Top guide
Core shroud
ICM guide tube
ΔP/SLC piping
Feedwater Sparger
Core Spray Sparger
Core Plate
Jet pump

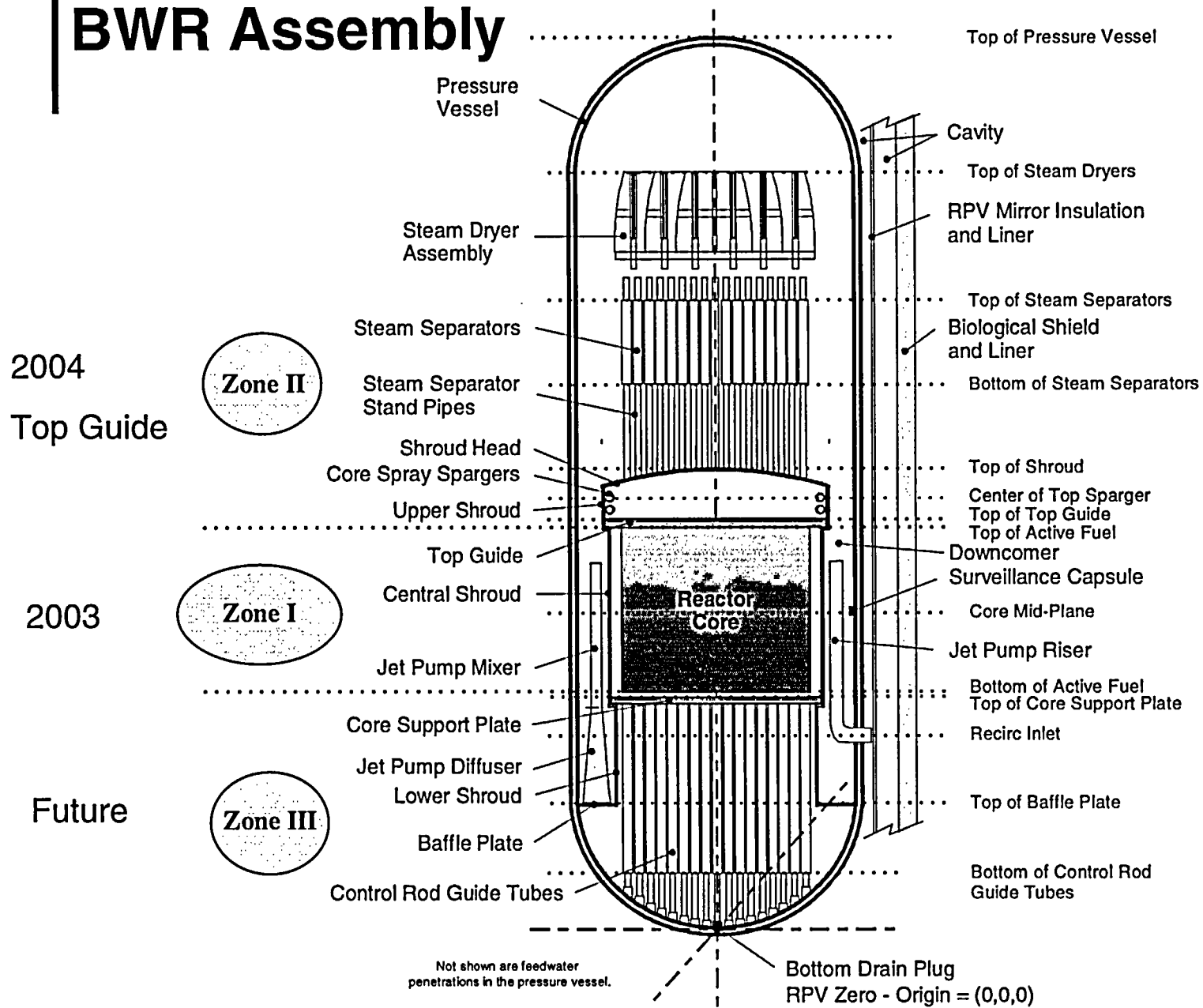# Status of RAMA Fluence Methodology

Bob Carter

EPRI

EPRI

Overview of RAMA

- Calculates neutron and gamma flux distributions

- Uses 3-D modeling
  - actual representation of component shapes
  - capable of modeling entire reactor system

- Integral transport solution in 3-D

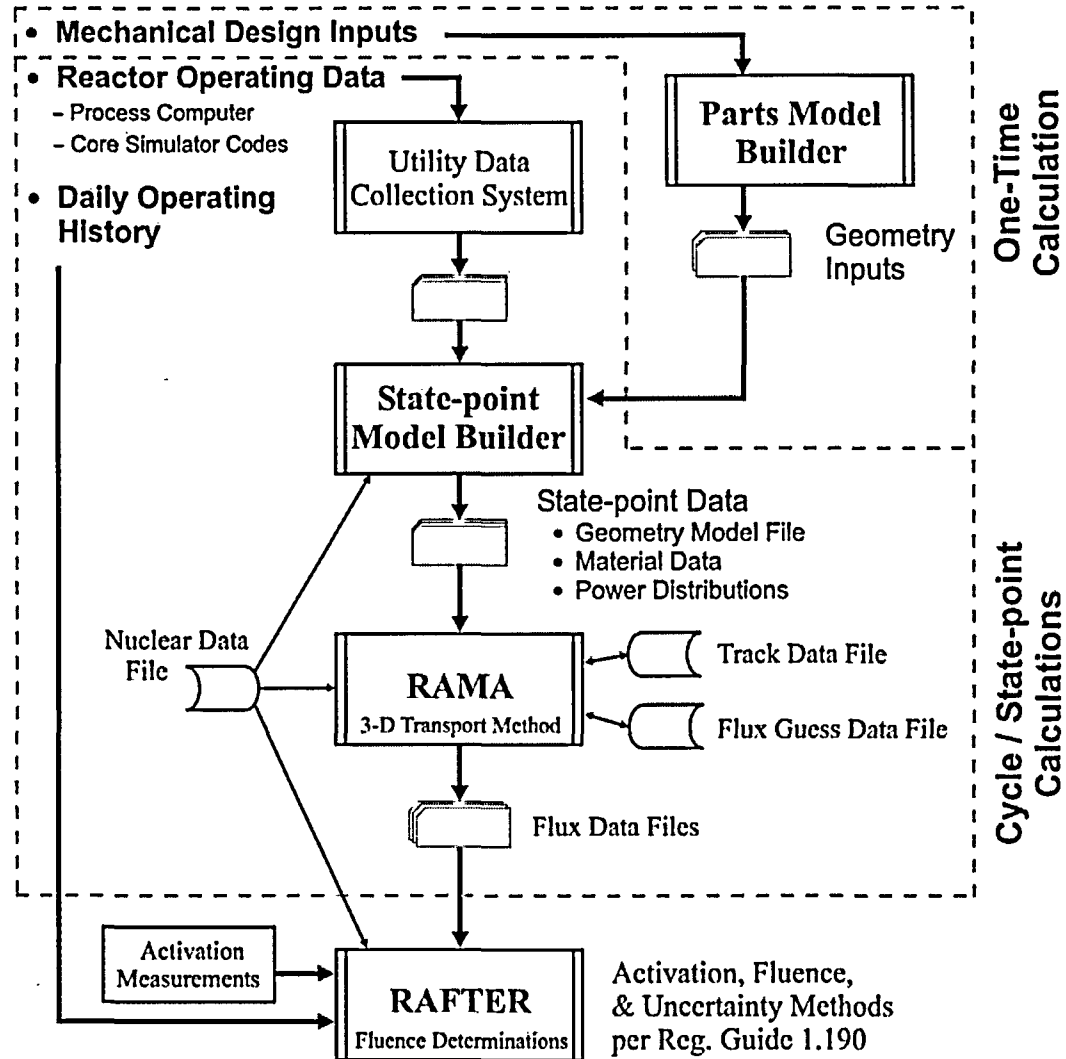- Detailed (p7) anisotropic scattering treatment

Overview of RAMA – Modeling

- Accurate 3-D Modeling
  - Straight and Curved Surfaces
  - Symmetry Modeling Capability

- Automated Geometry Modeling Tools Available
  - Parts Model Builder (PMB)
    - Generates geometry models of standard components
    - User specified dimensions and meshing
    - Each component built separately and combined later
  - State-point Model Builder
    - Uses the reactor operating data (i.e., state point data) to process inputs for the geometry model built by the PMB code
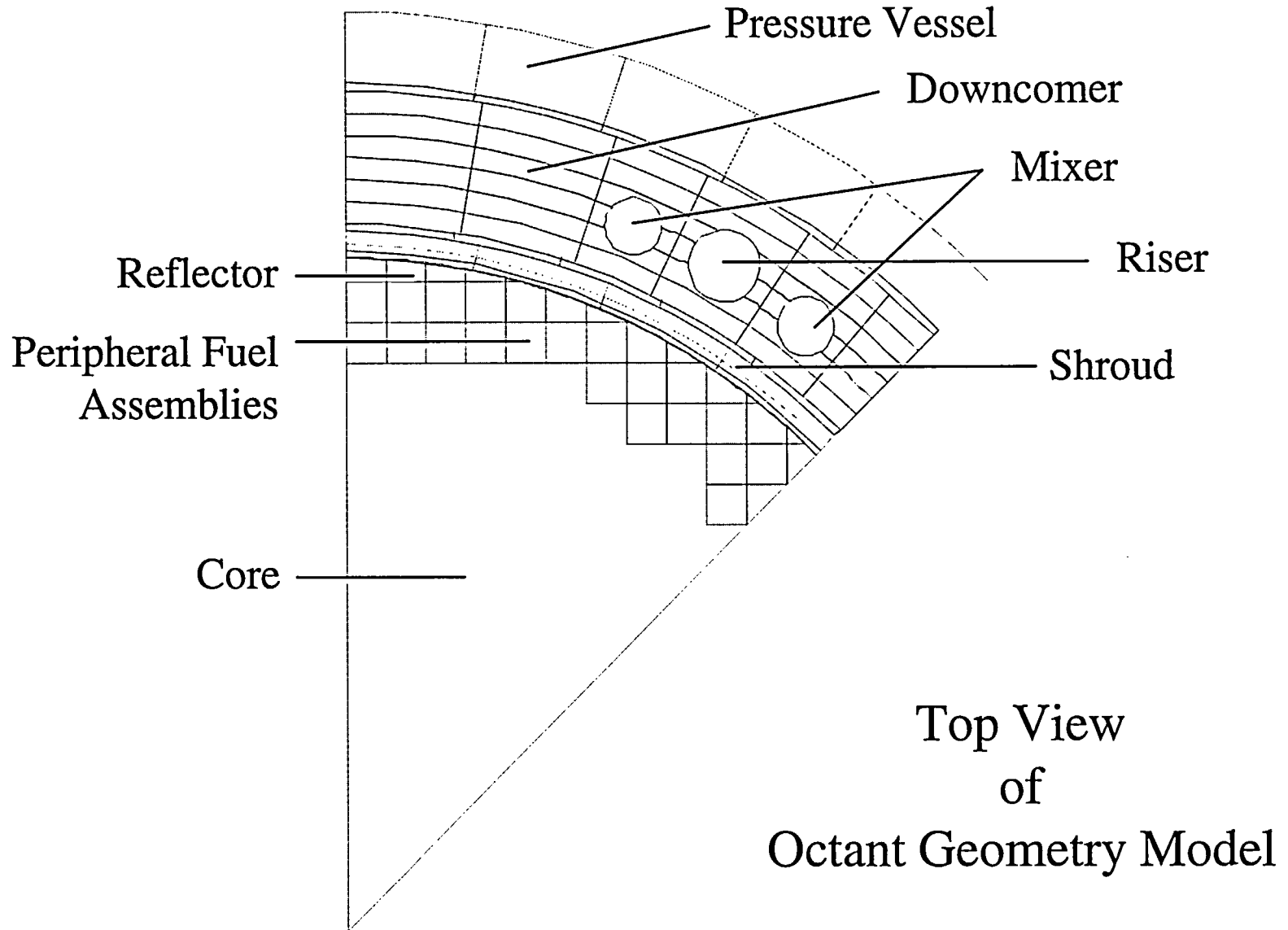
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BWR Assembly

Top of Pressure Vessel

Pressure Vessel

Cavity

Top of Steam Dryers

RPV Mirror Insulation and Liner

Steam Dryer Assembly

Top of Steam Separators

Steam Separators

Biological Shield and Liner

2004

Zone II

Steam Separator Stand Pipes

Bottom of Steam Separators

Top Guide

Shroud Head
Core Spray Spargers

Top of Shroud

Center of Top Sparger
Top of Top Guide
Top of Active Fuel

Upper Shroud

Top Guide

Downcomer

Central Shroud

Surveillance Capsule

2003

Zone I

Core Mid-Plane

Jet Pump Mixer

Jet Pump Riser

Core Support Plate

Bottom of Active Fuel
Top of Core Support Plate

Jet Pump Diffuser

Recirc Inlet

Future

Zone III

Lower Shroud

Top of Baffle Plate

Baffle Plate

Control Rod Guide Tubes

Bottom of Control Rod Guide Tubes

Reactor Core

Not shown are feedwater penetrations in the pressure vessel.

Bottom Drain Plug
RPV Zero - Origin = (0,0,0)

BWRVIP

4

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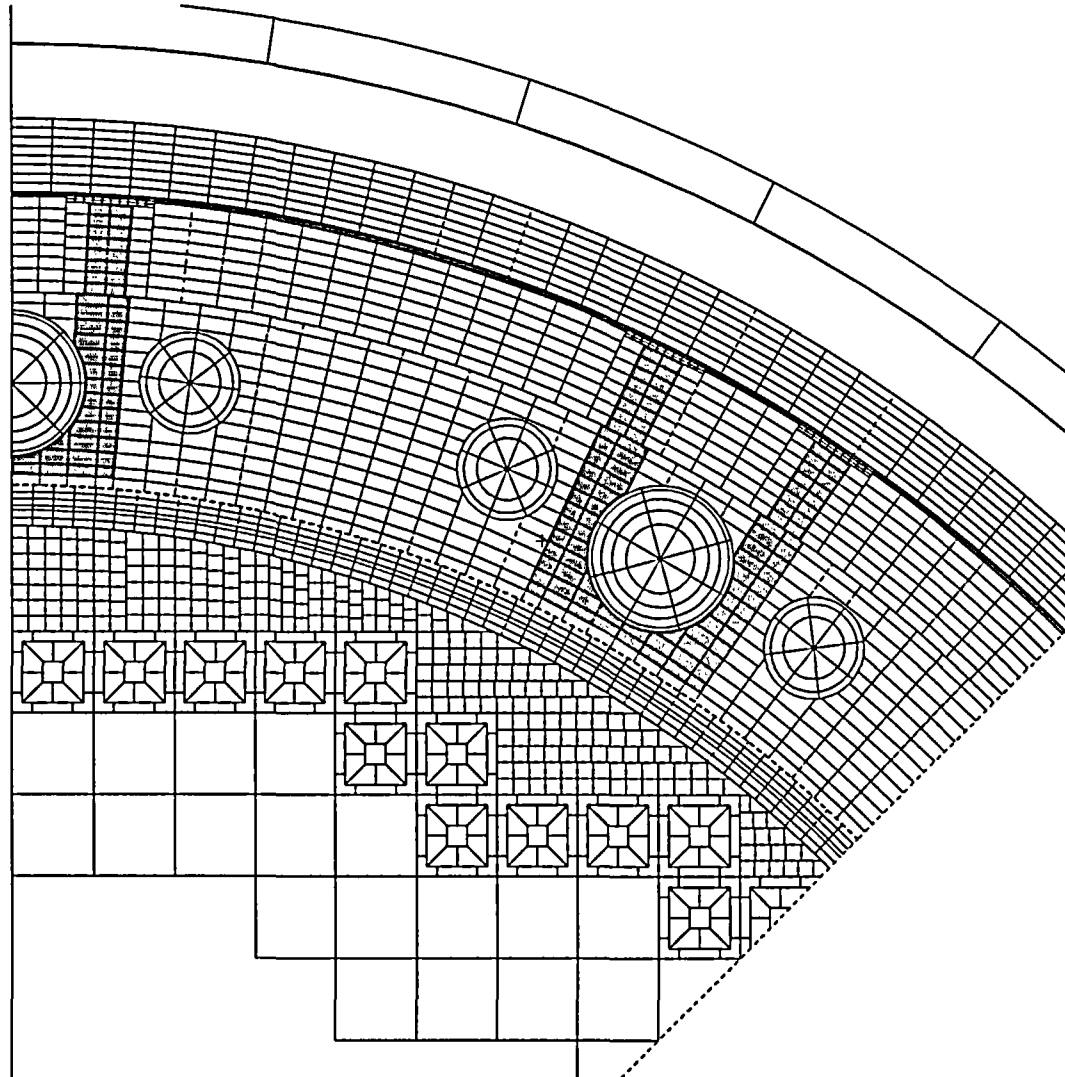# RAMA Fluence Methodology Calculation Flow Diagram

RAMA Model

Pressure Vessel

Downcomer

Mixer

Reflector

Riser

Peripheral Fuel
Assemblies

Shroud

Core

Top View
of
Octant Geometry Model

RAMA Model
Peripheral Pin-by-Pin Vs Coarse Mesh

BWR-4
Homogenized Fuel Assembly Model

BWR-4
Peripheral Pin-by-Pin Geometry
Fuel Assembly Model

Pressure Vessel
Downcomer
Shroud
Reflector

Core

N
0

0   345.44 cm

E

Pressure Vessel
Downcomer
Shroud
Reflector
Peripheral
Fuel Assemblies

Core

N
0

0   345.44 cm

E
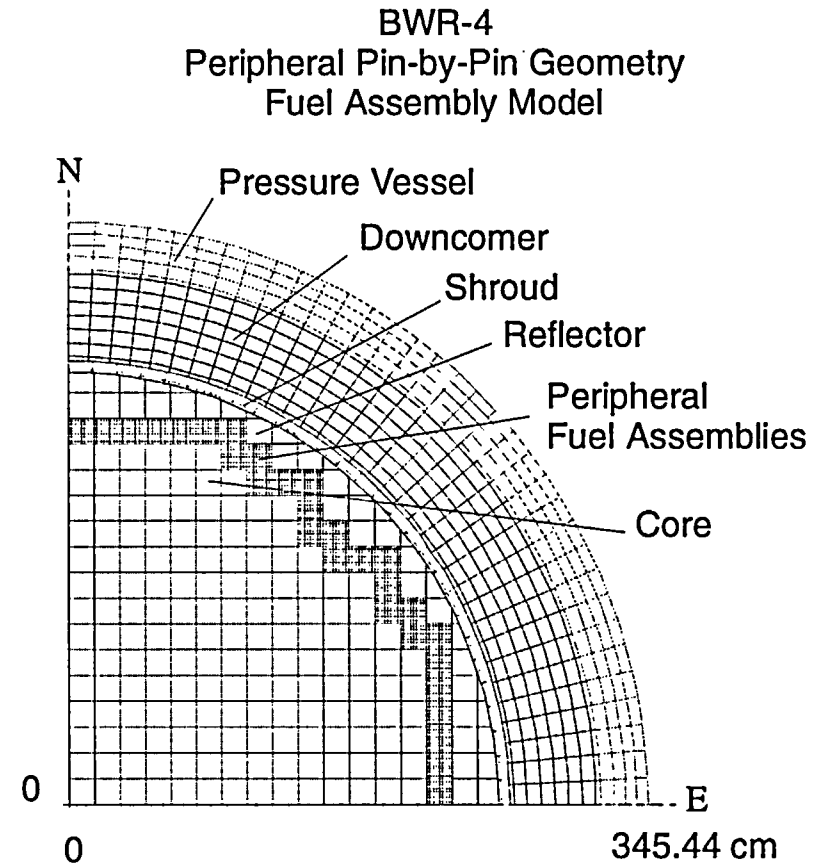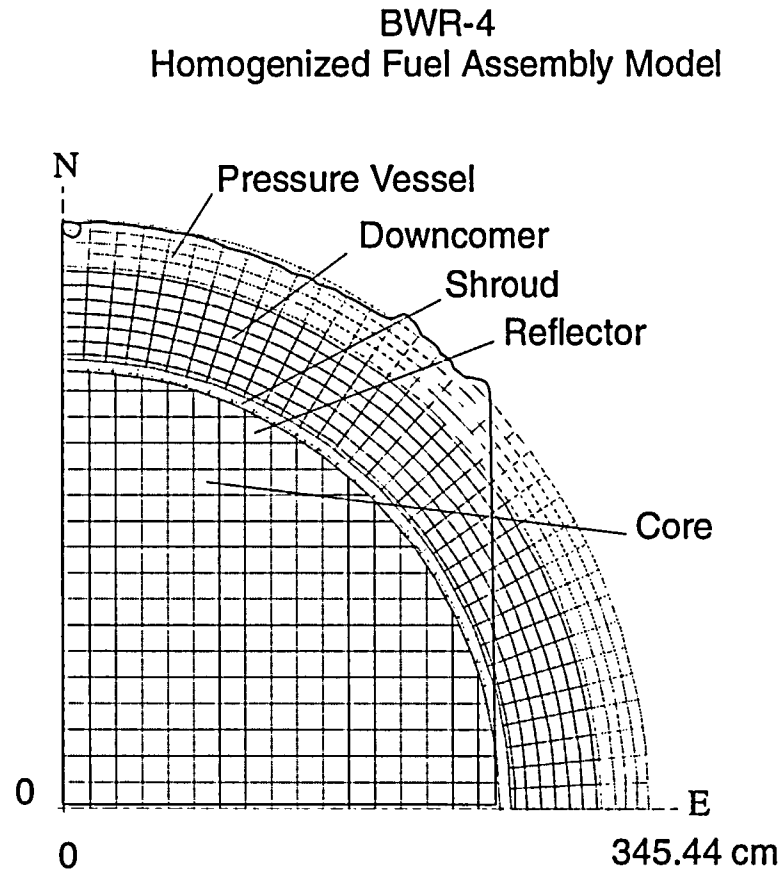
Example of Hatch 1 Model

Benchmarking of RAMA in 2003

- Regulatory Guide 1.190 Benchmarks
  - Poolside Critical Assembly
  - Venus-3
  - H.B. Robinson
  - BWR Numerical Benchmark

- Plant Applications
  - Susquehanna Unit 2 first surveillance capsule
  - Hope Creek first cycle dosimetry
  - Hatch Unit 1 jet pump riser brace boat sample

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Results of Benchmarking

- In general, all RAMA benchmarking calculations performed to date are in good agreement with measurements
  - RAMA does not agree well with some aspects of the BWR numerical benchmark
    - Possible reasons include differences in required inputs between 2-D code (DORT) and RAMA

RAMA Reports in 2003

- BWRVIP-114: BWR Vessel and Internals Project, RAMA Fluence Methodology Theory Manual

- BWRVIP-115: BWR Vessel and Internals Project, RAMA Fluence Methodology Benchmark Manual - Evaluation of Regulatory Guide 1.190 Benchmark Problems

- BWRVIP-117: BWR Vessel and Internals Project, RAMA Fluence Methodology Plant Application – Susquehanna U2

- BWRVIP-121: BWR Vessel and Internals Project, RAMA Fluence Methodology Procedure Manual

- BWRVIP-xxx: BWR Vessel and Internals Project, RAMA Fluence Methodology Plant Application – Hope Creek

Planned Activities for RAMA in 2004

- NRC report on comparison of DORT and RAMA for jet pump riser brace location at Hatch 1

- Fluence reanalysis of SSP Capsules D, G and H (BWRVIP-87)

- Fluence of SSP Capsules A, B and C from Cooper plant
  - Includes reanalysis of 2 original capsules previously withdrawn

- Benchmarking of core shroud and top guide samples removed from Susquehanna U2

- Address NRC comments on RAMA fluence methodology

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Summary

- RAMA is a robust methodology to facilitate the building of complex reactor problems, and to perform the three-dimensional flux calculation, fluence analysis, and uncertainty analysis.

- Development of software completed

- RAMA calculations are in very good agreement with benchmark problems indicating the methodology is accurately predicting neutron flux, dosimetry measurements, and component fluence.

- Several 2004 activities planned to further benchmark RAMA and address NRC comments