ANL HWR CRYOMODULE SHIPPING PLAN

PIP2IT Transportation Review

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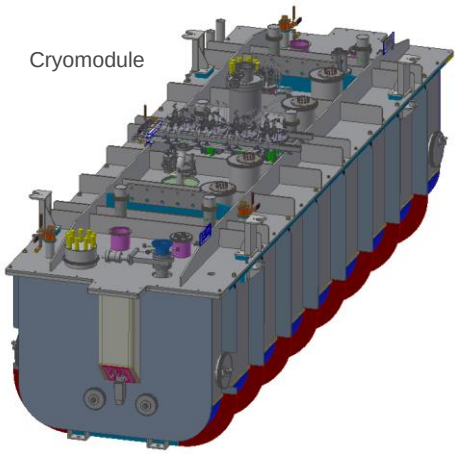
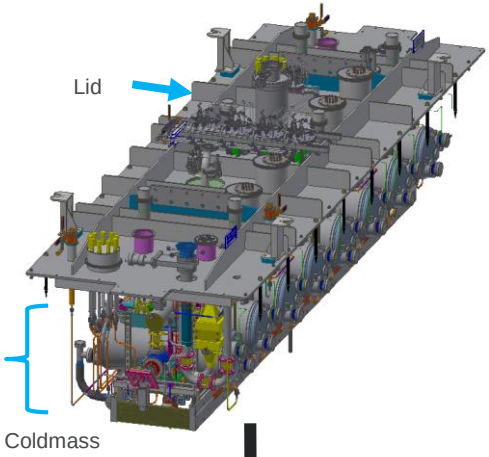
Outline

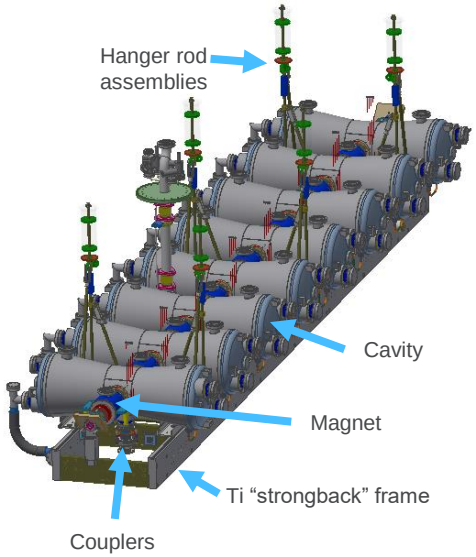
- Cryomodule structure
  - Overview
  - Subassemblies and components
- Protecting the cryomodule
- Transportation mount designs
  - Vertical
  - Lateral
  - Longitudinal
- Allowable loads and recommended pre-tension values
- Review

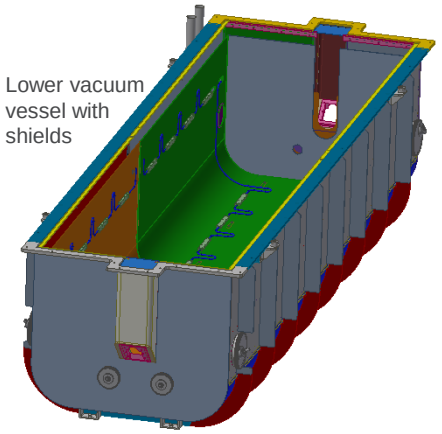
Cryomodule Structure - Overview

- Main components include
  - Lid
  - Coldmass
  - Lower vacuum vessel
- Accelerator components are supported on a strongback frame and hung from the lid via six hanger rod assemblies
- Lid and coldmass are assembled outside of the lower vacuum vessel and lowered in
- Additional components are connected through bottom ports after lid installation
- Primary concern is motion of coldmass during shipment





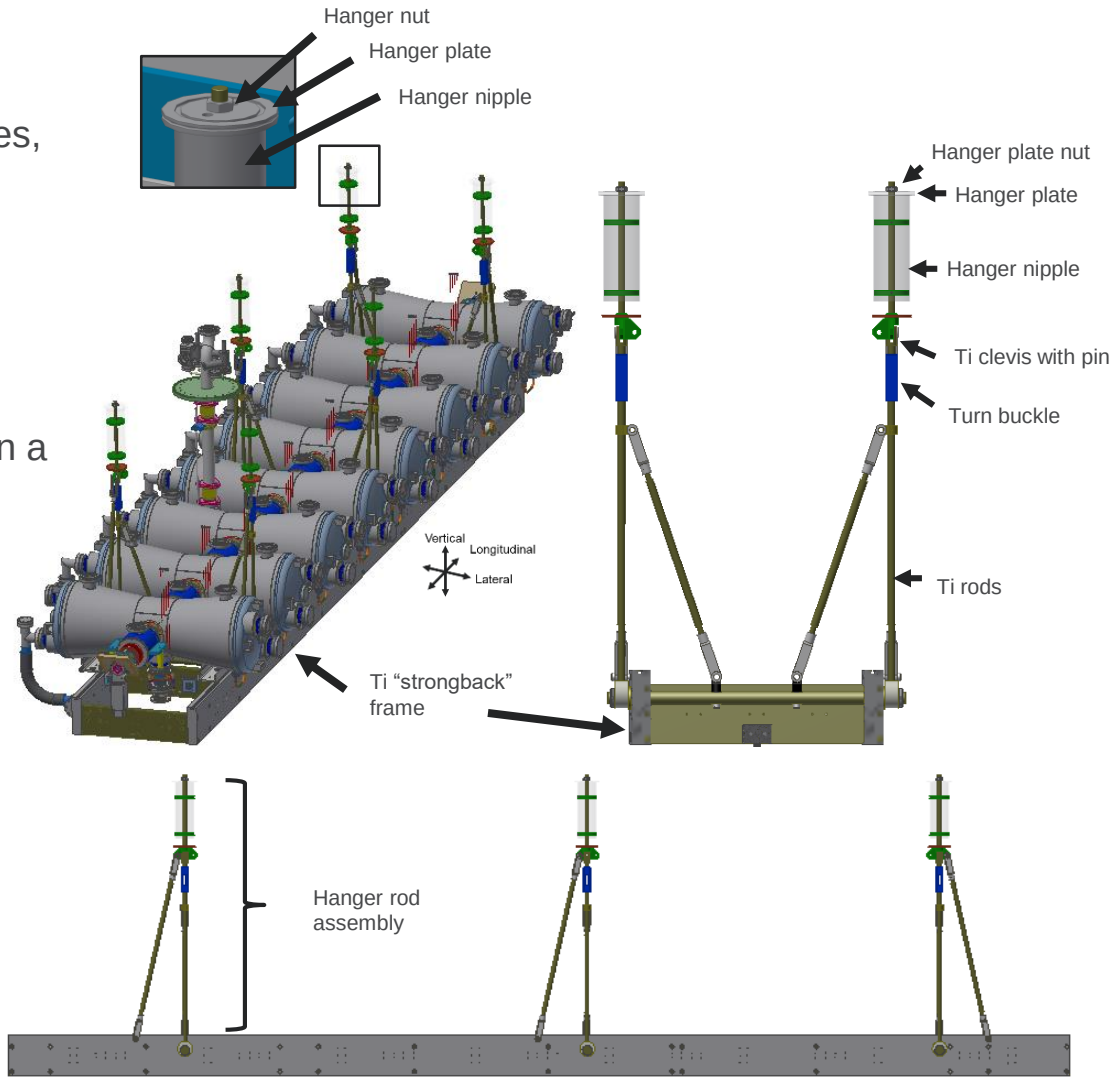




Cryomodule Structure - Hanger Rod Assemblies

Hanger rod assemblies

- Support the strongback frame, cavities, magnets, and other accelerator hardware
- Provide bracing in the lateral and longitudinal direction
- Hang from the lid via a nut bearing on a plate
- Comprised of titanium and stainless steel components



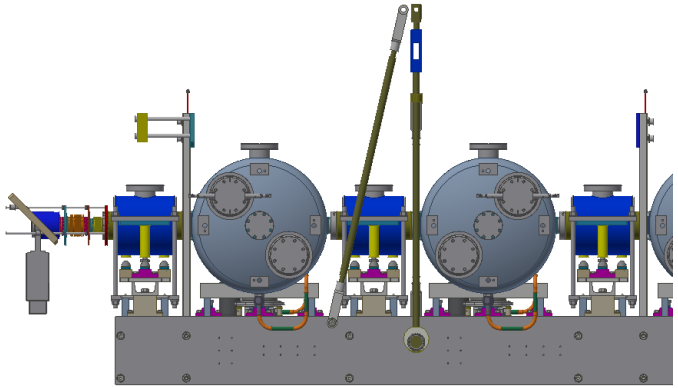
Cryomodule Structure – Strongback, Cavities, Magnets

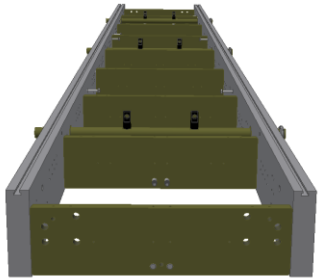
Strongback frame

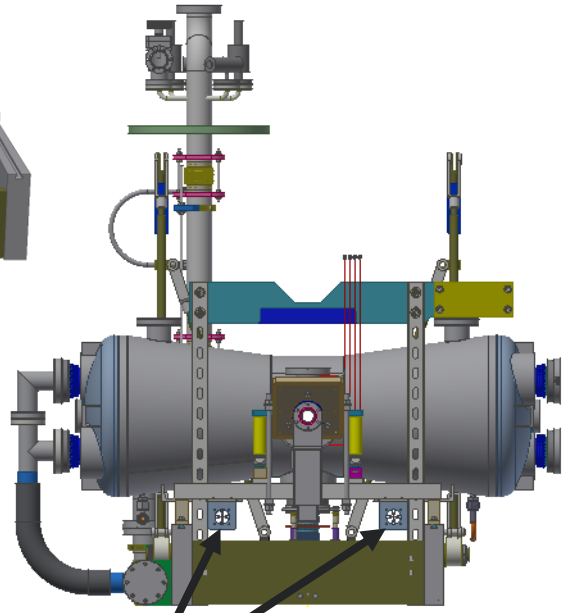
- Primary point of attachment for all beamline components
- 2” x 8” titanium rails with T-slots

Cavities and Magnets

- 8 cavities, 8 magnets
- 3-point kinematic mounts for alignment
- Hold-downs to maintain position on strongback
- Four fiducial targets per cavity and magnet for alignment







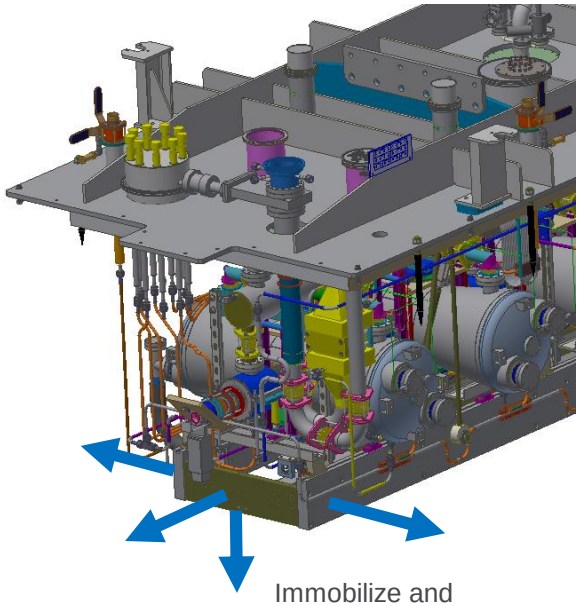
Protecting the Cryomodule

Concerns

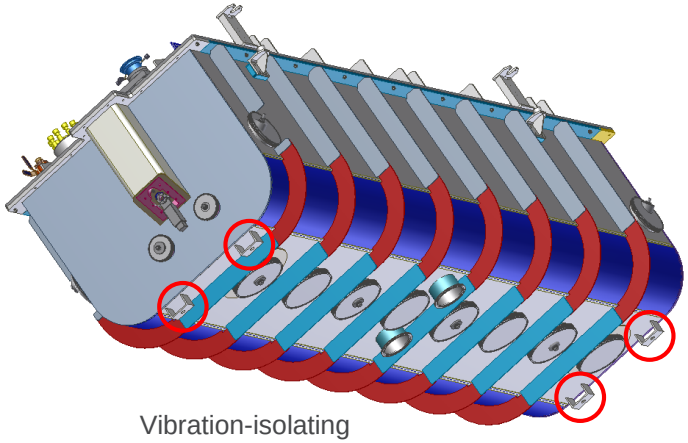
- Coldmass behaves as rigid body pendulum
- Movement of coldmass could damage components and perturb alignment

Our solution

- Immobilize coldmass within vacuum vessel
- Use mounts that tension coldmass from all sides
- Use vibration-dampening mounts between cryomodule and truck bed



Immobilize and apply tension



Vibration-isolating mounts locations

Transportation Mount Design – Vertical Mounts

Purpose

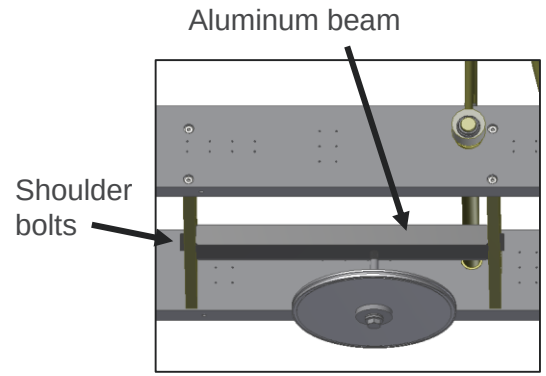
- To restrict vertical motion of strongback

Components

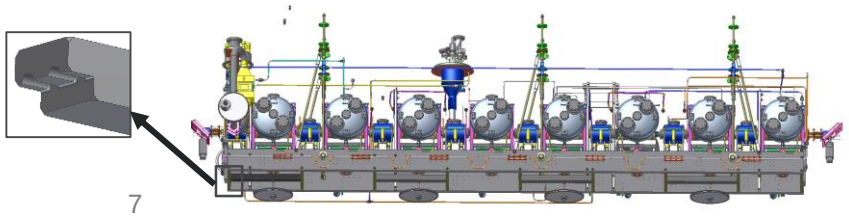
- Aluminum beams
- Stainless steel coupler port covers with large clearance hole
- Oversized and spherical washers
- Tensioning bolts
- Plastic bearing rings

Features

- Tension can be controlled by tightening bolts
- Permits misalignment of at least ± 0.25” in lateral and longitudinal directions



Labelled components are 304/316 SST unless otherwise noted



Transportation Mount Design – Lateral Mounts

Purpose

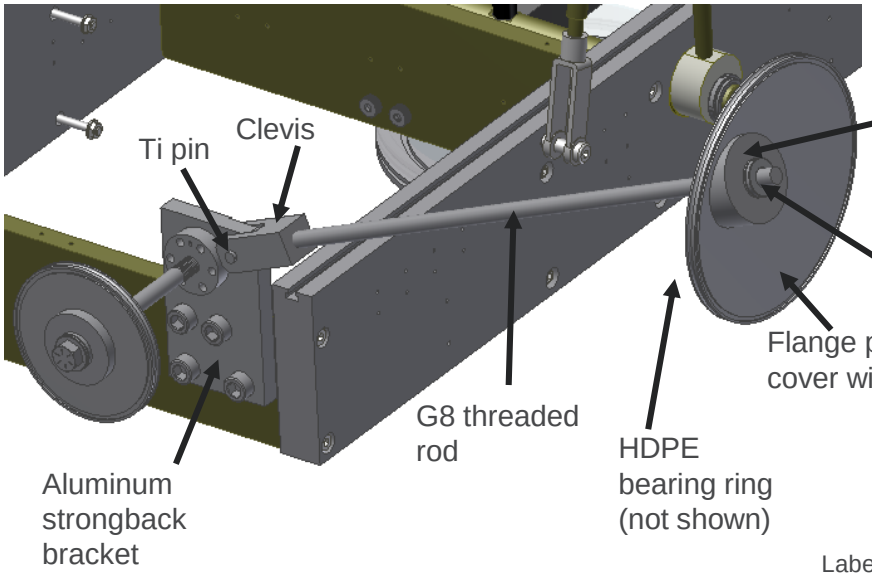
- To restrict lateral motion of strongback

Components

- Aluminum strongback brackets
- Clevis and pins
- Stainless steel side port covers with large clearance hole
- Oversized, angled and spherical washers
- Tensioning rods
- Plastic bearing rings

Features

- Tension can be controlled by tightening nuts
- Permits misalignment of at least ± 0.25” in all directions



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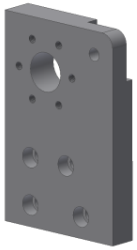
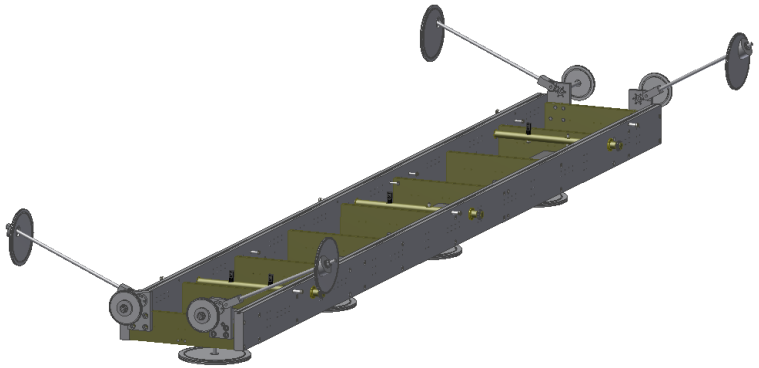




Transportation Mount Design – Longitudinal Mounts

Purpose

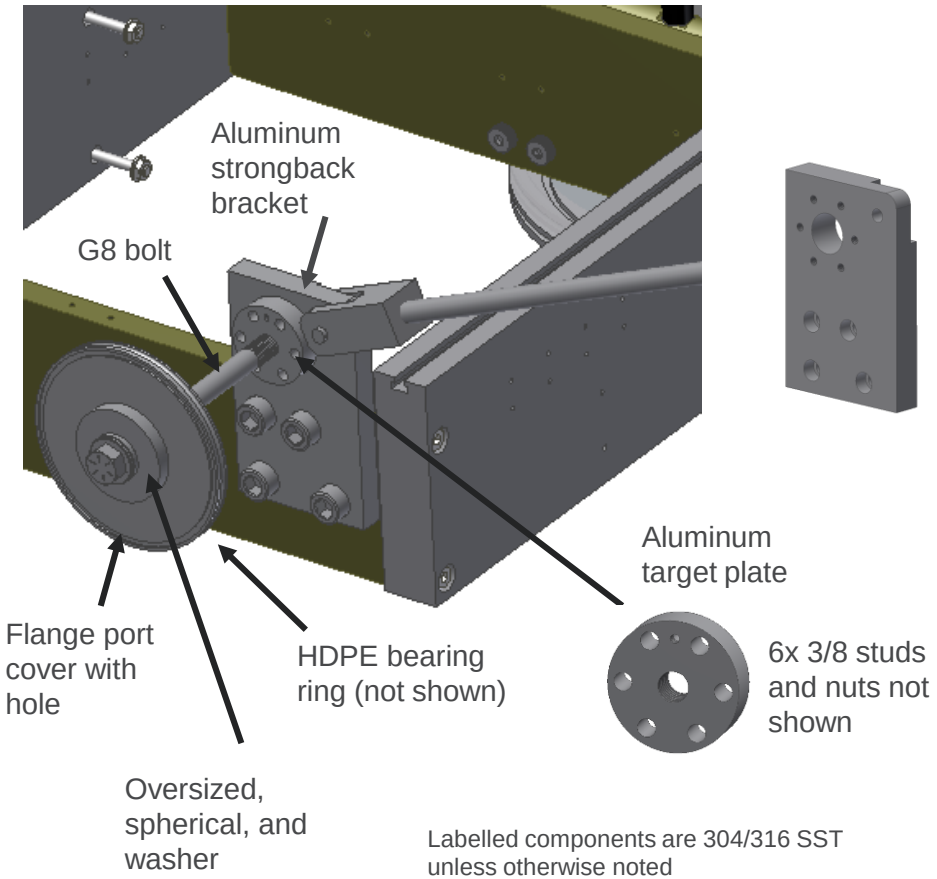
- To restrict longitudinal motion of strongback

Components

- Aluminum strongback bracket
- Stainless steel coupler port covers with large clearance hole
- Oversized and spherical washers
- Tensioning bolts
- Plastic bearing rings
- Aluminum target plate

Features

- Tension can be controlled by tightening bolts
- Permits misalignment of at least ± 0.25” in lateral and longitudinal directions
- Target plate is removable to give access to fiducial targets after shipment



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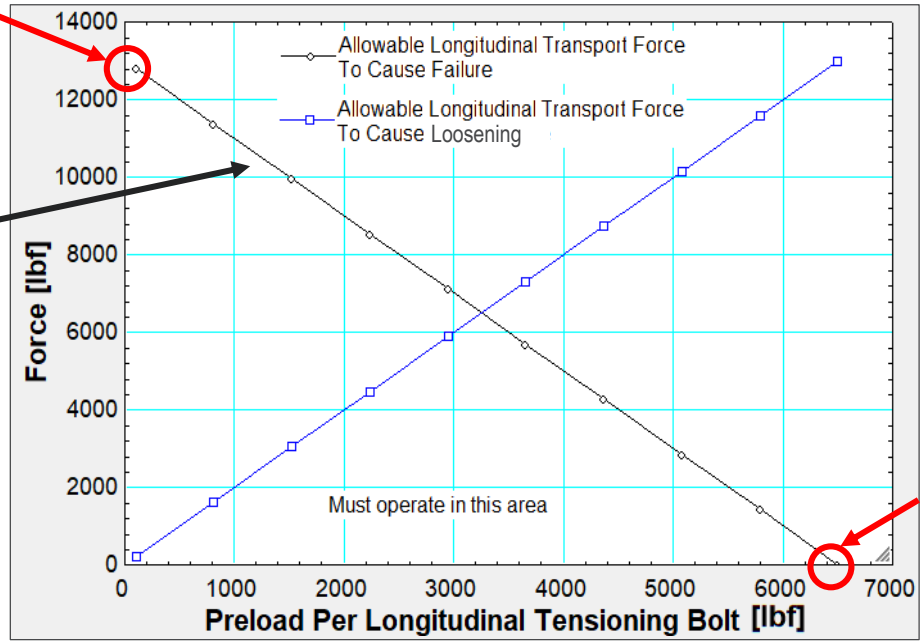
Balance Between Pre-tension and Allowable Load

PRO: Pre-tension increases allowable transportation loads

CON: Pre-tension increases loads on the mounts and structures

Max allowable strength of weakest component with zero pre-tension

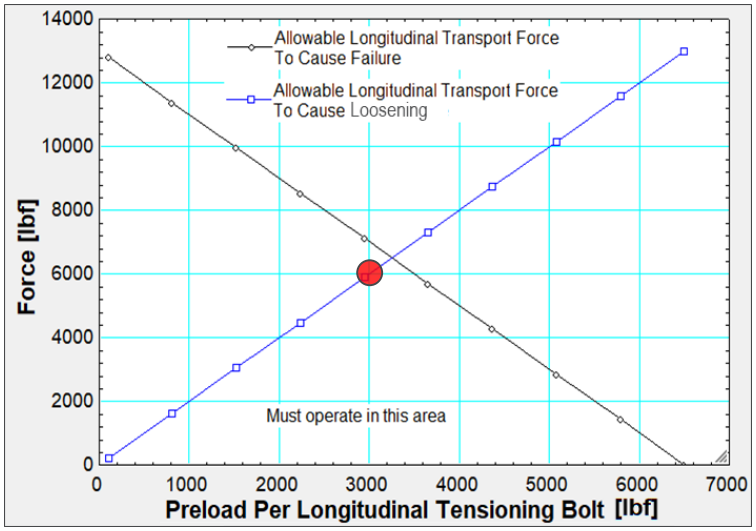
Dictated by strength of weakest component



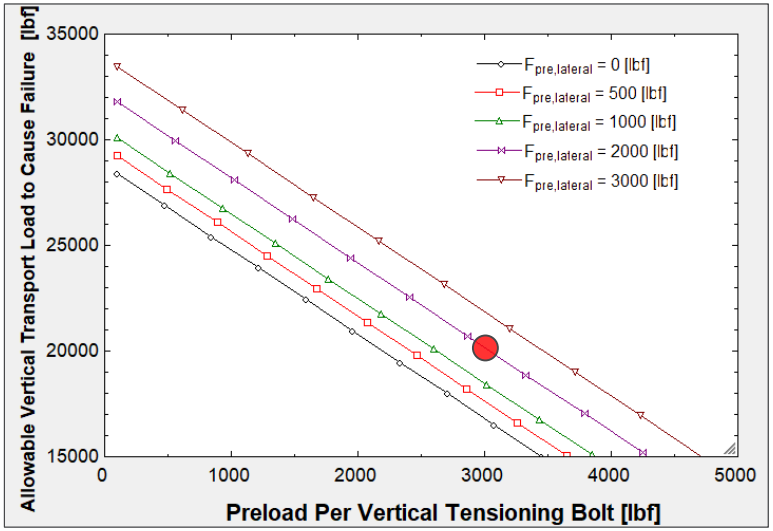
Pre-tension that causes immediate failure

Selection of Pre-tension Values

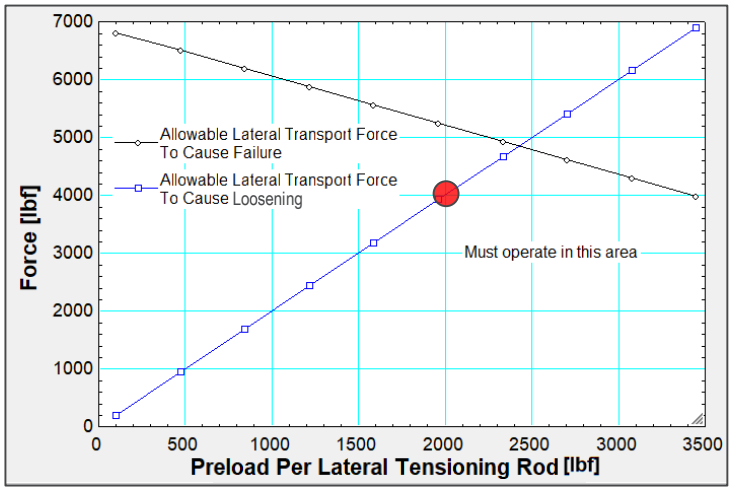
Longitudinal



Vertical



Lateral



Direction	Pre-tension per bolt/rod [lbf]	Allowable Transport Load [lbf]	Limiting Condition	Limiting component
Vertical	3,000	20,200	Failure	Bottom port flange cover
Lateral	2,000	4,000	Mount loosens	Side port flange cover
Longitudinal	3,000	6,000	Mount loosens	Target port flange cover

Comments

- Vertical transport load does not cause loosening
- Lateral load expected to be smallest

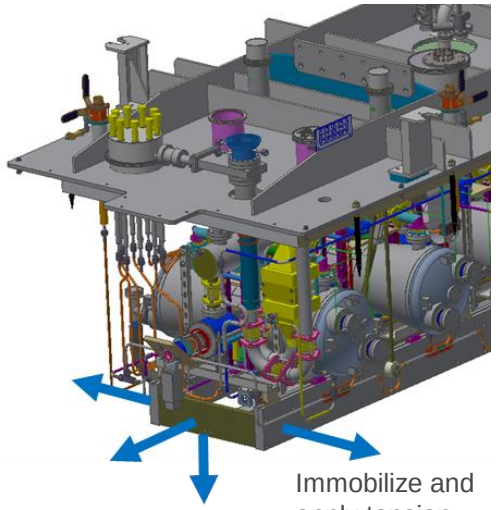
Review

Concerns

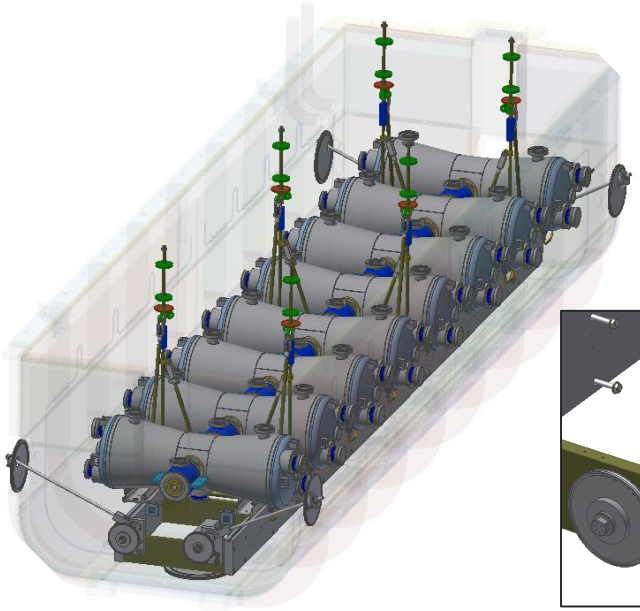
- Movement of coldmass could damage components and perturb alignment

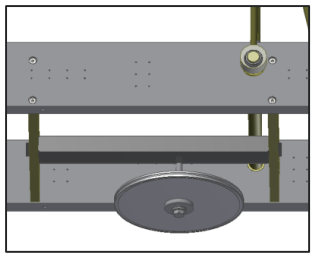
Solution

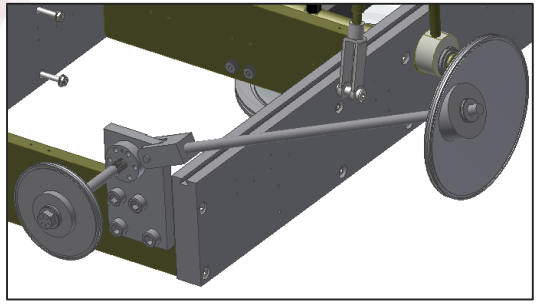
- Mounts to immobilize strongback in all directions
- Pre-tension mounts to increase allowable loads
- Use vibration-dampening mounts between cryomodule and truck bed



Immobilize and apply tension







Questions?