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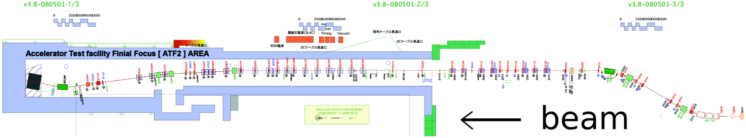
Prospect of comparing pulse-to-pulse ground motion and orbit at ATF2

Y. Renier

CERN

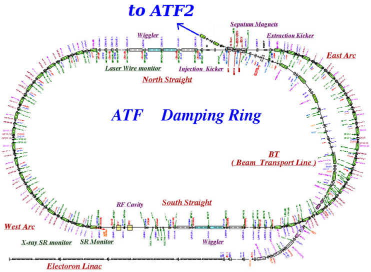
ALCPG11
22 Mars 2011

Accelerator Test Facility 2



ATF2 is:

- ILC BDS scaled down in E (Similar to CLIC's one).
- 1^{st} experiment with local chromaticity correction.
- using the beam of ATF DR ($\epsilon_x \simeq 1nm \;\; \epsilon_y \simeq 4pm$).



ATF2 Goals

Beam Size

- Focus beam to $\sigma_x = 3\mu m$ $\sigma_y = 37nm$.
- Get reproducible results.

Stability

- Use ILC-like trains : Intra-train feedback (Feedback On Nanosecond Timescale).
- Aim to achieve nanometer beam stability at IP.
- Not applicable to CLIC (where bunch spacing is too small).

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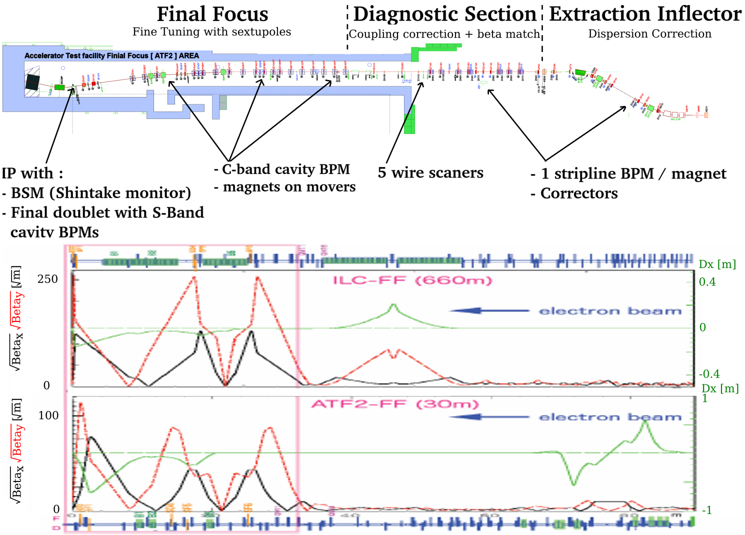
Comparison of ATF2 with ILC and CLIC

parameters	ATF2	ILC	CLIC
beam energy (GeV)	1.3	500	3000
10^{10}particles/bunch	$1-2$	2	0.4
bunches / train	$1-30$	2625	312
$f_{rep}(Hz)$	$1-6$	5	50
$\beta_x^*(mm)$	4	21	6.9
$\beta_y^*(\mu m)$	100	400	70
$\gamma\epsilon_x(nm.rad)$	5000	1000	660
$\gamma\epsilon_y(nm.rad)$	30	40	20
$\sigma_x^*(nm)$	3000	640	45
$\sigma_y^*(nm)$	37	5.7	1
$L^*(m)$	1	$3.5-4.5$	3.5
ξ_y	10^4	10^4	5×10^4

Instrumentation



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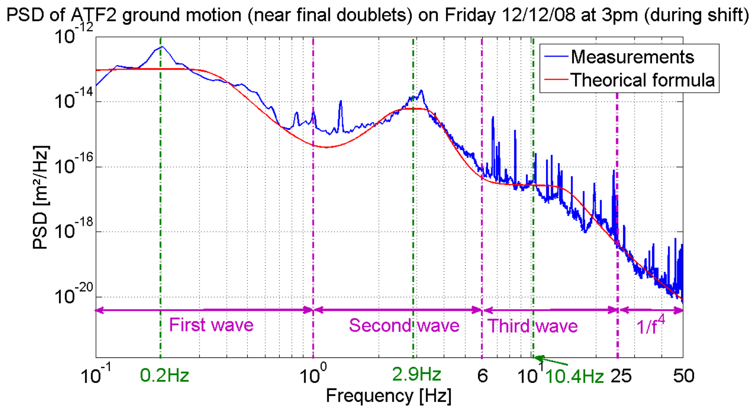
ATF2 Ground Motion Measurements[1]



Power Spectral Density property

$$A^2 = \int_{f=0}^{\infty} p(f)\,\mathrm{d}f \qquad (1)$$

[1] made by B. Bolzon

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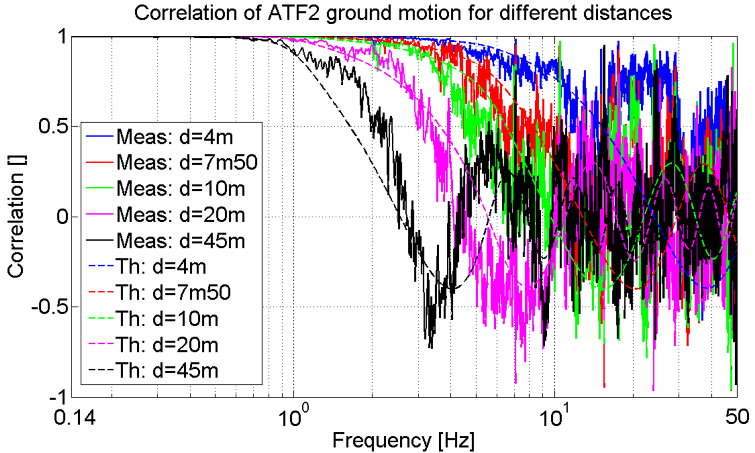
ATF2 Ground Motion Measurements[1]



Coherence definition

$$C(f) = 1 - \frac{p(f, L)}{2 \times p(f)} \qquad (2)$$

[1] made by B. Bolzon

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Description of the Feed Forward at ATF2

Feed Forward

- In CLIC no bunch to bunch feedback is possible.
- Measure Ground Motion on quadrupoles between the pulses.
- Correct for the effects before the next pulse.

Test at ATF2

- Lower frequency at ATF2 ($6Hz$) than in CLIC.
- ATF2 and CLIC BDS optics are similar.
- High resolution BPMs available ($\simeq 100nm$).
- μm level reconstruction achieved.
- Would demonstrate the principle of such a correction.
- Just need some sensors and fast-enough correctors.

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Simulation

Conditions

- ATF2 nominal lattice (sextupoles off).
- Ground Motion (GM) model based on measurements.
- Used PLACET tracking code.
- Elements are displaced by the amount of relative motion compared with the 1^{st} element.
- Incoming beam jitter.
- BPM and sensor noise included.
- Limited number of sensors (geophones).

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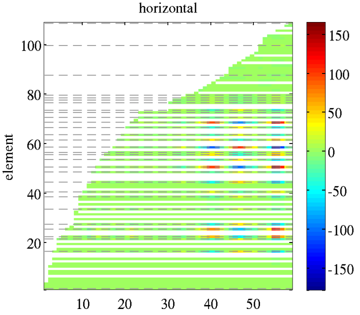
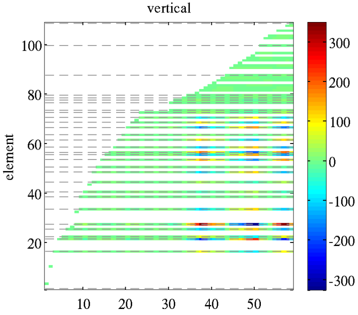
Algorithm

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.





ATF2 Project
Y. Renier
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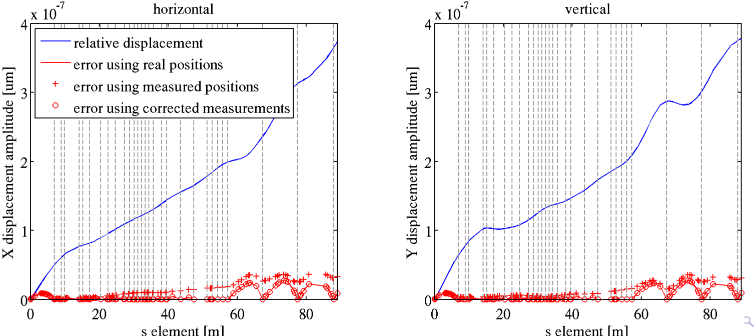
Algorithm

Algorithm - Each Pulse

- From the measured GM interpolate the displacements of other elements linearly with the distance (GM measurements corrected).
- Deduce the induced beam displacements.
- Reconstruct and remove incoming jitter from measurement.



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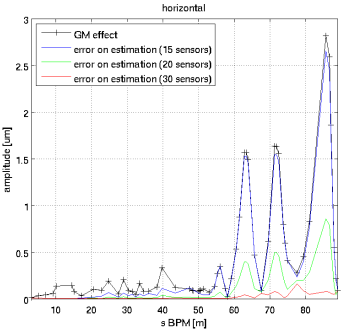

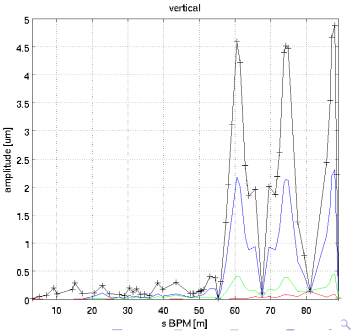

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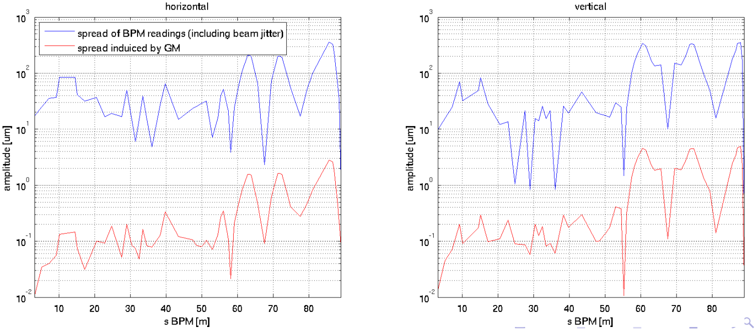
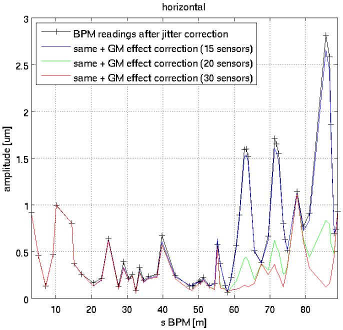
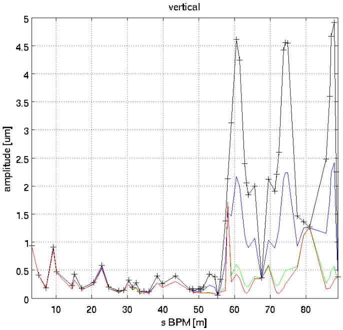


Jitter Correction Results

Principle

- Remove predicted GM effect from measurements.
- Reconstruct pulse to pulse $x, x', y, y', \frac{\Delta_E}{E}$ and propagate.





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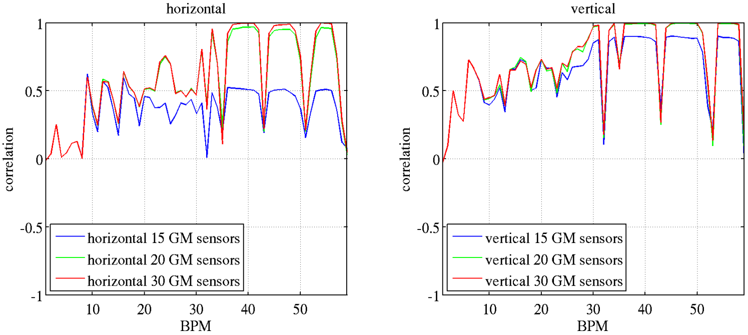
Correlation between jitter corrected displacements and estimated GM effects



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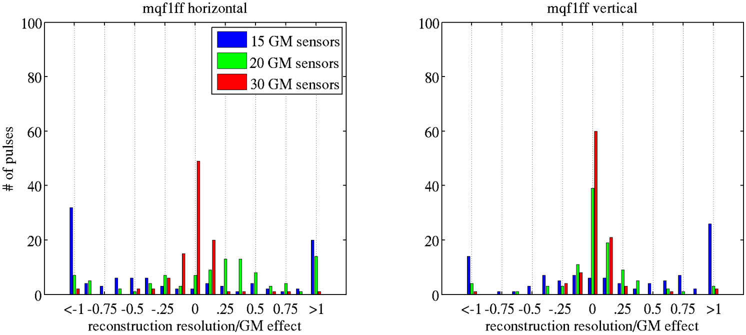
Ratio of residual measurements over expected



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Conclusion & Prospects

Conclusion

- Concept of feed-forward understood.
- Beam jitter subtraction is critical.
- With 30 sensors at $6Hz$, GM effect is measurable.

Prospects

- Errors on magnet fields not considered yet.
- Feed forward implementation (in CLIC) is under study (J. Pfingstner).
- Presently, sextupoles must be turned off.

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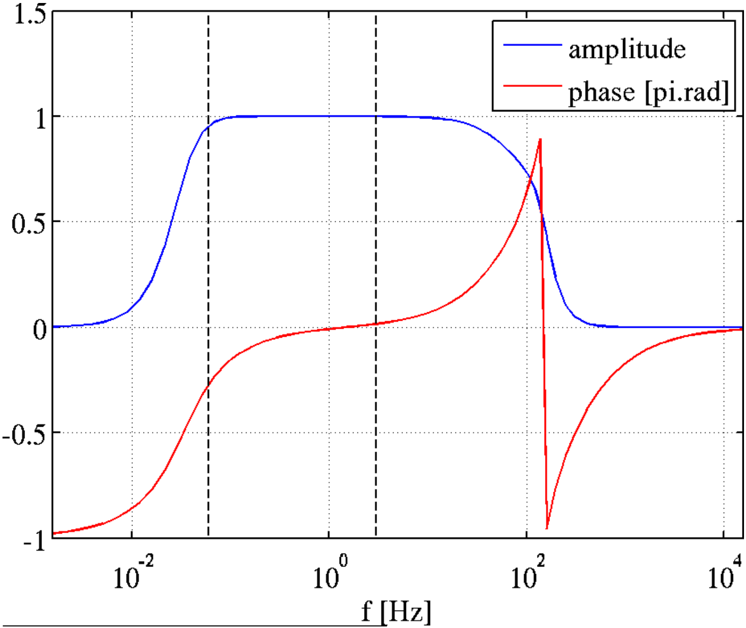
GM sensors Transfer Function[1]



[1] Courtesy of J. Pfingstner

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ATF2 Ground Motion Model Parameters Fit[1]

Model

- Wave Propagation ⇒ close enough elements move together.
- 3 Waves with adjusted amplitude, frequency, velocity and width.
- Good agreement with measurements once tunned.

Parameter table

$$p(f) = \sum_{i=1}^{3} \frac{a_i}{1 + [d_i(\frac{f-f_i}{f_i})^2]^4} \quad (3)$$

$$C(f, L) = J_0\left(\frac{2\pi f L}{v}\right) \quad (4)$$

f1	[Hz]	0.2
a1	[m**2/Hz]	1.0 E-13
d1	[1]	1.1
v1	[m/s]	1 000
f2	[Hz]	2.9
a2	[m**2/Hz]	6.0 E-15
d2	[1]	3.6
v2	[m/s]	550
f3	[Hz]	10.4
a3	[m**2/Hz]	2.6 E-17
d3	[1]	2.0
v3	[m/s]	250

[1] made by B. Bolzon

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