A Monte-Carlo Based Spectroscopic Characterization of a ^{137}Cs Irradiator with Attenuating Material

Sameer Taneja, M.S.

University of Wisconsin Medical Radiation Research Center

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Specific Aims

[1] Experimental verification of a Monte Carlo (MCNP5) model of ^{137}Cs irradiator

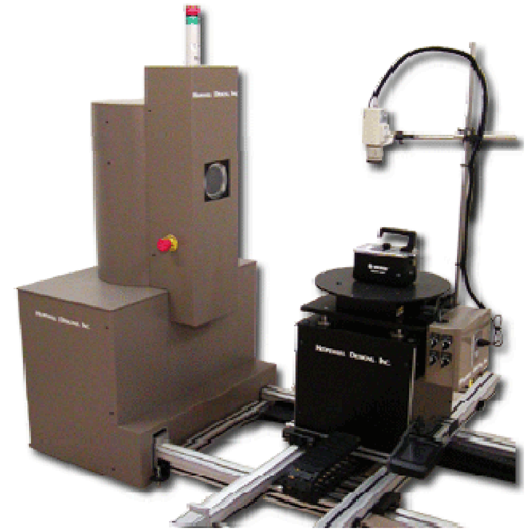
- Experimental and simulation methods
- Model verification results

[2] Identify differences in energy spectra as a function of attenuation

- Simulation methods
- Results and calculations

Introduction

- ^{137}Cs irradiators are used for the calibration of survey meters at the UWADCL
- Lead attenuators are used to modulate the exposure rate
- Changes in the energy spectrum as a result of these attenuators remains unaccounted for
- Direct energy spectra measurements are particularly difficult due to high fluence

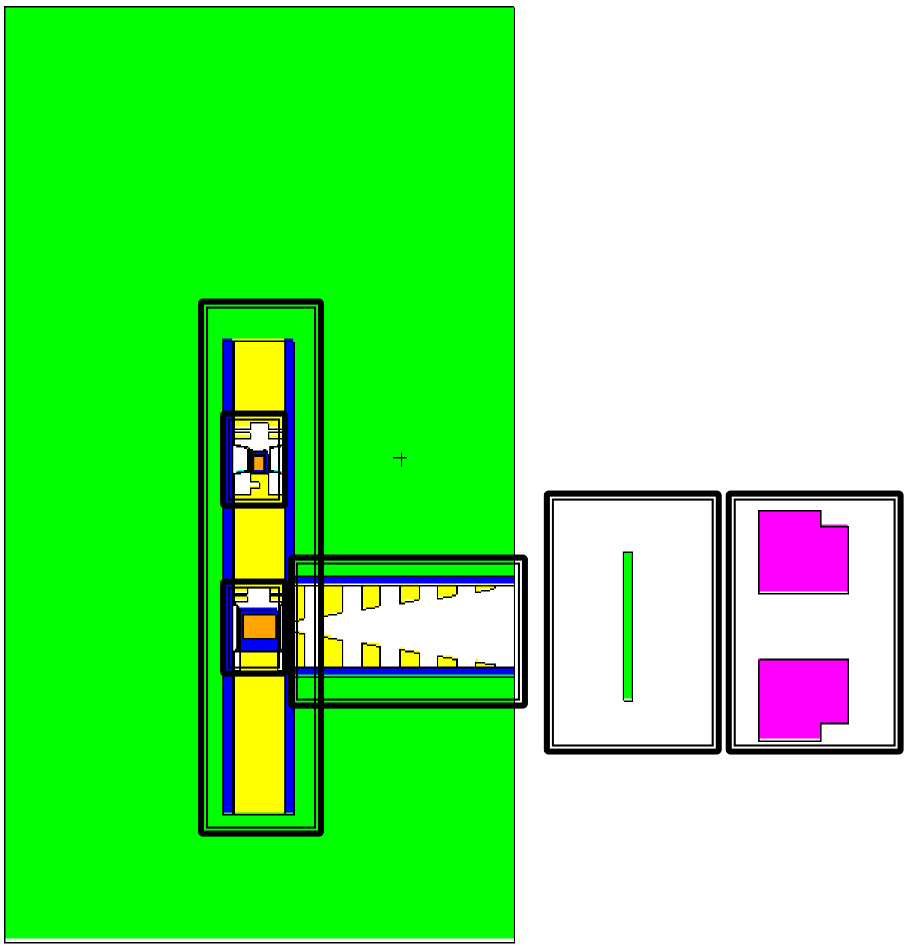


Hopewell Designs G-10 Irradiator

Ludlum model 14-C with pancake probe

Hopewell Designs. http://www.hopewelldesigns.com/
Biodex . http://www.biodex.com/

MC Model Verification



[1] Active Volume

[2] Tungsten rod

[3] Inner, cone-shaped primary collimator

[4] UWADCL custom built secondary collimator

[5] Lead attenuators

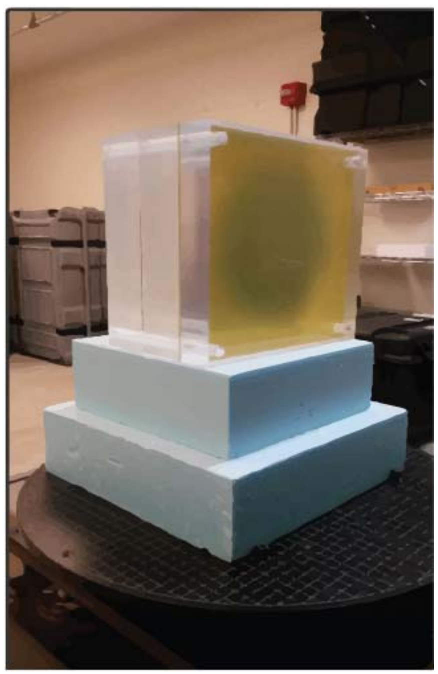
MC Model Verification

- ^{137}Cs irradiator was modeled in MCNP5 and benchmarked by comparing percent depth dose (PDD) curves and profiles

Experimental Methods

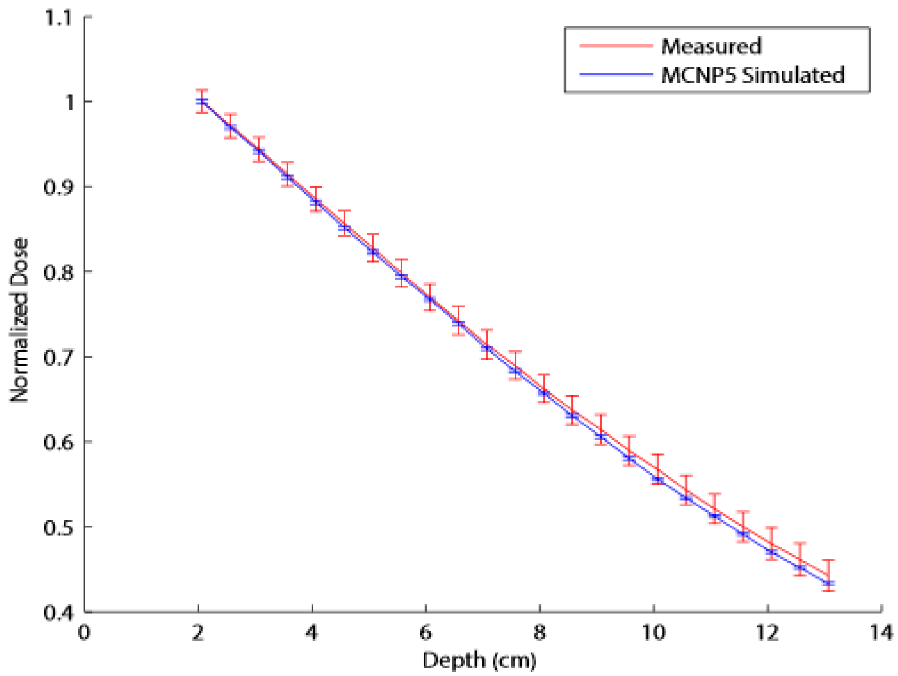
PDDs

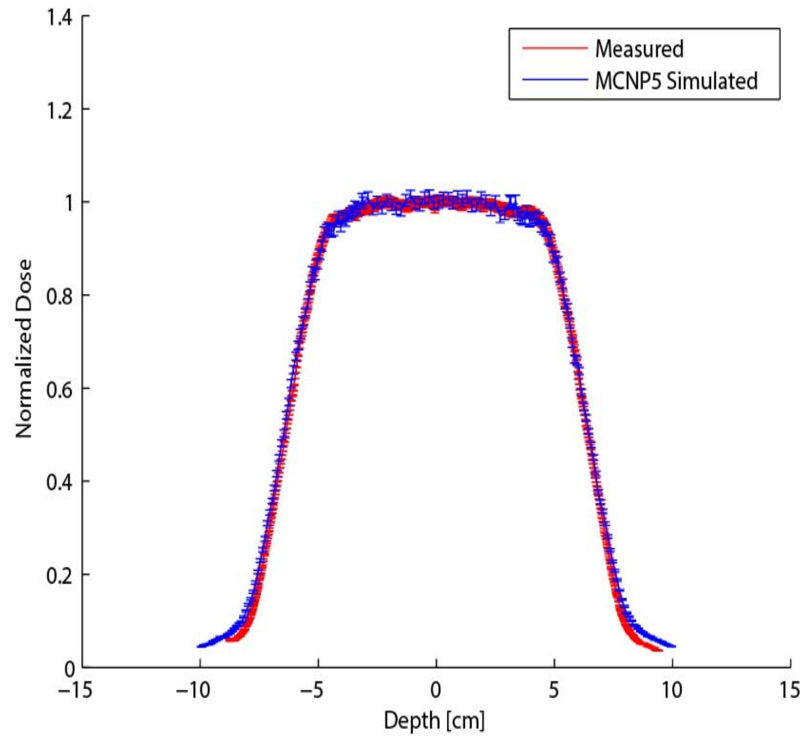
Profiles



- PDDs
  - A12 Farmer-type chamber
  - 0.5 cm increments
  - Depths of 2.25 to 13.25 cm
  - normalized to shallowest depth
- Profiles
  - EBT3 film
  - OD of pixel values were analyzed
  - Normalized to average of flat profile region

MC Model Verification





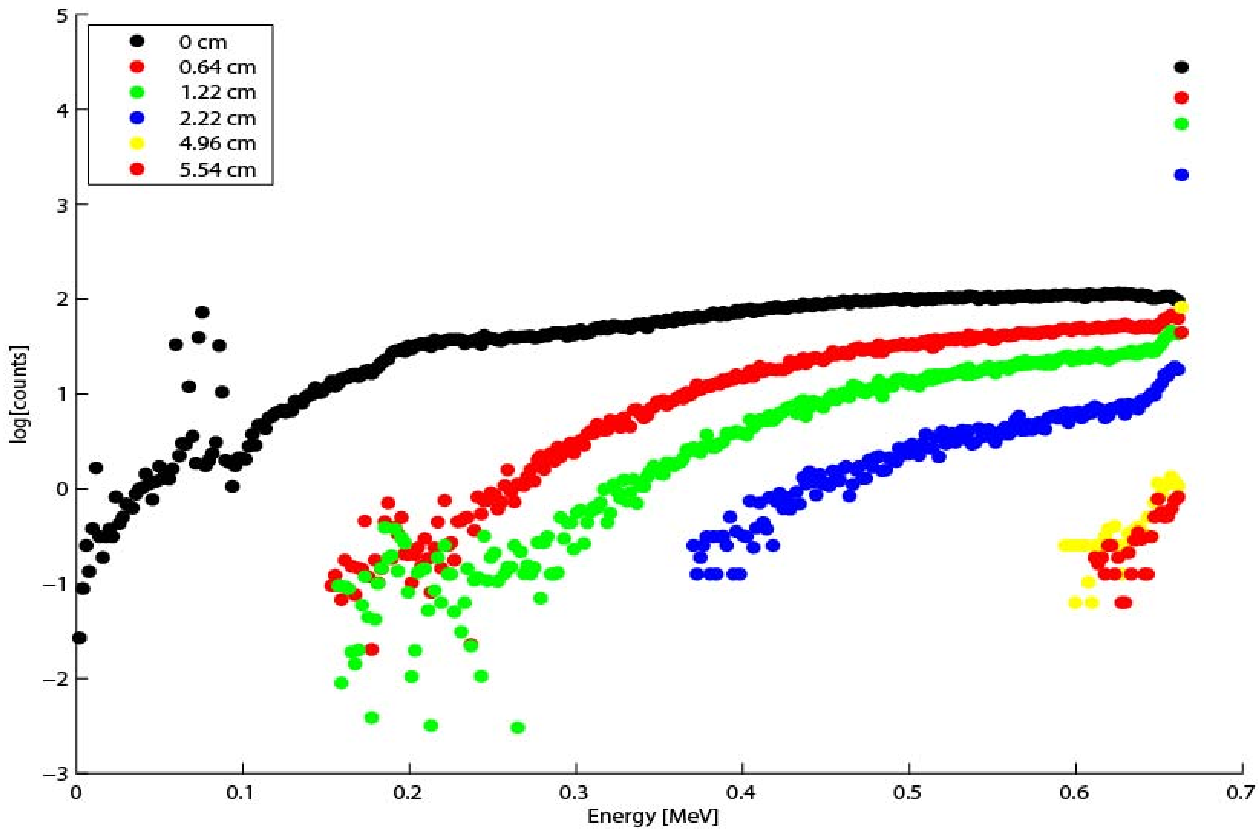
Spectra simulations

- Simulated using the verified irradiator geometry
- Methods
  - Investigated energy spectrum at 100 cm from the exposed source
  - A modified flux tally was used
  - Simulations completed for attenuating material thicknesses ranging from no attenuation to 5.54 cm.
  - Average energy was calculated

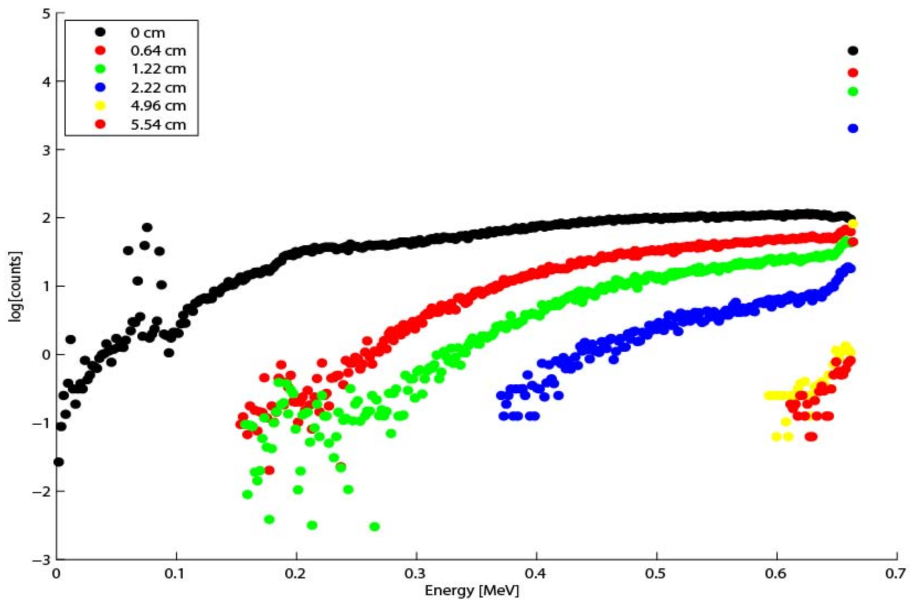
$$E_{av} = \frac{\sum_{i}^{imax} E_i \phi(E_i)}{\sum_{i}^{imax} \phi(E_i)}$$

E_{av}	Average Energy
E_i	Energy of bin i
$\phi(E_i)$	Fluence of bin i

Spectra simulations



Spectra simulations



Spectral characteristics for varying attenuator thicknesses		
Thickness [cm]	Average Energy [keV]	Uncertainty [%]
0	582	0.11
0.64	626	0.18
1.22	637	0.26
2.22	646	0.49
4.32	652	1.69
4.96	655	2.47
5.54	653	3.32

Conclusions

- Creates and experimentally validates an MCNP5 model of a ^{137}Cs irradiator
- Simulations show attenuators significantly affect the energy spectra.
- Spectral changes may affect survey meter response
- Future work will aim to quantify the effects of these spectral changes on the response of survey meters.

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Questions?