Instrument for the Identification of Live and Dead Bacteria

ECEN 403 – 970

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Team 52 (URS)

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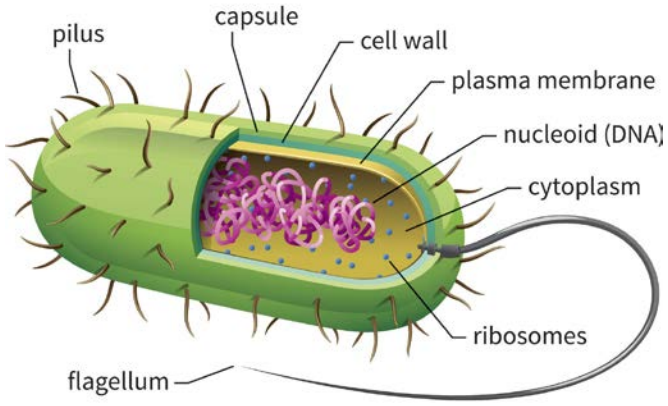
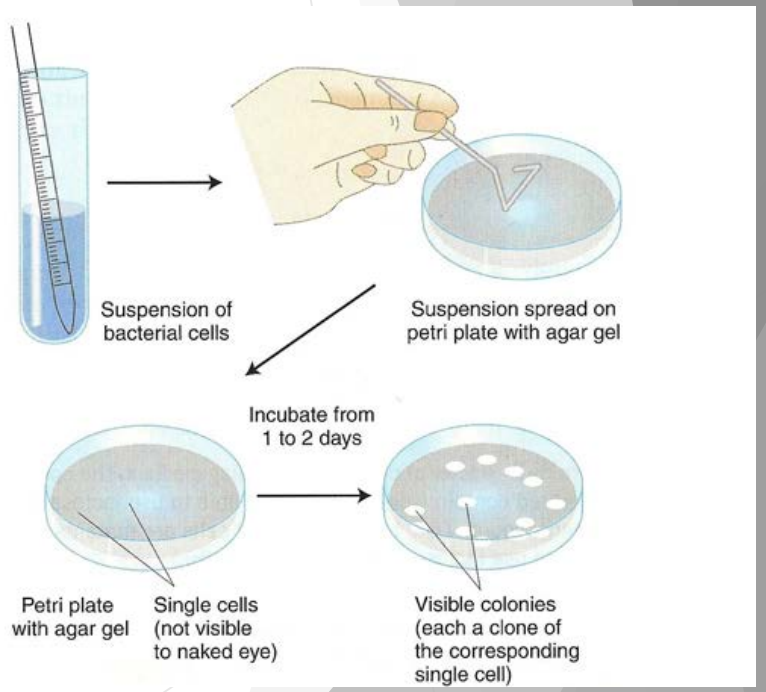
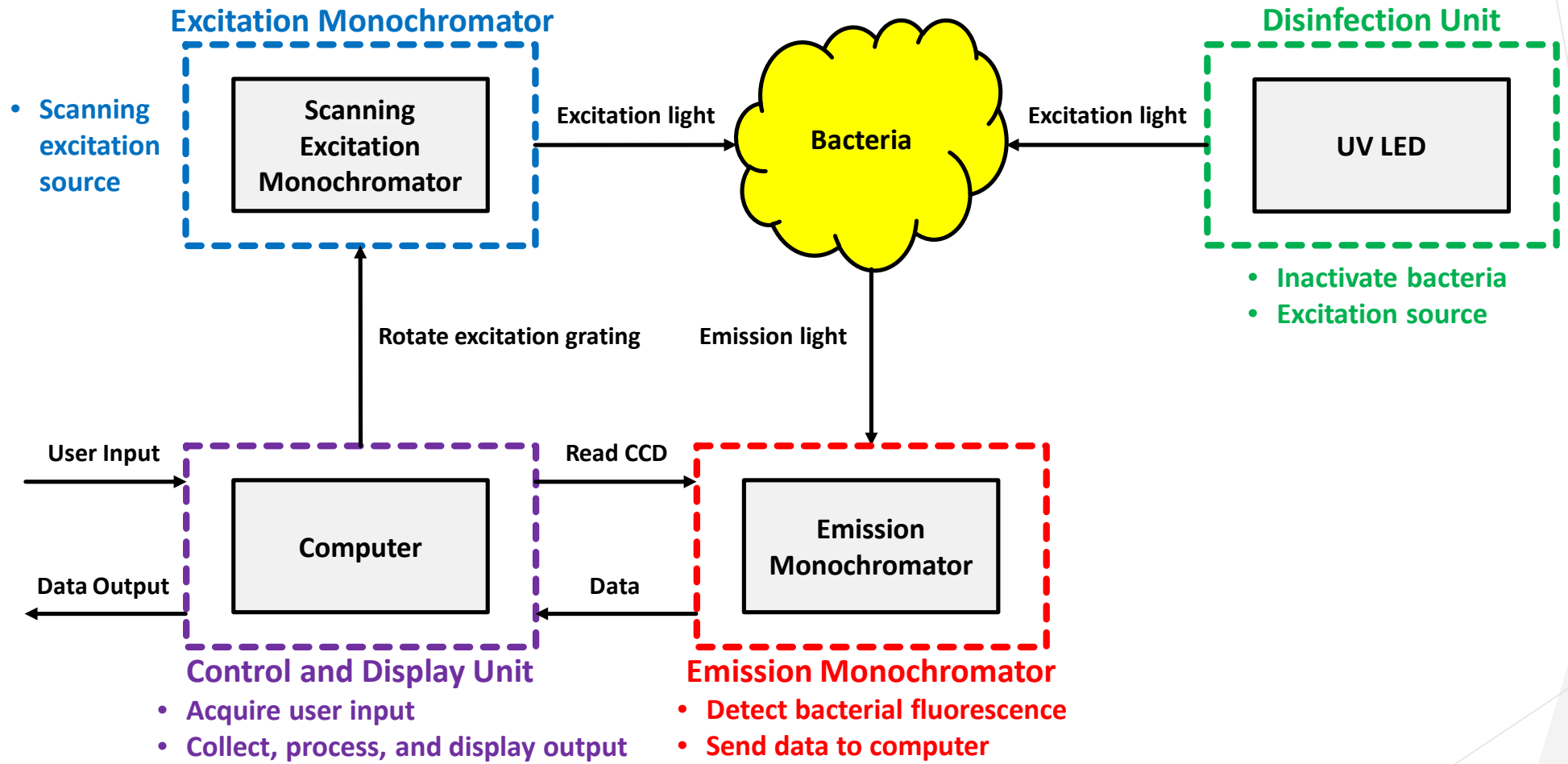
Problem Statement and Goals

- **Bacteria are a serious threat to human life**
- **Current identification procedures are slow (≈ 1 to 2 days)**
- **Goals:**
  - Utilize **fluorescence spectroscopy** to detect bacteria
  - Apply **PCA** to distinguish live and dead bacteria
  - Develop a **portable prototype** for rapidly identifying live and dead bacteria





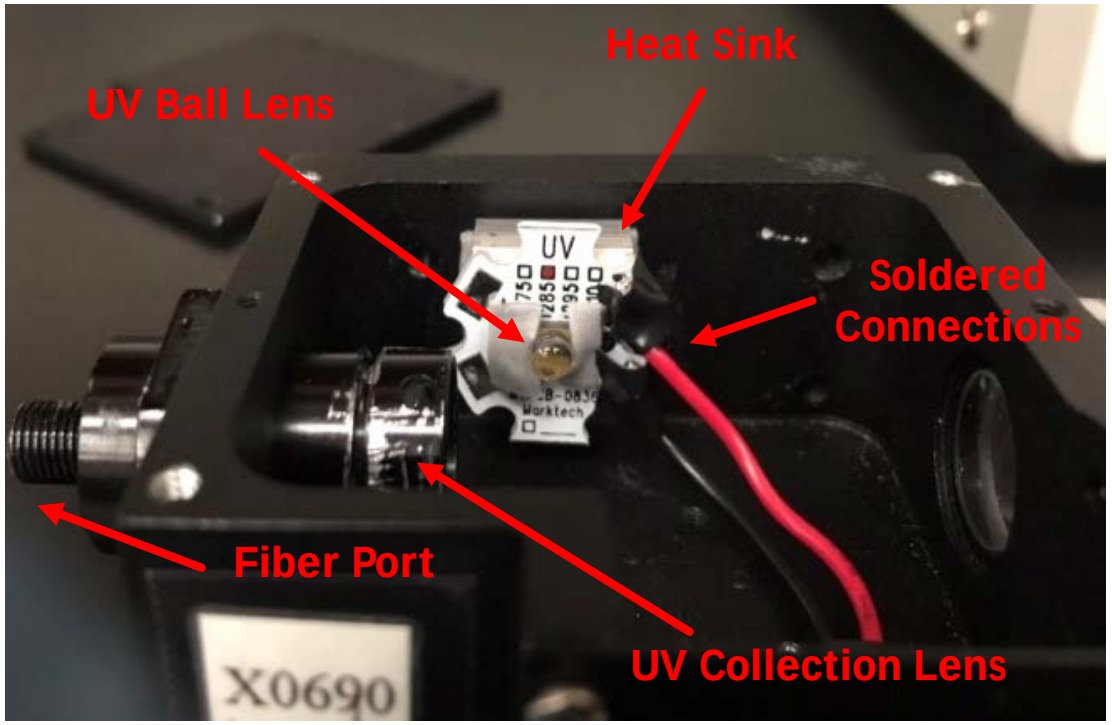
System Overview



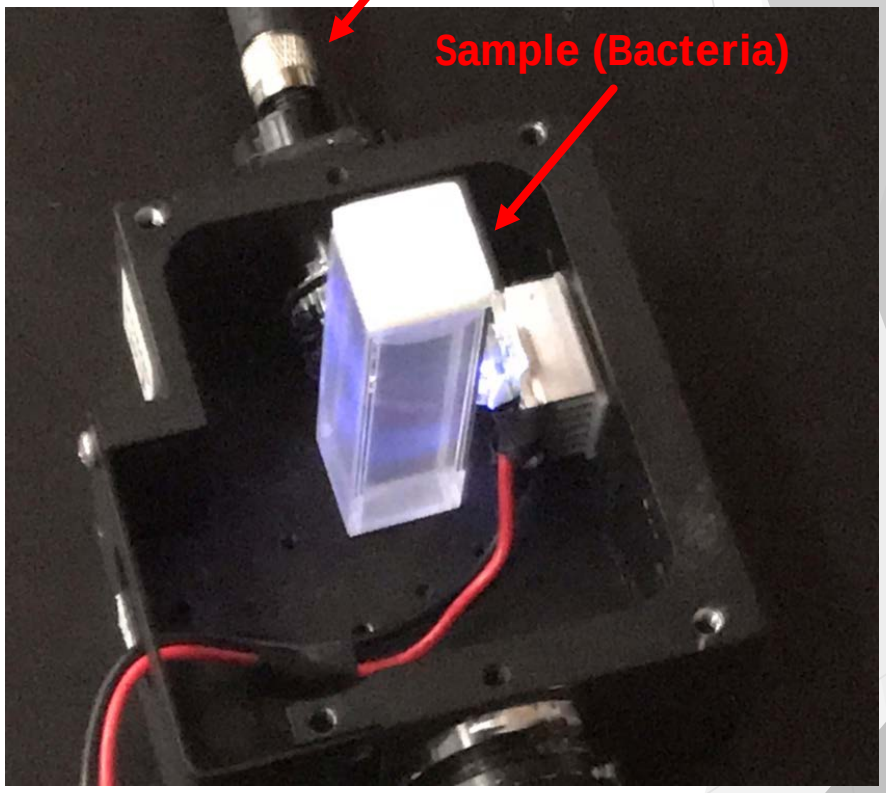
Disinfection Unit Subsystem

Accomplishments since the last presentation <3> hours	Ongoing progress/problems and plans until the next presentation
• Slight optical realignments made to increase excitation and fluorescence intensity • Additional testing performed to further validate disinfection and excitation capabilities	• Design and machine small cover to reduce background interference during acquisitions

Disinfection Unit Subsystem



Configuration of disinfection unit.

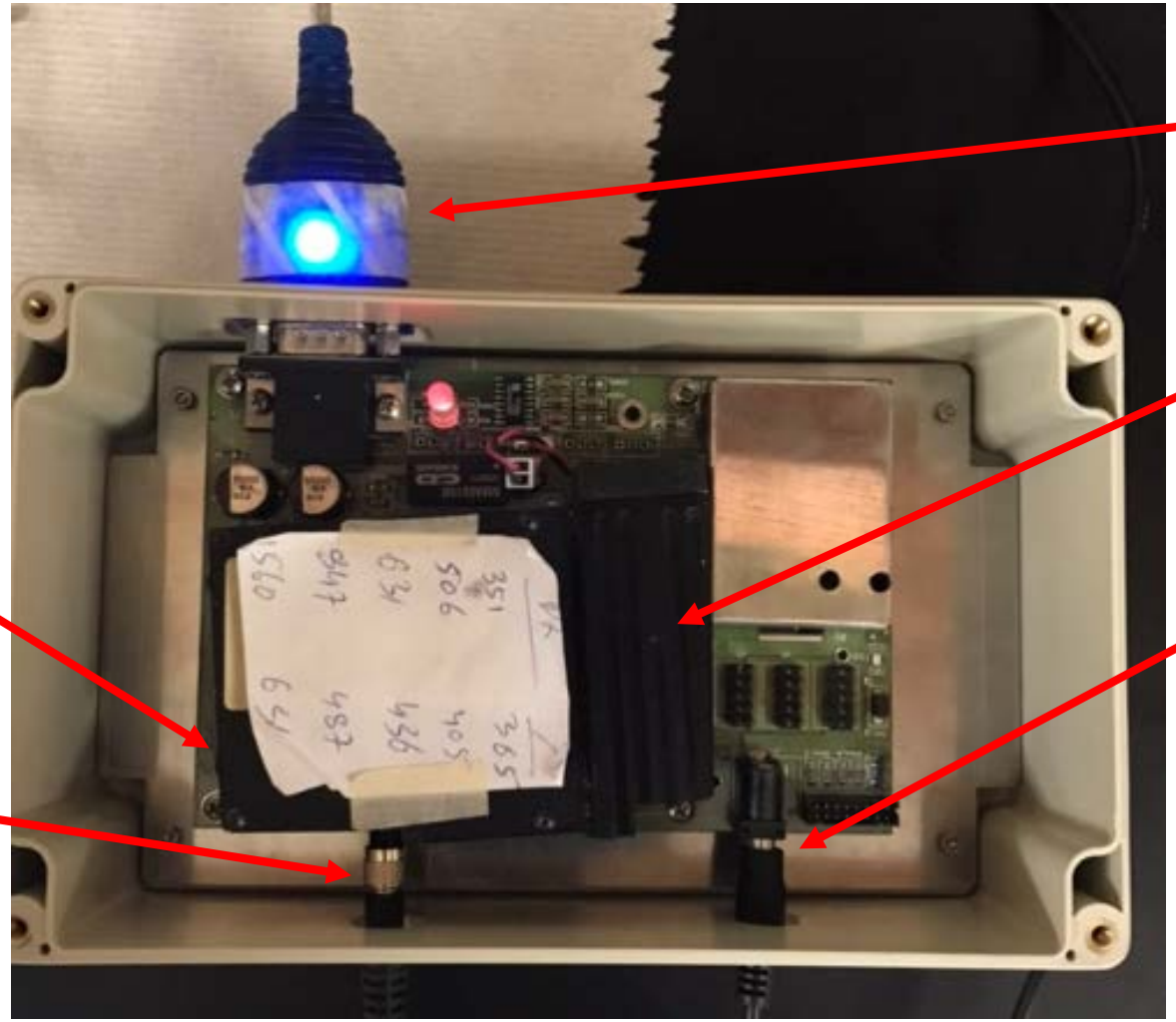


Excitation and disinfection setup.

Emission Monochromator Subsystem

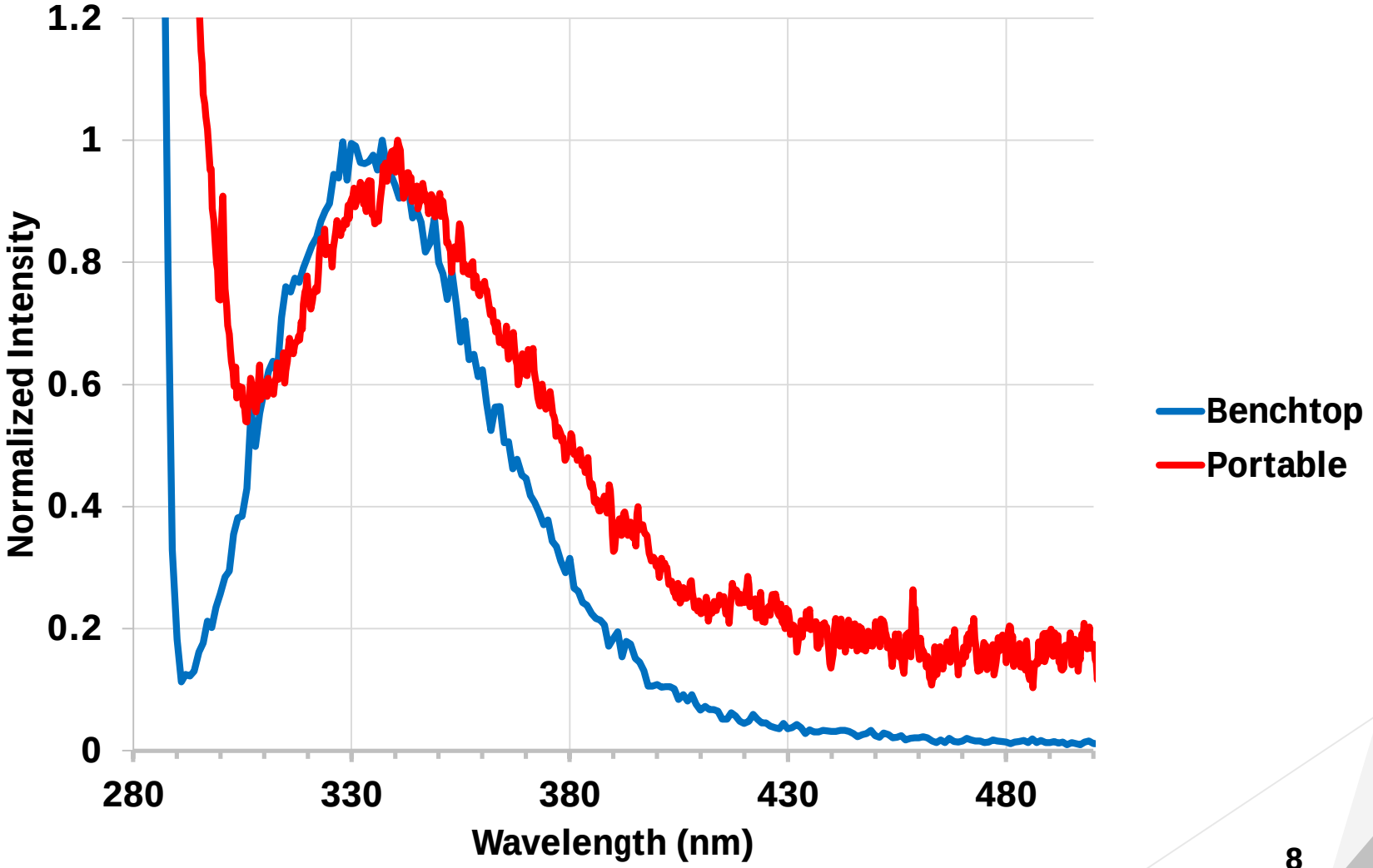
Accomplishments since the last presentation <12> hours	Ongoing progress/problems and plans until the next presentation
• Slight optical adjustments made to further increase UV sensitivity • Additional testing performed to further validate UV sensitivity capabilities • Median filtering implemented to reduce noise in recorded spectra • Subsystem tested with the excitation monochromator and disinfection unit subsystems	• Continue increasing sensitivity to lower integration time • Reduce noise in recorded spectra • Resolve any machining issues • Continue testing subsystem with excitation monochromator (for next semester)

Emission Monochromator Subsystem



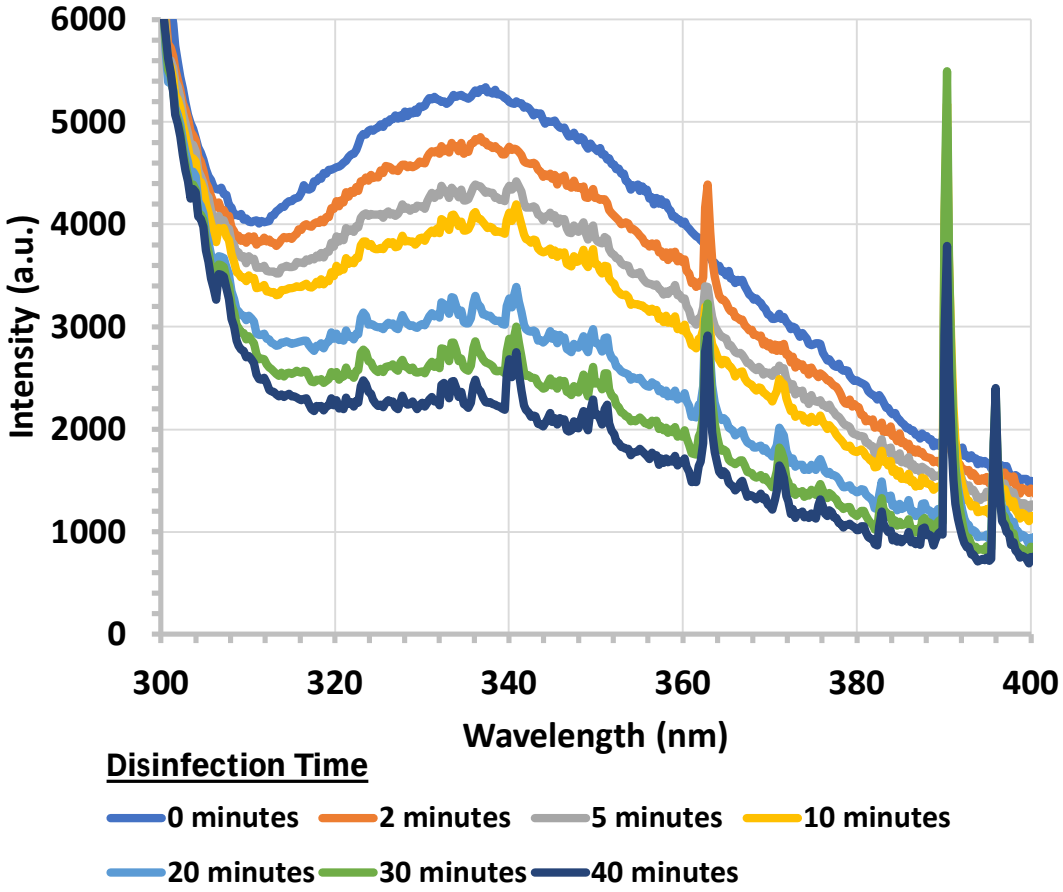
Configuration of emission monochromator.

Emission Monochromator Validation

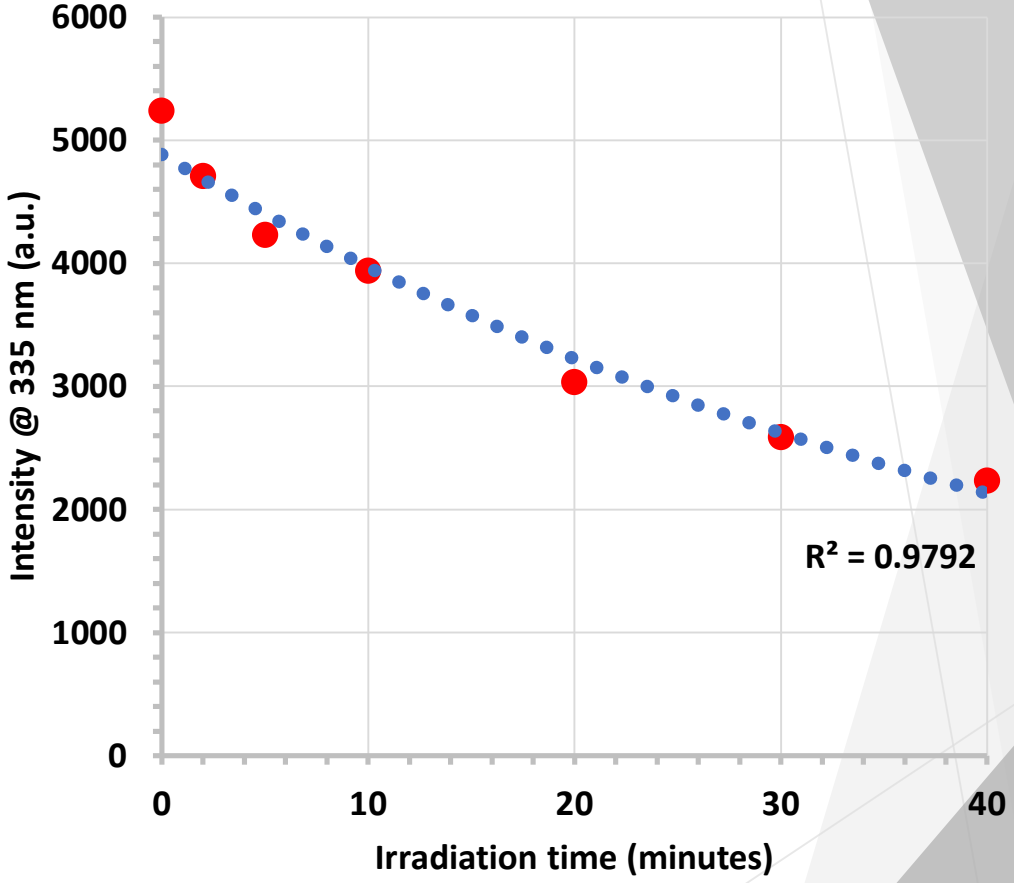


E. coli fluorescence spectrum (EX = 280 nm).

Emission Monochromator Validation



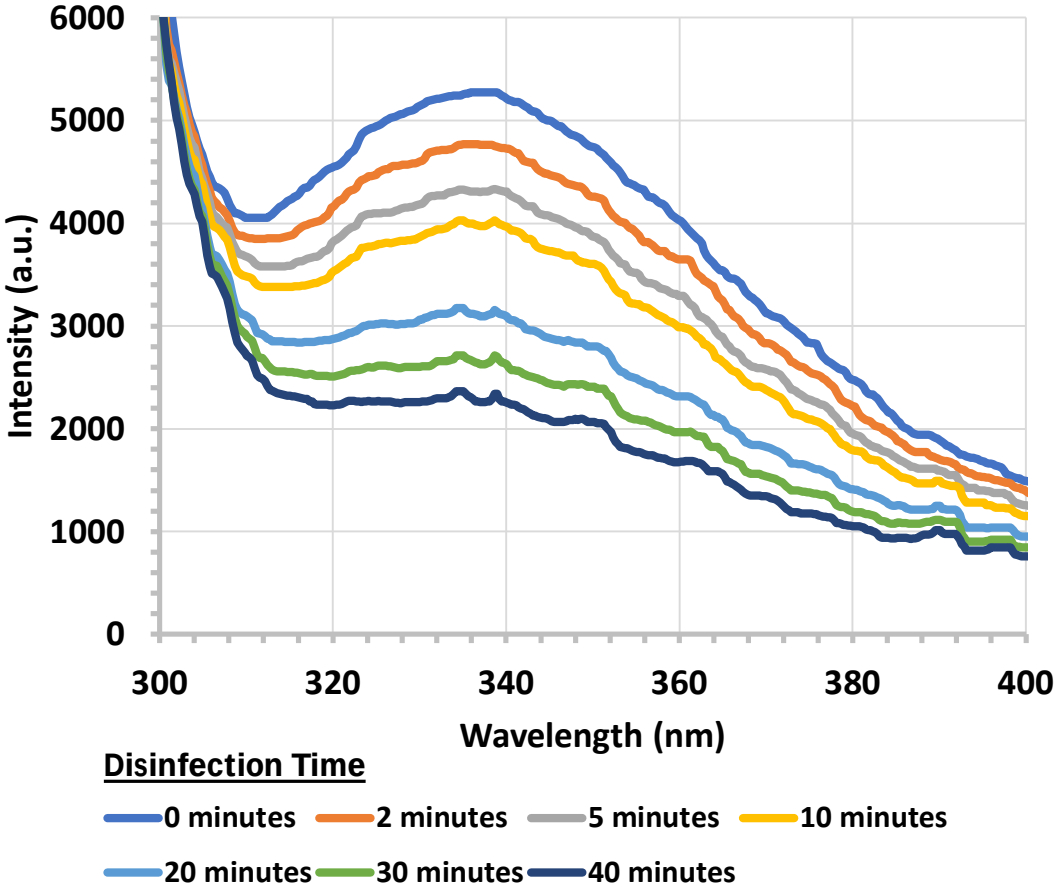
E. coli fluorescence decay with disinfection.



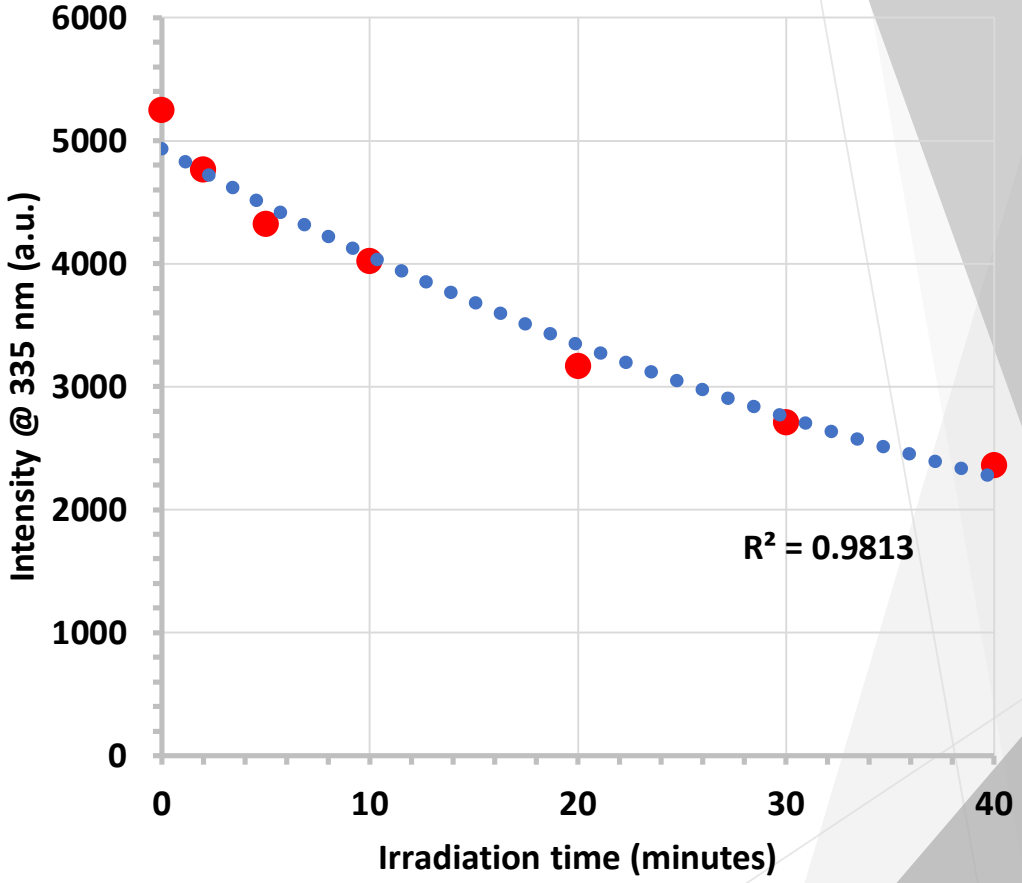
Peak fluorescence intensity decay with disinfection.

Integration time: 5 seconds; Average: 1; Median filtering: No

Emission Monochromator Validation



E. coli fluorescence decay with disinfection.

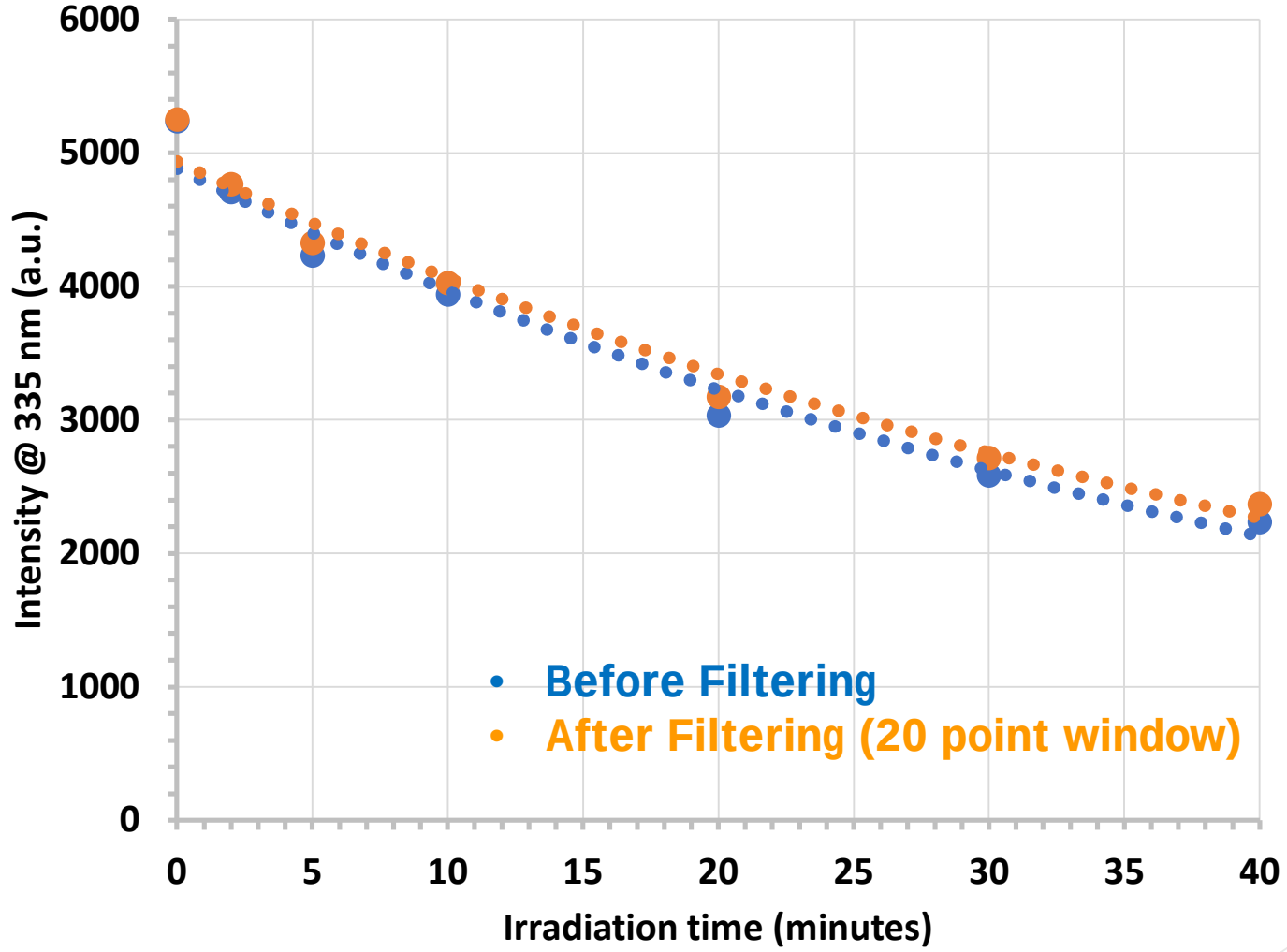


Peak fluorescence intensity decay with disinfection.

10

Integration time: 5 seconds; Average: 1; Median filtering: Yes (20 point window)

Emission Monochromator Validation

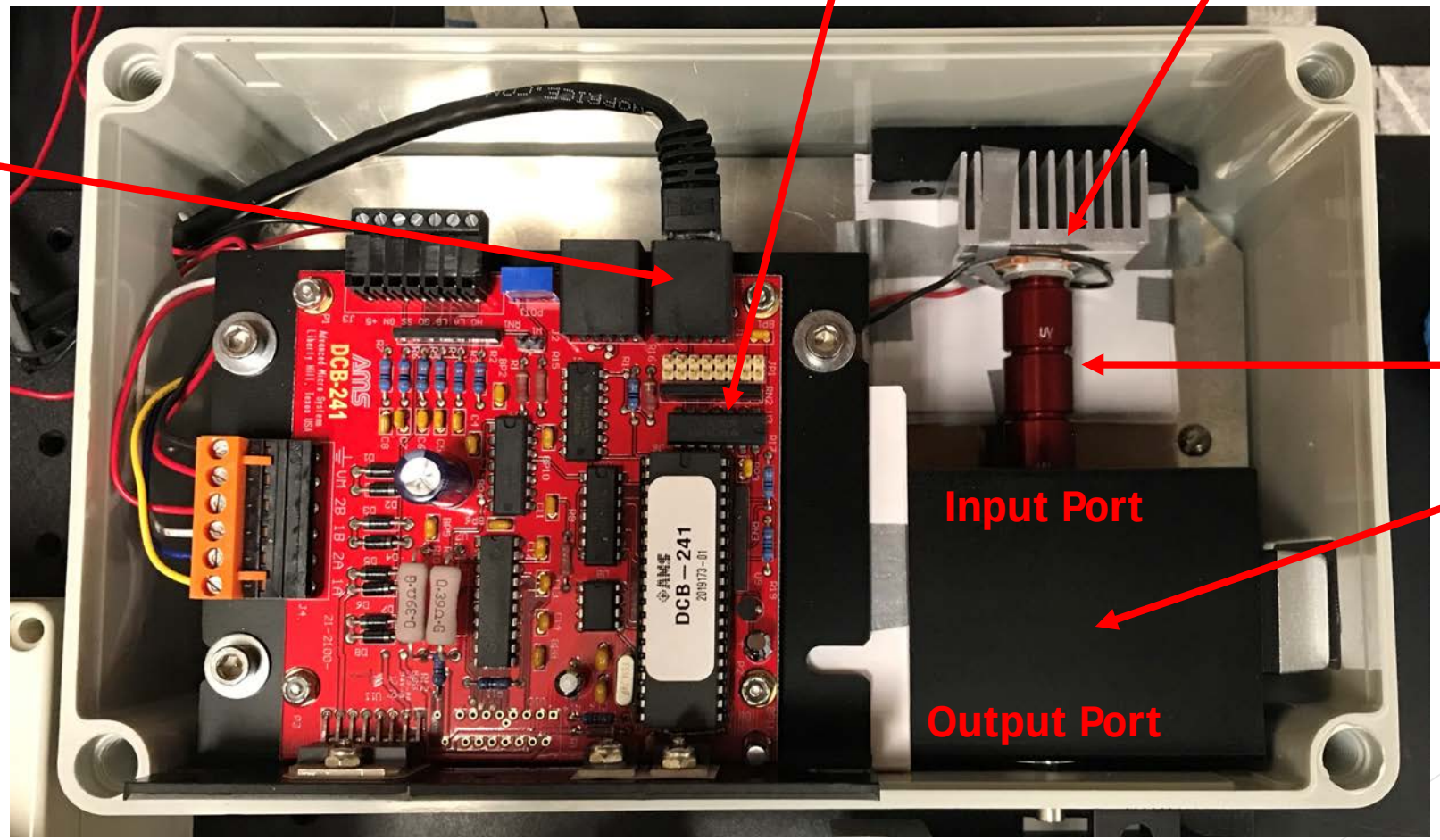


Effect of median filtering on fluorescence decay and peak intensities.

Excitation Monochromator Subsystem

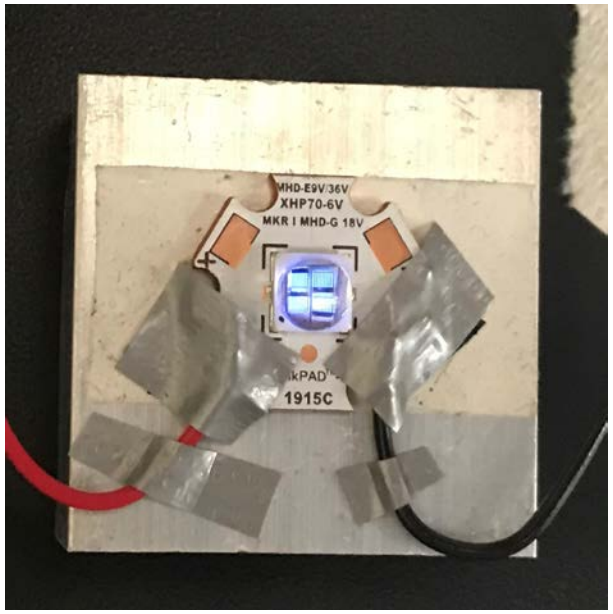
Accomplishments since the last presentation <30> hours	Ongoing progress/problems and plans until the next presentation
• Stepper motor controller and driver (DCB 241) calibrated and validated • High-power UVC LED (280 nm) mounted and wired through soldered connections • Coupling optics aligned and fixed in enclosure • Subsystem tested as scanning excitation source through experimental setup	• Investigate using other or additional UV LEDs as excitation source • Manage heat dissipation with UVC LED • Finalize UVC LED and mount in enclosure • Resolve any machining issues • Continue testing subsystem as excitation source (for next semester)

Excitation Monochromator Subsystem

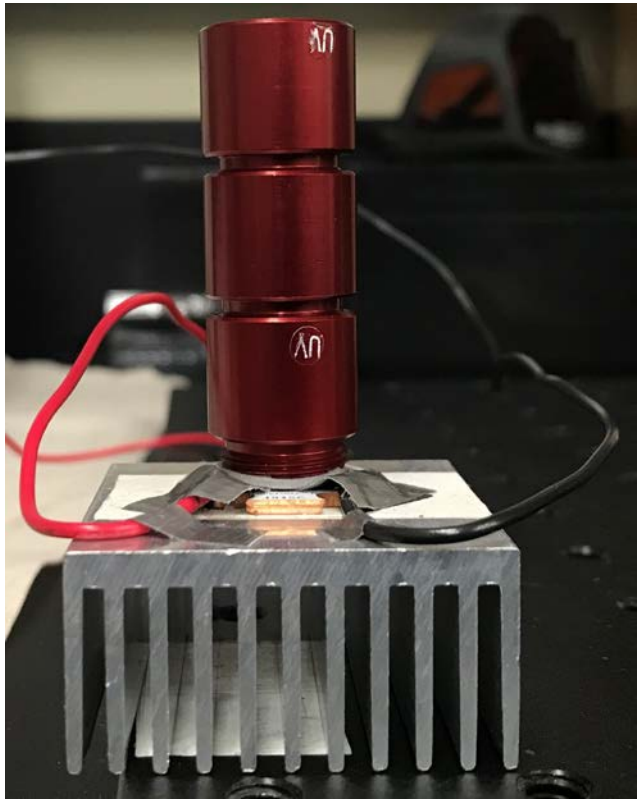


Configuration of excitation monochromator.

Excitation Monochromator Subsystem



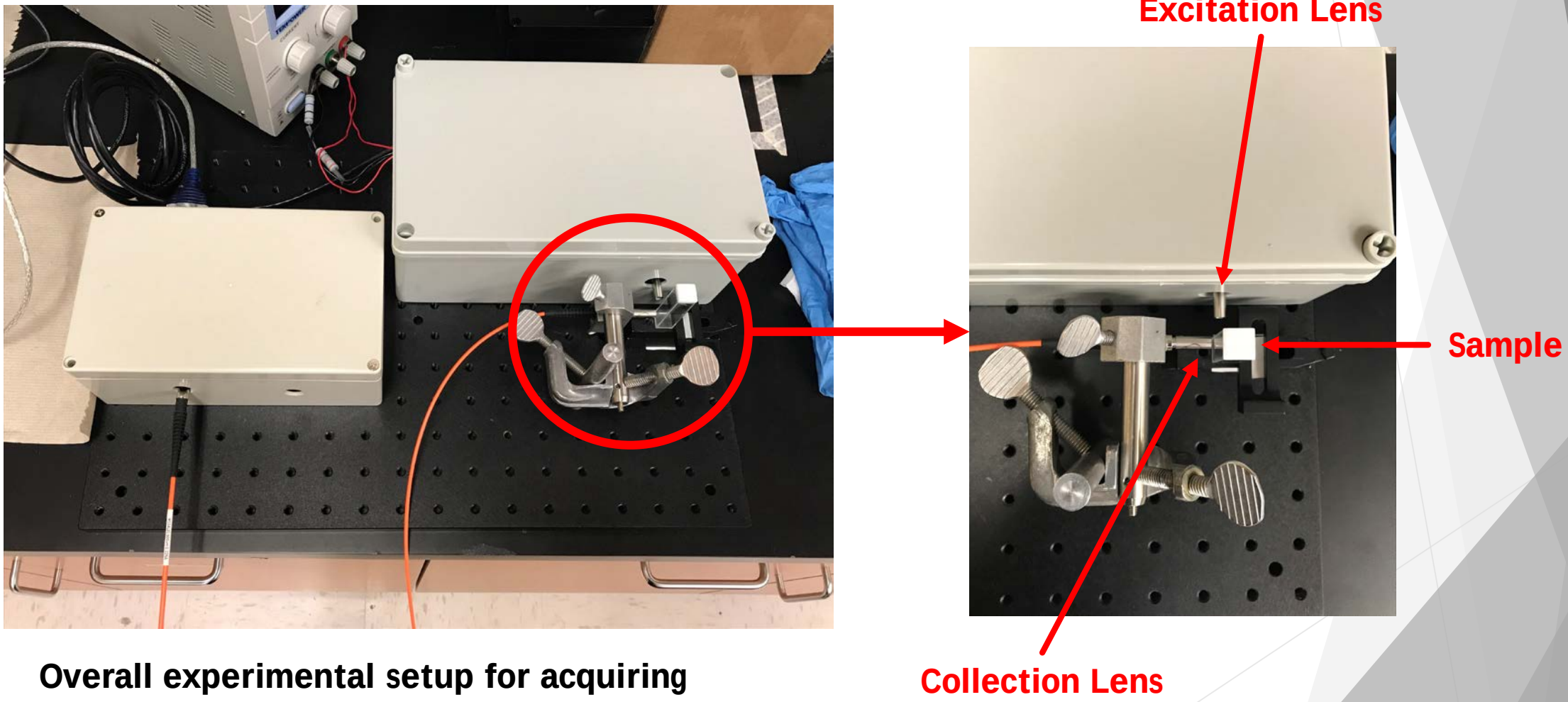
High-power UVC LED mounted on heat sink with thermal adhesive.



UV coupling lenses mounted on top of high-power UVC LED for maximizing excitation intensity.

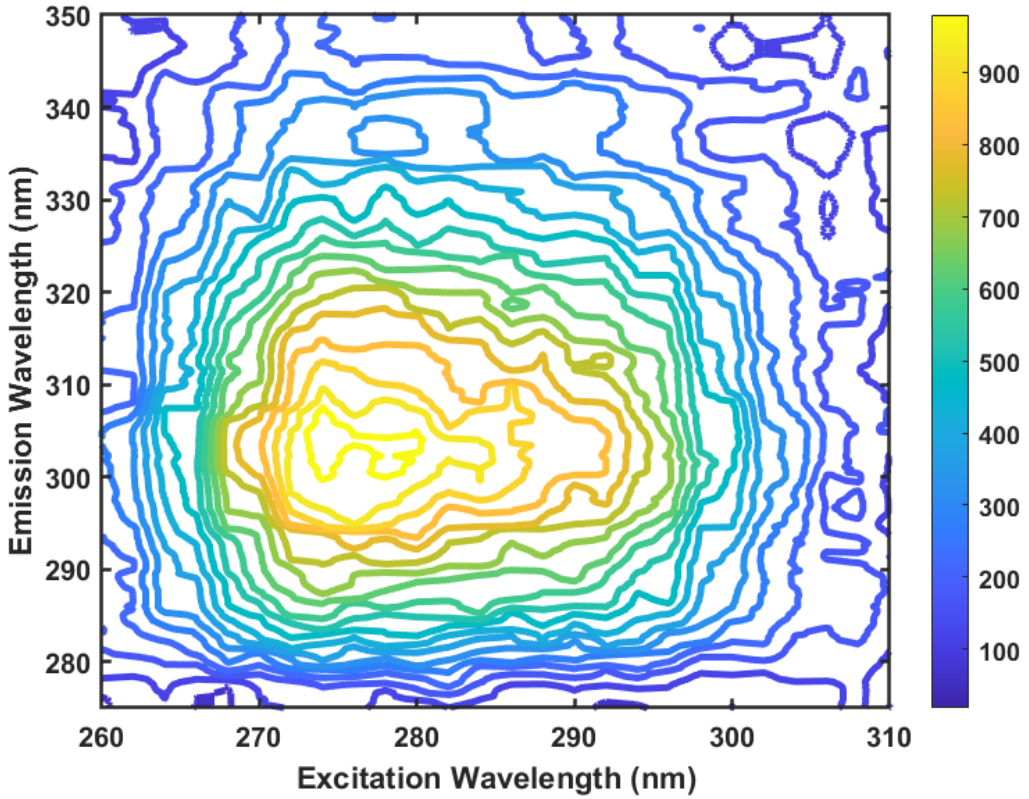
Dial and wavelength readout of scanning Mini-Chrom monochromator.

Excitation Monochromator Validation

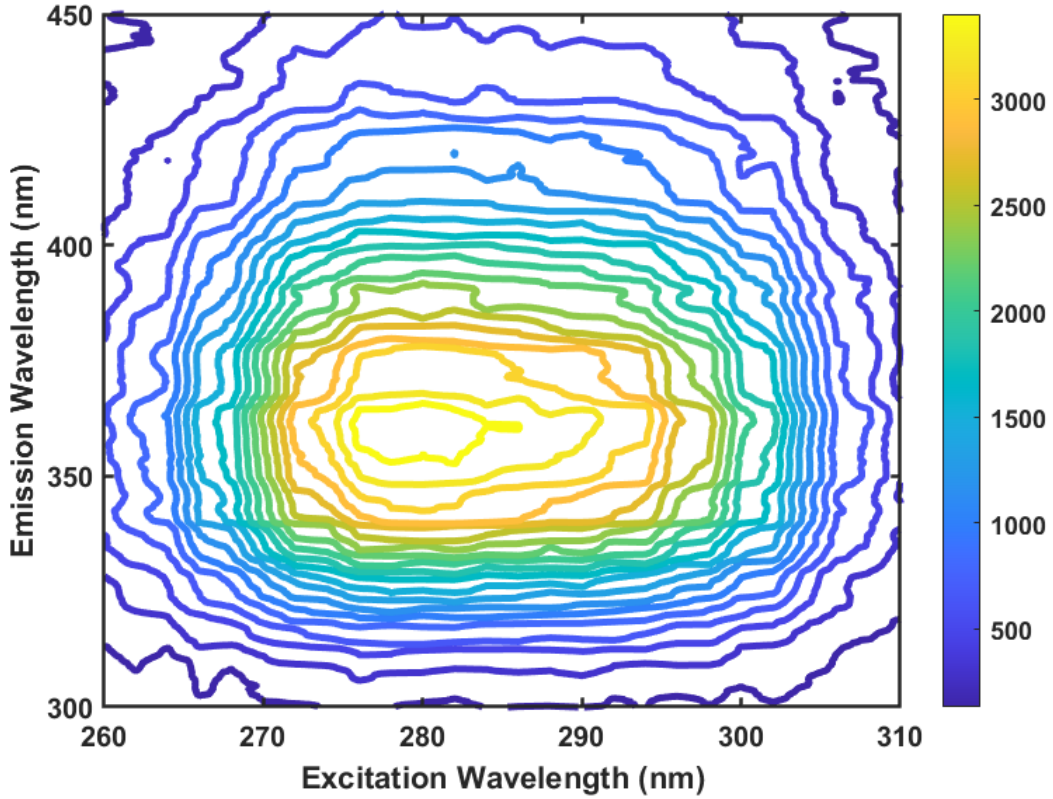


Overall experimental setup for acquiring excitation-emission matrix (EEM) of sample.

Excitation Monochromator Validation



2D contour plot of EEM for tyrosine.



2D contour plot of EEM for tryptophan.

Integration time: 5 seconds; Average: 1; EX: 260-310 nm in 2 nm steps; Median filtering: Yes (20 point window)

Excitation Monochromator Validation

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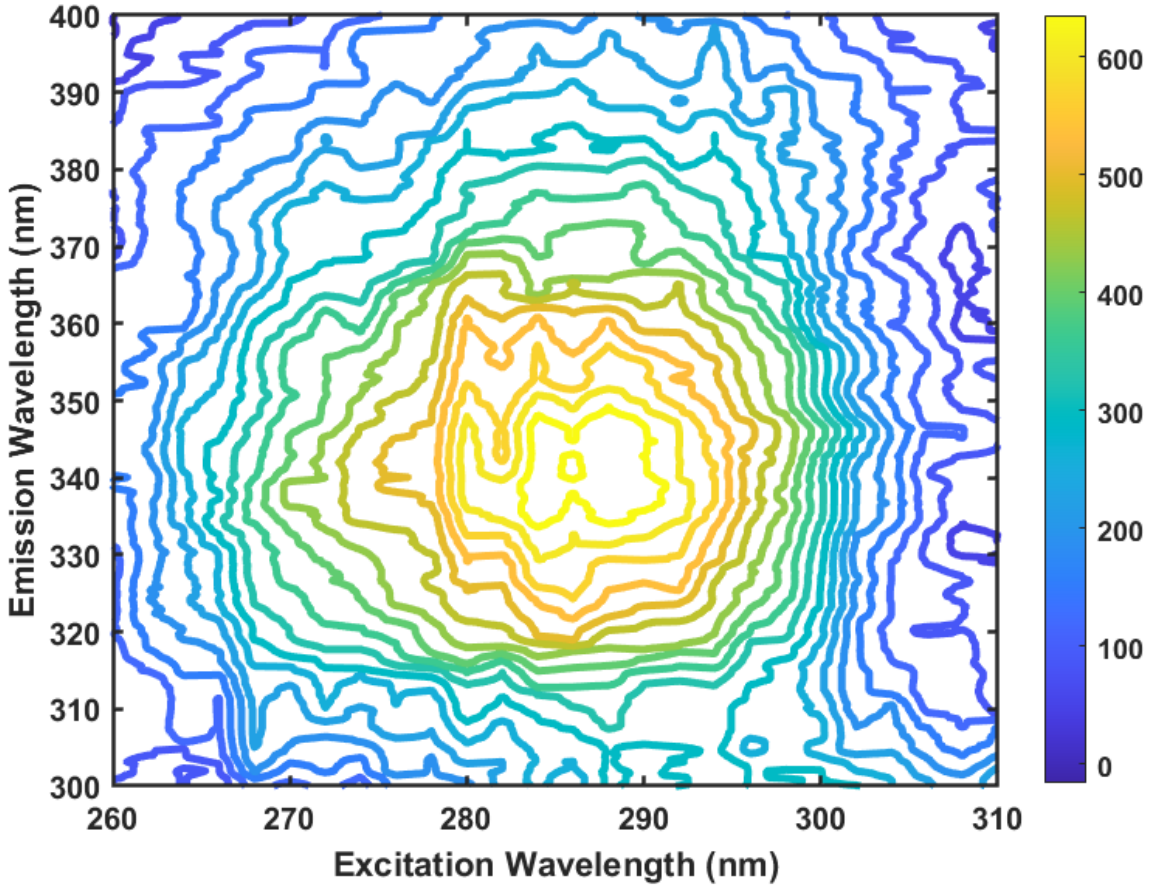
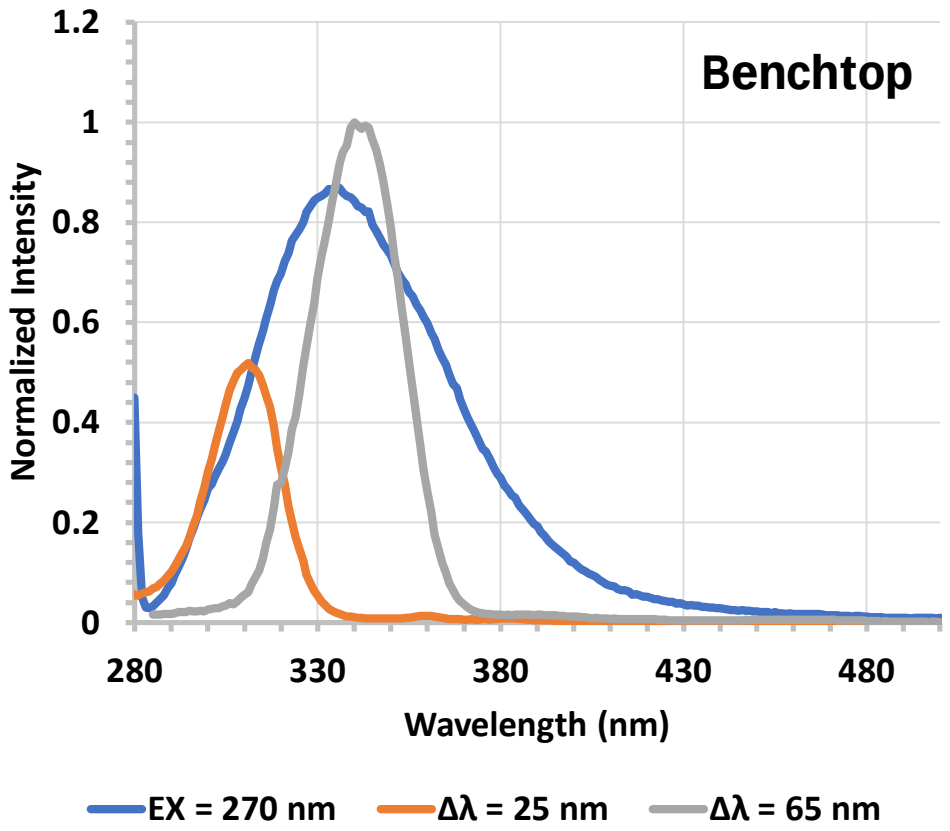


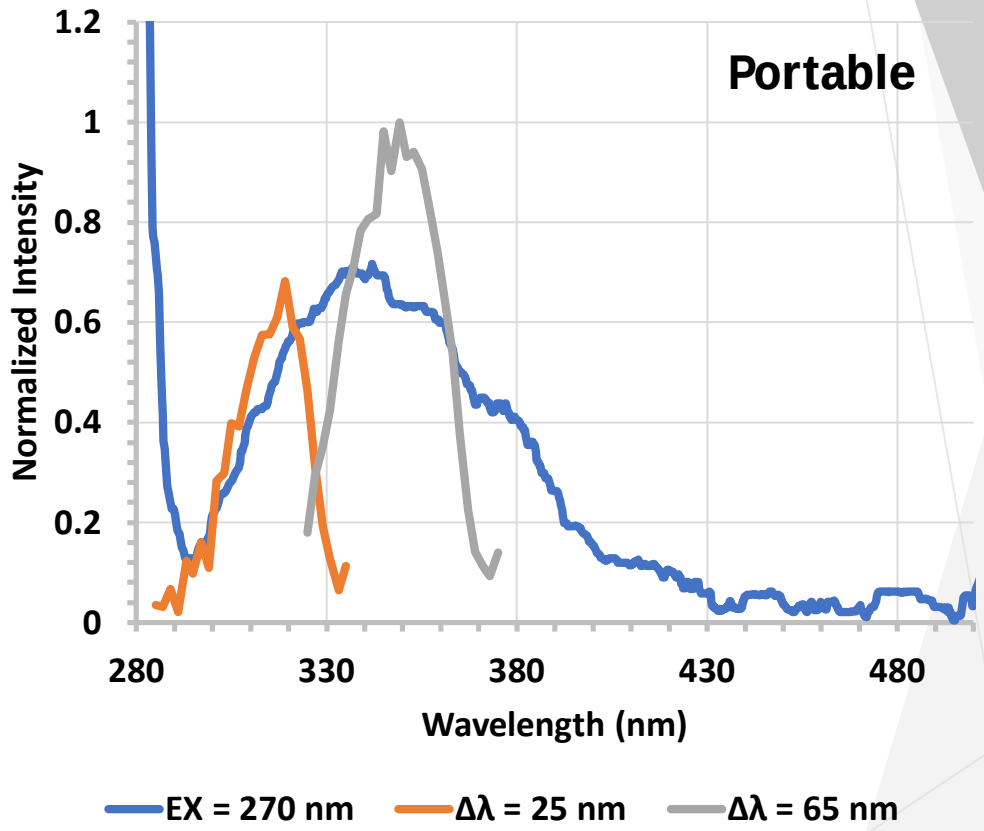
2D contour plot of EEM for bacteria *(E. coli)*.

Integration time: 30 seconds; Average: 1; EX: 260-310 nm in 2 nm steps; Median filtering: Yes (50 point window)

Excitation Monochromator Validation



Synchronous spectra of *E. coli* (Benchtop).



Synchronous spectra of *E. coli* (Portable).

Integration time: 30 seconds; Average: 1; EX: 260-310 nm in 2 nm steps; Median filtering: Yes (50 point window)

Control and Display Unit Subsystem

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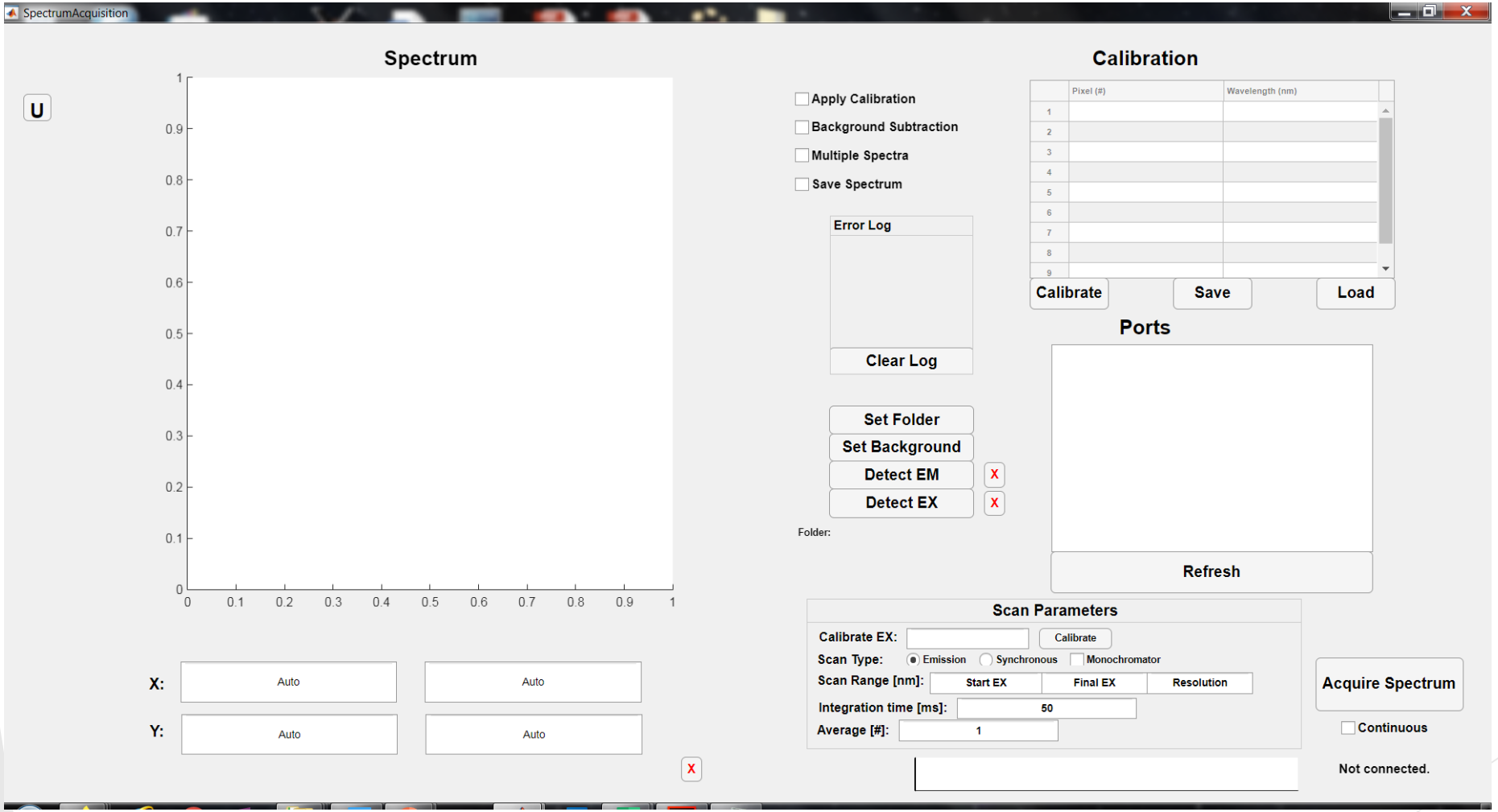
Accomplishments since the last presentation **<20> hours**	**Ongoing progress/problems and plans until the next presentation**
• Processing GUI created through App Designer • Acquisition GUI debugged and improved with more functionalities • Serial communication through USB port validated for both monochromators • Median filtering applied on input PCA data to improve clustering	• Attempt to create unified GUI for acquiring and processing data • Continue optimizing communication speed (baud rate, data compression, etc.) • Continue optimizing PCA parameters • Continue debugging code

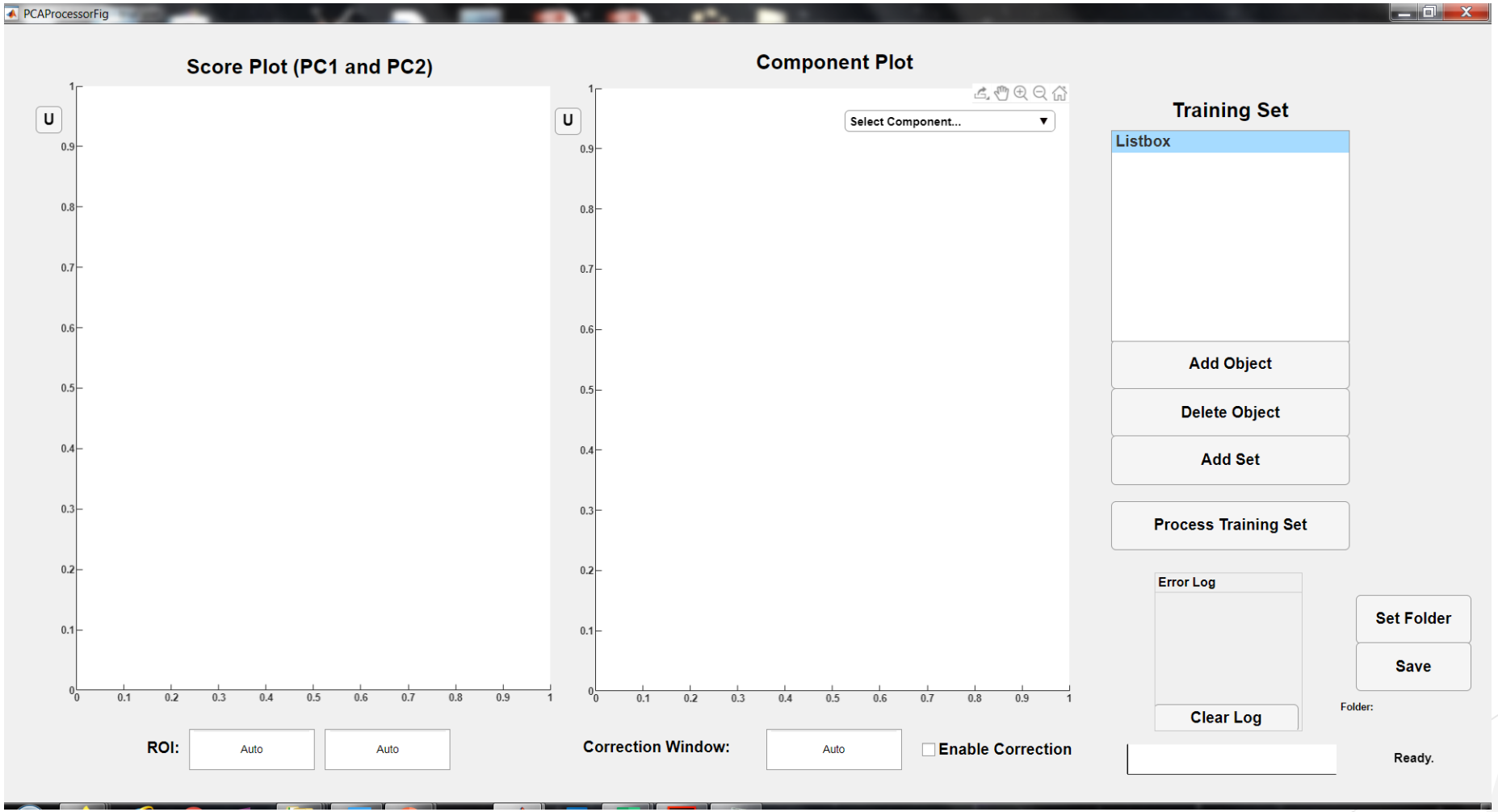
Control and Display Unit Subsystem



Serial communication cable.

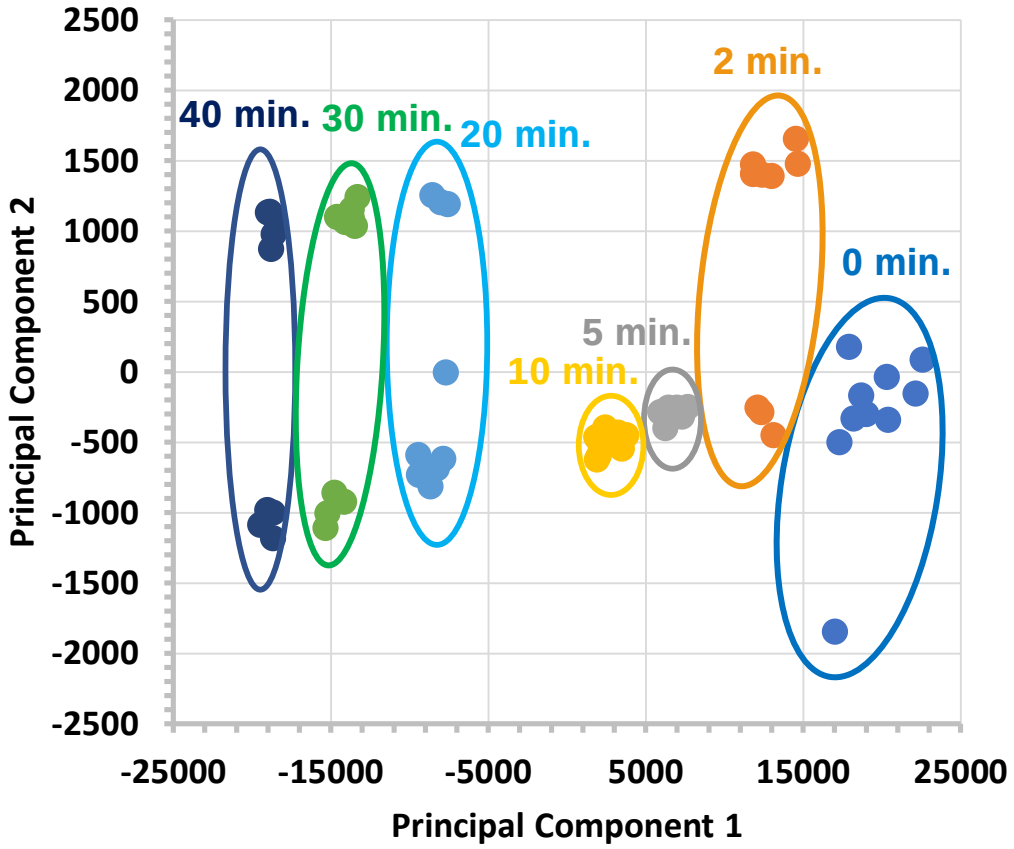
MATLAB Acquisition GUI for communicating with excitation and emission monochromators.

Control and Display Unit Subsystem

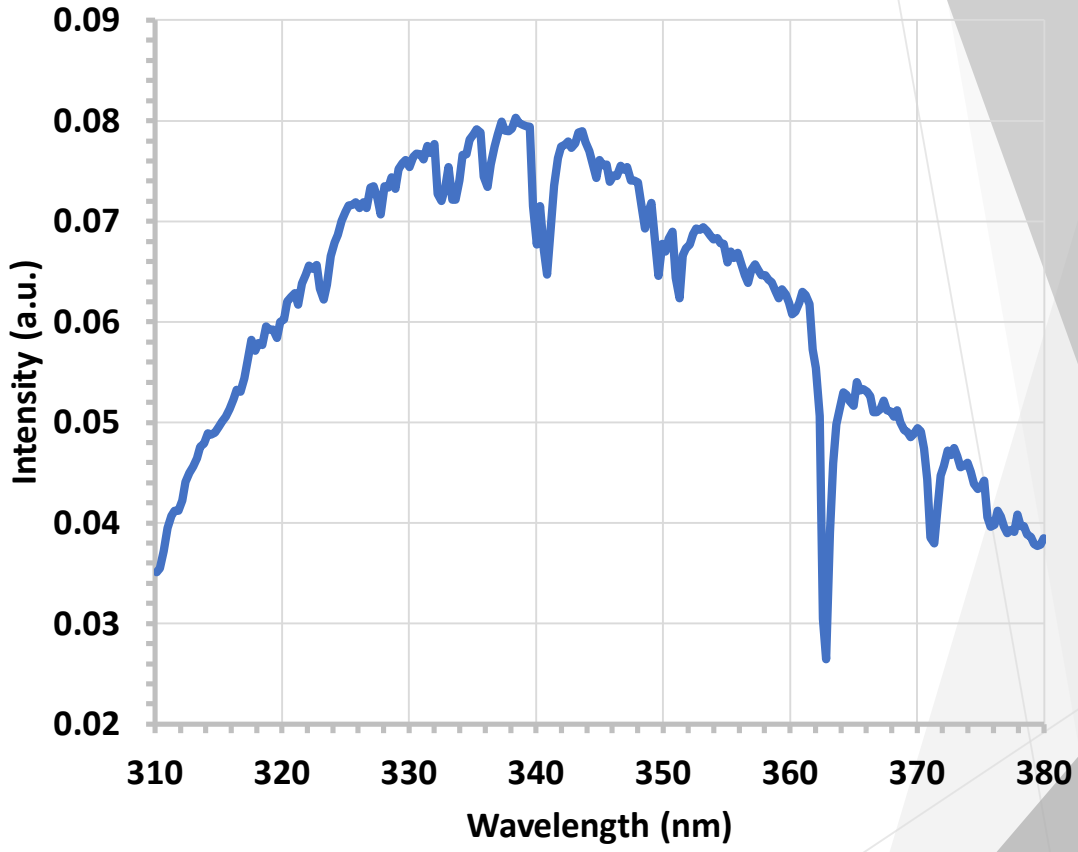


MATLAB Processing GUI for performing and optimizing PCA on recorded data.

Control and Display Unit Validation



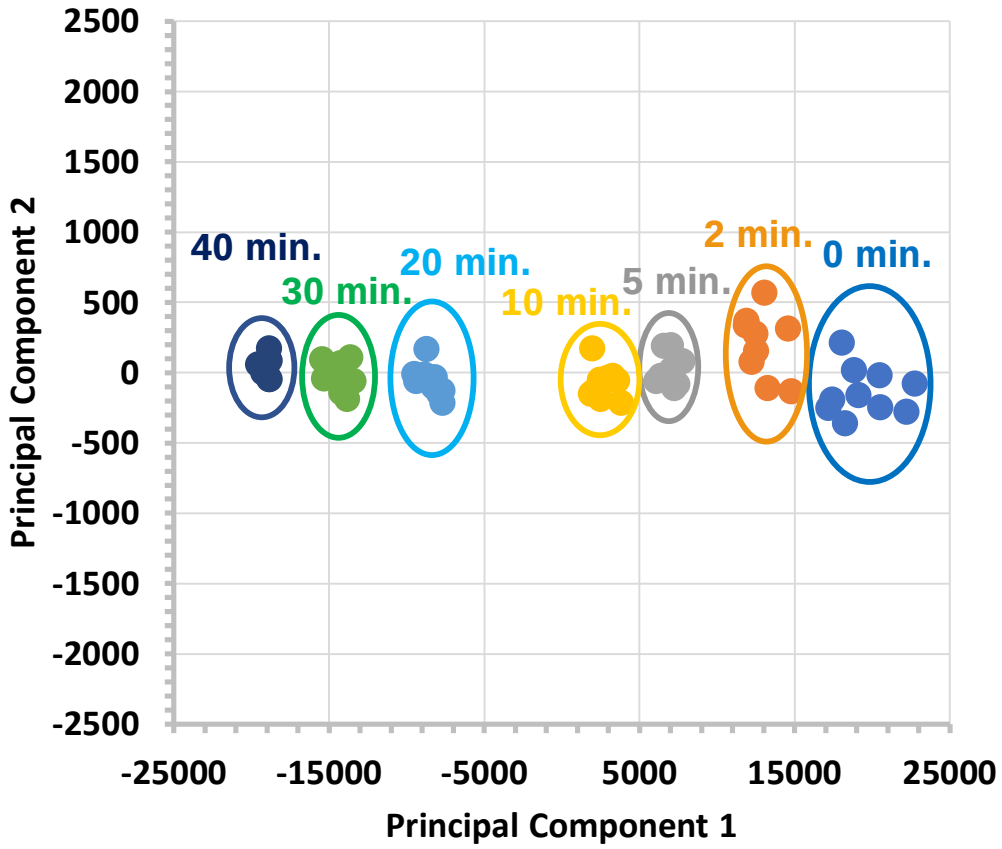
PCA Score Plot



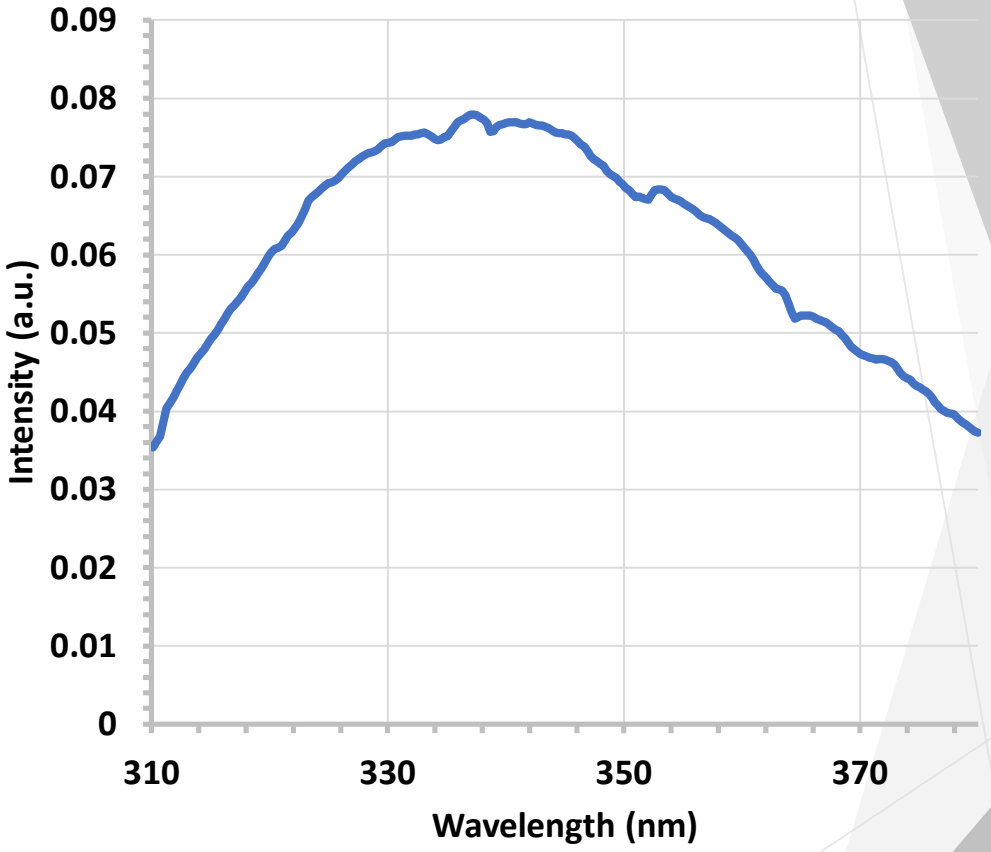
PCA Principal Component 1 Plot

PCA data range: 310-380 nm; Median filtering: No

Control and Display Unit Validation



PCA Score Plot



PCA Principal Component 1 Plot

PCA data range: 310-380 nm; Median filtering: Yes (20 point window)

Execution and Validation Plan

- **Currently:** Have completed practically all execution steps on schedule, validated all major subsystem functionalities, and begun integration of all subsystems

	October 11th	October 18th	October 25th	November 1st	November 8th
Control and Display Unit	Develop MATLAB code for communicating with emission monochromator	Develop MATLAB code for communicating with excitation monochromator	Develop MATLAB code for processing data (plotting, PCA, etc.)	Develop simple GUI for interfacing with all subsystems	Validate GUI communication and processing requirements
Disinfection Unit	Select UV LED and optical fiber for subsystem	Design enclosure for subsystem	Machine enclosure for subsystem	Validate disinfection and excitation functions of subsystem	Couple with emission monochromator
Excitation Monochromator	Select UV LED and microcontroller for subsystem	Design enclosure for subsystem	Machine enclosure for subsystem	Validate scanning capability of subsystem	Couple with emission monochromator
Emission Monochromator	Optimize sensitivity characteristics of subsystem	Design enclosure for subsystem	Machine enclosure for subsystem	Validate usage with disinfection unit	Couple with excitation monochromator

Execution

Validation

Completed (Execution)

Completed (Validation)

Incomplete

Thank You!

Questions?