# Application of Serpent to Reactor Physics Modelling Problems at CNL

## 7th International Serpent User Group Meeting, November 2017

**Presented by Sourena Golesorkhi, with material from Alex Levinsky**

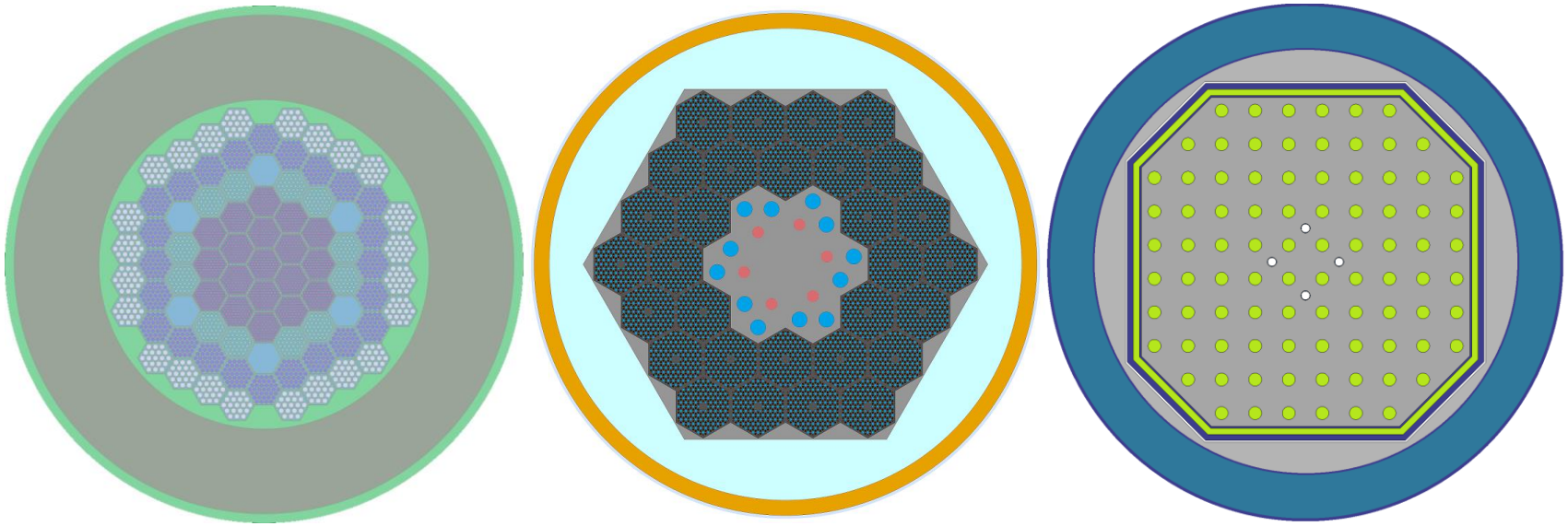
# Topics

- Small modular and advanced reactors
- Cross section generation
- Nuclear data uncertainty
- Transient analysis

* Analysis (mostly) performed with Serpent 2.1.24-28

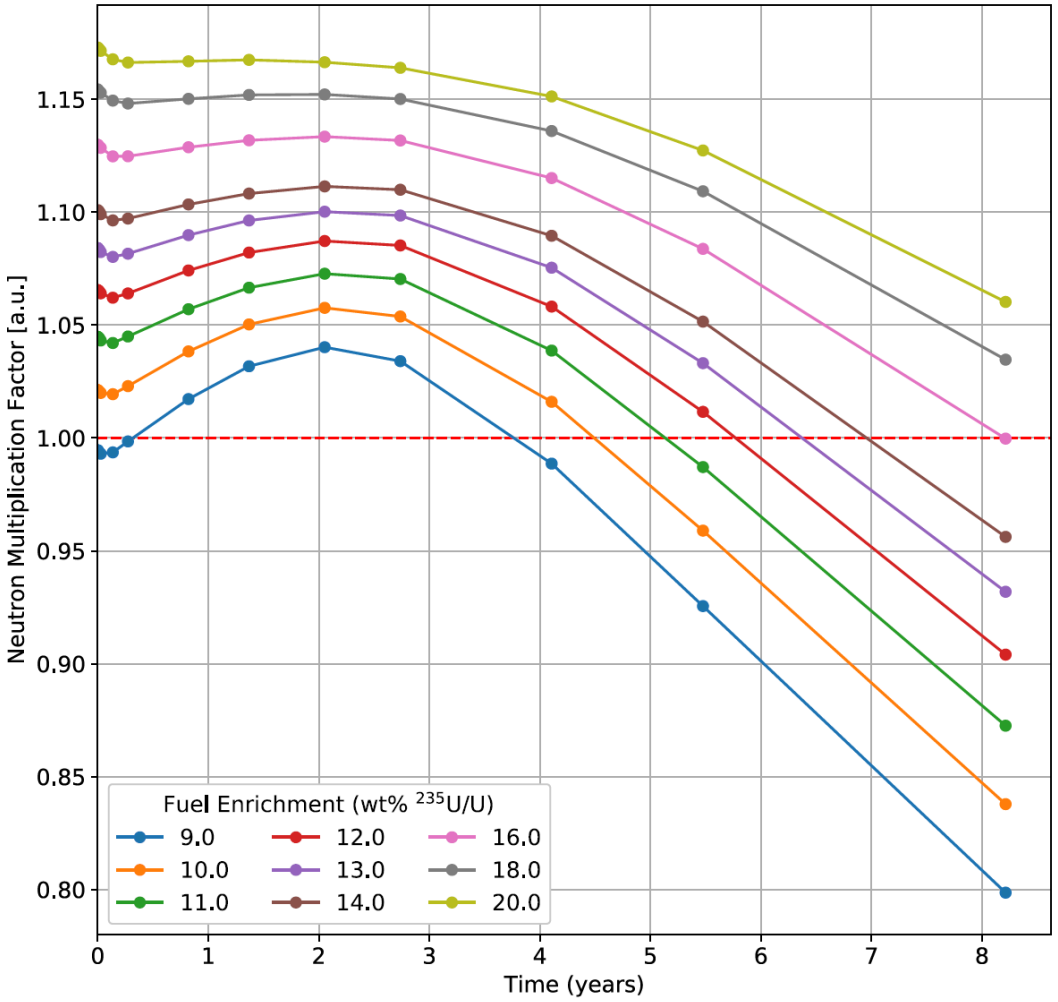
# Small Modular and Advanced Reactors

- Lead Cooled Fast Reactor
- High Temperature Gas-Cooled Reactor
- Molten Salt Reactor

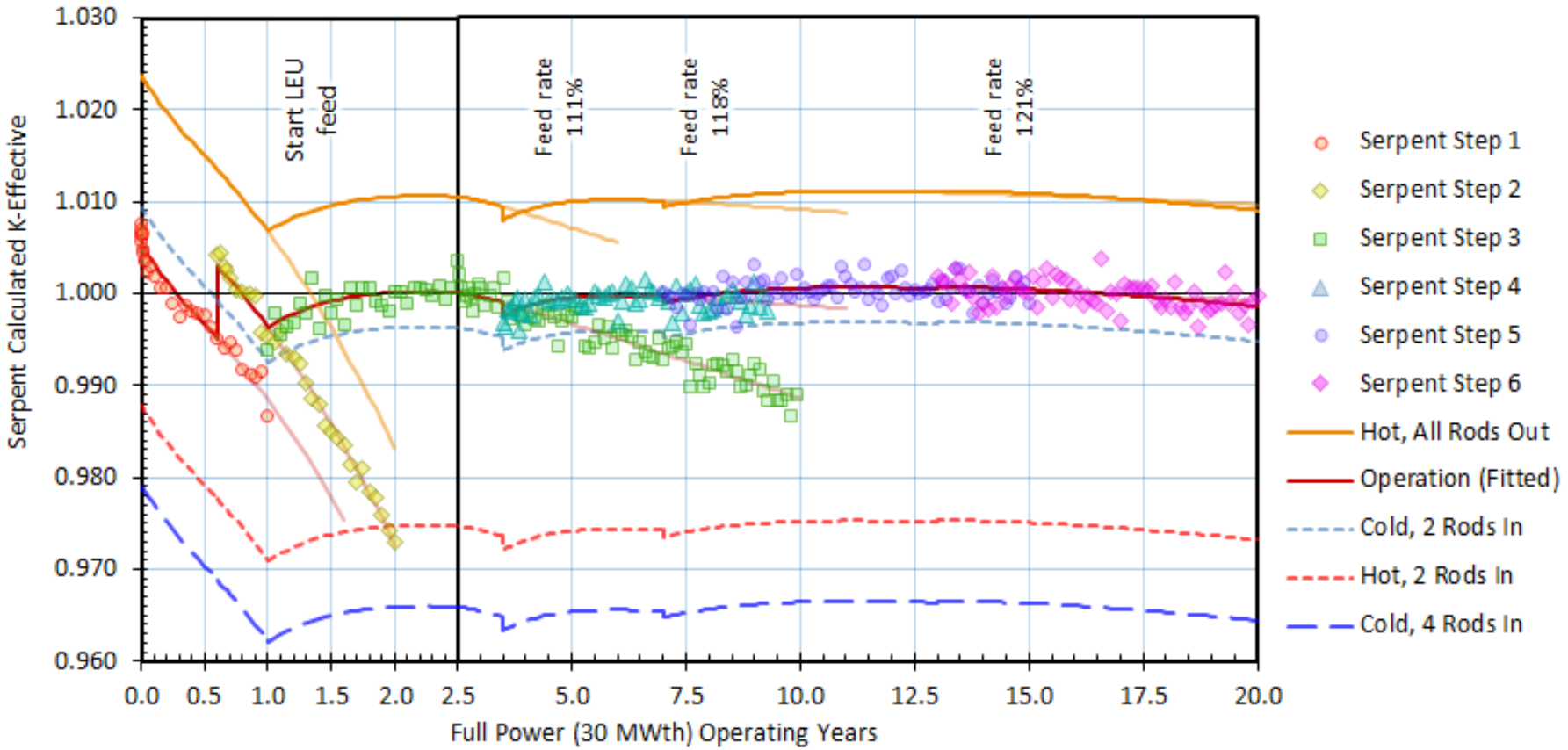


# SMRs (cont'd)

- Comparison of concepts by:
  - Fuel cycle length
  - Reactivity coefficients
  - Fuel utilization
  - Spent fuel characteristics
  - Physical dimensions
- Parametric studies



# SMRs (cont'd) – MSR Fuel Cycle

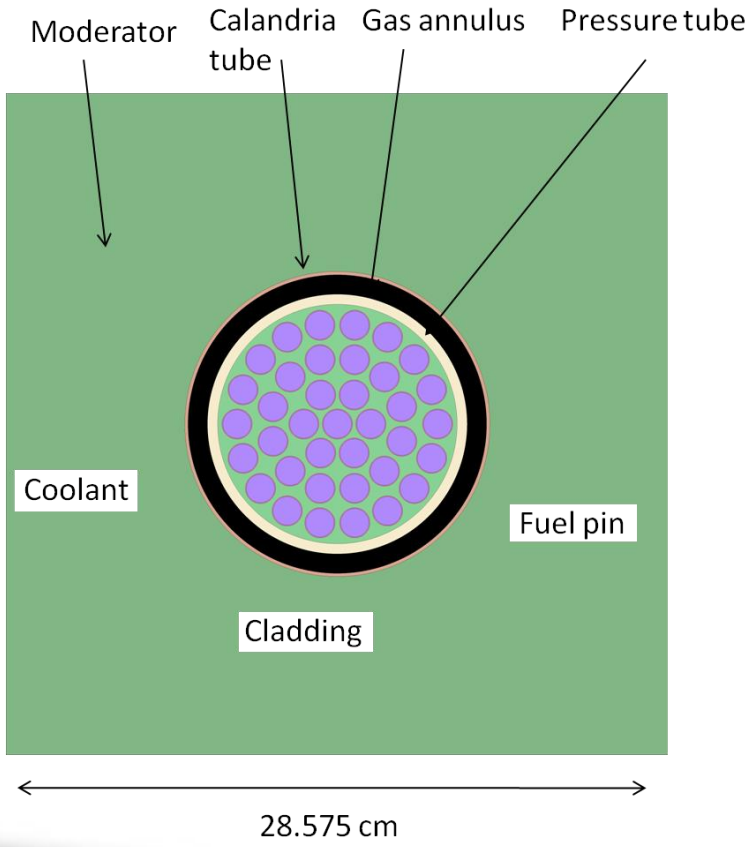



A. Levinsky, F. P. Adams, S. Golesorkhi, A. Trottier, D. Roubtsov, and J. Alexander, "Comparison of the Main Operational Characteristics of the Lead-Cooled, Gas-Cooled, and Molten Salt Small Modular Reactor Concepts", Submitted to PHYSOR 2018.

Journal paper in progress

# Cross Section Generation

- Simulate 2D or 3D CANDU bundle burnup.
- Reactivity device “supercells”.
- Generate homogenized macroscopic cross sections.
- Natural uranium and thorium-based fuels



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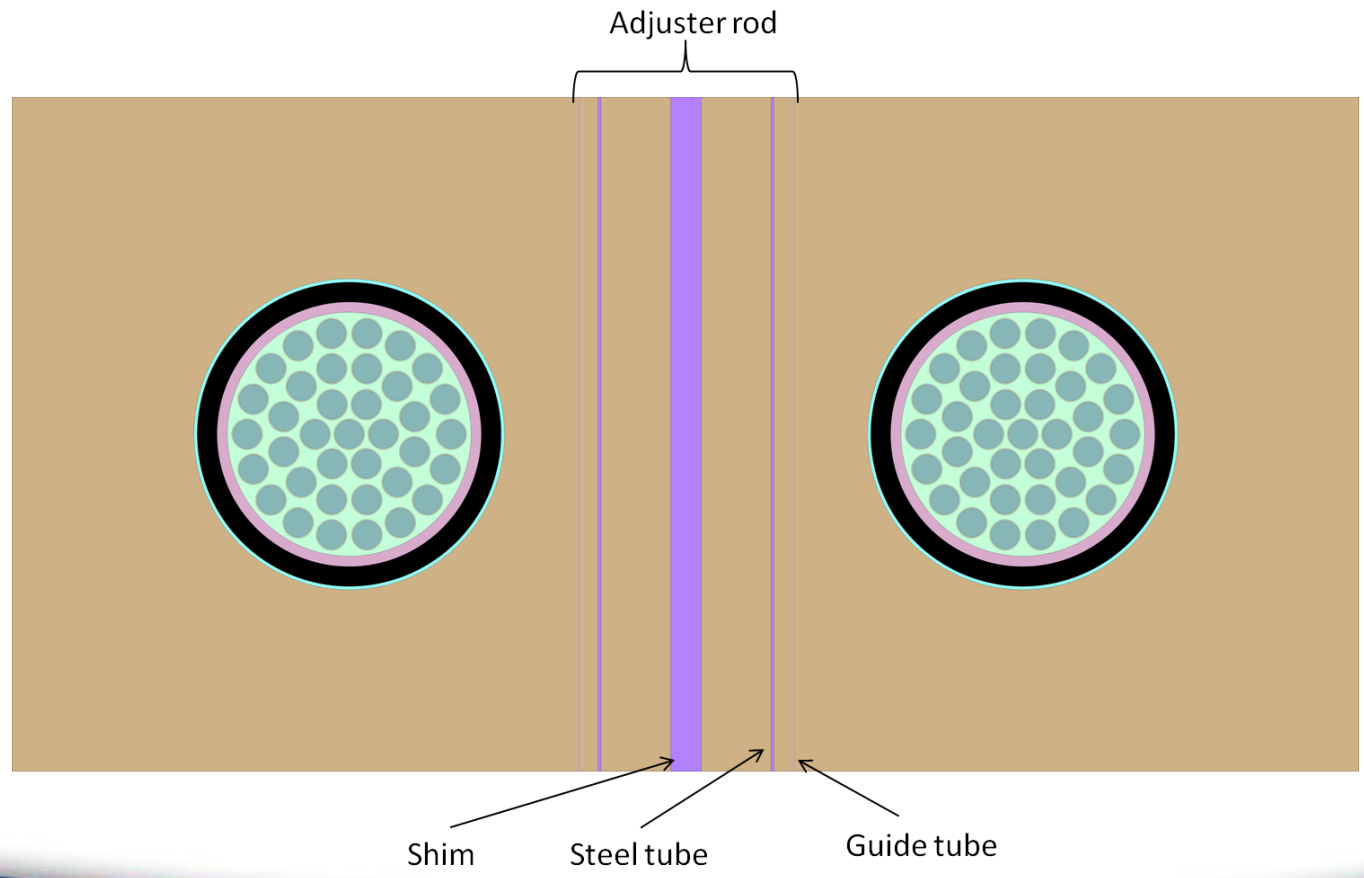
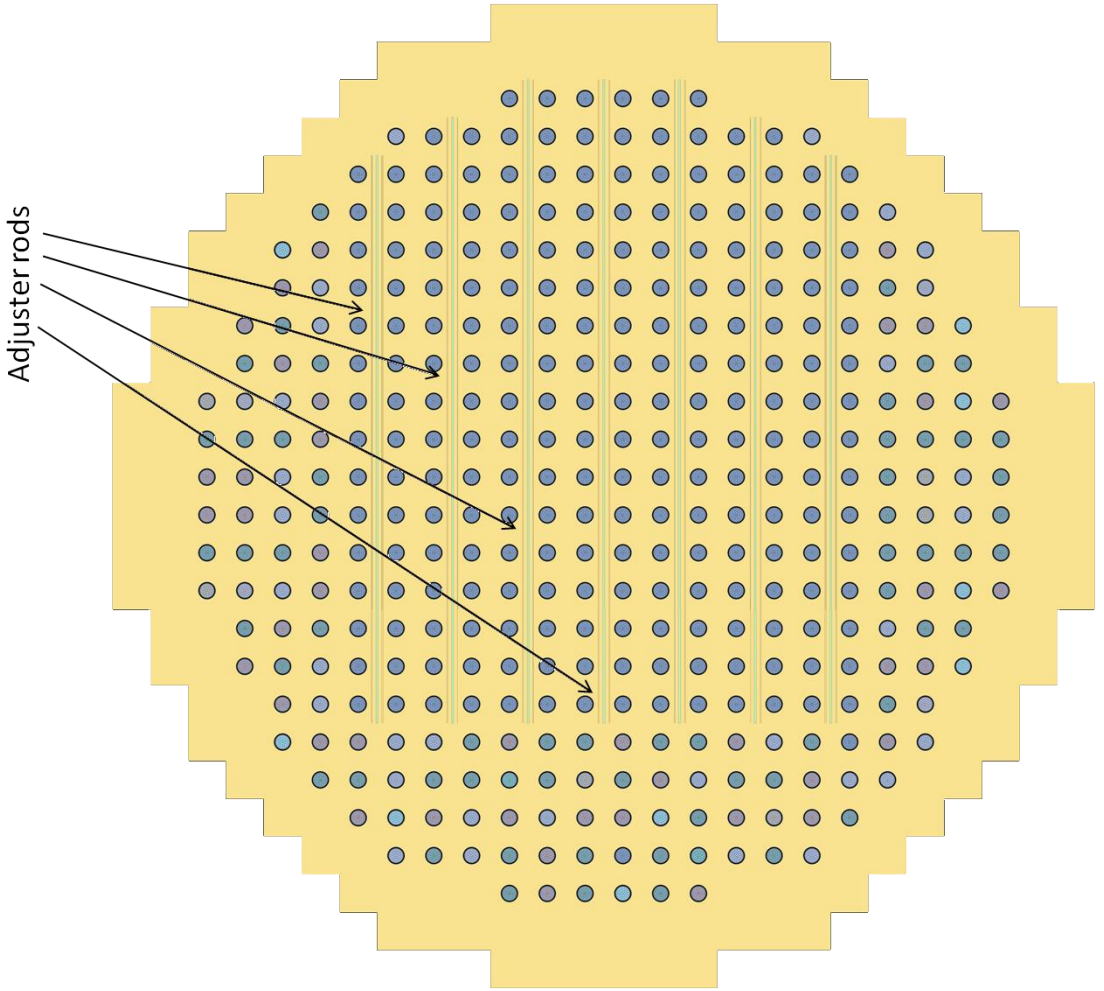


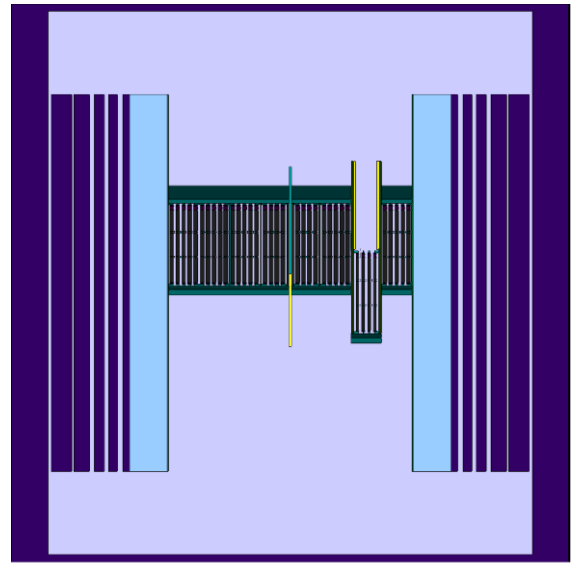
# XS Generation (cont'd)

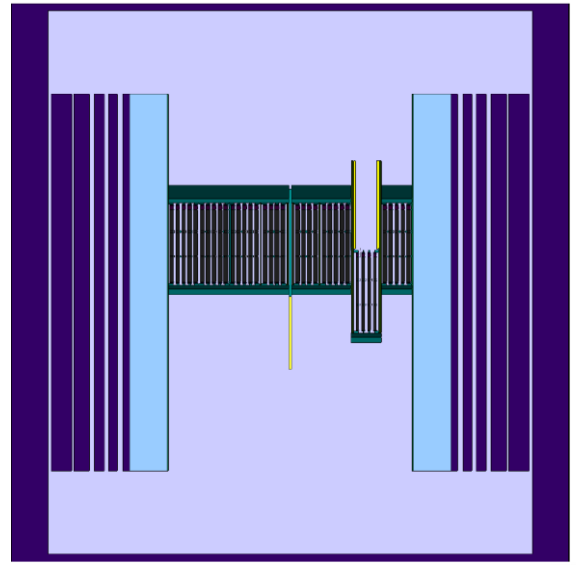
- Generated macroscopic XS used in full core diffusion codes NESTLE-C and DONJON.
- Developed package of Python scripts to extract and convert macroscopic cross sections into format needed for the two codes.
- Journal paper in progress.



# Transient Analysis

- Modelled the SPERT I  power excursion experiment and SPERT III transient rod ejection experiment.
- In collaboration with Serpent development team.



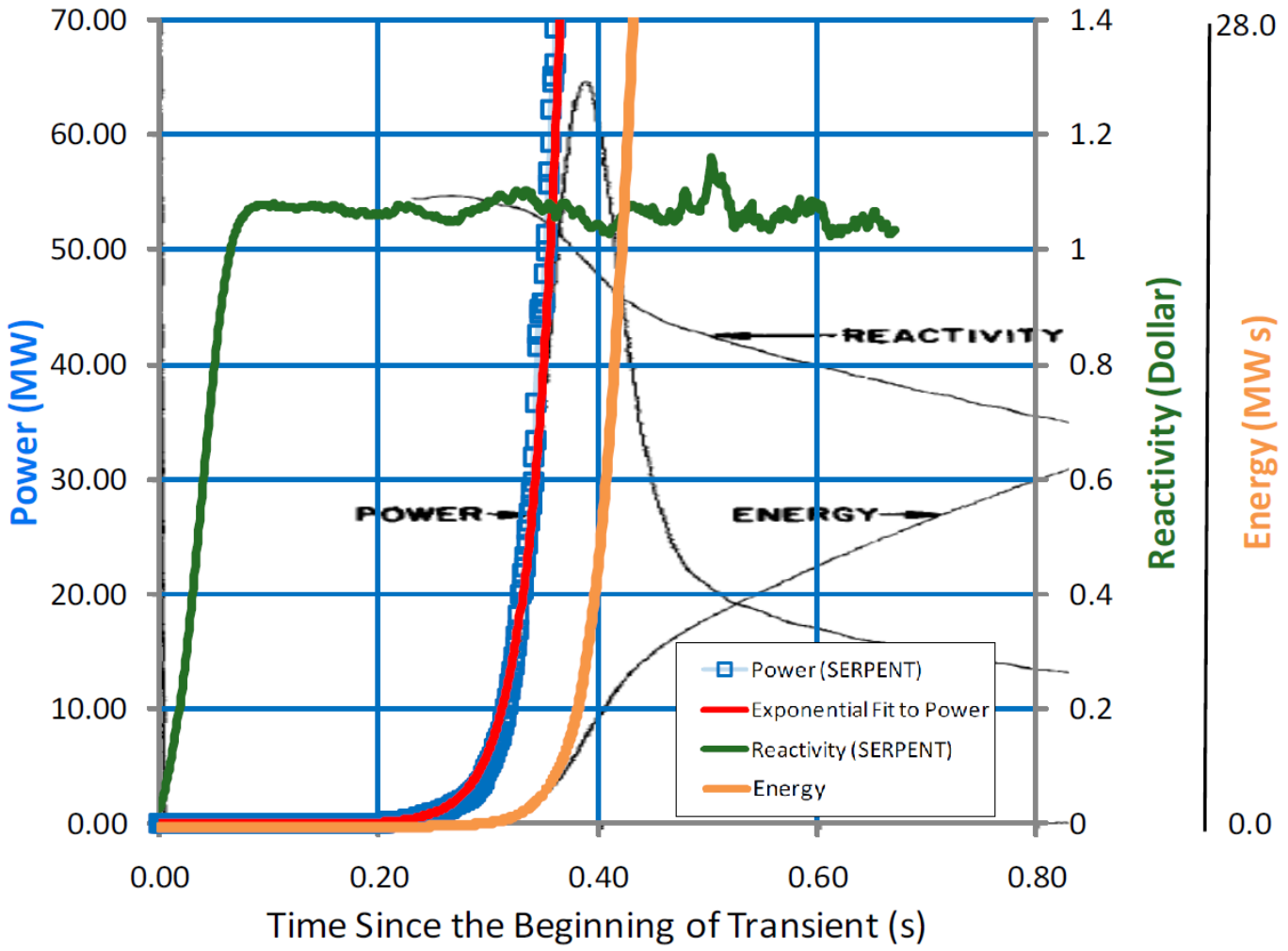


A. Levinsky, F. P. Adams, V. N. P. Anghel, V. Valtavirta, "Modeling of the SPERT Transients Using SERPENT2 with Time Dependent Capabilities," ANS Transactions Vol 116, pp 1045-1048, Presented at 2017 ANS Summer Meeting

A. Levinsky, F. P. Adams, V. N. P. Anghel, V. Valtavirta, "Modeling of the SPERT Transients using Serpent2 with Time  Dependent Capabilities," Paper in progress

# SPERT III (cont'd)

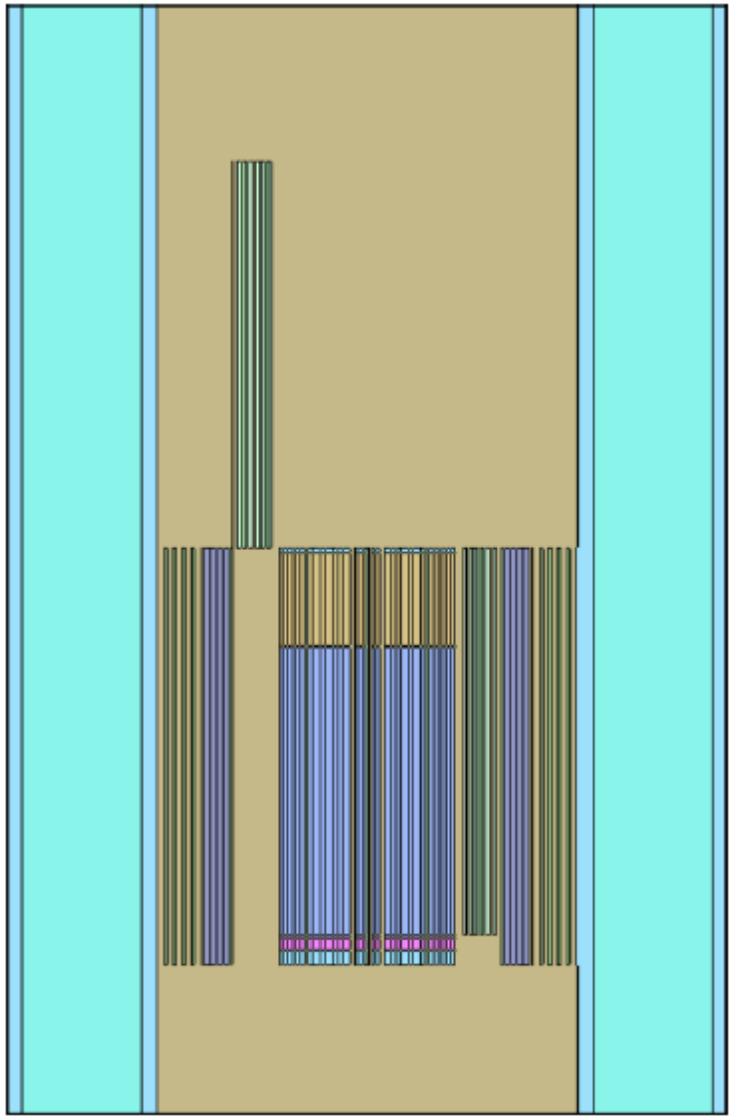
- Rod ejection for 0.11 s, followed by 0.7 s transient.
- Power increases first linearly and then exponentially.
- Good agreement with experimental data in the short initial time frame (<0.35 s).
- Since temperature feedback is not modelled, power increases infinitely after initial rise.
- In progress: model the temp feedback with FINIX.



# Nuclear Data Uncertainty

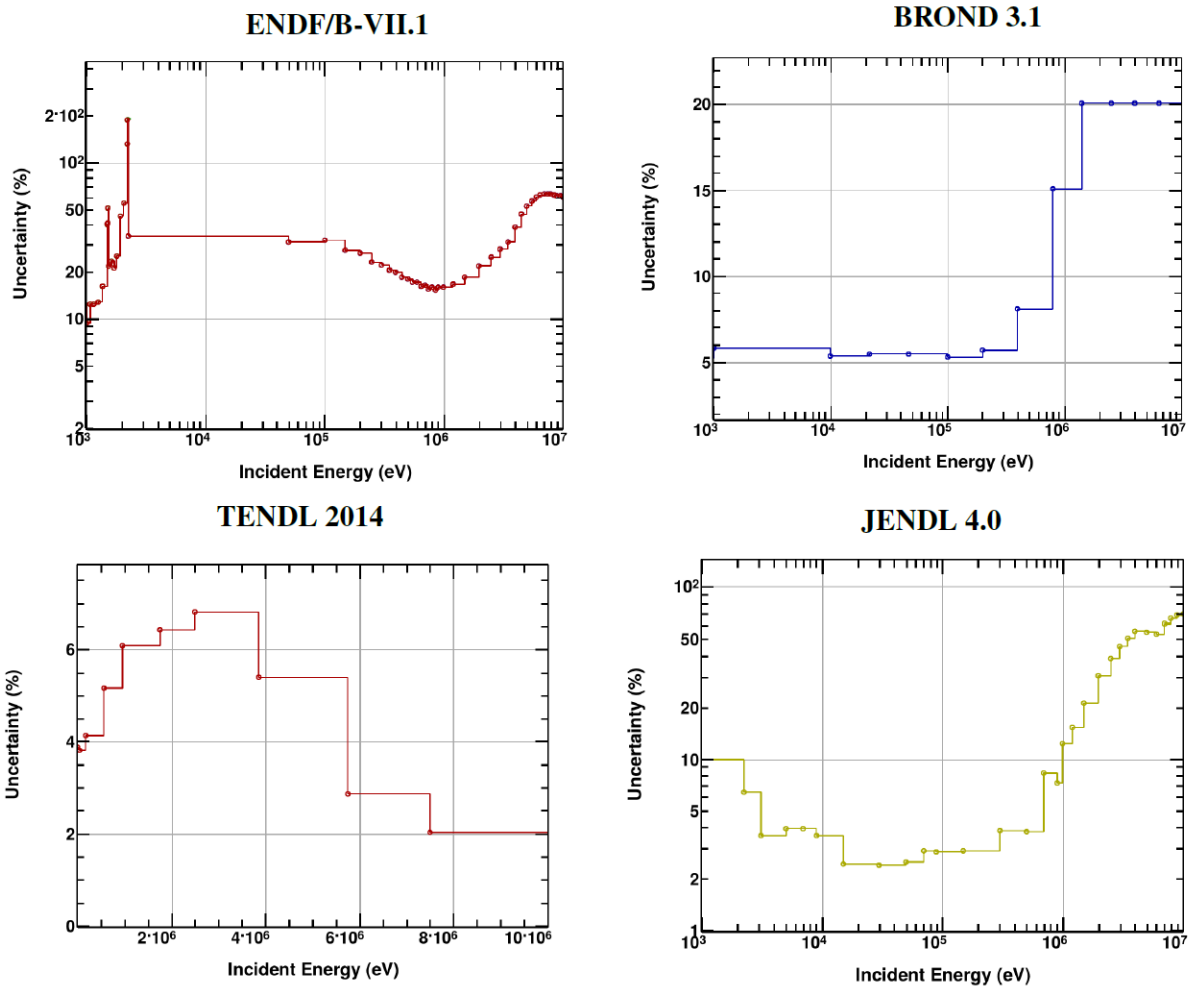
- Perform transient calculations with perturbed nuclear data.
- Lead Fast Reactor rod ejection.
- Find sensitivity of reactor power to cross sections of fuel ($^{16}O$, $^{235}U$, $^{238}U$), coolant ($^{206}Pb$, $^{208}Pb$), Zircaloy, steel, and poison ($B_4C$).

A. Trottier, F. P. Adams, A. Levinsky, and D. Roubtsov, "Nuclear Data Sensitivity for Reactor Physics Parameters in a Lead-Cooled Reactor", Submitted to Annals of Nuclear Energy



# Nuclear Data (cont'd)

- Found that the reactor is most sensitive to $^{235}U(n,\gamma)$ reaction.
- A review of available nuclear data for this reaction was performed.




A. Levinsky, D. Roubtsov, F. P. Adams, and A. Trottier, "Effect of Uncertainties in $^{235}U(n,\gamma)$ Nuclear Data on the Control Rod Ejection Transient in a Lead-Cooled Reactor", Submitted to PHYSOR 2018

# Challenges

- Unavailability of some data in Serpent 2 output, requiring duplicate parallel Serpent 1 calculations.
  - Delayed neutron precursor decay heat data.
  - Limits Serpent's applicability to XS generation.
  - This information is required for all full core analyses, not just CANDU diffusion.
- Current implementation of memory usage is a challenge, especially in transient calculations.
  - Peak in memory usage is observed at the beginning of calculation when the code loads initial data.
  - More efficient sharing of data among MPI process may improve code applicability to transient modeling.

# Thank you. Merci.

## Questions?

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