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Title:	MCNP for Weapon Effects Modeling
Author(s):	Tim Goorley XCP-3 Monte Carlo Codes Los Alamos National Laboratory
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MCNP for Weapon Effects Modeling

Tim Goorley[1]

[1] XCP-3 Monte Carlo Codes

Los Alamos National Laboratory

April 1, 2011

HEART Conference

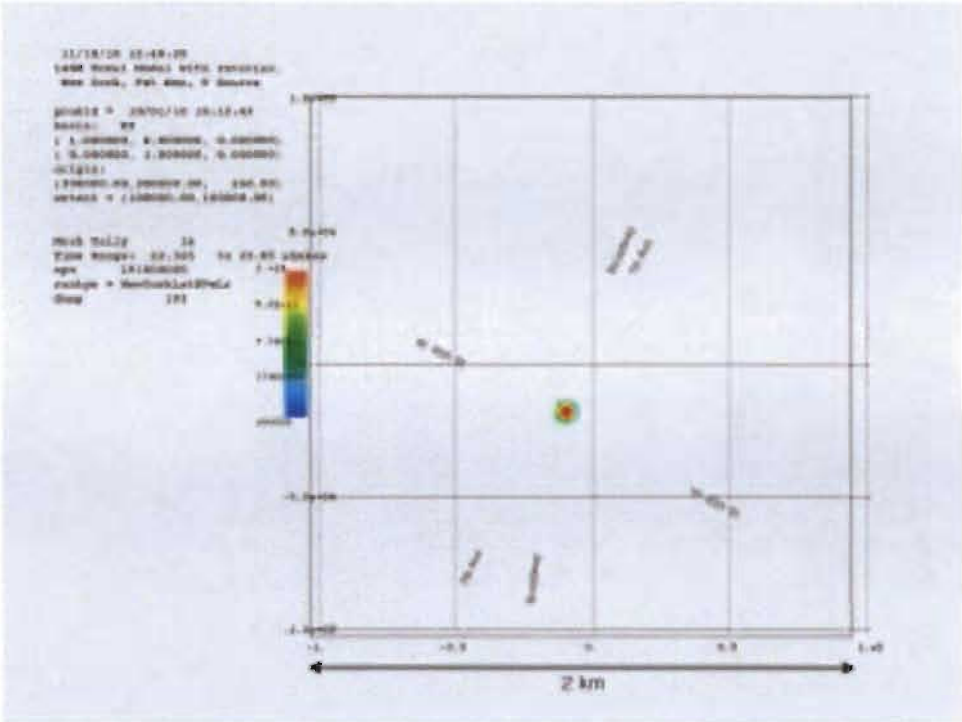
Abstract

- MCNP is a continuous energy Monte Carlo radiation transport code that is already used in Weapons Effect simulations at Los Alamos National Laboratory. MCNP can perform coupled neutron, photon and electron simulations to determine subsequent 3D spatial, energy and time dependant flux, dose, energy deposition (heating), nuclear reactions, radiation detector response, and nuclear criticality. MCNP can calculate the Compton currents necessary for EMP calculations. Recent MCNP advances have demonstrated a capability to feed these currents into a Maxwell solver (HEMPV) for electric field effects in an urban environment. Additional work is progressing and planned to enhance this capability.

Many MCNP WE Applications

- **Pre Detonation**
  - Intrinsic Radiation Detection
  - Active Interrogation
  - Intrinsic Radiation Personnel Dose
  - Criticality Safety
- **Post Detonation**
  - Prompt Neutron and Photon Dose
  - Fallout Dose
  - Convolution with US Census Population Data
  - Radioisotope Production
  - Nuclear Forensics
  - Visible Light Transport (Flash Blindness)
  - Compton Electron Currents for EMP

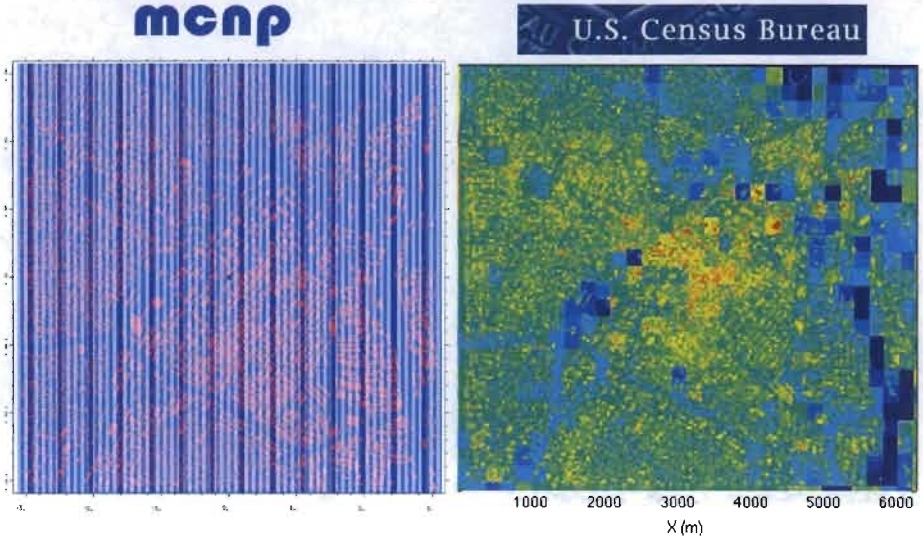
Radiation leakage from blast in urban environment

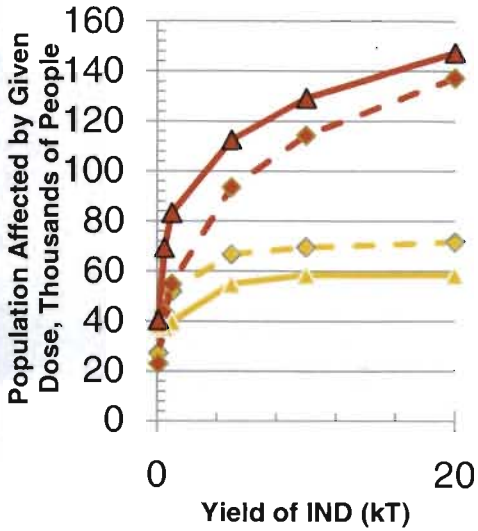


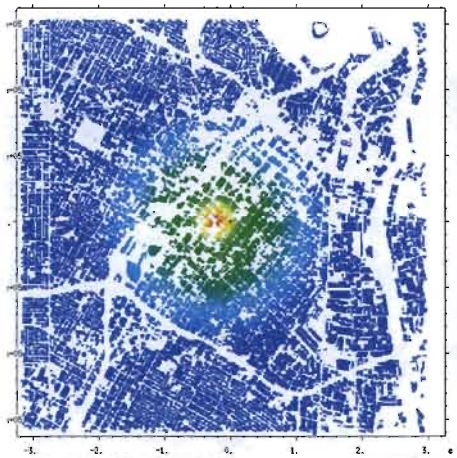
MCNP for Urban Consequences Modeling

The following capabilities have been exercised:

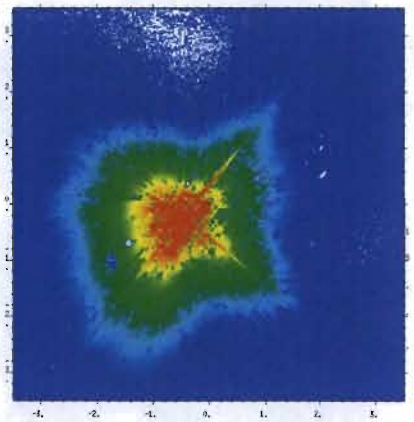
- Geometries from NGA
- Prompt Dose
- Idealized Fallout Dose
- Radioisotope Production
- Convolution of dose date with US Census Data



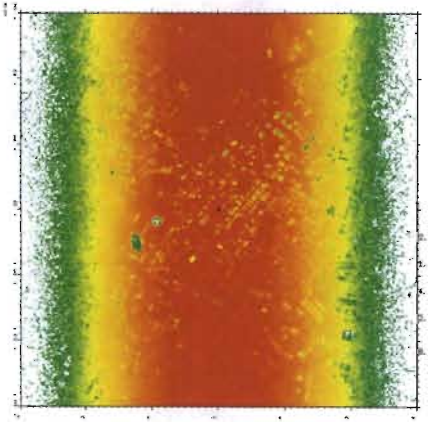




Al-28 production in cement



Gamma Leakage Dose

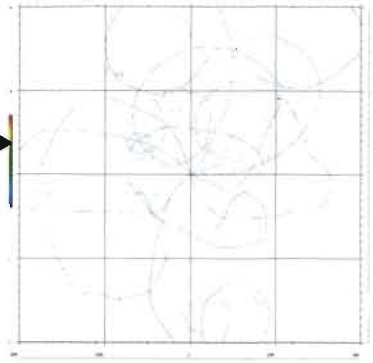


Fallout Dose

Effects from a 20 kT Little Boy in downtown LA – All Squares ~ 6 km per edge

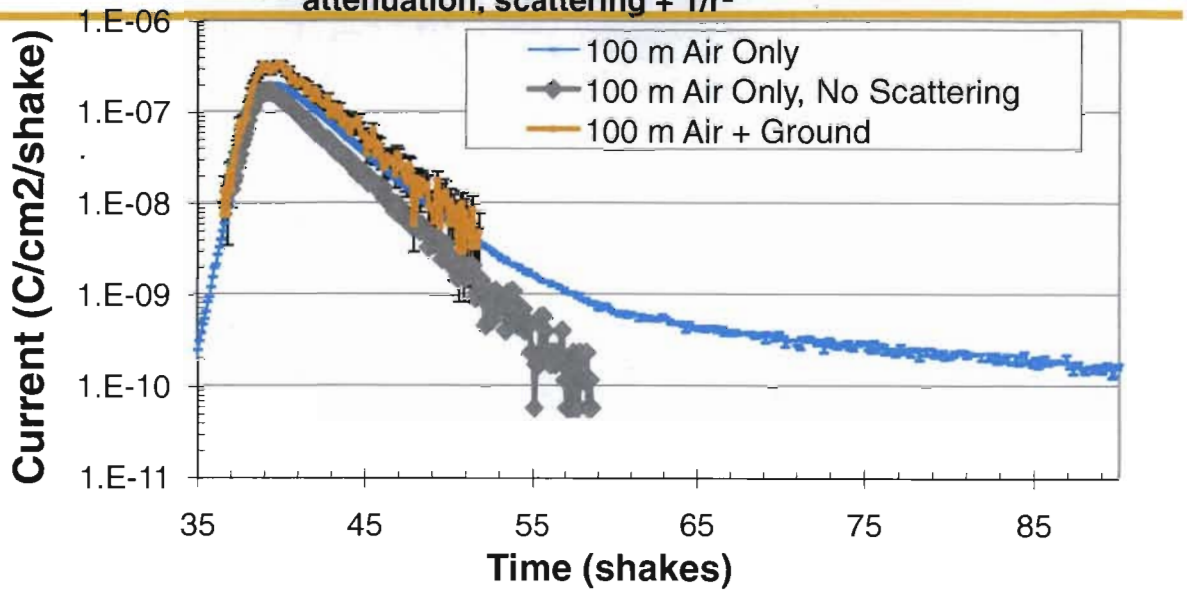
Completed MCNP Efforts for Urban EMP

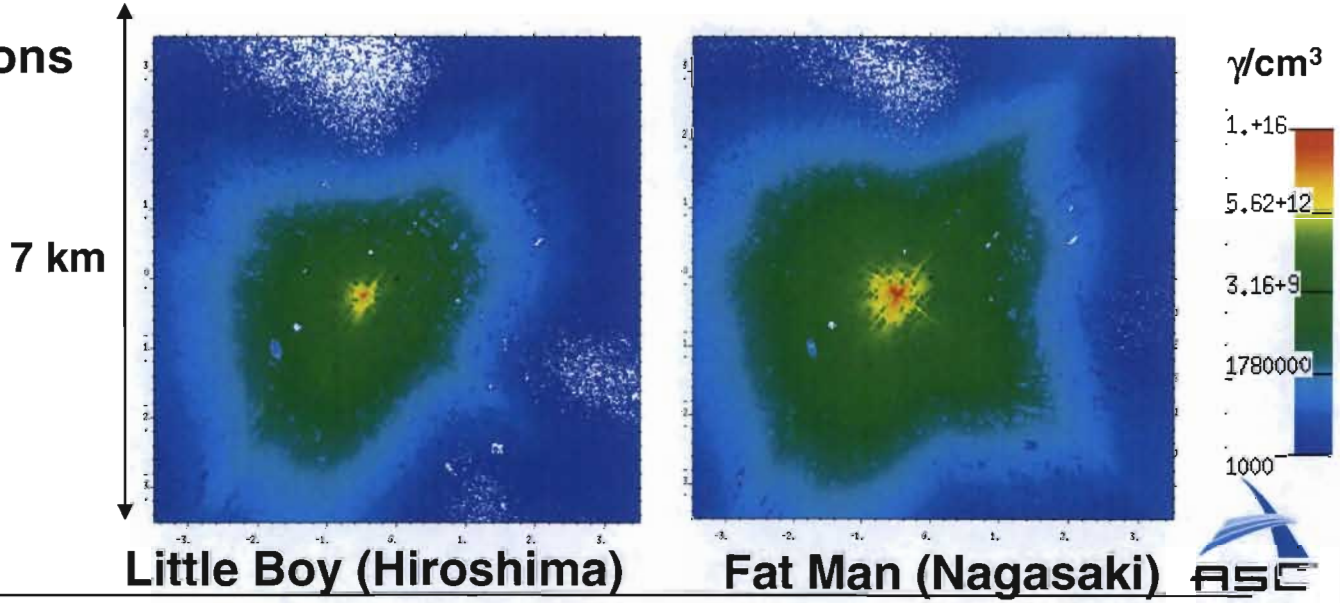
- **Time Dependant Sources & Tallies**
- **Incorporated Magnetic fields (in air)** **2007** →
- **City specific geometries – 5x5 km** **2009**
  - National Geospatial Intelligence Agency database
  - Use Lattice geometry to create grid
- **Compton Current Comparisons** **2010**
- **Photon Flux – E field strength** **2010**
  - Through NTS empirical correlations (Bob Roussel-Dupré)
- **Electron current tally modifications** **2010**
- **MCNP Current (x,y,z,I,j,k,t) (one way) Input into HEMPV** **2010** →
  - High resolution, currents everywhere at all times – many zeros
  - Gigabyte text files – slow running, slow debugging
- **Lowered Photon Energy threshold to 1 eV** **2011**
  - Previously lower threshold was 1 keV



MCNP Investigations

- Free Air vs Ground
- Scattering vs No
- Spectra Comparisons





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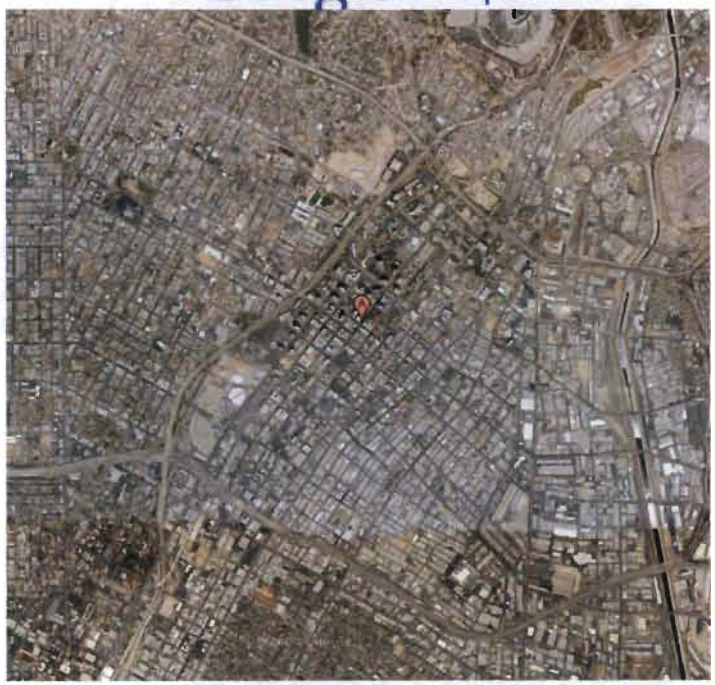
Urban EMP – Using NTS empirical relations

mcnp



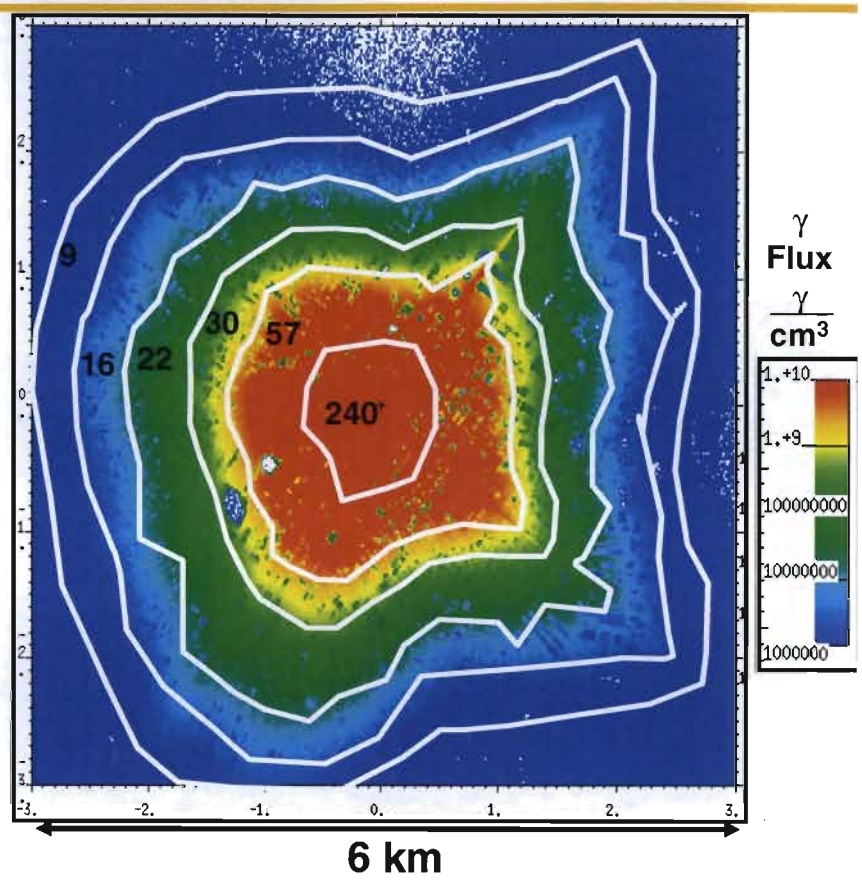
6 km

Surface burst of Fat Man ~ 10 kT in downtown LA

White Contours: Electric Field strength in kV/m

Circuit failure expected above 10 kV/m

Color scale: Photon Flux
Note 4 orders of magnitude decrease in underlying photon flux



6 km

- The results presented here are based on source region simulation levels from MCNP. This is part of the LANL EMP start-up project's goal of incorporating first physics principle source region calculations into legacy EMP code and then migrating to a fully integrated EMP physics package.
  - note: these calculations are going to be given to the NISAC systems analyst team to produce an more representative evaluation of equipment /infrastructure failure.

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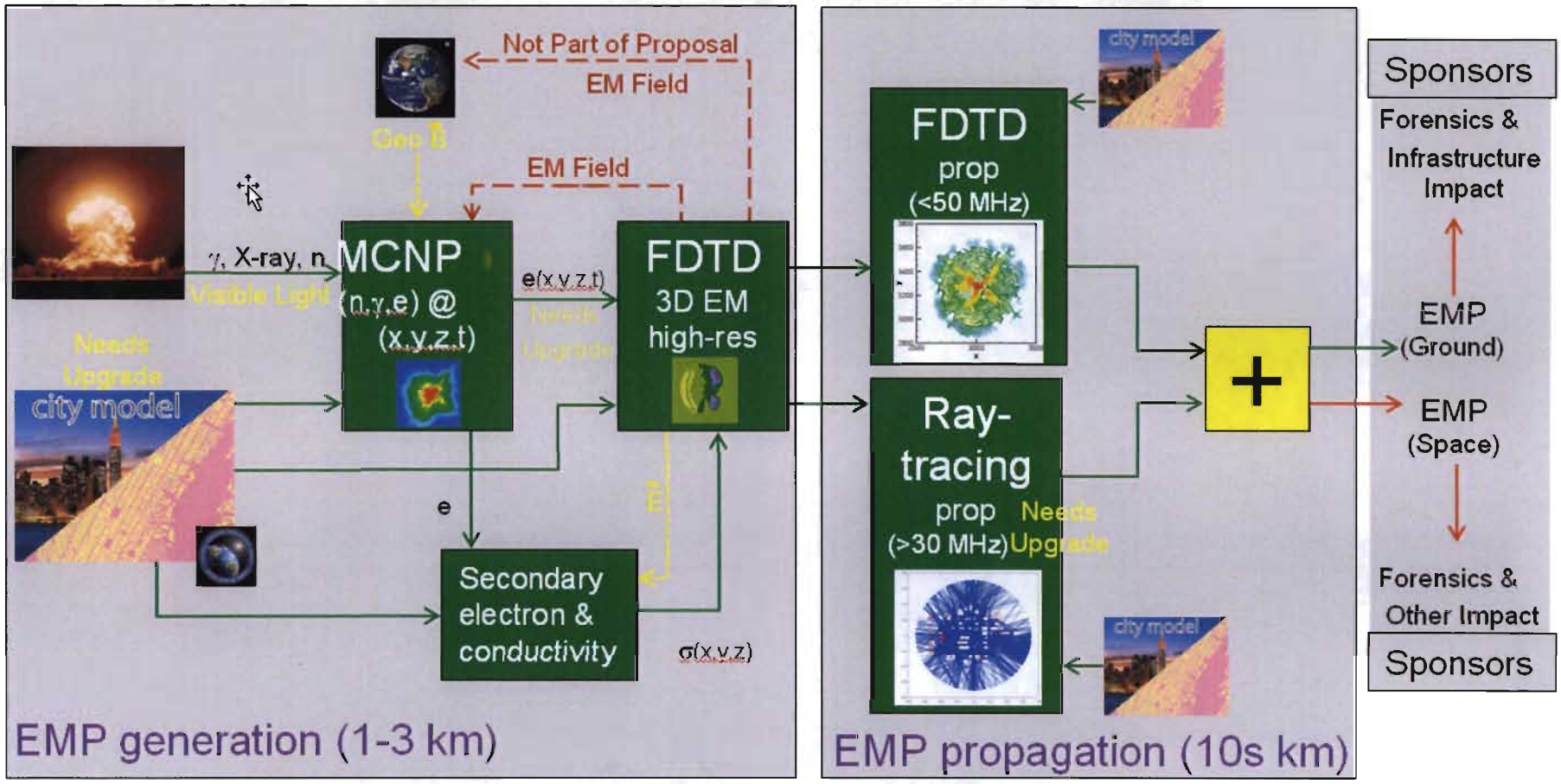
Contact: Bob Roussel-Dupré rroussel-dupre@lanl.gov

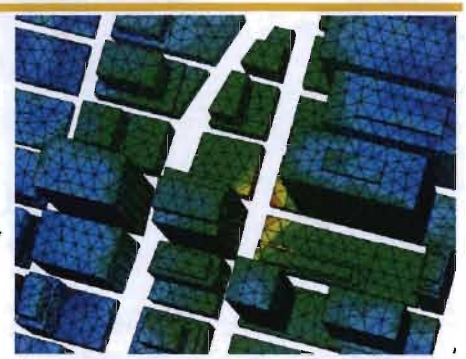
Planned MCNP Efforts for Urban EMP

- **Lower electron transport down to 1 eV** — **2011**
  - Include molecular effects from O_2 & N_2
- **Smart tallies for burst** — **2011**
  - Eliminate many zeros, significant memory reduction
- **Incorporate HEMPV into MCNP** — **2012-13**
  - Maxwell Solver to create E field
  - Will solve problems with large file sizes
- **Incorporate E field effects** — **2012-13**
  - MCNP assumed electrons slow down
- **MCNP Parallelism R&D** — **2011-13**

Urban EMP – First Principles Calculation Approach



MCNP6 is merger of MCNP5 + MCNPX + new stuff



- **What is MCNP6?**
  - All capability of MCNP5 1.60
  - All capability of MCNPX 2.7.0
  - Read Abaqus (CAD & CAE tools) unstructured mesh geometries
  - Explicit tracking of charged particles in magnetic fields
  - Link with LANL SN code Partisn for automatic generation of weight windows.
  - Low energy photon and electron expansion (down to 1 eV – includes optical light)
  - Improved variance reduction for radiography & nested DXTRAN spheres
- **Webpage navigation of documentation**
  - ~250 Megabytes of reports, V&V documents, journal articles
- **On same DVD as MCNP5 1.60 & MCNPX 2.7.0**
  - So that users can try for themselves and gain confidence in the new code.
- **MCNP6 Distribution Mechanism**
  - Source and Executables through RSICC (http://rsicc.ornl.gov/Default.aspx)
  - Patches updated to LANL website (requires users to compile)

MCNP6 is available now

- **MCNP6 initial "limited" release**
  - Stable, frozen version, tested with ~ 1600 test problems.
  - Already sent to RSICC for preliminary testing
  - Will be distributed to ~40 friendly users to help test code & create test suites
- **Separate AWE distribution mechanism**
  - Direct give of DVD to AWE of most current version (~1/quarter)
  - AWE contact: Adrian Gannon (JOWOG 6 chair): Adrian.Gannon@awe.co.uk
  - ~30 AWE members of "mcnp users group"
  - May – June 2011 secondment of AWE MCNP developer to XCP-3
  - Potential LANL MCNP developer to go to AWE for 3 months in fall of 2011.
- **Other Active Collaborations (who have MCNP6)**
  - ARA – Kyle Millage, Josh Bergman, Kevin Kramer
  - LLNL – ALE3D team (lead by Rose McCallen), Lila Chase
  - West Point – Physics and Nuclear Engr Dept - Major Mike Shannon
- **First "Production Release" – Expected Fall 2011**
  - DOE ASC will pay for free distribution for all of FY11 and FY12

Summary

- **MCNP currently has a lot of capability than can be applied to Urban EMP calculations**
- **Efforts are underway to expand this capability**
  - Especially the inclusion of a Maxwell solver (HEMPV)
  - Memory reduction efforts (ie. even larger extents & higher resolution)
- **MCNP6 is available for advanced user testing**

LANL XCP-3 Mission:

- **Develop MCNP for evolving DOE, DoD and DHS missions.**
  - Add new physics, parallel capability, tallies, etc.
  - Figure out how to pass information between programs.
  - Find synergy amongst varied customers.
- **Continuing V&V**
  - Necessary to find (and fix) inaccuracies
  - Better to know something is wrong, even better to have it fixed.
- **User Support**
  - Documentation
  - Teach how to use MCNP
  - Limited user assistance.
- **Beta version of merged MCNP & MCNPX (MCNP6) available to limited audience (those willing to help test and report their findings).**

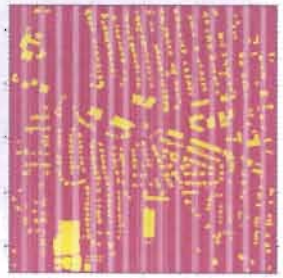
Realistic Geometry Models

Realistic geometries can be represented in MCNP as:

1) **Voxels**
   - **Medical**
   - **Urban Landscapes**

2) **Unstructured Meshes**
   - **CAE/CAD**
   - **Link with Abaqus**
   - **Still an art**

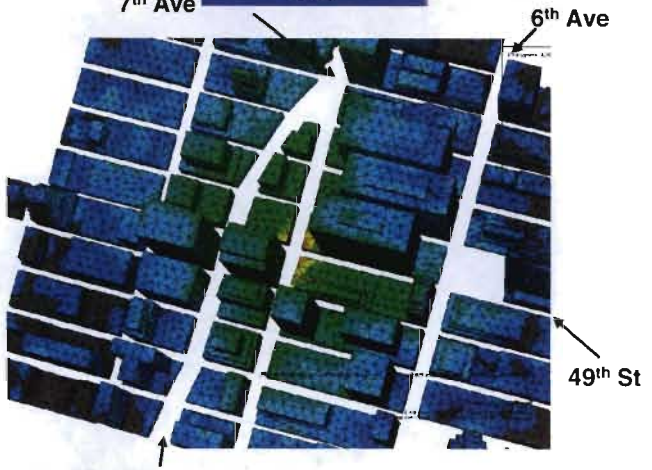
3) **Solid Combinatorial Geometry**
   - **Traditional MCNP geometry**

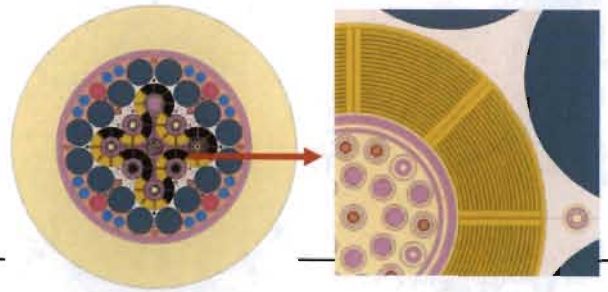


Abaqus

mcnp

Asteroid Itokawa deflection studies





Nuclear Reactor (ATR @ INL)

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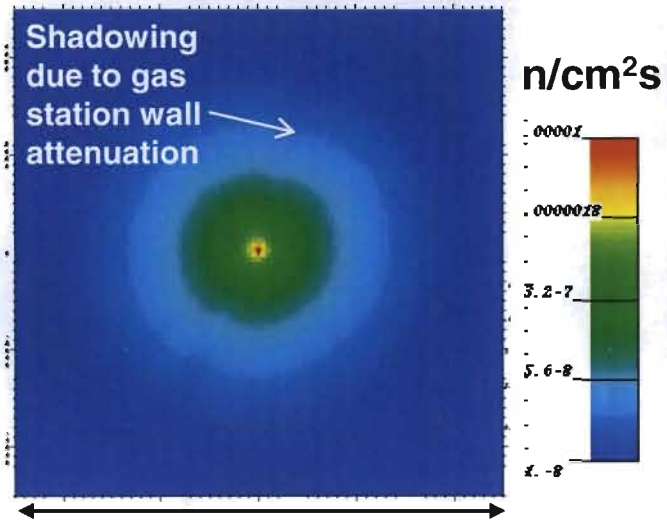
Operated by Los Alamos National Security, LLC for NNSA

1 km

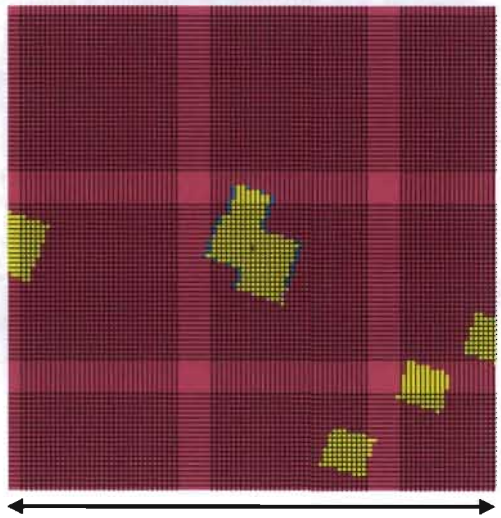
ASC

Intrinsic Radiation for Emergency Response Exercise

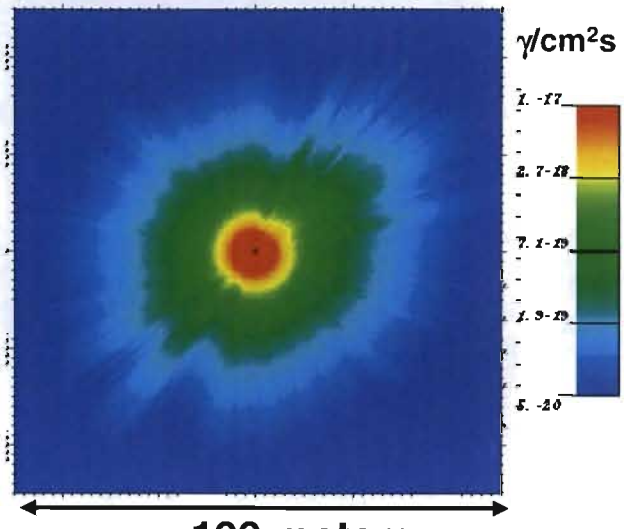
N flux from 1 MeV n source

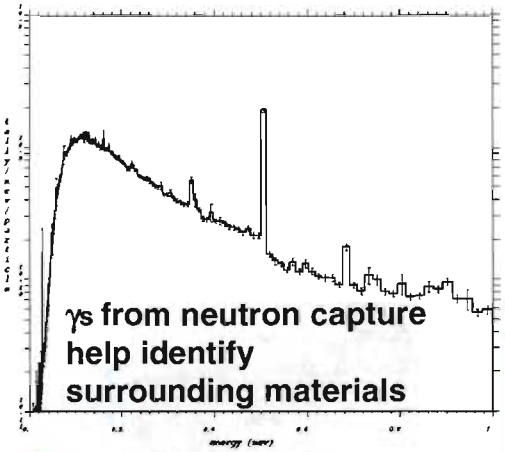


Geometry



γ flux from 100 keV γ src

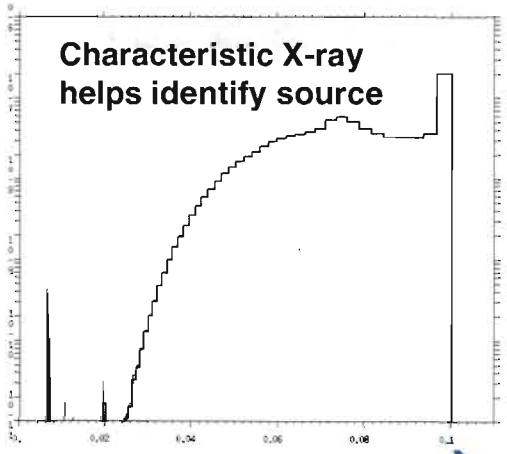




Calculate neutron & photon detector responses from realistic shielded sources provided for Nuclear Emergency Response exercise in Gainesville, FL (with urban environment), Chicago, New York, Las Vegas, etc.

Detector response close to prediction

Sponsors:
MCNP & Urban Geometry – ASC / IC
InRad – Stockpile Sys, NA-42, NA-47, C-7
Detector Response – NA-42, NA-47



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ASC