Detector Calibration Procedure

Pulser Calibration

If the value of the preamplifier “test input” capacitance is known, a pulsar can be used to give an absolute system calibration with a reasonable accuracy. The value of the test input capacitance varies between models of preamplifier, but is usually 1 pF.

However a more reliable method is to use a “charge terminator” of known capacitance, which is placed between the pulser and the preamp input (in place of the detector) (see fig.1):

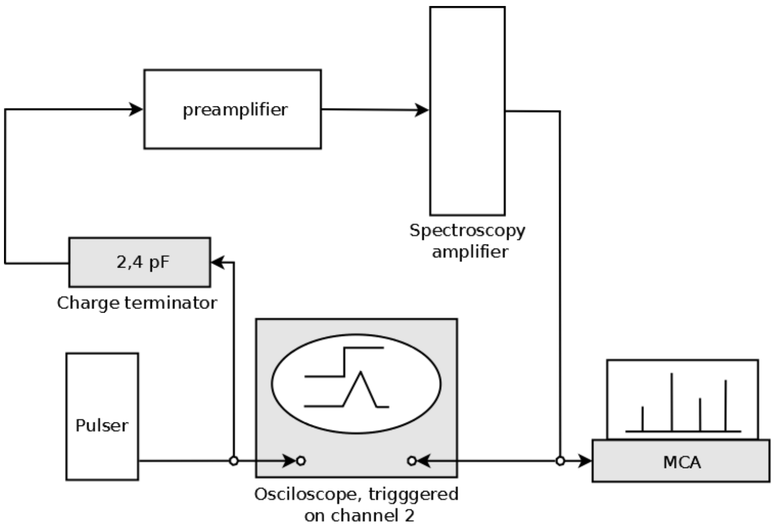


Fig.1. Scheme of the calibration of the spectroscopic system using charge terminator.

Used devices: Pulser – Precision Pulse generator ORTEC 419
Shaping amplifier – ORTEC 671
Digital oscilloscope – LeCroy WaveRunner 640Zi
MCA – Multi-channel analyzer ORTEC MCA Easy

1. Connect the attenuated output from a precision pulser via T-piece to the charge terminator, and to the channel 1 of digital oscilloscope. The output of the charge terminator is connected to the detector input of the preamplifier (disconnecting any detector). Set the scope channel 1 on the DC1MΩ coupling!

   Whilst the calibration is carried out the scope and preamplifier must both be connected in the circuit, since the pulse amplitude measured on the scope depends on the correct loading of the pulser.

2. Connect the output of the spectroscopy amplifier via T-piece to channel 2 of the oscilloscope and to the multi-channel analyzer (MCA) input. Set the oscilloscope trigger to the channel 2 and set the scope channel 1 on the DC1MΩ coupling.

This provides a cleaner signal for the trigger, compared to the very small pulser signals.

3. Use averaging on the oscilloscope to improve the noise on the very small pulser signals. Take to care to adjust the trigger level and gain on channel 2 so that the oscilloscope always triggers cleanly on the amplifier output pulser, even at very small pulser amplitudes.

4. Acquire pulse height spectra on MCA for 8 – 10 different pulser amplitudes. For each amplitude, measure the **peak to peak height of the pulser signal** (in millivolts, from channel 1 of the oscilloscope using the scope cursors) versus the **MCA peak centroid** (in channel number). Depending on the system gain, cover the required range of pulsar signal amplitudes, making sure that you measured at very low pulser amplitude (e.g. down to 2 or 5 mV). For Amplifier gain 500, Fine gain 0.5, shaping time 3μs and polarity NEG and for Int. OSC, attenuation 2x2x5x ON, polarity POS and normalize trimmer 1, pulse height trimmer set in the interval 0-1.7 (0.5-5.0mV on the C1 channel of oscilloscope).

   Tabulate the data in the form:

Peak centroid (channel number)	Pulser signal amplitude (mV)	Pulser signal amplitude (C)[1]	Pulser signal amplitude (keV)[2]

   [1]the signal amplitude in Coulombs is calculated from the signal amplitude in mV knowing the value of the charge terminator capacitance C_{QT}:

$$Q_{pulser} = V_{pulser} C_{QT}$$

   [2]the signal amplitude in keV is dependent on the *W* value of the detector. First calculate the number of electron-hole pairs produced (ehp):

$$ehp = \frac{Q_{pulser}}{1.6 \times 10^{-19}}$$

$$E_{pulser} = ehp \times W$$

   The accepted value for C_{QT} = 2.4 pF,

   Therefore with V_{pulser} in mV, and E_{pulser} in keV, then:

$$E_{pulser}(keV) = \frac{V_{pulser} \times C_{QT} \times W}{1.6 \times 10^{-19}}$$

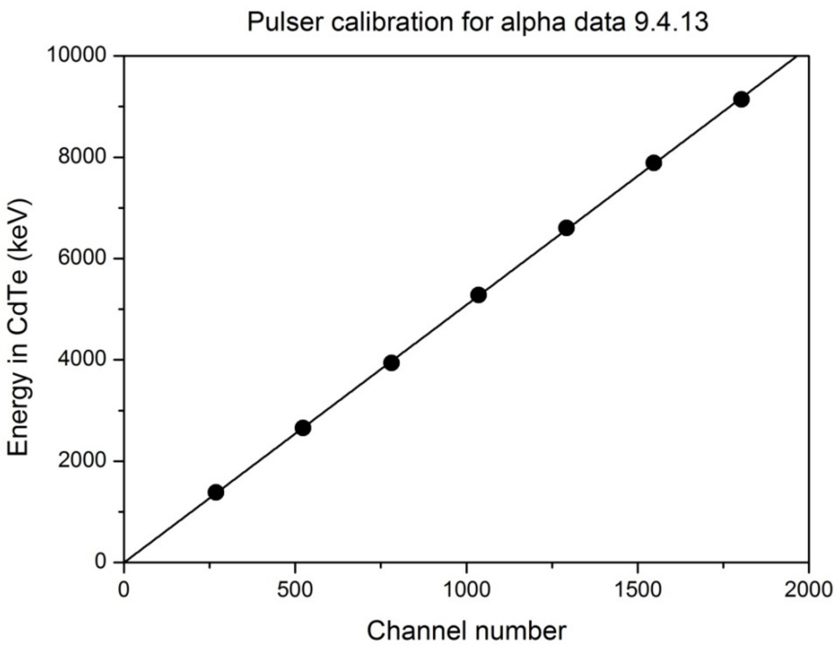
$$E_{pulser}(keV) = V_{pulser}(mV) \times C_{QT}(pF) \times W(eV/ehp) \times 6.25$$

5. Plot a calibration graph of pulsar signal amplitude in keV (Y axis) vs. MCA peak centroid in channel number (X axis). A linear regression applied to this graph gives a gradient (keV/channel) and intercept (keV).

Table1. Electron-hole pair creation energy (W) of some detector materials

Material	**W value (eV/ehp)**
Germanium	3.0
Silicon	3.6
Gallium Arsenide	4.3
Indium Phosphide	4.2
Cadmium Telluride	4.5
Cadmium Zinc Telluride	4.5 – 5.0
Silicon Carbide	9
Diamond	13

The MCA offset (i.e. channel number at zero signal amplitude) is given by the intercept of the data on the X-axis.



Example of typical pulser calibration plot, for CdTe detector (W = 4.4 eV/ehp), covering the energy range 0 – 10000 keV

Additional Calibration using a silicon detector

As an additional check to the pulser calibration, replace your detector with a pre-characterized silicon detector, keeping all the other elements of the electronics and readout system identical.

Record a pulse height spectrum on the MCA for the silicon detector using a source that produces a signal in the required energy range (e.g. an ^{241}Am alpha source at 5.49 MeV, or a ^{241}Am gamma source at 59.6 keV). Alpha source measurements should be carried out in vacuum to avoid energy loss of the alpha particle in air.

The data point from the silicon detector should lie on the line of the pulsar calibration date in your calibration graph!