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3D Clustering in the CMS High Granularity Calorimeter

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In 2029, the High Luminosity phase of the LHC (HL-LHC) is planned to begin taking data, bringing an unprecedented level of radiation and average particle interactions per brunch-crossing (pileup/PU). In order to preserve the same physics performance that the CMS detector achieves now, the collaboration has decided to replace the endcaps of the current electromagnetic and hadronic calorimeters (ECAL and HCAL, respectively) with the High Granularity Calorimeter (HGCAL). My work has focused primarily on optimizing the performance of the HGCAL trigger primitive generator (TPG) system. The TPG system constructs clusters of energy deposits that likely belong to the same primary particle. These clusters form one type of trigger primitive that are sent to the central Level 1 Trigger which uses them to select interesting events. The energy response and resolution of these trigger primitives were measured for simulated photon, electron, and pion particle-gun samples, both in the absence of pileup interactions as well as with 200 PU (the ultimate case for the HL-LHC). An energy weighting procedure is performed on all samples to account for the energy losses the clusters have due to thresholds and leakage; an additional correction is applied to the pileup samples to account for the (approximately) linear increase of pileup contamination with the pseudo-rapidity $|\eta|$. The TPG performance is well optimized for constant radii —it can however be further improved by varying the radii independently in each layer of the HGCAL, with the aim of better mimicking the true transverse development of the particle showers throughout the detector. For this we plan to build and train a machine learning model to determine these radii, optimizing with the energy response and resolution.

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