

## Beam-Profiling using ImageJ

R.S. Marjoribanks November 2020

edited from notes by Alex Kai Wei, 2020)

Relevant labs: HeNe, GAUS, other

**ImageJ** is a public-domain Java-based image processing program in extremely wide use for image analysis. In addition to a very large range of functions for microscopy analysis, it has wide use in optics for characterizing and manipulating diffraction images and for beam-profiling laser beams. It was originally developed at the US National Institutes of Health, and enjoys an enormous base of extensions (plug-ins and macros) which have been crowd-sourced from scientists around the world, many of them research students.

### Installation of ImageJ

ImageJ should already be installed on lab computers, together with plugin(s) needed to control several kinds of USB web cameras and CCD cameras. You can also save images with other, proprietary, camera software, then open these images using ImageJ. ImageJ is much better than other beam-profiling software you may find installed on lab computers.

If you wish to run from a personal laptop, follow these steps:

1. Download ImageJ from: <https://imagej.nih.gov/ij/download.html>. Ensure that the correct version for your computer system is installed.
2. Install a plugin for capturing images. It is suggested that you use *WebcamCapture* found here: <https://imagej.nih.gov/ij/plugins/webcam-capture/index.html>.
3. Extract these files into the *plugins* folder for ImageJ.

### Capturing a beam image

1. Connect a compatible USB camera, and open ImageJ. Under the Plugins tab, select Plugins→*WebcamCapture*→*IJ webcam plugin*.
2. A window will pop up showing the options for the camera. You can change the “Camera name” using the dropdown menu.

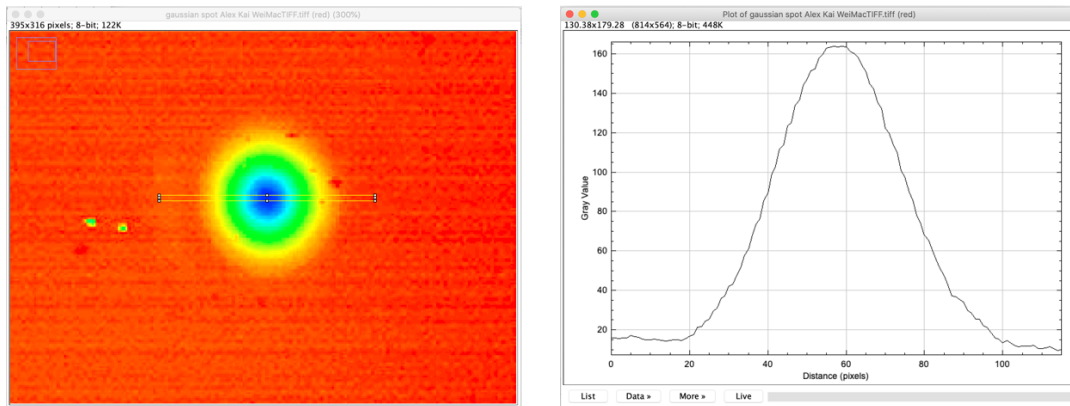
*If on a personal computer the camera is not detected by ImageJ, check that the appropriate drivers are installed for the camera. For Windows computers, this process should be automatic when a camera is plugged in, but if there is no driver, simply look up “camera name” + “driver” or check the drivers among the computer devices:*

- a. *On a Windows computer you can check for drivers by going to Control Panel → Hardware and Sound → Devices and Printers: Device Manager. Find your device, (most likely under unknown or Universal Serial Bus controllers), right click on the device and select “Update Driver”. Choose “Search automatically for updated driver software” and the necessary driver should be automatically installed for you. If not, you will need to download the driver from a 3<sup>rd</sup> party through downloading the driver from the internet.*
  - b. *For now, the rest of the settings do not need to be touched as calibration of the pixels into  $\mu\text{m}$  is unknown. This process will be done manually. Press OK.*
3. A new window with live output from the camera should pop up.
  4. Use neutral-density filters, and a polarizer in a rotation mount to ensure that the image is not saturated (exceeding the maximum useful intensity of the camera).

- To capture an image, simply save the current output of ImageJ, preferably as a TIFF file (lossless). The saved image-type can be specified, using *File* → *Save As*.

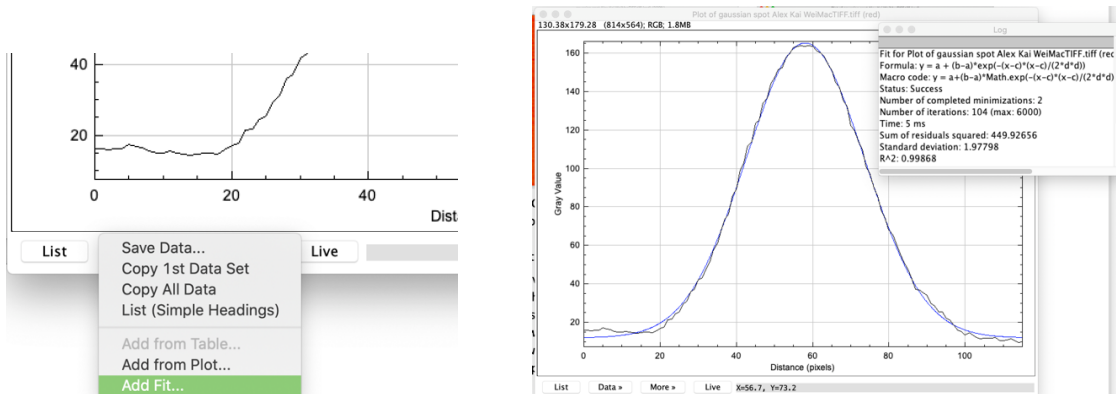
### Processing the Image

- Scientific cameras for beam-profiling are typically monochrome, and data is immediately useful for quantitative analysis. Check what type of image you have by selecting *Image* → *Type*.
- Some APL cameras are RGB Bayer-filter colour cameras. For these, first split the saved image into separate 8-bit fields for Red, Green, and Blue:
  - Select *Image* → *Colour* → *Split Channels*. This replaces the image with three windows with monochrome images, R, G, B. For most purposes, you'll work with the R image.
  - A useful option to visualize the beam profile is false colour, in which different intensities are assigned different colours: for example, select *Image* → *Lookup Tables* → *Spectrum*. BONUS: this table usually tags saturated regions of any image (pixel values > 255) in red.
- On your saved image, first select the rectangle cursor in *Main Window* then draw a thin horizontal rectangular box across the beam, covering both the beam and surrounding background.



Press “CTRL+K” or select *Analyze* → *Plot Profile*. This will bring up the plot of the intensity of the beam profile against the pixels that were selected in the box drawn earlier. This is known as a *lineout* through the profile. Note that the x axis might appear in units of  $\mu\text{m}$ , but the default calibration is 1px:1 $\mu\text{m}$ , the x-values simply count the pixels across.

- You have the option to click on *Data* at the lower left in the profile, and choose a fitting function, here a gaussian. When fitting a gaussian-profile beam-waist  $w_0$ , remember that this intensity is actually the *square* of the function for the *E*-field. You can also export the data as a text-file.



Other tips:

When the beam is too large to fit onto the camera sensor, you can use your own phone camera to take an image of the beam profile projected onto a card or piece of paper and still achieve useful results. Calibration may be problematic, but consider using graph-paper or including a ruler in the image.