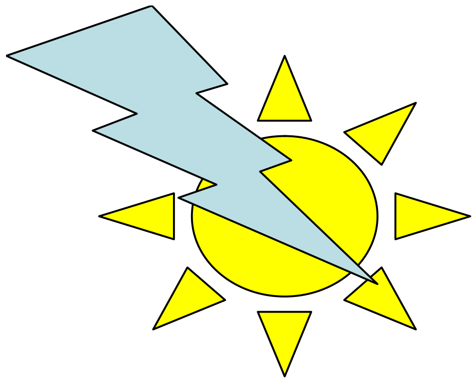


Mirror Suspension Control commissioning learning

E. Majorana
INFN

MSC workgroup

Virgo-Ligo joint meeting

LIGO-G070363-00-Z

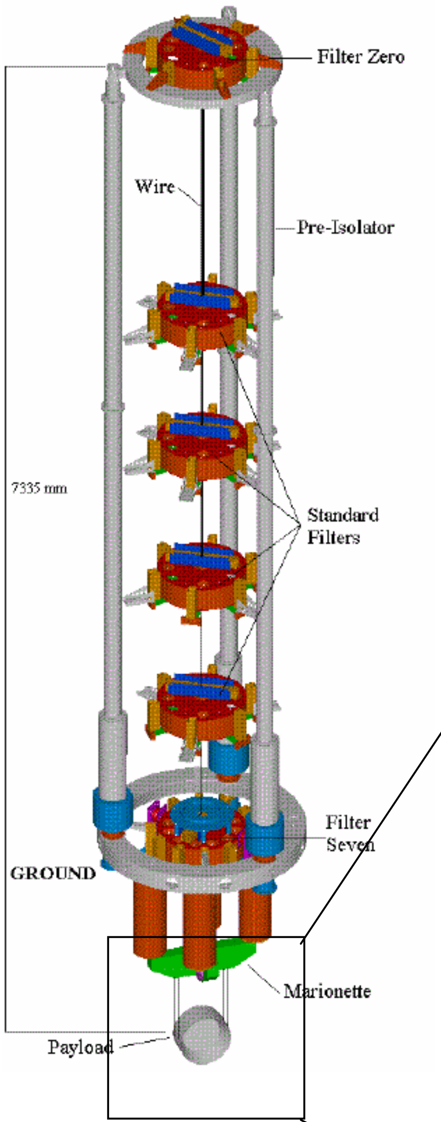
outline

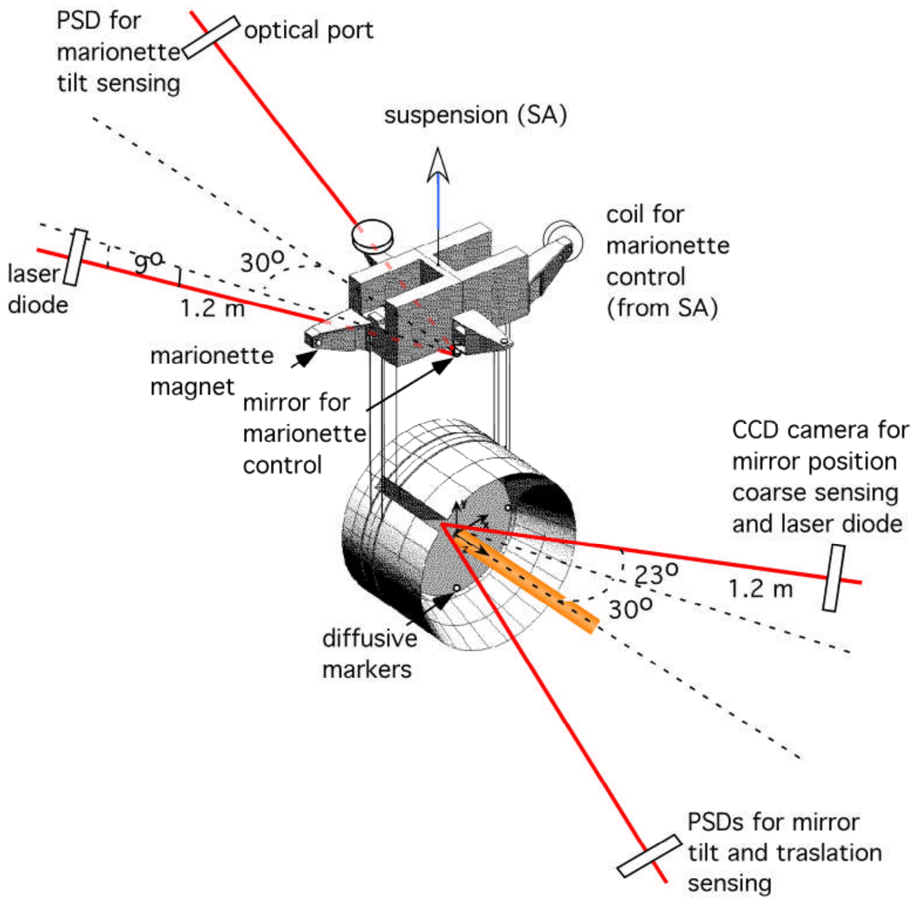
- Wellcome (3 slides)
- recent improvements
- VSR1 MSC configuration

Virgo "standard-super-attenuator"suspension …

Soft isolator concept:

1. very efficient passive attenuation
2. active controls for normal mode damping





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The mission of Mirror Suspension Control workgroup: commissioning-oriented activity

Virgo sensitivity (at LF !)

Virgo duty-cycle

In fall 2006 the majority of main ITF control issues had been addressed:

1) lock acquisition strategy
2) automatic alignment (~)
3) suspensions and local controls had allowed all above
4) some smart ideas for improvements were ready

To start noise hunting, stable operation was needed:

=> MSC performance started to be **integrated in ITF issues**

STANDARD CONFIGURATION FOR LONG SUSPENSIONS

stage	variable	actuator ref
SA TOP	**Pos/Accel** 3D+yaw	Ground(~)/stars
SA BOTTOM	**Position** yaw	Ground
PAYLOAD	**Position** 2D+pitch/yaw	SA BOTTOM

Basic requirements: sensing and actuation diagonalization

+

hiearchical control

Recent improvements

> **conclusions.** (Apr 2nd, commissioning meeting)

Operation:
Continuous attention on operation issues

Strategy disturbance rejection:
- A large effort was spent on ID sensing optimization and on "soft operation"
- Tools to emulate crucial environmental situations have been developed
- Marionette reallocation in 4 suspensions
- GIPC in-line

To be done before (possibly before the MegaRun):
-further technical noise reduction (locking reallocation improvs being done)
-improvement of short suspension performance (InjB,MC,OutB, possibly)

Short suspensions (MC,IB)

MC suspension:

V-damp: one vertical accelerometer out of order

=> no V-damp implementable for VSR1

H-damp: IP needs mechanical tuning

=> only small patches to improve it have been set

IB suspension:

V-damp: tested but it implies a major revision involving bench LC

=> no V-damp implementable for VSR1

H-damp: no major evidence of such a need

=> only small patches to improve it have been set

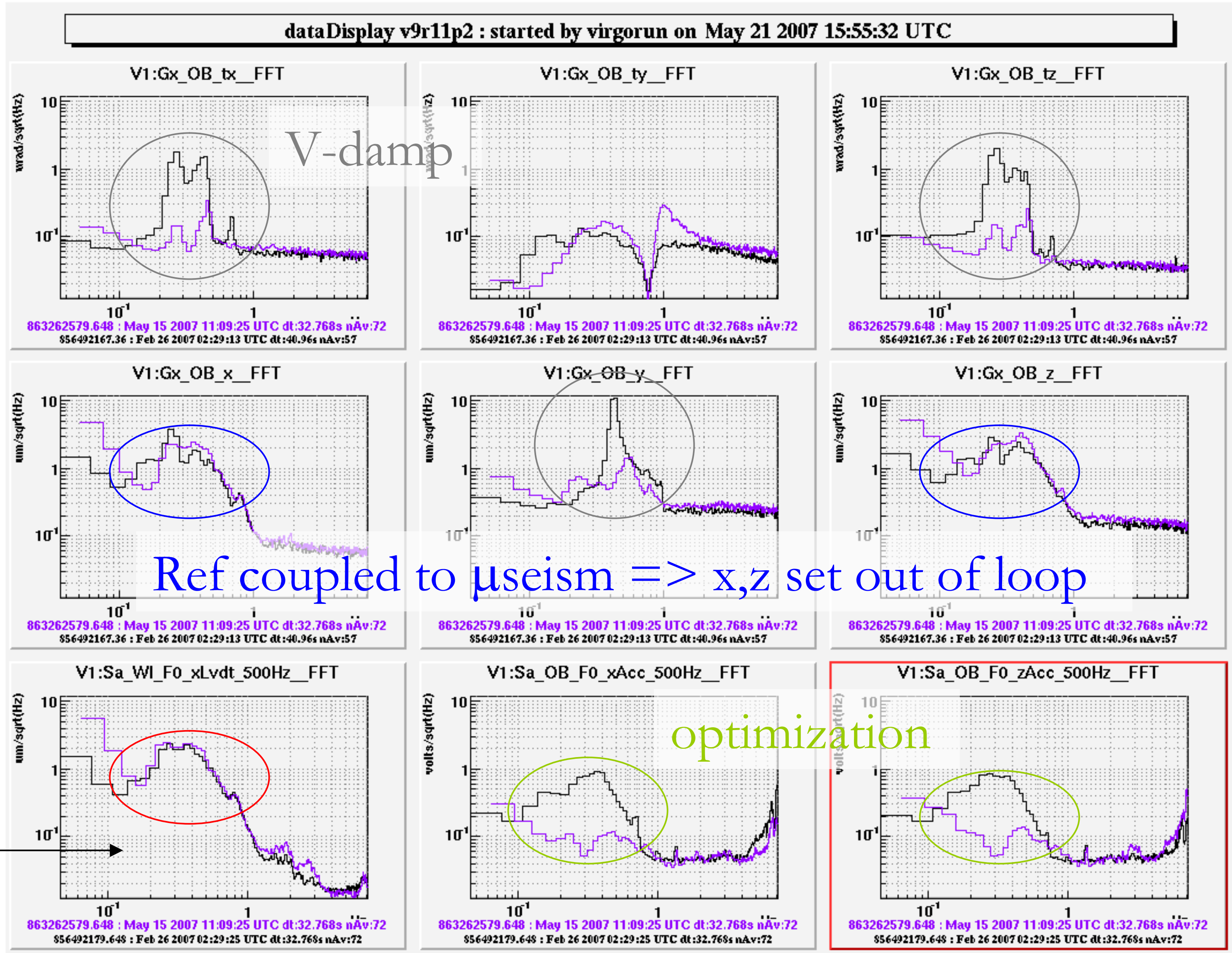
Short suspensions (OB)

OB suspension:
V-damp: implemented
H-damp: tuned

=> LC configuration slighly changed to accomplish the improvement performed at the suspension top.

Short suspensions (OB)

Comparison before/after optimization.



under similar µseism disturb.

Further improvements: non-linear coupling compensation.

Tilt recoil (yaw) on payload and suspension chain due to large longitudinal correction.

LF disturbance

↓

Big zM (marionette corr.) ⇒ Yaw side-effects

L-term | Q-term

SA:

$ty^{F7}=a*zM+b*zM^2$

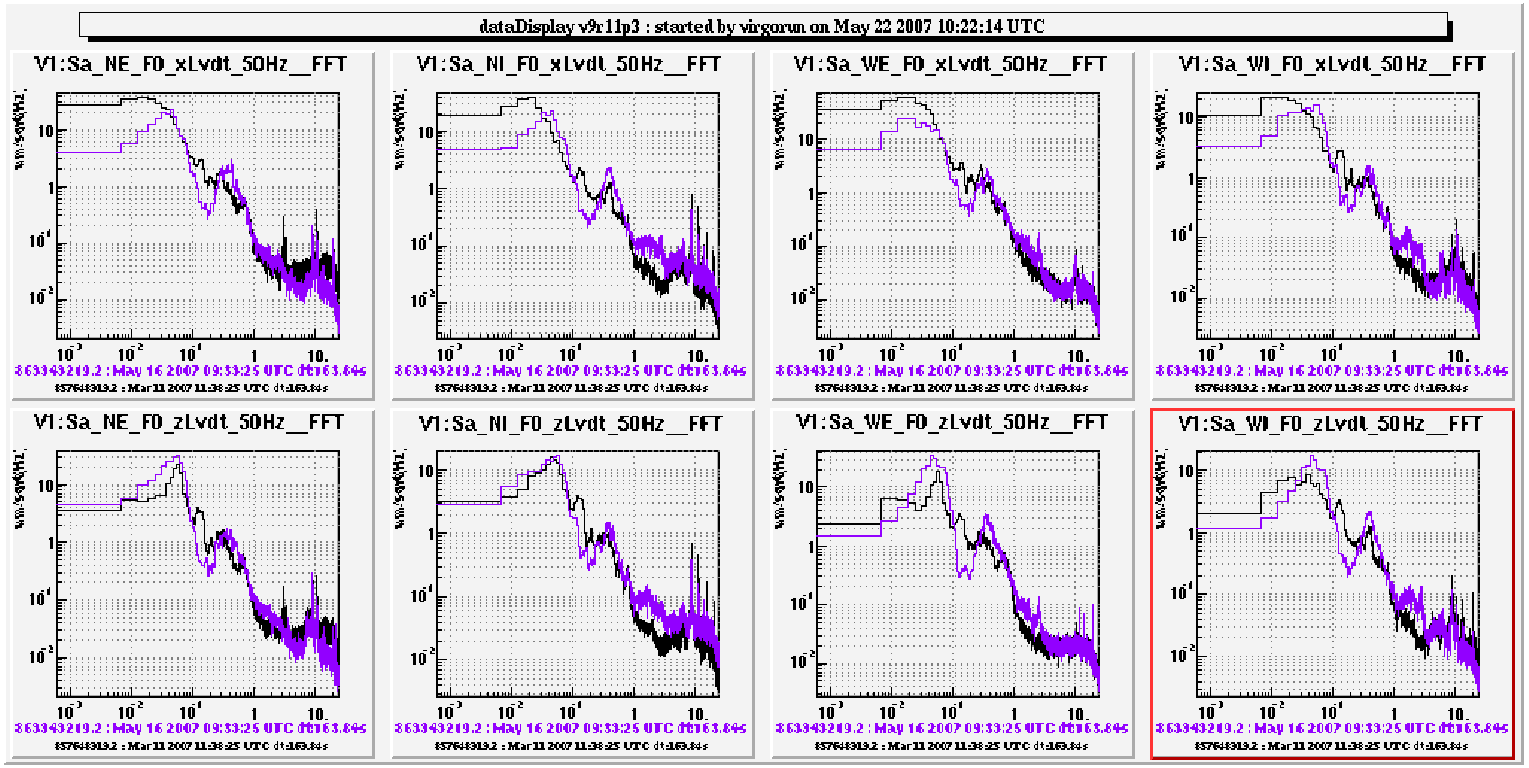
Payload:

$ty^{ma}=c*zM+d*zM^2$

actuators balanced (to keep the lock) | Q-term

Further improvements: SA direct effect

Example: windy/quake data comparison May16 - March 11



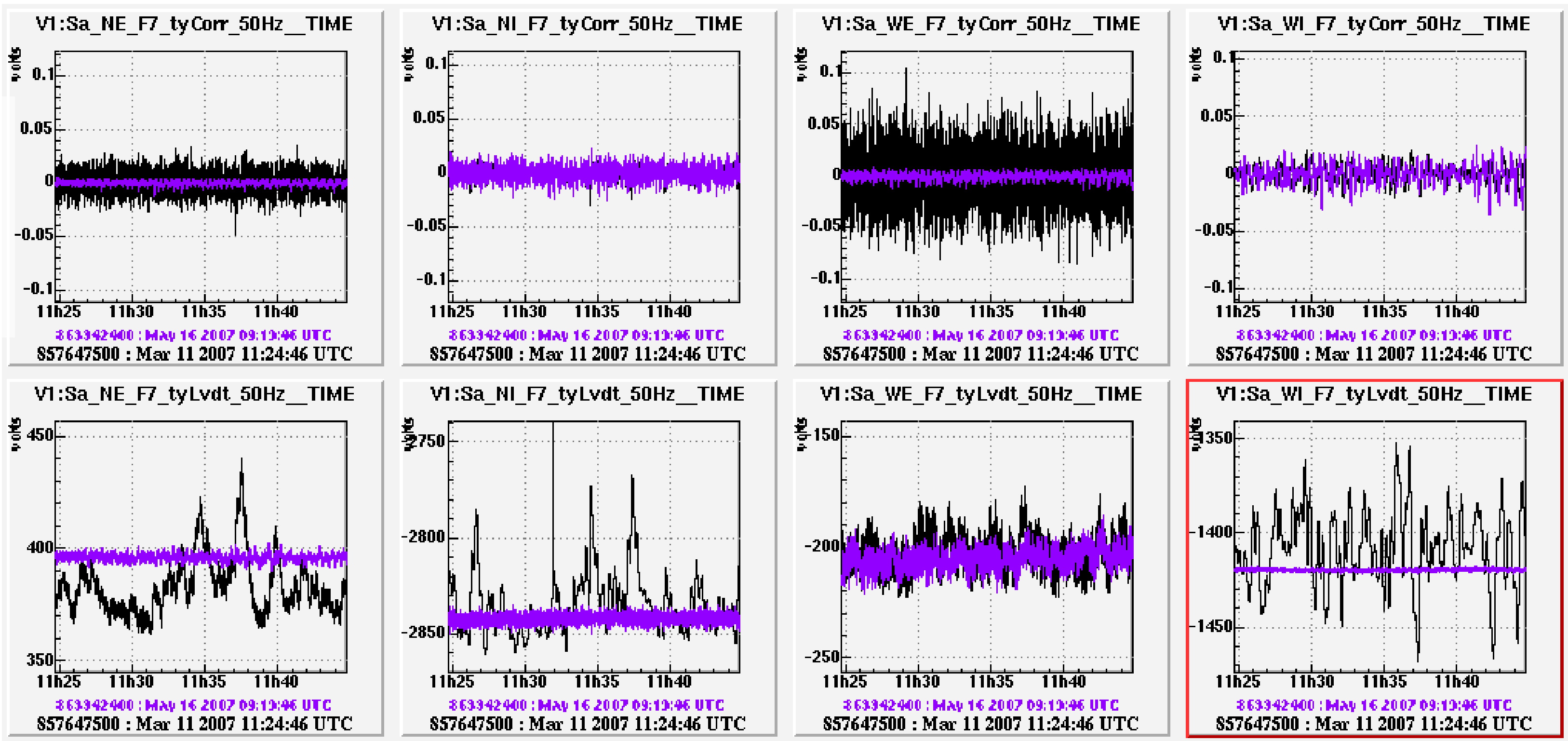
Further improvements: SA direct effect

Example: windy/quake data comparison May16 - March 11

zM->ty^{F7}Corr
Benefit:
damping gain
@ F7 reduced.

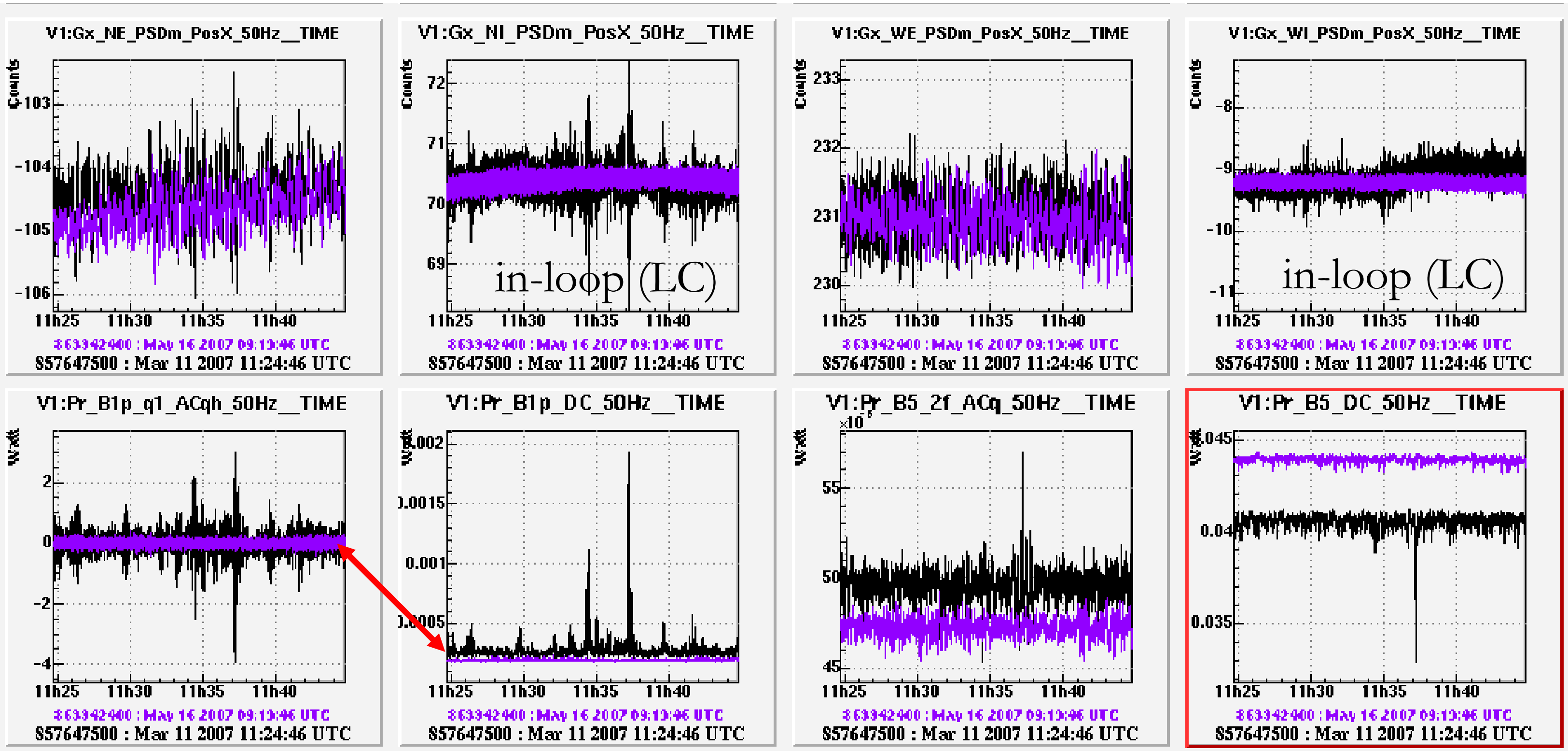
zM->ty^{F7}
Benefit:
recoil
cancelled.

EM-MS



Further improvements: effect on payload alignment

Great stability improvement under LowFreq disturbance conditions



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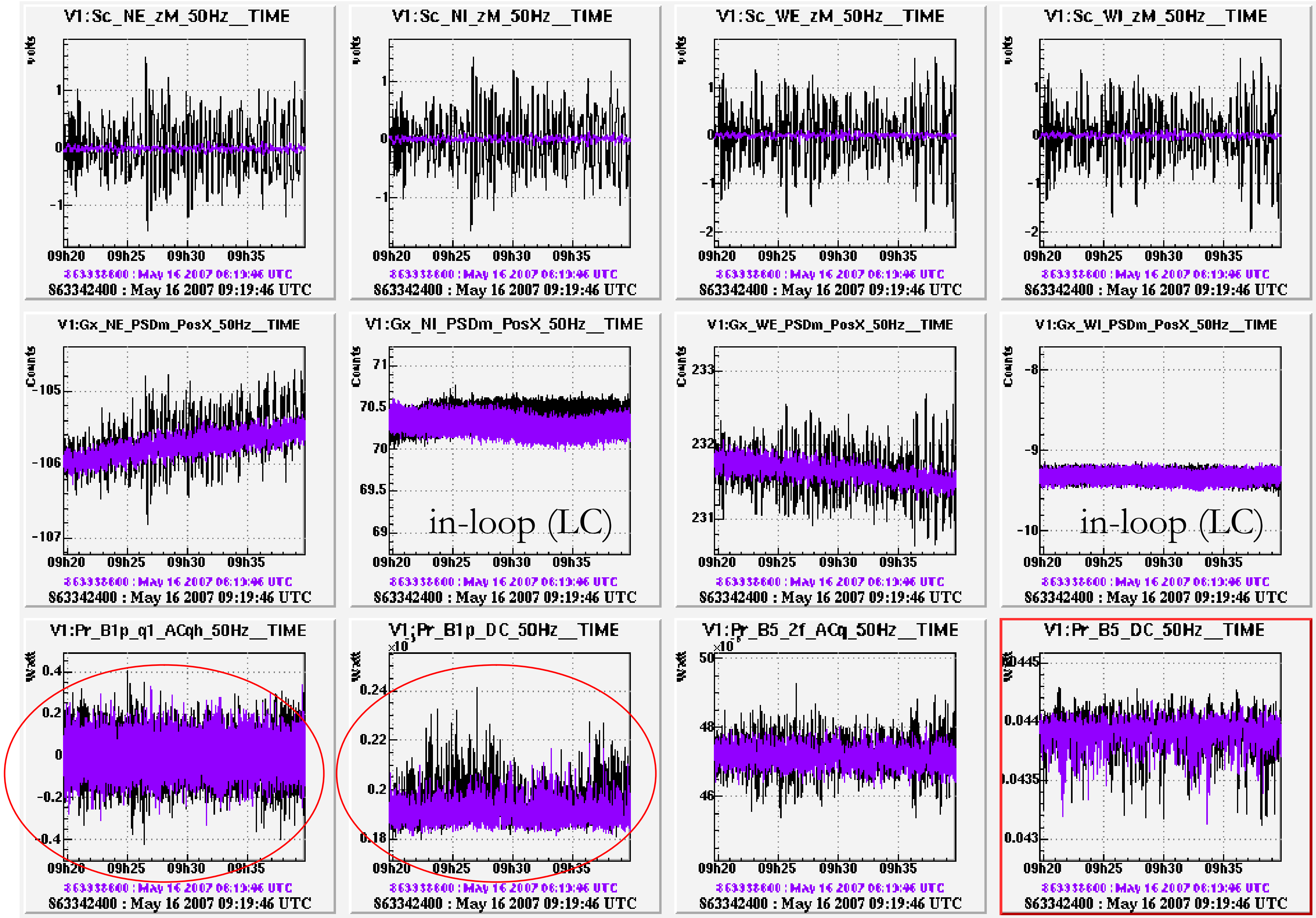
Further improvements: effect on payload alignment

Before/during a recent quake, large zM, small effect on DF



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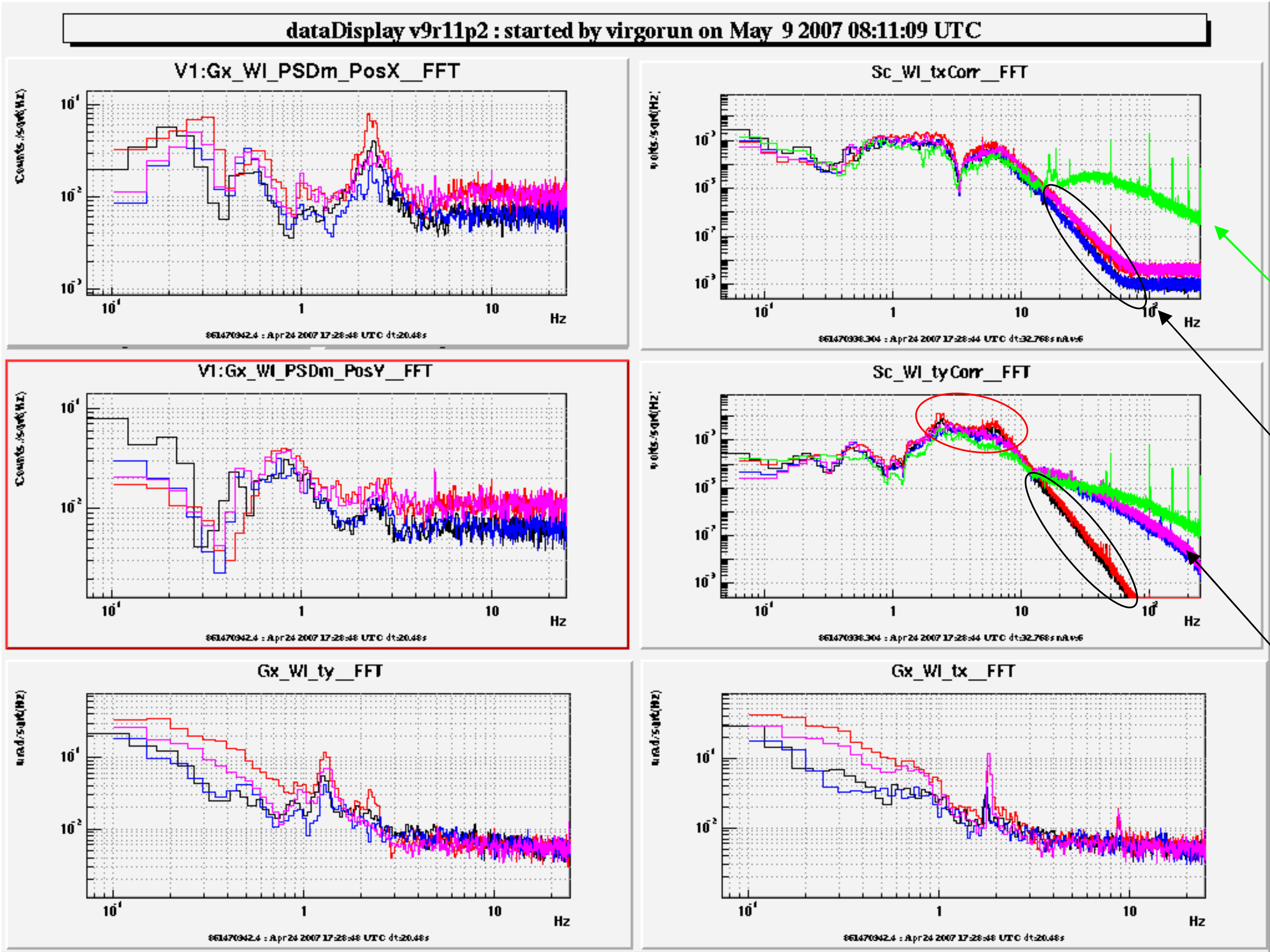
Further improvements: angular LC roll-off less aggressive

Marionette angular LC



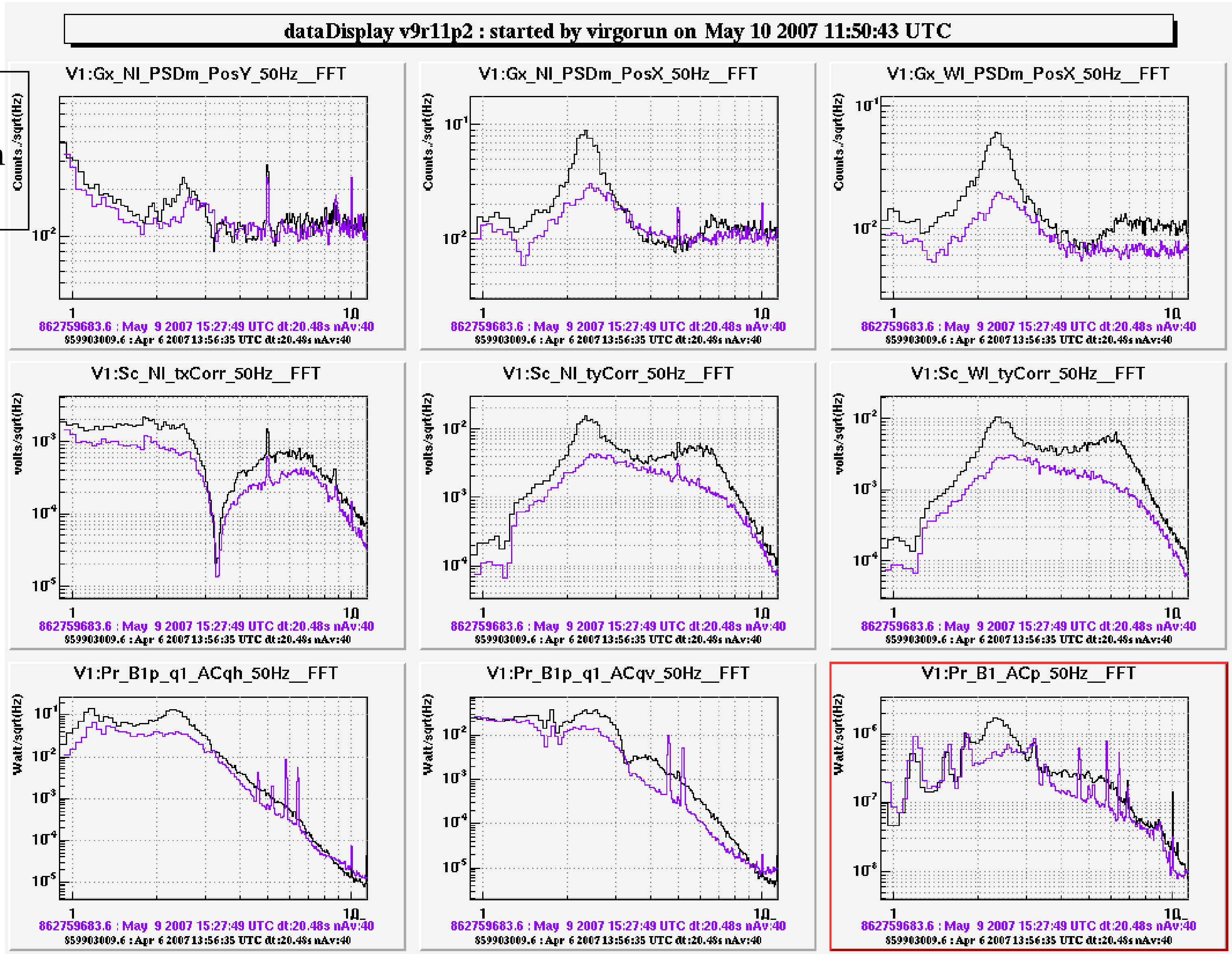
Benchmark provided by actual AA (WE,NE) and noise projections before VSR1

to accomplish Virgo specs from f > 15 Hz and to tollerate ±1 mm off-centering

New ty corrector

Further improvements: angular LC roll-off less aggressive

LF overall benefit:
- Smaller correction
- better DF



VSR1 MSC configuration:

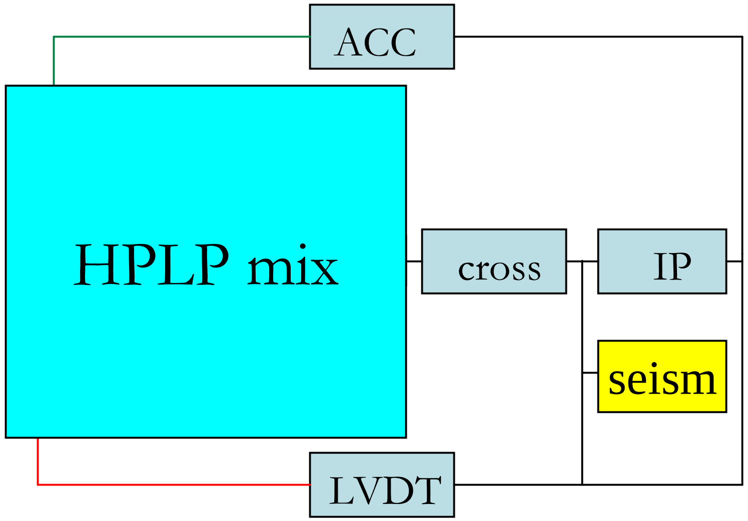
- Tuning of Pos/Acc sensor blending
- GIPC
- Locking force re-allocation

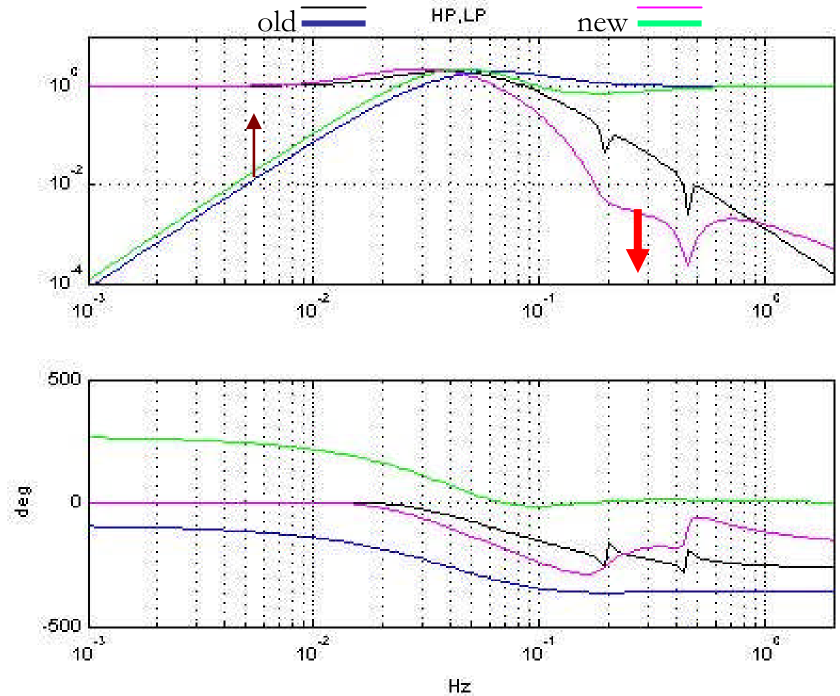
Tuning of Pos/Acc sensor blending

> disturbance rejection: **single-suspension tuning**

Example

hybrid filters (on-the-fly tuning)





mix =0.5 'medium' attenuation of LVDT µseism noise
Compared to the starting config (crossover @ 50 mHz)

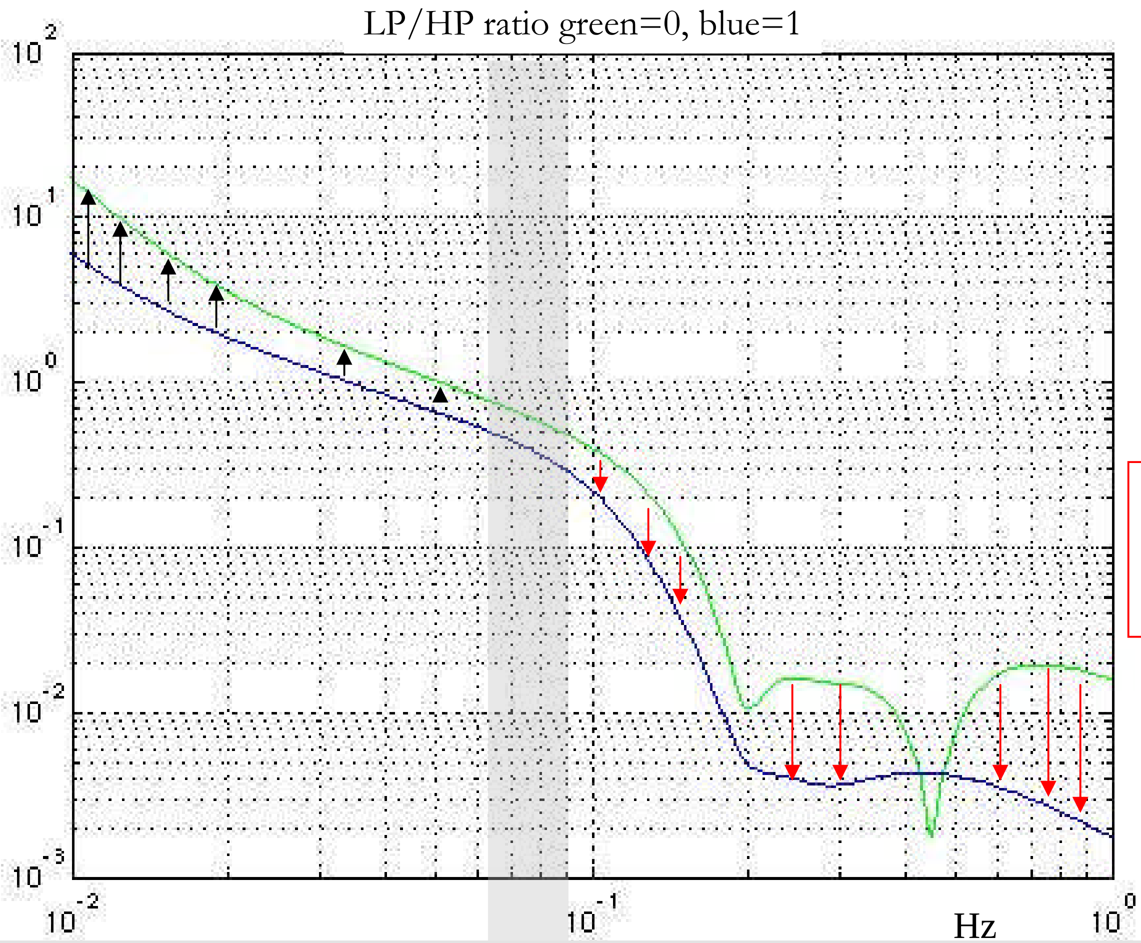
mix =0 (wind-earthqukes, f <70mHz):
"aggressive" attenuation of accelerometer tilt noise.

mix =1 (µseism, 150-600 mHz) :
"aggressive", slightly worsened against tilt noise.

We expect lo learn more from VSR1 continuous operation.
A battery of features is ready.

VSR1: WI-NI

mix 1 => 0
sea => wind

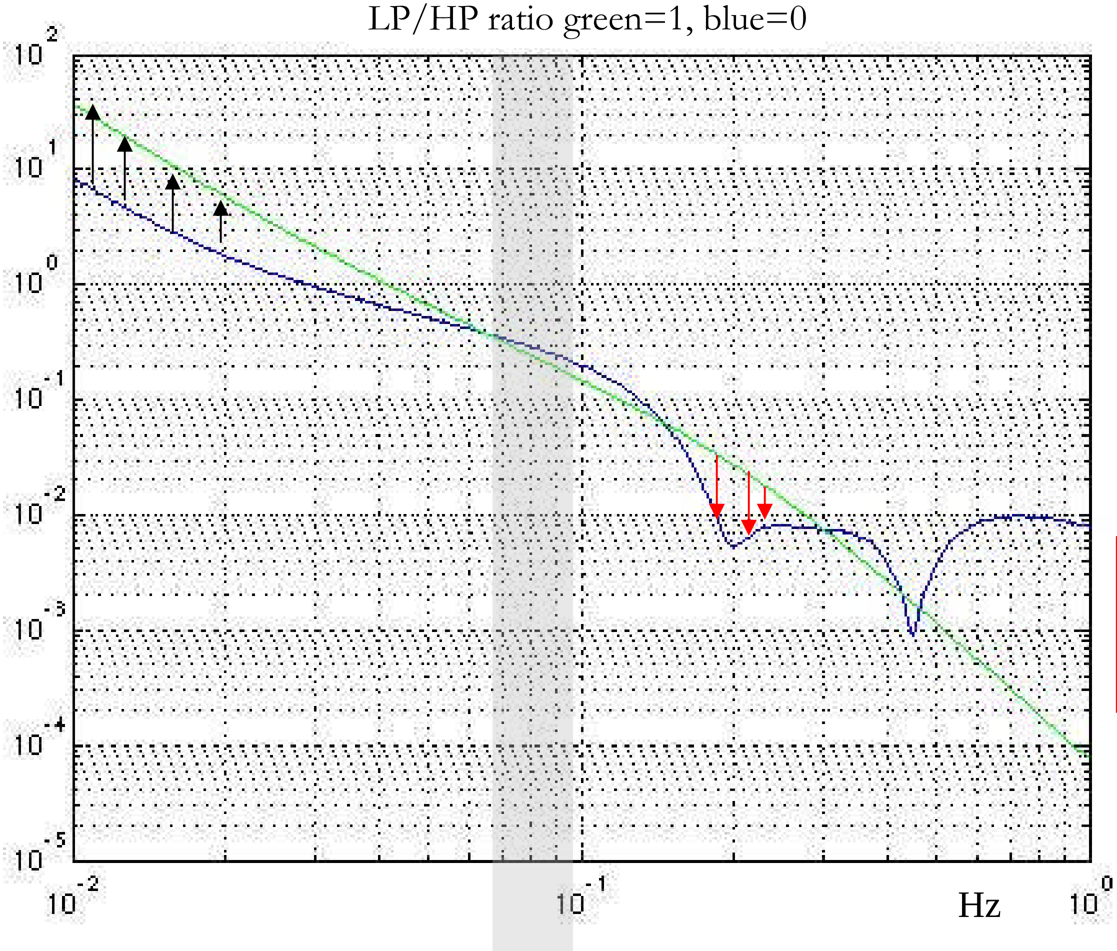


mix 0 => 1
wind => sea

note: mixing balance slightly effective around the crossover frequency

VSR1: PR-BS-WE-NE

mix 0 => 1
sea => wind



mix 1 => 0
wind => sea

Note: the simple blending with crossover @ 70mHz (green) could not be used due to µseism noise through LVDTs without some smart tricks…

GIPC

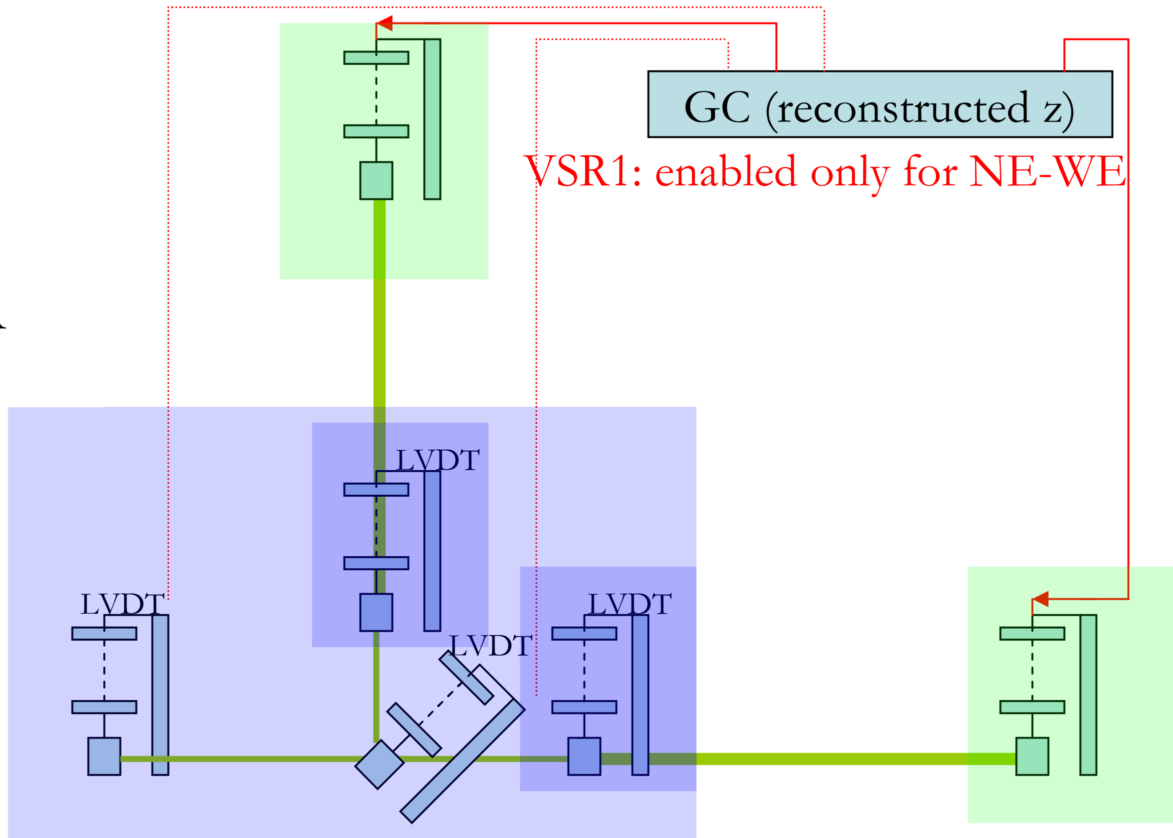
GIPC (Global Inverted Pendulum Control)

wind disturbance rejection without □ esism drawbacks.

The mirror position, provided by the GC, with respect to suspended test-masses, can be used instead of IP position read-out measured by LVDTs.

Example:

- strong **anti-wind** NE-WE
- featured **anti-wind-µseism** at BS-PR
- strong **anti-wind-µseism** at NI-WI



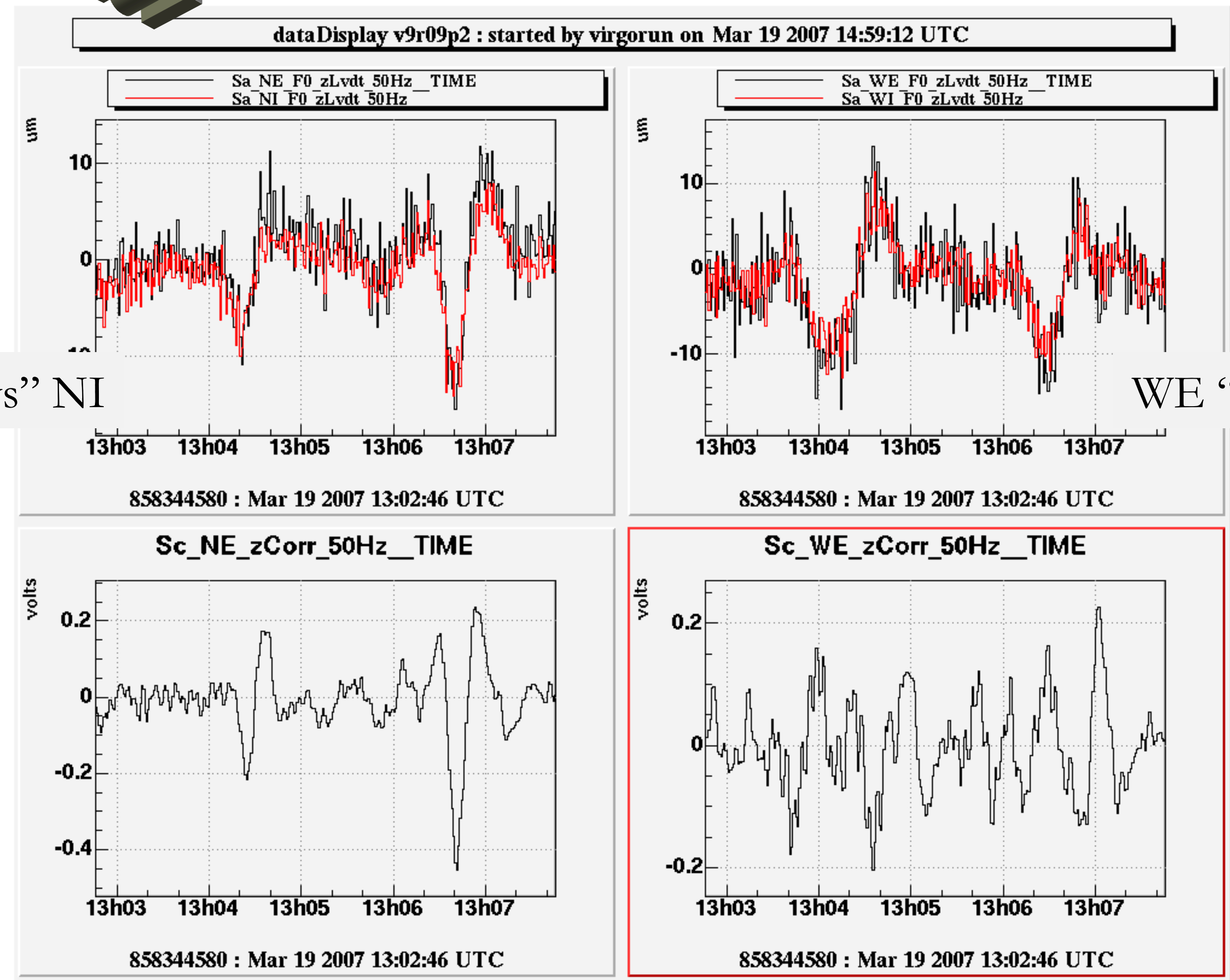
note:

- automatic engagement (locking)
- SciM-transparent in quiet conditions

Stormy weather

Example1: NE_GIPC,WE_GIPC

step9

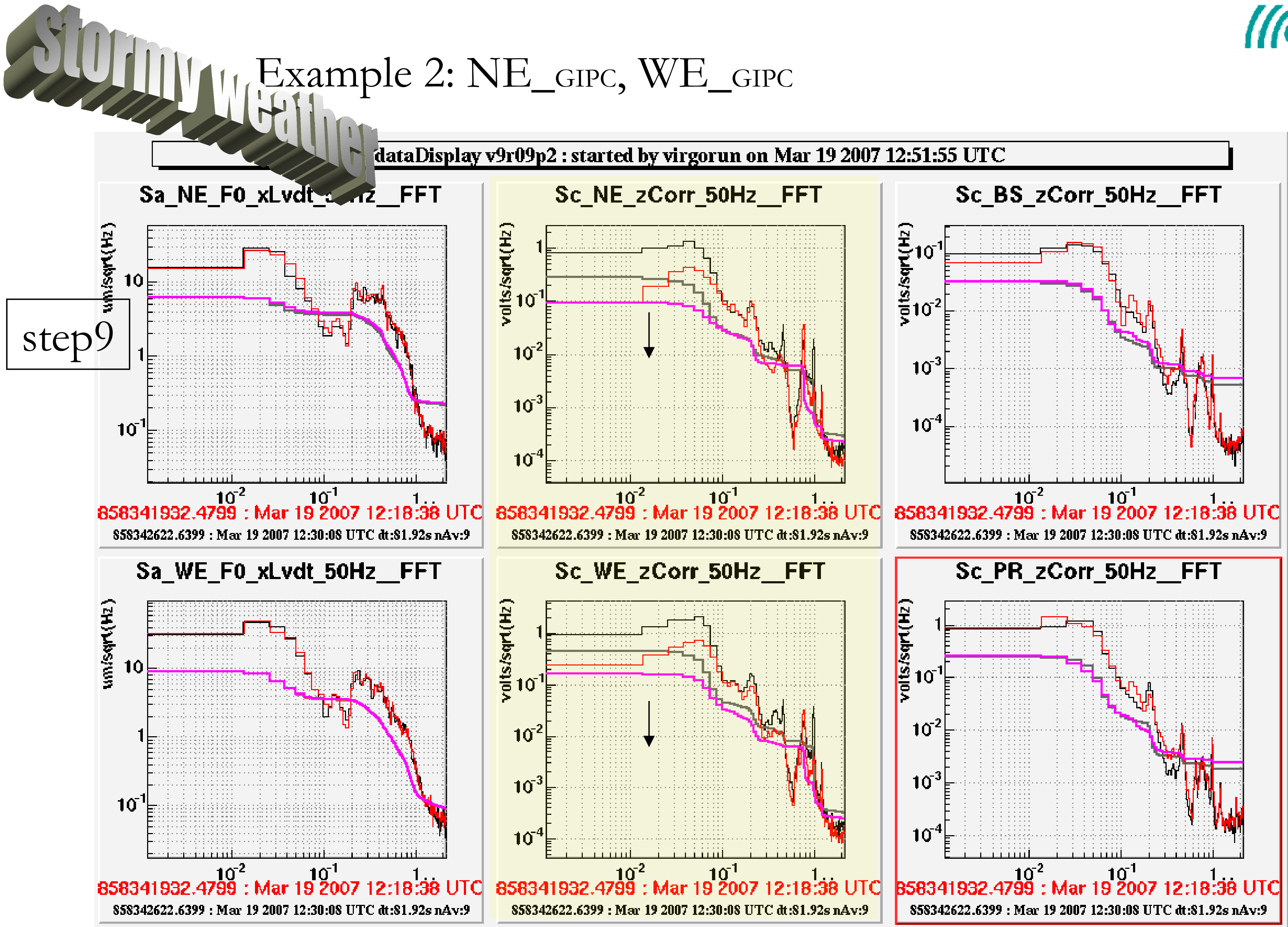


NE “follows” NI

WE “follows” WI

Example 2: NE_GIPC, WE_GIPC

step9



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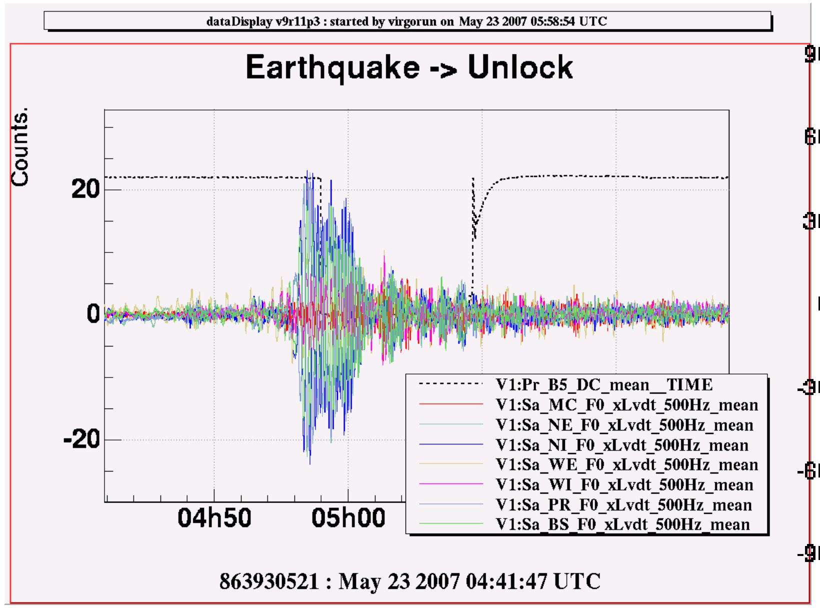
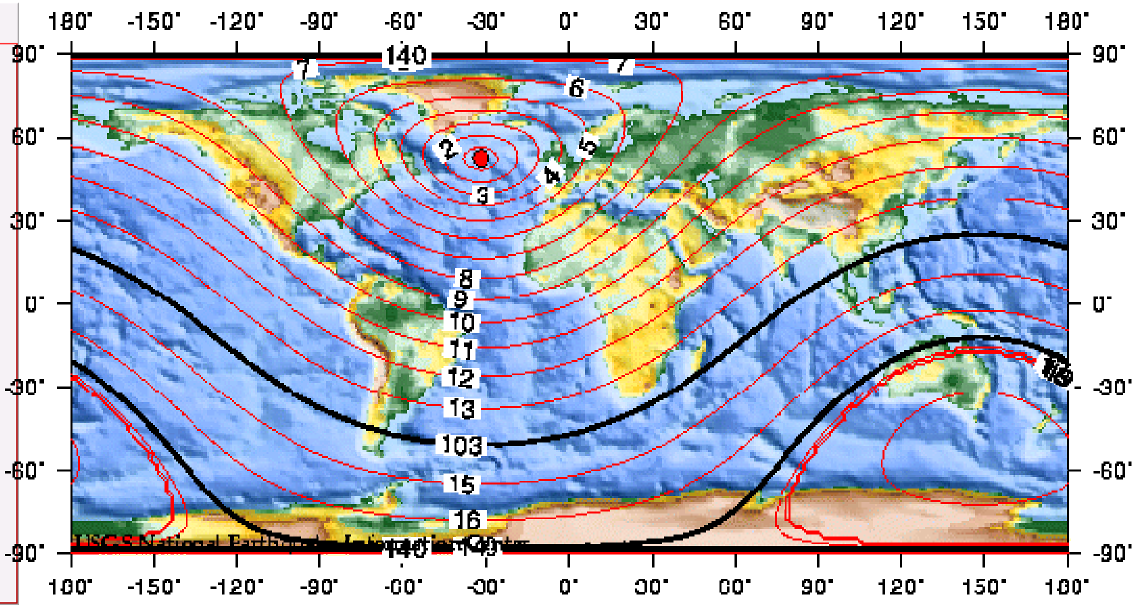
GIPC YES/NO

As long as the disturbance is at low frequency and localized, GIPC is very effective (cars, jumping visitors, "bombing", wind…)

As the disturbance becomes "common" (earthquakes…), GIPC may play a negative role ….

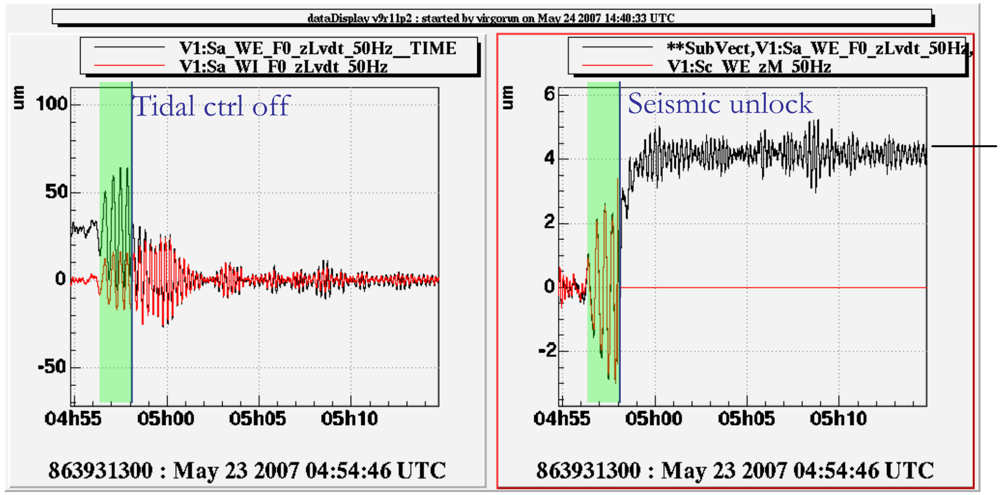




NORTHERN MID-ATLANTIC RIDGE (mag 5.7)

Ex: in this case GIPC provided an anomalous correction to WE, twice larger than it had to be.

GIPC YES/NO: differental/common



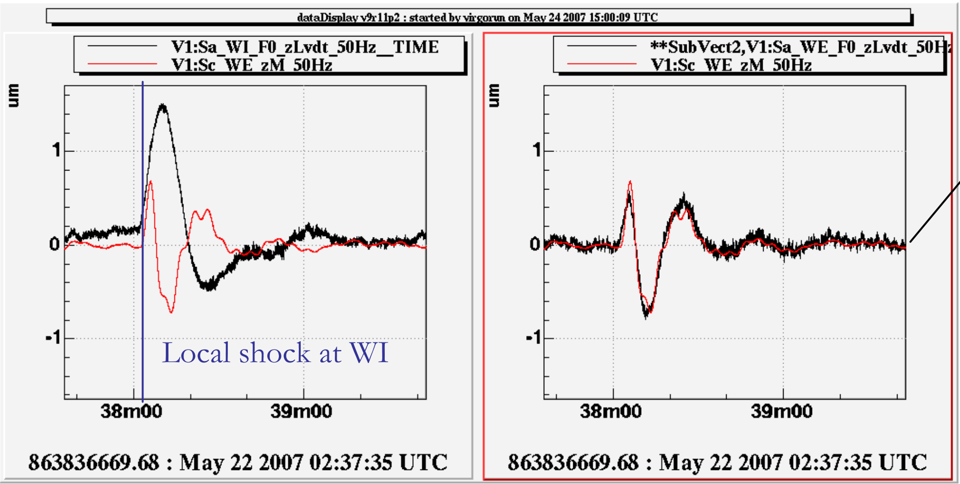
COMMON

Voltage-rescaled differential LVDT motion:

-copied by zM before the seism disturbance

-**amplified by the common**, because

zM=0 while **$z^{Acc} \neq 0$**



DIFFERENTIAL

Voltage-rescaled differential LVDT motion:

-copied by zM

-**Compensates WI local motion**, and the correction is significantly reduced

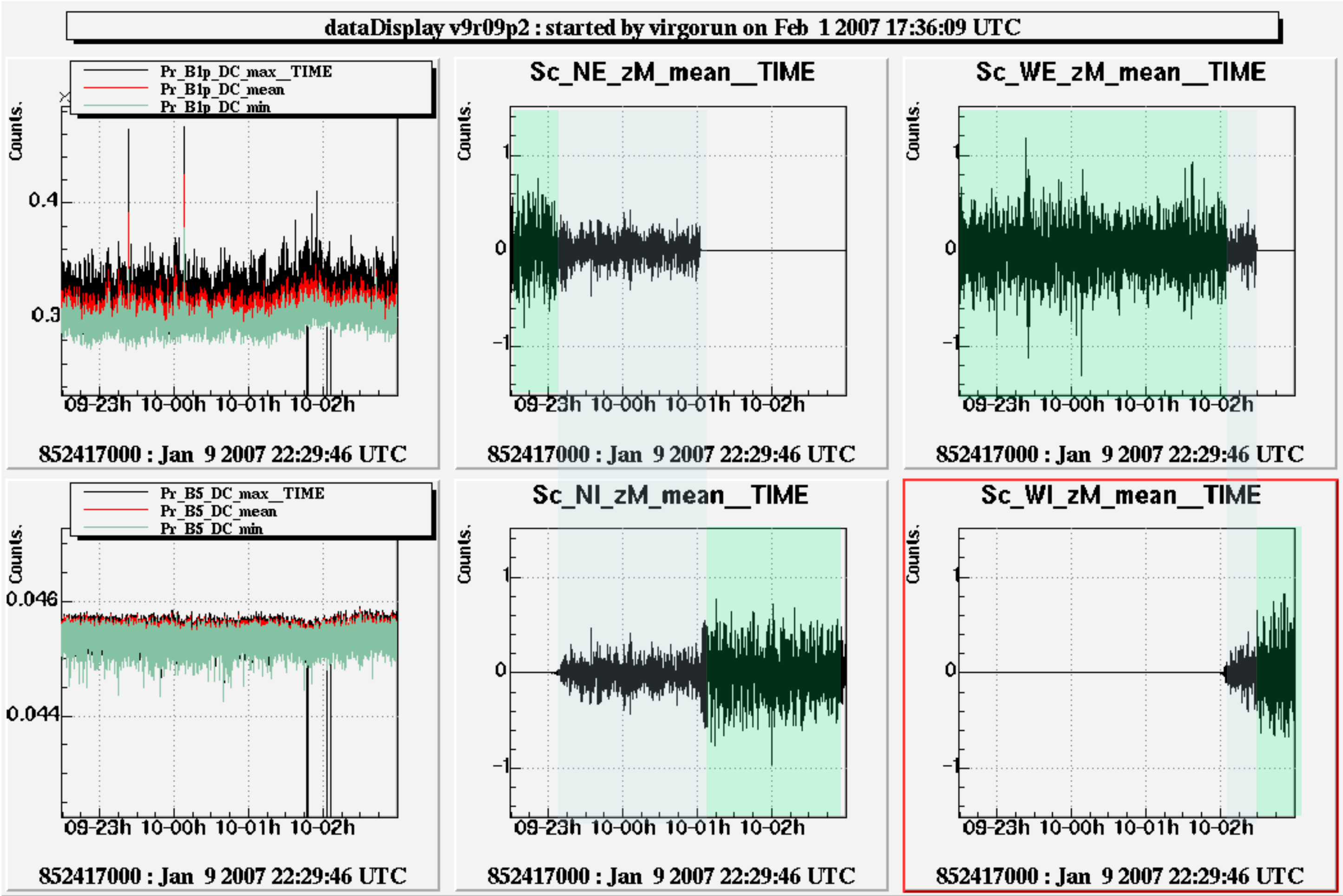
The solution: make GIPC sensed by $z^{Acc}_{IN} - z^{Acc}_{END}$

Through the continuous observation (few weeks) one can estimate the rate of significant disturbances and discriminate the best configuration (earthquakes ? Wind … other… ?)

•Ex: 7 days with no/yes GIPC (requires AdjMode, ~3 min) ?

•We are investigating how to calibrate/trigger the GIPC action only when needed.

Locking force re-allocation

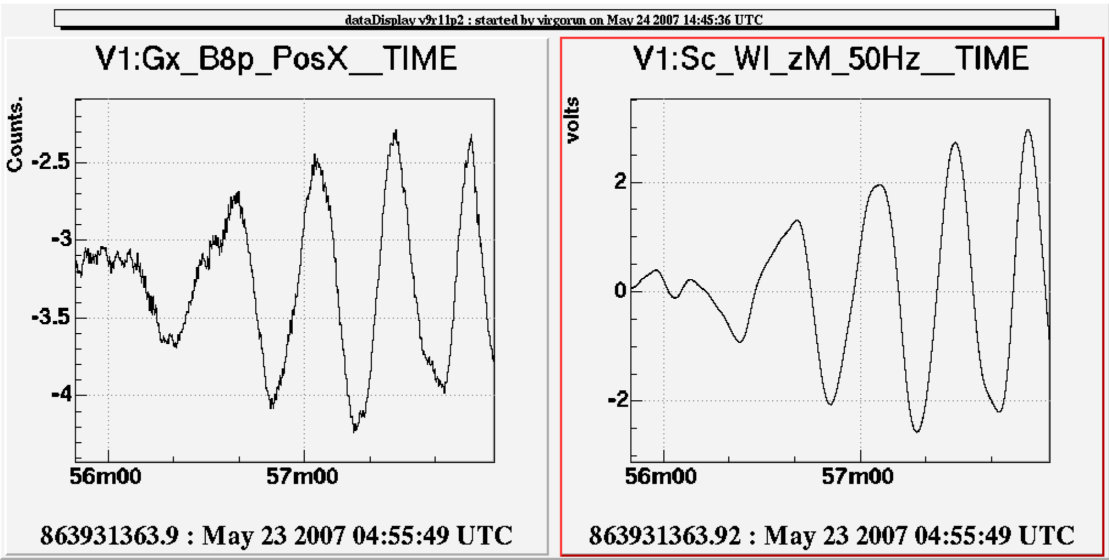


Since WSR8 the lock zM correction is applied to four marionettes (NI,NE,WI,WE) instead of two (NE,WE) in order to avoid zM saturation related to torque recoil.

4 Mario YES/NO: WI-NI are under LC

-zM action actuates also tz payload motion
and, also..,
- LC are well performing, but marionette t_y read-out senses also t_z (roll)

Large zM
↓
zM => t_z
↓
t_z => t_y^{LC}
↓
t_yCorr $^{WI/NI}$
=> misalignment



CCD camera at B8 port

Makes
ITF lock
more fragile

The solutions: - removing zM from input marionettes
- setting WINI under AA

(B8-port position signal OK, but today usable as drift control only)

After recent improvements related compensation of Mario/F7 quadratic couplings, the re-allocation to 4 marionettes could be removed:

Benefits:
- Easier reconstruction of longitudinal ITF degrees of freedom;
- no residual actuation cross-coupling (under LC through tz) related to correction (zM).

How:
- Almost transparent from the side of MSC;
- some work elsewhere (locking parameters…)

> conclusions.

Some relevant improvements before VSR1 :

- the major one : quadratic yaw compensation using zM

Some relevant features of VSR1 configuration :

- flexible-to-learning ID configuration (mix,GIPC)
  note: HP/LP blending usable without GIPC even in presence of medium level of disturbance at LF is in line
- only conservative choices implemented (a family of products available)

Proposal for possible improvements :

- GIPC ON/OFF periods (some solution on the paper)
- only conservative choices implemented (a family of products available); further continuous-operation periods are needed.