Exercises for the Calorimeter Reconstruction and Machine Learning Workshop 2024

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October 2024

1. The nuclear interaction length of a material is given by

$$\lambda_{\text{int}} = \frac{A}{N_A \rho \sigma_{\text{tot}}} \approx 35\text{g/cm}^2 A^{1/3} \tag{1}$$

while as a reminder the radiation length is defined as

$$X_0 = \text{const.} \frac{A}{N_A \sigma_{\text{pair}}} \propto A/Z^2. \tag{2}$$

Plot both nuclear interaction length and radiation length for as a function of A and Z. Put markers for materials in our material list for simulation.

2. Adapt your EM calorimeter to also capture Hadronic showers.

   a) Plot the deposited energy per sensor layer for a few example events caused by pions to get a feeling for the shower development.

   b) What happens in terms of performance, cost etc.?

   c) Also create a DNN and train it to regress the initial particle energy. How do energy sum and DNN regression relate qualitatively?

   d) Produce a resolution plot as a function of true energy (same as CMS plot from EM lecture).

3. Build an optimal hadronic calorimeter (no transversal granularity) for showers between 1 and 100 GeV and stay below 50k CHF.