CHALMERS

The Superconducting Gravimeter's first eight months

OSO-FGS Fundamental Geodetic Station
Onsala Space Observatory

Hans-Georg Scherneck

March 2010

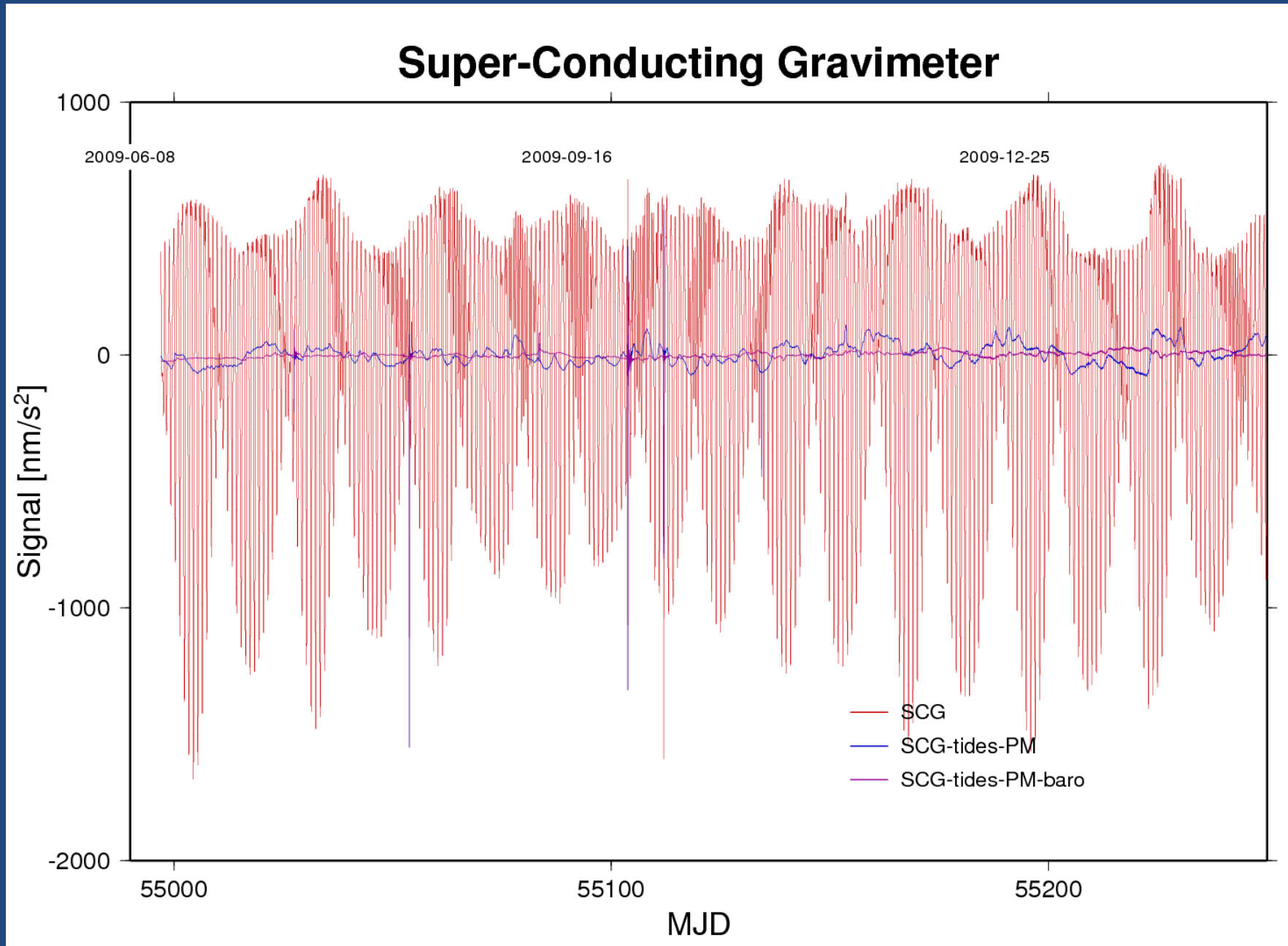
Overview

Events:

- Installation June 2-12
- In operation since June 15
- Calibration campaigns
  - July, FG5 233 ”Greta”
  - Nov., FG5 220 IfE Hannover

Working themes:

- Gravimetric tie to the old pillar
- Data flow
- Ancillary sensors
- Establish FGS parameters
  - Tides
  - Atmospheric loading coeff.
  - Drift
- Characterise performance


Super-Conducting Gravimeter
1000
0
-1000
-2000
2009-06-08
2009-09-16
2009-12-25
Signal [nm/s²]
SCG
SCG-tides-PM
SCG-tides-PM-baro
55000
55100
55200
MJD

Tide analysis

1. Tidal least-squares, high-passed $g(t)$ -> TM1
2. Subtract:

   g(t) - [TM1 + const * (LPtides + PolMot)] -> R1(t)

3. Estimate drift = $a_1 (t-t_0) + a_2 \exp(-t/a_3)$

4. Tidal + Baro least-squares of $g(t)$ - PolMot – drift -> TM2
5. Subtract:

   g(t) - [TM2 + const * (VLPtides + Polmot) + drift] -> R2(t)

Iterate Tide model TM*n* and residual R*n*

Every ”tidal least-squares” includes an outlier iteration (crit: > 7σ)

RESULTS: ADMITTANCES, LOCAL COPHASES

SITE/FILE: MC0906-10m.ts lon/lat: 11.9260 57.3964

Normalized Chi^2 of fit : 5.01D+01, R= 7.08D+00 , X_1 X_2 = 1.00 2.30, Nev=47
The error information below is compatible with a unit normalized Chi^2.
<rslist>d> rmsu= 7.08044252198473 weff= 1.00000000000000 rchi= 1.00064262960750

	#b	Dominating tide argum.numbers	Frequ. [cyc/d]	Amplit. [m]	Phase [deg]	Co..admittance parameter..Quad +- 68.3% conf		Gain	Cophase	
Ssl	1	2 0 0 2 0 0 0 0	0.0054758	1.095D-02	346.8	-0.942979 +-0.002495	0.449899 +-0.002444	1.044806	-25.51	Ssl
Mm	3	2 0 1 0-1 0 0 0	0.0362916	1.243D-02	61.8	-1.190973 +-0.002133	-0.089322 +-0.002165	1.194318	4.29	Mm
Mf	5	2 0 2 0 0 0 0 0	0.0732022	2.354D-02	159.6	-1.147035 +-0.000908	-0.005515 +-0.000907	1.147048	0.28	Mf
Mt	7	2 0 3 0-1 0 0 0	0.1094938	4.508D-03	41.5	-1.132616 +-0.004428	0.010693 +-0.004421	1.132666	-0.54	Mt
Sig1	9	2 1-3 2 0 0 0-1	0.8618093	2.819D-03	212.8	-1.143102 +-0.006250	0.026052 +-0.006243	1.143399	-1.31	Sig1
Q1	11	2 1-2 0 1 0 0-1	0.8932441	1.765D-02	143.8	-1.138095 +-0.002269	0.007639 +-0.002268	1.138120	-0.38	Q1
O1	13	2 1-1 0 0 0 0-1	0.9295357	9.219D-02	25.6	-1.142307 +-0.000300	-0.002410 +-0.000299	1.142309	0.12	O1
M1	15	2 1 0 0 1 0 0 1	0.9664463	7.246D-03	303.4	-1.140772 +-0.010760	-0.010807 +-0.010774	1.140823	0.54	M1
P1S1	17	2 1 1-2 0 0 0-1	0.9972621	4.269D-02	198.5	-1.153565 +-0.000621	-0.002276 +-0.000621	1.153567	0.11	P1S1
K1	19	2 1 1 0 0 0 0 1	1.0027379	1.275D-01	185.4	-1.153656 +-0.000200	-0.000701 +-0.000200	1.153656	0.03	K1
J1	21	2 1 2 0-1 0 0 1	1.0390296	7.262D-03	67.2	-1.158730 +-0.006162	0.002881 +-0.006153	1.158733	-0.14	J1
OO1	23	2 1 3 0 0 0 0 1	1.0759401	3.973D-03	165.0	-1.139578 +-0.004801	-0.005688 +-0.004809	1.139592	0.29	OO1
3N2	25	2 2-3 2 1 0 0 0	1.8282556	5.286D-04	156.3	-1.146202 +-0.042601	-0.006653 +-0.042615	1.146221	0.33	3N2
2N2	27	2 2-2 2 0 0 0 0	1.8645472	2.187D-03	38.1	-1.117916 +-0.010463	-0.026207 +-0.010460	1.118223	1.34	2N2
N2	29	2 2-1 0 1 0 0 0	1.8959820	1.370D-02	329.1	-1.164963 +-0.005575	-0.047430 +-0.005571	1.165928	2.33	N2
M2	31	2 2 0 0 0 0 0 0	1.9322736	7.154D-02	211.0	-1.176871 +-0.000408	-0.026457 +-0.000408	1.177168	1.29	M2
L2	33	2 2 1 0-1 0 0 2	1.9685653	2.022D-03	272.8	-1.199513 +-0.031013	-0.004430 +-0.031029	1.199521	0.21	L2
S2	35	2 2 2-2 0 0 0 0	2.0000000	3.329D-02	23.8	-1.169986 +-0.000757	-0.007076 +-0.000757	1.170007	0.35	S2
K2	37	2 2 3 0-1 0 0 0	2.0417675	5.058D-04	72.5	-1.153710 +-0.039268	-0.033387 +-0.039274	1.154193	1.66	K2
3 1	39	3 1 0 0 0 0 0 2	0.9661368	1.769D-03	105.5	-1.071653 +-0.038717	-0.008061 +-0.038648	1.071683	0.43	3 1
3 2	41	3 2-1 0 0 0 0 1	1.8956725	9.786D-04	311.1	-1.111361 +-0.047033	0.009224 +-0.047002	1.111399	-0.48	3 2
M3	43	3 3 0 0 0 0 0 2	2.8984104	5.067D-04	136.5	-1.065533 +-0.033300	-0.020659 +-0.033315	1.065733	1.11	M3
BARO	45	<~/TD/d/MC0906-10m.ts>				-3.180200 +-0.003403				BARO
/	46	Linear [nm/s^2]/(36289*1.66667D-01[h])				23.562263 +-0.130168				/
/	46	Linear [nm/s^2]/[year]				34.150315 +-0.188662				/
--	47	Const 1.000D+00				0.060961 +-0.037248				

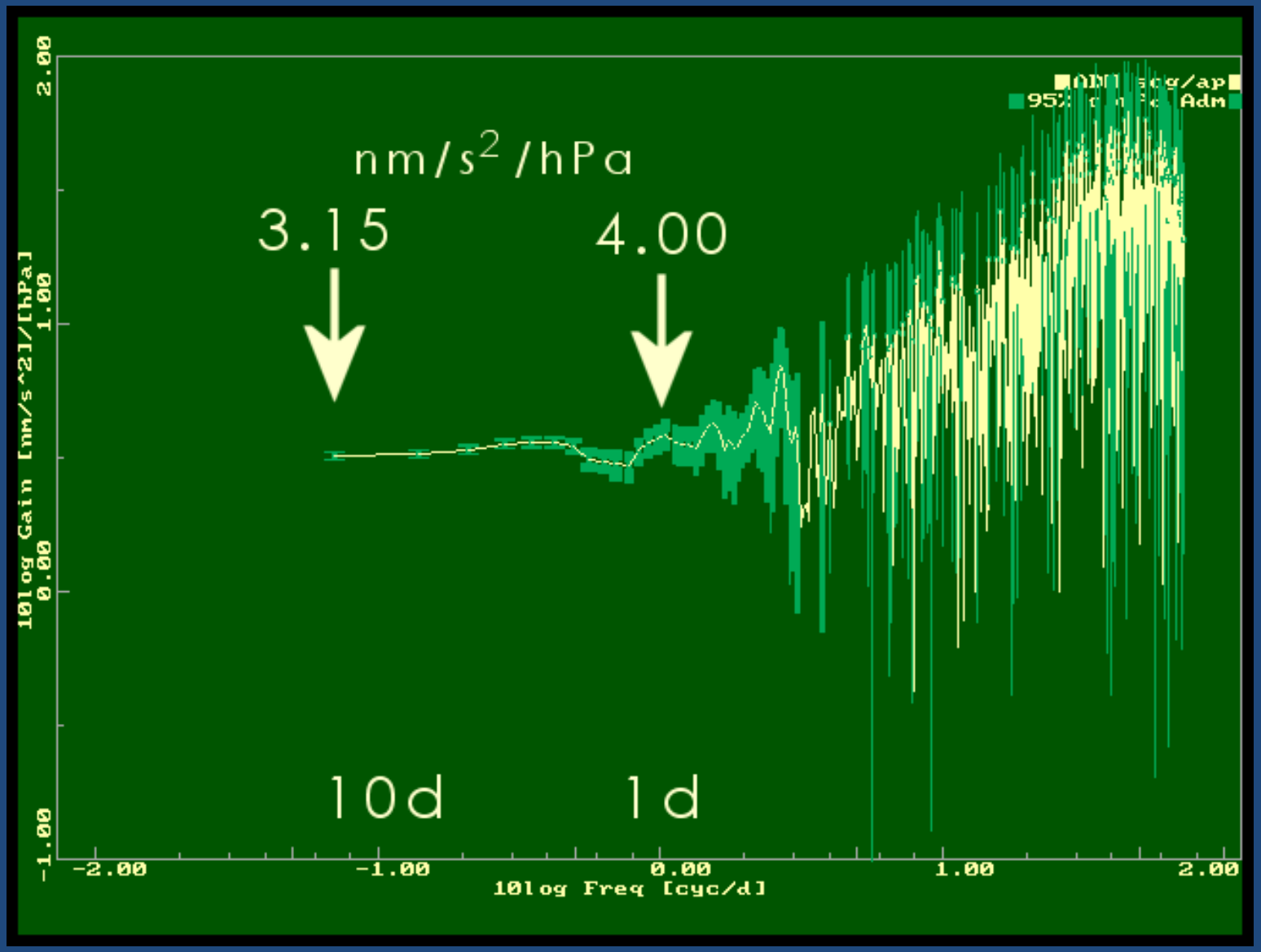
Barom. coeff. -3.1802 ± 0.0034 nm/s^2 / hPa

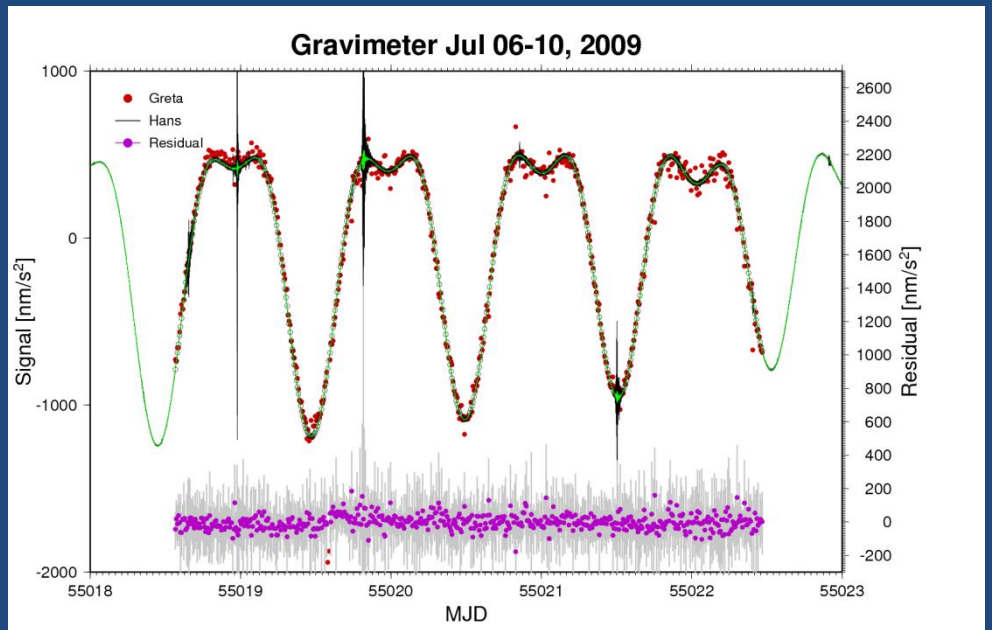
OBS!
δ-factors need verification whether they comply with the Wahr-Dehant convention)

Additional linear drift +34 nm/s^2/yr
a-priori applied -108

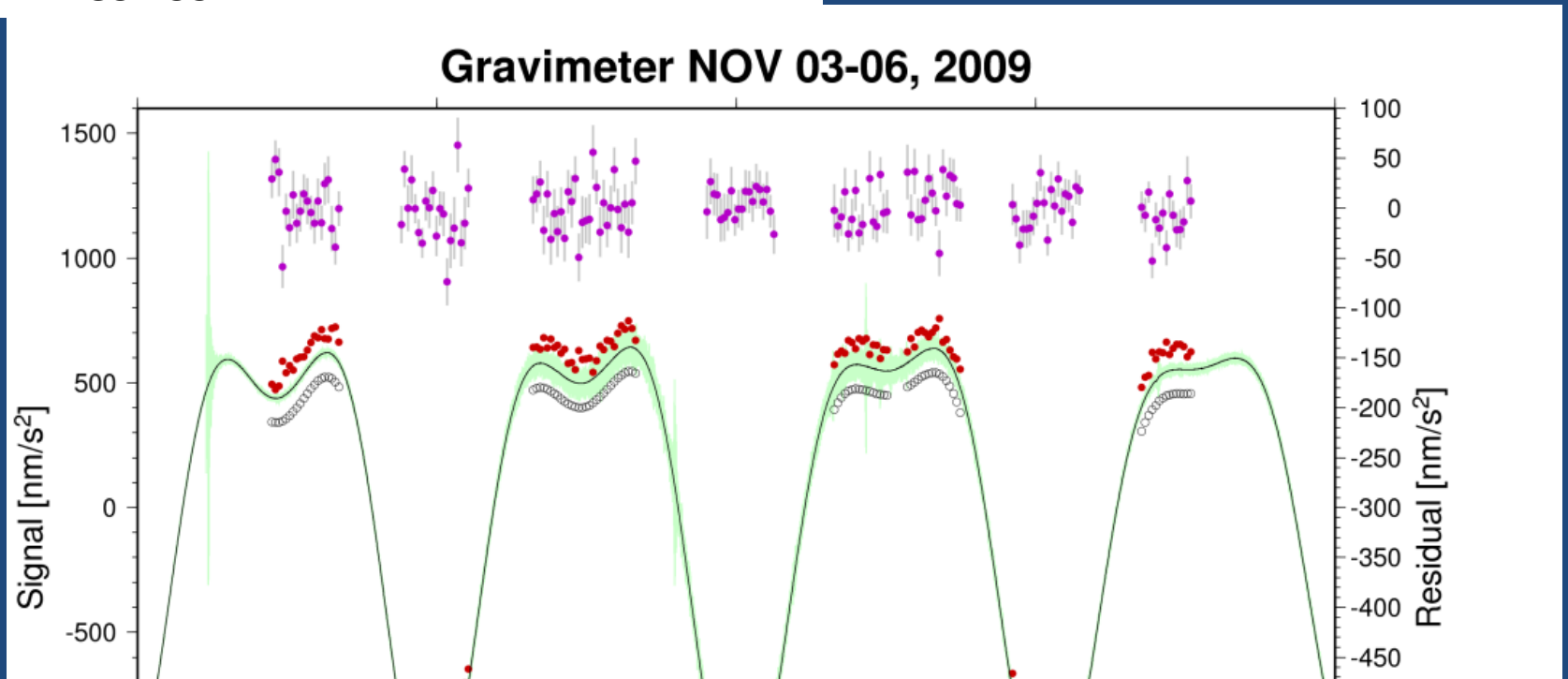
-74 nm/s^2/yr

Gravity/Barometer Gain Spectrum




Gravimeter Jul 06-10, 2009
Greta
Hans
Residual
Signal [nm/s²]
Residual [nm/s²]
MJD
1000
0
-1000
-2000
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
55018
55019
55020
55021
55022
55023

LMV FG5 233


Gravimeter NOV 03-06, 2009
Signal [nm/s²]
Residual [nm/s²]
1500
1000
500
0
-500
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450

Calibration results

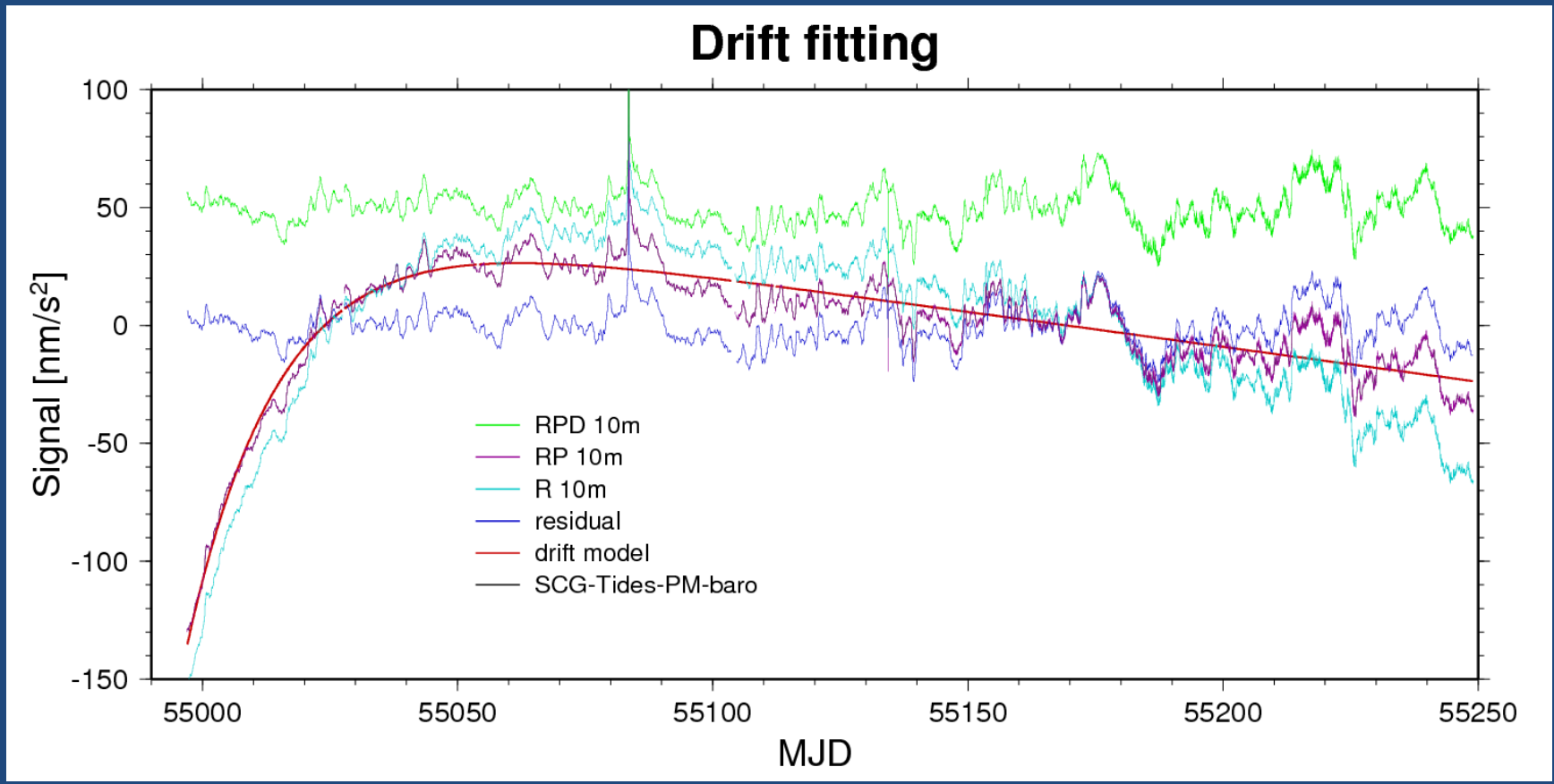
FG5-233: -776.2 ± 2.9 (0.37%)

FG5-220: -776.0 ± 1.5 (0.19%)

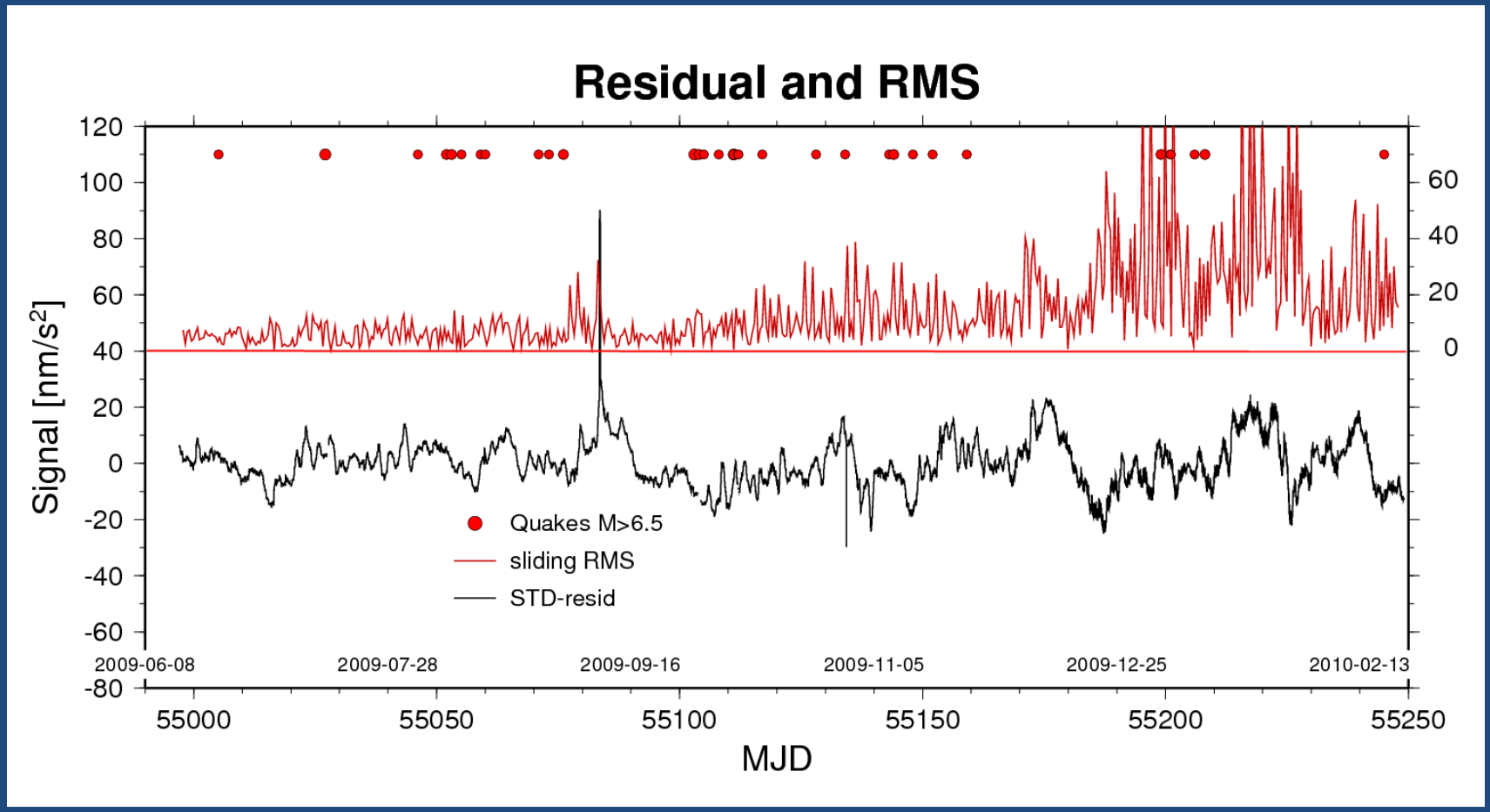
Drift

(-186.5 ±8.3) × exp{[t - (2009-06-15 01:10)] / (441 ±28)h }

+ (-108 ±4)/yr nm/s^2


Drift fitting
100
50
0
-50
-100
-150
Signal [nm/s²]
55000
55050
55100
55150
55200
55250
MJD
RPD 10m
RP 10m
R 10m
residual
drift model
SCG-Tides-PM-baro

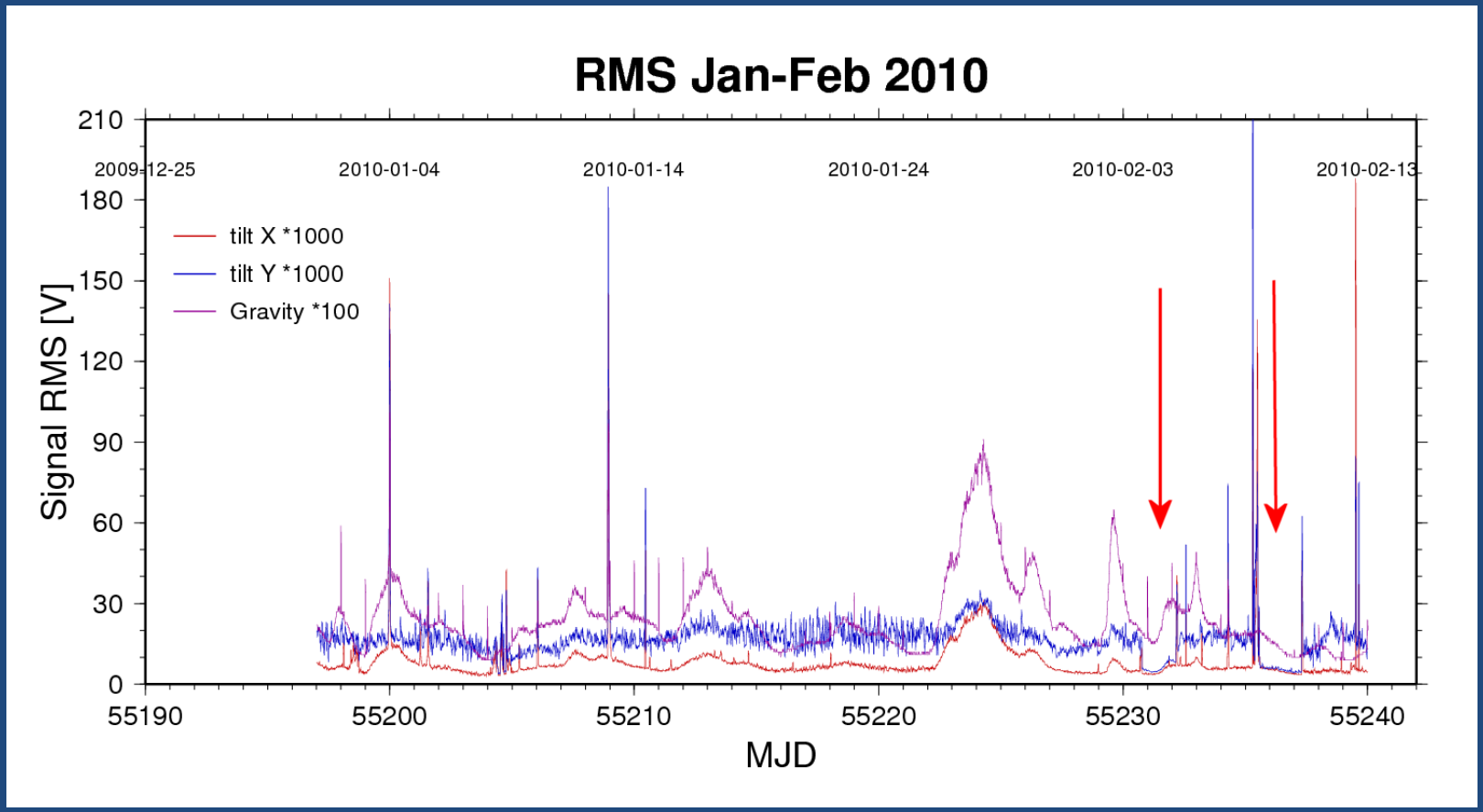
Residual


Residual and RMS
Signal [nm/s²]
120
100
80
60
40
20
0
-20
-40
-60
-80
60
40
20
0
Quakes M>6.5
sliding RMS
STD-resid
2009-06-08
2009-07-28
2009-09-16
2009-11-05
2009-12-25
2010-02-13
55000
55050
55100
55150
55200
55250
MJD

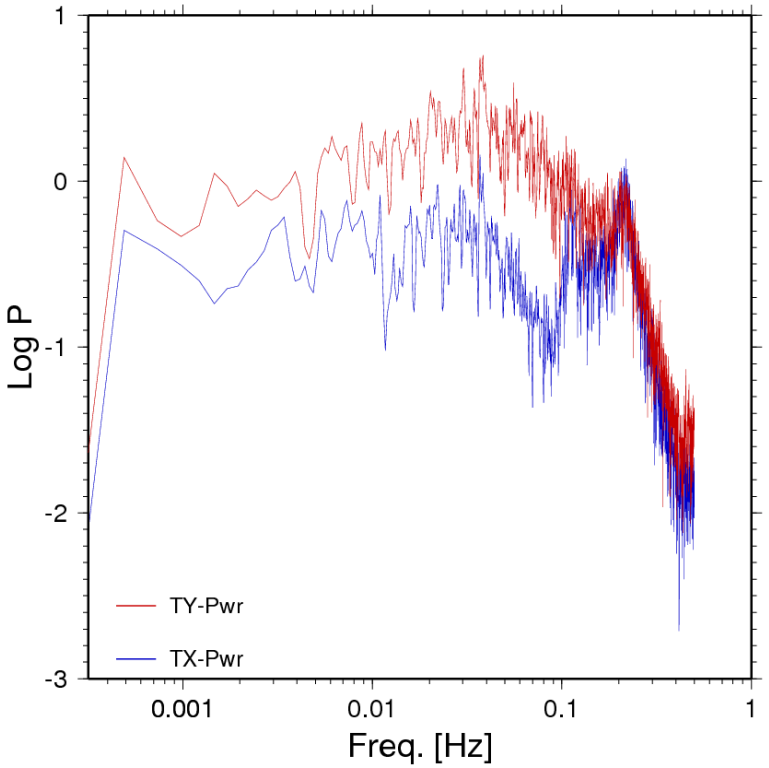
Performance

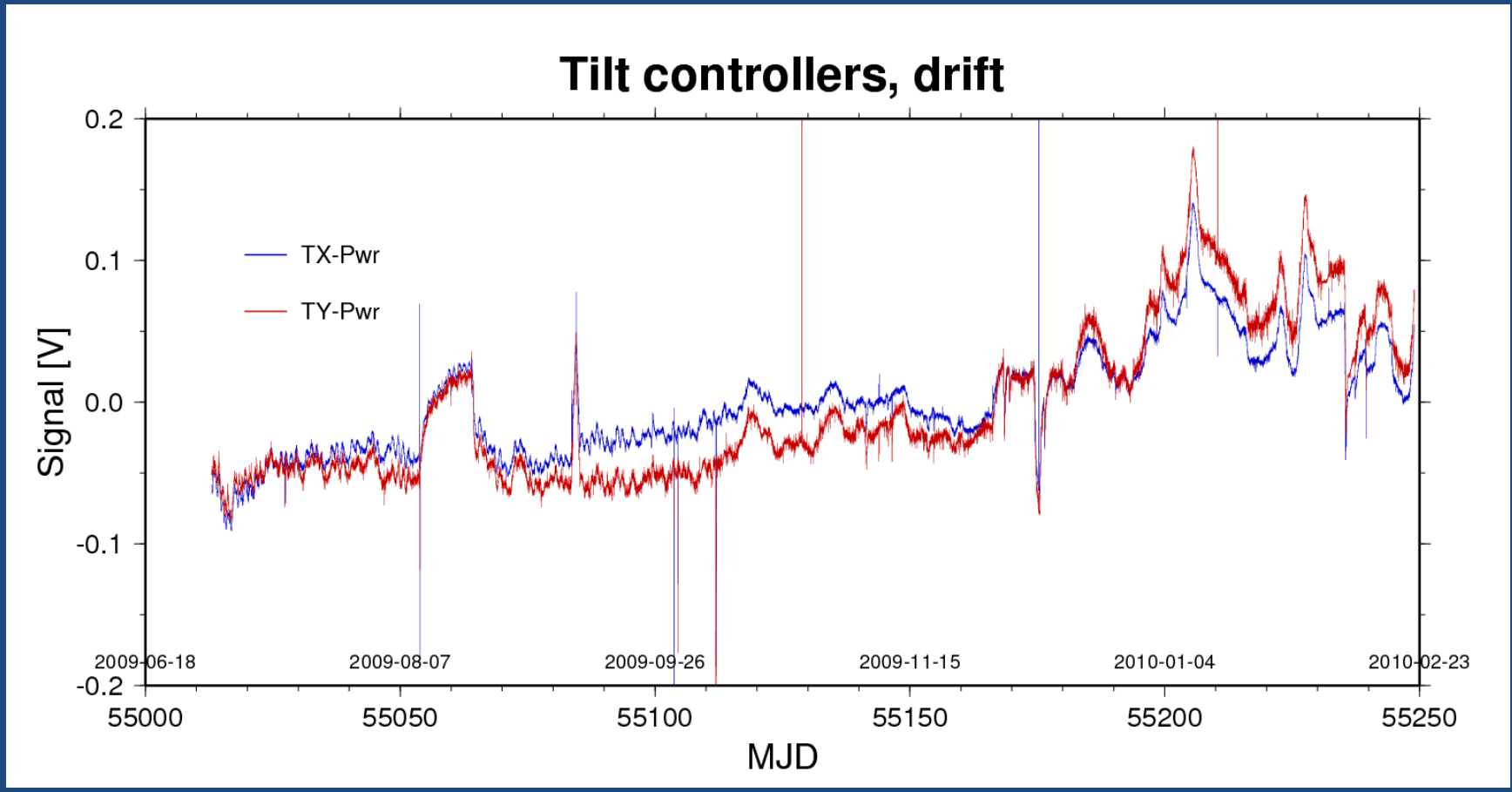
- Tilt control
- GPS timing
- Free Oscillations
- A curiosity

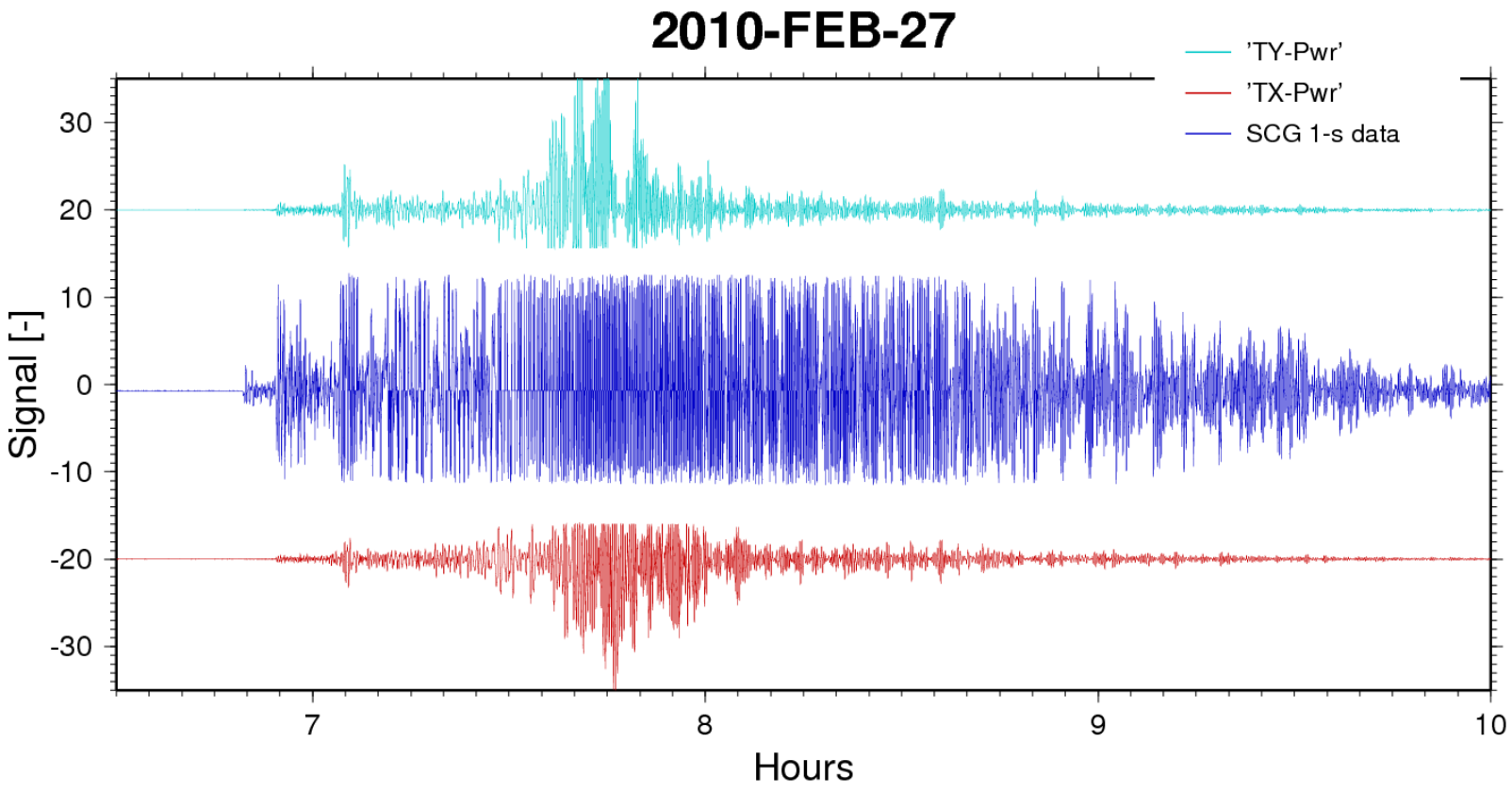
Tilt control

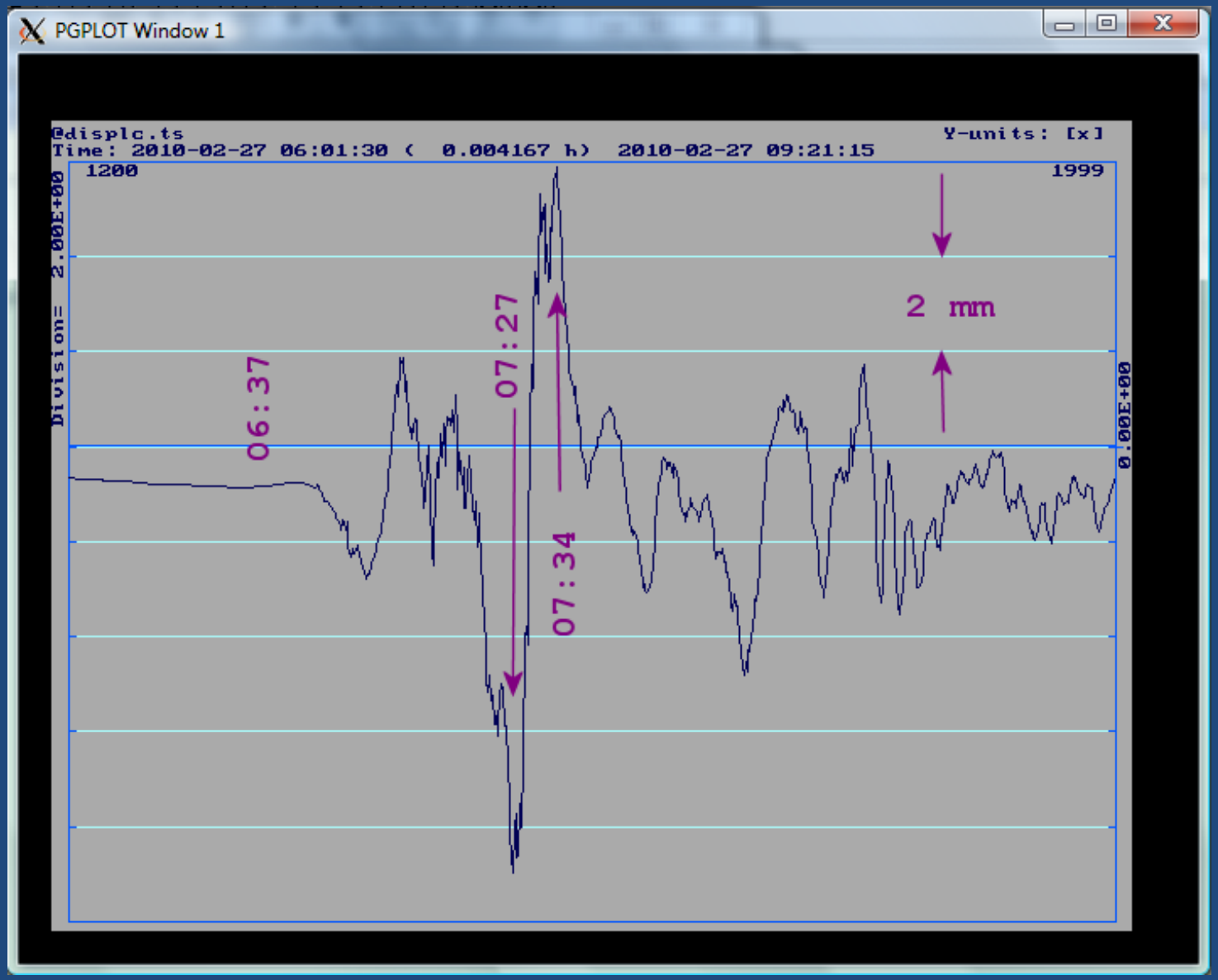


Tilt control

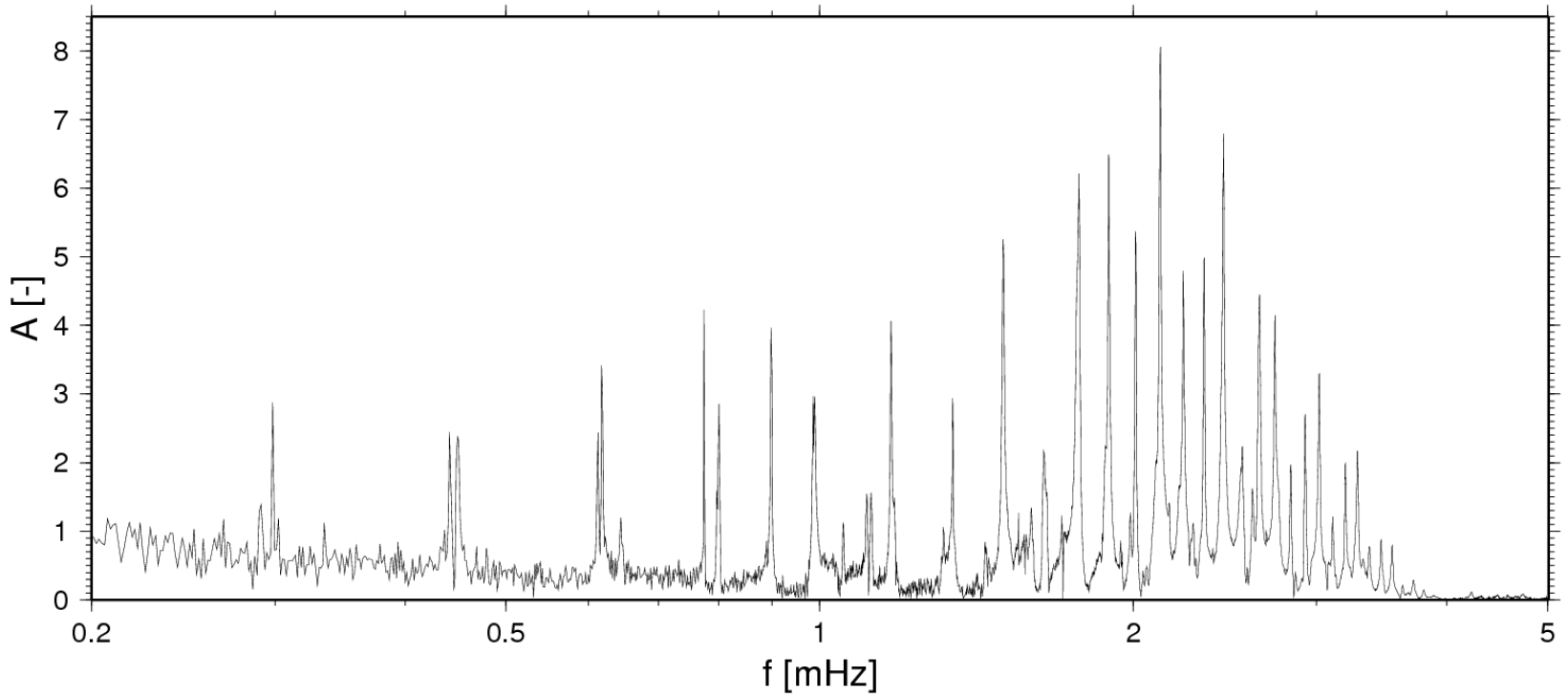



Tilt controllers, drift
TX-Pwr
TY-Pwr
Signal [V]
0.2
0.1
0.0
-0.1
-0.2
2009-06-18
2009-08-07
2009-09-26
2009-11-15
2010-01-04
2010-02-23
55000
55050
55100
55150
55200
55250
MJD


2010-FEB-27
'TY-Pwr'
'TX-Pwr'
SCG 1-s data
Signal [-]
30
20
10
0
-10
-20
-30
7
8
9
10
Hours


PGPLOT Window 1
@displc.ts
Time: 2010-02-27 06:01:30 (0.004167 h) 2010-02-27 09:21:15
Y-units: [x]
1200
1999
Division= 2.00E+00
0.00E+00
06:37
07:27
07:34
2 mm

Mode spectrum Chile Feb.27, 2010



A curiosity

- Antenna pointing – does the SCG feel it?
- Show `AntennaPointing.pdf`

http://www.oso.chalmers.se/~hgs/SCG/AntennaPointing.html

What's next

- Tidal phasor analysis
- Kattegat loading
- Air pressure loading 1D , 3D