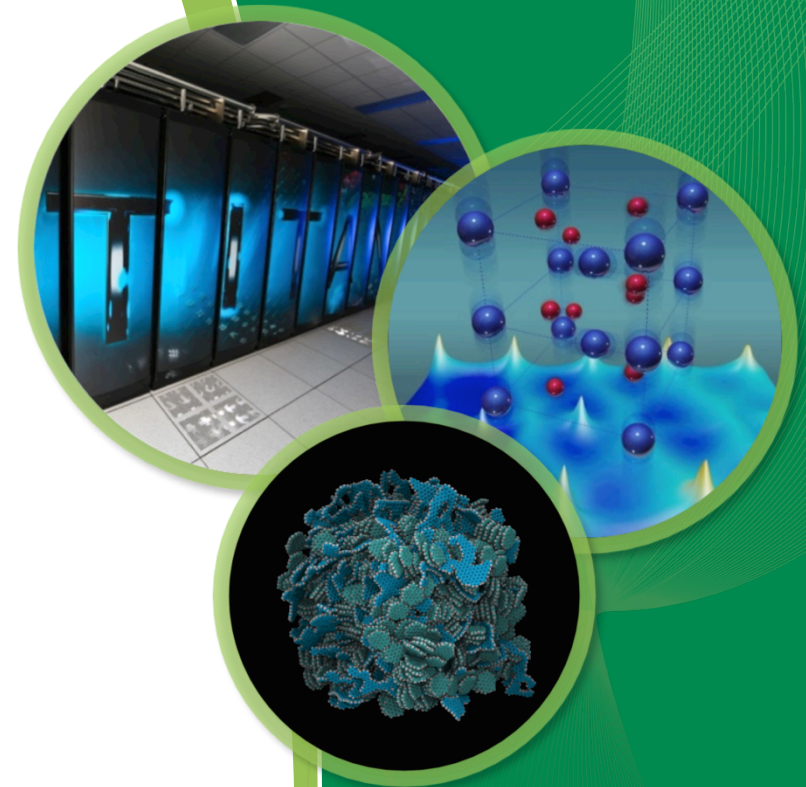


Fulcrum User Interface

Capability Introduction

Robert A. Lefebvre

October 2016



Presentation Outline

- Fulcrum Mission Statement
- Fulcrum Component Overview
- Fulcrum Input Editor
- Fulcrum Data Plotting
- Fulcrum Geometry Visualization

Fulcrum Mission Statement

Provide a cross-platform graphical user interface (GUI) designed to facilitate problem creation, modification, navigation, validation, and visualization, as well as output and data file interaction as needed by new and experienced users.



Fulcrum Component Overview

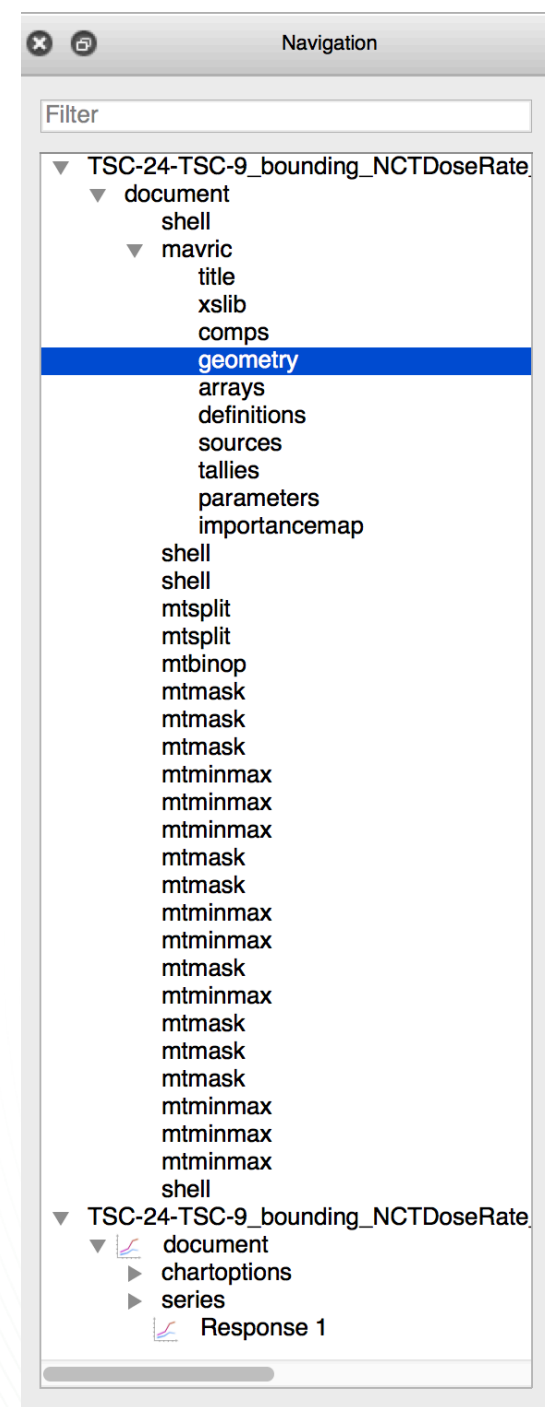
The screenshot displays the Fulcrum software interface with several key components highlighted:

- Input Editor:** Shows a list of geometric objects and their properties. A red box highlights the text "Input Editor" over the object list.
- Document Navigation:** A tree view on the left side of the interface, with a blue box highlighting the text "Document Navigation".
- Data Plot:** A scatter plot titled "radial axis plot at a=6.1098, b=-1.9435 generated on Thu Jul 28 17:01:33 2016". The y-axis is labeled "Responses" (log scale) and the x-axis is "radial axis". A blue box highlights the text "Data Plot".
- Geometry Viewer:** A 3D visualization of the geometry with a color-coded response map. A blue box highlights the text "Geometry Viewer".

The interface also includes a menu bar (File, Edit, View, Run, Help), a toolbar, and a status bar at the bottom right showing "View origin: (0, 0, -1.9435)".

Fulcrum Document Navigation

- Hierarchical Listing of Document
 - Quick Navigation to input component
 - Plot creation
- Open Associated Files
 - Lists files with matching extension-less filename
 - streamlines opening associated files
- Filter
 - Regular expression based item filtering
- Dockable
 - Dock to main Fulcrum application
 - Float in separate window
 - Hide completely



Fulcrum Input Editor

- Syntax Highlighting
- Top Level Quick Navigation
- Cursor Context
- Preserves User Input Format
- Current Input Block Highlight
- Input Autocompletion
- Input Validation
- Customizable Input Execution

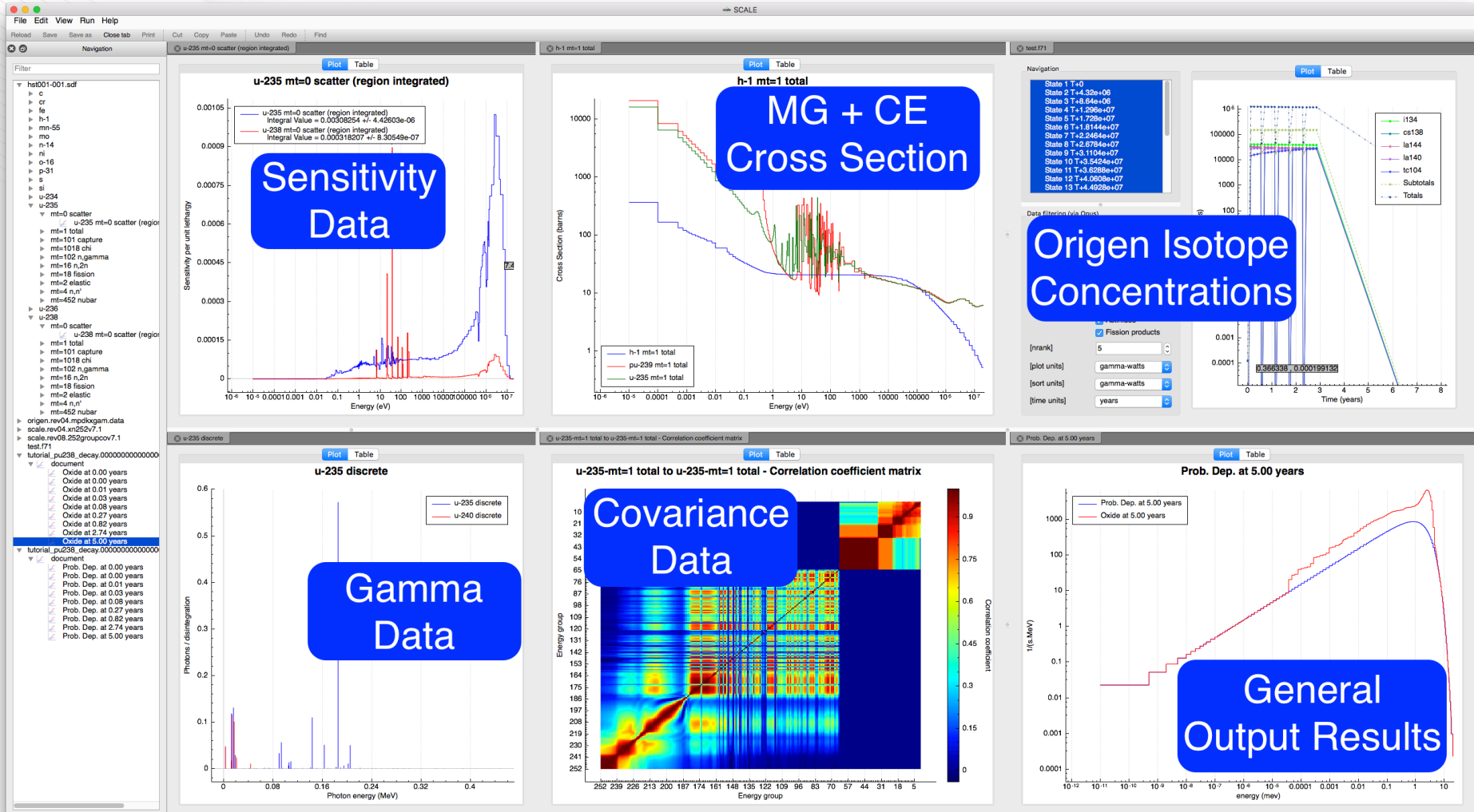
```
TSC-24-TSC-9_bounding_NCTDoseRate_02-02-2004.inp*
comps SCALE 6.2 Run View... Edit...
1809 ' - fresh fuel UO2 composition
1810 u02 1431 den=10.0538 1 293.00 92234 0.0271 92235 4.04 92236 0.0140 92238 96.9190 end
1811 ' =====Fuel Assembly 24 Node 18
1812 ' - fresh fuel UO2 composition
1813 uo2 1432 den=10.0538 1 293.00 92234 0.0271 92235 3.04 92236 0.0140 92238 96.9190 end
1814 '-----
1815 ' homogenized compositions in the activation source regions of assembly ID = 1
1816 ' lower end fitting
1817 wtptBottom01 401 1.48 8 26000 68.30 24000 19.00 28000 9.50
1818 25000 2.00 14000 1.00 6000 0.08 15000 0.04 27000 0.08 1.0 293.0 end
1819 ' gas plenum
1820 wtptPlenum01 501 0.71 8 26000 0.67 24000 0.24 28000 0.06
1821 25000 0.01 14000 0.01 40000 97.33 50000 1.59 8016 0.09 1.0 293.0 end
1822 ' upper end fitting
1823 wtptTopEnd01 601 0.86 12 26000 57.04 24000 19.44 28000 18.31
1824 42000 1.60 25000 1.73 14000 0.91 6000 0.07 15000 0.04 22000 0.07
1825 41000 0.65 13000 0.07 27000 0.07 1.0 293.0 end
1826 ' lower in-core spacer

line:1810 column:1 - Validation Error: name value "u02" is not one of the allowed values: [ ... "u-241" "u-242" "u-uo2" "u232-uo2" "u233-uo2" "u234-uo2" ... ]
line:1810 column:1 - Validation Error: stdcomp children "wtpt" sum to 101 for 92000 group - instead of the required sum of 100

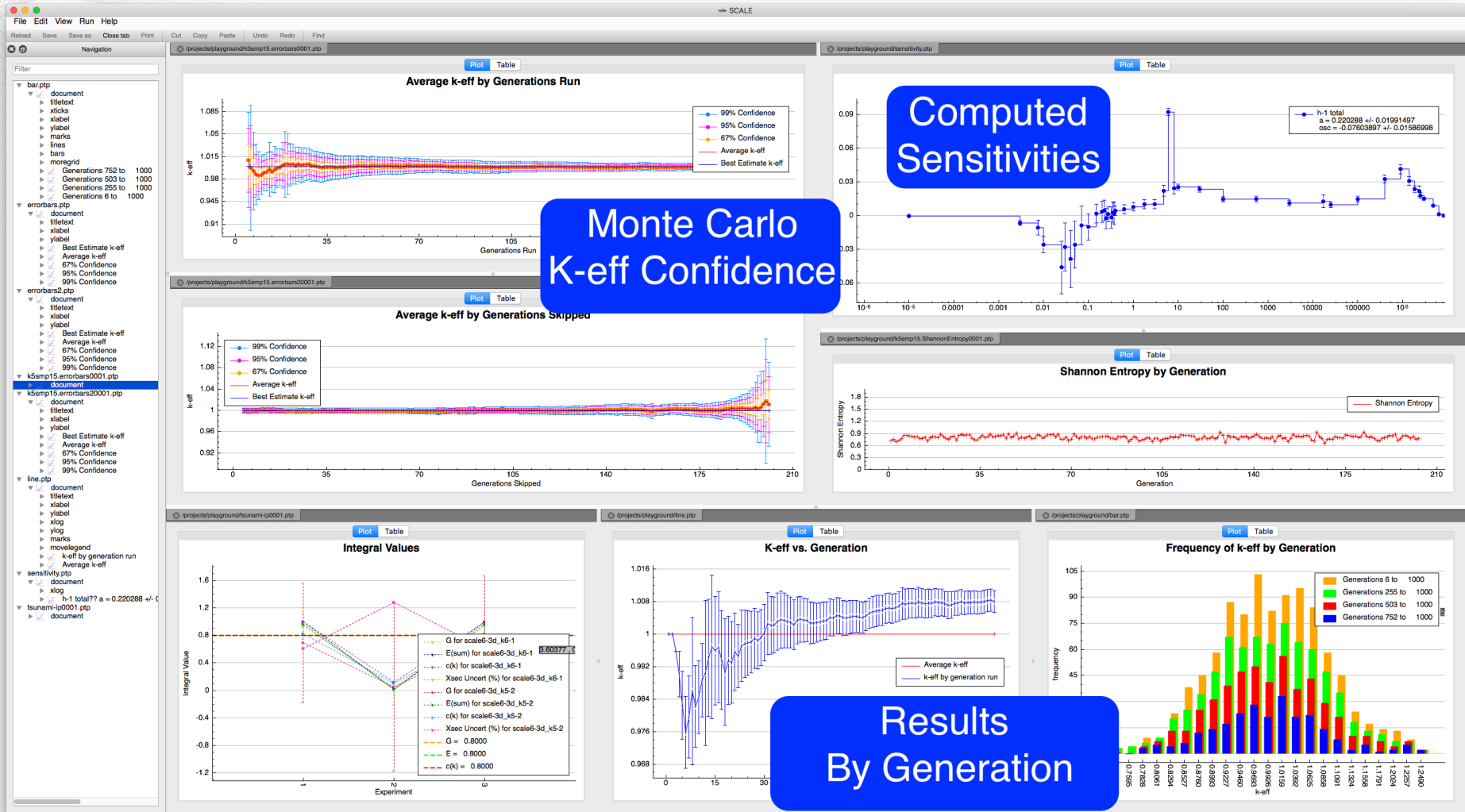
Line: 1810, Col: 1 /mavric/comps/stdcomp/name Validation Messages
```

Fulcrum Plot Data

- Supports Most Major SCALE Data Formats
- Export to Image (supports svg)

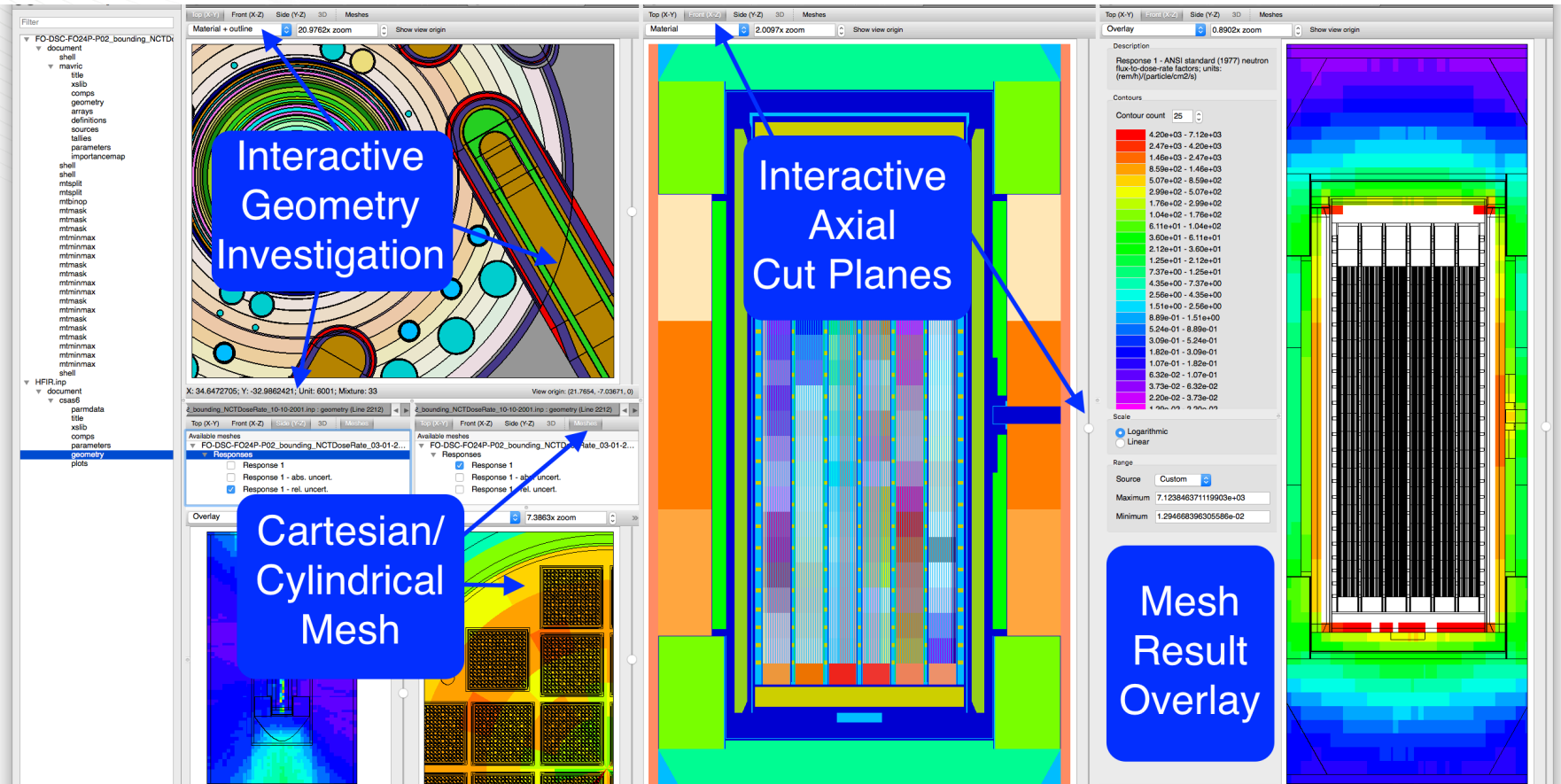


Fulcrum General Output Result Plots



Fulcrum Geometry Visualization

- Interactive Geometry Visualization
- Support for Most Mesh Data*



*Currently Support: 3dmap, Mesh Importance Map, Mesh Source Map, and Denovo Flux File

Summary

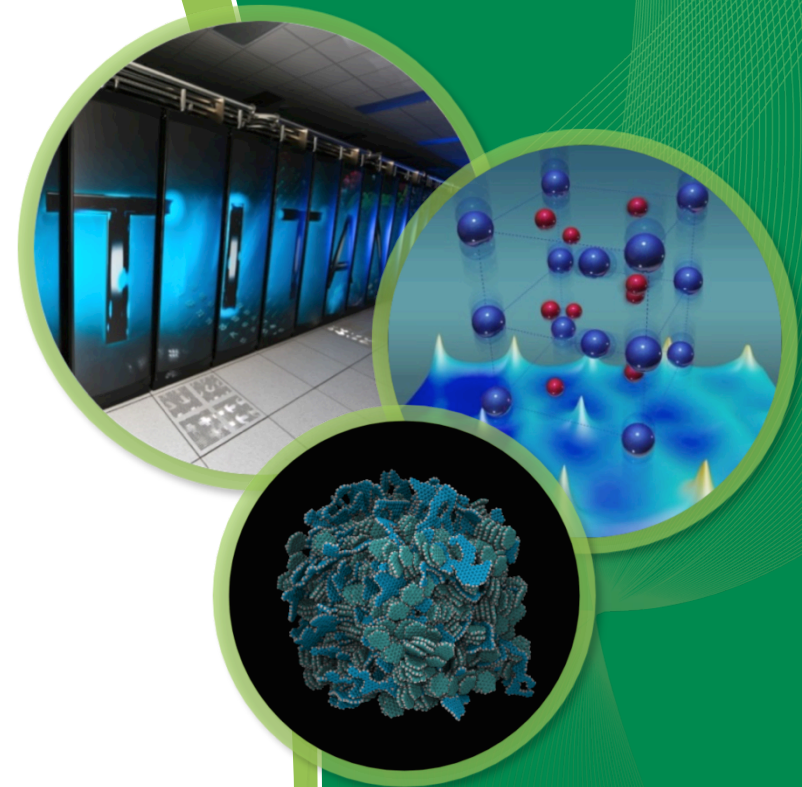
- Input editor facilitates problem creation, modification, navigation, validation, execution and output file viewing in a consistent, platform independent manner.
- Data plotting facilitates a fast, interactive means of interrogating input and output data.
 - Supports most SCALE data formats.
- Geometry viewer facilitates a fast, interactive means of interrogating SCALE Geometry.
 - Supports KENO and NEWT (non-polygon rendering).
- Fulcrum provides a modular workspace with splitting and drag-and-drop configurable layout.
- Questions?

Fulcrum User Interface

Input Editor Overview

Robert A. Lefebvre

October 2016



Presentation Outline

- Fulcrum Input Editor Components
- Text Editor Settings
- Syntax Highlighting
- Document Quick Navigation
- Cursor Context
- Input Block Start and End Highlighting
- Input Autocompletion
- Input Validation
- Input Execution
- Output File Viewing
- Miscellaneous Features
- Future Features

Fulcrum Input Editor Components

The image displays the Fulcrum Input Editor interface, showing a code editor with various components highlighted by blue callout boxes. The interface includes a menu bar (File, Edit, View, Run, Help), a toolbar (Reload, Save, Save as, Close tab, Print, Cut, Copy, Paste, Undo, Redo, Find), and a main editing area. The code is organized into sections, with a central 'Synchronized Input Text Editor' box. The callouts are:

- Customizable Execution**: Points to the 'Run' button in the toolbar.
- Document Quick Navigation**: Points to the 'SCALE 6.2' dropdown menu.
- Context Aware Input Autocompletion**: Points to the list of geometric shapes (cone, cylinder, etc.) on the left side of the editor.
- Synchronized Input Text Editor**: A central box pointing to the main code editing area.
- Cursor Context**: Points to the highlighted line 'unit=1 region=7' in the code.
- Execution Messages**: Points to the output window showing the results of a simulation run.
- Syntax Highlights**: Points to the color-coded text in the code, such as 'end definitions' and 'Sources Block'.
- Input Block Highlights**: Points to the highlighted code block for 'read sources'.
- Input Validation**: Points to the error message at the bottom: 'line:49 column:22 - Validation Error: region value "30" does not exist in set: [././././cone/id ...]'. Below this, a list of available region IDs is shown.

```
34 global unit 1
35 cylinder 1 8.255 25.40 -25.40
36 cylinder 2 10.795 27.94 -27.94
37 cylinder 3 20.955 27.94 -27.94
38 cylinder 4 13.335 40.64 30.48
39 cylinder 5 13.335 -30.48 -40.64
40 cylinder 6 35.56 45.72 -45.72
41
42 cone - kenovi (configurable) 2.4 -152.4
43 cone
44
45
46
47
48
49
50
51
52
53 end geom
54 dodecahedron - kenovi (configurable)
55 ellipsoid - kenovi (configurable)
56 'Defini
57 hexprism - kenovi (configurable)
58 read def
59 hopper - kenovi (configurable)
60 hopper
61 parallelepiped - kenovi (configurable)
62 end parallelepiped
63 pentagon - kenovi (configurable)
64 dist pentagon
65 plane - kenovi (configurable)
66 plane
67 xpplane
68 end ypplane
69 zpplane
70 grid
71 quadratic
72 rhexprism
73 rhomboid - kenovi (configurable)
74 rhomboid
75 ring - kenovi (configurable)
76 ring
77 sphere - kenovi (configurable)
78 sphere
79 end geometry
```

```
114 meshTally 1
115 photon
116 gridGeometryID=8
117 responseID=5
118 unit=1 region=7
119 energyBoundsID=1
120 end meshTally
121
122 multiplier=1000.0
123 end tallies
124
```

```
43
44
45
46 MAVRIC, part 2, writing the forward discrete ordinates input
47 *****
48
49 constructMacroMaterialRAYS (46 x-bins, 46 y-bins)
50
51 Total numMacros: 23
```

```
89 linear 30 0.00e6 1.50e6
90 bounds 0.510e+6 0.512e+6 1.172e6 1.174e6 1.331e6 1.333e6 end
91 end energyBounds
92 end definitions
93
94 'Sources Block
95
96
97 read sources
98 src 1
99 title="one of cobalt-60"
100 useNormConst
101 multiplier=37e9
102 cylinder 8.255 25.40 -25.40
103 photons
104 eDistributionID=1
105 end src
106 end sources
107
108 'Tallies Block
109
110 ' only collect mesh tally information outside the package (in air region)
111 ' multiplier converts responses from rem/hr to mrem/hr
112
113 read tallies
114 meshTally 1
115 photon
116 gridGeometryID=8
117 responseID=5
118 unit=1 region=7
119 energyBoundsID=1
```

line:49 column:22 - Validation Error: region value "30" does not exist in set: [././././cone/id ...]

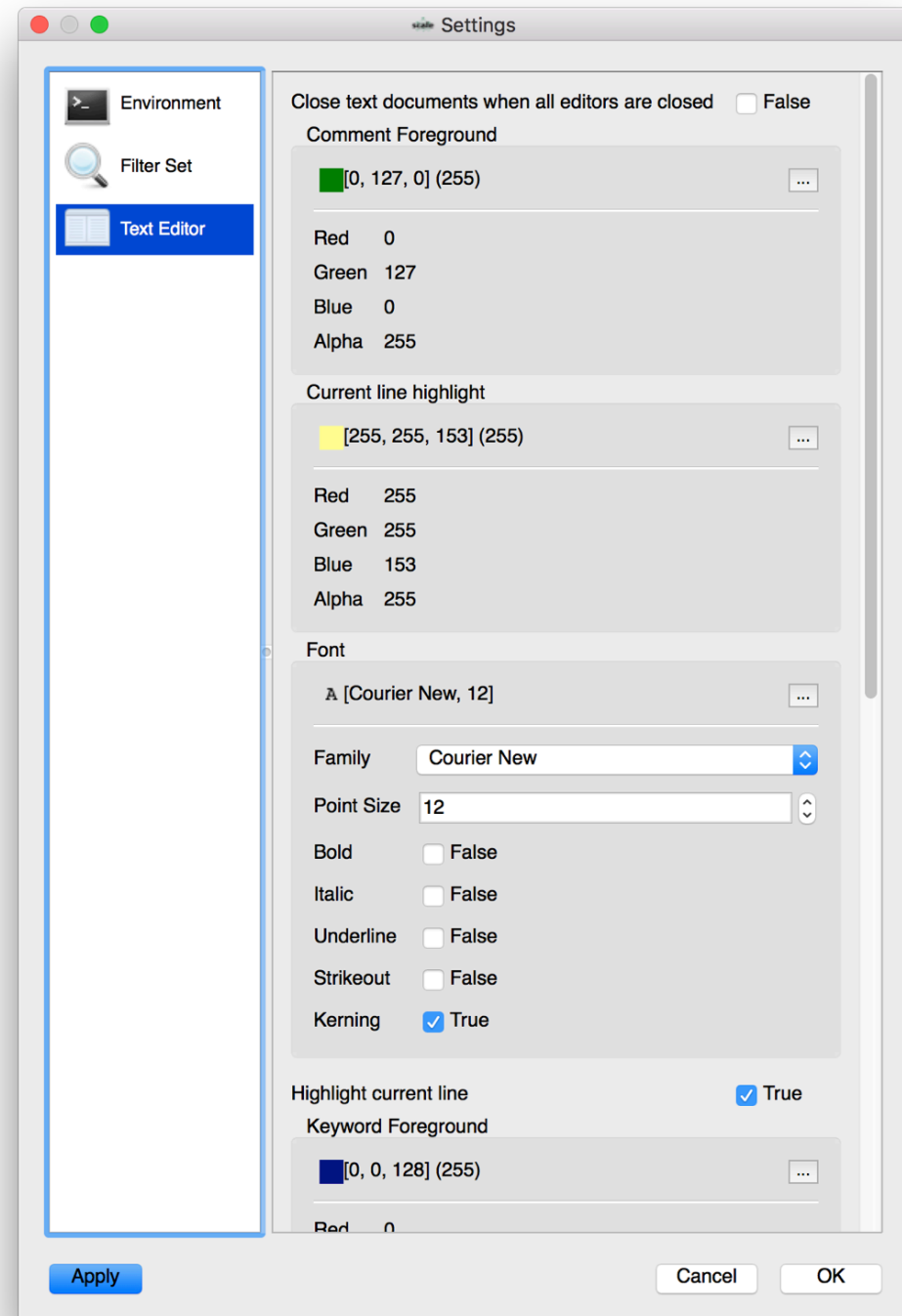
- ././././cuboid/id
- ././././cylinder/id
- ././././dodecahedron/id
- ././././ecylinder/id
- ././././ellipsoid/id
- ././././hexprism/id
- ././././hopper/id
- ././././parallelepiped/id
- ././././pentagon/id
- ././././plane/id
- ././././quadratic/id
- ././././rhexprism/id
- ././././rhomboid/id
- ././././ring/id
- ././././sphere/id
- ././././wedge/id
- ././././xcylinder/id

```
Line: 41, Col: 9 /mavric/geometry/global_unit
```

```
Line: 105, Col: 11 /mavric/sources/source/term
```

Text Editor Settings

- Change font attributes
- Change syntax color by category
- Change current line highlight
- Modify recognized input file extensions
 - Add a '.i' extension
- Update default input editor close behavior
 - When closing a tab, should the document also be closed if the closed tab is the last document tab.
- Accessed via File>Settings



Syntax Highlights

SCALE

File Edit View Run Help

Reload Save Save as Close tab Print Cut Copy Paste Undo Redo Find

mavric.aos100.inp

document SCALE 6.2 Run View... Edit...

```
9 *****
10 ' Simplified model of the AOS-100
11 '
12 ' Alpha Omega Services Inc (AOS)
13 ' International Isotopes Inc. of Idaho Falls, Idaho is the exclusive worldwide
14 ' distributor of the AOS Ra... tem
15 *****
16
17 =mavric
18 AOS-100: Demonstrate use of ... transport
19 v7-200n47g
20
21
22 ' Composition Block - standard SCALE input
23 -----
24 read composition
25   ss304           1   end
26   wptTungsten    2  17.8 4  74182 26 74183 14 74184 31 74186 29 end
27   dry-air        3   end
28 end composition
29
30 -----
31 ' Geometry Block - SCALE standard geometry package (SGGP)
32 -----
33 read geometry
34   global unit 1
35     cylinder 1  8.255  25.40 -25.40
36     cylinder 2 10.795  27.94 -27.94
37     cylinder 3 20.955  27.94 -27.94
38     cylinder 4 13.335  40.64  30.48
39     cylinder 5 13.335 -30.48 -40.64
40     cylinder 6 35.56   45.72 -45.72
41
42     cuboid 99 139.7 -139.7 139.7 -139.7 152.4 -152.4
43
44     media 3 1 1
45     media 1 1 2 -1
46     media 2 1 3 -2
47     media 2 1 4
48     media 2 1 5
49     media 1 1 6 -3 -4 -5
50
51     media 3 1 99 -6
52   boundary 99
53 end geometry
54
55 -----
56 ' Definitions Block
57 -----
58 read definitions
59   response 5
60     title="ANSI standard (1977) neutro...s"
61     doseData=9504
62   end response
63
64   distribution 1
65     title="cobalt-60 gammas/decay"
66     discrete 347140 826100 1173228 1332492 2158570 2505692 end
67     truepdf 0.000075 0.000076 0.9985 0.999826 0.000012 0.00000002 end
68   end distribution
69
70   gridGeometry 7
71     title="mesh for discrete ordinates/importance map/biased source"
```

Sequence Declarator
Foreground

Number
Foreground

Keyword
Foreground

mavric.aos100.inp

document SCALE 6.2 Run View... Edit...

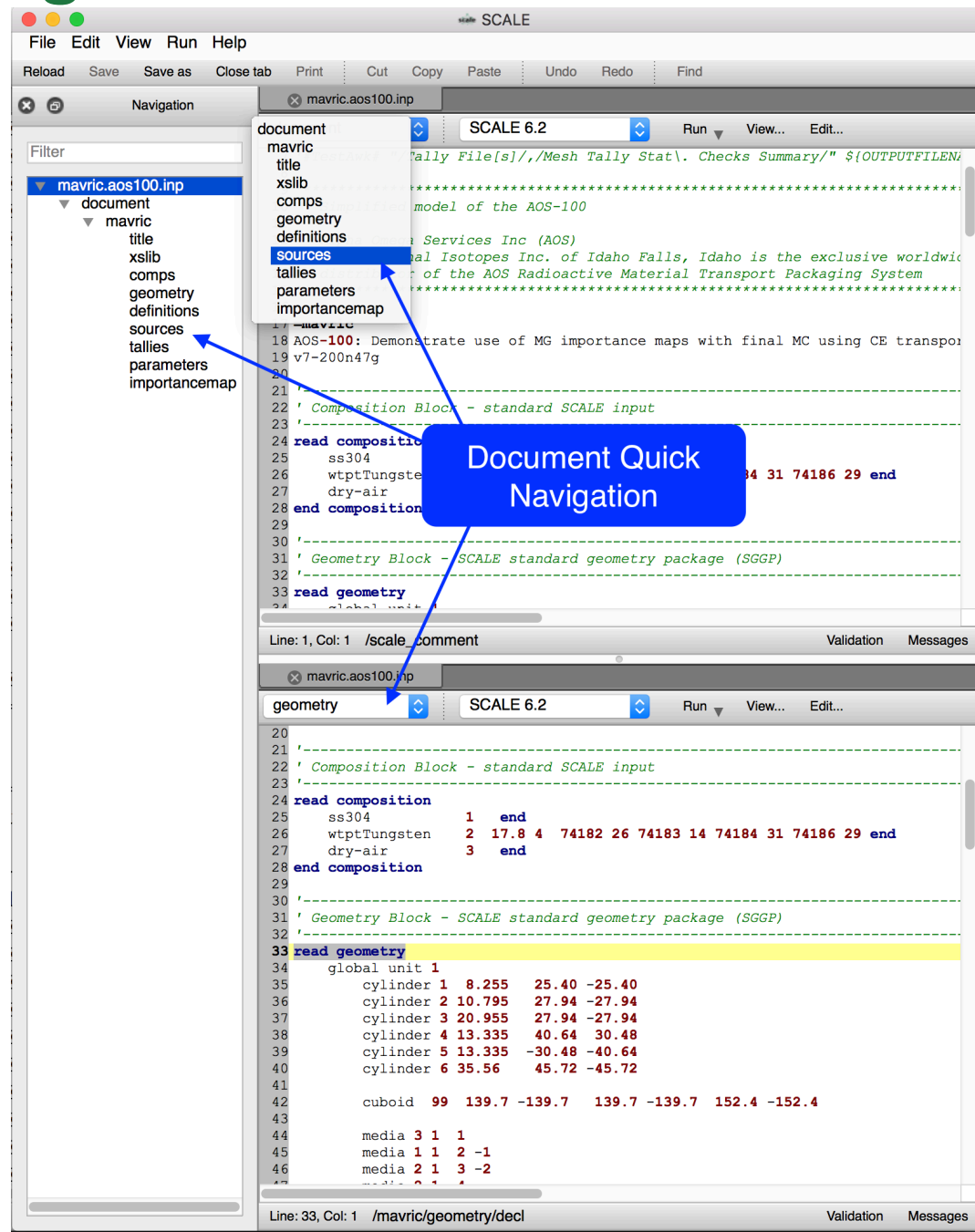
```
53 end geometry
54
55 -----
56 ' Definitions Block
57 -----
58 read definitions
59   response 5
60     title="ANSI standard (1977) neutro...s"
61     doseData=9504
62   end response
63
64   distribution 1
65     title="cobalt-60 gammas/decay"
66     discrete 347140 826100 1173228 1332492 2158570 2505692 end
67     truepdf 0.000075 0.000076 0.9985 0.999826 0.000012 0.00000002 end
68   end distribution
69
70   gridGeometry 7
71     title="mesh for discrete ordinates/importance map/biased source"
72     xLinear 28 -35.56 35.56
73     yLinear 28 -35.56 35.56
74     zLinear 36 -45.72 45.72
75
76     xLinear 22 -139.7 139.7
77     yLinear 22 -139.7 139.7
78     zLinear 24 -152.4 152.4
79   end gridGeometry
80
81   gridGeometry 8
82     title="mesh for mesh tally - 1 inch voxels"
83     xLinear 110 -139.7 139.7
84     yLinear 110 -139.7 139.7
85     zLinear 120 -152.4 152.4
86   end gridGeometry
87
88   energyBounds 1
89     linear 30 0.00e6 1.50e6
90     bounds 0.510e+6 0.512e+6 1.172e6 1.174e6 1.331e6 1.333e6 end
91   end energyBounds
92 end definitions
93
94 -----
95 ' Sources Block
96 -----
97 read sources
98   src 1
99     title="one Ci of cobalt-60"
100    useNormConst
101    multiplier=37e9
102    cylinder 8.255 25.40 -25.40
103    photons
104    eDistributionID=1
105  end src
106 end sources
107
108 -----
109 ' Tallies Block
110 ' only collect mesh tally information outside the package (in air region)
111 ' multiplier converts responses from rem/hr to mrem/hr
112 -----
113 read tallies
114   meshTally 1
115     photon
```

String
Foreground

Comment
Foreground

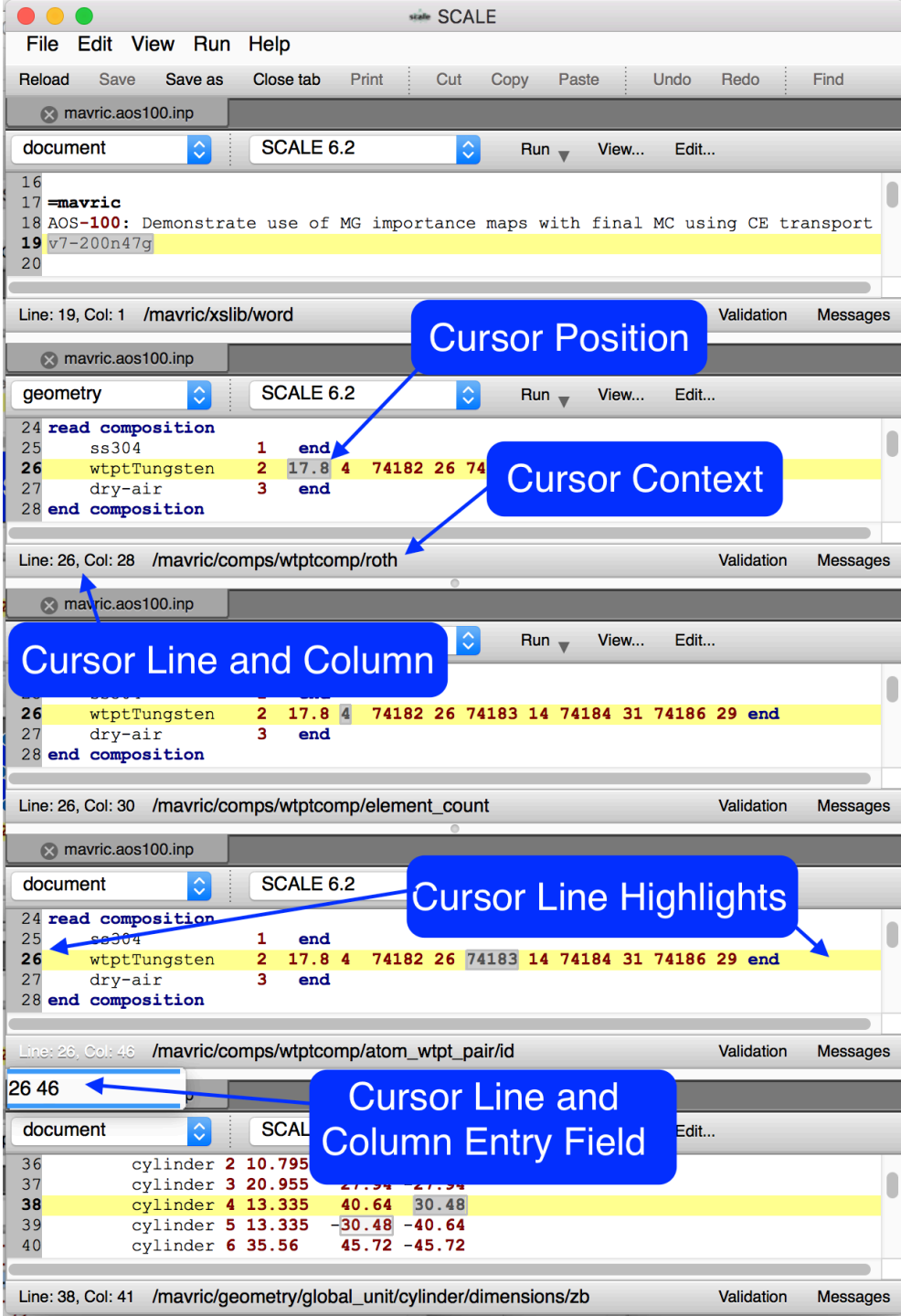
Document Quick Navigation

- Provides document outline.
- Quickly navigate to section from input editor drop-down or navigation tree.
- Places text cursor at start of input block.



Cursor Context

- Fulcrum uses cursor position to determine cursor context, line, column, and highlighting.
- Cursor context provides a file directory-style listing of the input component at cursor position.
 - Helpful for identifying position-dependent input components.
 - Helpful for advanced SCALE features like Sampler model perturbations.
- Cursor line highlights provide fast cursor acquisition via bold-faced line number and highlighted line visual indicators.
- Cursor line and column entry fields provide quick navigation
 - Useful for entering line and column numbers included in job execution failure messages.
 - Accessible via clicking Line, Col text.



Input Block Start and End Highlighting

- Helps new users identify sections of input.
- Re-enforces SCALE's Read Block construct.
- More effectively communicates Record Blocks which could have user-specified beginning.
- Assists users in identifying new input component sections, such as the Component and Array Blocks used in Origen and Origen input.

The image displays four screenshots of the SCALE software interface, illustrating different input block types. Each screenshot shows a code editor with a yellow highlight and a blue callout box with arrows pointing to the highlighted text.

- Read Blocks:** The first screenshot shows a code editor with a yellow highlight on lines 24-28. The callout box is labeled "Read Blocks". The code includes a table with columns for material names, indices, and values.
- Record Blocks:** The second screenshot shows a code editor with a yellow highlight on line 26. The callout box is labeled "Record Blocks". The code includes a table with columns for material names, indices, and values.
- Component Block:** The third screenshot shows a code editor with a yellow highlight on line 3. The callout box is labeled "Component Block". The code includes a component definition for "origami" with various options and parameters.
- Array Block:** The fourth screenshot shows a code editor with a yellow highlight on line 7. The callout box is labeled "Array Block". The code includes a component definition for "fuelcomp" with a "mix" block.

Input Autocompletion Overview

Input Autocompletion provides the user a jump start in input creation and editing. Autocompletion uses the cursor's context within the input to determine what input components are available and can be inserted. The types of autocompletion are as follows:

- Static input component insertion.
 - Inserts a boilerplate piece of input requiring the user to update fields with appropriate values.
 - Provides complete component incorporating component order, etc.
- Configurable input component insertion.
 - Uses a popup window to capture component values and substitutes these values into a template creating and inserting a complete piece of input (potentially an entire input).
- Input value substitution. Uses cursor context to provide a list of legal attribute values.
 - Convenient for selecting parameter values from a list (htm=yes or no).
 - Helpful for substituting identifiers needed from other input components (available mixtures, region ids etc).

Input Autocompletion : Static Text

Access Autocomplete via
* CTRL+SPACE Keys, or,
* Edit...>Autocomplete

- Inserts default values. Requires user to update values as needed.

The screenshot shows the SCALE software interface with the 'cylinder' command selected in the input field. A dropdown menu is open, listing various geometric shapes and their parameters. The 'cylinder' option is highlighted in blue. The menu items include: cone, cuboid, cylinder, xylinder, yzylinder, zcylinder, boun, dodecahedron, ellipsoid, hexprism, hopper, parallelepiped, pentagon, plane, xplane, yplane, zplane, quadratic, rhexprism, rhomboid, ring, sphere, and gridGeometry. The status bar at the bottom indicates 'Line: 40, Col: 9 /mavric/geometry/global_unit'.



The screenshot shows the SCALE software interface with the 'cylinder' command completed. The code now includes a 'cuboid' command with default values: 'cuboid 99 139.7 -139.7 139.7 -139.7 152.4 -152.4'. A blue callout box points to these values with the text 'Default Id, Radius, Ztop and Zbottom Inserted'. The status bar at the bottom indicates 'Line: 41, Col: 1 /mavric/geometry/global_unit'.

Input Autocompletion : Static Text

- Static text insertion allows new and experienced users to quickly select and generate input that has order dependent components
 - Standard Composition Records require a sequence of unlabeled components (mixture, volume fraction, temperature, etc).
 - The requirement for the user to recall the correct order of entry is significantly reduced.
- Cursor context facilitates the user in identifying the inserted components needing to be changed.
 - Greatly assists the user in the worst of order-dependent, unlabeled input entry.

Access Autocomplete via
 * CTRL+SPACE Keys, or,
 * Edit...>Autocomplete

```

File Edit View Run Help
Reload Save Save as Close tab Print Cut Copy Paste Undo Redo Find
mavric.aos100.inp*
document SCALE 6.2 Run View... Edit...
9 *****
10 ' Simplified model of the AOS-100
11 '
12 ' Alpha Omega Services Inc (AOS)
13 ' International Isotopes Inc. of Idaho Falls, Idaho is the exclusive worldwide
14 ' distributor of the AOS Radioactive Material Transport Packaging System
15 '*****
16
17 ==mavric
18 AOS-100: Demonstrate use of MG importance maps with final MC using CE transport
19 v7-200n47g
20
21 -----
22 ' Composition Block - standard SCALE input
23 -----
24 read composition
25 ss304 1 end
26
27 stdcomp - basic (configurable)
28 end stdcomp - basic
29 stdcomp - basic + volume fraction
30 /--- stdcomp - basic + volume fraction + temperature
31 ' Ge stdcomp - basic + volume fraction + temperature + isotopics
32 /--- stdcomp - basic + atomic density (configurable)
33 read stdcomp - basic + atomic density
34 stdcomp - basic + atomic density + temperature
35 wtptcomp - basic (configurable)
36 wtptcomp - basic
37 wtptcomp - basic + volume fraction
38 wtptcomp - basic + volume fraction + temperature
39 wtptcomp - basic + volume fraction + temperature + isotopics
40 atomcomp - basic (configurable)
41 atomcomp - basic
42 atomcomp - basic + volume fraction
43 atomcomp - basic + volume fraction + temperature
44 atomcomp - basic + volume fraction + temperature + isotopics
45 solution - rho + density + temperature + volume fraction
46 solution - molar + density + temperature + volume fraction
47 solution - massfrac + density + temperature + volume fraction
48 solution - molefrac + density + temperature + volume fraction
49 solution - molality + density + temperature + volume fraction
50
51 media 3 1 99 -6
52
53 end
54
55 ' De
56 /---
57 /---
58 read
59
60
61
62
63
64
65
66 truepdf 0.000075 0.000076 0.9985 0.999826 0.000012 0.0000002 end
67 end distribution
68
69
70 gridGeometry 7
    
```

Order Dependent Static Input Enumerations

Line: 26, Col: 5

Input Autocompletion : Static Text

- Static text autocompetition also facilitates abbreviated input to include the component's description allowing users to discover and/or more quickly recall the necessary input components for their analysis.
- Cursor context allows the autocompletion popup to show what is legal and has not already been specified.

Access Autocomplete via
* CTRL+SPACE Keys, or,
* Edit...>Autocomplete

The screenshot shows the SCALE 6.2 software interface. The main window displays a text file named 'csas6_7.inp' with a list of parameters for a simulation. The parameters are listed in a table-like format with columns for item number, name, and various numerical values. An autocompletion popup is visible over the 'gen' parameter on line 43, listing various options with their descriptions. The popup is highlighted in blue. The interface includes a menu bar (File, Edit, View, Run, Help) and a toolbar (Reload, Save, Save as, Close tab, Print, Cut, Copy, Paste, Undo, Redo, Find). The status bar at the bottom shows 'Line: 31, Col: 19 / csas6/parameters' and 'Validation Messages'.

```
document | SCALE 6.2 | Run | View... | Edit...
24 uranium 10 den=18.76 1 293 92235 93.2 92238 5.6 92234 1.0 92236 0.2 end
25 uranium 11 den=18.76 1 293 92235 93.2 92238 5.6 92234 1.0 92236 0.2 end
26 uranium 12 den=18.76 1 293 92235 93.2 92238 5.6 92234 1.0 92236 0.2 end
27 uranium 13 den=18.76 1 293 92235 93.2 92238 5.6 92234 1.0 92236 0.2 end
28 uranium 14 den=18.76 1 293 92235 93.2 92238 5.6 92234 1.0 92236 0.2 end
29 end comp
30 read param
31 pgm=yes plt=yes
32 end param
33 read geom
34 global unit 1
35 *** one through t wta
36 'one top piece wth
37 cuboid 10 2p6.3 wtl
38 'two middle pie sig
39 cuboid 20 2p6.3 msh
40 'three bottom pie ttl
41 cuboid 30 4p6.3 dbh
42 *** four is item dbl
43 cylinder 40 4.55 gen
44 *** five is item npp
45 cylinder 50 5.76 nsk
46 *** six is item 4 res
47 cylinder 60 4.55 nbk
48 *** seven and eig xnb
49 'seven nfb
50 cuboid 70 2p3. xfb
51 'eight xld
52 cylinder 80 4.57 beg
53 *** nine is item nb8
54 cylinder 90 4.55 nl8
55 *** ten is item 7 nqd
56 cylinder 100 5.7 ngp
57 *** eleven is ite pnm
58 cylinder 110 4.5 cxm
59 *12 through 14 is cep
60 'twelve fno
61 cylinder 120 5.7 fni
62 'thirteen dbr
63 cuboid 130 4p6.3 dbx
64 'fourteen app
65 sphere 140 6. flx
66 *** fifteen is th fdn
67 'fifteen adj
68 cuboid 150 4p2 ptb
69 media 1 1 +10 vol=20.5546356 delayed neutrons
70 media 2 1 +20 -10 vol=245.678420867
71 media 3
72 media 4
73 media 5
74 media 6
75 media 7
76 media 8
77 media 9
78 media 10
79 media 11
80 media 12
81 media 13
82 media 14
83 media 0 1
84 -110 -120 -130 -140 vol=31432.726088316

Parameters
with descriptions

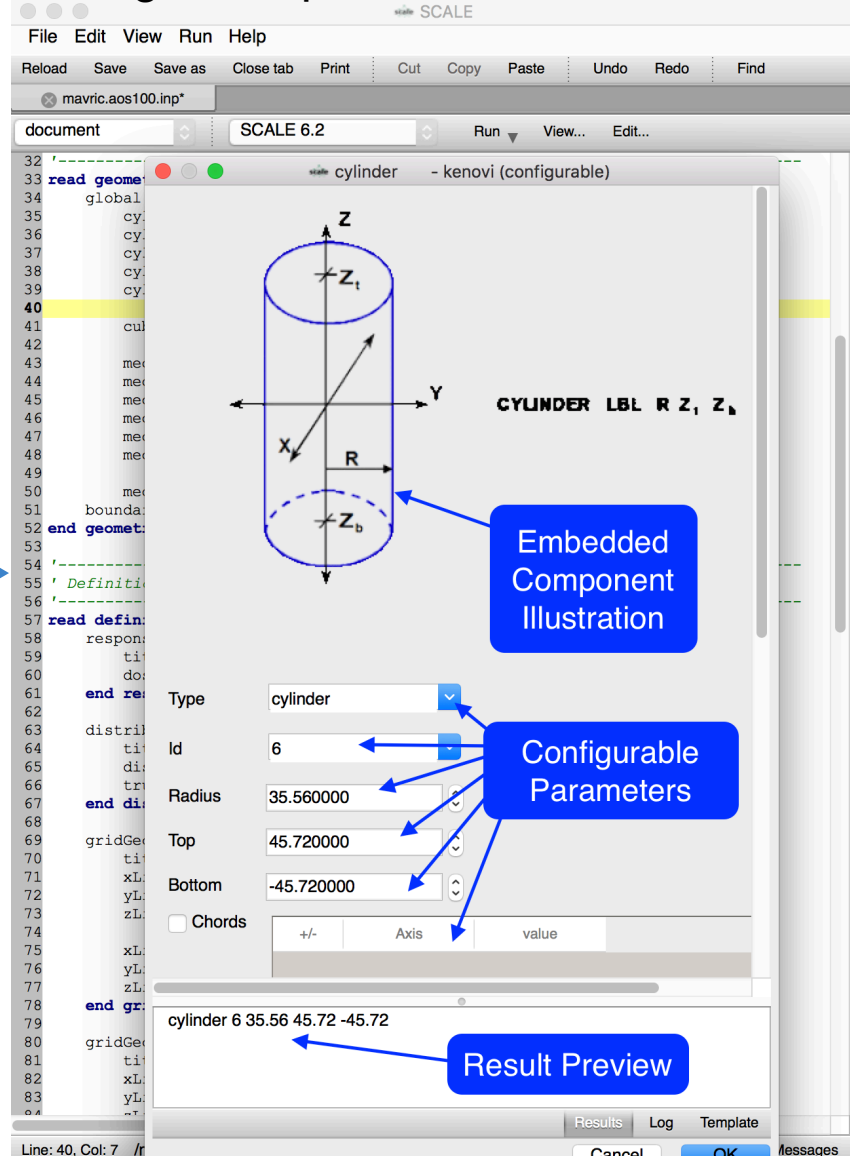
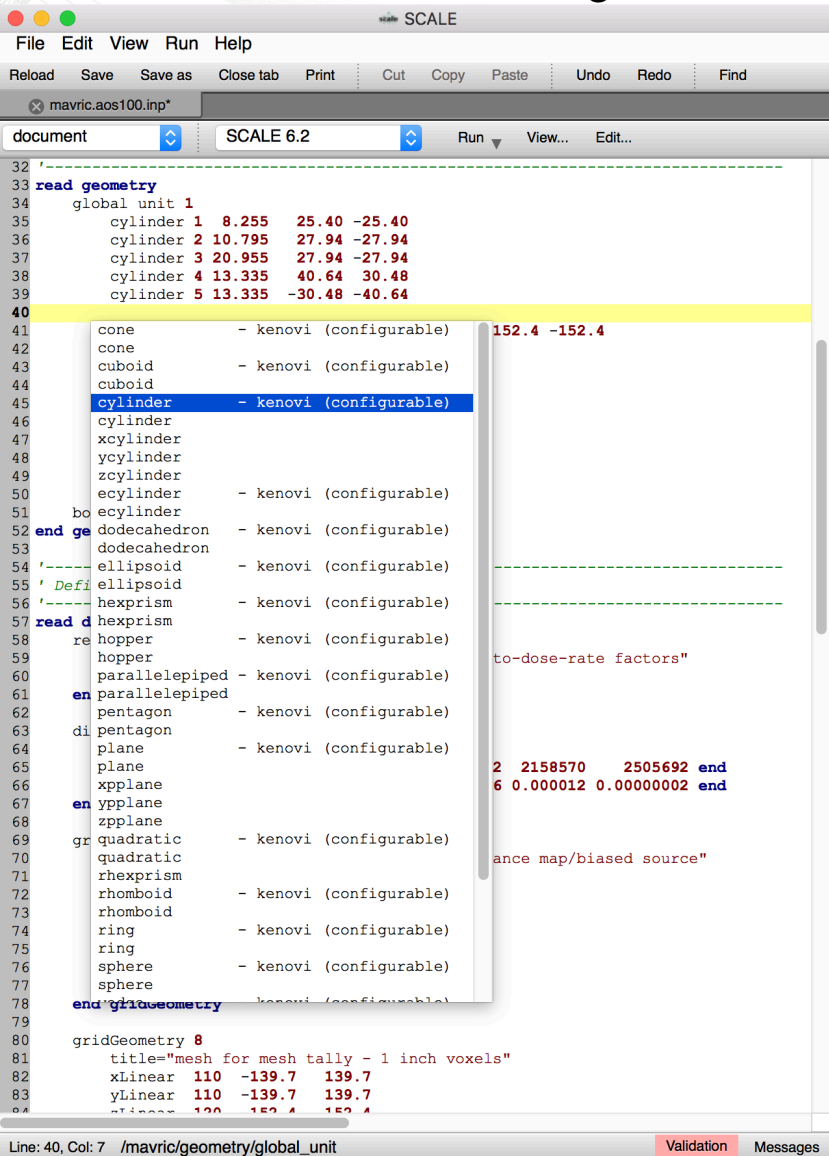
Line: 31, Col: 19 / csas6/parameters Validation Messages
```

Parameters
with descriptions

Input Autocompletion : Configurable Text

Access Autocomplete via
* CTRL+SPACE Keys, or,
* Edit...>Autocomplete

- Allows user to configure values prior to inserting into input.



Input Autocompletion : Configurable Text

- Configurable autocompletion allows entire input creation.
- Results preview facilitates learning input syntax.
- Attributes can be labeled even when the actual input attribute may not have a label.
- Attributes can have a drop-down listing the available or common values to specify.

Access Autocomplete via
* CTRL+SPACE Keys, or,
* Edit...>Autocomplete

The screenshot displays the SCALE software interface. At the top, there is a menu bar with 'File', 'Edit', 'View', 'Run', and 'Help'. Below the menu bar, there are buttons for 'Reload', 'Save', 'Save as', 'Close tab', 'Print', 'Cut', 'Copy', 'Paste', and 'Undo'. The main window title is 'NewProblem.inp' and the current configuration is 'SCALE 6.2'. The 'Run' button is highlighted.

The configuration window, titled 'origami - UO2 express form (configurable)', contains the following fields:

Attribute	Value
Title	this-is-my-title
Fuel Type	w17x17
Uranium (MTU)	1.0
Enrichment (Wt%U235)	4.5
Burnup (MWd/MTU)	40000
Cycles	3
Number of Burnup Interpolations per Cycle	4
Cooling Time (days)	1825
Power History - Percent Up	95
Power History - Average Power (MW/MTU)	40
Moderator Density (g/cc)	0.7332

A blue callout box labeled 'Results Preview' points to a window showing the generated input file content:

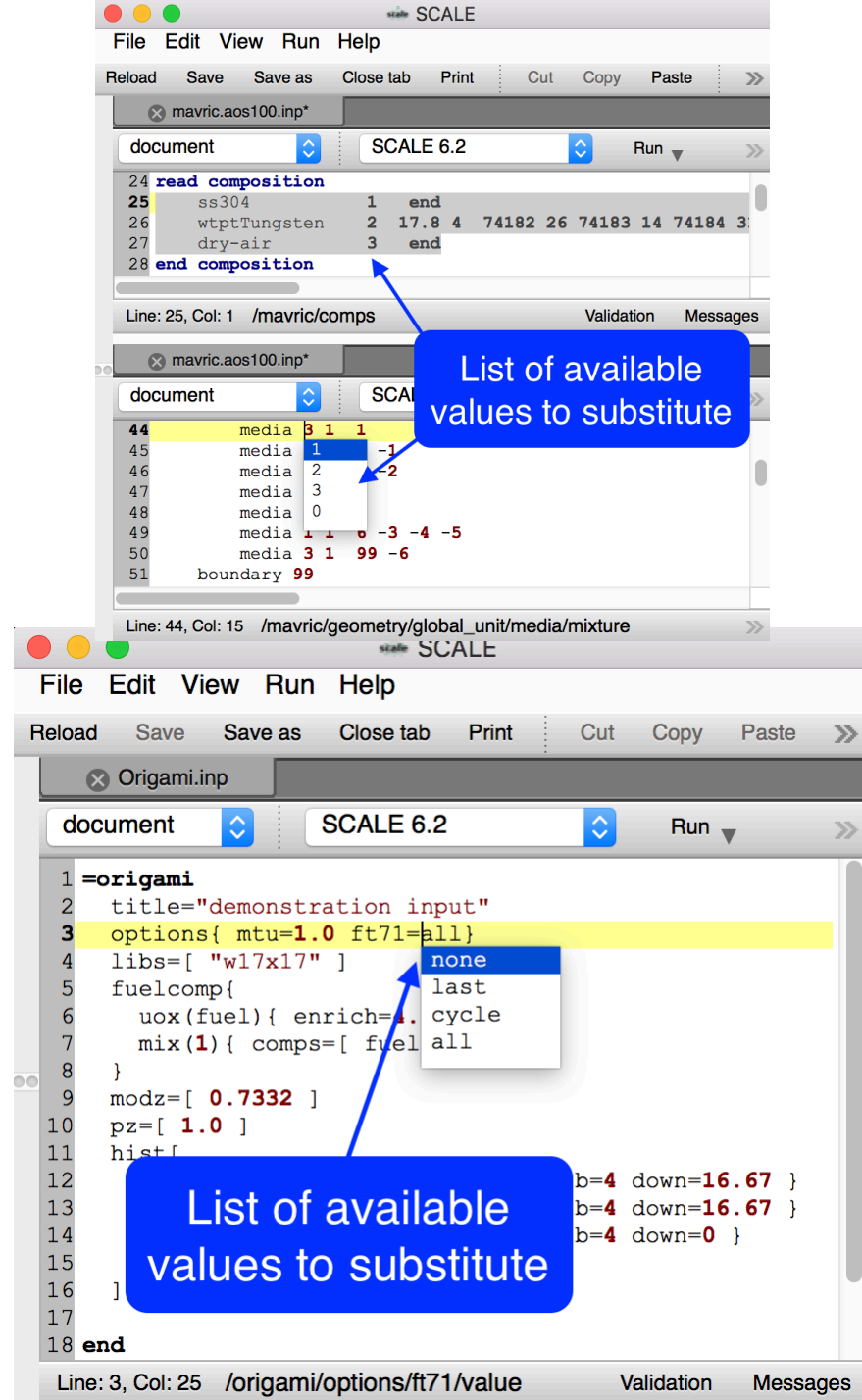
```
=origami
title="this-is-my-title"
options{ mtu=1.0 ft71=all}
libs=["w17x17"]
fuelcomp{
  uox(fuel){ enrich=4.5 }
  mix(1){ comps=[ fuel=100 ] }
}
modz=[ 0.7332 ]
pz=[ 1.0 ]
hist{
  cycle{ power=40 burn=333.33 nlib=4 down=16.67 }
  cycle{ power=40 burn=333.33 nlib=4 down=16.67 }
  cycle{ power=40 burn=333.33 nlib=4 down=0 }
  cycle{ down=1825 }
}
end
```

At the bottom of the configuration window, there are buttons for 'Results', 'Log', and 'Template'. At the bottom of the results preview window, there are 'Cancel' and 'OK' buttons. The status bar at the bottom shows 'Line: 1, Col: 1' and 'Validation Messages'.

Input Autocompletion : Value Substitution

- When autocompletion is requested on an existing value that is either a member of a set of predefined or existing input component values/identifiers, an autocomplete popup is presented listing the available values to substitute.
- Helps user quickly remember/learn what is legal/available.

Access Autocomplete via
* CTRL+SPACE Keys, or,
* Edit...>Autocomplete



Input Validation Overview

- SCALE validation messages consist of parse and validation errors along with the input line and column.
 - Clicking the message will quick navigate to the location in the input editor
- SCALE parse errors prevent the further processing of input and are hard errors in that the interpretation of the input is incomplete.
 - Parse errors typically involve the input that guides the input parser. E.g., number of element-weight-percent pairs not matching actual number provided in the input.
- SCALE validation uses over 20 rules to provide immediate validation. These include value ranges, value uniqueness – is it unique in an input context, value existence – does the value exist in an input context, value enumeration – is the value a member of a list of values.

Input Validation Overview

- Parse errors cascade into other parse errors as the input parser attempts to find legitimate input.
- Parse errors often cause the input parser to terminate early preventing the entire input from being validated.
 - Example below has wtpt element count (line 27) specified as 3, but only has 2 (8000,7000) specified causing a parse error and cascade.

The image displays two screenshots of the SCALE software interface, illustrating the impact of parse errors on validation and navigation.

Top Screenshot: Shows the input file `mavric.aos100.inp` with the following content:

```
23 '-----  
24 read composition  
25   ss304           1   end  
26   wtptTungsten   2 17.8 4 74182 26 |74183 14 74184 41 74186 29 end  
27   wtptdry-air    3 0.0012 3 8000 23.5 7000 76.5081 end  
28 end composition
```

The error messages displayed are:

- line:27 column:55 - Parse Error: expected composition nuclide id, found 'end'
- line:28 column:1 - Parse Error: expected sequence terminator, found 'end composition'
- line:17 column:1 - Validation Error: mavric has 0 "geometry" occurrences - when there should be a minimum occurrence of 1
- line:17 column:1 - Validation Error: mavric has 0 "sources" occurrences - when there should be a minimum occurrence of 1
- line:26 column:5 - Validation Error: wtptcomp children "wtpt" sum to 110 - instead of the required sum of 100

The status bar shows: Line: 26, Col: 41 / /mavric/comps/wtptcomp/atom_wtpt_pair/id

Bottom Screenshot: Shows the same input file with the cursor at the end of line 28:

```
23 '-----  
24 read composition  
25   ss304           1   end  
26   wtptTungsten   2 17.8 4 741  
27   wtptdry-air    3 0.0012 3 800  
28 end composition
```

The status bar shows: Line: 28, Col: 16 /

Callouts in blue boxes highlight the following issues:

- Parse vs validation errors:** Points to the parse error on line 27 and the subsequent validation errors.
- No cursor context after parse error or document quick navigation due to parse error:** Points to the status bar showing the cursor at the end of line 28, indicating that the parser has terminated early and no further context is available.

Input Validation : Required Input

- Required input should minimally occur once in the input.
- When required input is missing autocompletion can quickly generate the missing blocks.

The screenshot shows the SCALE software interface. The main window displays a code editor with the following content:

```
1 =mavric
2 Demonstration input
3 v7-200n47g
4 read comp
5 ' TODO: define comp
6 end comp
7
8 ' TODO: define geometry
9
10 ' TODO: define sources
11
```

A blue callout box labeled "Require input missing" points to lines 5, 8, 10, and 11. The error message at the bottom of the window reads:

```
line:1 column:1 - Validation Error: mavric has 0 "geometry" occurrences - when there should be a minimum occurrence of 1
line:1 column:1 - Validation Error: mavric has 0 "sources" occurrences - when there should be a minimum occurrence of 1
line:4 column:1 - Validation Error: comps has zero of: [ stdcomp wptcomp atomcomp arbmcomp soln solution ] - at least one must occur
```

The status bar at the bottom indicates the current position: "Line: 4, Col: 1 /mavric/comps/decl".

Input Validation : Value Errors

Value constraint errors can be hard to find. Input validation provides immediate feedback on the following.

- Simple value ranges
 - E.g., $0.0 < x \leq 100$
- More complex
 - Expected value sums
 - Expected value function (increasing, decreasing, etc.)
 - Component relationship
 - E.g., $X > Y$

The image shows three screenshots of the SCALE software interface, illustrating validation errors in input files. Each screenshot shows a code editor window with a message pane below it. Blue callout boxes provide context for the errors.

Top Screenshot: Shows a validation error for an incorrect weight-percent sum. The error message is: "line:26 column:5 - Validation Error: wtptcomp children "wtpt" sum to 100.5 - instead of the required sum of 100". The code snippet shows a table of components with their weight percentages.

Middle Screenshot: Shows a validation error for zone radii overlap. The error message is: "line:30 column:1 - Validation Error: multiregion children "radius" are not strictly increasing at line:31 column:30". The code snippet shows a table of cylindrical regions with their radii.

Bottom Screenshot: Shows a validation error for a relationship between two components. The error message is: "line:40 column:35 - Validation Error: zb value "27.94" is greater than or equal to the allowed maximum exclusive value of "27.94" from "../zt". The code snippet shows a table of cylindrical regions with their dimensions.

Input Validation : Reference Errors

Using component identifiers can lead to duplicate or missing identifiers.

- Checks if the component's identifier is unique in the required input contexts.
 - Ensure all geometry regions have unique identifiers.
- Check if the component identifier references an existing component

Identifier is duplicate - both input locations are provided.

Region (cone, cuboid, etc.) with given id (99) does not exist in the specified input.

Missing component search paths.

Input Execution Overview

- Execution is preconfigured to execute the SCALE included with Fulcrum.
- Execution of other applications (e.g., prior SCALE release) can be setup.
- Only local execution (no cluster or queue support, yet).
- Execution can be in the background.
 - Allows closing Fulcrum without cancelling/terminating the execution.
- Input listing, mixing table, alias expansion, and volume calculation [prototype] are available via quick execution buttons.
- Messages from executions are stored in time stamped tabs.

Input Execution : Customized Configurations

- Add new
- Clone existing
- Remove existing
- Modify existing
- Show executable help
- Provide additional arguments

The image displays the SCALE application interface. The main window, titled 'SCALE', has a menu bar with 'File', 'Edit', 'View', 'Run', and 'Help'. Below the menu bar are buttons for 'Reload', 'Save', 'Save as', 'Close tab', 'Print', 'Cut', 'Copy', 'Paste', 'Undo', 'Redo', and 'Find'. A toolbar shows a document icon, a dropdown menu with 'SCALE 6.2' selected, and buttons for 'Run', 'View...', and 'Edit...'. A 'Customize...' button is also visible. The main area shows a list of configurations with 'SCALE 6.2' selected. Below this are 'Add', 'Clone', and 'Remove' buttons. A 'Help' button is located at the bottom left of the configuration window. A blue callout box labeled 'Help Information' points to the 'Help' button. The 'Configurations' window has a 'Properties' section with fields for 'name' (SCALE 6.2), 'executable' (/Applications/SCALE-6.2.1.app/Contents/Resources/bin/scalerte), and 'arguments' ('-m'). At the bottom of the configuration window are 'Help', 'Apply', 'Cancel', and 'OK' buttons. A 'scalerte help' window is open, showing the usage and options for the scalerte command. The help text includes: 'Usage: scalerte <options> inputfile(s)', 'Where options are:', '-a: Specify alias file.', '-a path/to/aliasesfile', '-c: Return centrm output to filename.centrmfiles directory.', '-f: Add hostname to output filename.', '-h: Print this help message', '-I: Number of threads to use for MPI/OpenMP directives. -I 4.', '-m: Turn messages on', '-M: Specify a machine names file for SCALE parallel capabilities.', '-M /path/to/machine/names/file', '-n: Nice level, ignored on windows. -n 2', '-N: Number of MPI processes to run. -N 20.(ONLY AVAILABLE WITH MPI BUILT SCALE)', '-o: Overrides the default 'inputfile.out'' output name.', '-o path/to/outputfile.', and a NOTE: 'NOTE: If the path/to/outputfile already exists, it will be deleted. If the option is specified while in stack mode (multiple input files) the value provided is prepended to the inputfile's basename.'

Input Execution : Running Jobs

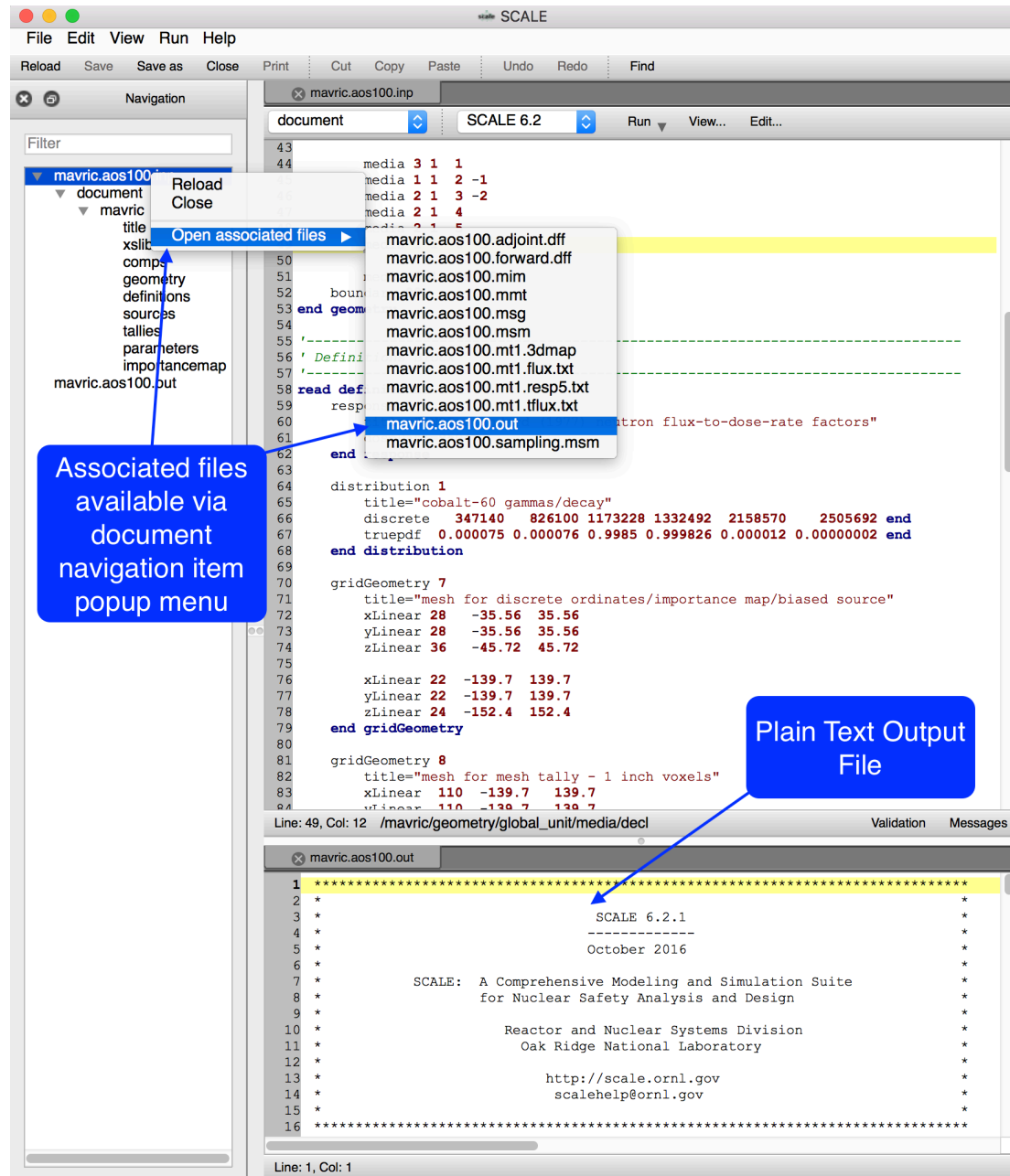
- Run launches the selected configuration (SCALE 6.2).
- For Run a time-stamped Messages Tab is added with application messages panel.
- Alternatives are conveniently available via the Run drop-down.
 - Run in background launches the job but with a terminal instead of a messages tab.
 - Expand aliases unrolls aliased input (TRITON).
 - Input listing provides directory-like input listing useful for Sampler model perturbation.
 - Mixing table lists the atomic number densities (atoms/b-cm) per nuclide per mixture.
 - Calculate volumes (prototype) runs a user-specified number of rays per geometry axis and accumulates media volumes. The complete input with media 'vol' cards is echoed in the message tab.

The screenshot displays the SCALE 6.2 user interface. At the top, the 'Run' menu is open, showing several alternatives: 'Run in background', 'Expand aliases', 'Input listing', 'Mixing table', and 'Calculate volumes'. A blue callout box labeled 'Convenient Run Alternatives' points to this menu. Above the menu, a blue callout box labeled 'Selected execution configuration when Run invoked' points to the 'SCALE 6.2' dropdown menu. Below the menu, a blue callout box labeled 'Message Tab per Run invocation' points to a new tab titled 'Wed Oct 12 23:05:57 2016' which contains a message: 'Starting the Monte Carlo game with 00003ECD7B4B...E8B'. Below this, another blue callout box labeled 'Convenient Run Alternatives' points to the 'Run in background' option in the menu. The bottom part of the screenshot shows a table of mixture data.

Entry	Mixture	Nuclide	Density (atoms/b-cm)	Temperature (K)
6	Mixture = 1 with density(g/cc) = 7.9400 and temperature(K) = 293.00			
7				
8				
9	1	6012	3.150793e-04	
10	2	6013	3.407812e-06	
11	3	14028	1.570105e-03	
12	4	14029	7.976252e-05	
13	5	14030	5.264157e-05	
14	6	15031	6.946885e-05	
15	7	24050	7.591783e-04	
16	8	24052	1.464000e-02	
17	9	24053	1.660058e-03	
18	10	24054	4.132236e-04	
19	11	25055	1.740717e-03	
20	12	26054	3.421905e-03	
21	13	26056	5.371659e-02	
22	14	26057	1.240550e-03	
23	15	26058	1.650942e-04	
24	16	28058	5.268730e-03	
25	17	28060	2.029506e-03	
26	18	28061	8.822118e-05	
27	19	28062	2.812878e-04	
28	20	28064	7.163575e-05	
29				
30	Mixture = 2 with density(g/cc) = 17.8000 and temperature(K) = 293.00			

Output File Viewing

- Easy to access from the Input file's list of associated files popup context menu.
- No intelligent outline, yet.
- Output file Can be drag-n-dropped onto Fulcrum from a file browser (as can any SCALE file with an extension, *.inp, *.out, etc.).



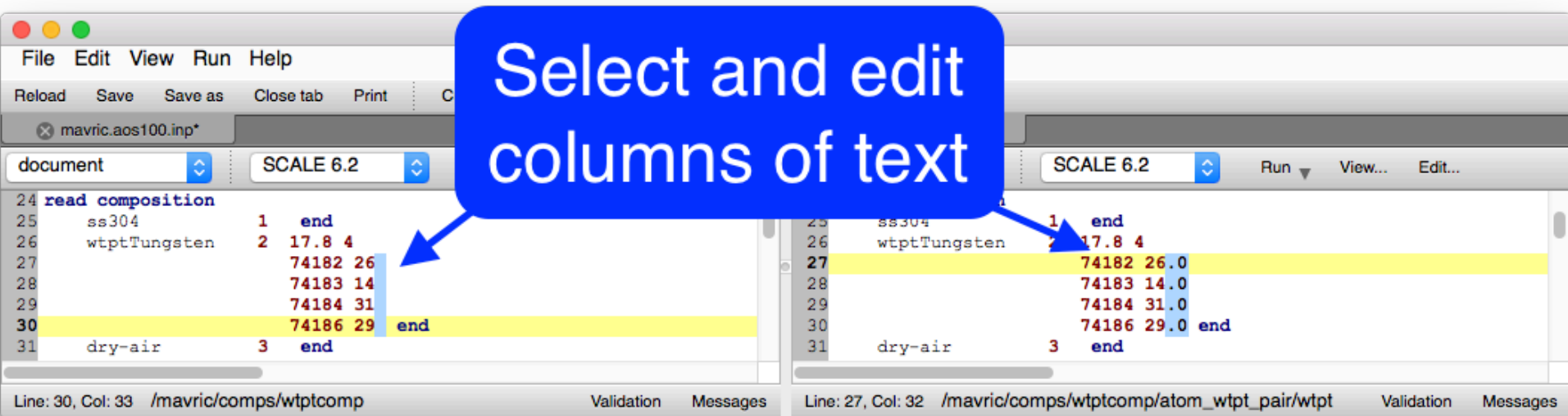
Miscellaneous Features

- Column select/edit
 - via ALT+left click+mouse drag key and mouse combo
- Go to definition – allows quick navigation to input components definition via a right click popup context menu.
 - E.g., anywhere an identifier is used to reference another input component.
- Math evaluator
 - Ability to evaluate selected text as a math expression – replaces selection with expression's result.
- Comment toggle
 - Ability to comment/uncomment selected lines
- Indent/unindent
 - Ability to indent/unindent selected lines
- Auto saves – automatic back up to *inputname.fulcrum.autosave*.
 - File exists only while there are unsaved document changes
- Features illustrated on following slides

Miscellaneous : Column Selection/Edit

Formatting related text into aligned columns allows for faster recognition and column-wise text operations.

- Fulcrum provides column selection via ALT+MOUSE SELECTION.
- With column selection made, any edits are made to all columns for each row.
 - E.g., Update all isotope weight percent values to have a decimal digit.



Miscellaneous : Go To Definition

The 'Go To Definition' feature (available via right clicking an input component) is intended to facilitate the user in quickly navigating to the component being referencing. New users can discover input component relationships. Experienced users can have their navigation accelerated, especially in larger inputs.

- Referenced mixture identifier – goes to the mixture's definition.
- Referenced Geometry unit identifiers (holes) – goes to the unit definition.

The screenshot displays the SCALE 6.2 software interface. A context menu is open over a code editor, showing options such as 'Goto definition of mixture', 'Autocomplete', 'Toggle comment', 'Find', 'Indent', 'Unindent', 'Evaluate', 'Undo', 'Redo', 'Cut', 'Copy', 'Paste', 'Delete', and 'Select All'. A blue callout box points to the 'Goto definition of mixture' option, containing the text: "Cursor context used in definition look up and navigation". The background shows two code editors with text like 'media 3 1 99 -6' and 'dry-air 3 end'.

Miscellaneous : Math Evaluations

Often engineering specifications require conversion to input specifications. Even if a calculator is readily available, a human component is required to enter the converted (e.g, inches to centimeters) value into the input. Fulcrum provides an inline math expression evaluator.

- Removes/mitigates typographical errors related to converted numeric input entry.
- Encourages documentation of engineering specifications that require conversion.
- Full complement of math functions available :
 - +, -, *, /, ^, sqrt, cos, sin, root, abs, min, max, avg, sum, mul, floor, ceil, exp, log, logn, log10, hyp, if, clamp, inrange, sign, deg2rad, tan, equal, acos, asin, atan, cosh, tanh, sec, csc, cot, sinh, round, roundn, d2g, g2d, r2d
- Evaluation occurs on highlighted text.

The image displays two side-by-side screenshots of the SCALE software interface, illustrating the inline math expression evaluator. Both screenshots show a code editor window titled 'mavric.aos100.inp*' with a menu bar (File, Edit, View, Run, Help) and a toolbar (Reload, Save, Save as, Close tab, Print, Cut, Copy, Paste, Undo, Redo, Find). The code editor contains the following text:

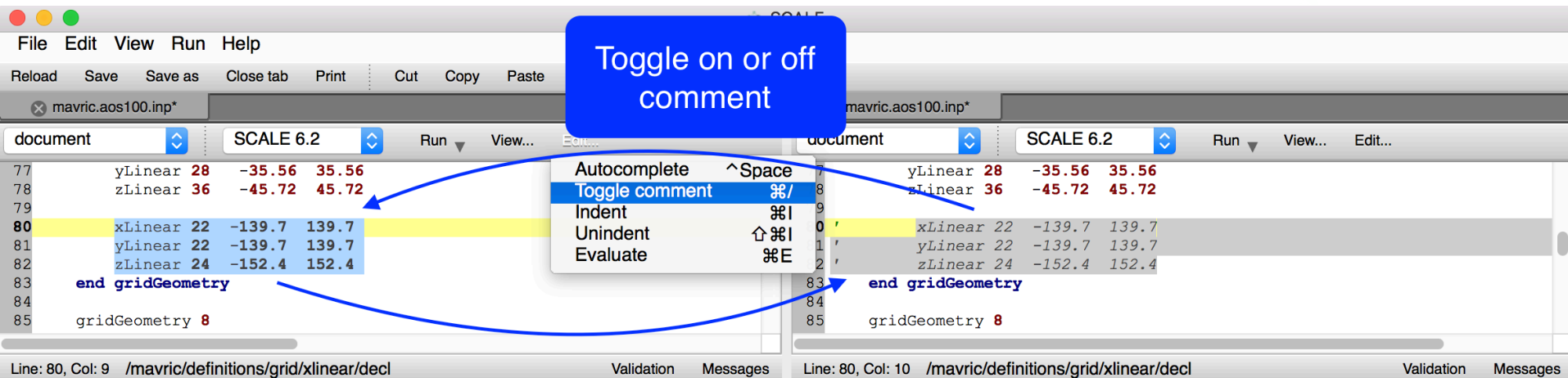
```
34 '-----  
35 ' Geometry Block - SCALE standard geometry packa  
36 ' Input units in centimeters  
37 '-----  
38 read geometry  
39   global unit 1  
40   ' Cavity cylinder in inches is specified as  
41   ' radius=20.9677 height=129.032 located at z=-64.516  
42   cylinder 1 20.9677/2.54 (-64.516 + 129.032)/2.54 -64.516/2.54
```

In the left screenshot, the math expression `(-64.516 + 129.032)/2.54` is highlighted in yellow, and a context menu is open over it with the 'Evaluate' option selected. In the right screenshot, the math expression `20.9677/2.54` is highlighted in yellow, and the result `25.4` is displayed next to it. A blue callout box with the text 'Math expressions and evaluation' has arrows pointing to the highlighted expressions in both screenshots. The status bar at the bottom of each window shows 'Line: 42, Col: 36 / Validation Messages' on the left and 'Line: 42, Col: 42 / Validation Messages' on the right.

Miscellaneous : Comment Toggle

Comment toggling allows users to quickly comment or uncomment pieces of input.

- Allows comment creation.
- Mitigates user needing to recall what a comment looks like.
- Assists in input development iterations.
- CMD+/ on OS X and CTRL+/ on Windows and Linux.



Miscellaneous : Input Indent/Unindent

Hierarchical input (Sequence > Read Block > Component Record) can be depicted using levels of indentation. Input indent and unindent facilitates quick formatting to visually depict hierarchy.

The image displays two screenshots of the SCALE software interface, illustrating the use of the Indent and Unindent menu options. The interface shows a code editor with a menu open over the code. The code is as follows:

```
77 yLinear 28 -35.56 35.56
78 zLinear 36 -45.72 45.72
79
80 xLinear 22 -139.7 139.7
81 yLinear 22 -139.7 139.7
82 zLinear 24 -152.4 152.4
83 end gridGeometry
84
85 gridGeometry 8
```

In the first screenshot, the 'Indent' option is selected in the menu, and a blue callout box indicates 'Indent selected text a tab (4 spaces)'. The second screenshot shows the 'Unindent' option selected, with a blue callout box indicating 'Unindent selected text a tab (4 spaces)'. The status bar at the bottom of the interface shows 'Line: 80, Col: 1 /mavric/definitions/grid'.

Miscellaneous : File Autosaves

Any file Fulcrum edits - currently only text files - are immediately backed up to a *filename.fulcrum.autosave*. In the scenario that Fulcrum or the application or computer crashes the autosave file will persist.

- Upon Fulcrum restart, when reloading the original file, Fulcrum will check for *filename.fulcrum.autosave* and load this instead, mitigating any lost progress.
- A save of the file will remove the autosave.

Input Editor : Future Features

- Enhanced cursor context presentation.
 - Display input record information under cursor with labels.
 - Linked help documentation – press F1 and get help section describing the input record under the cursor.
- Enhanced input component forms.
 - Allows displaying input record/block under cursor in a visual form – allows seamless input text to form round-tripping without loss of input formatting or input [quality assurance] comments.
- Input Differences.
 - Visually difference two inputs.
- Enhanced output review capability.
 - Warning and error quick navigation.
 - Upgraded HTML output.

Summary

- Fulcrum Input Editor Components
- Text Editor Settings
 - Syntax colors and default editor behaviors
- Syntax Highlighting
 - Input component color
- Document Quick Navigation
- Cursor Context
 - Formal location in the input document
- Input Block Start and End Highlighting
- Input Autocompletion
 - Creation and editing of input
- Input Validation
 - Simple and complex
- Input Execution
 - customizable
- Output File Viewing
- Miscellaneous Features
 - Find/Replace
 - Column select/edit
 - Comment toggle
 - Selection indent/unindent
 - Inline math evaluations
- Future Features coming soon to a Fulcrum on your desktop

Exercise 1 : Lady Godiva

Create the Lady Godiva experiment using CSAS6.

Problem definition :

Lady Godiva consists of **17.482** cm diameter sphere.

Run **V7-252 multiregion** cross section with **vacuum right boundary** condition, and **10000 particles per generation** with **200 generations skipped**.

Isotope	Atomic Number Density
U-234	0.000491995
U-235	0.0449996
U-238	0.002498

Exercise 1 : Lady Godiva

Purpose :

- 1) New Input creation.
- 2) Autocompletion of input.
- 3) Execution and output viewing.

Exercise 1 : Lady Godiva : Task 1

Creation New document named InputEditorExercise1.inp

- File>New File...
- Specify InputEditorExercise1.inp.

You should now have a blank input file.

Exercise 1 : Lady Godiva : Task 2

Autocomplete a **csas6** sequence.

- With cursor in text editor, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination.
- Select the **csas6 – Criticality safety analysis using KENO-VI**.
- Change ‘title-goes-here’ to ‘Lady godiva.’
- Change ‘xslib-goes-here’ to ‘v7-252.’

You should now have an input file with minimum required input blocks. Notice the validation errors indicating what is needed.

Exercise 1 : Lady Godiva : Task 3

Autocomplete 3 **stdcomps** with **atomic density** and **temperature** for the listed isotopes.

- With cursor in comps block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **stdcomp – basic + atomic density + temperature**.
- Update the isotope and atomic density (**aden**)
- Repeat the above 2 steps for each isotope in the table.

You should now have a complete composition block.

Isotope	Atomic Number Density
U-234	0.000491995
U-235	0.0449996
U-238	0.002498

Exercise 1 : Lady Godiva : Task 4

Autocomplete the cell block and **17.482 diameter spherical multiregion cell**.

- With cursor below the comps block and above the geometry block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **cells**.
- With cursor in the cells block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **multiregion - spherical**.
- Update the multiregion zone input to reflect the proper sphere **radius**.

You should now have an input with complete comp and cell data. The validation messages should indicate error about global unit's missing media,hole, etc.

Exercise 1 : Lady Godiva : Task 5

Autocomplete the sphere.

- With cursor below the global unit and above the unit boundary, select **Edit>Autocomplete**, or press **CTRL +SPACE** key combination and select the **sphere**.
- Update the sphere **radius** to the appropriate value.

You should now have an input with a sphere region specified but no media.

Exercise 1 : Lady Godiva : Task 6

Autocomplete the media.

- With cursor below the sphere and above the unit boundary, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **media**.

You should now have an input with a sphere region specified and media. Notice the media material and region definition vector was updated as the default values matched the generated material id from task 3 and 5.

There should be no validation errors.

Exercise 1 : Lady Godiva : Task 7

Execute the first input iteration.

- Click the Run button.
- Click the Messages panel.
- Note the k-eff value of $\sim 1.0007 + \text{ or } - 0.0016$.

At this point you should have a functioning input, that needs a parameter block.

Exercise 1 : Lady Godiva : Task 8

Autocomplete the parameter block and run again.

- With cursor below the cells block and above the geometry block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **parameters**.
- With cursor in the parameter block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **npg – no. per generation**. Update to **10000**.
- With cursor in the parameter block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **nsk – generations skipped**. Update to **200**.
- Click the Run button.
- Click the Messages panel.
- Note the k-eff value of $\sim 0.9999 + \text{ or } - 0.0044$

Exercise 1 : Lady Godiva : Task 9

Open the output.

- In the document **Navigation** panel right click the InputEditorExercise1.inp file.
- Mouse over Open associated files.
- Select the InputEditorExercise1.out file.
- Conduct a find on 'best estimate.'
- Notice the expected value.

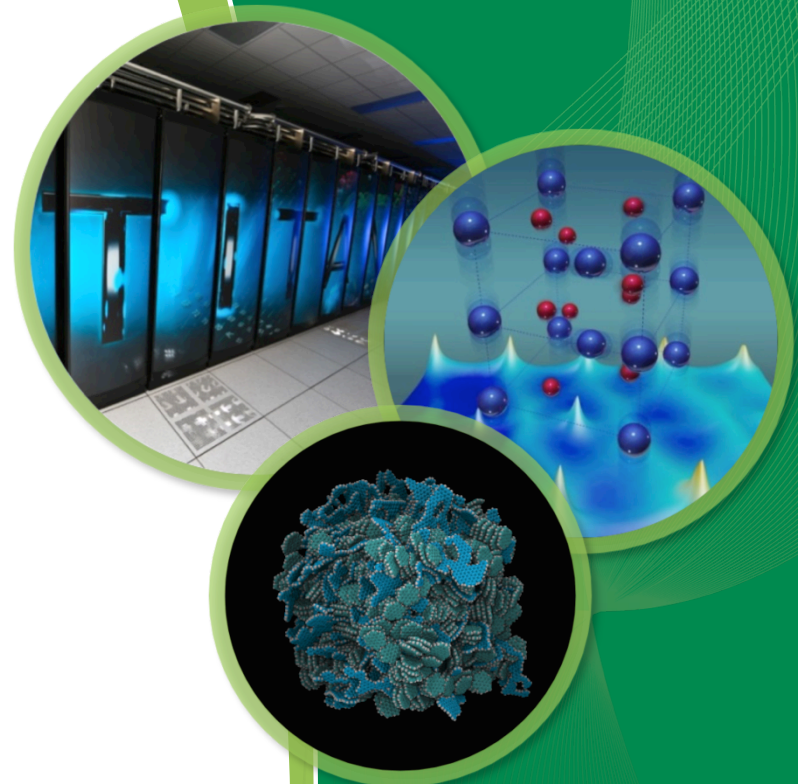
Exercise complete.

Fulcrum User Interface

Plot Data Overview

Robert A. Lefebvre

October 2016

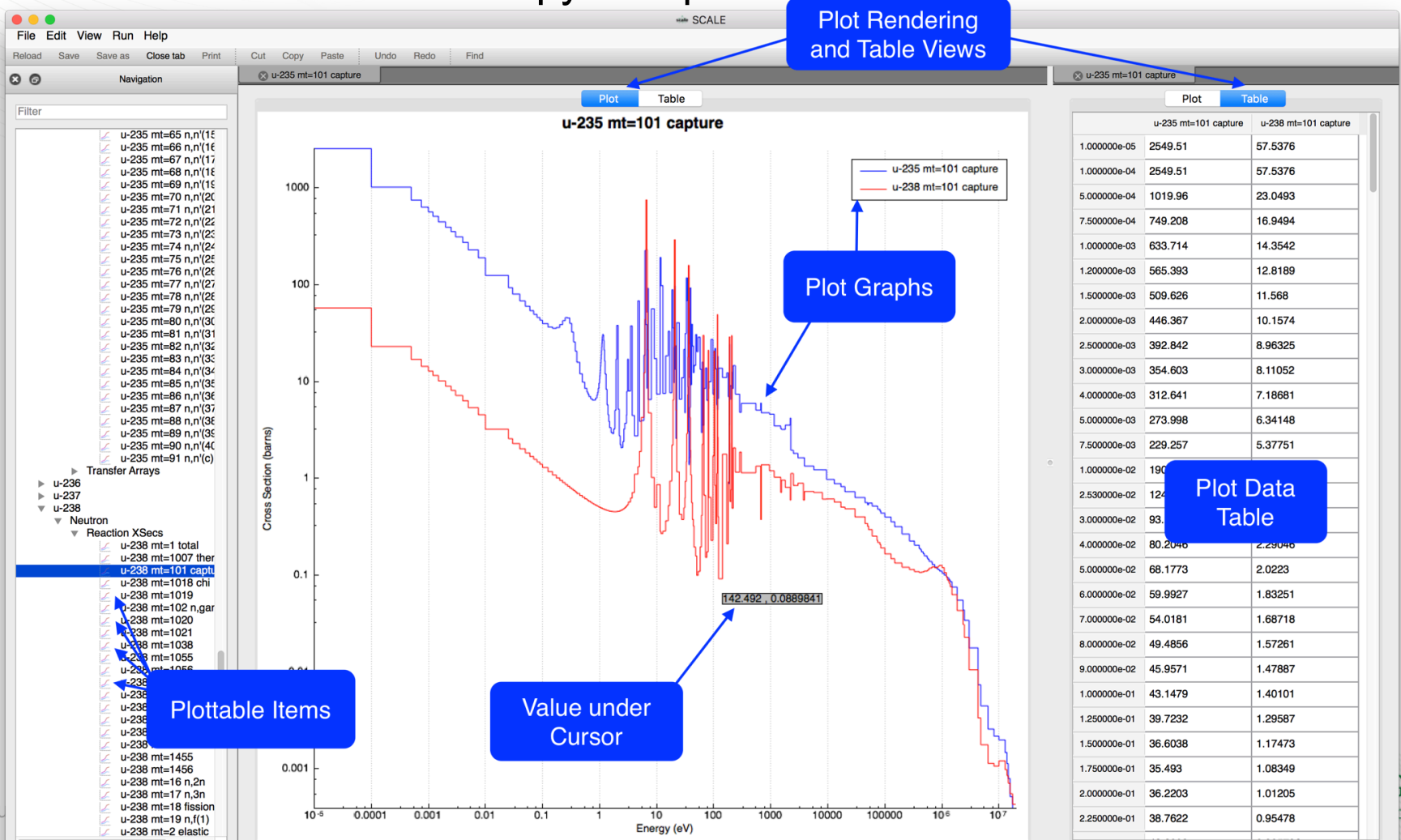


Presentation Outline

- General Plot Overview
- Plot Controls
- AMPX Cross Section Data
- Covariance Data
- ORIGEN Isotope Concentration Data (F71)
- F71 Special Plot Controls (PlotOPUS)
- ORIGEN Gamma Data
- General Output Result Plots

General Plot Overview

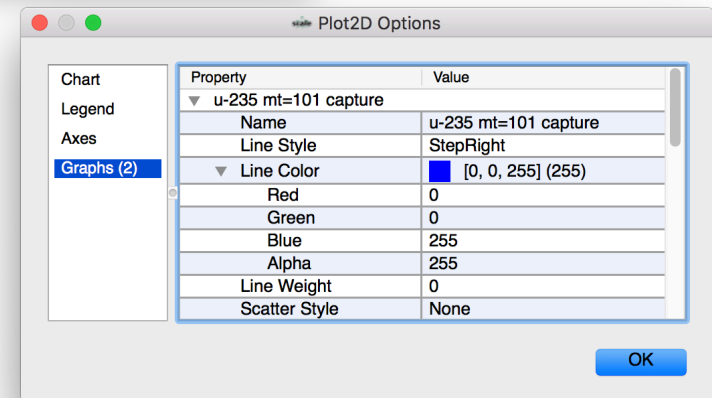
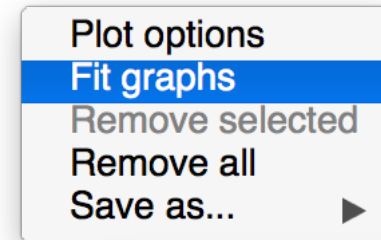
- Interactive and configurable plot rendering
- Plot data table displays graph data.
 - allows row and table copy to clipboard.



Plot Controls

Fulcrum plots consist of graph, bars, or color maps, which can be manipulated as follows.

- Select graph via left click in plot or legend.
 - Remove selection via context menu 'Remove selected'
- Zooming is performed via the mouse scroll action.
 - Zoom in by scrolling up.
 - Zoom out by scrolling down.
- Reset to original via context menu Fit graphs.
- Panning is performed via a click and drag.
 - Pan right by left clicking and dragging left.
 - Pan up by left clicking and dragging down.'
- Save Plot as
 - PDF (includes scalable vector graphics SVG),
 - PNG and JPG image format
 - Interactive Scale Plot Format (SPF)
- Plot attributes (color, style, etc.) can be changed via context menu Plot options.
- Plot Legend can be drug to 9 cardinal positions via left-click and drag.



Plot Controls : Plot Options

- Chart – Allows changing the plot title and title visibility.
- Legend – Allows changing the legend's font and visibility.
- Axis – Allows changing axis visibility, label text, label text font, axis scale, axis range, axis grid, tick label font and tick text attributes (rotation, precision, etc.).
- Graphs – Allows changing graph name, line style, line color, line weight, scatter style, scatter size, pen style, adaptive sampling*, errors bars.
- Bars – Allows changing bar graph name.
- Color Map – Allows changing color map graph name and color gradient.

Plot Controls : Plot Creation

Plots can be created standalone or added to existing.

- Double left-click a plot to create a new plot.
- Alternatively, right click and select New plot.
- Add to preexisting plot via a right click and selecting Add graph to....
 - Add is only available for plots with matching axes.

The screenshot shows a list of plots with the following entries:

- u-235 mt=1 total
- u-235 mt=101 capture
- u-235 mt=1019
- u-235 mt=102 n,gamma
- u-235 mt=1020
- u-235 mt=1021
- u-235 mt=1038
- u-235 mt=1055
- u-235 mt=1056
- u-235 mt=1099 weight.function
- u-235 mt=1419
- u-235 mt=1420
- u-235 mt=1421
- u-235 mt=1438
- u-235 mt=1452
- u-235 mt=1455
- u-235 mt=1456
- u-235 mt=16 n,2n
- u-235 mt=17 n,3n
- u-235 mt=18 fission
- u-235 mt=19 n,f(1)
- u-235 mt=2 elastic
- u-235 mt=20 n,nf
- u-235 mt=2000
- u-235 mt=2022 within-grp.scats
- u-235 mt=21 n,2nf
- u-235 mt=27 absorption
- u-235 mt=3 nonelastic

The context menu is open over the first item, showing the following options:

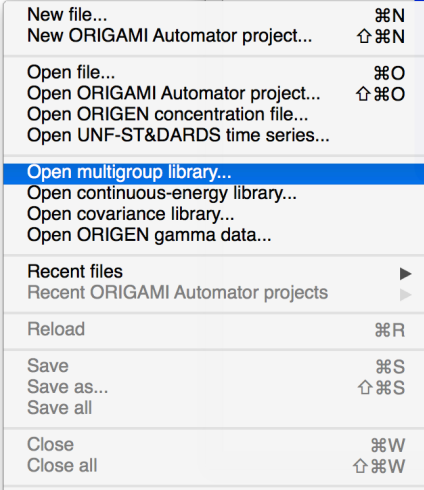
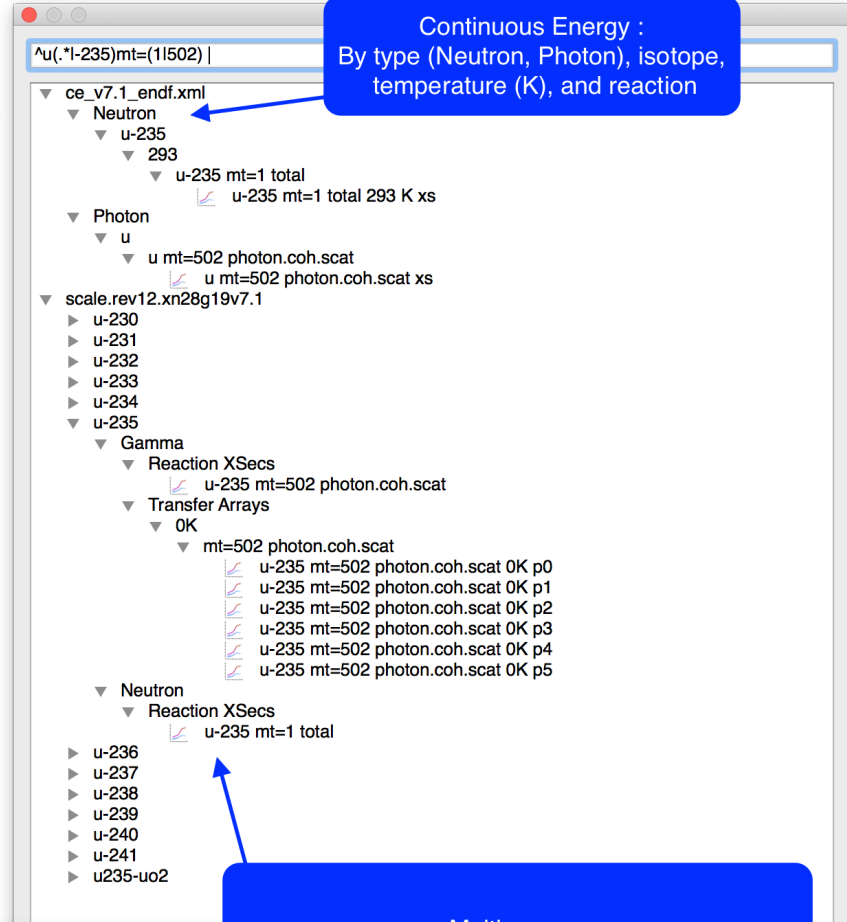
- New plot
- Add graph to "u-235 mt=101 capture"

A blue callout box contains the text: "Default action of New plot, or add to existing graph".

AMPX Cross Section Data

AMPX Cross Section Data is available in multigroup (MG) and continuous-energy form and is located at $\{\text{SCALE}\}/\text{data}$. Because the files do not have a unique extension, the user must load them specifically by type.

- Load MG XS data via File>Open multigroup library...
- Load CE XS data via File>Open continuous-energy library...
- CE XS data are displayed hierarchically
 - by Neutron or Photon, Isotope, Temperature (K), and Reaction.
- MG XS data are displayed hierarchically
 - By Isotope, Neutron or Gamma, Reaction XS or transfer array.



Plot Exercise 1

Description:

Compare the **252 MG** vs. **CE U-235 Fission** cross section at **293K** and produce a **PDF** of the **108 barn** peak between **0.1-10 eV**.

Intent:

Familiarity with loading CE and MG libraries.

Familiarity with plot controls (zoom and pan).

Familiarity with combining plots.

Familiarity with saving plots.

Plot Exercise 1 : Task 1

1. Load CE V7.1 ENDF library from the SCALE/data directory.
2. Find the U-235 Isotope at 293K.
3. Double click the 293 navigation item to load the reactions at that temperature.
4. Find the U-235 mt=18 fission 293 K xs entry.
5. Double click the entry to create a 2D plot.
6. Done.

Plot Exercise 1 : Task 2

1. Load 252 group MG library from the SCALE/data directory.
2. Find the U-235 Isotope Neutron Reaction XSecs entry.
3. Find U-235 mt=18 fission entry.
4. Right click the entry to obtain a popup context menu.
5. Click the Add to graph to... menu item.
6. Done.

Plot Exercise 1 : Task 3

1. Pan the plot to be centered at 1 eV.
 - Left click and drag
2. Zoom the plot to the requested eV range.
 - Scroll up zooms in.
3. Repeat steps 1 and 2 as needed to center plot about the ~108 barn cross section peak near 1 eV.
4. Right click to obtain the plot context menu.
5. Select Save as>PDF and specify PlotExercise1.pdf.
6. Done

Exercise complete.

Covariance Data

Covariance Data is available at SCALE/data. Because the files do not have a unique extension, the user must load them specifically by type.

- Correlation coefficient matrix color map plots
- Covariance matrix color map plots
- Isotope Reaction Standard Deviation by energy or group graph plots

New file... ⌘N
 New ORIGAMI Automator project... ⇧⌘N

Open file... ⌘O
 Open ORIGAMI Automator project... ⇧⌘O
 Open ORIGEN concentration file...
 Open UNF-ST&DARDS time series...

Open multigroup library...
 Open continuous-energy library...
Open covariance library...
 Open ORIGEN gamma data...

Recent files
 Recent ORIGAMI Automator...

Reload

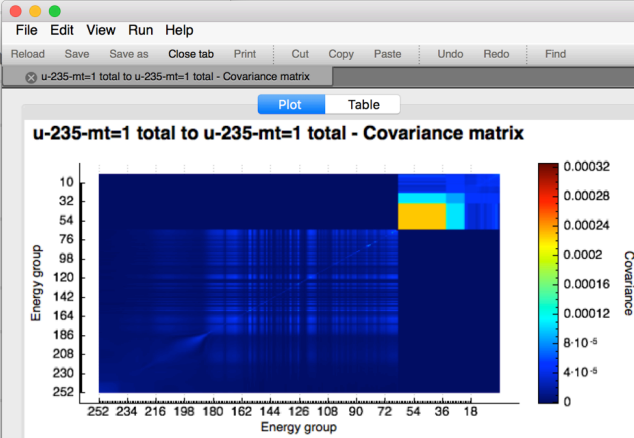
Save
 Save as...
 Save all

Close
 Close all

Print

Settings...
 Reset settings

Exit



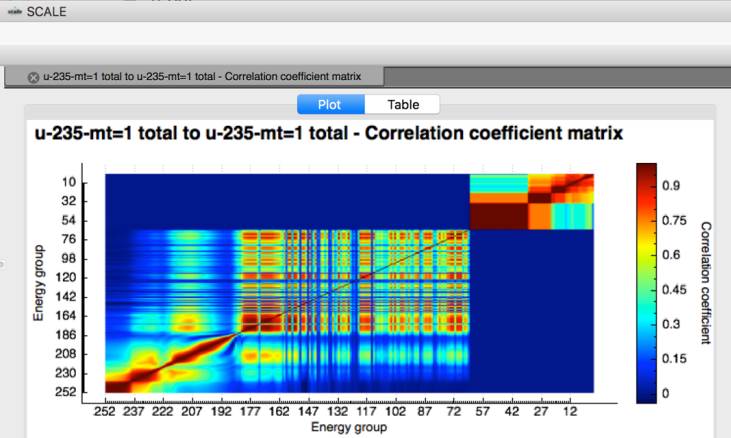
Navigation

u-235

- u-235
 - mt=1 total
 - u-235
 - u-235-mt=1 total to u-235-mt=1 total
 - u-235-mt=1 total to u-235-mt=1 total - Correlation coefficient matrix
 - u-235-mt=1 total to u-235-mt=1 total - Covariance matrix
 - u-235-mt=1 total to u-235-mt=102 n,gamma
 - u-235-mt=1 total to u-235-mt=102 n,gamma - Correlation coefficient matrix
 - u-235-mt=1 total to u-235-mt=102 n,gamma - Covariance matrix
 - u-235-mt=1 total to u-235-mt=18 fission
 - u-235-mt=1 total to u-235-mt=18 fission - Correlation coefficient matrix
 - u-235-mt=1 total to u-235-mt=18 fission - Covariance matrix
 - u-235-mt=1 total to u-235-mt=2 elastic
 - u-235-mt=1 total to u-235-mt=2 elastic - Correlation coefficient matrix
 - u-235-mt=1 total to u-235-mt=2 elastic - Covariance matrix
 - u-235 mt=1 total - Std dev by energy**
 - u-235 mt=1 total - Std dev by group
 - mt=1018 chi
 - mt=102 n,gamma
 - mt=16 n,2n
 - mt=18 fission
 - mt=2 elastic
 - mt=4 n,n'
 - u-235
 - u-235-mt=4 n,n' to u-235-mt=2 elastic
 - u-235-mt=4 n,n' to u-235-mt=2 elastic - Correlation coefficient matrix
 - u-235-mt=4 n,n' to u-235-mt=2 elastic - Covariance matrix
 - u-235-mt=4 n,n' to u-235-mt=4 n,n'
 - u-235-mt=4 n,n' to u-235-mt=4 n,n' - Correlation coefficient matrix
 - u-235-mt=4 n,n' to u-235-mt=4 n,n' - Covariance matrix
 - u-235 mt=4 n,n' - Std dev by energy
 - u-235 mt=4 n,n' - Std dev by group
 - mt=452 nubar
 - u-235
 - u-235-mt=452 nubar to u-235-mt=452 nubar
 - u-235-mt=452 nubar to u-235-mt=452 nubar - Correlation coefficient matrix
 - u-235-mt=452 nubar to u-235-mt=452 nubar - Covariance matrix

Correlation Coefficient and Covariance Matrix Color Map Plots

Standard Deviation Graph Plots



Correlation coefficient matrix

Correlation coefficient matrix

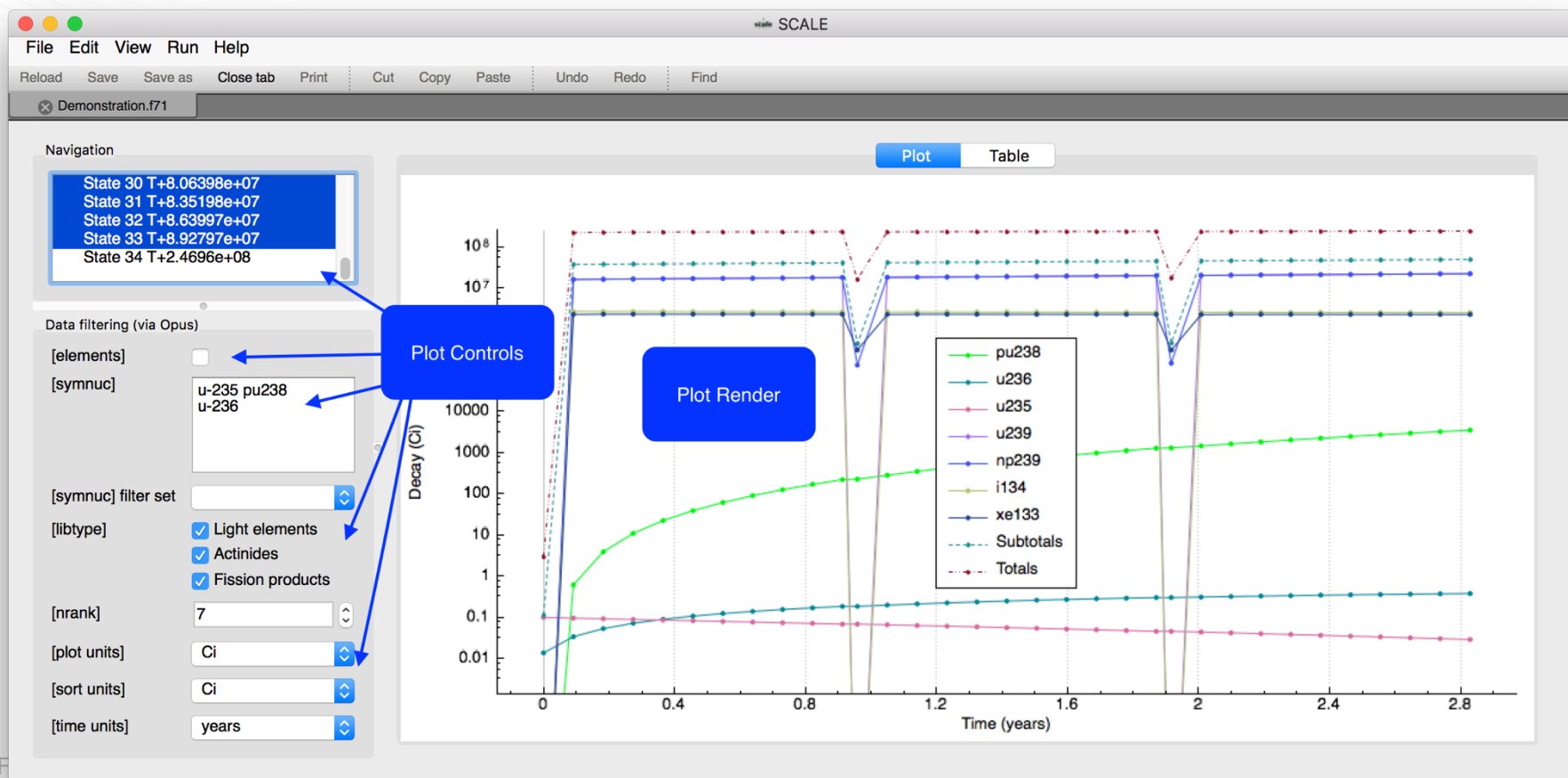
Correlation coefficient matrix

Correlation coefficient matrix

ORIGEN Isotope Concentration Data (F71)

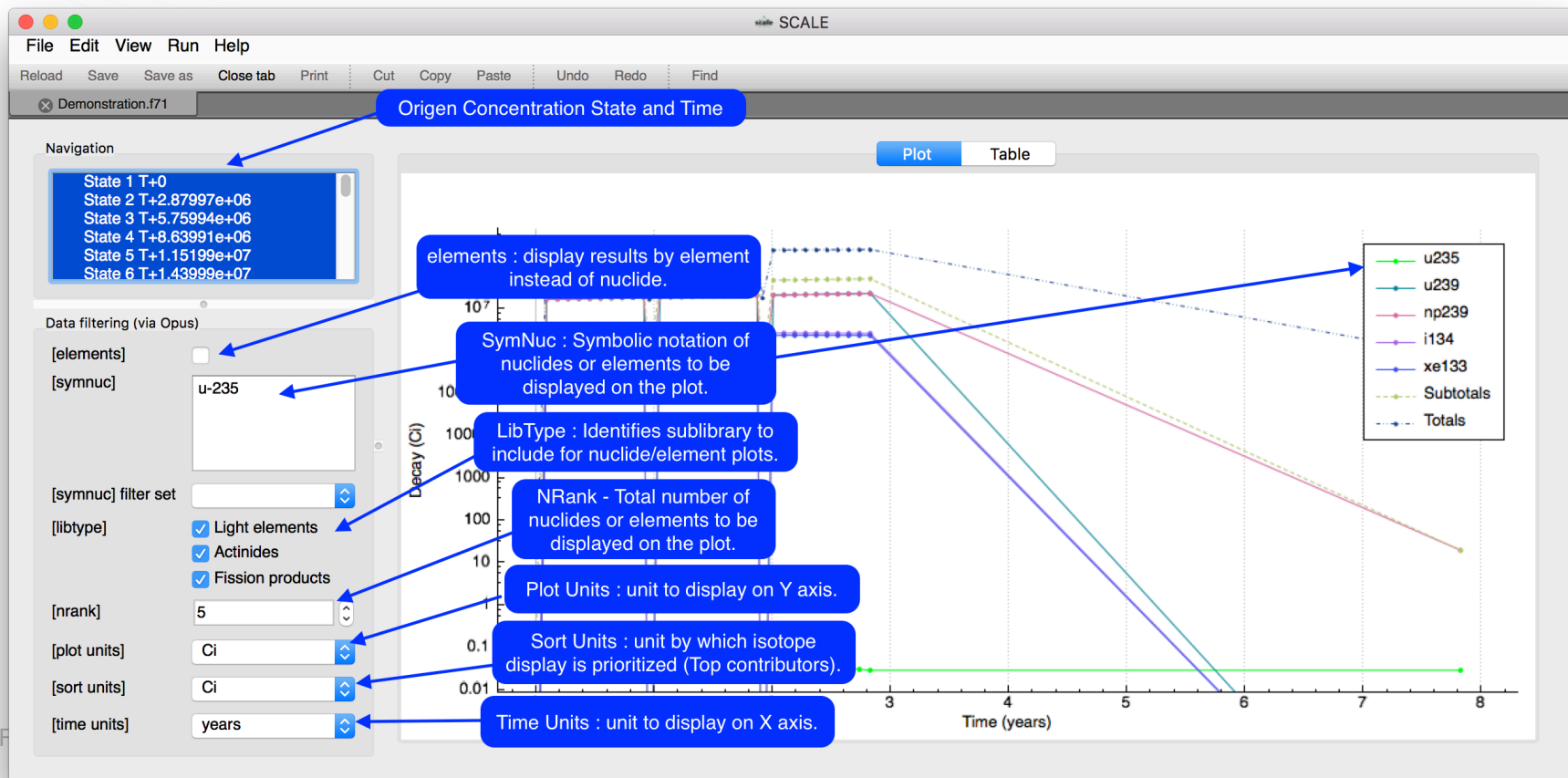
Origen concentration data contains results from depletion, decay, and activation calculations. The plot capabilities are centered about the expected Fulcrum interactive plot with the addition of a more familiar PlotOPUS style set of controls.

- Easy selection of state information to display.
- Easy display of nuclides or elements by id or category.
- Easily display different units (Decay, Mass, Number).



F71 Special Plot Controls (PlotOPUS)

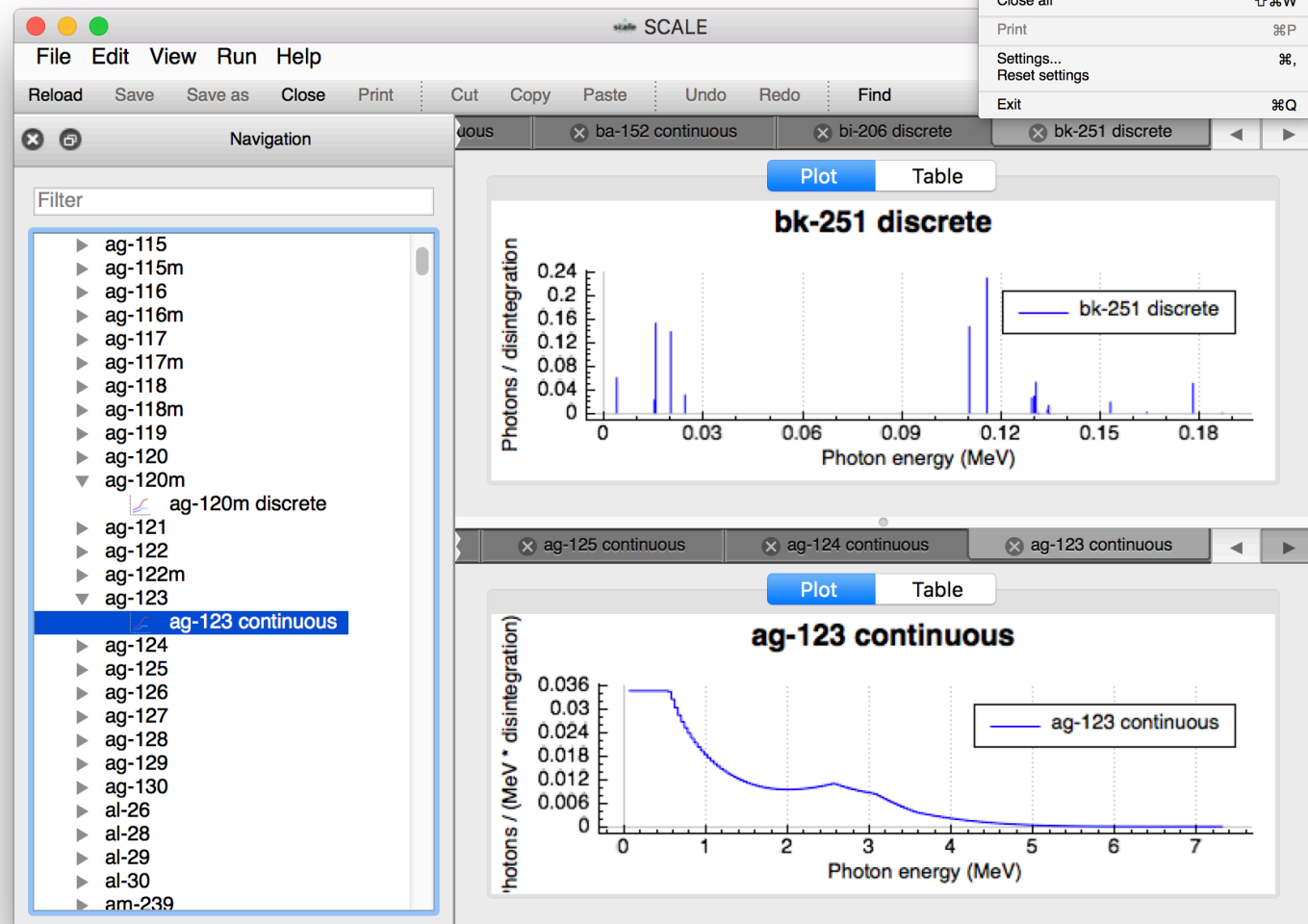
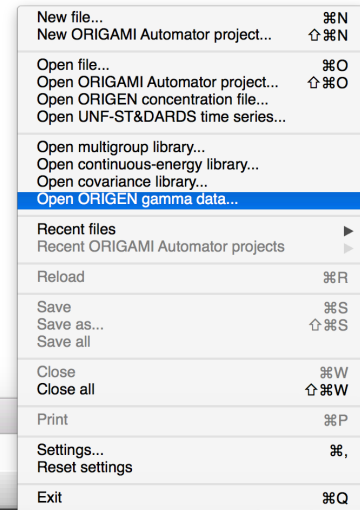
- Navigation allows selection of state information at a given time point.
- Element allows display of results by element instead of nuclide.
- SymNuc allows specifying nuclides or elements to include in the plot.
- Libtype allows display of nuclides or elements contained in the light elements, actinides, and fission product isotope sets.
- Nrank allows limiting the display of the top contributors.
- Time, Plot, and Sort Units allows changing the X and Y axis and the nuclides or elements displayed based on contribution.



ORIGEN Gamma Data

The master photon data library, located at SCALE/data/origen_data/origen.rev###.mpdkxgam.data, provides both discrete and continuous energy gamma lines.

- Opened via File>Open ORIGEN gamma data...

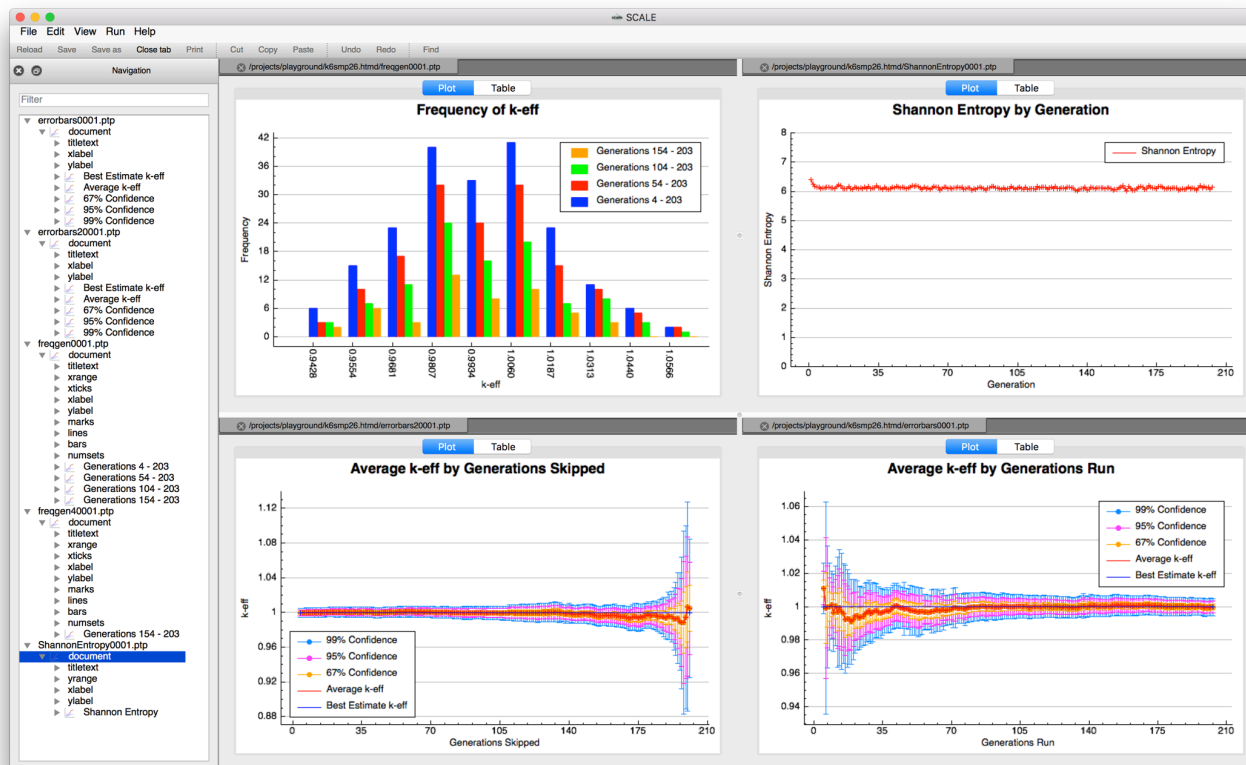


General Output Result Plots

- Keno k-effective By Generation.
- Keno Frequency Distributions.
- Keno Flux.
- Keno Final edit of fissions, absorptions, and leakage.
- MAVRIC batch convergence data for point detector and region tallies.
- MAVRIC response input and multigroup representation.
- Sampler histograms, histories, running averages, and scatter plots.
- Opus Plots (plt)
- And others...

Keno Result Plots

- Plot of average k-effective by generation run
- Plot of average k-effective by generations skipped
- Final edit of fissions, absorptions, and leakage
- Frequency distributions
- Shannon Entropy
- Flux plotting



Summary

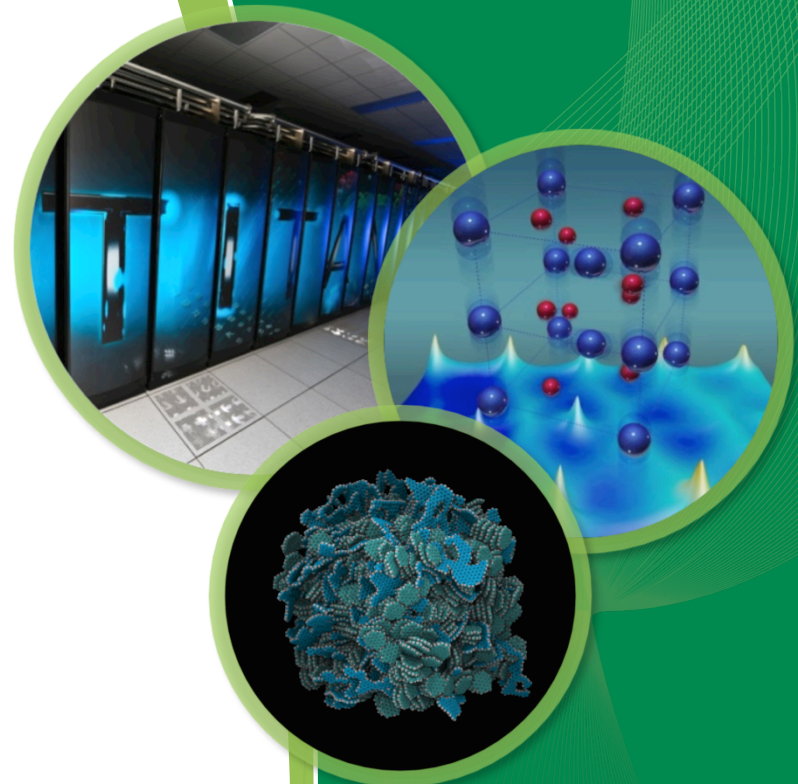
- Plot Overview
- Interactive plot controls
- AMPX Cross Section Data
- Covariance Data
- ORIGEN Isotope Concentration Data (F71)
- F71 Special Plot Controls (PlotOPUS)
- ORIGEN Gamma Data
- General Output Result Plots
- Questions?

Fulcrum User Interface

Geometry Viewer Overview

Robert A. Lefebvre

October 2016



Presentation Outline

- Geometry Viewer Overview
- Activating the Geometry Viewer
- Viewer Controls
- Axis Views
- Render Modes
- Geometry Magnification
- View Origin
- Show View Origin
- View Origin Preserved Across View Plane (Top to Front, etc.)
- Geometry Error Presentation
- Miscellaneous Features
- Mesh Overlay Overview
- Mesh Overlay Supported Formats
- Mesh Overlay Controls
- Future Features

Geometry Viewer Overview

Geometry viewer uses ray tracing to present a perspective as close to the particle transport as possible to the user.

The screenshot shows the Geometry Viewer interface with several key components labeled:

- Axis Views:** Located at the top left, showing view options like Top (X-Y), Front (X-Z), Side (Y-Z), 3D, and Meshes.
- Geometry Viewer Tab:** Shows the originating line number to disambiguate multiple geometries.
- Available Meshes:** A list of meshes available for overlay, including 'mavric.aos100.adjoint.dff' and 'mavric.aos100.mt1.3dmap'.
- Material:** A dropdown menu for selecting materials.
- 1.0000x zoom:** A zoom control display and controller.
- Show view origin:** A button to toggle the display of the view origin.
- Render mode drop-down:** A control for selecting the render mode.
- View zoom display and control:** A control for adjusting the view zoom.
- Display crosshair at view's origin:** A crosshair icon in the center of the render area.
- Geometry Render Area:** The main area where the geometry is rendered.
- View plane slide control:** A slider on the right side that changes the elevation of the view plane.
- View origin display and controller:** A control for the view origin.
- Under-cursor Information:** A box at the bottom left showing coordinates: X: 0.6181416; Y: 34.6159292; Unit: 1; Mixture: 1.
- View origin: (0, 0, 0):** A label at the bottom right indicating the current view origin.

Geometry Viewer Overview

- Axis Views provide 2D axis-aligned geometry renderings.
- Available Meshes to Overlay allows combining geometry rendering with mesh-based results.
- Render Modes – toggle between different material, outline, and mesh overlay render modes.
- Show view origin – highlights exact point at center of view with crosshair.
- Position, Unit, and Mixture under Cursor – communicates geometry information under mouse cursor.
- View origin – displays and provides control of the origin of the view.
- Axis view plane slide controller – interactively manipulates the elevation of the view plane.
- Context Menu (via right click) – allows changing color and saving images.

Activating the Geometry Viewer

Activating the geometry viewer can be accomplished via the Input Editor's View...>View geometry button or the Document Navigation geometry item's popup context menu.

- If multiple geometry input blocks exist in the document, a selection will be provided.

The screenshot shows the SCALE software interface. The Document Navigation tree on the left shows a selection of 'geometry' under the 'mavric' folder. A 'Visualize' button is highlighted next to it. The Input Editor on the right shows a 'View geometry' button highlighted. A 'Popup Context Menu in Document Navigation tree' is also shown. The main editor area displays the input file content, including a 'read geometry' block with a table of cylinder and cuboid parameters.

global unit	1				
cylinder	1	8.255	25.40	-25.40	
cylinder	2	10.795	27.94	-27.94	
cylinder	3	20.955	27.94	-27.94	
cylinder	4	13.335	40.64	30.48	
cylinder	5	13.335	-30.48	-40.64	
cylinder	6	35.56	45.72	-45.72	
cuboid	99	139.7	-139.7	139.7	-139.7 152.4 -152.4
media	3	1	1		
media	1	1	2	-1	
media	2	1	3	-2	

The Visualize dialog box is shown, titled 'Visualize'. It contains the text 'Select the geometry to visualize' and a dropdown menu with 'geometry (line 119)' selected. There are 'Cancel' and 'OK' buttons at the bottom.

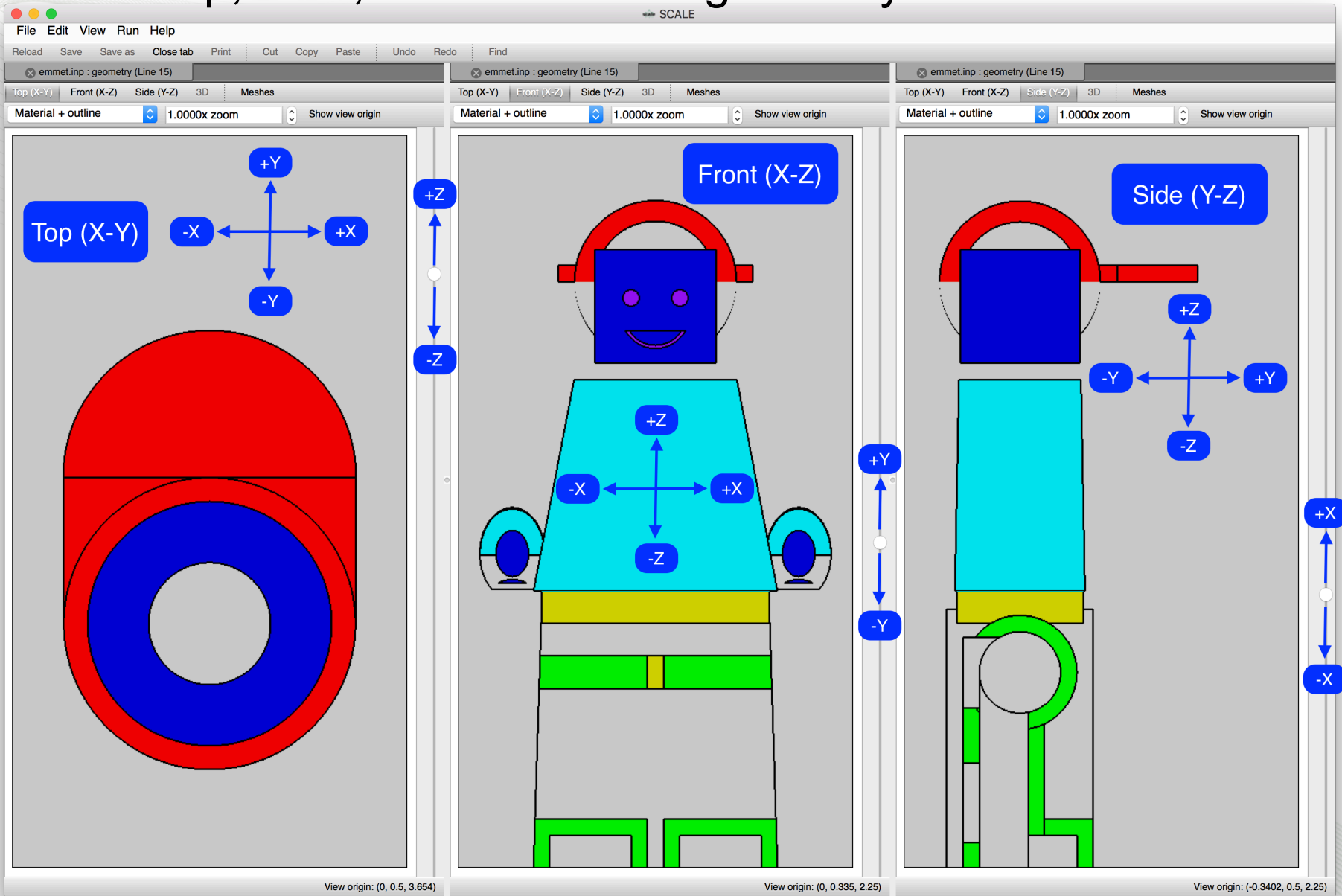
Geometry Viewer Controls

Geometry viewer controls facilitate manipulation of the geometry rendering.

- Axis (X,Y,Z) rendered.
 - Top (X-Y) – view plane intersects Z axis.
 - Front (X-Z) – view plane intersects the Y axis.
 - Side (Y-Z) – view plane intersects the X axis.
- Elevation (axis intersection) of the view plane rendered.
- Type of rendering.
 - material, outline, mesh, etc.
- View origin (point at center of view plane).
- Geometry Magnification.

Axis Views

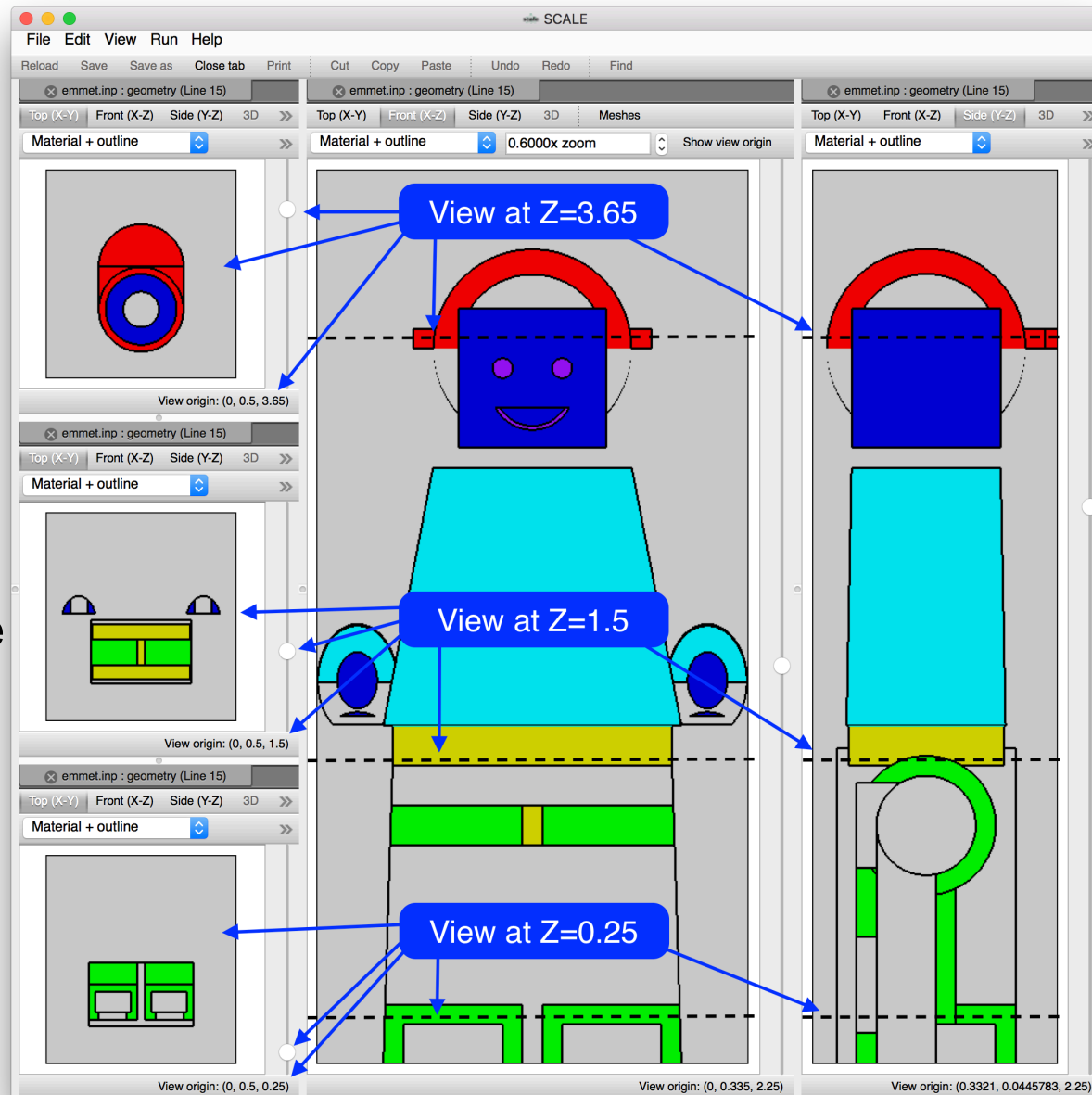
- Axis views provide standard orthographic model projections of the top, front, and side of the geometry.



Axis Views : Elevation Control

View plane elevation is controlled via a slide control on the right side of each geometry view.

- View plane elevation corresponds to view plane control – the higher the slider control, the higher the view plane.
 - Top (X-Y) - raising the slider increases the Z intersect.
 - Front (X-Z) – raising the slider increases the Y intersect.
 - Side (Y-Z) – raising the slider increases the Z intersect.

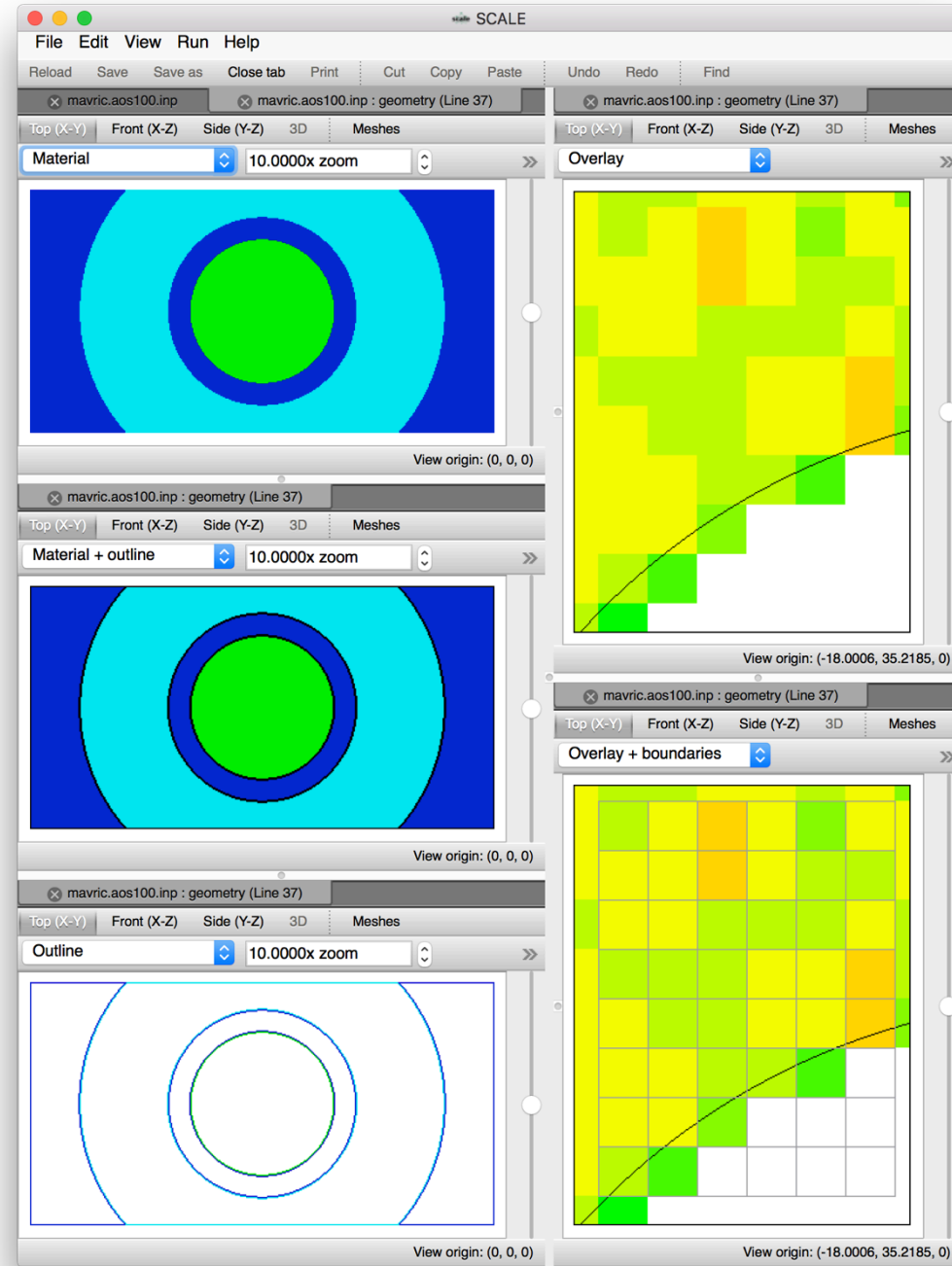


- ✓ Material
- Material + outline
- Outline
- Overlay
- Overlay + boundaries

Render Modes

Render modes control the information displayed.

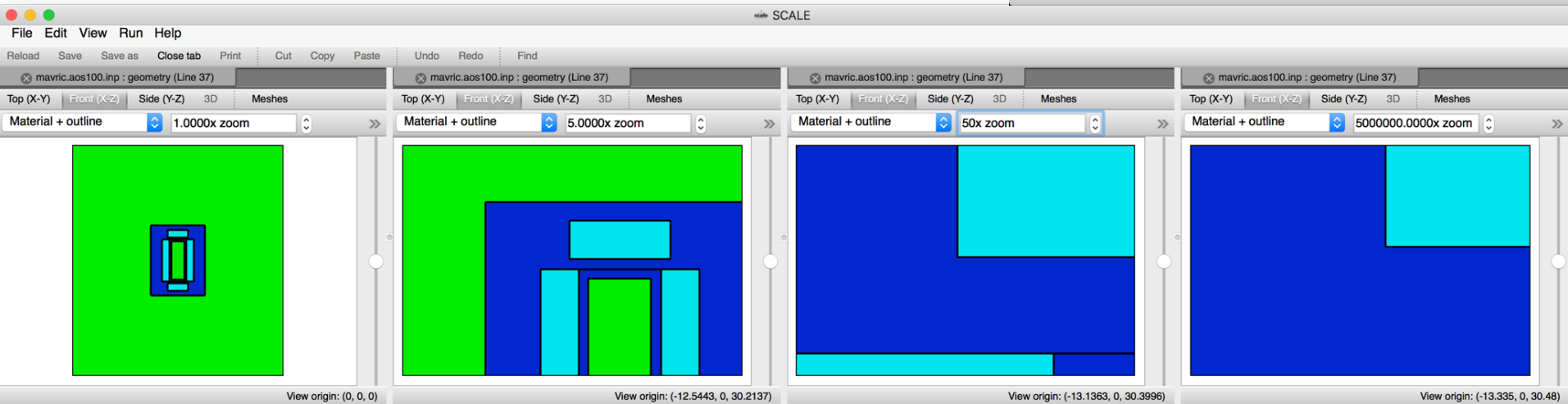
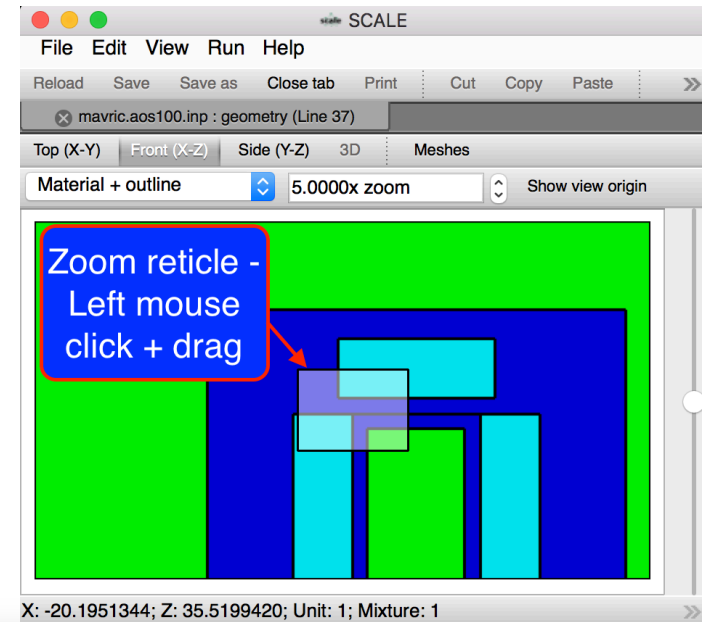
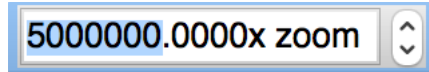
- Material displays only the materials/mixtures.
 - Can hide geometry region outlines that are the same material.
- Material + outline displays the material and the region outlines.
 - Displays region outline in black.
 - Useful for contrasting geometry regions.
- Outline displays only geometry region outlines.
 - Displays region outline in material color.
- Overlay displays geometry region outline and mesh data results.
- Overlay + boundaries displays geometry region outline, mesh boundaries*, and mesh data results



Geometry Magnification (Zoom)

Ray traced geometry rendering allows for significant magnification.

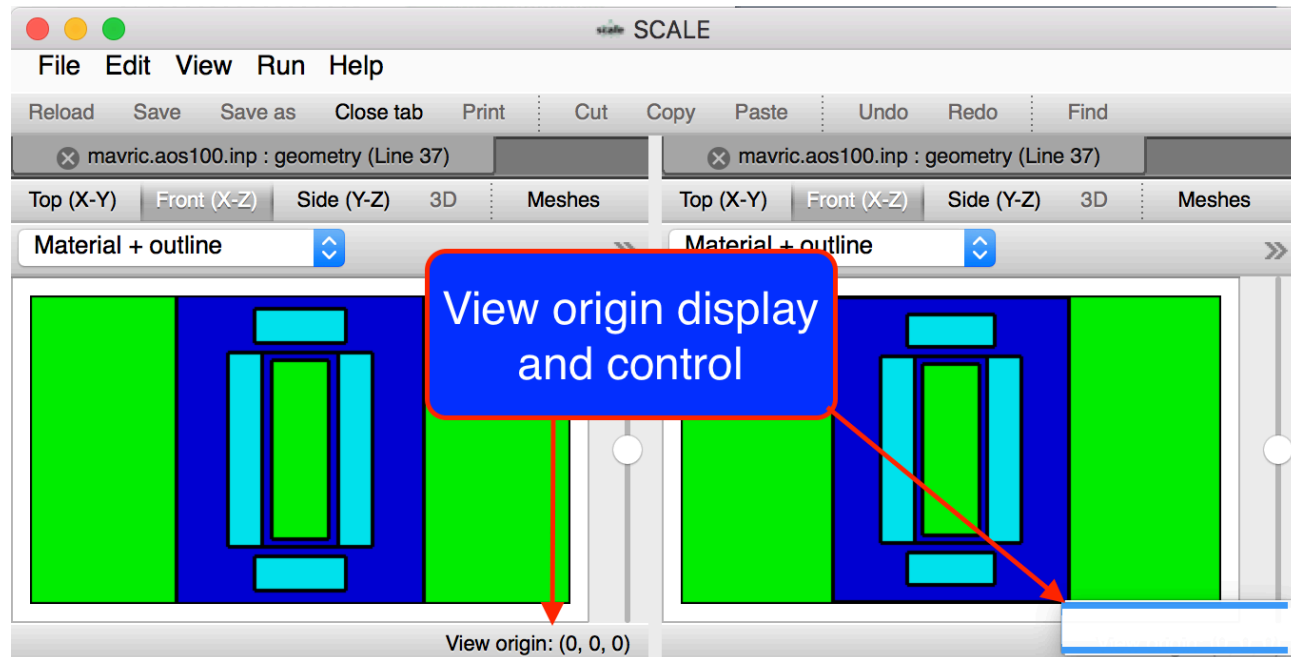
- Specific value typed by user.
- Incremented or decremented via zoom editor spinner controls.
- Visually specified via a user-drawn zoom reticle.
 - Left click and drag down and to the right.



Geometry View Origin Display and Control

Often when geometry errors are encountered, an X,Y,Z position is included in the error message. The ability to quickly navigate to this location and inspect the geometry is facilitated by the view origin control.

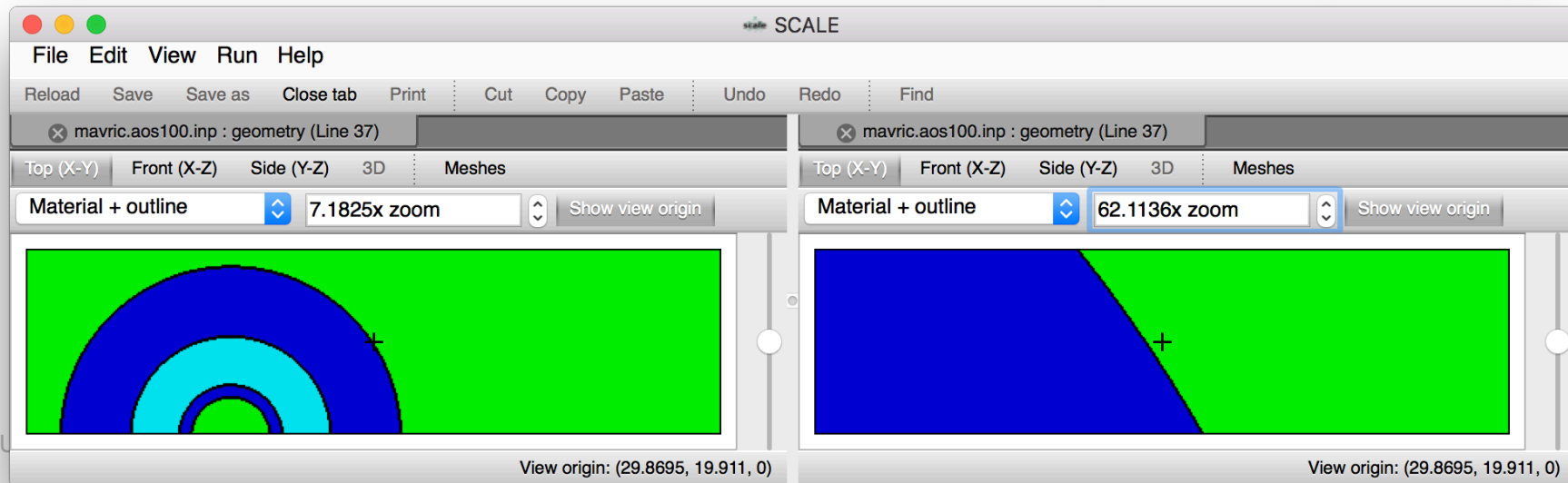
- Left click the View origin display to activate X,Y,Z entry.
- 3 Modes of Origin input
 - Single value : Updates the view plane elevation (axis intersect – same as slider control).
 - Two values : Updates the view plane 2D origin (pans the image).
 - Top (X-Y) – sets the X and Y coordinates of the origin.
 - Front (X-Z) – sets the X and Z coordinates of the origin.
 - Side (Y-Z) – sets the Y and Z coordinates of the origin.
 - Three values : Updates the view plane elevation and the view plane 2D origin.
- Double Left click centers the view origin at the point clicked.
- Useful when combined with the Show View Origin.



Show View Origin

With ray traced geometry rendering allowing significant magnification, it can be difficult to focus on a specific location. The Show view origin button was added to unambiguously display the location of the view's origin.

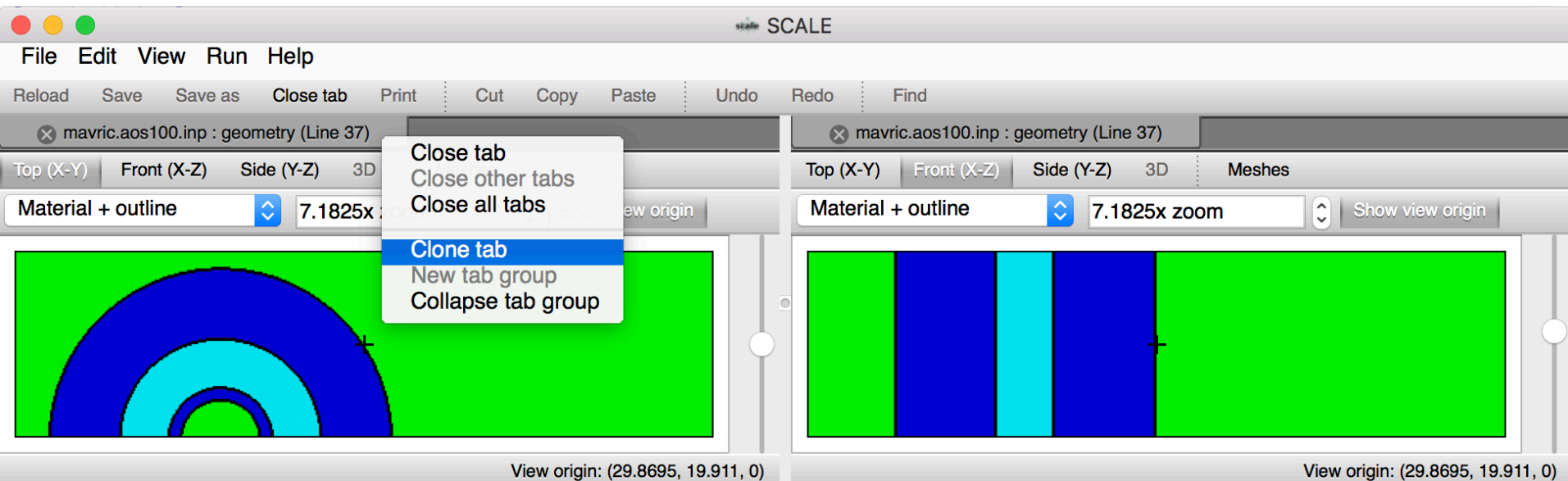
- Very useful when debugging geometry at a given location.
 - Enter the location via the view origin control.
 - Show the view origin.
 - Magnify as needed.



View Origin Preserved Across View Plane

The geometry viewer is often used for geometry verification and debugging. Both typically involve known locations – X,Y,Z of lost particle, etc.

- View origin is preserved during view plane changes (Top to Front, etc.)
 - Facilitates quickly identifying locations where initial view plane is epsilon ($1e-15$) off a tangent surface.
- Cloneable geometry viewer with subsequent view plane change allows quick visual comparison of location.



Geometry Errors : Undefined Space

Undefined space lacks any geometry specification. This typically happens when a space is not accounted for with a material statement.

- Cursor information lacks mixture information.
- Undefined space is rendered with grey stripes.

```
1 =csas6
2 Simple pin cell demonstrating geometry error
3 ce_v7.1
4 read comp
5   uo2 1 end
6   h2o 2 end
7 end comp
8 '-----
9 ' Simple pin geometry demo
10 '-----
11 read geometry
12   global unit 1
13   com="Fuel pin 1"
14   zcylinder 10 0.54 0.0 14.28
15   cuboid 20 -0.63 0.63 -0.63 0.63 0.0 14.28
16 ' MISSING media statement referencing zcyl 10
17 ' media 1 1 10 <-- needed
18   media 2 1 20 -10
19   boundary 20
20 end geometry
21 end data
22 end
```

Undefined space :
zcylinder 10 not
referenced in media

Undefined space
displayed as striped grey
region with no mixture
listed on mouse over

Line: 17, Col: 39 /csas6/geometry/global_unit/scale_comment Validation >> X: -0.0497938; Y: -0.0541237; Unit: 1; Comment: "Fuel pin 1" >> E

Geometry Errors : Double-Defined Space

Double-defined space has more than a single geometry specification for a give space. This typically happens when a space is not excluded appropriately.

- Cursor information lists multiple mixtures.
- Double-defined space is rendered using alternating striped mixture colors.
- **NOTE** : the tangent planes of adjacent regions can appear as double-defined space but are infinitely thin.

```
1 =csas6
2 Simple pin cell demonstrating geometry error
3 ce_v7.1
4 read comp
5   uo2 1 end
6   zirc 2 end
7   h2o 3 end
8 end comp
9
10 ' Simple pin geometry demonstrating geometry error
11 -----
12 read geometry
13   global unit 1
14   com="Fuel pin 1"
15   zcylinder 10 0.54 0.0 14.28
16   zcylinder 20 0.64 0.0 14.28
17   cuboid 30 -0.75 0.75 -0.75 0.75 0.0 14.28
18   media 1 1 10
19 ' media 2 1 20 -10 <-- needed
20   media 2 1 20
21   media 3 1 30 -20
22   boundary 30
23 end geometry
24 end data
25 end
```

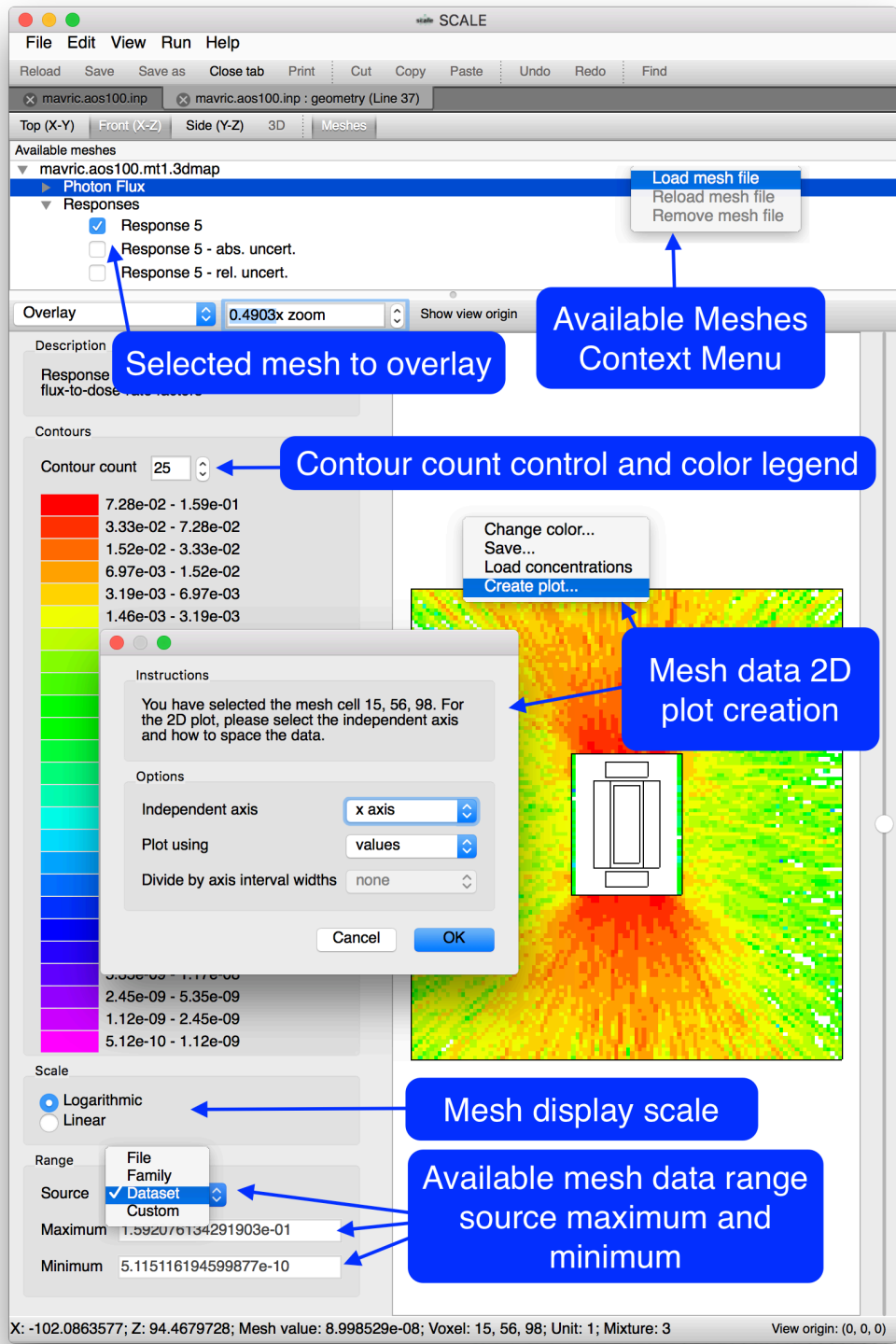
Double-defined space:
zcylinder 10 and 20
overlap

Double-defined space
displayed as alternating
striped material color
and multiple mixtures

Line: 19, Col: 42 /csas6/geometry/global_unit/scale_comment Validation Messages X: -0.0489691; Y: 0.0103093; Unit: 1; Comment: "Fuel pin 1"; Mixture: [1, 2] View origin: (0, 0, 7.14)

Mesh Overlay Overview

- Loading Mesh Data.
 - Supported formats (see slide 89).
- Render Modes.
- Contours and color legend.
- Scale – Log and Linear.
- Range – File, Family, Dataset, or Custom.
- Position, Mesh value, Mesh Voxel, Unit, and Mixture under Cursor.
- Context Menu.
- 2D Plot creation.

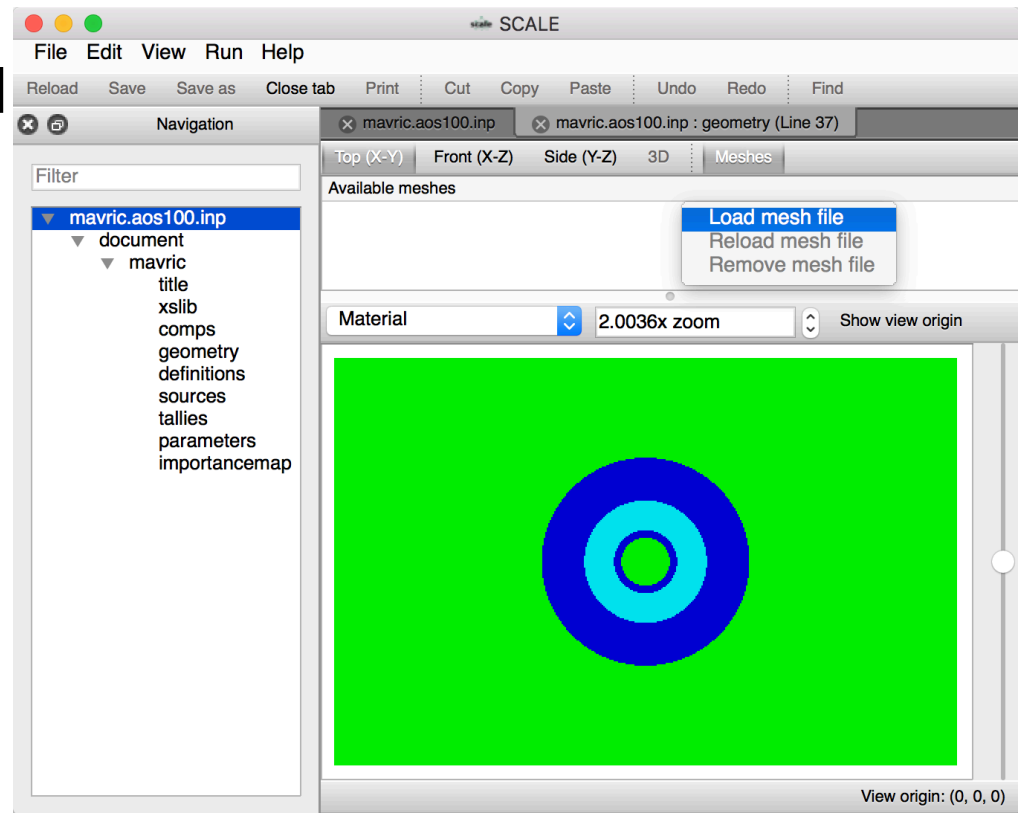


Mesh Overlay : Loading Mesh Data

With the available Meshes window open, a context menu is available via right click. This context menu will allow loading new, and removing or reloading existing mesh files.

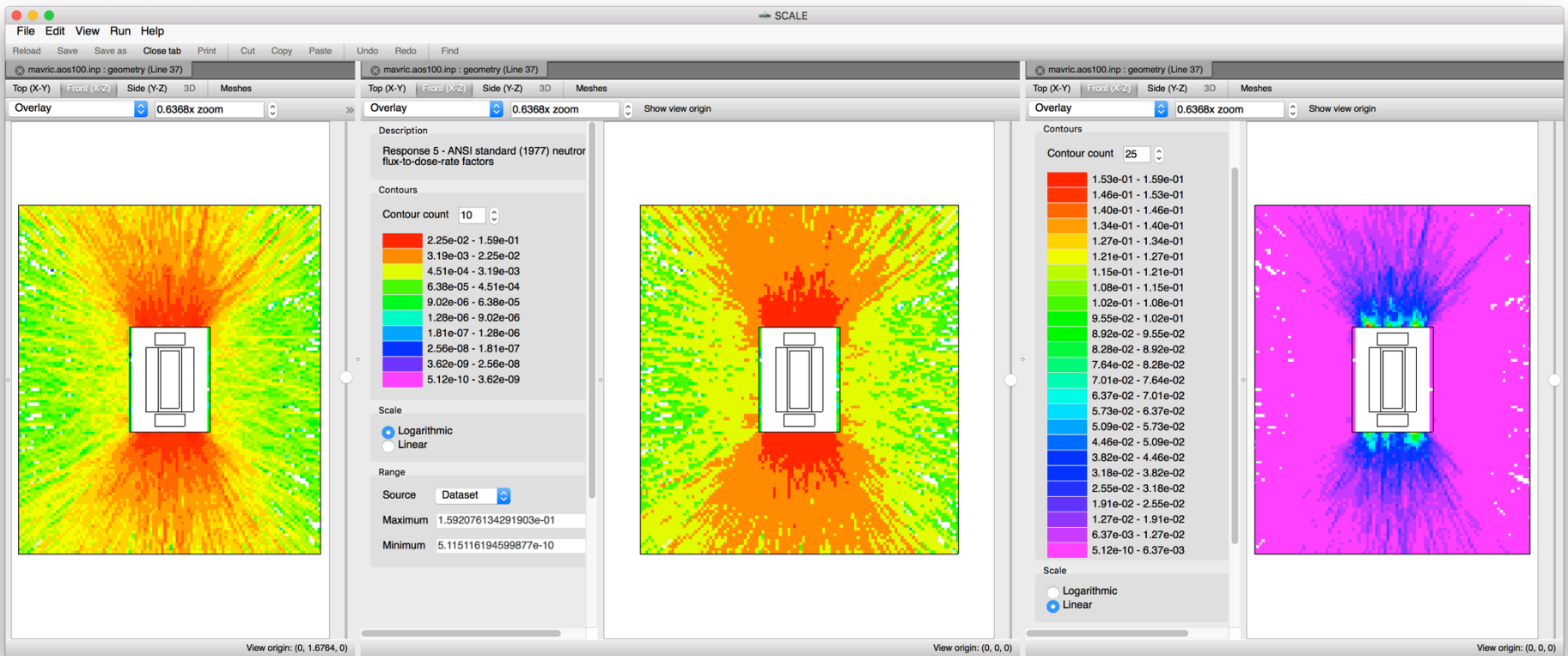
- Right click in Available meshes to access Load mesh file dialog. Select the mesh to load.
- Most of SCALE's major mesh formats are supported

✓ Supported files (*.3dmap *.mim *.msm *.dff)
Mesh files (*.3dmap)
Mesh importance files (*.mim)
Mesh source files (*.msm)
Denovo flux files (*.dff)



Mesh Contours, Color Legend, and Scale

- Controls influenced by MAVRIC's MeshView plot program.
- Allows changing contour count from 25 to 2 enhancing data contrast.
- Can improve print quality for black and white printouts.
- Linear and logarithmic scale data display.



Mesh Overlay : Data Ranges

The overlaid dataset's data range can be selected as the file, family, dataset or as custom user-specified.

- The file indicates the entire mesh file context.
- The family range provides context to a selected dataset.
- Custom allows down-selection.

Available meshes

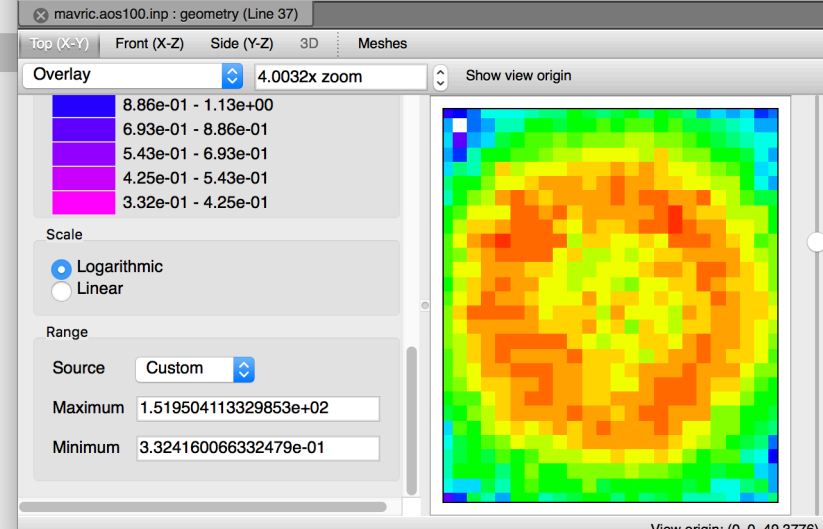
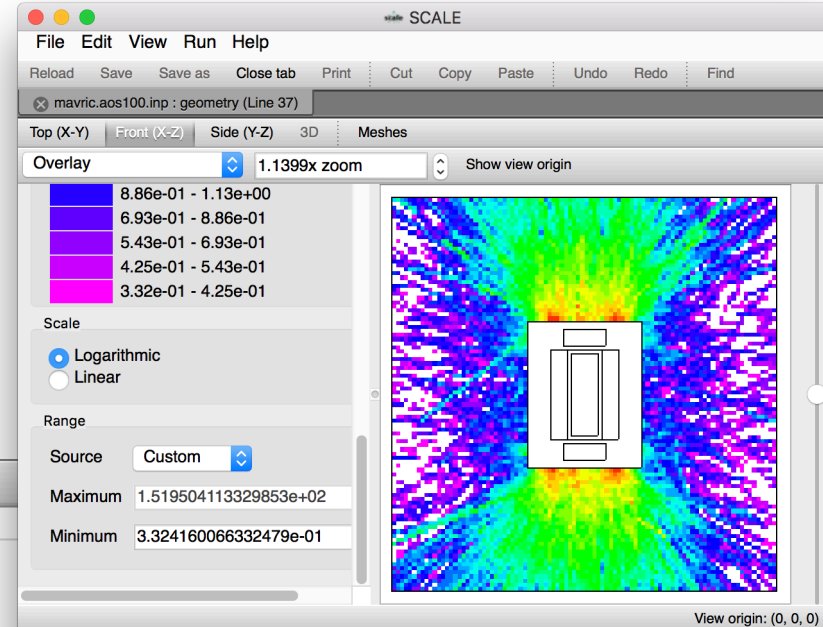
- ▼ mavric.aos100.mt1.3dmap
 - ▼ Photon Flux
 - group 1
 - group 1 - abs. uncert.
 - group 1 - rel. uncert.
 - group 2
 - group 2 - abs. uncert.
 - group 2 - rel. uncert.

Range

Source **Dataset**

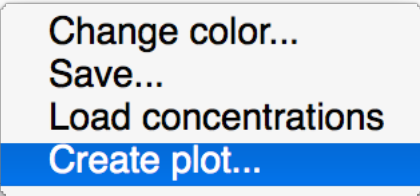
Maximum 1.519504113329853e+02

Minimum 3.324160066332479e-07



Mesh Overlay : Integrated 2D Plot Creation

Mesh data can be further investigated via the integrated 2D plot creation capability. 2D Plot creation is available via the Create plot popup context menu.



- Plot options include

- Independent axis
 - Cartesian X,Y, and Z.
 - Cylindrical Radial, Theta, and Z.
 - Group when group-wise data is available.
- Plot using values or indices.
- When data is group-wise axis interval widths can optionally be divided linearly or logarithmically.

The screenshot shows the SCALE software interface with several components and annotations:

- Navigation Panel:** A tree view on the left showing the project structure. The 'geometry' folder is selected.
- Meshes Panel:** A panel on the right showing the 'Overlay' mesh with a 3.8000x zoom.
- Annotations:**
 - 1. Locate point of interest. Right click and select Create plot...** points to a specific location on the mesh overlay.
 - 2. Configure plot options and click OK. The MAVRIC Chart file will be generated.** points to the 'ChartOptions' text area.
 - 3. Selection of Chart document will display 2D plot values with uncertainties.** points to the 'document' dropdown menu.
- ChartOptions:** A text area containing configuration parameters such as 'titletext x axis plot at a=0, b=47.74', 'xlogscale false', 'ylogscale true', 'xgridlines true', and 'ygridlines true'.
- Options Dialog:** A dialog box with 'Instructions' and 'Options' sections. The 'Independent axis' is set to 'x axis', 'Plot using' is set to 'values', and 'Divide by axis interval widths' is set to 'none'.
- 2D Plot:** A line graph titled 'x axis plot at a=0, b=47.7493 generated on Mon Oct 17 14:45:03 2016'. The y-axis is 'Photon Flux' (log scale from 0.001 to 100) and the x-axis is 'x axis' (linear scale from -120 to 120). The plot shows a series of data points with error bars.

Geometry Viewer : Future Features

- 3D Ray traced visualization.
 - Material Transparency.
 - Geometry Culling Surfaces (similar to Keno3D cutaways).
 - Mesh Overlays.
- Geometry view to Input material definition quick view.
 - Allows display of input that creates the material under the cursor.
 - Allows display of isotopic number densities that compose the material under the cursor.
- Geometry view to Input region definition quick view.
 - Allows display of input region/media statement that creates geometry under cursor.
- Visualize any unit on-demand with an optional nesting level.
 - Allows investigating single geometry units with limited depth/complexity.
- Enhanced input and geometry coupling.
 - Display grid/cylinder geometry prior to job execution.
 - Display detector/source locations prior to job execution.

Summary

- Geometry Viewer Overview
- Activating the Geometry Viewer
- Viewer Controls
- Axis Views
- Render Modes
- Geometry Magnification
- View Origin
- Show View Origin
- View Origin Preserved Across View Plane (Top to Front, etc.)
- Geometry Error Presentation
- Miscellaneous Features
- Mesh Overlay Overview
- Mesh Overlay Supported Formats
- Mesh Overlay Controls
- Future Features
- Questions?