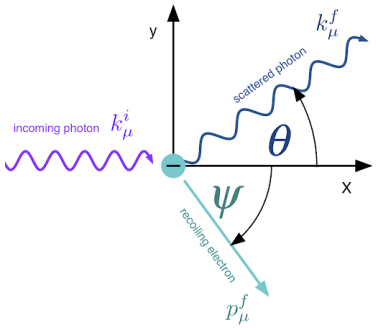
Physics Dataset Practice Problems

Week of July 13, 2020

1 Compton Scattering

How does the differential Compton Scattering cross section $\frac{d\sigma}{d\Omega}$ depend on direction? You devise an experiment in which you are able measure the differential cross section "seen" by individual scattered photons at polar and azimuthal angles θ and ϕ. You perform your measurements using LINAC energies of E_L = 6, 10, 15, or 18 MV, each time measuring $\frac{1}{\bar{\sigma}(E_L)}\frac{d\sigma}{d\Omega}(\theta, \phi)$ for photons of individual energy $E_\gamma \leq E_L$. Your measurements are tabulated in the dataset `compton.csv`.



1.1 Visualize the Dataset

Plot

1. The measured cross section versus polar and azimuthal angles for a single beam energy.

2. The average scattering polar angle $|\bar{\theta}| = \frac{\sum_i |\theta_i| \frac{d\sigma}{d\Omega}_i}{\sum_i \frac{d\sigma}{d\Omega}_i}$ versus E_L. You should find that higher energy beams are more forward-scattered.

1.2 Build a Model

Use machine learning to model the function $\frac{1}{\sigma}\frac{d\sigma}{d\Omega} = f(E_L, \theta, \phi)$. Use your model(s) to predict the fraction of Compton photons scattered into $d\Omega$ given ($E_L = 12$ MV, $\theta = 0.25, \phi = 2$), and ($E_L = 8$ MV, $\theta = -1, \phi = 1$). Additionally, compare the RMSE of your models on a testing dataset (20% held out), and plot predicted scattering profiles for a new beam energy using your models.