Workshop on Electronics for Physics Experiments and Applications @INFN



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Low Latency Data Acquisition for Future Gravitational Waves Detectors

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Future gravitational wave detectors will require increasingly sophisticated control systems to enhance sensitivity and expand operational range. A key challenge is optimizing the entire data acquisition and processing loop, from ADC conversion to real-time elaboration and DAC actuation, where low, deterministic latency is essential for improving overall system performance and extending control bandwidth. In this talk, we will present our efforts to address this challenge, focusing on the integration of FPGA-based solutions to enable high-bandwidth data handling and improve system flexibility. We will discuss the development of a custom board based on Ultrascale FPGAs, along with advanced interfaces enabling fast and efficient data conversion and transfer to powerful real-time processing cores and DAQ units. This solution integrates high-speed ADC/DAC interfaces, using low-latency communication protocols like JESD204, and incorporates advanced data transfer mechanisms toward DSP or GPU based processors. In particular, in the view of using GPUs, a significant effort is dedicated on overcoming the limitations of traditional PCIe transactions, leveraging hardware accelerators and direct memory access techniques to optimize data flow. These developments provide a strong foundation for next-generation control architectures, with the potential to integrate machine learning techniques to further enhance adaptability and performance.

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