The Abdus Salam International Centre for Theoretical Physics

IAEA

Joint ICTP-IAEA School on Systems-on-Chip based on FPGA for Scientific Instrumentation and Reconfigurable Computing

Project 1 - Stage 2

Digital Pulse Processing for Isotope Identification

Prepared by
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Trieste - Italy
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Stage 2

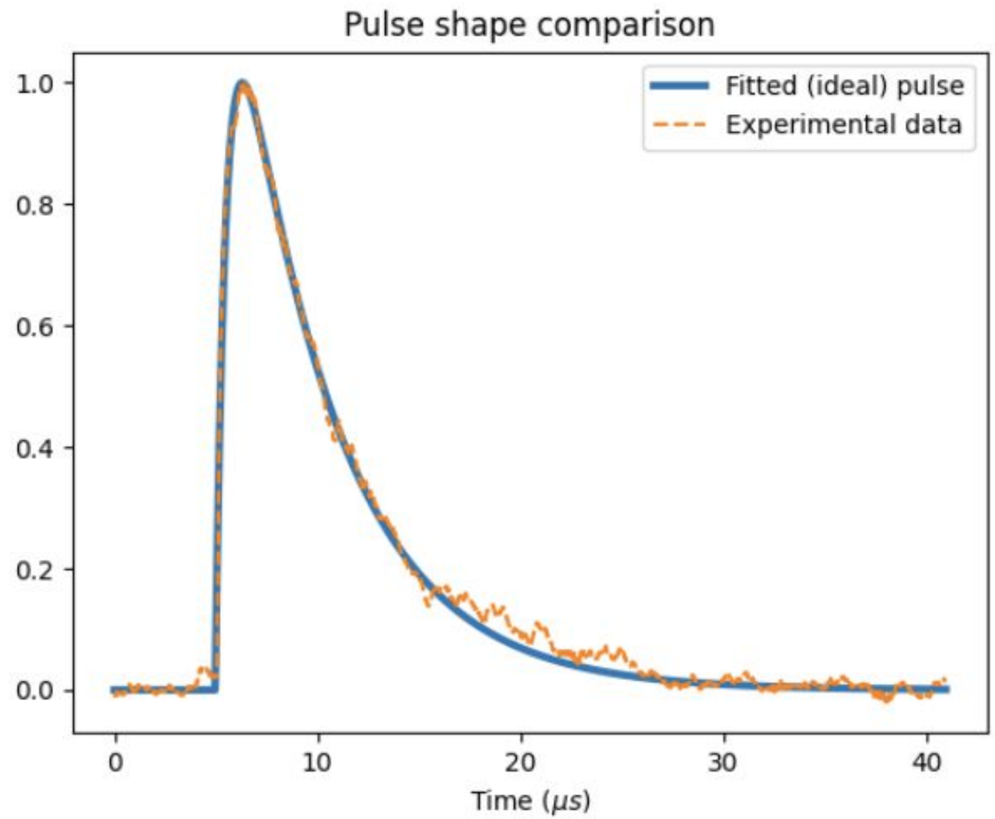
Digital pulse processing for isotope identification

Before starting

Pull the repo 😉

Parameters from Stage 1

- NaI(Tl) detector
  - τ_d ~ 1.20μs
  - τ_r ~ 0.22 μs
- CLYC detector
  - τ_d ~ 4.97μs
  - τ_r ~ 0.47 μs



Lab Project 1 - stage 2: specific objectives

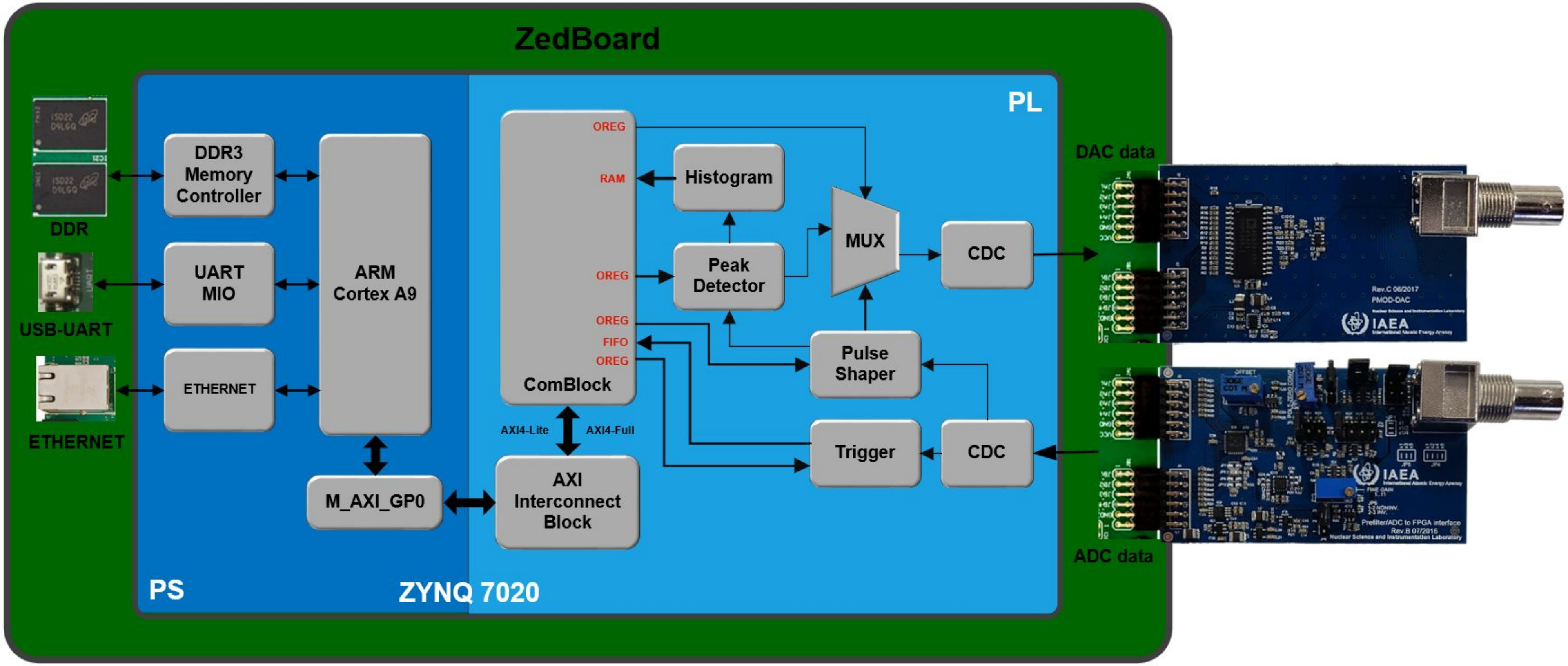
- Build a digital pulse processing system (DPP) to compute the energy spectrum in the SoC/FPGA
- Identify the provided isotope source by its energy spectrum

Methodology

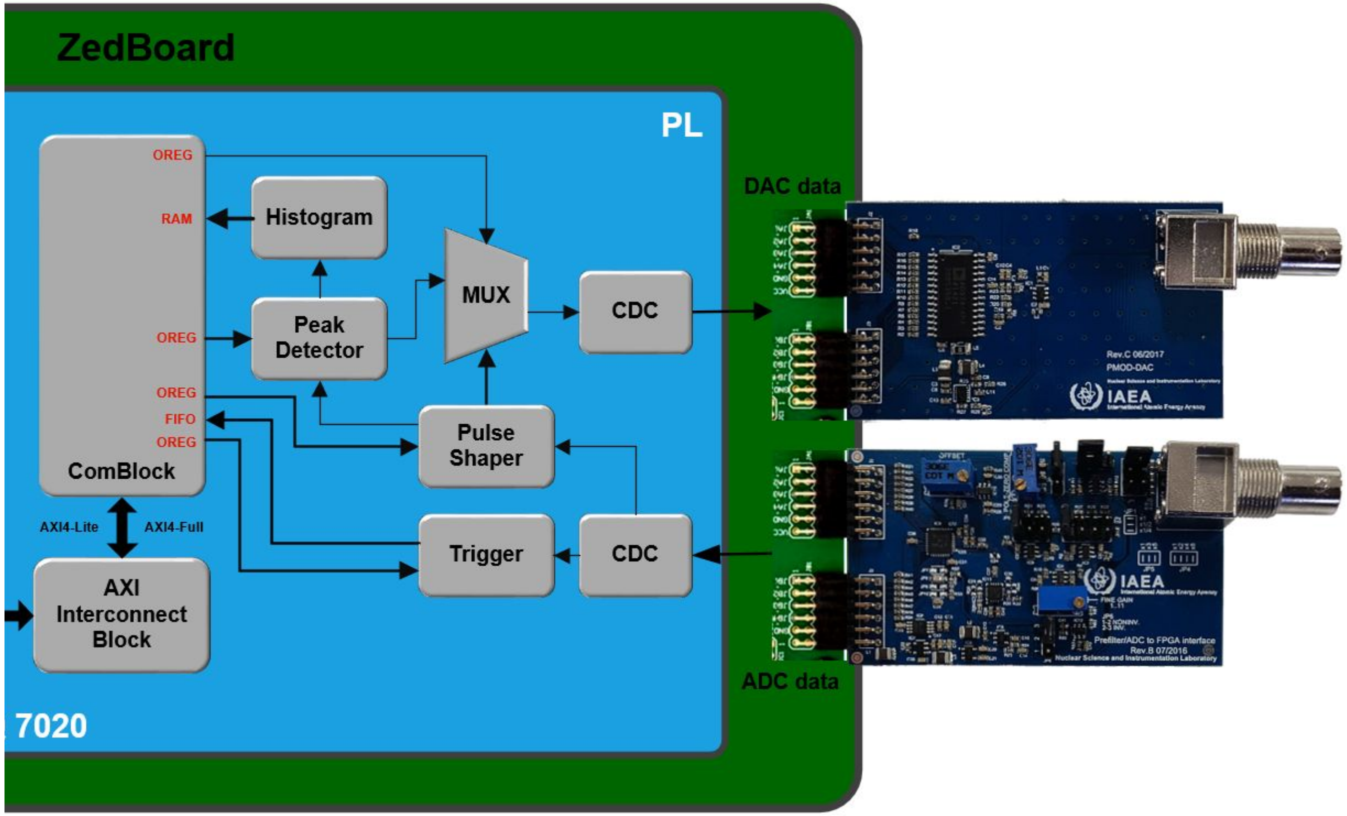
- Compute the 32-bit unsigned representation of the parameters from Stage 1
- Build up the DPP system using the provided IP cores
- Include the oscilloscope block to assess the signal shapes
- Use the ComBlock's features:
  - Output registers to set the parameters for the IP cores
  - DP RAM to store the real-time data from the histogram generator (spectrum)
  - Input FIFO to store the oscilloscope traces
- Add the missing code into the base Jupyter Notebook (JN) to complete the system with UDMA

Stage 2.1 - DPP design in SoC

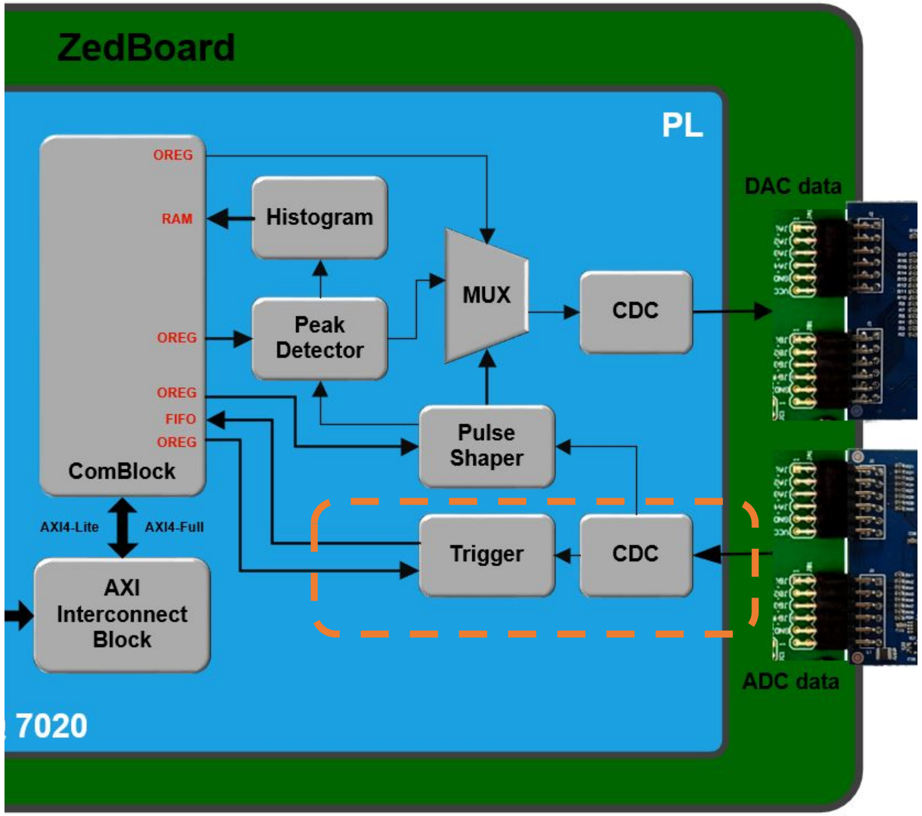
Design description - DPP overview



Design description - Analog front-end



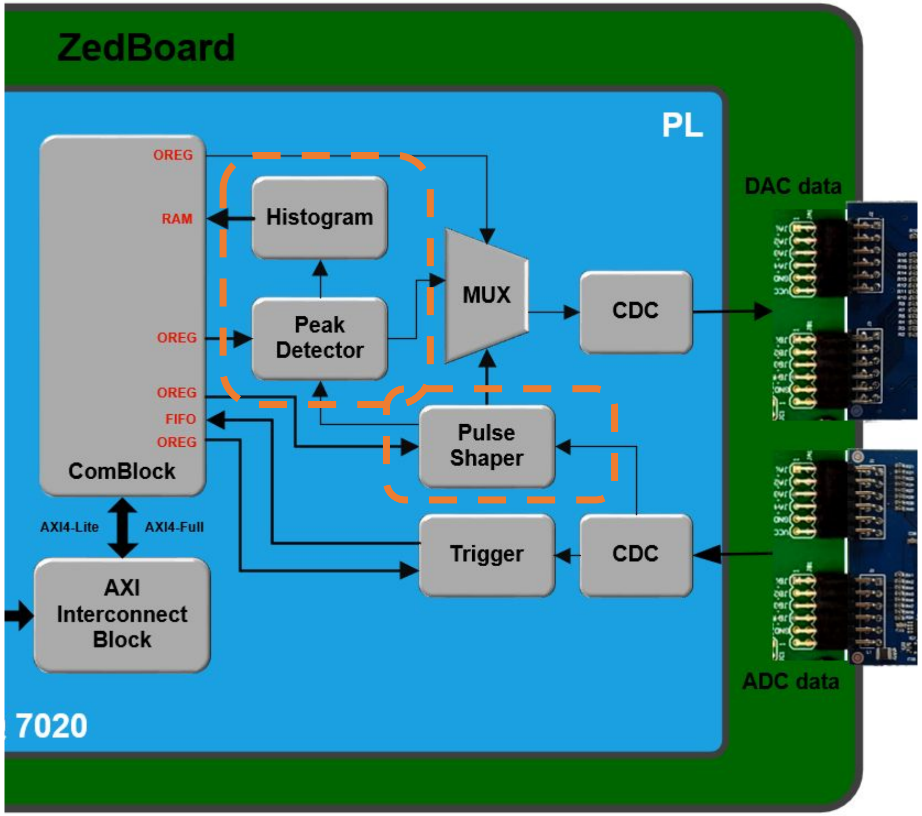
Design description - Oscilloscope (trigger logic)



Trigger logic - basic oscilloscope core

- Input registers
  - Pulse length (in sample units)
  - Threshold level (in ADC units)
  - Samples before trigger (delay)
- Output stream
  - Captured pulse

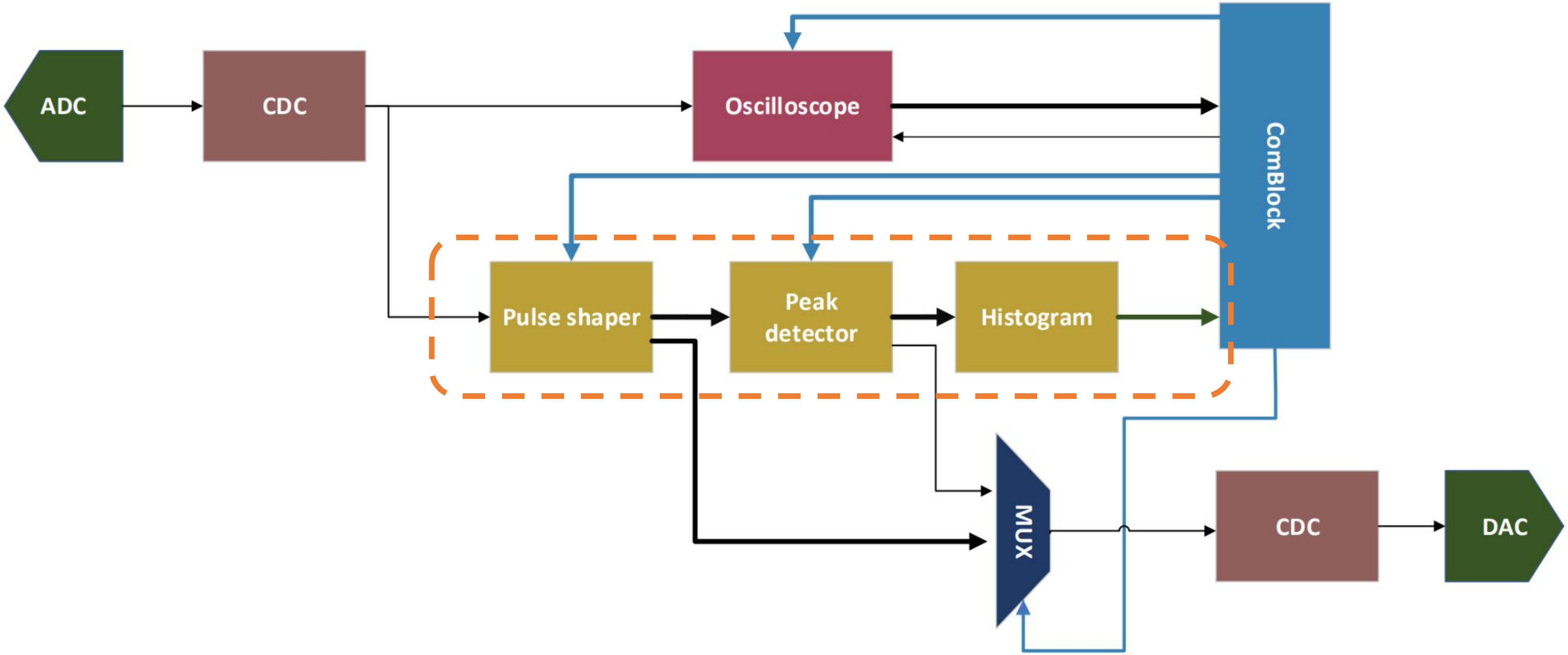
Design description - DPP



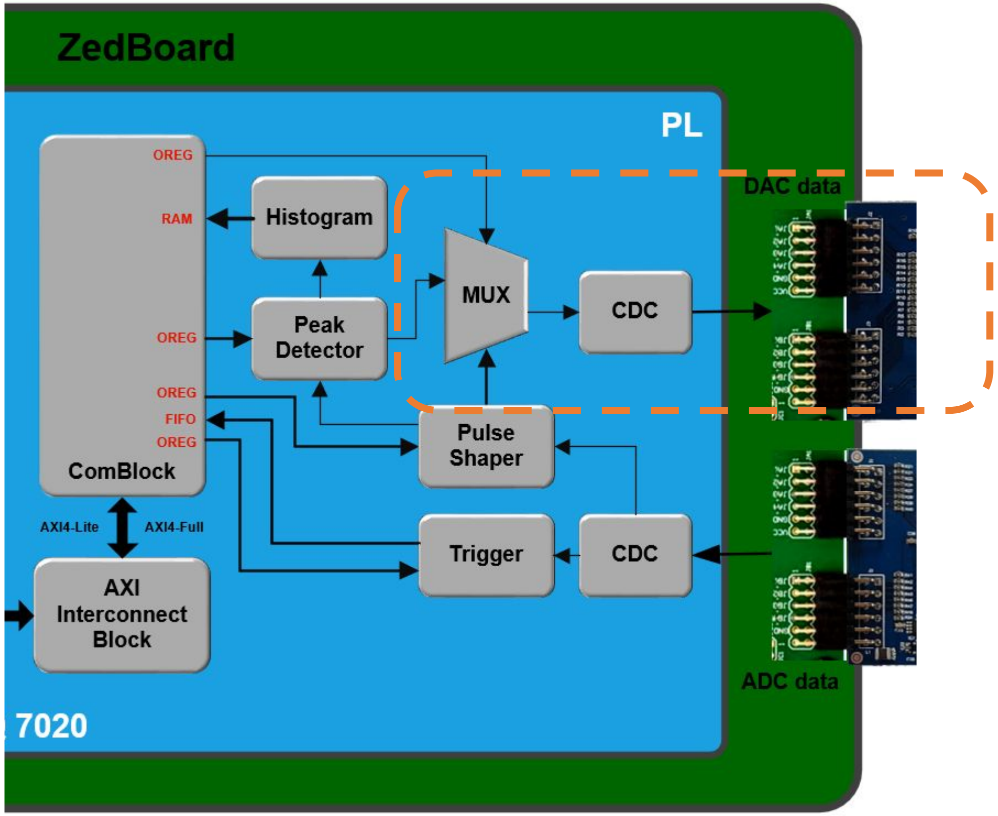
Continuous processing (triggerless)

- Pulse shaper
  - Trapezoid/triangle output
- Peak detector
  - Finds peak of trapezoid
- Histogram
  - Stores each amplitude as a value in the RAM address

Design description - DPP data path



Design description - D/A output

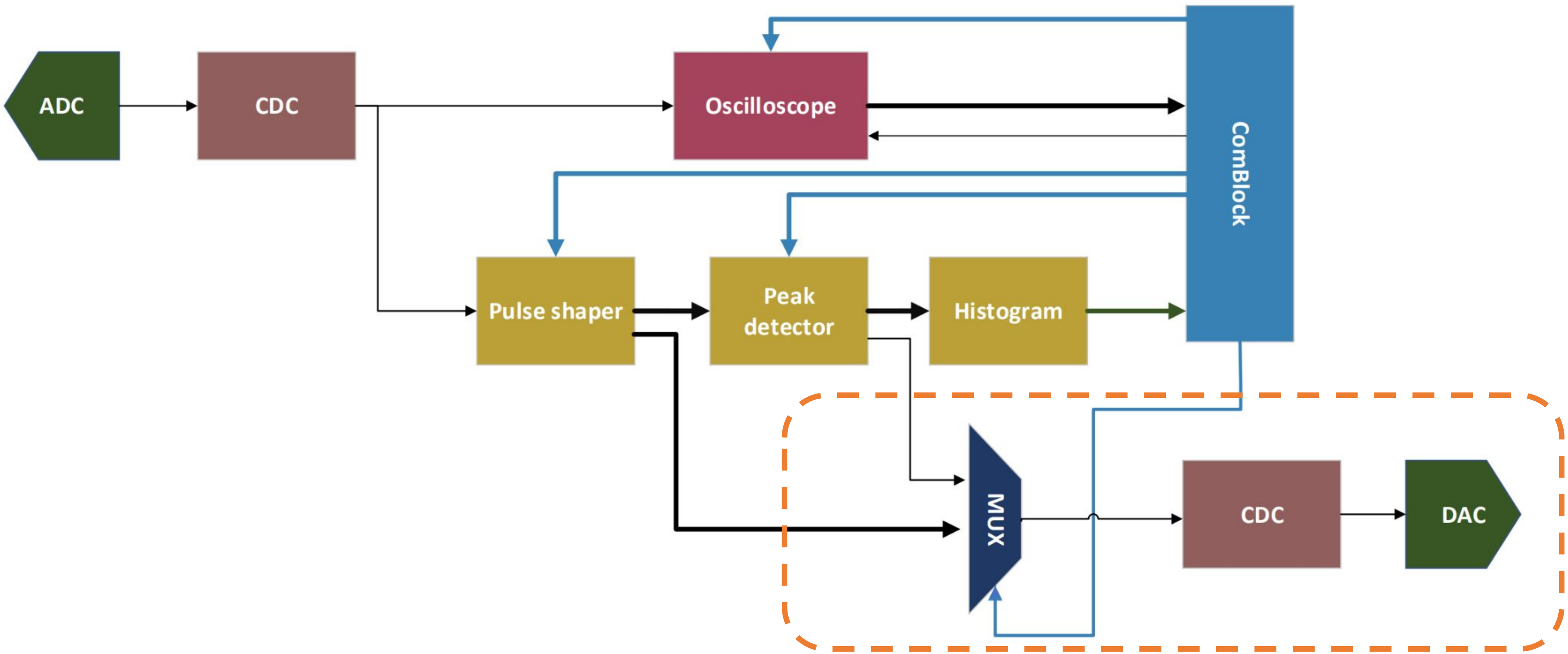


Outputs to external oscilloscope

- Original trace
- Pulse shaper
    - Trapezoid output
    - Pulse output
    - Square output
- Peak detector
    - Peak seeking

Uses multiplexer (MUX) for output selection

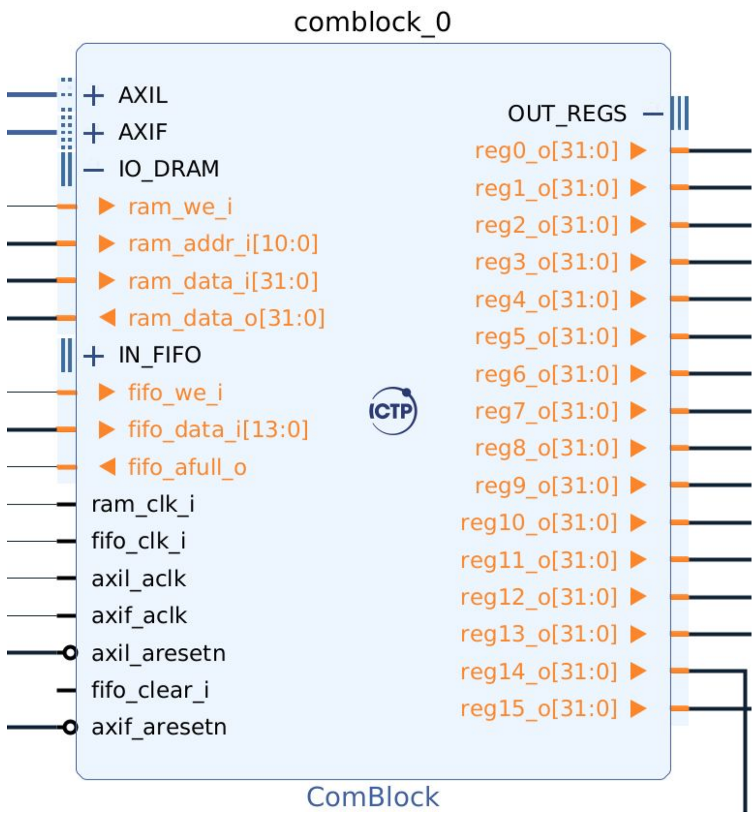
Design description - D/A output



Stage 2.2 - Isotope identification

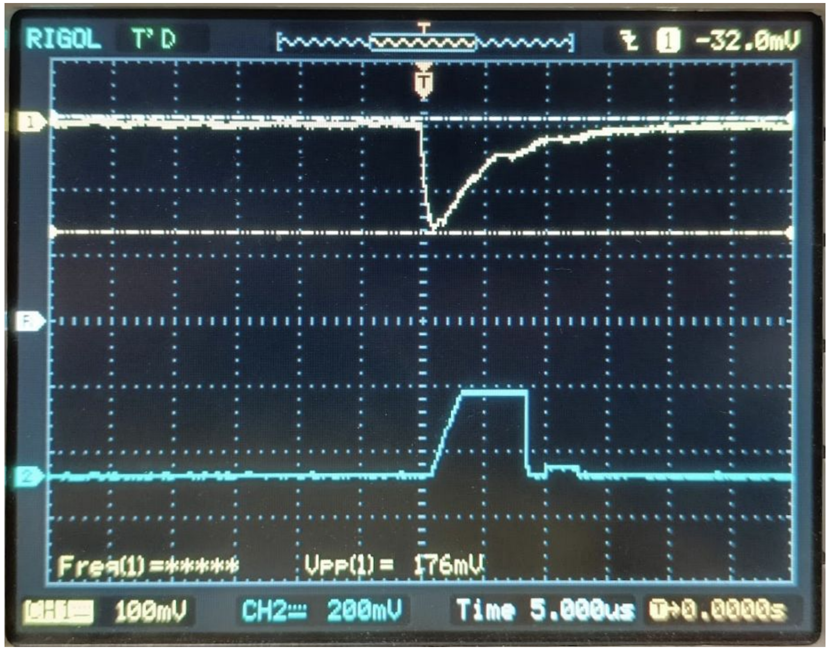
Isotope identification

- Set the working parameters for the IP cores using ComBlock output registers.



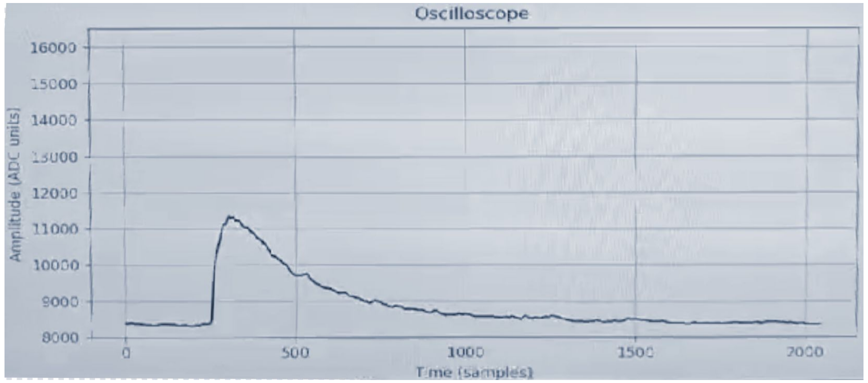
Isotope identification

- Set the working parameters for the IP cores using ComBlock output registers.
- Verify the functionality of the DPP subsystems using the MUX and D/A output.



Isotope identification

- Set the working parameters for the IP cores using ComBlock output registers.
- Verify the functionality of the DPP subsystems using the MUX and D/A output.
- Use the embedded oscilloscope to visualize the raw data (from ComBlock I-FIFO) in JN.



Isotope identification

- Set the working parameters for the IP cores using ComBlock output registers.
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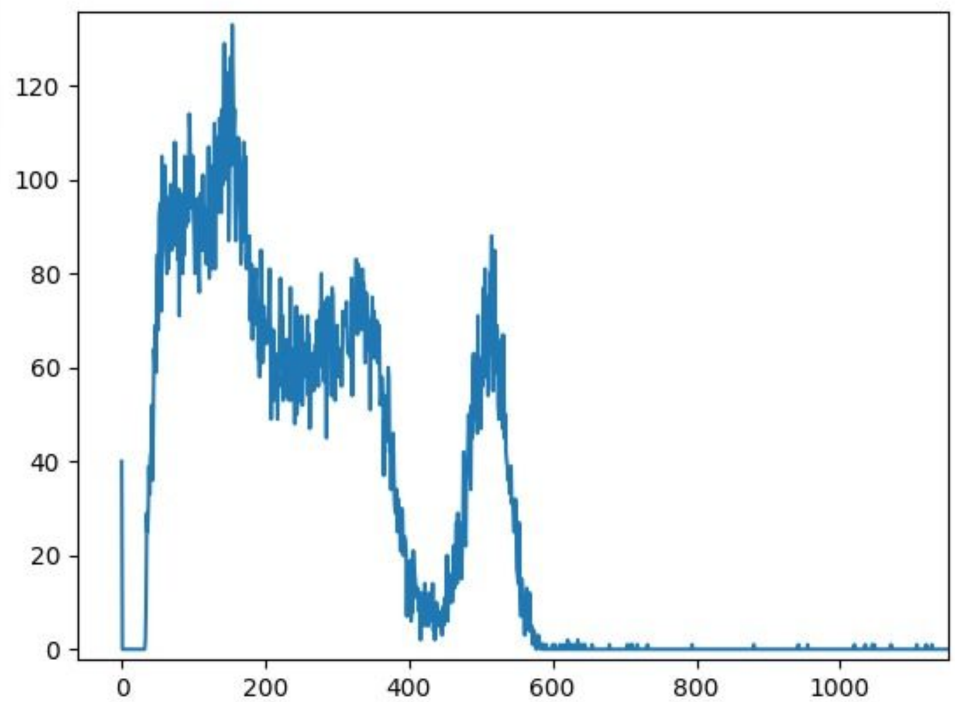
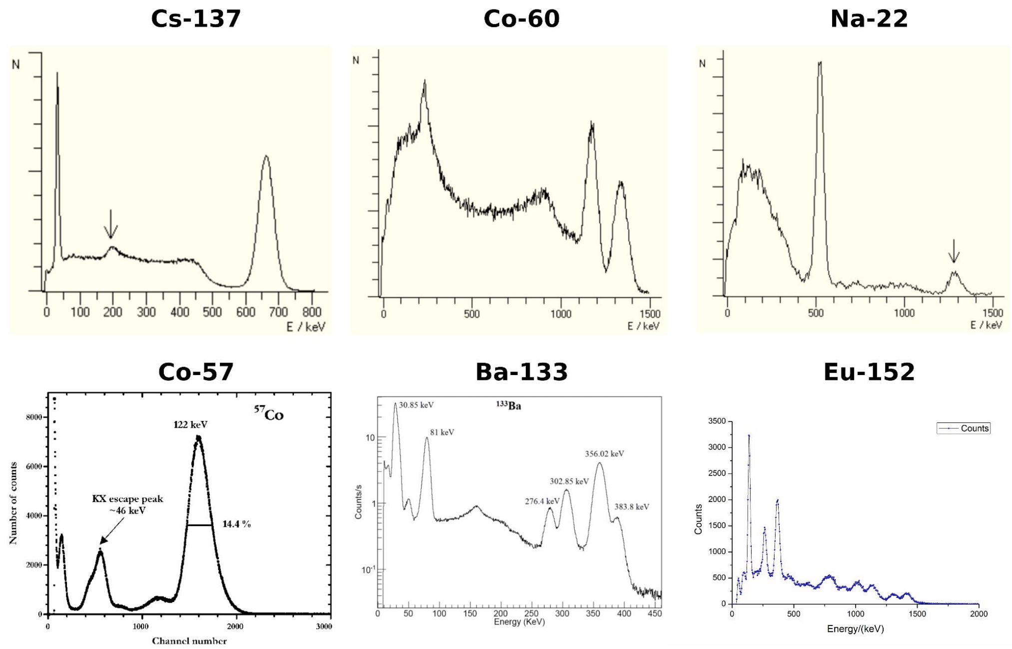
- Reset and record the spectrum from the detector with a source placed closeby.



Isotope identification

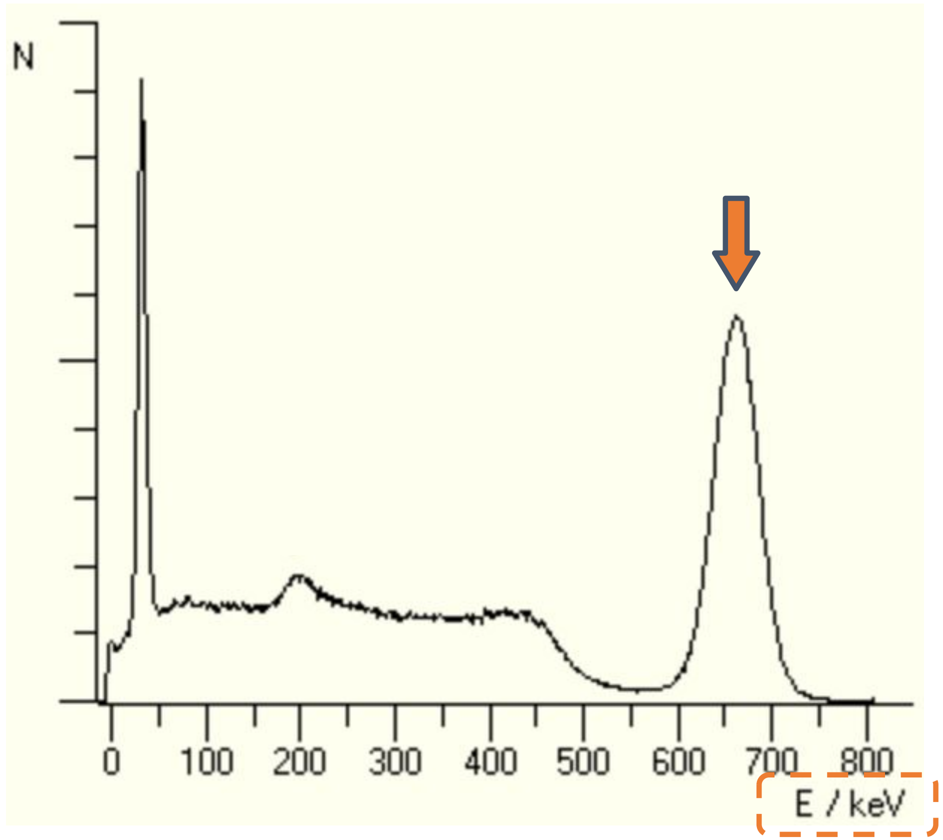
- Set the working parameters for the IP cores using ComBlock output registers.
- Verify the functionality of the DPP subsystems using the MUX and D/A output.
- Use the embedded oscilloscope to visualize the raw data (from ComBlock I-FIFO).
- Reset and record the spectrum from the detector with a source placed closeby.
- Determine the isotope placed close to the detector by inspecting the resulting spectrum.



Challenge - Energy calibration

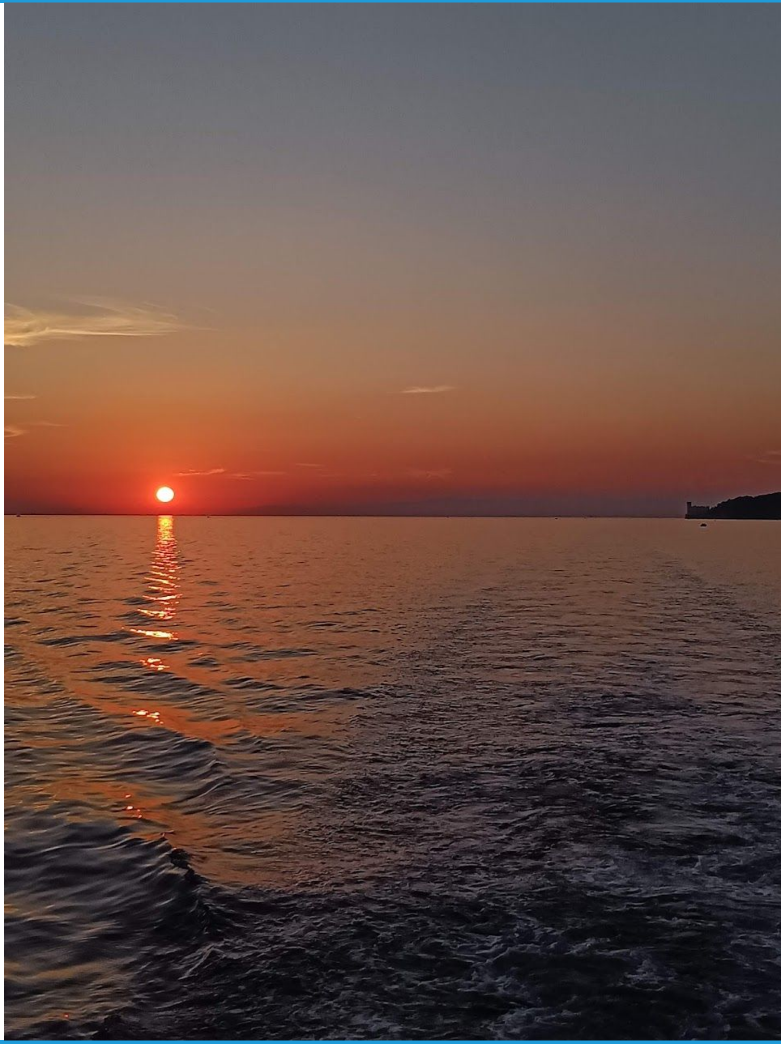
- Gaussian fit of the photopeak
- Baseline as base energy point

Outcomes
- Calibrated energy scale
- Detector resolution at Cs-137 photopeak



Just before starting

- Do NOT use a host (local) computer physically connected to the ZedBoard+detector setup.
- Request access to the ZedBoard (attach) setup only AFTER you finished coding the Jupyter Notebook.



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Thank you!

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