Oak Ridge National Laboratory

Nuclear Criticality Safety Program

SCALE Activities in FY24

W. Wieselquist and K. Bekar

2024 NCSP Annual Technical Program Review

December 3, 2024

U.S. DEPARTMENT OF ENERGY

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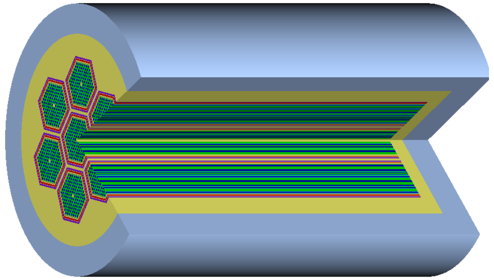
Overview

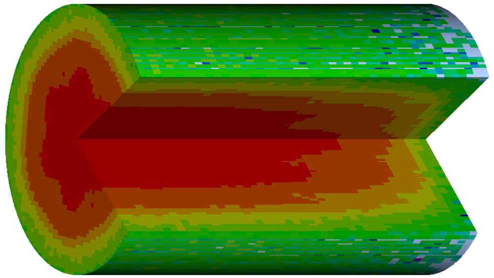
Primary NCSP-funded capabilities

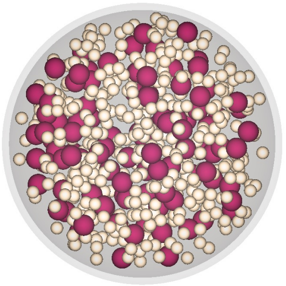
- **CSAS** for Criticality Safety Analysis
- **TSUNAMI** for Sensitivity and Uncertainty Analysis (S/UQ)
- **Fulcrum** Graphical User Interface (GUI) of SCALE
- **Sampler** for Integrated Optimization and UQ
- **VADER** for Bias Estimation
- **MAVRIC** for Shielding and Criticality Alarm Modeling

Production release: 6.3 series (6.3.3 patch update slated for FY25 Q2)

NCS-related features: ENDF/B-VIII.0 data; Shift Monte Carlo code integration in CSAS, TSUNAMI, and MAVRIC; 3D visualization in Fulcrum; new VADER; Sampler enhancements







SCALE Products / Owners

AMPX	Jordan McDonnell
CSAS	Kursat Bekar
DATA	Jesse Brown
FULCRUM	Rob Lefebvre
MAVRIC	Cihangir Celik
OMNIBUS	Seth Johnson
ORIGAMI	Steve Skutnik
ORIGEN	BK Jeon
POLARIS	Matt Jessee
SAMPLER	Ugur Mertyurek
STDCOMP	Rob Lefebvre*
TRITON	Rike Bostelmann
TSUNAMI	Jordan McDonnell*
VADER	**Lisa Fassino**
XSPROC	Kang Seog Kim

*Interim owner

New product owner for FY24

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SCALE 6.3 Online Manual

scale-manual.ornl.gov

SCALE

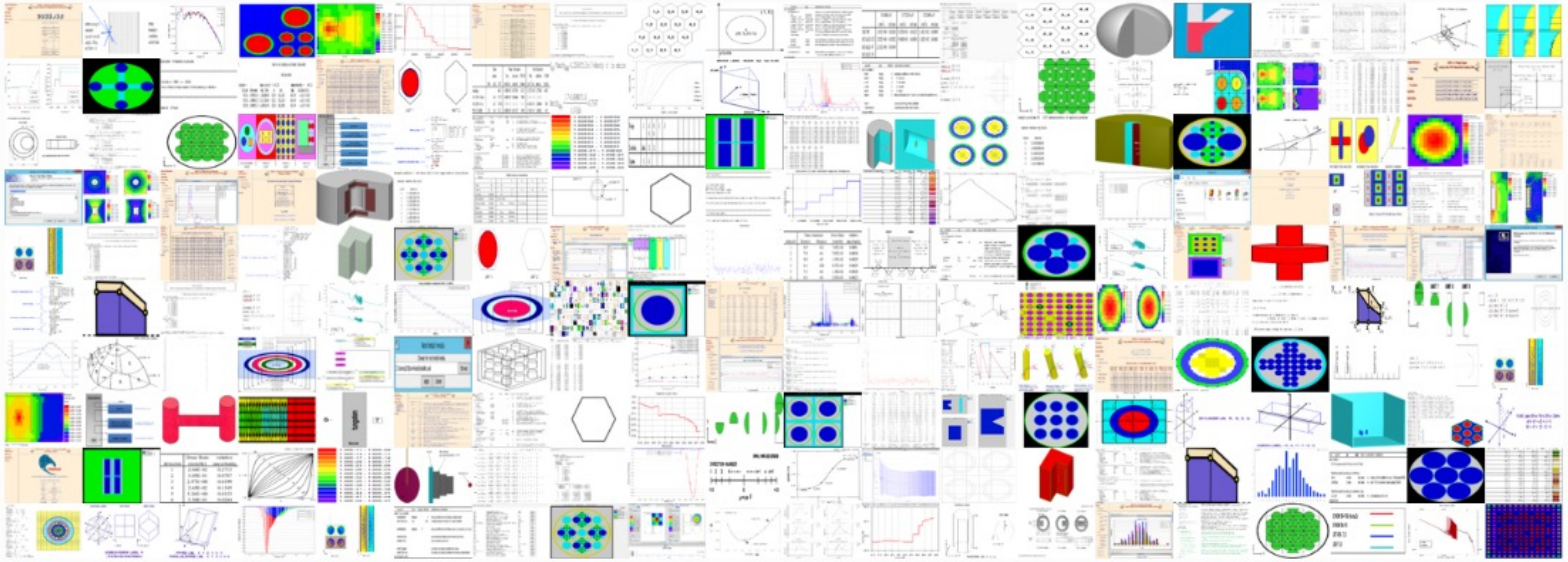
Search docs

SCALE

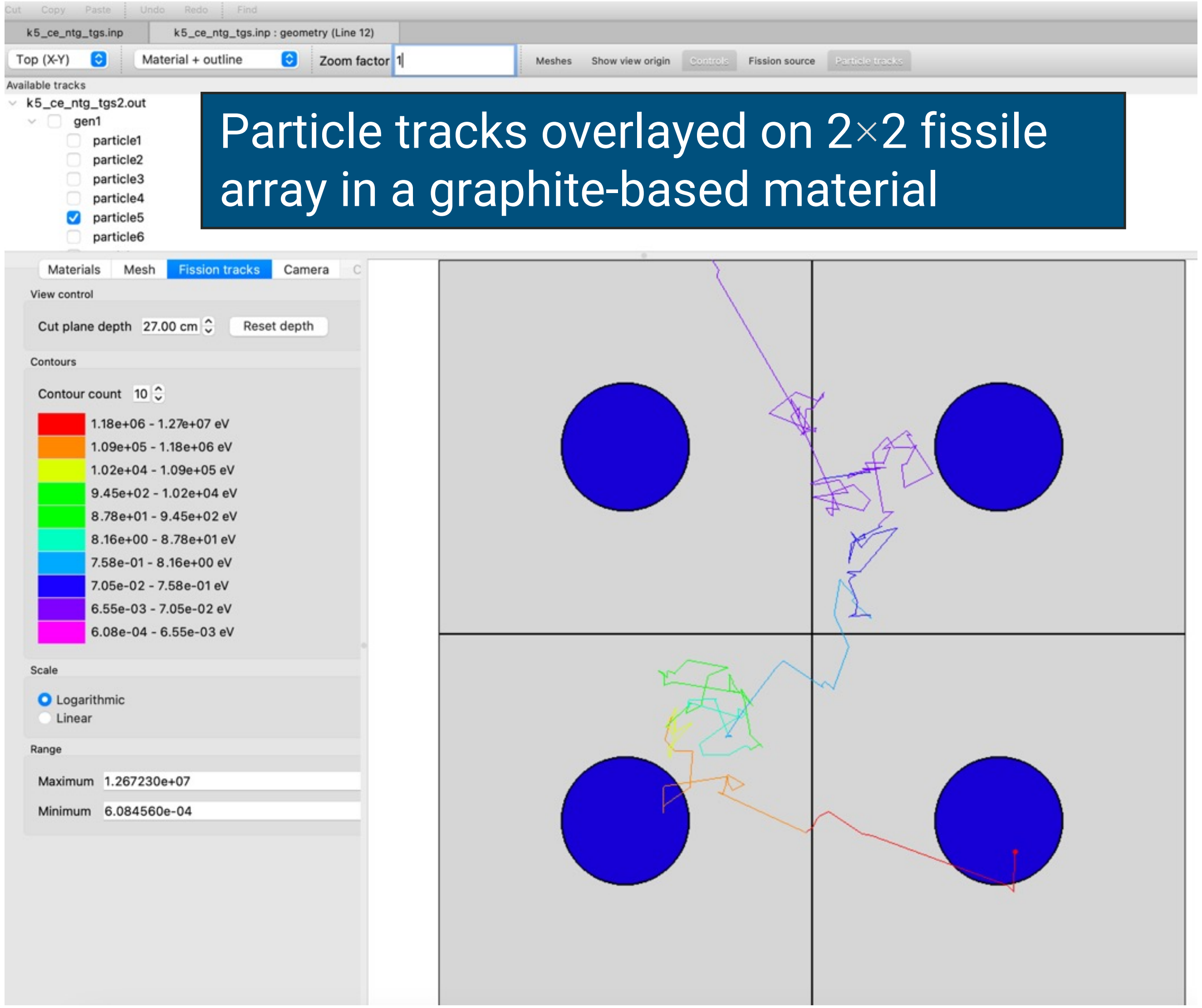
SCALE 6.3.2 User Manual

SCALE is a comprehensive modeling and simulation suite for nuclear safety analysis and design developed and maintained by Oak Ridge National Laboratory under contract with the U.S. Nuclear Regulatory Commission, U.S. Department of Energy, and the National Nuclear Security Administration to perform reactor physics, criticality safety, radiation shielding, and spent fuel characterization for nuclear facilities and transportation/storage package designs.

Visit the SCALE website for additional information.



Particle track visualization in SCALE 6.3.3



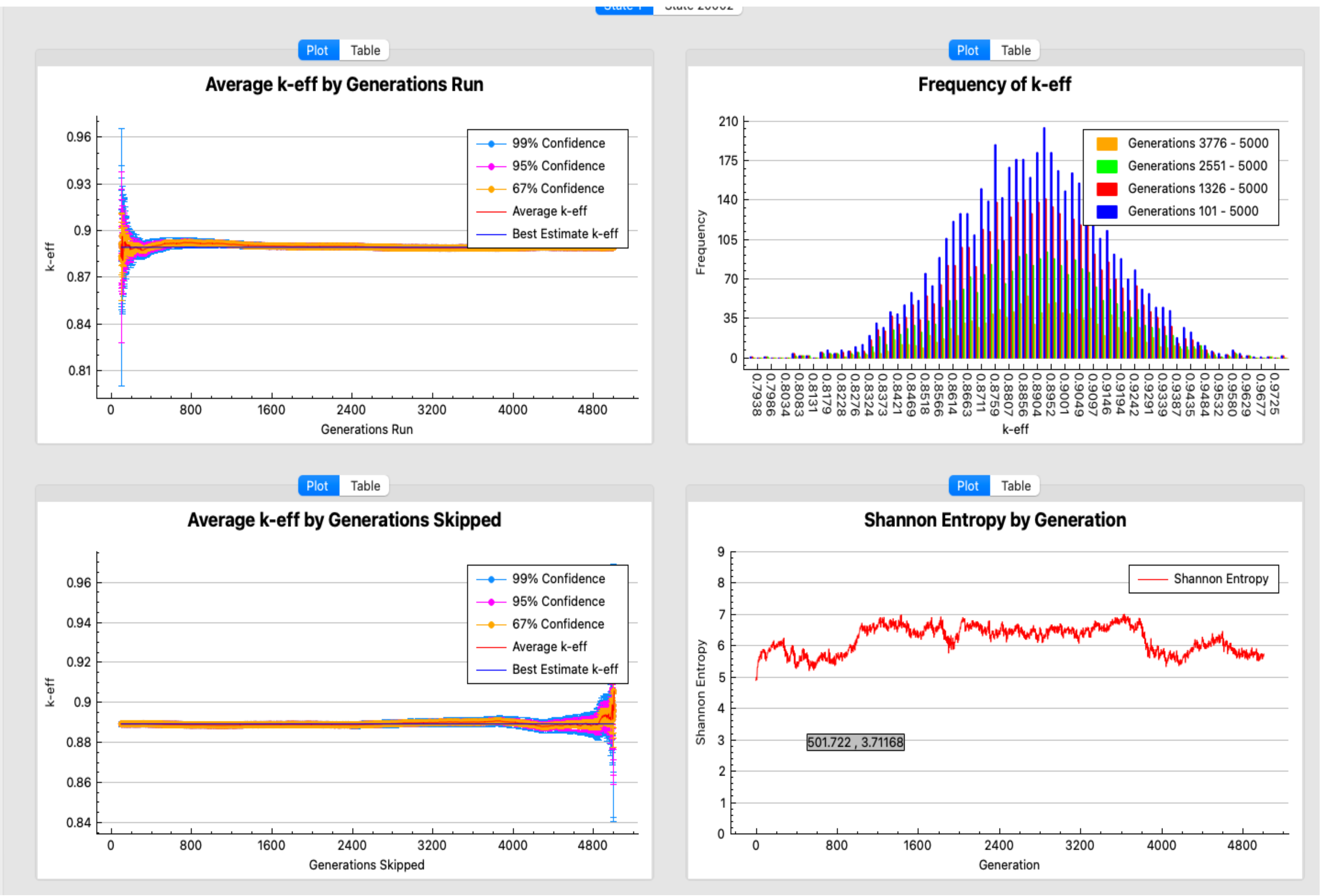
S. Skutnik, R. Lefebvre, K. Bekar, C. Celik

- Available in **CSAS*, TSUNAMI***
- Display tracks with average track energy per segment using a color-coded legend
- New keywords in parameter blocks to allow for filtering particle track output from specific particles and generations

*** Only available with KENO-based sequences in 6.3.3**

Available for Shift-based sequences in SCALE 7.0

Convergence plot viewer in SCALE 6.3.3



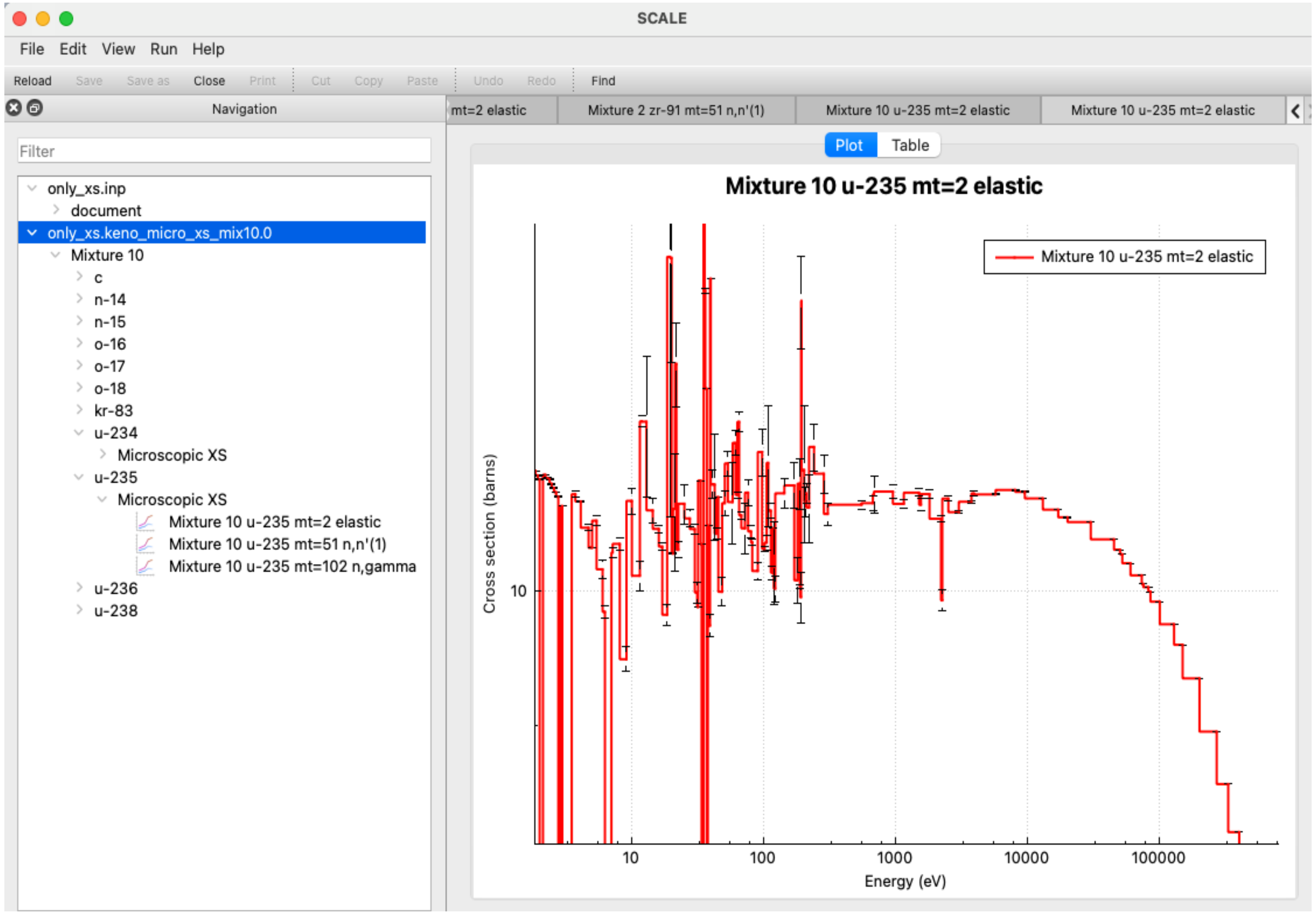
S. Skutnik, K. Bekar

Improved access to convergence plots in CSAS:

- ➢ Allow the generation of convergence plots as a default option
- ➢ Add convergence plot viewer to Fulcrum
- ➢ Dynamic tile-plot view

Additional frequency distribution plots with Shift-based sequences

Reaction tally visualization in SCALE 6.3.3



S. Skutnik, K. Bekar

Visualization capability for

- reaction cross sections
- reaction rates
- mixture-averaged fluxes

Single or multiple plot sets

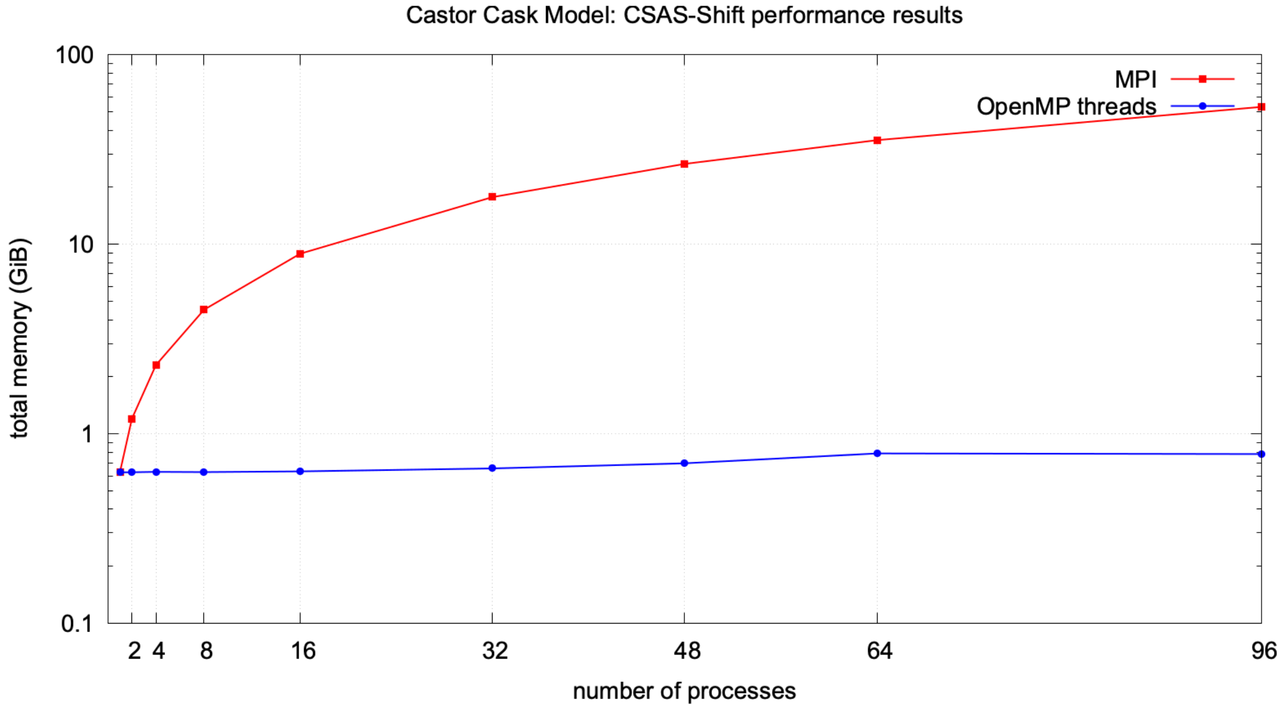
Available with Shift sequences in SCALE 7.0

Upcoming NCS Capabilities in SCALE 7.0

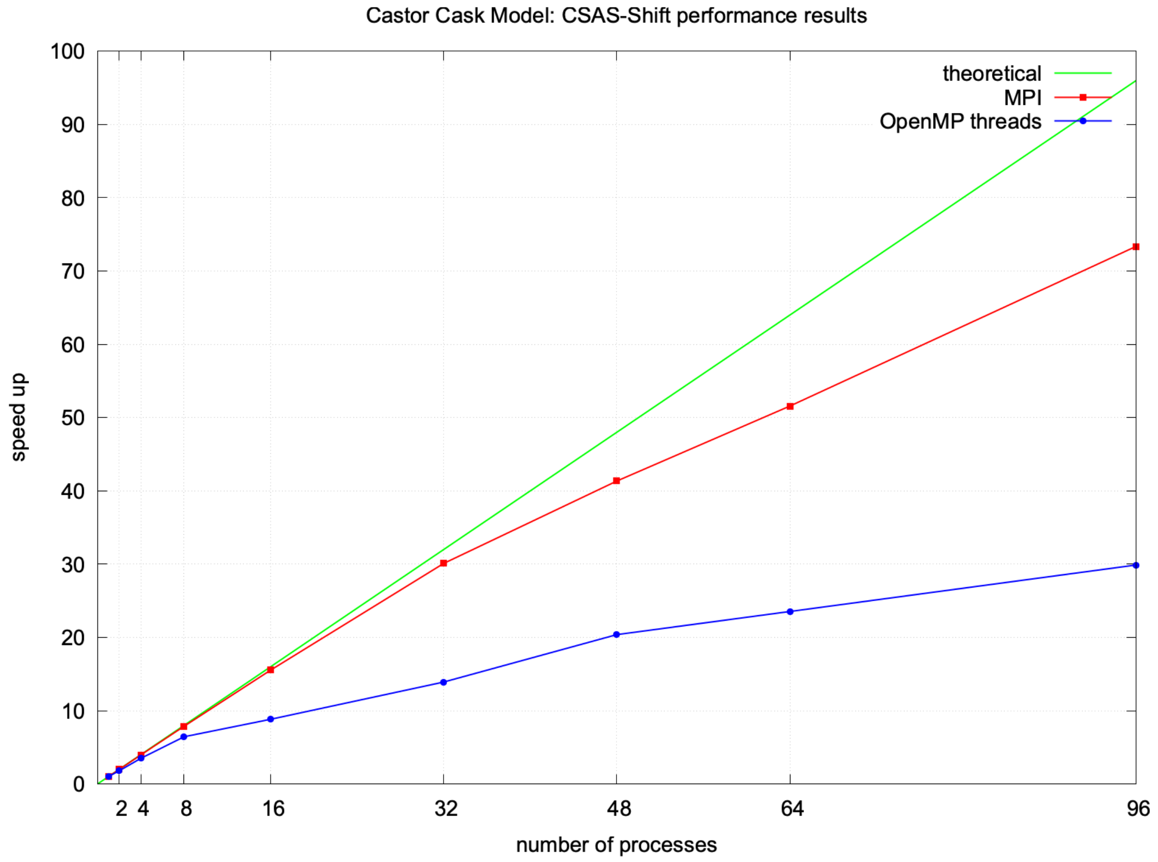
T. Evans, C.Celik, K. Bekar

CPU threading in Shift Sequences

- Available in CSAS, MAVRIC, and TSUNAMI with Shift transport
- Better resource management for multi-core laptop or desktop computer as well as HPC clusters
- Better memory management when using with MPI
- OpenMP, dynamic/static scheduling



Memory performance; Shift threading vs Shift MPI



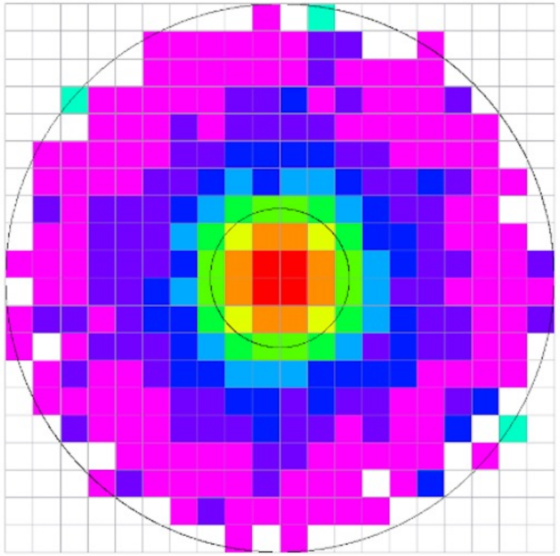
Parallel speedup; Shift threading vs Shift MPI

Sensitivity, uncertainty, and validation capabilities (1/2)

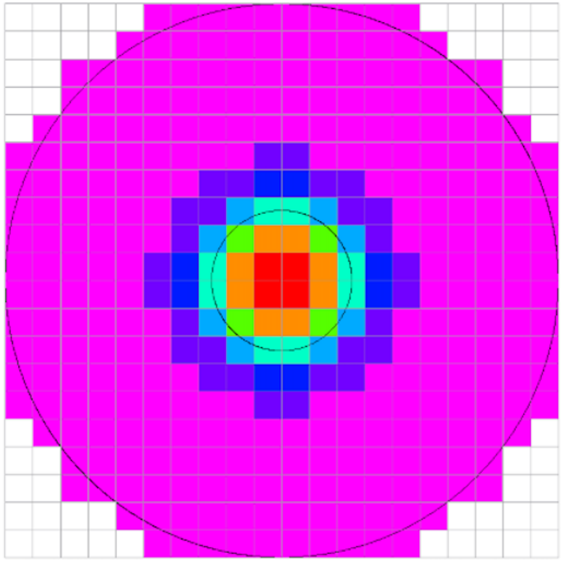
TSUNAMI CLUTCH with hybrid F*(r) Importance Calculations

T. Greene, W. Marshall, K. Bekar

- Continue testing and analysis to verify the methodology



Monte Carlo-estimated F*(r) importance



Hybrid F*(r) importance, with complete domain coverage

TSUNAMI primer updates

V. Karriem, A. Shaw, J. McDonnell

- TSUNAMI Primer with SCALE 6.3.2 release was resumed—to be finalized in FY 25.

TSUNAMI-IP VADER input generation

J. McDonnell

- Generate modern VADER inputs (for bias/bias uncertainty estimation) from TSUNAMI-IP

VADER Updates

L. Fassino, A. Shaw

- Manual update including complete description of available methods and tests
- Expanded unit testing and revisions to fix minor issues

Sensitivity, uncertainty, and validation capabilities (2/2)

Flexible sensitivity tally specification

K. Bekar, B. Langley

```
read tallies
   read sensitivity
      method=CLUTCH
      read fstar
         file=external.3dmap
      end fstar
   end sensitivity

   read sensitivity DP
      method=DP
      …
   end sensitivity
end tallies
```

Reaction-based CE data perturbation capability

K. Bekar, C. Celik

- Calculations with user-defined data perturbations to understand sensitivity to ANY data (e.g.TSL data angular distributions)
- Continued verification of approach

Automated direct perturbation (DP) capability

K. Bekar, J. McDonnell, T. Greene

- DP calculations for the nuclide-reaction pairs selected automatically from a sensitivity data file (SDF)

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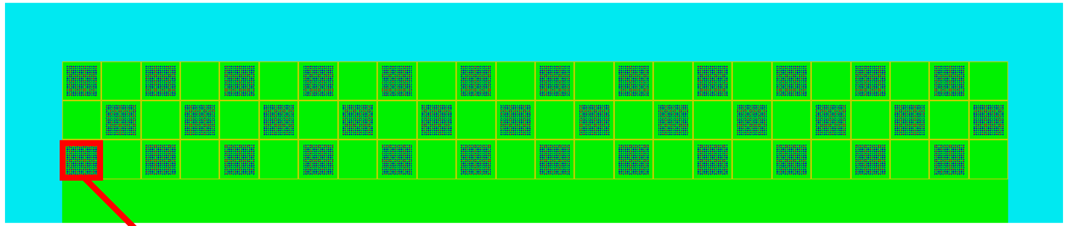
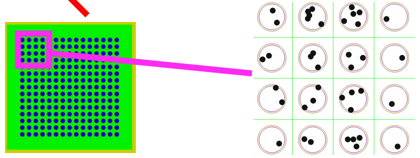
Summary

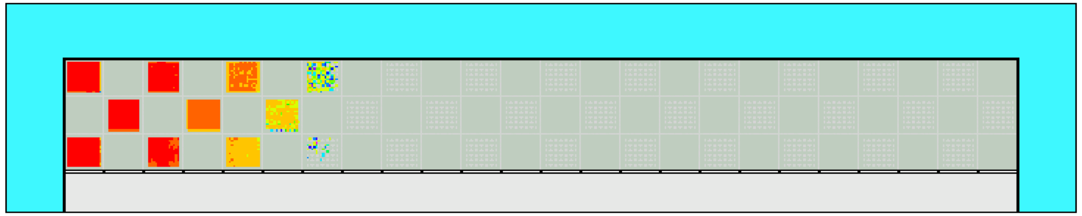
- **FY24 shifted some of our focus to the user experience**
  - SCALE 6.2 (2016) brought a new strategy via Fulcrum for helping users set up their input
  - SCALE 6.3 (2023) continued that strategy
  - SCALE 7.0 (2026+) will focus on personal compute performance (e.g. threading) and improved experience with outputs, as well as new features
  - Any pure performance or post-processing capabilities will also go into 6.3.x maintenance releases
- **Government Use Agreement (GUA)**
  - The GUA is a 3-way agreement between ORNL Technology Transfer office, SCALE team, and destination site POC (**Inquire at scalehelp@ornl.gov**)
  - Enables site to use their on-site export control to vet employees and decide whether to give access to SCALE
  - We have GUAs with
    - **INL** for NEAMS collaborations with Shift
    - **BNL** for nuclear data testing
    - **SNL** for MELCOR accident analysis
    - **ANL** for DNCSH model development
    - **Y-12** for general NCS analyses
    - **NRC** for confirmatory analysis of license applications



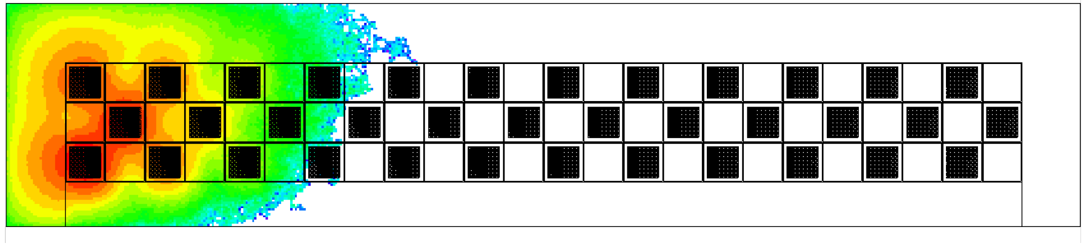
Model geometry: OECD source convergence benchmark 1, checkerboard storage of assemblies



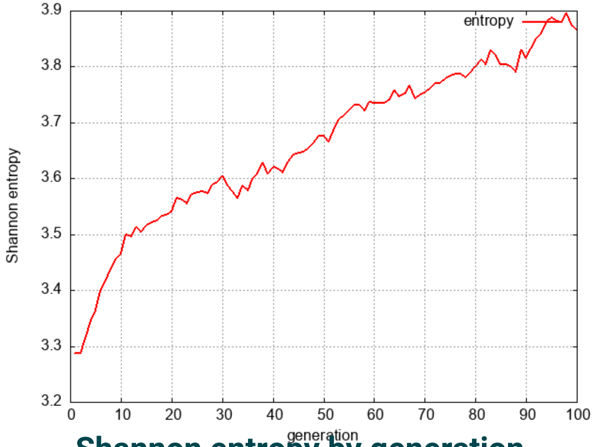
Initial fission source points



Fission source distribution



Flux distribution



Shannon entropy by generation

Thanks to the NCSP for their support!

Questions?

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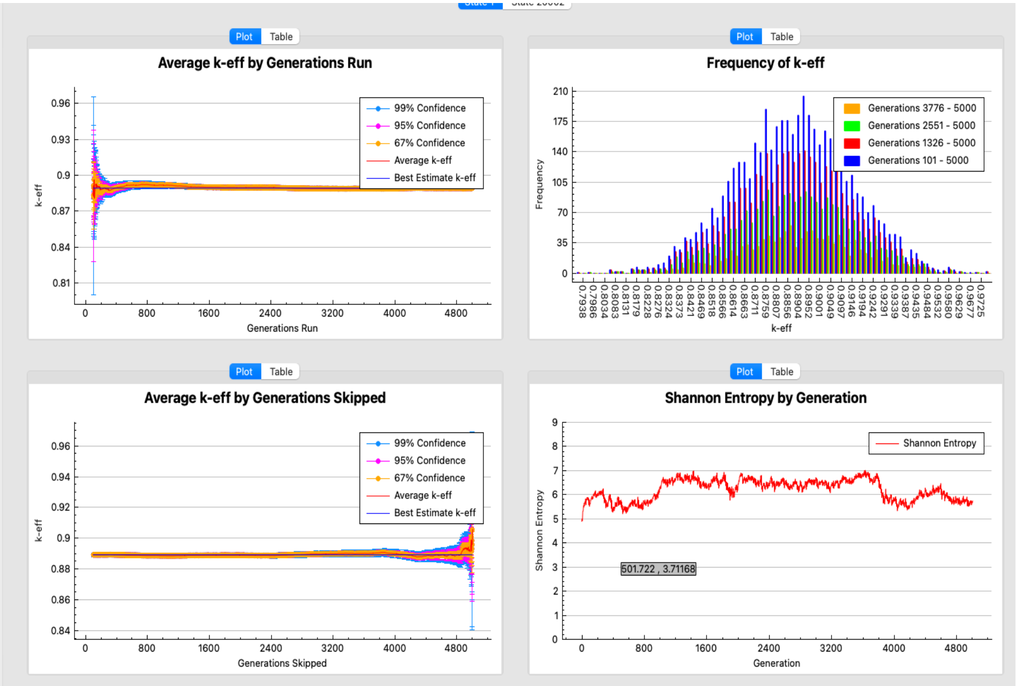

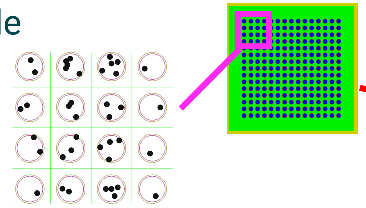

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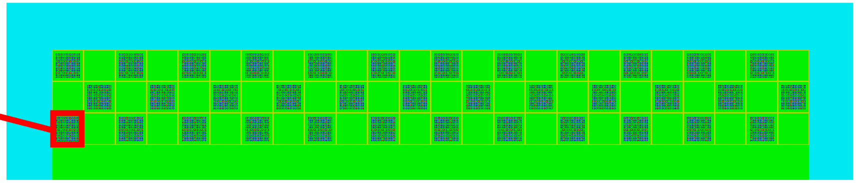
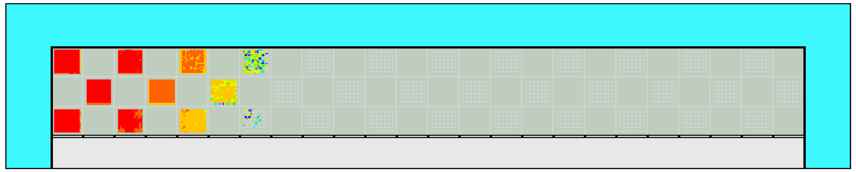


Model geometry



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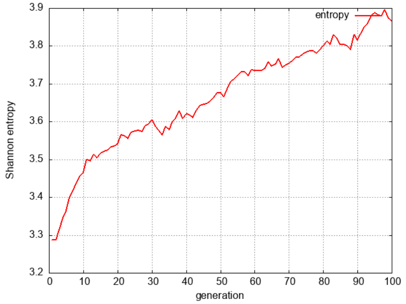
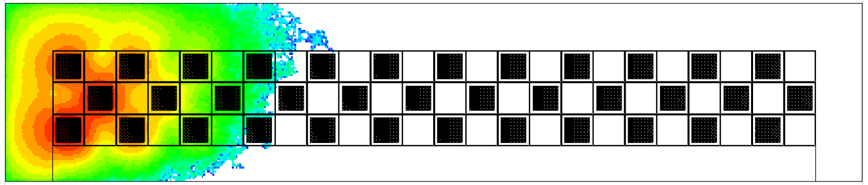


Shannon entropy by generation



Flux distribution

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