Calibration of Electronic Read-out chains for the MICROMEGAS chambers

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1   CAEN V550

This is a CRAM unit coupled to a 10-bit ADC. Its differential inputs are 50 Ω adapted. The gain can be selected among 4 values. Our setting is 1023 ADU[1] for 1.5 V. Two sets of measures have been performed, with a DC power supply as input signal. The module tested here is module 4, channel 1. The sequencer is auto-triggered by acquisition software. The manual indicates that it is a 10-bit ADC with 1.5 V dynamic, which leads to $1500/(2^{10} - 1) =$1.466 mV/ADU or 0.682 ADU/mV.

1.1   Calibration with common mode signal

1.1.1   Setup

Setup is shown in fig. 1. The $signal^+$ is monitored with a precision voltmeter.
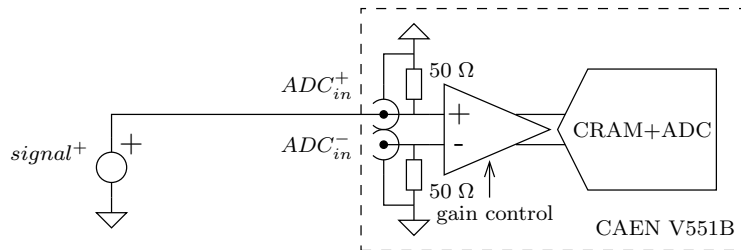
Figure 1 – V550 ADC in common mode

1.1.2   Results

$signal^+$ (mV)	ADU
0	10
150	105
250	167
500	326
1000	645
1500	963

The corresponding conversion ratio is 1.574 mV/ADU or 0.635 ADU/mV.

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[1] Analog to Digital Unit

1

1.2 Calibration with differential mode signal

1.2.1 Setup

Setup is shown in fig. 2. The $signal^+$, $signal^-$ and $signal = signal^+ - signal^-$ are monitored with a precision voltmeter.
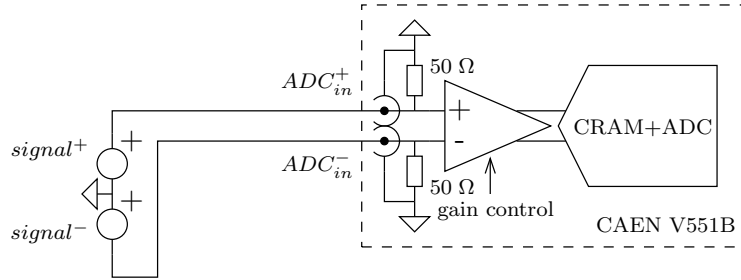

Figure 2 – V550 ADC in differential mode

1.2.2 Results

$signal^+$ (mV)	$signal^-$ (mV)	$signal$ (mV)	ADU
0	0	0	9
150	-150	300	200
300	-300	600	390
500	-500	1000	645
750	-750	1500	962

The corresponding conversion ratio is 1.574 mV/ADU or 0.635 ADU/mV.

The conversion ration of CAEN V550 is 1.574 mV/ADU or 0.635 ADU/mV, either in single-ended or in differential mode.

2 Gassiplex board

Figure 3 shows the general architecture of Gassiplex board, from CEA/IRFU, equipped with 6 Gassiplex 0.7-3 chip from CERN (only one channel is represented), thus providing 96 analog readout channels. The gain of these chips (and chips only, V_{out}), in gaseous detector mode, is 3.675 mV/fC (from Gassiplex
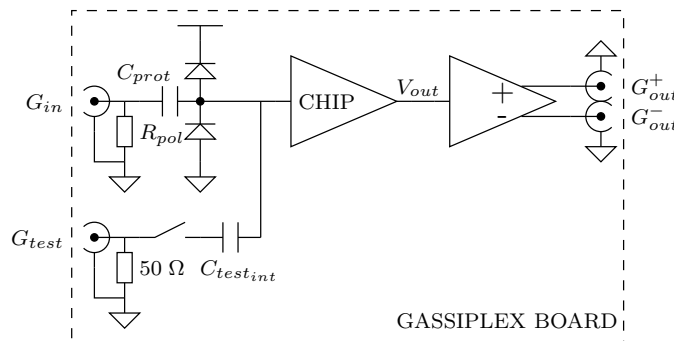

Figure 3 – Gassiplex board

documentation). The board itself has a differential output stage which doubles the signal. The theorical board gain is 7.35 mV/fC. In order to measure the gain of these boards, we use an HP pulse generator with a precision attenuator (Wavetek). With a ΔV of 400 mV on a 50 Ω resistor, the injected charges through a 1 pF capacitor are :

Attenuation (dB)	Injected charge (fC)
0	400
-10	126.5
-20	40
-30	12.65
-40	4
-50	1.265

2.1 Calibration with internal capacitor

2.1.1 Setup

Each channel has its own test capacitor $C_{test_{int}} \simeq 1$ pF. Exact value is not very well known, but matching from channel to channel must be very good. The pulse generator is connected to the test input (G_{test}) of Gassiplex board through the attenuator. The relevant differential output voltage ($G_{out}^+ - G_{out}^-$) is measured on 2 channels of the oscilloscope.
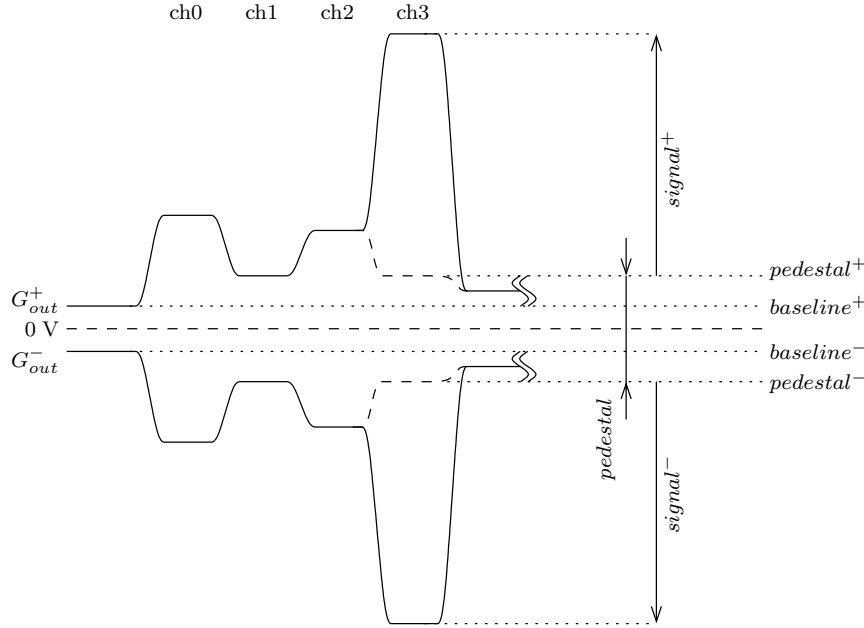

Figure 4 – Gassiplex board differential output signals

2.1.2 Results

The following results are for board number 42, channel number 3, with 40 fC input charge according to fig. 4. The differential output signal on $G_{out} = G_{out}^+ - G_{out}^-$. The pedestal, also differential, is defined as $pedestal = pedestal^+ - pedestal^-$[2]. The measure is $signal = signal^+ - signal^- = G_{out} - pedestal = (G_{out}^+ - pedestal^+) - (G_{out}^- - pedestal^-)$. The following table gives the experimental points in mV.

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[2]For Catherine : $pedestal^+ + pedestal^-$ should be equal to zero, but in reality, it is equal to offset.

Q_{inj} (fC)	G_{out}^+	$pedestal^+$	G_{out}^-	$pedestal^-$	$signal^+$	$signal^-$	$signal$
40	194	34	-198	-37	160	-161	321

The corresponding board gain is 8.025 mV/fC.

2.2   Calibration with external capacitor

2.2.1   Setup

Another test has been performed with an injection test box (fig. 5), connected at the G_{in} input of a Gassiplex board (board 42, channel 3). The $C_{test_{ext}}$ capacitor in the box has been carefuly measured at 1.038 pF±1%@1 MHz with a HP4284A LCR meter. The capacitance seems to decrease *vs* frequency. The pulse from thess generator involves high frequency (several 100 MHz), so it is possible that actual capacitance is slightly lower.
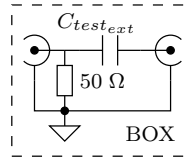

Figure 5 – External injection capacitor in its box

2.2.2   Results

Experimental points are in mV :

Q_{inj} (fC)	G_{out}^+	$pedestal^+$	G_{out}^-	$pedestal^-$	$signal^+$	$signal^-$	$signal$
41.52	182	35	-186	-39	147	-147	294

The corresponding gain is 7.08 mV/fC.

2.3   Gassiplex chip gain verification

To check the chip gain only, the response to a 41.52 fC signal through $C_{test_{ext}}$ has been measured with a 10× passive probe on a V_{out} node. The following table presents the results.

Q_{inj} (fC)	V_{out} (mV)	$pedestal$ (mV)	$signal$ (mV)
41.52	-114	22	-136

The corresponding gain is 3.27 mV/fC for the chip only (only one channel tested).

2.4   Gassiplex board + CAEN V550 ADC

The theorical gain of a Gassiplex board is 7.35 mV/fC and the theorical conversion factor of the CAEN V550 ADC is 0.682 ADU/mV, thus giving a theorical conversion factor of 5.01 ADU/fC.

A similar evaluation can be made with measured values : the measured Gassiplex board gain is 7.08 mV/fC and the measured CAEN V550 ADC convertion ratio is 0.635 ADU/mV, giving a conversion factor of 4.49 ADU/fC.

2.5 Setup

The Micromegas detector are polarized with their working high voltage. As the gain of the Gassiplex boards as been verified with an external capacitor, the internal capacitor will be used for these tests. The pulse generator and attenuator values given in 2 have been used. The Gassiplex boards are read by CAEN V550 ADCs. Several NIM counters are used to select the Gassiplex channel to be excited, and to generate 1 000 pulses for each input charge, *i.e.* 126.5, 40 and 12.65 fC. For each charge, the ADC count histogram is fitted with a gaussian and the mean is plotted versus injected charge and a linear function fitted to the measured points, which gives the conversion ratio (fig. 6).
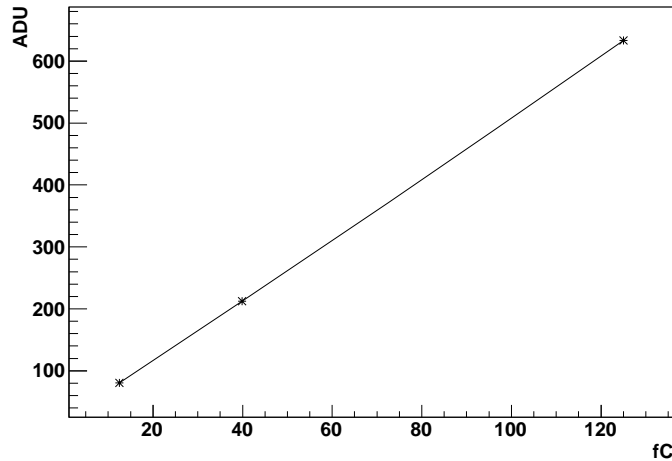

Figure 6 – ADC Unit versus input charge for one Gassiplex channel (anode readout)

2.6 Results

The mean conversion ratio over 384 channels (4 boards) is 4.85±0.25 ADU/fC with a standard deviation of 0.07 ADU/fC. The conversion ratio distribution of one board (96 channels) is given fig. 7.

2.7 Important note

According to the Gassiplex documentation, a chip gain of 3.675 mV/fC has been performed with an external capacitor, while a similar test with the internal capacitors gives a gain of 3.8 mV/fC. I suggest to substract 3.29% to 4.85 ADU/fC, the convertion ratio obtained with internal capacitor to match the convertion ratio obtained with external capacitor. Thus, the 4.85±0.25 ADU/fC becomes 4.69±0.25 ADU/fC.

The conversion ratio of a Gassiplex board on a CAEN V550 ADC is 4.69±0.25 ADU/fC

3 ORTEC 142C

3.1 Theorical value

The gain of the ORTEC 142C charge preamplifier given in units of MeVin Si is 20 mV/MeV. With an ionization potential of 3.6 eV, the charge deposited in Si is about 44.2 fC/MeV, the gain of the preamplifer
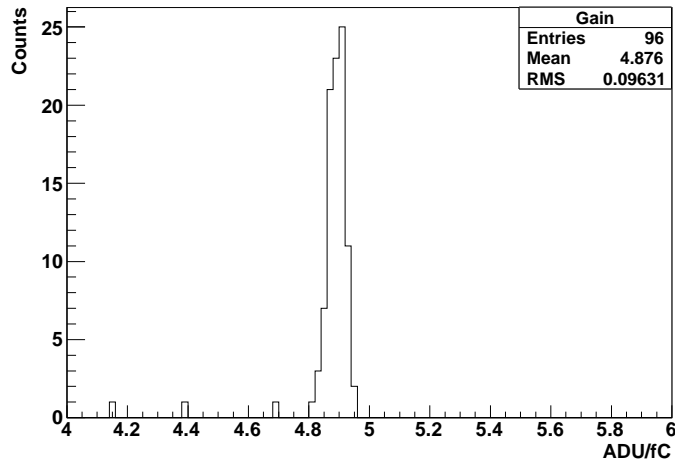
Figure 7 – Gain distribution for one Gassiplex board

should then be 452.5 µV/fC.

3.2 Setup

Be careful! The E output of the 142C charge preamplifier is 93 Ω adapted : it *must* be loaded by an ORTEC spectroscopy amplifier like the ORTEC 570. Additionaly, the T output must be 50 Ω adapted, even if unused (please read the manual). Setup is presented in fig. 8. The accuracy of the 570 spectroscopy amplifier gain setting has been verified. Two sets of measures have been performed, either with the regular O_{in} input associated with the so-called box (containing the external capacitor), either with a pulser directly connected to the O_{test} test input. In the latter case, the voltage is monitored with an oscilloscope, as the pulse generator is no longer adapted.
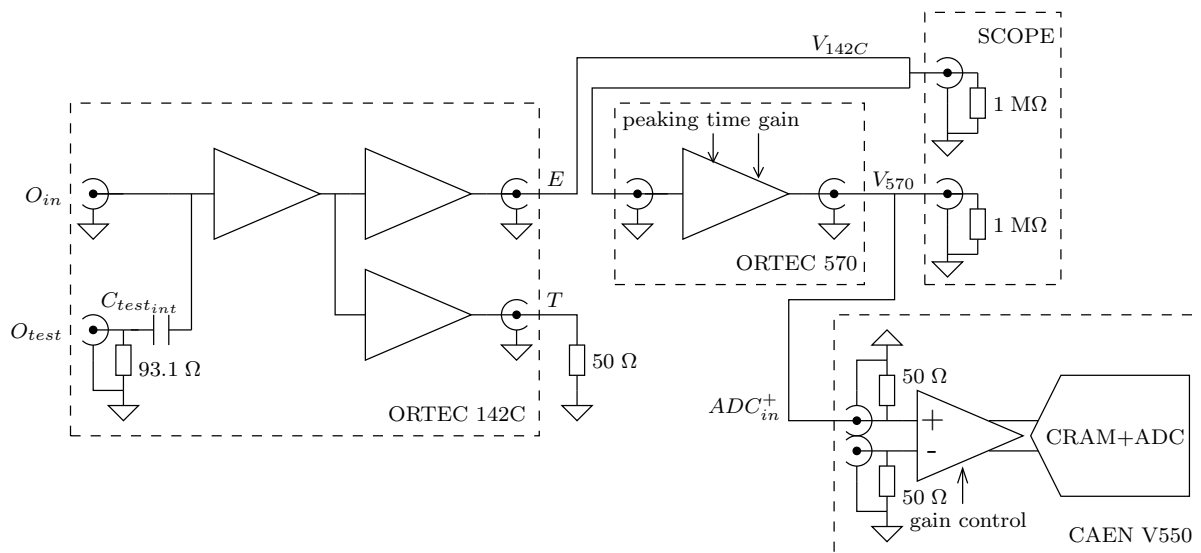

Figure 8 – Calibration of the ORTEC 142C charge preamplifier

6

3.3 Results

With external capacitor :

Q_{in} (fC)	ΔV_{142C} (mV)	ΔV_{570} (mV)	ADU
0	0	0	9
41.2	14.6	145	100
131.3	46	460	298
412	146	1440	924

With internal capacitor :

Q_{in} (fC)	ΔV_{142C} (mV)	ΔV_{570} (mV)	ADU
0	0	0	9
33.6	12.7	125	88
105.6	40.2	394	259
336	126	1244	801
1048	400	3900	−

Experimental data have been fitted with straight line, as shown in fig. 9.

3.4 Summary

	Gain with C_{ext}		Gain with C_{int}	
142C	0.351±0.004 mV/fC	2.849±0.032 fC/mV	0.378±0.021 mV/fC	2.645±0.147 fC/mV
570	3.480±0.071 mV/fC	0.287±0.006 fC/mV	3.713±0.342 mV/fC	0.269±0.024 fC/mV
V550	2.359±0.137 ADU/fC	0.424±0.025 fC/ADU	2.199±0.026 ADU/fC	0.455±0.005 fC/ADU

> The conversion ratio of the ORTEC 142C+570 and CAEN V550 ADC is 2.199±0.026 ADU/fC.

4 Detector with ^{55}Fe

All subsequent measurements have been performed with the same chamber (β2), gas mixture (Ar-CO_2 90-10) and operating voltage (mesh@-510 V and drift@100 V/cm), and are intended for checking the measured calibration constants of the ORTEC and Gassiplex chains. They are realized by reading out ^{55}Fe signals from the mesh (through the ORTEC chain) and the chamber pads (through the Gassiplex chain) and measuring the charge that corresponds to the photopeak of the ^{55}Fe spectrum. The time T1 has been adjusted for each case.

4.1 Gassiplex+V550 spectrum

The ^{55}Fe source X-rays convert mainly above 4 adjacent pads. The photopeak position averaged over the 4 pads is estimated to be at 781.3±1 ADU and the pedestal to be at 20 ADU (fig. 10). The ADC count distribution is plotted *vs* input charge, fitted with a gaussian, and the corresponding means have been fitted with $y = p0 \cdot x + p1$. With a gain of 4.85±0.25 ADU/fC (C_{int}), the peak corresponds to 157 fC. With a gain of 4.69±0.25 ADU/fC (C_{int} corrected), the peak corresponds to 162 fC.

## 4.2   142C+570+V550 spectrum

The peak position of the corresponding spectrum is estimated to be at $377.1 \pm 1.4\, ADU$ and the pedestal to be at $9\, ADU$ (fig. 10). With a gain of $2.199 \pm 0.026\, ADU/\text{fC}$ (C_{int}), the peak corresponds to 167 fC. With a gain of $2.359 \pm 0.137\, ADU/\text{fC}$ (C_{ext}), the peak corresponds to 156 fC.
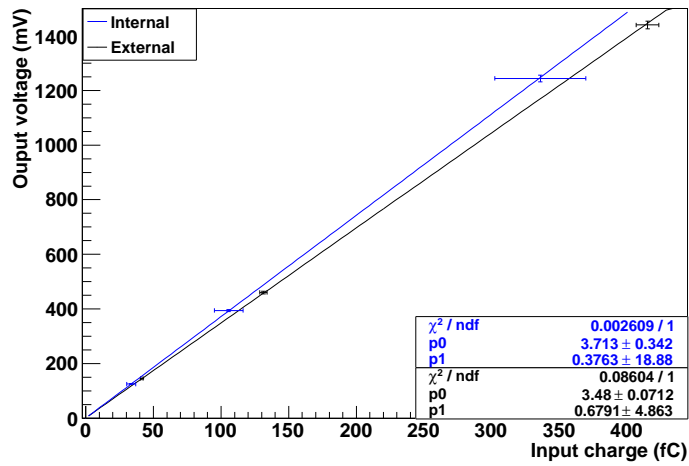
4.3   142C+570+scope spectrum

A gain of $3.480 \pm 0.07\, \text{mV/fC}$ has been formerly established. With the 142C+570+oscilloscope, we have obtained a peak around 600 mV (fig. 11), *i.e.* 172.4 fC.
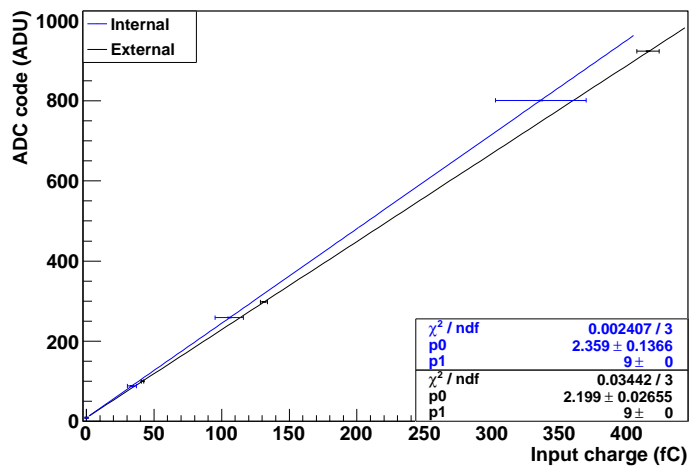
The three peak positions in charge are in very good agreement with preceding measurements.
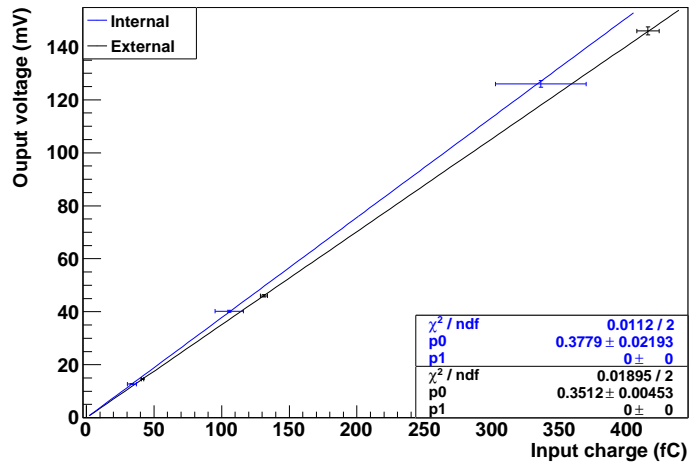
(a) 142C preamplifier

(b) 570 amplifier

(c) V550 Analog to Digital Converter

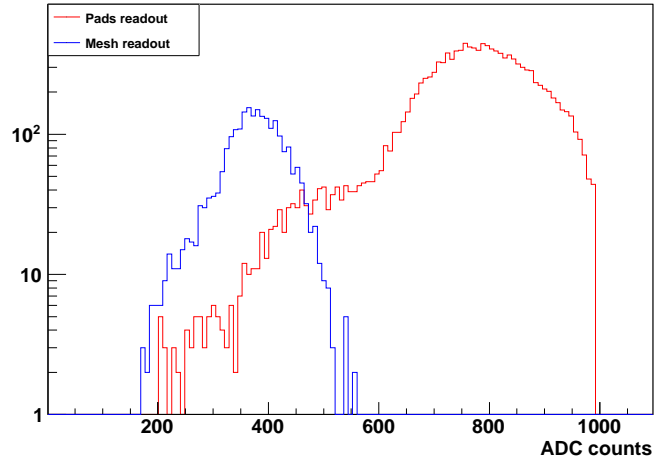Figure 9 – Experimental data and fit results for mesh readout

Figure 10 – ^{55}Fe spectrum measured on mesh (ORTEC chain) and pad (Gassiplex) readout
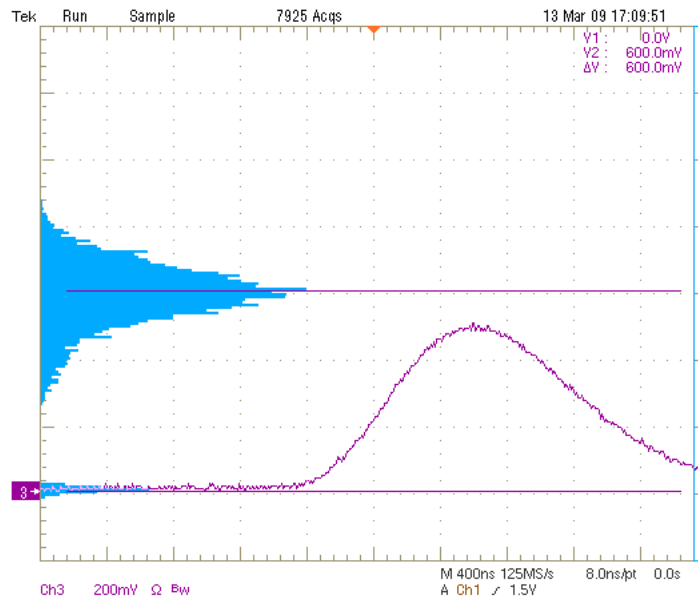

Figure 11 – ^{55}Fe spectrum measured with an oscilloscope