Agile Data Acquisition: Record Polarimetry & Quantum Optics measurements (AgilDA)

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ABSTRACT

Modern experimental science is based on the use of sophisticated scientific instrumentation. The cost of modern instrumentation is typically quite high and each instrument has a very specific set of capabilities. This is partially due to the usage of specialized processing units in the hardware, which are based on Application-Specific Integrated Circuits (ASICs) or Field Programmable Arrays (FPGAs). These specialized processing units are able to cope with the high processing rate required by the application of each device. Therefore, current commercial-off-the shelf (COTS) instrumentation devices lack flexibility. They are designed for some specific, not very complex tasks, and they are not able to deliver any other except the predefined, by the manufacturer, capabilities. Moreover, the capability of capturing the raw data of the analog to digital converters for customized processing is typically not possible or limited to a very low sampling rate.

We envision a new era in the Data Acquisition (DAQ) where a single device is not restricted to a limited set of tasks, but is able to adapt and to be reconfigured, essentially defined, by software. This can be achieved by interconnecting the DAQ frontend hardware directly to a host via a high-speed interface, exploiting more general-purpose processing units like Central Processing Units (CPUs) and Graphics Processing Units (GPUs) that provide very high processing power at a low cost, which drops exponentially with time. Furthermore, every digitized sample will be available for processing providing maximum flexibility. Real-time processing and instantaneous results will be made possible for a large number of specialized applications, where today only off-line or sparse data processing is possible.

In order to understand the actual requirements and to showcase the advantage of a high-performance software defined DAQ platform, real-life applications should be the driving force.

Pulsed cavity ring-down polarimetry has been shown, to have record sensitivity and the ability to measure in new regimes (such as thin films and open-air conditions). However, attempts in recent years to make the data acquisition fast and compact enough for a real-time commercial instrument, which would increase the impact of the method exponentially, have failed.

Coincidence experiments in strong-laser-field physics and quantum optics demand the use of an ultra-high bandwidth, dynamic range, multichannel DAQ system. The system should be capable to record low photon number energy fluctuations in high repetition rates for long acquisition times, conditions that are required for the characterization of the quantum state of the light. However, there is no COTS device capable of providing this performance.

These are two discrete applications where this technology will be applied and provide solutions that are not available today.