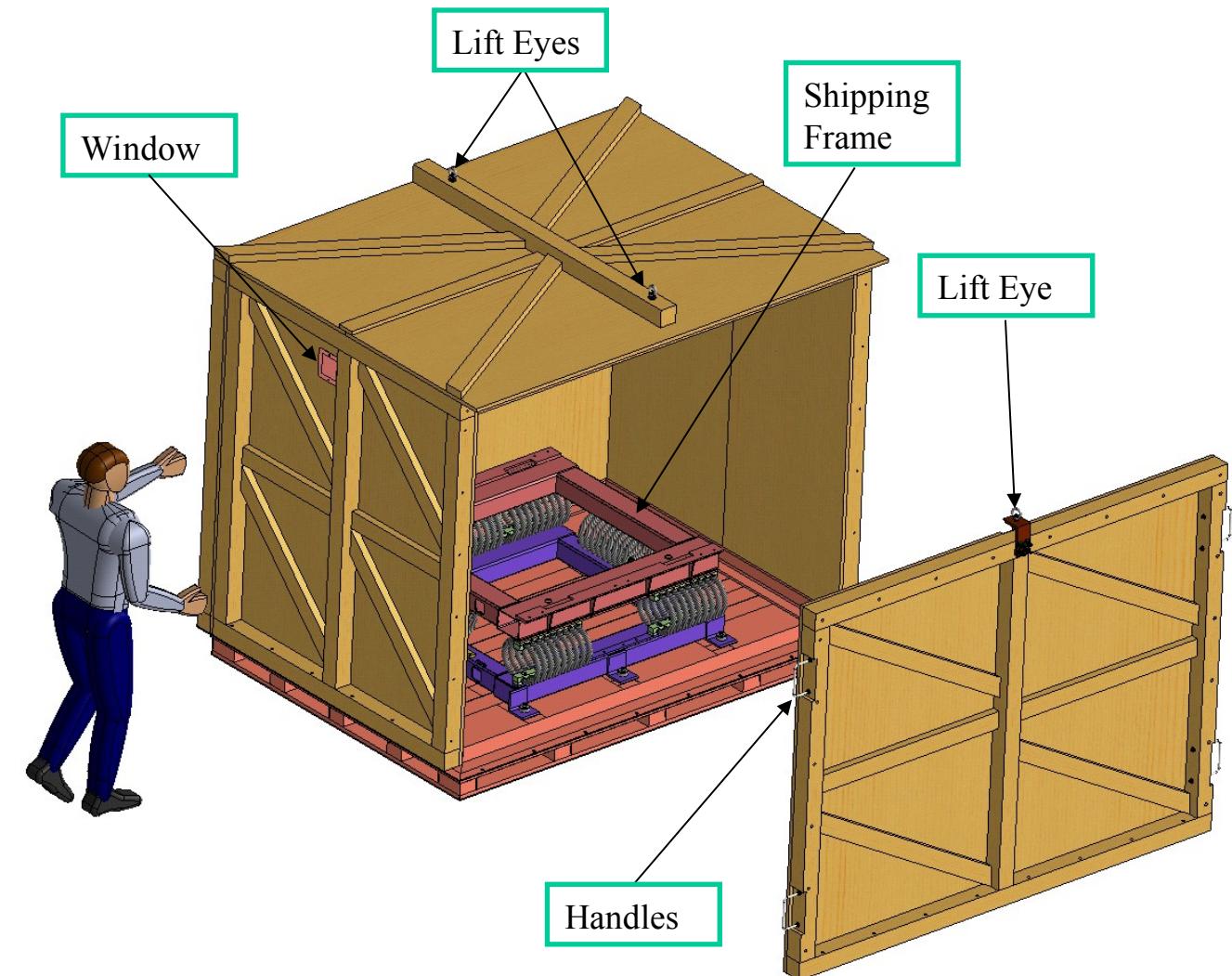
Shipping Hardware Review

Jamison Noenickx

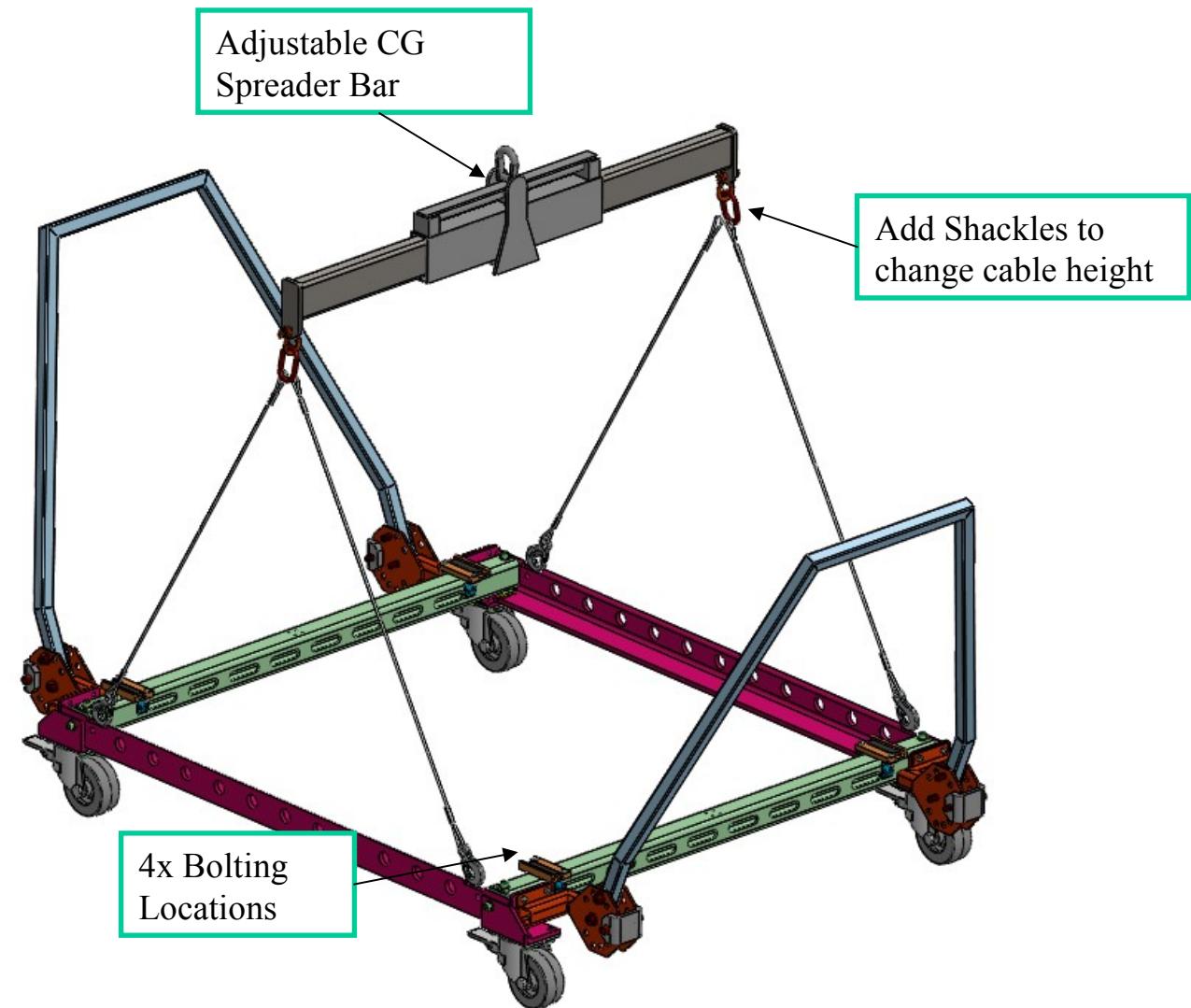
8/27/19



- Wood Box est. ~1531 kg (3368 lb) and < 1645 kg (3618 lb), 96 in x 72 in x 85 in Height. Volumetric weight is 1605 kg ($\text{cm}^3/6000$).
 - Optical Breadboard 682 kg (~1500 lb) and < 909 kg (2000 lb)
 - Shipping Frame 291 kg (640 lb)
 - Aluminum Box 276 kg (608 lb)
- Weatherproof
- Placard (Label: MAG-AO-x, University of Arizona)
- Lifting Cart est. 141 kg (309 lb)
- Lifting Spreader Bar est. 34 kg (75 lb)



Updated Lifting Cart



- Cart bolts to optical breadboard from below
- Dual use for lifting and as a cart
- Lifts with adjustable spreader bar

Clean Room Hook Height is about 3.4 meters
Final Rigging Length will take clean room hook height into account

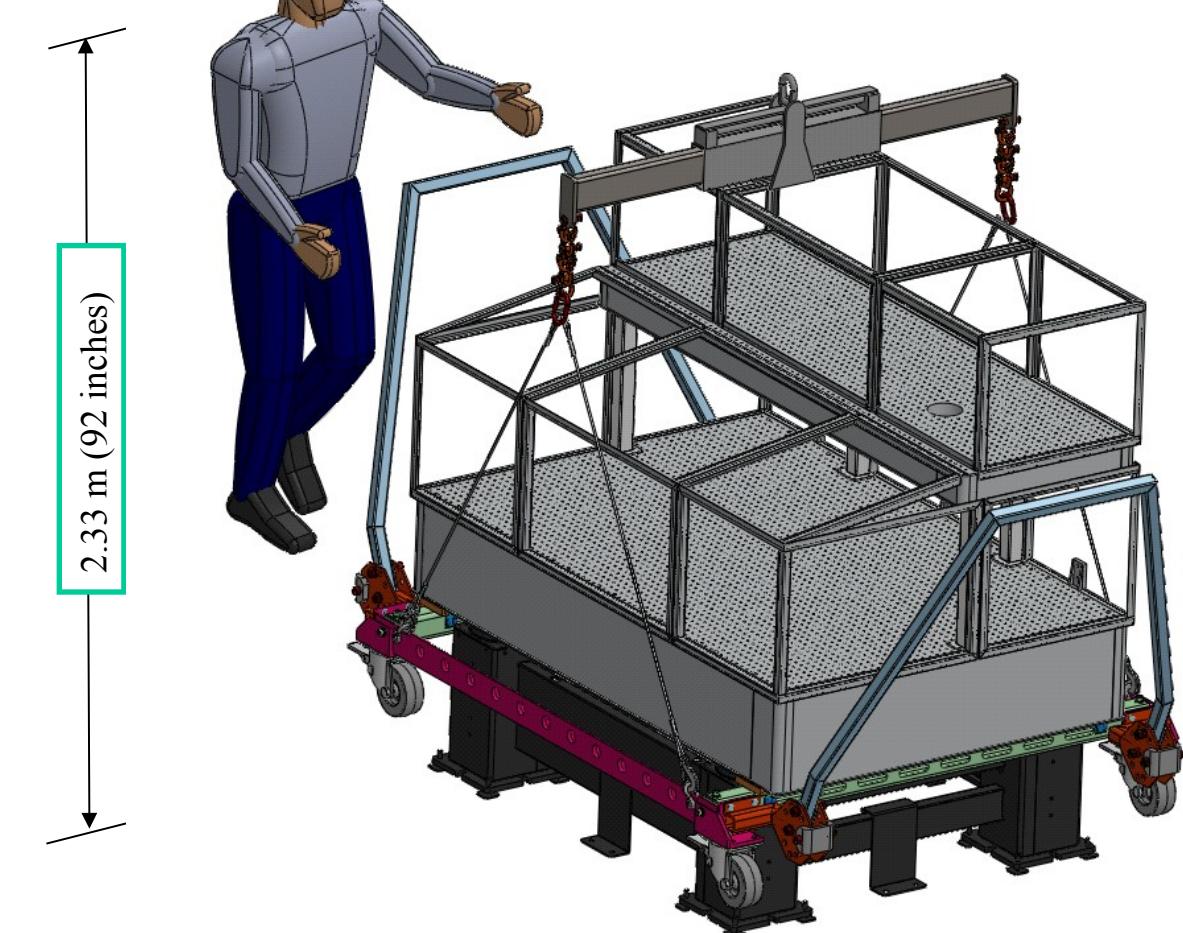
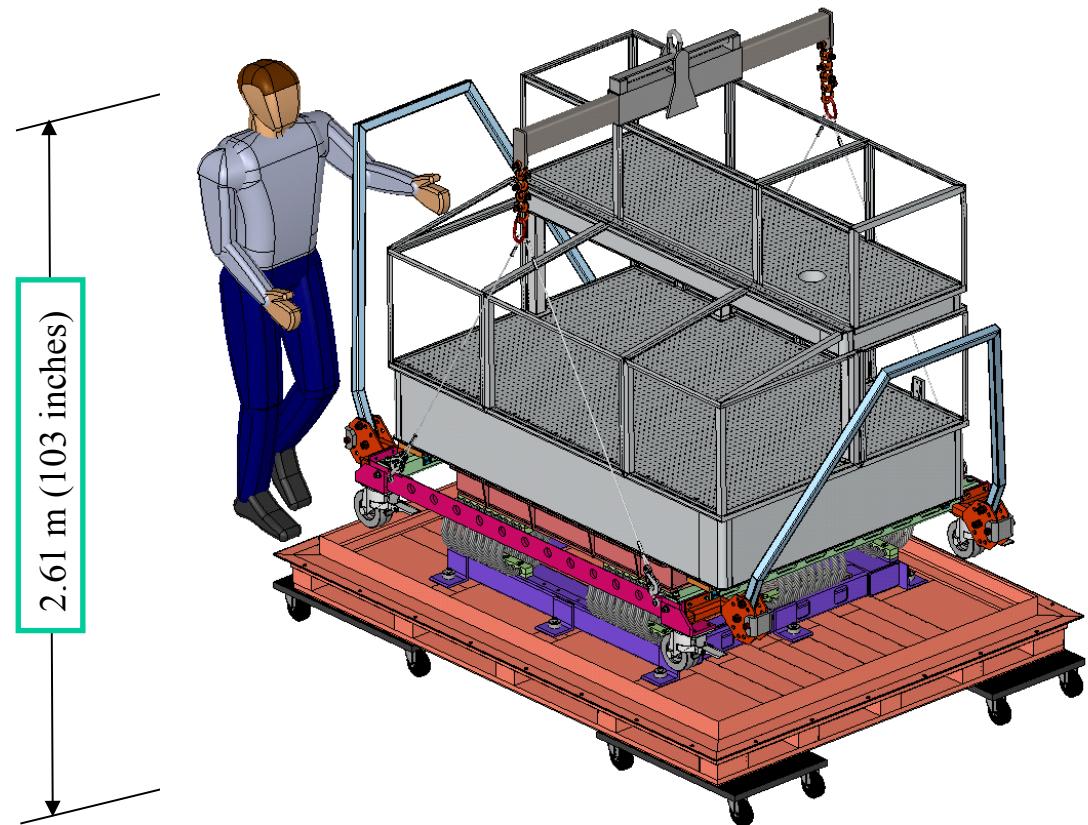
- Electronics Cabinet Shipping Box, est. weight 747 kg (1644 lb)
 - Shipping Box, est. 318 kg (700 lb) wood box, Depth 55.13 in, Width 99.18 in, Height 40.63 in.
 - Electronics Cabinet (not including handles or casters) est. 429 kg (944 lb), Depth 46.125 in, Width 28.125 in, Height 83.68 in.
 - Shipping horizontally has a volumetric mass of 607 kg ($\text{cm}^3/6000$).
- Wood Crate ships Rack on its side
- Crate to be flipped on its side and unpacked in unpacking room of clean room facility
- Crane required for tipping the shipping container up to vertical
- Unpacked rack will be transported vertically to the telescope

Lifting Configuration

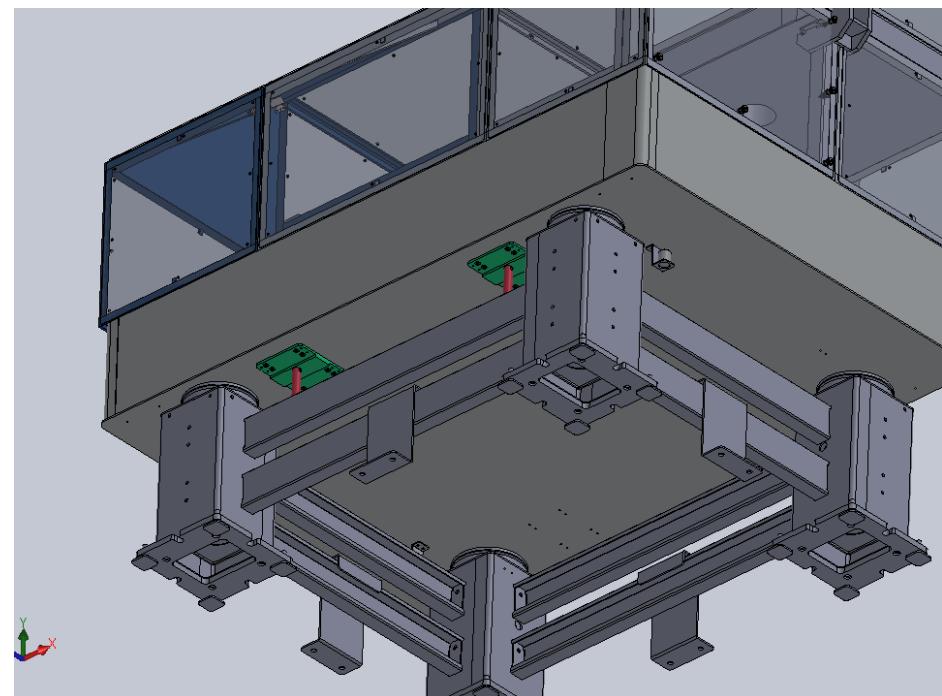
Shipping Pallet

Needs to be raised 5 inches

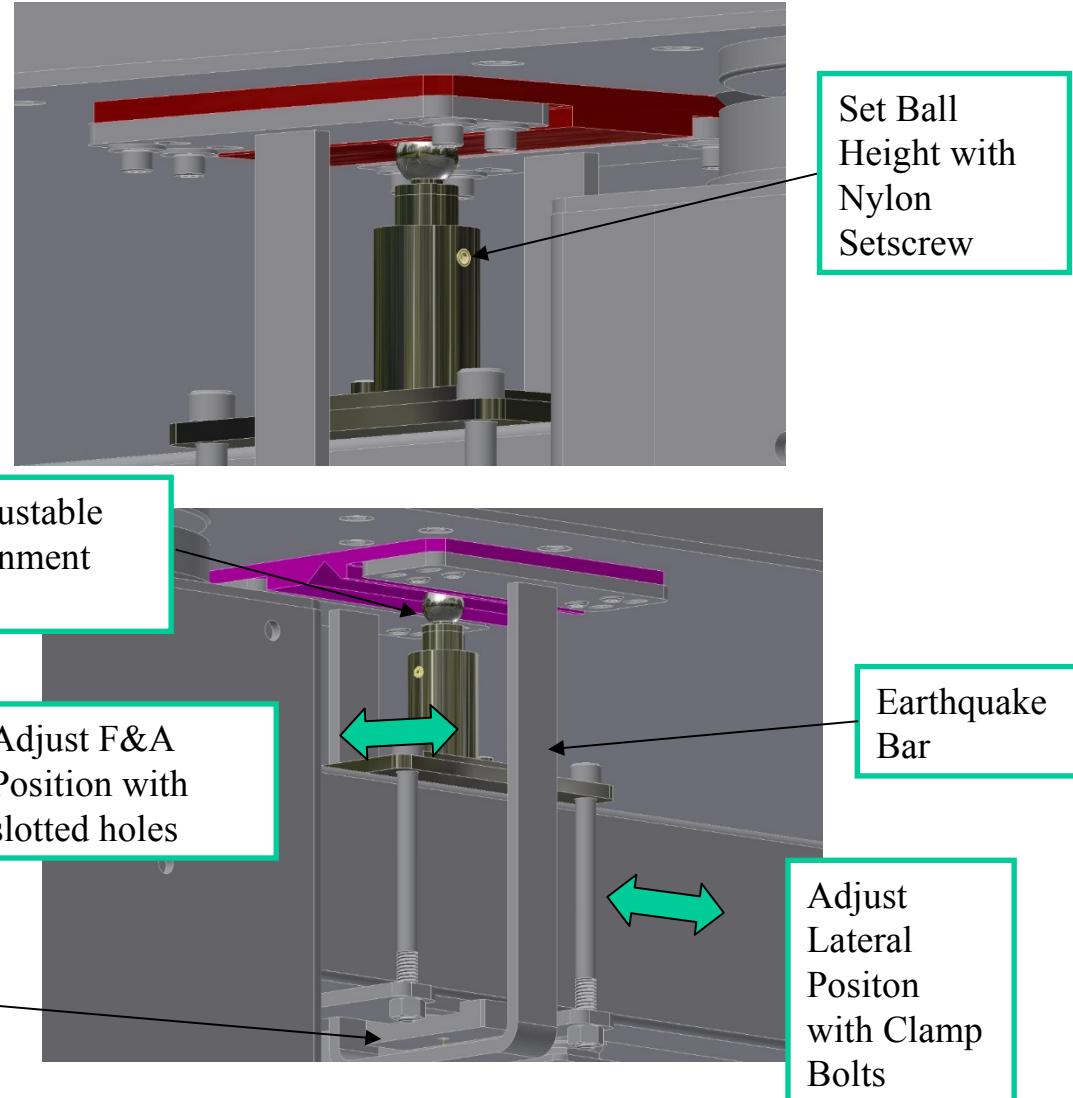
Breadboard Table Legs



Two alignment balls ensure repeatable locating on the table legs.

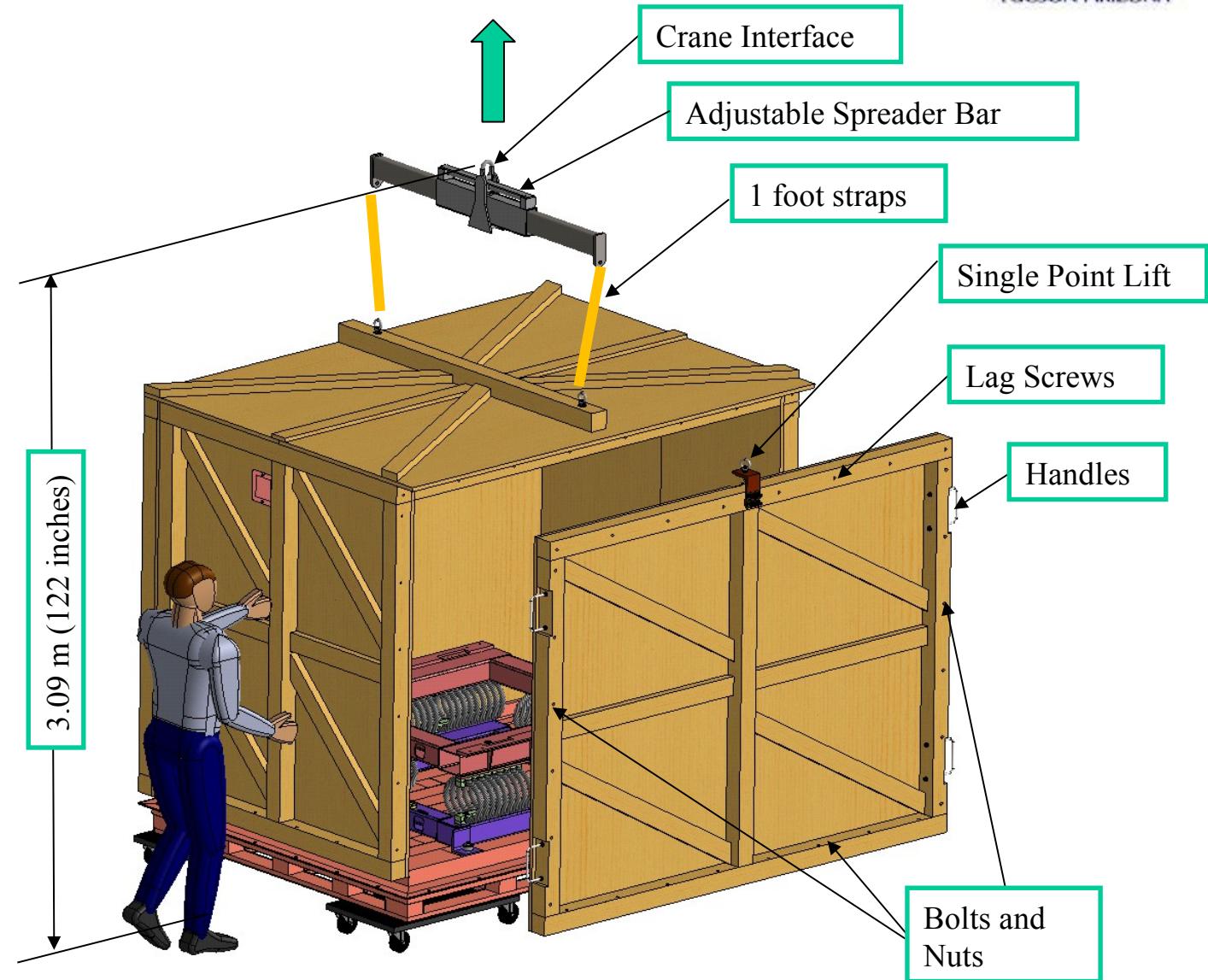


Tilt Limit Bumper



Box Lifting Configuration

- Use Bench Lifting Spreader Bar with Center Pick Configuration
- Pallet will have guides for the lid, but the tilt from the lift requires people at each corner.
- 5 People Recommended: 4 people to handle the box lid, plus 1 crane operator



The Cart in Action



Installing Cart at the Loading Dock



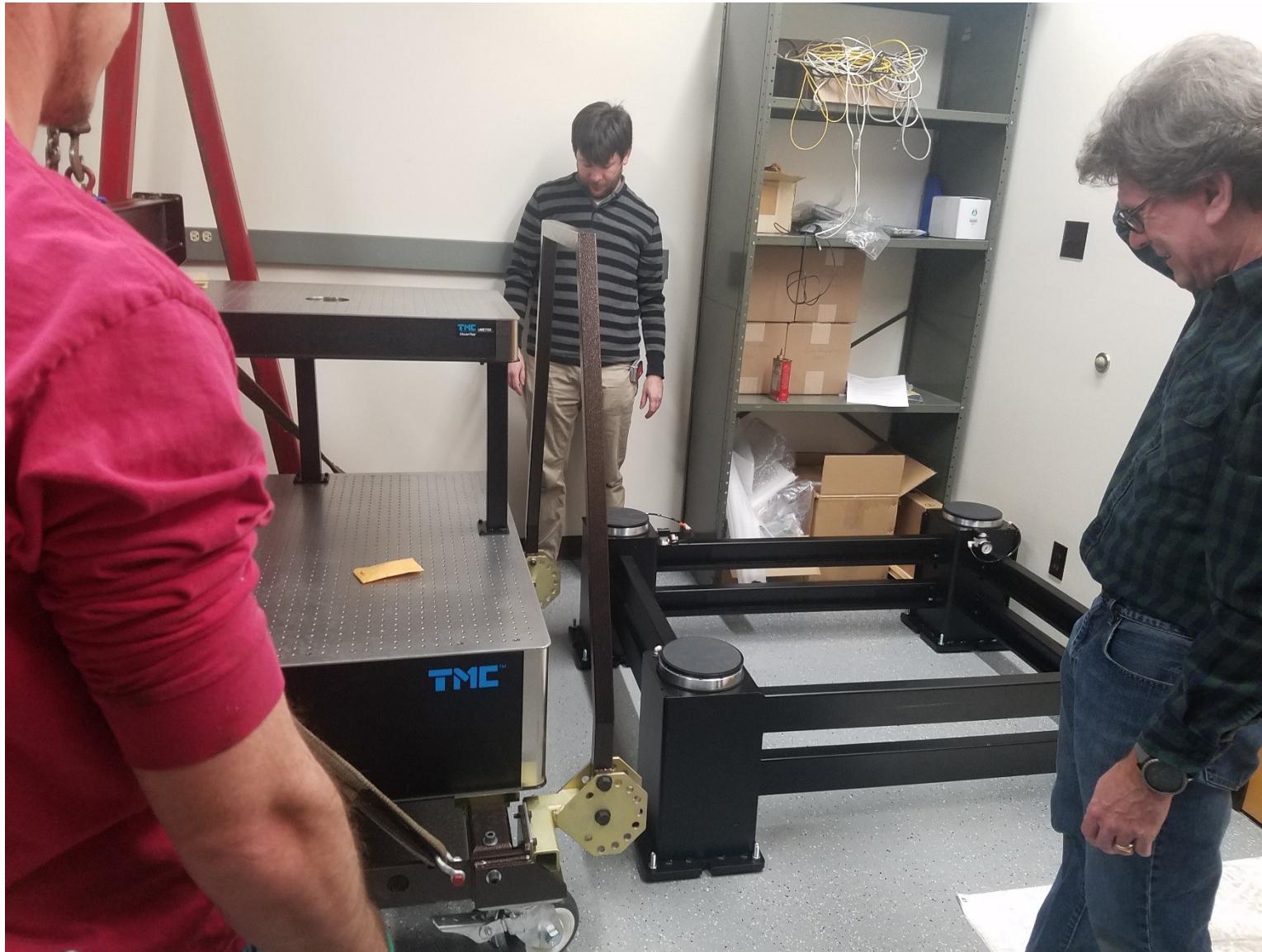
Transporting Down Hall



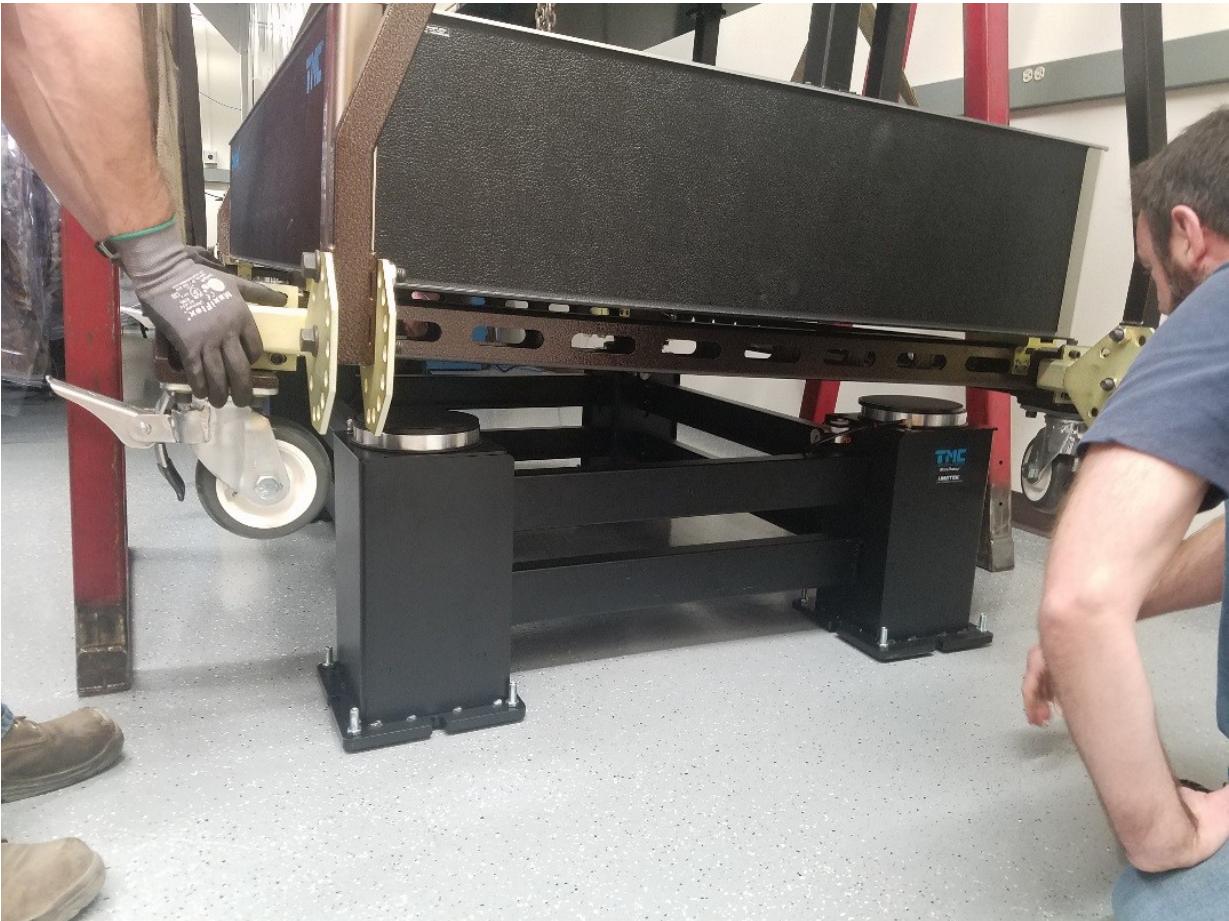
Clean Room



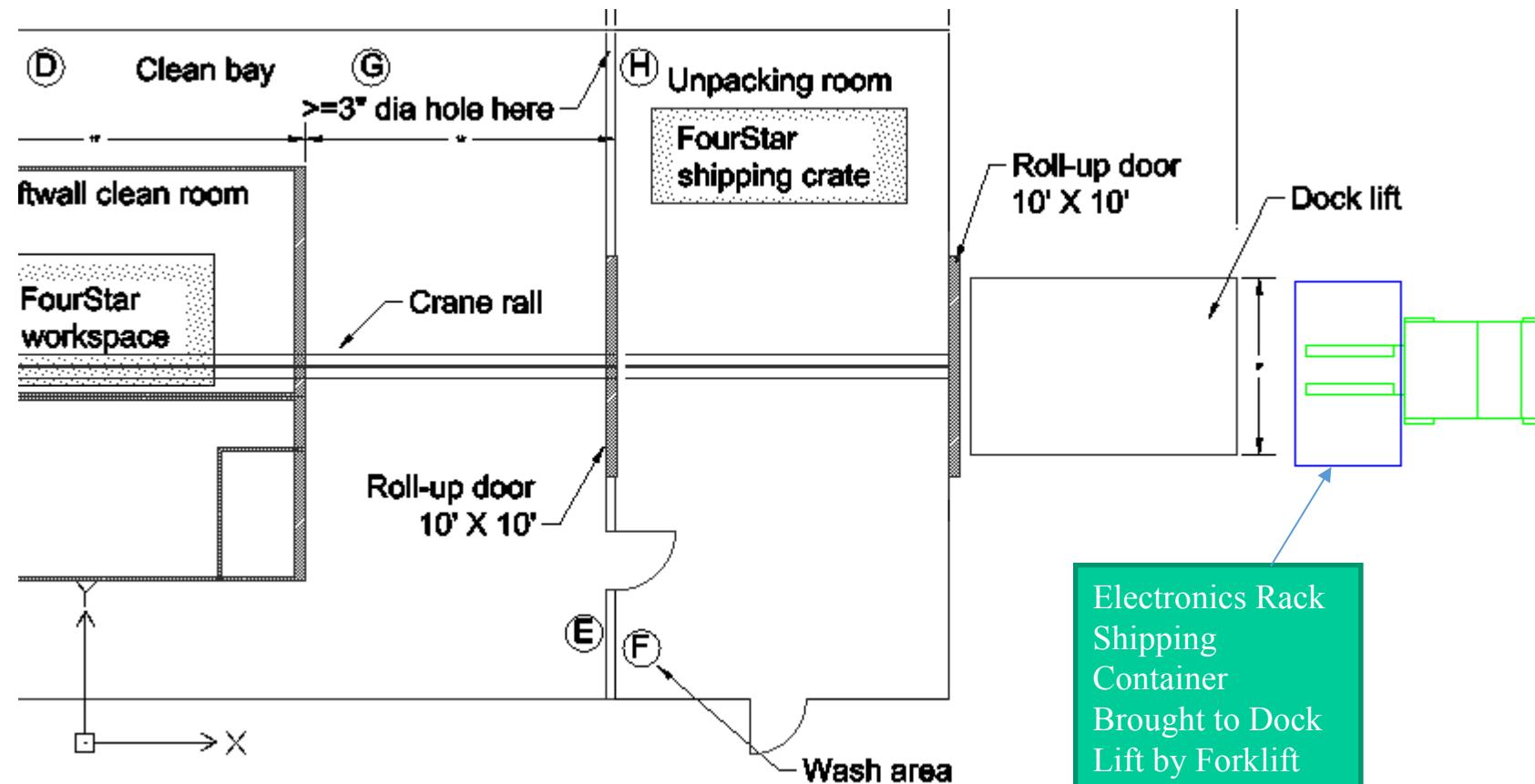
Preparing to Set down on legs



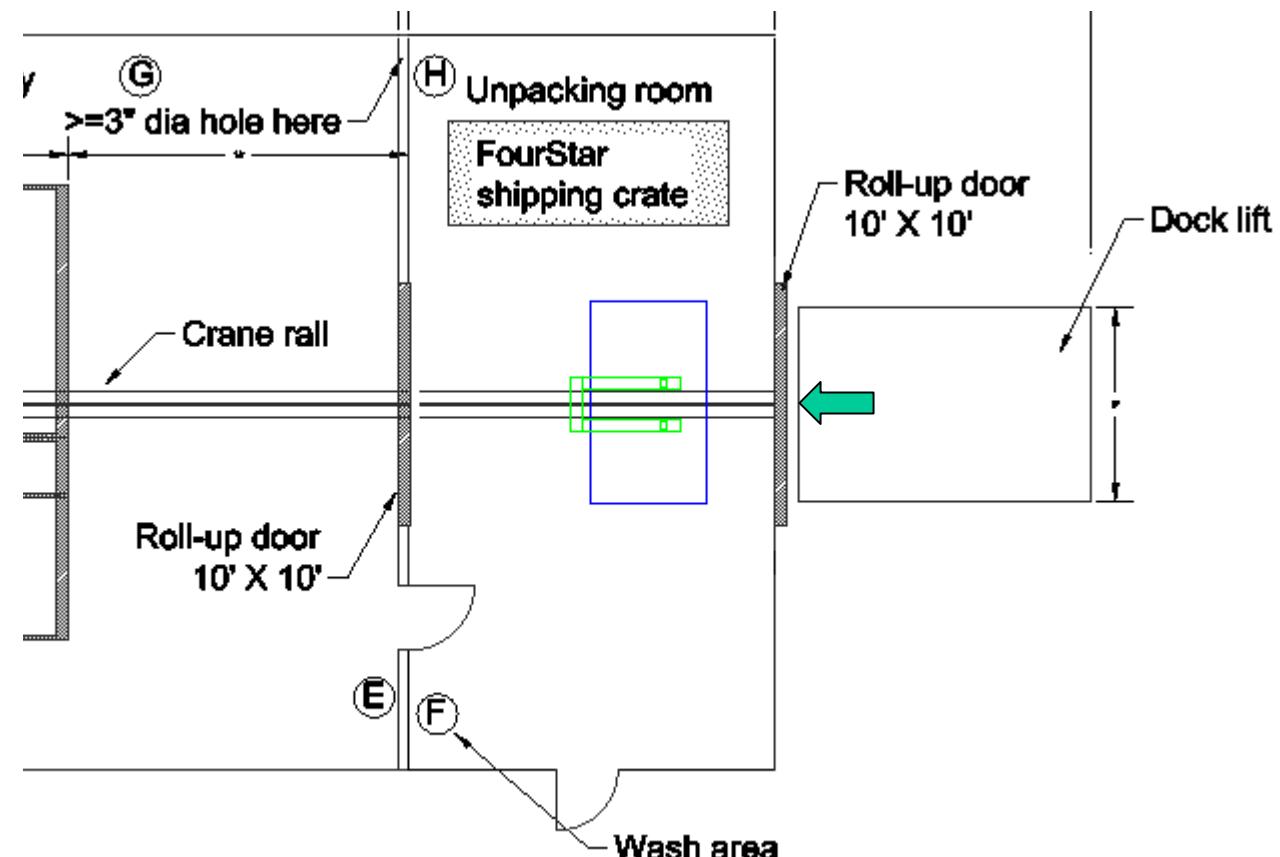
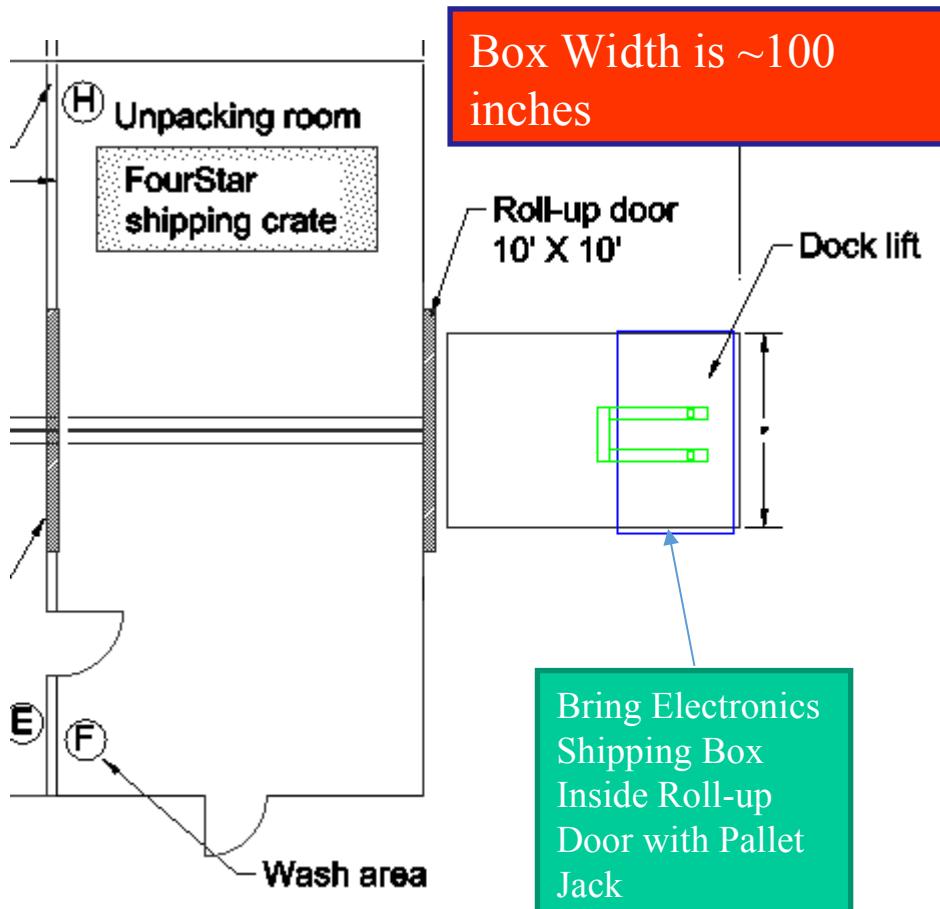
Down on Legs



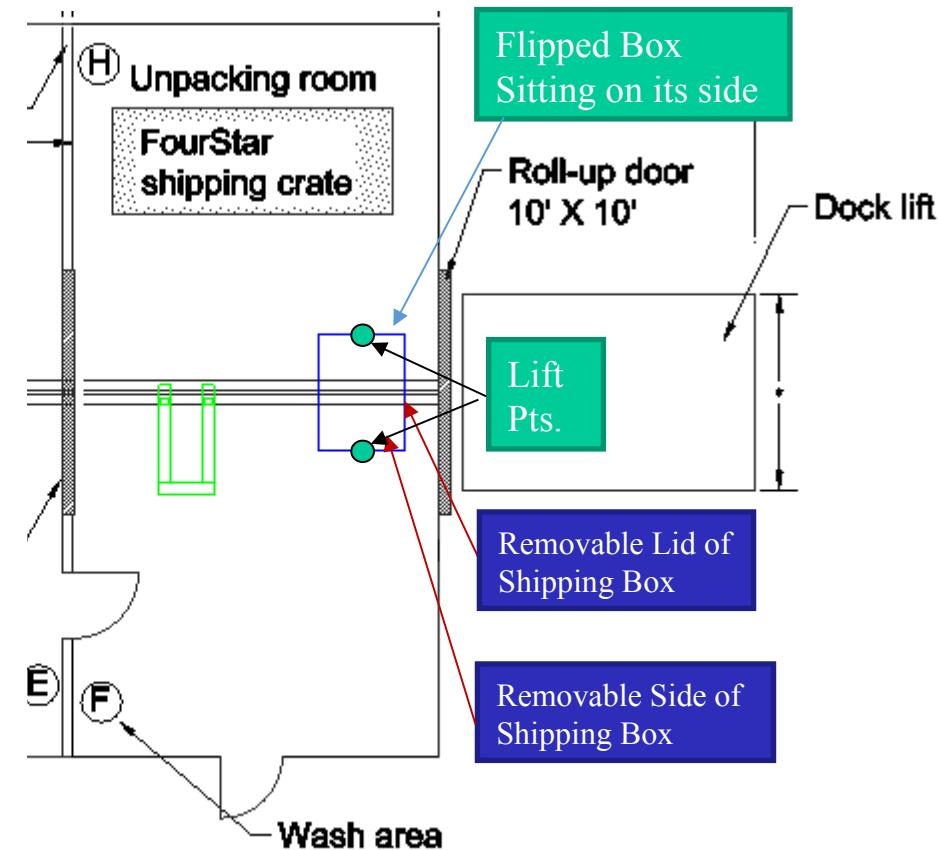
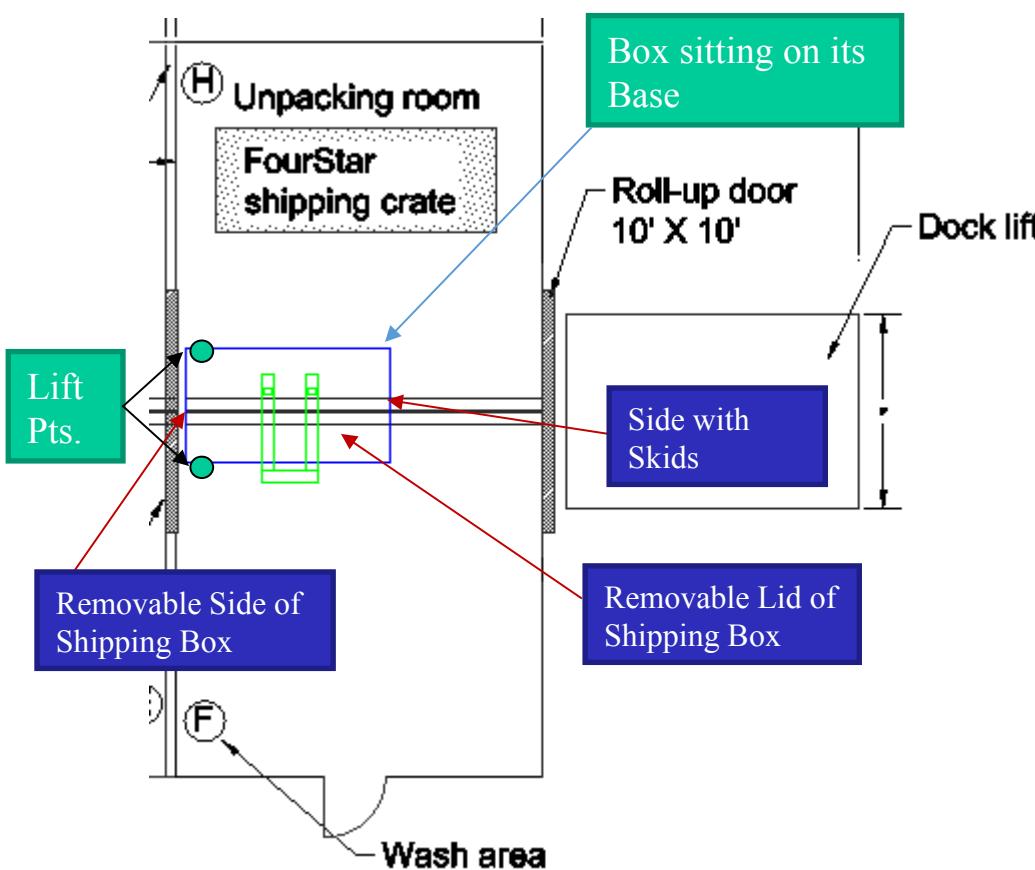
Electronics Rack Box Initial Staging



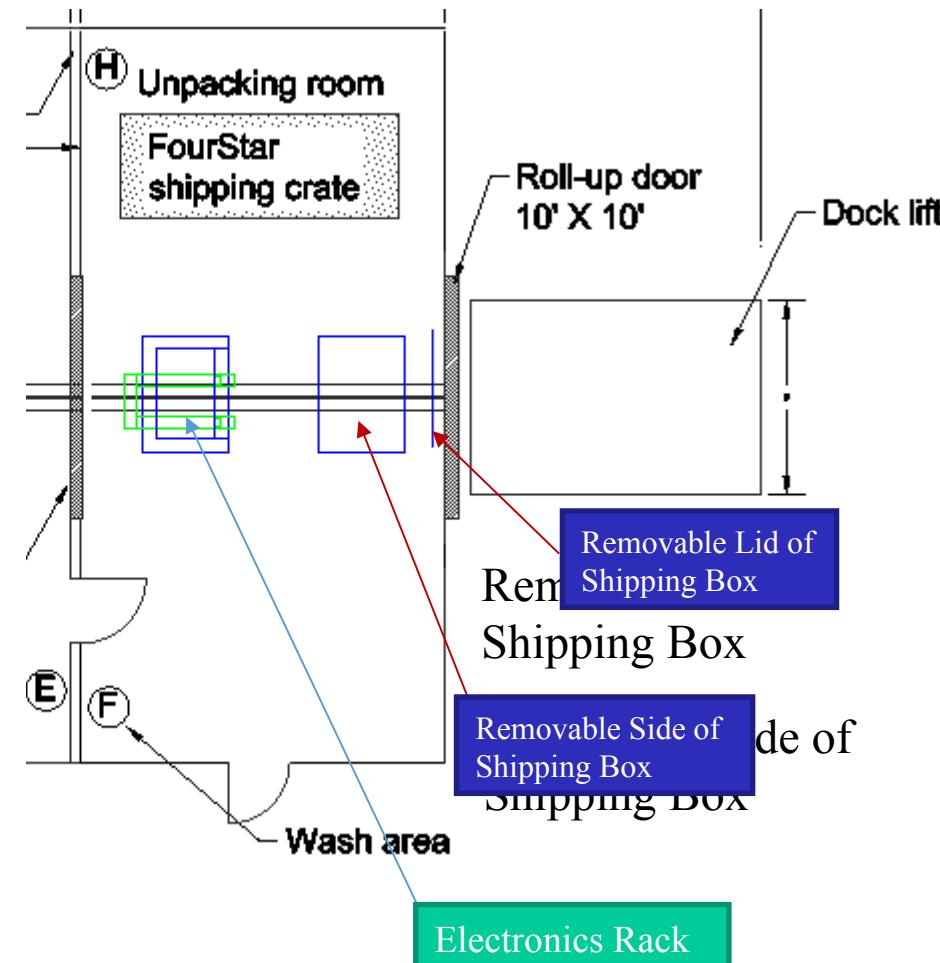
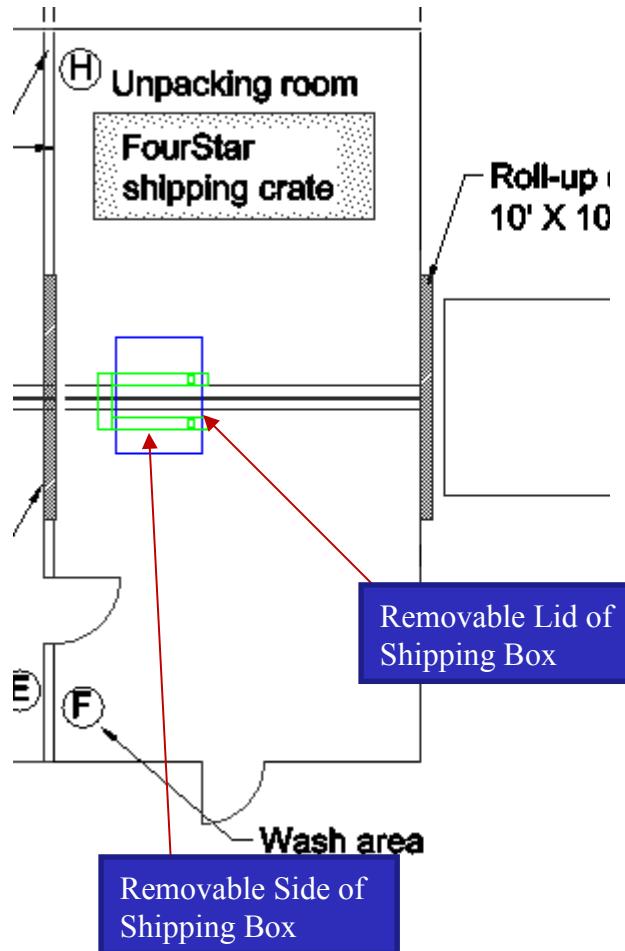
Step 1. Bring Electronics Box Inside Unpacking Room



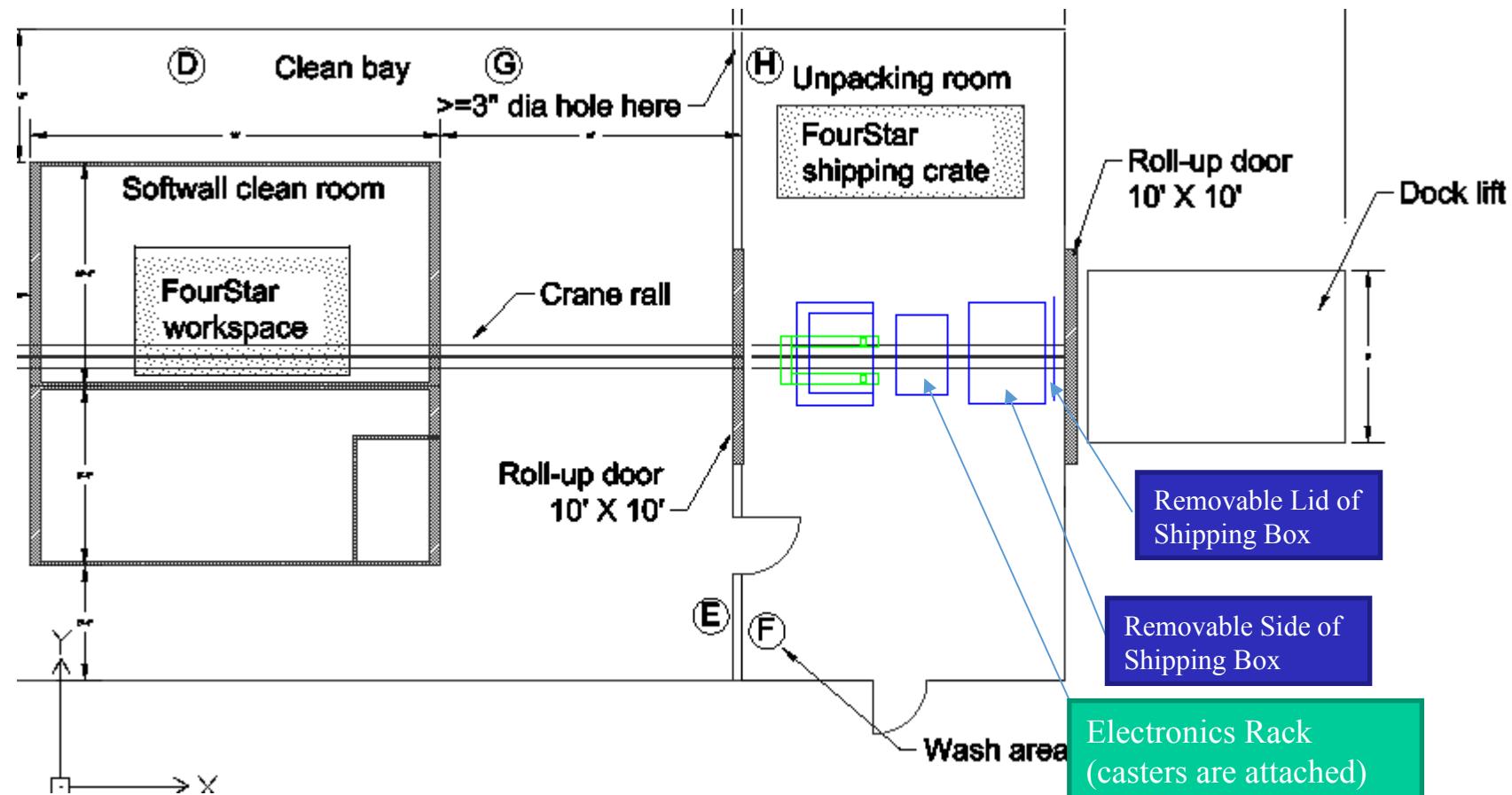
Step 2. Align Box under the Crane with lift points near inner rollup door
 Step 3. Flip Box to vertical orientation



Step 4. Move Box under Crane near inner rollup door.
 Step 5. Remove Lid and Side of Shipping Box.

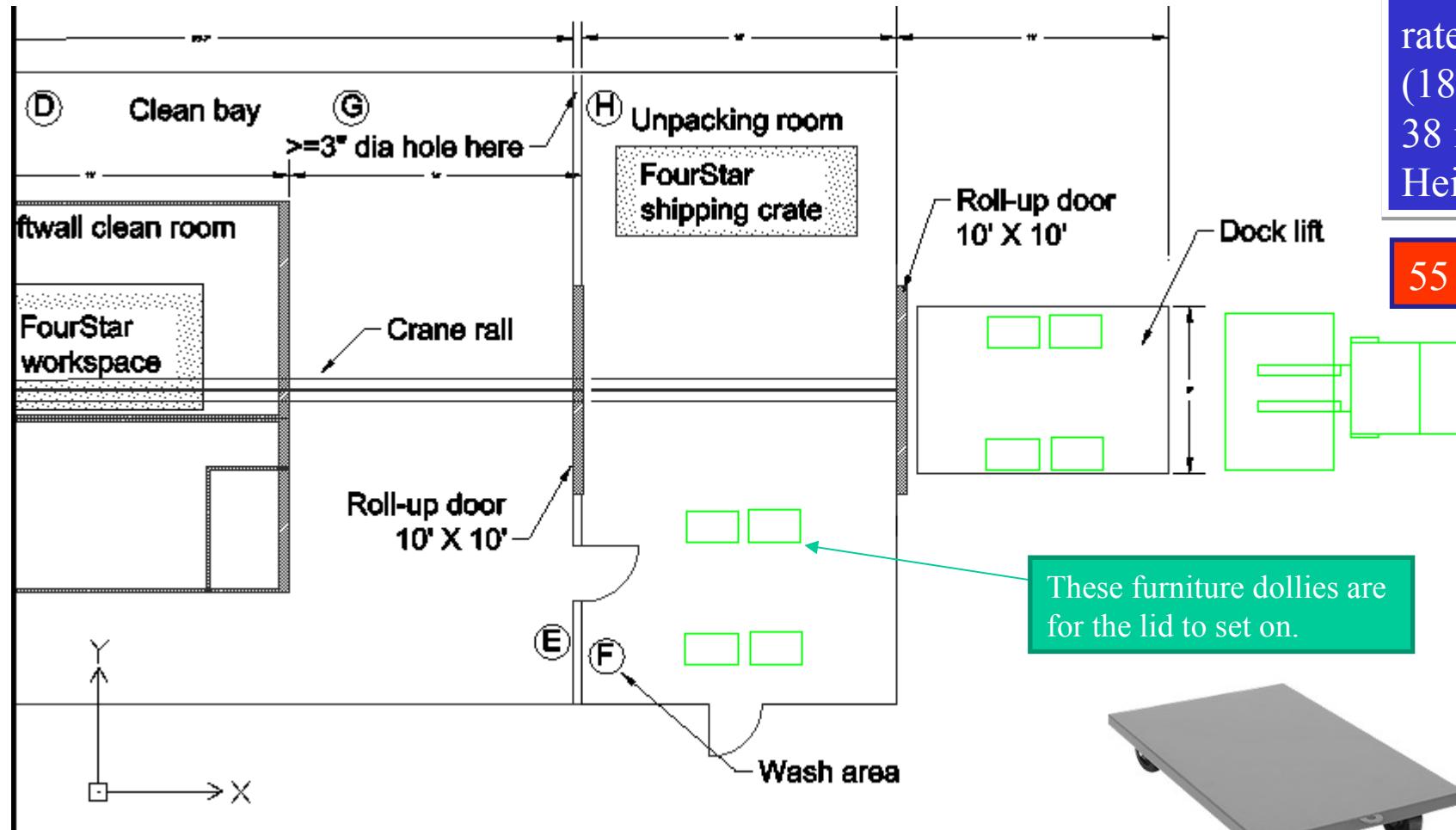


Step 6. Using Crane, Remove Electronics Rack from Shipping Box. Lift a few inches and Move through Opening on Side of the Box



Initial Staging for Instrument Box

Set up 8 furniture dollies as shown.

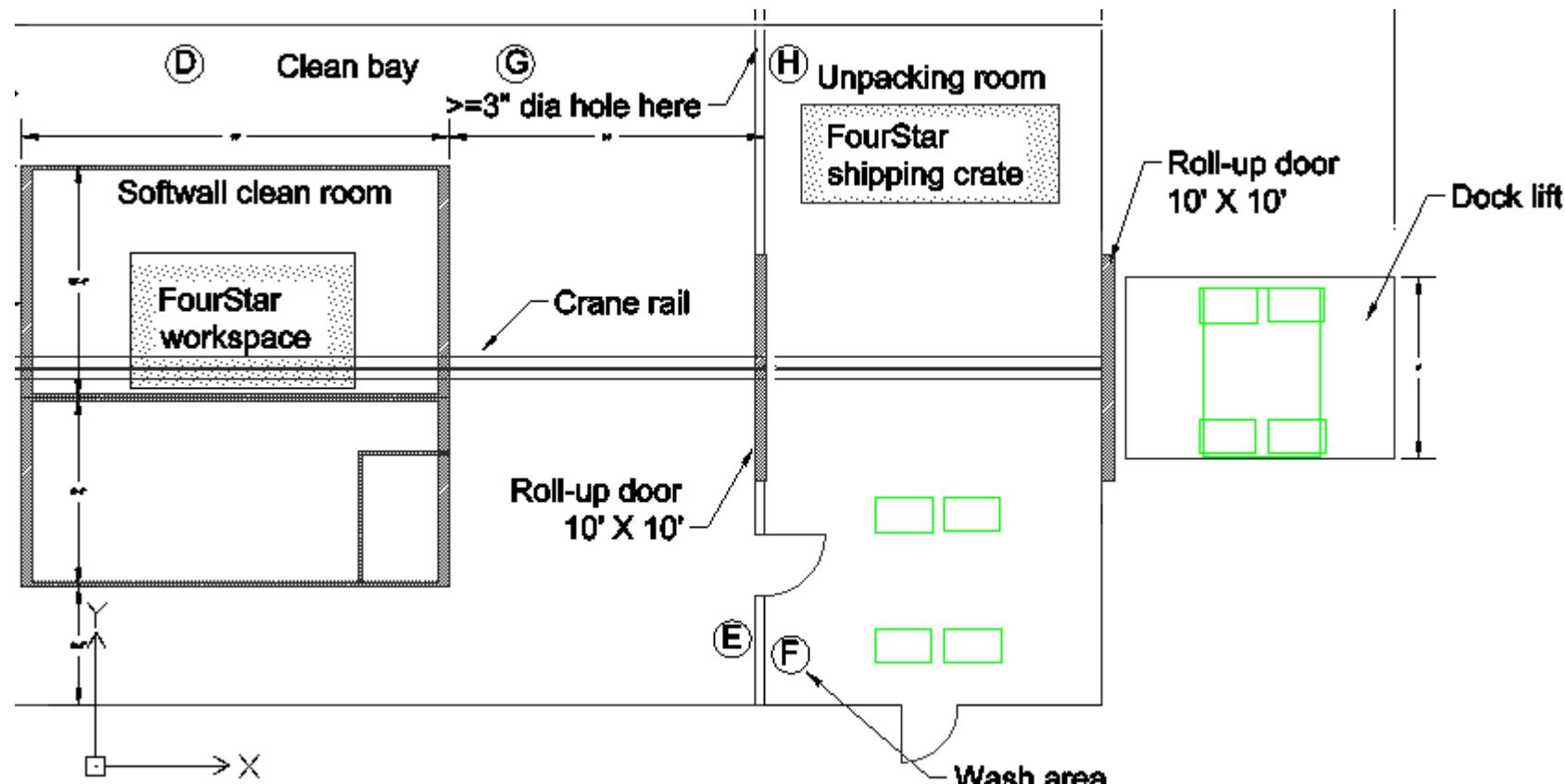


Will require a forklift rated at or above 4000 lb (1800 kg) at load center 38 inches and Fork Lift Height TBD

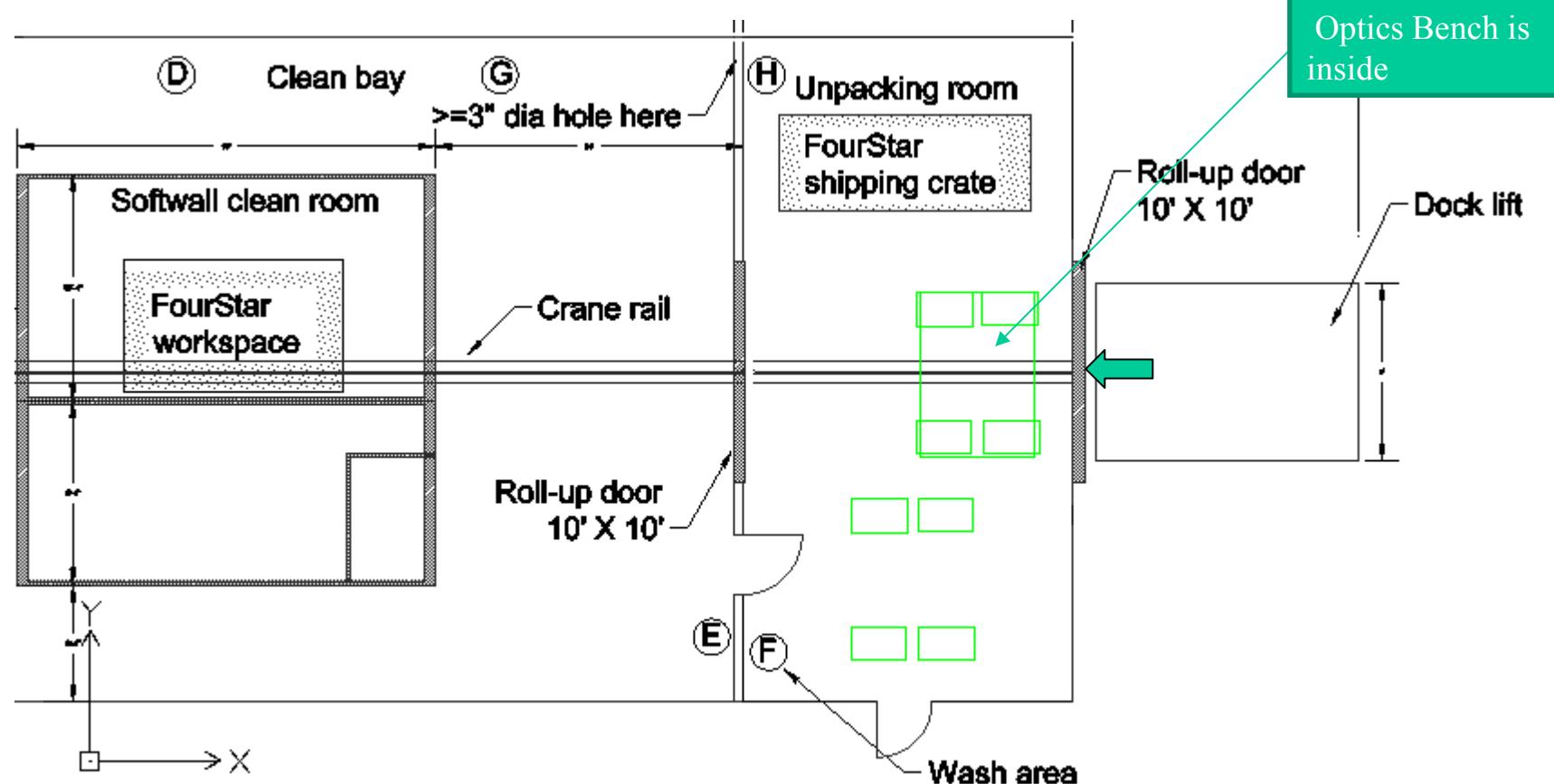
55 inch forks required



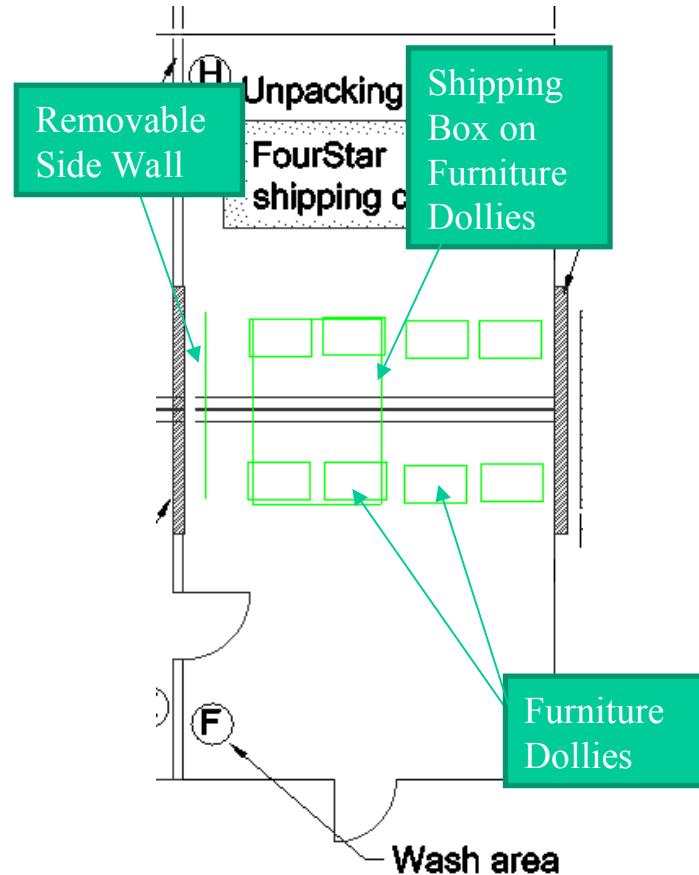
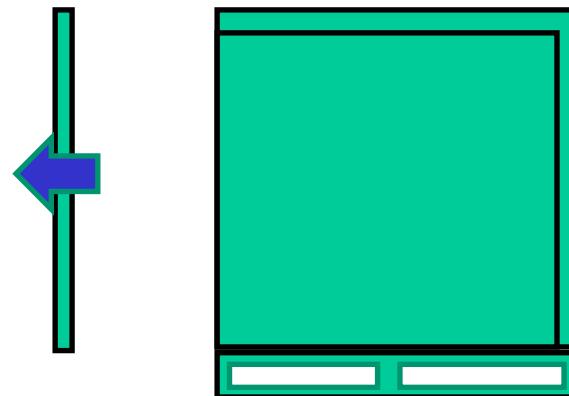
Step 1: Set Box down on furniture dollies on Dock Lift



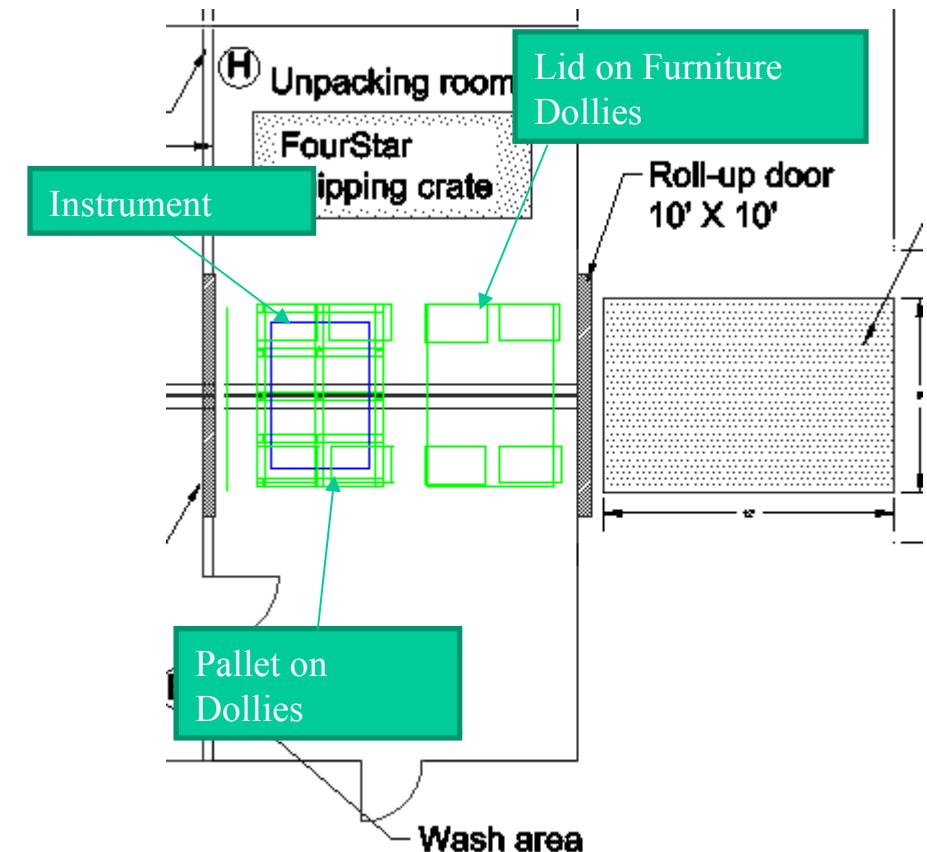
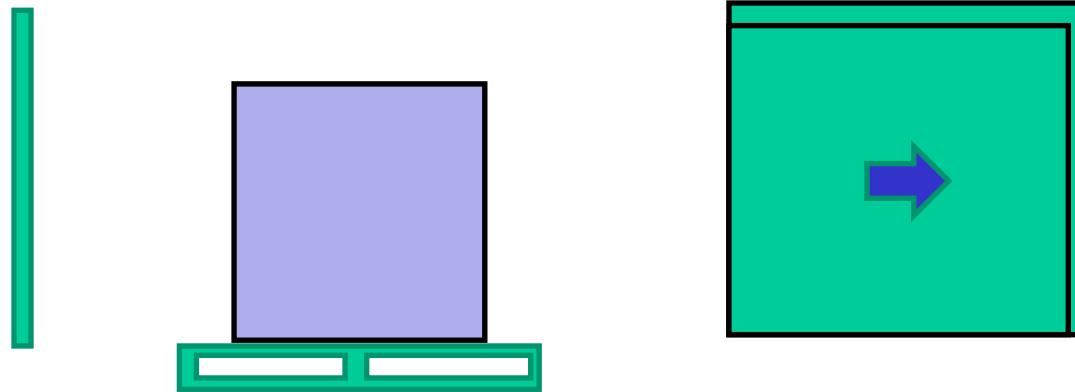
Step 2: Roll Box into Unpacking Room



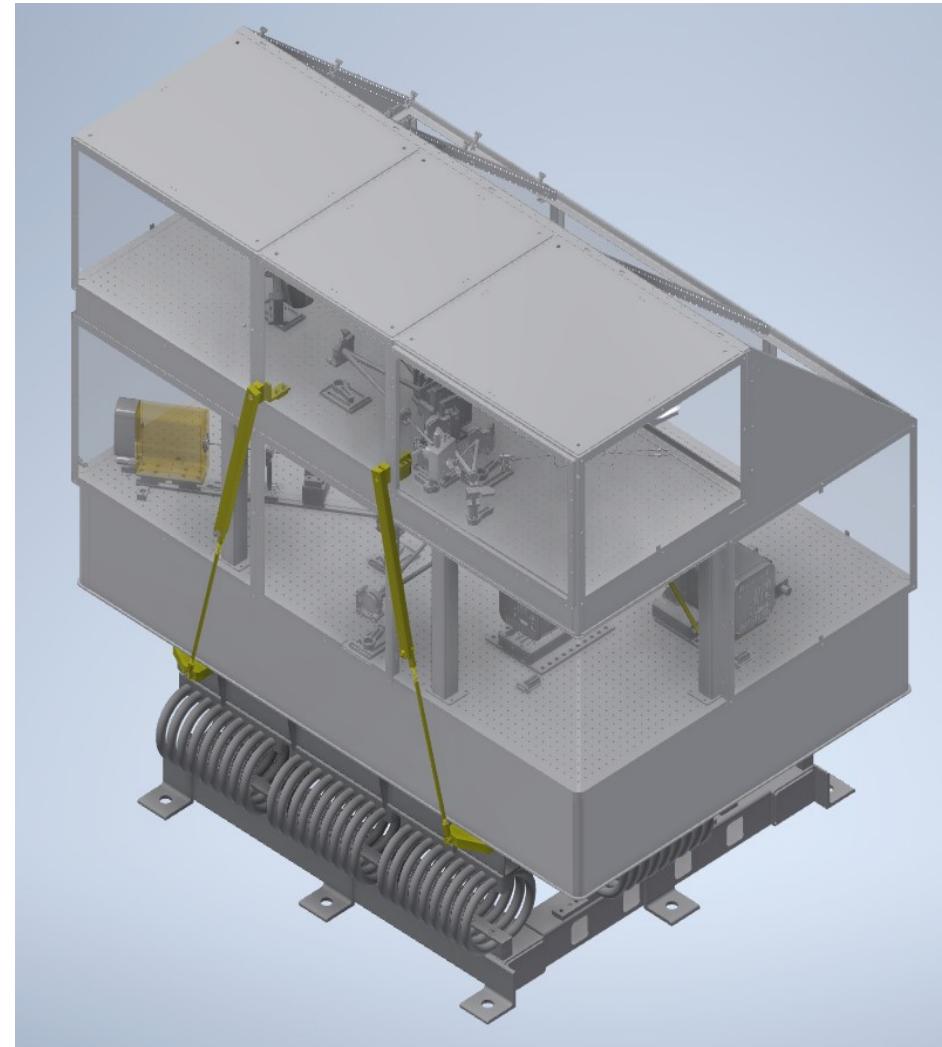
Step 3: Remove Side Wall of Box



Step 4: Remove Lid and Remaining Walls of Box using Crane



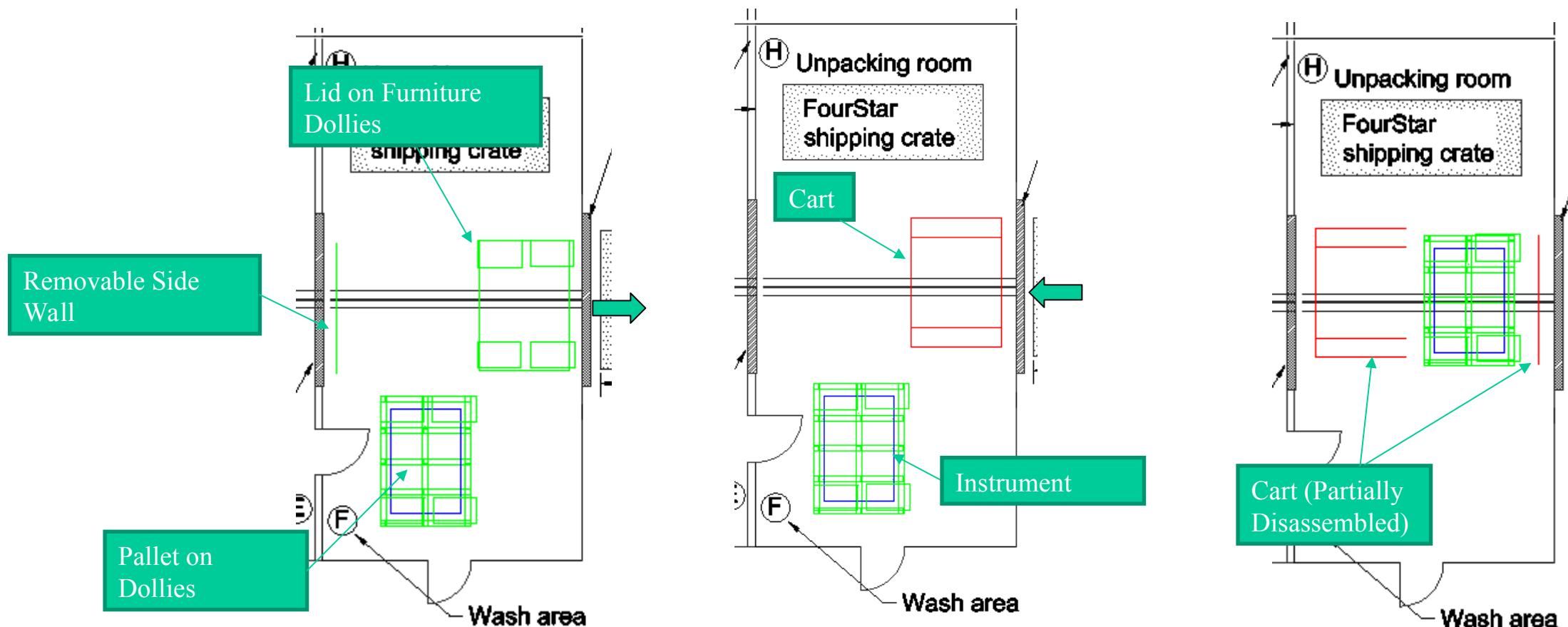
Step 5: Remove Rear Shipping Clamps



Step 6: Remove Lid from Unpacking Room

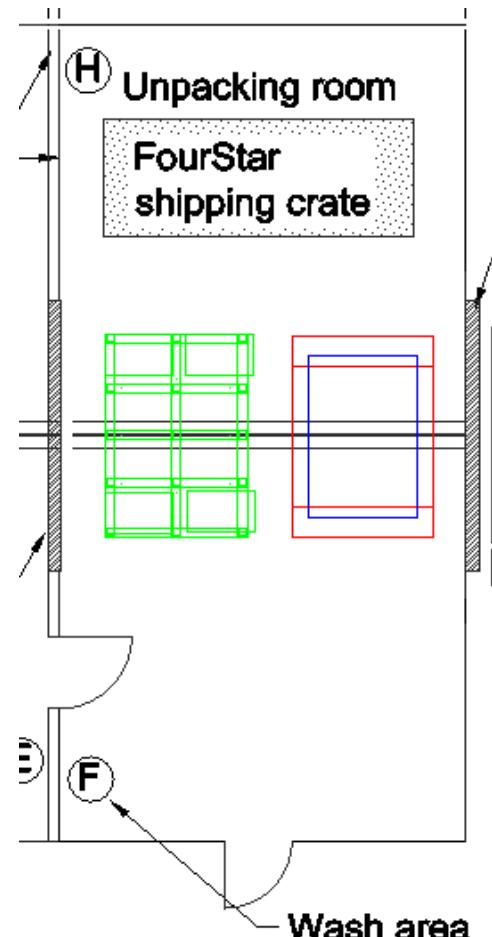
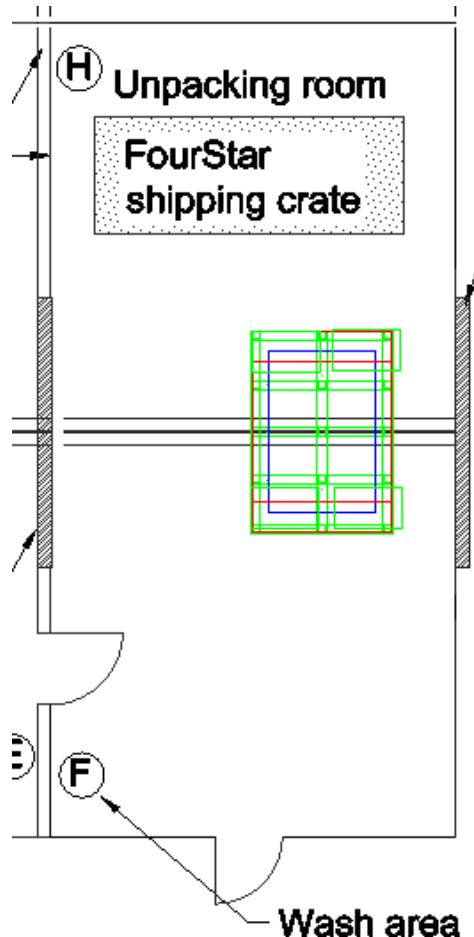
Step 7: Roll Handling Cart into Clean Room

Step 8: Partially Disassemble Cart



Step 9: Bolt Cart on bottom of Instrument Breadboard

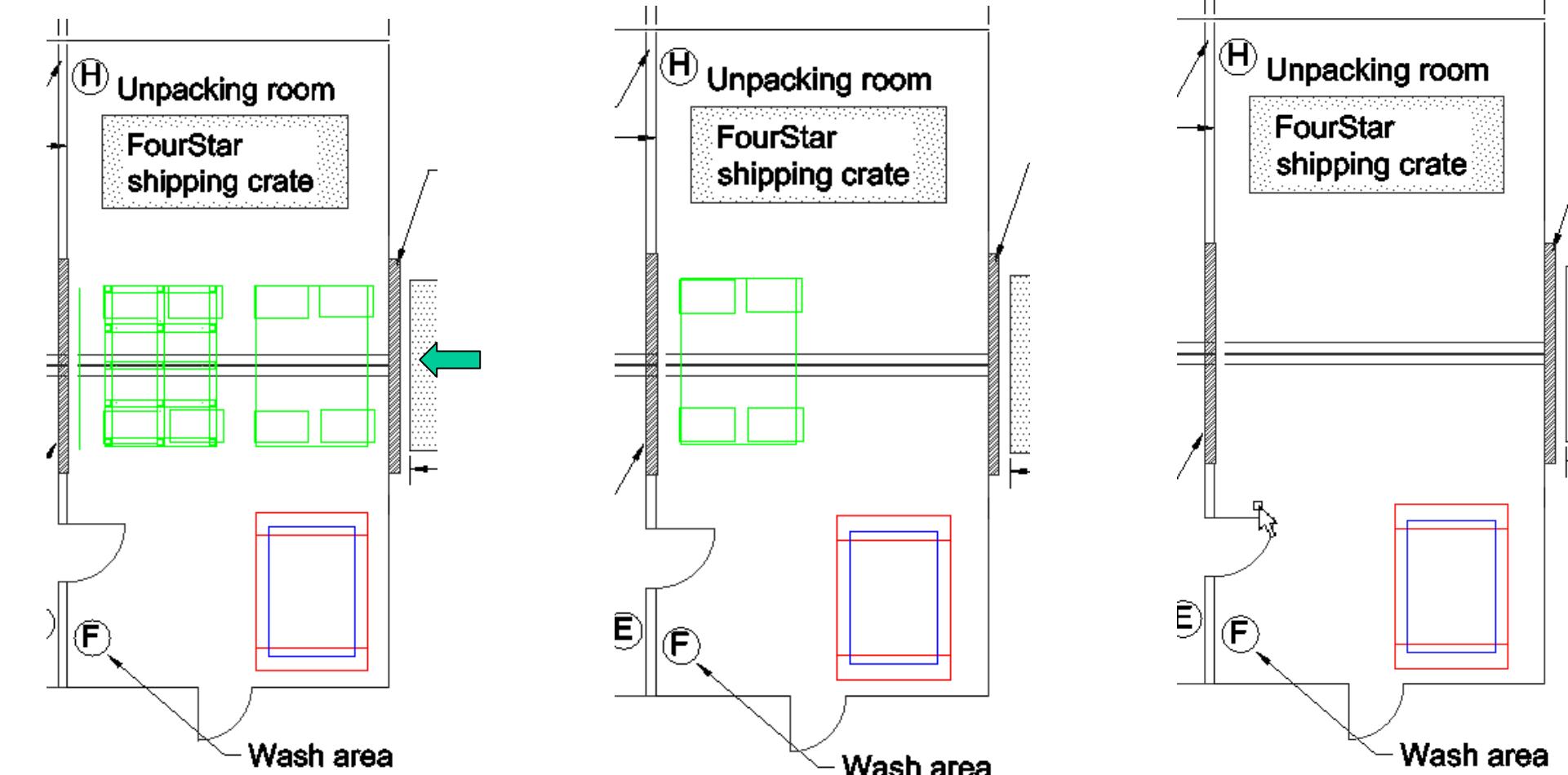
Step 10: Remove Instrument from Shipping Pallet using Crane



Step 11: Place Lid and Walls Back on Box Pallet

Step 12: Move Assembled Shipping Box Out of Unpacking Room

Step 13: Roll Optical Bench on Cart to Desired Location

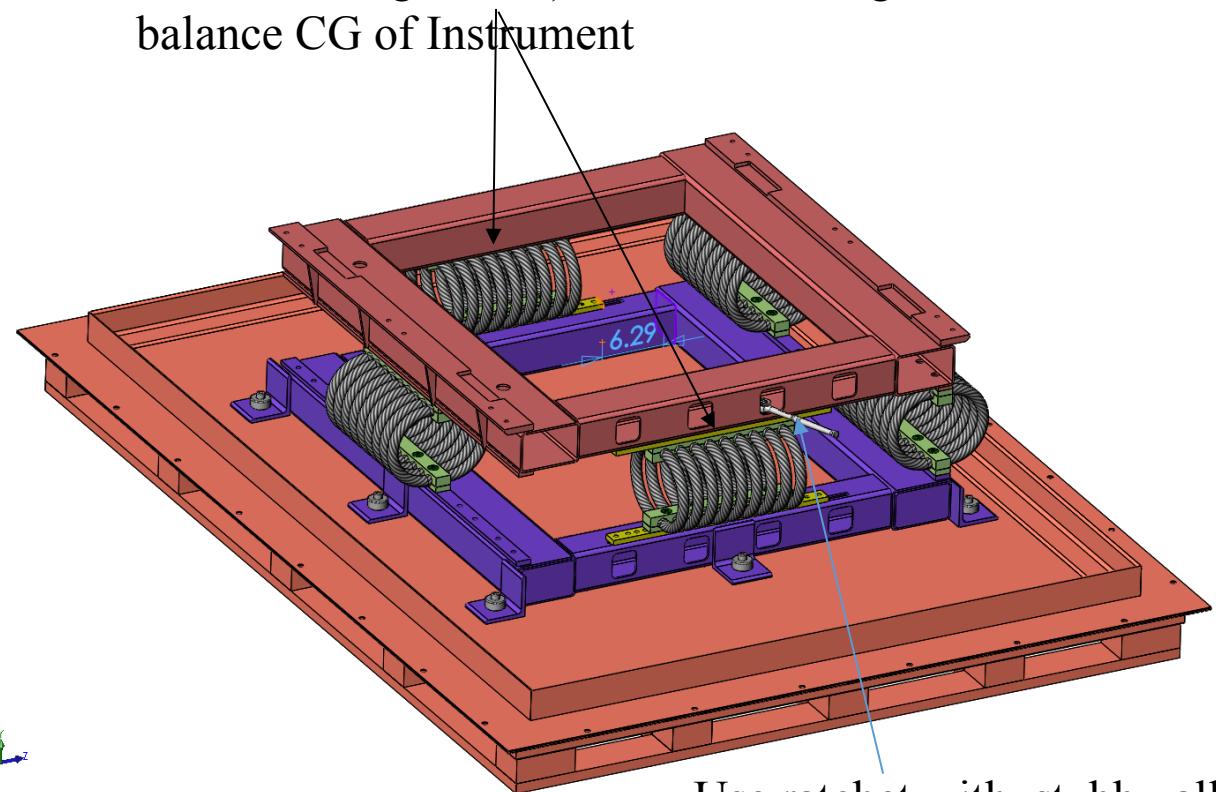


- A crate with the table legs will be included in the first shipment
- The table legs will need to be assembled in the clean room
- The optical bench will be lowered onto the table legs with the crane.

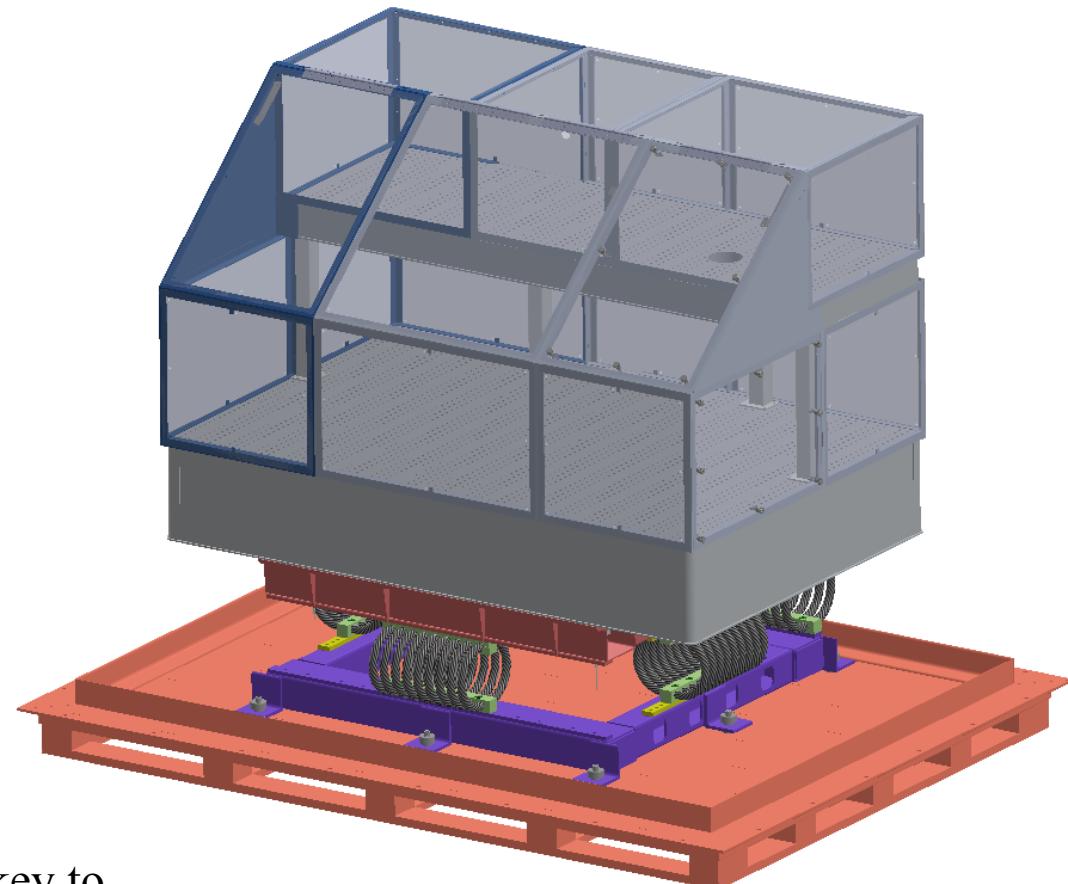
- We plan to move the instrument on the cart, on the Isuzu flatbed, much like we currently move the ASM. This will save us from repacking it and from having to move the box up to the telescope, minimizing forklift needs.
- Dust protection will be provided by the dust cover, and we will shrink wrap before each trip up and down the mountain.
- Then we can run it into the elevator to the observing platform preventing a large jib crane lift from the chamber floor.

- Refer to “MagAO-X alignment at Telescope, Laird Close”

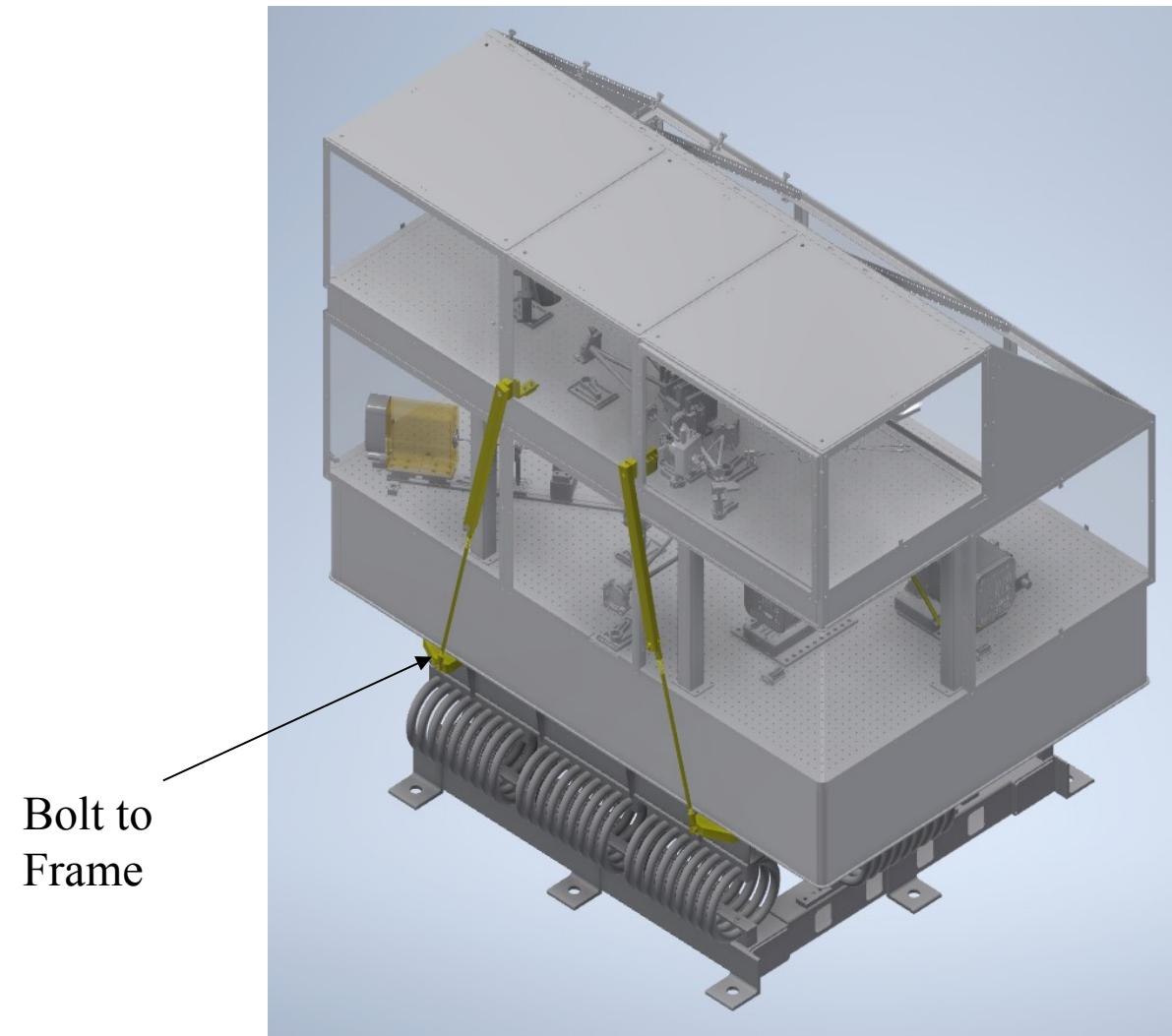
Set the two center isolators using adjustable mounting bars to 6.29 inches as shown (for 5 isolator configuration), from inside edge of frame, to balance CG of Instrument



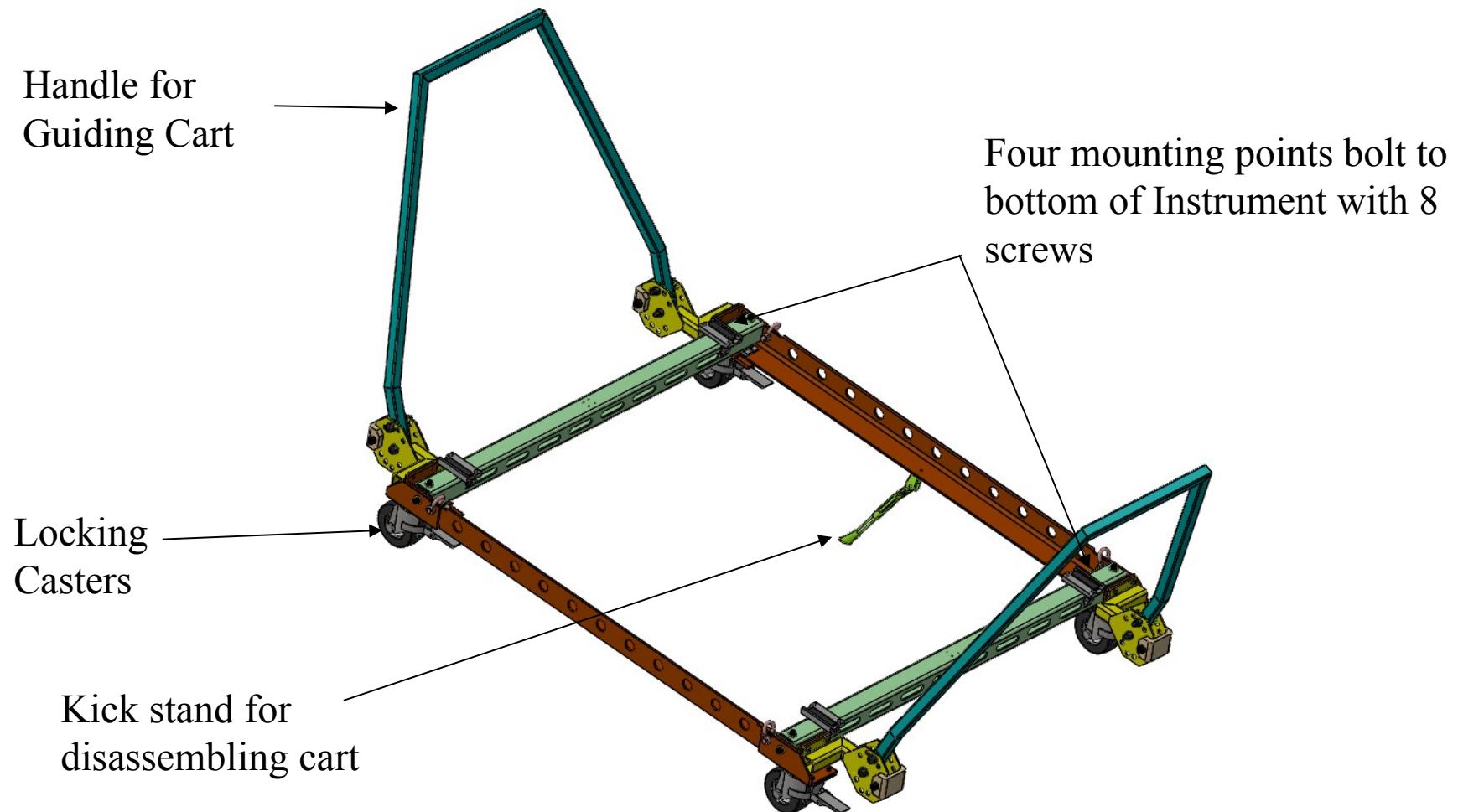
Use ratchet with stubby allen key to
adjust center isolators



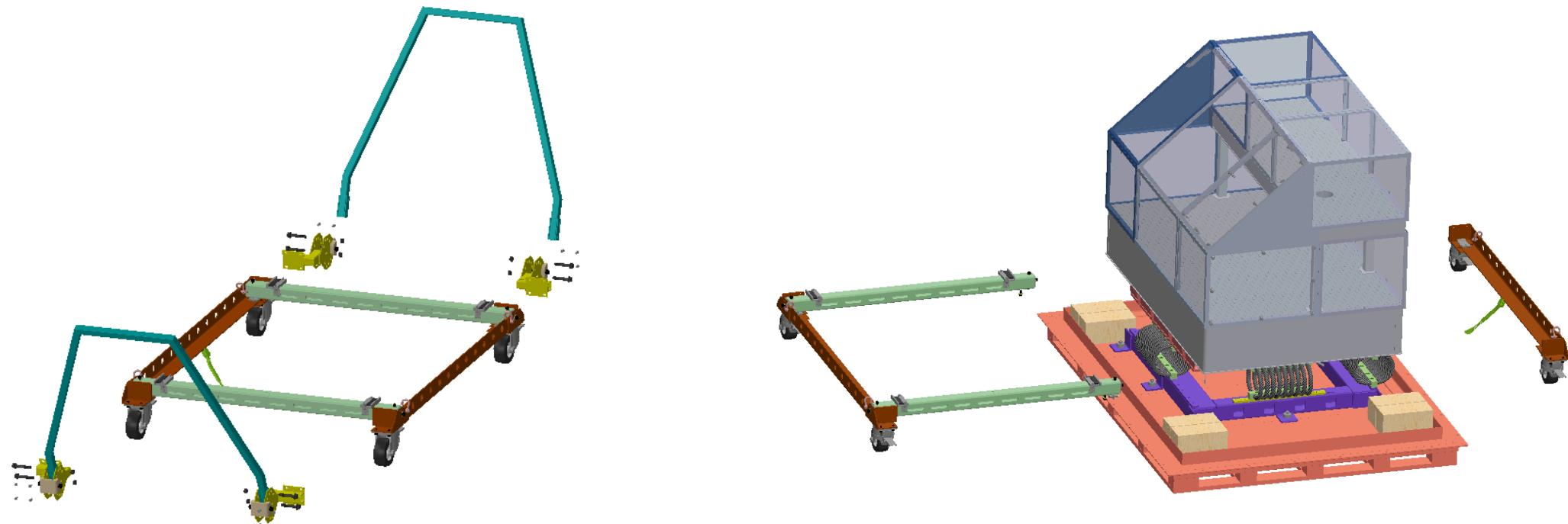
Shipping Clamps to be removed when the box is opened



Handling Cart

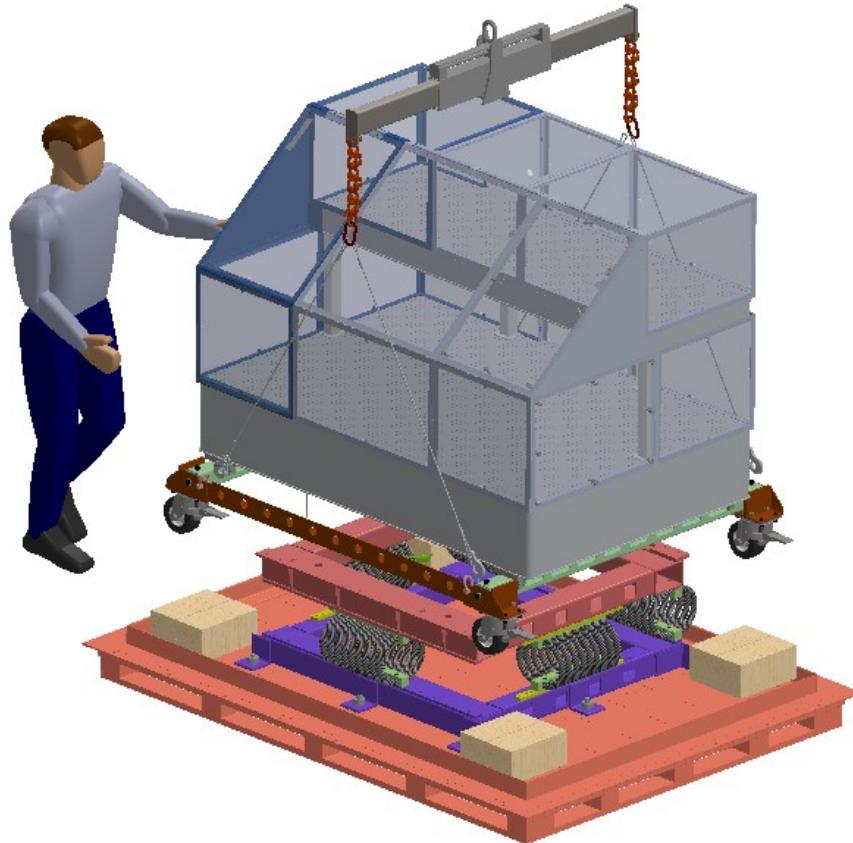


Disassemble Handling Cart and Place on Wooden Cribbing on the Shipping Pallet

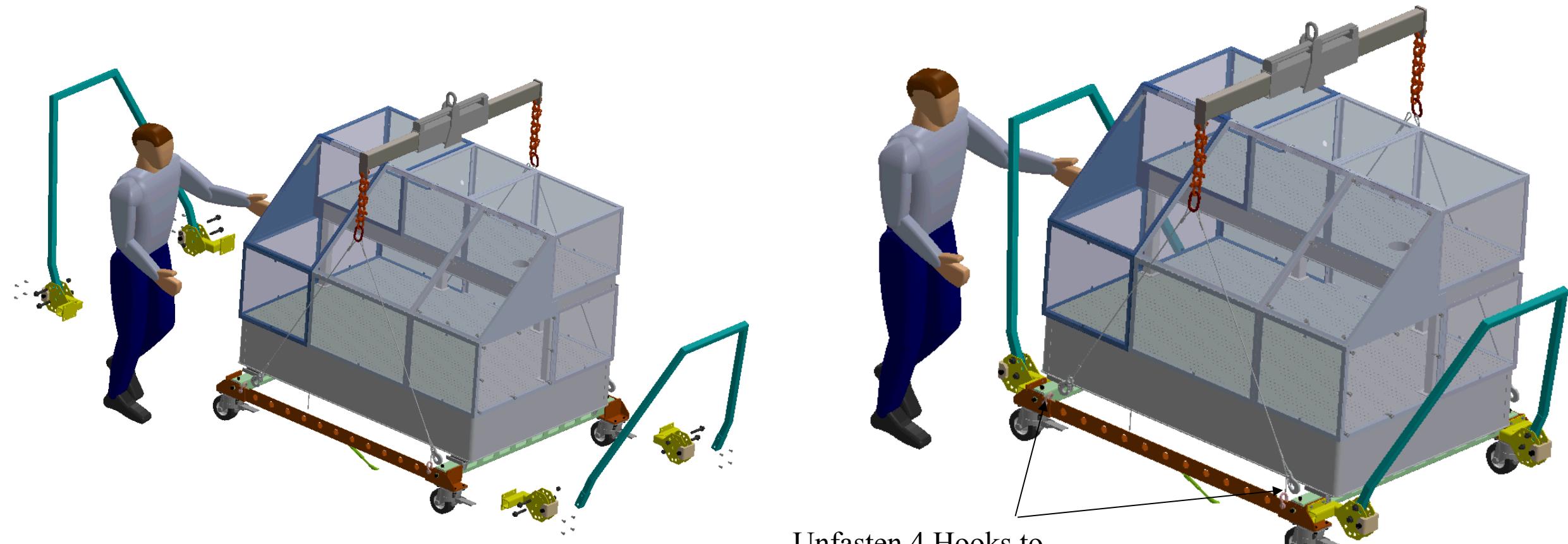


Cart is separated and placed around shipping frame, raised on wood cribbing to clear the wire rope isolators.

Bolt Lifting Cart to the Instrument and Unbolt Instrument from Shipping Frame. Lift Frame.



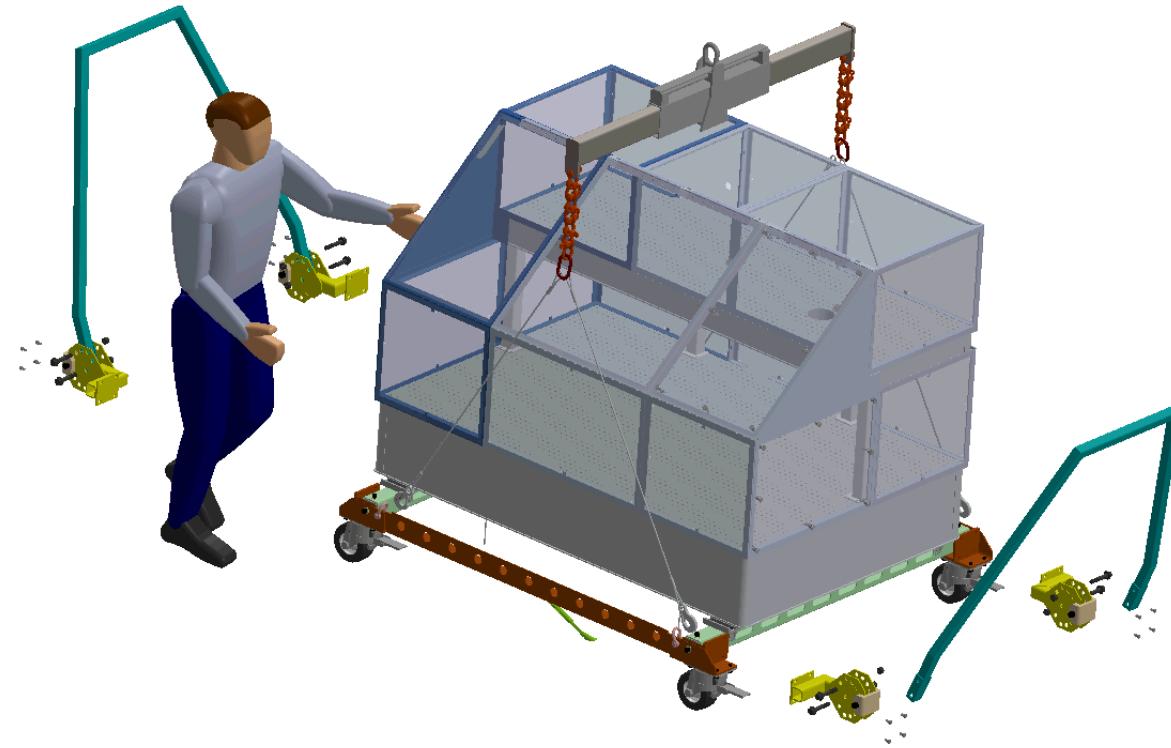
Lower onto Floor and Install Handles to Create Rolling Cart Configuration



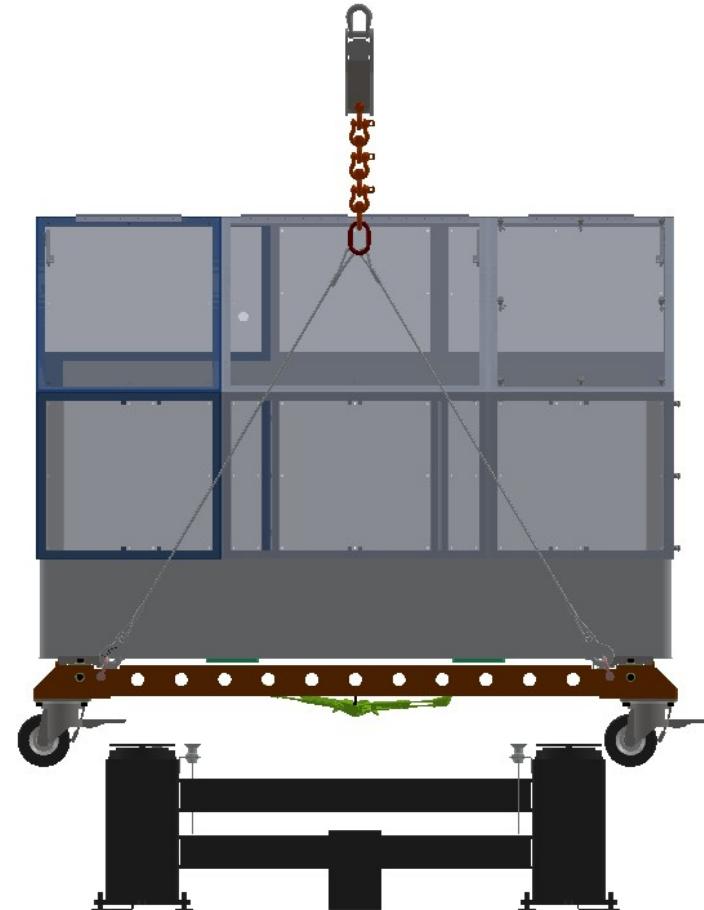
Roll Instrument to New Destination



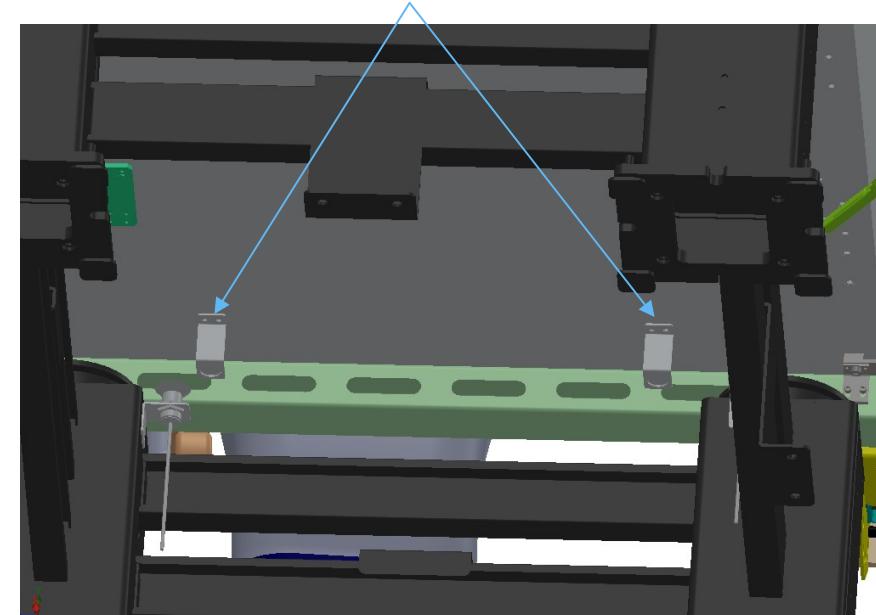
When Done Moving Instrument,
Remove Handle
Bars from Cart.
Reattach Spreader Bar



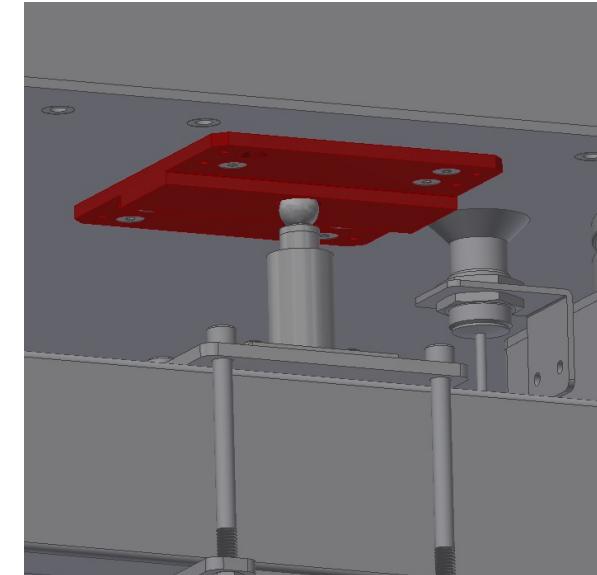
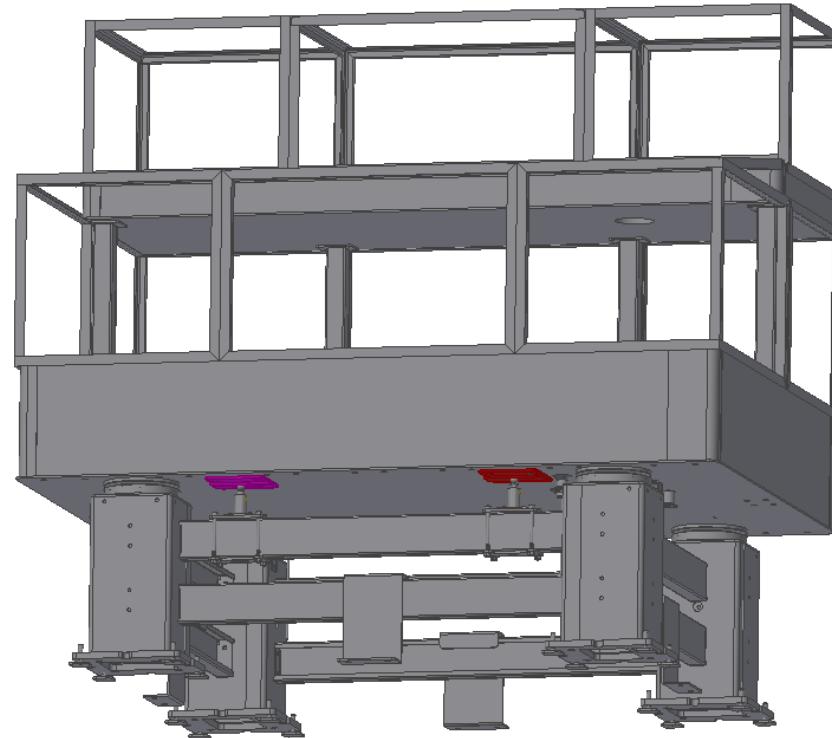
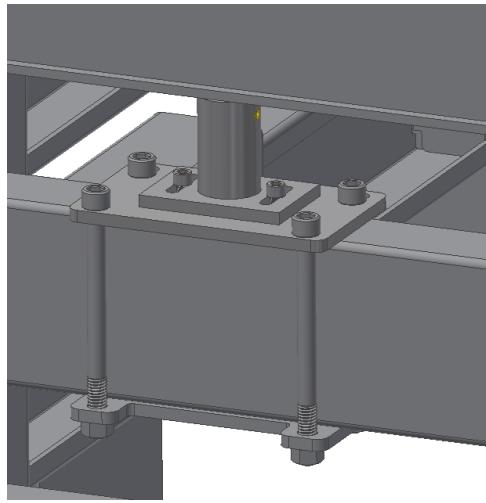
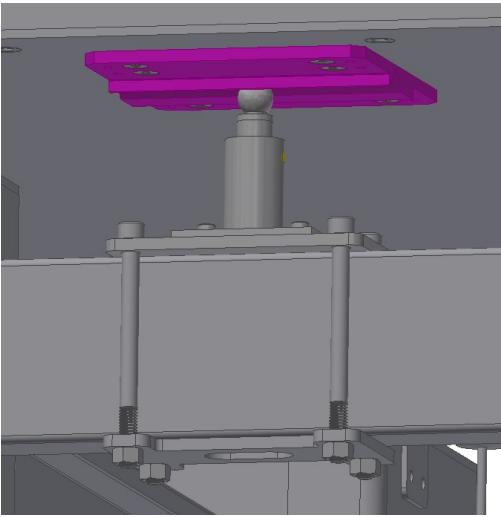
Lift Instrument onto the Table Legs
Watch out for the Accelerometers



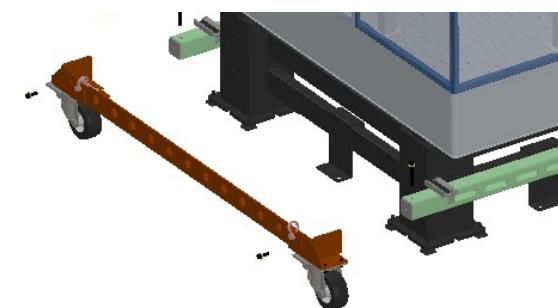
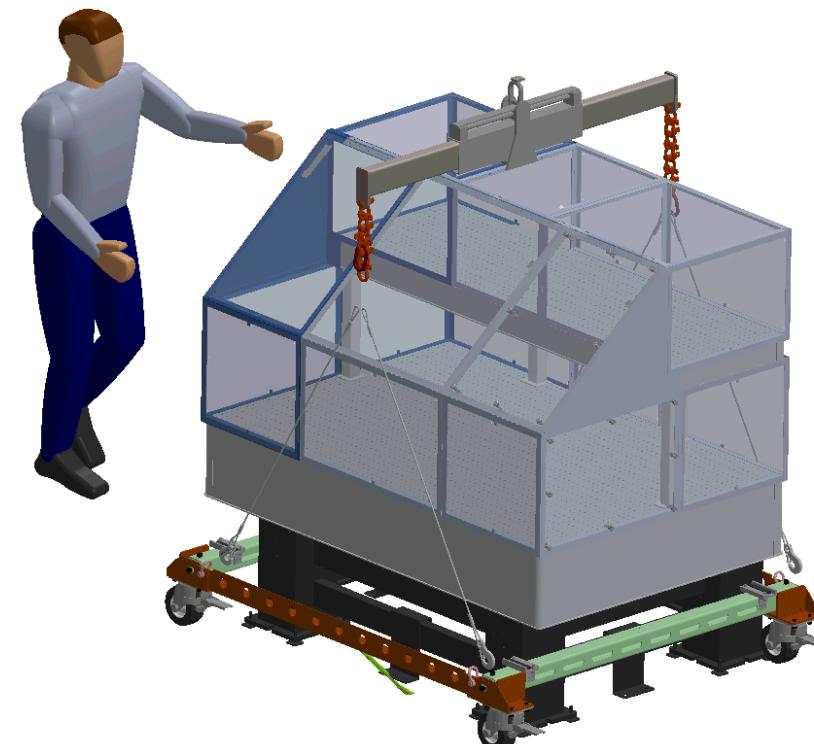
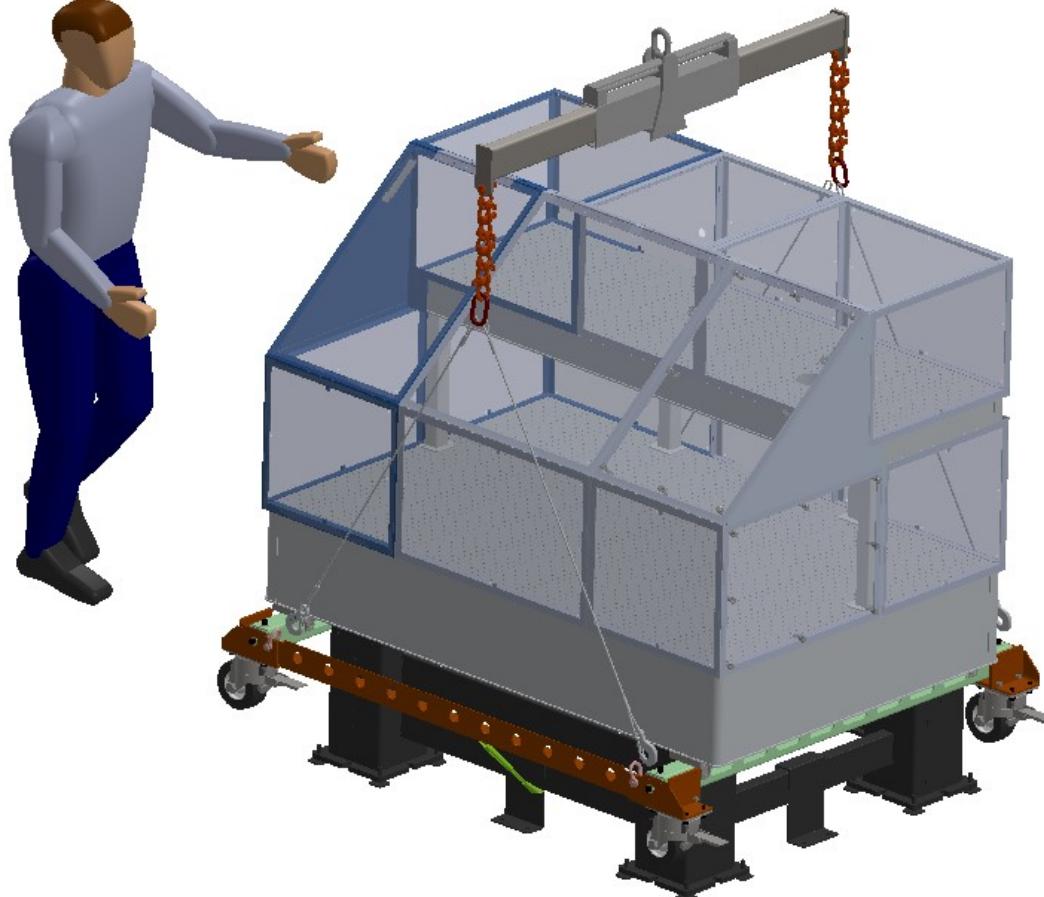
Watch for
accelerometers



Set the Lateral Position of the Bench using the Guide Pins



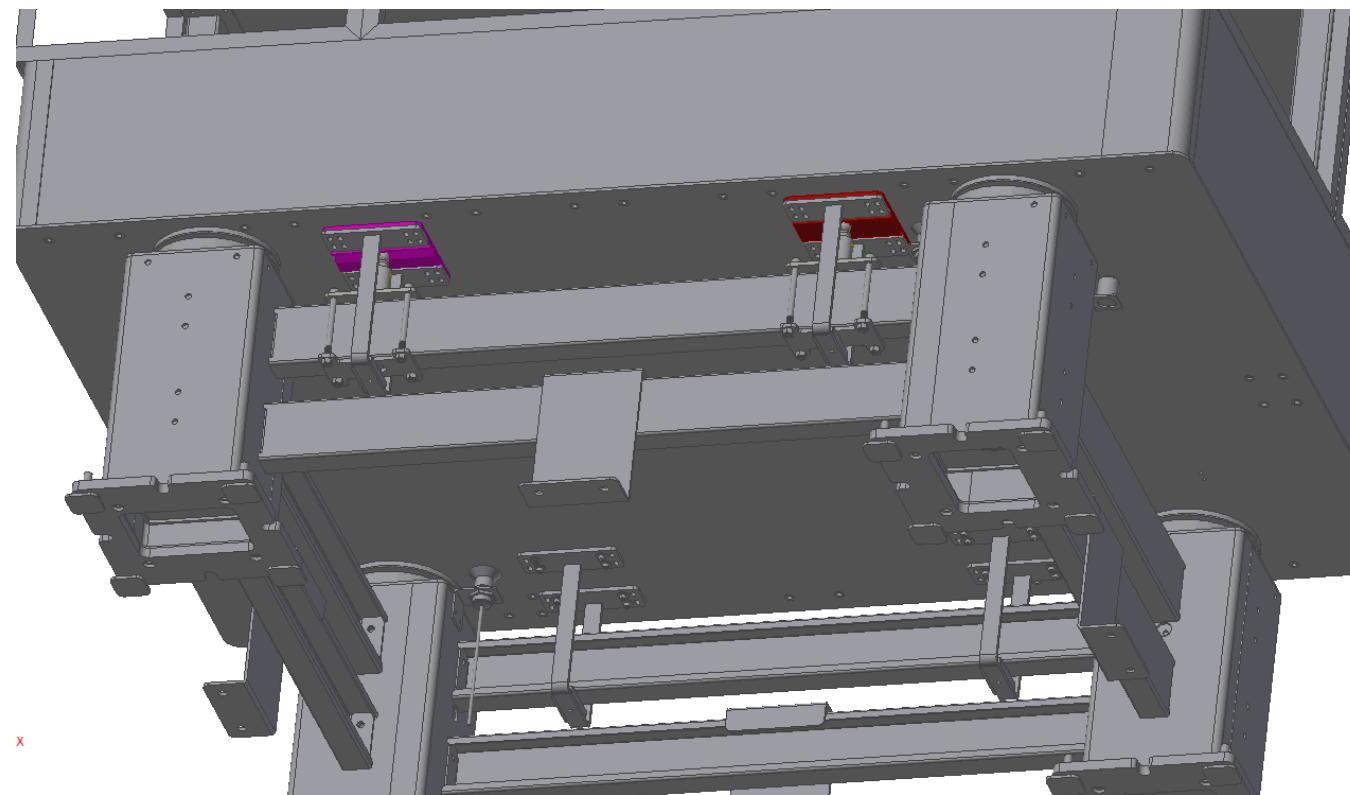
Unbolt Cart from Instrument and Lower Cart Remove Cart from around Table Legs



Install Earthquake Bars

Instrument can now be rolled on the table leg wheels.

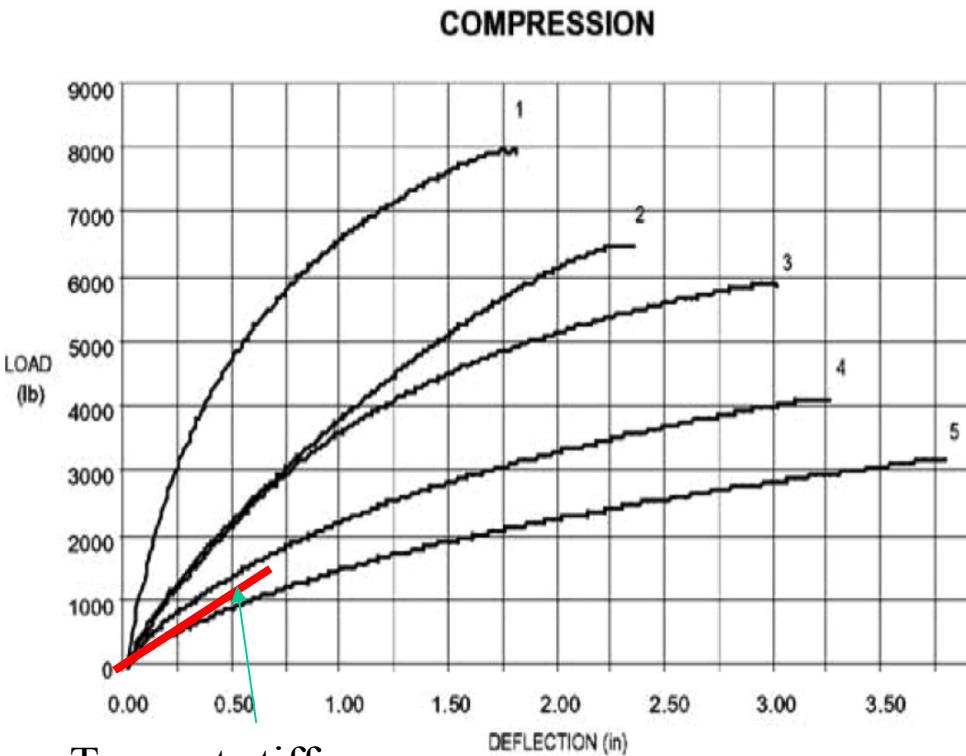
Refer to “MagAO-X alignment at Telescope, Laird Close”



Note 1: Lift can be done with or without handles attached to cart



Note 2: Number of Isolators in shipping frame will be either 5 or 7



Tangent stiffness at transportation loads

# Isolators	18 inch Drop Deflection @ 1750 lb	Axial Transportation G's (goal is to be < 2g's)	Lateral Transportation G's (not including 0.3 g's for driving on hills and 0.5 g's for slamming on brakes)
	Peak Deflection of Instrument during a Drop	Peak G's on Instrument without a drop	Peak G's on Instrument without a drop
5	4.3 / 4.2 inches	2.33	1.34
7	3.6 / 4.2 inches	2.54	1.46

The exact number of isolators will be determined during the packing process, based on the as-built Instrument configuration.

5 isolator and 7 isolator configuration

Configuration	Quantity Isolators	Nominal middle isolator centerline offset	Reference Dimension
A	5 isolators	+2.095 in	6.29 in
B	7 isolators	-1.355 in	2.84 in

