Russian Roulette with a Hot-Headed Phantom II:

Monte Carlo efficiency calculations of a voxelized BOMAB

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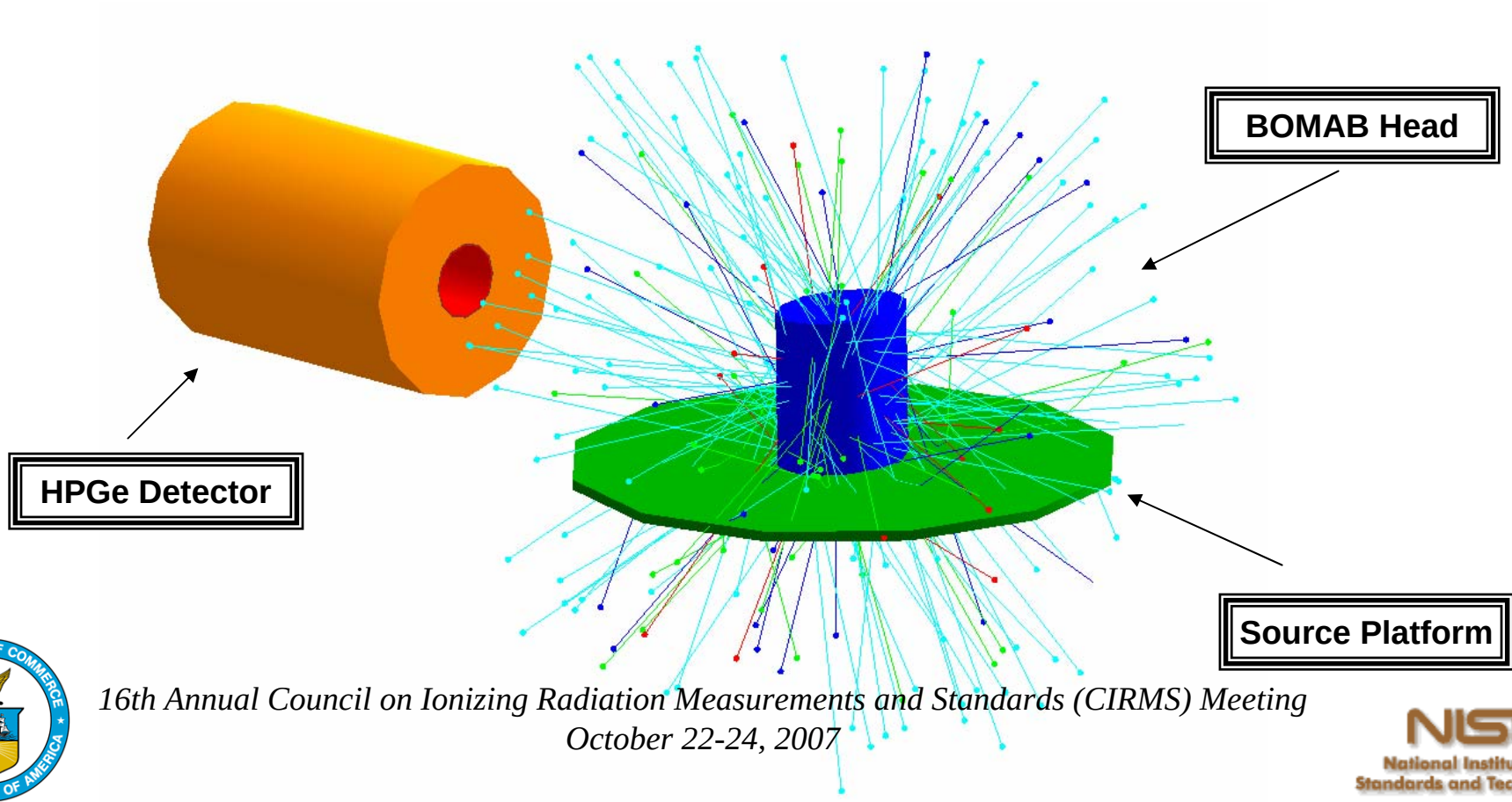

16th Annual Council on Ionizing Radiation Measurements and Standards (CIRMS) Meeting
October 22-24, 2007

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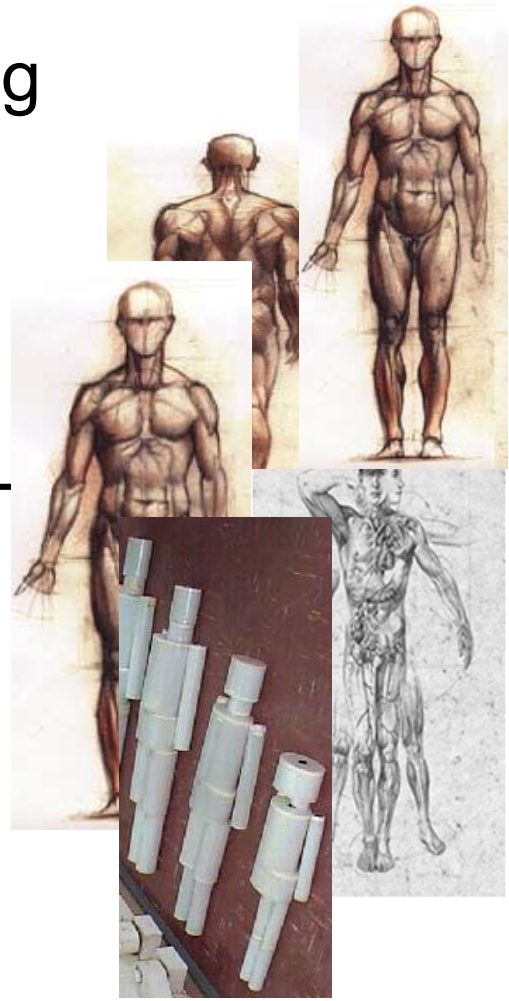
Project Exigence

- The accuracy of whole-body counting is greatly dependent on the use of ***reliable efficiency calibration*** techniques.
- Not possible to create ***SRMs*** for ALL geometries- ***just too many***!
- The fabrication process of complicated geometries (e.g. human body) is ***time consuming*** and ***expensive***.



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Project Goals

- A ***practical alternative*** to building a population of physical whole-body phantoms would be to develop ***computational standards***.

- ***Experiment*** against ***Monte Carlo*** radiation transport simulation

  - MCNP Input file (Scan2MCNP & Moritz)
  - Simulated Eff. = Experimental Eff.

- Two Tracks: ***Experimental*** & ***Computational***

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Project Object

- Test source with selected geometry-

  BOttle **M**anikin **AB**sorption Phantom (***BOMAB***)

  ~ simulates ICRP 23 Reference Man

- ***BOMAB:***

  - 10 seamless hollow bottles
  - Polyethylene plastics
  - Recessed fill port w/ screw cap

Experimental Track

- Filled bottles w/ ***nitric acid*** and then spiked with a known amount of ***Ga-67*** (half-life ≈ 3.2 days)

- Ga-67 emits gamma rays with 10 different energies. We were interested in only 5: 93kev, 184keV, 209keV, 300keV, 393keV

- HPGe detector Gamma System

-Phantom Position System

-about 50,000 counts

-Repeat at different distances

-Calculate Experimental Efficiency

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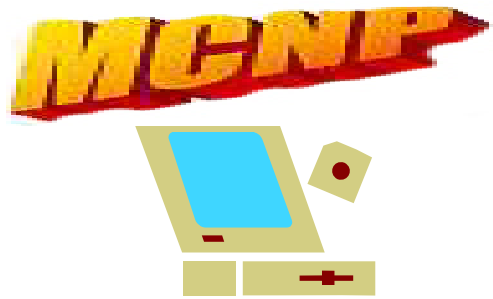
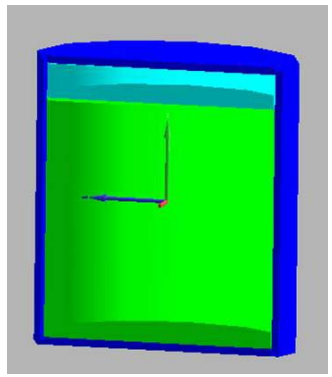
Theoretical Track

- Estimate of the BOMAB ***efficiency***

by Monte Carlo computation.



- **Monte Carlo N-Particle Transport Code (MCNP):**
  - User creates an ***input file*** that describes:
    - Geometry of source, detector, environment
    - Materials (type, density, atomic ratios)
    - Radiation source (energy)
  - Tally number of photons that hit detector.
  - Output is an efficiency vs. energy distribution.



- "Approximate" versus "Voxel" BOMAB

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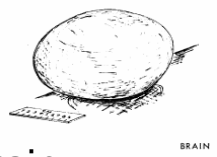
Phantoms

- Mathematical phantoms

  Equation-based phantom description by a combination of surface equations.



Brain

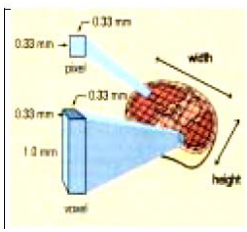
The brain is an ellipsoid given by

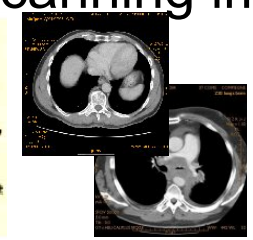
$$\left(\frac{x}{6}\right)^2 + \left(\frac{y}{9}\right)^2 + \left(\frac{z - 86.5}{6.5}\right)^2 \leqq 1,$$

and the volume is 1,470 cm³

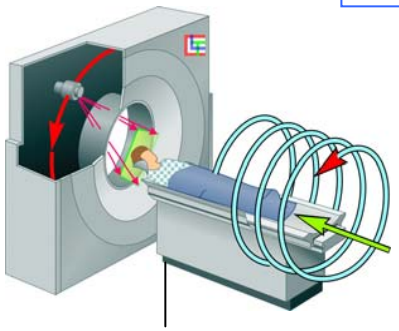
- Voxel phantoms

  Image-based tomographic phantoms, defined by voxels from CT or MRI scanning images of the object.

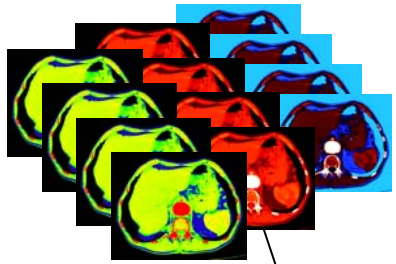




Creating a Voxel Phantom

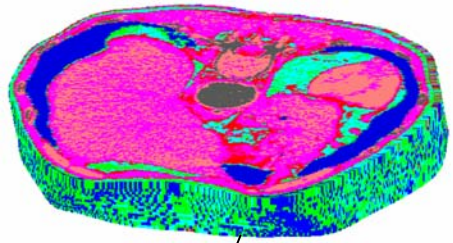


CT SCAN

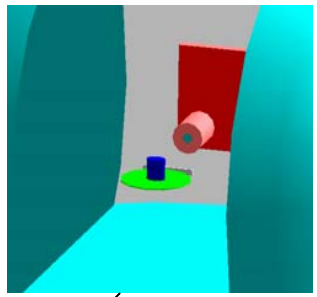


DICOM IMAGES

(**D**igital **I**maging and **Co**mmunications in **M**edicine standard format)



Scan2MCNP

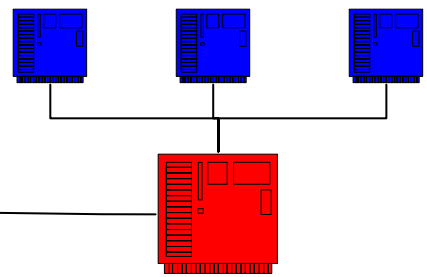


Moritz

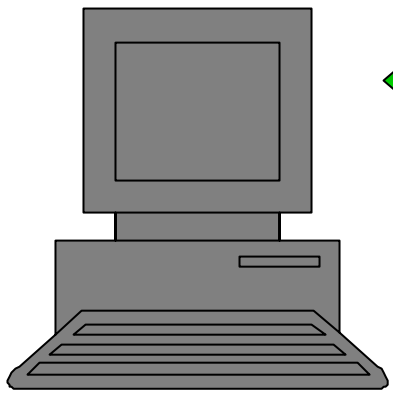
MCNP

Input

200+ nodes



Raritan



Output

Efficiency versus Energy Distribution

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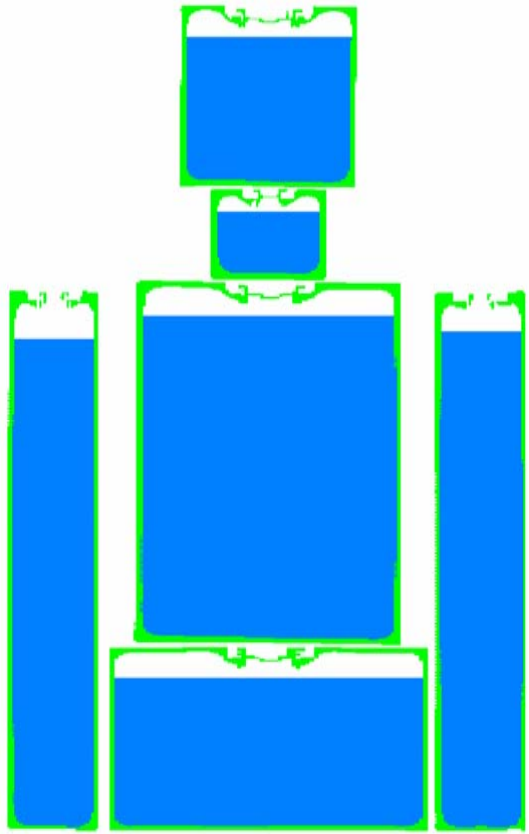
Voxel NIST Phantom

- 10 Bottle = 10 voxel lattices
- 9,125,879 voxels
- Voxel size ≈
  2.4mm x 2.4mm x 1.0mm
- Long computation time
- Input File ≈ 137,000 lines



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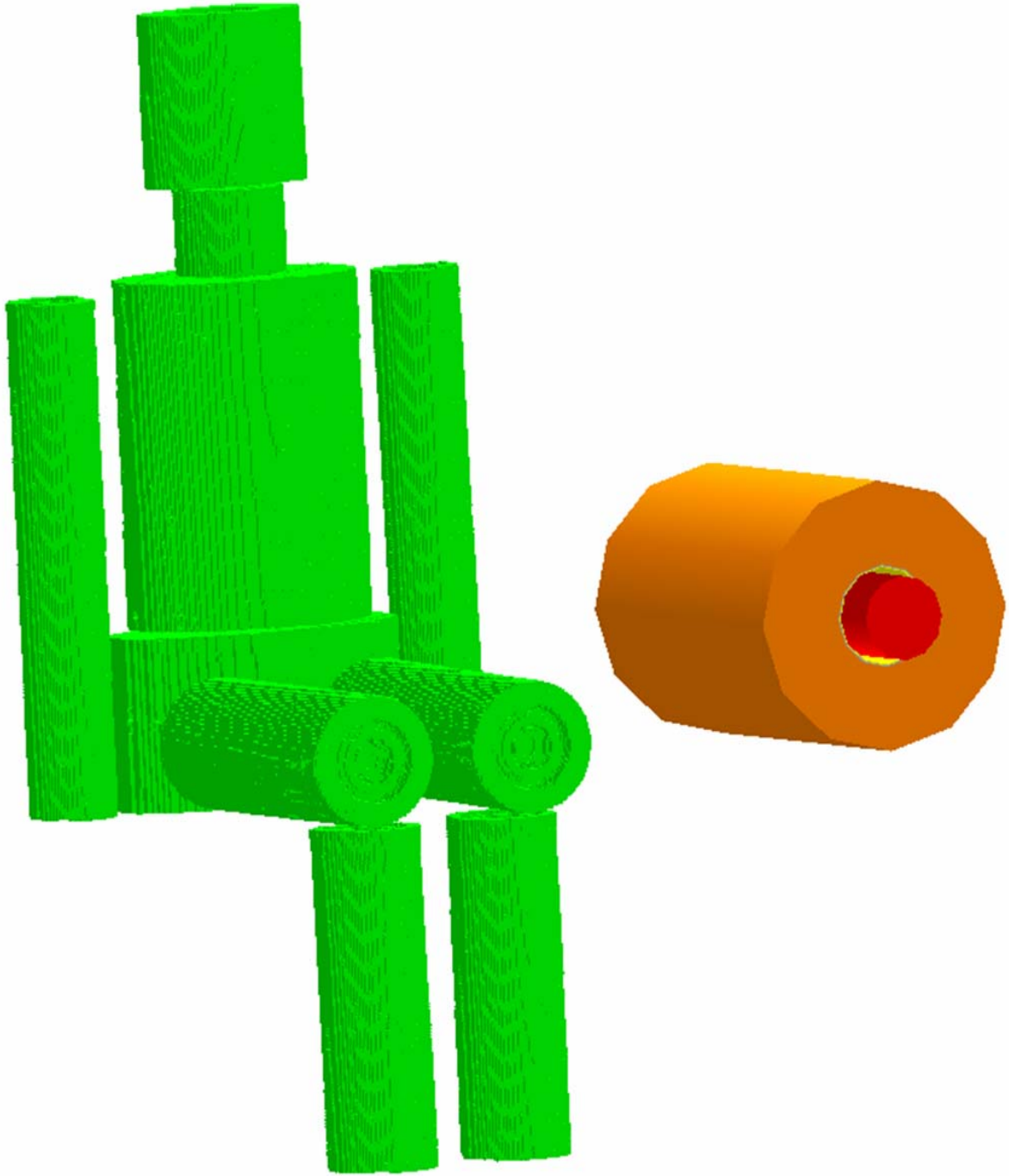

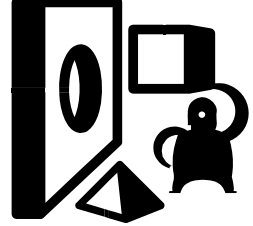

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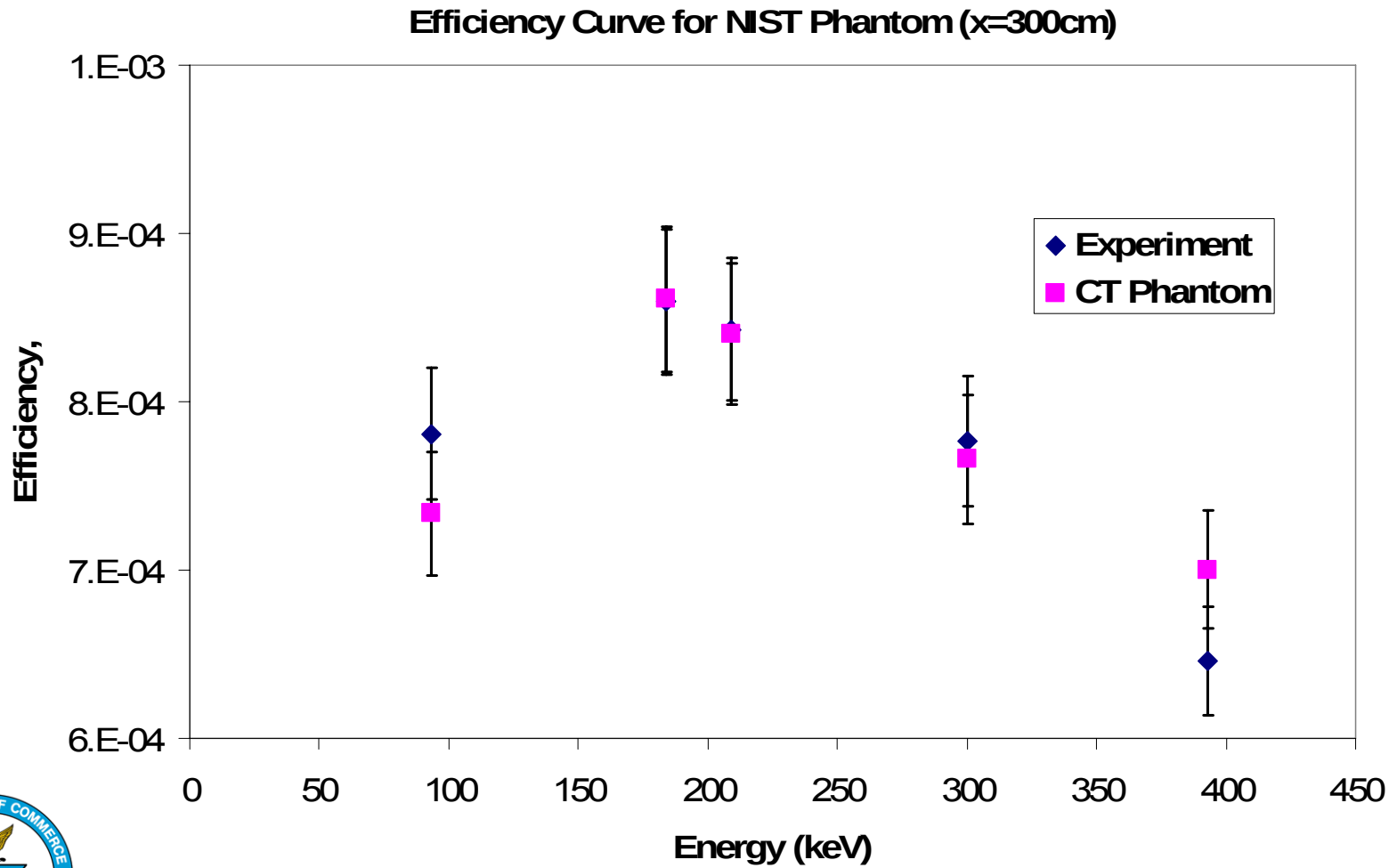
Results (Full Phantom)



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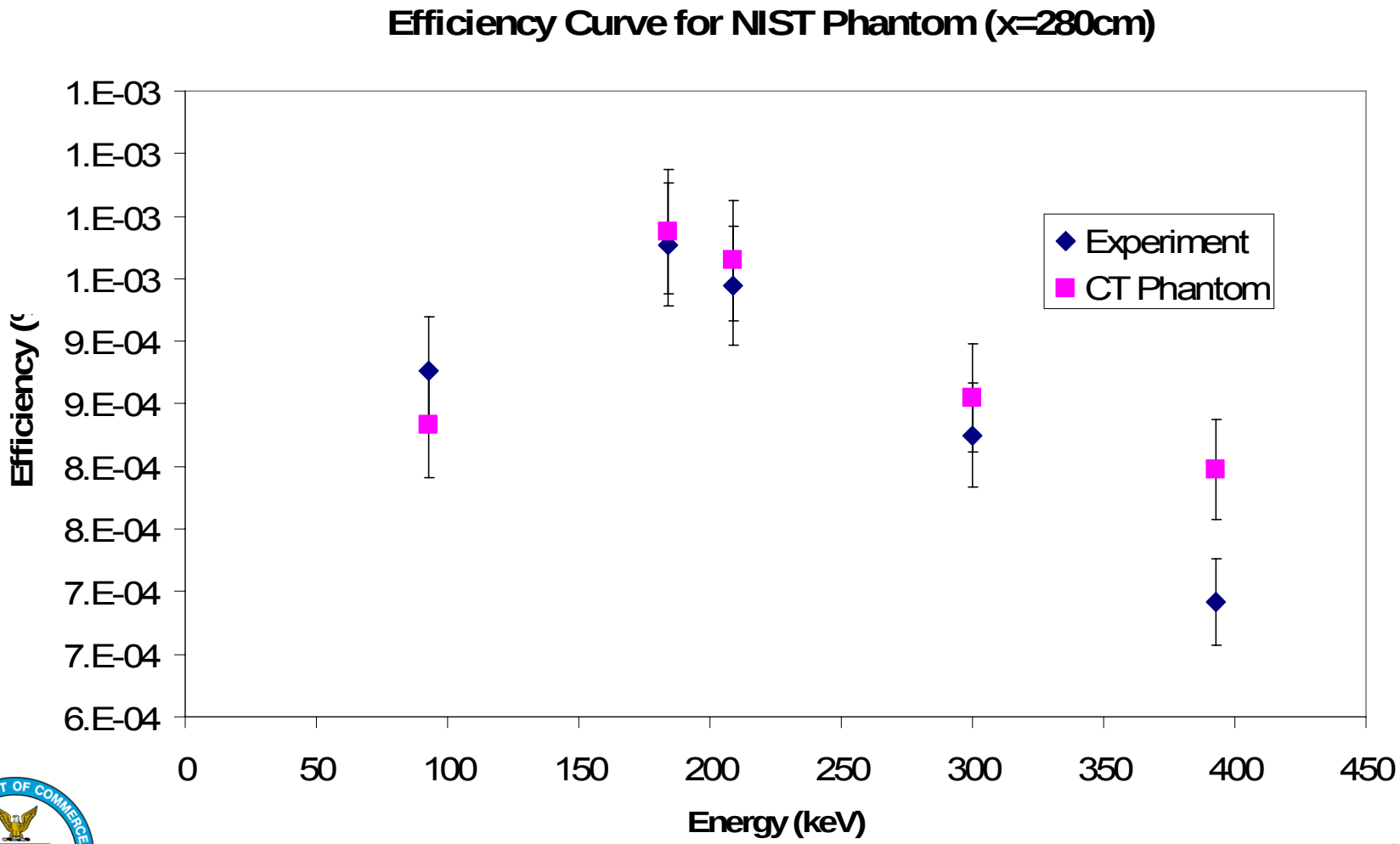

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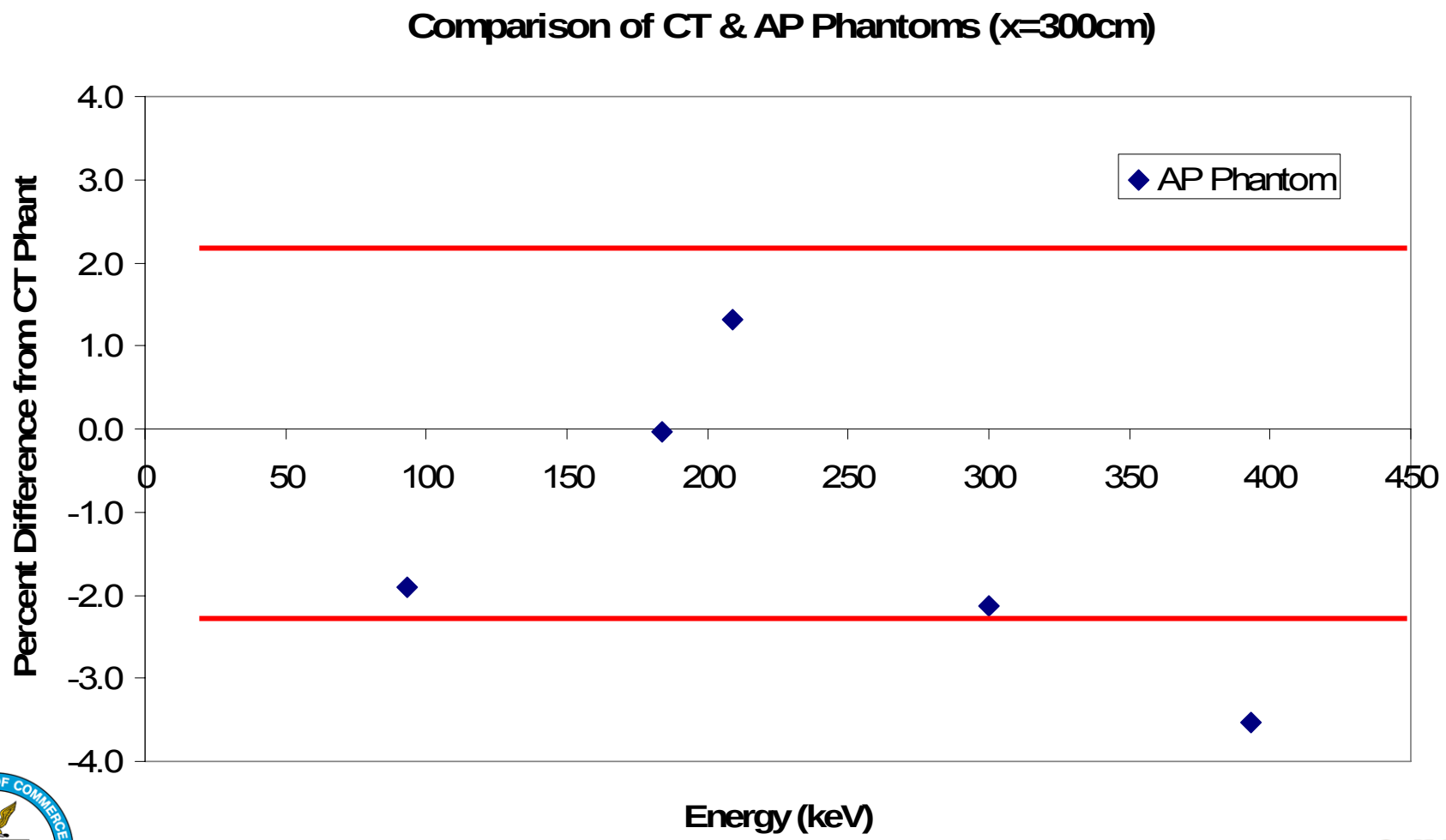
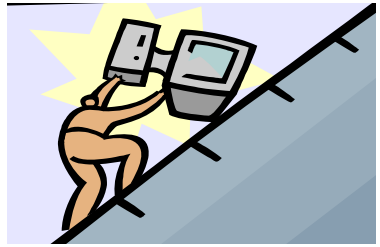
Results (Full Phantom)



Future

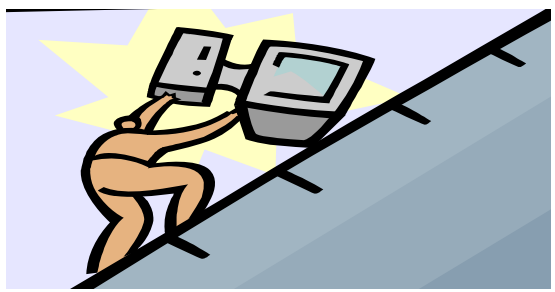


- Optimization of our detector model to best fit with experimental data.
- Create phantoms with smaller voxel size.
- Measure phantoms in the DOE phantom library.
- Model additional phantoms in MCNP

FUTURE *FOCUS*

- To develop a prototype of analytical anthropomorphic phantom to be used in simulation applications of radioprotection study or medical physics.

  - To build customized anthropomorphic phantom created as a voxelized model, and to calibrate it against a NIST standard.



Questions? ?

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