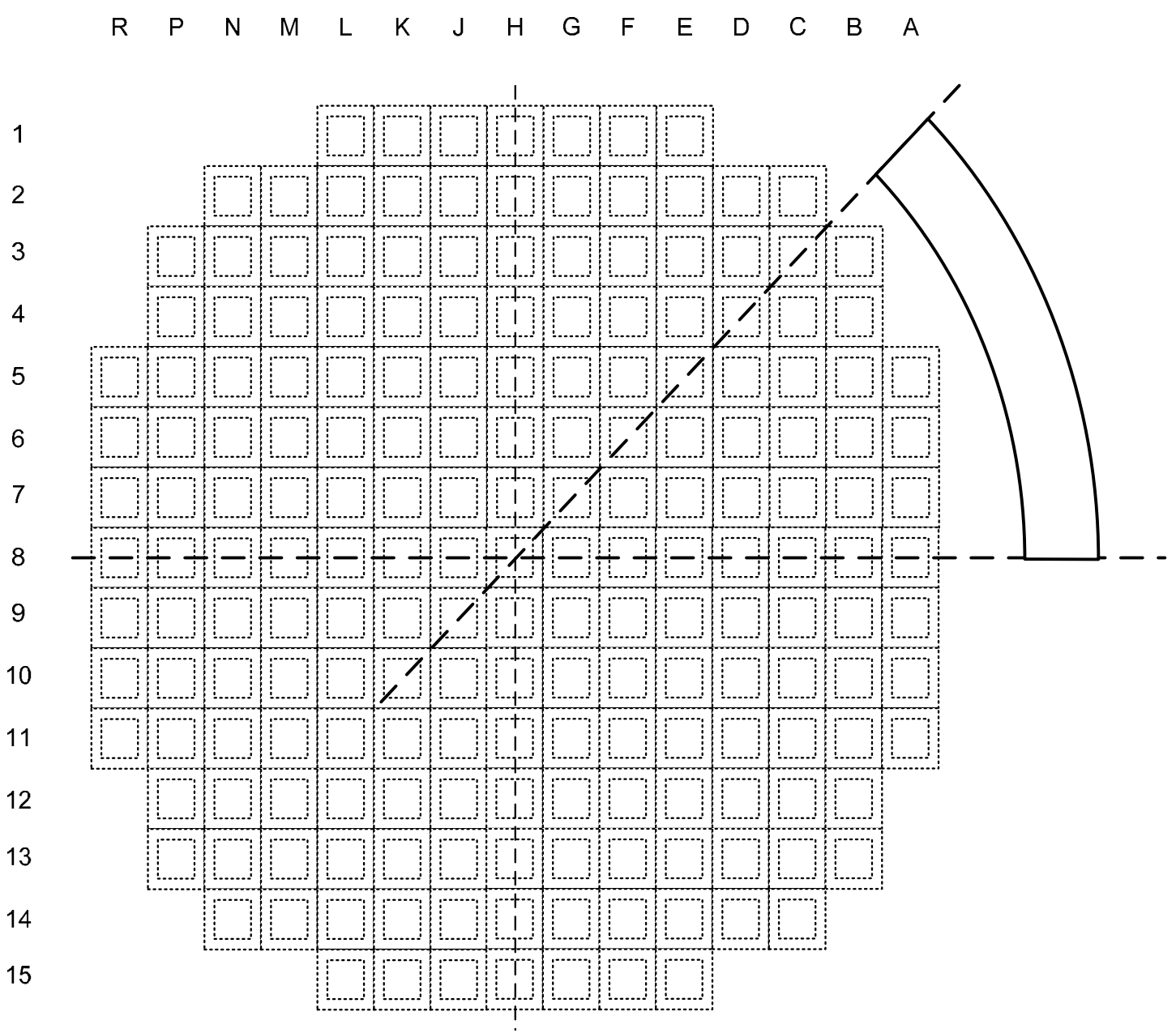
Lab #5: Monte Carlo - PWR Core

Pavel Hejzlar

11/4/2005

3-D PWR Core Model

- Simplified
- All fresh UO2 fuel at 3 w/o
- $1/8^{th}$ symmetry
- Both thermal hydraulic and fuel temperature feedbacks ignored
- Source file generation (difficult)


R P N M L K J H G F E D C B A
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Main data

```
STANDARD WESTINGHOUSE 4-LOOP PWR CORE MODEL
c
c -------------------------------------------------------
-----------
c  Typical Westinghouse 4-loop PWR core
c -------------------------------------------------------
-----------
c  CORE
c    Number of primary loops                    4
c    Total thermal power rating              3411 MW(thermal)
c    Total electricity output                1150 MW(electrical)
c    Number of assemblies                     193
c    Core dimensions                       15X15 assemblies
c    Core barrel ID/OD                3.76/3.87 m
c -------------------------------------------------------
-----------
c  PRIMARY COOLANT
c    System pressure                         15.5 MPa
c    Inlet water temperature               565.85 K
c    Average water temperature              583.1 K
c    Average water density                  0.705 g/cc
c -------------------------------------------------------
```

Assembly data

```
c  FUEL ASSEMBLY DESIGN
c    Assembly lattice                    17X17 square lattice
c    Number of fuel rods                   264
c    Number of guide tubes                  25
c    Pin-to-pin pitch                     1.26 cm
c    Assembly pitch                       21.5 cm
c    Fuel pellet (UO2) density            10.4 g/cc
c    Average fuel temperature              900 K
c    Fuel pellet radius                 0.4096 cm
c    Gap thickness                         82 um
c    Fuel rod diameter                   0.95 cm
c    Guide tube inner radius           0.5690 cm
c    Guide tube outer radius           0.6147 cm
c    Clad/can material                Zircolay-4
c    Active fuel height                    3.66 m
c ---------------------------------------------------------
```

Assumptions

```
c  ASSUMPTIONS
c    (1) The fuel reload differences are ignored, and all
UO2 pellet use
c        3 w/o enrichment.
c    (2) Axial blanket designs in a fuel assembly are not
considered.
c    (3) Axial vairations of coolant density are ignored.
All the fuel
c        and coolant are modeled at their average conditions.
c    (4) All control rods are not modeled.
c -------------------------------------------------------
```

Fuel assembly model

```
c   fuel rod
    1  1 -10.4         -1  u=1  imp:n=1  tmp=7.7553e-8   $ UO2 pellet
    2  2 -0.001   (1 -2)   u=1  imp:n=1                  $ gap
    3  3 -6.550   (2 -3)   u=1  imp:n=1  tmp=5.3520e-8   $ Zr-4 clad
    4  4 -0.705        +3  u=1  imp:n=1  tmp=5.0246e-8   $ coolant, 583.1K
c
c   guide tube
    5  4 -0.705        -4  u=2  imp:n=1  tmp=5.0246e-8   $ coolant inside
    6  3 -6.550   (4 -5)   u=2  imp:n=1  tmp=5.3520e-8   $ guide tube (GT)
    7  4 -0.705        +5  u=2  imp:n=1  tmp=5.0246e-8   $ coolant outside
c
c   17X17 lattice
    8  0  -6 7 -8 9  u=3  imp:n=1  lat=1  fill=-8:8 -8:8 0:0
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  1  1  1  2  1  1  2  1  1  2  1  1  1  1  1
       1  1  1  2  1  1  1  1  1  1  1  1  1  2  1  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  2  1  1  2  1  1  2  1  1  2  1  1  2  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  2  1  1  2  1  1  2  1  1  2  1  1  2  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  2  1  1  2  1  1  2  1  1  2  1  1  2  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  1  2  1  1  1  1  1  1  1  1  1  2  1  1  1
       1  1  1  1  1  2  1  1  2  1  1  2  1  1  1  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
       1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
-    9  0          (-10 11 -12 13)  u=4  imp:n=1  fill=3
    10  4 -0.705   (10:-11:12:-13)  u=4  imp:n=1  tmp=5.0246e-8
 c
```

Core and reflector model

```
c  core configuration
  11  4 -0.705  -14 15 -16 17  u=5  imp:n=1  lat=1  fill=-8:8 -8:8 0:0
c         R  P  N  M  L  K  J  H  G  F  E  D  C  B  A
       5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5
       5  5  5  5  5  4  4  4  4  4  4  4  5  5  5  5  5    $ 1
       5  5  5  4  4  4  4  4  4  4  4  4  4  5  5  5  5    $ 2
       5  5  4  4  4  4  4  4  4  4  4  4  4  4  5  5  5    $ 3
       5  5  4  4  4  4  4  4  4  4  4  4  4  4  5  5  5    $ 4
       5  4  4  4  4  4  4  4  4  4  4  4  4  4  4  5  5    $ 5
       5  4  4  4  4  4  4  4  4  4  4  4  4  4  4  5  5    $ 6
       5  4  4  4  4  4  4  4  4  4  4  4  4  4  4  5  5    $ 7
       5  4  4  4  4  4  4  4  4  4  4  4  4  4  4  5  5    $ 8
       5  4  4  4  4  4  4  4  4  4  4  4  4  4  4  5  5    $ 9
       5  4  4  4  4  4  4  4  4  4  4  4  4  4  4  5  5    $ 10
       5  4  4  4  4  4  4  4  4  4  4  4  4  4  4  5  5    $ 11
       5  5  4  4  4  4  4  4  4  4  4  4  4  4  5  5  5    $ 12
       5  5  4  4  4  4  4  4  4  4  4  4  4  4  5  5  5    $ 13
       5  5  5  4  4  4  4  4  4  4  4  4  4  5  5  5  5    $ 14
       5  5  5  5  5  4  4  4  4  4  4  4  5  5  5  5  5    $ 15
       5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5
c
c  one-eighth core cut
  12  0  (18 19 -20 (-21:-22) -23 24 -25) imp:n=1 fill=5  $ 1/8th core
  13  4 -0.705  (18 19 -26 (20:23:(21 22)) 24 -25)   $ radial reflector
      imp:n=1  tmp=5.0246e-8
  14  5 -7.90 (18 19 26 -27 24 -25) imp:n=1   $ stainless steel baffle
  15  4 -0.705  (18 19  -20 (-21:-22) -23 28 -24)  $ bottom reflector
      imp:n=1  tmp=5.0246e-8
  16  4 -0.705  (18 19  -20 (-21:-22) -23 25 -29)  $ top reflector
      imp:n=1  tmp=5.0246e-8
  17  0  #12 #13 #14 #15 #16  imp:n=0
```

Notes for runs

- use source file MySrc located in Pavel directory on mightyalpha
- copy it to file srctp in your directory before running MCNP (keep the original copy of the source file to be able to use it for second run)
- do not make runs at the last minute before turning homework in (it takes significant CPU and more people running at the same time can slow the server to a crawl)