Multiple GM sensors at ATF2

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CERN

20 March 2012

Headlines

Detection of the Ground Motion Effects

Influence of the Simulation's Parameters

Planning

Conclusion and Prospects

Headlines

Motivation

- GM sensors are usually only compared to other GM sensors
- Objective : detect Ground Motion (GM) effect on beam trajectory.
- Such a correlation would demonstrate possibility to make a feed forward.
- Feed forward would allow trajectory correction based on GM measurements in CLIC.
- Feed forward would allow big saving (avoid quadrupole stabilization in CLIC)

Simulation

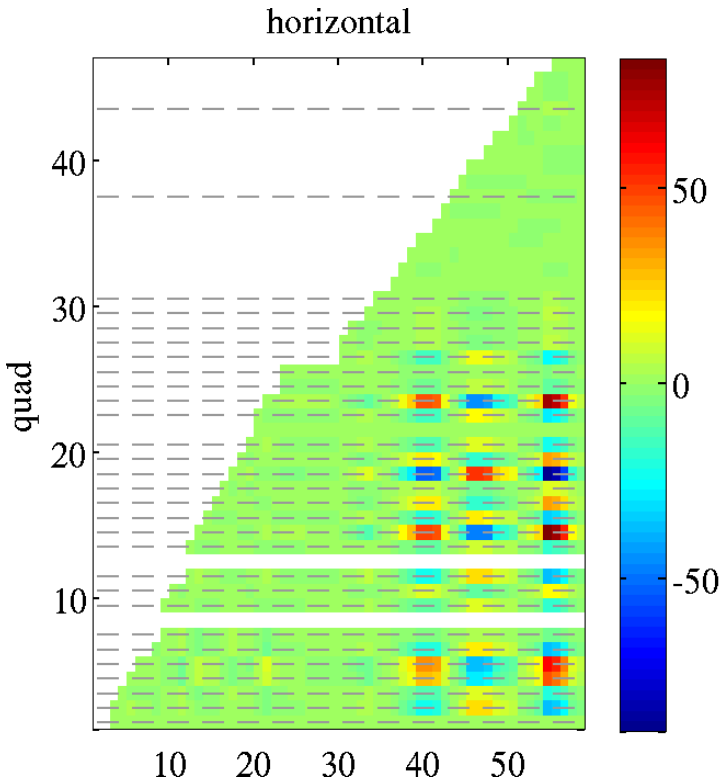
Conditions

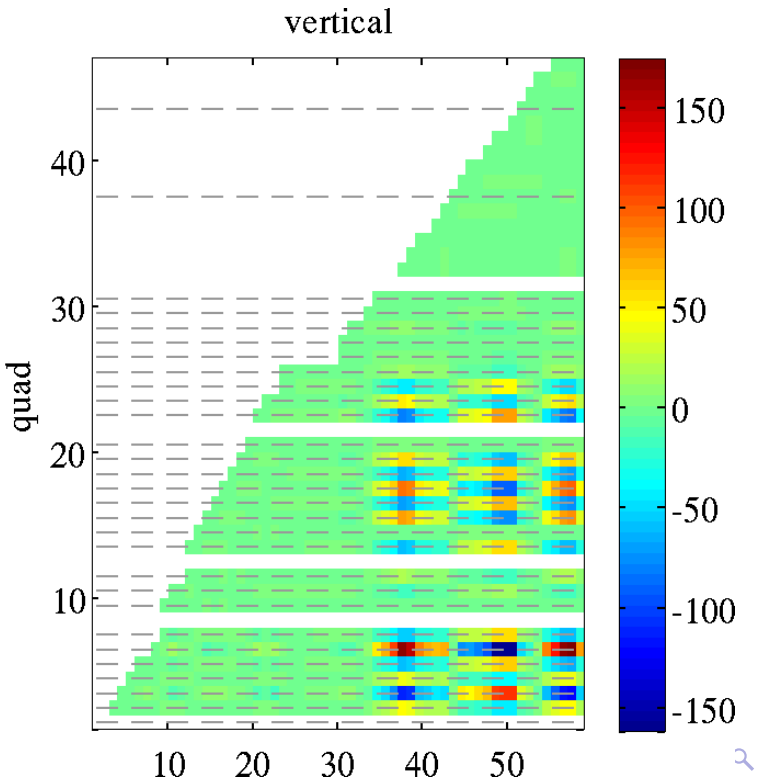
- ATF2 nominal lattice.
- Elements misaligned initially (RMS=100μm).
- Trajectory is then steered.
- Ground Motion (GM) model based on measurements.
- Elements are displaced by the amount of relative motion compared with the 1^{st} element.
- Incoming beam jitter (6 Hz, 100 pulses).
- Quadrupoles errors of $\frac{dK}{K} = 10^{-4}$ included.
- BPM and sensor bandwidth included.
- Limited number of sensors (Guralp Seismometers).

Algorithm

Initialization

- Compute the matrices of the effects of element displacements on BPM readings.
- Find the elements with the higher effects and select them to have GM sensor.
- Put also a sensor on the first and last element.





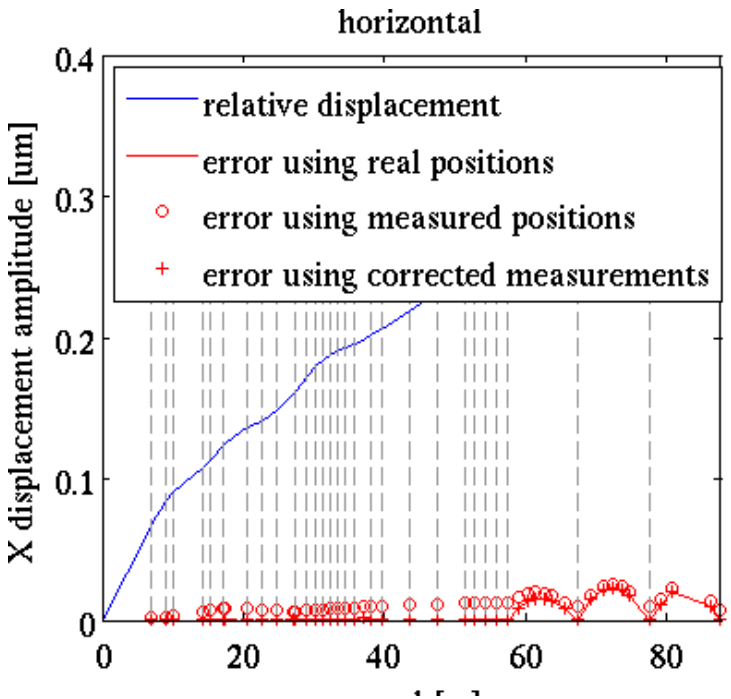
Placement of the sensors

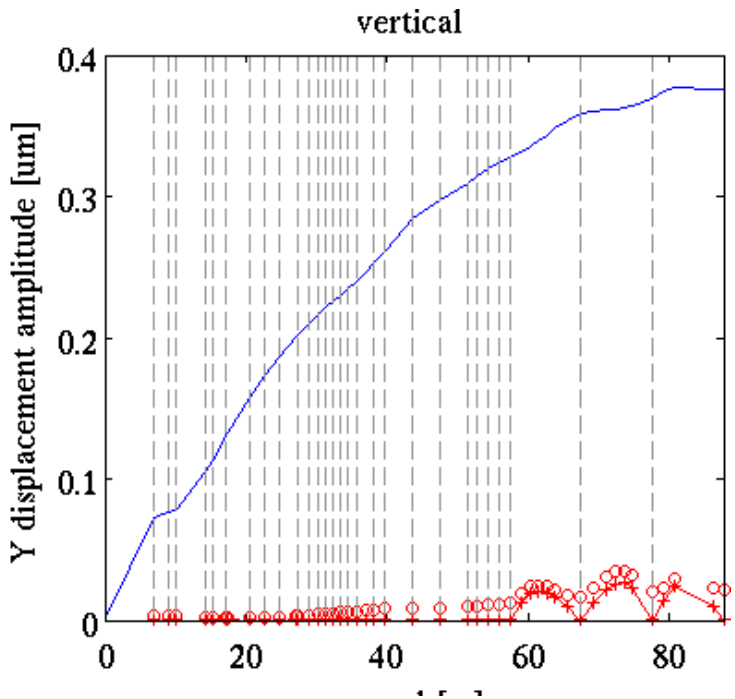
15 sensors	30 sensor (1)	30 sensor(2)
qs1x	qs1x	qf15x
qf1x	qf1x	qd16x
qd2x	qd2x	qf17x
qf3x	qf3x	qd18x
qf4x	qf4x	qf19x
qd5x	qd5x	qd20x
qf11x	qf6x	qf21x
qd12x	qf7x	qm16ff
qf13x	qd8x	qm15ff
qd14x	qf9x	qm14ff
qf15x	qd10x	qm13ff
qd16x	qf11x	qm12ff
qd18x	qd12x	qf7ff
qf19x	qf13x	qf3ff
qd0ff	qd14x	qd0ff

Algorithm

Algorithm - Each Pulse

- From the measured GM interpolate the displacements of other elements linearly with the distance.
- Subtract induced beam displ. from BPM meas.
- Remove incoming beam jitter from BPM meas.





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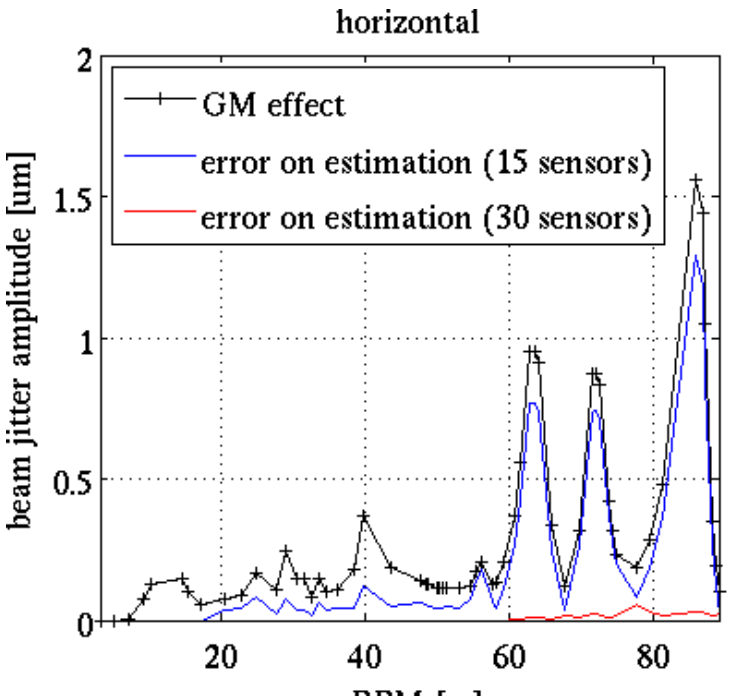

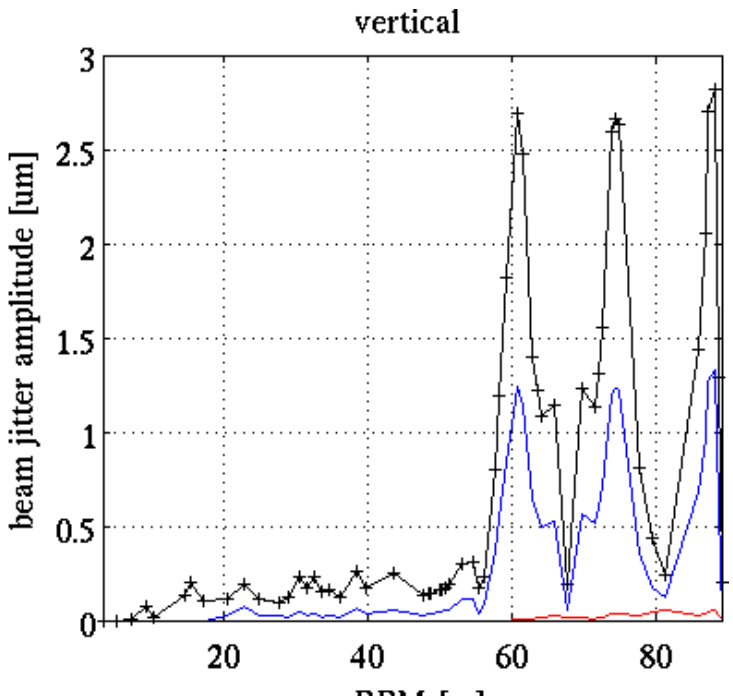

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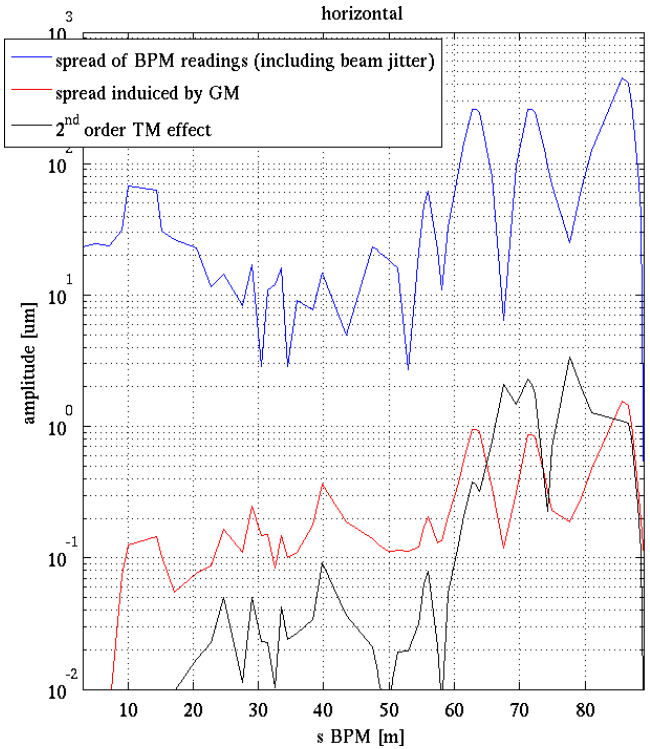
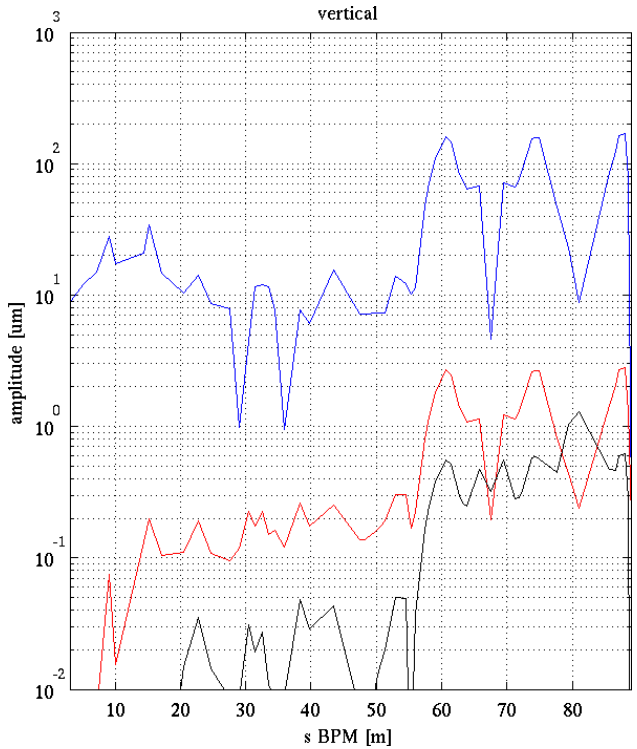
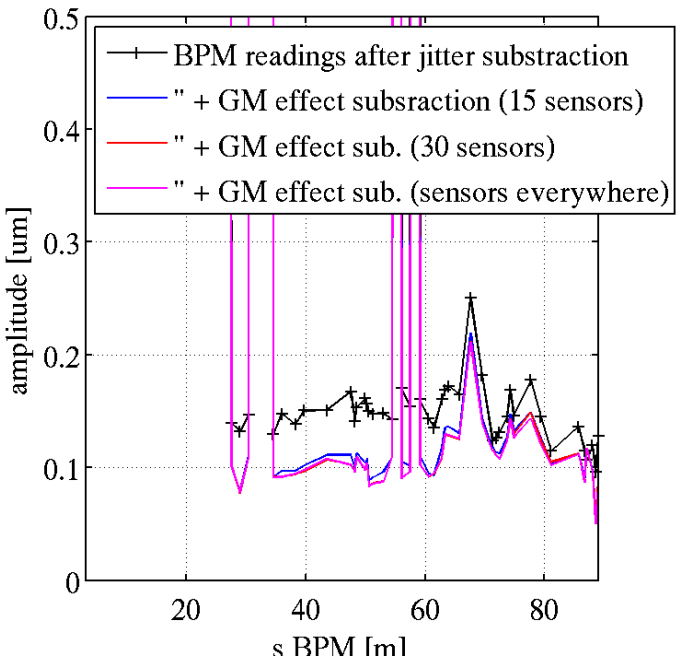


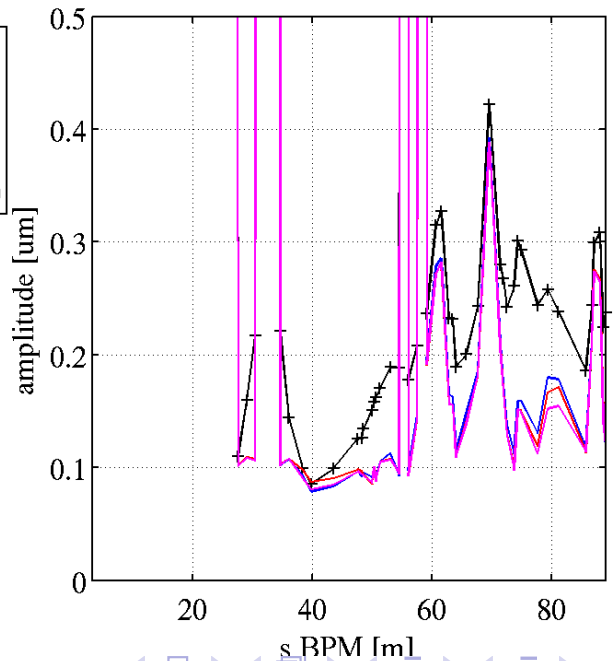


Beam Jitter Effects Results

Principle

- Remove predicted GM effect from BPM readings.
- Remove injection beam jitter.
- Remove non-linear effects.
- Compute injection beam jitter again.
- Look at the RMS of the residuals at each BPM.

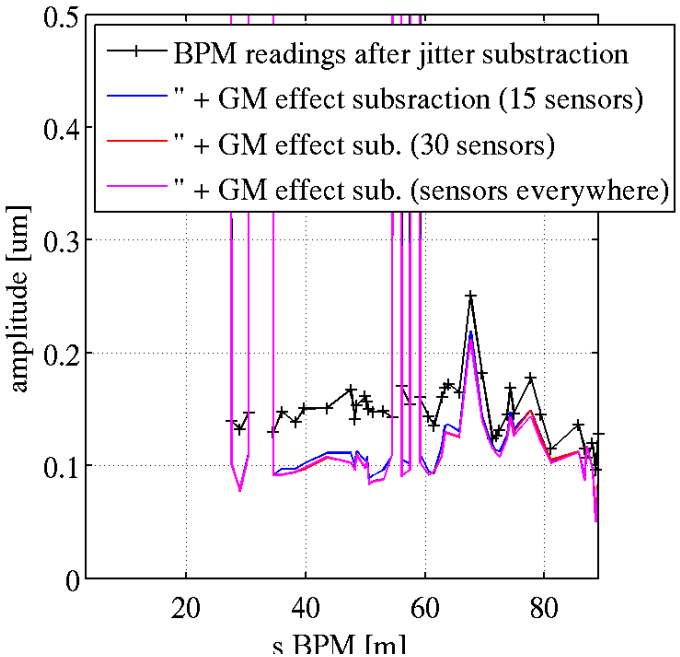


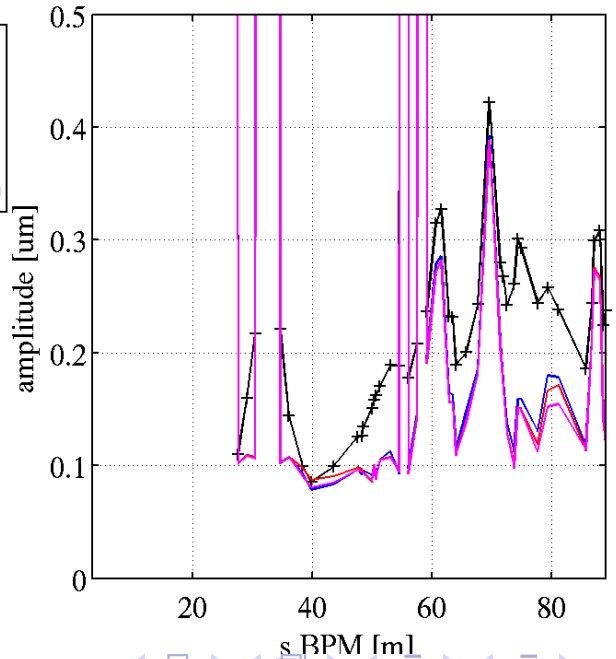


Beam Jitter Effects Results

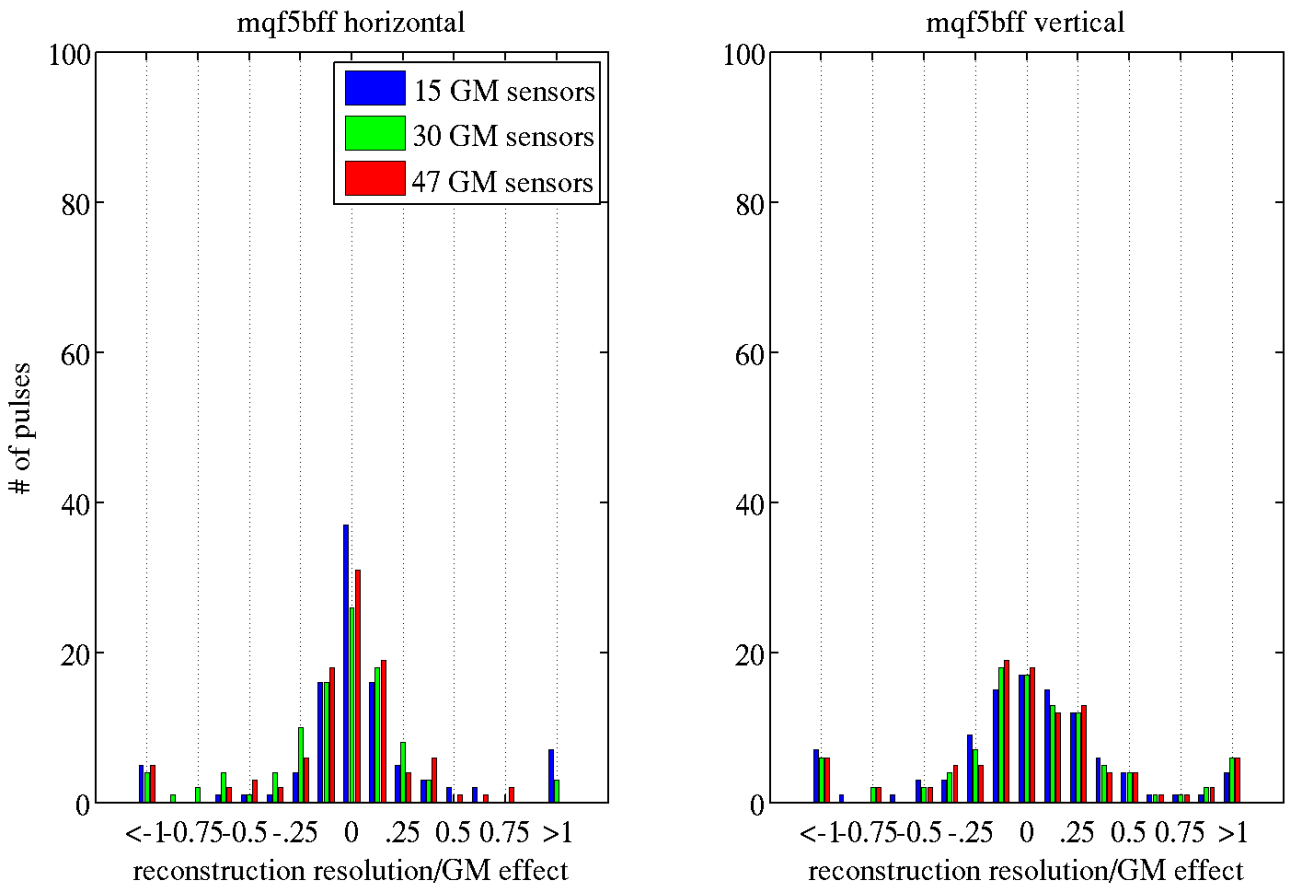
Results

- Only cavity BPMs are precise enough (0.1μm).
- Residuals are lower subtracting GM effects.
- Works with >= 15 sensors.
- Sextupole-beam offsets determined at 10s μm level.
- Higher residuals in FF from errors on jitter.



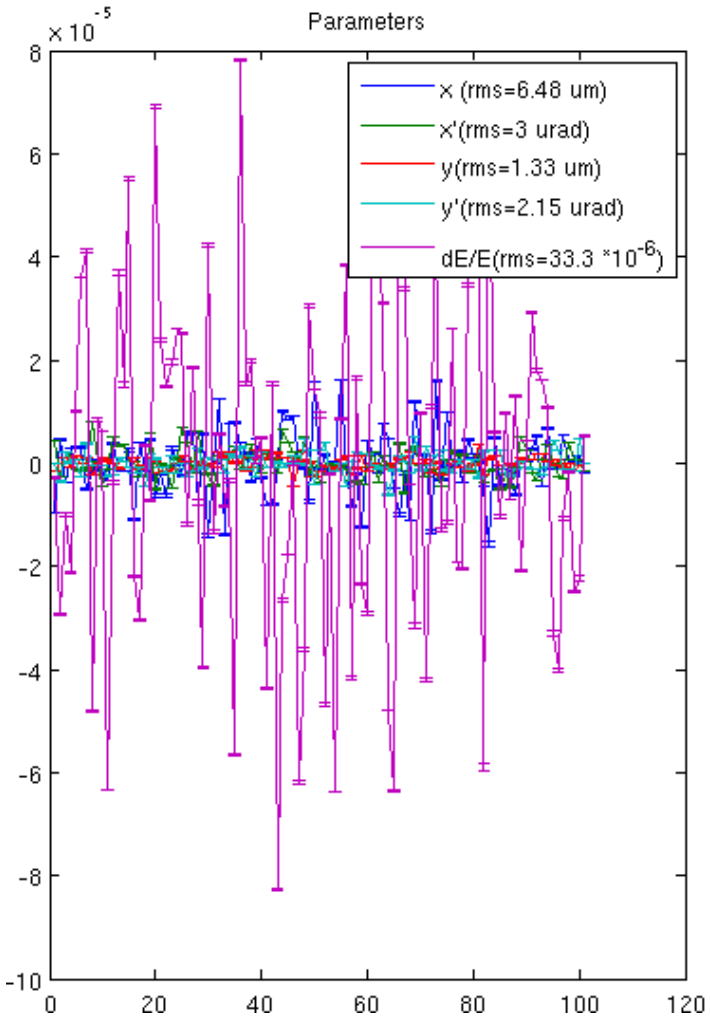


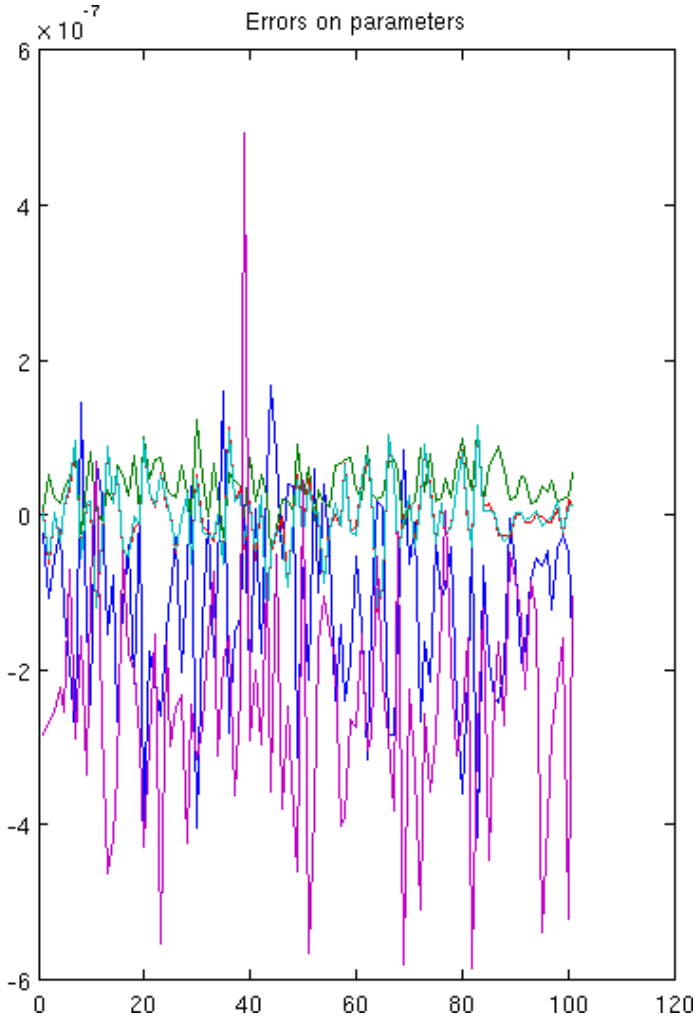
Ratio of residual over expected GM effect on BPM readings (MQF5BFF s=71m)



Residuals are much lower than GM effects.

Reconstructed incoming parameters





Parameters are reconstructed with $\simeq$ 1% precision !

Headlines

Detection of the Ground Motion Effects

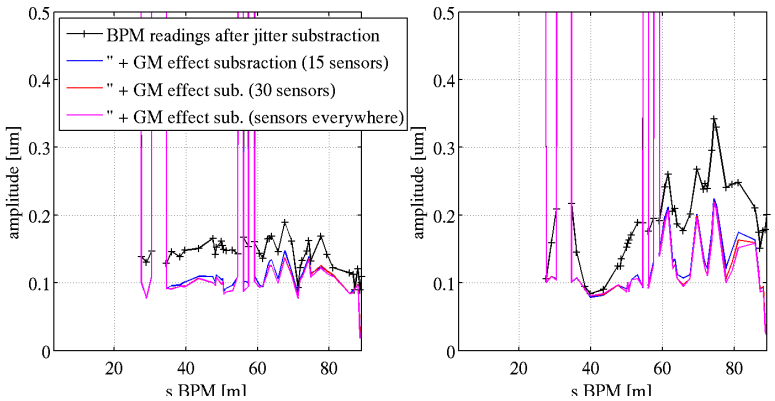
Influence of the Simulation's Parameters

- Elements Misalignments
- Beam Jitter Amplitude
- Repetition Rate
- Quadrupole strength error
- BPM Scale Errors
- Beam jitter with 1 %BPM scale errors

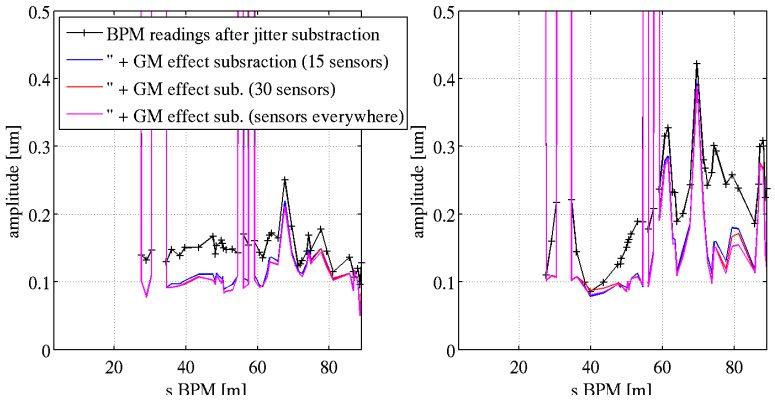
Planning

Conclusion and Prospects

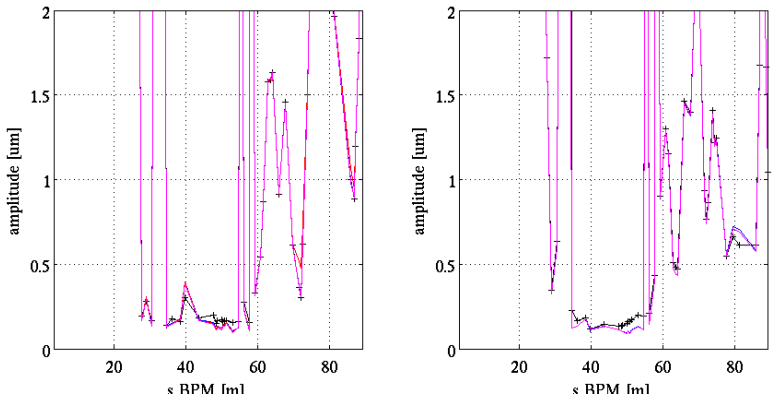
Elements Misalignments



$10\mu m$ misalignment

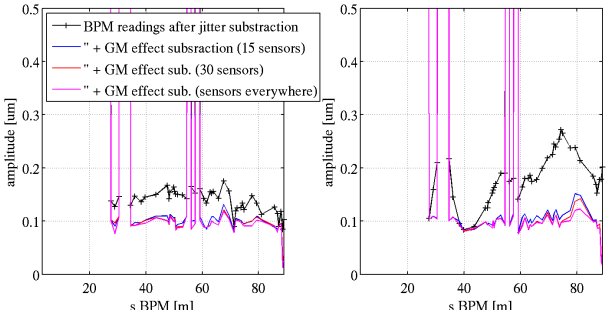


$100\mu m$ misalignment

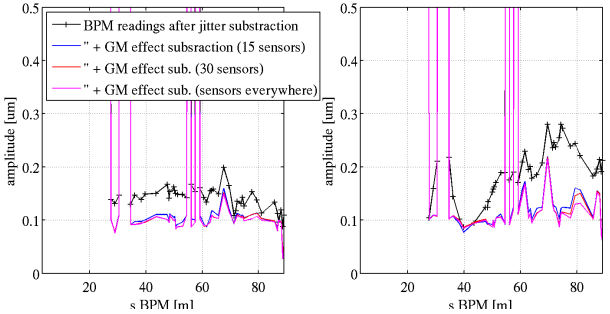


$1000\mu m$ misalignment

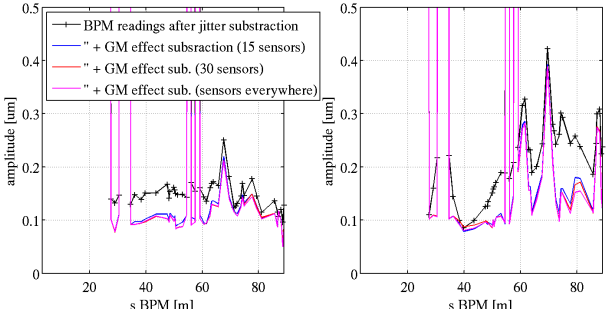
Beam Jitter Amplitude



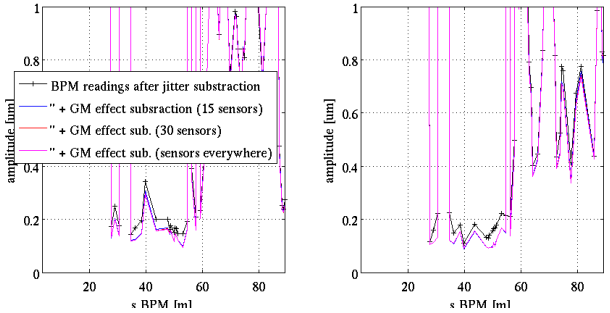
0.1× jitter



0.5× jitter

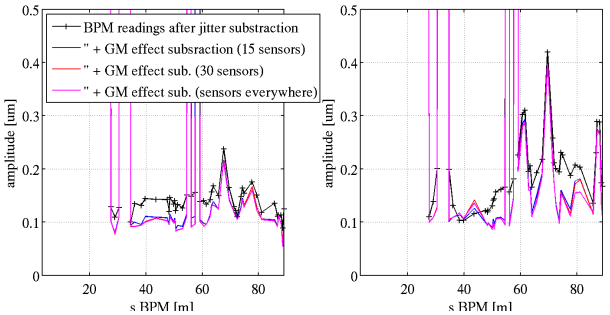


1× jitter ($\simeq 0.1\sigma$, $\frac{dE}{E} = 5.10^{-4}$)

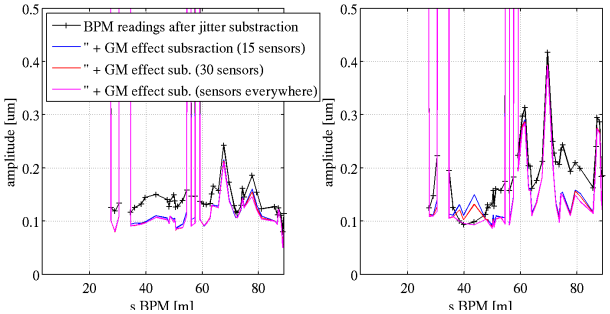


5× jitter (scale changed)

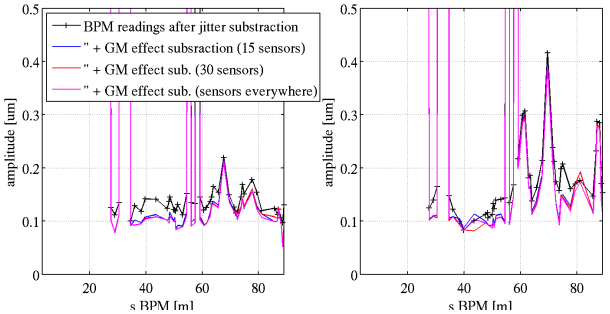
Repetition Rate



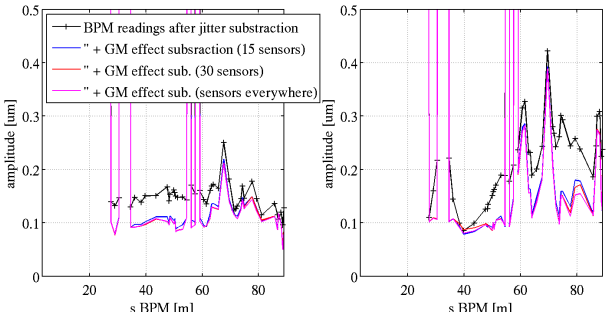
0.75*Hz*



1.5*Hz*

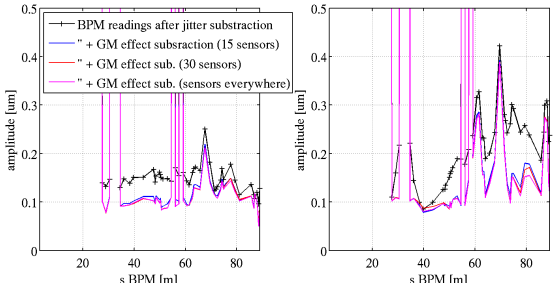


3*Hz*

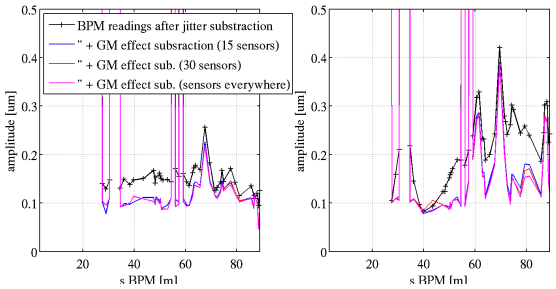


6*Hz*

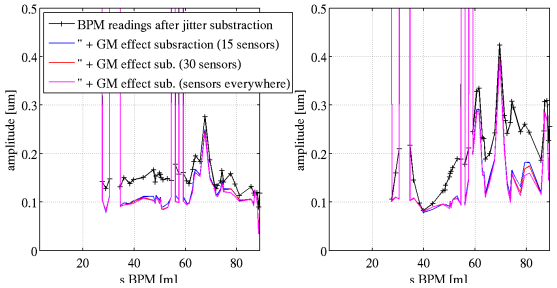
Quadrupole strength error



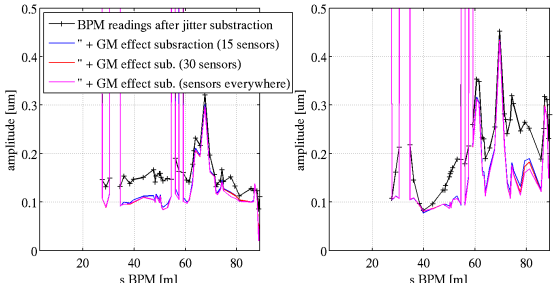
$$\frac{dK}{K} = 1.10^{-4}$$



$$\frac{dK}{K} = 2.10^{-4}$$

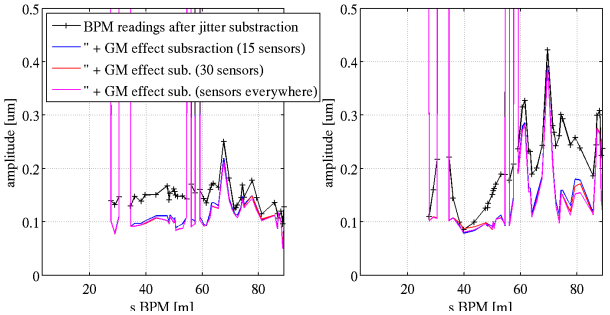


$$\frac{dK}{K} = 5.10^{-4}$$

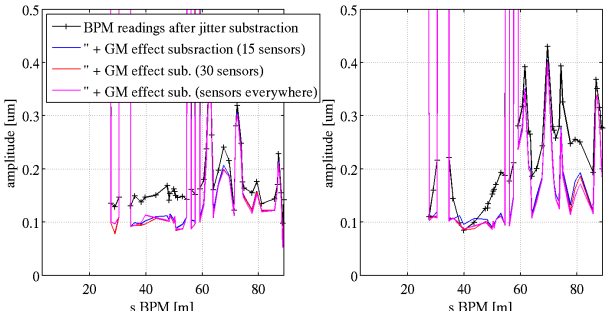


$$\frac{dK}{K} = 10.10^{-4}$$

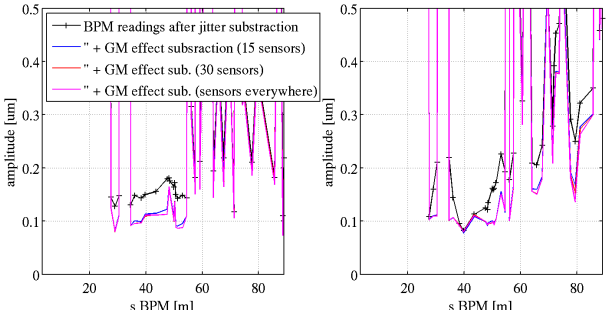
BPM Scale Errors



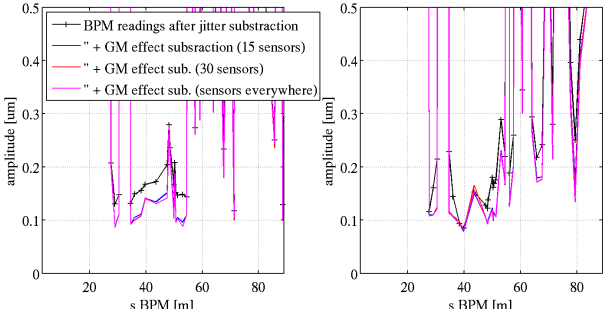
0% scale errors



0.1% scale errors

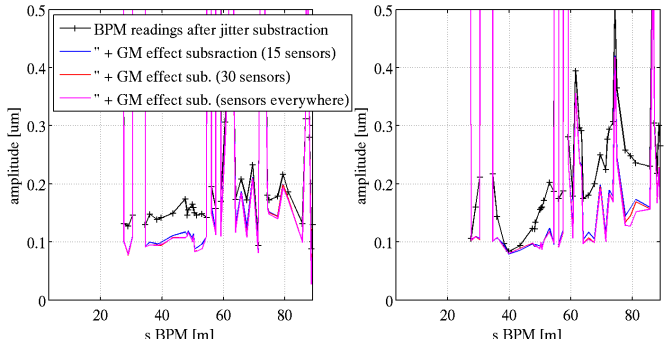


0.5% scale errors

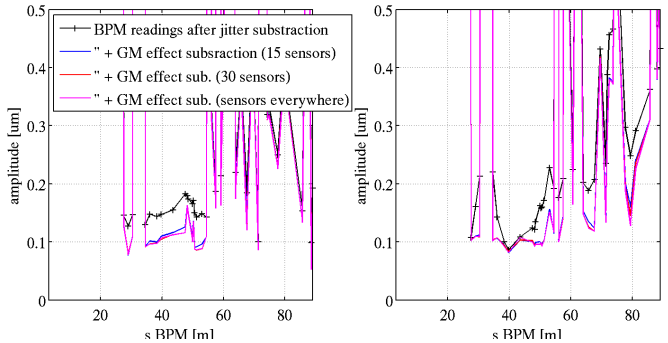


1% scale errors

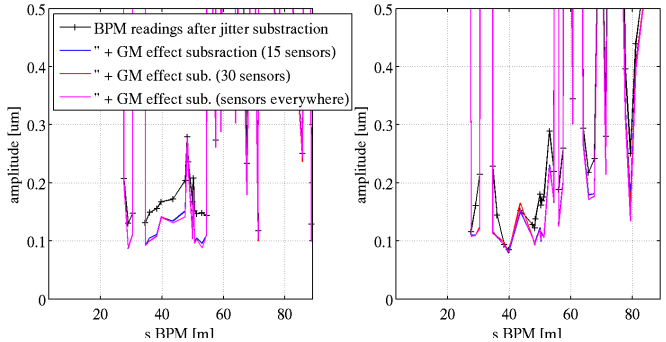
Beam jitter with 1 %BPM scale errors



1% scale errors, 0.2× jitter



1% scale errors, 0.5× jitter



1% scale errors,1× jitter

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Conclusion and Prospects

Planning

Name	2012 H1	2012 H2
GM feed-forward		
LAPP buys 15 Guralps		
Readout tests at CERN		
Installation in ATF2		
First tests at 1 & 6 Hz		

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Detection of the Ground Motion Effects

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Conclusion & Prospects

Conclusion

- Beam jitter subtraction is critical.
- With 15 sensors, GM effect is measurable.
- Non-linearities might be used to determine sextupole displacements.
- BPMs scale factors are critical.
- Lower beam jitter helps a lot.