INTERNATIONAL LINEAR COLLIDER

SLAC

ILC Feedback Studies

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5-Hz Integrated Feedback Simulations

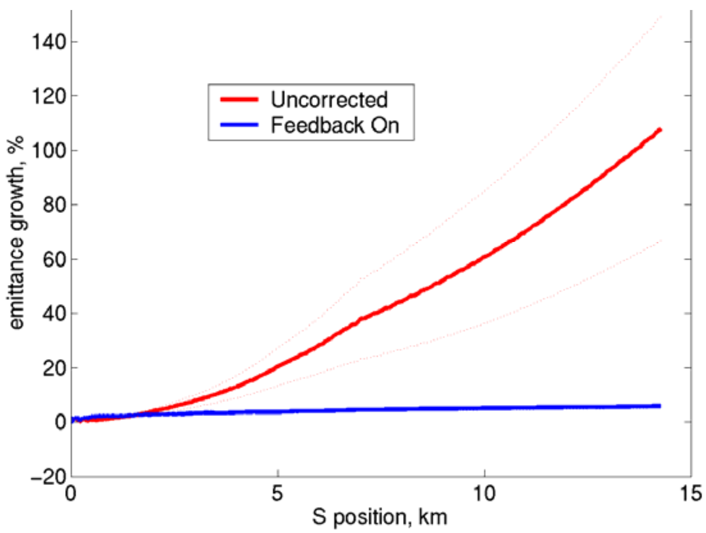
- **Linac feedback** distribution: 5 distributed loops per beam, each with 4 horizontal and 4 vertical dipole correctors, and 8 BPMs (X&Y). Based on SLC experience and NLC simulations by LJH.
- **BDS feedback** distribution: 1 BDS loop per beam, 9 BPMs and 9 dipole correctors, both horizontal and vertical. Based on NLC simulations by Seryi.
- Linac and BDS feedbacks **"Cascaded"** system of 6 loops per beam: loops don't overcompensate beam perturbations, but can be independently disabled for operational convenience. SLC-style "single cascade" (each loop communicates beam information to single adjacent downstream loop).
- **Linac and BDS** loops have **exponential response of 36 5-Hz pulses**.

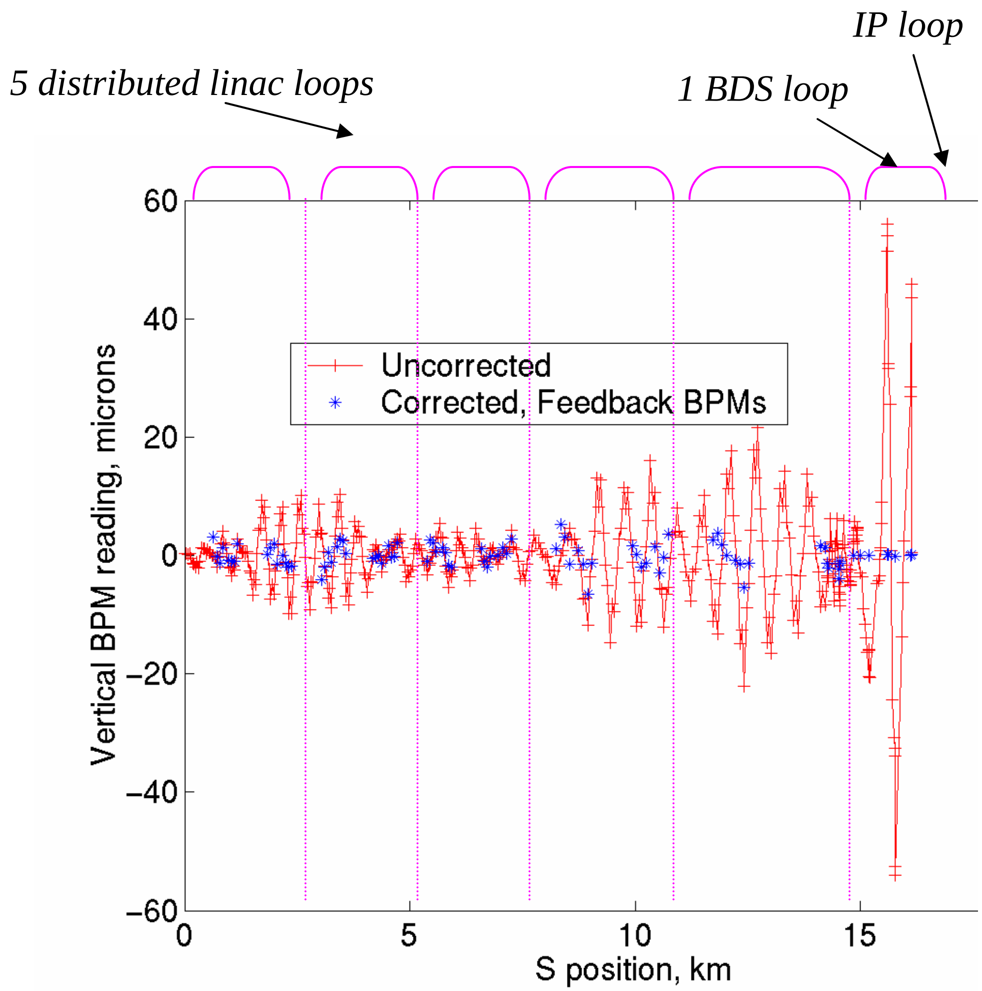
  IP deflection (X&Y), not cascaded, **exponential 6 pulses** (like SLC).
- **Matlab/liar/dimad/guinea-pig** platform. Upgraded liar/dimad for energy and current jitter, and dispersion measurements.
- **KEK-model ground** motion (noisy site). Study effects of **component jitter, energy, current, kicker jitter**. Problems: BDS beamsize very sensitive; using dispersion compensation and perfect energy measurement.

Feedback Simulations

BPM readings after 30 minutes ground motion

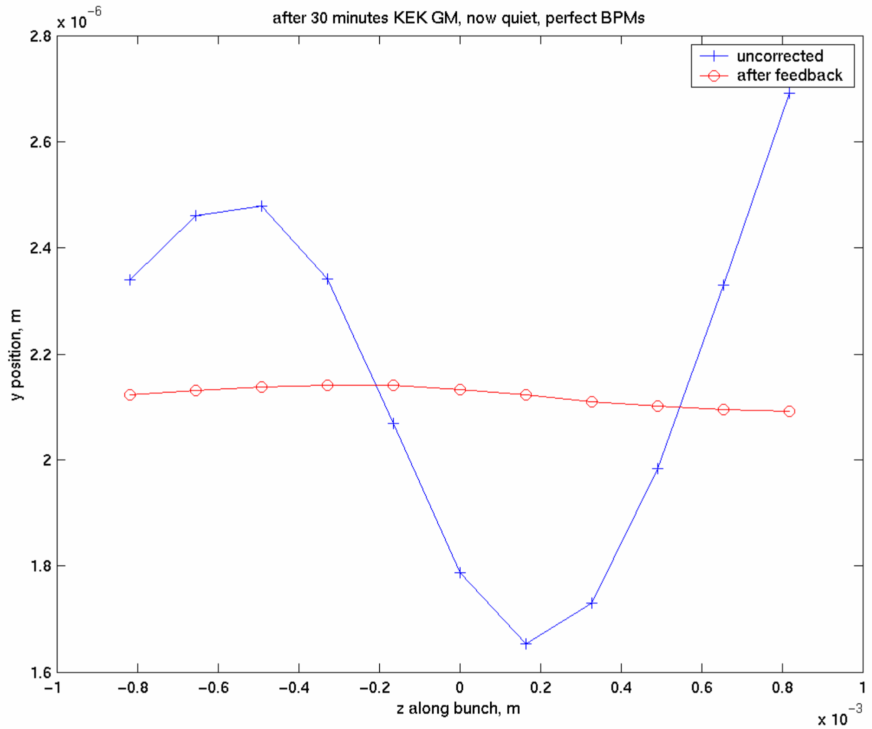
Emittance growth in linac
~100% after 30 min “KEK”
ground motion + jitter for 10 seeds,
6% with feedback (3% with feedback
without jitter).





Feedback Simulations

"Banana-bunch" shape is seen at end of LINAC after 30 minutes of "K" ground motion. Fixed with feedback.



BDS Feedback Issues

- BDS feedback **essential in vertical** plane, maintains beamsize with large ground motion.
- Horizontal BDS feedback included for operational reasons; but in simulations, **horizontal feedback is sensitive to energy** jitter. Simulations included no cases in which it improves the beamsize; needs great care to avoid increasing by X&Y beamsizes.
- With energy jitter and horizontal BDS feedback, **essential to have pulse-pulse energy measurement** (initially assumed perfect), and feedback dispersion compensation.
- Example: Start with perfect machine without jitter, offset energy by 0.03% (less than bunch-bunch jitter), take BPM references, and let BDS feedback stabilize to references with no other imperfections:

  >> X beamsize growth is 45%, Y beamsize growth is ~350%!

  Need careful handling, probably dispersion correction knobs.
- 9 **discrete locations is operationally non-ideal**: no redundancy, no resistance to flaky BPM instrumentation. (Nicer to have distributed BPMs, but has not worked well in simulation.)
- **Phase advances not ideal** for corrector/BPM locations; very sensitive to perfect model/calibration of transport matrices. (Oscillations can result if not careful).

Beamsize growth effects, with feedback

Single-beam studies of beamsize growth, with 5-hz feedback in LINAC and BDS.

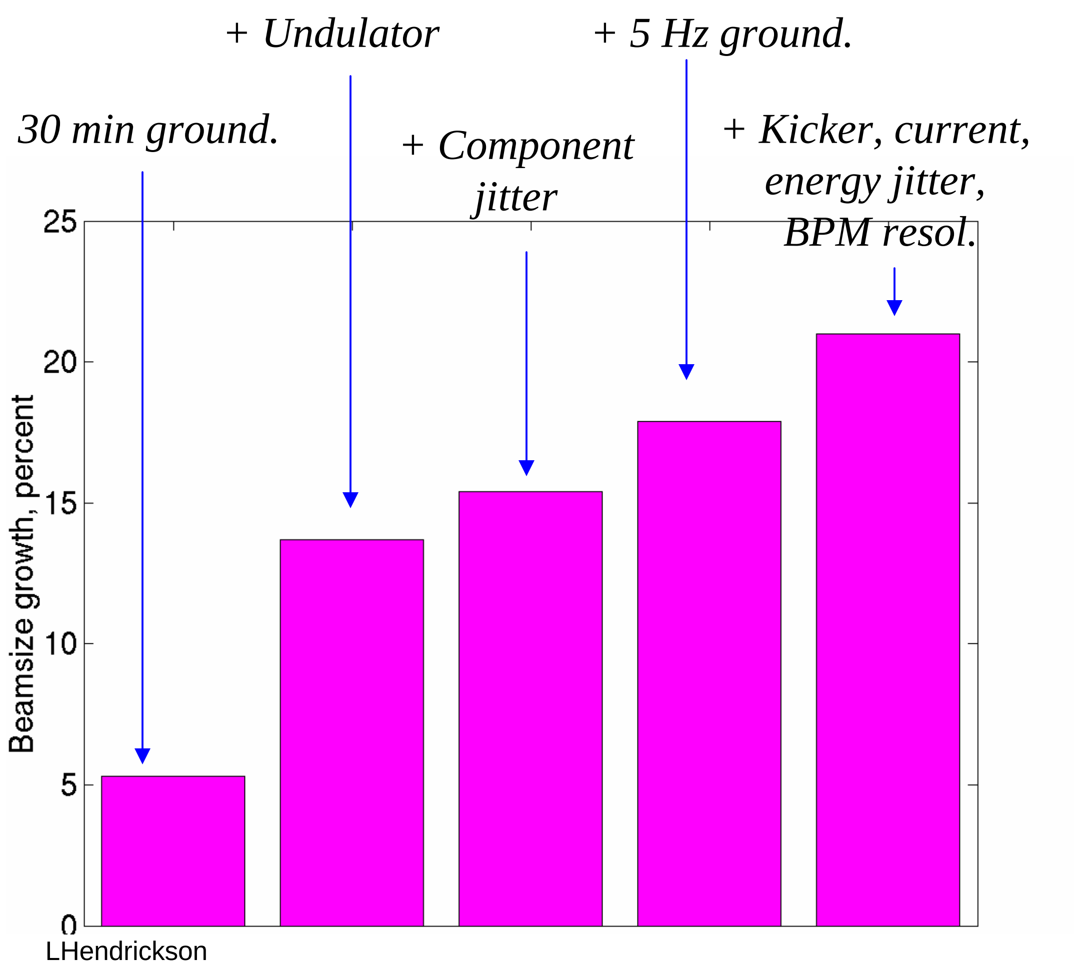
Perfect initially, add 30 minutes “KEK” ground motion”, let feedback converge -> 5% beamsize growth (380% without feedback).

Increase energy spread for undulator (.15% end of linac; this effect needs more study!) -> 14%.

Add component jitter (25 nm BDS, 50 nm linac) -> 15%.

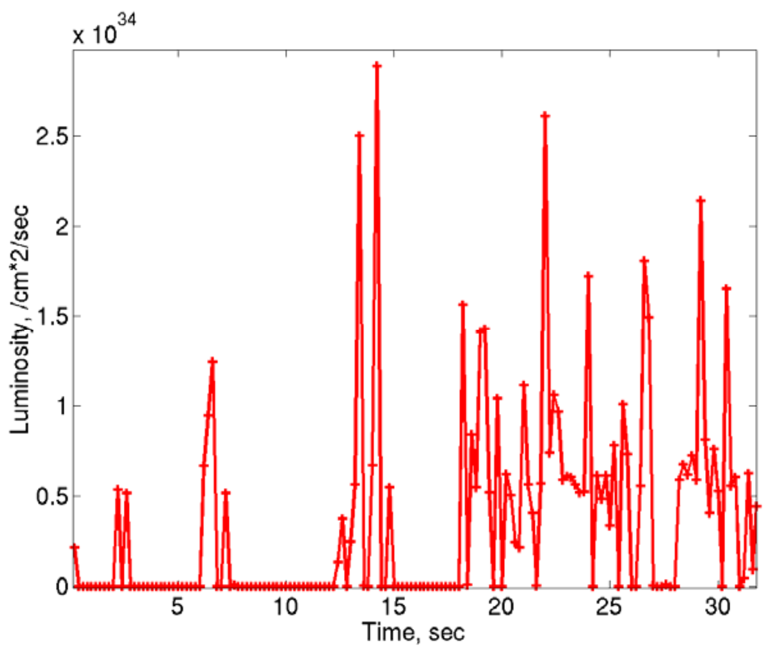
Add 5-Hz “KEK” ground motion -> 18%.

Add kicker jitter (.1 sigma), current jitter (5%), energy (.5% uncorrelated amplitude on each klys, 2 degrees uncorrelated phase on each klys, 0.5 degrees correlated phase on all klystrons, BPM resolution .1 um. -> 21%

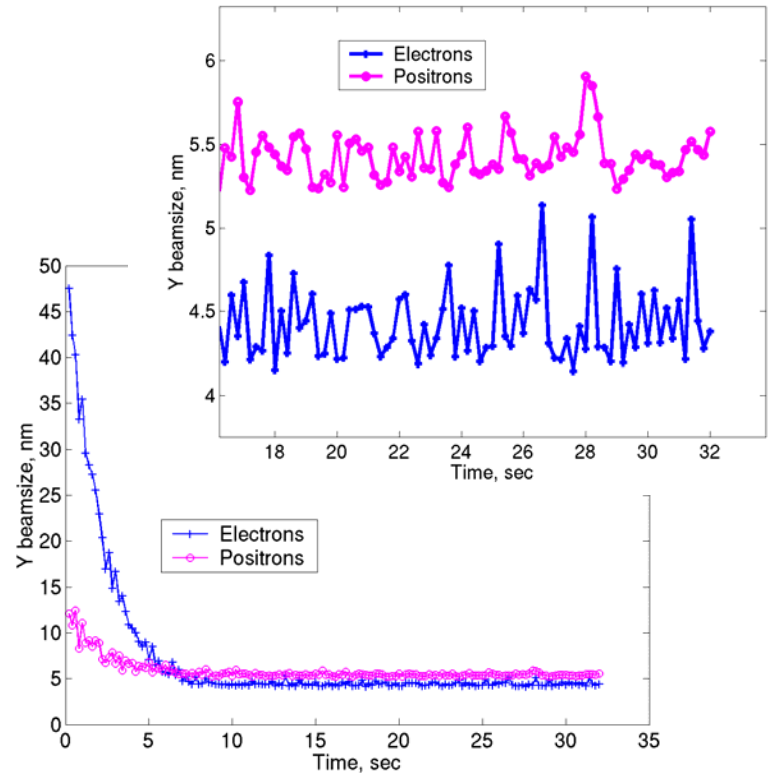


2-beam Integrated Feedback Simulations

2 beams, 5-Hz linac, BDS and IP deflection feedback. Perfect initially, feedback turned on after 30 minutes of “KEK” ground motion. 5 Hz ground motion, added component jitter, kicker, energy, current jitter. No angle feedback, no intratrain feedback. For the first ~20 seconds, IP feedback cannot keep up with large BDS steering changes. After 20 seconds, beams kept in collision but luminosity is poor (~20% in preliminary simulations, ~79% with perfect intratrain IP feedback).



Beam-size jitter in steady-state.



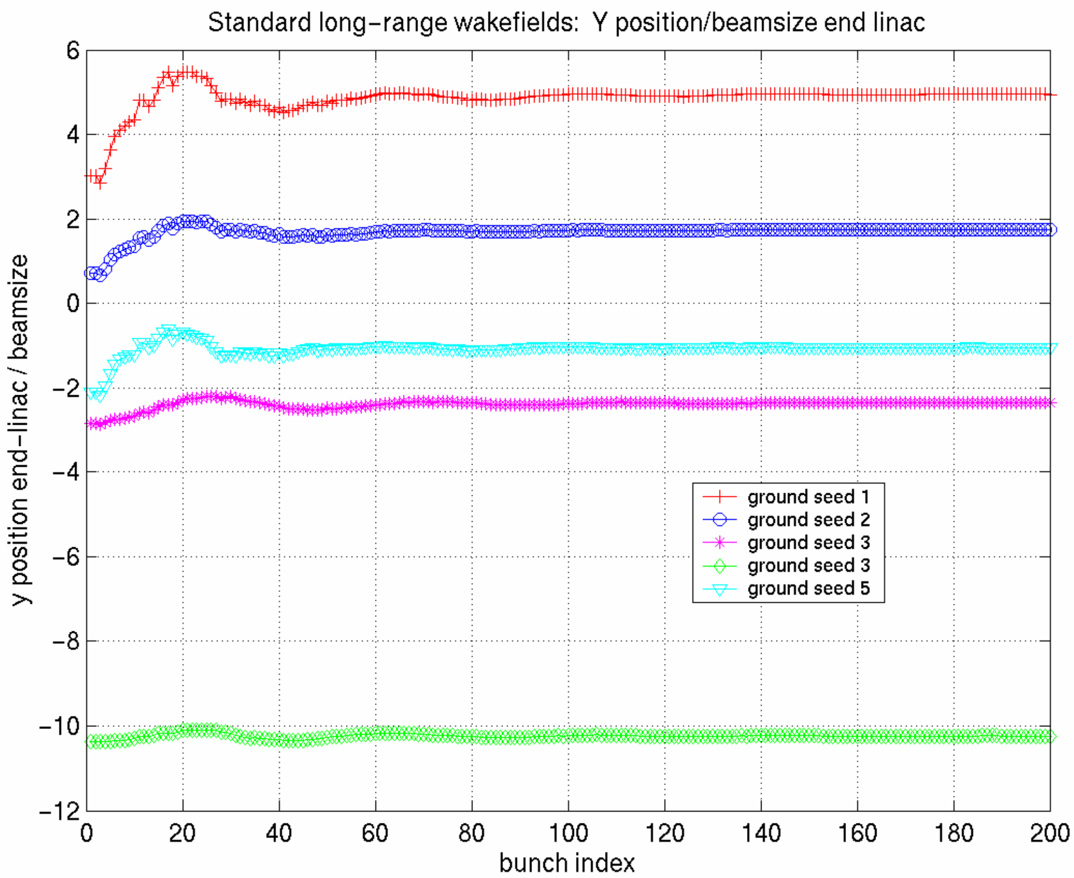
Beam sizes decrease after feedback is turned on. (Note seed-dependent beamsize from ground motion; in this seed, e- becomes smaller).

Long-range wakefields (RJones)

Standard wakefields, after 30 minutes “K” ground motion.

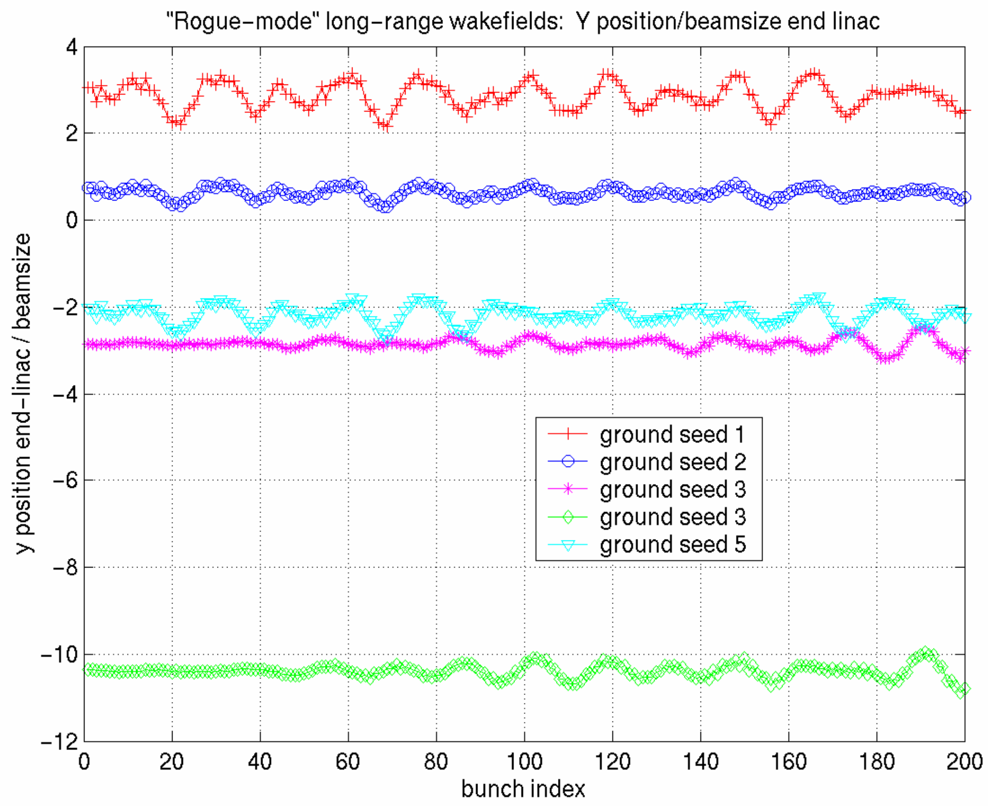
Oscillation over first ~30 bunches up to 2-3*beamsize.

5 different ground motion seeds shown. Train-straightener can fix completely.



Long-range wakefields (RJones)

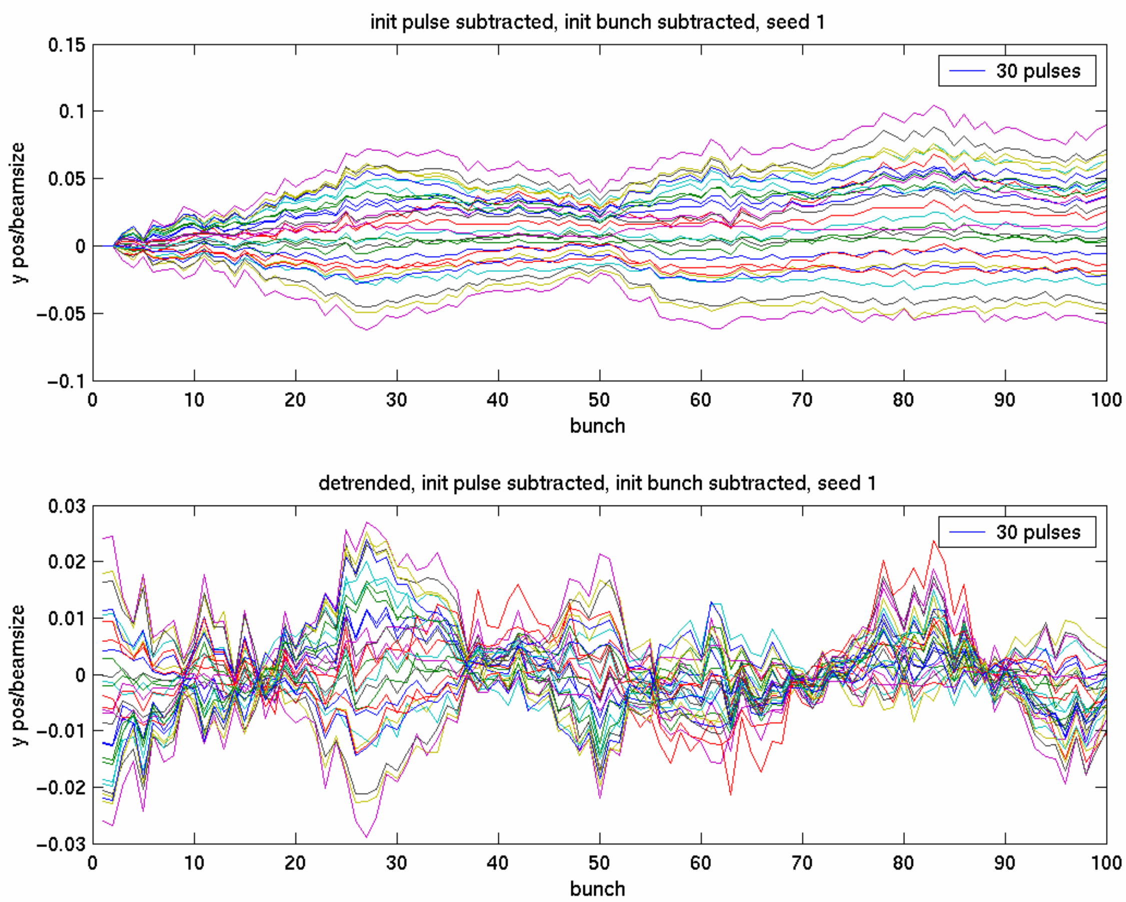
Possibility of undamped HOM: Check bunch-bunch jitter end-of-linac. Need to check > 200 bunches. But this is unrealistically pessimistic, because probably not all structures have rogue modes. (Frisch/RJones suggest: in future, mix rogue and standard structures in linac).



Long-range wakefields (RJones)

Possibility of undamped HOM: Check bunch-bunch jitter end-of-linac. 30 min ground motion, without steering feedback, then 30 5-hz pulses.

With a train straightener, bunch-bunch position jitter is still significant.



Detrending approximates the effect of long-timescale bunch-bunch position feedback at end of the linac: results are good.
-> Rogue wakes not a serious problem for bunch-bunch jitter.

Future Possibilities

- Apply **optimization knobs** (waist, etc) , optimize on beamsize or luminosity.
- Apply **dispersion knob** in BDS (with feedback correctors), optimize on beamsize or luminosity. Check second-order dispersion correction.
- Add **angle correction** to IP feedback (currently just spot-checked, should make part of regular simulation).
- **Stabilize** specific BDS components.
- Apply **train-straightener** at end of linac (possibly elsewhere).
- Apply **bunch-bunch feedback** at IP, end-of-linac, possibly elsewhere.
- Update simulations for **new (March) decks** (now using TESLA linac matched onto NLC BDS), and **new parameter sets**.
- Check BDS horizontal feedback dispersion correction, with **imperfect energy measurement**. (How imperfect?).
- Start from **initially imperfect machine**, from steering, etc.
- **Integrated simulations** with different timescales, hours, seconds, bunch-bunch.