

Monte Carlo simulation : a Geant4 simulation

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Monte Carlo Simulation

- Monte Carlo methods (or Monte Carlo experiments) are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results.
 - Monte Carlo simulations are methods to estimate results by repeating a random process.
 - The transport of the particle is done using the physics of the interaction of the particles with matter. Other techniques transport the particles as a group[1].
- Approximation particle interaction with matter using random number
- Cross-section = Probability
- Many MC code for radiation-matter interactions
- MCNP, FLUKA, Geant4,..



[1] Jabbari, K. (2011). Review of fast Monte Carlo codes for dose calculation in radiation therapy treatment planning. *Journal of medical signals and sensors*, 1(1), 73.

Monte Carlo Simulation

- The **mean free path** is performed in Geant 4 using cross section of a particular physics process (λ).
- Defined as the **inverse of the macroscopic cross section** (M):

$$M(E) = \sum_i \left((N\rho\omega_i / A_i) \cdot \sigma(Z_i, E) \right)$$

➤
$$\lambda(E) = \left(M(E) \right)^{-1}$$

Where:

N : Avogadro's number

ρ : density of the medium

ω_i : proportion by mass of the i^{th} element

A_i : mass of a mole of the i^{th} element

$\sigma(Z_i, E)$: total cross section per atom of the process

\sum_i : runs over all elements composing the material



Geant4

- Geometry And Tracking
- International collaboration, created in 1998
- Open-Source simulation code, based on C++
- Toolbox



Geant 4

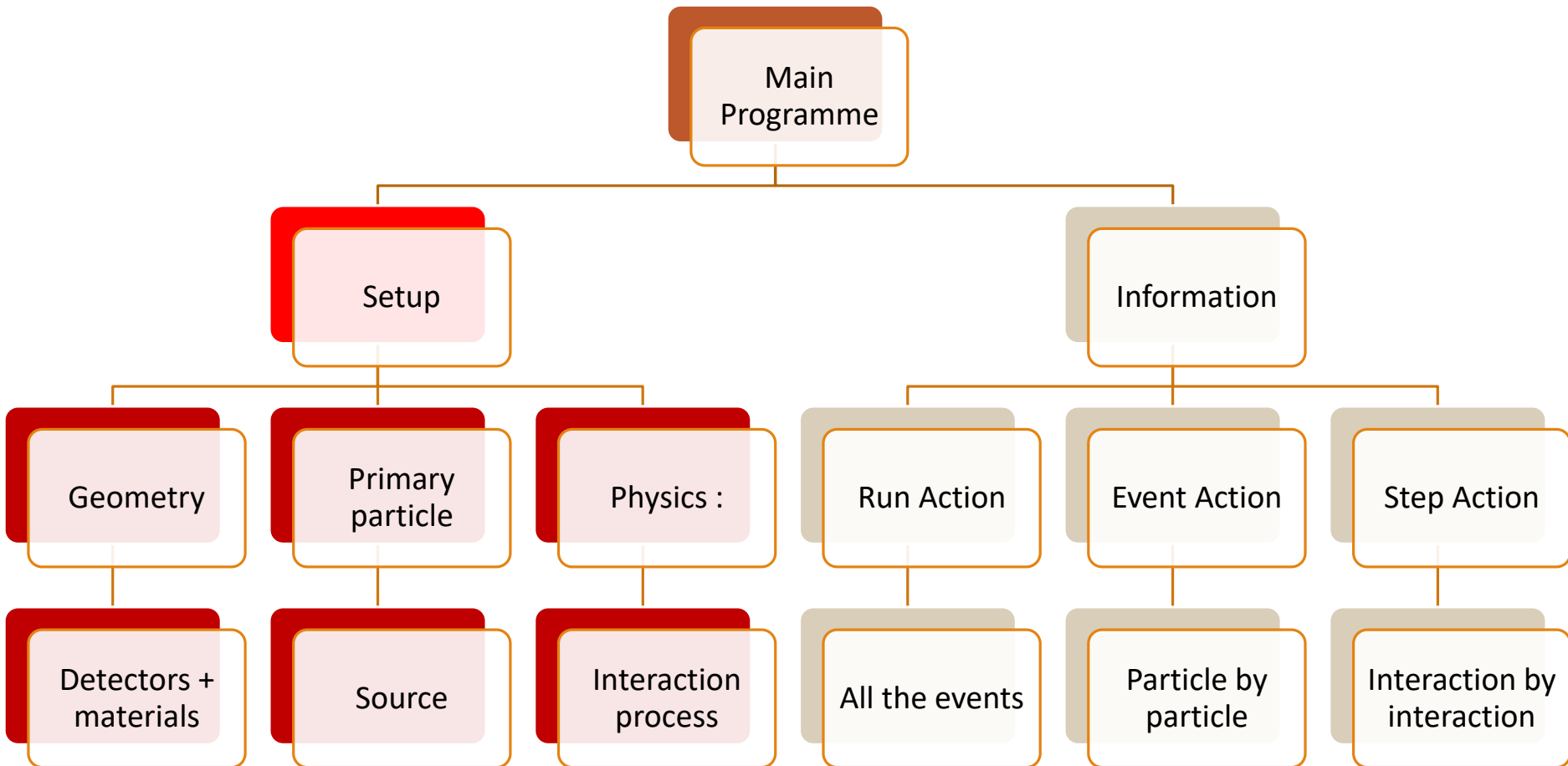


Beginner



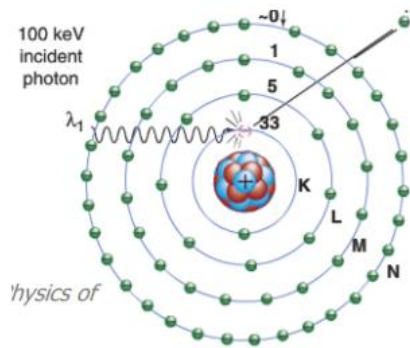
Expert

Geant4 program structure



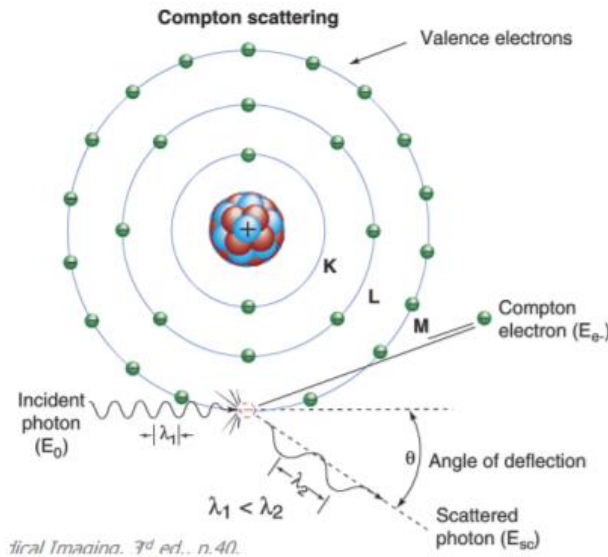
Compton effect in γ -spectroscopy

Photoelectric effect 



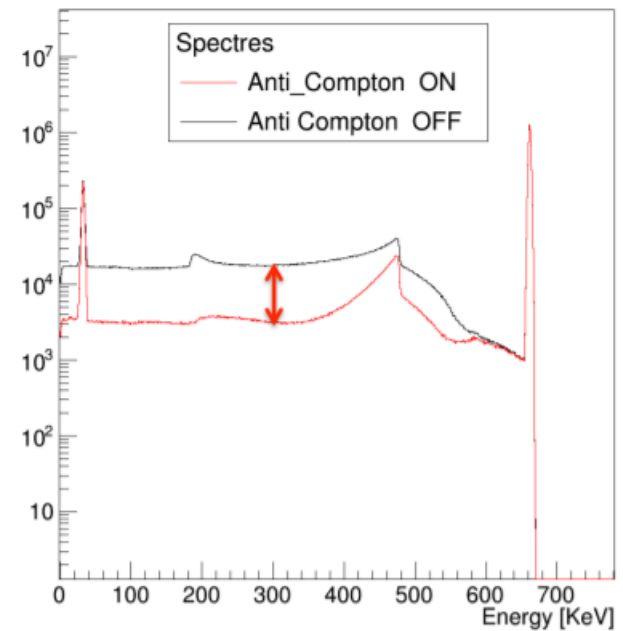
$$E_{dep} = E_{gamma} - w_e$$

Compton scattering 

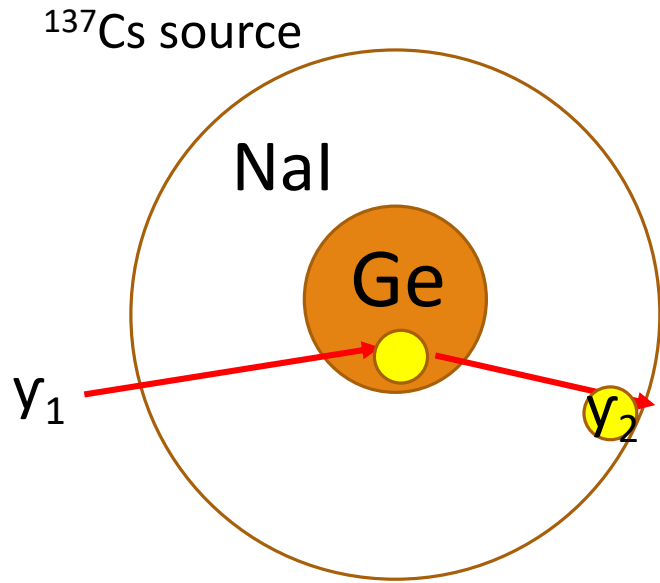


$$E' = E / (1 + \alpha(1 - \cos\theta)) \quad \text{with} \quad \alpha = E / m_e c^2$$

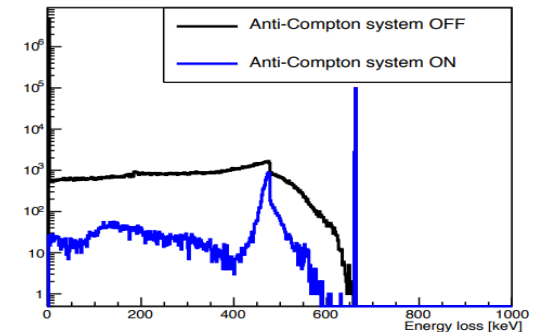
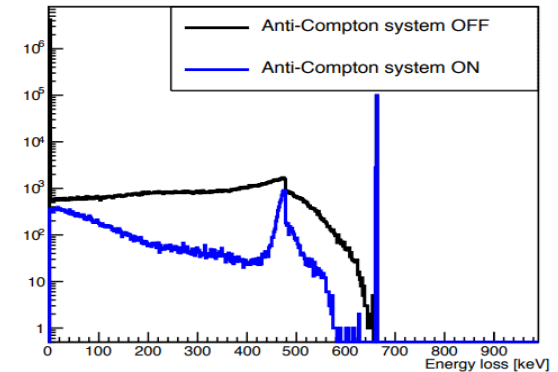
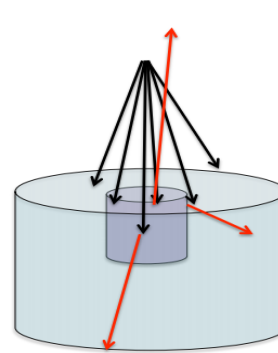
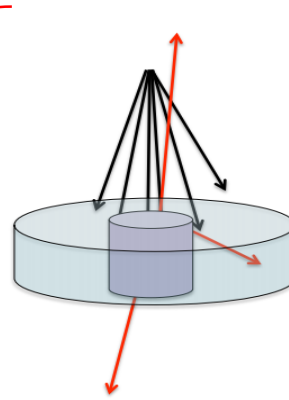
Geant4



Anti-Compton system: remove the background from the spectrum



Bias on the gamma spectrum as a function of the position of the NaI detector



Thank you for listening
