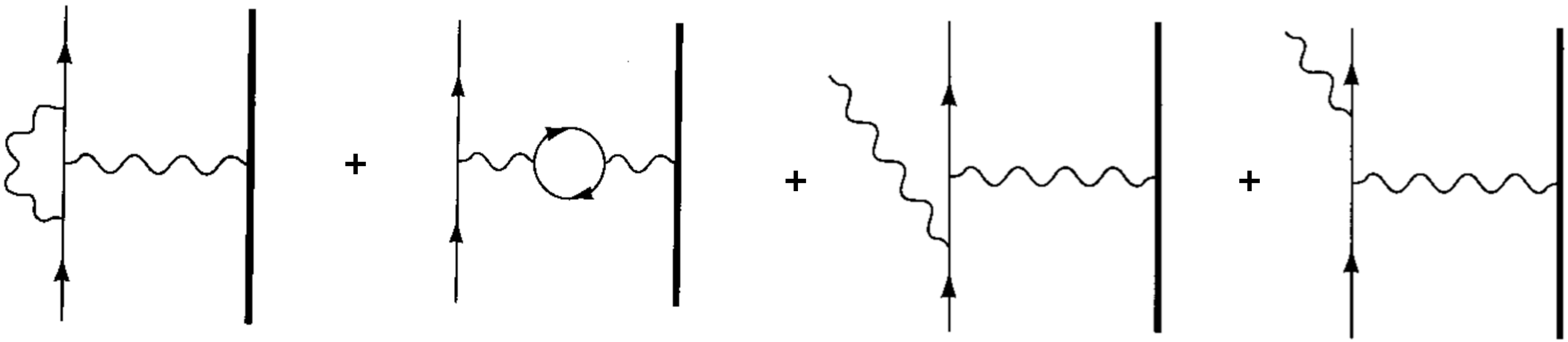
Radiative Corrections using Equivalent Radiators

Yashvinder Singh
(Stony Brook University)

Radiative Corrections

- Cross section changes due to quantum corrections

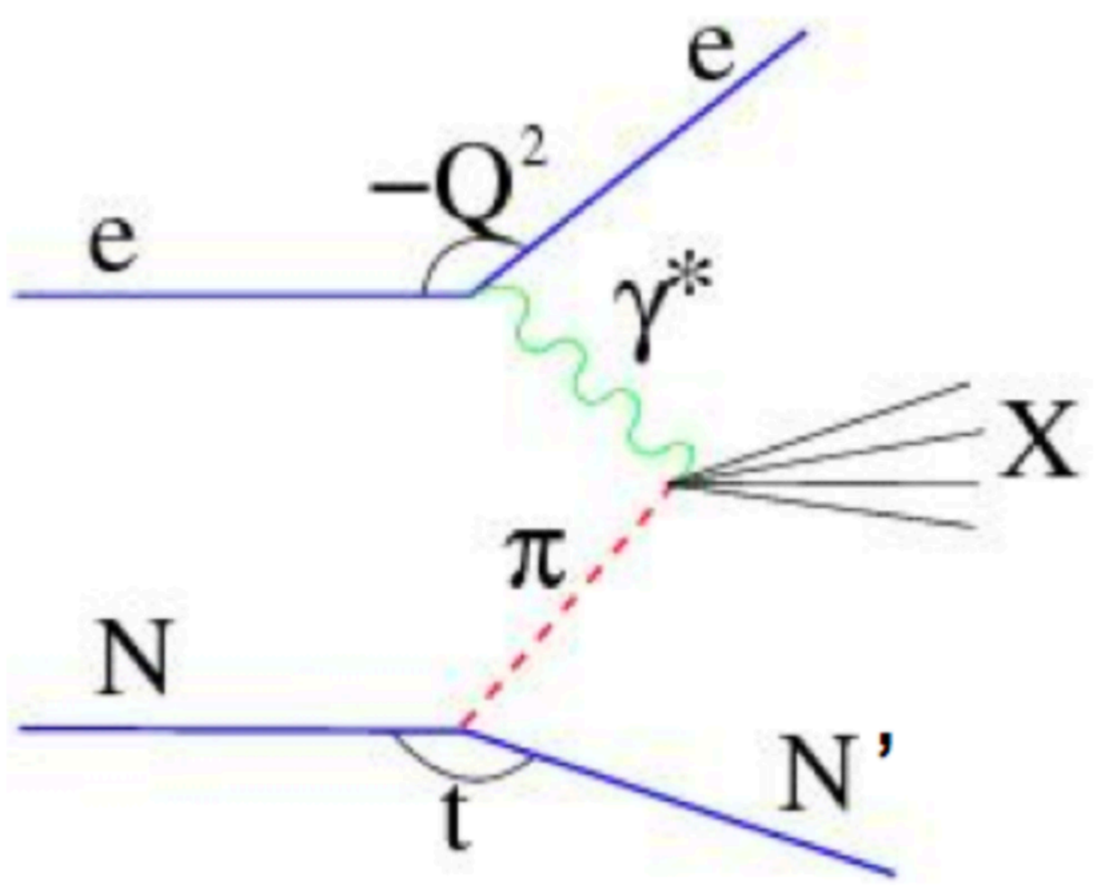


\+ higher order corrections

$$\Rightarrow d\sigma = d\sigma_0 \left(1 + \delta \right)$$

Motivation

- Need to estimate δ before any scattering experiment
- Working on event generator for radiative corrections in Tagged Deep Inelastic Scattering (TDIS) project
- TDIS* aims to probe mesonic content of nucleons by scattering electrons against hydrogen and deuterium targets
- Generator can be extended to other scattering experiments also



Feynman diagram for electron scattering from the pion cloud of the nucleon N, with initial nucleon at rest

[*] C.E. Keppel *et al.*, Measurement of Tagged Deep Inelastic Scattering (TDIS), A Hall-A and SBS Collaboration Proposal, Jefferson Lab Experiment PR12-15-006, May 15, 2015.

Peaking Approximation

Under soft photon approximation:

$$A(\Omega_\gamma) = -\frac{\alpha\omega^{02}}{4\pi^2}\left[\frac{k'}{\omega\cdot k'} - \frac{p'}{\omega\cdot p'} - \frac{k}{\omega\cdot k} + \frac{p}{\omega\cdot p}\right]^2$$

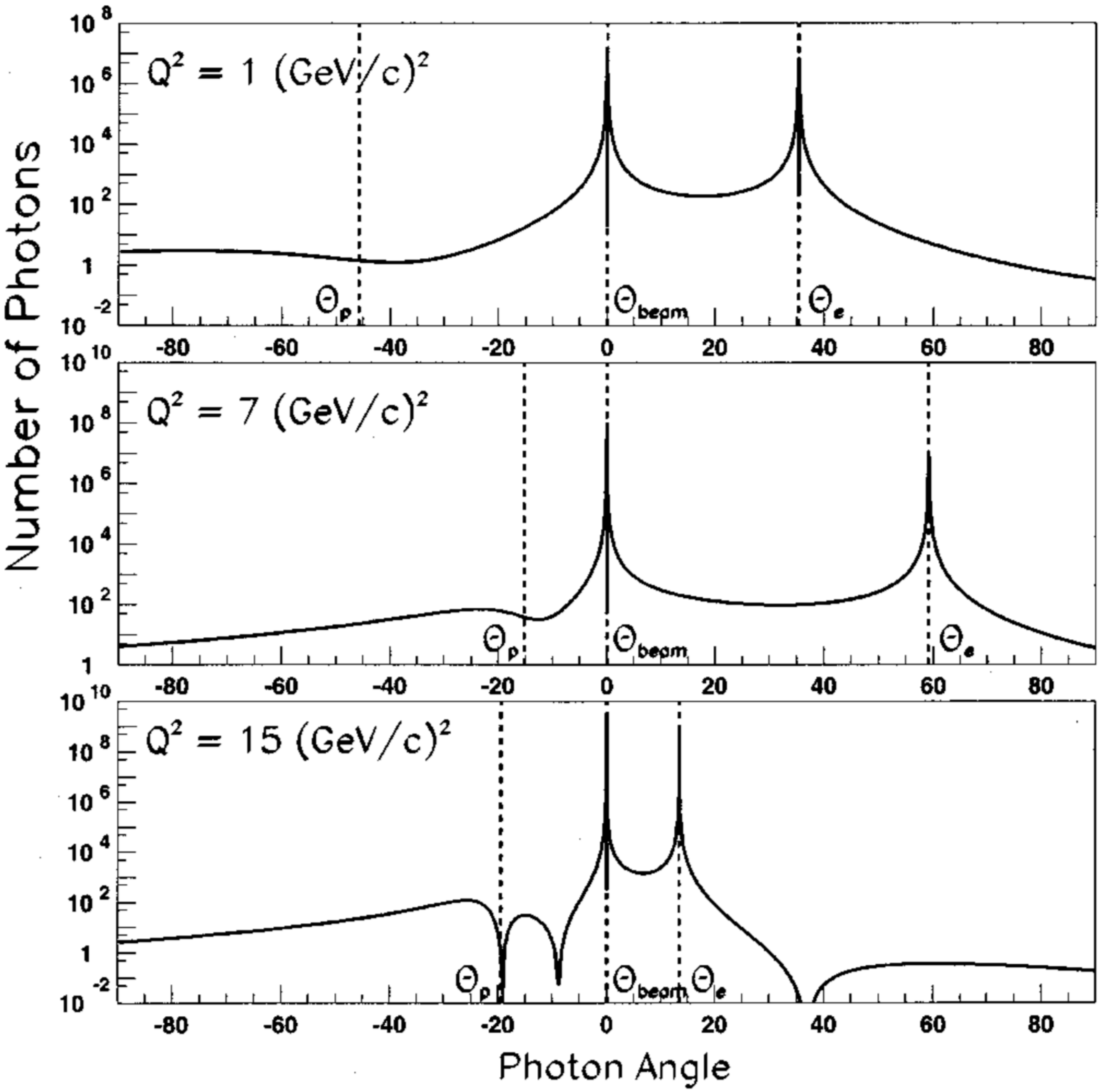
ω = photon 4 vector

k = incident electron 4 vector

k' = scattered electron 4 vector

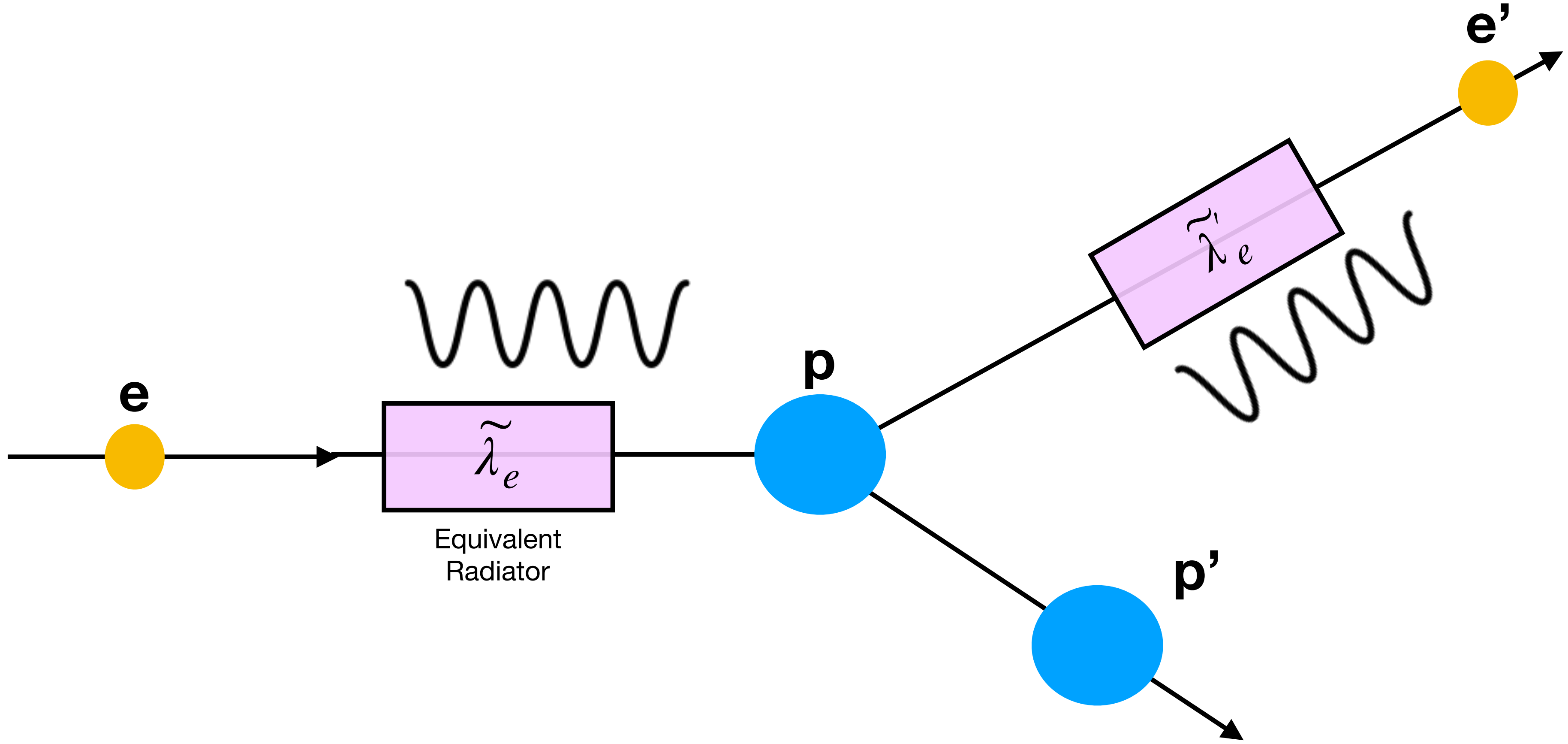
p = incident proton 4 vector

p' = scattered proton 4 vector



Ent, R. ; Filippone, B. W. ; Makins, N. C.R. ; Milner, R. G. ; O'Neill, T. G. ; Wasson, D. A. / Radiative corrections for (e,e′p) reactions at GeV energies. In: Physical Review C - Nuclear Physics. 2001 ; Vol. 64, No. 5. pp. 546101-5461023.

Equivalent Radiator Method



$$\lambda_e = \frac{\alpha}{\pi}\left[\ln\left(\frac{4\mathbf{k}^2}{m^2}\right) - 1\right] \qquad \tilde{\lambda}_e = \lambda_e + \frac{\alpha}{\pi}\left[2\ln\left(\frac{|\mathbf{k}|}{|\mathbf{k}'|}\right) + \ln\left(\frac{1-\cos(\theta_e)}{2}\right)\right],$$

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Implementation

- Input initial electron energy E_0 and number of events N
- Repeat these steps N times:
  1. Generate a random θ in the acceptance range
  2. Radiate a photon with 50% chance along the incoming electron

$$I(E_i, E_f, \lambda) = E_i^{-1} \frac{[ln(E_i/E_f)]^{(\lambda/ln2)-1}}{\Gamma(\lambda/ln2)}$$

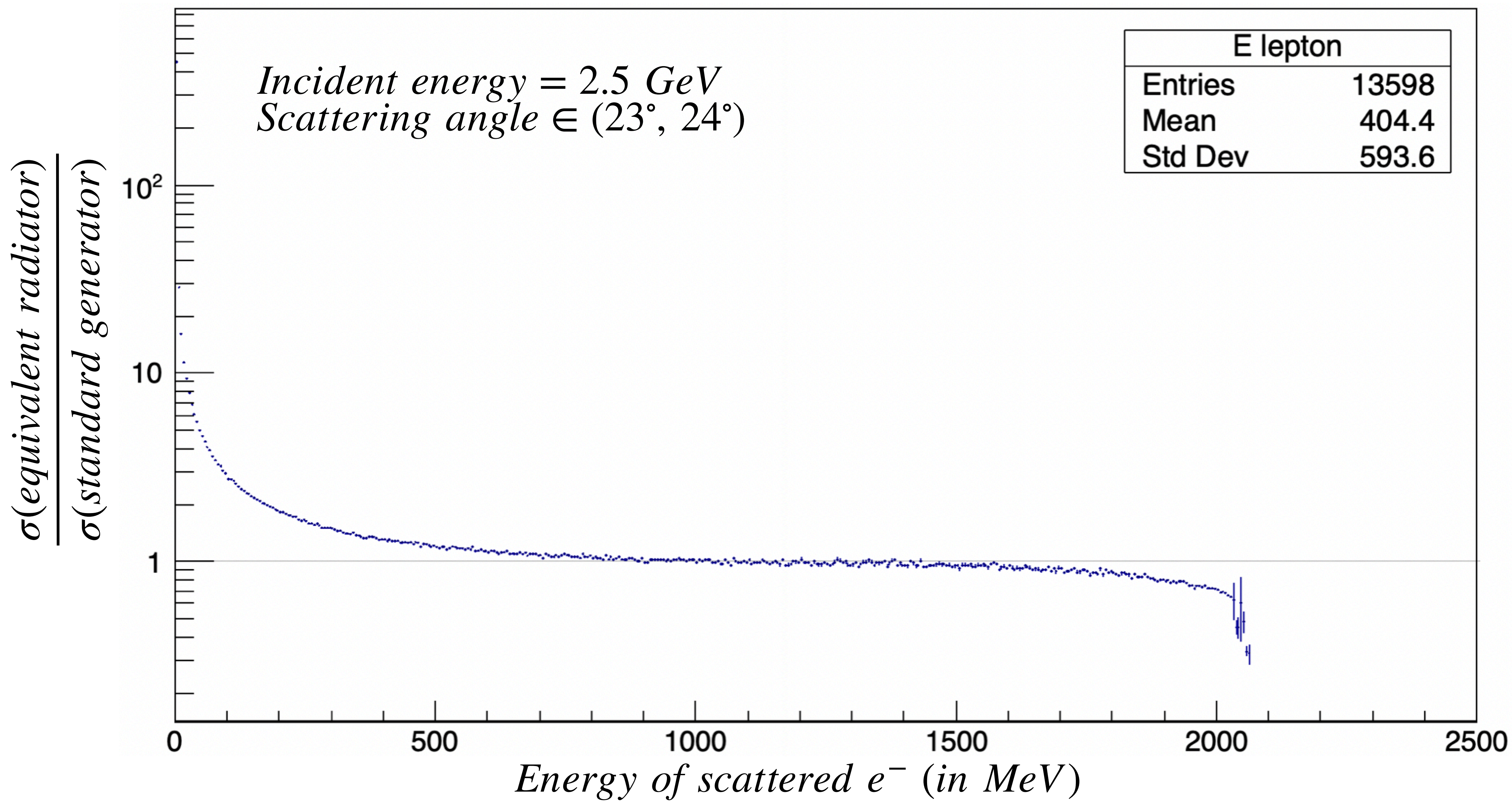
  3. Update the incoming electron energy
  4. Calculate Rosenbluth cross section
  5. If no emission in step 2, radiate a photon along the outgoing electron
  6. Multiply cross section with the probability of photon radiation

- Code (uses Root, C++) available at: https://github.com/yashvindersingh/SISS

[*] L.M. Mo and Y.S. Tsai, Rev. Mod. Phys. 41, 205 (1969)

Comparison

- Comparison of this implementation with a standard* event generator for ep scattering:



- Getting good approximation for energies not too high and not too low

[*] A.V. Gramolin, V.S. Fadin, A.L. Feldman, et al. A new event generator for the elastic scattering of charged leptons on protons. arXiv: 1401.2959.

Summary

- Equivalent radiator is a fast and lightweight method for radiative corrections
- Equivalent radiator generator can be easily combined with other generators
- Gives only weighted events
- Not meant for precision measurements
- Can be extended easily for proton bremsstrahlung

Thank You

Extra Content

Red = my curve

Green = esepp curve