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ATLAS Trigger and Data Acquisition Upgrades for the High Luminosity LHC

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Summary

The ATLAS experiment at CERN has started the construction of upgrades for the "High Luminosity LHC", with collisions due to start in 2026. In order to deliver an order of magnitude more data than previous LHC runs, 14 TeV protons will collide with an instantaneous luminosity of up to 7.5×1034 cm $-$ 2s $-$ 1, resulting in much higher pileup and data rates than the current experiment was designed to handle. While this is essential to realise the physics programme, it presents a huge challenge for the detector, trigger, data acquisition and computing. The detector upgrades themselves also present new requirements and opportunities for the trigger and data acquisition system.

The approved baseline design of the TDAQ upgrade comprises: a hardware-based low-latency real-time Trigger operating at 40 MHz, Data Acquisition which combines custom readout with commodity hardware and networking to deal with 5.2 TB/s input, and an Event Filter running at 1 MHz which combines offline-like algorithms on a large commodity compute service augmented by hardware tracking. Commodity servers and networks are used as far as possible, with custom ATCA boards, high speed links and powerful FPGAs deployed in the low-latency parts of the system. Offline-style clustering and jet-finding in FPGAs, and track reconstruction with Associative Memory ASICs and FPGAs are designed to combat pileup in the Trigger and Event Filter respectively.

This paper will report recent progress on the design, technology and construction of the system. The physics motivation and expected performance will be shown for key physics processes.

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