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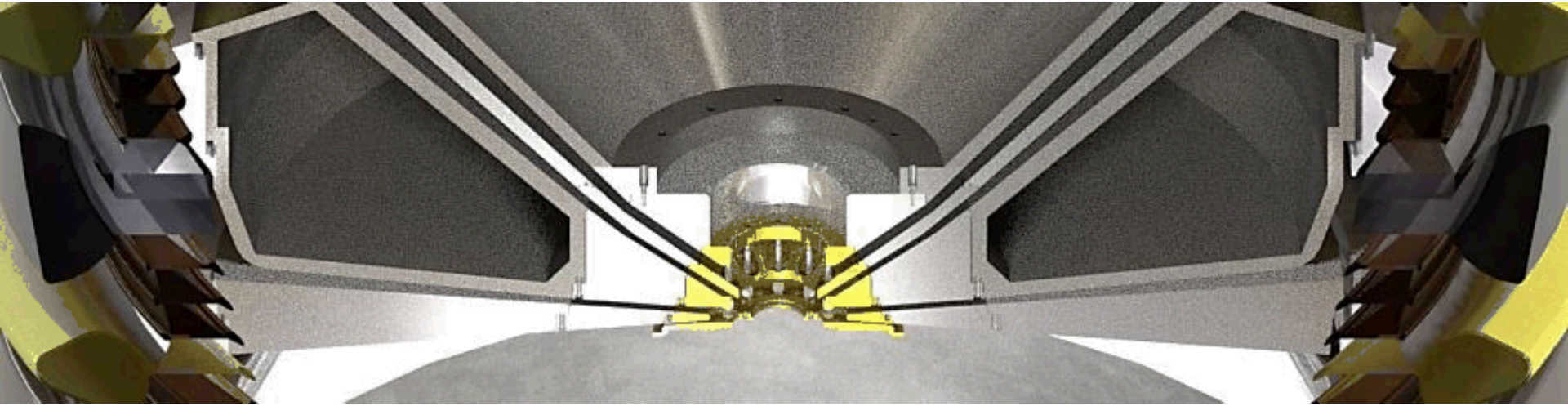

Saturn Reproducibility Review

Summer 2014

Andrew Biller – Org. 1342

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Problem Statement

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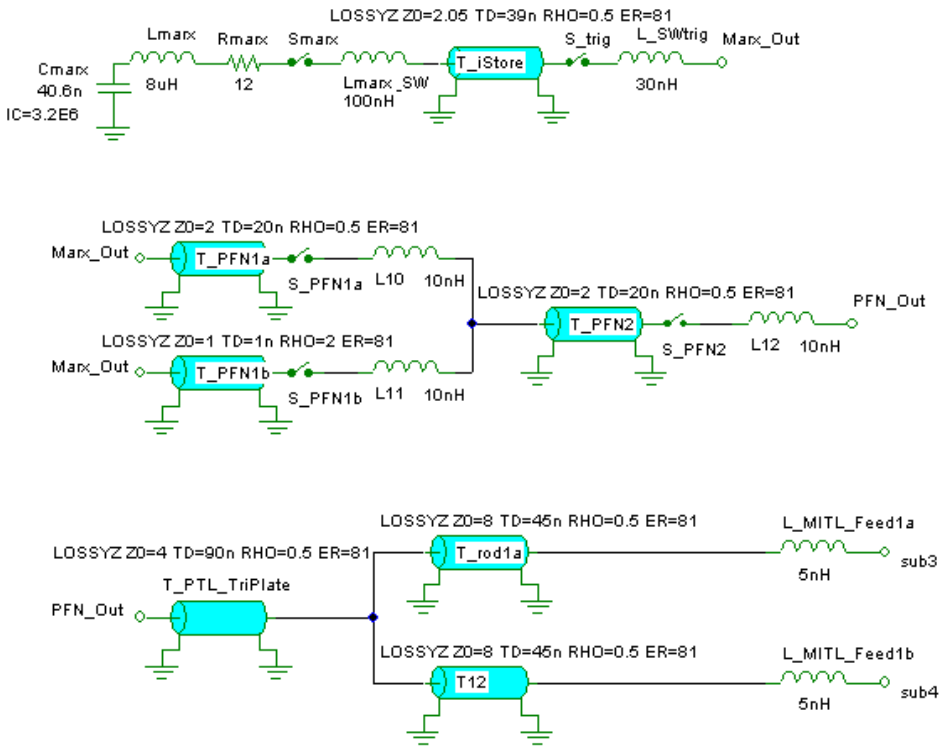
- The Saturn Accelerator has dropped out of acceptable reproducibility requirements due to many factors, such as:
  - Age/Usage
    - Built in 1987
    - ~5000 Shots
  - MITL damage
    - Misaligned MITLS can warp convolutes, and, in extreme cases, fuse them together
  - VIS damage
    - Cathode/Anode support ring modifications
    - Alignment hardware can't be used
- Why is this important?

Background

- 36 Radial Modules
  - Marx Generators
  - Intermediate Storage
  - Pulse Forming Network
  - Load Feed
  - MITLs
- "L_MITL_Feed" 5 nH Inductance is dependent on the MITL positioning
- In an early report on Saturn's electrical design, it was found that just a 1 nH increase in inductance caused a 3% loss in peak diode power at the bottom layer.[1]



Castle Model of a Single Saturn Module

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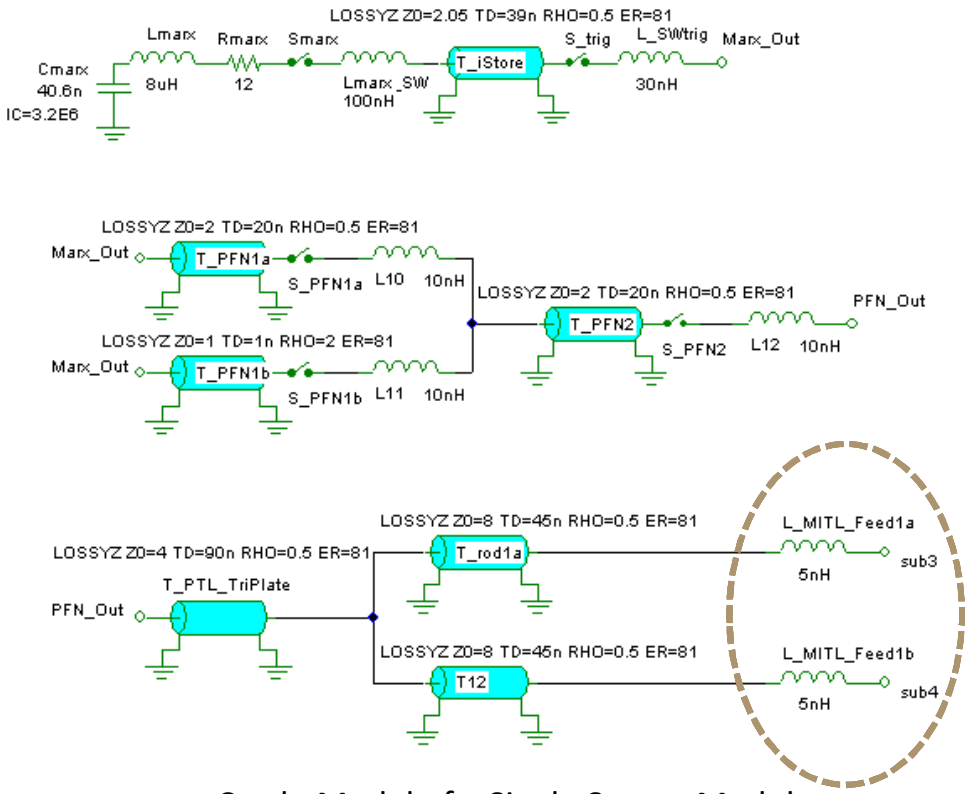

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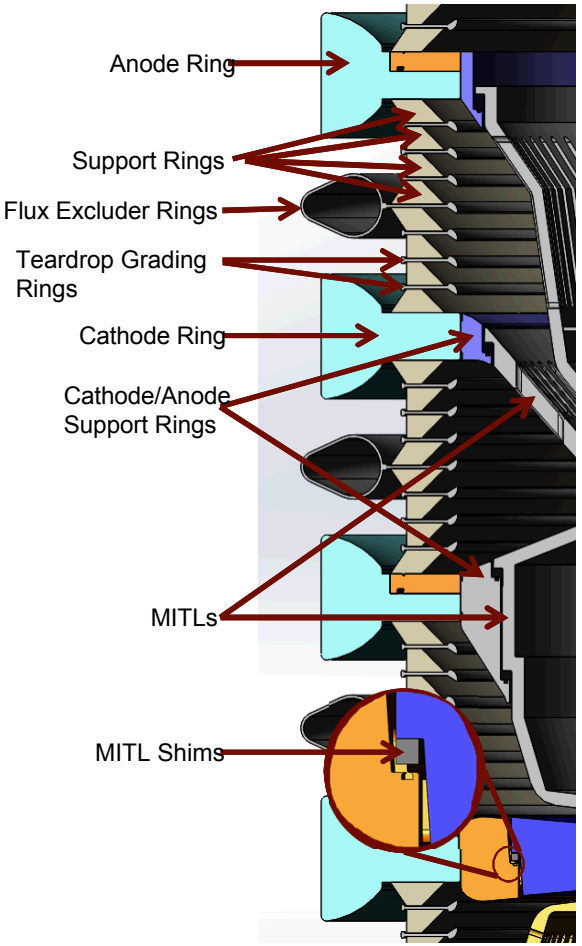
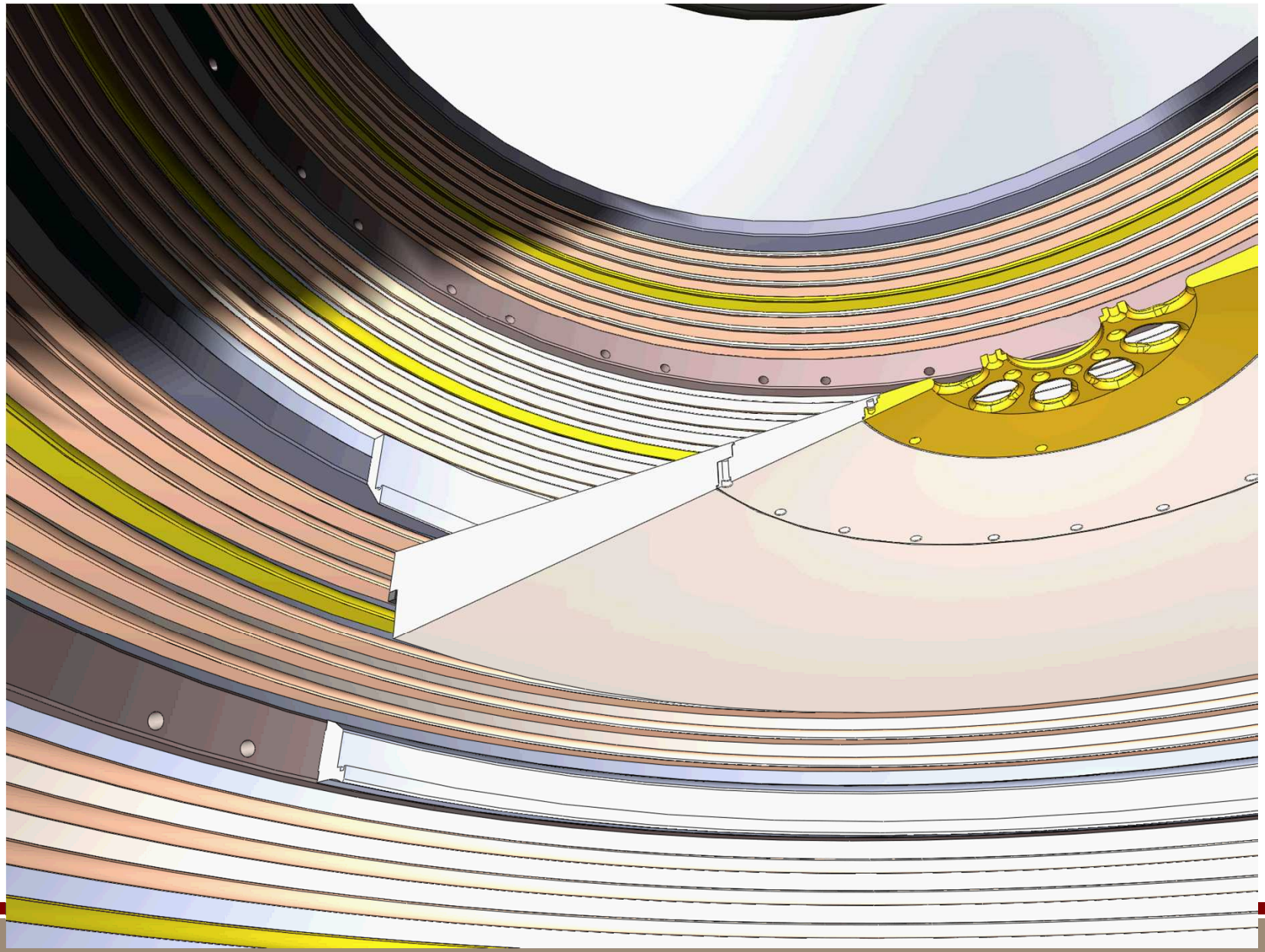
Background

- MITL-Insulator Stack Interface was found to be a primary contributor to lack of reproducibility
  - Aligned by lowering the MITL convolutes one-by-one onto the cathode and anode rings
    - Checked for concentricity, planarity, and height
      - Concentricity is adjusted with a “cheater bar”, and planarity is modified by adjusting alignment bolts that the MITLs rest on.
    - Time consuming
    - Requires the full attention of many crew members
    - Confined space work



Background



Research

- Pneumatic system
- Hydraulic system
- Fixed system
  - Z Pulsed Power Facility
    - PBFA II-Z was designed to accommodate +1.0/-1.2 cm adjustments in the MITL AK gaps.[2]
    - On Saturn, "the electrical gaps between the cones taper to 1.0 cm and must be controlled to within 0.1 cm", this adjustment is made at the support rings, however.[3]
  - Faster turnover
  - Increased reliability
  - Simple
  - Tight tolerance
  - No mechanical system needs to be added to the stack
  - Works well in a high shock environment, as Saturn has seen over 200Gs on some of its equipment.[4]

Z Pulsed Power Facility

Output Comparison:
10 MA, 40ns FWHM (Saturn)
20 MA, 4 ns – 40 ns FWHM (Z Accelerator)

Turnover:
Unload MITLS – 2 hrs
Refurbishment – 1 hr
Final Wipe/Reinstall – 1.5 hrs
Install Load Hardware – 1.5 hrs
Vacuum Pump Down - 2 hrs

Tolerancing:
< 0.030" (A/K Gap)
± 0.002" (Concentricity)

Higher Current & Peak Power
↓
Higher Shock

Fewer Number of Configurations

[2]Spielman, R. B. (1996). PBFA II-Z: A 20-MA Driver for Z-Pinch Experiments, pp. 403.
[3]J. Boyes, J. Cap, G. Douglas, T. Franklin, J. Hart, H. Ives, . . . D. L. Pellow. Engineering Design of the Saturn Accelerator. SAND87-0303C (1987), pp 3.
[4]R. E. Craven. Shock Mitigation for the PFLs at the Saturn Accelerator. SAND97-1534 (1997), pp.18.

Solution

- Fixed MITL alignment

Pros	Cons
Improved reproducibility (through better alignment)	Limited configurations
Planarity, concentricity, and height adjustments are more consistent	Machine down time during conversion (depending on how much is changed)
Fast turnaround • More shots • Increased crew availability	New operating procedures, design analysis, and safety analysis required
Less damaging to hardware	
Less confined space work Increased safety	
New, expensive hardware required. (Pro & Con)	

Items to Consider

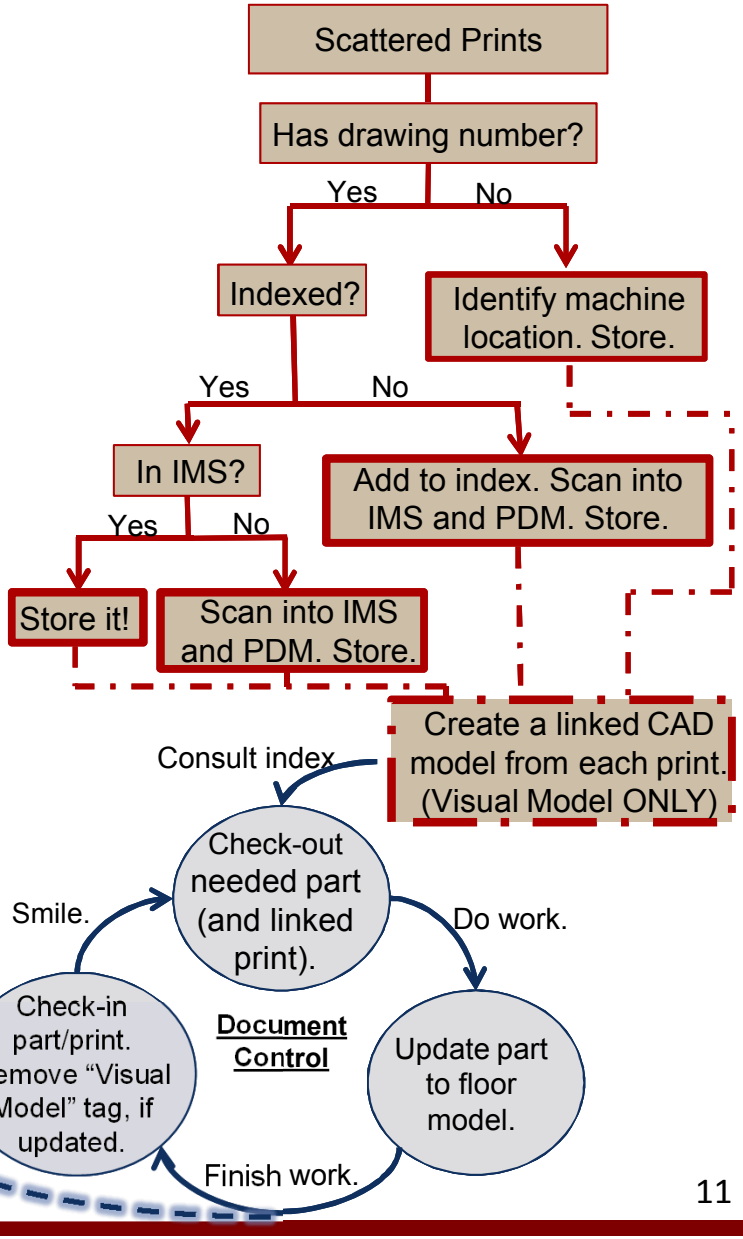
- Add capability to install/withdraw MITLS with one crane pick
  - Flipper capability
- If new MITLS will be fabricated, account for the diagnostic ports used/unused and if any additional ones are desired
  - Design to allow easy refurbishments
- Review the current contact gaskets being used
  - Spira Gaskets used at Z
    - Gasket sometimes welds to the MITLS, requiring additional refurbishment
- Keep in mind additional configurations and if adaptations would be possible
- Verify that adequate loading/unloading hardware is present

Implementation

- The following will be required to implement the proposed solution:
  - Create an up-to-date CAD model of Saturn's Center Section
  - Design and procure new MITLS and necessary vacuum insulator stack components
  - Create new Operating Procedures (OPs) for procedures involving the new MITLS
  - Risk Analysis
    - Vacuum/Oil/Water/High Voltage/Confined Space/Fall Hazard
    - Failure Mode Effects Analysis (FMEA)
  - Safety Analysis

Side Projects

- Crew Turnover Recovery
- Saturn Print Consolidation
  - Recovering lost documents
  - Create index and new system
- Adding an Additional Document Control System
  - A good system… (easy to use, WANT to use)
  - Recovered documents must be accessible
  - Check-in/Check-out
- Modeling the Saturn Accelerator
  - Reference Only → Actual Model



Thanks / Questions

Sandia National Laboratories

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