A^{3}MCNP Computer Exercises

by

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Using A^{3}MCNP

Here, we will utilize the simplified VENUS problem to demonstrate the A^{3}MCNP code.

- Copy the necessary input files

```
cp /usr/local/workshop/a3/cpa3mcnp .
./cpa3mcnp
cd a3
```

- Discussion on the new input information for A^{3}MCNP

```
vi venus.a31
vi venus.a32
vi venus.a33
vi sailor96_zaid.in
```
(given as part of the code)

COMPUTER EXERCISE #1

1. Run A^{3}MCNP

```
runa3_1 venus sailor96
runa3_2 venus
runa3_3 venus
```

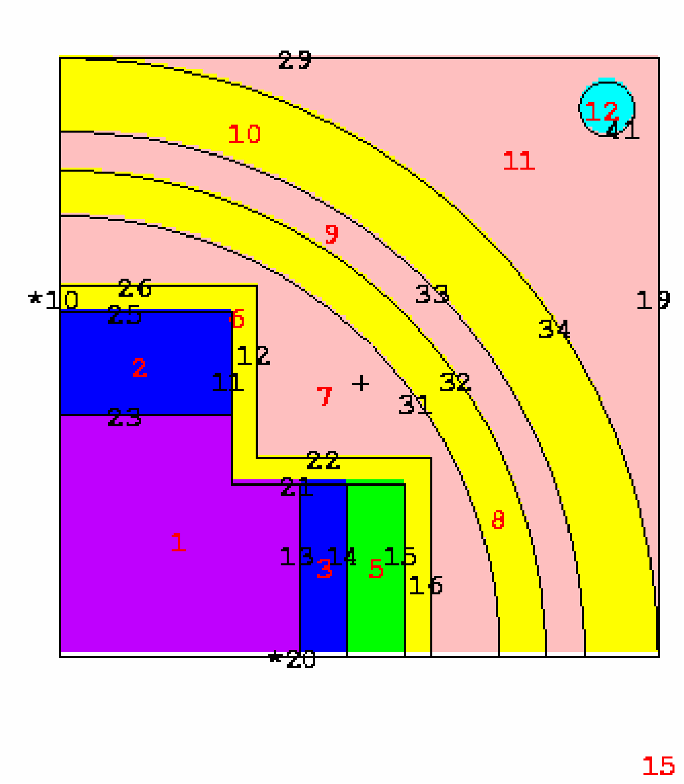
2. Run MCNP4C2

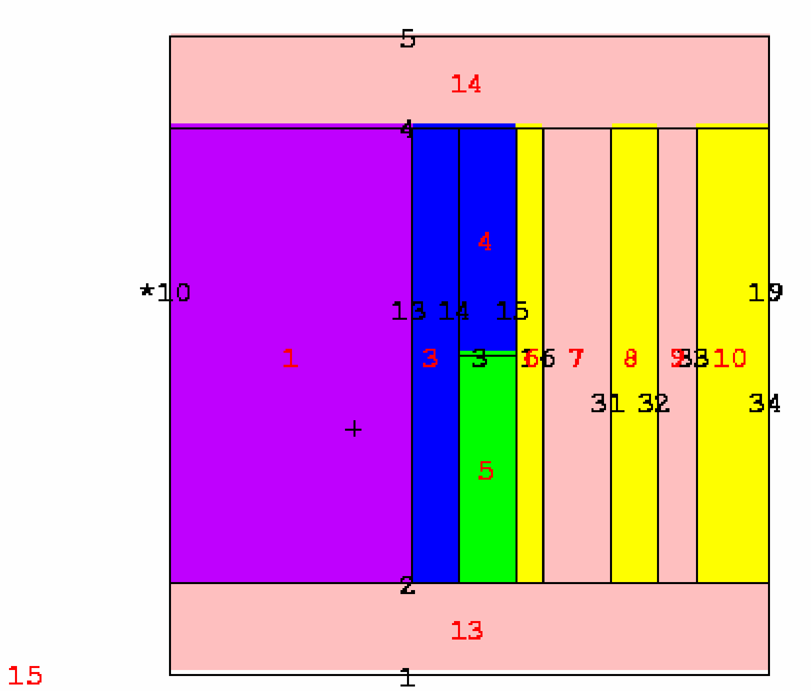
```
run3_0 venus
```

3. Compare the results

vi venus_3o (A^{3}MCNP output)
vi venus_0o (MCNP4C2 output)

SIMPLIFIED VENUS-3 MODEL





file: venus

```
message: DATAPATH=/usr/mcnpxs

TITLE: Simplified VENUS-3 Model
c
c        10th International Training Course/Workshop on
c        Methodologies for Particle Transport Simulation...,
c
c    CELL CARDS
c    core region
1    1 7.16E-02  (2 -4  10 -13  20 -21)
                :(2 -4  10 -11  21 -23)       $ fuel1
2    2 7.16E-02  (2 -4  10 -11  23 -25)       $ fuel2a
3    2 7.16E-02  (2 -4  13 -14  20 -21)       $ fuel2b
4    2 7.16E-02  (3 -4  14 -15  20 -21)       $ fuel2c (above PLSA)
5    3 9.34E-02  (2 -3  14 -15  20 -21)       $ PLSA
6    4 -7.90     (2 -4  10 -12  25 -26)       $ baffle1
                :(2 -4  11 -12  21 -25)       $ baffle2
                :(2 -4  12 -15  21 -22)       $ baffle3
                :(2 -4  15 -16  20 -22)       $ baffle4
7    5 -1.00     (2 -4  10 -12  26 -31)       $ water (baffle-barrel)
                :(2 -4      12  22 -31)
                :(2 -4  16 -31  20 -22)
8    4 -7.90      2 -4  10  20  31 -32        $ barrel
9    5 -1.00      2 -4  10  20  32 -33        $ water (barrel-vessel)
10   4 -7.90      2 -4  10  20  33 -34        $ vessel
11   5 -1.00      2 -4  10  20  34 -19 -29 #12  $ outside vessel
12   6 -2.70      2 -4 -41                    $ dosimeter
13   5 -1.00      1 -2  10 -19  20 -29        $ bottom reflector
14   5 -1.00      4 -5  10 -19  20 -29        $ top reflector
15   0          (-1:5:-10:19:-20:29)          $ outside

c
c    SURFACE CARDS
c
c    NOTE: * indicates reflective boundaries
c
c    top and bottom model boundaries
1    pz   95.00         $ bottom of model
2    pz  105.00         $ fuel bottom
3    pz  130.00         $ fuel midplane
4    pz  155.00         $ fuel top
5    pz  165.00         $ top of model
c
c    symmetry boundaries/outer boundaries
*10  px    0.0
19   px    65.573
*20  py    0.0
29   py    65.573
c
c    planes (normal to x-axis)
11   px    18.90         $ inner square/baffle in
12   px    21.758        $ inner square/baffle out
13   px    26.46         $ fuel1/fuel2 boundary
14   px    31.50         $ fuel/PLSA boundary
15   px    37.80         $ core/baffle boundary
16   px    40.658        $ baffle outer boundary
c
c    planes (normal to y-axis)
21   py    18.90         $ inner square/baffle in
22   py    21.758        $ inner square/baffle out
23   py    26.46         $ fuel1/fuel2 boundary
25   py    37.80         $ core/baffle boundary
26   py    40.658        $ baffle outer boundary
c
c    outside of core
31   cz    48.283        $ barrel IR
32   cz    53.273        $ barrel OR
33   cz    57.545        $ vessel IR
```

```
34   cz    65.573        $ vessel OR
c
c    cavity dosimeter at 45 deg
41   c/z  60.0 60.0 3.00 $ (c/z - cylinder parallel to z-axis)
c    segmenting planes
42   pz 115
43   pz 125
44   pz 135
45   pz 145.

c
c    DATA CARDS
mode n               $ neutron only
imp:n  1 13r  0      $ set all cell importances to unity
c
c    TALLY CARDS
c   default energy bins (SAILOR/BUGLE group structure) for tallying
e0    1.003E+00  1.353E+00  1.653E+00  1.920E+00  2.231E+00  2.346E+00
      2.365E+00  2.466E+00  2.725E+00  3.012E+00  3.679E+00  4.966E+00
      6.065E+00  7.408E+00  8.607E+00  1.000E+01  1.221E+01  1.419E+01
      1.733E+01
c
f14:n  (1 2 3 4)
fc14   volume flux in the core
fm14   1.271E+13 $ Source normalization factor
c
f24:n  10
fc24   volume flux in vessel
sd24   38814.0  $ volume of pv (1/4)*(Ro^2 - Ri^2)*pi*h
fm24   1.271E+13 $ Source normalization factor
c
f32:n  33
fc32   surface flux, vessel inner surface
sd32   4519.57  $ inner area
fm32   1.271E+13 $ Source normalization factor
c
f42:n  34
fc42   surface flux, vessel outer surface
sd42   5150.09  $ outer area
fm42   1.271E+13 $ Source normalization factor
c
f104:n 12
fc104  volume flux in cavity dosimeter
fq104  e s
fm104  1.271E+13 $ Source normalization factor
c
f114:n 12
fc114   Cu(n,a) reaction rate (BUGLE-96) in cavity dosimeter
fm114   1.271E+13 $ Source normalization factor
c     Note: response cross sections for the Cu(n,a) reaction are from
c           the BUGLE-96 multigroup library (Ref: RSICC DLC-185)
c     energy multiplier card
em114  0.0000E-00  1.6179E-08  2.4778E-07  6.7643E-07  8.1765E-07  9.4358E-07
       2.9883E-06  8.2245E-06  4.8528E-05  5.9165E-04  3.3924E-03  1.0490E-02
       1.8464E-02  2.7224E-02  3.7670E-02  4.3444E-02  3.2358E-02
e114   1.653E+00   1.920E+00   2.231E+00   2.346E+00   2.365E+00   2.466E+00
       2.725E+00   3.012E+00   3.679E+00   4.966E+00   6.065E+00   7.408E+00
       8.607E+00   1.000E+01   1.221E+01   1.419E+01   1.733E+01
c
f124:n 12
fc124   Cu(n,a) reaction rate (CE ENDF/B-VI) in cavity dosimeter
c     Note: response cross sections for the Cu(n,a) reaction are from
c           the MCNP continuous energy (CE) ENDF/B-VI library (Ref: RSICC DLC-189)
c     energy multiplier card
fm124   1.271E+13 $ Source normalization factor
c                           material 100, reaction type 107 (n,alpha)
c
c
c
c    MATERIAL CARDS
c
```

```
c    core mixture         atom density = 7.16E-02
m1    1001.60c 4.19E-01   8016.60c 4.20E-01   5010.60c 4.19E-05
     92235.60c 2.79E-03  92238.60c 9.78E-02  40000.60c 5.59E-02
     24050.60c 2.43E-05  24052.60c 4.68E-04  24053.60c 5.31E-05
     24054.60c 1.32E-05  26054.60c 3.30E-05  26056.60c 5.13E-04
     26057.60c 1.17E-04  26058.60c 1.57E-06  28058.60c 2.86E-03
     28060.60c 1.09E-03  28061.60c 4.73E-05  28062.60c 1.50E-04
     28064.60c 3.81E-05
c
c    core mixture         atom density = 7.16E-02
m2    1001.60c 4.19E-01   8016.60c 4.20E-01   5010.60c 4.19E-05
     92235.60c 2.79E-03  92238.60c 9.78E-02  40000.60c 5.59E-02
     24050.60c 2.43E-05  24052.60c 4.68E-04  24053.60c 5.31E-05
     24054.60c 1.32E-05  26054.60c 3.30E-05  26056.60c 5.13E-04
     26057.60c 1.17E-04  26058.60c 1.57E-06  28058.60c 2.86E-03
     28060.60c 1.09E-03  28061.60c 4.73E-05  28062.60c 1.50E-04
     28064.60c 3.81E-05
c
c   PLSA                  atom density = 7.16E-02
m3    1001.60c 4.19E-01   8016.60c 4.20E-01   5010.60c 4.19E-05
     92235.60c 2.79E-03  92238.60c 9.78E-02  40000.60c 5.59E-02
     24050.60c 2.43E-05  24052.60c 4.68E-04  24053.60c 5.31E-05
     24054.60c 1.32E-05  26054.60c 3.30E-05  26056.60c 5.13E-04
     26057.60c 1.17E-04  26058.60c 1.57E-06  28058.60c 2.86E-03
     28060.60c 1.09E-03  28061.60c 4.73E-05  28062.60c 1.50E-04
     28064.60c 3.81E-05
c
c    stainless steel      atom density = 8.69E-02
m4    6000.60c 2.73E-03  14000.60c 1.03E-02  25055.60c 1.75E-02
     24050.60c 8.70E-03  24052.60c 1.68E-01  24053.60c 1.90E-02
     24054.60c 4.73E-03  26054.60c 3.96E-02  26056.60c 6.15E-01
     26057.60c 1.41E-02  26058.60c 1.88E-03  28058.60c 6.72E-02
     28060.60c 2.57E-02  28061.60c 1.11E-03  28062.60c 3.53E-03
     28064.60c 8.95E-04
c
c    water                atom density =
m5    1001.60c 6.67E-01   8016.60c 3.33E-01   5010.60c 8.00E-05
c
c    aluminum             atom density = 6.02E-02
m6   13027.60c 1.00E+00
c
c    response cross section for Cu-63(n,alpha) from CE ENDV/B-VI
m100   29063.60c  1.0
c
c
nonu     $ fission in all cells is treated as capture
c
c     neutron histories are terminated if their energy falls below 5 MeV
cut:n   j  5.00
c print 110   $ print table 110 - first 50 histories
print
c
c    void    $ void material regions
ctme  02      $ time cutoff card (minutes)
c     nps  100000  $ follow 1E+5 particle histories
c
```

file: venus.sdef

```
c
c    SOURCE CARDS
sdef  erg=d1  pos=d2
c
c       SAILOR/BUGLE 47-group structure
si1 h   1.000e-11  1.000e-7   4.140e-7   8.764e-7   1.855e-6   5.043e-6
        1.068e-5   3.727e-5   1.013e-4   2.144e-4   4.540e-4   1.585e-3
        3.355e-3   7.102e-3   1.503e-2   2.188e-2   2.418e-2   2.606e-2
        3.183e-2   4.087e-2   6.738e-2   1.111e-1   1.832e-1   2.972e-1
        3.688e-1   4.979e-1   6.081e-1   7.427e-1   8.208e-1   1.003e+0
        1.353e+0   1.653e+0   1.920e+0   2.231e+0   2.346e+0   2.365e+0
        2.466e+0   2.725e+0   3.012e+0   3.679e+0   4.966e+0   6.065e+0
        7.408e+0   8.607e+0   1.000e+1   1.221e+1   1.419e+1   1.733e+1
c       typical PWR fission spectrum
sp1 d 0  1.3464e-11 1.0080e-10 2.3789e-10 7.3247e-10 3.7774e-09 1.0123e-08
         8.2702e-08 3.4003e-07 9.1003e-07 2.8049e-06 2.2923e-05 5.6253e-05
         1.7296e-04 5.3045e-04 5.9161e-04 2.2158e-04 1.8892e-04 6.2068e-04
         1.0843e-03 3.8297e-03 7.9326e-03 1.6195e-02 3.0840e-02 2.1559e-02
         4.1541e-02 3.7103e-02 4.6232e-02 2.6923e-02 6.2179e-02 1.1339e-01
         8.8005e-02 7.0140e-02 7.1859e-02 2.3970e-02 3.8290e-03 1.9742e-02
         4.6115e-02 4.4058e-02 7.8188e-02 8.3999e-02 3.2243e-02 1.6918e-02
         5.9238e-03 2.6238e-03 1.1094e-03 1.8428e-04 4.2592e-05
c
c       source point positions
si2  l
        6.93    .63 106.75      8.19    .63 106.75      9.45    .63 106.75
       10.71    .63 106.75     11.97    .63 106.75     13.23    .63 106.75
       14.49    .63 106.75     15.75    .63 106.75     17.01    .63 106.75
       18.27    .63 106.75     19.53    .63 106.75     20.79    .63 106.75
       22.05    .63 106.75     23.31    .63 106.75     24.57    .63 106.75
       25.83    .63 106.75     27.09    .63 106.75     28.35    .63 106.75
       29.61    .63 106.75     30.87    .63 106.75      6.93   1.89 106.75
…
…
c
c       source point probabilities
sp2  d
        .7865   .8719   .8842   .8914   .8886   .9096   .9168   .9309   .9331
        .8850   .8751   .8599   .8356   .7946   .7575   .7409   .5792   .5665
        .5511   .5350   .7770   .8658   .8880   .8842   .8985   .9163   .9320
        .9331   .8822   .8698   .8552   .8314   .7940   .7528   .7441   .5806
        .5657   .5451   .5321   .7675   .8658   .8866   .8946   .8955   .8998
        .9125   .9344   .9248   .8774   .8632   .8446   .8157   .7840   .7372
        .7424   .5821   .5630   .5392   .5292   .7491   .8708   .8857   .8946
…
…
```

file: sailor96_zaid.in

```
  142       = mtp
  1001    3  This file corresponds to the SAILOR96 library
  5010    7
 40000   27
 92235   43
 92238   47
  8016   51
 24000   63
 24050   63
 24052   63
 24053   63
 24054   63
 25055   67
 26000   71
 26054   71
 26056   71
 26057   71
 26058   71
 28000   75
 28058   75
 28060   75
 28061   75
 28062   75
 28064   75
  6000   79
 11023   95
 12000   99
 13027  103
 14000  107
 19000  111
 20000  115
t
 13
   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
  16  17  18  18  20  21  22  23  24  25  26  27  28  29  30
  31  32  33  34  35  36  37  38  39  40  41  42  43  44  45
  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
  61  62  63  64  65  66  67  68  69  70  71  72  73  74  75
  76  77  78  79  80  81  82  83  84  85  86  87  88  89  90
  91  92  93  94  95  96  97  98  99 100 101 102 103 104 105
 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135
 136 137 138 139 140 141 142
```

file: venus.a31

```
c
c ----- A3MCNP parameters (step 1, Sn mesh generation)
c
c       isn isrcc igm nsctm iht ihm iups neut
sngp     2   12   47   3    3   70   0   47
c
c    Sn spatial mesh input
c      x1    x2  y1   y2      z1      z2    xt   yt   zt pzlev
snmsh   0.    64.  0.   64.   95.    165.0  3.2  3.2  10.  -7
c
c    back-thinning parameters for different materials
snthn 3.2 3.2 3.2 3.2 3.2 3.2 3.2
c
c    Sn boundary condition - snbc()=(ibl,ibr,ibi,ibo,ibb,ibt)
c       ibl ibr   ibi ibo   ibb ibt
snbc     1   0     1   0     0   0
c
c    Sn energy group structure
c    SAILOR 47-group neutron structure
snsi   1.0e-7 4.14e-7 8.764e-7 1.855e-6 5.043e-6 1.068e-5
       3.727e-5 1.013e-4 2.144e-4 4.454e-4 1.585e-3 3.355e-3
       7.102e-3 1.503e-2 2.188e-2 2.418e-2 2.606e-2 3.183e-2
       4.087e-2 6.738e-2 1.111e-1 1.832e-1 2.972e-1 3.688e-1
       4.979e-1 6.081e-1 7.427e-1 8.208e-1 1.003 1.353 1.653
       1.920 2.231 2.346 2.365 2.466 2.725 3.012 3.679 4.966
       6.065 7.408 8.607 1.000e+1 1.221e+1 1.419e+1 1.733e+1
snsp   0.0 39r
      .003 .01 .012 .018 .02 .04 .03
snacc 2 2
     6.4  32.0 $coarse-mesh interfaces along x
     6.4  32.0 $coarse-mesh interfaces along y
```

file: venus.a32

```
c
c ----- A3MCNP parameters (step 2, variance reduction parameters generation)
c
wwp:n 5 3 5
wwa:n 47 0 1
```

file: venus.a33

```
c
c ----- A3MCNP parameters (step 3, accelerated simulation)
c
wwp:n 5 3 5
wwa:n 47 1 1
```

A^{3}MCNP COMPUTER EXERCISE #2

Reduce the size of the detector (adjoint source)

1. Edit “venus” to divide Cell 12 into 2 cells: 12 and 121

   vi venus

   Before:

   ```
   11   5 -1.00      2 -4  10  20  34 -19 -29 #12  $ outside vessel
   12   6 -2.70      2 -4 -41                      $ dosimeter
   ```

   After:

   ```
   11   5 -1.00      2 -4  10  20  34 -19 -29 #12 #121  $ outside vessel
   12   6 -2.70      45 -4 -41                          $ dosimeter
   121  6 -2.70      2 -45 -41                          $ dosimeter 2
   ```

2. Modify cell importance values

   Before:

   ```
   imp:n  1 13r  0      $ set all cell importances to unity
   ```

   After:

   ```
   imp:n  1 14r  0      $ set all cell importances to unity
   ```

3. Run MCNP4C and A^{3}MCNP

4. Examine output files

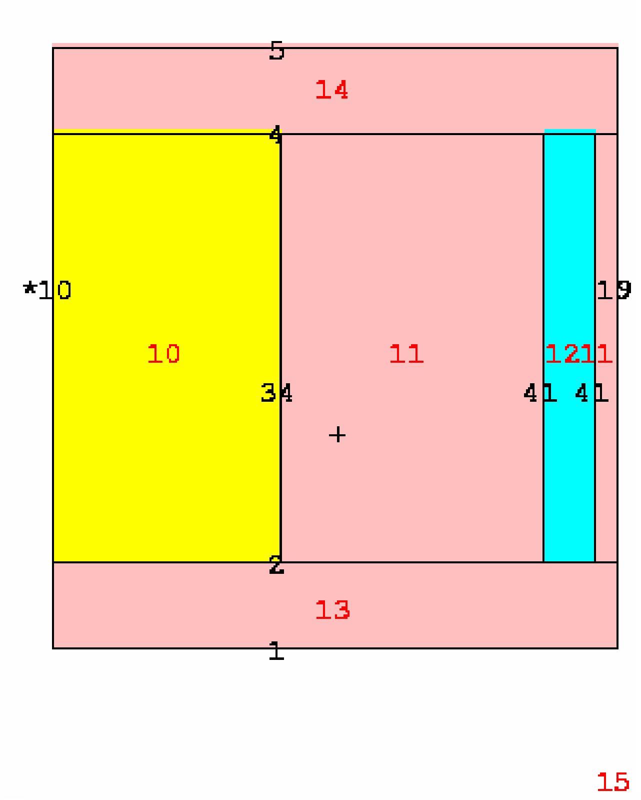
   vi venus_0o

   vi venus_3o

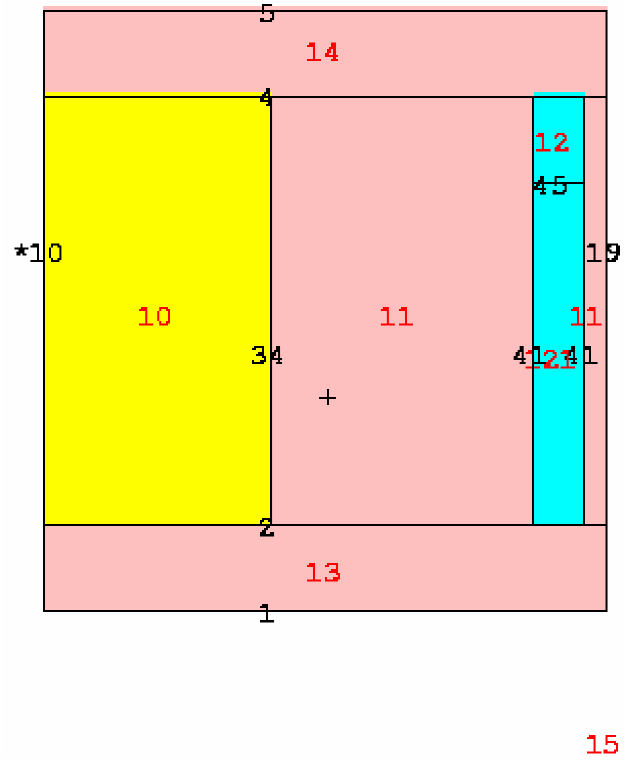
SIMPLIFIED VENUS-3 MODEL

Exercise #2

Before



After



A^{3}MCNP COMPUTER EXERCISE #3

Coarsen fine meshes for S$_N$ adjoint calculation using the back-thinning approach

1. Edit “venus.a31” to apply the back-thinning option

```
vi venus.a31
```

Before:

```
c       isn isrcc igm nsctm iht ihm iups neut
sngp     2   12   47    3       3   70   0     47
```

After:

```
c       isn isrcc igm nsctm iht ihm iups neut
sngp     1   12   47    3       3   70   0     47
```

2. Run A^{3}MCNP
Observe the reduction of number of fine meshes

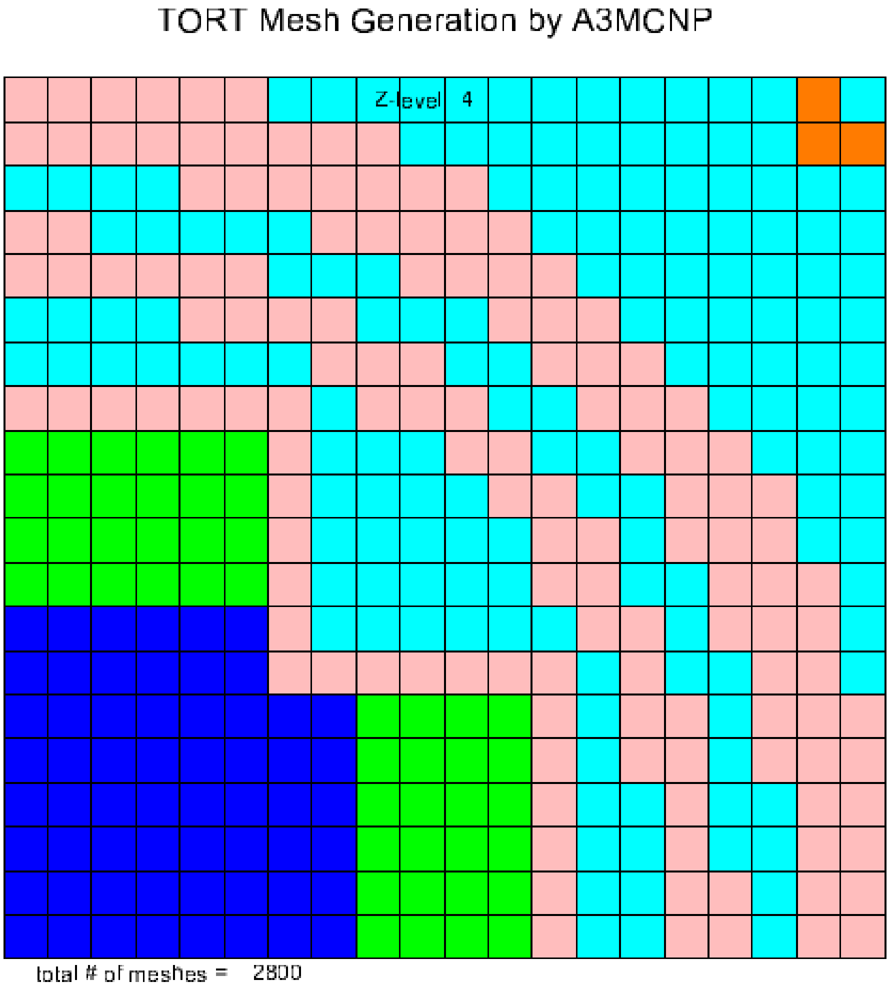
```
runa3_1 venus sailor96
runa3_2 venus
runa3_3 venus
```

4. Examine output files
Look for tally fluctuation charts at the end of file
Compare results with and without back-thinning

```
vi venus_3o
```

SIMPLIFIED VENUS-3 MODEL

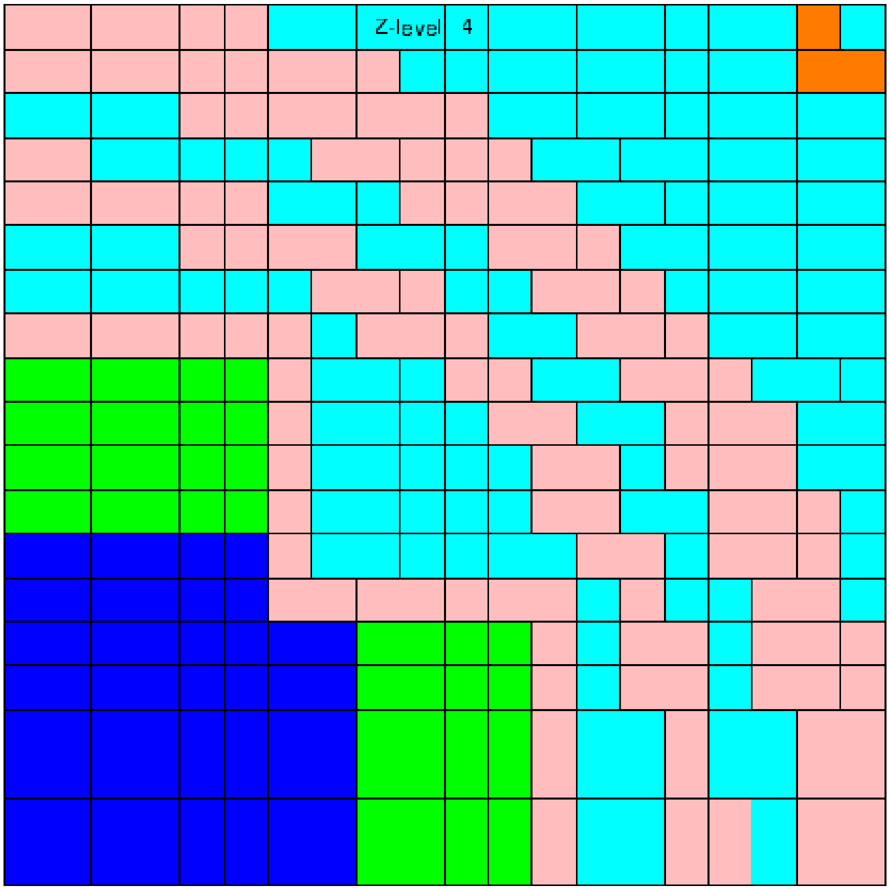
Exercise #3, uniform mesh distribution



SIMPLIFIED VENUS-3 MODEL

Exercise #3, with back-thinning

TORT Mesh Generation by A3MCNP



original # of meshes = 2800
# of meshes (after back-thinning) = 1488
reduction of 46.9%