FRINGOE

FG-α SPECTROMETER

User Manual

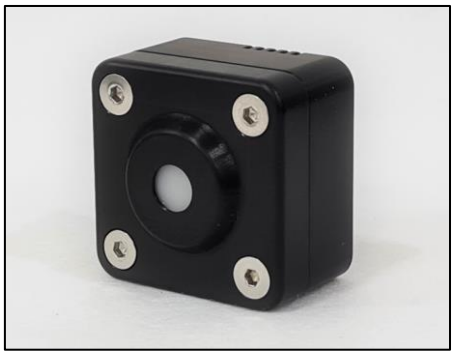
TABLE OF CONTENTS

1 GETTING STARTED

1.1 DEVICE INTRODUCTION

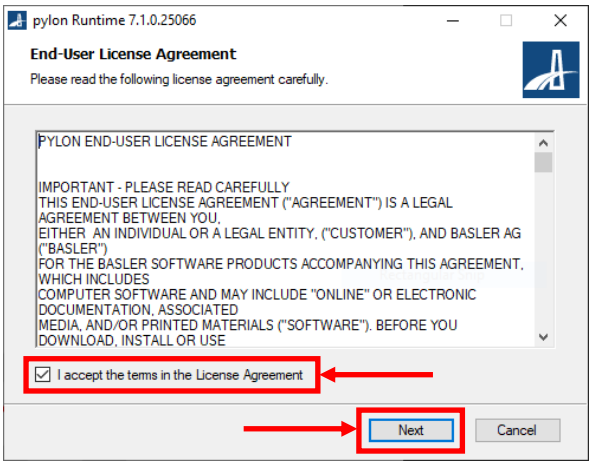
The FG-α is a small form-factor irradiance calibrated spectrometer designed for lab and field use. An OEM version is also available for integration into systems. Some of its key features are:

- Spectral irradiance-calibrated ($W/m^2/nm$)
- USB 3.0 powered interface, with locking screws for secure connection
- Easy-to-use Demo GUI for control and data acquisition
- Stand-alone device (e.g. optical bench) or integrate into a larger system

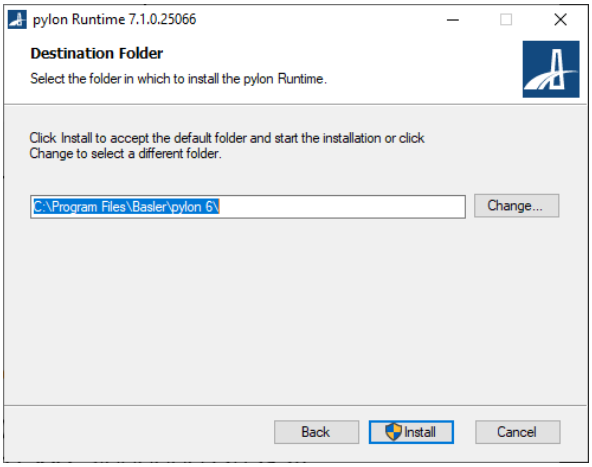


1.2 SOFTWARE INSTALLATION

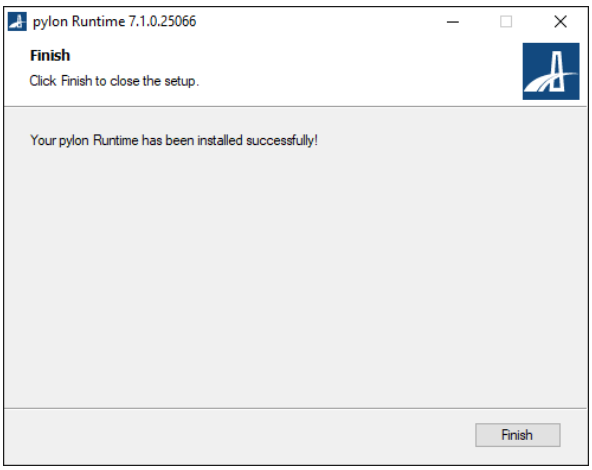
1. Double-click on **pylon_Runtime_7.1.0.25066.exe** to install the Basler camera driver.
2. Accept the license agreement and click on **Next** to continue.



3. Select the destination folder to install the driver and click on **Install** to start the installation of the driver.



4. When the installation is done, click on **Finish**.



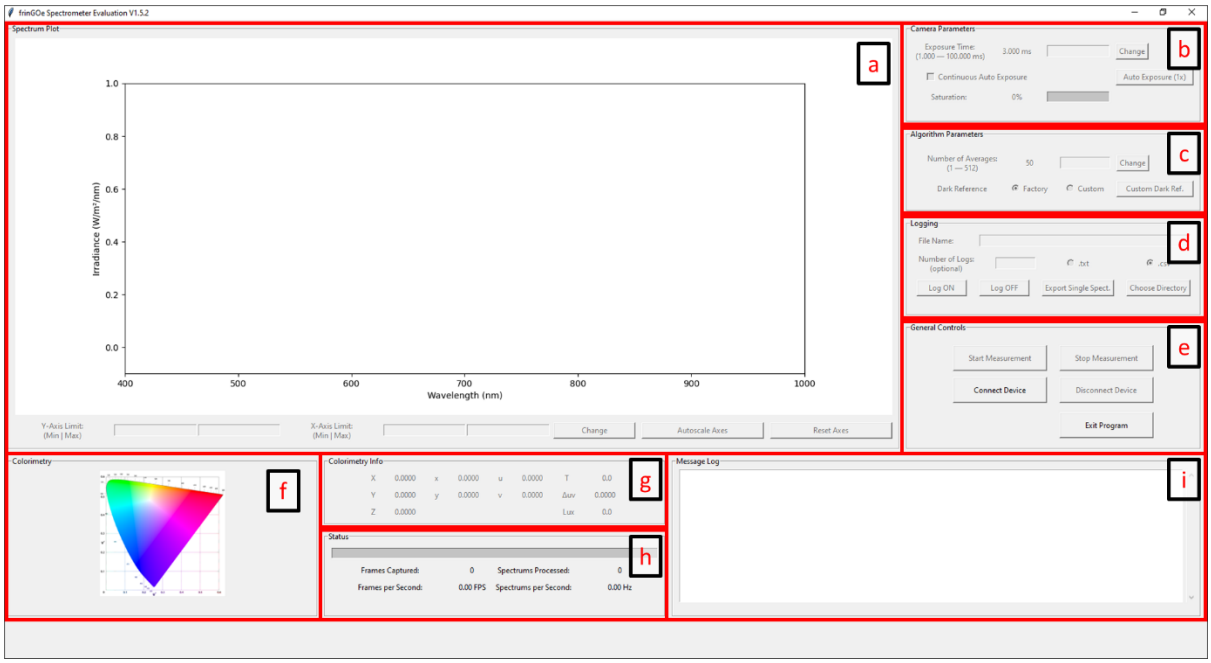
1.3 HARDWARE INSTALLATION

FG-*α* comes with a single USB 3.0 Micro-B connector port with locking screw holes.

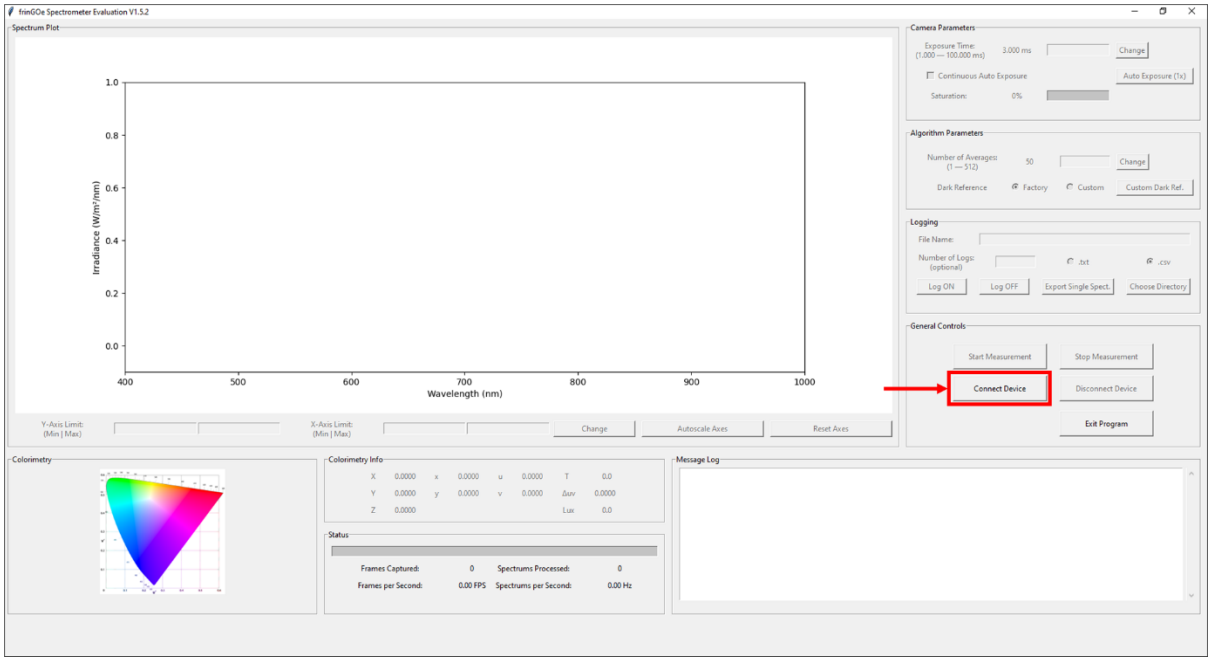
1. Connect the USB 3.0 Micro-B end of the cable to the USB 3.0 Micro-B port on the device. Locking with thumb screws are optional but recommended for a secure connection.
2. Connect the USB Type-A end of the cable to your PC.
    a. Although the device can be connected via a USB 2.0 interface, it is recommended to connect FG-*α* to a USB 3.0 SuperSpeed port for full speed operation.
3. Run the software.

1.4 SOFTWARE OPERATION

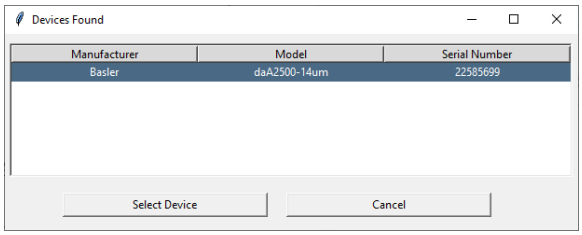
1. Copy the **FG-alpha_vX.X** folder to your local drive.
2. Copy the calibration folder (calibration folder name = device serial number) into the **FG-alpha_vX.X\FG** folder.
3. Double-click on **FG_Spectrometer_Demo_v*X.X*.exe** to run the FG-Spectrometer program. Wait for the program to initialize.
4. A window titled **frinGOe Spectrometer Evaluation V*X.X*** will appear on the screen. The window is divided into frames for ease of reference.
    a. Spectrum Plot frame
    b. Camera Parameters frame
    c. Algorithm Parameters frame
    d. Logging frame
    e. General Controls frame
    f. Color Space Indicator frame
    g. Colorimetry Info frame
    h. Status frame
    i. Message Box frame



5. Click on **Connect Device** under the General Controls frame for the program to select and initialise the device.



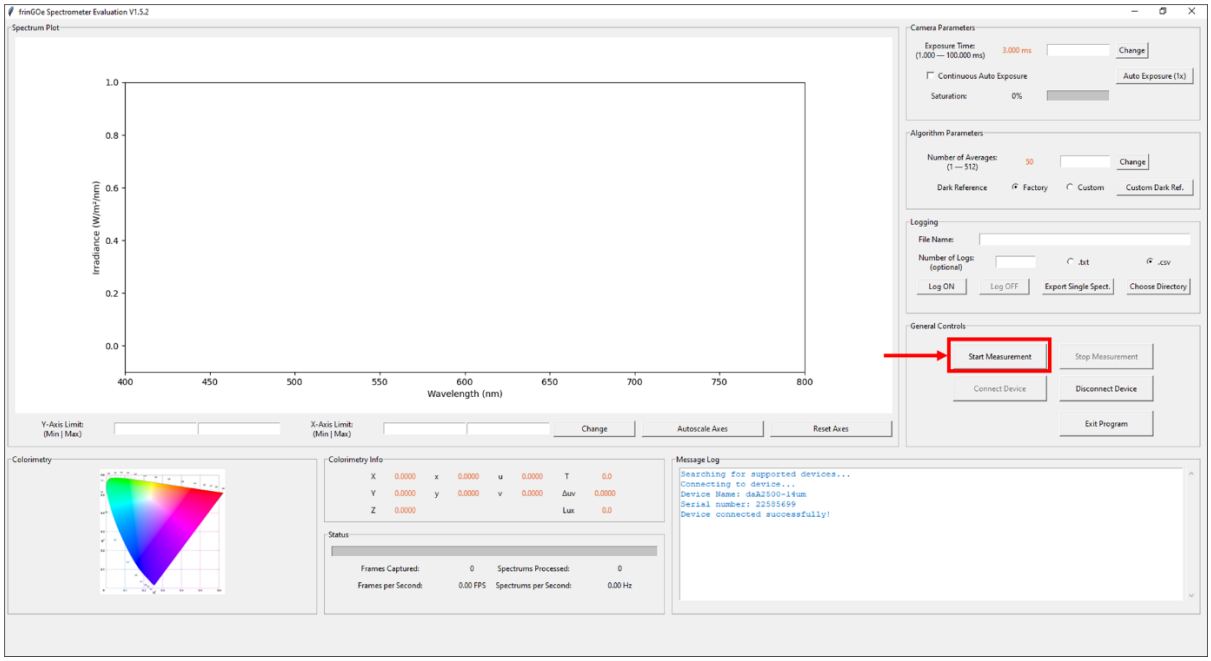
a. A dialog box will pop up for device selection. Select the FG-*α* unit with the correct serial number and click on **Select Device**.



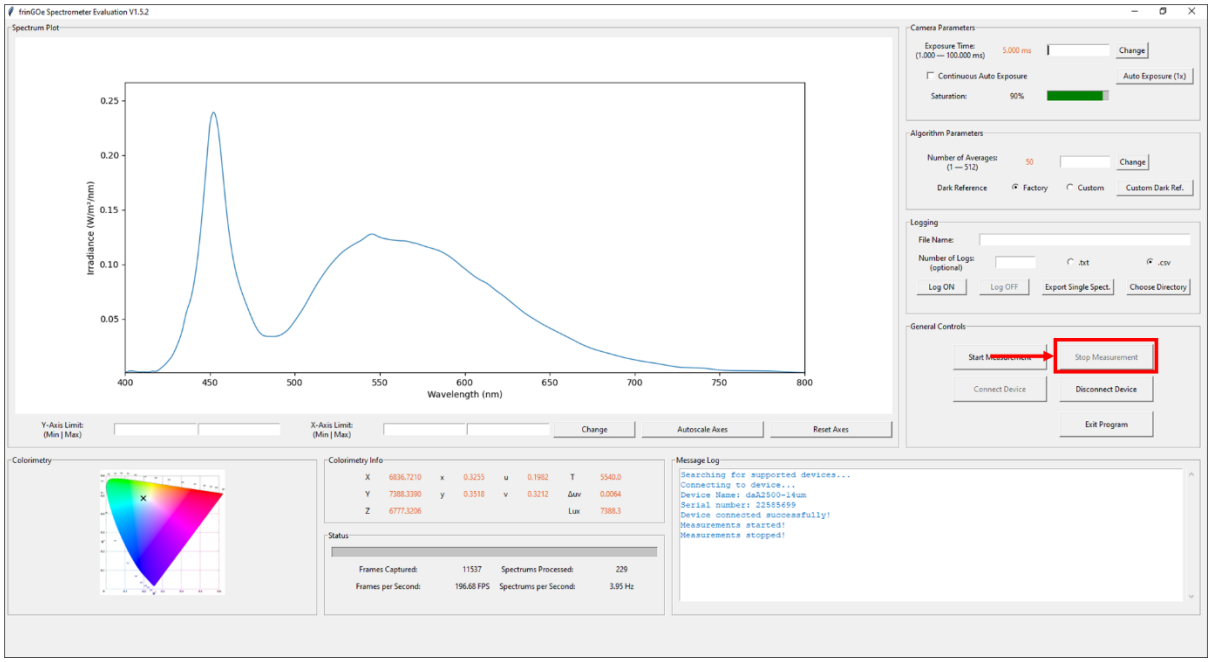
b. The **Message Log** will show the device info if the device has been properly initialised.

c. If there is no device displayed, please check that the drivers are successfully installed and the **Basler USB3 Vision Cameras** are available in the **Device Manager**. Otherwise, attempt to remove and re-insert the USB connector or restart the computer.

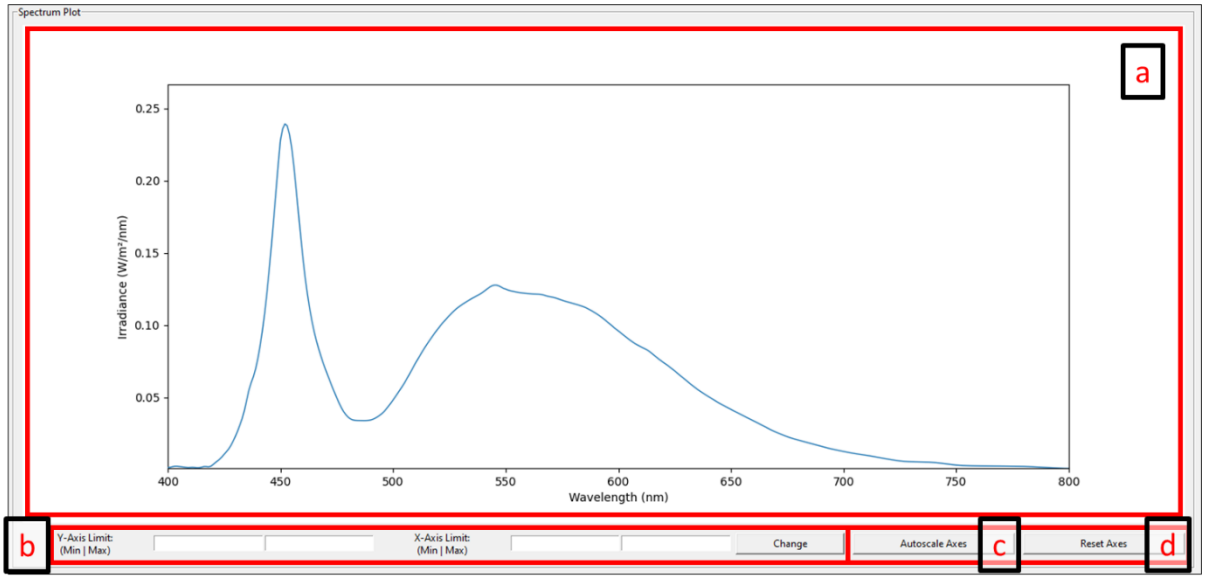
6. Click on **Start Measurement** under the General Controls frame to start image capture and begin processing spectrums.



7. Click on **Stop Measurement** to stop the process.

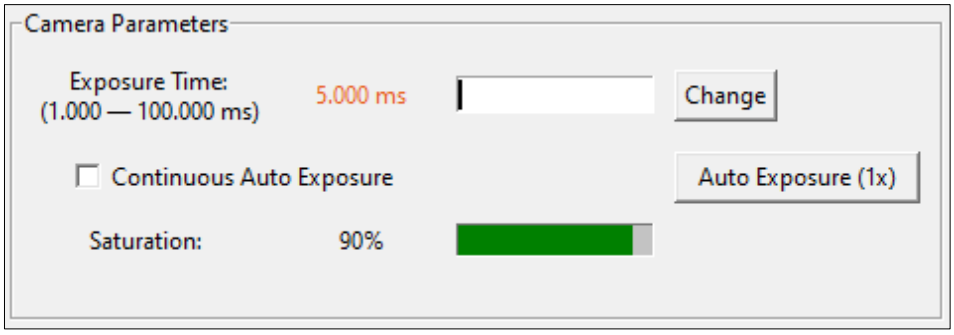


8. Observe the spectrum waveform under the **Spectrum Plot** frame.
    a. Displays the spectrum with Wavelength (nm) on the X-axis and Spectral Irradiance ($W/m^2/nm$) on the Y-axis.
    b. Adjust the axis limits by entering the lower and upper limits into the input boxes. Click on **Change** to confirm the new limit settings.
        i. Any boxes left blank will leave the current limit values unchanged.
        ii. Invalid values (e.g. non-numerical characters) are ignored.
    c. Click on **Autoscale Axes** to scale the current spectrum in the plot automatically.
    d. Click on **Reset Axes** to reset axes to default values.
        i. Default: (X-axis: 400 | 800, Y-axis: 0 | 1)



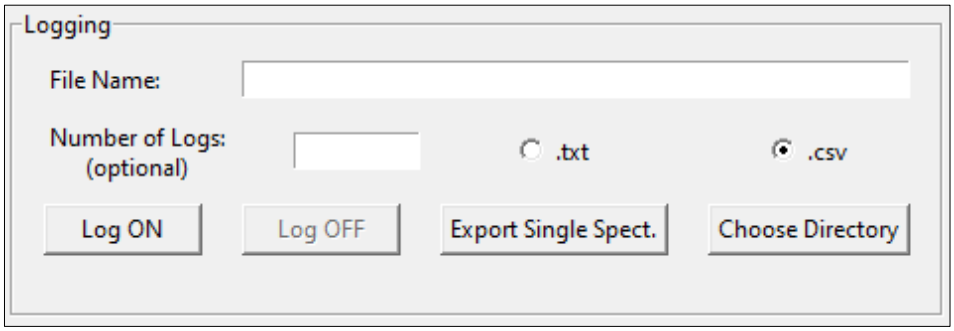
9. Change the device's exposure time settings under the **Camera Parameters** frame.
    a. The **Exposure Time** shows the current exposure time setting on the device. The device operates with exposure timings between 1.000ms and 100.000ms inclusive.
    b. To manually adjust the exposure time, key in the desired exposure time in milliseconds (ms) into the input box. Click on **Change** to set the exposure time.
    c. The saturation bar indicates the percentage of the maximum pixel value captured compared to the pixel saturation level. To perform accurate measurements with the device, ensure that the saturation percentage is not at 100% (interferogram is saturated at this point).
    d. Click on **Auto Exposure (1x)** to automatically optimize the Exposure Time once, based on the signal captured by the device.
        i. Auto Exposure will attempt to match the exposure time such that the maximum sensor pixel value is approximately 90% to saturation.

e. Click on **Continuous Auto Exposure** checkbox to automatically adjust the exposure settings in a continuous manner. Click on the checkbox again to disable this feature.



10. Change the number of averages and dark reference options under the **Algorithm Parameters** frame. The number of averages parameter indicates the number of image frames to be used in processing for a single spectrum waveform output.
    a. The **Number of Averages** shows the number of averages set. The GUI limits the Number of Averages between 1 and 512, inclusive.
        i. Generally, increasing the number of averages results in a better Signal-to-noise Ratio (SNR) at the expense of time.
    b. To change the number of averages, key in the desired number of averages into the input box. Click on **Change** to set the Number of Averages.
    c. Click on **Custom Dark Ref.** to initiate the process of capturing a custom dark reference file. This process may take some time, please wait until the message box shows “Custom dark reference has been saved successfully!”.
        i. Device should be set up correctly for a dark image capture before clicking on the **Custom Dark Ref.** button.
    d. The dark reference radio buttons specify which dark reference file should be used to generate the spectrum. The **Factory** setting uses the dark reference file provided by default. The **Custom** setting uses the dark reference file as saved by the user in step 8c.

11. Spectrum data can be logged and exported as a file. This is controlled under the **Logging** frame.
    a. Click on **Choose Directory**. A pop-up window will open to prompt for a folder. Click on the desired folder and then click **Select Folder**. All logged data will be saved into this folder.
    b. Select an extension for the file to be saved as by clicking on the radio button **.txt** or **.csv**.
    c. Input a **File Name** into the input box. The program will prefix the start date and time into the file name automatically. The format will be *YYYYMMDD_HHmmSS_<File Name>*.
        i. If no file name was provided, the *<File Name>* field will be left blank.
    d. **Number of Logs** indicates a specific number of logs to be recorded for a single session. Leaving it blank will allow the program to log indefinitely or until the user stops logging.
    e. Click on **Log ON** to begin the logging process. This button will start the measurement automatically, if not already doing so. Click on **Log OFF** to stop the logging process.
    f. Click on **Export Single Spect.** to export the most recent spectrum plot displayed on screen.



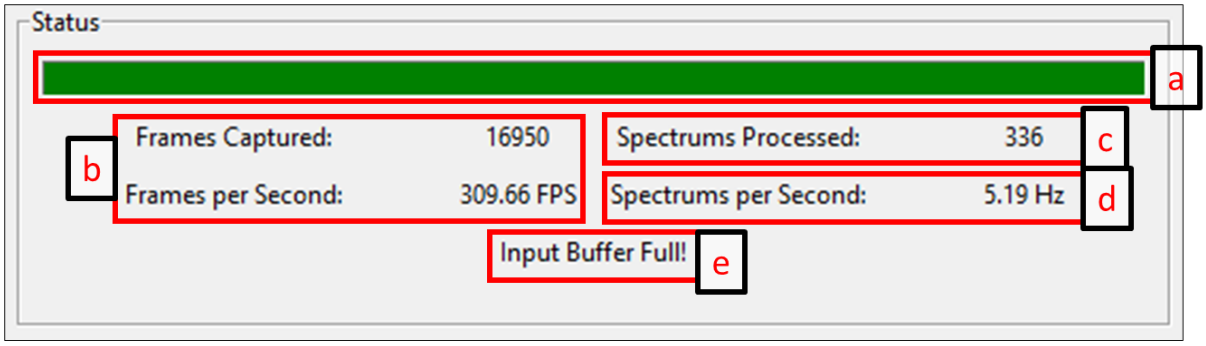
12. The **Message Box** frame contains the message box which displays messages and indicates the state of the program. Use the scrollbar located on the right side of the frame to navigate up or down.
13. The **Status** frame provides information on the progress of the program.
    a. The status progress bar shows the completion rate of the current task.
    b. **Frames Captured** & **Frames per Second** show the frame information of the camera.
    c. **Spectrums Processed** is the total number of spectrums that have been processed since the program started.
    d. **Spectrum per Second** is the current rate at which spectrum outputs are being generated.

e. **Input Buffer Full!** indicates that the device acquisition speed is faster than the processing speed on the host computer. This notification does not appear if the processing speed is able to keep up with the device acquisition speed. Refer to Message Box for instructions.

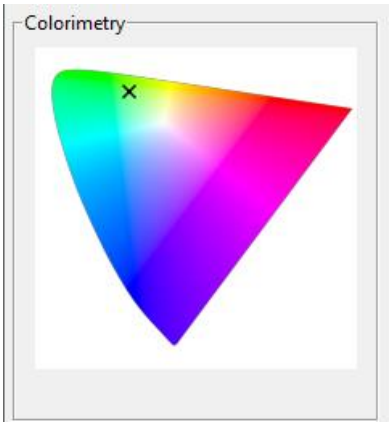
   i. Operating the device in this condition does not affect the spectrum quality. However, the device is not operating at its optimal performance as some frames are discarded while only the most recent image frames will be processed.

   ii. To overcome this condition, increase the exposure time and/or increase the number of averages.

   iii. Notification will turn off automatically when processing speed is faster than device acquisition speed.



14. The **Colorimetry** frame displays the chromaticity coordinates of the current measurement on a *CIE 1976 UCS* (uniform chromaticity scale) diagram.



15. The **Colorimetry Info** frame provides colorimetric information of the current measurement in accordance with CIE 1976 colour space model.

   a. CIE XYZ tristimulus values

   b. CIE xy chromaticity values

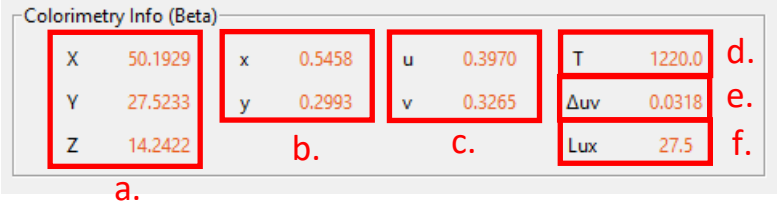
   c. CIE uv chromaticity values

   d. Correlated colour temperature (CCT) in kelvins (K)

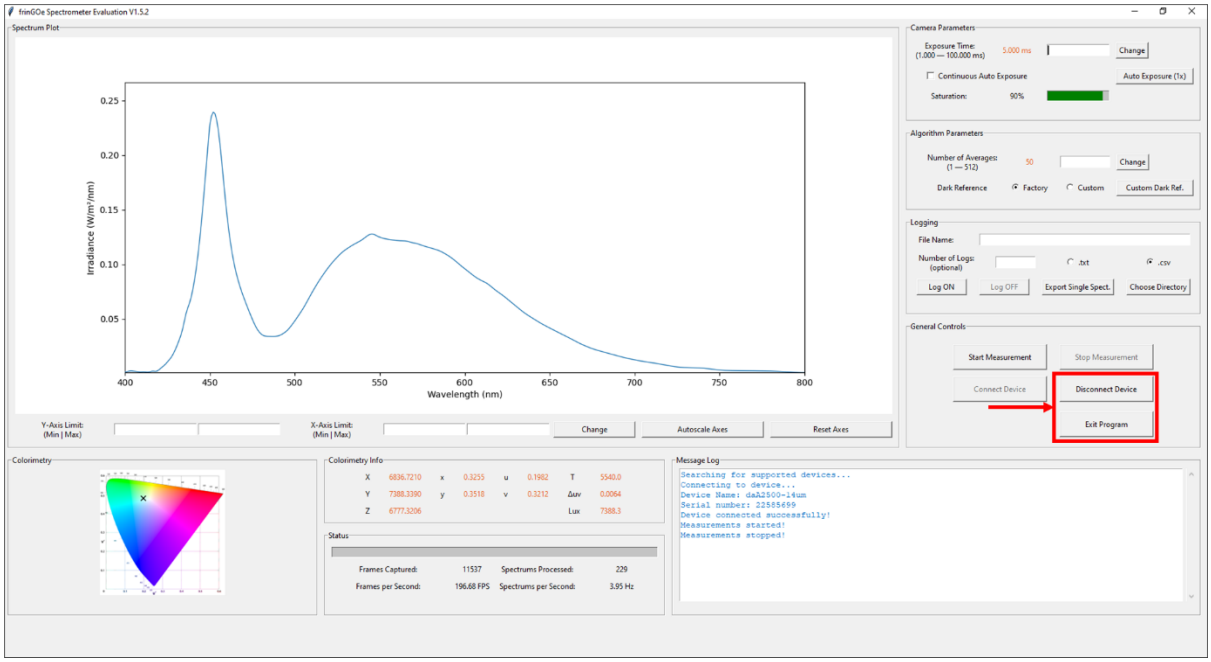
e. Differ in distance from the Planckian locus in the CIE colour space

   i. CIE recommends that the concept of CCT should not be used if the chromaticity of a test source differs on the chromaticity diagram by more than 5×10^{-2} from the Planckian locus, hence CCT will appear as 'N.A.' when the above is true.

f. Illuminance (lux)



16. Click on **Disconnect Device** and **Exit Program** to safely close the device and quit the program.

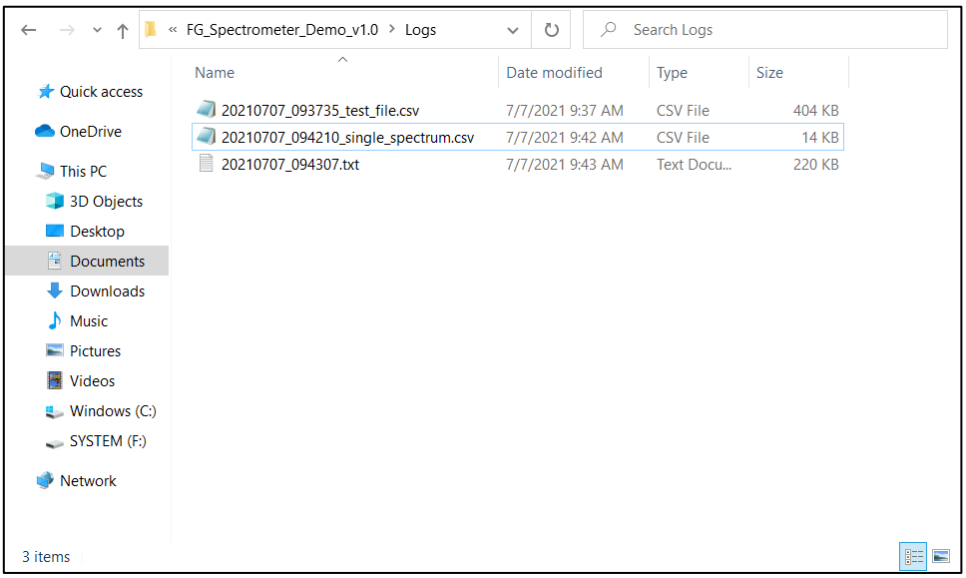


1.5 PYTHON API

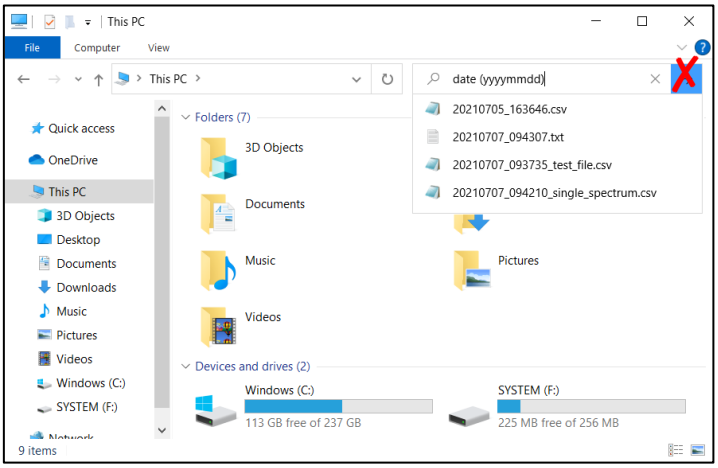
Please refer to the **API_reference_vX.X.pdf** for the reference document to FG-*α*. The **FG_API.py** API file is provided in the **FG** folder. An example code to use the API is provided in the **API_example.py** script.

2 INTERPRETATION OF LOGGED FILES

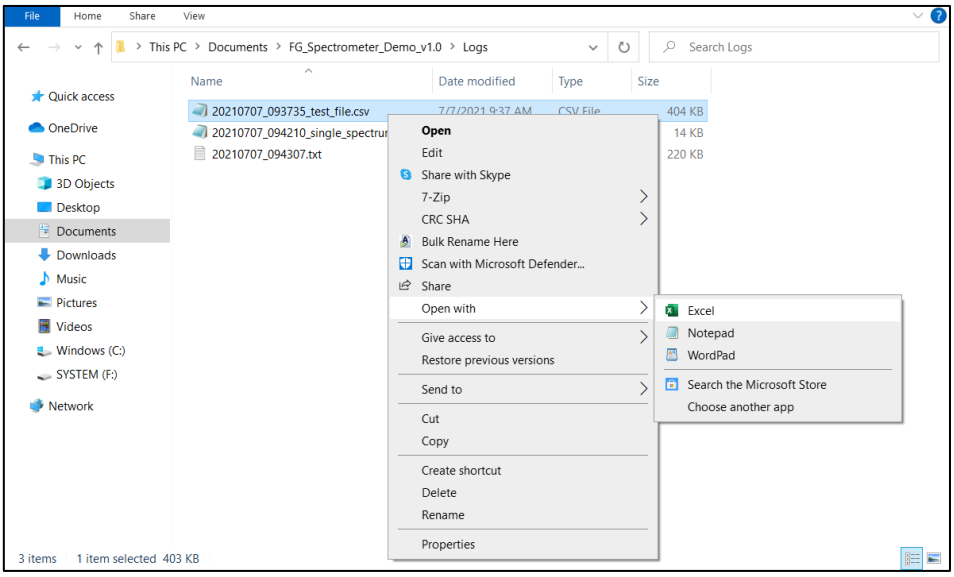
1. The saved log files will appear in the chosen directory or by default **FG_Spectrometer_Demo_v*X.X*\Logs**.



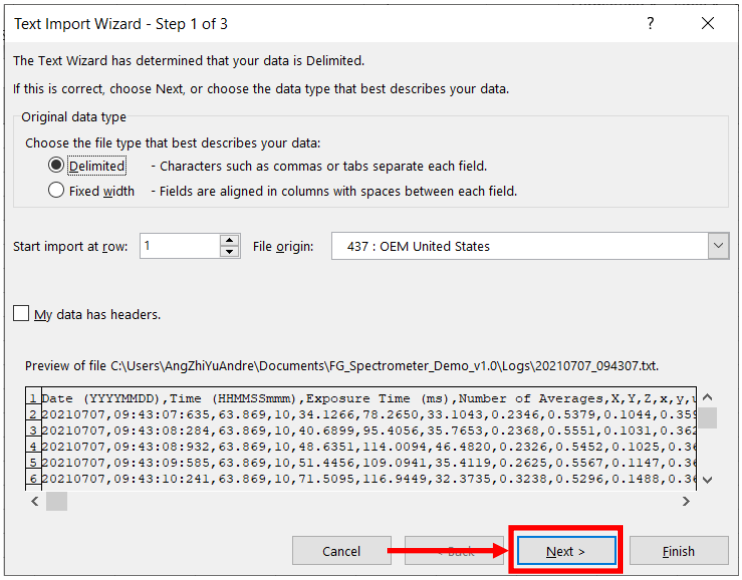
   a. If you have forgotten the file directory and have exited the program, you may attempt to search for the file by typing '**date (yyyymmdd)'** into the search box in a windows explorer root folder.
      i. DO NOT press enter or click on the search arrow button. The search will take a long time and not display your file.
      ii. You may right-click on the file and select **Open file location**.



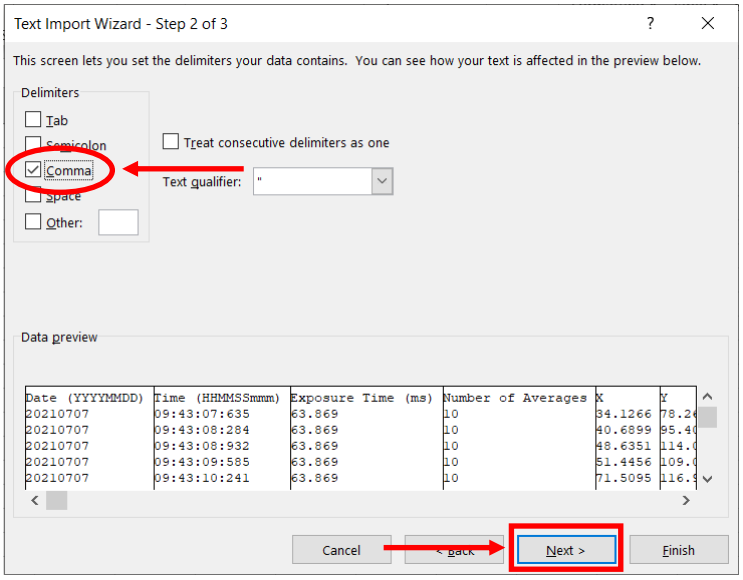
2. Double-click to open the file.
    a. To open a .csv file in Microsoft Excel, right-click on the file, and select **Open with > Excel**.



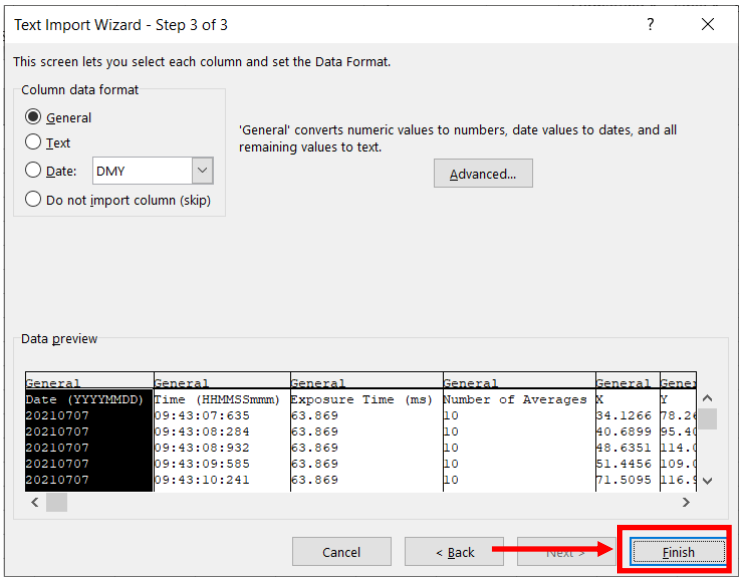
    b. To open a .txt file in Microsoft Excel, open a blank Excel workbook.
        i. Click on **File** > **Open** > **Browse**.
        ii. Select the .txt file and click **Open**.
        iii. Check that the settings are similar. Click **Next**.



        iv. Uncheck the **Tab** delimiter and check the **Comma** delimiter. Click **Next**.

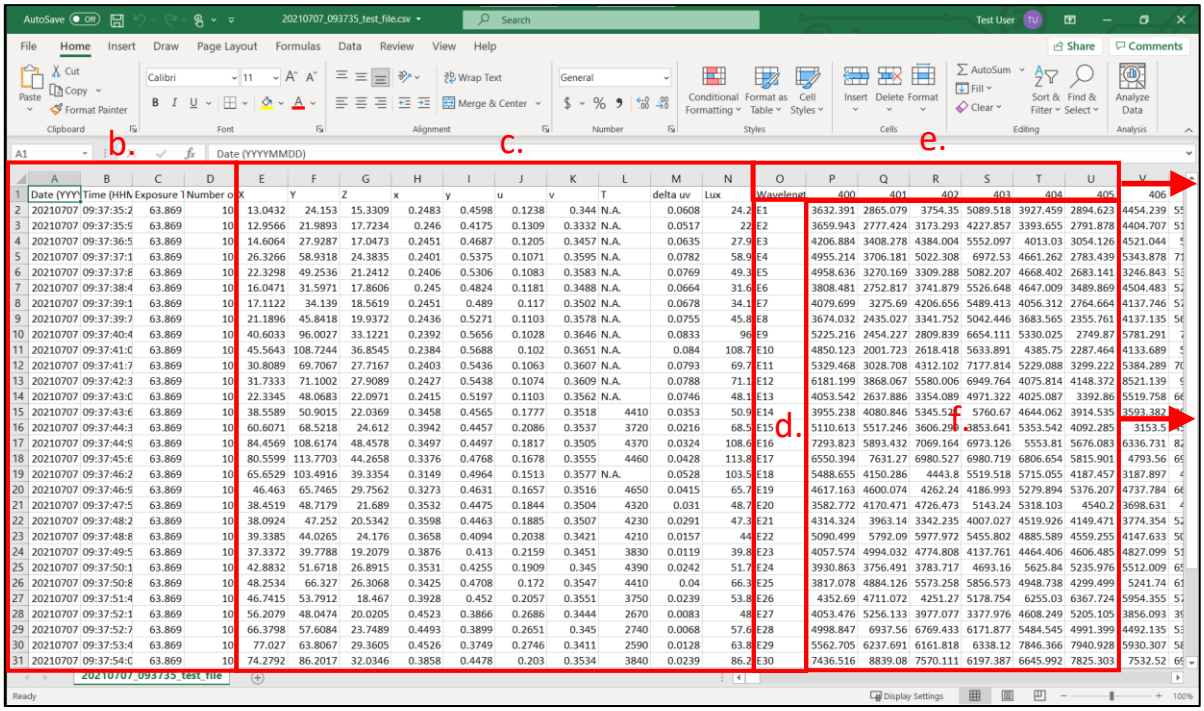


v. Click **Finish**.



3. The formatted csv file will appear as shown below:
    a. Row 1 displays the header for subsequent rows for columns A to N.
        i. It may be useful to freeze the top row by going to **View** > **Freeze Panes** > **Freeze Top Row**.
    b. The columns A to D shows the Date, Time, Exposure Time, and Number of Averages respectively.
    c. The columns E to N shows the colorimetry info. The letter headers correspond to the letters displayed in the program's Colorimetry Info frame.
    d. Column O shows the spectrum index number.
    e. The wavelengths on the first row (400nm to 800nm in steps of 1nm) are the spectrum plot X-axis values.

f. The columns P to OZ contain the spectrum plot Y-axis values corresponding to the wavelength value in row 1.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Date (YYY	Time (HHM	Exposure T	Number o	X	Y	Z	x	y	u	v	T	delta uv	Lux	Wavelengt	400	401	402	403	404	405	406
2	20210707	09:37:35:2	63.869	10	13.0432	24.153	15.3309	0.2483	0.4598	0.1238	0.344	N.A.	0.0608	24.2	E1	3632.391	2865.079	3754.35	5089.518	3927.459	2894.623	4454.239
3	20210707	09:37:35:9	63.869	10	12.9566	21.9893	17.7234	0.246	0.4175	0.1309	0.3332	N.A.	0.0517	22	E2	3659.943	2777.424	3173.293	4227.857	3393.655	2791.878	4404.707
4	20210707	09:37:36:5	63.869	10	14.6064	27.9287	17.0473	0.2451	0.4687	0.1205	0.3457	N.A.	0.0635	27.9	E3	4206.884	3408.278	4384.004	5552.097	4013.03	3054.126	4521.044
5	20210707	09:37:37:1	63.869	10	26.3266	58.9318	24.3835	0.2401	0.5375	0.1071	0.3595	N.A.	0.0782	58.9	E4	4955.214	3706.181	5022.308	6972.53	4661.262	2783.439	5343.878
6	20210707	09:37:37:8	63.869	10	22.3298	49.2536	21.2412	0.2406	0.5306	0.1083	0.3583	N.A.	0.0769	49.3	E5	4958.636	3270.169	3309.288	5082.207	4668.402	2683.141	3246.843
7	20210707	09:37:38:4	63.869	10	16.0471	31.5971	17.8606	0.245	0.4824	0.1181	0.3488	N.A.	0.0664	31.6	E6	3808.481	2752.817	3741.879	5526.648	4647.009	3489.869	4504.483
8	20210707	09:37:39:1	63.869	10	17.1122	34.139	18.5619	0.2451	0.489	0.117	0.3502	N.A.	0.0678	34.1	E7	4079.699	3275.69	4206.656	5489.413	4056.312	2764.664	4137.746
9	20210707	09:37:39:7	63.869	10	21.1896	45.8418	19.9372	0.2436	0.5271	0.1103	0.3578	N.A.	0.0755	45.8	E8	3674.032	2435.027	3341.752	5042.446	3683.565	2355.761	4137.135
10	20210707	09:37:40:4	63.869	10	40.6033	96.0027	33.1221	0.2392	0.5656	0.1028	0.3646	N.A.	0.0833	96	E9	5225.216	2454.227	2809.839	6654.111	5330.025	2749.87	5781.291
11	20210707	09:37:41:0	63.869	10	45.5643	108.7244	36.8545	0.2384	0.5688	0.102	0.3651	N.A.	0.084	108.7	E10	4850.123	2001.723	2618.418	5633.891	4385.75	2287.464	4133.689
12	20210707	09:37:41:7	63.869	10	30.8089	69.7067	27.7167	0.2403	0.5436	0.1063	0.3607	N.A.	0.0793	69.7	E11	5329.468	3028.708	4312.102	7177.814	5229.088	3299.222	5384.289
13	20210707	09:37:42:3	63.869	10	31.7333	71.1002	27.9089	0.2427	0.5438	0.1074	0.3609	N.A.	0.0788	71.1	E12	6181.199	3868.067	5580.006	6949.764	4075.814	4148.372	8521.139
14	20210707	09:37:43:0	63.869	10	22.3345	48.0683	22.0971	0.2415	0.5197	0.1103	0.3562	N.A.	0.0746	48.1	E13	4053.542	2637.886	3354.089	4971.322	4025.087	3392.86	5519.758
15	20210707	09:37:43:6	63.869	10	38.5589	50.9015	22.0369	0.3458	0.4565	0.1777	0.3518	4410	0.0353	50.9	E14	3955.238	4080.846	5345.52	5760.67	4644.062	3914.535	3593.382
16	20210707	09:37:44:3	63.869	10	60.6071	68.5218	24.612	0.3942	0.4457	0.2086	0.3537	3720	0.0216	68.5	E15	5110.613	5517.246	3606.29	3853.641	5353.542	4092.285	3153.5
17	20210707	09:37:44:9	63.869	10	84.4569	108.6174	48.4578	0.3497	0.4497	0.1817	0.3505	4370	0.0324	108.6	E16	7293.823	5893.432	7069.164	6973.126	5553.81	5676.083	6336.731
18	20210707	09:37:45:6	63.869	10	80.5599	113.7703	44.2658	0.3376	0.4768	0.1678	0.3555	4460	0.0428	113.8	E17	6550.394	7631.27	6980.527	6980.719	6806.654	5815.901	4793.56
19	20210707	09:37:46:2	63.869	10	65.6529	103.4916	39.3354	0.3149	0.4964	0.1513	0.3577	N.A.	0.0528	103.5	E18	5488.655	4150.286	4443.8	5519.518	5715.055	4187.457	3187.897
20	20210707	09:37:46:9	63.869	10	46.463	65.7465	29.7562	0.3273	0.4631	0.1657	0.3516	4650	0.0415	65.7	E19	4617.163	4600.074	4262.24	4186.993	5279.894	5376.207	4737.784
21	20210707	09:37:47:5	63.869	10	38.4519	48.7179	21.689	0.3532	0.4475	0.1844	0.3504	4320	0.031	48.7	E20	3582.772	4170.471	4726.473	5143.24	5318.103	4540.2	3698.631
22	20210707	09:37:48:2	63.869	10	38.0924	47.252	20.5342	0.3598	0.4463	0.1885	0.3507	4230	0.0291	47.3	E21	4314.324	3963.14	3342.235	4007.027	4519.926	4149.471	3774.354
23	20210707	09:37:48:8	63.869	10	39.3385	44.0265	24.176	0.3658	0.4094	0.2038	0.3421	4210	0.0157	44	E22	5090.499	5792.09	5977.972	5455.802	4885.589	4559.255	4147.633
24	20210707	09:37:49:5	63.869	10	37.3372	39.7788	19.2079	0.3876	0.413	0.2159	0.3451	3830	0.0119	39.8	E23	4057.574	4994.032	4774.808	4137.761	4464.406	4606.485	4827.099
25	20210707	09:37:50:1	63.869	10	42.8832	51.6718	26.8915	0.3531	0.4255	0.1909	0.345	4390	0.0242	51.7	E24	3930.863	3756.491	3783.717	4693.16	5625.84	5235.976	5512.009
26	20210707	09:37:50:8	63.869	10	48.2534	66.327	26.3068	0.3425	0.4708	0.172	0.3547	4410	0.04	66.3	E25	3817.078	4884.126	5573.258	5856.573	4948.738	4299.499	5241.74
27	20210707	09:37:51:4	63.869	10	46.7415	53.7912	18.467	0.3928	0.452	0.2057	0.3551	3750	0.0239	53.8	E26	4352.69	4711.072	4251.27	5178.754	6255.03	6367.724	5954.355
28	20210707	09:37:52:1	63.869	10	56.2079	48.0474	20.0205	0.4523	0.3866	0.2686	0.3444	2670	0.0083	48	E27	4053.476	5256.133	3977.077	3377.976	4608.249	5205.105	3856.093
29	20210707	09:37:52:7	63.869	10	66.3798	57.6084	23.7489	0.4493	0.3899	0.2651	0.345	2740	0.0068	57.6	E28	4998.847	6937.56	6769.433	6171.877	5484.545	4991.399	4492.135
30	20210707	09:37:53:4	63.869	10	77.027	63.8067	29.3605	0.4526	0.3749	0.2746	0.3411	2590	0.0128	63.8	E29	5562.705	6237.691	6161.818	6338.12	7846.366	7940.928	5930.307
31	20210707	09:37:54:0	63.869	10	74.2792	86.2017	32.0346	0.3858	0.4478	0.203	0.3534	3840	0.0239	86.2	E30	7436.516	8839.08	7570.111	6197.387	6645.992	7825.303	7532.52

3 APPLICATION NOTES

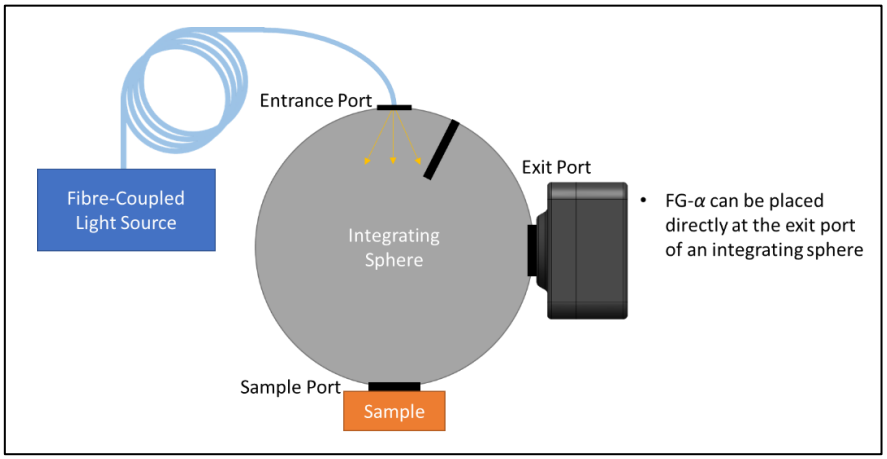
3.1 APPLICATION EXAMPLES

3.1.1 Light Source Measurements

- FG-α works best for diffused light sources.
- If the light source is a point source or highly directional (i.e. laser), please make sure to diffuse it sufficiently before measurement.

3.1.2 Reflectance Measurements with Integrating Sphere

- FG-α can fully replace the fibre-coupled spectrometer and its fibre.
- Below is an example of how FG-α can be used with an integrating sphere for reflectance measurements:



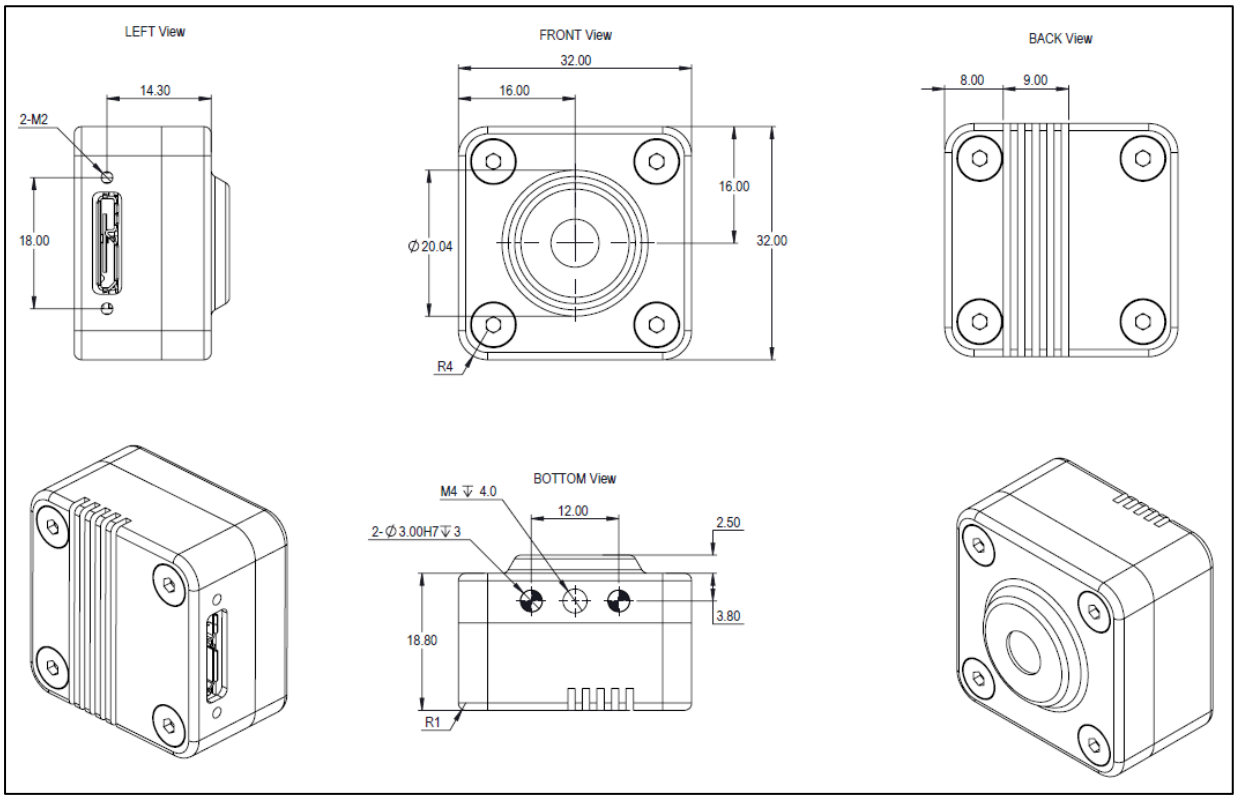
3.1.3 Mounting for Laboratory Use

- For usage in the laboratory, FG-α can be mounted to a standard optical post using the M4 mounting hole.

4 TECHNICAL NOTES

4.1 MECHANICAL INTERFACE CONTROL DOCUMENT (ICD)

The FG-*α* Spectrometer comes with an M4 female screw hole for mounting. Two 3.00mm H7 dowel holes are also included for alignment purposes. Units indicated in diagram below are in millimetres (mm).



4.2 THERMAL CONSIDERATIONS

The FG-*α* Spectrometer may warm up during operation due to the sensor. The crystal operates passively and does not generate any heat.

4.3 TECHNICAL SPECIFICATIONS

Optical	
Spectral Range	450 - 850 nm (Typical)
Spectral Resolution	<2% @ Centre Wavelength
Electrical	
Power Requirements	1.3 W (Typical) @ 5 VDC (USB powered)
Mechanical	
Dimensions, W x L x H	32 x 32 x 21.3 mm^3 (main body)
Weight	40 grams
Operating Conditions	
Operating Temperature	10 - 45°C (20 - 80% non-condensing)
Storage Temperature	0 - 55°C
Software	
GUI	Demo Graphical User Interface provided (FG_Spectrometer_Demo_vx.x.exe)
API	Python API available

4.4 TECHNICAL SUPPORT

For enquiries or clarifications, please contact us at contact@fringoe.com.

5 ORDERING INFORMATION

Order Code	Spectral Range	Notes
FG1-VN	450 – 850nm	Typically in-stock.
FG1-VIS	400 – 750nm	Built-to-order. Lead-time to-be-advised.
FG1-NIR	650 – 950nm	Built-to-order. Lead-time to-be-advised.
FG1-xxx-OEM	Customized	Unhoused version available. Email contact@fringoe.com for more information.

- To order, email the order code and quantity to contact@fringoe.com for a quotation.