RELAP5-3D Development Status

Presented by

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Outline

- Overview of development activities
- Selected reviews
  - Parallel computation
  - 3D downcomer model
  - Improved fuel deformation model
  - 1994 Decay heat model
  - 1995 Water properties
- Ongoing development
- Future work

Development Highlights

Item	Objective
Precompiler for Parallel Processing	Clean up coding for parallel processing on multiple CPU's
Semi-implicit Coupling*	Allow RELAP5-3D to couple to other codes semi-implicitly
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 3D component
RELAP5 Graphical User Interface (RGUI)*	Further enhancements
Fuel Deformation Model	Cause flow area and volume to reduce due to fuel swelling
1994 ANS Decay Heat	Implement 1994 standard
1995 Water Properties	Implement IAPWS-95 standard for water properties
PYGMALION	Restore functionality

* Presentation in seminar

Other Activities

- ATHENA Development
  - Pb/Bi wall heat transfer and void model
  - ITER heat transfer option
- RELAP5/RT Support
  - Installed at Palo Verde, Comanche Peak, Salem, Hope Creek
- INER Support
  - Appendix K version of RELAP5-3D
- INSP Support
- Non-nuclear Applications

Pre-compiler for Parallel Processing

- Objective: Render parallel coding easier to read and maintain
- Method: Achieve parallel execution capability solely through the use of precompiler directives

Example Speed-Up from Parallel Execution

Problem: AP600 model (620 volumes)

	Single Thread	Two Threads	% Change
CPU time (sec)	26115.33	36073.22	+38.1
Wall clock time (sec)	26416.78	18344.03	-30.6

Downcomer Pressure Drop Model

Problem: Original implementation of 3D component model required at least two radial nodes to properly compute the pressure change due to momentum flux from a one-dimensional pipe to a multidimensional downcomer.

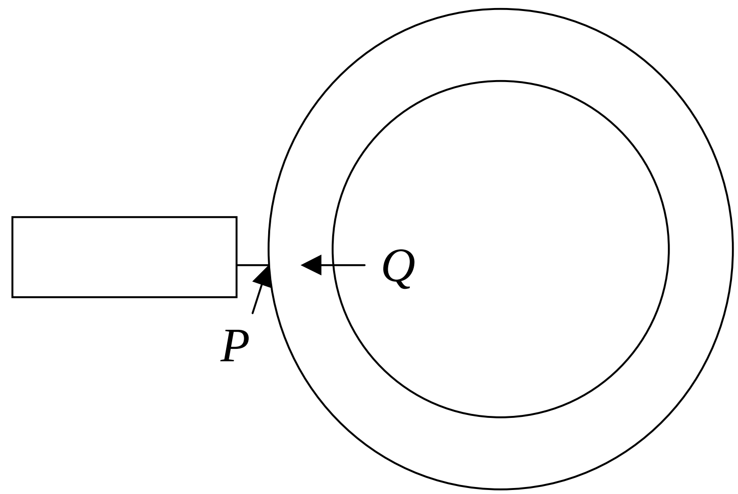
$$\Delta p_{MF} = \rho\left(v_r \frac{\partial v_r}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_r}{\partial \theta} + v_z \frac{\partial v_r}{\partial z} - \frac{v_\theta^2}{r} \right)$$

Cross derivative terms ill-defined for one radial ring

Downcomer Pressure Drop Model (cont'd)

The last term is computed assuming v_θ is constant in the radial direction:

$$\int_P^Q \frac{v_\theta^2}{r}\,dr = v_\theta^2 \log\left({r_Q}/{r_P} \right)$$



The momentum flux pressure change is then given by:

$$\Delta P = -\rho\left[v_r \Delta v_r - v_\theta^2 \log\left({r_Q}/{r_P} \right) \right]$$

Improved Fuel Deformation Model

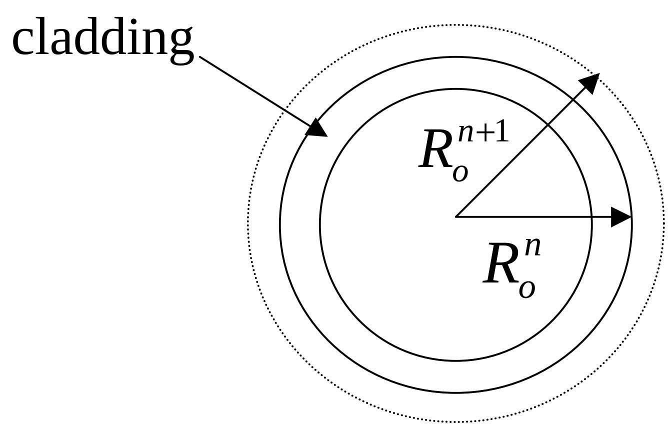
The existing fuel swelling and rupture model was improved to account for the effects on control volume flow area, volume, and hydraulic diameter.

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

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

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

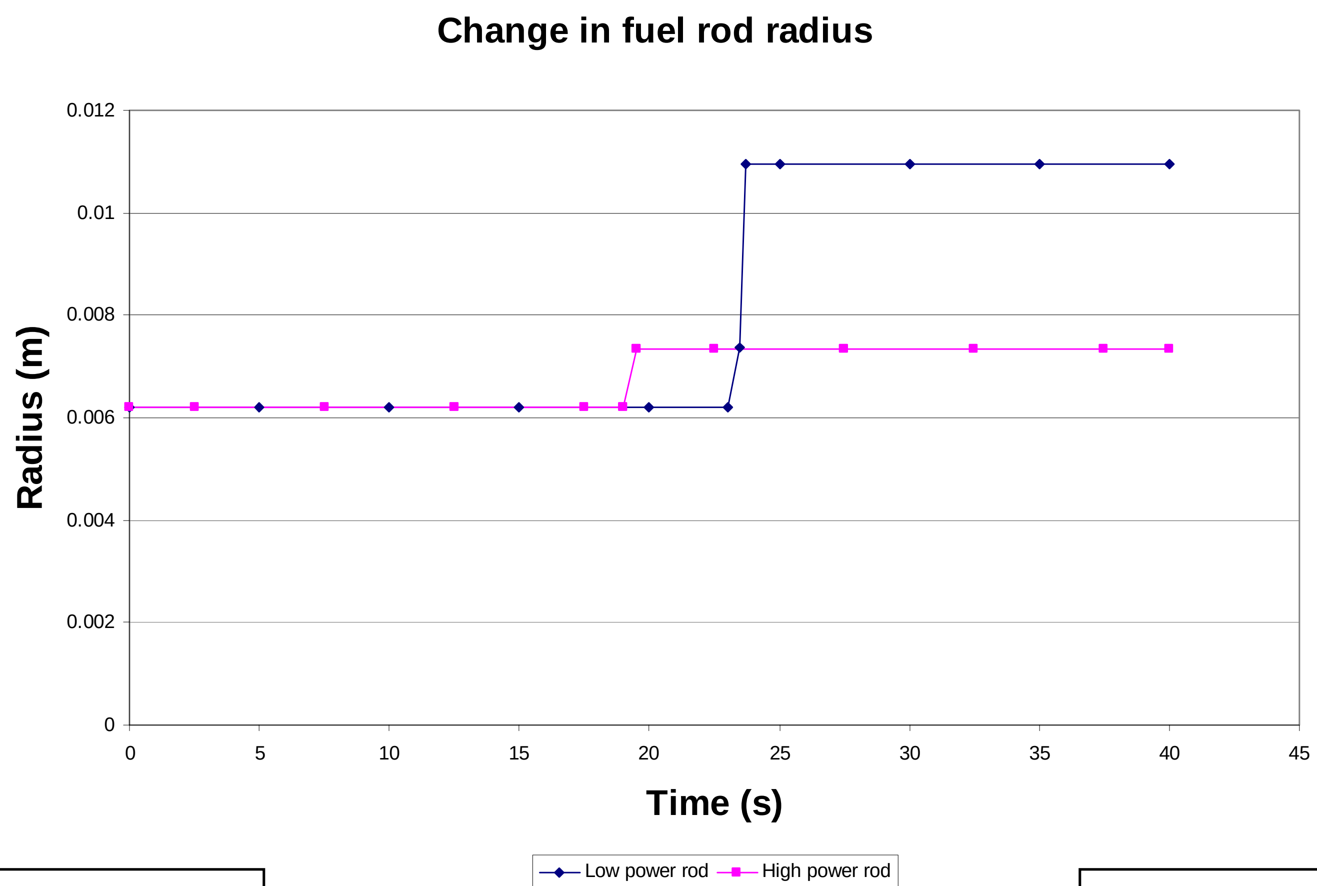
$$D_h^{n+1} = D_h^n \frac{A^{n+1}}{A^n}$$



L_h= heat slab length, L_v= volume length

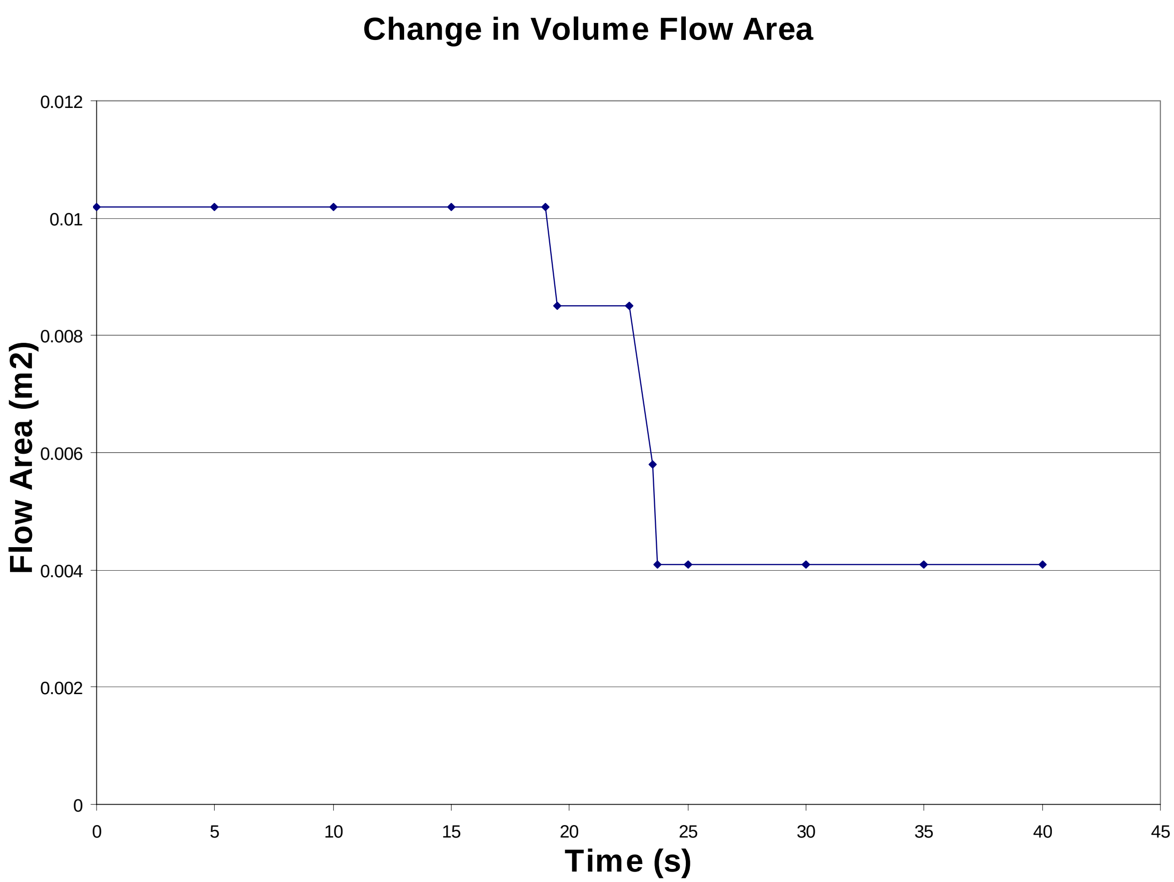
Improved Fuel Deformation Model (cont'd)

Sample problem: Burst of low and high power fuel rods



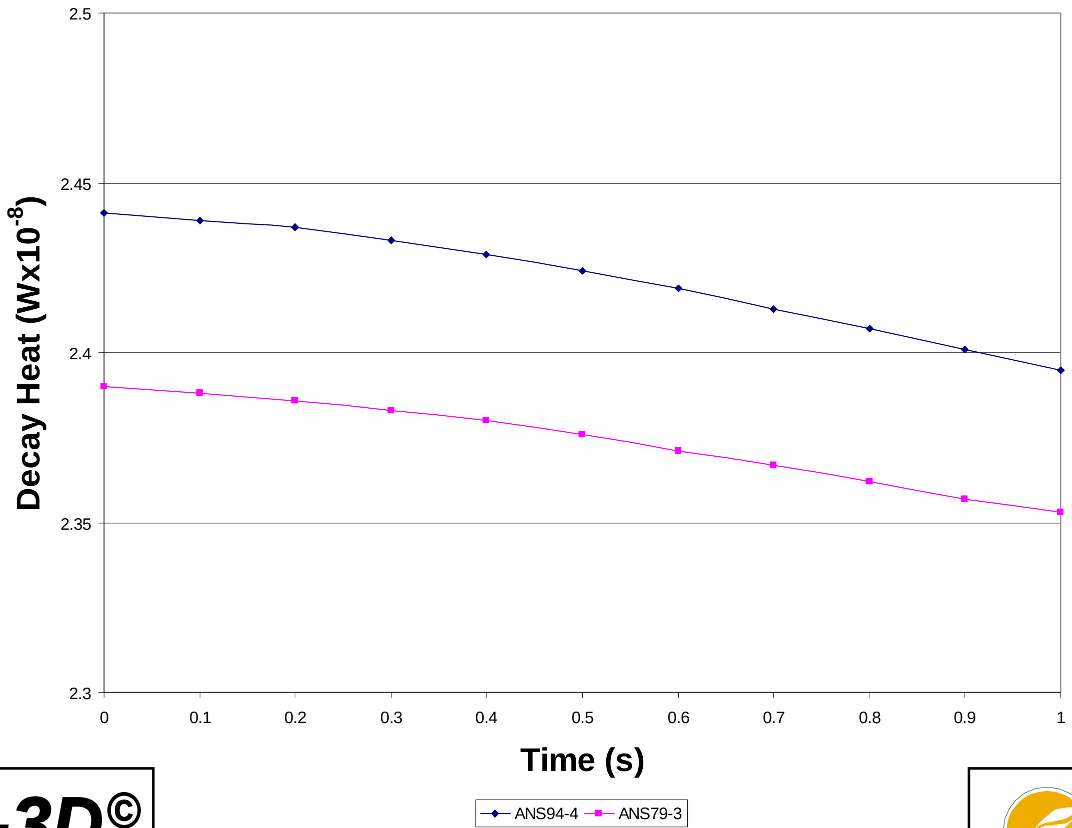
Improved Fuel Deformation Model (cont'd)

Effect on volume flow area



1994 Decay Heat Standard

The ANS94-4 Standard produces slightly higher decay heat than the ANS79-3 Standard



New Water Properties

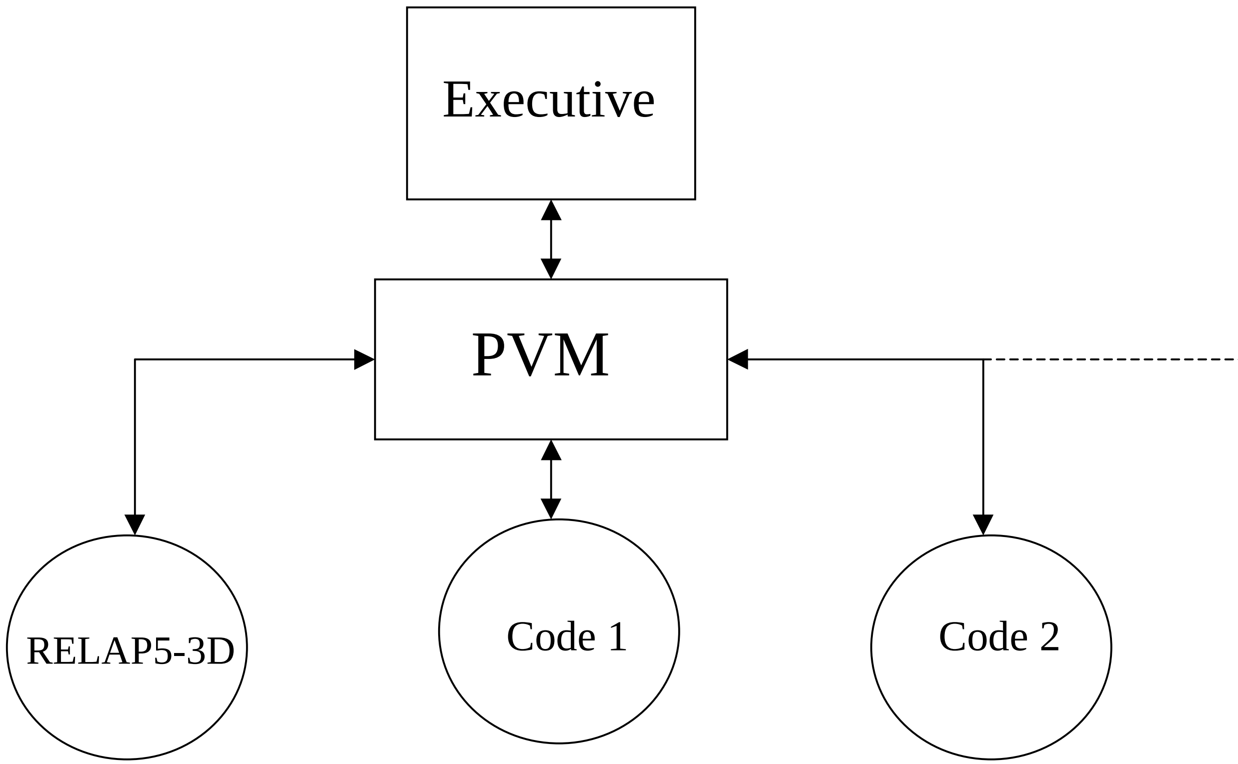
- Implemented IAPWS-95 Formulation
- New tables built from calls to NIST STEAM routines from new ‘stgh2o95’ program in environmental library
- Transport property tables also built from NIST routines: thermal conductivity, dynamic viscosity, and surface tension

Ongoing Development

Advancing the code coupling capability:

- Executive for code coupling
- Kinetics coupling

Executive for Code Coupling

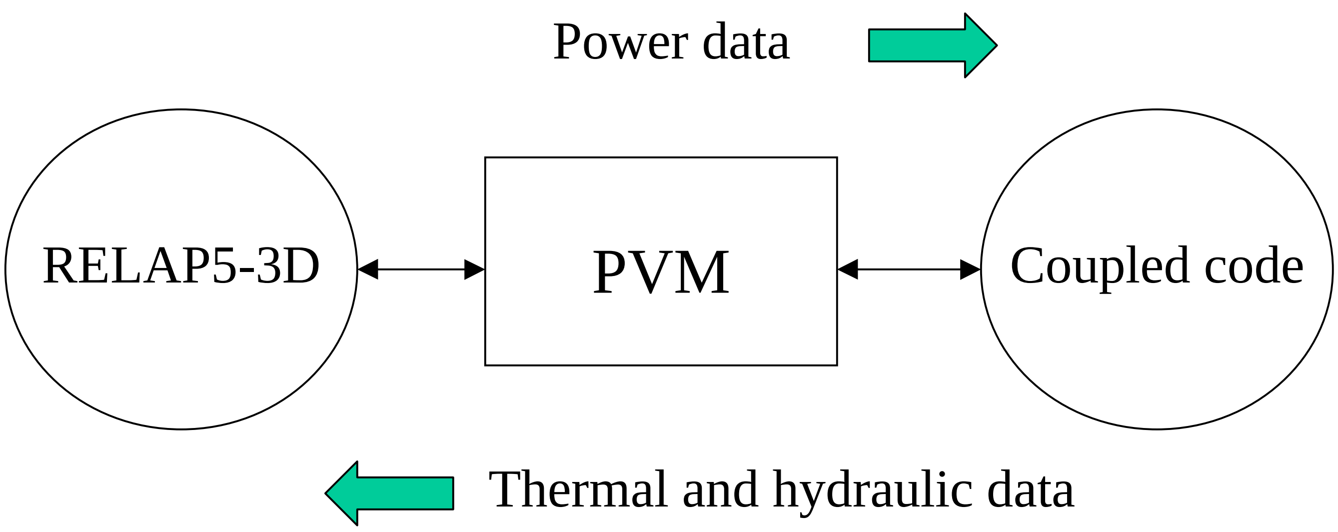


Functions of the Executive

- Start the codes to be coupled
- Coordinate choice of time step size
- Control code output (plot/print frequencies)
  – Each code maintains its own output files
- Explicit or semi-implicit coupling

Kinetics Coupling

Objective: Transmit Kinetics-related data between RELAP5-3D and a coupled code



Future 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