

The fluorescence detector and how to use it

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1. The fluorescence detector

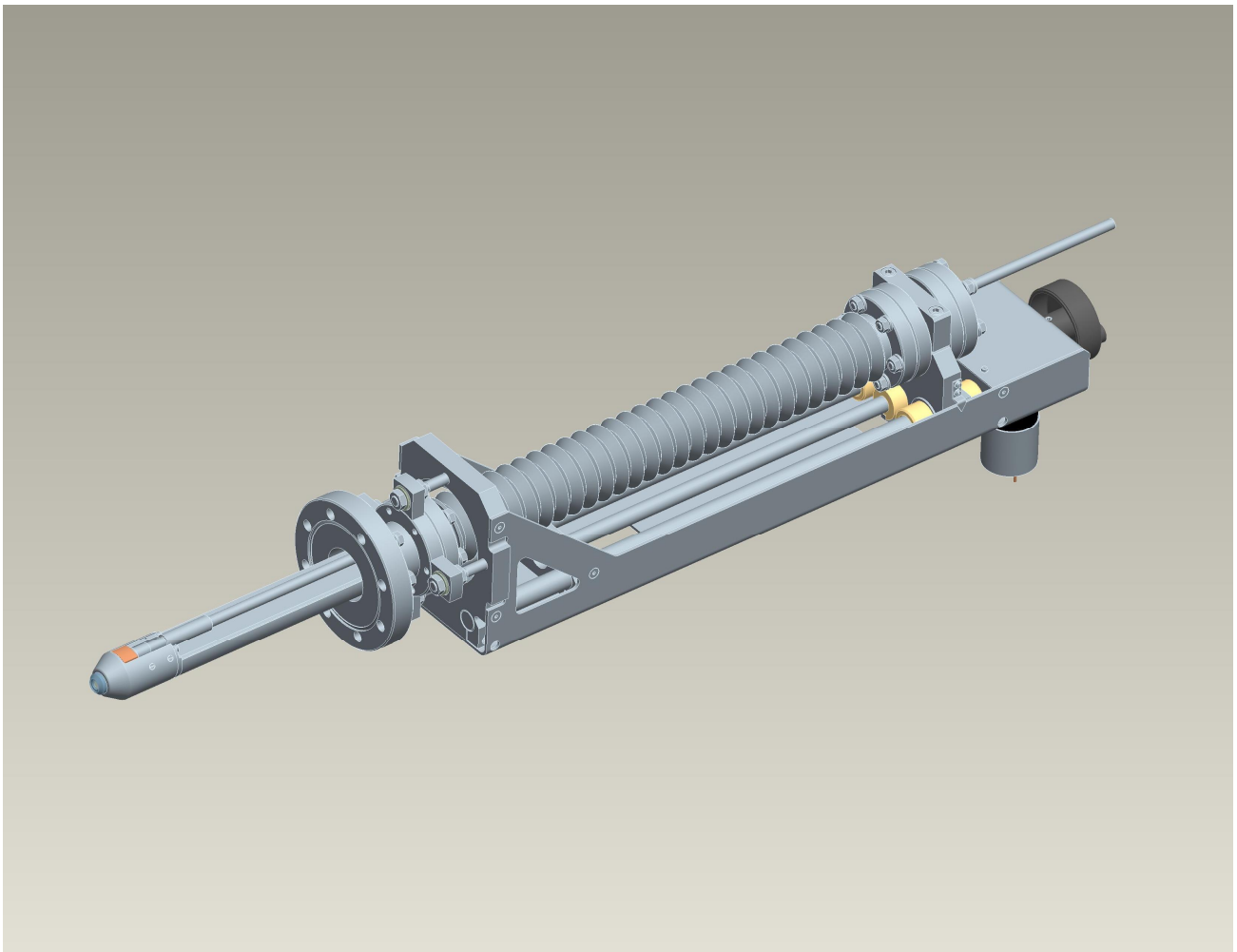


Figure 1: The fluorescence detector.

The soft X fluorescence detector of the beamline BEAR is a Semiconductor Drift Detector (SDD) developed by PNDetector GmbH. The Fig. 1 shows a layout of the whole detector, including the mechanic assembly.

The main characteristics of the detector are:

Sensitive area: 30mm^2

Distance from sample $\approx 20\text{mm}$

Solid angle ≈ 0.075 sterad

Energy range $150\div 8000\text{eV}$

Sensor cooled by Peltier cell ($T \approx 15^\circ\text{C}$)

Energy resolution 133 eV @ MnK α (13.4mV/keV preamplifier output)

Low level noise 150 eV

Built in electronics JFET

MCA with 8192 channels, (calibrated @ ^{55}Fe K line (6 keV), Ga L α line (1098 eV), As L α line (1282 eV))

2. General description of the system

The fluorescence detector system is based on:

- 2.1 The detector itself;
- 2.2 The cooling system;
- 2.3 The electronic system based on:
 - 2.3.1 A signal preamplifier;
 - 2.3.2 A Multi Channel Acquisition electronic device;
 - 2.3.3 The power supplies;
- 2.4 The mechanic assembly including the movement system.

2.1 The detector itself

The detector is a Silicon Drift Detector. A picture of the detector and of its mechanical cage is shown in Fig. 2a). The working principle of the device is shown in Fig 2b). The photoelectrons are collected by the small anode ($<100\text{fF}$), characterized by a low capacitance. The detecting area has a thickness of $500\mu\text{m}$, with a Be $10\text{-}25\mu\text{m}$ thick window: this implies that the energy cutoffs are $100\text{-}150\text{eV}$ - 30 keV .

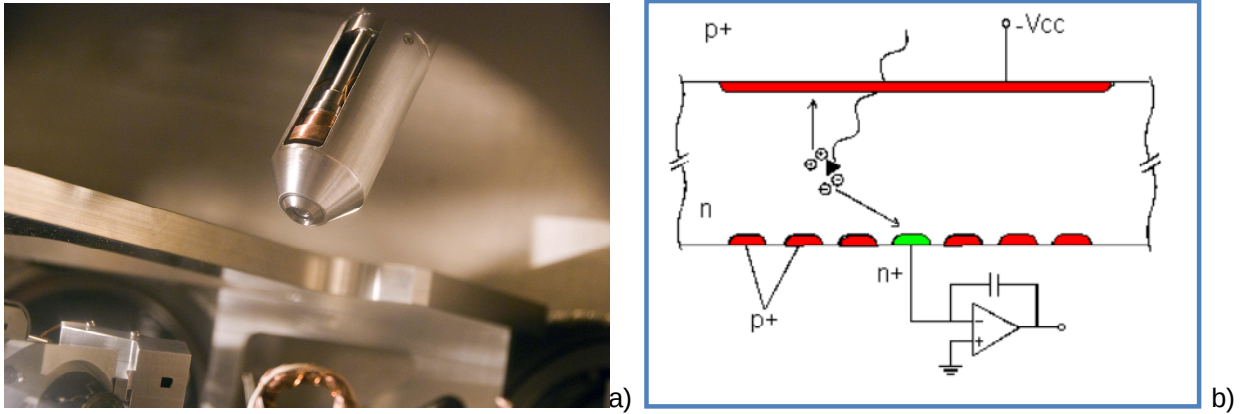


Figure 2: Picture of the detector a); Scheme of the detecting area b).

2.2 The cooling system.

The cooling system consists in a 1-stage Peltier cell that operates at ($T_{air} 15^{\circ}C$), cooled down by a water system (Fig. 3).

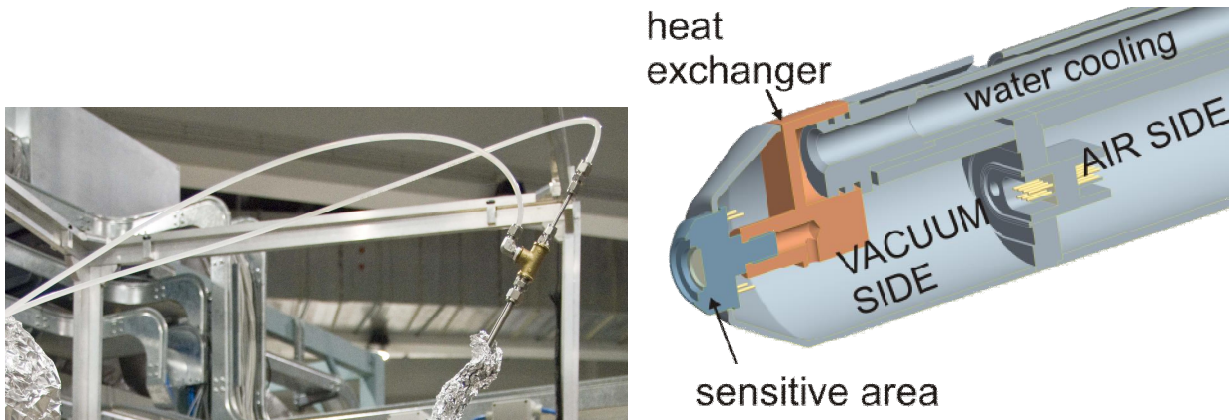


Figure 3: The water supply system a); The detector area and the cooling system b).

2.3 The electronics

A simplified scheme of the electronics is shown in Fig. 4. The electronics has been developed by XGlab. It is based mainly on a preamplifier device placed far from the detector, a signal shaping amplifier ADC Multi Channel Analyzer (MCA) device and the power supplies.

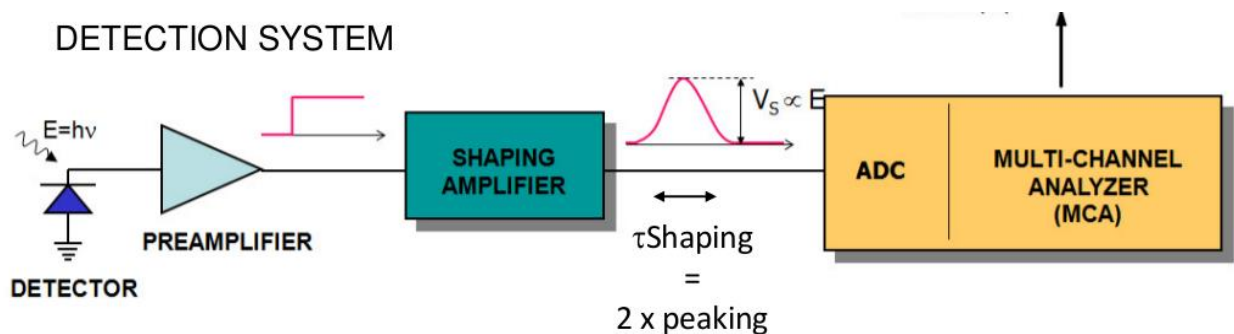


Figure 4: Simplified scheme of the detector and electronics.

2.3.1 The preamplifier

It consists in a pre-amplifier placed at the end of the detector mechanical system (Fig. 4). Differently from standard XG-Lab system, it is connected to the detector with a 1 m flat cable and is fed with external linear power supplies. The amplified signal is sent to the Analog to Digital Converter (ADC) inside the MCA box. The preamplifier output (**OUT**) is a periodic ramp signal with period 5-10ms and amplitude 2-3 V. On this ramp, are present the useful pulse signals (**POSITIVE**) whose amplitude is proportional to the photon energy: the relationship is **13.4mV/keV**.

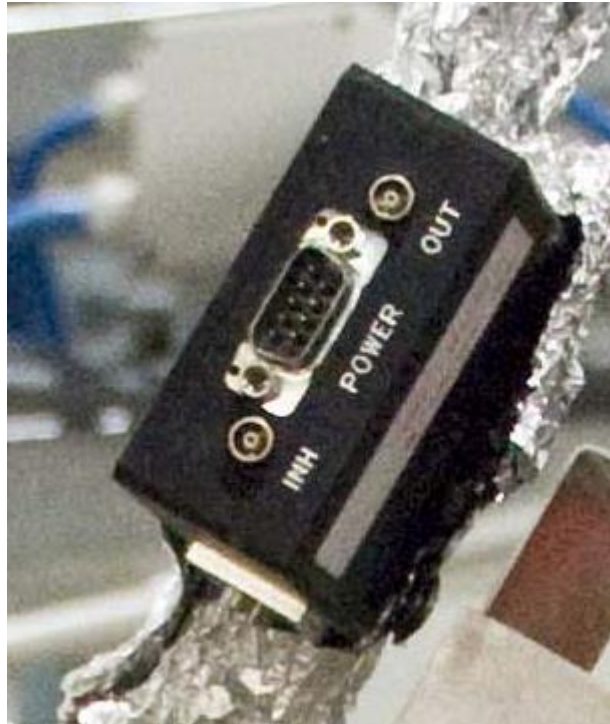


Fig. 4: The preamplifier

2.3.2 The Digital pulse processor (MCA) Zeus

The Digital pulse processor (Fig. 5) converts the analog signal coming from the preamplifier, processes it (filter, gain, offset) through the MCA and send the processed digital data to the computer by USB.

It is based on:

Input analog conditioning stage (prefilter, gain, offset).

High performance 150 MHz 16-bit analog-to-digital converter (ADC).

A last generation digital Field Programmable Gate Array (FPGA) SPARTAN6 @ 100MHz.

The on-chip RAM for storing the acquired spectrum.

USB2.0 interface (FTDI).

Custom made control software and libraries provides data visualization and analysis.



Fig. 5: The Multi Channel Acquisition system

2.3.3 The power supplies

The preamplifier system is provided with an external D.C. power supply (Agilent E3631A) and a High Voltage D.C. supply. This solution replaced the standard XG-Lab to take into account the noise introduced by the long flat cable between detector and preamplifier.

2.4 The mechanics and the motion system mechanism.

The whole detector mechanism has been projected and developed at the TASC workshop. Is is based on air-vacuum interface, a 600 mm linear motion drive, motorized with a simple DC motors. The motor power supply is positioned beside the other power supplies.

3. Hardware Connections

The procedure to perform correctly the measurements are:

3.1 Preliminary connections

- **Water cooling**: make sure that the water in the cooling system is flowing (the levers in the taps must be in vertical position).
- **Connections for movement**: Connect the motor to the motor power supply,
- **Connections PC electronics**: check the USB connection between the computer and the MCA.

3.2 Connections between the MCA and the amplifier

PreAmplifier	MCA
INH	INH
OUT	IN
	Power (no connection)

3.3 Connections between power supplies and preamplifier

The DC power supply (Agilent E3631A) feeds the preamplifier with the grey cable DB9 terminated (power). This cable is devoted to HV, Peltier and preamplifier electronics:

High Voltage power supply	Agilent E3631A	Cable colors- Input
	(Peltier) 6 V à 350 mA (set limit to 400 mA)	Grey: P+ Violet: P-
	+12 V: 53_42 mA (limited to 100 mA)	Black: +12 V
	-24V: 31÷33 mA (limited to 100 mA)	Brown: -24 V
(HV) -150 V, 1 mA (not limited)		Red: -HV (-150 V)
	Temperature reading	Orange
	GND (common)	Blue
	GND_ AUX (common)	Yellow
	NC (ground)	Green

3.4 Operations

- Connect the RS232 type connectors with bananas.
- Read the labels on the DC and AC power supplies.
- Before any connection make sure that the supplies are switched off and all the E3631 settings are correct.
- Connect the common of the two power supplies with a banana-banana connector.
- Before to turn the system on double check that the wiring and the settings are correct.
- On E3631A check the display limit and check the voltages pressing the different channels.
- **PELTIER**: E3631A OUTPUT ON: check Peltier voltage.

The temperature reading is made using a voltmeter on the temp-read cable with respect to GND (common) of the power supplies.

Conversion factor: $1\text{ }33\text{mV}/^{\circ}\text{C}$;

reading at 25°C : $V_t=4.270\text{V}$.

A good reading for a -15°C is between 5.5 and 6 V. To read the voltage you have to turn the system on.

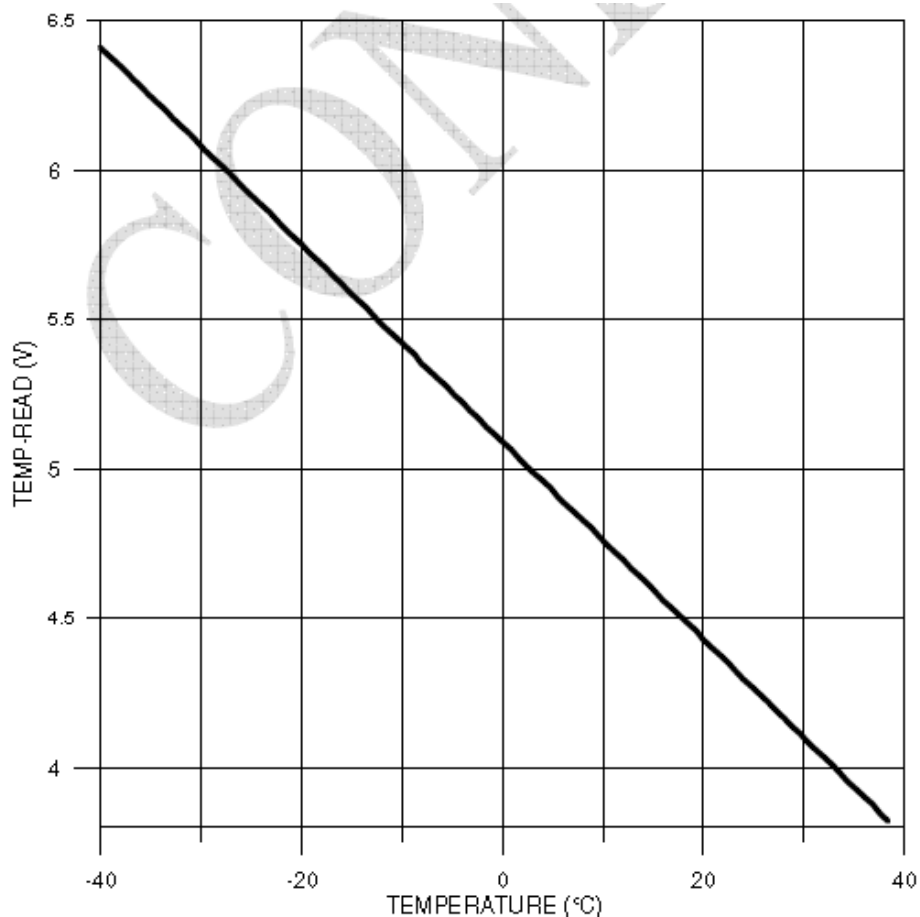


Fig. 6: Temperature as a function of the Voltage given by temperature sensor.

- Verify absorptions.

To turn the system off first switch HV to off and then press OUTPUT OFF on E3631A.

4. Acquisition of a fluorescence Spectrum

Once prepared and verified all the connections, the user has first to complete the hardware setup moving detector and sample and then setting the measurement by software.

4.1 Sample Detector setup

Positioning of detector close to sample: With HV switched off, move down the detector with the motor till the red sign reaches the level of the black arrow (corresponding to about 30 mm from the sample).

Positioning of sample: With 0 order position the sample centred respect to the beam. A good value of $\bar{U}_m$ is around 148 to be at 45° respect to the light and almost perpendicular to the detector (see Fig. 7). Once positioned the sample, set an approximate monochromator energy.

Dark inside the chamber: Verify that no light comes inside the experimental chamber (that is all windows are black covered and that the gauge is off).

Turn detector on: turn on the HV power supply.

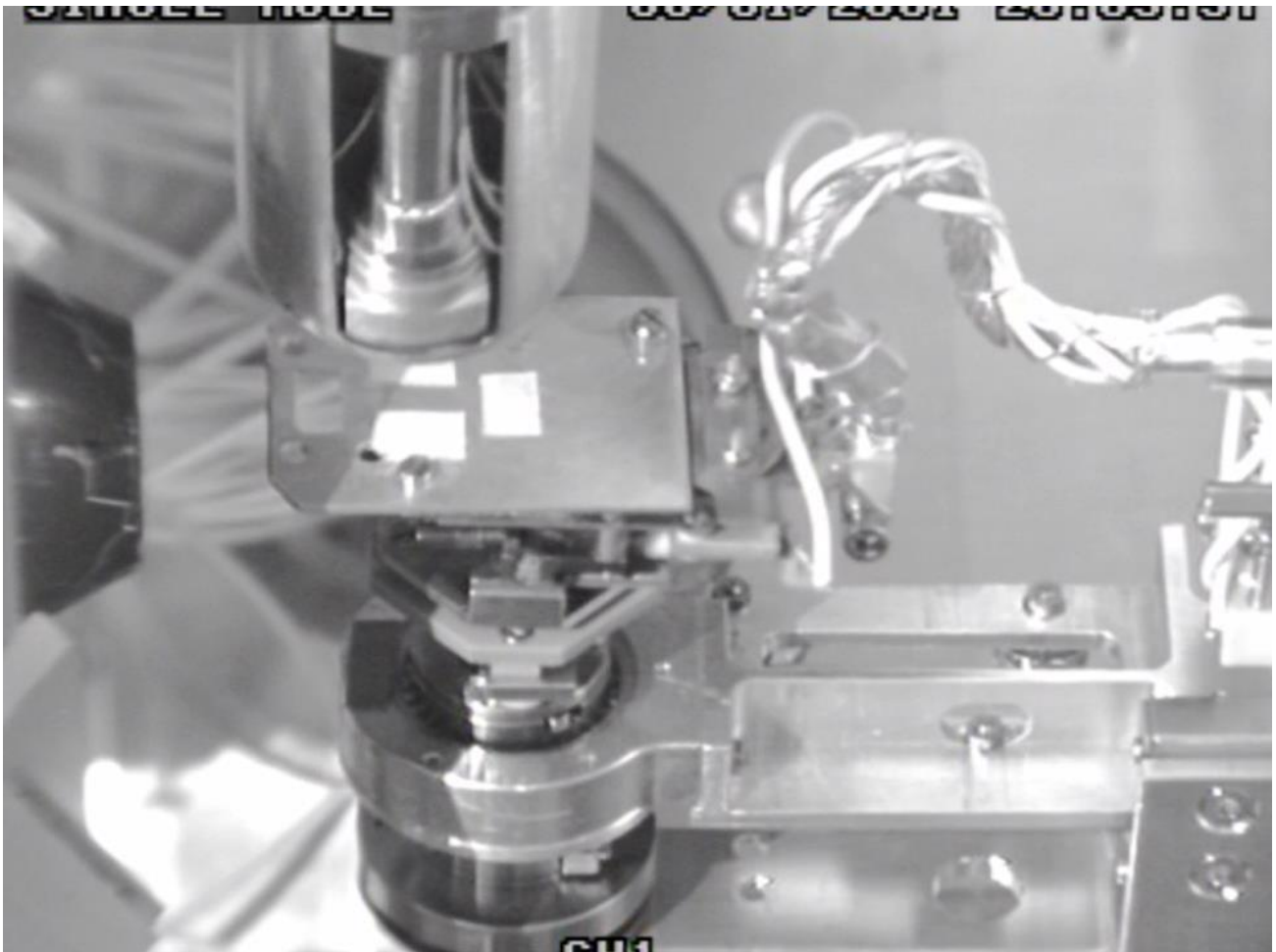


Figure 7: Picture showing the detector placed over powdered samples.

4.2 Software configuration

-Monochromator configuration: set the monochromator energy a few eV above the absorption energy of the element you wish to analyze.

-Detector configuration: push the **configure** fluorescence detector button on the bottom right of the acquisition software and then again on **configure** on the main configuration screen (see Fig. 8).

You should see **MCA configured** under the button. The trigger level in the top right of the configuration screen defines the threshold of the ADC. A value between 34 and 36 is usually good. You can leave the other options to the default values.

- Background check: close the shutter and acquire a spectrum to check the noise level through the dead time value. A good value should be below a few percent.

- Determination of the channel window: Open the shutter and acquire the spectrum again. Position the cursors of the channel window around the fluorescence line of the element and take note of their value.

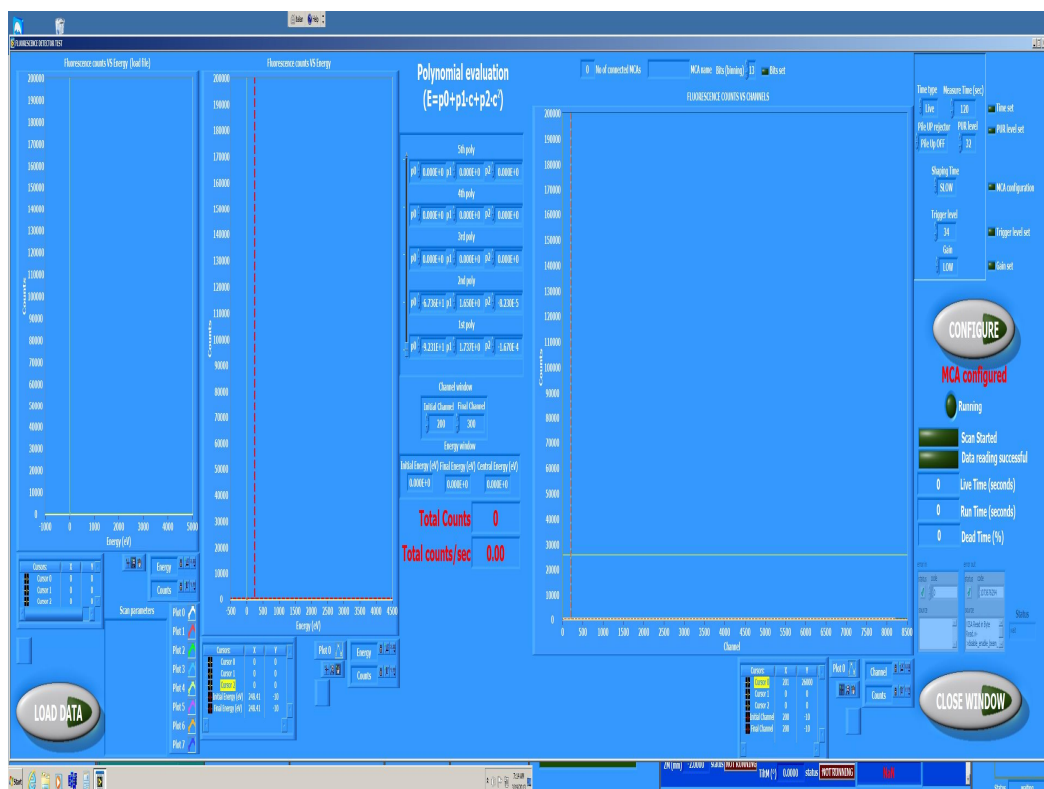


Figure 8: Fluorescence detector main configuration screen.

- Configuration of fluorescence yield measurements: configure **fluorescence** either on instrument 1 or 3. A window like the one in Fig. 9 pops up. Enter the values of the channel window cursors, the trigger level and the measure time (typical 1-5 secs). All the other options should be left to the default values.

Integration time (sec): 1.000, Single shot time (sec): 0.100, Number of shots: 10
 GAIN: LOW, TRIGGER: 34, PILE UP REJECTOR: OFF, TIME TYPE: RUN, SHAPING TIME: SLOW
 Initial Channel: --, Final Channel: --, Normalize to live time: yes, Bits: 13

Figure 9: Fluorescence detector instrument configuration screen.

4.3 End of fluorescence measurements

Once finished measurements, the user has to perform the following operations:

Turn detector off: turn off the HV power supply.

Light into chamber: Turn gauge on.

Removal of detector: With HV switched off, move up the detector till the end of the travel.