Energy Loss Model

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Last time Review

Ionization- SAMC

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

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

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

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

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

Last time Review Ionization-geant4

How:

- ❑ Below an energy threshold: the energy loss is continuous

$$\left.\frac{dE}{dx}\right]_{T<T_{cut}} = 2\pi r_e^2 mc^2 n_{el} \frac{1}{\beta^2}\left[\ln\frac{2(\gamma+1)}{(I/mc^2)^2} + F^{\pm}(\tau,\tau_{up}) - \delta\right]$$

- ○ T_{cut} : mininum cut for δ-ray production
- ○ δ : density effect function

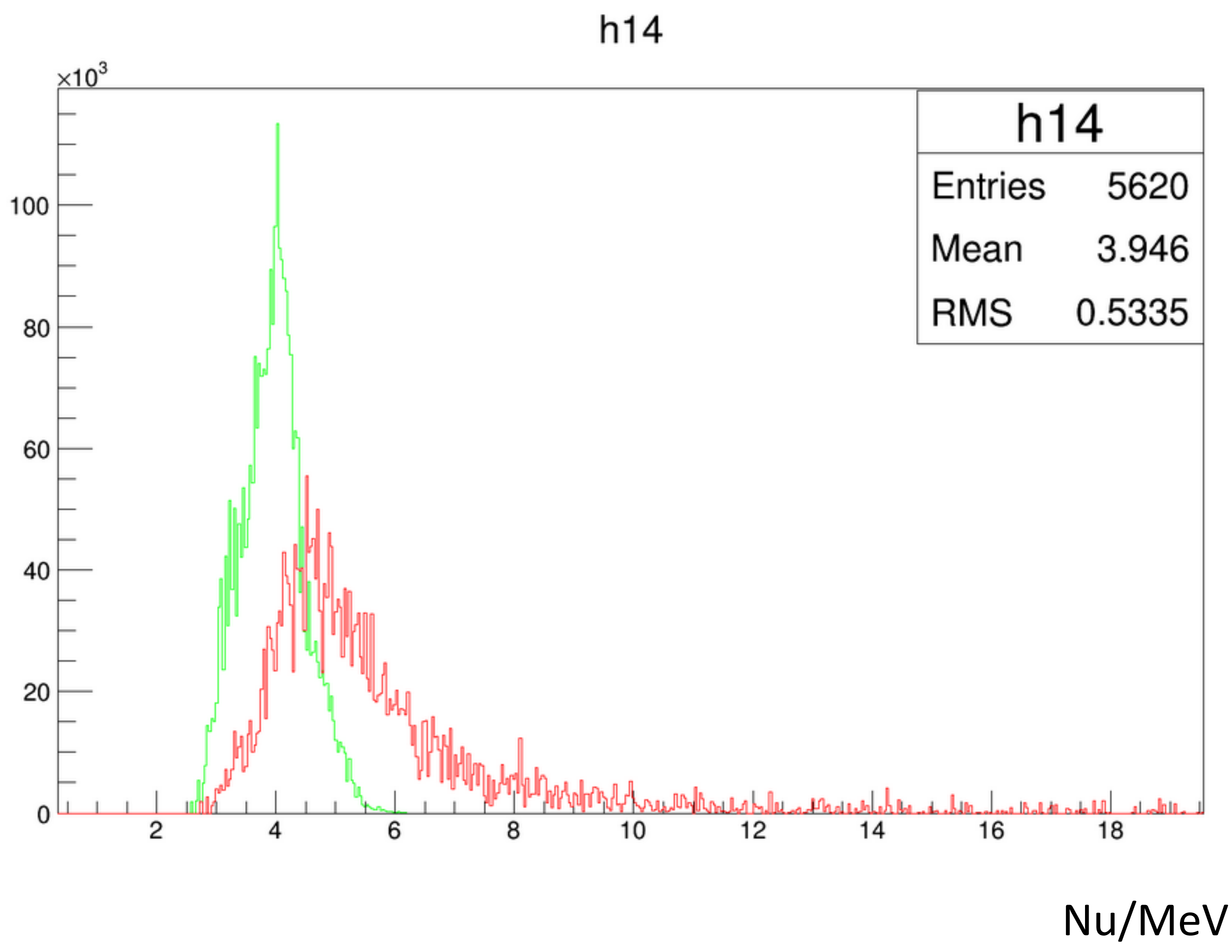
$$F^{+}(\tau,\tau_{up}) = \ln(\tau\tau_{up}) - \frac{\tau_{up}^2}{\tau}\left[\tau + 2\tau_{up} - \frac{3\tau_{up}^2 y}{2} - \left(\tau_{up} - \frac{\tau_{up}^3}{3}\right)y^2 - \left(\frac{\tau_{up}^2}{2} - \tau\frac{\tau_{up}^3}{3} + \frac{\tau_{up}^4}{4}\right)y^3\right]$$

✓ continuous energy loss has fluctuations, to take partially draggling effect

- ❑ above a energy threshold: simulated by the explicit secondary particles

Moller Scattering
$$\frac{d\sigma}{d\epsilon} = \frac{2\pi r_e^2 Z}{\beta^2(\gamma-1)} \times \left[\frac{(\gamma-1)^2}{\gamma^2} + \frac{1}{\epsilon}\left(\frac{1}{\epsilon} - \frac{2\gamma-1}{\gamma^2}\right) + \frac{1}{1-\epsilon}\left(\frac{1}{1-\epsilon} - \frac{2\gamma-1}{\gamma^2}\right)\right]$$

Model Comparison



Only Ionization
Green: gean4
Red: SAMC

Red: not include δ-ray production
But include
Continuous energy loss

External Bremesstrahlung- SAMC

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

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

- For Z>4

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

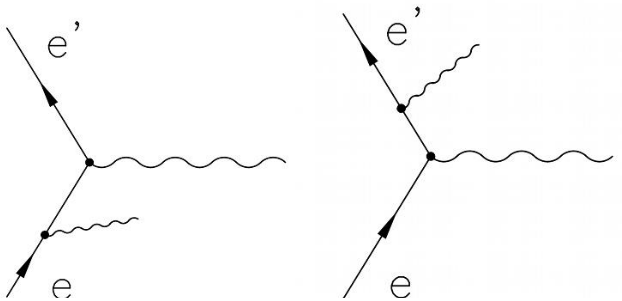
- For Z<4, can find in Table.

- SAMC did not use the latest b value in the formula

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

Internal Bremesstrahlung- SAMC

- Loss energy due to the real photons emmited from the Bethe-Heitler diagrams (e-p scattering process), can be treated external equivalent radiators



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

- $\nu = \frac{3\alpha}{4\pi}[\ln(\frac{Q^2}{m^2}) - 1]$ like bt in the external bremesstrahlung

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

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

Bremesstrahlung - g2psim

➢ External Bremesstrahlung

- Consider a small energy interval dE, the probability of finding an electron in this interval with initial energy E_0 and energy E

$$I_e(E_0, E, t) = bt(E_0 - E)^{-1} \left[\frac{E}{E_0} + \frac{3}{4}\left(\frac{E_0 - E}{E_0}\right)^2\right] \left(\ln\frac{E_0}{E}\right)^{bt}$$

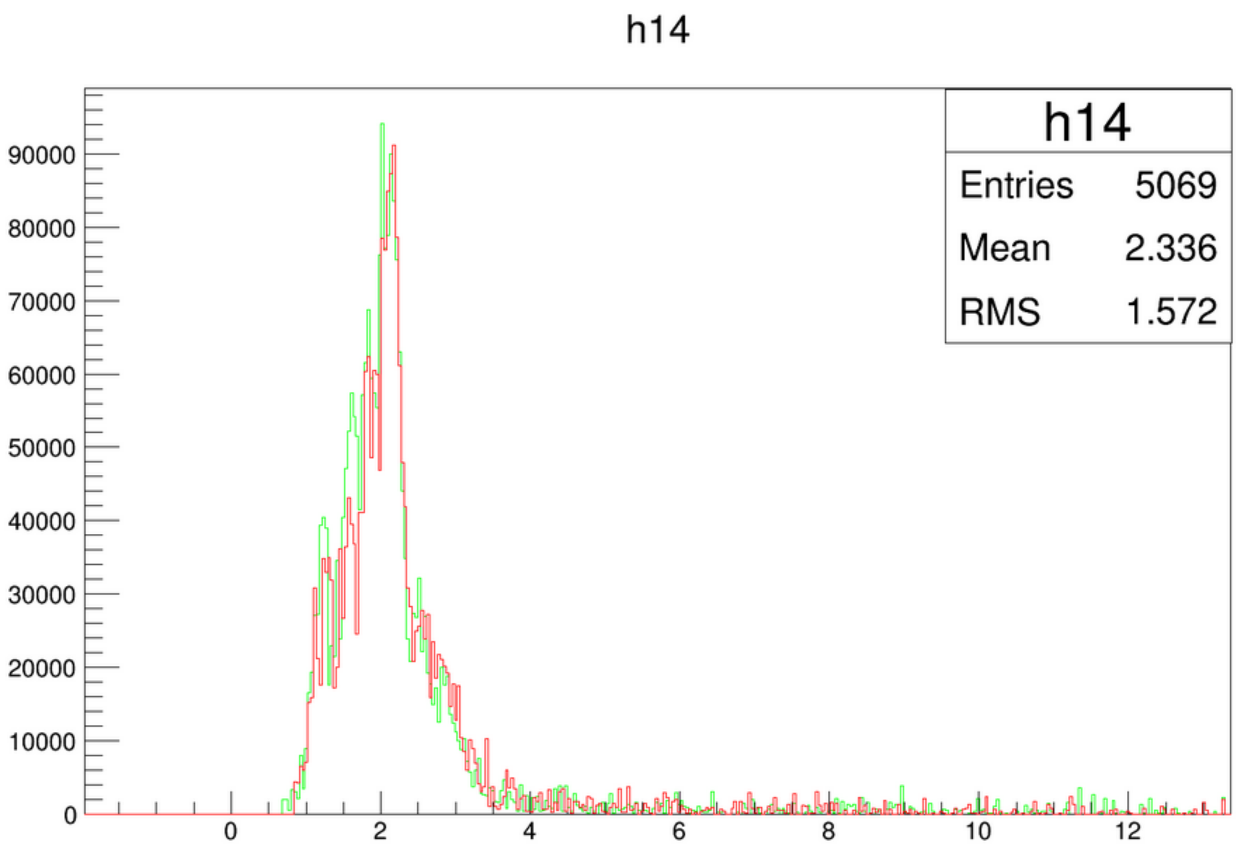
- samples an energy loss according to the distribution using the acceptance-rejection method

➢ Internal Bremesstrahlung

- equivalent radiator approximation

❑ *SAMC* : $\Delta E = E_0 R^{1/bt}$

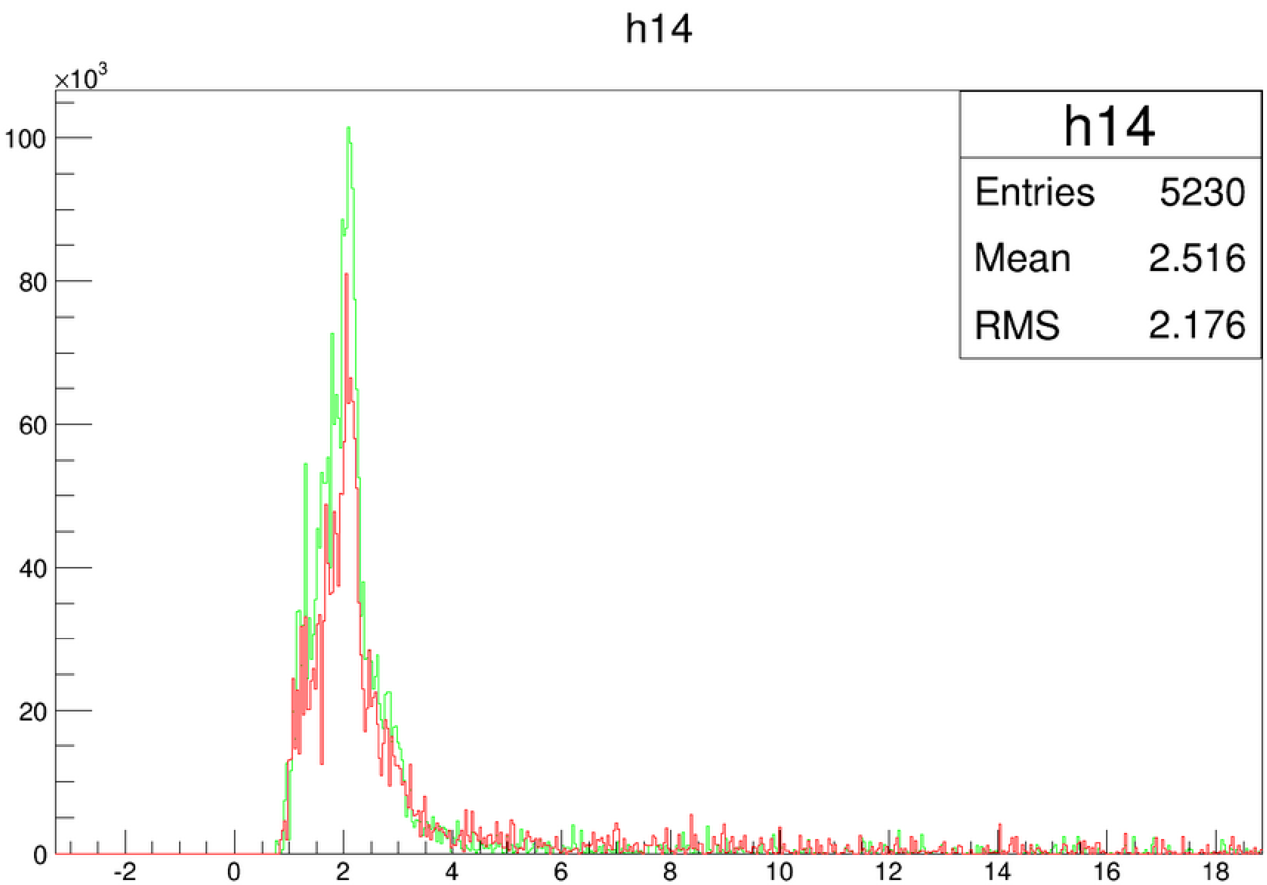
Model Comparison



Only Bremesstrahlung
Red: external
Green: Internal

Nu/MeV

Model Comparison



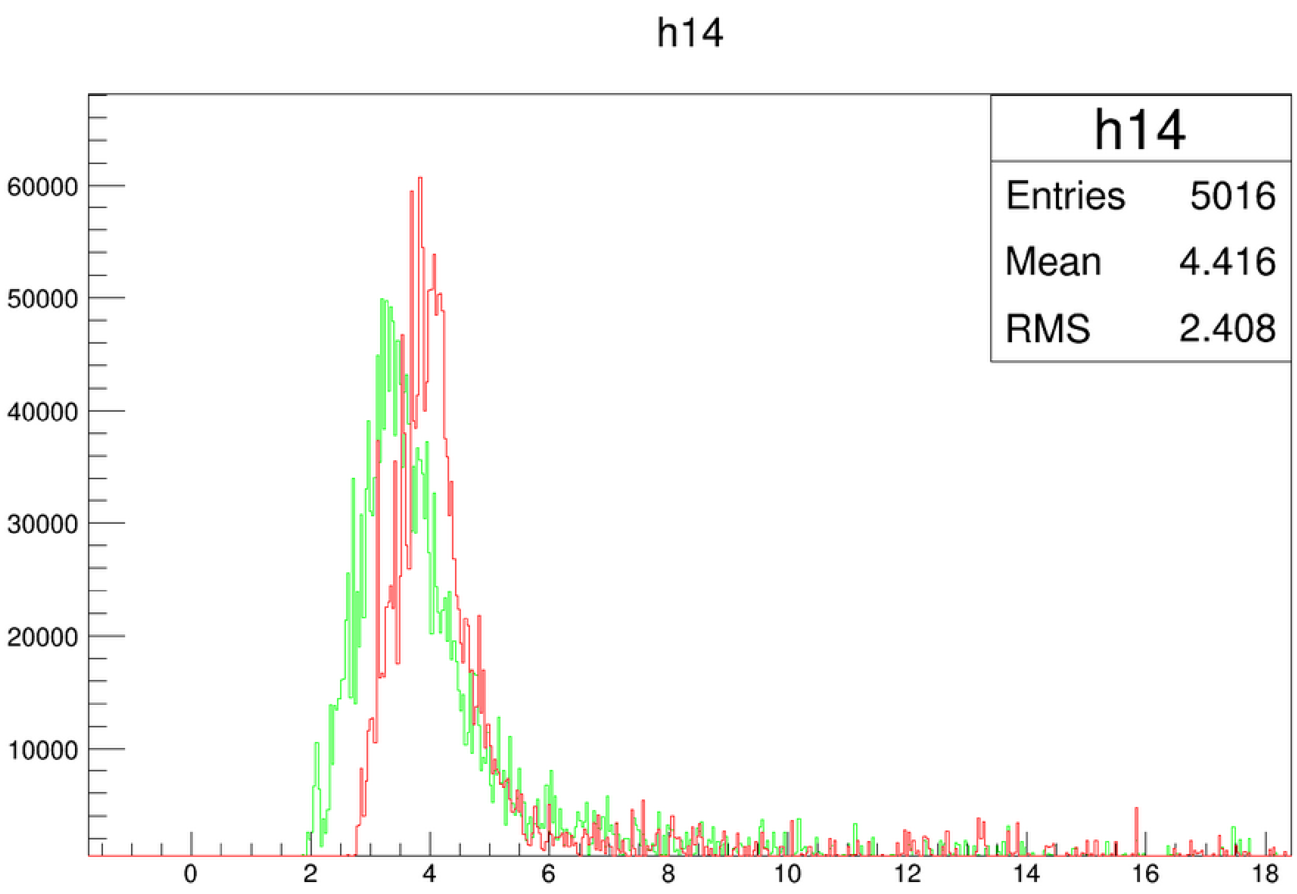
Ttotal Bremesstrahlung

Red: g2psim

Green: SAMC

Nu/MeV

Model Comparison



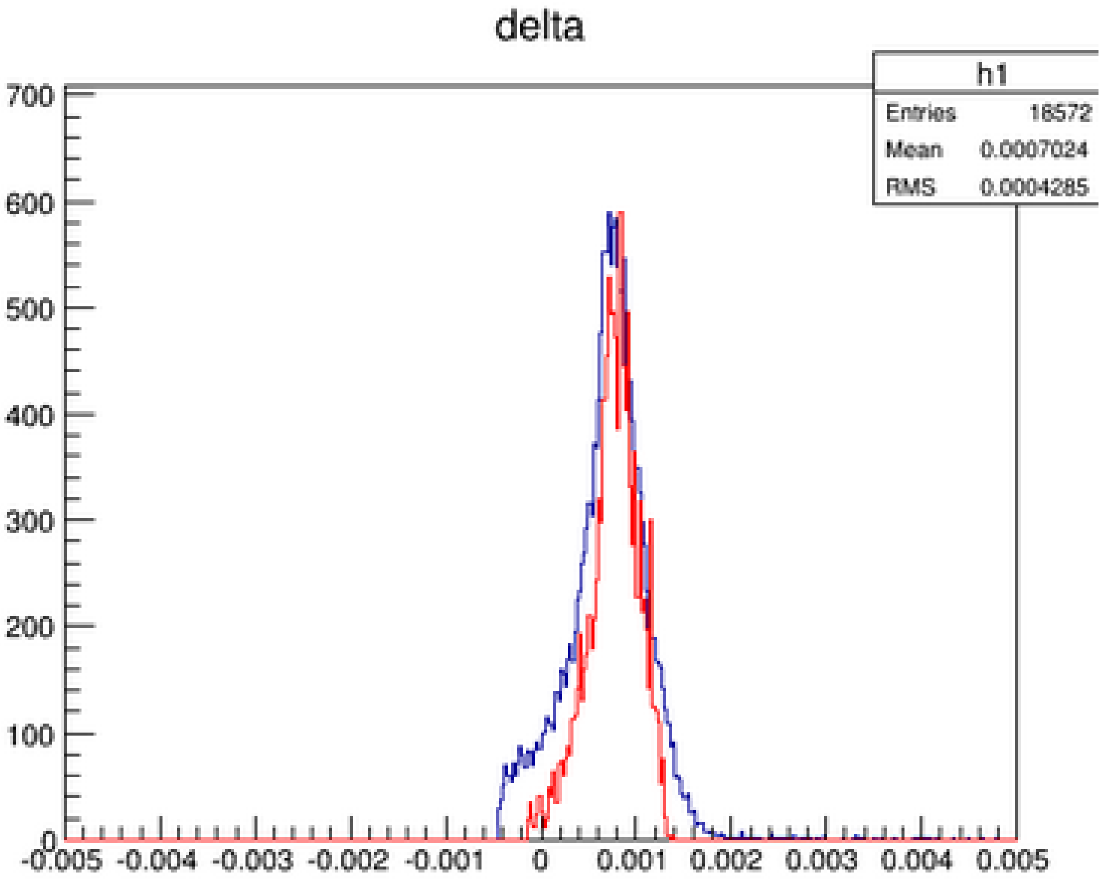
Nu/MeV

Ioni+ Bremesstrahlung

Red: Ioni (geant4, fluc) Brems(g2psim)

Green: SAMC

Model Comparison

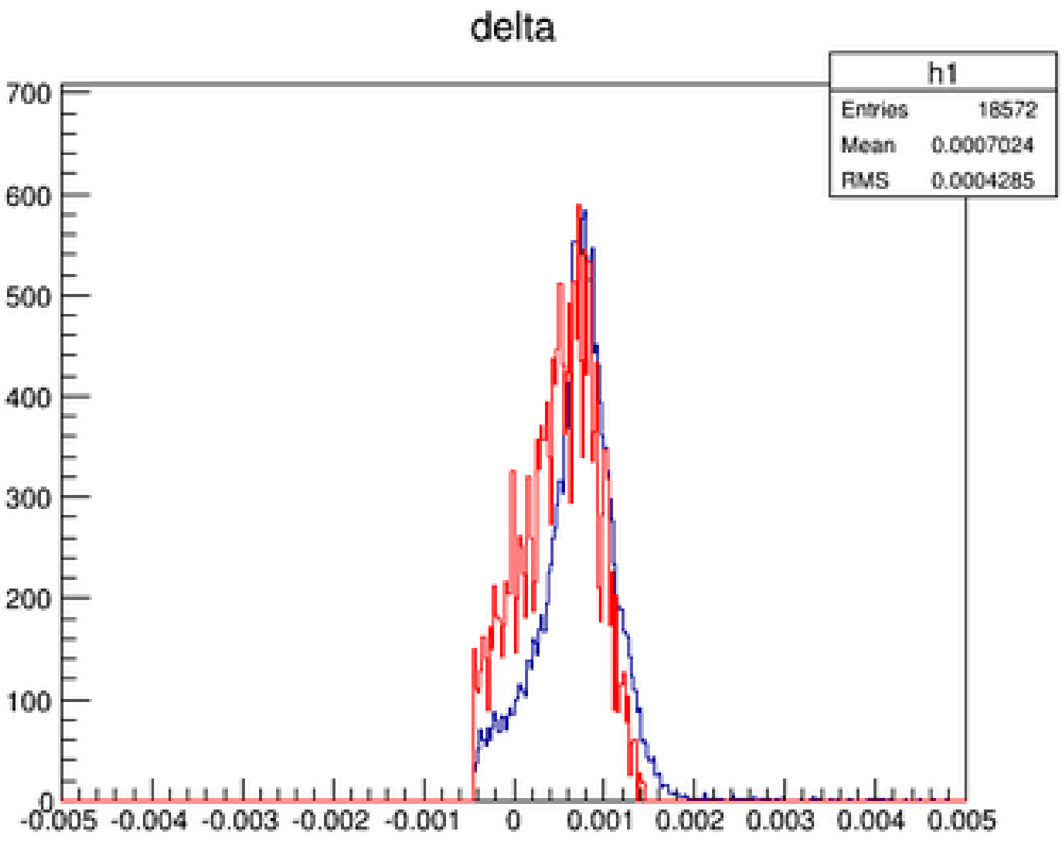


Ioni+ Bremesstrahlung

Red: Ioni (geant4, fluc)
Brems(g2psim)

Blue: Data

Model Comparison



Ioni+ Bremesstrahlung

Red: Ioni (SAMC, landau)
Brems(g2psim)

Blue: Data

Todo

- SAMC seems the better one?
- consider the physics processes order
- Check it on other target settings
- Packing simulation