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Deep learning techniques for energy clustering in the CMS ECAL

The reconstruction of electrons and photons in CMS depends on topological clustering of the energy deposited by an incident particle in different crystals of the electromagnetic calorimeter (ECAL).

These clusters are formed by aggregating neighbouring crystals according to the expected topology of an electromagnetic shower in the ECAL. The presence of upstream material (beampipe, tracker and support structures) causes electrons and photons to start showering before reaching the calorimeter. This effect, combined with the 3.8T CMS magnetic field, leads to energy being spread in several clusters around the primary one. It is essential to recover the energy contained in these satellite clusters in order to achieve the best possible energy resolution for physics analyses.

Historically satellite clusters have been associated to the primary cluster using a purely topological algorithm which does not attempt to remove spurious energy deposits from additional pileup interactions (PU). The performance of this algorithm is expected to degrade during LHC Run 3 (2022+) because of the larger average PU levels and the increasing levels of noise due to the ageing of the ECAL detector. New methods are being investigated that exploit state-of-the-art deep learning architectures like Graph Neural Networks (GNN) and self-attention algorithms. These more sophisticated models improve the energy collection and are more resilient to PU and noise, helping to preserve the electron and photon energy resolution achieved during LHC Runs 1 and 2.

This talk will cover the challenges of training the models as well the opportunity that this new approach offers to unify the ECAL energy measurement with the particle identification steps used in the global CMS photon and electron reconstruction.

Significance

The talk will report a brand new approach in CMS ECAL energy clustering based on graph neural networks and attention mechanism.

References

Speaker time zone

Compatible with Europe

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