

## On the relation between image resolution and the estimated $\sigma$ of a Gaussian like spot

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The purpose of this work is to determine the minimum image resolution required for pepper pot measurements. To accomplish this task, a HeNe laser is used to produce a Gaussian like spot. By changing the zoom setting of camera and the distance between the target and camera, images of different resolution of the spot have been taken. Our image post processor has been used to measure  $\sigma$  from these images.

### D) Captured Images.

To make a gaussian fit of the laser spot required us to capture three images: the laser spot image, the background image, and the fiducial image. Since the light of HeNe laser is very bright, the laser spot images are saturated even with the camera aperture nearly closed. Therefore, the COHO camera's shutter was set to either 4k or 10k while capturing images of the laser spot. The background images were taken with laser off under the same conditions. And the fiducial images were taken with the shutter off. The following three figures are examples of these images.

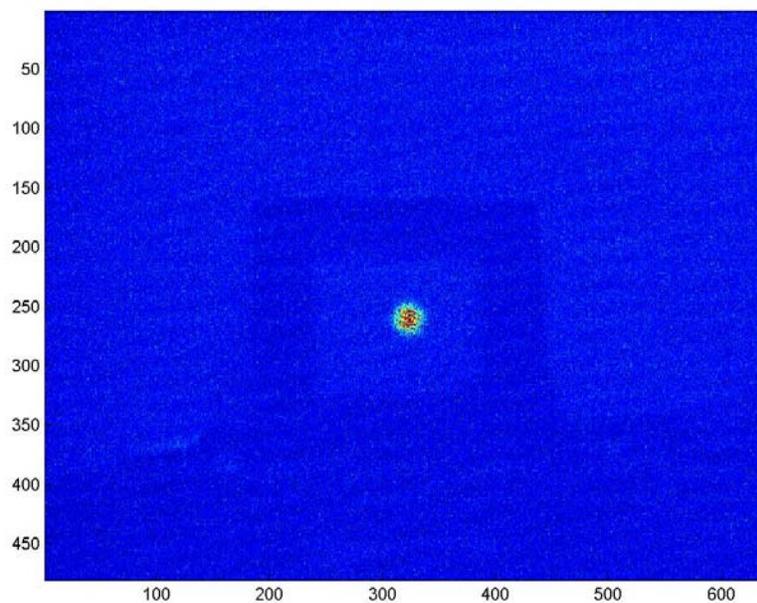


Figure 1) Image of laser spot

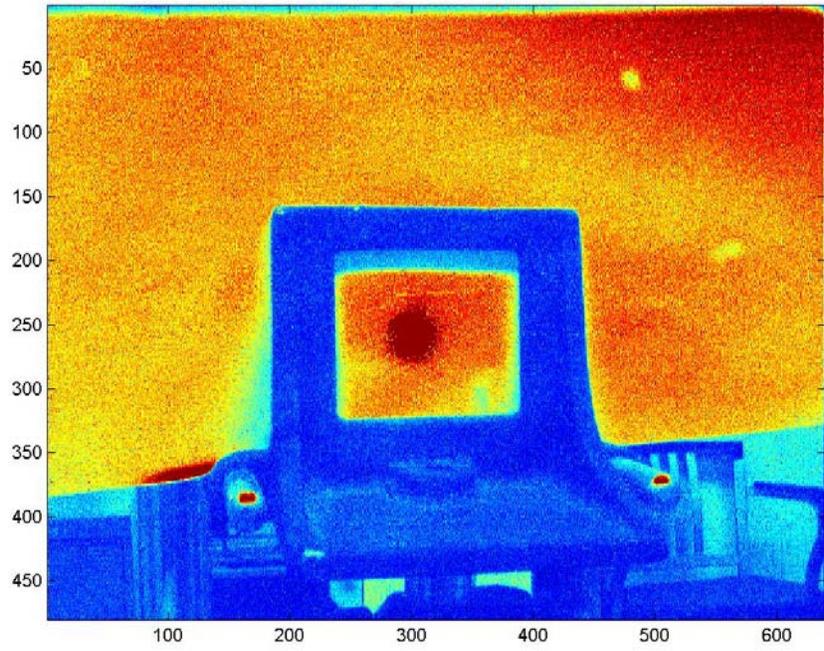


Figure 2) Fiducial image

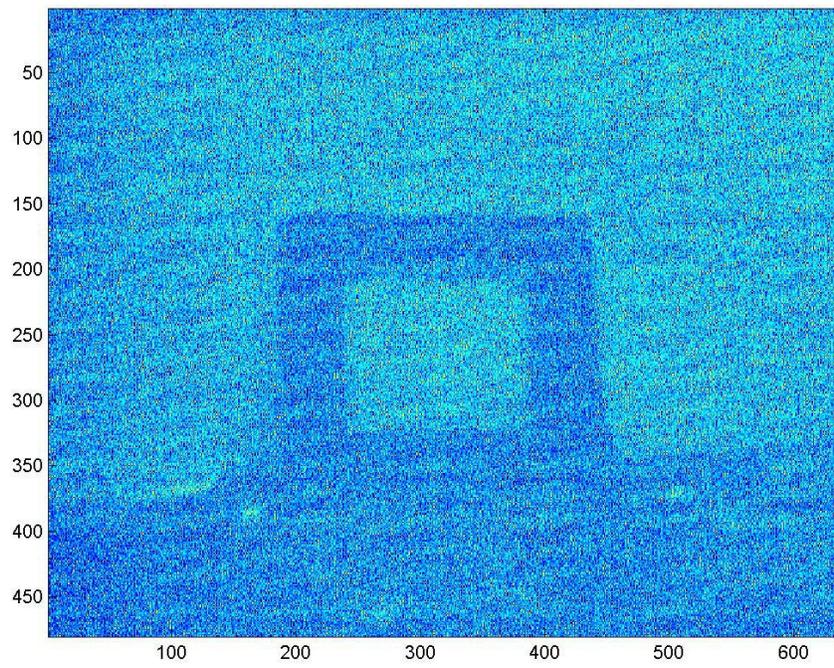


Image of the background.

## II) Gaussian Fitting

Using the three images of section I, we can now perform the gaussian fit. The first step is to subtract the background (Fig 2) from the raw data (Fig 1) with the resultant file shown in Figure 4. The spot was then projected in the x direction a gaussian was fitted to the spot.

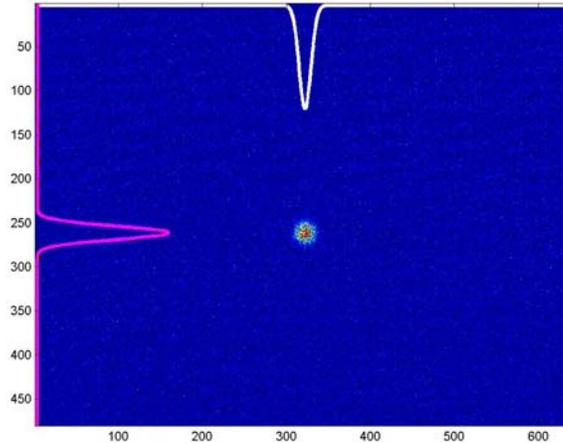


Figure 4) Result image.

The results of the fitting study are shown in Table 1 and plotted in Figure 5. The first column of Table 1 shown the result of the gaussian fit in pixels, column three shows the pixel-to-mm scaling factor obtained from the fiducial, and finally, column four shows the  $1 \sigma$  width of the gaussian spot in mm. Column three shows the number of pixels across the entire spot. This was done by eye. We attempted to count the number of pixels from where it looked like the spot started to where it ended so it is approximately  $>95\%$  of width of the spot.

**Table 1) Fitting Results**

$\sigma$ (pixels)	Spot width ( pixels)	Scale (pixels /mm)	$\sigma$ (mm)
26.1	110	14.91	1.750503018
19.063	75	11.19	1.70357462
13.796	55	8.49	1.624970554
11.507	46	6.89	1.670101597
8.416	33	5.09	1.653438114
7.136	26	4.42	1.614479638
4.934	16	2.762	1.786386676
3.83	15	2.15	1.781395349
3.759	9	1.773	2.120135364
3.021	8	1.163	2.597592433
2.49	8	1.31	1.900763359
2.236	7	0.872	2.564220183
2.035	6	0.581	3.502581756
1.46	4	0.465	3.139784946

The results from the study shown in Table 1, are plotted out in Figure 5. From this figure, we estimate that the required minimum resolution of spot is about 15 pixels. Above this resolution, the error of  $\sigma$  obtained from the image could bellow 10%. For resolution between 10 pixels and 15 pixels, the error could be 10% to 20%.

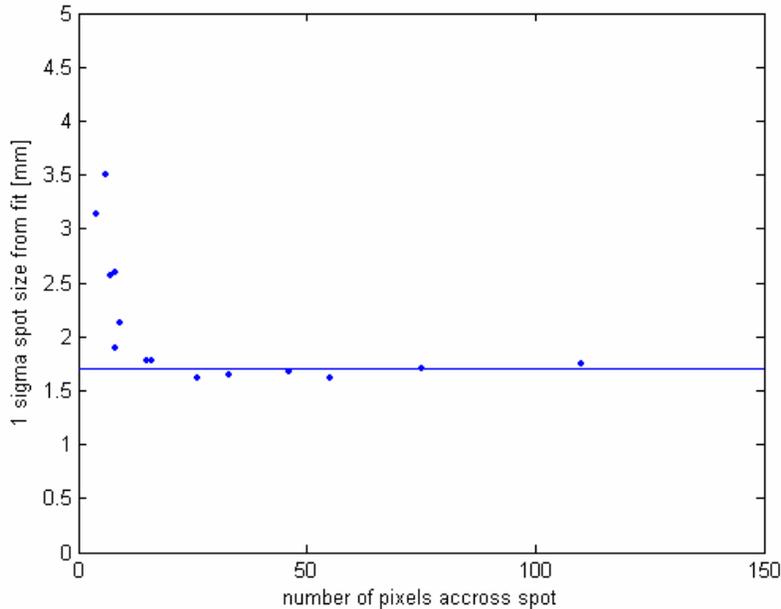


Figure 5). The width of the spot (dots) as a function of the number of pixels across the spot. This shows that the fit of the spot is asymptotes to about 1.7 mm (solid line) when at least 15 pixels are used across the spot.

### Conclusions:

The required minimum resolution is **15 pixels across the entire spot** (although it may be better to use at least 30 pixels) or **5 pixels per 1 sigma** (although it may be better to use at least 10 pixels).