

Final Report on aLigo Particle Imaging Using a Nikon D7100 Camera and MATLAB

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Purpose

- Need to be able to efficiently and accurately identify the contamination level of the optics within Advanced LIGO.
- Toupview forces the user to go through every step of processing the image by hand. Also, the information it provides about the size of the particles is in pixels, making it necessary to calculate the resolution of the camera and convert from pixels to meters.
- The following process based on tests images taken at a distance of 40 inches of a 3 inch diameter optic surrounded by a ring of green LEDs that illuminate the dust on the surface of the optic.

Taking the Images

- Nikon D7100 with an AF Micro Nikkor 200mm 1:4 D lens and a Nikon TC-201 2x Teleconverter
- Partially controlled using ControlMyNikon
- Partially controlled by hand - hand focusing
- Ratio of 112762.5 pixels/ 1 meter. If you use this process at a different distance or with a different model camera, lens, or teleconverter, calculate the new pixel/meter ratio and switch it with the ratio in the code
- 53 mm x 35 mm

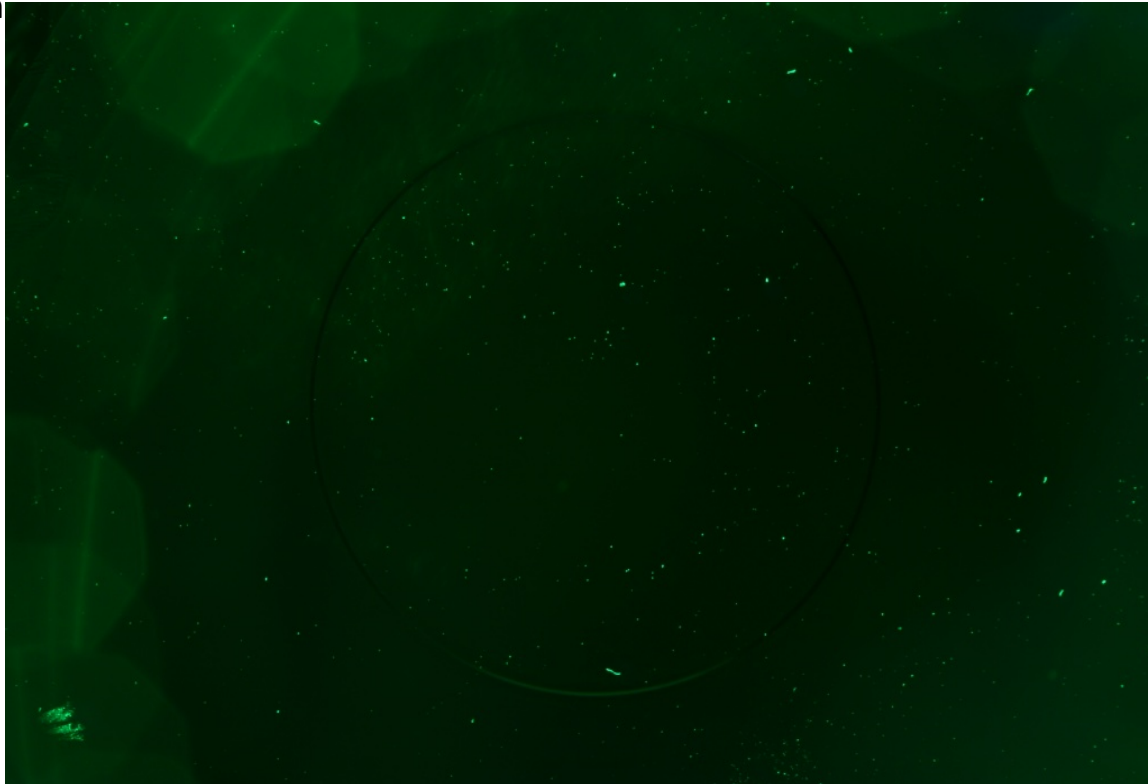


Image of the Test Optic

Processing the Images

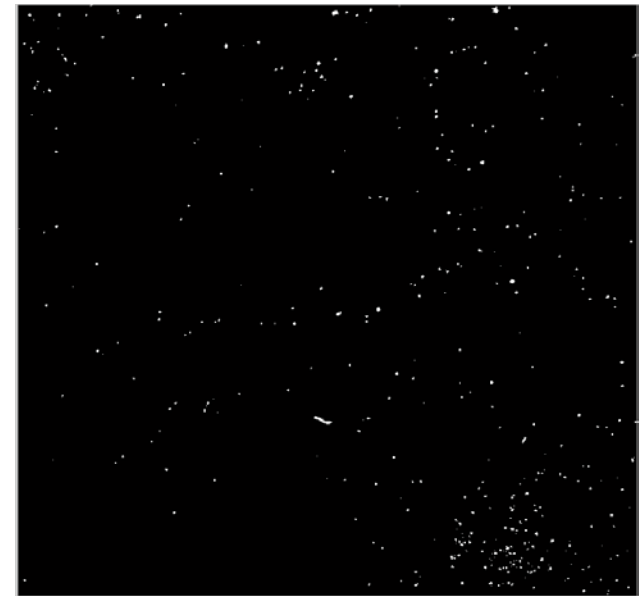
- Processed in MATLAB using code that utilizes MATLAB's Image Processing Toolbox. Need version 9.
- You have to hand threshold the image using hand thresholding app



Original Image



Automatic Thresholding

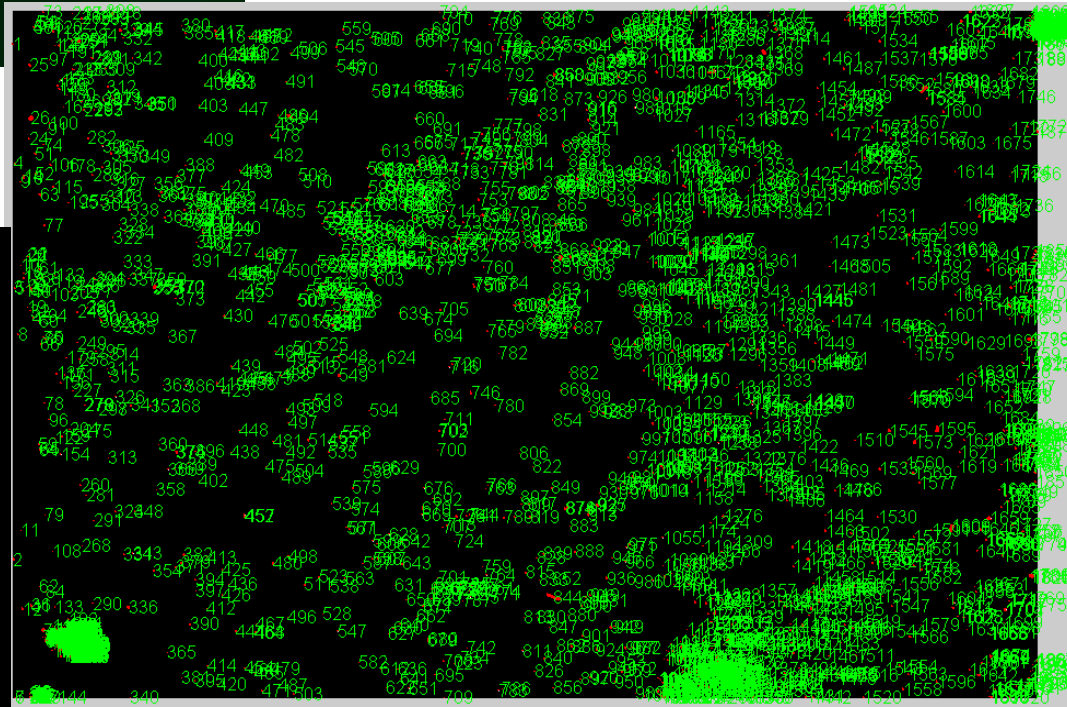
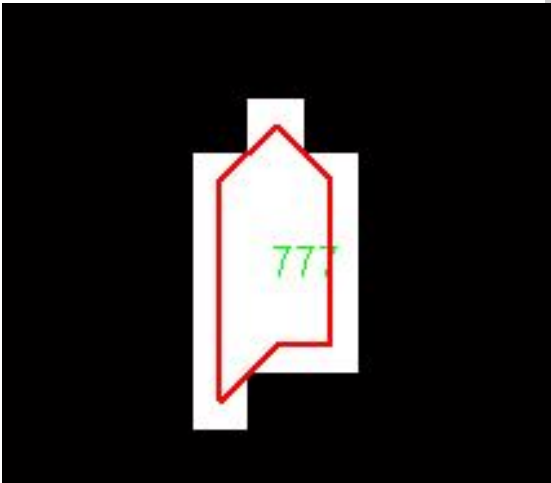
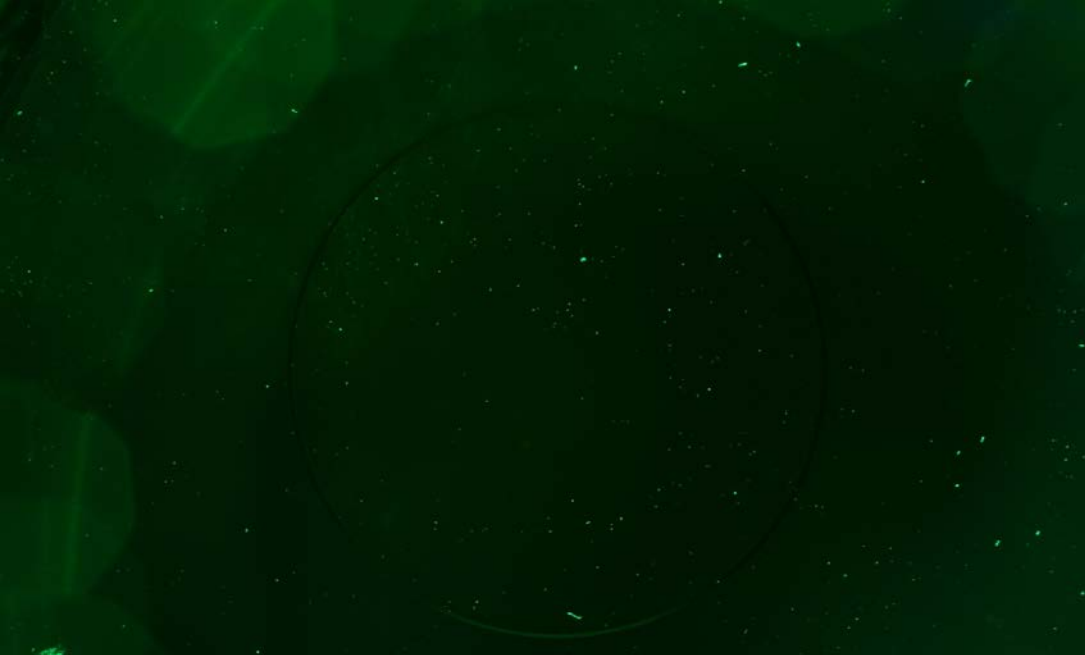


Hand Thresholding

- Outlines the particles, counts them, labels each of them with a number, and measures their areas, perimeters, and diameters (assuming the particles are perfect circles).
- Creates a bar graph of the particles' diameters.

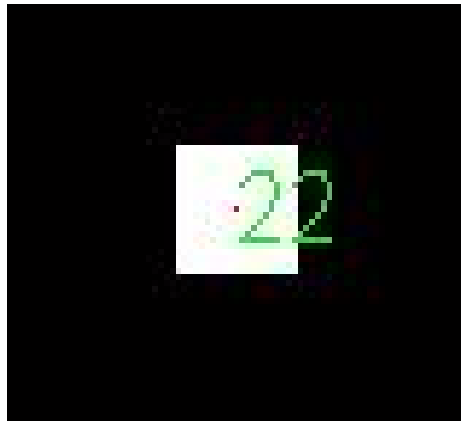
Code

- [LIGO-G1400866-v3](#): Presentation of aLigo Particle Imaging Using a Nikon D7100 Camera and MATLAB



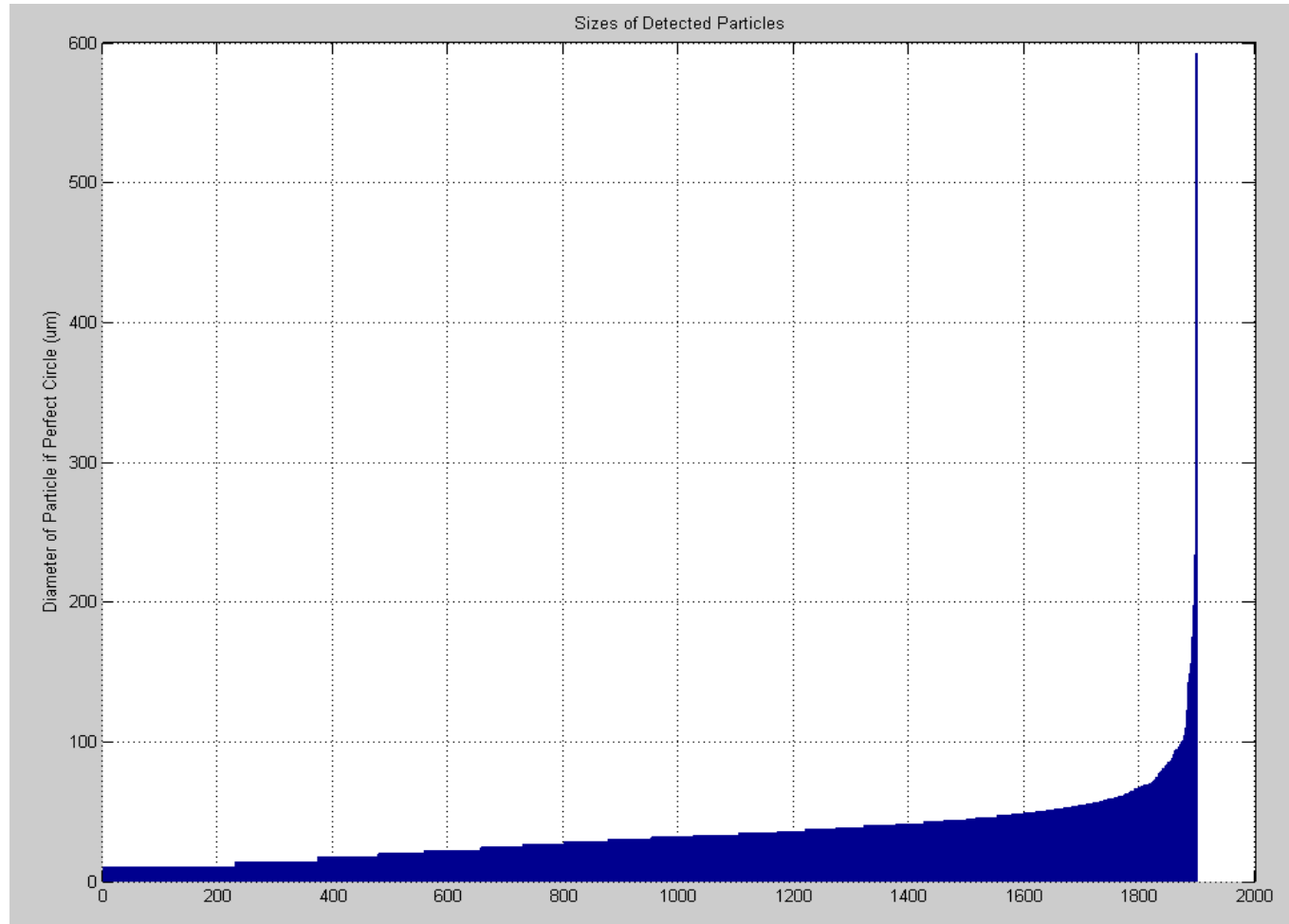
About the Results

- Cannot measure the perimeter of the smallest size particles because resolves as one pixel

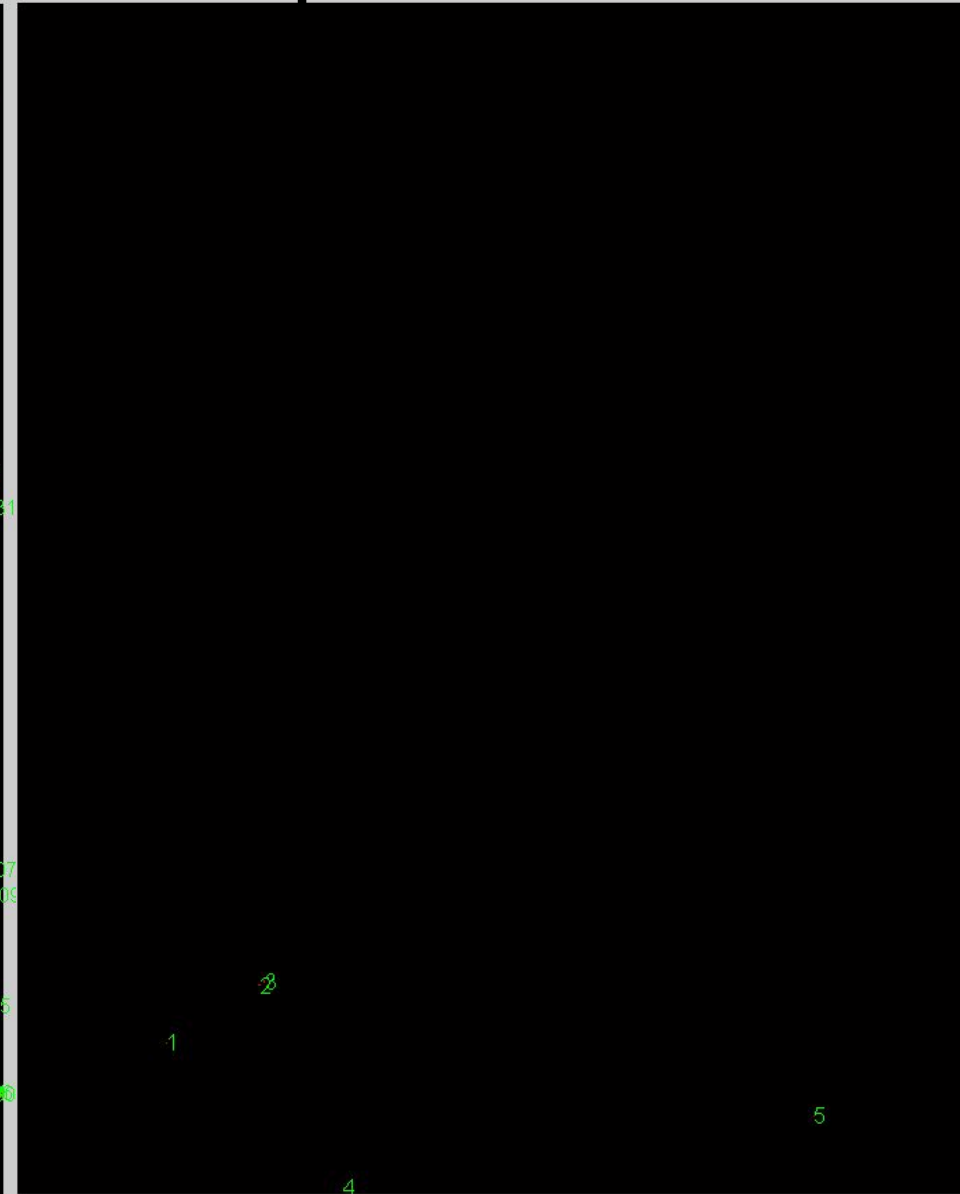
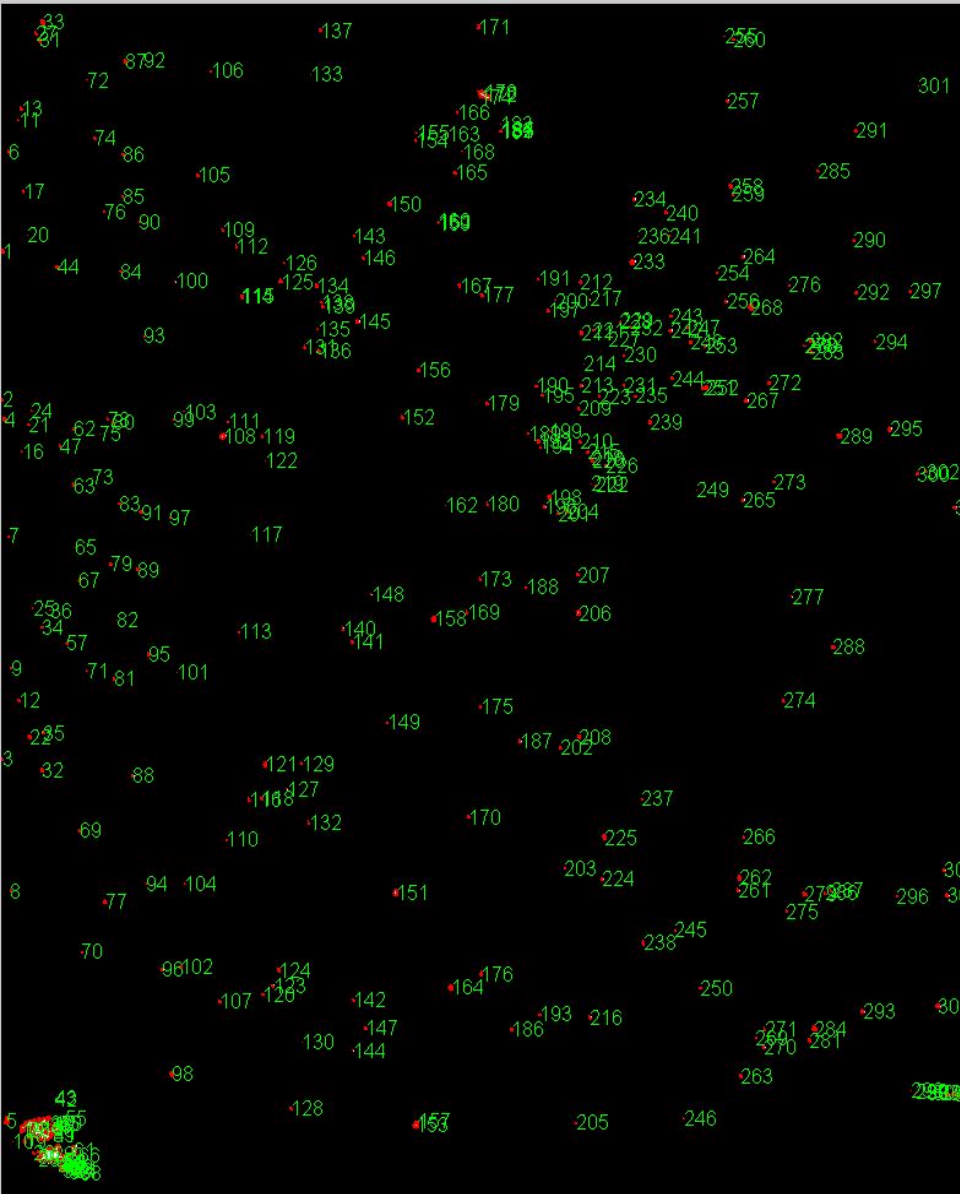


About the Results

- Smallest two sizes are 10.0066881 μm and 14.15159403 μm and two of the adjacent larger sizes are 93.33617298 and 93.87105514; measures the particles on the images down to 10.0066881 microns with a maximum margin of error of 4 microns
- Number of particles there are of the same size in the test image: 229 at 10.0066881 μm , 72 at 24.51127986 μm , 34 at 42.45478208 μm , and single digits around 60 μm .
- Gaps between the sizes from multiple microns to around one micron at around 33 μm and to fractions of microns at around 50 μm .



Proof of Concept



References

References:

The Mathworks tutorial for Image Segmentation Using the Color Thresholder App:

<http://www.mathworks.com/help/images/image-segmentation-using-the-color-thesholder-app.html>

Related Documents:

[LIGO-T1400474-v1](#): LIGO SURF Progress Report 1: Particle Imaging and Analysis for Advanced LIGO

[LIGO-T1400506-v1](#): LIGO SURF Progress Report 2: Particle Imaging and Analysis for Advanced LIGO

[LIGO-T1400494-v1](#): Data Comparing the Abilities of Matlab and Toupview to Detect Particles

[LIGO-T1400491-v1](#): Data for aLigo Particle Imaging: Resolution of Nikon D7100 with 2x Teleconverter

[LIGO-T1400467-v1](#): Data for aLigo Particle Imaging: Resolution of Nikon D7100

[LIGO-T1400515-v3](#): Process for aLigo Particle Imaging Using a Nikon D7100 Camera and MATLAB

[LIGO-T1300665-v9](#): The LIGO Particulate Evaluation Tool (PET)

A detailed account can be found in my two progress report, the first of which is located in the document LIGO-[T1400474-v1](#) and second of which is located in the document LIGO-[T1400506-v1](#). A step by step explanation of the process can be found in the document LIGO-[T1400515-v3](#)