# Design and Development of High-Speed Data Acquisition System and Online Data Processing with a Heterogeneous FPGA/GPU Architecture

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## Motivation

In our previous work at TELBE [1,2], we developed a unique 100 kHz high repetition rate pulse-resolved arrival time monitor with high dynamic range and temporal resolution ~10 fs that overcome the major limitations of 4th generation light sources in terms of their use in time-resolved ultrafast experiments.

In this work, we are demonstrating our current development for pulse-resolved detection that operates at a few MHz repetition rates with online data analysis. The new technology is based on FPGA microarchitecture and KALYPSO detector [3].

## Current System @ TELBE

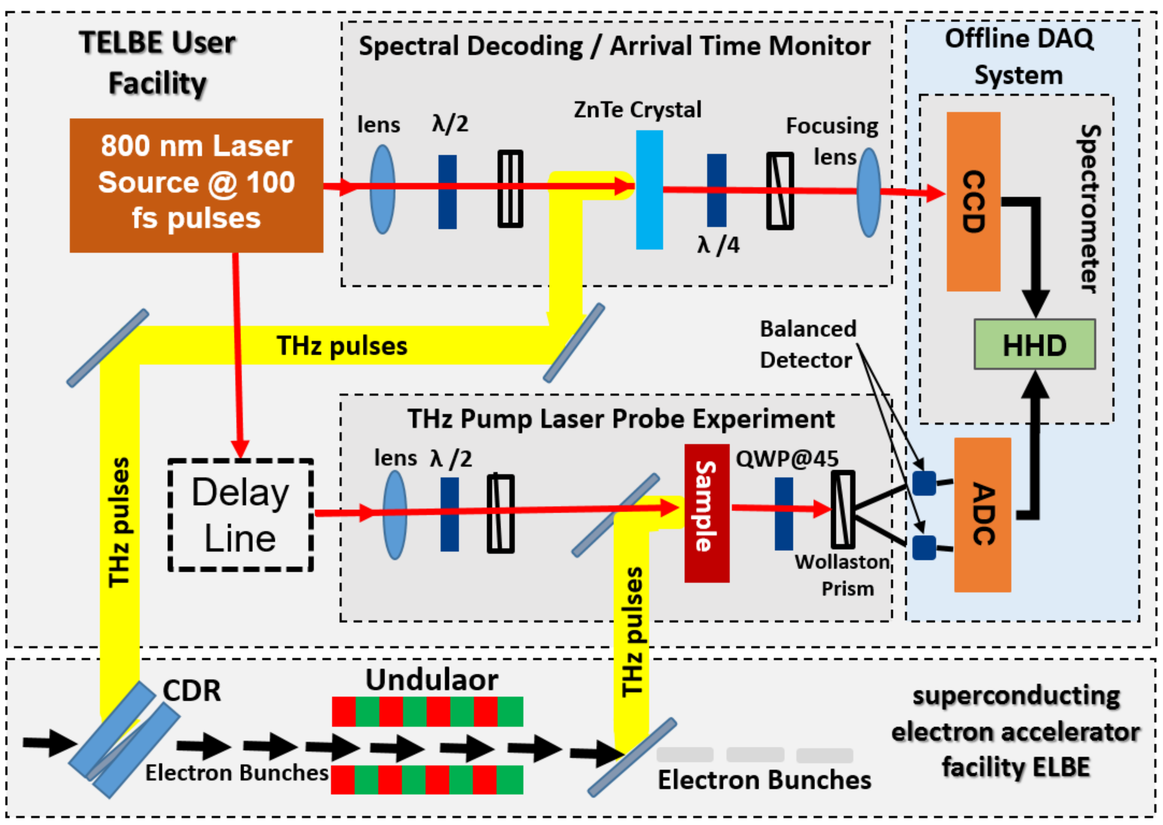



Fig 1. Schematic of the pulse-resolved data acquisition system developed at TELBE with repetition rate = 100 kHz, ADC at 10 MHz with 8 channels, and a few 10 fs time resolution

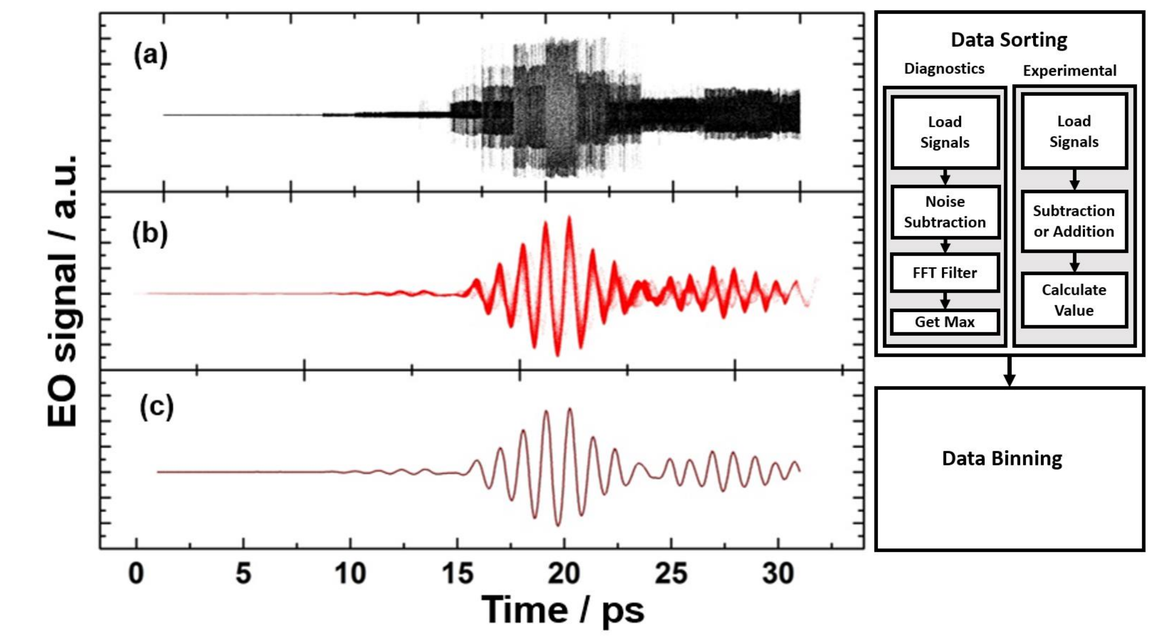



Fig 2. EOS of 0.9 THz undulator pulse :
(a) Raw, unsorted data. Timing from delay stage position only.
(b) Added arrival time data from pulse-resolved diagnostics.
(c) Averaged data in 50 fs wide bins.

## High-speed DAQ system

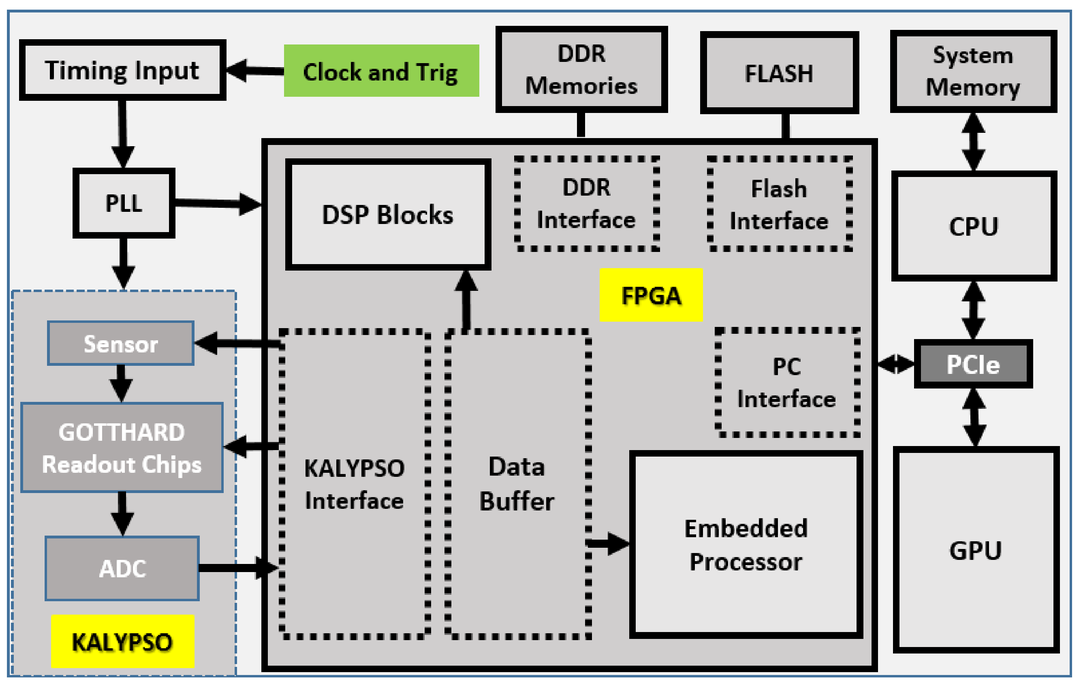



Fig 3. Block Diagram of the Heterogeneous FPGA/GPU DAQ and Processing System

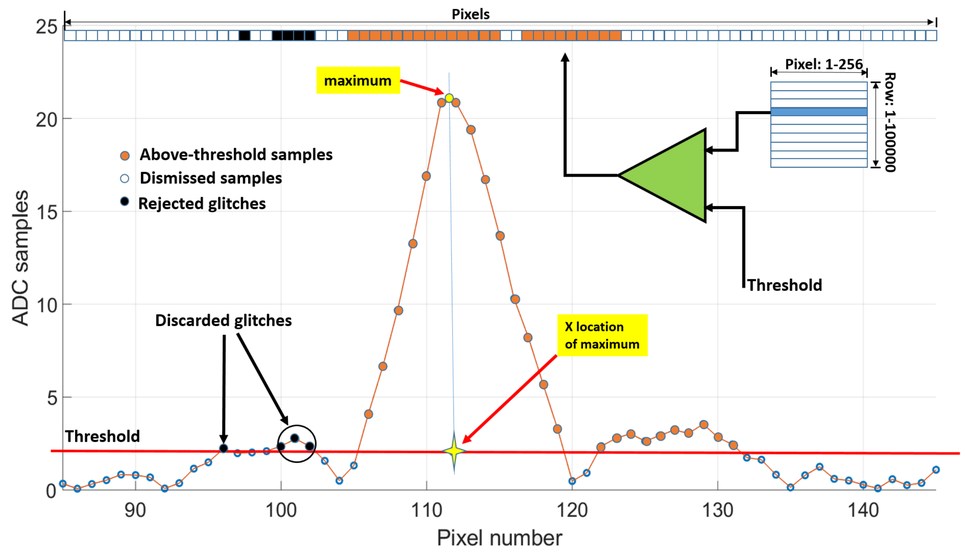
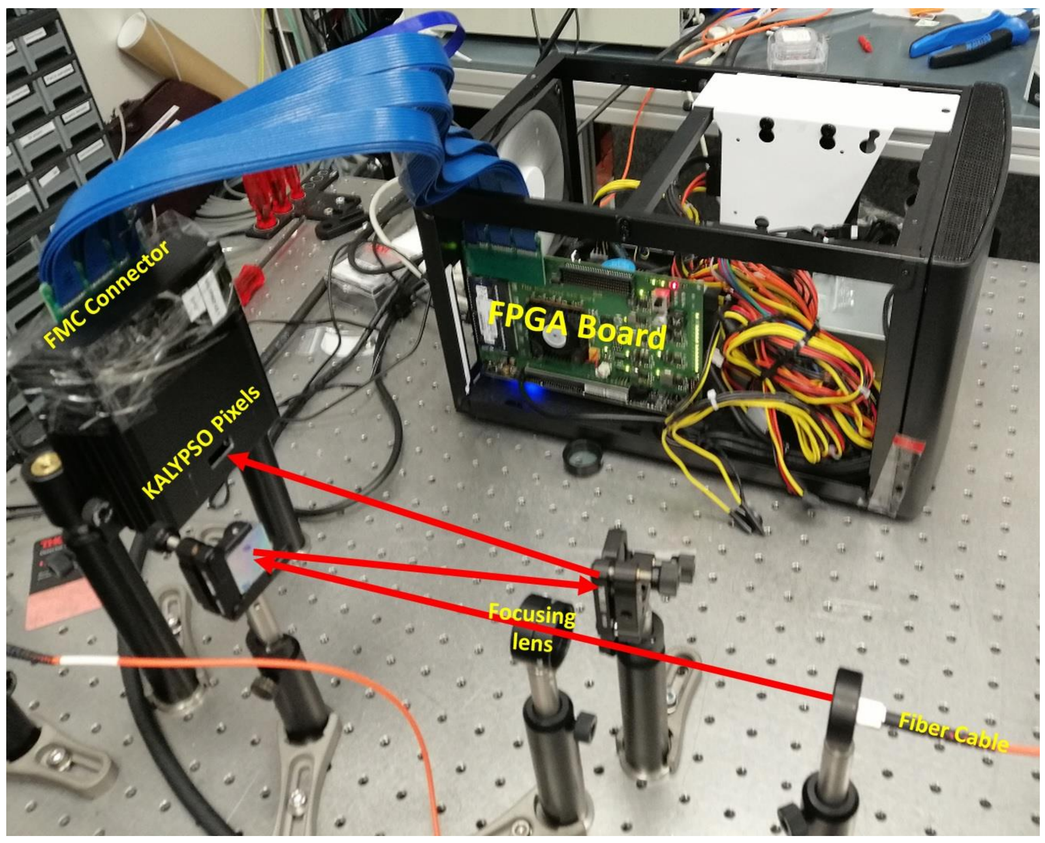



Fig 4. A vector containing the arrival time information of the THz pulse. Data were taken at 100 kHz repetition rate.




## OUTLOOK & next steps

- upgrade to 13 MHz repletion rate utilizing the KALYPSO detector v.3 and high throughput DAQ developments from KIT.
- Implementing 8 ADC channels at 1000 MHz and higher bit resolution.
- Supporting two arrival-time monitor inputs in parallel.

## References:

[1] **S. Kovalev et al.,** *Probing ultra-fast processes with high dynamic range at 4th-generation light sources: Arrival time and intensity binning at unprecedented repetition rates*, Struct. Dyn. 4, 024301, Pages: 1-7 (2017).
[2] **B. Green et al.,** *High-Field High-Repetition-Rate Sources for the Coherent THz Control of Matter*, Sci. Rep. 6, 22256, Pages: 1-9 (2016).
[3] **L. Rota et al.,** *KALYPSO: A Mfps Linear Array Detector for Visible to NIR Radiation*, Proceedings of IBIC2016, WEPG46, Pages: 740-743 (2016).