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MCNP6 Developments: A 2025-26 Year in Review

Michael E. Rising, XCP-3, LANL

2026 MCNP[®] User Symposium

August 24–26, 2026

LA-UR-26-XXXXX

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The Team



Roadmap

MCNP6 Today

- History

- MCNP6.3.2

- Nuclear Data Updates

Our Team, Products, and Programs

- Our Team

- Our Products

- Current Sponsors

The Last Year in Review

- MCNP6.3.2 and MCNP6.4 Code Efforts

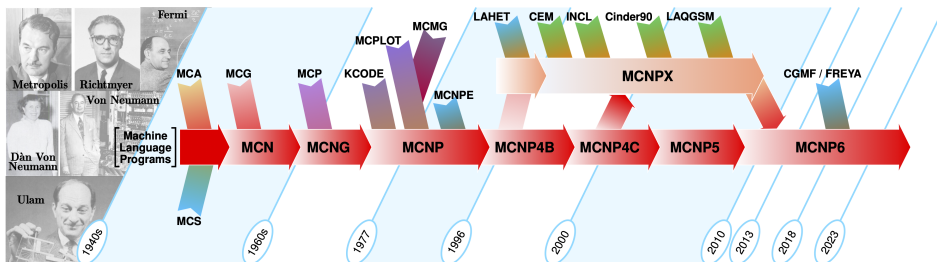
- Other Ongoing Efforts

MCNP6 Today



Release Timeline

Many MCNP[®] code versions and releases in 6 different decades with significant methods, algorithms, and codes developed prior to the first official version of the MCNP code in 1977



- ▶ MCNP6.1 released in July 2013
 - ▶ MCNP6.1.1 released in July 2014
- ▶ MCNP6.2 released in April 2018
- ▶ MCNP6.3 released in February 2023
 - ▶ MCNP6.3.1 released in May 2025

MCNP6.3.2 will be released in 2026

MCNP6.3.2 In Progress

- ▶ Purely a bugfix release.
- ▶ No new features or other general improvements.
- ▶ The user manual is already available on the website [here](#).
- ▶ The source code is frozen.
- ▶ Remaining work includes:
 - ▶ Bundling executables and packaging code
 - ▶ Running and documenting V&V results
 - ▶ Finalizing release notes
- ▶ An announcement to the community will be made when the code is released.

LA-UR-26-23119, Rev. 1

MCNP[®]

Code Version 6.3.2

Theory & User Manual

Document compiled from git hash 923abafdb on May 1, 2026.

This document cannot be made Section-508 compliant (accessible to persons with disabilities) at this time. If you need help accessing this document, please email mcnp_help@lanl.gov.



MCNP6.3.2 Code Changes: Bug Fixes (1/3)

- ▶ Fixed inconsistent, simultaneous use of tabular data and model physics for light ions.
- ▶ Fixed light-ion tabular data tallying inconsistencies related to tally multipliers, heating, and source-type FMESH tallies.
- ▶ Fixed thread-safety issue for FT LET tally scoring and fluence-to-dose conversions.
- ▶ Fixes related to the release of the [ENDF/B-VIII.1 ACE libraries](#).
 - ▶ Fixed an issue where ACE files that may generate a multiplicity exceeding 20 may cause memory corruption.*
 - ▶ Fixed an issue with outgoing photon distributions that appear to have more than 999 outgoing discrete lines.*
 - ▶ Note that errata files have been released on the Nuclear Data Team website that fixes this issue for the impacted isotopes.

* ***Timeframe: July 2025–July 2026***

MCNP6.3.2 Code Changes: Bug Fixes (2/3)

- ▶ Fixed errors related to Compton-induced fluorescence when using EPRDATA libraries.*
- ▶ Fixed an issue with tracking that could lead to memory corruption. The issue could, but is not guaranteed, to occur after the message `warning: laj overflow` is issued.*
- ▶ Fixed an issue where the combination of adjoint-weighted tallies (`KPERT` or `kinetics = yes` and/or `precursor = yes` on `KOPTS`) and MPI parallel execution would cause the results to differ from a non-MPI parallel calculation.*
- ▶ Fixed the CMake build system to better support the new `ifx` compiler.
- ▶ Fixed an input processing bug where the last element within a fully-specified lattice fill with a transformation would not be transformed.*

* ***Timeframe: July 2025–July 2026***

MCNP6.3.2 Code Changes: Bug Fixes (3/3)

- ▶ Fixed a bug where the heavy-ion particle velocity was not calculated/saved correctly. This would impact tallies that rely on the particle velocity (e.g., time bins).*
- ▶ Fixed a bug where perturbations (PERT) applied to photons give incorrect results when the material is specified isotopically.*
- ▶ Fixed an error in tallying of the elastic scattering cross section for fissile isotopes with thermal scattering treatment applied.*
- ▶ Added an error flag in MPI calculations to prevent the code from crashing with limited information.*

*** *Timeframe: July 2025–July 2026***

MCNP6.3.2 Documentation Updates

- ▶ All MCNP6.3.2 documents (will become) available on website
 - ▶ Release notes (TBD).
 - ▶ User and theory manual ([LA-UR-26-23119](#), Rev.1)*
 - ▶ Improved discussion surrounding the single-event electron capability and data libraries.
 - ▶ Expanded the variance of the variance derivation.
 - ▶ Various typos, equation fix-ups, and improvements throughout.
 - ▶ Build guide (TBD).
 - ▶ V&V report (TBD).
- ▶ Again, when the release is finalized, an announcement will be made and the release webpage will be updated with:
 - ▶ Documentation and important links.
 - ▶ Additional build information for third-party dependencies.
 - ▶ Some information for unsupported build environments.

* ***Timeframe: July 2025–July 2026***

Nuclear Data Updates

- ▶ **Lib81** : incident neutron files
 - ▶ 557 target nuclei
 - ▶ 8 temperatures : 293.6 K, 600 K, 900 K, 1200 K, 2500 K, 0.1 K, 233.15 K, 273.15 K
 - ▶ Extensions : 10c to 17c
 - ▶ Some errata files are also available for installation.
- ▶ **ENDF81SaB** : thermal scattering files
 - ▶ 103 materials
 - ▶ Extensions : 70t to 89t depending on the material
 - ▶ 70t will either be room temperature (or close to it) or the lowest available temperature
 - ▶ This is a big library at over 40 GB

Released September 26, 2025

Our Team, Products, and Programs



MCNP Team

- ▶ To support many MCNP code and related products there are many folks directly involved at varying levels
 - ▶ Roughly 20 individuals involved
 - ▶ Covering all aspects of product development
 - ▶ Administrative (e.g., registrations, planning) support
 - ▶ Time and effort level ranges from 10-100%
- ▶ The core development team is likely smaller than expected
 - ▶ Roughly 8–10 core developers
 - ▶ Code and documentation changes
 - ▶ User support and training
 - ▶ Time and effort level ranges from 75-100%



MCNP Team Changes

- ▶ **Joining** the team:
 - ▶ **Antonio Huerta**
 - ▶ Post-Master's Graduate Research Assistant joined in fall of 2025.
 - ▶ M.S. in Nuclear Engineering from Oregon State University.
 - ▶ Working on building machine learning models with application benchmarks and sensitivity tallies.
 - ▶ **Matthew Lazaric**
 - ▶ Post-Doctoral Research Assistant joined in spring of 2026.
 - ▶ Ph.D. in Nuclear Engineering from University of New Mexico.
 - ▶ Working on improving the accuracy and speed of the correlated neutron-photon physics models CGM/CGMF in MCNP6.



Monte Carlo Code and Nuclear Data Team Products (1/3)

- ▶ The MCNP code
 - ▶ ~500,000 lines of source code, build system, and utilities
 - ▶ Model data
 - ▶ Documentation
 - ▶ User and theory manual
 - ▶ Build guide
 - ▶ Verification and validation (V&V) report
 - ▶ Release notes
 - ▶ Supplementary scripts and tools
 - ▶ Python MCNP package (π_{mcnp}) 
- ▶ Nuclear data libraries
 - ▶ Distributed on the nuclear data team website
 - ▶ <https://nucleardata.lanl.gov/>

Monte Carlo Code and Nuclear Data Team Products (2/3)

- ▶ MCNPTools
 - ▶ Open-source release in 2022
 - ▶ Available on GitHub (<https://github.com/lanl/mcnptools>)
- ▶ Whisper
 - ▶ Open-source release pending
- ▶ Intrinsic Source Constructor (ISC)
 - ▶ New version distributed with MCNP6.3.1 code including α, n source capability
- ▶ CGMF fission event generator
 - ▶ Open-source release in 2020
 - ▶ Available on GitHub (<https://github.com/lanl/CGMF>)
- ▶ The GitHub LANL/MCNP team page will grow as we open-source more capabilities (<https://github.com/orgs/lanl/teams/mcnp>)

Monte Carlo Code and Nuclear Data Team Products (3/3)

- ▶ MCNP and NJOY user training
 - ▶ Introduction- and Intermediate-level courses
 - ▶ Advanced criticality, variance reduction, and data processing courses
 - ▶ Application-specific courses (e.g., nuclear criticality safety, safeguards, radiation protection and health physics)
- ▶ MCNP and nuclear data team websites
 - ▶ Collection of historic and modern resources
 - ▶ Distribution of processed nuclear data libraries
- ▶ Outreach
 - ▶ MCNP help line
 - ▶ User forum
 - ▶ User symposium
 - ▶ American Nuclear Society workshops



Current Sponsors

- ▶ LANL Site Support Project
- ▶ DOE Nuclear Criticality Safety Program
- ▶ DOE Advanced Scientific Computing Program
- ▶ Engineering Campaigns
- ▶ LANL Laboratory Directed Research and Development Program(s)

LANL Site Support Project

- ▶ Institutional support for the MCNP code and nuclear data
- ▶ Support for existing capabilities
 - ▶ Modernization
 - ▶ Maintenance
 - ▶ Bug fixes
 - ▶ User support
- ▶ Examples
 - ▶ Cinder code modernization
 - ▶ Qt-plotter technology preview
 - ▶ Supporting nuclear data availability online
 - ▶ MCNP User Symposium

DOE Nuclear Criticality Safety Program

- ▶ General support for criticality safety applications
- ▶ Methods development
 - ▶ Monte Carlo algorithms research
 - ▶ MCNP code improvements
 - ▶ Sensitivity / uncertainty upper subcritical limit (USL) calculations
- ▶ Verification and validation testing
- ▶ Advanced criticality calculations training
- ▶ User support
- ▶ Examples
 - ▶ Development of analytic and semi-analytic verification tests
 - ▶ Criticality accident alarm system benchmarking and feature support
 - ▶ Whisper USL code and benchmark catalogue

DOE Advanced Scientific Computing Program

- ▶ Support development for advanced high performance computing platforms
- ▶ Methods development
- ▶ Algorithm improvements and optimization
- ▶ Advanced geometry and multiphysics coupling
- ▶ User support
- ▶ Examples
 - ▶ Tracking on boundary representation (BRep) surfaces (e.g., STL)
 - ▶ Automated weight-window generation

Engineering Campaigns

- ▶ Support development for mesh geometry representations
- ▶ Algorithm improvements and optimization
- ▶ Advanced geometry and multiphysics coupling
- ▶ Tools for improved user workflow
- ▶ User support
- ▶ Examples
 - ▶ Unstructured mesh development
 - ▶ V&V of applications using UM geometry

LANL Laboratory Directed Research and Development Program(s)

- ▶ Short-term support, from months to 1–3 years
- ▶ Support development of new, targeted capabilities
 - ▶ New features
 - ▶ Extended/enhanced capabilities
 - ▶ Both within the MCNP code and external tools
- ▶ Examples
 - ▶ In progress
 - ▶ CGM and MCNP6 improvements for correlated physics applications
 - ▶ Recently completed
 - ▶ Multigroup cross section calculations
 - ▶ Generalized tally/nuclear data sensitivity capability
 - ▶ Delta-tracking implementation for nuclear reactor design
 - ▶ High-fidelity UM modeling for multiphysics coupling

The Last Year in Review

July 2025–July 2026



Code Changes: New Features

- ▶ Replaced CINDER'90 with Cinder 2026 in BURN.
- ▶ Add spherical FMESH tracking support.
 - ▶ With this addition to FMESH, the TMESH feature will be marked for deprecation in the MCNP6.4 release.
- ▶ π mcnp (Python MCNP package)
 - ▶ Input parser module
 - ▶ Unstructured mesh module
 - ▶ Interrogation and manipulation capabilities
 - ▶ XDMF file generation from HDF5
 - ▶ MCNP input file generation from mesh file
 - ▶ DRIVR module for automated weight-window generation
 - ▶ MCTAL file reader and data retrieval module

* In MCNP6.3.2 / Targeted for the MCNP6.4 code

Code Changes: Enhancements (1/2)



- ▶ Reduce memory usage during unstructured mesh initialization.
- ▶ Improved element-wise unstructured mesh tracking feature.
- ▶ Write information from print tables to organized results group.
- ▶ Change default electron physics quadrupole interpolation scheme to `qp01_2`
- ▶ Improvements to the Qt and 3D ray-tracer plotter.
- ▶ Improvements to the new angular-dependent thick-target bremsstrahlung model.
- ▶ Calculate light reflection energy limits only for photons to improve performance.
- ▶ Rework CMake flags to handle dependency variations.
- ▶ Remove spaces from the data structures names in the runtape HDF5 file.

* In MCNP6.3.2 / Targeted for the MCNP6.4 code



Code Changes: Enhancements (2/2)

- ▶ Tally plugin enhancements and fixes.
- ▶ Replacement of the MCNPUM with HDF5-representation in runtape.
- ▶ Move giant arrays off stack, into heap or static memory.
- ▶ Add a magnetic field cards print table 65.
- ▶ Improved particle tracking code, coincidence detection logic, and source code comments.
- ▶ Reduce peak memory usage for large numbers of materials.



* In MCNP6.3.2 / Targeted for the MCNP6.4 code



Code Changes: Bugfixes (1/4)

- ▶ Fixed bug in 2nd-order pentahedron face logic.
- ▶ Fixed bug when writing pseudocell densities and temperatures to the XDMF file.
- ▶ Added used variable in PTRAC MPI path when built without parallel HDF5.
- ▶ Fixed an issue where the combination of adjoint-weighted tallies (KPERT or kinetics = yes and/or precursor = yes on KOPTS) and MPI parallel execution would cause the results to differ from a non-MPI parallel calculation.
- ▶ Fixed an issue with outgoing photon distributions that appear to have more than 999 outgoing discrete lines.
- ▶ Fixed and improve multiple refraction coefficient errors.
- ▶ Fixed an issue where ACE files that may generate a multiplicity exceeding 20 may cause memory corruption.

* In MCNP6.3.2 / Targeted for the MCNP6.4 code

Code Changes: Bugfixes (2/4)

- ▶ Fixed user bins not being written to MCTAL for radiograph tallies.
- ▶ Fixed FMESH cylindrical mesh lines plotting.
- ▶ Fixed photon data table loading in MODE P E problem with IMP:P=0.
- ▶ Fixed inconsistencies between standard F4/F6 tallies and unstructured mesh edits.
- ▶ Fixed a bug where the heavy-ion particle velocity was not calculated/saved correctly. This would impact tallies that rely on the particle velocity (e.g., time bins).
- ▶ Fixed silent crash when electron EMAX < 1 keV.
- ▶ Fixed errors related to Compton-induced fluorescence when using EPRDATA libraries.
- ▶ Fixed the CMake build system to better support the new `ifx` compiler.

* In MCNP6.3.2 / Targeted for the MCNP6.4 code

Code Changes: Bugfixes (3/4)

- ▶ Fixed an input processing bug where the last element within a fully-specified lattice fill with a transformation would not be transformed.
- ▶ Fixed an issue with tracking that could lead to memory corruption. The issue could, but is not guaranteed, to occur after the message `warning: laj overflow` is issued.
- ▶ Fixed a bug where perturbations (PERT) applied to photons give incorrect results when the material is specified isotopically.
- ▶ Fixed an error in tallying of the elastic scattering cross section for fissile isotopes with thermal scattering treatment applied.
- ▶ Added an error flag in MPI calculations to prevent the code from crashing with limited information.

* In MCNP6.3.2 / Targeted for the MCNP6.4 code

Code Changes: Bugfixes (4/4)

- ▶ Fix particle tracking when magnetic fields deflect particles into zero importance regions.
- ▶ Fix incorrect error for missing H-3 data in GDR.DAT
- ▶ Improved torus tracking when negative distances are encountered.
- ▶ Resolved FT8 RES tally giving all zeros.
- ▶ Allow KSEN and material cards in any order.

* In MCNP6.3.2 / Targeted for the MCNP6.4 code

Code Changes: Clean-up

- ▶ Update inconsistent build system target interfaces.
- ▶ Refactor unstructured mesh element face arrays and subroutines to improve readability.
- ▶ Replaced `mpark::variant` with `std::variant`.
- ▶ Removed unused pre-processor sentinels.
- ▶ Removed unused parameters and variables.
- ▶ Added Fortran linter for static analysis.
- ▶ FMESH initialization and code organization improvements.
- ▶ Refactor code used during unstructured mesh input processing.
- ▶ Refactored iterated fission probability tallies into modular structure.
- ▶ Added doxygen-based comments to portions of source code.
- ▶ Replaced `boost::hana` with STL-based capability.
- ▶ Removed the `mcplib` module file.

* In MCNP6.3.2 / Targeted for the MCNP6.4 code

Code Changes: Deprecated and/or Removed Features

- ▶ Remove `um_post_op` utility.
- ▶ Remove legacy `EEOUT` unstructured mesh output file.
- ▶ Remove `GMVFILE` from `EMBED` card.
- ▶ Remove `um_convert` utility.
- ▶ Deprecated `DRXS`.

* In MCNP6.3.2 / Targeted for the MCNP6.4 code

Other Ongoing Efforts



MCNP Classes and Workshops

- ▶ Both in-person and virtual classes
 - ▶ 6 weeklong full-day in-person classes at LANL
 - ▶ 4 weeklong full-day virtual classes *at* LANL
 - ▶ 2 weeklong classes at OECD/NEA
 - ▶ 1 weeklong criticality class at PNNL
 - ▶ 1 weeklong criticality class at SNL
- ▶ Enrollment each year for all classes is typically 200-300 attendees.
- ▶ Class topics covered
 - ▶ Introduction, Intermediate
 - ▶ Criticality, Variance Reduction
 - ▶ Unstructured Mesh, Nuclear Safeguards, Radiation Protection & Health Physics
- ▶ Workshops provided
 - ▶ 2025 NCSD Topical Meeting

Tracking on Boundary Representation (BRep) Surfaces



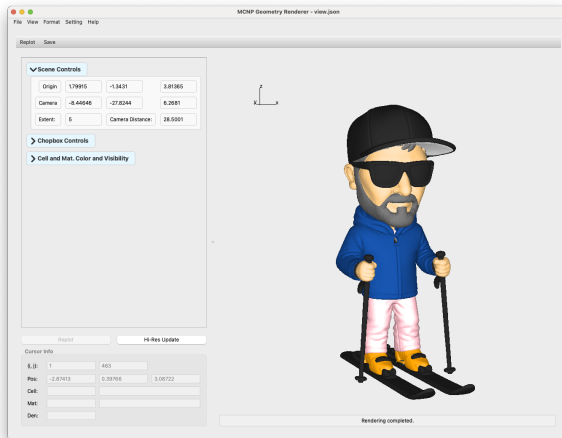
- ▶ STL (Stereolithography) format
 - ▶ Commonly used for 3D printing
 - ▶ Needs to be watertight (like a macrobody)
 - ▶ Will work within native CSG geometry as a new surface type

"Dummy" STL Input

```
c
10 100 -1.0 -1    $ Inside STL
20 200      1 -2    $ Outside STL
30  0      2    $ Graveyard

c
1 stl file=bobblehead-mike.stl
2 so 1000

c
nps 100
mode n
sdef
c
fc4 bobblehead mike flux tally
f4:n 10
```

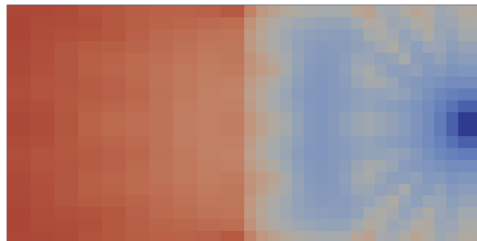


Automated Weight Window Generator



- ▶ DRIVR: Deterministic Response and Importance for Variance Reduction
 - ▶ Handles MCNP and PARTISN executions to generate weight windows

```
1  =====
2  Phase 1/4: Discrete mesh source (FMESH)
3  =====
4  -> Running MCNP (NPS=1e6) ...
5  [done] Running MCNP (NPS=1e6)          [ 1.4s ]
6  -> Reading FMESH source from meshtal ...
7  [done] Reading FMESH source from meshtal [ 0.0s ]
8  =====
9  Phase 2/4: Generate PARTISN input from geometry
10 =====
11 -> Running MCNP to generate PARTISN input ...
12 [done] Running MCNP to generate PARTISN input [ 1.4s ]
13 =====
14 Phase 3/4: PARTISN adjoint calculation
15 =====
16 -> Running PARTISN adjoint calculation ...
17 [done] Running PARTISN adjoint calculation [ 1.8s ]
18 -> Reading adjoint flux ...
19 [done] Reading adjoint flux [ 0.0s ]
20 -> Writing weight windows (WWINP) ...
21 [done] Writing weight windows (WWINP) [ 0.2s ]
22 =====
23 Phase 4/4: Final MCNP with weight windows
24 =====
25 -> Running final MCNP with weight windows ...
26 [done] Running final MCNP with weight windows [ 54.7s ]
```



Deterministic weight windows

F4 Tally Comparison
(11.7× performance increase vs analog)

Method	Mean	Rel. Err.	FOM
Analog	1.80E-8	0.24	1.99E2
CADIS	2.24E-8	0.02	2.34E3



Summary



Summary

- ▶ Over the past ~1 year we have focused on:
 - ▶ Bugfixes, modernization, and clean-up.
 - ▶ Bringing some big code changes in to replace legacy features.
 - ▶ Adding capability to the π mcnp project.
 - ▶ Finishing the MCNP6.3.2 release
 - ▶ Learning how AI can be appropriately used in MCNP code development.
- ▶ As always, we want your feedback (send it directly to us or post/reply to threads on the new forum)



Questions?



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