OAK RIDGE National Laboratory

SCALE and NCSP

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Oak Ridge National Laboratory

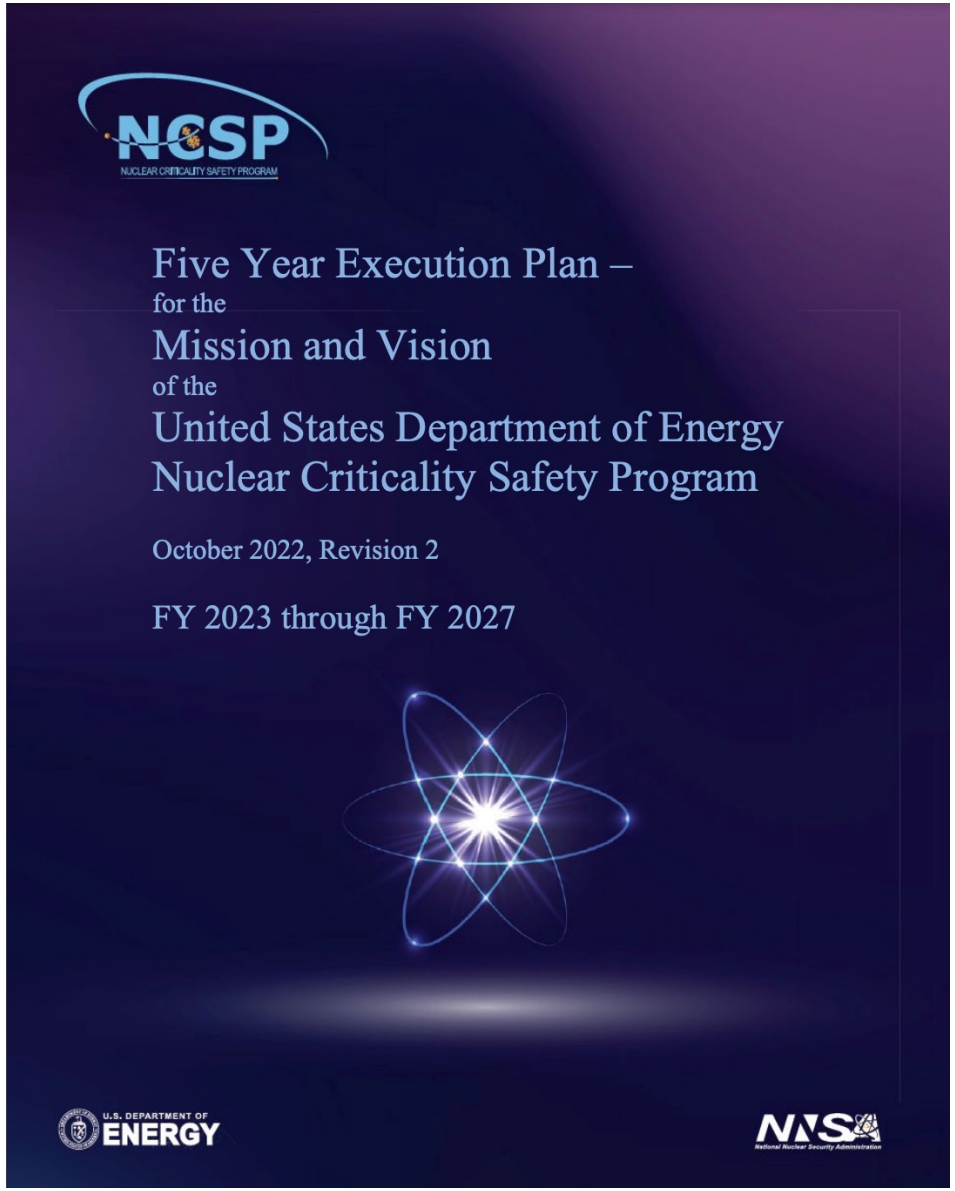
ORNL is managed by UT-Battelle LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

Nuclear Criticality Safety Program

https://ncsp.llnl.gov/

- The NCSP mission is to provide sustainable expert leadership, direction, and the technical infrastructure necessary to develop, maintain, and disseminate essential technical tools, training, and data required to support safe, efficient fissionable material operations within the United States (U.S.) Department of Energy (DOE).
- Technical Program Elements
  - **Analytical Methods (AM)**
    - **AMPX & SCALE (Fulcrum, CSAS, Sampler, VADER, TSUNAMI, MAVRIC)**
    - NJOY & MCNP
  - Information Preservation and Dissemination (IPD)
  - Integral Experiments (IE)
  - Nuclear Data (ND)
  - Training and Education (TE)



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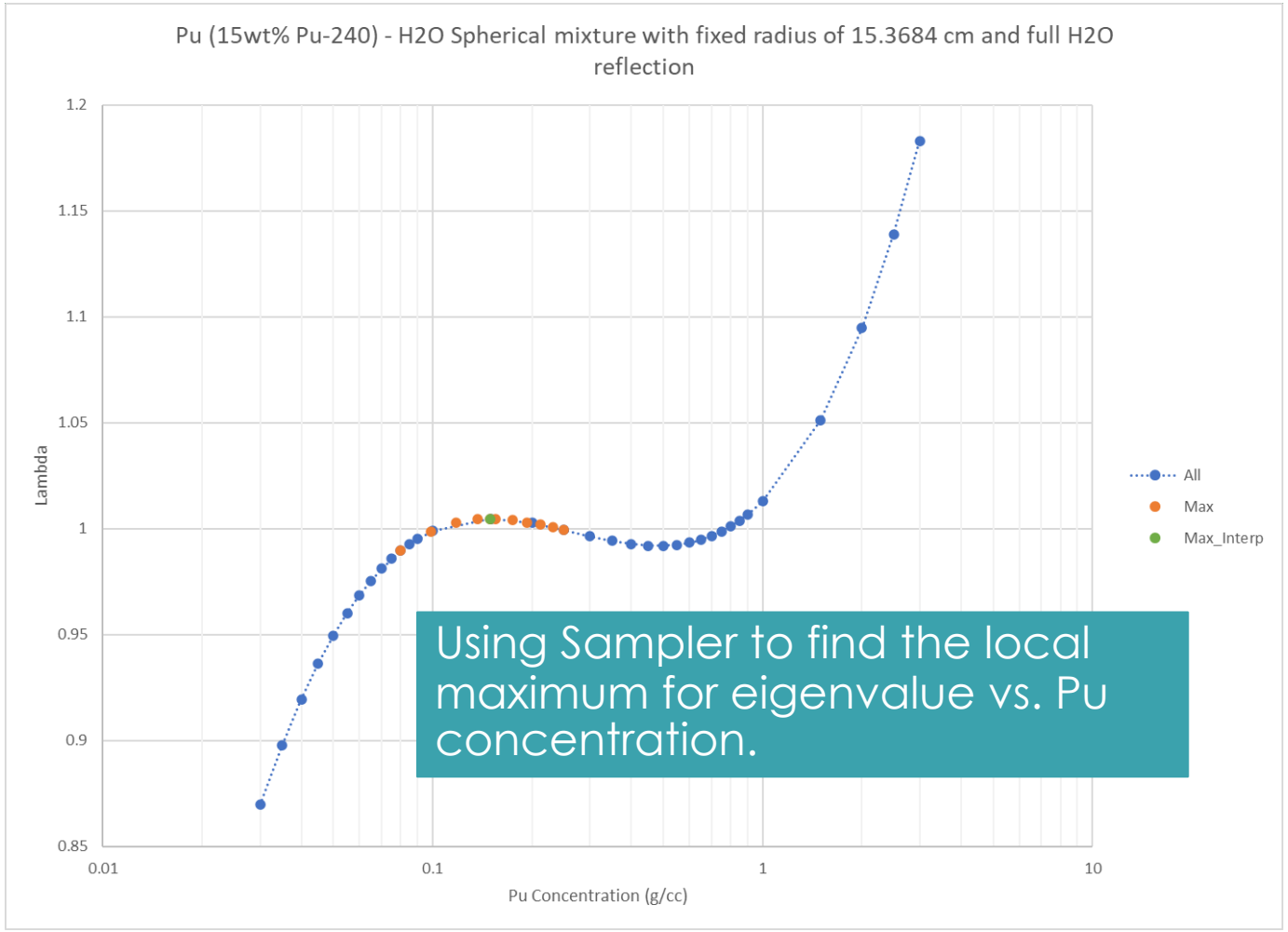
2022-2023 NCSP/SCALE highlights (1/2)

- **Infrastructure**
  - Online manual
  - Virtualization of developer testing machines (full test suite time reduced from 8 to 1.5 hours)
- **VADER trending (new in 6.3)**
  - Standard methods for parametric and non-parametric bias analysis
  - Will grow in functionality to meet needs/desires of criticality safety community
- **Sampler UQ (7.0 beta)**
  - New min/max searches
  - Refactoring being pursued to support pre/post-processing with Python



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2022-2023 NCSP/SCALE highlights (2/2)

- **CSAS generalized tally**
  - New data blocks for tally definitions
  - Single energy group bounds limitation relaxed for tallies
- **CSAS/KENO performance improvements**
  - Up to factor of two reduction in memory usage for CE data arrays
  - Significant improvement in runtime
- **Shift vs. KENO vs. MCNP k-eff estimators**
  - New k-eff estimators in Shift

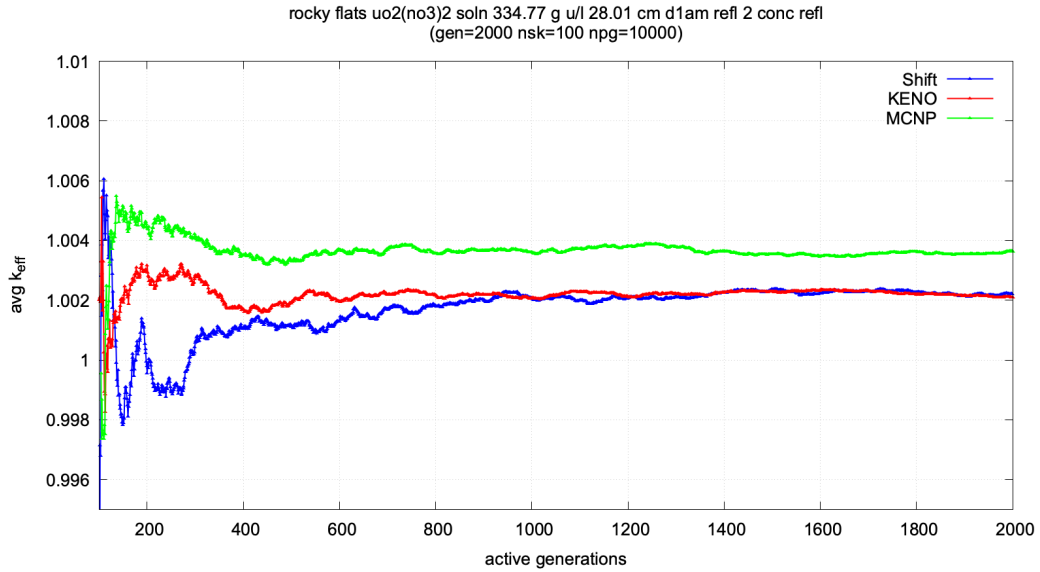
model	KENO 6.2.4 memory (MB)	KENO 6.3.x memory (MB)
CASTOR Cask - 440/84	780.2	499.1
GBC-32 Generic 32-Assembly Cask	1164.6	806.0
ROCKY FLATS uo2(no3)2 soln	777.8	537.4

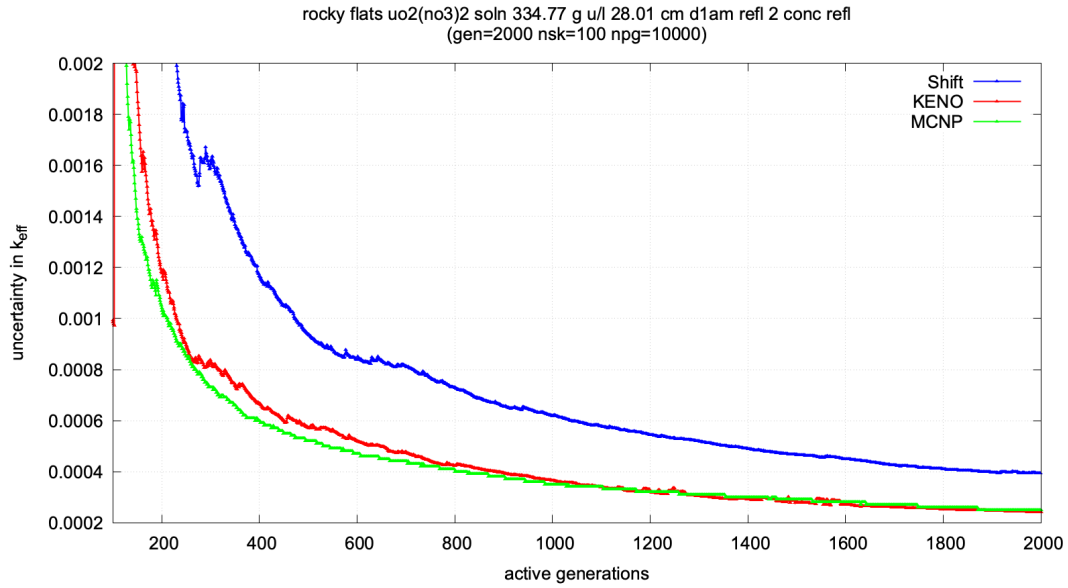
model	KENO 6.2.4 runtime (min.)	KENO 6.3.x runtime (min)
CASTOR Cask - 440/84	139.88	122.51
GBC-32 Generic 32-Assembly Cask	92.09	66.36
ROCKY FLATS uo2(no3)2 soln	107.03	88.65

- **R&D**
  - Revisit source convergence diagnostics in KENO codes
  - TSUNAMI-3D/CLUTCH with deterministically calculated F*(r) mesh importance
  - Exploring CLUTCH/IFP like methodologies for MG-TSUNAMI
- **Study comparing validation basis assessment methods**

Shift vs. KENO vs. MCNP k-eff estimators

- **Shift**
  - track-length estimator for both CE and MG modes
- **KENO**
  - absorption estimator for CE mode
  - collision estimator for MG mode
- **MCNP**
  - absorption, collision, and track-length estimators, and their combinations

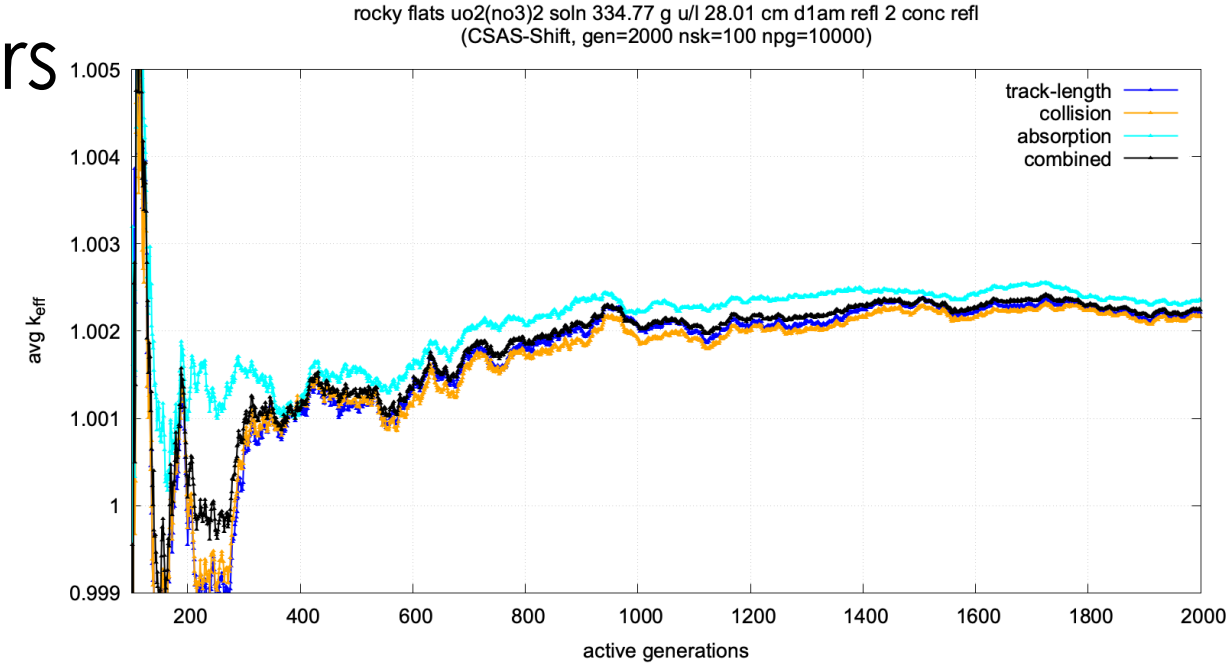




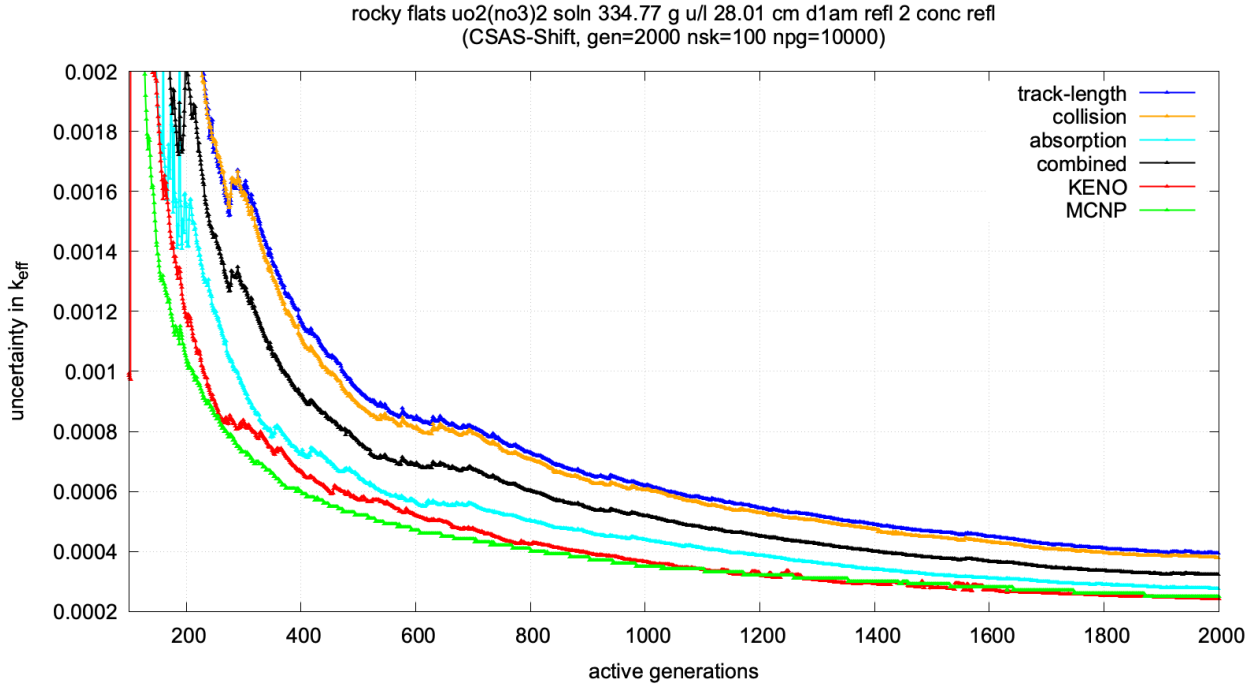
KENO and Shift apply a correction to the variance of k-eff to obtain the true variance

CSAS-Shift new k-eff estimators

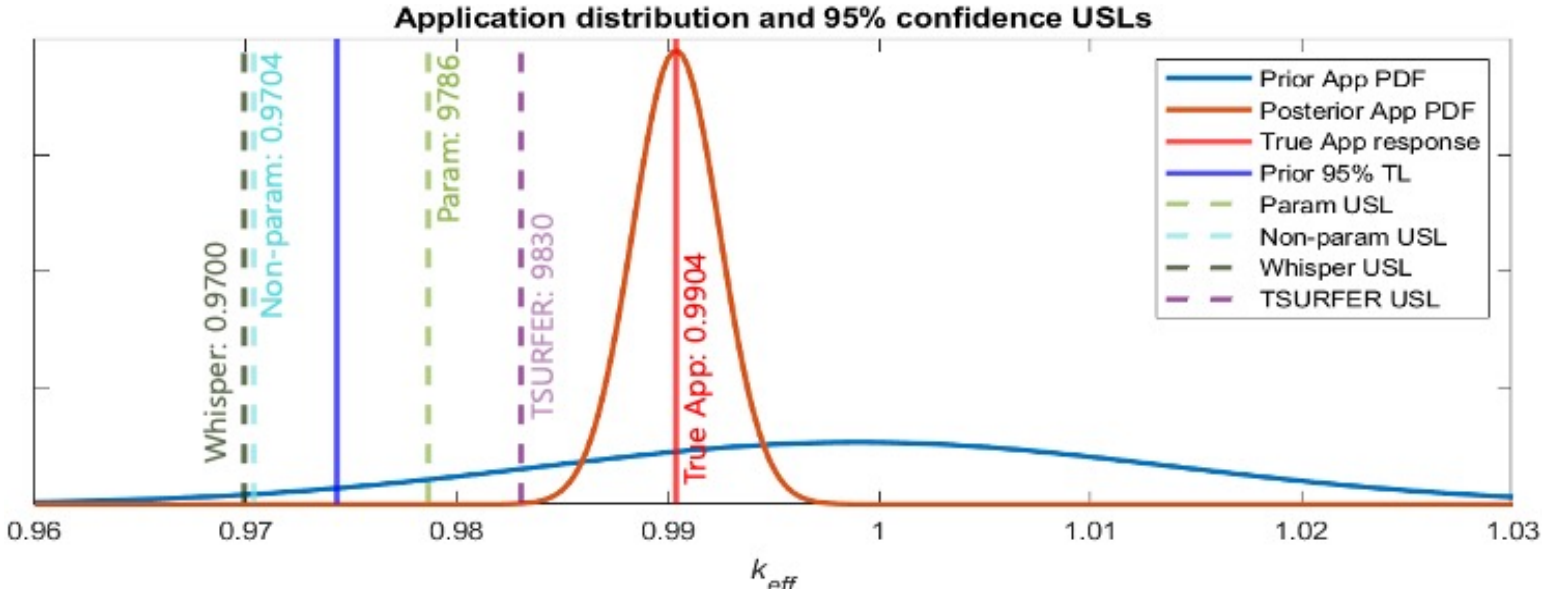
- **Shift (SCALE 7.0-beta4)**
  - three estimators and their combinations (simple and statistically combined forms)



- **CSAS-Shift (SCALE 7.0-beta6)**
  - MG mode, track-length and collision estimator, and their simple combination
  - CE mode, three estimators, and their simple combination



USL Comparison for Four Different Methodologies



From ORNL/TM-2022/2772, "*Comparative Analysis of Confidence Metrics for Nuclear Criticality Safety*"

Nonparametric:
- Determined by largest bias regardless of its relevance to application condition.
- Can produce higher USLs than Whisper (i.e., can be less conservative than Whisper)

Parametric:
- Basic statistical averaging of exp biases with relevance incorporated indirectly via expert experiment selection.
- Impacted by using low relevance experiments.

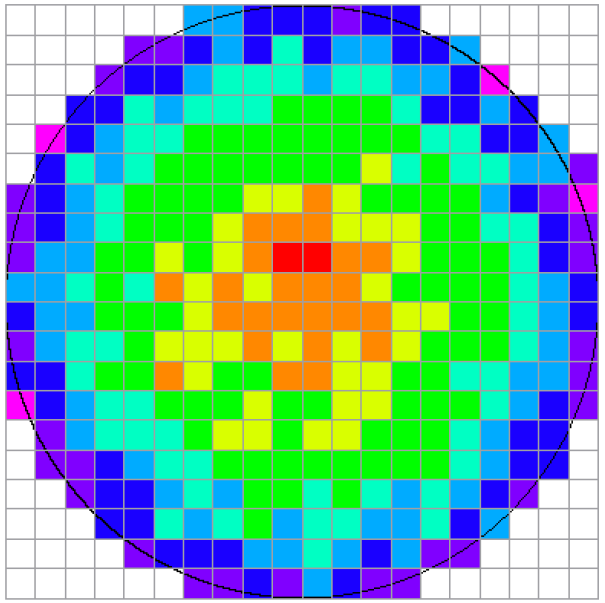
Whisper:
- Uses extreme-value principles but doesn't enforce i.d.d. sampling; CM not rigorously related to 95/95 tol. limit.
- Opposite to Bayes theorem, low relevance experiments can degrade confidence from high relevant experiments

TSURFER:
- Employs Bayes theorem as statistical basis for assimilating exp biases based on relevance to application
- Derives value from many low relevance experiments
- Results sensitive to uncharacterized error sources

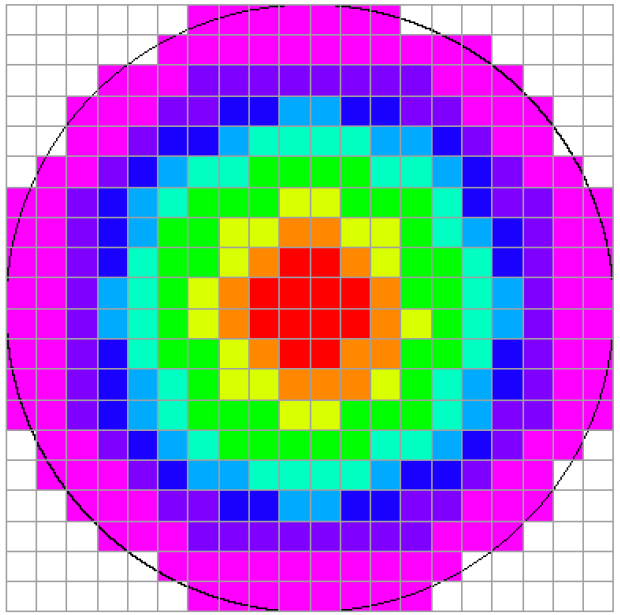
R&D Topics

- **Deterministic F*(r) calculation**
  - Aimed to improve F*(r) mesh importance in TSUNAMI-3D/CLUTCH calculations
    - Capability to read importance map from an external file (in 3dmap format)
    - Capability to calculate F*(r) function with Denovo deterministic calculation

TSUNAMI-IFP estimated F*(r) mesh



Deterministically calculated F*(r) mesh



- **Revisit existing source convergence diagnostics in KENO**
  - Test the validity of the existing diagnostics tests for practical criticality safety applications
  - Improve the existing diagnostics tests
  - Explore the additional tests to provide a better guidance