Measurement of a $^{60}$Co Teletherapy Spectrum Using a Compton Spectrometer

Introduction and Motivation

Most common beam parameter: absorbed dose to water
Most basic beam parameter: energy spectrum

Affects:
- Dosimeter response and correction factors
- Dose distribution
- Dose calculations
- Difficult to measure
- High-energy photons: penetrating
- High fluence rates: pulse pile-up and dead time
- Shielding

Goal

To measure the spectrum of a $^{60}$Co teletherapy unit using a Compton spectrometry setup

Compton Scattering Spectrometry

- Reduces fluence on detector
- Decreases energy
- Introduce scattering rod to beam
- Measure singly-scattered spectrum:
  \[ \Phi_s(\Delta \nu') \]
- Apply corrections to get:
  \[ \Phi_h(\Delta \nu) \]
**Outline**

- Introduction
- Background
- Methods and Materials
  - Spectrometry system
  - Spectra measurements
  - Measurement corrections
  - Monte Carlo
- Results
- Conclusions

**Spectrometry System**

- Theratronics T1000 $^{60}$Co irradiator
- REGe detector (Canberra, Inc.)
  - Closed-ended coaxial
  - FWHM 1.9 keV at 1332 keV
- Collimation/shielding (Hopewell Designs)
  - 30-cm-long tungsten aperture
    ($\varnothing$ 2 mm)
  - >10 cm lead
- Scatterer: Aluminum rod ($\varnothing$ 6 mm)

**Methods and Materials**

- Compton scattering measurements
  - 10 x 10 cm$^2$
  - $\varphi = 22.5^\circ$ ($d = 250$ cm)
  - $\varphi = 70.0^\circ$ ($d = 150$ cm)
- Primary beam measurements
  - 10 x 10 cm$^2$
  - No scattering rod
  - $\varphi = 0^\circ$ ($d = 600$ cm)

**Measurement Corrections: Energy and Efficiency Calibration**

- Energy calibration (measured)
  - Multinuclide standard source (NIST-traceable for energy)
- Detector response correction (calculated)
  - Model detector and shielding in MCNP5
  - Characterize for monoenergetic photons
  - Includes efficiency and other artifacts
  - Use backwards stripping technique

**Measurement Corrections: Compton Scattering Relations**

- Energy-angle relationship: accounts for energy shift
- Klein-Nishina cross-section: corrects peak magnitudes
Introduction and Motivation
- Background
- Methods and Materials
- Results
  - Pre-reconstruction
  - Post-reconstruction
  - Spectra comparisons
- Conclusions

Methods and Materials
- Verified with measurements
  - 10 x 10 cm²
  - Profile (5 cm depth)
  - Percentage depth-dose
- Calculated spectrum

Results
- Includes background subtraction and corrections for detector effects
- Further corrected for Compton relations

Spectra Comparisons
**Spectra Comparisons**

- Measured teletherapy spectrum using Compton scattering technique
- Decreased resolution with increasing scattering angle
- Future work
  - 60Co measurements
  - Maximize count rate
  - Investigate lower-energy continuum
  - Improve correction methodology
  - Apply technique to linac spectra

**Future Work**

- Introduction and Motivation
- Background
- Methods and Materials
- Results
- Conclusions

**Conclusions**

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**Measurement Corrections: Detector Efficiency**

- Energy- and geometry-dependent
- Accounts for gamma interactions (CS, PP/TP, fluorescence)
  - Detector
  - Shielding
  - Collimation

THANK YOU