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# GPUs for fast triggerimg and pattern matching at the CERN experiment NA62

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. This approach is promising to achieve very high resolution in online reconstruction of physical observables used in trigger systems.

## Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

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 (K+-> pi nu nubar); 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.

The very innovative approach presented here aims at exploiting the parallel computing power of commercial GPUs (Graphics processing unit) 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.

Most difficulties related to the reconstruction of physical observables used for trigger purposes can be reconduced to pattern recognition problems. Such issues of this kind can be treated through parallel algorithms. The fast ellipse recognition in a two dimensional array, for instance, can be addressed using the generalized Hough transform approach; the linear interpolation with standard methods can be achieved at high resolution exploiting the GPU computing power.

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. This information at the trigger level is an essential ingredient for the online particle identification aming at selecting interesting events with a higher efficiency.

In the future this approach will be extended to the reconstruction of other physical observables such as the particles'momenta in tracking detectors or energy clusters in calorimeters.
The challenges and the prospects of this promising idea are discussed.

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