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A Low-Cost, Portable Fluorescence Correlation Spectrometer for Disease Diagnosis

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A Low Cost, Portable Fluorescence Correlation Spectrometer for Disease Diagnosis

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THE NEED

HIV diagnosis and viral load monitoring in Zambia is limited to clinics with lab settings, and difficult to access for many people in rural areas.
The Macha Hospital in Zambia has partnered with us as we design an HIV viral load device.

Zambia

Macha Mission Hospital

(https://eyecarefoundation.eu/projects/zambia/macha-eye-care-department/)

Existing Device

(https://newlifescientific.com/cepheid-genexpert-iv-18480698)

Needs lab setting
~$17,000/device
~ $10/test
< 1 hour
~30 viruses/mL

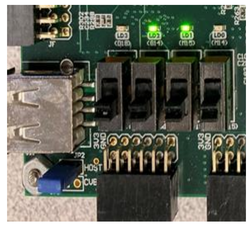
Our Device

Targets:
Portable (10" x 8" x 3")
~ $1500/device
~ $10/test
<10 minutes
~1000 viruses/mL

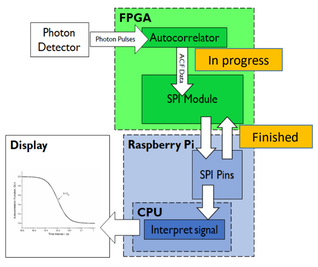
SIGNAL PROCESSING

Designing and testing a program to transmit data from a field programmable gate array (FPGA) to a Raspberry Pi through Serial Peripheral Interface (SPI).

The FPGA LEDs turned on to represent the binary value of the data received from the Raspberry Pi.



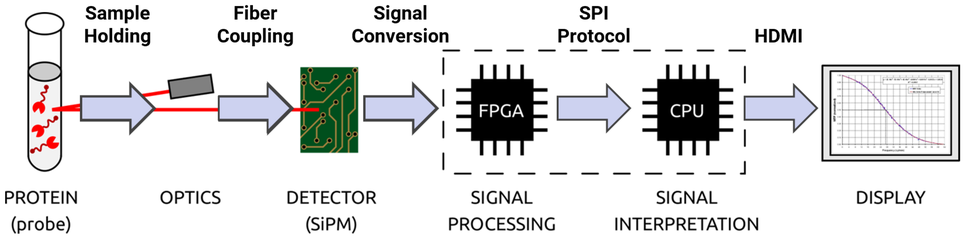
Current progress towards ideal data flow:



Results: The FPGA can properly send and receive data through SPI.
Future Work: Test transmitting autocorrelation data.

DIAGNOSTIC STRATEGY

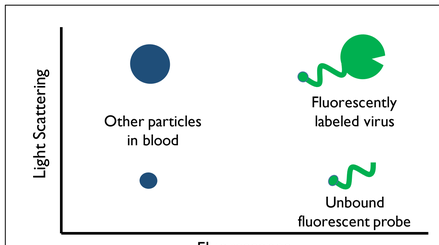
The following Diagnostic Strategy has been proposed for HIV viral load determination:



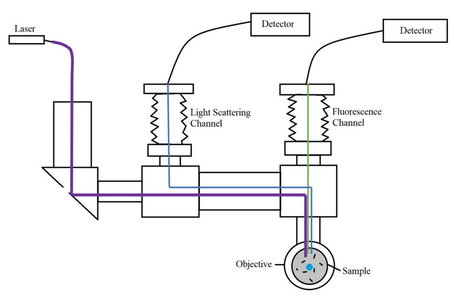
Future Work: Integration of completed modules to test a full prototype system.

OPTICS – NEW METHOD

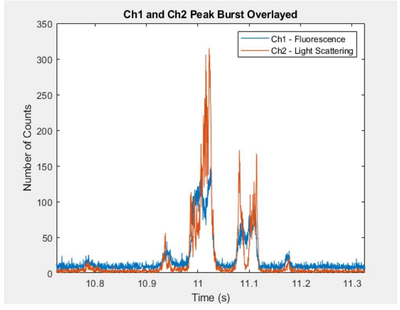
Two channel burst analysis spectroscopy adds to the fluorescence detection currently being used to also detect light scattering. This allows for the visualization of individual viral events through intensity vs time graphs.



Two channel detection allows for a more specific detection of labeled viruses based on size and fluorescence, which limits noise from other particles.



Optics Setup



Single Viral Detection

Results: Single viral detection is possible using fluorescently labeled bacteriophage of comparable size to HIV, which created activity in both channels simultaneously. About 100 of these events have been recorded in two sizes of phage.
Future Work: Analyze the method's ability to differentiate different types of particles.

DETECTOR CIRCUITRY

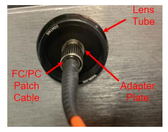
The casing simplified what complex detector circuit design from multiple parts into a portable container with minimal external connections.

Modular Casing

Aluminum box acts as casing shell to provide electrical and light shielding to the circuit.

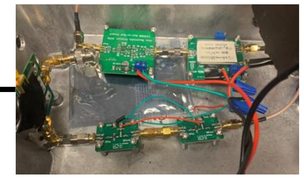
Features:

Single USB input/output to FPGA



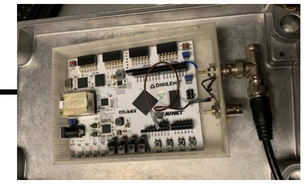
SiPM coupling through casing wall

Inside of Casing:



Layer 1: Detector Circuit

Layer 2: USB hub and DC-DC boosters



Layer 3: FPGA

Results: Created a casing that provides shielding and stability to circuit with minimal inputs/outputs.
Future Work: Begin to integrate modular design into a single PCB.

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Reviewers: Dr. Randall Fish, Dr, Harold Underwood, Dr. Abaz Kryemadhi
Members: Nathan Cordell, Castine Donoff, Jeffrey Gao, Sam Gulinello

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