Enhancements in SCALE 6.1

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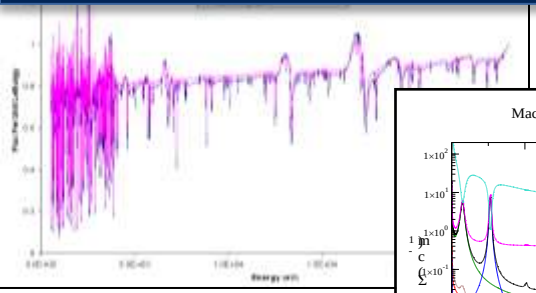
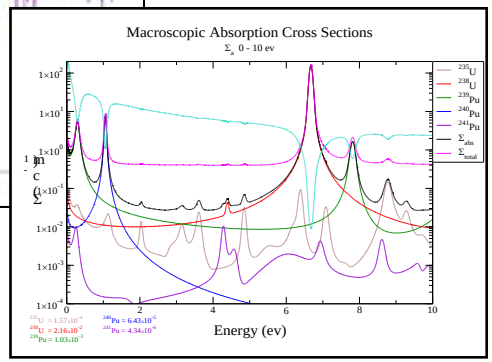
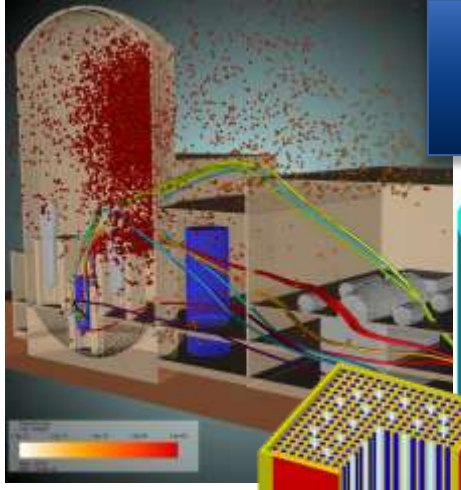
SCALE Project Leader
November 9, 2010

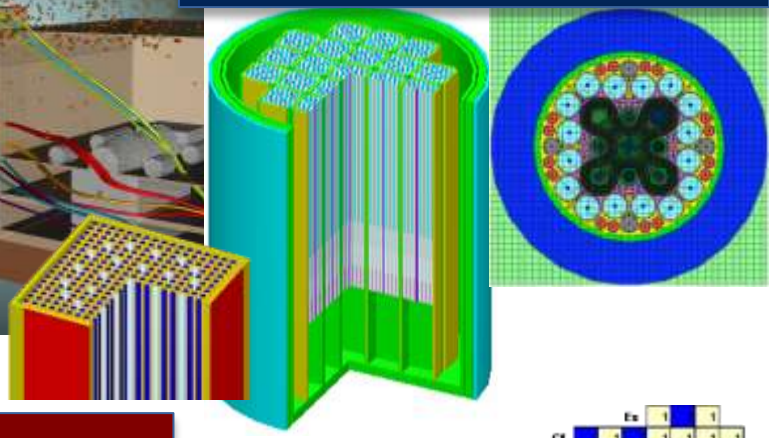
Current Nuclear Data Libraries with Continuous-Energy Resonance Processing





High-Resolution Geometry Modeling in Monte Carlo and Deterministic Transport

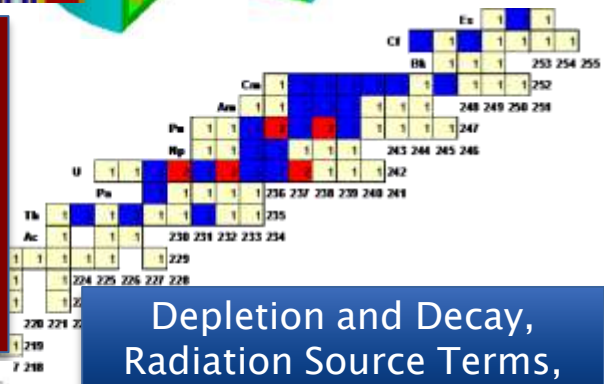




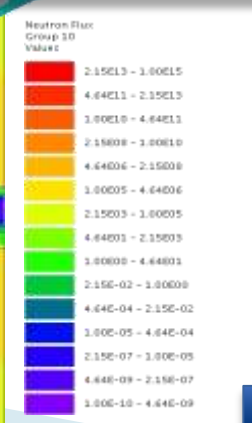
SCALE 6.0 Capabilities

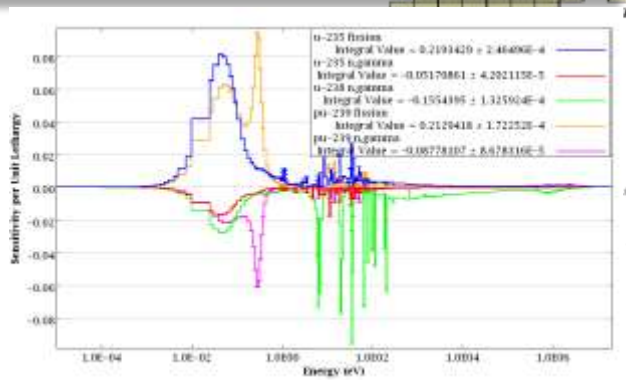
- Cross-section processing
- Reactor physics
- Criticality safety
- Radiation shielding
- Sensitivity and uncertainty analysis
- Spent fuel and HLW characterization

Radiation Shielding with Automated Variance Reduction

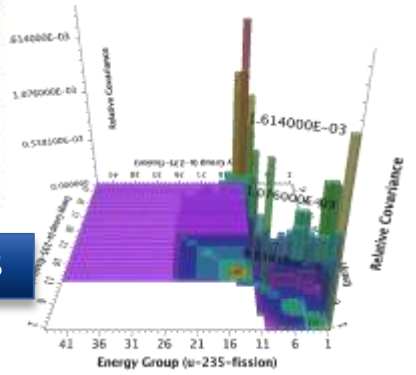


Depletion and Decay, Radiation Source Terms, and Decay Heat





Sensitivity and Uncertainty Analysis



SCALE 6.1 Highlights

- Objective of SCALE 6.1 release is primarily enhancements in two key areas:
  - TSUNAMI Mesh Volumes
  - TRITON Bugs
- Other features developed under specific projects are captured in this release

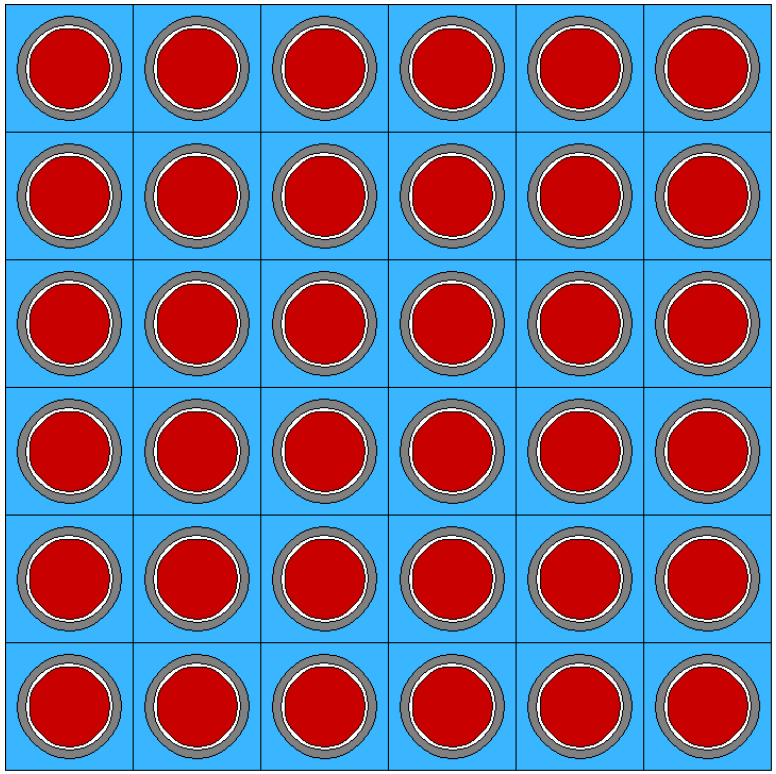
Criticality Safety

- KENO
  - Easier mesh specification
  - Improved mesh volume calculation
  - Improved mesh output edits
  - Region mean free paths in CE KENOs enabled
- Fission source distribution output
  - For CAAS or visualization
  - MG/CE, KENO V.a/KENO-VI
  - Exported in .3dmap format with uncertainties

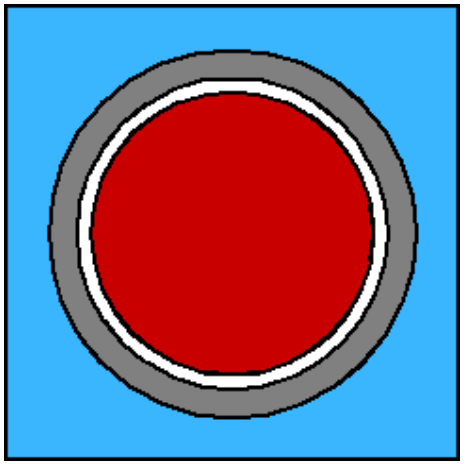
KENO Mesh Accumulator

- For TSUNAMI, forward and adjoint fluxes are accumulated over same mesh, then multiplied together prior to summing over a region (e.g. all fuel pins).
- Volume of each material within each mesh region is required.

Array Without Automated Mesh

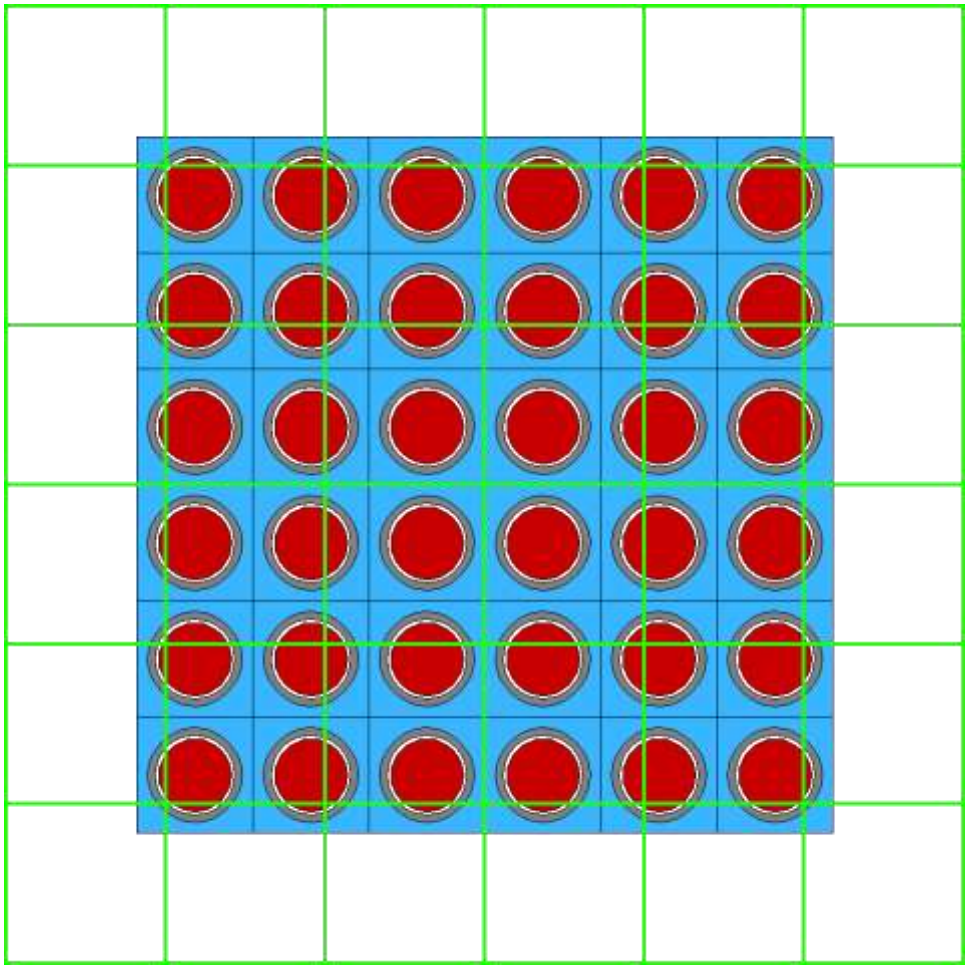


6×6 Array of 4-region cell
for 144 regions

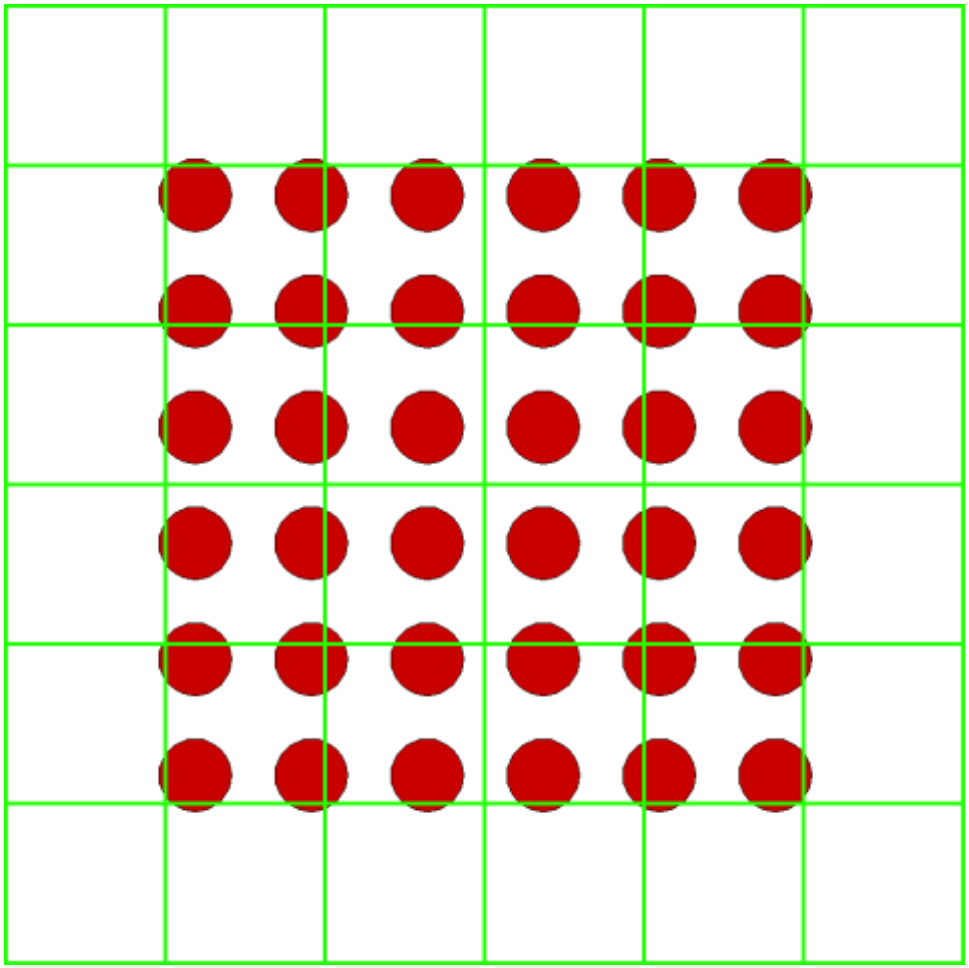


4 flux regions
fuel, gap, clad, mod.

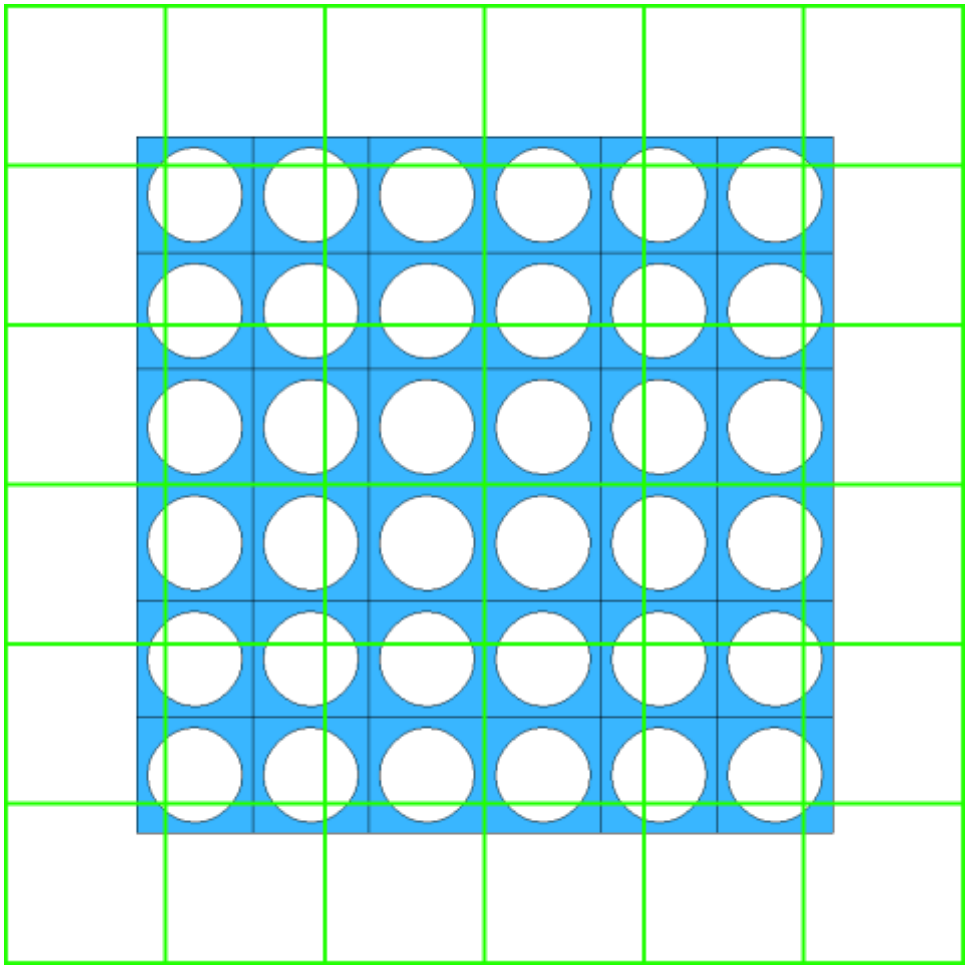
Automated Mesh (1.375 x pitch)



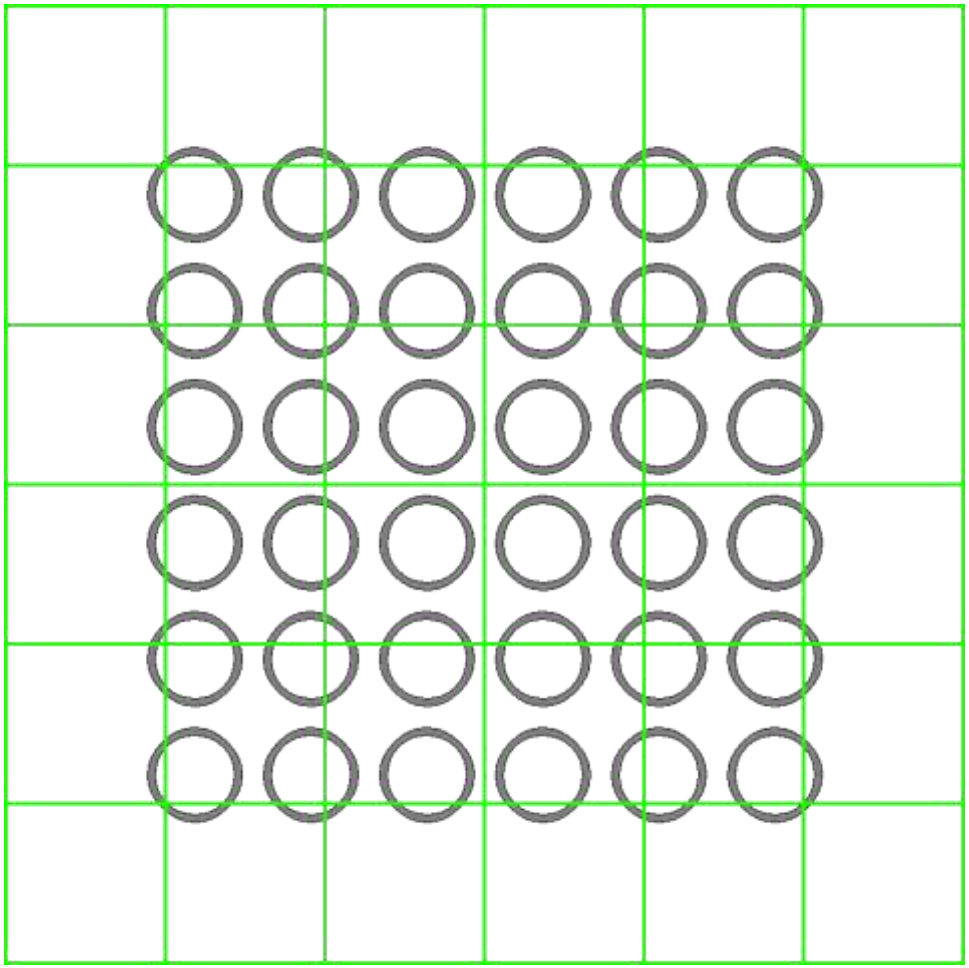
Automated Mesh Fuel Regions



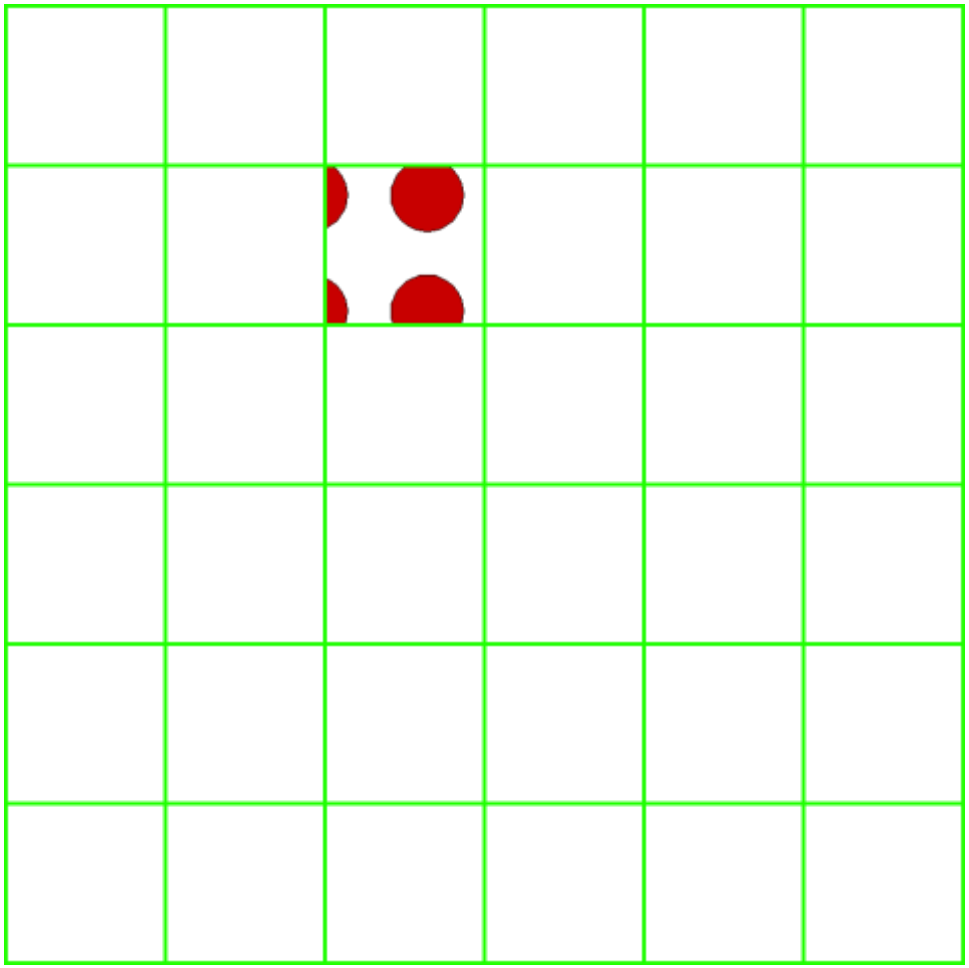
Automated Mesh Moderator Regions



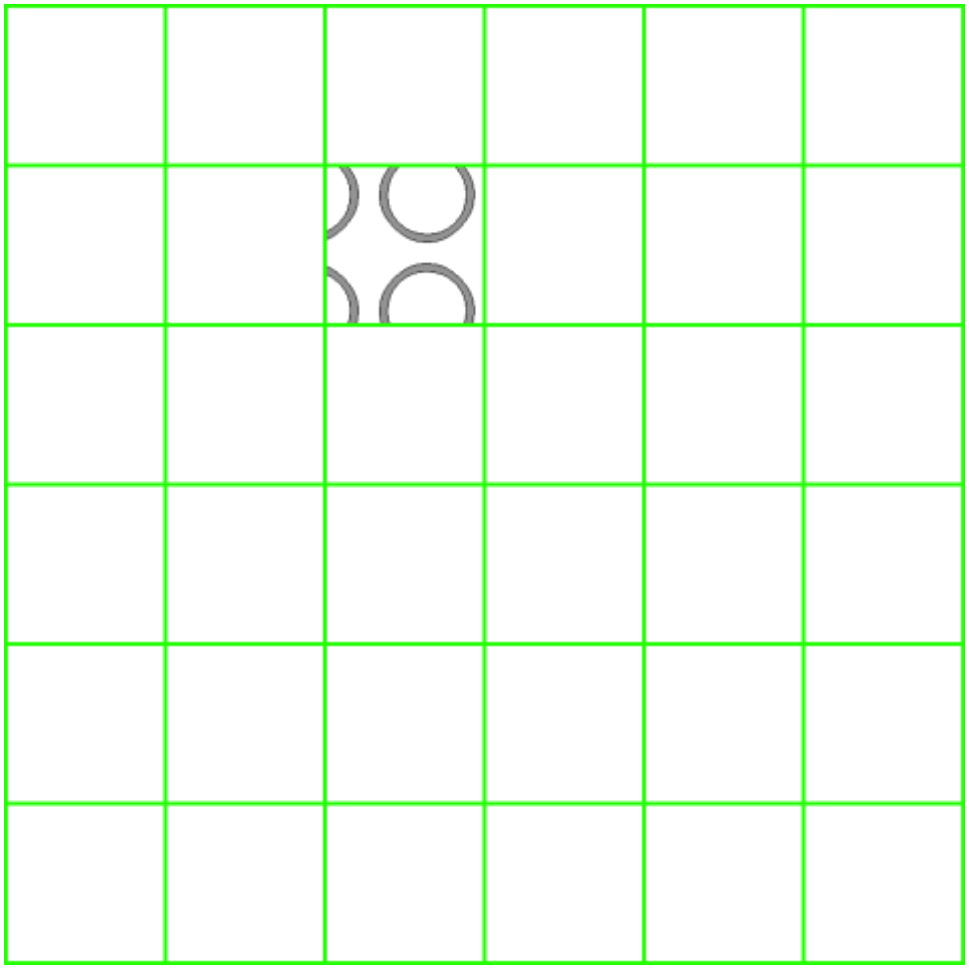
Automated Mesh Clad Regions



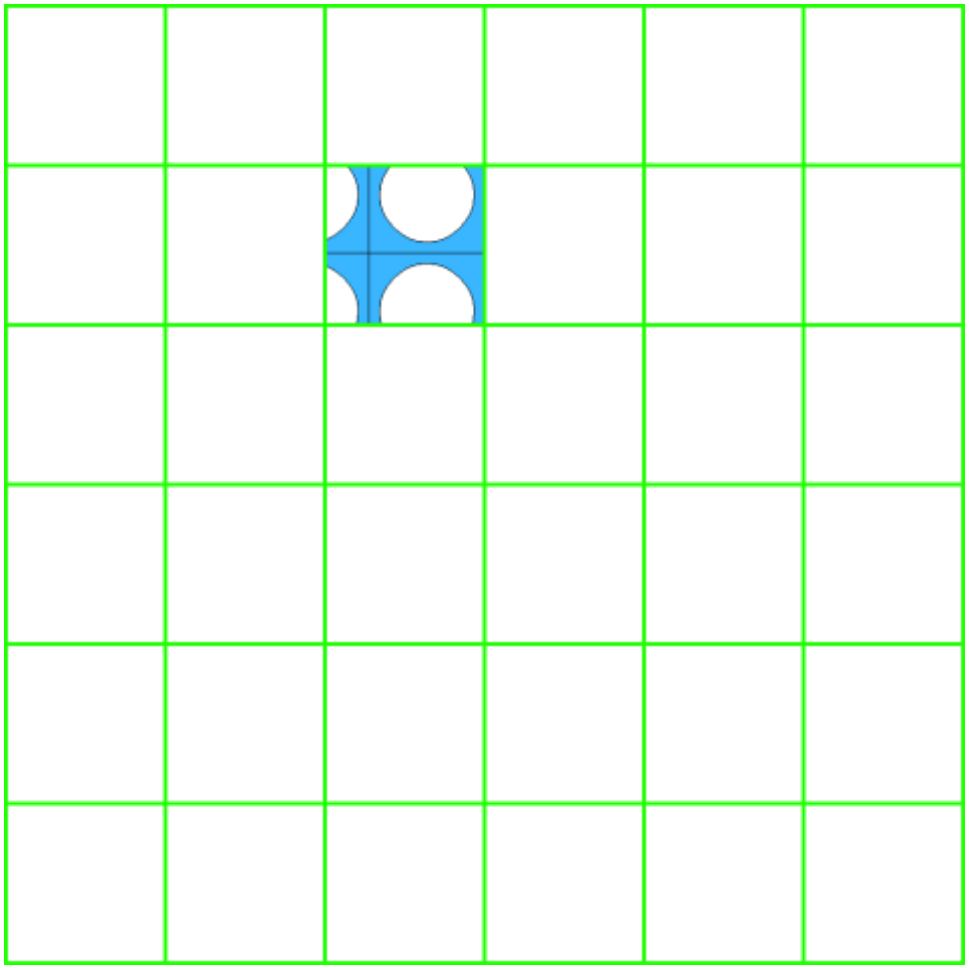
Automated Mesh
Single Fuel Mesh



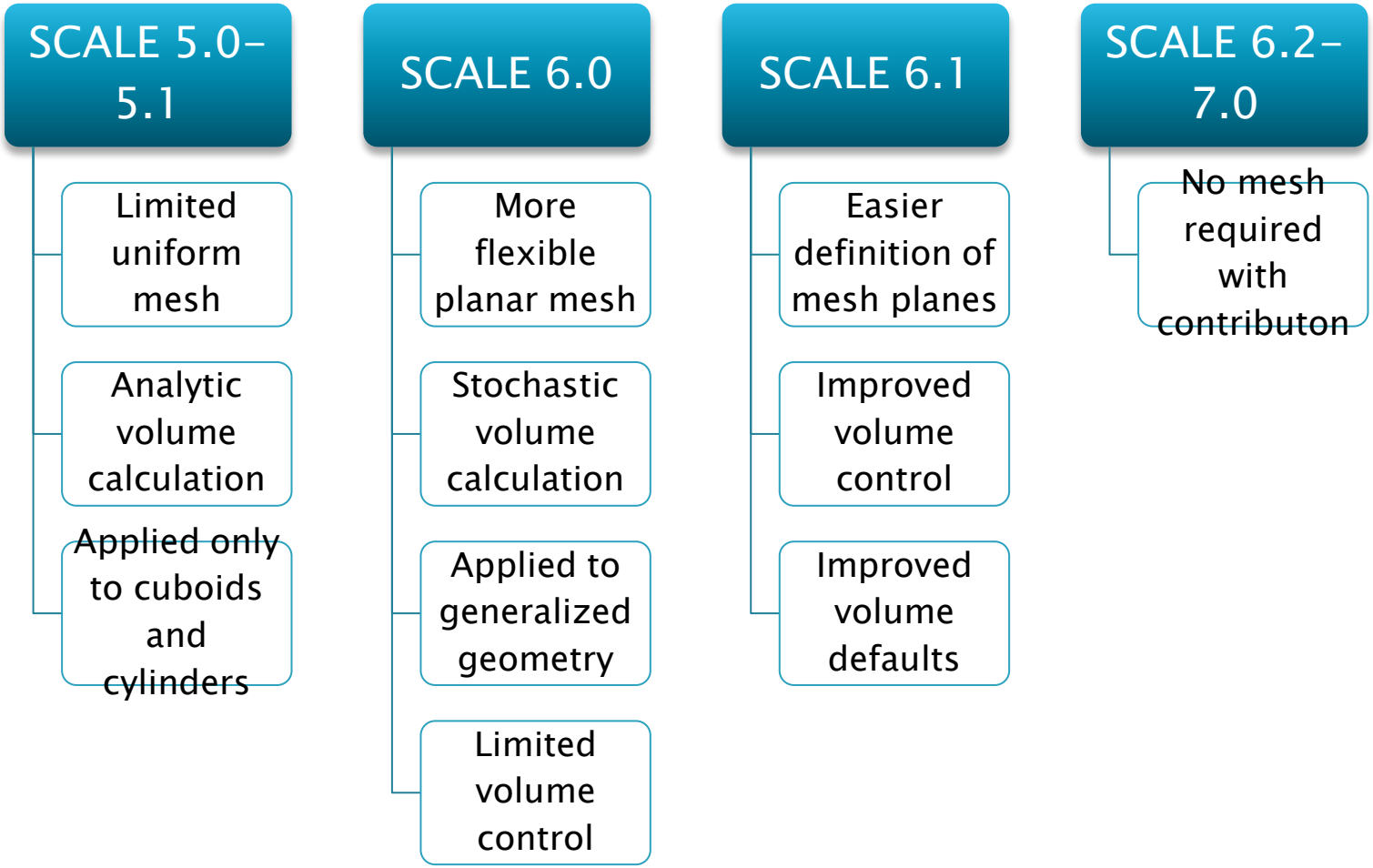
Automated Mesh
Single Clad Mesh



Automated Mesh
Single Moderator Mesh

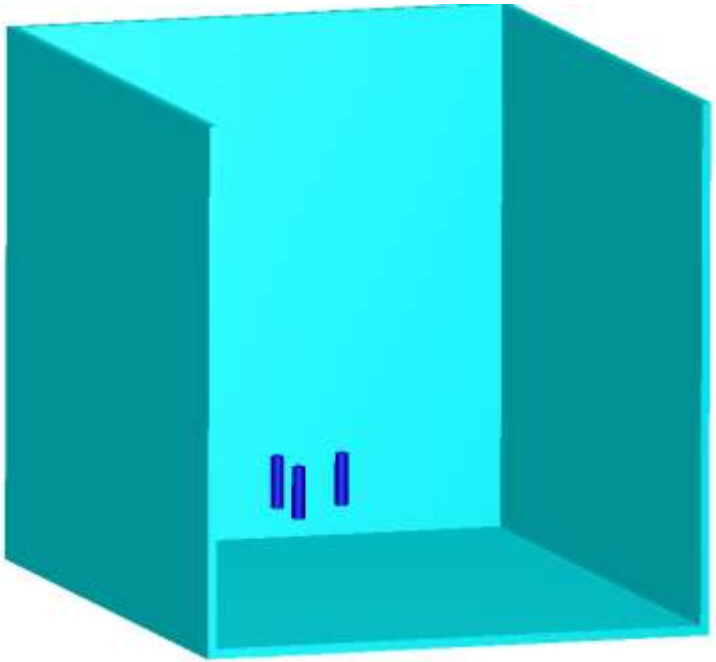


Evolution of TSUNAMI Mesh

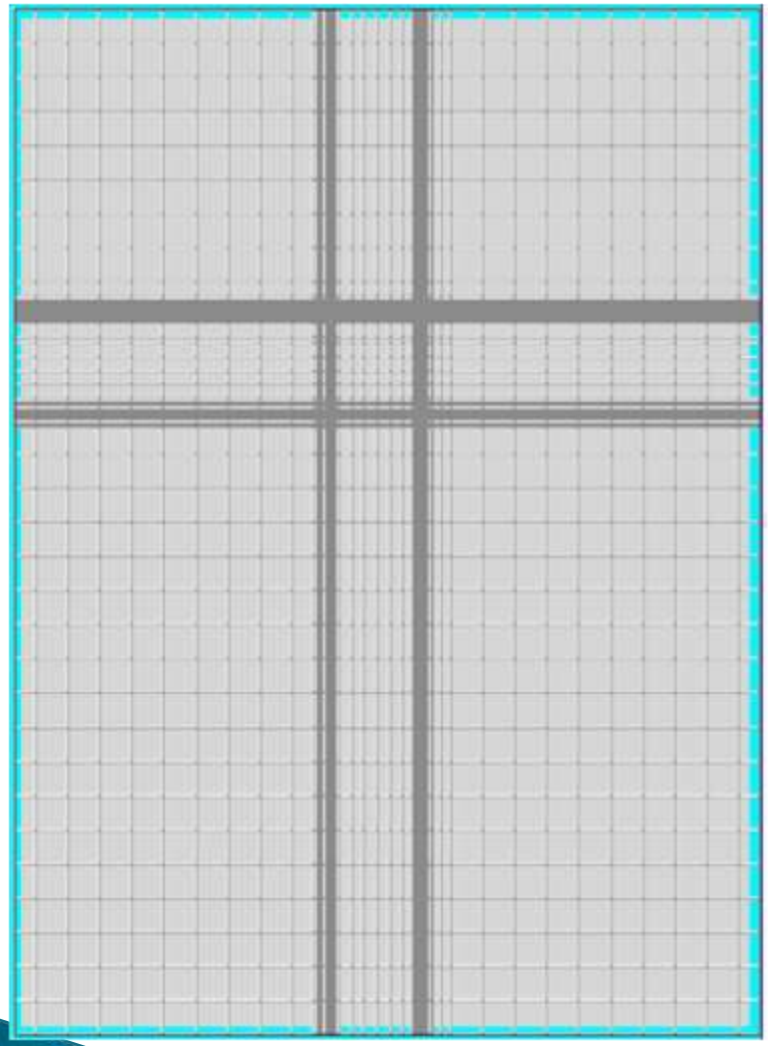


Example: PU-SOL-THERM-014

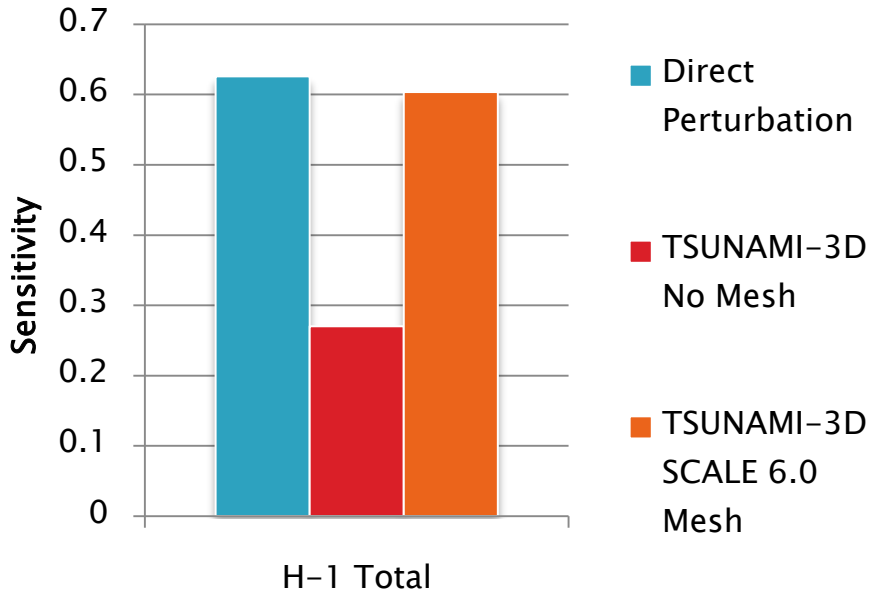
- Pu solution cans (~30 cm)
- Large room (~15 m)
- Desire 3 cm mesh for fissile solution
- Uniform mesh would create ~80,000,000 mesh intervals
- Require ~300 GB of RAM



SCALE 6.0 Planar Mesh



- Mesh refined across fissile solution
- Requires ~140,000 mesh intervals
- ~500 MB of RAM



Planar Mesh

SCALE 6.0

```
read gridgeometry 1
  xplanes
  -750 -700 -650 -600 -550 -500 -450 -400 -350 -331 -325 -322 -319
  -316 -313 -311 -310 -307 -304 -301 -298 -295 -292 -291 -271 -261
  -241 -221 -201 -180 -175 -172 -169 -166 -163 -160 -160 -157 -154
  -151 -148 -145 -142 -139 -100 -50 0 50 100 150 200 250 300 350
  400 450 500 550 600 650 700 750
 end
  yplanes
  -585 -550 -500 -450 -400 -350 -300 -250 -200 -150 -116 -110 -107
  -104 -101 -98 -96 -95 -92 -89 -86 -83 -80 -77 -76 -56 -36 -16 4
  24 40 43 44 46 49 52 55 58 61 64 64 67 70 84 100 150 200 250 300
  350 400 450 500 550 585
 end
  zplanes
  -540 -500 -450 -406 -386 -366 -346 -345 -342 -339 -336 -333 -330
  -327 -326 -324 -321 -319 -316 -313 -310 -307 -306 -304 -300 -286
  -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500
  550 570
 end
end gridgeometry
```

SCALE 6.1

```
read gridgeometry 1
  xlinear 30 -750 750
  xlinear 15 -331 -291
  xlinear 15 -179 -139
  ylinear 24 -585 585
  ylinear 15 -116 -76
  ylinear 15 44 84
  zlinear 22 -540 570
end gridgeometry
```

Mesh Volume

- To compute sensitivity coefficients, the volume of each region within each mesh interval must be quantified.
- Beginning with SCALE 6.0, KENO computes the volume through a stochastic sampling process.
- SCALE 6.0 defaults:
  - 5000 points per generation for 1000 generations
- SCALE 6.1 defaults:
  - 5000 points if volume $< 13{,}600$ cm^3
  - For larger volumes

$$points = \frac{volume}{ln\left(volume/5000\right)}$$

Volume Input

With SCALE 6.1 defaults, PU-SOL-THERM-014 mesh volumes are computed with ~150,000,000 points for 1000 batches

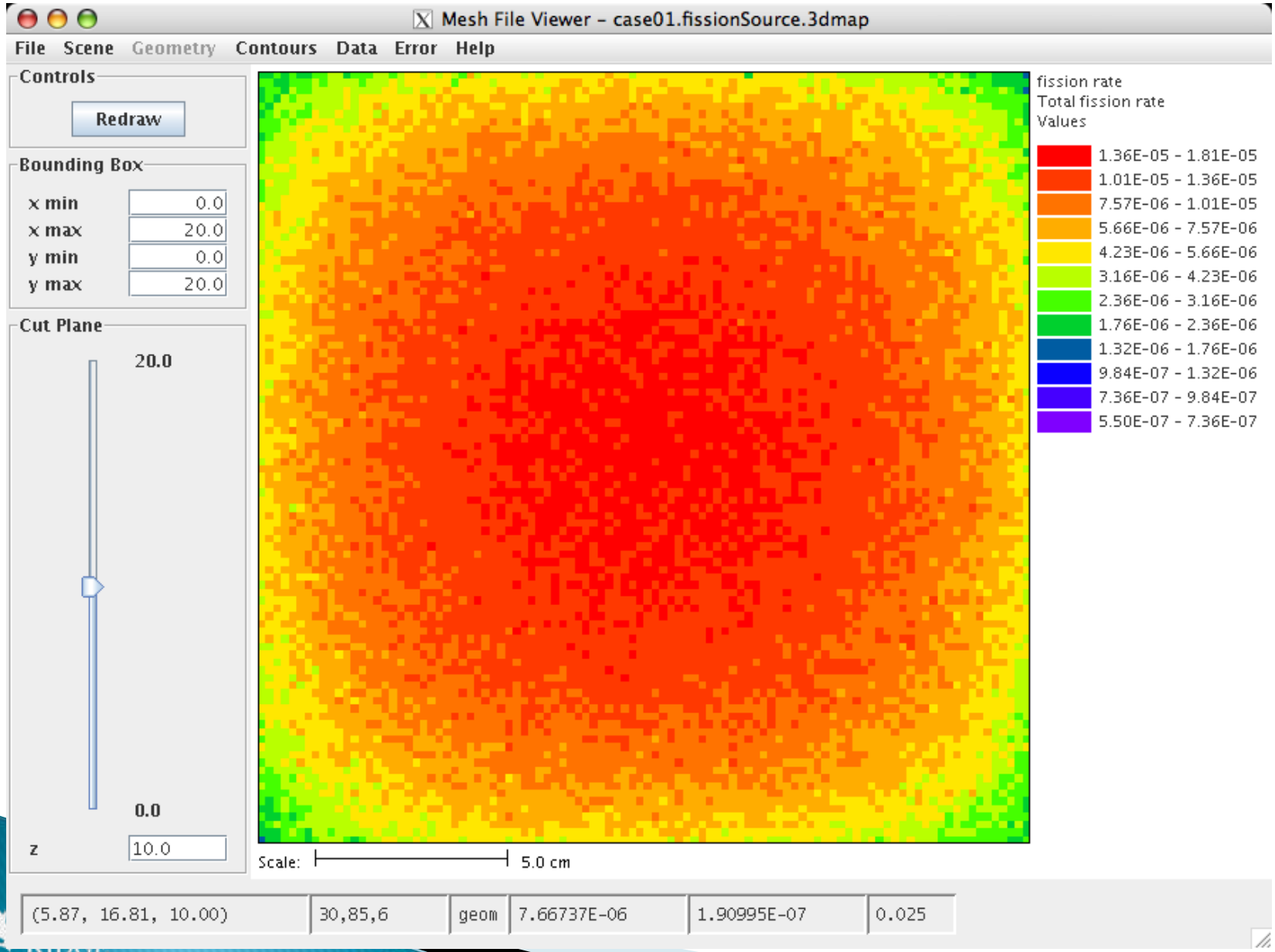
- Input sampling directly

```
read volume
 points=25000
 batches=4000
end volume
```

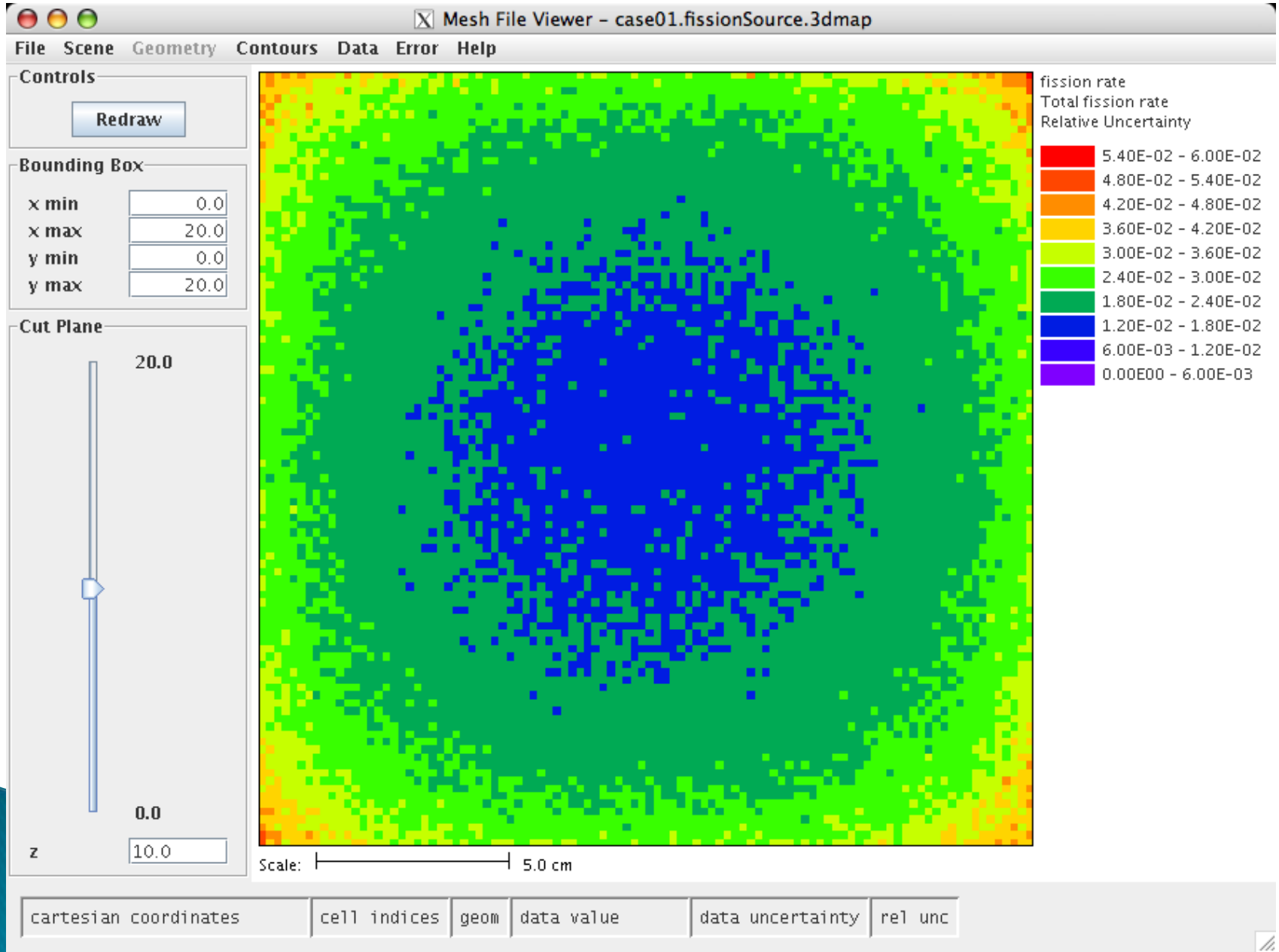
- Input sampling density:

```
read volume
 sample_den=0.1
 batches=4000
end volume
```

Fission Source Viewing

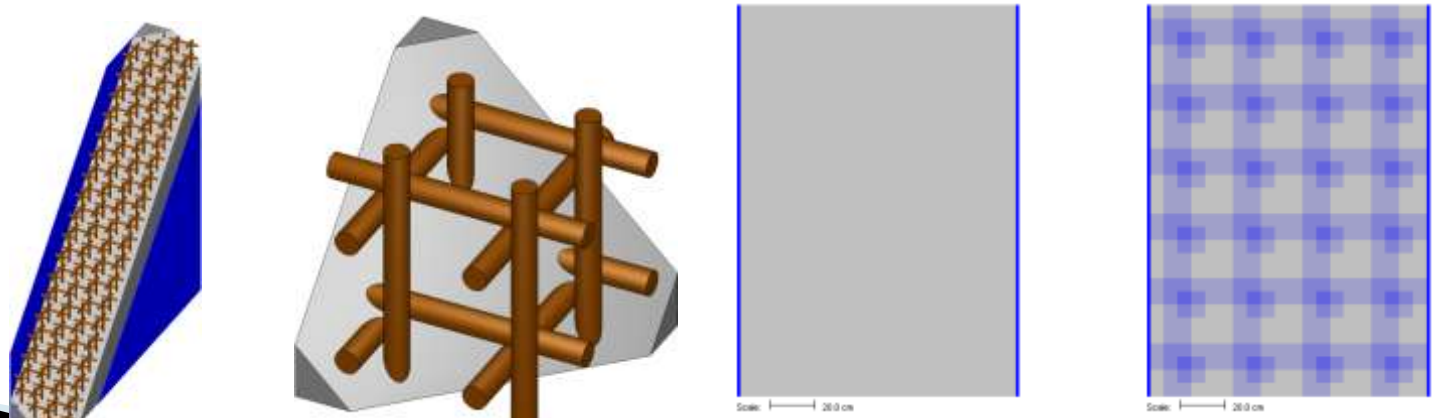


Fission Source Uncertainty

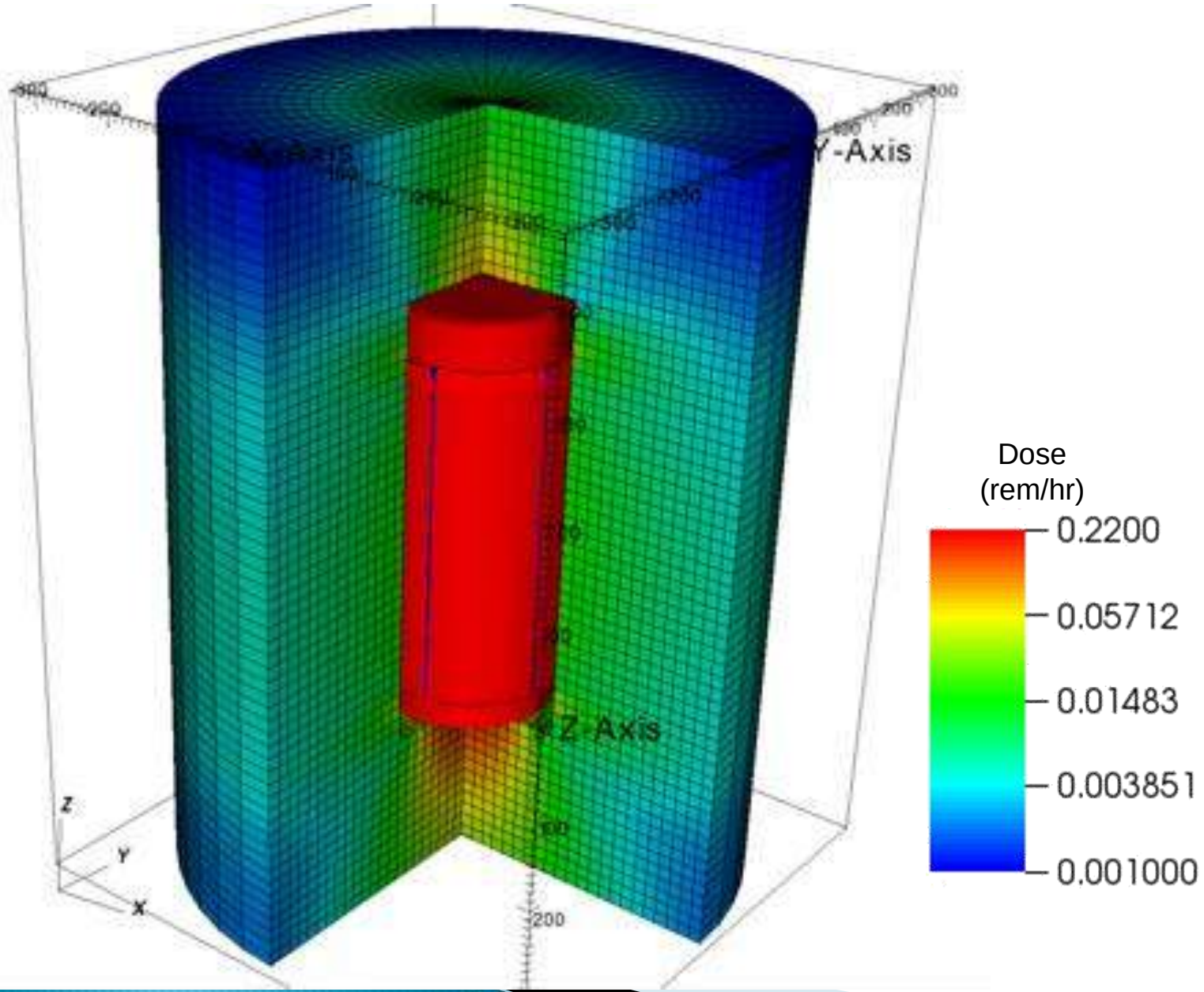


Shielding Analysis – MAVRIC

- Multiple sources
- Spatial variation of sources
- Energy distributions from ORIGEN or AMPX
- Macro materials for Denovo calculation
- Cylindrical mesh grids
- MAVRIC Utilities



Cylindrical Mesh Tally



Dose
(rem/hr)

0.2200
0.05712
0.01483
0.003851
0.001000

Depletion and Decay

- Arbitrary group structures for COUPLE/ORIGEN
- Support for ENDF/B-VII decay libraries
- Energy-dependent fission yields
- Cross section transitions from multiple sources
  - JEFF-3.0/A based AMPX libraries
  - AMPX library from SCALE
  - Input from user

Reactor Physics

- TRITON bug fixes as documented newsletter
  - KMART updates to correct mixture power distributions
  - KENO blocks START, VOLUME, and PLOT now work
- TRITON enhancements
  - Greatly improved runtime for large models
  - Speedup in cell data and reaction rate calculations
- Parallel capabilities
  - Threaded NEWT with OpenMP
  - Parallel branch cases with RUNNER (MPI)
- NEWT improvements
  - HTGR prismatic geometry
  - n-gamma libraries
  - CMFD
  - Better grid generation
  - Better few-group cross section generation
  - Improved output edits

Sensitivity and Uncertainty

- Improved KENO mesh and mesh volume greatly benefits TSUNAMI-3D
- TSUNAMI-2D based on NEWT is introduced
- Generalized perturbation theory calculations in 1D and 2D provide sensitivities/uncertainties due to cross sections for:
  - Flux ratios
  - Reaction rate ratios
  - Few group cross sections, etc
- TSURFER
  - Additional uncertainty edits
  - Additional plots
  - Improved output

TSURFER Output

TSURFER – Mozilla Firefox

File Edit View History Bookmarks Tools Help

file:///cpesrv/home19/qol/test/tsurfer.htmd/TSURFER.0001.html

Getting Started Latest Headlines

General Information

Messages

Input Data

Results

- Application and Bias Summary
- **Plots**
  - XS Adjustments
  - Adjust k_{eff}
  - Initial XS Covariance Matrix
  - Adjusted XS Covariance Matrix
  - Correlation

TSURFER - Adjust and Initial k_{eff} Plot

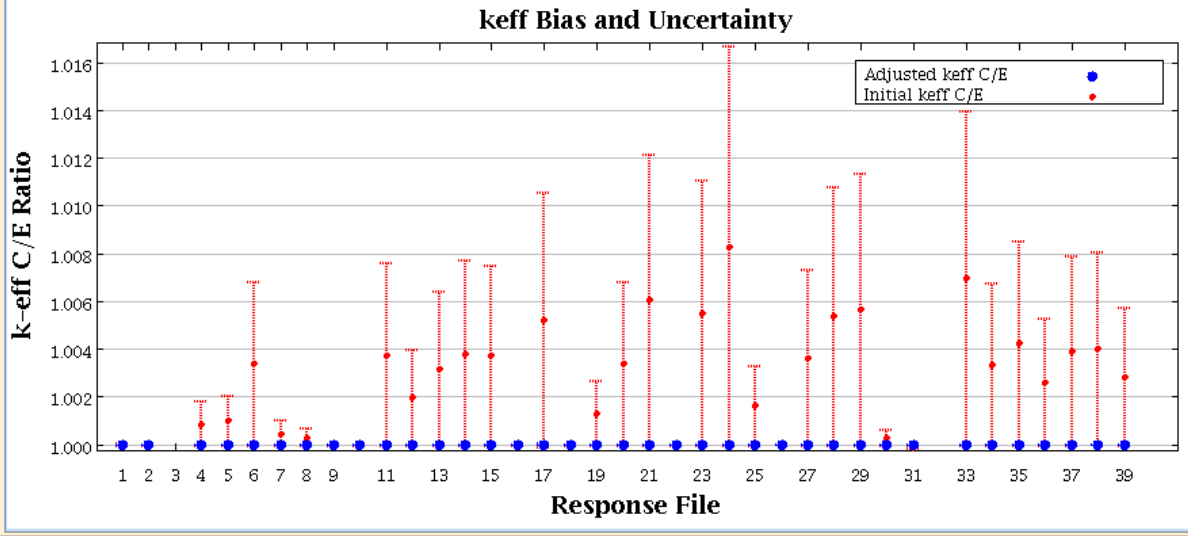
tsurfer sample problem

Plot of Adjusted and Initial k_{eff} C/E

Double-click an item on right side of window to plot, or select multiple items and right click to plot.

File Options Format Window Help

keff Bias and Uncertainty



Applet javapeno.javapeno started

OAK RIDGE National Laboratory

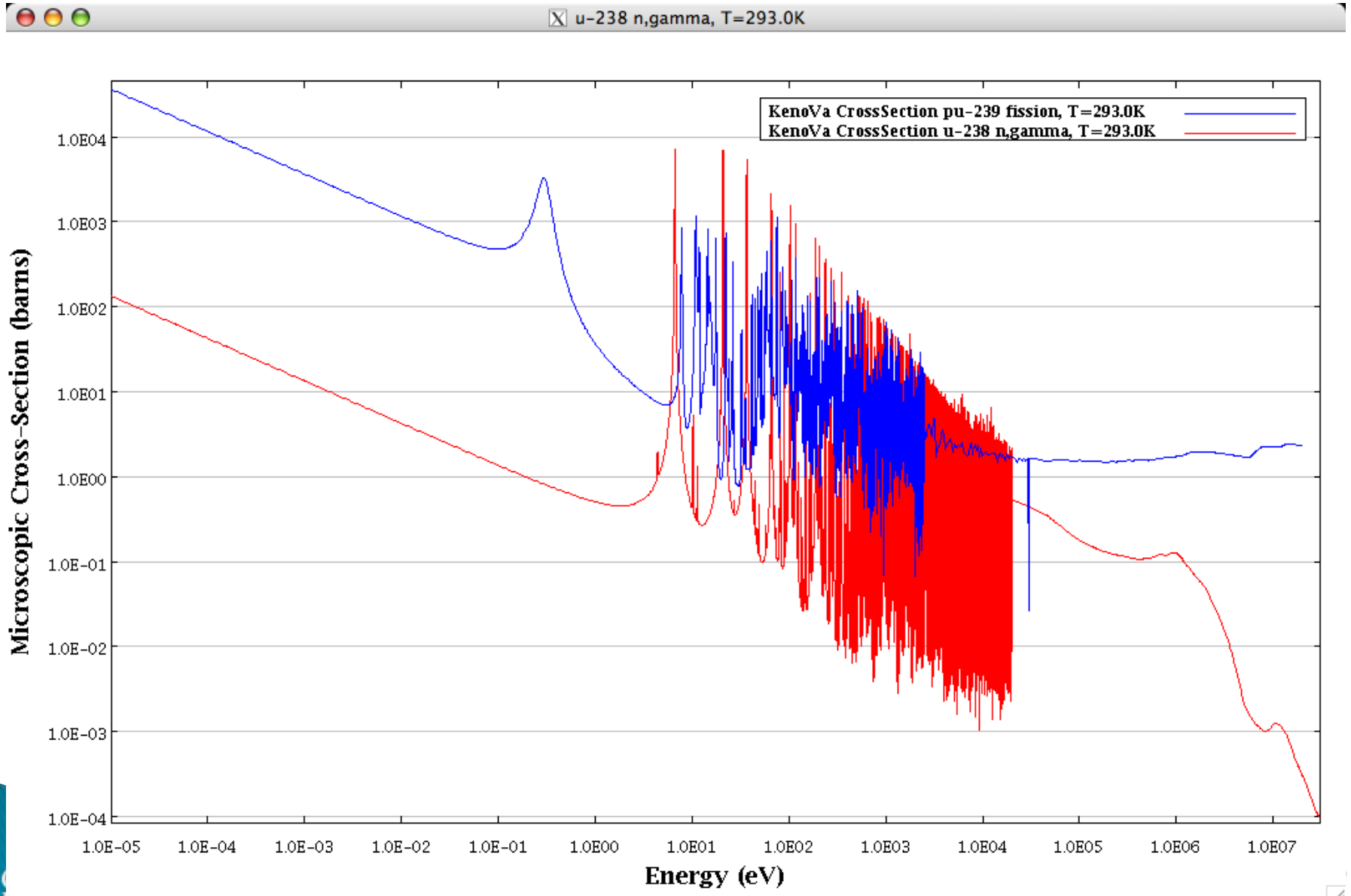
Nuclear Data

- Improved probability table data for unresolved resonance region for U and Pu
- 238-group neutron libraries
  - New weighting spectrum with modified tie-in of fission spectrum – better VHTR performance
  - Use of double-precision in AMPX routines
- ORIGEN Library
  - ENDF/B-VII decay and fission libraries with JEFF multigroup cross sections in many group structures
  - Decay libraries with 2227 nuclides
    - 174 actinides
    - 1149 fission products
    - 904 structural activation materials
- Coupled n-gamma libraries
  - Many improvements in gamma yield data

Graphical User Interfaces

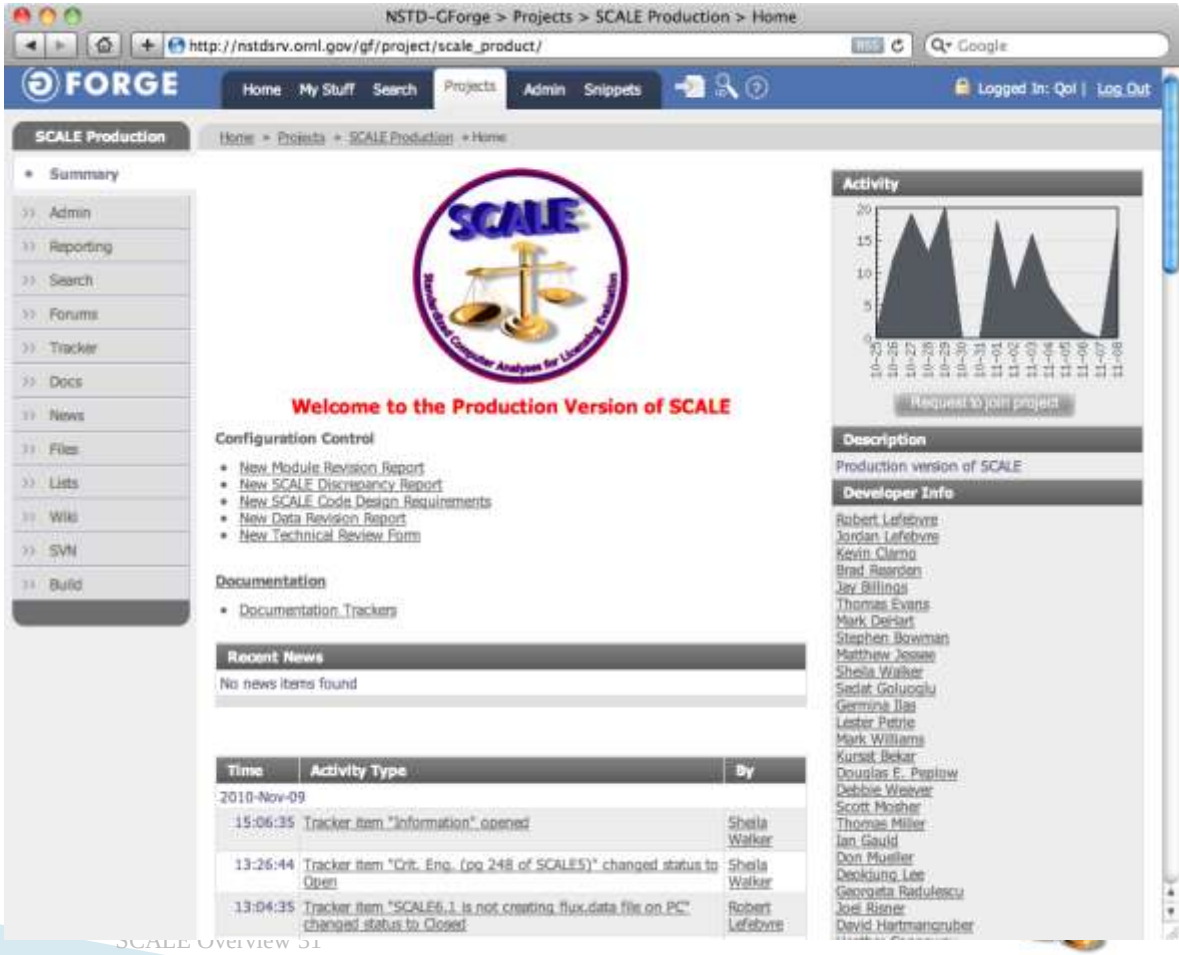
- GeeWiz
  - Substantial improvement in functionality and stability
  - Added code support
    - STARBUCS
    - TRITON
    - MAVRIC enhancements
    - TSUNAMI-GPT
- Javapeño
  - CE KENO cross section plotting
  - OPUS plotting (replaces PlotOPUS)
  - NEWT contour plots
  - Custom installer

Continuous-energy Plot



Infrastructure Moderization

- GForge
  - Collaborative development environment with web interface.
  - All issues can be identified and tracked.
  - SCALE QA now conducted and tracked within GForge
  - SCALE development ideas and issues are easily tracked to resolution
  - SCALE Help migrated to GForge

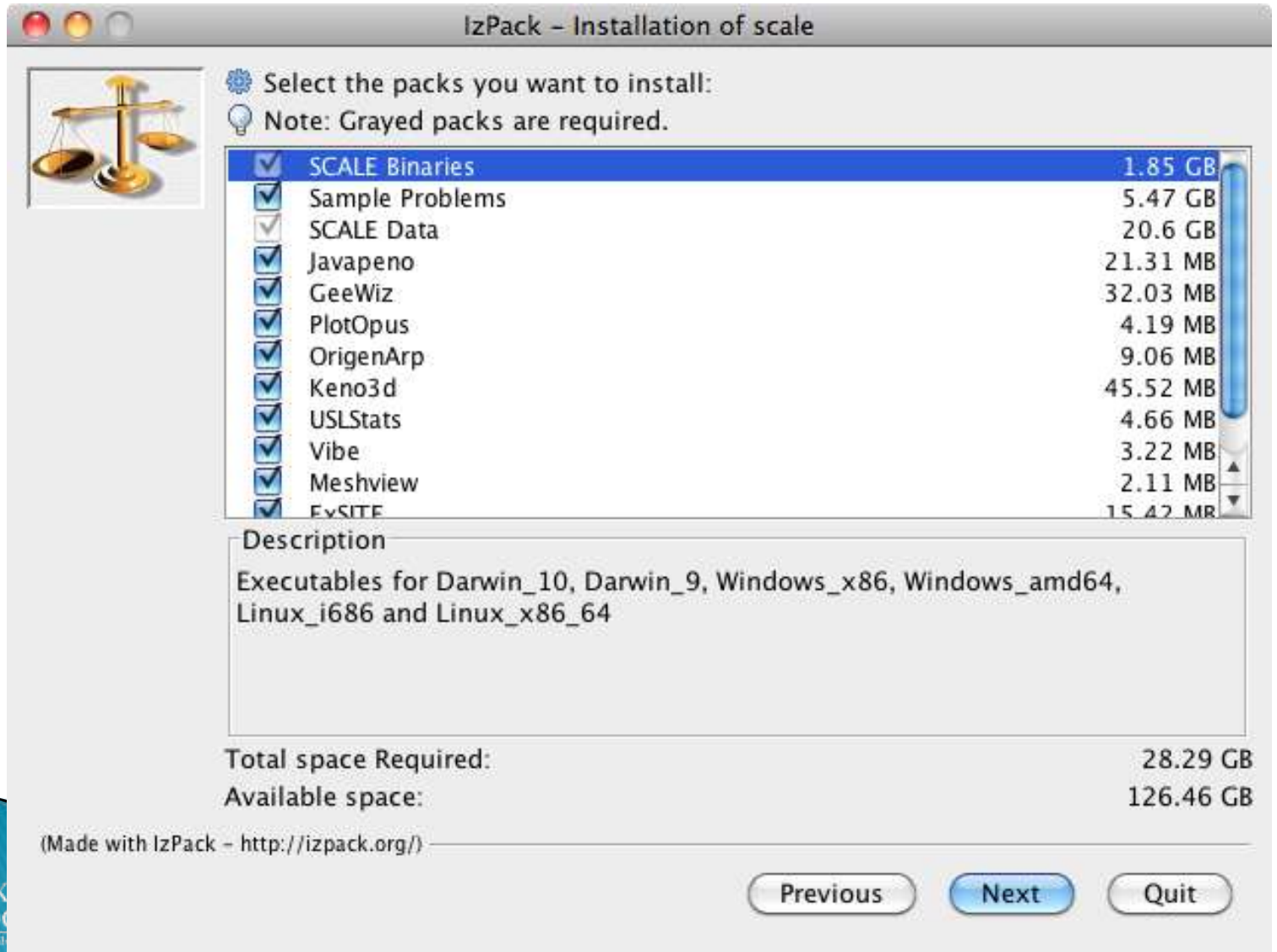


Infrastructure Moderization

- Build system
  - CMake build system
  - Same code and build system will be used on all platforms, Linux, Mac, Windows
  - 64-bit Windows build for first time
  - Supported platforms:
    - Linux 32- and 64-bit
    - Mac 32- and 64-bit
    - Windows 32- and 64-bit

New Installer

- Consistent experience on Linux, Mac, Windows



Schedule

- SCALE 6.1 beta sent to limited distribution
- Delivery to RSICC by end of November
- Distribution to end-users after a few weeks of testing at RSICC
  - Likely late 2010 or early 2011


SCALE
Standardized Computer Analyses for Licensing Evaluation