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Script-Assisted Board Layout for the CMS HGCAL Readout Electronics

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The CMS Phase II High-Granularity Calorimeter (HGCAL) relies on passive boards known as wagons to transmit signals from silicon sensor modules to upstream electronics for further processing. Such wagon boards face many design constraints that result in over 50 unique varieties, each of which requires the precise placement of dozens of components onto a PCB layout. A suite of tools has been developed to both algorithmically compute all required board varieties and to then automate the placement of all components onto a layout, greatly simplifying the design process and reducing the work needed to be done by hand.

Summary (500 words)

The CMS endcap calorimeter will be entirely replaced as part of the Phase II upgrade. The new High-Granularity Calorimeter (HGCAL) design requires robust transmission of signals from the individual silicon sensor modules to upstream electronics that perform data aggregation and processing. This transmission is performed by passive boards known as wagons, whose design must meet a wide range of constraints. In addition to the nontrivial challenges associated with accommodating large, hexagonal modules into a circular detector geometry, these constraints also include limited space, varying data rates, and the minimization of the number of individual board layouts needed. From the basic positions, orientations, and computed data rates for each hexagonal sensor module, a tool has been developed to determine the number and varieties of wagon boards required to satisfy these constraints and to output a unique identifier for each. Maximum consolidation of varieties and minimization of both front-end and back-end resources are also taken into account. The design of each wagon board in the collection of over 50 required varieties presents a significant challenge, as the placement by hand of dozens of components per board, which depend on the locations and orientations of the modules it services, would require an inordinate amount of design time. Thus, a complementary tool was developed to take the wagon board variety identifier, determine the positions of all board components, and generate a file that can be read by Altium, a PCB design software program. After importing the file, the component can be matched to the appropriate footprint, traces can be easily extended between connected components, and then only the task of pairing the appropriate connector pins is left to be done by hand. The elimination of the burden of determining the positions for all of the various components in the plethora of different layouts greatly reduces the complexity of the design process and makes the delivery of such designs in a realistic timeframe feasible. Thus, from simply the module mapping of the HGCAL silicon sensor modules, an algorithmic suite of tools has demonstrated the ability to determine all of the required boards subject to the constraints and to provide templates for their PCB layouts, automating a significant portion of the design process.

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