A Modular Data Acquisition System for Reconstruction of Radiation Dose Spatial Distribution in Radiotherapy Treatment Planning

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Introduction

The proposed Data Acquisition (DAQ) system is the part of the project which aims to build a reconfigurable detector for the measurement of radiation dose spatial distribution. It is an extremely important field of study since cancer is one of the deadliest diseases worldwide, accounting for nearly ten million deaths in 2020 [1].
For more general overview of the project ⇒ see the contribution by Maciej Kopeć **A reconfigurable detector for measuring the spatial distribution of radiation dose for applications in the preparation of individual patient treatment plans**.

DAQ System Architecture

Hardware

- 64 readout channels per slice generating <50 Mbit/s data stream
- 8 slices per crate synchronized with Precision Time Protocol (PTP)
- Virtually unlimited scalability possibilities through crate stacking
- MAROC3a front-end readout Application Specific Integrated Circuit (ASIC) [2] allowing simultaneous readout of photon counting and energy

Firmware

- Based on eXtensible FPGA Control Platform (XFCP) [3]
- Functional parts of readout ASIC mapped and accessible via UDP/IP outward
- Submodules working in parallel to ensure collection of analog and photon counting data upstreams

Software

- Proxy Nodes maintain communication with mirrored firmware functional blocks [4]
- Each Proxy Node is implemented as Python thread
- Collected data (register states and continuous streams) are broadcasted to consumer widgets

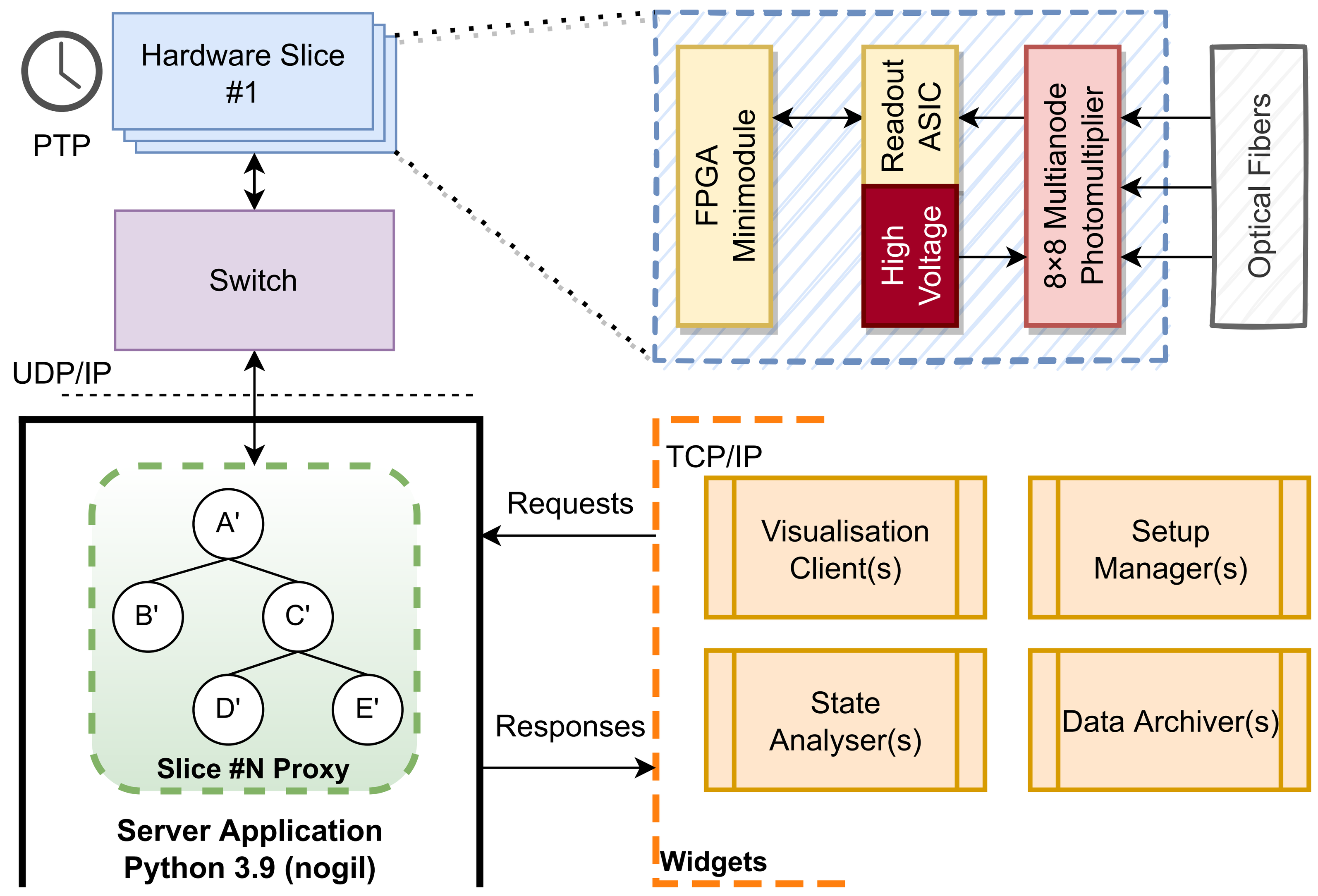

Figure 1: Schematic of the DAQ architecture. Hardware components (top), software architecture (bottom)

Results and Discussion

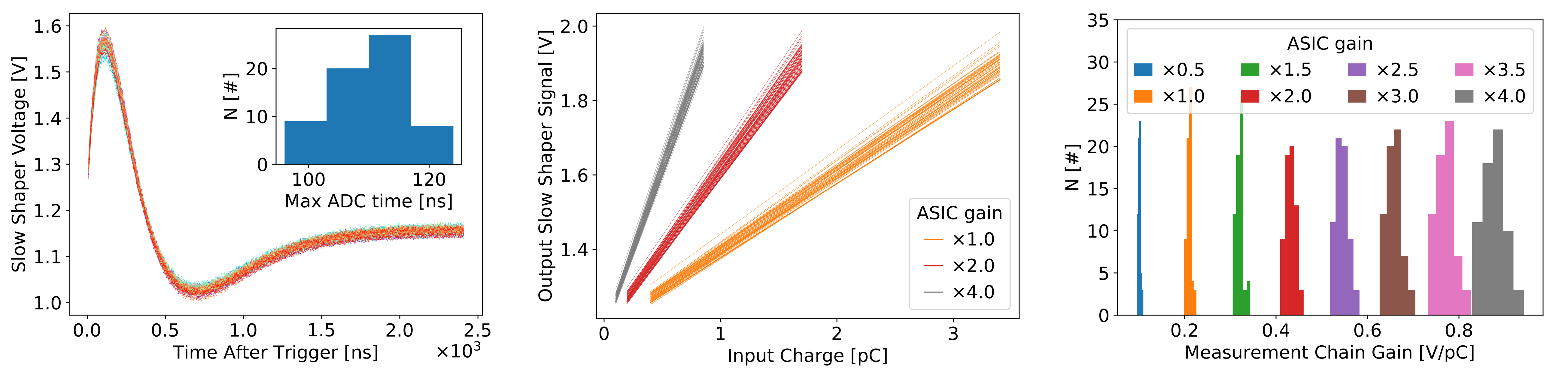

Figure 2: Slow shaper output signal characteristics (left), selected response curves (center), measurement chain gain distributions (right)

Analog readout results–Figure 2

- ASIC slow shaper characteristics present maximum output ∼110 ns after trigger
- For each ASIC channel, gain and input charge combination output responses preserve very good linearity in whole dynamic range

Photon counting results with 660 nm laser pulses (1 kHz repetition rate)–Figure 3

- XY-positioned laser in front of Photomultiplier Tubes (PMT) in a light-tight black box
- Photon rates depend on the relative positions but central PMT cell always responds with expected rate
- Little background (≪10 1/s)

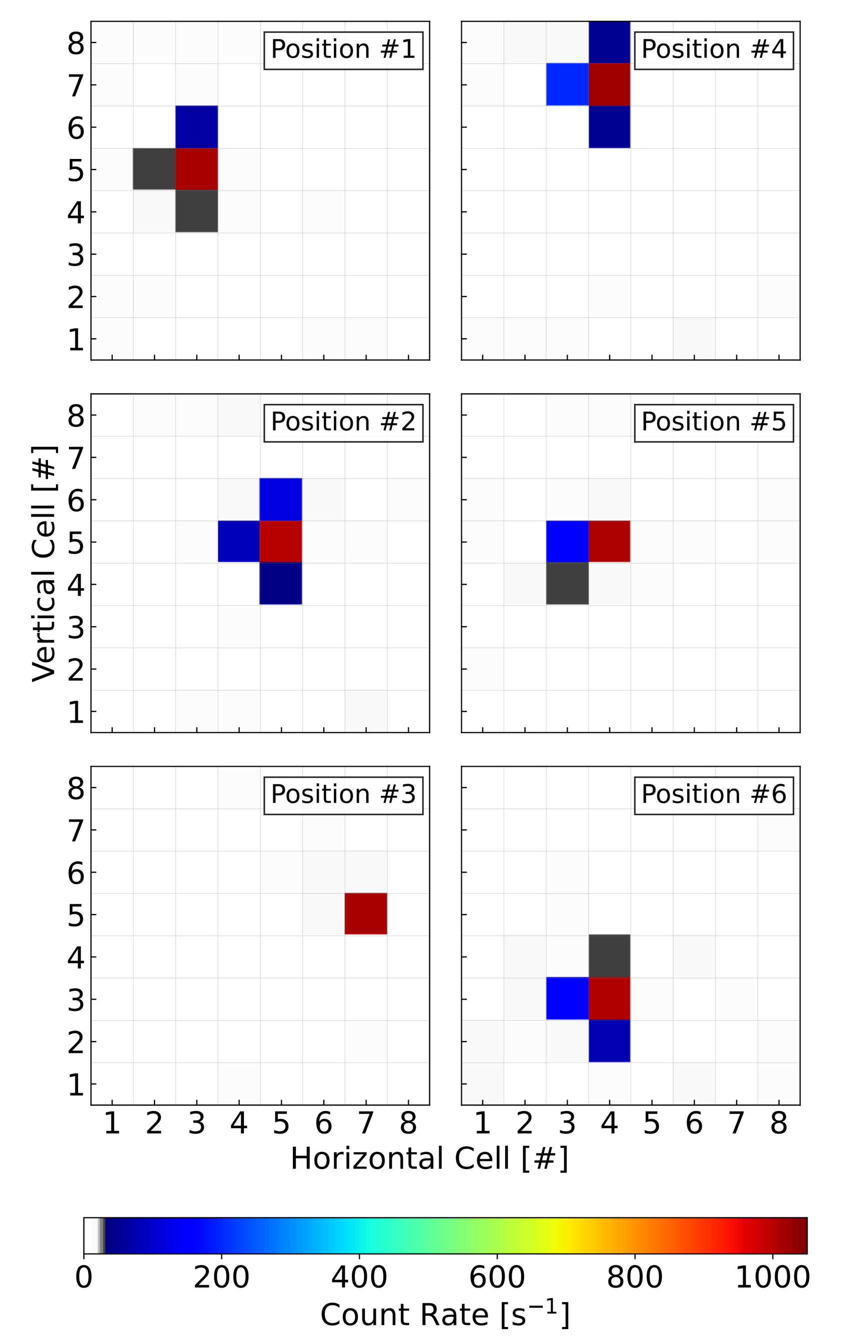

Figure 3: Example results of anode by anode illumination scan

Conclusion We showed that the proposed DAQ is working and providing desired outputs in terms of signal quality and overall system reliability. Further steps will concentrate on systematic system calibration, software upgrades and integration.

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