U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
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Use of SCALE to Generate Neutron Cross Sections Libraries in Support of PARCS/TRACE Reactor Analysis Activities

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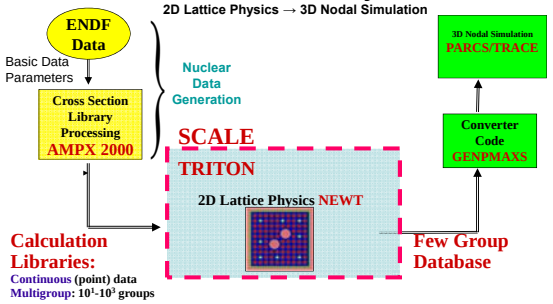
Introduction

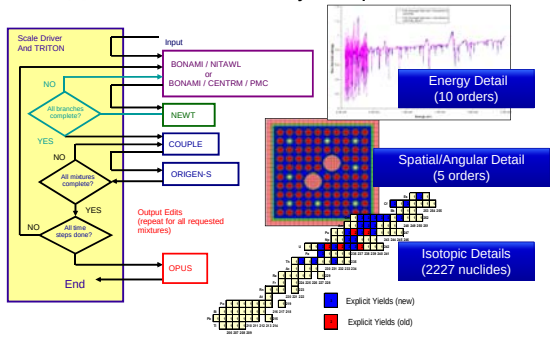
- The SCALE computer code was developed at Oak Ridge National Laboratory (ORNL) for NRC beginning in 1976
- It is a multi-purpose computational system for analyses of various nuclear systems and phenomena, including:
  - Criticality safety
  - Radiation shielding
  - Spent nuclear fuel and high level waste characterization
  - Reactor physics
- The scope of this presentation deals with the use of SCALE in generating the neutron cross section libraries needed by the PARCS/TRACE reactor analysis codes.

Reactor Core Analysis

2D Lattice Physics → 3D Nodal Simulation



TRITON Control Module
Lattice Physics Sequence



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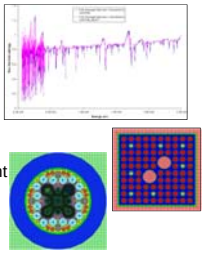
TRITON
Reactor Physics Analysis

- 2D Lattice physics analysis
  - few-group cross-section preparation
  - branch states
- Key features:
  - continuous-energy resonance self-shielding
  - flexible geometry modeling
  - depletion with ORIGEN, with most recent data for more than 2000 nuclides
- Additional capabilities
  - 3D Monte Carlo depletion
  - 1D depletion using XSDRN
  - 2D sensitivity and uncertainty analysis



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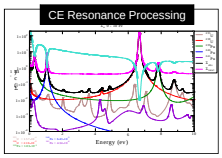
Resonance Self-Shielding of Multigroup Cross Sections

- CENTRM (Continuous Energy TRansport Module) calculates 1-D discrete ordinates continuous energy flux spectrum for a unit cell.
- PMC (Pointwise Multigroup Converter) uses continuous energy flux and cross sections from CENTRM to generate problem-dependent multigroup cross sections.
- CENTRM/PMC explicitly handles effects from the following:
  - fissile material in the fuel and surrounding moderator
  - overlapping resonances
  - anisotropic scattering
  - inelastic level scattering
- BONAMI
  Bondarenko factors for unresolved resonance region



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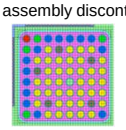
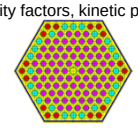
NEWT

2-D Multigroup Transport Solver

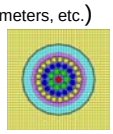
- NEWT (NEW Transport Algorithm) is a two-dimensional transport solver
  - uses discrete ordinates (solves for angular fluxes)
  - is based on the Extended Step Characteristics (ESC) method
  - uses arbitrary geometry with automated grid generation
  - calculates a steady-state flux solution
  - calculates lattice physics data (few-group cross-sections, assembly discontinuity factors, kinetic parameters, etc.)



BWR 8x8



VVER 440



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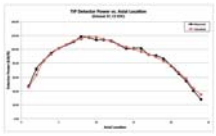
BWR Lattice Physics Analysis using SCALE and PARCS

- Recent evaluation of Peach Bottom Unit 2 Cycles 1 and 2 using SCALE 6.1:
  - SCALE evaluated10 lattice designs.
  - Each lattice design depleted at 6 different in-channel void fractions and Control Rod (CR) conditions (0%, 40%, 80% with CR in and out).
  - Each depletion calculation modeled at ~40 depletion steps and 12 branch cases.
  - The analysis did over 4,800 evaluations to generate few-group cross-section database.

Peach Bottom Unit 2 Cycle 1 Lattice



Peach Bottom Unit 2 Cycle 2 TIP Power at EOC

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Evolution of SCALE Lattice Physics

- SCALE 5.0 (2004)
  - initial release of TRITON/NEWT
- SCALE 5.1 (2006)
  - double-heterogeneous XS processing capability
  - Coarse Mesh Finite Difference (CMFD) acceleration
  - generation of database file for GENPMAXS
- SCALE 6.0 (2008)
  - prismatic assemblies
- SCALE 6.1 (2011)
  - CMFD for prismatic assemblies
  - parallel computation of branch cases
  - support for user-input Dancoff factors

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Future Lattice Physics Enhancements

- Run time improvements
  - Reduce run time by approximately a factor of 5.
  - Modernization of cross-section processing, transport, and depletion modules.
  - Improved parallelism
- New capability
  - Embedded Self-Shielding Method (ESSM) for cross-section processing.
  - New Method of Characteristics flux (MoC) solver similar to industry codes.
- Simplified user interface
  - Simplified LWR-specific input will be ~100 lines.
  - Simplified lattice physics output.

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