

# ***Overview of Recent RELAP5 Development***

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*2000 Information Exchange Forum  
October 16-20, 2000    Obninsk, Russia*

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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***

# 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.

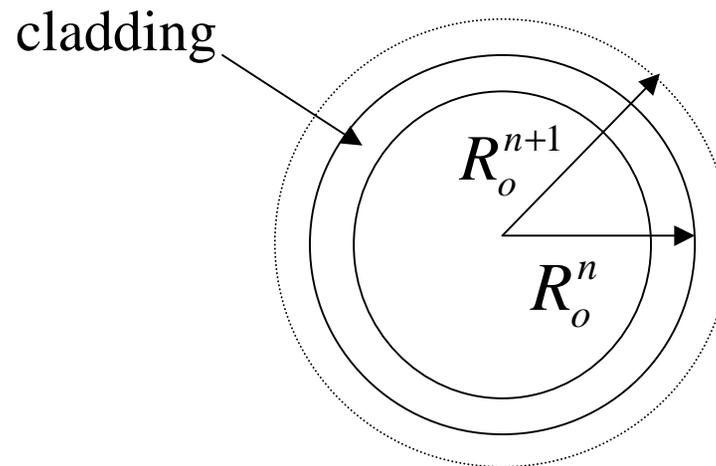
$$A^{n+1} = A^n - \Delta A$$

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

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

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

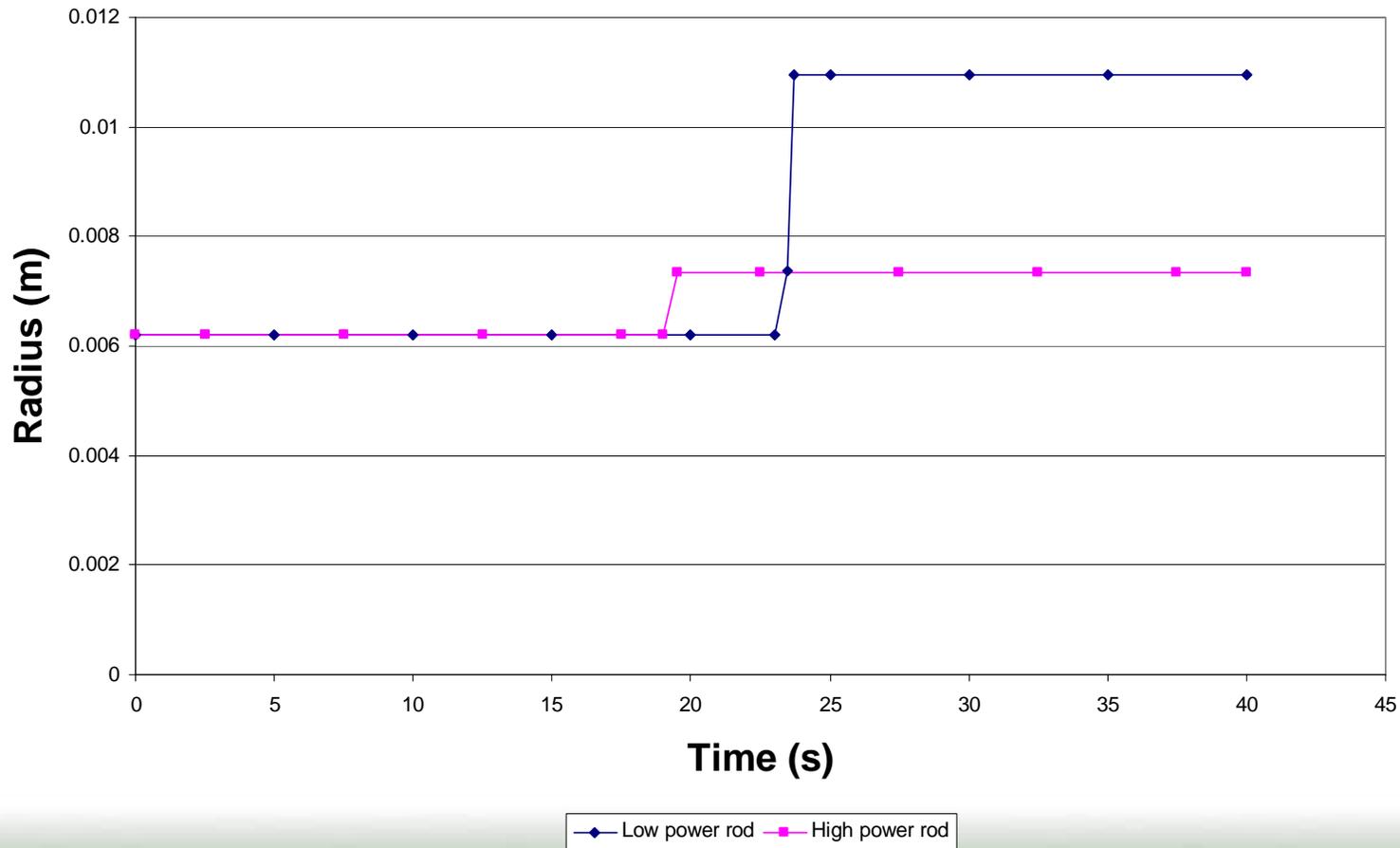
$L_h =$  heat slab length,  $L_v =$  volume length



# Improved Fuel Deformation Model (continued)

Sample problem: Burst of low and high power fuel rods

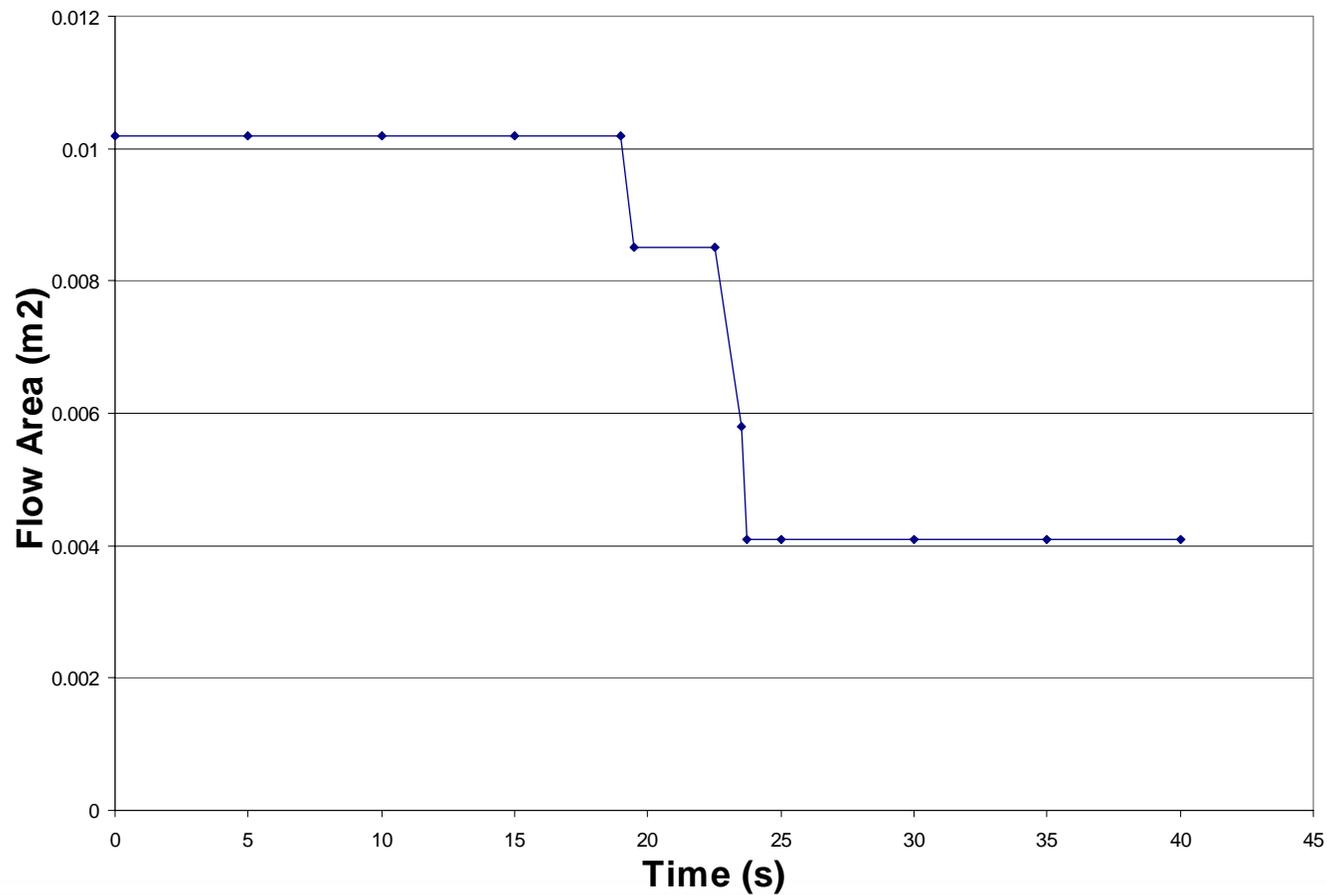
Change in fuel rod radius



# Improved Fuel Deformation Model (continued)

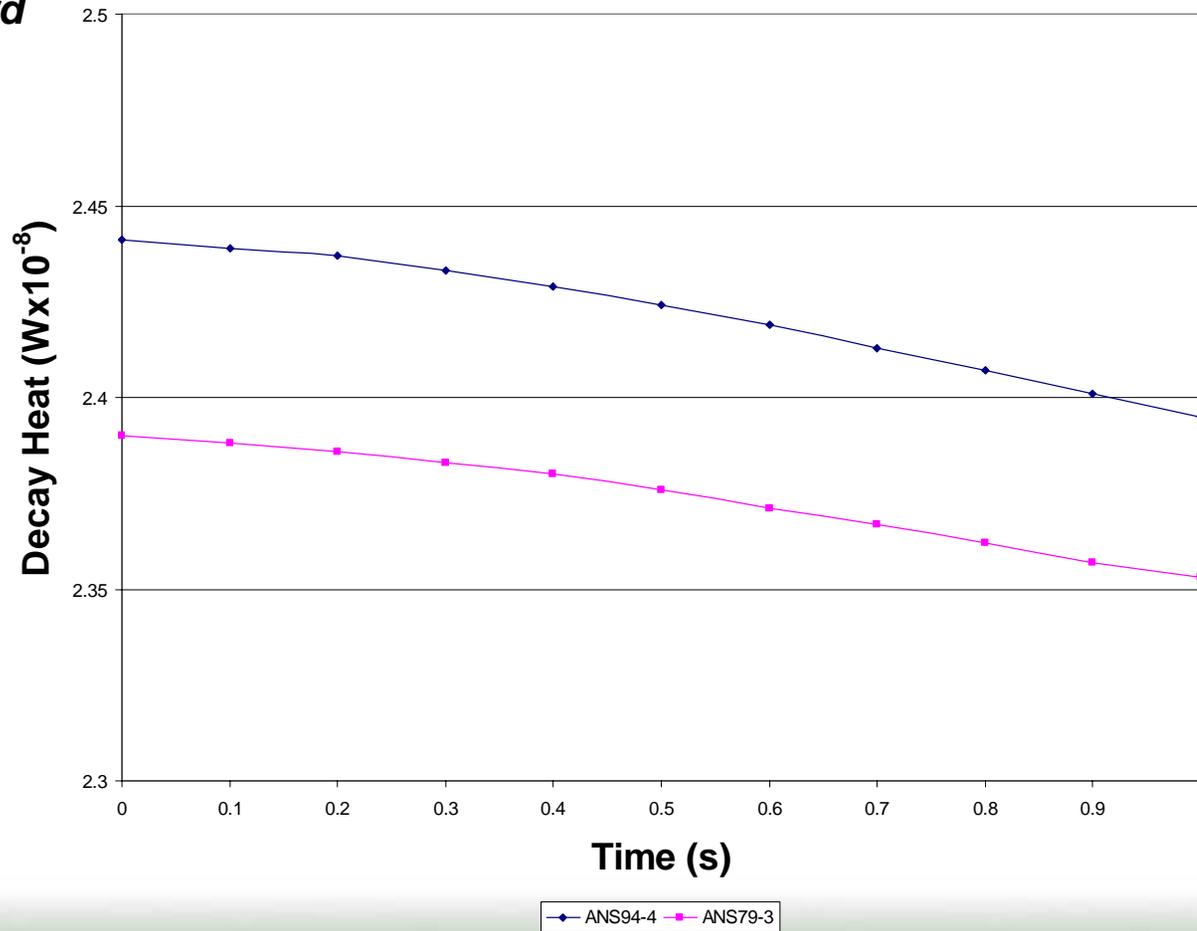
Effect on volume flow area

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<sup>©</sup> 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***

# ***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***

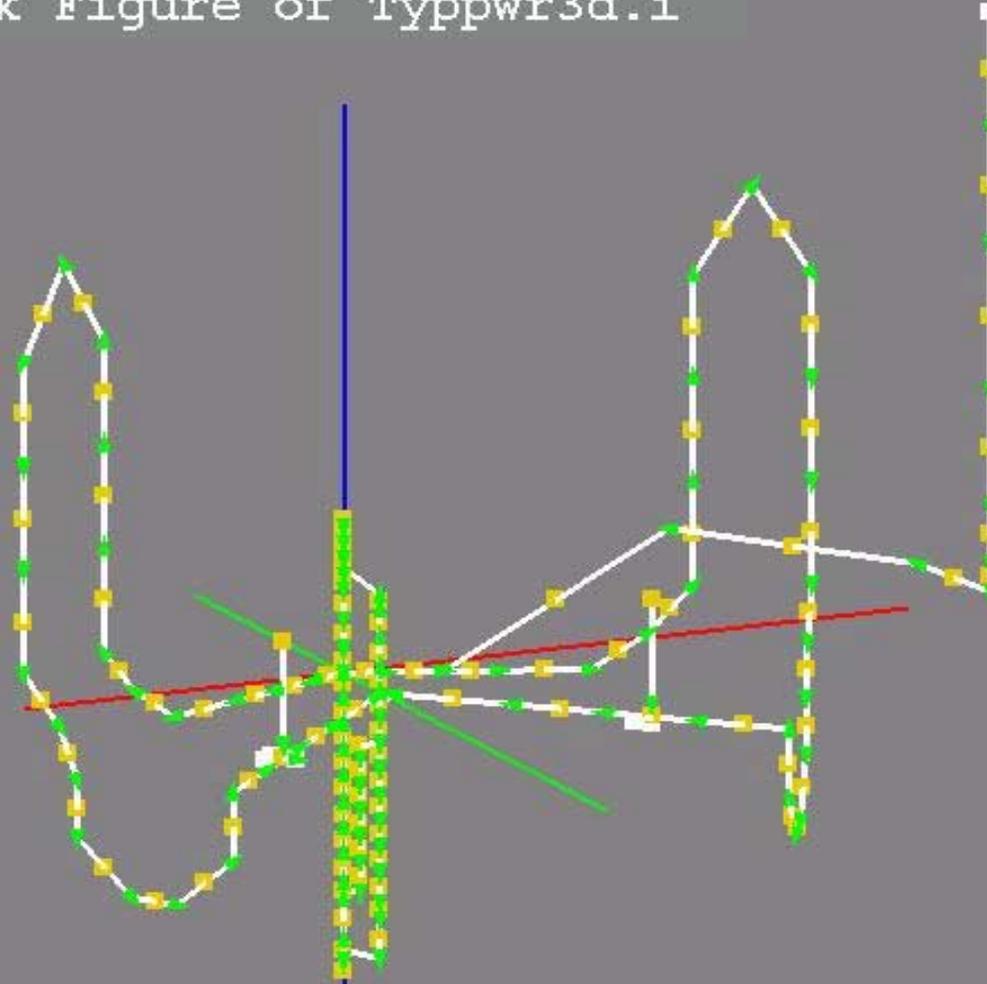
# ***Major Recent Developments in RGUI***

- ***Three-Dimensional Pipes***
  - ***Wireframes, solid surfaces, color maps***
- ***XY-Plots***
  - ***MS-Windows and Unix via tkXMGR5***
  - ***Dynamically updating Point-and-Click plots***
- ***User Annotation***

# Isometric Stick Figure

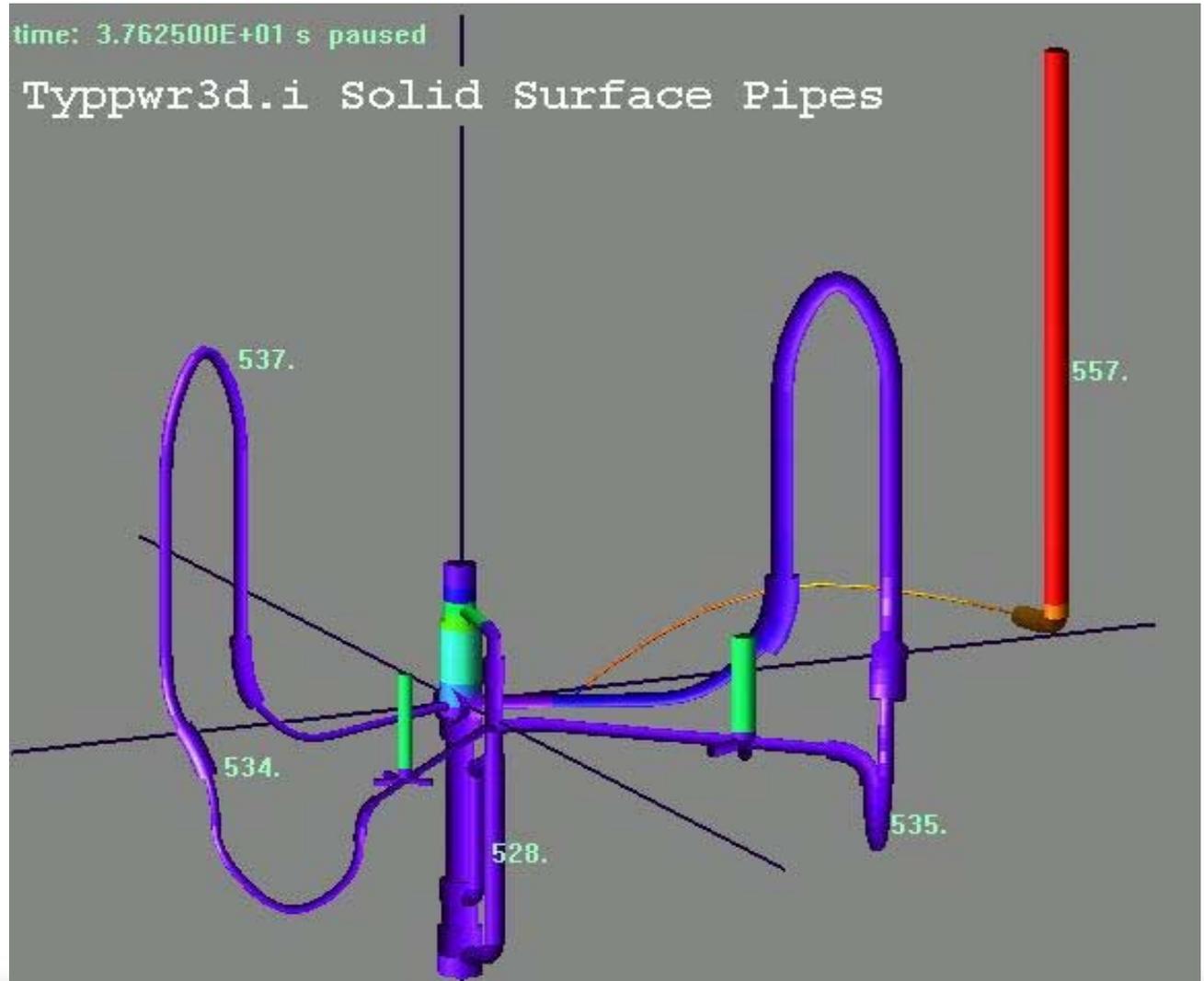
time: 6.312500E+00 s paused

Stick Figure of Typpwr3d.i

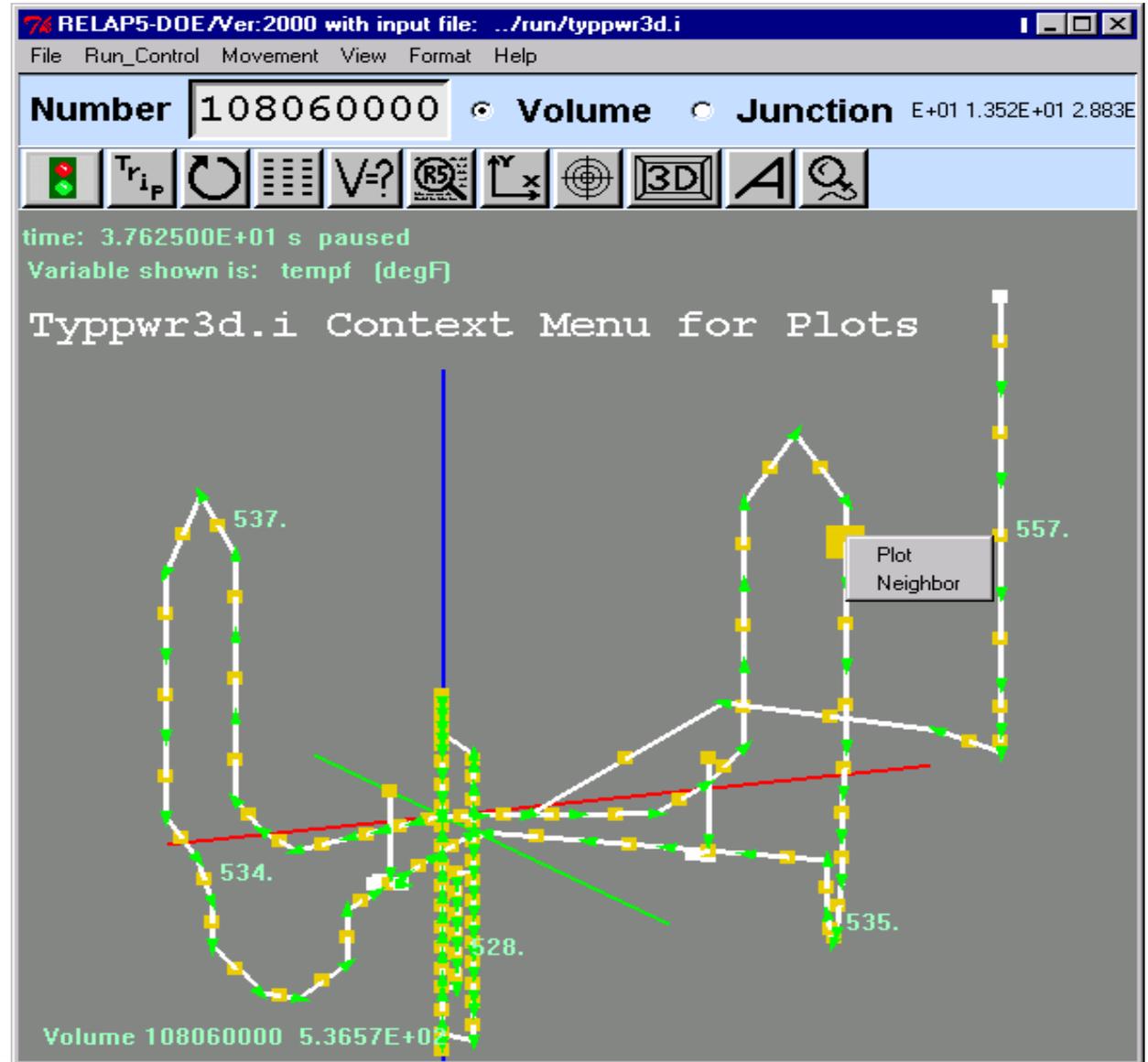


# Improved Display of Multiple Parameters

- **Display variable is fluid temperature.**
- **Color map variable is void fraction.**
- **Flow Area**
- **Three pieces of information at every volume.**

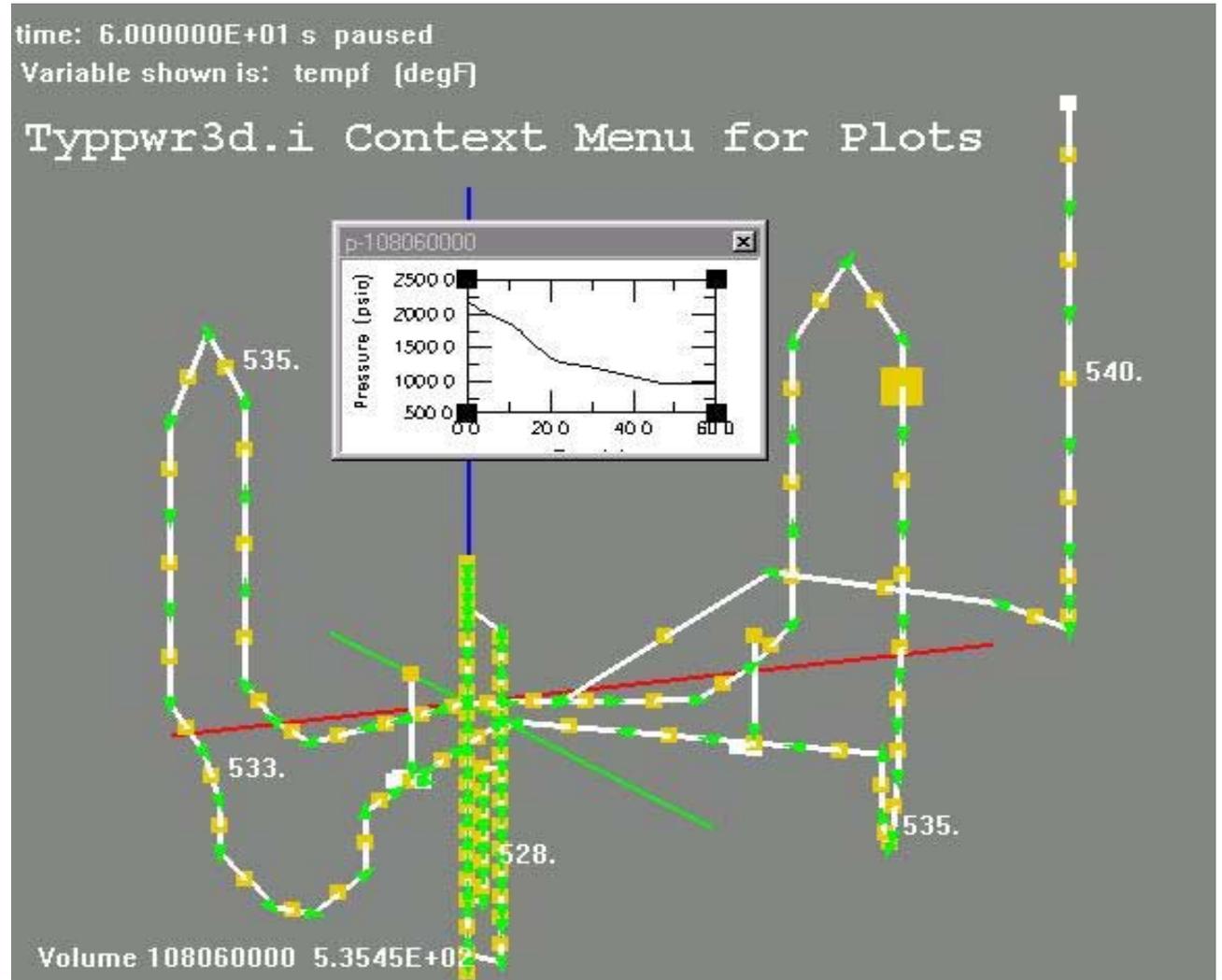


- **Point and click plots available via context menu (right button)**
- **Full sized X-Y plots through the X-Y Plot button**
- **X-Y plots via tkXMGR (adapted from XMGR5) are available on all supported platforms**



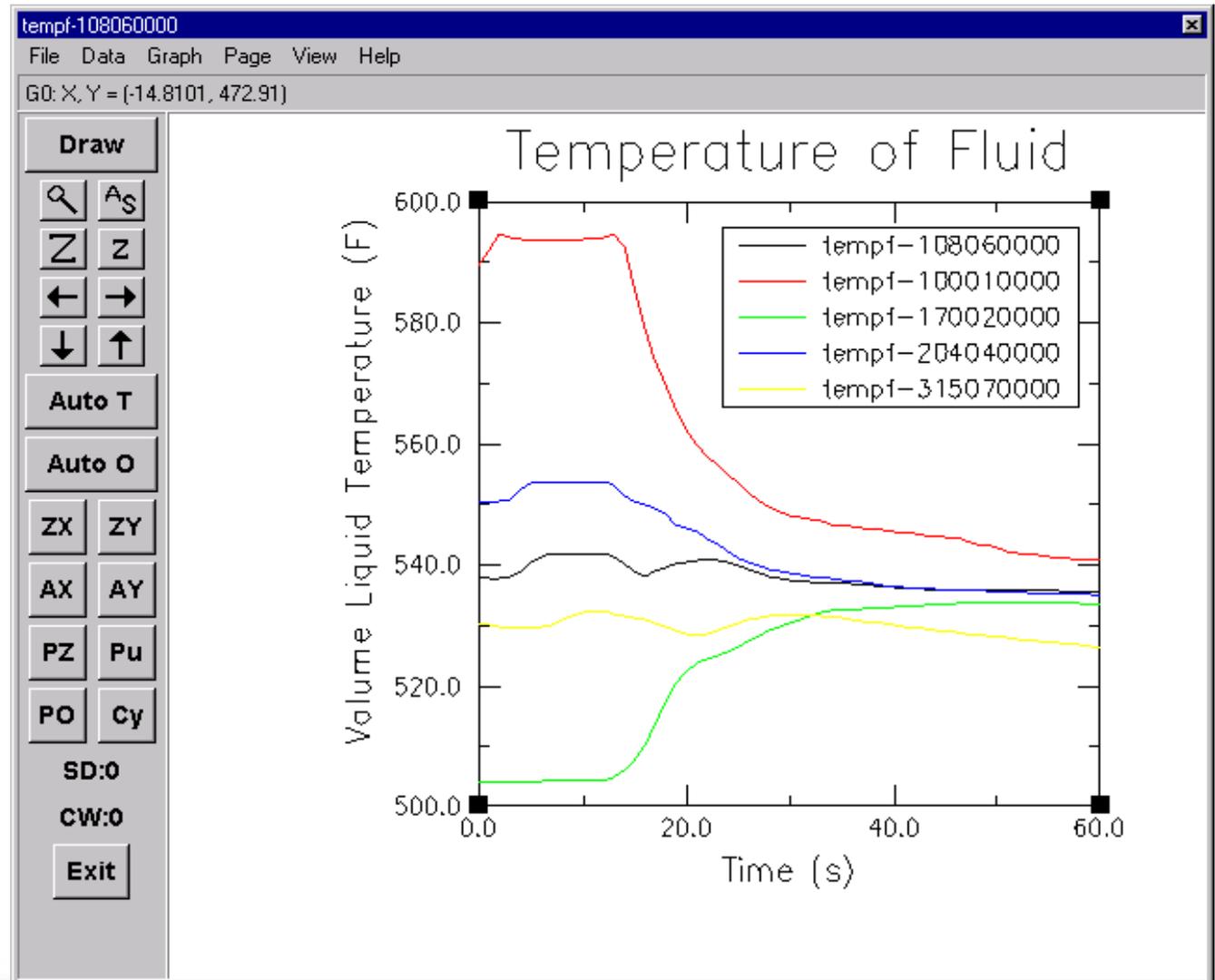
# Point And Click Plot

- **Plot title bar shows variable and number**
- **Automatically updates during calculation**
- **Axes rescale dynamically as calculation proceeds**



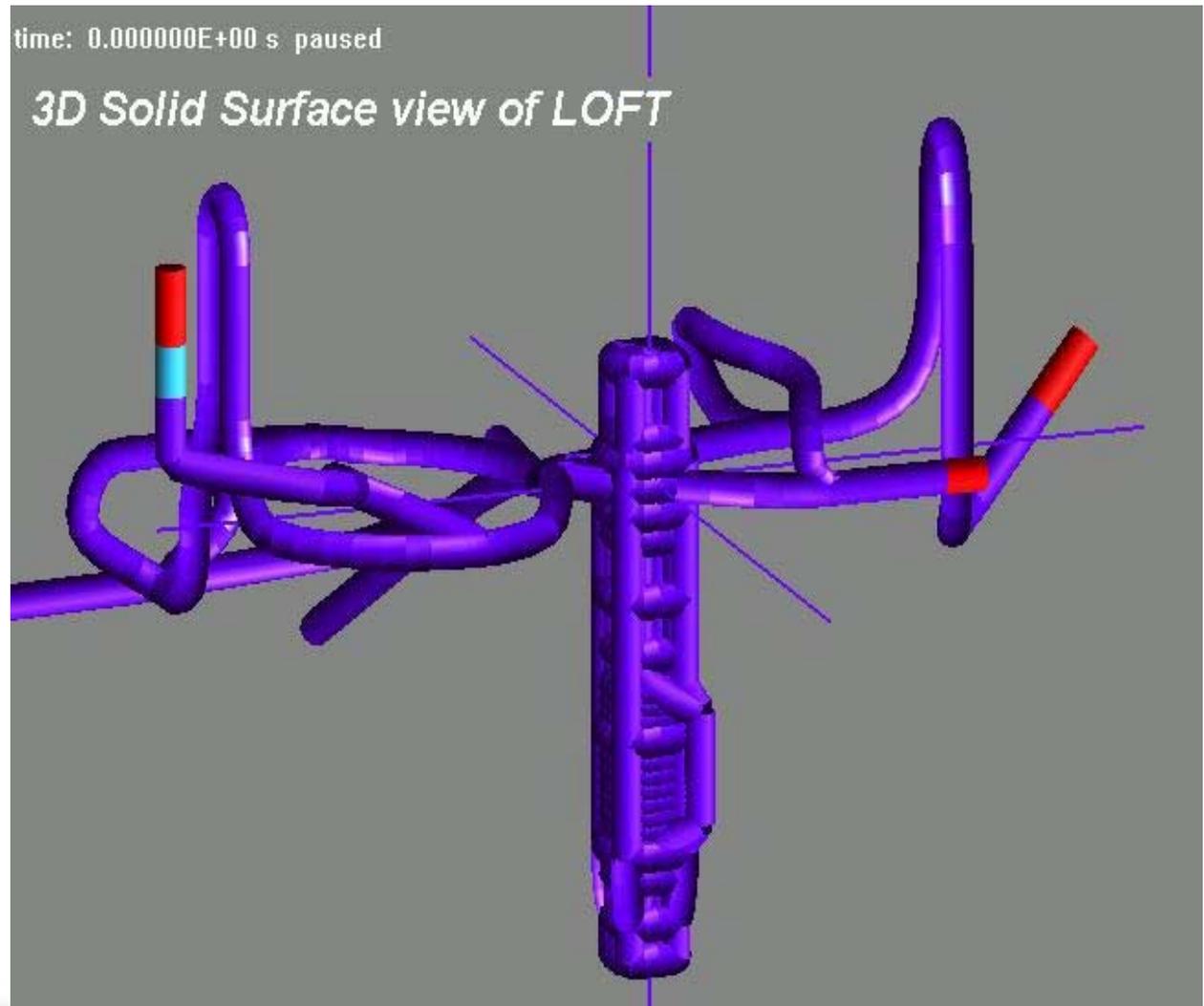
# Full Screen tkXMGR

- **All XMGR capabilities available**
- **Launch from**
  - Isometric Image
  - RELAP5-3D Station
- **Unix & MS-Windows**

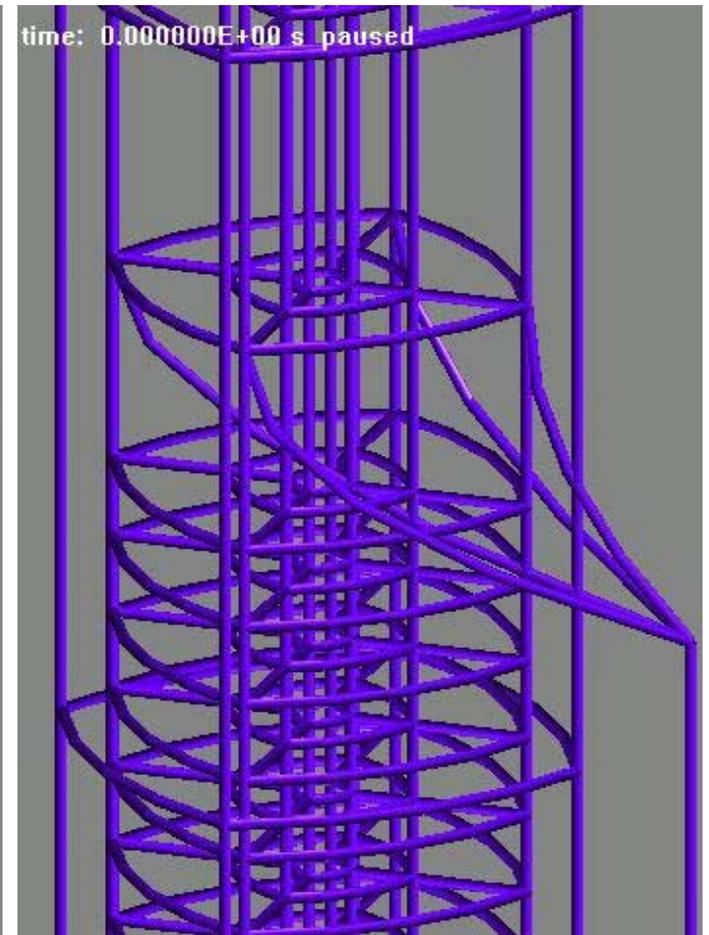
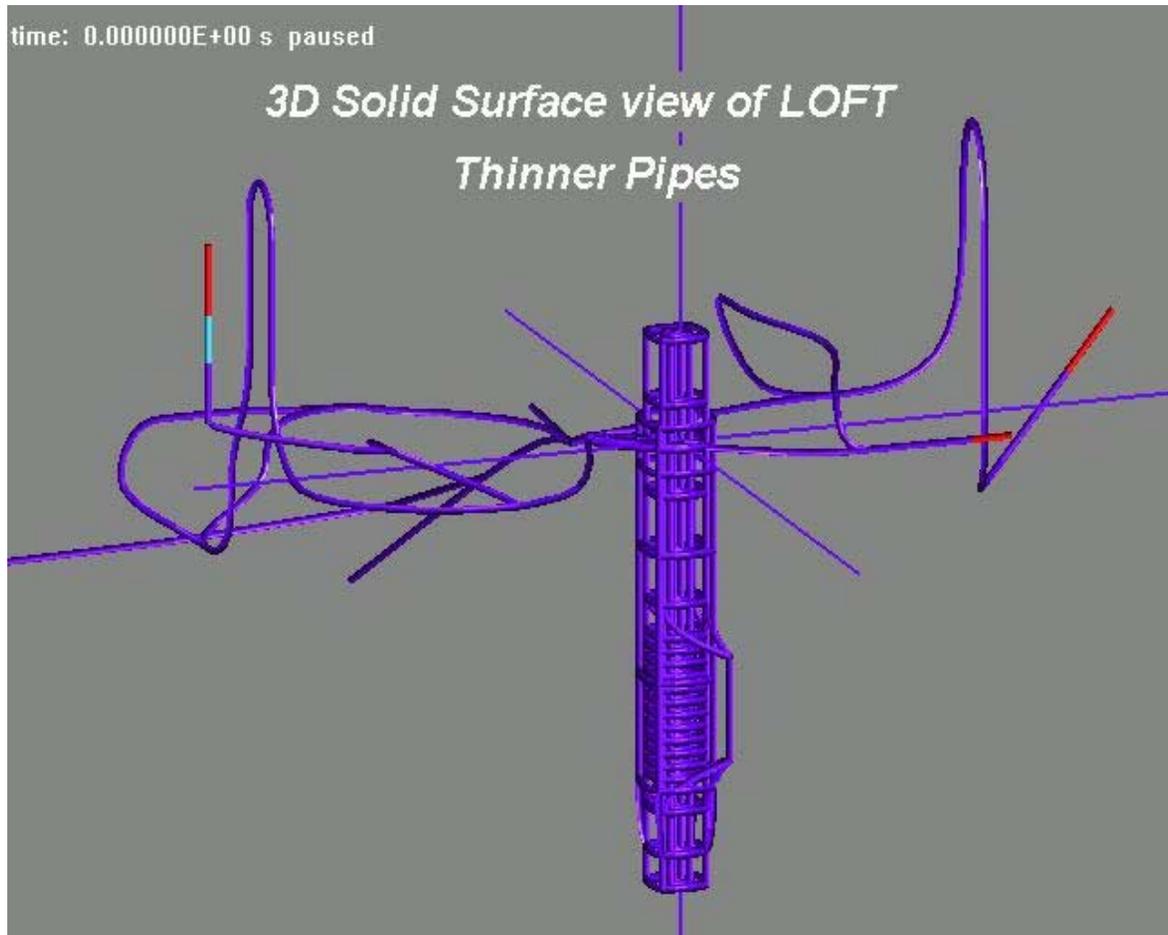


# 3D Pipe View of a 3D Plant Model: LOFT

- *Components easy to identify*
- *Cannot see inside the vessel*



# 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***

# ***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***