

IMPERIAL COLLEGE LONDON

A DUMMIES' GUIDE TO

The Gabor Lens

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Preface

After entering the code of the front door, you should see a view similar to this:



Figure 1: A photograph of the Imperial College Gabor Lens Lab

You might go "Woah!" if this is the first time you entering an actual research lab, being at the frontier of physics, doing something that no one has never done. This device in front of you is unique so you might worry that you will break it, but don't worry.

This guide is designed to teach you the basic operation of the lens. I have worked on the lens for the past 8 months for both my BSc project and UROP. I shall now pass my knowledge down to you using this guide. Good luck!

1 Equipments

The whole experimental set-up consists of 9 components:

1. Plasma lens
2. Tektronix DPO 3014 Digital Phosphor Oscilloscope
3. Pressure pumps
4. Pressure gauges
5. 16 segmented detectors
6. Junction box (a.k.a Medusa)
7. High voltage supply
8. Current supply
9. Cooler

1.1 Instructions for Tektronix DPO 3014 Digital Phosphor Oscilloscope

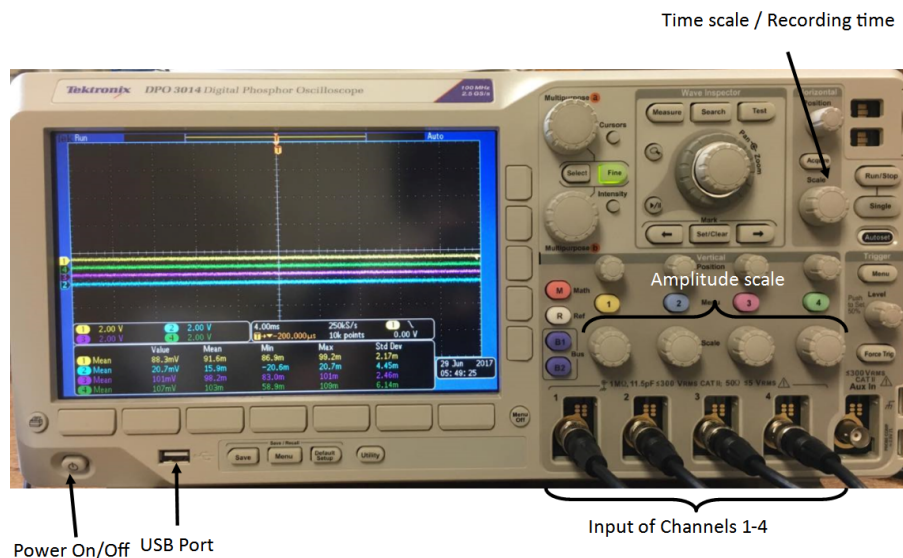


Figure 2: Tektronix DPO 3014 Digital Phosphor Oscilloscope with annotations

To record a waveform:

1. Press the "Menu" button
2. Select "Save Waveform"
3. Choose which channel to record using "Multipurpose (a)"
4. Choose destination using "Multipurpose (b)". Select "File" when a USB is inside the USB port
5. Select "File Details"
6. Select "Edit File Name" and use the keyboard to name the file

7. Select "Save"

To change the duration of the recording, use "Time scale" in Figure 2.

To change the number of samples per second:

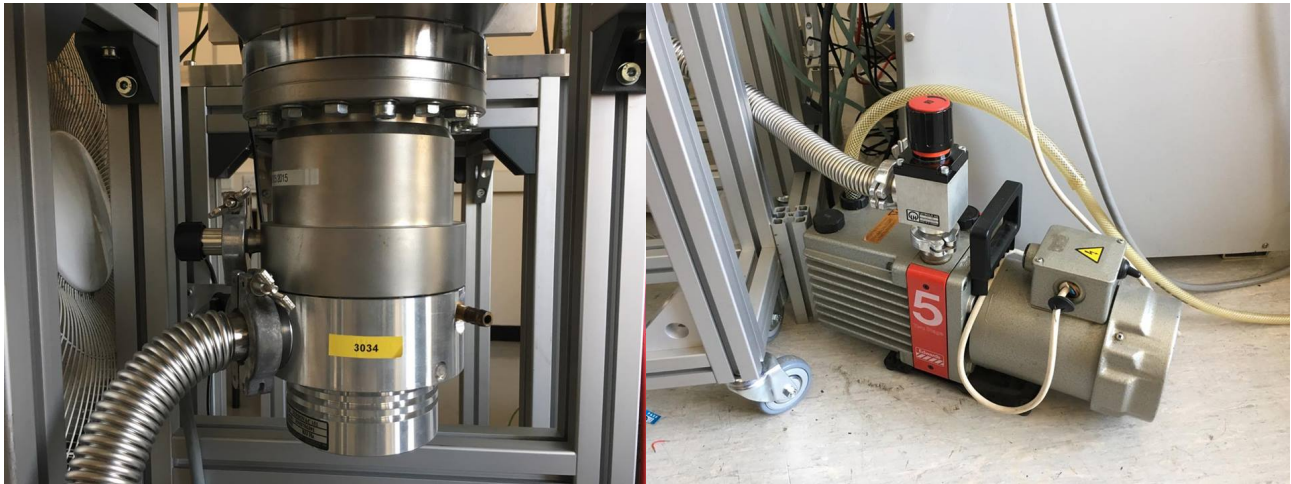
1. Press the "Acquire" button
2. Select "Record Length"
3. Select the total number of points to determine the sample rate depending on the recording duration

The waveform can then be Fourier transformed using a computer code to investigate the stability of the plasma.

1.2 Instructions for Breaking and Creating Vacuum

There are 2 pumps responsible for creating the vacuum chamber inside the lens:

1. Turbo molecular pump
2. Roughing pump



(a) Photograph of the turbo molecular pump

(b) Photograph of the roughing pump

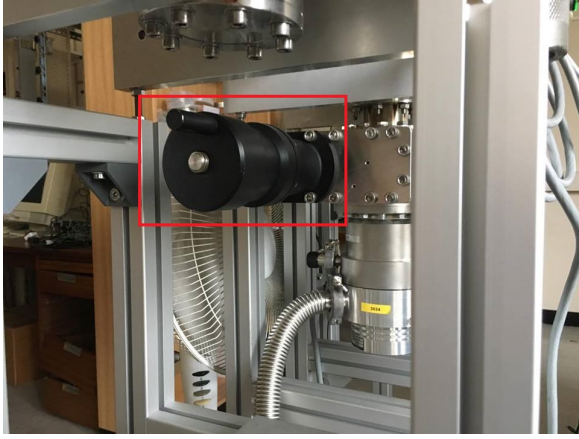
There are also 3 valves located at different places throughout the set-up

1. Between the turbo molecular pump and the vacuum chamber
2. Between the turbo molecular pump and the roughing pump
3. At the top of the vacuum chamber

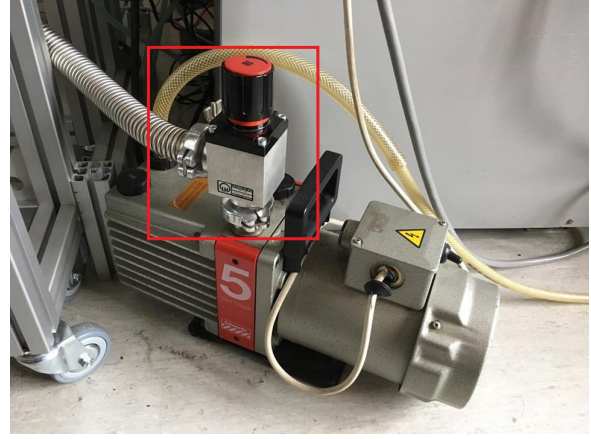
The turbo molecular pump consists of stack of fans, and the compression ratio from the entrance to the exit is about 10^6 . The turbo pump can also be optimised to allow certain gas species to flow in by adjusting the speed of the fans inside the pump to the average speed of the gas molecules. In order to not damage the fans, the turbo pump should only be switched on after pumping down from normal air pressure to 10^{-1} mbar to avoid objects from falling in. This can be done by using the roughing pump as it can produce a pressure down to 10^{-2} mbar.

But the main problem of using the roughing pump is that it uses a very volatile oil between the steel plates (similar to how a rotary engine works). If this flows into the turbo molecular pump or the vacuum chamber, that is a huge problem as the evaporated oil increases the pressure and ionises into plasma when the lens operates.

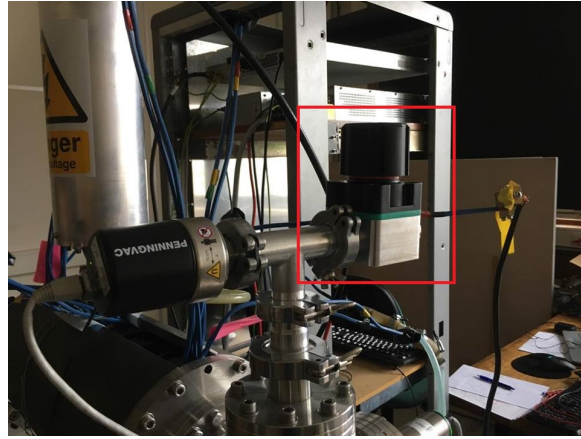
To prevent damage to the turbo molecular pump and the in flux volatile oil, please follow the following instructions carefully:



(a) The valve between the turbo molecular pump and the vacuum chamber



(b) The valve between the turbo molecular pump and the roughing pump



(c) The valve at the top of the vacuum chamber

Figure 4: The location of all the valves are shown inside the red square

1.2.1 Creating vacuum

1. Close valve 3, with valves 1 and 2 opened
2. Switch on roughing pump, the volatile oil will not diffuse towards the turbo pump and vacuum chamber as the pressure of the roughing pump is lower than air pressure
3. Switch on the turbo molecular pump when the pressure of the vacuum chamber has fallen down to 10^{-1} milibar

Never have the vacuum chamber at air pressure when the turbo molecular pump at low pressure because that would damage the turbo molecular pump as it is designed only to flow one way, hence always have valve 1 opened when the turbo pump is on.

1.2.2 Breaking vacuum

1. Open valve 3 to break the vacuum in the vacuum chamber, this should be done over a duration of half a minute
2. Wait 10 minutes for the fans inside the turbo molecular pump to stop rotating before opening valves 1 and 2 after switch off
3. Open valves 1 and 2

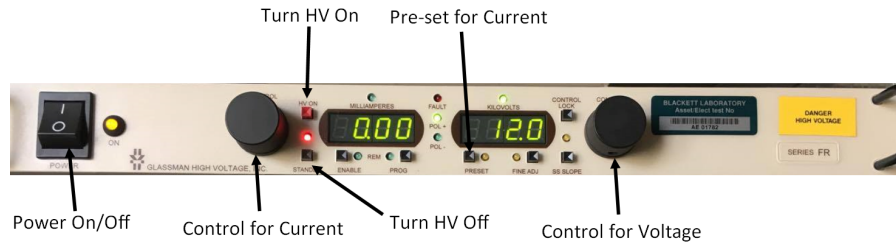


Figure 5: A photograph of the HV supply with annotations

1.3 Instructions for the High Voltage Supply

The combination of the cylindrical electrode and the grounded electrode at both ends confines the electron plasma longitudinally and expelled the positive ions. The plasma can be operating in 2 different regimes:

1. Voltage regime
2. Current regime

The voltage regime basically means that the parameter controlling the plasma is the voltage, and vice versa for current regime. The voltage regime is known as the stable regime of the plasma, it also has the greatest focusing power which is favourable, whereas the current regime is unstable and has less focusing power.

1.4 Instructions for the Current Supply

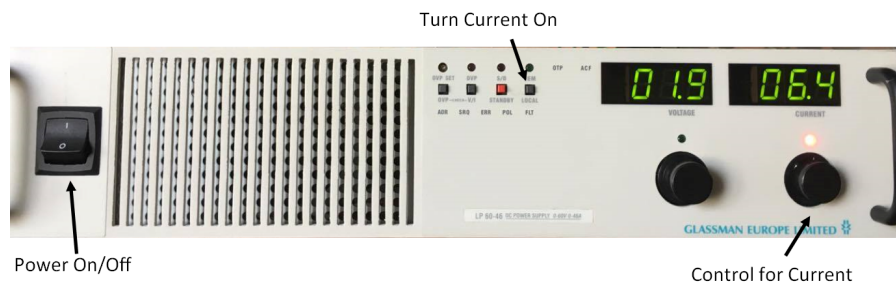


Figure 6: A photograph of the current supply with annotations

The current supply flows a current through the solenoid that winds around the lens, creating an axial magnetic field, confining the plasma. The control is simple and no further explanation is required.

A continuous flow of current in the solenoid would increase the temperature and pressure of the lens significantly, hence a cooler was installed. Whenever you wish to operate the lens, remember to turn on the cooler!

1.5 Instructions for the Cooler

The location of the cooler is shown below:

The control for the cooler is very simple, basically just switch on the "Mains", then the "Cooling":

Do be careful with items such as the pressure meter that is sitting on top of the cooler, they will slowly move their ways to the edge of the cooler and fall off due to the vibration of the cooler!

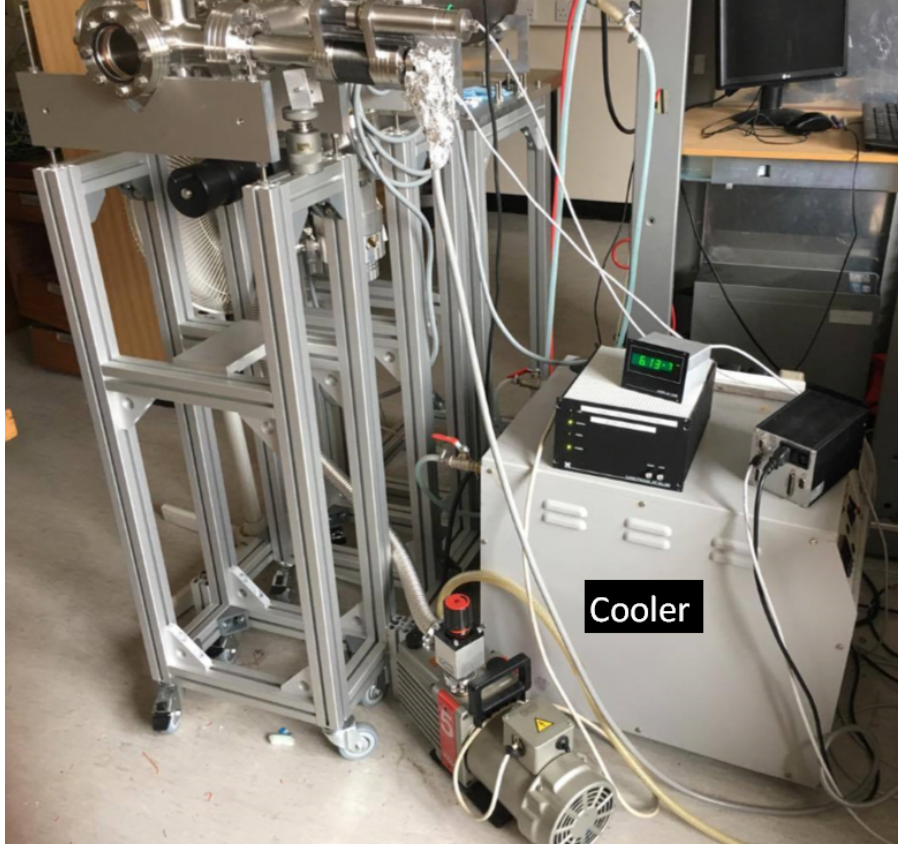


Figure 7: A photograph showing the location of the cooler



Figure 8: A photograph showing the switches to turn on the cooler

1.6 Instructions for Combining Different Segments into Channels

This is done using the junction box. A Celebration tin was specially reconstructed to act as a Faraday cage, and the junction box is placed inside it to reduce the noise in the signal.

The junction box can be taken outside of the tin. Each of the segment from the detector feeds into the junction box. Depending on how each segments are combined into different channels, different arrangements can be done such as sectors and concentric circles.

Each segment has a colour and a number labeled on the wire, the number labels the order from the innermost to the outermost circle, and the colour labels which sector it is from on the detector.

In Figure 5, the photograph shows the junction box in the sector arrangement, where all the colour of the wires are the same in all 4 channels. To arrange the junction box in concentric circles, simply put all the same number into one channel.

The detector is also adjustable inside the lens using the scale on the lens.



Figure 9: A photograph showing the junction box inside the Celebration tin



Figure 10: A photograph of the 16-segment detector in different arrangements: sector (middle), concentric circle (right)



Figure 11: A photograph of the 16-segment detector fed into the junction box in the sector arrangement, each segment has a colour and a number labeled on the wire