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Vertex Imaging in Hadron Calorimetry using AI/ML Tools

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The fluctuations in energy loss to processes that do not generate measurable signals, such as binding energy losses, set the limit on achievable hadronic energy resolution in traditional energy reconstruction techniques. The correlation between the number of hadronic interaction vertices in a shower and invisible energy is found to be strong and is used to estimate invisible energy fraction in highly granular calorimeters in short time intervals (<5 ns). We simulated images of hadronic showers using GEANT4 and deployed a neural network to analyze the images for energy regression. The neural network-based approach results in significant improvement in energy resolution, from 13% to 4% in the case of a Cherenkov calorimeter and from 7% to 4% for an ionization calorimeter for 100 GeV pion showers. We discuss the significance of the phenomena responsible for this improvement and the plans for experimental verification of these results.

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