How to do an optimum setup for the MCA527

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This paper describes how to do a setup for a MCA527 with an arbitrary detector for an application, with a focus on IAEA and Euratom applications.

Goal of the adjustments are best spectral resolution, but also high throughput, a good dynamic range, and exact the window of photon energies which is needed for the applications.

Compared with its predecessor, the MCA166, the MCA527 offers additional possibilities to optimize and fine adjust the measurements. This variety of possible settings however may confuse the average user. So this shall be a step by step guide how to adjust the settings. For this, it is assumed that the MCA527 and the corresponding detector are connected and radioactive source similar to those occurring in the application are available.

Also it is assumed that when connecting to the computer, the MCA527 is reset to its default values.

High voltage

Most gamma detectors need some kind of high voltage to operate. Setting this is easy in most cases, as value and polarity of the high voltage is indicated on the detector. If polarity indicated on the detector and offered by the

MCA don't match (blue for negative, red for positive) the HV module within the MCA has to be exchanged. So just go to Setup-High voltage and enter the high voltage indicated on the detector.

Exceptions:

-For scintillation detectors with photomultiplier (e.g. NaI, LaBr, ect.) the HV may be varied around 10-20% to change the amplitude of the preamplifier signal, if this is necessary.

-For HPGe detector the high voltage setting is in many cases uncritical, as in most cases there is a large plateau, where resolution, efficiency, and preamplifier signal amplitude hardly changes with voltage. Selecting a HV value different from the one indicated on the detector is an option mostly if the HV value on the detector is higher than the MCA527 can deliver (e.g. 4000V). In this case it is recommended to measure the dependence of resolution and efficiency on high voltage and check if the chosen value is still within the plateau.
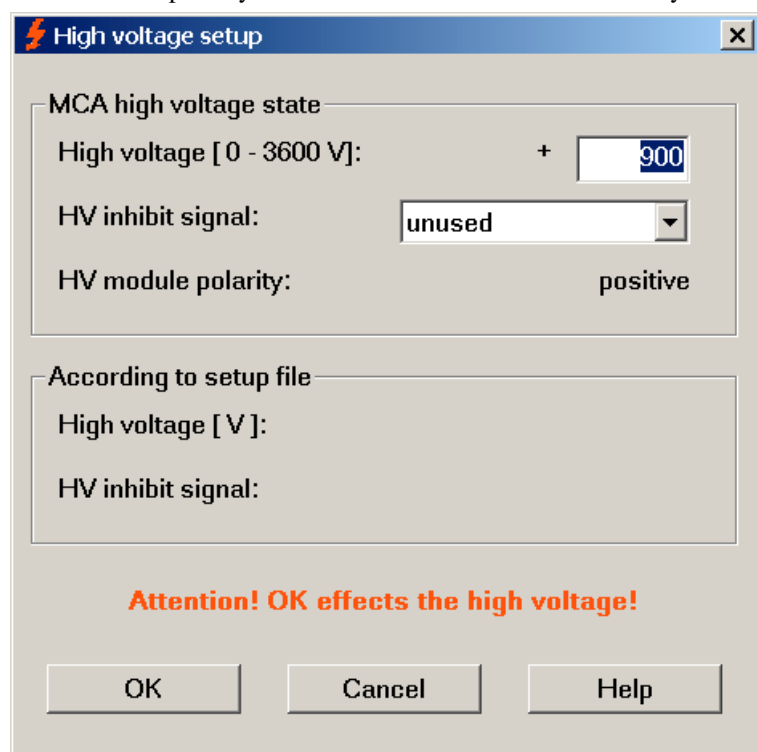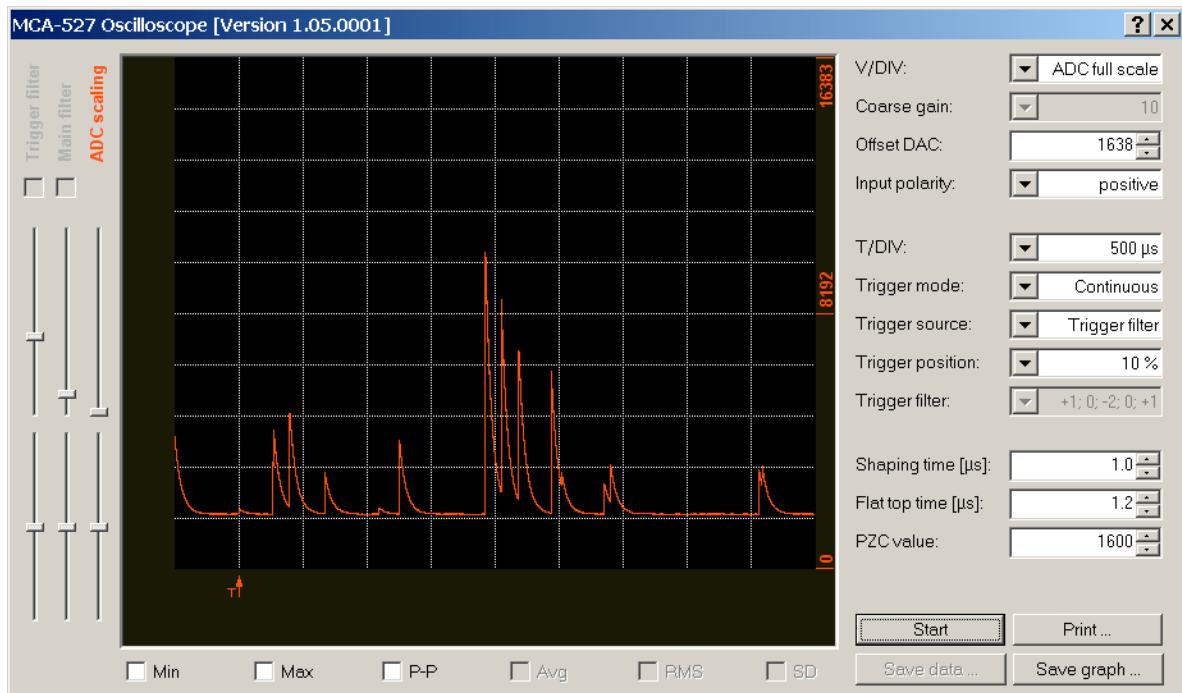
For a HPGe detector, check that the **HV inhibit** signal is set to the correct mode and that the signal is connected.

Signal presence, polarity, coarse gain

If HV is set, the next thing is to check the preamplifier signal. This is done best with the oscilloscope mode, goto Setup-Amplifier-Oscilloscope.

Expected are pulses with a fast (<1μs) rise and a slow (around 50μs) decay.

Positive preamplifier signal, also the amplitude is acceptable.

Check if such signals are present. If the pulses point downwards, set input polarity to negative.
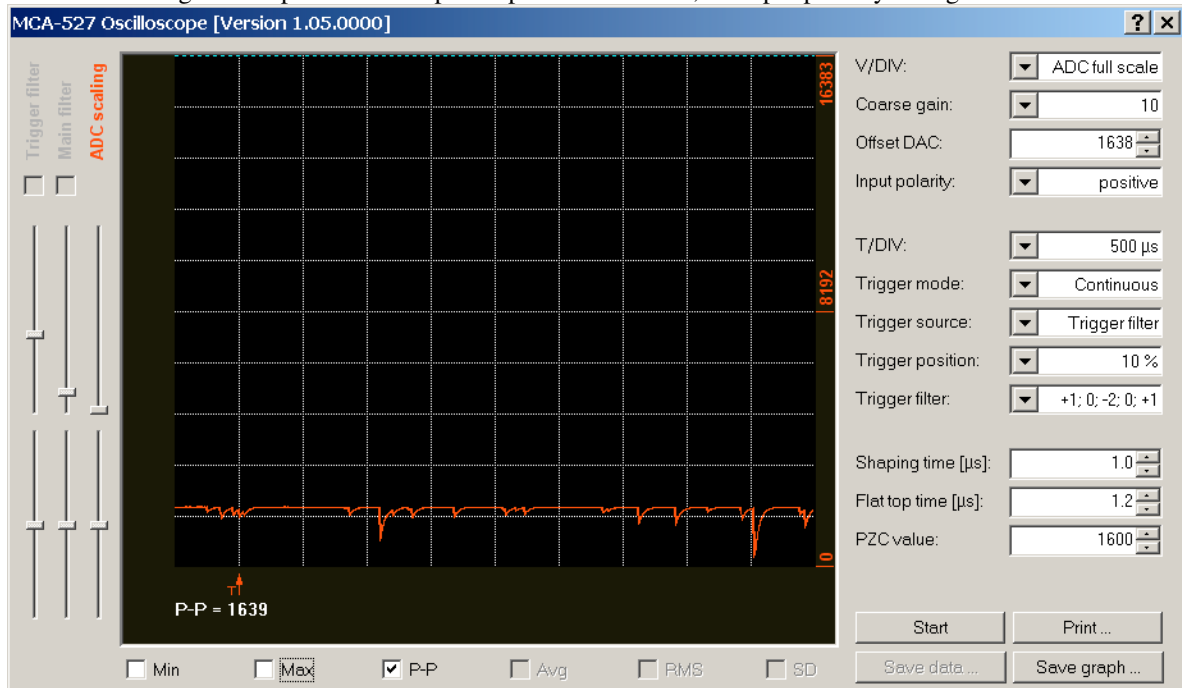
Negative preamplifier signal. In this case, input polarity should be set to negative, and also it is possible to increase coarse gain by another step.
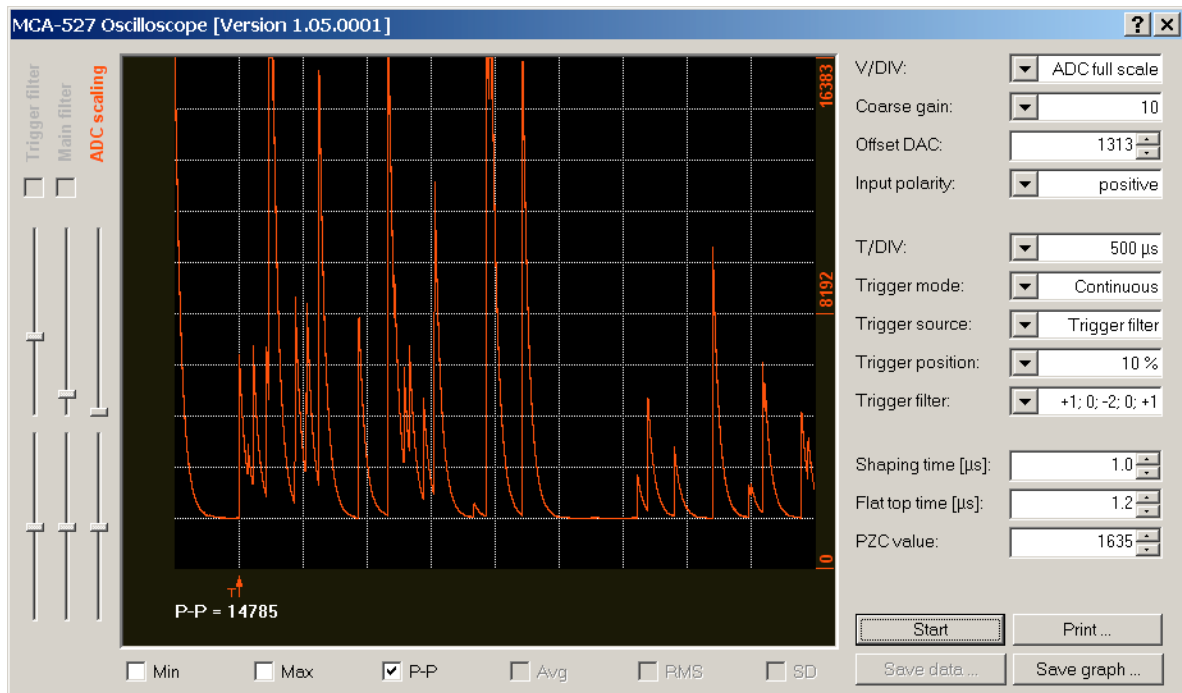
Preamplifier signal too large, it exceeds the oscilloscope window and therefore the ADC measurement range. Reduce coarse gain.

If the amplitude seem quite small, increase coarse gain. If the signal exceeds the oscilloscope window, and not only in exceptional cases, then decrease coarse gain.

If signal amplitude allows it, coarse gain settings of 2 and 5 should be avoided as they are attenuating the signal in reality. Especially for HPGe the resolution will then be less than optimum.

Special cases:

If no signal can be seen, and the oscilloscope window tells "Waiting for trigger", then change Trigger mode to "free run".
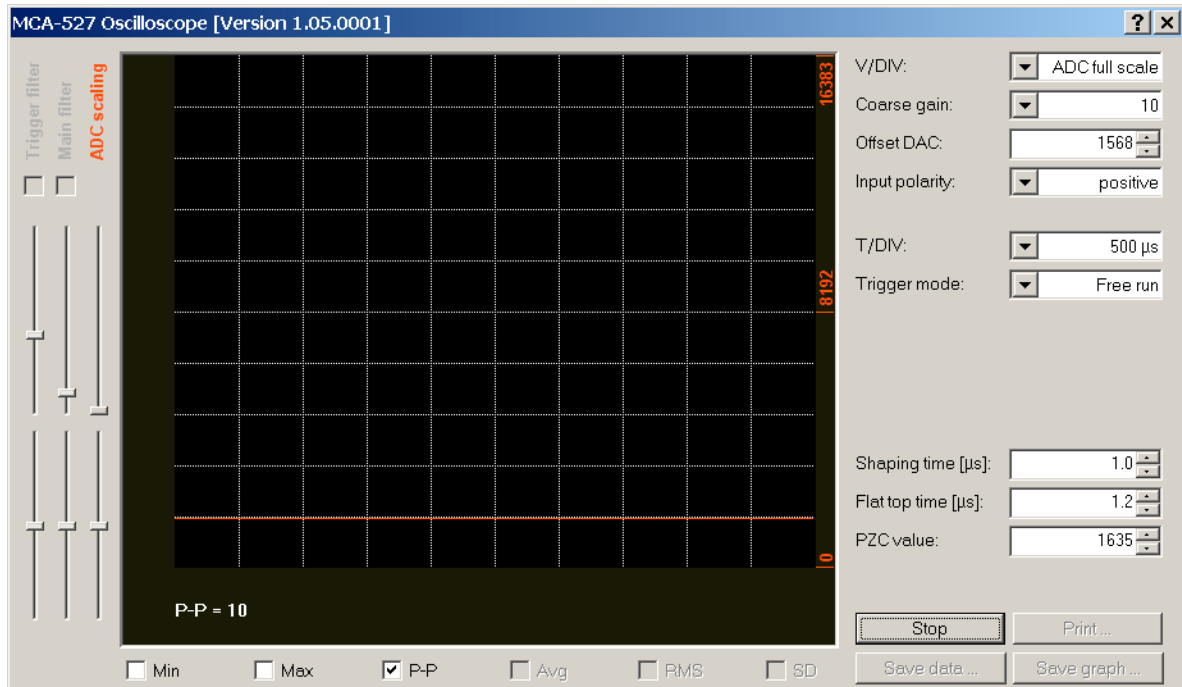
No signal present. Check if high voltage is set (polarity?), HV cable connected, signal cable connected, preamplifier supply connected. In case of a very insensitive detector, put a source close to it. Check if there are preamplifier supply currents. Check detector.
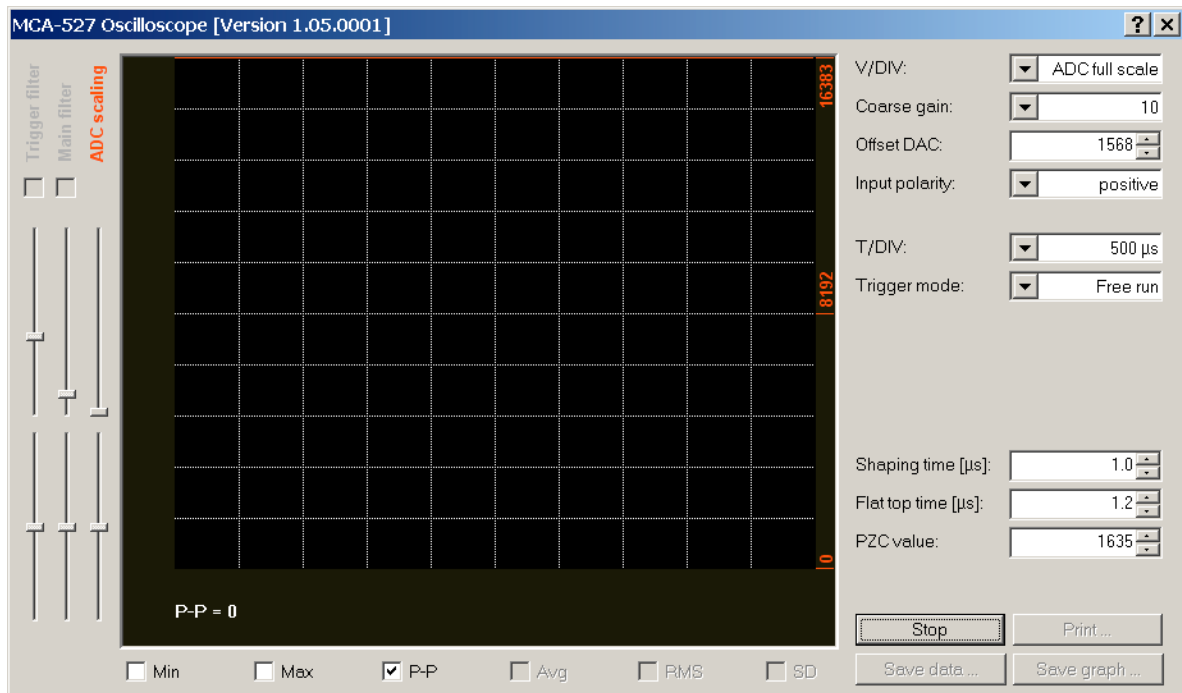
Signal is permanently out of range, here much to positive. Try smaller coarse gain. Significant offset can be a sign of a degrading detector with leakage currents. Up to 100mV may be acceptable. Very high offsets may be a sign of a defective preamplifier or detector, also a warm HPGe would exhibit such a behavior.

Without any signal or even with extreme DC Offset, it is useless to try a setup, rather there should be troubleshooting on the detector.
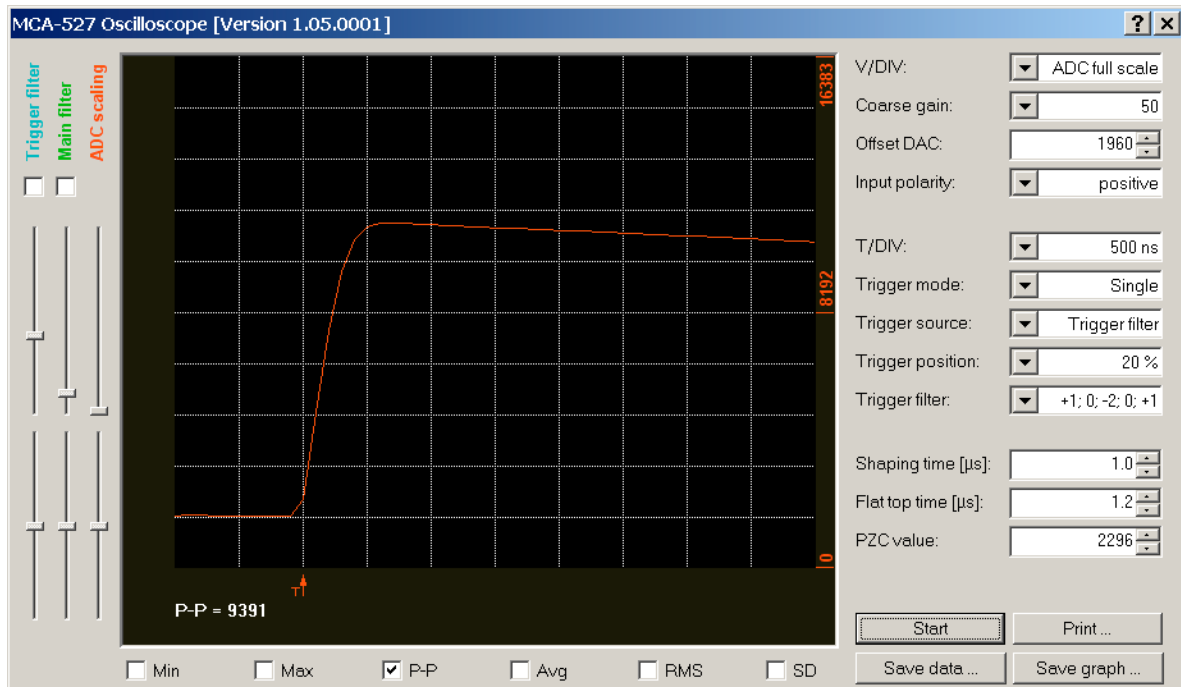
Signal rise time, Flattop setting
Next setting to be adjusted is the Flat top setting, which corresponds to the rise of the preamplifier signal. The purpose of this is to exclude the rise part of the signal from evaluation as this would only add error to the amplitude evaluation.
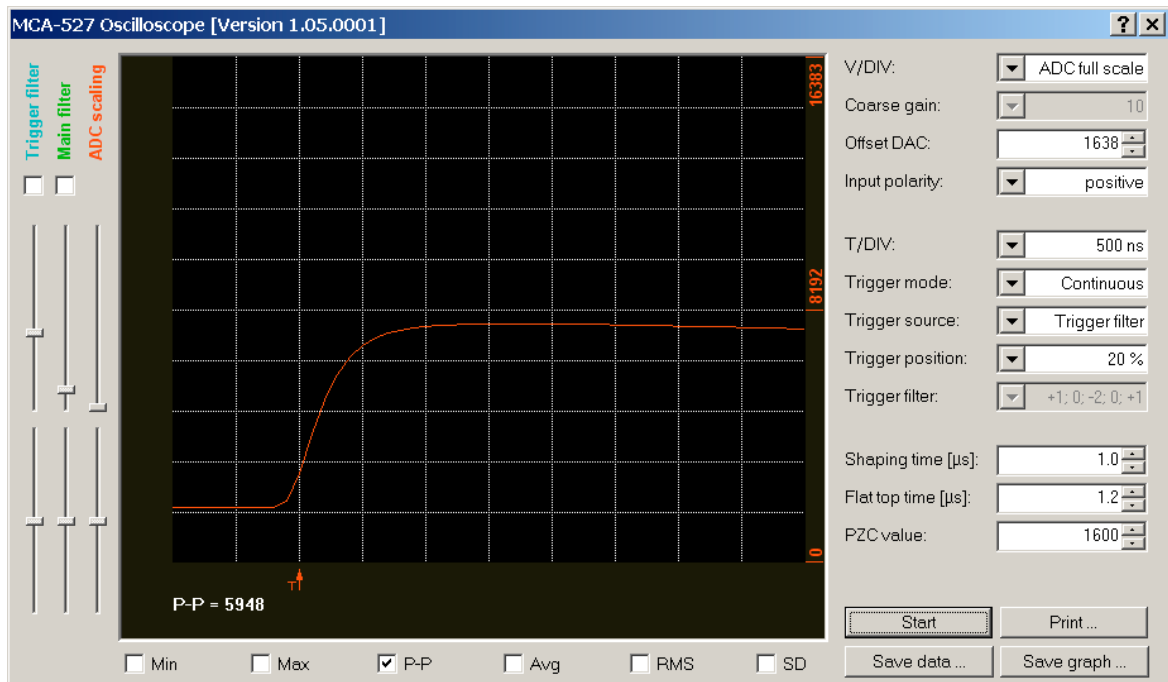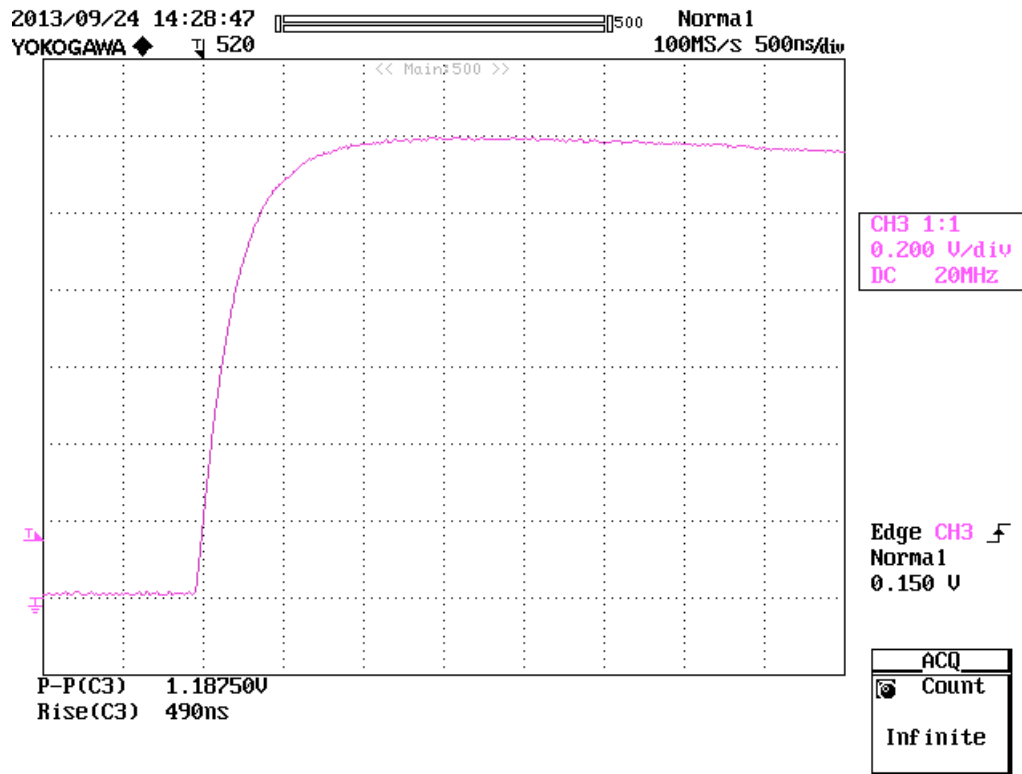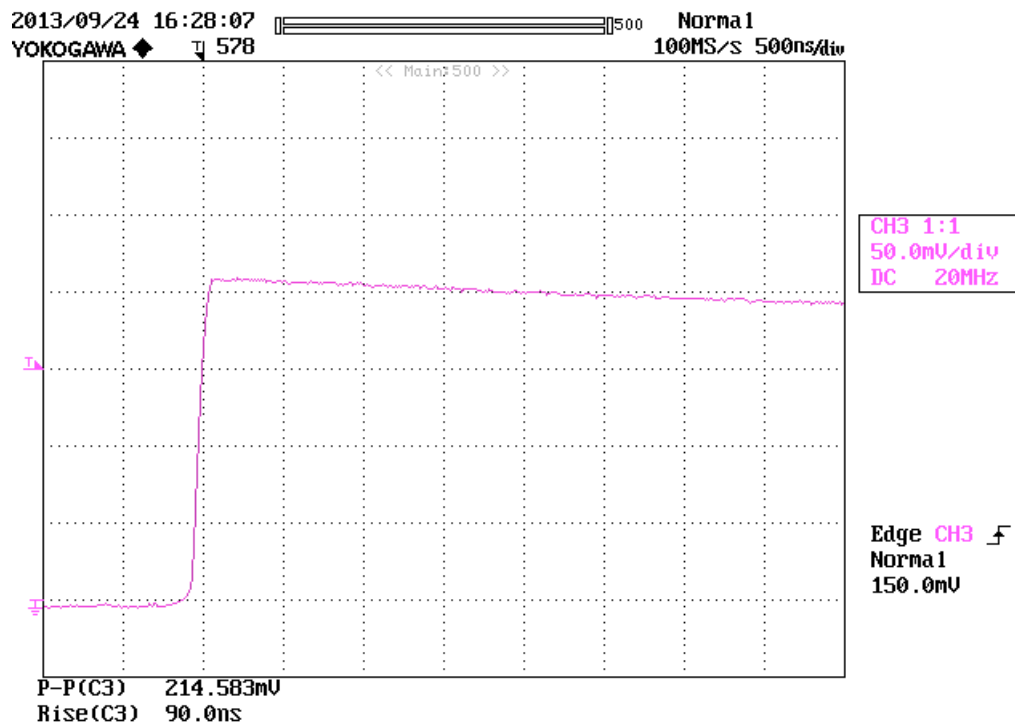
Rise of the preamplifier signal of a NaI detector. The finite rise time is not limited by the electronics but a property of the NaI crystal.

A good approach for the flattop setting is to take the time the signal needs from the baseline to its maximum height.

Rise of the preamplifier signal of a CZT detector. The rise time is principally very fast (<100ns), but the input low pass filter of the MCA527 does not allow to make use of this fast rise times. Flat top settings below 0.6 µs should never be used therefore.
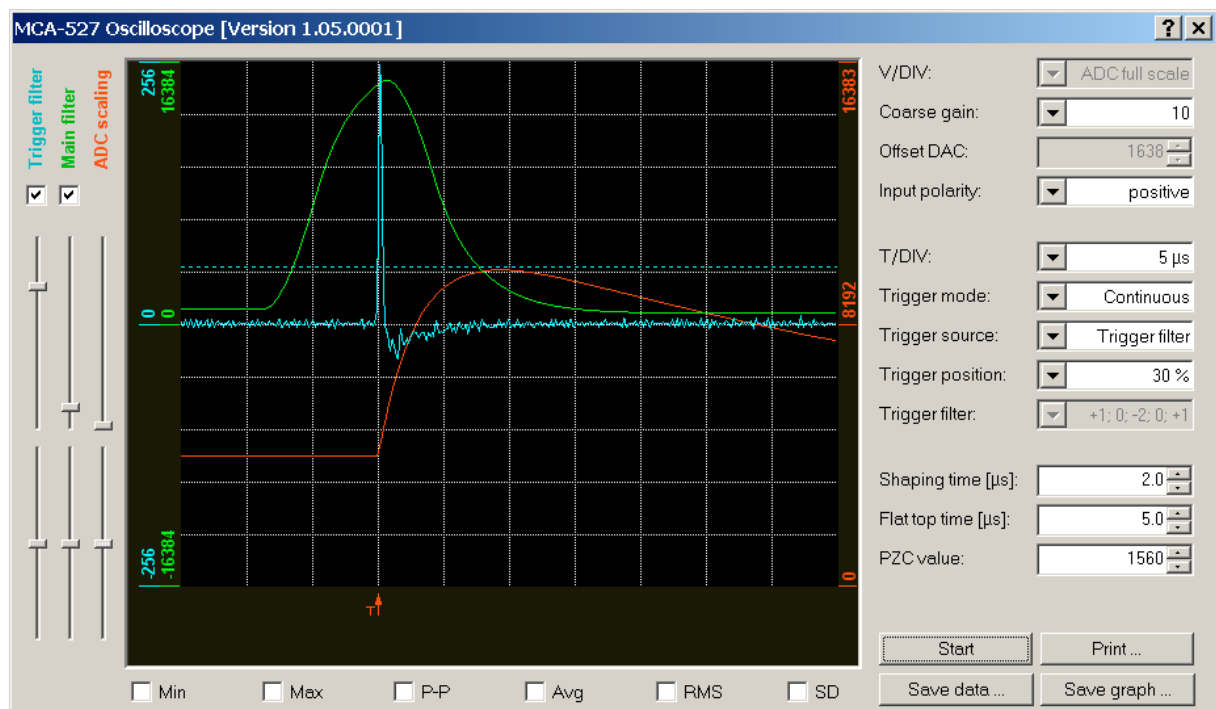
Special case: Very slow rise time signal of an (rather exotic) SrI detector. Here a flattop setting of 10µs may be appropriate, but also a slower trigger filter might be useful.

Typical settings are 1.6µs for NaI and 0.8µs for HPGe, LaBr and CZT. The default setting of 1.2µs is just a compromise between these both. Smaller settings than 0.6µs should never be used.

Shaping time

The shaping time defines, how many data points are used for averaging the signal height. The shaping time is half the integration time, so a shaping time of 1µs means that 2µs (=20sample values) before and 2µs after the signal rise are used to calculate the amplitude value.

Optimum shaping time depends on the noise characteristic of the detector and further there is a trade off between resolution and high count rate capability. Detectors with a low amount of high frequency noise, like almost all scintillation detectors with photomultiplier, can be run with a short shaping time like 0.1-0.2µs. For semiconductor detectors or detectors with photodiode, high frequency electronic noise is much more an issue and shaping times in the range 0.8...2µs are optimum. The standard setting of 1µs will do in most cases, and more than 4µs are seldom useful.

If it is known that very high count rates may occur, the lowest acceptable shaping time should be chosen, e.g. for spent fuel measurements with CZT detectors 0.7µs shaping time is ok.

PZC

PZC adjustment should be done always, and individually for each detector, whereas most other settings can stay the same for a whole class of detectors. For doing PZC adjustment, use Setup-Amplifier Setup-PZC adjustment-Automatic PZC by offset minimization.

Fine gain, number of channels, Energy calibration

Fine gain and number of channels is defined by the application. E.g. for some uranium enrichment measurements, the 186 keV peak is required to be in channel 300, whereas for other applications a fixed energy calibration of 0.075 keV/channel is required.

For adjusting fine gain, use Setup-Amplifier Setup-Visual amplifier adjustment and use F4 and F5 to adjust fine gain coarsely. Then create a ROI around the peak to adjust and use Auto (F10) to do the fine adjustment.

It is worth to mention that 512 channels with fine gain 2 is exactly the same as 1024 channels, fine gain 1 and the upper 512 channels ignored. So if e.g. for uranium measurement the high energy components in the spectrum force to choose a rather low coarse gain. Then increasing the number of channels is an alternative to increase fine gain, with the advantage that also the high energy part of the spectrum can be seen for verification.

USB charging

Switch off for mobile applications. In most cases the battery of the MCA will last much longer than the battery of a laptop.

Some examples about the influence of setting on the measurement are also found in the manual.

# Other settings for use in special cases

Trigger filter

The aim of the trigger filter is to detect signals for further evaluation. Its time resolution is important for pile up rejection, its sensitivity is important for the lower spectrum cutoff.

For almost all cases the default setting (10-201, double differenciating) is ok and a good compromise between sensitivity and time resolution.
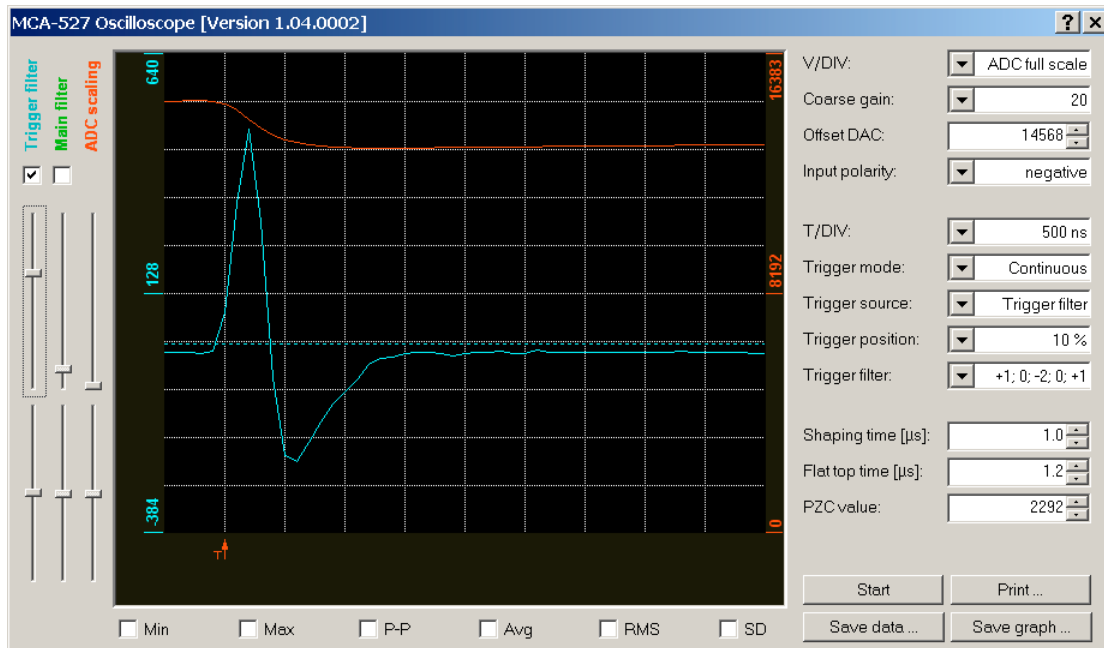
Preamp signal (NaI detector) and trigger filter output signal shown in the oscilloscope window. From this picture it can be seen that the time resolution of this is about 0.5µs.

If an especially low cutoff at rather low count rates is required, the (-101) filter can be used, in case especially good pile up rejection required at the expense of an insensitive low energy spectrum cutoff the (1-21) can be used.
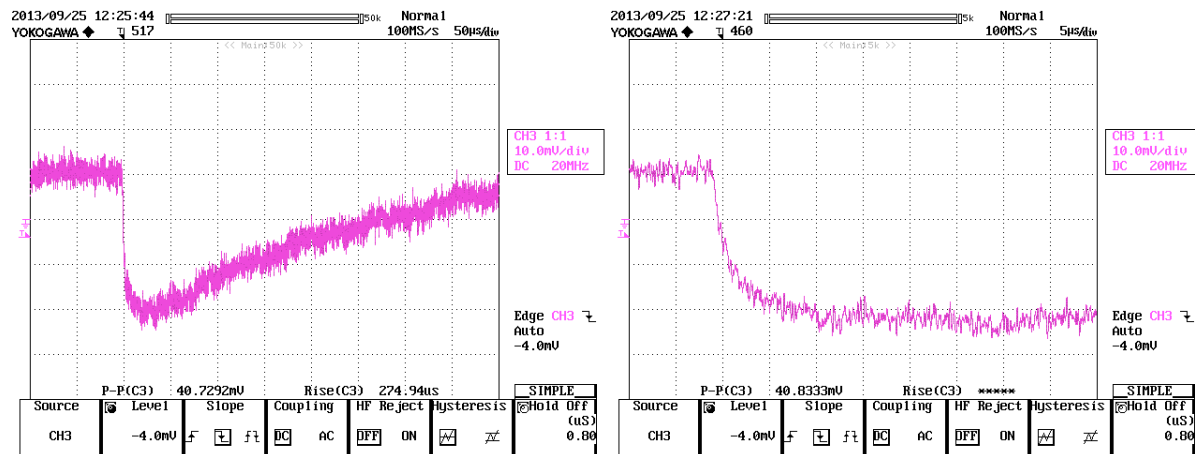
Worst case scenario: Preamplifier signal of a CsI detector with photodiode readout. This is somehow a worst case scenario, as it combines a very slow signal rise, which even seems to come from 2 time constants with a high noise level.
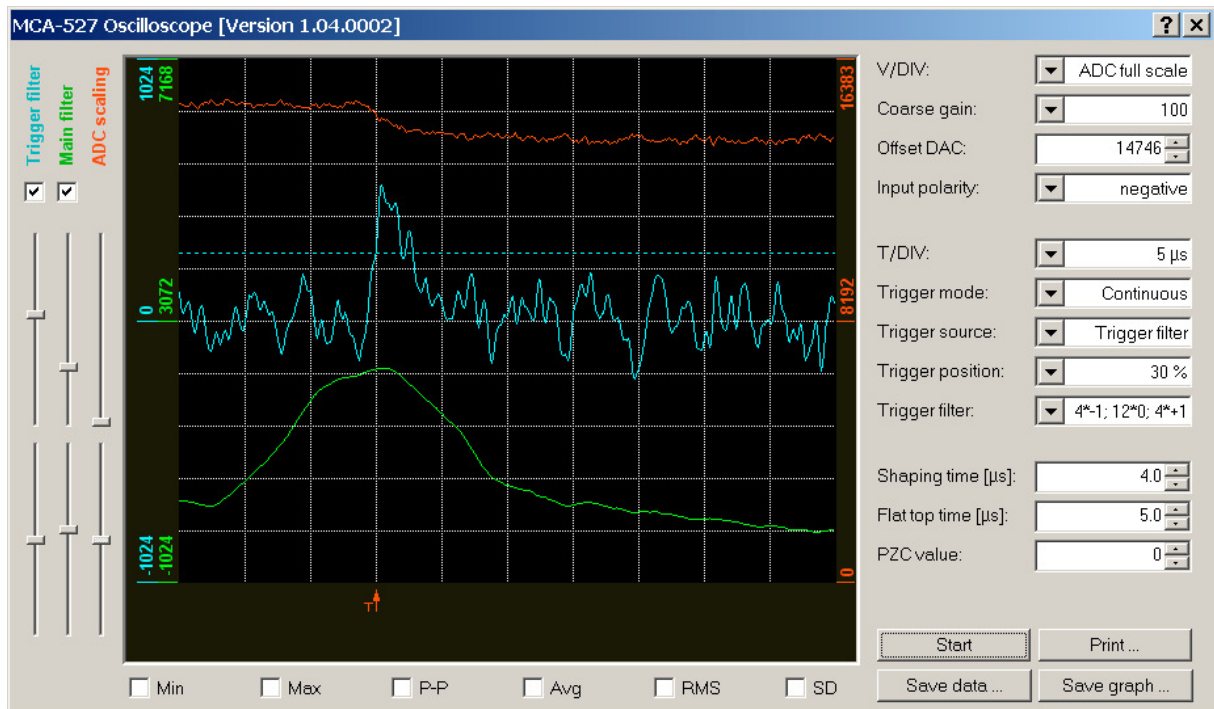
Preamplifier signal of a CsI detector with photodiode readout. Here only the slow (4-1;12*0;4*1) trigger filter works.*

The (4*-1;12*0;4*1) may have some practical use for detectors with a really slow rise time (e.g. CsI, SrI) as the other filters are far to insensitive for this slow signals. Further filter optimization for those slow detectors may still be done.

**Trigger filter sensitivity:**
Normally the default here should do.

Typically, the treshold is adjusted automatically. For this the RMS noise on the trigger filter output signal is calculated, and the threshold is set to 7 times this value. This is normally high enough so that triggering by noise very seldom occurs. However, this assumes that noise is gaussian distributed.

Especially at high amplification levels also periodic noise (e.g. from switch mode power supplies) may show up and this is not correctly suppressed. In this case it may be necessary to increase the threshold until noise is not visible any more.
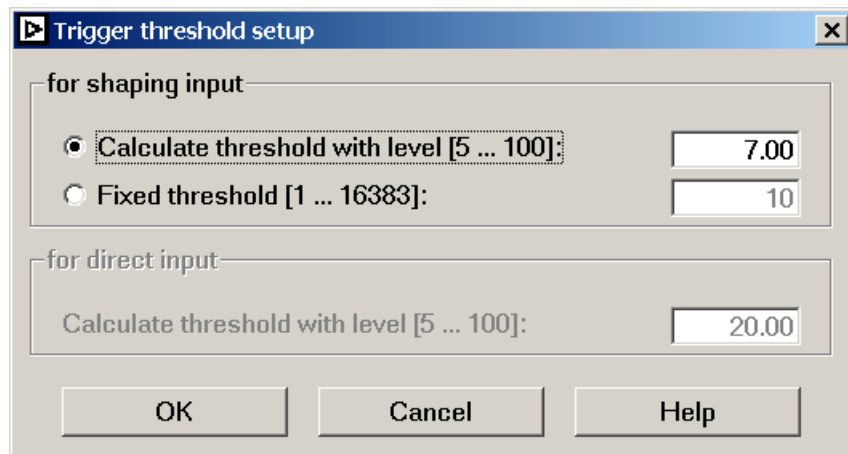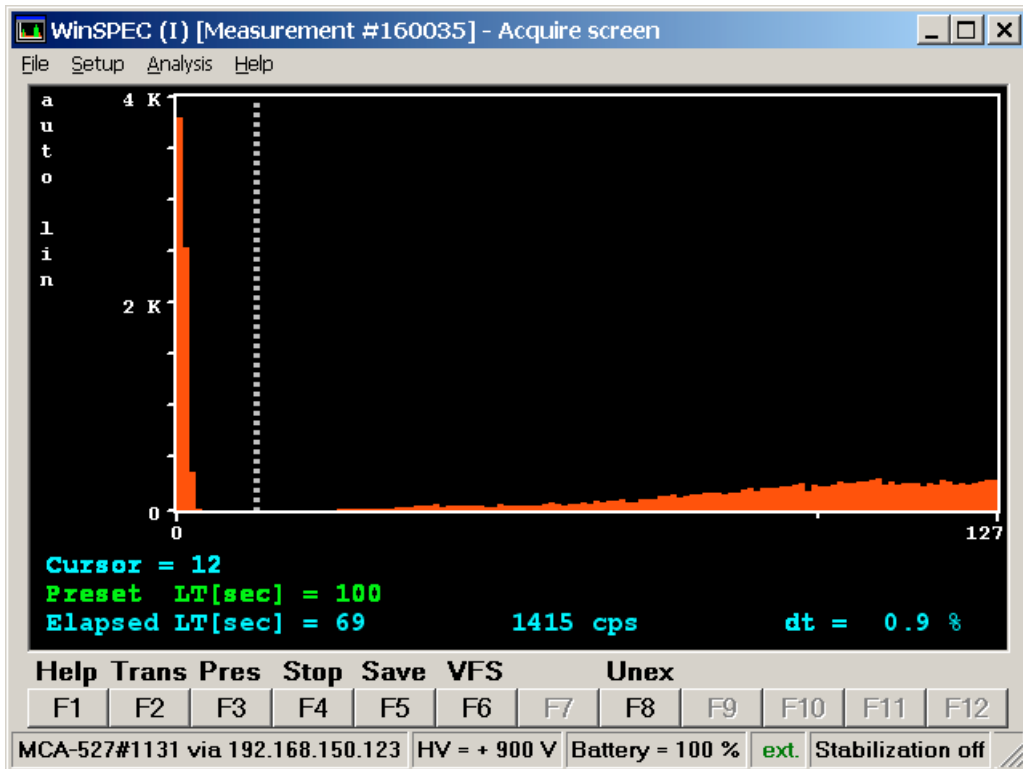
Example for trigger filter threshold set too low. At the low energy end of the spectrum a noise peak can be seen and count rate is higher than expected.

Pile-up rejector
By default this is on.
Should be switched off only with preamplifier signals which exhibit ringing or otherwise are misinterpreted as double pulse. For the function of the pile-up rejector, press Cntrl-F during a measurement to see the pile-up rejector statistics and time resolution.
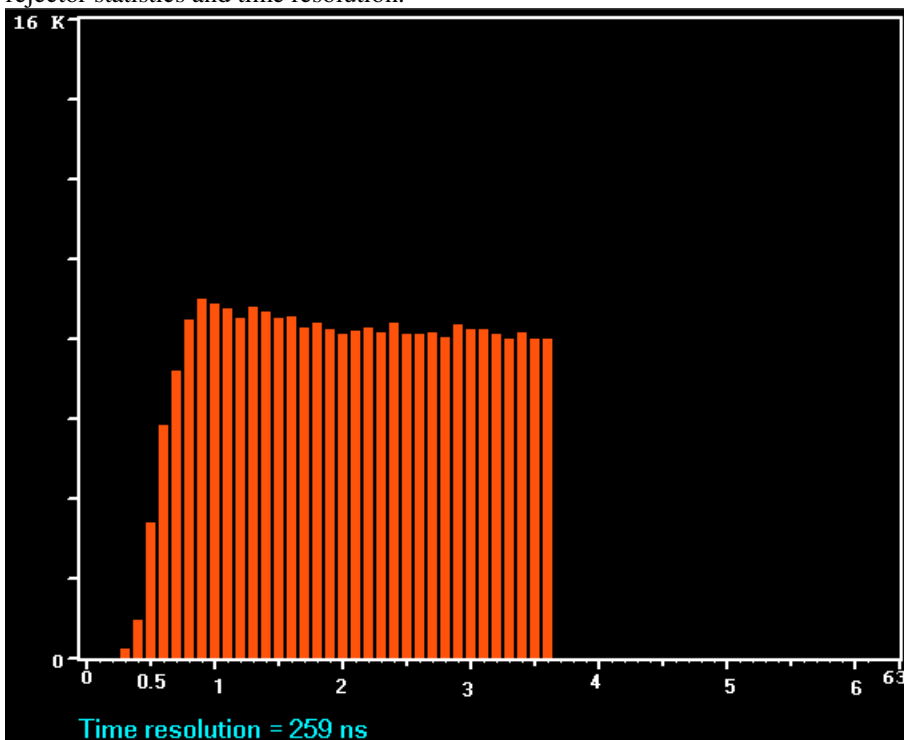
Statistical distribution of pile-up rejector times, here typical as expected for a NaI-detector
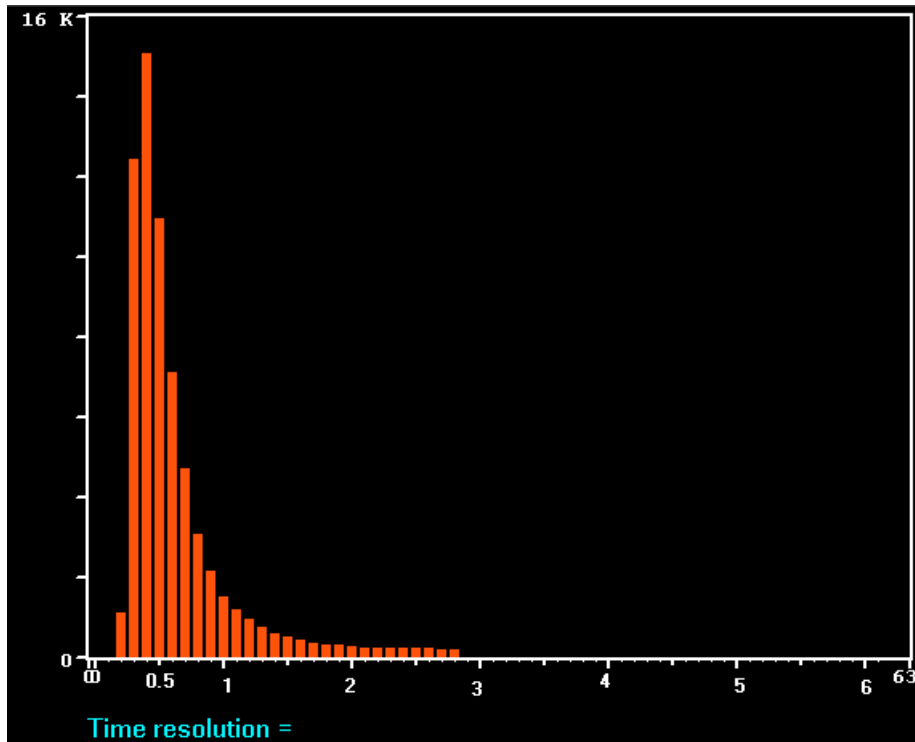
Statistical distribution indication preamplifier signal ringing.

LF rejection
This is by default off.
It is a completely different filter, and maybe applied in very special cases with a strong amount of low frequency noise, like operating a semiconductor detector in an environment with strong mechanical vibrations. It employs a 3rd order low pass filter, which does not even require PZC adjustment. With this filter, shaping time settings should be about 3 times longer than normal. Resolution of this is generally worse than standard but hardly influenced by low frequency fluctuations.
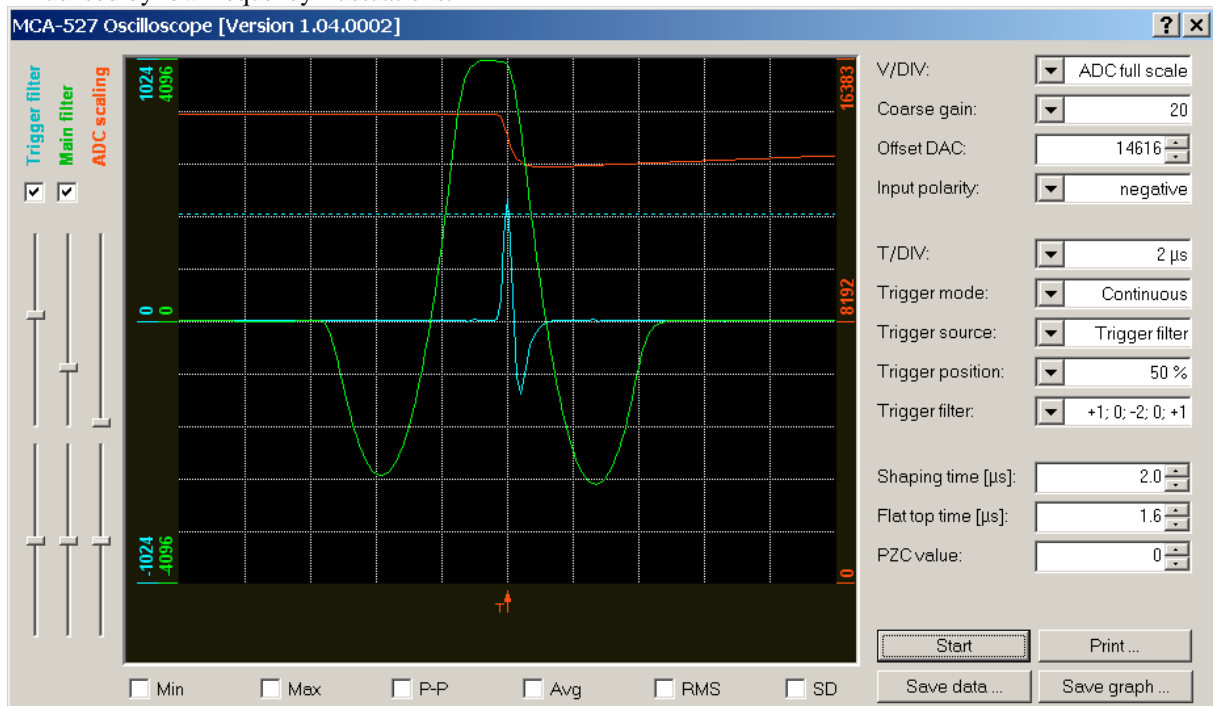
Main Filter output signal of the LF rejection main filter. This filter is triple differentiating and does not require PZC adjustment.

MCA setup – ADC input direct
This mode may be used with already gaussian shaped signals, or preamplifier signals where the decay time is too short to adjust PZC properly.
This mode is not preferred as it does not provide time resolution to do pile-up suppression and also the spectral resolution to be obtained may not be optimum.

Jitter correction
Experimental feature, designed to improve resolution by improving the time resolution. Little effect, not well tested, don't use.

MCA-527 DAC offset adjustment
Mostly useless feature, as offset adjustment should be performed automatically. But it shows a nice histogram of the incoming signal to the ADC, and it allows to check if the offset adjustment works correct and if the coarse gain setting is ok.

Base line restoring
Feature to optimize the averaging of the base line restorer with respect to count rate and low frequency noise for best resolution. Rather complicated but little effect, so best use the standard setting of 1/16.

Processor clock
Default 400MHz, can be increased to 600MHz. Causes the MCA to consume about 20mA more current from the battery, but as long as the signal processor can handle the algorithms in time, it has absolutely no effect. As there is hardly any setting where the processor is at its limits at the moment, ignore this setting.