13th FORTH RETREAT 2022

AgilDA

AGILE DATA ACQUISITION:

RECORD POLARIMETRY & QUANTUM OPTICS MEASUREMENTS

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TEAM

IESL - Co-Investigators

- Prof. Peter Rakitzis
  - Polarimetry

- Dr. Paraskevas Tzallas
  - Quantum Optics

ICS - Principal Investigator

- Dr. Stefanos Papadakis
  - Software Defined Instrumentation

MOTIVATION

Scientific Instrumentation

- Cost: Expensive to extremely expensive
- Capabilitites: Single to few tasks
- Programmability: None to limited at best
- Upgradability scheme: Better buy a new one
- Post processing: Screenshots, CSV files, text files, low bit rate stream…

REAL WORLD PROBLEMS / APPLICATIONS

Pulsed cavity ring-down polarimetry

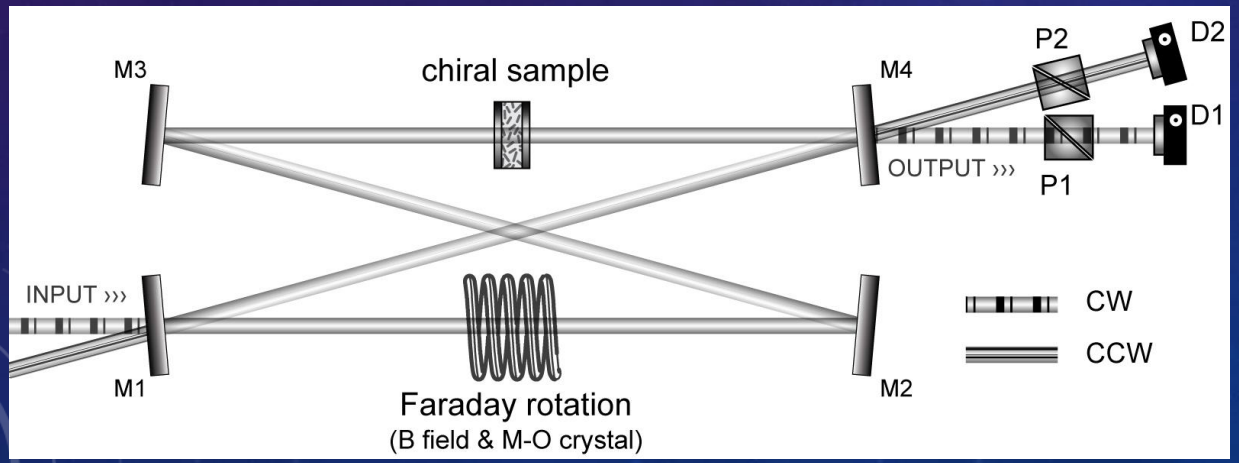
- record sensitivity and the ability to measure in new regimes (such as thin films and open-air conditions)
- only failed attempts to make the data acquisition fast and compact enough for a real-time commercial instrument

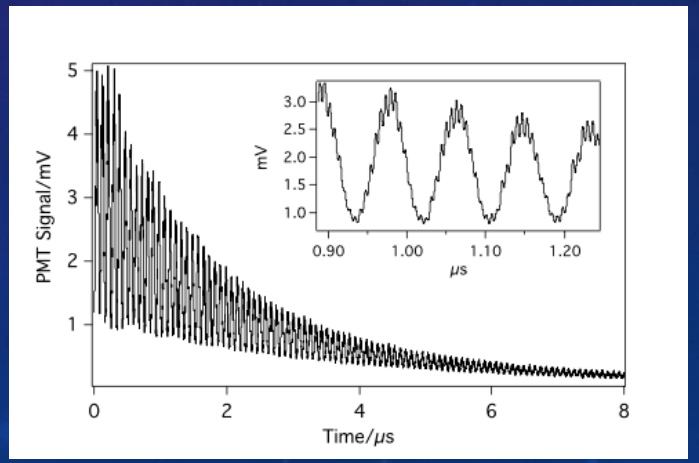
Coincidence experiments in strong-laser-field physics and quantum optics

- characterization of the quantum state of the light: must record low photon number energy fluctuations in high repetition rates for long acquisition times
- need for ultra-high bandwidth, high dynamic range, multichannel DAQ system
- no COTS device capable of providing this performance

APPLICATION I
PULSED CAVITY RING-DOWN POLARIMETRY

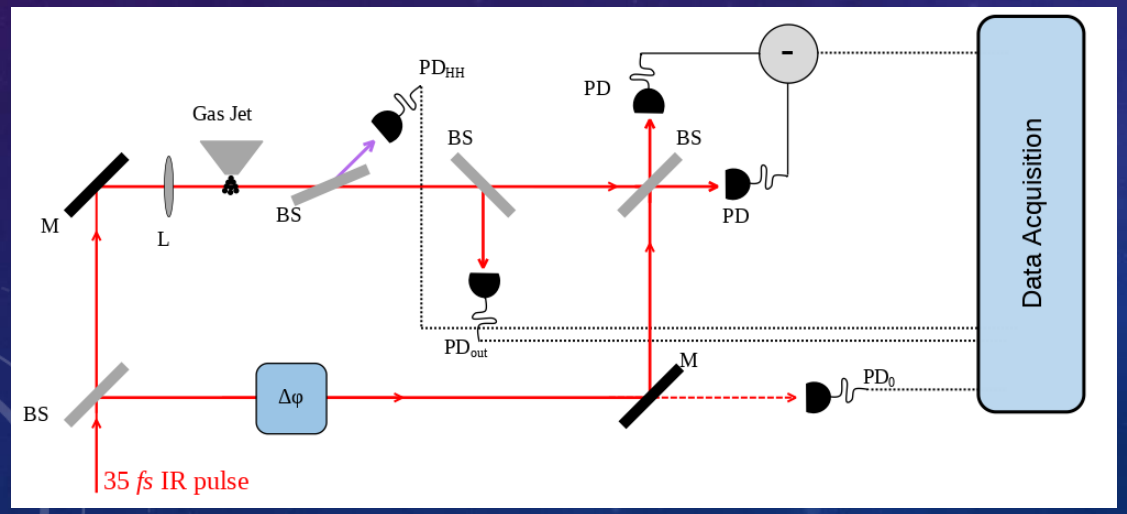
- 2 channels [4 channels ideally]
  - CW/CCW pairs of alternating B+/B- fields
- 10 kHz laser pulse repetition rate
  - analyze & fit 10 000 traces per channel per second in order to calculate their frequency with high accuracy & precision

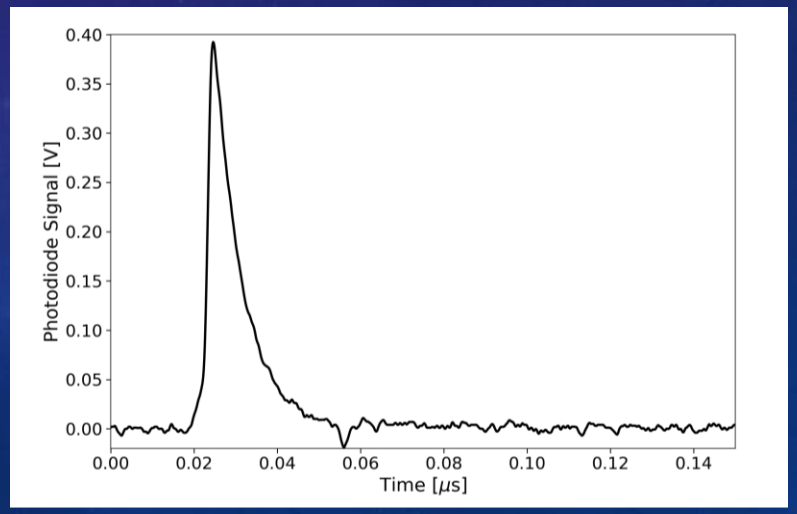




APPLICATION II
COINCIDENCE EXPERIMENTS IN STRONG-LASER-FIELD PHYSICS AND QUANTUM OPTICS

- 4 channels minimum [8 channels or more ideally]
  - 14bit or more dynamic range
- 1 kHz laser pulse repetition rate minimum
- 30 min of runtime minimum
- Real-time noise compensation and pulse detection





WISHES

What if you could…

- exploit every single sample of the ADCs acquired data
- upgrade your processing units freely
- use a robust programming language, i.e. C/C++
- program it limited only by your PC’s processing units [which you can upgrade easily]

ATTACK

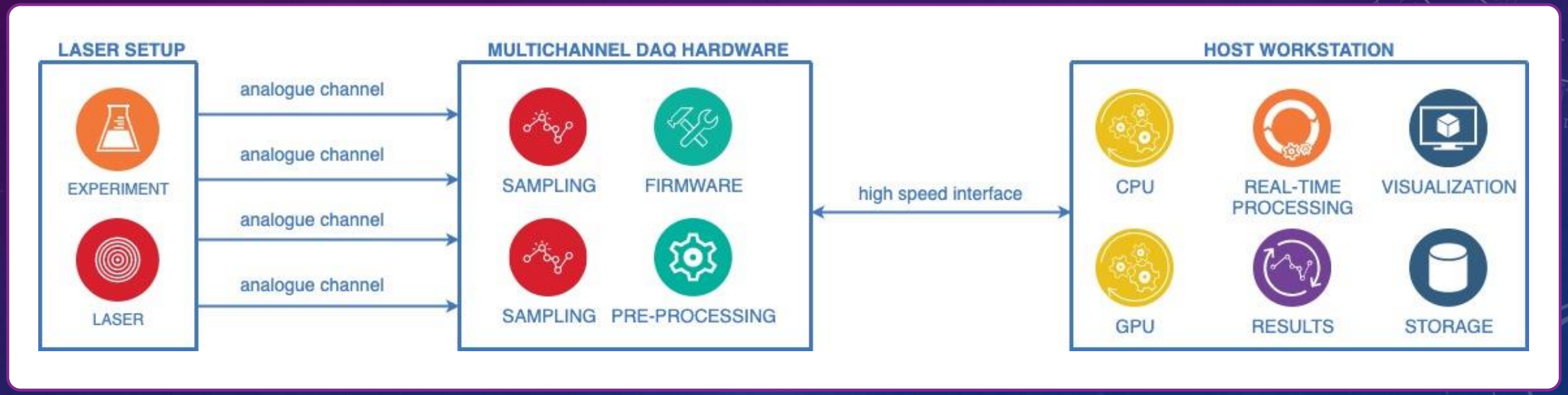
software-defined DAQ platform:

- operates in high sampling rates in real-time
- allows direct access to and unrestricted manipulation of all the captured data (samples)
- provides the flexibility required by contemporary complex experiments

advantages over existing solutions:

- maximum flexibility in the processing of any captured signal
- easy and low-cost upgradeability
- direct communication between the instrument and the processing libraries/software
- complex calculations of high sampling rate data in real-time

SOLUTION OVERVIEW



SPECIFICS

DAQ frontend

- platform: Xilinx ZYNQ
- (RF)SoC: Zynq UltraScale+ & Zynq-7000
- ADCs: 8x 5GS/s 14bit

DAQ backend

- interface: PCIe [Gen3, x16 ~15GB/s]
- processing: NVIDIA GPUs [GPUDirect]
- storage: NVME SSDs

SO FAR

Progress:

- Defined the requirements & the details of the two applications
- Advanced the theoretical background of the two applications
- Provided ZYNQ platform basic system implementation [FPGA modules, data streaming, soft interfaces]
- Prepared a set of highly accurate frequency calculation processes for the polarimetry experiment

Pandemic obstacles:

- Zero hardware availability
- Specialized personnel runaway

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data acquisition on steroids