KSU FUEL UPGRADE

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KSU Reactor Facility

- TRIGA Mk II
- Fueled with 8.5% U content, 20% enriched U-ZrH
- Licensed to 1.25 MW, but limited by reactivity to 550 kW

Problem Statement

- Incorporate 12% fuel into core
- Six new elements on order, expected to arrive at end of year
- Show that new elements can be incorporated without violating TS, SAR
  - Shutdown margin
  - Maximum excess reactivity
  - Accident analyses

Motivation

- Current max power = 550 kW
- License limit = 1250 kW
- Power coefficient = -0.0018 to -0.002 $ / kW from 600 kW to 1 MW (from Torrey Pines TRIGA data)
- Add'l reactivity to reach license limit:

$$[1250\ \text{kW} - 550\ \text{kW}] \times -0.0018\ \$ / \text{kW} = \$1.26$$

Design Constraints

Kansas State University

Design Constraints:

- Max C / A peaking = 2.0 (SAR)
- New element T < T(IFE)
- Maximum excess ρ = $4.00 (TS)
- Minimum SD margin = $0.50 (TS)

Current Conditions:

- Max Peaking = 1.50
- Excess ρ = $2.50
- SD margin = $1.61

Modeling Strategy

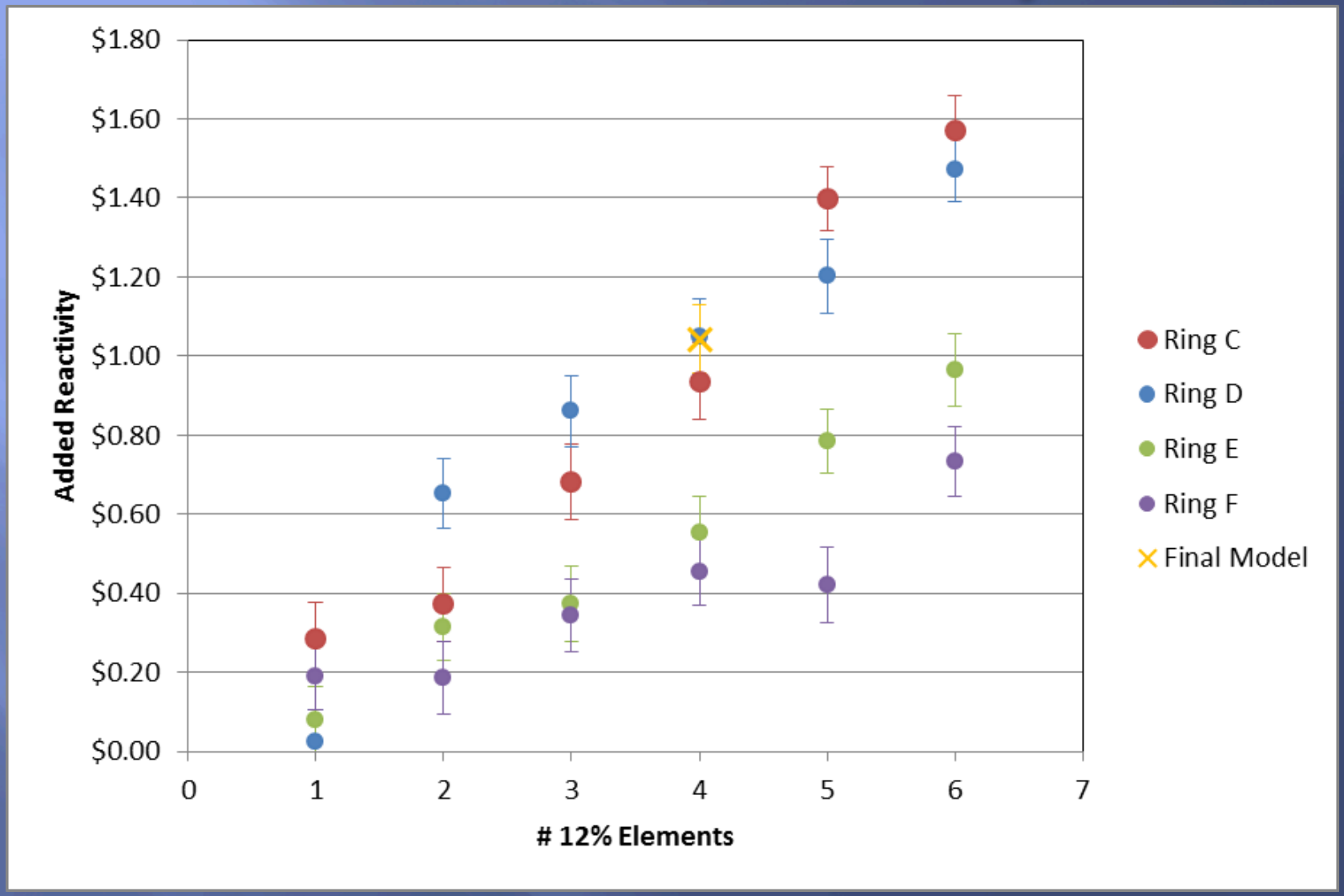
- It's easier to get a fresh element right than a depleted core
- Model reactivity perturbation due to new elements, add to known reactivity

- Depletion modeled as reduction in ^{235}U – no ^{236}U, ^{149}Sm, ^{239}Pu, etc.
- Use MATLAB to calculate cell / core power peaking based on MCNP output
- Only worry about "fine" depletion effects if power peaking is close to 2.0

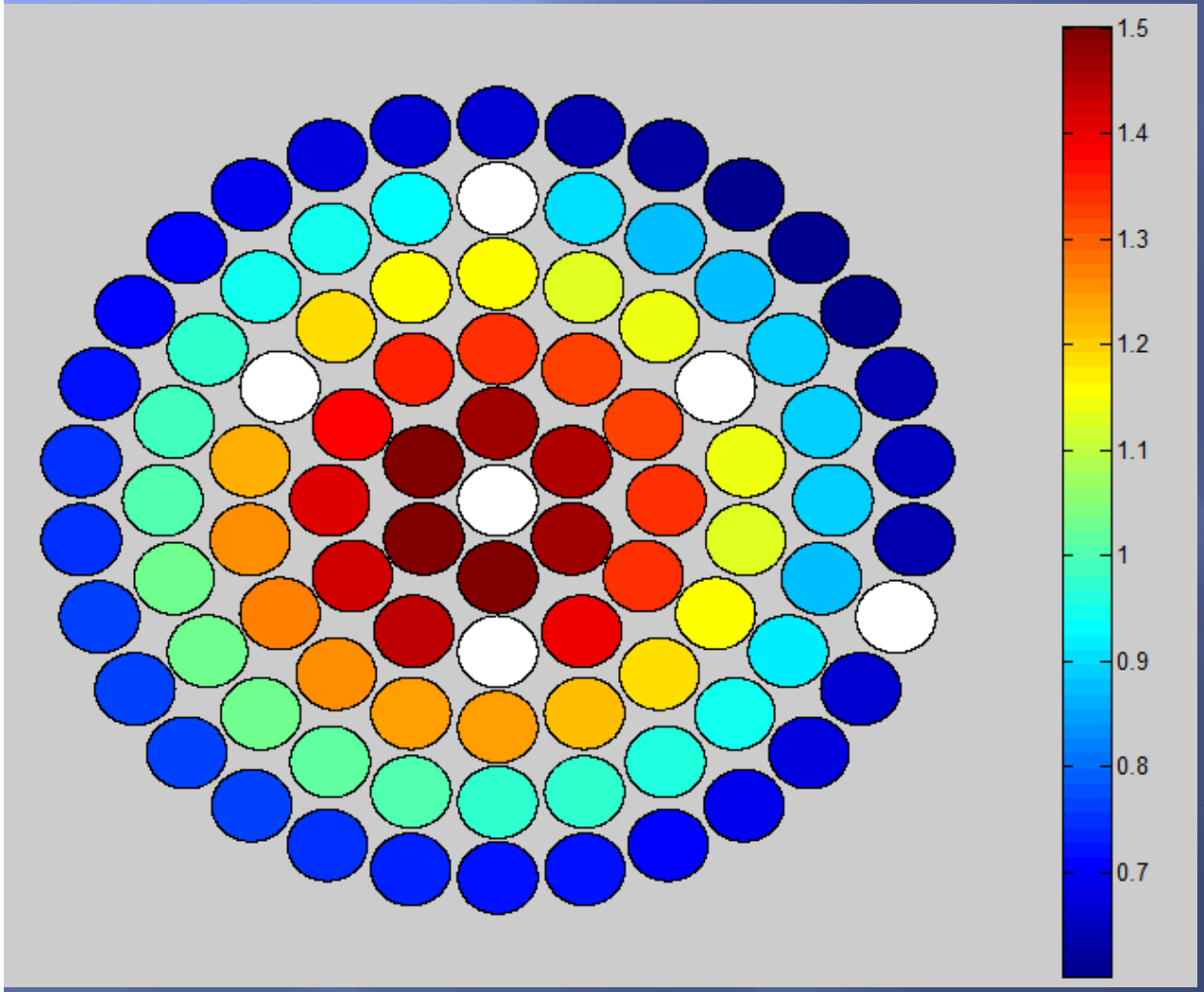
Design Strategy

- Put 12% fuel near control rods
  - Increase rod worth (for SD margin)
  - Increase fuel worth when rods withdrawn due to water regions
- Maximize core reactivity with a fairly low amount of new fuel

Added Reactivity



Unperturbed Core



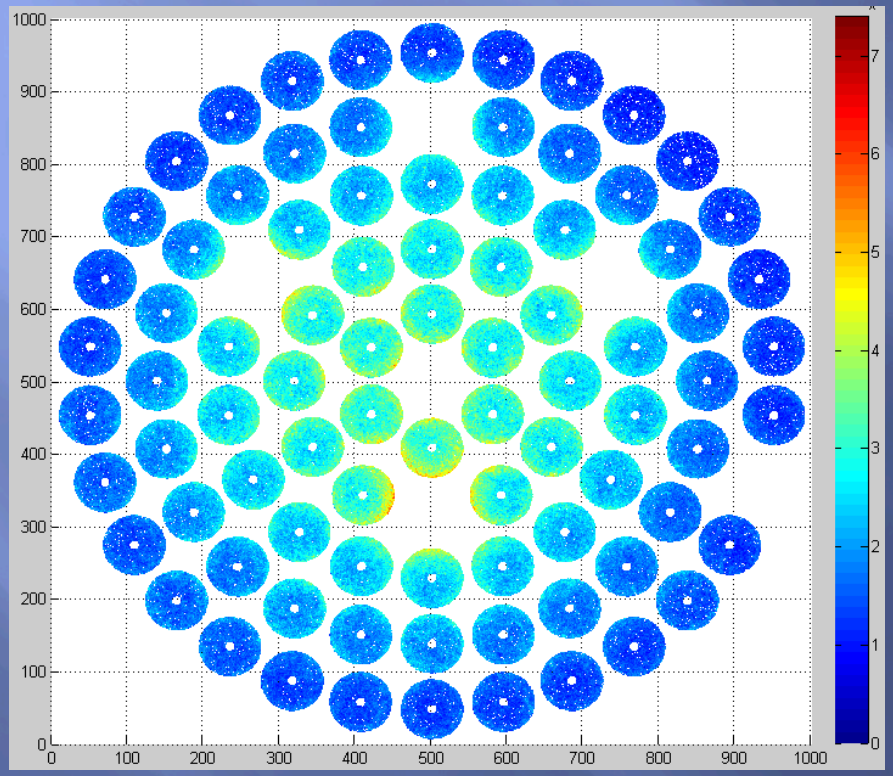
Max Cell / Core Avg = 1.502
Min Cell / Core Avg = 0.602

Final Model

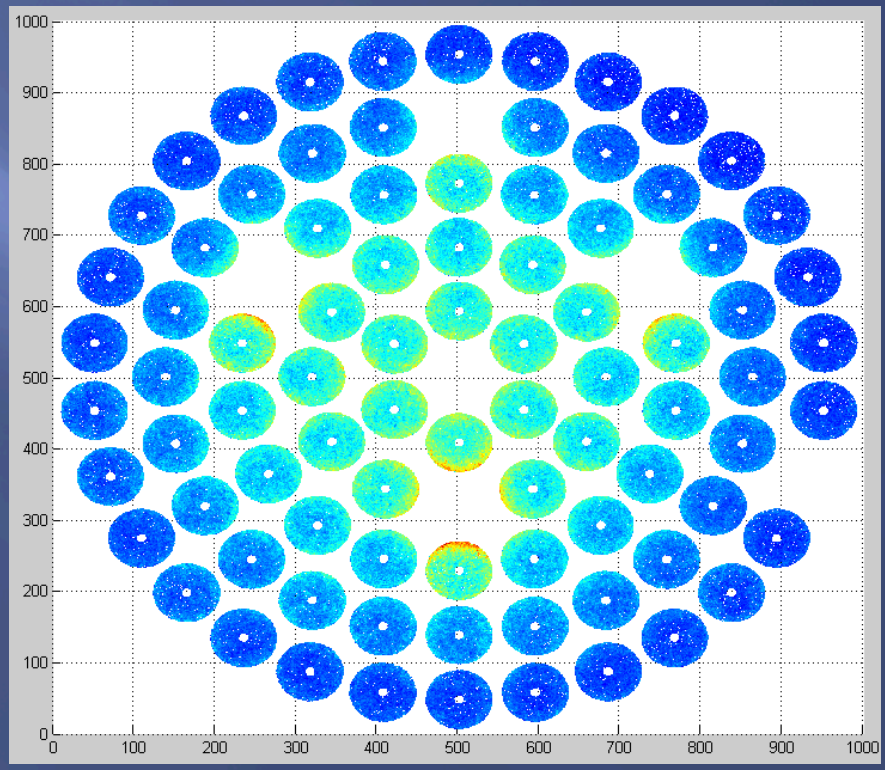
- Additional reactivity = $1.04 +/- 0.09
  - Nominal element loading
  - Expect to reach ~1 MW
  - Satisfy SD margin and excess ρ requirements
- Max cell / average power peaking = 1.50
  - Satisfy SAR assumptions
- Lattice positions: D-1, D-5, D-10, D-15
  - Each 12% element is adjacent to a control rod
  - Expect to increase RW, SD margin (versus 12% model with alternative placement)

Final Model

Old Core

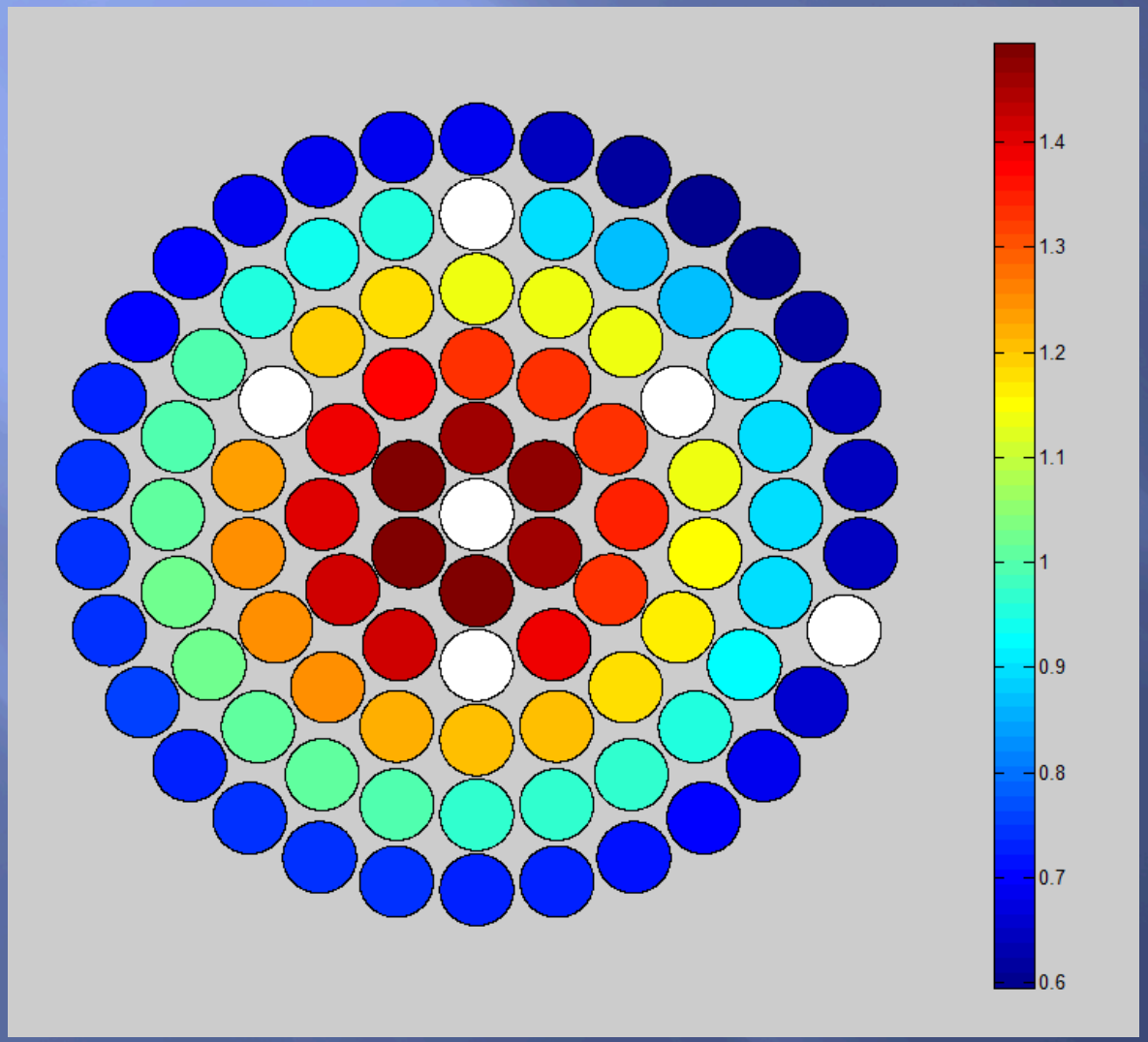


New Core



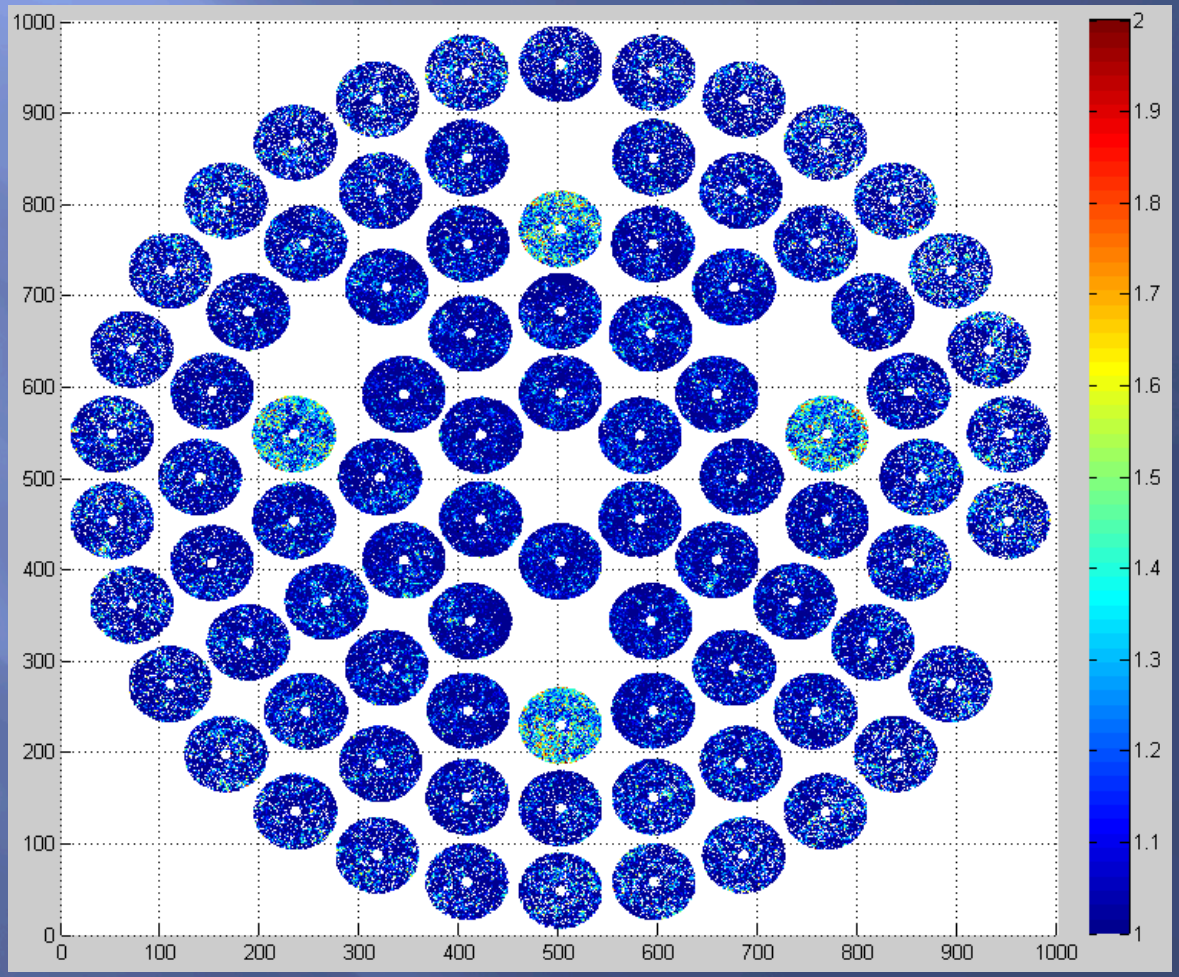
Mesh tally, fluence per source neutron

New Core Peaking



Max Cell / Core Avg = 1.495
Min Cell / Core Avg = 0.596

New / Old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1

Going Forward

- Need to add 12% elements to TS
- Review SAR for other issues
- Elements may differ from assumptions in analysis
  - Re-work analysis to check effect of off-nominal loads
  - Load one element at a time, check reactivity