Performing k_{eff} Validation of As-Loaded Criticality Safety Calculations Using UNF-ST&DARDS: Sensitivity Calculations

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Outline

1. Introduction and background
2. F*(r) mesh selection
3. Number of latent generations
4. Conclusion
5. Future work

Introduction and background

- UNF-ST&DARDS performs many analyses for as-loaded SNF canisters: criticality safety, shielding, thermal-hydraulic, containment
  - Overall plan for NCS validation presented by Clarity in Minneapolis
  - Experiment selection presented in next paper
- Sensitivity data generated for each cask using TSUNAMI-3D sequence
  - CLUTCH method only option in SCALE 6.2.3 for such large models
  - 32 PWR assemblies in 18 axial zones with 29 isotopes per zone

Introduction and background (continued)

- CLUTCH method uses F*(r) function for importance instead of an explicit adjoint calculation
- F*(r) is tallied by voxel during inactive cycles using the IFP method
  - Input for number of latent generations for the IFP calculation (CFP)
  - User-supplied mesh for F*(r) function (MSH or GridGeometry block)
  - NPG and NSK for tallying F*(r) function
- Direct perturbation calculations (DPs) are used to check the accuracy of the sensitivities calculated by TSUNAMI-3D

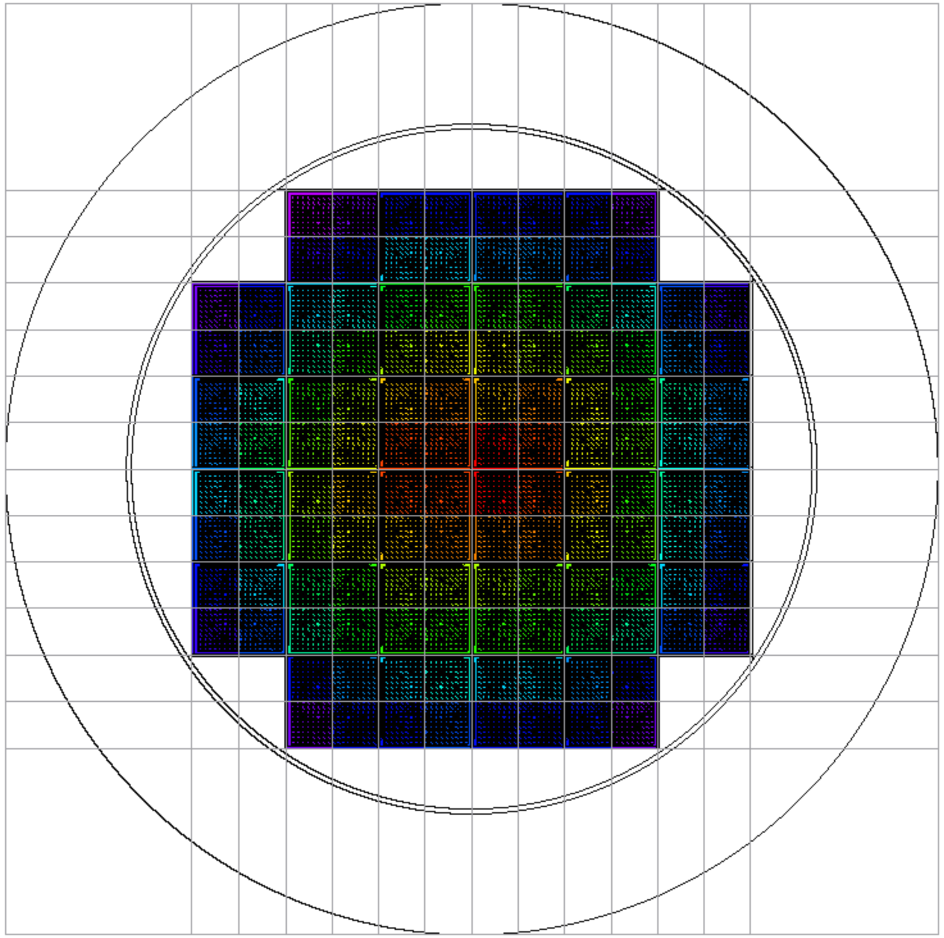
F*(r) mesh selection

- Generic guidance for F*(r) function:
  - Mesh spacing is 1-2 cm Cartesian mesh
  - Number of histories to tally is 10 – 100 histories per voxel
  - Developed based on testing with critical experiments
- For MPC-32, this would result in an approximately 86×86×183 mesh: ~1.35 million voxels
  - 13.5 – 135 million histories to tally F*(r) function
- Small mesh will also have large uncertainty
- Essentially all sensitivity in the top few feet of the fuel

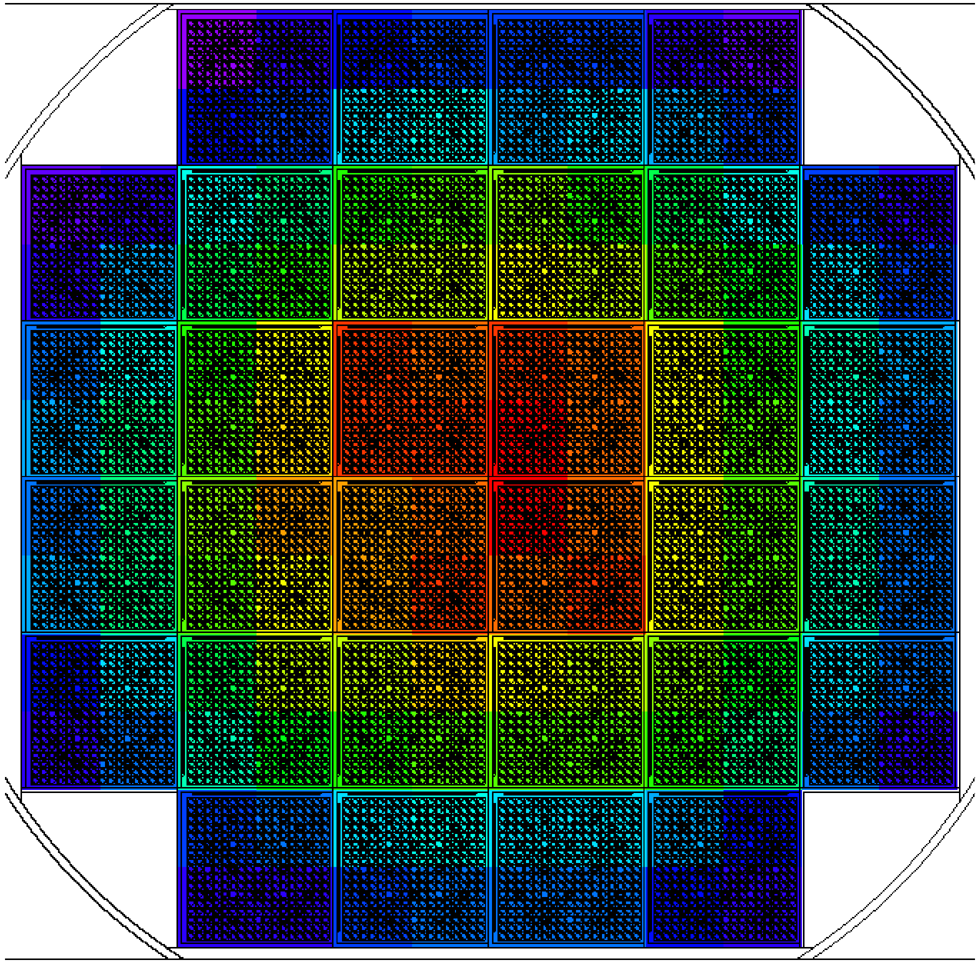
F*(r) mesh selection (continued)

- F*(r) function can be output and visualized in Fulcrum
  - Large relative uncertainties and evident statistical fluctuations in importance values
- Coarse mesh structures investigated
  - Half or full storage cell in X and Y
  - Variable axial mesh with large intervals in the lower portions of the model
- Ultimately, half cell in X and Y (each storage cell quartered) and variable Z intervals selected

F*(r) mesh selection (continued)



F*(r) Function and Mesh

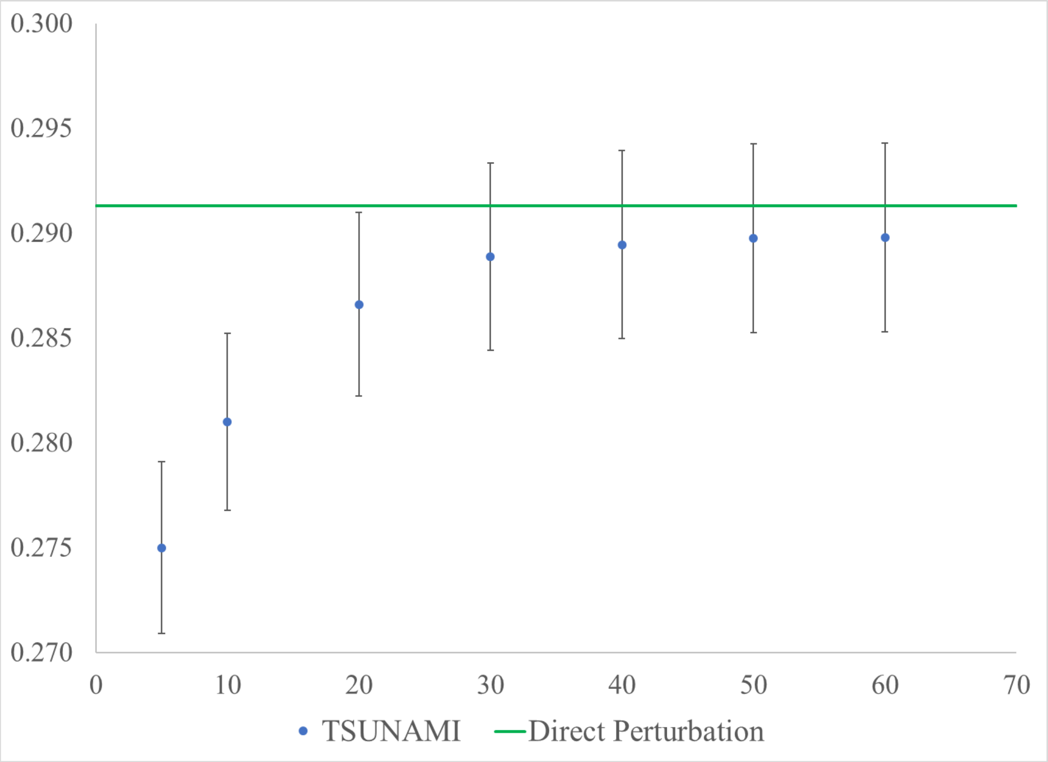


F*(r) Function Only

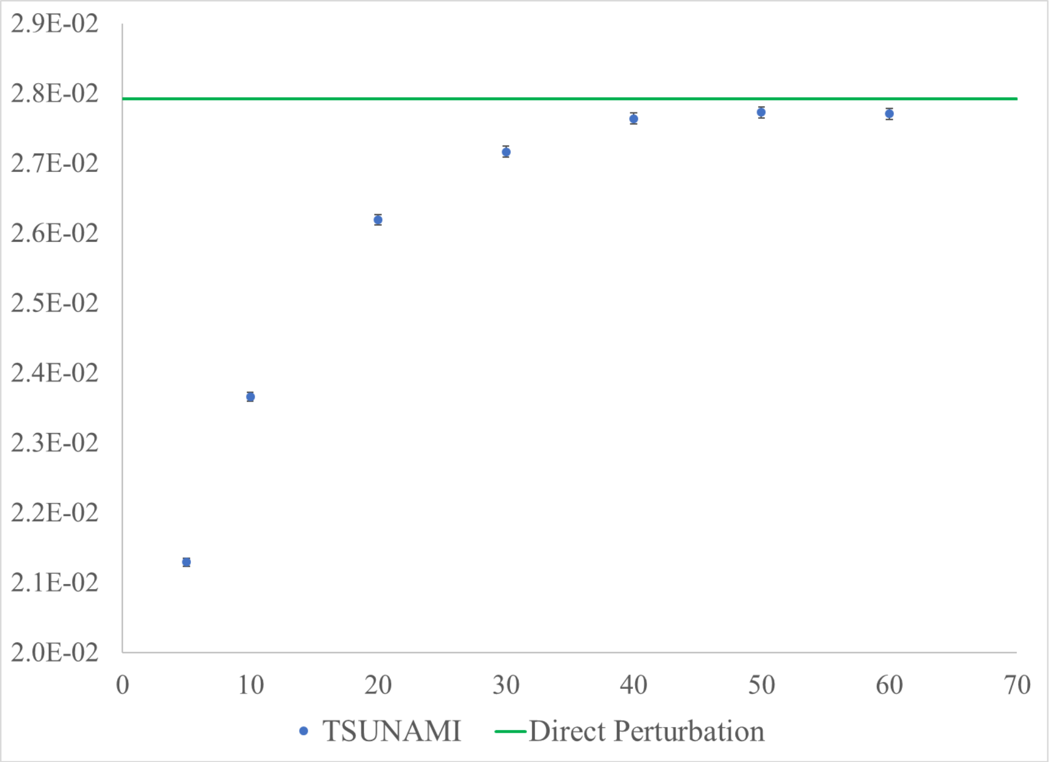
Number of latent generations

- Generic guidance for CFP is “usually between 5 and 10”
- Higher numbers should be more accurate, but will increase uncertainty because fewer fission chains last long enough to contribute to tallies
- Increasing CFP to 20 and 30 yielded better agreement with DP results
  - Additional calculations with CFP increased to 40, 50, and 60 performed for this paper
- H-1 sensitivity most challenging, large magnitude sensitivity to calculate accurately with TSUNAMI-3D

Number of latent generations (continued)



^{1}H Total Sensitivity



^{235}U Total Sensitivity

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Conclusion

- Sufficiently accurate sensitivities were calculated using:
  - $F^*(r)$ mesh based on half cell size in X and Y, variable axially
  - 30 latent generations
  - 50,000 neutrons per generation
  - 500 skipped generations to tally the $F^*(r)$ function
  - 1,500 active generations
- Sensitivities used for critical experiment selection, as discussed in the next presentation

Future work

- TSUNAMI-3D
  - Determine if this large number of latent generations is needed for accurate results in IFP as well
  - Further investigate impact of F*(r) function uncertainties on accuracy of sensitivity calculations
- UNF-ST&DARDS
  - Implement parameters and mesh for automated TSUNAMI-3D calculations
  - Expand number of cask types examined, especially to BWR systems

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Questions?

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