Rayleigh Scattering In GEANT4

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Rayleigh Scattering Formula

- According to Eqn. 9.84 in Jackson, the differential scattering cross section for Rayleigh scattering are:

$$\frac{d\sigma}{d\Omega} = k^4 a^6 \left| \frac{\varepsilon - 1}{\varepsilon + 2} \right|^2 \left| \varepsilon^* \cdot \varepsilon_0 \right|^2$$

- Where ε is dielectric constant, a is radius, k is wave number = 1/λ.
- ε_0 and ε* are the polarization vector of incoming and outgoing photon and

$$d\Omega = d\cos\theta_p d\phi_p$$

Both angles are the angle for the outgoing photon.

Rayleigh Scattering Formula

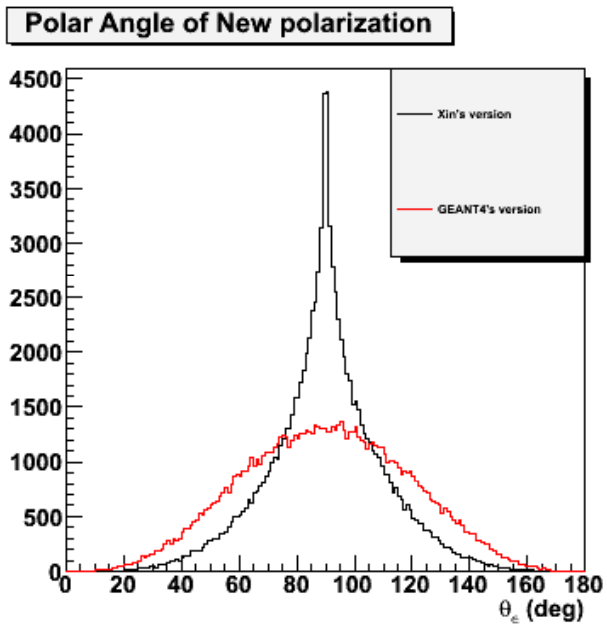
- In addition to the differential cross section, one has to make sure that the two photon polarization vector and the outgoing photon momentum vector are all in the same plane.
- Therefore, the correct way to simulate the angular distribution is:
  - Randomly generate the outgoing photon momentum vector.
  - Calculate the outgoing photon polarization vector,
    - Perpendicular to the momentum vector
    - Same plane as the momentum vector and initial polarization vector
  - Weight or Generate distribution according to $\cos^2(\theta)$
    - Here θ is the angle between the two photon polarization vectors.

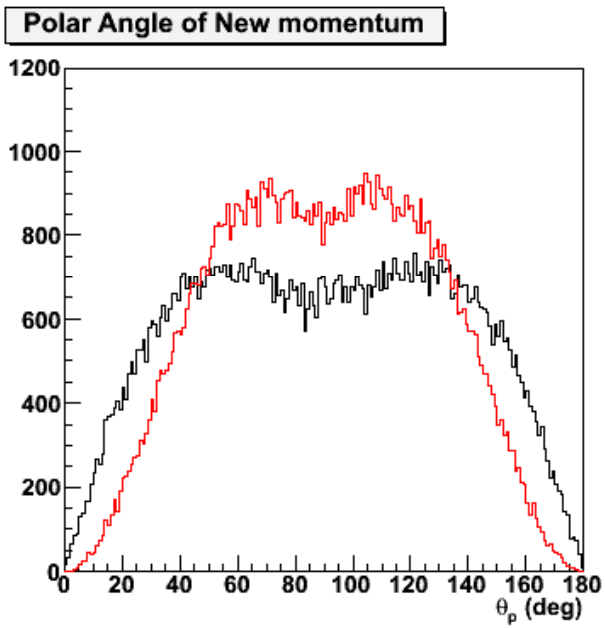
$$\frac{d\sigma}{d\Omega} = k^4 a^6 \left|\frac{\varepsilon - 1}{\varepsilon + 2}\right|^2 \left|\varepsilon^* \cdot \varepsilon_0\right|^2$$

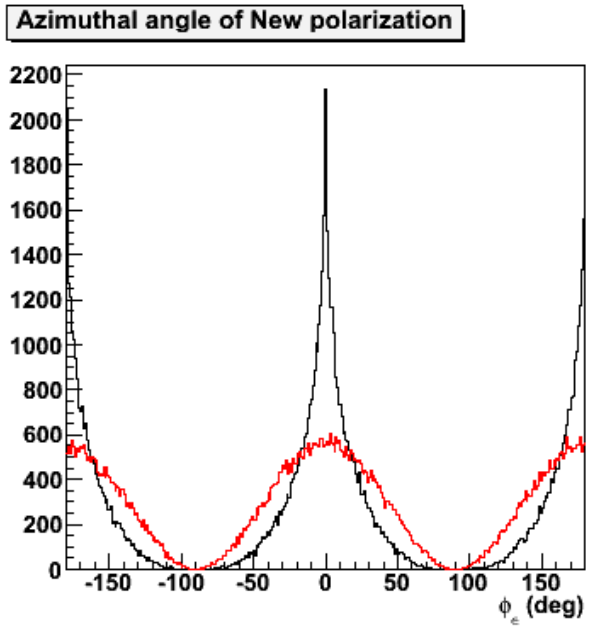
Rayleigh Scattering in GEANT4

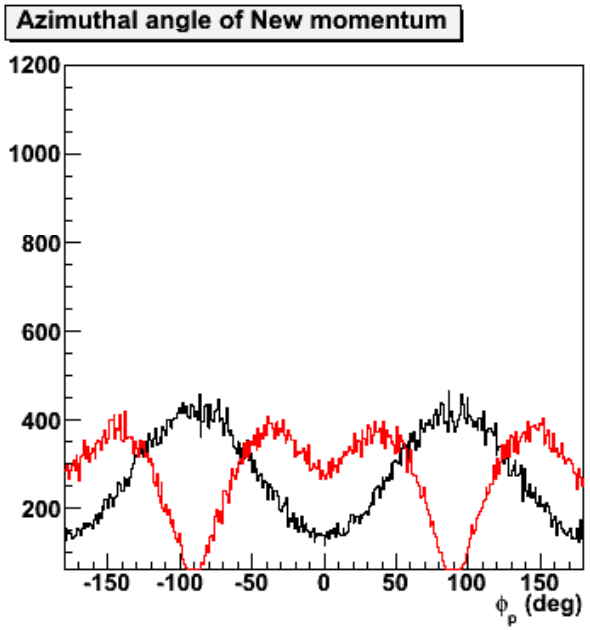
- In the current version of GEANT4, the code confused θ with θ_p
  - Therefore $\sigma \sim \cos^3 \theta$
  - It generates the θ (angle between polarizations)
  - Also generates the ϕ angle
  - It then calculates the momentum vector
    - Perpendicular to the polarization vector
    - Same plane as in the two polarization vectors.
- Therefore, it would leads to quite different distributions.

Comparisons









Black: Correct way

Red: Current in GEAN4

Quite different distributions in polar and azimuthally angular distribution.