Interfacing EMCCD Camera used in Ion Trap experiments with Python

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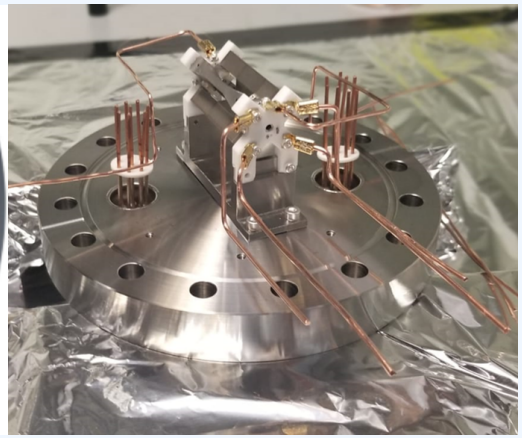


Overview

- Iontraps and EMCCD Cameras
- Motivation and Aims of the Project
- Current Progress
- Future plans

Iontraps and EMCCD Cameras

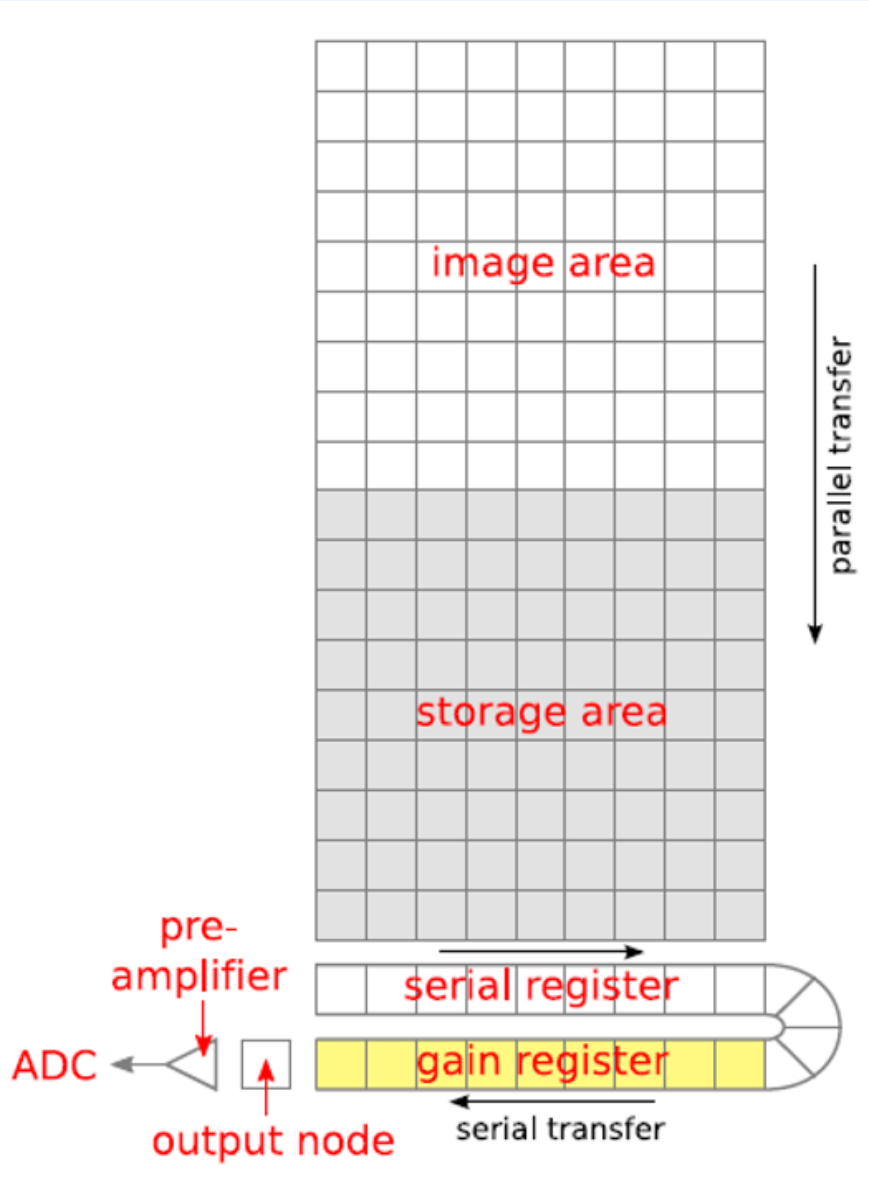
Ion traps

- An ion trap is a device that is used to levitate small clouds of ions, or a single atomic ion, in free space, inside a vacuum chamber.
- For example a Penning trap confines the motion of the ions through the use of static electric and magnetic fields

EMCCD Cameras

- A Charged Coupled Devide (CCD) is a silicon based semiconductor chip which captures light and converts the photons to digital data in the form of electrons
- An Electron Multiplying CCD (EMCCD) has an identical structure to conventional CCDs but is more sensitive and capable of single photo detection
- The shift register in EMCCDs are extended to include the Gain register which significantly improves low light detection

EMCCD Cameras



Motivation and Aims of the Project

Motivation and Aims

- Write a program in Python to interface an Andor iXon Ultra EMCCD camera used in ion trap experiments.
- Find a method of distinguishing between a bright ion and a dark ion
- Find the setting of the program which takes the best images of the ions

Current Progress

The Program

- Two separate programs were written in Python: one to control the EMCCD camera and take pictures of ion(s) and the other to load the images
- A Dynamic Link Library (DLL) containing various functions of the camera used by the program to control the camera
- Both programs are object oriented and have its own graphical user interface (GUI) created using QT Creator software

Camera Control Program

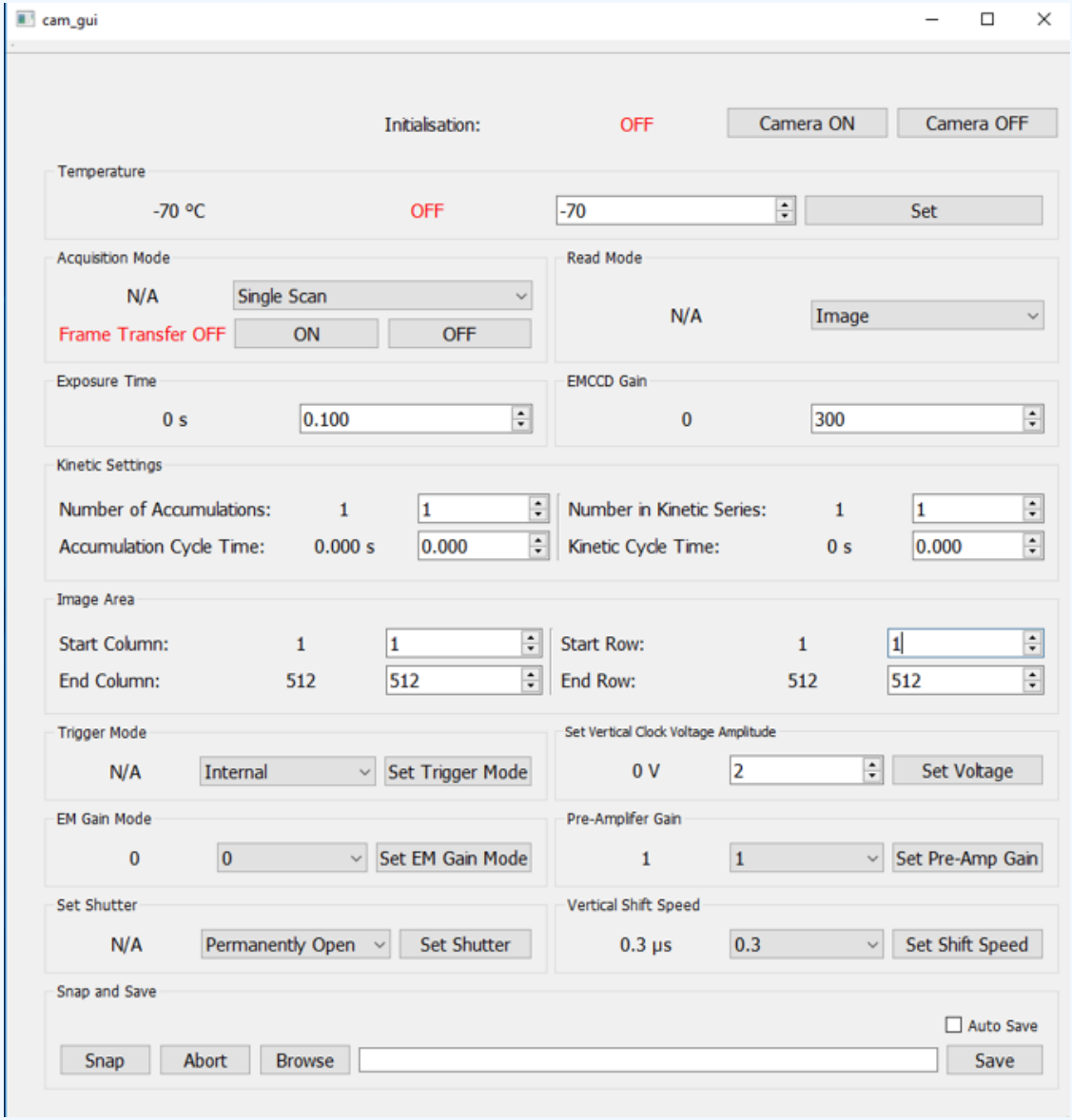
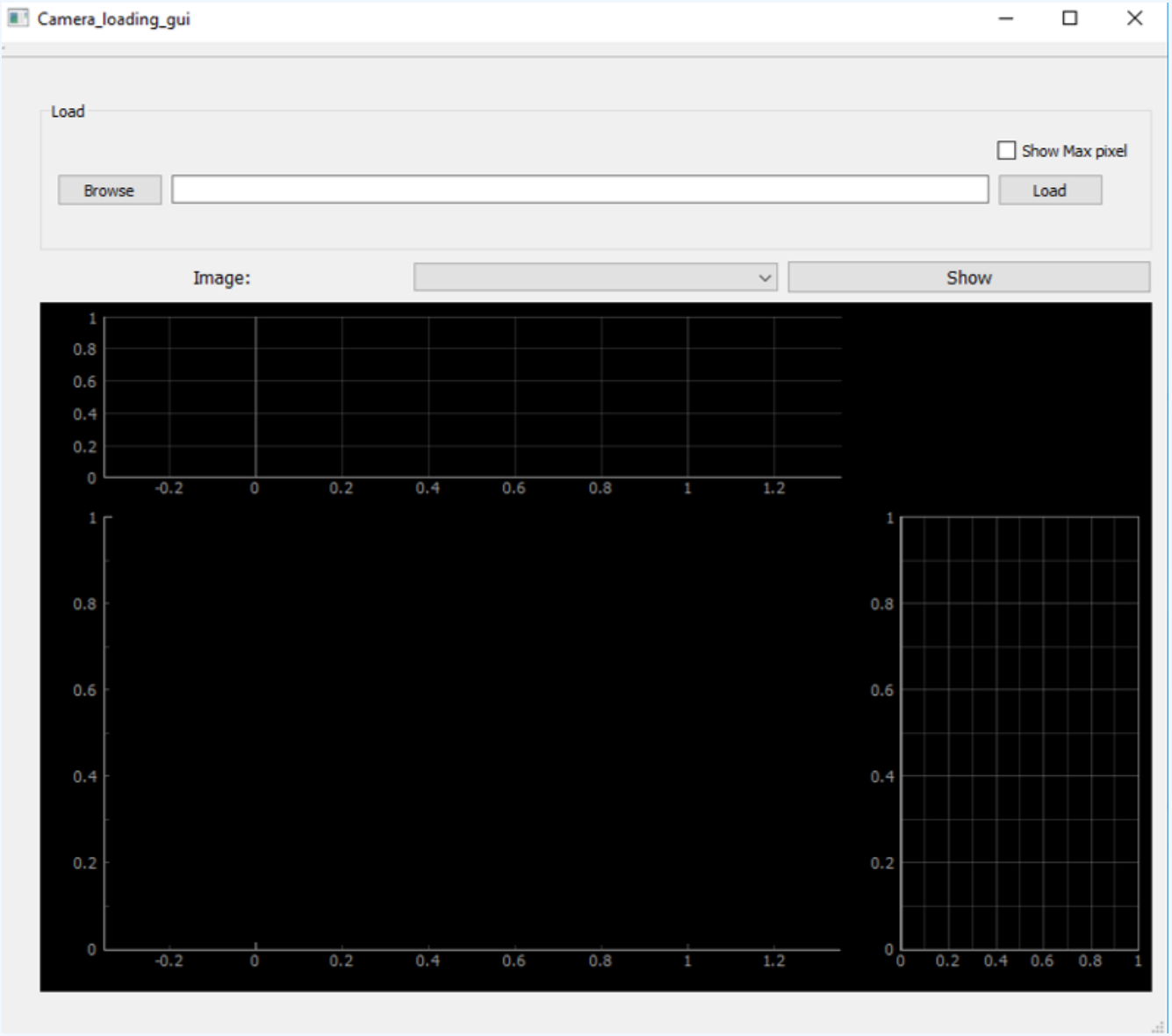


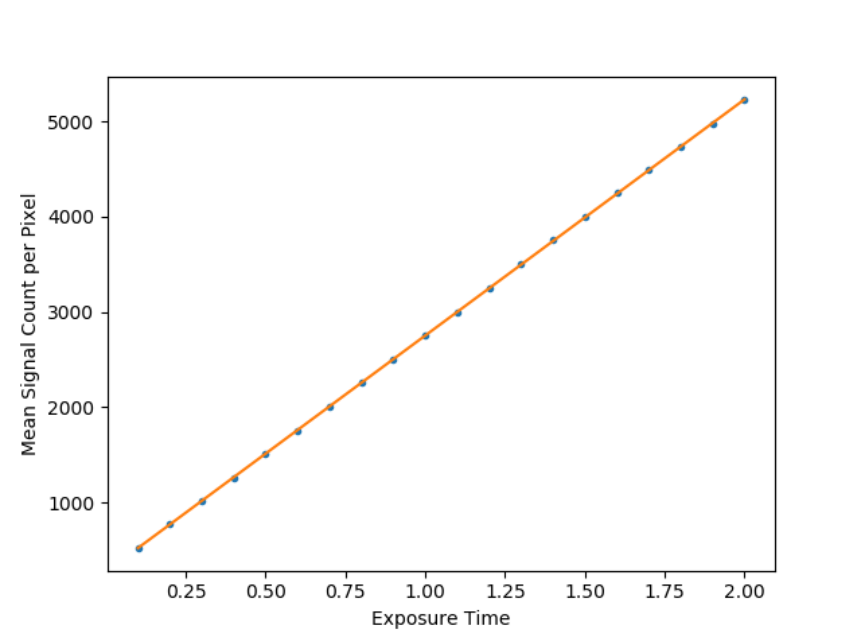
Image Loading Program



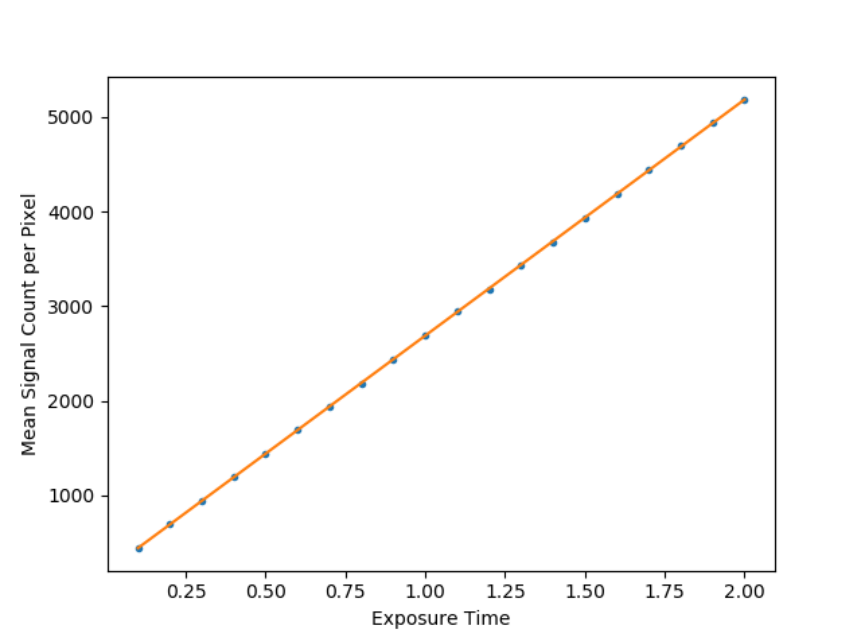
Investigating Camera Properties

- The camera control program was first tested with noise readings and compared with commercial software to ensure the python program is working as expected
- The affect of the Exposure time and EMCCD gain on the mean noise reading per pixel were tested

Mean Signal Count vs. Exposure time

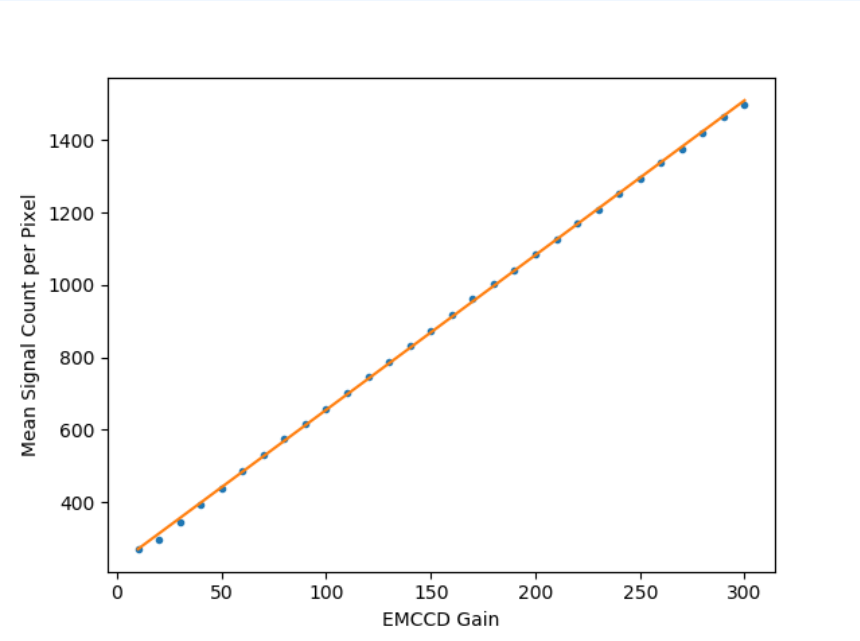


(a) Python Program

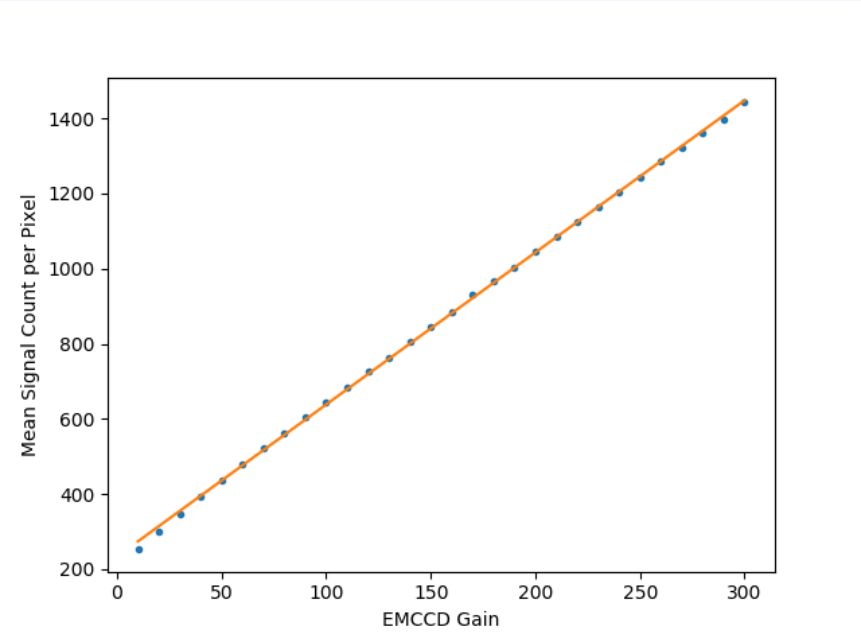


(b) Commercial Software

Mean Signal Count vs. EMCCD Gain

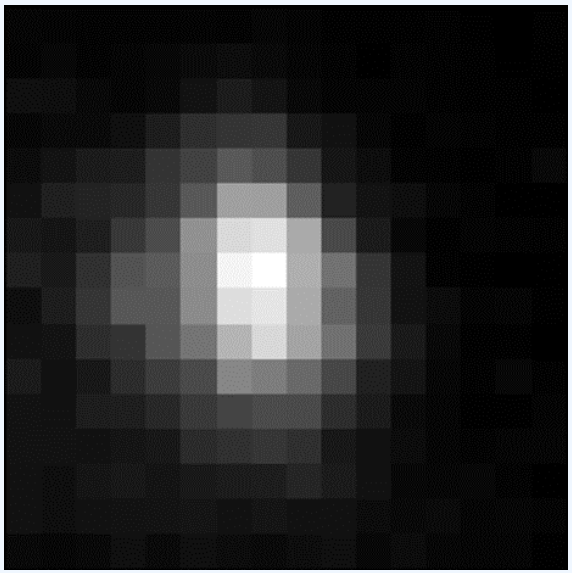


(a) Python Program

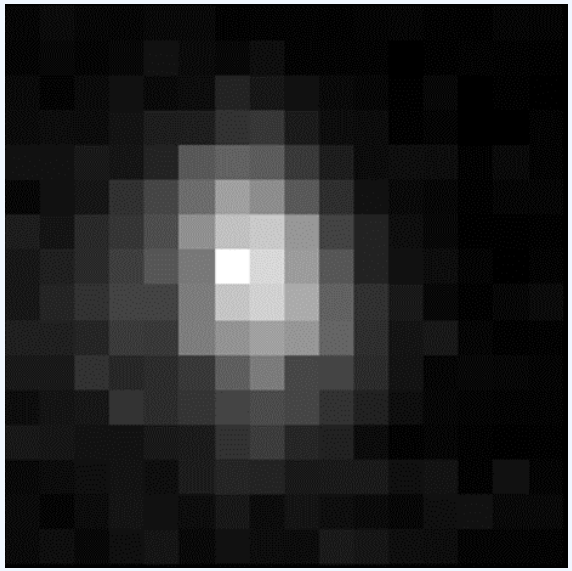


(b) Commercial Software

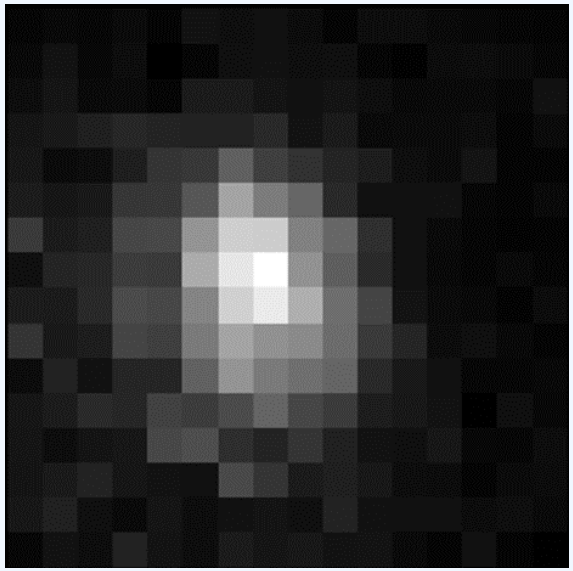
Images of Single Ion at Different Exposure Times



(a) 5 Second Exposure

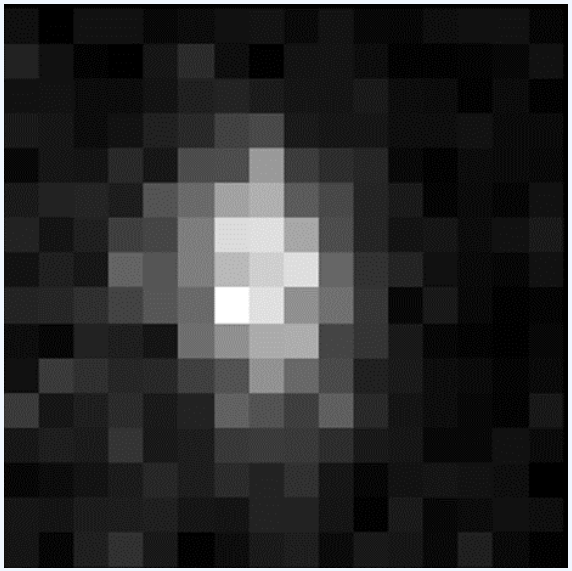


(b) 2 Second Exposure

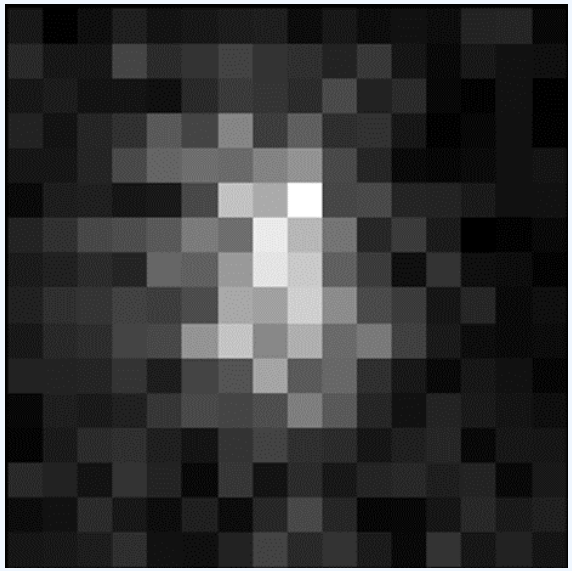


(c) 1 Second Exposure

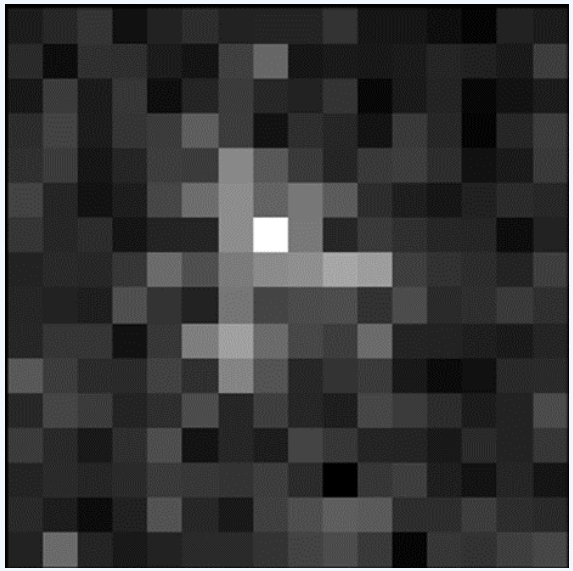
Images of Single Ion at Different Exposure Times (cont.)



(d) 0.7 Second Exposure



(e) 0.4 Second Exposure

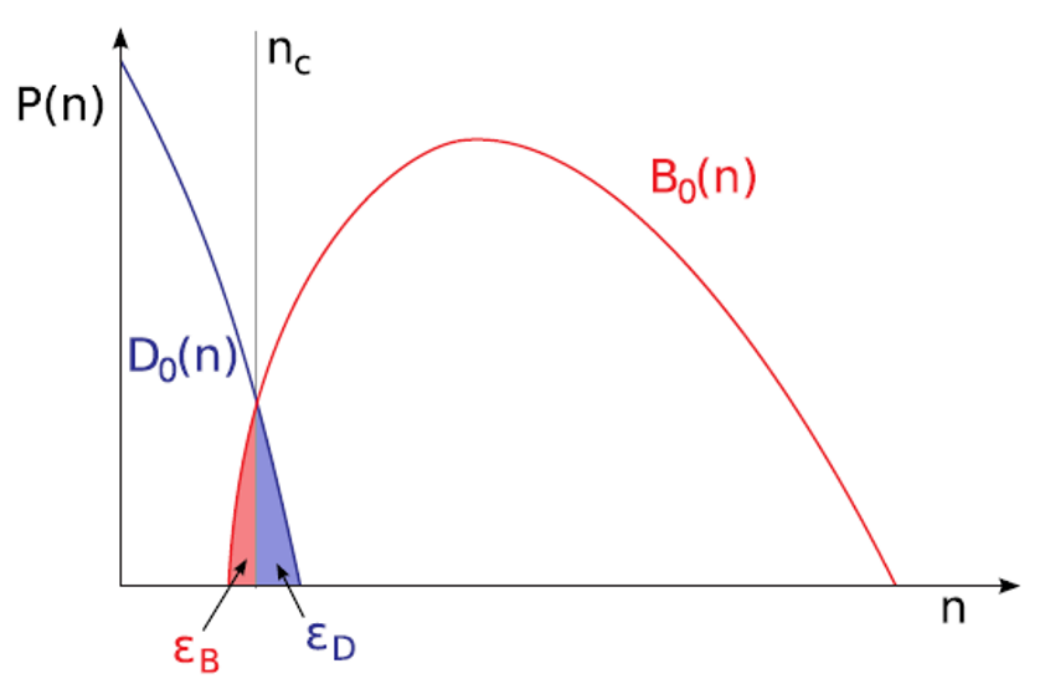


f) 0.1 Second Exposure

Future Plans

Future Plans

- Investigate the minimum exposure required for a bright ion to be able to be distinguished from a dark ion
- A bright ion can no longer be distinguished from a dark ion if the distibution of the dark ion and bright ion signal counts have a large overlap



Future Plans (cont.)

- Comparing the differences in quality for image taken when the camera is externally triggered by the experiment and when the came camera triggers the experiment and the start of exposure
- The EMCCD has a ’keep clean’ cycle which clears the sensor to ensure it is charge free before the next exposure.
- Externally triggering the camera may interupt the keep clean cycle and produce a more noisy image
- The camera gives of a ’fire signal’ during exposure which can be used to trigger the start of the experiment at the end of a ’keep clean’ cycle

Conclusions

- A python program with a GUI was created to acquire pictures of fluorescence of single ions and another program was created to view the images and show the vertical and horizontal projections
- A reliable method/algorithm is required to distinguish bright ions from dark ions at short exposure time
- Find the camera triggering mode which gives images of highest signal to noise ratio

Thank You for Listening!