Scattering Problems

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11.06.14

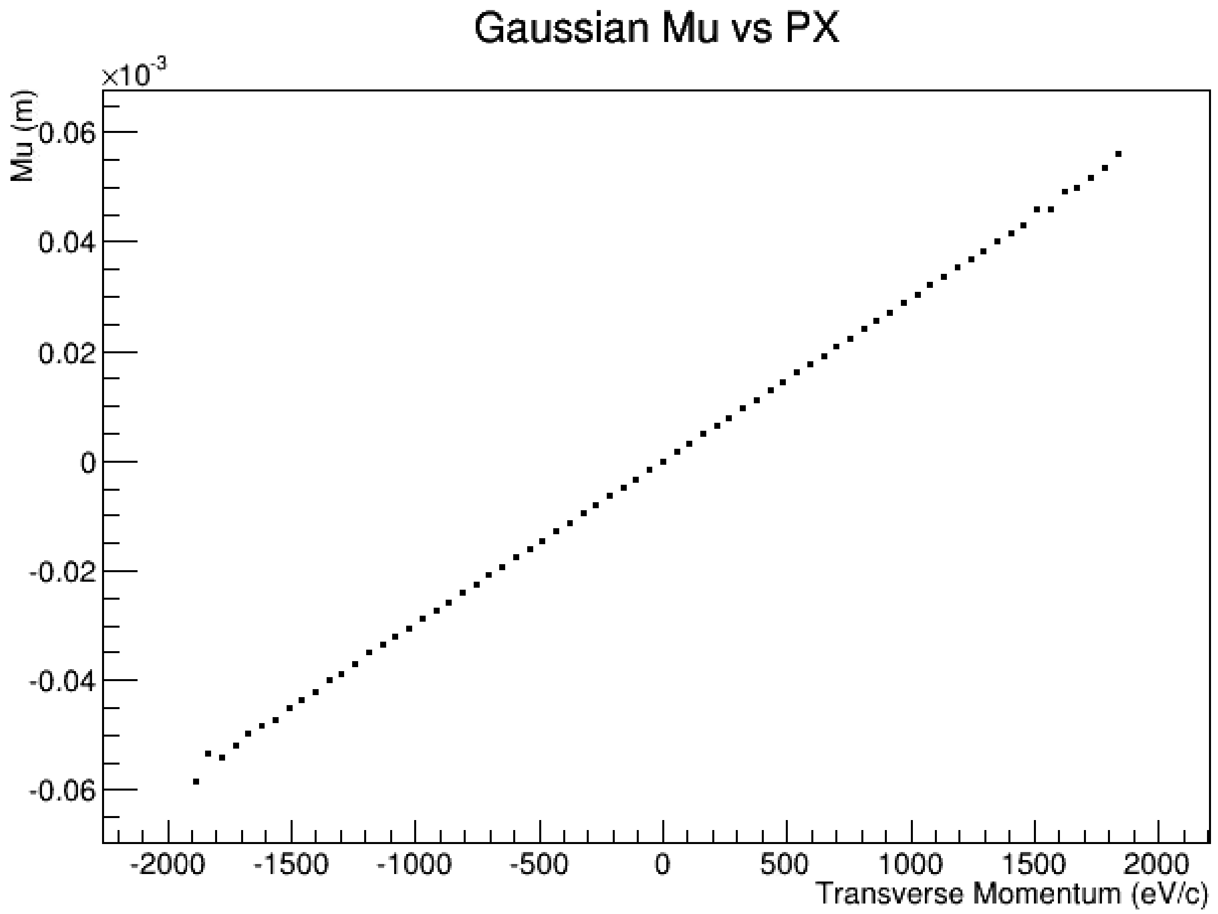
Statement of the Problem

- When using Monte Carlo simulations of particles through matter, both X and PX are roughly Gaussian.
- However, these Gaussian variables are not independent.
- Since we already have a good PX distribution, we set this as the independent variable (i.e. as a base to pick our X variables).
- How exactly this joint distribution is described is the problem.

Statement of Attempted Solutions

- <u>Functionalization</u>
  - Since we know we are seeking a roughly Gaussian distribution, we are seeking some μ and σ which are functions of the final momentum PX.
  - μ is easily found as it is linearly distributed (see Fig. 1 on next page).
  - σ can be functionalized, but it's not clear if it depends solely on PX or also some other variables (e.g. energy or material parameters Z, A, ρ). This means we may have to test every single combination of variables, i.e. $\sigma(L, E, Z, A, \rho)$ which is quite time-consuming.
  - Moreover it has been found that σ has a complicated functionality when only considering absorber length as a variable (3 separate parameters).

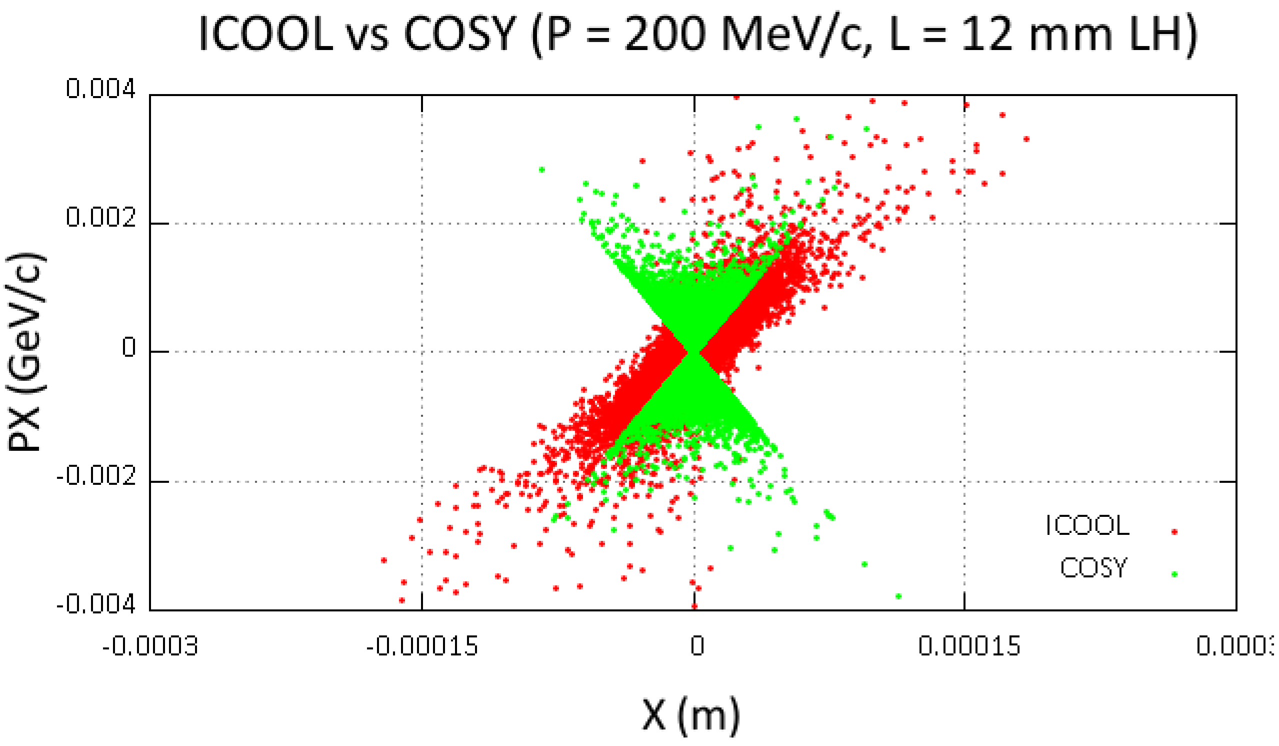
Figure 1: Linearity of μ



Statement of Attempted Solutions

- <u>Theory</u>
  - There do exist several theoretical grounds to construct a joint X-PX distribution.
  - Many (e.g. Bielajew et. al.) consider small steps where $\Delta x \sim \sin(\theta)$, but this is clearly incorrect (see Fig. 2 on next page).
  - PDG has a nice article, but this appears to simply be a linear approximation (see Fig. 3). However, it is a nice starting point.
  - PDG: $\mu = L\theta_0/\sqrt{3} * \theta\rho_{cc}, \sigma = L\theta_0/\sqrt{3} * \sqrt{1-\rho_{cc}^2}$ (no θ dependence in σ!)
  - I have experimented with implementing θ dependence into σ with some success (see Fig. 4).

Figures 2 and 3: Various Theories



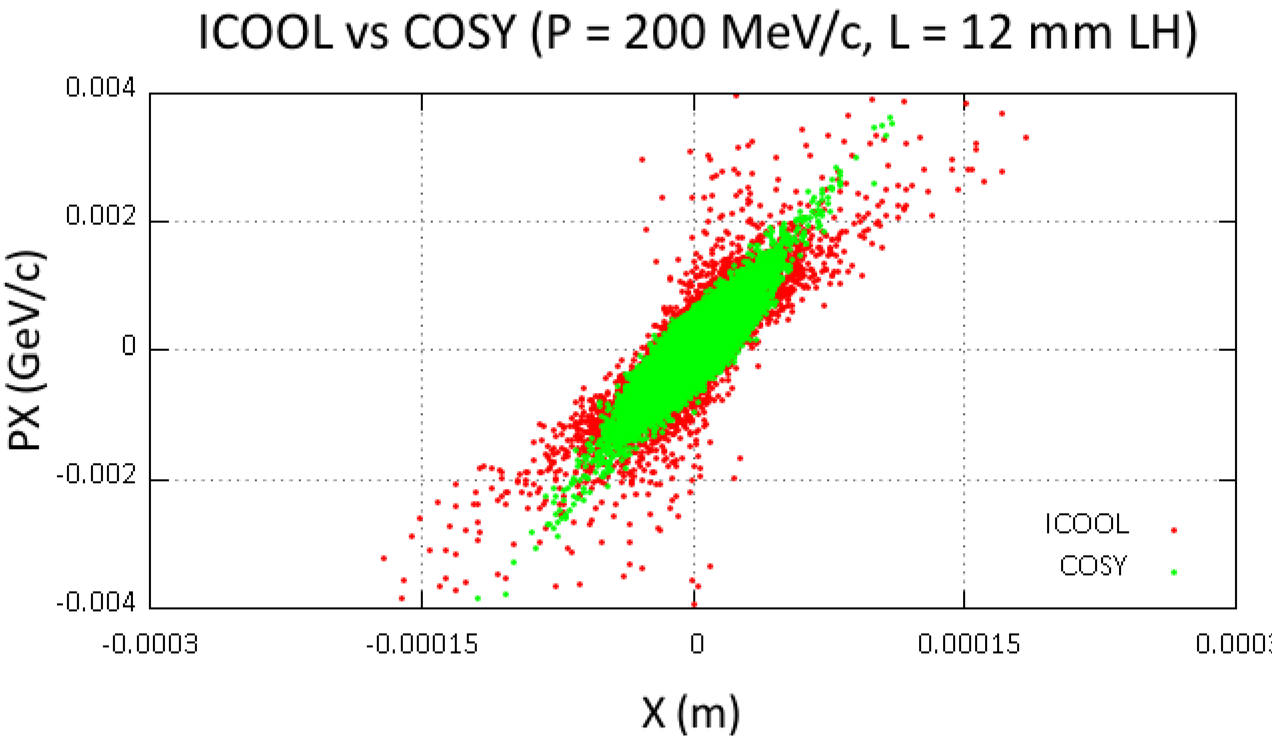


Figure 4: PDG with Correction

$$\sigma_c = 1 - \cos(\theta)$$