# Overview of Recent RELAP5 Development

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# *Outline*

- *Overview of development activities*
- *Selected reviews*
  - *Kinetics user subroutine*
  - *Improved fuel deformation model*
  - *1994 decay heat model*
- *Future work*
- *RELAP5 GUI*

# *Development Highlights*

| Item | Objective |
|------|-----------|
| Nodal Kinetics User Subroutine | Further enhancements |
| RELAP5 Graphical User Interface (RGUI) | Further enhancements |
| PYGMALION | Restore functionality |
| Semi-implicit Coupling | Allow RELAP5-3D to couple to other codes semi-implicitly |
| Fuel Deformation Model | Cause flow area and volume to reduce due to fuel swelling |
| 1994 ANS Decay Heat | Implement 1994 standard |
| Improved Matrix Solution of the Field Equations | Reduce time step reductions caused by ill-conditioned matrices |
| Downcomer Pressure Drop | Allow single radial ring downcomer in 3-D component |
| 1995 Water Properties | Implement IAPWS-95 standard for water properties |
| Precompiler for Parallel Processing | Clean up coding for parallel processing on multiple CPU's |

# *Improvements to the Nodal Kinetics User Subroutine*

- *User access to kinetics print routines*

- *User access to resize the code memory allocation*

- *Additional variable added to track control rod tip position*

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# *Improved Fuel Deformation Model*

The existing fuel swelling and rupture model was improved to account for the effects on control volume flow area, volume, and hydraulic diameter.

$$A^{n+1} = A^n - \Delta A$$

$$\Delta A = \left[ \pi \left( \left( R_o^{n+1} \right)^2 - \left( R_o^n \right)^2 \right) \right] \frac{L_h}{L_v}$$

$$V^{n+1} = V^n \frac{A^{n+1}}{A^n}$$

$$D_h^{n+1} = D_h^n \frac{A^{n+1}}{A^n}$$

cladding

$R_o^{n+1}$

$R_o^n$

*$L_h$= heat slab length, $L_v$= volume length*

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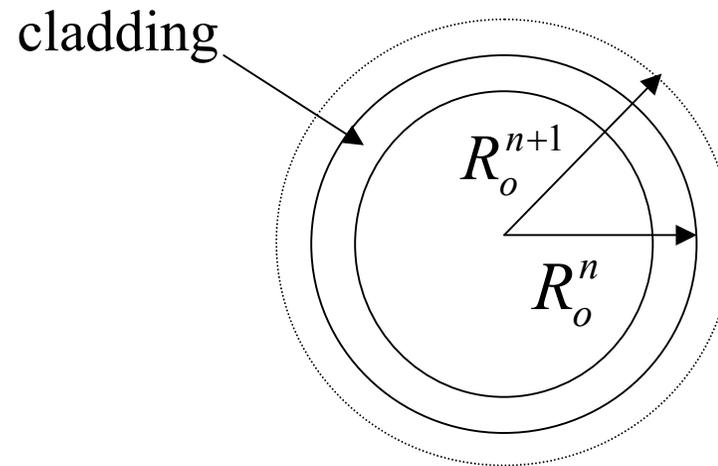
# Improved Fuel Deformation Model (continued)

## Sample problem: Burst of low and high power fuel rods

**Change in fuel rod radius**
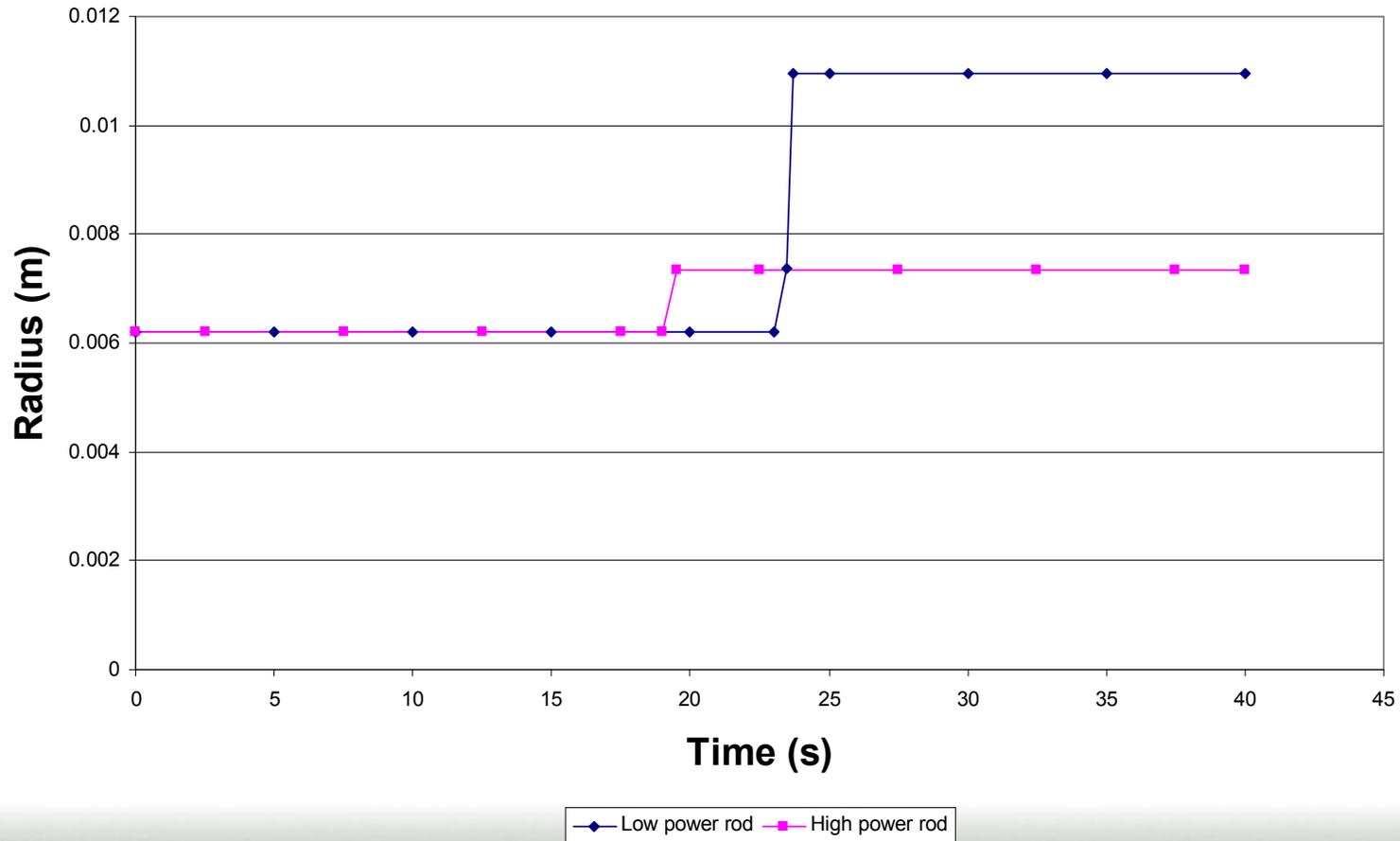
# *Improved Fuel Deformation Model (continued)*

Effect on volume flow area

**Change in Volume Flow Area**
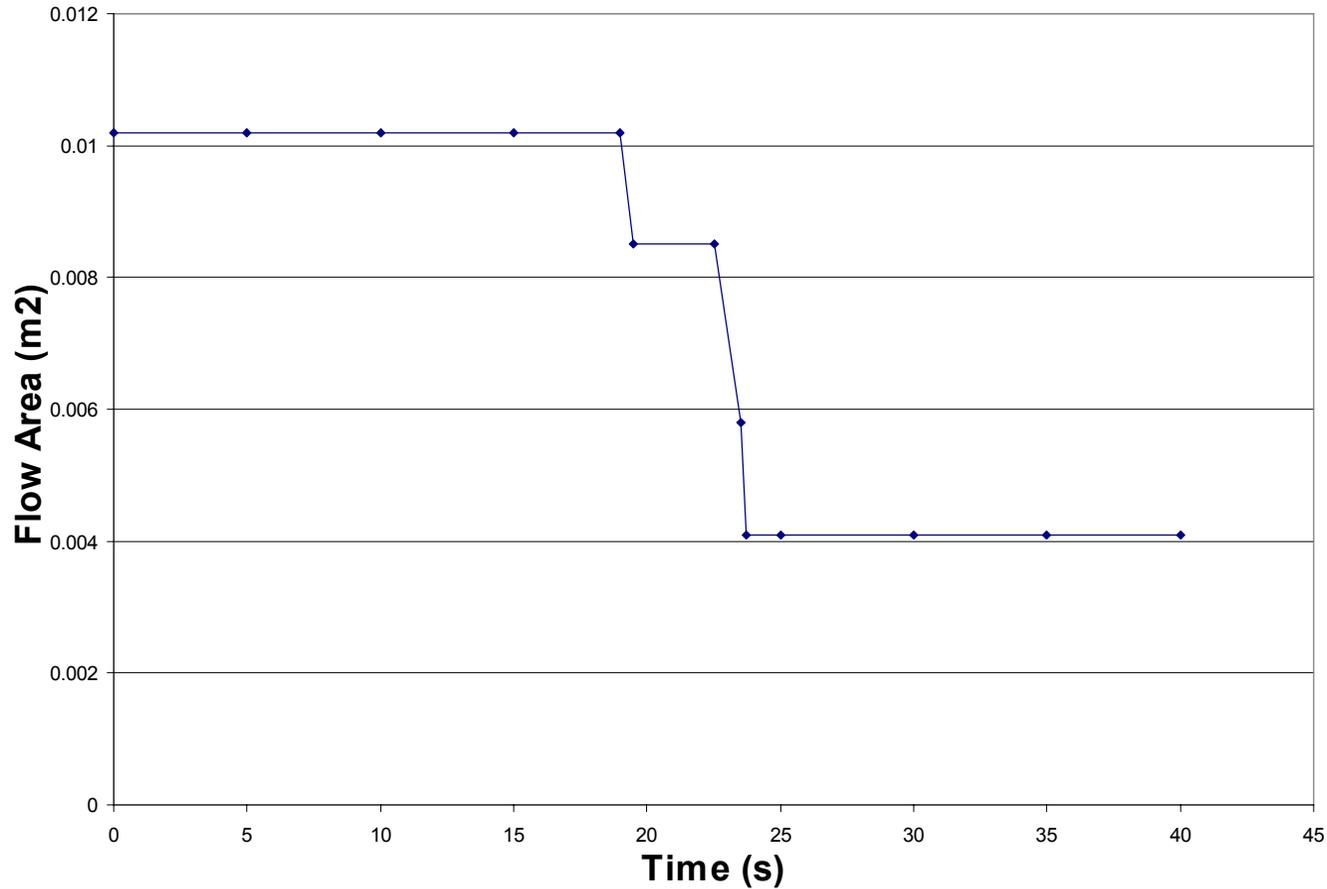
# *1994 Decay Heat Standard*

**The ANS94-4 Standard produces slightly higher decay heat than the ANS79-3 Standard**
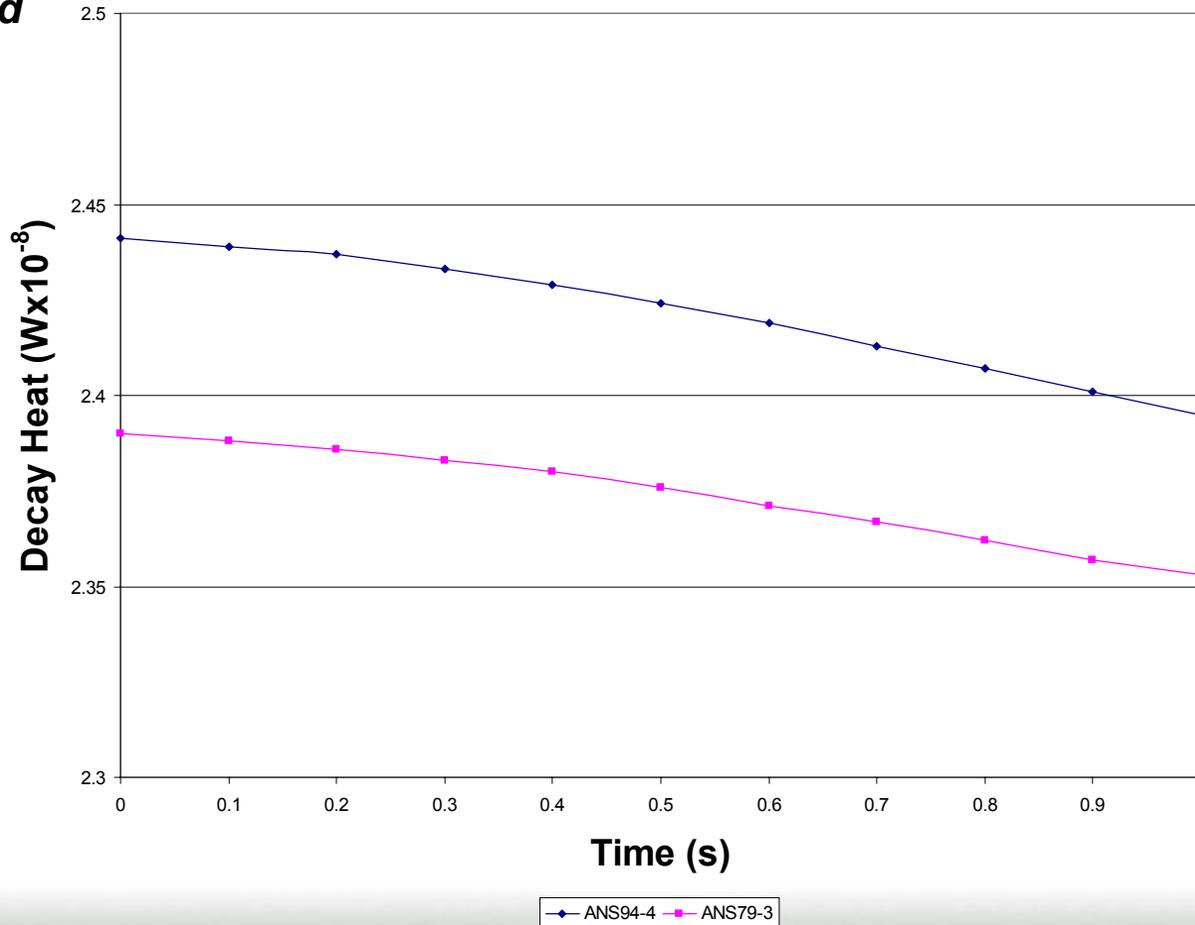
# *Future RELAP5-3D$^©$ Development*

- *Coupling follow-on tasks*
- *Further parallelization*
- *Convert bit-packing to FORTRAN 90*
- *Remedy code problems:*
  - *Oscillations in default critical flow model*
  - *Oscillations from flow regime transitions*
  - *Unphysical temperatures when filling a vertical stack*

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# *RELAP5 Graphical User Interface (RGUI) Basics*

- *Automatic isometric display rather than NPA-type user constructed representation of model*

  - *Eliminates mask construction, saves time*

  - *Automatic display reveals modeling errors*

  - *Works with any correct input deck for RELAP5/MOD3 or higher*

  - *Needs NO INFORMATION from user to make image*

- *Represent plant models in 3D*

# *Major Recent Developments in RGUI*

- **Three-Dimensional Pipes**

  - *Wireframes, solid surfaces, color maps*


- *XY-Plots*

  - *MS-Windows and Unix via tkXMGR5*

  - *Dynamically updating Point-and-Click plots*


- *User Annotation*

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# *Isometric Stick Figure*
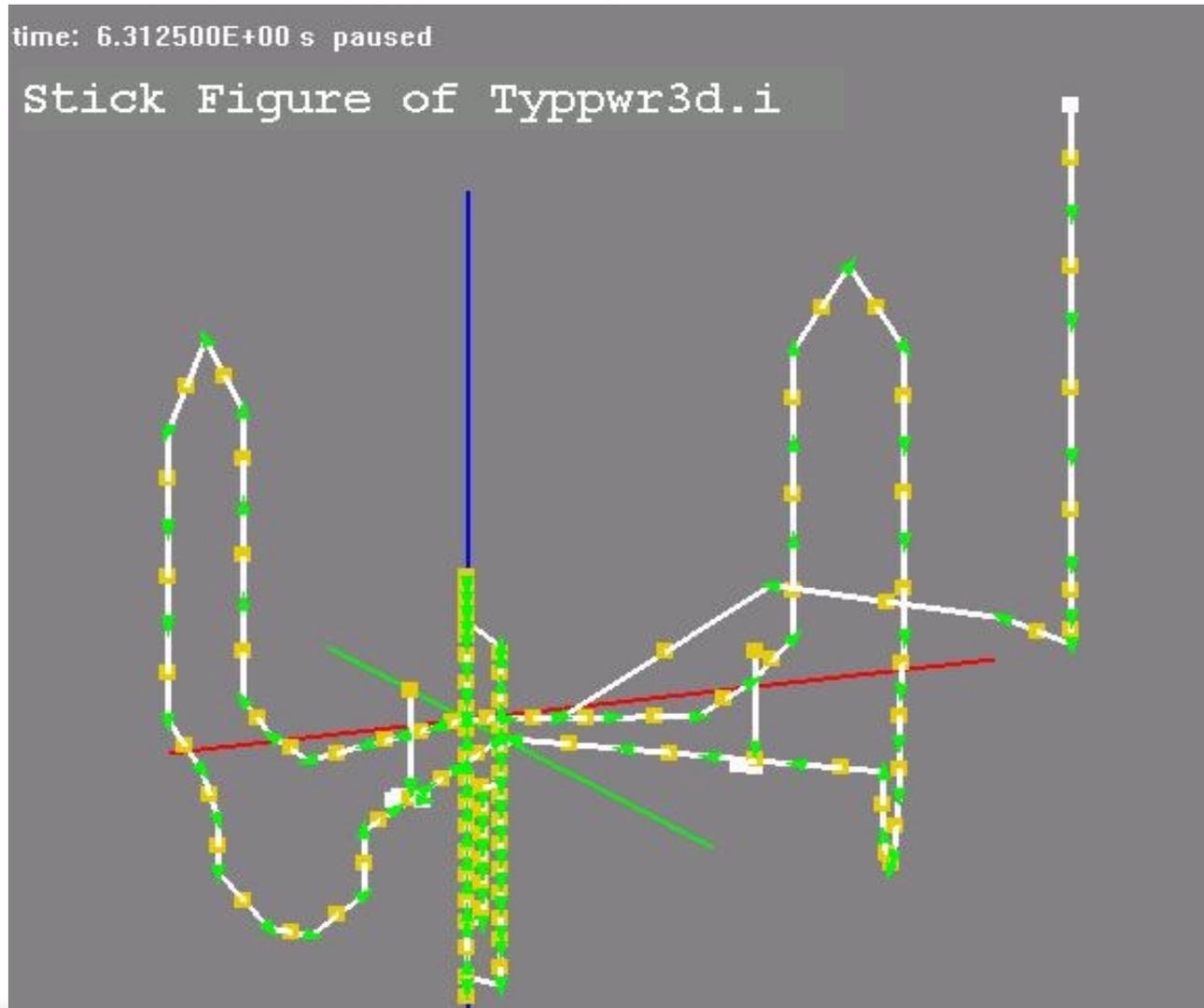
# *Improved Display of Multiple Parameters*

- *Display variable is fluid temperature.*

- *Color map variable is void fraction.*

- *Flow Area*

- *Three pieces of information at every volume.*



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Typpwr3d.i Solid Surface Pipes

537.

557.

534.

528.

535.

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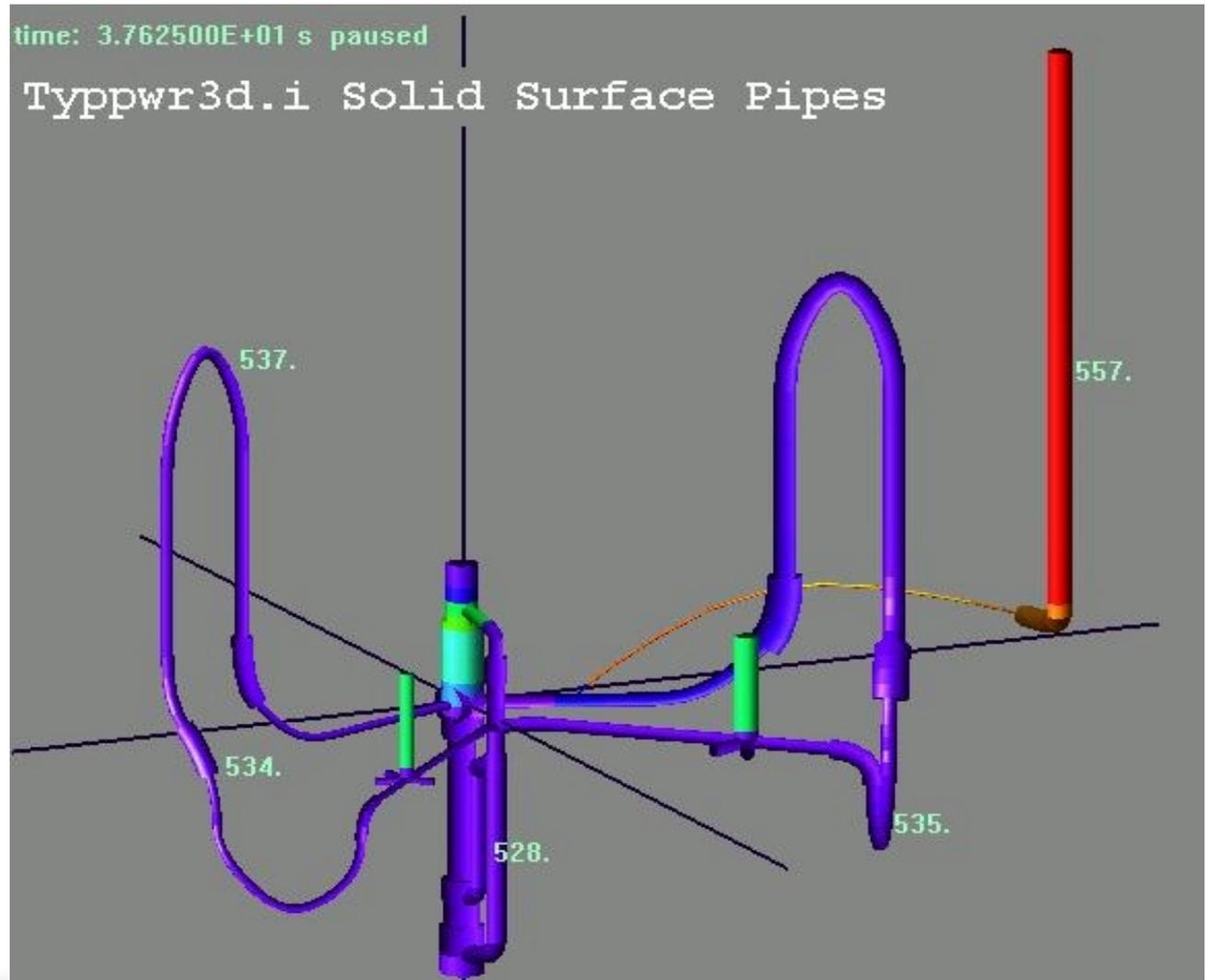
- *Point and click plots available via context menu (right button)*

- *Full sized X-Y plots through the X-Y Plot button*

- *X-Y plots via tkXMGR (adapted from XMGR5) are available on all supported platforms*
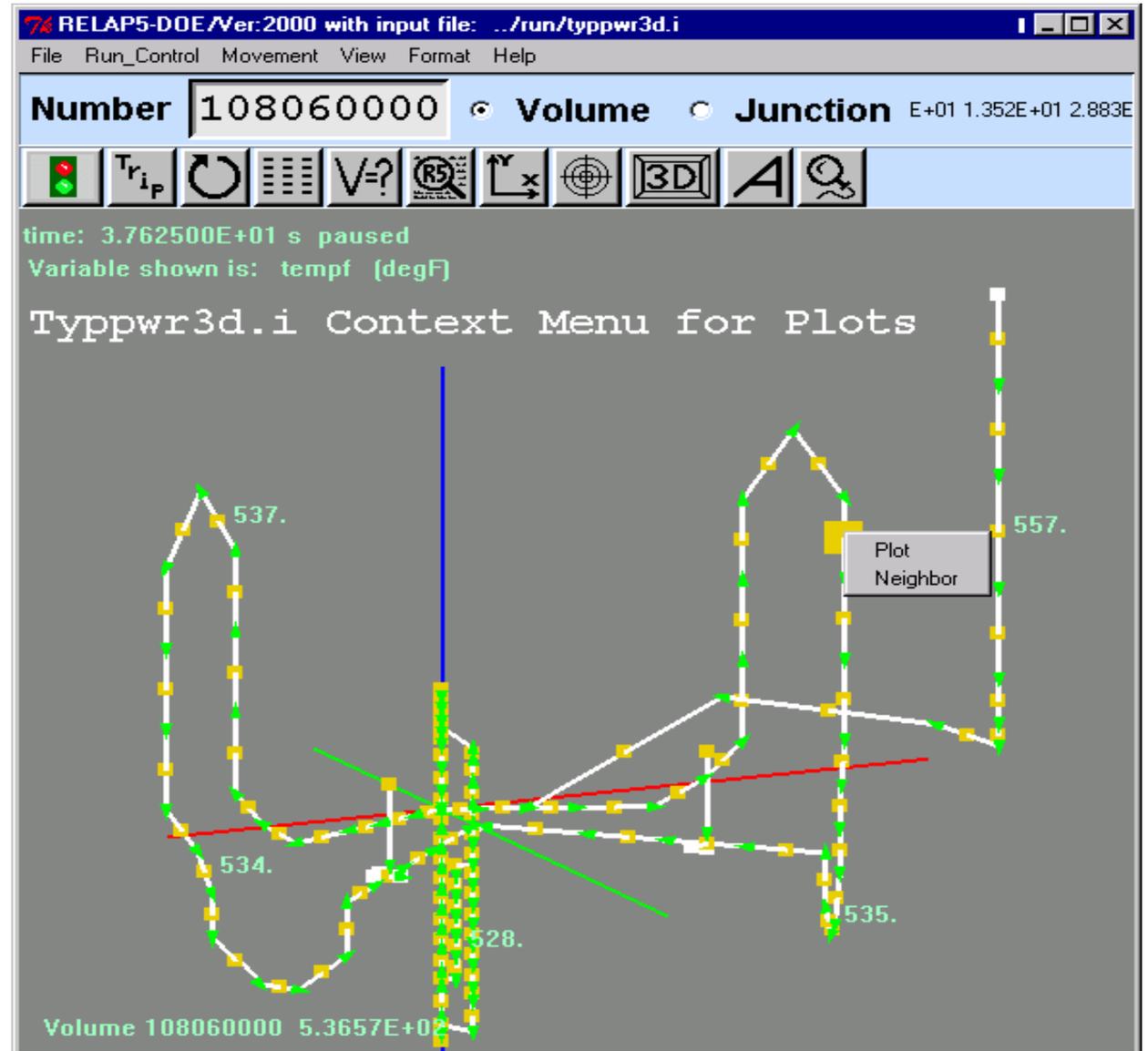
# Point And Click Plot

- *Plot title bar shows variable and number*

- *Automatically updates during calculation*

- *Axes rescale dynamically as calculation proceeds*



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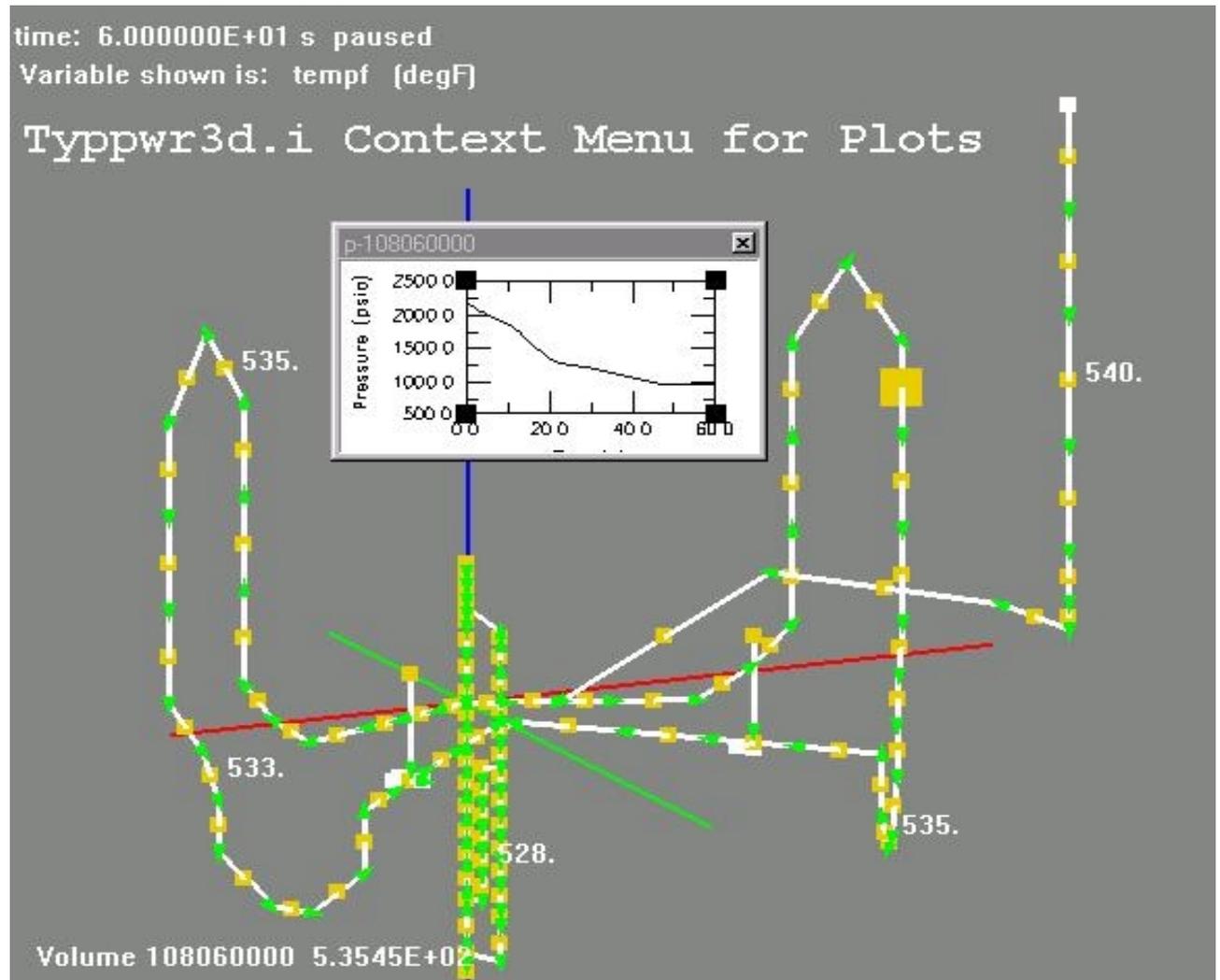
# *Full Screen tkXMGR*

- ***All XMGR capabilities available***

- ***Launch from***
  - *Isometric Image*
  - *RELAP5-3D Station*

- ***Unix & MS-Windows***
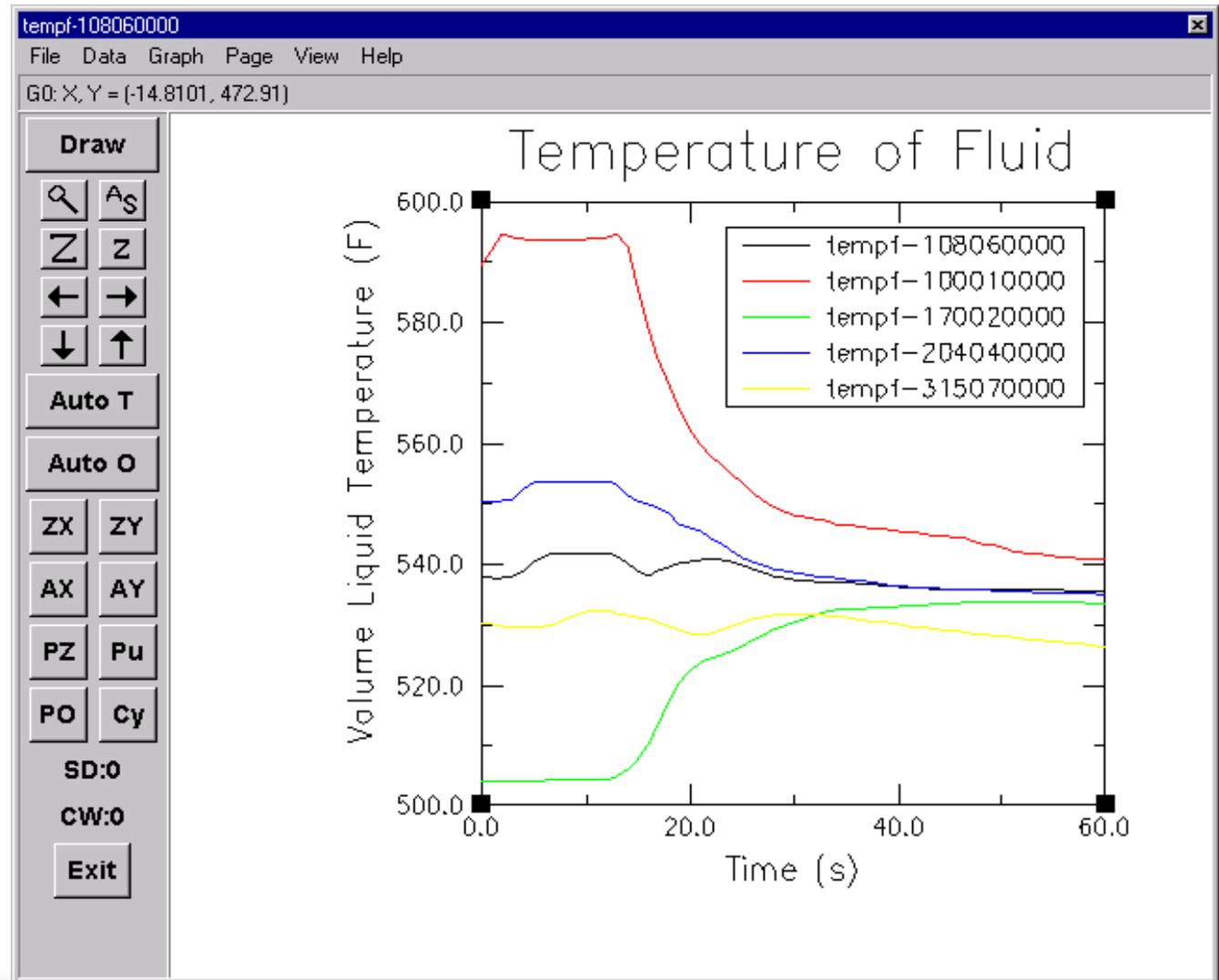
# *3D Pipe View of a 3D Plant Model: LOFT*

- *Components easy to identify*

- *Cannot see inside the vessel*

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3D Solid Surface view of LOFT

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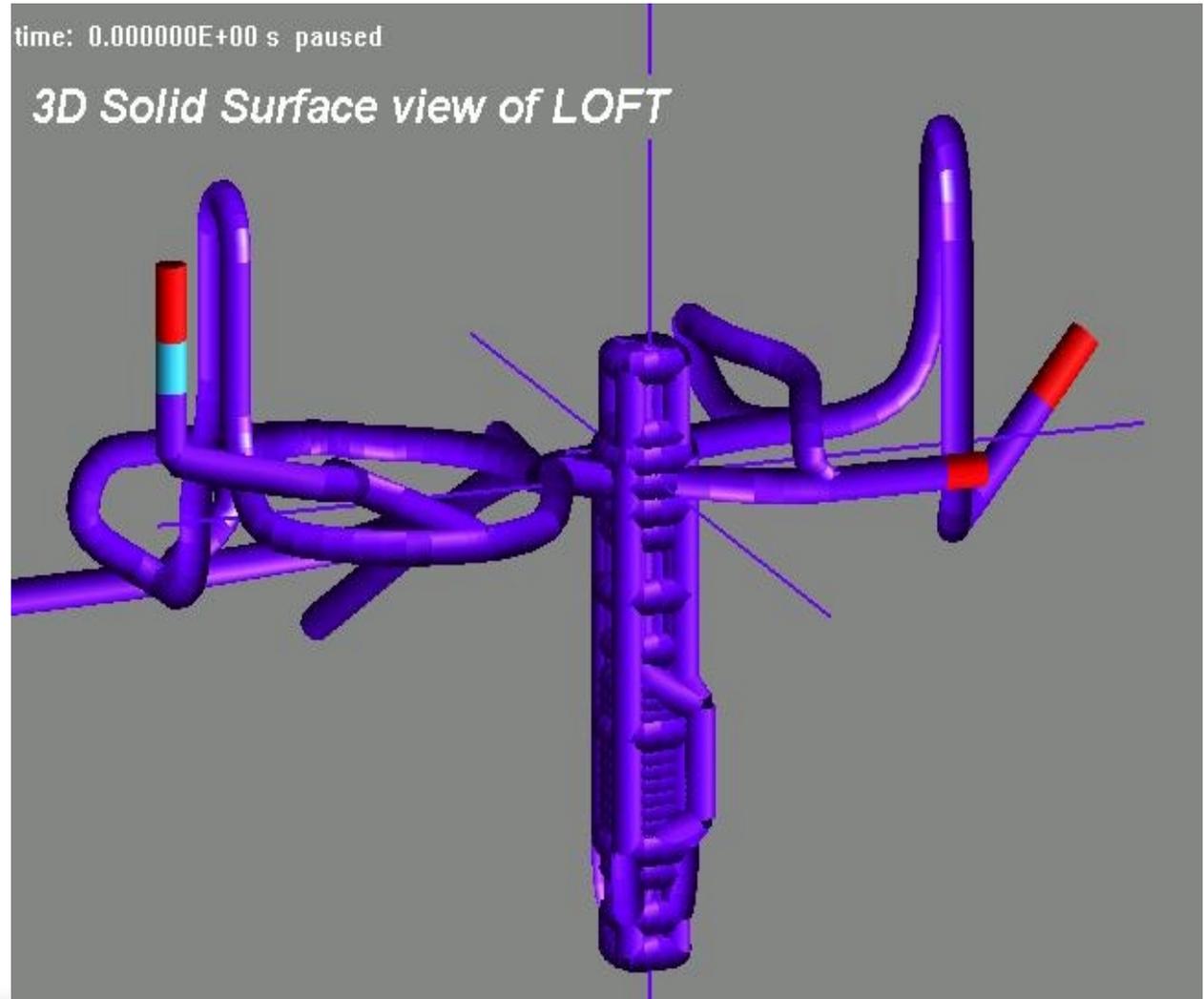
# *3D Pipe View of LOFT, continued*
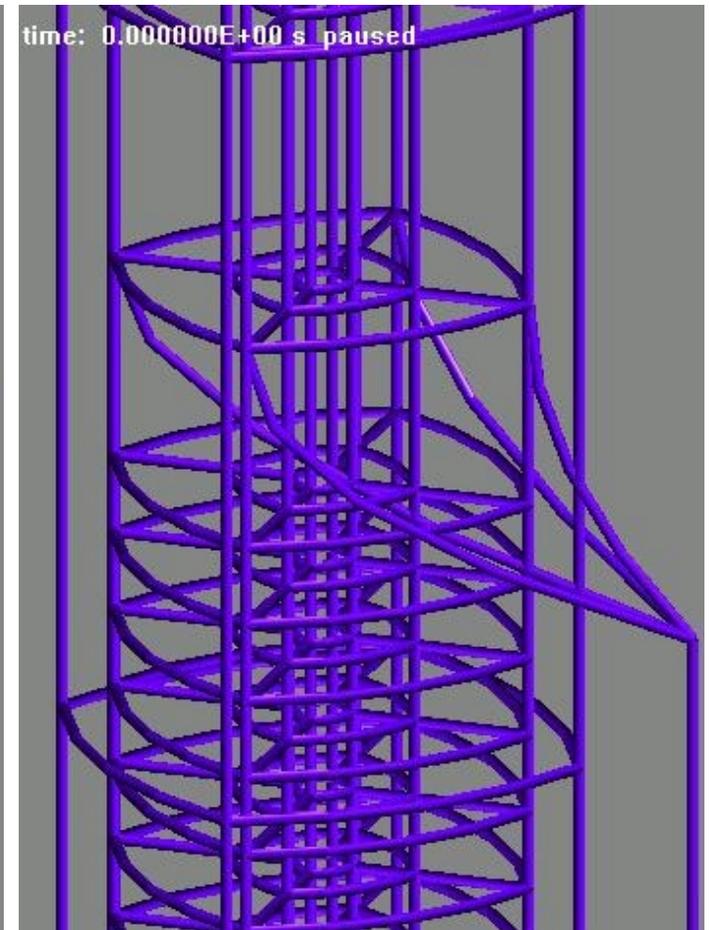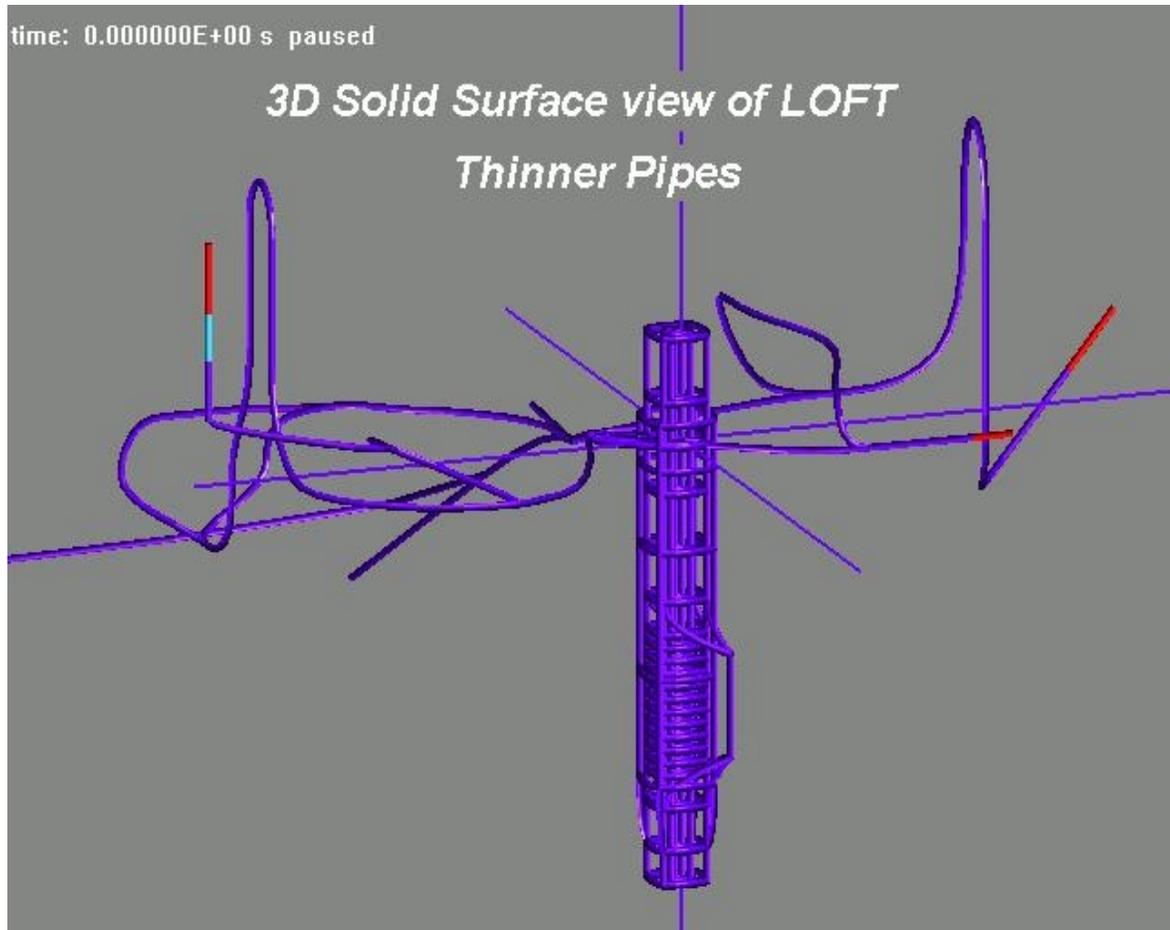
# *New Developments Scheduled for RGUI Version 1.3*

- *Print feature*

- *Input Model Builder*

- *Balloon Help*

- *Neighbors list*

- *User Image Display Aid*

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# *Future Developments Being Considered for RGUI*

- *Modification to run with earlier versions of RELAP5*

- *Displays for*
    - *heat structures*
    - *control variables*
    - *trip logic*
    - *3-D neutron kinetics*
    - *multi-D heat conduction*

- *Speed-up of visuals*

- *3D cross-sections of hydrodynamic visuals*