Simulation update

Energy loss

- Ionization
- External bremesstrahlung
- Internal bremesstrahlung

Ionization

- The probability distribution of energy loss Δ by ionization is a Landau distribution, peaked at

$$\Delta_0 = \xi \left[\ln \left(\frac{\xi}{\epsilon'} \right) + 0.20 \right]$$

$$\xi = \frac{2\pi \alpha^2 N_A}{m_e \beta^2} \frac{Z}{A} d$$

$$\ln \epsilon' = \ln \left[\frac{\left(1 - \beta^2\right) I_0^2 Z^2}{2 m_e \beta^2} \right] + \beta^2$$

- N_A Aagadro number, $\beta = {}^{v}/_{c}$, d is the averaged density multiplied by length, A is the averaged mass number, I_0 is the ionization energy of material
- Bethe-Block function is not useful for describing energy loss by single electrons

External bremesstrahlung

- Loss energy due to the real photons emmited from the interaction of the EM field of target nuclei.

$$I_{ext}(E_0, E, t) = \frac{bt}{\Gamma(1+bt)} \left(\frac{\Delta E}{E_0}\right)^{bt} \frac{\psi(\Delta E/E)}{\Delta E}$$

- Updated the b value from Yung-su Tsai (RevModPhys.46.815)

- For Z>4

$$b = \frac{4}{3}\left[1 + \frac{Z+1}{9\ln\left(1194Z^{-2/3}\right) + \ln\left(184.15Z^{-1/3}\right)}\right]$$

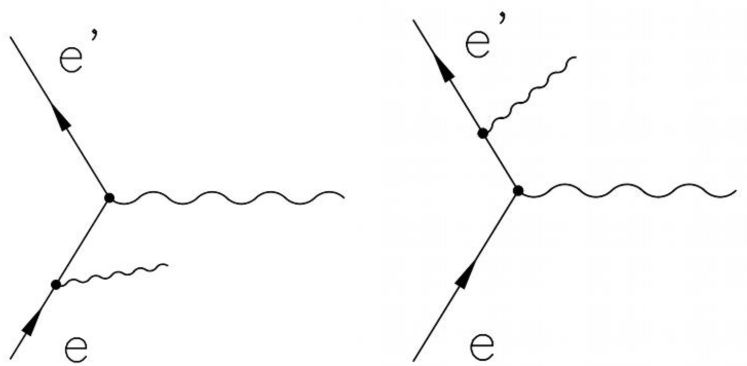
- For Z<4, can find in Table B.2 in the thesis.

- SAMC did not use the latest b value in the formula, which not include Coulomb correction

$$b = \frac{4}{3}(1 + \frac{1}{9}[\frac{Z+1}{Z+\psi}][\ln(183Z^{-1/3})]^{-1}) \qquad \psi = \ln(1440Z^{-2/3})/\ln(183Z^{-1/3})$$

Internal bremesstrahlung

- Loss energy due to the real photons emmited from the Bethe-Heitler diagrams (e-p scattering process), can be treated external equivalent radiators, one before and one after the scattering vertex, with thickness v.



$$I_{int}(E_0, E_0 - k_0, \nu) = \frac{\nu}{k_0}\left(\frac{k_0}{E_0}\right)^{\nu}\psi\left(k_0/E_0\right)$$

$$\nu = \frac{2\alpha}{\pi}\ln\left(\frac{Q^2}{m_e^2} - 1\right)$$ like bt in the external bremesstrahlung

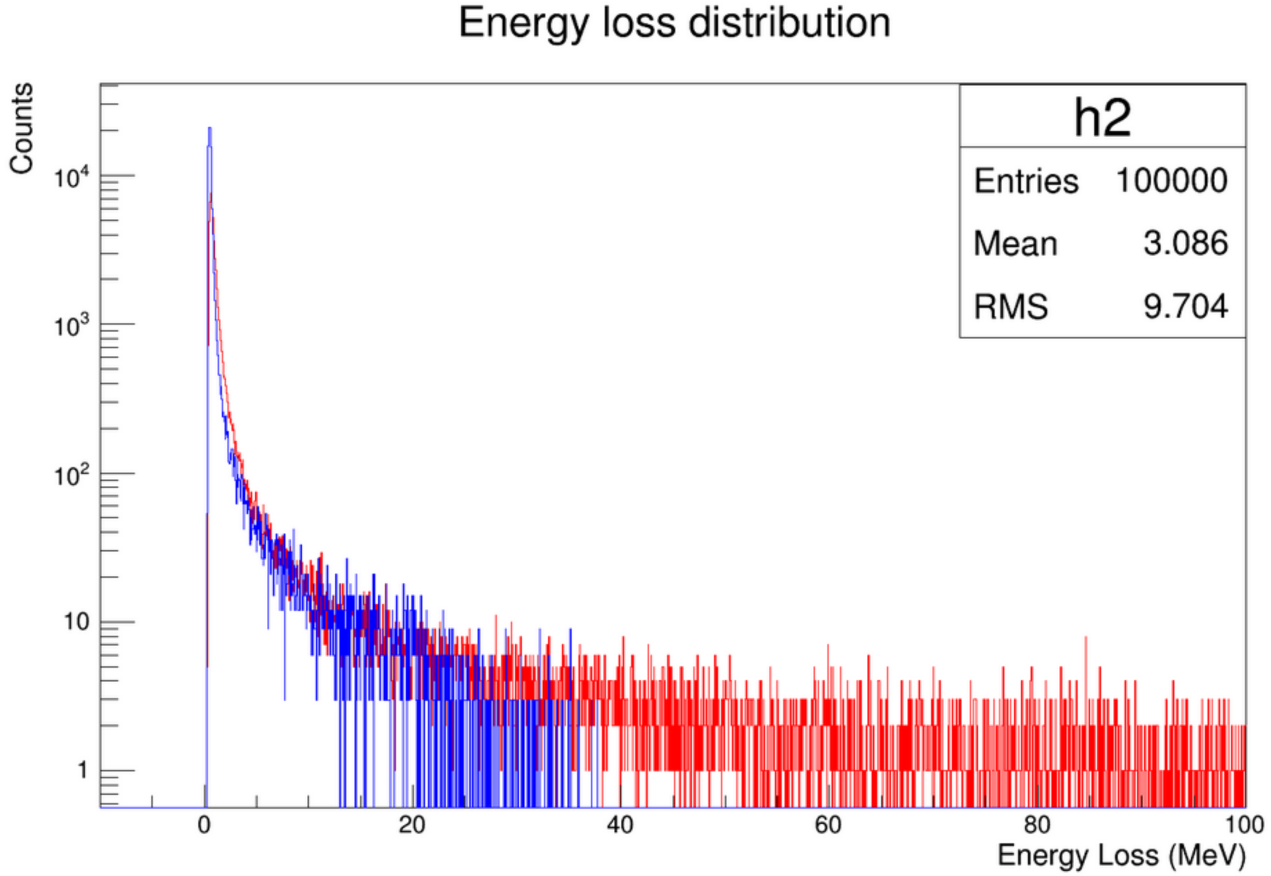
$$\psi(y) = 1 - y + \frac{3}{4}y^2$$

For a Monte Carlo simulation of total bremesstrahlung: random energy loss

$$\Delta E = E_0 R^{1/bt}$$

Geant4 compared with g2psim

- Red: g2psim; Blue: geant4 ; cross section not weighted
- Carbon without He, no field



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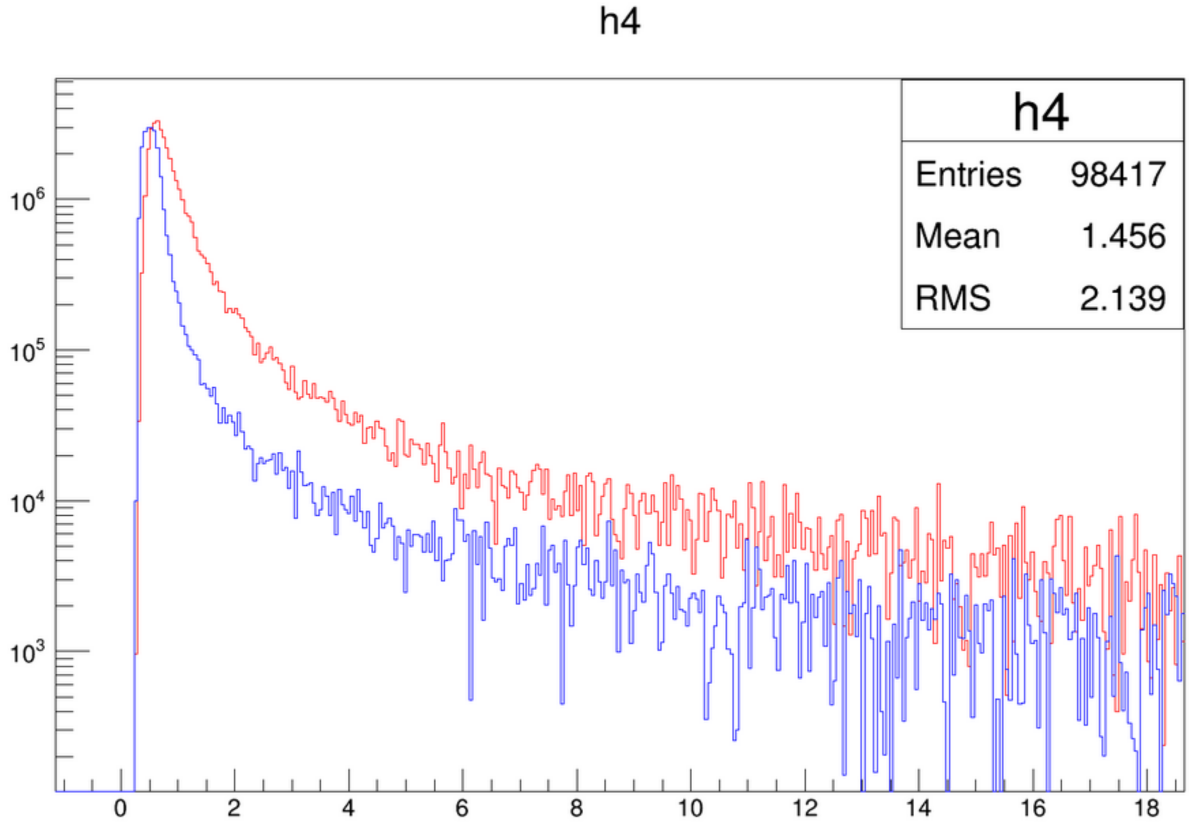

Geant4 compared with g2psim

- Red: g2psim; Blue: geant4 ; cross section weighted
- Carbon with He, 2.5T field