Updated on 2016.6.3

Status report : about the Monolithic Accelerometers(ACCs) Test

❐ Goal

① Estimate the sensitivity of the ACC on(and off) the IP,
by comparing to L-4C geophone sensitivity, and 3 channel correlation analysis.
→ ~~Get the ACC's sensitivity limit at high frequencies.~~

② Confirm the controllability with the blending,
using the LVDTs and the ACCs.(mostly in same configuration with Sekiguchi-san's)

→ This test is to be done at BS hanging test.

❐ Due date

Mid of June, ~2016.6.18

→ Due date was changed to 2016.5.27

❐ Participants (mainly)

Joris, Fabian, Takahashi-san, Hirata-san, Fujii,

Updated on 2016.6.3

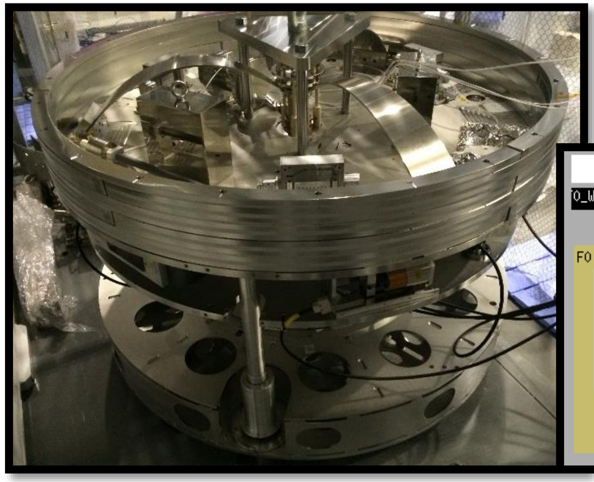
Status report : about the Monolithic Accelerometers(ACCs) Test

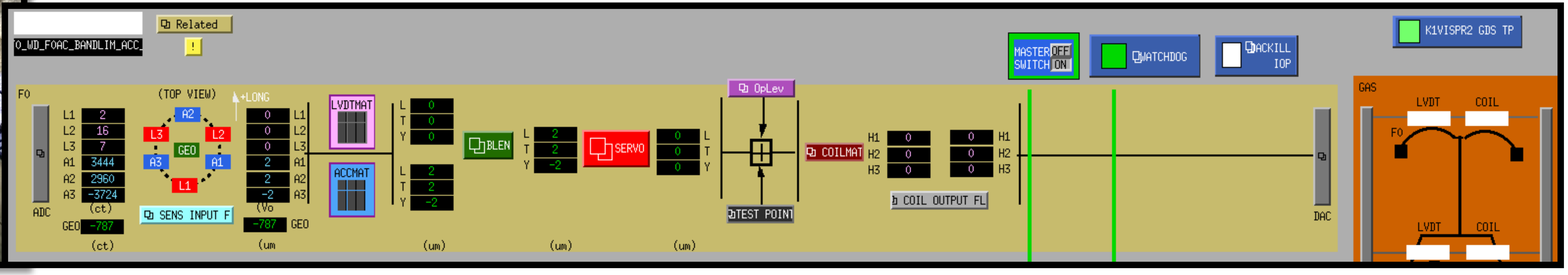
❒ What is done, at this stage ;

* Signals from 3 ACCs, 1 Geophone are monitored. (LVDTs are to be added within this month.)
* building the digital system, medm screen for this test. Excitation is able to be injected.
* Cups and metal board (not wooden board) are installed under the IP legs.
* Resonance frequency of the IP translational mode is tuned at ~440 mHz.
* ACC signals are calibrated.
* ACC-LVDT gains are increased.

I agree they are calibrated, but be sure to use my measurements as your LVDT readout seems not performing well, most probably because of the non-symmetry of the powersupply

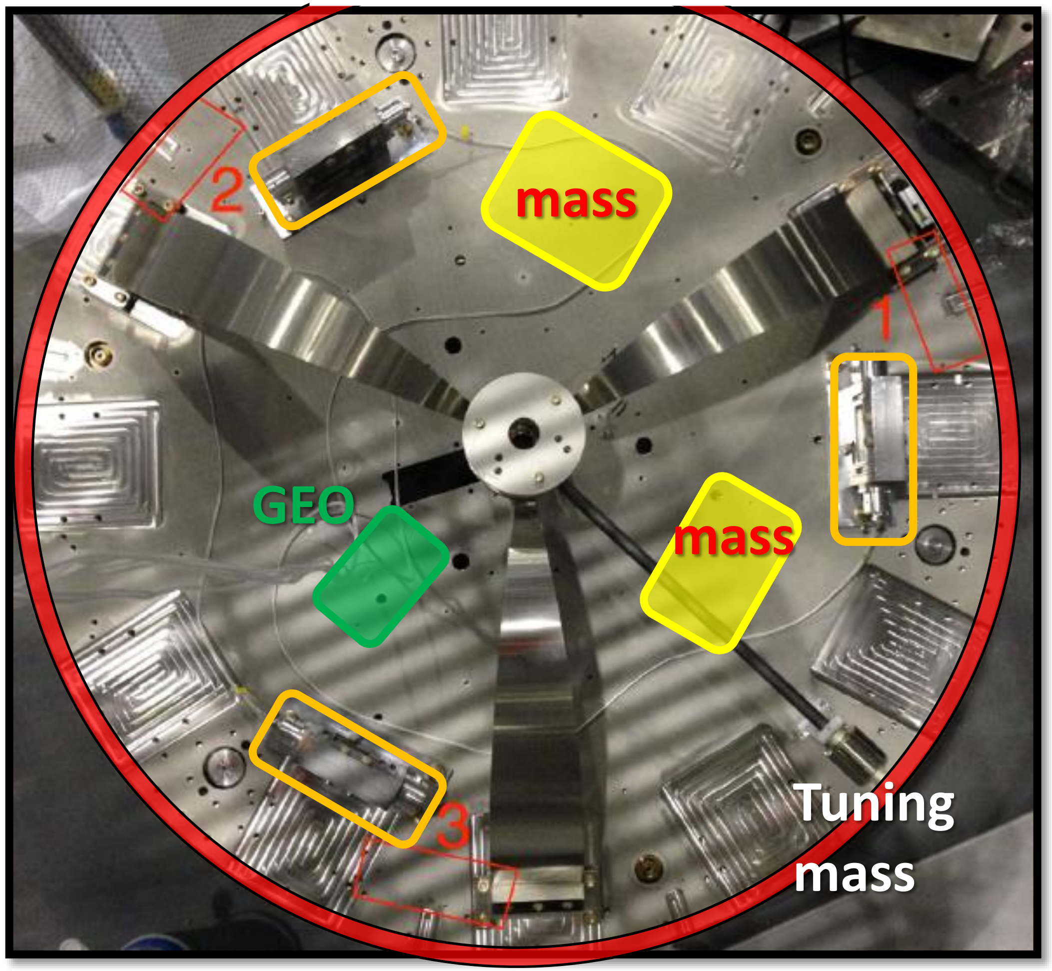
* All the geophone, the accelerometers were replaced on a optical table.



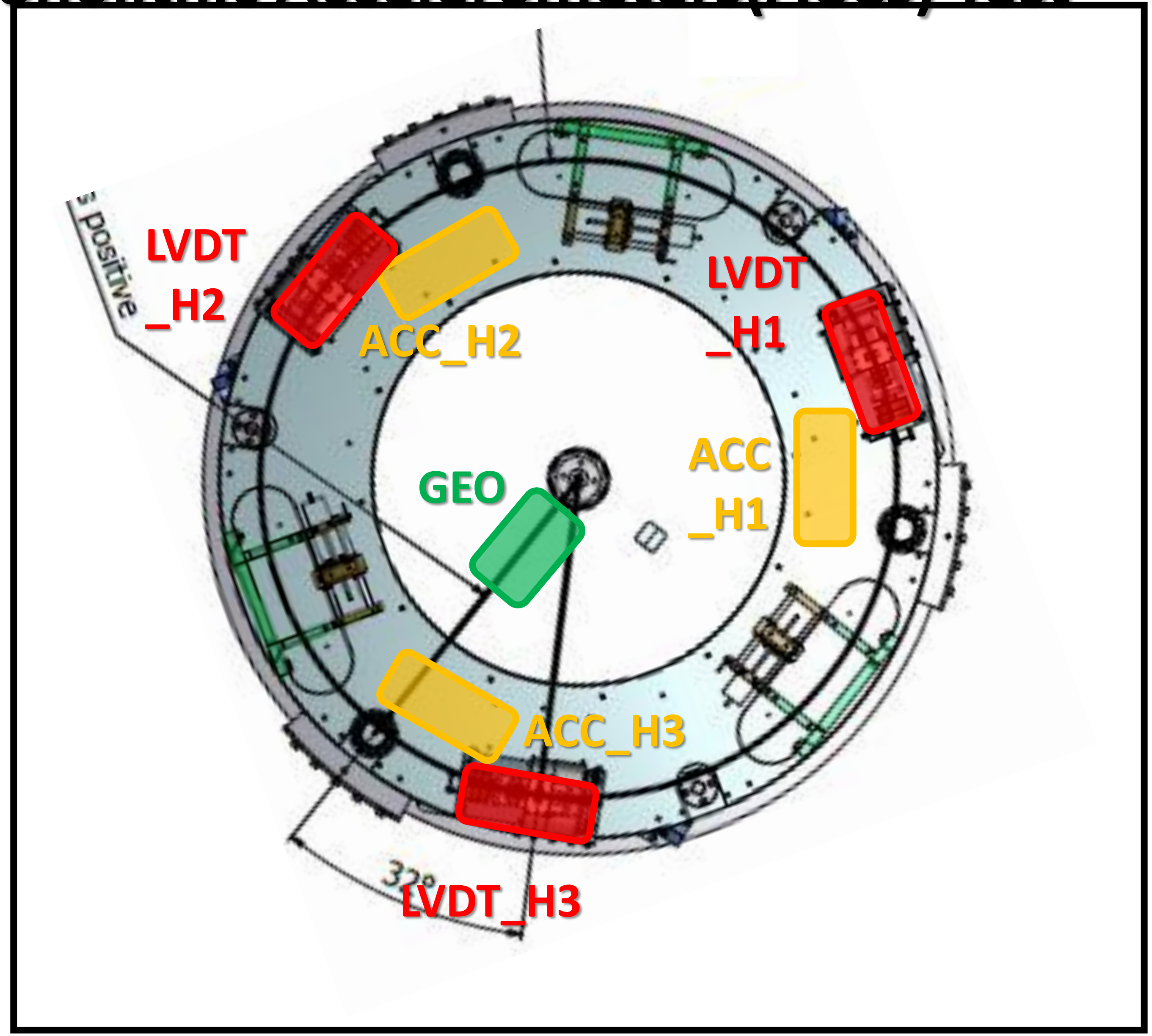


Status report : about the Monolithic Accelerometers(ACCs) Test

❐ **before 2016.5.25**

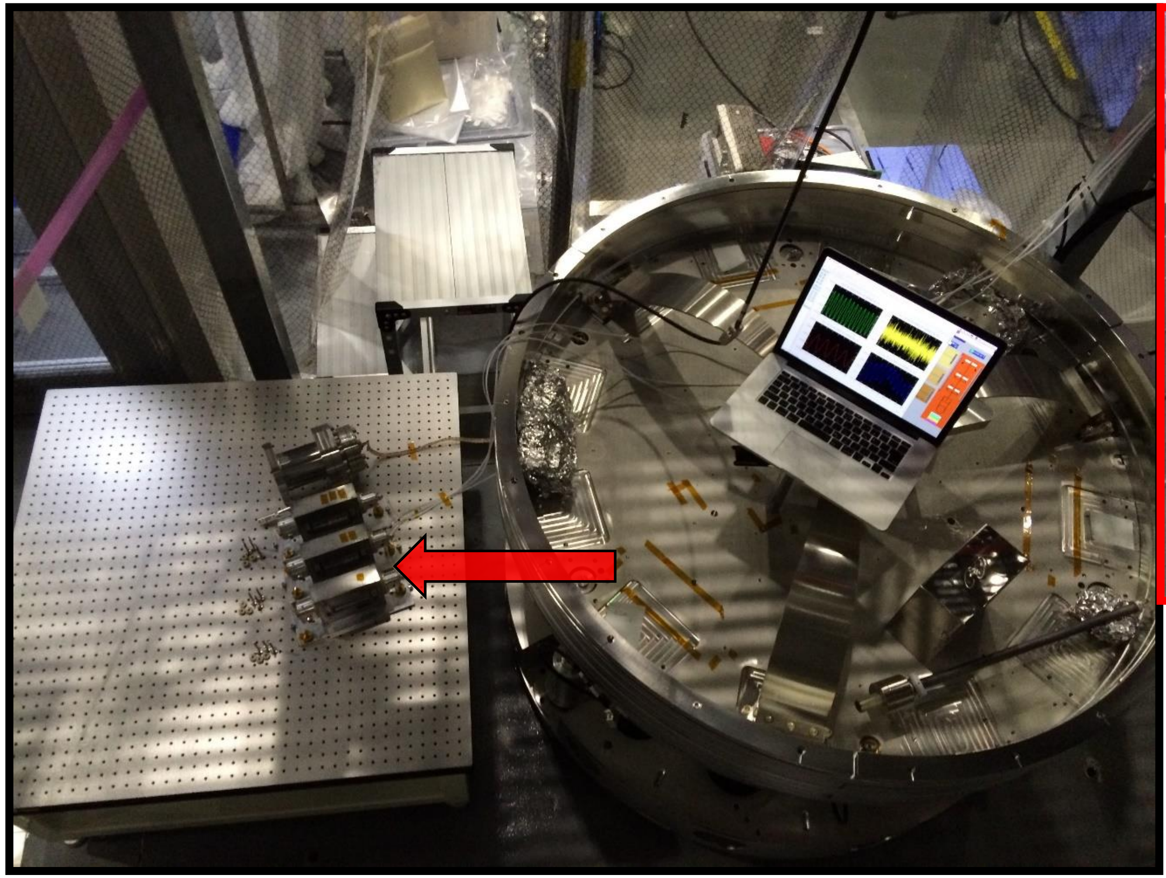


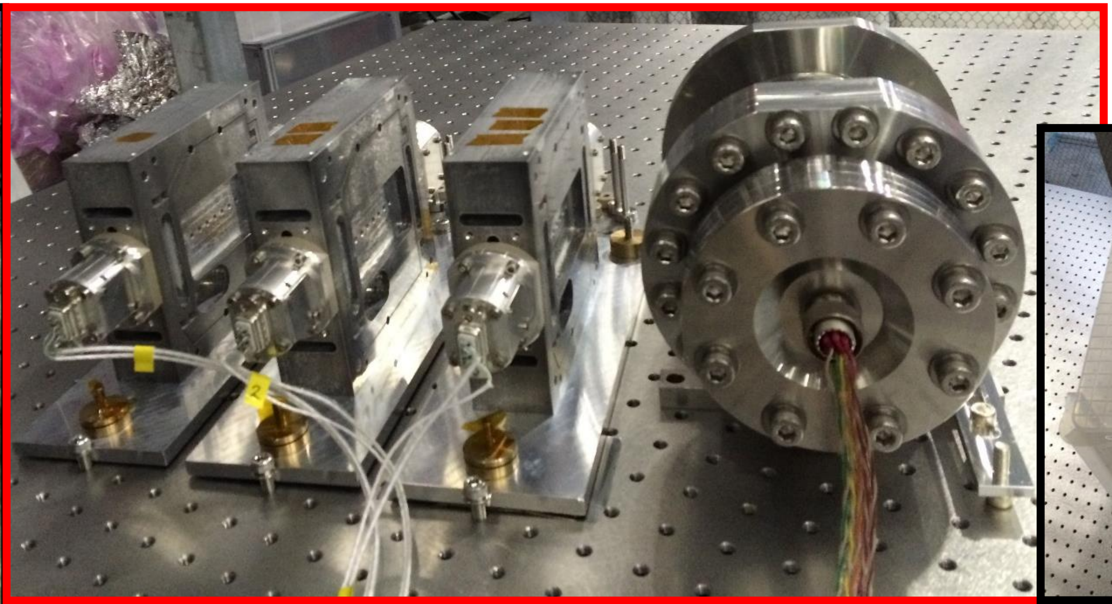
Nothing is suspended on the Top GAS.

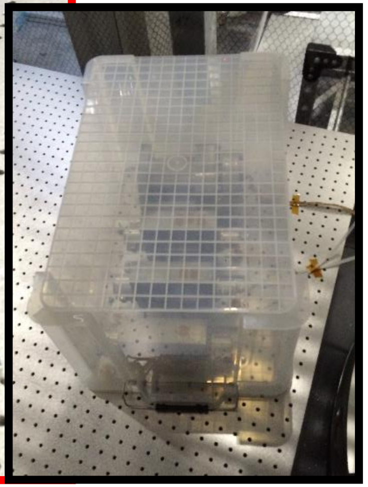


Status report : about the Monolithic Accelerometers(ACCs) Test

❐ After 2016.5.26







* All the Geophone, accelerometers are replaced onto a optical table, which was bought by VIS.
* All of them are in a tag box, to prevent an effect from the air flow of clean booth.

Do you think you can do this before LAPP?

* Proper air shields, wanted by Joris and me, are delivered, on 2016.6.3.
→ I would like to install them, and to see the sensitivities at low frequencies.

Updated on 2016.6.3

Status report : about the Monolithic Accelerometers(ACCs) Test

❒ To do list

❒ ACCs

* ~~Tune the output of the ACCs~~
* ~~Calibration (more precisely)~~
* Install their "Air shields"

(~~* ACC TF meas.~~)

*

❒ LVDTs

* Install to the IP stage, Cabling(圧着)
* Calibration
*

❒ Filters

* Confirm and install the input filters of the ACCs and Geophones
* install servo filters for the blending.
*

❒ Others

* Do actuator diagnalization
* Measure force TFs of the IP
* Stepper motor working confirmation(動作確認)
* Install a geophone on the ground(to be confirmed).

(Something might be missed.
Some A/I can be added.)

Status report : about the Monolithic Accelerometers(ACCs) Test

❐ Schedule

(circled) : work days on IP

Sun	Mon	Tue	Wed	Thu	Fri	Sat
2016.1.31						
	2016.2.15					
		2016.4.5	2016.4.6	2016.4.7	2016.4.8	2016.4.9
2016.4.10	2016.4.11	2016.4.12	2016.4.13	2016.4.14	2016.4.15	2016.4.16
2016.4.17	2016.4.18	2016.4.19	2016.4.20	2016.4.21	2016.4.22	2016.4.23
2016.4.24	2016.4.25	2016.4.26	2016.4.27	2016.4.28	2016.4.29	2016.4.30
2016.5.1	2016.5.2	2016.5.3	2016.5.4	2016.5.5	2016.5.6	2016.5.7
2016.5.8	2016.5.9	2016.5.10	2016.5.11	2016.5.12	2016.5.13 Today	

* Byebye Joris
* 2 LVDTs strange

* 2 LVDTs were Removed for fixing,

* Cabling for LVDT, geo
* 1 LVDT, 1Geo ready

* RT model was made again

* IP tuned at ~550 mHz
* All the LVDTs are removed.

* Brief manual for pre-isolator ins. was made.

* Investigated other DoF coupling of “wide cavity” OSEM

* IP tuned at 440 mHz
* Wooden boards wete replaced

* Soldering, cabling fot ACCs

* Rough signal check

* holidays

* Adjusted LVDT output Voltage

* Cabling, alignment for ACCs

* Rough calibration of ACCs

Status report : about the Monolithic Accelerometers(ACCs) Test

❐ Schedule

Sun	Mon	Tue	Wed	Thu	Fri	Sat
2015.5.15	2016.5.16	2016.5.17	2016.5.18	2016.5.19	2016.5.20	2016.5.21
2015.5.22	2016.5.23	2016.5.24	2016.5.25	2016.5.26	2016.5.27	2016.5.28 Due date
2015.5.29	2016.5.30	2016.5.31	2016.6.1	2016.6.2	2016.6.3	2016.6.4
2015.6.5	2016.6.6	2016.6.7	2016.6.8	2016.6.9	2016.6.10	2016.6.11
2015.6.12	2016.6.13	2016.6.14	2016.6.15	2016.6.16	2016.6.17	2016.6.18 ~~Due date~~

* reviewing meeting at U Totama

* Changing LVDT gain
* Confirming some resistance

* ACC_H3 calibration

* MEDM screen modification

* MEDM screen modification

* Replacing ACC's positions

* iPR3 TF meas.
* ACC checking.

* TF, spectra measurement on a optical table.
* Putting a temporary air shield.

* ACC_H1, H2 Calibration
* Q (w/o ctrl)

* Installing "Air shields" ?

Is team B doing anything before the hanging test or are they too busy?

<u>What would be done by type B team.</u>

* Installing Air shields
* Installing LVDT
* Controlling test

Status report : about the Monolithic Accelerometers(ACCs) Test

❒ Next step for the next week:

~~* Tune the outputs the ACCs by adjusting the "LVDT cards" .~~

~~* Calibrate the ACCs more precisely with using aluminum foil etc.~~

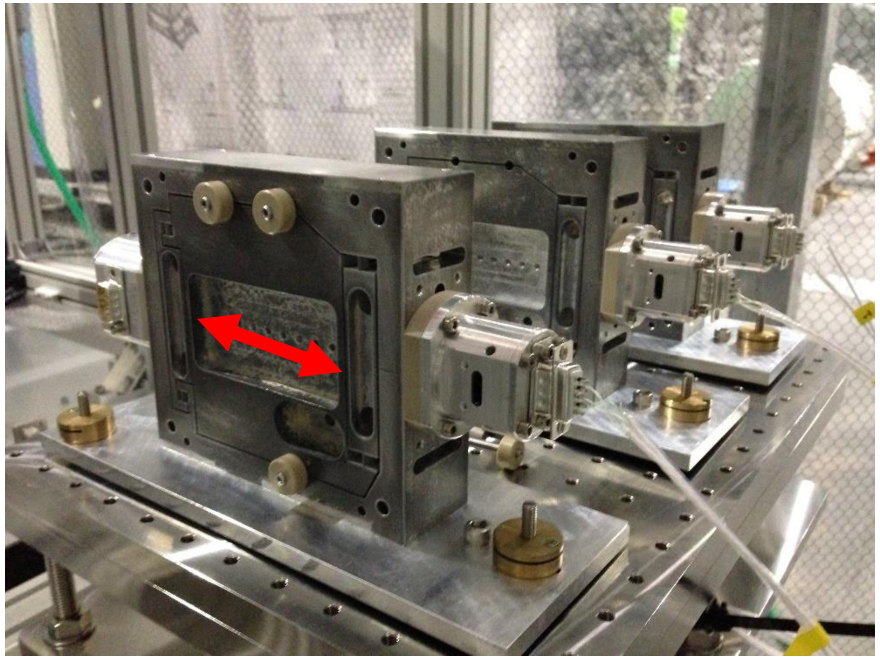
* if the LVDTs would be returned, install and do cabling, calibration.

❒ ~~To be investigated, found in this week ;~~

* the natural frequencies of the ACCs : all the freq. are shifted stiffer, in some reason.

	Jan.		May
ACC1 :	0.46 Hz	→	0.6 Hz
ACC2 :	0.89 Hz	→	~ 1.4 Hz
ACC3 :	1.0 Hz	→	~ 1.5 Hz

This is really untrue. You did by hand and timed the modes; it has to do with the LVDT readout and not with the mechanics.



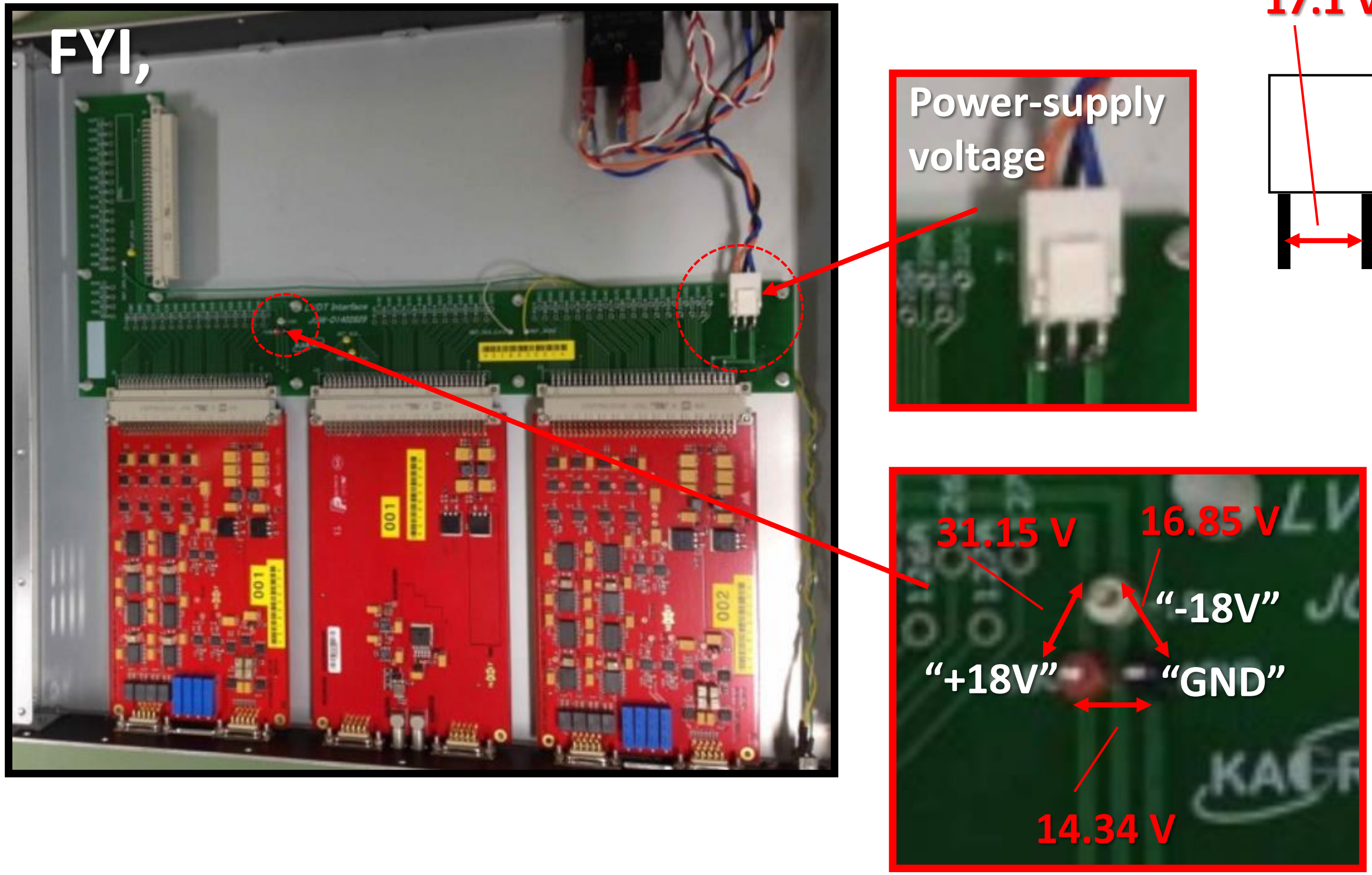
Status report : about the Monolithic Accelerometers(ACCs) Test

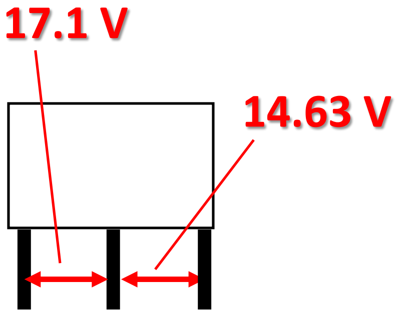
Settings and Results

- ❒ ACC-LVDT gains, etc.
- ❒ natural frequencies, Q factors of accelerometers
- ❒ Tilt calibration
- ❒ Spectra measurement on ACC-LVDT
- ❒ sensitivities, noises of accelerometers

Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Setting / ACC-LVDT gains, etc.



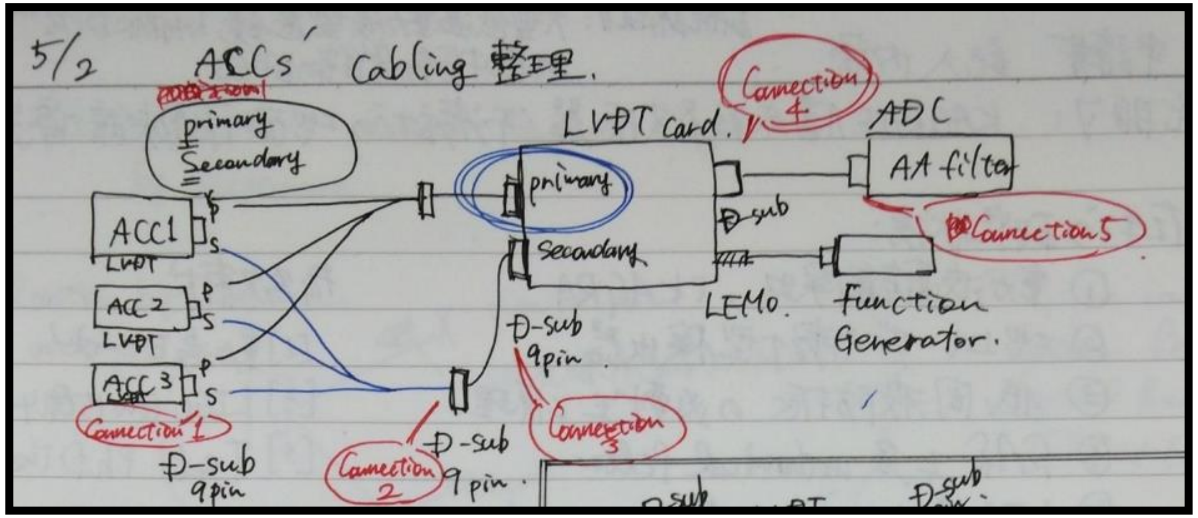


This is terrible. I would say to shut down the LVDT boards as this might damage the OPamps and other components.

(Measured values by a multi-meter)

Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Setting / ACC-LVDT gains, etc.



At connection 3

Resistance [Ohm]	1-6 pin	2-7 pin	3-8 pin	4-9 pin	5 pin
Primary port	O.F.	86.8	86.0	97.1	O.F.
Secondary port	O.F.	42.2	43.1	42.4	O.F.

(Not used) (1-6 pin) (Not used) (5 pin)

At connection 1 →

①With Power supply, With modulation

(Not used) (2-7 pin) (Not used) (4-9 pin)

Resistance [Ohm]	1-6 pin	2-7 pin	3-8 pin	4-9 pin
ACC_H1	966	O.F.	O.F.	O.F.
ACC_H2	972	O.F.	O.F.	O.F.
ACC_H3	971	O.F.	O.F.	O.F.

②With Power supply, Without modulation

Resistance [Ohm]	1-6 pin	2-7 pin	3-8 pin	4-9 pin
ACC_H1	966	O.F.	185.1	O.F.
ACC_H2	972	O.F.	198.2	O.F.
ACC_H3	972	O.F.	212.9	O.F.

③Without Power supply, Without modulation

Resistance [Ohm]	1-6 pin	2-7 pin	3-8 pin	4-9 pin
ACC_H1	994	O.F.	4740	O.F.
ACC_H2	993	O.F.	4650	O.F.
ACC_H3	994	O.F.	4700	O.F.

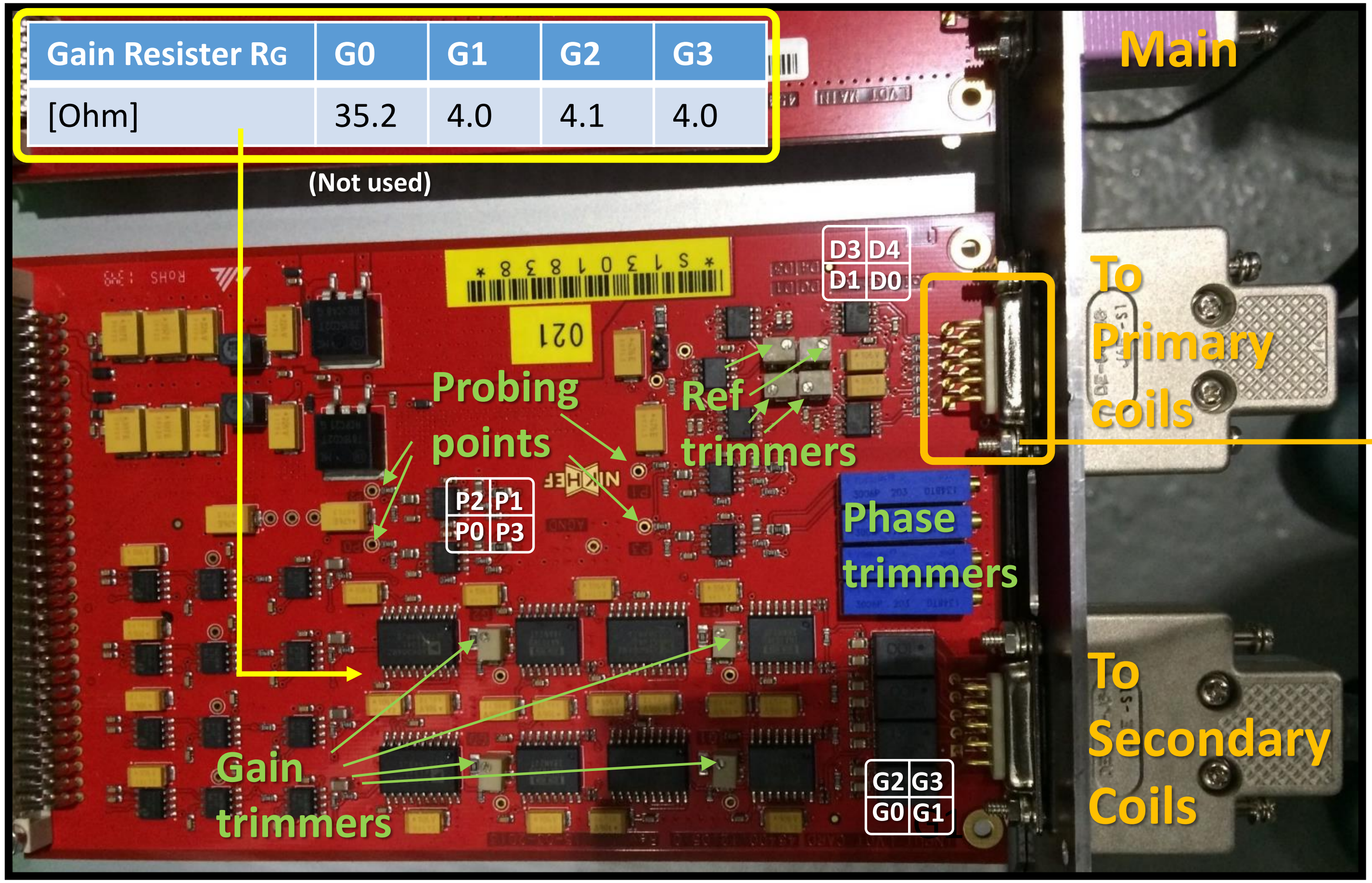
Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Setting / ACC-LVDT gains, etc.

(ref : http://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=4798)

(Not used)

Gain Resister RG	G0	G1	G2	G3
[Ohm]	35.2	4.0	4.1	4.0



Func. Generator
4.3 Vpp, 10 kHz

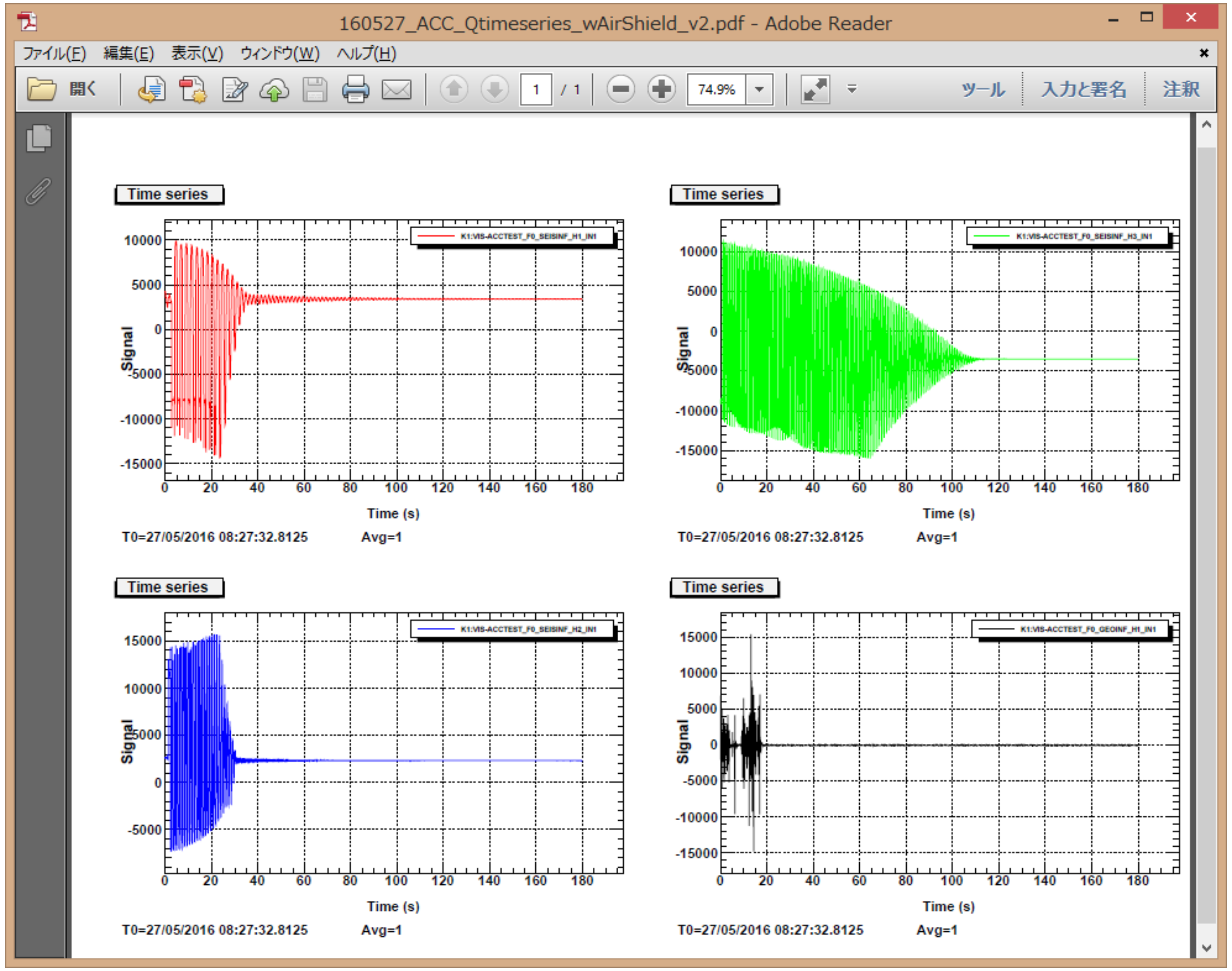
Primary port	1 pin	2 pin	3 pin	4 pin	5 pin
Vpp , 10 kHz	1.36	4.16	4.16	4.08	0.240
Primary port	**6 pin**	**7 pin**	**8 pin**	**9 pin**	
Vpp, 10 kHz	1.36	4.08	4.08	4.08	

→ **According to below formula, current amp-gain is around <u>1501</u>.**

INA103 amp: $G = 1 + \frac{6k\Omega}{R_G}$

Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Results / Natural frequencies, Q factors of ACCs



From decay signals,
*** natural frequencies and**
*** Q factors**
of the ACCs, with and without air shield, are obtained.
Below formulae are used.

$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right) \sin(2\pi f_1 t + \varphi_1)$$

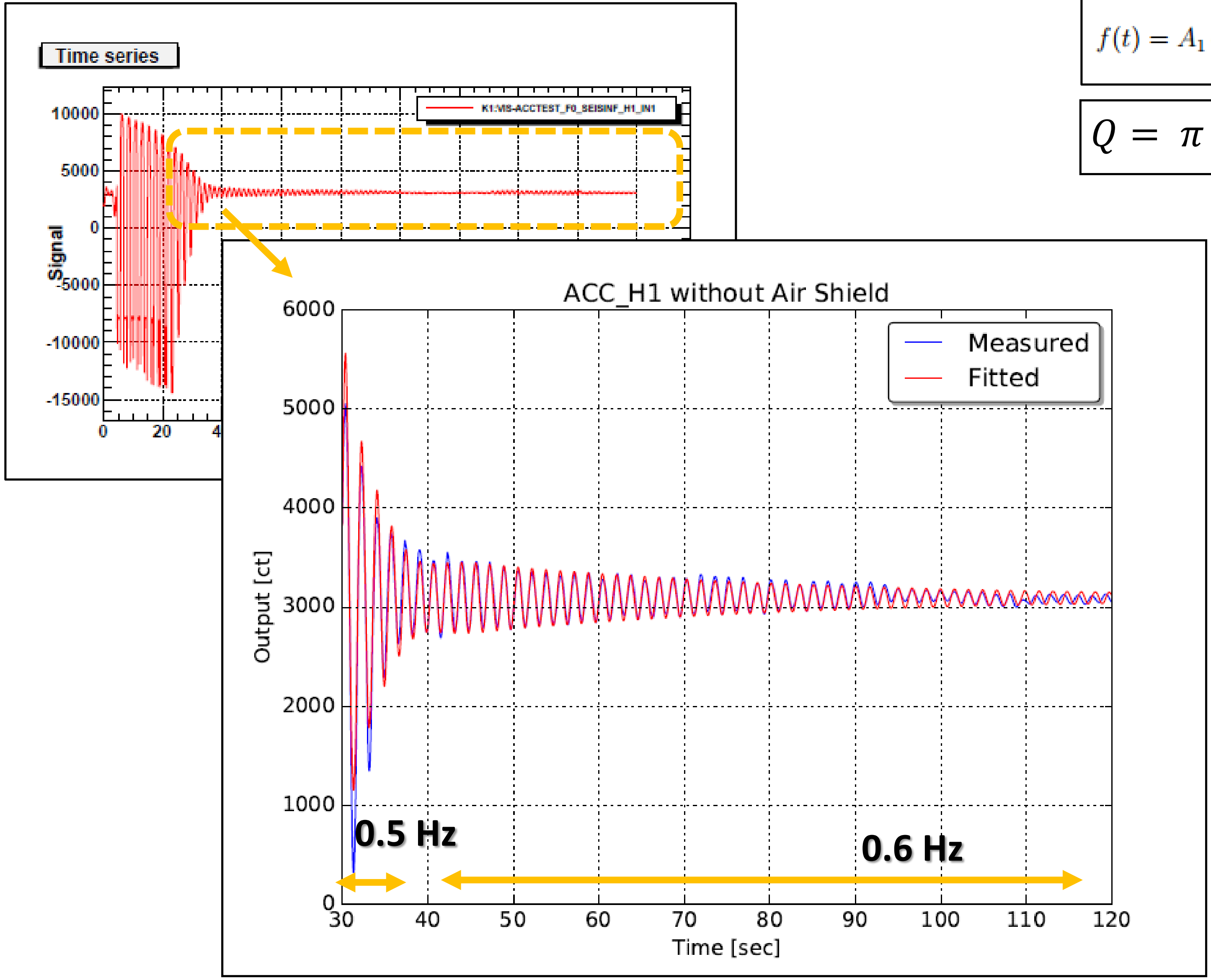
or

$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right) \sin(2\pi f_1 t + \varphi_1) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right) \sin(2\pi f_2 t + \varphi_2) + x_0.$$

$$Q = \pi\, f_0\, \tau_e$$

As results shown in next some slides,
natural frequencies at steady phase are different from the ones at non-steady phase.

Status report : about Q factor of the Accelerometers(ACCs)



$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right)\sin(2\pi f_1 t + \varphi_1) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right)\sin(2\pi f_2 t + \varphi_2) + x_0.$$

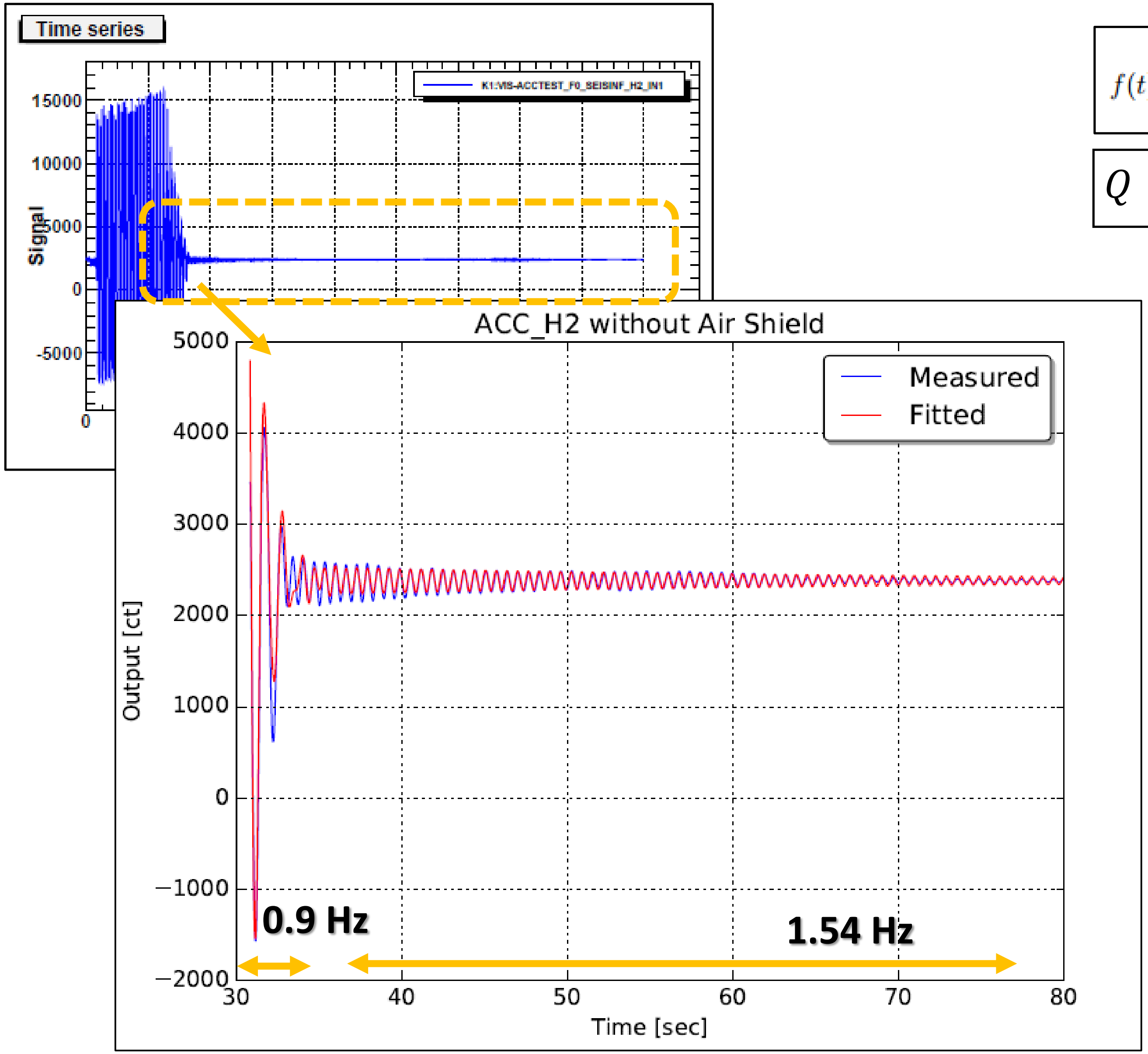
$$Q = \pi f_0 \tau_e$$

Without Air Shield

	f_0 [Hz]	τ_e [sec]	Q
1st	0.537	2.65	4.47
2nd	0.607	40.4	77.1

***Linear range :**
from about -5,000 to 5000 ct

Status report : about Q factor of the Accelerometers(ACCs)



$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right)\sin(2\pi f_1 t + \varphi_1) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right)\sin(2\pi f_2 t + \varphi_2) + x_0.$$

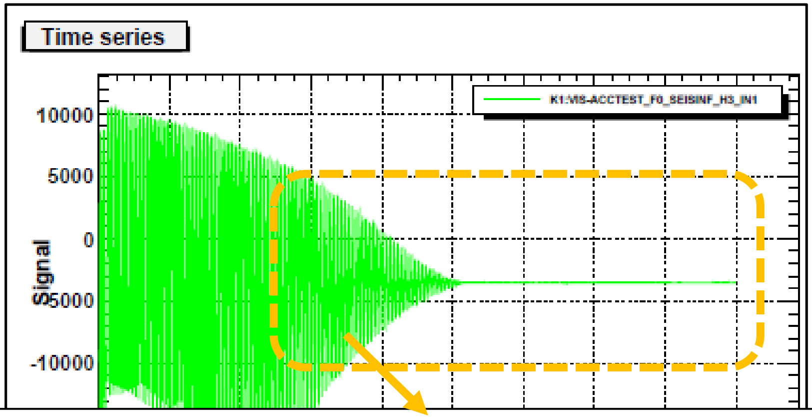
$$Q = \pi f_0 \tau_e$$

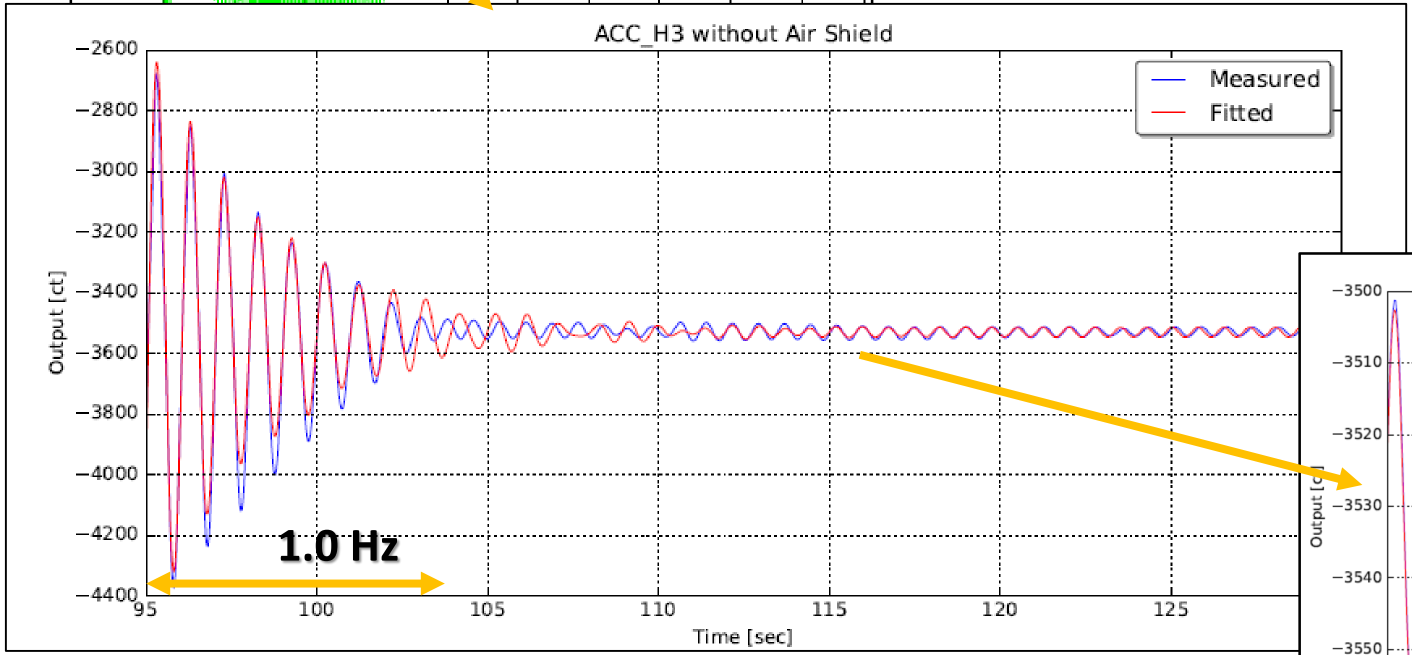
Without Air Shield

	f_0 [Hz]	τ_e [sec]	Q
1st	0.90	0.91	2.59
2nd	1.54	35.5	172

***Linear range :**
from about -3,000 to 6000 ct

Status report : about Q factor of the Accelerometers(ACCs)





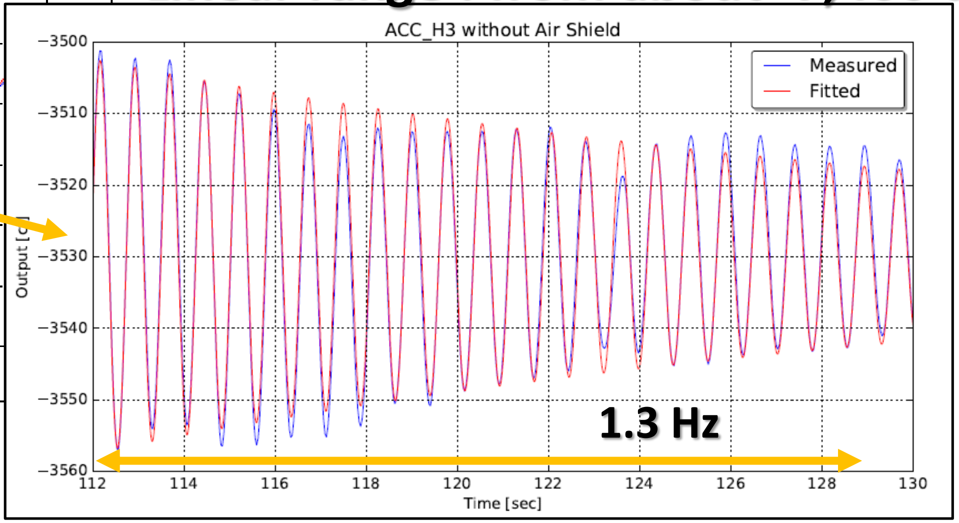
$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right)\sin(2\pi f_1 t + \varphi_1) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right)\sin(2\pi f_2 t + \varphi_2) + x_0.$$

$$Q = \pi f_0 \tau_e$$

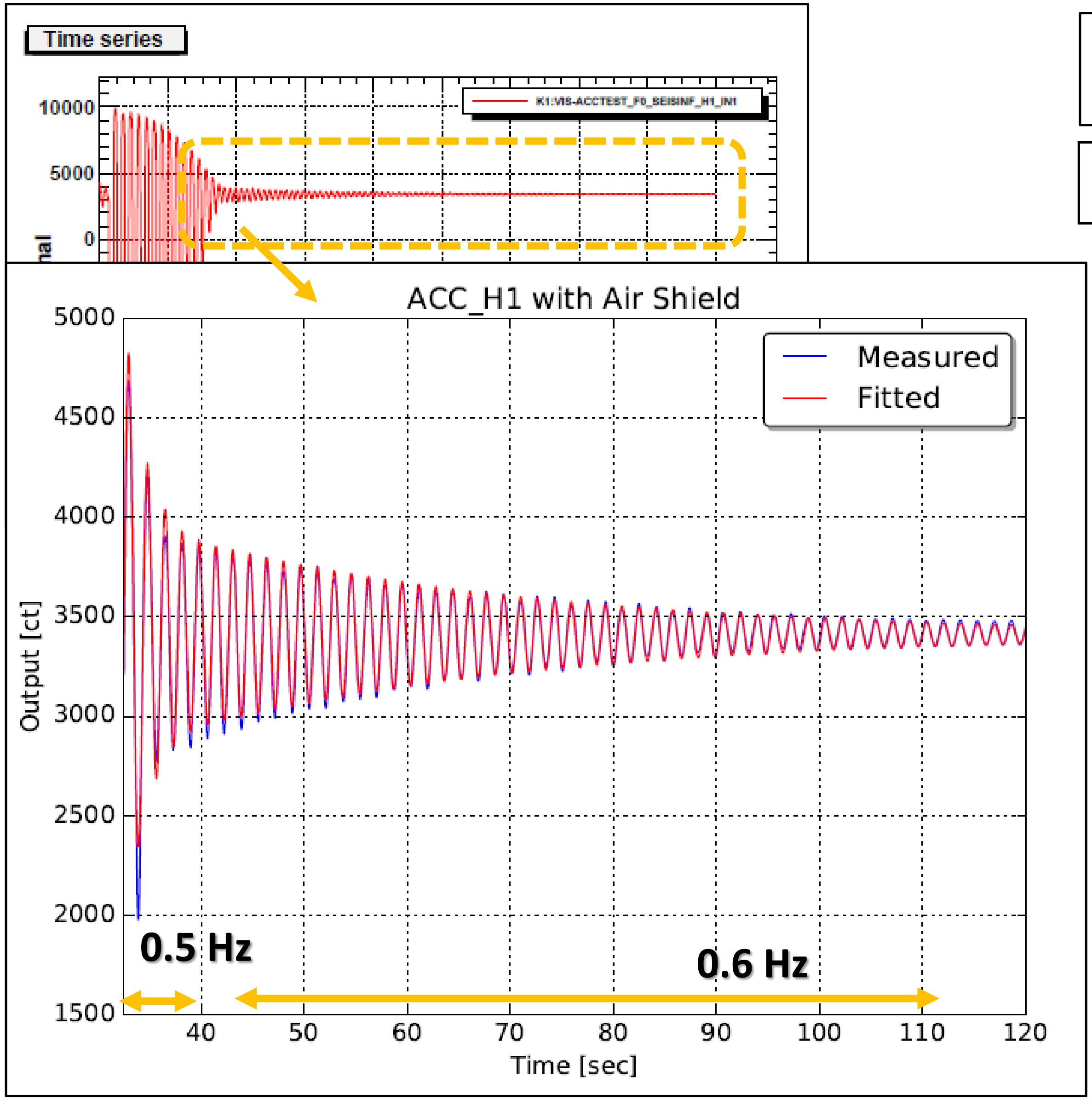
Without Air Shield

	f_0 [Hz]	τ_e [sec]	Q
1st	1.01	3.57	11.3
2nd	1.31	21.5	88.8

***Linear range : from about -7,400 to 5000 ct**



Status report : about Q factor of the Accelerometers(ACCs)



$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right)\sin(2\pi f_1 t + \varphi_1) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right)\sin(2\pi f_2 t + \varphi_2) + x_0.$$

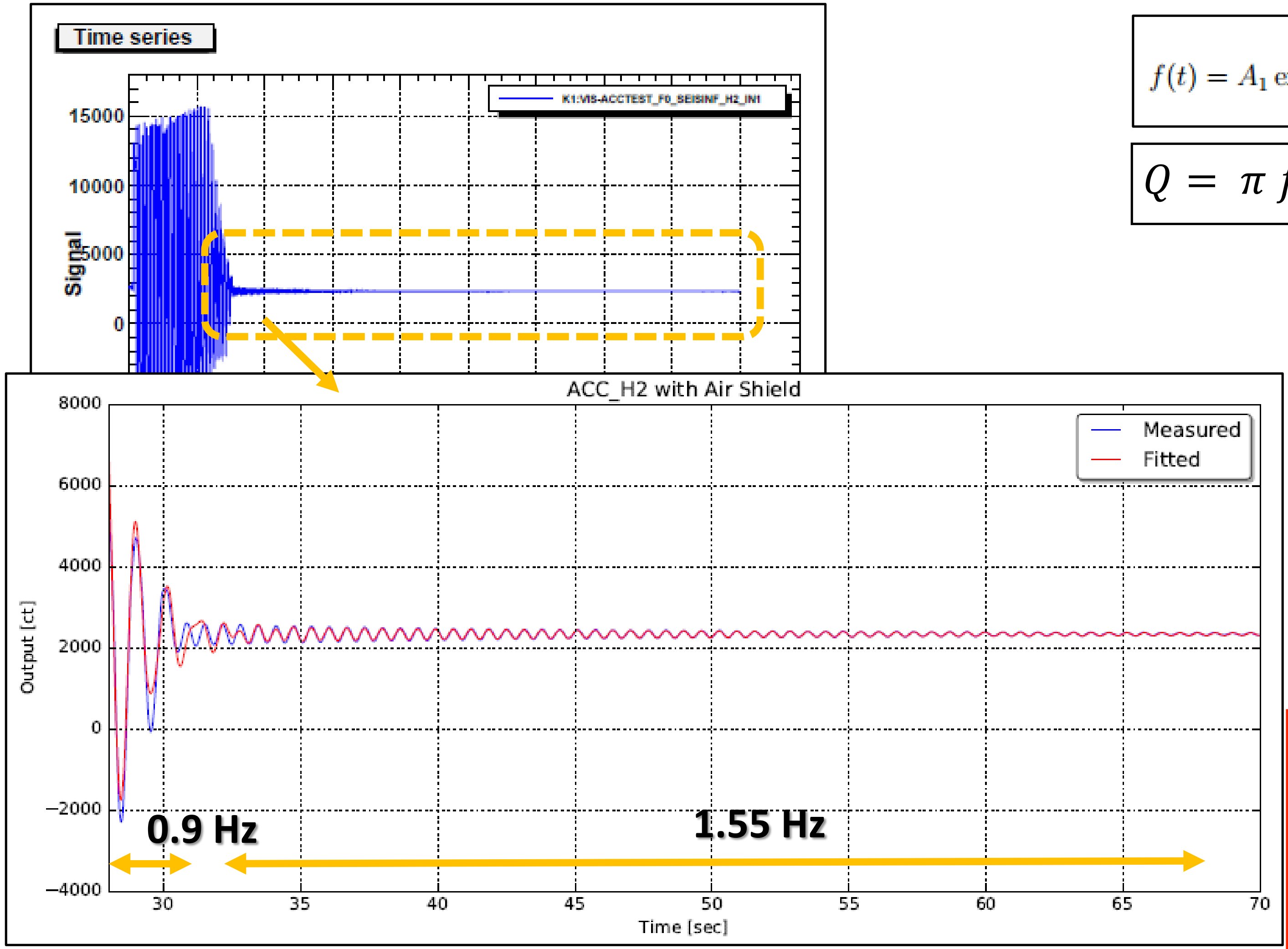
$$Q = \pi f_0 \tau_e$$

With Air Shield

	f_0 [Hz]	τ_e [sec]	Q
1st	0.545	1.56	2.67
2nd	0.609	34.8	66.5

***Linear range :**
from about -5,000 to 5000 ct

Status report : about Q factor of the Accelerometers(ACCs)



$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right)\sin(2\pi f_1 t + \varphi_1) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right)\sin(2\pi f_2 t + \varphi_2) + x_0.$$

$$Q = \pi f_0 \tau_e$$

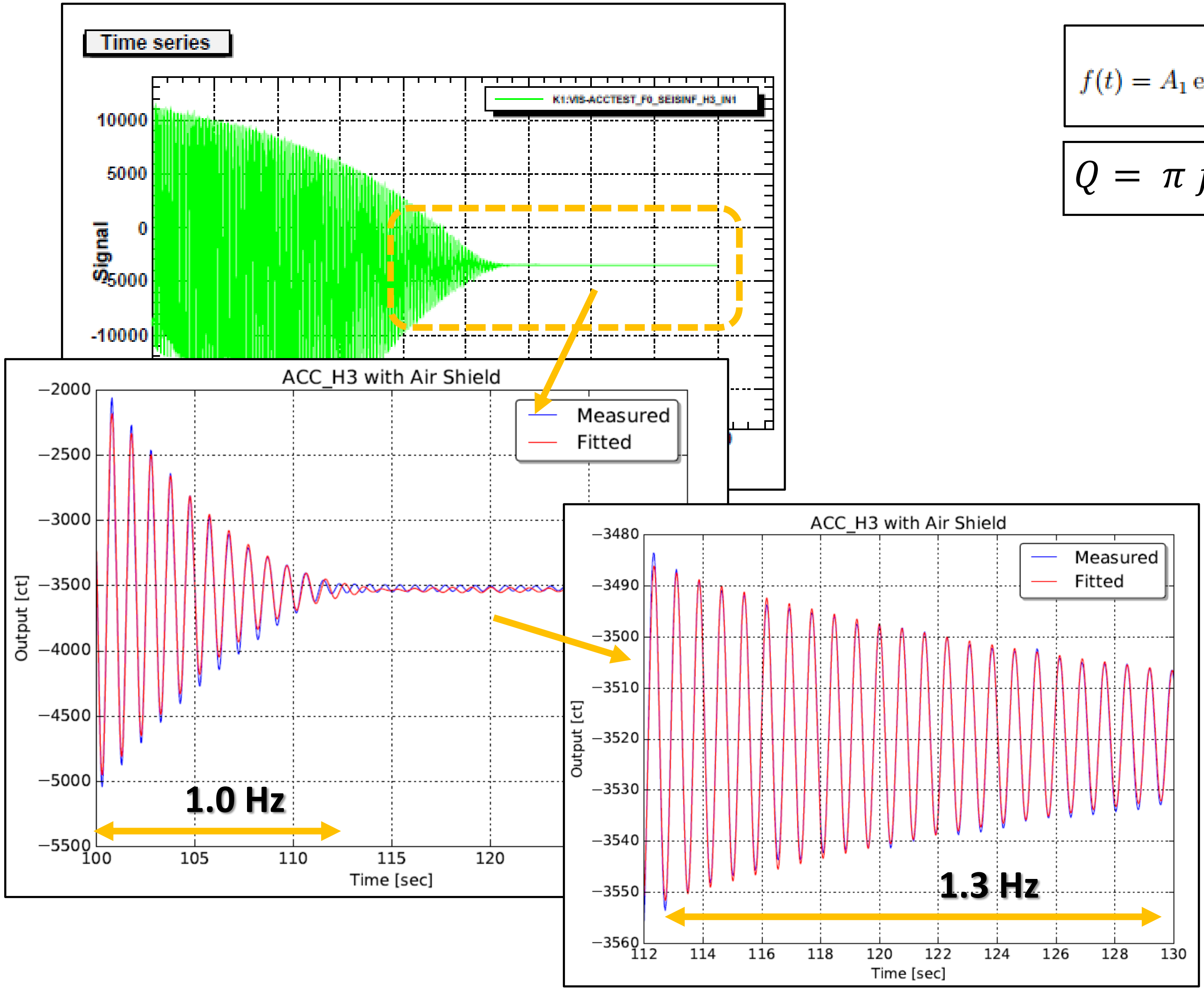
With Air Shield

	f_0 [Hz]	τ_e [sec]	Q
1st	0.897	1.23	3.47
2nd	1.55	22.9	112

***Linear range :**
from about -3,000 to 6000 ct

I think these measurements were good training, but before you fix the LVDT powersupply, I think all has to be redone. It looks so non-linear to me (time signals ACCs, strange Q measurements with different f_0's. I think the above 1 Hz peaks you see in spectra is really non-physical but artifact from LVDT non-linearity

Status report : about Q factor of the Accelerometers(ACCs)



$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right)\sin(2\pi f_1 t + \varphi_1) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right)\sin(2\pi f_2 t + \varphi_2) + x_0.$$

$$Q = \pi f_0 \tau_e$$

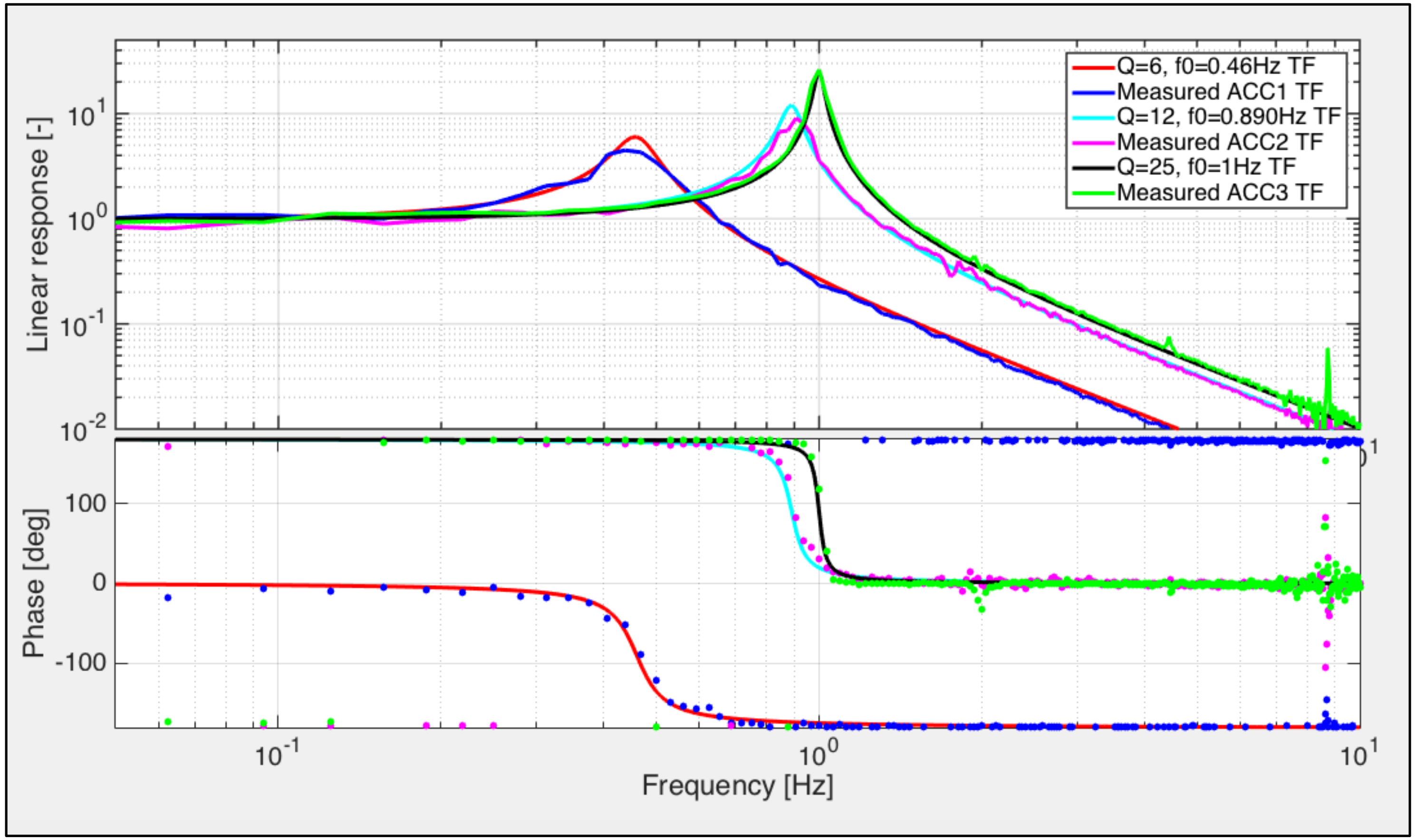
With Air Shield

	f_0 [Hz]	τ_e [sec]	Q
1st	0.99	4.28	13.3
2nd	1.31	18.3	75.0

***Linear range :**
from about -7,400 to 5000 ct

Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Results / Natural frequencies, Q factors of ACCs



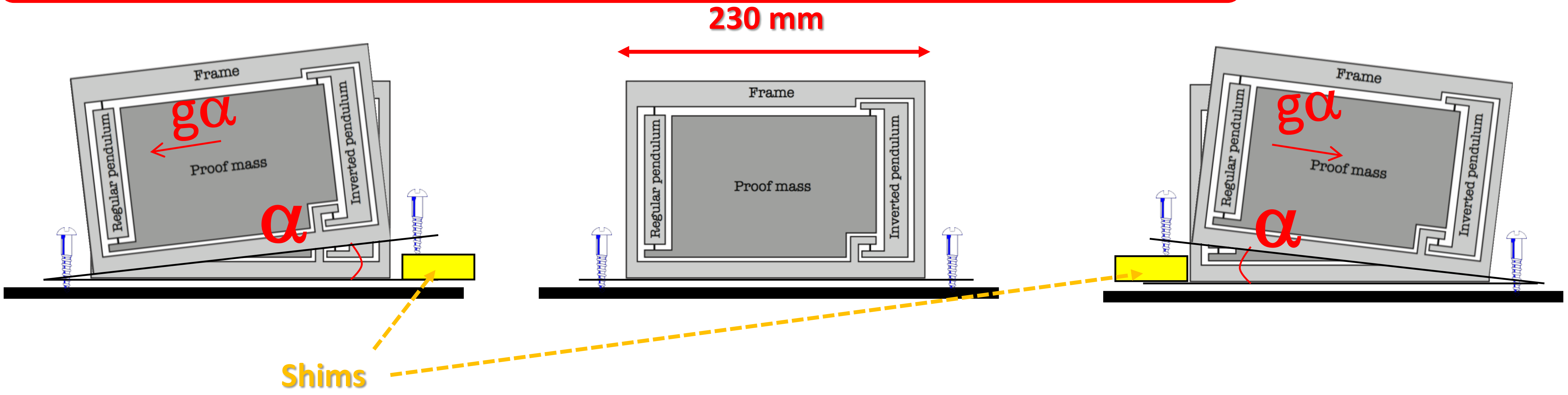
Natural frequencies and Q factors at non-steady phase, in my measurement, seem to be consistent with previous measurement which was done by Joris. (Except for ACC_H1.)
http://klog.icrr.u-tokyo.ac.jp/osl/index.php?r=639

Then, the parameters shown in this table are obtained, to do below slides' calculation.

	f_0 [Hz]	Q
ACC_H1	0.61	67
ACC_H2	1.55	112
ACC_H3	1.31	75

Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Results / Tilt calibration, which is done on 2016.5.25



Calibration factor is calculated as

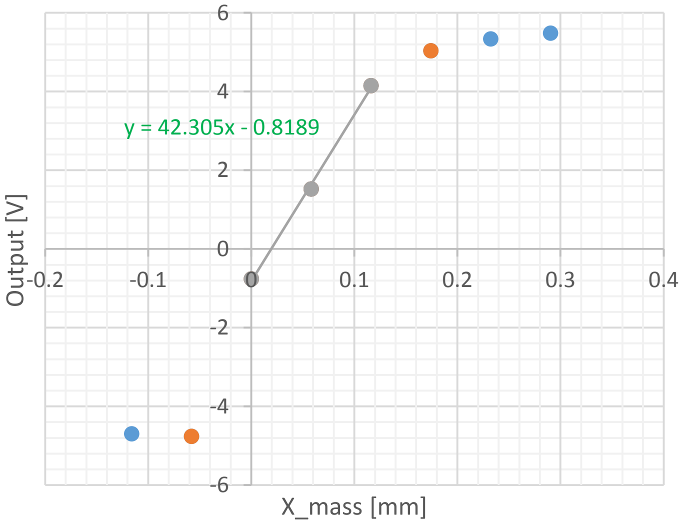
$$\mathit{Calibration\ factor}_{\mathrm{LVDT}} \equiv \frac{X_{mass}}{V_{\mathrm{LVDT}}} = \frac{\alpha * g / {\omega_0}^2}{V_{\mathrm{LDVT}}} \ [\mathrm{mm/V}]$$

, where a is a tilt angle of the accelerometer, g is gravitational acceleration, w0 is a natural frequency of the accelerometer.

Status report : about the Monolithic Accelerometers(ACCs) Test

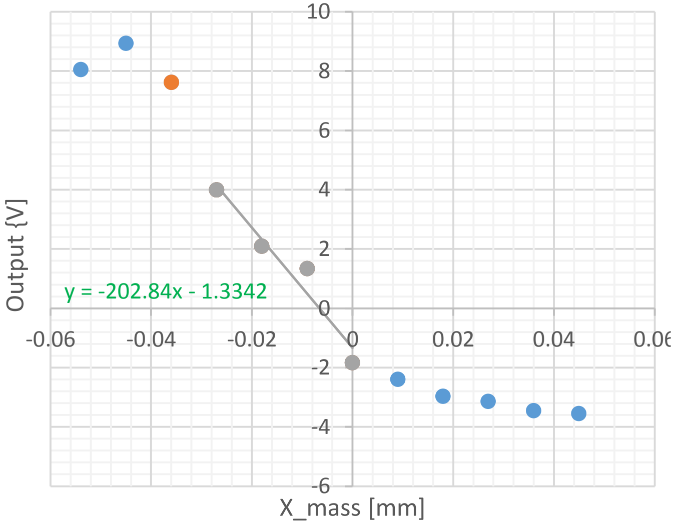
❖ Results / Tilt calibration, which is done on 2016.5.25

ACC_H1 natural frequency is 0.61 Hz



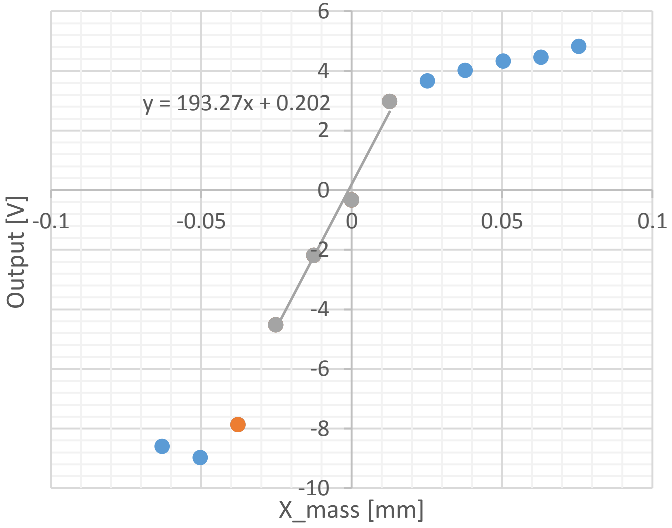
ACC_H1 Calibration factor is 42.3 V/mm

ACC_H2 natural frequency is 1.55 Hz



ACC_H2 Calibration factor is 202.8 V/mm

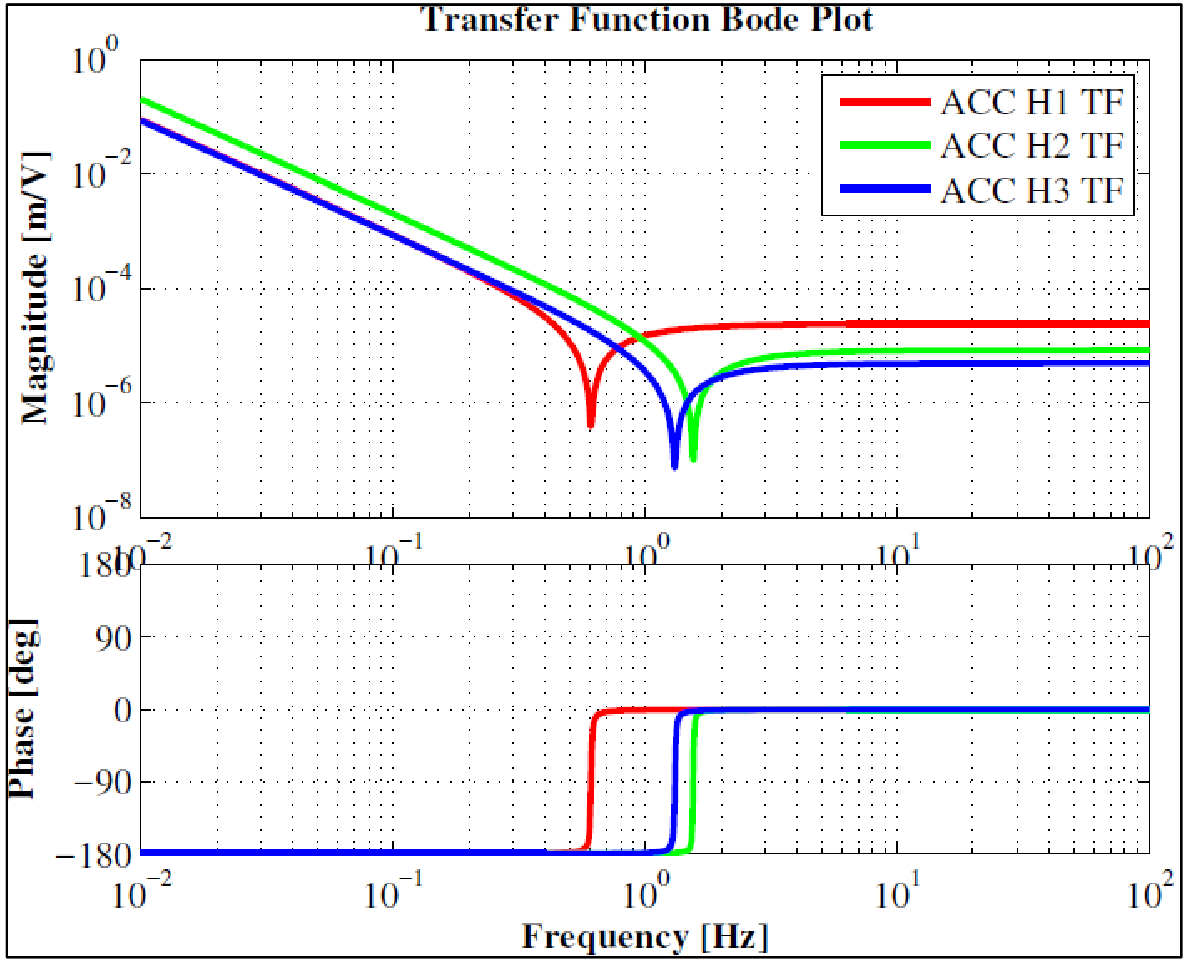
ACC_H1 natural frequency is 1.31 Hz



ACC_H3 Calibration factor is 193.3 V/mm

Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Results / Transfer functions from LVDT outputs to displacement

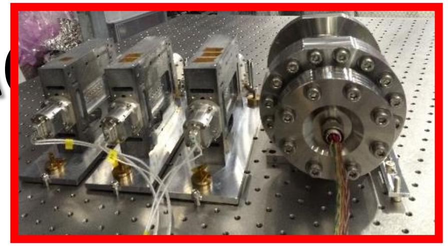


$$TF_{\mathrm{LVDT2Disp.}} \equiv \frac{X_{mass}}{V_{\mathrm{LVDT}}} * \frac{s^2 + \frac{\omega_0}{Q} * s - \omega_0{}^2}{s^2} \ [\mathrm{mm/V}]$$

The parameters , which I got, are here:

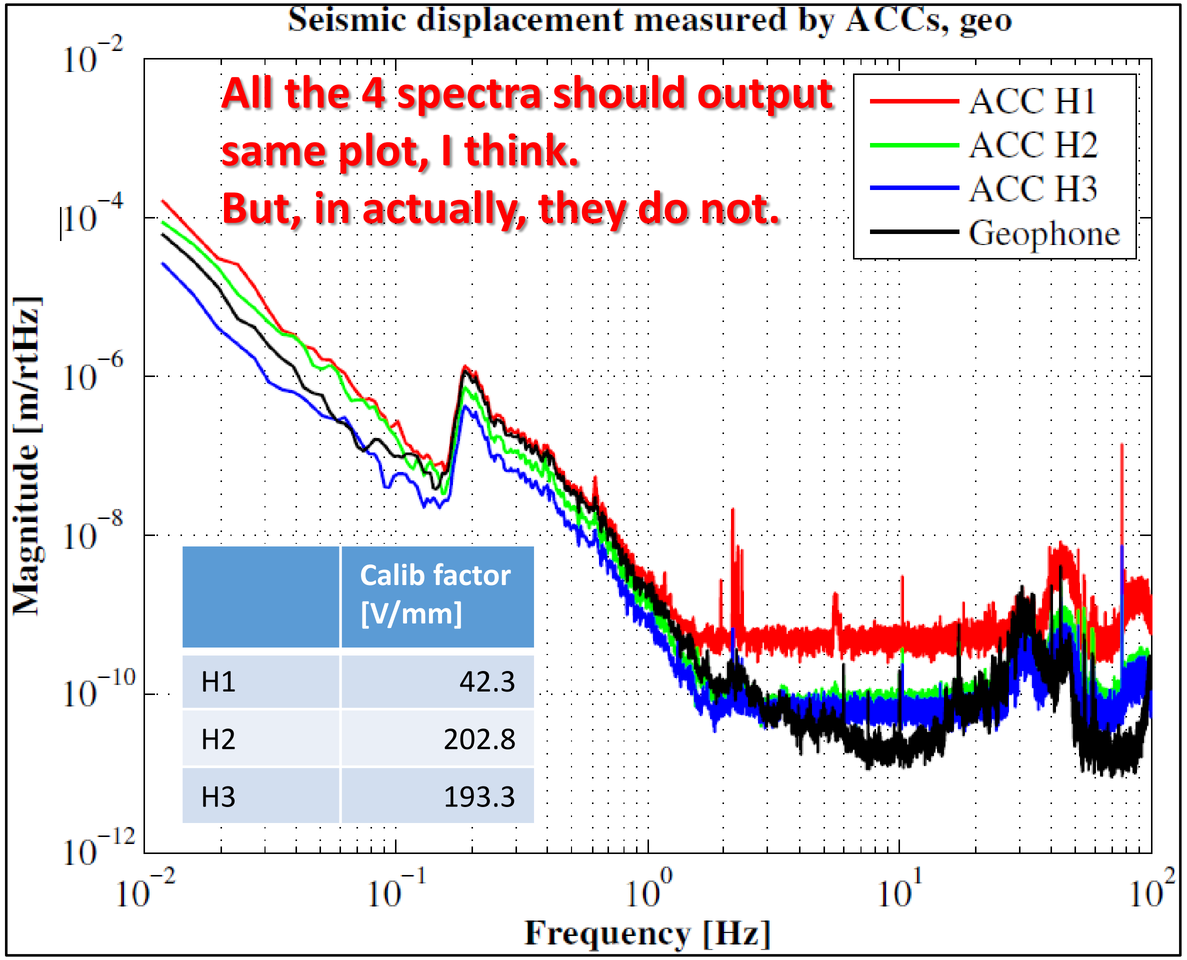
	f_0 [Hz]	Q	Calibration factor [V/mm]
ACC_H1	0.61	67	42.3
ACC_H2	1.55	112	202.8
ACC_H3	1.31	75	193.3

Status report : about the Monolithic Accelerometers(A

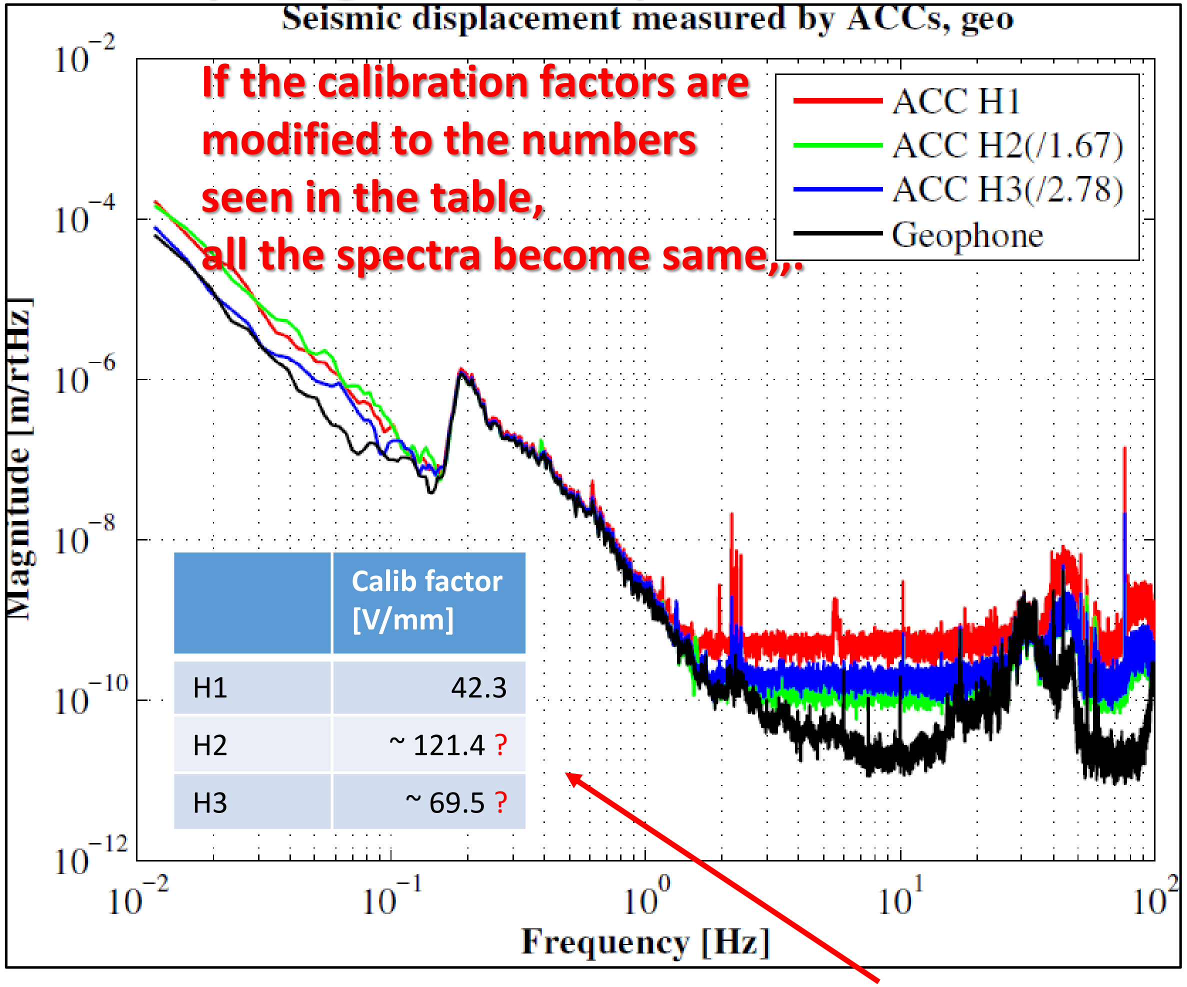


Results: Spectra measured on 2016.6.2

BUT, my calibration factors might NOT be correct, with comparing to the Geophone,,.



	Calib factor [V/mm]
H1	42.3
H2	202.8
H3	193.3

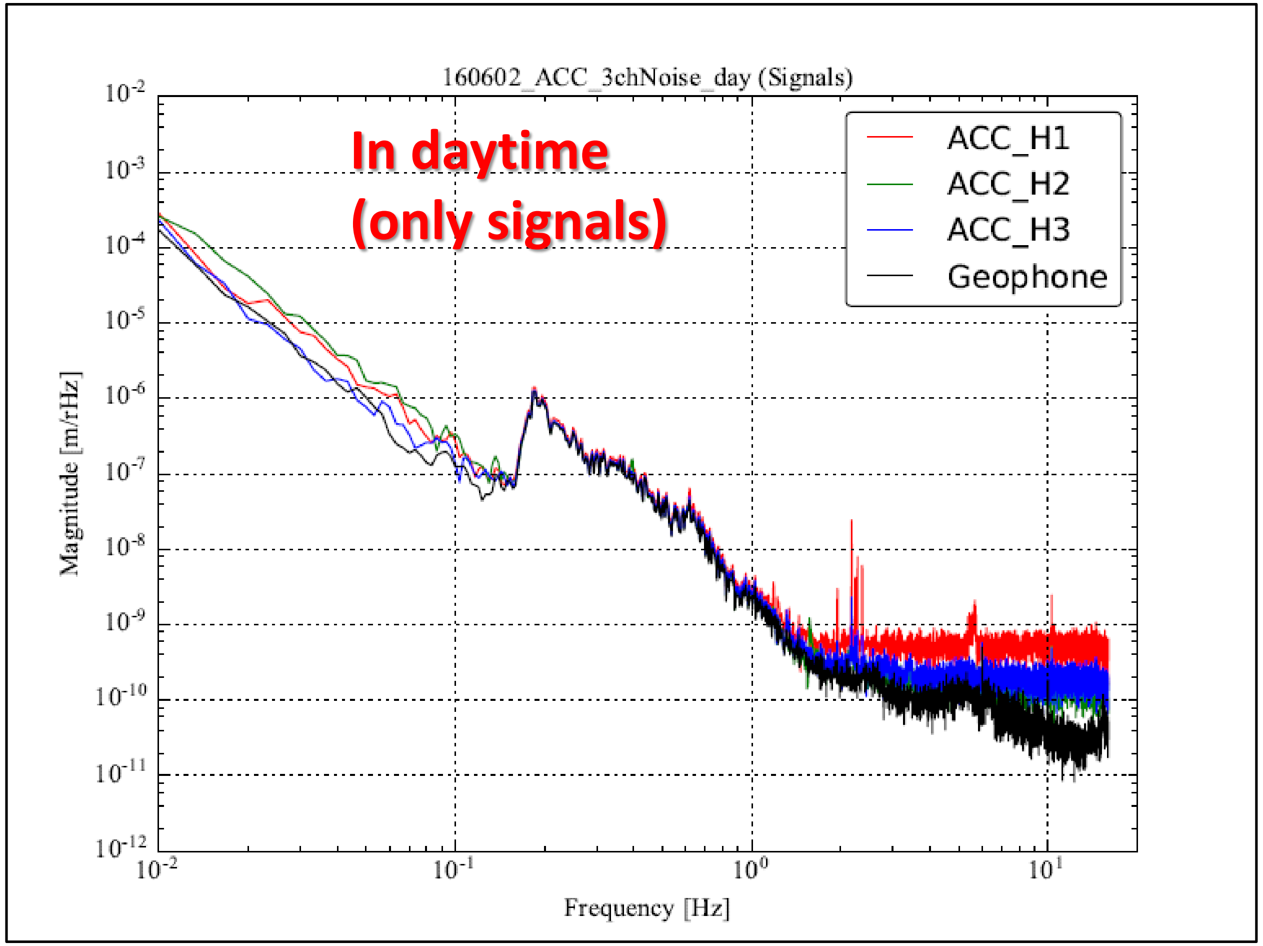


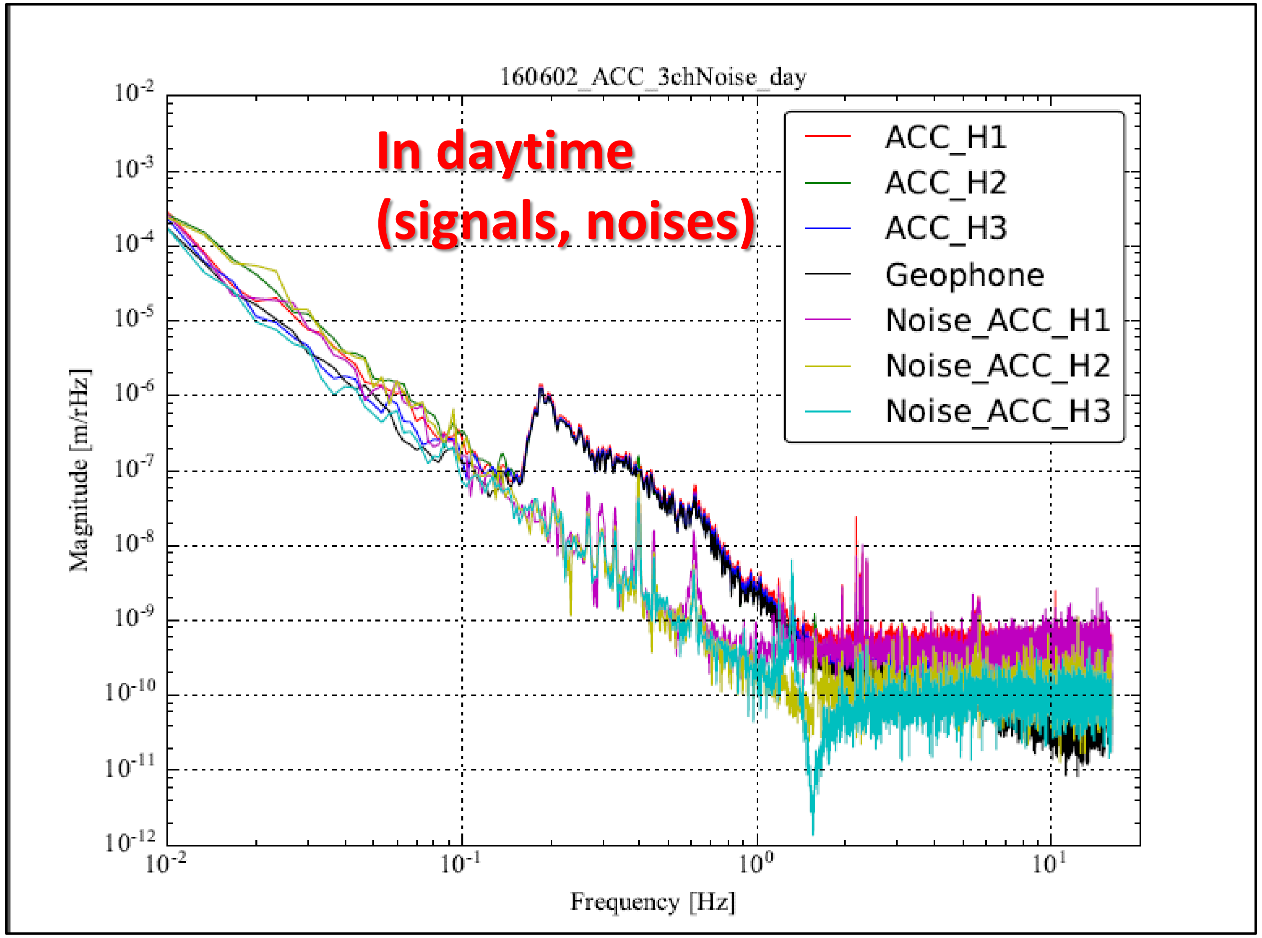
	Calib factor [V/mm]
H1	42.3
H2	~ 121.4 ?
H3	~ 69.5 ?

For the time being, I changed the calibration factors to right ones in below,,.

Status report : about the Monolithic Accelerometers(ACCs) Test

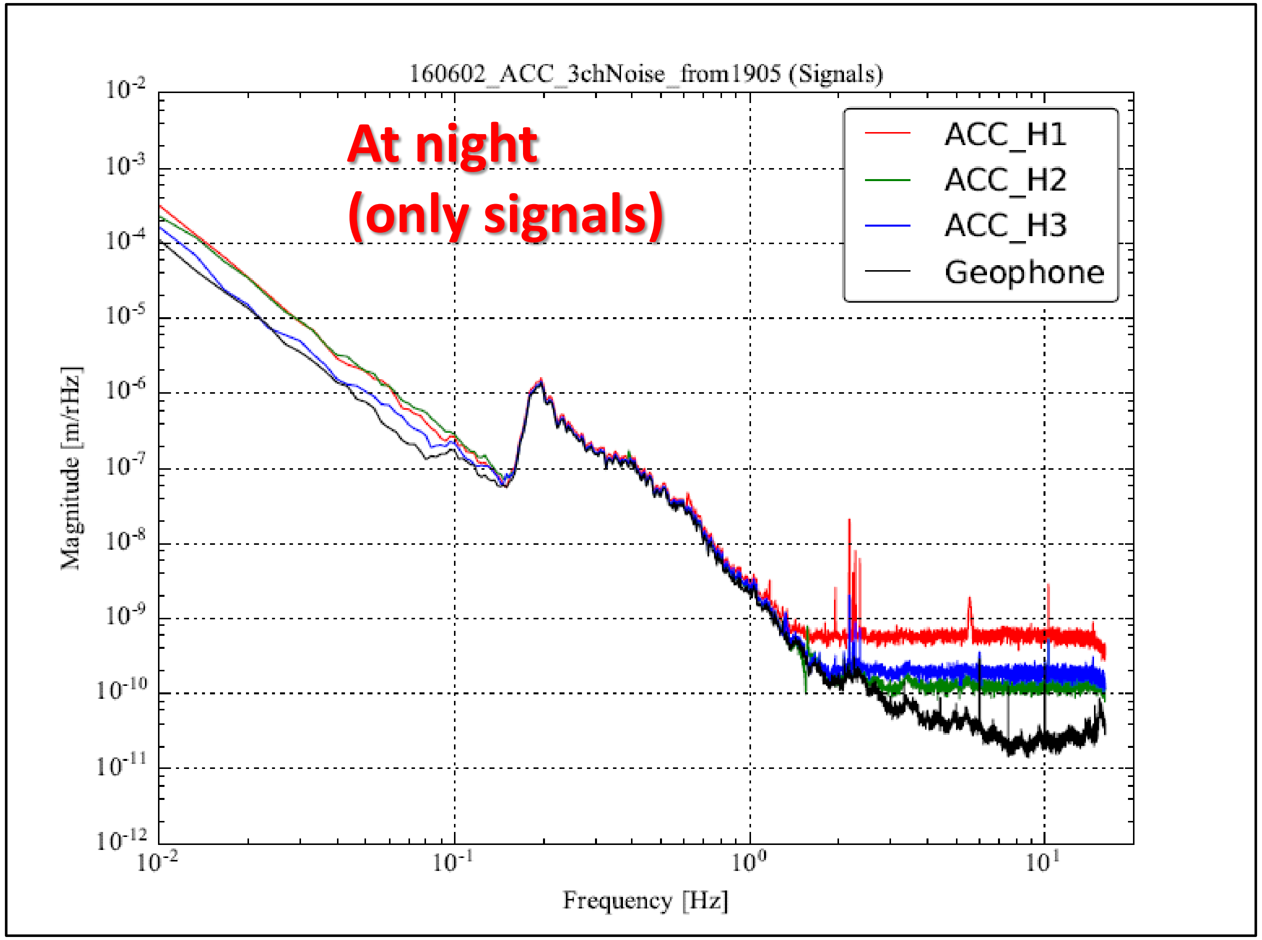
Results: noises of the accelerometers / 3ch correlation analysis

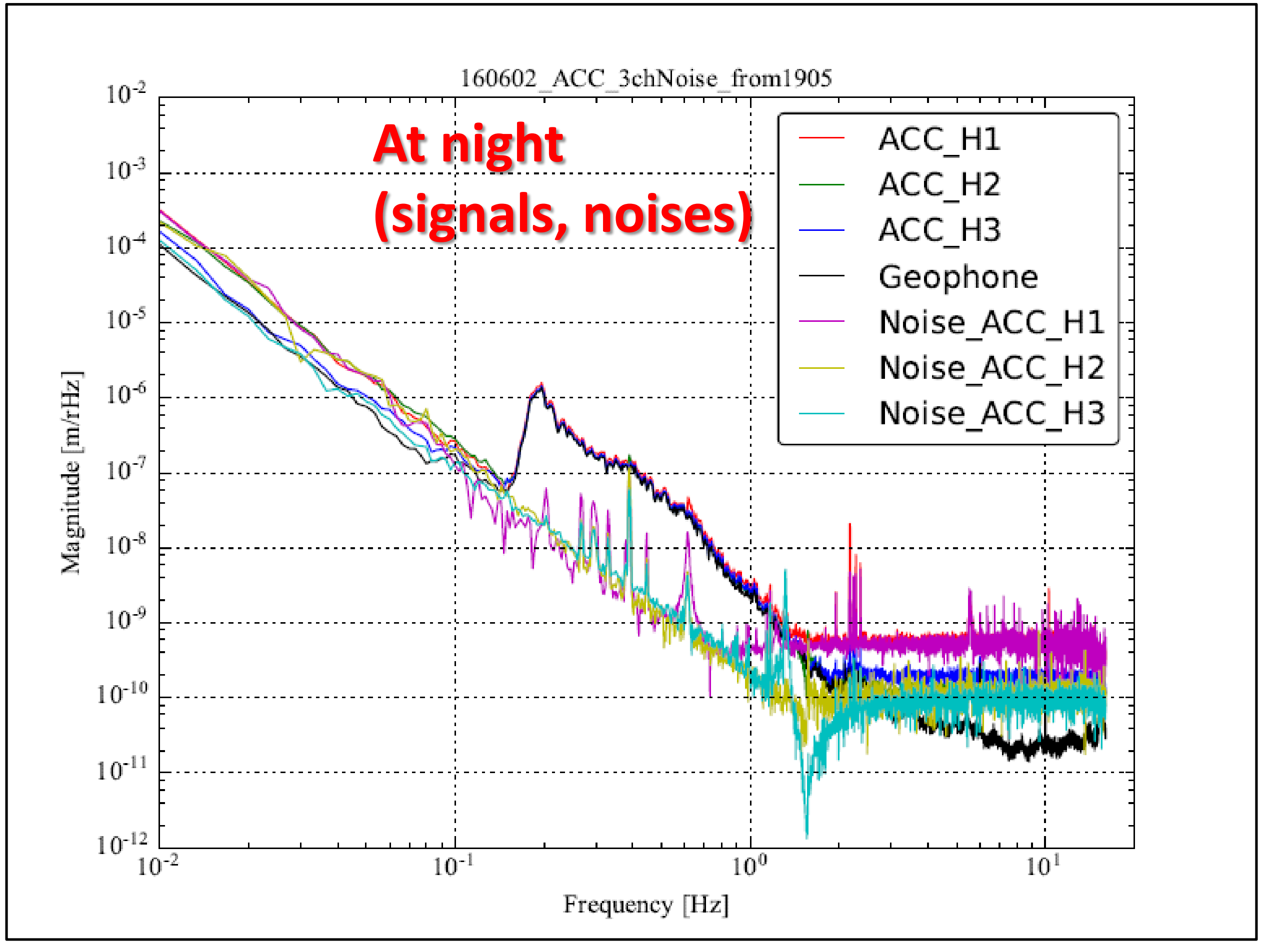




Status report : about the Monolithic Accelerometers(ACCs) Test

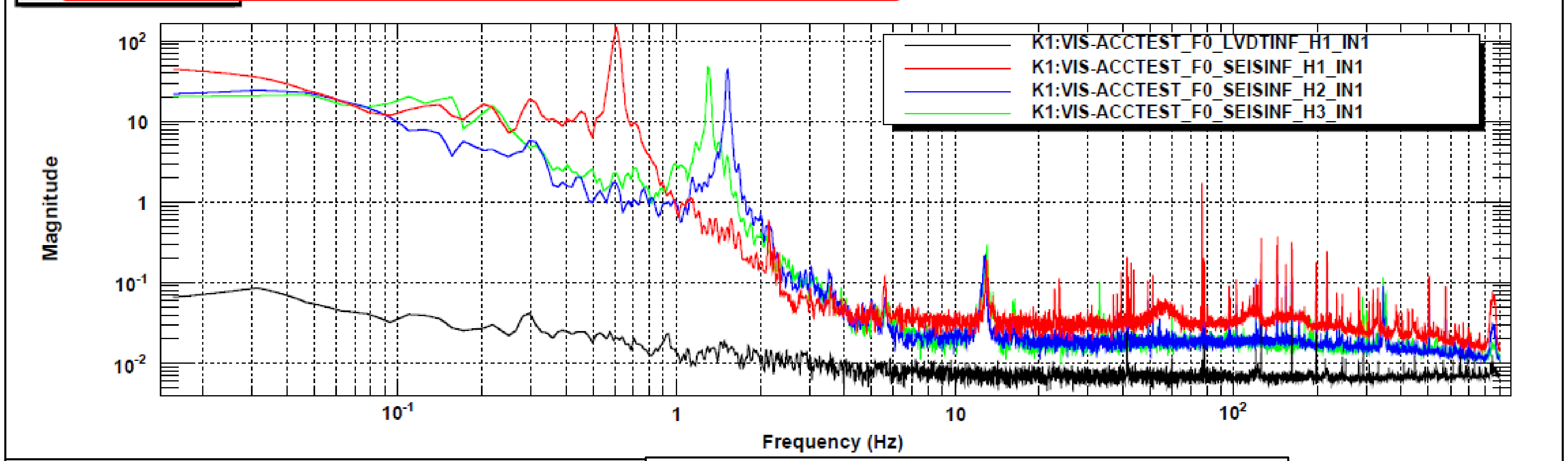
Results: noises of the accelerometers / 3ch correlation analysis

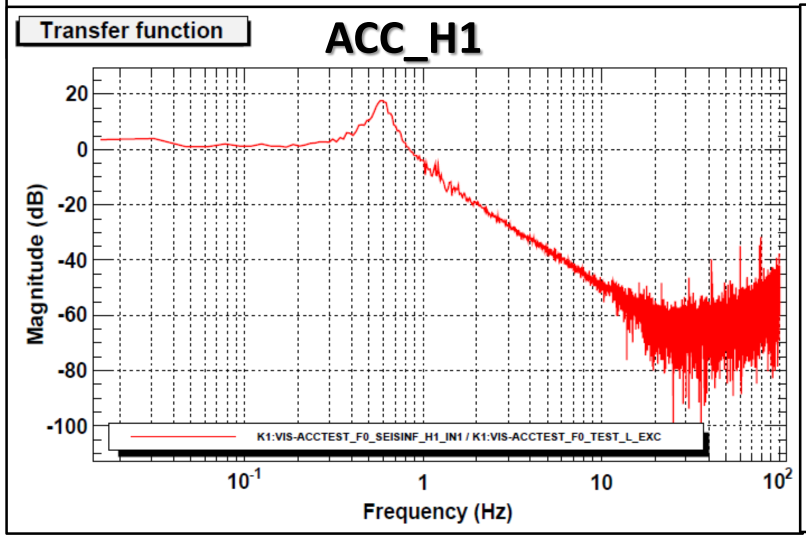


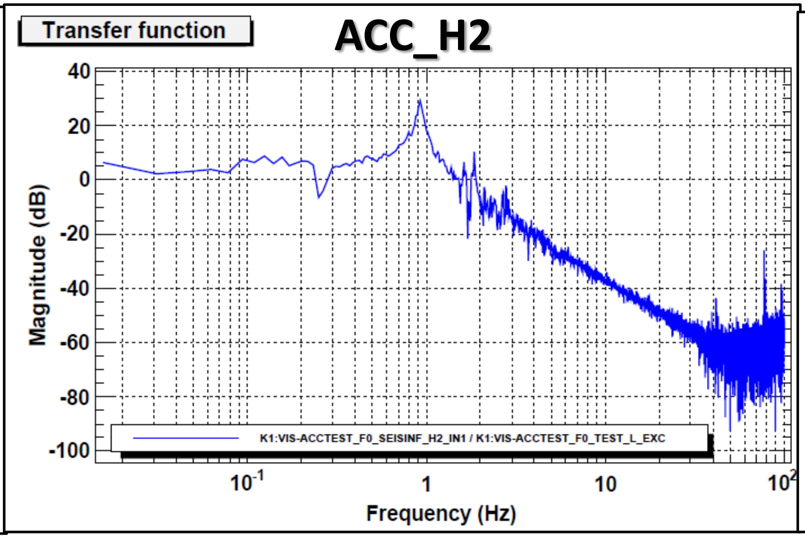


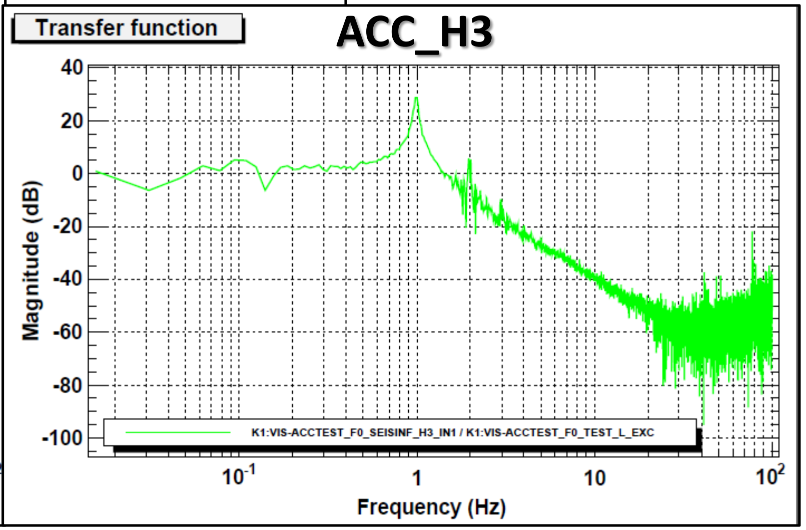
Status report : about the Monolithic Accelerometers(ACCs) Test

❖ Results /force TF of ACC-LVDT









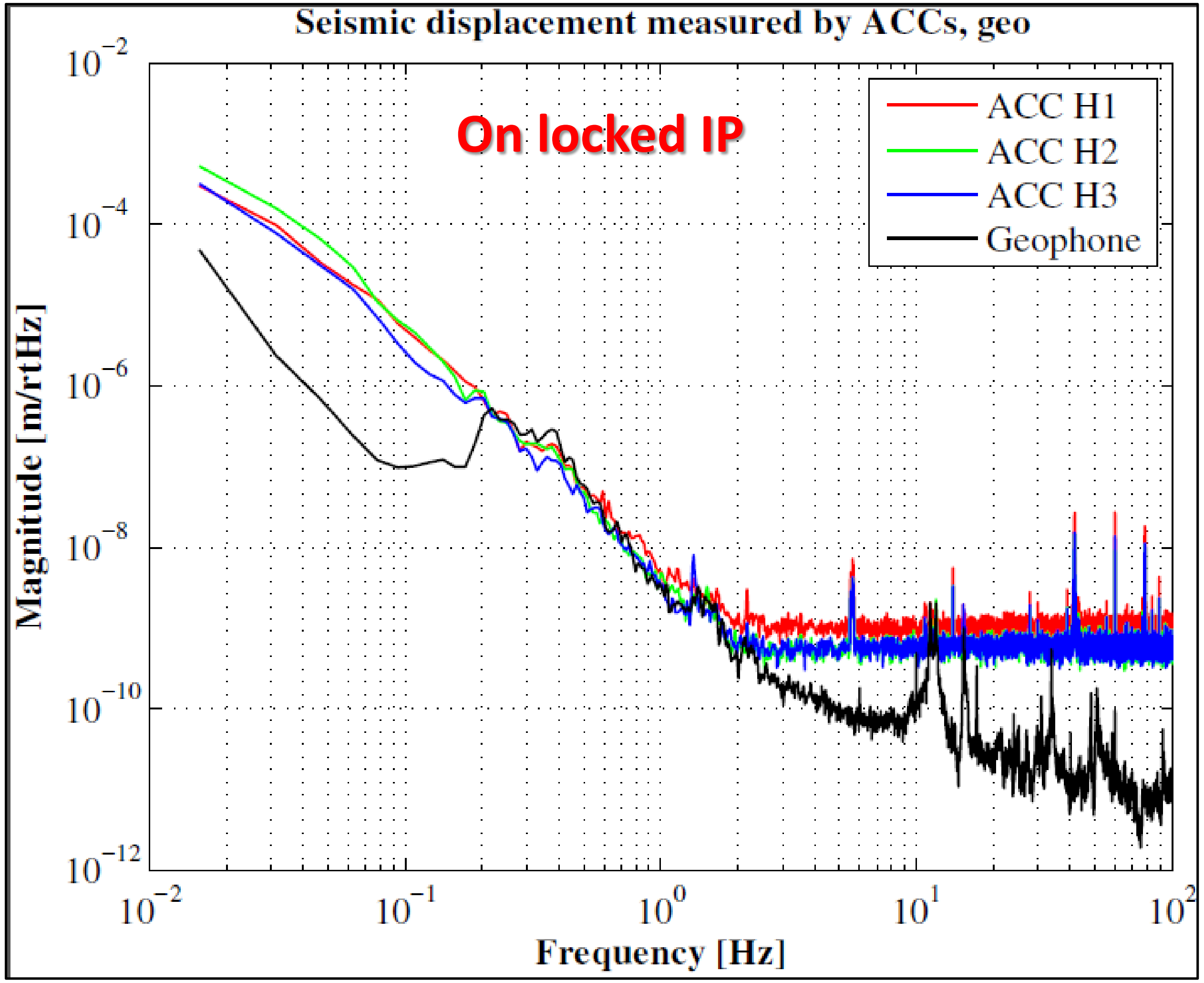
Status report : about the Monolithic Accelerometers(ACCs) Test

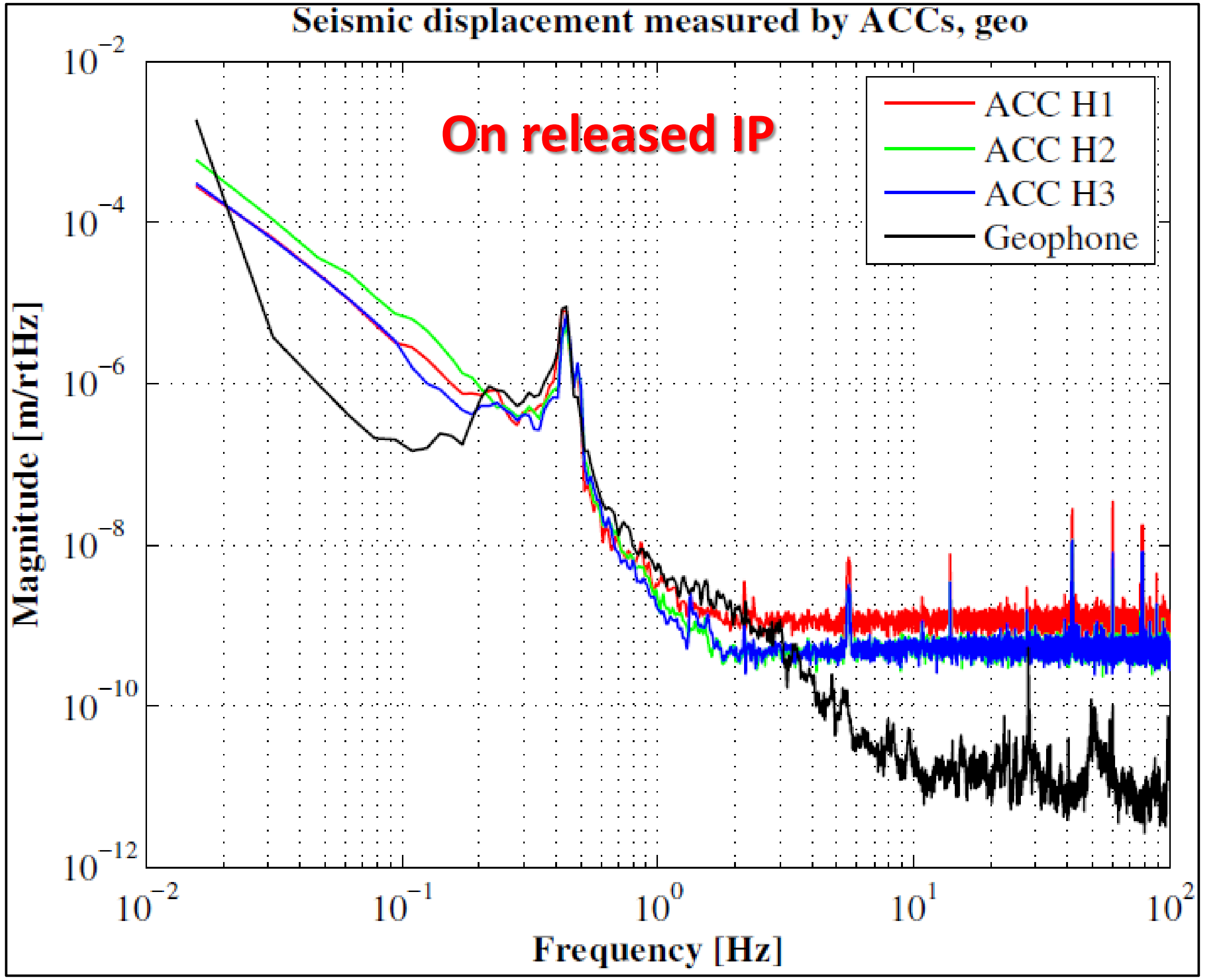
Settings and Results

- ❒ ACC-LVDT gains, etc.
- ❒ natural frequencies, Q factors of accelerometers
- ❒ Tilt calibration
- ❖ Spectra measurement on ACC-LVDT
- ❒ sensitivities, noises of accelerometers

Status report : about the Monolithic Accelerometers(ACCs) Test

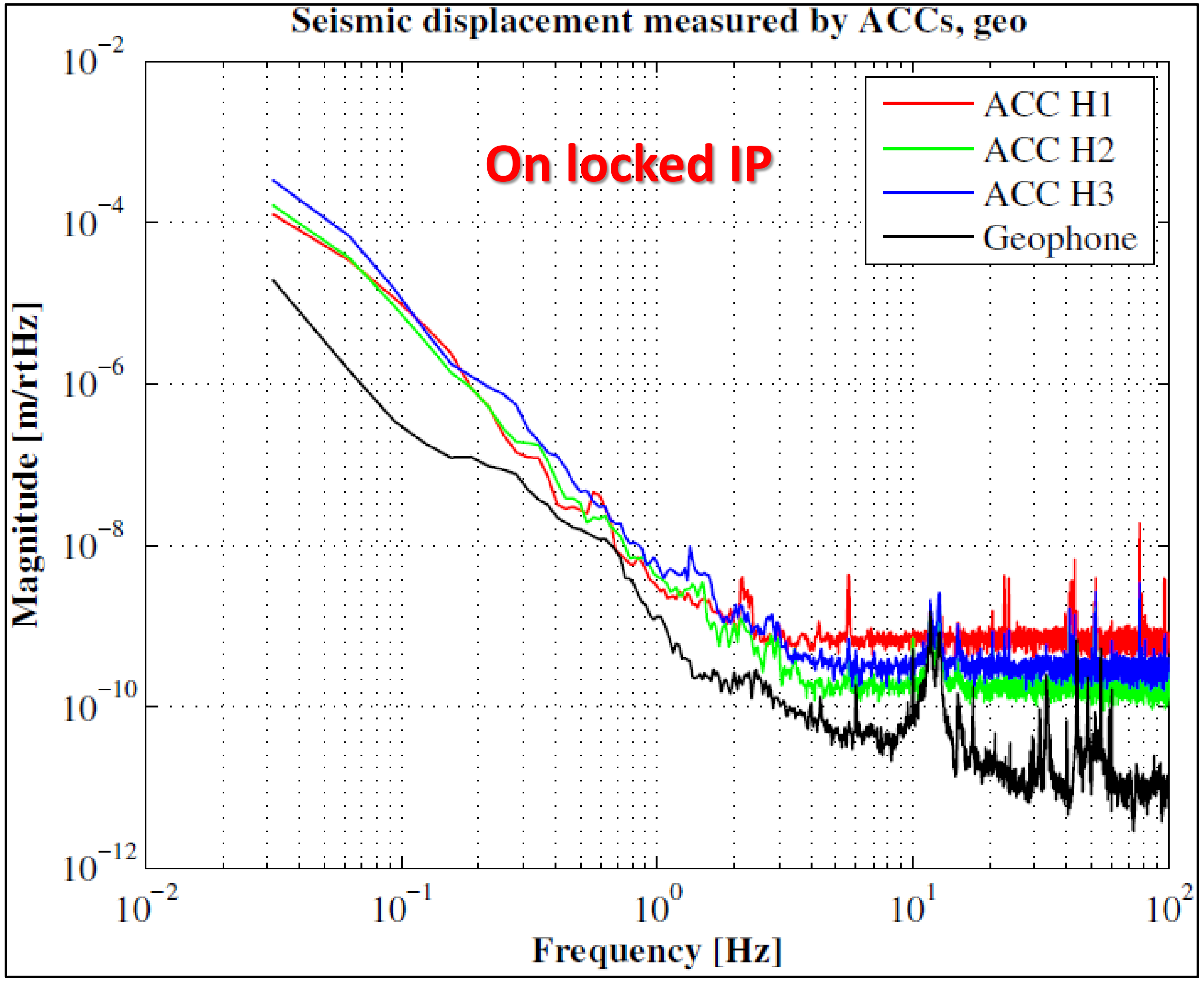
Results: Spectra measured on IP, BEFORE increasing ACC-LVDT gain.

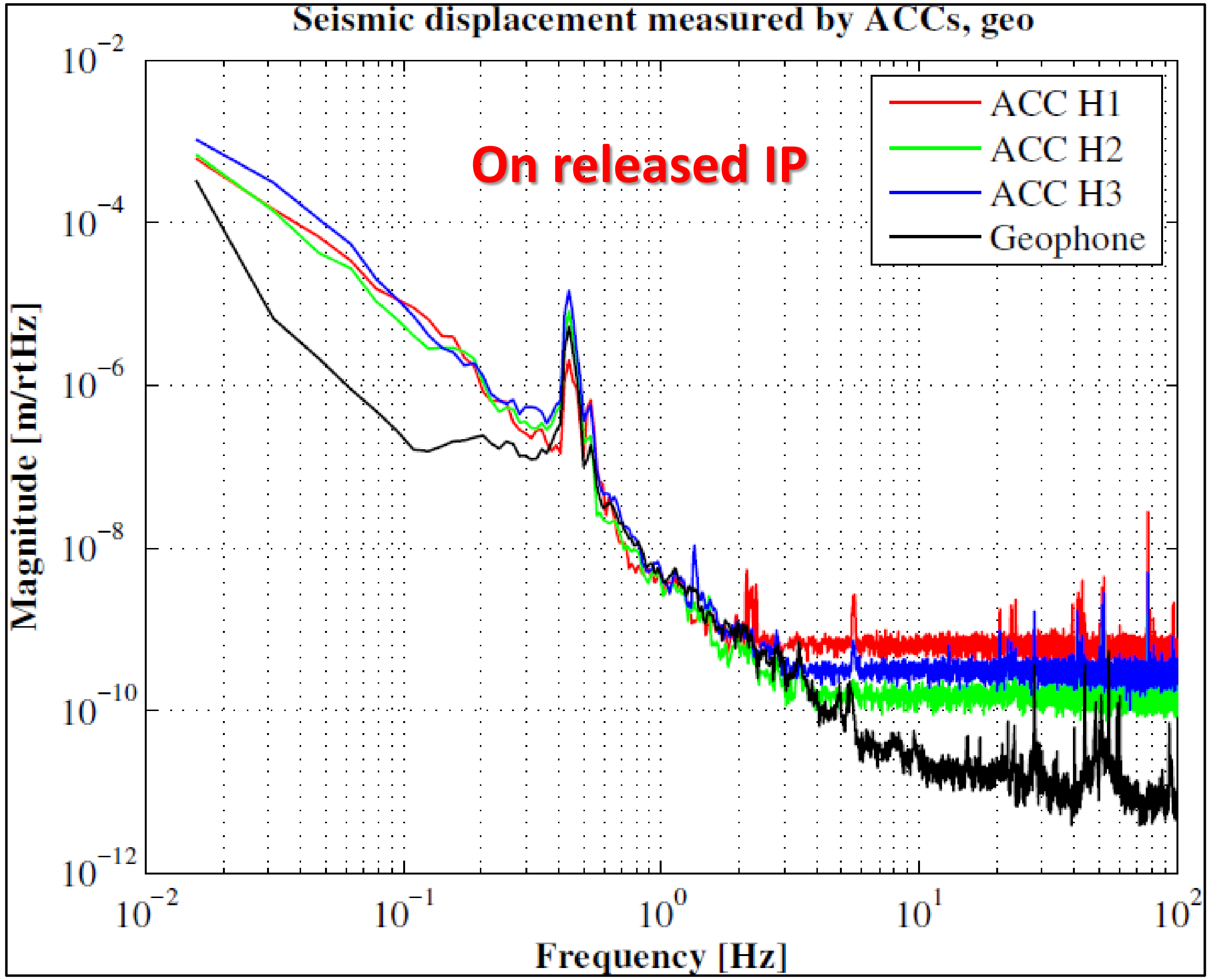




Status report : about the Monolithic Accelerometers(ACCs) Test

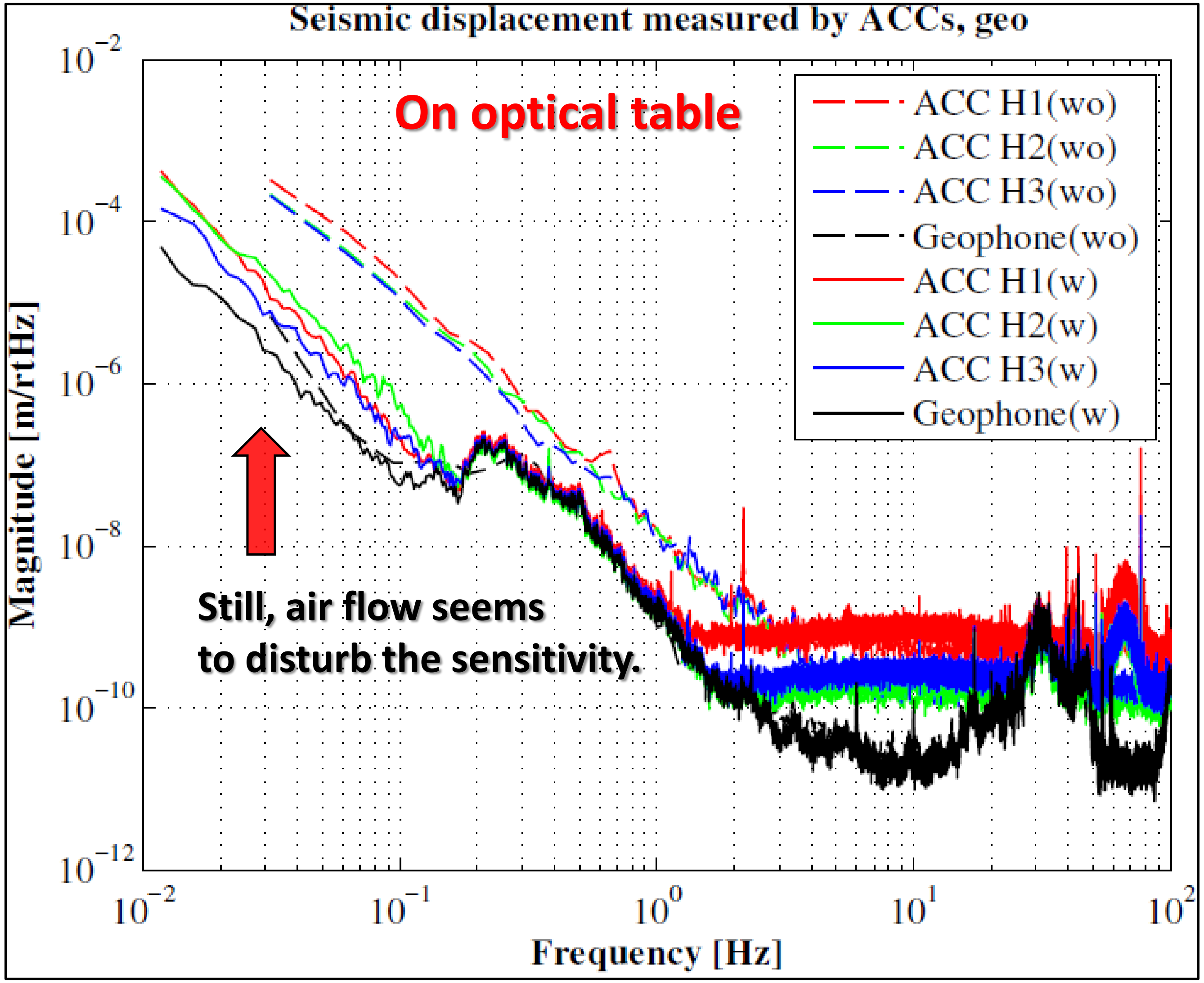
Results: Spectra measured on IP, AFTER increasing ACC-LVDT gain.





Status report : about the Monolithic Accelerometers(ACCs) Test

Results: Spectra measured on optical table, AFTER increasing ACC-LVDT gain.



Without air shield, measured on 2016.5.27, day

With air shield, Measured on 2016.6.5, night

I think it's very difficult to look at these plots knowing all that might be/ is wrong with the calibrations etc. I think, with the wrong calibrations and just making lines of GEO and ACCs fall on top of each other is nice to get an order of magnitude feeling, but not more than that!

Sensitivity limit ≅ 10^{-10} m /√Hz

*** Sensitivity limit should be lower, right? If you have LVDT-readout sensitivity plot, please let me know.**