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Saturn Recapitalization

Saturn MITL Design Update

PPC/SOFE 2021

Presented by:

Jon Douglass

Contributions from:

Kevin Austin, Kate Bell, Jack Cassidy, Prithwish Das, Colton Gibney, Brian Hutsel, Debbe Kirschner, Kraig Leonard, John Lott, Thomas Mulville, Alex Nash, Tim Pointon, Jeff Tunell, Mark Savage, Michael Sullivan, and Ben Ulmen

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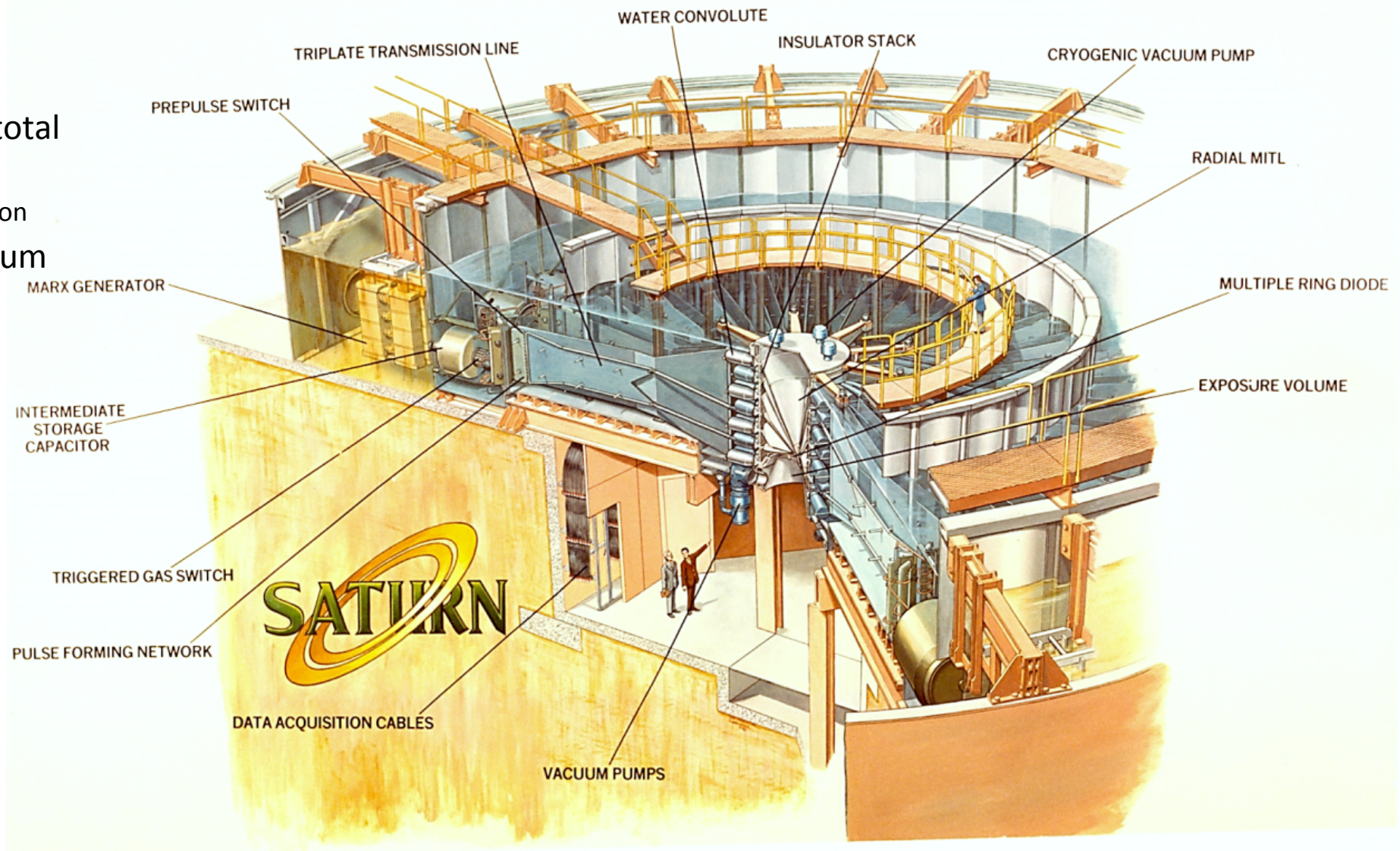
Saturn Overview

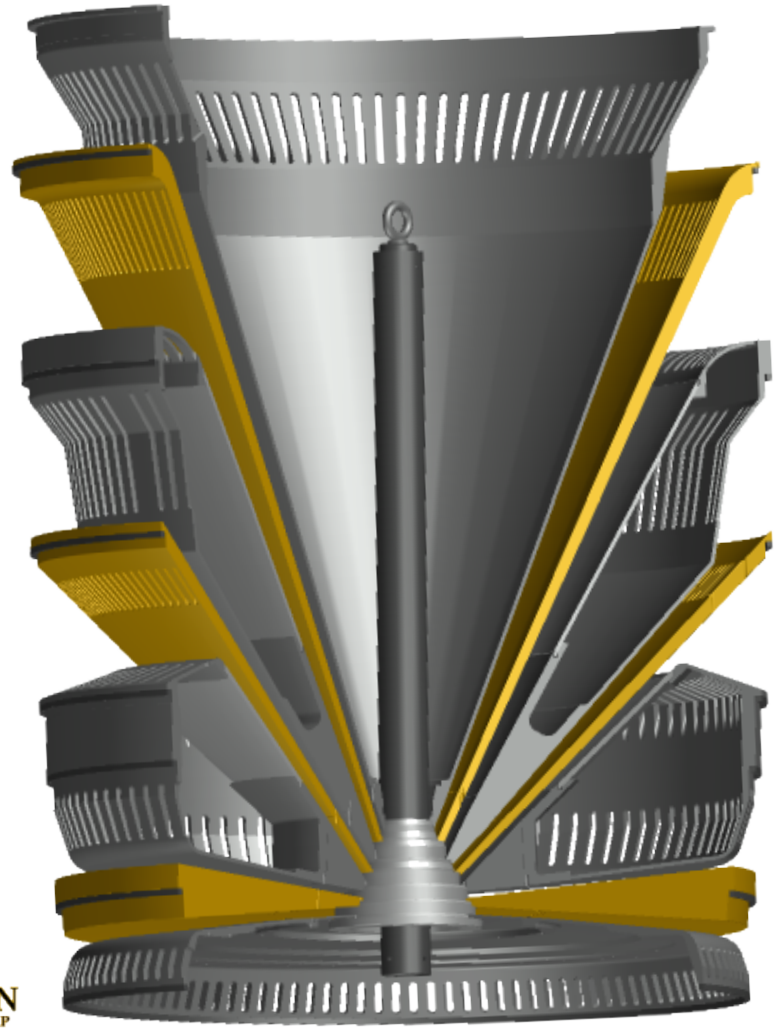
The Saturn facility at Sandia National Laboratories

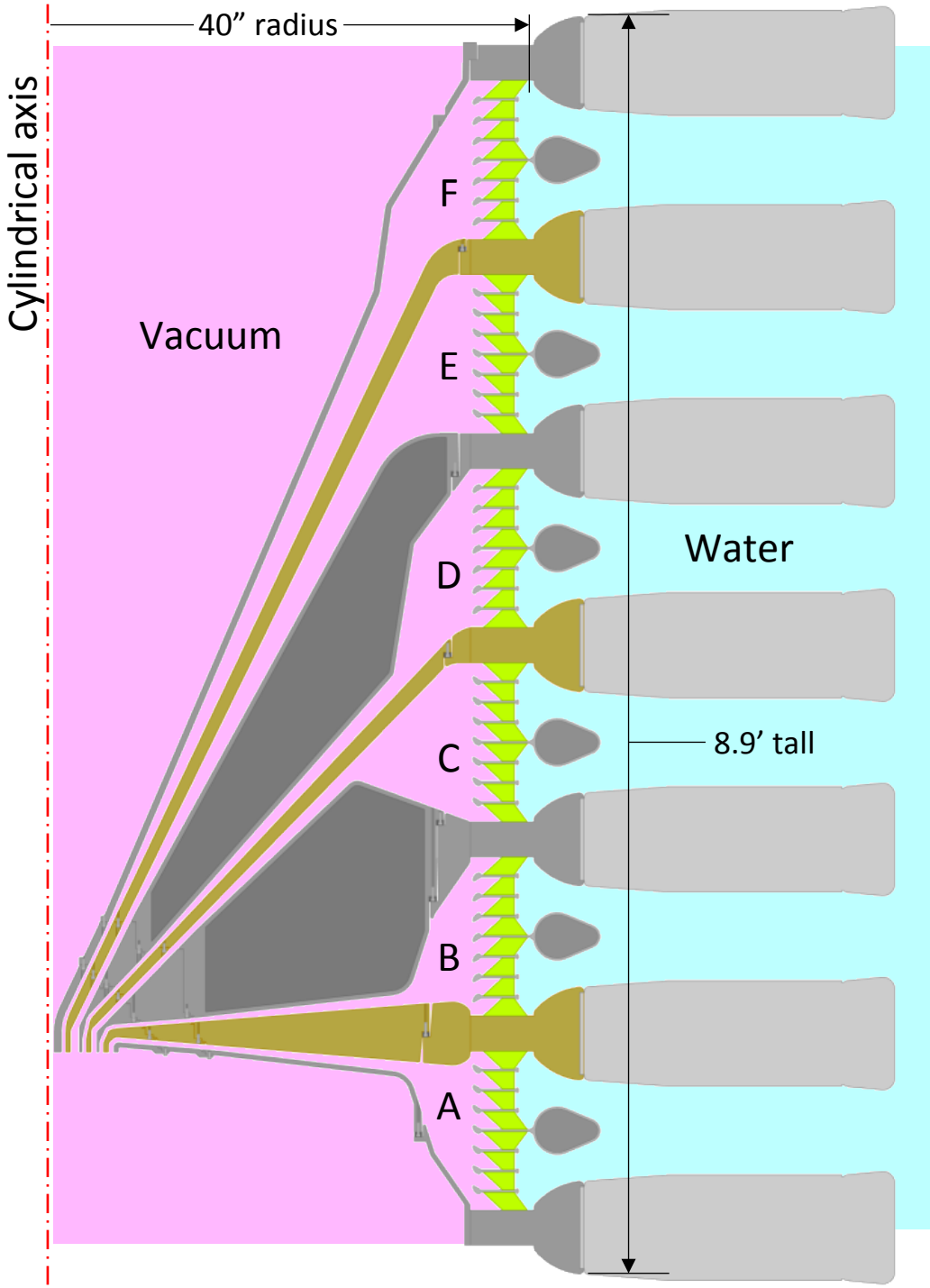
- Driver parameters:
  - Completed in 1987
  - Designed for 12 MA peak total current
    - About 10 MA in typical operation
  - 3 MV Peak voltage at vacuum interface
  - 40 ns FWHM Power pulse
  - Driver diameter 100’



The Saturn facility at Sandia National Laboratories

- Six vacuum interface levels, “A” through “F”
  - Seven MITL electrodes are installed/removed before/after every shot in a single-lift operation





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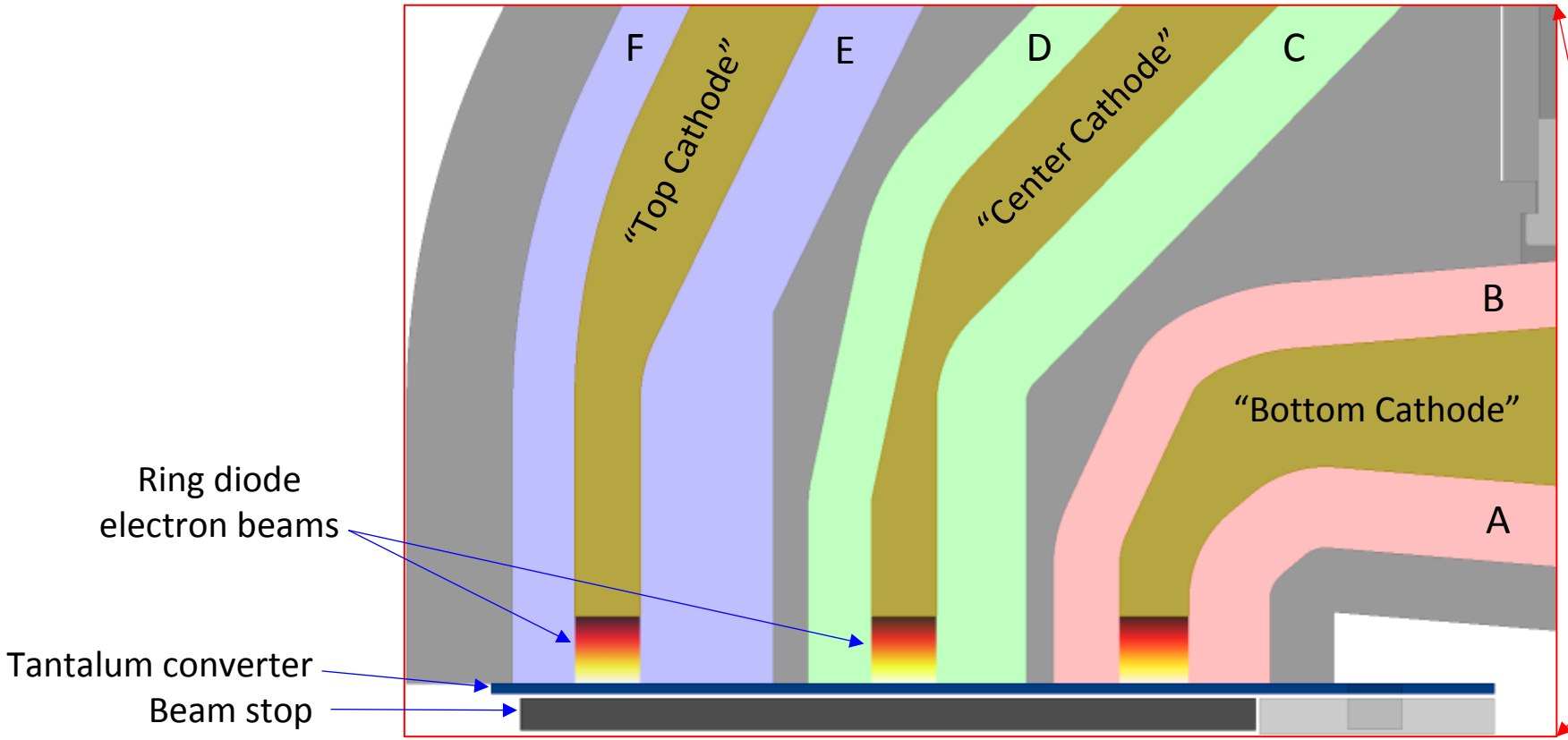
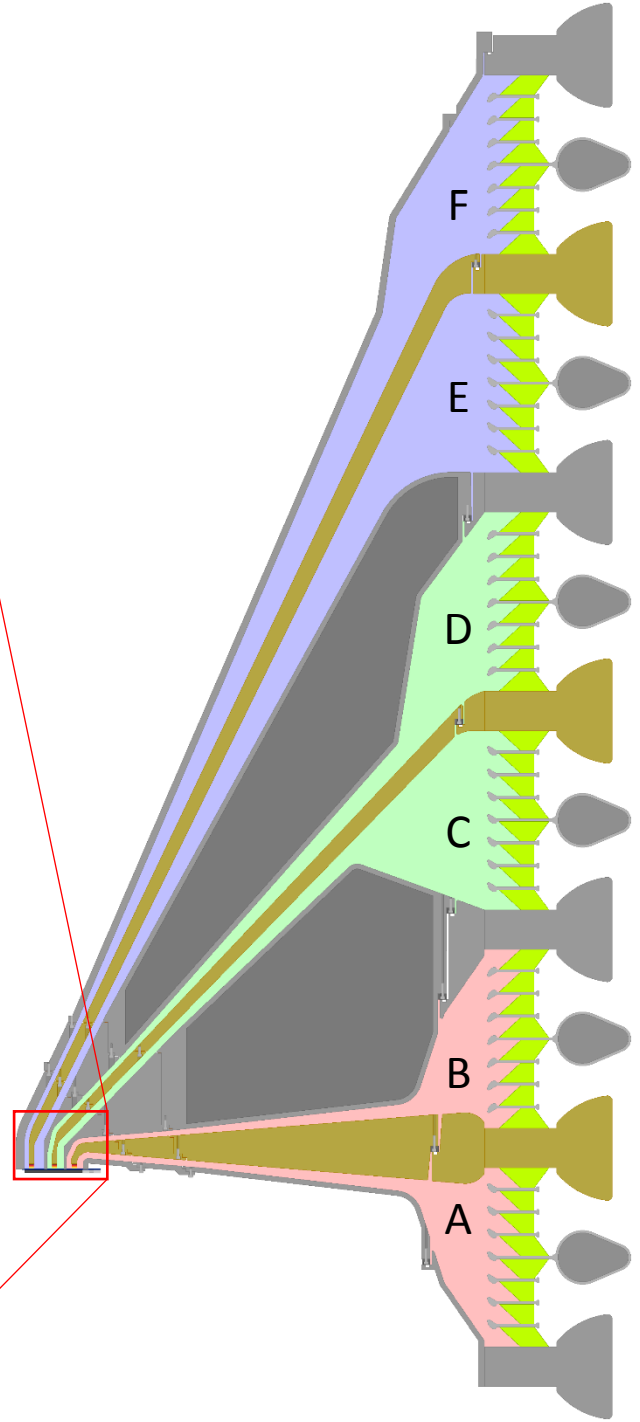
The Saturn facility at Sandia National Laboratories

- High-power bremsstrahlung x-ray source
  - Radiation generated by three ring diode electron beams
    - Ring diodes are nested – gives rise to the name “Saturn”
  - Each ring diode is driven by a pair of vacuum power feed levels (MITLS)
    - Inductance must be well-balanced in each pair of levels (e.g., A&B, C&D, E&F)





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SATURN RECAP

Saturn Recapitalization

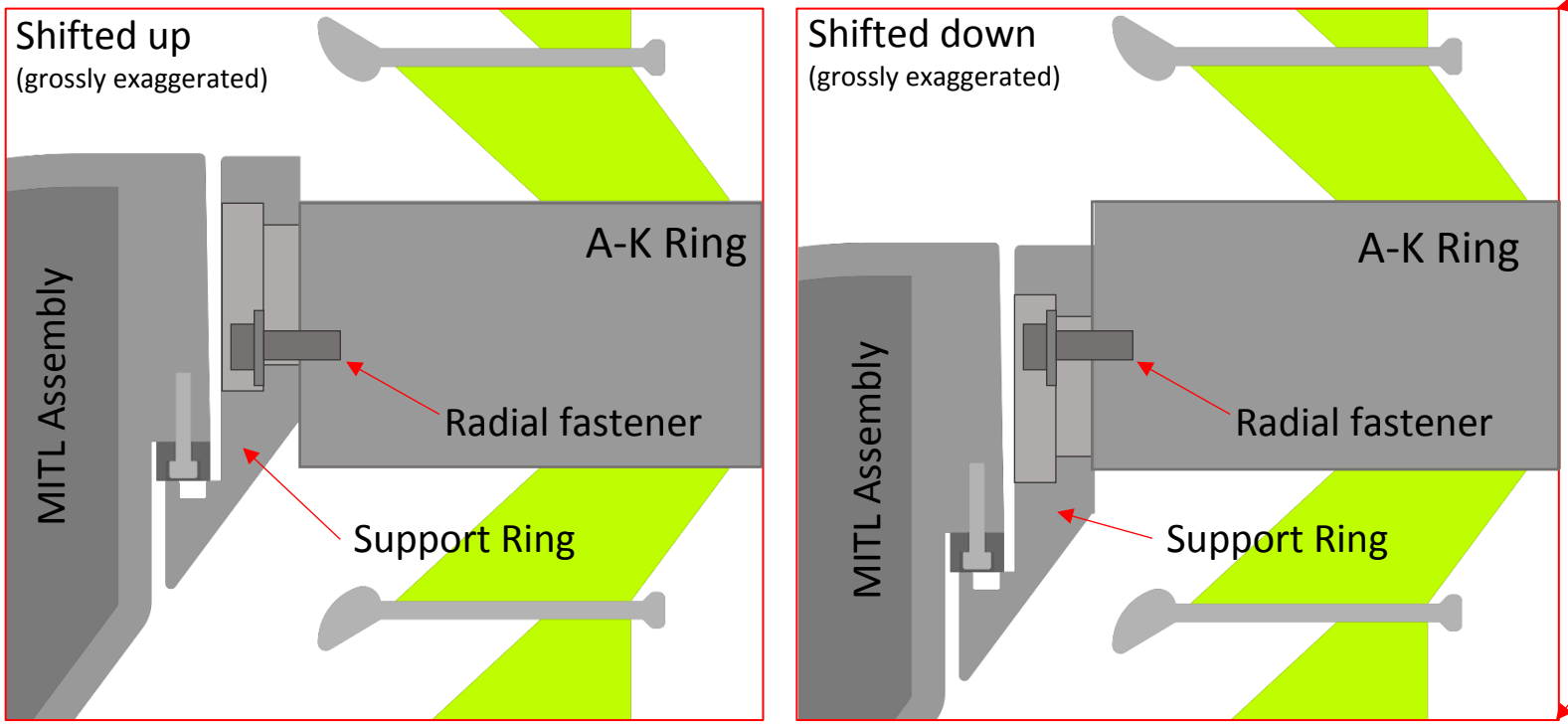
MITL Design Update Activities

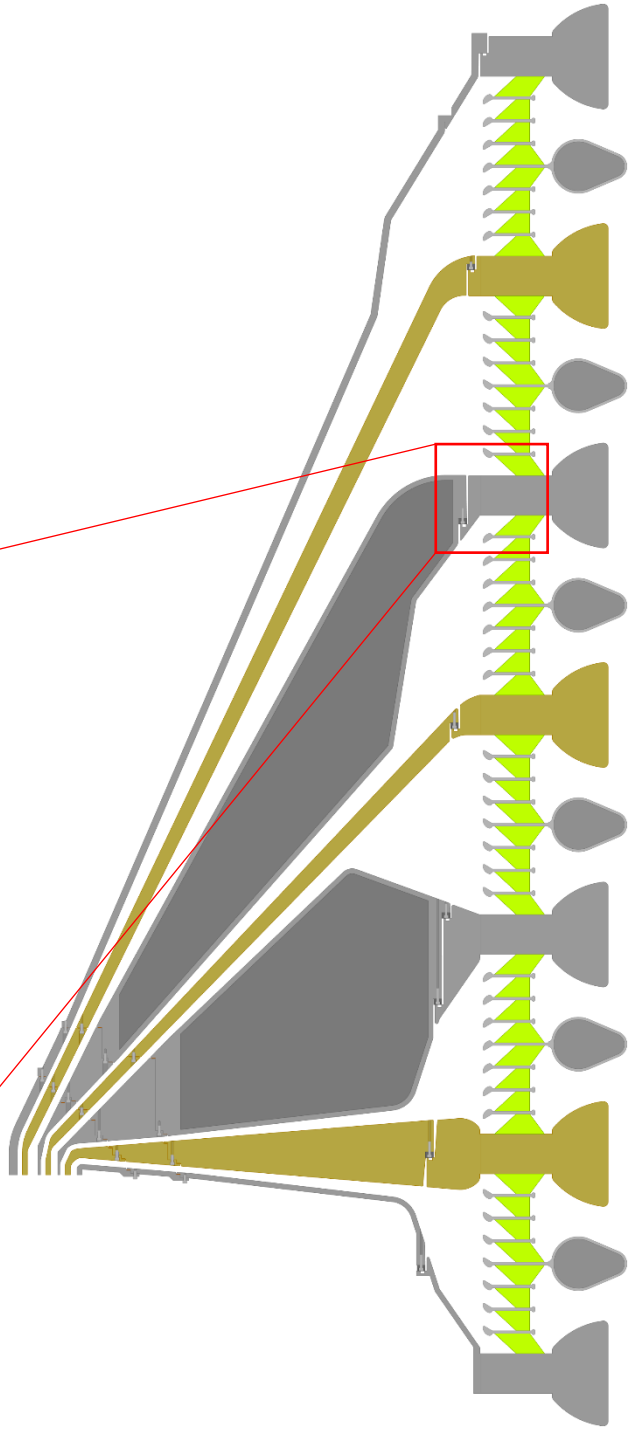
Saturn Recapitalization – MITL activities

- MITL performance and operational efficiency
  - Electrode alignment
  - Electrode current contacts
  - Inductance balance
  - Electrostatic analysis (not shown here)
  - PIC Simulations (not shown here)
- Material selection
  - Evaluate all-stainless configuration
- Manufacturing
  - Implement simple changes for ease of fabrication

Saturn Recapitalization – MITL activities

- MITL performance – electrode alignment
  - Present Saturn has MITL "Support Rings" that are adjusted before every shot to provide vertical MITL alignment
    - Support rings are radially fastened to A-K Rings; not very rigid
    - Mechanical shock from a Saturn shot knocks the support rings out of alignment
  - Support Ring alignment takes about 30 minutes





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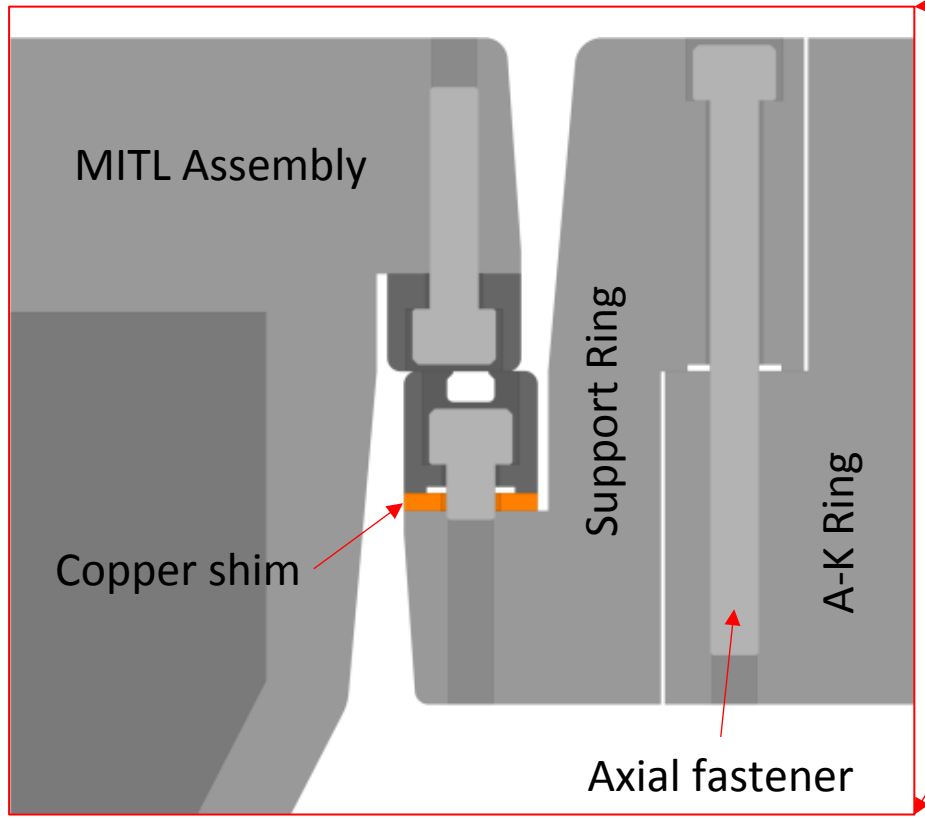
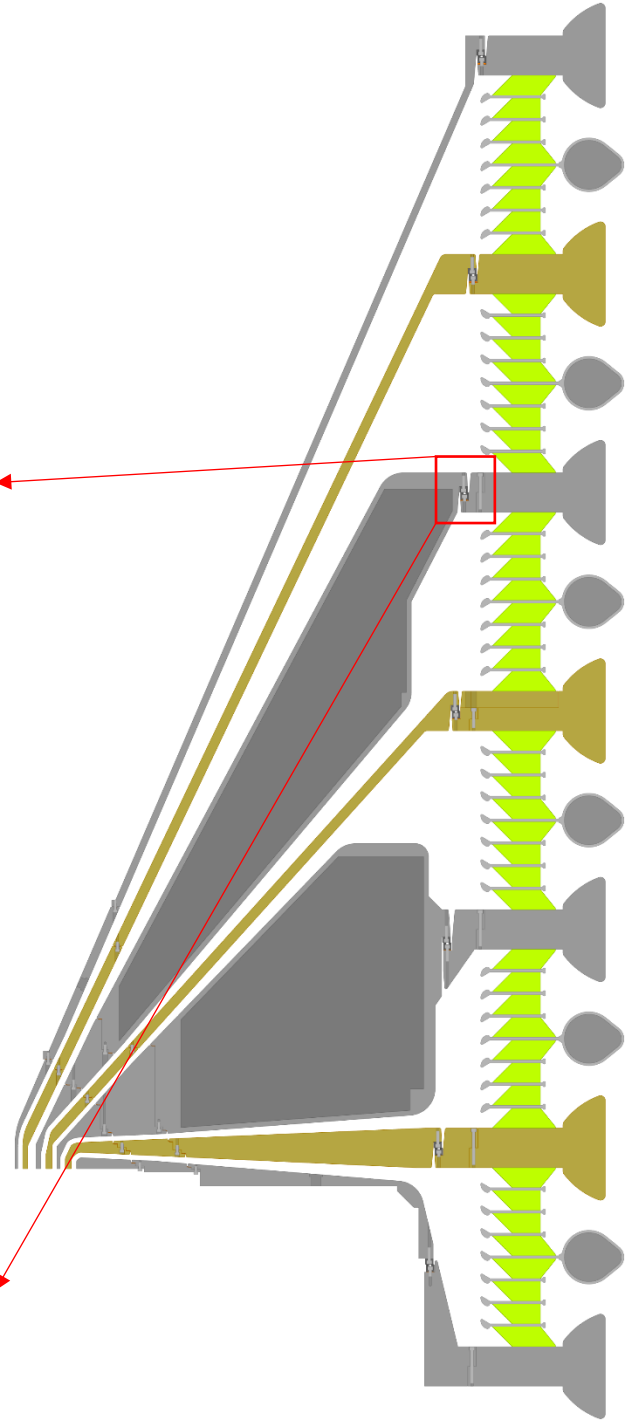
Saturn Recapitalization – MITL activities

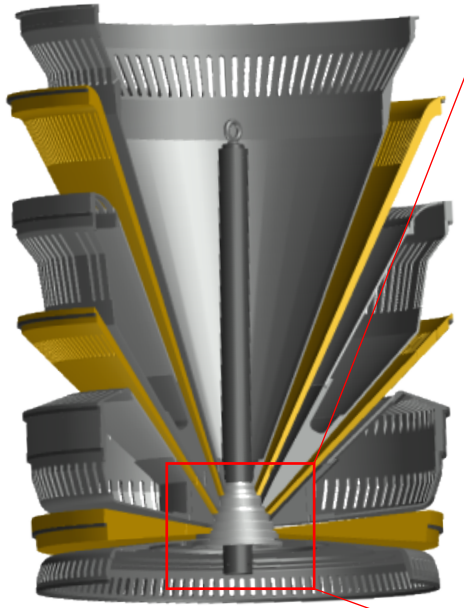
- MITL performance – electrode alignment
  - Updated design has revised Support Ring interfaces
    - Axially fastened Support Rings – very rigid
    - Shims for vertical alignment – adjustment seldom required

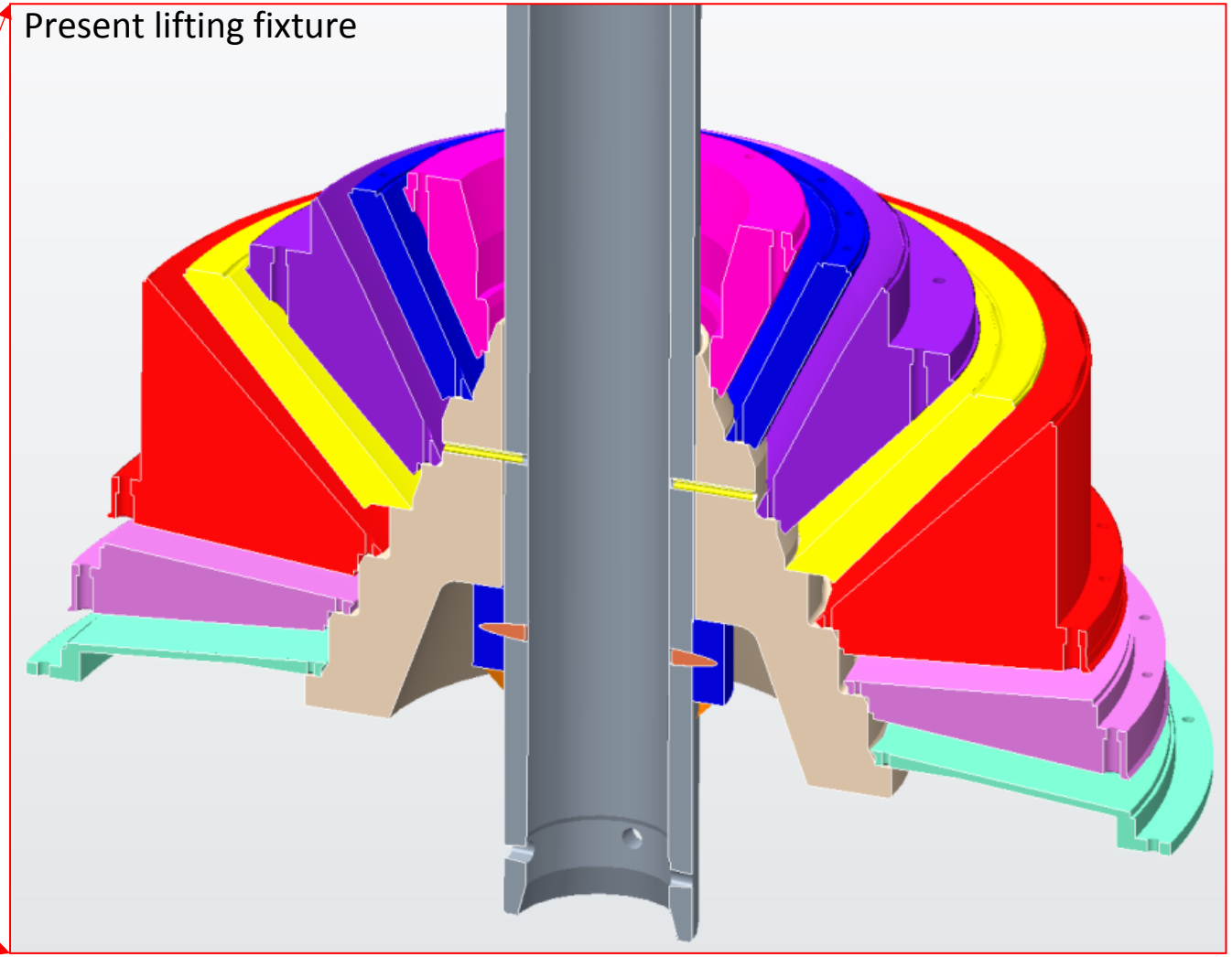




Saturn Recapitalization – MITL activities

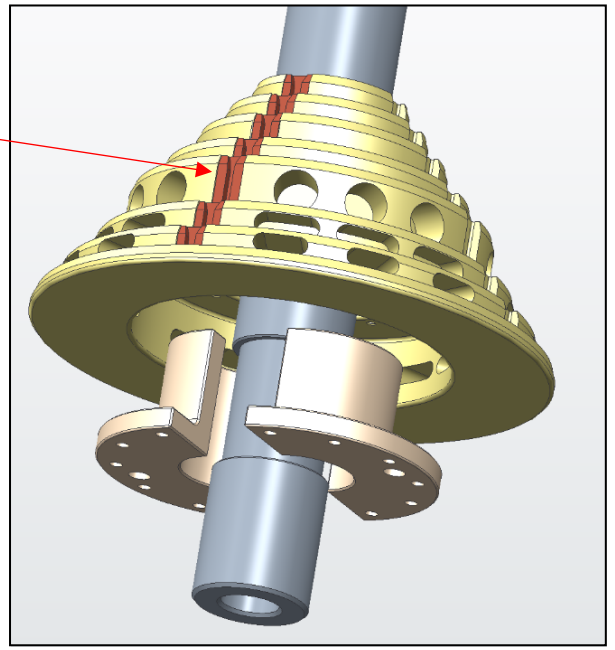
- MITL performance – electrode alignment
  - Lifting fixtures are being updated to provide more accurate MITL placement
  - In present design MITLs sit directly on fixture
    - Narrow contact surfaces, worn surfaces, and limited precision
    - Lateral placement of electrodes can deviate from coaxial by as much as 0.05”
    - No azimuthal alignment features
    - Fine adjustment is required after lift

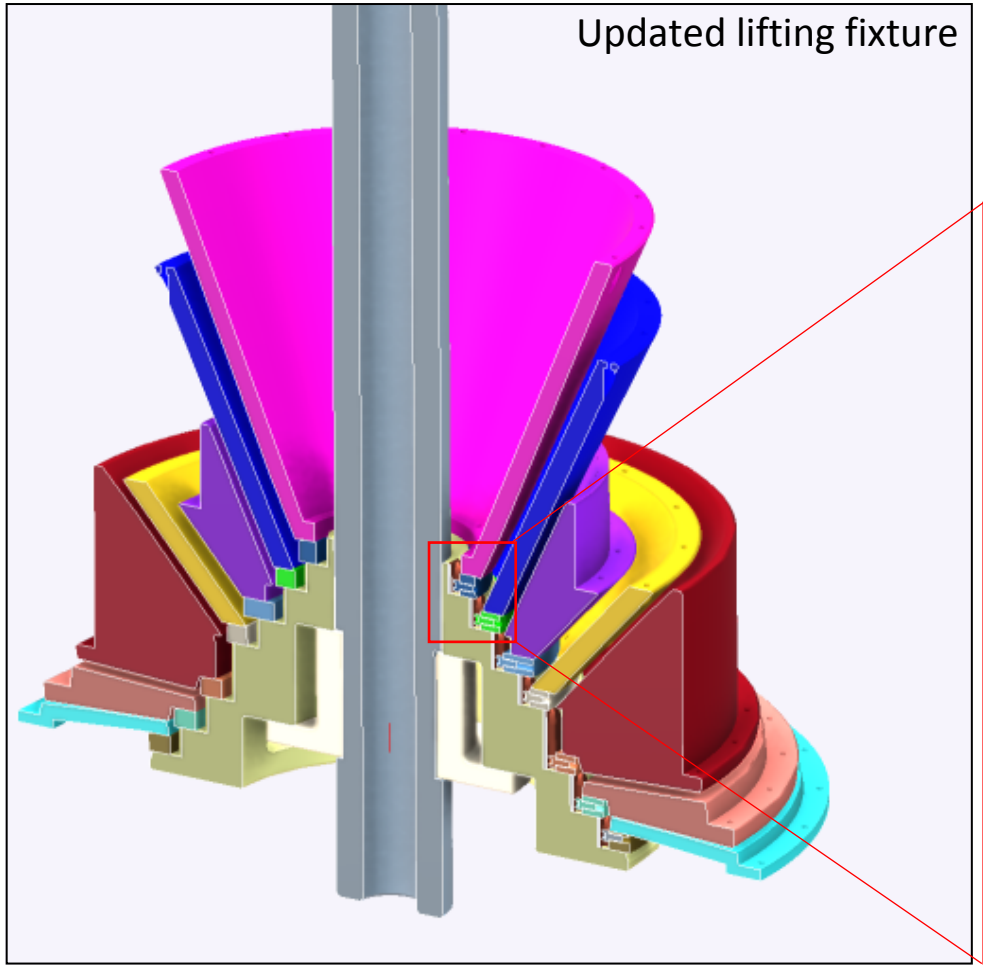


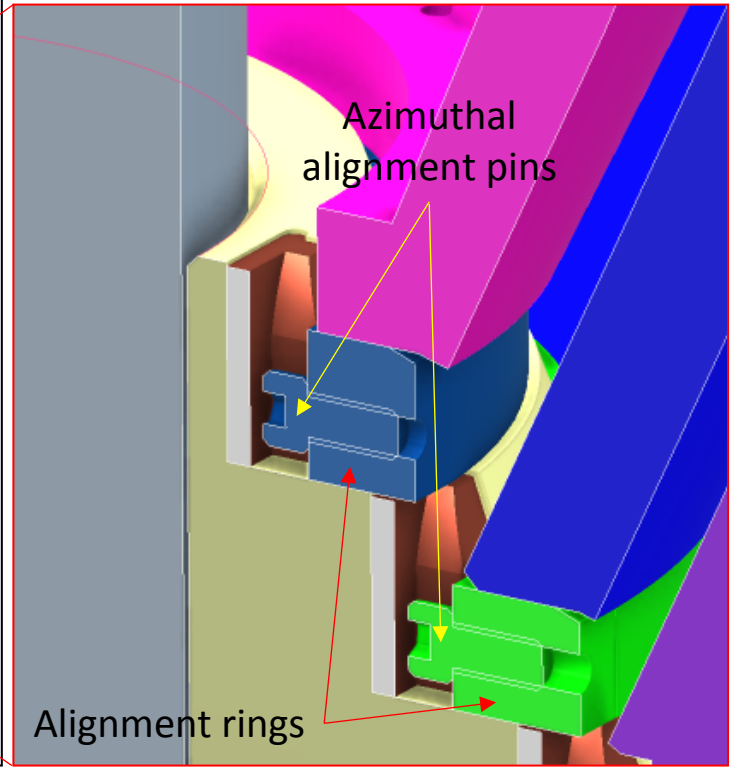


Saturn Recapitalization – MITL activities

- MITL performance – electrode alignment
  - Lifting fixtures are being updated to provide more accurate MITL placement
  - Updated design uses Z-style, detachable alignment rings
    - Wide contact surfaces that are not subject to shot debris or refurb wear
    - Integrated azimuthal alignment

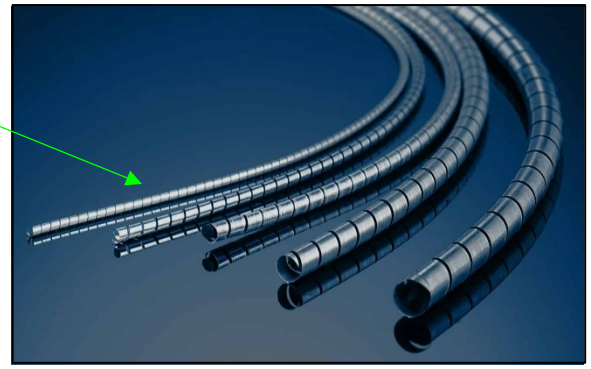


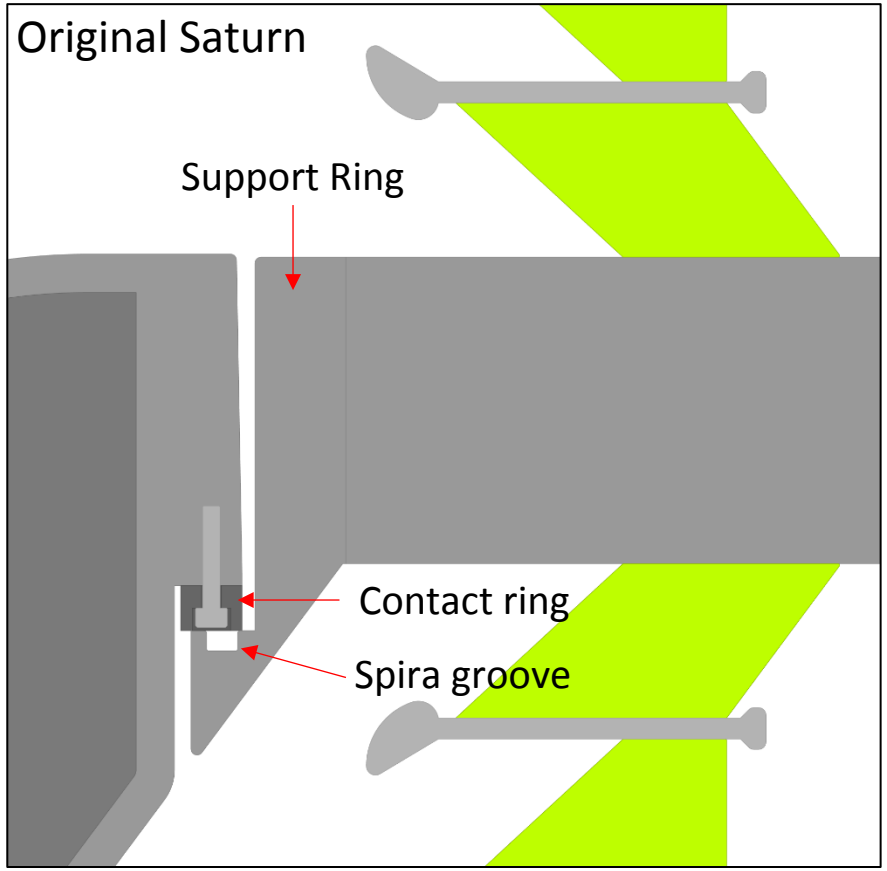


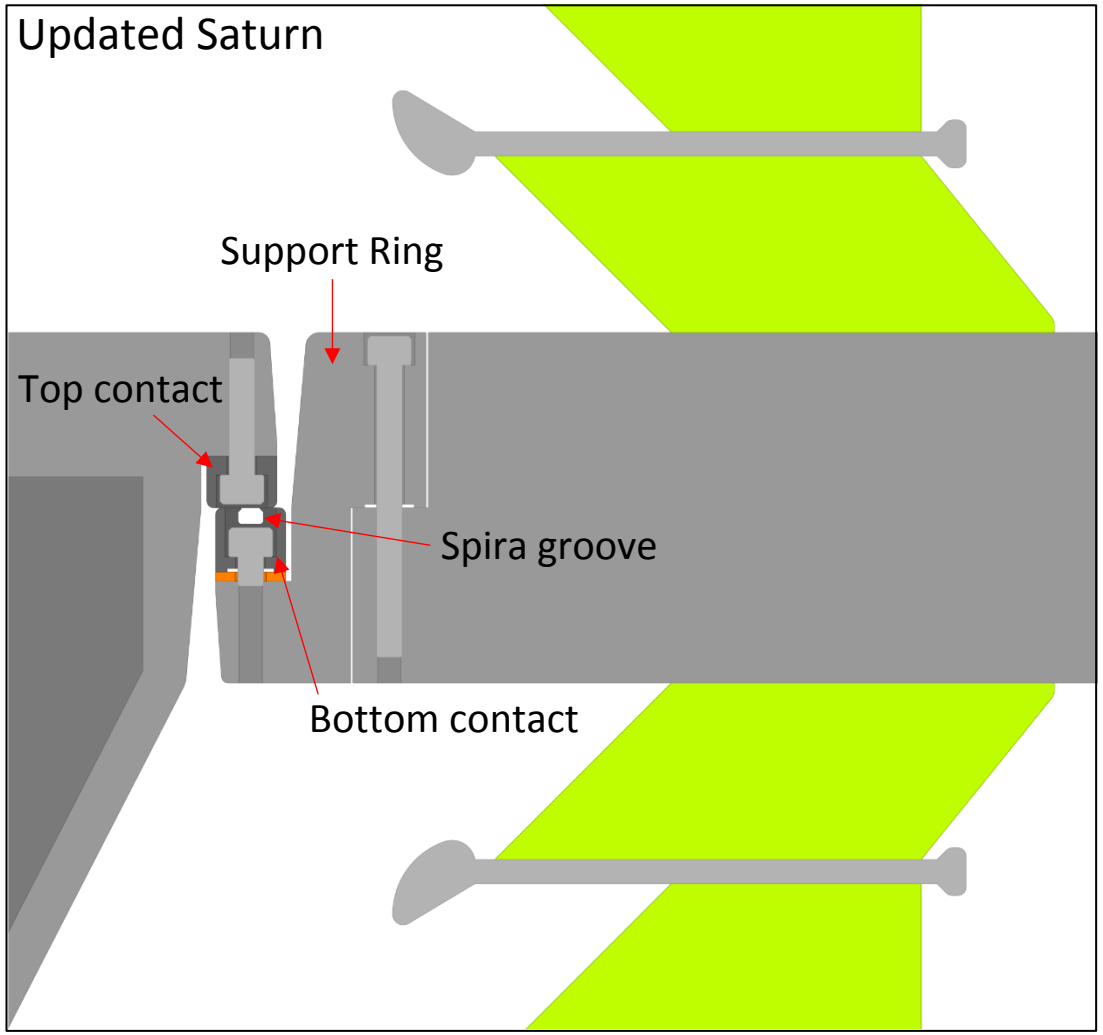


Saturn Recapitalization – MITL activities

- MITL performance – electrode current contacts
  - Adopting Z-style gravity contacts at outer interfaces
    - Replaceable, segmented contact strips on both sides of interface
    - Captive groove for Spira gasket in bottom contact







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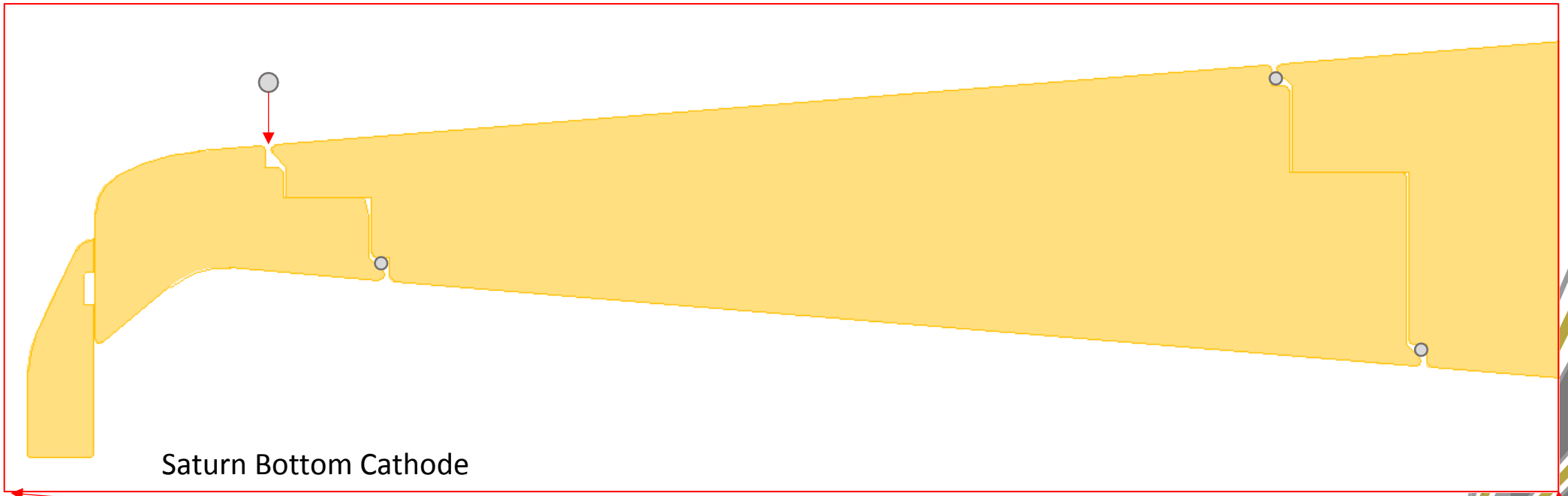
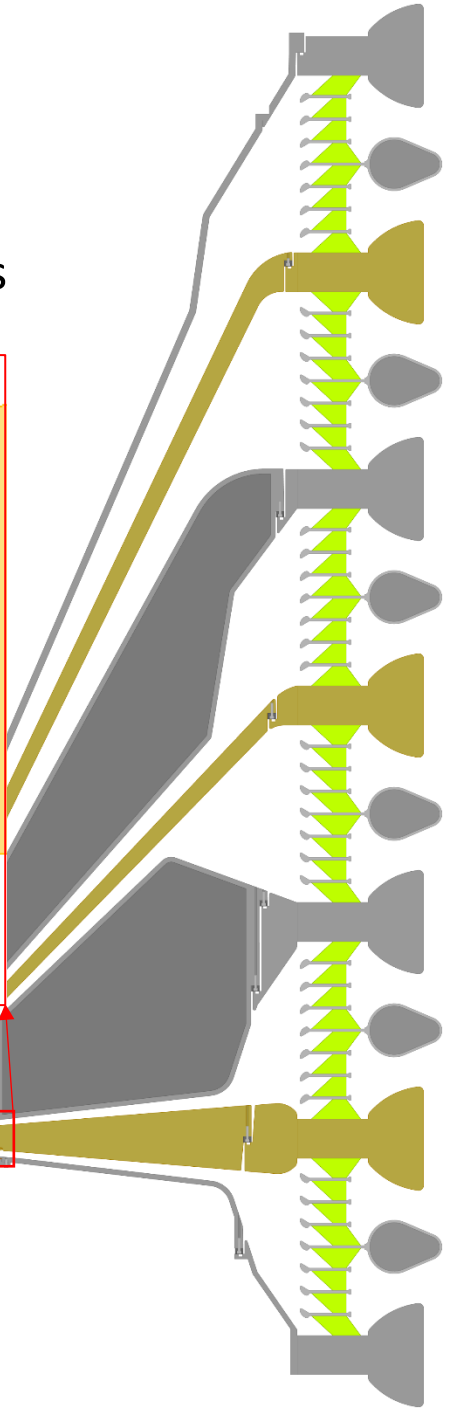
Saturn Recapitalization – MITL activities

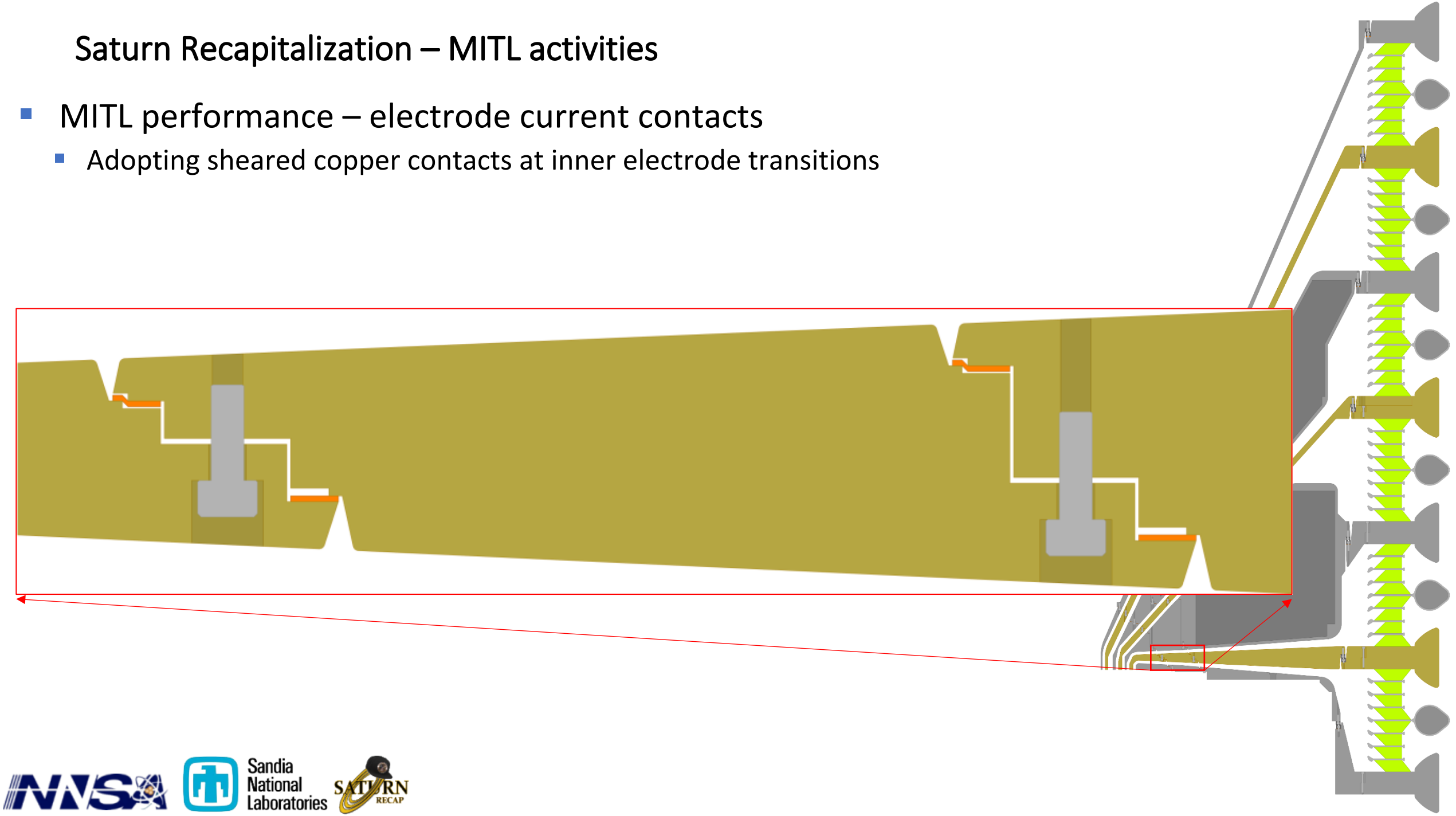
- MITL performance – electrode current contacts
  - Present Saturn uses crushed aluminum tube at inner electrode transition current contacts





Saturn Recapitalization – MITL activities

- MITL performance – electrode current contacts
  - Adopting sheared copper contacts at inner electrode transitions

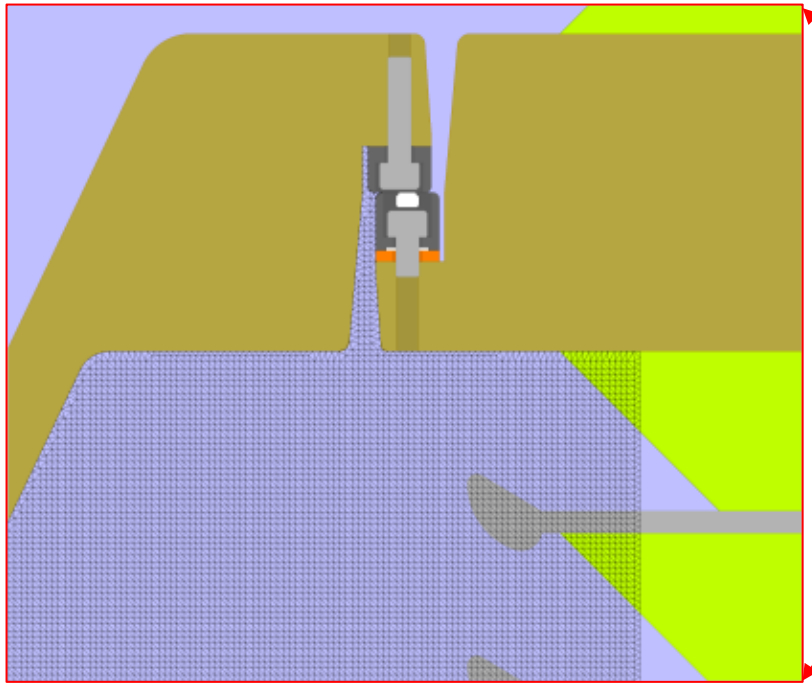


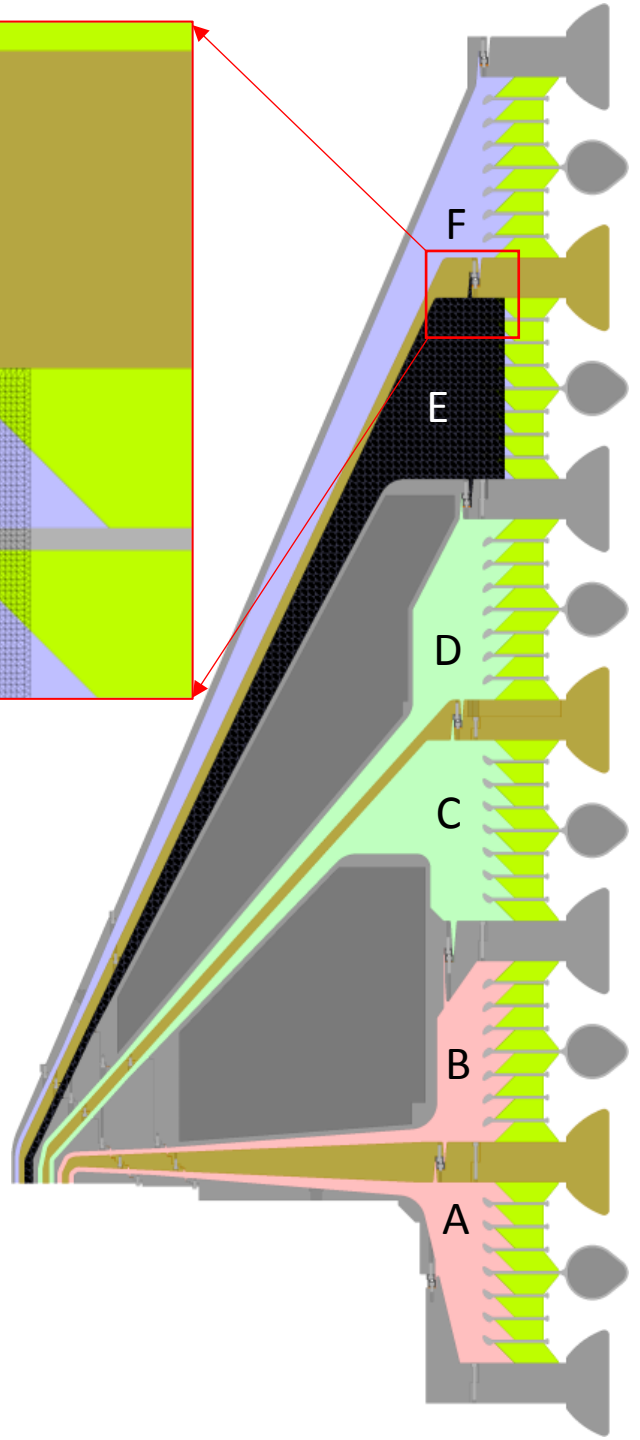
Saturn Recapitalization – MITL activities

- MITL performance – inductance balance
  - Numerical integration of irregular triangular mesh

$$L = \frac{\mu_0}{2\pi} \int \frac{1}{r} dA$$

  - Domain extends from diode tip to insulator stack
    - Includes fine details of electrode profiles





	MITL Level	Original Saturn	Minimum Gap Size	Updated Saturn	Minimum Gap Size
Ring 3	A	15.5 nH	13 mm	15.6 nH	10.1 mm
	B	15.6 nH	10 mm	15.6 nH	10.0 mm
Ring 2	C	27.8 nH	13.5 mm	26.1 nH	9.6 mm
	D	27.1 nH	10 mm	26.0 nH	10.0 mm
Ring 1	E	51.7 nH	14 mm	50.4 nH	13.2 mm
	F	54.8 nH	10 mm	50.4 nH	9.3 mm

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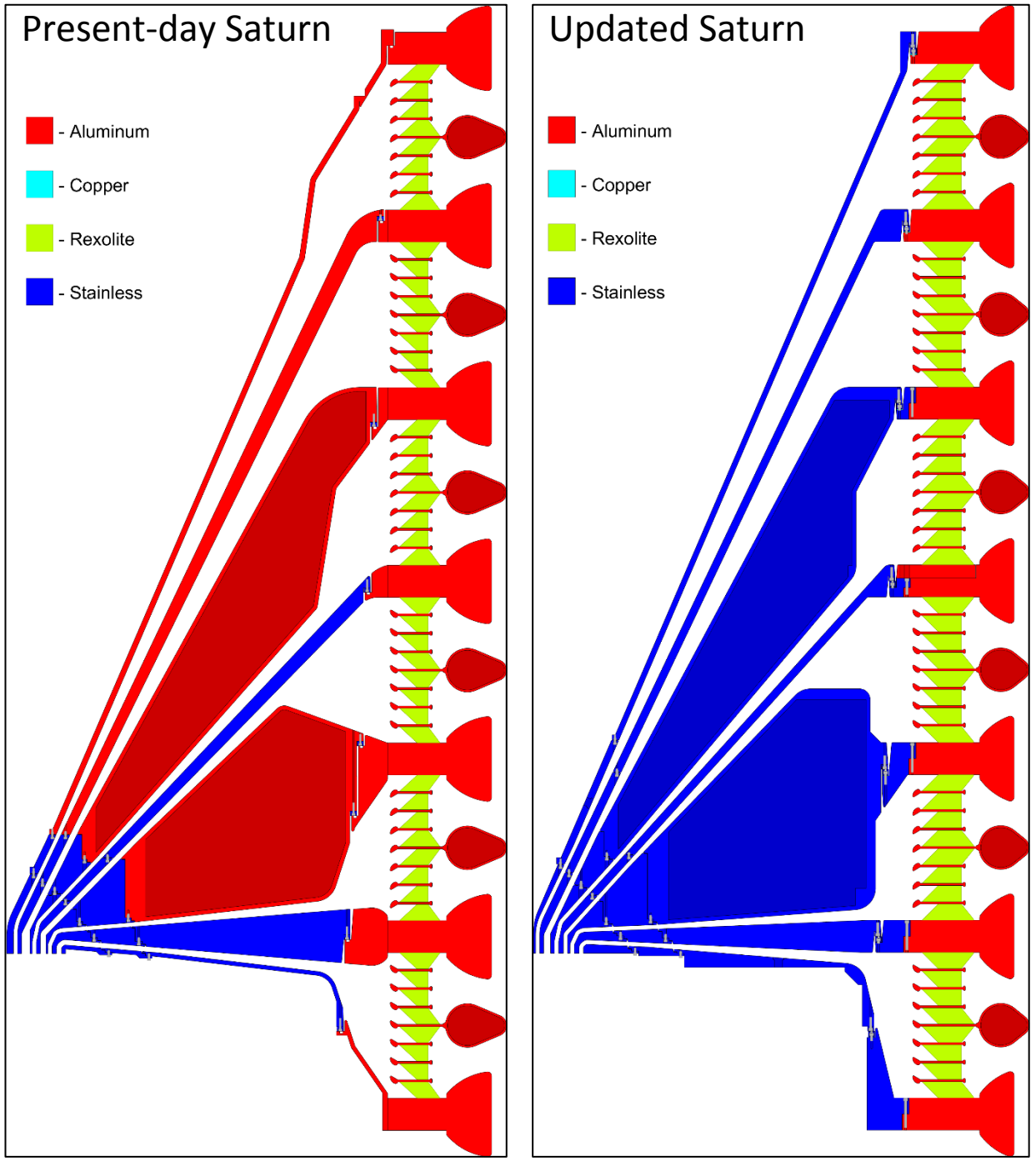
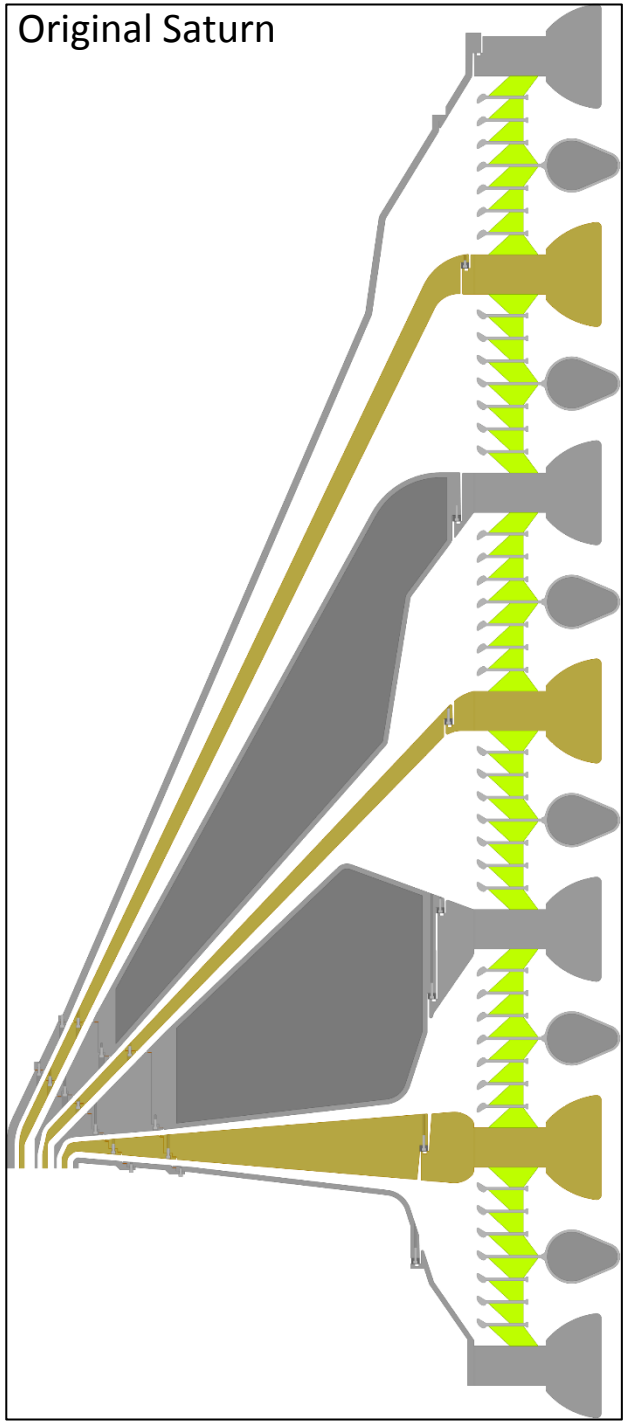
Saturn Recapitalization – MITL activities

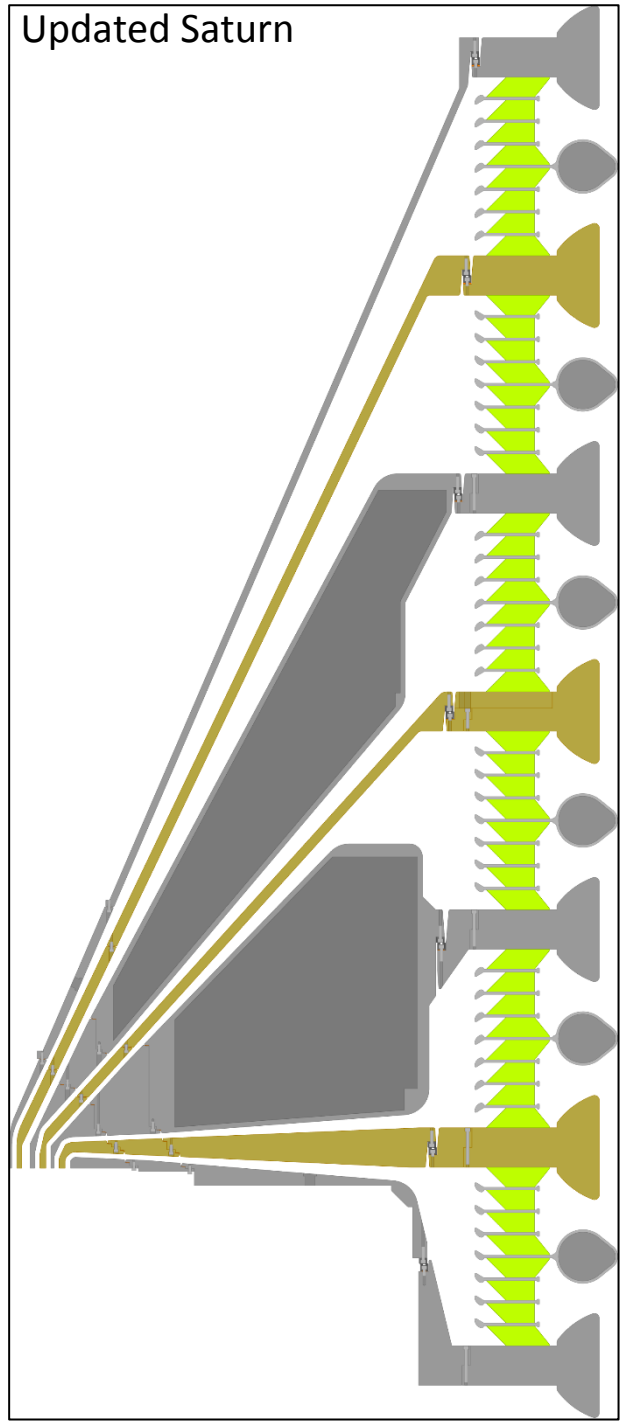
- Material selection
  - Present Saturn has several aluminum electrodes
  - Fabrication of all MITL electrodes from stainless is feasible



Saturn Recapitalization – MITL activities

- Fabrication considerations
  - Eliminated multi-angle conical surfaces
  - Eliminated large radii of curvature
  - Eliminated monitors in center anodes
  - Top and Center Cathodes are constant thickness
  - Minimized thickness of Bottom Cathode
  - No multi-level contact interfaces
  - All parts include horizontal and vertical fixturing surfaces
  - Reduced height of tallest cones





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