Polaris Tutorial

Presented to:

SCALE Users' Group Workshop

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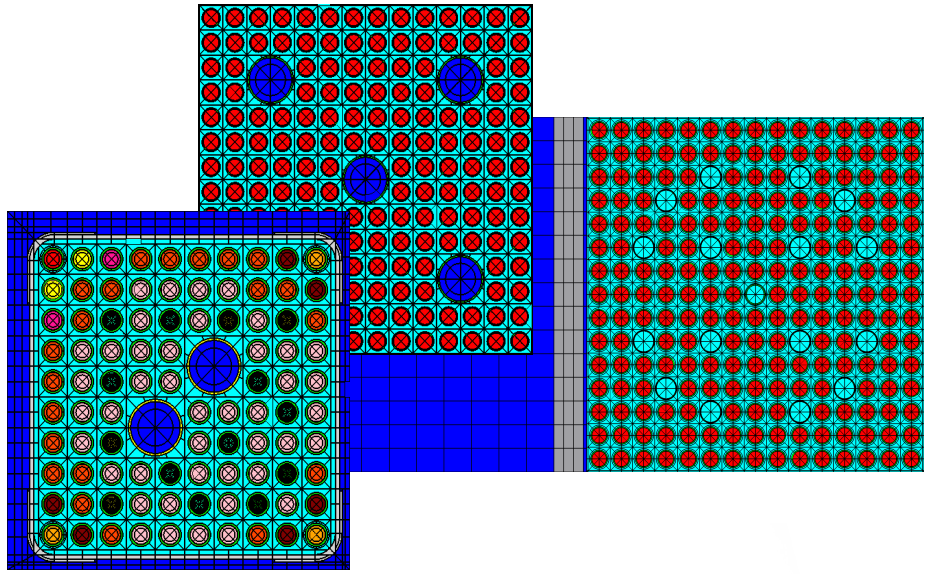
Polaris Overview

- Fast 2-D lattice physics
- Simple Input
  - Assembly geometry
  - Material definitions
  - Range of system conditions
- Output
  - Assembly-averaged few-group cross sections
  - Used as input for PARCS/TRACE core analysis
- Modeling Requirements
  - Accurate prediction of lattice k-eff, pin power distribution, and few-group cross-sections
  - Relatively fast: 10,000s of transport calculations per core analysis



Wide range of LWR geometry support

Tutorial Outline

- 3 How-tos:

1. How to setup a simple input model?
2. How to setup a PWR depletion model?
3. How to setup a BWR model?

How to setup a simple input model?

```
=polaris
%---------------------------------------%
% general options
%---------------------------------------%
title "W17x17 pin cell"
      "Polaris training"

lib "v7-56"   %v7-252 is default

    %equivalent to

library "v7-56"



end
```

Basics

- title - optional
  - double quotes
  - one or more titles allowed
- comment %
  - does not have to be first character on line
  - currently cannot appear INSIDE cards
- library (lib) - optional
  - “v7-252” or “fine_n”
  - “v7-56” or “broad_n”
  - default “v7-252”

Basics

```
1  =polaris
2  %--------------------------------------%
3  % general options
4  %--------------------------------------%
5  title "W17x17 pin cell"
6        "Polaris training"
7  lib "v7-56"  %v7-252 is default
8  %--------------------------------------%
9  % geometry
10 %--------------------------------------%
11 geometry W17 : ASSM npins=1
12                    ppitch=1.26
13                    sym=FULL
14
15    %equivalent to
16
17 geom W17 : ASSM 1 1.26 FULL
18
19    %equivalent to
20
21 geom W17 : ASSM 1 sym=FULL
22                       ppitch=1.26
23
24    %equivalent to
25
26 geom W17 : ASSM 1 1.26
27
28
29 end
30
```

- geometry or geom

geom GNAME : ASSM npins=Int ppitch=Real [sym=FULL|SE]

- GNAME – assembly name
- ASSM – indicates assembly geometry
- npins - # of pins on side of the assembly
- ppitch – pin pitch (cm)
- sym – optional
  - FULL or SE
  - default FULL
- Keywords npins=, ppitch=, and sym=
  - Optional if in correct order
  - Required once out of order

Basics

```
=polaris
%--------------------------------------%
% general options
%--------------------------------------%
title "W17x17 pin cell"
      "Polaris training"
lib "v7-56"  %v7-252 is default
%--------------------------------------%
% geometry
%--------------------------------------%
geom W17 : ASSM 1 1.26 FULL
%--------------------------------------%
% comps and mats
%--------------------------------------%
composition c_f31 : UOX 3.1
material FUEL.1 : c_f31 dens=10.26
                        temp=600

    %equivalent to

comp F31 : UOX 3.1
mat FUEL.1 : F31 10.26 600

end
```

- composition or comp

comp CNAME : UOX enr=Real

- CNAME – composition name
- UOX – indicates uranium dioxide
- enr – U-235 enrichment %
- material or mat

mat MNAME : CNAME [dens=Real] [temp=Real]

- MNAME – material name (Word.Int)
- CNAME – composition name
- dens – density (g/cm^3)
- temp – temperature (K)

Compositions and Materials

- Basic Concept
  - **composition** defines a set of isotopes and their relative distribution
  - **material** is a **composition** at a given density and temperature
  - same **composition** can define multiple **mats**
- Naming convention
  - **composition**: what is it? (ZIRC4)
  - **material**: what does it do? (CLAD.1)

- Several comp cards exists
  - comp CNAME : NUM …
    - define by atom %
  - comp CNAME : WT …
    - define by weight %
  - comp CNAME : FORM …
    - define chemical compound
  - comp CNAME : CONC …
    - define number densities
  - comp CNAME : LW …
    - define borated water

Composition Examples

```
=polaris
%-------------------------------------
% comp examples
%-------------------------------------

comp D2O        : FORM 1002=2 O16=1

comp F30        : UOX 3.0
comp GDUO2      : WT GD2O3=7 F30=-100

comp waba       : CONC
            5010=2.98553E-03
            5011=1.21192E-02
            6000=3.77001E-03
            8016=5.85563E-02
           13027=3.90223E-02

comp WATER      : LW borppm=1300

        %equivalent to

comp WATER      : LW 1300

end
```

Pre-defined compositions

Standard Molecular Compositions

CNAME	*Description*
H2O	light water
B4C	Boron carbide burnable poison material
ER2O3	Erbium oxide burnable poison material
GD2O3	Gadolinium oxide burnable poison material
FILLGAS	Helium gas

Standard Reactor Mixtures and Alloys

CNAME	*Description*
AIC	Ag-In-Cd control rod absorber material
PYREX	Pyrex glass
ZIRC2	Zircaloy-2 clad material
ZIRC4	Zircaloy-4 clad material
SS304	Stainless Steel 304
SS316	Stainless Steel 316
INC718	Inconel 718
WATER	Light water with trace amount of boron

Pre-defined compositions have reference density. dens= not required for mat card.

pin

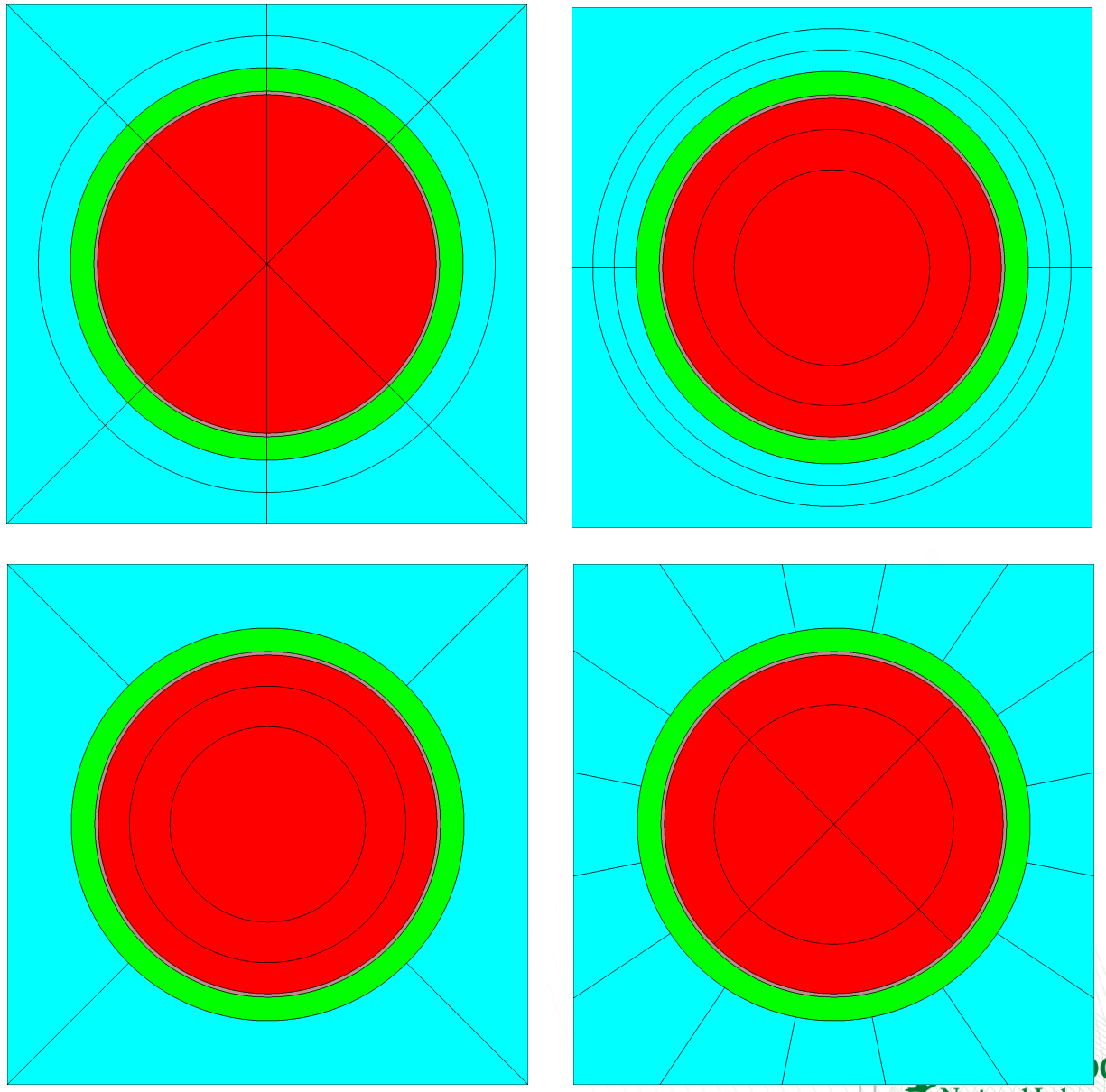
```
=polaris
%---------------------------------------%
% general options
%---------------------------------------%
title "W17x17 pin cell"
      "Polaris training"
lib "v7-56"   %v7-252 is default
%---------------------------------------%
% geometry
%---------------------------------------%
geom W17 : ASSM 1 1.26
%---------------------------------------%
% comps and mats
%---------------------------------------%
comp c_f31   : UOX 3.1
mat FUEL.1 : c_f31 10.26 600
mat GAP.1   : FILLGAS temp=600
mat CLAD.1 : ZIRC4    temp=600
comp WATER : LW 1300
mat COOL.1 : WATER 0.661 600
%---------------------------------------%
% pins
%---------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 1      1     1      1
      : 8      8     8      8
end
```

pin PINID [size=Int] [nsect=Int]
: r1 r2 … ri … rN
: M1 M2 … Mi … MN [Mout]
[: nr1 nr2 … nri … nrN nrout]
[: ns1 ns2 … nsi … nsN nsout]

- PINID – pin identifier
- size – 1 is default. size=2 creates 2x2 pin cell
- nsect – number of sectors
- r – zone radius (cm)
- M – zone material
- nr_i – number of rings in zone i
- ns_i – number of sectors in zone i
- Additional value of M, nr, ns for outermost region
- nr_{out} – A value of 1 means 1 additional ring is added in the outermost region

Basics

```
=polaris

%---------------------------------------%
% pin examples
%---------------------------------------%

pin A : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 1      1     1      1
      : 8      8     8      8


pin B : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 3      1     1      2
      : 1      1     1      4


pin C : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 3      1     1      0
      : 1      1     1      -4


pin D : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 2      1     1      0
      : -4     1     1      -16

```



Exercises

```
=polaris
%--------------------------------------%
% general options
%--------------------------------------%
title "W17x17 pin cell"
      "Polaris training"
lib "v7-56"  %v7-252 is default
%--------------------------------------%
% geometry
%--------------------------------------%
geom W17 : ASSM 1 1.26
%--------------------------------------%
% comps and mats
%--------------------------------------%
comp c_f31   : UOX 3.1
mat FUEL.1 :c_f31 10.26 600
mat GAP.1   : FILLGAS temp=600
mat CLAD.1 : ZIRC4    temp=600
comp WATER : LW 1300
mat COOL.1 : WATER 0.661 600
%--------------------------------------%
% pins
%--------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 1      1     1      1
      : 8      8     8      8
end
```

- Part 1 w17x17_pin.inp
  1. Finish pin cell input shown here.
  2. Run calculation
  3. Walk through output
  4. Record transport keff.
- Part 2 (on your own)
  1. Run with 900 K fuel w17x17_pin_900K.inp
  2. Compute reactivity coefficient
  3. Revert fuel to 600 K. Run with 1000 ppm boron w17x17_pin_1000ppm.inp
  4. Compute reactivity coefficient
- Part 3 (on your own) w17x17_pin_clad.inp
  1. Revert boron change.
  2. Let's analyze a new advanced cladding.
  3. Compute k-eff for the following clad material
  4. 7.1 g/cc with a composition of 75 wt% Fe, 20 wt% Cr, and 5 wt% Al. (See comp WT example on "Composition Examples")

How to setup a PWR depletion model?

OAK RIDGE National Laboratory

hgap

```
=polaris

%--------------------------------------%
% geometry
%--------------------------------------%
geom W17 : ASSM 1 1.26
hgap 0.04 : COOL.1 : 2 : 1

    %equivalent to

hgap 0.04 : COOL.1

    %equivalent to

hgap 0.04   0.04   0.04   0.04
   : COOL.1 COOL.1 COOL.1 COOL.1
   : 2      2      2      2
   : 1      1      1      1
```

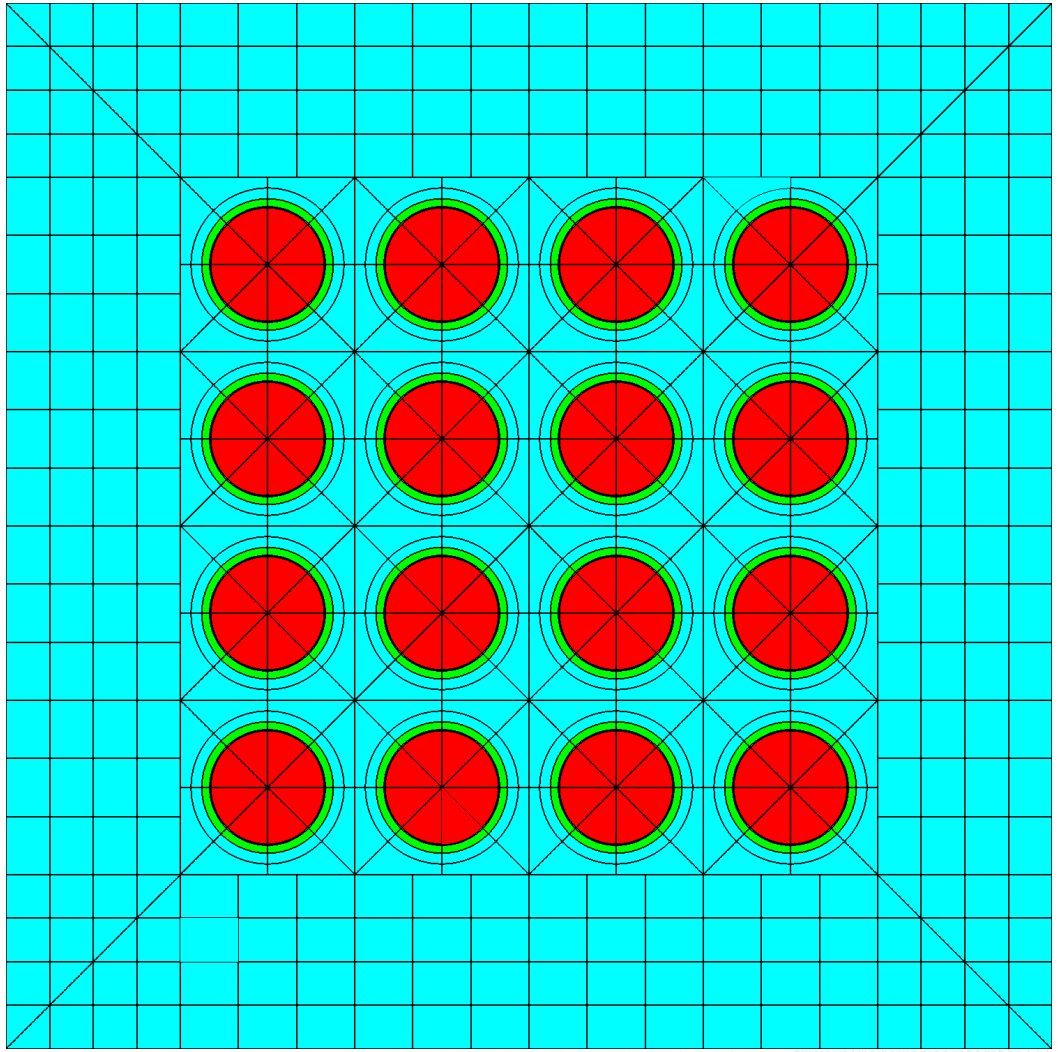
- hgap - optional
  - half distance between adjacent assemblies

```
hgap  [  dE    dN   dW    dS  ]
      [: ME   MN   MW   MS ]
      [: nfE   nfN  nfW  nfS  ]
      [: ndE  ndN  ndW  ndS ]
```

- d – half distance (cm)
- M – material name
- nf – number of faces per pin (2)
- nd – number of divisions (1)
- 1, 2, 4 values are acceptable
  - 1: same values for all 4 faces (PWR)
  - 2: East=South and North=West (BWR)
  - 4: general case, all four sides can be different

hgap

```
=polaris
%----------------------------------------%
% general options
%----------------------------------------%
title "W17x17 4x4 with gap"
      "Polaris training"
lib "v7-56"  %v7-252 is default
%----------------------------------------%
% geometry
%----------------------------------------%
geom W17 : ASSM 4 1.26
hgap 1.26 : COOL.1 : 3 : 4
%----------------------------------------%
% comps and mats
%----------------------------------------%
comp c_f31   : UOX 3.1
mat FUEL.1 : c_f31 10.26 600
mat GAP.1   : FILLGAS temp=600
mat CLAD.1 : ZIRC4   temp=600
comp WATER : LW 1300
mat COOL.1 : WATER 0.661 600
%----------------------------------------%
% pins
%----------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 1      1     1      1
      : 8      8     8      8
end
```



channel

```
=polaris

%---------------------------------------%
% geometry
%---------------------------------------%
geom W17 : ASSM 1 1.26
hgap 0.04
channel COOL 1 8

    %equivalent to

channel COOL nschan=8 nrchan=1
```

- channel – defines default for outermost **pin** region

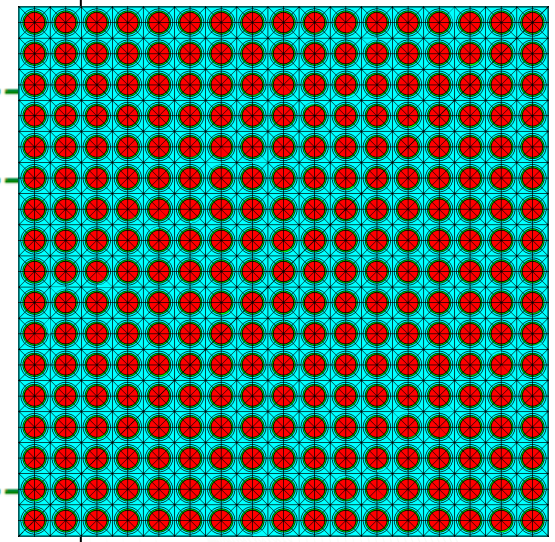
channel [Mchan=MCLASS] [nrchan=Int] [nschan=Int]

- Mchan – material class
- nrchan – additional rings in outermost pin region
- nschan – sectors in outermost pin region

channel

```
=polaris
%-----------------------------------------%
% general options
%-----------------------------------------%
title "W17x17"
      "Polaris training"
lib "v7-56"  %v7-252 is default
%-----------------------------------------%
% geometry
%-----------------------------------------%
geom W17 : ASSM 17 1.26
hgap 0.04 : COOL.1
%-----------------------------------------%
% comps and mats
%-----------------------------------------%
comp c_f31   : UOX 3.1
mat FUEL.1 : c_f31 10.26 600
mat GAP.1   : FILLGAS temp=600
mat CLAD.1 : ZIRC4   temp=600
comp WATER : LW 1300
mat COOL.1 : WATER 0.661 600
%-----------------------------------------%
% pins
%-----------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1 COOL.1
      : 1      1     1      1
      : 8      8     8      8
end
```

```
=polaris
%-----------------------------------------%
% general options
%-----------------------------------------%
title "W17x17"
      "Polaris training"
lib "v7-56"  %v7-252 is default
%-----------------------------------------%
% geometry
%-----------------------------------------%
geom W17 : ASSM 17 1.26
hgap 0.04 : COOL.1
channel COOL 1 8
%-----------------------------------------%
% comps and mats
%-----------------------------------------%
comp F31    : UOX 3.1
mat FUEL.1 : F31 10.26 600
mat GAP.1   : FILLGAS temp=600
mat CLAD.1 : ZIRC4   temp=600
comp WATER : LW 1300
mat COOL.1 : WATER 0.661 600
%-----------------------------------------%
% pins
%-----------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1
      : 1      1     1
      : 8      8     8
end
```



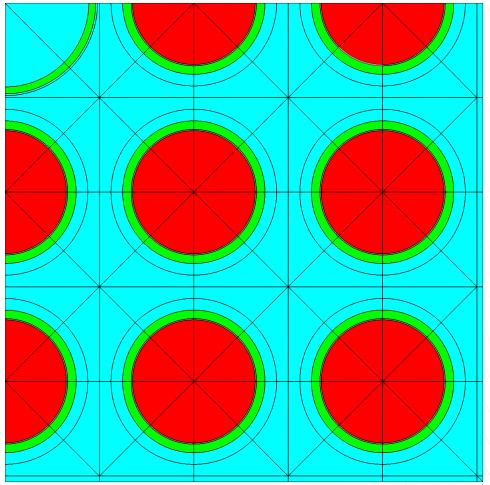
pinmap

```
=polaris
geom W17 : ASSM 5 1.26 SE
hgap 0.04 : COOL.1
channel COOL 1 8
%---------------------------------------%
% comps and mats
%---------------------------------------%
comp c_f31   : UOX 3.1
mat FUEL.1 : c_f31 10.26 600
mat GAP.1   : FILLGAS temp=600
mat CLAD.1 : ZIRC4   temp=600
comp WATER : LW 1300
mat COOL.1 : WATER 0.661 600
%---------------------------------------%
% pins
%---------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1
      : 1      1     1
      : 8      8     8
pin I : 0.559 0.605 : COOL.1 CLAD.1
      : 1       1   : 8      8
%---------------------------------------%
% maps
%---------------------------------------%
pinmap
I
F F
F F F
end
```

- pinmap – pin layout

pinmap $PINID_1$ $PINID_2$ … $PINID_i$ … $PINID_N$

- supports full, quarter, or octant symmetry
- For 5x5 assembly, the pinmap can contain
  - 25 entries (geom sym=FULL)
  - 15 entries (SW diagonal sym=FULL)
  - 9 entries (SE quadrant, geom sym=SE)
  - 6 entries (SSE octant, geom sym=SE)



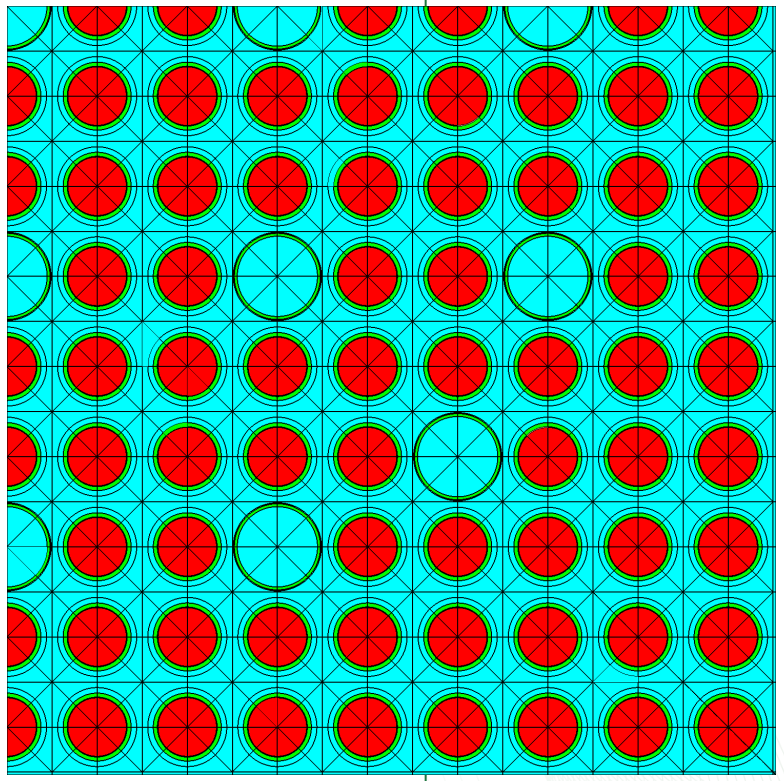
system PWR

Material	Composition	Plot Color	Additional info
Unless noted otherwise, T=565K, nr=1, ns=8, nf=2, nd=1			
COOL.1	H2O	cyan	**pin** coolant material, nr=2
COOL.2	H2O	aquamarine	use for large guide tubes with user-defined mesh
MOD.1	H2O	blue	optional, use for inner guide tube material
Water materials initialized to boron = 0 ppm, density = 0.743 g/cc			
FUEL.1	n/a	red	depletable **(deplete),** auto-expanded **(shield)**
BP.1	n/a	n/a	depletable **(deplete),** auto-expanded **(shield)**
CNTL.1	AIC	pink	auto-expanded **(shield)**
CNTL.2	B4C	cadetblue	auto-expanded **(shield)**
CLAD.1	ZIRC4	lime	
TUBE.1	ZIRC4	yellow	optional for guide tubes
GAP.1	FILLGAS	rosybrown	
STRUCT.1	SS304	goldenrod	blade sheath/central support material

system PWR

```
=polaris
%-------------------------------------%
% general options
%-------------------------------------%
title "W17x17" "Polaris training"
lib "v7-56"  %v7-252 is default
system PWR
%-------------------------------------%
% geometry
%-------------------------------------%
geom W17 : ASSM 17 1.26 SE
hgap 0.04
%-------------------------------------%
% comps and mats
%-------------------------------------%
comp c_f31   : UOX 3.1
mat FUEL.1 :c_f31 10.26
%-------------------------------------%
% pins
%-------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1
pin I : 0.559   0.605
      : COOL.1  CLAD.1
pin G : 0.561   0.602
      : COOL.1  CLAD.1
```

```
%-------------------------------------%
% maps
%-------------------------------------%
pinmap
I
F F
F F F
G F F G
F F F F F
F F F F F G
G F F G F F F
F F F F F F F F
F F F F F F F F F
end
```



state

```
%--------------------------------------%
% maps
%--------------------------------------%
pinmap
I
F F
F F F
G F F G
F F F F F
F F F F F G
G F F G F F F
F F F F F F F F
F F F F F F F F F
%--------------------------------------%
% state
%--------------------------------------%
state ALL  : temp=590
state COOL : dens=0.68
             boron=1300
state FUEL : temp=900
state CLAD : temp=700
end
```

- state – (part 1) – set state properties for materials

state MNAME|MCLASS
p1=val1 p2=val2 … pi=vali … pN=valN

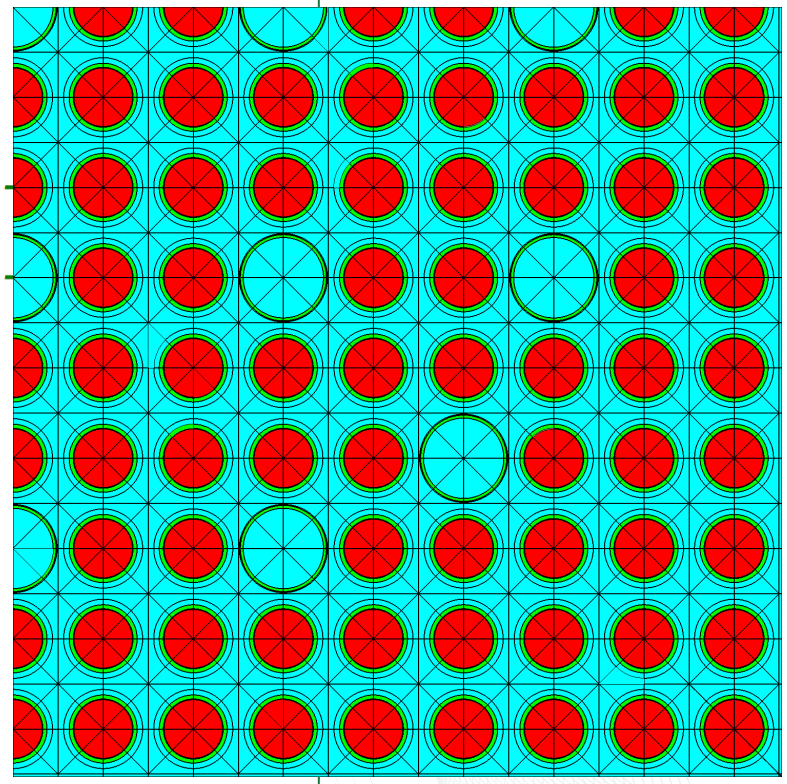
- MNAME or MCLASS – material name (FUEL.1) or material class (FUEL)
- p_i – property name
  - all materials have dens= and temp= properties
  - system PWR: COOL and MOD have boron= properties
  - system BWR: COOL and MOD have boron= and void= properties
- val_i – property value

state

Rev 1

```
=polaris
%--------------------------------------%
% general options
%--------------------------------------%
title "W17x17" "Polaris training"
lib "v7-56"   %v7-252 is default
system PWR
%--------------------------------------%
% geometry
%--------------------------------------%
geom W17 : ASSM 17 1.26 SE
hgap 0.04
%--------------------------------------%
% comps and mats
%--------------------------------------%
comp c_f31    : UOX 3.1
mat FUEL.1 : c_f31 10.26
%--------------------------------------%
% pins
%--------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1
pin I : 0.559   0.605
      : COOL.1  CLAD.1
pin G : 0.561   0.602
      : COOL.1  CLAD.1
```

```
%--------------------------------------%
% maps
%--------------------------------------%
pinmap
I
F F
F F F
G F F G
F F F F F
F F F F F G
G F F G F F F
F F F F F F F F
F F F F F F F F F
%--------------------------
% state
%--------------------------
state ALL   : temp=590
state COOL  : dens=0.68
              boron=1300
state FUEL  : temp=900
state CLAD  : temp=700
end
```

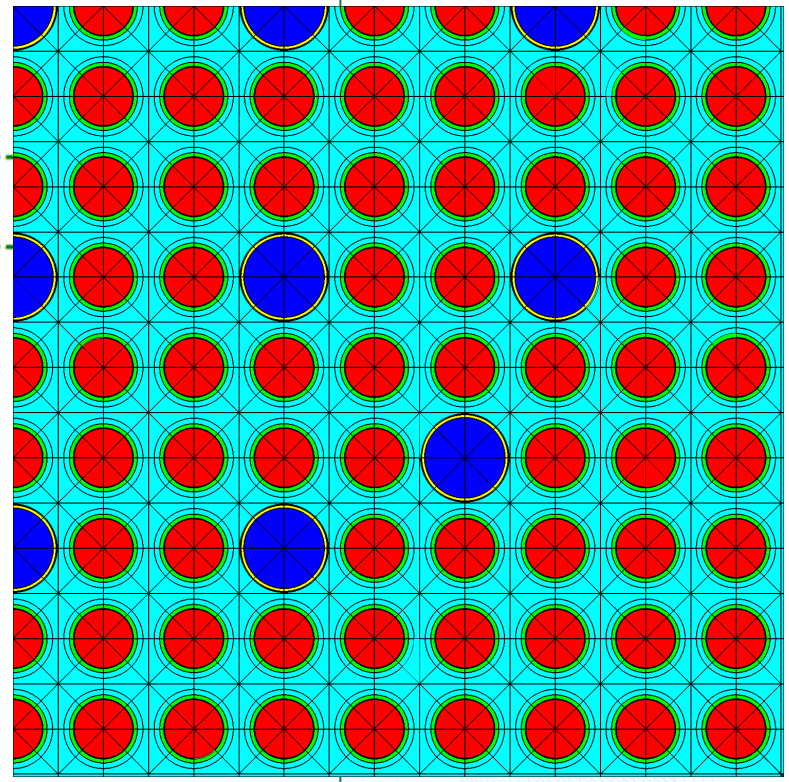


state

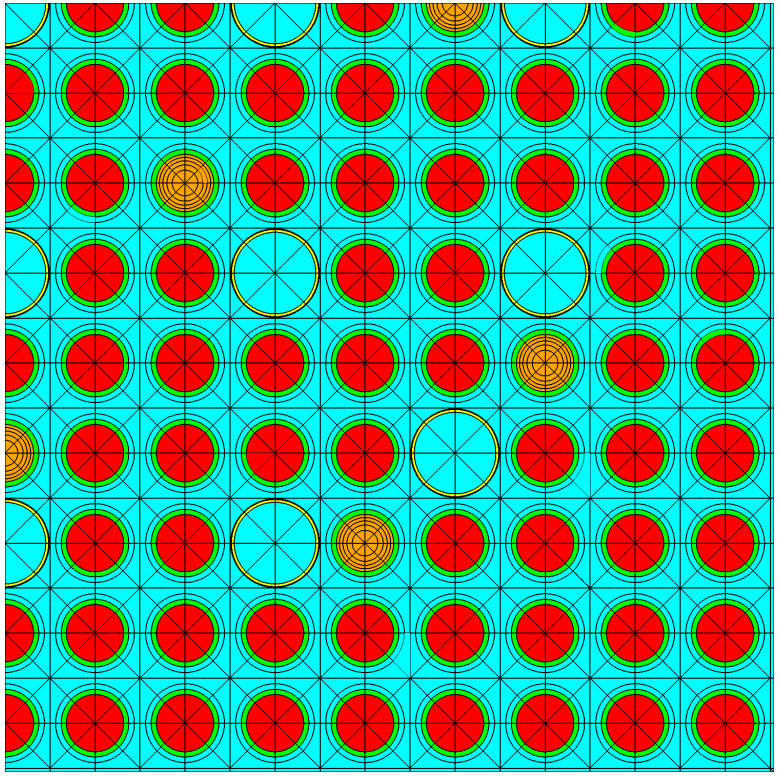
Rev 2: with MOD.1 and TUBE.1

```
=polaris
%-------------------------------------%
% general options
%-------------------------------------%
title "W17x17" "Polaris training"
lib "v7-56"  %v7-252 is default
system PWR
%-------------------------------------%
% geometry
%-------------------------------------%
geom W17 : ASSM 17 1.26 SE
hgap 0.04
%-------------------------------------%
% comps and mats
%-------------------------------------%
comp c_f31   : UOX 3.1
mat FUEL.1 : c_f31 10.26
%-------------------------------------%
% pins
%-------------------------------------%
pin F : 0.4096 0.418 0.475
      : FUEL.1 GAP.1 CLAD.1
pin I : 0.559 0.605
      : MOD.1 TUBE.1
pin G : 0.561 0.602
      : MOD.1 TUBE.1
```

```
%-------------------------------------%
% maps
%-------------------------------------%
pinmap
I
F F
F F F
G F F G
F F F F F
F F F F F G
G F F G F F F
F F F F F F F F
F F F F F F F F F
%-------------------------------------%
% state
%-------------------------------------%
state ALL   : temp=590
state COOL  : dens=0.68
              boron=1300
state MOD   : dens=0.71
              boron=1300
              temp=575
state FUEL  : temp=900
state CLAD  : temp=700
state TUBE  : temp=580
end
```



Exercises



- W17x17
  1. Finish W17x17 lattice (rev1) w17x17.inp
  2. Finish rev2 with MOD.1 and TUBE.1 w17x17_rev2.inp
  3. Compare k-eff and pin powers
  4. copy w17x17_rev2.inp w17x17_czp.inp
  5. Use state to set all materials to 293K
  6. Use state to set COOL and MOD density to 1.0 (1300 ppm boron)
  7. record k-eff

Depletion

```
%--------------------------------------%
% maps
%--------------------------------------%
pinmap
I
F F
F F F
G F F G
F F F F F
F F F F F G
G F F G F F F
F F F F F F F F
F F F F F F F F F
%--------------------------------------%
% state
%--------------------------------------%
power 40
bu 0 4 8 12 %burnup 0 is optional

      %equivalent to

pow              40    40    40
bu MWD/MTIHM : 4000 8000 12000

      %equivalent to

pow  40  40  40
t  0 100 200 300 %time 0 is optional

end
```

- power (or pow), bu, and t

pow p1 … pi … pN

bu [units=GWD/MTIHM|MWD/MTIHM] : b1 … bi … bN

t [units=SECONDS|MINUTES|HOURS|DAYS|YEARS]: t1 … ti … tN

- power is required
- bu vs t
  - user preference
  - t is required for decay steps
  - t=0 or bu=0 is optional
- Example 1, Constant power:
  - only 1 power value is needed, but multiple values are accepted
  - multiple power values: required same number of bu (or t) values (ignoring the initial 0 value)
- NOTE: we may change **t** to **time** in future release

```
%--------------------------------------%
% maps
%--------------------------------------%
pinmap
I
F F
F F F
G F F G
F F F F F
F F F F F G
G F F G F F F
F F F F F F F F
F F F F F F F F F
%--------------------------------------%
% state
%--------------------------------------%
pow 40   35   30  0
t   100  200  300 330

  %equivalent to

pow 40   35   30  0
dt  100  100  100 30

  %equivalent to

pow       40   35   30   0
dt HOURS 2400 2400 2400 720
end

```

Depletion

- dbu, dt – incremental burnup and time steps

dbu b1 … bi … bN [: units=GWD/MTIHM|MWD/MTIHM]

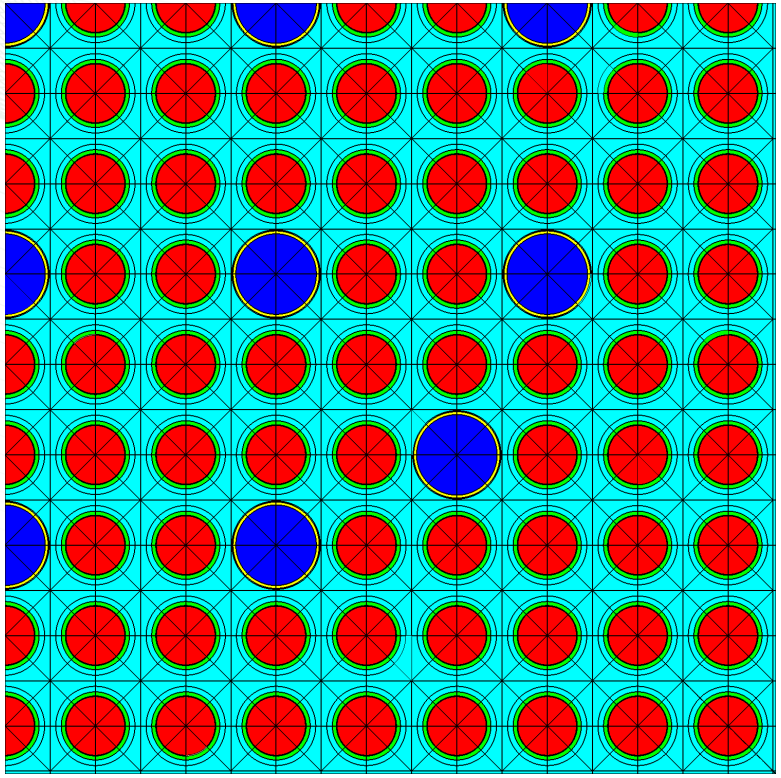
dt t1 … ti … tN [: units=SECONDS|MINUTES|HOURS|DAYS|YEARS]

- dbu and dt do not support an initial 0 value
- multiple power values: required same number of dbu (or dt) values
- Example 2, Power history:
  - time-based input is required because of decay steps

Depletion Methodology

- Polaris uses predictor-corrector depletion:
  - burnup step [bu, bu+dbu]:
    1. flux calculation at bu
    2. deplete (predictor step)
    3. flux calculation at bu+dbu
    4. re-deplete with new flux (corrector step)
    5. average isotopics at bu+dbu from step 2. and step 4.
  - decay step [t, t+dt]:
    1. flux calculation at t
    2. decay calculation to t+dt
- **deplete card** – specifies depletion regions
- **shield card** – specifies how materials are expanded
- system PWR defaults
  - deplete ALL=NO FUEL=YES BP=YES
  - shield ALL=N FUEL=R BP=R CNTL=R
- system BWR defaults
  - deplete ALL=NO FUEL=YES
  - shield ALL=N FUEL=R CNTL=R
- R: every radial ring is a unique depletion region

Exercises



- Part 1
  - copy w17x17_rev2.inp as w17x17_depl.inp
  - Power: 40 W/g
  - Burnup steps: 0 0.1 5 10
  - Review depletion output
- Part 2 (on your own)
- copy w17x17_depl.inp as w17x17_depl2.inp
  - Power: 40 W/g, 30 W/g starting at 20 GWD/MTU
  - Burnup steps: 0 0.1 5 10 20 30

How to setup a BWR model?

OAK RIDGE National Laboratory

box

```
=polaris
%---------------------------------------%
% general options
%---------------------------------------%
title "GE7x7"
lib "v7-56"   %v7-252 is default
%---------------------------------------%
% geometry
%---------------------------------------%
geom bwr7x7 : ASSM 7 1.88
hgap 0.5 1.0
box 0.2 1.0 0.09

     %equivalent to

box thick=0.2 rad=1.0 icdist=0.09

     %equivalent to

box rad=1.0 thick=0.2 icdist=0.09

     %equivalent to

box 0.2 1.0 0.09 Mbox=CAN.1

     %equivalent to

box 0.2 1.0 0.09 0.0 0.0 Mbox=CAN.1

```

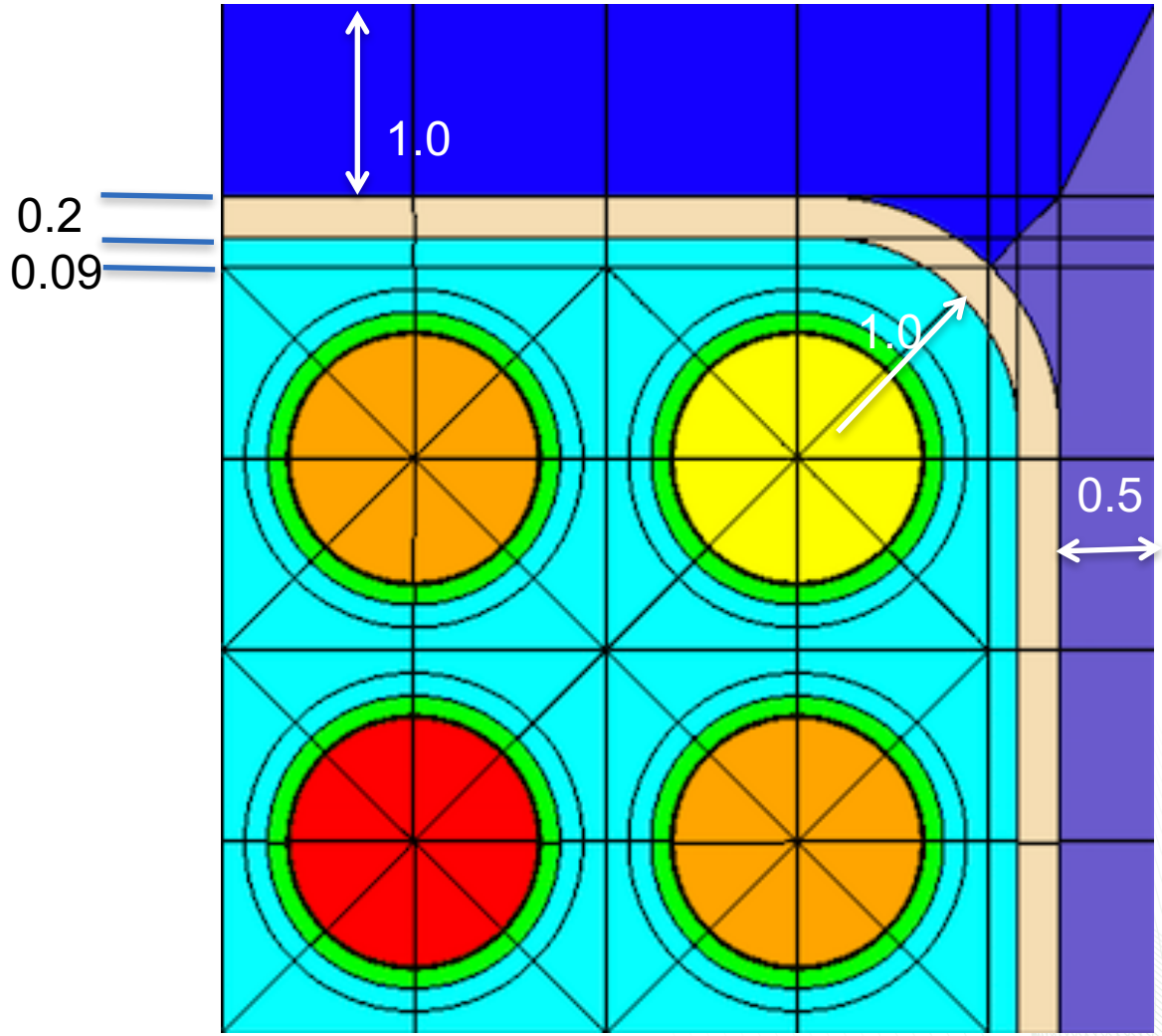
- box - specifies channel box geometry

box thick=Real [rad=Real icdist=Real xrad=Real xlen=Real Mbox=MNAME]

- thick – nominal thickness of box wall (cm)
- rad – corner radius for rounded corners (cm)
- icdist – inner channel gap (cm)
- xrad - extra thickness for corners (cm): default 0
- xlen - extra box wall length (cm): default 0
- Mbox – box material: default CAN.1 (sys BWR)

box

```
=polaris
%-----------------------------------------%
% general options
%-----------------------------------------%
title "GE7x7"
lib "v7-56"   %v7-252 is default
%-----------------------------------------%
% geometry
%-----------------------------------------%
geom bwr7x7 : ASSM 7 1.88
hgap 0.5 1.0
box 0.2 1.0 0.09

      %equivalent to

box thick=0.2 rad=1.0 icdist=0.09

      %equivalent to

box rad=1.0 thick=0.2 icdist=0.09

      %equivalent to

box 0.2 1.0 0.09 Mbox=CAN.1

      %equivalent to

box 0.2 1.0 0.09 0.0 0.0 Mbox=CAN.1

```



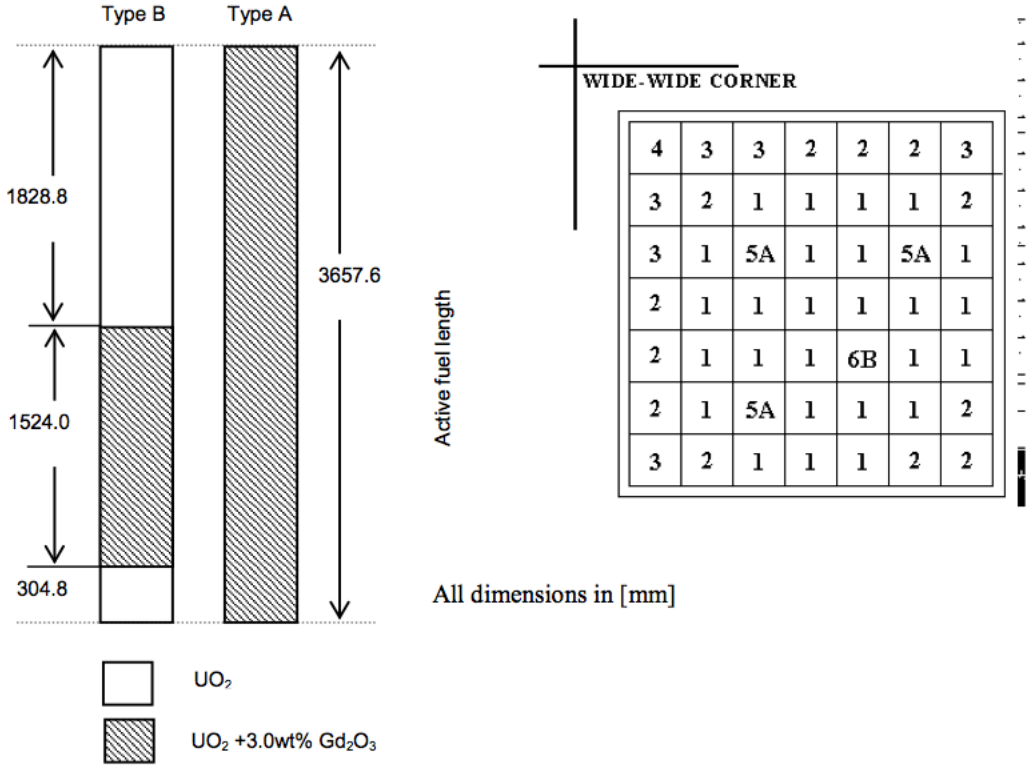
Material	Composition	Plot Color	Additional info
Unless noted otherwise, T=557K, nr=1, ns=8, nx=1, ny=1, nf=2, nd=1			
COOL.1	void=0, boron=0	cyan	**pin** coolant material, nr=2, **cross** exterior material
COOL.2	void=0, boron=0	aquamarine	use for large water rods with user-defined mesh
MOD.1	void=0, boron=0	slateblue	narrow **hgap** material, uniform **hgap** material
MOD.2	void=0, boron=0	blue	wide **hgap** material, **cross** interior material
Water materials initialized to void=0, boron=0, rho_l = 0.743 g/cc, rho_g = 0.0353 g/cc			
CAN.1	ZIRC2	wheat	**box** material, **cross** liner material
CNTL.1	AIC	pink	
CNTL.2	B4C	cadetblue	
CLAD.1	ZIRC2	lime	
TUBE.1	ZIRC2	yellow	
GAP.1	FILLGAS	rosybrown	
STRUCT.1	SS304	goldenrod	blade sheath/central support material

Exercise: Peach Bottom 2

Figure 6: PB-2 assembly design - Type 2 initial fuel and lattice

Assembly design for Type 2 initial fuel

Rod type	^{235}U (wt.%)	Gd_2O_3 (wt.%)	No. of rods
1	2.93	0	26
2	1.94	0	12
3	1.69	0	6
4	1.33	0	1
5A	2.93	3.0	3
6B	2.93	3.0	1



Total fuel, kg				212.65			
Rod type	Number of rods	Pellet density UO_2 (g/cm^3)	Pellet density UO_2+Gd_2O_3 (g/cm^3)	Stack density (g/cm^3)	Gd_2O_3 (g)	UO_2 (g)	Stack length (cm)
1	25	10.42	–	10.32	0	4 352	365.76
1s	1	10.42	–	10.32	0	3 935	330.20
2	12	10.42	–	10.32	0	4 352	365.76
3	6	10.42	–	10.32	0	4 352	365.76
4	1	10.42	–	10.32	0	4 352	365.76
5A	3	–	10.29	10.19	129	4 171	365.76
6B	1	10.42	10.29	10.27	54	4 277	365.76

Pellet outer diameter = 1.21158 cm.
Cladding = Zircaloy-2, 1.43002 cm outer diameter × .09398 cm wall thickness, all rods.
Gas plenum length = 40.132 cm.

- pb2.inp
- Pin pitch – 1.87452
- Lattice pitch – 15.24
- Narrow gap – 0.47498
- Wide gap – 0.9525
- 10 rings for gad pins
- Channel thickness – 0.2032
- Channel radius – 0.9652
- 40% void
- T-Fuel – 900K
- Compute k-eff and pin power map

Source: LWR UAM Benchmark NEA/NSC/DOC(2013)7