Optical Spectroscopy in the Pulsed DC Large Electrode System at CERN

Ruth Peacock[1,2,3], Graeme Burt[1,2], Walter Wuensch[3]
[1]Lancaster University, Lancaster, United Kingdom
[2]Cockcroft Institute of Accelerator Science and Technology, Daresbury, United Kingdom
[3]CERN, Geneva, Switzerland

Overview

Compact Linear Collider (CLIC) is one of the proposed next generation high energy colliders. Breakdown rate in such a collider is one of the major limiting factors for operation at high gradients. The Large Electrode System (LES) is a pulsed DC system used for breakdown analysis at CERN.

The LES allows for different parameters to be changed and record the impact on breakdowns. This system is capable of reaching 10kV and the gap between electrodes can be between 20μm and 100μm. Typically a pulsed voltage from a MARX generator is used within the system allowing for different parameters to be varied.

Pulsed DC Large Electrode System

Figure 1 displays an image of the cross section of the LES. The cameras used for capturing images of the breakdowns can be seen perpendicular to each other. The cameras are placed next to the windows that are lined up with the gap between the electrodes.

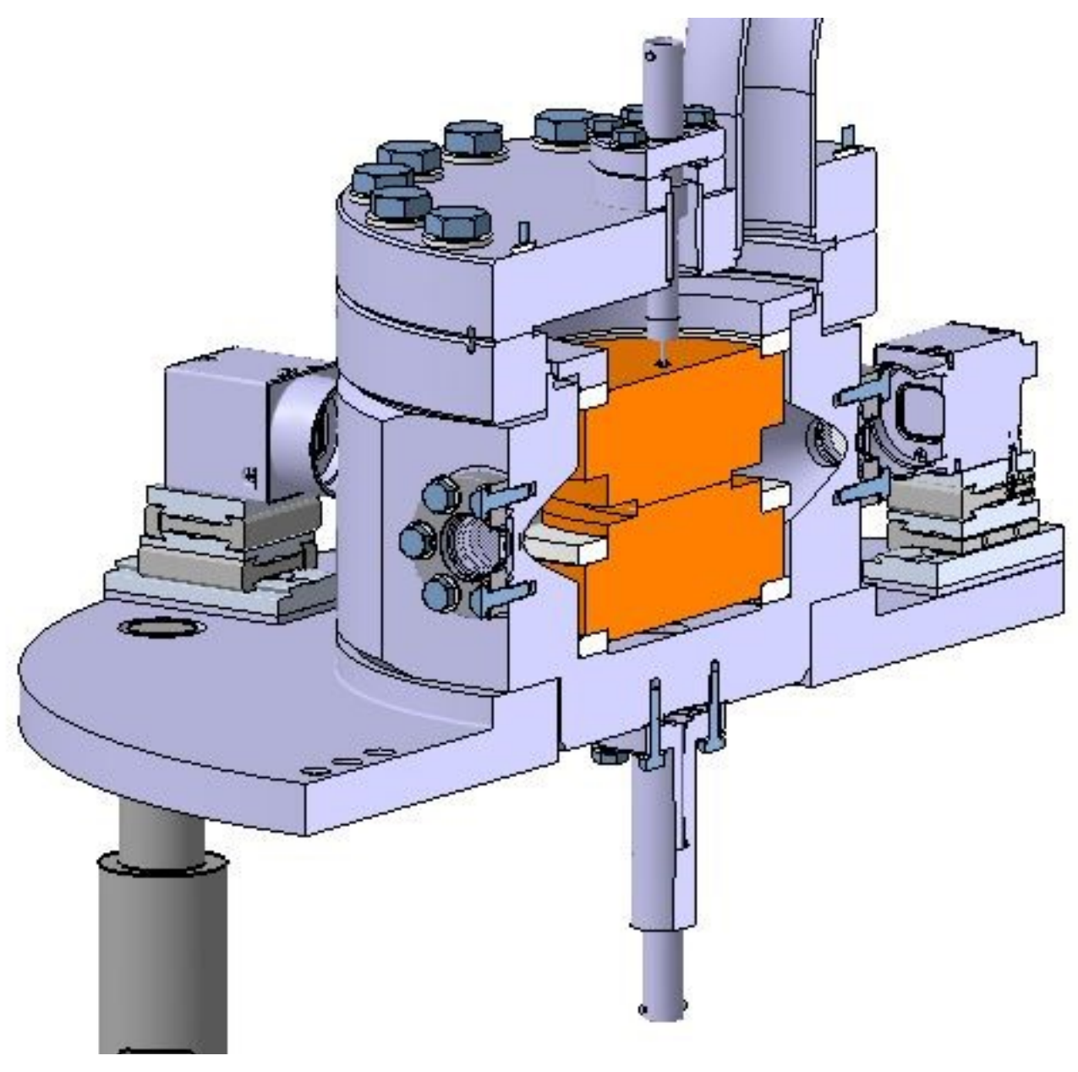

Figure 1— Cross section of the Large Electrode System (LES)

When a breakdown occurs the image is saved and coordinates of the breakdown determined. Figure 2 is an image taken from one camera of a single breakdown within the system. From this it can be seen that there is an intense white line of light from the arc.

Figure 2— Camera Image of a breakdown

One interest in using a spectrometer within the system is to measure the light related to field emission. By applying a constant voltage to the system it is possible to measure dark currents. During Measurement the camera was triggered without the occurrence of a breakdown. Figure 3 shows the current voltage diagram of the electrode couple used for spectrometer measurements. As expected the amount of current increases with voltage, in theory this should relate to the amount of light released.

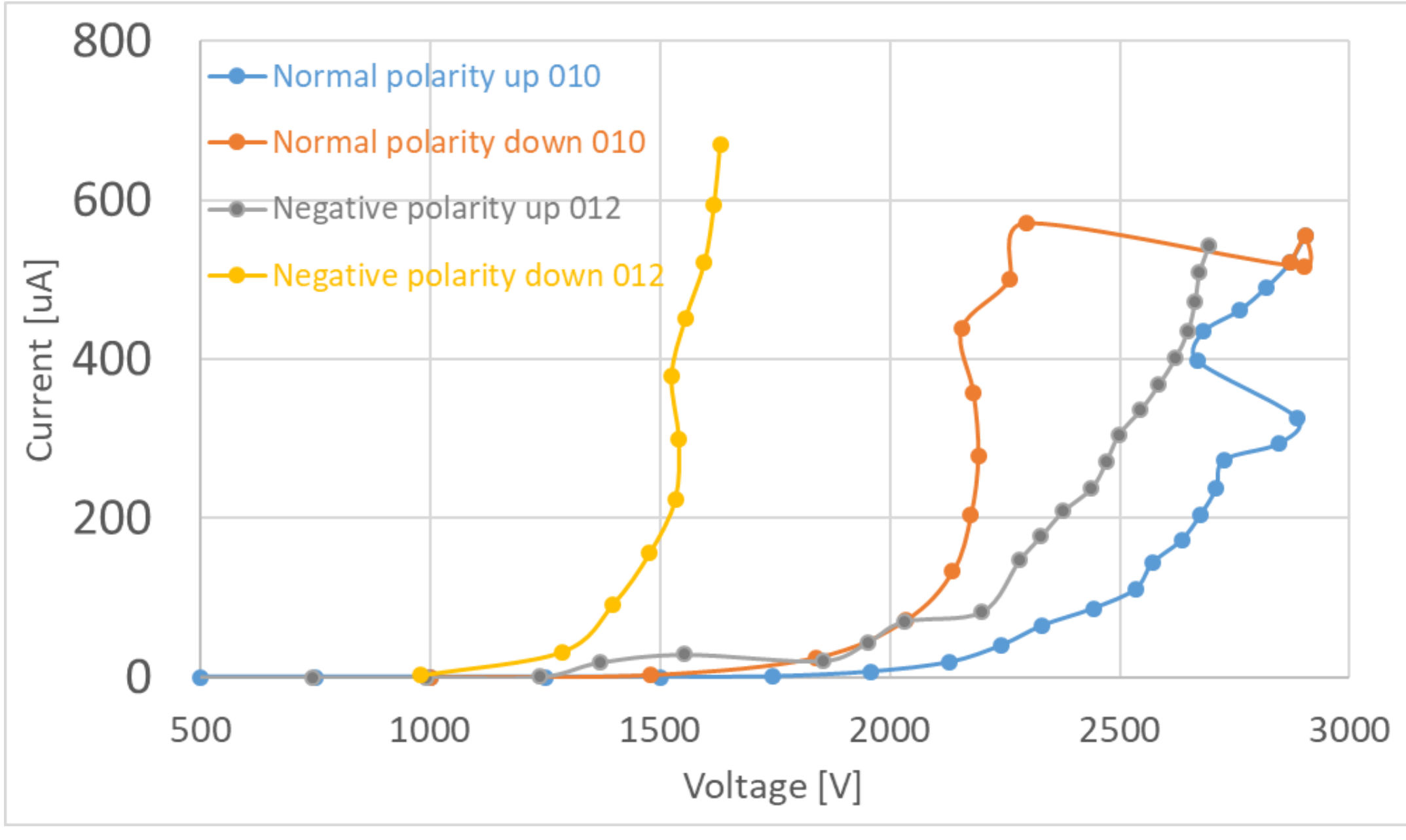

Figure 3— Current vs Voltage diagram

Setup

To integrate the spectrometer one of the cameras was removes a collimator put in its place. One camera remains attached to the system to indicate if there is any light or whether a breakdown has occurred. Figure 4 shows a schematic of the current setup for integrating the spectrometer with the LES. Figure 5 is an image of the physical setup for the spectrometer with the LES in the lab.

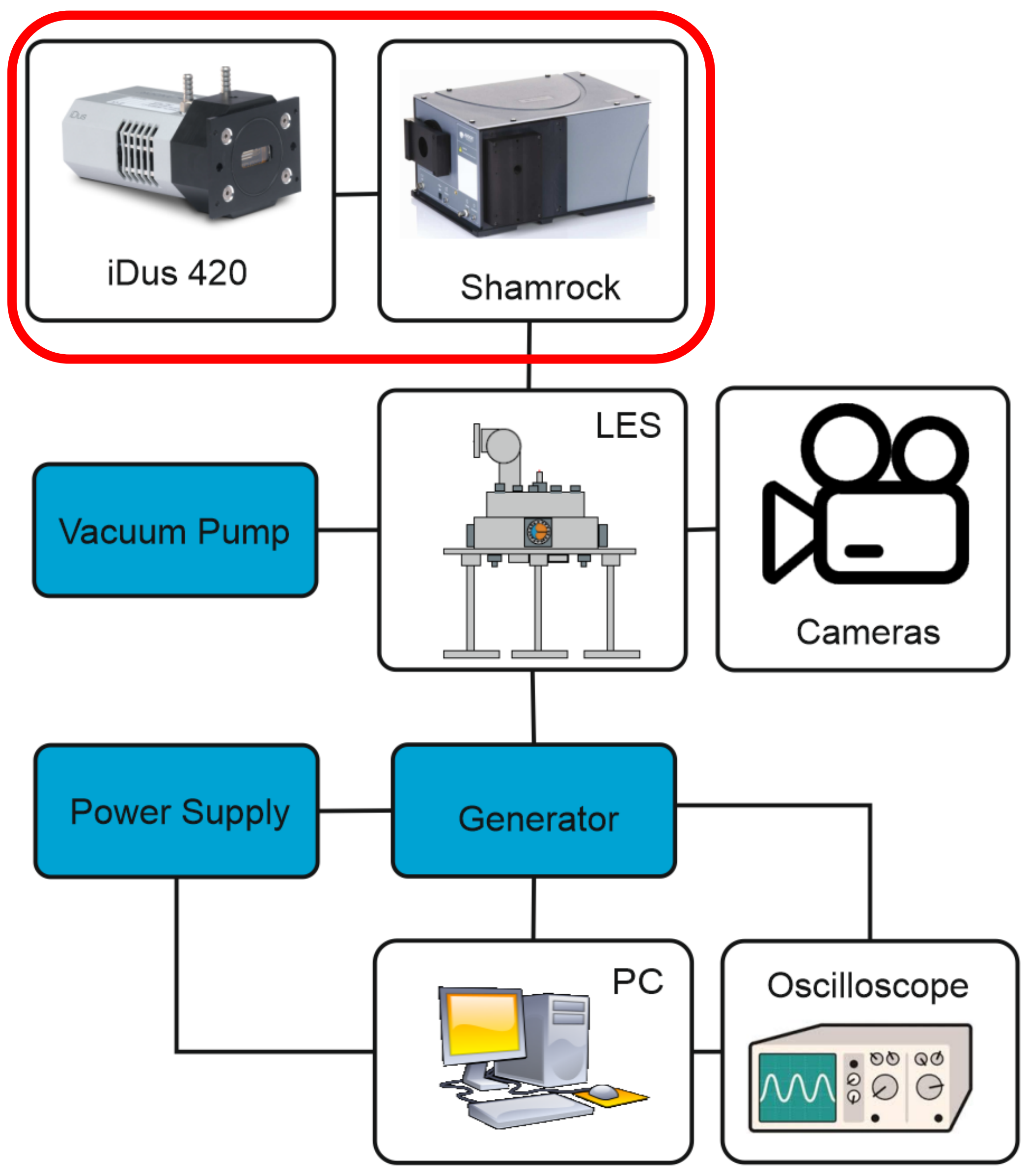

Figure 4— Schematic of the setup of the spectrometer and LES

The spectrometer used is a Shamrock shown in figure 5, this uses a series of mirrors and a grating turret, the turret provides three different gratings with different ranges of wave lengths. It is then possible select a wavelength to filter. An iDus CCD camera collects the data from the shamrock. Using the Andor Solis software it is possible to view and save results on a computer.

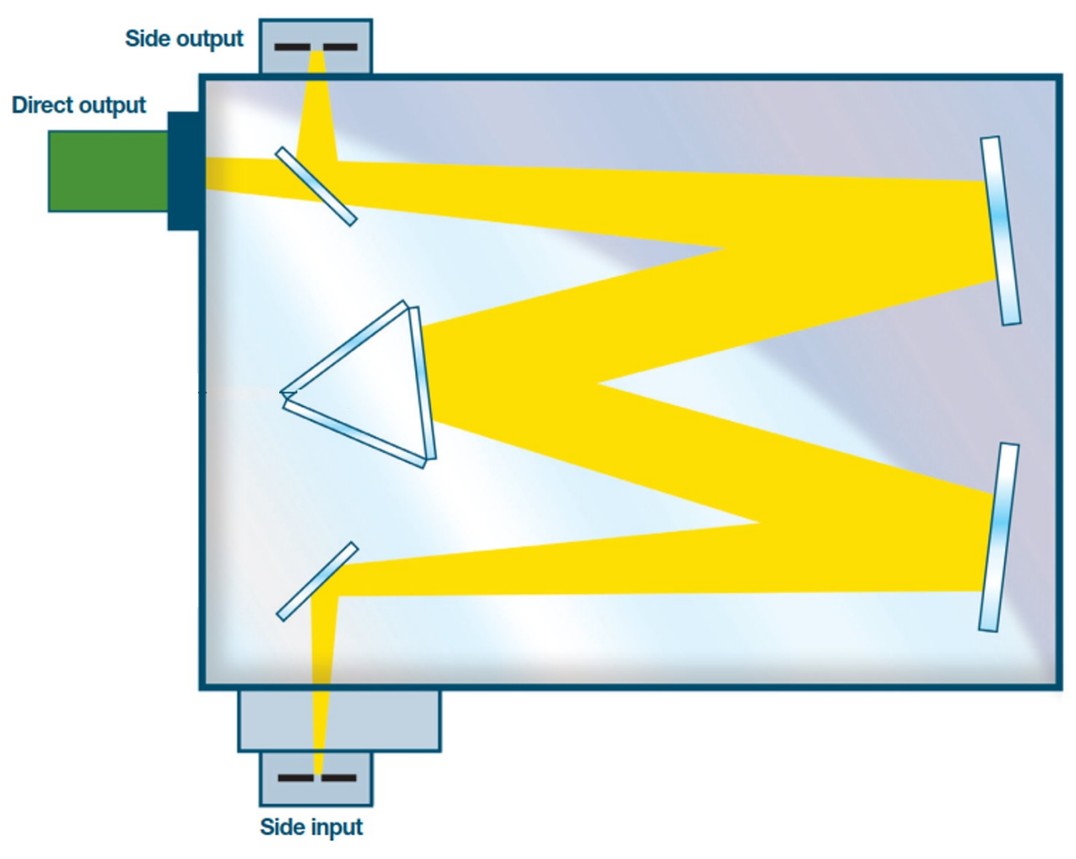

Figure 5—Layout of the inside of the Shamrock

One technique used for triggering the spectrometer is to connect it to the MARX generator. This allows for the spectrometer to be synchronised with the pulsing of the system, this could focus on the spectra before, during or after a breakdown to look at the different possible light sources.

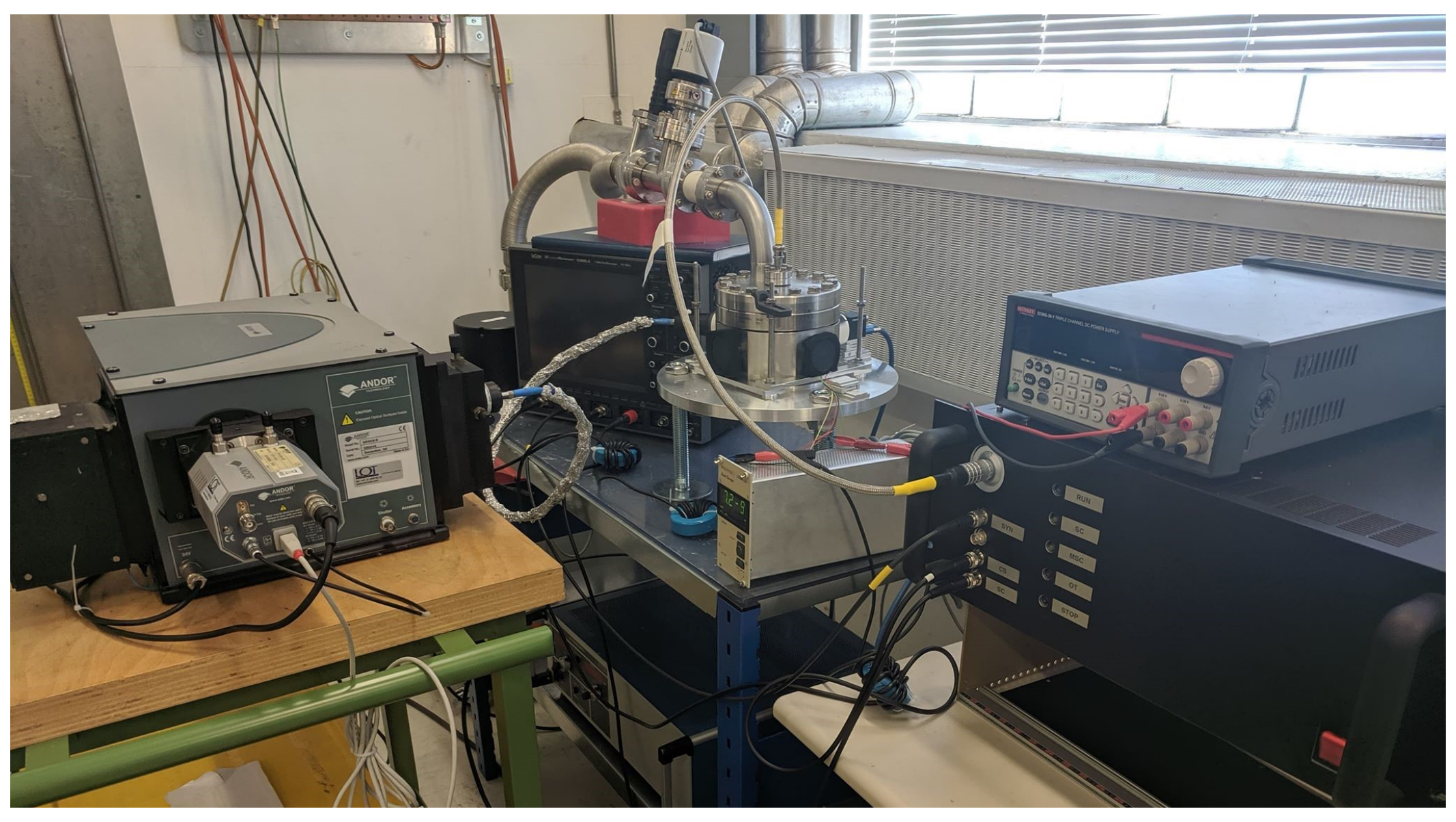

Figure 5—Image of the spectrometer with the LES System.

Measurements

During Breakdown

During a breakdown there is a high intensity light produced. Figure 6 shows the waveform captured with the current setup of this light. Due to its high intensity compared to other possible light sources with the system only this light can be seen during a long exposure. The waveform shows that this is a broadband light that rages over the visible spectrum.

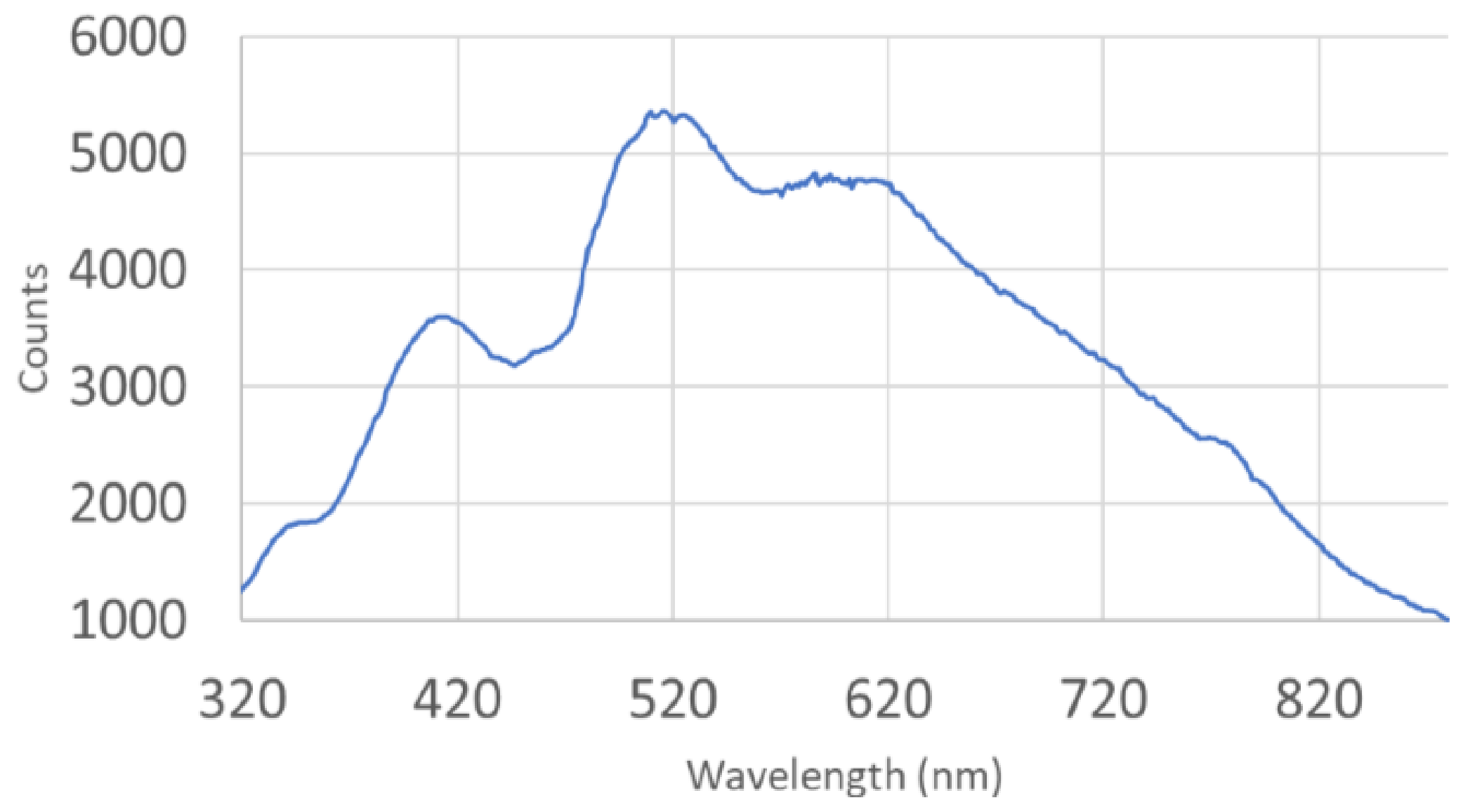

Figure 6—Measurements of light detected by the spectrometer during a breakdown.

During Field Emission

Figure 7 shows the results whilst using a constant voltage applied between the two electrodes. There was a light found that peaks around the 600nm which is in red wavelength range. Voltages given for these results are the voltage from the power supply and not the voltage across the gap. The source of this light is currently unknown but possibilities include: photoemission, Optical Transition Radiation and surface plasmon resonances.

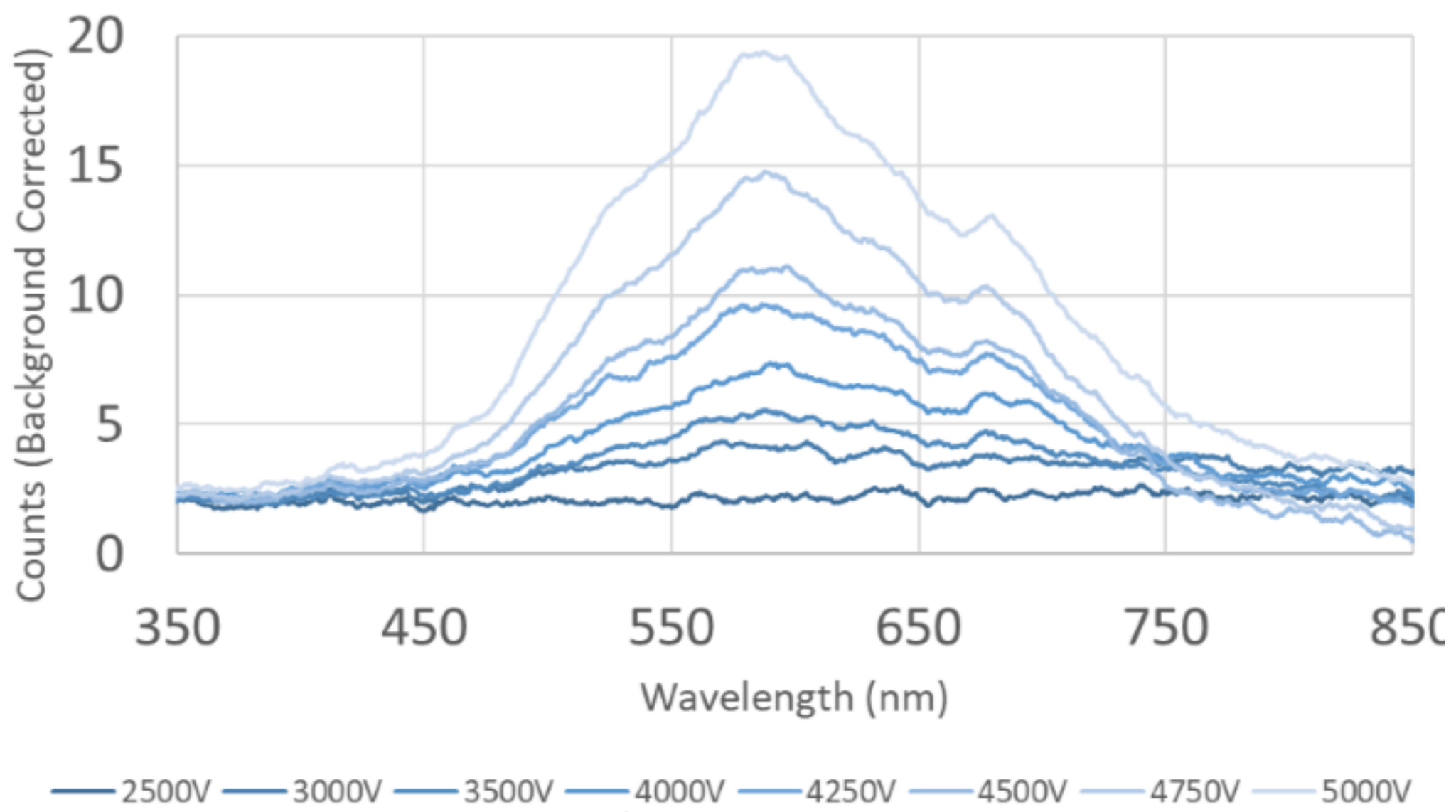

Figure 7—Measurements of light detected by the spectrometer during when different voltages are applied.

Figure 8 displays a plot of the voltage verse the maximum number of counts from figure 7. From this it can be seen that the relationship between the two variables follows a similar curve to Figure 3.

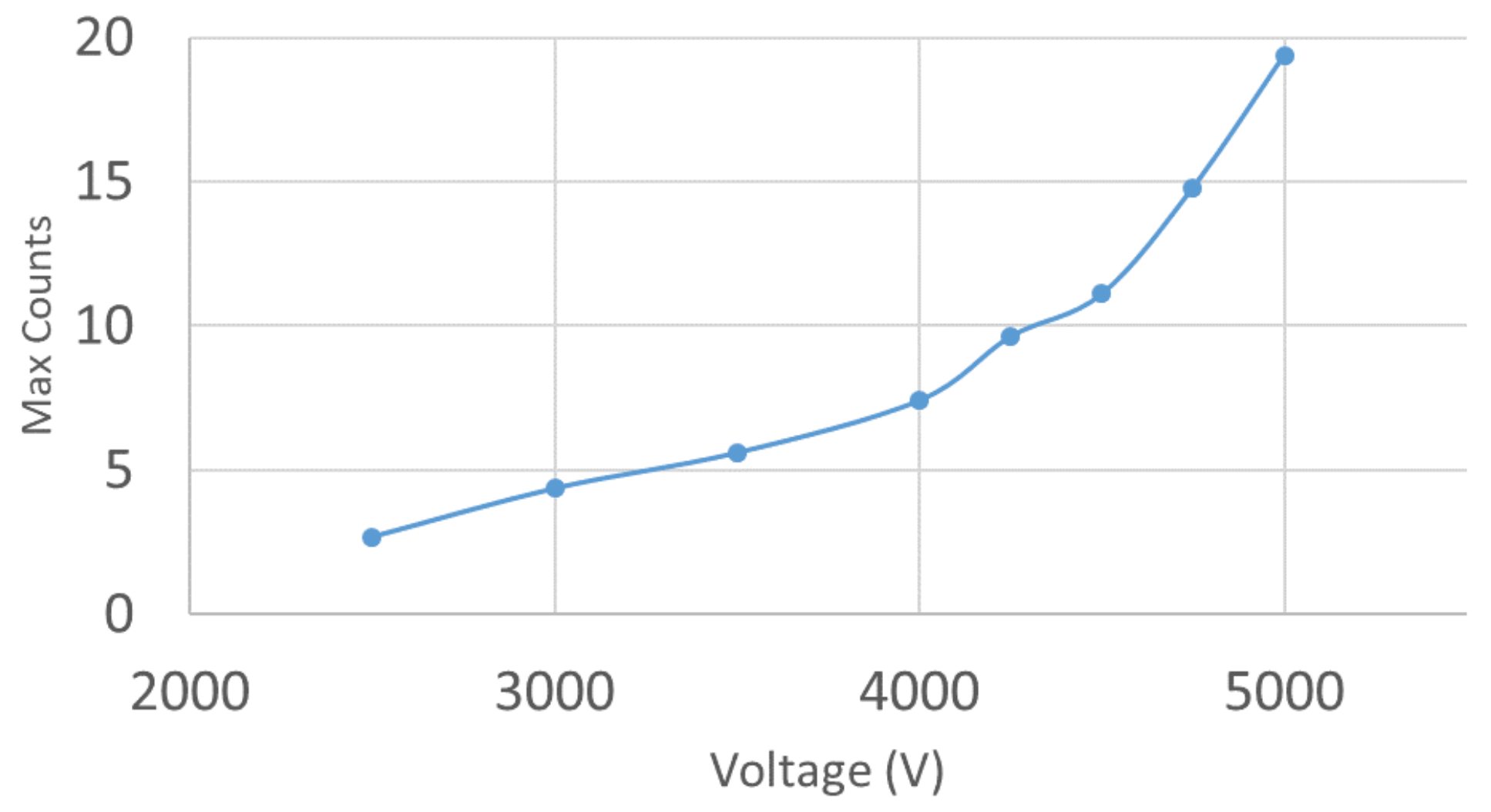

Figure 8—Voltage vs Counts

Future Work

Electrons emitted from the cathode as a result of field emission are accelerated towards the anode before impacting on the surface. There are different types are light emission that can occur when electrons hit the surface of a metal. These include photoemission, optical transition radiation (OTR), and the presence of surface plasmon resonances. The aim is to determine the cause by differentiating between the different possible sources.

Contact: ruth.peacock@cern.ch

CERN European Organization for Nuclear Research