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Deep learning techniques for energy clustering in the CMS electromagnetic calorimeter

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The reconstruction of electrons and photons in the Compact Muon Solenoid (CMS) detector 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 causes electrons and photons to start showering before reaching the ECAL. 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 to achieve the best possible energy resolution. 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. This talk will cover the challenges of training the models and the opportunities offered by the deep learning techniques.

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