Update on IP feedback simulation

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MDI Group Meeting
25 november 2007

Guidelines

1. Ground Motion Study
   - Measurement at KEK (Courtesy of R. Sugahara et al.)
   - Developed generator
   - Andrei Seryi's implentation of ground motion
   - Conclusion on ground motion
2. Feedback on beam position at IP
   - Proportional corrector
   - Proportional Derivative Integrator corrector (PID)
3. Conclusion & Prospects

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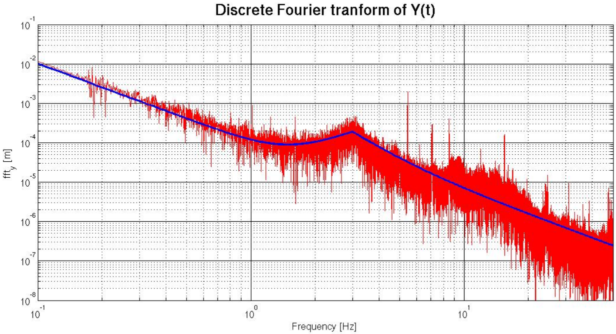
Fourier transform of measured ground motion

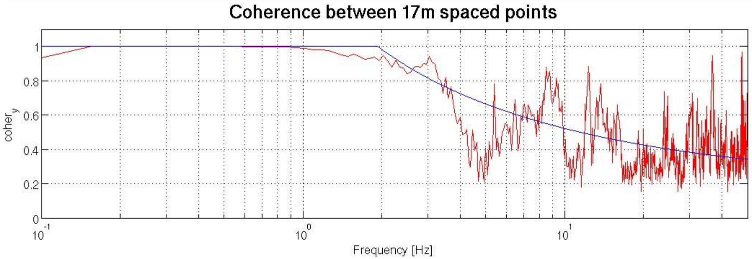


- In red: Measurements
- In blue: curve fitted on measurements

Coherence of ground motion

Definition

Coherence $C_{y_1,y_2}(\omega)$: Real function $\in [0,1]$ which gives a measure of correlation between y_1 and y_2 at each frequency ω .



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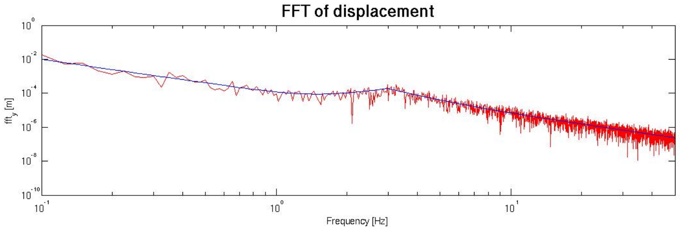
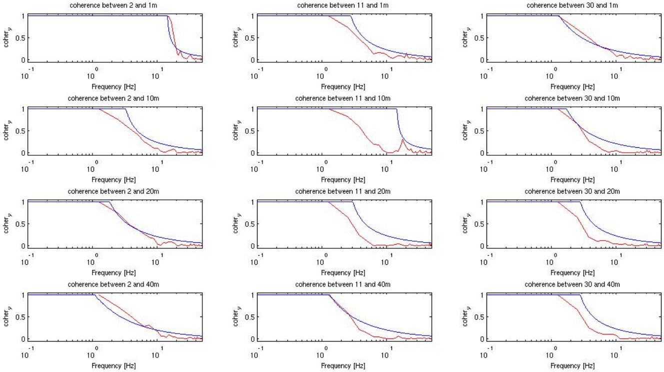
Simulated data analysis (Developed generator)

Really great accordance with the curve fitted on results.



- In red: Data from generator.
- In blue: Curve fitted on measurements.

Simulated data analysis (Developed generator)



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Generator modified by Glen White to fit mesurements at KEK

ATL law

$$< \Delta X^2 >= ATL \frac{T}{T+T_O} \text{ with } T_0 = \frac{\pi}{2}\sqrt{\frac{AL}{B}}$$

Power Spectrum

$$P(\omega, k) = \frac{A}{\omega^2 k^2} [1 - \cos(L_0 k)] \text{ with } L_0 = \frac{B}{A\omega^2}$$

- $A = 1.10^{-17}\ ms^{-1}$: coefficient of ATL law.
- $B = 5.10^{-18}\ m^2 s^{-3}$: incoherent part.

Some peaks are added to be more close of the spectra.

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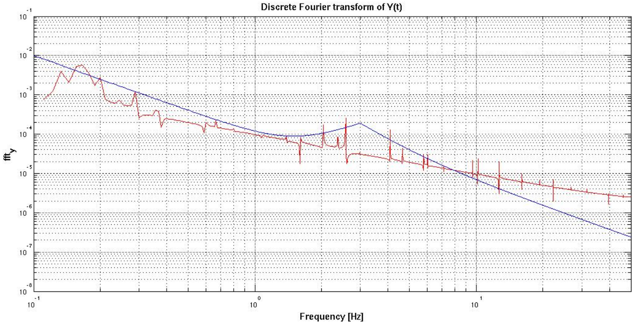
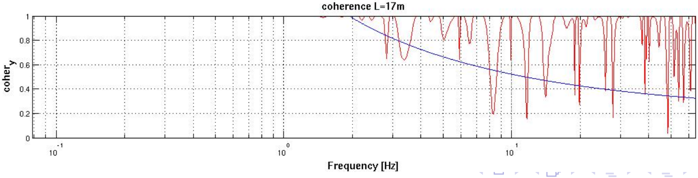
Simulated data analysis





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Conclusion on ground motion

1. Generator developped with good frequency behaviour but bad coherence properties
2. Test of other generators :
   - Problems found in the one used in Placet.
   - The one used by Glen White seems good.

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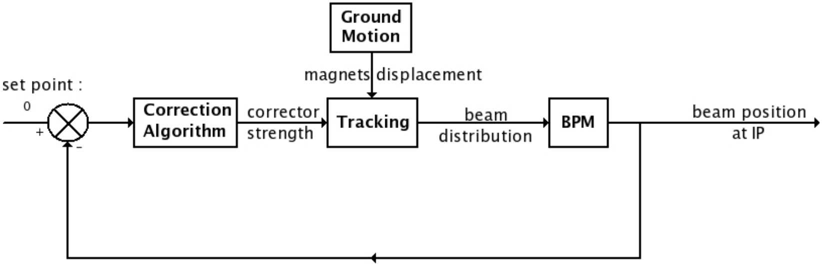
What is a proportional corrector ?

Schema of principle of the feedback :



$$C(p) = \frac{S(p)}{E(p)} = k_p$$

What k_p should be chosen ?

What is a proportional corrector ?

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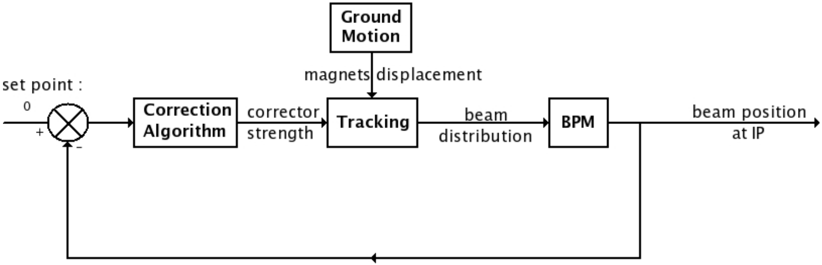


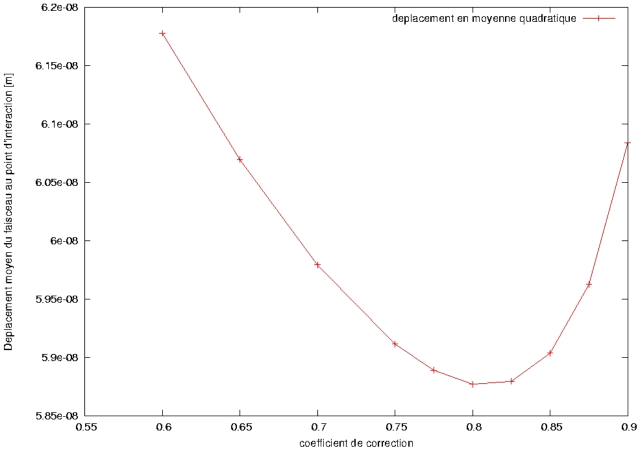
$$\color{red}{C(p)} = \frac{S(p)}{E(p)} = k_p$$

What k_p should be chosen ?

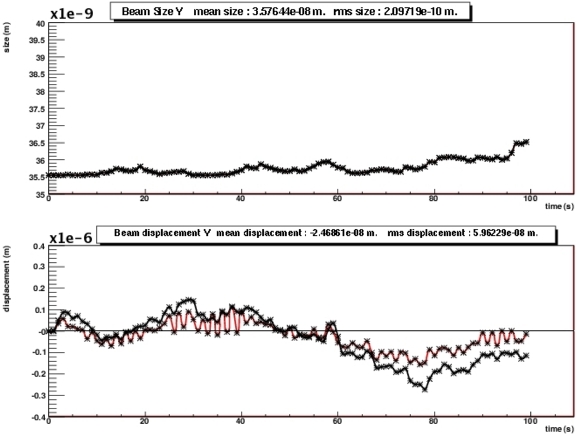
Tuning corrector

Method

Simulation for various coefficient and choose the most adapted.



Simulation results



Legend

– : without feedback

– : with feedback

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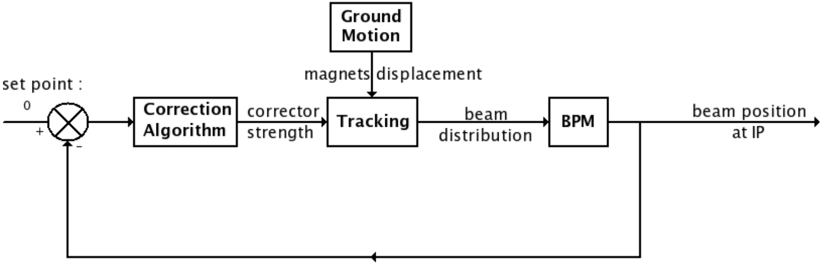
What is a PID corrector ?

Schema of principle :



$$C(p) = k_p + \frac{k_i}{p} + k_d \cdot p$$

Tuning of corrector

3 coefficients : hardly adjustable “manually” as previously.

Major tuning method

Type	Settling Criteria	Name
Set-point change / disturbance	25% damping	Zieglar-Nichols
Set-point change, no overshoot & min.	response time	Chien, Hrones & Reswick
Set-point change, 20% overshoot & min.	response time	Chien et. al.
Disturbance, no overshoot & min.	response time	Chien et. al.
Disturbance min	control area	Takahashi

Tuning of corrector

As it minimizes the error without any other constraint, Takahashi's method was implemented.

Takahashi's method

1. Start with all coefficients to 0.
2. Increase k_p up to auto-oscillation. Take :
   - T_0 : The period of auto-oscillation.
   - k_0 : k_p at this moment.
3. Use following coefficients (T is repetition rate):

k_p	k_i	k_d
$0.6k_0 - 0.5k_i T$	$1.2\frac{k_0}{T_0}$	$\frac{3}{40}k_0 T_0$
0.5533	1.1067	0.2767

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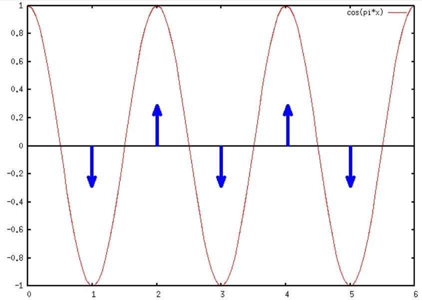
Implementation of Takahashi's method

1. The most unstable frequency is $2T$ as at such frequency correction will each time increase the error $\Rightarrow T_0 = 2T$.
2. Coefficient at this frequency which produce exponential increase of the displacement is the one correcting an y displacement by a -y position on the next beam. $\Rightarrow k_0 = \frac{1}{R_{43}(kicker \rightarrow IP)}$.



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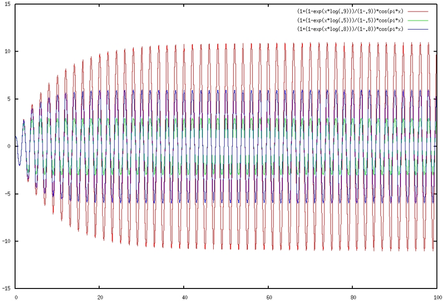
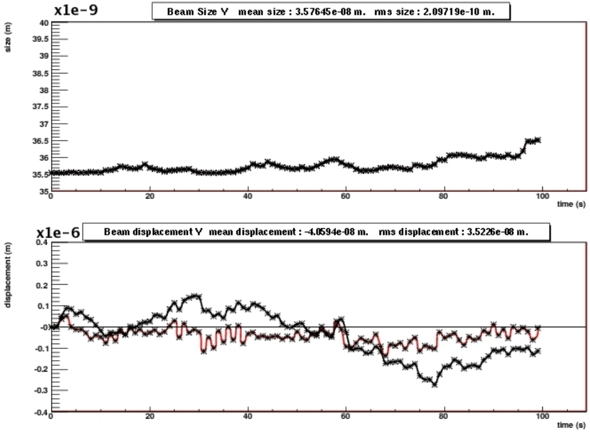


Results of simulation



Legend

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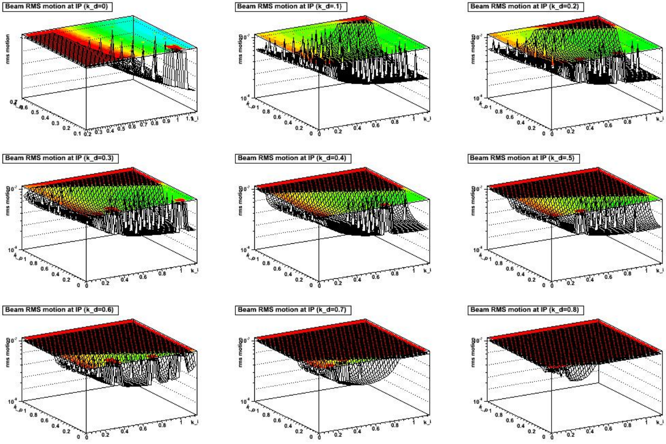
Tuning of corrector - 2

3 coefficients : hardly adjustable “manually” as said previously.
But not impossible ! Min at $k_p = 0.38$ $k_i = 1.18$ $k_d = 0$



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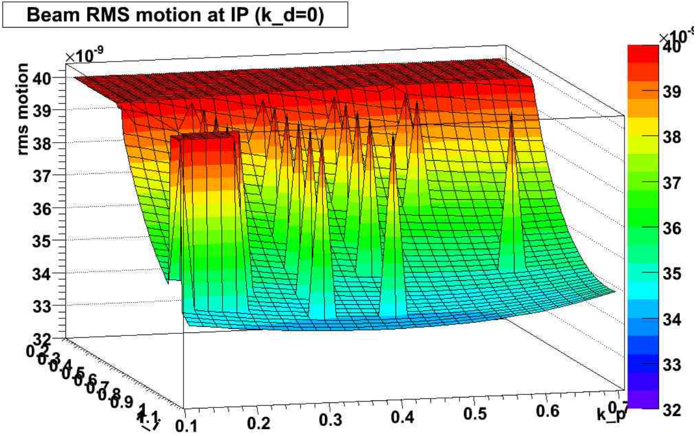

Conclusion

- Analysis of ground motion and creation of a generator, analyze the existing one.
- Simulation of effects of these vibrations with a position feedback.
- Decrease by 3 the amplitude of simulated vibrations thanks to a fully optimized PID controller (conservatives results with the developped generator).
- Nevertheless, vibrations remain 3 times bigger than objectives.

Prospects

- Simulation of feedback with the Glen White generator.
- Simulation of full lattice from extraction to IP thanks to lattice file given by Javier Resta Lopez.

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