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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 the DVD team in the development of a field portable HIV viral load measurement device.

Macha Mission Hospital

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

Zambia

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

ACKNOWLEDGMENTS

Project Manager: Dr. Randall Fish
Client: Dr. Edgar Simulundu
Technical Consultants: Dr. Matthew Farrar, Dr. Abaz Kryemadhi
Members: David Brink, Laura Frederick, Al Mokris, Ryan Oyler, Jessica Paulus

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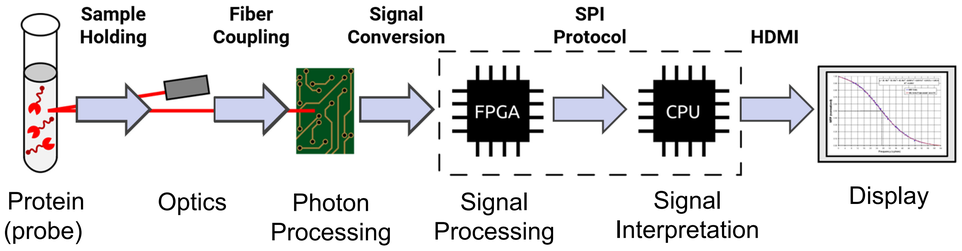
the Collaboratory for strategic partnerships and applied research

NOVEL DIAGNOSTIC STRATEGY

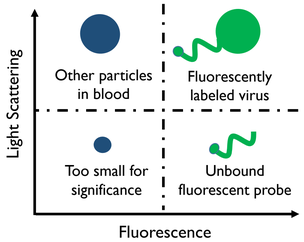
The following Diagnostic Strategy has been proposed for HIV viral load determination:



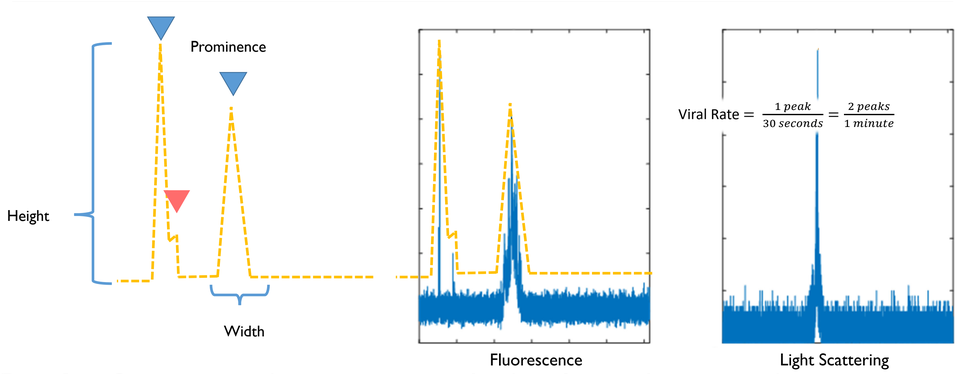
Future Work: Integration of completed modules to test a full prototype system.

OPTICS – NEW METHOD

Two channel burst analysis spectroscopy adds detection of light scattering to the fluorescence detection currently being used. This allows for the visualization of individual viral events through intensity vs time graphs. A documented step-by-step procedure now lets anyone learn to run a test with minimal prior knowledge.



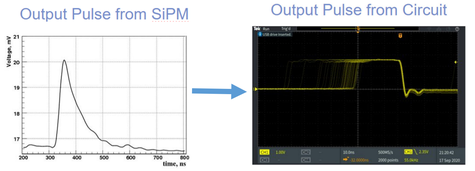
Two channel detection allows for a more specific detection of labeled viruses based on size and fluorescence (rather than just one of the factors), which limits noise from other particles.

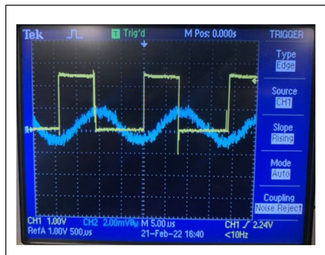


Results: Our optimized program correctly identifies viral events with greater accuracy than with a single fluorescence channel method. Matching scattering peaks with fluorescence labeled virus detection provides an automated calculation of viral rate for a viral load diagnostic.
Future Work: Optimize new method to determine concentration of viruses

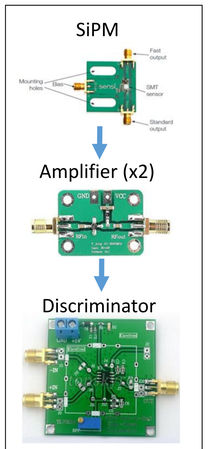
PHOTON PROCESSING

The goal is to convert a short duration, low amplitude photon pulse from a detector into a digital signal for signal analysis and interpretation.





In **blue**, we see the input sinewave from a function generator. **Yellow** shows the output from amplifying and discriminating portions of the circuit.

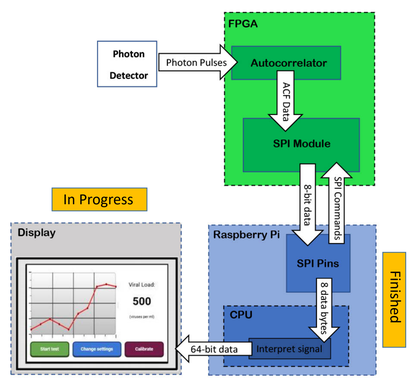


Results: The operation of the amplifying and discriminating circuitry has been confirmed for small amplitude signals.
Future Work: Confirm short pulse operation of circuit and test its autocorrelation capabilities.

SIGNAL INTERPRETATION

Data from high-speed field programmable gate array processing must be transferred to a Raspberry Pi through Serial Peripheral Interface for post-processing and display to a clinician.

- The Raspberry Pi sends SPI commands to the FPGA
- The FPGA sends 64-bit data points in 8-bit bytes to the Raspberry Pi
- The Raspberry Pi concatenates these bytes into the original 64-bit data point



Results: The transfer of data between the FPGA and Raspberry Pi has been confirmed.
Future Work: Test and verify the functionality of the post-processing correlation program and clinician display.

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