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## End-to-end particle and event identification at the Large Hadron Collider with CMS Open Data

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From particle identification to the discovery of the Higgs boson, deep learning algorithms have become an increasingly important tool for data analysis at the Large Hadron Collider.

We present an innovative end-to-end deep learning approach for jet identification at the LHC. The method combines deep neural networks with low-level detector information, such as calorimeter energy deposits and tracking information, to build a discriminator to identify different particles. Using two physics examples as references: electron and photon discrimination and quark and gluon discrimination, we demonstrate the performance of the end-to-end approach using simulated events with full detector geometry available as CMS Open Data. We also offer insights into the importance of the information extracted from various sub-detectors and describe how end-to-end techniques can be extended to event-level classification using information from the whole detector.

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