# A Case Study in the Application of TSUNAMI-3D – Part 3, Continuous Energy – Iterative Fission Probability Method

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# Outline

1. Background and introduction
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# Background and introduction

- Use of sensitivity/uncertainty (S/U) methods has increased over the last decade
- Tools within both SCALE and MCNP can determine sensitivities and apply nuclear data uncertainties
- A case study in TSUNAMI use is presented here using the Iterated Fission Probability (IFP), continuous energy (CE) sensitivity calculation method
- Companion papers using the multigroup and CLUTCH CE sensitivity methods were presented in Las Vegas (Nov 2016)
- <u>Direct perturbations</u> are especially important to generate reference results

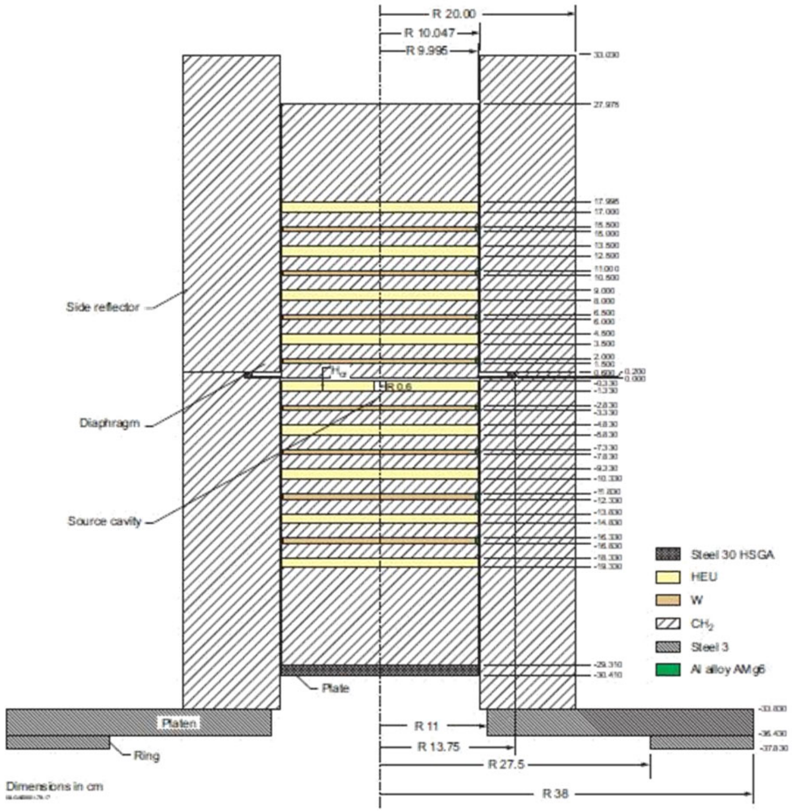
# Direct perturbation calculations

- Sensitivity data file (SDF) is created using the TSUNAMI-3D sequence
- TSUNAMI sensitivity can be confirmed by using DP calculations
- DP sensitivity *is* the (reference) sensitivity
- Select important isotopes, elements, and/or materials of interest
  - Include at least the primary fission and moderator species
  - Also include materials/isotopes of interest (e.g., absorber/FP)

# Direct perturbation calculations (cont.)

- Perturbation selected to cause ±0.5% Δ*k* change based on TSUNAMI calculated sensitivity
  - Perturbation large enough to yield accurate results and small enough to generate a linear response
- Uncertainty-weighted linear least squares fit of $k_{eff}$ points used to determine the DP sensitivity
  - Slope of the trend line is the sensitivity
- Desirable for the differences between TSUNAMI and DP sensitivities to be: 1) less than 5%, 2) less than 0.01 in absolute sensitivity, and 3) less than 2 standard deviations using the combined uncertainties

# Case study experiment (HEU-MET-MIX-017)



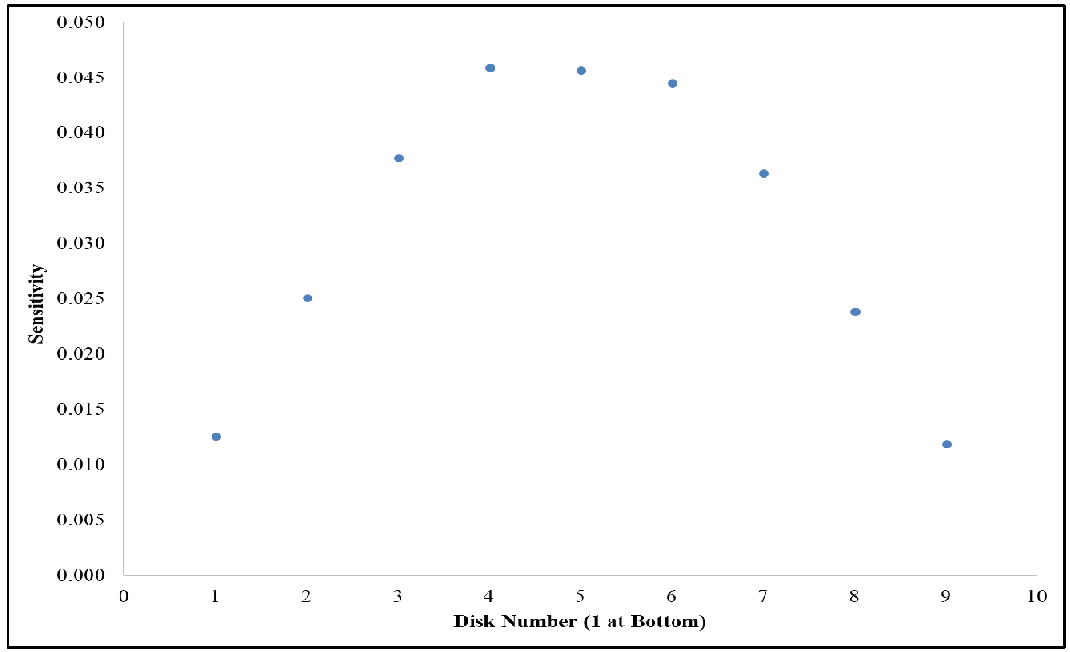

- Model from the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook
- 1 case/configuration
- Heterogeneous cylinder of alternating disks of HEU, polyethylene, and tungsten reflected by polyethylene
- Core is divided by a horizontal gap into 2 sections: a movable bottom part and a stationary top part
- Calculations used KENO V.a

## Results

- Model contains a unique mixture for each of the HEU disks, one mixture for all polyethylene disks and one mixture for polyethylene reflector
- 10 latent generations and 30 million active particles for results presented
  - More latent generations theoretically more accurate but higher uncertainty
  - 5 and 20 latent generations looked at; no significant variation in sensitivity accuracy for this problem
- $^{1}H$ sensitivity predicted better than multigroup calculations regardless of number of latent generations

# Results (continued)

| Isotope | ΔS (%) | ΔS (σ) | ΔS (abs) |
|---|---|---|---|
| C (refl) | 1.45 | 0.93 | -0.0005 |
| C (disks) | 0.25 | 0.08 | -0.0001 |
| H (disks) | 1.70 | 0.48 | 0.0010 |
| $^{235}U$ (disk 1) | 2.26 | 1.16 | -0.0003 |
| $^{235}U$ (disk 2) | 0.77 | 0.49 | -0.0002 |
| $^{235}U$ (disk 3) | 0.19 | 0.13 | 0.0001 |
| $^{235}U$ (disk 4) | 1.38 | 1.02 | 0.0006 |
| $^{235}U$ (disk 5) | 1.40 | 1.03 | -0.0006 |
| $^{235}U$ (disk 6) | 0.69 | 0.50 | 0.0003 |
| $^{235}U$ (disk 7) | 0.10 | 0.07 | 0.0000 |
| $^{235}U$ (disk 8) | 2.51 | 1.57 | -0.0006 |
| $^{235}U$ (disk 9) | 3.97 | 2.03 | -0.0005 |





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# Conclusions

- Use of DP calculations provides confidence in calculated sensitivities
  - Essentially confirms settings (number of latent generations, division of materials, etc.) yield correct results
- Case study for HMM-017 shows approach for challenging system
  - IFP yielded acceptable results "out of the box"
- Same case study presented in previous papers
  - CE methods attractive for systems with no 1D cell for XS processing

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