Implementation and Validation of Non-Uniform Magnetic Fields into PENELOPE/penEasy

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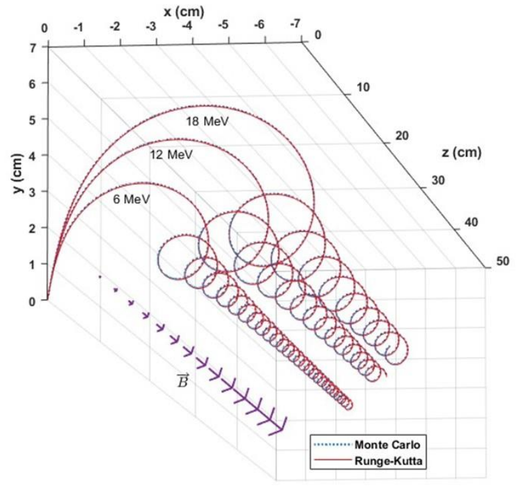
Impact / Innovation

- This work provides a reliable and accurate means of simulating electron transport via PENELOPE[1] in non-uniform (realistic) magnetic fields.
- We validate our implementation of non-uniform magnetic fields in PENELOPE against a 4th-order Runge-Kutta (RK4) numerical solution.

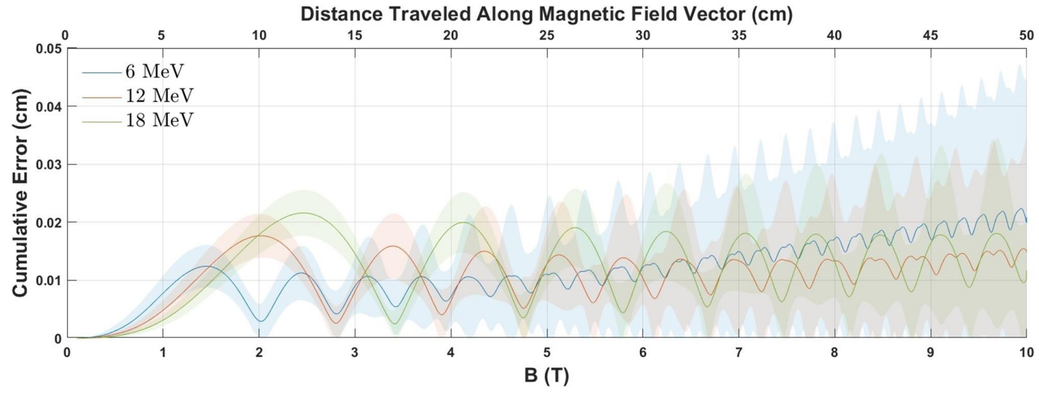
Materials & Method

- A means of introducing a magnetic field map to PENELOPE simulations from a user-defined text file is developed.
- We introduce a trilinear interpolation scheme into PENELOPE source code so that the field can be obtained at any point in the volume.
- As validation, 6, 12, and 18 MeV test electrons with a polar angle of 45° were transported through a linearly increasing magnetic field directed parallel to the z-axis with a strength from 0 T to 10 T over 50 cm.
- 25 MC trajectories for each energy were evaluated against the RK4 prediction.

Results



Electron trajectories in a linearly increasing magnetic field predicted by MC and RK4 methods.



The cumulative error is shown as the difference between the MC and RK4 methods. The 95% confidence interval from 25 histories is shown by the shaded region.

Code available on GitHub

Conclusions

- PENELOPE simulations using our implementation of arbitrary non-uniform magnetic fields yield electron trajectories consistent with RK4 solutions and our implementation can be confidently used in further studies.

References

1. Sempau, J., E. Acosta, J. Barò, J. M. Fernández-Varea, and F. Salvat (1997). An algorithm for Monte Carlo simulation of coupled electron-photon transport. *Nucl. Instrum. Meth. B 132*, 377 – 390.2.

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