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System Design and Prototyping for the CMS Level-1 Trigger at the High-Luminosity LHC

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The High-Luminosity LHC will open an unprecedented window on the weak-scale nature of the universe, providing high-precision measurements of the standard model as well as searches for new physics beyond the standard model. Such precision measurements and searches require information-rich datasets with a statistical power that matches the high-luminosity provided by the Phase-2 upgrade of the LHC. Efficiently collecting those datasets will be a challenging task, given the harsh environment of 200 proton-proton interactions per LHC bunch crossing. For this purpose, the trigger and data acquisition system of the Compact Muon Solenoid (CMS) experiment will be entirely replaced. Novel design choices have been explored, including ATCA prototyping platforms with SoC controllers and newly available interconnect technologies with serial optical links with data rates up to 28 Gb/s. Trigger data analysis will be performed through sophisticated algorithms, including widespread use of Machine Learning, in large FPGAs, such as the Xilinx Ultrascale family. The system will process over 60 Tb/s of detector data with an event rate of 750 kHz. The system design and prototyping are described and examples of trigger algorithms reviewed.

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