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A new paradigm using GPUs for fast triggering and pattern matching at the CERN experiment NA62

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We describe a pilot project for the use of GPUs in an online triggering application at the CERN NA62 experiment, and the results of the first field tests together with a prototype data acquisition system.

Summary

Two major trends can be identified in the development of trigger and DAQ systems for particle-physics experiments: the massive use of general-purpose commodity systems such as commercial PC farms for data acquisition, and the reduction of trigger levels implemented in hardware, towards a pure software selection system ("triggerless").

The NA62 experiment at the CERN SPS aims at measuring an ultra-rare decay of the charged kaon; the signal has to be extracted from a huge background which is ten orders of magnitude more frequent.
With an input particle rate of 10 MHz, some tens of thousands detector channels and the requirement of avoiding zero suppression as much as possible, triggerless readout into PCs is not affordable.

An innovative approach aims at exploiting the parallel computing power of commercial GPUs to perform fast computations in software in the early trigger stages.
General-purpose computing on GPUs is emerging as a new paradigm in several fields of science, although so far applications have been tailored to the specific strengths of such devices, exploiting parallelization and avoiding real-time applications.
With the steady reduction of GPU latencies, and the increase in link and memory throughputs, the use of such devices for real-time applications in high-energy physics data acquisition and trigger systems is becoming ripe.

A pilot project within NA62 aims at integrating GPUs into the central L0 trigger processor, and also to use them as a fast online processors for computing trigger primitives.
Several TDC-equipped sub-detectors with sub-nanosecond time resolution will participate to the first-level NA62 trigger (L0), fully integrated with the data-acquisition system, to reduce the readout rate of all sub-detectors to 1 MHz, using multiplicity information asynchronously computed over time windows of a few ns, both for positive sub-detectors and for vetos.
The online use of GPUs would allow the computation of more complex trigger primitives already at this first trigger level.
Cheap commercial links can be used to collect trigger primitives, and the task of the dedicated central processor is to perform time matching of those, generate the trigger signal and re-align it in time for synchronous distribution.

We describe the architecture of the proposed system and present the performances achieved in tests on a real detector data acquisition system, to perform online recognition of rings from a RICH detector with sub-nanosecond time resolution.
The challenges and the prospects of this promising approach are discussed.

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