LMQXFA Design Modification Due To Requirement Changes

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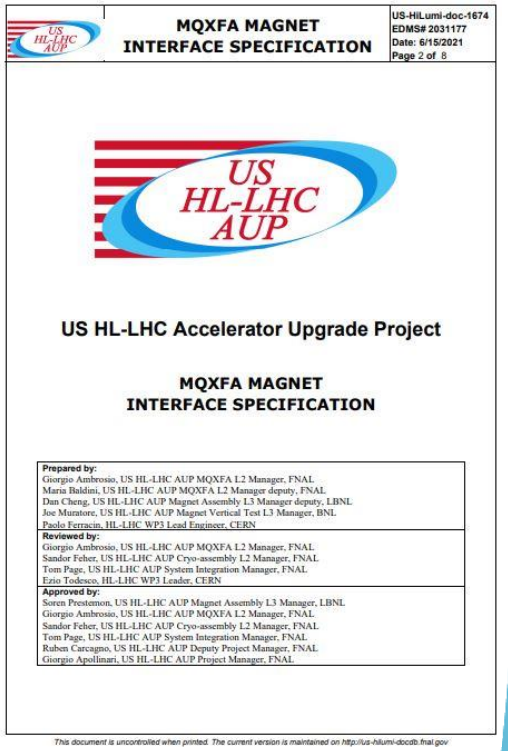
Cold Mass Shell Design

- **Old Requirement**:
  - The interference between magnet and cold mass shell shall be kept under control and the coil pre-load increase shall not exceed 15 MPa at room temperature
- **New Requirement**:
  - The circumferential average interference after welding between the St.Stl. shell inner surface and magnet outer surface along each magnet length must be ≥ - 0.2 mm, resulting in average coil pre-load increase ≤ 3.2 MPa at room temperature
- **Equivalent Frictional Force at Room Temperature**
  - A 0.2 mm of circumferential average interference translates to a 0.5 MPa radial pressure or a 8.79 MN frictional force over the full length of a magnet


MQXFA MAGNET INTERFACE SPECIFICATION

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US HL-LHC AUP

US HL-LHC Accelerator Upgrade Project

MQXFA MAGNET
INTERFACE SPECIFICATION

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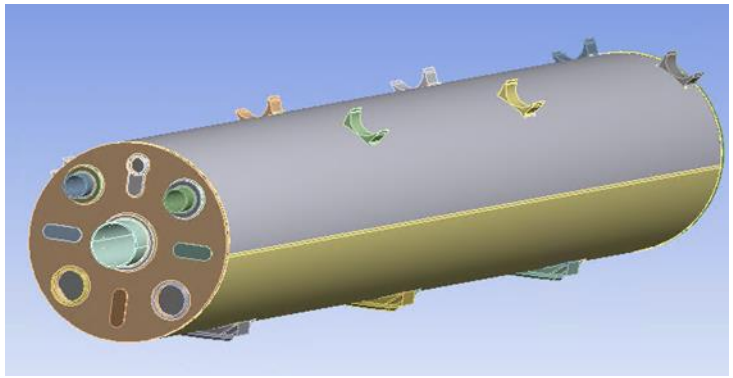
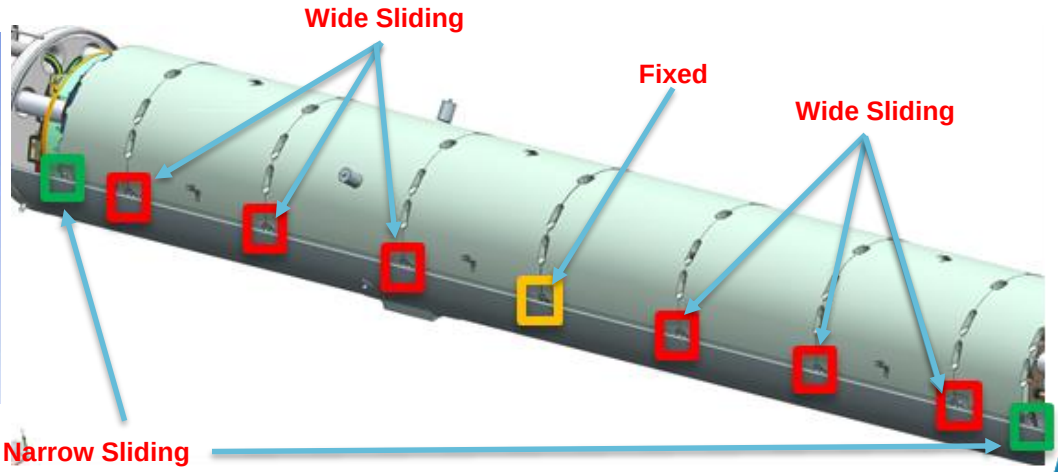
Cold Mass Shell Design

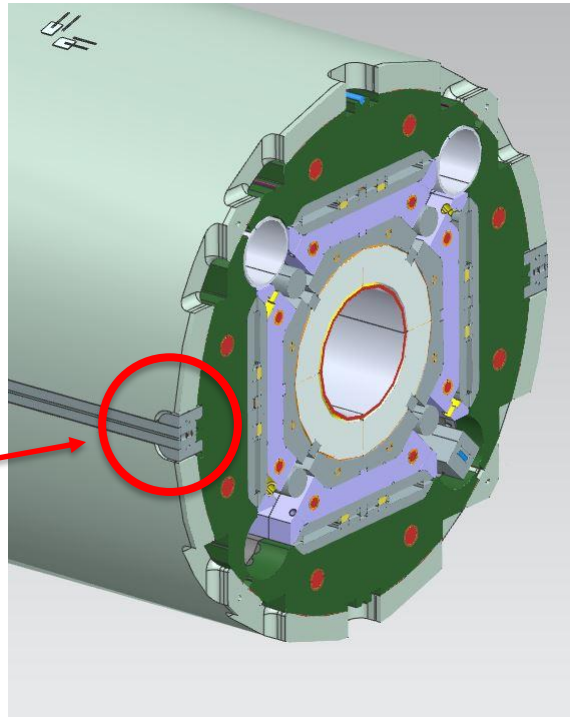
- **Original shell length (undersized)**:
  - Weld shrinkage of .045” (1.14 mm) per weld
  - Warm pre-load applied by interference of 0.020” (0.5 mm) on circumference
  - Developed (arc) length: 75.904” (37.952 per half shell)
- **Revised shell length (perfect fit – oversized)**:
  - Adjust weld shrinkage (~0.06”)
  - Remove warm pre-load (undersizing)
  - Removing the contact pressure between the shell and the magnet creates shipping challenges that must be addressed & analyzed: Axial load path is shifted through 4 of the 36 Tack Blocks (8 narrow sliding, 24 wide sliding & 4 fixed)



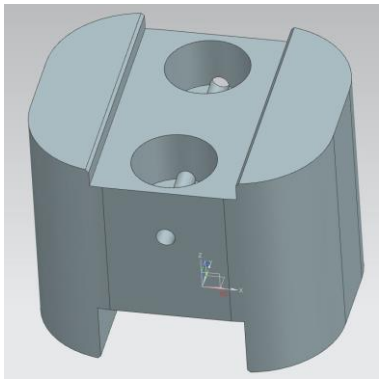


Cold Mass Shell Design

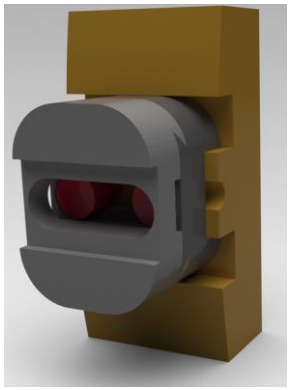
- **Tack Blocks**:
  - Shipping forces can shift from 2G to -0.5 G during shipping
  - When shipping forces shift, normal force will be reduced.
  - First point to resist horizontal movement will be the bolts at the tack blocks
- **Welds**:
  - Welds need to absorb161.8 MPa at 1G or 323.6 MPa at 2G
  - Cyclic shipping loads may overstress welds attaching backing strip to tack block



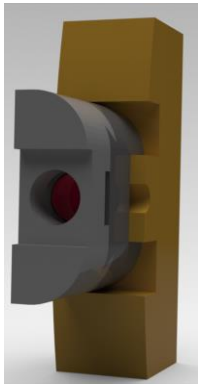
FIXED TACK BLOCK



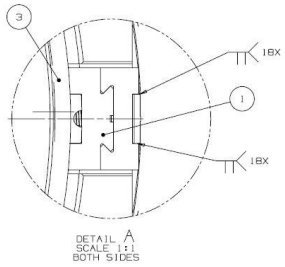
Fixed



Wide Slidding

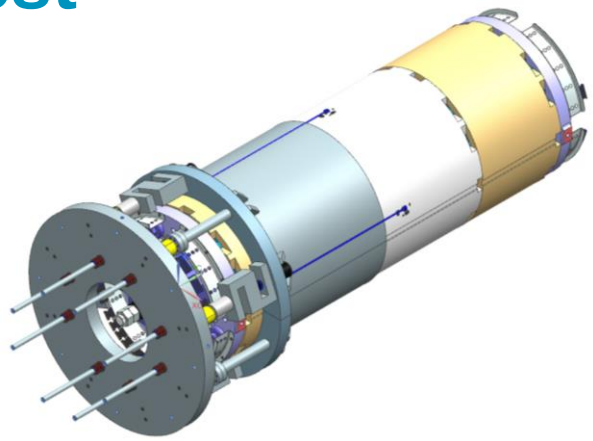


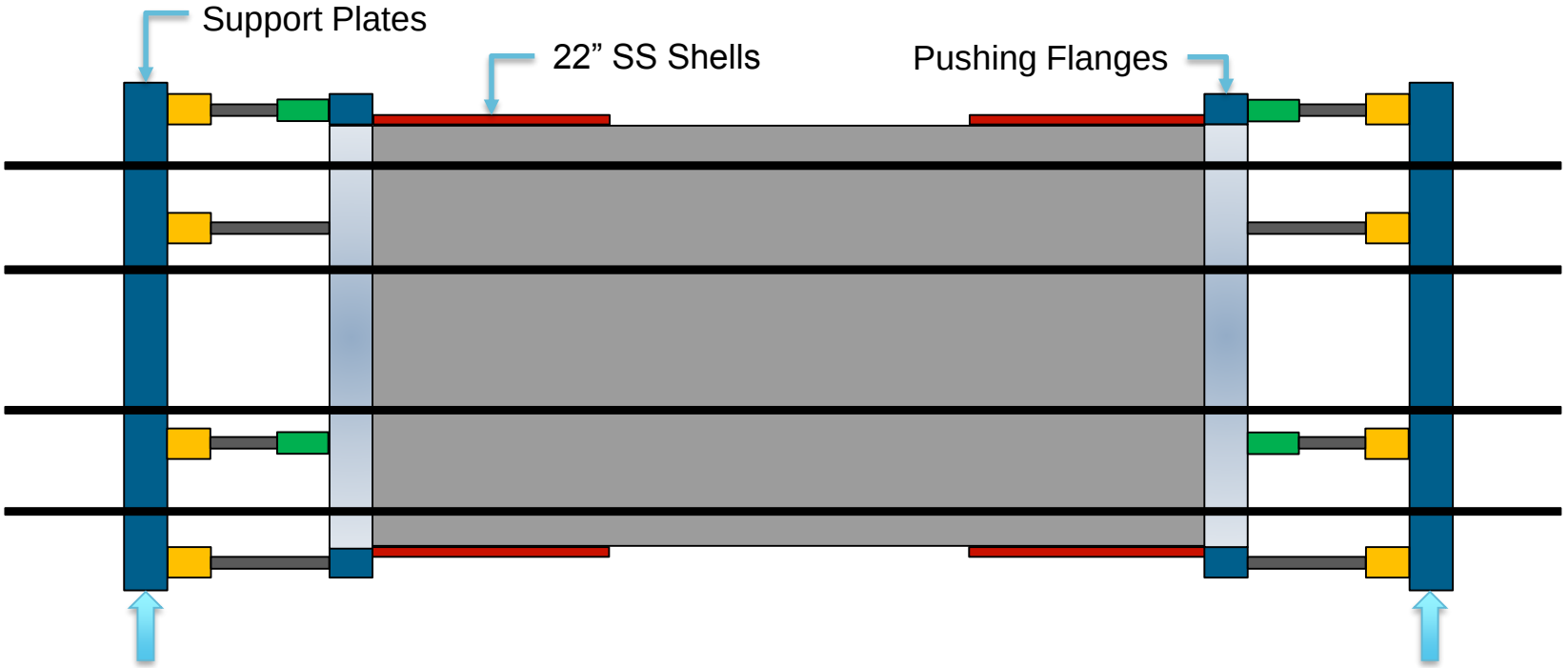
Narrow Slidding



Cold Mass Friction Test

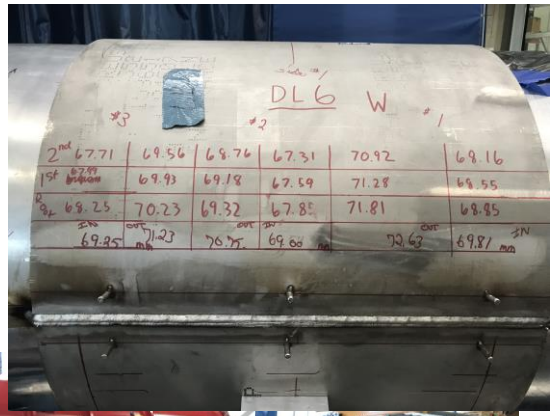
- **Test Goal**
  - Determine the force required to break the friction between the st.stl. outer shell and the aluminum inner shell using various longer developed length
  - Frictional force must be greater than 42.3 KN (prevent slippage) & less than 538 KN (new requirement) when accounting for a 22 inch shell



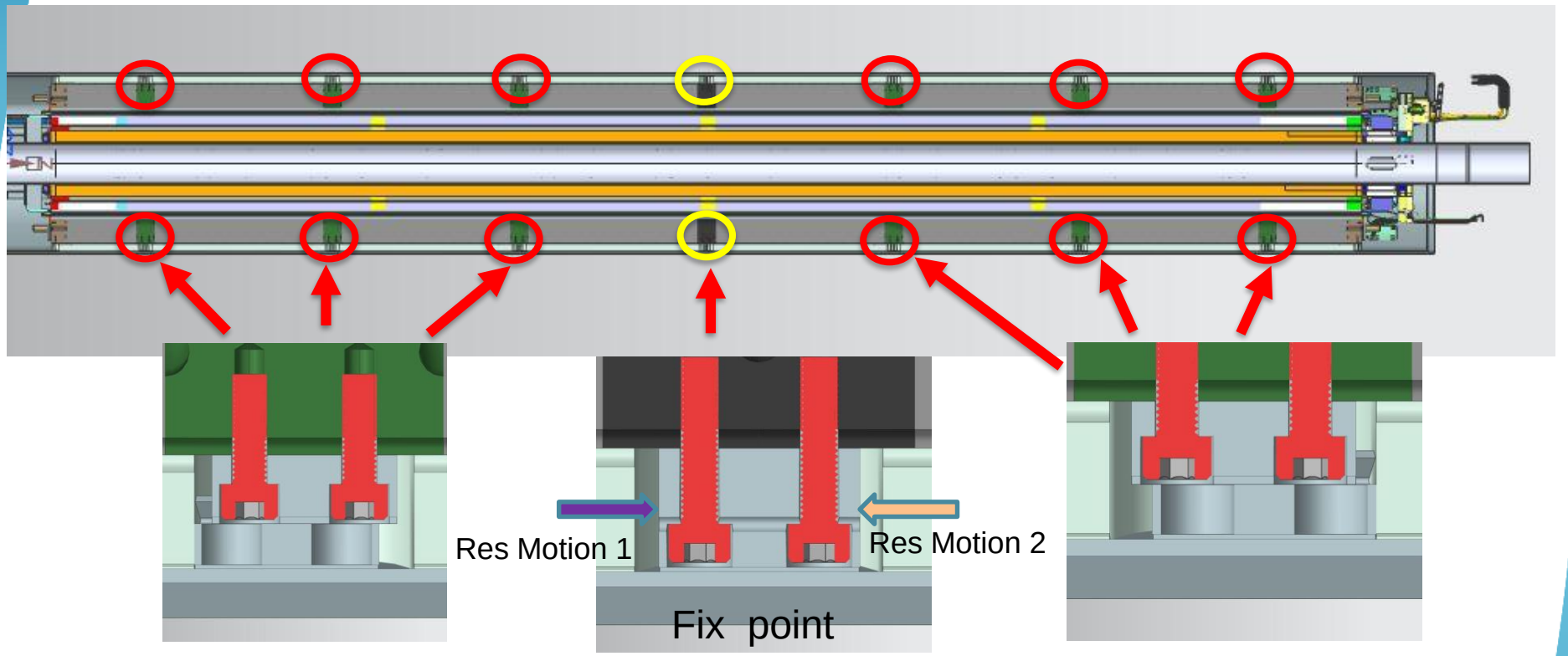


Cold Mass Friction Test

- **Shells of various length to be tested**:
  - Al shell outer circ = (avg OD + pre-stress) Original
  - Al shell outer circ = (avg OD + pre-stress) Original w/ rev weld shrink
  - SS shell inner circ. = Al shell outer avg. circ.
  - SS shell inner circ. = Al shell max circ.
  - SS shell inner circ. = Al shell max dia. + 0.25 mm.
  - SS shell inner circ. = Al shell max dia + 0.5 mm
- **Controls/Data:**
  - Survey MQXFS1 magnet shell OD/circumference
  - Measure shell thk using UT
  - Shell measurement (Pi tape):
    - SS shell circumference at fit up
    - SS shell circumference after welding
  - Weld shrinkage measured w/ caliper



Optional Configuration of Tack Blocks



- 2x fixed tack blocks in center of magnet – lock magnet to shell (no movement)
- 12x sliding tack blocks - outer piece is preset away from center of magnet & up tight against magnet aluminum wall then welded to shell backing strip - fixes shell axially to magnet in warm condition
- SS shell shrinks relative to yoke in cold condition

Summary

- Interference between magnet and stainless steel shell will be minimized by increasing the developed shell length
- Original warm interference conditions is removed
- Adjustment for latest weld shrinkage data is included
- Friction testing is in process to determine optimum shell developed length and resulting frictional forces
- Tack blocks can be aligned to allow movement in one direction and assist with preventing magnet slippage during shipping