MODELING COMPTON SCATTERING WITH GEANT4

1 Abstract

The purpose of this report is to evaluate the implementation of Compton scattering in GEANT4. This is accomplished by comparing the differential scattering cross-section from the Klein-Nishina equation to those obtained with GEANT4 simulations.

2 Methodology

The simulation geometry involves a photon source interacting with the target material, which for this exercise is chlorine gas at standard temperature and pressure. The geometry is completely linear with the target perpendicular to the gamma beam. The target thickness was set to 20 cm. A tally was included in routine SteppingVerbose.cc to extract the photon energy loss, position, and momentum during the execution [2]. For Compton scattering the incident photon energy loss is equivalent to the scattered electron energy. In order to calculate the differential Compton scattering cross-section the entire electron energy loss spectrum was divided by the number of incident gammas. In addition, the spectrum was supposed to be scaled down by the luminosity of the target. This step was not performed. The investigation entailed the execution of various GEANT4 runs with the two different processes defined in GEANT4: the general Compton process included in routine G4ComptonScattering, which will be referred to as the ’’general” process, and a low energy Compton process included in routine G4LowEnergyCompton. In order to obtain enough events a total of 10 million gammas were generated for each GEANT4 Compton process.

The differential scattering cross-section values from the Klein-Nishina equation [1] were obtained via the program DiffE KleinNishina.c, which was provided in class for this study. The program was executed to generate the values for an incident photon energy of 1 MeV starting at the ejected electron energy of 0 eV in steps of 100 eV.

3 Results

Figure 1 shows the differential Compton scattering cross-section for the two GEANT4 implementations and the Klein-Nishina equation. There is very good agreement between the results. The GEANT4 processes seem to produce a slightly lower value than the Klein-Nishina equation. The Compton edge appears to be located near 8 keV. There seems to be another smaller edge at slightly higher energies than that of the Compton edge for both GEANT4 processes. This feature does not match well with theory since there is only one point of maximum ejected electron energy, which should correspond with the highest value of the differential Compton scattering cross-section.
Figure 1: Differential Compton Scattering Cross-Section for 1 MeV gammas. Blue is the general GEANT4 process, red is the GEANT4 low energy process, and green are the values from the Klein-Nishina equation.

4 Conclusion

GEANT4 appears to correctly model Compton scattering. Both the general and the low energy processes yield differential scattering cross-sections comparable to the Klein-Nishina Equation.
References
