Los Alamos
NATIONAL LABORATORY
memorandum
Applied Physics Division
X-5: Diagnostics Applications

To/MS: Distribution
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Symbol: X-5:RN(U)-JSH-01-01
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Subject: MCNP4C2

MCNP4C2[TM1] is finished. The load date is *loddat = 01/20/01*. MCNP4C2 [2] will be released to RSICC for sponsors, such as the criticality safety community, and others whom we designate.

This MCNP4C2 documentation supersedes the preliminary version [3] released December 22, 2000. The code has changed since then as required [4] by the MCNP Board of Directors (BoD) at their January 9, 2001, meeting:

1. Revise interactive geometry plotting to make the "ROTATE", "COLOR", and "SCALES" (both options 1 and 2) buttons into toggles rather than immediately redrawing. (JSH)
2. Implement "NoLines" option in interactive plotter so geometry plots can have any combination of lines for cell boundaries or the weight window mesh. (JSH)
3. Lee Carter's patch [5] to extend macrobodies to MCTAL files, SSW and SSR surface sources, event logs and PTRAK was integrated. (LLC)

Summary of New MCNP4C2 Features

Major New Features:

1. Photonuclear physics. (MCW)
2. Interactive plotting. (JSH)
3. Plot superimposed weight window mesh. (JSH)
4. Implement remaining macrobody surfaces. (LLC)
5. Upgrade macrobodies to surface sources and other capabilities. (LLC)
6. Revised summary tables. (MCW/JSH)
7. Weight window improvements:
   (a) Add weight window scaling factor. (JSH)

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[1] MCNP is a trademark of the Regents of the University of California, Los Alamos National Laboratory

[2] J. F. Briesmeister, Ed., "MCNP - A General Monte Carlo N-Particle Transport Code, Version 4C," LA-13709-M, Los Alamos National Laboratory (April 2000)

[3] John S. Hendricks, "MCNP4C2," X-5:RN(U)-JSH-00-48 (December 22, 2000)

[4] John S. Hendricks and Gregg C. Giesler, "Jan 9, 2001 MCNP BoD," X-5:JSH-01-02 (January 9, 2001)

[5] John S. Hendricks, "Macrobody Upgrade," X-5:RN(U)-JSH-01-03 (January 31, 2001)

(b) Allow 1 wwg coarse mesh per direction. (JAF)

(c) Eliminate blanks when writing generated WWN card. (JSH)

(d) Write out normalization constant for mesh windows. (JSH)

Minor New Features:

1. Remove 4B tracking fixes. (JSH)
2. Save particle attributes in stack. (JSH)
3. Shortcut for electrons below cutoff. (KJA)
4. Include bremsstrahlung produced below energy cutoff in photon summary table. Make electron summary balance. (AS)
5. Warn of unavailable delayed neutrons. (JSH)
6. Print random number index. (JSH)
7. Fatal error for CTME time cutoff and PVM. (JSH)
8. Fatal error if analog capture with alpha. (JSH)
9. Eliminate a DVF Qwin prompt inconvenience. (GWM)

Summary of MCNP4C2 Corrections

Significant Bugs:

1. Wrong record size causes PVM/SSW, SSR combination crash. (LJC)
2. KCODE source overwrites common in PVM mode. (JAF)
3. $20 PVM hangs with positive number of PVM tasks. (JSH)
4. $20 Bad pointers for unresolved resonance treatment. (JSH)
5. $20 Interrupts crash Lahey Fortran executables. (ECS)
6. $20 Bad energies with law 61 scatter and detectors. (JSH)
7. $20 Identical surfaces with reflection or white boundary fail. (LLC)
8. $4 Cannot read datapath on newer PC compilers. (JFB/GWM)
9. $4 Crash if inadequate space for F6:n,p tallies. (CJW/JSH)
10. $4 Torus will not translate. (LLC)

Lesser Bugs and corrections:

1. Corrected net multiplication. (REP)
2. Correct exponential transform. (JSH/TEB)
3. Perturbations wrong with 1-group xsecs. (JAF)
4. Better diagnostics for failed source position sampling. (AS)
5. Faulty surface transformation initiation causes crash on cray. (JSH)

6. Multigroup adjoint puts upper weight cutoff in wrong place in summary table. (JSH)
7. Correct setting of DBCN(8). (REP)
8. Correct error messages (write hangs multitasking). (JSH)
9. Avoid infinite loop (unicos roundoff) if 1 azimuth bin of mesh-based weight window. (TEB)
10. Protect from floating to integer roundoff errors. (JSH)
11. Fix numerical weight window mesh tracking problems. (JAF)
12. Consistency between rectangular and cylindrical mesh tracking. (JAF)
13. Cleanup: unpack IEX in BANKIT. (JSH)
14. Wrong PVM line count. (GWM)
15. More precise error message (KPRINT). (JAF)
16. Solaris F90 bug workaround. (REP)
17. Solaris F90 problems with JSOURC ERPRNT. (REP)
18. Correct harmless 4B plot logic error. (JSH)
19. Remove unused variables. (JAF/TEB/JSH)
20. Typos in comments. (JSH/JAF)
21. Workarounds for Sun F90 compiler. (REP)
22. Correct weight window theta mesh indexing. (TEB/JAF/JSH)
23. Warn of missing material on BBREM (Bremsstrahlung biasing) card. (AS)
24. Print reaction number in event log and PTRAK. (GWM)
25. Eliminate overwrite in MCPLOT. (TBK/JSH)

Major New MCNP4C2 Features

1. ***Photonuclear Physics.***
   Morgan White's Doctoral Dissertation [6] has been integrated into MCNP. [7] Morgan has prepared a detailed description of the photonuclear interface [8] and a brief primer for simulating photonuclear interactions. [9] Also available are the MCNP Manual Appendix F (data formats) [10] and Appendix G (data libraries). [11] The photonuclear capability produces both photoneutrons and photonuclear photons from photon collisions.

[6] M. C. White, "Development and Implementation of Photonuclear Cross-Section Data for Mutually Coupled Neutron-Photon Transport Calculations in the Monte Carlo N-Particle (MCNP) Radiation Transport Code," Los Alamos National Laboratory report LA-13744-T (July 2000).

[7] John S. Hendricks, "MCNP Photonuclear Physics," X-5:RN(U)-JSH-00-19 (November 13, 2000)

[8] Morgan C. White, "User Interface for Photonuclear Physics in MCNP(X)," X-5:MCW-00-88(U) (July 26, 2000)

[9] Morgan C. White, A Brief Primer for Simulating Photonuclear Interactions with MCNP(X)," X-5:MCW-00-89(U) (July 26,2000)

[10] Morgan C. White, "Class 'u' ACE Format — Photonuclear Data," X-5:MCW-00-86U (July 26, 2000)

[11] Morgan C. White, "Release of the LA150U Photonuclear Data Library," X-5:MCW-00-87 (July 26, 2000)

User Interface Changes:

Mm card:
PNLIB = *id* changes the default photonuclear table identifier to *id*.

New MPNm Photonuclear material card:
MPNm ZA_{PN1} ZA_{PN2} ...
The MPNm card allows different photonuclear ZAIDs than specified on the Mn card. For example,
M23 1001.60C 2 8016.60c .9 8017.60c .1
MPN23 0 8016 8016

PHYS:P card:
Form: PHYS:P EMCPF IDES NOCOH PNB
PNB = -1 Analog photonuclear particle production
= 0 No photonuclear particle production
= 1 Biased photonuclear particle production
The user interface changes are described in more detail in References 2, 3 and 4.

2. ***Interactive Plotting.***
MCNP4C2 introduces interactive point-and-click geometry plotting [12] for all systems with XLIB graphics (basically, everything.) Figure 1 displays 3-cell macrobody geometry with interactive geometry plot legends and buttons. The legend for the plot is in the upper left hand corner and is unchanged from MCNP4C. All the other (red) markings in the margin are commands for manipulating the plot.

On the top horizontal legend, UP, RT, DN, LF move the plot frame to the right, left, or up or down. The origin (center) of the plot can be moved by clicking "Origin" and then clicking the new location of the origin within the picture. ".1 .2 Zoom 5. 10." enables zooming in and out. For example, if you click "5." and then any point within the picture, the plot zooms in to that point by a factor of 5.

The "Edit" command in the left legend provides information for the current plot cell quantity at the cursor point. It is followed by black lettering identifying the present cell and coordinates of wherever the last click was in the picture. The commands "CURSOR" and "SCALES" are the same as MCNP4C, namely form a cursor to zoom into a part of the picture, or add scales showing the dimensions of the plot. "WW MESH" is described in the next section. "ROTATE" rotates the picture 90°. "PostScript" creates a PostScript publication quality picture in the file plotm.ps ("FILE" command in MCNP4C.) "COLOR" is a toggle to turn off colors and produce a line drawing only. "XY YZ ZX" can be clicked to get MCNP4C PX, PZ, or PY plots. "LABEL" controls surface and cell labels.

[12] John S. Hendricks, "Point-and-Click Plotting with MCNP," Radiation Protection for Our National Priorities, Spokane, Washington, p. 313-315 (September 17-21, 2000)

The right legend lists plot cell quantities. If "cel" is clicked, then the cell labels ("LABEL") will be cell numbers, If "imp" is clicked then the cell labels will be importances. The particle type is controlled by "PAR" in the right margin, and "N" in the right margin controls the number on the cell quantity. For example, "wwn3:p" would provide photon weight windows in the 3rd energy group and be clicked in using the "wwn", "P", and "N" in the right margin.

The lower legend controls the plots. "Redraw" redraws the picture in case part of it got cropped or otherwise needs to be refreshed. "Plot>" returns control to the command window so that plot commands can be entered in the old MCNP4C command style. "End" terminates the plot session. Command style commands can also be entered in the Plot Window by clicking in the lower left hand corner where it says "Click here or picture or menu." The lower left legend also suggests what further action is needed. For example, if you click "Zoom" the lower left legend will change to tell you to either double click or make your next click somewhere within the picture.

User Interface Change:
"Interact" is a new plot command to return from the command window mode to the point-and-click mode.

3. ***Plot Superimposed Weight Window Mesh.***
Figure 1 also shows the new plotting of the superimposed weight window mesh. In problems where the weight window mesh is input from the WWINP file the point-and-click button "MESH off" appears. It can be toggled to "WW MESH" to get the lines of the mesh-based weight window boundaries. [13] [14] Both the XYZ rectangular and the RZθ cylindrical meshes can be plotted in any arbitrary combination of mesh and plot orientations. In the plot command window mode the *PLOT*> command is meshpl N where N = 0/1/2/3 = No Lines / CellLine / WW MESH/ WW+Cell.

To plot the values of the mesh windows, click *wwn* in the right margin, toggle *par* and *N* in the lower right margin to get the weight window particle type and number, and then click the cell label entry (*LABEL* 2nd parameter, lower left).
User Interface Change:
"Meshpl N" is a new plot command for problems where a WWINP file is input. N = -1/0/1 = No Lines / MESH off / WW MESH. The interactive plotting buttons are No Lines / MESH off / WW MESH which appear only if a WWINP file is read in.

4. ***Implement Remaining Macrobody Surfaces.***
MCNP4C introduced five macrobodies: SPH, BOX, RPP, RCC, RHP/HEX. Lee Carter has added five more [15] to MCNP4C2:

[13] John S. Hendricks, "Plotting Superimposed Meshes in MCNP," X-5:RN(U)-JSH-01-04 (December 21, 2000)

[14] John S. Hendricks, "Mathematics for Plotting Superimposed Meshes in MCNP," X-5:RN(U)-JSH-01-04 (February 5, 2000)

[15] John S. Hendricks, "Extended Macrobodies," X-5:RN(U)-JSH-00-32 (September 6, 2000)

REC Right Elliptical Cylinder
TRC Truncated Right-angle Cone
ELL ELLipsoid
WED WEDge
ARB ARBitrary polyhedron

User Interface Change:

```
REC  Vx Vy Vz   Hx Hy Hz   V1x V1y V1z   V2x V2y V2z

where Vx Vy Vz = x,y,z coordinates of bottom cylinder
      Hx Hy Hz = cylinder axis height vector
      V1x V1y V1z = ellipse major axis vector (normal to Hx Hy Hz)
      V2x V2y V2z = ellipse minor axis vector (orthogonal to H and V1)


If there are 10 entries instead of 12, the 10th entry is the minor
axis radius, where the direction is determined from the cross product
of H and v1.

Example:  REC  0 -5 0  0 10 0  4 0 0  2
          a 10-cm high elliptical cylinder about the y-axis with
          the center of the base at x,y,z=0,-5,0 and with
          major radius 4 in the x-direction and minor radius 2
          in the z-direction.
```

TRC: Truncated Right-angle Cone

```
TRC  Vx Vy Vz   Hx Hy Hz  R1 R2

where Vx Vy Vz = x,y,z coordinates of bottom of truncated cone
      Hx Hy Hz = cone axis height vector
      R1 = radius of lower cone base
      R2 = radius of upper cone base

Example:  TRC  -5 0 0  10 0 0  4 2
          a 10-cm high truncated cone about the x-axis with the
          center of the 4 cm radius base at x,y,z = -5,0,0 and with
          the 2 cm radius top at x,y,z = 5,0,0
```

ELL: ELLipsoid

```
ELL V1x V1y V1z    V2x V2y V2z   Rm

If Rm > 0:
      V1x V1y V1z = 1st foci coordinate
      V2x V2y V2z = 2nd foci coordinate
      Rm = length of major axis
```

```
If Rm < 0:
      V1x V1y V1z = center of ellipsoid
      V2x V2y V2z = major axis vector (length = major radius)
      Rm = minor radius length

Examples:  ELL  0 0 -2  0 0 2  0 0 6
           ELL  0 0 0   0 0 3  2
           an ellipsoid at the origin with major axis of length 6
           in the z-direction and minor axis radius of length 4
           normal to the z-axis
```

WED: Wedge

```
WED   Vx Vy Vz   V1x V1y V1z   V2x V2y V2z  V3x V3y V3z

   Vx Vy Vz = vertex.
   V1x V1y V1z = vector of 1st side of triangular base
   V2x V2y V2z = vector of 2nd side of triangular base
   V3x V3y V3z = height vector

   A right-angle wedge has a right triangle for a base defined
   by V1 and V2 and a height of V3.
   The vectors V1, V2, and V3 are orthogonal to each other.

Example:  WED  0 0 -6  4 0 0  0 3 0  0 0 12
          a 12 cm high wedge with vertex at x,y,z = 0,0,-6.
          The triangular base and top are a right triangle
          with sides of length 4 (x-direction) and 3 (y-direction)
          and hypotenuse of length 5.
```

ARB: ARBitrary polyhedron

```
ARB    ax ay az   bx by bz   cx cy cz   ...  hx hy hz  N1 N2 N3 N4 N5 N6
```

There must be 8 triplets of entries input for the ARB to describe the (x,y,z) of the corners, although some may not be used (just use zero triplets of entries). These are followed by six more entries, N, which follow the prescription: each entry is a 4 digit integer that defines a side of the ARB in terms of the corners for the side. For example, the entry 1278 would define this plane surface to be bounded by the 1st, 2nd, 7th, and 8th above triplets (corners). Since three points are sufficient to determine the plane, only the 1st, 2nd, and 7th corners would be used in this example to determine the plane. The distance from the plane to the fourth corner (corner 8 in the example) is determined by MCNP. If the absolute value of this distance is greater than 1.e-6, an error message is given and the distance is printed in the outp file along with the (x,y,z) that would lie on the plane. If the 4th digit is zero, the fourth point is ignored. For a four sided ARB, 4 non-zero 4-digit integers (last digit is zero for four sided since there are only 3 corners for each side) are required to define the sides. For a five sided ARB, 5 non-zero 4-digit integers are required, and 6 non-zero 4-digit integers are required for a six sided ARB. Since there must be 30 entries altogether for an ARB (or MCNP gives an

error message), the last two integers are zero for the four sided ARB and the last integer is zero for a five sided ARB.

```
Example:  ARB  -5 -10 -5  -5 -10 5   5 -10 -5  5 -10 5   0 12 0   0 0 0
             0  0   0   0  0  0   1234 1250 1350 2450 3450 0
          a 5-sided polyhedron with corners at x,y,z = (-5,-10,-5),
          (-5,-10,5),(5,-10,-5),(5,-10,5),(0,12,0) and planar facets
          constructed from corners 1234, etc.
```

Facet numbering:

```
REC:   1 Elliptical cylinder
       2 Plane normal to end of Hx Hy Hz
       3 Plane normal to beginning of Hx Hy Hz

TRC:   1 Conical surface
       2 Plane normal to end of Hx Hy Hz
       3 Plane normal to beginning of Hx Hy Hz

ELL:   Treated as regular surface, so no facet

WED:   1 Slant plane including top and bottom hypotenuses
       2 Plane including vectors V2 and V3
       3 Plane including vectors V1 and V3
       4 Plane includng vectors V1 and V2 at end of V3
         (top triangle)
       5 Plane includng vectors V1 and V2 at beginning of V3
         (bottom triangle, including vertex point)

ARB:   1 plane defined by corners N1
       2 plane defined by corners N2
       3 plane defined by corners N3
       4 plane defined by corners N4
       5 plane defined by corners N5
       6 plane defined by corners N6
```

5. ***Upgrade macrobodies to surface sources and other capabilities.***
Lee Carter upgraded[5] MCNP macrobody capability to
   - Allow macrobody facets on SSW surface source writes and SSR surface source reads;
   - Allow surface source facets on SF (surface flagging) tally cards;
   - Print surface facets in the event log output and PTRAK files.
   - Print surface facets in the MCTAL file.

6. ***Revised Summary Tables.***
Morgan White proposed (and the 7/25/00 MCNP Board of Directors meeting approved) sweeping changes in the summary tables and provided a good first-cut rewrite. I have further rewritten much of the summary table arrays and output as illustrated in Figure 2. The main

changes are Print Table 130 which has a new horizontal format for cells so that the increasing number of events and reactions can be vertical. Print table 140 separates photonuclear and photoatomic events. The problem summary also regroups events and adds photonuclear interactions.

7. ***Weight Window Improvements.***
The following improvements have been made for the weight window and weight window generator variance reduction methods.
   (a) Add weight window scaling factor. Now input windows may be multiplied by a user-specified constant (7th entry on WWP card); [16]
   (b) Allow 1 superimposed mesh weight window coarse mesh per direction and make the default 1 fine mesh in each direction; [17]
   (c) Eliminate blanks when writing generated WWN card to the OUTP file.
   (d) Write out normalization constant used in generating weight windows (usually half the average source weight) for mesh windows.

   User Interface Changes:
   WWP:n card, new 7th entry is multiplicative constant for all lower weight bounds on WWNi:n cards or WWINP file mesh-based windows of particle type n.
   WWG card 9th entry flags undocumented developmental recursive Monte Carlo feature.
   MESH card defaults are now 1 fine mesh per coarse mesh and now 1 coarse mesh per direction is allowed.

Description of Minor New Features

1. Remove 4B tracking fixes. The 20th entry on the DBCN card now causes MCNP4C2 to track MCNP4C. (JSH)
2. Save particle attributes in stack. Morgan White in his photoneutron patch proposed a subroutine to put particle descriptors (GPBLCM, JPBLCM and sometimes UDT arrays) in a stack while photonuclear events took place. This functionality has been generalized and applied wherever it is needed. (JSH)
3. Shortcut for electrons below cutoff. If electrons are below the electron energy cutoff they do not produce bremsstrahlung photons as in MCNP4C. This speeds the code but affects tracking of MCNP test problem 23. (KJA)
4. Include bremsstrahlung produced below energy cutoff in the photon summary table and make electron summary balance. Ken Adams' MCNP4C electron enhancements deliberately let the electron summary table be out of balance in order to show energy lost to bremsstrahlung production below the photon energy cutoff. (AS) [18] has put the electron table back in balance and shows the bremsstrahlung photons not produced below the photon energy cutoff

[16] Thomas E. Booth, "Theoretical and Practical Mesh-Based Weight Window Generator Suggestions for MCNP," X-5:RN(U)-TEB-00-40 (September 27, 2000)

[17] Jeffrey A. Favorite, "Four Enhancements for the MCNP Mesh-Based Weight Window Generator," X-5:RN(U)-JAF-00-13 (May 25, 2000)

[18] Avneet Sood, "Electron Summary Table Balance," X-5:AS-00-153 (U) (December 11, 2000)

as produced and captured in the photon summary table. (AS)

5. Warn of unavailable delayed neutrons. If delayed neutrons are requested and a fissionable nuclide does not have delayed neutron data available a warning is issued. Approved at 2/10/00 MCNP BoD. (JSH)
6. Print random number index. In ERRPRN messages (warnings and fatal errors during the transport of particles) and for large histories at point detectors the random number index rather than the octal random number itself is printed. Approved at 7/25/00 MCNP BoD. (JSH)
7. Fatal error for CTME time cutoff and PVM. This caused wrong answers because of incomplete accumulation of task data. Approved at 7/25/00 MCNP BoD. (JSH)
8. Fatal error if analog capture with alpha. With analog capture it was possible for alpha time absorption to cause very low particle weights which, unchecked by weight cutoff, caused underflow. Approved at 7/25/00 MCNP BoD. (JSH)
9. Eliminate a DVF Qwin prompt inconvenience that caused the code to wait for a user prompt on PCs with DVF Qwin. (GWM)

Summary of MCNP4C2 Corrections

Significant Bugs:

1. Wrong record size causes PVM/SSW, SSR combination crash. Surface source reads and writes simply do not work with PVM multiprocessing. (LJC)
2. KCODE source overwrites common in PVM mode. (JAF)
3. PVM hangs with positive number of PVM tasks. $20 to Neill Taylor (UKAEA Fusion, Abingdon, UK) [19] (JSH)
4. Bad pointers for unresolved resonance treatment. $20 to Alfred Hogenbirk, NRG, Petten, Netherlands. [20] (JSH)
5. Interrupts crash Lahey Fortran executables. $20 to David Seagraves (ESH-4, LANL) [21] (ECS)
6. Bad energies with law 61 scatter and detectors. $20 to Chikara Konno (JAERI, Japan). [22] (JSH)
7. Identical surfaces with reflection or white boundary fail. $20 to Bruce Wilkin (AECL Research, Chalk River, Ontario, Canada) [23] (LLC)
8. Cannot read datapath on newer PC compilers. $4 to Nick Savin (Westinghouse Savannah River, Aiken, SC) [24] (JFB/GWM)

[19] John S. Hendricks, "MCNP Cash Award," X-5:JSH-00-155 (December 20, 2000)

[20] John S. Hendricks, "MCNP Cash Award," X-5:JSH-00-53 (April 24, 2000)

[21] Elizabeth C. Selcow, "MCNP Cash Award," X-5:ECS-00-101 (August 10, 2000)

[22] John S. Hendricks, "MCNP Cash Award," X-5:JSH-00-127 (October 30, 2000)

[23] John S. Hendricks, "MCNP Cash Award," X-5:JSH-00-152 (December 6, 2000)

[24] John S. Hendricks, "MCNP Cash Award," X-5:JSH-00-150 (November 20, 2000)

9. Crash if inadequate space for F6:n,p tallies. $4 to Frej Wasastjerna (VTT, Finland) [25] (CJW/JSH)
10. Torus will not translate. (LLC) $4 to Dennis Allen (BNFL, UK) [26] (LLC)

Lesser Bugs and corrections:

1. Correct the net multiplication in the problem summary table [27] (REP)
2. Correct exponential transform. [28] The following are wrong when the exponential transform (EXP card) is used in MCNP4C: generated mesh-based weight windows, track length k_{eff} estimate, track length α perturbation estimates, summary accounts for the exponential transform, multigroup weight window generation, and the DXTRAN weight cutoffs. Fortunately, the exponential transform is seldom used for these applications. (JSH/TEB)
3. Perturbations are wrong with one-group multigroup cross section data. [29] (JAF)
4. Better diagnostics for failed source position sampling, namely, print the source distribution number and the coordinates of the source point. [30] (AS)
5. Faulty surface transformation initiation causes crash on cray (subroutine TRFMAT). (JSH)
6. Multigroup adjoint puts upper weight cutoff in wrong summary table array. (subroutine MGACOL) (JSH)
7. Correct setting of random number index (8th entry on DBCN card.) [31] (REP)
8. Error message corrections. Write statements during multitasking cause the code to hang without proper multitasking lock settings. (JSH)
9. Avoid a UNICOS roundoff error which causes the code to hang in an infinite loop if there is 1 azimuthal bin in the mesh-based weight window. (TEB)
10. Protect from floating to integer roundoff errors by adding nint functions in appropriate places. (JSH)
11. Fix numerical weight window mesh tracking problems.[17] (JAF)
12. Consistency between rectangular and cylindrical mesh tracking.[17] (JAF)
13. Cleanup the unpacking of variable IEX in BANKIT for later use in PTRAK[20] (JSH)
14. Wrong PVM line count if $*ifdef, pvm$ compiler directives. (GWM)
15. More precise error message (subroutine KPRINT).[29] (JAF)

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[25] Christopher J. Werner, "MCNP Cash Award," X-5:CJW-00-93 (August 3, 2000)

[26] John S. Hendricks, "MCNP Cash Award," X-5:JSH-00-128 (October 30, 2000)

[27] Richard E. Prael, "Reformulation of the New Multiplication Calculation," X-5:REP-00-14 (January 26, 2000)

[28] Thomas E. Booth, "Correcting the Exponential Transform in MCNP4C," X-5:RN(U)-TEB-00-42 (October 17, 2000)

[29] Jeffrey A. Favorite, "An Error in the MCNP4C Perturbation Capability for Eigenvalue Problems," X-5:RH(U)-JAF-00-39 (September 25, 2000)

[30] Avneet Sood, "Improved Source Distribution Efficiency Message," X-5:AS-00-104 (August 15,2000)

[31] Richard E. Prael, "Inconsistency in Setting Initial Conditions for Random Number Generator," X-5:REP-00-117 (September 14, 2000)

16. Solaris F90 bug workaround (block data: n*' ' fails). (REP)
17. Solaris F90 problems with ERPRNT call in JSOURC. (REP)
18. Correct harmless 4B plot logic error (subroutine PTOST). (JSH)
19. Remove unused variables (subroutines AVRWGI, KSKCYC, etc.) (JAF/TEB/JSH)
20. Typos in comments (subroutine IPBC, ACALC, EXORDP, etc.). (JSH,JAF)
21. Workarounds for the Sun Solaris F90 compiler. (subroutines MAIN, GXAXIS) (REP)
22. Correct mesh-based weight window theta mesh indexing. (TEB/JAF/JSH)
23. Warn of missing material on BBREM (Bremsstrahlung biasing) card. The 1st 49 entries are energy bins, and the 50th entry onward is materials. If the count is off or the material(s) omitted, MCNP4C would assume the 1st problem material, sometimes giving wrong answers without warning. (AS)
24. Print reaction number (MTP) rather than type (NTYN) in event log and PTRAK. (GWM)
25. Eliminate overwrite in MCPLOT. If more than 100 Million histories were run then stars would partially overwrite the legend NPS print field. (TBK/JSH)

File Location

The MCNP4C2 installation, test, and executable files are located on both open and closed systems in directories install, test, exe under the following nodes:

cfs get dir=/x5code/mcnp4c2/...

hpss get /hpss/mcnp/mcnp4c2/...

Acknowledgement

MCNP4C2 is the collaborative effort of the X-5 Eolus Monte Carlo code development team: Gregg W. McKinney (Team Leader), Thomas E. Booth, Judith F. Briesmeister, Leland L. Carter, Lawrence J. Cox, R. Arthur Forster, William B. Hamilton, John S. Hendricks, Russell D. Mosteller, Richard E. Prael, Elizabeth C. Selcow, Avneet Sood, Stephen White.

Figure 1

MCNP4C2 Interactive Plotter

Plot shows the MCNP4C2 interactive geometry plot
with superimposed weight window mesh and mesh values.

Figure 2

New MCNP4C2 Output

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problem summary

     run terminated when     10000 particle histories were done.

 neutron creation     tracks      weight        energy            neutron loss        tracks      weight        energy
                                  (per source particle)                                         (per source particle)

 source                    0    0.            0.                  escape               19789    3.5482E-03    9.4101E-03
                                                                   energy cutoff            0    0.            0.
                                                                   time cutoff              0    0.            0.
 weight window             0    0.            0.                  weight window            0    0.            0.
 cell importance           0    0.            0.                  cell importance          0    0.            0.
 weight cutoff             0    0.            0.                  weight cutoff            0    0.            0.
 energy importance         0    0.            0.                  energy importance        0    0.            0.
 dxtran                    0    0.            0.                  dxtran                   0    0.            0.
 forced collisions         0    0.            0.                  forced collisions        0    0.            0.
 exp. transform            0    0.            0.                  exp. transform           0    0.            0.
 upscattering              0    0.            0.                  downscattering           0    0.            2.3205E-02
 photonuclear          18019    3.4978E-03    4.9208E-02          capture                  0    2.4858E-04    5.1662E-03
 (n,xn)                 3540    5.9790E-04    1.0977E-03          loss to (n,xn)        1770    2.9895E-04    1.2525E-02
 prompt fission            0    0.            0.                  loss to fission          0    0.            0.
 delayed fission           0    0.            0.
     total             21559    4.0957E-03    5.0306E-02              total            21559    4.0957E-03    5.0306E-02

   number of neutrons banked                  19789        average time of (shakes)              cutoffs
   neutron tracks per source particle     2.1559E+00         escape            4.5281E+01         tco   1.0000E+34
   neutron collisions per source particle 4.0429E+01         capture           2.4422E+00         eco   0.0000E+00
   total neutron collisions                  404286         capture or escape 4.2476E+01         wc1   1.0000E-20
   net multiplication              0.0000E+00 0.0000        any termination   3.9376E+01         wc2   1.0000E-21

 photon creation      tracks      weight        energy            photon loss         tracks      weight        energy
                                  (per source particle)                                         (per source particle)

 source                10000    1.0000E+00    1.0000E+02          escape                3377    1.6891E-01    6.9469E+00
                                                                   energy cutoff            0    0.            0.
                                                                   time cutoff              0    0.            0.
 weight window             0    0.            0.                  weight window            0    0.            0.
 cell importance           0    0.            0.                  cell importance          0    0.            0.
 weight cutoff             0    0.            0.                  weight cutoff            0    0.            0.
 energy importance         0    0.            0.                  energy importance        0    0.            0.
 dxtran                    0    0.            0.                  dxtran                   0    0.            0.
 forced collisions         0    0.            0.                  forced collisions        0    0.            0.
 exp. transform            0    0.            0.                  exp. transform           0    0.            0.
 from neutrons            57    5.7000E-03    1.3011E-02          compton scatter          0    0.            8.2078E+00
 bremsstrahlung            0    0.            0.                  capture              28979    1.7652E+00    1.3602E-01
 p-annihilation        18382    1.7356E+00    8.8693E-01          pair production       9191    8.6782E-01    8.5432E+01
 photonuclear          12126    2.6750E-03    5.6736E-03          photonuclear abs         0    2.0186E-03    1.8333E-01
 electron x-rays           0    0.            0.
 1st fluorescence        982    5.9956E-02    8.9155E-05
 2nd fluorescence          0    0.            0.
     total             41547    2.8040E+00    1.0091E+02              total            41547    2.8040E+00    1.0091E+02

   number of photons banked                   21374        average time of (shakes)              cutoffs
   photon tracks per source particle      4.1547E+00         escape            7.0085E-01         tco   1.0000E+34
   photon collisions per source particle  2.7609E+01         capture           1.1451E-01         eco   1.0000E-03
   total photon collisions                   276091         capture or escape 1.6566E-01         wc1   1.0000E-20
                                                            any termination   1.1439E-01         wc2   5.0000E-21

 computer time so far in this run     0.00 minutes          maximum number ever in bank        12
 computer time in mcrun               0.00 minutes          bank overflows to backup file       0
 source particles per minute            0.0000E+00          dynamic storage          0 words,          0 bytes.
 random numbers generated                 6225852           most random numbers used was     2373 in history     9229

 range of sampled source weights = 1.0000E+00 to 1.0000E+00
```

```
neutron  weight balance in each cell                print table 130

        cell index        1           2
       cell number        1           2       total

 external events:
          entering  0.0000E+00  3.5482E-03  3.5482E-03
            source  0.0000E+00  0.0000E+00  0.0000E+00
     energy cutoff  0.0000E+00  0.0000E+00  0.0000E+00
       time cutoff  0.0000E+00  0.0000E+00  0.0000E+00
           exiting -3.5482E-03 -3.5482E-03 -7.0963E-03
                   ----------  ----------  ----------
             total -3.5482E-03  0.0000E+00 -3.5482E-03

 variance reduction events:
     weight window  0.0000E+00  0.0000E+00  0.0000E+00
   cell importance  0.0000E+00  0.0000E+00  0.0000E+00
     weight cutoff  0.0000E+00  0.0000E+00  0.0000E+00
 energy importance  0.0000E+00  0.0000E+00  0.0000E+00
            dxtran  0.0000E+00  0.0000E+00  0.0000E+00
 forced collisions  0.0000E+00  0.0000E+00  0.0000E+00
    exp. transform  0.0000E+00  0.0000E+00  0.0000E+00
                    ----------  ----------  ----------
              total  0.0000E+00  0.0000E+00  0.0000E+00

 physical events:
           capture -2.4858E-04  0.0000E+00 -2.4858E-04
            (n,xn)  5.9790E-04  0.0000E+00  5.9790E-04
    loss to (n,xn) -2.9895E-04  0.0000E+00 -2.9895E-04
           fission  0.0000E+00  0.0000E+00  0.0000E+00
   loss to fission  0.0000E+00  0.0000E+00  0.0000E+00
      photonuclear  3.4978E-03  0.0000E+00  3.4978E-03
                    ----------  ----------  ----------
              total  3.5482E-03  0.0000E+00  3.5482E-03
```

photon weight balance in each cell print table 130

cell index	1	2	
cell number	1	2	total
external events:			
entering	0.0000E+00	1.6891E-01	1.6891E-01
source	1.0000E+00	0.0000E+00	1.0000E+00
energy cutoff	0.0000E+00	0.0000E+00	0.0000E+00
time cutoff	0.0000E+00	0.0000E+00	0.0000E+00
exiting	-1.6891E-01	-1.6891E-01	-3.3781E-01
	---	---	---
total	8.3109E-01	0.0000E+00	8.3109E-01
variance reduction events:			
weight window	0.0000E+00	0.0000E+00	0.0000E+00
cell importance	0.0000E+00	0.0000E+00	0.0000E+00
weight cutoff	0.0000E+00	0.0000E+00	0.0000E+00
energy importance	0.0000E+00	0.0000E+00	0.0000E+00
dxtran	0.0000E+00	0.0000E+00	0.0000E+00
forced collisions	0.0000E+00	0.0000E+00	0.0000E+00
exp. transform	0.0000E+00	0.0000E+00	0.0000E+00
	---	---	---
total	0.0000E+00	0.0000E+00	0.0000E+00
physical events:			
from neutrons	5.7000E-03	0.0000E+00	5.7000E-03
bremsstrahlung	0.0000E+00	0.0000E+00	0.0000E+00
capture	-1.7652E+00	0.0000E+00	-1.7652E+00
p-annihilation	1.7356E+00	0.0000E+00	1.7356E+00
pair production	-8.6782E-01	0.0000E+00	-8.6782E-01
photonuclear	2.6750E-03	0.0000E+00	2.6750E-03
photonuclear abs	-2.0186E-03	0.0000E+00	-2.0186E-03
electron x-rays	0.0000E+00	0.0000E+00	0.0000E+00
flourescence	5.9956E-02	0.0000E+00	5.9956E-02
	---	---	---
total	-8.3109E-01	0.0000E+00	-8.3109E-01

neutron activity of each nuclide in each cell, per source particle print table 140

cell index	cell name	nuclides	atom fraction	total collisions	collisions * weight	wgt. lost to capture	wgt. gain by fission	wgt. gain by (n,xn)	photons produced	photon wgt produced	avg photon energy
1	1	13027.40c	1.00E+00	404286	7.3001E-02	2.4858E-04	0.0000E+00	2.9895E-04	57	5.7000E-03	2.2827E+00
	total			404286	7.3001E-02	2.4858E-04	0.0000E+00	2.9895E-04	57	5.7000E-03	2.2827E+00

total over all cells by nuclide	total collisions	collisions * weight	wgt. lost to capture	wgt. gain by fission	wgt. gain by (n,xn)	photons produced	photon wgt produced	avg photon energy
13027.40c	404286	7.3001E-02	2.4858E-04	0.0000E+00	2.9895E-04	57	5.7000E-03	2.2827E+00

photoatomic activity of each nuclide in each cell, per source particle print table 140

cell index	cell name	nuclides	atom fraction	total collisions	collisions * weight	wgt. lost to capture
1	1	13000.02p	1.00E+00	276091	1.6833E+01	1.7652E+00
	total			276091	1.6833E+01	1.7652E+00

total over all cells by nuclide	total collisions	collisions * weight	wgt. lost to capture
13000.02p	276091	1.6833E+01	1.7652E+00

photonuclear activity of each nuclide in each cell, per source particle print table 140

cell index	cell name	nuclides	atom fraction	total collisions	collisions * weight	photons produced	photon wgt produced	avg photon energy	neutrons produced	neutron wgt produced	avg neutron energy
1	1	13027.00u	1.00E+00	9733	2.0186E-03	12126	2.6750E-03	2.1210E+00	18019	3.4978E-03	1.4068E+01
	total			9733	2.0186E-03	12126	2.6750E-03	2.1210E+00	18019	3.4978E-03	1.4068E+01

total over all cells by nuclide	total collisions	collisions * weight	photons produced	photon wgt produced	avg photon energy	neutrons produced	neutron wgt produced	avg neutron energy
13027.00u	9733	2.0186E-03	12126	2.6750E-03	2.1210E+00	18019	3.4978E-03	1.4068E+01

summary of photons produced in neutron collisions

cell	number of photons	weight per source neut	energy per source neut	avg photon energy	mev/gm per source neut	weight/neut collision	energy/neut collision
1 1	57	5.70000E-03	1.30115E-02	2.28271E+00	1.79760E-08	7.80816E-02	1.78238E-01
2 2	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3 3	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
total	57	5.70000E-03	1.30115E-02	2.28271E+00			

energy interval	number of photons	number frequency	cum number distribution	weight of photons	weight frequency	cum weight distribution
20.000	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
15.000	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
10.000	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
9.000	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
8.000	1	1.75439E-02	1.75439E-02	1.00000E-04	1.75439E-02	1.75439E-02
7.000	0	0.00000E+00	1.75439E-02	0.00000E+00	0.00000E+00	1.75439E-02
6.000	0	0.00000E+00	1.75439E-02	0.00000E+00	0.00000E+00	1.75439E-02
5.000	2	3.50877E-02	5.26316E-02	2.00000E-04	3.50877E-02	5.26316E-02
4.000	6	1.05263E-01	1.57895E-01	6.00000E-04	1.05263E-01	1.57895E-01
3.000	3	5.26316E-02	2.10526E-01	3.00000E-04	5.26316E-02	2.10526E-01
2.000	17	2.98246E-01	5.08772E-01	1.70000E-03	2.98246E-01	5.08772E-01
1.000	19	3.33333E-01	8.42105E-01	1.90000E-03	3.33333E-01	8.42105E-01
0.500	9	1.57895E-01	1.00000E+00	9.00000E-04	1.57895E-01	1.00000E+00
0.100	0	0.00000E+00	1.00000E+00	0.00000E+00	0.00000E+00	1.00000E+00
0.010	0	0.00000E+00	1.00000E+00	0.00000E+00	0.00000E+00	1.00000E+00
0.000	0	0.00000E+00	1.00000E+00	0.00000E+00	0.00000E+00	1.00000E+00
total	57	1.00000E+00		5.70000E-03	1.00000E+00	

JSH:jsh

Distribution:
X-5 File
A. R. Heath, X-5, MS F663
T. J. Seed, X-5, MS F663
G. W. McKinney, X-5, MS F663
T. E. Booth, X-5, MS F663
J. F. Briesmeister, X-5, MS F663
L. L. Carter, X-5, MS F663
L. J. Cox, X-5, MS F663
J. D. Court, X-5, MS F663
G. P. Estes, X-5, MS F663
J. A. Favorite, X-5, MS F663
S. C. Frankle, X-5, MS F663
R. A. Forster, X-5, MS F663
W. B. Hamilton, X-5, MS F663
J. S. Hendricks, X-5, MS F663
R. C. Little, X-5, MS F663
R. D. Mosteller, X-5, MS F663
R. E. Prael, X-5, MS F663
C. E. Ragan, X-5, MS F663
R. R. Roberts, X-5, MS F663
E. C. Selcow, X-5, MS F663
A. Sood, X-5, MS F663
C. J. Werner, X-5, MS F663
M. C. White, X-5, MS F663
S. W. White, X-5, MS F663
H. G. Hughes, CCS-4, MS D409
H. Lichtenstein, CCS-4, MS D409
G. C. Giesler, CIC-12, MS B295
D. A. Rutherford, NIS-8, MS B230