

Possibility to detect ground motion at ATF2

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Headlines

Detection of the Ground Motion Effects

Influence of the Simulation's Parameters

Conclusion and Prospects

Detection of the
GM Effects

Simulation
Jitter determination

Influence of the
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Parameters

Elements Misalignments
Beam Jitter Amplitude
Repetition Rate
Quadrupole strength error
BPM Scale Errors

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Conditions

- ▶ ATF2 nominal lattice.
- ▶ Elements misaligned initially (RMS=100 μ m).
- ▶ Trajectory is then steered.
- ▶ Ground Motion (GM) model based on measurements.
- ▶ Elements are displaced by the amount of relative motion compared with the 1st 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).

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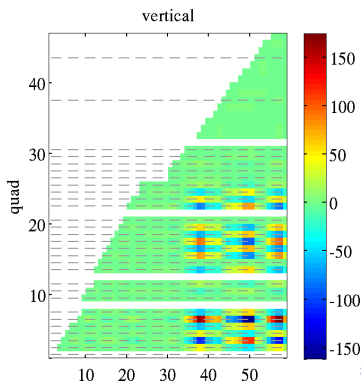
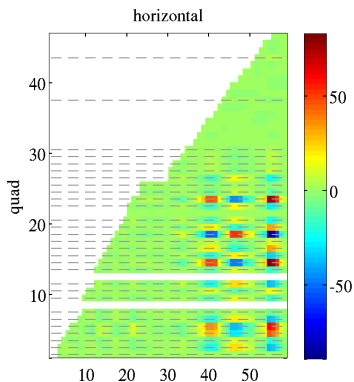
BPM Scale Errors

Conclusion and Prospects

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

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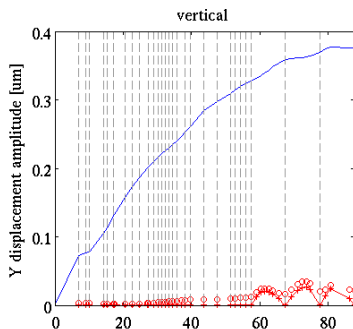
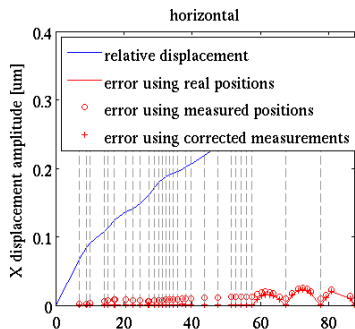
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Algorithm - Each Pulse

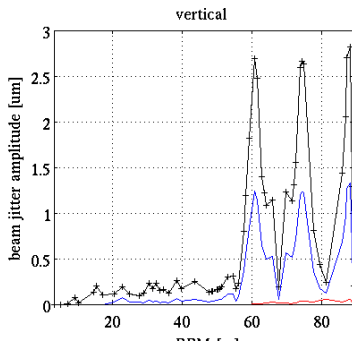
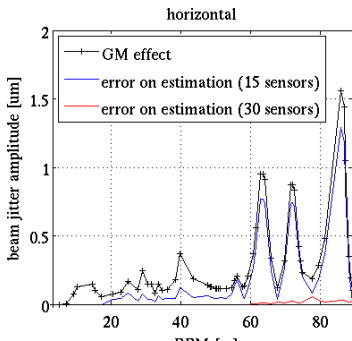
- ▶ From the measured GM interpolate the displacements of other elements linearly with the distance.
- ▶ Subtract induced beam displ. from BPM meas.
- ▶ Remove incoming beam jitter from BPM meas.



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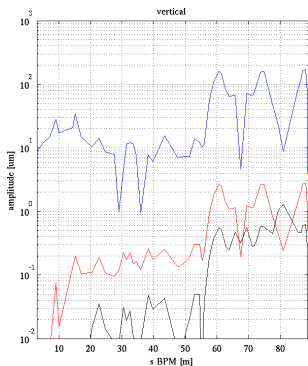
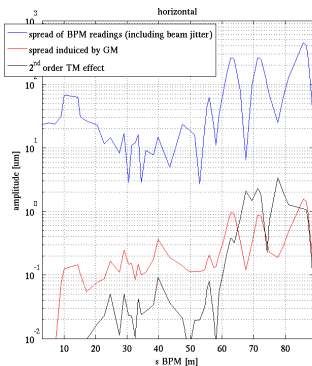
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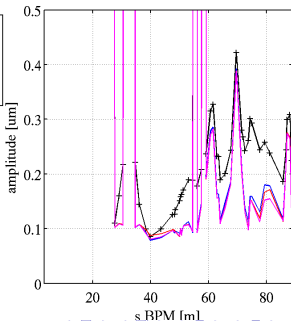
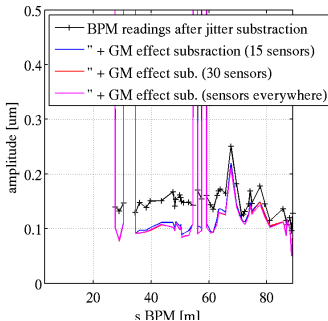
BPM Scale Errors

Conclusion and Prospects

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.



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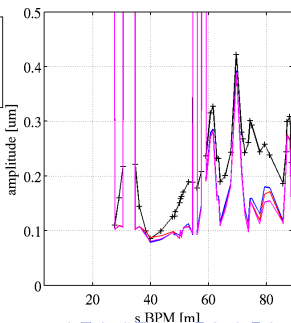
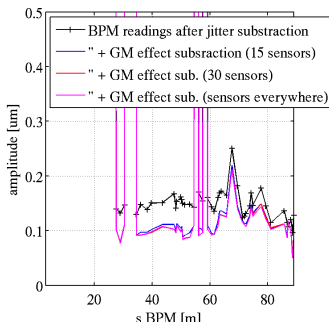
Quadrupole strength error

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Results

- ▶ Only cavity BPMs are precise enough ($0.1\ \mu\text{m}$).
- ▶ Residuals are lower subtracting GM effects.
- ▶ Works from 15 sensors.
- ▶ Sextupole-beam offsets determined at $10\ \mu\text{m}$ level.
- ▶ Higher residuals in FF from errors on jitter.



Detection of the GM Effects

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Beam Jitter Amplitude

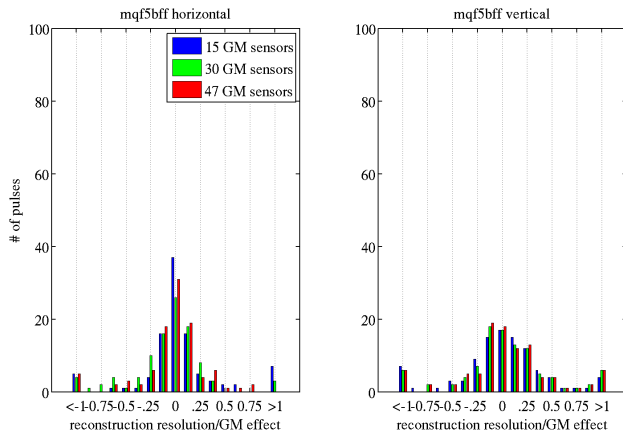
Repetition Rate

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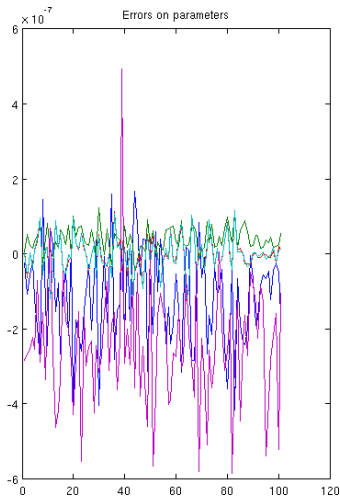
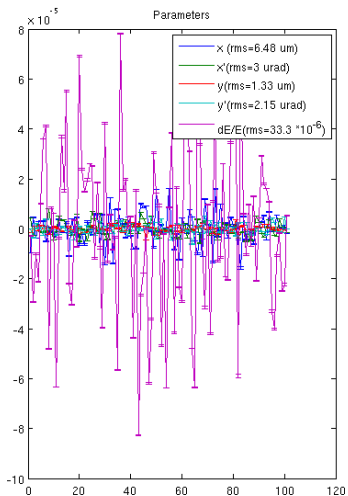
Conclusion and Prospects

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 !

Detection of the GM Effects

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Elements Misalignments

Beam Jitter Amplitude

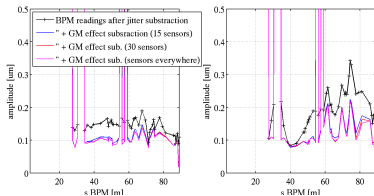
Repetition Rate

Quadrupole strength error

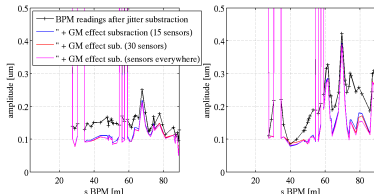
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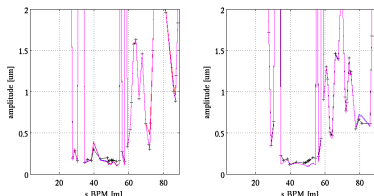
Elements Misalignments



$10\mu m$ misalignment



$100\mu m$ misalignment



$1000\mu m$ misalignment

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Beam Jitter Amplitude

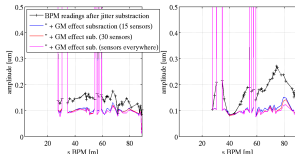
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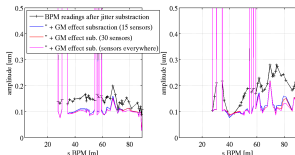
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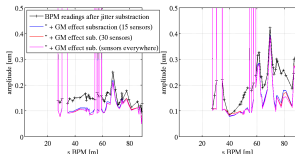
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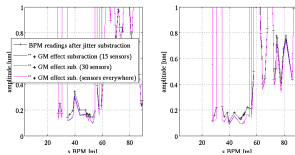
0.1 × jitter



0.5 × jitter

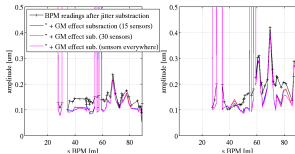


1 × jitter ($\approx 0.1\sigma$, $\frac{dE}{E} = 5.10^{-4}$)

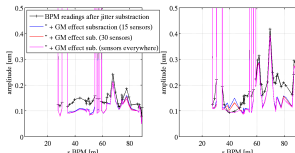


5 × jitter (scale changed)

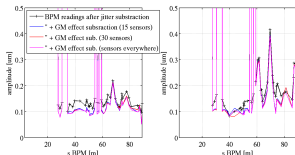
Repetition Rate



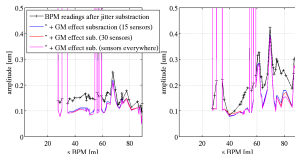
0.75Hz



1.5Hz



3Hz



6Hz

Detection of the GM Effects

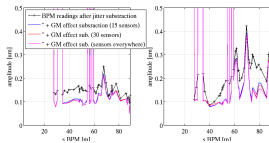
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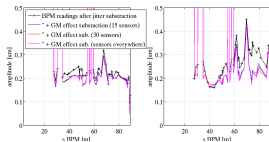
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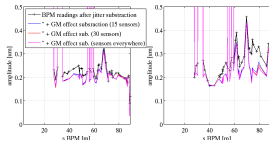
Quadrupole strength error



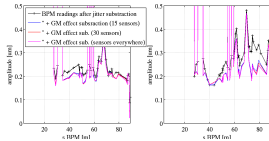
$$\frac{dK}{K} = 1.10^{-4}$$



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



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



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

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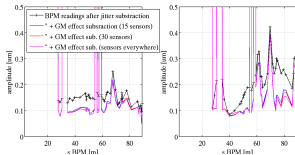
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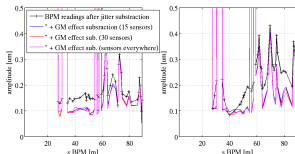
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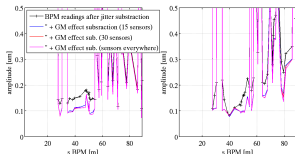
Conclusion and Prospects



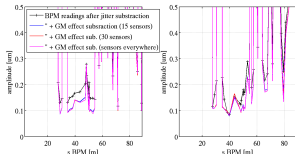
0% scale errors



0.1% scale errors



0.5% scale errors



1% scale errors

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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.
- ▶ BPM resolution demonstrated, scale factors must be improved (SVD based method ?).