The Monash University Compton Scattering Model

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Outline

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Standard Monte Carlo Compton Scattering Models

- Based on Ribberfors' Compton scattering model[a]
- Developed to model energy and angular distributions of Compton scattering photons off atomic electrons
- Experimentally validated at low energies[b]
- Model was not designed to include energy and angular distributions of Compton electron
- Loss of electron pre-collision momentum information due to 2D projection into photon plane
- Majority of models, Livermore and Penelope, restirct Compton electron to photon plane and estimate ϕ

[a] Phys. Rev. B. 12(6), 2067-2074, 1975
[b] NIM A, 349, 489-494, 1994

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Monash University Compton Scattering Model: G4MUComptonModel

- Utilises a two-body relativistic three-dimensional scattering framework in the relativistic impulse approximation
- Implemented new algorithms to determine scattered photon energy and ejected Compton electron direction
- G4LivermoreComptonModel was used as a template for the creation of G4MUComptonModel
- Utilised selected computational algorithms from G4LivermoreComptonModel to sample:
  - Klein–Nishina cross-section
  - shell and momentum of target electron
  - atomic deexcitation

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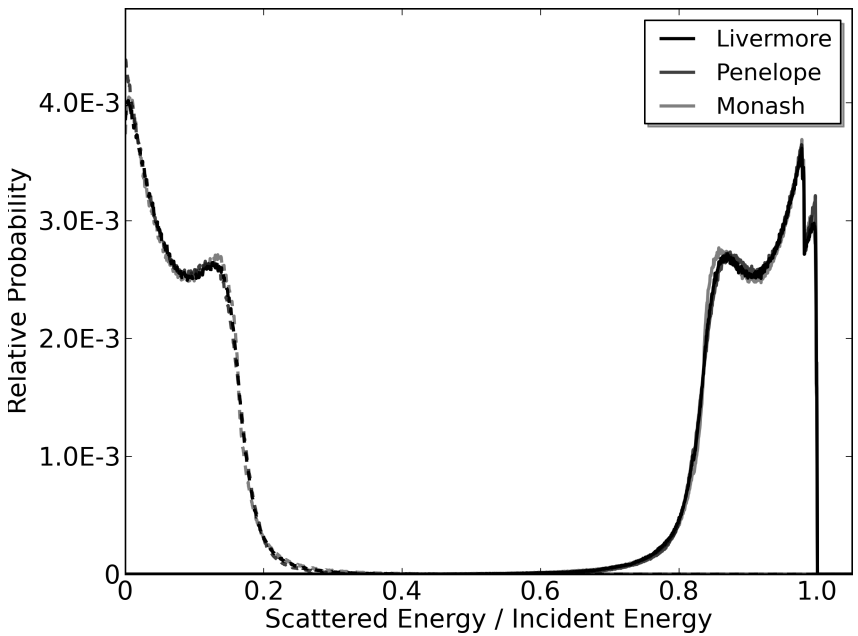
Validation and comparison of G4MUComptonModel

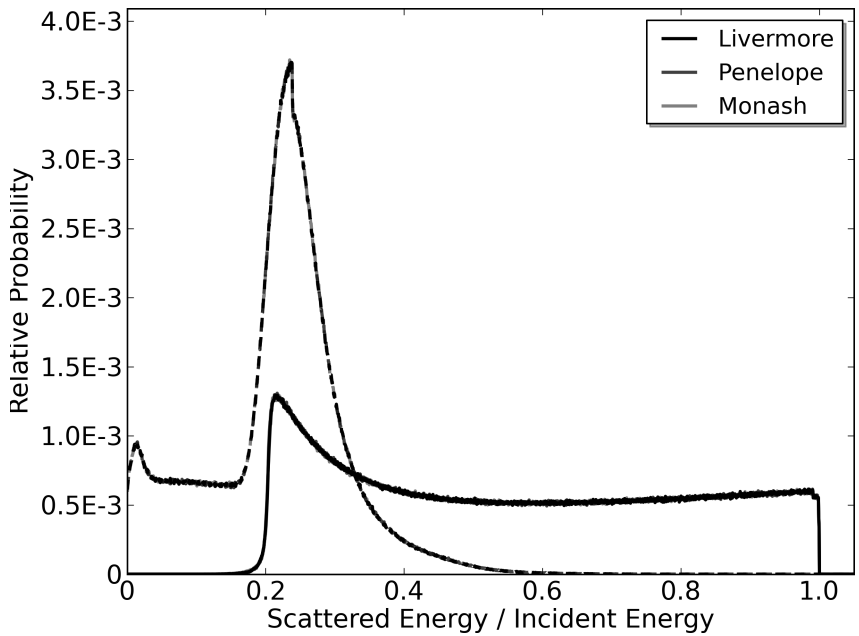
- Comparison of G4MUComptonModel to G4LivermoreComptonModel and G4PenelopeComptonModel:
  - Scattered photon energy spectra
  - Compton electron kinetic energy spectra
  - Compton electron directionality
- Three materials: Carbon (C), Copper (Cu) and Lead (Pb)
- Tested over an energy range of 10 keV to 10 MeV

Scattered photon and Compton electron kinetic energy spectra

Cu 50 keV



Cu 1 MeV



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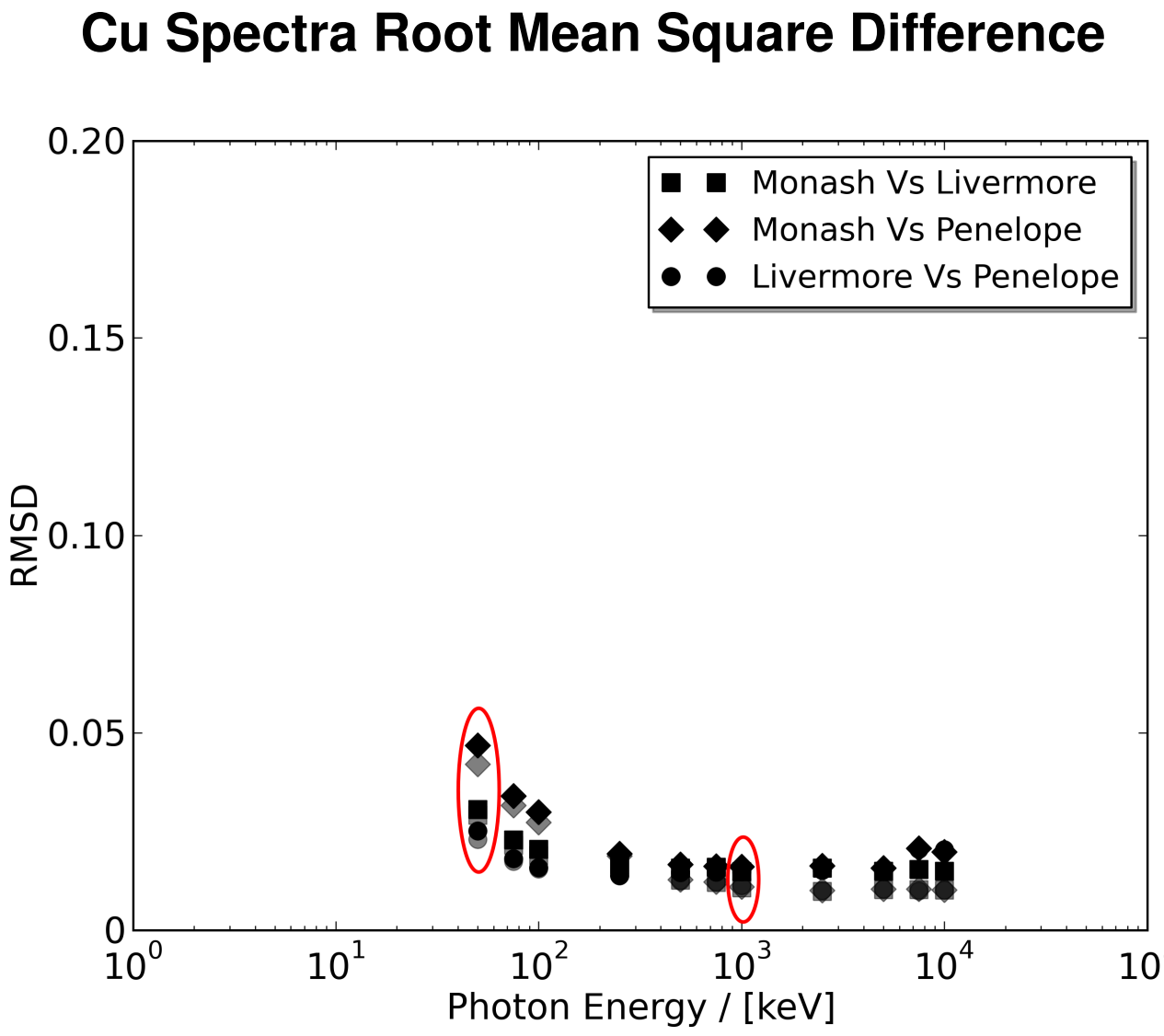
Scattered photon and Compton electron kinetic energy spectra



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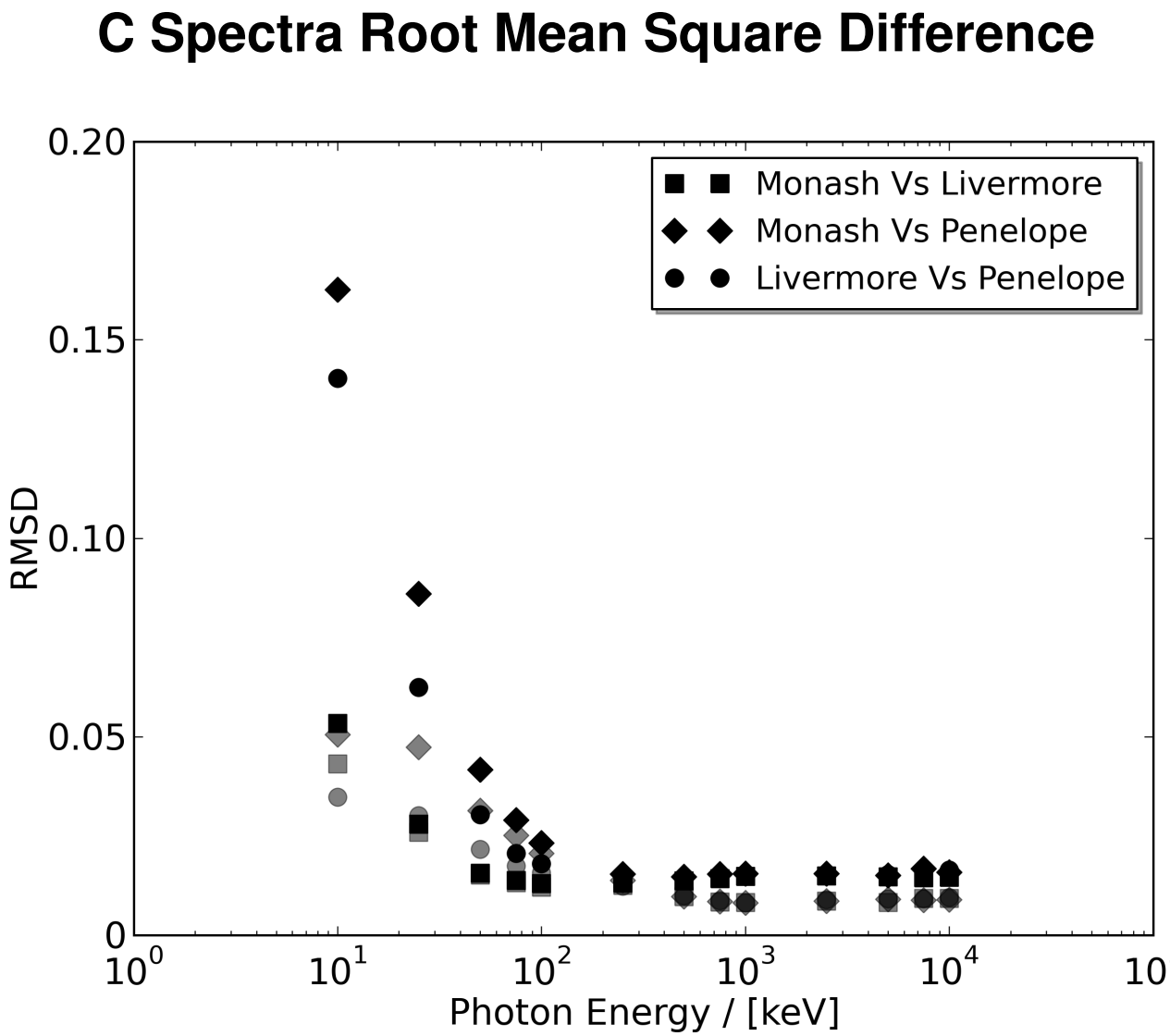
Scattered photon and Compton electron kinetic energy spectra



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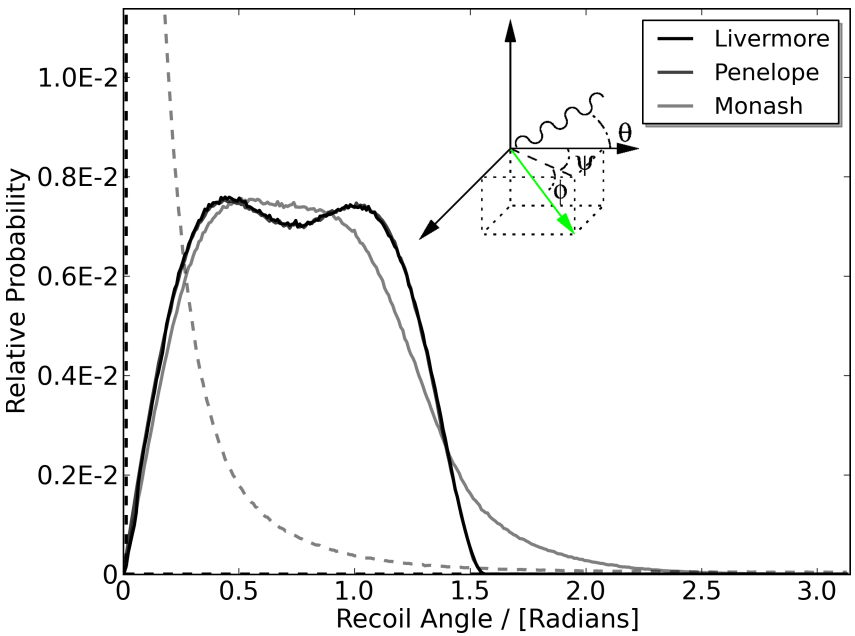
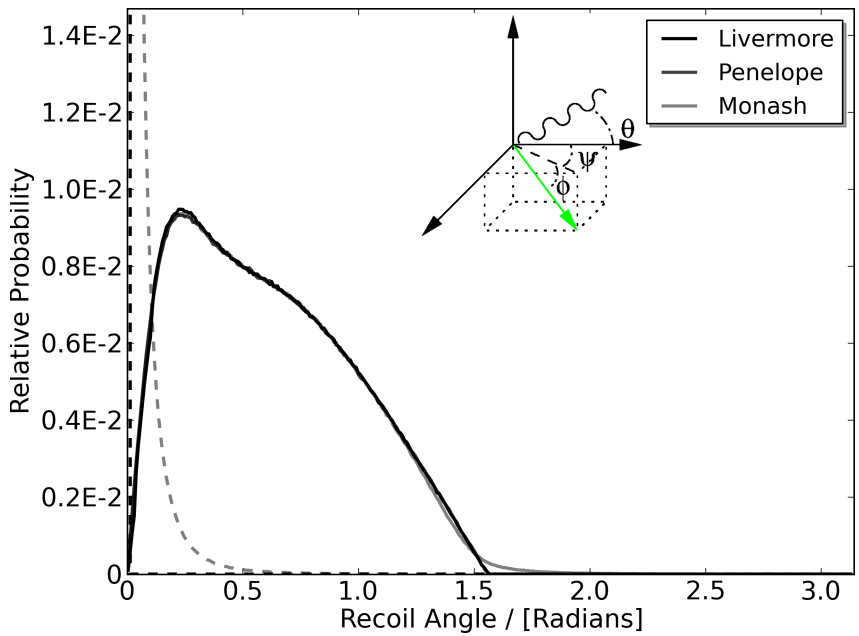
Polar and azimuthal Compton electron ejection angle distributions

Cu 50 keV



Cu 1 MeV



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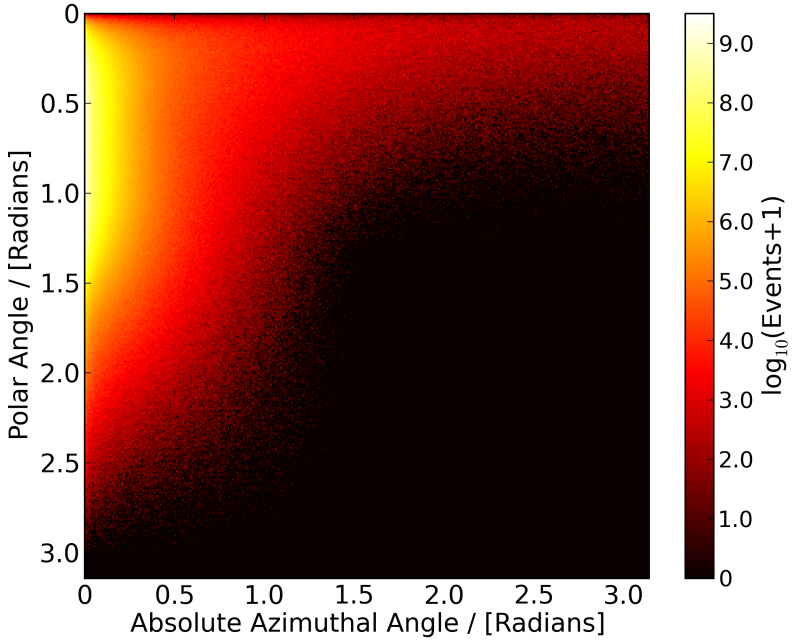
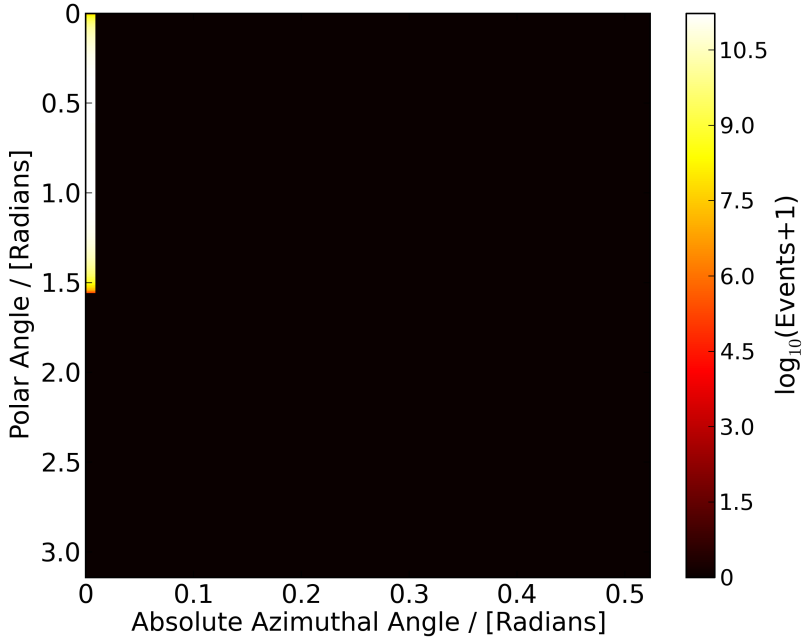
Polar and azimuthal Compton electron ejection angle distributions

Monash Cu 50 keV



Penelope Cu 50 keV



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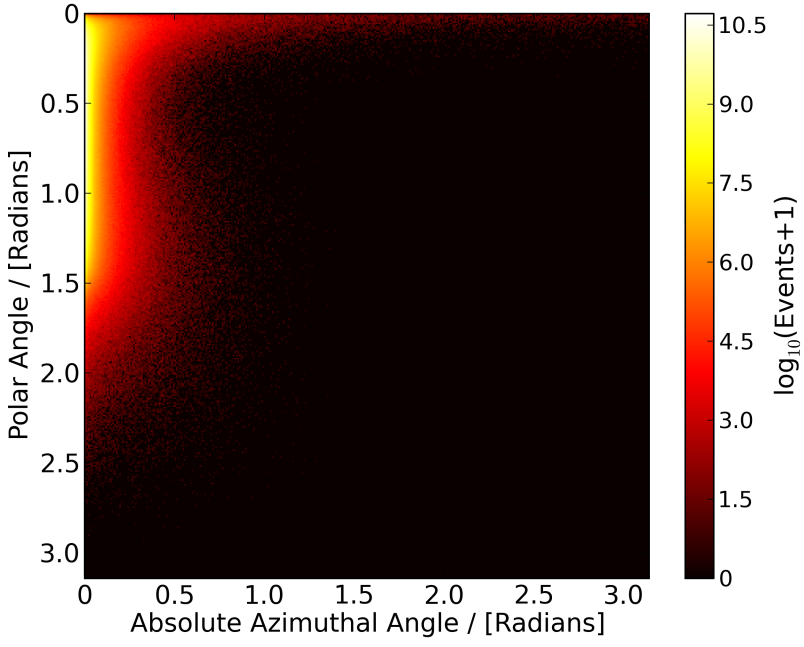
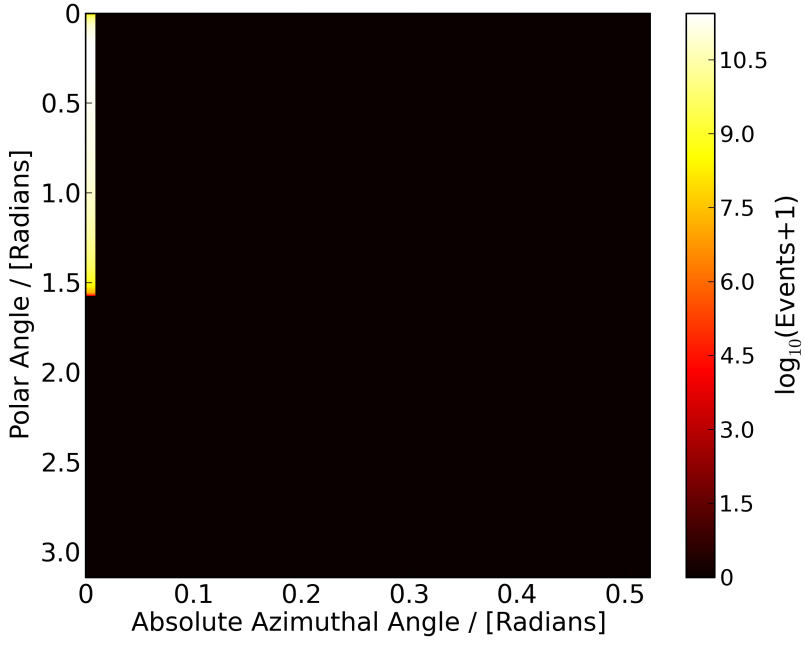
Polar and azimuthal Compton electron ejection angle distributions

Monash Cu 1 MeV



Penelope Cu 1 MeV



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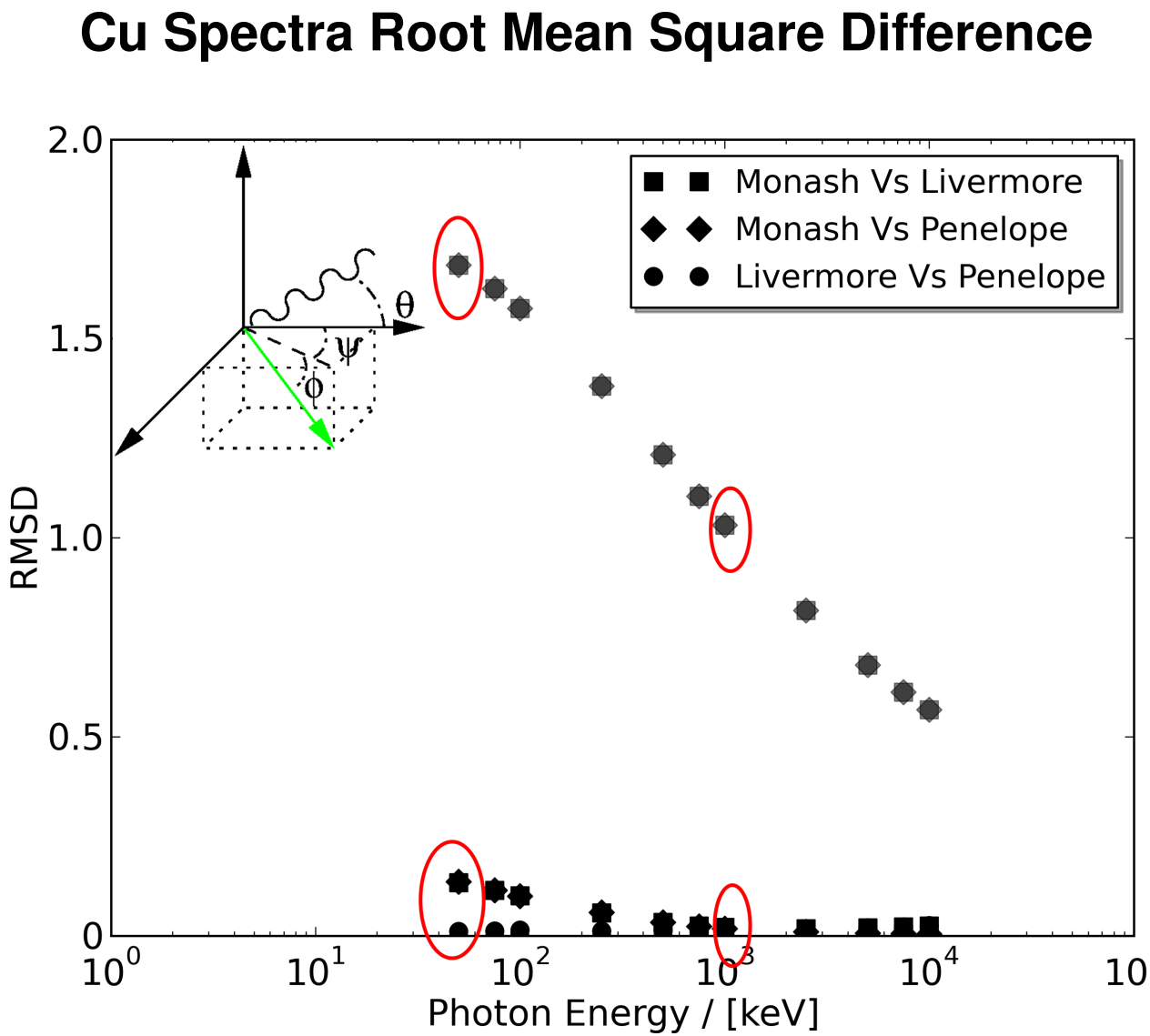
Polar and azimuthal Compton electron ejection angle distributions



Conclusion

- High level of agreement between the Monash, Livermore and Penelope for scattered photon and Compton electron kinetic energy spectra
- Compton electron polar angle distributions of Monash approach Livermore and Penelope at around 2.5 MeV
- Compton electron azimuthal angle distributions of Monash never fully approach those of Livermore and Penelope
- Incident photon energy and atomic number dependence on Monash's Compton electron polar and azimuthal angle distributions
- G4MUComptonModel is a viable alternative to the Compton scattering models of Livermore and Penelope

Further Work

- Photon polarisation
- Addition of electron momentum density functions calculated with GRASP2K Dirac-Hartree-Fock wavefunctions[1]
- Development of a model to account for influence of the atomic electromagnetic field potential in the relativistic impulse approximation
- Experimental validation of Compton electron algorithms

[1] Com. Phys. Commun. 177 597-622, 2007

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