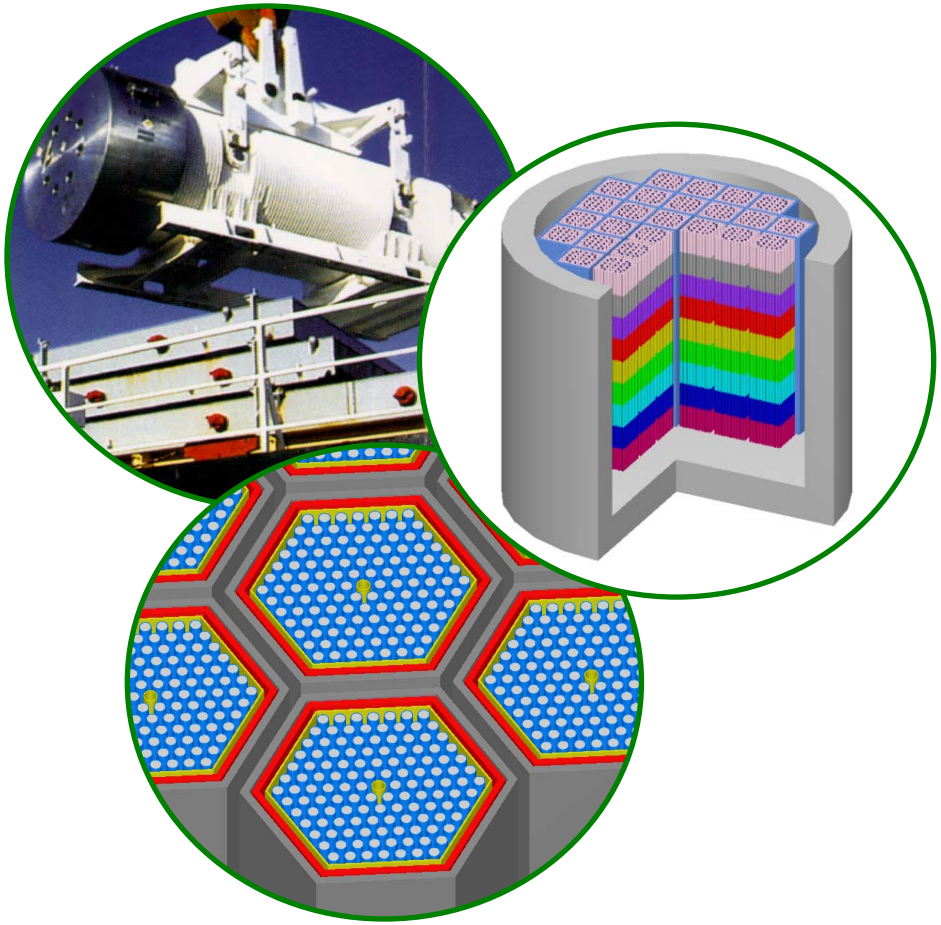
SCALE TSUNAMI Sensitivity and Uncertainty Analysis Capabilities and Data



Brad Rearden
SCALE Project Leader

September 22, 2009
Pocatello, Idaho USA

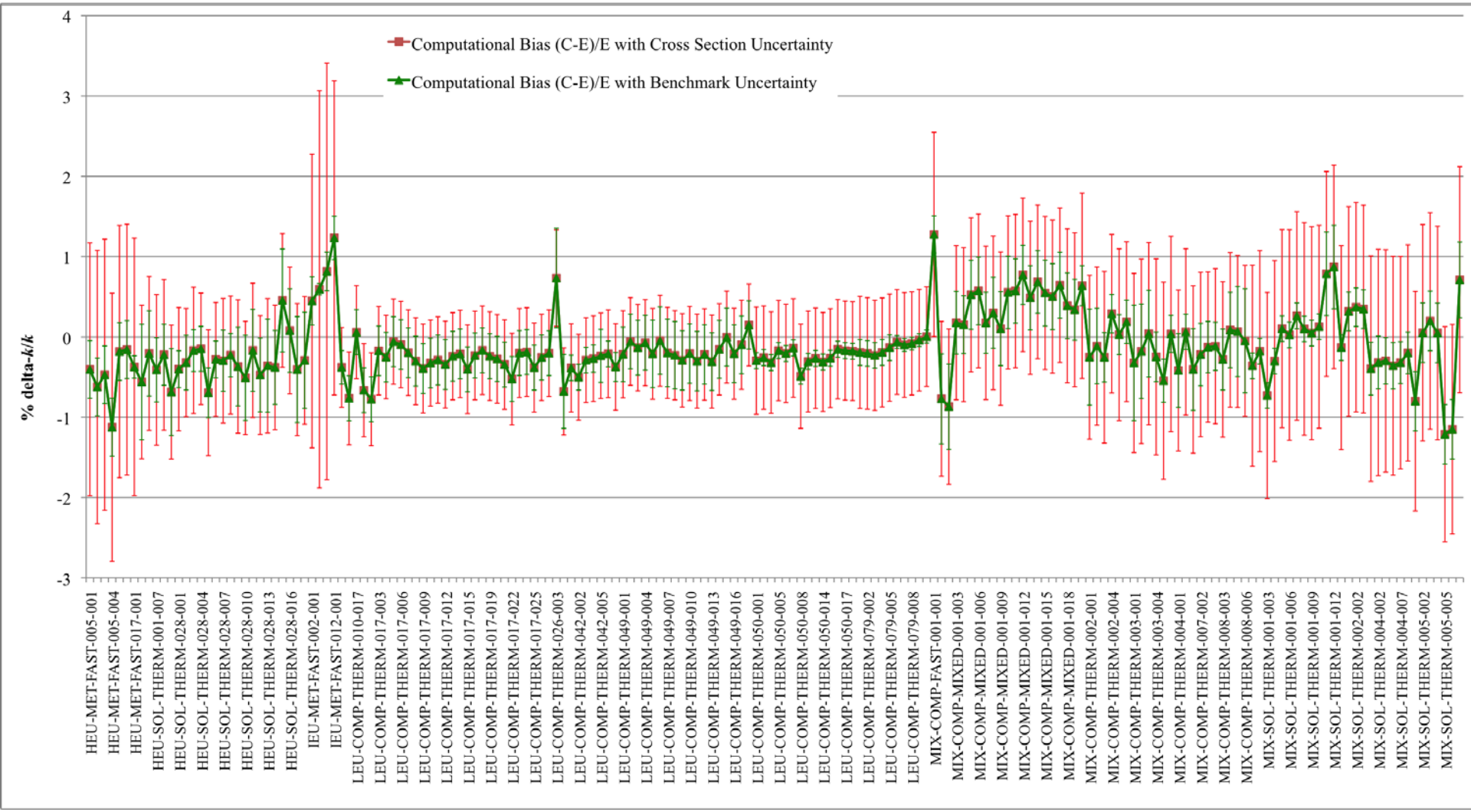
Computational Biases and Their Bounds

- Premise of TSUNAMI validation concept
  - Computational biases are primarily caused by errors in the cross-section data
  - Errors are bounded by cross-section uncertainties represented in covariance data

2

186 Benchmark Experiments

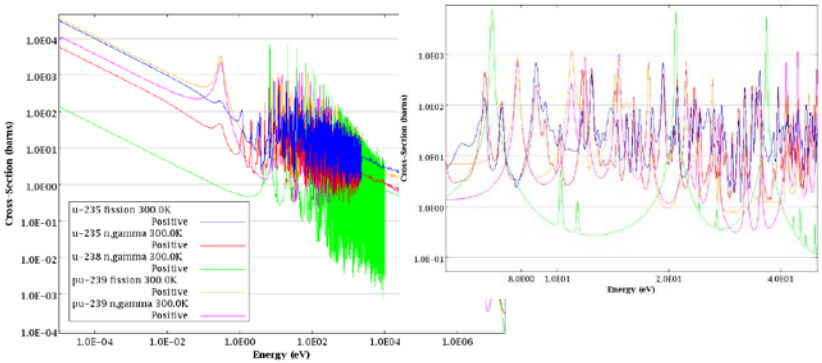
SCALE 6 ENDF/B-VII.0



Production Sensitivity/Uncertainty Tools in SCALE 6.0

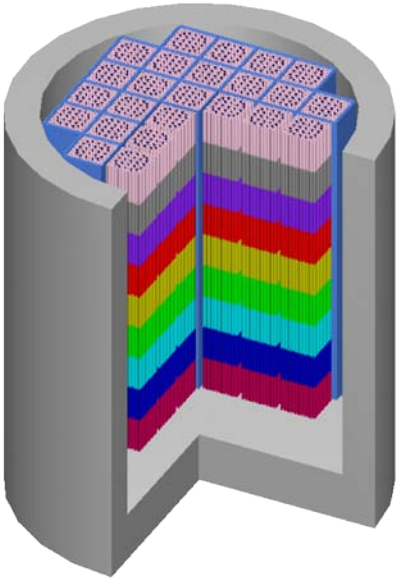
Multi-Group Resonance Self-Shielding

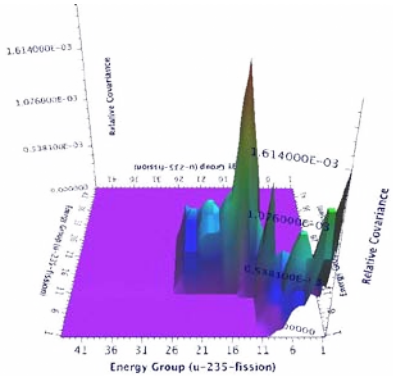
Uses of continuous-energy transport to preserve physics. Inclusion of "implicit sensitivity", up to 40% contribution for thermal/intermediate systems



KENO V.a or KENO-VI

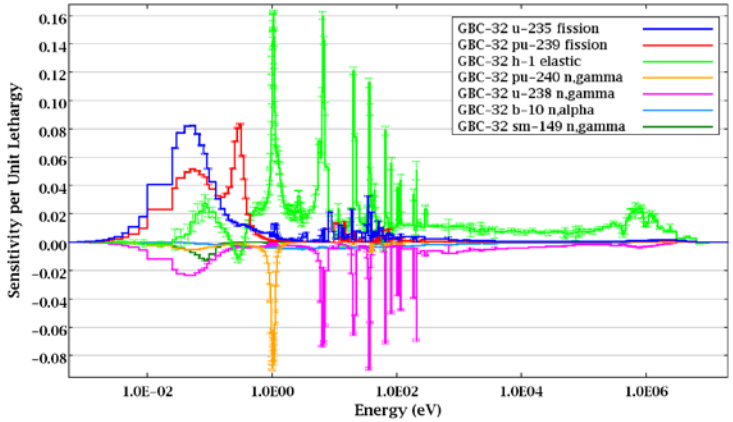
Forward/Adjoint multi-group Monte Carlo for explicit geometrical representation. Models as large as full-core reactors with pin-by-pin geometry.





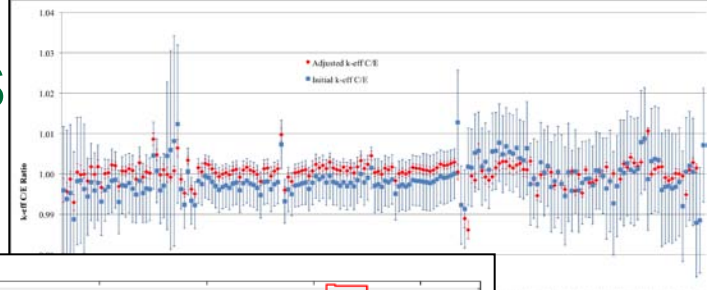
Sensitivity and Uncertainty

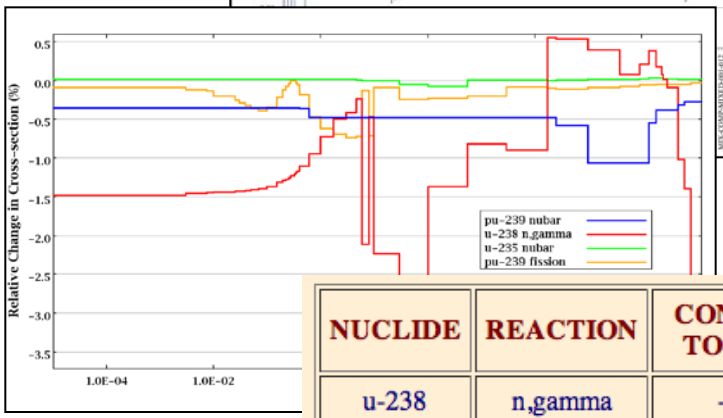
Multi-group sensitivity coefficient generation for all nuclides and reactions. Uncertainty propagation from cross-section covariance data to k_{eff}



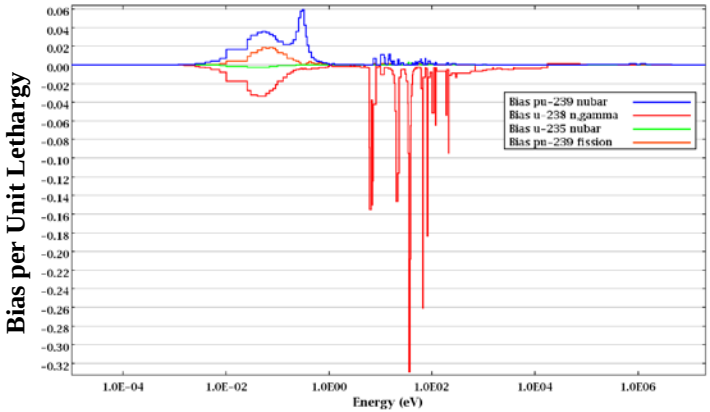
SCALE 6.0 Validation Tools

- Cross-section Covariance Data
  - Comprehensive library with 401 materials
- Similarity Assessment
  - Integral similarity
  - Nuclide/reaction-specific similarity
- Bias Assessment
  - Trending on similarity
  - Data adjustment
  - Integral
  - Nuclide-reaction specific
  - Energy-dependent
- Gap Analysis
  - Identify validation gaps and bound impact on application
- Experiment Design
  - Fine-tune experiments to fill identified gaps

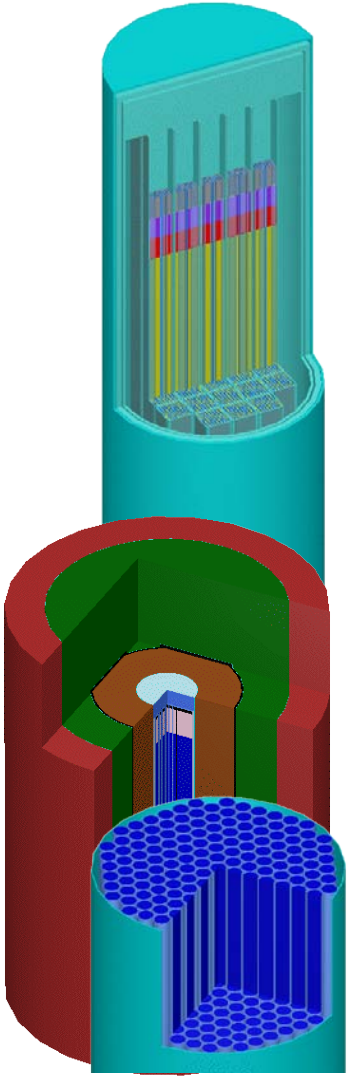




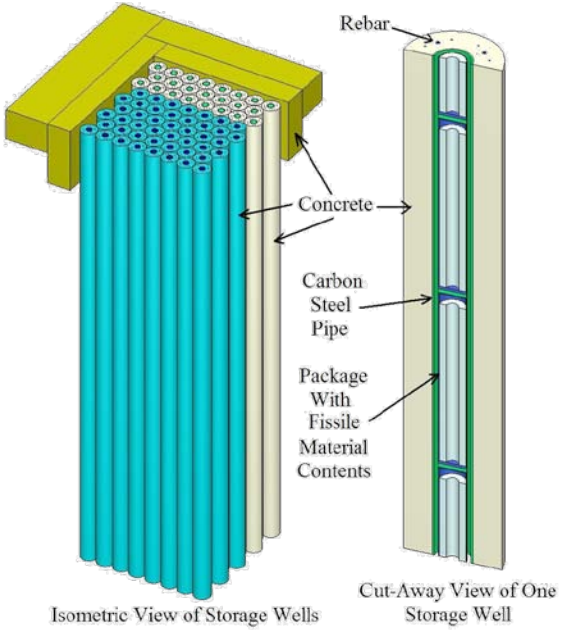
NUCLIDE	REACTION	CONTRIBUTION TO BIAS % dk/k
u-238	n,gamma	-2.1084E-01
pu-239	nubar	1.2761E-01
pu-239	fission	3.9872E-02
o-16	elastic	3.2243E-02
pu-239	n,gamma	-2.5810E-02
pu-239	chi	1.0248E-02

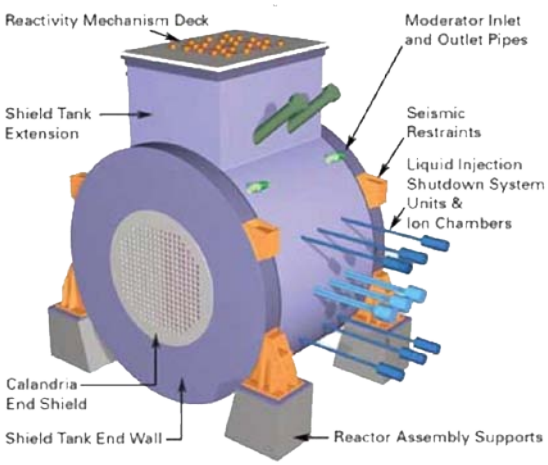


Applications of TSUNAMI Methods to Support Licensing Activities



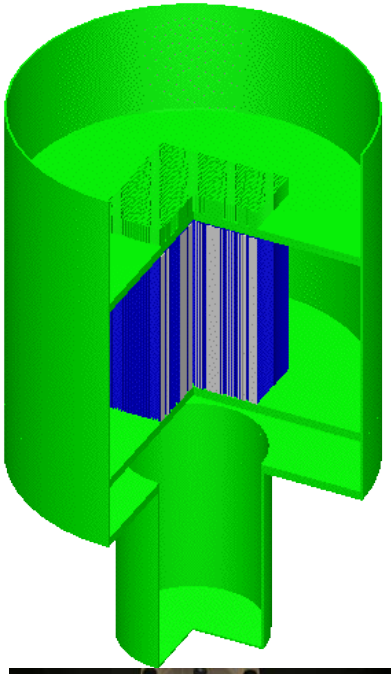
- Licensees
  - Support of ^{233}U Processing
  - Fission Surface Power System (Lunar/Mars Surface)
  - Mixed-Oxide Fuel Fabrication Facility
  - >5 wt-% LEU Studies
  - AECL ACR-1000 Code Validation
  - Yucca Mountain Post-Closure Criticality Analysis
  - Reactor/Fuel vendors
- Regulatory License Reviews
  - US NRC
  - German BFS
  - Others?

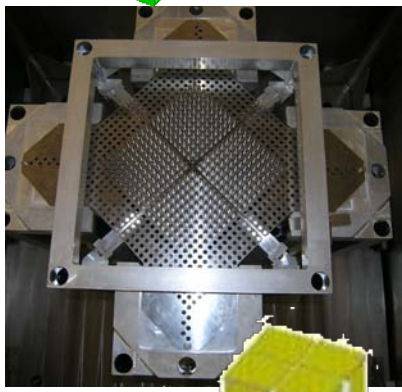


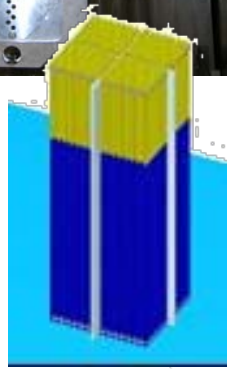


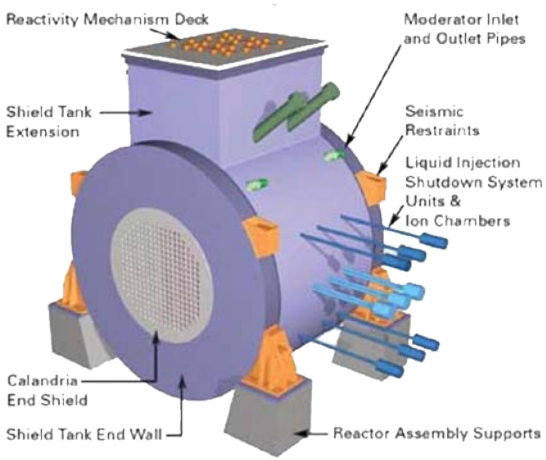
Applications of TSUNAMI to Experiment Optimization

- Required step in US DOE NCSP C_EdT Process
- SNL 7% UO_2 Criticals
  - Experiments optimized for storage applications for BWR and PWR fuel assemblies from 5-10 wt%
- CEA Valduc/IRSN MIRTE Experiments
  - Reference configurations designed with TSUNAMI









- **AECL, Canada**
  - **ACR-1000 validation**
- **Other proprietary work**

Expanding Use of TSUNAMI

- The TSUNAMI approach to validation is gaining acceptance throughout the global criticality safety community.
  - >250 criticality safety practitioners have attended TSUNAMI training sessions
  - OECD/NEA currently has two expert groups in uncertainty analysis where TSUNAMI plays a major role (UACSA, UAM)
- In all TSUNAMI studies, most significant effort is generation of sensitivity data for experiments from ICSBEP handbook.
- #1 request from TSUNAMI users is to have TSUNAMI data distributed with ICSBEP Handbook for use in scoping calculations.

2009 ICSBEP Handbook TSUNAMI Data for 419 Benchmarks

- HEU-MET-FAST
  - 24 cases
- HEU-SOL-THERM
  - 52 cases
- IEU-MET-FAST
  - 4 cases
- LEU-COMP-THERM
  - 31 cases
- LEU-SOL-THERM
  - 19 cases
- MIX-COMP-FAST
  - 1 case
- MIX-COMP-THERM
  - 15 cases
- PU-MET-FAST
  - 9 cases
- PU-SOL-THERM
  - 34 cases
- U233-COMP-THERM
  - 3 cases
- U233-MET-FAST
  - 8 cases
- U233-SOL-INTER
  - 29 cases
- U233-SOL-MIXED
  - 8 cases
- U233-SOL-THERM
  - 182 cases

Questions?

Contact:

Brad Rearden

scalehelp@ornl.gov

http://www.ornl.gov/scale/tsunami