Scientific Applications of FPGAs at the LHC

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ABSTRACT

The next generation of high throughput data acquisition systems is capable of acquisition at rates far exceeding our ability to save data. To process data in real-time specialized computing systems are needed with incredibly high throughput so that data can be quickly assessed to determine whether it is sufficiently interesting for further processing. With a raw data rate exceeding 1 Petabit per second, particle detectors at the Large Hadron Collider at the Europe Center for Nuclear Research (CERN) contend with some of the largest data rates ever encountered. With planned upgrades in the near future, these rates will continue to grow, further complicating our ability to process data effectively to continue to understand the fundamental properties of the universe. In this talk, we present the current, FPGA-based, LHC data acquisition system, and we discuss the plenitude of data challenges that are currently being addressed. Furthermore, we discuss various aspects of the system, and we present deep learning base solutions that are quickly being adopted by the LHC. Furthermore, we discuss the lower throughput computationally complex systems and discuss how FPGAs can augment the system leading to enhanced physics performance. Throughout the talk, we discuss the scientific implications possible with an improved system. Finally, we discuss related problems in other scientific fields, including astrophysics and materials science. We present new challenges that, if solved, can open paths to new avenues of fundamental scientific research.

CCS Concepts/ACM Classifiers

Applied computing~Physical sciences and engineering~Physics

Computer systems organization~Real-time systems~Real-time system specification

Author Keywords

High Energy Physics; Dark Matter; LHC; CERN; Real-time Systems; Low-latency; Deep Learning

BIOGRAPHY

Philip Harris joined the MIT faculty in 2017. Since joining MIT, Philip has helped found the Fast Machine Learning group aimed at deploying processor accelerated machine learning algorithms for realtime and high throughput scientific applications including the LHC. Additionally, Philip leads the real-time particle reconstruction group on the CMS experiment. Born in Sao Paulo, he received his B.S in Physics from Caltech in 2005, and his Ph.D from MIT in 2011 on research performed at CERN with the CMS experiment. From 2011-2013, Philip was a CERN fellow working on the Higgs Boson discovery. From 2014-2017, he was a CERN staff scientist leading the effort on dark matter searches at the CMS experiment.

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