APPENDIX A: MCNP INPUT DECK

The code input lines below is generated using a combination of the three calculational tools used in this study: OSCAR-3, OSMINT and MCNP5. The code lines describes the core model incorporating the preliminary PBMR fuel irradiation rig with a detailed three dimensional model of the pebble fuel containing about 15 000 coated fuel particles. Some of the code input lines are removed for sensitivity of such data and for reducing the large volume of this input.

OSMINT 5.4.5 beta

```
c-------------------------------------------------------------------------------------------------------------------------------
c ***** COR! === OSMINT fills main ass. boxes into core box
1    0        -314:+315:-316:+317:-308:+309                    imp:n=0
2    3        -0.998000E+00 +314 -315 +316 -317 +308 -309
                        #3 #5 #6 #7 #8                          imp:n=1
5    2 -0.271000E+01 +304 -300 +302 -303 +5337 -22   imp:n=1
6    2 -0.271000E+01 +301 -305 +302 -303 +5337 -22   imp:n=1
7    2 -0.271000E+01 +303 -307 +304 -305 +5337 -22   imp:n=1
8    2 -0.271000E+01 -302 +306 +314 -315 +5337 -22   imp:n=1
3    0        +300 -301 +302 -303 +308 -309 fill=1           imp:n=1
4    0        -311 +310 +312 -313     lat=1   u=1            imp:n=1
           fill=-4:4 -4:3 0:0
c
c ***** MAP! === OSMINT writes serial numbers and universe maps
c  A1sAl   A2sBe  A3rng    A4rng   A5hBe  A6hBe  A7hBe    A8sBe    A9sAl
c  B1sAl   B2sBe   E735D  E727D  E728D  B6ipr    E739D   B8Mo1    B9sBe
c  C1sAl   C2sBe   C3Mo1  E723D  C128D  EF05L  C131D  E729D    C9sBe
c  D1sAl   D2sBe  E722D  E712D   E675D  D6ipr    E724D   D8Mo1   D9sBe
c  E1sPb   E2sBe   E3Mo1  E718D  C127D  E711D  C129D   E730D    E9sAl
c  F1sPb   F2sBe   E698D   E720D  E717D  F6ipr    EF07L    F8Mo1   F9sBe
c  G1sPb  G2sBe  G3Mo1  E721D  C123D   E714D  C130D   E734D    G9hyd
c  H1sPb  H2sBe  E738D   E732D  E731D   E733D  E740D   H8sBe    H9sAl
     3      4     5       6       7       7       7       4       3
     3      4    101    102    103     60     104    105     4
     3      4    106    107    108    109    110    111      4
     3      4    112    113    114     9      115    116     4
    13      4    117    118    119    120    121    122     3
    13      4    123    124    125     9     126    127     4
    13      4    128    129    130    131    132    133     14
    13      4    134    135    136    137    138     4       3
c-------------------------------------------------------------------------------------------------------------------------------
c
c ***** ASS!====== OSMINT writes fuel and control assemblies
c ***** RES!====== OSMINT writes the non fuel assemblies
c
c some lines were omitted intentionally
c-------------------------------------------------------------------------------------------------------------------------------
c
c
```

c PEBBLE AND RIG CELLS
c COATED FUEL PARTICLE CELLS
c --------------------------
810 500 7.23298e-02   -710   u=50 imp:n=1 $ reference -1 NW
811 501 5.06387e-02   710 -711   u=50 imp:n=1 $ buffer layer
812 502 9.32555e-02   711 -712   u=50 imp:n=1 $ IPyC layer
813 503 9.57463e-02   712 -713 u=50 imp:n=1 $ SiC layer
814 504 9.47596e-02   713 -714   u=50 imp:n=1 $ OPyC layer
c
815 500 7.23298e-02   -715   u=50 imp:n=1 $ reference -1 NE
816 501 5.06387e-02   715 -716   u=50 imp:n=1 $ buffer layer
817 502 9.32555e-02   716 -717   u=50 imp:n=1 $ IPyC layer
818 503 9.57463e-02   717 -718 u=50 imp:n=1 $ SiC layer
819 504 9.47596e-02   718 -719   u=50 imp:n=1 $ OPyC layer
c
820   500 7.23298e-02   -720   u=50 imp:n=1 $ reference -1 S
821   501 5.06387e-02   720 -721   u=50 imp:n=1 $ buffer layer
822   502 9.32555e-02   721 -722   u=50 imp:n=1 $ IPyC layer
823   503 9.57463e-02   722 -723 u=50 imp:n=1 $ SiC layer
824   504 9.47596e-02   723 -724   u=50 imp:n=1 $ OPyC layer
c
825   500 7.23298e-02   -725   u=50 imp:n=1 $ reference
826   501 5.06387e-02   725 -726   u=50 imp:n=1 $ buffer layer
827   502 9.32555e-02   726 -727   u=50 imp:n=1 $ IPyC layer
828   503 9.57463e-02   727 -728 u=50 imp:n=1 $ SiC layer
829   504 9.47596e-02   728 -729   u=50 imp:n=1 $ OPyC layer
c
830   500 7.23298e-02   -730   u=50 imp:n=1 $ reference +1 N
831   501 5.06387e-02   730 -731   u=50 imp:n=1 $ buffer layer
832   502 9.32555e-02   731 -732   u=50 imp:n=1 $ IPyC layer
833   503 9.57463e-02   732 -733 u=50 imp:n=1 $ SiC layer
834   504 9.47596e-02   733 -734 u=50 imp:n=1 $ OPyC layer
c
835   500 7.23298e-02   -735   u=50 imp:n=1 $ reference +1 SW
836   501 5.06387e-02   735 -736 u=50 imp:n=1 $ buffer layer
837   502 9.32555e-02   736 -737 u=50 imp:n=1 $ IPyC layer
838   503 9.57463e-02   737 -738 u=50 imp:n=1 $ SiC layer
839   504 9.47596e-02   738 -739 u=50 imp:n=1 $ OPyC layer
c
840   500 7.23298e-02   -740   u=50 imp:n=1 $ reference +1 SE
841   501 5.06387e-02   740 -741 u=50 imp:n=1 $ buffer layer
842   502 9.32555e-02   741 -742 u=50 imp:n=1 $ IPyC layer
843   503 9.57463e-02   742 -743 u=50 imp:n=1 $ SiC layer
844   504 9.47596e-02   743 -744 u=50 imp:n=1 $ OPyC layer
c
845   500 7.23298e-02   -745   u=50 imp:n=1 $ reference -1 NW
846   501 5.06387e-02   745 -746 u=50 imp:n=1 $ buffer layer
847   502 9.32555e-02   746 -747 u=50 imp:n=1 $ IPyC layer
848   503 9.57463e-02   747 -748 u=50 imp:n=1 $ SiC layer
849   504 9.47596e-02   748 -749 u=50 imp:n=1 $ OPyC layer
c
850   500 7.23298e-02   -750   u=50 imp:n=1 $ reference -1 NE
851   501 5.06387e-02   750 -751 u=50 imp:n=1 $ buffer layer

```
852   502  9.32555e-02          751 -752 u=50  imp:n=1  $ IPyC layer
853   503  9.57463e-02            752 -753 u=50  imp:n=1  $ SiC layer
854   504  9.47596e-02          753 -754 u=50  imp:n=1  $ OPyC layer
c
855   500  7.23298e-02            -755       u=50  imp:n=1  $ reference -1 S
856   501  5.06387e-02          755 -756 u=50  imp:n=1  $ buffer layer
857   502  9.32555e-02          756 -757 u=50  imp:n=1  $ IPyC layer
858   503  9.57463e-02            757 -758 u=50  imp:n=1  $ SiC layer
859   504  9.47596e-02          758 -759 u=50  imp:n=1  $ OPyC layer
c
c INTER COATED PARTICLE
c ----------------------------
c
860   505  8.72394e-02 714 719 724 729 734 739 744 749 754 759 &
    u=50          imp:n=1                    $ graphite matrix
c
c COATED PARTICLE LATTICE
c ------------------------
c
861   0  -761 764  -760 763  -765 762 -767 766    $ infinite lattice
     lat=2 fill=50                 u=52               imp:n=1
c
c PEBBLE CELLS
c -------------
c
870   0             -770      fill=52     u=54    imp:n=1  $ fuel region
871   505  8.72394e-02   770 -771 u=54    imp:n=1  $ non-fuel region, graphite
872   506  8.62363e-02   771         u=54    imp:n=1  $ graphite insert for a pebble
c
c RIG CELLS
c
883     0            -780 +781 -782    fill=54   u=56  imp:n=1
884 510 -0.0001787 -783 +784 -785 (+780:-781:+782) u=56 imp:n=1
885 511 -7.92 -786 +787 -788 (+783:-784:+785) u=56 imp:n=1
886 510 -0.0001787 +786:-787:788 u=56           imp:n=1
891    0                  -790     fill=56    u=58          imp:n=1
892     511  -7.92          790 -791            u=58        imp:n=1  $ SS 316 rig
893     512  -1.00          791 -792           u=58        imp:n=1  $ water
894     513  -2.7           792                u=58         imp:n=1  $ aluminum
895     0                  -793     fill=58    u=60         imp:n=1
896     512  -1.00          793      u=60                    imp:n=1  $ water
c-----------------------------------------------------------------------------------------------------------------------------------------

c ***** FHLS ====== OSMINT writes fuel and control surfaces
c fuel LEU/HEU assemblies surface
c some lines were omitted intentionally
c
c SURFACE CARDS
c ------------------------------------------------------------------------------------------------------------------------------------
c COATED FUEL PARTICLE SURFACES
c
710  s  -0.09307375  +0.0537362  -0.1519888  0.025    $ reference -1 NW
711  s  -0.09307375  +0.0537362  -0.1519888  0.0343  $ reference -1 NW
```

```
712  s  -0.09307375  +0.0537362  -0.1519888  0.0381  $ reference -1 NW
713  s  -0.09307375  +0.0537362  -0.1519888  0.0416  $ reference -1 NW
714  s  -0.09307375  +0.0537362  -0.1519888  0.0456  $ reference -1 NW
c
715  s  +0.09307375  +0.0537362  -0.1519888  0.025    $ reference -1 NE
716  s  +0.09307375  +0.0537362  -0.1519888  0.0343  $ reference -1 NE
717  s  +0.09307375  +0.0537362  -0.1519888  0.0381  $ reference -1 NE
718  s  +0.09307375  +0.0537362  -0.1519888  0.0416  $ reference -1 NE
719  s  +0.09307375  +0.0537362  -0.1519888  0.0456  $ reference -1 NE
c
720  s   0      +0.1074723  -0.1519888  0.025    $ reference -1 S
721  s   0      +0.1074723  -0.1519888  0.0343  $ reference -1 S
722  s   0      +0.1074723  -0.1519888  0.0381  $ reference -1 S
723  s   0      +0.1074723  -0.1519888  0.0416  $ reference -1 S
724  s   0      +0.1074723  -0.1519888  0.0456  $ reference -1 S
c
725  so                              0.025    $ reference
726  so                              0.0343  $ reference
727  so                              0.0381  $ reference
728  so                              0.0416  $ reference
729  so                              0.0456  $ reference
c
730  s    0      +0.1074723  +0.1519888  0.025    $ reference +1 N
731  s    0      +0.1074723  +0.1519888  0.0343  $ reference +1 N
732  s    0      +0.1074723  +0.1519888  0.0381  $ reference +1 N
733  s    0      +0.1074723  +0.1519888  0.0416  $ reference +1 N
734  s    0      +0.1074723  +0.1519888  0.0456  $ reference +1 N
c
735  s  -0.09307375  -0.0537362  +0.1519888  0.025    $ reference +1 SW
736  s  -0.09307375  -0.0537362  +0.1519888  0.0343  $ reference +1 SW
737  s  -0.09307375  -0.0537362  +0.1519888  0.0381  $ reference +1 SW
738  s  -0.09307375  -0.0537362  +0.1519888  0.0416  $ reference +1 SW
739  s  -0.09307375  -0.0537362  +0.1519888  0.0456  $ reference +1 SW
c
740  s  +0.09307375  -0.0537362  +0.1519888  0.025    $ reference +1 SE
741  s  +0.09307375  -0.0537362  +0.1519888  0.0343  $ reference +1 SE
742  s  +0.09307375  -0.0537362  +0.1519888  0.0381  $ reference +1 SE
743  s  +0.09307375  -0.0537362  +0.1519888  0.0416  $ reference +1 SE
744  s  +0.09307375  -0.0537362  +0.1519888  0.0456  $ reference +1 SE
c
745  s  -0.09307375  +0.0537362  +0.3039776  0.025    $ reference +2 NW
746  s  -0.09307375  +0.0537362  +0.3039776  0.0343  $ reference +2 NW
747  s  -0.09307375  +0.0537362  +0.3039776  0.0381  $ reference +2 NW
748  s  -0.09307375  +0.0537362  +0.3039776  0.0416  $ reference +2 NW
749  s  -0.09307375  +0.0537362  +0.3039776  0.0456  $ reference +2 NW
c
750  s  +0.09307375  +0.0537362  +0.3039776  0.025    $ reference +2 NE
751  s  +0.09307375  +0.0537362  +0.3039776  0.0343  $ reference +2 NE
752  s  +0.09307375  +0.0537362  +0.3039776  0.0381  $ reference +2 NE
753  s  +0.09307375  +0.0537362  +0.3039776  0.0416  $ reference +2 NE
754  s  +0.09307375  +0.0537362  +0.3039776  0.0456  $ reference +2 NE
c
755  s    0      +0.1074723  +0.3039776  0.025    $ reference +2 S
```

```
756  s    0      +0.1074723  +0.3039776  0.0343  $ reference +2 S
757  s    0      +0.1074723  +0.3039776  0.0381  $ reference +2 S
758  s    0      +0.1074723  +0.3039776  0.0416  $ reference +2 S
759  s    0      +0.1074723  +0.3039776  0.0456  $ reference +2 S
c-------------------------------------------------------------------------------------------------------------------------
c COATED FUEL PARTICLE SURFACES
c
760  p   +1   1.7320508  0   +0.18614750    $ NE
761  px  +0.09307375                        $ E
762  p   -1   1.7320508  0   -0.18614750    $ SE
763  p   +1   1.7320508  0   -0.18614750    $ SW
764  px  -0.09307375                        $ W
765  p   -1   1.7320508   0  +0.18614750    $ NW
766  pz  -0.1519888                         $ bottom
767  pz   0.3039776                         $ top
c-------------------------------------------------------------------------------------------------------------------------
c PEBBLE SURFACES
c
770  so   2.5                               $ fuel region
771  so   3.0                               $ non-fuel graphite region
c-------------------------------------------------------------------------------------------------------------------------
c RIG SURFACES
c 780    rcc   0   0  -3.5    0   0  7      3.3505    $ graphite insert
c 781    rcc   0   0  -3.579  0   0  7.158  3.39    $ gas loop
c 782    rcc   0   0  -3.749  0   0  7.498  3.475  $ SS 316 capsule
780 cz 3.3505
781 pz -3.5
782 pz +3.5
783 cz 3.39
784 pz -3.579
785 pz +3.579
786 cz 3.475
787 pz -3.749
788 pz 3.749
c Thimble tube and waterbox
790    cz       3.5                        $ gas loop
791    cz       3.6
792    cz      3.67
793    rpp -3.7905 3.7905 -3.7855 3.7855 -30 30 $ Al waterbox

c DATA CARDS
c ***** Other material === User input
c ---------------------------------------------------------------------------------------------------------------------
c MATERIAL CARDS
c
c PEBBLE MATERIALS
c
m500 92235    2.36760e-03    92238    2.17423e-02    8016     4.82199e-02    $ UO2 kernel
m501       6000    5.06387e-02                          $ Buffer layer
mt501       grph.60t
m502       6000    9.32555e-02                          $ IPyC layer
mt502      grph.60t
m503      14000     4.78149e-02      6000     4.79313e-02            $ SiC layer
```

```
mt503       grph.60t
m504        6000     9.47596e-02                          $ OPyC
mt504       grph.60t
m505        6000     8.72390e-02     5010     8.40174e-08     5011     3.07574e-07        $ graphite matrix
mt505       grph.60t
m506        6000     8.62363e-02                          $ graphite cup
mt506       grph.60t
c-------------------------------------------------------------------------------------------------------------------------
c RIG MATERIALS
c
m510    2004       1                $ helium
m511    26000   0.655   24000  0.170 &
        28000   0.120   25055  0.020  &
        42000   0.025   14000  0.010        $ SS 316 for rig and capsule
m512    8016       1   1001 2            $ water
mt512    lwtr.60t
m513    13027     1                    $ aluminum
c  ************************************Fuel Element Material*****************
c  ***** MAT!======= OSMINT writes present core fuel materials
c some lines were omitted intentionally
c-------------------------------------------------------------------------------------------------------------------------
c CRITICALITY SOURCE
kcode 100000 1.00  15 215
ksrc   0.0 0.0 0.0
mode n p
c-------------------------------------------------------------------------------------------------------------------------
c CORE FLUX TALLIES
c
fc14 energy dependent neutron flux spectrum in the SAFARI-1 core
f14:n  3
fm14 1.6467918e18
e14    1e-10  1e-9  1e-8  1e-7  0.625e-6  1e-6  1e-5  1e-4  1e-3  5.53 e-3 1e-2 1e-1 0.821  1  18i   20
c
fc24 energy dependent neutron flux in the SAFARI-1 core
f24:n  3
fm24 1.6467918e18
e24    0.625e-6      5.53e-3      0.821      20
c
fc34 energy dependent photon flux spectrum in the SAFARI-1 core
f34:p  3
fm34 1.6467918e18
e34    1e-3  1e-2 1e-1 1 98i 100
c
c-------------------------------------------------------------------------------------------------------------------------
c CORE MESH TALLIES
c
fc44 Total  neutron flux in the core
fmesh44:n geom=rec origin -34.695 -28.35 -29.685
         imesh=34.695       iints =  9
         jmesh=36.45         jints = 8
         kmesh=29.685       kints =1
fm44        1.6467918e18
c
```

```
fc54 Total  photon flux in the core
fmesh54:p geom=rec origin -34.695 -28.35 -29.685
          imesh=34.695       iints =  9
          jmesh=36.45         jints = 8
          kmesh=29.685       kints =1
fm54         1.6467918e18
c
fc64 Axial  neutron flux in the core
fmesh64:n geom=rec origin -34.695 -28.35 -29.685
          imesh=34.695       iints =  1
          jmesh=36.45         jints = 1
          kmesh=29.685       kints =10
fm64       1.6467918e18
c
fc74 Axial photon flux in the core
fmesh74:p geom=rec origin -34.695 -28.35 -29.685
          imesh=34.695       iints =  1
          jmesh=36.45         jints = 1
          kmesh=29.685       kints =10
fm74        1.6467918e18
c-------------------------------------------------------------------------------------------------------------------------
c CORE HEATING TALLIES
c
fc84 Axial  neutron heating in the core
fmesh84:n geom=rec origin -34.695 -28.35 -29.685
          imesh=34.695       iints =  1
          jmesh=36.45         jints = 1
          kmesh=29.685       kints =10
          emesh= 0.625e-6  5.53e-3  0.821  20
          eints=           1         1           1      1
fm84       2.638105e5   0   1   -4
c
fc94 Total fission heating in the core
fmesh94:n geom=rec origin -34.695 -28.35 -29.685
          imesh=34.695       iints =  9
          jmesh=36.45         jints = 8
          kmesh=29.685       kints =1
fm94       2.638105e5   0   -6    -8
c
fc104 Axial photon heating in the core
fmesh104:p geom=rec origin -34.695 -28.35 -29.685
          imesh=34.695       iints =  1
          jmesh=36.45         jints = 1
          kmesh=29.685       kints =10
fm104 2.638105e5   0   -5   -6
c-------------------------------------------------------------------------------------------------------------------------
c B6 NEUTRON AND PHOTON FLUX TALLIES
c
fc114 energy dependent neutron flux spectrum in the core position B6
f114:n     (4<4[1 -3 0])
fm114 1.6467918e18
sd114 3.70771587e3
e114 1e-10  1e-9  1e-8  1e-7  0.625e-6  1e-6  1e-5  1e-4  1e-3  5.53 e-3 1e-2 1e-1 0.821  1  18i   20
```

```
c
fc124 energy dependent neutron flux in the core position B6
f124:n     (4<4[1 -3 0])
fm124 1.6467918e18
sd124 3.70771587e3
e124  0.625e-6   5.53e-3   0.821  20
c
fc134 energy dependent photon flux spectrum in the core position B6
f134:p     (4<4[1 -3 0])
fm134 1.6467918e18
sd134 3.70771587e3
e134    1e-3  1e-2  1e-1 1 98i 100
c-------------------------------------------------------------------------------------------------------------------------
c MESH TALLIES IN B6
fc144 Axial neutron flux in B6
fmesh144:n geom=rec origin 3.855 20.25 -29.685
         imesh=11.565          iints= 1
         jmesh=28.35           jints= 1
         kmesh=29.685        kints=10
fm144     1.6467918e18
c
fc154 Axial photon flux in B6
fmesh154:p geom=rec origin 3.855 20.25 -29.685
         imesh=11.565      iints=1
         jmesh=28.35       jints=1
         kmesh=29.685    kints=10
fm154     1.6467918e18
c
fc164 axial neutron heating in B6
fmesh164:n geom=rec origin 3.855 20.25 -29.685
         imesh=11.565          iints=1
         jmesh=28.35           jints=1
         kmesh=29.685        kints=10
fm164  2.638105e5   0   1   -4
c
fc174 axial photon heating in B6
fmesh174:p geom=rec origin 3.855 20.25 -29.685
         imesh=11.565          iints=1
         jmesh=28.35           jints=1
         kmesh=29.685        kints=10
fm174  2.638105e5   0   -5  -6
c-------------------------------------------------------------------------------------------------------------------------
c NEUTRON AND PHOTON FLUXES IN THE RIG REGIONS
c
fc184 Neutron flux in the rig and pebble regions
f184:n   870   871   872   883   884   885   886   891   892   893   894   895   896
fm184 1.6467918e18
sd184      1      1      1      1      1      1      1      1      1      1      1      1      1
c
fc194 Photon flux spectrum in the rig and pebble regions
f194:p   870   871   872   883   884   885   886   891   892   893   894   895   896
fm194     1.6467918e18
sd194      1      1      1      1      1      1      1      1      1      1      1      1      1
```

c----------
c NEUTRON AND PHOTON HEATING IN THE RIG REGIONS
c
fc16 Neutron heating in the rig and pebble regions
f16:n 870 871 872 883 884 885 886 891 892 893 894 895 896
fm16 2.638105e5
sd16 1 1 1 1 1 1 1 1 1 1 1 1 1
c
fc26 Photon heating in the rig and pebble regions
f26:p 870 871 872 883 884 885 886 891 892 893 894 895 896
fm26 2.638105e5
sd26 1 1 1 1 1 1 1 1 1 1 1 1 1
c
fc36 Coupled neutron and photon heating in the rig and pebble regions
f36:n,p 870 871 872 883 884 885 886 891 892 893 894 895 896
fm36 2.638105e5
sd36 1 1 1 1 1 1 1 1 1 1 1 1 1
c
fc17 Fission heating in the fuel region of the pebble
f17:n 870
fm17 2.638105e5
sd17 1
c----------