2002 DOE Lung Intercalibration Workshop
May 7-9, 2002
Augusta, Georgia

A Practical Study -
Using an ISOC's System For Lung Counting

Kelly Crandall,

Ronald Smith

Lung Calibrations

- **Traditional Calibrations - Lung Systems**
  - **Calibration**
    - **Torso Phantom**
      - **Phantom with several overlays**
    - **Lung sets**
      - **1 or more lung sets**
  - **Lengthy process**
    - **Several days to weeks**

Find Alternative Method

- Investigate replacing traditional (empirical) calibration methods with mathematical calibrations
  - Monte Carlo N-Particle (MCNP) code
    - "MCNP is a general-purpose Monte Carlo N-Particle code that can be used for neutron, photon, electron, or coupled neutron/photon/electron transport, including the capability to calculate eigenvalues for critical systems"

In Vivo Studies

- There are several in vivo studies where the MCNP code had been used for
  - Designing and testing detectors
  - Testing new equipment
  - Modeling phantoms
  - Calibrations
  - Variety of other in vivo topics

SRS

- At SRS, the MCNP code is used by Health Physics Technology (HPT) for
  - Waste characterization
  - Facility Designs
  - Instrument Evaluations
  - Shielding
  - ISOCS

DOE

- **DOE Initiative**
  - **However, I needed a MCNP software product that met the DOE Site initiative**
    - **WSRC Strategic Plan for Information Technology**
      - **FY2000-FY2002 (WSRC-TR-99-00067)**
    - **Commercial product that would incorporate into existing software package (ABACOS 2000)**
  - **Other Needs**
    - **Easy to use**
    - **Versatile**
      - **Lung Counting, Whole Body counting, wounds, bone surfaces, thyroids, etc.**
    - **Long term support**

Conversation

- **Talked to several people at Canberra**
  - **Asked if the idea of using MCNP was on the drawing board for Lung Counting with ABACOS 2000**
  - **No, but it is feasible**
- **Have you done any test with ABACOS to determine if it is feasible**
  - **No, but they had a software product that used the MCNP code with the Genie 2000 as the base product**
    - **Called ISOCS**

ISOCS

- **At SRS**
  - **ISOCS - In Situ Object Counting System**
    - **BEGe Detectors (Broad energy germanium detector)**
    - **Monte Carlo N-Particle code for mathematical modeling**

ISOCS

Idea

- At this point, I liked the idea
  - But I needed some data
  - SRS had purchased ISOCS within the last 2 years
    - Purchased by Health Physics Technology
  - Resident ISOCS Expert (Ron Smith)
    - Ron had completed 100's ISOCS models for a wide variety of projects at SRS and commercial
      - Ranging from complete facility decommissioning to waste assaying

Study Design

- We got together to design a very simple study

- Purpose of the Study
  - I wanted tangible evidence that the current ISOCS MCNP code would work for Lung Counting
  - Ron wanted to test the bounds of his system

Study Design

- I would supply the following to Ron
  - Torso Phantom, chest thickness (1.59 cm)
  - 4 Lung Phantoms Sets
    - Pu-238, Am-241, U-235, Th-234 in equilibrium with natural Uranium
  - Analyze the results, using the DOELAP performance criteria for relative bias and precision
- Ron
  - Model the torso and lung phantoms
  - Perform 5 measurements (30 to 60 min) for each lung phantom

Relative Bias

B_r shall be within -0.25 to + 0.50

$$B_{ri} = (A_i - A_{ai}) / A_{ai}$$

$$B_r = \overline{B}_{ri} = \frac{\sum_{i=1}^{N} B_{ri}}{N}$$

Relative Precision

S_B shall be less than or equal to 0.4

$$S_B = \sqrt{\frac{\sum_{i=1}^{N} (B_{ri} - B_r)^2}{(N-1)}}$$

Study Pro's and Con's

- **Pro's**
  - Both software packages (ISOCS and ABACOS 2000) use Genie 2000 as the base product for counting

- **Con's**
  - ISOCS used a single detector
    - Detector characterization had a limited range
      - 45 to 10,000 keV
        - ISOCS was limited for measuring Pu-238 (43 keV lines)
  - The SRS lung counting systems uses a 4 detector germanium array
    - Positioning was an issue

DOELAP Lung Phantoms

- Blind testing - I wanted to test ISOCS MCNP code with lung phantom sets
  - Fortuantley, I had just completed testing on the SRS lung counting systems using the 2002 DOELAP lung phantom sets
    - Ron performed 5 measurements for each DOELAP lung phantom set
  - Unfortunately, DOELAP results have not been released
    - Other laboratories are still counting the lung phantom sets

Other Lung Sets

- We performed the same test with 4 (known) lung phantoms
  - Th-234 (Nat-U)
  - U-235
  - Pu-238
  - Am-241

ISOCS Results

Lung Phantom	Acquisition Time (minutes)	Certificate Activity (nCi)	ISOCS Measurements (nCi)	Relative Bias (-0.25 to +0.50)	Relative Precision (≤ to 0.4)
Am-241	30	502	523	+0.04	0.006
Pu-238	60	1,251	1069	-0.15	0.06
U-235	30	19.8	18.0	-0.09	0.05
Th-234 Nat-U	30	104.4	87.3	-0.16	0.04

Summary

- ISOCS Measurements were within
  - -16 % to + 4 % percent of the certificate activity
  - Amazing considering we were using a single detector 4 inches above the chest

- Pursue making the ISOCS MCNP code a standard product with ABACOS 2000 software platform

Mathematical Efficiency
-vs-
Empirical Efficiency

Ron Smith, CHP

Westinghouse Savannah River Site

Points of Discussion

- What is ISOCS?
- Why an interest in this study
- How the study was conducted
- Results of the study

What is ISOCS?

- ISOCS - InSitu Object Counting System
- ISOCS is a software product developed by Canberra Industries
- The ISOCS software is used to perform an efficiency calibration mathematically. Efficiency calibrations currently over an energy range of 45 keV to 10000 keV
- ISOCS software inputs include Spatial orientation of detector to target, material composition, material dimensions

Why An Interest?

- ISOCS is a new technology on the Savannah River Site - Less than 2 years on site.
  - Empirical efficiency -vs- Mathematical efficiency
  - Demonstrate how complex geometries can be modeled sufficiently with simple geometries
  - Blind testing of the ISOCS system utilizing irregularly shaped objects.

How the Study was conducted

- **Equipment used**
  - Single broad energy germanium detector
  - Electronics - Inspector 2K
  - Laptop computer
  - Software - Genie 2K suite and ISOCS

How the Study was conducted

- **Torso Phantom**
  - Lung phantom assayed with ISOCS efficiency - 241Am, 238Pu, Th-234 in equilibrium with Natural Uranium, and 235U
  - Chest wall thickness of 1.59 cm was used.

How the Study was conducted

- **Measurement setup**
  - Detector is mounted on the ISOCS cart looking straight down.
  - Phantom laying on foam pad supported by cart frame.
  - Detector end cap 11 cm above chest wall.
  - Detector centered above bottom of left lung.
  - Used for all measurements

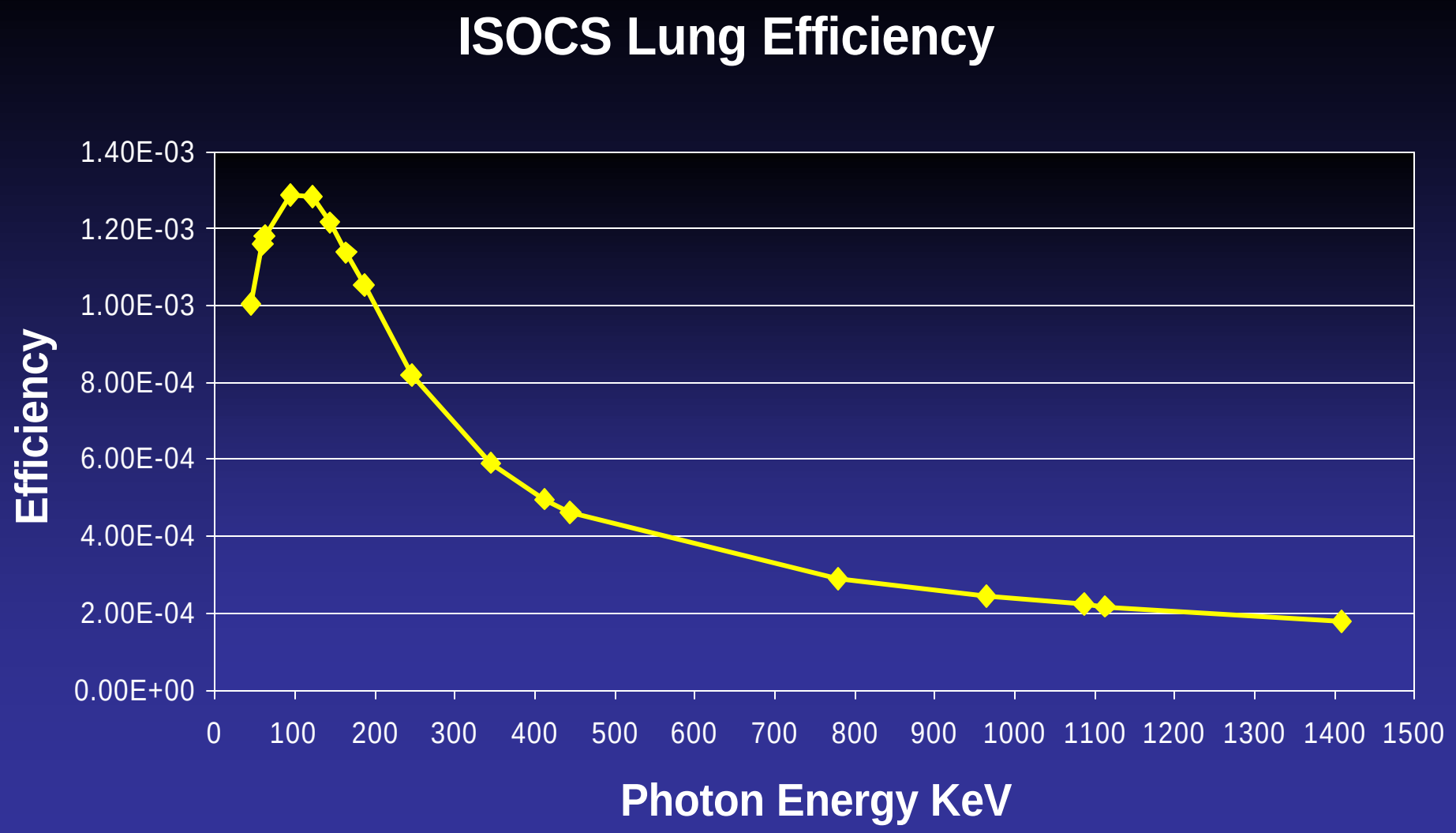
How the Study was conducted

- **Measurement**
  - Five repeat measurements for each lung phantom
  - Each measurement - 1800 to 3600 second acquisition

How the Study was conducted

- **ISOCS Model of the Lungs**
  - Standard ISOCS template was used
  - Complex cylinder model - 30 cm height, 30 cm diameter, 4 discrete layers, wall thickness of 1.59 cm.
  - Right lung - 5 cm height
  - Left lung - 3.5 cm height
  - Average Lung separation distance 3 cm
  - Lung density 0.27 g/cm3
  - Wall density of 1.1 g/cm3
  - Lung separation 1.0 g/cm3

ISOCS Cylindrical Lung Model 1.59 cm Chest Wall



Results

Lung Phantom	Acquisition Time (minutes)	Certificate Activity (nCi)	ISOCS Measurements (nCi)	MDA (nCi)
Am-241	30	502	523	12.7
Pu-238	60	1,251	1069	823
U-235	30	19.8	18.0	6.1
Th-234 Nat-U	30	104.4	87.3	15.9

Summary

- ISOCS standard template geometries are adequate to model many complex geometries.
- MCNP characterized detectors and associated ISOCS software could be utilized for lung counting.
- Development of a standard lung phantom as a standard ISOCS template would ensure repeatable measurement performance from site to site.