Main Linac simulation with Ground motion by SLEPT

KUBO, Kiyoshi (KEK)

ISG-X at SLAC, June 2003

Ground motion according to realistic model newly added to SLEPT

References:

[1] Andrey Sery and Olivier Napoly , "Influence of ground motion on the time evolution of beams in linear colliders",
Phys. Rev. E 53, 5323-5337 (1996).

[2] P.Tenenbaum, et. al.,"Recent Development in the LIAR Simulation Code",
Proc. of EPAC2003, p518 (2003)

1. Make power spectrum, p(ω, k),
   from parameters A and B of ‘modified ATL law’
   and frequencies, amplitudes, width and velocity of some resonance. [1]

2. Divide (ω,k) plane into bins, [2]
   (ω (i), k (j))   (i=1~ni, j=1~nj)
   ω (i+1) /ω (i) = const.,
   k(j+1)/ k (j) = const.

$$a(i,j) = \sqrt{p(\omega(i),k(j))d\omega dk\pi}$$

$$y(s,t) = \sum_{i,j} a(i,j)\left[\cos(k(j)s + \omega(i)t + \theta(i,j)) + \cos(-k(j)s + \omega(i)t + \theta(i,n_j + j))\right]$$

Usually, we need to caculate motion at $(s_l, n\Delta t)$: $y(s_l, n\Delta t)$

Δt: time step, s_l: position of lth element.

Define

$$C_i(s_l,t) \equiv \sum_j a(i,j)\left[\cos(k(j)s_l + \omega(i)t + \theta(i,j)) + \cos(-k(j)s_l + \omega(i)t + \theta(i,n_j + j))\right]$$

$$S_i(s_l,t) \equiv \sum_j a(i,j)\left[\sin(k(j)s_l + \omega(i)t + \theta(i,j)) + \sin(-k(j)s_l + \omega(i)t + \theta(i,n_j + j))\right]$$

$$\left(y(s_l,t) = \sum_i C_i(s_l,t) \right)$$

$$D_i \equiv \cos(\omega(i)\Delta t)$$

$$E_i \equiv \sin(\omega(i)\Delta t)$$

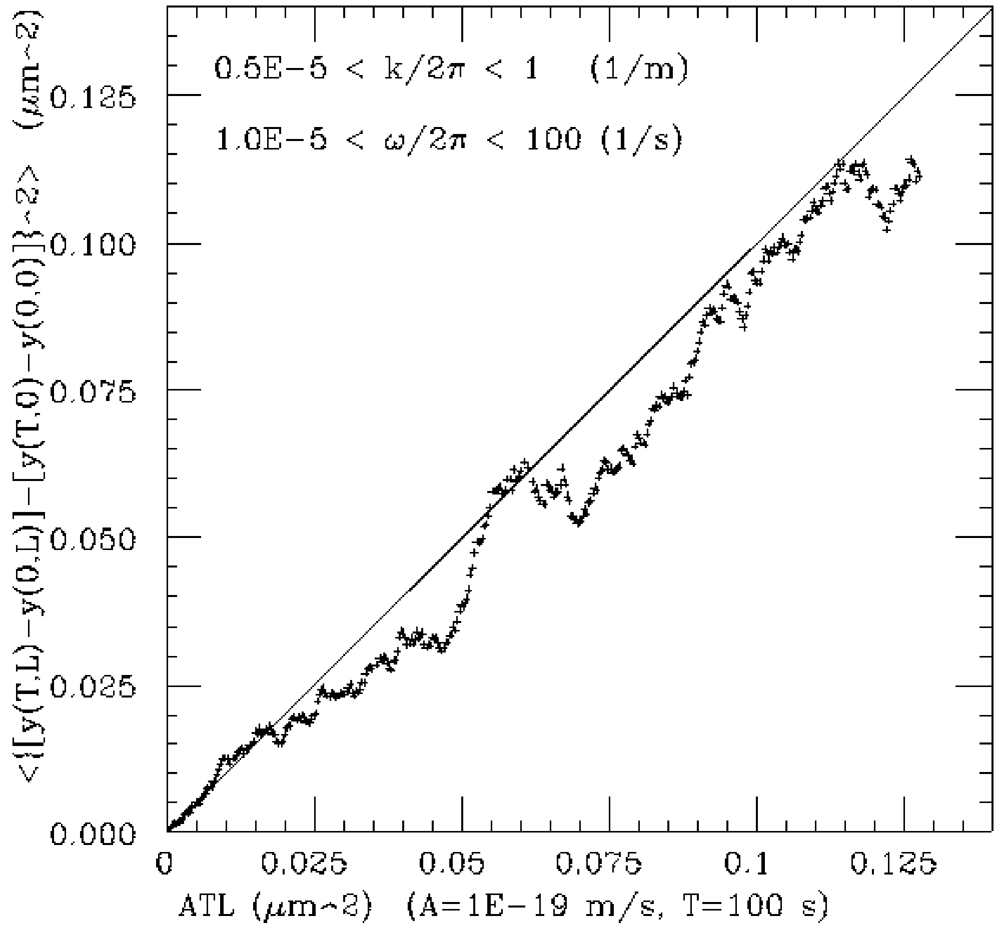
Then,

$$C_i(s_l, t+\Delta t) = D_i C_i(s_l,t) - E_i S_i(s_l,t)$$

$$S_i(s_l, t+\Delta t) = E_i C_i(s_l,t) + D_i S_i(s_l,t)$$

No trigonometric function calculations in time steps.

Check ATL (large B, no resonance)



Procedure of mover correction

(1) Ground motion
(2) Beam measurement
(3) Q-mover correction
(4) Cavity mover correction
repeat from (1) to (4)

Assume no G.M. from (2) to (4)

Emittance at linac end was looked at (1), (2) and (4) or

(A) after GM,
(B) after Q-mover correction,
(C) after Cavity mover correction

Ground motion model:

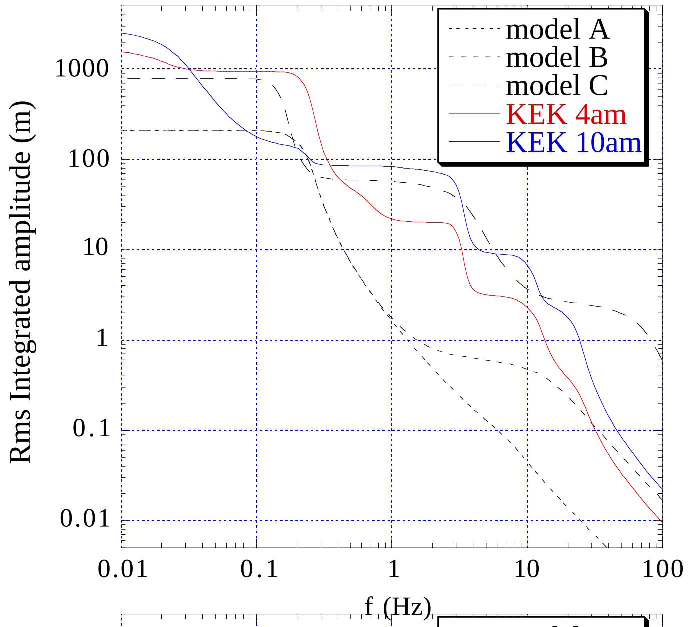
A, B, C (http://www.slac.stanford.edu/~seryi/gm/model/
gm_model_A.data,
gm_model_B.data
gm_model_C.data.)

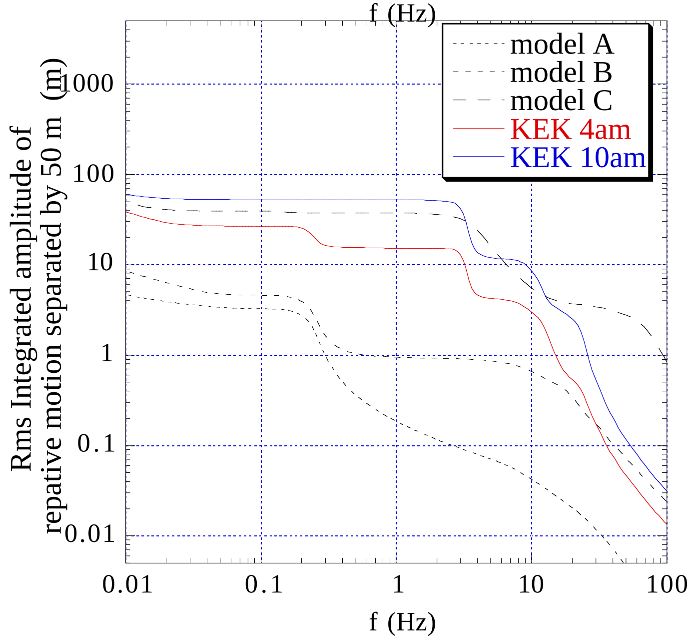
C_nores (Same as C but no resonance)

Ground motion models

(KEK models are preliminary)

	A	B	C	KEK (4AM)	KEK (10AM)
A (m/s)	1E-19	5E-19	1E-17	1E-17	1E-17
B (m^2/s^3)	5E-19	1E-18	5E-18	5E-18	5E-18
Resonances Freq. (Hz)	0.001 0.2 5	0.001 0.2 4.5	0.14 2.5 50	0.012 0.22 0.5 3.0 10.0 20.0	0.012 0.22 1.1 2.0 3.0 10.0 20.0
Amplitude (m^2 s)	1E-9 3.5E-13 1E-21	1E-9 3.5E-13 2.5E-20	1E-11 1E-15 1E-19	1E-10 1E-11 5E-15 5E-16 1.5E-18 1.3E-20	3E-10 1.5E-13 2.0E-15 1.5E-15 5.0E-15 1.8E-17 5.0E-19
“d” (~1/width)	1.0 3.5 1.3	1.0 3.5 0.35	5 1.5 1.5	1.0 5.5 2.0 8.5 3.5 3.0	0.7 6.5 7.0 3.0 8.0 5.5 4.0

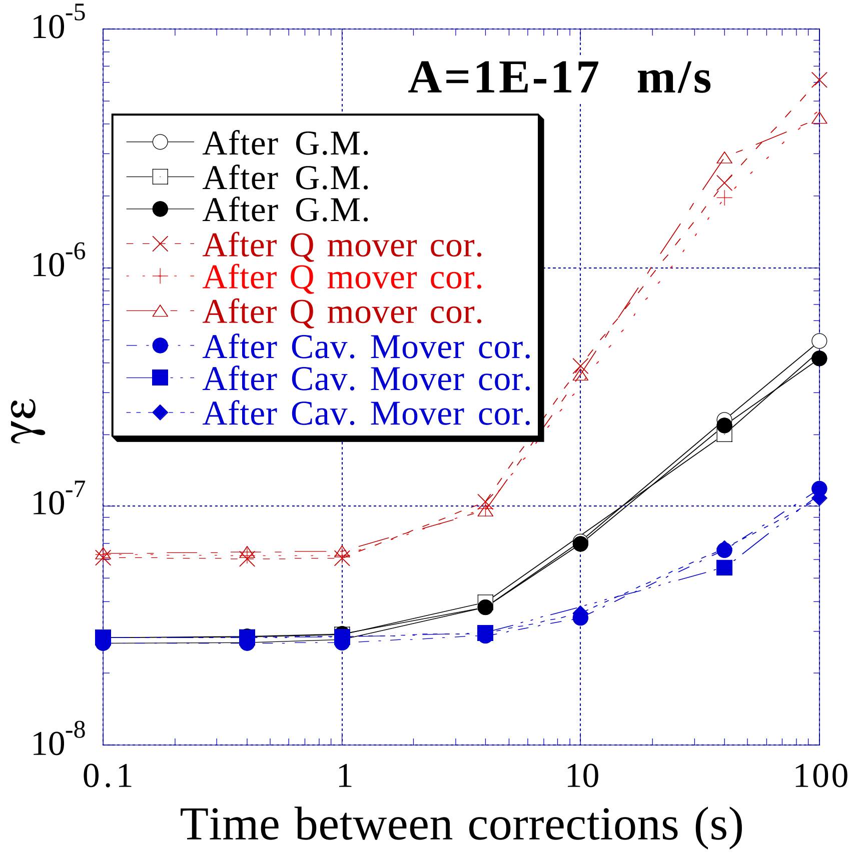




γε at linac end vs.
Time between corrections
for model C_nores.

After G.M.,
After Q-mover correction
After Cav-mover correction

Three random seeds for each.

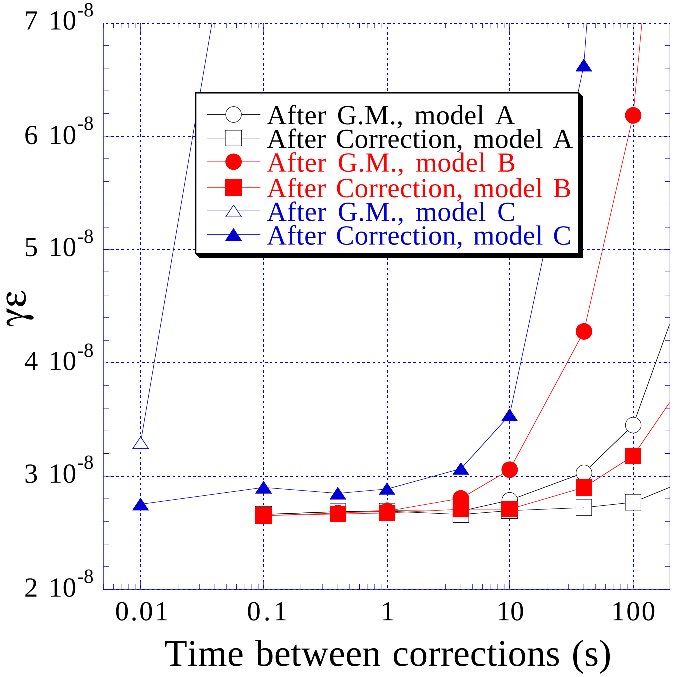


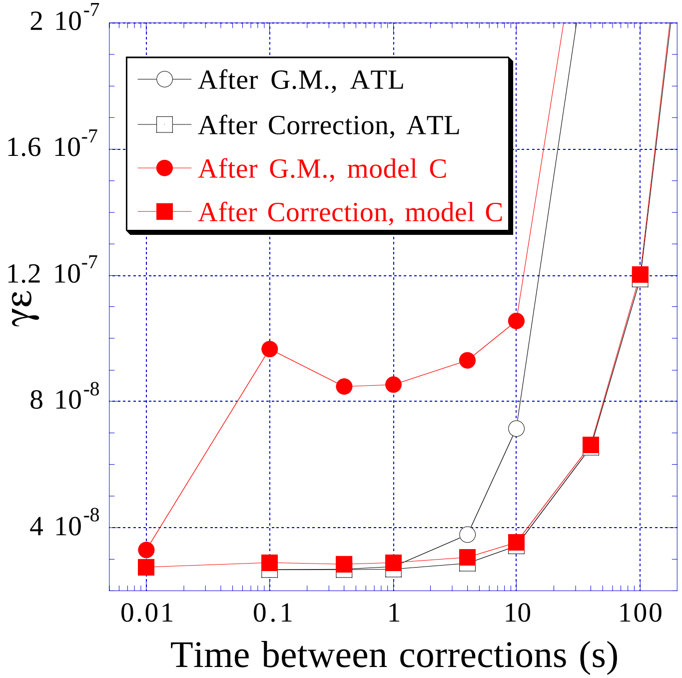
Emittance is large between Q-mover correction and Cavity mover correction.

Orbit changes by Q-mover correction cause emittance dilution due to wakefield.

The time should be short to avoid luminosity loss.

γε at linac end vs. Time between corrections for GM models





Large emittance after ground motion (before mover correction).

Need faster feadback in linac for model B and C.

Motion due to resonaces, not ATL, is important for this effect.

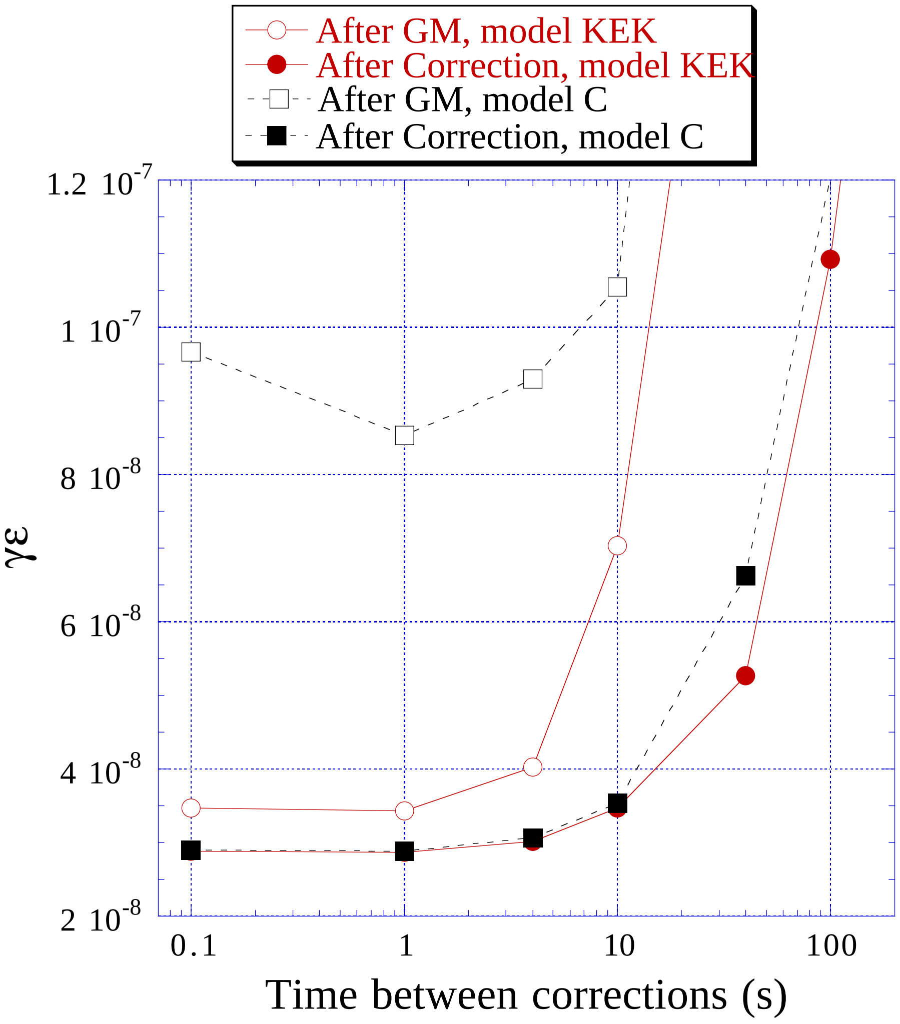
Model C has large emittance even after correction.

Time between corrections > 10 s will not be acceptable.

KEK-4am and model C
(preliminary)

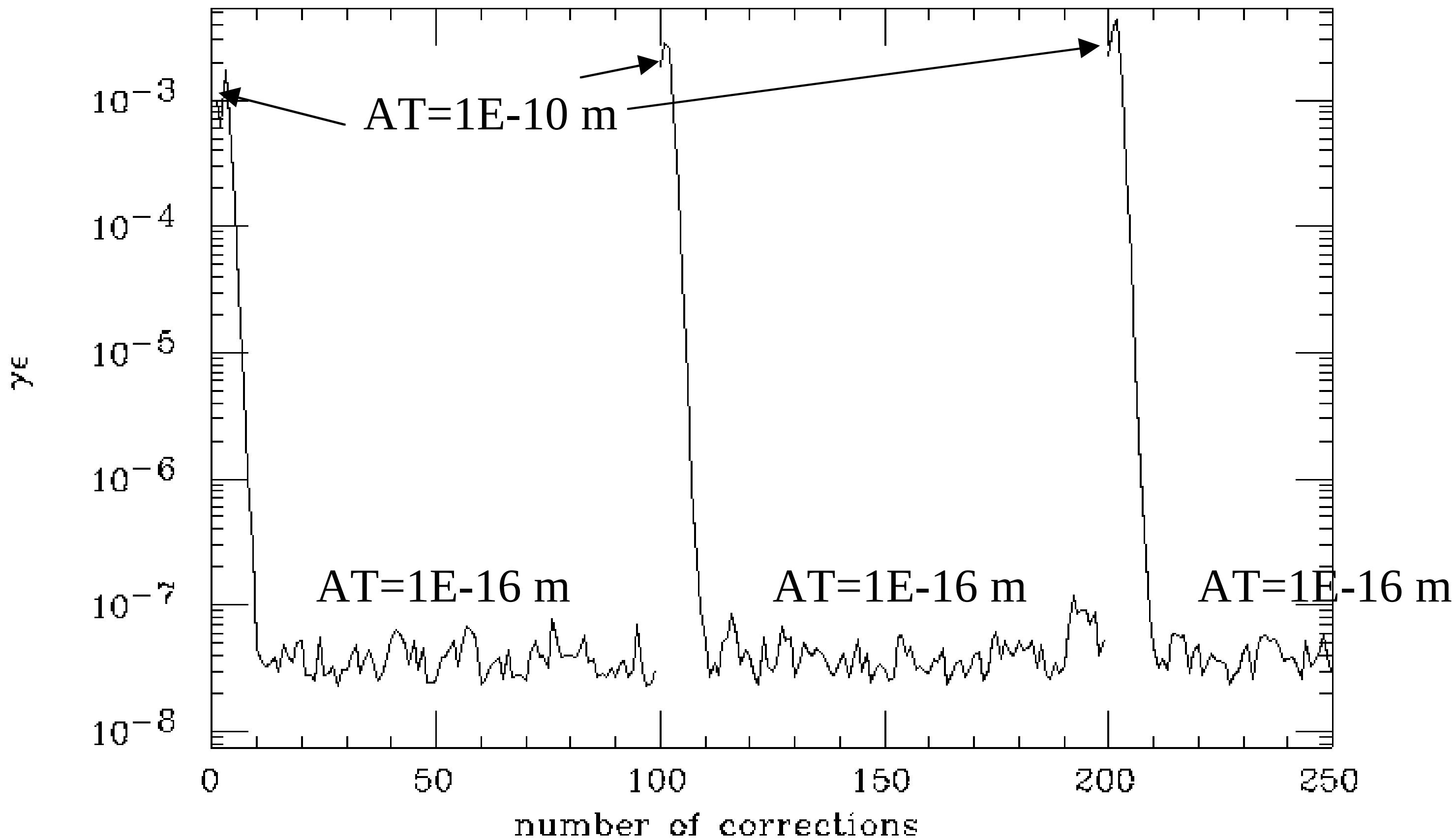
Main difference is short time "after GM", because of high frequency resonance of model C.

Need to simulate faster feedback.



After beam shut down, how the correction work?

ATL motion, set large AT before 1, 100, 200th correction.



Small emittance will be recovered in 10 corrections.

SUMMARY

- Ground motion model newly included in SLEPT.
- When Q-mover correction is done, Cavity mover correction should follow quickly.
- Time between corrections should be as small as possible.

  <10 s assuming model C.
- Need Faster feedback in the linac for high freq. motion.
- After long shut down (after big ground motion), small emittance will be recovered in 10 iteration of corrections.

Future Plan

Simulation with G.M. model of KEK site.

Include fast feedback in linac.

Look luminosity, not only emittance.