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Q Curve Systematic Studies for E94-010 and E95-001

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Abstract

We present here the effects of the pick-up coil circuit loading by the water and by the Helium target cells, and the study of the circuit response to cell temperature variations.

1 Purpose

The study of the pick-up coil loading effect by the target cell and the study of the circuit response under various temperature conditions are necessary to extract the Helium cell polarization, since the response of the pick-up circuit may be different with a cold water cell and with a hot Helium cell. Reproducing the same experimental conditions as in the hall (same pick-up coils, same RF excitation voltage, same RF frequency), we decide to study the behaviour of the circuit at 91 kHz under the following conditions :

- Loading effect
  - 1 : no cell between the pick-up coils, room temperature
  - 2 : Helium cell between the pick-up coils, room temperature
  - 3 : no cell between the pick-up coils, room temperature
  - 4 : water cell between the pick-up coils, room temperature
  - 5 : no cell between the pick-up coils, room temperature
  - 6 : water cell between the pick-up coils, room temperature
- Temperature effect
  - Helium cell between the pick-up coils, room temperature
  - Helium cell between the pick-up coils, increasing temperature
  - Helium cell between the pick-up coils, pumping temperature of 175 ^{o}C, two lasers on
  - Helium cell between the pick-up coils, decreasing temperature
  - Helium cell between the pick-up coils, room temperature

A full Q curve sweep (from 60 kHz to 300 kHz) will also be performed at each step.

2 Loading Effect

A LabVIEW virtual instrument has been written to measure the pick-up circuit response at 91 kHz. 30 samplings of 50 lock-in responses are performed, that is a total of 1500 measurements. The lab temperature is stabilized at 23.5 ^{o}C for the Helium loading effect and at 24 ^{o}C for the water loading effect . For each series of measurements, we calculate the average response of the circuit and its error, as shown in Tables 1 and 2. By RMS, we understand the square root of the variance, calculated as the mean of the squares minus the square of the mean. The results for the Helium cell are shown on Figure 1 and for the water cell on Figure 2. Within our experimental precision, both studies show no obvious loading effect due to the presence of a cell between the pick-up coils.

3 Temperature Effect

To study the response of the pick-up circuit to various temperatures, we have monitored the time evolution of the lock-in response during the typical temperature conditions of E94-010 and E95-001. The temperature of the target cell, the temperature of one of the the pick-up coils and the temperature of the oven have been measured continuously using the RTD system, for three days, while we were increasing and decreasing the oven temperature (from room temperature up to 175 ^{o}C, to 170 ^{o}C and back down). We have observed a very strong correlation of the lock-in response with the temperature of the lab, as shown by Figures 3, 4 and 5. Even the oscillations of the control system are clearly measured. Our system suffered two major shutdowns during the thunderstorm, but only stabilized data have been used to estimate the correction factor. This factor $C = (Hot - Cold)/Cold$ is obtained from the ratio of two linear fits to stabilized data at 170 ^{o}C (oven pumping temperature) and at 22 ^{o}C (oven room temperature). We extract :

$$C = 0.0036 + -0.0002 \tag{1}$$

The error on this correction has been estimated by varying the fit ranges, on the time scale.

Table 1: *Pick-up circuit response - Helium loading effect*

Series	**Mean (μV)**	**RMS (μV)**	**Normalized Response**	**Shape**
1	0.2745	0.0004	1.0000	Line
2	0.2741	0.0004	0.9985	Line
3	0.2740	0.0003	0.9982	Line

Table 2: *Pick-up circuit response - Water loading effect*

Series	**Mean (μV)**	**RMS (μV)**	**Normalized Response**	**Shape**
4	0.3008	0.0008	1.0000	Line
5	0.2998	0.0005	0.9967	Line
6	0.2995	0.0007	0.9957	Line

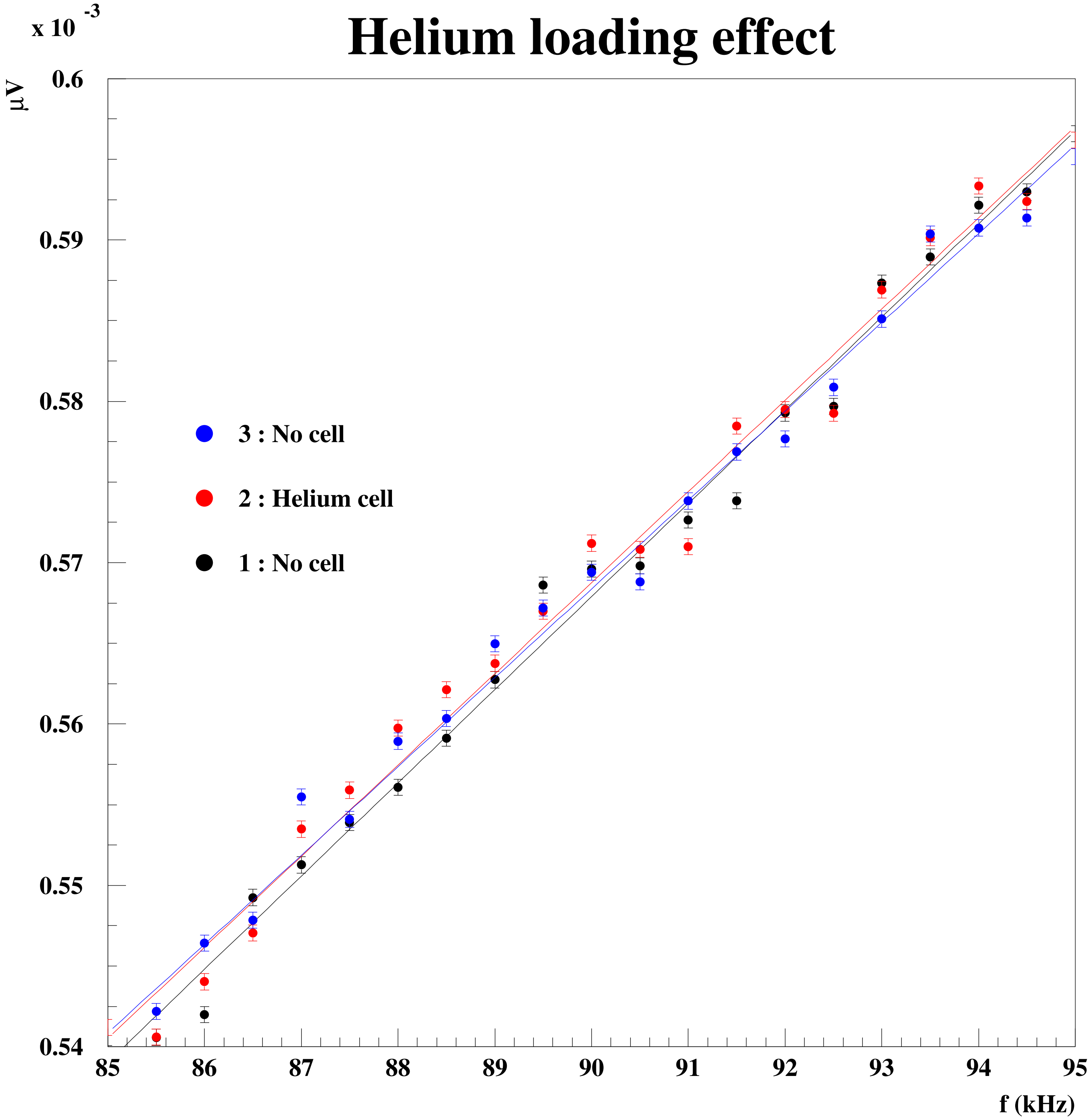

Figure 1: helium loading effect : lock-in response versus RF frequency, for the first three series of measurements. All three are compatible : no loading effect. Refer to the three steps given in the text.

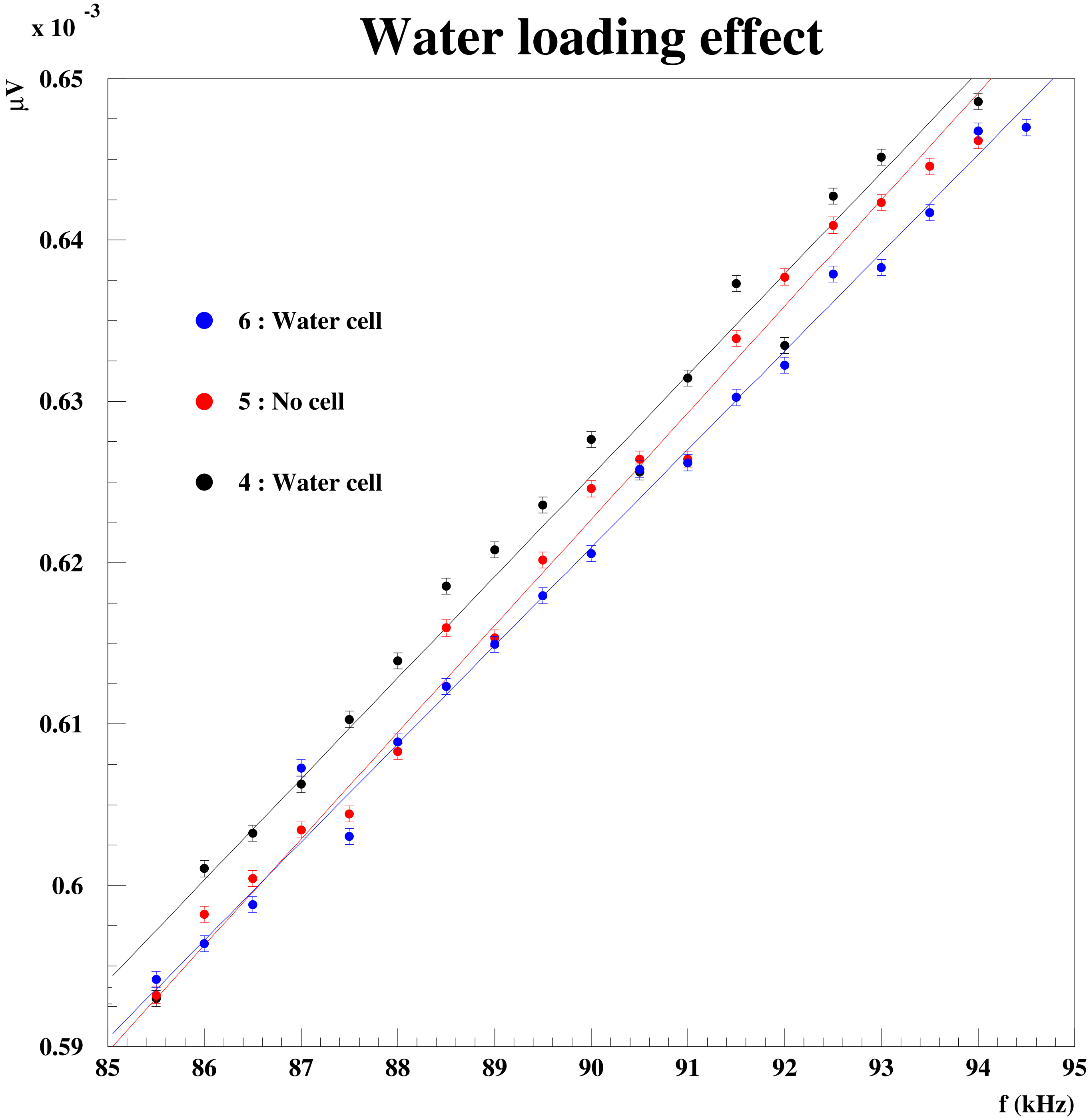

Figure 2: water loading effect : lock-in response versus RF frequency. No obvious loading effect. Refer to the three steps given in the text.

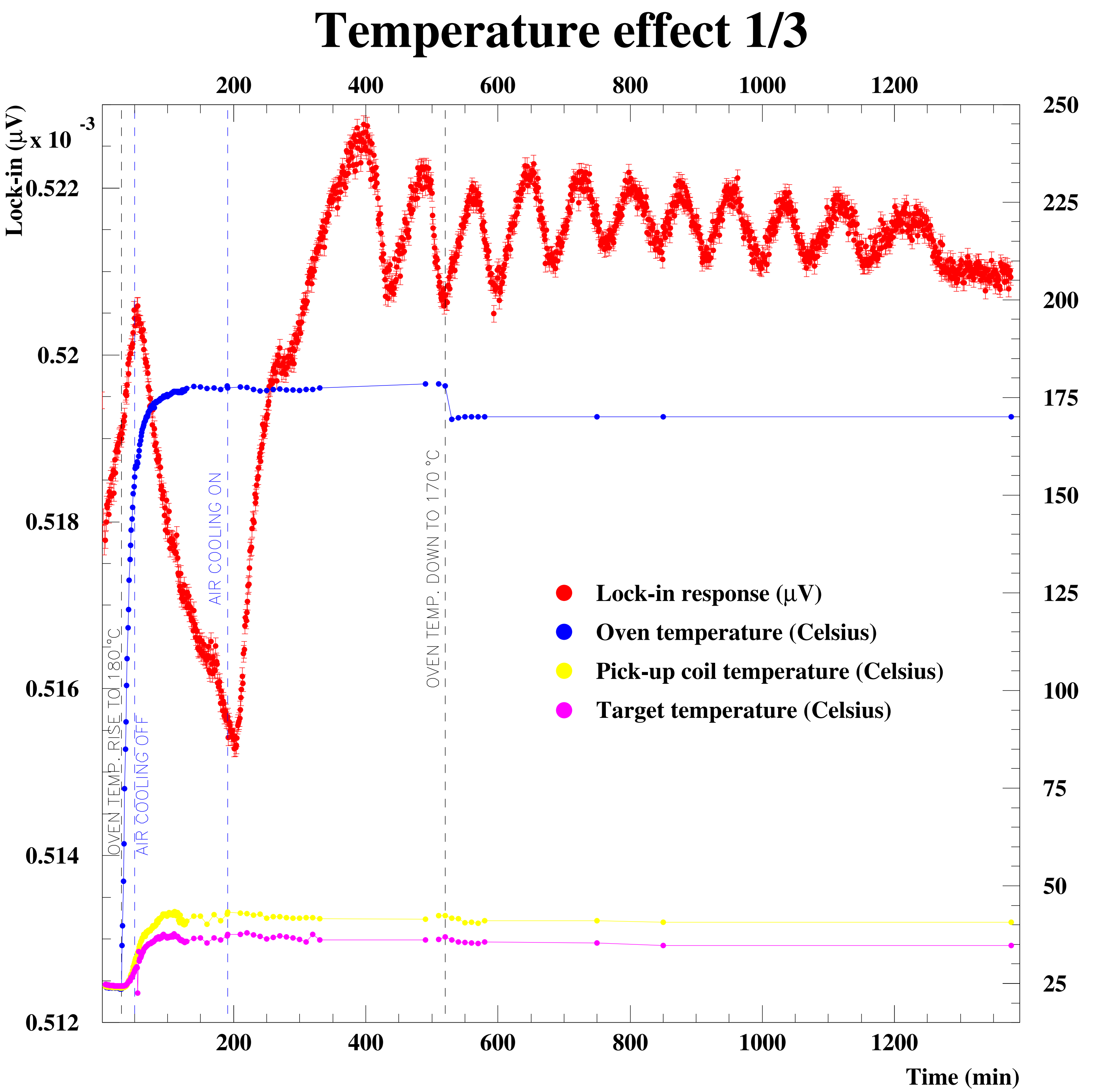

Figure 3: first time evolution of the lock-in response. Strong correlation with the room temperature.

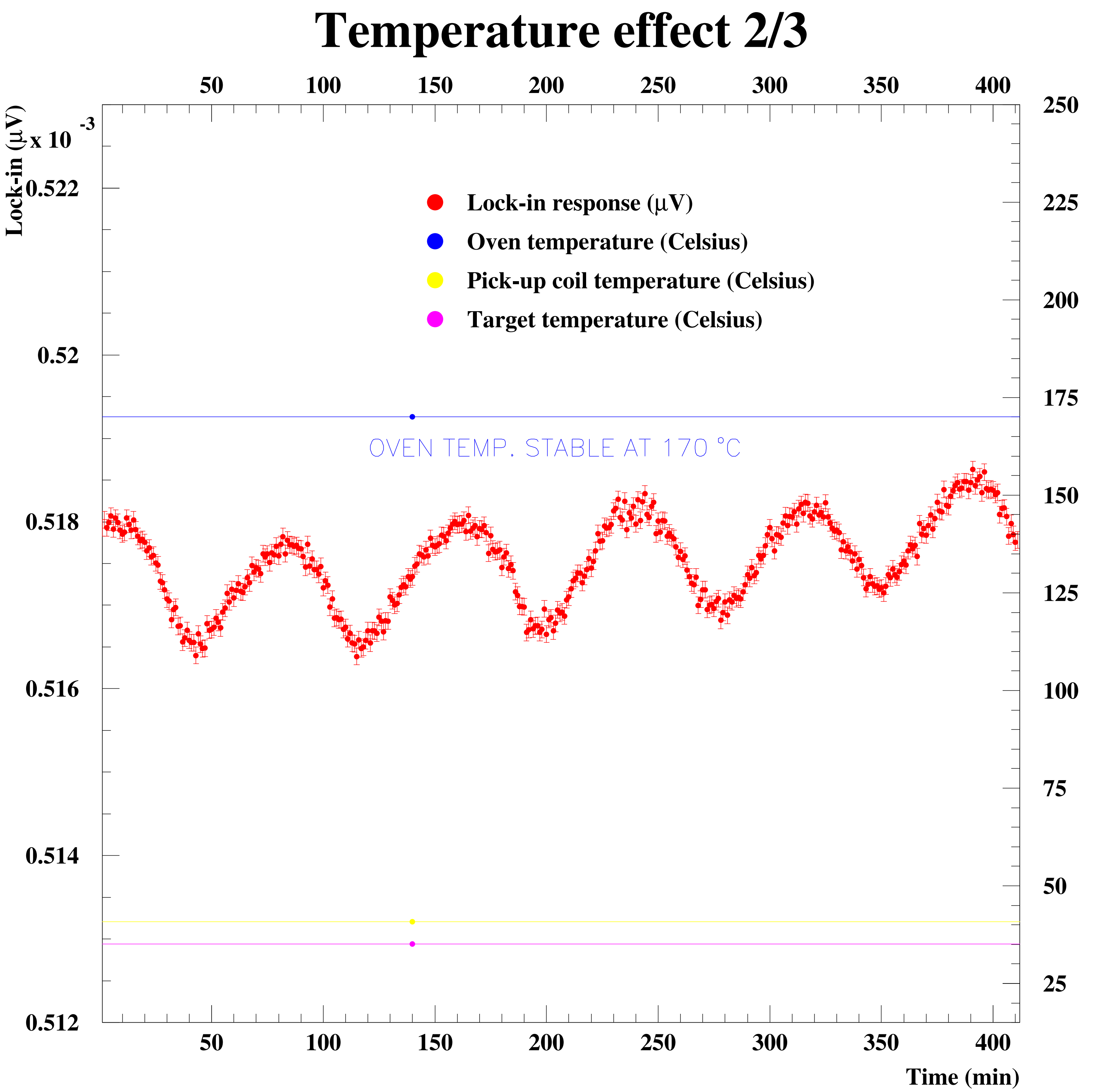

Figure 4: second time evolution, after power shutdown of the RF function generator (thunderstorm). The oscillation is due to the room temperature control system.

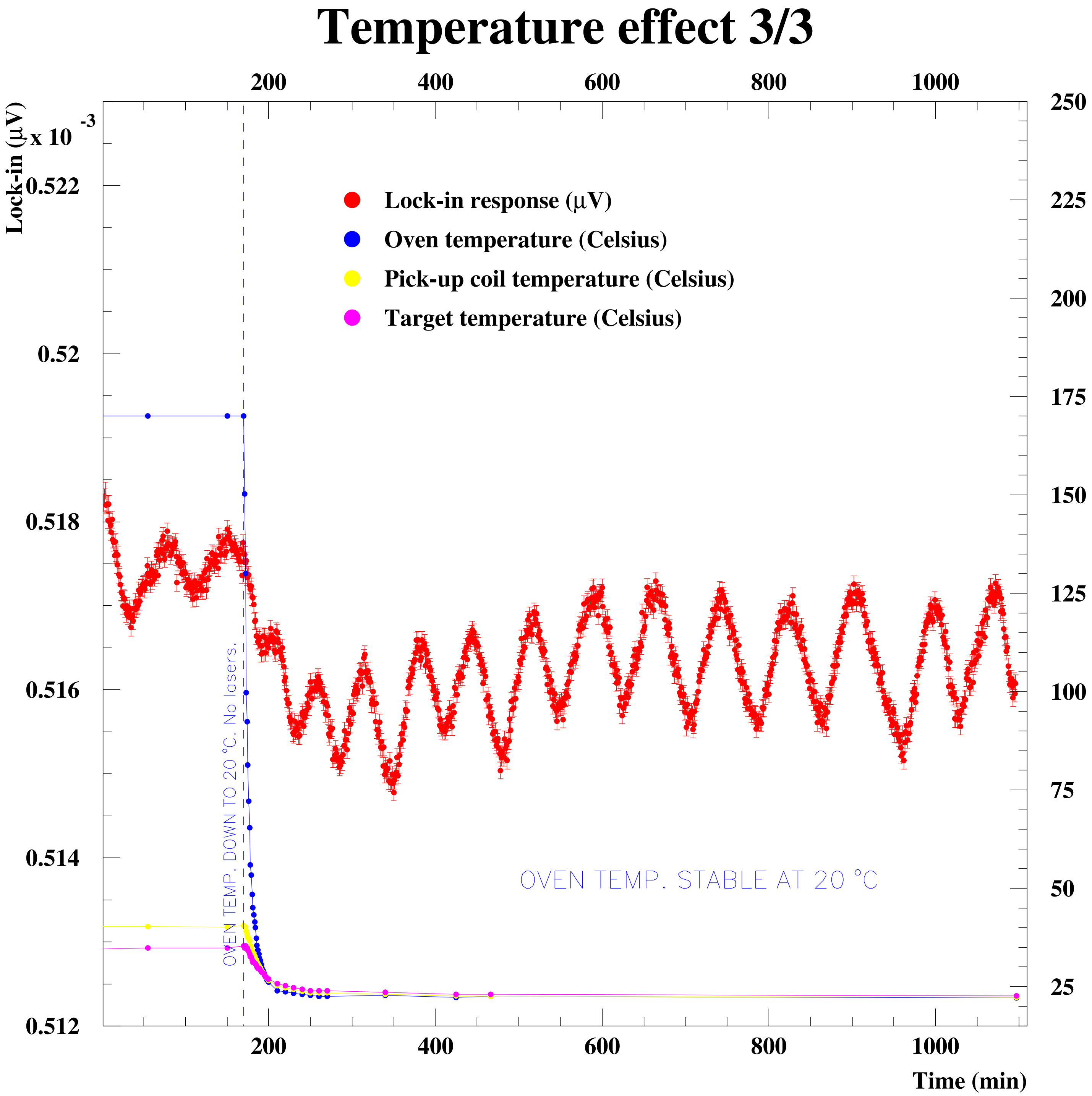

Figure 5: third time evolution, showing the effect of the oven temperature decrease, from 170 ^{o}C to 20 ^{o}C.

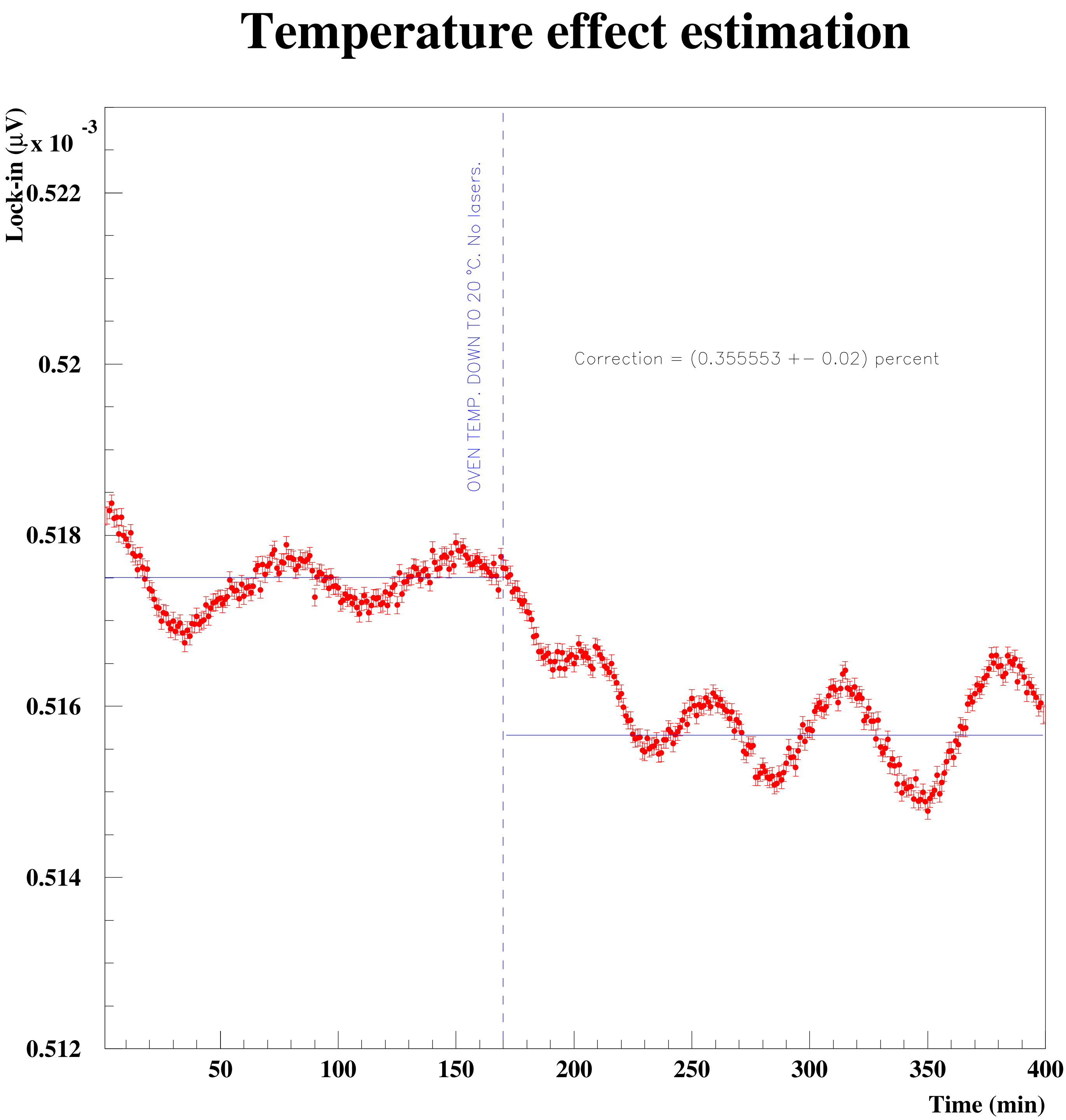

Figure 6: estimation of the temperature correction due to the temperature drop (from 170 ^{o}C to 22 ^{o}C).