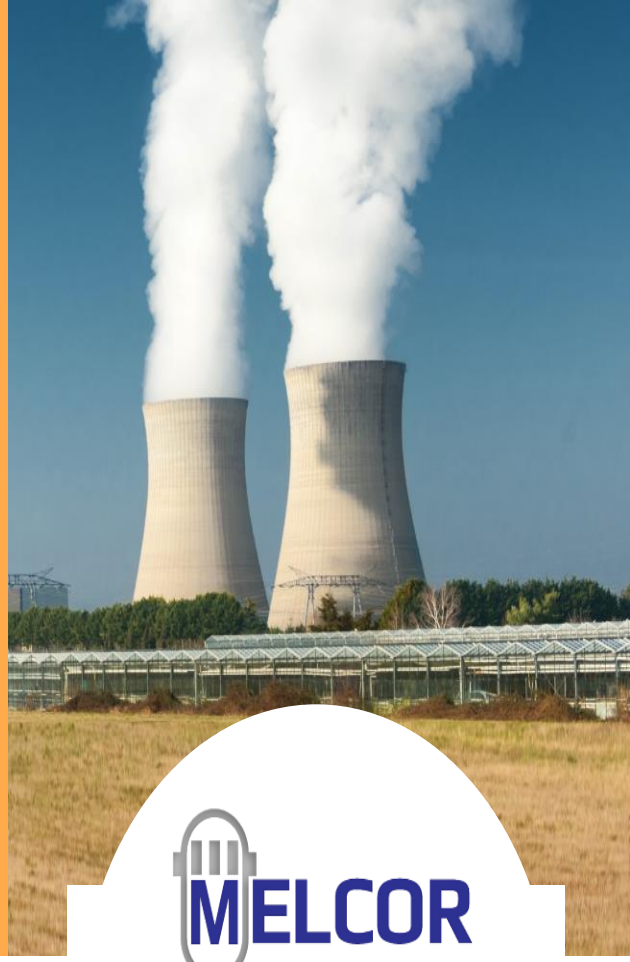
Sandia National Laboratories

Securing the future of Nuclear Energy



MELCOR

Recent SNAP Development

2024 European MELCOR Users' Group Meeting

April 15th-18th, 2024

Contributions from Don Ulshafer, ISL, Inc.

U.S.NRC

SAND2024-04212C

U.S. DEPARTMENT OF ENERGY NNSA

SNAP Overview

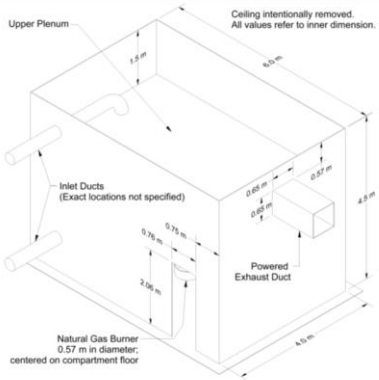
- SNAP Model Editor Introduction
  - Interface
  - GUI vs ASCII
- Post-Processing with SNAP
  - Animations
  - Indicators
- What's new in SNAP

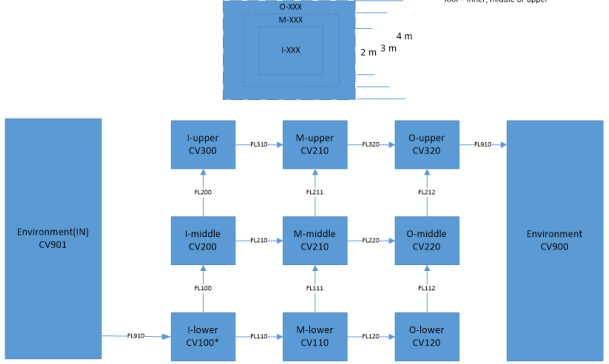
SNAP Model Editor

- Model Editor
  - Unique plug-ins handle specific model details for a given code (MELCOR, RELAP, etc.)
  - Stores both MELGEN and/or MELCOR user input
  - Can convert older MELGEN/MELCOR 1.86 input to 2.x
  - Import/Export ASCII files
  - Built-in Capabilities
    - Support for multiple files & subcomponents
    - Support for user comments
    - Tool/Tips & Helps
    - User manual guidance available
    - ASCII view of model
    - Job scheduler
    - Run jobs in interactive mode (linked to animation)
    - Access to numerics (python, etc.)
    - Integration with GIT
    - Integration with APTPLOT
    - Uncertainty analysis with DAKOTA plugin

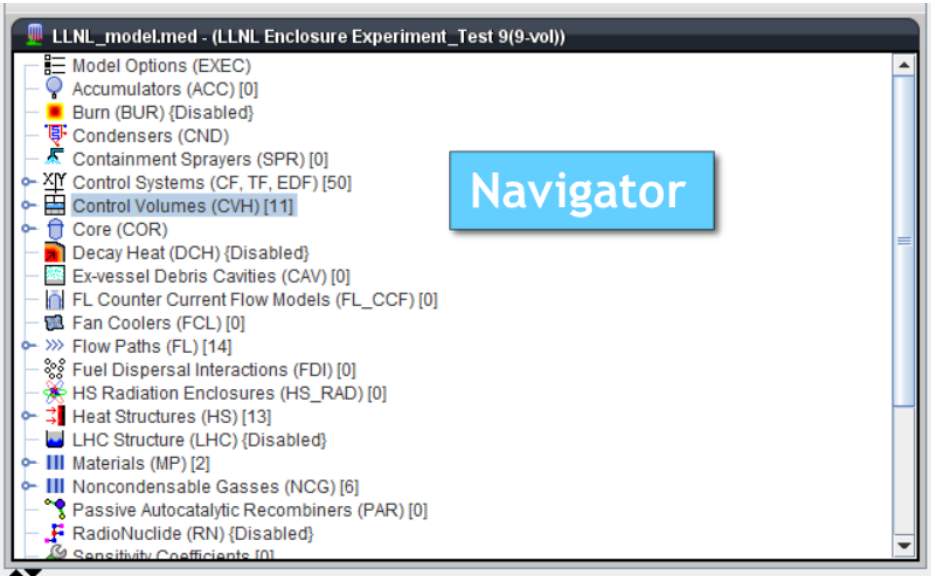
SNAP Model Editor utilized significantly in introductory MELCOR workshops to reduce time discussing input syntax

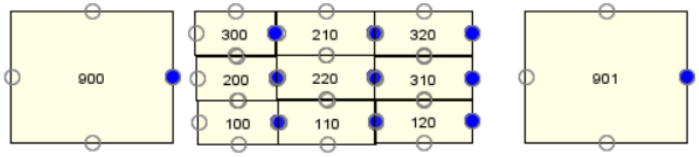
Model Editor Interface



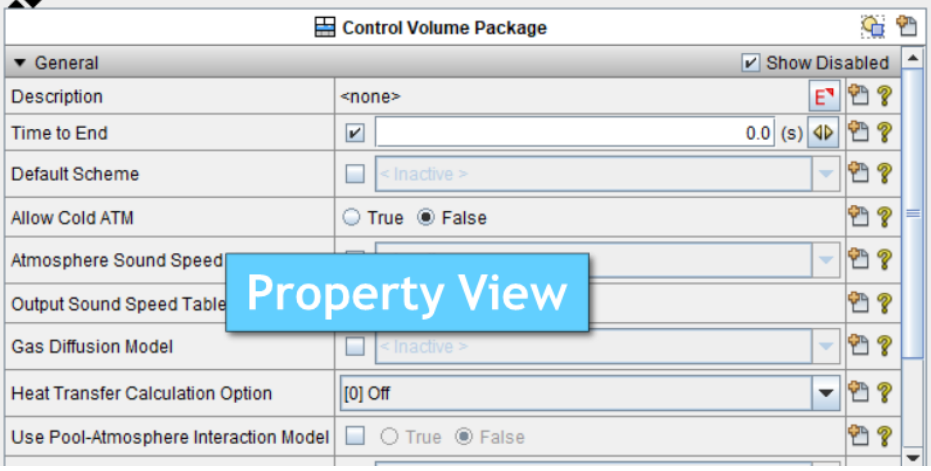


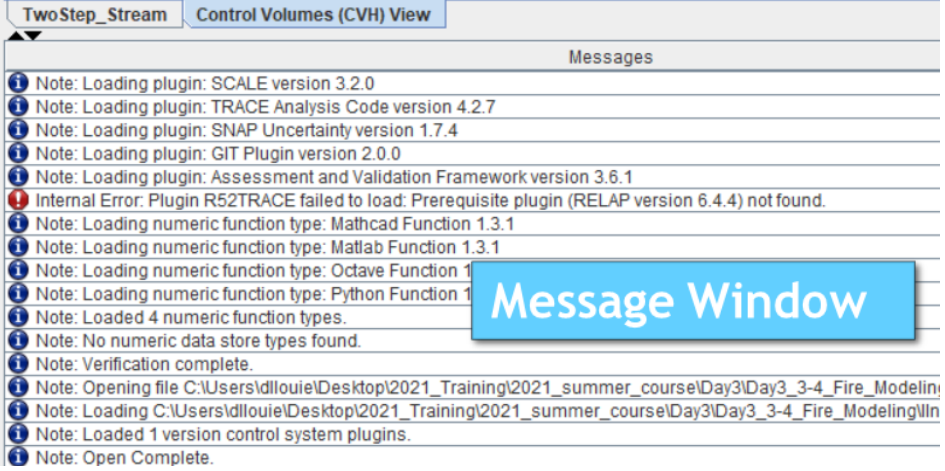
MELCOR





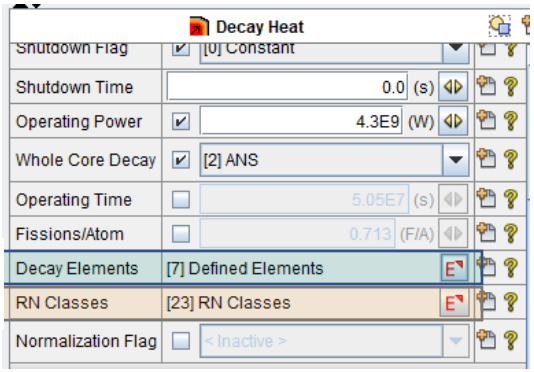
Views

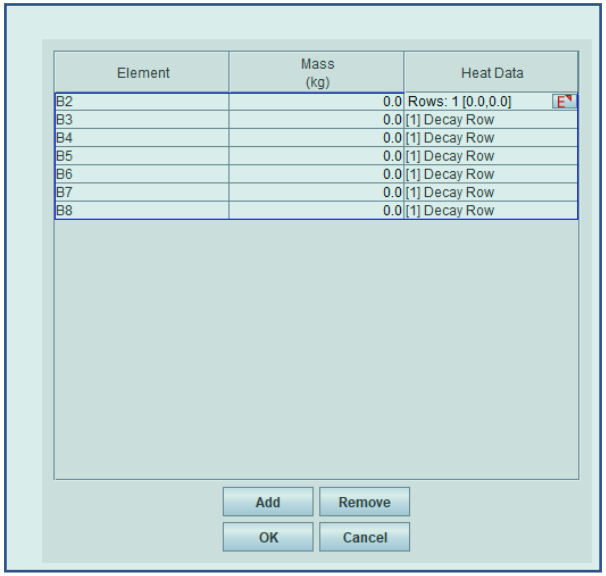


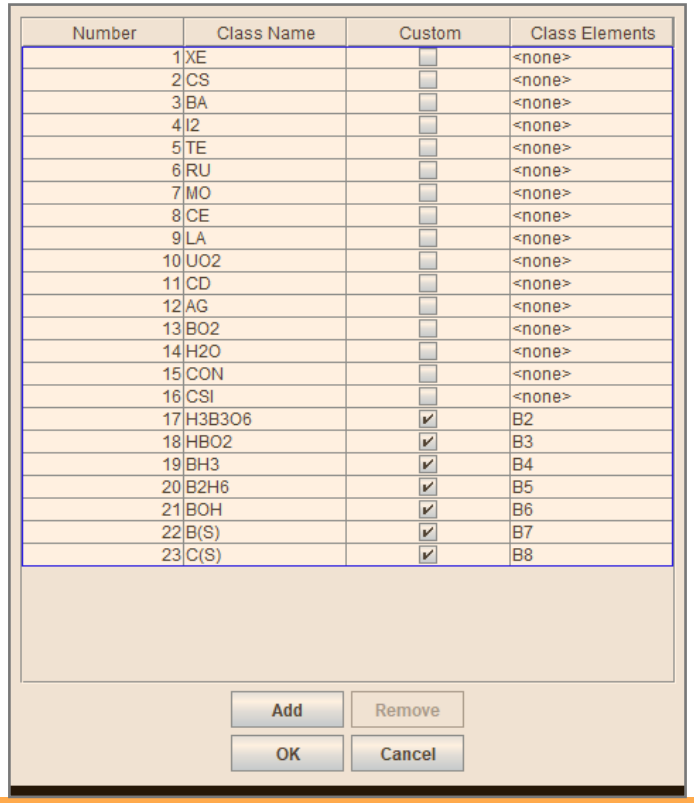


SNAP

RN Classes should be defined before Decay Elements





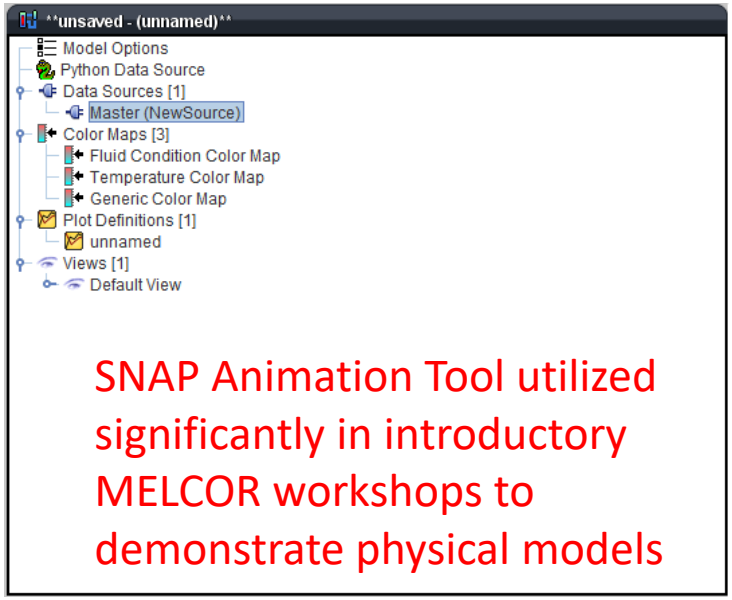


ASCII

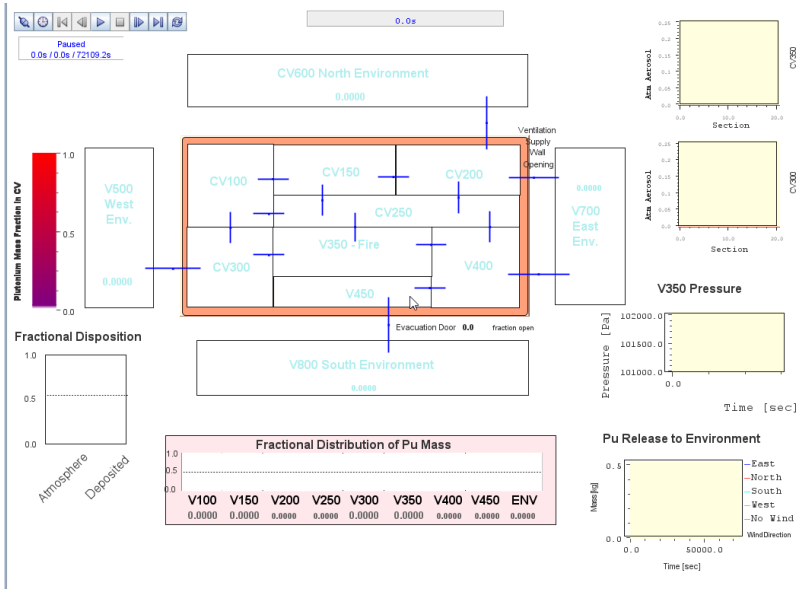
```
DCH_CL  'CS'   DEFAULT
DCH_CL  'BA'   DEFAULT
DCH_CL  'I2'   DEFAULT
DCH_CL  'TE'   DEFAULT
DCH_CL  'RU'   DEFAULT
DCH_CL  'MO'   DEFAULT
DCH_CL  'CE'   DEFAULT
DCH_CL  'LA'   DEFAULT
DCH_CL  'UO2'   DEFAULT
DCH_CL  'CD'   DEFAULT
DCH_CL  'AG'   DEFAULT
DCH_CL  'BO2'   DEFAULT
DCH_CL  'H2O'   DEFAULT
DCH_CL  'CON'   DEFAULT
DCH_CL  'CSI'   DEFAULT
DCH_CL  'H3B3O6'    USER    1 !n        clselm
                              1          'B2'
DCH_CL  'HBO2'    USER    1 !n        clselm
                              1          'B3'
DCH_CL   'BH3'    USER    1 !n        clselm
                              1          'B4'
DCH_CL  'B2H6'    USER    1 !n        clselm
                              1          'B5'
DCH_CL   'BOH'    USER    1 !n        clselm
                              1          'B6'
DCH_CL  'B(S)'    USER    1 !n        clselm
                              1          'B7'
DCH_CL  'C(S)'    USER    1 !n        clselm
                              1          'B8'
DCH_EL   'B2'    0.0    1 !n         time        dcheat
                              1          0.0         0.0
DCH_EL   'B3'    0.0    1 !n         time        dcheat
                              1          0.0         0.0
DCH_EL   'B4'    0.0    1 !n         time        dcheat
                              1          0.0         0.0
DCH_EL   'B5'    0.0    1 !n         time        dcheat
                              1          0.0         0.0
DCH_EL   'B6'    0.0    1 !n         time        dcheat
```

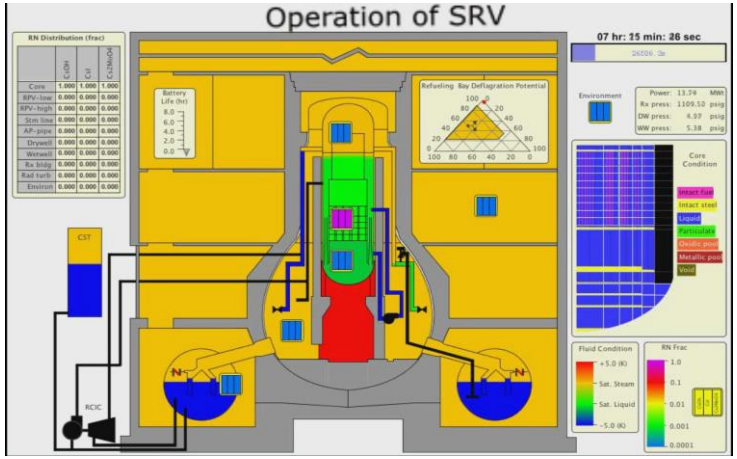
Post Processing with SNAP

- Animation Model is a separate model from the MELCOR model
  - File>New select Animation model
  - Data connection to the plotfile(s) must be established
  - Animations are displayed in View Port

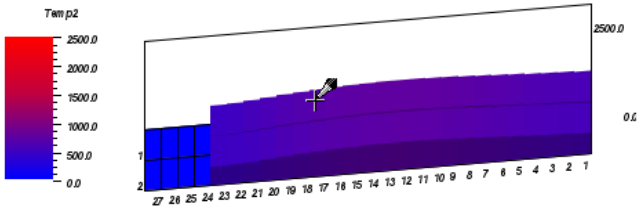


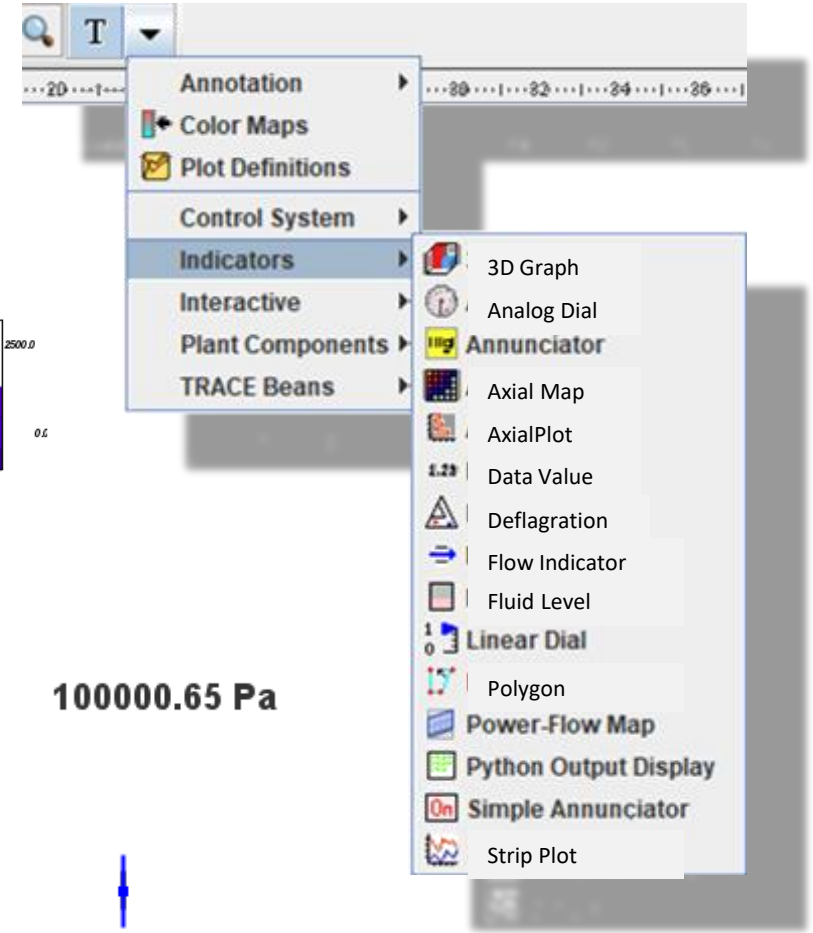
SNAP Animation Tool utilized significantly in introductory MELCOR workshops to demonstrate physical models

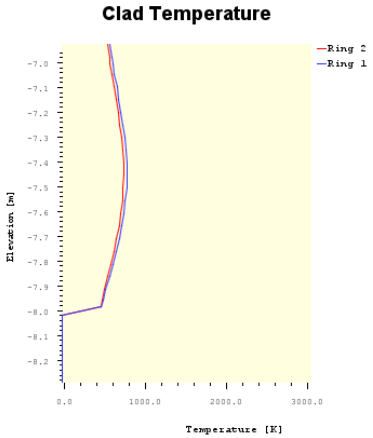




Indicators







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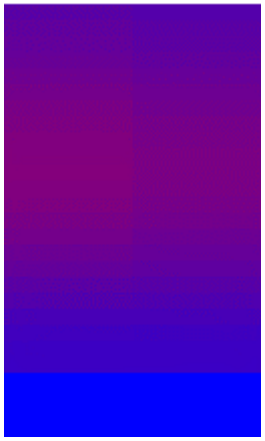
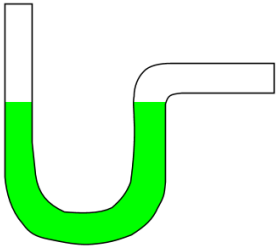
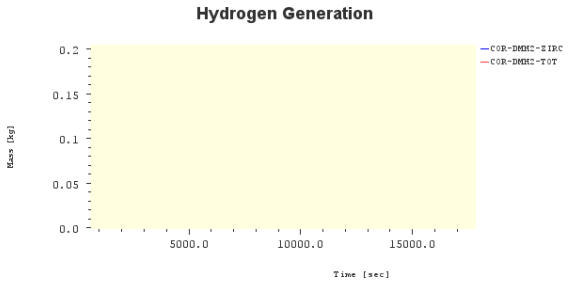
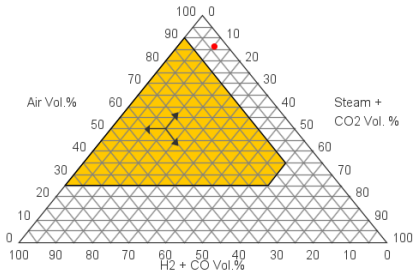




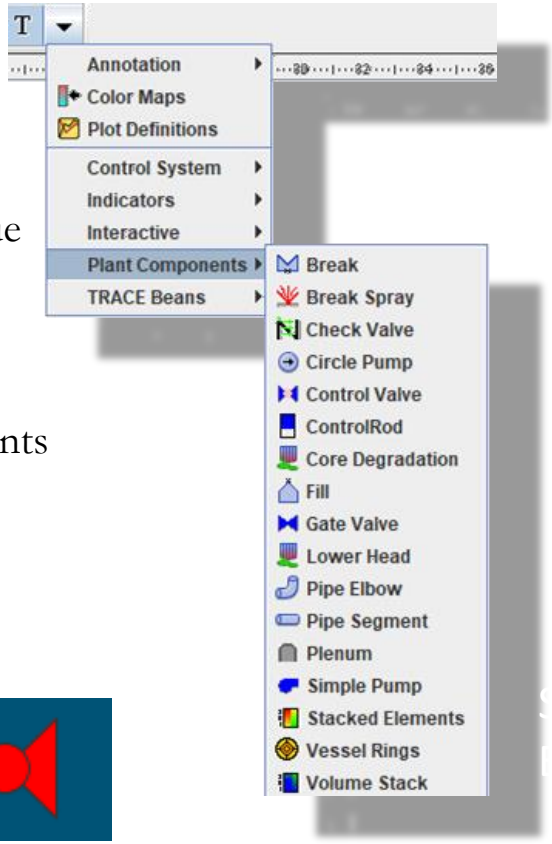


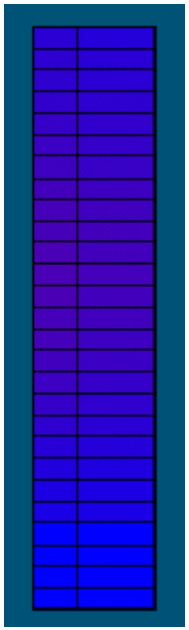


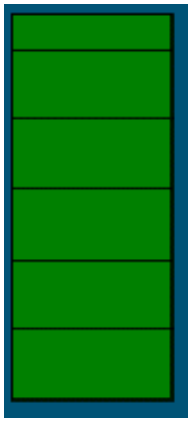
Plant Components

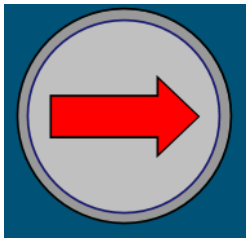
Represents a component

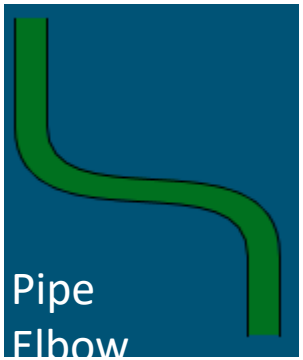
- Some of these components are unique to TRACE or other code.
- Simple Components
  - Sprays, valves, break, pumps
- Simplification of Complex Components
  - Core Degradation component
  - Lower Head component
  - Stacked Elements
  - Volume Stack

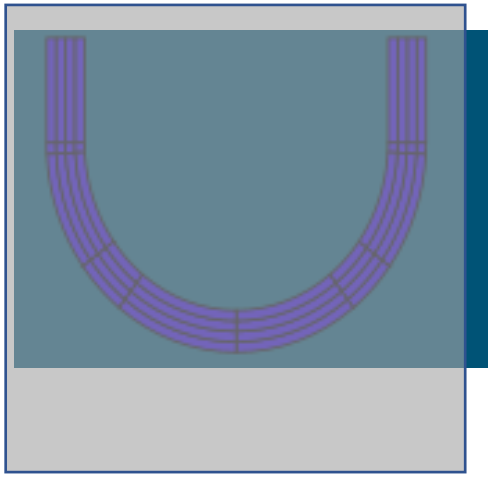


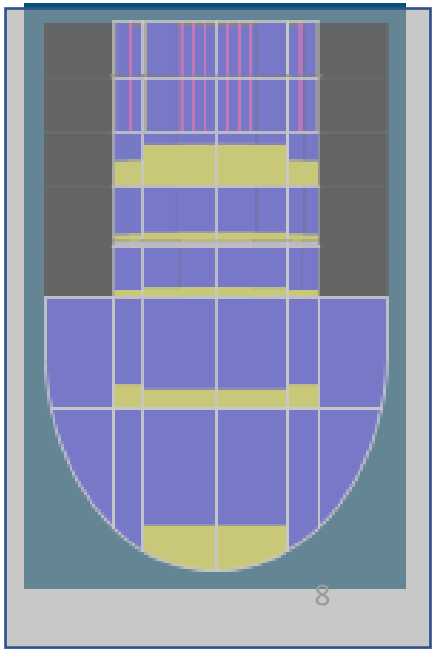








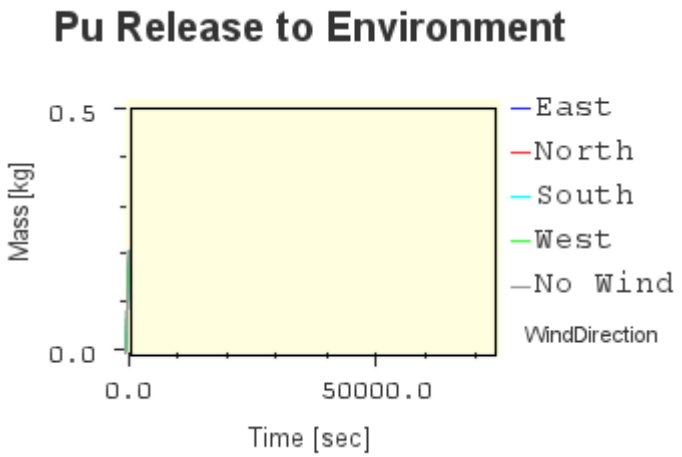


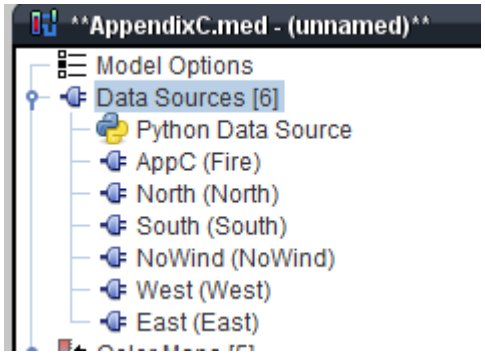


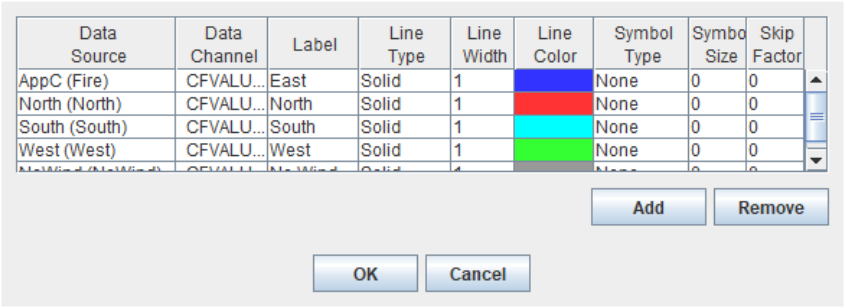
Data Sources

- Attaching a plotfile
  - Data Sources
    - Plot file data
    - Python Data Sources
  - Multiple data sources can be specified
    - One source is designated master and used to determine Tstart, Tend, and time steps
      - Other sources are interpolated between time steps
  - Selecting Data Source
    - Click on Master in the Data Source Tree in the Navigator and set the Source Run URL in the Properties to a completed Job
    - Click the Data Connector Icon
  - Number of Source Runs
    - Data Source can span multiple plot files assuming they are from sequential restart runs.

- Click Data Connection to make connection to the data source.

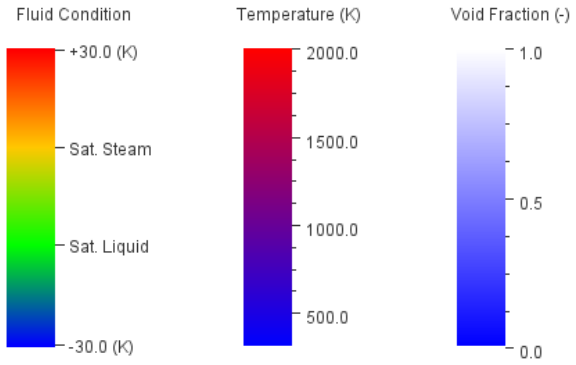




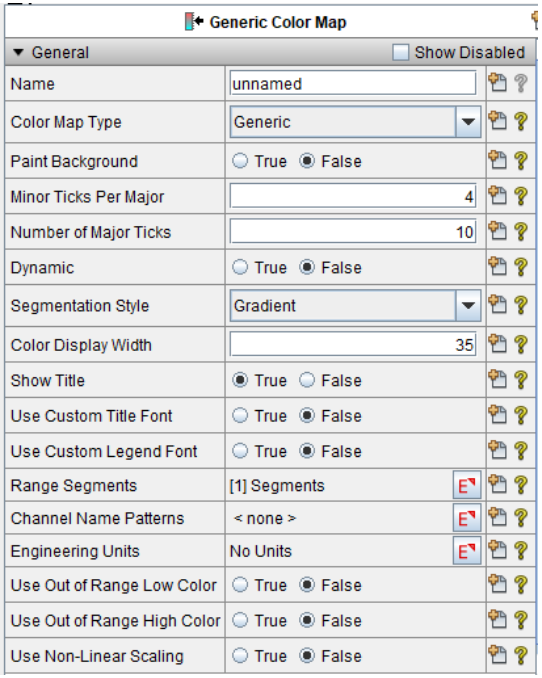


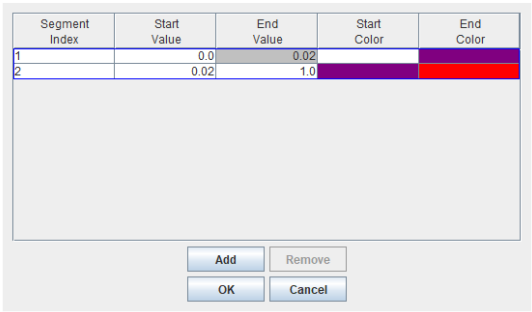
Color Maps

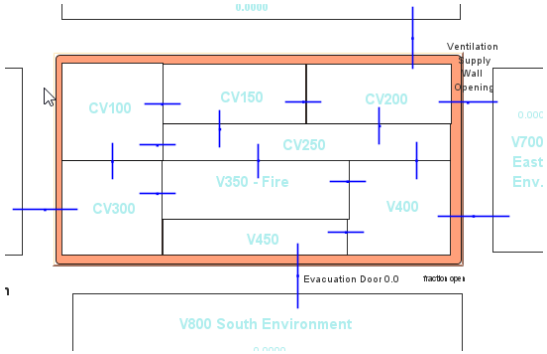
- Built-in Color Map Options
  - Fluid Condition Color Map
  - Temperature Color Map
  - Void Fraction Color Map
  - Generic Color Maps



- Creating a Generic Color Map
  1. Right Click Color Maps in the Navigator>New
  2. Right Click the new Generic Color Map>Add To View
  3. Adjust some Properties
     - Set Color Map Type to Generic
     - Specify Dynamic as True
     - To create a pressure color map, set Channel Name Pattern to MELCOR "CVH-P_%V"
       - Review the MELCOR User's Guide to see all the available plot channels
       - %V is a place holder for the components Control Volume number (see notes for a detailed description on its use)







SNAP MELCOR Plug-in: What's New

- Full Support for MELCOR 2.2 r2023.0 Input Specifications
  - New Editors
  - Import/Exporters
- Support for command line arguments on job step configuration
- Improvements to User Interface
  - More Intuitive layout
  - Cleaner look and fell
  - Improved ergonomics
  - Introduction to Automated Testing Framework
- Partial ASCII import & export
- Bug fixes

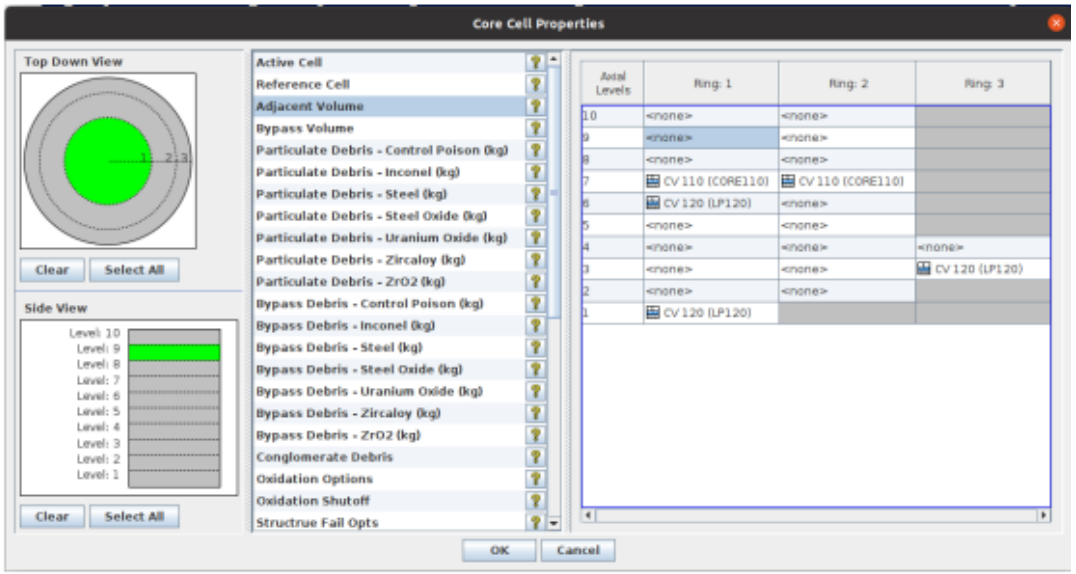
MELCOR Input Specification Updates

Full support for the following new MELCOR model inputs

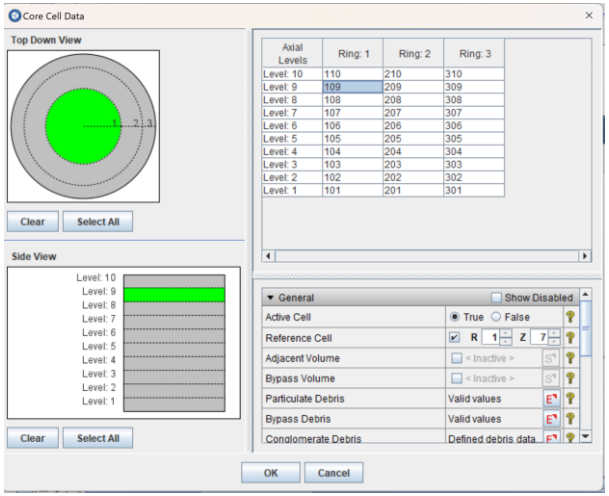
Input	Code Package	Location	Property
CV_PDIA	Control Volumes (CVH)	Category Node	User specified pool diameter
NCG_SC	Sensitivity Coefficients	Create Menu	NCG (2090-2099)
FDI_SC	Sensitivity Coefficients	Create Menu	FDI (4602-4699)
COR_BL	Core (COR)	Attribute Group	Beam Length
COR_GOX	Core (COR)	General Property	Oxidation Modeling
COR_MHU	Core (COR)	General Property	Hold-up behavior
COR_CMT2	Core (COR)	Attribute Group	Secondary Materials
COR_CNV	Core (COR)	General Property	Convective Heat Transfer
COR_LHM	Core (COR)	Attribute Group	Melting Model

UI Improvements – Core Properties

- Split Panel Makes Use of Greater Visual Space
  - All Values from All Axial and Radial Levels Displayed
- Graphical Guidance for Users
  - Help Info Accessible Adjacent to Each Property Type
  - Enabling Information Displayed
- Multi-Row/Column Functionality Supported
  - Editable Properties
  - Copy-Pasting

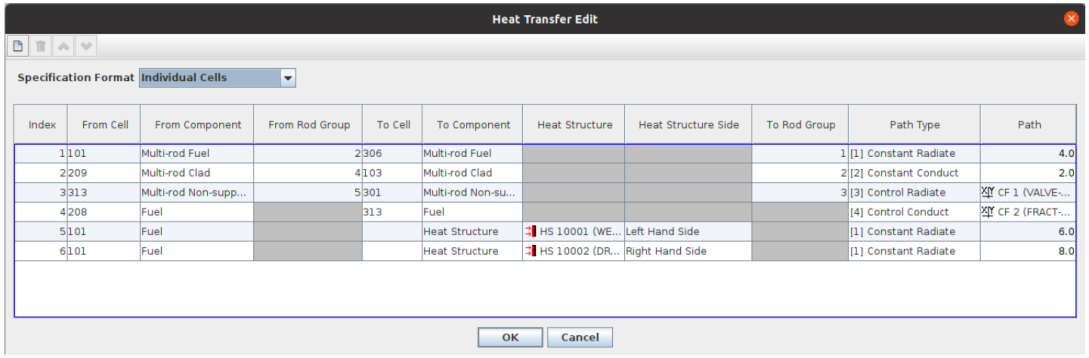


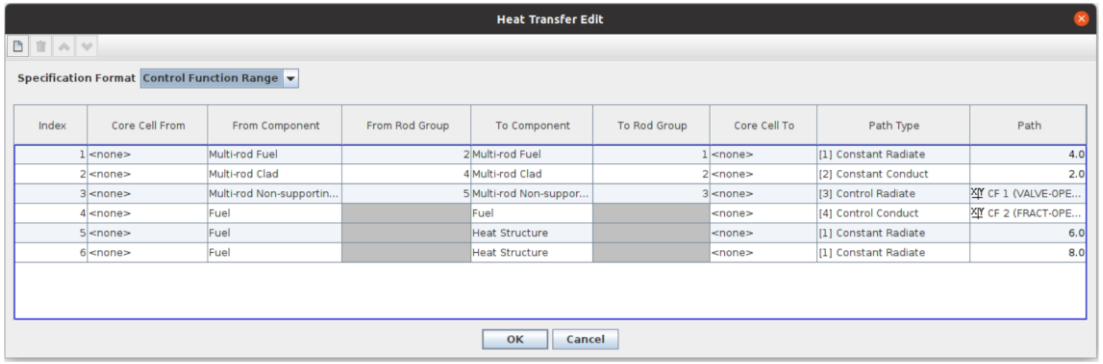
Deprecated Interface



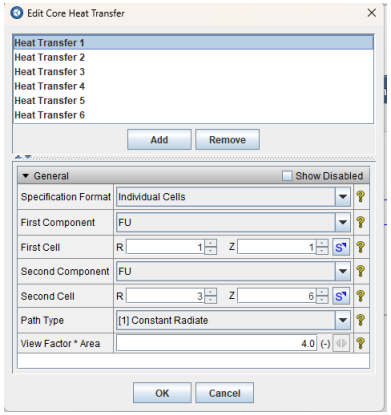
UI Improvements – COR User-Defined Heat Transfer Paths

- Data for Multiple HT Paths available (view & edit) from Single View
  - Previously only a single HT path visible/editable at a time
  - Rows can be re-ordered
- Toggle Specification Modes
  - Input by range
  - Input by single cell
- Improved User Interface
  - Column Removal Reduces Crowding
  - Descriptive Enumerations
    - Previously only abbreviated names displayed
  - Simplistic Inline Editors
  - Descriptive Header Tooltips.



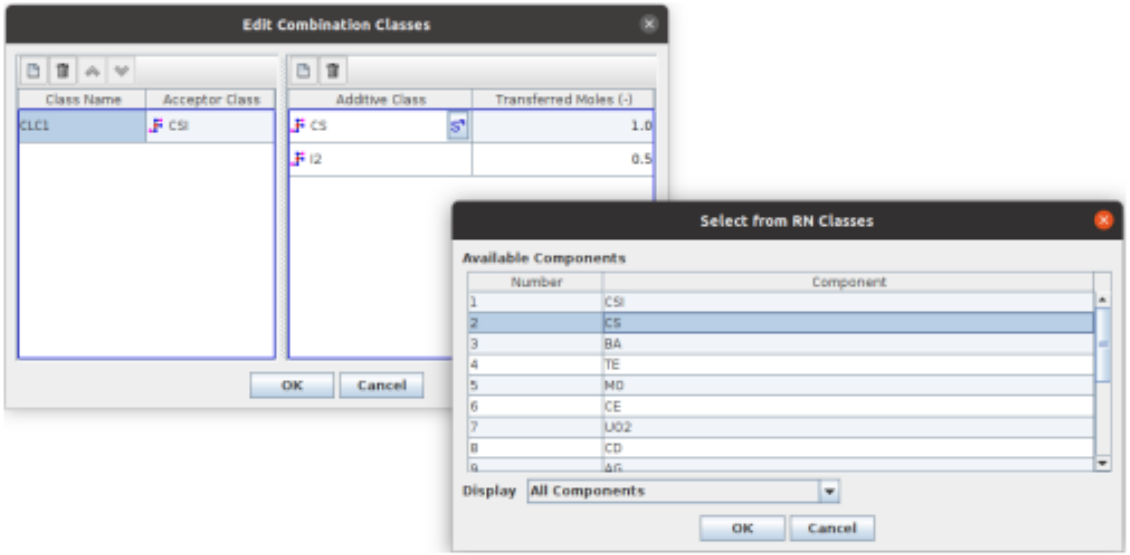


Deprecated Interface

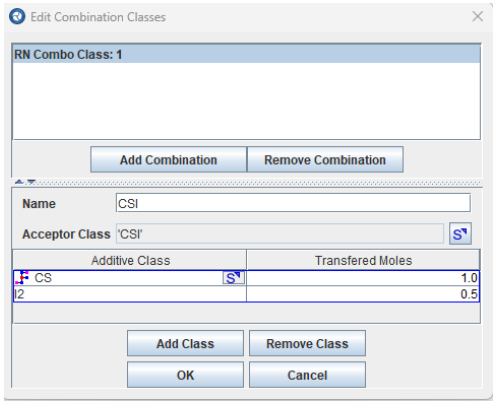


UI Improvements – RN Release Combinations

- Multi-Editable Tables
- Additive Class Pane Displayed on Selection of Acceptor Class
- RN Class Selectors
  - Alternatively, Additive and Acceptor Classes Pasting from External Sources
- Simple Toolbar buttons (Add, Remove and Re-order)

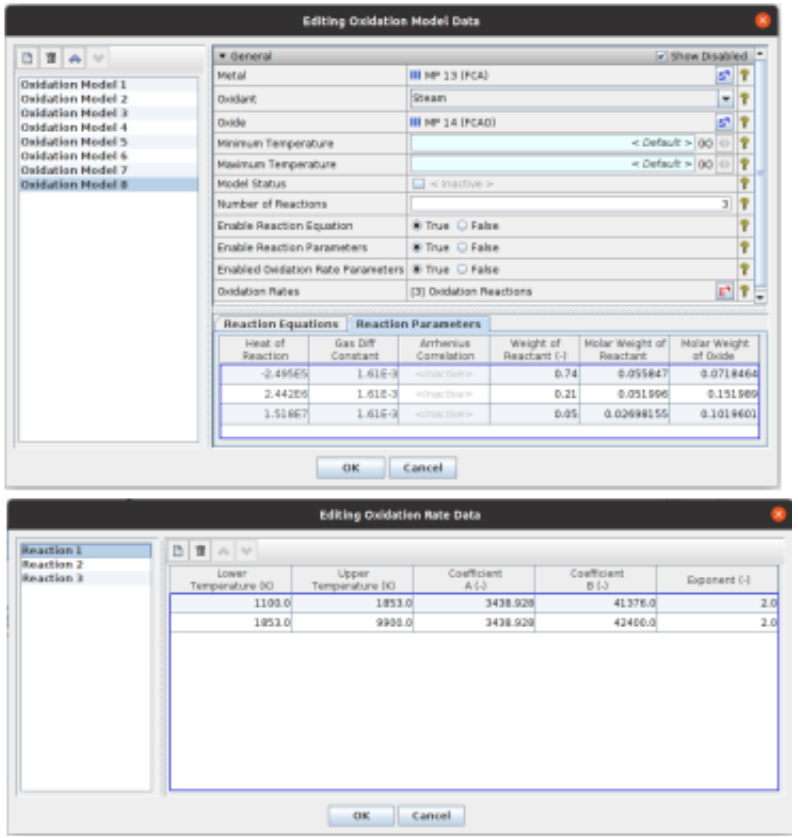


Deprecated Interface



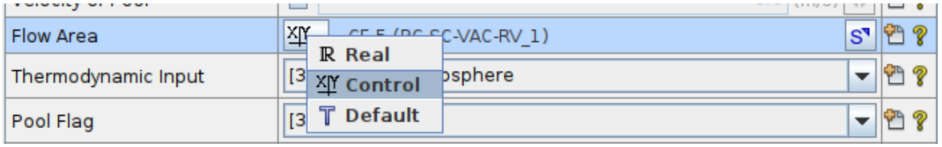
UI Improvements – Core Oxidation Modeling

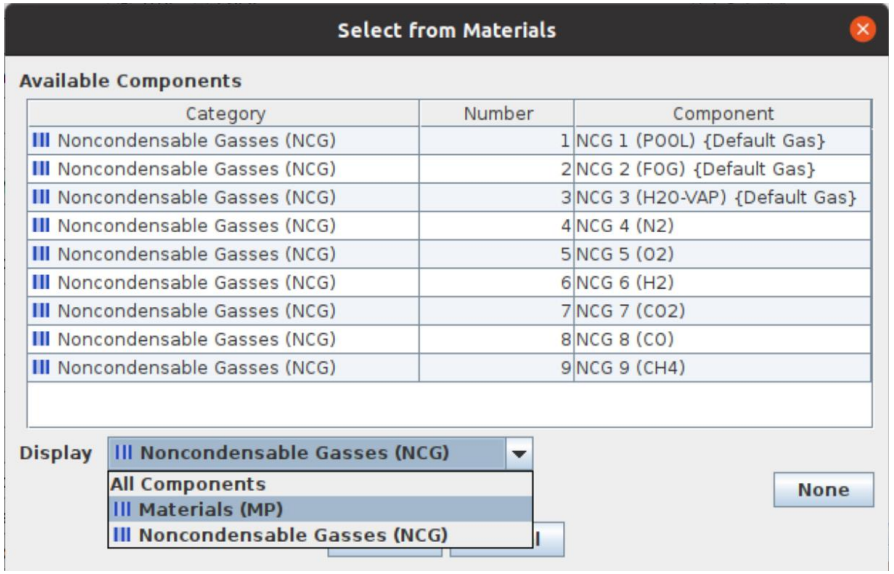
- Define Multiple Oxidation Models
  - Add/Remove/Re-order models
- Oxidation Model Property View
- Enabling Information Display
- Oxidation Rates Property Editor
  - Reactions automatically added
  - Displays oxygen rates for each reaction
  - Add/Remove/Re-order input

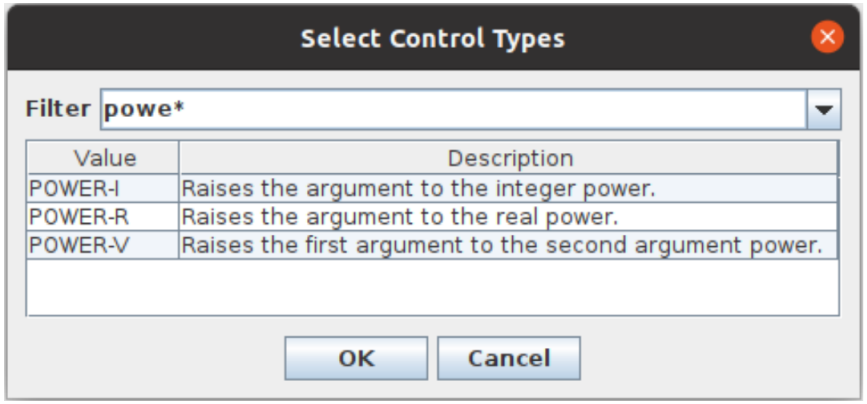


UI Improvements - General

- Real vs Control reference property editor
  - Inline mode selection
  - Enter real values
  - Control Function selection
  - Default value mode
- Component Selection Editor
  - Filterable categories
  - None option
- Named Value Selector
  - Filterable
  - Search wildcards

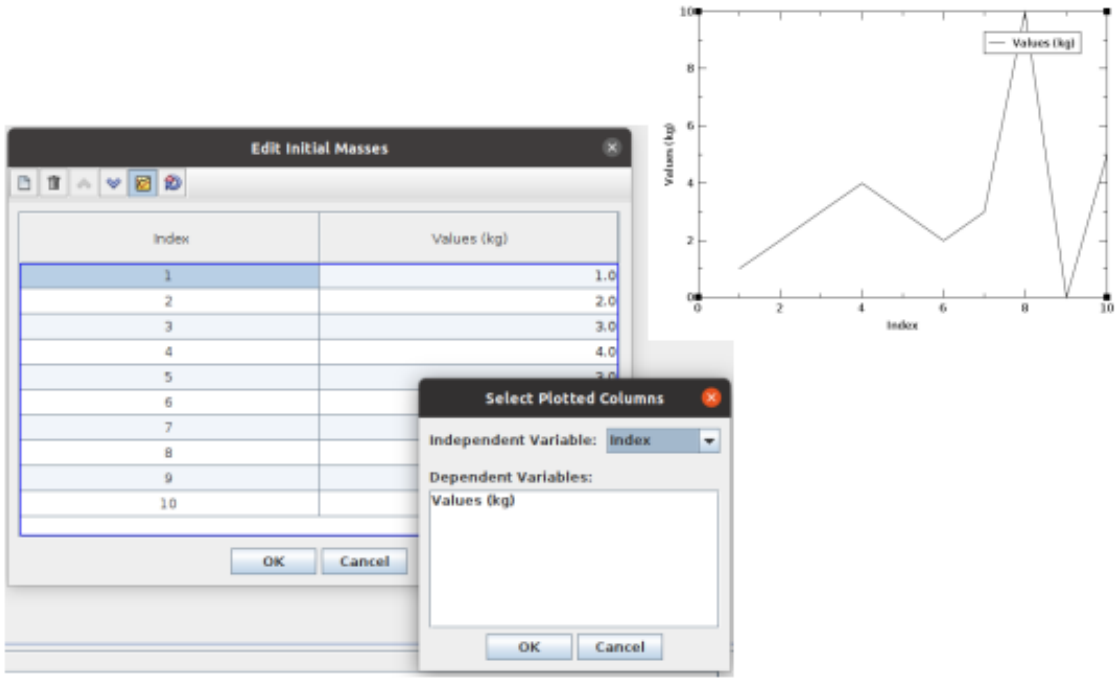






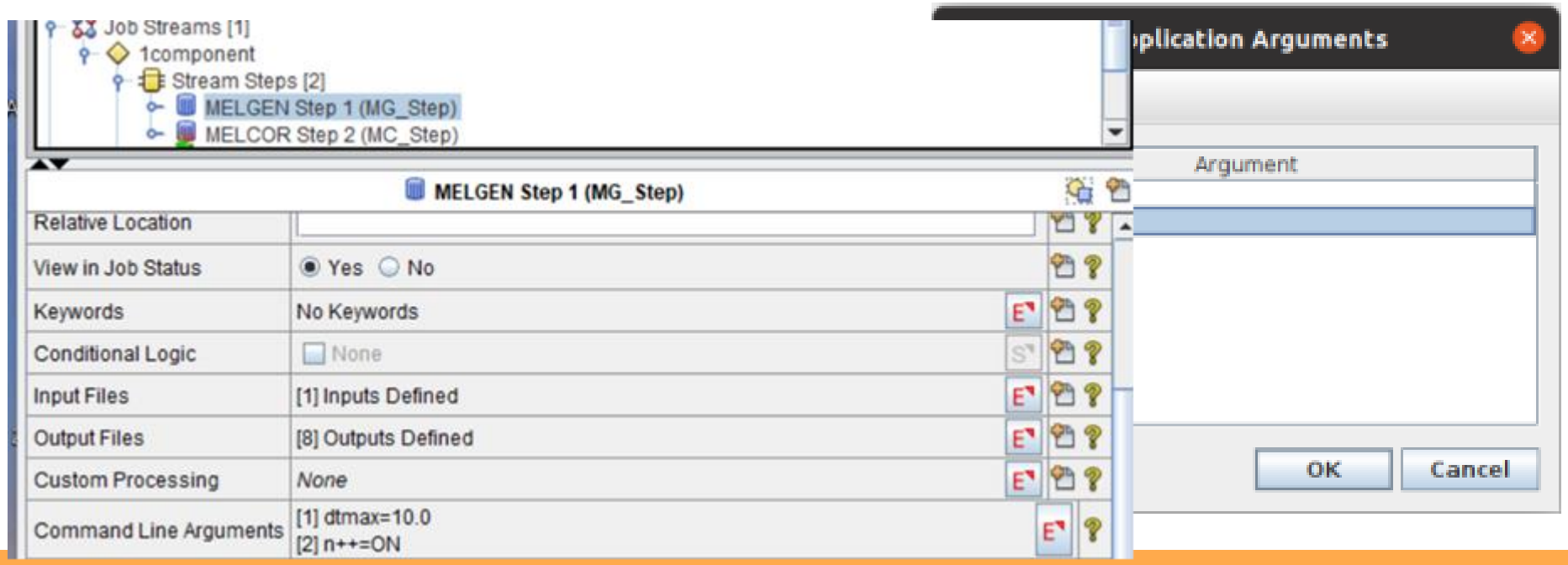
UI Improvements – General Continued

- Real array table editor updates
- Standard for simple real tables
- New toolbar layout of features
- Sort values button
- Orders ascending dependent values
- Plot from Table Button:
- APTPLOT Automatically configured
- Configurable independent and dependent plot variables



MELCOR Job Command-line Arguments

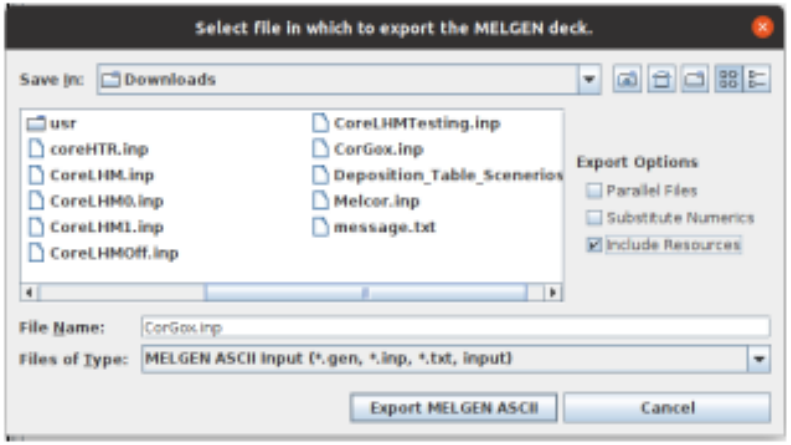
- MELGEN/MELCOR Command lines
- Examples:
  - C=xx, DTMAX=xx , N++= xx, NCF= xx NQE=xx, NT=xx,OW=xx, SCnnnn(m)=xx, SF=xx, ST=xx, TEND=xx, VAR=xx MAXNCYCLE=xx, NEWNCYCLE=xx, CPUEND=xx
  - See UG (EXEC-UG)
- Supported on 1.8.6 and 2.2 job steps
- Supported for MELGEN & MELCOR separately

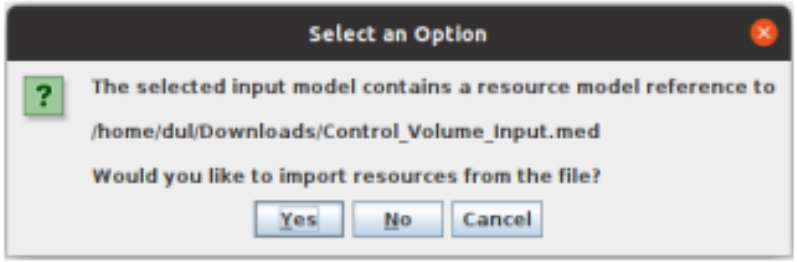


Import/Export Resources

- Retain SNAP Meta Resources
  - Notes
  - Views
  - Cases
  - Numerics
  - Streams
- ASCII Header Mapping Directive
- Externally Modify ASCII
  - Notepad++
  - Word
- Exportable for MELGEN
  - MELCOR cases permit ASCII modifications

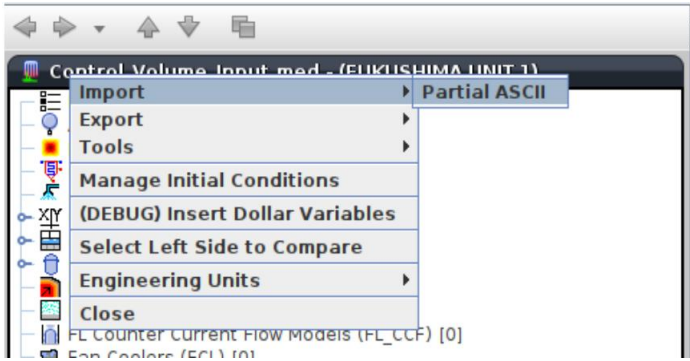
```
!************************************
!*        NUMERIC MAP               *
!************************************
!*med:/home/dul/Downloads/Control_Volume_Input.med
!*udn:ri,m:$ri,v:1234.0
!*m: SNAP:Symbolic Nuclear Analysis Package, Version 4.2.0, October 27, 2023
!*m: PLUGIN:MELCOR Version 2.8.4
!*m: CODE:MELCOR Version 2.2
!*m: DATE:2/15/24
!!
!!************************
!!'FUKUSHIMA UNIT 1'
!!************************
!!
```



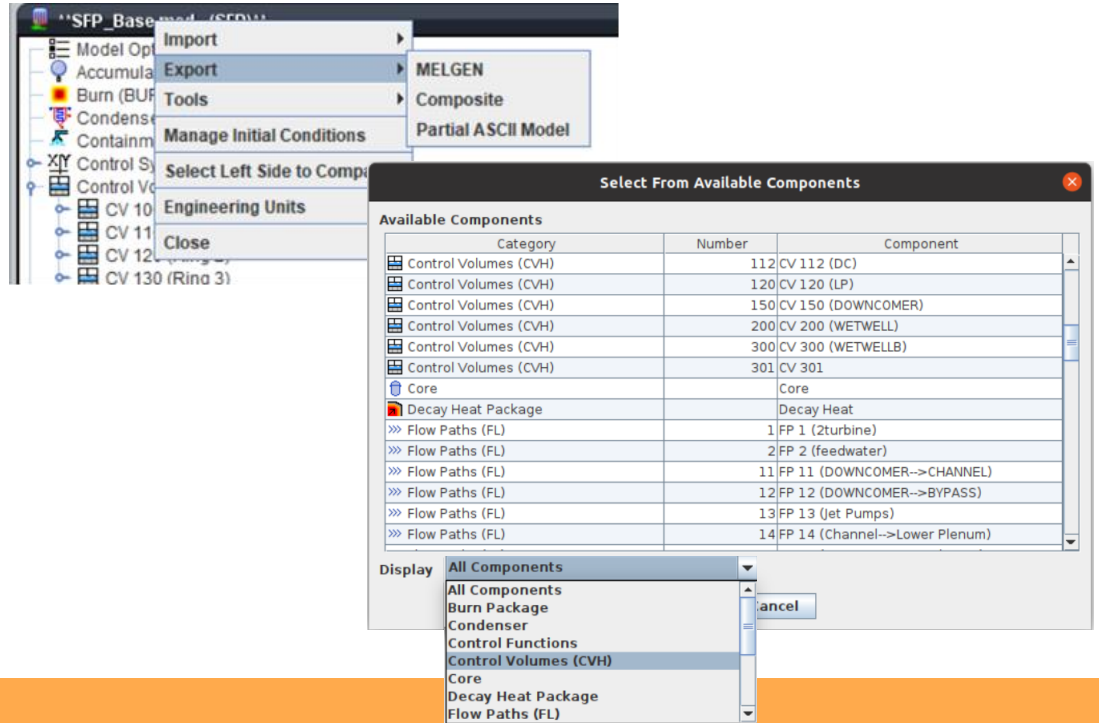


Partial ASCII Import/Export

- Import component(s):
  - Replaces existing components if previously defined.
    - Overwritten (deleted) component(s) removed
    - If object number matches but name does not match an existing object then a new object is created rather than replacing
  - Individual or multiple objects can be imported from a file
    - All objects in ASCII file are imported
  - Partial import item off model node

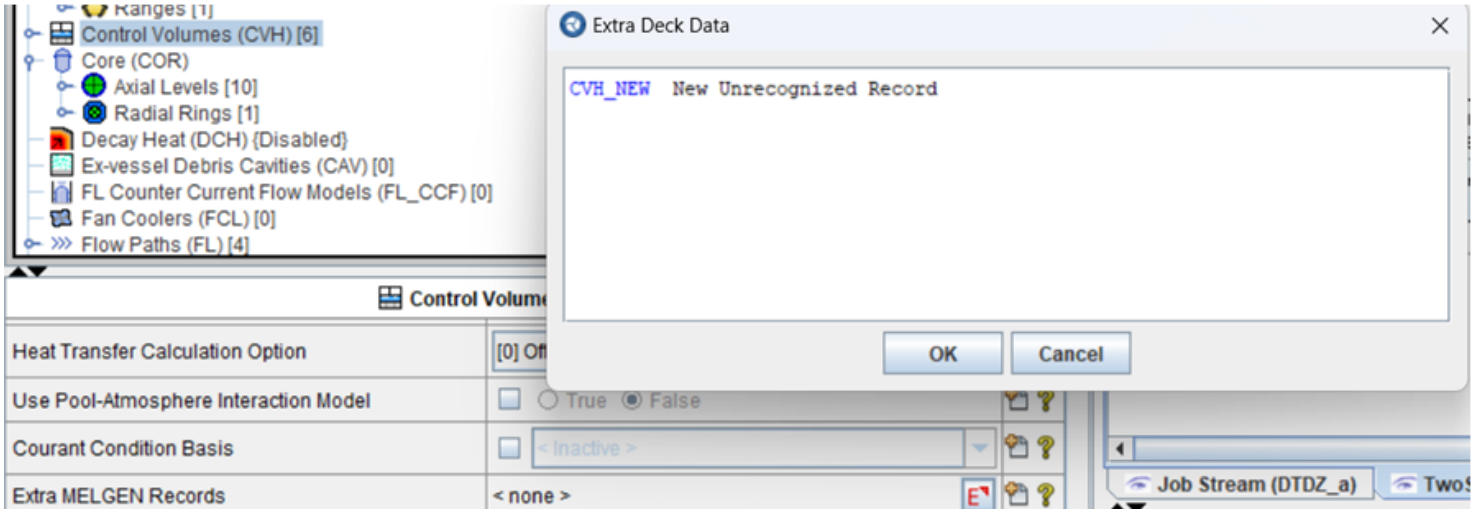


- Export
  - Previously only possible by Show ASCII>Copy ASCII for component to Clipboard>Paste into text file.
  - Export ASCII of selected components
  - Filterable component export UI



Support for Unrecognized Input Records

- Need for SNAP to allow unrecognized input records
  - SNAP development lags behind MELCOR development.
  - Inherent consequence of development by 3rd party.
  - Provide Users access to new model features/capabilities within SNAP environment
  - Particularly important for use at Workshops.
- Implementation
  - Extra MELGEN/MELCOR record input can now be specified in SNAP
  - Input for each package.
  - Future development will allow new fields on existing records or new records for MELCOR objects (HS, FL, CVH, …)

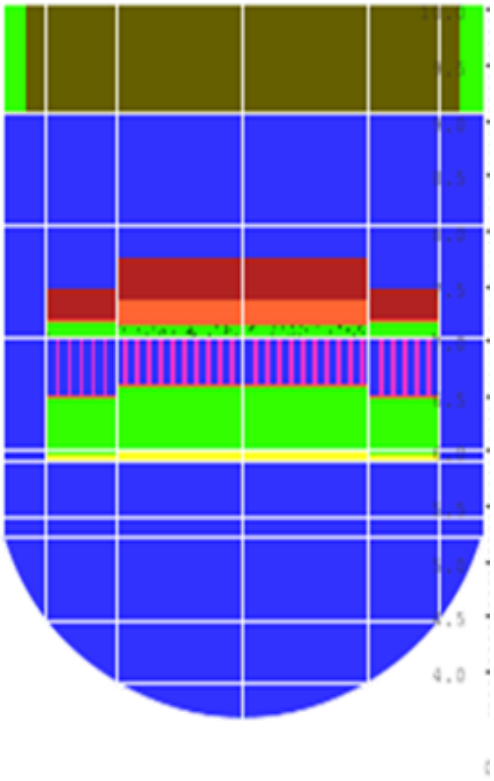


SNL/ISL MELCOR SNAP Discussions

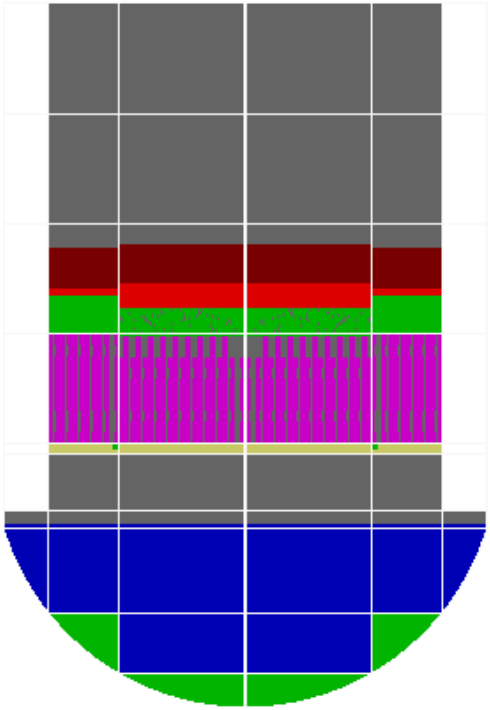
- One week in-person meeting between MELCOR code developer and the GUI plug-in developer
  - February 19 – February 23, 2024
  - Improved alignment between MELCOR and SNAP developers
  - Extremely positive and successful meeting
- Discussions and Topics
  - Latest updates to the MELCOR plug-in
  - New capabilities in SNAP that could be implemented into MELCOR plug-in
  - Recent model developments at Sandia and future GUI support requirements
  - Feedback from MELCOR/SNAP users
  - Discussion on SNAP bugs/issues

Issue: Error in SNAP Degradation Display

SNAP Degradation Display



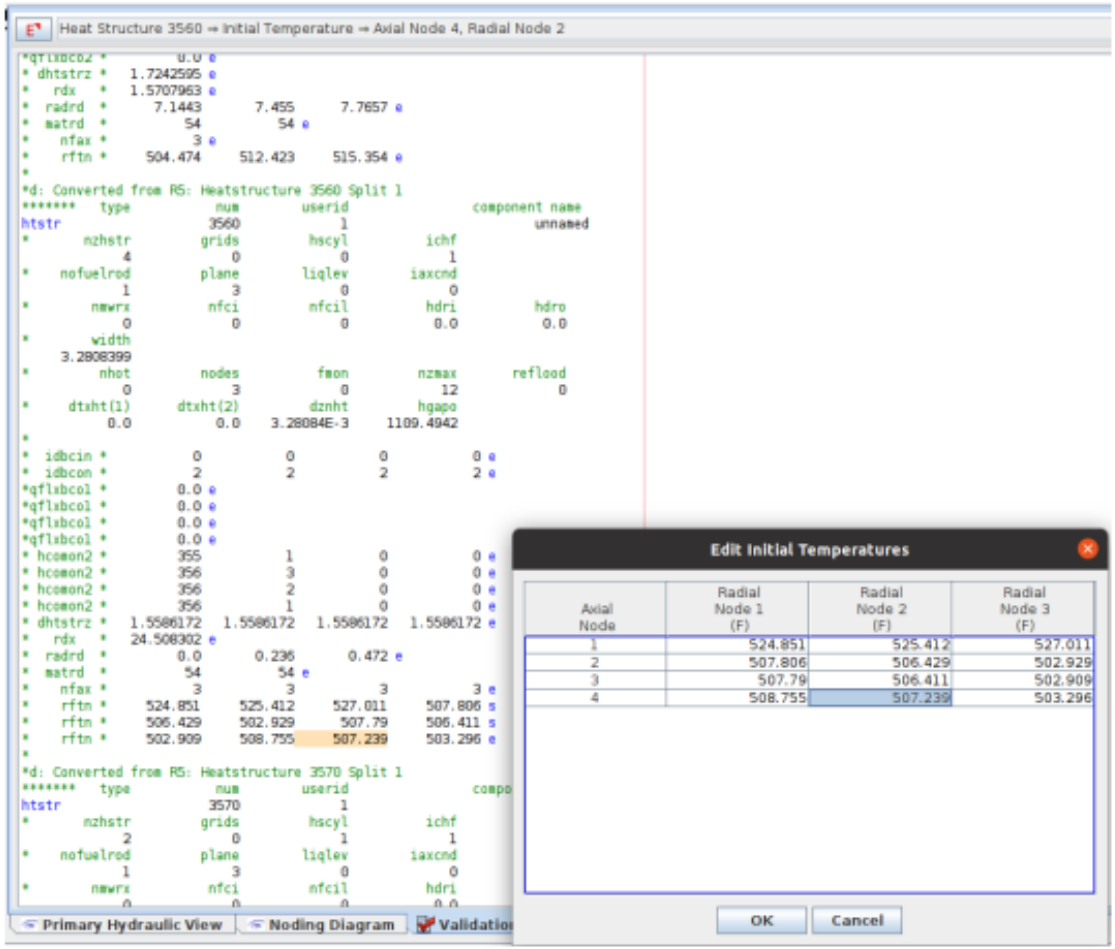
PTFREAD/HTML Degradation Display



- SNAP displays null cells as though they were active.
  - SNAP shows PD in upper outer ring which should be null
- Upper levels of MP2 in rings 1 and 2 for SNAP are different where they are approximately the same for HTML.
- HTML displays blocking of conglomerate between fuel rods.
- SNAP is showing large formation of PD on core support plate (likely conglomerate mass)
- Water is below core support plate in HTML and fully flooded in SNAP
- HTML shows relocated PD on lower head

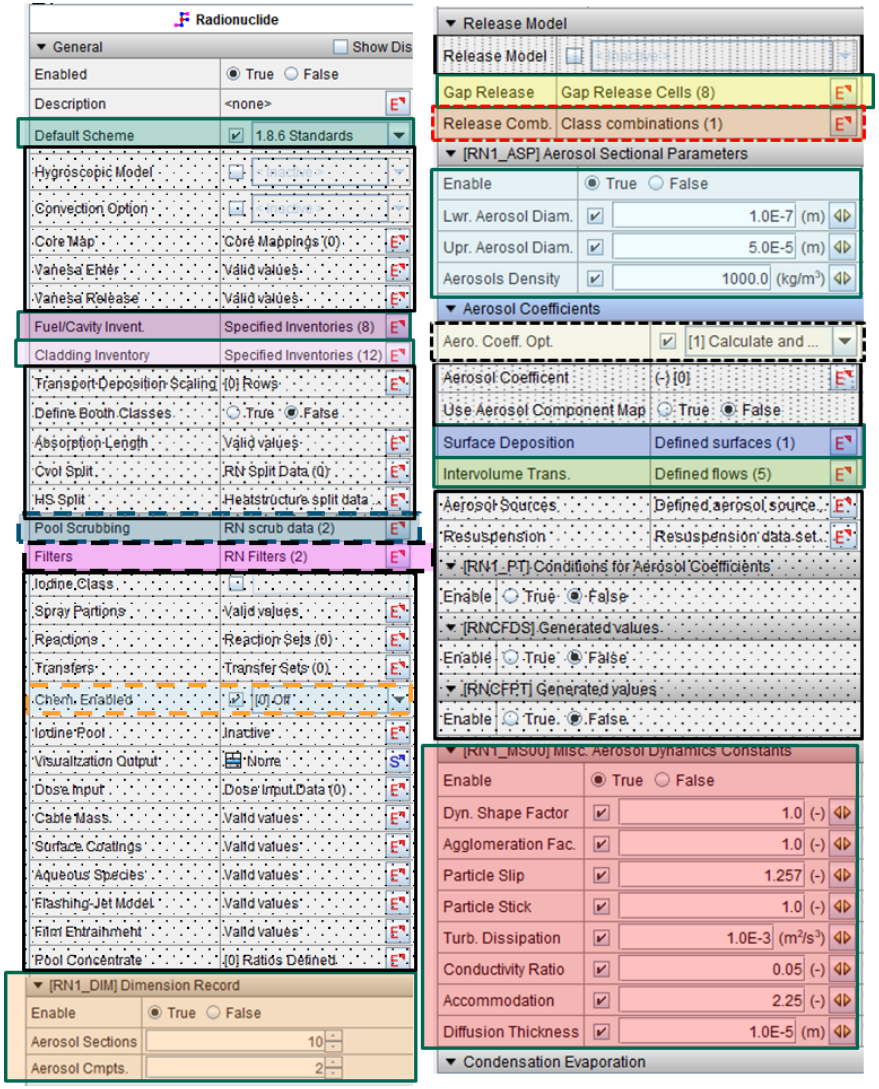
Future Improvement: Validation Window & ASCII Context

- Full ASCII Model Contents
  - No Export Required
  - Case Data Appended
- ASCII View Highlighting
- Search Capabilities
- Deltailed Breadcrumb information
- Quickly Navigate from ASCII view to GUI Edit Location
  - Double-click to Jump
  - Editors Opened
  - Table Cells and Modes Selected
- Available in ASCII views



Future Improvement: Default/Full view of MELCOR Input

- MELCOR is feature rich and allows users access to many input parameters and optional models.
  - Overload of input requirements available to new MELCOR users invites problems with user/effects
  - Though many options are available, the default view should only show that data that is required or frequently modified by the user
  - Optional data should be masked out by default
  - Toggle could hide optional input from view (unless user has made changes to this input)



Questions