

# SCALE Activities in FY23

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# ORNL AM2 SCALE: Overview

- NCSP-facing codes
  - criticality safety (**CSAS**)
  - shielding (**MAVRIC**)
  - sensitivity/uncertainty (**TSUNAMI** and **Sampler**)
  - bias analysis (**VADER**)
- Maintain new/current production version (v6.3 series)
  - coordination – management, SQA
  - support – interact with users, documentation, [scalehelp@ornl.gov](mailto:scalehelp@ornl.gov)
  - maintenance – fix bugs
- New capabilities/features (v7.0 series)

## 6.3 Product Owners

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

\*Interim owner

**New product owner for FY23/FY24**

# SCALE 6.3 In a Nutshell

- Significant strides towards modernizing and centralizing Monte Carlo capabilities with Shift integration
- Improvements to uncertainty quantification and sensitivity analysis
- Performance improvements to Polaris for LWR lattice calculations
- **New capabilities targeting advanced reactors**

1. **MAVRIC** – radiation shielding
2. **CSAS** – criticality safety
3. **TRITON** – general reactor fuel depletion
4. **ORIGEN** – general depletion/decay/activation
5. **ORIGAMI** – LWR spent fuel isotopics generation
6. **Polaris** – LWR reactor fuel depletion
7. **TSUNAMI** – sensitivity, similarity analysis, and data assimilation
8. **Sampler** – general uncertainty propagation
9. **AMPX** – nuclear data processing (transforms ENDF/B to SCALE format)
10. **SCALE nuclear data libraries** – curated, verified, and validated
11. **ORIGEN reactor libraries** – data to generate system-specific spent fuel isotopics
12. **VADER** – trending-based validation
13. **OMNIBUS** – Leadership class Monte Carlo Transport (experimental)

# Updates on **scale.ornl.gov**

- 6.3 validation reports slated for Q2/Q3 FY24
- 6.3 online manual  
<https://scale-manual.ornl.gov>
- 6.3.2 maintenance patch will be available in Q2/Q3 FY24
- Full reference list on  
<https://ornl.gov/scale/references>
- New version info site  
<https://scale.publicsites.ornl.gov/>

## 2023 Publications:

Kang Seog Kim, Dorothea Wiarda, Chris Chapman, Jordan McDonnell, and William A. Wieselquist, "**Improvement of the SCALE-6.3/XSProc Pointwise Slowing-Down Capability with the Bound Thermal Scattering Data Including High Forward Peaks**," *Transactions of the American Nuclear Society*, **129**, 817–820 (November 2023).

Donny Hartanto, Friederike Bostelmann, Benjamin R. Betzler, Kursat B. Bekar, Shane W. Hart, and William A. Wieselquist, "**SCALE depletion capabilities for molten salt reactors and other liquid-fueled systems**," *Annals of Nuclear Energy*, **196**, 110236, 2024 (available online November 2023). DOI:10.1016/j.anucene.2023.110236

Tara Pandya, Tarek Ghaddar, Friederike Bostelmann, Matthew Jessee, and Philip Brit, "[Modeling Enhancements and Demonstration of Shift Capabilities for PBR and MSR](#)," ORNL/TM-2023/3072, UT-Battelle, LLC, Oak Ridge National Laboratory (October 2023).

Germina Ilas and Rabab Elzohery, "[Validating Actinides and Fission Products for Burnup Credit Criticality Safety Analyses – Nuclide Compositions Prediction with Extended Validation Basis](#)," NUREG/CR-7303(ORNL/SPR-2023/2885), U.S. Nuclear Regulatory Commission, Oak Ridge National Laboratory (September 2023).

D. Hartanto, G. Redulescu, R. Elzohery, F. Bostelmann, W. Wieselquist, K.C. Wagner, and D. Luxat, "**SCALE & MELCOR non-LWR Fuel Cycle Demonstration Project – Sodium-Cooled Fast Reactor**," NRC Public Workshop, presented virtually from Oak Ridge, Tennessee September 20, 2023.

Ugur Mertuyurek and William A. Wieselquist, "[Assessment of Core Physics Characteristics of Extended Enrichment and Higher Burnup LWR Fuels using the Polaris/PARCS Two-Step Approach Vol. 2: BWR Fuel](#)," ORNL/TM-2022/2444, UT-Battelle, LLC, Oak Ridge National Laboratory (August 2023). [[supporting files](#)]

Steve E. Skutnik, Ugur Mertuyurek, Muhammad Rizki Oktavian, and William A. Wieselquist, "[Transition Core Modeling for Extended Enrichment & Accident-Tolerant Fuels Using Polaris/PARCS](#)," ORNL/TM-2023/2834, UT-Battelle, LLC, Oak Ridge National Laboratory (July 2023). [[supporting files](#)]

Alex Shaw, Friederike Bostelmann, Donny Hartanto, Erik Walker, and William A. Wieselquist, "[SCALE Modeling of the Sodium Cooled Fast-Spectrum Advanced Burner Test Reactor](#)," ORNL/TM-2022/2758, UT-Battelle, LLC, Oak Ridge National Laboratory (July 2023).

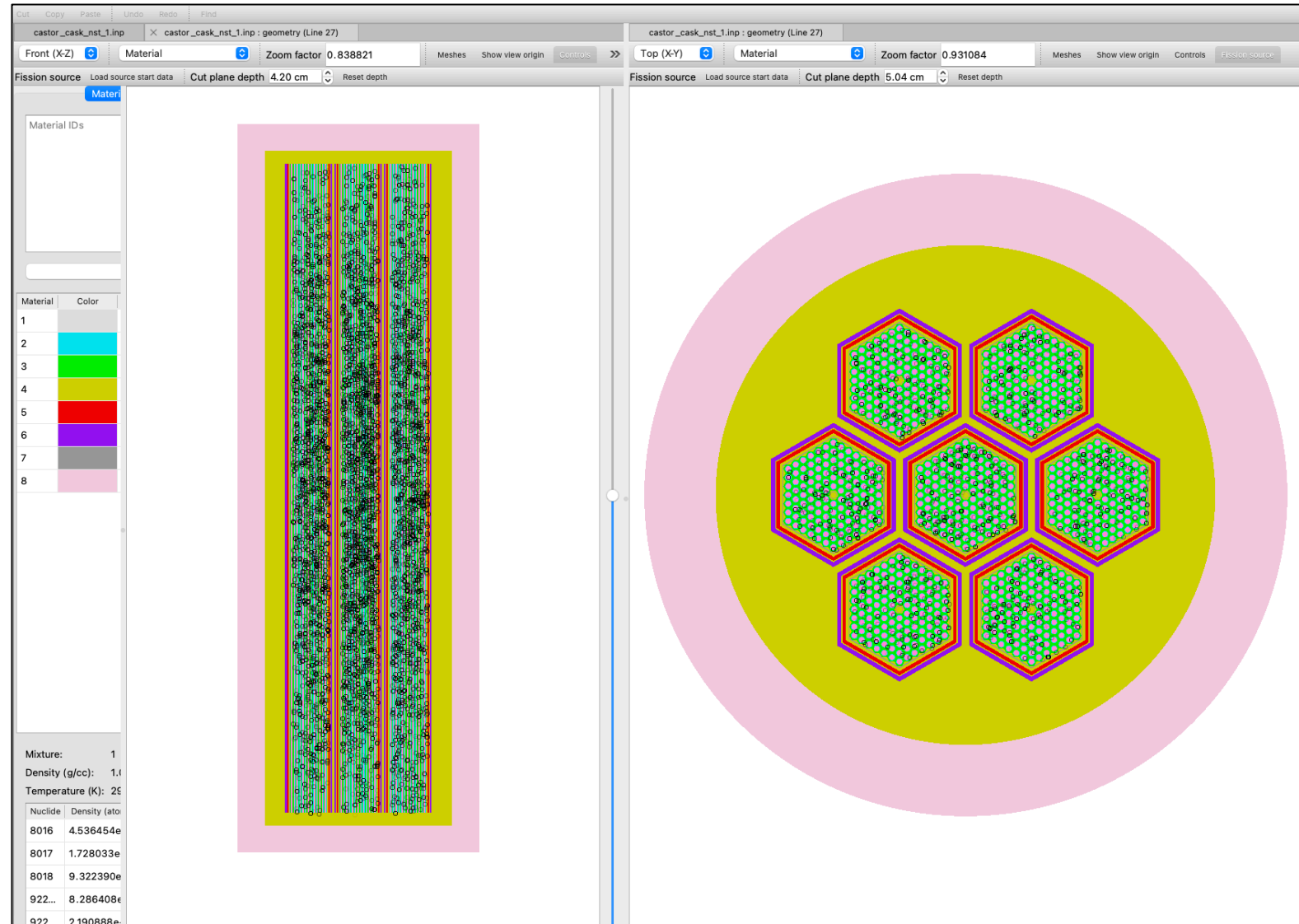
# Code updates

- **Fulcrum GUI**

- Fission point visualization with 2-D version  
**(SCALE 6.3.2)**

- **Criticality Accident Alarm System (CAAS) modeling with Shift sequences**

- CSAS-Shift saves mesh-based fission source in HDF5 **(7.0 beta)**
- MAVRIC-Shift reads mesh-based fission source from HDF5 for detector modeling with automated CADIS variance reduction **(7.0 beta)**



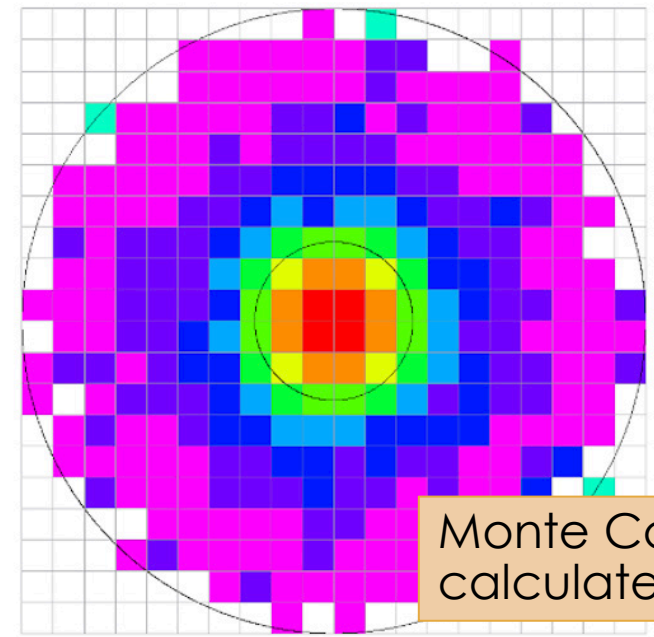
2-D views of fission neutrons starting points overlaid on Castor Cask model

# Improvements to S/U capabilities

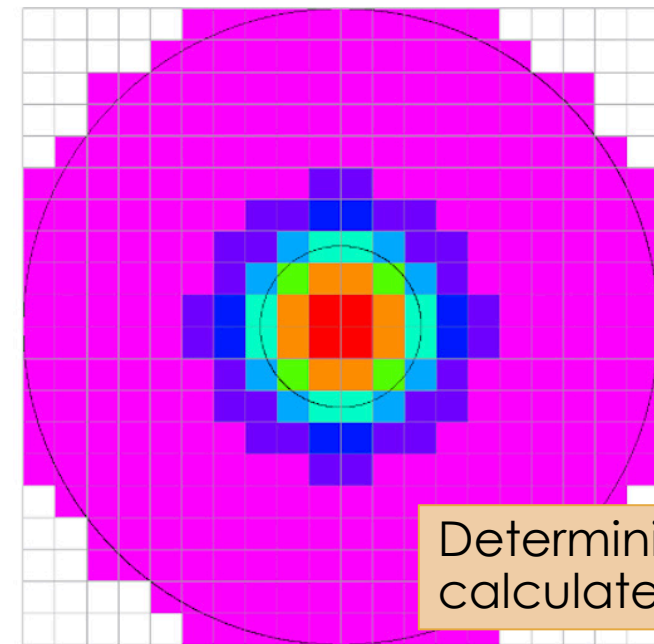
- External  $F^*(r)$  read capability for CLUTCH method enables straightforward  $F^*$  sensitivity studies and uncertainty reduction **(7.0 beta)**
- Ability to calculate  $F^*(r)$  from deterministic adjoint fluxes and birth spectrum (Denovo and KENO, respectively) on the same mesh **(7.0 beta)**

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

New input data block named *sensitivity* in tallies data block



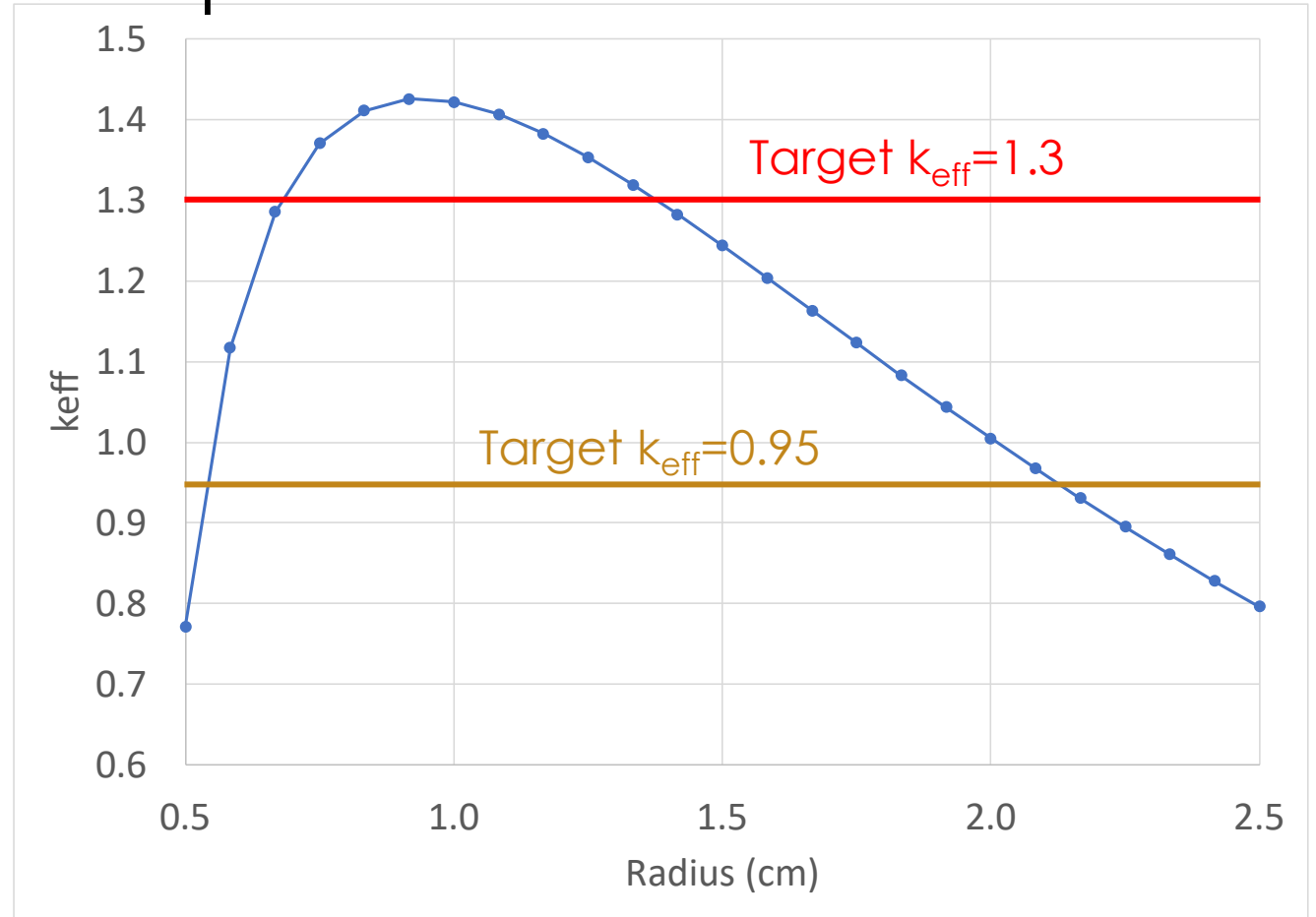
Monte Carlo  
calculated  $F^*$



Deterministic  
calculated  $F^*$

# Improvements to UQ with Sampler

- Allow specification of user-defined distributions for input quantities, such as density, temperature, geometry
- Improvements to parametric capability to find target values (see figure on right)
- Ability to calculate correlation coefficient of any two output quantities—basically  $c_k$  equivalent for anything

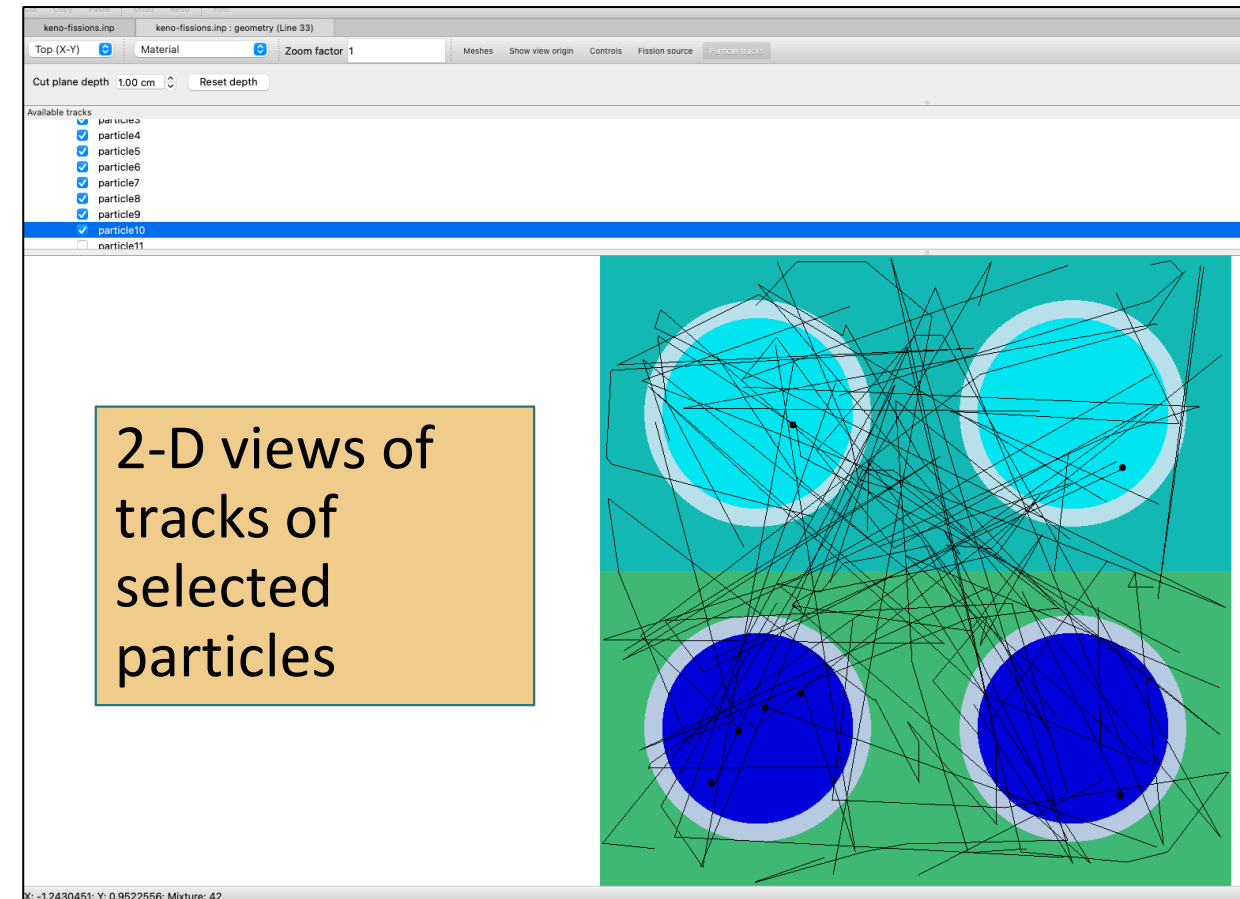


response	target_response	radius(interp)	response(interp)
Case c1:response lambda	0.95	5.39323e-01	9.50124e-01
		2.12211e+00	9.50000e-01
Case c1:response lambda	1.3	6.77949e-01	1.30000e+00
		1.37785e+00	1.30000e+00

# In-progress efforts for 7.0 betas

- Capability to apply user defined perturbation to the CE cross sections within the defined energy range
- MG version of CLUTCH method
- Enhancements in  $c_k$  output edits; uncertainty and  $c_k$  per nuclide and uncertainty plots vs. energy
- New k-eff estimators in CSAS-Shift and TSUNAMI-Shift sequences
- Particle track visualization

```
read perturbation
  nuc=SCALE_ID MT=reaction_mt
  mul=multiplier
  emin=min_energy emax=max_energy
end perturbation
```



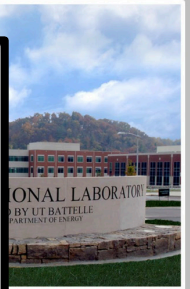


# Summary

- SCALE 6.3 available from RSICC
  - New features
  - New ENDF/B-VIII.0 data including covariances
  - Updated parallel infrastructure enables parallel capability on Windows
  - Production release with maintenance until 2026 at minimum addressing
    - Code or data bugs
    - Performance
    - Ease of installation
- New Government Use Agreement (GUA) for SCALE 7.0 beta access
  - Site licenses available for non-commercial testing and feedback, handled through ORNL technology transfer
  - Inquire by sending an email about the “GUA” to [scalehelp@ornl.gov](mailto:scalehelp@ornl.gov)

ORNL/TM-2020/1601  
**KENO-VI Primer: Performing Calculations Using SCALE's Criticality Safety Analysis Sequence (CSAS6) with Fulcrum**

ORNL/TM-2020/1664  
**KENO V.a Primer: Performing Calculations using SCALE's Criticality Safety Analysis Sequence (CSAS5) with Fulcrum**



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December 2020

These primers, written for SCALE 6.2 are still a great way to learn SCALE/CSAS in 6.3.

Approved for public release.  
Distribution is unlimited.

Kursat Bekar  
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December 2020

<https://www.osti.gov/biblio/1760121>

<https://code.ornl.gov/scale/primers/kenovi>

<https://www.osti.gov/biblio/1760129>

<https://code.ornl.gov/scale/primers/kenova>