openScope Traveller Imaging Platform
User Guide and Assembly Manual

University of Cape Town
openScopes Connect Africa

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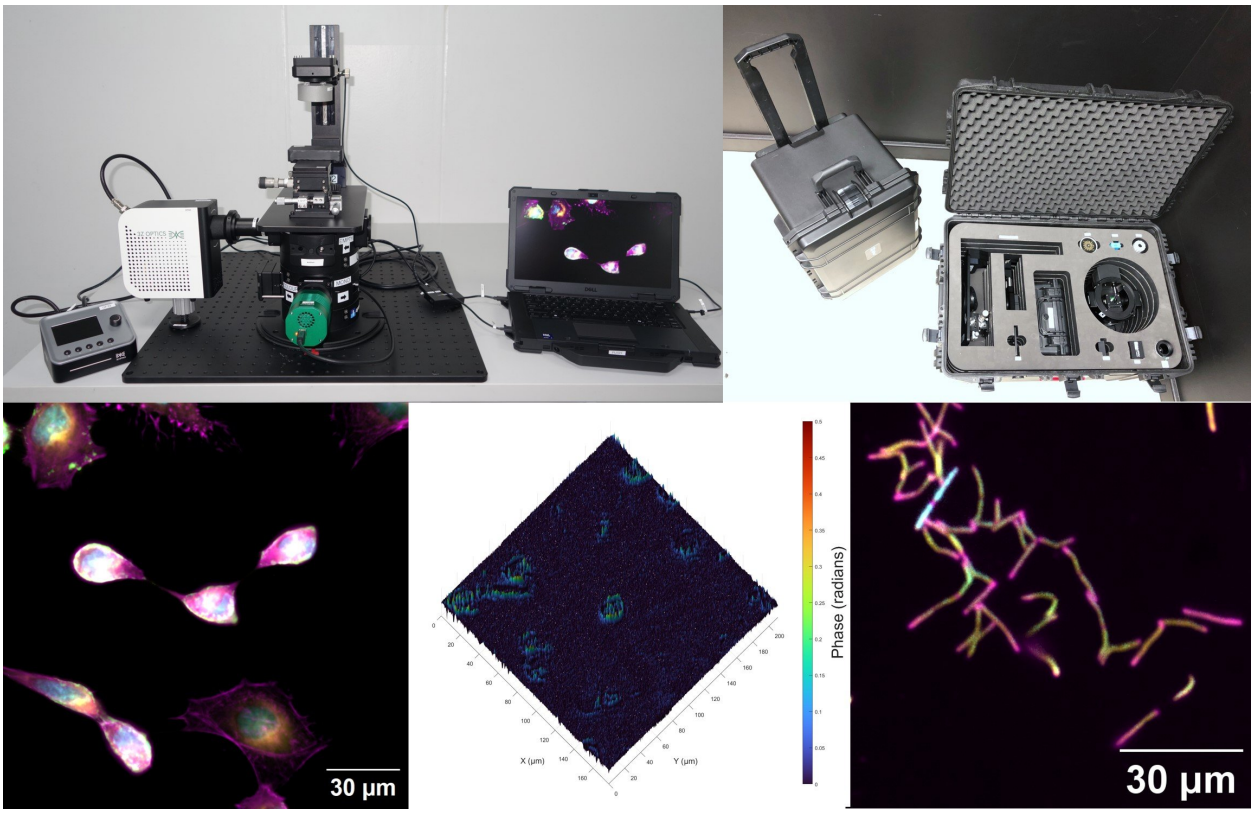

Contents

Compliance and Purpose

This user manual has been designed to comply with the following standards:

- **IEEE 1063:** Standard for Software User Documentation
- **ISO/IEC 82079-1:** Preparation of information for use (Instructions for use)
- **ISO/IEC 26514:** Systems and software engineering – Documentation for end users

Intended Audience: Technical staff, researchers, and trained users responsible for setup, operation, or maintenance of the openScope Traveller imaging system.

Scope: This document provides installation, configuration, operation, maintenance, and troubleshooting instructions for the openScope Traveller microscopy platform.

Symbols and Safety Notices

Legend of Symbols:

- **DANGER:** Indicates an immediate hazard with a high risk of serious injury or death.
- **WARNING:** Indicates a potential hazard that could cause injury.
- **CAUTION:** Indicates a situation that may result in equipment damage.
- **NOTICE:** Important information that ensures proper operation.

Example:

- **DANGER:** Do not attempt to disassemble the LED array while it is powered.
- **WARNING:** Bright LED light may damage vision—avoid direct viewing.
- **CAUTION:** Only use the supplied power adapter to avoid overvoltage.
- **NOTICE:** Ensure software is updated before first use.

Glossary

Base Layer
The foundational mechanical structure upon which optical modules are mounted.

Filter Layer
The mechanical structure upon which the optical filter modules are mounted.

Detection Layer
The mechanical structure upon which cameras are mounted.

Camera (Kikker/Rana)
Imaging devices capturing visible light (monochrome or colour).

Tube Lens Layer
Modular stage upon which the tube lens is mounted.

Core Layer
Modular stage

Filter Cube
Interchangeable cube holding excitation and emission filters for fluorescence imaging.

Fluorescence LED light source (IRIS-400N)
Multi-wavelength light source for fluorescence excitation.

OpenFrame
Control software used to interact with cameras, illumination, and data storage.

Tip-Tilt Mirror
Optical component that adjusts the beam direction via angular deflection.

XYZ Stage
Mechanically adjustable sample platform offering fine positioning control for three axes.

1 Introduction

The **openScope Traveller** (or just the Traveller) is a modular, open-source digital microscopy platform designed to provide accessible, field-deployable imaging capabilities for research and teaching. It supports both **brightfield** and **fluorescence imaging** modalities, and can be configured for **advanced time-lapse acquisitions**. The Traveller has been engineered for portability, rapid setup, and reliable operation in both laboratory and field settings.

The Traveller is adapted from the **openFrame microscope**, a modular and cost-effective platform developed around open-hardware principles. At its core, the openFrame architecture uses stackable cylindrical aluminum layers aligned along a central optical axis. This modular design provides a flexible framework that can accommodate both standard and specialised microscope components. The architecture also makes it straightforward to interface with external optical cage assemblies, offering users an extended range of experimental configurations.

By maintaining compatibility with open-source software tools such as Micro-Manager and ImageJ/Fiji, openFrame-based microscopes remain easy to maintain, simple to upgrade, and adaptable to most light microscopy techniques. This ensures that Traveller users benefit from both hardware modularity and software flexibility.

This manual covers the Traveller's **assembly**, **software setup**, **operation**, and **maintenance**. While the Traveller represents a compact implementation of the openFrame ecosystem, users should note that the framework supports larger and more elaborate designs. These extended systems can include additional imaging modalities and integrations for core imaging facilities. Although beyond the scope of this manual, such expansions remain available for advanced users and institutions seeking enhanced capabilities.

Key Features:

- Lightweight and portable (fits in two Pelican cases)
- Ease of assembly and reconfiguration
- Preconfigured software environment for rapid imaging startup
- Modular optical and illumination design, enabling customisation
- Ideal for resource-limited laboratories, teaching environments, and fieldwork

2 Safety and Handling Instructions

- **Electrical Safety:** Use only grounded outlets and verified power adapters. Disconnect power before modifying components.
- **Optical Safety:** Avoid direct exposure to LEDs. Use safety goggles when using high-intensity or fluorescence LEDs.
- **Mechanical Safety:** Handle all mounts and rails with care. Secure base on a stable surface before assembly.
- **Transport:** Always transport using the original Pelican cases and packaging. Avoid stacking or placing weight on the cases.
- **Tools:** Avoid use of any third-party tools on the Traveller. Only use the supplied tools with the Traveller when indicated to do so.

3 Kit Overview

Packing Contents

The openScope Traveller kit is shipped in two Pelican cases:

- **Case A (Mechanical assembly and cameras):** Foundational base assembly, transillumination pillar and stage, camera case
- **Case B (Electronics and Illumination):** LED array, lenses, IRIS-400N, toolkit, power supplies, cables, laptop preinstalled with imaging and control software

Visual Inventory

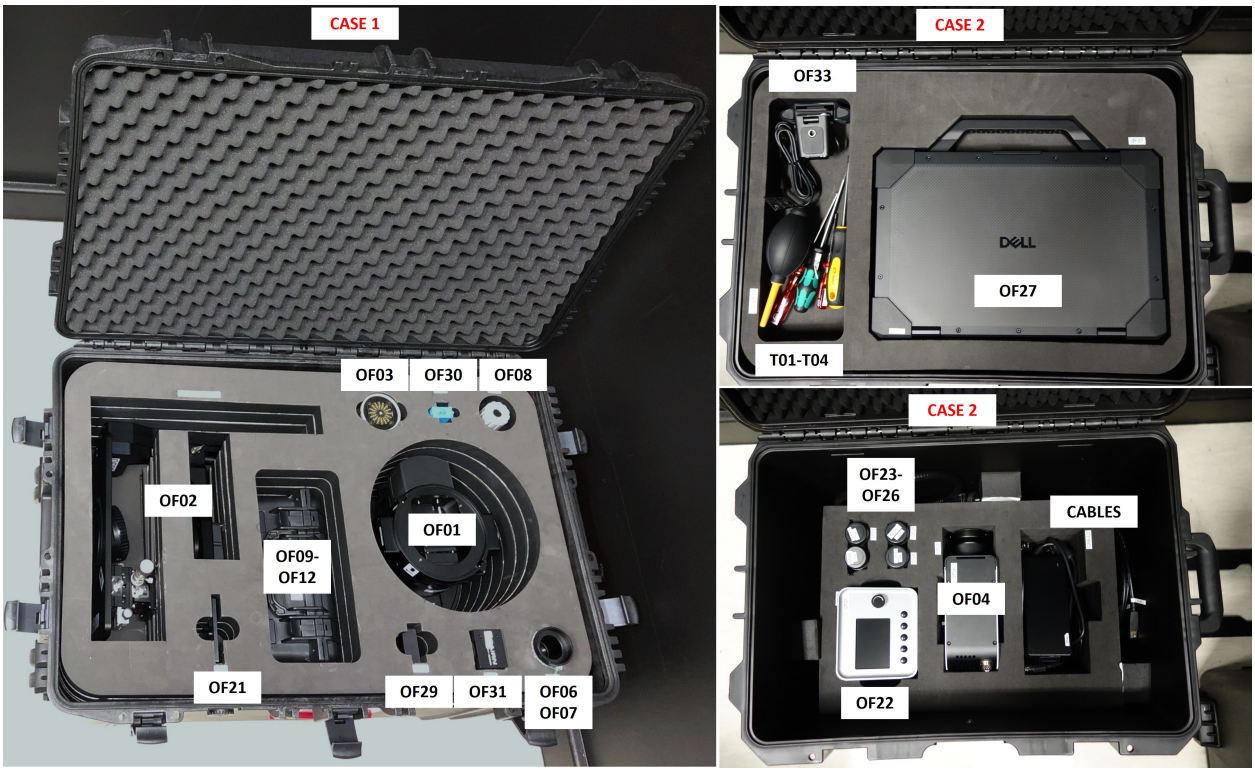

Figure 1: Visual layout of components in cases. Left: case 1 and its contents, right: case 2 upper and lower layers and their contents.

4 Inventory and Unpacking

1. Unclip and open each Pelican case.

2. Cross-check contents using the checklist.
3. Inspect components for any damage or missing parts.

Packing Contents

The openScope Traveller kit is shipped in two Pelican cases and includes the following main components:

4.1 Main Assembly Components

Part ID	Description
OF01	openFrame main assembly
OF02	Stage and transillumination assembly

4.2 Transillumination System

Part ID	Description
OF03	Transillumination source
OF18	Transillumination USB cable

4.3 IRIS-400 System

Part ID	Description
OF04	IRIS-400
OF05	IRIS dust cover
OF06	IRIS ring adaptor
OF07	IRIS-400 collimating lens and tube
OF08	IRIS pedestal
OF22	IRIS controller
OF23	IRIS-400 power cable
OF19	IRIS-400 interlink (between controller and optical unit)

4.4 Camera Systems

4.4.1 Rana Camera

Part ID	Description
OF11	Rana colour camera
OF12	Rana dust cover
OF15	Rana USB cable

4.4.2 Kikker Camera

Part ID	Description
OF09	Kikker monochrome camera
OF10	Kikker dust cover
OF16	Kikker USB cable
OF20	Kikker Power cable

4.5 Connectivity

Part ID	Description
OF17	USB Hub

4.6 Stage Objectives and accessories

Part ID	Description
OF21	Slide holder
OF23	Objective 10X 0.25 NA
OF24	Objective 20X 0.40 NA
OF25	Objective 40X 0.65 NA
OF26	Objective 100X-oil 1.25 NA
OF29	Stage cover
OF30	Test slides
OF31	Texas red filter cube

4.7 Laptop and laptop cables

Part ID	Description
OF27	Dell Rugged Laptop
OF28	Laptop charger

4.8 ScopeView

Part ID	Description
OF32	Gooseneck
OF33	Camera

4.9 Tools

Part ID	Description
T01	Phillips screwdriver
T02	Hex key driver 2mm
T03	Hex key driver 2.5mm
T04	Hex key driver 3mm

5 Assembly Guide

This assembly guide is intended to be followed in the order of the instructions. An instructional video guide covering assembly of the travellerScope is available at https://youtu.be/YOlEHORwTDU and can be referred to for additional clarity on the assembly process.

An alphanumeric code gives a reference to the part numbers required for each assembly step. Please ensure that sufficient time is allocated to the assembly process; it is suggested to allocate approximately two hours to assemble the Traveller.

Wear gloves and handle parts with care to protect optical components of the Traveller.

Following completion of steps 1-7 outlined below, the assembled Traveller should resemble Figure 2.

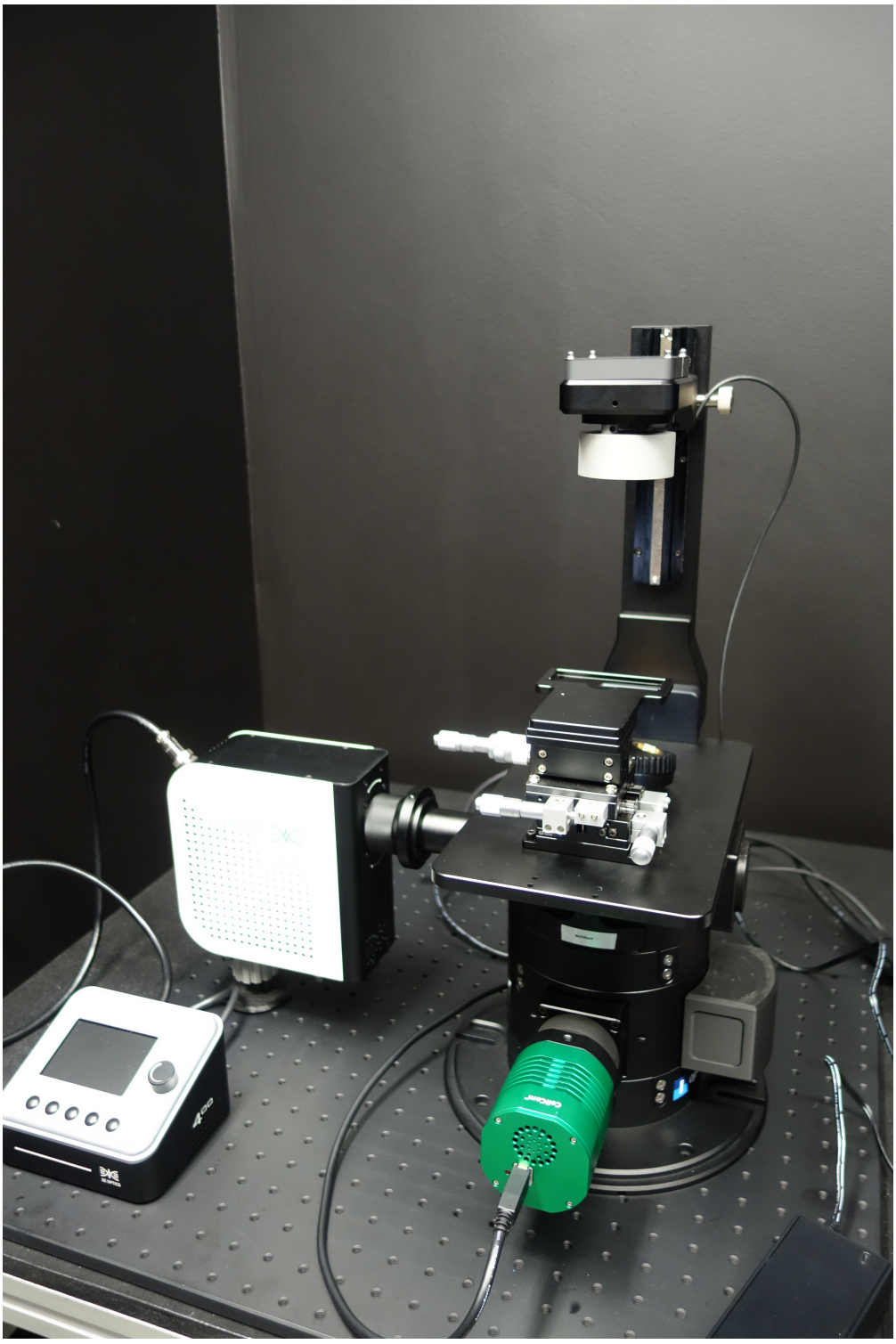

Figure 2: Assembled Traveller microscope.

Step 0: Toolkit

Remove the toolkit from the case. Only the tools supplied with the kit must be used with the openScope. These tools have been specifically included as the only ones required for assembling and using the microscope. Only use tools on the microscope when explicitly mentioned in the instructions. Using tools not supplied with the openScope may cause damage to the instrument. The tools present in the toolkit are:

- Phillips screwdriver (size PH1) #T01
- Hex key driver 2mm #T02
- Hex key driver 2.5mm #T03
- Hex key driver 3mm #T04

Step 1: Foundational openFrame Assembly

Important: Once assembled, the openFrame should not be moved. When choosing a location, select a room with:

- minimal vibrations,
- minimal dust,
- controlled ambient light.

1. Remove the foundational openFrame (part OF01) from the larger Pelican case (C1) and place it on a sturdy table. A work surface of 110cm $\times$ 80cm (or larger) is recommended. **The foundational openFrame is a heavy item and removing it from the Pelican case must be done with care to avoid injury or component damage.** Please seek the assistance of an additional person to remove the openFrame if necessary.
2. Remove baffels C4 and C5 from the foundational assembly (Figure 3).

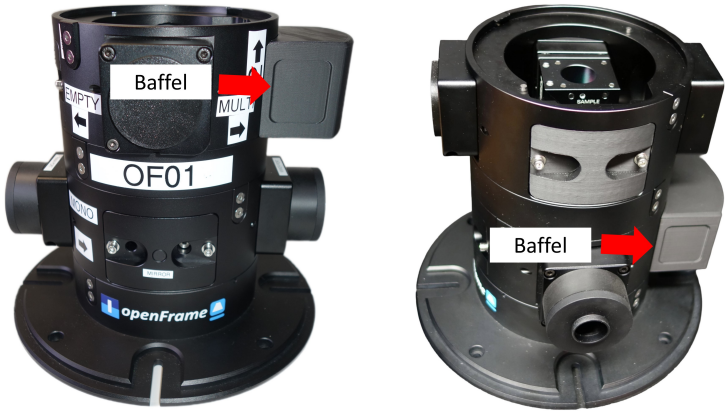

Figure 3: Foundational openFrame mechanical assembly (OF01).

Step 2: Installing the Stage and Transillumination Pillar

1. Loosen screws S02 and S03, located on OF01, with the 2.5mm Hex key driver (T03). **Screws should be loose but not entirely out.**
2. Remove OF02 from the larger Pelican case, C1.
3. Align the arrow labels ($\rightarrow$1 and $\rightarrow$2) on OF01 and ($\rightarrow$1 and $\rightarrow$2) on the underside of OF02 to couple OF01 and OF02 together (Figure 4). Note:$\rightarrow$1 aligns with its respective $\rightarrow$1 counterpart. The dowel pins click into place and the stage will be level upon correct seating.

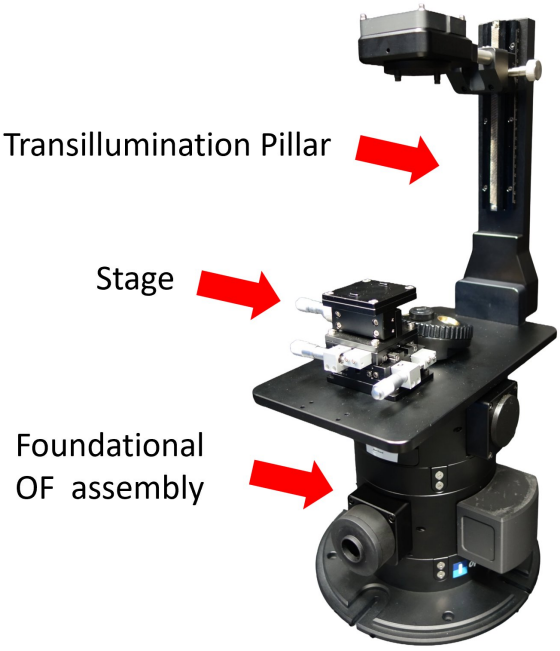

Figure 4: Stage and transillumination pillar mounted to the foundational openFrame mechanical assembly.

4. Tighten S02 and S03 using the 2.5mm Hex key driver (T03) (Figure 5).

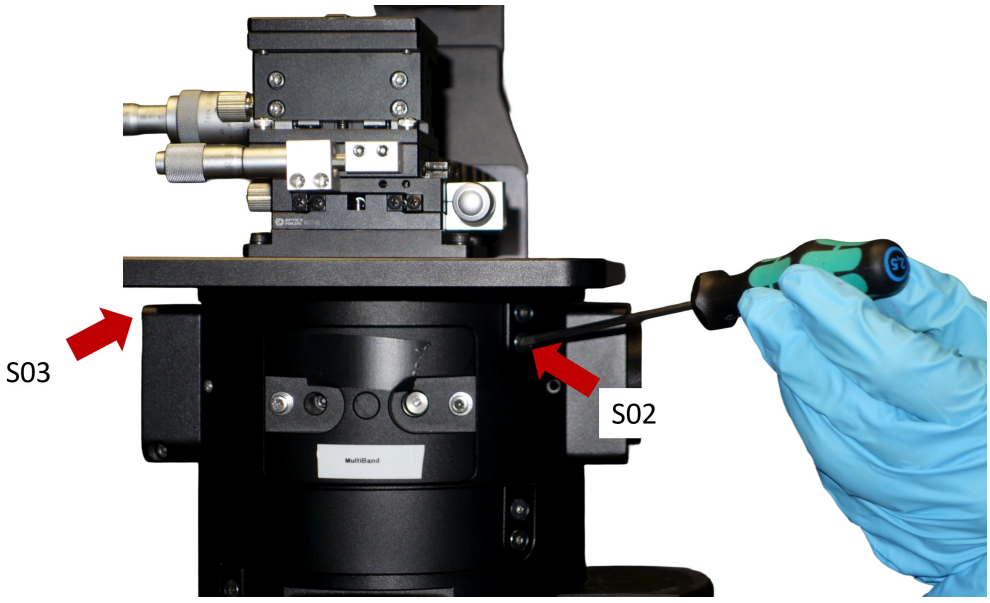

Figure 5: Tightening screws (S02 and S03) to secure the stage with 2.5mm Hex key driver (T03).

5. The height adjustment screw on the transillumination pillar may be turned to raise or lower the source as required (Figure 6).

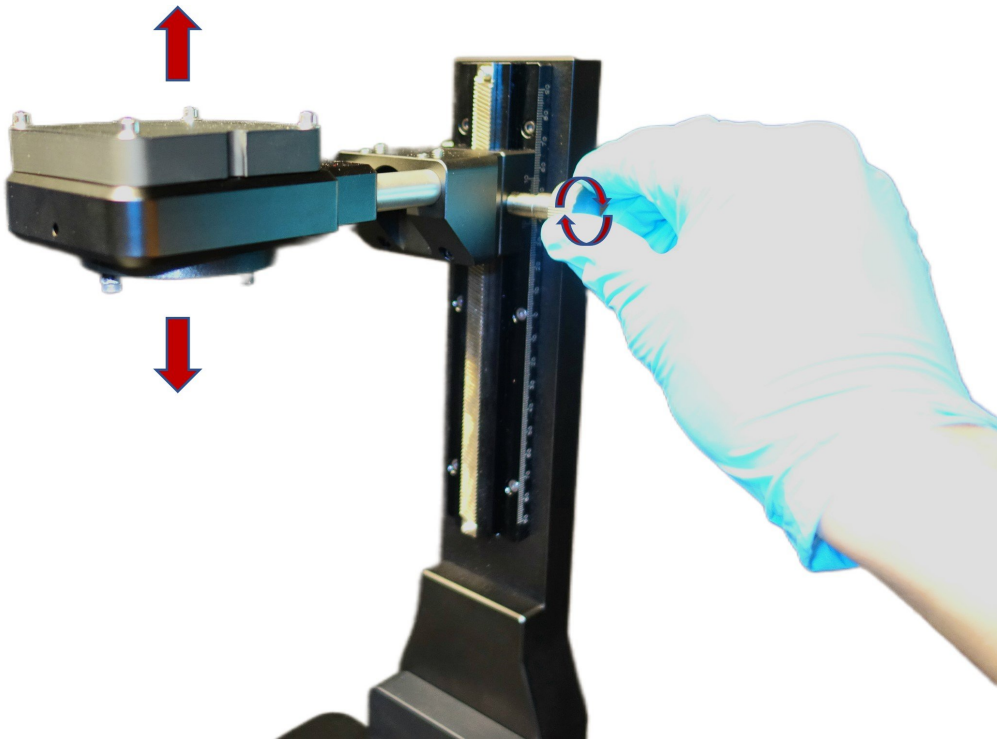

Figure 6: Adjusting the transillumination source height.

Step 3: Adding the Transillumination Source

Figure 7: Transillumination source (front and back).

1. Remove the transillumination source (OF03, Figure 7) from the Pelican case.
2. Loosen the top two screws on OF03 (Figure 7) using the 2.5mm Hex key driver (T03). Screws should be loose but not entirely out.
3. Ensure the USB connector faces towards the transillumination pillar.

4. Locate the mounting posts on the transillumination arm (OF02) and gently press OF03 into place. Avoid pressing directly on the LEDs (Figure 8).
5. Apply even pressure on the perimeter and tighten screws with the 2.5mm Hex key driver (T03) to secure the transillumination source in place.

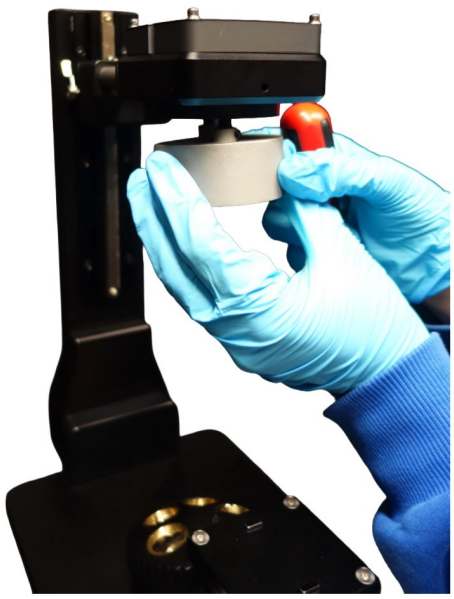

Figure 8: Fitment of the transillumination source onto the transillumination pillar and arm.

Step 4: Attaching the Camera Modules

1. Remove the camera box from the larger Pelican case.
2. For the monochrome Kikker camera (OF09):
    - Keeping the camera facing downwards (to minimise dust falling on the detector) remove dust cover OF10, see Figure 9.
    - Mount OF09 on the kikker port by turning clockwise until mounted. Ensure the label faces upwards (Figure 10A). **Do not overtighten.**
3. For colour Rana camera (OF11):
    - Keeping the camera facing downwards (to minimise dust falling on the detector) remove dust cover OF12.
    - Mount OF11 on port OF13 by turning clockwise until mounted. Ensure the label faces upwards(Figure 10B). **Do not overtighten.**

Figure 9: Dust covers (blue c-mount thread) present on each camera sensor port.

(a) Kikker fitment (b) Rana fitment

Figure 10: Installing each camera in its respective port on the Traveller.

Step 5: Adding the IRIS-400 Fluorescence Source

1. Remove IRIS-400 (OF04) from the smaller Pelican case. Handle carefully to protect optics and electronics.
2. Remove the pedestal (OF08) from the larger pelican case (C2). Place the pedestal (OFO8) on the working surface approximately 20cm to the left of the IRIS port on the openFrame OF01 (Figure 11). The pedestal will support the IRIS-400 once installed, as shown in Figure 15.

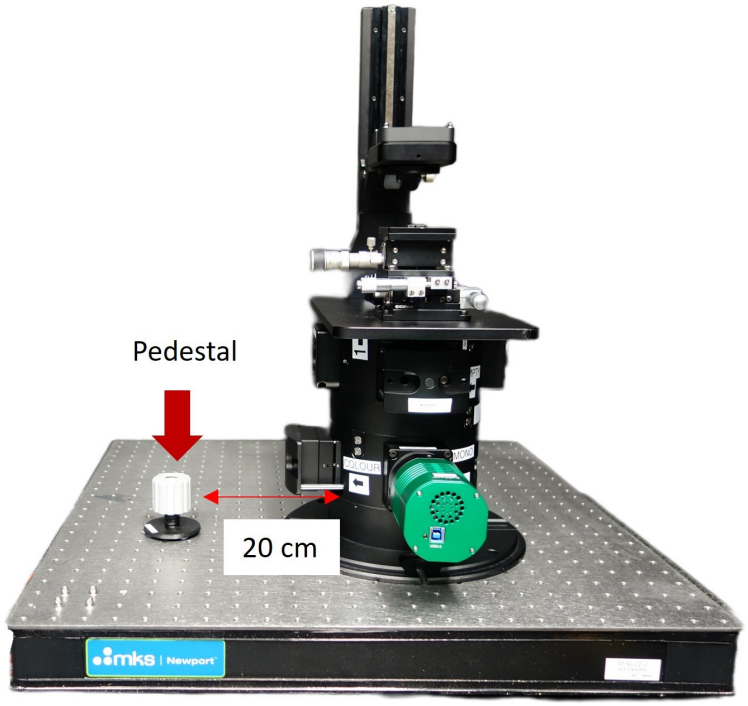

Figure 11: Placing the pedestal.

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3. Remove dust cover (OF05) from the IRIS-400 (OF04) as shown in Figure 12.

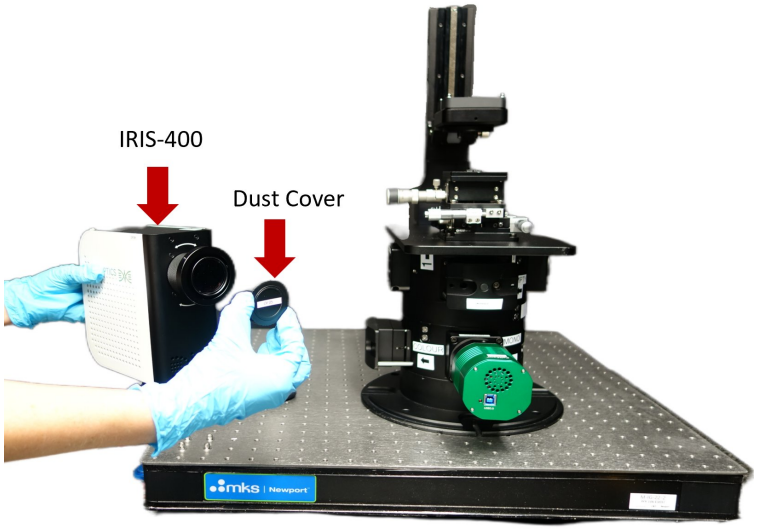

Figure 12: Removing the dust cover.

4. Remove OF06 and OF07 from the case.
5. Guide OF06 into the IRIS-400 optical output port (OF04), as shown in (Figure 13).

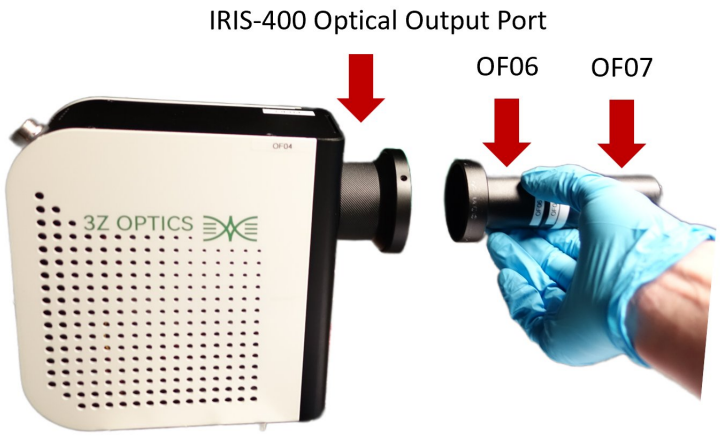

Figure 13: Guiding OF06 into the optical output port.

6. Secure OF06 with three grub screws using the 2mm Hex key driver (T02) (see Figure 14).

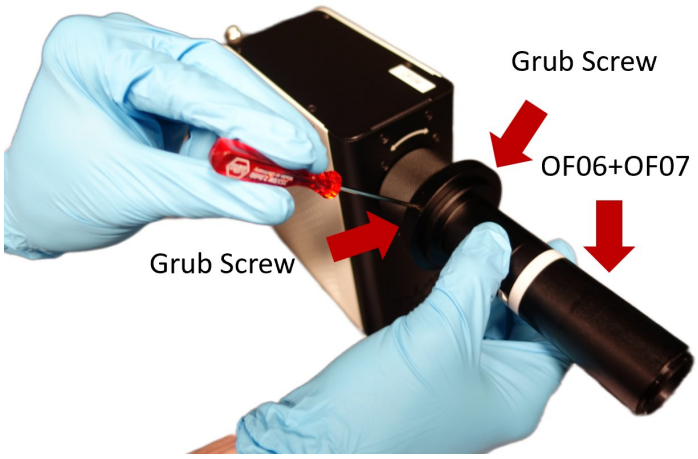

Figure 14: Tightening the three grub screws.

7. Insert OF07 into the openFrame OF01. This will couple the IRIS-400 to the openFrame. Insert the tube only as far as the guideline mark (do not exceed). The pedestal (OF08) should be underneath the IRIS-400 main body. Rotate pedetal (OF08) to adjust the pedestal height until it gently supports the IRIS-400 (Figure 15). Rotate OF08 either anti-clockwise to raise or clockwise to lower the pedestal height. Once complete, the mounted IRIS-400 should resemble the setup in Figure 15.

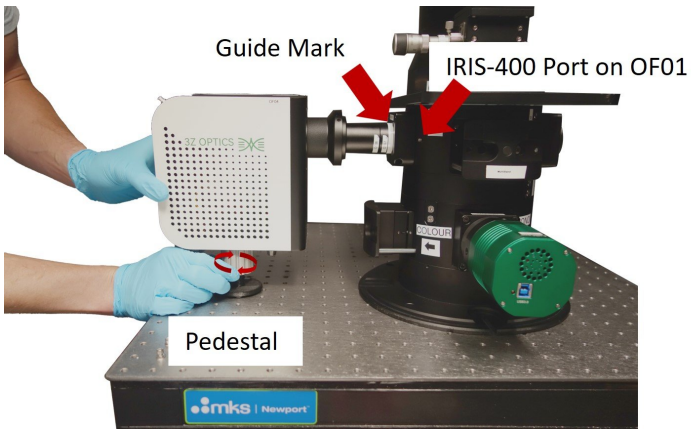

Figure 15: IRIS-400 supported by the pedestal and coupled to the fluorescence port of the Traveller.

Step 6: Power and Data Cabling

1. Connect IRIS-400 controller (OF22) OUTPUT jack to the IRIS-400 main body (OF04) using cable OF19. Ensure the IRIS-400 main body (OF04) is secure and supported whilst doing so.
2. Connect DC power cable connector OF23 to the INPUT jack of the IRIS-400 controller (OF22) (ensure correct orientation). Ensure that the guide pin is oriented correctly; otherwise, the cable will not secure correctly, and the pins risk damage. Ensure arrows on the connector are facing upward as per Figure 16.
3. **Rana connection to USB hub:** Insert cable OF15 into OF15 labelled port on the USB-HUB (OF17). Connect the other side of OF15 to Rana (OF11).
4. **Kikker connection to USB hub:** Insert cable OF16 into OF16 labelled port on the USBHUB (OF17). Connect the other side of cable OF16 to Kikker (OF09).
5. **Kikker connection to power supply:** Connect the DC adaptor 12V (OF20) to the Kikker camera (OF09).
6. Insert USB hub cable OF17 into laptop port P01.
7. Connect the transillumination source (OF03) to the USB-C cable (OF18). Connect the other end (USB 2.0) into port P02 of the laptop.
8. Place the slide holder (OF21) on the XYZ stage (magnetically mounted and will clip in to place).
9. Remove the two travel screws located on either side of the multiband cube using the 3mm Hex key driver (T04). See Figure 17, which shows the two screws on one side of the Traveller.
10. Remove the two travel screws located on either side of the mirror adjustment slider using the 3mm Hex key driver (T04). See Figure 18.

Figure 16: Connection of DC power connector (OF23) to the INPUT jack of the IRIS-400 controller (OF22)

Figure 17: Right-side transport screw on multiband cube. Unscrew and remove both right and left screws. Store screws in a safe place.

Figure 18: Remove travel screws on mirror slider. Unscrew and remove both right and left screws. Store screws in a safe place.

Step 7: Final Assembly Steps!

1. Connect the power cable (OF28), to the laptop port P03.
2. Connect the laptop power cable (OF28), kikker power cable (OF20), and IRIS-400 power cable (OF23) to the ac mains power supply.
3. Objectives may be mounted into the turret as required. The turret may be manually rotated. Note: To protect objectives, only mount the required objectives.
4. Congratulations, you have successfully assembled the Traveller and can proceed with the software guide!

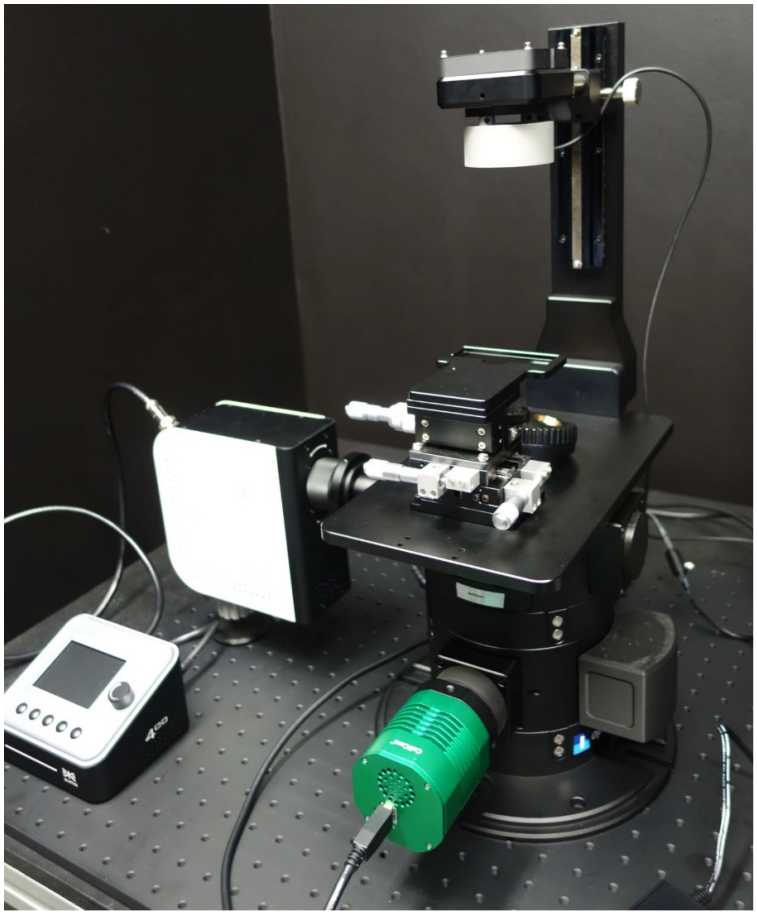

Figure 19: Completed Traveller hardware assembly.

6 Software Guide

First Launch Instructions

In the Assembly Guide, you successfully assembled the hardware for the Traveller. **Well done!** You are now ready to power on the system and initialise the software.

1. Ensure all applicable USB connectors from the openScope Traveller are connected to the laptop.
2. Confirm the following connections:
   - OF17 → Laptop port **P01**
   - OF18 → Laptop port **P02**
3. Connect the laptop to its power supply.
4. Power on the laptop.
5. Log in using the following credentials:

Username: IDM
Password: OSCA2025

6. Launch the Micro-Manager software platform by clicking on its desktop icon.
7. In the Micro-Manager startup window:
   - Select the **Default User** profile.
   - Ensure the hardware configuration file `CellCam_MultimodeLED.cfg` is selected (see Figure 20) before proceeding.

Figure 20: Select the Default user profile and displayed configuration.

8. The Micro-Manager control window will open (see Figure 21).

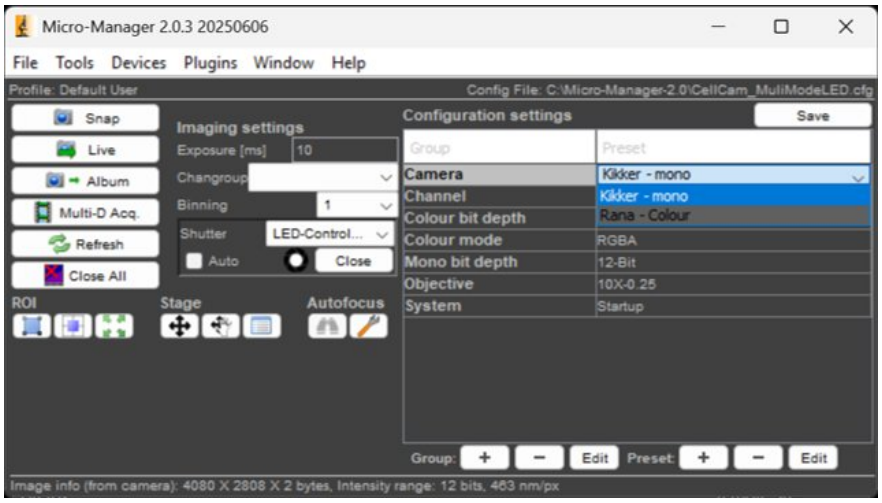

Figure 21: Micro-Manager control window after successful startup.

9. Follow the appropriate imaging guide 6 based on your requirements:
   - **Brightfield Imaging** 6.1 — for transmitted light imaging.
   - **Fluorescence Imaging** 6.2 — for fluorescence imaging.

6.1 Brightfield Imaging

Brightfield imaging with the Traveller microscope and Micro-Manager software requires correct hardware connections and proper software initialisation. Ensure that all cables

are securely connected and that Micro-Manager has been launched using the appropriate base configuration file.

1. Insert an objective lens into the objective turret. It is recommended to start with a **low-magnification** objective and progress to higher magnifications. **Note:** Do not use immersion oil with any objective lenses except the supplied 100×-oil objective.

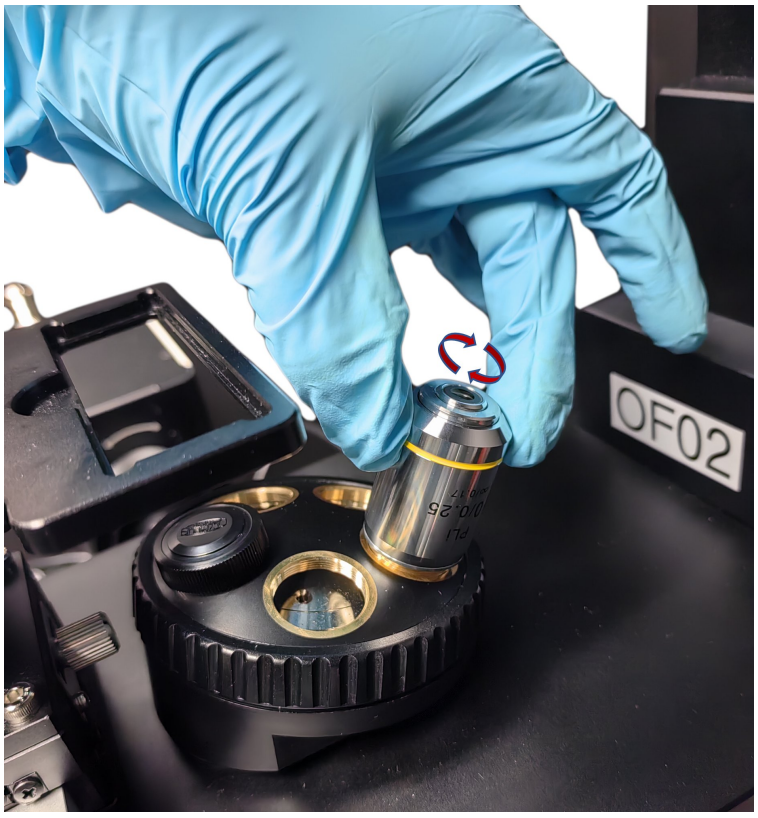

Figure 22: Inserting the objective into the turret. Rotate the objective to ensure it is secure and turn the turret to position the objective underneath the stage.

2. In the Micro-Manager hardware configuration window, select the appropriate objective lens from the **Objective** menu.

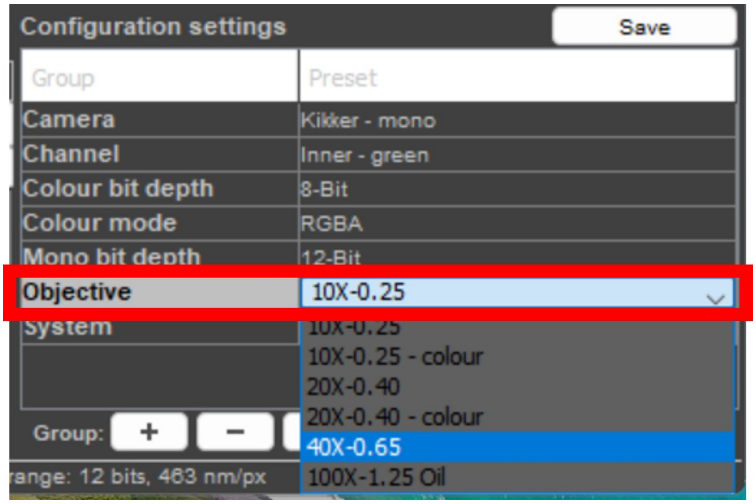

Figure 23: Ensure the correct objective lens is selected. Note that **this needs to be updated manually every time you change objectives** to ensure the metadata associated with your image is correct.

3. Verify that the filter cube position in the filter layer is set to an **empty position**. See Figure 24.

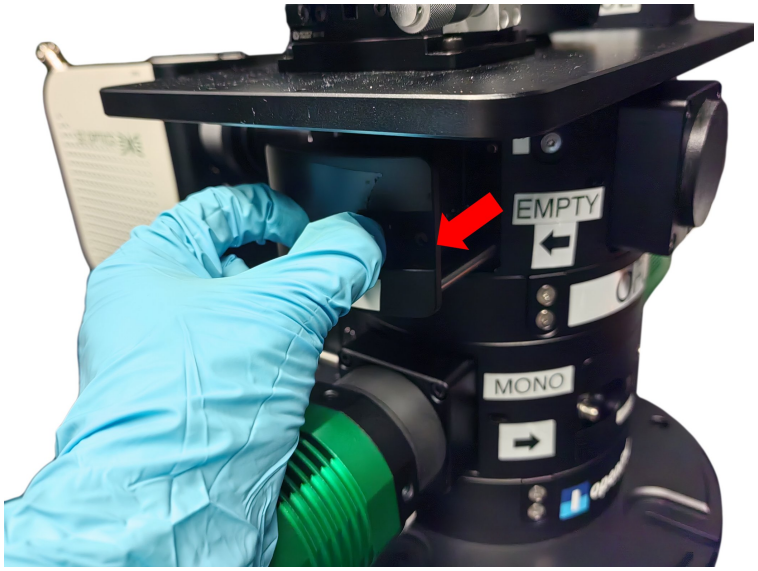

Figure 24: Ensure the filter cube is in the empty position by pulling the filter slider out towards the user as indicated by the empty label.

4. Carefully place a prepared sample slide on the microscope stage. Ensure the **coverslip faces downward** toward the objective lens.
5. Ensure the **Shutter** checkbox option is set to **Auto**.

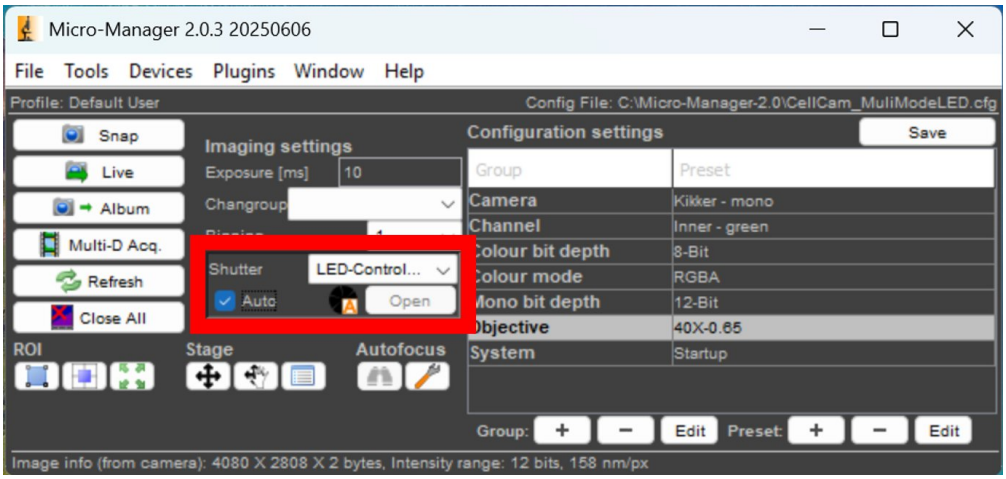

Figure 25: Ensure Auto shutter checkbox is selected in the Micro-Manager configuration window.

6. From the Micro-Manager camera selection menu, choose the desired camera device. Begin with the monochrome camera for most imaging applications. For colour imaging (e.g., histology samples), you may switch to the Rana camera. **Suggested camera selection:**

   - **Kikker (Monochrome)** — for high-sensitivity grayscale imaging.
   - **Rana (Colour)** — for colour imaging.

7. Adjust the **camera tilt mirror** on the frame to direct the optical path to the selected camera. For colour imaging, push the slider to the **left**. For monochrome imaging, push the slider to the **right** (see Figure 26).

Figure 26: Adjust the camera tilt mirror on the frame to direct the optical path to the selected camera. To select the monochrome camera, pull the mirror slider out to the right. To select the colour camera, pull the mirror slider out to the left.

8. In the Micro-Manager control window, open the **Channel** menu and select a brightfield illumination source. Recommended setting: **Mid RGB**.

9. Click the **Live** button in the Micro-Manager control window to begin live image preview. Two windows will appear:

    - The **Preview Window** — displays the live camera feed.
    - The **Histogram Window** — displays exposure and dynamic range information.

    Refer to the additional documentation **13** if unfamiliar with interpreting histograms.

10. If no image appears and the histogram is skewed left, increase the exposure (Figure 27). A typical exposure range for brightfield imaging on this system is between 1ms and 50ms.

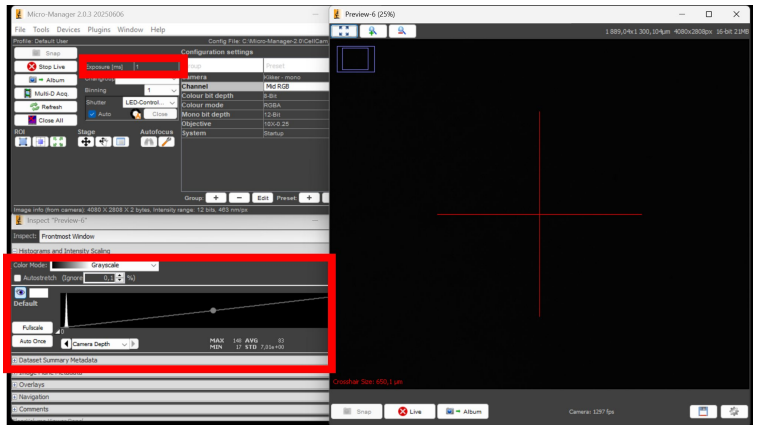

Figure 27: No image and the histogram is skewed to the left - increase exposure.

If the preview is overexposed (white image) or the histogram is skewed right, decrease the exposure. See Figure 28.

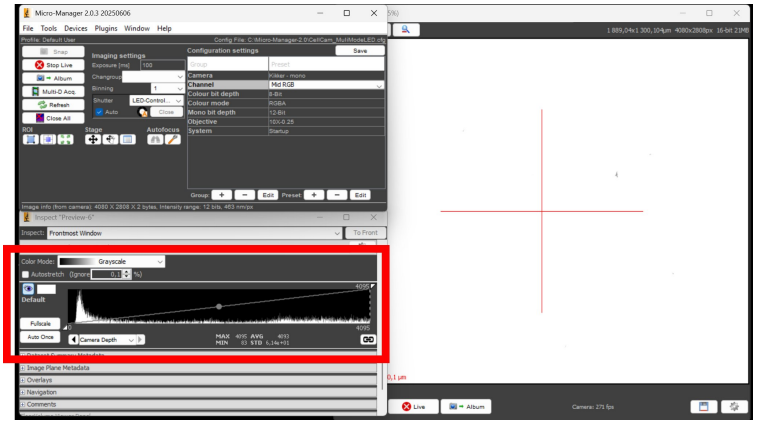

Figure 28: Preview is overexposed or the histogram is skewed to the right - decrease exposure.

Once the histogram is in the correct range (Figure 29), proceed to find focus.

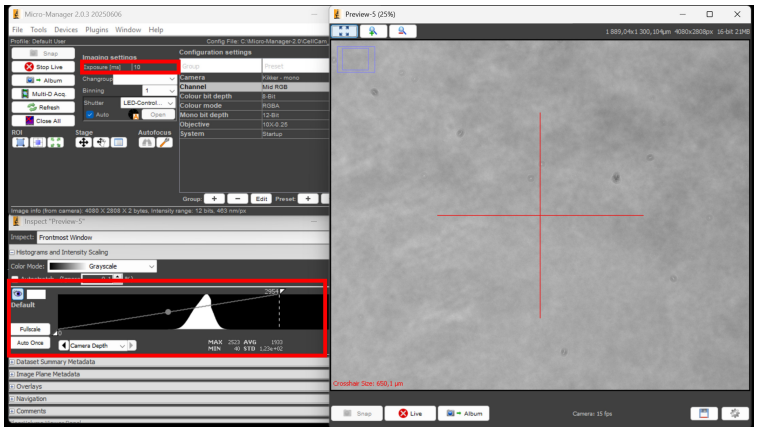

Figure 29: Histogram in good range for finding focus.

11. Once the sample becomes visible, use the **X and Y micrometer knobs** to move the sample laterally (see Figure 30). Bring the sample into focus by carefully rotating the **Z (focus) knob**. **Caution:** Do not allow the objective lens to contact the sample slide—this may cause damage.

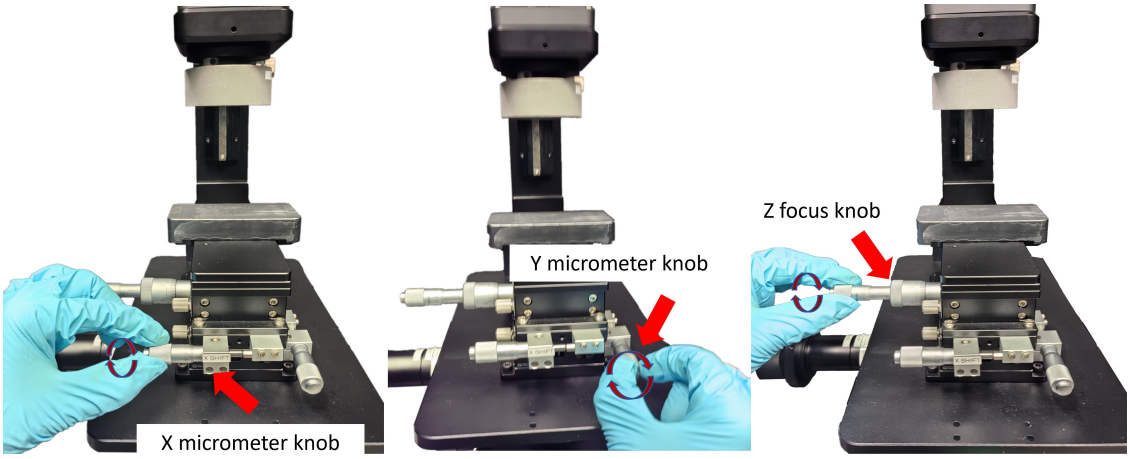

Figure 30: Use the X, Y micrometer knobs to move the sample laterally and the focus knob to bring the sample into focus.

12. After achieving focus, examine the histogram to verify adequate dynamic range without underexposure or saturation (Figure 31). Examine the Min and Max values displayed underneath the histogram which give the intensity of the least and most saturated pixels. Remember, you want to maximise contrast and range but avoid clipping (having pixels at the lowest and highest intensity values). Ensure that there are no under- or oversaturated pixels. For a 12-bit monochrome image, there should not be pixels with an intensity value of 4095. If there are oversaturated pixels, decrease the exposure or LED intensity.

13. Capture images using one of the following methods:

- Click **Save** in the lower-right corner of the live display window to save the current view directly (Figure 31).
- Alternatively, click **Stop Live**, then click **Snap** and save the image.

Please refer to Data Management (Section 7) for data storage guidelines.

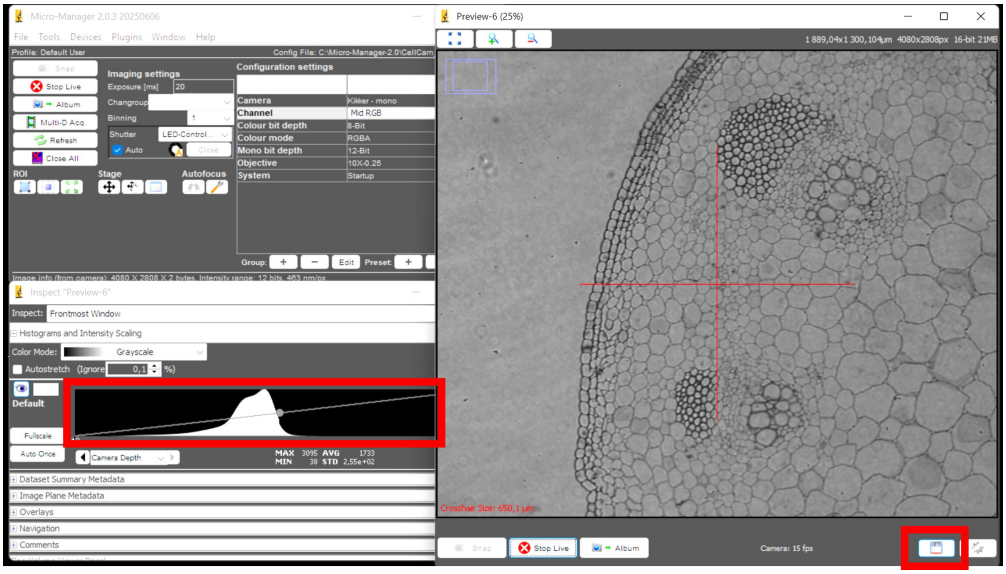

Figure 31: Examine the histogram to ensure you are maximising the dynamic range of the camera without oversaturating any pixels. Then save the image by clicking on the floppy disk icon in the bottom right corner of the image.

6.2 Fluorescence Imaging

Fluorescence imaging with the Traveller microscope and Micro-Manager software requires correct hardware connections and proper software initialisation. Ensure that all cables are securely connected and that Micro-Manager has been launched using the appropriate base configuration file.

1. **Insert the objective lens** into the turret. Begin with a low-magnification objective lens and progress to higher magnifications as needed (Figure 32). Do not use immersion oil with any objective lens except the supplied 100× objective.

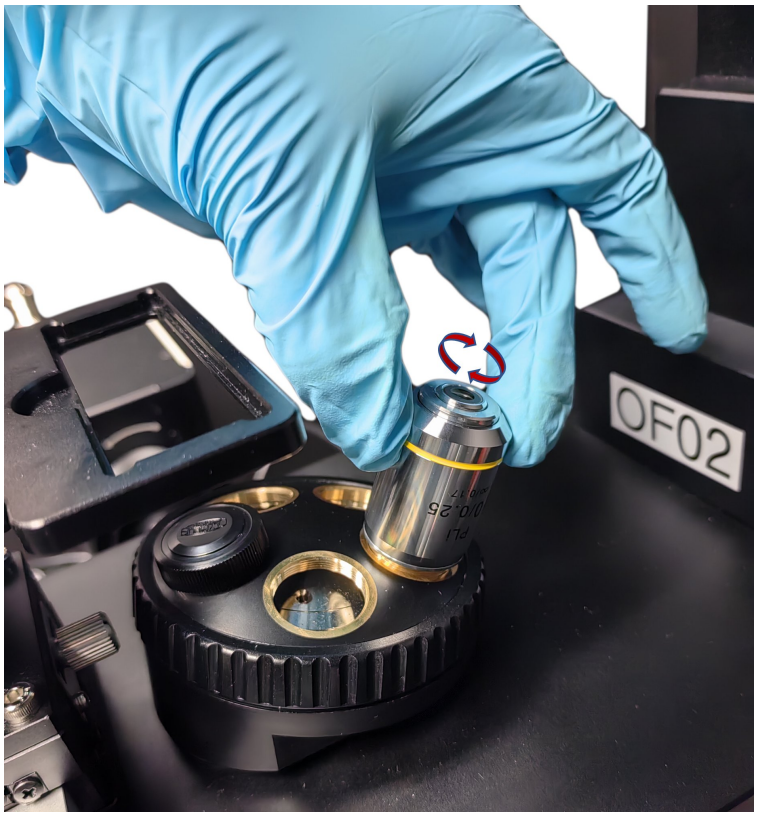

Figure 32: Inserting the objective into the turret. Rotate the objective to ensure it is secure and turn the turret to position the objective underneath the stage.

2. In the Micro-Manager hardware configuration window, select the appropriate objective from the **Objective** menu (Figure 33). Note that **this needs to be updated manually every time you change objectives** to ensure the metadata associated with your image is correct.

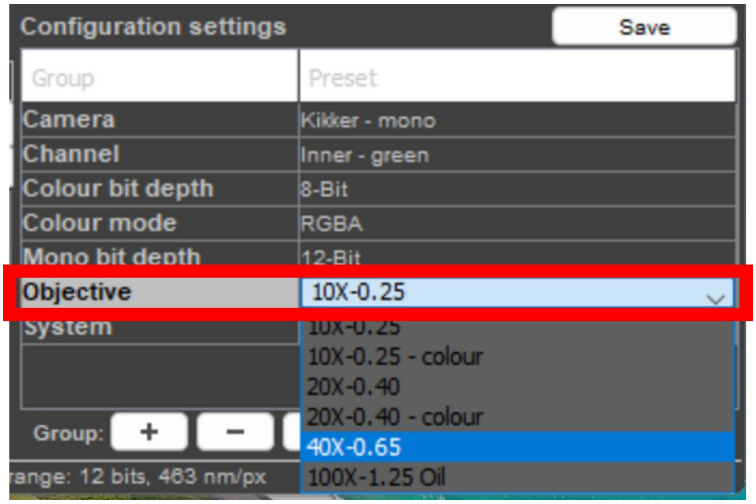

Figure 33: Ensure the correct objective is selected. Note that this needs to be updated manually every time you change objectives to ensure the metadata associated with your image is correct.

3. **Verify the filter cube position:** ensure that the filter layer is set to the **Multiband** position to enable DAPI, FITC, and TRITC channels.

Figure 34: Ensure that the multiband filter is positioned in the optical path. If not, pull the slider in the direction indicated by the ”MULTI” label.

4. Carefully place a prepared sample slide on the stage holder with the coverslip facing down toward the objective. **Cover the slide with the stage cover** (Figure 35) - this is important to minimise detection of ambient light in the room.

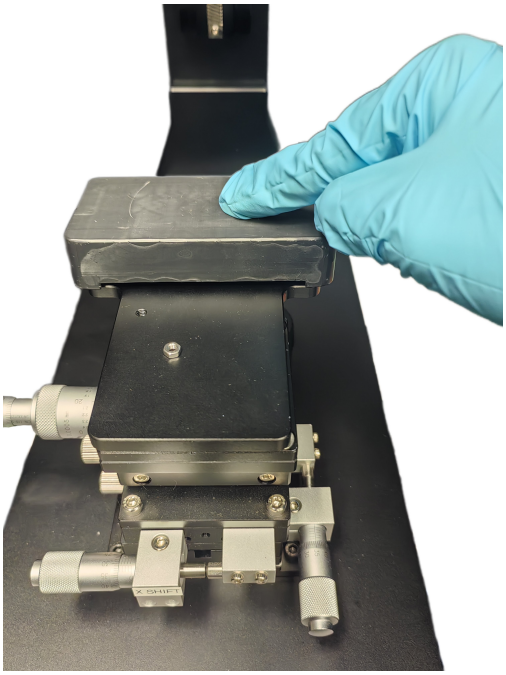

Figure 35: Cover the slide with the stage cover.

5. From the camera selection menu, select the **Kikker** camera.
6. Ensure the **Shutter** checkbox option is set to **Auto**.

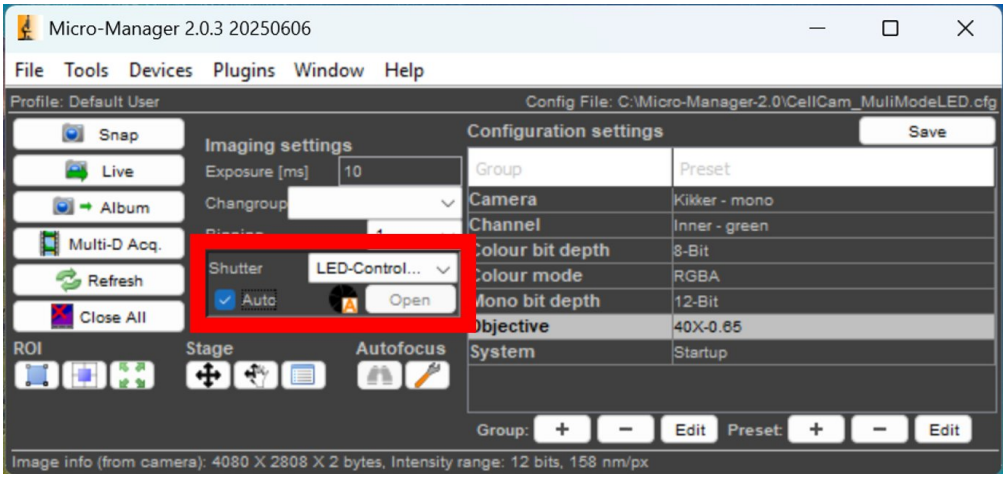

Figure 36: Ensure Auto shutter checkbox is selected.

7. Adjust the mirror slider on the microscope frame so that the optical path is directed to the monochrome camera (**Kikker**). Ensure the mirror slider is pushed fully to the right.

Figure 37: Direct the light path to the monochrome camera by pushing the mirror slider to the right.

8. In the Micro-Manager control window, select **OFF** from the **Channel** menu.
9. Click the **Live** button in the Micro-Manager control menu to begin live image preview. Two additional windows will appear:
    - The **Preview Window** displays the live camera feed.
    - The **Histogram and Metadata Window** provides exposure, gain, and image intensity information. The histogram should initially show minimal intensity since the IRIS-400 illumination source is off. Refer to the additional documentation **13** if unfamiliar with interpreting histograms.
10. Locate the power button on the back of the IRIS-400 controller (OF22) and power on the unit.
11. Consult the excitation and emission spectra of your fluorophore of interest and select an LED of appropriate wavelength to excite your fluorophore. It is important that you know the absorption and emission spectra of all of the fluorophores used in your experiment and ensure that they are compatible with the filter sets and IRIS-400 LEDs when you are planning your imaging experiment. *If you are using the daffodil root slide supplied with the Traveller, you can look at autofluorescence using the Green LED*.
12. To select the LED of interest, press the desired wavelength button (**R**, **G**, **B**, or **UV**) on the IRIS-400 controller (OF22). When a fluorescence channel is selected, a red dot will appear next to the corresponding wavelength intensity indicator (Figure 38).
13. Adjust illumination intensity by clicking once on the desired wavelength button (**R**, **G**, **B**, or **UV**) and rotating the control knob on the right side of the unit (Figure 38).

- **Tip:** Begin with longer wavelengths (e.g., red or green) before proceeding to higher-energy shorter wavelengths (blue or UV) to minimise photodamage.
- **Tip:** Begin with a lower LED intensity and gradually increase it until the sample is clearly visible. This minimises photobleaching and reduces thermal drift for delicate specimens.

14. Press the wavelength button a second time to activate illumination.

Figure 38: When pressing the desired wavelength button, a red dot will appear next to the LED of interest. Adjust the illumination intensity by rotating the dial. Press the button underneath the LED of interest to turn the LED on.

15. Click the **Live** button again to preview the illuminated sample.
16. If no image appears and the histogram is compressed to the left (Figure 39), increase the exposure time in milliseconds. A typical exposure range for fluorescence imaging on this system is between 100ms and 800ms.

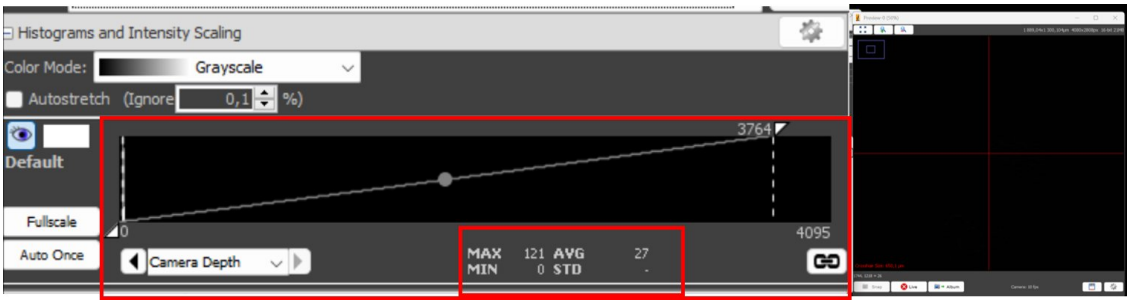

Figure 39: Example of an image where exposure time and/or LED intensity should be increased.

Conversely, if the image appears white and the histogram is saturated to the right 40, decrease the exposure time or LED intensity.

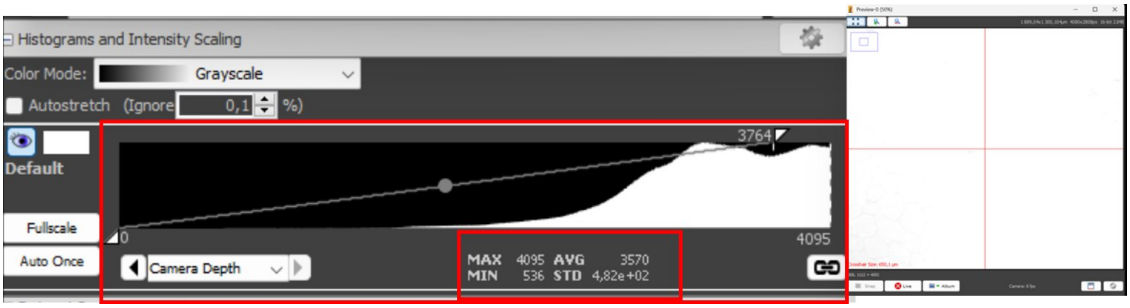

Figure 40: Example of an image where exposure time and/or LED intensity should be decreased.

17. Once an optimal exposure is set, adjust the sample position and bring it into focus using the XYZ stage:
    - Use the X and Y micrometer knobs (Figure 41) to translate the sample.
    - Use the Z focus knob (Figure 41) to adjust the focal plane. Avoid bringing the objective too close to the coverslip to prevent damage.

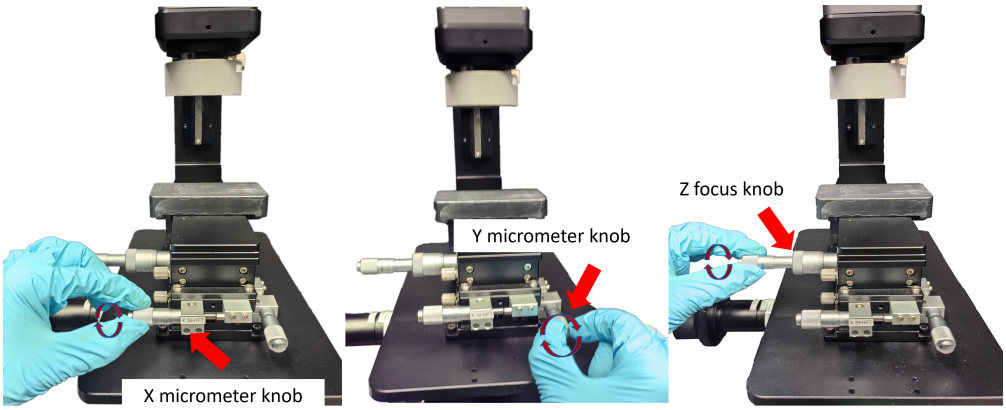

Figure 41: Use the X, Y micrometer knobs to move the sample laterally and the focus knob to bring the sample into focus.

18. Use coarse and fine focus controls on the pillar to bring the region of interest into sharp focus.

19. Once in focus, review the histogram and fine-tune exposure if needed. Examine the Min and Max values displayed underneath the histogram which give the intensity of the least and most saturated pixels (Figure 42). Remember, you want to maximise contrast and range but avoid clipping (having pixels at the lowest and highest intensity values). Ensure that there are not under- or oversaturated pixels. For a 12-bit monochrome image, there should not be pixels with an intensity value of 4095. If there are oversaturated pixels, decrease the exposure or LED intensity.

An example of a histogram with a good range that avoids over- or undersaturated pictures is shown below (Figure 42). Note that the shape of the histogram will vary depending on the type of sample you are imaging. For example, a sparse sample will have more low-value pixels than a dense sample.

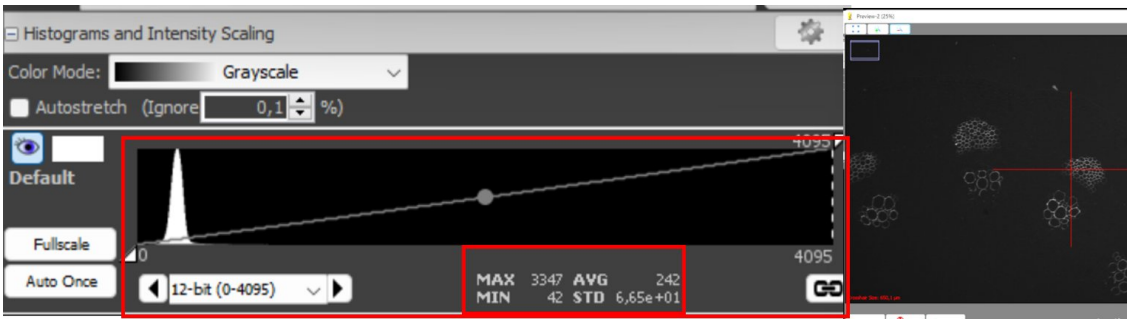

Figure 42: An example of a histogram where the range is large and clipping is avoided.

20. You are now ready to capture your first image! **Capture images** using one of the following methods:

    - Click **Save** in the lower-right corner of the live display window to save the current view directly.
    - Alternatively, click **Stop Live** and then **Snap** to acquire and save a single image.

    Please refer to Data Management (Section 7) for data storage guidelines.

7 Data Management

Proper handling and transfer of imaging data are essential for maintaining both system performance and research integrity. This section provides guidance on temporary storage, data transfer, and long-term archiving.

Storage Guidelines

- During image acquisition, all data should be saved to the dedicated temporary storage drive (**D:/**). Users must create a clearly labeled folder (e.g., with their name or institution) for organisational purposes.
- The temporary storage drive (**D:/**) is purged periodically to maintain free space. Data stored here is **not permanent** and may be deleted without notice.
- Under no circumstances should data be saved directly to the local system disk (**C:/**). This partition is reserved for the operating system and imaging software backend, and improper use may compromise system performance.

- At the conclusion of your imaging session, copy or transfer all data to one of the following:
  - Removable media such as a USB flash drive or external hard disk
  - Cloud-based storage services accessible via the laboratory network or your institutional credentials
- Verify the integrity of transferred data by reopening a subset of files before deleting from the temporary storage drive.
- If multiple users are scheduled, ensure that all data has been removed promptly to free up space for subsequent sessions.

File Formats and Conventions

- Default image formats include TIFF (8-bit or 12-bit), and AVI for time-lapse sequences.
- File naming convention: texttttYYYYMMDD_SampleID_UserInitials_ImagingMode. Example: texttt20250620_EColi_FM_BF.tif.
- All metadata (exposure time, illumination mode, objective lens, and user-defined notes) is embedded within TIFF headers when supported.
- Users are encouraged to maintain a parallel digital lab notebook recording acquisition parameters and file references.

Data Security and Backup

- Always maintain at least two independent copies of critical datasets (e.g., local + external drive, or local + cloud).
- Encrypt sensitive or unpublished data before uploading to shared platforms if required by institutional policy.
- Check your institution's data management policy to ensure compliance with storage duration, privacy, and sharing requirements.

NOTICE: The openScope team cannot be held responsible for lost data resulting from failure to transfer files from temporary storage.

8 Maintenance and Cleaning

Optical Components

- **Wear powder-free gloves at all times.**
- **Use the bulb blower to remove dust on objective lenses only if visible artefacts are present due to dust on the objective lens.**
- **Avoid touching any of the optical components directly unless specifically instructed to by the openScope support team.**

9 Disassembly

Disassembly of the frame follows the reverse order of the Assembly Guide Section 5.

Storage Protocol

- Always pack the hardware in the supplied Pelican cases.
- Store in a dry, cool environment.

Software Maintenance

- Check GitHub monthly for updates: https://github.com/ImperialCollegeLondon/openFrame
- Use update script located in `/openScope/update.sh`

10 Troubleshooting

Issue	Cause	Solution
No camera feed	USB disconnected or driver missing	Reconnect USB and restart software
Image too dark	LED not powered	Check LED connection and power supply
Poor resolution	Lens smudged or misaligned	Clean objective lens with bulb blower, refocus
GUI crash	Missing Python dependency	Run update script to reinstall

11 Scopeview

12 Fluorophore Excitation Reference

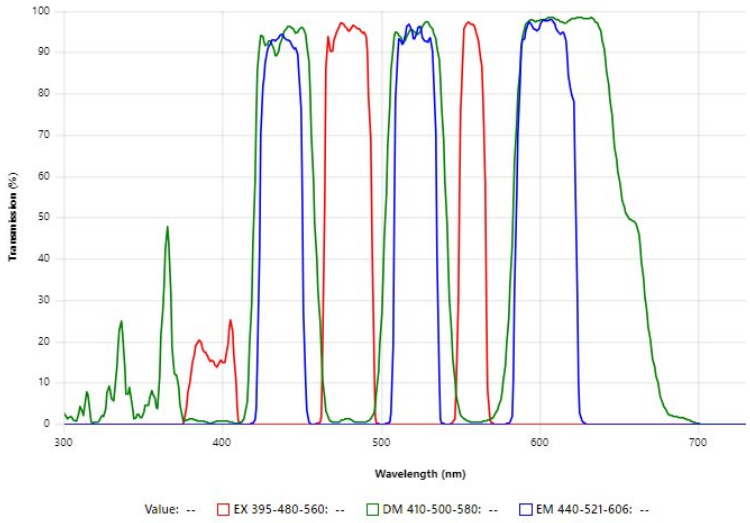

Figure 43: Triple band pass filter (DAPI/Green/Orange) supplied in the Traveller filter slider. Red - Excitation, Green - dichroic mirror, Blue - Emission filter

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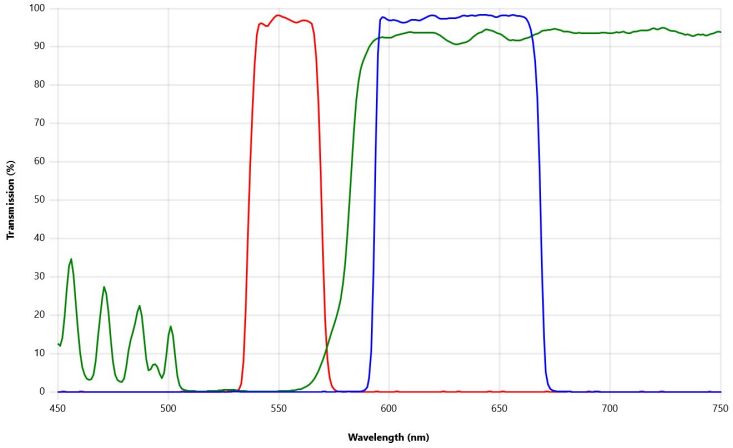

Figure 44: Texas Red Filter set supplied with the Traveller. Red - Excitation, Green - dichroic mirror, Blue - Emission filter

375 - 28 475-40 560 - 35 625-40

13 Introduction to histograms

What is a histogram?

A histogram is a graphical representation of the pixel intensities in an image. The **X axis** represents the range of available intensity values or the bit depth of your image. The **Y axis** represents the number of pixels at each intensity value (Figure 45). The shape of a histogram shows how pixel intensities are distributed in an image. By examining the histogram you can determine if your image is too light or dark and determine the degree of contrast. This will enable you to optimise your microscopy experiment and produce useful, quantifiable microscopy data.

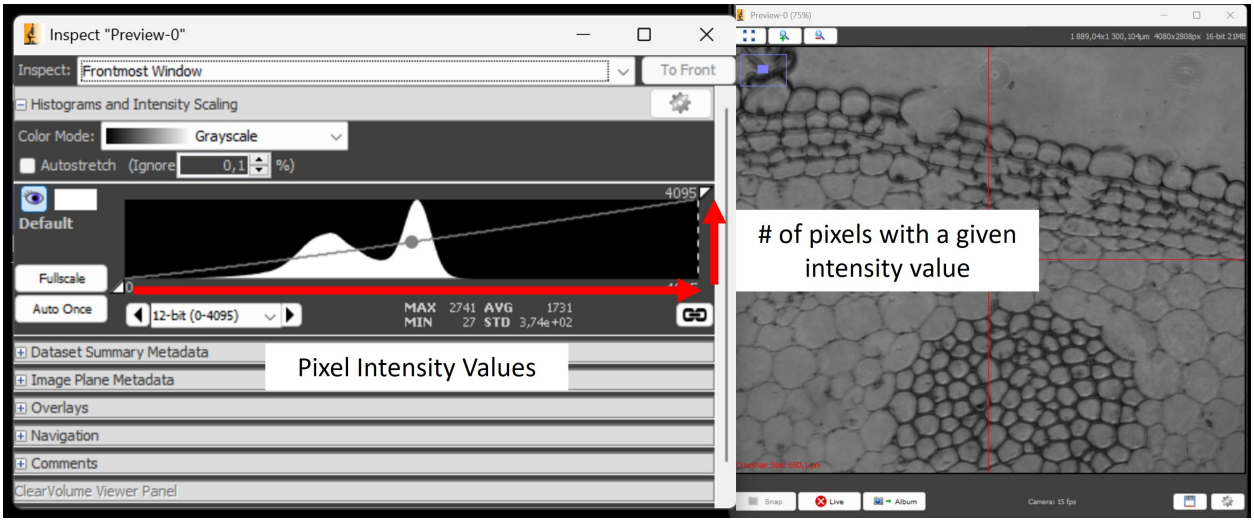

Figure 45: Interpreting histograms. The X axis depicts the range of possible pixel intensities while the Y axis depicts the number of pixels with a given pixel intensity.

How to interpret a histogram?

If your histogram occupies a narrow range on the X axis, most of your pixels have the same intensity value and there is low **low contrast**. If your histogram occupies a wide range of pixel intensity values, you have **high contrast**.

Ideally, you want to **maximise contrast** (that is, have a histogram with a wide distribution of pixel values) while **avoiding clipping**, which occurs when your image has pixels with intensity values at the minimum or maximum intensity value. A sharp peak at 0 may indicate loss of detail in dark regions. A sharp peak at the maximum intensity indicates oversaturated pixels and will reduce the details detectable in your image.

Adjusting the Display Range (Min/Max values) in Micromanager

You can change the appearance of your image in Live view by adjusting the minimum and maximum display values shown on the histogram. These adjustments do not alter the underlying pixel intensity data but instead alter the way those values are displayed on your screen to enable you to better visualise features in your sample. Adjusting the min/max values can enable visualisation of low-intensity images and enhance contrast to enable you to capture optimal images of your sample.

How to adjust the min/max display values

1. Identify the min and max triangular sliders at the top and bottom of the histogram (Figure 46). The left slider (minimum) sets the darkest displayed value while the right slider (maximum) sets the brightest displayed value.
2. Click and drag these sliders to the left or right to adjust the display range.
3. Adjust until you can clearly see the features of interest.
4. Make sure that the histogram shows that all parts of the intensity curve of your image fall between the min and max display value that you set. Do not set the minimum or maximum values so far inward that they exclude real pixel values in your image. Setting the min or max values further inward than real pixel values will result in the inability to distinguish features in dark or light areas.

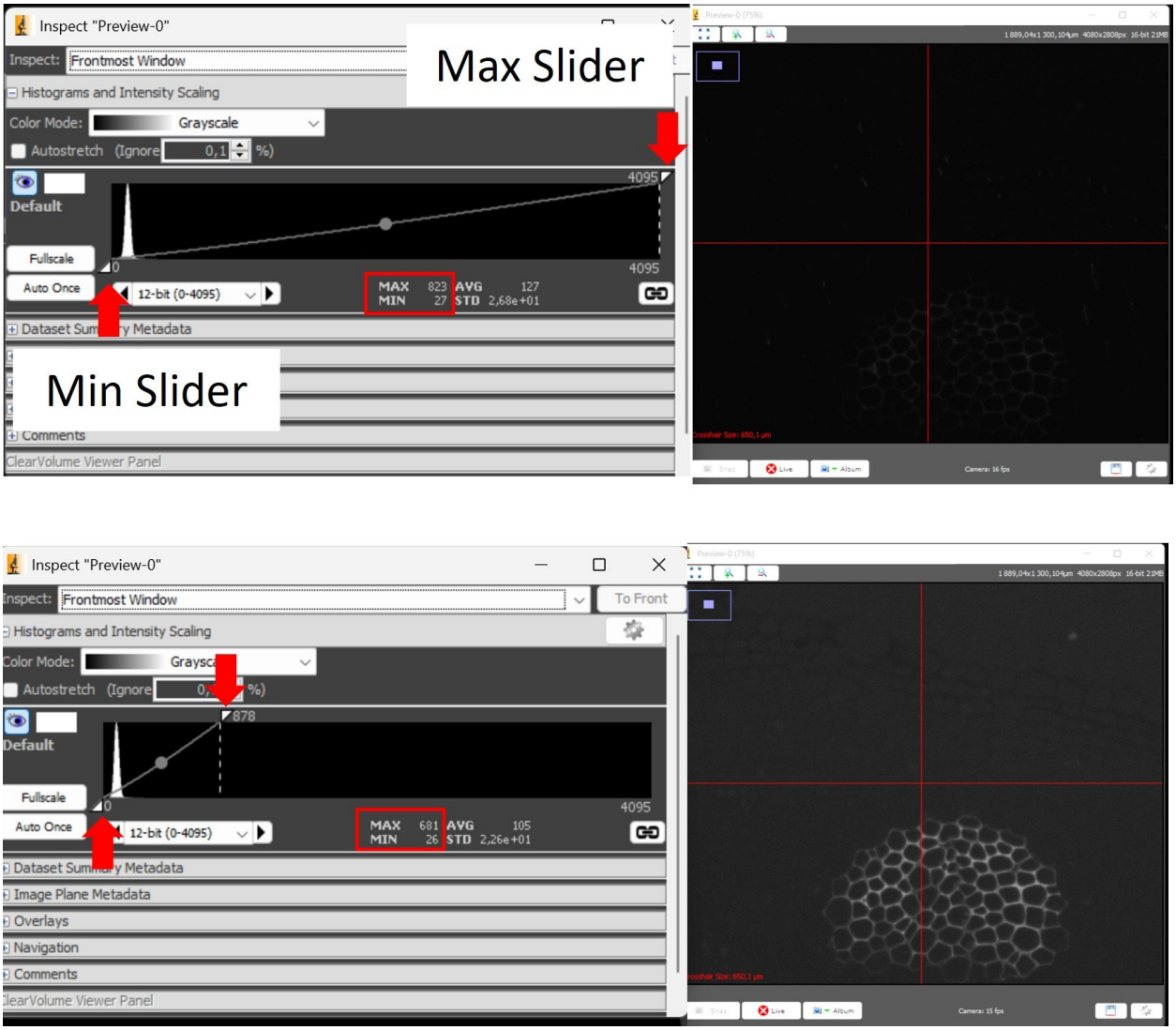

Figure 46: Adjusting the display range. Upper pannel shows the FOV with default min and mix display values. Min and Max sliders are indicated with red arrows and and min and max values are highlighted by the red box. Lower pannel shows FOV after the maximum display value has been reduced to just above the maximim pixel value to enable visualisation with low intensity illumination.

14 Technical Specifications

- Total Weight: Approx. $40\,\mathrm{kg}$

15 Appendices

A. CAD Diagrams

See repository: https://github.com/ImperialCollegeLondon/openFrame

B. openScope Traveller Repository

See repository: https://github.com/frasermo/OSCA

C. openScope Traveller Video Channel

See channel: https://www.youtube.com/@openScopeTraveller

D. Sample Images

Located in `/openScope/images/Converted Images/samples/`.

F. Software License

16 Revision History

Version	Date	Changes	Author
0.1	2025	Initial Release	Montandon, Knopp, Jacobs.