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Generating Light Water Reactor ORIGEN Libraries with Polaris

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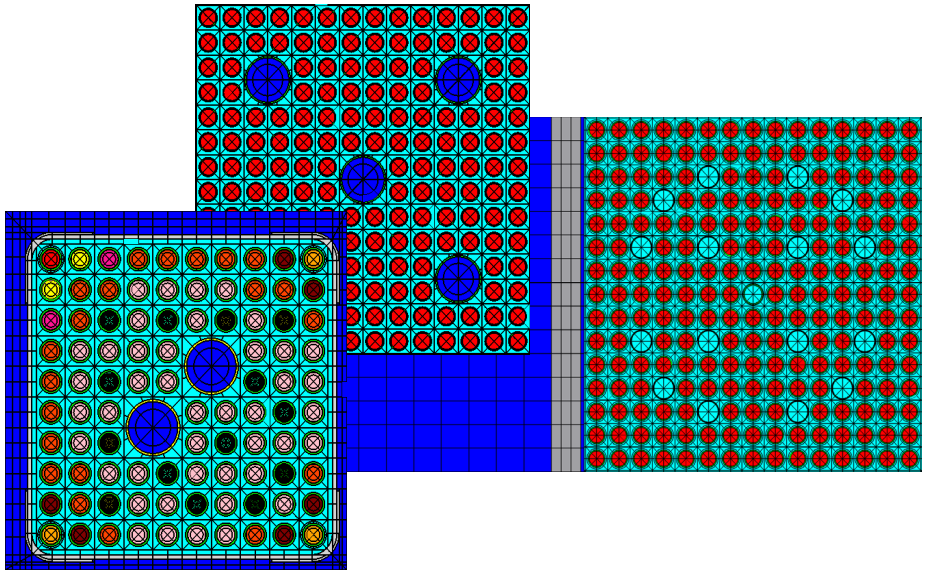
U.S. DEPARTMENT OF ENERGY

Polaris Overview

- Fast 2-D lattice physics
- Simple Input
  - Assembly geometry
  - Material definitions
  - Range of system conditions
- Output
  - Assembly-averaged few-group cross sections (.t16 file)
  - ORIGEN Isotope Library (.f71 file)
  - NEW for SCALE 6.3! ORIGEN Cross section Library (.f33 file)
- Modeling Requirements
  - Accurate prediction of lattice k-eff, pin power distribution, few-group cross-sections, depletion inventories
  - Relatively fast: 10,000s of transport calculations per core analysis
- https://www.ornl.gov/sites/default/files/PolarisOverview.pdf



Wide range of LWR geometry support

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PART I: Polaris Overview

- https://www.ornl.gov/sites/default/files/PolarisOverview.pdf
- PWR Geometry

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Part II: ORIGEN Library creation

What is an ORIGEN Library?

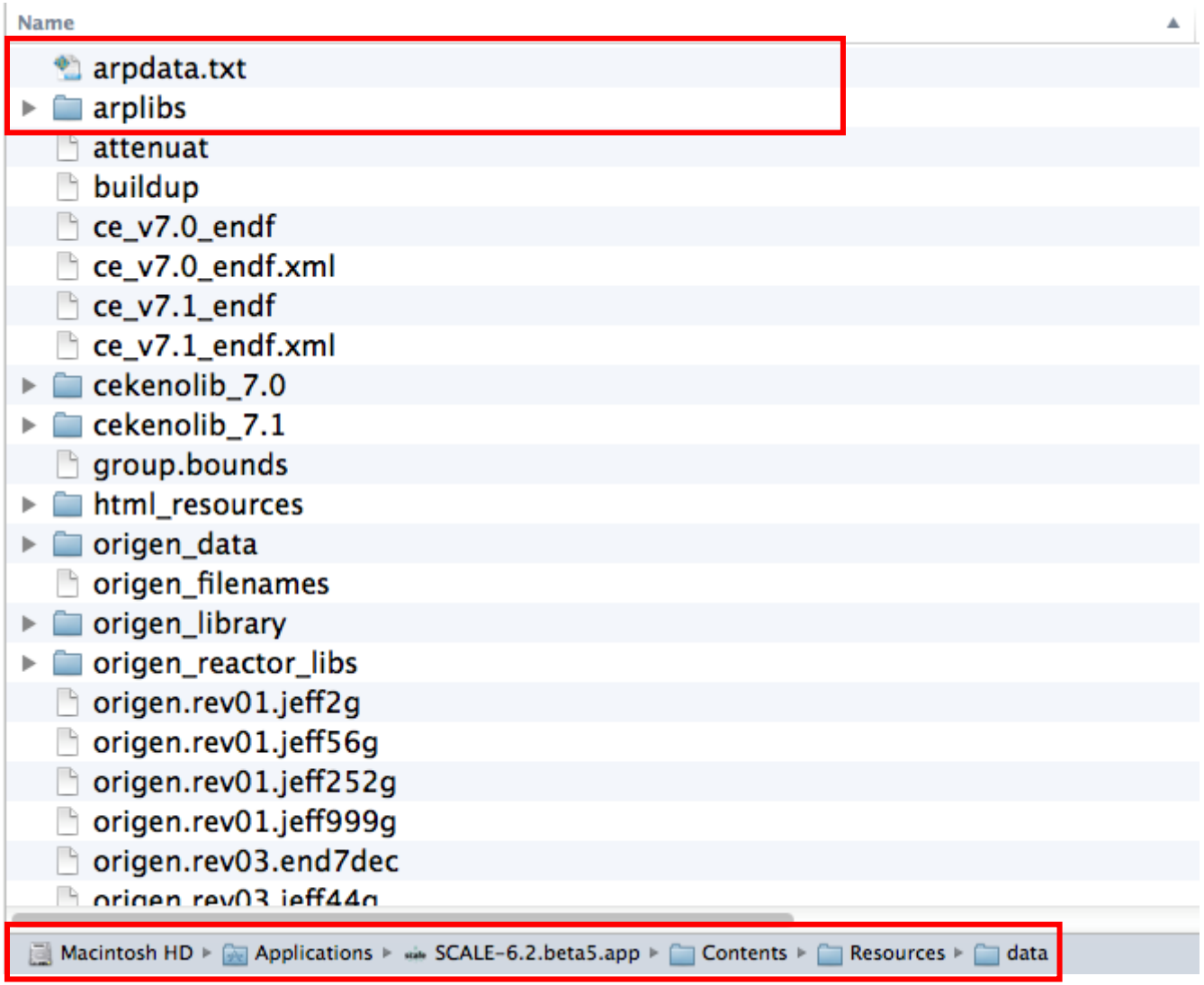
- ORIGEN libraries contain 1-group cross section data used to solve the depletion (Bateman) equation
- ORIGEN libraries are generated and used internally as part of the TRITON and Polaris sequences

$$\frac{dN_i}{dt} = \sum_{j=1}^{m} l_{ij}\lambda_j N_j + \bar{\Phi}\sum_{k=1}^{m} f_{ik}\sigma_k N_k - (\lambda_i + \bar{\Phi}\sigma_i + r_i)N_i$$

ORIGEN Reactor Libraries in SCALE

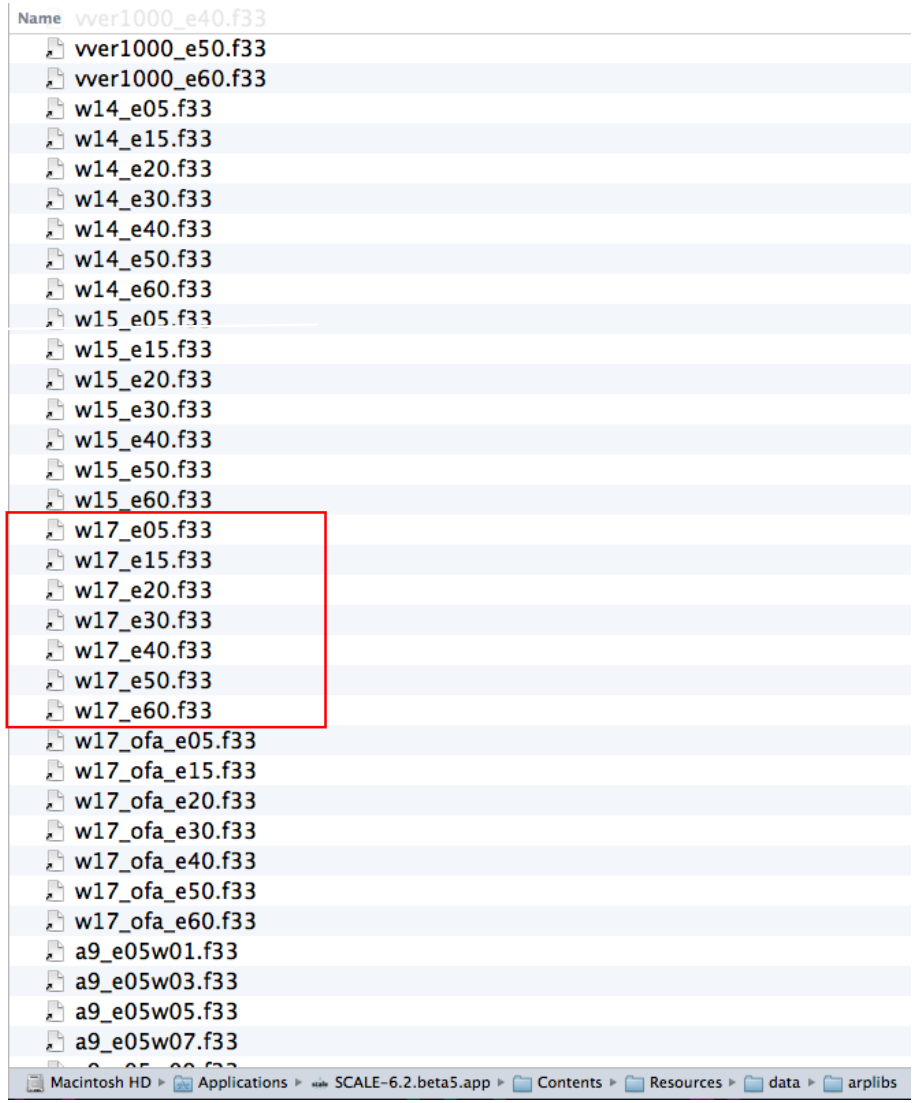
- Fuel/reactor specific ORIGEN libraries reside in the SCALE subdirectory scale\data\arplibs\
- The file *arpdata.txt* is located at scale\data\arpdata.txt
- The file *arpdata.txt* contains information on the libraries
  - Fuel type (name used to specify library)
  - Number of values for each variable parameter
  - Parameter values
  - Burnup values for each library position
  - Filenames for parameter-dependent libraries

SCALE Directory Structure – Data Directory



SCALE Data – arplibs Directory

Library files for W17x17



SCALE Data – arpdata.txt Entry for a PWR Library

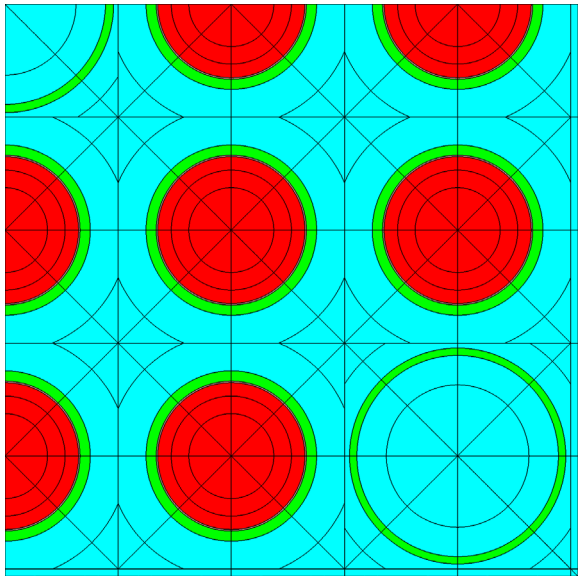
```
!ce14x14                                                    !LibraryName
6 1 11                                                      NumEnr NumDen NumBU
1.5 2.0 3.0 4.0 5.0 6.0                                     Enrichments
0.7332                                                      Coolant/Mod Densities
'ce14_e15.f33' 'ce14_e20.f33' 'ce14_e30.f33'                Library File Names
'ce14_e40.f33' 'ce14_e50.f33' 'ce14_e60.f33'

        0.   1500.   4500.   7500. 10500. 13500.           Burnup Values
16500. 31500. 46500. 58500. 70500.
```

SCALE data – arpdata.txt Entry for a BWR library

```
!ge9x9-7                                                        !LibraryName
6 5 11                                                          NumEnr NumDen NumBU
1.5 2.0 3.0 4.0 5.0 6.0                                         Enrichments
0.1 0.3 0.5 0.7 0.9                                             Coolant/Mod Densities
'g9_e15w01.arplib' 'g9_e15w03.arplib' 'g9_e15w05.arplib'
'g9_e15w07.arplib' 'g9_e15w09.arplib' 'g9_e20w01.arplib'
'g9_e20w03.arplib' 'g9_e20w05.arplib' 'g9_e20w07.arplib'
'g9_e20w09.arplib' 'g9_e30w01.arplib' 'g9_e30w03.arplib'
'g9_e30w05.arplib' 'g9_e30w07.arplib' 'g9_e30w09.arplib'        Library File Names
'g9_e40w01.arplib' 'g9_e40w03.arplib' 'g9_e40w05.arplib'
'g9_e40w07.arplib' 'g9_e40w09.arplib' 'g9_e50w01.arplib'
'g9_e50w03.arplib' 'g9_e50w05.arplib' 'g9_e50w07.arplib'
'g9_e50w09.arplib' 'g9_e60w01.arplib' 'g9_e60w03.arplib'
'g9_e60w05.arplib' 'g9_e60w07.arplib' 'g9_e60w09.arplib'
      0.   1500.   4500.   7500. 10500. 13500.                  Burnup Values
16500. 31500. 46500. 58500. 70500.
```

Tutorial Problem: Generate ORIGEN libraries for WEC "5x5" model

- **Open** wec17x17 model in Fulcrum. **Save As**: 2.0.inp
  1. **Change** enrichment to 2%
  2. **Deplete**
     - power 40
     - bu 0 0.1 5 10 15 20 25 30
- **Repeat** steps above for 3% and 6% enrichment
- Should have 3 files in your file directory:
  - 2.0.f33
  - 3.0.f33
  - 6.0.f33



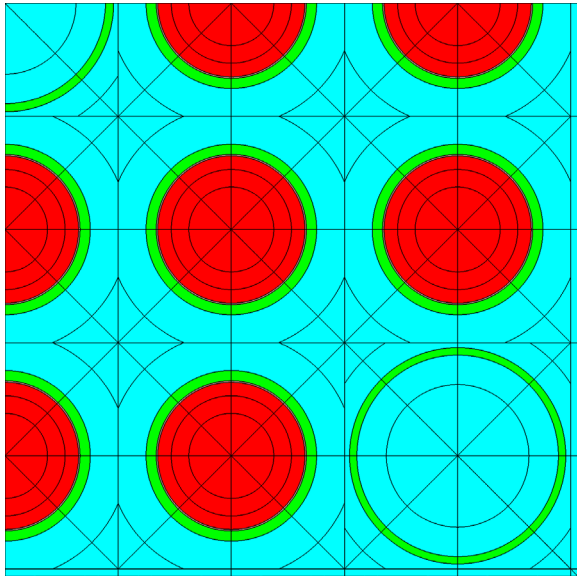
Change "2" to "3" and "6", depending on TRITON run

Part 2: ORIGAMI

- Collect f33 files into your input directory called my_arplibs
- Copy arpdata.txt (in SCALE data directory) to my_arpdata.txt (in your input directory)
- In my_arpdata.txt, create new data set (my_w5x5) with 3 enrichments, 1 moderator density, and 8 burnups.
- Copy the following in new input file:

```
=shell
ln -s "${INPDIR}/my_arplibs" arplibs
cp "${INPDIR}/my_arpdata.txt" arpdata.txt
end
```

- Perform an irradiation case in ORIGAMI of 1 MTU, 2.5% enriched, 30 GWD/MTU, 3 cycles, 4 interpolations/cycle, 1000 days cooling, 95% uptime, 40 MW/MTU average power.
- Plot the actinide masses (grams) as a function of time (days).



Part 2: ORIGAMI

- Collect f33 files into your input directory called my_arplibs
- Copy arpda… input directo…
- In my_arpda… 1 moderator…
- Copy the fol…

```
1 =sh
2 ln
3 cp
4 end
```

- Perform an ir… GWD/MTU, 3… uptime, 40 M…
- Plot the actir…