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Use of multivariate regression techniques for ultimate energy measurement

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The measurement of electromagnetic showers in a transversely segmented calorimeter may be subject to local containment losses related to gaps between the segments which vary according to the position and angle of the incident particle. Furthermore in the case where a significant amount of material is present upstream of the calorimeter within a strong magnetic field, some fraction of the energy of the initial particle may not reach the calorimeter or may not be included in the clustering used to reconstruct the shower. The amount of energy lost to such mechanisms depends on the distribution of upstream material, but also is subject to significant stochastic fluctuations. In a hadronic environment, electromagnetic showers may be further contaminated by additional energy from hadronic activity, primarily from low energy photons produced by neutral meson decays. To the extent that these effects do not entirely factorize, and that information relevant to the shower to shower variations and fluctuations is available in the profile of the shower itself, optimal energy reconstruction may be achieved with multivariate regression techniques. These techniques may also provide a per-shower estimate of the energy resolution, which may vary significantly according to the properties of the shower. We describe a particular implementation of these methods for the CMS Electromagnetic Calorimeter, and evaluate the performance in terms of energy measurement for both data and simulated LHC events. This specific implementation includes extensions of traditional Boosted Decision Tree-based regression algorithms to more explicitly take into account the shape of the energy response distribution.

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