Adaptive Alignment in Presence of Ground Motion & Technical Noise

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28 September 2006

The 9th International Workshop on Accelerator Alignment

Sep. 25-29, 2006 SLAC, Stanford, CA, USA

Outline

- The aims related to the ILC project
- Status of art
- Ground motion model
- One-to-one dynamic alignment algorithm
- Benchmark results for 4 different sites
- Experimental & numerical data (FNAL site)
- Summary

The aims related to the ILC project

- Develop the C++ version of the GM model implemented before for the LIAR code in Fortran;
- Provide benchmarks for different types of GM spectra;
- Incorporate the GM model into CHEF;
- Implement the dynamic steering algorithm under GM perturbations;
- Study the stability and efficiency of the steering algorithm with GM.

GM status of art

References

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Ground motion model

- Power spectrum of displacement x(t,s) is

$$P(\omega,k)=\lim_{T\to\infty}\lim_{L\to\infty}\frac{1}{T}\frac{1}{L}\left|\int_{-T/2}^{T/2}\int_{-L/2}^{l/2}x(t,s)e^{-i\omega t}e^{-iks}dt\ ds\right|^2$$

- Relative power spectrum. Approximation

$$\rho(\omega,L)=\frac{1}{2\pi}\int_{-\infty}^{\infty}P(\omega,k)2[1-\cos(kL)]dk;\quad \rho(\omega,L)\approx\begin{cases}AL/\omega^2,\ 0<\omega<\omega_0,\\ B/\omega^4,\ \omega>\omega_0.\end{cases}$$

- Relative misalignment

$$\left\langle\Delta X^2\right\rangle=ATL+ATL\frac{2}{\pi}f(x_0)+\frac{BT^3}{6\pi}g(x_0),\quad x_0=\frac{T}{2}\sqrt{\frac{B}{LA}},$$

$$f(x)=Si(2x)-\frac{1-\cos(2x)}{2x},\quad g(x)=2Si(2x)+\frac{\cos(2x)}{x}+\frac{\sin(x)[\sin(x)+x\cos(x)]}{x^3}.$$

One-to-one steering algorithm

3-element adaptive alignment scheme

$$\Delta x_i = C\frac{L_1 L_2}{L_1 + L_2}\left\{\left[\frac{\beta_{i-1}}{L_1}A_{i-1} + \frac{\beta_{i+1}}{L_2}A_{i+1}\right] - \left[\frac{1}{L_1} + \frac{1}{L_2} - k_i\left(1 - \frac{\Delta E}{2E}\right)\right]A_i\right\},$$

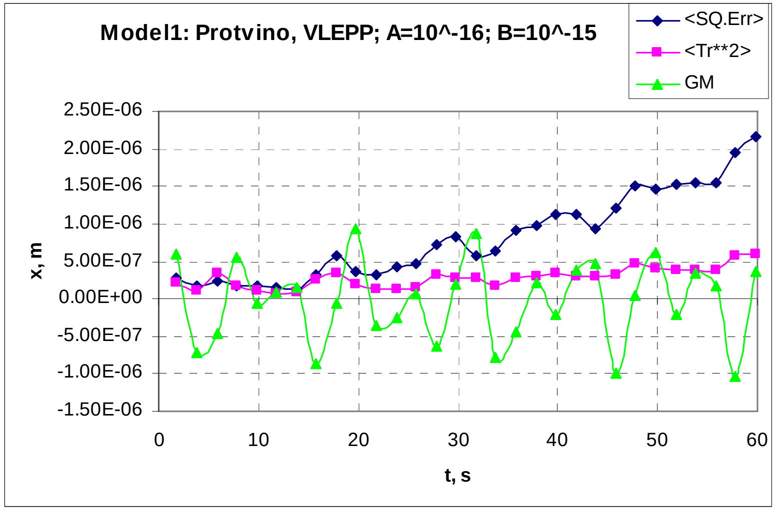
where A_i – BMP reading, k – inverse focusing distance, x_i – quad position, L_1, L_2 – distance to the previous/next lenses $\Delta E/E$ – energy dispersion,

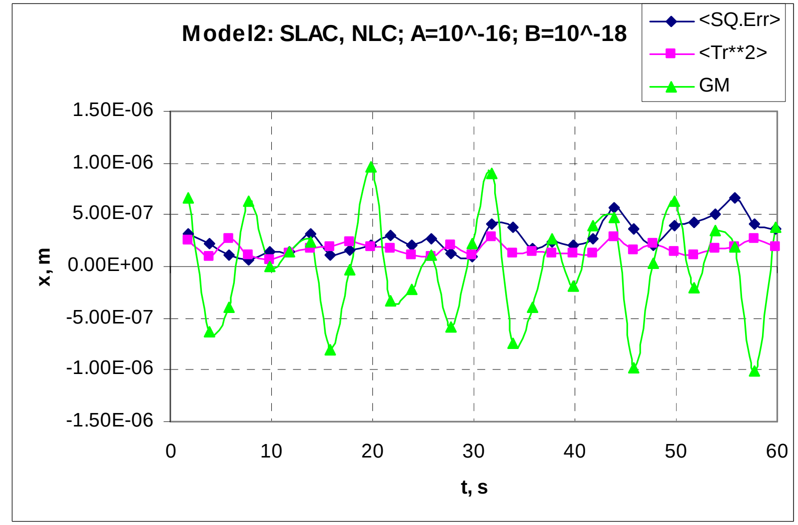
$\beta_i = 1 - k_i l/4$. l – quad length.

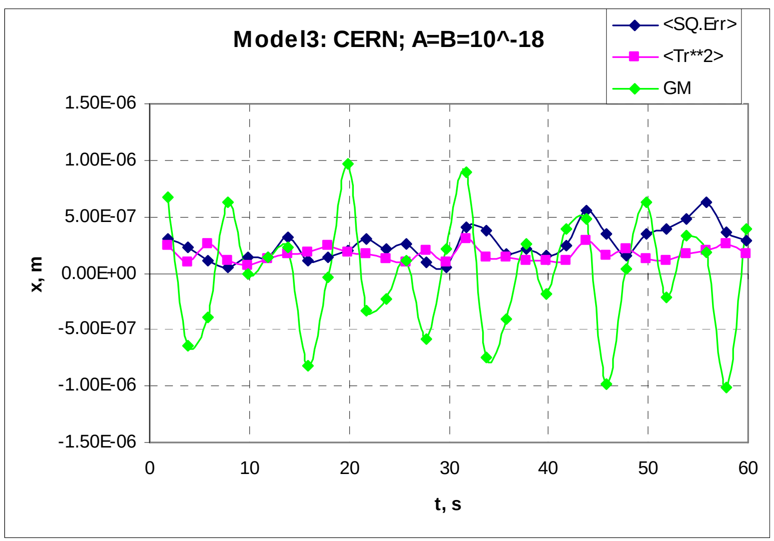
Parameters of numerical model

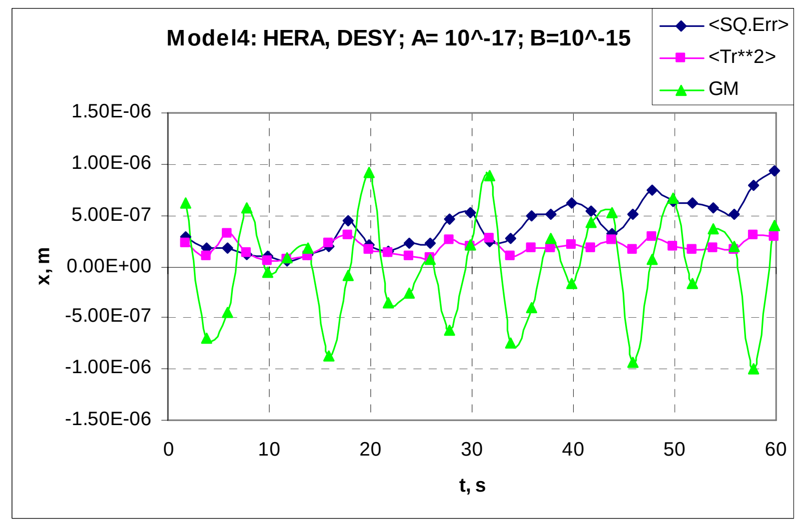
- Number of quads N = 100;
- Energy spread $\Delta E/E = 1\%$;
- Distance between quads L = 34 m;
- Random BPM misalignment $\sigma = 1$ nm;
- BPM read interval $\Delta t = 0.2$ s (5Hz);
- Convergence coefficient C=0.05;
- Initial quad's misalignment $\sigma(A) = 1$ um.

GM Spectra for 4 different sites



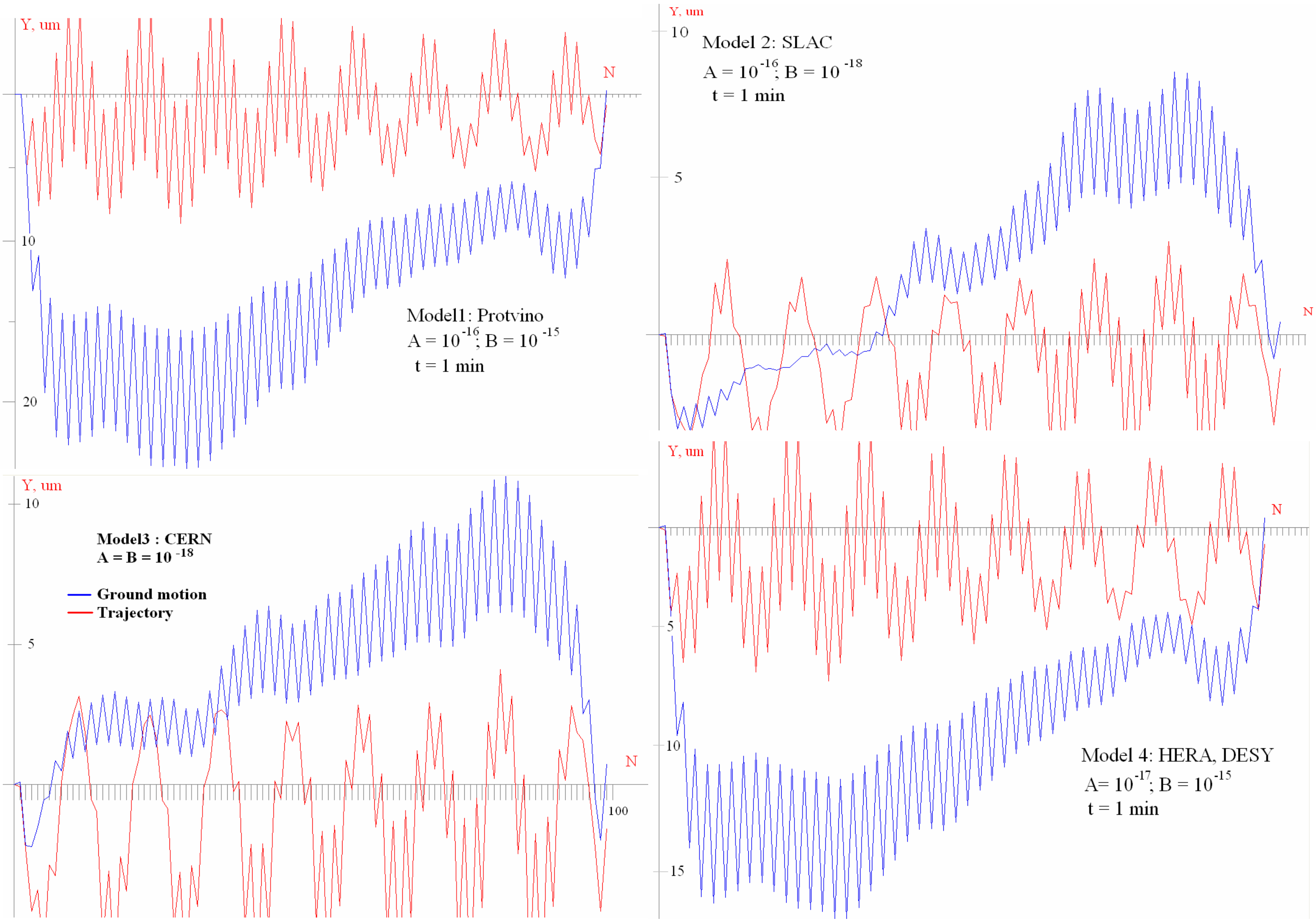






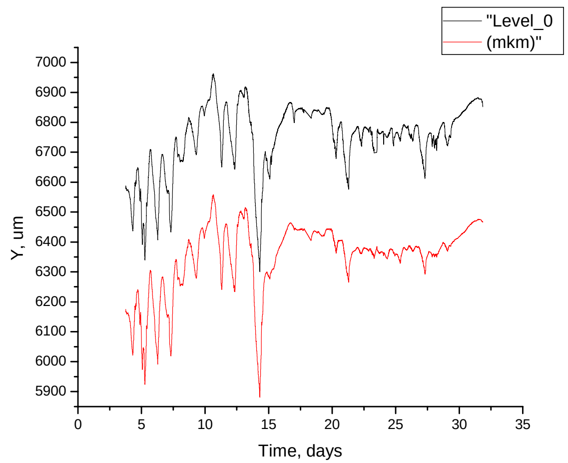
GM variance over the structure; Trajectory variance; GM displacement $x(t,s_0)$ at particular point s_0

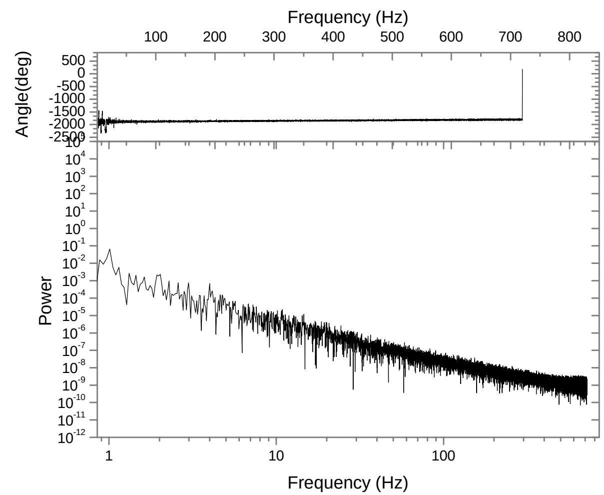
Ground motion & trajectories at different sites

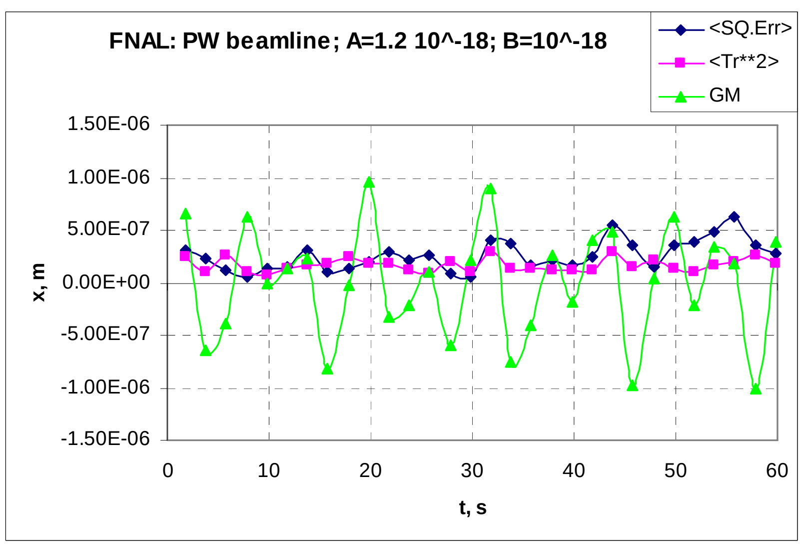


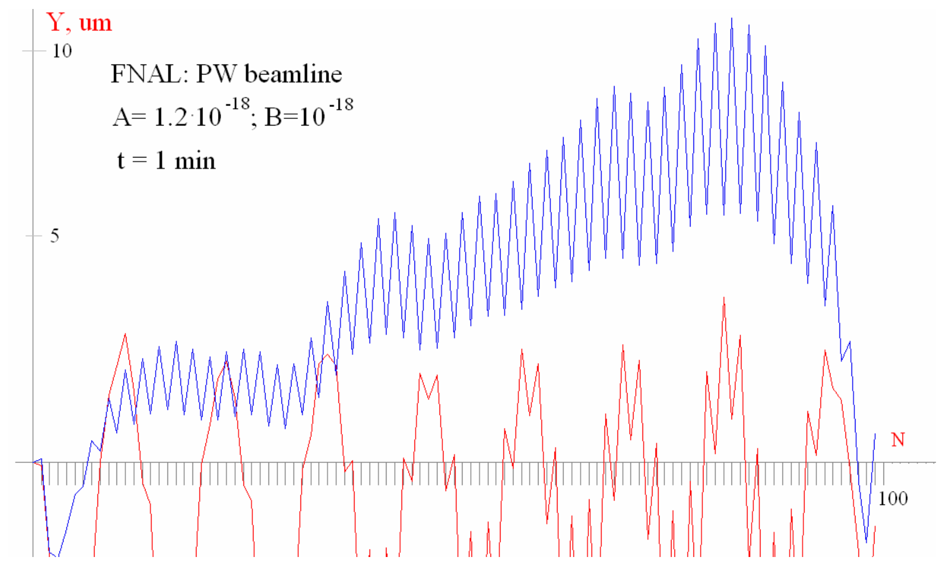
Ground motion data at PW beamline Fermilab, Oct. 99

Experimental data presented by V. Shiltsev, S.Signatulin

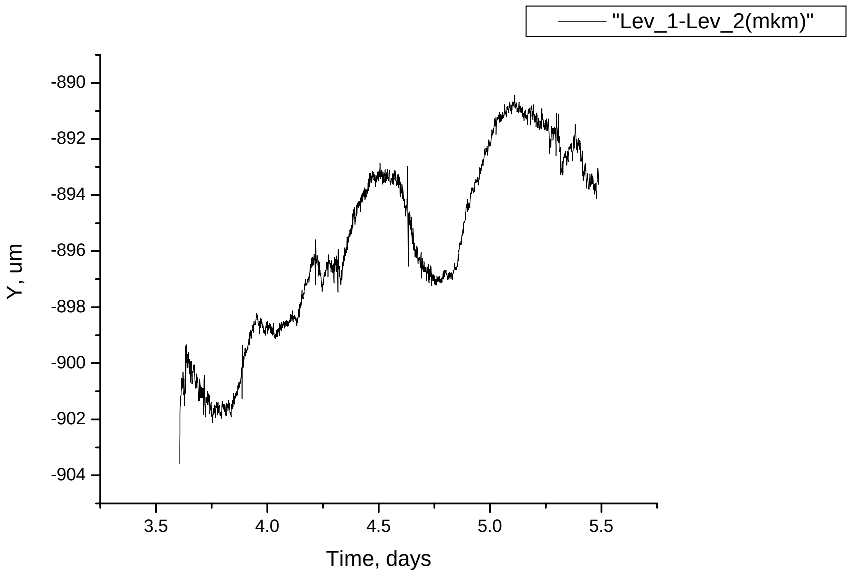


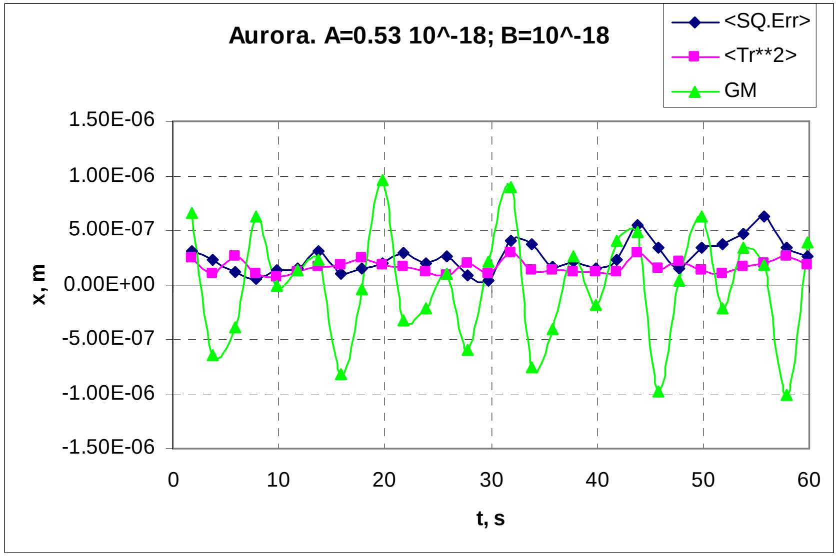


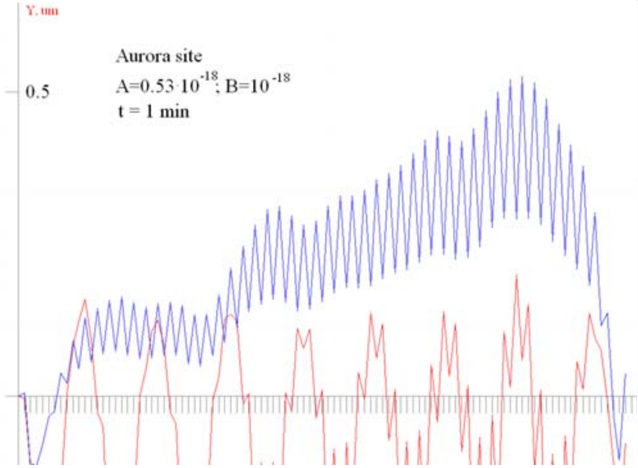


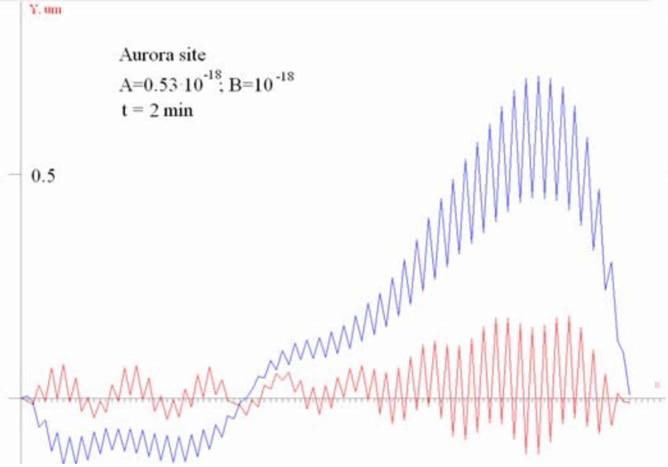


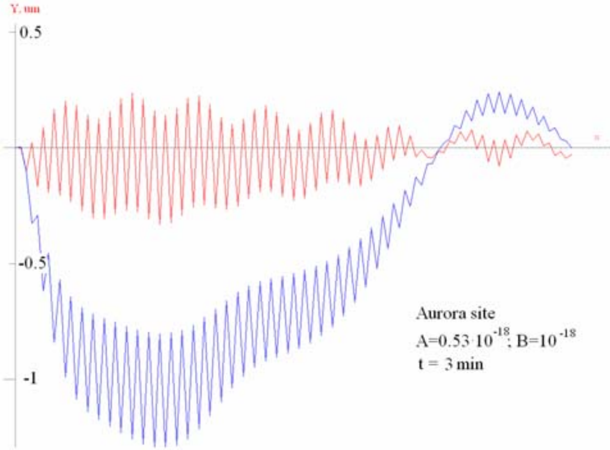
Ground motion at Aurora site











Acknowledgements

- Special thanks for the help to my colleagues :
- Andrey Seryi – GM model algorithm & the code:
- Nikolay Solyak - steering algorithm, the problem formulation for the ILC project;
- Vladimir Shiltsev, Shavkat Signatulin – experimental data at FNAL site.