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Title:	MCNP6 Status
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MCNP6 Status

Tim Goorley,

XCP-3: Monte Carlo Codes

Los Alamos National Lab

JOWOG 6 Briefing
June 25-29, 2012

MCNP6 Status

- **MCNP6 Beta 2 distributed from RSICC since Feb 2012**
- **MCNP6 Beta 3 now frozen**
  - Beta 3 is expected to contain all capabilities in the MCNP6 production release
  - DVD of MCNP6 Beta 3 with Steve McCready
- **MCNP6 Beta 3 RSICC release expected end of summer 2012**
- **MCNP6 production release after feedback (and perhaps bug fixes) from Beta 3 (hopefully Spring 2013)**

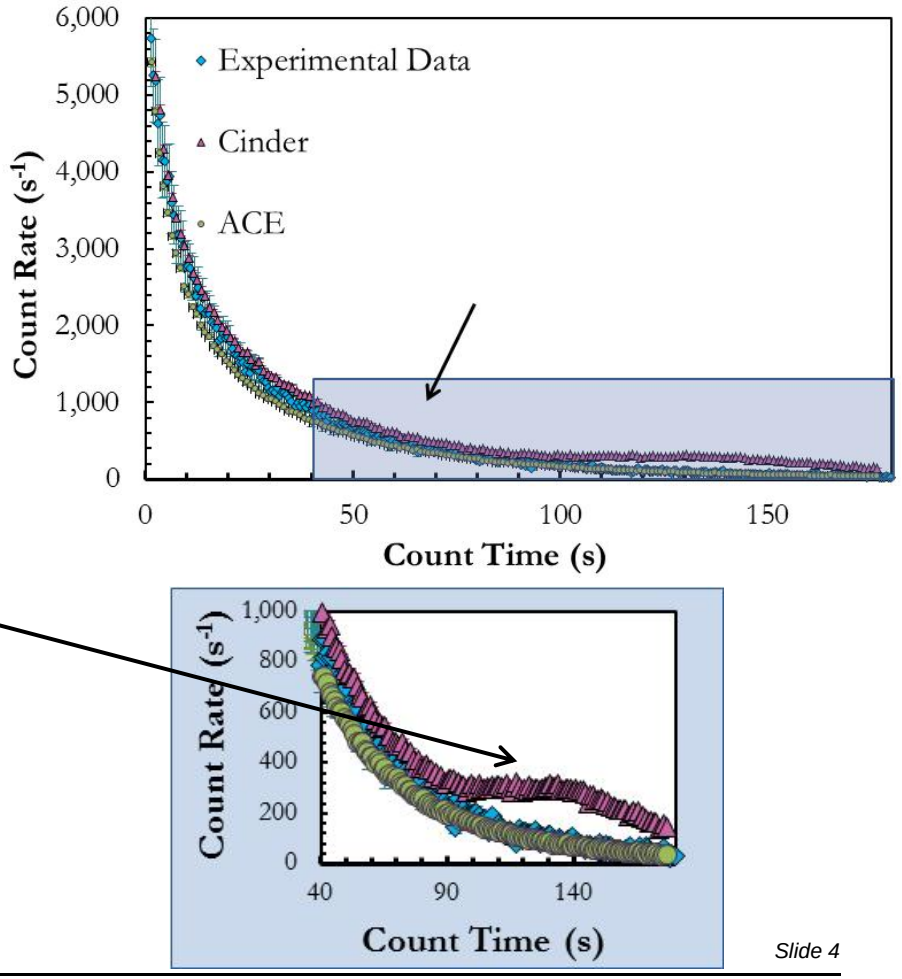
MCNP6 Beta 2 New Capabilities – Those not in MCNP5 or X

- **Unstructured Meshes**
  - 4,5,6 sided objects with bilinear or quadratic faces.
  - Parallel setup and initialization
  - LNK3DNT geometry creation and file read
- **Low energy electron (10 eV) & low energy photon (1eV) transport**
  - NO molecular cross sections, which dominate physics at these energies
- **Complete atomic relaxation X-rays (not just K & average L shell emissions)**
- **Muonic capture**
- **Continuous Energy adjoint-based perturbations**
- **Explicit tracking of all charged particles in magnetic fields**
- **Nested DXTRAN spheres**
- **Improved photon form factors (where backscatter is important)**
- **Surface and cell flagging with MCNP5 style mesh tallies**

MCNP6 Beta 2 New Capabilities – Those not in MCNP5 or X

- **Improved V&V test suites**
  - High energy (CEM3.03 and LAQGSM3.03)
  - Delayed neutron detection

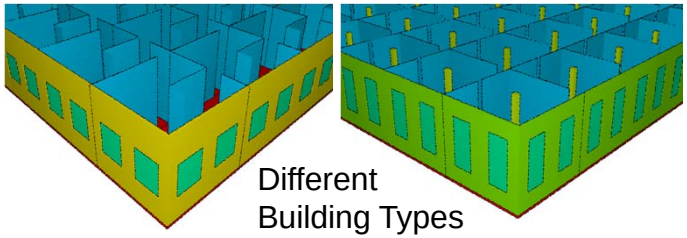
A Masters student, Madison Sellers, from the Royal Military College (RMC) of Canada attended a MCNP class two years ago. I happened to learn the work that she was doing – taking microgram sample quantities of U and Pu, irradiating them in their CANDU nuclear reactor, and measuring the delayed neutron emissions. Tim Goorley asked her to come to LANL that summer and simulate her experiment with MCNP, and add a new validation test suite. She agreed. As it happens, the two different ways to simulate delayed neutrons in MCNP (with CINDER and with ACE ENDF/B-VII data), produce 2-3x different neutron emission rates at about 2 minutes (below right) . Madison's experiments allowed us to determine which method matches the data best. This summer, Madison will return and simulate the delayed gammas she has measured this past year.



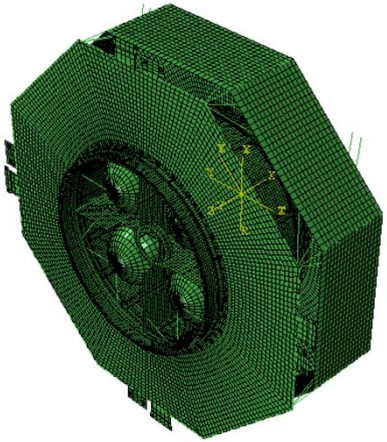
MCNP can model intricate geometries

- **Many combinations of geometry capabilities**
  - Surfaces & cells
  - Lattice – easy to insert detailed models of buildings
  - Unstructured Mesh (tets & hexes) (for CAD/CAE geo)

ARA Urban Radiation Transport Modeling talk by Kramer, Li, Millage, Sanchez, talk TODAY!



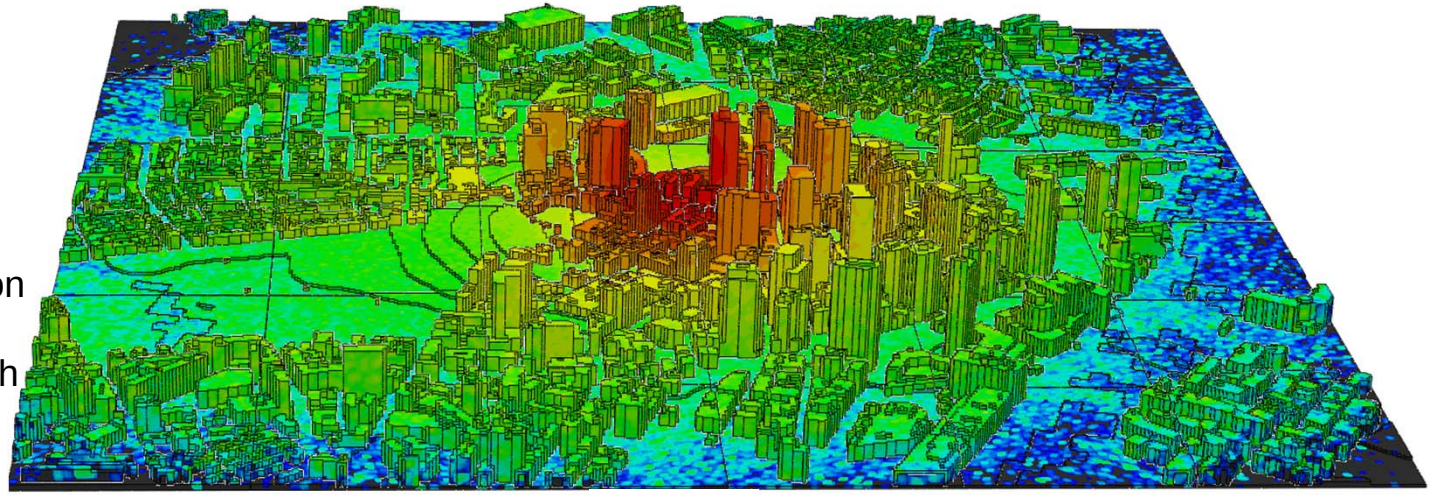
Different Building Types



NASA Spacecraft
They use ABAQUS too!

MMS reference configuration only and does not represent actual flight hardware

Use NGA Data,
ground, water, air, buildings,
elevation effects.



Gamma Flux in Boston
Created from
Unstructured tet mesh

7 km

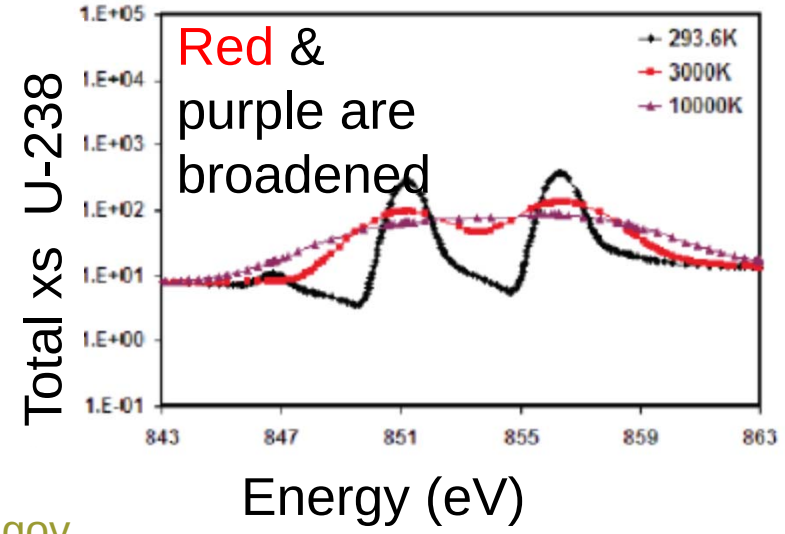
MCNP6 Beta 3 New Capabilities

- **Removal of DBCN 29 – The MCNP5/X user flag**
- **Unstructured mesh**
  - MCNP Plotting of UM within CGS geometry
  - Relative uncertainties
  - Volumetric sources
  - Pre & Post processing script executables (if you didn't get the source version)
- **On-The-Fly Doppler Broadening for temperature effects**
  - Developed for running 1000s of different temps in nuclear reactors
- **Continuous energy cross section sensitivity analysis for Keff**
- **Mesh surface tallies (F1/F2 like tallies on Cartesian meshes)**

- **Alpha testing of ENDF/B-VII.1 release at LANL**
  - Likely beta version by end of summer 2012

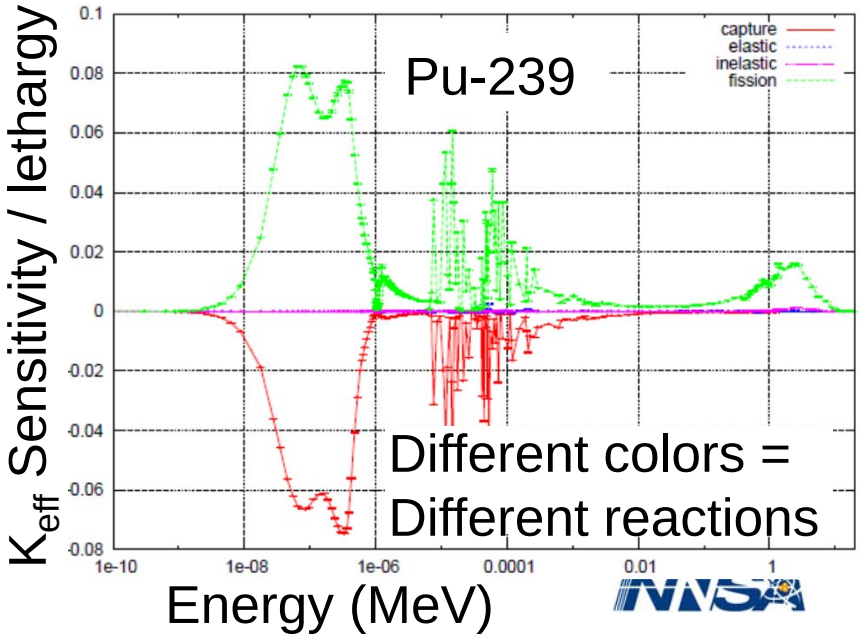
New MCNP6 Features Released

- **On-The-Fly Doppler cross section (xs) broadening**
  - Accurate temperature corrections for neutrons: 1000s of Temps in 1 run
  - Preprocess fitting parameters, 1.1x slower in runtimes, Gbytes of storage



Contact: Forrest Brown, fbrown@lanl.gov

- Continuous Energy cross section sensitivity for K_{eff}
  - Competes with Oak Ridge code SCALE
  - Helps guide where expensive cross section measurements should be focused.
  - Sensitivity study required before criticality experiments at Nevada



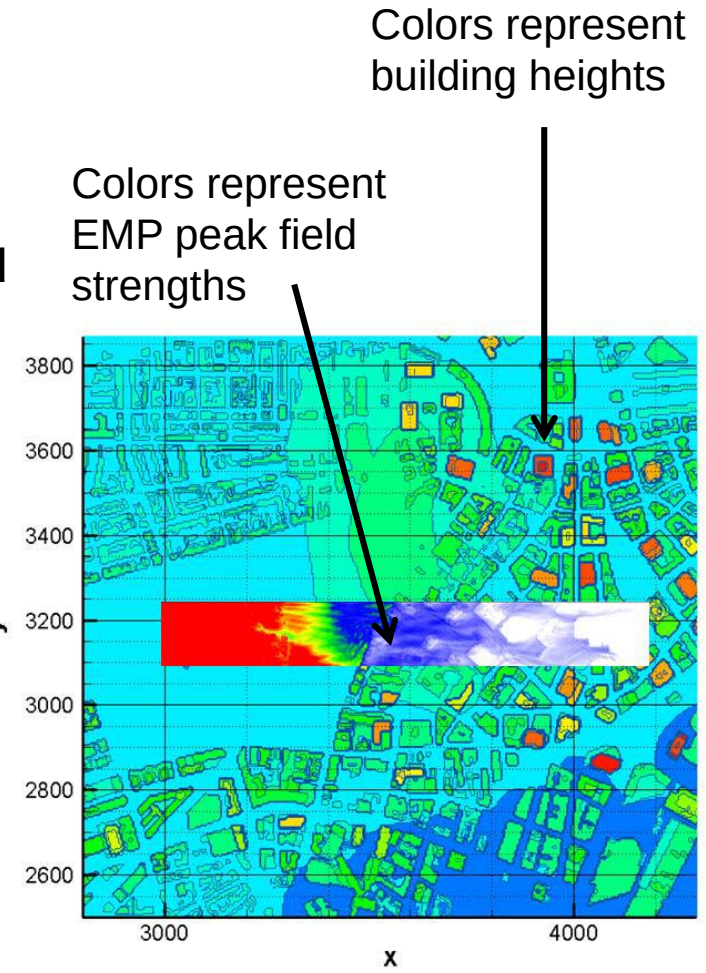
Contact: Brian Kiedrowski

MCNP6 Beta 3 Bug Fixes

- **Unstructured mesh**
  - Resolved some tracking issues
  - More Robust 2nd order intersection routines – still needs more testing
- **Resolved large memory restart crashes**
- **OMP Threading locks for MCNPX features [in progress]**
  - MCNPX capabilities were not developed with shared-memory threads in mind
  - Running these features with threads results in silent wrong answers or crashes.
  - Previously, check on DBCN 29 prevented running with threads
  - Now accessing certain features: Burnup/depletion, mcnpx mesh tallies, CINDER will prevent threads from running.
  - Some features, such as the cosmic-ray background and SDEF modifications will work with threads, because there is a threading lock on the source routines.

MCNP6 Additional Capabilities - EMP

- **Electro magnetic pulse (EMP)**
  - Incorporating LANL EM solver – FDTD (Finite Difference Time Domain)
  - Includes air chemistry effects
- **Demonstration calculations of Houston and Boston performed for FEMA December 2011.**
  - "Once-through" calculation – MCNP gamma source and Compton electron creation, then large file read by FDTD.
  - Does not include self consistent effects of EMP changing Compton electron transport
  - Self consistent version in progress (initial V&V test cases being analyzed)
- **EMP capability not in general released version of MCNP.**



MCNP6 Additional Capabilities - QUIC

- **Linking MCNP6 to LANL atmospheric dispersal code QUIC results in the following capabilities:**
- **Import US City geometries from NGS**
- **Analysis of US census database – population effects**
- **Atmospheric transport for fallout radioisotope spatial distributions**

Atmospheric dispersal coupled to radiation transport

Preliminary capability for dirty bombs only.

Hypothetical Event – If “Smoking Nissan Pathfinder” in Times Square on May 21, 2010 had 2300 Curies of CsCl.

Dose (Time)	Exposed Population
1 mrem (96 hr)	**59,133**
500 mrem (1 yr)	**85,026**
2 mrem (1 hr)	**22,122**
1 rem (96 hr)	**6,165**
5 rem (96 hr)	**1,003**
25 rem (96 hr)	**592**

Need coupling to different code for Atmospheric dispersal from Nuclear Weapon!

MCNP6 Documentation

- **Draft MCNP6 Manual**
  - Updated June 13, 2012
  - Unfortunately, the manual editor retired
- **Unstructured Mesh User's Guide**
- **Recent Journal Articles (Nuclear Technology Special Issue, Dec 2012):**
  - Initial MCNP6 Overview, T. Goorley, et al..
  - MCNP6 Unstructured Mesh Initial Validation And Performance Results, Roger Martz
  - MCNP Variance Reduction Developments In The 21st Century, Thomas E. Booth, R. Arthur Forster, and Roger L. Martz
  - The MCNP6 Delayed-Particle Feature, Joe W. Durkee, Jr., Michael R. James, Gregg W. McKinney, Laurie S. Waters, and John T. Goorley
- **Other Journal Articles**
  - F.B. Brown, W.R. Martin, G. Yesilyurt, S. Wilderman, "Progress with On-The-Fly Neutron Doppler Broadening in MCNP", *Trans. Am. Nuc. Soc.* 106 (2012).
  - G. Yesilyurt, W.R. Martin, F.B. Brown, "On-The-Fly Doppler Broadening for Monte Carlo Codes", *Nuclear Science & Engineering* 171, 239-257 (2012).
- **Mcnp.lanl.gov website has most of the 1 GByte of .pdf files available**
- **CEM3.03 and LAQGSM3.03 primers (for high energy simulations)**

MCNP6 Development Team Updates

- **Retirees in the last five or so years: (~150 man-years of experience)**
  - John Hendricks — now a free-lance contractor
  - Art Forester — 30% time with XCP-3
  - Dick Prael — volunteers 20% time to XCP-3
  - Denise Pelowitz (Manual Editor) — volunteers 5% time
  - Laurie Waters

- **MCNP6 Development Team:**
  - Forrest Brown, Jeff Bull, Joe Durkee, Mike Fensin, Grady Hughes, Mike James, Russ Johns, Brian Kiedrowski, Roger Martz, Gregg McKinney, Jeremy Sweezy, Trevor Wilcox, Tony Zukaitis (in two different groups)
  - Goorley - XCP-3 Group Leader (but doesn't do any code development work)
  - Summer 2012 – 4 Students.

MCNP6 Proposed & Future Efforts

- **Optical light**
  - Transmission/Scattering/Attenuation in Air
  - Optical Light production from gamma ray (via secondary electron) interactions with N_2 and NO
  - NA-22 proposal for 3 year effort joint with Sandia National Laboratory
  - Experimental V&V with SNL HERMES machine
- **Implementing Electric Fields (for EMP but available for everyone)**
- **EMP V&V efforts**
  - Interesting NTS & Pacific tests
  - Comparisons with SNL Heremes machine
- **Unstructured mesh**
  - Working on charged particle transport in UM and LNK3DNT meshes
  - Add variance reduction methods
- **Parallelism – updating code for 10-100K processors, use new methods**
- **Microscopically Correct nuclear reactions – needed for coincidence**

MCNP6/ENDF/NJOY Workshop at LANL

- **We, the development teams for MCNP, NJOY, and parts of ENDF, would like to invite you to a proposed 3 day workshop October 30, 31 and November 1 2012, to be held at Los Alamos National Laboratory. At this workshop, we will review new and developing missions that MCNP6 and the underlying nuclear data are being asked to address. LANL will also present its internal plans to address these missions and recent advances in these three capabilities and we will be interested to hear your input on these topics. Additionally we are interested in hearing from you additional technical advances, missions, concerns, and other issues that we should be considering for both short term (1-3 years) and long term (4-6 years)? What are the additional existing capabilities and methods that we should be investigating? The goal of the workshop is to refine priorities for mcnp6 transport methods, algorithms, physics, data and processing as they relate to the intersection of MCNP, NJOY and ENDF.**
- **Invitation only (but 4-5 from AWE invited)**
- **Draft Issues: Correlations, Temperatures, covarienace, uncertainty, Light ion transport, Low energy photon & electron, etc.**

Questions

- **Any interest in secondments with XCP-3?**
- **What are your top 5 code development wants?**

- **Please contact Tim (jgoorley@lanl.gov) for specific questions.**