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Outline

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About Us
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
  - Qt-plotter technology preview
  - Dedicated user support specialist
  - 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
  - Fission matrix convergence testing and acceleration
  - 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
  - Remote memory access tallies at extreme scales
  - Reusable shared component libraries
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
  ▶ Recently completed
    ▶ Multigroup cross section calculations
    ▶ Multiphysics coupling tools
  ▶ Ongoing
    ▶ Generalized tally/nuclear data sensitivity capability
    ▶ Delta-tracking implementation for nuclear reactor design
Monte Carlo Code and Nuclear Data Team Products (1)

- 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
  - Data downloader
  - V&V framework

- Nuclear data libraries
  - Distributed on the nuclear data team website
  - https://nucleardata.lanl.gov/
Monte Carlo Code and Nuclear Data Team Products (2)

- MCNPTools
  - Open-source release in 2022
  - Available on GitHub (https://github.com/lanl/mcnptools)

- Whisper
  - Open-source release pending approval

- Intrinsic Source Constructor (ISC)
  - New version distributed with MCNP6.3

- 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)

- 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)

- MCNP and nuclear data team websites
  - Collection of historical and modern resources
  - Distribution of processed nuclear data libraries

- Outreach
  - User forum
  - User symposium
  - American Nuclear Society workshops
MCNP Team (1)

To support all of the aforementioned MCNP 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%
MCNP Team (2)

The core development team is likely smaller than expected
- Roughly 6–8 core developers
  - Code changes
  - Documentation updates
  - User support and training
- Time and effort level ranges from 75-100%

- Various changes over the past few years has resulted in a relatively young team
  - Roughly 50% of the core team earned their highest degree within the last 5 years
  - Only 3 members of the core team were part of the MCNP6.2 release
The Last Year in Review
Code Changes: New Features in MCNP6.3

- Finalized unstructured mesh (UM) HDF5 format and content
- Semantic versioning added to new HDF5 file formats
  - Restart (runtpe)
  - PTRAC
  - UM model and elemental edits
- Extensive new feature testing and clean-up
  - Fission matrix bugs fixed (e.g. continue-run, array-out-of-bounds)
  - Fission matrix developer override file removed
  - Moved fission matrix results to runtpe results group
- Set a default for new FMESH batch statistics option

Timeframe: July 2021–October 2022
Code Changes: Enhancements in MCNP6.3 (1)

- 10,000 point detectors now allowed
- Added many comment, warning and deprecation messages
  - Any deprecated feature that is in use now issues a deprecation warning message (see next slide)
  - Fatal errors and warning messages thrown where previously unchecked incompatible features were used
    - UM with FCL
    - UM with charged particles
    - ACT card input parsing checking
- Added/fixed build-system support to utilities
  - FIT_OTF
  - GRIDCONV

Timeframe: July 2021–October 2022
Aside: Deprecated Features in MCNP6.3

Features that are still available in MCNP6.3, but are planned for future removal

- FMESH output formats
- Legacy unstructured mesh EEOUT file formats
- Embedded geometry background and matcell flexibility
- Legacy PTRAC file formats
- PTRAC options COINC and CAP
- Legacy unstructured mesh utilities
- MCNPUM and GMV UM file formats
- TIR, TIC, PI, MPN input cards
Code Changes: Enhancements in MCNP6.3 (2)

- Extended number of reactions in loaded data
- Prepared for ENDF/B-VIII.1 changes
  - $S(\alpha, \beta)$ incoherent and coherent elastic
  - Photonuclear point-detector tally support
- Default now xsdir_mcnp6.3
- ACT DG=lines improved speed and memory usage
- CGMF 1.1.1 (same as on https://github.com/lanl/cgmf) now used
- Removed copyrighted fluence-to-dose conversion factors (see next slides)

*Timeframe: July 2021–October 2022*
Aside: Removed Features in MCNP6.3

- Random number generator options only set through RAND card, not DBCN
- Removed HTAPE utility
- Removed MCNP RANDOM utility
- *Removed built-in fluence-to-dose response functions*
Aside: Built-in Response Functions Extracted (1)

- Due to both copyright concerns and maintainability of the built-in fluence-to-dose response functions, the IC=10–40 built-in DE/DF functions are no longer available in the MCNP source code.

- The fluence-to-dose response functions are available in the Response Functions Appendix of the MCNP6.3 user manual (available here).
Aside: Built-in Response Functions Extracted (2)

- Both table listings and plots are available in the Response Functions Appendix

Neutron ICRP74-1996 Anterior-Posterior AP dedf Cards and Plots
Code Changes: Bugfixes in MCNP6.3

- ACE charged particle bug fixed - using recoil physics now
- Point detector (F5) tally fix
- Multigroup adjoint fix
- $S(\alpha, \beta)$ cache fix
- TMESH and energy deposition issues identified and/or fixed (see next slide)
- Electron G-S table fix with multiple elements
- Vertical input variable length
- Charged-particle capture bug fixed
- Fixed IC=99 on DE/DF conversion factors
- Compiler bug workarounds

Timeframe: July 2021–October 2022
Aside: Energy Deposition Improvements

In MCNP6.3, there are three primary changes to TMESH and/or energy deposition:

1. Consistent treatment of particle energy deposition as they pass through or are born below the energy cutoff
   ▶ Particles crossing below the energy cutoff contribute the remainder of their energy to the local energy deposition tally
   ▶ Particles born below energy cutoff contribute their energy to the local energy deposition tally

2. Fixed charged-particle TMESH tally energy deposition in a magnetic field

3. Added warning message about electron energy deposition in a magnetic field
   ▶ Due to the electron energy straggling, the proper fix is complicated and may require some refactoring and algorithmic changes
Code Changes: Clean-up in MCNP6.3

- Continued UM refactor and clean-up work
- UM material consistency checking
- Removed all COMMON blocks in the code in favor of derived types
- Cleaned up old, unused compiler pre-processor definitions
- Added/updated/corrected utilities documentation and instructions
  - Removed a couple of utilities from distribution
  - Added README and user manual entries for everything

**Timeframe: July 2021–October 2022**
Documentation Overhaul

- Newly updated MCNP website (https://mcnp.lanl.gov/)
- Updated MCNP6.3 documentation
  - User and theory manual (available here)
  - Build guide
  - V&V report
  - Release notes
- Find documents on the website as they become available
  - https://mcnp.lanl.gov/reference_collection.html#mcnp630.refs

*Timeframe: July 2021–October 2022*
Testing in MCNP6.3

- Tested new CP2020 data
- Ported validation suites to new V&V framework
  - Criticality expanded benchmarks
  - LAQGSM (partial) benchmarks
- Ported verification suites to new V&V framework
  - Continuous-energy and multigroup analytic k-effective problems
  - Kobayashi particle streaming problems

*Timeframe: July 2021–October 2022*
MCNP Classes

- Continued virtual classes
  - ~12 weeklong full-day classes at LANL
  - ~3 weeklong half-day classes at OECD/NEA

- Topics covered
  - Introduction, Intermediate
  - Criticality, Variance Reduction
  - Unstructured Mesh, *Nuclear Safeguards

*Newly developed in 2021 with NEN-1 colleagues at LANL

Timeframe: July 2021–October 2022
MCNP Workshops

- Focus on MCNP6.3 features, capabilities, and V&V efforts

- 2022 ANS Nuclear Criticality Safety Division Embedded Topical
  - New criticality features (i.e., fission matrix)
  - Doppler broadening resonance correction
  - $S(\alpha, \beta)$ updates and fixes

- 2022 ANS Radiation Protection and Shielding Division Topical (ICRS14/RPSD2022)
  - New particle track output updates for advanced detector response
  - Updates to fluence-to-dose response functions
  - Energy deposition and perturbation fixes

**Timeframe: July 2021–October 2022**
Modernization

- Examples of work done in previous years’ efforts for MCNP6.3
  - HDF5 formats (RUNTAPE, PTRAC, UM model/edits)
  - XDMF support (FMESH, UM model/edits)
  - CMake/CTest/CPack build system

- Continued these efforts for future releases (i.e., MCNP6.4)
  - Extending FMESH capabilities to cover all of TMESH capabilities
  - Dynamic source plugin to replace SOURCE.F90 capability
  - Geometry arrays and derived-type restructuring
  - Replaced random number generator with C++ version

- Throughout most of these efforts, several code bugs were discovered and have been fixed for MCNP6.3 already (many listed in previously slides)

*Timeframe: July 2021–October 2022*
LANL Research and Development Projects

- Project sponsors
  - Laboratory Directed Research and Development (LDRD)
  - Technical Maturation (TechMat) program

- Capabilities under development targeted for future release (i.e., MCNP6.4)
  - New adjoint-based generalized tally / cross section sensitivity capability
  - Delta-tracking capability for nuclear reactor design applications
  - Unstructured mesh element-wise specifications (e.g., sources, temperatures, densities)

*Timeframe: July 2021–October 2022*
Summary
Summary

- Over the past year+ we have been very busy and have accomplished many things

- The MCNP6.3 release is imminent
  - The approved, final documents have been making their way to the website
  - The code executables and source are already packaged up for distribution
  - The new installer is being finalized and tested now, for all platforms
  - The package will be sent to RSICC before the end of October 2022
**Looking Toward the Future**

Some things to think about as MCNP6.3 is requested and/or used...

- Many of our recent efforts have been focused on making development, updates, and distribution of the code and documents more robust and streamlined
  - We will be revising/updating documents more frequently than ever before
  - We will be exploring avenues to distribute official patches to MCNP6.3
    - Allows us to be more responsive to bugs and issues that are identified
    - To be able to apply a patch to MCNP6.3, it will require having the source code

- We want your feedback ([mcnp_help@lanl.gov](mailto:mcnp_help@lanl.gov))
  - New features (e.g., HDF5-formatted files, fission matrix convergence acceleration)
  - The new Qt-based Technology Preview executable
Questions?