

Frequent Fulcrum Functions: The Basics of SCALE's Graphical User Interface

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



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ENERGY

Summary

This tutorial introduces the Fulcrum graphical user interface and the basic functions that enhance the common activities of **creating, editing, navigating, executing**, and **visualizing** SCALE input files.

This tutorial will help you become familiar with the Fulcrum input file text editor and the integrated input development environment features of **autocompletion, automatic checking, cursor context**, and **input navigation**. In addition, the Fulcrum and **SCALE runtime environment** will be reviewed to improve the understanding of job execution workflow.

* This tutorial does not cover data and geometry plotting. Please see the **Advanced User Interface Capabilities** tutorial for details regarding plotting data and geometry.

No prior experience with SCALE is required. You can follow along using SCALE 6.2 or 6.3-beta.

User Notice

This tutorial is intended to train users in the use of the Fulcrum input capabilities.

It is not intended to train users in the use of the SCALE code system's cross section processing, criticality safety, depletion, shielding, sensitivity and uncertainty, or source term computational modules.

Schedules and contact information for specific tutorials and training courses can be found at <https://www.ornl.gov/scale/scale-training>

Outline

- Vision
- Overview
- Text Editor
- Document Navigation
- Input Autocompletion
- Automatic Input Checks
- Accelerators
 - Comments, Calculator, and Custom Workspaces

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 Components Overview

The screenshot displays the Fulcrum software interface with four main components highlighted by blue boxes:

- Document Navigation:** Located on the left, it shows a tree view of the project structure. The 'geometry' folder is selected, and a list of geometry objects (cylinder, media, boundary, unit, com, cuboid) is displayed.
- Input Editor:** Located in the center, it shows the input data for the selected geometry object. The data is organized into units (401, 501, 601) and contains parameters like 'assembly_id', 'reactor_id', 'guide tube', and 'assembly type'.
- Data Plot:** Located at the bottom left, it shows a scatter plot of 'Responses' (log scale) versus 'radial axis'. The plot is titled 'radial axis plot at a=6.1098, b=-1.9435 generated on Thu Jul 28 17:01:33 2016' and shows a single data series labeled 'Response 1'.
- Geometry Viewer:** Located on the right, it shows a 3D visualization of the geometry. The view is titled 'Geometry Viewer' and shows a rectangular structure with a central vertical channel. The view is set to 'Top (X-Y)' and '0.5811x zoom'.

The interface also includes a menu bar (File, Edit, View, Run, Help) and a toolbar with various icons for file operations, editing, and viewing.

Input Navigation

TSC-24-TSC-9_bounding_NCTDoseRate_02-02-2004.inp*

comps

SCALE 6.2

Run

View...

Edit...

```

1809 '      - fresh fuel UO2 composition
1810 uo2      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 "uo2" 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

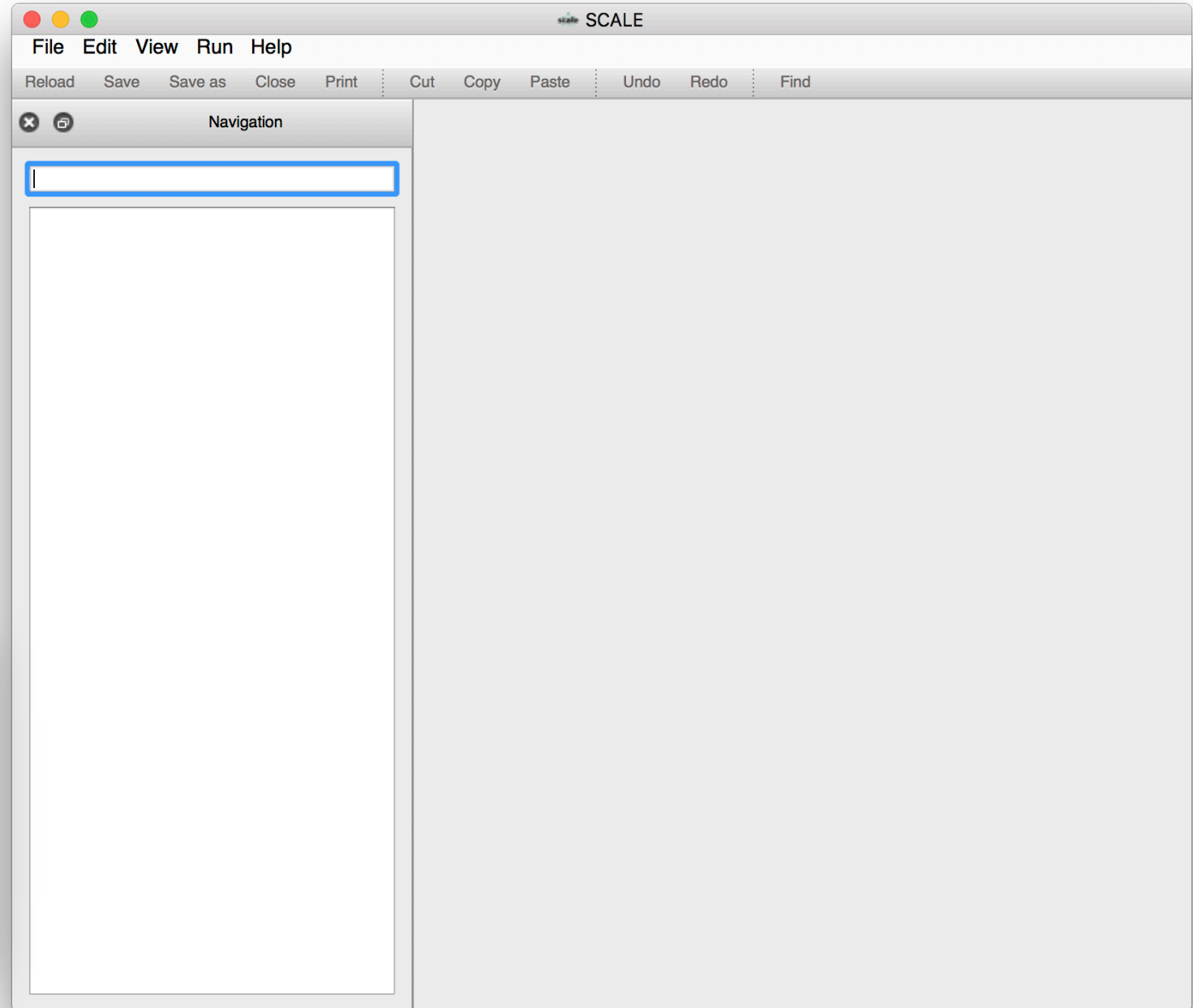
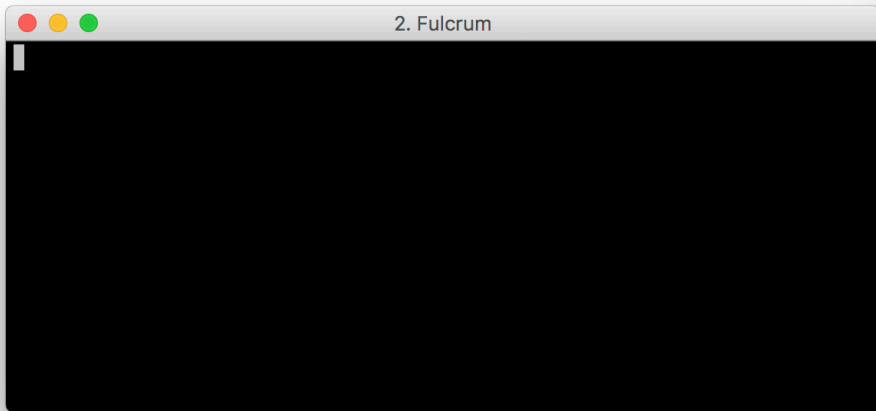
Messages

Tutorial Requirements

- Have SCALE 6.2.x or 6.3 beta installed
- SCALE Data installed
- Have **Frequent_Fulcrum_Functions** training pack downloaded
 - includes input files

Fulcrum Startup Screen

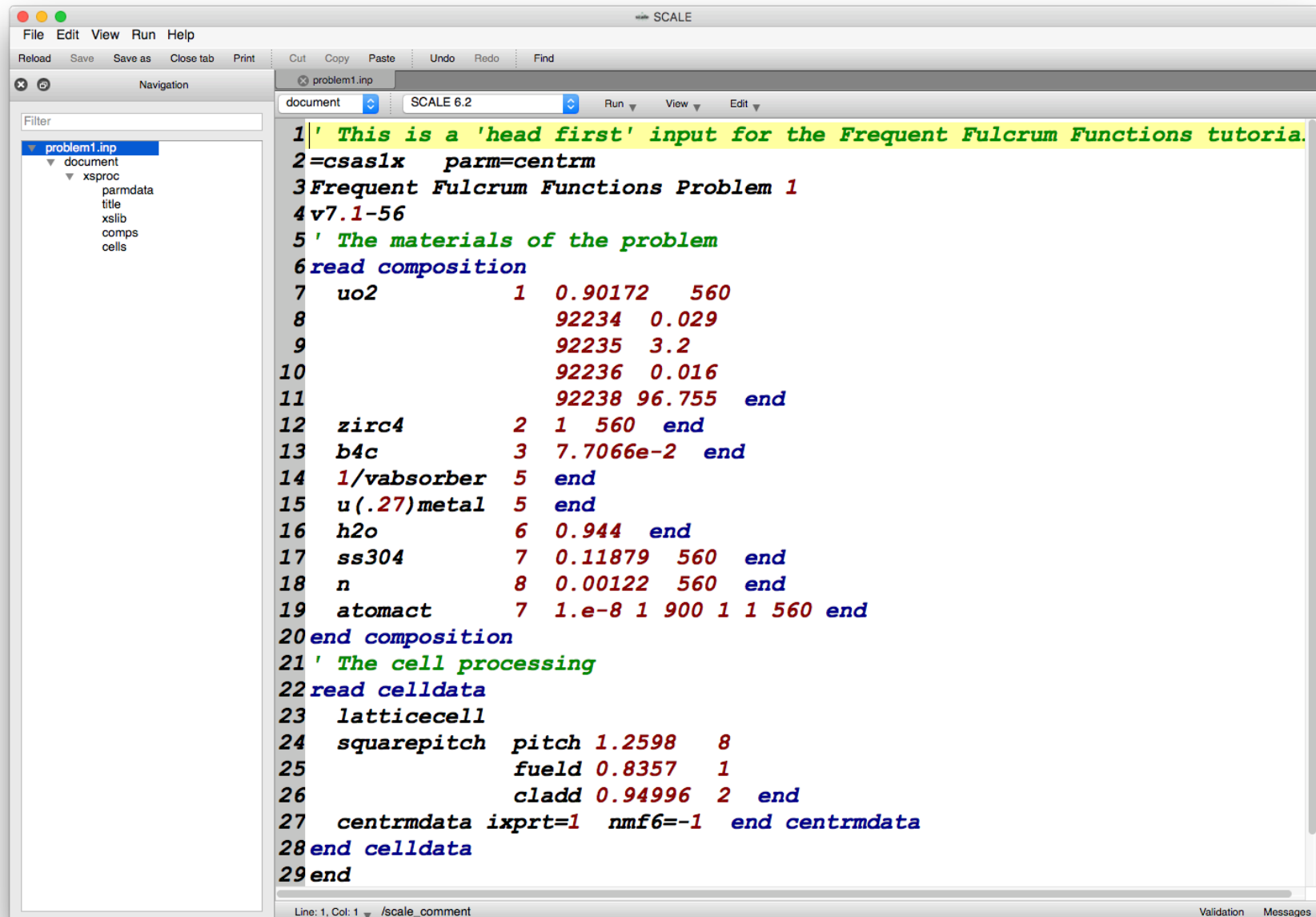
- **Start Fulcrum**
- Little to look at
- Lean and mean
- Always has a terminal/CMD window in the background that contains log messages



Headfirst – text editor

- Open the **Frequent_Fulcrum_Functions > problem1.inp**
- Text too small or too big?
- Text not the right color?
- Highlighted line annoying?
- Highlighted line not the right color?

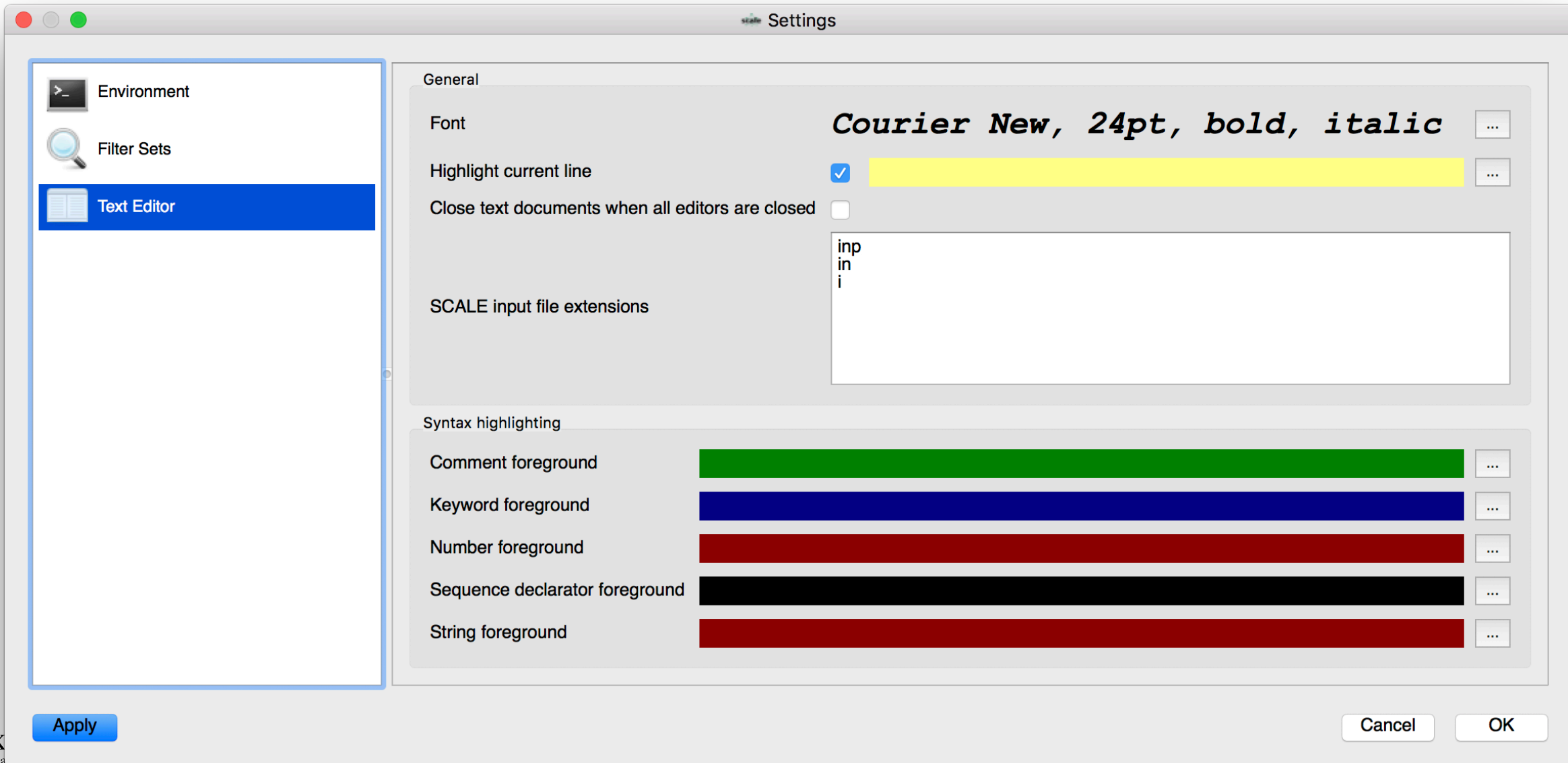
To the Text Editor Settings!



```
1 ' This is a 'head first' input for the Frequent Fulcrum Functions tutorial.
2 =csas1x  parm=centrm
3 Frequent Fulcrum Functions Problem 1
4 v7.1-56
5 ' The materials of the problem
6 read composition
7  uo2          1  0.90172  560
8                92234  0.029
9                92235  3.2
10               92236  0.016
11               92238 96.755  end
12  zirc4        2  1  560  end
13  b4c          3  7.7066e-2  end
14  1/vabsorber  5  end
15  u(.27)metal  5  end
16  h2o          6  0.944  end
17  ss304        7  0.11879  560  end
18  n            8  0.00122  560  end
19  atomact      7  1.e-8 1 900 1 1 560  end
20 end composition
21 ' The cell processing
22 read celldata
23  latticecell
24  squarepitch  pitch 1.2598  8
25                fuel  0.8357  1
26                cladd 0.94996  2  end
27  centrmdata  ixprt=1  nmf6=-1  end centrmdata
28 end celldata
29 end
```

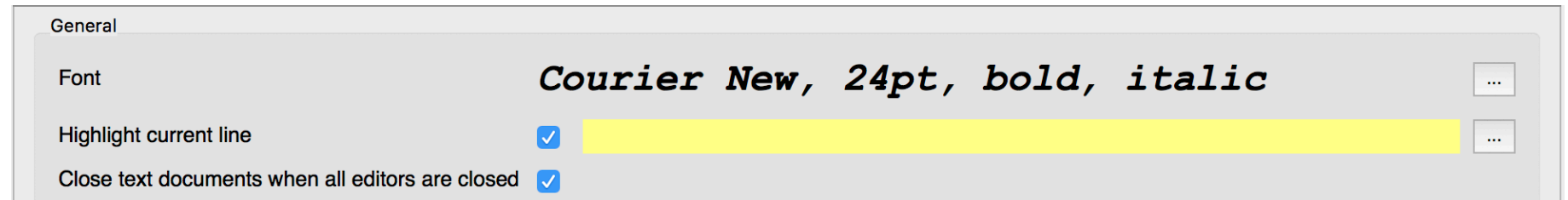
Fulcrum Text Editor Settings

- Accessible from File > Settings... > Text Editor



Fulcrum Text Editor Settings

- Most settings are self-explanatory and can be adjusted as needed to suit your preferences
- Click the checkbox for **Close text documents when all editors are closed**
 - Fulcrum supports multiple editor tabs per document, when the last tab is closed, the document is removed from the **Navigation** panel (list of open files)



- The **SCALE input file extensions** allows adding additional extensions that Fulcrum will recognize as input files
 - Input files must have one of these extensions to have the Fulcrum advanced text editor capabilities applied
 - **DON'T FORGET TO CREATE YOU INPUT FILE WITH AN EXTENSION**
- “Syntax highlighting”?

What is SCALE "Syntax Highlighting"? Paint by Patterns

The image displays two side-by-side screenshots of the SCALE 6.2 editor interface, illustrating syntax highlighting for different code elements. Blue callout boxes with arrows point to specific code features:

- Sequence Declarator Foreground:** Points to the `/mavric` keyword in the left screenshot.
- String Foreground:** Points to the title string `"cobalt-60 gammas/decay"` in the right screenshot.
- Number Foreground:** Points to numerical values like `8.255`, `25.40`, and `-25.40` in the left screenshot.
- Keyword Foreground:** Points to keywords like `read definitions`, `end response`, and `end distribution` in both screenshots.
- Comment Foreground:** Points to the comment `'only collect mesh tally information outside the package (in air region)'` in the right screenshot.

The editor windows show the following code snippets:

Left Window (Line 17, Col: 9 /mavric):

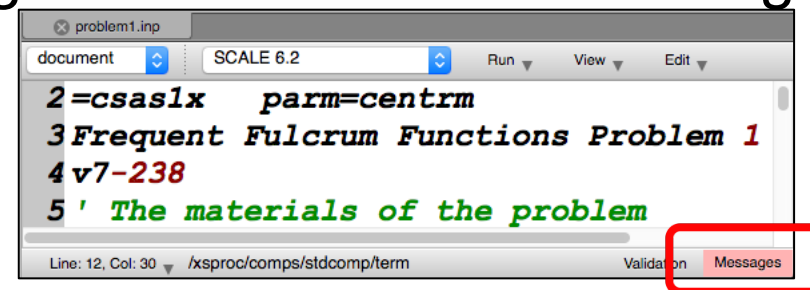
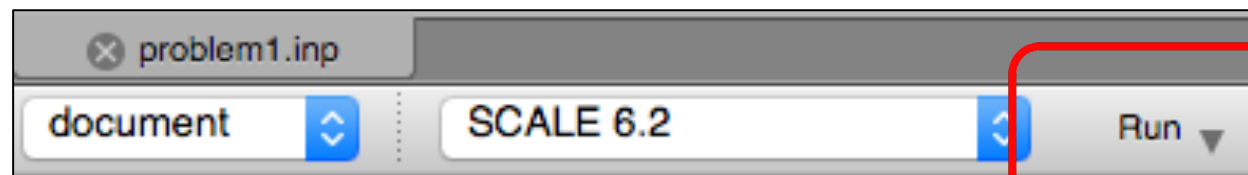
```
9 *****
10 ' Simplified model of the AOS-100
11 '
12 ' Alpha Omega Services Inc (AOS)
13 ' International Isotopes Inc. of Idaho Falls, Idaho is the exclusive worldwide
14 ' distributor of the AOS Reactor System
15 ' *****
16
17 /mavric
18 AOS-100: Demonstrate use of
19 v7-200n47g
20
21
22 ' Composition Block - standard SCALE input
23
24 read composition
25 ss304 1 end
26 wtptTungsten 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 ' Definitions Block
56
57 read definitions
58 response 5
59 title="ANSI standard (1977) neutron flux-to-dose-rate factors"
60 doseData=9504
61 end response
62
63 distribution 1
64 title="cobalt-60 gammas/decay"
65 discrete 347140 826100 1173228 1332492 2158570 2505692 end
66 truepdf 0.000075 0.000076 0.9985 0.999826 0.000012 0.00000002 end
67 end distribution
68
69 gridGeometry 7
70 title="mesh for discrete ordinates/importance map/biased source"
```

Right Window (Line 27, Col: 28):

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

Headfirst – Input execution

- Click the Text Editor's **Run** button
- Observe the **Messages** panel button indicate messages are available for viewing



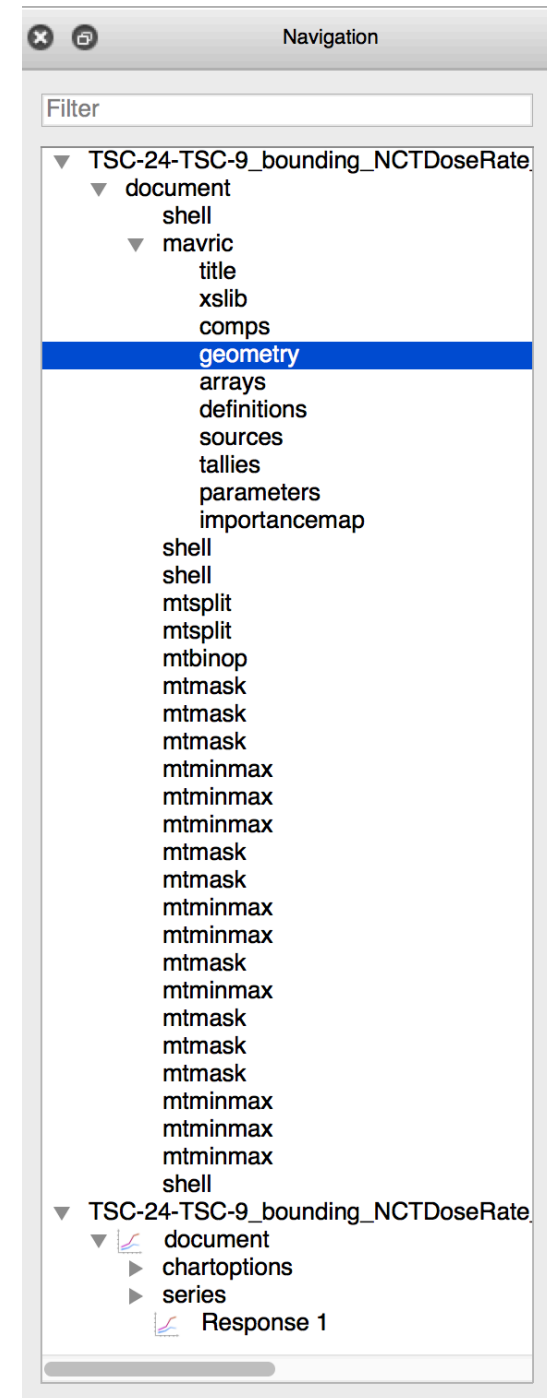
- Open the **Messages** panel via left-click and observe the job running (~1 minute)
- Where is my output file?
 - Introducing the **Navigation** panel!

A screenshot of the Messages panel showing the output of the job. The output is as follows:
6read composition
7uo2 1 0.90172 560
8 92234 0.029
9 92235 3.2
The status bar at the bottom shows 'Line: 7, Col: 35 /xsproc/comps/stdcomp'. The 'Messages' button in the bottom right corner is highlighted with a red rectangular box.

59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
	10	20338	4.18E-08	0.60495	2.44E-12	4.51E-13	1.78E-05	0.00E+00	0.01						
	11	20800	4.18E-08	0.60495	2.66E-11	-4.06E-12	-2.33E-05	0.00E+00	0.01						
	12	22748	4.18E-08	0.60495	1.62E-11	-1.92E-12	-2.40E-06	0.00E+00	0.01						
	13	23180	4.18E-08	0.60495	4.49E-12	-6.91E-13	-3.74E-05	0.00E+00	0.01						
	14	25128	4.18E-08	0.60495	-3.29E-12	-9.61E-13	-1.28E-06	0.00E+00	0.01						
	outr	innr	1-balance	eigenvalue	1-source	1-scatter	1-upscat	search	time						
	iter	iter		ratio	ratio	ratio	ratio	param	(min)						
	15	25536	4.18E-08	0.60495	-7.68E-12	1.95E-14	-7.83E-06	0.00E+00	0.02						
	lambda		0.60495	production/absorption		6.050E-01									

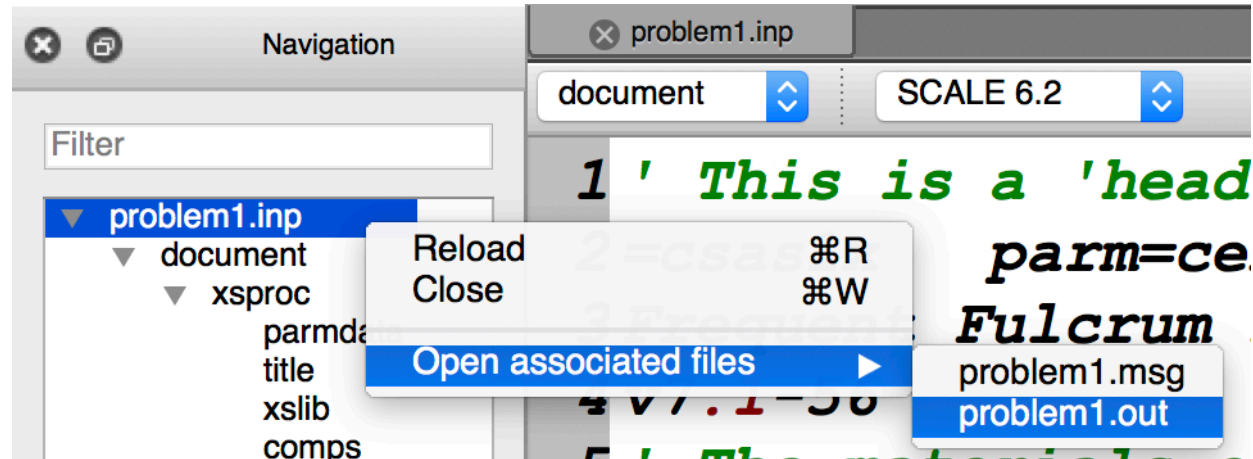
Fulcrum Document Navigation

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

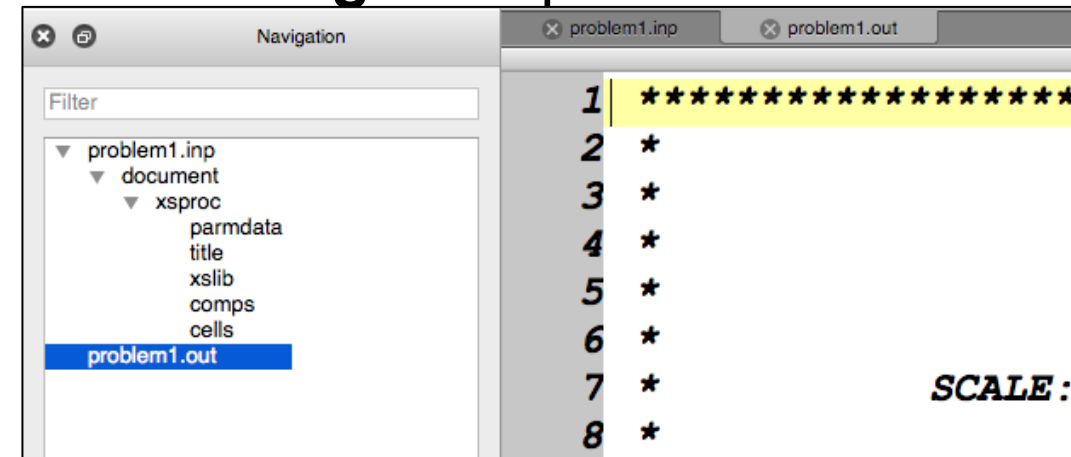


Headfirst – Opening results

- Once your job is complete you can access results via the **Navigation** panel's **Open Associated Files**
- In the **Navigation** panel right click on **problem1.inp**



- Observe the **problem1.out** output file is added to the **Navigation** panel and a new **problem1.out** text editor tab is displayed.

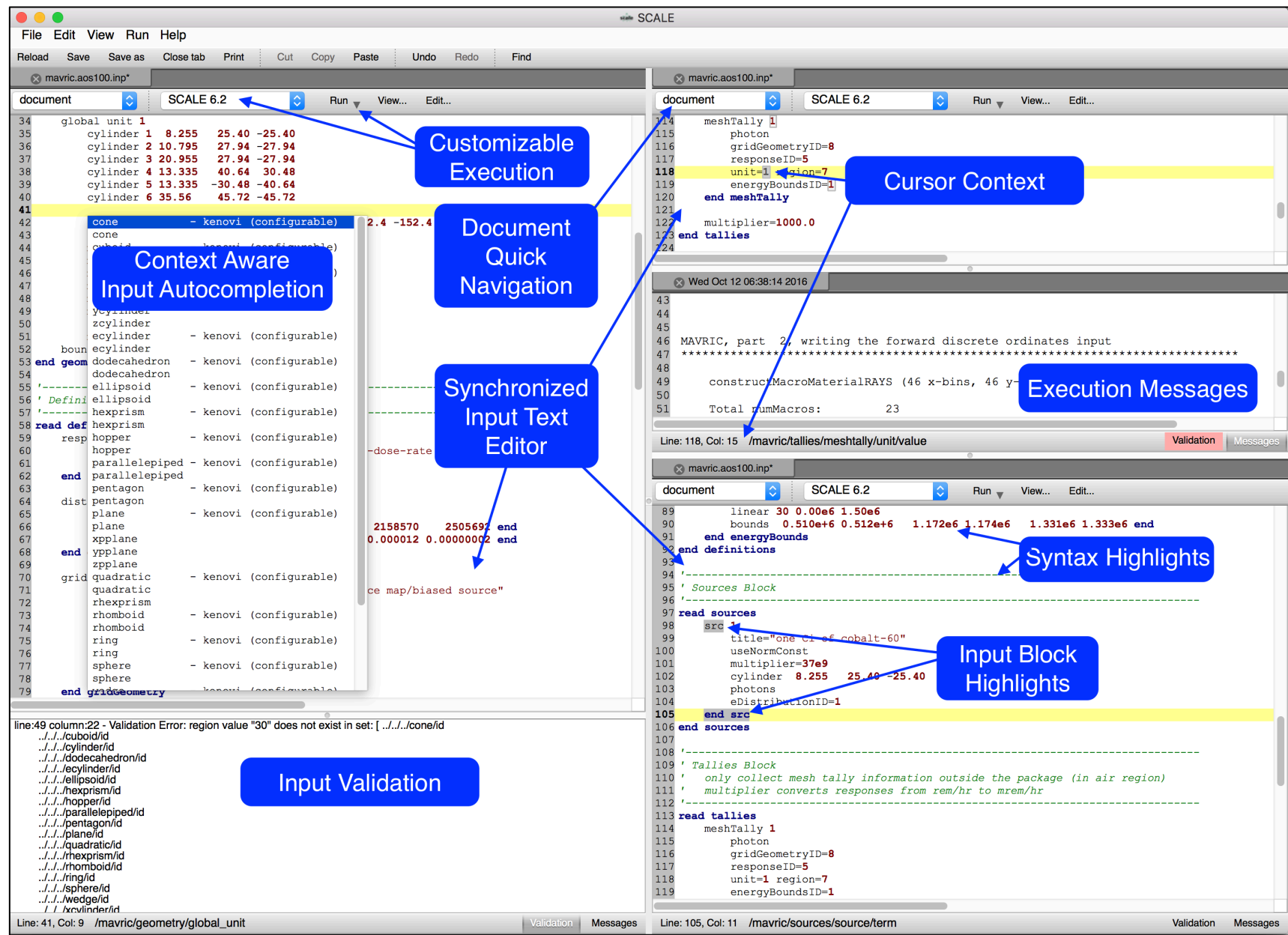


Headfirst Checkpoint!

- You have verified SCALE and Fulcrum are operational on your machine's Operating System
- You are aware of the configurability of the Fulcrum Text Editor via **Text Editor Settings**
- You know where the problem **Run** button is located so you can execute an input
- You know where the **Messages** panel button is and when there are unread messages
- You have been introduced to the **Navigation** panel
- You know how to see and open associated files via the **Navigation** panel's **Open Associated Files...** feature
- Let's look at the **Text Editor Features** in more depth
- **Questions!?**

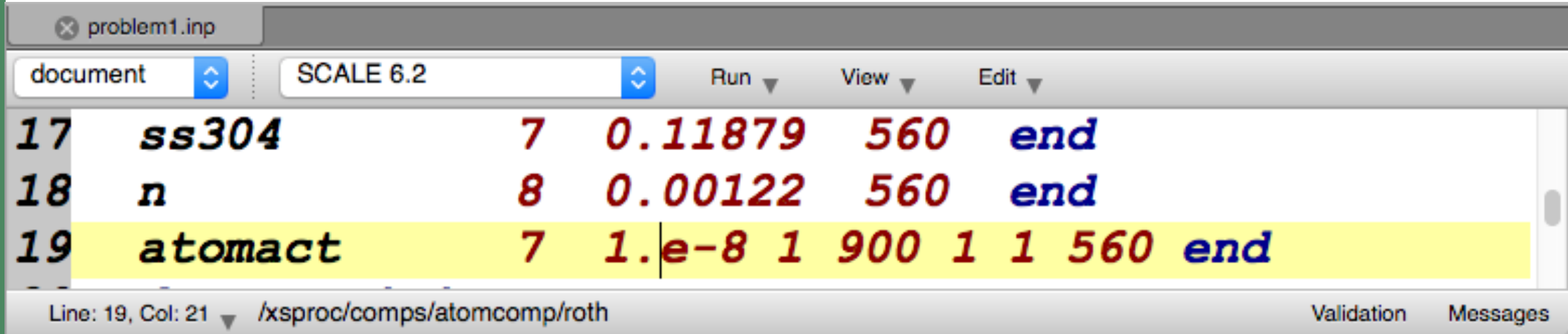
Fulcrum Text Editor Features | Overview

- Customizable Execution
- Quick Navigation
- Cursor Context
- Execution Messages
- Input Validity checks
- Syntax highlights
- Current block highlight
- Context aware input autocompletion
- Synchronized and split workspaces



Cursor Context PSA - 'The More You Know'

- Unsure of what a field is in the input?
- Place the text cursor on the field and observe the full field's name:



The screenshot shows a text editor window titled 'problem1.inp'. The editor contains three lines of data. Line 19 is highlighted in yellow. The status bar at the bottom indicates 'Line: 19, Col: 21' and the path '/xspoc/comps/atomcomp/roth'. The text in the editor is as follows:

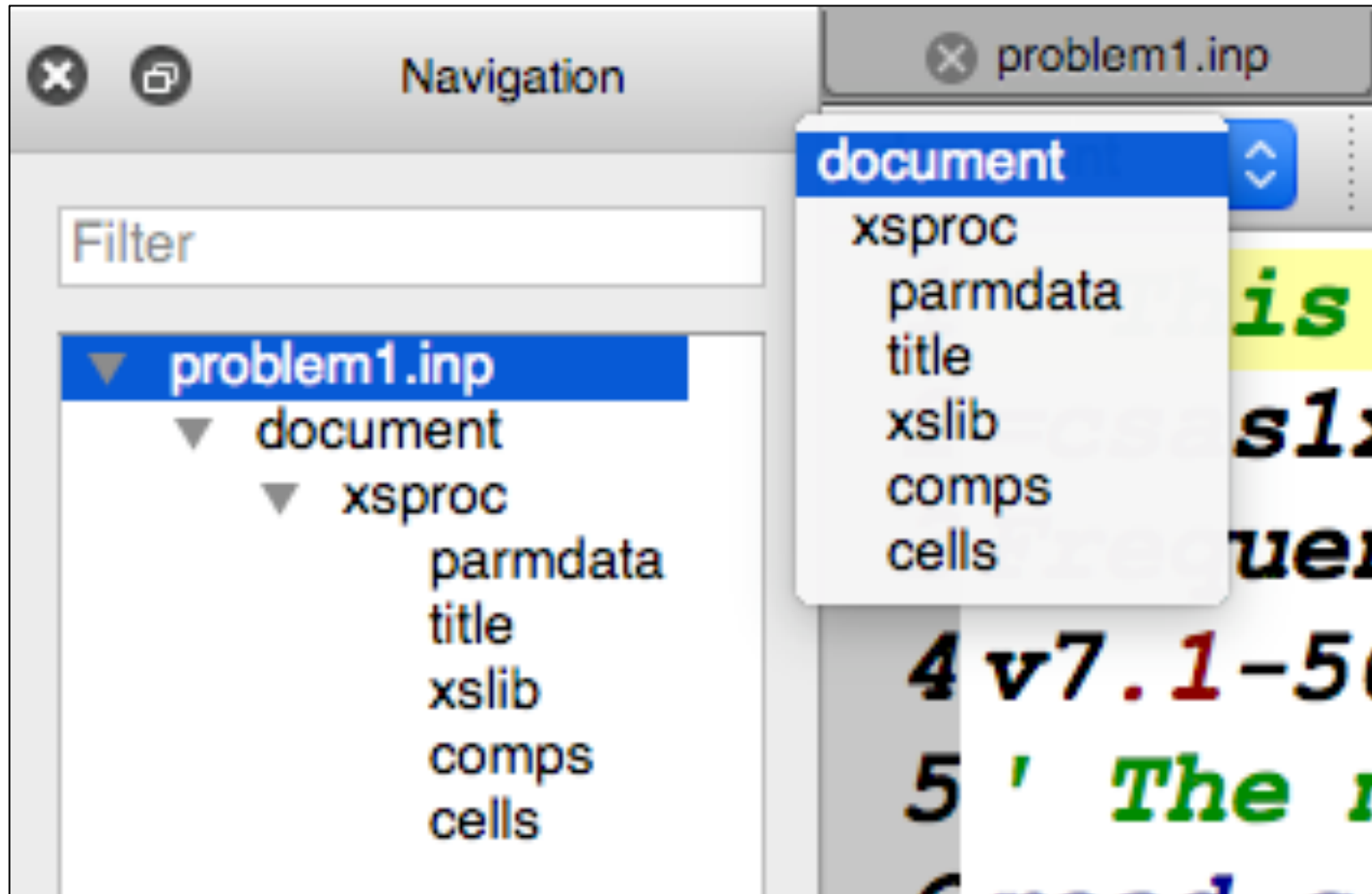
```
17  ss304          7  0.11879  560  end
18  n              8  0.00122  560  end
19  atomact        7  1.e-8  1  900  1  1  560  end
```

/xspoc / comps/atomcomp/roth

Sequence | block | record | field - theoretical density

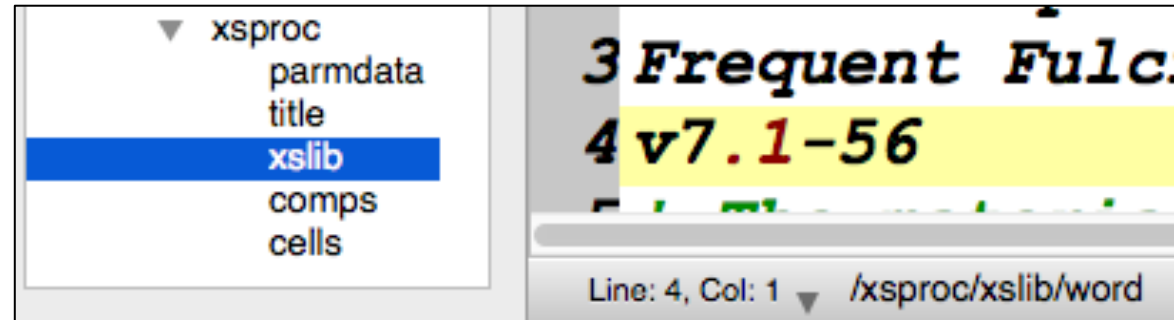
Quick Navigation

- Primary input components (xslib, comps, cells, geometry, etc.) available via **Navigation** panel and the text editor's **document** navigation drop-down

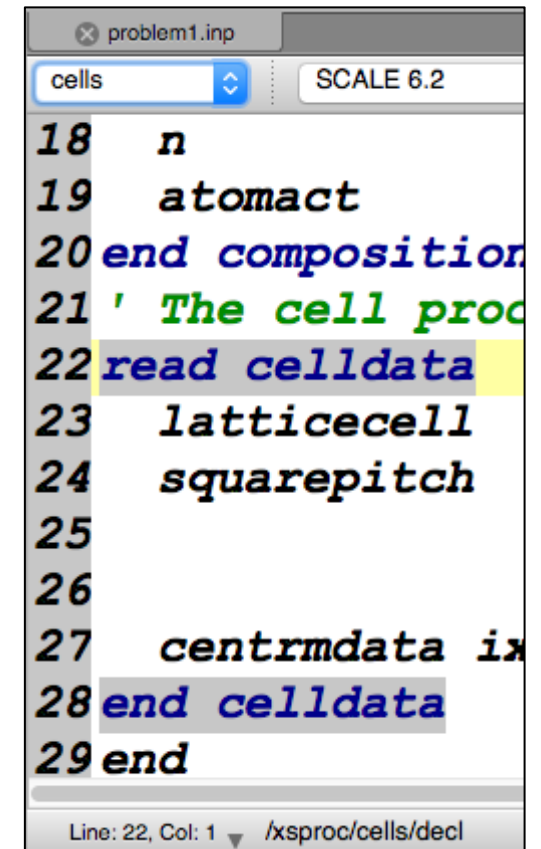
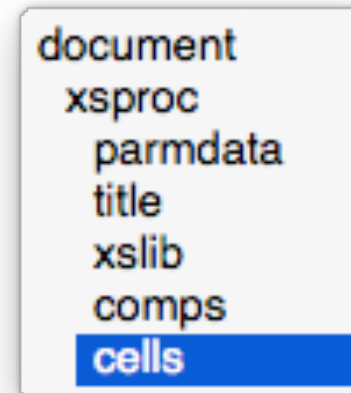


Quick Navigation | Hands On

- Double left-clicking an input component (**xslib**) in the **Navigation** panel to jump your cursor to that input component



- Left-clicking the text editor's **document** navigation and select a desired input component (**cells**)
 - Observe block highlighting indicate the start and end of the records



Quick Navigation | Goto Definition

- A lot of input data in SCALE is referential
 - I.e., an identifier from associated input component
 - E.g., geometry record referencing a material via the material identifier
- Fulcrum provides a quick navigation to the **definition** of an input field
 - Right click an input field and select **Goto Definition of <NAME>**

Goto Definition | Hands On

- In **problem1.inp** on line 24 column 31, you will find the use of a **mixture** that fills the **pitch** of the **latticecell**

```
24 squarepitch pitch 1.2598 8
```

Line: 24, Col: 31 ▾ /xspoc/cells/lattice/pitch/mixture

- What defines mixture 8?
- Right-click** on the **8** and select **Goto definition of mixture**
- Observe the input cursor jump to line 18, column 17, the definition of **mixture 8**:
A nitrogen (**n**) standard composition at **560K** with volume fraction (**vf**) of **0.00122**.



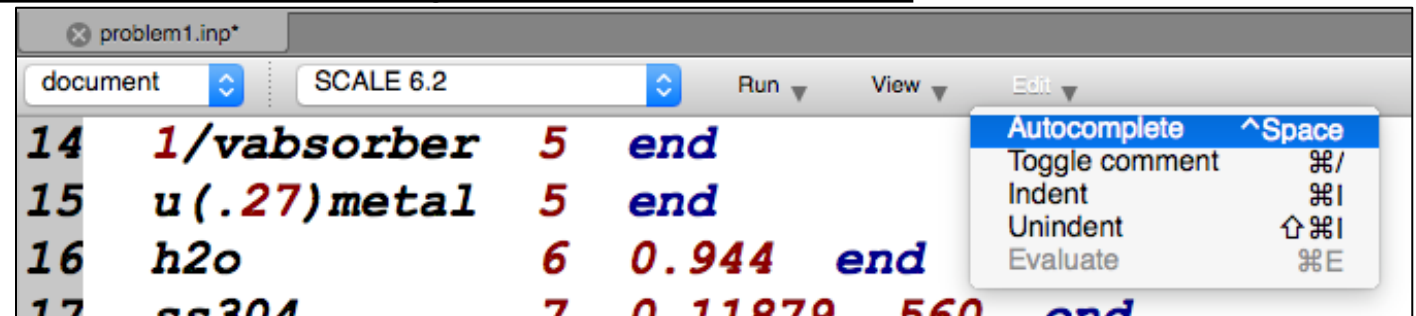
```
18 n 8 0.00122 560 end
```

Line: 18, Col: 17 ▾ /xspoc/comps/stdcomp/mixture

Input Autocompletion

Autocompletion provides you a jumpstart with input creation and editing via 3 constructs

- Static/default input insertion
 - Inserts boilerplate input that usually requires you to update fields for correctness
- Input substitution
 - Uses cursor context to present you with a list of input values to substitute for current value
- Configurable input insertion
 - Provides a graphical widget and resultant text preview
- Autocompletion is engaged via the **control+space (CTRL+SPACE)** keyboard sequence. Also, **Edit > Autocomplete** will display autocompletion



Autocompletion | Hands On Static text

- In **problem1.inp** add a new line **after** line 27

```
27  centrmdata ixprt=1 nmf6=-1 end centrmdata
28
29 end celldata
```

Line: 28, Col: 1 ▾ /xspc/cells Validation

- Press the **CTRL+SPACE** key combination to activate autocompletion on line 28 and observe the list of available input components.
- Select infinite homogeneous medium (**inhommed - basic**)
- Observe the static text inserted with default mixture identifier of 1

```
28 inhommed 1 end
```

Line: 28, Col: 11 ▾ /xspc/cells/inhommed/mixture

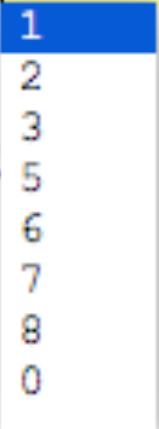
- This mixture identifier needs to be updated
 - This introduces you to the input substitution variant of autocompletion

inhommed	- basic
lattice	- squarepitch
lattice	- triangepitch
lattice	- sphsquarep
lattice	- sphtriangp
lattice	- symmslabcell
lattice	- asquarepitch
lattice	- atriangpitch
lattice	- asphsquarep
lattice	- asphtriangp
lattice	- asymslabcell
multiregion	- slab
multiregion	- cylindrical
multiregion	- spherical
multiregion	- buckledslab
multiregion	- buckledcyl
doublehet	- rod + squarepitch
doublehet	- rod + triangepitch
doublehet	- rod + asquarepitch
doublehet	- rod + atriangpitch
doublehet	- pebble + sphsquarep
doublehet	- pebble + sphtriangp
doublehet	- pebble + asphsquarep
doublehet	- pebble + asphtriangp
doublehet	- slab + symmslabcell
doublehet	- slab + asymslabcell
centrmdata	
moredata	

Autocompletion | Hands On Input Substitution

- Autocompletion that occurs on an existing input field will present a list of legal values for that field that upon selection will **substitute** the field with the selected
 - Aids in quickly remembering and selecting values for a field
- Update the **inhommed** from **1** to **3** via autocompletion with your cursor at the **1** and selecting **3**
 - This action lists all available mixtures from the composition block

```
28 inhommed 1 end
29
30 end cellda
31 end
32
```



```
6 read composition
7   uo2          1  0.90172  560
8                92234  0.029
9                92235  3.2
10               92236  0.016
11               92238 96.755  end
12   zirc4        2  1  560  end
13   b4c          3  7.7066e-2  end
14   1/vabsorber  5  end
15   u(.27)metal  5  end
16   h2o          6  0.944  end
17   ss304        7  0.11879  560  end
18   n            8  0.00122  560  end
19   atomact      7  1.e-8 1 900 1 1 560  end
20 end composition
```

Autocompletion | Hands On Input Substitution Continued

- The **infhommed** isn't a great example, so let's try compositions

- Perform an autocomplete on nitrogen (**n**) on line 18, column 4 and observe the complete list of available compositions be listed

```
18 n 8 0.00122 560 end
19 1/vabsorber 7 1.e-8 1 900 1 1 56
20 ac-206 ition
21 ac-207 'rocessing
22 ac-208 ata
23 ac-209 ell
24 ac-210 tch pitch 1.2598 8
25 ac-211 fuel 0.8357 1
26 ac-212 cladd 0.94996 2 end
27 ac-213 ta ixprt=1 nmf6=-1 end c
28 ac-214 l end
```

- Press the **right-arrow key** to move the cursor after the **n** and observe the autocompletion list update

```
18 n 8 0.00122 560 end
19 n 7 1.e-8 1 900 1 1 56
20 n-10 ition
21 n-11 'rocessing
22 n-12 ata
23 n-13 ell
24 n-14 tch pitch 1.2598 8
25 n-15 fuel 0.8357 1
```

Autocompletion | Hands On Input Substitution Continued

- Begin typing **it** (to form **nit**) and observe the list update

18	nit	8	0.00122	560	end
19	ato	7	1.e-8	1	900 1 1 560

- Press **RETURN** or **ENTER** to select **nitrogen**

18	nitrogen	8	0.00122	560	end
----	----------	---	---------	-----	-----

Line: 18, Col: 11 ▾ /xsproc/comps/stdcomp/name Validation Messages

Autocompletion | Configurable input

- Configurable forms provide a graphical widget that presents a more interactive experience that is accompanied by the resulting text that will be inserted
 - All configurable autocompletion options are clearly marked with **(configurable)** following their description

<code>stdcomp</code>	<code>- basic (configurable)</code>
<code>stdcomp</code>	<code>- basic</code>
<code>stdcomp</code>	<code>- basic + volume fraction</code>
<code>stdcomp</code>	<code>- basic + volume fraction + temperature</code>
<code>stdcomp</code>	<code>- basic + volume fraction + temperature + isotopics</code>
<code>stdcomp</code>	<code>- basic + atomic density (configurable)</code>
<code>stdcomp</code>	<code>- basic + atomic density</code>
<code>stdcomp</code>	<code>- basic + atomic density + temperature</code>
<code>wtptcomp</code>	<code>- basic (configurable)</code>
<code>wtptcomp</code>	<code>- basic</code>
<code>wtptcomp</code>	<code>- basic + volume fraction</code>
<code>wtptcomp</code>	<code>- basic + volume fraction + temperature</code>
<code>wtptcomp</code>	<code>- basic + volume fraction + temperature + isotopics</code>
<code>atomcomp</code>	<code>- basic (configurable)</code>
<code>atomcomp</code>	<code>- basic</code>
<code>atomcomp</code>	<code>- basic + volume fraction</code>
<code>atomcomp</code>	<code>- basic + volume fraction + temperature</code>
<code>atomcomp</code>	<code>- basic + volume fraction + temperature + isotopics</code>
<code>solution</code>	<code>- rho + density + temperature + volume fraction</code>
<code>solution</code>	<code>- molar + density + temperature + volume fraction</code>
<code>solution</code>	<code>- massfrac + density + temperature + volume fraction</code>
<code>solution</code>	<code>- molefrac + density + temperature + volume fraction</code>
<code>solution</code>	<code>- molality + density + temperature + volume fraction</code>

Autocompletion | Configurable input cont'd

- Upon selecting a **configurable** autocompletion option a graphical widget is displayed with widgets for each input field to allow toggle of input field values
- A **Results** table displays the resulting text that will be inserted
- More to follow in future exercises

The screenshot shows a window titled "stdcomp - basic (configurable)". It contains several input fields and checkboxes:

- Composition:** A dropdown menu showing "uo2".
- Mixture:** A text input field containing "10".
- Theoretical Density:** A checkbox (unchecked) and a text input field containing "10.960000".
- Volume Fraction:** A checkbox (checked) and a text input field containing "1.000000".
- Temperature:** A checkbox (checked) and a text input field containing "293.000000".
- Isotopic Weight Percents:** A checkbox (checked) and a table.

	+/-	Isotope	Weight Percent
1	+ -	92238	95.000000
2	+ -	92335	5.000000

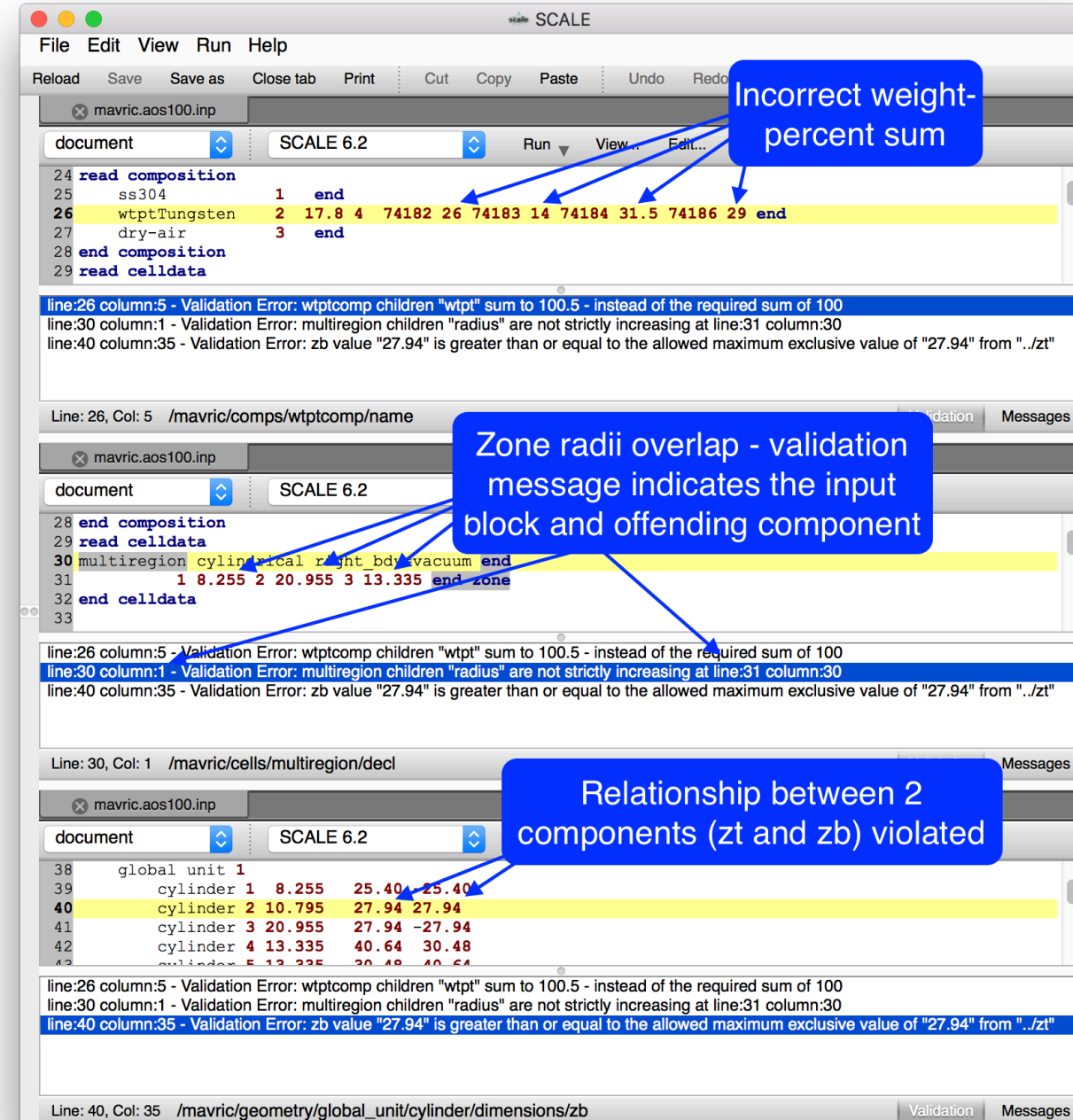
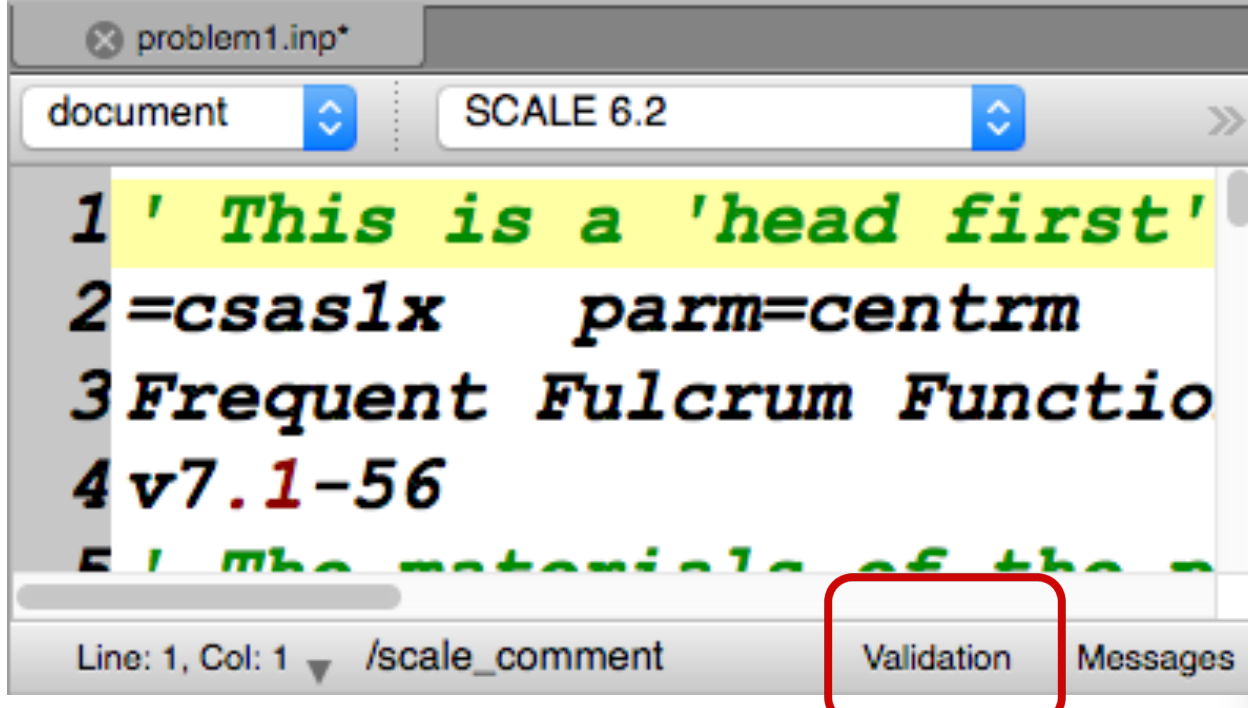
Below the table is an "Add row" button. At the bottom of the window, there is a text area containing the following text:

```
uo2 10 1.0 293.0
92238 95.0
92335 5.0 end
```

At the bottom right, there are buttons for "Results", "Log", "Template", "Cancel", and "OK".

Input Validation | Automatic input checking

- Fulcrum applies numerous input checks to your input while you are editing
 - Results of input checks are listed in the text editor's **Validation** panel located in the lower right corner, adjacent to the **Messages** panel
 - Left-clicking the message quick-navigates to the error location



Input Checking | Parse Vs Validation Errors

- Input checks can result in a parse or validation error
- Input **parse errors** indicate something is wrong with the input structure
 - An extra field is present causing input parsing to fail which
 - Can have collateral validation errors as a result of an incomplete understanding of the input
- Input **validation errors** indicate illegal input
 - E.g., missing required input fields, unallowed value, or incorrect type

```
11          92238 96.755  end
12  z |irc4      2  1  560  end
```

line:12 column:5 - Parse Error: expected mixture or mixture alias, found 'irc4'

line:12 column:17 - Parse Error: expected sequence terminator, found '2'

line:12 column:3 - Validation Error: name value "z" is not one of the allowed values: [... "yb-181" "ytterbium" "yttrium" "zinc" "zirc2" "zirc4" ...]

line:12 column:3 - Validation Error: stdcomp has zero of: [mixture alias] - exactly one must occur

Input Validation | Simple examples

7	uo2	1	0.90172	-560
line:7 column:29 - Validation Error: temp value "-560" is less than or equal to the allowed minimum exclusive value of 0				

7	uo2	1	0.90172	560
8		92234	1.029	
9		92235	3.2	
10		92236	0.016	
11		92238	96.755	end
line:7 column:3 - Validation Error: stdcomp children "wtpt" sum to 101 for 92000 group - instead of the required sum of 100				

7	u02	1	0.90172	560
line:7 column:3 - Validation Error: name value "u02" is not one of the allowed values: [... "u-241" "u-242" "u-uo2" "u232-uo2" "u233-uo2" "u234-uo2" ...]				

Input Validation | Complex examples

25	<i>squarepitch</i>	<i>pitch</i>	1.2598	8	
26		<i>fuel</i>	0.8357	1	
27		<i>cladd</i>	1.94996	2	<i>end</i>

line:25 column:22 - Validation Error: dimension value "1.2598" is less than the allowed minimum inclusive value of "1.94996" from "../cladd/dimension"

Line: 25, Col: 22 ▾ /xspc/cells/lattice/pitch/dimension

- Referential error indicating the /xspc/cells/lattice/pitch/dimension (1.2598) cannot be less than the clad diameter (**cladd**) dimension (1.94996) relatively located at “../clad/dimension”.
- I.e., fuel < cladd < pitch

Input Validation | Complex examples cont'd

```
25 squarepitch pitch 1.2598 18
```

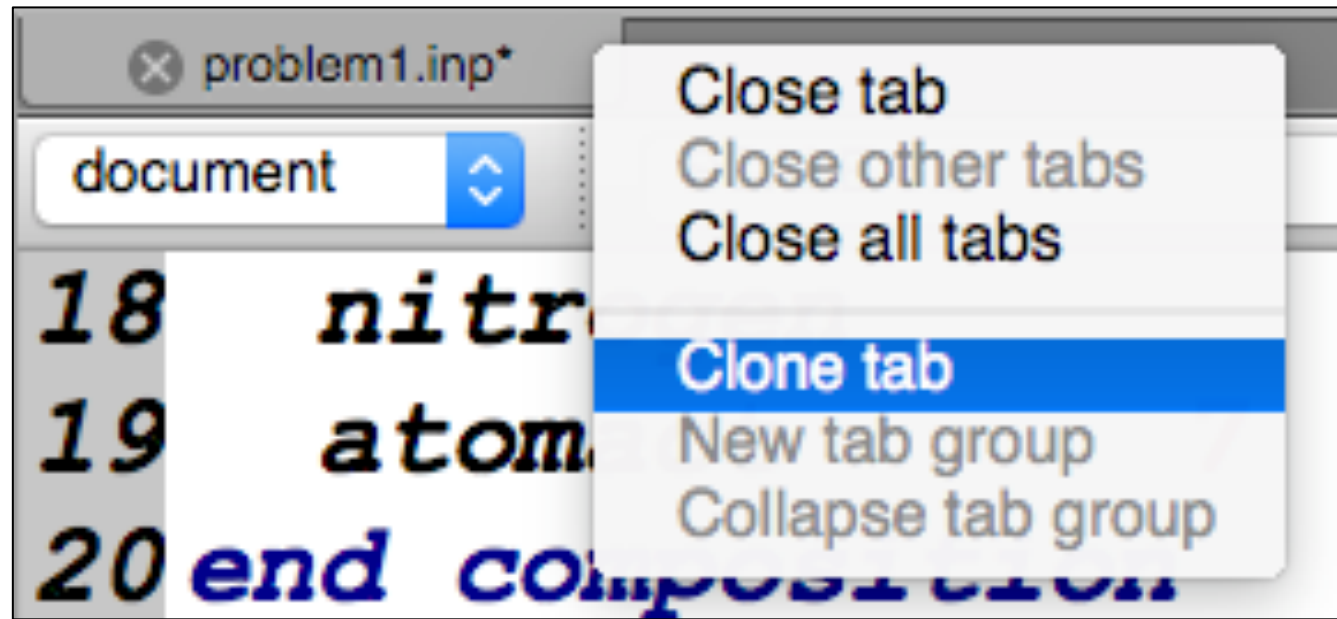
line:25 column:31 - Validation Error: mixture value "18" does not exist in set: [../../../../comps/stdcomp/mixture
../../../../comps/soln/mixture
../../../../comps/stdcomp/alias
../../../../comps/soln/alias
../../../../comps/atomcomp/mixture
../../../../comps/atomcomp/alias
../../../../comps/wtptcomp/mixture
../../../../comps/wtptcomp/alias
../../../../comps/arbcomp/mixture
../../../../comps/arbcomp/alias
../../../../comps/solution/mix/mixture
../../../../comps/solution/mix/alias]

Line: 25, Col: 33 ▾ /xspoc/cells/lattice/pitch/mixture

- Referential error indicating the /xspoc/cells/lattice/pitch/mixture must exist at /xspoc/cells/lattice/pitch/../../../../X. Equivalent to /xspoc/X
- I.e., /xspoc/comps/stdcomp/mixture

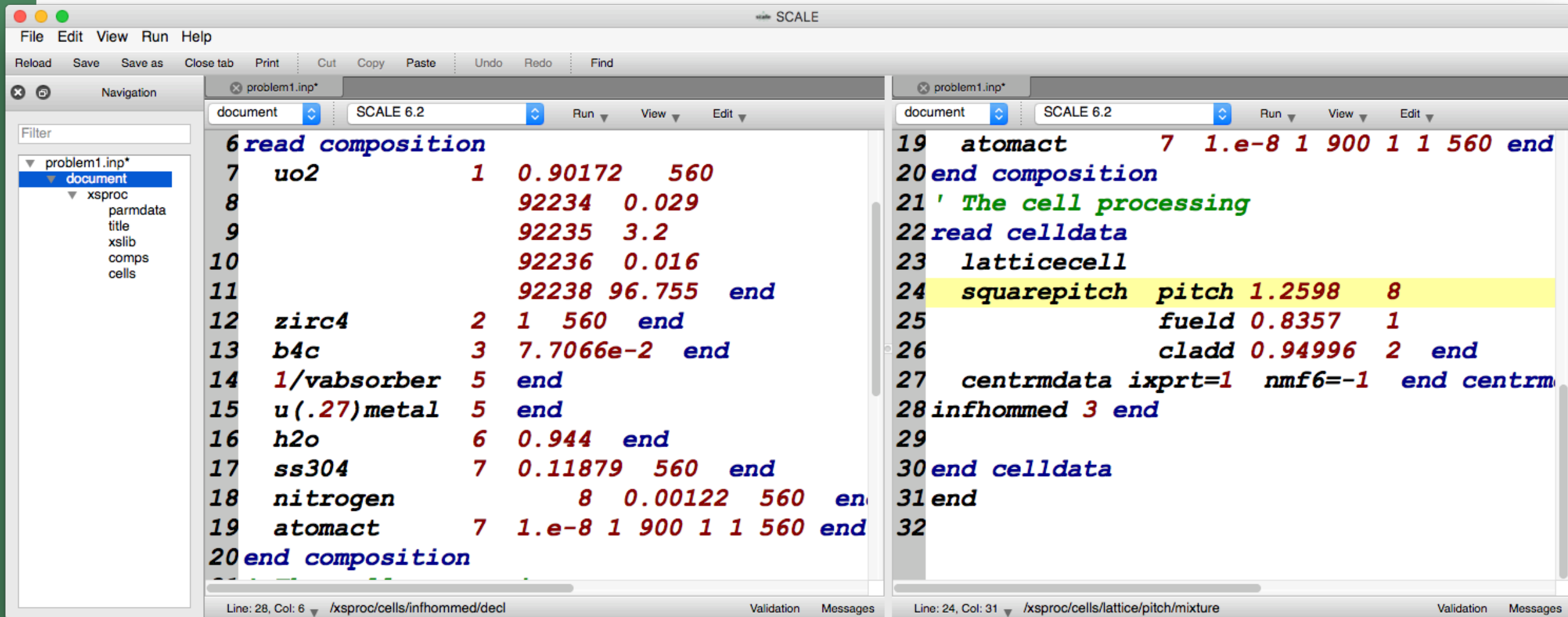
Workspaces | Synchronized and split editors

- Fulcrum takes advantage of the newer, more affordable, higher resolution, and larger displays with the ability to split text editors into multiple workspaces
 - Both vertical and horizontal arrangements
 - Single and multi-document
- Text documents can be cloned by **right-clicking** the editor tab and selecting **clone tab**



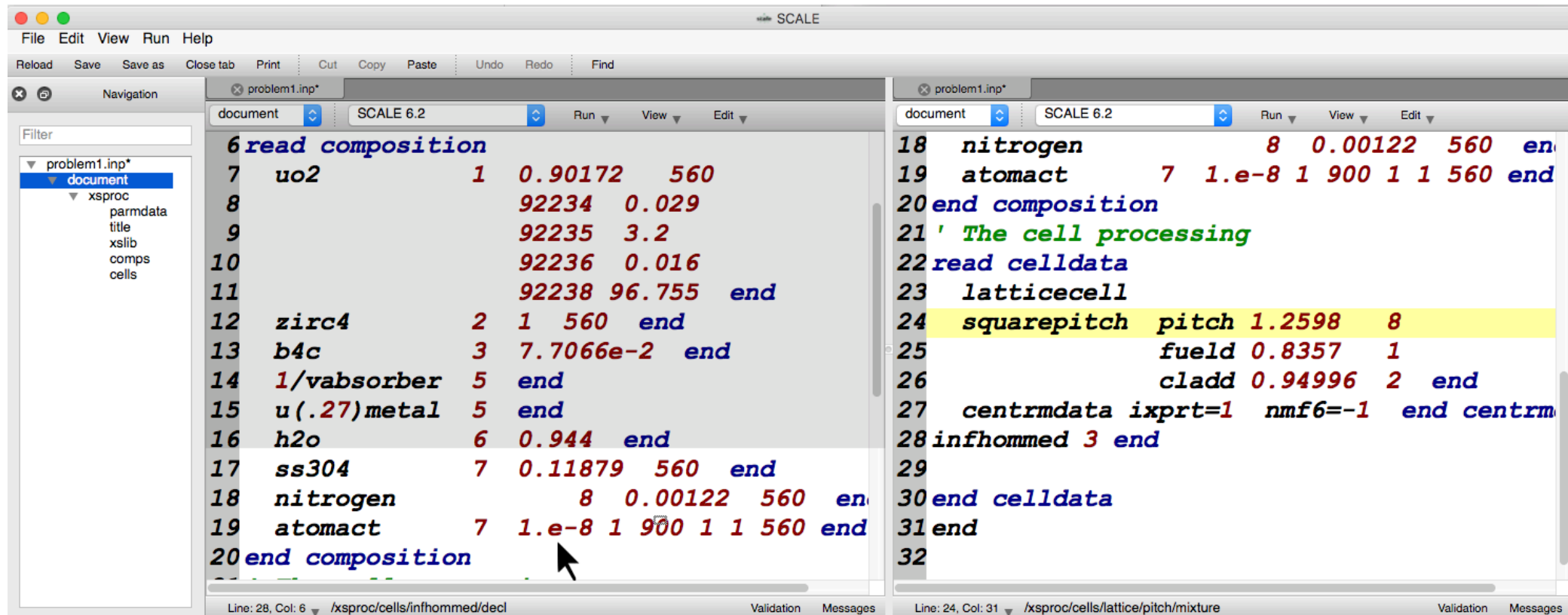
Workspaces | Split Editor continued

- Split editor allows for viewing and editing associated input sections
 - E.g., Composition and Cell data or Composition and geometry data



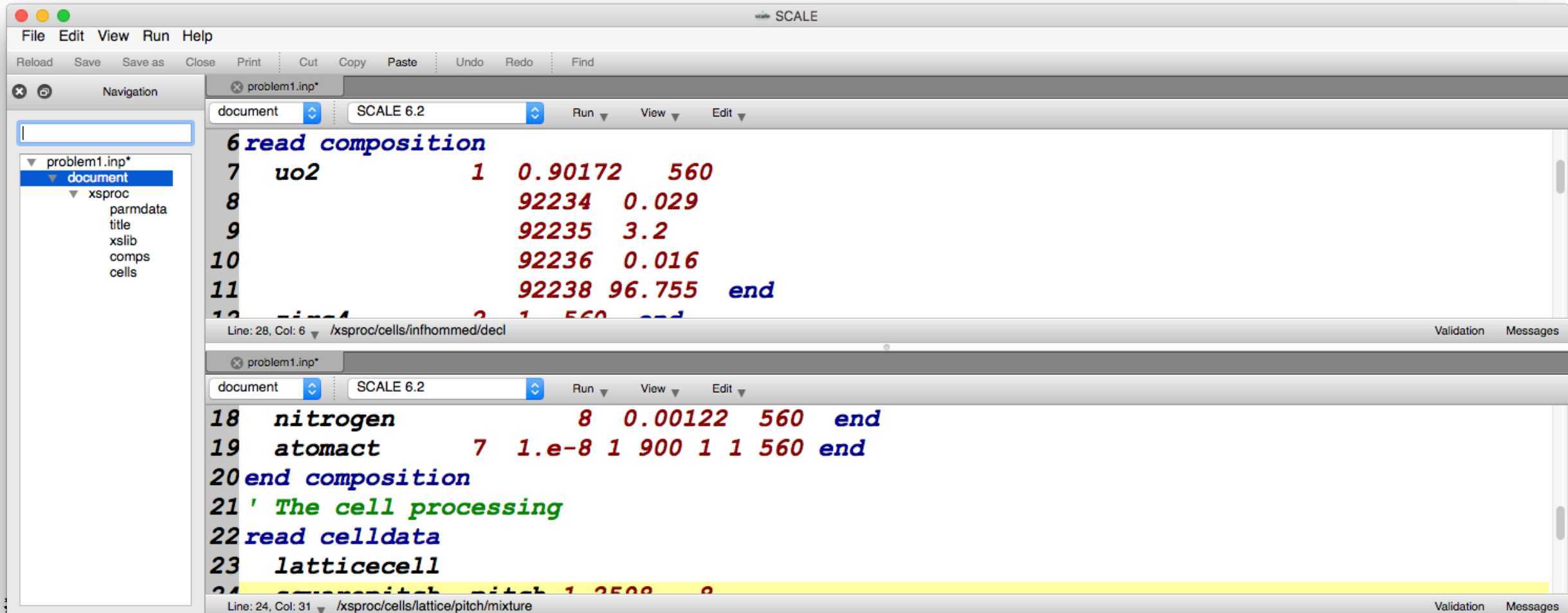
Workspaces | Split Editor cont'd

- Rearranging workspaces is facilitated by click-and-drag of the desired tab to the new location
- Left-click and drag the **right problem1.inp** tab to the **bottom-center** of the **left problem1.inp** tab



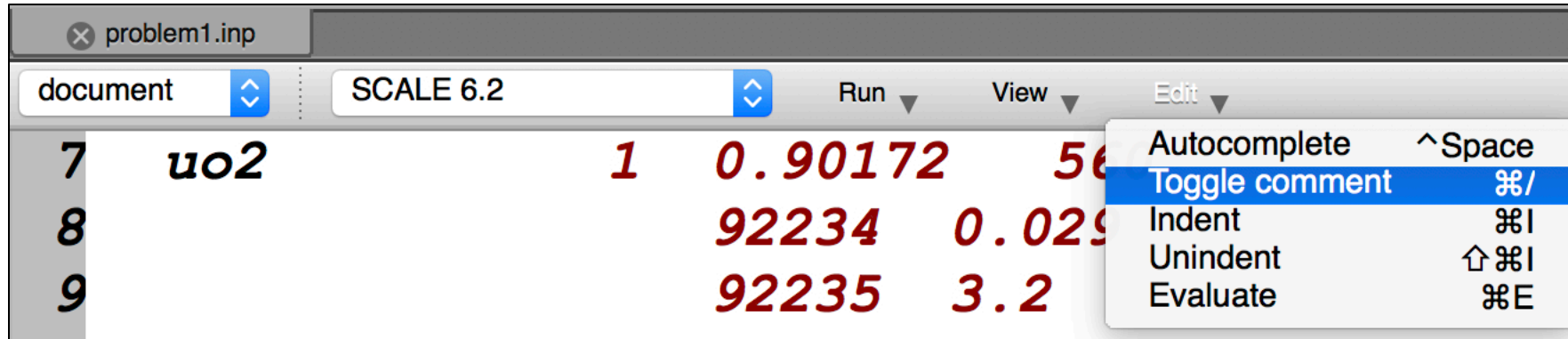
Workspaces | Split Editor cont'd

- Splits can occur on to the bottom, left, right, or top of tab
- Closing splits can be accomplished by closing the last tab or right-click and selecting **close all tabs**



Comments | Made Convenient

- Comment and uncomment input using **Edit > Toggle comment** or **CMD+ /** (Mac) **CTRL+ /** (Windows/Linux)



- Toggles comment for the current line or selection
 - The cursor can be anywhere on a line to toggle the comment on or off

Comments | In Practice

- Comment-out unused composition records by selecting the lines

```
13  b4c          3  7.7066e-2  end
14  1/vabsorber  5  end
15  u(.27)metal  5  end
16  h2o          6  0.944    end
17  ss304        7  0.11879   560  end
18  nitrogen     8  0.00122   560  end
```

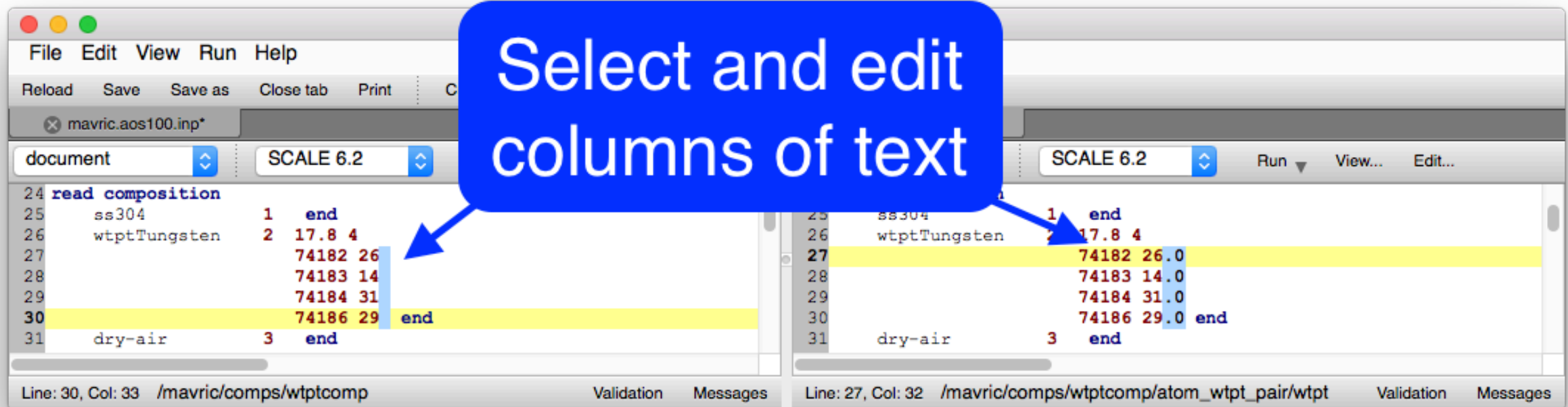
- Toggle comment via **Edit > Toggle comment** or **CMD+/'** (Mac) **CTRL+/'** (Windows/Linux)

```
13  b4c          3  7.7066e-2  end
14  ' 1/vabsorber  5  end
15  ' u(.27)metal  5  end
16  ' h2o          6  0.944    end
17  ' ss304        7  0.11879   560  end
18  nitrogen     8  0.00122   560  end
```

Column Text Selection and Editing

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

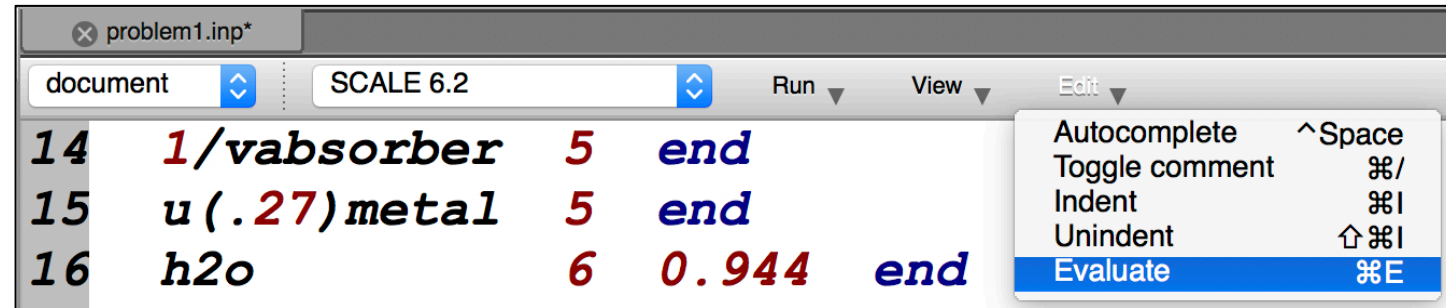
- Column selection via **ALT+MOUSE SELECTION**.
- With column selection made, any edits are made to all columns for each row.
- E.g., Update all isotope weight percent values to have a decimal digit.



Expression Evaluation | Embedded Calculator

- An integrated expression evaluation engine is available in Fulcrum
- Accessible via **Edit > Evaluate** or **CTRL+E** (Windows/Linux) **CMD+E** (Mac)

- Arithmetic operators: +, -, *, /, ^
- Supports typical functions:



The screenshot shows a code editor window titled 'problem1.inp*' with a menu bar containing 'document', 'SCALE 6.2', 'Run', 'View', and 'Edit'. The code in the editor is:

```
14 1/vabsorber 5 end
15 u(.27)metal 5 end
16 h2o 6 0.944 end
```

The 'Edit' menu is open, showing options: 'Autocomplete' (with a ^Space shortcut), 'Toggle comment' (with a // shortcut), 'Indent' (with a || shortcut), 'Unindent' (with a ^|| shortcut), and 'Evaluate' (with a %E shortcut). The 'Evaluate' option is highlighted in blue.

sqrt(x)	cos(x)	sin(x)	root(x)	abs(x)
min(x1,x2,...)	max(x1,x2,...)	avg(x1,x2,...)	sum(x1,x2,...)	mul(x1,x2,...)
floor(x)	ceil(x)	exp(x)	log(x)	logn(x)
log10(x)	hyp(x,y)	if(C,T,F)	clamp(r1,v,r2)	inrange(l,v,u)
sign(x)	deg2rad(x)	tan(x)	equal(x,y)	acos(x)
asin(x)	atan(x)	cosh(x)	tanh(x)	sec(x)
csc(x)	cot(x)	sinh(x)	round(x)	roundn(x,p)
d2g(x)	g2d(x)	r2d(x)	pi	

Expression Evaluation | In Practice

- Calculate the fuel area given the fuel diameter of 0.8357
- Enter a comment with **pi*(fueld=0.8357/2.0)^2**

```
20 end composition
21 ' The cell processing
22 ' pi*(fueld=0.8357/2.0)^2
23 read celldata
24 latticecell
25 squarepitch pitch 1.2598 8
26 fuel 0.8357 1
27 cladd 0.94996 2 end
```

- Select the text and evaluate it
- I.e., **Edit > Evaluate** or
CMD+E (Mac) or
CTRL+E (Windows/Linux)

```
20 end composition
21 ' The cell processing
22 ' 0.548518
23 read celldata
24 latticecell
25 squarepitch pitch 1.2598 8
26 fuel 0.8357 1
27 cladd 0.94996 2 end
```

Text Editor Overview Checkpoint #2!

- You are now aware of the Fulcrum text editor's **Cursor Context** to assist you in identifying and becoming familiar with SCALE input fields
- You are now practiced in quickly navigating using the **Quick Navigation** features including **Goto Definition**
- You are now practiced in performing input **autocompletion** including interactive field substitution
 - You are aware of **Configurable** autocompletion forms
- You are now aware of the input **Validation** panel and the automatic **input checking** performed
 - The difference between an input parse and validation error
- You are now practiced in **cloning** and rearranging **tab** workspace **layout**
- **Questions!?**

Exercise Preparation

- Close all files via clicking **File > close all**
- Alternatively, closing files can be accomplished by one of the following operations
 - Click **File > Close**
 - Right-click file in the **Navigation** panel and select **close**
 - Close the tab
 - Only closes file if **File > Settings > Text Editor > Close text documents when all editors are closed** is enabled
- **Ready to start our exercise, Lady Godiva**

Exercise | Lady Godiva

- Interesting piece of history
- Model a 'simplified' version
- Exercise isn't about criticality analysis but Fulcrum functionality
- Use Fulcrum to **create**, **edit**, **visualize**, and **execute** input

https://ncsp.llnl.gov/LA13638/reports/046.ref_046.pdf

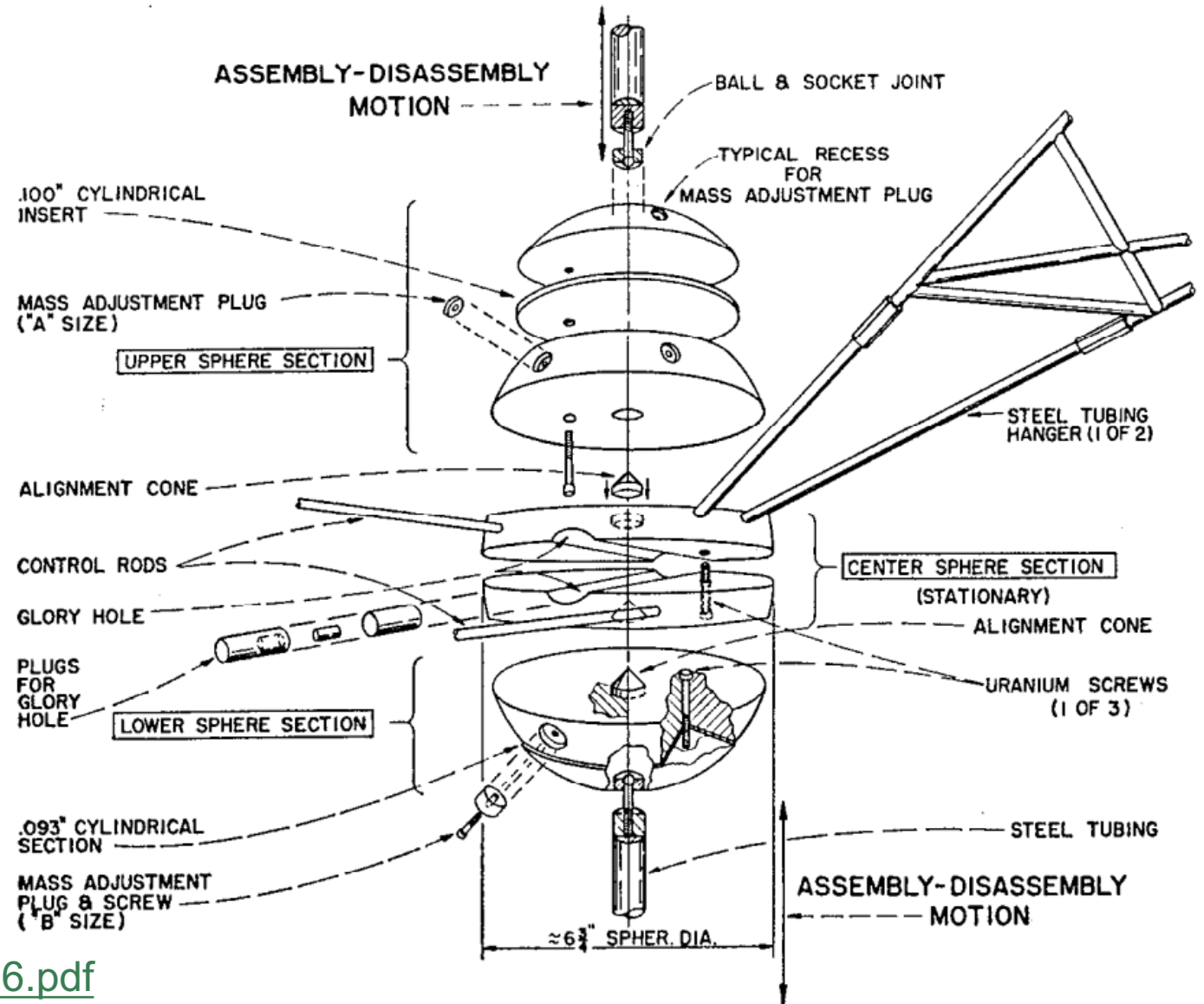


FIG. 1. View of Godiva components. With the exception of the steel support structure and the ball portions of the flexible mounts, all parts are uranium. The upper and center sphere sections are shown separated into basic pieces.

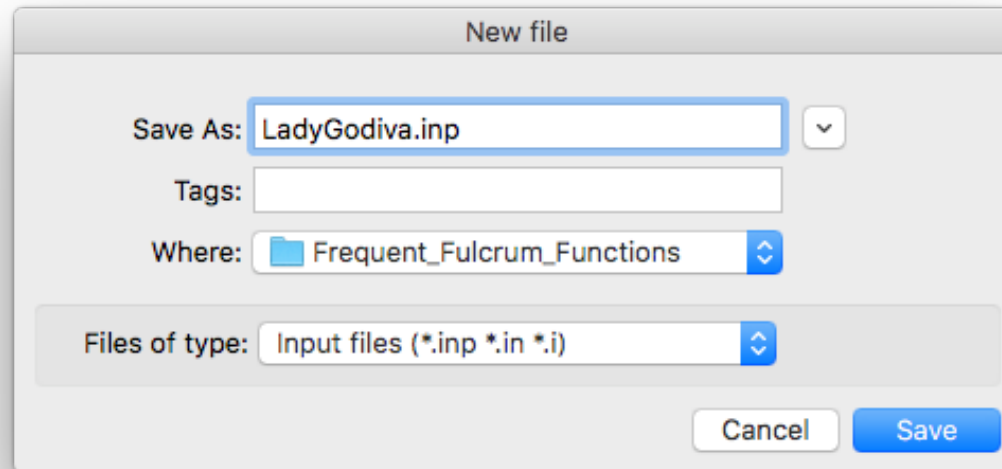
Exercise | Lady Godiva - Simplified

- Create the Lady Godiva experiment using the **CSAS6** criticality safety analysis sequence
- Lady Godiva consists of ~**6.75 in diameter** slightly elongate “sphere” or **ellipsoid**
- Enriched to **90% ^{235}U**
- Average density is “slightly less than **19 gm/cm³**”
- **15/16 in radius cylindrical** channel
- Use **V7.1-252n** cross-section library (**xslib**)
- Use **multiregion cell** processing with **vacuum right boundary condition**
- Use 10000 particles per generation in the **parameters** to CSAS

https://ncsp.llnl.gov/LA13638/reports/046.ref_046.pdf

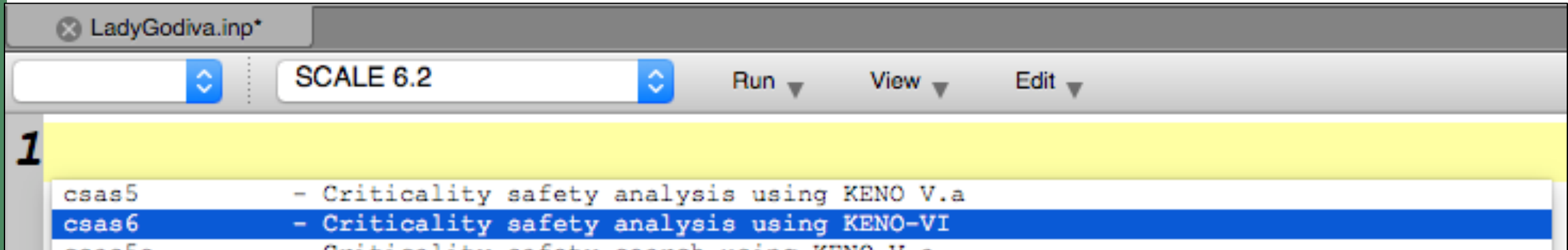
Lady Godiva | New File

- Click **File > New file...**
- Navigate to the **Frequent_Fulcrum_Functions** folder
- Name the file **LadyGodiva.inp**
 - **REMEMBER TO SPECIFY THE EXTENSION (.inp)**
 - No extension means no input intelligence (no navigation, cursor context, autocompletion, etc.)



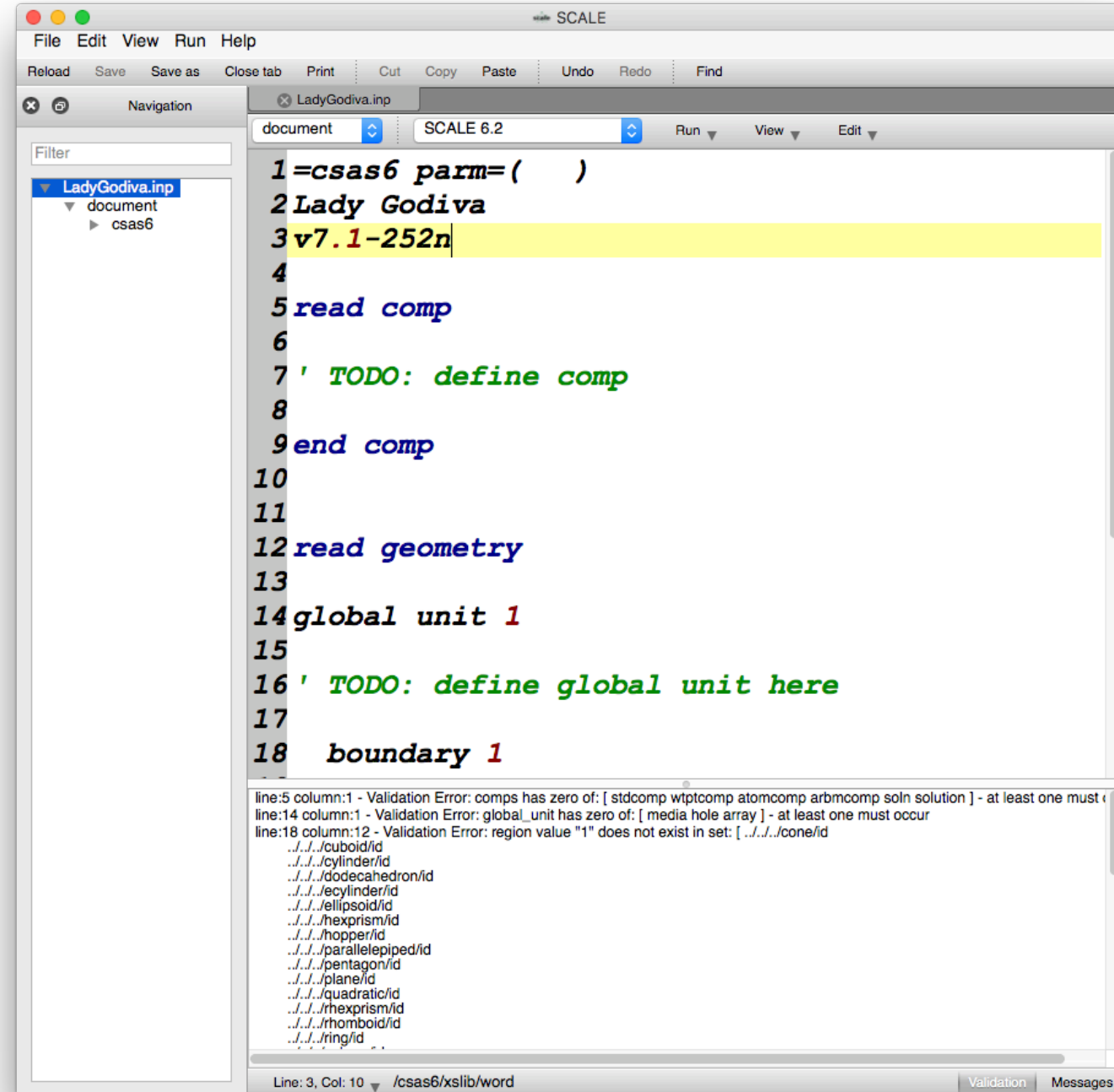
Criticality Safety Analysis Sequence – CSAS6

- With your cursor in the text editor perform an autocompletion via the **CTRL-SPACE** keyboard sequence
- Select **CSAS6 – Criticality safety analysis using KENO-VI**



Title and Cross-Section Library

- Replace **title-goes-here** with **Lady Godiva**
- Replace **xslib-goes-here** with **v7.1-252n**
 - In 6.3 autocompletion is available



```
1=csas6 parm=( )
2Lady Godiva
3v7.1-252n
4
5read comp
6
7' TODO: define comp
8
9end comp
10
11
12read geometry
13
14global unit 1
15
16' TODO: define global unit here
17
18boundary 1
```

line:5 column:1 - Validation Error: comps has zero of: [stdcomp wptcomp atomcomp arbmcomp soln solution] - at least one must occur
line:14 column:1 - Validation Error: global_unit has zero of: [media hole array] - at least one must occur
line:18 column:12 - Validation Error: region value "1" 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

Line: 3, Col: 10 /csas6/xslib/word

Composition | 90% ^{235}U , Slightly less than 19 gm/cm^3

- Remove the **TODO** comment in the **read comp** block
- Press **CTRL-SPACE** to display composition options
- Select **stdcomp – basic (configurable)**
- Update **Composition** to be **uranium**
- Click the **Theoretical Density** checkbox
- Specify a **Theoretical Density** of **18.95**
- Click the **Isotopic Weight Percents** checkbox
- Click the **Add row** button
- The default **Isotope** added is ^{238}U (**92238**). Update its **Weight Percent** to **10%**
- Click the **Add row** button, again
- Change the **Isotope** to ^{235}U (**92235**)
- Change the **Weight Percent** to **90%**

stdcomp - basic (configurable)

Composition: uranium

Mixture: 1

☒ Theoretical Density: 18.950000

☒ Volume Fraction: 1.000000

☒ Temperature: 293.000000

☒ Isotopic Weight Percents

	+/-	Isotope	Weight Percent
1	+ -	92238	10.000000
2	+ -	92235	90.000000

Add row

uranium 1 den=18.950000 1.0 293.0
92238 10.0
92235 90.0 end

Results Log Template

Cancel OK

Composition Review | 90% ^{235}U , Slightly less than 19 gm/cm^3

- Notice **Temperature** was automatically enabled by clicking **Isotopic Weight Percents**
 - This is because the input is position-dependent and requires **Temperature** to be specified
 - **Theoretical Density** has a label (**den=**) so it is not required and not automatically enabled
- Review the **Results** panel
 - Note all parameters
- Press **OK** to insert the **Result** text into the comp block

stdcomp - basic (configurable)

Composition: uranium

Mixture: 1

☒ Theoretical Density: 18.950000

☒ Volume Fraction: 1.000000

☒ Temperature: 293.000000

☒ Isotopic Weight Percents

	+/-	Isotope	Weight Percent
1	+ -	92238	10.000000
2	+ -	92235	90.000000

Add row

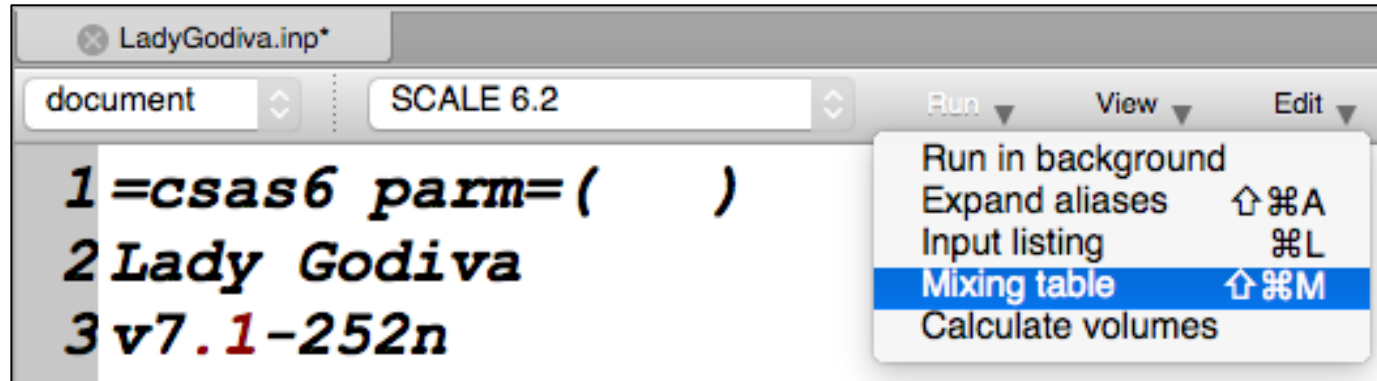
uranium 1 den=18.950000 1.0 293.0
92238 10.0
92235 90.0 end

Results Log Template

Cancel OK

Mixture Table | Composition check

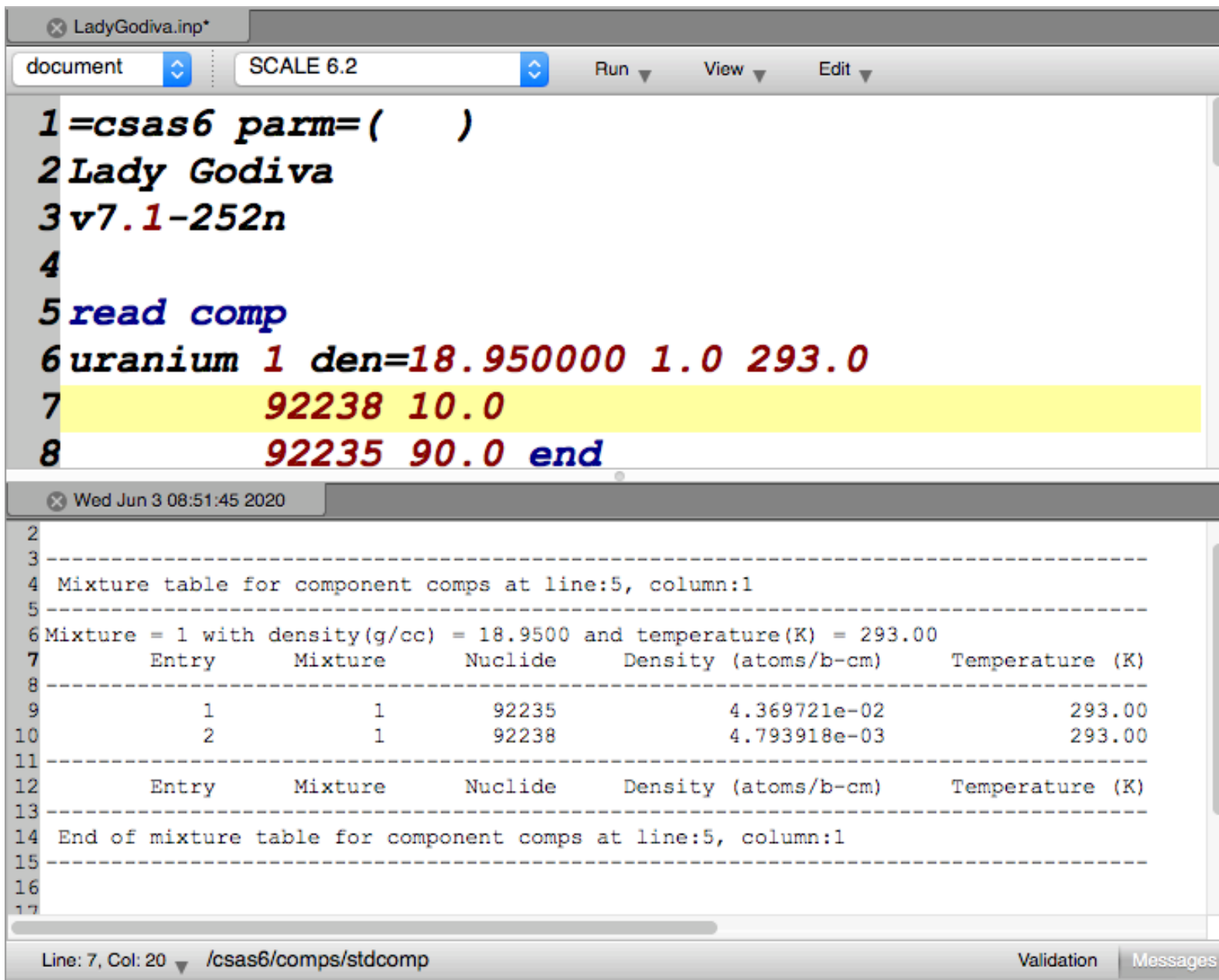
- Let's take a peek at the problem's mixture table
- Click the drop-down icon on the Text Editor's **Run** button and select **Mixing table**



- This will process the composition block and provide a view of each Mixture nuclide's density (**atoms/b-cm**) placing a summary edit into the **Messages** panel

Mixture Table | Composition check cont'd

- Open the **Messages** panel and observe the **Mixture table**
- Verify the **Mixture 1 density (g/cc)** is the same as that provided in the comp block
- Close the **Messages** tab and click the **Messages panel** button to hide it



The screenshot shows a software interface with a code editor and a messages panel. The code editor contains the following script:

```
1=csas6 parm=( )
2Lady Godiva
3v7.1-252n
4
5read comp
6uranium 1 den=18.950000 1.0 293.0
7      92238 10.0
8      92235 90.0 end
```

The messages panel displays the output of the script, including a table of mixture data:

```
2
3-----
4 Mixture table for component comps at line:5, column:1
5-----
6 Mixture = 1 with density(g/cc) = 18.9500 and temperature(K) = 293.00
7      Entry      Mixture      Nuclide      Density (atoms/b-cm)      Temperature (K)
8-----
9              1              1          92235          4.369721e-02          293.00
10             2              1          92238          4.793918e-03          293.00
11-----
12      Entry      Mixture      Nuclide      Density (atoms/b-cm)      Temperature (K)
13-----
14 End of mixture table for component comps at line:5, column:1
15-----
16
17
```

The status bar at the bottom indicates the current line and column: Line: 7, Col: 20. The file path is /csas6/comps/stdcomp. The messages panel is currently open, showing the output of the script.

Cross-Section Processing | MultiRegion Cell

- On a line after **end comp** but before **read geometry** perform an autocompletion (**CTRL-SPACE**) and select the **cells** option.

```
10 end comp
11
12 cells
   parameters
13   biasing
   start
   geometry
```

- Remove the **cells** block **TODO** comment
- With your cursor inside the **cells** block perform an autocompletion (**CTRL-SPACE**) and select **multiregion - spherical**
- This inserts a default multiregion with placeholder values for **mixture** and **radii**

```
11 read celldata
12
13 infhommed - basic
   lattice  - squarepitch
14 lattice  - triangpitch
   lattice  - sphsquarep
15 lattice  - sphtriangp
   lattice  - symmslabcell
16 lattice  - asquarepitch
   lattice  - atriangpitch
17 lattice  - asphsquarep
   lattice  - asphtriangp
18 lattice  - asymslabcell
   multiregion - slab
19 multiregion - cylindrical
   multiregion - spherical
20 multiregion - buckledslab
   multiregion - buckledcyl
```

Cross-Section Processing | MultiRegion Cell Cont'd

- The default Multiregion has 3 mixture-radii pairs but we only need 1 pair

```
12 multiregion spherical right_bdy=vacuum end
13           1 0.0 2 0.0 3 0.0 end zone
14
```

line:12 column:1 - Validation Error: multiregion children "radius" are not strictly increasing at line:13 column:30
line:12 column:1 - Validation Error: multiregion children "radius" are not strictly increasing at line:13 column:36
line:13 column:28 - Validation Error: mixture value "2" does not exist in set: [../../comps/stdcomp/mixture
../../comps/soln/mixture
../../comps/stdcomp/alias
../../comps/soln/alias
../../comps/atomcomp/mixture
../../comps/atomcomp/alias
../../comps/wtptcomp/mixture
../../comps/wtptcomp/alias
../../comps/arbcomp/mixture
../../comps/arbcomp/alias
../../comps/solution/mix/mixture
../../comps/solution/mix/alias]
line:13 column:34 - Validation Error: mixture value "3" does not exist in set: [../../comps/stdcomp/mixture
../../comps/soln/mixture
../../comps/stdcomp/alias
../../comps/soln/alias
../../comps/atomcomp/mixture
../../comps/atomcomp/alias
../../comps/wtptcomp/mixture
../../comps/wtptcomp/alias
../../comps/arbcomp/mixture
../../comps/arbcomp/alias
../../comps/solution/mix/mixture
../../comps/solution/mix/alias]

- Remove Mixture 2 and 3

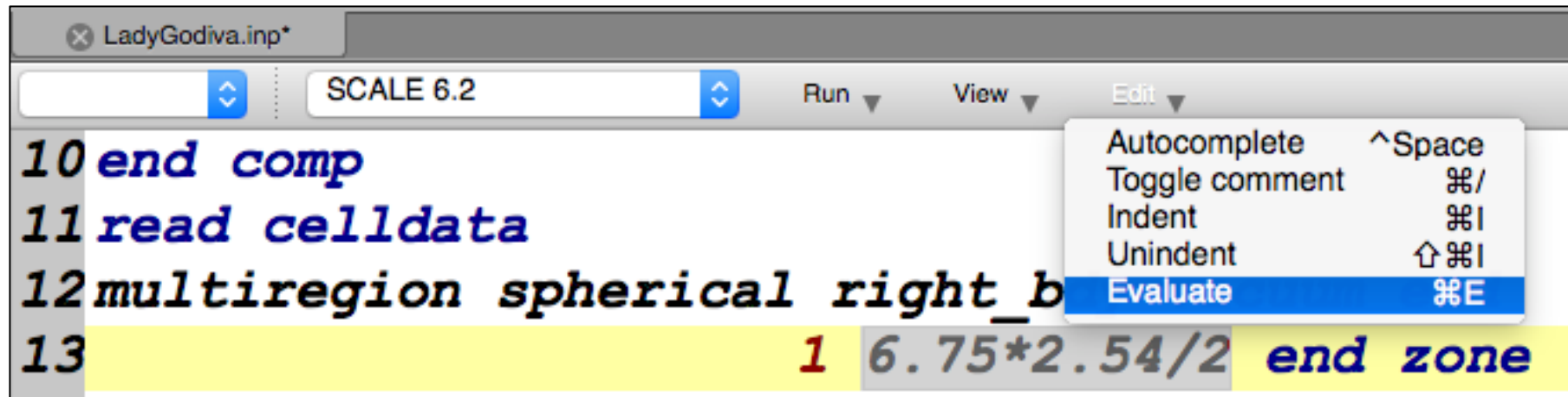
```
12 multiregion spherical right_bdy=vacuum end
13           1 0.0 end zone
```

Cross-Section Processing | MultiRegion Cell Cont'd

- SCALE users **centimeters**, not inches. There are **2.54 cm** per **in**
- Given the **diameter** of ~**6.75 in**, update the **radius** field to be **6.75 in * 2.54 cm / in / 2 (6.75 * 2.54 / 2)** and select the equation

```
12 multiregion spherical right_bdy=vacuum end
13 1 6.75*2.54/2 end zone
```

- Click the **Edit > Evaluate** button



- Observe the equation evaluate to the **radius** in **cm**

Cross-Section Processing | MultiRegion Cell Review

- Note the **uranium** mixture **1** at **90 wt%** ^{235}U with **density** slightly below **19 g/cc**
- Note the **spherical multiregion** cell processing
 - with **vacuum** (default) **right boundary** condition
 - and **uranium** mixture **1** with **radius** of **8.5725 cm** (or ~6.75 in diameter)

```
5 read comp
6 uranium 1 den=18.950000 1.0 293.0
7          92238 10.0
8          92235 90.0 end
9
10 end comp
11 read celldata
12 multiregion spherical right_bdy=vacuum end
13          1 8.5725 end zone
14 end celldata
```


Monte Carlo Parameters

- CSAS6 uses the KENO VI Monte Carlo transport code which has a **parameter** that controls the **number of particles per generation**
- With your cursor after **end cell** and before **read geometry** perform an autocompletion (CTRL-SPACE) and select the **parameters** option
- Remove the **TODO** comment
- Perform autocompletion (CTRL-SPACE) and find and select the **number of particles per generation** parameter

```
14 end celldata
15
16 parameters
17 biasing
   start
   arrays
   geometry
```

```
15 read parameters
16
17 rnd          - random number
18 tme          - execution time (min)
19 tba          - batch time (min)
20 wta          - average weight
21 wth          - wt. for splitting
22 wtl          - russian roulette wt.
23 sig          - deviation limit
24 msh          - size of flux mesh
25 ttl          - ce temperature tol.
26 dbh          - upper dbrc energy cutoff
27 dbl          - lower dbrc energy cutoff
28 gen          - no. of generations
29 npg          - no. per generation
30 nsk          - generations skipped
31 res          - gens. between restart
```

Monte Carlo Parameters

- The default **NPG** is **1000**
- Update **NPG** to be **10000**

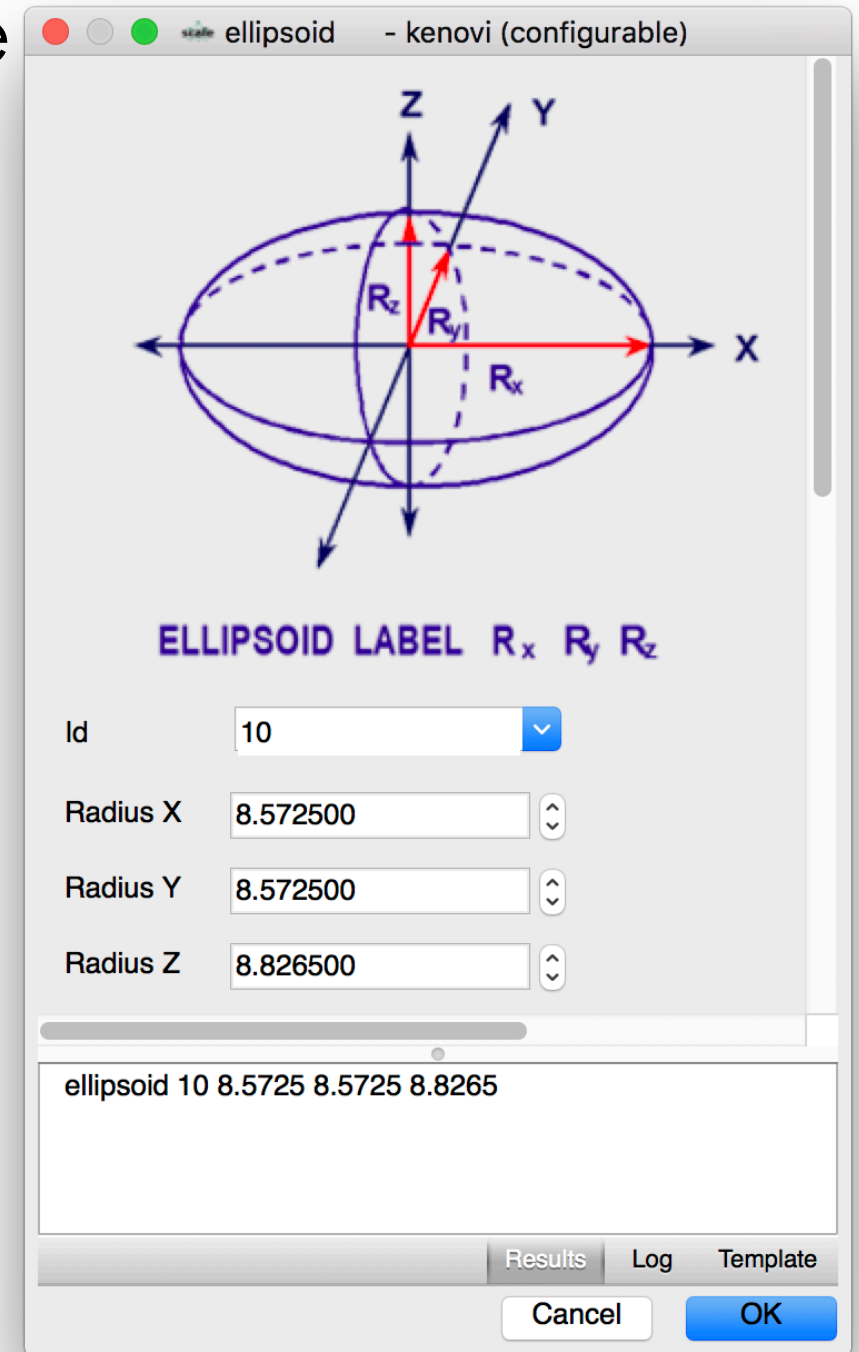
```
15 read parameters
16 npg=10000
```

Lady Godiva | Geometry Simplified

- CSAS6 geometry models are composed of bounded regions of space called a **Unit**
- The entire geometry model is encompassed by the **Global Unit**, which is provided by default in the CSAS6 autocomplete option
- Each **Unit** must have a **Boundary** record that lists the geometry surface/volume that bound the unit of space
- For Lady Godiva you need a 'slightly elongated sphere' or **ellipsoid** with **radius** of **~6.75 in** and a **15/16 in radius cylindrical** channel
- For the sake of simplicity the model will be encompassed by a box aka **cuboid**

Lady Godiva | Slightly Elongated Sphere

- Delete the geometry comment
' **TODO: define global unit here**
- Perform an autocompletion (CTRL-SPACE) and select **ellipsoid – kenovi (configurable)**
- Enter an **Id** of **10**
- Enter **Radius X** and **Y** of **8.5725 cm**
(~6.75 in)
- Enter **Radius Z** of 'slightly elongated'
8.8265 cm (~6.95 in)
- Click **OK**



Lady Godiva | Cylindrical Channel

- Perform an autocompletion (CTRL-SPACE) and select **xcylinder**

```
24 ellipsoid 10 8.5725 8.5725 8.8265
25 xcylinder 1 1.0 1.0 -1.0
26
```

- Update the **radius** (dimensions/r) to be **15/16*2.54**

```
25 xcylinder 1 15/16*2.54 1.0 -1.0
```

- **Evaluate** the expression to convert to **centimeters**

```
25 xcylinder 1 2.38125 1.0 -1.0
```

- Update **xtop** and **xbottom** (dimensions/xt and xb) to **8.5725** (~6.75 in)

```
25 xcylinder 1 2.38125 8.5725 -8.5725
```

- Update **Id** to be **20**

```
25 xcylinder 20 2.38125 8.5725 -8.5725
```

Lady Godiva | Problem Extents

- With your cursor on the next empty line perform an autocompletion (CTRL-SPACE) and select **cuboid**

```
25  xcylinder 20 2.38125 8.5725 -8.5725
26  cuboid 1 1.0 -1.0 1.0 -1.0 1.0 -1.0
27
```

- Update the **ld** to be **30**

```
26  cuboid 30 1.0 -1.0 1.0 -1.0 1.0 -1.0
```

- Update the **plus_x/y/z** and **minus_x/y/z** dimensions to be **9** and **-9**

```
26  cuboid 30 9.0 -9.0 9.0 -9.0 9.0 -9.0
```

- Pro tip:** use **6p9.0** to repeat **9.0** 6 times with **alternating sign**

```
26  cuboid 30 6p9.0
```

Lady Godiva | Uranium Ellipsoid

- With the geometry regions specified we must specify the material that makes up the geometry. This is accomplished using the **media** record
- With your cursor on the next empty line perform an autocompletion (CTRL-SPACE) and select **media – kenovi (configurable)**
- Note the default **Material** is **1** which is the **uranium mixture**
- Click **Add row** to insert a new row into the **Regions** table
- The **Regions** table **State** column indicates the material is **inside** or **outside** of the listed region

The screenshot shows a software window titled "media - kenovi (configurable)". At the top, there is a "Material" dropdown menu set to "1". Below it is a "Regions" table with three columns: "+/-", "Id", and "State". The table contains one row with the values "1", "1", and "inside". Below the table is an "Add row" button. At the bottom of the window, there is a text area containing the text "media 1 1 1". The bottom right corner has buttons for "Results", "Log", "Template", "Cancel", and "OK".

	+/-	Id	State
1	<input type="button" value="+"/> <input type="button" value="-"/>	1	inside

media 1 1 1

Lady Godiva | Uranium Ellipsoid cont'd

- Update the **Id** column value to the **ellipsoid Id** of **10**
- Click **Add row** to insert a **second** row into the **Regions** table
- Update the **Id** column value to the **xcylinder Id** of **20** and update the **State** column value to be **outside**
- This indicates that mixture **10** (aka **uranium**) is to be **inside** the **ellipsoid** but **outside** the **xcylinder**
 - Note the negative sign indicates **outside**
- Click **OK**

The screenshot shows a software window titled "media - kenovi (configurable)". It features a "Material" dropdown set to "1" and a "Regions" table. The table has columns for a row index, a "+/-" sign, an "Id", and a "State". Row 1 has Id 10 and State "inside". Row 2 has Id 20 and State "outside". Below the table is an "Add row" button. At the bottom, there is a text area containing "media 1 1 10 -20" and a set of buttons: "Results", "Log", "Template", "Cancel", and "OK".

	+/-	Id	State
1	+ -	10	inside
2	+ -	20	outside

media 1 1 10 -20

Lady Godiva | Void Channel

- With your cursor on the next empty line perform an autocompletion (CTRL-SPACE) and select **media**
- Update the **mixture** to **0** (aka void)
- Note the **Validation** panel listing the default **region** of **1** not existing
- Click the **Validation** message to navigate to the incorrect **region**
- Perform autocompletion (CTRL-SPACE) to list available **region**
- Select the **xcylinder** id of **20**

```
28      media 1 1 1
line:28 column:13 - Validation Error: region value "1" does not exist in set: [ ../../cone/id
../../cuboid/id
../../cylinder/id
../../dodecahedron/id
../../ecylinder/id
../../ellipsoid/id
../../sphere/id ]
Line: 28, Col: 13 /csas6/geometry/global_unit/media/rdv/region
```

```
25   xcylinder 20 2.38125 8.5725 -8.5725
26   cuboid 30 6p9.0
27   media 1 1 10 -20
28   media 0 1 1
```

line:28 column:13 - Validation Error: reference "1" does not exist in set: [../../cone/id
 ../../cuboid/id
 ../../cylinder/id]

Lady Godiva | Void Extents

- With your cursor on the next empty line perform an autocompletion (CTRL-SPACE) and select **media – kenovi (configurable)**
- Update the **Material** to be **void (aka 0)**
- Click **Add row** 3 times
- Specify **inside** of **cuboid 30** (extents)
- Specify **outside** of **xcylinder 20** (channel)
- Specify **outside** of **ellipsoid 10** ('slightly elongated sphere')
- Again, note **outside** is indicated with **negative sign** on region **id**

The screenshot shows a window titled "media - kenovi (configurable)". It has a "Material" dropdown set to "0". Below it is a "Regions" table with three rows. Each row has a region number, a sign (+/-) with '+' and '-' buttons, a region ID, and a state (inside/outside) with a dropdown arrow. Below the table is an "Add row" button. At the bottom, a text area contains the command "media 0 1 30 -20 -10". The bottom right has "Results", "Log", and "Template" tabs, and "Cancel" and "OK" buttons.

	+/-	Id	State
1	<input type="button" value="+"/> <input type="button" value="-"/>	30	inside
2	<input type="button" value="+"/> <input type="button" value="-"/>	20	outside
3	<input type="button" value="+"/> <input type="button" value="-"/>	10	outside

Add row

media 0 1 30 -20 -10

Results Log Template

Cancel OK

Lady Godiva | Boundary

- Each **Unit** of space in KENOVI requires a **boundary** to be specified
- A default **boundary** record is included with the **csas6** autocompletion option so you only need to update the **region** being referenced
- Note the **Validation** panel highlights this todo.
- Click the validation error message to goto the incorrect **region**
- Perform autocompletion (CTRL-SPACE) and select the **cuboid 30** (extents)

```
29  media 0 1 30 -20 -10
30  boundary 1
```

line:30 column:12 - Validation Error: region value "1" does not exist in set: [../../cone/id
../../cuboid/id
../../cylinder/id
../../dodecahedron/id
../../ecylinder/id
../../ellipsoid/id

Line: 30, Col: 12 /csas6/geometry/global_unit/boundary/rdv/region Validation

```
26  cuboid 30 6p9.0
27  media 1 1 10 -20
28  media 1 1 20
29  media 0 1 30 -20 -10
30  boundary 1
```

line:30 column:12 - Validation Error: region value "1" does not exist in s

10
20
30

Lady Godiva | Geometry Review

- **Ellipsoid** 'slightly elongated sphere'

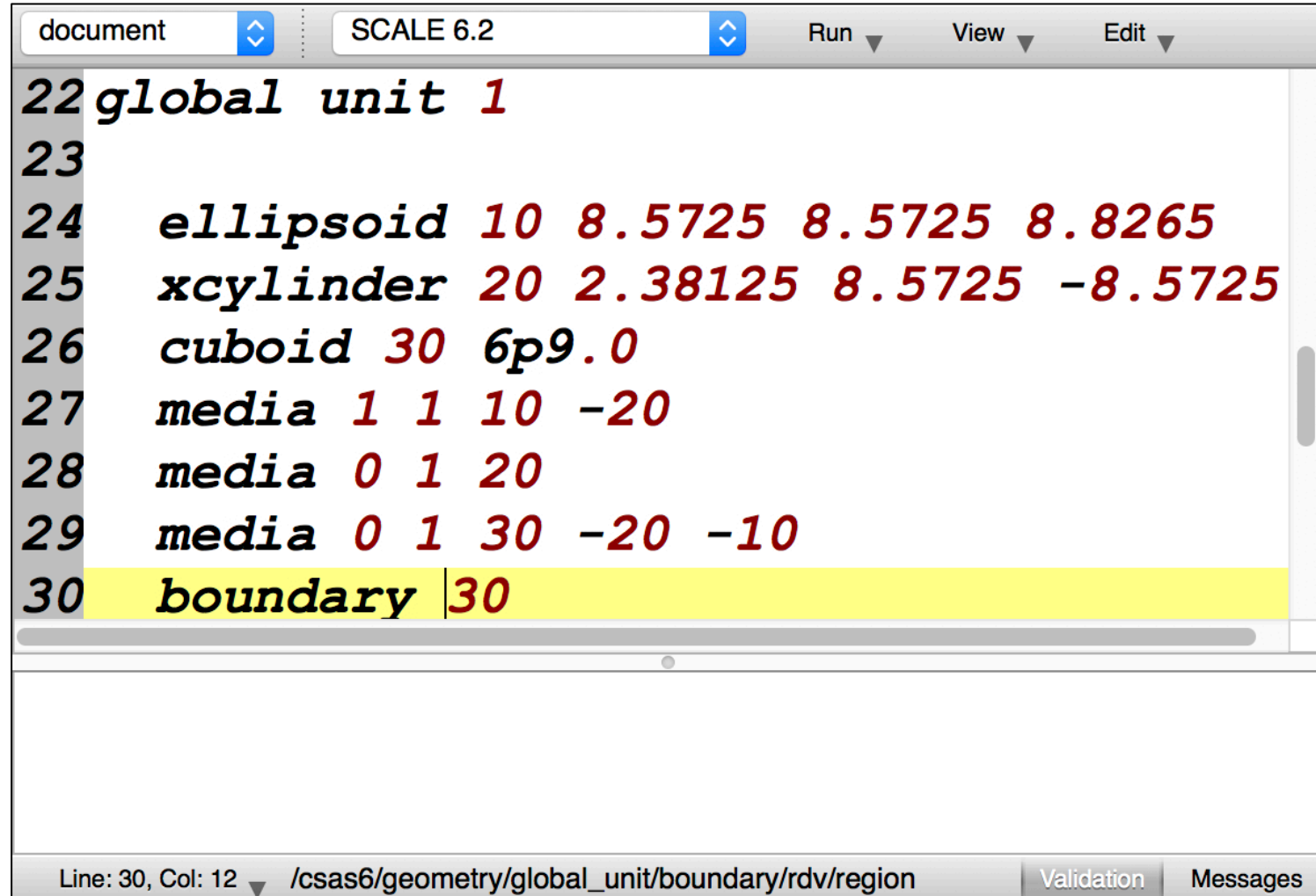
- **Xcylinder** channel

- **Cuboid** problem extents

- **Media** indicate specific mixture is **inside** and **outside** (-) of specific geometry regions

- **Boundary** encapsulates the **Unit** of space

- Note no validation errors, but because geometry specifications are complex additional checks are required in the form of **visual verification**

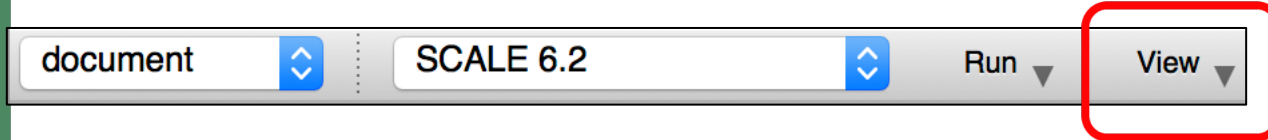


```
document SCALE 6.2 Run View Edit
22 global unit 1
23
24 ellipsoid 10 8.5725 8.5725 8.8265
25 xcylinder 20 2.38125 8.5725 -8.5725
26 cuboid 30 6p9.0
27 media 1 1 10 -20
28 media 0 1 20
29 media 0 1 30 -20 -10
30 boundary 30
```

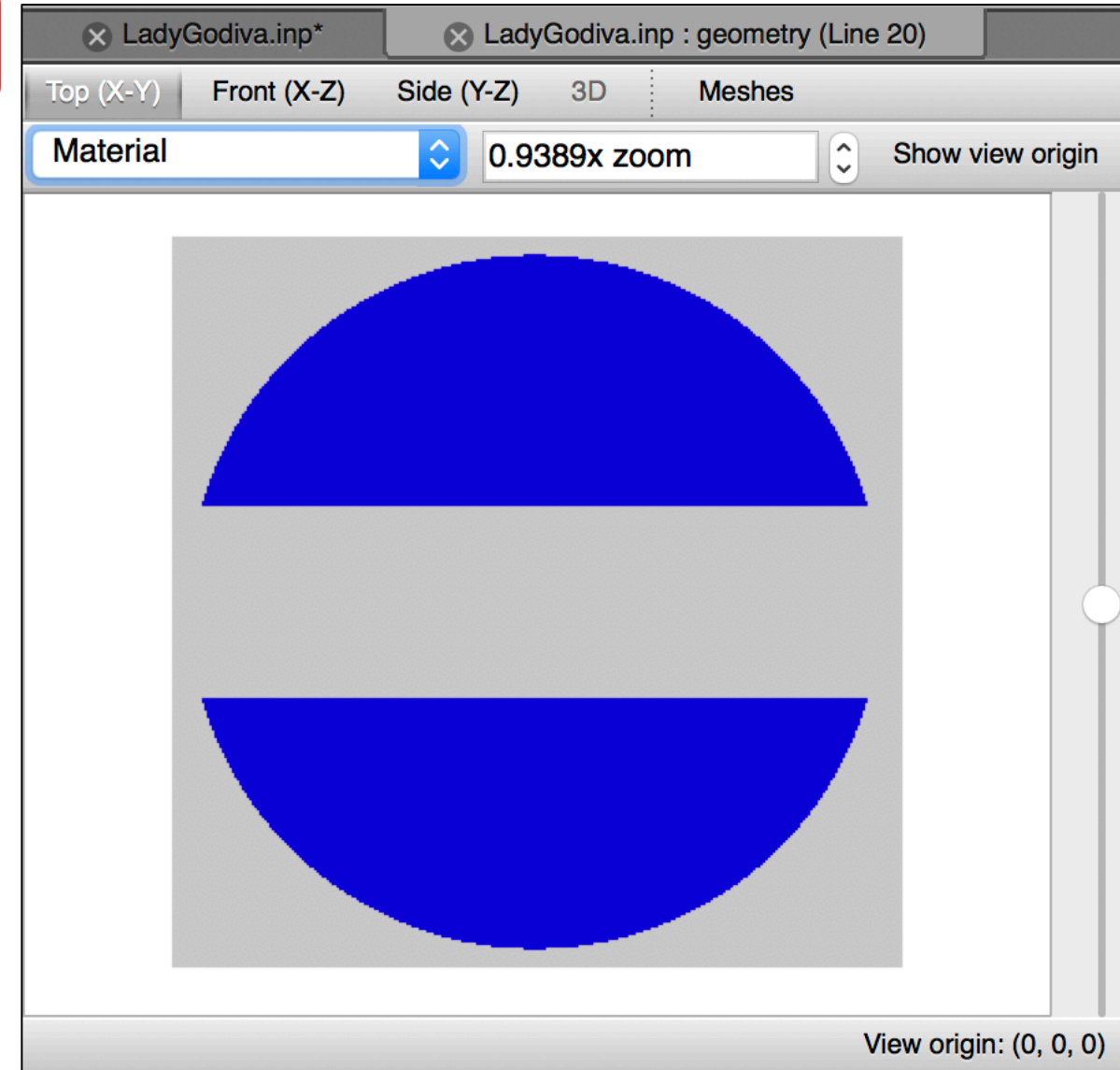
Line: 30, Col: 12 /csas6/geometry/global_unit/boundary/rdv/region Validation Messages

Lady Godiva | Geometry Visualization

- Click the **view** button to visualize the geometry

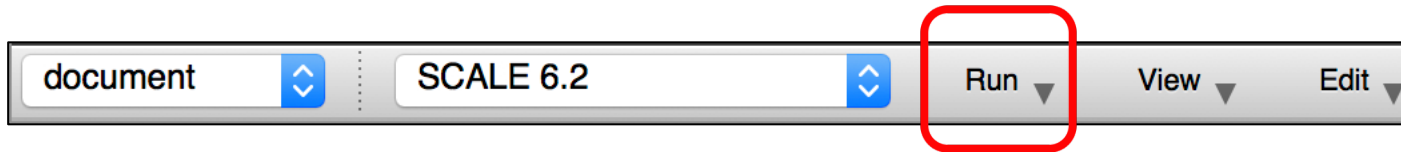


- Additional details related to geometry visualization are listed in the Advanced User Interface Capabilities tutorial
- Close the **geometry tab**



Lady Godiva | Input Execution

- In the LadyGodiva.inp text editor tab click the **Run** button



- Note the **Messages** panel indicate unread messages. Click the **Messages** panel
- Observe input run to completion without error

```
Mon Jun 22 08:50:09 2020
497
498      203      8.63771E-01      8.61946E-01      4.95248E-04      6.05220E+00
499
500
501 lady godiva
502      *****      final results table      *****
503 best estimate system k-eff 0.86167 + or - 0.00049
504
505 Energy of average lethargy of Fission (eV) 8.52735E+05 + or - 8.0274
506 k-effective satisfies the chi**2 test for normality at the 95 % level
507
508 Scale job /Users/raq/OneDrive - Oak Ridge National Laboratory/Document
509 Output is stored in /Users/raq/OneDrive - Oak Ridge National Laborato
510
511 Process finished with 0 return code; ran in 31 secs, finished at Mon
```

Line: 23, Col: 1 /csas6/geometry/global_unit Validation Messages

Lady Godiva | Summary

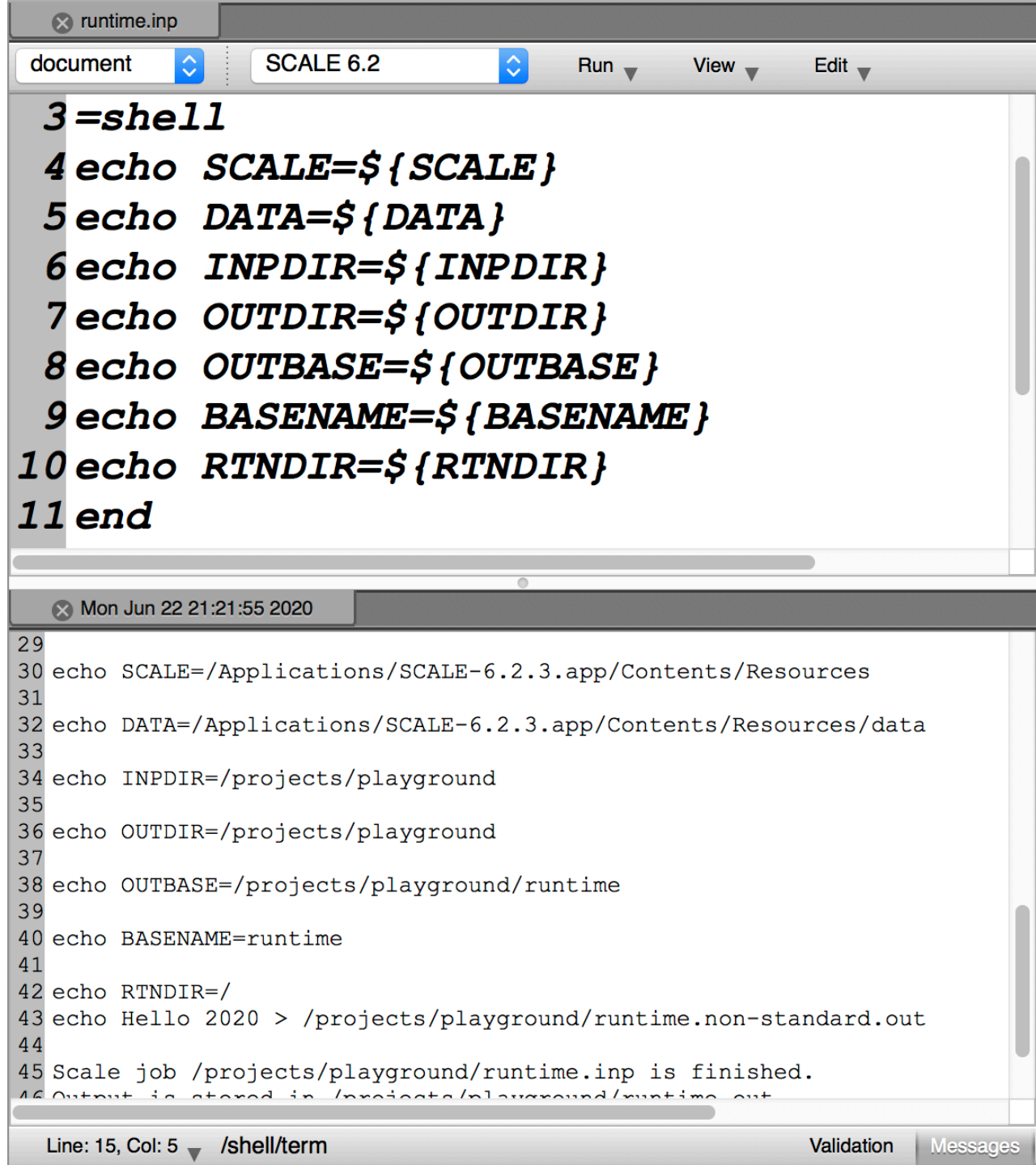
- You are now practiced using the Fulcrum text editor's **Cursor Context** to assist you in identifying and confidently editing SCALE input fields
- You are now practiced in performing input **autocompletion** including interactive field substitution and the use of **Configurable** autocompletion forms
- You are now practiced in using the input **Validation** panel and the automatic **input checking** to quickly address outstanding issues/todos
- You are now practiced in using the integrated expression **evaluation** capability
- You have successfully created a functioning criticality safety analysis sequence input using KENO VI and executed the input
- **Questions?**
- Now, let's look at better understanding the SCALE input execution
 - Also known as the SCALE Runtime Environment (scalerte)
- Click **File > Close all** to prepare for the next exercise

SCALE Runtime | Best Practices & Good to Knows

- The SCALE Runtime (SCALERTE) has been developed to assist users in executing jobs and retrieving results
- **BUT**, it can only assist you if you know how to best use it
- This next exercise is to assist you in understanding and leveraging the SCALERTE capabilities and includes **best practices** involving the following runtime variables
 - **Input directory** (INPDIR),
 - **Output directory** (OUTDIR),
 - **Output base path** (OUTBASE),
 - **Return directory** (RTNDIR),
 - **file name without extension** (BASENAME),
 - **path to SCALE** (SCALE), and
 - **path to SCALE data** (DATA)

SCALE Runtime | Basics

- Open the Frequent_Fulcrum_Functions/**runtime.inp** problem file
- Click the text editor's **Run** button to launch the job
- Each job is run in a working directory with access to the following runtime variables
 - **SCALE** path to the SCALE install
 - **DATA** path to the SCALE data directory
 - **INPDIR** path to directory containing the input file
 - **OUTDIR** path to directory that will contain the output file(s)
 - **OUTBASE** path to the output file excluding the extension
 - **BASENAME** name of the input excluding the extension
 - **RTNDIR** that of which we do not speak...



The screenshot shows a text editor window titled 'runtime.inp' with a menu bar (document, SCALE 6.2, Run, View, Edit). The editor contains a shell script with 11 lines. Below the editor is a terminal window showing the execution output of the script, with line numbers 29 through 46. The terminal output shows the values of the runtime variables and the completion of the job.

```
3=shell
4 echo SCALE=${SCALE}
5 echo DATA=${DATA}
6 echo INPDIR=${INPDIR}
7 echo OUTDIR=${OUTDIR}
8 echo OUTBASE=${OUTBASE}
9 echo BASENAME=${BASENAME}
10 echo RTNDIR=${RTNDIR}
11 end
```

```
29
30 echo SCALE=/Applications/SCALE-6.2.3.app/Contents/Resources
31
32 echo DATA=/Applications/SCALE-6.2.3.app/Contents/Resources/data
33
34 echo INPDIR=/projects/playground
35
36 echo OUTDIR=/projects/playground
37
38 echo OUTBASE=/projects/playground/runtime
39
40 echo BASENAME=runtime
41
42 echo RTNDIR=/
43 echo Hello 2020 > /projects/playground/runtime.non-standard.out
44
45 Scale job /projects/playground/runtime.inp is finished.
46 Output is stored in /projects/playground/runtime_out
```

Line: 15, Col: 5 /shell/term Validation Messages

SCALE Runtime | Comments on Flexibility

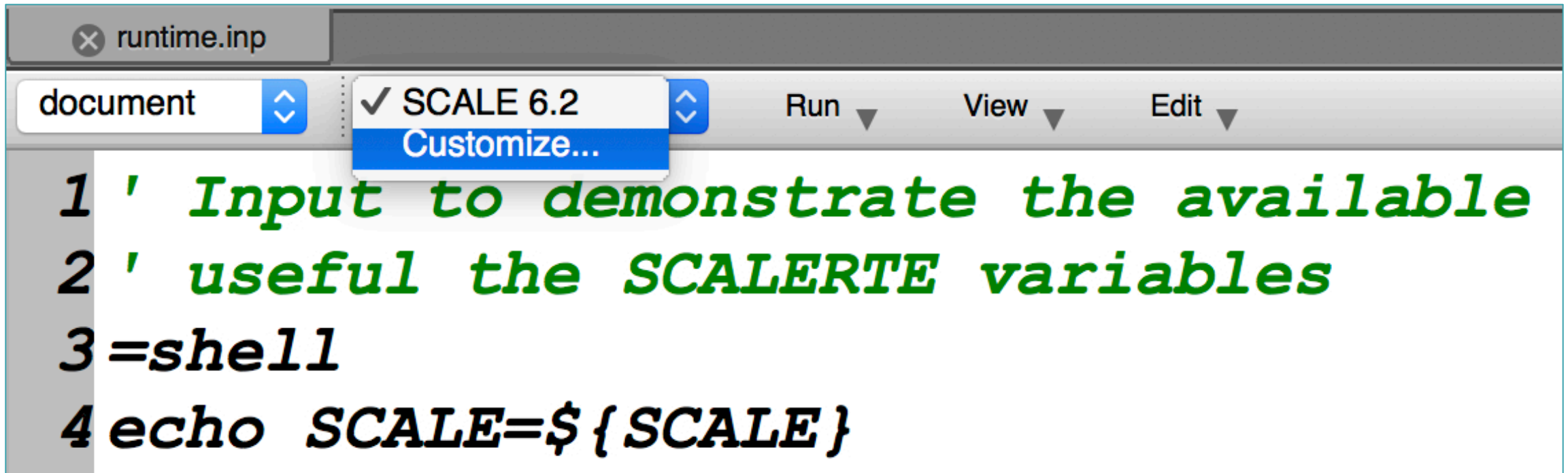
- When launching an input, the SCALERTE copies the input to a **working directory**
 - Good to know if providing custom data (E.g., cross section library)
 - Need to copy or link data into the working directory
 - Need to copy or link input-associated data (E.g., sensitivity data files, ORIGEN isotopics)
- When completing a job, the SCALERTE copies standard result data to the **output directory**
 - By default the **output directory** is the **input directory**
 - But a user can change this via **-o** options. E.g., **scalerte -o alternate_out_name...**
 - Good to know for copying non-standard result data back to the **output directory**
 - **OUTBASE** allows for post-sequence **shell** commands to return data to the **output** directory with a sensical name (e.g., **\${OUTBASE}.f71**, **\${OUTBASE}.macrolib**)
 - Good to know for write-protected **input directory**
 - The SCALERTE allows for redirecting **output** to a different filename and **directory**

SCALE Runtime | RTNDIR | Just Don't!

- **RTNDIR** is the directory to which the execution/terminal prompt will **return** upon completion of the job
- Always use **OUTDIR** or **OUTBASE**
- **Never use RTNDIR**
- **RTNDIR** has been an error perpetrated on you by the GeeWiz interface in part due to its inability to deal with multiple input files simultaneously
- Always always use **OUTDIR** or **OUTBASE**
- **Never ever use RTNDIR**
- When an arbitrary user executes your input, they can override the **output name**
 - Using **RTNDIR** disregards the user's request and can have unexpected results
- **Just don't use RTNDIR** Always use **OUTDIR** or **OUTBASE**

SCALE Runtime | Customized with Dated Output

- Click the **SCALE 6.2 > Customize...** menu item

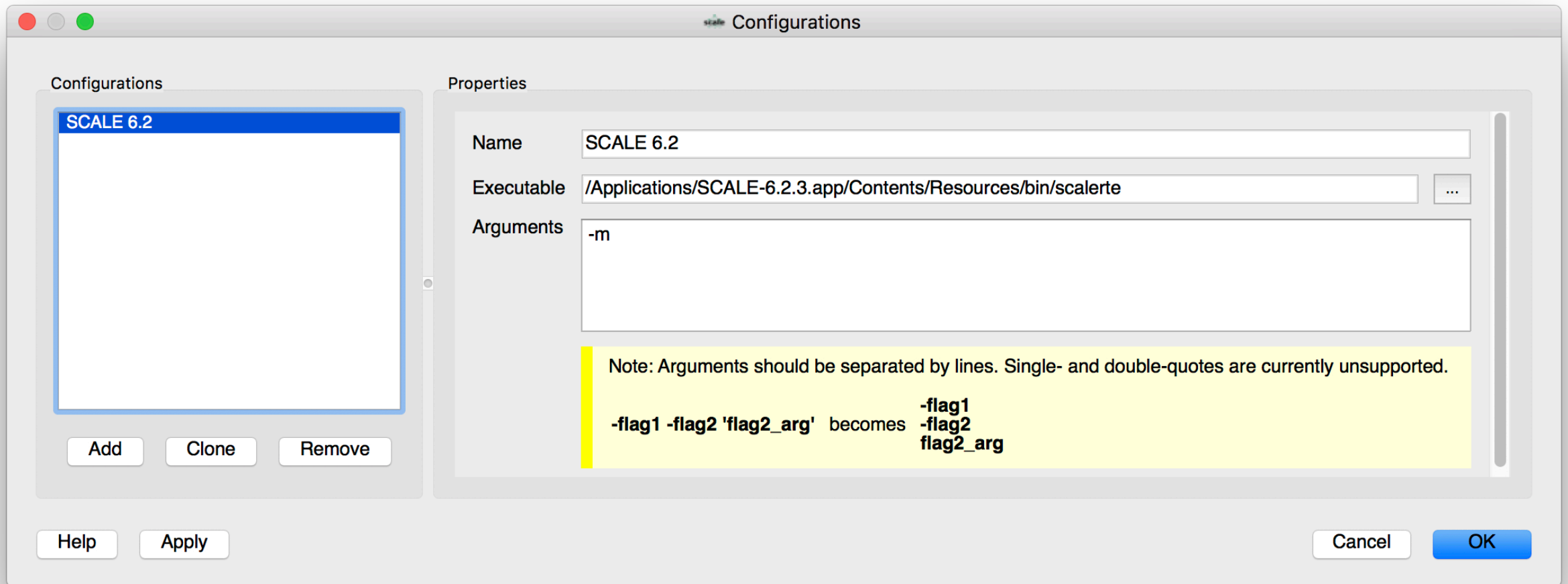


The screenshot shows a window titled 'runtime.inp' with a menu bar containing 'document', 'SCALE 6.2', 'Run', 'View', and 'Edit'. The 'SCALE 6.2' menu is open, showing a 'Customize...' option. The main text area contains the following code:

```
1 ' Input to demonstrate the available  
2 ' useful the SCALE RTE variables  
3 =shell  
4 echo SCALE=${SCALE}
```

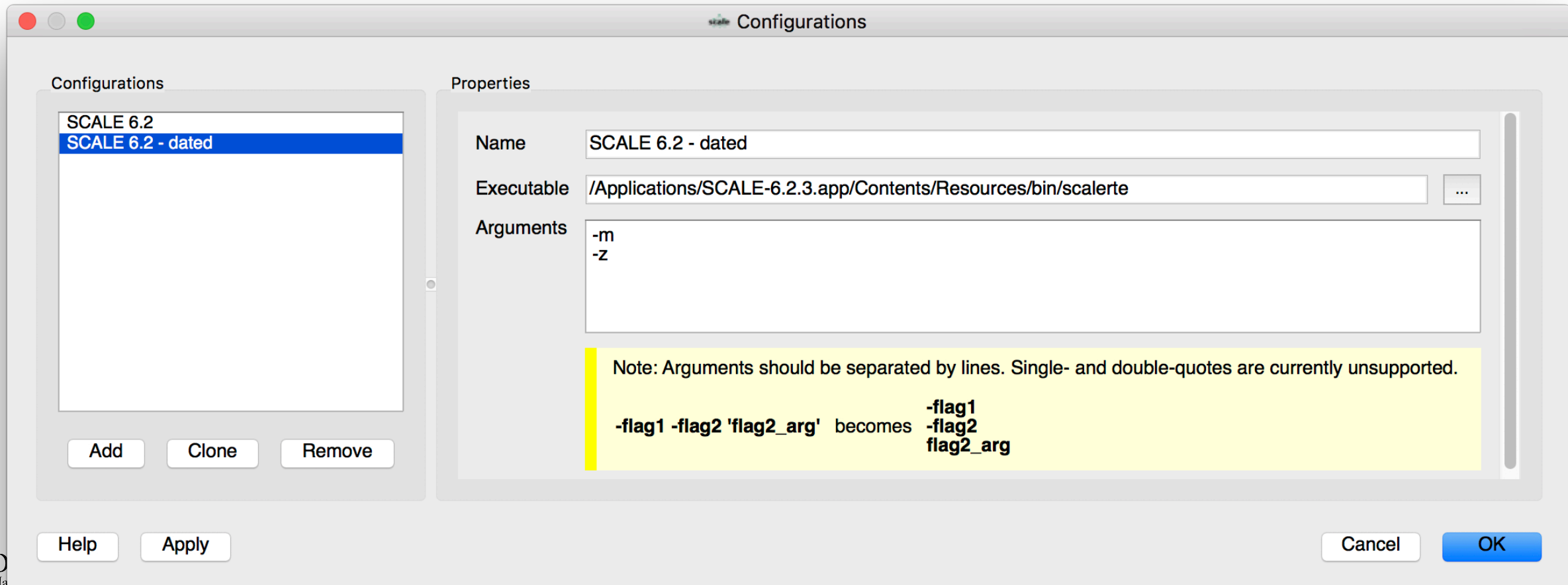
SCALE Runtime | Customized with Dated Output cont'd

- Click the **Clone** button to copy the current **Configuration** in preparation for adding a **dated variant**



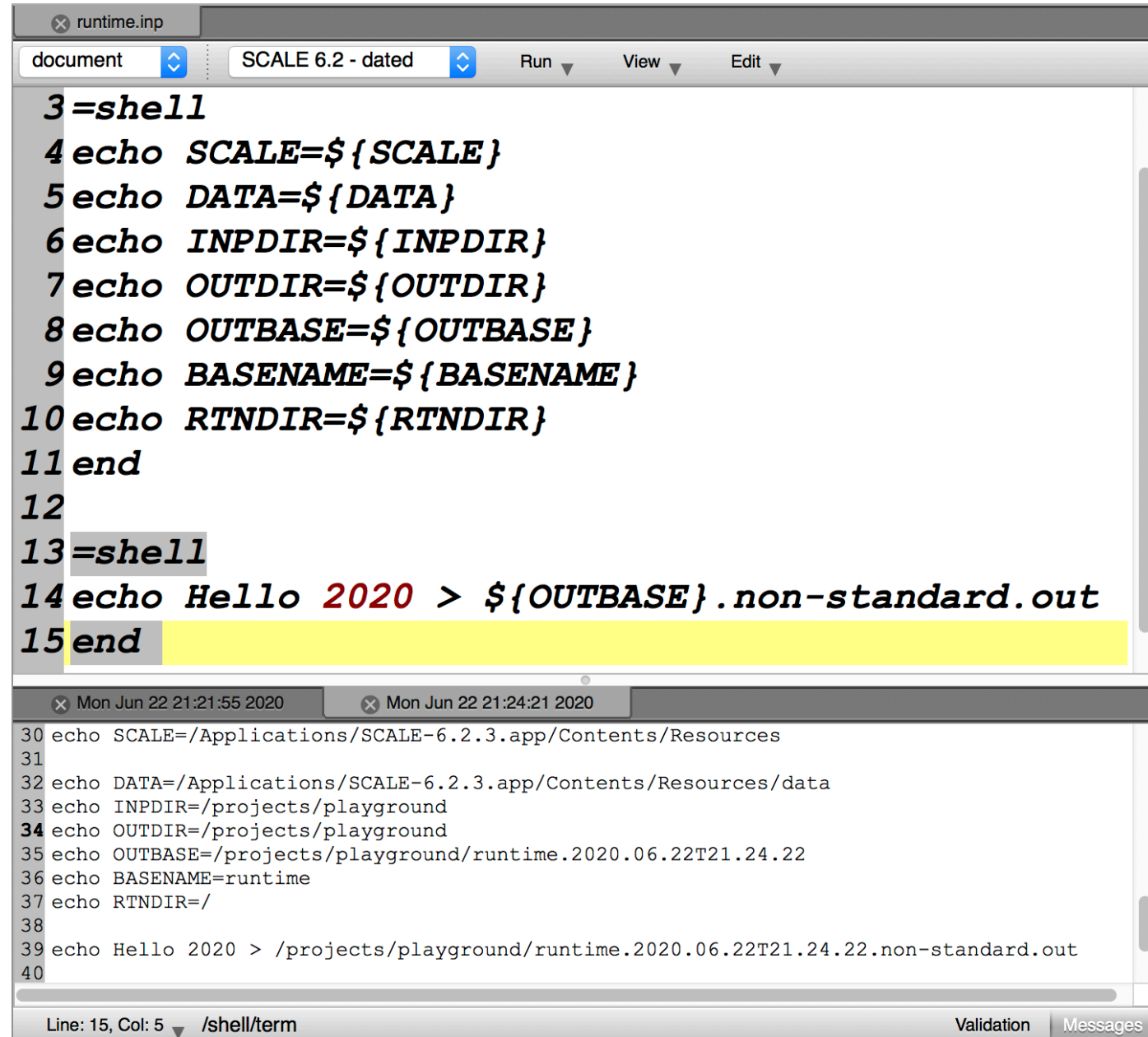
SCALE Runtime | Customized with Dated Output cont'd

- Update the **Name** to be **SCALE 6.2 - dated**
- Add **-z** option to the **Arguments** list to have **SCALERTE timestamp** each result set
- Click **Apply** and **Ok**



SCALE Runtime | Dated Output

- Select the new **SCALE 6.2 - dated**
- Click Text Editor's **Run** button
- Observe the **OUTBASE** now includes the **date** (YYYY.MM.DDThh.mm.ss)
- This serves as a reminder that any user can execute your input and change the **output** name and **directory**
 - Always use **OUTDIR** and **OUTBASE** for returning non-standard results



The screenshot shows a text editor window titled "runtime.inp" with a menu bar containing "document", "SCALE 6.2 - dated", "Run", "View", and "Edit". The editor contains a script with the following lines:

```
3=shell
4echo SCALE=${SCALE}
5echo DATA=${DATA}
6echo INPDIR=${INPDIR}
7echo OUTDIR=${OUTDIR}
8echo OUTBASE=${OUTBASE}
9echo BASENAME=${BASENAME}
10echo RTNDIR=${RTNDIR}
11end
12
13=shell
14echo Hello 2020 > ${OUTBASE}.non-standard.out
15end
```

Below the editor, there are two tabs showing the output of the script. The first tab, titled "Mon Jun 22 21:21:55 2020", shows the output of the first shell block. The second tab, titled "Mon Jun 22 21:24:21 2020", shows the output of the second shell block. The output of the second shell block is highlighted in yellow.

```
30 echo SCALE=/Applications/SCALE-6.2.3.app/Contents/Resources
31
32 echo DATA=/Applications/SCALE-6.2.3.app/Contents/Resources/data
33 echo INPDIR=/projects/playground
34 echo OUTDIR=/projects/playground
35 echo OUTBASE=/projects/playground/runtime.2020.06.22T21.24.22
36 echo BASENAME=runtime
37 echo RTNDIR=/
38
39 echo Hello 2020 > /projects/playground/runtime.2020.06.22T21.24.22.non-standard.out
40
```

The status bar at the bottom indicates "Line: 15, Col: 5" and the shell is "/shell/term". There are also "Validation" and "Messages" buttons on the right.

Frequent Fulcrum Function Conclusion

- You are now exposed and practiced in using Fulcrum's frequent functionalities for input editing
- Thank you for following along!
- Questions?