Birks Quenching

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Introduction

- In the past few years, for our main hadronic string model Fritiof (FTF), we were unable to improve the description of both thin-target and thick-target (hadronic showers) data
  - Development driven to improve the thin-target data description gave worse hadronic showers – i.e. higher energy response
- We have investigated possible reasons for this tension:
  - Production of π°
  - Tuning of model parameters driven by light targets (H & C)

  but we have not found anything wrong
- Moreover, whenever more precise physics was included in the FTFP_BERT physics list, the problem got worse, i.e. even higher energy response in hadronic showers
  - Use Binary Cascade (BIC) instead of Bertini (BERT) for nucleons below a few GeV
  - More refined hadron elastic

Birks Quenching (1/2)

- Could it be the Birks quenching the cause of the problem ?

- Reminder of the Birks Quenching :

Detector-specific suppression of the "visible" energy with respect to the local "deposited" energy by ionizing particles due to intrinsic saturation effects in light-emitting scintillators or electron-ion recombination effects.
The higher the local deposited ionization density, dE/dx, the more quenching.
Described by the simple, phenomenological relation :

$$\Delta E\_visible = \frac{\Delta E}{1 + K * \frac{\Delta E}{\Delta x}}$$

Birks Quenching (2/2)

- For scintillator-based calorimeters, the coefficient used for Birks quenching was obtained from old measurements, by fitting under the assumption of **no delta-ray emissions**
  - i.e. assuming that the "energy loss" is the same as the "local deposited energy"
- This implies that the ionization density, dE/dx, was overestimated, and therefore the **Birks coefficient was underestimated**
- So, in realistic simulations where delta-rays are emitted, a higher Birks coefficient – and therefore a bigger quenching – should be used, which implies smaller visible energy

Proposal

- We suggest to **fit** the Birks coefficient by imposing the ***π / e* ratio** in simulation to be the same as measured in test-beam data at one beam energy (arbitrarily chosen)
  - Independent from the calibration
  - Convenient (but not necessary) to use for the fit the same beam energy as for the calibration
  - The same procedure could be applied also for different active media, e.g. Liquid Argon …

Note : this extra free parameter will, of course, compensate also for some of the uncertainties in modelling hadronic physics, but for different observables (energy fluctuations and shower shapes) at the same energy, as well as for all observables at different energies, there is no reduction in "predictive power"