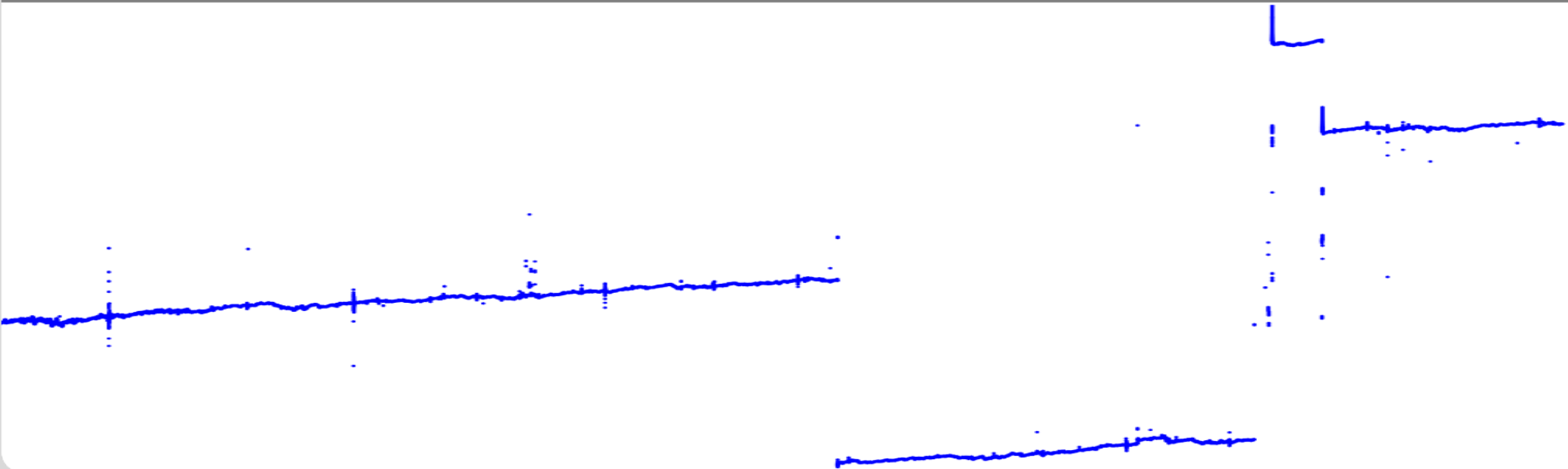


Drift and steps in the data of the superconducting gravimeter SG056 at BFO

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Geophysical Institute, Black Forest Observatory (BFO)



- The superconducting gravimeter SG056 at BFO
- Instrumental drift
 - Applied corrections
 - Drift in the remaining signal
 - Comparison with readings of absolute gravity
- Surprises:
 - Comparison: IGETS data vs. raw data
 - Which kind of intervention causes steps?

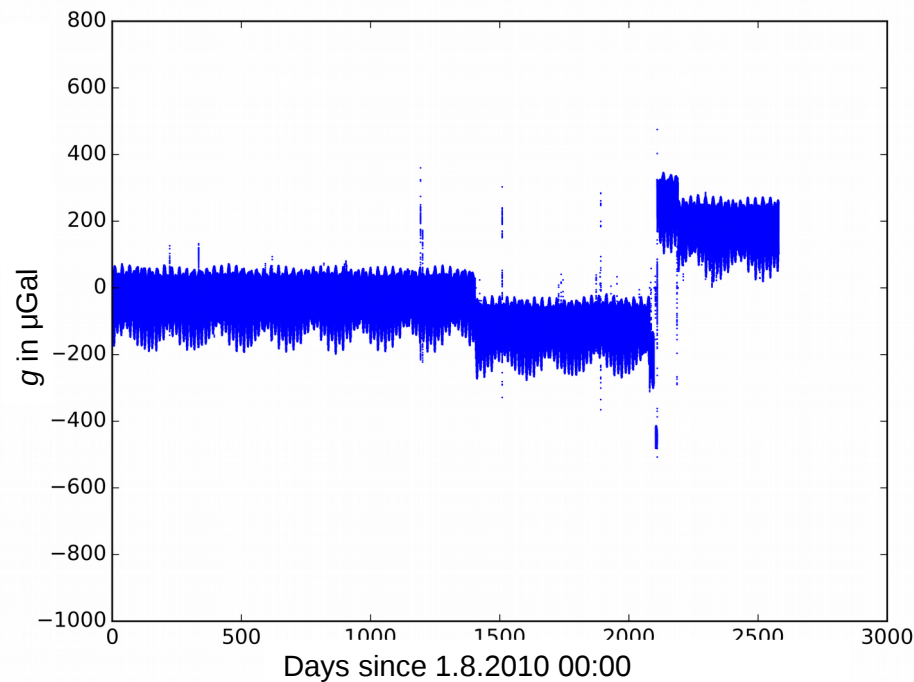
Superconducting Gravimeter SG056 at BFO

- In operation since September 2009
- Two sensors:
 - Lower Sensor 1: mass: 17.7 g
 - Upper Sensor 2: mass: 4.34 g
- Drift (*Widmer-Schnidrig et al. 2012*)
 - Sensor 1: 0.06 $\mu\text{Gal}/\text{year}$
 - Sensor 2: 12.8 $\mu\text{Gal}/\text{year}$

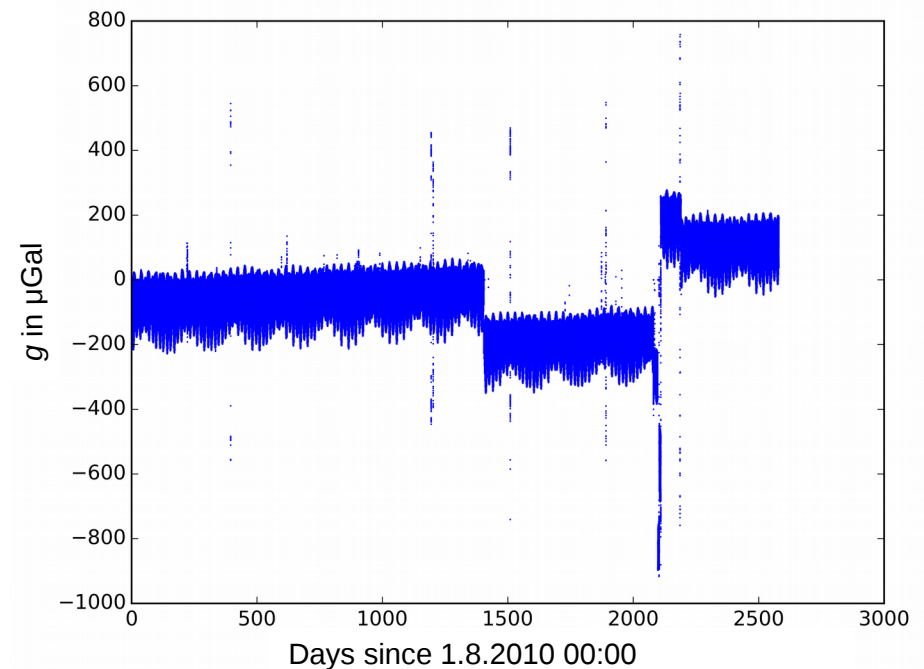
Data correction

- Raw data of the SG056, sampling rate: 1min
- 1.8.2010-23.8.2017
- 4 big steps due to power failure at dewar control system

Raw data Sensor 1



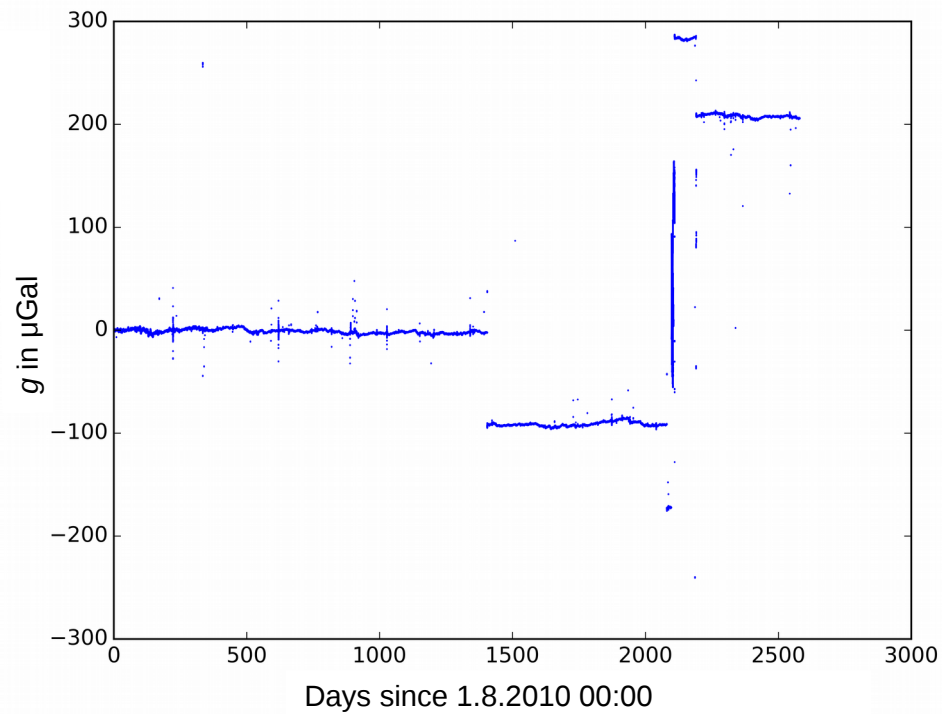
Raw data Sensor 2



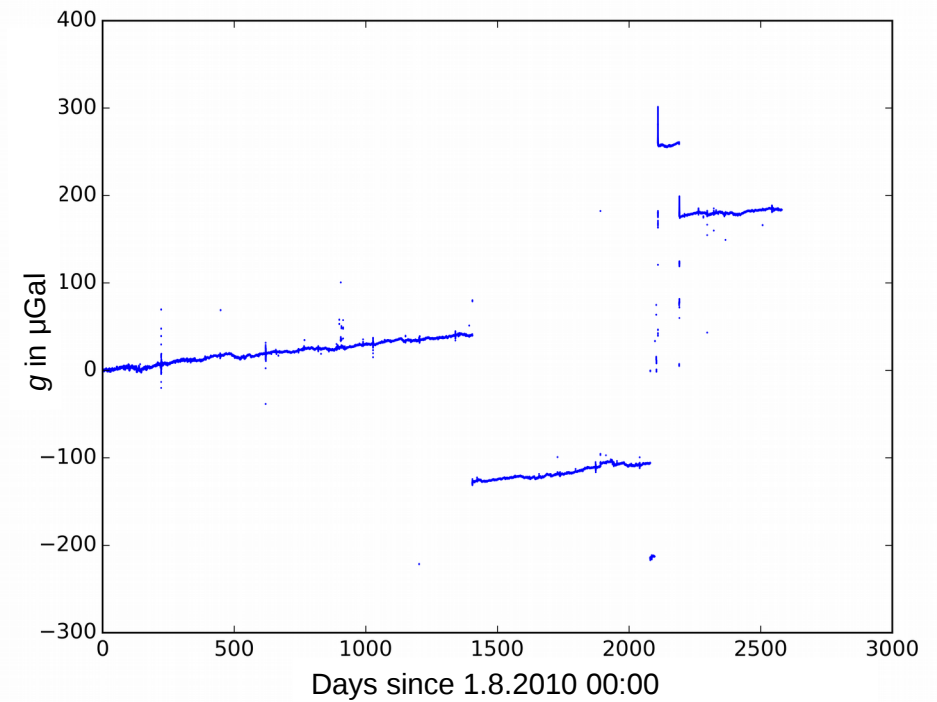
- Tide model from tidal analysis with Eterna (Eva Schroth)
- Pole tide and length-of-day variation with a factor of 1.16
- Atmospheric loading ($-0.3 \mu\text{Gal/hPa}$)

Data correction

Corrected data Sensor 1



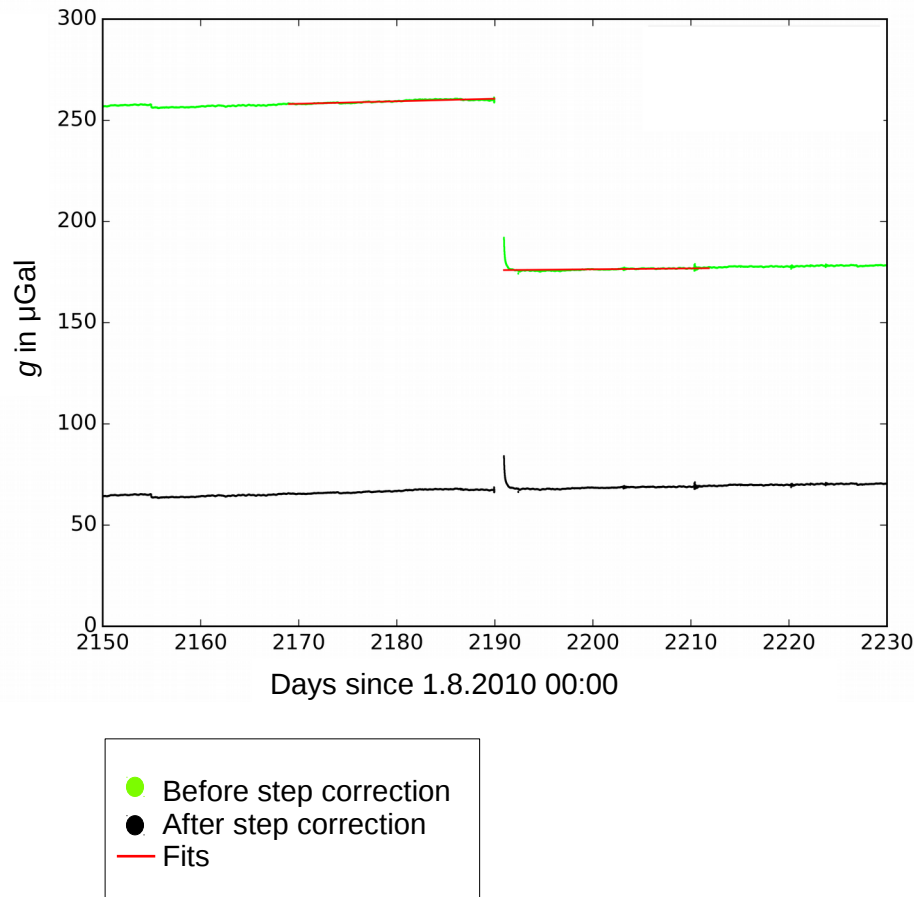
Corrected data Sensor 2



Data correction

Correction of steps

Step 4 of sensor 2 (29.7.2016):



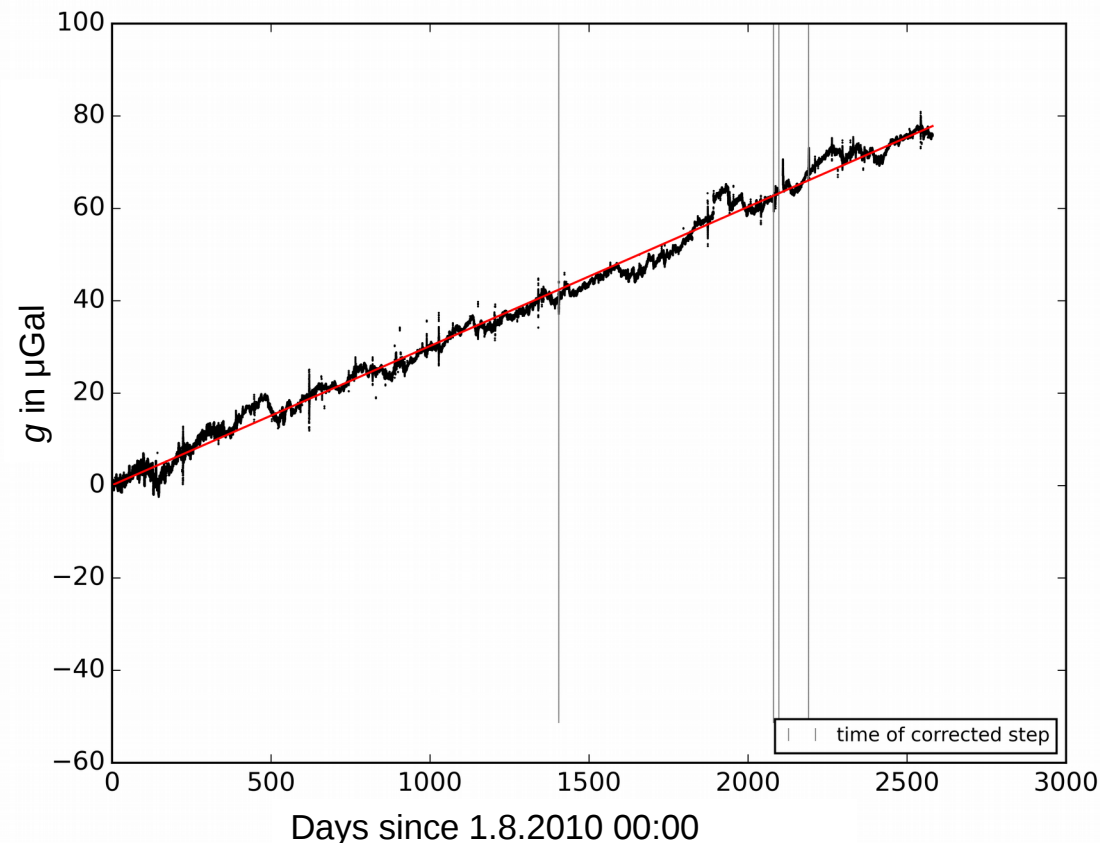
Different Length of fit =>
Different step size estimation

- 4 lengths between 30000 (~21 days) and 525600 (~1 year) samples tested
- Result varies by up to 5 μGal
 - corresponding to the amplitude of the remaining signal

Determination of the drift

Sensor 2

- Slope of the linear fit: $(11.0 \pm 0.7) \mu\text{Gal}/\text{year}$
- Uncertainty from different step corrections

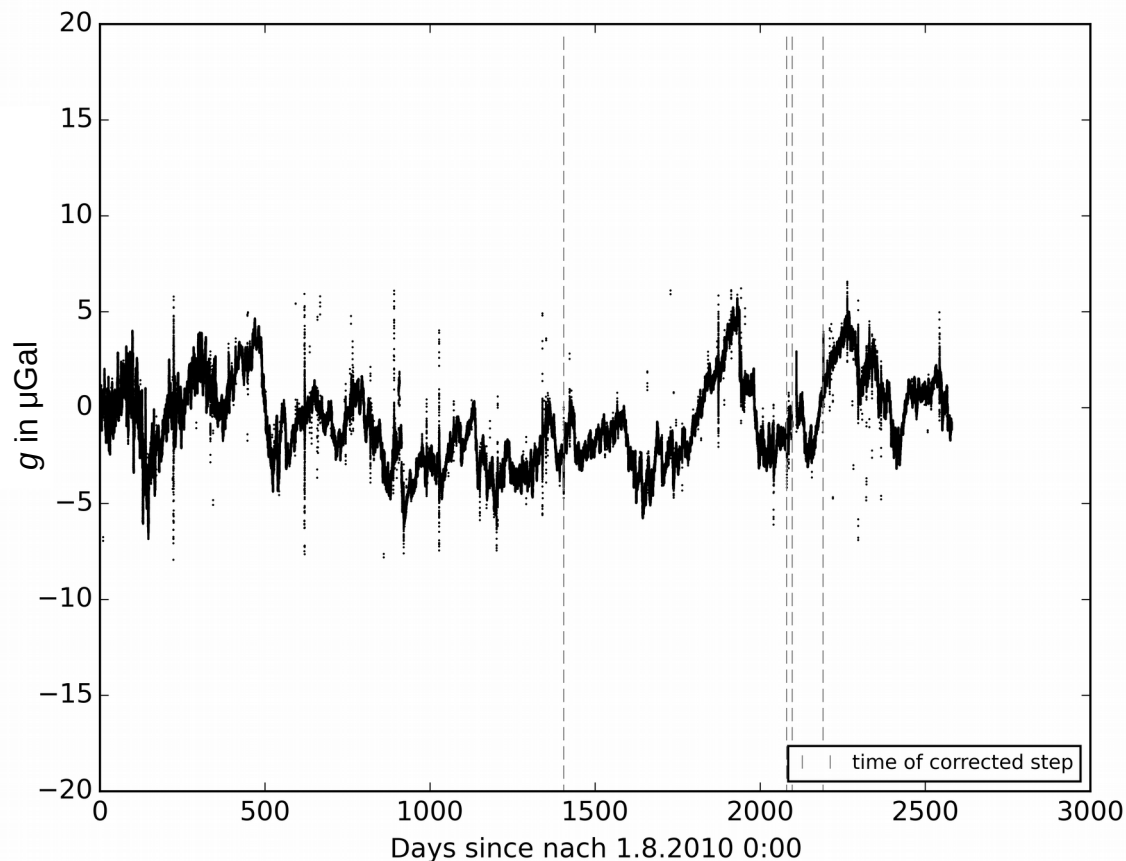


Determination of the drift

Sensor 1

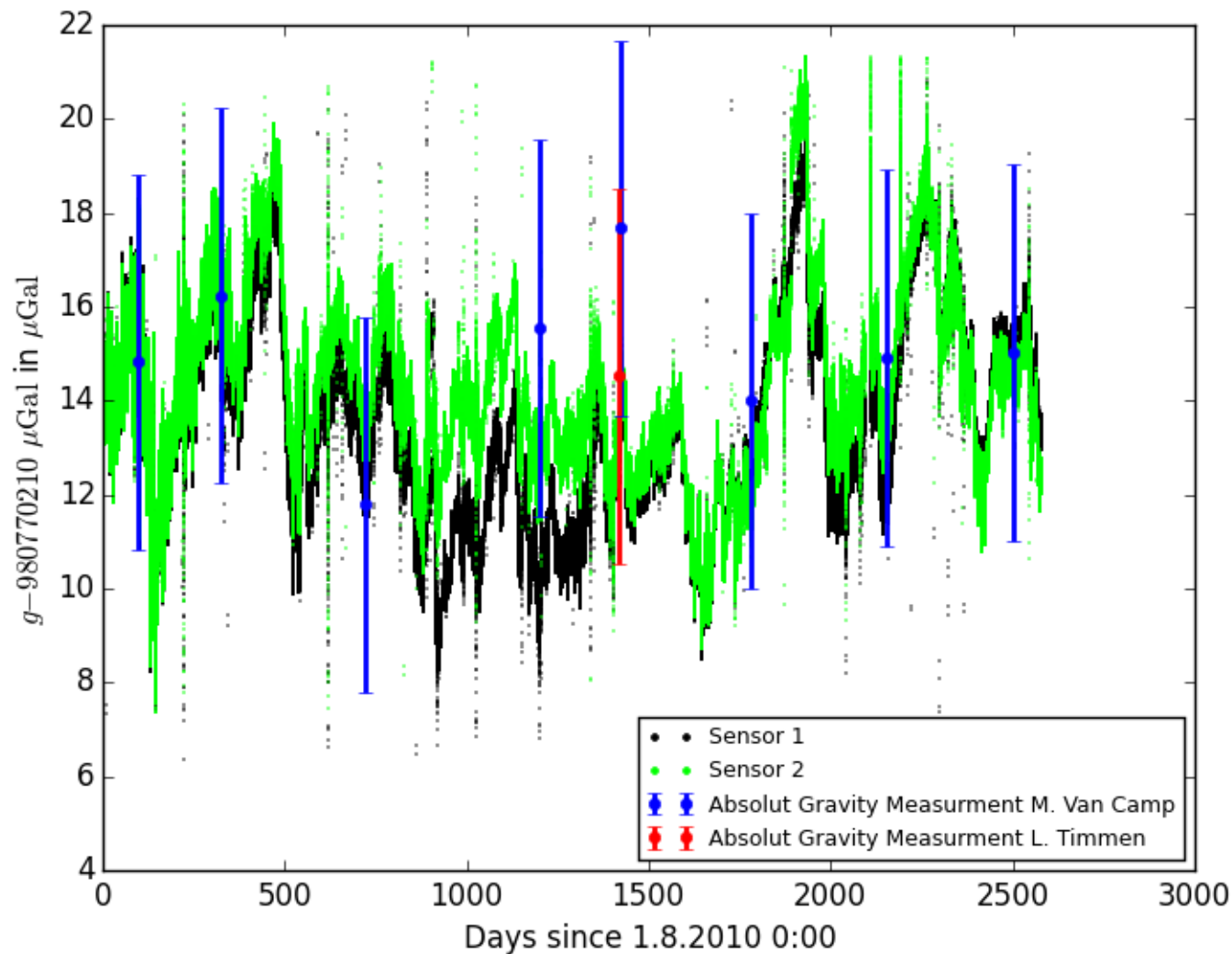
■ No Trend visible

■ Trend < $0.7 \mu\text{Gal}/\text{year} \approx \left(\frac{5 \mu\text{Gal}}{7 \text{ years}} \right)$



Comparison with absolute gravity data

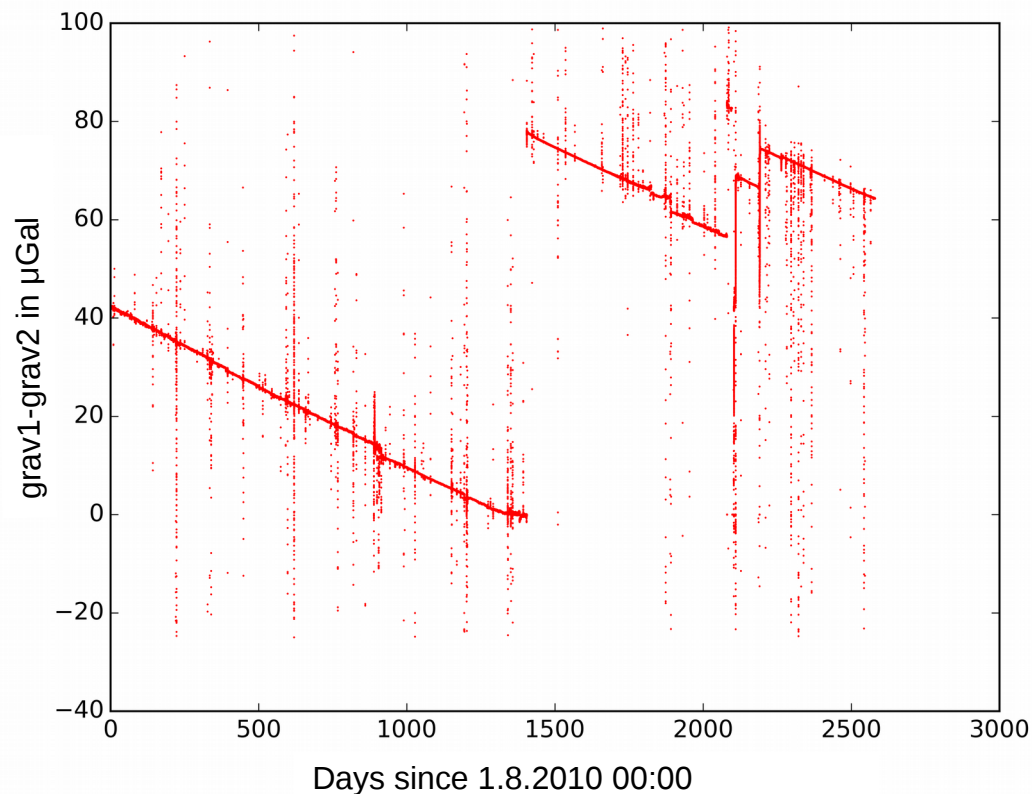
Data of Sensor 2 corrected with drift model



Comparison: Raw data vs. IGETS data

Difference between the signal of both sensors

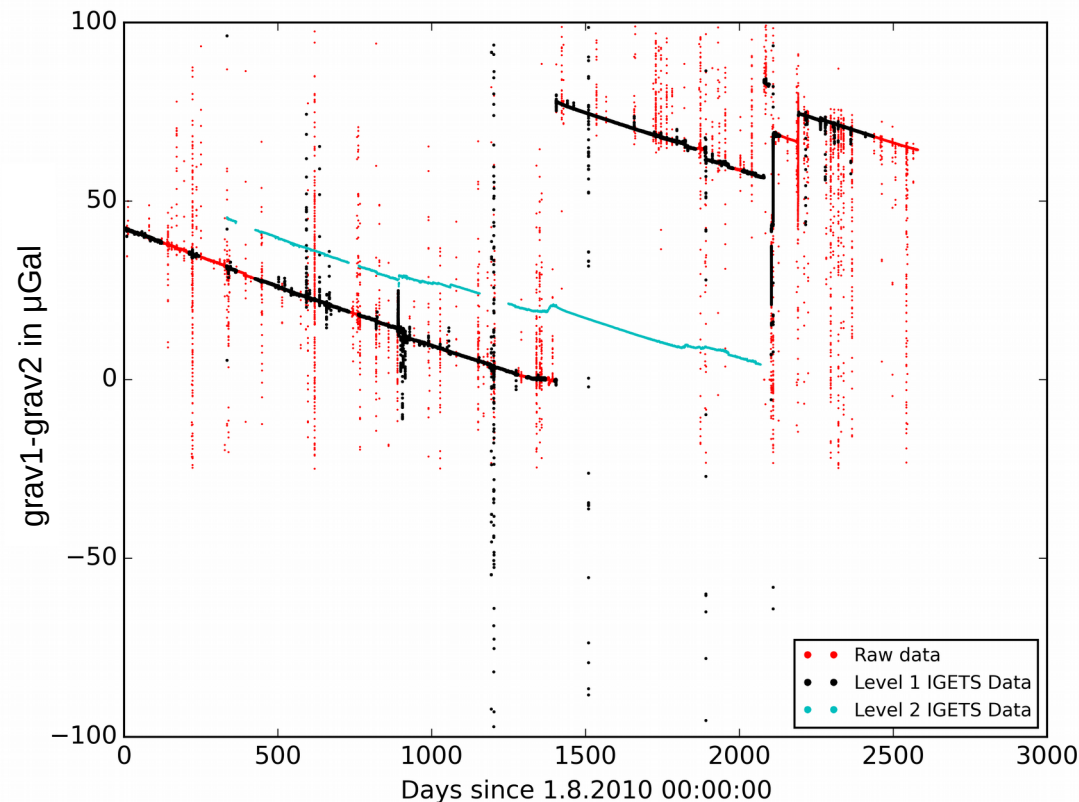
Raw data, sampling rate 1 min



Comparison: Raw data vs. IGETS data

Comparison with:

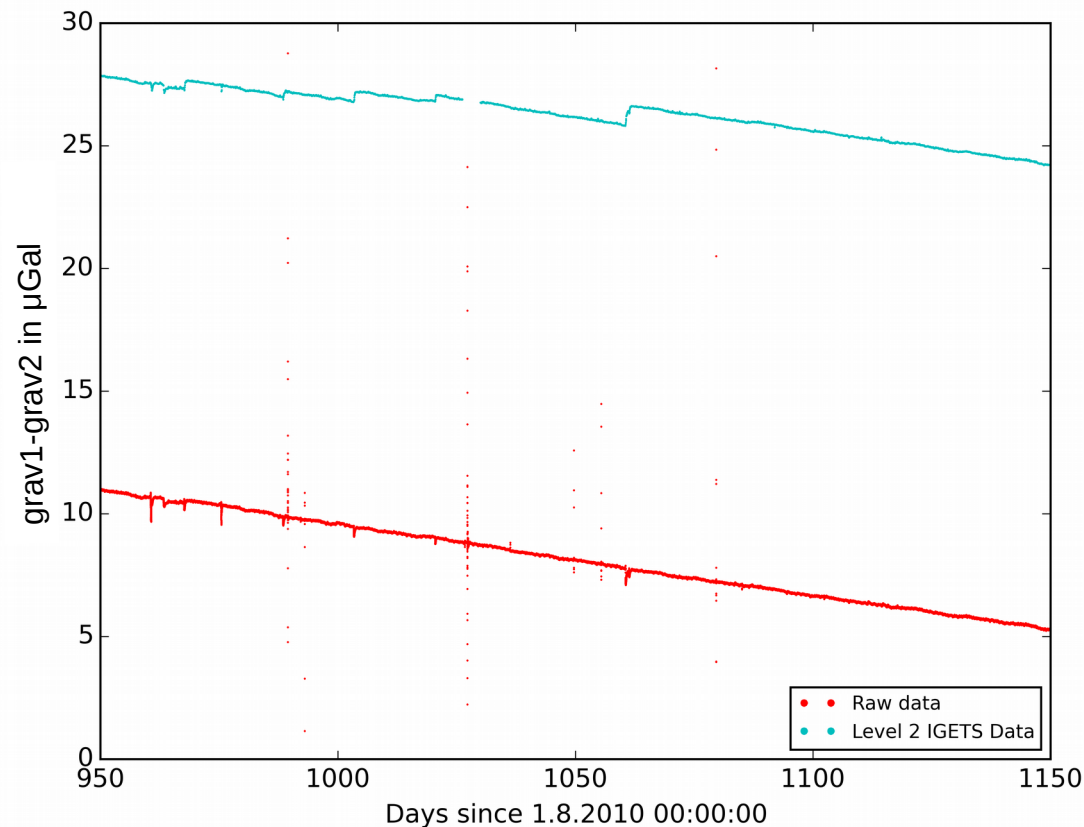
- IGETS level 1 data (sampling rate 1 min) (black)
- IGETS level 2 data (sampling rate 1 h) (cyan)



Comparison: Raw Data vs IGETS Data

Displayed time span: 8.3.2013 to 24.9.2013

- Raw data: red
- IGETS level 2 data: cyan

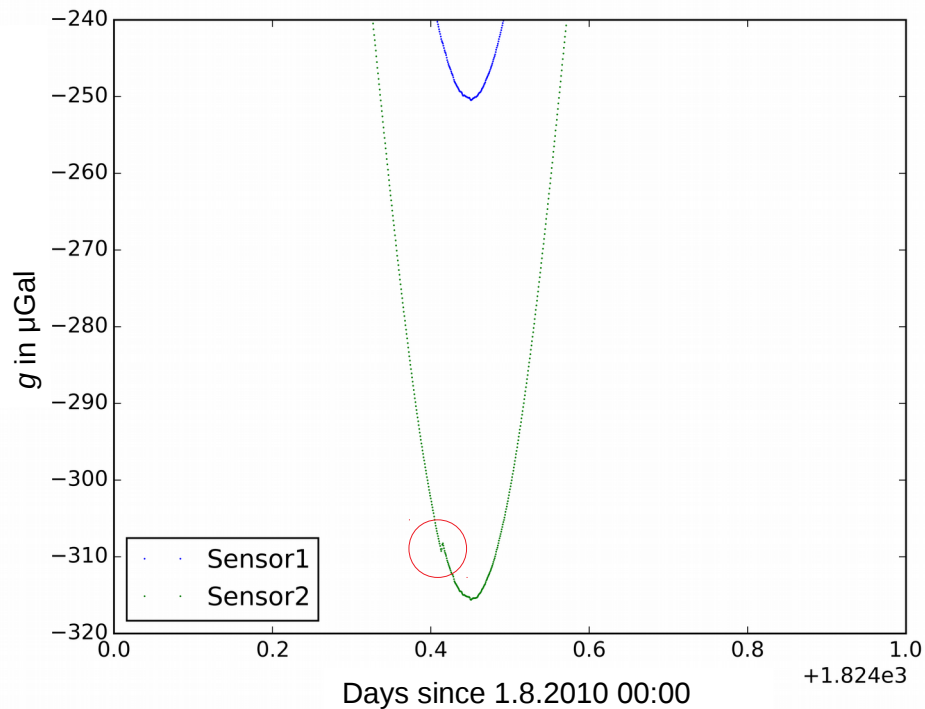


Very weak intervention causes step

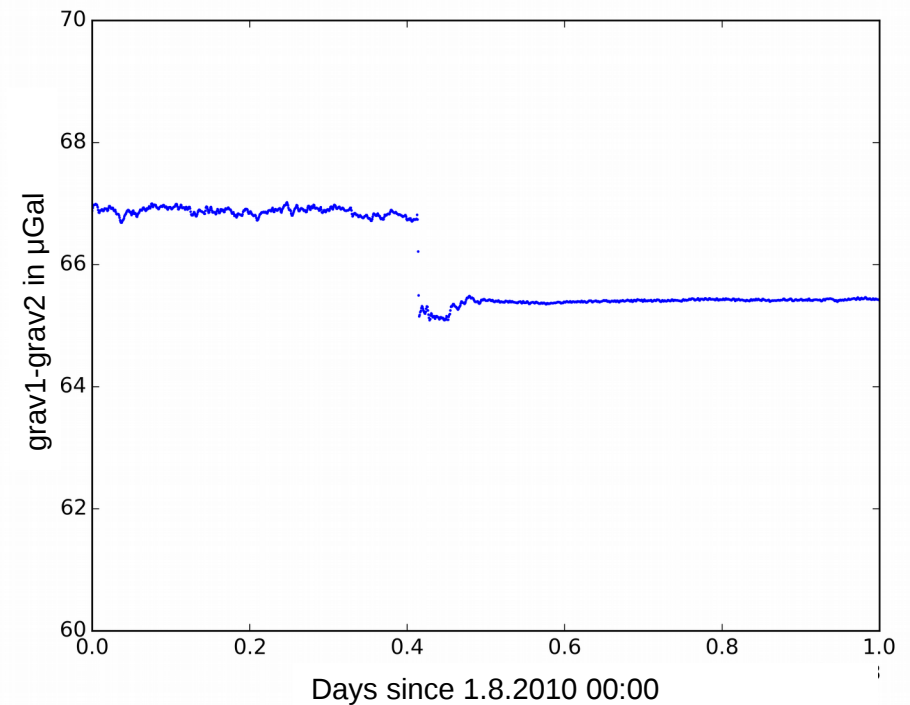
30.7.2015:

- Longer stay of 3 persons in the SG-chamber
- Door open for 2 h

Raw data of both sensors



Difference between both sensors

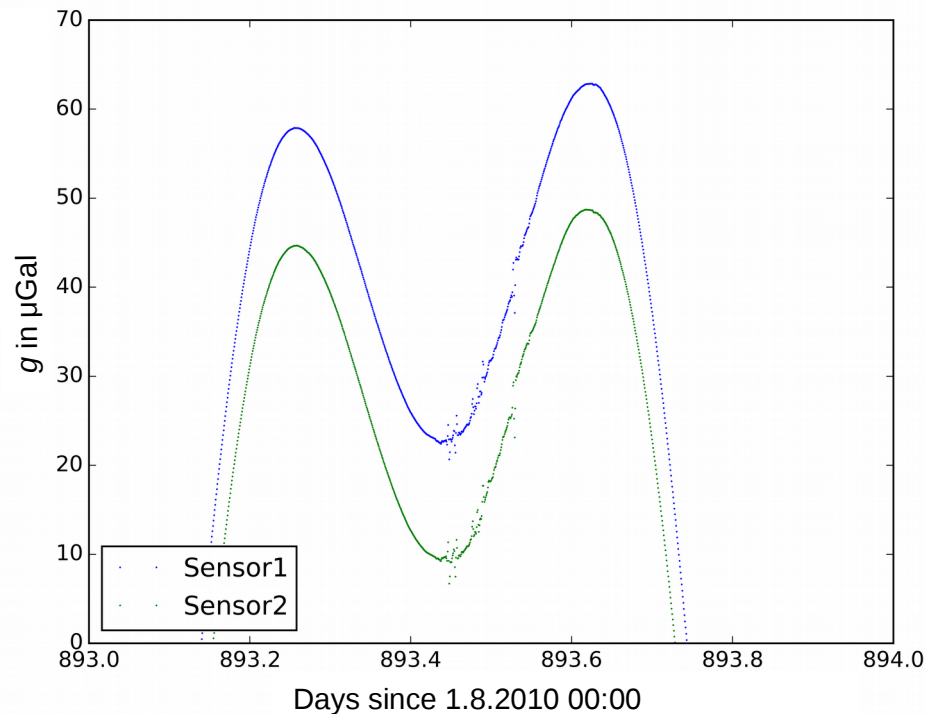


Big intervention causes comparatively small step

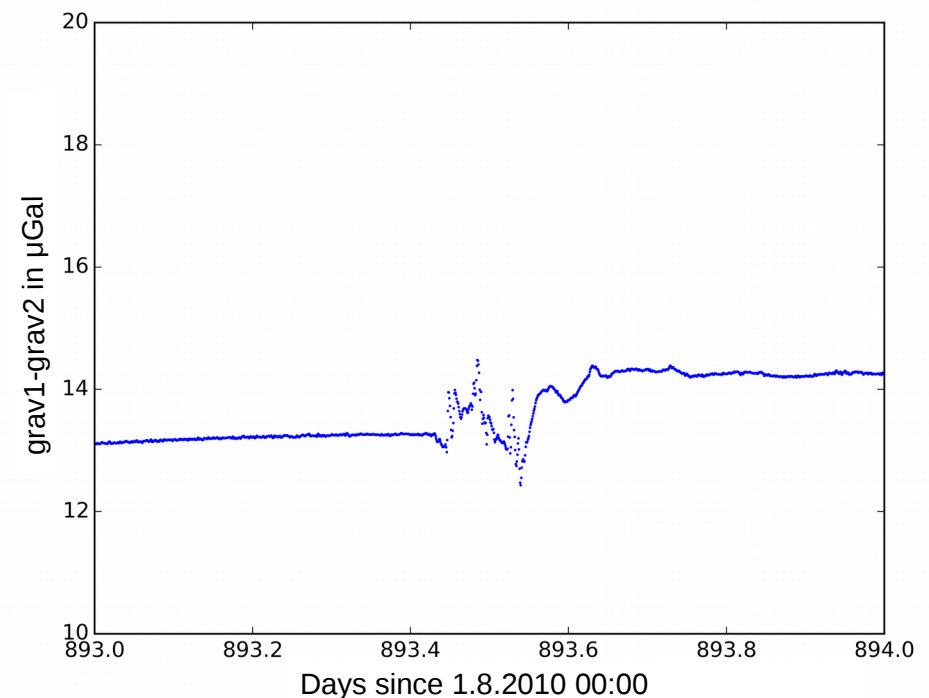
10.1.2013:

- Cold head got replaced
- Neck of dewar was purged with warm Helium gas

Raw data of both sensors



Difference between both sensors



- Sensor 1:
 - Practically no drift $\Rightarrow < 0.7 \mu\text{Gal/year}$
- Sensor 2:
 - Linear drift within margin of error
 - Drift: $(11.0 \pm 0.7) \mu\text{Gal/year}$
 - $\sim 2x$ as big as Membach, $\sim 100x$ as big as Brussels
(*Crossley et al. (2004)*)
- Steps in the difference of both sensors for IGETS data that do not occur in raw data
- Big interventions can cause comparatively small steps
- Very small interventions can cause steps

Thank you to...

...Michel van Camp for contributing absolute gravity measurements

... Ludger Timmen for contributing absolute gravity measurements and for providing an assessment of the accuracy of absolute gravity measurements

Different step size estimations

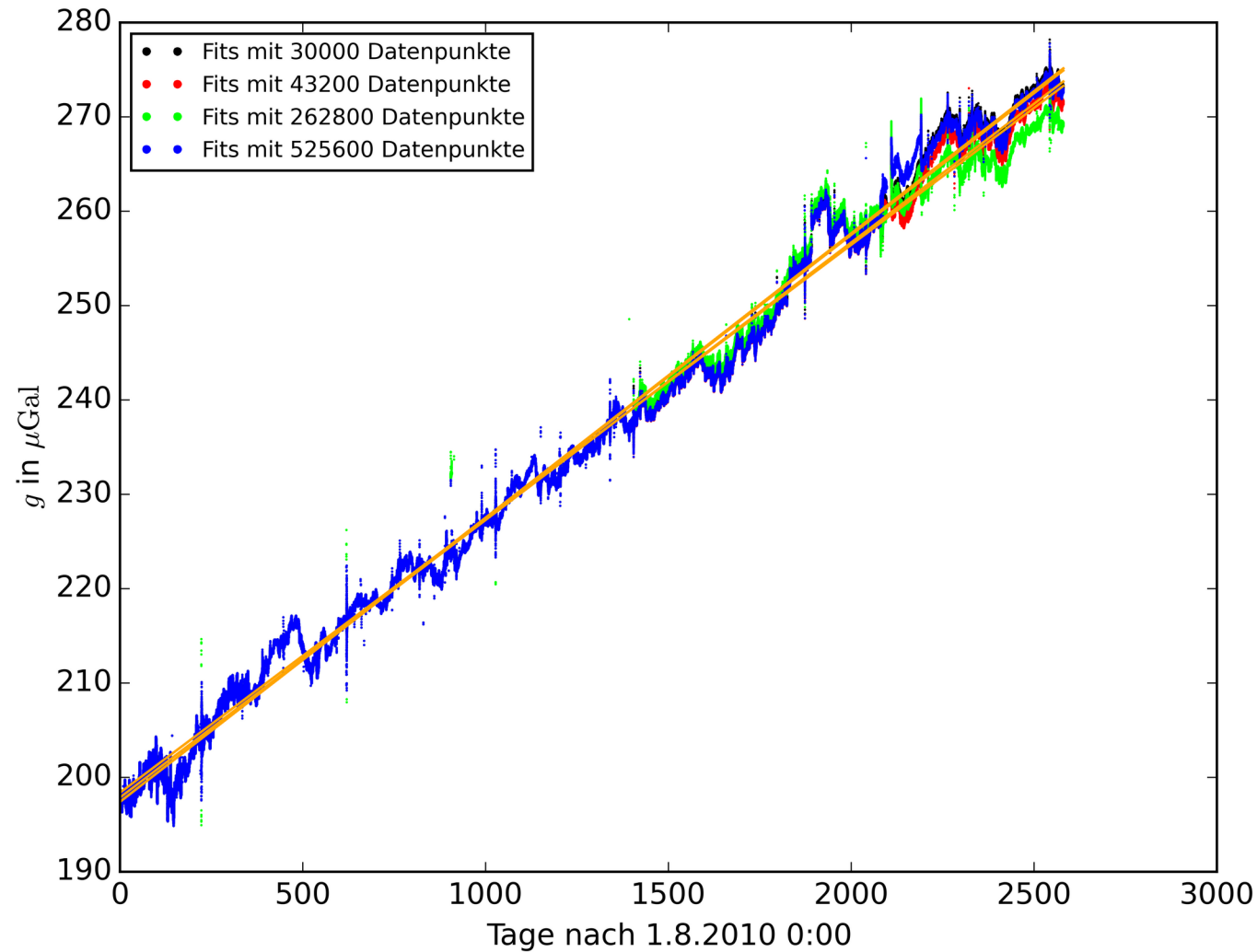
Sensor 1:

Zeitpunkt	Datum	Sprunghöhe in μGal bei Fits aus x Datenpunkten			
		$x = 30000$	$x = 43200$	$x = 262800$	$x = 525600$
1404,4604	05.06.2014	-90,30	-89,64	-90,73	-89,06
2080,0632	11.04.2016	-81,15	-81,02	-78,86	-82,72
2096,9306	27.04.2016	455,67	457,04	454,87	454,87
2189,9472	29.07.2016	-77,42	-77,45	-73,36	-73,59

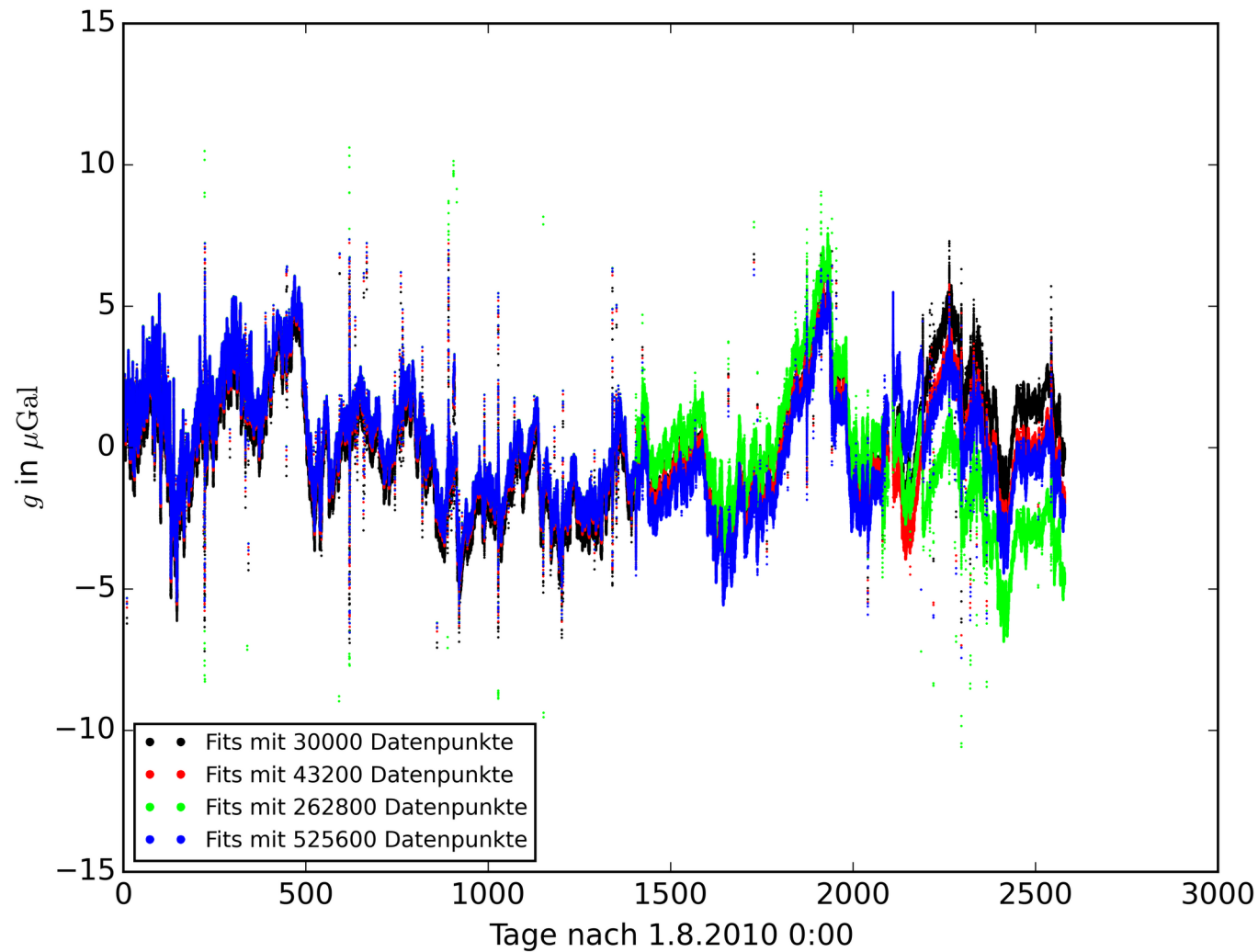
Sensor 2:

Zeitpunkt	Datum	Sprunghöhe in μGal bei Fits aus x Datenpunkten			
		$x = 30000$	$x = 43200$	$x = 262800$	$x = 525600$
1404,4604	05.06.2014	-168,39	-167,85	-169,08	-167,89
2080,0625	11.04.2016	-107,85	-107,82	-105,73	-110,09
2096,9306	27.04.2016	468,84	470,18	467,99	467,99
2189,9500	29.07.2016	-84,71	-84,95	-81,29	-81,68

Different Step Corrections Sensor 2

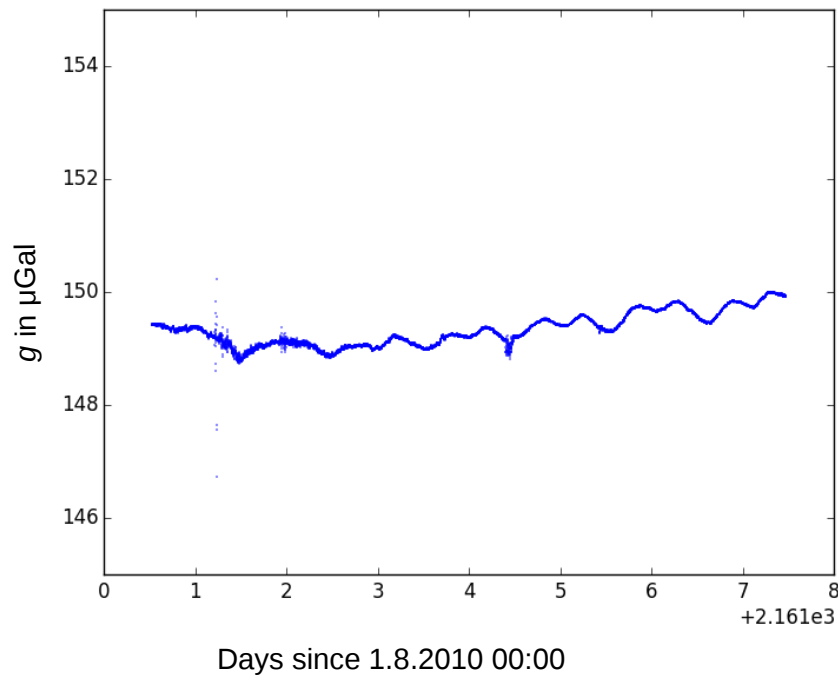


Different Steps Corrections Sensor 1

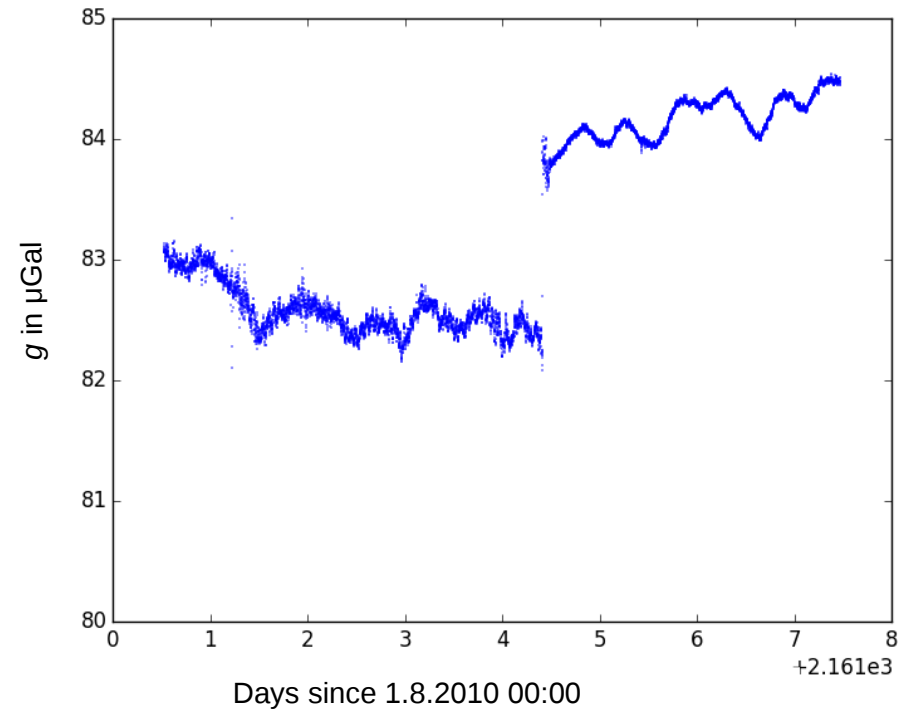


Corrected Data 30.7.2015

Sensor 1



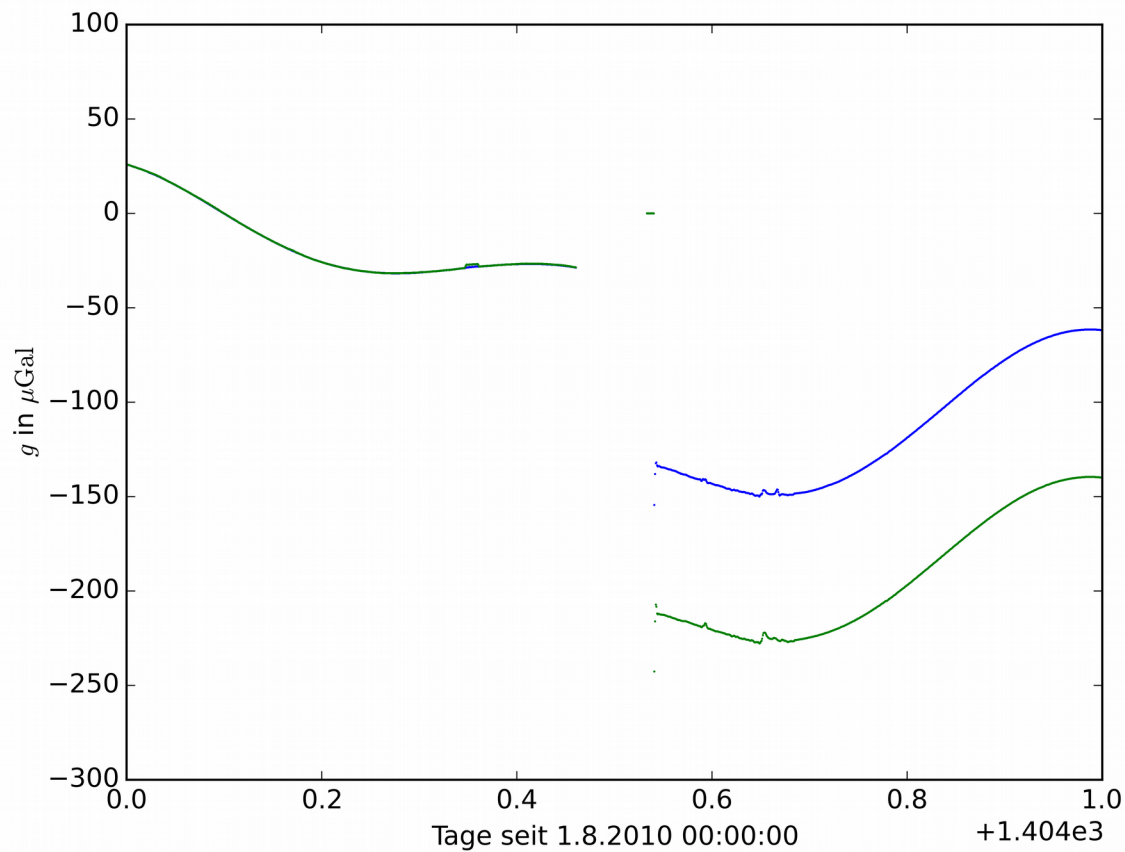
Sensor 2



Causes for steps

■ 5.6.2014:

- 2h Stromausfall
- Kühkopf mit Helium gespült



Causes for steps

21.1.2013:

- Fußschrauben verdreht um Vertikalität neu zu justieren

