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What's New with MCNP6.2 & Whisper-1.1

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What's New with MCNP6.2 & Whisper-1.1

- Introduction
- New General Features Relevant to NCS
- Changes in Nuclear Data Libraries
- Changes in MCNP6.2 Coding
- Whisper-1.1 Release
- Guidance for NCS Practitioners
- Verification-Validation

Introduction

- 2017 is the 70th anniversary of the first Monte Carlo code for particle transport
  - John von Neumann created the first MC code in 1947
  - Targeted the Eniac, actually ran in 1948
- 2017 is the 40th anniversary of the MCNP code
  - The roots of MCNP extend back to von Neumann's original MC code
- Recent RSICC releases of MCNP

MCNP5	– 2003-2013, R.I.P.
MCNP6.1	– 2013, production version
MCNP6.1.1	– 2014, same criticality, faster, beta features for DHS
MCNP6.2	– 2017, includes Whisper code & benchmarks

When? Any day now. Endless delays in completing documentation.

Would like to have the MCNP User Manual on the web, rather than a controlled publication

New General Features Relevant to NCS (1)

- **MCNP6.2 performance**
  - **1.5 – 2 times faster than MCNP6.1 for NCS applications**
  - **Slightly faster than MCNP6.1.1 and MCNP5-1.60**
  - **Reasons for speedups**
    - Hash-based cross-section lookup, with inline binary searches
    - Efficient checking for global options
    - Enhancements to parallel threading
- **Longer line-length for input files**
  - **Up to 128 characters per line** [80 character limit for previous 40 yrs]
  - **Can improve clarity of input files**
- **Longer filenames & command-lines**
  - **Filenames can have up to 256 characters**
  - **Command-line can have up to 4096 characters**
- **Logfile for installation & testing**
  - **Logfiles to document MCNP6.2 code installation & testing**
  - **Logfiles to document Whisper-1.1 installation & testing**

New General Features Relevant to NCS (2)

- **Analytic Criticality Benchmark Suite**
  - **Now using continuous-energy portions of MCNP6.2, not multigroup**
  - **Very important for verifying the overall criticality algorithms**
  - **Easy-to-use perl utilities for creating artificial cross-section ACE files**
    - simple_ace.pl, simple_ace_mg.pl

- **Whisper-1.1 is included with the MCNP6.2 release**
  - **Whisper-1.1 code**
  - **Utility scripts for ease-of-use**
    - whisper_mcnp.pl, whisper_usl.pl, mcnp_pstudy.pl
  - **1101 ICSBEP benchmark cases**
  - **Nuclear covariance data, in new ACE format**
  - **Documentation & SQA - 70 reports**

    overview, theory, user manual, release notes, applications
    nuclear covariance data, SQA, MCNP6 verification-validation,
    general references on adjoints/perturbation/sensitivity-analysis

Changes in Nuclear Data Libraries (1)

- **MCNP6.2 release includes ENDF/B-VII.1 nuclear data**
  - **All older data is also still included**
  - **MCNP6.2 & Whisper-1.1 installation takes ~45 GB of disk space**
    - ~37 GB is data – ACE files
    - ~ 5 GB MCNP6.2 – code, tests, V&V suites, Reference Collection
    - ~ 3 GB Whisper-1.1 – code, benchmarks, sensitivity catalog, covariances
- **ENDF/B-VIII.0 nuclear data targeted for release in December 2017**
  - **LANL Data Team is investigating web-based distribution, not DVDs**
- **2 updates:**
  - **New Listing of Available ACE Data**
  - **New default XSDIR file for MCNP6.2**
- **3 corrections for data errors, with new ACE files:**
  - **Revised Nuclear Data for Hydrogen**
  - **SiO_2 S(α,β) Thermal Scattering Data**
  - **Zirc-Hydride S(α,β) thermal scattering data at 1200K**

Changes in Nuclear Data Libraries (2)

- **New Listing of Available ACE Data**
  - Updated report listing all of the ACE datasets available with MCNP6.2
  - LA-UR-17-20709, in MCNP website Reference Collection
  - This reference should be used in place of previous listings to ensure that the proper ACE data files are used in NCS calculations.

- **New default XSDIR file for MCNP6.2**
  - The XSDIR file used by MCNP is a datafile containing available ACE files, with the preferred (default) files listed first.
  - MCNP5 and previous versions used a file named *xsdir*
  - MCNP6.1 and MCNP6.1.1 used a file named *xsdir_mcnp6.1*
  - MCNP6.2 uses a file named *xsdir_mcnp6.2*

  - While *the xsdir_mcnp6.2* file can be used with any of the MCNP6 versions, it should <u>not</u> be used with MCNP5, since the default thermal scattering treatment is continuous (which was not correctly handled by MCNP5).

Changes in Nuclear Data Libraries (3)

- **Revised Nuclear Data for Hydrogen**
  - **The ENDF/B-VII.1 ACE data files for hydrogen released with MCNP6.1 and MCNP6.1.1 did not include data for photon production.**
    - **BAD: ACE files 1001.80c through 1001.86c**
    - While (n,g) reactions were properly included in all relevant cross-sections, the specific data for the number and energy of photons produced in the (n,g) reactions was not included in those ACE files.
  - **Updated ACE files for hydrogen**
    - **NEW: ACE files 1001.90c through 1001.96c**
    - These files are identical to the previous hydrogen data files, except that the photon production data is included
    - These are the preferred hydrogen ACE files in *xsdir_mcnp6.2*
  - **LANL testing does not show any differences in results for any of the problems in the Criticality V&V Suites**
  - **Only coupled neutron-photon calculations would be affected**

Changes in Nuclear Data Libraries (4)

- **SiO_2 S(α,β) Thermal Scattering Data**
  - **SiO_2 S(α,β) thermal scattering data released with MCNP6.1 and MCNP6.1.1 was incorrect, due to errors in the ENDF/B-VII.1 data at the time**
    - **BAD: ACE files sio2.30t through sio2.36t**
  - **The ENDF/B-VII.1 errors were corrected, and the ACE files for SiO_2 S(α,β) thermal scattering data were regenerated.**
    - **NEW: ACE files sio2.10t through sio2.16**
    - These are the preferred SiO_2 S(α,β) ACE files in *xsdir_mcnp6.2*
- **Zirc-Hydride S(α,β) thermal scattering data at 1200K**
  - **ACE file for thermal scattering in hydrogen at 1200K released with MCNP6.1 and MCNP6.1.1 was incorrect.**
    - **BAD: ACE file h-zr.27t**
  - **The errors were corrected**
    - **NEW: ACE file h-zr.28t**

Changes in MCNP6.2 Coding (1)

- **General improvements in going from MCNP6.1 to MCNP6.2:**
  - **MCNP6.2 performance**
    - 1.5-2 times faster than MCNP6.1 for NCS applications
    - Slightly faster than MCNP6.1.1 and MCNP5-1.60
    - Reasons for speedups
      - Hash-based cross-section lookup, with inline binary searches
      - Efficient checking for global options
      - Enhancements to parallel threading
  - **Longer line-length for input files**
    - Up to 128 characters per line [80 character limit for previous 40 yrs]
    - Can improve clarity of input files
  - **Longer filenames & command-lines**
    - Filenames can have up to 256 characters
    - Command-line can have up to 4096 characters

Changes in MCNP6.2 Coding (2)

- In going from MCNP6.1 to MCNP6.2:
  - Important changes for developers & SQA:
    - Fortran compiler
    - Compliance with Fortran 2003 International Standard
    - Software Quality Assurance
  - Non-numeric changes:
    - Warning issued if the neutrons/cycle is too small
    - Removal of limit on boundary-list entries for cell descriptions
  - More than 300 bugs were fixed, but only 3 are relevant to NCS applications:
    - Continuous $S(\alpha,\beta)$ numerics
    - k-adjoint first k-effective estimate
    - Coincident surface treatment

Changes in MCNP6.2 Coding (3)

- **Fortran compiler**
  - **The production versions of MCNP6 have been compiled using the Intel Fortran compilers and the gcc compiler for C/C++ portions of the code.**
    - MCNP6.1 and MCNP6.1.1 were built using **Intel Fortran Version 12**
    - MCNP6.2 was built using Intel **Fortran Version 17**
- **Compliance with Fortran 2003 International Standard**
  - **MCNP6.2 source coding is now 100% compliant with the Fortran 2003 international standard.**
  - **In addition, standards-checking is always performed by the compilers for every build of MCNP6.2**
- **Software Quality Assurance**
  - **MCNP6.2, Whisper-1.1, the MCNP Reference Collection, and the MCNP data files are all maintained under strict SQA procedures.**
  - **All coding, data, and test problems are maintained using the *git* code management tools and the TeamForge configuration management suite for tracking all modifications, changes, and documents.**

Changes in MCNP6.2 Coding (4)

- **Warning issued if the neutrons/cycle is too small**
  - For the past 10 years, the MCNP developers have presented recommendations on "best practices" for NCS calculations in MCNP classes, conferences, and university classes.
  - One of the "best practices":
    - Always use at least 10,000 neutrons/cycle in NCS calculations
    - Avoids nonconservative k_{eff} bias from the renormalization that occurs each cycle in the numerical iterations
  - MCNP6.2 checks that the number of neutrons/cycle is 10,000 or greater, and issues a warning message if that condition is not true.
  - Example:

warning. Using <10k neuts/cycle can give significant renormalization bias.

Changes in MCNP6.2 Coding (5)

- **Removal of limit on boundary-list entries for cell descriptions**
  - **In defining cells (regions) in the MCNP input, part of the input is a list of bounding surfaces, with + or – to indicate sense and possible parentheses and union operators.**
    - Previously, an internal parameter *mlgc* defined the max length of the list
    - In very old versions of MCNP, the length of the surface list (including operators) was limited to 999 entries.
    - Over the years, this limit was raised occasionally, and was 9,999 in MCNP5-1.60, MCNP6.1, and MCNP6.1.1.
    - Nevertheless, a number of users had complex geometry where larger limits were needed.
  - **In MCNP6.2, this limit was entirely eliminated.**
  - **MCNP6.2 examines the problem specifications and dynamically determines the space required for handling the boundary-list information.**

Changes in MCNP6.2 Coding (6)

- **Continuous S(α,β) numerics**
  - **MCNP6.1 had a small, rare error dealing with continuous-energy S(α,β) data:**
    - For some S(α,β) datasets at the very lowest energies (typically 10^{-5}-10^{-4} eV), NJOY lumps together scattering probabilities smaller than 10^{-6}.
    - MCNP6.1 did not handle that properly. Fixed in MCNP6.1.1.
    - Insignificant impact on results, but some very minor differences in a few problems with thermal scattering using MCNP6.1 and MCNP6.1.1
  - **After the release of MCNP6.1.1 with the S(α,β) fix, additional problems were found with rare round-off errors for certain S(α,β) datasets - zr-h.20t and zr-h.30t. Would result in code crashes.**
    - In continuous-energy sampling for the exit energy, round-off problems led to improper cancellation and the square root of a negative number.
    - **For MCNP6.2, additional round-off checks were introduced, and if needed the sampling is performed by a robust method that avoids negative square roots.**
    - Since this round-off problem was extremely rare, the different robust method is only used if needed.
      - In nearly all cases, the previous method works correctly.
      - This hybrid approach was taken to avoid changing the random number usage for all MCNP problems. Only the rare problems affected by the round-off error use different random number sequences, hence verification-validation testing is unchanged except for a very few cases.

Changes in MCNP6.2 Coding (7)

- **k-adjoint first k-effective estimate**
  - **In the calculation of adjoint-weighted reactor kinetics parameters, an estimate of *Keff* for the previous block in the iterated fission probability method is needed**
    - As originally implemented, the block *Keff* estimate was initialized at the end of the block after the first adjoint-weighted tally scores were made.
    - Consequently, the first estimate of these tallies utilized *Keff* information from the inactive cycles introducing a small bias.
    - Shortly after the MCNP6.1.1 official release, the coding for this was fixed, with the block-estimate of *Keff* now initialized at the beginning of the block.
  - **This bug fix does give small changes in results for adjoint-weighted reactor kinetics parameters.**
    - However, this change is very small, generally much smaller than the statistics of the tallies computed.
    - In the case where a user is generally conservative when setting the number of inactive cycles, by discarding more cycles than necessary (even just a few), this bug fix has no impact on the quality of the results.

Changes in MCNP6.2 Coding (8)

- **Coincident surface treatment (1)**

  - **The *universe* and *fill* concepts were introduced into MCNP in the late 1980s.**

  - **When defining a cell in MCNP input, the cell can be filled with a universe rather than a single homogeneous material.**
    - We will refer to the cell being defined and filled as a ***container*** **cell**.
    - A **universe** is a collection of cells (tagged with the same *u=n* universe number *n*).

  - **The problem encountered with the original universe/fill treatment occurred when a bounding surface of one or more cells in a universe was coincident with one of the container bounding surfaces.**

  - **When this occurred, MCNP sometimes made a wrong decision on which surface a particle had hit (i.e., in a universe cell or the container cell), and lost particles or silent errors were the result.**

Changes in MCNP6.2 Coding (9)

- **Coincident surface treatment (2)**

  – **In the early 1990s, a "fix" for the coincident-surface problem was introduced, first appearing in the release of MCNP4C in 2000.**

    - Unfortunately, that fix was flawed. It relied on preprocessing the bounding surface data for all cells and only considered coincident planes
    - Did not account for possible rotations that can be specified for filling a container with a (rotated) universe.
    - Thus, if a universe was rotated on-the-fly during tracking when filling a container cell, then lost particles or silent errors could be produced.
    - By accident, the coincident-surface fix worked correctly for 0^{o} and 180^{o} rotations, but was incorrect for all other rotations.
    - There was also an absolute tolerance of 0.0001 cm used in the scheme for selecting the surface that was hit. (The tolerance could be changed by the *dbcn(9)* input entry.)

Changes in MCNP6.2 Coding (10)

- **Coincident surface treatment (3)**
  - **For MCNP6.2, the coincident surface treatment was revised.**
    - All planar surfaces are flagged as possibly coincident.
    - During tracking in a cell contained in a universe, the distances to the bounding surfaces at all universe levels are examined, and the minimum distance is retained.
      - Each distance has an associated level or depth, with level=0 the “real world,” level=1 the next deeper universe in the geometry hierarchy, level=2 next deeper, etc.
      - Then, to allow for round-off in the distance calculations, starting at the smallest depth or level (closest to 0), distances are examined in order of depth to see if they are within a relative tolerance of $\pm 10^{-6}$ from the minimum distance.
      - If so, that distance is the one selected, and the remaining distances are ignored.
        - » A relative tolerance of $\pm 10^{-6}$ is entirely plausible and consistent as an estimate of possible round-off in the distance calculations that are performed using 53-bit-precision IEEE standard arithmetic.
      - **Retaining the smallest distance (within the round-off tolerance) at the least-deep level is what is desired.**
        - » Note that this distance may actually be larger than the distance at a different (deeper) level, but is the correct logical choice given arithmetic round-off.
      - **This choice prevents the selection of an incorrect surface distance.**

Changes in MCNP6.2 Coding (11)

- **Coincident surface treatment (4)**
  - **The newly revised coincident-surface treatment is the default for MCNP6.2, with a default relative tolerance for distance round-off checking of 10^{-6}.**
  - **The older, flawed treatment can be used instead if desired, by setting *dbcn(100)* to a nonzero value.**

    The use of the *dbcn(100)* option to choose between old and new coincident-surface treatments is provided for a limited time, to permit users to run a problem either way for verification purposes. It is likely that this option will be removed in the next future release (after MCNP6.2).
  - **For either the new or old treatment, the default for checking distance round-off can be overridden by setting *dbcn(9)***
    - If the newer treatment is used, the *dbcn(9)* value is a **relative tolerance** for round-off checking. The default is $\mathbf{10^{-6}}$
    - If the older treatment is used, the *dbcn(9)* value is an **absolute distance** for round-off checking. The default is **0.0001 cm**

Changes in MCNP6.2 Coding (12)

- **Coincident surface treatment (5)**
  - It is unavoidable that some, but not all, problems that use the universe/fill capabilities will show different results with the new coincident-surface treatment versus the old one.
  - This is due to the different approaches to dealing with arithmetic round-off in the distance calculations.
  - The new coincident surface logic prevents errors when rotated fills are used and is the preferred treatment.
  - In our testing experience, both new and old treatments gave the same results within statistics for all problems that did not involve rotated fills.
  - For problems with rotated fills and coincident-surfaces, the new approach was correct, and the old approach was incorrect.
  - For problems that do not use universe/fill capabilities, these changes have of course no effect on results

Whisper-1.1 Release

- **Whisper-1.1 code** **(Linux, Mac, Windows)**
  - Upgrade from Whisper-1.0 in 2014 to Whisper-1.1 in 2016
  - During total & thorough code review, **no** bugs were found
  - General performance improvements (threading)
  - Support for 256-character filenames
- **Utility scripts for ease-of-use** **(Linux, Mac, Windows)**
  - whisper_mcnp.pl – setup & run MCNP6 for sensitivity-profile
  - whisper_usl.pl – run Whisper to get baseline USLs
  - mcnp_pstudy.pl – setup MCNP input files for parameter studies
- **Covariance data files**
  - Low-fidelity BLO 44-group data, in new ACE format
- **1101 ICSBEP benchmark cases**
  - MCNP input files
  - Catalog of sensitivity-profiles for every benchmark
- **Documentation - 70 reports -** overview, theory, user manual, release notes, applications, nuclear covariance data, SQA, MCNP6 verification-validation, general references on adjoints/perturbation/sensitivity-analysis

Guidance For NCS Practitioners (1)

- **NCS practitioners should be aware of the following items related to changes in MCNP6.2, relative to the previous versions MCNP6.1 and MCNP6.1.1:**
  - **MCNP6.2 includes all of the standard features for NCS calculations that have been available for the past 15 years, along with new features for sensitivity-uncertainty based methods for NCS validation.**
  - **Only a few minor bug-fixes or enhancements were made to MCNP6.2**
  - **MCNP6.2 was thoroughly verified against previous versions.**
    - Reference: **LA-UR-17-23822** in MCNP Reference Collection on website
    - In very many cases, results from MCNP6.2 will match exactly results from MCNP6.1 or MCNP6.1.1
    - In some cases results may differ but agree within combined statistical uncertainties.
  - **All things considered, MCNP6.2 results are as reliable or more reliable than any previous release of MCNP.**
  - **An immediate benefit of using MCNP6.2 (rather than MCNP6.1) is that the new version is typically 1.5-2 times faster.**

Guidance For NCS Practitioners (2)

- **NCS practitioners should be aware of the few instances where ACE data files were corrected and new versions released.**
  - Calculations involving **zirc-hydride S(α,β) data at high temperatures** should be checked to determine whether erroneous data were used.
  - **Coupled neutron-photon calculations** should be checked to determine whether they would be affected by the previous lack of **(n,g) photon production data for hydrogen**
  - Calculations involving **SiO_2 S(α,β) data** should be checked and possibly repeated

- **The coding changes to MCNP6.2 physics are relatively insignificant.**
  - Corrections to the S(α,β) thermal scattering numerics are generally negligible relative to problem statistics (or, in rare cases, prevent aborts).
  - Similarly, the changes to adjoint-weighting for computing kinetics parameters may result in small differences, generally negligible compared to problem statistics.

Guidance For NCS Practitioners (3)

- **The change to the MCNP6.2 geometry treatment to correctly handle coincident surfaces in problems with *universe/fill* features will produce different round-off in the geometry tracking.**
  - This will produce differences in results relative to previous versions, but those differences should be small relative to problem statistics, and are not a concern.
  - Any large differences that arise are an indication of previous (undetected) errors in older versions of MCNP.
  - If any such large differences are found, NCS practitioners should not hesitate to contact the MCNP developers for assistance in further diagnosing the differences.

- **It is standard practice for NCS work that only validated computer codes, data, and computer systems be used.**
  - In verifying and validating MCNP6.2, NCS practitioners should carefully consider and review the verification-validation work reported by the MCNP developers (**LA-UR-17-23822)**, as well as the updates to the ACE nuclear data libraries.

Guidance For NCS Practitioners (4)

- NCS practitioners are encouraged to install and test the new release of MCNP6.2, with a goal of adopting it as soon as practical.
- Note that the last version of MCNP5 was released in 2010, and MCNP6.1 was released in 2013.
- Due to resource limitations, versions of MCNP that are more than 5 years old are not supported by the MCNP Team at LANL.

MCNP6.2 & ENDF/B-VII.1 Verification-Validation

MCNP Verification & Validation Suites for Criticality

Verification Suites

- REGRESSION
  - 161 code test problems
  - Run by developers for QA checking
- VERIFICATION_KEFF
  - 75 analytic benchmarks (0-D and 1-D)
  - Exact solutions for k_{eff}
  - Past – multigroup,
    New – continuous-energy
- VERIFICATION_GENTIME
  - 10 benchmarks (analytic or comparisons to Partisn) for reactor kinetics parameters
- KOBAYASHI
  - 6 void & duct streaming problems, with point detectors, exact solutions
- Ganapol Benchmarks [in progress]
  - Exact, semi-analytic benchmark problems
  - Fixed source, not criticality
- Gonzales Benchmark [in progress]
  - Exact analytic benchmark with elastic scatter, including free-gas scatter

Validation Suites

- VALIDATION_CRITICALITY
  - 31 ICSBEP Cases
  - Too small a suite for serious V&V
  - Today, used for
    - Code-to-code verification, with real problems & data
    - Compiler-to-compiler verification, with real problems & data
    - Timing tests for optimizing MCNP coding & threading
- VALIDATION_CRIT_EXPANDED
  - 119 ICSBEP Cases
  - Broad-range validation, for developers
- VALIDATION_CRIT_WHISPER
  - 1101 ICSBEP Cases
  - Used with Whisper methodology for serious validation
  - Will be expanded, as time permits

Testing Methodology

- **Validation Suites**
  - **All calculations used ENDF/B-VII.1 cross-sections**
  - **Continuous S(alpha,beta) physics, not old discrete treatment**
    - **MCNP6.1 had a small, rare error in dealing with the continuous S(α,β) data:**
      - For some S(α,β) datasets at the very lowest energies (typically 10^{-5} – 10^{-4} eV), NJOY lumps together scattering probabilities smaller than 10^{-6}. MCNP6.1 did not handle that properly.
      - This problem was fixed in MCNP6.1.1 & MCNP6.2
      - **Insignificant impact on results, but should be some very minor differences for problems with thermal scattering between MCNP6.1 and later versions.**
- **Fortran Compilers**
  - **Intel-12 - MCNP6.1 & MCNP6.1.1, Intel-15,16,17 - MCNP6.2**
  - **Using different compilers always leads to minor differences due to roundoff**
  - **Roundoff differences due to the noncommutative and nonassociative nature of computer arithmetic, and the rearrangement of the order of operations by optimizing compilers.**
  - **Roundoff differences are not errors, but must be examined in detail**
- **Running strategy**
  - **All calculations performed with OpenMP threading, with 8-16 cpu-cores**
  - **Mac Pro, 12-core Xeon, 2 hyperthreads/core, OS X 10.9.5, 14 MCNP threads**
  - **Linux, 1 HPC node, 8 dual-core Xeons, Chaos linux, 16 MCNP threads**

MCNP6 Criticality Results vs Exact Results

Case	Name	Analytic keff	MCNP_Multigroup C/E-1	MCNP_Multigroup std		MCNP Continuous Energy C/E-1	MCNP Continuous Energy std	
01	PUa-1-0-IN	2.61290	-0 pcm	0		-0 pcm	0	
02	PUa-1-0-SL	1.00000	0	5		6	5	
03	PUa-H2O(1)-1-0-SL	1.00000	8	5	*	1	5	
04	PUa-H2O(0.5)-1-0-SL	1.00000	2	5		3	5	
05	PUb-1-0-IN	2.29032	-0	0		-0	0	
06	PUb-1-0-SL	1.00000	4	4		0	4	
07	PUb-1-0-CY	1.00000	-4	4	*	3	4	
08	PUb-1-0-SP	1.00000	6	4	*	6	4	*
09	PUb-H2O(1)-1-0-CY	1.00000	-3	4		5	4	
10	PUb-H2O(10)-1-0-CY	1.00000	5	4		5	5	
11	Ua-1-0-IN	2.25000	0	0		0	0	
12	Ua-1-0-SL	1.00000	6	4	*	-3	4	
13	Ua-1-0-CY	1.00000	4	4		3	4	
14	Ua-1-0-SP	1.00000	1	4		-5	4	*
15	Ub-1-0-IN	2.33092	0	0		0	0	
16	Ub-H2O(1)-1-0-SP	1.00000	-2	4		-1	4	
17	Uc-1-0-IN	2.25608	0	0		0	0	
18	Uc-H2O(2)-1-0-SP	1.00000	-1	4		0	4	
19	Ud-1-0-IN	2.23267	-0	0		-0	0	
20	Ud-H2O(3)-1-0-SP	1.00000	4	4		7	4	*
21	UD2O-1-0-IN	1.13333	-0	0		-0	0	
22	UD2O-1-0-SL	1.00000	3	2		0	2	
23	UD2O-1-0-CY	1.00000	-1	2		-5	2	**
24	UD2O-1-0-SP	1.00000	1	3		-4	2	**
25	UD2O-H2O(1)-1-0-SL	1.00000	2	2		-2	2	*
26	UD2O-H2O(10)-1-0-SL	1.00000	-5	2	**	1	2	
27	UD2O-H2O(1)-1-0-CY	1.00000	4	2	*	-1	2	
28	UD2O-H2O(10)-1-0-CY	1.00000	0	2		3	2	
29	Ue-1-0-IN	2.18067	0	0		0	0	
30	Ue-Fe-Na-1-0-SL	1.00000	-1	5		7	4	*
31	PU-1-1-IN	2.50000	0	0		0	0	
32	PUa-1-1-SL	1.00000	8	5	*	7	5	*
36	Ua-1-1-CY	1.00000	2	4		-3	4	
38	UD2Oa-1-1-IN	1.20559	0	0		0	0	
39	UD2Oa-1-1-SP	1.00000	-2	3		2	3	
40	UD2Ob-1-1-IN	1.22739	-0	0		-0	0	
41	UD2Ob-1-1-SP	1.00000	8	3	**	6	3	*
		RMS Differences	3 pcm	±3 pcm		3 pcm	±3 pcm	

1 pcm = 0.00001

Validation Rossi Alpha Test Suite Results

	Benchmark		MCNP5 1.60 ENDF/B-VII.0		MCNP6.1 ENDF/B-VII.0		MCNP6.1 & MCNP6.1.1 ENDF/B-VII.1		MCNP6.2 ENDF/B-VII.1	
	rossi-α	std	rossi-α	std	rossi-α	std	rossi-α	std	rossi-α	std
U233 Benchmarks										
Jezebel-233	-100	(1)	-108	(1)	-108	(1)	-107	(1)	-107	(1)
Flattop-23	-26.7	(5)	-30.2	(4)	-30.2	(4)	-29.8	(4)	-29.8	(4)
HEU Benchmarks										
Godiva	-111	(2)	-113	(1)	-113	(1)	-113	(1)	-113	(1)
Flattop-25	-38.2	(2)	-39.7	(2)	-39.5	(2)	-39.6	(2)	-39.5	(2)
Zeus-1	-0.338	(7)	-0.363	(2)	-0.363	(2)	-0.360	(2)*	-0.360	(2)
Zeus-5	-14.8	(1)	-10.8	(1)	-10.8	(1)	-10.7	(1)	-10.7	(1)
Zeus-6	-3.73	(5)	-4.14	(3)	-4.16	(3)	-4.11	(3)*	-4.10	(3)
IEU Benchmarks										
BIG TEN	-11.7	(1)	-11.8	(1)	-11.8	(1)	-11.7	(1)	-11.7	(1)
STACY-30	-0.0127	(3)	-0.0133	(3)	-0.0133	(3)	-0.0121	(3)***	-0.0121	(3)
STACY-46	-0.0106	(4)	-0.0104	(2)	-0.0104	(2)	-0.0106	(2)	-0.0106	(2)
Pu Benchmarks										
Jezebel	-64.0	(10)	-65	(1)	-65.1	(8)	-63.2	(7)**	-63.2	(7)
Flattop-Pu	-21.4	(5)	-21.0	(3)	-21.0	(3)	-20.2	(3)**	-20.2	(3)
THOR	-19.7	(10)	-20	(1)	-19.7	(7)	-20.6	(7)*	-20.6	(7)

Notes
- All results in 10^4 generations/second
- Color indicates type of diff, * indicates magnitude of diff:

compiler/hardware — * = diff > 1 std
nuclear data — ** = diff > 2 std
minor k-adjoint bug fix — *** = diff > 3 std

Summary

VALIDATION_CRITICALITY – 31 ICSBEP cases

	Mac OS X				Linux		
	match	Sab-fix	coinc r/o	compiler	match	Sab-fix	coinc r/o
mcnp6.1 (ref)							
mcnp6.1.1	30	1	-	-	30	1	-
mcnp6.2 old coinc sur	29	1	-	1	30	1	-
mcnp6.2 new coinc sur	27	1	2	1	28	1	2

VALIDATION_CRIT_EXPANDED – 119 ICSBEP cases

	Mac OS X – 12 cores			Linux – 16 cores		
	match	coinc r/o	speedup	match	coinc r/o	speedup
mcnp6.1 (ref)						
mcnp6.1.1	119	-	1.9	119	-	2.0
mcnp6.2 old coinc sur	119	-	1.9	119	-	2.2
mcnp6.2 new coinc sur	108	11	1.9	108	11	2.2

VALIDATION_CRITICALITY – Mac OS X - 2017-03-28

```
610_12_71 – 2013, mcnp6.1,   Intel-12, endf/b-vii.1
611_12_71 – 2014, mcnp6.1.1, Intel-12, endf/b-vii.1
621_17_71 – 2017, mcnp6.2,   Intel-17, endf/b-vii.1, with old coincident-surface treatment
620_17_71 – 2017, mcnp6.2,   Intel-17, endf/b-vii.1, with new coincident-surface treatment
```

	610_12_71_mac		611_12_71_mac		621_17_71_mac		620_17_71_mac		
	keff	std	deltak	std	deltak	std	deltak	std	Reason for diffs
					OLD coinc-sur		NEW coinc-sur		
U233 Benchmarks									
JEZ233	1.0000	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
FLAT23	0.9974	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
UMF5C2	0.9960	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
FLSTF1	0.9845	(11)	0.0000	(15)	0.0000	(15)	0.0000	(15)	
SB25	0.9997	(10)	0.0000	(14)	0.0000	(14)	0.0009	(14)	roundoff, coinc-sur
ORNL11	1.0018	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
HEU Benchmarks									
GODIVA	0.9988	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
TT2C11	1.0009	(8)	0.0000	(11)	0.0000	(11)	0.0000	(11)	
FLAT25	1.0034	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
GODIVR	0.9989	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
UH3C6	0.9957	(8)	0.0000	(11)	0.0000	(11)	0.0000	(11)	
ZEUS2	0.9976	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
SB5RN3	0.9945	(13)	0.0000	(18)	0.0000	(18)	0.0000	(18)	
ORNL10	1.0001	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)	
IEU Benchmarks									
IMF03	1.0019	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
BIGTEN	0.9952	(5)	0.0000	(7)	0.0000	(7)	0.0000	(7)	
IMF04	1.0082	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
ZEBR8H	1.0193	(5)	0.0000	(8)	-0.0011	(8)*	-0.0011	(8)*	roundoff, compiler
ICT2C3	1.0023	(7)	0.0012	(9)*	0.0012	(9)*	0.0012	(9)*	Sab-fix
STACY36	0.9981	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
LEU Benchmarks									
BAWXI2	1.0025	(5)	0.0000	(8)	0.0000	(8)	-0.0004	(8)	roundoff, coinc-sur
LST2C2	0.9960	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
Pu Benchmarks									
JEZPU	0.9990	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
JEZ240	0.9999	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
PUBTNS	0.9980	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
FLATPU	1.0004	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
THOR	0.9976	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
PUSH2O	1.0013	(8)	0.0000	(11)	0.0000	(11)	0.0000	(11)	
HISHPG	1.0121	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
PNL2	1.0050	(10)	0.0000	(14)	0.0000	(14)	0.0000	(14)	
PNL33	1.0068	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
Wall-clock:	19.6 min		11.8 min		11.8 min		11.7 min		
Threads:	12		12		12		12		
Rel. Speed:	1.00		1.66		1.66		1.67		

VALIDATION_CRITICALITY – Linux - 2017-04-07

610_12_71 – 2013, mcnp6.1, Intel-12, endf/b-vii.1
611_12_71 – 2014, mcnp6.1.1, Intel-12, endf/b-vii.1
621_17_71 – 2017, mcnp6.2, Intel-17, endf/b-vii.1, with old coincident-surface treatment
620_17_71 – 2017, mcnp6.2, Intel-17, endf/b-vii.1, with new coincident-surface treatment

	610_12_71_lin		611_12_71_lin		621_17_71_lin		620_17_71_lin		
	keff	std	deltak	std	deltak	std	deltak	std	Reason for diffs
U233 Benchmarks									
JEZ233	1.0000	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
FLAT23	0.9974	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
UMF5C2	0.9960	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
FLSTF1	0.9845	(11)	0.0000	(15)	0.0000	(15)	0.0000	(15)	
SB25	0.9997	(10)	0.0000	(14)	0.0000	(14)	0.0009	(14)	roundoff, coinc-sur
ORNL11	1.0018	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
HEU Benchmarks									
GODIVA	0.9988	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
TT2C11	1.0009	(8)	0.0000	(11)	0.0000	(11)	0.0000	(11)	
FLAT25	1.0034	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
GODIVR	0.9989	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
UH3C6	0.9957	(8)	0.0000	(11)	0.0000	(11)	0.0000	(11)	
ZEUS2	0.9976	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
SB5RN3	0.9945	(13)	0.0000	(18)	0.0000	(18)	0.0000	(18)	
ORNL10	1.0001	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)	
IEU Benchmarks									
IMF03	1.0019	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
BIGTEN	0.9952	(5)	0.0000	(7)	0.0000	(7)	0.0000	(7)	
IMF04	1.0082	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
ZEBR8H	1.0182	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
ICT2C3	1.0023	(7)	0.0012	(9)*	0.0012	(9)*	0.0012	(9)*	Sab-fix
STACY36	0.9981	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
LEU Benchmarks									
BAWXI2	1.0025	(5)	0.0000	(8)	0.0000	(8)	-0.0004	(8)	roundoff, coinc-sur
LST2C2	0.9960	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
Pu Benchmarks									
JEZPU	0.9990	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
JEZ240	0.9999	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
PUBTNS	0.9980	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
FLATPU	1.0004	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	
THOR	0.9976	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
PUSH2O	1.0013	(8)	0.0000	(11)	0.0000	(11)	0.0000	(11)	
HISHPG	1.0121	(5)	0.0000	(8)	0.0000	(8)	0.0000	(8)	
PNL2	1.0050	(10)	0.0000	(14)	0.0000	(14)	0.0000	(14)	
PNL33	1.0068	(7)	0.0000	(9)	0.0000	(9)	0.0000	(9)	

	610_12_71_lin	611_12_71_lin	621_17_71_lin	620_17_71_lin
Wall-clock:	18.9 min	10.2 min	9.6 min	9.6 min
Threads:	16	16	16	16
Rel. Speed:	1.00	1.86	1.97	1.97

MCNP6 – Performance History

Run Times for VALIDATION_CRITICALITY Suite on Various Computers

Computer	CPU Speed (GHz)	Mem. Speed (GHz)	Processors, Cores	MCNP Threads used	MCNP Version	Total Time (minutes)
MacBook 2010	2.7	1.1	1 - i7, 2 x 2 HT	4	mcnp6.1.1	88
MacBook 2013	3.0	1.6	1 - i7, 2 x 2 HT	4	mcnp6.1	62
				4	mcnp6.1.1	42
Mac Pro 2010	3.0	0.67	2 - Xeon, 4	8	mcnp6.1	44
				8	mcnp6.1.1	28
Windows 2012	2.7	1.3	2 - Xeon, 6	10	mcnp6.1.1	19
Mac Pro 2012	2.4	1.07	2 - Xeon, 4 x 2 HT	16	mcnp6.1.1	22
Mac Pro 2014	2.7	1.9	1 - Xeon, 12 x 2 HT	12	mcnp5-1.60	14
				12	mcnp6.1.1	14
				12	mcnp6.1.1	12 ⇐
				12	mcnp6.2	12 ⇐
HP Linux 2016	3.1	2.4	2 - Xeon, 12 x 2 HT	24	mcnp6.2	8 ⇐

MCNP6.2 preserves all performance improvements from MCNP6.1.1, and is much faster than MCNP6.1 & slightly faster than MCNP5

Runtimes are wall-clock for the entire suite of 31 problems, including cross-section I/O & output

VALIDATION_CRIT_EXPANDED – Mac OS X – 2017-04-11 (1)

```
610_12_71_mac    = mcnp6.1   + Intel 12 + endf/b-vii.1 + macosx
611_12_71_mac    = mcnp6.1.1 + Intel 12 + endf/b-vii.1 + macosx
621_17_71_mac    = mcnp6.2.0 + Intel 17 + endf/b-vii.1 + macosx, with old coincident-surface treatment
620_17_71_mac    = mcnp6.2.0 + Intel 17 + endf/b-vii.1 + macosx, with new coincident-surface treatment
```

	610_12_71_mac		611_12_71_mac		621_17_71_mac		620_17_71_mac		
	keff	std	deltak	std	deltak	std	deltak	std	
U233 Benchmarks									
u233-met-fast-001	1.0000	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-002-case-1	0.9983	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-002-case-2	1.0003	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-003-case-1	0.9995	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-003-case-2	0.9995	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-006	0.9984	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-004-case-1	0.9988	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-004-case-2	0.9956	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-005-case-1	0.9959	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-met-fast-005-case-2	0.9952	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-sol-inter-001-case-1	0.9845	(5)	0.0000	(7)	0.0000	(7)	0.0000	(7)	
u233-comp-therm-001-case-3	1.0034	(4)	0.0000	(5)	0.0000	(5)	-0.0006	(5)*	coinc r/o
u233-sol-therm-001-case-1	1.0010	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-sol-therm-001-case-2	1.0010	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-sol-therm-001-case-3	1.0007	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-sol-therm-001-case-4	1.0007	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-sol-therm-001-case-5	0.9996	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
u233-sol-therm-008	1.0016	(2)	0.0000	(2)	0.0000	(2)	0.0000	(2)	
LEU Benchmarks									
leu-comp-therm-008-case-1	1.0006	(2)	0.0000	(4)	0.0000	(4)	-0.0005	(4)*	coinc r/o
leu-comp-therm-008-case-2	1.0005	(2)	0.0000	(4)	0.0000	(4)	0.0002	(4)	coinc r/o
leu-comp-therm-008-case-5	1.0006	(2)	0.0000	(4)	0.0000	(4)	0.0004	(4)	coinc r/o
leu-comp-therm-008-case-7	1.0004	(2)	0.0000	(4)	0.0000	(4)	-0.0004	(4)	coinc r/o
leu-comp-therm-008-case-8	0.9997	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
leu-comp-therm-008-case-11	1.0007	(2)	0.0000	(4)	0.0000	(4)	0.0003	(4)	coinc r/o
leu-sol-therm-002-case-1	0.9994	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
leu-sol-therm-002-case-2	0.9964	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	

VALIDATION_CRIT_EXPANDED – Mac OS X – 2017-04-11 (2)

	610_12_71_mac		611_12_71_mac		621_17_71_mac		620_17_71_mac	
	keff	std	deltak	std	deltak	std	deltak	std
HEU Benchmarks								
heu-met-fast-001	0.9994	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-008	0.9962	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-018-case-2	0.9995	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-1	0.9949	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-2	0.9945	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-3	0.9989	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-4	0.9974	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-5	1.0012	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-6	1.0020	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-7	1.0019	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-028	1.0027	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-014	0.9977	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-8	1.0023	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-9	1.0023	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-10	1.0052	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-11	1.0094	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-003-case-12	1.0087	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-013	0.9975	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-021-case-2	0.9979	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-022-case-2	0.9976	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-012	0.9984	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-019-case-2	1.0069	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-009-case-2	0.9966	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-009-case-1	0.9977	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-011	0.9985	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-020-case-2	1.0006	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-004-case-1	1.0034	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-015	0.9947	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-fast-026-case-c-11	1.0032	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-comp-inter-003-case-6	0.9948	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)
heu-met-inter-006-case-1	0.9929	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-inter-006-case-2	0.9968	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-inter-006-case-3	1.0008	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-met-inter-006-case-4	1.0072	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
u233-comp-therm-001-case-6	0.9988	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)
heu-sol-therm-013-case-1	0.9985	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-sol-therm-013-case-2	0.9969	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-sol-therm-013-case-3	0.9939	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-sol-therm-013-case-4	0.9953	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
heu-sol-therm-032	0.9992	(2)	0.0000	(2)	0.0000	(2)	0.0000	(2)

VALIDATION_CRIT_EXPANDED – Mac OS X – 2017-04-11 (3)

	610_12_71_mac		611_12_71_mac		621_17_71_mac		620_17_71_mac		
	keff	std	deltak	std	deltak	std	deltak	std	
Pu Benchmarks									
pu-met-fast-001	0.9993	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-002	1.0003	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-022-case-2	0.9984	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
mix-met-fast-001	0.9998	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
mix-met-fast-003	1.0004	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-006	1.0001	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-010	0.9996	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-020	0.9983	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-008-case-2	0.9977	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-005	1.0019	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-025-case-2	0.9991	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-026-case-2	0.9987	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-009	1.0048	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-023-case-2	0.9994	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-018	0.9993	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-019	1.0004	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-024-case-2	1.0025	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-011	1.0000	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-021-case-2	0.9935	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-021-case-1	1.0047	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-met-fast-003-case-103	0.9990	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-comp-inter-001	1.0116	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
mix-comp-therm-002-case-pnl30	1.0002	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
mix-comp-therm-002-case-pnl31	1.0018	(4)	0.0000	(5)	0.0000	(5)	-0.0006	(5)*	coinc r/o
mix-comp-therm-002-case-pnl32	1.0020	(2)	0.0000	(4)	0.0000	(4)	-0.0003	(4)	coinc r/o
mix-comp-therm-002-case-pnl33	1.0063	(2)	0.0000	(4)	0.0000	(4)	-0.0001	(4)	coinc r/o
mix-comp-therm-002-case-pnl34	1.0045	(2)	0.0000	(4)	0.0000	(4)	0.0001	(4)	coinc r/o
mix-comp-therm-002-case-pnl35	1.0063	(2)	0.0000	(4)	0.0000	(4)	-0.0004	(4)	coinc r/o
pu-sol-therm-009-case-3a	1.0191	(2)	0.0000	(2)	0.0000	(2)	0.0000	(2)	
pu-sol-therm-011-case-16-5	1.0054	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)	
pu-sol-therm-011-case-18-1	0.9941	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-sol-therm-011-case-18-6	1.0005	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)	
pu-sol-therm-021-case-1	1.0053	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)	
pu-sol-therm-021-case-3	1.0043	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)	
pu-sol-therm-018-case-9	1.0026	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)	
pu-sol-therm-034-case-1	1.0007	(4)	0.0000	(5)	0.0000	(5)	0.0000	(5)	

VALIDATION_CRIT_EXPANDED – Mac OS X – 2017-04-11 (4)

	610_12_71_mac		611_12_71_mac		621_17_71_mac		620_17_71_mac	
	keff	std	deltak	std	deltak	std	deltak	std
IEU Benchmarks								
ieu-met-fast-003-case-2	1.0028	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-005-case-2	1.0024	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-006-case-2	0.9958	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-004-case-2	1.0075	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-001-case-1	1.0009	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-001-case-2	0.9999	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-001-case-3	1.0011	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-001-case-4	1.0015	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-002	0.9991	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
ieu-met-fast-007-case-4	1.0045	(2)	0.0000	(2)	0.0000	(2)	0.0000	(2)
mix-met-fast-008-case-7	1.0192	(2)	0.0000	(2)	0.0000	(2)	0.0000	(2)
ieu-comp-therm-002-case-3	1.0038	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
leu-sol-therm-007-case-14	0.9947	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
leu-sol-therm-007-case-30	0.9971	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
leu-sol-therm-007-case-32	0.9959	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
leu-sol-therm-007-case-36	0.9990	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
leu-sol-therm-007-case-49	0.9972	(2)	0.0000	(4)	0.0000	(4)	0.0000	(4)
Wall-clock:	301.2 min		158.7 min		156.0 min		156.4 min	
Threads:	12		12		12		12	
Rel. Speed:	1.00		1.90		1.93		1.93	

Conclusions

- **All current versions of MCNP6 – 6.1, 6.1.1, 6.2 – perform correctly for the 3 suites of analytic benchmarks & ICSBEP problems**
- **MCNP6 testing is performed very frequently for criticality problems during all MCNP code development**
  - New features for non-criticality problems are disallowed if they affect criticality results
  - Because it only takes 12 minutes to run the VALIDATION_CRITICALITY suite using threading, it is run daily or weekly during development
  - MCNP6 performance is also monitored, with corrections or optimization if criticality performance changes
- **There are no technical or correctness issues to delay switching to the latest version of MCNP6**
  - MCNP5 is no longer supported
  - Newer versions – can use continuous S(a,b) data (MCNP5 cannot)
  - Newer versions – better performance & use of computer resources
  - Newer versions – bug fixes (few, since neutronics is mature)
  - Newer versions – better support from developers