EasyPET Exercise

Martin Grossmann / 10.07.2018

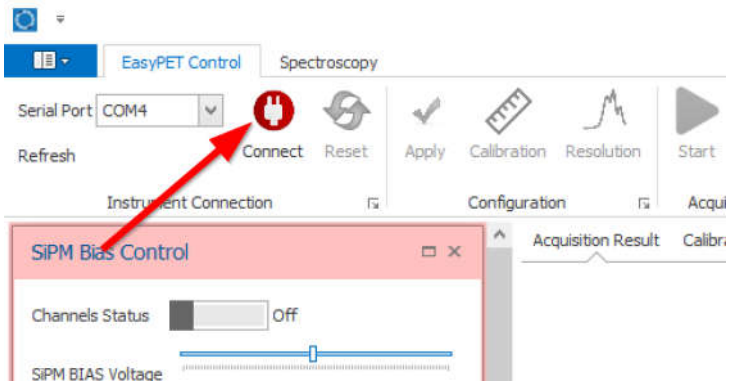
Caution with Radioactive Sources

For this exercise we will use radioactive sources of Na^{22}, a β^+ emitter that will provide γ radiation. Our sources are sealed plastic discs with an activity of approx. 12 µCi each. As additional precaution we keep the sources in plastic zip bags most of the time. Please handle the sources with caution and follow the safety rules:

1. **Let your instructor do most of the source handling**
2. Minimize the time you are handling the sources directly
3. Maximize your distance from the sources during the experiment
4. When not needed store the sources in the lead castle (small desk in the corner)

0. Setup

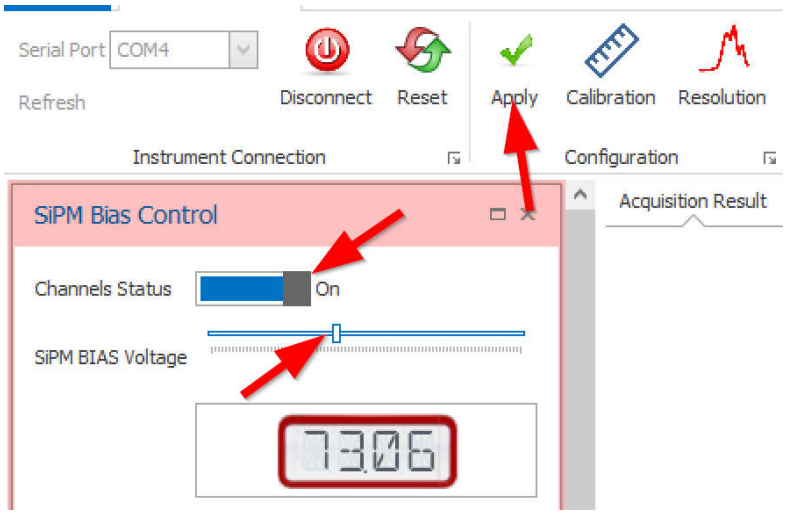
Start the EasyPET GUI and connect the EasyPET and the MCA via USB/Serial Port



Check what is the correct bias voltage for your device:

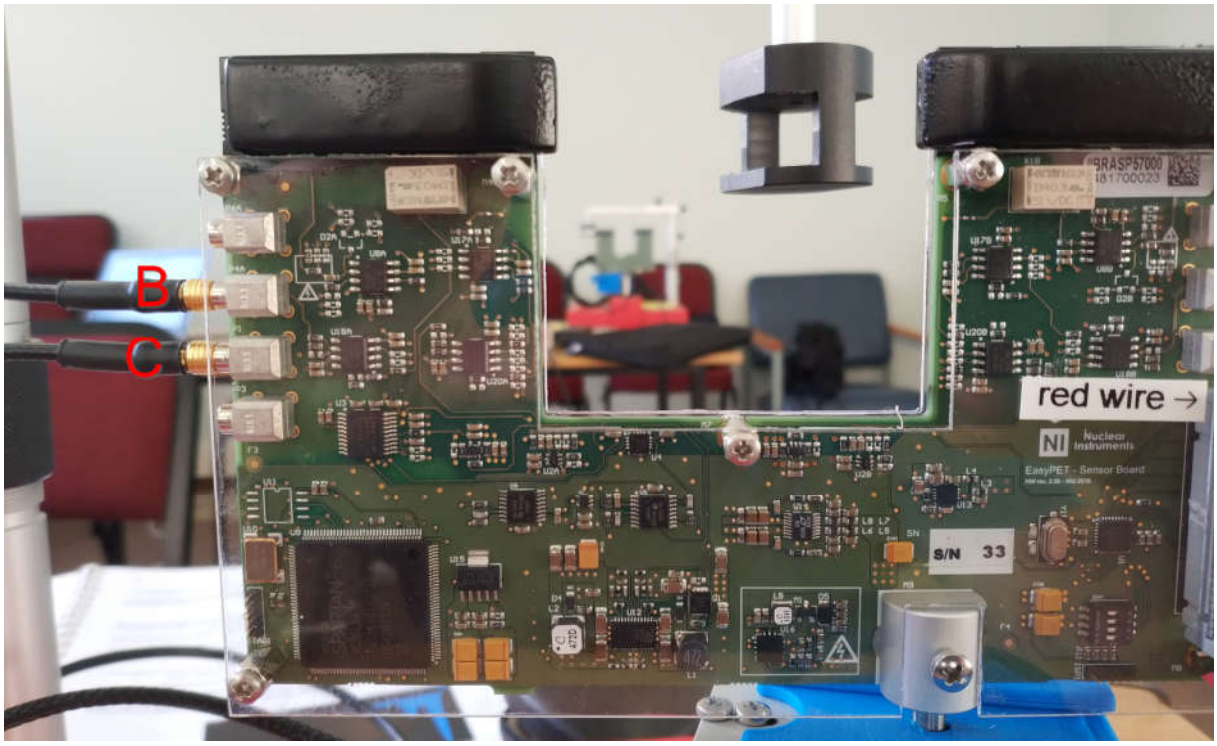
Serial Number	Bias Voltage
26	73.04 V
28	73.27
33	73.24
34	73.32

Set the correct voltage with the slider, switch the voltage on, and click Apply



Connect:

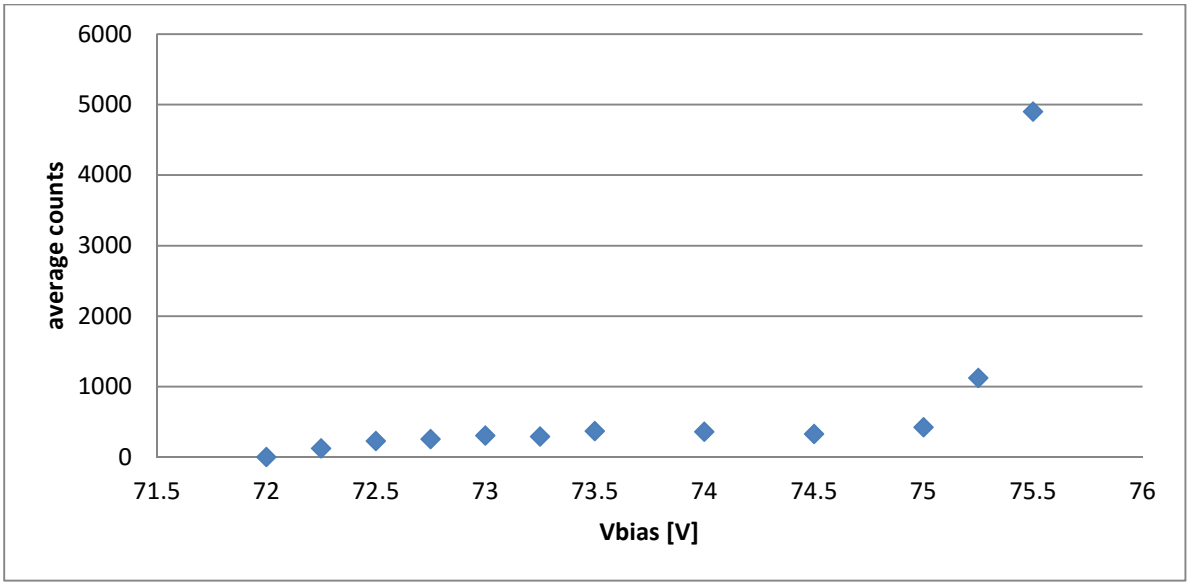
EasyPET output B (analog signal from SiPM channel 1) to MCA Input
EasyPET output C (comparator signal channel 1) to MCA GP I/O 1




CAEN
DT5770 Digital MCA
0
100%
00:00:00
GP I/O 2
MON OUT
B
C

1. SiPM characteristics

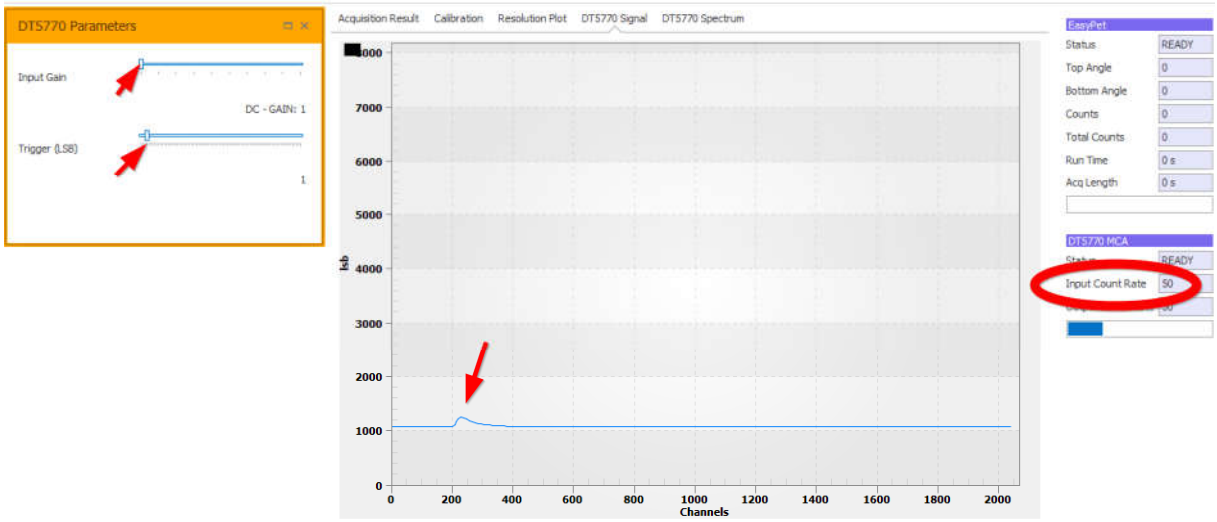
Voltage scan: record and plot the number of dark counts (without any source). A reasonable voltage range is 70.0 V … 75.5 V. The MCA displays the counts per second. Record 10 measurements (for 10 seconds). Report the average (measured counts divided by number of measurements). Plot a curve with the average against the bias voltage. You should find a curve that looks like this:



Identify 3 regions: zero gain, linear gain, Geiger Müller region.

2. Single Pulses

In the Spectroscopy tab select Oscilloscope, click “Start” and look at individual pulses.

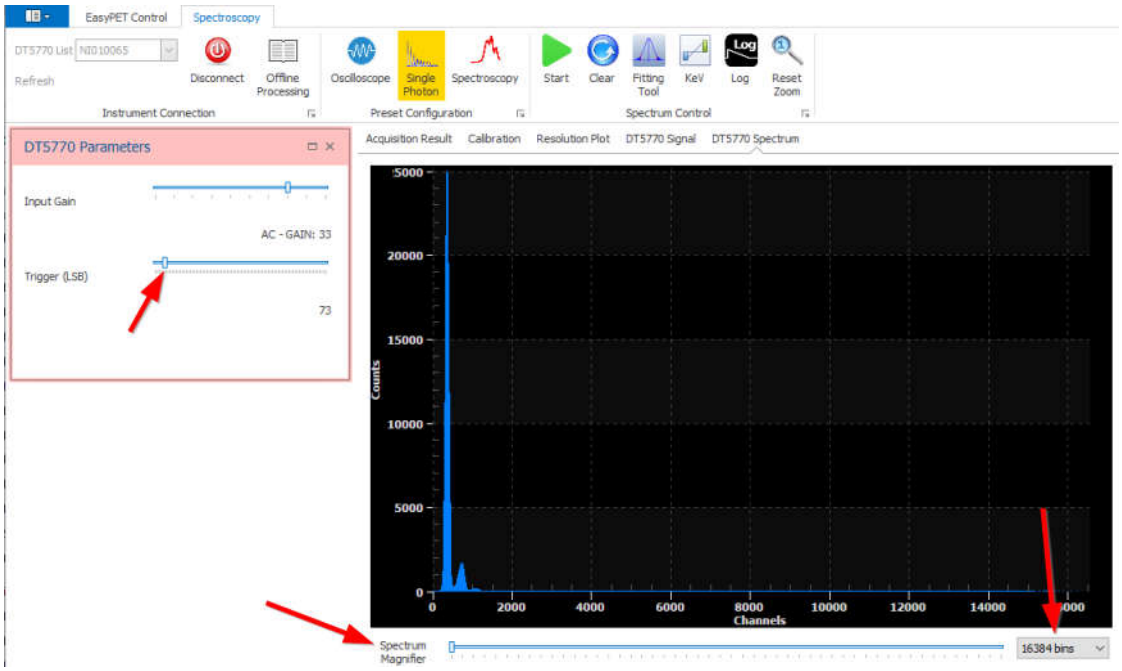


Observe how the rate goes up when you bring the source close to the detector (the rate is shown in the GUI and also on the MCA display).

The “DT5770 Parameters” allow you to change the gain and the internal trigger of the MCA. Observe how the signal changes with the gain, and how the rate changes with the trigger.

3. Multi Photon Spectrum

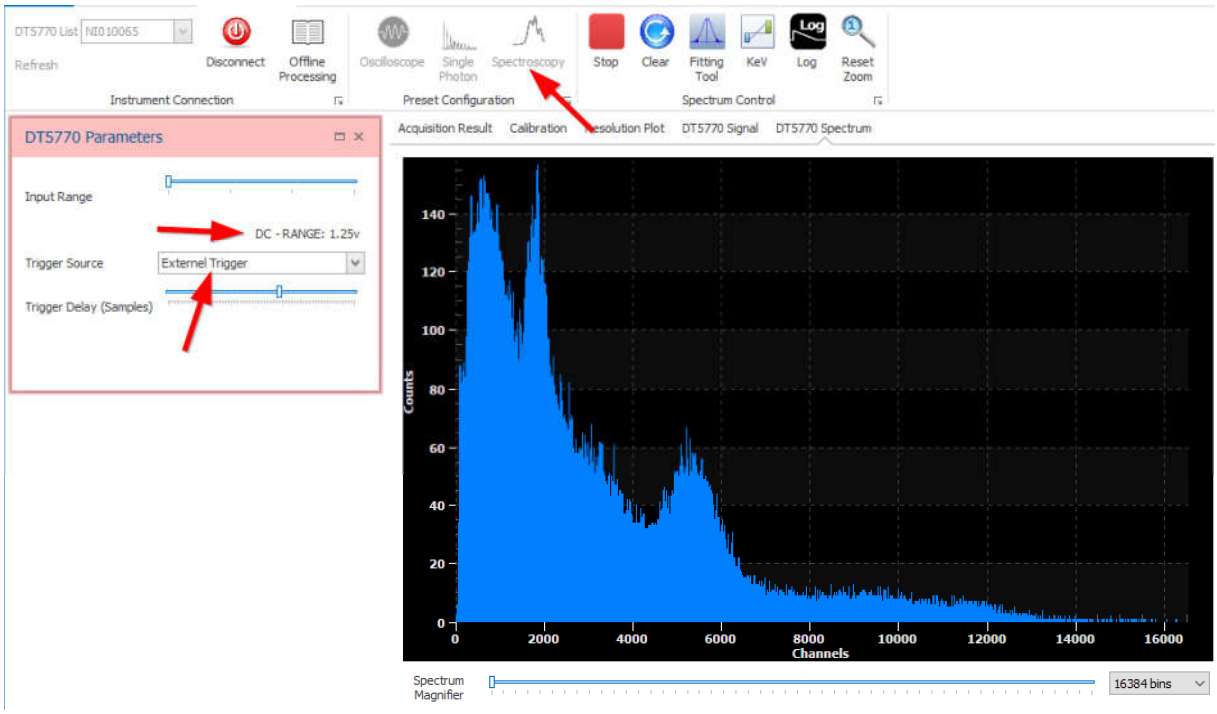
In the Spectroscopy tab select Single Photon – this sets default values for gain and trigger. Observe the spectrum and identify the peaks corresponding to 1, 2, 3 … SiPM cells firing. Use the Fitting Tool to measure the peak positions and check linearity. You can adjust the histogram parameters for an optimal resolution.



4. Gamma spectrum

Place a source on detector and fix the zip bag with tape

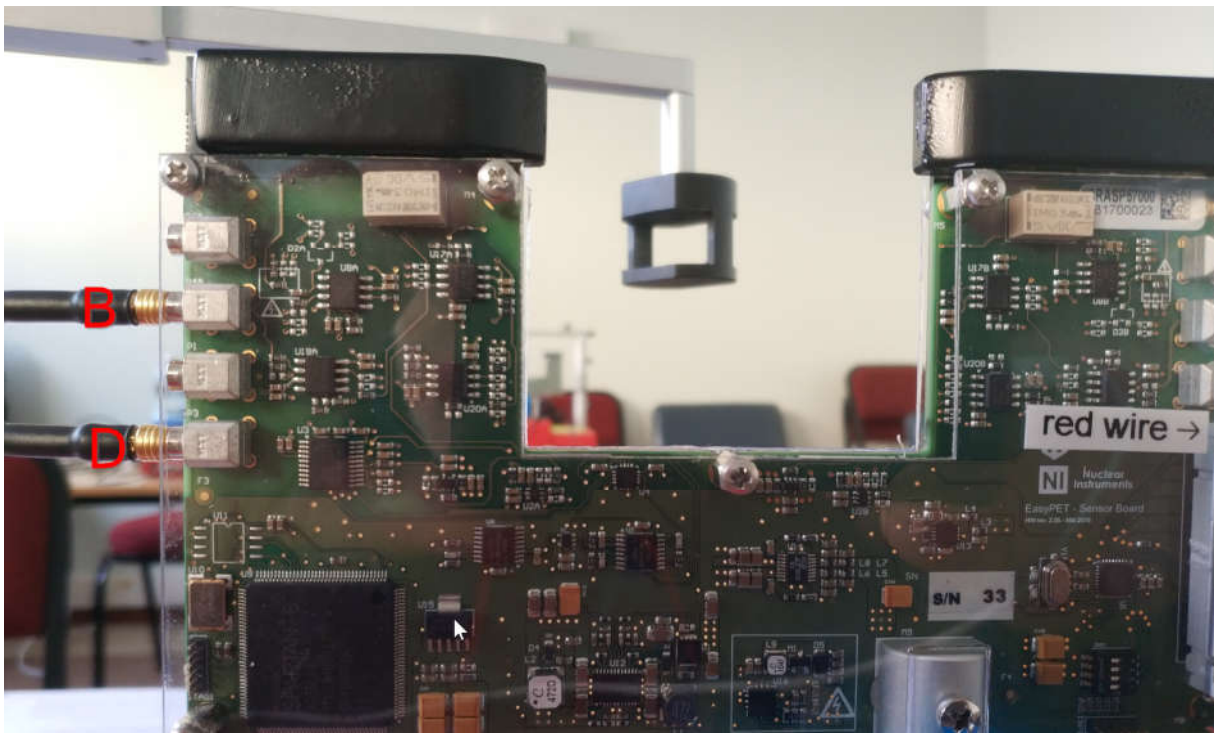
In the Spectroscopy tab select Spectroscopy. Check that the gain is DC (1.25 V). Seelct Trigger Source "External" – this triggers with the comparator of the EasyPET.



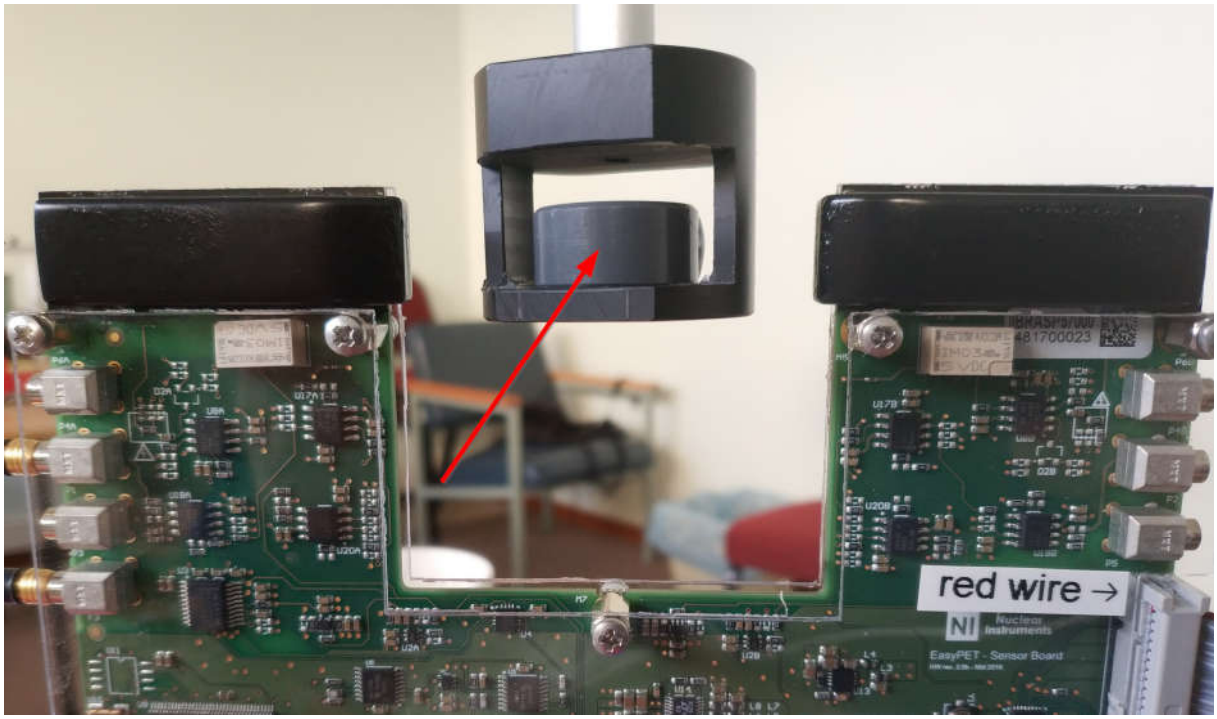
Observe the Compton spectrum and the 511 keV peak. Can you see 1275 keV from the Ne^{22} decay? Use the fitting tool to check the position of the two peaks.

4. Gamma spectrum in coincidence

Change the external trigger from the comparator to the coincidence output

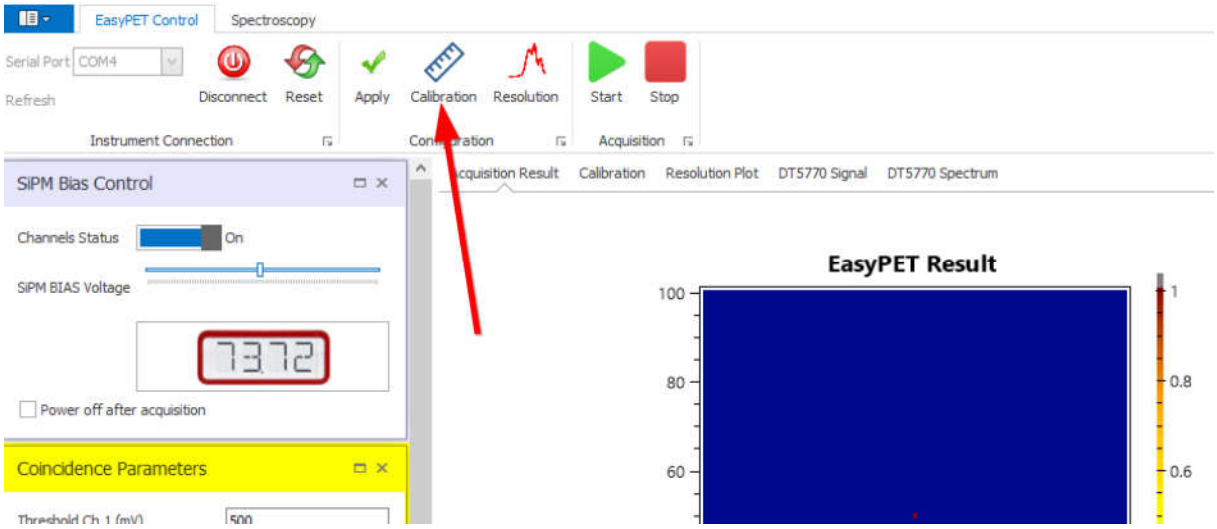


Let your instructor place the source in the source holder.



The first task is to make sure that the source is really in the detector center. This operation is somewhat difficult because the source and the detectors are both really small, and it is quite hard to properly align them.

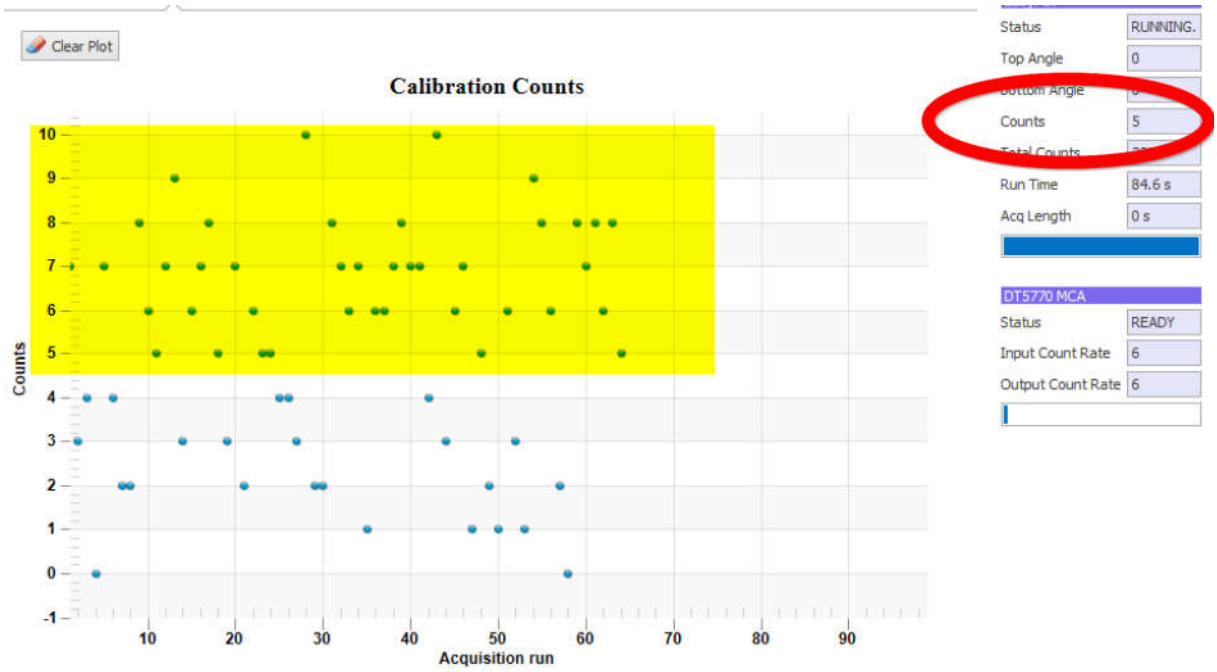
Go to the EasyPET tab and run the calibration



The EasyPET will perform two rotations to reference its position. Be careful that the signal and trigger cables do not obstruct this movement. Once stopped the GUI will show the number of coincidence counts from both detectors.

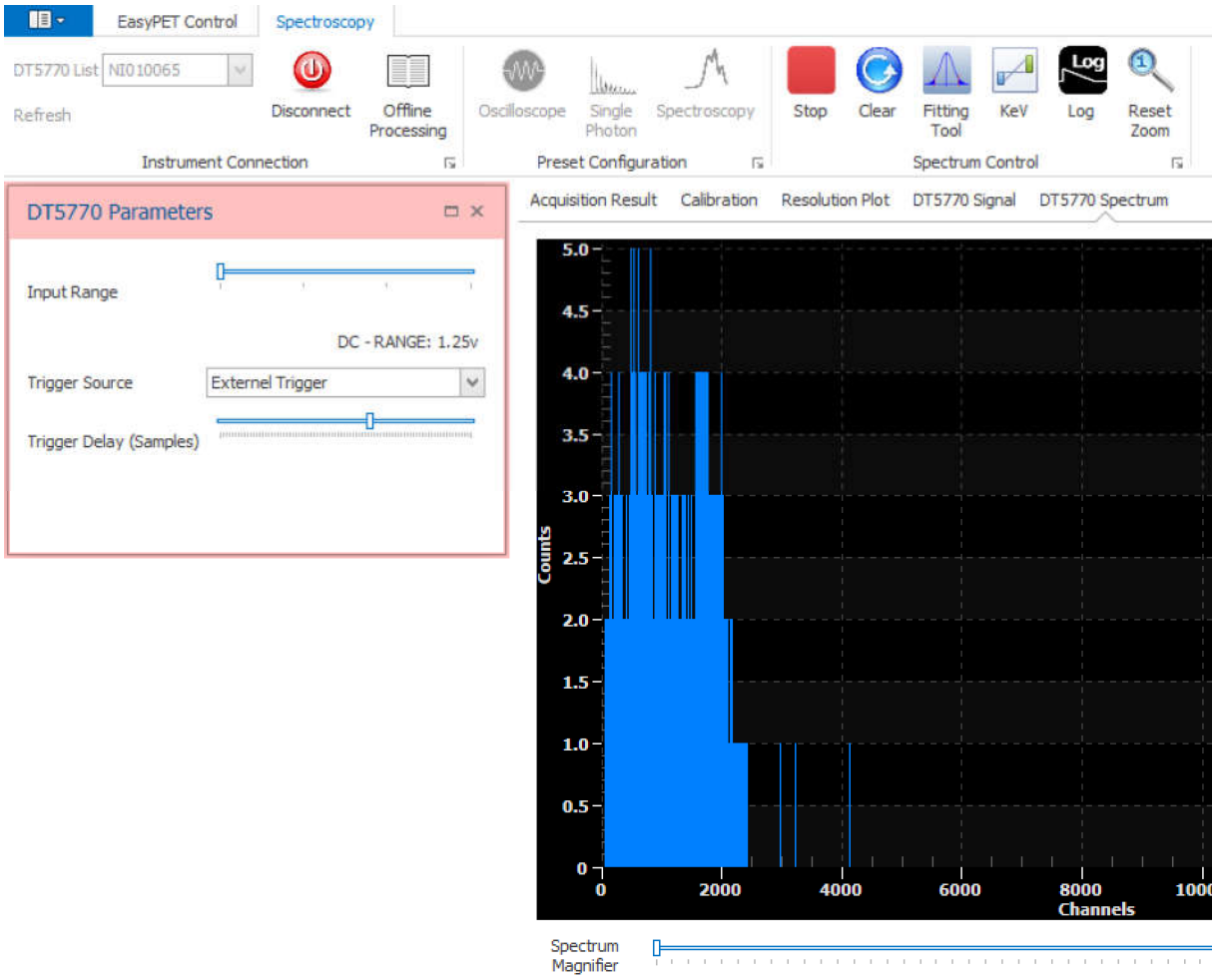
Your instructor will show you how to adjust the height of the source.

- If you have 0 or 1 count per second the alignment is not good.
- If you have 5…10 counts per second the alignment is good for the following experiments.



In the Spectroscopy tab select Spectroscopy. Check that the gain is DC (1.25 V). Select Trigger Source “External” – this triggers with the coincidence signal of the EasyPET.

Since the rate now is much lower than in the previous experiment it takes a while to acquire a reasonable spectrum.



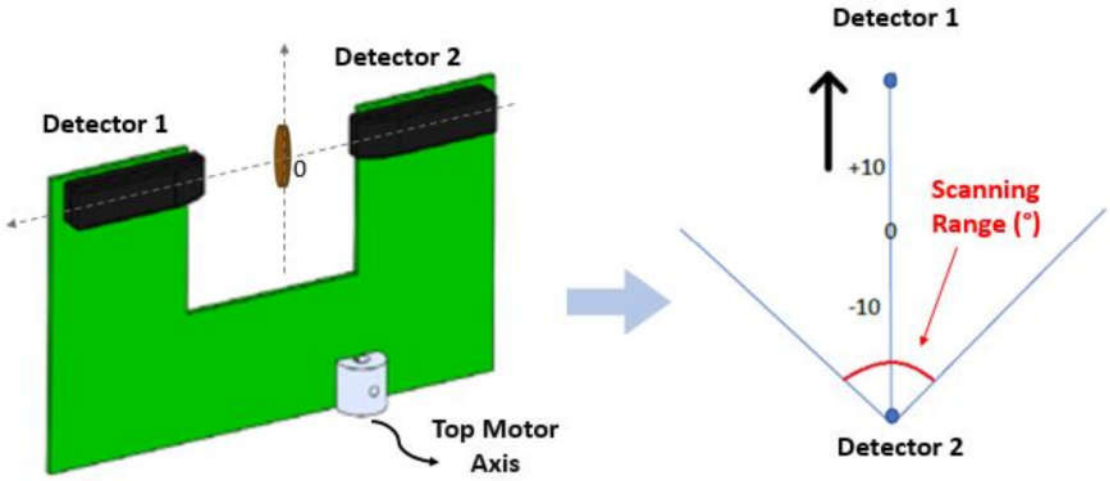
What is the difference compared to the spectrum in the previous exercise (gamma spectrum triggered with comparator)?

We will start image acquisition and the detector will move. Therefore remove the signal & trigger cable from the EasyPET so they don't interfere with the detector rotation.

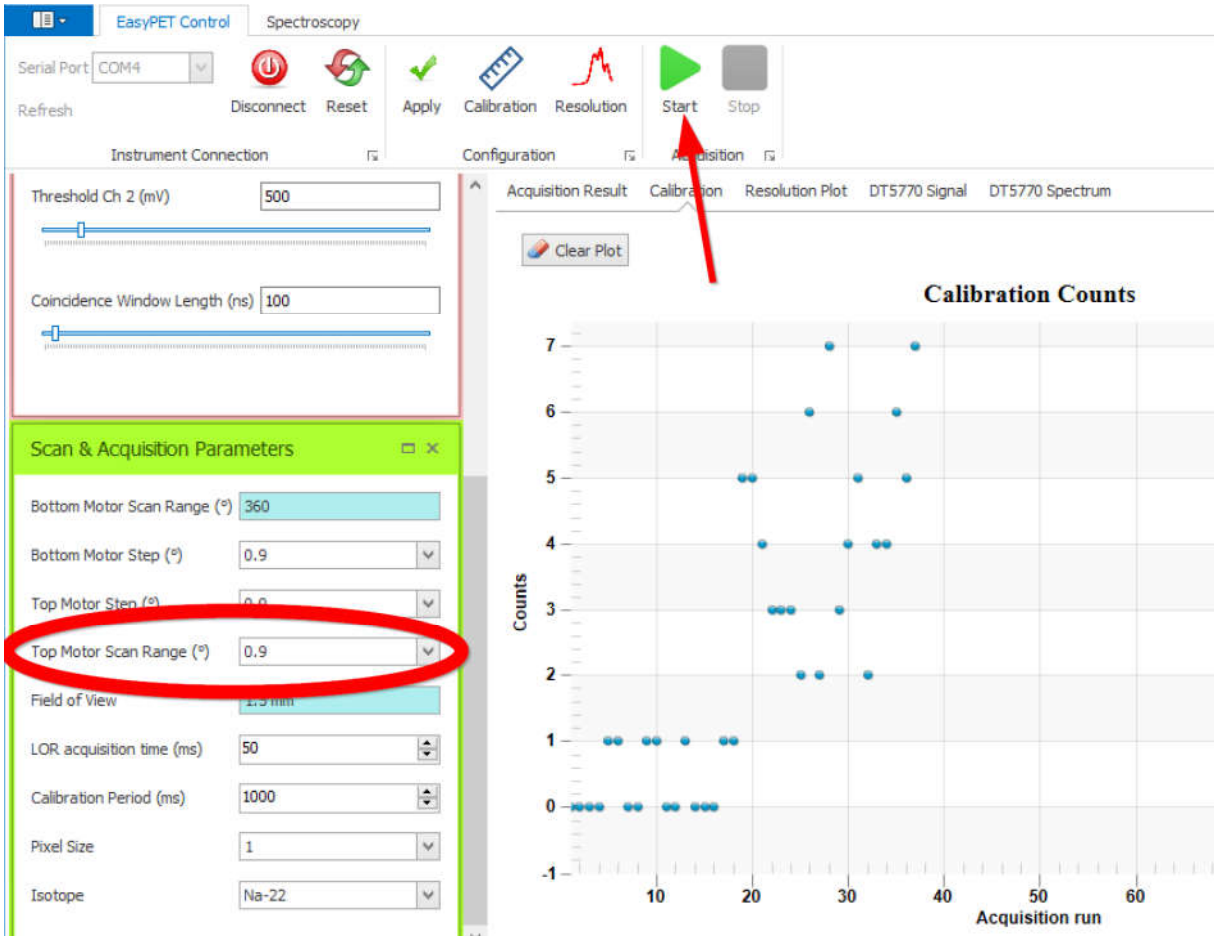
After removing the cables verify with the EasyPET calibration that the source is still well centered.

5. Detector movement for PET imaging

Identify the two motors and the two rotation axis. The bottom motor will perform a full 360^{o} rotation in steps while the top motor at each position scans a certain angular range



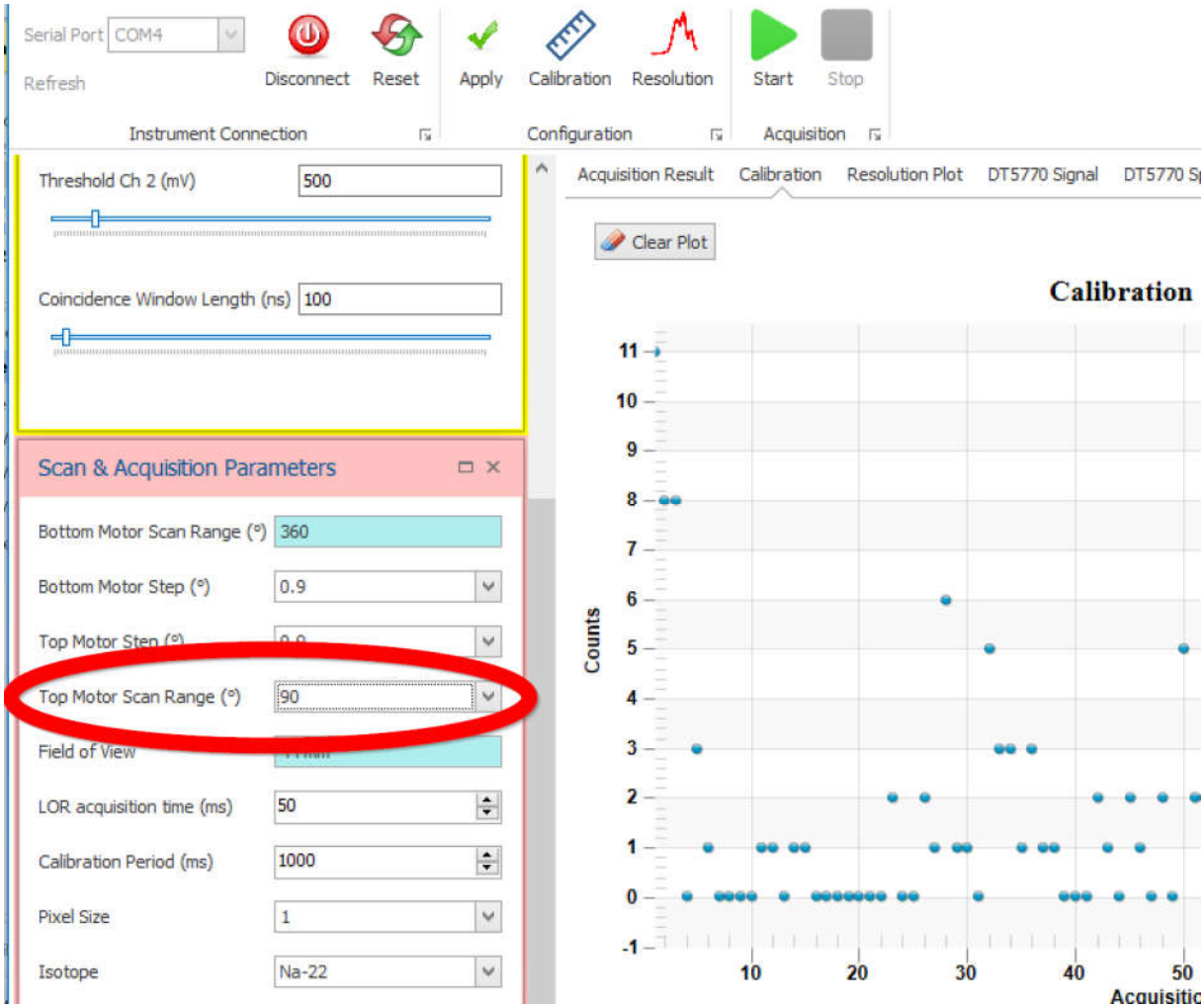
In order to understand this movement run it once with a very limited scan range for the top motor. In the EasyPET tab, go to “Scan & Acquisition Parameters” and change the “Top Motor Scan Range” from 90 to 0.9



Run the acquisition and observe the two motors’ motion. Observe how the source always stays between the two detectors. In the end the bottom motor goes back to the starting position. (Don’t worry about the acquired image; that will come in the next step).

6. PET image

Now you are ready for the acquisition of a PET image. Put the top motor scanning range back to 90



Start the acquisition. It will take around 40 minutes to complete a scan. You will slowly see the PET image being built up in the GUI

7. Spatial resolution

Repeat a PET run with two sources. Can you resolve them?