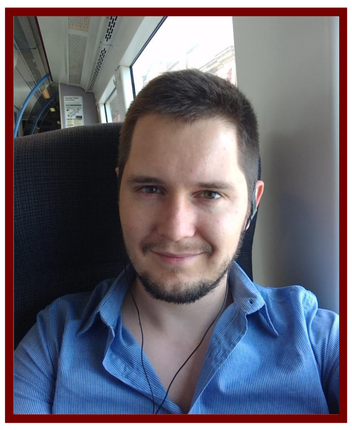

Emulation of a prototype FPGA track finder for the CMS Phase-2 upgrade with the CIDAF emulation framework

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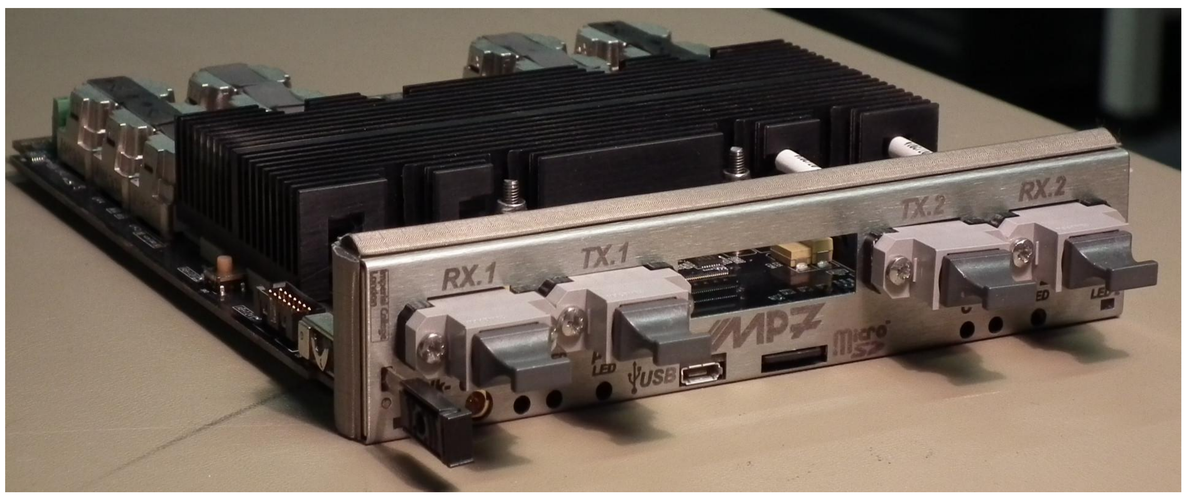
[2] Supported by EU FP7-PEOPLE-2012-ITN project nr 317446, INFIERI, “Intelligent Fast Interconnected and Efficient Devices for Frontier Exploitation in Research and Industry”

Motivation

The **CMS collaboration** plans to upgrade its outer silicon tracker detector by 2026. This **"Phase-2" upgrade** prepares the experiment for the High Luminosity phase of the LHC (**HL-LHC**), The upgraded tracker electronics will provide a list of reconstructed **tracks** to the **Level-1 trigger**, to improve its performance.

A proposed track finding system is based on a **Hough transform** implemented in firmware, designed for **FPGA** hardware. Currently, a demonstrator for the system is being commissioned. The latter is based on **MP7 cards**, featuring a Xilinx **Virtex-7** XC7VX690T FPGA.



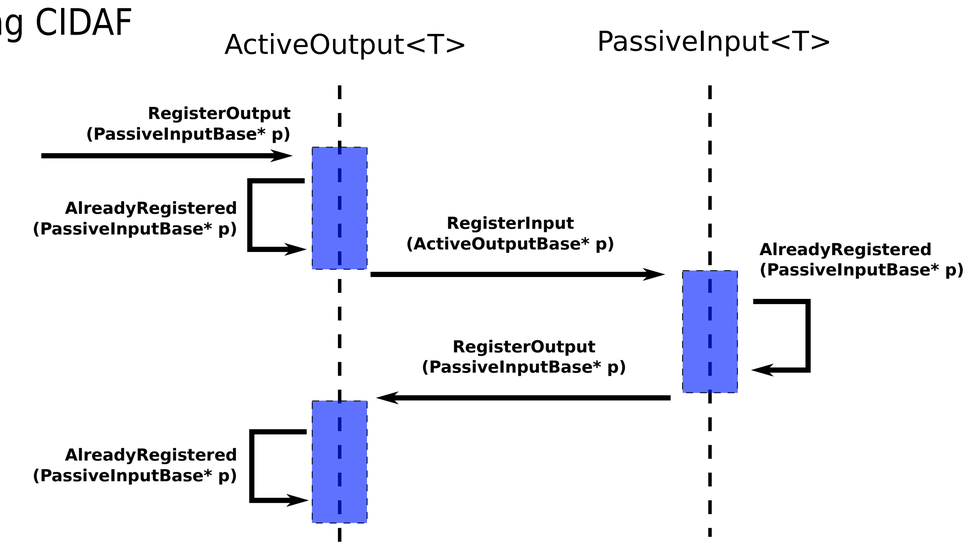
To test the behavior of the firmware, a **software emulator in C++** and an emulation infrastructure to help its development have been written. This **software infrastructure** has been named **CIDAF** (CIrcuit DAta Flow), is **independent** from the specifics of the system being emulated and can be used in **many different applications**.

CIDAF is available for testing from the author of this poster.

CIDAF

CIDAF is a **library** providing a series of facilities that aid in the development of **C++ emulations of firmware**. It features a **clocking** system, a **data transfer** system and tools to help bringing the behavior of the simulation to coincide with the one of the hardware, e.g. **support for fixed-width integers**.

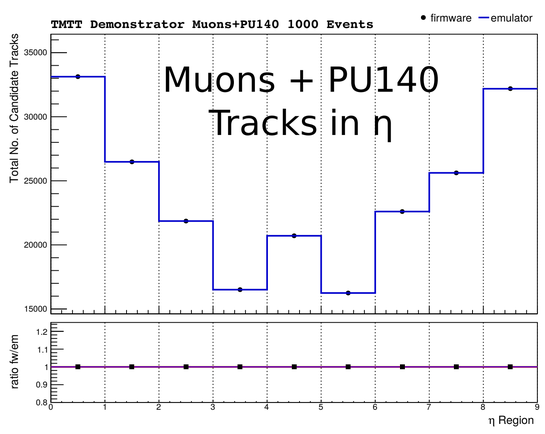
In a typical use case, a simulation for individual components making up a complex firmware would be written in C++, taking as a reference the hardware description language source. The components would then be connected together using CIDAF

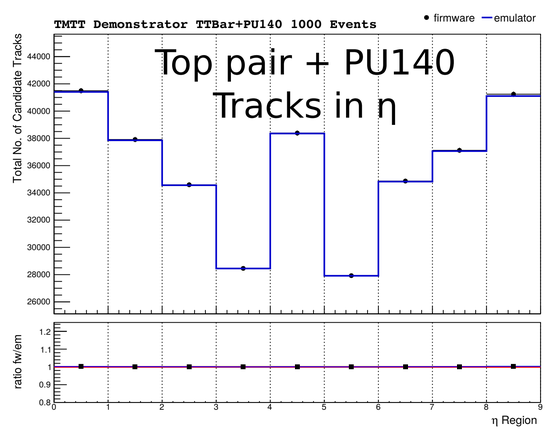


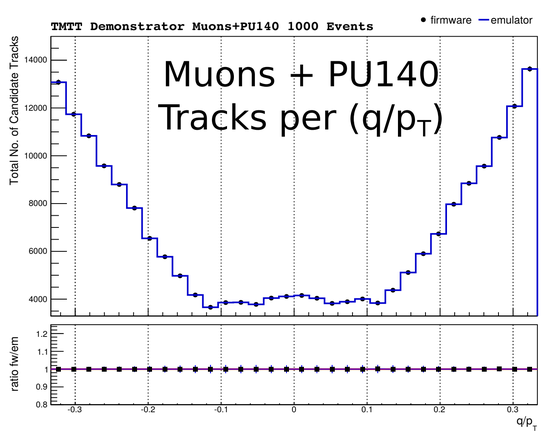
Connections and disconnections between components (as in figure) employ a double handshake, so pointer-safety is ensured when objects are disconnected, destroyed or moved.

Results from HT firmware emulation

Comparison between firmware running on hardware (black dots) and emulator implemented with CIDAF (blue line)







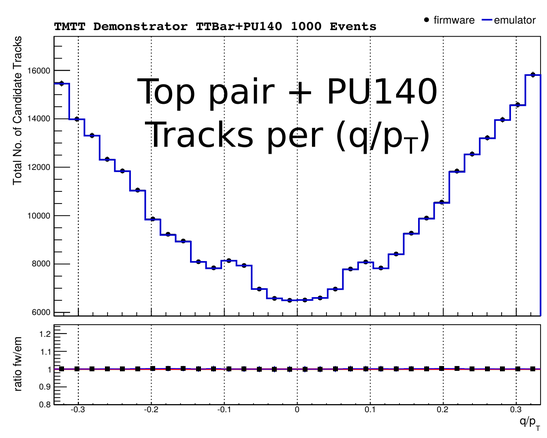
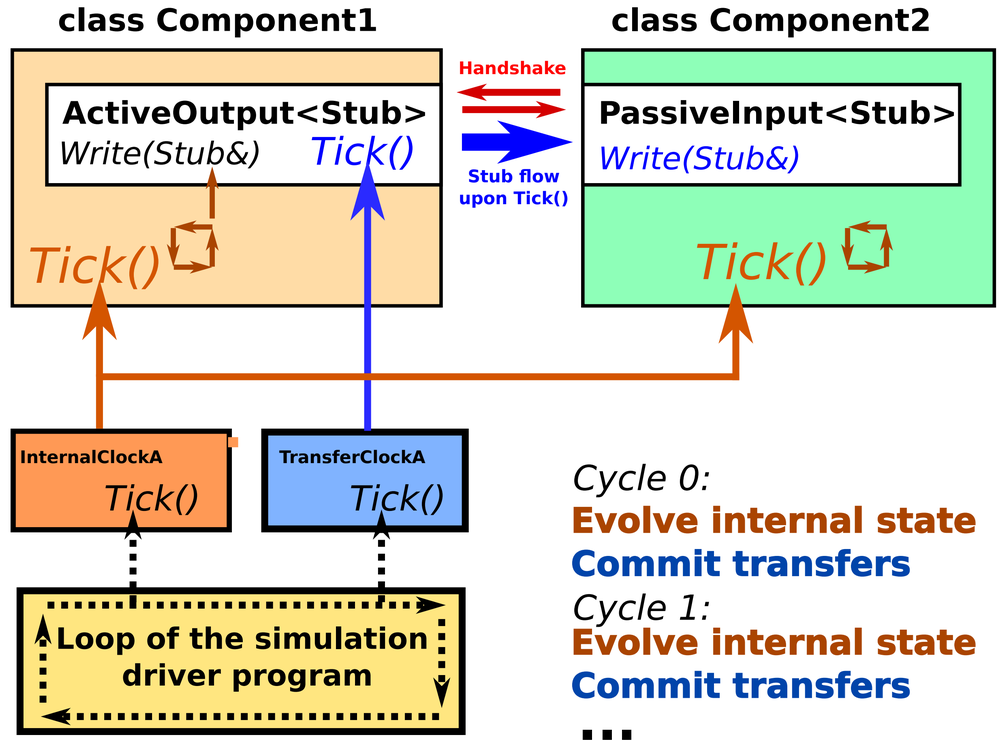


Table on the right: average number of tracks per event found over 1000 events, for each of the listed types of simulated Monte Carlo samples.

Sample (1000 evts each)	avg. # tracks / event fw	emu
Muons + PU0	5.442	5.442
Muons + PU140	215.35	215.339
Top Pair + PU140	321.999	321.537
Top Pair + PU200	874.799	873.926

Emulation example



Cycle 0:
Evolve internal state
Commit transfers
Cycle 1:
Evolve internal state
Commit transfers
...

A driver program triggers the clock responsible for evolving the internal state of Component1 and Component2, then initiates the transfer of data from Component1 and Component2 by triggering the clock associated to the Component1's ActiveOutput. This repeats at each emulation cycle.

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