NWQD Operating App Documentation

Author: Bera Yavuz

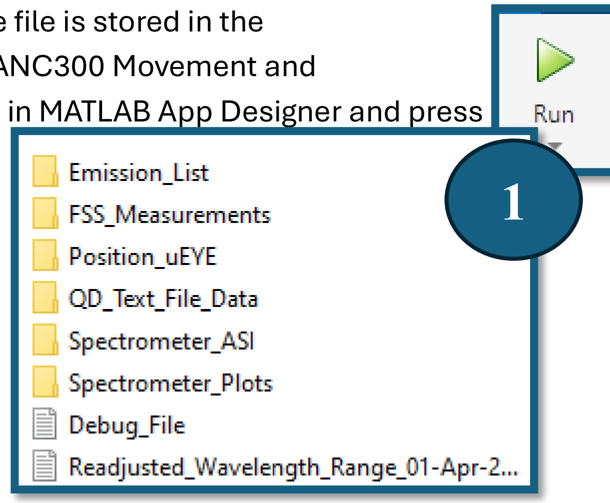
Last Updated: March 2025

Document Contents

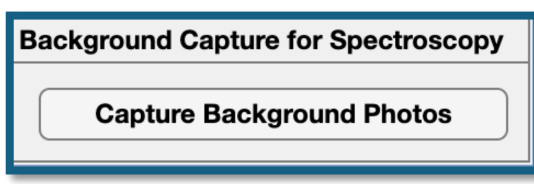
This guide outlines the steps to properly initialize the NWQD Operating App when opening it for the first time in a day. If the **setup has already been performed**, the **application will launch normally without requiring these steps**.

Opening the App: Daily First-Time Setup

1. **First, locate the NWQD_Operating_App.mlapp file.** The file is stored in the directory: C:\Users\Quantum Dot\Desktop\Bera Yavuz - ANC300 Movement and Images\Scripts_&_Debugging_Tools. Once found, open it in MATLAB App Designer and press the **"Run"** icon to launch the application.



2. **Upon launch, the application automatically creates a main folder with the path:** C:\Users\Quantum Dot\Desktop\Bera Yavuz - ANC300 Movement and Images\QD_Data\day_month_year_test. Several subfolders are also generated within this main directory. See the reference image 1 for the complete folder structure.
3. When launched, the application will display an error message stating: **"Required Wavelength file is missing. The application will now close."** This behavior is intentional and expected. Once the application closes automatically, navigate to the folder: **C:\Users\Quantum Dot\Desktop\Original_Trispec** and open the application **FWHM_ver_richard.m**. Upon launching, the user will see a live spectrum. Using a reference laser of their choice (**any laser with a known wavelength that will appear in the spectrum is acceptable**), the user can capture and save a text file. The reference laser is optional and not required but recommended for long scanning sessions. The file should be appropriately named and stored in the **current data folder**, as shown in **Reference Image 1 (bottom file).**
4. To proceed with any emission-related function, the user must first capture background photos using the **"Capture Background Photos"** button in the **Manual Updating** tab. Failure to do so will result in an error message appearing in the respective text box when attempting any emission-related process, indicating that a background photo is required.
5. The app is now ready for use.



If the application is closed and relaunched within the same day, only **Step 4**—capturing a background photo for noise—needs to be repeated. This step should also be performed whenever the user detects a significant change in noise levels.

Overview

The NWQD Operating is a MATLAB App designer application that enables the user to interface with the **Nanowire Quantum Dots (NWQD).** The application includes a variety of features such as a **fully customizable raster scan**, **specific movement to an inquired QD**, as well as **importing a list of inquired QDs and doing processes such as emission and fine structure splitting (FSS) readings**.

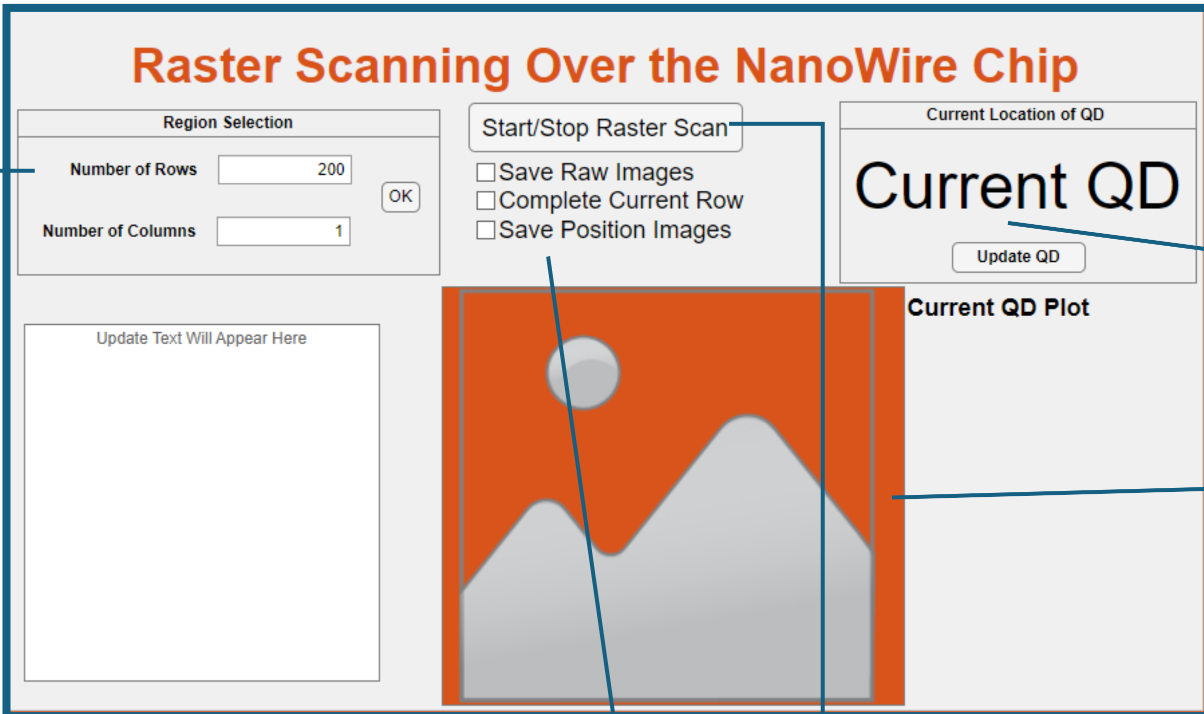
Alongside the QD related procedures, the application also allows the user to view both the ASI Live Feed (camera used for spectrometer) as well as Ueye live feed (camera used for position tracking). The user is also able to change ASI camera settings such as **exposure, gain, gamma and brightness.**

It is important to note that the application uses a class matlab file called **"functionsContainer.m."** This file is essential for the functionally of the application as almost all **crucial functions** used throughout are called via this class file. **If an unexpected error ever occurs, the user is recommended to read through this file.**

If the user is unsure how a function works they can call for a function description via the command **"help functionsContainer.(name of function)".** This returns a custom description that includes a general overview of the input variables and the output variables.

```
>> help functionsContainer.Dual_ANC300_Movement
  Description:
  - Allows simultaneous movement in both axes without setting voltage and frequency (faster compared to ANC300Movement)
  Inputs:
  Axis_ID_Direction - stepping direction. Accpetable inputs: "bottomright", "bottomleft", "topleft", "topright"
  Rest of inputs are self explanatory
  Outputs:
  No output variable as function only writes and sends serial commands to the ANC300
```

Raster Scan Tab



Displays Current QD ID

Displays an Emission Plot of Current QD

– **Plots saved** in ***Spectromer_Plots*** **subfolder**

Region Selection

Defines the scan area by specifying the **Number of Rows** and **Columns** (range: 1–200).

Input Validation

- Values outside the 1–200 range are automatically rejected.
- The **OK** button must be pressed to confirm selections.

Default Behavior

If no values are confirmed before initiating a raster scan, the system defaults to:

- **200 rows**
- **1 column**

First Press: Activates the raster scan (button turns **green**). **Second Press:** Pauses the scan (button turns **red**) and stops at the next QD. This toggle function allows real-time control over scan execution. The color-coded feedback ensures clear operational status.

(Note: The system completes the current dot measurement before pausing to maintain data integrity.)

Save Raw Images

Enables saving raw ASI spectrum images. Useful if raw data retention is required. (Not recommended—files consume significant memory.)
Location: *Spectrometer_ASI subfolder*

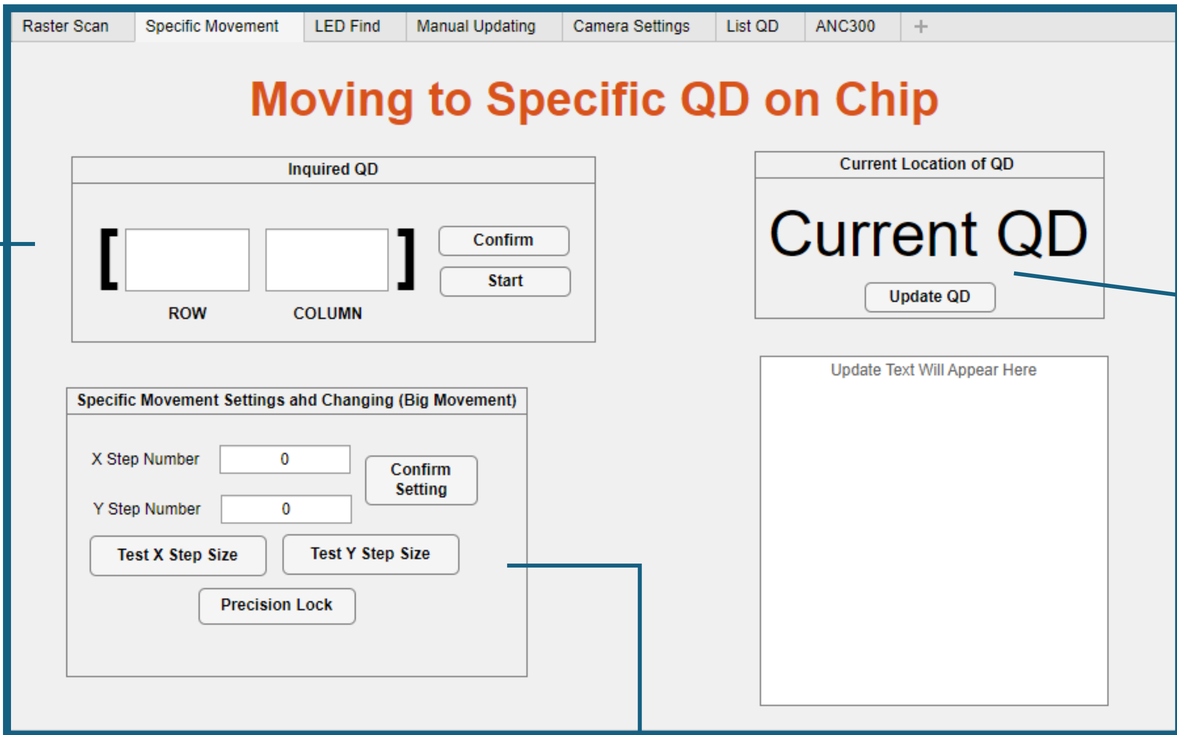
Complete Current Row

If checked, the system will finish scanning the current row before proceeding with the defined raster scan region. (**Keep enabled** unless performing a **very small, targeted scan**.)

Save Position Images

Recommended to leave enabled. Saves a **position reference image** at each dot for post-scan verification.
Location: *Spectrometer_Plots subfolder*

Specific Movement Tab



Displays Current QD ID

1. **User Input Requirement:**

The user must **manually enter the ID** of the target Quantum Dot (QD) in the designated input field.

Confirmation is required before initiating movement by pressing the **Confirm** button.

2. **Validation Check:**

If the user attempts to press **Start** without first confirming a QD selection, the system will display an error prompt in the textbox

Movement Algorithm

The system navigates toward the target QD in discrete steps, advancing in increments of 4 dots per movement. The step size (x/y displacement per step) is user-configurable.

Position Persistence & Calibration

Current x and y coordinates are retained between sessions to maintain positioning consistency.

Newly entered step values must be saved using the **Confirm Settings** button to update system parameters.

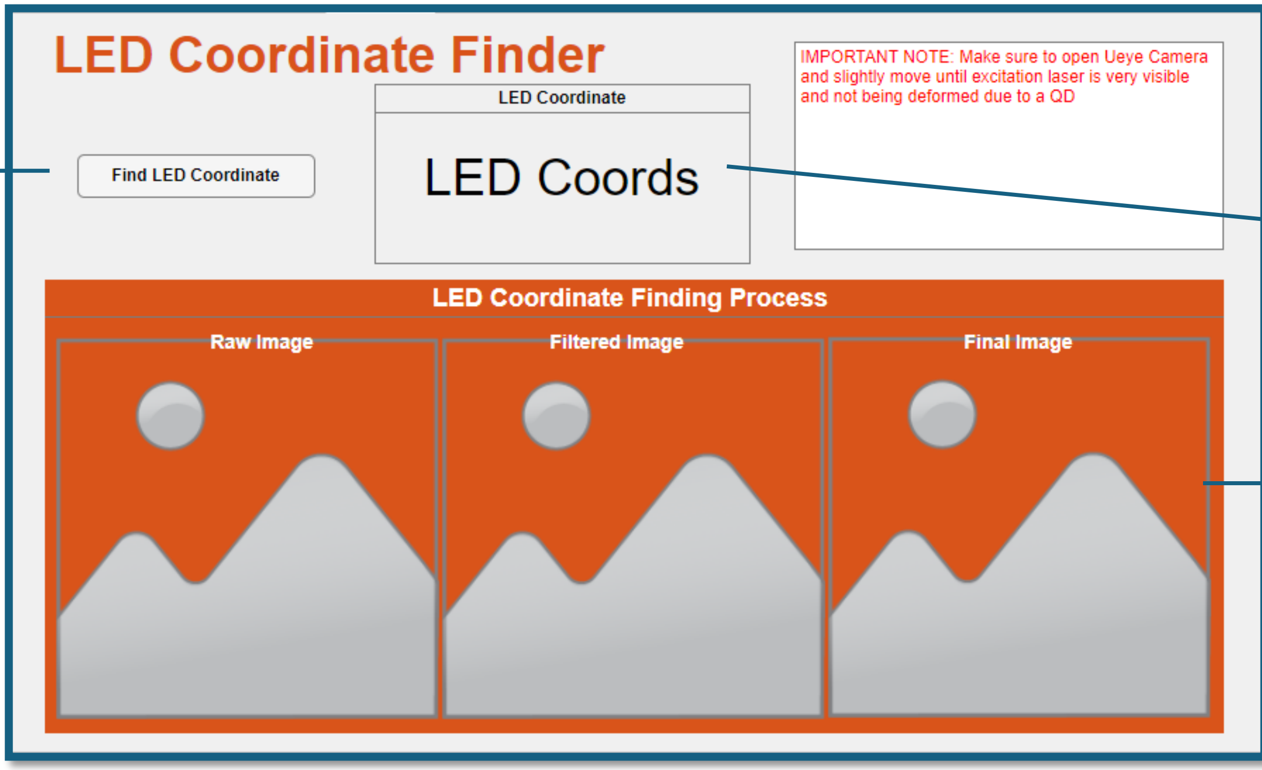
Validation & Fine-Tuning

The configured step size can be verified using the **Test X/Y Step** buttons.

For precise alignment, the **Precision Lock** feature enables positioning onto the dot nearest to the excitation laser.

Recalibration Note: Step values typically remain stable and only require adjustment following a cryostat warm-up cycle, which may induce minor nanowire displacement.

LED Find Tab



Displays Current LED Coordinate

Find LED Coordinate Function: This feature performs image analysis on the current camera frame to identify the **brightest pixels (corresponding to the excitation laser spot)** and calculates its center coordinates, which serve as the reference point for all subsequent movements in the application. Important Note: For **optimal results, slightly offset the excitation laser from the quantum dot position** before measurement to ensure a clean, unobstructed image of the laser spot without sample interference. This reference position is critical for maintaining alignment accuracy throughout all operations.

(***Technical Note:*** The algorithm uses peak intensity detection and centroid calculation to determine the laser's precise center position.)

The LED Coordinate Finding Process assists the user in verifying the detected LED position by providing three distinct images for analysis and confirmation:

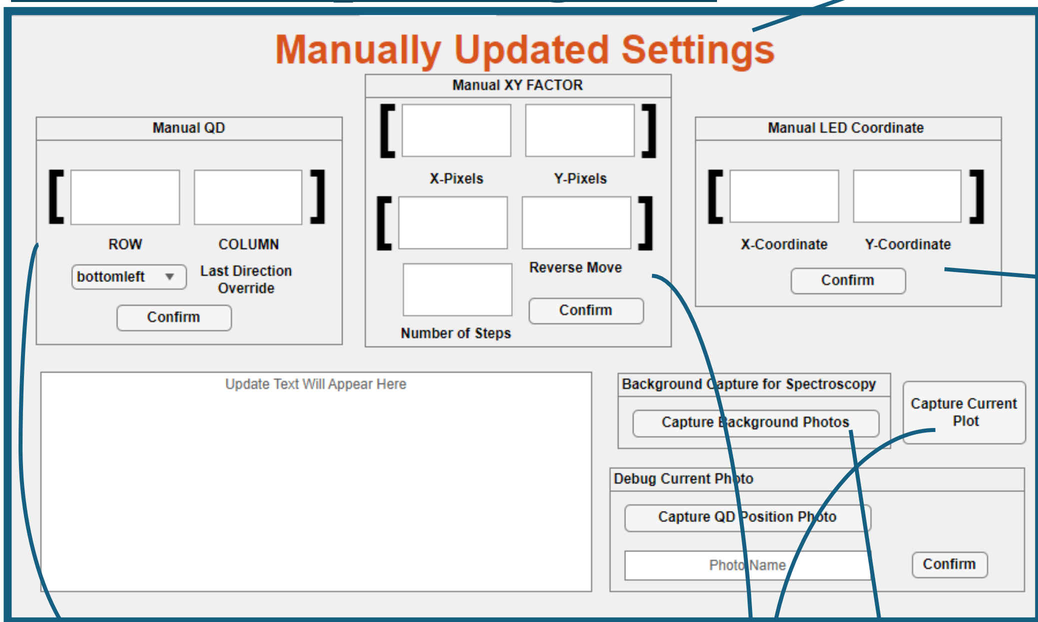
Original Position Image – Displays the raw, unprocessed image for reference.

Binarized Bright Spot Image – A thresholded version highlighting the brightest regions, isolating potential LED candidates.

Detected LED Position – The final output indicating the most probable LED location, determined based on brightness and spatial analysis.

This multi-step visualization ensures accuracy by allowing the user to validate that the detected coordinate corresponds to the true LED location and not an erroneous artifact.

Manual Updating Tab



The Manual Updating Tab allows advanced users to directly modify critical system parameters

Note: *These settings should only be modified by experienced users, as improper adjustments may affect system accuracy and performance.*

Manul LED Coordinate Panel

Use the live camera feed to locate the brightest spot (LED center).

Click on the center in the image to pin the exact position.

Confirm the coordinate in the provided input boxes.

Manul QD Panel

If the user manually repositions the nanowire chip, they must update the system with the new location by specifying the corresponding **Row and Column ID**. This ensures synchronization with system.

Additionally, the **Last Direction Override** setting determines the scan direction (bottom-to-up or up-to-bottom) for completing the current row during the raster scan.

Capture Background Photos

Critical for spectroscopy.
Block all light sources (ensure complete darkness).
Run this function to capture and subtract background noise.
Note: *Always perform before spectral measurements.*

Capture Current Plot

As the name entails, simply captures and displays an emission plot at the given moment

Manul XY Factor Panel

During slow, precise movements between individual dot positions, the system relies on **step/pixel unit factors** to accurately correlate piezo motor steps with image pixel displacements.
1. **Issue a Known Movement Command** – Direct the piezo to move a defined number of steps (e.g., 200 steps) in a specified direction.
2. **Capture and Analyze Displacement** – Use the **"Capture QD Position Photo"** algorithm to measure the actual pixel displacement in the acquired image.
3. **Update X/Y Scaling Factors** – Recalculate the step-to-pixel conversion factors based on the commanded movement and observed displacement.

Note: This process ensures accurate positioning and should only be performed when necessary, such as after cryostat thermal cycling.

Manual Updating Tab Continued

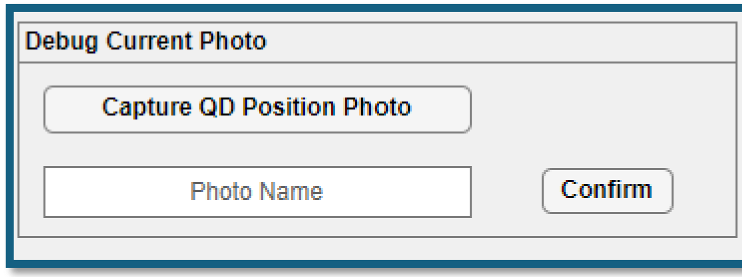
Capture QD Position Photo

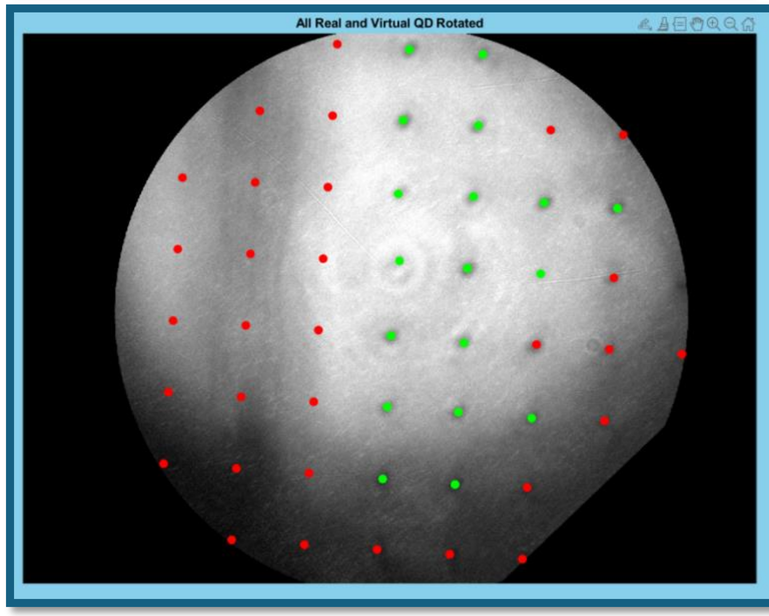
To capture and analyze a position photo, begin by entering a descriptive name for the snapshot and confirming it. Once confirmed, pressing the *Capture* button will take an immediate snapshot of the current position and display a fully processed analysis frame. This includes the raw image alongside the system's processed output—such as detected dots, thresholded regions, or coordinate markers—providing insight into how the system interprets the scene.

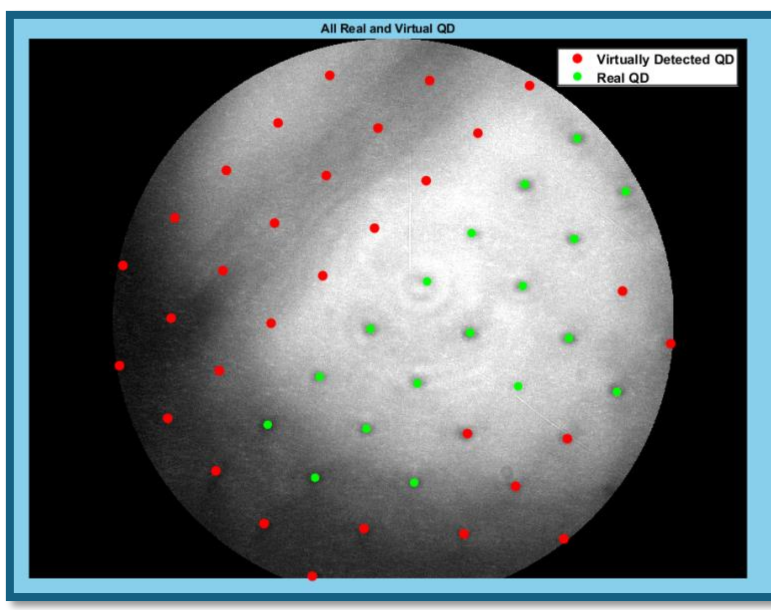
This tool is primarily designed for **debugging and validation**. If features like dots or grids aren't being detected correctly, it may indicate the need to adjust image analysis settings in FunctionsContainer.m (e.g., sensitivity thresholds or noise filters). It also serves as a transparent way to observe backend processes like binarization or alignment calculations.

Note: This is a *preview-only* function—no settings are automatically saved. For permanent adjustments, modify the relevant parameters and rerun the analysis.

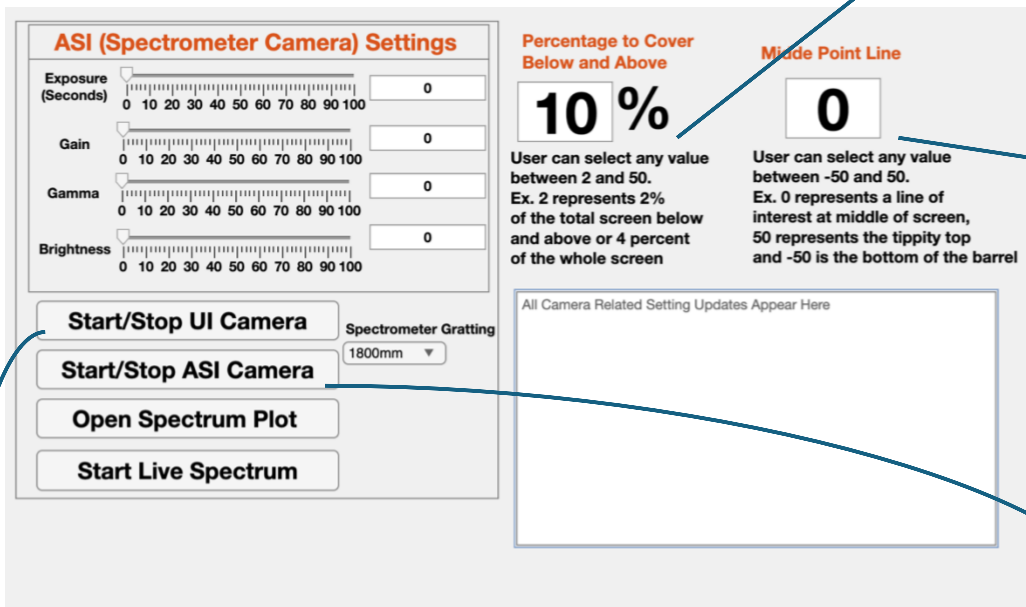
For clarity, refer to the example output diagrams







Camera Settings Tab



Percentage to Cover Below and Above

- Specifies the portion of the screen used for spectral data analysis.
- **Adjustable between 2% and 50%.**
- Example: A **setting of 10% means** 10% of the screen **below and above the middle is analyzed.**

Middle Point Line

- Defines the reference line for spectrum positioning.
- Adjustable **between -50 and 50.**
- **0** represents the **middle of the screen.**
- **50** represents the **topmost** position, while **-50** represents the **bottom.**

UI Camera

Controlled using the **Start/Stop UI Camera** button. Pressing it will launch a separate window with a live feed of the Ueye position camera

ASI (Spectrometer) Camera

Controlled using the **Start/Stop ASI Camera** button. Pressing it will launch a separate window with a live feed of the ASI alongside red lines indicating the portion of the screen used for spectral analysis

Spectrometer Grating

This setting does not affect the spectrometer's functionality but is **used solely for naming conventions in data files**. Users can select from three options—**1800 mm, 150 mm, and 1200 mm**—to label their data appropriately. The chosen value is **saved between sessions**

Spectrometer Settings

Exposure (Seconds)

- Controls the exposure time of the ASI Camera.
- A higher exposure time allows more light to be captured but may lead to saturation.

Gain

- Adjusts the camera's sensitivity to light.
- Higher gain increases brightness but may introduce noise.

Gamma

- Adjusts the gamma correction for image brightness.
- Useful for optimizing contrast in the spectral image.

Brightness

- Controls the overall brightness of the captured image.
- Higher values make the image brighter but can cause overexposure

Note: *The settings have predefined limits, and upon launching the application, the slider values automatically adjust to reflect these constraints.*

Live Spectrum Feature

To view a live spectrum plot, first start the ASI Camera, then click **Open Spectrum Plot** to create and open an empty plot window. Press **Start Live Spectrum** to begin or pause the live spectrum; the button label will toggle between "Start" and "Pause" accordingly.

List QD Tab

The **QD List** function enables users to analyze a curated selection of quantum dots (QDs) by applying one of two primary processing methods:

Fine Structure Splitting Algorithm – Computes the energetic separation between excitonic states, providing detailed spectral characterization.

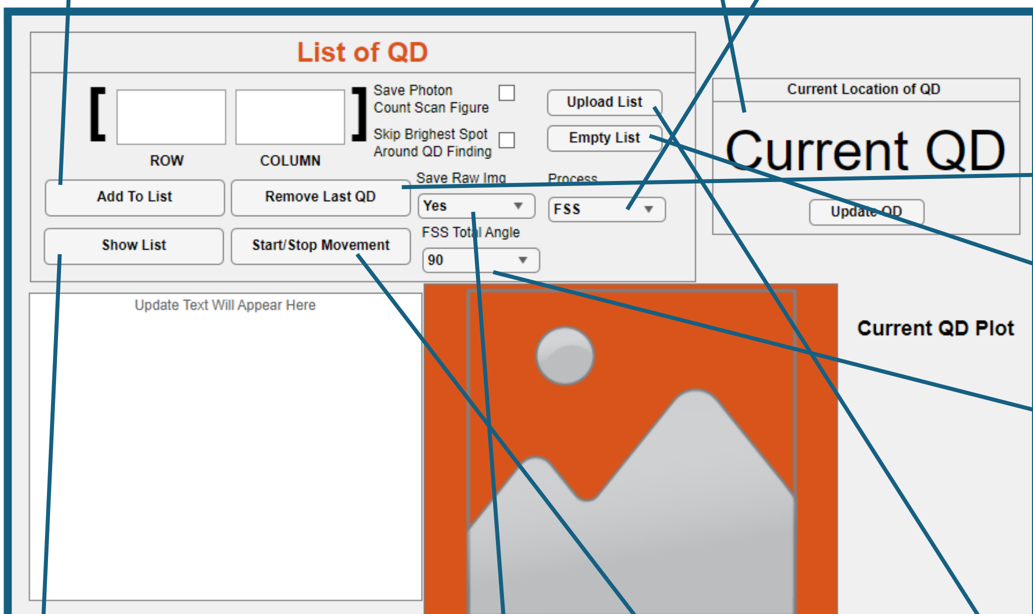
Simple Emission Reading Algorithm – Extracts fundamental emission properties, such as peak wavelength and intensity, for rapid evaluation.

These two options are available within the ***Process* dropdown menu**. *FSS* corresponds to the Fine Structure Splitting (FSS) algorithm, while *Emission* represents the alternative selection.

Add To List Button

To add a quantum dot (QD) to the list, the user must enter the corresponding QD ID into the designated Row and Column fields and then proceed by pressing the button

Displays Current QD ID



Remove Last QD Button

When pressed, this button removes the most recently added quantum dot (QD) from the user-defined list.

Empty List Button

Completely empties out all QD list

FSS Total Angle Dropdown

Users can choose from four preset rotation angles—**90°**, **180°**, **270°**, and **360°**—which determine how much the HWP motor rotates. Larger angles provide higher accuracy in the FSS but also increase the overall wait time.

Show List Button

Selecting this button displays the complete list of quantum dots (QDs) entered by the user. The list is presented within the built-in text box for review and reference.

First Press: Activates the list scan (button turns **green**). **Second Press:** Pauses the list (button turns **red**) and stops at the next QD. This toggle function allows real-time control over list execution.

Save Raw Img Dropdown

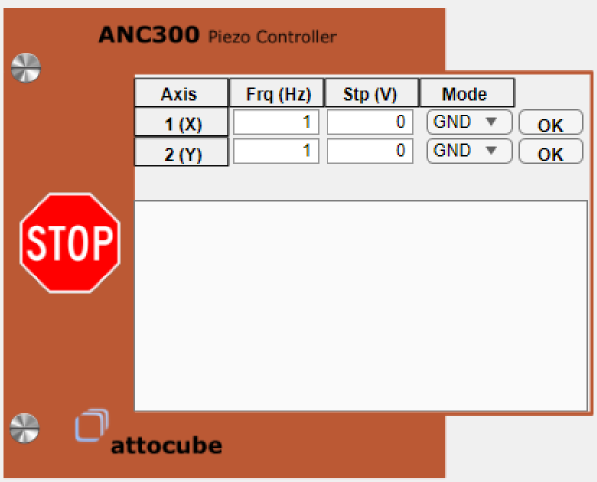
This feature functions identically to the dropdown checkbox found in the *Raster Scan* tab. For details on its operation, please refer to the corresponding section in the documentation.

Upload List Button

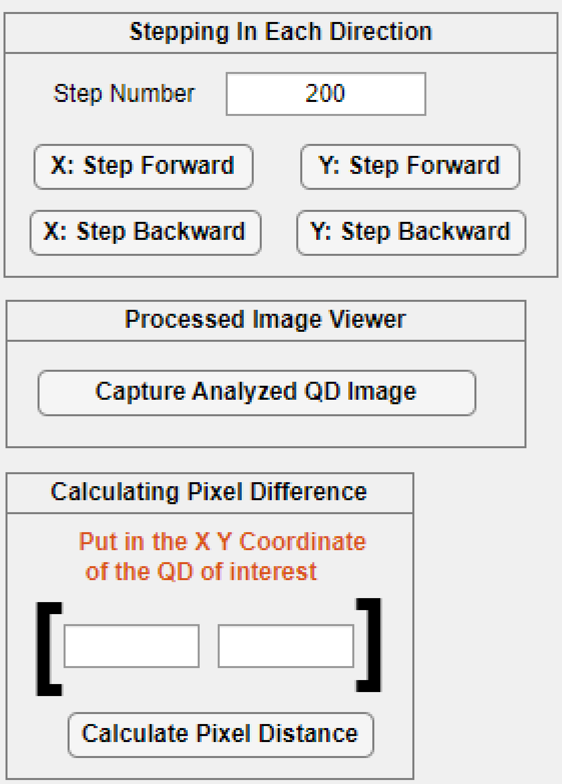
Pressing this button allows the user to upload a predefined list of quantum dot (QD) entries instead of manually entering each value. The list must be provided in a text file format.

Default File Location: *C:\Users\Quantum Dot\Desktop\Bera Yavuz - ANC300 Movement and Images\QD_Data\QD_Search.txt*

ANC300 Tab



Stop Button: Immediately halts all movement across all axes.



This section of the code is used for the **Cryostat Thermal Cycling Procedure**. Please refer to that section for detailed instructions.

Y-Axis Controls

- ***Frequency (Frq) [Hz]:*** Adjusts the stepping frequency for the Y-axis. Acceptable range: ***1 – 1000 Hz.***
- ***Step Voltage (Stp) [V]:*** Sets the step voltage applied to the Y-axis. Acceptable range: ***0.000 – 150.000 V.***
- ***Mode:*** Selects the operation mode for the Y-axis, can bet set to grounded mode (GND) or stepping mode (STP)
- ***OK Button:*** Confirms and applies the selected Y-axis settings.

X-Axis Controls

- ***Frequency (Frq) [Hz]:*** Adjusts the stepping frequency for the X-axis. Acceptable range ***1 – 1000 Hz.***
- ***Step Voltage (Stp) [V]:*** Sets the step voltage applied to the X-axis. Acceptable range: ***0.000 – 150.000 V.***
- ***Mode:*** Selects the operation mode for the X-axis, can bet set to grounded mode (GND) or stepping mode (STP)
- ***OK Button:*** Confirms and applies the selected X-axis settings.

- ***Step Number***: The user can input any number between 1 and 300 to set the step size for forward and backward movements.
- ***X: Step Forward:*** Moves along the defined X-axis by the specified 'Step Number.'
- ***X: Step Backward:*** Moves backwards along the defined Y-axis by the specified 'Step Number.'
- ***Y: Step Forward:*** Moves along the defined Y-axis by the specified 'Step Number.'
- ***Y: Step Backward:*** Moves backwards along the defined Y-axis by the specified 'Step Number.'

Capture Analyzed QD Image Button: Refer to the 'Manual Updating Continued' section, as the behavior is identical to the 'Capture QD Position Photo' function, except without image rotation.

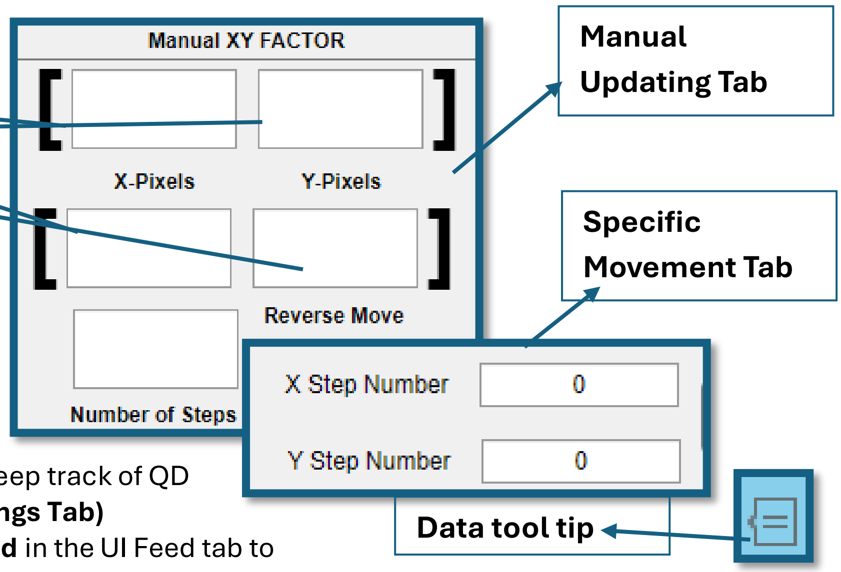
Calculating Pixel Difference

Using the analyzed image created in the **newly formed tab** by the **'Capture Analyzed QD Image'** button, the user can click on any QD they have traveled from. This will **display the X and Y coordinates**, which the user **must input into the coordinates boxes**. The system will then calculate and return the pixel difference (amount traveled) using the LED's current position in the text area.

This **guide outlines** the **steps to properly initialize the NWQD Operating App** after a **full cryostat thermal cycle.** If the cryostat has not been warmed up and cooled back down, this section can be disregarded.

Cryostat Thermal Cycling Procedure

1. After **completing a full cryostat thermal cycle**, open the NWQD Operating App. If this is the first time opening the app for the day, refer to the 'Daily First-Time Setup' section. Otherwise, proceed with normal operation.
2. Typically, the user only needs to adjust six factors:
   - **Manual X Factor**
   - **Manual Y Factor**
   - **Manual X Factor Backwards**
   - **Manual Y Factor Backwards**
   - **X Step Number** (for large movements)
   - **Y Step Number** (for large movements)



3. For the easiest method, the user is recommended to navigate to a section of the QD that is easily identifiable, such as the top-right corner, where the bordering QD can be found.
4. The user should now open the live UI feed to keep track of QD movement. (**Button Located in Camera Settings Tab)**
5. The user can then **press the data tooltip found** in the UI Feed tab to manually **locate the center point** of the **LED** and update the 'LED Find' tab. If the **light** is **bright enough** and **undistorted**, they can **attempt** to use the **automated 'LED Find'** button.
6. To start with **fast movement between dots**, the user should first **navigate** to the **'Specific Movement' tab**. From here, they can press the **'Test X Step Size' and 'Test Y Step Size' buttons**. The expected outcome is a movement of **4 dots in total** (e.g., [1, 1] to [1, 5]). If this is not the case, the user can adjust the **X Step Number and Y Step Number values** until the results **meet their expectations**. The user can then use the 'Precision Lock' button to lock onto the closest dot while debugging. This movement is not exact and just has to be roughly in the right ballpark.
7. Once satisfied with the fast movement variables, the user should navigate to the 'ANC300' tab. Here, they will find three panels on the right side: **Stepping in Each Direction, Processed Image Viewer, and Calculating Pixel Difference.**
   i. First, **position the excitation laser on the desired QD** and use the **'Precision Lock'** button mentioned earlier to **ensure the excitation laser is situated directly on top** of it.
   ii. Next, input a step number; the **recommended value is 200**.
   iii. **Press one** of the four **respective movement buttons**: X: Step Forward, Y: Step Forward, and so on.
   iv. Once the **movement is complete**, indicated by the buttons returning to their original color (from green), press the **'Capture Analyzed QD Image'** button. This will generate an **analyzed image with green and red dots marking QDs**, and an **orange dot** representing the position of the **LED**.
   v. Using the **data tooltips feature** of the tab, click on the **QD the excitation laser was originally on** and input the X and Y coordinates into the **'Calculating Pixel Difference'** tab. Then, press **'Calculate Pixel Difference**.'
   vi. This output will appear in the text area, make sure to save the pixel and step information somewhere then put the info into the respective sections in the ‘Manual Updating’ Tab
8. Repeat Step 7 for each direction, and once completed, everything is ready for use!"