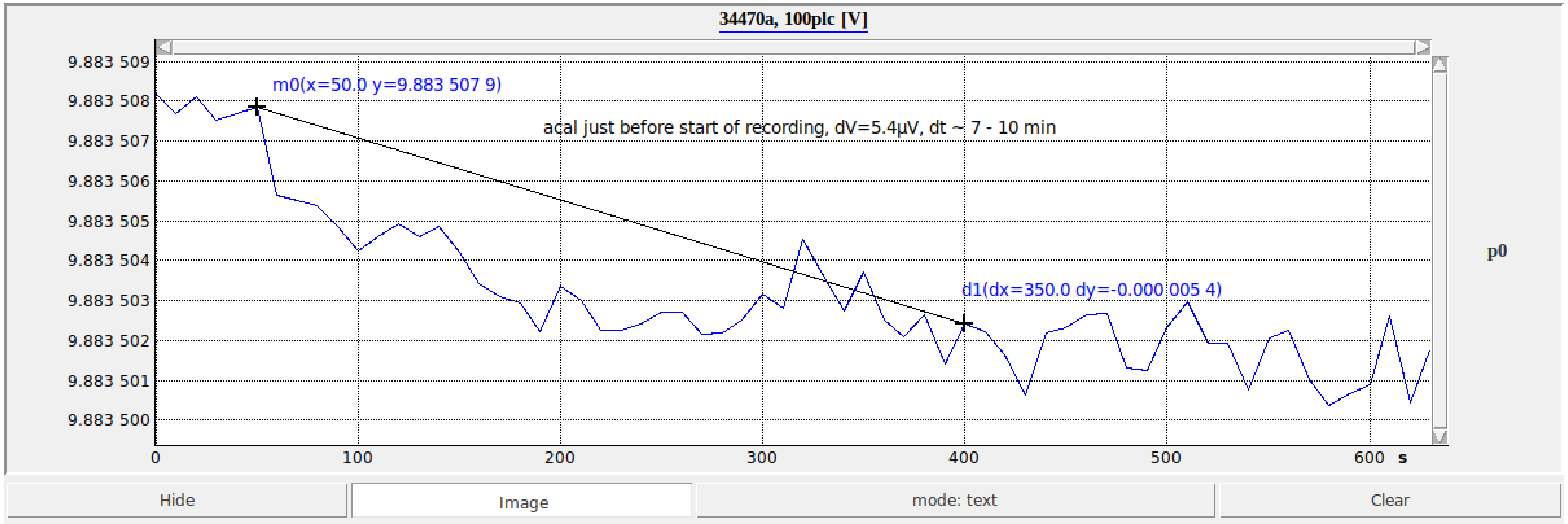
ACAL JUMP on Keysight 34470a



Although there is no exact overview about it, this process probably always occurs after an ACAL, as reported in the EEVBlog forum, but the delta V of the jump seems to be different. On my device dV is ~ 5µV. After about 10 min the stationary value is reached.

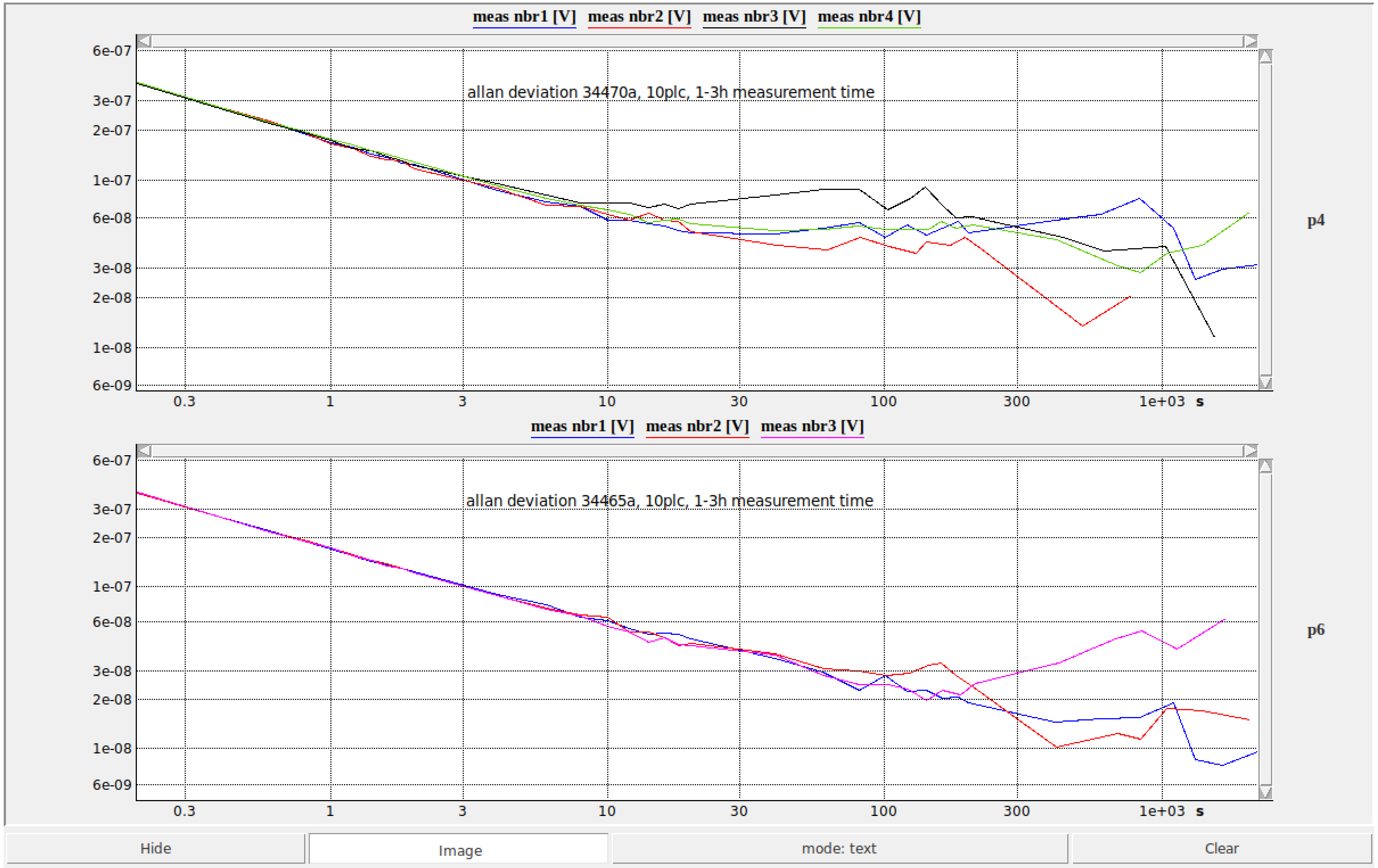
With the little brother 34465a the phenomenon is not to be observed.

Surely unattractive for the flagship of the True-Volt series, but one could live with it, if this instability has no further effects.

In the following, this will always be clarified in comparison to the 34465a.

I. ADC-Noise

Let's first look at the Allan Deviation function in relation to the integration time with shortend input:



The function value of the allan deviation for a given integration time yields a probability interval. Or, more precisely, the function value corresponds to the standard deviation. This means that on average 68% of the measured values measured by the voltmeter with this specific integration time are within the interval average +- the standard deviation; at average +- 3 * standdard deviation 99% of the measured values are already within this interval.

The function value is therefore a measure that expresses whether the display of the voltmeter is affected by noise. With a 7.5 digit voltmeter this is the case in the 10V range, if the standard deviation is lower than 166nV (99% of the measurements lie in an intervall less than average +- 0.5µV

The larger the integration times become, the more one moves away from the thermal noise via the 1/f noise towards the drift[1] of the voltmeter.

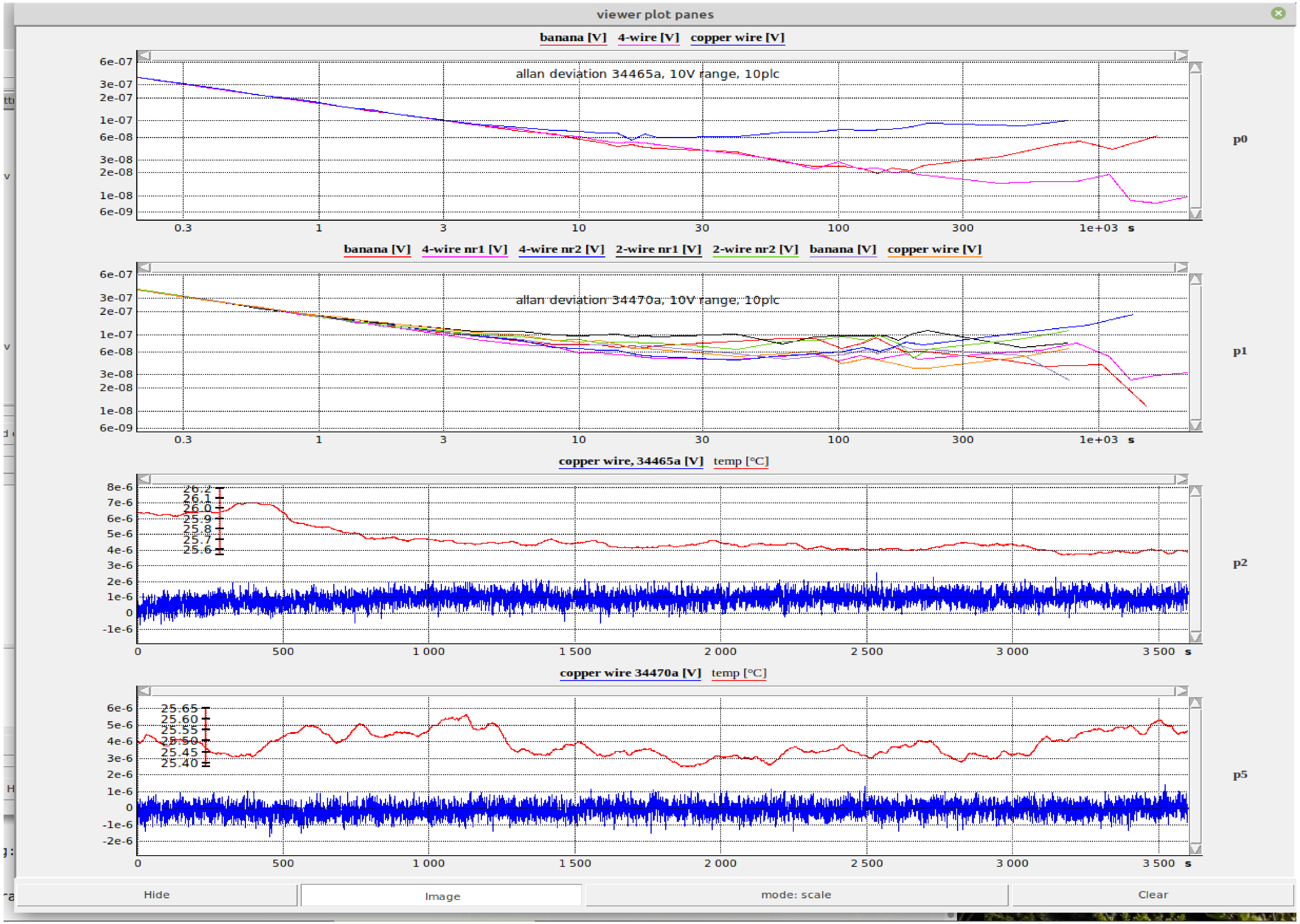
This method has the disadvantage that the function values become more and more inaccurate with increasing integration time[2].

If one compares the two diagrams, it is noticeable that for smaller integration times they are the same for both devices. As the noise of the reference voltage is not received at the short-circuited input, this was to be expected because the ADC is identical for both instruments. However, the fact that the point at which the common linear characteristic is left behind starts at the 34479a with significantly shorter integration times could indicate that the autozero mechanism could play a role here. However, one can also see that these interferences are just below the critical 166nV for the 34470a.

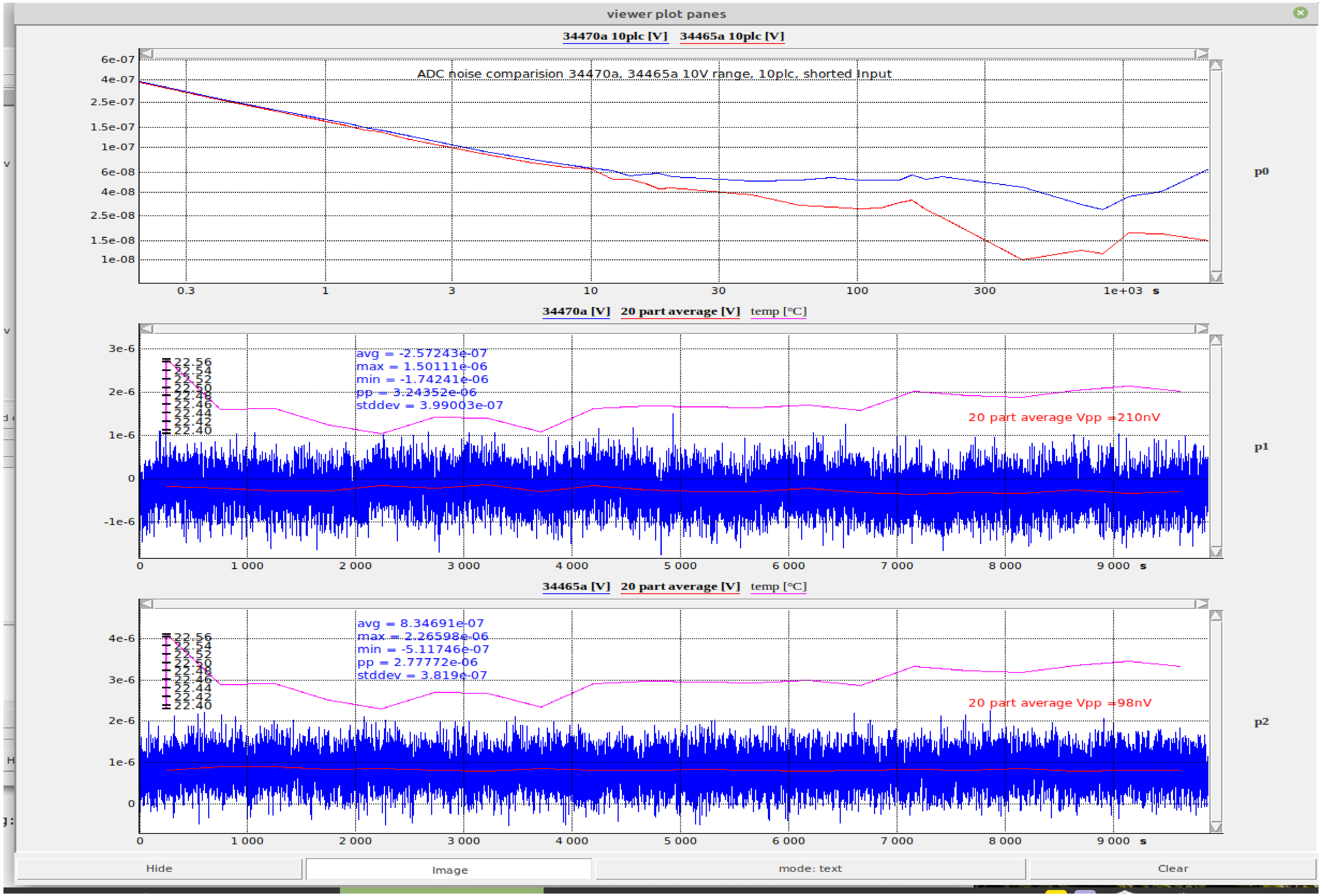
However, before we go any further, we would like to point out that it is by no means easy to create a perfect short circuit due to thermal Voltages. The methods used are documented below. But, and this is important, if you look at the curves over the different shorting plugs, the picture is the same:

1 Since the drift depends on the ambient temperature, this part of the curve is usually different from measurement to measurement, because normally the temperatures in my room change about 0.3 to 0.4°C over the measurement period.

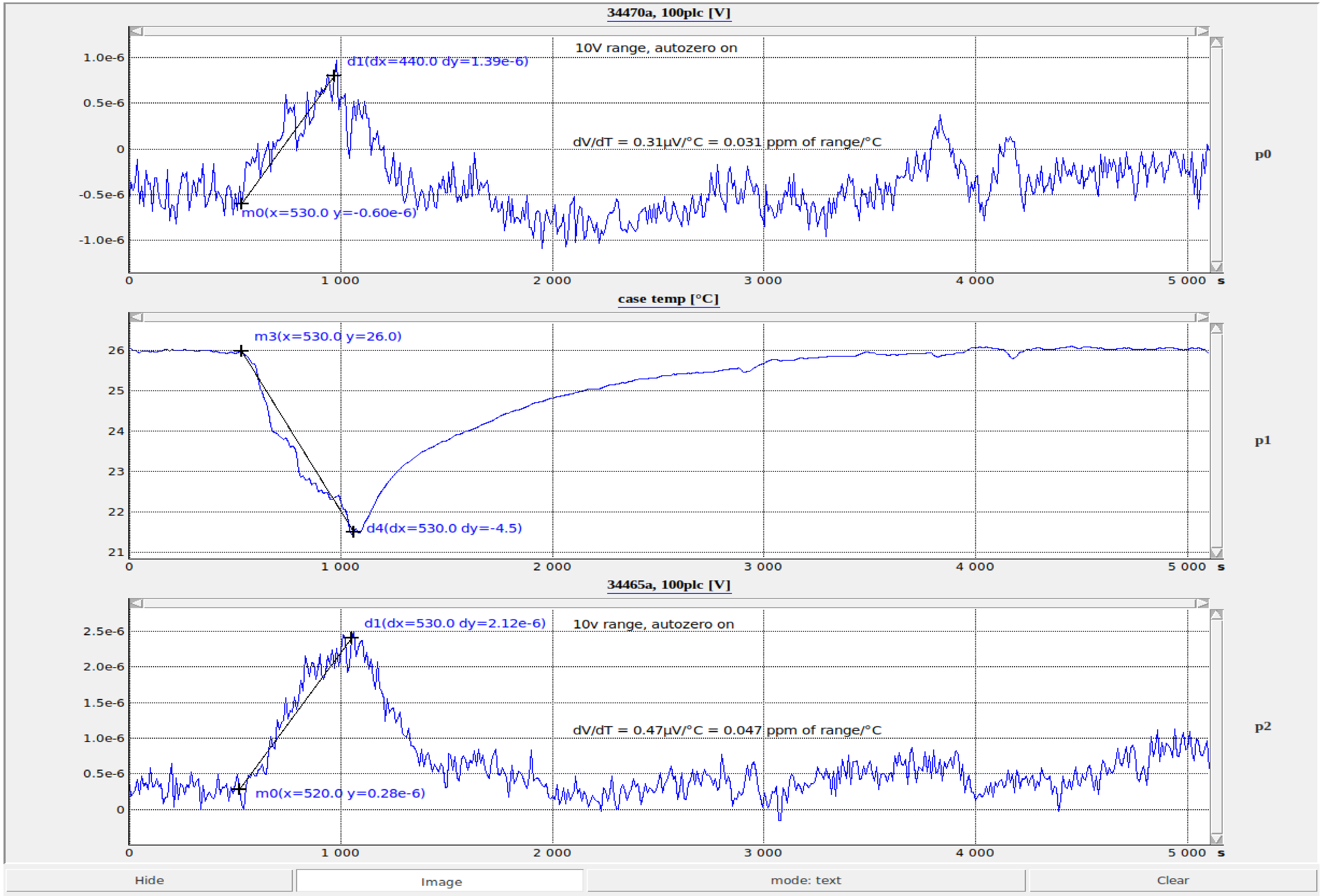
2 This is because to simulate higher integration times from a series of values measured, for example, with 10 plc, the measured values must be divided into intervals of equal length and the average value is formed in each interval. The number of measured values therefore decreases with increasing integration time. From a statistical point of view, this means that the confidence interval of the function value becomes longer and longer. This is the reason why, when several series of measurements are carried out, large differences between the curves can be seen at the right end of the diagram.



In the next diagram the influence of faster drift movements on the Allan function is again somewhat illustrated:

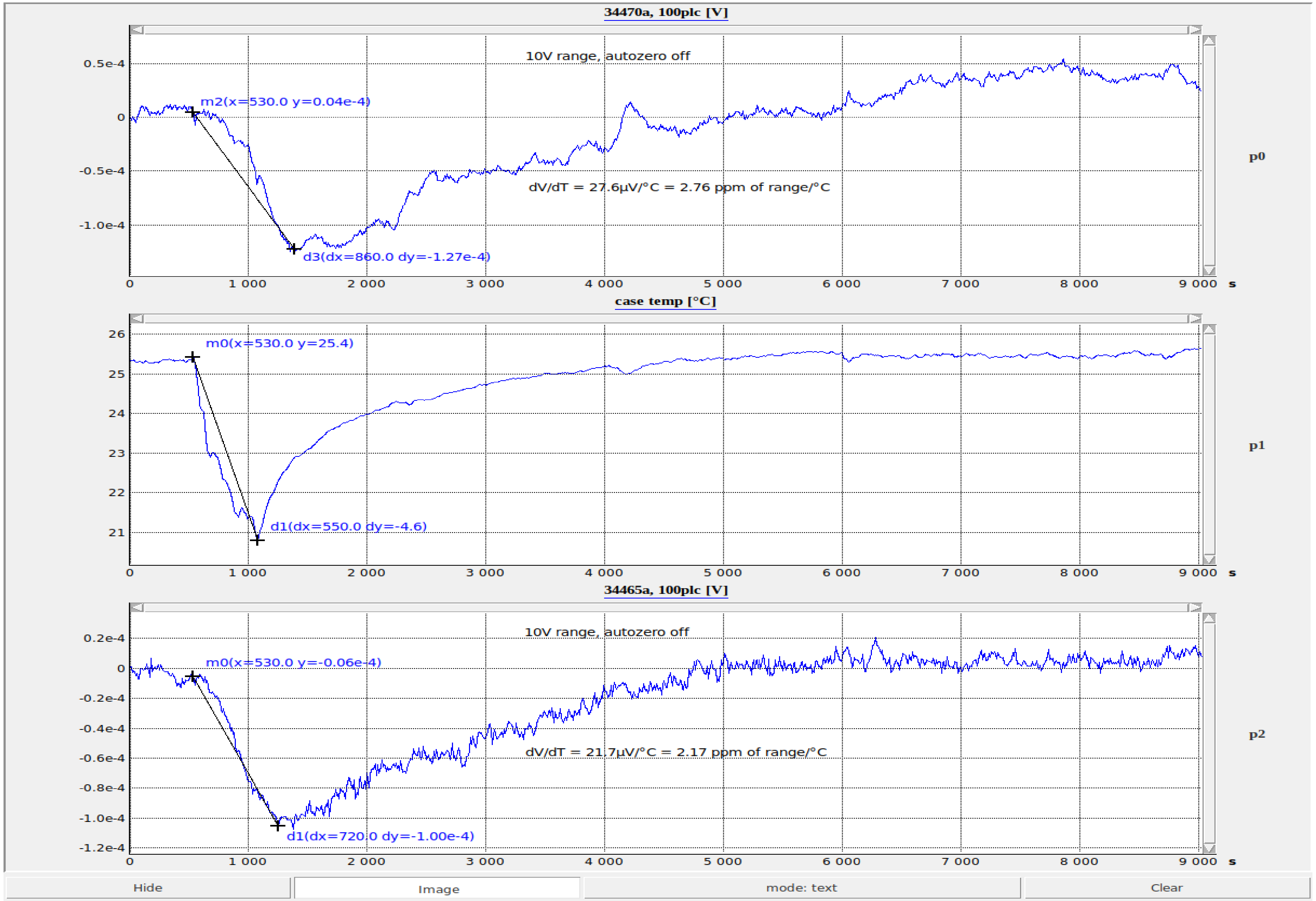

viewer plot panes
34470a 10plc [V] 34465a 10plc [V]
ADC noise comparision 34470a, 34465a 10V range, 10plc, shorted input
p0
34470a [V] 20 part average [V] temp [°C]
avg = -2.57243e-07
max = 1.50111e-06
min = -1.74241e-06
pp = 3.24352e-06
stddev = 3.99003e-07
20 part average Vpp =210nV
p1
34465a [V] 20 part average [V] temp [°C]
avg = 8.34691e-07
max = 2.26598e-06
min = -5.11746e-07
pp = 2.77772e-06
stddev = 3.819e-07
20 part average Vpp =98nV
p2
Hide
Image
mode: text
Clear

II. Zero Input Drift



The values should be excellent. The 34470a is ahead by a nose. However, you should keep in mind that the drift of the reference voltage is not included here, but only that of the ADC and the preamplifier of the voltmeter. One could object that the cooling time is not sufficient to produce the same temperature jump in the device as on the surface. So I made a second attempt with a cooling down difference of 10°C and a cooling down time of 1.5h. The result was similar.

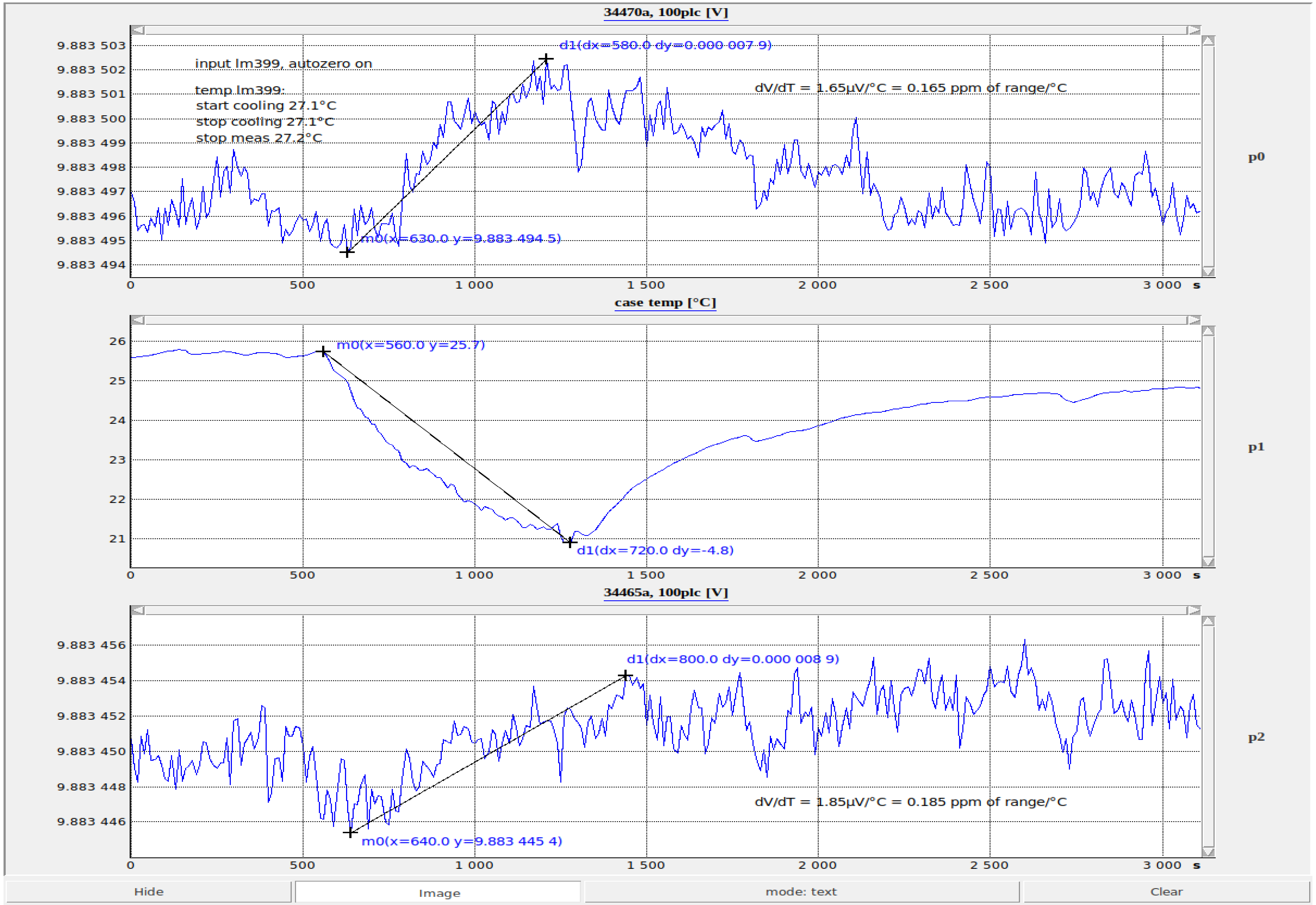
In the next step we make the same attempt, but with autozero off.



The result is an order of magnitude worse.

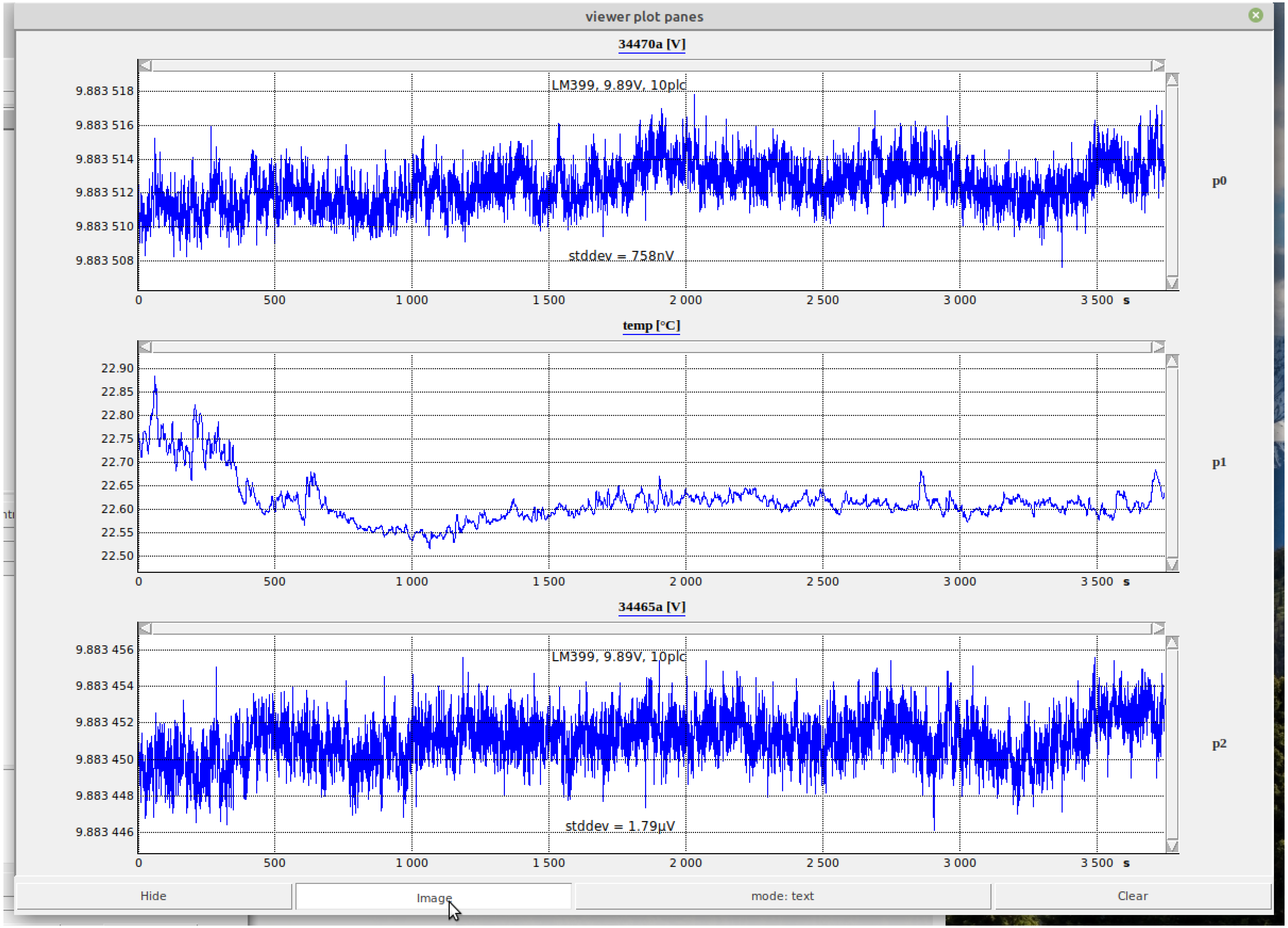
So in the final result it becomes clear that an instability of autozero manifests itself in increased drift, as we have seen in the previous diagrams.

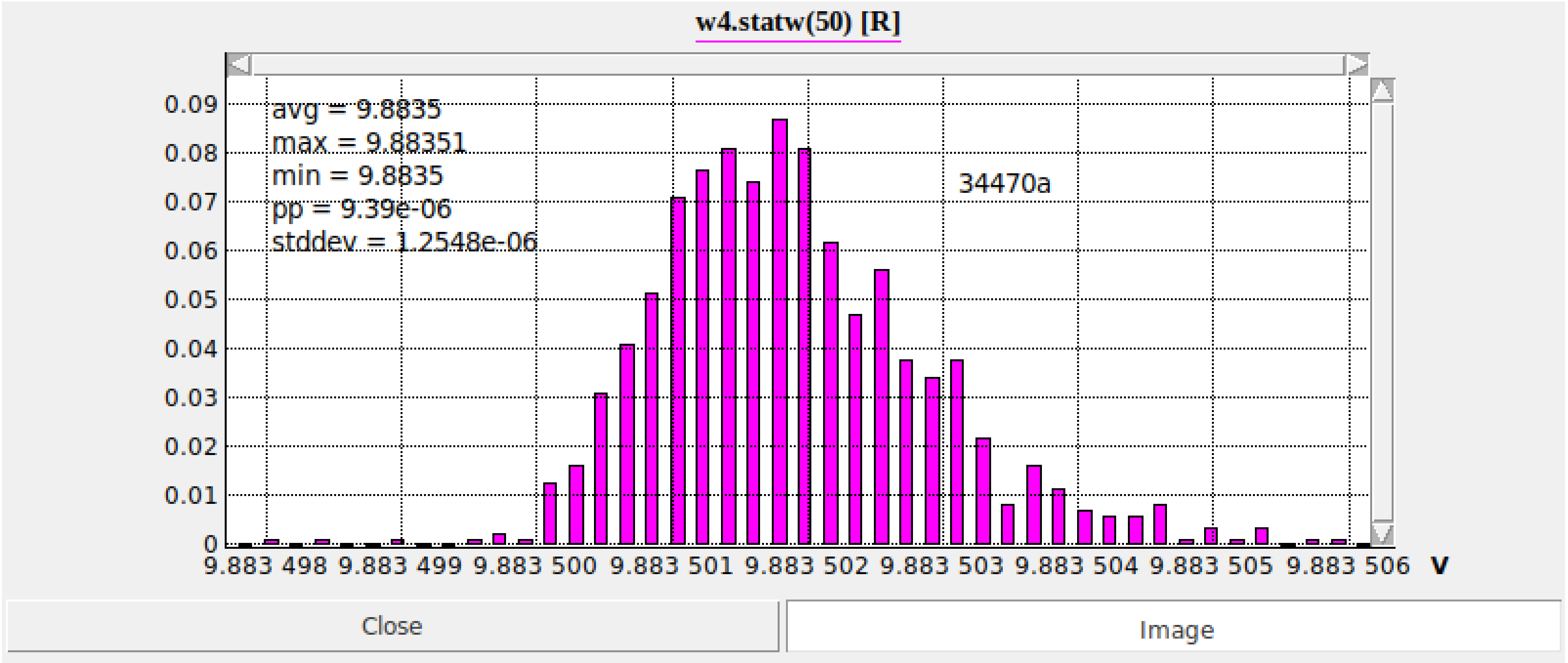
III. Drift measuring 10V

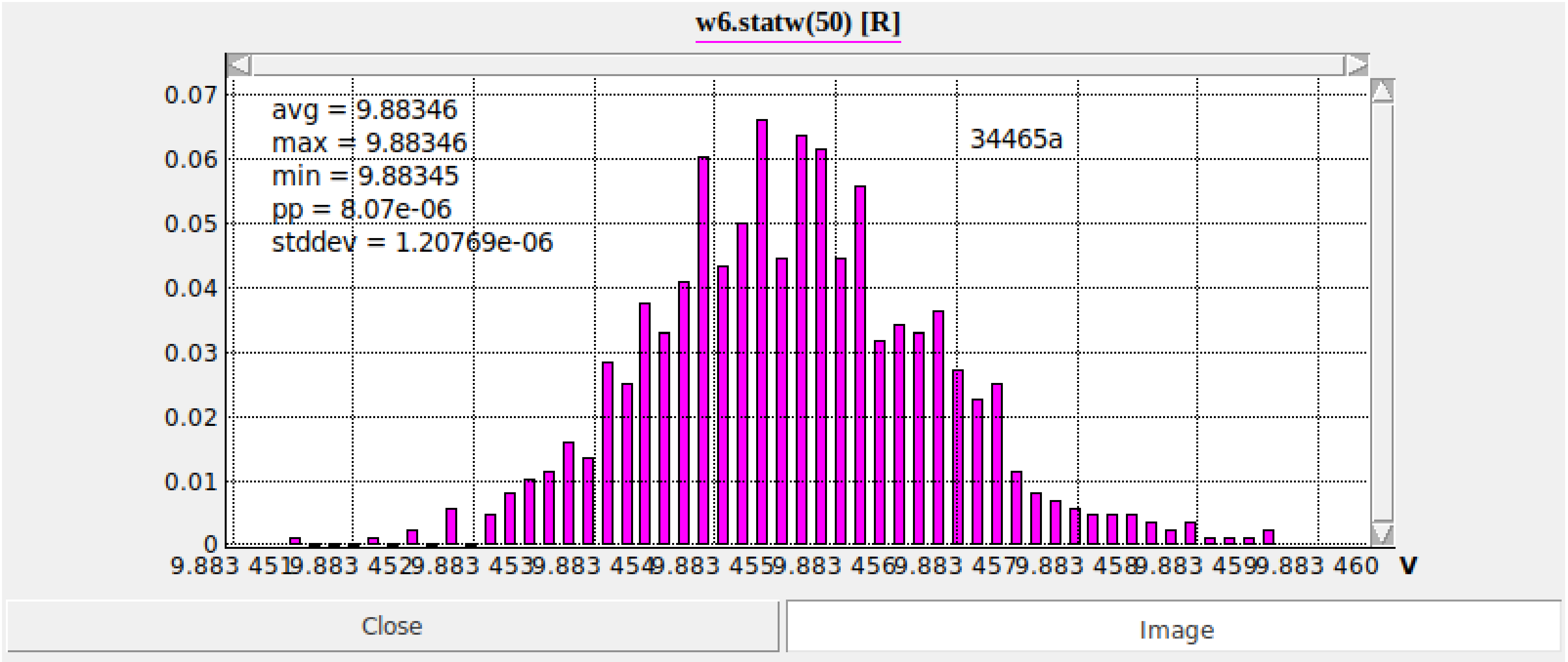


The result is excellent, but there is no significant difference between the two devices. Of course, the measured voltage must not change during the test. This voltage source is a reference based on the LM399, which is embedded in three nested housings that are insulated from each other so that temporary air temperature fluctuations due to thermal mass do not change the core temperature. The reference voltage was also housed in a different room. The core temperature did not change during the cooling period.

IV. Noise measuring 10V

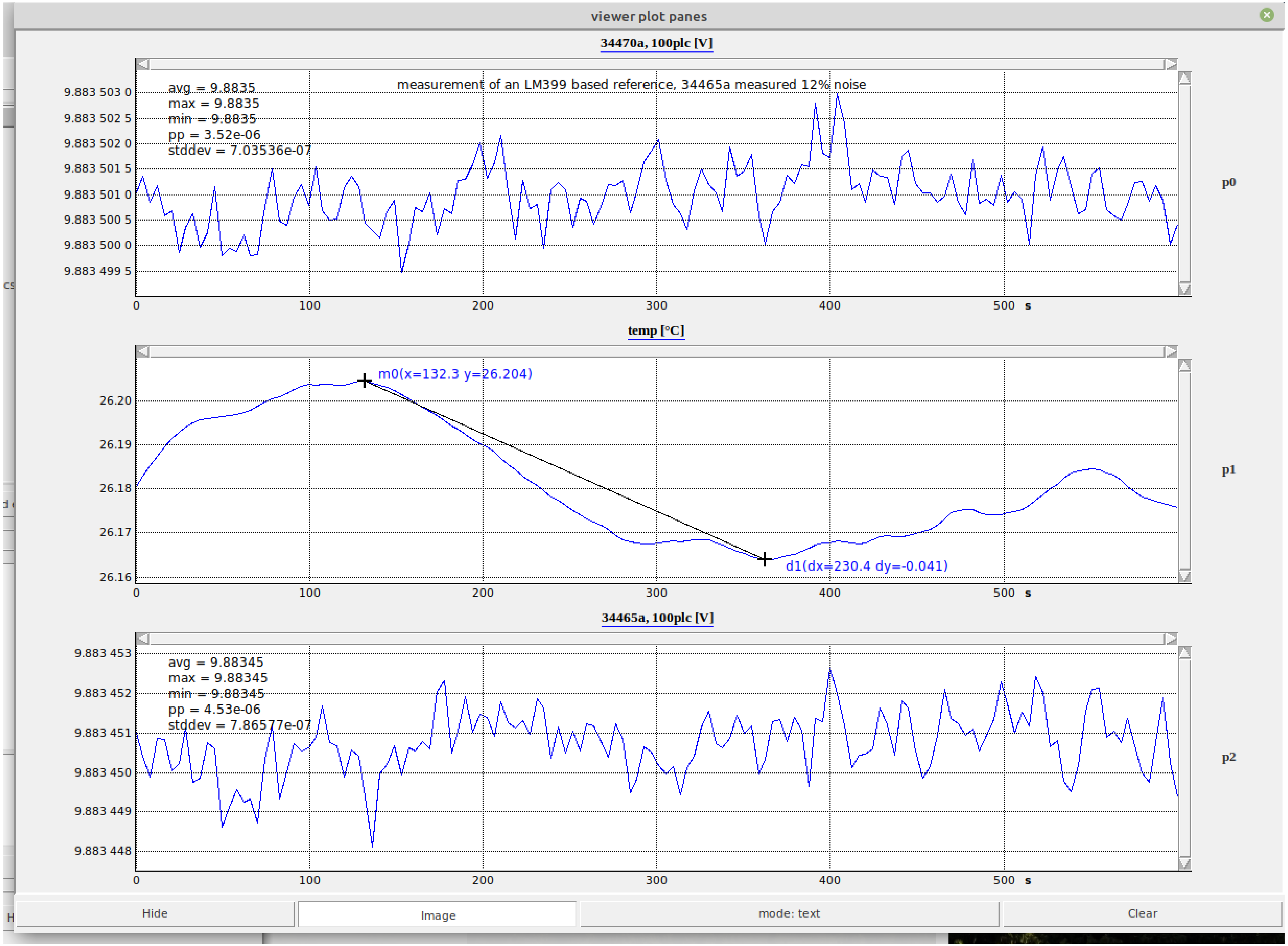


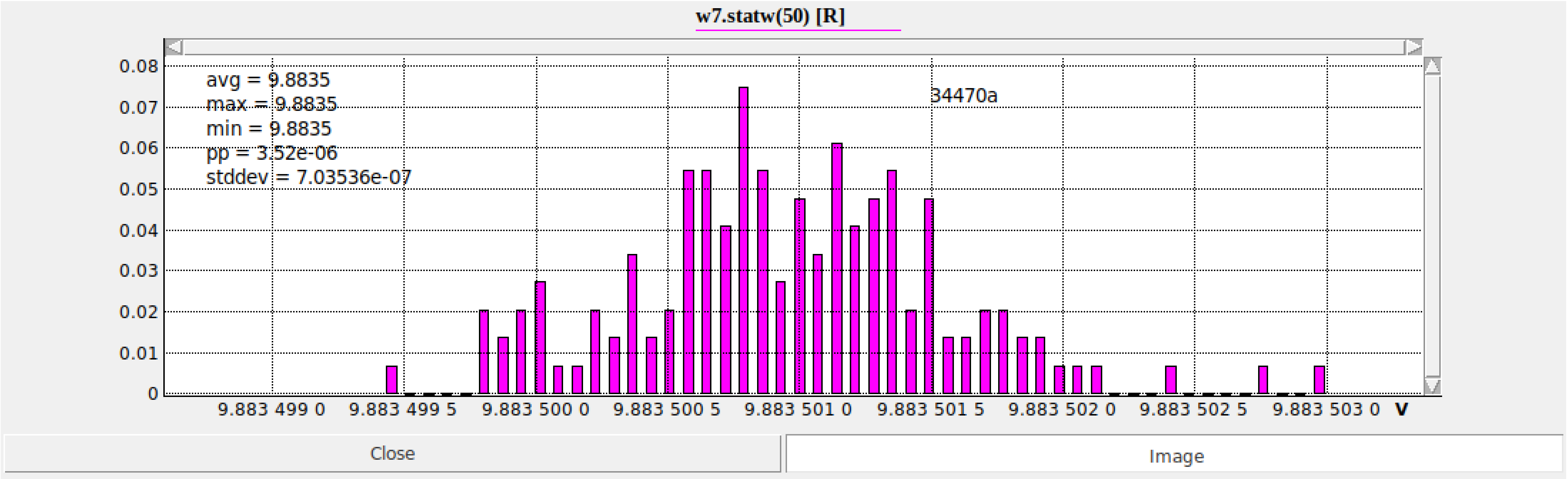


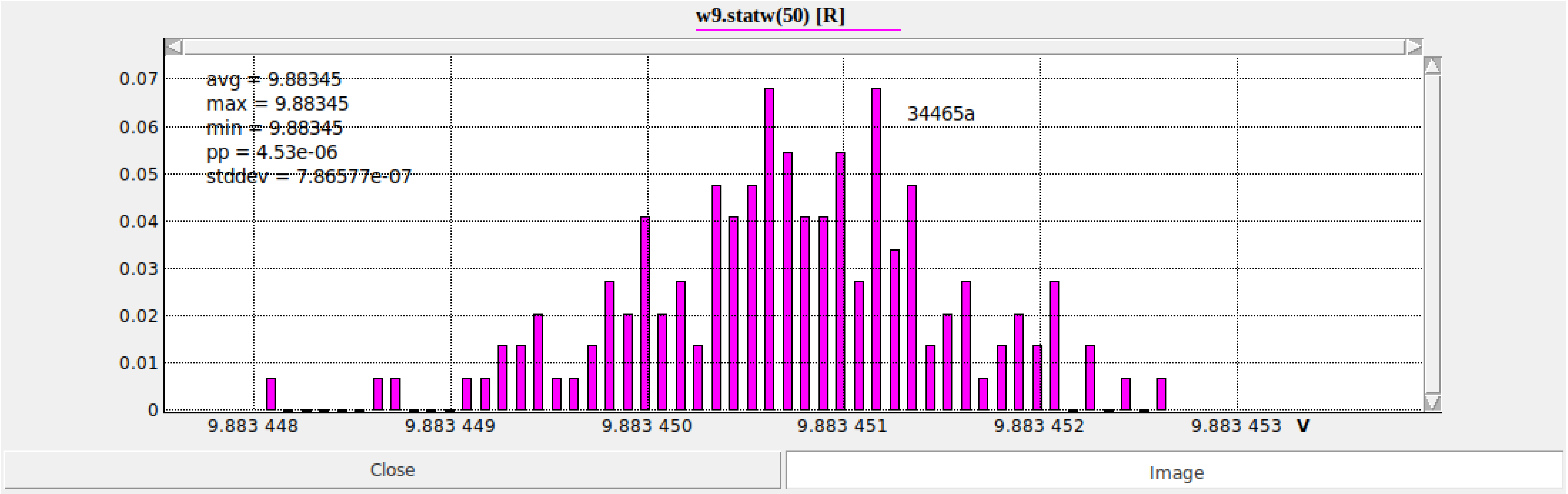


The histogram with 50 bins clearly shows that the 34470a drifts more due to the temperature change. Therefore the histogram is asymmetric and no longer normally distributed. This is also reflected in the fact that the ratio stddev/pp no longer corresponds to the value 6, as it would be in the normal distribution.

I repeated the experiment again, now with a much shorter measuring time, in which the temperature changes only by 0.04°C during the 10 minutes measuring time. Now the result for the 34470a is only slightly better and I think it‘s the more realistic result. Of course this is only a rough comparison and not an exact measurement. This would require completely different technical equipment, which I do not have at my disposal.


viewer plot panes
34470a, 100plc [V]
measurement of an LM399 based reference, 34465a measured 12% noise
avg = 9.8835
max = 9.8835
min = 9.8835
pp = 3.52e-06
stddev = 7.03536e-07
p0
temp [°C]
m0(x=132.3 y=26.204)
d1(dx=230.4 dy=-0.041)
p1
34465a, 100plc [V]
avg = 9.88345
max = 9.88345
min = 9.88345
pp = 4.53e-06
stddev = 7.86577e-07
p2
Hide
Image
mode: text
Clear


w7.statw(50) [R]
avg = 9.8835
max = 9.8835
min = 9.8835
pp = 3.52e-06
stddev = 7.03536e-07
34470a
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
9.883 499 0
9.883 499 5
9.883 500 0
9.883 500 5
9.883 501 0
9.883 501 5
9.883 502 0
9.883 502 5
9.883 503 0
V
Close
Image


w9.statw(50) [R]
avg = 9.88345
max = 9.88345
min = 9.88345
pp = 4.53e-06
stddev = 7.86577e-07
34465a
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
9.883 448
9.883 449
9.883 450
9.883 451
9.883 452
9.883 453
V
Close
Image

V. Conclusion

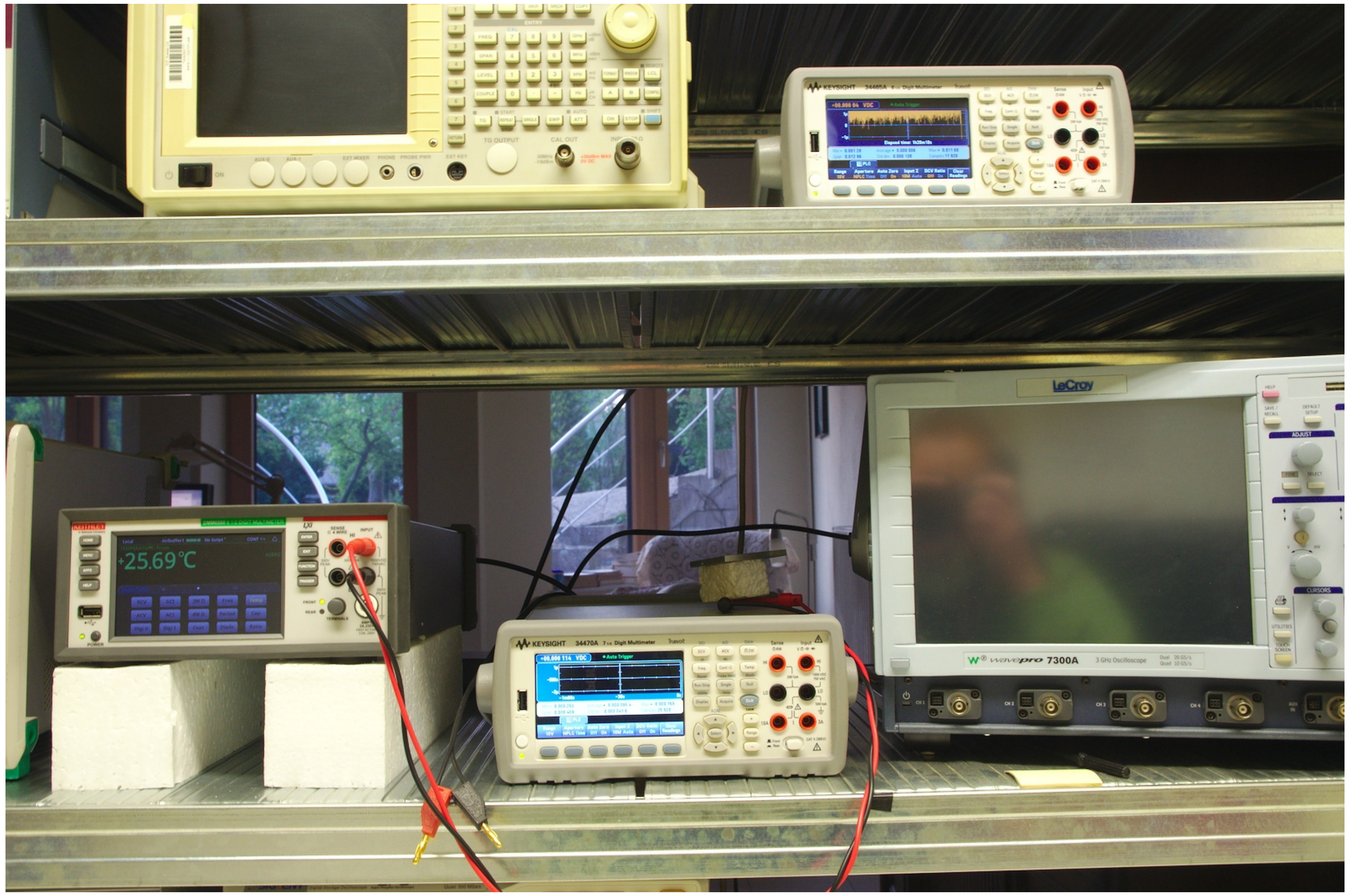
As a result, the 34470a performs significantly worse than the 34465a in terms of zero point stability. However, this doesn't go so far that the 34470a could be denied to be a 7.5 digit voltmeter.

So the only difference compared to the 34465a is the lower noise of the reference voltage source, but the difference seems not to be significantly better.

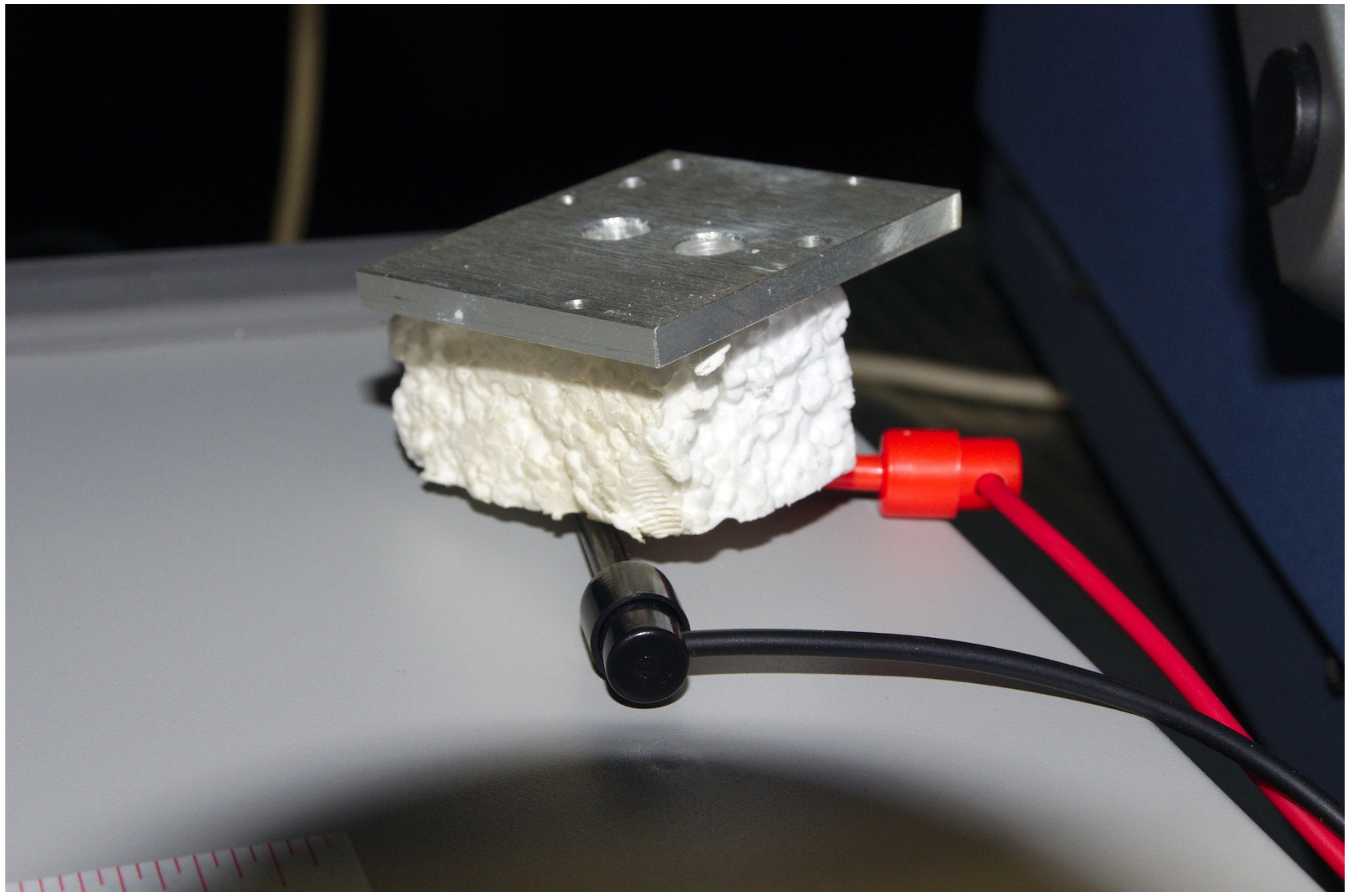
Not quite, there is also the consequent limitation of the display accuracy to 6.5 digits, which makes the use of the 34465a for accurate measurements, especially for statistics, quite complicated. This may be seen as a targeted sales promotion for the 34470a, but it certainly doesn't correspond to the technical possibilities of the 34465a.

So Keysight would be very well advised to finally take this problem seriously and provide a remedy. Otherwise I see no future for the 34470a, who will want to pay double the price for something if it does not also mean a significant leap in performance.

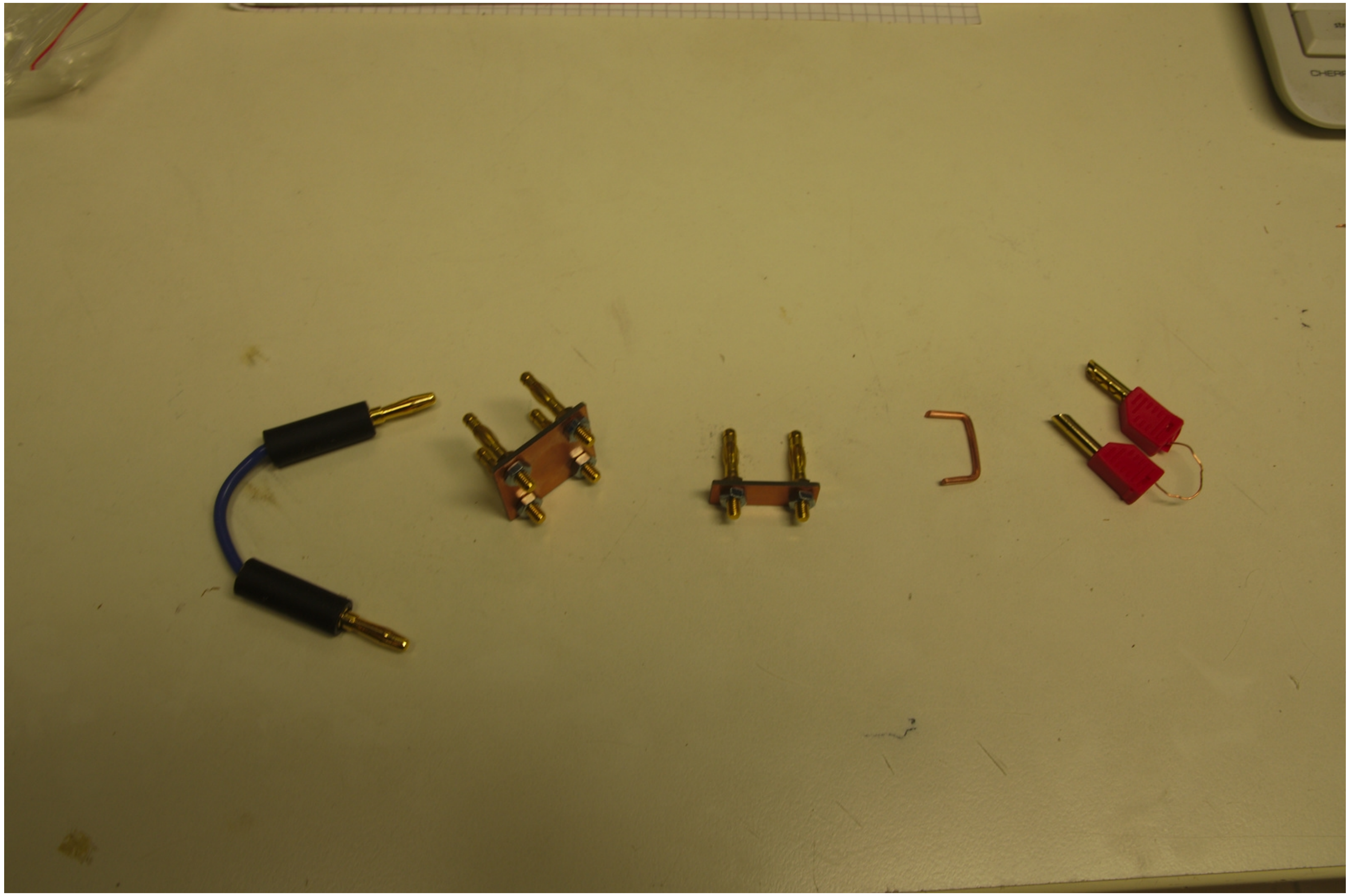
VI. Documentation of the test arrangement



The three voltmeters involved. Not stacked on top of each other and sufficient lateral distance so that all are subject to the same temperature conditions. The room temperature did not change more than approx. 0.4° (except for the specific cooling).



The surface of the housing of the 34470a was chosen as the reference temperature point. The NTC resistor is isolated from the air, so that the air turbulence is somewhat compensated. Measurements were taken with a Keithley DMM6500.



The tested short-circuit plugs. Sorted from left to right for decreasing stability. A certain thermal mass seems to be necessary to compensate for the temperature fluctuations of the air. All banana plugs have a gold surface, all cables are bare copper, no soldering. A science in itself, but one that should not be deepened at this point.