

KENO: Visualizing Models and Data

SCALE 6.3.1

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

Learning Objectives

- Describe different methods of visualizing data and geometry associated with KENO models
- Demonstrate how these tools can be used for error checking
- Provide examples for further study to allow for optimization of data/geometry presentation within the SCALE system

Outline

- Sub module 1: Running SCALE
- Sub module 2: Basic model visualization (Fulcrum 2D & 3D)
- Sub module 3: Results visualization (3dmap)
- Sub module 4: Plotting cross sections

Sub module 1: **Running SCALE**



Command line options

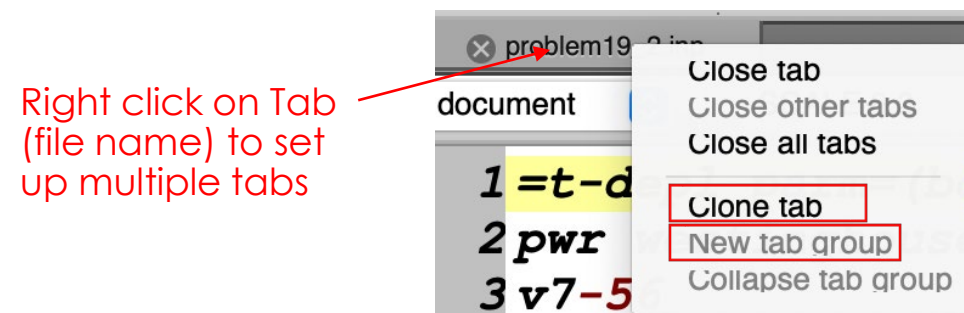
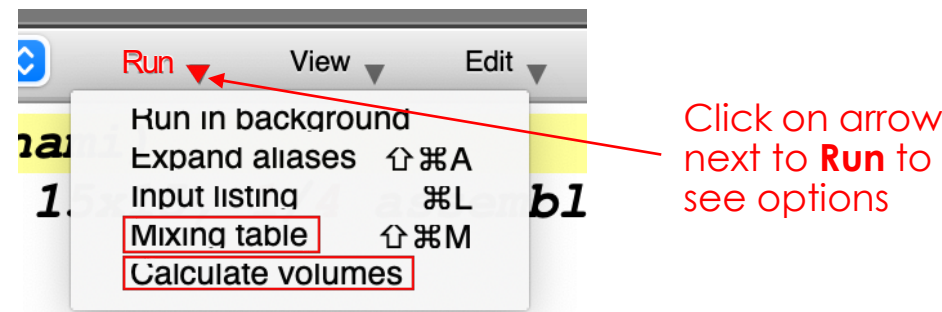
- SCALE is executed by the SCALE runtime environment (scalerte)
 - Located in the SCALE install directory under “bin”
- Command line options:
 - Specify the full path, e.g.,
`/coolcodes/scale-6.3.1/bin/scalerte myinput.inp`
 - Add an alias to scalerte in your shell settings file
`alias scale6.3.1="/coolcodes/scale-6.3.1/bin/scalerte"`
 - Basically the same on PC, just different syntax e.g. `c:\scale-6.3.1\bin\scalerte`
 - Can also drag and drop onto scalerte or scalerte shortcut

Fulcrum

- Platform-independent!
- Graphical user interface and integrated development environment for SCALE input files
- Looks like a text editor, but it's more powerful
 - Syntax highlighting and input checking
 - Integrated geometry visualization
 - Expression evaluation
- Run SCALE directly from Fulcrum
- View messages and/or text output in Fulcrum
- Access files associated with those already opened

Fulcrum cheat sheet

- Shortcuts:
 - **CTRL+SPACE** – auto-completion
 - **CTRL+/**** (Windows/Linux) **CMD+/**** (Mac) – comment in/out input lines
 - **CTRL+E** (Windows/Linux) **CMD+E** (Mac) – evaluate selected mathematical expression
 - **ALT+MOUSE SELECTION** – column-wise text selection and modification
 - **SHIFT+ENTER** – jump to next row, start at indentation of current row
- Input check:
 - **Validation** window through lower right corner
 - **View** geometry
- Additional features:
 - **Run > Mixing table** – Check compositions through mixing table
 - **Run > Calculate volumes** – Calculate volumes
 - **Right click on tab > New tab group** – Use side-by-side view through multiple tabs
 - **Right click in Mesh panel within geometry visualization** – Allows loading of new mesh data for data overlay
 - **Right click in the Messages panel** – Allows termination of running jobs



- Notes:
 - Auto-completion does not work if there is a validation error (including incomplete input) above the current location
 - Validation of *array* input is limited and cannot check (1) the consistency between number of specified elements vs. provided unit number and (2) whether or not the array completely fills a shape → use visualization and run problem with *parm=(check)*
 - Validation of *hole* placement is limited and cannot check overlap between holes or holes with other shapes → use visualization and run problem with *parm=(check)*

Execute options

scalerte **[-options] inputfile** **OR** scalerte **inputfile [-options]**

where **-options** is

- m:** Turn messages on
- r:** Keep the temporary directory
- T:** Specify the temporary directory (implies **-r**). **-T /dir/path/**
- l:** Number of threads used for multi-core processors
- z:** Add the date to the output file name
(makes output name unique)

Example: **scalerte -m -T ./inputfile.tmp inputfile**

Other features

- Many more runtime options are available
 - "Running SCALE" section of the SCALE 6.3.1 Manual <https://scale-manual.ornl.gov/installing-building.html#scale-variables>
 - Or type **scalerte** (no options or filenames) on the command line to see a list of the available options on your system
- All these features and additional features can be used
- You can use wildcards to run multiple files or add multiple files to run to the command line

Examples:

```
scalerte mycase1.inp &  
scalerte -m -I 4 mycase1.inp mycase2.inp mycase3.inp  
scalerte -m -T 4 mycase*inp
```

run in background

run multiple files

Other useful info

- When SCALE executes, by default it creates a temporary working directory to store files
 - While job is still running, *tempdir.path* file gives path to working directory
 - Also printed in msg file and output file
 - Starting with SCALE 6.2, output file is in OUTDIR during execution, so checking progress no longer requires navigating to TMPDIR
- Have a long-running KENO job you want to wrap up and keep what has already been calculated?
 - Create a file named **stop_keno** in the temporary working directory (TMPDIR); the file need not contain anything
 - KENO will stop running at the end of the current generation and cleanly wrap up, generating all output and data files

Other useful info (cont.)

- Use the SCALE environment variables and the shell command to save files from the temporary directory
 - `OUTDIR`, `TMPDIR`, `BASENAME` are most commonly used
 - Precede environment variable with “\$” and enclose the environment variable in curly braces: `${OUTDIR}`
 - `OUTDIR` should be used instead of `RTNDR`
- “<” character can be used for file injection of external files
- Example: use the shell command to link and file inject composition definitions

```
=shell
  ln -s /user/coolcodes/composition.txt comp.txt
end
...
=csas5
...
read composition
<comp.txt
end composition
```

Output files

- Most of the important information (if not all, for particular problems) can be found in the “.out” file
 - Every SCALE run creates a .out file, and most of the results are stored in this file, including most error messages
 - For KENO sequences*, an HTML version of the output file that can be opened in a browser is also created by default: *BASENAME.html*
- The messages file “.msg” contains information printed to the screen: this file can provide useful error messages that may not be contained in the output file
 - Note that on Windows this file extension is associated with Outlook, which can't open it: you'll need to “open with” Fulcrum, Wordpad, or other text editor

*For Windows, SCALE 6.3.0 and 6.3.1 will create an html file but it will be empty. Functions on Linux and Mac and in 6.3.2. A fix is available to implement.

Sub module 2: **Basic model visualization (Fulcrum 2D & 3D)**



Fulcrum plots

- Interactive, quick and easy to generate while editing a model
- Navigate to “geometry” in file structure, right click -> visualize
 - OR Ctrl+Shift+V (visualize) OR click view -> geometry
- XY, XZ, and YZ planes are available with sliders to move through geometry
- 3D visualization new with SCALE 6.3.1
- Provides global coordinates of mouse pointer tip
- Can position cut plane precisely by setting origin
- Zoom: click upper left/lower right, or use zoom factor field
- Shift+click to pan

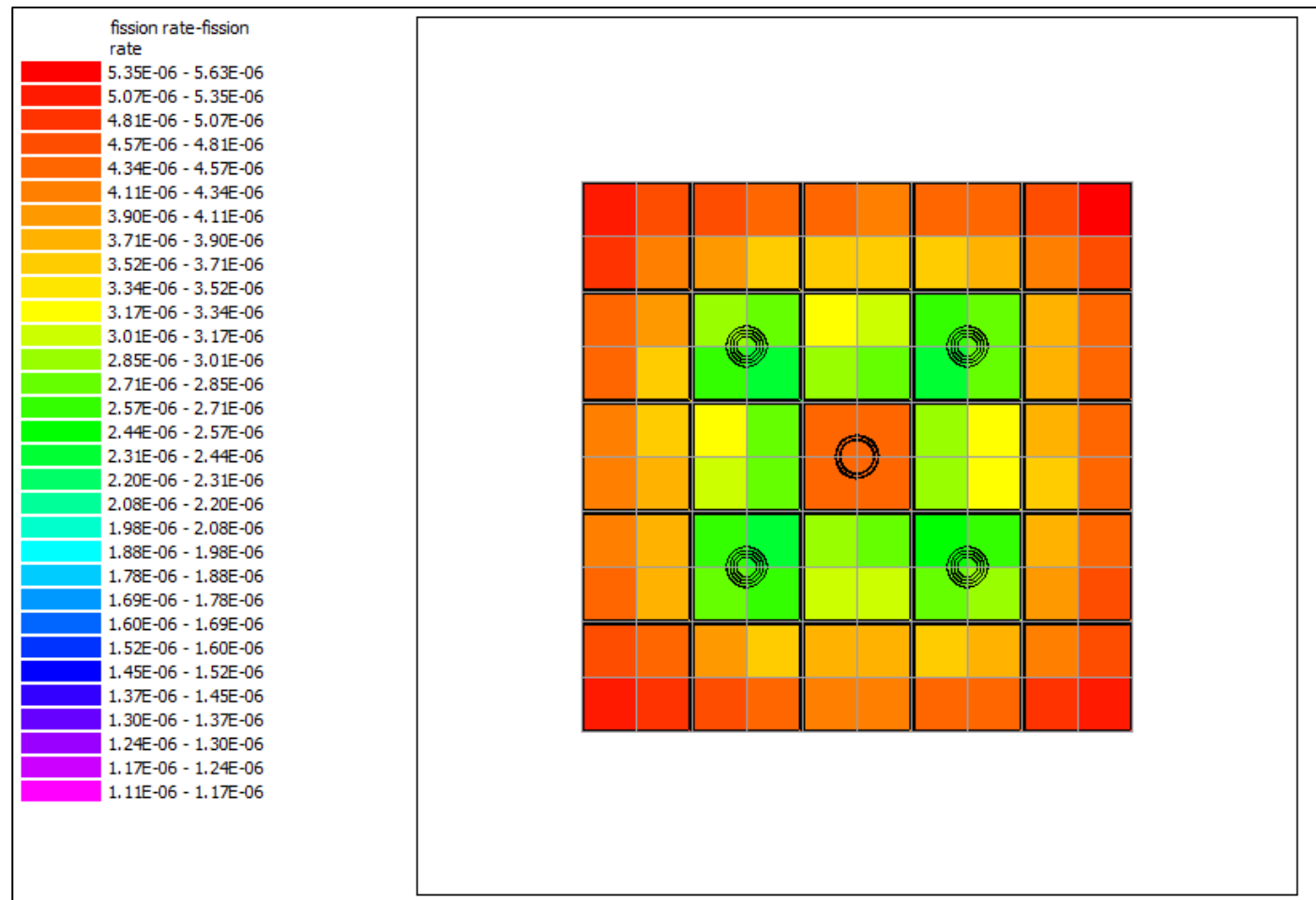
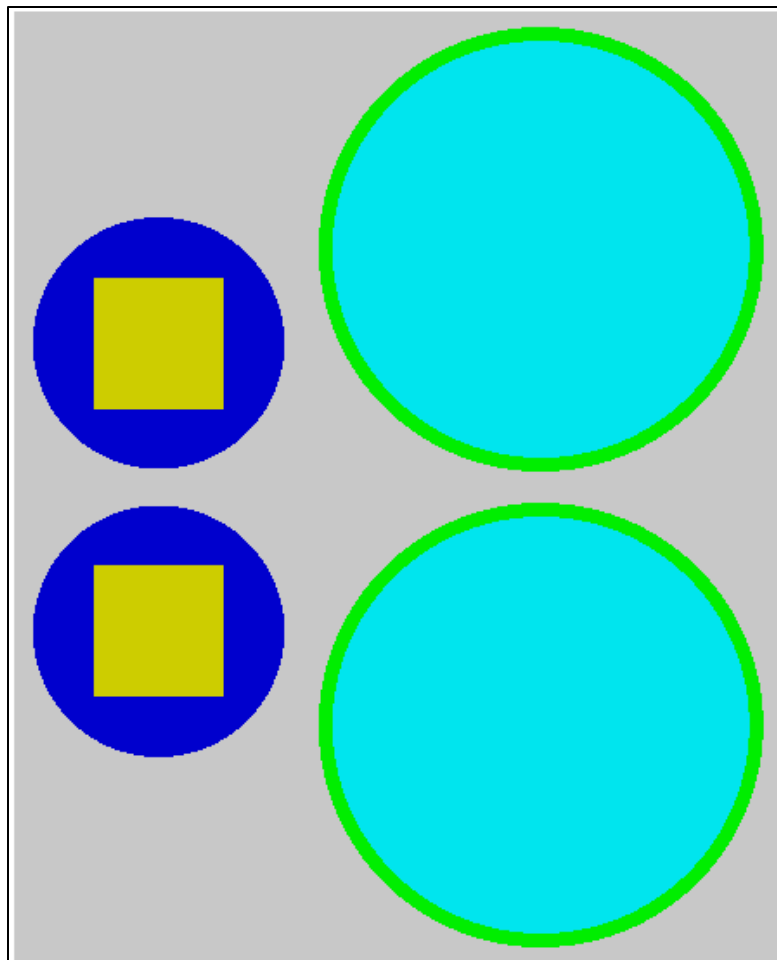
More about Fulcrum plots

- Can visualize mesh-based data (3dmap files) on real geometry
- Can select to display outline or not along with material, overlay or neither
- Click and drag to left to reset frame
- Right-click on figure to change colors or save image
 - Hide materials when in 3D view

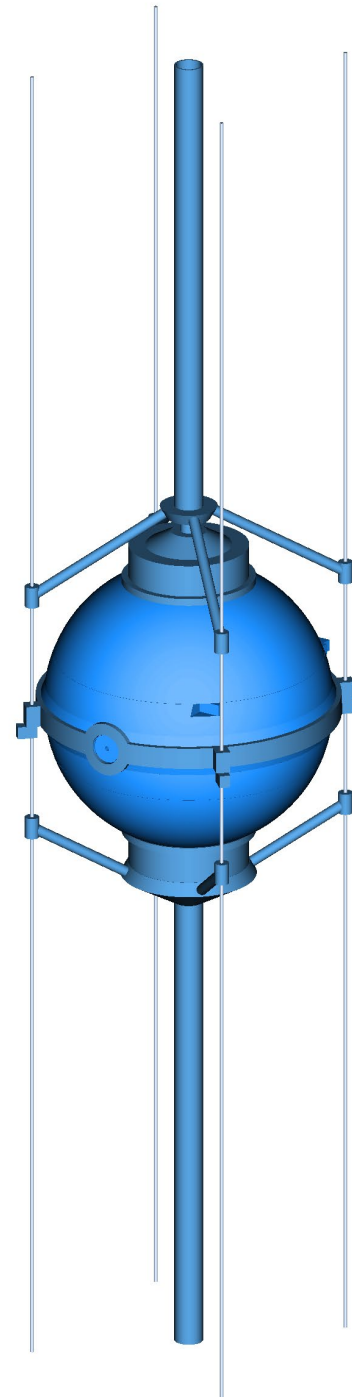
More about Fulcrum plots

- Can visualize mesh-based data (3dmap files) on real geometry
- Can select to display outline or not along with material, overlay, or neither
- Reset of frame in 2D is click and drag to left
- Right-click on figure to change colors or save image
 - Hide materials when in 3D view

Some Fulcrum plots

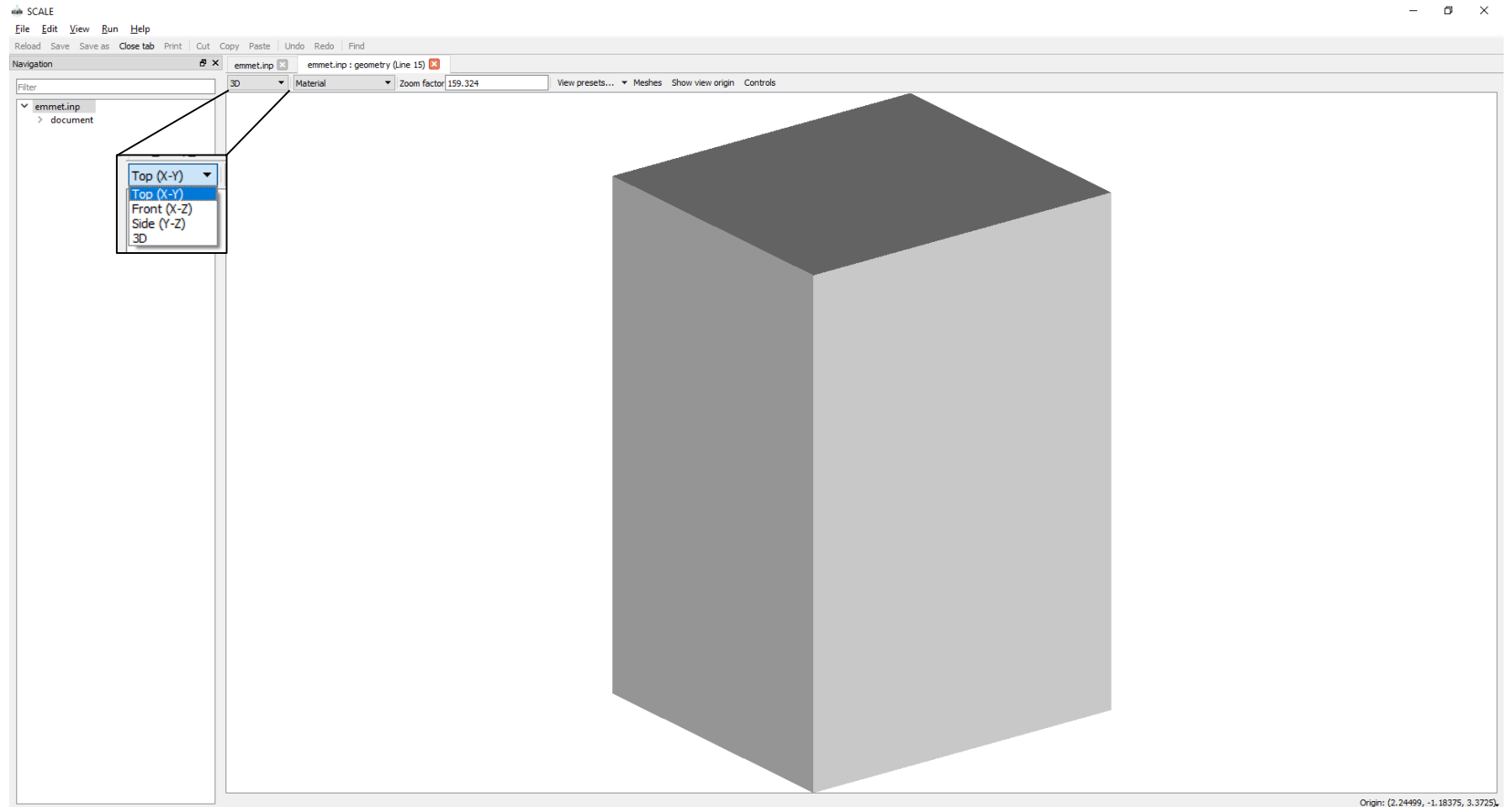


Some Fulcrum plots

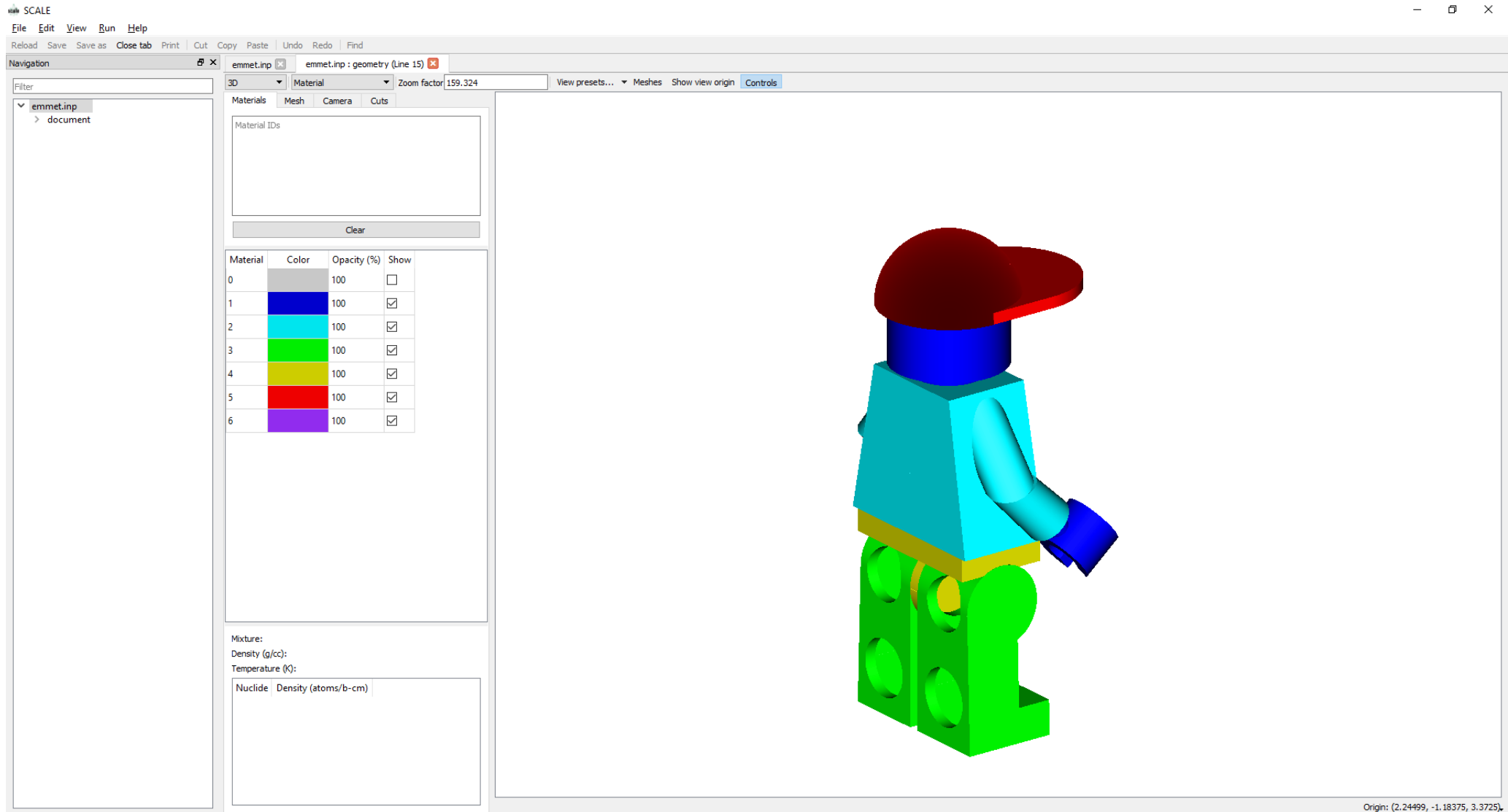


Fulcrum visualization

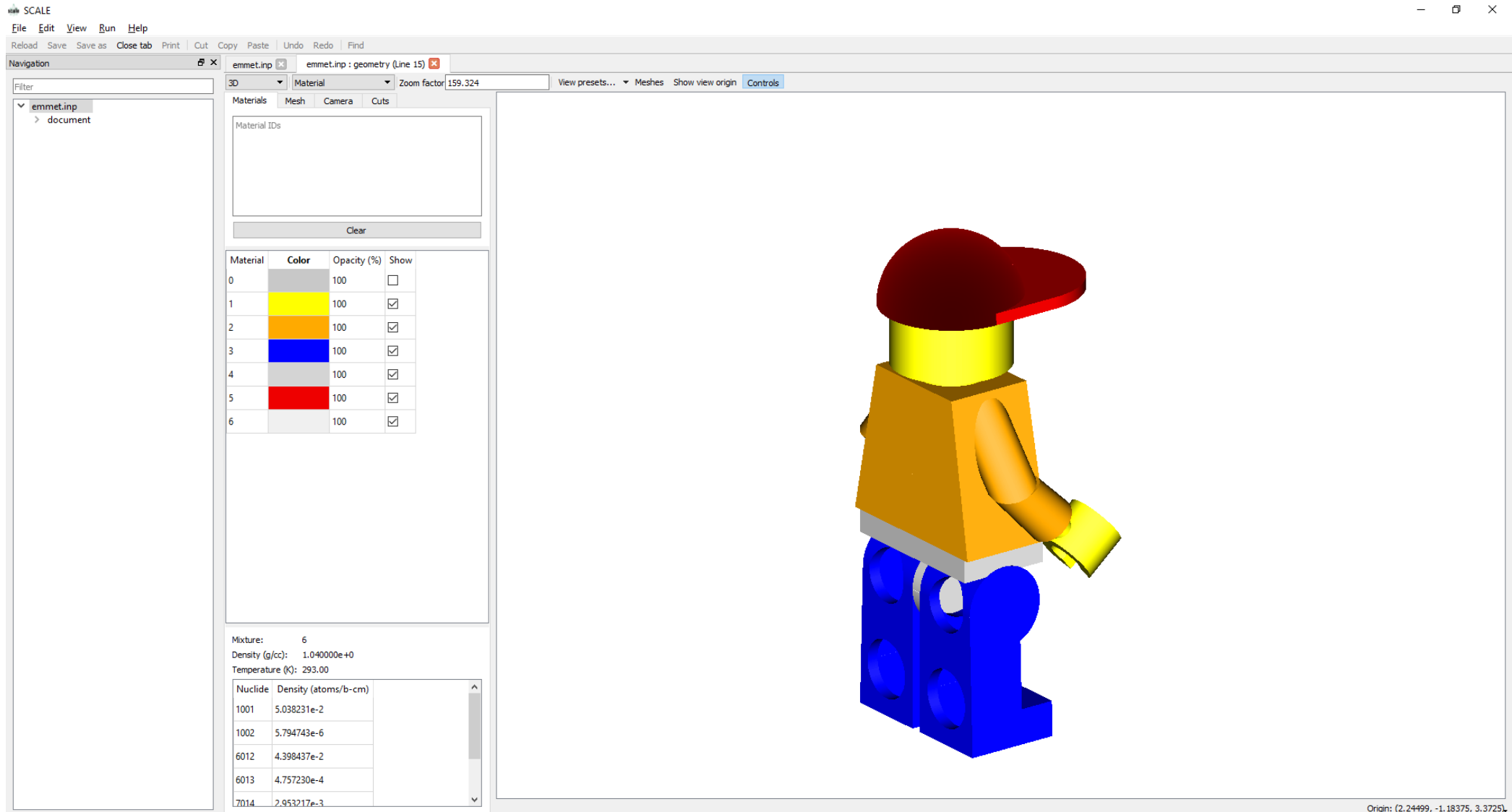
- Click “Controls” just above middle of view pane
- Defaults to “Materials”
- Uncheck void (Mix. 0)



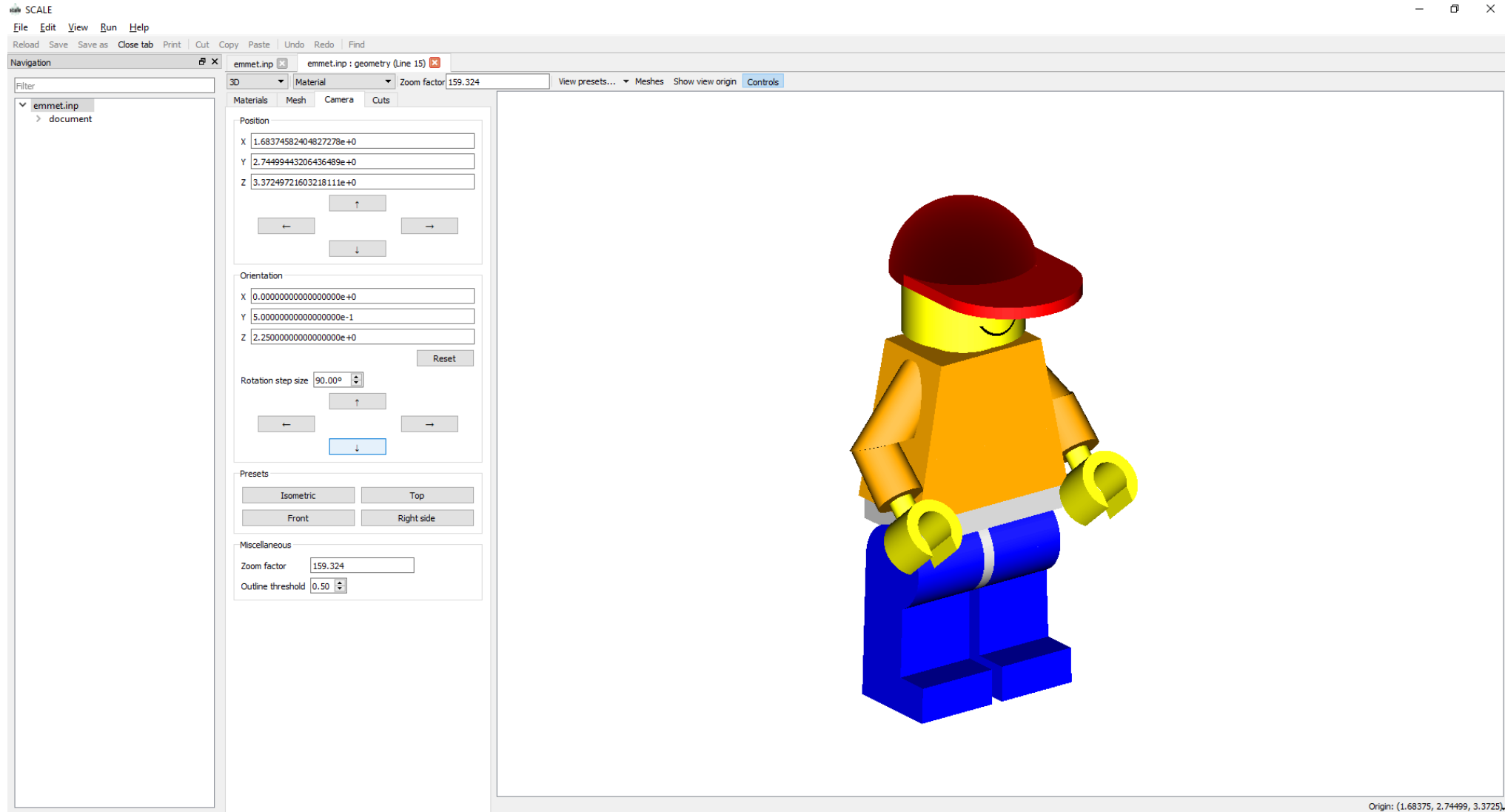
The statue emerges from the block



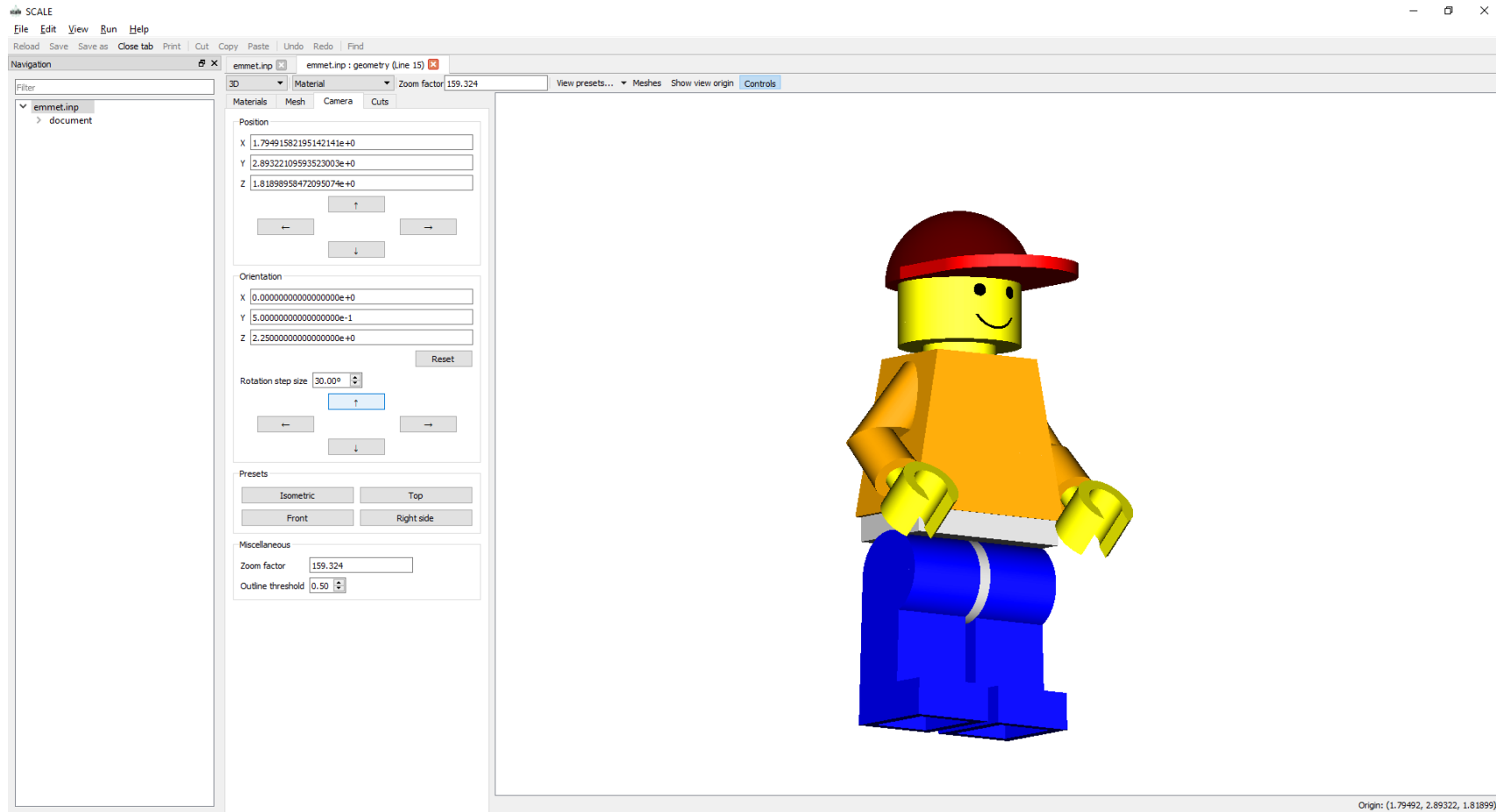
Right-click on image, select number → change color



Click on camera, rotation step 90°, click left arrow (←)

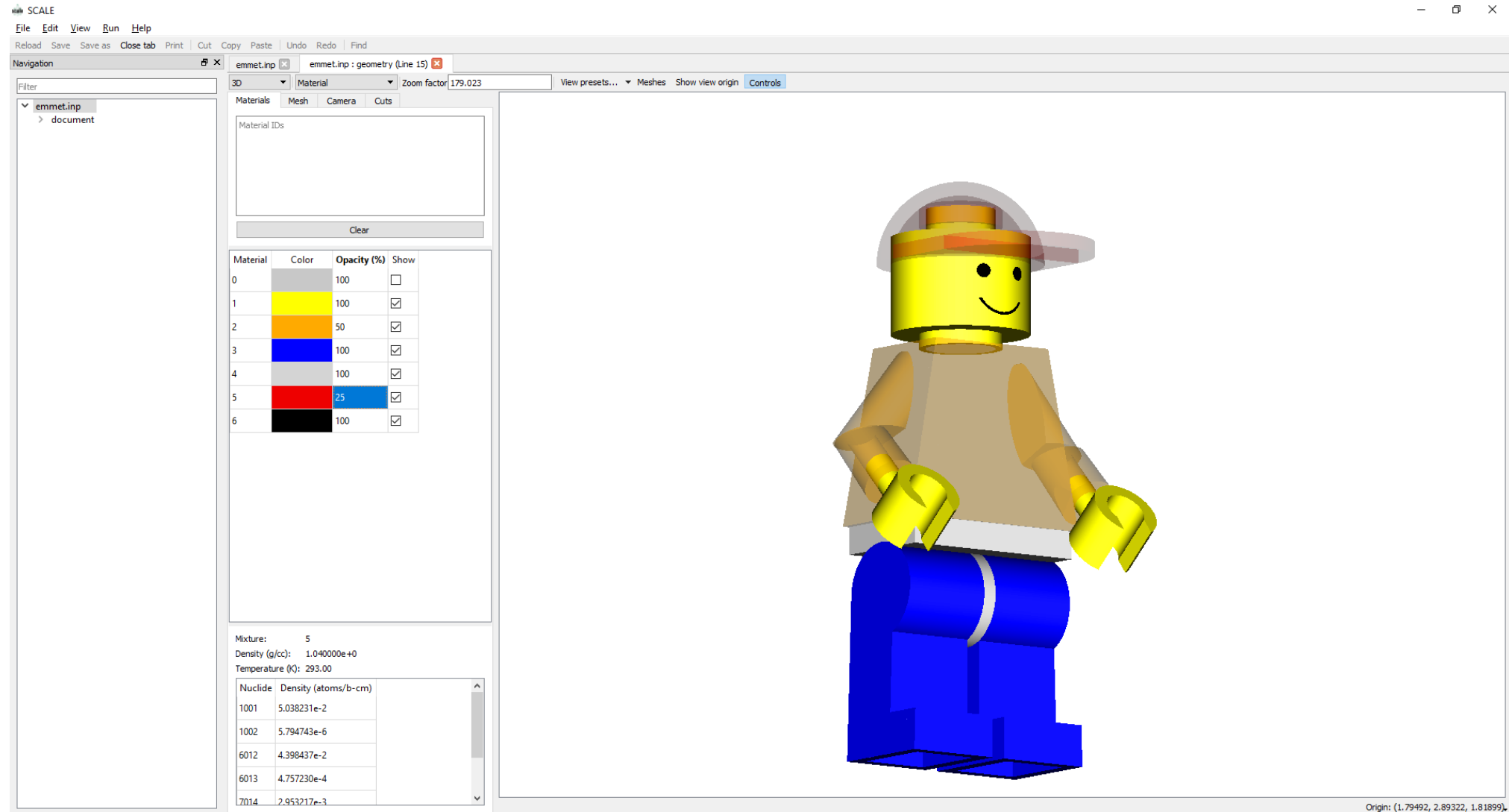


Set rotation step 30°, click up arrow (↑)



Everything is awesome!

Can also change material opacity



Modification of cuts

- After cut is made:
 - Click on cut in top pane
 - Make changes to cut in middle pane
 - Click save at bottom right
- OR:
 - Click remove just below top pane
- Cuts can also be named for convenience

Name	Style	Description
New cut	Block	Left-half, clamped

Remove

Cut name: New cut

Cut style

☒ Block Left half

☐ Pie slice X-axis Angle: 60.0000°

Clamp to bounding box ☒

Cut offsets

X: 0.0000000000000000e+0

Y: 0.0000000000000000e+0

Z: 0.0000000000000000e+0

Rotation

A1: 0.0000°

A2: 0.0000°

A3: 0.0000°

These angles correspond to the Euler angle convention.

- A1: rotation about Z
- A2: rotation about X'
- A3: rotation about Z''

Add Save

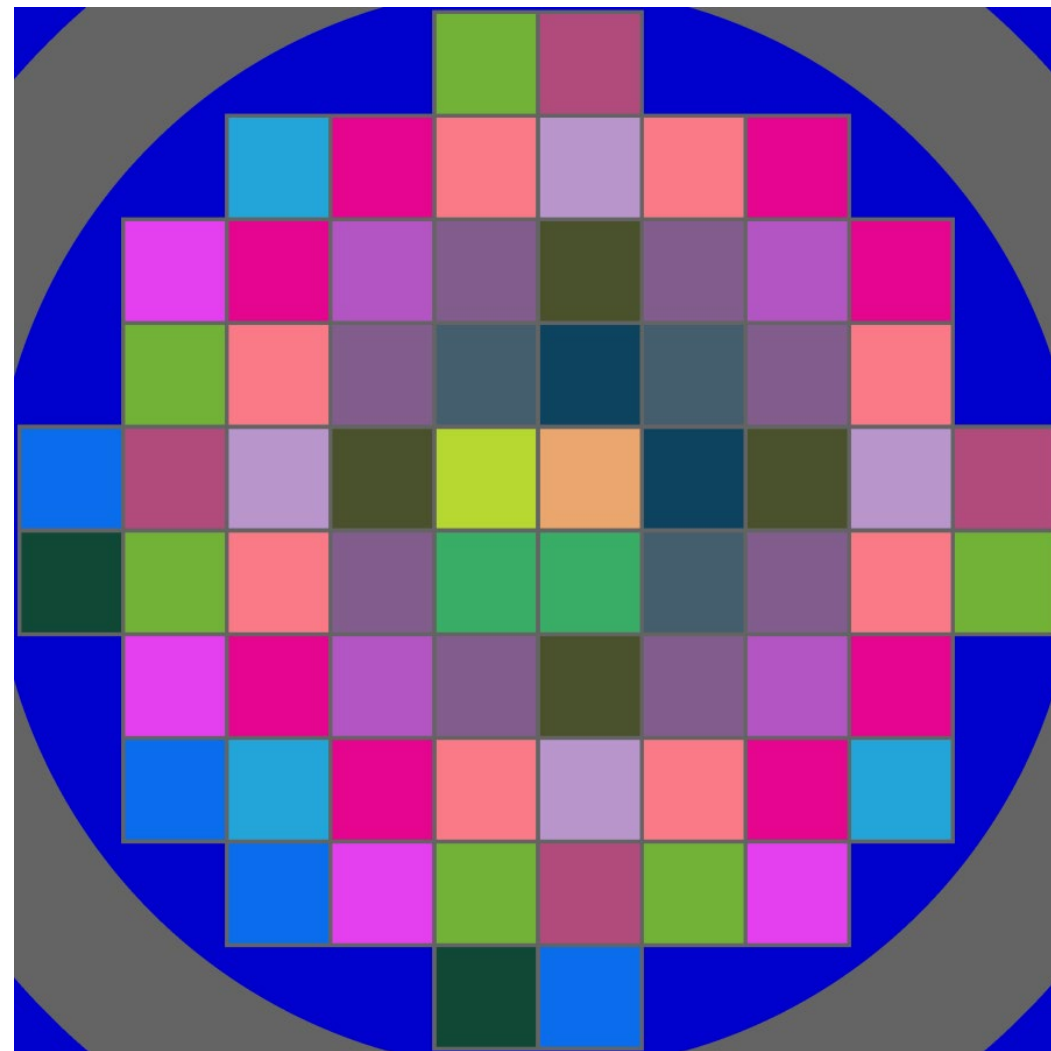
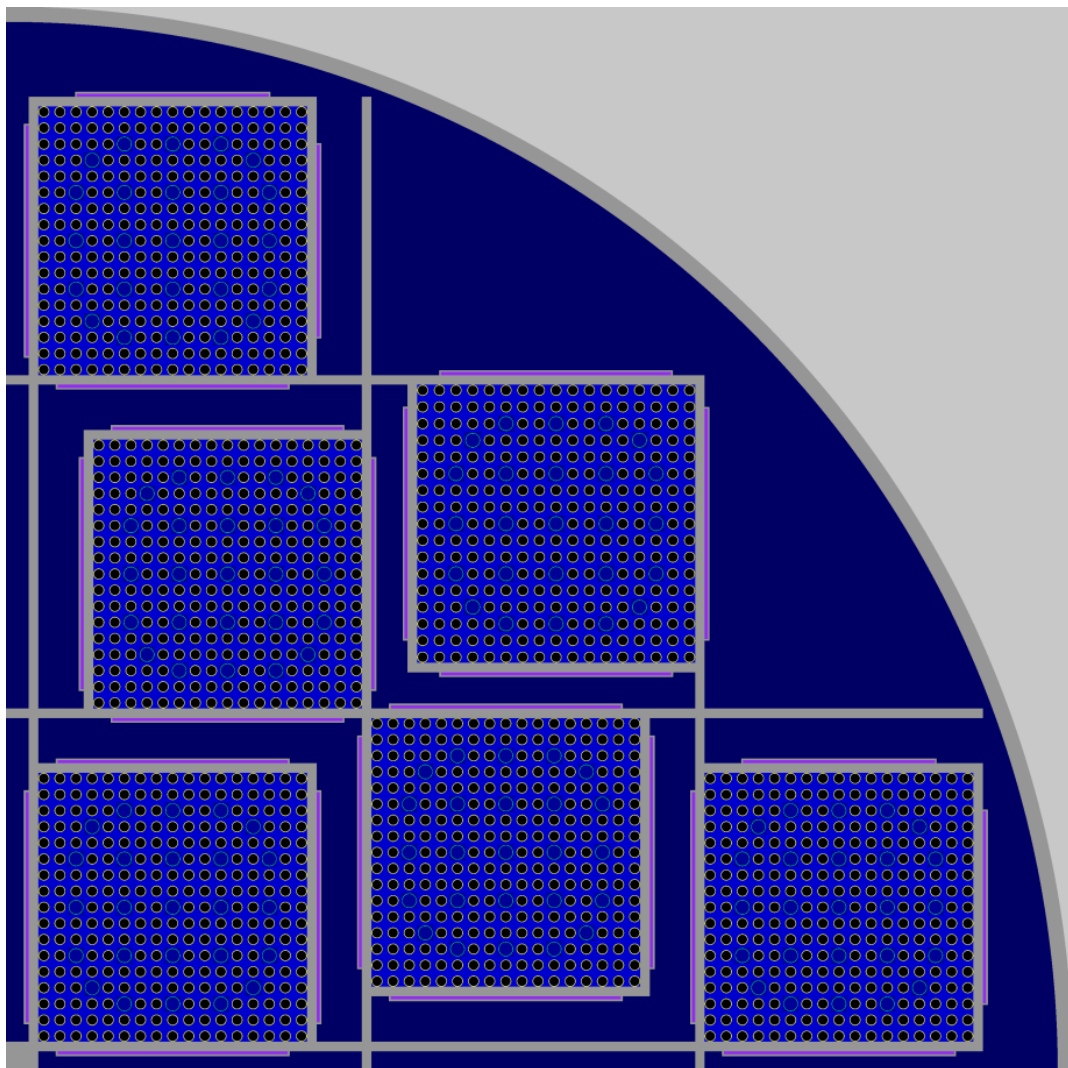
Create 2D slice plots of geometry

- Define upper left and lower right corners of rectangle in global geometry to trace picture
 - XUL, YUL, ZUL and XLR, YLR, ZLR
- Select orientation of plot
 - Typ=xy, yz, xz (EASIER)
 - Or specify direction cosines uax and vdn (HARDER)
- Specify number of pixels across OR down
 - nax or ndn – larger numbers more resolution

Colors in 2D plots

- Ordered quadruplets of mixture #, RGB values
- Format:
 - CLR= MX# R G B MX# R G B ... END COLOR
- As in other parts of SCALE, void is mixture 0
- The same color can be applied to multiple mixtures
- Example:
 - clr=1 0 0 0 2 230 230 120 3 0 0 205 end color
- Default/sample color codes in Table 8.1.22 of the manual

Example 2D plots



Sub module 3: **Results visualization (3dmap)**



Mesh tally plotting

- Fission source mesh tally developed for use with Monaco in criticality accident alarm system (CAAS) analysis
- Expanded in SCALE 6.2 with multiple mesh capabilities
- Tally results generated in 3dmap file, which can be used for visualization in Fulcrum
- Available tally quantities:
 - Fission neutron production (CDS)
 - Flux averaged over voxel (GFX)
 - New in SCALE 6.3: Fission rate averaged over voxel (FIS)

Grid geometry specification

- Specify tally mesh in Grid block
 - Can specify xplanes, yplanes, and zplanes
 - Provide xlinear, ylinear, zlinear
 - Or both – SCALE will remove duplicates
 - Example:

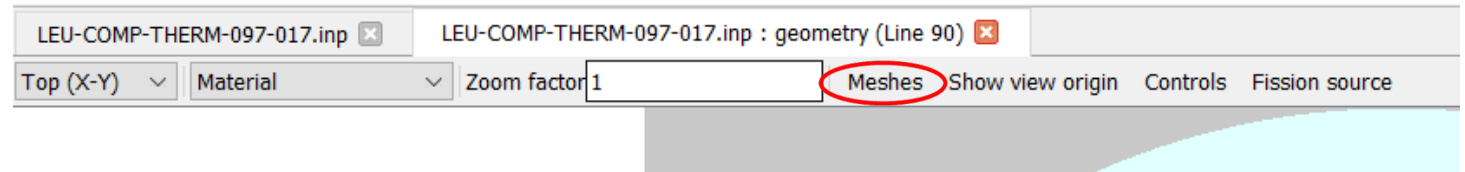
```
read grid
  xplanes=2p8 2p7 2p6 2p5 2p4 2p3 2p2 2p1 0 2p39.6 end
  yplanes=2p8 2p7 2p6 2p5 2p4 2p3 2p2 2p1 0 2p39.6 end
  zplanes=-30.6 60.1 end
  zlinear 30 0 30
end grid
```

- Each grid must be specified in a separate block

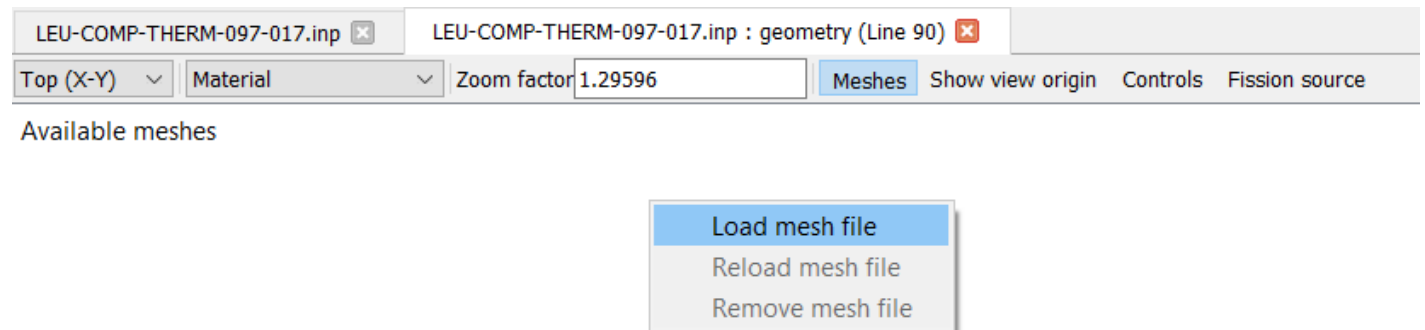
Visualization

- *BaseName.fissionSource.3dmap* file generated and returned
- Can be opened in Fulcrum

– Click meshes button:

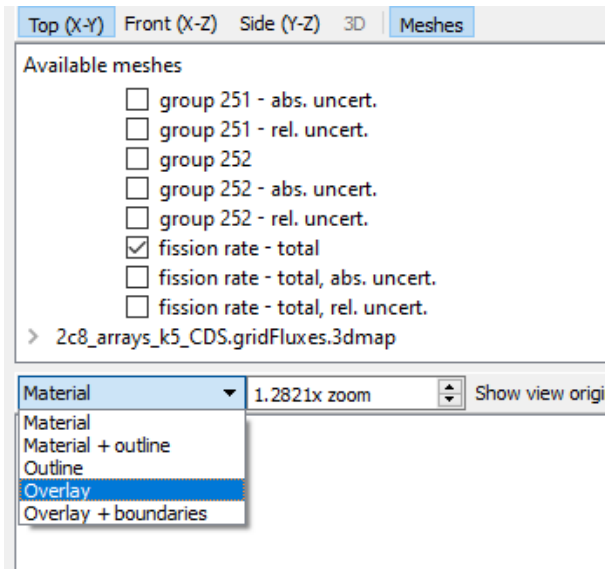
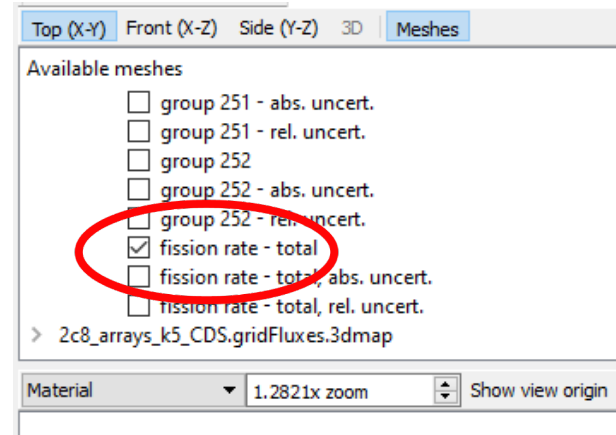


– Right-click -> Load mesh file:



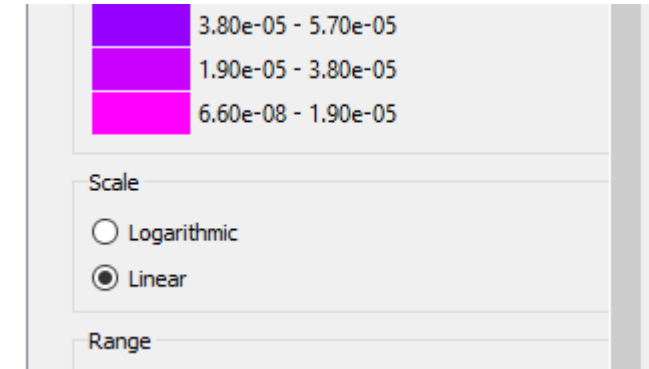
Visualization (cont.)

- Select quantity to display:
- Display data overlay or overlay and mesh boundaries
 - Overlay vs. Overlay+Boundaries

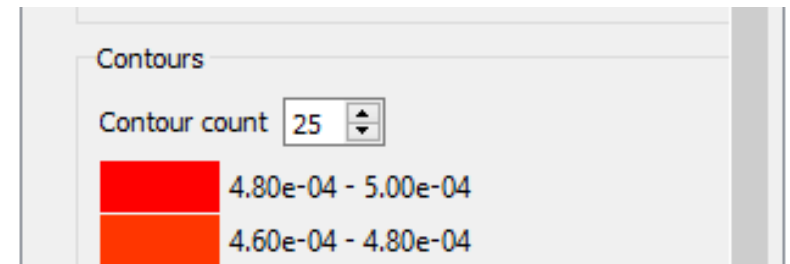


Visualization (cont.)

- Probably want color scale to be linear
- Can set data range for color display
 - Select “Custom” from drop down
 - Type desired min and max values in appropriate fields
- Set number of color fields
 - Can combine with range to make convenient bins

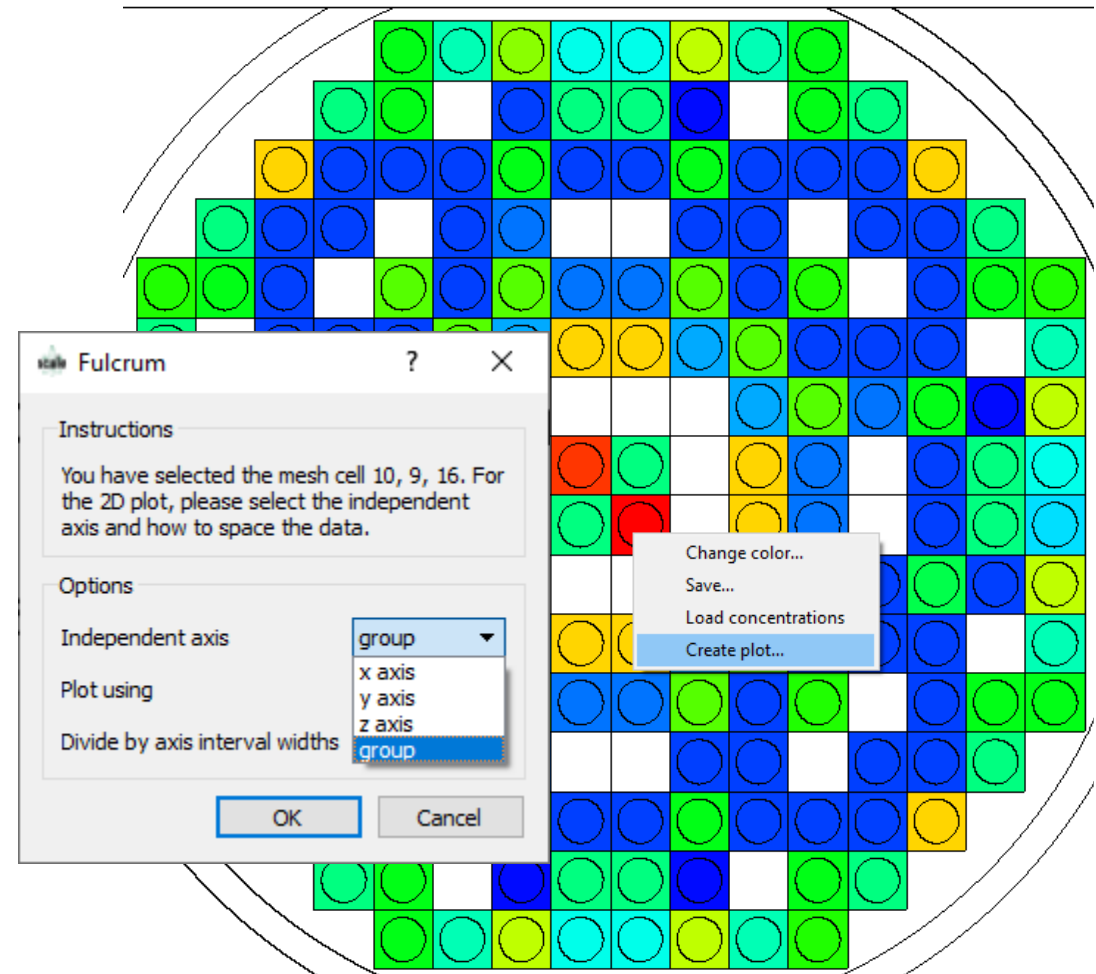
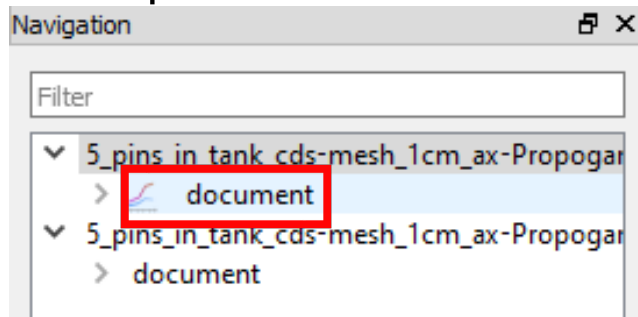


A 'Range' configuration panel. The 'Source' dropdown is set to 'Custom'. The 'Maximum' field contains the value 5.000000000000000e-04, and the 'Minimum' field contains the value 1.000000000000000e-09.

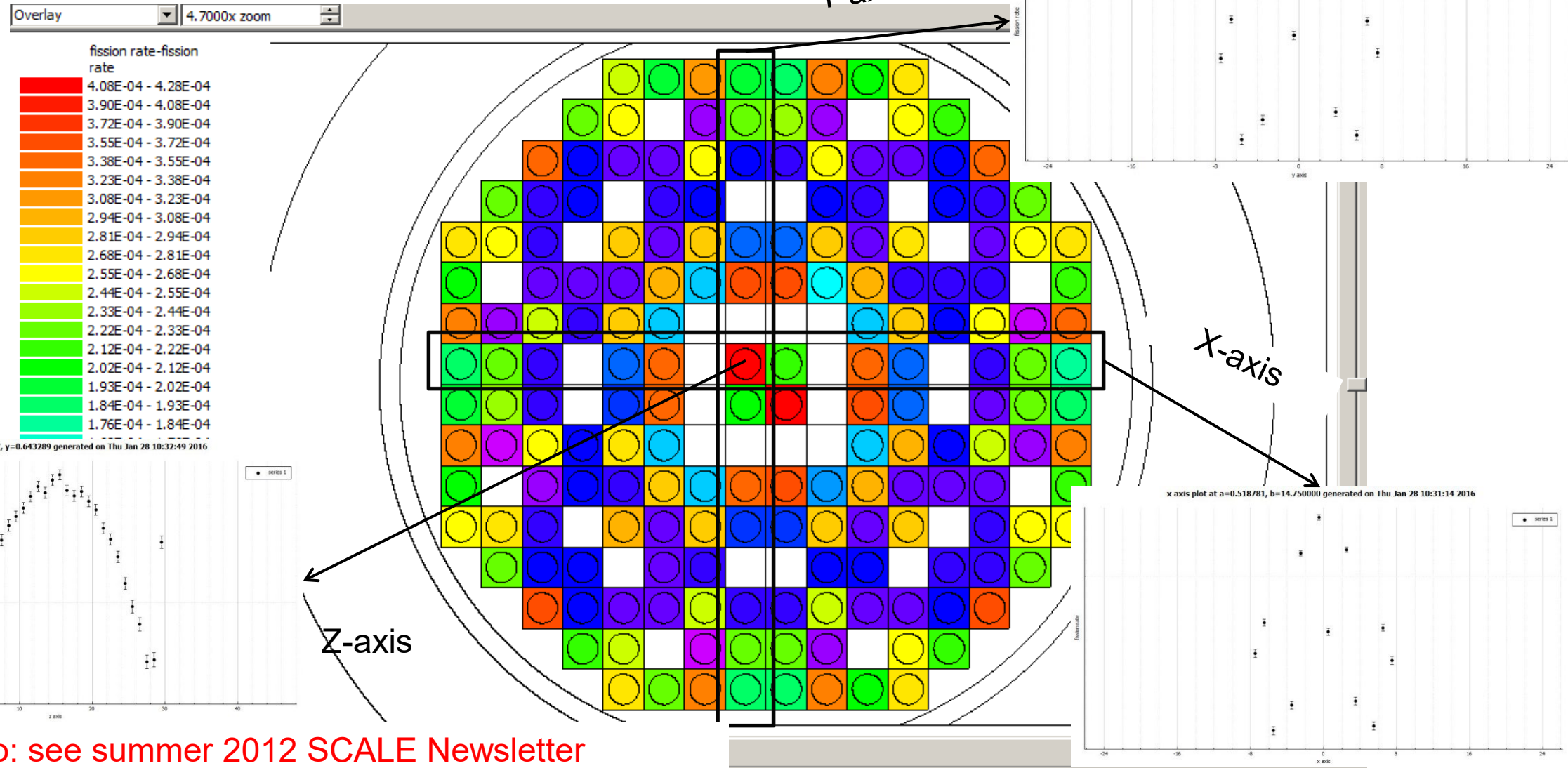


Visualization (continued even more)

- Can create 2D plot along X, Y, or Z axis
 - Right-click in desired location -> Create plot -> Independent axis
- Creates and opens new 2D plot (in ptp format) to be visualized within Fulcrum
 - Double-click on “Document” to generate plot



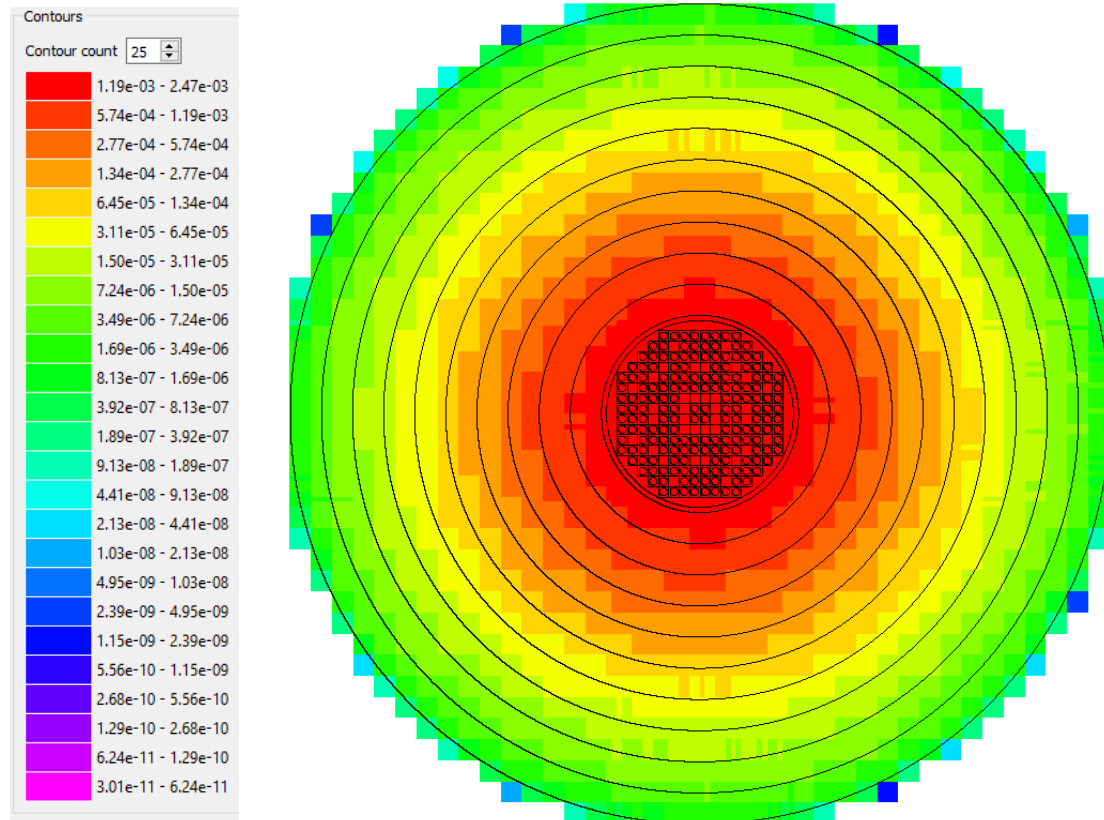
Example CDS plots



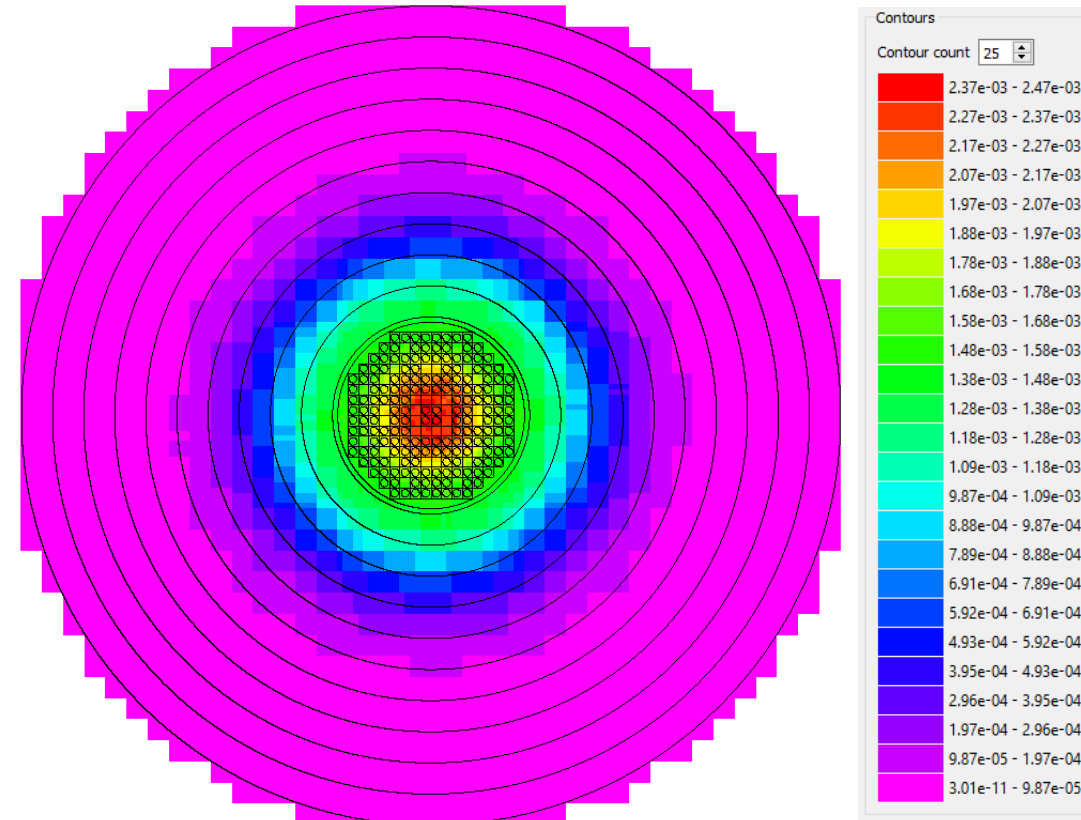
Also: see summer 2012 SCALE Newsletter

Example GFX plots

Logarithmic scale

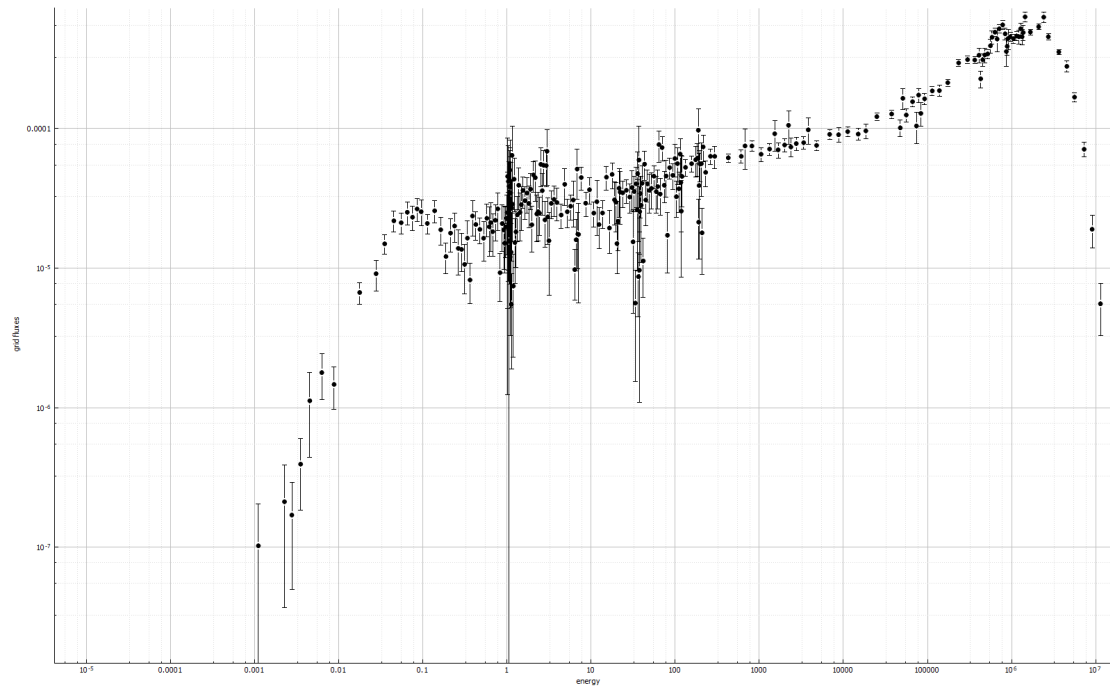


Linear scale

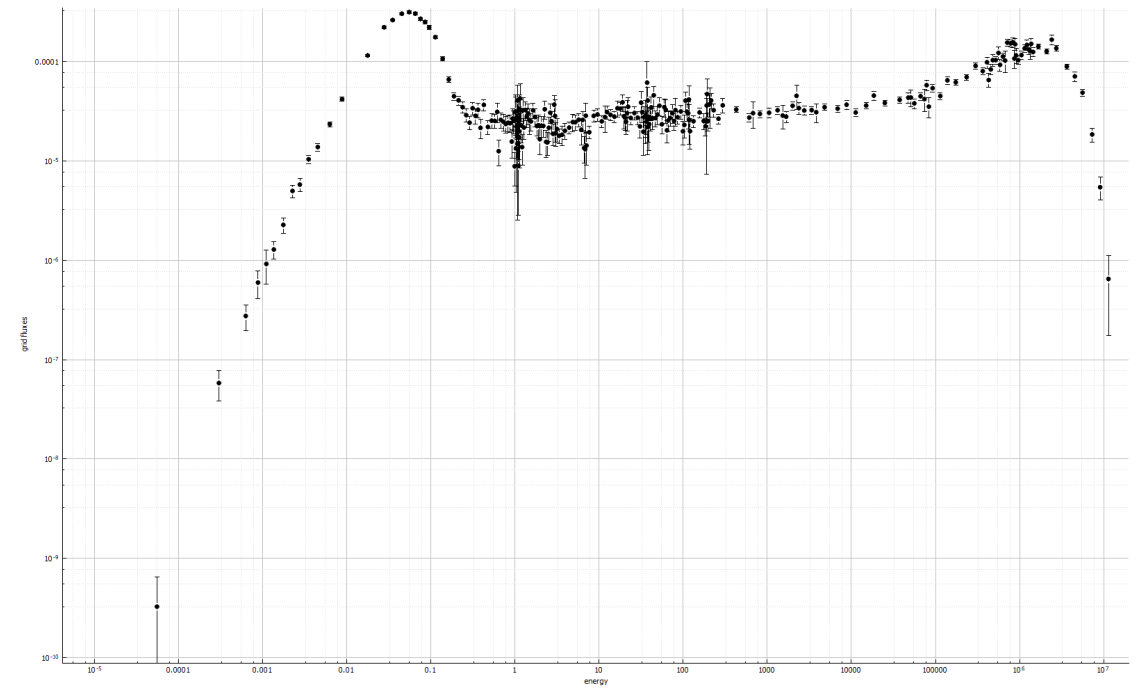


Flux by group, divided by lethargy (logarithmic bin width)

One of the central rod locations



Reflector location, just outside tank



Sub module 4: **Plotting cross sections**



Plotting Multigroup Cross Sections

- AMPX-formatted multigroup data
 - Open multigroup library
 - Navigate to data directory: c:\scale-6.3.1\data
 - Examples:
 - scale.rev05.xn252v7.1 – 252-group ENDF/B-VII.1
 - scale.rev04.xn56v7.1 – 56 group ENDF/B-VII.1
 - Nuclides available to plot appear in file tree (in alphabetical order)
 - Browse to desired data and double-click to plot or right-click for more options
 - Example: scale.rev05.xn252v7.1->b10->Neutron->Reaction Xsecs->b-10 n,alpha
 - Can use filter to reduce options
 - Filter can be slow—especially, for some reason, when deleting it

Plotting continuous energy cross sections

- Similar to plotting multigroup data, but “open continuous-energy data”
- Select xml file for desired library
 - Example: ce_v7.1_endf.xml

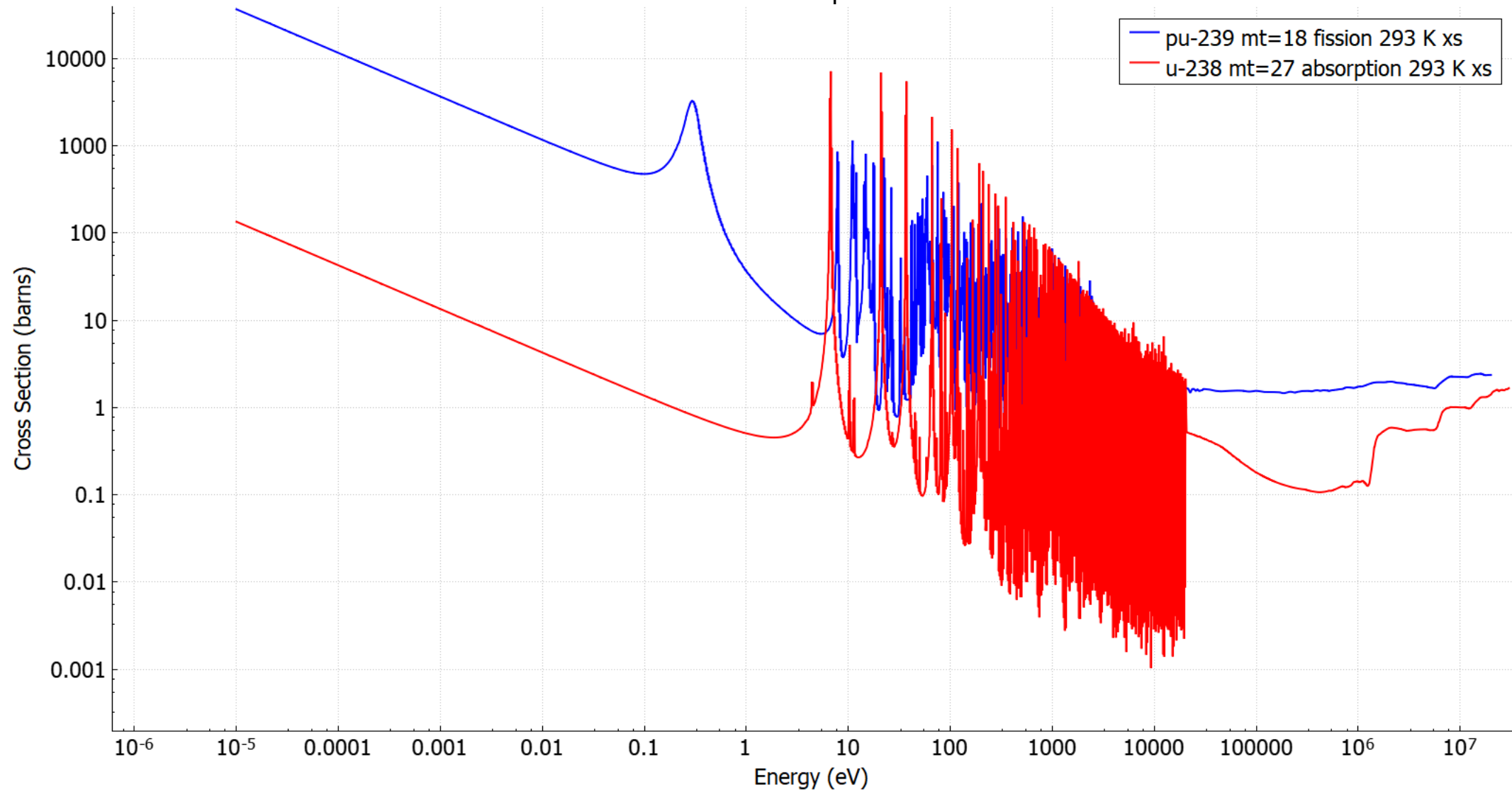
Plotting multigroup covariance data

- COVERX-formatted cross section covariance data
 - Similar to cross section libraries, but “open covariance library”
 - Examples:
 - scale.rev08.252groupcov7.1
 - scale.rev08.56groupcov7.1
 - View energy-energy covariances to plot
 - Double-click for matrix plot
 - Right-click for standard deviation plots

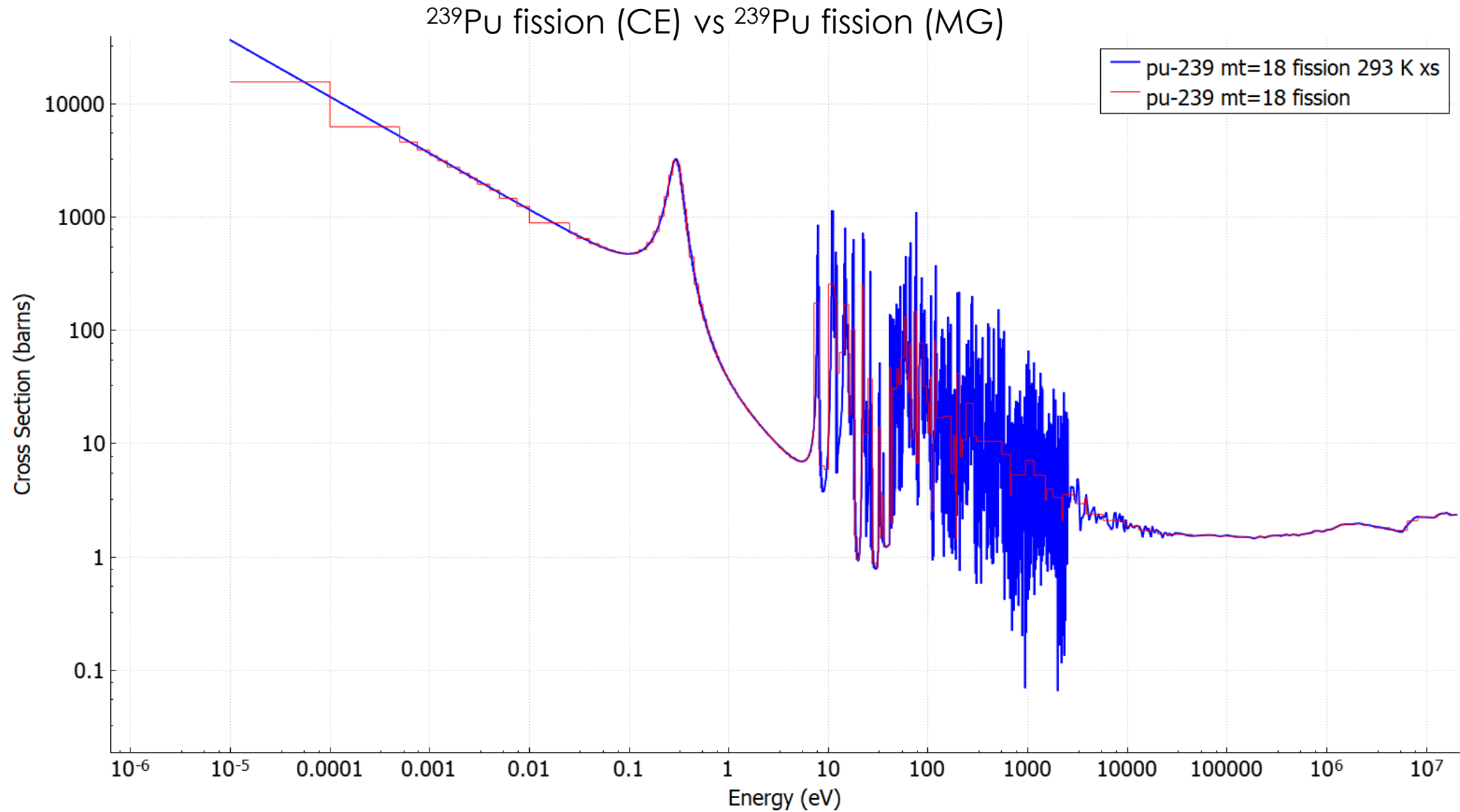
Let's visualize some data!

Example plots

^{239}Pu fission vs ^{238}U absorption cross section



Example plots, cont.



Questions?