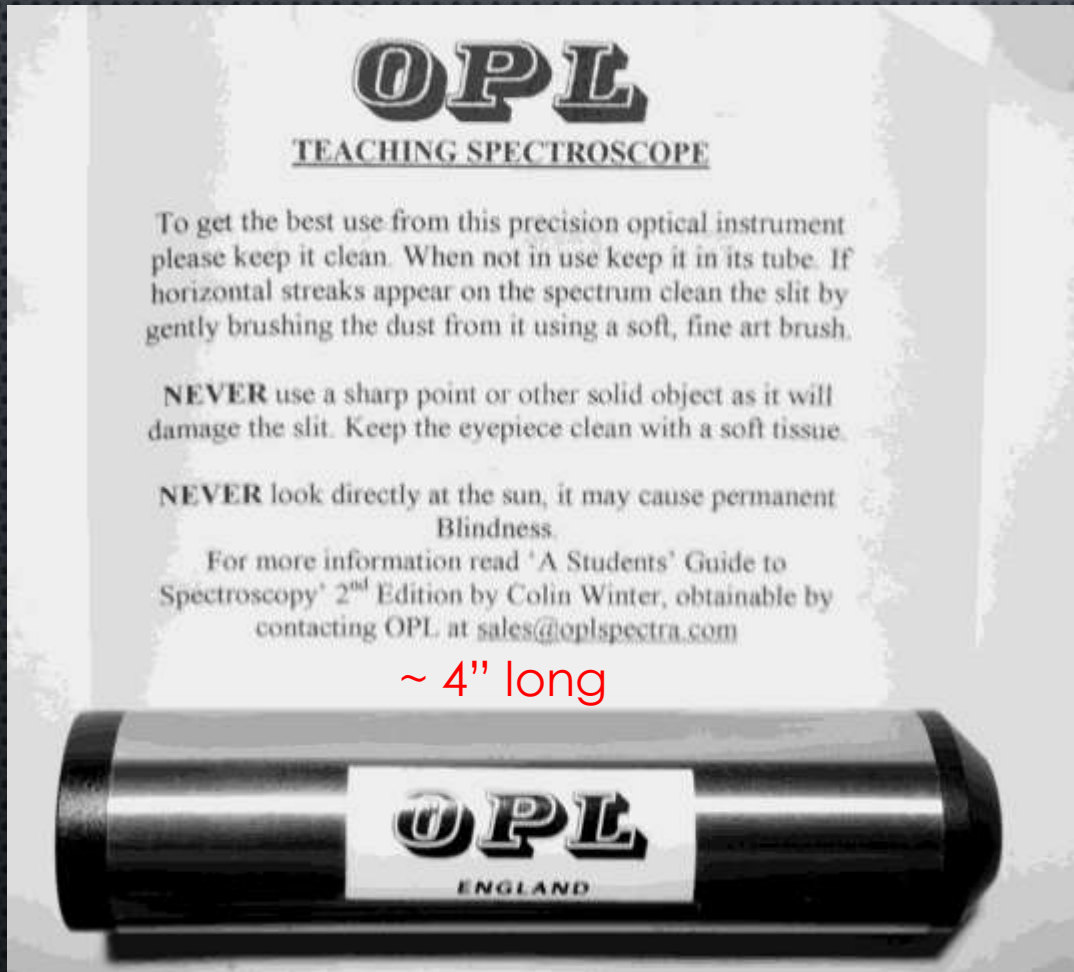


Turning a Teaching Spectroscope into a Spectrometer

Paul M. Adams
January 3, 2020

Use teaching spectroscope to observe fluorescence.
Record spectrum with Olympus TG camera



OD of spectroscope
is 0.975-0.980"

This would be ~ ID of
the adapter, +
0.005"?

Will have to remove
OPL sticker if it
interferes?

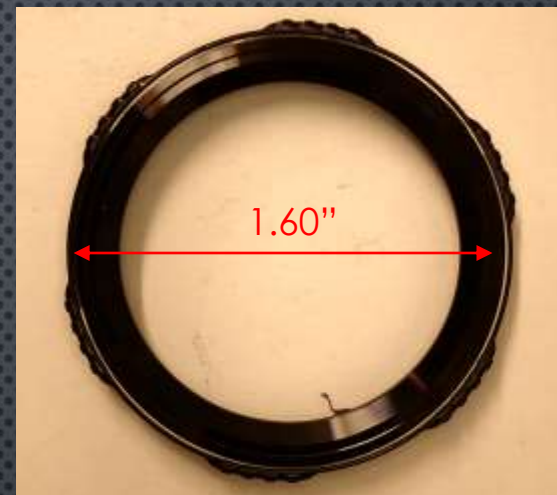
Purchased (\$100) from Mathais of Mikon (also Shannon Minerals)

<https://www.shannonsminerals.com/shop/index.php/shannonsminerals/opl-teaching-spectroscope-1.html>

Camera with bayonet ring installed



Outside of ring



1.60" = OD of adapter

Camera with bayonet ring removed



Inside of ring with bayonet

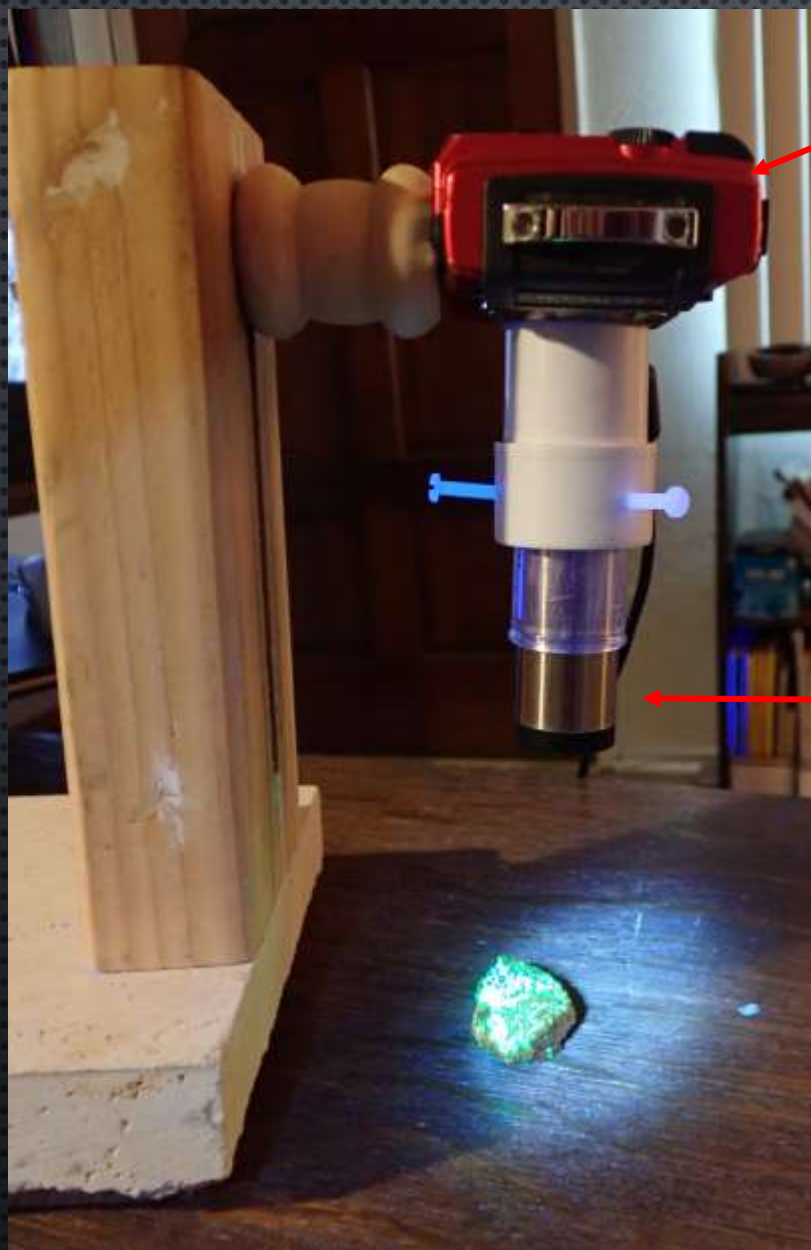


Create adapter from PVC fitting epoxied to camera bayonet mount



Camera: A-mode, Auto WB, 16M
Adjust exposure offset as necessary.

The adapter should be centered and level on the bayonet ring. I tried using a circular bubble level when doing the epoxy job but screwed up because the bubble level was ~ the same diameter as the PVC tube and wasn't level on the tube. As a result the spectroscope is tilted with respect to the camera. The ID of the PVC coupler was machined out to the OD of the spectroscope. The set screws hold the scope in place but also allow some alignment adjustment. Spectroscope was inserted all the way to the camera window.



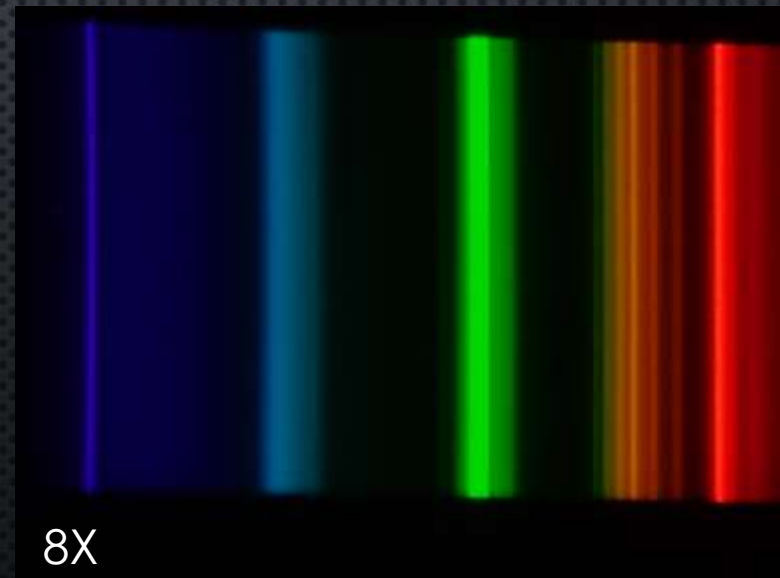
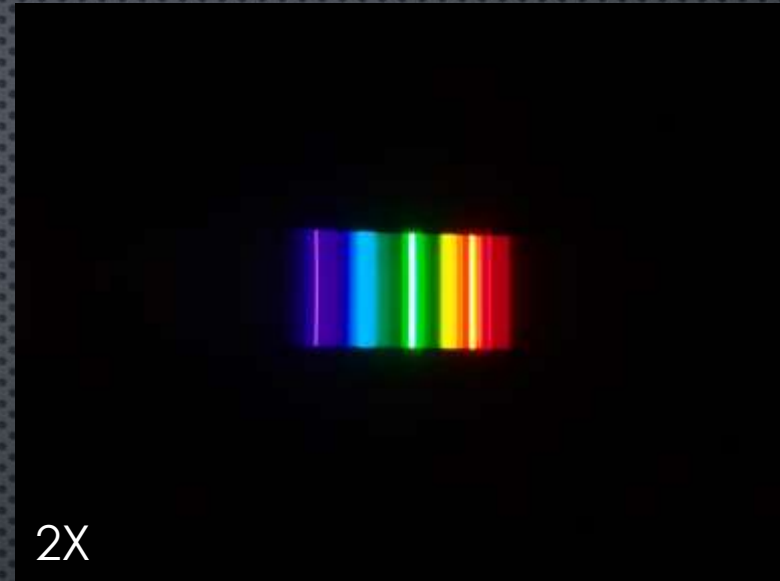
Olympus TG-3 camera

Epoxy adapter tube to bayonet mount that came with camera, but which is removed to use ring light

Spectroscope

Zoom lens to maximum so spectrum fills field of view. Keep zoom setting the same for wavelength calibration and recording samples!

Compact Fluorescent Lamp Calibration Spectrum as a Function of Camera Zoom Level



Note: spectrum is not optimally aligned

Solar Spectrum with Fraunhofer Lines broken into RGB Channels



R

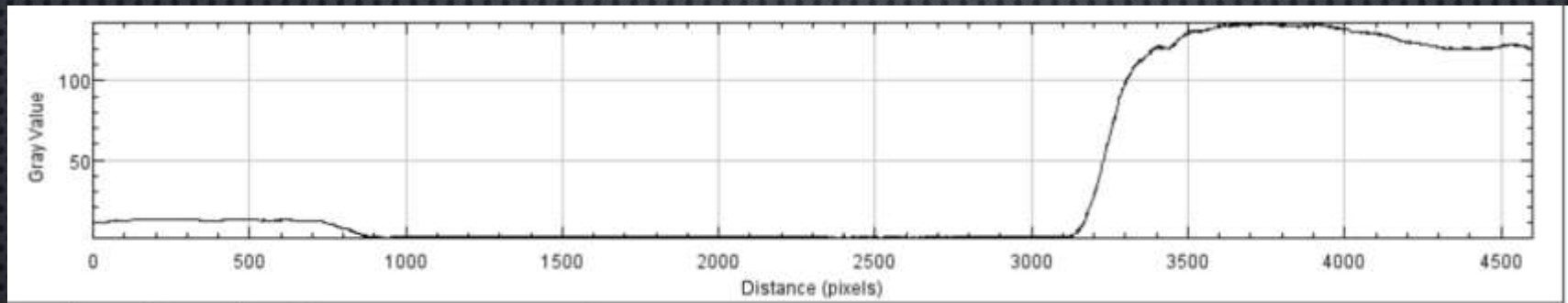
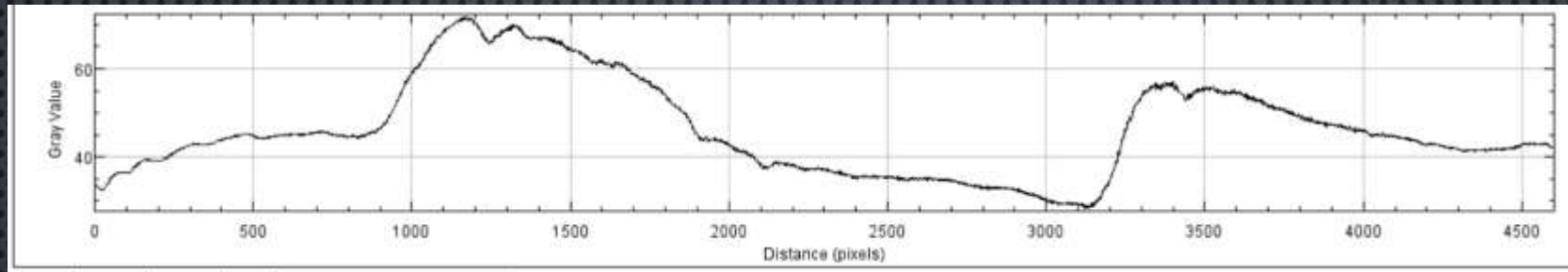


G

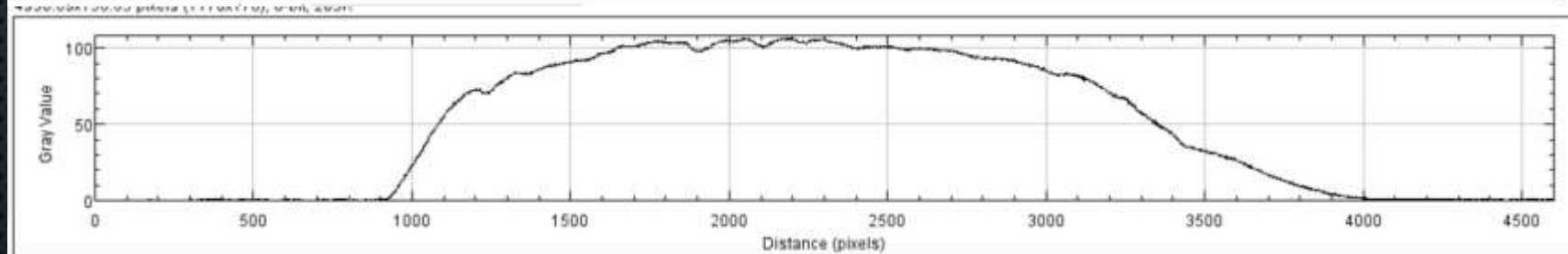


B

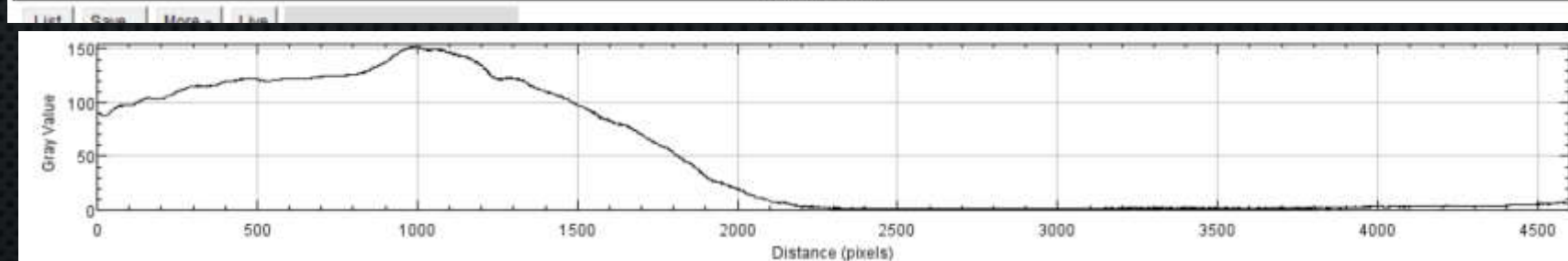
Solar Spectrum with Fraunhofer Lines



R

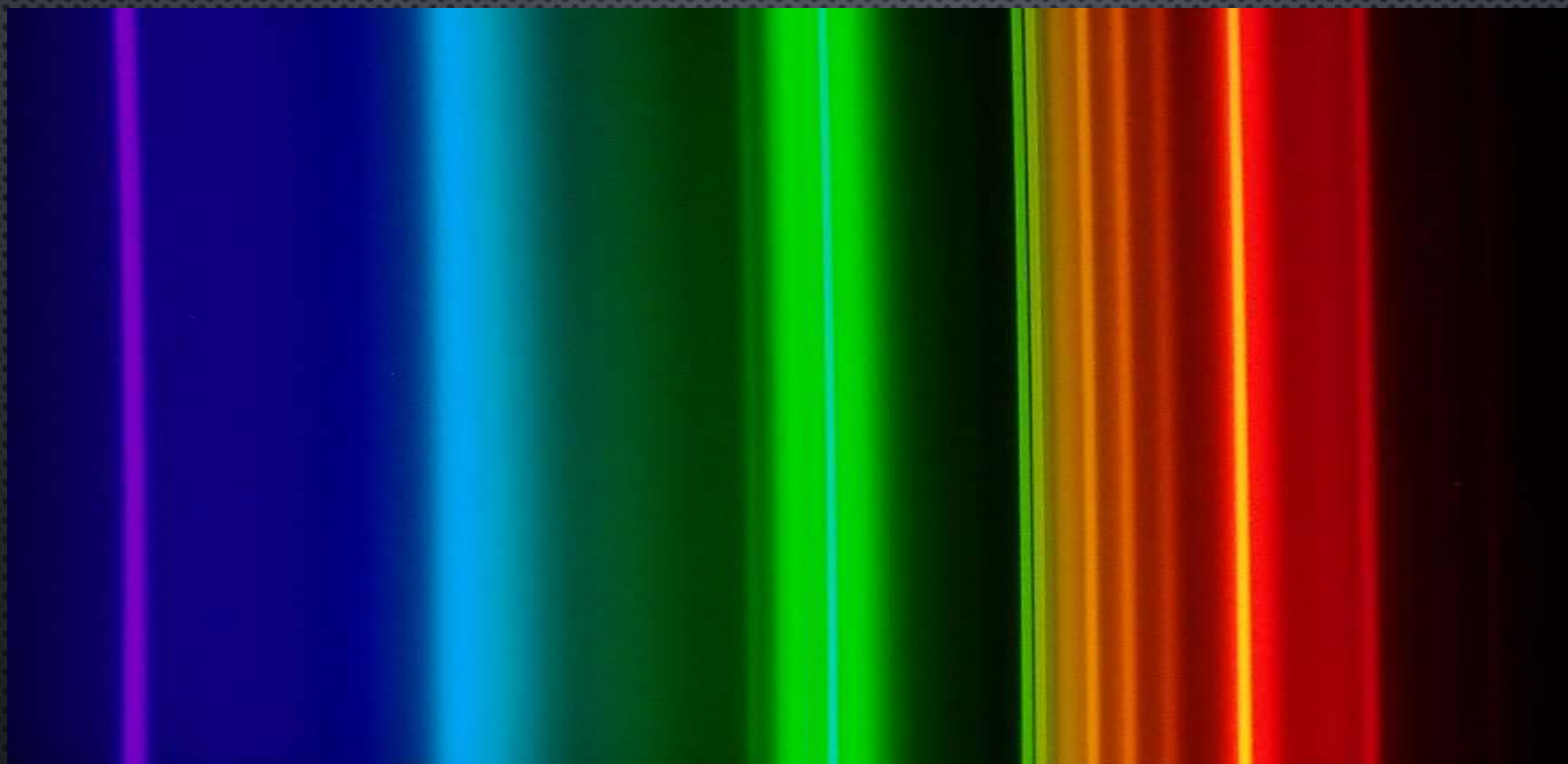


G



B

Compact Fluorescent Lamp Calibration Spectrum



Compact Fluorescent Cal Spectrum Broken Down into Red-Green-Blue Channels



R

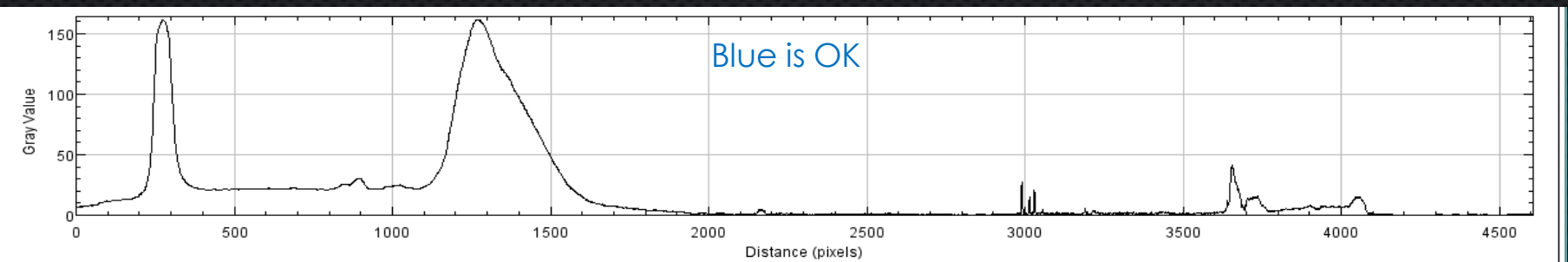
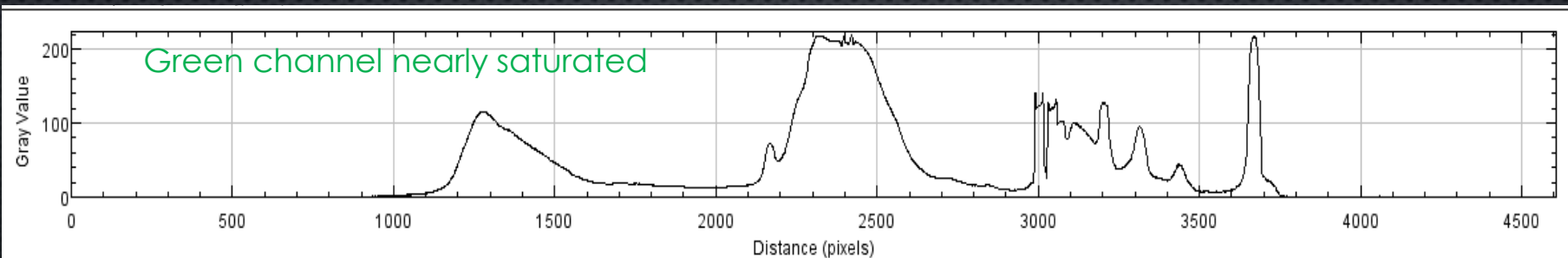
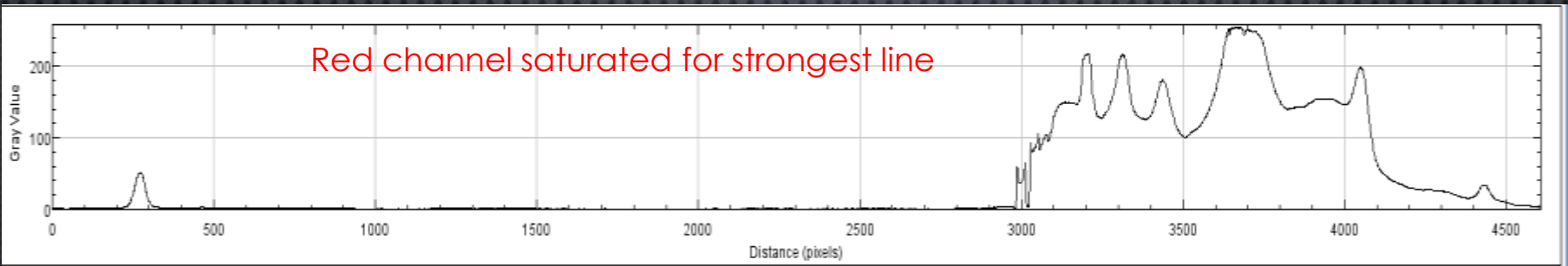
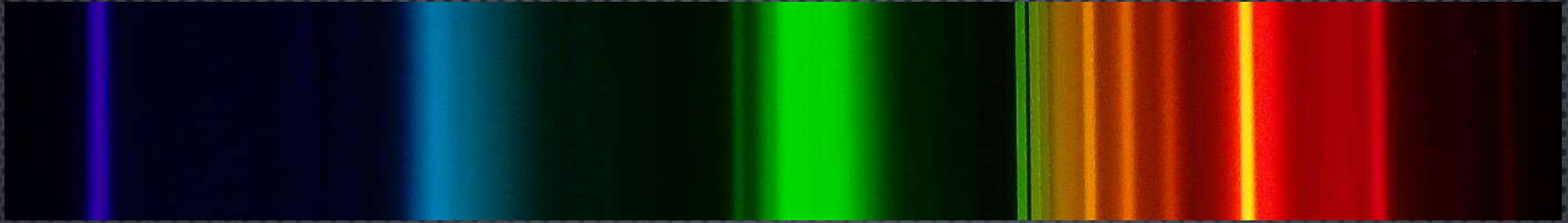


G



B

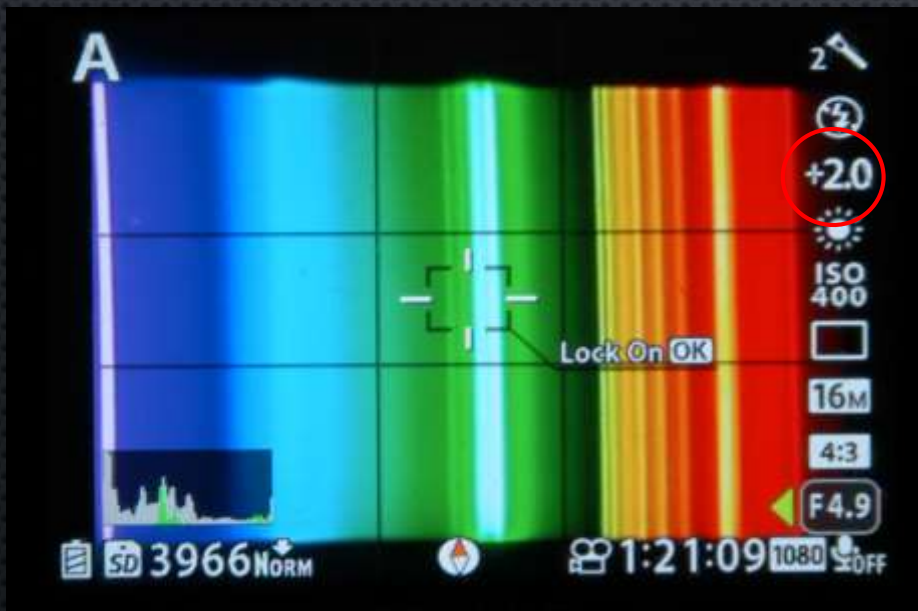
Compact Fluorescent Cal Spectrum



Press "Info" button on TG (repeatedly) until live histogram is displayed.
Used to optimize exposure

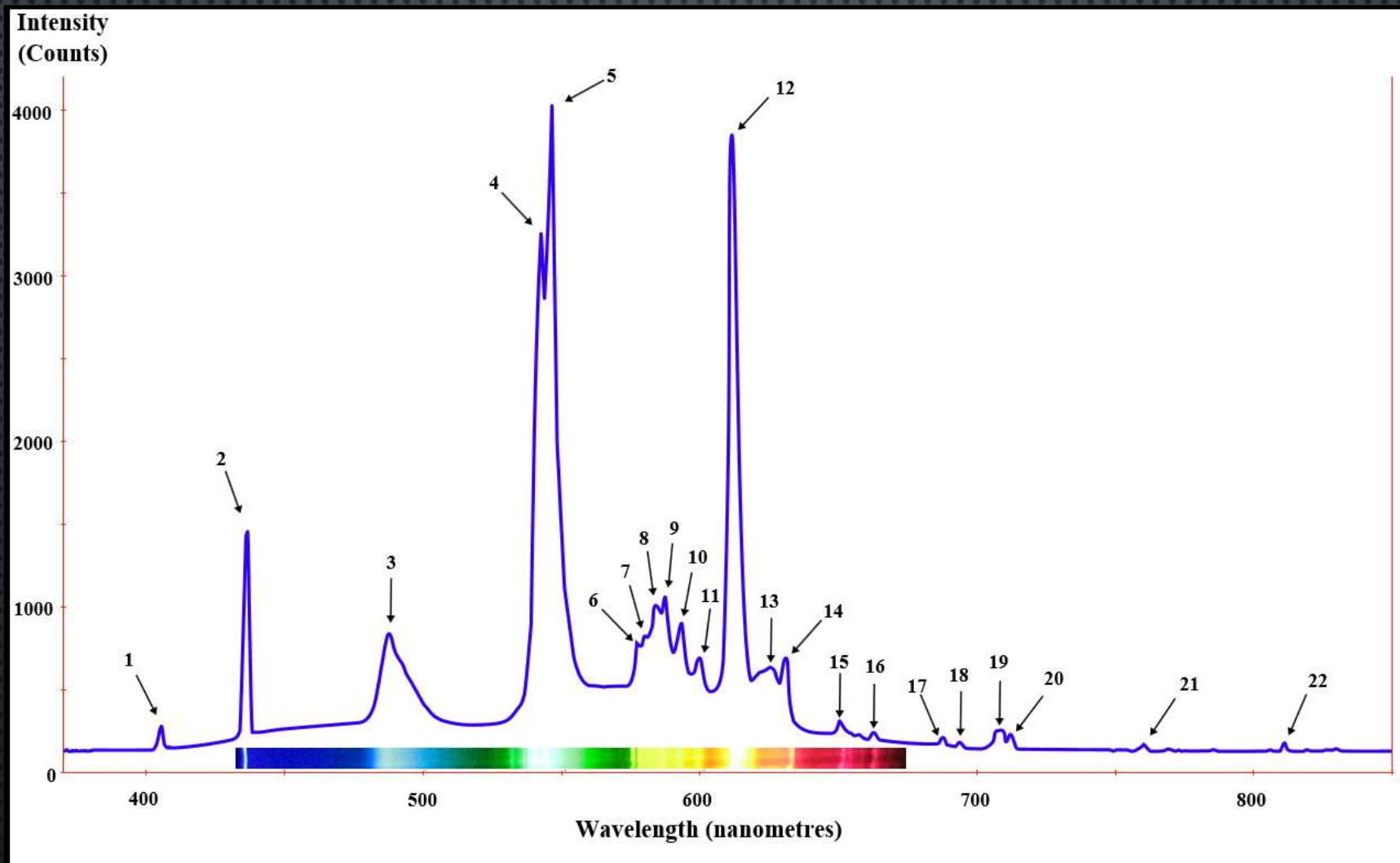


Slightly underexposed, not all levels used. Increase exposure compensation > -2



Some channels overexposed, 255 max reached. Dial back exposure compensation $< +2$

Fluorescent Lamp Spectrum



https://commons.wikimedia.org/wiki/File:Fluorescent_lighting_spectrum_peaks_labelled.gif

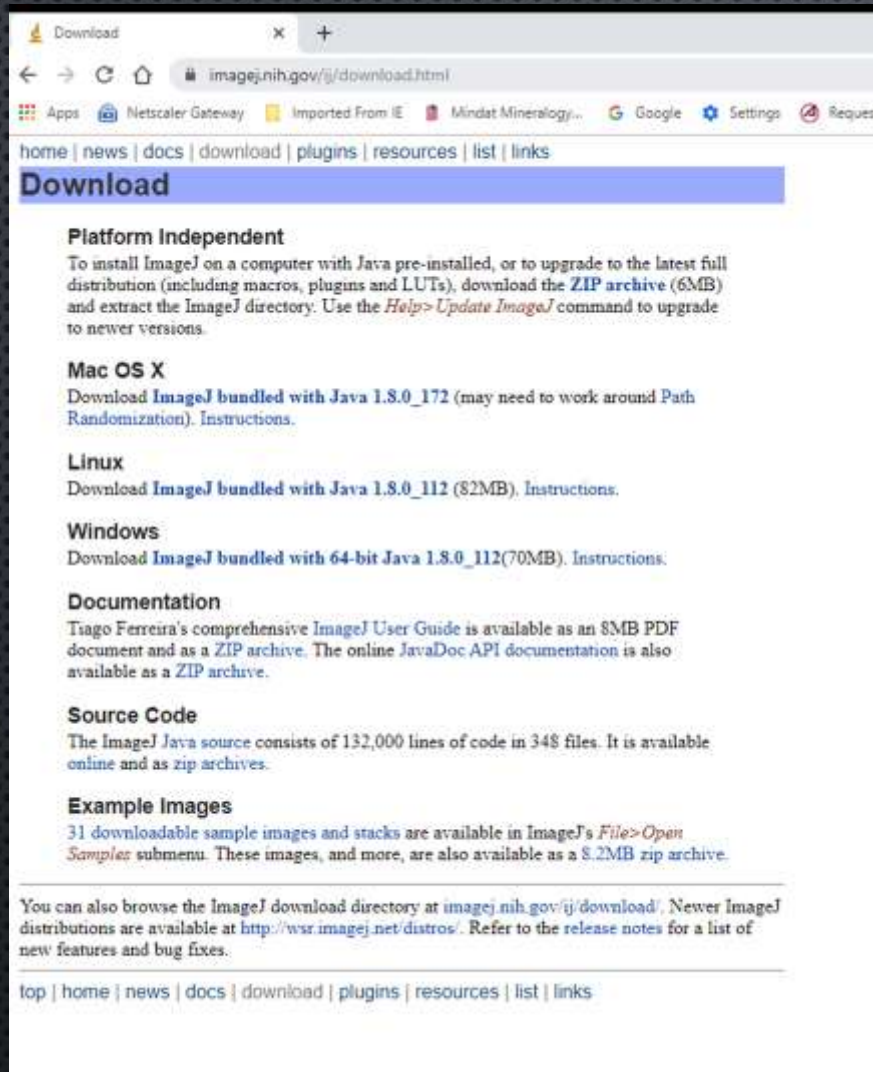
Fluorescent Lamp

Peak number	Wavelength of peak (nm)	Species producing peak	Actual line location (nm)
1	405.4	mercury	404.656
2	436.6	mercury	435.833
3	487.7	terbium from Tb^{3+}	~485 to 490
4	542.4	terbium from Tb^{3+}	~543 to 544
5	546.5	mercury	546.074
6	577.7	likely terbium from Tb^{3+} or mercury	576.960 for Hg or ~578 for Tb
7	580.2	mercury or terbium from Tb^{3+}	579.066 for Hg or ~580 for Tb
8	584.0	possibly terbium from Tb^{3+} or europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~580
9	587.6	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~587
10	593.4	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~593
11	599.7	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~598
12	611.6	europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~611
13	625.7	likely terbium from Tb^{3+}	~625
14	631.1	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~630
15	650.8	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~650
16	662.6	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~661
17	687.7	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~687-688
18	693.7	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~693
19	707 and 709	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~707 and ~709
20	712.3	likely europium in $\text{Eu}^{+3}:\text{Y}_2\text{O}_3$	~712
21	760.0	likely argon	758.9315 or 763.5106 (??)
22	811.0	likely argon	811.531

- Note that the terbium could be either Tb^{3+} , $\text{Ce}^{3+}:\text{LaPO}_4$ or $\text{Tb}^{3+}:\text{CeMgAl}_{11}\text{O}_{19}$.

https://commons.wikimedia.org/wiki/File:Fluorescent_lighting_spectrum_peaks_labelled.gif

Image-J/FIJI Download



The screenshot shows a web browser window with the address bar displaying imagej.nih.gov/ij/download.html. The page has a navigation bar with links: home | news | docs | download | plugins | resources | list | links. The main content area is titled "Download" and contains several sections: "Platform Independent" (describing installation on Java-pre-installed systems), "Mac OS X" (linking to a download of ImageJ with Java 1.8.0_172), "Linux" (linking to a download of ImageJ with Java 1.8.0_112), "Windows" (linking to a download of ImageJ with 64-bit Java 1.8.0_112), "Documentation" (linking to a user guide and JavaDoc), "Source Code" (linking to the source code), and "Example Images" (linking to sample images and stacks). At the bottom, there is a note about browsing the download directory and newer distributions.

Download

Platform Independent
To install ImageJ on a computer with Java pre-installed, or to upgrade to the latest full distribution (including macros, plugins and LUTs), download the [ZIP archive](#) (6MB) and extract the ImageJ directory. Use the *Help> Update ImageJ* command to upgrade to newer versions.

Mac OS X
Download [ImageJ bundled with Java 1.8.0_172](#) (may need to work around Path Randomization). [Instructions](#).

Linux
Download [ImageJ bundled with Java 1.8.0_112](#) (82MB). [Instructions](#).

Windows
Download [ImageJ bundled with 64-bit Java 1.8.0_112](#) (70MB). [Instructions](#).

Documentation
Tiago Ferreira's comprehensive [ImageJ User Guide](#) is available as an 8MB PDF document and as a [ZIP archive](#). The online [JavaDoc API documentation](#) is also available as a [ZIP archive](#).

Source Code
The ImageJ Java source consists of 132,000 lines of code in 348 files. It is available [online](#) and as [zip archives](#).

Example Images
31 downloadable sample images and stacks are available in ImageJ's *File>Open Samples* submenu. These images, and more, are also available as a [8.2MB zip archive](#).

You can also browse the ImageJ download directory at imagej.nih.gov/ij/download/. Newer ImageJ distributions are available at <http://wsr.imagej.net/distros/>. Refer to the [release notes](#) for a list of new features and bug fixes.

top | home | news | docs | download | plugins | resources | list | links

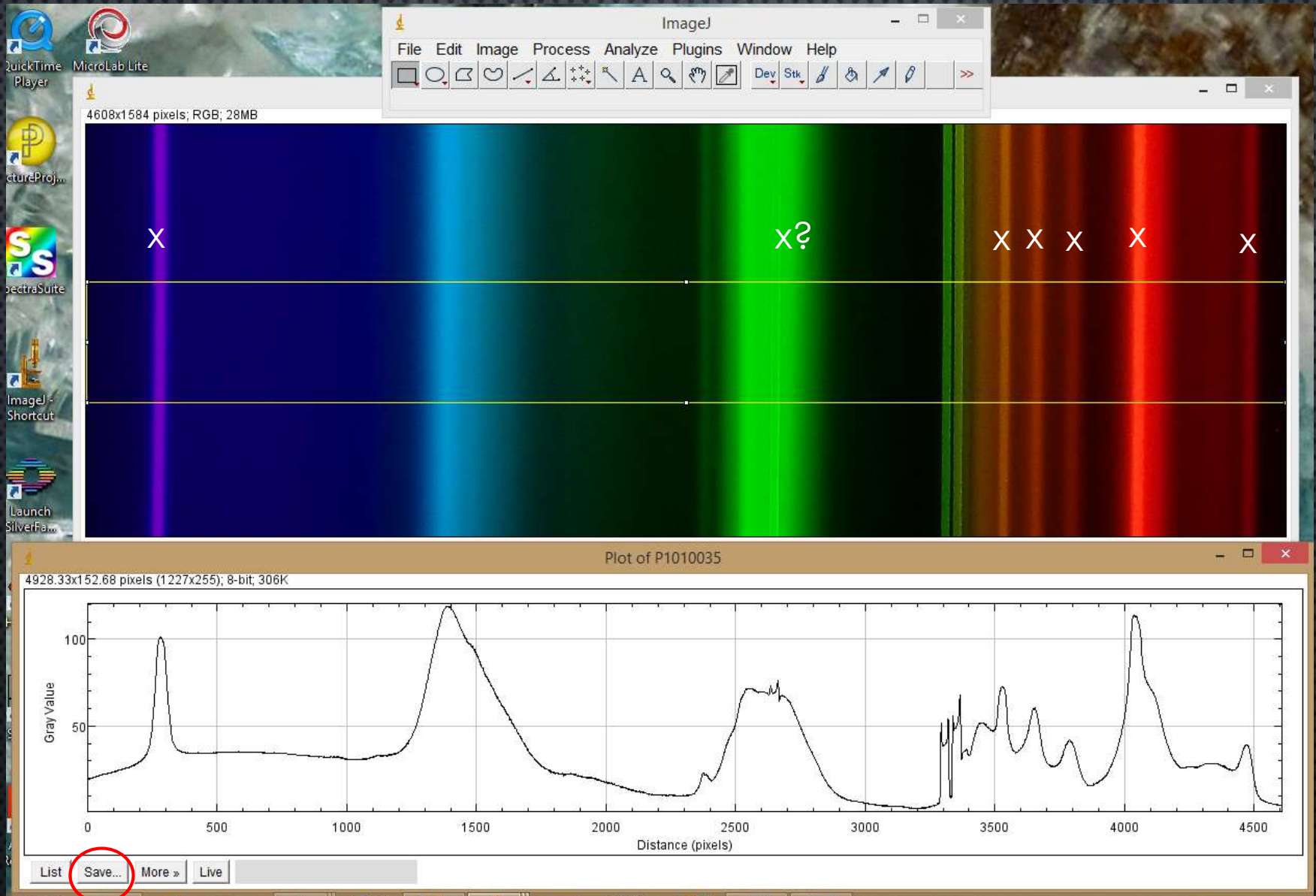
FIJI = Full Image-J Implementation

Includes all plugins-macros already installed . They are not necessary for using the spectroscope, but do take up more memory.

<https://imagej.nih.gov/ij/download.html>

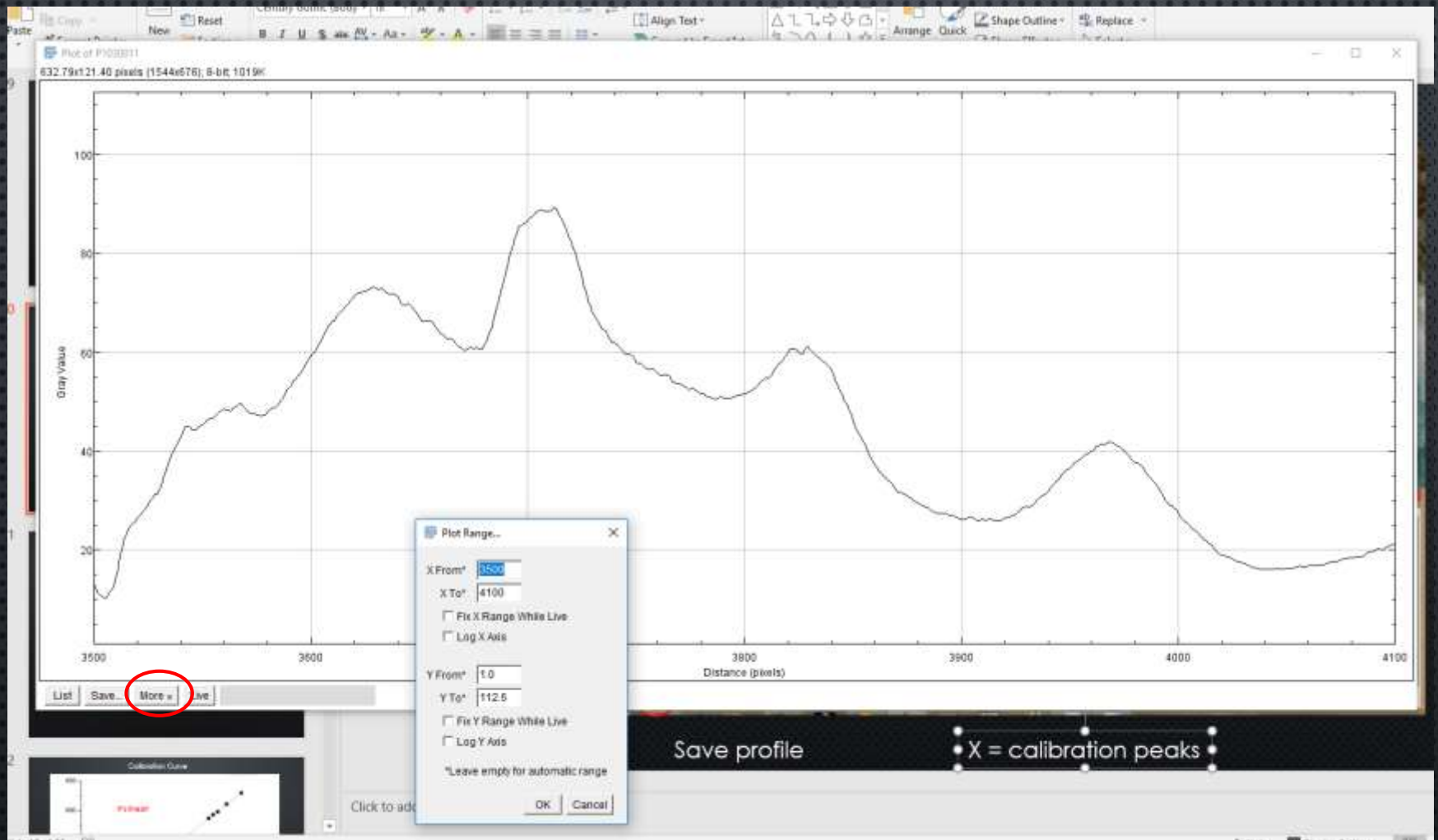
<https://imagej.net/Fiji/Downloads>

Open images in Image-J. Crop. With Box-tool/ Analyze/Plot Profile



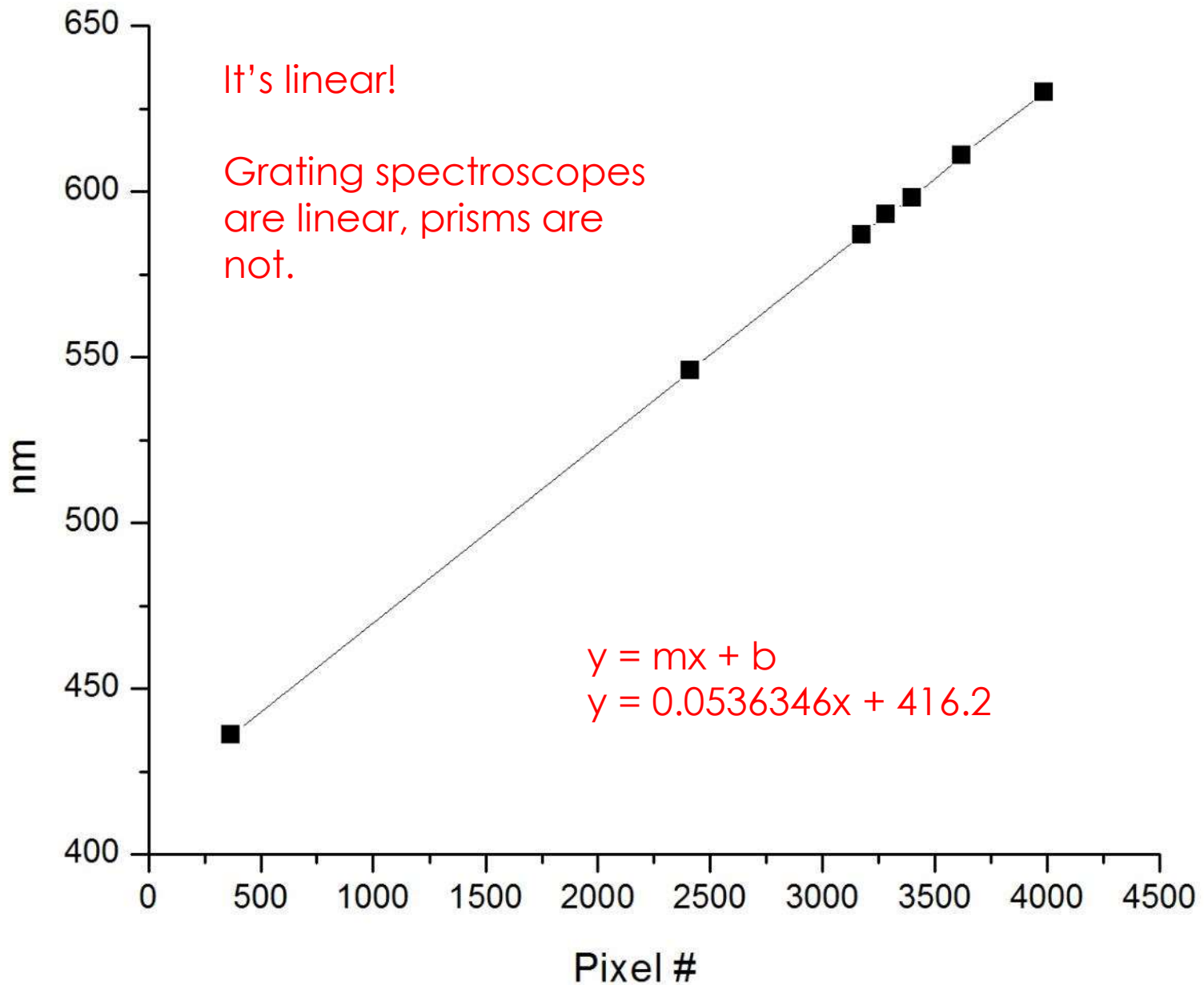
Save profile X = calibration peaks

Pixel #1 is the left most in the box not the image. Make sure the left edge of the box = the left edge of the image!



More/Set range: zooms in. Cursor reads out x-position to manually find peak locations

Calibration Curve



Excel program does least squares refinement and delivers m and b

$y = mx + b$

Excel FORMULAS tab interface showing the function library and the selection of the LINEST function.

	A	B	C
1	292	436	
2	2669	546	
3	3534	587	
4	3657	593	
5	3794	598	
6	4046	611	
7	4474	630	
8	Pixel nm	0.046491 m	
9	#	422.0002 b	
10			
11			
12			

LINEST says it delivers m and b, but I only saw m? I had to calculate b.

Image-J also does curve fitting (least square straight line) and returns $m(b)$ and $b(a)$

The screenshot displays the ImageJ interface with the 'Analyze' menu open. The 'Tools' option is selected, revealing a submenu where 'Curve Fitting...' is highlighted. In the background, a PowerPoint slide titled 'POCKET SPECTROSCOPE rev2 - PowerPoint' is visible, showing an Excel spreadsheet with a linear regression graph. The 'Curve Fitter' dialog box is open, showing a 'Straight Line' fit with the equation $y = a + bx$. The fit parameters are displayed as $a = 422.36252$, $b = 0.046491$, and $R^2 = 0.9999$. The graph shows a series of data points (red dots) and a fitted straight line (blue line) on a grid. The X-axis ranges from 0 to 4000, and the Y-axis ranges from 450 to 600. The data points are labeled with their X and Y coordinates in the background table.

ImageJ

File Edit Image Process **Analyze** Plugins Window Help

Measure Ctrl+M
Analyze Particles...
Summarize
Distribution...
Label
Clear Results
Set Measurements...
Set Scale...
Calibrate...
Histogram Ctrl+H
Plot Profile Ctrl+K
Surface Plot...
Gels
Tools

Tools

- Save XY Coordinates...
- Fractal Box Count...
- Analyze Line Graph
- Curve Fitting...**
- ROI Manager...
- Scale Bar...
- Calibration Bar...
- Synchronize Windows
- Grid...

Curve Fitter

Straight Line Fit Open Apply Show settings

292 436
2669 546
3534 587
3657 593
3794 598
4046 611
4474 630

Import file and change x (pixel#) or type in all values

$y = a + bx$
4925.47x247.89 pixels (530x255); RGB; 528K

Straight Line
 $y = a + bx$
 $a = 422.36252$
 $b = 0.046491$
 $R^2 = 0.9999$

Y

X

List Save... More »

Excel program does linear regression

FILE HOME INSERT

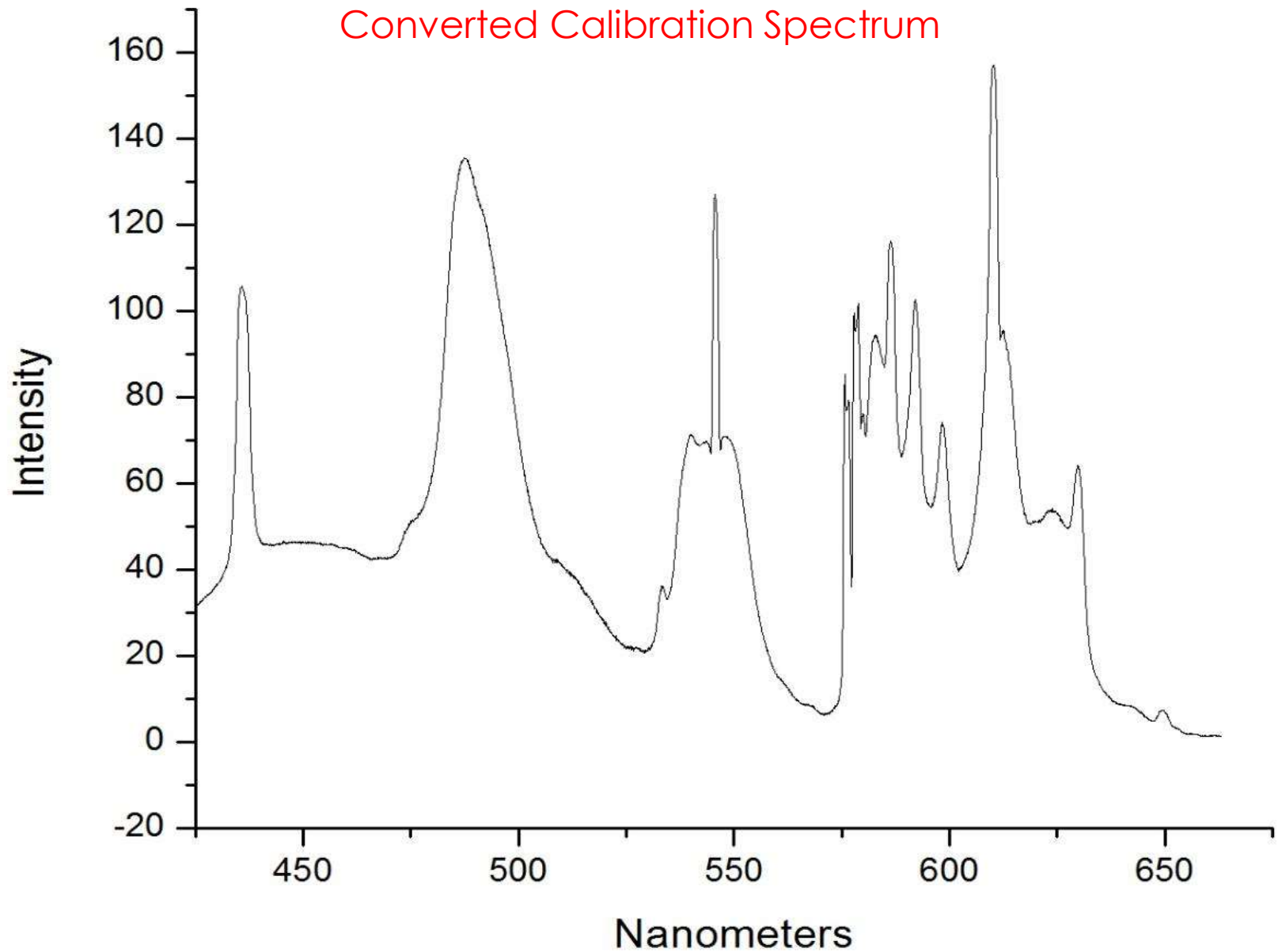
fx Insert Function

Σ AutoSum Recently Used

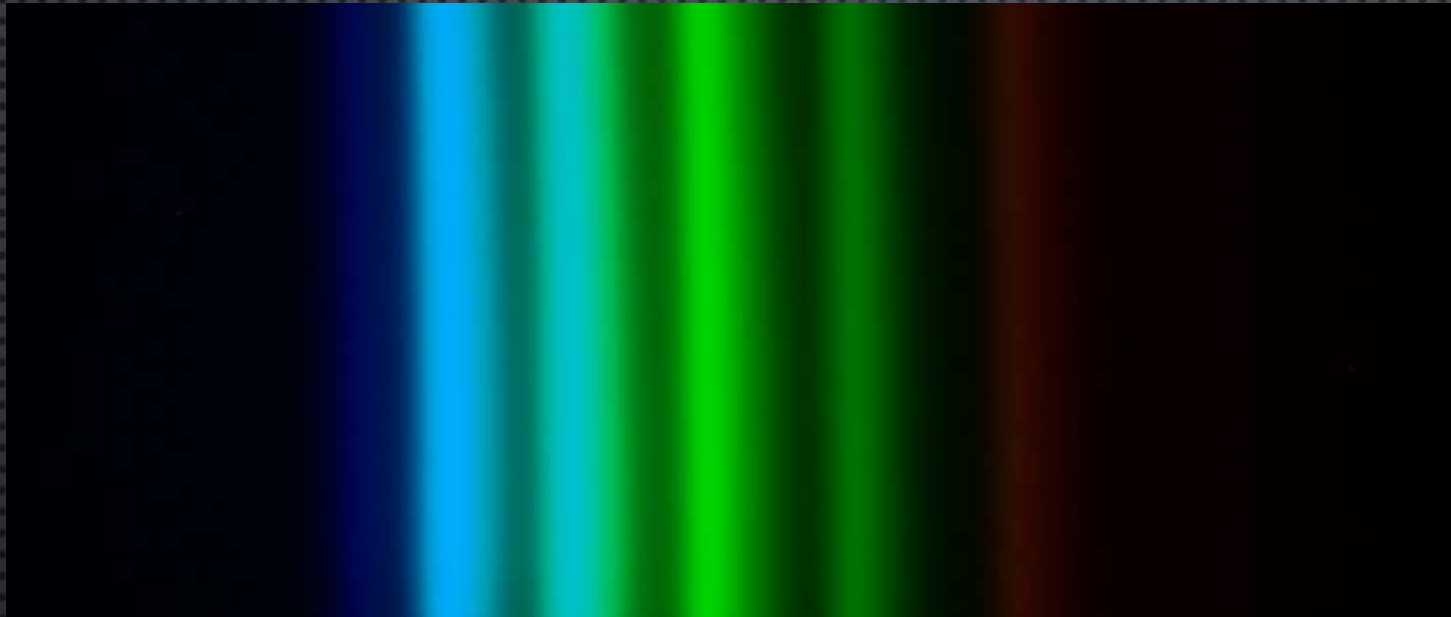
Pixel nm

#

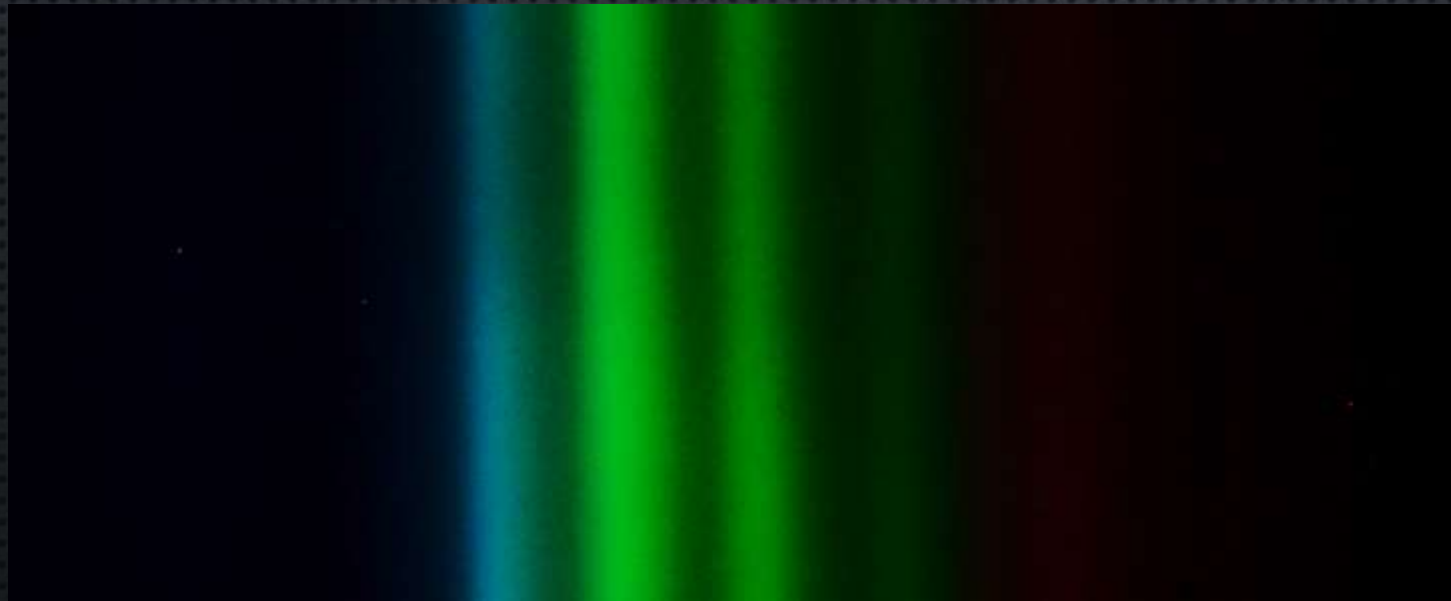
Use Excel program to apply calibration – conversion to nanometers



Possibly use for field discrimination? WiFi transfer to cell phone.



Bobcookite

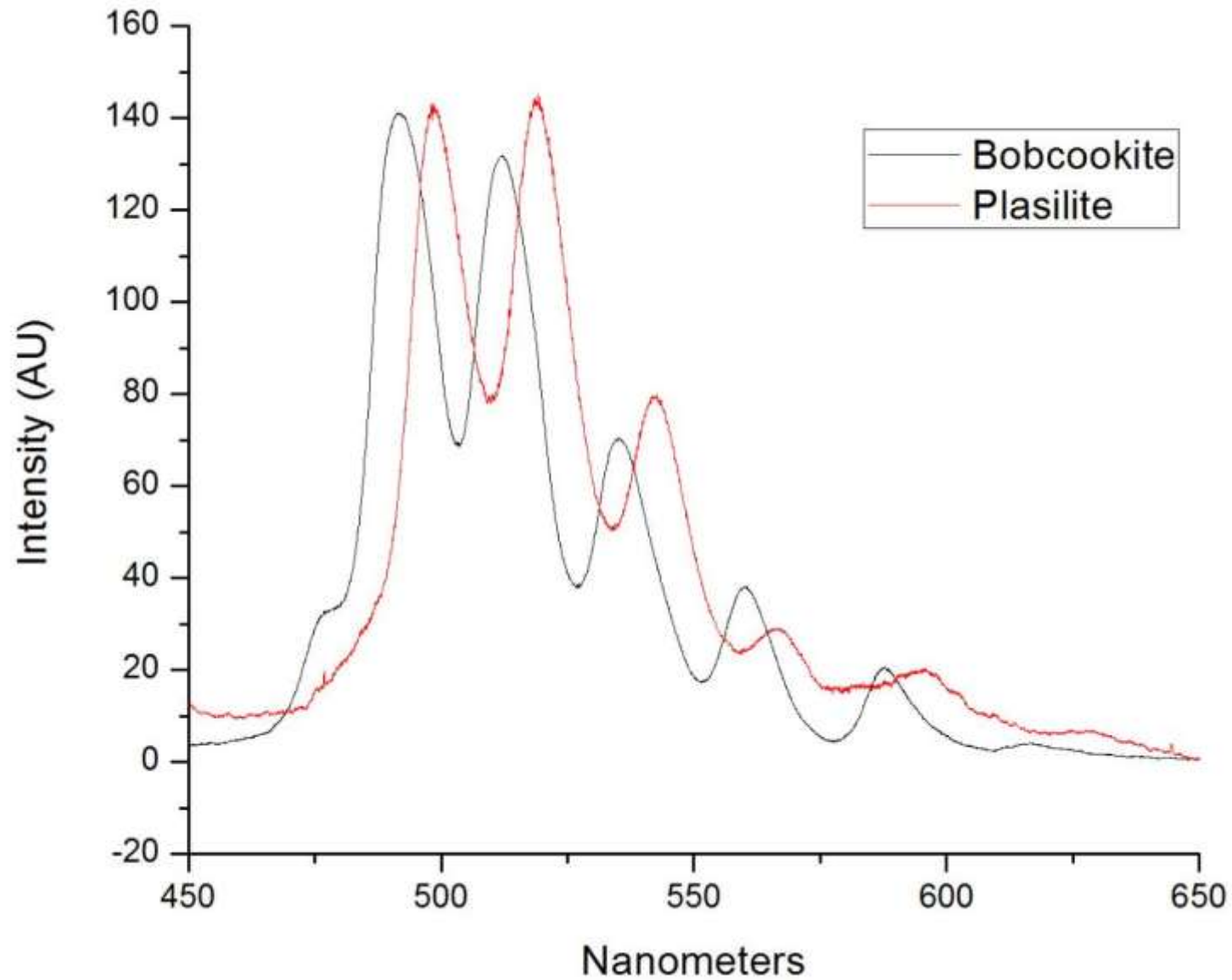


Plasilite

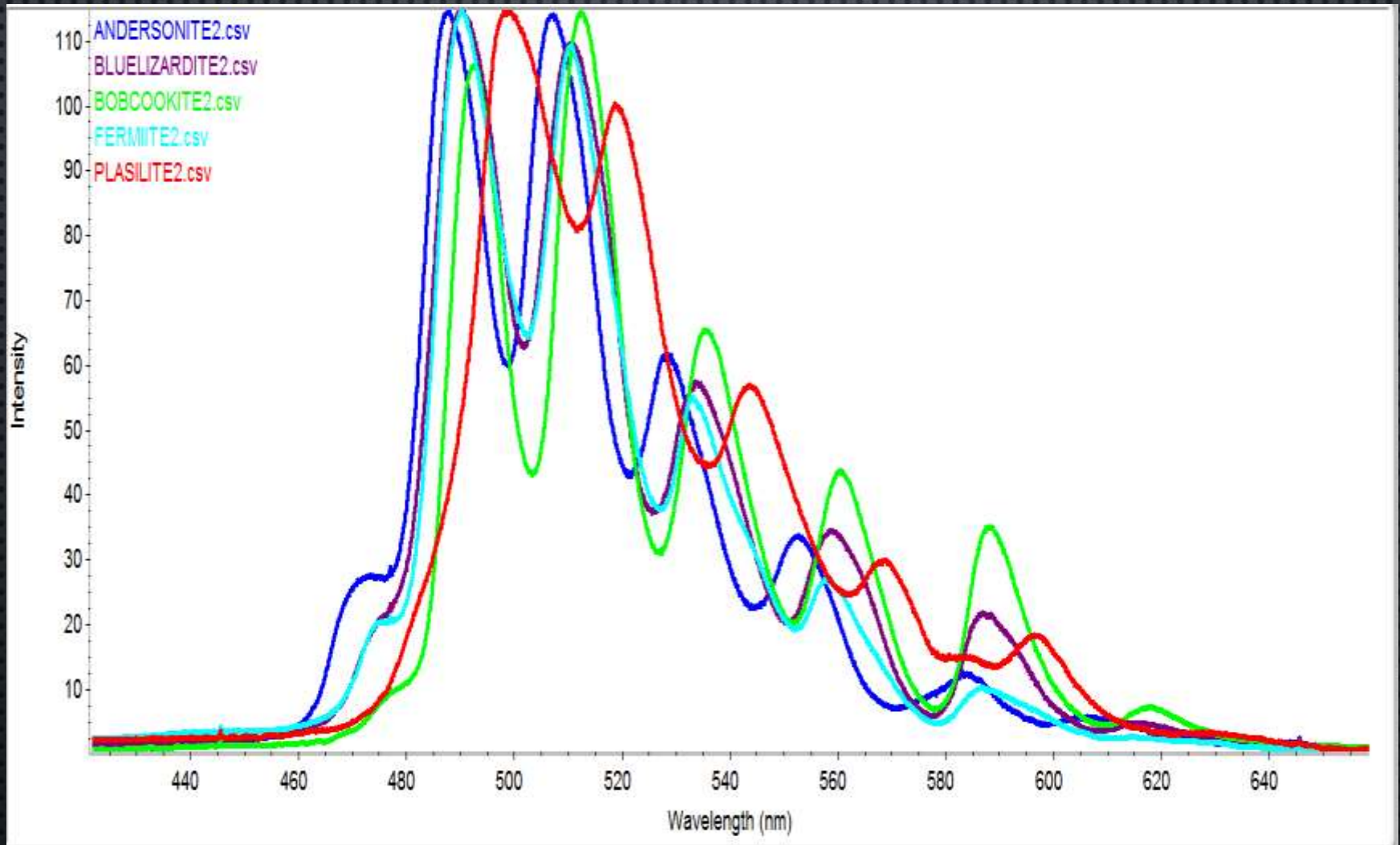


Natrozippeite

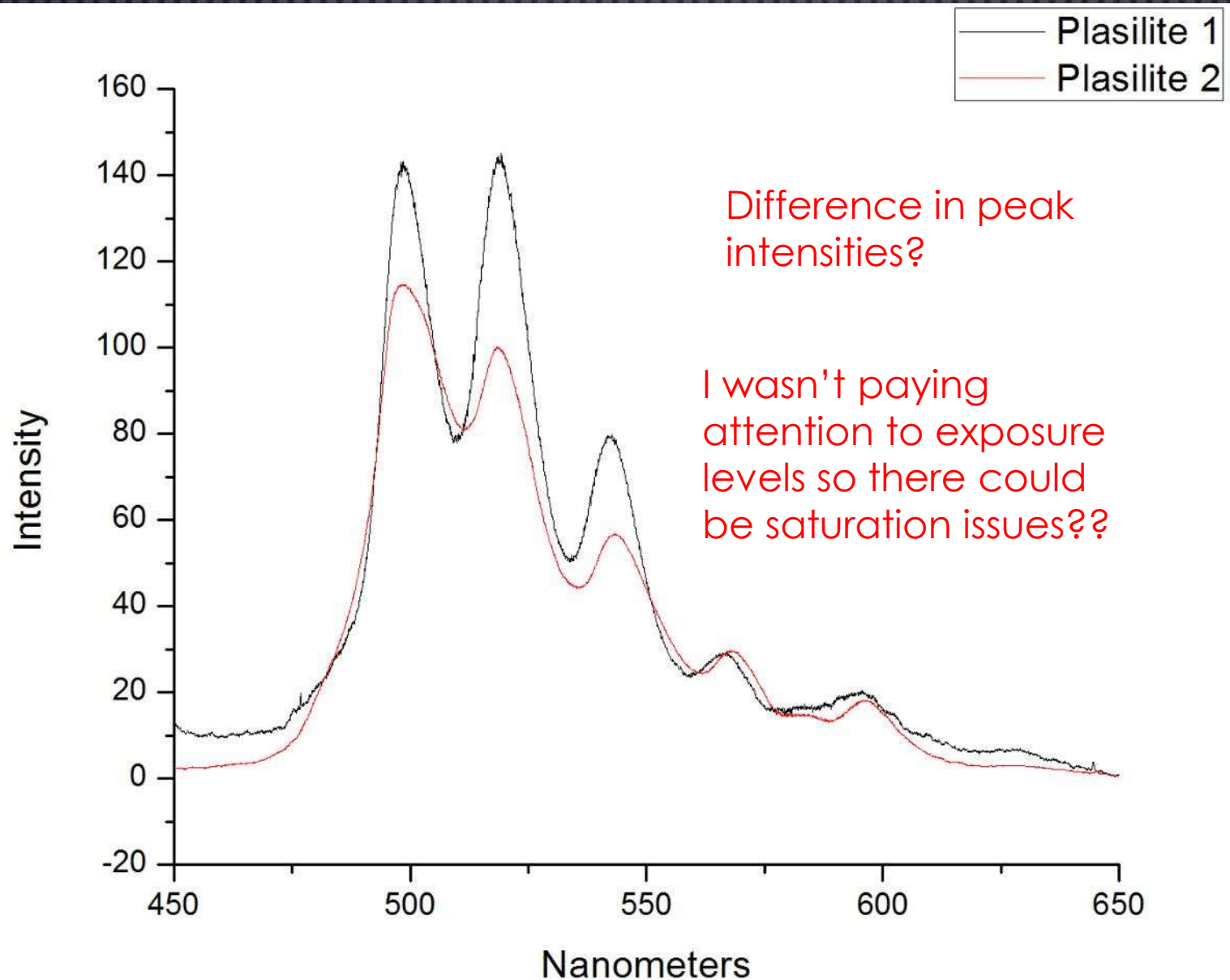
7 nm peak shift



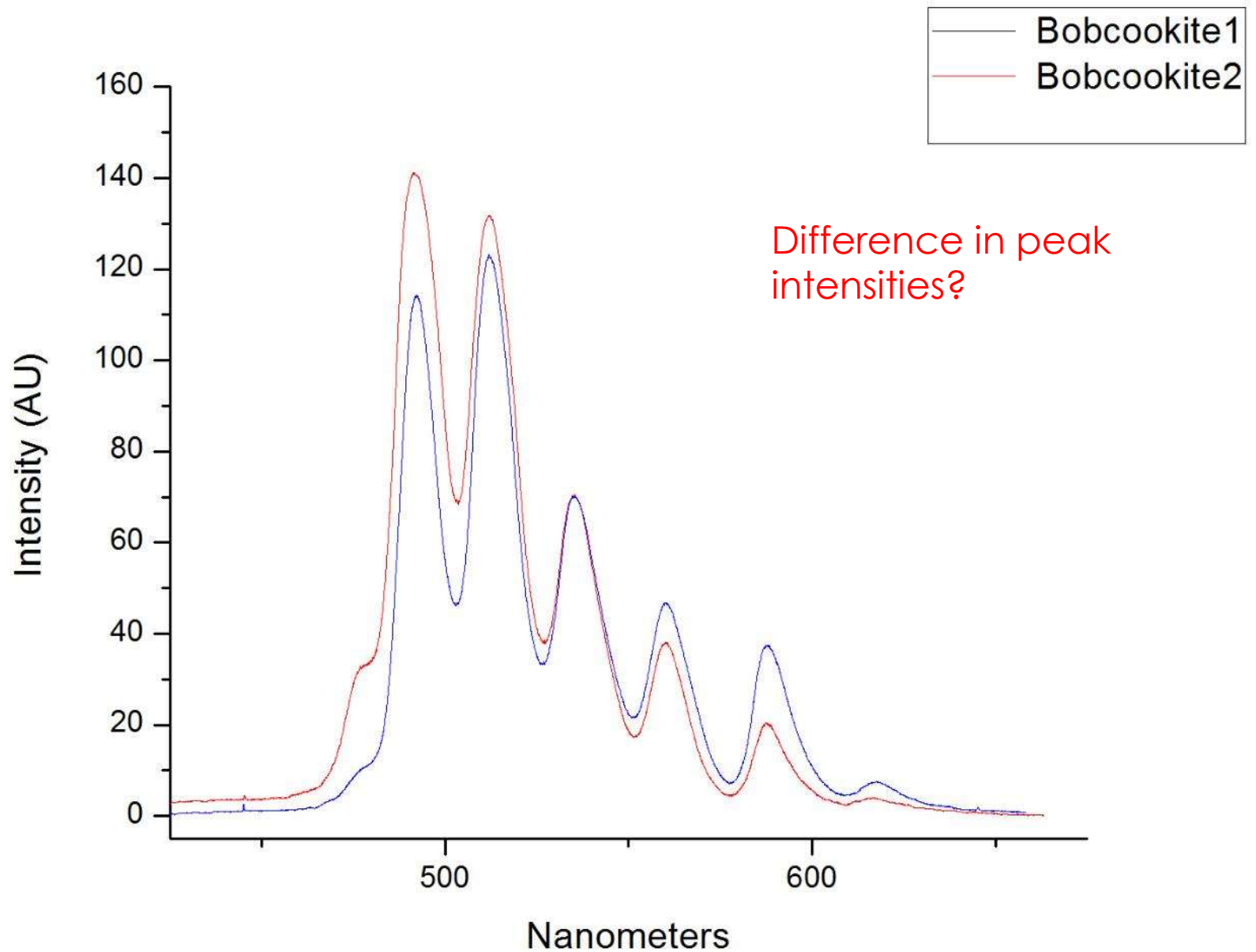
Subtle differences between common species
12 nm shift between andersonite and plasite



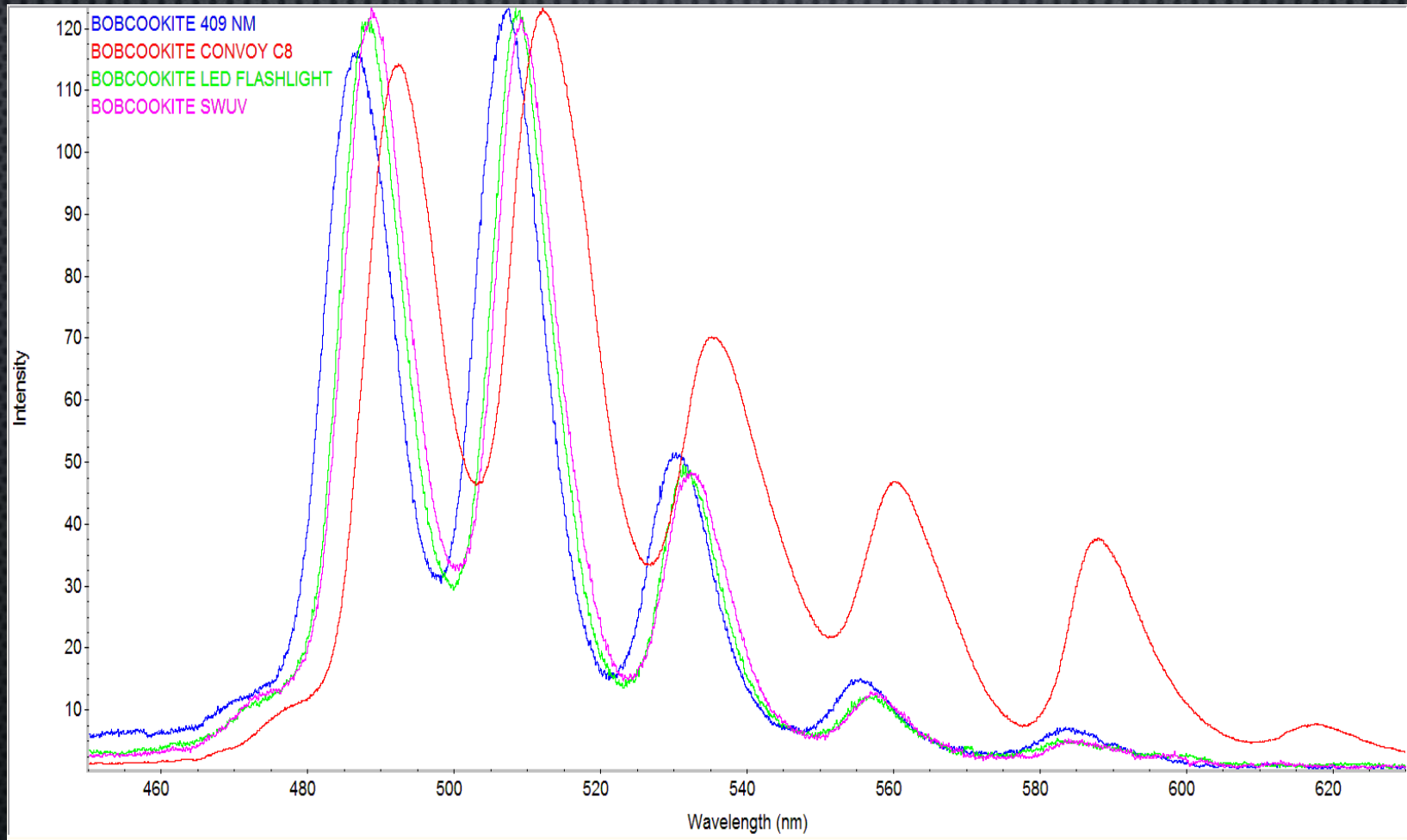
Plasilite: Two specimens – two calibrations



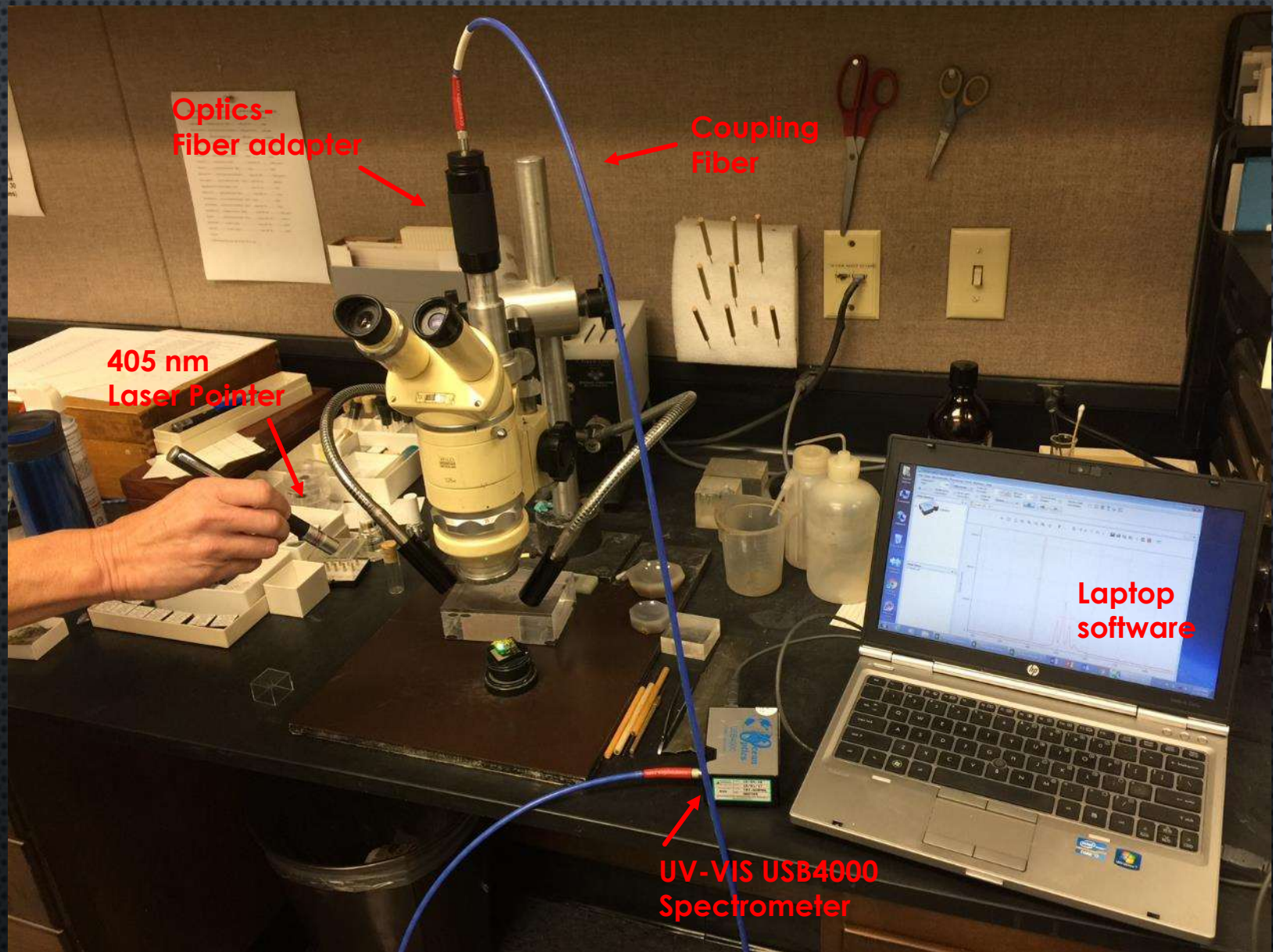
Bobcookite: Two specimens – two calibrations



Subtle peak shifts depending on excitation wavelength?



Comparison with Ocean Optics USB4000 Spectrometer



For macro samples (without microscope. i.e. bare fiber) LED flashlight was adequate

<http://oceanoptics.com/product/usb2000uv-vis/>

Mod...Mod...Mod...U... x

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Application-ready Spectrometer for the UV-VIS

Please [contact us online](#) for more information about ordering this product.



+

TAGS:

COMPATIBLEFASTMODULARPORTABLE

The Most Popular Miniature Spectrometer in the World

The USB2000+UV-VIS is a miniature spectrometer pre-configured for general UV-VIS measurements. Covering a wide wavelength range, from 200 to 850 nm, this high-performance spectrometer fits into the palm of your hand giving your measurements new flexibility. Using the modular approach, you can customize your measurement with our wide array of sampling accessories and light sources.

+

 PRODUCT DETAILS

+

 SPECIFICATIONS

+

 DOWNLOADS

+

 APPLICATIONS

+

 MEASUREMENT TECHNIQUES

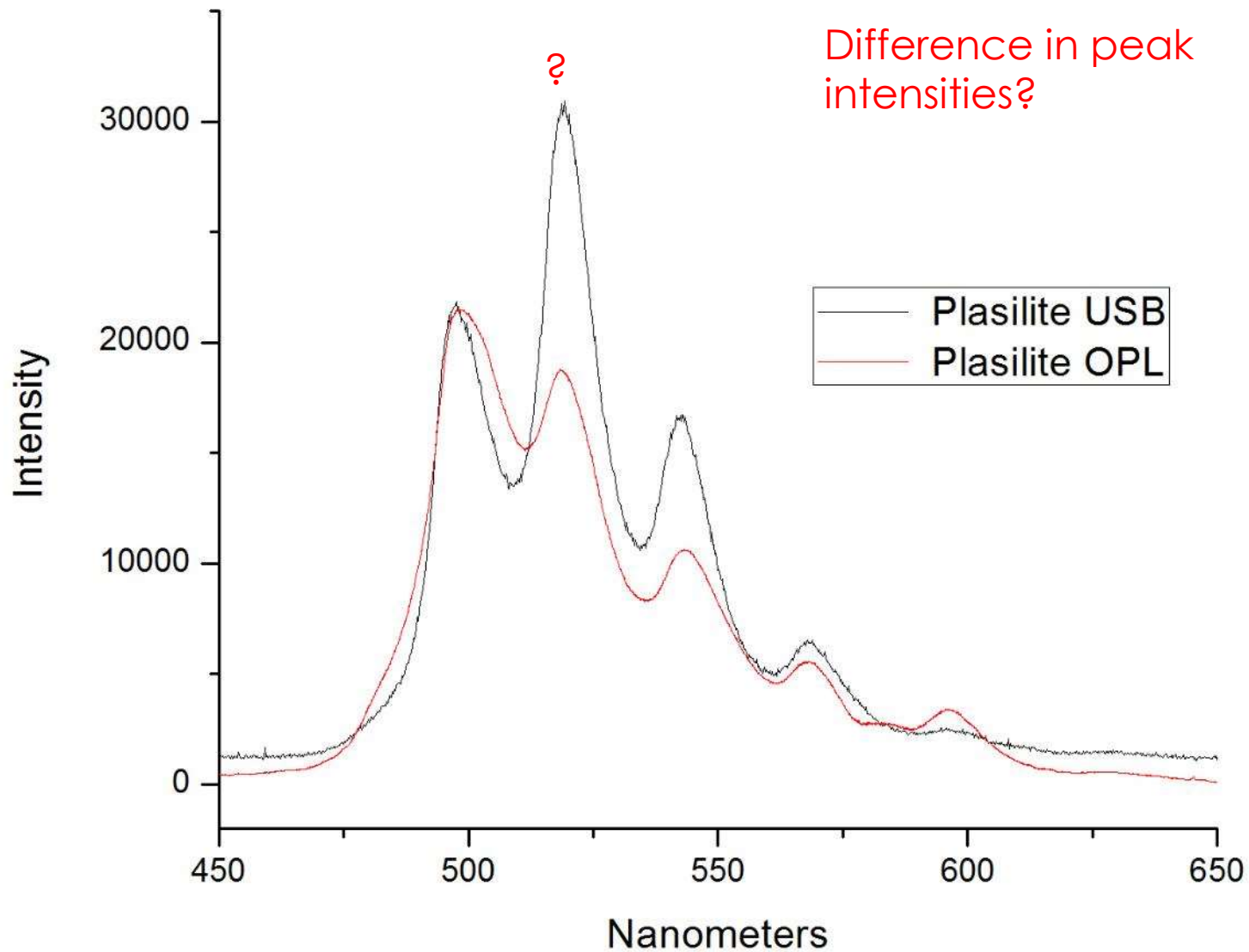
+

 RELATED PRODUCTS

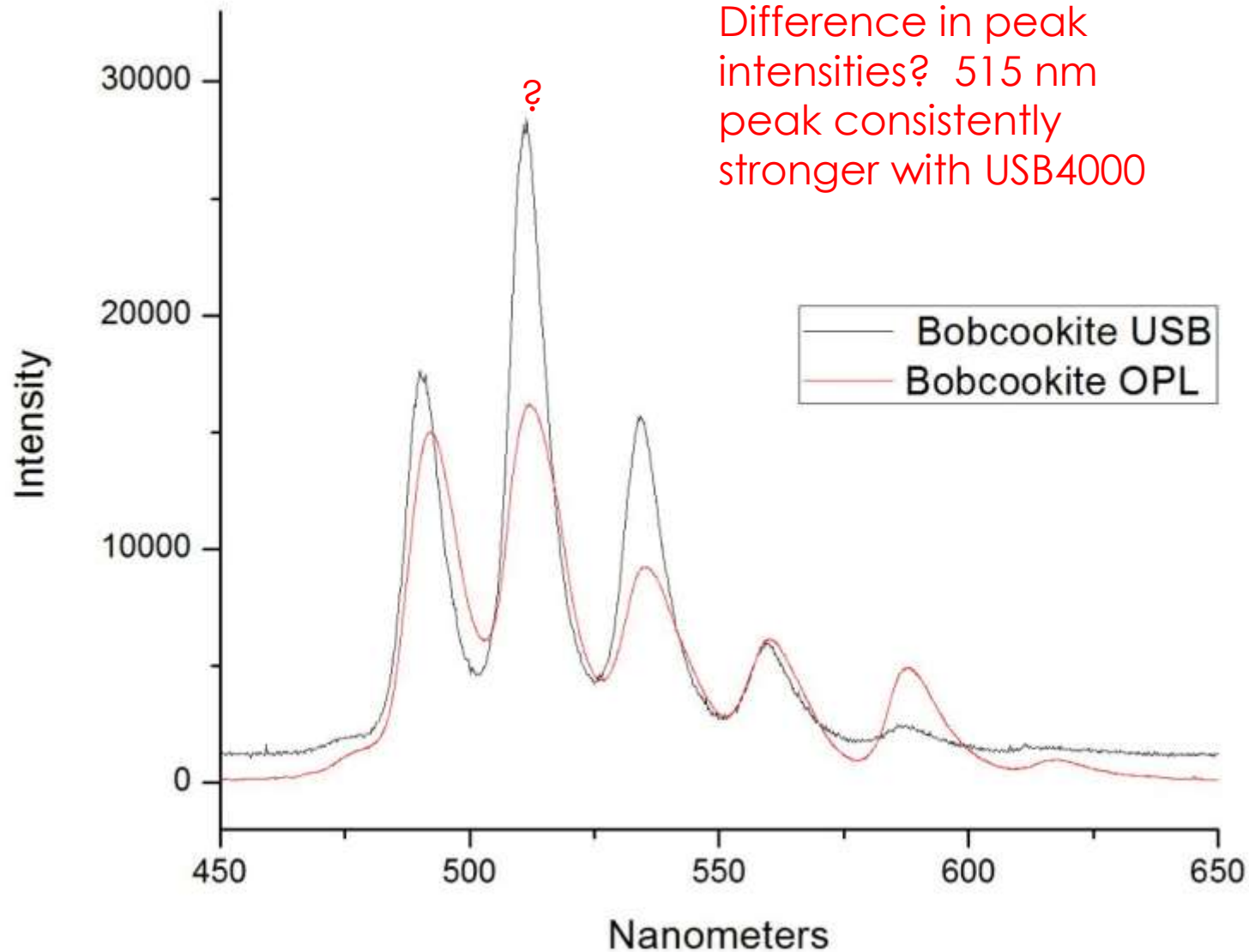
+

 FAQ (FREQUENTLY ASKED QUESTIONS)

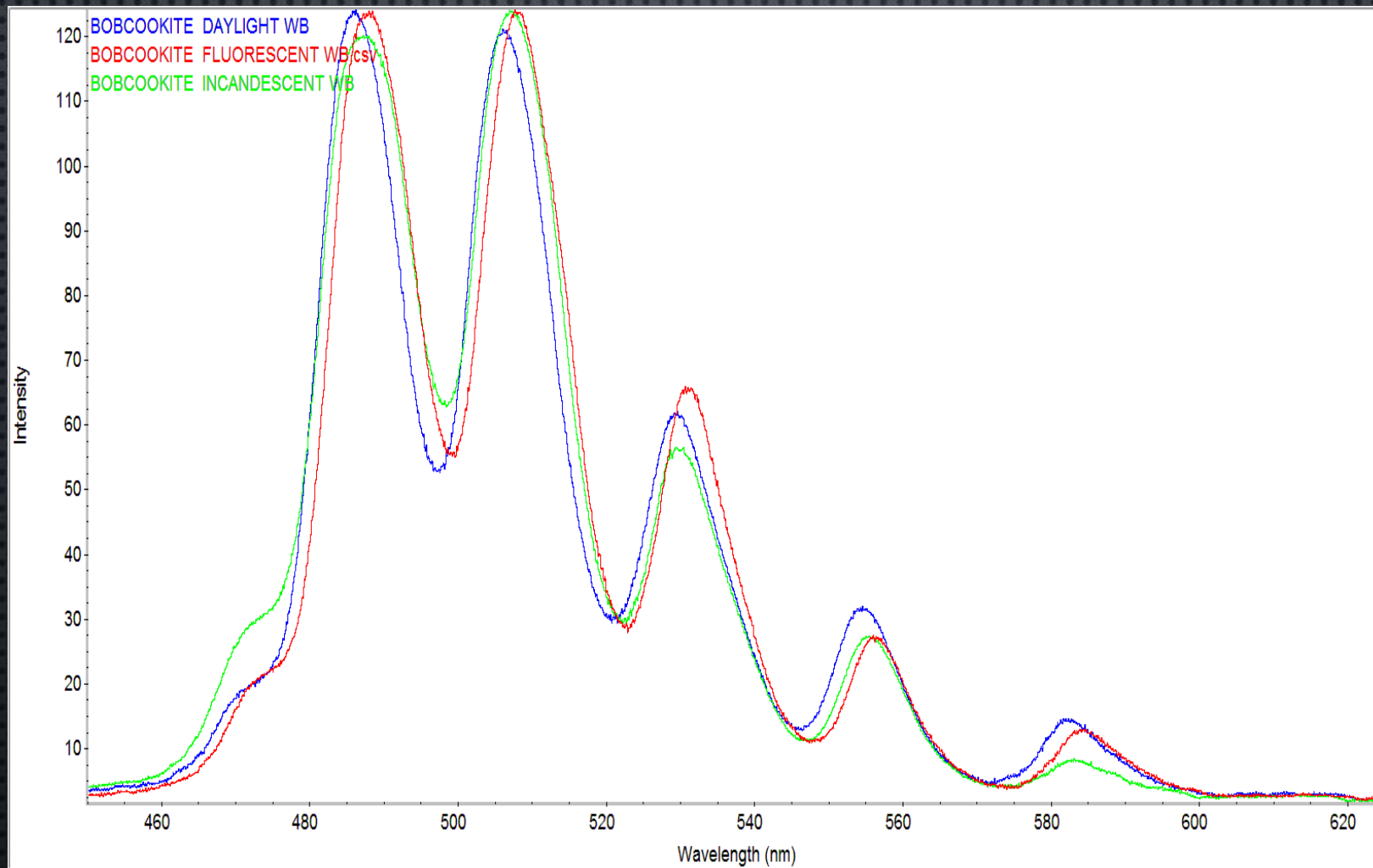
Ocean Optics USB4000 with LED Flashlight Comparison with OPL Pocket Spectroscope with Convoy C8



Ocean Optics USB4000 with LED Flashlight Comparison with OPL Pocket Spectroscope with Convoy C8



Convoy C8 as a Function of Camera White Balance



Spectroscopic properties of uranium(VI) minerals studied by time-resolved laser-induced fluorescence spectroscopy (TRLFS)

By G. Geipel^{1,*}, G. Bernhard¹, M. Rutsch¹, V. Brendler¹ and H. Nitsche^{1,2}

¹ Forschungszentrum Rossendorf, Institute of Radiochemistry, P.O. Box 510 119, D-01314 Dresden, Germany

² University of California at Berkeley and Lawrence Berkeley National Laboratory, The Glenn T. Seaborg Center, MS 70A-1150, Berkeley, CA 94720, USA

266 nm excitation

Mineral	fluorescence emission bands/nm					
	Phosphates					
Chemikovite						
Saleeite	489.0	501.1	522.1	545.7	570.9	600.9
Autunite	488.6	504.0	524.2	548.0	573.9	602.4
Metaautunite	491.3	501.8	522.9	546.9	572.2	591.7
Uranocircite	488.1	503.5	523.9	547.0	572.1	599.7
Metauranocircite	488.9	502.5	523.7	547.4	573.4	602.6
Sabugalite	491.4	506.4	527.7	550.8	575.9	604.8
Threadgoldite	489.7	501.4	522.1	545.6	571.2	601.3
Ranunculite	491.4	501.2	521.9	545.5	570.5	600.3
Phuralumite	496.9	500.6	520.3	542.9	568.7	599.9
	Arsenates					
Troegerite	485.5	502.2	524.4	547.4	572.7	604.8
Novacekite	486.3	502.6	523.1	546.8	572.8	601.7
Metanovaceckite	492.1	504.3	526.7	549.7	575.5	608.2
Uranospinitite	488.2	502.2	523.6	547.2	573.0	600.7
Metauranospinitite	489.9	502.7	526.8	549.2	574.5	604.3
Heinrichite	495.0	505.8	528.4	551.4	577.7	604.6
Metaheinrichite	492.4	505.7	527.9	551.4	576.9	606.1

Conclusions

The fluorescence data of minerals can be used as fingerprints to determine secondary mineral coatings on rock materials, and can support the interpretation of spectra of unknown ternary and quaternary solution species. These data are also useful to identify uranyl(VI) species sorbed on mineral and rock surfaces and on certain bacteria.

By comparing the fluorescence data of several mineral series, we were able to study the influence of secondary metal ions, anions and the bound water molecules on the fluorescence properties of the uranyl group. Information on the axial U–O bond length is derived from the band spacing of the fluorescence emission maxima. The vibrational ground state transition frequency is equal to the IR band of the symmetric stretching vibration ν_1 of the UO_2^{2+} ion. We found an empirical correlation between the vibrational frequency of the ground state and the fluorescence lifetime.

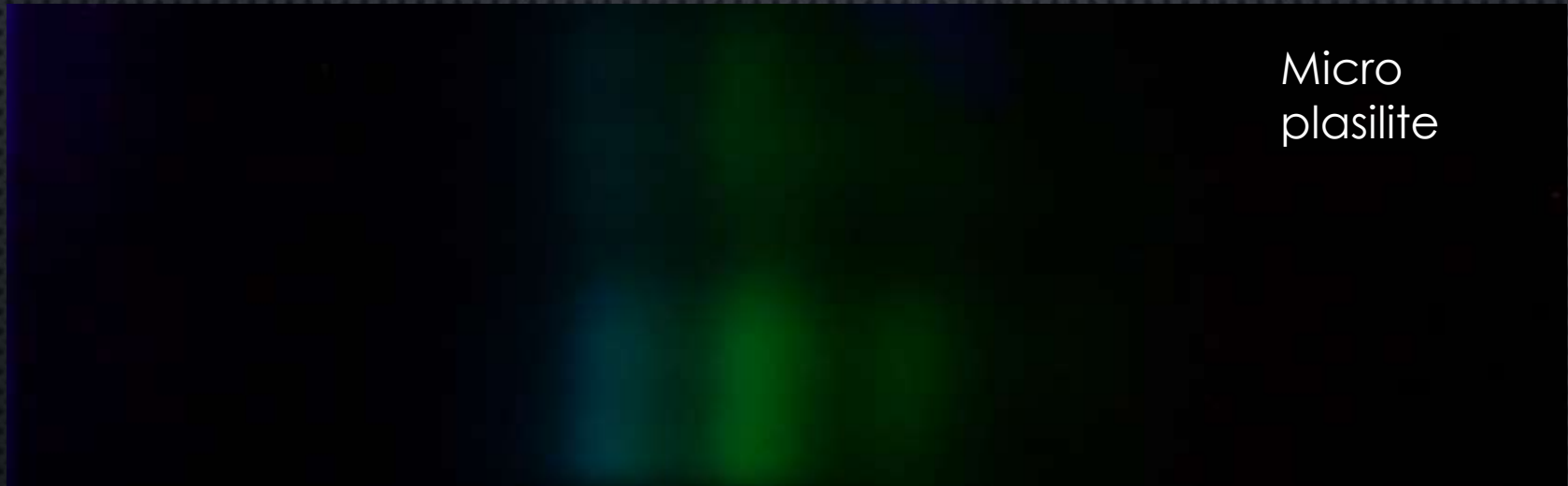
Proof of Concept:

Can spectroscope be used on a microscope to examine small crystals?



- Leitz Ortholux 2 microscope with 4X objective
- Spectroscope and camera in trinocular port – no transfer optics – same adapter as on macrostand – i.e. loose fit !
- 409 nm laser pointer (Convoy doesn't have enough output!)
- “macro” bobcookite and micro plasilite (0.1 mm? cluster of crystals?)

Leitz microscope with 4X objective

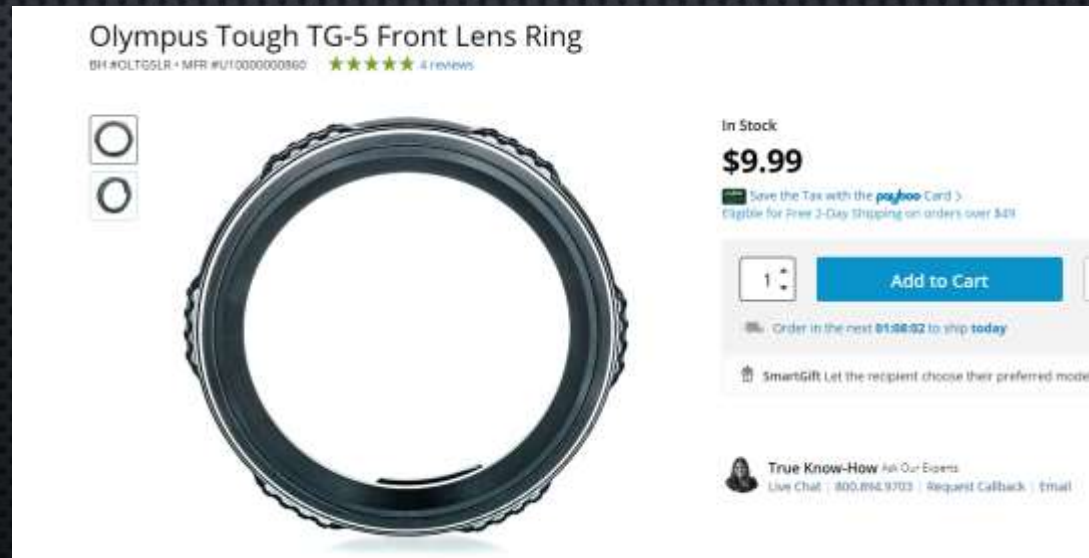


Very hard to hand hold laser pointer in FOV !!

Comments

I have a TG-3 (also a TG-5 at work). The TG-5 has many more features including ability to store RAW images (may have greater dynamic range). Image-J will not open Olympus RAW. TG-5 may have more control over shutter speeds allowing for longer exposures for weakly fluorescing samples (or shorter exposures for strong emitters).

It may be possible to couple the spectroscope/camera to a microscope with different adapter? Order a separate bayonet ring from B&H? There is also a bayonet to 40.5 mm thread adapter (\$19.95).





Spectragryph free(?) spectroscopy software. Very comprehensive package!!

Spectragryph - optical spectroscopy software

effemm2.de/spectragryph/download_dfg9us90e578z.html

Apps Netscaler Gateway Imported From IE Mindat Mineralogy... Google Settings Request Hazardous... Medical Flat Panel... gemlab.co.uk at J.K...

© 2016: Dr. Friedrich Menges Software-Entwicklung Spectroscopy Ninja | Spectrometer Hardware | Spectragryph Software Imprint


Spectroscopy Ninja presents:   **Spectragryph**
- optical spectroscopy software -


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Download of Spectragryph (fully functional trial version) [Start](#) > [Step 2](#) > [Step 3](#) > last Step

Now, really!

 **Download Spectragryph**
(lengthy install v1.2.13 from Oct 01 2016, size 13.1 MB)

 **COMODO**

The Spectragryph install file is digitally signed with a SHA-256 Comodo code signing certificate (learn more about [here](#)).

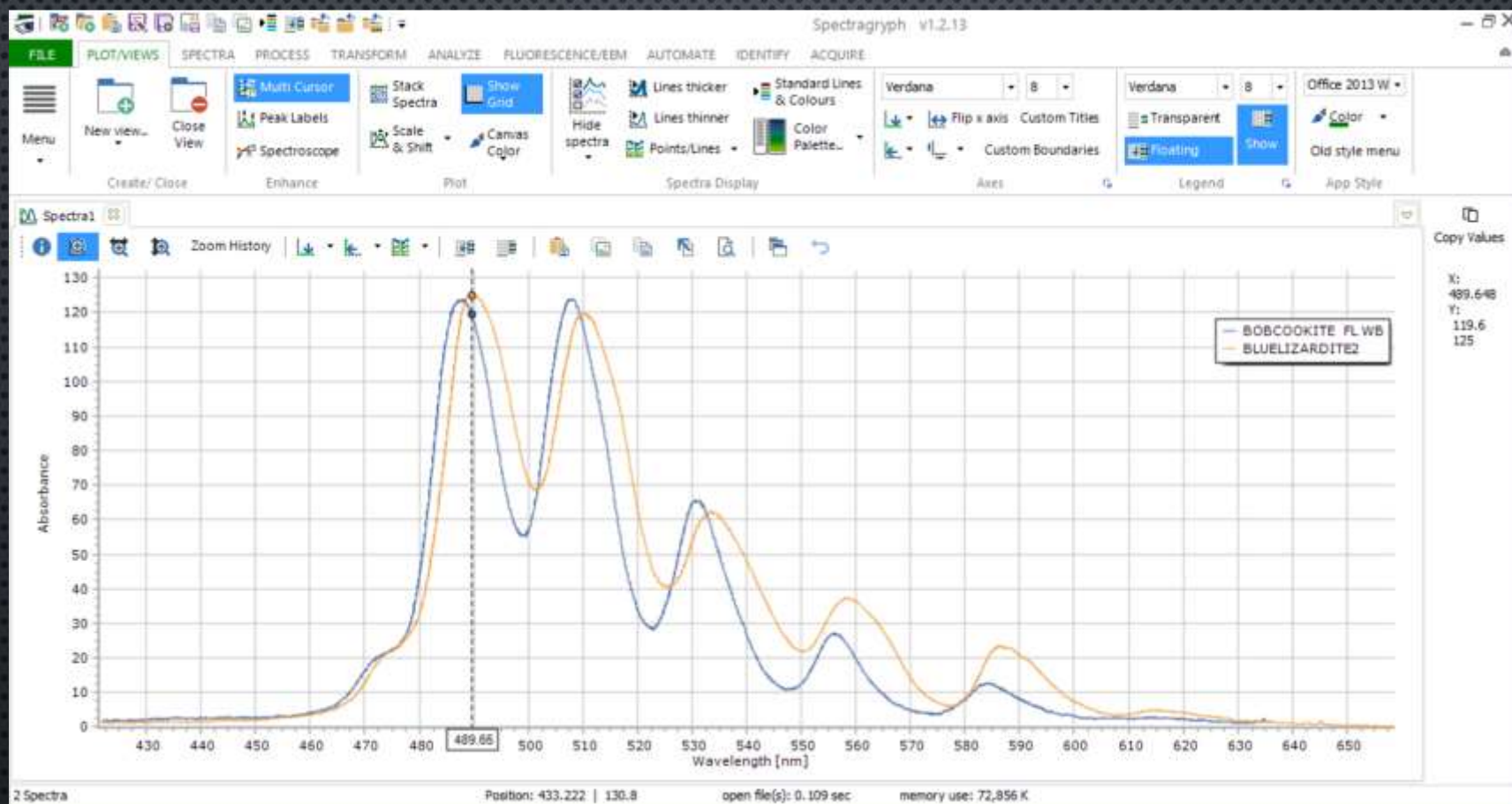
As a result, it is

spectragryph_insta...exe

Show all X

4:40 PM 1/6/2020

Spectragryph free spectroscopy software



These spectra were calibrated .csv files but it looks like it will also do the wavelength calibration from the CFL spectrum and also create databases!

Spectrum: BOBCKOOKIE FL WB

wavelength [nm]	absorbance	FWHM [nm]
488.272	123.75	15.4075
507.544	124	15.3093
530.514	65.781	11.2272
555.902	27.356	10.9612
584.228	12.716	8.48067