Calibrating calorimeter signals in the ATLAS experiment using an uncertainty-aware neural network

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Within the frame of experimental physics with the ATLAS experiment at the Large Hadron Collider (LHC), precise **jet reconstruction** plays an important role in many interesting final states. Jets can be reconstructed from energy deposits in the calorimeter cells, which are grouped into topologically connected cells in order to form clusters, called **topo-clusters**.

Topo-clusters are calibrated to correctly measure the energy deposited by electromagnetic showers, thus providing no compensation for the fraction of deposited energy not contributing to the signal in the complex development of hadronic showers. This leads to on average smaller observed signal for hadrons depositing the same energy as electrons, positrons, and photons.

An alternative calibration of topo-clusters to the standard approach in ATLAS is now being considered. It consists of a **machine learning** based local calibration which employs features of these topo-clusters that are sensitive to the origin of the signal at their location, the effect of pile-up on their signals, the cluster kinematics, and some event-level quantities reflecting the collision environment.

This talk presents the results of a deterministic deep neural network (DNN) with an heteroscedastic loss. It is based on a Bayesian neural network (BNN) which showed great performance on a recent study [1]. The likelihood function considered in both models is a Gaussian Mixture (GM), which consists of a weighted sum of gaussians. This function is predicted per topo-cluster, from which the mode (value with the highest value of the likelihood) is taken as a prediction with its GM corresponding uncertainty.

Both models provide a consistent uncertainty estimate. In this talk, the comparison with these two networks is presented, as well as the performance for Run 2 and Run 3 simulations.

References

[1] ATLAS Collaboration, *Precision calibration of calorimeter signals in the ATLAS experiment using an uncertainty-aware neural network*, 2024, `https://arxiv.org/pdf/2412.04370`.