MilliQan Meeting

11/20/19, Ryan Schmitz

Investigation into G4 Delta Ray modeling

Have been playing email tag with a few Geant people; currently waiting on response from the head of all Geant EM physics. In the meantime, I've looked more deeply into Geant4 MuIonization modeling

Useful tool: G4EmCalculator

- Can be used to calculate explicit tables for cross-sections and dE/dX values for various parts of the detector
- A little finicky… still trying to get it to work. But useful when it does

Geant4 Ionization modeling

Two components: First, mean rate of energy lost (stopping power), which does NOT generate a particle:

- E=Muon energy (~GeV or less)
- T_cut=range cut energy (corresponding to mean free path of 0.7mm in a particular material by default)
- N_at = # of atoms per volume

$$\frac{dE_{soft}(E, T_{cut})}{dx} = n_{at} \cdot \int_0^{T_{cut}} \frac{d\sigma(Z, E, T)}{dT} T \, dT$$

Geant4 Ionization modeling

Second component: Energy loss due to ionization interactions which produce an electron

- E=Muon energy (~GeV or less)
- T_cut=range cut energy (corresponding to mean free path of 0.7mm in a particular material by default)
- T_max=”Maximum energy transferable to the free electron”

$$\sigma(Z, E, T_{cut}) = \int_{T_{cut}}^{T_{max}} \frac{d\sigma(Z, E, T)}{dT} \, dT$$

Geant4 Ionization modeling

Differential cross-section seems to derive from Bethe-Bloch. Distribution has a term proportional to 1/T^2, correction for 1/T, and constant term w.r.t electron energy T which scales as 1/E^2Only possible change we could make is the energy of the muons, but for e.g. collision muons we think we're doing a decent job.

Found some evidence that certain Geant EM models might not match data 100%, but it was totally unclear if the G4 EM working group has addressed these or if the problems exist for EM_option4. Need to get full response from Vladimir first

$$\frac{d\sigma}{dT} = 2\pi r_e^2 mc^2 Z \frac{z_p^2}{\beta^2} \frac{1}{T^2} \left[1 - \beta^2 \frac{T}{T_{max}} + \frac{T^2}{2E^2} \right]$$

General other updates

- Have been working with Gregory looking at cosmics which did not hit the detector. Goal is to find the ideal min/max nPE rejection ratio which optimizes signal acceptance/background rejection

- I'm told he just completed a run of 45M muons; going to probably have an answer to this question in the next week or so. He might present at some point at these meetings via Skype

- Question of scaling per-bar between sim and experiment has been discussed (for a throughgoing muon, what is our signal?). Per-bar nPE should be available for collision muons in the HTML archives of the sim analysis (e.g. http://uaf-7.t2.ucsd.edu/~ryan/milliqan/geant_sim or bennett's equivalent)