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The First Prototype for the FastTracker Processing Unit

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Modern experiments search for extremely rare processes hidden in much larger background levels. As the experiment complexity and the accelerator backgrounds and luminosity increase we need increasingly complex and exclusive selections.

We present the first prototype of a new Processing Unit, the core of the FastTracker processor for Atlas, whose computing

power is such that a couple of hundreds of them will be able to reconstruct all the tracks with transverse momentum above 1

GeV in the ATLAS events up to Phase II instantaneous luminosities ($5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$) with an event input rate of 100 kHz and

a latency below hundreds of microseconds. We plan extremely powerful, very compact and low consumption units for the far

future, essential to increase efficiency and purity of the Level 2 selected samples through the intensive use of tracking.

This strategy requires massive computing power to minimize the online execution time of complex tracking algorithms.

The time consuming pattern recognition problem, generally referred to as the “combinatorial challenge”, is beat by the

Associative Memory (AM) technology [2] exploiting parallelism to the maximum level: it compares the event to precalculated

“expectations” or “patterns” (pattern matching) at once looking for candidate tracks called “roads”. This approach

reduces to linear the typical exponential complexity of the CPU based algorithms. The problem is solved by the time data are

loaded into the AM devices.

We describe the board prototypes that face the very challenging aspects of the Processing Unit: a huge amount of detector

clusters (“hits”) must be distributed at high rate with very large fan-out to all patterns (10 Millions of patterns will be located

on 128 chips placed on a single board) and a huge amount of roads must be collected and sent back to the FTK post-pattern recognition

functions. The Processing Unit consists of a 9U VME board, the AMBoard, controlled by an AUX card on the back of the crate. The AMBoard has a modular structure consisting of 4 mezzanines, the Local Associative

Memory Banks

(LAMB). Each LAMB contains 32 Associative Memory (AM) chips, 16 per side. The proto - AUX card provides hits on 8

buses for a total of 12 Gbits/sec to the AMBoard through 12 high frequency serial links and will sink the found roads through

other 16 high frequency serial links (24 Gbits/sec). A special P3 connector allows the communication between the front and

rear boards placed on the same VME slot. A custom board profile has been studied and simulated at the CAD to guarantee a perfect board-to-board closure of the P3 connector without a backplane support in that region. A network of high speed serial links characterize the bus distribution on the AMBoard. The hit buses are fed to the four LAMBs and distributed to the 32 AM chips on the LAMB, through fanout chips. The LAMB realization has represented a significant technological challenge, due to the high density of chips allocated on both sides, and to the use of advanced packages and high frequency serial links.

We report on the design and first tests of the Processing Unit.

[1] A. Andreani et al., The FastTracker Real Time Processor and Its Impact on Muon Isolation, Tau and b-Jet Online

Selections at ATLAS, Conference Record 17th IEEE NPSS Real Time Conference Record of the 17th Real Time Conference,

Lisbon, Portugal, 24 - 28 May 2010.

[2] M. Dell'Orso and L. Ristori, "VLSI structures for track finding", Nucl. Instr. and Meth., vol. A278, pp. 436-440, (1989).

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