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The ATLAS FTK Auxiliary Card: A Highly Functional VME Rear Transition Module for a Hardware Track Finding Processing Unit

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The ATLAS Fast TrackKer is a hardware-based track finder for the ATLAS High Level Trigger. Pattern recognition and preliminary track fitting are performed by VME Processing Units consisting of an Associative Memory Board (AMB) containing custom associative memory chips for pattern recognition, and the Auxiliary Card (AUX), a powerful rear transition module which formats the data for the AMB and performs linearized fits on AMB track candidates. We report on the design and testing of the AUX, which utilizes six FPGAs to process up to 32 Gbps of hit data and fit one track candidate per nanosecond

Summary

In order to preserve the ability to select rare physics processes in the face of increasing LHC luminosity in 2015 and beyond, the ATLAS experiment is installing a hardware based track finder to aid the High Level Trigger (HLT). The ATLAS Fast TrackKer (FTK) uses a mix of custom and commercial electronics to reconstruct all charged particles with a transverse momentum of 1 GeV or greater in the acceptance of the silicon tracking detectors at the full 100 kHz first level trigger rate. The pattern recognition and preliminary track fitting is carried out by the Processing Units (PU), each of which consists of a 9U Associative Memory Board (AMB) populated with custom associative memory chips for pattern recognition paired with a highly functional rear transition module, called the Auxiliary Card (AUX), which performs the data preparation and track fitting.

The AUX receives the silicon hits at a rate of up to 48 Gbps, converts them to coarse resolution hits, which it sends directly to the AMB for use in pattern recognition at a rate of up to 24 Gbps through a special P3 connection. It additionally stores the full resolution hits for later use. Matched patterns are sent back from the AMB, again through the P3 connector, and the AUX fetches the corresponding full resolution hits in order to perform a linearized track fit at a rate of 1 fit per ns. The tracks passing a χ^2 cut are sent to downstream parts of the FTK system which do a final determination of the track parameters utilizing information from more layers of the silicon detectors.

The AUX implements this functionality in six Arria-V FPGAs per board, two of which are used for the data reduction to coarse resolution hits and four of which are used as parallel track fitting engines. There are 128 PU in the entire FTK system, for a combined processing power of 1 track fit per 5 picoseconds. Hits are fed to the AUX through two 6 Gbps QSFP connectors, and good tracks are sent downstream optically through a 2 Gbps SFP connection.

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