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MCNP4B™ Verification and Validation

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by

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ABSTRACT

Several new features and bug fixes have been incorporated into the new release of MCNP.[1] As required by the MCNP Software Quality Assurance Plan,[2] these changes to the code and the test set are documented here for user reference. This document summarizes the new MCNP4B features and corrections, separated into major and minor groupings. Also included are a code cleanup section and a section delineating problems identified in LA–12839 [3] which have not been corrected. Finally, we document the MCNP4B test set modifications and explain how test set coverage has been improved.

I. INTRODUCTION

Every three or four years a new version of MCNP is released internationally. MCNP4A was released October 1, 1993, and has been stable ever since. MCNP4B will be released sometime in 1997. Intermediate versions are released periodically to sponsors and LANL users. We report here the new features and the verification and validation changes for MCNP4XQ, released at LANL April 8, 1996. MCNP4XQ is a near-final version of MCNP4B. We anticipate adding only bug corrections and the AVATAR capability before this code is released as MCNP4B.

Other intermediate MCNP4B versions were released as 4XL, 4XM, 4XN, 4XO, and 4XP. MCNP4XP was released at LANL and to sponsors on June 10, 1995. In the following description of new code features and corrections, the code version where the change was made is listed, such as 4XL.

MCNP4B and all of its intermediate versions, 4XL, 4XM, 4XN, 4XO, 4XP, and 4XQ, are the work of many people. An attempt has been made to associate the developer's initials and documentation with each feature and correction.

As updated versions of MCNP are developed and archived, an effort is made to produce a test set evolution to mirror those modifications. As the evolution of MCNP is dynamic in nature, so is test set evolution, and documentation is required periodically to preserve these changes and the logic behind them. The last major test set revision was produced by Ron Brockhoff and documented in LA-12839.[3] Those modifications are included here. All modifications have been grouped into these main categories:

- Additions to increase total test set coverage
- Additions to cover new features
- Additions to test new bug fixes
- Changes to facilitate output comparison
- Changes to reduce overall size of output
- Others

The MCNP manual has also been upgraded. It will be issued with MCNP4B. The MCNP manual documents MCNP4B; what is reported herein is complimentary and contains information not in the MCNP4B manual, namely a summary of changes from MCNP4A such as features, corrections, and Software Quality Assurance changes to the test set.

II. MCNP4B FEATURES AND CORRECTIONS

A. Summary of MCNP4B Features and Corrections

The philosophy of MCNP is "Quality, Values, and then Features." Before listing the significant new MCNP4B enhancements, it is useful to remind the reader of the two higher priorities: quality and value.

"Quality" includes strict configuration management, multiple levels of review, adherence to IEEE and ISO-9000 Software Quality Assurance principles, traceable documentation of all changes, source code availability, extensive benchmarking against other codes and experiments, a verification test set with 97% coverage, widespread code distribution with intense user scrutiny, and cash rewards for bugs.

"Value" includes portability to many platforms, the ability to utilize modern software capabilities such as PVM multitasking and X-windows graphics, limited free user support and extensive sponsored user support, training classes, an installation package, source code availability, a stable environment of a single international version for a period of years, and an active research program. A consequence of "Quality" and "Value" is that MCNP has become the U. S. university standard and the international standard of Monte Carlo radiation transport codes; and MCNP has survivability—the code will be around for a long time.

"Features" are very important—just not more important than "Quality" and "Value." MCNP4B has eleven major new features:

- Differential Operator Perturbations (GWM);
- Enhanced electron physics (HGH/KJA);
- PVM load balance and fault tolerance (GWM);
- PVM upgrades to the latest PVM version (GWM);
- Cross-section plotting (JSH/KJA/TAP/FJE);
- Universe mapping (JSH/SDN/GWM/JCC);
- Postscript plotting capability (GWM);
- Testing improvements (JDC/JSH);
- T3D and LP64 architectures (GWM/ABM);
- PC XWindows (GWM);
- HMCNP inclusion (REP).

MCNP4B also has 13 minor new features, 14 significant error corrections, 50 minor error corrections, and 17 cleanup corrections.

The following sections list all features and corrections in all MCNP4B preliminary versions. The intermediate version where the correction or feature was introduced (e.g., 4XQ) is provided along with the principal developer's initials (e.g., GWM).

B. Major New Features

1. *Differential Operator Perturbations:* First- and second-order differential operator perturbations are now possible with the PERT card for all tallies and k_{eff}. (LA–13098, GWM/4XO).[4]

   Examples:
   pert2:n,p cell=3,12 mat=8 rho=-1.2
   pert2:n,p cell=1 8i 10 rho=0

2. *Enhanced Electron Physics:* Landau energy-loss straggling has been implemented for secondary electron energy and angle distributions along with photoelectric electron production improvements to upgrade the MCNP electron physics to the level of the Integrated Tiger Series (ITS) ver. 3. Options have been added to (DBCN card) to select ITS1.0 physics, ITS3.0 physics, or newer, potentially superior physics. (X–6:HGH–93–745, 746, X–6:HGH–94–267, 733, XTM:95–HGH:KJA–86, 319, XTM:95–236, 249, XTM:JSH–96–59, HGH /KJA /4XQ).

3. *PVM Load Balancing and Fault Tolerance:* Multitasking with Parallel Virtual Machine (PVM) software has been greatly enhanced by load balancing, which sends more particles to less busy or faster processors, and fault tolerance, which enables problems to continue even if some processors doing the problem become unavailable. (X–6:GWM–95–212, XTM:GWM–95–111,128, GWM/4XQ).

4. *PVM Upgrades:* MCNP has been upgraded to the latest PVM version.

5. *Cross-Section Plotting:* All cross sections of nuclides or mixed materials used in a problem can be plotted with the IXZ execution option. (X–6:TAP–94–380,435,508, X–6:KJA–94–797, XTM:FJE–95–122,199,212, XTM:JSH–96–44,84, JSH/KJA/TAP/FJE, 4XO,4XP,4XQ).

   Examples: (execute with MCNP IXZ)
   mcplot> xs=6012.40c
   mcplot> xs=m1 par=p mt=6

6. *Universe Map / Lattice Activity:* Sources, collisions, and tracks in each element of lattices and repeated structures geometries are now output in Print Table 128 which also serves as a universe map. (XTM:95–120,155,300,321, JSH/SDN/GWM/JCC/4XQ).

7. *Postscript Files:* The FILE command while plotting causes plots to be written to postscript files. (X–6:GWM–94–171) (GWM/4XL).

   Examples: (works for geometry, tally, and cross-section plotters)
   file — send next plot to *plotm.ps*;
   file all — send all remaining plots to *plotm.ps*;
   file — none send all remaining plots to terminal only.

8. *Testing Improvements:* The MCNP test set was improved to increase test coverage of old features and include coverage of new features. Code modifications were added to minimize differences between platforms such as printing true zeros, turning off timing in continue runs, etc.. (X–6:JSH–94–755, JSH/4XN) (LA–12839[3], XTM:JDC–95–149,150,186,187,189, XTM:JSH–96–84, XTM:JDC–96–112, JDC,RCB,JSH, 4XN,4XQ).

9. *T3D and LP64 Architectures:* Upgrades were made to run on the Cray T3D (*define T3D) (XTM:GWM–95–128, GWM/4XL) and 64-bit multitasking workstations (*define lp64) such as the SGI and DEC Alpha (XTM:95–114, 115, 121, 146, 147 GWM/ABM, 4XQ).

10. *PC X-windows:* X-windows on the PC was enabled using MetaWare High C 3.3, DESQview/X 2.0 with the MetaWare X11 toolkit. The PC version no longer requires Lahey software. (GWM, 4XP,4XQ).

11. *LCS HMCNP:* The HMCNP capabilities of the LAHET Code System (LCS) were added by revising the surface source (SSR, SSW cards) (XTM:JSH–95–188,243, XTM:JSH–96–107, REP/4XQ).

C. Minor New Features

1. *BFP:* The multigroup Boltzmann-Fokker-Planck (BFP) algorithm in MCNP was fully tested and documented. (XTM:95–235, MAH/KJA/4XQ).

2. *Dynamic Memory Requirements Reduced:* The storage space required for tallies, statistical analysis, most summary tables, and diagnostics, was reduced by up to a factor of two for problems run without multitasking. (XTM:JSH–96–84, JSH/4XQ).

3. $S(\alpha, \beta)$ *Assignments:* Print Table 102 was added to indicate which $S(\alpha, \beta)$ datasets are utilized by which material (Mn) (XTM:95–JSH–225) (JSH/4XQ).

4. *C Upgrade:* The MCNP C routines were upgraded to eliminate the need for FABS and DIFFTIME, two ANSI standard routines that were not always available on all systems. CNINT replaced NINT to avoid conflicts on SUN and Convex workstations. (X–6:JSH–94–755, GWM, 4XP,4XQ).

5. *Timing Profiles:* UNICOS timing profiles (*define profil) were enabled to allow developers to see where the code spends its time. (X–6:KJA–95–147, XTM:95–144) (KJA/4XP).

6. *F8 Variance Reduction:* Enable variance reduction with F8 tallies with the FATAL option on (X–6:JSH–94–143, GPE/JSH/4XK).

7. *FM Additional Reactions:* Add FM card reactions -1 and -3 for the neutron total and elastic cross sections at the data library temperature without MCNP thermal effects (X–6:JSH–94–119, JSH/4XK).

8. *New Plotter Options:* Add HELP and ? options to plotter (same as *options* command) (X–6:JSH–94–16, JSH/4XK).

9. *Print Storage Requirements:* Print the field length as MDAS or the size of dynamically allocated common (LLFL) in decimal words (4 or 8 bytes depending upon system) and Megabytes. Thus field length no longer includes fixed common or the size of the code but is now consistent across platforms and is not zero on most systems (X–6:JSH–94–101, JSH/4XK/4XL).

10. *Signal-to-Noise FOM:* Divide the figure-of-merit (FOM) into its two constituent components so that there is a machine-independent signal-to-noise component (X–6:RAF–94–131, RAF/4XK).

11. *Source Distribution Frequency Tables:* Cell-based distributions now print the cell number as the distribution value rather than the COMMON pointer location in Print Table 170. (X–6:ELR–604, X–6:GWM–94–600, X–6:JSH–94–607, ELR/GWM/JSH/4XN).

12. *FM and MT Combination:* MT $S(\alpha, \beta)$ cards are no longer ignored for materials appearing only on FM tally multiplier cards. (X–6:JSH–94–143, JSH/4XK).

13. *Tally Plot Factors:* Enabled a negative factor to plot tallies in reverse order. Suggested by Jacek Arkuszewski, PSI, Switzerland. (JSH/4XP).

D. Significant Corrections

In rare cases, the following bugs could cause wrong answers without warning.

1. *Photon Physics for H< 50 keV:* Incoherent photon scattering was wrong for hydrogen with detailed physics below 50 keV because the fine-structure constant was not squared. The form factor is 97% of what it should be at 50 keV; 79% at 30 keV; 19% at 10 keV; 5% at 5 keV and 1% at 1 keV. *MCNP4A Workaround:* None. But incoherent photon scatter off hydrogen at these low energies is usually insignificant, and only the angular distribution is affected; once a photon undergoes multiple collisions, errors in angular distribution are undetectable. (X–6:JSH–93–650, TEB/4XK).

2. *F5, DXTRAN / Simple Photon Physics Conflict:* Form factors were erroneously used with incoherent photon scatter for contributions to detectors and DXTRAN with simple physics. *MCNP4A Workaround:* None, but you should not be using simple physics in a low-energy regime where form factors matter in the first place. (X–6:JSH–93–656, JSH/4XK).

3. *Photon Coherent Scatter:* Contributions to detectors and DXTRAN from photon coherent scattering are wrong if there is more than one detector or DXTRAN sphere and very wrong if there is also thick-target bremsstrahlung because the form factor is not properly stored at the point of last collision. Note that this does not affect transport, just detector/DXTRAN contributions. (X–6:JSH–93–661, JSH/4XK).

4. *Simple Photon Physics:* Simple photon physics (optional) in conjunction with thick-target bremsstrahlung (default) failed with detectors or DXTRAN (optional) because the photon cross sections are overwritten. *MCNP4A Workaround:* Do not use simple photon physics, thick-target bremsstrahlung, and detectors or DXTRAN together. For this bug, $4 was awarded to Robert Buchl, Rocky Flats. (X–6:JSH–93–721, JSH/4XK).

5. *Knock-on Electron Scatter:* Knock-on electron-scattering secondary angular distributions were slightly wrong. *MCNP4A Workaround:* None, but the effect is very small. (X–6:HGH–93–745/4XK) (HGH).

6. *DXTRAN and Monodirectional Sources:* DXTRAN was usually wrong with monodirectional sources. *MCNP4A Workaround:* If the direct contribution from a monodirectional source is a significant contributor to a DXTRAN sphere, check to make sure those answers are reasonable. There is no fix possible, but a warning message has been added to MCNP4B. (X–6:JSH–94–29, JSH/4XK).

7. DXTRAN/Repeated Structures Conflict: DXTRAN failed in repeated structures geometries. *MCNP4A Workaround:* None. Be sure the DXTRAN gain and loss are similar in the summary table balance to see if you are affected, or do not have DXTRAN spheres in filled cells. The problem is calculating the wrong distance to DXTRAN spheres during the random walk and killing particles that erroneously think they have reached a DXTRAN sphere. (X–6:JSH–94–101, ELR/GWM/JSH/4XK).

8. *FM and MT or PIKMT Conflict:* Total or elastic cross sections (reactions 1 and 2) on FM cards could undo the $S(\alpha,\beta)$ thermal treatment and PIKMT photon production. *MCNP4A Workaround:* If a material is used for tallying only (not on a cell card) use only non-$S(\alpha,\beta)$ nuclides, or do not use total and elastic (1 and 2) reactions, or do not use ZAIDs used in transport, or have the last FM bin use these nuclides in a material that is on the cell card. For this bug, $4 was awarded to Yuji Uenohara, Toshiba Corp., Japan. (X–6:JSH–94–118, JSH/4XK).

9. *White Boundaries:* The isotropic white boundary reflection of MCNP4A was changed to a cosine distribution so as to be isotropic in flux. The manual was ambiguous. For this bug, $4 was awarded to Alfred Hogenbirk, ECN - Netherlands. (X–6:JSH–94–379, JSH/4XL).

10. *TX, TY, TZ, TR Conflict:* The TR card does not work on a torus. This problem has not yet been corrected. Do not use the TR card on a torus.

11. *Electron / Repeated Structures Conflict:* Electrons got lost in repeated structures. *MCNP4A Workaround:* None, but no problem unless you are losing particles. (X–6:JSH–93–143, GPE/GWM/4XK).

12. *Slow Annihilation Photons:* Annihilation photons created by positrons created below the electron energy cutoff have the electron speed, not the speed of light. For this bug, $4 was awarded to Ray Muzic, University Hospitals of Cleveland (X-6:JSH-95-162, JSH/4XP).

13. *Electron Scattering:* The Goudsmit-Saunderson electron multiple scattering distribution sampling was corrected. Generally, the correction is insignificantly small. (X–6:HGH:KJA–95–745, XTM:95–HGH:KJA–236, KJA/HGH/4XQ).

14. *FT SCX:* The FT card with the SCX and SCD options caused some tallies to be made in the wrong bin. (JSH/4XQ).

E. Minor Corrections

1. *TR Card:* The nJ notation was enabled for use on TR cards. Improperly normalized or improperly specified surface transformations (TR card) are now correctly renormalized. For this bug, $4 was awarded to Jake Anderson, LANL. (XTM:JSH–95–51) (GWM/JSH/4XQ).

2. *DE0, DF0 Tally Volume Bug:* Dose function defaults (DE0, DF0) applied to three consecutive tallies and using linear interpolation could result in wrong tally volumes or areas being calculated. For this bug, $4 was awarded to Freek Keijzer, Urenco, Netherlands (XTM:JSH–96–88) (JSH/4XQ).

3. *Color Plots:* The MCNP C routine NINT function could cause color plot resolution to be off 1 pixel. For this bug, $4 was awarded to Pete Laughton, AECL-CRL, Canada. The correction is part of the MCNPC.ID overhaul described in minor features, above. (X–6:JSH–94–78, X–6:JSH–94–755, mc.592, GWM, 4XP,4XQ).

4. *NLIB, PLIB, ELIB:* Poor use of the NLIB, PLIB, and ELIB options on Mn cards could cause MCNP4A to crash with a dimensioning problem. (XTM:JSH–96–84, JSH/4XQ).

5. *Convex Tracking:* Extra parenthesis were strategically added to enable tracking on vector machines, particularly the Convex. (XTM:95–226, JSH/4XQ).

6. *Cross Sections:* Protect against crashing in some cases when the photon production yield multiplier is missing from the data library and fission cross sections are being expunged, JXS(20)=0, JXS(19)≠0. (XTM:SCF-95-301, RCL/JSH/4XQ).

7. *KCODE and PVM:* Continue run restarts in KCODE PVM problems used the number of histories rather than the number of cycles and did not stop when running in PVM multitasking mode. For this bug, $4 was awarded to Mike Milgram, AECL-CRL, Canada. (XTM:GWM–95–139, GWM/4XQ).

8. *Multigroup FM:* Specification of multigroup reactions on the FM card were made consistent with the manual and cross-section plotter. (XTM:JSH–96–44, JSH/4XQ).

9. *KCODE Photons:* Photon generation is turned off during KCODE settle cycles. (X–6:JSH–95–175, DKP/JSH/4XP).

10. *KCODE Lifetimes:* All lifetimes computed in KCODE problems are now labeled as "prompt" lifetimes in the output. (X–6:JSH–95–175, DKP/JSH/4XP).

11. *PTRAC / Cell Flagging Conflict:* PTRAC was improperly placed for cell flagging problems. For this bug, $4 was awarded to Penny Haskins, Jack McKisson (Radiation Tech, FL) (X–6:GWM–184–95) (GWM/4XP).

12. *PIKMT:* PIKMT failed if any nuclide lacks gamma production. (X–6:JSH–95–171, GPE/JSH/4XP).

13. *DEC Alpha:* The MCNPC.ID FLOAT function must be an integer to prevent the DEC Alpha from crashing. For this bug, \$4 was awarded to Lynn Abbot, Virginia Tech. (X–6:GWM–94-656, GWM/4XP).

14. *Law 4/44 Scattering:* Neutron scattering laws 4 and 44 give an infinite loop when a discrete reaction is followed by a continuous expunged reaction. This error only affects new libraries not yet released to the public. For this bug, \$4 was awarded to Vladimir Mares, GSF. (X–6:JSH–94–776, JSH/4X0).

15. *Occasional HP Crashes:* The HP crashed in continue runs if the first tally had scores 1.0E-31 below the average source weight. For this bug, \$4 was awarded to Bert Pohl, LLNL. (X–6:JSH–93–695, JSH/4XK).

16. *Multitasking/KCODE/SSR Conflict:* The multitasking version would hang for KCODE and surface sources because a multitasking lock was not set in STARTP (X–6:JSH–94–143, RAF/4XK).

17. *PTRAC Writing Error:* The PTRAC file for SABRINA caused a crash for binary writes. (GWM/4XK).

18. *Bad XSDIR Files:* Temperatures and other data were read incorrectly if the data goes past column 80 in XSDIR files. For this bug, \$4 was awarded to Tom Jordan, EMPC. (X–6:JSH–94–28, 29, JSH/4XL).

19. *MGOPT/NONU Conflict:* It is now a fatal error for NONU cards to be in multigroup adjoint problems. (X–6:JSH–94–29, JCW/JSH/4XK).

20. *MGOPT/MT Conflict:* The $S(\alpha, \beta)$ thermal treatment is now turned off when running multigroup. (X–6:JSH–94–29, JCW/JSH/4XK).

21. *MGOPT/TTB/$S(\alpha, \beta)$ Conflict:* The thick-target bremsstrahlung model and $S(\alpha, \beta)$ thermal treatment are now turned off when running multigroup. (X–6:JSH–94–29, SPP/JSH/4XK).

22. *MGOPT/VOID Conflict:* Disabled multigroup cross sections (which cause a crash) when using the VOID card (X–6:JSH–94–29, JCW/JSH/4XK).

23. *N/P Importance Conflict:* Nonzero photon importances in cells with zero neutron importances could cause a crash and are now a FATAL error. (X–6:JSH–94–29, JCW/JSH/4XK).

24. *MGOPT/XS Conflict:* Multigroup cross sections on XS cards caused a crash. (X–6:JSH–94–29, JSH/4XK).

25. *DRXS Data:* DRXS ZZAAA.nn worked but DRXS ZZAAA crashed. The default DRXS cross sections are now the continuous-energy cross sections if no DRXS table is found. For this bug, \$4 was awarded to Tom Jordan, EMPC. (X–6:JSH–94–28, 29, JSH/4XK).

26. *Exponential Transform:* The exponential transform could underflow. For this bug, $4 was awarded to Tom Jordan, EMPC. (X–6:JSH–94–28, 29, JSH/4XK).

27. *Default/Specified ZAID Conflict:* ZZAAA and ZZAAA.nn requested in the same problem caused the last one specified not to be found in the data libraries. (X–6:JSH–94–29, GWM/JSH/4XK).

28. *Repeated Structures / Event Log Conflict:* The event log was wrong in some repeated structures problems and wrote the wrong cell number. (GPE/GWM/4XK).

29. *Missing Output on SUNs and Other Systems:* The output and tty file flushing capability added by Charles Rombough at the behest of ESH-6 in MCNP4A was disabled because it causes about half the machines MCNP runs on to choke, including the Convex, Sun Solaris, HP, and IBM RS/6000 AIX. For this bug, $4 was awarded to Kristen Larson, UCSD. (X–6:JSH–94–50, 755, JSH/4XN).

30. *SDEF WGT:* Large values for the SDEF WGT keyword caused overflow errors. (TEB/GWM/4XL).

31. *Field Length:* The field length on many workstations was printed as zero. See "*Print Storage Requirements*" among minor features, above. (X–6:RAF–94–82, X–6:JSH–94–101, RAF/JSH/4XL).

32. $< ctrl - c > p$ *Interrupt:* If the $< ctrl - c > p$ interrupt for on-line plotting was followed by an erroneous MCPLOT command, MCNP returned to transport. Now it gives back the plot prompt. (X–6:JSH–94–101, GWM/4XK).

33. *MCPLOT TFC:* The MCPLOT TFC P command failed. (X–6:RAF–94,82, X–6:JSH–94–101, RAF/JSH/4XL).

34. *HP Fission Product Trap:* HP workstations crashed when using Foster Fission products, 45117.90c and 46119.90c, because these data have a lower energy of$E < 1.E - 11 MeV$. Bill Sailor, LANL A-3. (XTM:JSH–94–95, 476, JSH/4XL).

35. *MT/XS Conflict:* $S(\alpha, \beta)$ cross sections on XS cards caused a crash. For this bug, $4 was awarded Heidi McIlwain, AECL-WL, Canada. (X–6:JSH–94–122, JSH/4XK).

36. *PVM/Plotting Conflict:* Multitask pointer initialization was corrected so that multitasking versions and PVM versions can do plots without crashing. For this bug, $4 was awarded to Joe Chiaramonte, Schlumberger, CT. (X–6:JSH–94–133, GWM /JSH /4XK).

37. *KCODE plots from MCTAL Files:* MCTAL KCODE tally plots failed when read from MCTAL files. For this bug, $4 was awarded to Nelson Hanan, ANL. (X–6:JSH–94–142, JSH/4XK).

38. *# / $ Conflict:* Column input failed with $ comments. For this bug, $4 was awarded to G. Bruce Wilkin, AECL-WL, Canada. (X–6:JSH–94–79, JSH/4XK).

39. *Color Geometry Plots:* Random red surface labels appeared in color geometry plots with geometry errors. (tk.55, GWM/4XK).

40. *PRDMP:* The 4th PRDMP entry (the maximum number of dumps on a RUNTPE) failed on a continue run. (JSH).

41. *Repeated Structures Sources:* Corrected and upgraded repeated structures sources (X–6:GWM–94–600, X–6:ELR–94–604, X–6:JSH–94–607, X–6:GWM–94–772) (GWM/4XO).

42. *DRXS Data:* Discrete reaction (DRXS) energies above and below the total energy in the cross-section table (caused by events such as rare fission) were problematic. For this bug, $4 was awarded to Ron Knief, Ogden Environmental. (X–6:RAF–94–550, X–6:JSH–94–589, RAF/JSH/4XN).

43. *Volume Calculator:* Overflows in the volume calculator were corrected. For this bug, $4 was awarded to Bert Pohl, LLNL. (X–6:JCC–94–492, JCC/4XN).

44. *TMP Card:* Zero temperatures on the TMP card caused a crash. (X–6:RAF–94–564, RAF/4XN).

45. *Master-Slave Detectors:* The detector diagnostics summary is corrected in the case of master-slave detectors. (X–6:JSH–94–513, JSH/4XN).

46. *Allow ENDF/B-VI Upscatter:* Crashes with some new ENDF/B-VI data are now avoided when there is nonphysical upscatter in the evaluations. (X–6:JSH–94–379, JSH/4XL).

47. *Multigroup Photons:* Multigroup photon problems (such as the BUGLE Library) can now be run with more than 16 groups by dynamically dimensioning the EBL and FEBL arrays and adjusting the photon production printout in coupled neutron-photon multigroup problems with separate photon libraries. (X–6:ELR–94–362, X–6:JSH–94–468, ELR/JSH/4XL).

48. *Plotting Crash:* A superfluous lost particle check in TRACK could crash color plots. (X–6:JSH–94–143, GWM/4XK).

49. *Plotting Statistical Quantities:* The history score *f(x)* limits needed to be reset for the MPLOT run-time plotting to work. (X–6:RAF–94–82, RAF/4XK).

50. *Occasional Convex Crashes:* The Convex crashed with blank comment statements. (REP/JSH/4XK).

F. Code Cleanup

1. Correctly print copyright notice. (XTM:JSH–96–107, JSH/4XQ).

2. Clean up double precision statements. (XTM:JSH-96–107, GWM/JSH/4XQ).

3. Residual references to the Once More Collided Flux Estimator (OMCFE) were eliminated. (XTM:JSH–96–84, HGH/4XQ).

4. Removed unnecessary code and superfluous messages for reading MCTAL files. (XTM:HGH–96–51, HGH/4XQ).

5. Three versions of ROTAS and ISOS were consolidated into one each, and 26 calls to UPLEV were eliminated by changing all arguments to ISOS, ROTAS, and UPLEV and calling UPLEV from inside ISOS and ROTAS. (X–6:JSH–94–313, JSH/GWM/4XL).

6. Moved the thermal treatment to a more logical place. Specifically, do not sample the collision target velocity for the free gas thermal treatment until a thermal collision occurs. Also, use the lab and relative energies consistently. These changes were set up in MCNP4A but not implemented until MCNP4B as a cleanup measure because they affect tracking. (X–6:JSH:REP–92–163, JSH/4XK).

7. The KCODE SRCTP is now written only when RUNTPE is written, not every minute. (JSH/4XK).

8. DBCN(20) now makes MCNP4B track MCNP4A, not MCNP4.2. (JSH/4XK).

9. Eliminated references to CTSS, COS, and CFTLIB. (JSH/4XK).

10. The Fortran standard is violated in MCNP4A for blank line delimiters in the input file, though this does not have any effect. (REP/JSH/4XK).

11. Eliminated superfluous code (X–6:JSH–94–120, FWB/JSH/4XK).

12. Eliminated spurious XS card warning messages. (X–6:JSH–94–29, JSH/4XK).

13. Corrected illegal subroutine arguments where a constant sent to a subroutine is treated as a variable. (X–6:JSH–94–120, FWB/JSH/4XK).

14. We now print PCDOS and LAHEY **define* options in Print Table 98 if applicable. (JSH/4XK).

15. We now conform to the two-character convention for local variables in routine SIMPLX. (JSH/4XK).

16. Two prints in the statistical analysis exceeded 132 columns. (X–6:JSH–94–143, RAF/JSH/4XK).

17. Eliminated a harmless nuisance overflow message on the Sun. (TEB/GWM/4XK).

G. Unresolved Problems

The following reported problems in LA–12839[3] have not been resolved. These are considered to be minor nuisance problems that cannot be addressed at current funding levels.

1. Electron transport fails with WWG.
2. NPS -1 fails with KCODE problems — the output is not printed correctly in some cases. (X–6:RAF–90–9).
3. Source card combination problem with volume distributed source (SB -21 only causes SP -21 and SI 0 1).
4. DD entry with continue runs crashes if not in initial input.
5. Problem with tallying on a surface that has been transformed with use of repeated structures.
6. Incorrect bias through cylindrical window with a spherically symmetric surface source (X–6:ECS–92–204).
7. Change the NEWCEL error "zero lattice element hit" to "exited finite lattice." (X–6:GWM–93–597).
8. SDEF WGT normalization error with KCODE. Do not use the WGT entry on an SDEF card in a KCODE run! (X–6:RAF–93–617).
9. TRCL of a KX (cone) surface with a +1 or−1 fails in repeated structures. (RRR).
10. MCPLOT BAR command appears to be order sensitive. It does not work if it is the first command but works if it is the last.
11. F8:P,E says photon (should say photon, electron) and F8:N,P says neutron (should say F8 photon because F8:N is always disabled).
12. Toroidal geometries with large major radius and small minor radius can have lost particles.
13. The Real world lat=1 will not plot lattice surfaces, but lat=2 (hex) will.
14. Tallies on TRCL surfaces are not allowed.
15. Question whether PWT card is used if WWN1:P is used.
16. DXTRAN with flagged-cell tallies - only flagged if parent particle departs the cell.
17. SDEF bug with FPOS for RAD and EXT.
18. Make F6:P,E a warning that energy deposition does not include the electron contributions.
19. The VOID card with cell entries may not be reliable (maybe it is only unreliable with SSR).

III. TEST SET MODIFICATIONS AND CODE COVERAGE

MCNP maintains a suite of test problems designed specifically to utilize as many lines in the code as possible. This process gives a greater chance of finding new bugs introduced through upgrades and feature additions, as well as any effects a new patch may have on other, unchanged parts of the code. Ideally, 100% coverage would be desirable, but it is almost unattainable. The most important job of the test set is to cover the transport physics. Our goal is to have a test set that will uncover any error or fault introduced to the code that would lead to an incorrect answer. We do not test interrupts, timing, plotting, and other features that do not affect accurate answers. We do not attempt to test plotting because of the difficulty of producing a test set and a set of templates that are portable across platforms and as small and compact as possible for ease of handling and installation time constraints. In the MCNP4XQ analysis, using a version of the code compiled without plotting, 1,648 of 22,984 total lines in MCNP were lines that we could not cover and that have no relation to the calculation of problem solutions. Of the remaining 21,336 lines of code, 94%, or 20,069 lines are covered by the new test set. The modifications of the test set have been grouped into these main categories:

- Additions to increase total test set coverage
- Additions to cover new features
- Additions to test new bug fixes
- Changes to facilitate output comparison
- Changes to reduce overall size of output
- Others

A. Added Coverage

Several additions were made from the identification of uncovered lines of code in MCNP. These were found mainly through the use of the test set coverage code previously documented (XTM:95–149, and XTM:95–186, XTM:95–187, XTM:95–200).

Geometry Overspecification. In two problems, inp01 and inp07, geometry was overspecified to increase coverage:

- inp01

  ```
  1     so  5
  ```

  to

  ```
  1     s 0 0 0 5
  ```

- inp07

```
1     kx 18 0.22
```

to

```
1     k/x 18 0 0 0.22
```

High-Energy ENDF/B-VI Physics. Some ENDF/B-VI high-energy reactions were not covered because no high-energy cross sections were included in testlib1. An oxygen high-energy cross section was included in testlib1 and xsdir, and was designated 8016.00c. Material 6 in inp07 was modified to include this cross section. Once the high-energy cross section was included in the problem, it no longer lost particles, leaving another portion of the code uncovered. This difficulty was remedied with the DBCN card. The problem was started at a later point in the pseudorandom number sequence, allowing the problem to retain the 4000 history length, and still lose the particles as before. The DBCN card added was:

```
dbcn 7j 77
```

Cross-Section Trailing Zeros. Material 1 in inp04 was modified from 92000 to 92000.0 to produce the warning message about trailing zeros being dropped from cross section.

DXTRAN Sphere in a MODE P Problem. Test problem inp16 was modified to a mode p problem in the last test set revision, but many of the cards retained the neutron designation. All of the cards in the input deck were modified to reflect a mode p problem. When this was tested, the problem terminated due to the tally cells inside and outside of dxtran sphere fatal error. Surface 9

```
9     s 5 5 3 .5
```

and cell 12

```
12    1 -.9   -9  imp:p=1  u=5
```

were added, as well as modifications to the dxtran card

```
dxt:n 0 0 0 0.05 0.1
```

to

```
dxt:p 30 5 3 0.6 0.9
```

to enable the problem to run with a dxtran sphere.

Fatal Transformation. The following modifications were made to inp20 to test the fatal transformation error message. A message block was added containing:

```
message:  fatal
```

and the bad transformation card

```
tr20  5 6 7  1 0 0  0 0 1  0 0 0
```

was added.

Auger Electron Production. Auger electron production was covered in MCNP4A but was lost in the Ron Brockhoff test set revision. This loss was due to the modifications done in inp08. Many new features were added by Brockhoff to inp08, and the time it took to run the problem increased as well. In order to reduce the run time, Ron decreased the number of particles that were run, thus eliminating auger electron production. In order to obtain auger production without increasing the running time of inp08, a new input deck was created, a stripped down copy of inp08 that would include auger production and run much faster than inp08. This is the new test problem inp29. It runs the original 30,000 particles, as well as taking some of the testing burden from inp08 by including the rssa= and fatal message block, and having capital letters interspersed throughout the input deck. Figure A contains inp29.

Print Table 180. Print Table 180, neutron weight-window generator bookkeeping summary, was not tested anywhere in the test set. The seventh entry of the wwg card in inp08 was modified to obtain this print table:

```
wwg   24 2 0 1E8 0 0
```

to

```
wwg   24 2 0 1E8 0 0 1
```

Simple Photon Physics. A cut:p card was added to inp04 to force simple photon physics:

```
cut:p .1 .01 .5 .2 .8
```

Neutron Analog Capture. The cut:n card was modified in inp05 to force neutron analog capture:

```
cut:n 2j .001 .0005
```

to

```
cut:n 2j  0 0
```

Photon Heating Tally. A photon heating tally card was added to inp17:

```
f16:p 6
```

Multigroup Reactions on FM Cards. To test multigroup reactions on an FM card, the FM card of inp17 was modified:

```
fm4 ((1 2 (102)(101))(1.0 -1 2 0.000502))
```

to

```
fm4 ((1 2 (102)(101))(1.0 -1 2 0.000502)) (-1 1 -1) (-1 1 -2 -4) &
     (-1 1 -3) (-1 1 -5) (-1 1 301)
fq4 m e
```

```
  mEssAgE:  rssA=rssA08 &
   fAtAl.

testprob29 -- ssr from testprob07; copy of inp08 to test auger production
1      0   12
2      0   -12 #3 #6 #7
3      0   -71 -1 2
6      8 -1.2   -9 -11 8   $ cArbOn dIsk
7      9 -1.2   -10 -11 9  $ AnOthEr cArbOn dIsk

1      cx 15
2      px 0
71     x 40 0
8      px 100
9      px 110
10     px 120
11     x   0 20   -10 20
12     sO 170

m8     6012.40c .9 26000.40c .1
m9     6012.40c .6  1001.0 .2  29000 .2
pIkmt 6012 0    1001 -1           $   pikmt essential for auger electron
      26000 1 102001 1            $     production.
ssr   nEw 71  psc 1
f4:p  6 7
f24:e 6 7
e0     .01 .1 1 10
prdmp 2j -1
prInt 130 140
Imp:p,E,n  0 1 3r
mOdE E n p
Esplt:E .5 .01 .5 .1 .5 1         $   esplt causes problem to run faster
nps  30000
phys:E 1000 0 0 1 1 1.2 .8 .1 .7  $   phys:e causes problem to run faster
```

Fig. 1. Test Problem 29 – inp29

B. New Features

Three input decks have been modified to test the new perturbation feature in MCNP. These are the lines added to inp02, inp11, and inp18:

- inp02

```
m3     5010.03d .250 5011.40c .750   $ enriched b-10 of .250
pert1:n  cell=1  mat=3
```

- inp11

```
pert1:n,p  cell=1  rho=-8.75   $ 5% increase in tally 4
```

- inp18

```
pert1:n  cell=42,141,40,149  rho=-1.50
```

C. Bug Fixes

Several changes have been introduced to the input decks to test bugs that have been reported and fixed. The features of the code that contained these bugs were undetected in the old test set because they were previously untested. These were the nlib, plib, elib bug, the FT SCD option bug, and the S(α,β) specification bug.

nlib, plib, elib. (XTM:96–84) Previous to the bug fix, the nlib, plib, or elib options did not work correctly. These options have now been introduced into inp02 through inp09:

- inp02

```
m1     5010.03d .196 5011.40c .804   $ natural boron
```

to

```
m1     5010.00 .196 5011.40c .804 nlib=03d  $ natural boron
```

and

```
m3     5010.03d .250 5011.40c .750   $ enriched b-10 of .250
```

to

```
m3     5010.0 .250 5011.40c .750 nlib .03d  $ enriched b-10 of .250
```

- inp03

```
m1    92238.50m 1
m2    6012.50m 1
m3    8016.50m 1
m4    1001.50m 2  8016.50m 1  92235.50m 3
```

to

```
m1    92238 1 nlib=.50m
m2    6012 1  nlib=50m
m3    8016 1
m4    1001 2  8016 1  92235 3 nlib .50m
```

- inp04

```
m1    92000.0 1 1000 3
c m1    plib=02p 92000 1  1000 3
```

to

```
m1    plib=02p 92000 1  1000 3
```

- inp05

```
m2    6012.40c .9944 26058.60c 1
```

to

```
m2    6012 .9944 26058.60c 1 nlib 40
```

and

```
m4    5010 .4707  6012.40c .1177
```

to

```
m4    5010 .4707  6012 .1177
```

- inp06

```
m1    6012.40c  1
m2    29000.02c 1
```

to

```
m1    6012.40c  1 nlib 60
m2    29000.02c 1 plib .01
```

- inp07

```
m5    26058.60c 1  8016.40c 1
```

to

```
m5    26058     1  8016.40c 1 nlib=.60 elib=.01 plib=02
```

- inp08

```
m8    6012.40c .9 26058.60c .1
m9    6012.40c .6  1001.60c .2  29000.02c .2
```

to

```
m8    6012 .9 26058.60c .1 plib 02 elib 01 nlib 40
m9    6012.40c .6  1001.60c .2  29000.00 .2 nlib .02c plib .02p elib .01e
```

- inp09

```
m1    92235.50d 1
```

to

```
m1    92235 1   nlib=50d
```

and

```
m3    8016.40c 1  7014.50d 1
```

to

```
m3    8016.40c 1  7014.000 1 nlib .50
```

FT SCD Option. The following modification was made to inp03:

```
fu24 6 73 74 75 77 78 79
```

to

```
fu24 73 74 75 79 78 77
```

The tally fluctuation chart is written by default for the first bin. Cell 6 was removed so that the tfc would be written on cell 73, in order for the correct situation to arise for the FT SCD option bug to occur.

S(α,β) Specification. When an S(α,β) library was written in several different ways in the same problem, the code could not correctly load the library. This bug was corrected and inp12 modified to test this:

```
mt3   lwtr.01
mt4   lwtr.01
mt5   lwtr.01
```

to

```
mt3   lwtr
mt4   lwtr.01
mt5   lwtr.01t
```

D. Modifications for Easier Template File Comparisons

In order to streamline the comparison of output to correct templates (testoutp.tar and testmctl.tar), several modifications have been made. In inp23, Russian roulette takes place which affects transmission to a DXTRAN sphere. It was thought that the introduction of a DD card with a suitable fixed criteria would alleviate this. This change did not fix the problem because it was found to be mostly machine dependent. When a fixed Russian roulette criteria is stipulated, the Russian roulette procedure incorporates a multiplication and division when assigning particle weight. The bin selection procedure contains a multiplication. On different platforms, these operations have the possibility of differing in the insignificant digits, thus causing almost arbitrary bin placement. This placement occurs in Print Table 150, the dxtran diagnostics table.

Another platform-dependent operation is the interpolation procedure at zero. On many platforms, a linear interpolate at zero produced a small number but not the exact value of zero. Problem 2 had a cosine interpolation to obtain a zero bin. In order to achieve the exact value of zero, this modification was introduced:

```
c1   -.8 8i 1 t
```

to

```
c1   -.8 3i 0 4i 1 t
```

The comment line in each of the test problems was modified. Previously, each problem began with a designation such as prob8, or Prob 10. These were uniformly modified to testprobXX, with XX being the problem numbers 01 – 29. When input files or output files are concatenated into a large file, a search for a particular problem is much easier due to uniformity of titles.

Another modification added for clarity of output comparison was made to the runprob file. Previously, the file comparisons were done with the diff utility with no options. The -b option was added to each diff utility operation to ignore trailing blanks (space and tab characters) and to treat other strings of blanks as equivalent.

E. Output Reduction

As modifications were continually incorporated into the test set, the corresponding output files increased accordingly. With the implementation of test10b, the size of the outp templates grew to over 5 MEG. In order to reduce the size of the outp templates, the number of print tables printed was reduced to the minimum, without affecting coverage. With the reduction of print tables, outp templates were reduced over 3 MEG in size down to 2.01 MEG. Appendix A shows the print table coverage before reduction, and Appendix B the resultant minimum print table usage.

F. Others

Multigroup Problems. Several changes made would fall in the other category. When the last modification was made, LA–12839, several of the problems were changed radically. Several problems were modified to multigroup. These problems included cards for features that did not apply to multigroup problems. In inp17, the MT card designating $S(\alpha, \beta)$ treatment was removed, as was the PIKMT card. The DRXS card was also dropped from the multigroup problem inp03. These options are covered elsewhere in the test set.

Multitasking. There were many changes to the runprobmt file for multitasking. Previously, nine of the 28 test problems were not run multitasked. This omission left a significant part of the code that was untested in a multitask environment. Appendix C contains a copy of the new runprobmt. The problems run sequentially were:

inp01 inp07 inp08 inp09 inp17 inp18 inp21 inp26 inp28

Of these, the only problem that cannot justifiably be run multitasked is inp18, due to the fact that the new source overwrites the old. Therefore, inp18 is the only problem in the new test set which is run sequentially. These were the modifications for the other eight problems:

- inp01 – Problem inp01 was incompatible with multitasking because of the ptrack, eventlog, and debug options in the problem. In the new runprobmt, it is run tasks 4 with the fatal option. It produces large output diff files due to the eventlog feature, but otherwise tracks the sequential output.

- inp07 – Initially, inp07 was run sequentially only because it writes a surface source read file for other problems to use. In the new runprobmt, it is run first sequentially to produce the ssr file for later use; then is run multitasked. Because of ssw multitask incompatibility, it is run tasks 4 with the fatal option.

- inp08 – Problem inp08 uses the ssr file produced by the sequential run of inp07. In the new runprobmt, it is run both sequentially and tasks 4. In the multitasked run, it will produce large diff files, not only in the outp, but the mctal files, signifying that it does not track in the multitasked run. This area will have to be explored. As of now, there is a note in the runprobmt file indicating that large diff files are produced, and that this problem is being analyzed for further study.

- inp09 – Problem inp09 is a surface source write problem similar to inp07 and is run both sequentially to produce the ssr file, and tasks 4 with the fatal option.

- inp17 – Problem inp17 reads a source tape from inp09 and is run in the new runprobmt with tasks 4.

- inp21 – Problem inp21 is a ssw problem similar to inp07 and inp09 and is run both sequentially, to produce the ssr file, and tasks 4 with the fatal option.

- inp26 – Problem inp26 reads a runtpe and wssa file from inp09. It is run first sequentially, reading from the sequential version of inp09; then it tasks 2 with the fatal option, reading from the multitasked run of inp09. It is run at only tasks 2 so that the number of processors is less than the original run of 4 on inp09.

- inp28 – Problem inp28 was increased from sequential to tasks 4.

- Note: Problem inp29 is a virtual copy of inp08; therefore, it is run both sequentially and tasks 4. A note is included in the runprobmt file at inp29 which repeats the warning noted at inp08.

G. Coverage

The preliminary results obtained from the test coverage code package referenced above were:

```
Test Set Coverage

    The total number of lines in MCNP is     22984

    The number of lines entered is           20063

    The coverage is                         0.8729
```

An examination of the 2921 lines uncovered revealed 33 additional lines that were covered, and 1294 lines of code that were determined to be portions of the code that cannot be covered in a test set of this type. The breakdown of these 1294 lines is found in Table I. This brings the final coverage fraction to 0.9253.

Comparison to LA–12839. Ron Brockhoff reports 97% coverage in LA–12839. Table II compares the numbers in this report against his numbers. Table II shows that MCNP4XQ contains 1,930 additional lines of code compared to MCNP4XK in LA–12839. In LA–12839, 3,214 lines were deducted as being uncoverable in the test set. In MCNP4XQ, only 1,294 were found to be so. In the new test set code coverage package, more stringent criteria were applied to the lines of code that are deemed uncoverable. Furthermore, in LA–12839 goto statements could not be tracked and were included in the 3,214 figure. These are included in the MCNP4XQ figures. There were an additional 354 goto statements included in the uncovered lines of the MCNP4XQ analysis. When these were added to the number of lines deemed uncoverable, the final value of 1,648 is obtained. This figure increases coverage to 94.06%, or 2.66% less than in LA–12839. The MCNP4XQ analysis found that 20,069 lines of code were entered by the test set, an increase of 2,814 over the 17,255 covered in LA–12839. This represents a net increase of 884 line of code covered over and above the additional 1,930 lines added by the upgrade from MCNP4XK to MCNP4XQ.

TABLE I. LINES EXCLUDED FROM TESTING

Code Features	Lines
Plotting	453
Error Print	330
Expire	189
User Supplied	78
dbcn(20)	61
fshort	43
Spare	38
Interrupts	37
Code Development	25
Timing	18
Multitasking	13
cfs fetch	9
TOTAL	1294

TABLE II. COMPARISON WITH LA–12839

MCNP4XQ	Lines	LA–12839	Difference
22,984	Total	21,054	1,930
1,648	Subtracted	3,124	
21,336	Difference	17,840	
20,069	Covered	17,255	2,814
94.06	%	96.72	
Net Increase			884

IV. CONCLUSIONS

The differences between MCNP4B and MCNP4A are not to be found in the MCNP4B manual; they are summarized here. These differences consist of 11 major new features, 13 minor new features, 14 significant error corrections, 50 minor error corrections, and 17 cleanup corrections.

Further, the MCNP test set has been significantly upgraded since LA–12839, 8/1/94, intermediate MCNP version MCNP4XM. The updated test set covers an additional 2,814 lines more than the old set in LA–12839. Template size has been reduced by about half.

Although MCNP4B is not yet frozen, fewer and fewer changes will be made from now until the final release date. Everything herein is applicable to intermediate version MCNP4XQ released April 8, 1996. Only additional bug corrections and the addition of the AVATAR automatic variance reduction capability are expected between MCNP4XQ and the final version of MCNP4B.

REFERENCES

1. J. F. Briesmeister, Ed., "MCNP4A—A General Monte Carlo N-Particle Transport Code," Los Alamos National Laboratory report LA–12625–M (November 1993).

2. H. M. Abhold and J. S. Hendricks, "MCNP Software Quality Assurance Plan," Los Alamos National Laboratory report LA–13138 (April 1996).

3. R. C. Brockhoff and J. S. Hendricks, "A New MCNP Test Set," Los Alamos National Laboratory report LA–12839 (September 1994).

4. G. W. McKinney and J. L. Iverson, "Verification of the Monte Carlo Differential Operator Technique for MCNP," Los Alamos National Laboratory report LA–13098 (February 1996).

Appendix:

A. Test10b Print Table Usage

B. Test14 Print Table Usage

C. New RUNPROBMT File

D. Test Problem Summary

Appendix A: Test10b Print Table Usage

Print Table	Test Problem 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
10	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•					•	•	•				•	•	•
20 neutron						•		•																					
photon								•																					
electron								•																					
30	4	4	3	4	2	6	2	8	2		6		5	2	2		6	•			2	2	6				•	•	2
35	•																												
40	•	•	•	•	•	•	•	•	•	•	•		•	•	•		•	•			•	•	•				•	•	•
50 cell vols and masses	•	•	•	•	•	•	•	•	•	•	•		•	•	•		•	•		•		•	•				•	•	•
surface areas	•	•	•	•	•	•	•	•	•	•	•		•	•	•		•	•		•		•	•				•	•	•
tally seg. a, v, or m										•			•																
60	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•
62						•								•			•						•						
70 surfaces	•	•	•	•	•	•	•	•	•		•		•	•	•	•	•	•		•		•	•				•	•	•
periodic bound. cond.																•													
72	•	•			•	•	•	•	•		•			•	•			•									•		•
85				2				2		4										•		6							2
90																		•											
98						•											•											•	
100	•	•	•	•	•	•	•	•	•	•		•		•	•	•	•	•	•	•	•	•	•	•			•	•	•
102											•	•						•											
110	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•			•	•	•	•
120 neutron								•																				•	
photon								•													•								
electron																							•						
126 neutron	4	2	•		•	•	•	•	•	•	•	•	•	•	•		•	•	•					•	•	•	•	•	•
photon				•				•		•	•					•	•			•	•	•	•						•
electron								•												•			•						•
128 neutron														•	•		•	•											
photon																•	•												
electron																													

Test10b Print Table Usage (cont.)

	Test Problem																												
Print Table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
130 neutron external	4	2	•		•	•	•	•	•	•	•		•	•	•		•	•								•	•	•	•
variance reduction	4	2	•		•	•	•	•	•	•	•		•	•	•		•	•								•	•	•	•
physical	4	2	•		•	•	•	•	•	•	•		•	•	•		•	•								•	•	•	•
photon external				•				•		•	•						•				•	•	•						•
variance reduction				•				•		•	•						•				•	•	•						•
physical				•				•		•	•						•				•	•	•						•
electron external								•															•						•
variance reduction								•															•						•
physical								•															•						•
140 neutron	4	2	•		•	•	•	•	•	•	•			•	•		•	•								•	•	•	•
photon				•				•		•	•						•				•	•							•
electron																													
150 neutron		2									•																		
photon				•												•							•						
electron																													
160	16	14	3	4	2	6	2	3	2	2	10		4	2	2		6	2			2	2	5	•	•	2	•	•	2
161	16	14	3	4	2	6	2	3	2	2	10		4	2	2		6	•			2	2	5	•		2	•	•	2
162 cumulative tally	16	14	3	4	2	6	2	3	2	2	10		4	2	2		6	•			2	2	5			2	•	•	2
cum. unnormed tally	16	14	3	4	2	6	2	3	2	2	10		4	2	2		6	•			2	2	5			2	•	•	2
170 source distribution	4	2	•		•	•	•				•			•	•	•					•		•					•	
ssr summary								•														•					•		•
175									•								•	•						•					
178																	•									•			
180 neutron																													
photon																													
electron																													
190 neutron								•				•																	
photon								•																					
electron								•																					
198																												•	
200								•				•																	

Appendix B: Test14 Print Table Usage

	Test Problem																											
Print Table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
10	•	•					•									•											•	•	
20 neutron								•																					
photon								•																					
electron								•																					
30	4			4							6		5					•	2									•	
35	•																												
40											•																	•	
50 cell vols and masses										•																		•	
surface areas										•																		•	
tally seg. a, v, or m										•																			
60	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•
62						•								•			•						•						
70 surfaces																•												•	
periodic bound. cond.																•												•	
72		•													•														
85																				•									
90																		•											
98																												•	
100	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•			•	•	•
102												•						•											
110																		•										•	
120 neutron																												•	
photon																					•								
electron																							•						
126 neutron	4	2	•		•	•	•	•	•	•	•	•	•	•	•		•	•	•					•	•	•	•	•	•
photon				•				•		•	•					•	•			•	•	•	•						•
electron								•												•			•						•
128 neutron														•	•		•												
photon																•	•												
electron																													

Test14 Print Table Usage (cont.)

	Test Problem																												
Print Table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
130 neutron external																												•	•
variance reduction																												•	•
physical																												•	•
photon external																							•						•
variance reduction																							•						•
physical																							•						•
electron external																							•						•
variance reduction																							•						•
physical																							•						•
140 neutron																												•	•
photon																													•
electron																													
150 neutron		2									•																		
photon				•												•							•						
electron																													
160				4				3					4		2			2					•		•			•	
161				4				3					4		2			•					•					•	
162 cumulative tally				4				3					4		2			•										•	
cum. unnormed tally				4				3					4		2			•										•	
170 source distribution		2				•										•					•							•	
ssr summary																											•		
175									•								•	•						•					
178																										•			
180 neutron								•																					
photon								•																					
electron								•																					
190 neutron								•				•																	
photon								•																					
electron								•																					
198																												•	
200								•				•																	

Appendix C: New RUNPROBMT File

```
#! /bin/sh
# script to test ./mcnp  multitask version.
set -x
./mcnp tasks 4 name=inp01 fatal.
diff -b inp01m mctl01 > difm01
diff -b inp01o outp01 > difo01
rm -f inp01r
./mcnp name=inp02 tasks 4 fatal.
diff -b inp02m mctl02 > difm02
diff -b inp02o outp02 > difo02
rm -f inp02r
     ./mcnp tasks 4 name=inp03
diff -b inp03m mctl03 > difm03
diff -b inp03o outp03 > difo03
rm -f inp03r
./mcnp name=inp04 tasks 4
diff -b inp04m mctl04 > difm04
diff -b inp04o outp04 > difo04
rm -f inp04r
./mcnp name=inp05 tasks 4
diff -b inp05m mctl05 > difm05
diff -b inp05o outp05 > difo05
rm -f inp05r
./mcnp name=inp06 tasks 4
diff -b inp06m mctl06 > difm06
diff -b inp06o outp06 > difo06
rm -f inp06r
./mcnp name=inp07
diff -b inp07m mctl07 > difm07
diff -b inp07o outp07 > difo07
rm -f inp07r
./mcnp in=inp07 name=inp07a tasks 4 fatal
diff -b inp07am mctl07 > difm07a
diff -b inp07ao outp07 > difo07a
rm -f inp07ar
#
#  inp08 is run both sequentially and multitasked.
#  A very large diff will be created for both the
#  mctal and outp files of the multitasked run
#  (difm08a and difo08a).  This discrepancy has
#  been noted and is being analyzed.
#
./mcnp name=inp08 rssa=inp07w
diff -b inp08m mctl08 > difm08
diff -b inp08o outp08 > difo08
rm -f inp08r
./mcnp in=inp08 name=inp08a rssa=inp07w tasks 4 fatal
diff -b inp08am mctl08 > difm08a
diff -b inp08ao outp08 > difo08a
rm -f inp08ar
./mcnp name=inp09 tasks 1
diff -b inp09m mctl09 > difm09
diff -b inp09o outp09 > difo09
```

```
./mcnp in=inp09 name=inp09a tasks 4 fatal.
diff -b inp09am mctl09 > difm09a
diff -b inp09ao outp09 > difo09a
./mcnp name=inp10 tasks 4
diff -b inp10m mctl10 > difm10
diff -b inp10o outp10 > difo10
rm -f inp10r
./mcnp name=inp11 tasks 4
diff -b inp11m mctl11 > difm11
diff -b inp11o outp11 > difo11
rm -f inp11r
./mcnp name=inp12 tasks 4
diff -b inp12m mctl12 > difm12
diff -b inp12o outp12 > difo12
rm -f inp12r
./mcnp name=inp13 tasks 4
diff -b inp13m mctl13 > difm13
diff -b inp13o outp13 > difo13
rm -f inp13r
./mcnp name=inp14 tasks 4
diff -b inp14m mctl14 > difm14
diff -b inp14o outp14 > difo14
rm -f inp14r
./mcnp name=inp15 tasks 4
diff -b inp15m mctl15 > difm15
diff -b inp15o outp15 > difo15
rm -f inp15r
./mcnp name=inp16 tasks 4
diff -b inp16m mctl16 > difm16
diff -b inp16o outp16 > difo16
rm -f inp16r
cp inp09s srctp17
./mcnp name=inp17 tasks 4 s=srctp17
diff -b inp17m mctl17 > difm17
diff -b inp17o outp17 > difo17
rm -f inp17r srctp17
# new source overruns old - cannot multitask
./mcnp name=inp18
diff -b inp18m mctl18 > difm18
diff -b inp18o outp18 > difo18
rm -f inp18r
./mcnp name=inp19 tasks 4
diff -b inp19m mctl19 > difm19
diff -b inp19o outp19 > difo19
rm -f inp19r
./mcnp tasks 4 name=inp20
diff -b inp20m mctl20 > difm20
diff -b inp20o outp20 > difo20
rm -f inp20r
./mcnp name=inp21
diff -b inp21m mctl21 > difm21
diff -b inp21o outp21 > difo21
rm -f inp21r
```

New RUNPROBMT File (cont.)

```
./mcnp in=inp21 name=inp21a tasks 4 fatal
diff -b inp21am mctl21 > difm21a
diff -b inp21ao outp21 > difo21a
rm -f inp21ar
./mcnp name=inp22 rs=inp21w tasks 4
diff -b inp22m mctl22 > difm22
diff -b inp22o outp22 > difo22
rm -f inp22r
./mcnp name=inp23  tasks 4 fatal.
diff -b inp23m mctl23 > difm23
diff -b inp23o outp23 > difo23
rm -f inp23r
./mcnp name=inp24 tasks 4
diff -b inp24m mctl24 > difm24
diff -b inp24o outp24 > difo24
./mcnp name=inp25 tasks 3 run=inp24r C
diff -b inp25m mctl25 > difm25
diff -b inp25o outp25 > difo25
rm -f inp24r inp25r
./mcnp name=inp26 wss=inp09w tasks 1 run=inp09r CN
diff -b inp26m mctl26 > difm26
diff -b inp26o outp26 > difo26
rm -f inp09r
./mcnp in=inp26 name=inp26a wss=inp09aw tasks 2 run=inp09ar fatal CN
diff -b inp26am mctl26 > difm26a
diff -b inp26ao outp26 > difo26a
rm -f inp09ar
./mcnp name=inp27 rss=inp09w tasks 4
diff -b inp27m mctl27 > difm27
diff -b inp27o outp27 > difo27
rm inp27r
./mcnp name=inp28 tasks 4
mv ex5a.out inp28o
rm -f ex5a.run
diff -b inp28m mctl28 > difm28
diff -b inp28o outp28 > difo28
#
#  Since inp29 is a virtual copy of inp08, inp29
#  is run both sequentially and multitasked.  A
#  very large diff will be created for both the
#  mctal and outp files of the multitasked run
#  (difm29a and difo29a).  This discrepancy has
#  been noted and is being analyzed.
#
./mcnp name=inp29 rssa=inp07w
diff -b inp29m mctl29 > difm29
diff -b inp29o outp29 > difo29
rm -f inp29r
./mcnp in=inp29 name=inp29a rssa=inp07w tasks 4
diff -b inp29am mctl29 > difm29a
diff -b inp29ao outp29 > difo29a
rm -f inp29r
```

Appendix D: Input Summary by Card

Input Card Mnemonic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Problem Type Card																													
mode n							•	•		•	•	•					•											•	•
mode p				•				•		•	•					•	•			•	•	•	•						•
mode e								•												•			•						•
Geometry Cards																													
vol									•			•															•		
area								•				•																	
u														•	•	•	•	•						•					
trcl														•															
lat															•	•	•	•						•					
fill														•	•	•	•	•						•					
tr									•					•					•	•									
Variance Reduction Cards																													
imp:n	•	•	•			•	•		•	•	•		•	•	•		•	•	•					•			•	•	•
imp:p				•						•						•				•	•	•	•						•
imp:e																				•	•	•	•						•
pwt											•																		
ext						•																							
vect						•																							
fcl						•								•			•						•						
wwe								•				•																•	
wwn								•				•																•	
wwp						•		•				•																•	
wwg								•				•																	
wwge								•				•																	
pd		•		•																									
dxc		•		•																									
bbrem																							•						
Source Specification Cards																													
sdef	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•			•	•	•		•					•	
si	•	•	•		•	•	•		•	•	•	•		•	•	•							•					•	
sp	•	•	•	•	•	•	•		•	•	•	•		•	•	•							•					•	
sb	•	•	•			•	•			•			•	•							•		•						
ds			•		•	•	•									•													
sc	•	•	•				•														•								
ssw							•		•												•								
ssr								•														•					•		•
kcode									•								•	•						•	•	•			
ksrc																	•							•					

Input Summary by Card (cont.)

Input Card Mnemonic	Test Problem 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Tally Specification Cards																													
f1	•	•			•	•					•								•	•	•								
f2		•				•	•						•		•	•													
f4		•	•	•	•	•		•	•	•	•	•	•	•	•		•	•	•				•				•	•	•
f5	•	•		•		•		•			•					•	•												
f6				•				•								•	•			•			•	•					
f7							•		•					•			•												
f8								•									•			•		•	•						
*								•									•		•	•			•						
fc	•	•									•	•	•					•	•										
e	•	•	•	•		•	•	•	•		•	•				•		•	•	•	•	•					•	•	•
t	•	•		•		•																							
c	•	•				•																							
fq	•	•	•	•	•	•		•	•	•	•	•	•	•		•	•	•	•	•	•		•				•	•	
fm											•	•					•	•	•				•						
de				•		•							•																
df				•		•							•																
em	•											•																•	
tm	•																												
cm	•																												
cf				•			•																						
sf						•	•																						
fs					•					•			•																
sd							•				•			•	•	•		•	•				•	•					
fu		•	•																•										
tf		•																											
dd		•		•				•													•	•	•						
dxt		•		•							•					•							•						
ft		•	•	•															•	•	•		•					•	
Material Specification Cards																													
m	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•
drxs					•		•		•			•		•	•									•					
totnu														•															
nonu			•						•															•			•		
awtab	•																												
xs																			•										
void								•					•																
pikmt								•																					•
mgopt			•													•	•		•									•	

Input Summary by Card (cont.)

Input Card	Test Problem																												
Mnemonic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Energy and Thermal Cards																													
phys:n	•	•			•					•		•					•											•	
phys:p				•						•						•						•	•						
phys:e								•														•	•						•
esplit						•		•																					•
tmp		•									•	•																	
thtme		•										•																	
mt											•	•						•						•					
Problem Cutoffs																													
cut:n	•		•		•	•	•				•	•		•														•	
cut:p				•												•				•	•	•	•						
cut:e																				•	•	•	•						
elpt																•					•	•	•						
nps	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•			•	•	•	•	•					•	•
ctme		•										•							•	•	•	•							
Peripheral Cards																													
prdmp	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•
lost							•																						
dbcn	•	•					•															•							
files																													
print	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				•	•	•
mplot																													
ptrac	•	•						•										•					•						
pert		•									•							•											
continue																									•	•			

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