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COG Validation: SINBAD Benchmark Problems

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Abstract
We validated COG, a 3D Monte Carlo radiation transport code, against experimental data and MNCP4C simulations from the Shielding Integral Benchmark Archive Database (SINBAD) compiled by RSICC. We modeled three experiments: the Osaka Nickel and Aluminium sphere experiments conducted at the OKTAVIAN facility, and the liquid oxygen experiment conducted at the FNS facility. COG results are in good agreement with experimental data and generally within a few % of MCNP results.
There are several possible sources of discrepancy between MCNP and COG results: 1) the cross-section database versions are different, MCNP uses ENDFB VI 1.1 while COG uses ENDFB VIR7, 2) the code implementations are different, and 3) the models may differ slightly. We also limited the use of variance reduction methods when running the COG version of the problems.

Background
COG is a high-resolution code for the Monte Carlo simulation of coupled neutron, proton, gamma-ray, and electron transport in arbitrary 3-D.[1] In this work, we did not consider protons. COG transports neutrons with energies in the range of 10 –5 eV to 150 MeV, and photons with energies in the range of 10 eV to 100 GeV. It also transports electrons in the range of 10 keV to a few thousand GeV via the EGS4 electron transport kernel.[2] COG is designed to allow calculations of deep penetration (shielding) problems, criticality problems, and neutron activation problems. The geometry of the problem is specified with analytical surfaces and pseudo-surfaces and the final model is based on combinatorial geometry. Pulse height spectrum tally are available in addition to standard tallies. COG uses high-resolution pointwise cross-section databases. There are several COG neutron cross-section libraries available: ENDFB6R7, the ENDF/B-VI Release 7 database, ENDL-90, The LLNL Evaluated Nuclear Data Library, and RED2002, a hybrid based on a combination of the ENDFB library cross-sections (good at lower energies) and ENDL kinematics (good at higher energies).[3-5] Finally, the default gamma cross-sections library is EPDL97, the LLNL Evaluated Photon Data Library.[6] Please see the Transport section of the COG manual for details of particle physics and databases.[1]

Methods
COG has been extensively tested and validated in-house over the years.[7, 8] However, since COG will be made available to the public through RSICC, its authors wanted to validate the code against readily available and well-documented benchmark experiments such as the ones in the Shielding Integral Benchmark Archive Database (SINBAD) compiled by RSICC.[9]

SINBAD is a compilation of 41 fission and fusion shielding experiments, 21 of which have been modeled with Monte Carlo (McBEND, TRIPOLI, MCNP) or deterministic codes (ANISN and DOT3.5).

COG has been validated against three SINBAD experiments modeled with MCNP.[10] The problems were chosen to test several features of the code such as neutron and photon transport, secondary photon production, coupling of the photon-electron

transport, point detector, boundary crossing detector or surface detector, and angular flux.
A brief description of these experiments is given below. They are described in details in SINBAD. We used the MCNP inputs given in the SINBAD database. All problems were run on a single processor with COG version 10.19 and the ENDF/BVI R7 neutron cross-section library, and with MCNP4C and an earlier release of ENDF/BVI 1.1. All COG and MCNP inputs are given in the appendix.

The following plotting convention was adopted. COG results are plotted in red, MCNP results in black, and the measurements in blue. For each case, the first series of plot show a comparison of the COG and MCNP simulations with statistical uncertainties (one standard deviation), while the second series of plots show a comparison between COG and the measurements.

1. Osaka Nickel sphere Benchmark experiment (1983) SBE 7.002

Experiment description

Neutron leakage spectra from a 32 cm diameter nickel sphere were measured between 30 keV and 15 MeV by TOF techniques. A 2.5 cm diameter air cavity is at the center of the sphere. The source was a 14.1 MeV D-T neutron generator. The detector could see the whole surface of the sphere and was located 9.5 m from the sphere center. Two series of measurements were obtained, in the high energy region [1-15 MeV] and in the low energy region [0.03-15 MeV].

Problem description

We simulated an isotropic point source of 14 MeV neutrons located in a small spherical air cavity at the center of a nickel sphere. We considered two configurations: a simple spherical geometry problem (Figure 1.a), and a 3D model including an explicit model of the sphere and collimators, and an isotropic source (Figure 1.b). We used the source energy spectrum 2 recommended in SINBAD. We tallied neutron leakage current spectrum. The spherical geometry problem was run using a boundary-crossing detector in particle counting mode, and MCNP was run with an f1 tally. For the 3D model, we used a point detector tally.

Results

Agreement between COG and MCNP is excellent for the 1D model (Figure 2), and very good for the 3D model for energies above 300 keV (Figure 4.a & 4.b).
Regardless of the models, COG simulations are greater than the measurements in the range 5-12MeV, although the 3D model results are closer to the data. (Figure 3.a & 5.a) Similarly to MCNP results, the simple spherical geometry gave the best agreement with the experimental data around the 14 MeV peak (Figure 3.b & 5.b).

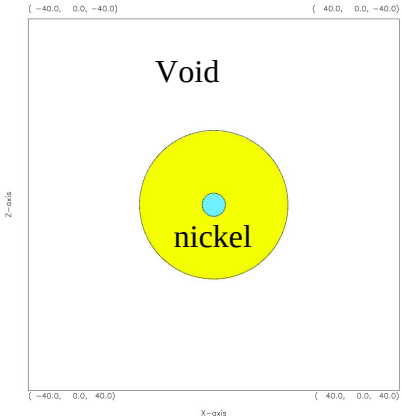


Figure 1.a OSAKA Nickel sphere geometry: One dimensional model of the experiment. An isotropic point source is located at the center of the air cavity (blue region)

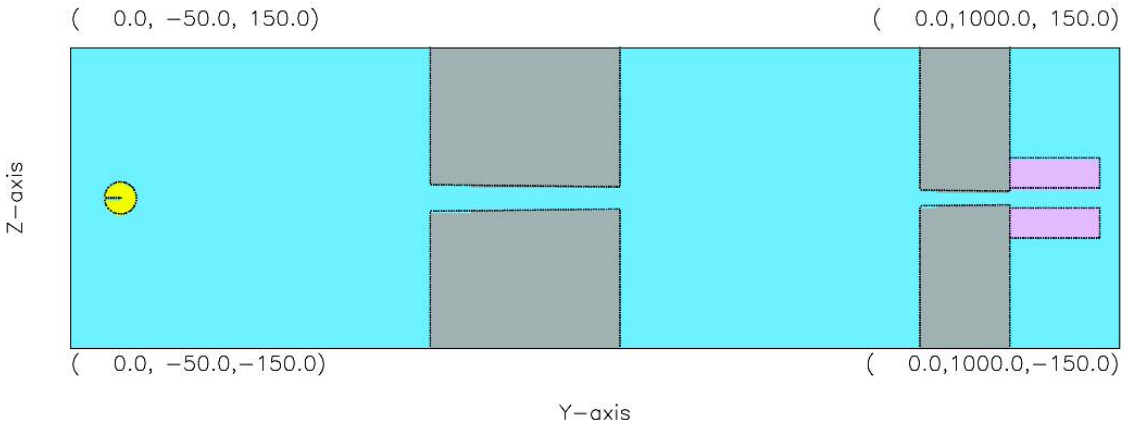


Figure 1.b OSAKA Nickel sphere geometry: Three-dimensional model of the experiment. The nickel sphere is represented in yellow, concrete walls in gray, the polyethylene collimator in pink, and air in blue. The point source is located at the center of the sphere, and the point detector is behind the collimator.

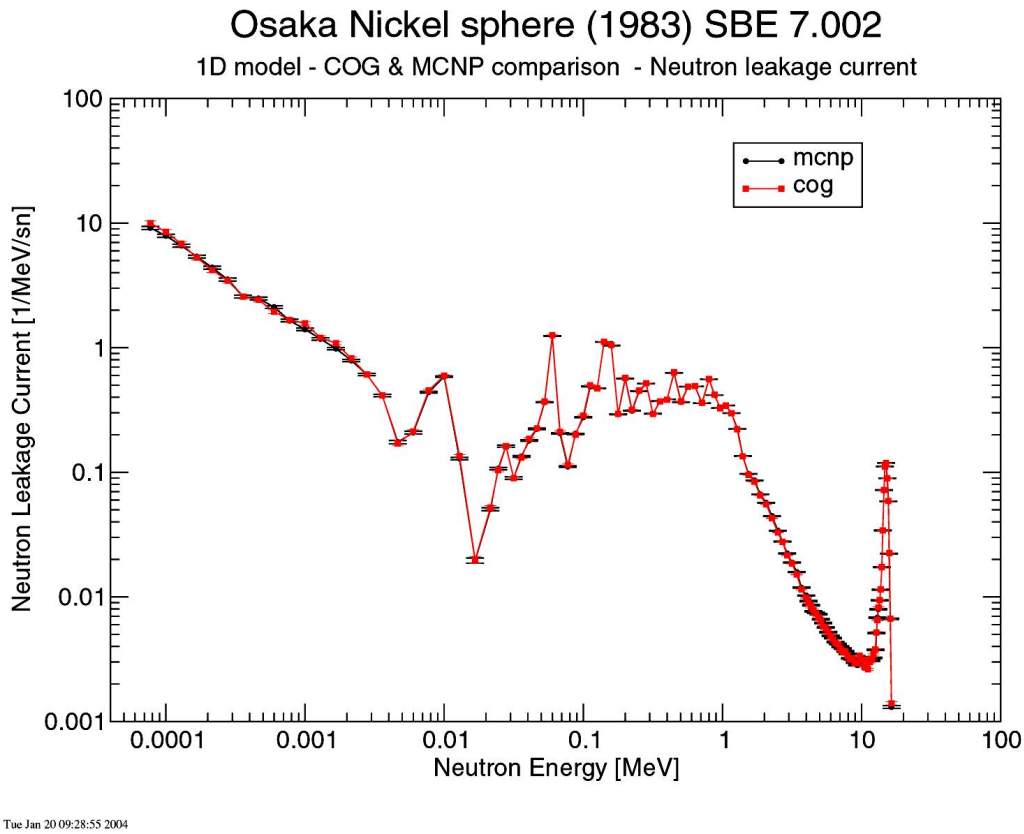
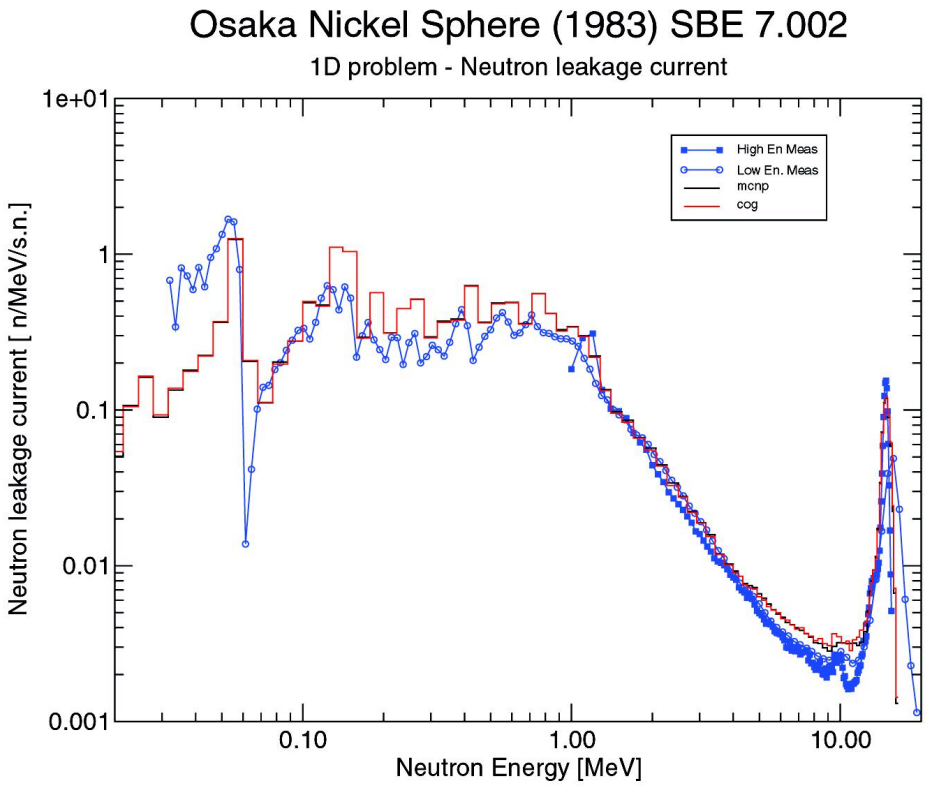


Figure 2. Comparison of COG and MCNP neutron leakage currents as a function of energy for the one-dimensional model of the OSAKA Nickel sphere experiment.



Figue 3.a Comparison of COG one-dimensional model with two series of measurements obtained in the high and low energy range. MCNP simulations are shown in black. This plot focuses on the low energy range.

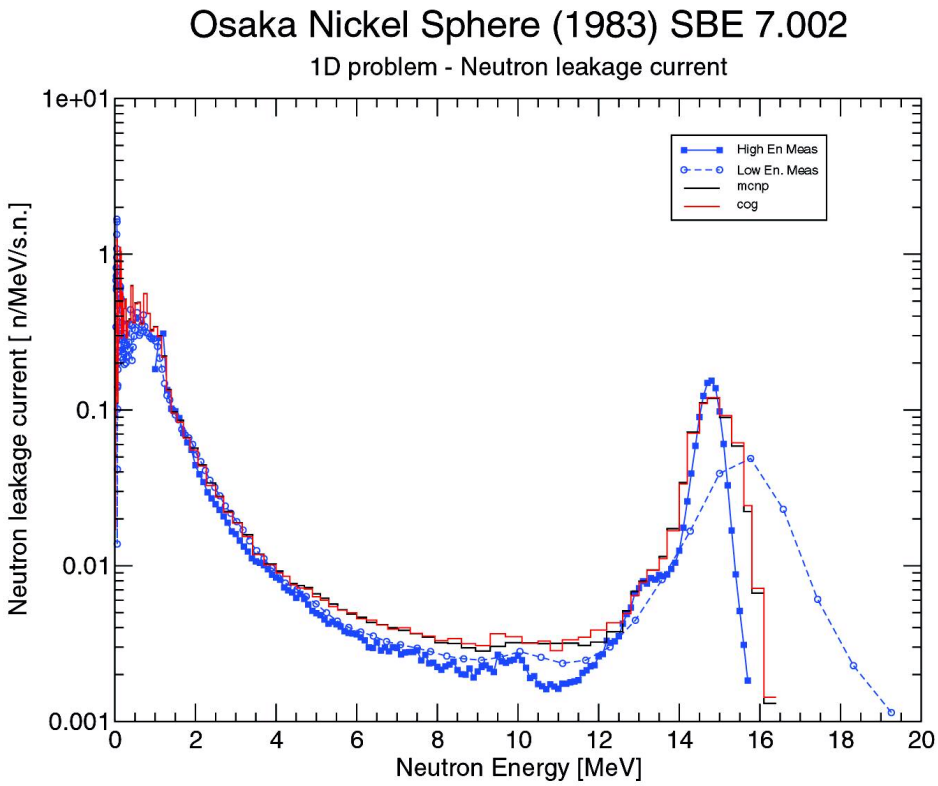


Figure 3.b Comparison of COG one-dimensional model with two series of measurements obtained in the high and low energy range. MCNP simulations are shown in black. This plot focuses on the high energy range

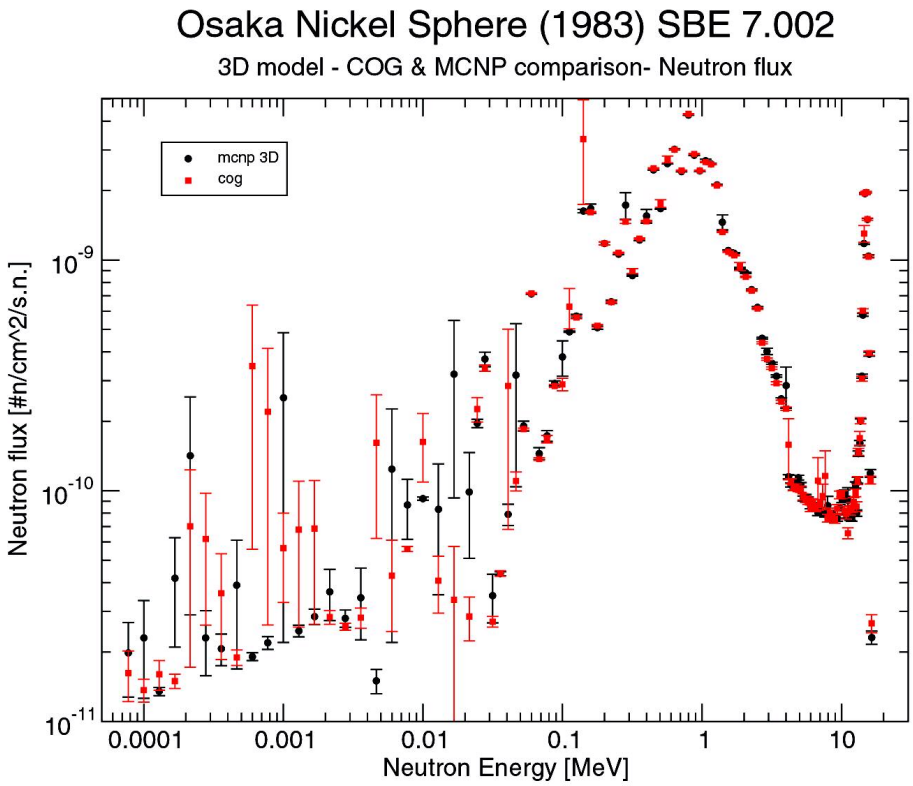


Figure 4.a Comparison of COG and MCNP neutron leakage fluxes as a function of energy for the Three-dimensional model of the OSAKA Nickel sphere experiment. This plot highlights the low energy range.

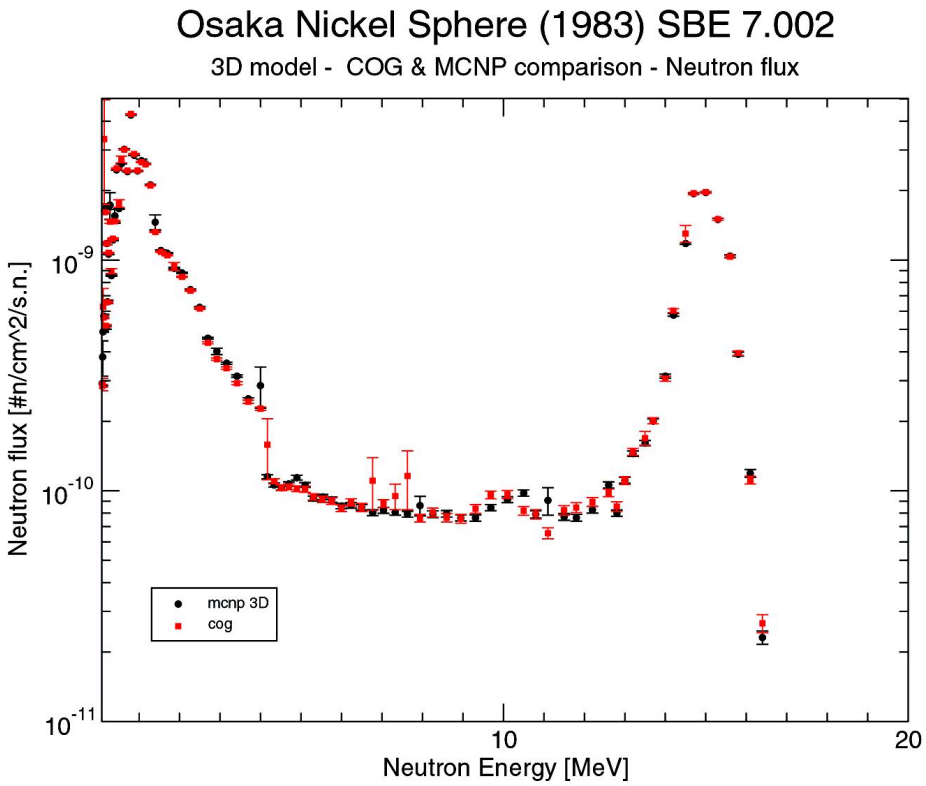


Figure 4.b Comparison of COG and MCNP neutron leakage fluxes as a function of energy for the Three-dimensional model of the OSAKA Nickel sphere experiment. This plot highlights the high energy range.

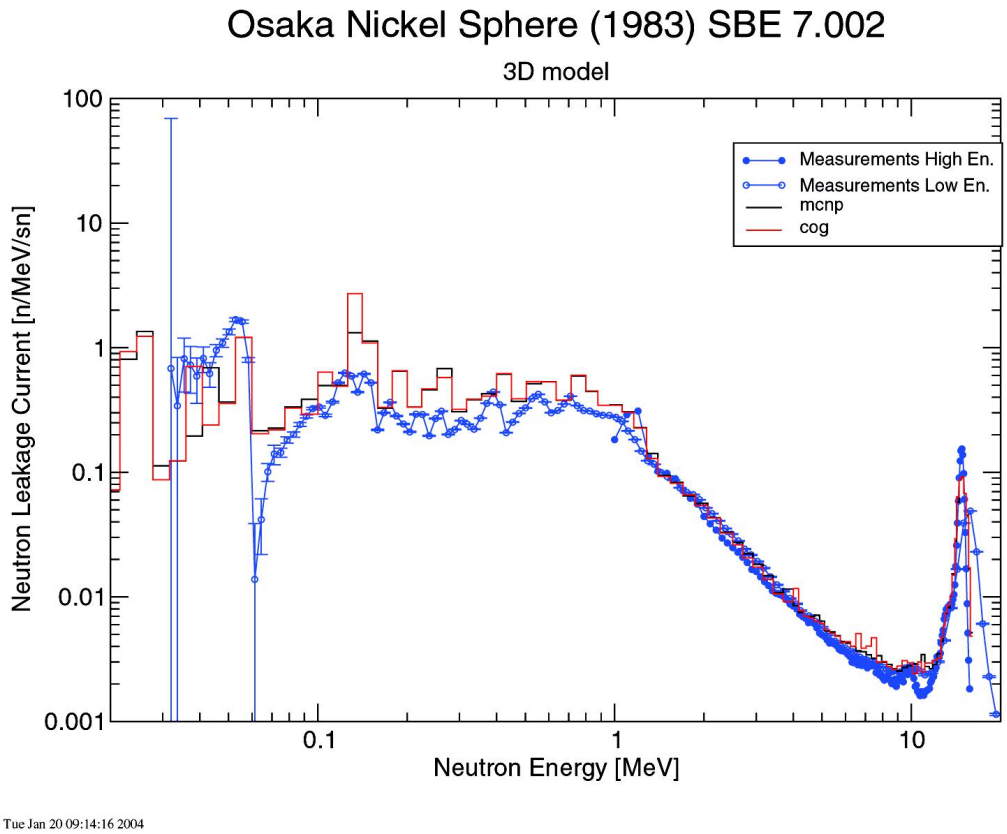


Figure 5.a Comparison of COG three-dimensional model with two series of measurements obtained in the high and low energy range. MCNP simulations are shown in black. This plot focuses on the low energy range.

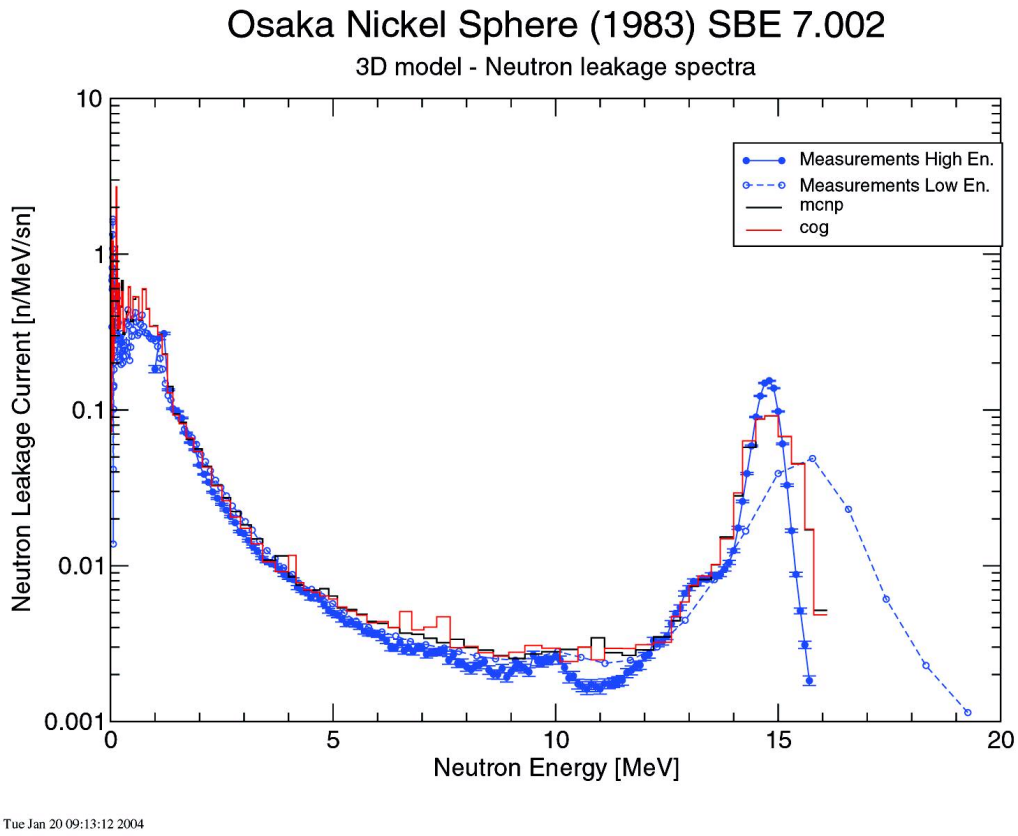


Figure 5.b a Comparison of COG three-dimensional model with two series of measurements obtained in the high and low energy range. MCNP simulations are shown in black. This plot focuses on the low energy range.

2. Osaka Aluminium Sphere (1988) SBE 7.003

Experiment description

Leakage neutron and gamma spectra from a 39.9 cm diameter aluminium sphere were measured. The sphere consists in a 20 cm diameter central cavity, surrounded by a 19.5 cm shell of aluminium powder sandwiched between 2 mm thick steel walls. The source was a 14.1 MeV D-T neutron generator.

Problem description

The experiment was modeled with a simple spherical geometry (Figure 6). We simulated two isotropic point sources, a neutron source and a photon source, located in a spherical air cavity at the center of an aluminium sphere. The photon source represents the gamma-rays produced by interactions of source neutrons with the target materials. The aluminium layer is sandwiched between two thin steel walls. The neutron and photon source problems were run independently. Electron transport was enabled for both problems and PEGS library files were created. We used the source spectrum given in the MCNP input corrected for an exponent error around 0.5MeV. We tallied the neutron leakage current and photon fluence exiting the sphere. The neutron detector was a boundary-crossing detector in particle counting mode, and the photon detector was a boundary-crossing detector.

Results

For energy greater than 3MeV, neutron spectra simulated with COG and MCNP match nicely, while below 3MeV, COG results are consistently lower than MCNP. (Figure 7) COG and MCNP photon spectra are in good agreement, except for photons with energy between 0.4-0.9MeV in the photon source simulation (Figure 9). COG results for neutrons and photons are in good agreement with the measurements (Figures 8 & 9). The main photon contribution is due to the (n,n'), (n,2n), reactions rather than the (n, xgamma) reactions.

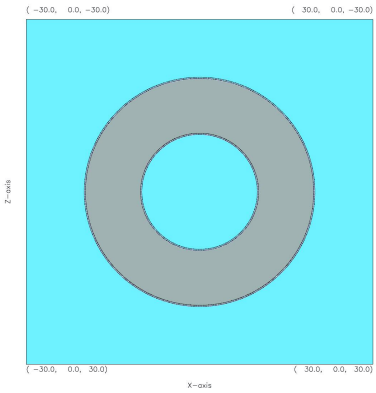


Figure 6. The COG model of the OSAKA aluminium sphere experiment uses a spherical geometry. Aluminium is shown in gray, the 2mm steel walls in black, and air in blue.

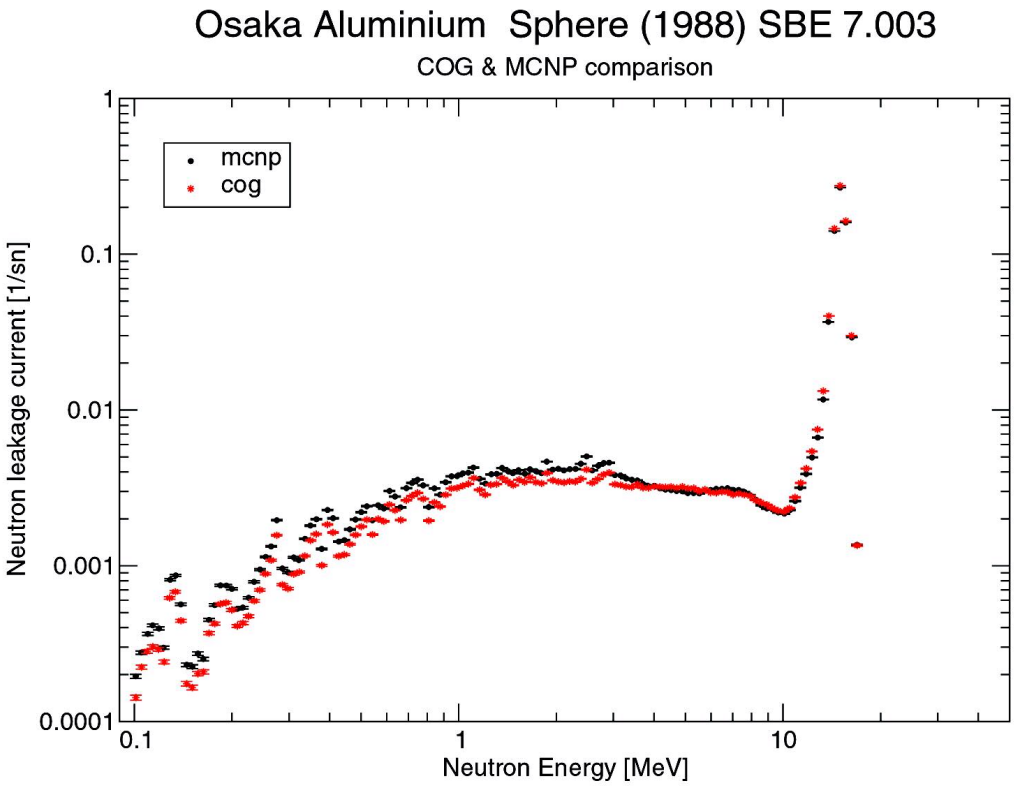


Figure 7. COG and MCNP neutron leakage spectra for the Osaka aluminium sphere experiment.

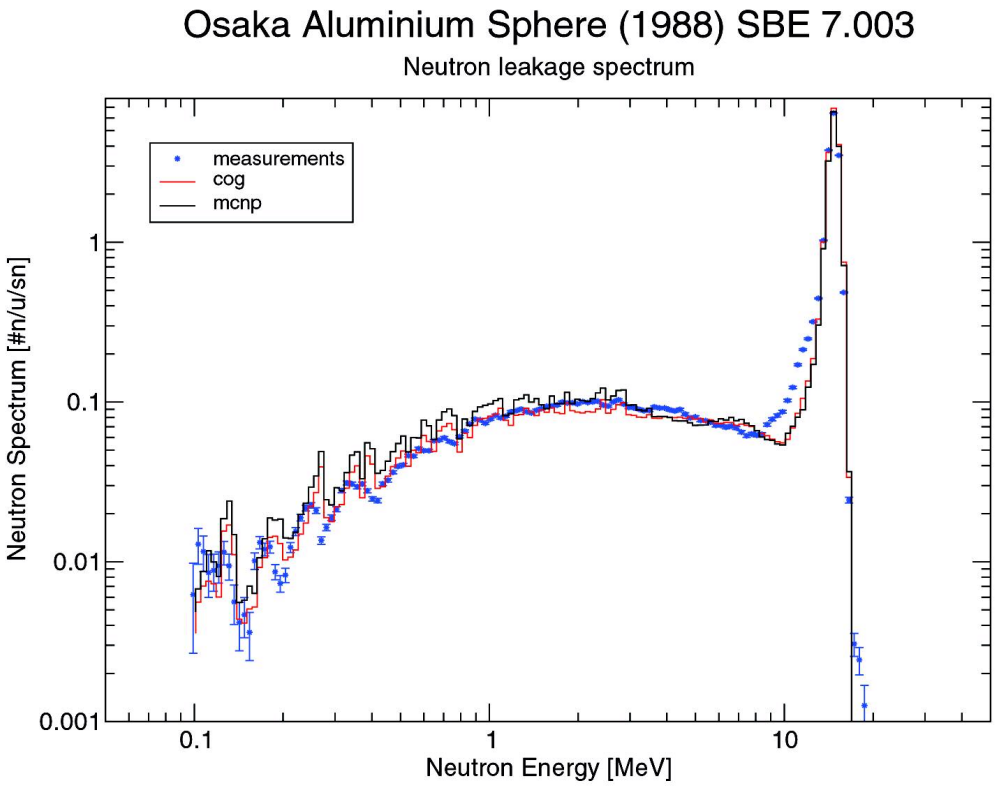


Figure 8. Comparison of COG neutron leakage current with measurements. MCNP simulations are shown in black.

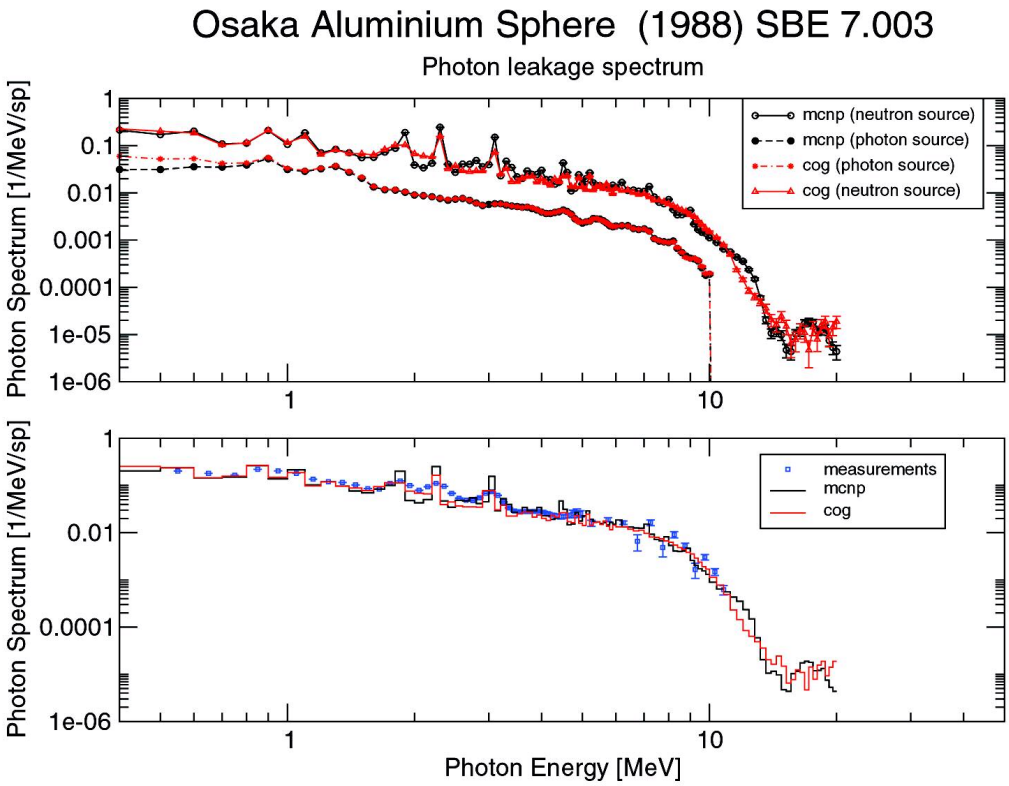


Figure 9. Comparison of simulated and measured photon flux as a function of energy for the Osaka aluminium sphere experiment. The top plot shows COG and MCNP simulations for two contributing sources; a) photons produced by neutron interactions in the sphere materials and b) photons generated in the target itself. For comparison to measurements, the two photons contributions shown in the top plot were added. The bottom plot shows COG results and measurements. MCNP simulations are shown in black.

3. FNS liquid oxygen (1989) SBE 3.006

Experiment description

Angular neutron spectra leaking from a 20 cm slab of liquid oxygen were measured at five angles ranging from 0 to 66.8 degrees with respect to the beam axis. The slab assembly was located 20 cm from the 14 MeV D-T neutron generator, and the detectors were located at about 7 m from the exit face of the slab. The measured energy range varied between 0.05 and 15MeV.

Problem description

The COG model is shown in Figure 10. The steel canister filled with liquid oxygen was modeled in detail including the aluminium foils inserted to limit thermal radiation. An isotropic point source of neutron was placed on one side of the canister, and the angular flux spectra were tallied with point detectors at 0., 12.2, 24.9, 41.8,and 66.8 degrees on the other side. We used a modified version of the MCNP source spectrum given in SINBAD, with smoothed values in two energy bins, [1.53-1.74] and [9.39-10] MeV.
Note that the MCNP input had to be modified to run with MCNP4C.
We developed a simpler version of the problem, in which the five point detectors are not collimated and are placed in void.

Results

For the collimated case, COG and MCNP results are similar at 0 and 12 degrees. For larger angles, COG results are lower than MCNP's, and the difference between these two codes increases with angle as shown in Figure 11 and 12. When the problem is run without detector collimation, COG and MCNP are in good agreement (Figure 13). The discrepancy observed in Figure 11 ad 12 could be due to modeling differences. In particular, COG handles rotation in a simpler way than MCNP. When plotted, the MCNP model showed that the collimation lines were not centered on the same point on the beam axis.

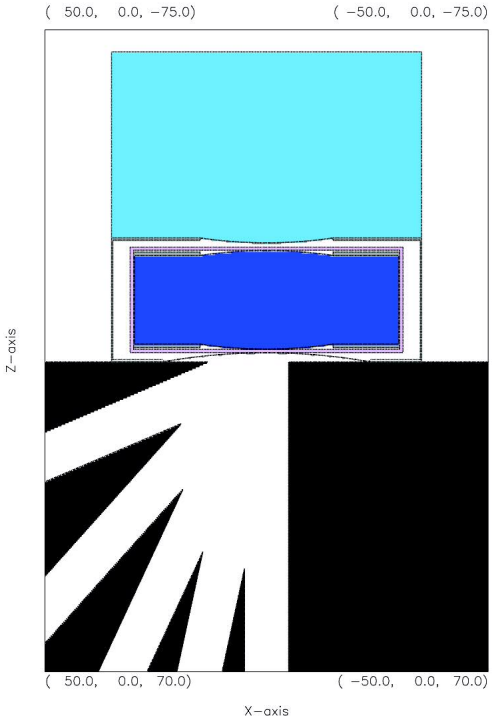


Figure 10. COG model: top view of the liquid oxygen slab experiment. The beam axis is aligned with the z-axis in the figure. An isotropic point source is in the region filled with air (light blue color). Aluminium is shown in pink, liquid oxygen in dark blue, and steel in gray. Collimation is simulated with a pure absorber shown here in black, while white regions represent vacuum. The point detectors are 7 m from the exit window of the canister.

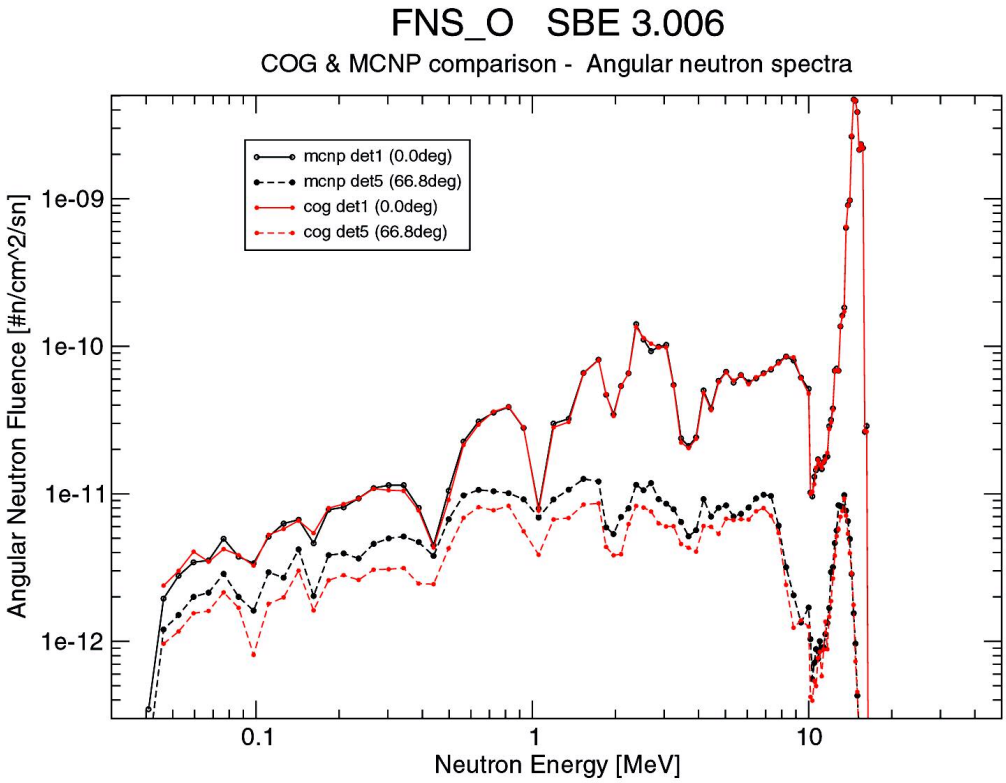
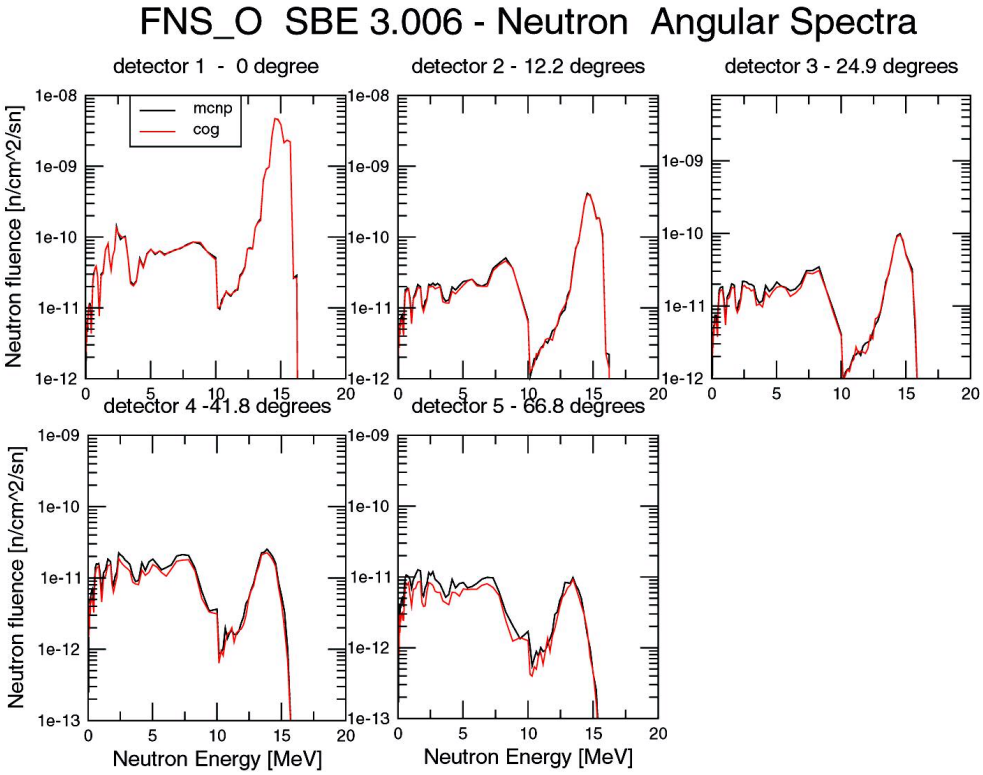


Figure 11. COG and MCNP neutron angular flux as a function of energy for detector 1 and detector 5. Detectors are collimated; detector 1 is on the beam axis (0.0 degree), and detector 5 is at an angle of 66.8 degrees with respect to the beam.



Figre 12 . COG and MCNP neutron angular fluence as a function of energy for five point detectors placed in the vacuum region. Collimators are placed between the exit face of the liquid oxygen slabs and the detectors.

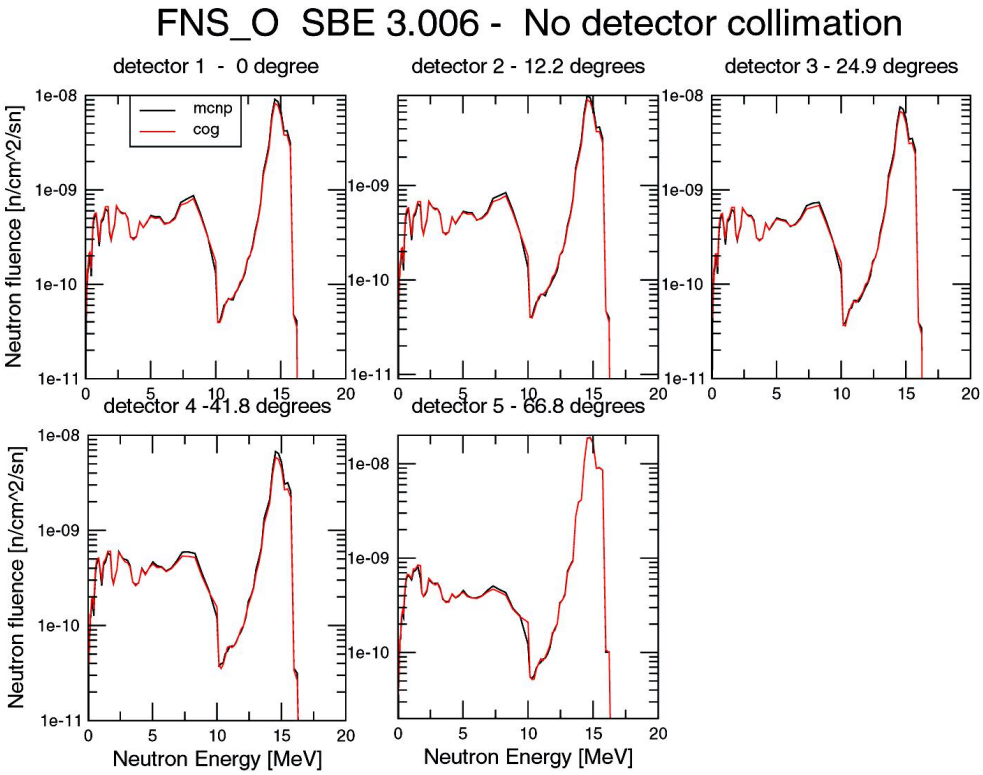


Figure 13. COG and MCNP neutron fluence as a function of energy for five point detectors placed in the vacuum region. There is no collimation, the pure absorber shown in figure 10 is replaced by vacuum.

4.Others

Three COG and MCNP inputs were developed to simulate leakage neutron and gamma spectra from pure nickel, aluminium, and iron spheres. They are based on Problems 1 and 2 described above, and were mainly used to check COG secondary photon production. Up to 10 MeV, agreement between the two codes is excellent for the nickel and iron cases (Figure 14 & 15), and good for the aluminium case (Figure 16). In that range the statistical undertainty (1σ) is below 2%. Above 10 MeV, results are unreliable, the statistical uncertainties are greater than 10%. It would be interesting to check if there are noticeable differences between the aluminium cross-section evaluation used by COG and MCNP. These evaluations date from 1997 and 1993 respectively.

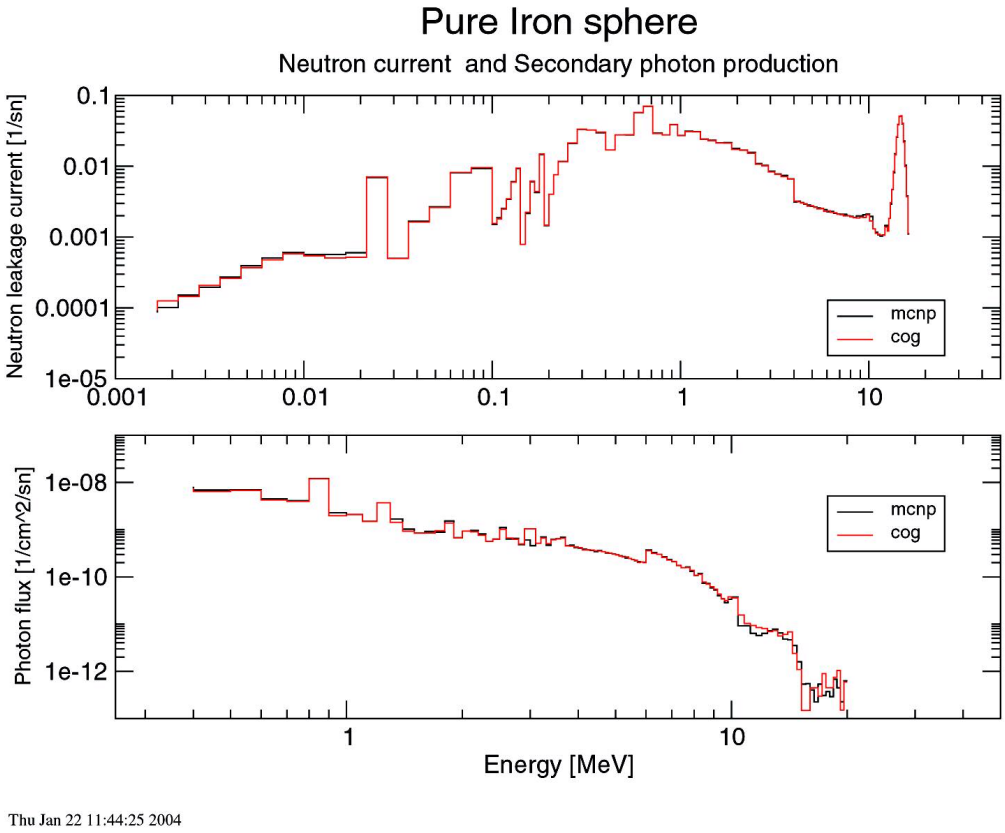


Figure 14. COG and MCNP neutron leakage current and photon fluence for a pure iron sphere.

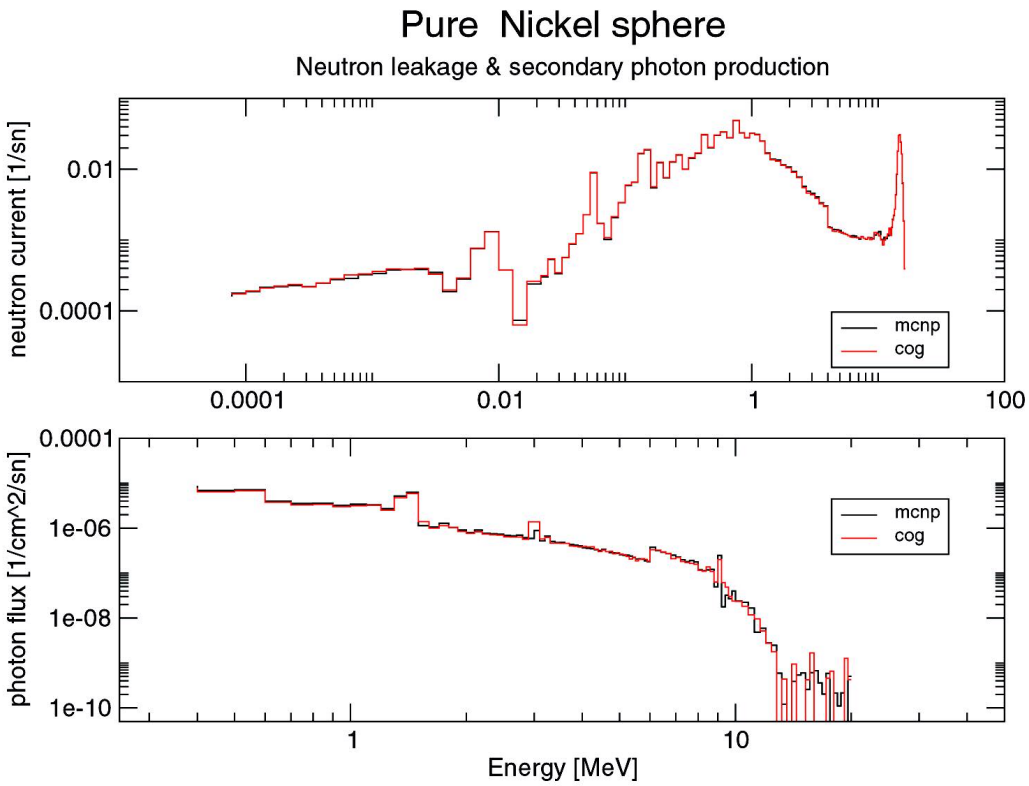
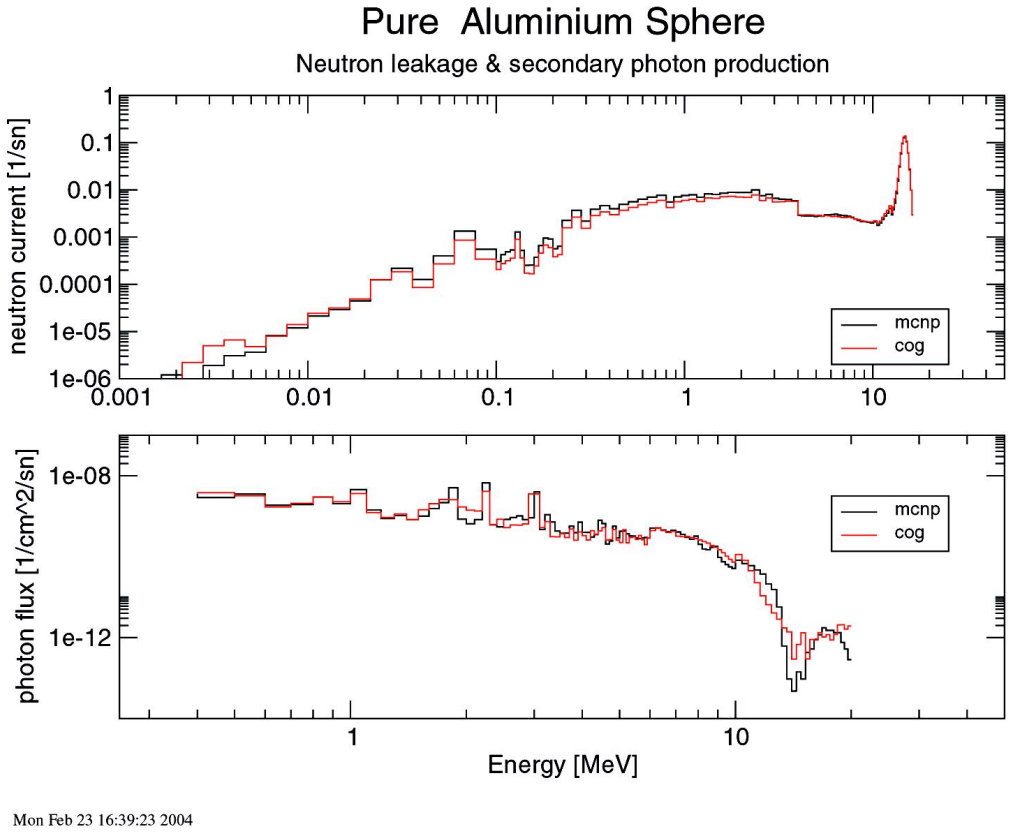


Figure 15. COG and MCNP neutron leakage current and photon fluence for a pure nickel sphere.



Figre 16 . COG and MCNP neutron leakage current and photon fluence for a pure aluminium sphere.

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APPENDIX

1. Osaka Nickel sphere Benchmark experiment (1983) SBE 7.002

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Oktavian Ni sphere R=16 cm, Spherical model, ENDF/B-VI, Source-2/Isotropic
$ COG input Based on simplified  MCNP/4B input by A. TRKOV, IJS, ANDREJ.TRKOV@IJS.SI

BASIC
   neutron

SURFACES
  1 SPHERE 2.50
  2 SPHERE 10.00
  3 SPHERE 16.00
  $ add sphere 4
  4 SPHERE 17.00

GEOMETRY
sector 1 sec1 -1
sector 2 sec2 1 -2
sector 3 sec3 2 -3
sector 4 sec4 +3 -4
BOUNDARY VACUUM +4

$ Pictures
 picture cs material color -40  0 -40   -40 0 40   40 0 40

MIX
$ Nickel with impurities (expressed as weight percent).
NLIB = ENDFB6R7
mat 1    28058 0.67144 28060 0.26554 28061 0.01169
         28062 0.03775 28064 0.00988
         14000 0.0016 25055 0.0015 26056 0.0004
         12000 0.0001 29063 7e-05 29065 3e-05
mat 2 # 1 8016 0.208
          7014 0.792

ASSIGN-MD  $ sector#  material#  density
  1 2 0.0012    2 1 8.85    3 1 8.85  4 0 0

ASSIGN-MC
              1 yellow   $ Nickel Sphere
              2 sky                 $ air

SOURCE
  npart = 3000000
  INCREMENT 1. P=1 E=1
  DEFINE POSITION = 1
   POINT 0. 0. 0.
  DEFINE ENERGY = 1 NEUTRON
   BIN
 1.1200E-01 6.5541E-06         1.2600E-01
6.5541E-04           1.4100E-01 2.2939E-03         1.5900E-01
2.6216E-03           1.7800E-01 3.9928E-03         2.0000E-01
1.0296E-02           2.2400E-01 1.1968E-02         2.5200E-01
1.1850E-02           2.8300E-01 1.0906E-02         3.1700E-01
1.4629E-02           3.5600E-01 1.4091E-02         4.0000E-01
1.2735E-02           4.4900E-01 1.6339E-02         5.0400E-01
1.6221E-02           5.6600E-01 1.7565E-02         6.3500E-01
1.6536E-02           7.1300E-01 1.6936E-02         8.0000E-01
1.7598E-02           8.7800E-01 1.6490E-02         9.6400E-01
1.5481E-02           1.0580E+00 1.5717E-02         1.1620E+00
1.4557E-02           1.2750E+00 1.3338E-02         1.4000E+00
1.3095E-02           1.5420E+00 1.1253E-02         1.6980E+00
1.1312E-02           1.8710E+00 1.0349E-02         2.0610E+00
8.8415E-03           2.2700E+00 8.0550E-03         2.5000E+00
8.3761E-03           2.7040E+00 1.0585E-02         2.9240E+00
6.3286E-03           3.1620E+00 5.6850E-03         3.4190E+00
5.0775E-03           3.6990E+00 4.6849E-03         4.0000E+00
4.4279E-03           4.1650E+00 4.2779E-03         4.3370E+00
3.6906E-03           4.5160E+00 3.6801E-03         4.7030E+00
```

```
3.6637E-03      4.8970E+00 3.6336E-03      5.0990E+00
3.3079E-03      5.3100E+00 3.5877E-03      5.5290E+00
3.0103E-03      5.7570E+00 2.9408E-03      5.9950E+00
3.0824E-03      6.2420E+00 3.1080E-03      6.5000E+00
3.2377E-03      6.7650E+00 3.0522E-03      7.0410E+00
2.9520E-03      7.3270E+00 3.2109E-03      7.6270E+00
2.8320E-03      7.9380E+00 2.6518E-03      8.2610E+00
3.1650E-03      8.5980E+00 3.1211E-03      8.9490E+00
2.9828E-03      9.3140E+00 3.6074E-03      9.6930E+00
3.7018E-03      1.0089E+01 3.8754E-03      1.0500E+01
4.5793E-03      1.0817E+01 5.0132E-03      1.1143E+01
5.2859E-03      1.1479E+01 6.1353E-03      1.1825E+01
6.8621E-03      1.2182E+01 8.4810E-03      1.2549E+01
9.8180E-03      1.2775E+01 1.1627E-02      1.3005E+01
1.4255E-02      1.3239E+01 1.9066E-02      1.3477E+01
2.7396E-02      1.3720E+01 5.0001E-02      1.3967E+01
1.3141E-01      1.4218E+01 3.9515E-01      1.4474E+01
7.1112E-01      1.4735E+01 8.2254E-01      1.5000E+01
6.3109E-01      1.5270E+01 4.3880E-01      1.5545E+01
1.7250E-01      1.5825E+01 5.0801E-02      1.6110E+01
1.0493E-02      1.6399E+01

DETECTOR
  $ Leakage Neutron Spectrum on surface of sphere 3
  number = bc1
  Boundary counts 3 4 3217.
   BIN ENERGY = neutron
      6.000E-05 7.740E-05 1.000E-04 1.290E-04 1.670E-04 2.150E-04
      2.780E-04 3.590E-04 4.640E-04 5.990E-04 7.740E-04 1.000E-03
      1.290E-03 1.670E-03 2.150E-03 2.780E-03 3.590E-03 4.640E-03
      5.990E-03 7.740E-03 1.000E-02 1.290E-02 1.670E-02 2.150E-02
      2.445E-02 2.780E-02 3.159E-02 3.590E-02 4.081E-02 4.640E-02
      5.272E-02 5.990E-02 6.809E-02 7.740E-02 8.798E-02 1.000E-01
      1.120E-01 1.260E-01 1.410E-01 1.590E-01 1.780E-01 2.000E-01
      2.240E-01 2.520E-01 2.830E-01 3.170E-01 3.560E-01 4.000E-01
      4.490E-01 5.040E-01 5.660E-01 6.350E-01 7.130E-01 8.000E-01
      8.780E-01 9.640E-01 1.058E+00 1.162E+00 1.275E+00 1.400E+00
      1.542E+00 1.698E+00 1.871E+00 2.061E+00 2.270E+00 2.500E+00
      2.704E+00 2.924E+00 3.162E+00 3.419E+00 3.699E+00
      4.000E+00 4.165E+00 4.337E+00 4.516E+00 4.703E+00 4.897E+00
      5.099E+00 5.310E+00 5.529E+00 5.757E+00 5.995E+00 6.242E+00
      6.500E+00 6.765E+00 7.041E+00 7.327E+00 7.627E+00 7.938E+00
      8.261E+00 8.598E+00 8.949E+00 9.314E+00 9.693E+00 1.009E+01
      1.050E+01 1.082E+01 1.114E+01 1.148E+01 1.183E+01 1.218E+01
      1.255E+01 1.277E+01 1.300E+01 1.324E+01 1.348E+01 1.372E+01
      1.397E+01 1.422E+01 1.447E+01 1.474E+01 1.500E+01 1.527E+01
      1.555E+01 1.583E+01 1.611E+01 1.640E+01

END
```

```
Oktavian Ni sphere R=16 cm, Spherical model, ENDF/B-VI, Source-2/Isotropic
C Simplified MCNP/4B input by A. Trkov, IJS, andrej.trkov@ijs.si
1     2  -0.0012      -1    imp:n=1
2     1  -8.85      1 -2    imp:n=1
3     1  -8.85      2 -3    imp:n=1.4
4     0            3       imp:n=0

1      so     2.50
2      so    10.00
3      so    16.00

mode n
sdef erg=d1  pos=0 0 0
C Source spectrum-2 (from sample MCNP input)
SI1  H
      1.1200E-01 1.2600E-01 1.4100E-01 1.5900E-01 1.7800E-01
      2.0000E-01 2.2400E-01 2.5200E-01 2.8300E-01 3.1700E-01
      3.5600E-01 4.0000E-01 4.4900E-01 5.0400E-01 5.6600E-01
      6.3500E-01 7.1300E-01 8.0000E-01 8.7800E-01 9.6400E-01
      1.0580E+00 1.1620E+00 1.2750E+00 1.4000E+00 1.5420E+00
      1.6980E+00 1.8710E+00 2.0610E+00 2.2700E+00 2.5000E+00
      2.7040E+00 2.9240E+00 3.1620E+00 3.4190E+00 3.6990E+00
      4.0000E+00 4.1650E+00 4.3370E+00 4.5160E+00 4.7030E+00
      4.8970E+00 5.0990E+00 5.3100E+00 5.5290E+00 5.7570E+00
      5.9950E+00 6.2420E+00 6.5000E+00 6.7650E+00 7.0410E+00
      7.3270E+00 7.6270E+00 7.9380E+00 8.2610E+00 8.5980E+00
      8.9490E+00 9.3140E+00 9.6930E+00 1.0089E+01 1.0500E+01
      1.0817E+01 1.1143E+01 1.1479E+01 1.1825E+01 1.2182E+01
      1.2549E+01 1.2775E+01 1.3005E+01 1.3239E+01 1.3477E+01
      1.3720E+01 1.3967E+01 1.4218E+01 1.4474E+01 1.4735E+01
      1.5000E+01 1.5270E+01 1.5545E+01 1.5825E+01 1.6110E+01
      1.6399E+01
SP1
      0.0000E+00 9.1757E-08 9.8311E-06 4.1291E-05 4.9811E-05
      8.7841E-05 2.4712E-04 3.3510E-04 3.6734E-04 3.7080E-04
      5.7052E-04 6.2002E-04 6.2400E-04 8.9866E-04 1.0057E-03
      1.2120E-03 1.2898E-03 1.4734E-03 1.3726E-03 1.4181E-03
      1.4552E-03 1.6345E-03 1.6449E-03 1.6672E-03 1.8595E-03
      1.7555E-03 1.9570E-03 1.9663E-03 1.8479E-03 1.8526E-03
      1.7087E-03 2.3287E-03 1.5062E-03 1.4611E-03 1.4217E-03
      1.4101E-03 7.3061E-04 7.3579E-04 6.6062E-04 6.8818E-04
      7.1076E-04 7.3399E-04 6.9796E-04 7.8571E-04 6.8635E-04
      6.9992E-04 7.6135E-04 8.0185E-04 8.5800E-04 8.4242E-04
      8.4426E-04 9.6325E-04 8.8076E-04 8.5653E-04 1.0666E-03
      1.0955E-03 1.0887E-03 1.3672E-03 1.4659E-03 1.5928E-03
      1.4517E-03 1.6343E-03 1.7761E-03 2.1228E-03 2.4498E-03
      3.1125E-03 2.2189E-03 2.6742E-03 3.3357E-03 4.5377E-03
      6.6573E-03 1.2350E-02 3.2984E-02 1.0116E-01 1.8560E-01
      2.1797E-01 1.7040E-01 1.2067E-01 4.8301E-02 1.4478E-02
      3.0325E-03

C  Nickel with impurities (expressed as weight percent).
M1     28058.60C -0.67144  28060.60C -0.26554  28061.60C -0.01169
      28062.60C -0.03775  28064.60C -0.00988
      14000.60C -0.0016   25055.60C -0.0015   26056.60C -0.0004
      12000.60C -0.0001   29063.60C -0.00007  29065.60C -0.00003
M2     8016.60C  0.208
      7014.60C  0.792
fc1  Leakage Neutron Spectrum on the Sphere Surface
f1:n 3
e1     6.000E-05 7.740E-05 1.000E-04 1.290E-04 1.670E-04 2.150E-04
      2.780E-04 3.590E-04 4.640E-04 5.990E-04 7.740E-04 1.000E-03
      1.290E-03 1.670E-03 2.150E-03 2.780E-03 3.590E-03 4.640E-03
      5.990E-03 7.740E-03 1.000E-02 1.290E-02 1.670E-02 2.150E-02
      2.445E-02 2.780E-02 3.159E-02 3.590E-02 4.081E-02 4.640E-02
      5.272E-02 5.990E-02 6.809E-02 7.740E-02 8.798E-02 1.000E-01
      1.120E-01 1.260E-01 1.410E-01 1.590E-01 1.780E-01 2.000E-01
      2.240E-01 2.520E-01 2.830E-01 3.170E-01 3.560E-01 4.000E-01
      4.490E-01 5.040E-01 5.660E-01 6.350E-01 7.130E-01 8.000E-01
      8.780E-01 9.640E-01 1.058E+00 1.162E+00 1.275E+00 1.400E+00
```

```
     1.542E+00 1.698E+00 1.871E+00 2.061E+00 2.270E+00 2.500E+00
     2.704E+00 2.924E+00 3.162E+00 3.419E+00 3.699E+00
     4.000E+00 4.165E+00 4.337E+00 4.516E+00 4.703E+00 4.897E+00
     5.099E+00 5.310E+00 5.529E+00 5.757E+00 5.995E+00 6.242E+00
     6.500E+00 6.765E+00 7.041E+00 7.327E+00 7.627E+00 7.938E+00
     8.261E+00 8.598E+00 8.949E+00 9.314E+00 9.693E+00 1.009E+01
     1.050E+01 1.082E+01 1.114E+01 1.148E+01 1.183E+01 1.218E+01
     1.255E+01 1.277E+01 1.300E+01 1.324E+01 1.348E+01 1.372E+01
     1.397E+01 1.422E+01 1.447E+01 1.474E+01 1.500E+01 1.527E+01
     1.555E+01 1.583E+01 1.611E+01 1.640E+01 T
nps   3000000
c deactivate energy cutoff, printout and cp-time limits
c cut:n 0  1.0e-2
c prdmp 1000000000 1000000000   0  1
c ctme  300
print
```

```
 Oktavian Ni sphere R=16 cm, 3D model, ENDF/B-VI, Source-2/isotropic
$ COG input based on 3-dimensional MCNP/4B input by A. TRKOV, IJS, ANDREJ.TRKOV@IJS.SI
 BASIC
   neutron
$
 1 SPHERE 0.4
 2 SPHERE 16.0
 3 CYL Y 0.4
 4 PLANE Y 0
 5 SPHERE 1200.0
 6 CONE -1465.169 16.0 -1465.169 -581.489 TR 0. 1515.489  0. 0. 1516.489  0.
 7 PLANE Y 310.0
 8 PLANE Y 500.0
 9 PLANE Y 800.0
10 PLANE Y 890.0
11 PLANE Y 980.0
12 CYL Y 10.0
13 CYL Y 40.0

 GEOMETRY
  sector 1 sec1 -1
  sector 2 sec2 1 -2 -3 -4
$ Sphere main body
  sector 3 sec3    -2 +1 +3
                   OR  -2 +1 +4
$ Source calculation (without the sphere)
$ 3     2  -0.0012   -2  #1  #2
$ From sphere to the first collimator
  sector 4 sec4   2 -7 -5
$ First collimator body
  sector 5 sec5   6 7 -8 -5
$ First collimator gap
  sector 6 sec6   -6 7 -8
$ Space between collimators
  sector 7 sec7   8 -9 -5
$ Main collimator body
  sector 8 sec8   6 9 -10 -5
$ Main collimator gap
  sector 9 sec9   -6 9 -10
$ Borated parafin
  sector 10 sec10  10 -11 12 -13
$ Detector region
  sector 11 sec11  10 -5 +11
             OR 10 -5 -12
             OR 10 -5 +13
 FILL 2
$ Outer void
  BOUNDARY VACUUM +5

$ Geometry Picture views
   picture cs sector  0. 1000 -40.  0 1000 50  0 -40 50
   picture cs material color -150. -54  0.  150 -54 0  150 1000 .0
   picture cs material color 0. -50 150.  0 -50 -150  0 1000 -150
   picture cs material color -40  0 -40   -40 0 40   40 0 40
   picture cs material color 0  -40 40   0 -40 -40   0 40 -40

 MIX
 NLIB = ENDFB6R7
$ Nickel with impurities (expressed as weight percent)
  mat 1  28058 0.67144 28060 0.26554 28061 0.01169
         28062 0.03775 28064 0.00988
         14000 0.0016 25055 0.0015 26056 0.0004
         12000 0.0001 29063 7.e-05 29065 3.e-05
$Material number in atom %
$ Air
  mat 2 # 1 8016 0.208
         7014 0.792
$ Borated parrafin
  mat 3 # 1 6000 0.29
         1001 0.58
```

```
      5010 0.026
      5011 0.104
$ Iron collimator (pure Fe-56)
 mat 4 # 1 26056 1
ASSIGN-MD  $ sector#  material#  density
 1 2 0.0012    2 2 0.0012    3 1 8.85    4 2 0.0012
 5 4 7.8826    6 2 0.0012    7 2 0.0012    8 4 7.8826
 9 2 0.0012    10 3 1    11 2 0.0012    12 0 0
ASSIGN-MC
           1 yellow   $ Nickel Sphere
           2 sky                $ air
           3 lavender     $ borated paraffin
           4 gray               $ iron

           0 orange  $ void

 SOURCE
  npart = 3000000
  INCREMENT 1. P=1 E=1
  DEFINE POSITION = 1
   POINT 0. 0. 0.
  DEFINE ENERGY = 1 NEUTRON
   BIN
 1.1200E-01 6.5541E-06       1.2600E-01
6.5541E-04          1.4100E-01 2.2939E-03       1.5900E-01
2.6216E-03          1.7800E-01 3.9928E-03       2.0000E-01
1.0296E-02          2.2400E-01 1.1968E-02       2.5200E-01
1.1850E-02          2.8300E-01 1.0906E-02       3.1700E-01
1.4629E-02          3.5600E-01 1.4091E-02       4.0000E-01
1.2735E-02          4.4900E-01 1.6339E-02       5.0400E-01
1.6221E-02          5.6600E-01 1.7565E-02       6.3500E-01
1.6536E-02          7.1300E-01 1.6936E-02       8.0000E-01
1.7598E-02          8.7800E-01 1.6490E-02       9.6400E-01
1.5481E-02          1.0580E+00 1.5717E-02       1.1620E+00
1.4557E-02          1.2750E+00 1.3338E-02       1.4000E+00
1.3095E-02          1.5420E+00 1.1253E-02       1.6980E+00
1.1312E-02          1.8710E+00 1.0349E-02       2.0610E+00
8.8415E-03          2.2700E+00 8.0550E-03       2.5000E+00
8.3761E-03          2.7040E+00 1.0585E-02       2.9240E+00
6.3286E-03          3.1620E+00 5.6850E-03       3.4190E+00
5.0775E-03          3.6990E+00 4.6849E-03       4.0000E+00
4.4279E-03          4.1650E+00 4.2779E-03       4.3370E+00
3.6906E-03          4.5160E+00 3.6801E-03       4.7030E+00
3.6637E-03          4.8970E+00 3.6336E-03       5.0990E+00
3.3079E-03          5.3100E+00 3.5877E-03       5.5290E+00
3.0103E-03          5.7570E+00 2.9408E-03       5.9950E+00
3.0824E-03          6.2420E+00 3.1080E-03       6.5000E+00
3.2377E-03          6.7650E+00 3.0522E-03       7.0410E+00
2.9520E-03          7.3270E+00 3.2109E-03       7.6270E+00
2.8320E-03          7.9380E+00 2.6518E-03       8.2610E+00
3.1650E-03          8.5980E+00 3.1211E-03       8.9490E+00
2.9828E-03          9.3140E+00 3.6074E-03       9.6930E+00
3.7018E-03          1.0089E+01 3.8754E-03       1.0500E+01
4.5793E-03          1.0817E+01 5.0132E-03       1.1143E+01
5.2859E-03          1.1479E+01 6.1353E-03       1.1825E+01
6.8621E-03          1.2182E+01 8.4810E-03       1.2549E+01
9.8180E-03          1.2775E+01 1.1627E-02       1.3005E+01
1.4255E-02          1.3239E+01 1.9066E-02       1.3477E+01
2.7396E-02          1.3720E+01 5.0001E-02       1.3967E+01
1.3141E-01          1.4218E+01 3.9515E-01       1.4474E+01
7.1112E-01          1.4735E+01 8.2254E-01       1.5000E+01
6.3109E-01          1.5270E+01 4.3880E-01       1.5545E+01
1.7250E-01          1.5825E+01 5.0801E-02       1.6110E+01
1.0493E-02          1.6399E+01

DETECTOR
 $ Leakage Neutron Spectrum at point detector
  number = pt1
  Point 0. 934. 0.
    BIN ENERGY = neutron
```

6.000E-05 7.740E-05 1.000E-04 1.290E-04 1.670E-04 2.150E-04
2.780E-04 3.590E-04 4.640E-04 5.990E-04 7.740E-04 1.000E-03
1.290E-03 1.670E-03 2.150E-03 2.780E-03 3.590E-03 4.640E-03
5.990E-03 7.740E-03 1.000E-02 1.290E-02 1.670E-02 2.150E-02
2.445E-02 2.780E-02 3.159E-02 3.590E-02 4.081E-02 4.640E-02
5.272E-02 5.990E-02 6.809E-02 7.740E-02 8.798E-02 1.000E-01
1.120E-01 1.260E-01 1.410E-01 1.590E-01 1.780E-01 2.000E-01
2.240E-01 2.520E-01 2.830E-01 3.170E-01 3.560E-01 4.000E-01
4.490E-01 5.040E-01 5.660E-01 6.350E-01 7.130E-01 8.000E-01
8.780E-01 9.640E-01 1.058E+00 1.162E+00 1.275E+00 1.400E+00
1.542E+00 1.698E+00 1.871E+00 2.061E+00 2.270E+00 2.500E+00
2.704E+00 2.924E+00 3.162E+00 3.419E+00 3.699E+00
4.000E+00 4.165E+00 4.337E+00 4.516E+00 4.703E+00 4.897E+00
5.099E+00 5.310E+00 5.529E+00 5.757E+00 5.995E+00 6.242E+00
6.500E+00 6.765E+00 7.041E+00 7.327E+00 7.627E+00 7.938E+00
8.261E+00 8.598E+00 8.949E+00 9.314E+00 9.693E+00 1.009E+01
1.050E+01 1.082E+01 1.114E+01 1.148E+01 1.183E+01 1.218E+01
1.255E+01 1.277E+01 1.300E+01 1.324E+01 1.348E+01 1.372E+01
1.397E+01 1.422E+01 1.447E+01 1.474E+01 1.500E+01 1.527E+01
1.555E+01 1.583E+01 1.611E+01 1.640E+01

END

```
Oktavian Ni sphere R=16 cm, 3D model, ENDF/B-VI, Source-2/Anisotropic
C 3-dimensional MCNP/4B input by A. Trkov, IJS, andrej.trkov@ijs.si
C  Central sphere cavity and beam duct
 1     2  -0.0012   -1
 2     2  -0.0012    1  -2  -3  -4
C  Sphere main body
 3     1  -8.85     -2  #1  #2
C  Source calculation (without the sphere)
c 3     2  -0.0012   -2  #1  #2
C  From sphere to the first collimator
 4     2  -0.0012    2  -7  -5
C  First collimator body
 5     4   0.08487   6   7  -8  -5
C  First collimator gap
 6     2  -0.0012   -6   7  -8
C  Space between collimators
 7     2  -0.0012        8  -9  -5
C  Main collimator body
 8     4   0.08487   6   9 -10  -5
C  Main collimator gap
 9     2  -0.0012   -6   9 -10
C  Borated parafin
10     3  -1.       10 -11  12 -13
C  Detector region
11     2  -0.0012   10  -5 #10
C  Outer void
12     0            5

 1     SO    0.4
 2     SO   16.0
 3     CY    0.4
 4     PY    0
 5     SO  1200.0
 6     Y    50.32 16.0 934. 6.35
 7     PY   310.0
 8     PY   500.0
 9     PY   800.0
10     PY   890.0
11     PY   980.0
12     CY    10.0
13     CY    40.0

C  Materials:
C  Nickel with impurities (expressed as weight percent)
M1     28058.60C -0.67144  28060.60C -0.26554  28061.60C -0.01169
       28062.60C -0.03775  28064.60C -0.00988
       14000.60C -0.0016   25055.60C -0.0015   26056.60C -0.0004
       12000.60C -0.0001   29063.60C -0.00007  29065.60C -0.00003
C  Air
M2     8016.60C  0.208
       7014.60C  0.792
c  Borated parrafin
M3     6000.60c  0.29
       1001.60c  0.58
       5010.60c  0.026
       5011.60c  0.104
C  Iron collimator (pure Fe-56)
M4     26056.60C  1.
MODE   N
C **** Source definition
SDEF   POS=0. 0. 0.  ERG=D1
C Isotropic Source spectrum-2
SI1  H
       1.1200E-01 1.2600E-01 1.4100E-01 1.5900E-01 1.7800E-01
       2.0000E-01 2.2400E-01 2.5200E-01 2.8300E-01 3.1700E-01
       3.5600E-01 4.0000E-01 4.4900E-01 5.0400E-01 5.6600E-01
       6.3500E-01 7.1300E-01 8.0000E-01 8.7800E-01 9.6400E-01
       1.0580E+00 1.1620E+00 1.2750E+00 1.4000E+00 1.5420E+00
       1.6980E+00 1.8710E+00 2.0610E+00 2.2700E+00 2.5000E+00
       2.7040E+00 2.9240E+00 3.1620E+00 3.4190E+00 3.6990E+00
```

```
     4.0000E+00 4.1650E+00 4.3370E+00 4.5160E+00 4.7030E+00
     4.8970E+00 5.0990E+00 5.3100E+00 5.5290E+00 5.7570E+00
     5.9950E+00 6.2420E+00 6.5000E+00 6.7650E+00 7.0410E+00
     7.3270E+00 7.6270E+00 7.9380E+00 8.2610E+00 8.5980E+00
     8.9490E+00 9.3140E+00 9.6930E+00 1.0089E+01 1.0500E+01
     1.0817E+01 1.1143E+01 1.1479E+01 1.1825E+01 1.2182E+01
     1.2549E+01 1.2775E+01 1.3005E+01 1.3239E+01 1.3477E+01
     1.3720E+01 1.3967E+01 1.4218E+01 1.4474E+01 1.4735E+01
     1.5000E+01 1.5270E+01 1.5545E+01 1.5825E+01 1.6110E+01
     1.6399E+01
SP1
     0.0000E+00 9.1757E-08 9.8311E-06 4.1291E-05 4.9811E-05
     8.7841E-05 2.4712E-04 3.3510E-04 3.6734E-04 3.7080E-04
     5.7052E-04 6.2002E-04 6.2400E-04 8.9866E-04 1.0057E-03
     1.2120E-03 1.2898E-03 1.4734E-03 1.3726E-03 1.4181E-03
     1.4552E-03 1.6345E-03 1.6449E-03 1.6672E-03 1.8595E-03
     1.7555E-03 1.9570E-03 1.9663E-03 1.8479E-03 1.8526E-03
     1.7087E-03 2.3287E-03 1.5062E-03 1.4611E-03 1.4217E-03
     1.4101E-03 7.3061E-04 7.3579E-04 6.6062E-04 6.8818E-04
     7.1076E-04 7.3399E-04 6.9796E-04 7.8571E-04 6.8635E-04
     6.9992E-04 7.6135E-04 8.0185E-04 8.5800E-04 8.4242E-04
     8.4426E-04 9.6325E-04 8.8076E-04 8.5653E-04 1.0666E-03
     1.0955E-03 1.0887E-03 1.3672E-03 1.4659E-03 1.5928E-03
     1.4517E-03 1.6343E-03 1.7761E-03 2.1228E-03 2.4498E-03
     3.1125E-03 2.2189E-03 2.6742E-03 3.3357E-03 4.5377E-03
     6.6573E-03 1.2350E-02 3.2984E-02 1.0116E-01 1.8560E-01
     2.1797E-01 1.7040E-01 1.2067E-01 4.8301E-02 1.4478E-02
     3.0325E-03
IMP:N  1  1  1  1  1  1  1  1  1  1  1  0
C     ******* FLUX TALLY ************
FC5    FLUX AT A POINT DETECTOR 934 CM FROM THE SPHERE CENTRE
F5:N   0 934 0 5
E5     6.000E-05 7.740E-05 1.000E-04 1.290E-04 1.670E-04 2.150E-04
     2.780E-04 3.590E-04 4.640E-04 5.990E-04 7.740E-04 1.000E-03
     1.290E-03 1.670E-03 2.150E-03 2.780E-03 3.590E-03 4.640E-03
     5.990E-03 7.740E-03 1.000E-02 1.290E-02 1.670E-02 2.150E-02
     2.445E-02 2.780E-02 3.159E-02 3.590E-02 4.081E-02 4.640E-02
     5.272E-02 5.990E-02 6.809E-02 7.740E-02 8.798E-02 1.000E-01
     1.120E-01 1.260E-01 1.410E-01 1.590E-01 1.780E-01 2.000E-01
     2.240E-01 2.520E-01 2.830E-01 3.170E-01 3.560E-01 4.000E-01
     4.490E-01 5.040E-01 5.660E-01 6.350E-01 7.130E-01 8.000E-01
     8.780E-01 9.640E-01 1.058E+00 1.162E+00 1.275E+00 1.400E+00
     1.542E+00 1.698E+00 1.871E+00 2.061E+00 2.270E+00 2.500E+00
     2.704E+00 2.924E+00 3.162E+00 3.419E+00 3.699E+00
     4.000E+00 4.165E+00 4.337E+00 4.516E+00 4.703E+00 4.897E+00
     5.099E+00 5.310E+00 5.529E+00 5.757E+00 5.995E+00 6.242E+00
     6.500E+00 6.765E+00 7.041E+00 7.327E+00 7.627E+00 7.938E+00
     8.261E+00 8.598E+00 8.949E+00 9.314E+00 9.693E+00 1.009E+01
     1.050E+01 1.082E+01 1.114E+01 1.148E+01 1.183E+01 1.218E+01
     1.255E+01 1.277E+01 1.300E+01 1.324E+01 1.348E+01 1.372E+01
     1.397E+01 1.422E+01 1.447E+01 1.474E+01 1.500E+01 1.527E+01
     1.555E+01 1.583E+01 1.611E+01 1.640E+01 T
C     *******    CUT OFF CARD    *******
C  CUT:N  1.00E16  1.00E-2 -0.5 -0.25
C     *******    NEUTRON HISTORY *******
NPS    3000000
C PRDMP  J -20 1 1 1
C CTME   2000
PRINT
```

2. Osaka Aluminium Sphere (1988) SBE 7.003

```
LEAKAGE FROM ALUMINIUM (40 CM DIA) SPHERE 3-D SURFACE TALLY (ENDF/B-VI)
$ COG input / neutron source

BASIC
$ track neutrons, photons and electrons
$ Length [cm]; Energy [MeV]; Time [sec]
  neutron
  photon
  electron
  cm
  MeV
  sec
  dnear ON  $ activate "dnear" option

SURFACES
 3 SPHERE 10.0
 4 SPHERE 10.2
 5 SPHERE 19.75
 6 SPHERE 19.95
 7 SPHERE 580.0
 8 SPHERE 581.0

GEOMETRY
sector 1 sec1 -3
sector 2 sec2 -4 3
sector 3 sec3 -5 4
sector 4 sec4 -6 5
sector 5 sec5 -7 6
sector 6 sec6 -8 7

Boundary vacuum +8

MIX
NLIB = ENDFB6R7
$ Aluminium (0.2% Fe-56, ignore Si, Cu)
  mat 1 w-p 1.223 13027 0.998
       26056 0.002
$ Steel (Cr 18.5%, Fe-56 70.4%, Ni 11.1%)
  mat 2 w-p 7.824 24000 0.185
       26056 0.704
       28000 0.111
$ Air
 mat 3 w-p  0.0012 8016 0.2307
        7014 0.7693

ASSIGN-M
1 3   2 2   3 1   4 2   5 3   6 0

ASSIGN-MC
            1 yellow   $ Aluminium Sphere
            2 sky                $ air
            3 gray               $ steel
            0 orange  $ void

EGS
 pegslib = egsAl.dat
$ electron transport enabled in the following sectors:
 esectors =  2 3 4
 ECut = 0.3  $ kill electron tranport for E < 0.3 MeV

 WALK-ENERGY
   photon region 2 to 4 0.299

SOURCE
 npart = 5000000
 increment 1. p=1 e=1 a=1
```

```
 define position = 1  point  0. 0. 0.
 define angle= 1 isotropic
 define energy = 1 neutron
   bin 1.00e-01 0.0000e+00 1.12e-01
0.0000e+00 1.26e-01 8.4667e-03 1.41e-01
3.2078e-03 1.59e-01 1.3347e-02 1.78e-01
1.2373e-02 2.00e-01 8.6500e-03 2.24e-01
1.5593e-02 2.52e-01 1.2494e-02 2.83e-01
1.3988e-02 3.17e-01 1.5797e-02 3.56e-01
1.5289e-02 4.00e-01 1.3567e-02 4.49e-01
1.5602e-02 5.04e-01 1.7710e-02 5.66e-01
1.7159e-02 6.35e-01 1.8103e-02 7.13e-01
1.8575e-02 8.00e-01 1.9821e-02 8.78e-01
1.8093e-02 9.64e-01 1.7351e-02 1.058e+00
1.7029e-02 1.162e+00 1.5965e-02 1.275e+00
1.4584e-02 1.40e+00 1.3317e-02 1.542e+00
1.2404e-02 1.698e+00 1.1572e-02 1.871e+00
1.0800e-02 2.061e+00 9.5885e-03 2.27e+00
8.9913e-03 2.500e+00 1.0250e-02 2.704e+00
1.5245e-02 2.924e+00 6.2689e-03 3.162e+00
5.1440e-03 3.419e+00 5.1821e-03 3.699e+00
4.6545e-03 4.000e+00 4.3103e-03 4.165e+00
3.7343e-03 4.337e+00 3.6391e-03 4.516e+00
3.3128e-03 4.703e+00 3.3134e-03 4.897e+00
3.0738e-03 5.099e+00 2.7431e-03 5.310e+00
2.3868e-03 5.529e+00 2.3026e-03 5.757e+00
2.2924e-03 5.995e+00 2.0672e-03 6.242e+00
2.2438e-03 6.50e+00 2.0343e-03 6.765e+00
1.8109e-03 7.041e+00 1.6829e-03 7.327e+00
1.7667e-03 7.627e+00 1.8508e-03 7.938e+00
1.6192e-03 8.261e+00 1.6006e-03 8.598e+00
1.7823e-03 8.949e+00 1.9307e-03 9.314e+00
2.0393e-03 9.693e+00 2.0028e-03 1.009e+01
2.1120e-03 1.050e+01 2.5331e-03 1.082e+01
2.7884e-03 1.114e+01 3.0059e-03 1.148e+01
3.6600e-03 1.183e+01 4.8200e-03 1.218e+01
6.1784e-03 1.255e+01 8.2955e-03 1.277e+01
1.0778e-02 1.300e+01 1.5808e-02 1.324e+01
2.9208e-02 1.348e+01 6.5208e-02 1.372e+01
1.4536e-01 1.397e+01 2.9968e-01 1.422e+01
5.1160e-01 1.447e+01 6.5481e-01 1.474e+01
7.3692e-01 1.500e+01 5.5556e-01 1.527e+01
3.2133e-01 1.554e+01 1.3621e-01 1.583e+01
5.1071e-02 1.611e+01 1.4721e-02 1.64e+01

$ *** TALLY CARDS ***
Detector
   number = bcd1
   boundary  counts 5 6 4227327.1
    Bin Energy = neutron
0.097122 0.10109 0.10521 0.1095
0.11397 0.11862 0.12347 0.1285
0.13375 0.13921 0.14489 0.1508
0.15696 0.16336 0.17003 0.17697
0.18419 0.19171 0.19953 0.20767
0.21615 0.22497 0.23415 0.24371
0.25365 0.264 0.27478 0.28599
0.29766 0.30981 0.32245 0.33561
0.34931 0.36357 0.3784 0.39385
0.40992 0.42665 0.44406 0.46218
0.48105 0.50068 0.52111 0.54238
0.56451 0.58755 0.61153 0.63648
0.66246 0.6895 0.71763 0.74692
0.7774 0.80913 0.84215 0.87652
0.91229 0.94952 0.98827 1.0286
1.0706 1.1143 1.1598 1.2071
1.2563 1.3076 1.361 1.4165 1.4743
1.5345 1.5971 1.6623 1.7301
1.8008 1.8742 1.9507 2.0303
2.1132 2.1994 2.2892 2.3826
```

2.4799 2.5811 2.6864 2.796
2.9101 3.0289 3.1525 3.2812
3.4151 3.5545 3.6995 3.8505
4.0076 4.1712 4.3414 4.5186
4.703 4.8949 5.0947 5.3026
5.519 5.7443 5.9787 6.2227
6.4766 6.741 7.0161 7.3024
7.6004 7.9106 8.2334 8.5694
8.9192 9.2832 9.662 10.056
10.467 10.894 11.339 11.801
12.283 12.784 13.306 13.849
14.414 15.002 15.615 16.252
16.915 17.605 18.324 19.072 19.85

number = bcd2
boundary 5 6 4227327.1
Bin Energy = photon
3.0E-01 4.0E-01 5.0E-01 6.0E-01
7.0E-01 8.0E-01 9.0E-01 1.0E+00
1.10E+00 1.20E+00 1.30E+00 1.40E+00
1.50E+00 1.60E+00 1.70E+00 1.80E+00
1.90E+00 2.00E+00 2.10E+00 2.20E+00
2.30E+00 2.40E+00 2.50E+00 2.60E+00
2.70E+00 2.80E+00 2.90E+00 3.10E+00
3.20E+00 3.30E+00 3.40E+00 3.50E+00
3.60E+00 3.70E+00 3.80E+00 3.90E+00
4.00E+00 4.10E+00 4.20E+00 4.30E+00
4.40E+00 4.50E+00 4.60E+00 4.70E+00
4.80E+00 4.90E+00 5.00E+00 5.10E+00
5.20E+00 5.30E+00 5.40E+00 5.50E+00
5.60E+00 5.70E+00 5.80E+00 5.90E+00
6.00E+00 6.20E+00 6.40E+00 6.60E+00
6.80E+00 7.00E+00 7.20E+00 7.40E+00
7.60E+00 7.80E+00 8.00E+00 8.20E+00
8.40E+00 8.60E+00 8.80E+00 9.00E+00
9.20E+00 9.40E+00 9.60E+00 9.80E+00
1.00E+01 1.04E+01 1.08E+01 1.12E+01
1.16E+01 1.20E+01 1.24E+01 1.28E+01
1.32E+01 1.36E+01 1.40E+01 1.44E+01
1.48E+01 1.52E+01 1.56E+01 1.60E+01
1.64E+01 1.68E+01 1.72E+01 1.76E+01
1.80E+01 1.84E+01 1.88E+01 1.92E+01
1.96E+01 2.00E+01

END

```
Analysis of OKTAVIAN Experiment for Secondary Gamma-Rays << Al-g >>
$LEAKAGE FROM ALUMINIUM (40 CM DIA) SPHERE 3-D SURFACE TALLY (ENDF/B-VI)
$ COG input / Photon source

BASIC
   photon
   electron
   cm
   MeV
   sec
   dnear ON  $ activate "dnear" option

SURFACES
 1 SPHERE 10.00
 2 SPHERE 10.20
 3 SPHERE 19.75
 4 SPHERE 19.95
 5 SPHERE 580.00
 6 SPHERE 20.0

GEOMETRY
sector 1 sec1 -1
sector 2 sec2 1 -2
sector 3 sec3 2 -3
sector 4 sec4 3 -4
sector 5 sec5 4 -6
sector 6 sec6 -5 6

Boundary vacuum +5

MIX
NLIB=ENDFB6R7
   mat 1 w-p 1.22 13027 1.0     $ Aluminium
   mat 2 w-p 7.9  24000  0.185
                 25055  0.013
                 26000  0.691
           28000. 0.111

ASSIGN-M  $ sector#  material#
1 0    2 2     3 1    4 2
5 0    6 0

EGS
 pegslib = egsAl_g.dat
$ electron transport enabled in the following sectors:
 esectors = 2 3 4
 ECut = 0.300  $ kill electron tranport for E < 0.050MeV

WALK-ENERGY
   photon region 2 to 4 0.3

SOURCE
 npart = 1000000

 increment 0.0862 p=1 e=1 a=1
 define Position = 1  point  0. 0. 0.
 define Angle= 1 isotropic
$SI1   0.6 93I 10.0
 define energy = 1 photon
   bin
 6.00000E-01  2.961e-2   7.00000E-01   4.793e-2
 8.00000E-01  9.615e-2   9.00000E-01   4.543e-2
 1.00000E+00  4.082e-2   1.10000E+00   5.335e-2
 1.20000E+00  6.609e-2   1.30000E+00   4.793e-2
 1.40000E+00  3.476E-2   1.50000E+00   2.035E-2
 1.60000E+00  1.733E-2   1.70000E+00   1.733E-2
 1.80000E+00  1.557E-2   1.90000E+00   1.326E-2
 2.00000E+00  1.257E-2   2.10000E+00   1.191E-2
 2.20000E+00  1.070E-2   2.30000E+00   1.014E-2
 2.40000E+00  1.070E-2   2.50000E+00   1.129E-2
```

2.60000E+00 1.014E-2 2.70000E+00 8.638E-3
2.80000E+00 7.761E-3 2.90000E+00 8.188E-3
3.00000E+00 8.638E-3 3.10000E+00 8.638E-3
3.20000E+00 8.188E-3 3.30000E+00 7.761E-3
3.40000E+00 7.356E-3 3.50000E+00 7.356E-3
3.60000E+00 7.356E-3 3.70000E+00 6.973E-3
3.80000E+00 6.264E-3 3.90000E+00 5.628E-3
4.00000E+00 5.335E-3 4.10000E+00 5.335E-3
4.20000E+00 5.628E-3 4.30000E+00 5.938E-3
4.40000E+00 6.264E-3 4.50000E+00 5.938E-3
4.60000E+00 5.057E-3 4.70000E+00 4.082E-3
4.80000E+00 3.476E-3 4.90000E+00 3.295E-3
5.00000E+00 3.476E-3 5.10000E+00 3.667E-3
5.20000E+00 4.082E-3 5.30000E+00 4.082E-3
5.40000E+00 3.869E-3 5.50000E+00 3.667E-3
5.60000E+00 3.295E-3 5.70000E+00 2.960E-3
5.80000E+00 2.806E-3 5.90000E+00 2.806E-3
6.00000E+00 2.960E-3 6.10000E+00 2.960E-3
6.20000E+00 2.960E-3 6.30000E+00 2.806E-3
6.40000E+00 2.659E-3 6.50000E+00 2.521E-3
6.60000E+00 2.389E-3 6.70000E+00 2.389E-3
6.80000E+00 2.521E-3 6.90000E+00 2.521E-3
7.00000E+00 2.389E-3 7.10000E+00 1.929E-3
7.20000E+00 1.642E-3 7.30000E+00 1.476E-3
7.40000E+00 1.399E-3 7.50000E+00 1.326E-3
7.60000E+00 1.326E-3 7.70000E+00 1.326E-3
7.80000E+00 1.326E-3 7.90000E+00 1.326E-3
8.00000E+00 1.326E-3 8.10000E+00 1.257E-3
8.20000E+00 1.070E-3 8.30000E+00 9.113E-4
8.40000E+00 8.188E-4 8.50000E+00 6.973E-4
8.60000E+00 6.609E-4 8.70000E+00 6.264E-4
8.80000E+00 5.938E-4 8.90000E+00 5.938E-4
9.00000E+00 5.628E-4 9.10000E+00 5.628E-4
9.20000E+00 5.335E-4 9.30000E+00 5.057E-4
9.40000E+00 4.306E-4 9.50000E+00 3.667E-4
9.60000E+00 2.960E-4 9.70000E+00 2.659E-4
9.80000E+00 2.659E-4 9.90000E+00 2.806E-4
1.00000E+01

DETECTOR
number = bcd2
boundary 5 6 4227327.1
Bin Energy = photon
3.0E-01 4.0E-01 5.0E-01 6.0E-01
7.0E-01 8.0E-01 9.0E-01 1.0E+00
1.10E+00 1.20E+00 1.30E+00 1.40E+00
1.50E+00 1.60E+00 1.70E+00 1.80E+00
1.90E+00 2.00E+00 2.10E+00 2.20E+00
2.30E+00 2.40E+00 2.50E+00 2.60E+00
2.70E+00 2.80E+00 2.90E+00 3.10E+00
3.20E+00 3.30E+00 3.40E+00 3.50E+00
3.60E+00 3.70E+00 3.80E+00 3.90E+00
4.00E+00 4.10E+00 4.20E+00 4.30E+00
4.40E+00 4.50E+00 4.60E+00 4.70E+00
4.80E+00 4.90E+00 5.00E+00 5.10E+00
5.20E+00 5.30E+00 5.40E+00 5.50E+00
5.60E+00 5.70E+00 5.80E+00 5.90E+00
6.00E+00 6.20E+00 6.40E+00 6.60E+00
6.80E+00 7.00E+00 7.20E+00 7.40E+00
7.60E+00 7.80E+00 8.00E+00 8.20E+00
8.40E+00 8.60E+00 8.80E+00 9.00E+00
9.20E+00 9.40E+00 9.60E+00 9.80E+00
1.00E+01
END

```
LEAKAGE FROM ALUMINIUM (40 CM DIA) SPHERE 3-D SURFACE TALLY (ENDF/B-VI)
C MCNP input
c    *** Cell cards ***
 1     3  -0.0012  -3
 2     2  -7.824   -4 3
 3     1  -1.223   -5 4
 4     2  -7.824   -6 5
 5     3  -0.0012  -7 6
 6     0            7

c    *** Surface cards ***
 3    so  10.0
 4    so  10.2
 5    so  19.75
 6    so  19.95
 7    so 580.0

c    *** Material cards ***
c Aluminium (0.2% Fe-56, ignore Si, Cu)
m1   13027.60c -0.998 26056.60c -0.002
c Steel (Cr 18.5%, Fe-56 70.4%, Ni 11.1%)
m2   24000.50c -0.185 26056.60c -0.704 28000.50c -0.111
c  Air
m3    8016.60C  0.208
      7014.60C  0.792
c    *** Data cards ***
mode n p e
imp:n 1 1 1 1 1 0
imp:p 1 1 1 1 1 0
imp:e 1 1 1 1 1 0
sdef pos=0. 0. 0. cel=1 erg=d1
c    *** Energy bin for source neutron ***
si1  h 1.000e-1 1.120e-1 1.260e-1 1.410e-1 1.590e-1
       1.780e-1 2.000e-1 2.240e-1 2.520e-1 2.830e-1
       3.170e-1 3.560e-1 4.000e-1 4.490e-1 5.040e-1
       5.660e-1 6.350e-1 7.130e-1 8.000e-1 8.780e-1
       9.640e-1 1.058e+0 1.162e+0 1.275e+0 1.400e+0
       1.542e+0 1.698e+0 1.871e+0 2.061e+0 2.270e+0
       2.500e+0 2.704e+0 2.924e+0 3.162e+0 3.419e+0
       3.699e+0 4.000e+0 4.165e+0 4.337e+0 4.516e+0
       4.703e+0 4.897e+0 5.099e+0 5.310e+0 5.529e+0
       5.757e+0 5.995e+0 6.242e+0 6.500e+0 6.765e+0
       7.041e+0 7.327e+0 7.627e+0 7.938e+0 8.261e+0
       8.598e+0 8.949e+0 9.314e+0 9.693e+0 1.009e+1
       1.050e+1 1.082e+1 1.114e+1 1.148e+1 1.183e+1
       1.218e+1 1.255e+1 1.277e+1 1.300e+1 1.324e+1
       1.348e+1 1.372e+1 1.397e+1 1.422e+1 1.447e+1
       1.474e+1 1.500e+1 1.527e+1 1.554e+1 1.583e+1
       1.611e+1 1.640e+1
c    *** Source distribution ***
sp1    0.000e-4 0.000e-0 0.000e-0 1.270e-4 5.774e-5
       2.536e-4 2.722e-4 2.076e-4 4.366e-4 3.873e-4
       4.756e-4 6.161e-4 6.727e-4 6.648e-4 8.581e-4
       1.098e-3 1.184e-3 1.412e-3 1.616e-3 1.546e-3
       1.556e-3 1.631e-3 1.771e-3 1.804e-3 1.823e-3
       1.891e-3 1.935e-3 2.002e-3 2.052e-3 2.004e-3
       2.068e-3 2.091e-3 3.354e-3 1.492e-3 1.322e-3
       1.451e-3 1.401e-3 7.112e-4 6.423e-4 6.514e-4
       6.195e-4 6.428e-4 6.209e-4 5.788e-4 5.227e-4
       5.250e-4 5.456e-4 5.106e-4 5.789e-4 5.391e-4
       4.998e-4 4.813e-4 5.300e-4 5.756e-4 5.230e-4
       5.394e-4 6.256e-4 7.047e-4 7.729e-4 7.951e-4
       8.659e-4 8.106e-4 8.923e-4 1.022e-3 1.281e-3
       1.687e-3 2.286e-3 1.825e-3 2.479e-3 3.794e-3
       7.010e-3 1.565e-2 3.634e-2 7.492e-2 1.279e-1
       1.768e-1 1.916e-1 1.500e-1 8.676e-2 3.950e-2
       1.430e-2 4.269e-3
c    *** Tally cards ***
fc21 Neutron current through the outer surface
f21:n 7
```

```
c    *** Energy bin ***
e21    0.097122 0.10109 0.10521 0.1095
       0.11397 0.11862 0.12347 0.1285
       0.13375 0.13921 0.14489 0.1508
       0.15696 0.16336 0.17003 0.17697
       0.18419 0.19171 0.19953 0.20767
       0.21615 0.22497 0.23415 0.24371
       0.25365 0.264 0.27478 0.28599
       0.29766 0.30981 0.32245 0.33561
       0.34931 0.36357 0.3784 0.39385
       0.40992 0.42665 0.44406 0.46218
       0.48105 0.50068 0.52111 0.54238
       0.56451 0.58755 0.61153 0.63648
       0.66246 0.6895 0.71763 0.74692
       0.7774 0.80913 0.84215 0.87652
       0.91229 0.94952 0.98827 1.0286
       1.0706 1.1143 1.1598 1.2071
       1.2563 1.3076 1.361 1.4165 1.4743
       1.5345 1.5971 1.6623 1.7301
       1.8008 1.8742 1.9507 2.0303
       2.1132 2.1994 2.2892 2.3826
       2.4799 2.5811 2.6864 2.796
       2.9101 3.0289 3.1525 3.2812
       3.4151 3.5545 3.6995 3.8505
       4.0076 4.1712 4.3414 4.5186
       4.703 4.8949 5.0947 5.3026
       5.519 5.7443 5.9787 6.2227
       6.4766 6.741 7.0161 7.3024
       7.6004 7.9106 8.2334 8.5694
       8.9192 9.2832 9.662 10.056
       10.467 10.894 11.339 11.801
       12.283 12.784 13.306 13.849
       14.414 15.002 15.615 16.252
       16.915 17.605 18.324 19.072 19.85
fc32 Photon current through the outer surface
f32:p 7
fm32 4227327.1              $ 4*Pi * R7
fq32 e t
c    *** Energy bin ***
e32  0.3  56i  6.0  19i  10.0  24i  20
t32  8.8  1e6  t
c
phys:n 20.0  0
phys:p 20.0  0  0
phys:e 20.0  0  0  0  0  1  0  1  1
c    *** Cut off card ***
c cut:n 1.0e16 1.0e-3 0.01
cut:n 1.0e6  0.0    -0.5  -0.25  0
cut:p 1.0e6  0.299  -0.5  -0.25  0
cut:e 1.0e6  0.3    -0.5  -0.25  0
c    *** Neutron history ***
nps  5000000
print
```

```
Analysis of OKTAVIAN Experiment for Secondary Gamma-Rays << Al-g >>
C MNCP input
c JAERI-Data/Code 98-024 p. 174 Fig. A-17
 1    0          -1
 2    2   -7.90     1 -2
 3    1   -1.22     2 -3
 4    2   -7.90     3 -4
 5    0           4 -5
 6    0           5

 1     so    10.00
 2     so    10.20
 3     so    19.75
 4     so    19.95
 5     so   580.00

mode  p e
imp:p 1  1  1  1  1  0
imp:e 1  1  1  1  1  0
sdef  erg=d1  wgt=0.0862
si1   0.6 93i 10.0
sp1   0.000e+0 2.961e-3 4.793e-3 9.615e-3 4.543e-3 4.082e-3 5.335e-3 6.609e-3
      4.793e-3 3.476e-3 2.035e-3 1.733e-3 1.733e-3 1.557e-3 1.326e-3 1.257e-3
      1.191e-3 1.070e-3 1.014e-3 1.070e-3 1.129e-3 1.014e-3 8.638e-4 7.761e-4
      8.188e-4 8.638e-4 8.638e-4 8.188e-4 7.761e-4 7.356e-4 7.356e-4 7.356e-4
      6.973e-4 6.264e-4 5.628e-4 5.335e-4 5.335e-4 5.628e-4 5.938e-4 6.264e-4
      5.938e-4 5.057e-4 4.082e-4 3.476e-4 3.295e-4 3.476e-4 3.667e-4 4.082e-4
      4.082e-4 3.869e-4 3.667e-4 3.295e-4 2.960e-4 2.806e-4 2.806e-4 2.960e-4
      2.960e-4 2.960e-4 2.806e-4 2.659e-4 2.521e-4 2.389e-4 2.389e-4 2.521e-4
      2.521e-4 2.389e-4 1.929e-4 1.642e-4 1.476e-4 1.399e-4 1.326e-4 1.326e-4
      1.326e-4 1.326e-4 1.326e-4 1.326e-4 1.257e-4 1.070e-4 9.113e-5 8.188e-5
      6.973e-5 6.609e-5 6.264e-5 5.938e-5 5.938e-5 5.628e-5 5.628e-5 5.335e-5
      5.057e-5 4.306e-5 3.667e-5 2.960e-5 2.659e-5 2.659e-5 2.806e-5
c
m1    13027.  1
m2    24000. -0.185  25055. -0.013   26000.  -0.691
      28000. -0.111
c
fc32  -----  photon spectrum  -----
f32:p 5
fm32  4227327.1      $ 4*pi*580*580
fq32  e  t
e32   0.3  56i  6.0  19i  10.0
t32   6.9  1e6  t
c
phys:p 20.0   0    0
phys:e 20.0   0    0    0    0    1    0    1    1
cut:p  1e6  0.299  -0.5   -0.25   0
cut:e  1e6  0.3    -0.5   -0.25   0
nps    1000000
ctme   1000000
prdmp  10000000 10000000   1  1
lost   10       10
print
```

3. FNS liquid oxygen (1989) SBE 3.006

```
fns-tof/ lo2 slab-tof          JENDL-3.2          '94-08-18
$ COG input

BASIC
  neutron
  MeV
  cm

SURFACES
 1 PLANE Z -28.0
 2 PLANE Z 0.0
 3 PLANE Z -27.5
 4 PLANE Z -0.5
 5 PLANE Z -25.90
 6 PLANE Z -2.10
 7 PLANE Z -25.20
 8 PLANE Z -2.80
 9 PLANE Z -24.80
 10 PLANE Z -3.20
 11 PLANE Z -24.0
 12 PLANE Z -4.0
 13 PLANE Z -70.0
 14 CYL Z 35.0
 15 CYL Z 34.7
 16 CYL Z 30.8
 17 CYL Z 30.0
 18 CYL Z 29.8
 19 CYL Z 23.25
 20 CYL Z 15.0
 21 SPHERE 136.146 TR 0. 0. 134.146
 22 SPHERE 136.146 TR 0. 0. 134.096
 23 SPHERE 102.8227 TR 0. 0. -105.7227
 24 SPHERE 102.8227 TR 0. 0. -105.6727
 25 SPHERE 102.8227 TR 0. 0. 77.7227
 26 SPHERE 102.8227 TR 0. 0. 77.6727
 27 SPHERE 102.8227 TR 0. 0. -129.7227
 28 SPHERE 102.8227 TR 0. 0. -129.6727
 29 CYL Z 4.977  $
 30 CYL   4.985 0 1200  TR 0. 0. 0.  148.7973 0 688.2148 $ Rotation
 31 CYL   5.012 0 1200  TR 0. 0. 0.  298.0163 0 642.0212 $ Rotation
 32 CYL   5.074 0 1200  TR 0. 0. 0.  477.4981 0 534.0526 $ Rotation
 33 CYL   5.212 0 1200  TR 0. 0. 0.  676.2307 0 289.8328 $ Rotation
 34 SPHERE 1000.0              $ World

GEOMETRY
sector 1 sec1          -13 -34
                       OR +13 -2 +14 -34
$ ************** source vacuum region: AIR *****************
 sector 3 sec3         -14 +13 -1
                       OR -27 +1 -20
$ ***************** material region ********************
$ ----sus316
sector 4 sec4          +1 -3 -14 +20
                       OR +4 -2 -14 +19
                       OR +3 -4 -14 +15
sector 5 sec5          +27 -28 -20
                       OR +21 -22 -19
sector 6 sec6          +9 -11 -17 +20
                       OR +12 -10 -17 +20
                       OR +11 -12 -17 +18
sector 7 sec7          +25 -26 -20
                       OR +23 -24 -20
$ ---- vacuum
sector 8 sec8          +3 -5 -15 +20
                       OR +6 -4 -15 +19
                       OR +5 -6 -15 +16
sector 9 sec9          +28 -5 -20
```

```
                        OR +22 +6 -19
sector 10 sec10 +7 -9 -17 +20
                        OR +10 -8 -17 +20
sector 11 sec11 +26 +7 -20
                        OR +24 -8 -20
$ ---- al
sector 12 sec12 +5 -7 -16
                        OR +8 -6 -16
                        OR +7 -8 -16 +17
$ ---- o
sector 13 sec13 +11 -12 -18
                        OR  -25 -11 -20
                        OR  -23 +12 -20
$ ******* detector vacuum region *******
 sector 14 sec14 +2 -34 -29
                        OR  +2 -34 -30
                        OR  +2 -34 -31
                        OR  +2 -34 -32
                        OR  +2 -34 -33

 sector 15 sec15 +2 -34 +29 +30 +31 +32 +33
BOUNDARY VACUUM +34

$ Geometry Picture views
  picture cs sector color -100. -54  -28.5    100 -54 -28.5    100 100 -28.5
  picture cs sector color -100. -54  -10    100 -54 -10    100 100 -10
  picture cs sector  50. 0 -80.    50 0 50    -50 0 50
  picture cs material color -100. -54  -28.5   100 -54 -28.5   100 100 -28.5
  picture cs material color -100. -54  -10.   100 -54 -10    100 100 -10
  picture cs material color  50. 0 -80.    50 0 50    -50 0 50
  picture cs material color  40. 0 -70.    40 0 40    -40 0 40


MIX
NLIB = ENDFB6R7
$ air
    mat 1 # 1.17868E-03  7014 0.78866    8016 0.21134

$ sus316: Cr=1.6787-2, Mn55=1.3420-3, Fe-6.0507-2, Ni=7.3429-3
  mat 2 # 7.89844 24050 0.00848  24052 0.16360
        24053 0.01855      24054 0.00462
        25055 0.01561      26054 0.04152
        26056 0.64547      26057 0.01478
        26058 0.00197      28058 0.05830
        28060 0.02229      28061 0.00097
        28062 0.00307      28064 0.00078

   mat 3 # 2.7  13027 1.0
$ o
    mat 4 # 1.1407  8016  1.0

ASSIGN-M  $ sector#  material
1 0   2 0   3 1
4 2   5 2   6 2   7 2
8 0   9 0  10 0  11 0
12 3  13 4  14 0 15 -1

ASSIGN-MC
            1 sky                   $ air
            2 gray                  $ iron/steel
            3 lavender      $ aluminium
            4 blue                  $ oxygen


SOURCE
npart = 2000000

 increment 1. p=1 e=1 a=1
 define position = 1  point  0. 0. -44.0
 define angle= 1
```

```
            0. 0. 1.
            isotropic
            IMP -1. 0.001  0.342 0.001   0.438 1.   1. 1.

 define energy = 1 neutron
            bin
0.0 0.0     0.040867 2.6124E-02 0.046308
3.4481E-02 0.052474 3.3150E-02 0.059461
2.6938E-02 0.067378 3.0194E-02 0.076349
2.5607E-02 0.086515 2.7734E-02 0.098035
2.8991E-02 0.11109 2.9141E-02 0.12588
2.6302E-02 0.14264 2.9641E-02 0.16163
2.8005E-02 0.18315 3.0887E-02 0.20754
3.0245E-02 0.23517 3.2826E-02 0.26649
3.2751E-02 0.30197 3.4530E-02 0.34217
3.3660E-02 0.38774 3.4872E-02 0.43936
3.4850E-02 0.49786 3.5502E-02 0.56415
3.5145E-02 0.63927 3.5064E-02 0.72438
3.3990E-02 0.82084 3.1826E-02 0.93013
3.0023E-02 1.054 2.7451E-02 1.1943
2.5196E-02 1.3533 2.2862E-02 1.5335
2.0E-02 1.7377                  $ modified, was p= 9.6E-03  E=  1.7377
1.8147E-02 1.8498 1.7170E-02 1.9691
1.5955E-02 2.0961 1.4685E-02 2.2313
1.3976E-02 2.3752 1.3360E-02 2.5284
1.3154E-02 2.6914 1.2994E-02 2.865
1.3420E-02 3.0498 1.0371E-02 3.2465
8.5640E-03 3.4559 7.2864E-03 3.6787
6.4825E-03 3.916 5.7965E-03 4.1686
5.3054E-03 4.4374 4.5713E-03 4.7236
4.3260E-03 5.0282 3.6910E-03 5.3525
3.3215E-03 5.6978 2.7708E-03 6.0652
2.5777E-03 6.4564 2.6035E-03 6.8728
2.1745E-03 7.3161 1.9697E-03 7.7879
1.8256E-03 8.2902 2.0836E-03 8.8249
2.1067E-03 9.394
2.1E-03 9.9999                  $ modified, was p=5.11E-04  E=  9.9999
2.0071E-03 10.157 2.0076E-03 10.317
1.9948E-03 10.48 2.3648E-03 10.645
2.6038E-03 10.812 2.5727E-03 10.983
2.8794E-03 11.156 3.3077E-03 11.331
3.2699E-03 11.51 3.9627E-03 11.691
6.1168E-03 11.875 6.1150E-03 12.062
6.3421E-03 12.252 1.2160E-02 12.445
1.2157E-02 12.641 1.2154E-02 12.84
2.5910E-02 13.042 2.8279E-02 13.248
2.8545E-02 13.456 1.1398E-01 13.668
1.6320E-01 13.883 1.6242E-01 14.102
4.4862E-01 14.324 8.0814E-01 14.55
8.1148E-01 14.779 7.0288E-01 15.012
3.7148E-01 15.248 3.7138E-01 15.488
3.5695E-01 15.732 4.0391E-03 15.98
4.0705E-03 16.231 0.0000E+00 16.487

DETECTOR
 $ Test: point detector aligned with beam axis theta=0.0 degree
 $ (others --//fluxes at 5 pt dts(th=0.0, 12.2, 24.9, 41.8, 66.8 deg)
 $ f5:n      0.0         0     703.0000        1
 $         148.7973      0     688.2148        1
 $         298.0163      0     642.0212        1
 $         477.4981      0     534.0526        1
 $         676.2307      0     289.8328        1

 number = pt1
 Point 0.0  0.0  703.
    Bin Energy = neutron
     4.0867-02  4.6308-02
     5.2474-02  5.9461-02  6.7378-02  7.6349-02  8.6515-02
     9.8035-02  1.1109-01  1.2588-01  1.4264-01  1.6163-01
     1.8315-01  2.0754-01  2.3517-01  2.6649-01  3.0197-01
```

3.4217-01 3.8774-01 4.3936-01 4.9786-01 5.6415-01
6.3927-01 7.2438-01 8.2084-01 9.3013-01 1.0540+00
1.1943+00 1.3533+00 1.5335+00 1.7377+00 1.8498+00
1.9691+00 2.0961+00 2.2313+00 2.3752+00 2.5284+00
2.6914+00 2.8650+00 3.0498+00 3.2465+00 3.4559+00
3.6787+00 3.9160+00 4.1686+00 4.4374+00 4.7236+00
5.0282+00 5.3525+00 5.6978+00 6.0652+00 6.4564+00
6.8728+00 7.3161+00 7.7879+00 8.2902+00 8.8249+00
9.3940+00 9.9999+00 1.0157+01 1.0317+01 1.0480+01
1.0645+01 1.0812+01 1.0983+01 1.1156+01 1.1331+01
1.1510+01 1.1691+01 1.1875+01 1.2062+01 1.2252+01
1.2445+01 1.2641+01 1.2840+01 1.3042+01 1.3248+01
1.3456+01 1.3668+01 1.3883+01 1.4102+01 1.4324+01
1.4550+01 1.4779+01 1.5012+01 1.5248+01 1.5488+01
1.5732+01 1.5980+01 1.6231+01 1.6487+01

number = pt2
Point 148.7973 0.0 688.2148
Bin Energy = neutron
4.0867-02 4.6308-02
5.2474-02 5.9461-02 6.7378-02 7.6349-02 8.6515-02
9.8035-02 1.1109-01 1.2588-01 1.4264-01 1.6163-01
1.8315-01 2.0754-01 2.3517-01 2.6649-01 3.0197-01
3.4217-01 3.8774-01 4.3936-01 4.9786-01 5.6415-01
6.3927-01 7.2438-01 8.2084-01 9.3013-01 1.0540+00
1.1943+00 1.3533+00 1.5335+00 1.7377+00 1.8498+00
1.9691+00 2.0961+00 2.2313+00 2.3752+00 2.5284+00
2.6914+00 2.8650+00 3.0498+00 3.2465+00 3.4559+00
3.6787+00 3.9160+00 4.1686+00 4.4374+00 4.7236+00
5.0282+00 5.3525+00 5.6978+00 6.0652+00 6.4564+00
6.8728+00 7.3161+00 7.7879+00 8.2902+00 8.8249+00
9.3940+00 9.9999+00 1.0157+01 1.0317+01 1.0480+01
1.0645+01 1.0812+01 1.0983+01 1.1156+01 1.1331+01
1.1510+01 1.1691+01 1.1875+01 1.2062+01 1.2252+01
1.2445+01 1.2641+01 1.2840+01 1.3042+01 1.3248+01
1.3456+01 1.3668+01 1.3883+01 1.4102+01 1.4324+01
1.4550+01 1.4779+01 1.5012+01 1.5248+01 1.5488+01
1.5732+01 1.5980+01 1.6231+01 1.6487+01

number = pt3
Point 298.0163 0.0 642.0212
Bin Energy = neutron
4.0867-02 4.6308-02
5.2474-02 5.9461-02 6.7378-02 7.6349-02 8.6515-02
9.8035-02 1.1109-01 1.2588-01 1.4264-01 1.6163-01
1.8315-01 2.0754-01 2.3517-01 2.6649-01 3.0197-01
3.4217-01 3.8774-01 4.3936-01 4.9786-01 5.6415-01
6.3927-01 7.2438-01 8.2084-01 9.3013-01 1.0540+00
1.1943+00 1.3533+00 1.5335+00 1.7377+00 1.8498+00
1.9691+00 2.0961+00 2.2313+00 2.3752+00 2.5284+00
2.6914+00 2.8650+00 3.0498+00 3.2465+00 3.4559+00
3.6787+00 3.9160+00 4.1686+00 4.4374+00 4.7236+00
5.0282+00 5.3525+00 5.6978+00 6.0652+00 6.4564+00
6.8728+00 7.3161+00 7.7879+00 8.2902+00 8.8249+00
9.3940+00 9.9999+00 1.0157+01 1.0317+01 1.0480+01
1.0645+01 1.0812+01 1.0983+01 1.1156+01 1.1331+01
1.1510+01 1.1691+01 1.1875+01 1.2062+01 1.2252+01
1.2445+01 1.2641+01 1.2840+01 1.3042+01 1.3248+01
1.3456+01 1.3668+01 1.3883+01 1.4102+01 1.4324+01
1.4550+01 1.4779+01 1.5012+01 1.5248+01 1.5488+01
1.5732+01 1.5980+01 1.6231+01 1.6487+01

number = pt4
Point 477.4981 0.0 534.0526
Bin Energy = neutron
4.0867-02 4.6308-02
5.2474-02 5.9461-02 6.7378-02 7.6349-02 8.6515-02
9.8035-02 1.1109-01 1.2588-01 1.4264-01 1.6163-01
1.8315-01 2.0754-01 2.3517-01 2.6649-01 3.0197-01
3.4217-01 3.8774-01 4.3936-01 4.9786-01 5.6415-01

```
    6.3927-01  7.2438-01  8.2084-01  9.3013-01  1.0540+00
    1.1943+00  1.3533+00  1.5335+00  1.7377+00  1.8498+00
    1.9691+00  2.0961+00  2.2313+00  2.3752+00  2.5284+00
    2.6914+00  2.8650+00  3.0498+00  3.2465+00  3.4559+00
    3.6787+00  3.9160+00  4.1686+00  4.4374+00  4.7236+00
    5.0282+00  5.3525+00  5.6978+00  6.0652+00  6.4564+00
    6.8728+00  7.3161+00  7.7879+00  8.2902+00  8.8249+00
    9.3940+00  9.9999+00  1.0157+01  1.0317+01  1.0480+01
    1.0645+01  1.0812+01  1.0983+01  1.1156+01  1.1331+01
    1.1510+01  1.1691+01  1.1875+01  1.2062+01  1.2252+01
    1.2445+01  1.2641+01  1.2840+01  1.3042+01  1.3248+01
    1.3456+01  1.3668+01  1.3883+01  1.4102+01  1.4324+01
    1.4550+01  1.4779+01  1.5012+01  1.5248+01  1.5488+01
    1.5732+01  1.5980+01  1.6231+01  1.6487+01

 number = pt5
 Point 676.2307 0.0 289.8328
   Bin Energy = neutron
    4.0867-02  4.6308-02
    5.2474-02  5.9461-02  6.7378-02  7.6349-02  8.6515-02
    9.8035-02  1.1109-01  1.2588-01  1.4264-01  1.6163-01
    1.8315-01  2.0754-01  2.3517-01  2.6649-01  3.0197-01
    3.4217-01  3.8774-01  4.3936-01  4.9786-01  5.6415-01
    6.3927-01  7.2438-01  8.2084-01  9.3013-01  1.0540+00
    1.1943+00  1.3533+00  1.5335+00  1.7377+00  1.8498+00
    1.9691+00  2.0961+00  2.2313+00  2.3752+00  2.5284+00
    2.6914+00  2.8650+00  3.0498+00  3.2465+00  3.4559+00
    3.6787+00  3.9160+00  4.1686+00  4.4374+00  4.7236+00
    5.0282+00  5.3525+00  5.6978+00  6.0652+00  6.4564+00
    6.8728+00  7.3161+00  7.7879+00  8.2902+00  8.8249+00
    9.3940+00  9.9999+00  1.0157+01  1.0317+01  1.0480+01
    1.0645+01  1.0812+01  1.0983+01  1.1156+01  1.1331+01
    1.1510+01  1.1691+01  1.1875+01  1.2062+01  1.2252+01
    1.2445+01  1.2641+01  1.2840+01  1.3042+01  1.3248+01
    1.3456+01  1.3668+01  1.3883+01  1.4102+01  1.4324+01
    1.4550+01  1.4779+01  1.5012+01  1.5248+01  1.5488+01
    1.5732+01  1.5980+01  1.6231+01  1.6487+01

END
```

```
fns-tof/ lo2 slab-tof                JENDL-3.2            '94-08-18
C MCNP input
c    ********************************************************
c    *                  cell card                           *
c    ********************************************************
c    ***************** external void *********************
 1    0     -13 : +13 -2 +14 : +34 : +2 -34 +29 +30 +31 +32 +33
 2    0          -21 -2 -19
c    ************** source vacuum region ******************
 3    1 4.9210-5     -14 +13  -1 : -27  +1 -20
c    ***************** material region ********************
c     ----sus316
 4    2 8.5979-2  +1  -3 -14 +20 :  +4  -2 -14 +19 :  +3  -4 -14 +15
 5    2 8.5979-2 +27 -28 -20     : +21 -22 -19
 6    2 8.5979-2  +9 -11 -17 +20 : +12 -10 -17 +20 : +11 -12 -17 +18
 7    2 8.5979-2 +25 -26 -20     : +23 -24 -20
c     ---- vacuum
 8    0          +3  -5 -15 +20 :  +6  -4 -15 +19 :  +5  -6 -15 +16
 9    0         +28  -5 -20     : +22  +6 -19
10    0           +7  -9 -17 +20 : +10  -8 -17 +20
11    0          +26  +7 -20     : +24  -8 -20
c     ---- al [changed density from +3.6244E-3*e24 atoms/cc to -2.7g/cc]
12    3 -2.7   +5  -7 -16     :  +8  -6 -16     :  +7  -8 -16 +17
c     ---- o
13    4 4.2947-2 +11 -12 -18     : -25 -11 -20     : -23 +12 -20
c    ******* detector vacuum region *******
14    0  +2 -34 -29 : +2 -34 -30 : +2 -34 -31 : +2 -34 -32 : +2 -34 -33
c    ------- the following is a blank delimeter

c    ***************************************
c    * surface card                        *
c    ***************************************
 1           pz          -28.0
 2           pz            0.0
 3           pz          -27.5
 4           pz           -0.5
 5           pz          -25.90
 6           pz           -2.10
 7           pz          -25.20
 8           pz           -2.80
 9           pz          -24.80
10           pz           -3.20
11           pz          -24.0
12           pz           -4.0
13           pz          -70.0
c    --------------------------------
14           cz           35.0
15           cz           34.7
16           cz           30.8
17           cz           30.0
18           cz           29.8
19           cz           23.25
20           cz           15.0
c    -----     test      ----------
21           sz           134.146   136.146
22           sz           134.096   136.146
23           sz          -105.7227  102.8227
24           sz          -105.6727  102.8227
25           sz            77.7227  102.8227
26           sz            77.6727  102.8227
27           sz          -129.7227  102.8227
28           sz          -129.6727  102.8227
c    21           pz           -0.05
c    22           pz           -0.10
c    23           sz        -105.7227  102.8227
c    24           sz        -105.6727  102.8227
c    25           pz          -24.05
c    26           pz          -24.10
c    27           sz        -129.7227  102.8227
c    28           sz        -129.6727  102.8227
```

```
c     -------------------------------
29            cz           4.977
30          1 cz           4.985
31          2 cz           5.012
32          3 cz           5.074
33          4 cz           5.212
34            so         1000.0
c     ------- the following is a blank delimeter

c    ***************************************
c    *  mode card       - neutron only    *
c    ***************************************
mode   n
c    ***************************************
c    *  transformation cards              *
c    *  rotation about the y axis by theta*
c    ***************************************
*tr1   0  0  0       12.2  90  102.2   90   0  90
                   77.8  90   12.2   +1
*tr2   0  0  0       24.9  90  114.9   90   0  90
                   65.1  90   24.9   +1
*tr3   0  0  0       41.8  90  131.8   90   0  90
                   48.2  90   41.8   +1
*tr4   0  0  0       66.8  90  156.8   90   0  90
                   23.2  90   66.8   +1
c    ***************************************
c    *   cell parameter cards             *
c    ***************************************
imp:n   0     1     1     1     1     1     1
        1     1     1     1     1     1     1
c    ******************************************************
c    *  source specification cards                        *
c    *  src1=point isotropic option                       *
c    *  sdir dirc. biasing - height reduction considered*
c    *  si(eng.) and sp(prob.) taken from betof source charac
c    *  modified proba for Enery=1.7377, 9.9999MeV      *
c cc    ******************************************************
sdef  erg=d1  pos=0 0 -44.0  vec=0 0 1  dir=d2  wgt=1.0
sb2   -31   4.0
si1   4.0867-02  4.6308-02
      5.2474-02  5.9461-02  6.7378-02  7.6349-02  8.6515-02
      9.8035-02  1.1109-01  1.2588-01  1.4264-01  1.6163-01
      1.8315-01  2.0754-01  2.3517-01  2.6649-01  3.0197-01
      3.4217-01  3.8774-01  4.3936-01  4.9786-01  5.6415-01
      6.3927-01  7.2438-01  8.2084-01  9.3013-01  1.0540+00
      1.1943+00  1.3533+00  1.5335+00  1.7377+00  1.8498+00
      1.9691+00  2.0961+00  2.2313+00  2.3752+00  2.5284+00
      2.6914+00  2.8650+00  3.0498+00  3.2465+00  3.4559+00
      3.6787+00  3.9160+00  4.1686+00  4.4374+00  4.7236+00
      5.0282+00  5.3525+00  5.6978+00  6.0652+00  6.4564+00
      6.8728+00  7.3161+00  7.7879+00  8.2902+00  8.8249+00
      9.3940+00  9.9999+00  1.0157+01  1.0317+01  1.0480+01
      1.0645+01  1.0812+01  1.0983+01  1.1156+01  1.1331+01
      1.1510+01  1.1691+01  1.1875+01  1.2062+01  1.2252+01
      1.2445+01  1.2641+01  1.2840+01  1.3042+01  1.3248+01
      1.3456+01  1.3668+01  1.3883+01  1.4102+01  1.4324+01
      1.4550+01  1.4779+01  1.5012+01  1.5248+01  1.5488+01
      1.5732+01  1.5980+01  1.6231+01  1.6487+01
sp1   0         1.4214-04
      2.1261-04  2.3162-04  2.1327-04  2.7087-04  2.6032-04
      3.1949-04  3.7848-04  4.3099-04  4.4082-04  5.6289-04
      6.0267-04  7.5334-04  8.3566-04  1.0281-03  1.1620-03
      1.3881-03  1.5339-03  1.8001-03  2.0387-03  2.3534-03
      2.6401-03  2.9843-03  3.2787-03  3.4783-03  3.7189-03
      3.8514-03  4.0062-03  4.1197-03 4.084-03 2.0343-03
      2.0484-03  2.0263-03  1.9854-03  2.0112-03  2.0467-03
      2.1441-03  2.2558-03  2.4800-03  2.0399-03  1.7933-03
      1.6234-03  1.5383-03  1.4642-03  1.4261-03  1.3083-03
      1.3177-03  1.1970-03  1.1469-03  1.0180-03  1.0084-03
      1.0841-03  9.6395-04  9.2930-04  9.1702-04  1.1141-03
```

```
      1.1989-03 1.2724-03 3.1532-04  3.2121-04  3.2516-04
      3.9020-04  4.3484-04  4.3993-04  4.9814-04  5.7884-04
      5.8531-04  7.1724-04  1.1255-03  1.1435-03  1.2050-03
      2.3468-03  2.3827-03  2.4186-03  5.2339-03  5.8254-03
      5.9374-03  2.4164-02  3.5089-02  3.5570-02  9.9593-02
      1.8264-01  1.8583-01  1.6377-01  8.7669-02  8.9130-02
      8.7095-02  1.0017-03  1.0217-03  0
c     ************************************************
c     *  material specification cards              *
c     ************************************************
c     ----- iron (fe) ------------------------------
c     --- air
m1    7014.60c 3.8810-5        8016.60c  1.0400-5
c     --- sus316: Cr=1.6787-2, Mn55=1.3420-3, Fe-6.0507-2, Ni=7.3429-3
m2   24050.60c 7.2940-4  24052.60c 1.4066-2  24053.60c 1.5948-3
     24054.60c 3.9701-4
     25055.60c 1.3420-3
     26054.60c 3.5699-3  26056.60c 5.5497-2  26057.60c 1.2706-3
     26058.60c 1.6942-4
     28058.60c 5.0130-3  28060.60c 1.9165-3  28061.60c 8.2975-5
     28062.60c 2.6361-4  28064.60c 6.6820-5
c     --- al
c m3   13027.60c 3.6244-3 wrong density!
 m3   13027.60c 1.0
c     --- o
m4    8016.60c 4.2947-2
c     drxs
c    ************************************************
c    *  tally specification cards                 *
c    ************************************************
fc5  --//fluxes at 5 pt dts(th=0.0, 12.2, 24.9, 41.8, 66.8 deg)
f5:n        0.0         0     703.0000         1
          148.7973      0     688.2148         1
          298.0163      0     642.0212         1
          477.4981      0     534.0526         1
          676.2307      0     289.8328         1
dd    0.5   100
e0    4.0867-02  4.6308-02
      5.2474-02  5.9461-02  6.7378-02  7.6349-02  8.6515-02
      9.8035-02  1.1109-01  1.2588-01  1.4264-01  1.6163-01
      1.8315-01  2.0754-01  2.3517-01  2.6649-01  3.0197-01
      3.4217-01  3.8774-01  4.3936-01  4.9786-01  5.6415-01
      6.3927-01  7.2438-01  8.2084-01  9.3013-01  1.0540+00
      1.1943+00  1.3533+00  1.5335+00  1.7377+00  1.8498+00
      1.9691+00  2.0961+00  2.2313+00  2.3752+00  2.5284+00
      2.6914+00  2.8650+00  3.0498+00  3.2465+00  3.4559+00
      3.6787+00  3.9160+00  4.1686+00  4.4374+00  4.7236+00
      5.0282+00  5.3525+00  5.6978+00  6.0652+00  6.4564+00
      6.8728+00  7.3161+00  7.7879+00  8.2902+00  8.8249+00
      9.3940+00  9.9999+00  1.0157+01  1.0317+01  1.0480+01
      1.0645+01  1.0812+01  1.0983+01  1.1156+01  1.1331+01
      1.1510+01  1.1691+01  1.1875+01  1.2062+01  1.2252+01
      1.2445+01  1.2641+01  1.2840+01  1.3042+01  1.3248+01
      1.3456+01  1.3668+01  1.3883+01  1.4102+01  1.4324+01
      1.4550+01  1.4779+01  1.5012+01  1.5248+01  1.5488+01
      1.5732+01  1.5980+01  1.6231+01  1.6487+01
fq0    e    f
c    ************************************************
c    * problem cutoff cards                        *
c    ************************************************
cut:n       0     4.0000-02   -10    -0.01
nps      2000000
c ctme      180
c    ************************************************
c    * peripheral cards                            *
c    ************************************************
prdmp      1000000    1000000
lost     10        10
print
```

4. Others

```
LEAKAGE FROM ALUMINIUM (40 CM DIA) SPHERE 3-D SURFACE TALLY (ENDF/B-VI)
$ COG input / Pure Aluminium sphere
BASIC
   neutron
   photon

   cm
   MeV
   sec

SURFACES
 1 SPHERE 10.0
 2 SPHERE 10.2
 3 SPHERE 19.75
 4 SPHERE 19.95
 5 SPHERE 580.0
 6 SPHERE 581.0

GEOMETRY
sector 1 sec1 -1
sector 2 sec2 -4 +1
sector 3 sec3 -5 +4
sector 4 sec4 -6 +5

Boundary vacuum +6

MIX
NLIB = ENDFB6R7
$ Pure Aluminium
  mat 1 w-p 1.223 13027 1.0

ASSIGN-M
1 0   2 1   3 0   4 0

ASSIGN-MC
              1 yellow   $ Aluminium Sphere
              2 sky                $ air
              3 gray               $ steel
              0 orange  $ void

 WALK-ENERGY
   photon region 2 to 4 0.299

SOURCE
 npart = 5000000
 increment 1. p=1 e=1 a=1
 define position = 1  point  0. 0. 0.
 define angle= 1 isotropic
 define energy = 1 neutron
   bin        1.00e-01
0.0000e+00 1.12e-01 0.0000e+00 1.26e-01
8.4667e-03 1.41e-01 3.2078e-03 1.59e-01
1.3347e-02 1.78e-01 1.2373e-02 2.00e-01
8.6500e-03 2.24e-01 1.5593e-02 2.52e-01
1.2494e-02 2.83e-01 1.3988e-02 3.17e-01
1.5797e-02 3.56e-01 1.5289e-02 4.00e-01
1.3567e-02 4.49e-01 1.5602e-02 5.04e-01
1.7710e-02 5.66e-01 1.7159e-02 6.35e-01
1.8103e-02 7.13e-01 1.8575e-02 8.00e-01
1.9821e-02 8.78e-01 1.8093e-02 9.64e-01
1.7351e-02 1.06e+00 1.7029e-02 1.16e+00
1.5965e-02 1.28e+00 1.4584e-02 1.40e+00
1.3317e-02 1.54e+00 1.2404e-02 1.70e+00
1.1572e-02 1.87e+00 1.0800e-02 2.06e+00
9.5885e-03 2.27e+00 8.9913e-03 2.50e+00
1.0250e-02 2.70e+00 1.5245e-02 2.92e+00
6.2689e-03 3.16e+00 5.1440e-03 3.42e+00
5.1821e-03  3.70e+00 4.6545e-03 4.00e+00
4.3103e-03 4.17e+00 3.7343e-03 4.34e+00
```

3.6391e-03 4.52e+00 3.3128e-03 4.70e+00
3.3134e-03 4.90e+00 3.0738e-03 5.10e+00
2.7431e-03 5.31e+00 2.3868e-03 5.53e+00
2.3026e-03 5.76e+00 2.2924e-03 6.00e+00
2.0672e-03 6.24e+00 2.2438e-03 6.50e+00
2.0343e-03 6.77e+00 1.8109e-03 7.04e+00
1.6829e-03 7.33e+00 1.7667e-03 7.63e+00
1.8508e-03 7.94e+00 1.6192e-03 8.26e+00
1.6006e-03 8.60e+00 1.7823e-03 8.95e+00
1.9307e-03 9.31e+00 2.0393e-03 9.69e+00
2.0028e-03 1.01e+01 2.1120e-03 1.05e+01
2.5331e-03 1.08e+01 2.7884e-03 1.11e+01
3.0059e-03 1.15e+01 3.6600e-03 1.18e+01
4.8200e-03 1.22e+01 6.1784e-03 1.26e+01
8.2955e-03 1.28e+01 1.0778e-02 1.30e+01
1.5808e-02 1.32e+01 2.9208e-02 1.35e+01
6.5208e-02 1.37e+01 1.4536e-01 1.40e+01
2.9968e-01 1.42e+01 5.1160e-01 1.45e+01
6.5481e-01 1.47e+01 7.3692e-01 1.50e+01
5.5556e-01 1.53e+01 3.2133e-01 1.55e+01
1.3621e-01 1.58e+01 5.1071e-02 1.61e+01
1.4721e-02 1.64e+01

Detector
  number = bcd1
  boundary counts 3 4 4227327.1
    Bin Energy = neutron
    1.290e-3 1.670e-3 2.150e-3
    2.780e-3 3.590e-3 4.640e-3 5.990e-3 7.740e-3
    1.000e-2 1.290e-2 1.670e-2 2.150e-2 2.780e-2
    3.590e-2 4.640e-2 5.990e-2 7.740e-2
    1.000e-1 1.060e-1 1.120e-1 1.190e-1
    1.260e-1 1.340e-1 1.410e-1 1.500e-1 1.590e-1
    1.680e-1 1.780e-1 1.890e-1 2.000e-1 2.120e-1
    2.240e-1 2.520e-1 2.830e-1 3.170e-1 3.560e-1
    4.000e-1 4.490e-1 5.040e-1 5.660e-1 6.350e-1
    7.130e-1 8.000e-1 8.780e-1 9.640e-1 1.058e+0
    1.162e+0 1.275e+0 1.400e+0 1.542e+0 1.698e+0
    1.871e+0 2.061e+0 2.270e+0 2.500e+0 2.704e+0
    2.924e+0 3.162e+0 3.419e+0 3.699e+0 4.000e+0
    4.165e+0 4.337e+0 4.516e+0 4.703e+0 4.897e+0
    5.099e+0 5.310e+0 5.529e+0 5.757e+0 5.995e+0
    6.242e+0 6.500e+0 6.765e+0 7.041e+0 7.327e+0
    7.627e+0 7.938e+0 8.261e+0 8.598e+0 8.949e+0
    9.314e+0 9.693e+0 1.009e+1 1.050e+1 1.082e+1
    1.114e+1 1.148e+1 1.183e+1 1.218e+1 1.255e+1
    1.277e+1 1.300e+1 1.324e+1 1.348e+1 1.372e+1
    1.397e+1 1.422e+1 1.447e+1 1.474e+1 1.500e+1
    1.527e+1 1.554e+1 1.583e+1 1.611e+1 1.640e+1

  number = bcd2
  boundary 3 4 4227327.1
    Bin Energy = photon
    3.0E-01 4.0E-01 5.0E-01 6.0E-01
    7.0E-01 8.0E-01 9.0E-01 1.0E+00
    1.10E+00 1.20E+00 1.30E+00 1.40E+00
    1.50E+00 1.60E+00 1.70E+00 1.80E+00
    1.90E+00 2.00E+00 2.10E+00 2.20E+00
    2.30E+00 2.40E+00 2.50E+00 2.60E+00
    2.70E+00 2.80E+00 2.90E+00 3.10E+00
    3.20E+00 3.30E+00 3.40E+00 3.50E+00
    3.60E+00 3.70E+00 3.80E+00 3.90E+00
    4.00E+00 4.10E+00 4.20E+00 4.30E+00
    4.40E+00 4.50E+00 4.60E+00 4.70E+00
    4.80E+00 4.90E+00 5.00E+00 5.10E+00
    5.20E+00 5.30E+00 5.40E+00 5.50E+00
    5.60E+00 5.70E+00 5.80E+00 5.90E+00
    6.00E+00 6.20E+00 6.40E+00 6.60E+00
    6.80E+00 7.00E+00 7.20E+00 7.40E+00
    7.60E+00 7.80E+00 8.00E+00 8.20E+00

8.40E+00 8.60E+00 8.80E+00 9.00E+00
9.20E+00 9.40E+00 9.60E+00 9.80E+00
1.00E+01 1.04E+01 1.08E+01 1.12E+01
1.16E+01 1.20E+01 1.24E+01 1.28E+01
1.32E+01 1.36E+01 1.40E+01 1.44E+01
1.48E+01 1.52E+01 1.56E+01 1.60E+01
1.64E+01 1.68E+01 1.72E+01 1.76E+01
1.80E+01 1.84E+01 1.88E+01 1.92E+01
1.96E+01 2.00E+01

END

```
LEAKAGE FROM ALUMINIUM (40 CM DIA) SPHERE 3-D SURFACE TALLY (ENDF/B-VI)
C MCNP input/ Pure aluminium sphere
c    *** Cell cards ***
 1    0          -1
 2    1  -1.223   -2 1
 3    0          -3 2
 4    0           3

c    *** Surface cards ***
 1    so  10.0
 2    so  19.95
 3    so 580.0

c    *** Material cards ***
c Aluminium
m1   13027.60c -1.
c    *** Data cards ***
mode n p
imp:n 1 1 1 0
imp:p 1 1 1 0
sdef pos=0. 0. 0. erg=d1
c    *** Energy bin for source neutron ***
si1  h 1.000e-1 1.120e-1 1.260e-1 1.410e-1 1.590e-1
       1.780e-1 2.000e-1 2.240e-1 2.520e-1 2.830e-1
       3.170e-1 3.560e-1 4.000e-1 4.490e-1 5.040e-1
       5.660e-1 6.350e-1 7.130e-1 8.000e-1 8.780e-1
       9.640e-1 1.058e+0 1.162e+0 1.275e+0 1.400e+0
       1.542e+0 1.698e+0 1.871e+0 2.061e+0 2.270e+0
       2.500e+0 2.704e+0 2.924e+0 3.162e+0 3.419e+0
       3.699e+0 4.000e+0 4.165e+0 4.337e+0 4.516e+0
       4.703e+0 4.897e+0 5.099e+0 5.310e+0 5.529e+0
       5.757e+0 5.995e+0 6.242e+0 6.500e+0 6.765e+0
       7.041e+0 7.327e+0 7.627e+0 7.938e+0 8.261e+0
       8.598e+0 8.949e+0 9.314e+0 9.693e+0 1.009e+1
       1.050e+1 1.082e+1 1.114e+1 1.148e+1 1.183e+1
       1.218e+1 1.255e+1 1.277e+1 1.300e+1 1.324e+1
       1.348e+1 1.372e+1 1.397e+1 1.422e+1 1.447e+1
       1.474e+1 1.500e+1 1.527e+1 1.554e+1 1.583e+1
       1.611e+1 1.640e+1
c    *** Source distribution ***
sp1    0.000e-4 0.000e-0 0.000e-0 1.270e-4 5.774e-5
       2.536e-4 2.722e-4 2.076e-4 4.366e-4 3.873e-4
       4.756e-4 6.161e-4 6.727e-4 6.648e-4 8.581e-4
       1.098e-3 1.184e-3 1.412e-3 1.616e-3 1.546e-3
       1.556e-3 1.631e-3 1.771e-3 1.804e-3 1.823e-3
       1.891e-3 1.935e-3 2.002e-3 2.052e-3 2.004e-3
       2.068e-3 2.091e-3 3.354e-3 1.492e-3 1.322e-3
       1.451e-3 1.401e-3 7.112e-4 6.423e-4 6.514e-4
       6.195e-4 6.428e-4 6.209e-4 5.788e-4 5.227e-4
       5.250e-4 5.456e-4 5.106e-4 5.789e-4 5.391e-4
       4.998e-4 4.813e-4 5.300e-4 5.756e-4 5.230e-4
       5.394e-4 6.256e-4 7.047e-4 7.729e-4 7.951e-4
       8.659e-4 8.106e-4 8.923e-4 1.022e-3 1.281e-3
       1.687e-3 2.286e-3 1.825e-3 2.479e-3 3.794e-3
       7.010e-3 1.565e-2 3.634e-2 7.492e-2 1.279e-1
       1.768e-1 1.916e-1 1.500e-1 8.676e-2 3.950e-2
       1.430e-2 4.269e-3
c    *** Tally cards ***
fc21 Neutron current through the outer surface
f21:n 3
c    *** Energy bin ***
e21          1.290e-3 1.670e-3 2.150e-3
     2.780e-3 3.590e-3 4.640e-3 5.990e-3 7.740e-3
     1.000e-2 1.290e-2 1.670e-2 2.150e-2 2.780e-2
     3.590e-2 4.640e-2 5.990e-2 7.740e-2
     1.000e-1 1.060e-1 1.120e-1 1.190e-1
     1.260e-1 1.340e-1 1.410e-1 1.500e-1 1.590e-1
     1.680e-1 1.780e-1 1.890e-1 2.000e-1 2.120e-1
     2.240e-1 2.520e-1 2.830e-1 3.170e-1 3.560e-1
     4.000e-1 4.490e-1 5.040e-1 5.660e-1 6.350e-1
```

```
     7.130e-1 8.000e-1 8.780e-1 9.640e-1 1.058e+0
     1.162e+0 1.275e+0 1.400e+0 1.542e+0 1.698e+0
     1.871e+0 2.061e+0 2.270e+0 2.500e+0 2.704e+0
     2.924e+0 3.162e+0 3.419e+0 3.699e+0 4.000e+0
     4.165e+0 4.337e+0 4.516e+0 4.703e+0 4.897e+0
     5.099e+0 5.310e+0 5.529e+0 5.757e+0 5.995e+0
     6.242e+0 6.500e+0 6.765e+0 7.041e+0 7.327e+0
     7.627e+0 7.938e+0 8.261e+0 8.598e+0 8.949e+0
     9.314e+0 9.693e+0 1.009e+1 1.050e+1 1.082e+1
     1.114e+1 1.148e+1 1.183e+1 1.218e+1 1.255e+1
     1.277e+1 1.300e+1 1.324e+1 1.348e+1 1.372e+1
     1.397e+1 1.422e+1 1.447e+1 1.474e+1 1.500e+1
     1.527e+1 1.554e+1 1.583e+1 1.611e+1 1.640e+1
fc32 Photon flux  through the outer surface
f32:p 3
c    *** Energy bin ***
e32  0.3  56i  6.0  19i  10.0  24i  20
c
c phys:n 20.0  0
c phys:p 20.0  0  0
c    *** Cut off card ***
c cut:n 1.0e6  0.0    -0.5  -0.25  0
c cut:p 1.0e6  0.299  -0.5  -0.25  0
c    *** Neutron history ***
nps  5000000
c nps 10000
print
```

```
LEAKAGE FROM IRON (40 CM DIA) SPHERE 3-D SURFACE TALLY (ENDF/B-VI)
$ COG Input Pure Iron sphere

BASIC
   neutron
   photon
   cm
   MeV
   sec

SURFACES
 1 SPHERE 10.0
 2 SPHERE 10.2
 3 SPHERE 19.75
 4 SPHERE 19.95
 5 SPHERE 580.0
 6 SPHERE 581.0

GEOMETRY
sector 1 sec1 -1
sector 2 sec2 -4 +1
sector 3 sec3 -5 +4
sector 4 sec4 -6 +5

Boundary vacuum +6

MIX
NLIB = ENDFB6R7
$ Pure Fe-56
  mat 1 w-p 7.8  26056 1.0

ASSIGN-M
1 0   2 1   3 0   4 0

ASSIGN-MC
              1 yellow   $ Aluminium Sphere
              2 sky                $ air
              3 gray               $ steel
              0 orange  $ void

 WALK-ENERGY
   photon region 2 to 4 0.299

SOURCE
 npart = 5000000
 increment 1. p=1 e=1 a=1
 define position = 1  point  0. 0. 0.
 define angle= 1 isotropic
 define energy = 1 neutron
   bin
              1.00E-01
0.0000E+00 1.12E-01 0.0000E+00 1.26E-01
8.4667E-03 1.41E-01 3.2078E-03 1.59E-01
1.3347E-02 1.78E-01 1.2373E-02 2.00E-01
8.6500E-03 2.24E-01 1.5593E-02 2.52E-01
1.2494E-02 2.83E-01 1.3988E-02 3.17E-01
1.5797E-02 3.56E-01 1.5289E-02 4.00E-01
1.3567E-02 4.49E-01 1.5602E-02 5.04E-01
1.7710E-02 5.66E-01 1.7159E-02 6.35E-01
1.8103E-02 7.13E-01 1.8575E-02 8.00E-01
1.9821E-02 8.78E-01 1.8093E-02 9.64E-01
1.7351E-02 1.06E+00 1.7029E-02 1.16E+00
1.5965E-02 1.28E+00 1.4584E-02 1.40E+00
1.3317E-02 1.54E+00 1.2404E-02 1.70E+00
1.1572E-02 1.87E+00 1.0800E-02 2.06E+00
9.5885E-03 2.27E+00 8.9913E-03 2.50E+00
1.0250E-02 2.70E+00 1.5245E-02 2.92E+00
6.2689E-03 3.16E+00 5.1440E-03 3.42E+00
5.1821E-03  3.70E+00 4.6545E-03 4.00E+00
4.3103E-03 4.17E+00 3.7343E-03 4.34E+00
```

3.6391E-03 4.52E+00 3.3128E-03 4.70E+00
3.3134E-03 4.90E+00 3.0738E-03 5.10E+00
2.7431E-03 5.31E+00 2.3868E-03 5.53E+00
2.3026E-03 5.76E+00 2.2924E-03 6.00E+00
2.0672E-03 6.24E+00 2.2438E-03 6.50E+00
2.0343E-03 6.77E+00 1.8109E-03 7.04E+00
1.6829E-03 7.33E+00 1.7667E-03 7.63E+00
1.8508E-03 7.94E+00 1.6192E-03 8.26E+00
1.6006E-03 8.60E+00 1.7823E-03 8.95E+00
1.9307E-03 9.31E+00 2.0393E-03 9.69E+00
2.0028E-03 1.01E+01 2.1120E-03 1.05E+01
2.5331E-03 1.08E+01 2.7884E-03 1.11E+01
3.0059E-03 1.15E+01 3.6600E-03 1.18E+01
4.8200E-03 1.22E+01 6.1784E-03 1.26E+01
8.2955E-03 1.28E+01 1.0778E-02 1.30E+01
1.5808E-02 1.32E+01 2.9208E-02 1.35E+01
6.5208E-02 1.37E+01 1.4536E-01 1.40E+01
2.9968E-01 1.42E+01 5.1160E-01 1.45E+01
6.5481E-01 1.47E+01 7.3692E-01 1.50E+01
5.5556E-01 1.53E+01 3.2133E-01 1.55E+01
1.3621E-01 1.58E+01 5.1071E-02 1.61E+01
1.4721E-02 1.64E+01

Detector
  number = bcd1
  boundary counts 3 4 4227327.1
    Bin Energy = neutron
    1.290e-3 1.670e-3 2.150e-3
    2.780e-3 3.590e-3 4.640e-3 5.990e-3 7.740e-3
    1.000e-2 1.290e-2 1.670e-2 2.150e-2 2.780e-2
    3.590e-2 4.640e-2 5.990e-2 7.740e-2
    1.000e-1 1.060e-1 1.120e-1 1.190e-1
    1.260e-1 1.340e-1 1.410e-1 1.500e-1 1.590e-1
    1.680e-1 1.780e-1 1.890e-1 2.000e-1 2.120e-1
    2.240e-1 2.520e-1 2.830e-1 3.170e-1 3.560e-1
    4.000e-1 4.490e-1 5.040e-1 5.660e-1 6.350e-1
    7.130e-1 8.000e-1 8.780e-1 9.640e-1 1.058e+0
    1.162e+0 1.275e+0 1.400e+0 1.542e+0 1.698e+0
    1.871e+0 2.061e+0 2.270e+0 2.500e+0 2.704e+0
    2.924e+0 3.162e+0 3.419e+0 3.699e+0 4.000e+0
    4.165e+0 4.337e+0 4.516e+0 4.703e+0 4.897e+0
    5.099e+0 5.310e+0 5.529e+0 5.757e+0 5.995e+0
    6.242e+0 6.500e+0 6.765e+0 7.041e+0 7.327e+0
    7.627e+0 7.938e+0 8.261e+0 8.598e+0 8.949e+0
    9.314e+0 9.693e+0 1.009e+1 1.050e+1 1.082e+1
    1.114e+1 1.148e+1 1.183e+1 1.218e+1 1.255e+1
    1.277e+1 1.300e+1 1.324e+1 1.348e+1 1.372e+1
    1.397e+1 1.422e+1 1.447e+1 1.474e+1 1.500e+1
    1.527e+1 1.554e+1 1.583e+1 1.611e+1 1.640e+1

  number = bcd2
  boundary 3 4 4227327.1
    Bin Energy = photon
    3.0E-01 4.0E-01 5.0E-01 6.0E-01
    7.0E-01 8.0E-01 9.0E-01 1.0E+00
    1.10E+00 1.20E+00 1.30E+00 1.40E+00
    1.50E+00 1.60E+00 1.70E+00 1.80E+00
    1.90E+00 2.00E+00 2.10E+00 2.20E+00
    2.30E+00 2.40E+00 2.50E+00 2.60E+00
    2.70E+00 2.80E+00 2.90E+00 3.10E+00
    3.20E+00 3.30E+00 3.40E+00 3.50E+00
    3.60E+00 3.70E+00 3.80E+00 3.90E+00
    4.00E+00 4.10E+00 4.20E+00 4.30E+00
    4.40E+00 4.50E+00 4.60E+00 4.70E+00
    4.80E+00 4.90E+00 5.00E+00 5.10E+00
    5.20E+00 5.30E+00 5.40E+00 5.50E+00
    5.60E+00 5.70E+00 5.80E+00 5.90E+00
    6.00E+00 6.20E+00 6.40E+00 6.60E+00
    6.80E+00 7.00E+00 7.20E+00 7.40E+00
    7.60E+00 7.80E+00 8.00E+00 8.20E+00

8.40E+00 8.60E+00 8.80E+00 9.00E+00
9.20E+00 9.40E+00 9.60E+00 9.80E+00
1.00E+01 1.04E+01 1.08E+01 1.12E+01
1.16E+01 1.20E+01 1.24E+01 1.28E+01
1.32E+01 1.36E+01 1.40E+01 1.44E+01
1.48E+01 1.52E+01 1.56E+01 1.60E+01
1.64E+01 1.68E+01 1.72E+01 1.76E+01
1.80E+01 1.84E+01 1.88E+01 1.92E+01
1.96E+01 2.00E+01

END

```
LEAKAGE FROM IRON (40 CM DIA) SPHERE 3-D SURFACE TALLY (ENDF/B-VI)
C MCNP input Pure iron sphere
c    *** Cell cards ***
 1    0          -1
 2    1  -7.8    -2 1
 3    0          -3 2
 4    0           3

c    *** Surface cards ***
 1    so  10.0
 2    so  19.95
 3    so 580.0

c    *** Material cards ***
c Iron
m1   26056.60c -1.
c    *** Data cards ***
mode n p
imp:n 1 1 1 0
imp:p 1 1 1 0
sdef pos=0. 0. 0. cel=1 erg=d1
c    *** Energy bin for source neutron ***
si1  h 1.000e-1 1.120e-1 1.260e-1 1.410e-1 1.590e-1
       1.780e-1 2.000e-1 2.240e-1 2.520e-1 2.830e-1
       3.170e-1 3.560e-1 4.000e-1 4.490e-1 5.040e-1
       5.660e-1 6.350e-1 7.130e-1 8.000e-1 8.780e-1
       9.640e-1 1.058e+0 1.162e+0 1.275e+0 1.400e+0
       1.542e+0 1.698e+0 1.871e+0 2.061e+0 2.270e+0
       2.500e+0 2.704e+0 2.924e+0 3.162e+0 3.419e+0
       3.699e+0 4.000e+0 4.165e+0 4.337e+0 4.516e+0
       4.703e+0 4.897e+0 5.099e+0 5.310e+0 5.529e+0
       5.757e+0 5.995e+0 6.242e+0 6.500e+0 6.765e+0
       7.041e+0 7.327e+0 7.627e+0 7.938e+0 8.261e+0
       8.598e+0 8.949e+0 9.314e+0 9.693e+0 1.009e+1
       1.050e+1 1.082e+1 1.114e+1 1.148e+1 1.183e+1
       1.218e+1 1.255e+1 1.277e+1 1.300e+1 1.324e+1
       1.348e+1 1.372e+1 1.397e+1 1.422e+1 1.447e+1
       1.474e+1 1.500e+1 1.527e+1 1.554e+1 1.583e+1
       1.611e+1 1.640e+1
c    *** Source distribution ***
sp1    0.000e-4 0.000e-0 0.000e-0 1.270e-4 5.774e-5
       2.536e-4 2.722e-4 2.076e-4 4.366e-4 3.873e-4
       4.756e-4 6.161e-4 6.727e-4 6.648e-4 8.581e-4
       1.098e-3 1.184e-3 1.412e-3 1.616e-3 1.546e-3
       1.556e-3 1.631e-3 1.771e-3 1.804e-3 1.823e-3
       1.891e-3 1.935e-3 2.002e-3 2.052e-3 2.004e-3
       2.068e-3 2.091e-3 3.354e-3 1.492e-3 1.322e-3
       1.451e-3 1.401e-3 7.112e-4 6.423e-4 6.514e-4
       6.195e-4 6.428e-4 6.209e-4 5.788e-4 5.227e-4
       5.250e-4 5.456e-4 5.106e-4 5.789e-4 5.391e-4
       4.998e-4 4.813e-4 5.300e-4 5.756e-4 5.230e-4
       5.394e-4 6.256e-4 7.047e-4 7.729e-4 7.951e-4
       8.659e-4 8.106e-4 8.923e-4 1.022e-3 1.281e-3
       1.687e-3 2.286e-3 1.825e-3 2.479e-3 3.794e-3
       7.010e-3 1.565e-2 3.634e-2 7.492e-2 1.279e-1
       1.768e-1 1.916e-1 1.500e-1 8.676e-2 3.950e-2
       1.430e-2 4.269e-3
c    *** Tally cards ***
fc21 Neutron current through the outer surface
f21:n 3
c    *** Energy bin ***
e21          1.290e-3 1.670e-3 2.150e-3
     2.780e-3 3.590e-3 4.640e-3 5.990e-3 7.740e-3
     1.000e-2 1.290e-2 1.670e-2 2.150e-2 2.780e-2
     3.590e-2 4.640e-2 5.990e-2 7.740e-2
     1.000e-1 1.060e-1 1.120e-1 1.190e-1
     1.260e-1 1.340e-1 1.410e-1 1.500e-1 1.590e-1
     1.680e-1 1.780e-1 1.890e-1 2.000e-1 2.120e-1
     2.240e-1 2.520e-1 2.830e-1 3.170e-1 3.560e-1
     4.000e-1 4.490e-1 5.040e-1 5.660e-1 6.350e-1
```

```
     7.130e-1 8.000e-1 8.780e-1 9.640e-1 1.058e+0
     1.162e+0 1.275e+0 1.400e+0 1.542e+0 1.698e+0
     1.871e+0 2.061e+0 2.270e+0 2.500e+0 2.704e+0
     2.924e+0 3.162e+0 3.419e+0 3.699e+0 4.000e+0
     4.165e+0 4.337e+0 4.516e+0 4.703e+0 4.897e+0
     5.099e+0 5.310e+0 5.529e+0 5.757e+0 5.995e+0
     6.242e+0 6.500e+0 6.765e+0 7.041e+0 7.327e+0
     7.627e+0 7.938e+0 8.261e+0 8.598e+0 8.949e+0
     9.314e+0 9.693e+0 1.009e+1 1.050e+1 1.082e+1
     1.114e+1 1.148e+1 1.183e+1 1.218e+1 1.255e+1
     1.277e+1 1.300e+1 1.324e+1 1.348e+1 1.372e+1
     1.397e+1 1.422e+1 1.447e+1 1.474e+1 1.500e+1
     1.527e+1 1.554e+1 1.583e+1 1.611e+1 1.640e+1
fc32 Photon current through the outer surface
f32:p 3
c fm32 4227327.1              $ 4*Pi * R7
c fq32 e t
c    *** Energy bin ***
e32  0.3  56i  6.0  19i  10.0  24i  20
c t32  8.8  1e6  t
c
phys:n 20.0  0
phys:p 20.0  0  0
c    *** Cut off card ***
cut:n 1.0e6  0.0    -0.5  -0.25  0
cut:p 1.0e6  0.299  -0.5  -0.25  0
c    *** Neutron history ***
nps  5000000
c nps 10000
print
```

```
Pure Ni sphere R=16 cm, Spherical model, ENDF/B-VI, Source-2/Isotropic
$ COG input
$
BASIC
   neutron
   photon
SURFACES
  1 SPHERE 2.50
  2 SPHERE 10.00
  3 SPHERE 16.00
  $ add sphere 4
  4 SPHERE 17.00

GEOMETRY
sector 1 sec1 -1
sector 2 sec2 1 -2
sector 3 sec3 2 -3
sector 4 sec4 +3 -4
BOUNDARY VACUUM +4

MIX
$ Nickel with impurities (expressed as weight percent).
NLIB = ENDFB6R7
mat 1    28058 0.67144 28060 0.26554 28061 0.01169
         28062 0.03775 28064 0.00988
         14000 0.0016 25055 0.0015 26056 0.0004
         12000 0.0001 29063 7e-05 29065 3e-05
mat 2 # 1 8016 0.208
          7014 0.792

ASSIGN-MD  $ sector#  material#  density
  1 2 0.0012    2 1 8.85    3 1 8.85  4 0 0

SOURCE
  npart = 3000000
  INCREMENT 1. P=1 E=1
  DEFINE POSITION = 1
   POINT 0. 0. 0.
  DEFINE ENERGY = 1 NEUTRON
   BIN
 1.1200E-01 6.5541E-06         1.2600E-01
6.5541E-04          1.4100E-01 2.2939E-03          1.5900E-01
2.6216E-03          1.7800E-01 3.9928E-03          2.0000E-01
1.0296E-02          2.2400E-01 1.1968E-02          2.5200E-01
1.1850E-02          2.8300E-01 1.0906E-02          3.1700E-01
1.4629E-02          3.5600E-01 1.4091E-02          4.0000E-01
1.2735E-02          4.4900E-01 1.6339E-02          5.0400E-01
1.6221E-02          5.6600E-01 1.7565E-02          6.3500E-01
1.6536E-02          7.1300E-01 1.6936E-02          8.0000E-01
1.7598E-02          8.7800E-01 1.6490E-02          9.6400E-01
1.5481E-02          1.0580E+00 1.5717E-02          1.1620E+00
1.4557E-02          1.2750E+00 1.3338E-02          1.4000E+00
1.3095E-02          1.5420E+00 1.1253E-02          1.6980E+00
1.1312E-02          1.8710E+00 1.0349E-02          2.0610E+00
8.8415E-03          2.2700E+00 8.0550E-03          2.5000E+00
8.3761E-03          2.7040E+00 1.0585E-02          2.9240E+00
6.3286E-03          3.1620E+00 5.6850E-03          3.4190E+00
5.0775E-03          3.6990E+00 4.6849E-03          4.0000E+00
4.4279E-03          4.1650E+00 4.2779E-03          4.3370E+00
3.6906E-03          4.5160E+00 3.6801E-03          4.7030E+00
3.6637E-03          4.8970E+00 3.6336E-03          5.0990E+00
3.3079E-03          5.3100E+00 3.5877E-03          5.5290E+00
3.0103E-03          5.7570E+00 2.9408E-03          5.9950E+00
3.0824E-03          6.2420E+00 3.1080E-03          6.5000E+00
3.2377E-03          6.7650E+00 3.0522E-03          7.0410E+00
2.9520E-03          7.3270E+00 3.2109E-03          7.6270E+00
2.8320E-03          7.9380E+00 2.6518E-03          8.2610E+00
3.1650E-03          8.5980E+00 3.1211E-03          8.9490E+00
2.9828E-03          9.3140E+00 3.6074E-03          9.6930E+00
3.7018E-03          1.0089E+01 3.8754E-03          1.0500E+01
```

```
4.5793E-03          1.0817E+01 5.0132E-03          1.1143E+01
5.2859E-03          1.1479E+01 6.1353E-03          1.1825E+01
6.8621E-03          1.2182E+01 8.4810E-03          1.2549E+01
9.8180E-03          1.2775E+01 1.1627E-02          1.3005E+01
1.4255E-02          1.3239E+01 1.9066E-02          1.3477E+01
2.7396E-02          1.3720E+01 5.0001E-02          1.3967E+01
1.3141E-01          1.4218E+01 3.9515E-01          1.4474E+01
7.1112E-01          1.4735E+01 8.2254E-01          1.5000E+01
6.3109E-01          1.5270E+01 4.3880E-01          1.5545E+01
1.7250E-01          1.5825E+01 5.0801E-02          1.6110E+01
1.0493E-02          1.6399E+01

DETECTOR
  $ Leakage Neutron Spectrum on surface of sphere 3
  number = bc1
  Boundary counts 3 4 3217.
   BIN ENERGY = neutron
       6.000E-05 7.740E-05 1.000E-04 1.290E-04 1.670E-04 2.150E-04
       2.780E-04 3.590E-04 4.640E-04 5.990E-04 7.740E-04 1.000E-03
       1.290E-03 1.670E-03 2.150E-03 2.780E-03 3.590E-03 4.640E-03
       5.990E-03 7.740E-03 1.000E-02 1.290E-02 1.670E-02 2.150E-02
       2.445E-02 2.780E-02 3.159E-02 3.590E-02 4.081E-02 4.640E-02
       5.272E-02 5.990E-02 6.809E-02 7.740E-02 8.798E-02 1.000E-01
       1.120E-01 1.260E-01 1.410E-01 1.590E-01 1.780E-01 2.000E-01
       2.240E-01 2.520E-01 2.830E-01 3.170E-01 3.560E-01 4.000E-01
       4.490E-01 5.040E-01 5.660E-01 6.350E-01 7.130E-01 8.000E-01
       8.780E-01 9.640E-01 1.058E+00 1.162E+00 1.275E+00 1.400E+00
       1.542E+00 1.698E+00 1.871E+00 2.061E+00 2.270E+00 2.500E+00
       2.704E+00 2.924E+00 3.162E+00 3.419E+00 3.699E+00
       4.000E+00 4.165E+00 4.337E+00 4.516E+00 4.703E+00 4.897E+00
       5.099E+00 5.310E+00 5.529E+00 5.757E+00 5.995E+00 6.242E+00
       6.500E+00 6.765E+00 7.041E+00 7.327E+00 7.627E+00 7.938E+00
       8.261E+00 8.598E+00 8.949E+00 9.314E+00 9.693E+00 1.009E+01
       1.050E+01 1.082E+01 1.114E+01 1.148E+01 1.183E+01 1.218E+01
       1.255E+01 1.277E+01 1.300E+01 1.324E+01 1.348E+01 1.372E+01
       1.397E+01 1.422E+01 1.447E+01 1.474E+01 1.500E+01 1.527E+01
       1.555E+01 1.583E+01 1.611E+01 1.640E+01

  $ Leakage Neutron Spectrum on surface of sphere 3
  number = bc2
  Boundary  3 4 3217.
   BIN ENERGY = photon
   3.0E-01     4.0E-01     5.0E-01     6.0E-01
    7.0E-01     8.0E-01     9.0E-01     1.0E+00
    1.10E+00    1.20E+00    1.30E+00    1.40E+00
    1.50E+00    1.60E+00    1.70E+00    1.80E+00
    1.90E+00    2.00E+00    2.10E+00    2.20E+00
    2.30E+00    2.40E+00    2.50E+00    2.60E+00
    2.70E+00    2.80E+00    2.90E+00    3.10E+00
    3.20E+00    3.30E+00    3.40E+00    3.50E+00
    3.60E+00    3.70E+00    3.80E+00    3.90E+00
    4.00E+00    4.10E+00    4.20E+00    4.30E+00
    4.40E+00    4.50E+00    4.60E+00    4.70E+00
    4.80E+00    4.90E+00    5.00E+00    5.10E+00
    5.20E+00    5.30E+00    5.40E+00    5.50E+00
    5.60E+00    5.70E+00    5.80E+00    5.90E+00
    6.00E+00    6.20E+00    6.40E+00    6.60E+00
    6.80E+00    7.00E+00    7.20E+00    7.40E+00
    7.60E+00    7.80E+00    8.00E+00    8.20E+00
    8.40E+00    8.60E+00    8.80E+00    9.00E+00
    9.20E+00    9.40E+00    9.60E+00    9.80E+00
    1.00E+01    1.04E+01    1.08E+01    1.12E+01
    1.16E+01    1.20E+01    1.24E+01    1.28E+01
    1.32E+01    1.36E+01    1.40E+01    1.44E+01
    1.48E+01    1.52E+01    1.56E+01    1.60E+01
    1.64E+01    1.68E+01    1.72E+01    1.76E+01
    1.80E+01    1.84E+01    1.88E+01    1.92E+01
    1.96E+01    2.00E+01
END
```

```
Pure Ni sphere R=16 cm, Spherical model, ENDF/B-VI, Source-2/Isotropic
C MCNP input
1     2  -0.0012      -1    imp:n=1
2     1  -8.85      1 -2    imp:n=1
3     1  -8.85      2 -3    imp:n=1
4     0            3       imp:n=0

1      so     2.50
2      so    10.00
3      so    16.00

mode n p
imp:p 1 1 1 0
sdef erg=d1  pos=0 0 0
C Source spectrum-2 (from sample MCNP input)
SI1  H
      1.1200E-01 1.2600E-01 1.4100E-01 1.5900E-01 1.7800E-01
      2.0000E-01 2.2400E-01 2.5200E-01 2.8300E-01 3.1700E-01
      3.5600E-01 4.0000E-01 4.4900E-01 5.0400E-01 5.6600E-01
      6.3500E-01 7.1300E-01 8.0000E-01 8.7800E-01 9.6400E-01
      1.0580E+00 1.1620E+00 1.2750E+00 1.4000E+00 1.5420E+00
      1.6980E+00 1.8710E+00 2.0610E+00 2.2700E+00 2.5000E+00
      2.7040E+00 2.9240E+00 3.1620E+00 3.4190E+00 3.6990E+00
      4.0000E+00 4.1650E+00 4.3370E+00 4.5160E+00 4.7030E+00
      4.8970E+00 5.0990E+00 5.3100E+00 5.5290E+00 5.7570E+00
      5.9950E+00 6.2420E+00 6.5000E+00 6.7650E+00 7.0410E+00
      7.3270E+00 7.6270E+00 7.9380E+00 8.2610E+00 8.5980E+00
      8.9490E+00 9.3140E+00 9.6930E+00 1.0089E+01 1.0500E+01
      1.0817E+01 1.1143E+01 1.1479E+01 1.1825E+01 1.2182E+01
      1.2549E+01 1.2775E+01 1.3005E+01 1.3239E+01 1.3477E+01
      1.3720E+01 1.3967E+01 1.4218E+01 1.4474E+01 1.4735E+01
      1.5000E+01 1.5270E+01 1.5545E+01 1.5825E+01 1.6110E+01
      1.6399E+01
SP1
      0.0000E+00 9.1757E-08 9.8311E-06 4.1291E-05 4.9811E-05
      8.7841E-05 2.4712E-04 3.3510E-04 3.6734E-04 3.7080E-04
      5.7052E-04 6.2002E-04 6.2400E-04 8.9866E-04 1.0057E-03
      1.2120E-03 1.2898E-03 1.4734E-03 1.3726E-03 1.4181E-03
      1.4552E-03 1.6345E-03 1.6449E-03 1.6672E-03 1.8595E-03
      1.7555E-03 1.9570E-03 1.9663E-03 1.8479E-03 1.8526E-03
      1.7087E-03 2.3287E-03 1.5062E-03 1.4611E-03 1.4217E-03
      1.4101E-03 7.3061E-04 7.3579E-04 6.6062E-04 6.8818E-04
      7.1076E-04 7.3399E-04 6.9796E-04 7.8571E-04 6.8635E-04
      6.9992E-04 7.6135E-04 8.0185E-04 8.5800E-04 8.4242E-04
      8.4426E-04 9.6325E-04 8.8076E-04 8.5653E-04 1.0666E-03
      1.0955E-03 1.0887E-03 1.3672E-03 1.4659E-03 1.5928E-03
      1.4517E-03 1.6343E-03 1.7761E-03 2.1228E-03 2.4498E-03
      3.1125E-03 2.2189E-03 2.6742E-03 3.3357E-03 4.5377E-03
      6.6573E-03 1.2350E-02 3.2984E-02 1.0116E-01 1.8560E-01
      2.1797E-01 1.7040E-01 1.2067E-01 4.8301E-02 1.4478E-02
      3.0325E-03
C  Nickel with impurities (expressed as weight percent).
M1     28058.60C -0.67144  28060.60C -0.26554  28061.60C -0.01169
      28062.60C -0.03775  28064.60C -0.00988
      14000.60C -0.0016   25055.60C -0.0015   26056.60C -0.0004
      12000.60C -0.0001   29063.60C -0.00007  29065.60C -0.00003
M2     8016.60C  0.208
      7014.60C  0.792
fc1  Leakage Neutron Spectrum on the Sphere Surface
f1:n 3
e1     6.000E-05 7.740E-05 1.000E-04 1.290E-04 1.670E-04 2.150E-04
      2.780E-04 3.590E-04 4.640E-04 5.990E-04 7.740E-04 1.000E-03
      1.290E-03 1.670E-03 2.150E-03 2.780E-03 3.590E-03 4.640E-03
      5.990E-03 7.740E-03 1.000E-02 1.290E-02 1.670E-02 2.150E-02
      2.445E-02 2.780E-02 3.159E-02 3.590E-02 4.081E-02 4.640E-02
      5.272E-02 5.990E-02 6.809E-02 7.740E-02 8.798E-02 1.000E-01
      1.120E-01 1.260E-01 1.410E-01 1.590E-01 1.780E-01 2.000E-01
      2.240E-01 2.520E-01 2.830E-01 3.170E-01 3.560E-01 4.000E-01
      4.490E-01 5.040E-01 5.660E-01 6.350E-01 7.130E-01 8.000E-01
      8.780E-01 9.640E-01 1.058E+00 1.162E+00 1.275E+00 1.400E+00
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      1.542E+00 1.698E+00 1.871E+00 2.061E+00 2.270E+00 2.500E+00
      2.704E+00 2.924E+00 3.162E+00 3.419E+00 3.699E+00
      4.000E+00 4.165E+00 4.337E+00 4.516E+00 4.703E+00 4.897E+00
      5.099E+00 5.310E+00 5.529E+00 5.757E+00 5.995E+00 6.242E+00
      6.500E+00 6.765E+00 7.041E+00 7.327E+00 7.627E+00 7.938E+00
      8.261E+00 8.598E+00 8.949E+00 9.314E+00 9.693E+00 1.009E+01
      1.050E+01 1.082E+01 1.114E+01 1.148E+01 1.183E+01 1.218E+01
      1.255E+01 1.277E+01 1.300E+01 1.324E+01 1.348E+01 1.372E+01
      1.397E+01 1.422E+01 1.447E+01 1.474E+01 1.500E+01 1.527E+01
      1.555E+01 1.583E+01 1.611E+01 1.640E+01 T
fc2  photon flux on sphere surface
f2:p 3
c    *** Energy bin ***
e2  0.3  56i  6.0  19i  10.0  24i  20
nps   3000000
print
```