Internal Mobilization of *in vivo* Glucose Sensing System

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According to 2013 statistics, nearly 10% of the entire United States population is forced to monitor their blood glucose levels to ensure they stay healthy [1], and this number will rise to 33% by 2050 if trends continue. To provide an alternative to obtaining direct blood samples multiple times per day to measure glucose levels, we seek to enhance our Quantum Cascade (QC) laser based noninvasive glucose sensor, which has very recently been proven effective to predict glucose concentrations in healthy human subjects [2]. Initially, this sensor required a large amount of space on an optical table and a specialized person to collect spectra. Here, we demonstrate software enhancement of the mid-infrared (mid-IR) QC laser-based non-invasive *in vivo* glucose sensor to both promote sensor mobility and improve prediction accuracy. Furthermore, we design a custom replacement mid-infrared integrating sphere approximately 13% of its current size.

A new graphical user interface allows for non-specialized clinicians to be able to use the equipment without extensive knowledge of the program's code and the requirement to run separate modules multiple times. One of these separate modules included a new shifting algorithm that increases accuracy by removing outliers in a more effective manner than the previous algorithm by removing trials whose inclusion causes the greatest increase of standard deviation (std. dev.) individually; this process is repeated until only the five most consistent spectra are left in order to make the average std. dev. decrease from 0.060 to 0.032, a 47% increase in accuracy (Fig. 2). A new dual lock-in amplifier unit is being implemented and programmed to simultaneously read data from the two detectors (signal and reference) within our compact setup that will negate the shift caused by asynchronous tuning rate of the laser motor and the delay of the old lock-in system consisting of two separate lock-ins units parsed together. Also, with future development, the 3" diameter mid-IR integrating sphere we currently use will be scaled to a 1 cm^3 cube with higher accuracy and a significantly smaller amount of space required. This work is supported in part by MIRTHE (NSF-ERC).

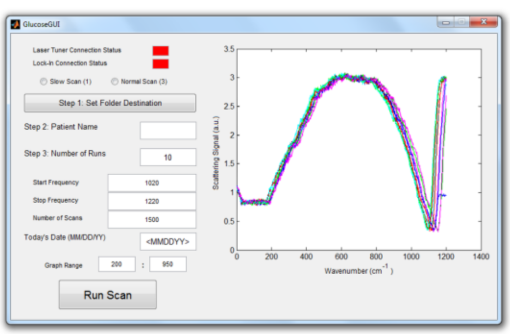

Fig. 1 Display of the MatLab GUI, wherein data is inputed on the left side of the screen and graphs displaying the readings from the QCL scans on the right axes. The red buttons display whether certain devices are plugged in, and other input steps are detailed in the buttons and side text.

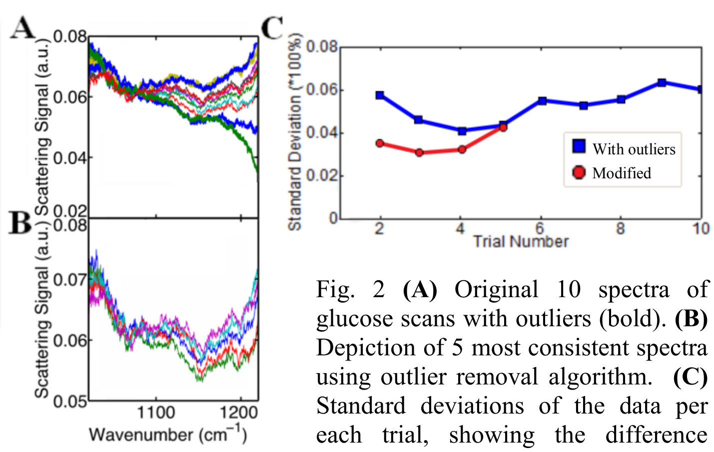

Fig. 2 **(A)** Original 10 spectra of glucose scans with outliers (bold). **(B)** Depiction of 5 most consistent spectra using outlier removal algorithm. **(C)** Standard deviations of the data per each trial, showing the difference between keeping the outliers and using the modified algorithm.

[1] American Diabetes Association, http://professional.diabetes.org/admin/UserFiles/0%20-%20Sean/FastFacts%20March%202013.pdf
[2] S. Liakat et al, "Mid-Infrared noninvasive *in vivo* glucose detection in healthy human subjects", CLEO 2014, June 2014, San Jose, CA.