Dynamic Simulations unsing PLACET

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Introduction

- Studies in 2006 concentrated on static alignment and tuning
- Dynamic effects are very important in ILC and CLIC

  $\Rightarrow$ started to prepare simulation tools

  $\Rightarrow$ preliminary results
- Main difference between CLIC and ILC
  - ILC has large time interval between pulses, instable beam-beam collisions but intra-pulse feedback
  - CLIC has smaller time interval between pulses, more stable beam-beam collisions, but intra-pulse feedback
  - in ILC most effects are expected from the BDS
  - in CLIC main linac is also important, stabilisation of elements is used

Integrated Dynamic Luminosity Simulations

- Before the integration, each subsystem should be studied seperately
  - feedback systems
  - impact of dynamic effects on correction procedure
- Different componenets that need inclusion
  - RTML

    ILC: lattice available, correction procedure not complete, feedback need definition

    CLIC: developing lattice
  - main linac

    ILC: lattice available, conceptual correction procedure, conceptual feedback, needs full study and adaptation to real lattice

    CLIC: lattice available, conceptual correction procedure, conceptual feedback, needs full study
  - BDS

    ILC: lattice available, correction procedure needs to be adopted and cross checked, are working on feedback systems/adopt from others

    ILC: lattice available, correction procedures being worked out, feedback needs to be defined

Overview of Talk

- We are still in a starting phase
- Some results on
  - impact of dynamic effects on main linac alignment
  - main linac feedback
  - impact of jitter on luminosity
  - feedback in BDS

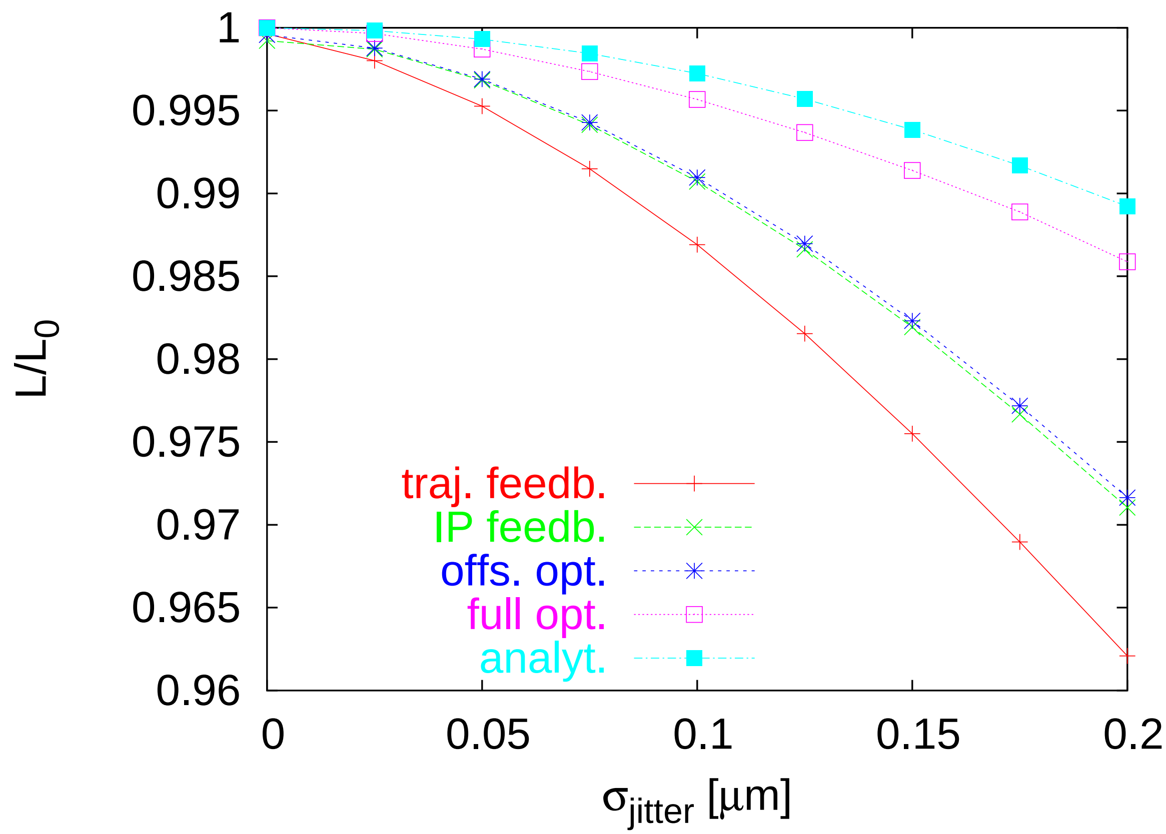
Simplified Simulations of ILC Main Linac Quadrupole Jitter

- Simplified main linac lattice with 32 cavities per quadrupole

  $\Rightarrow$ now 24 cavities per quadrupole

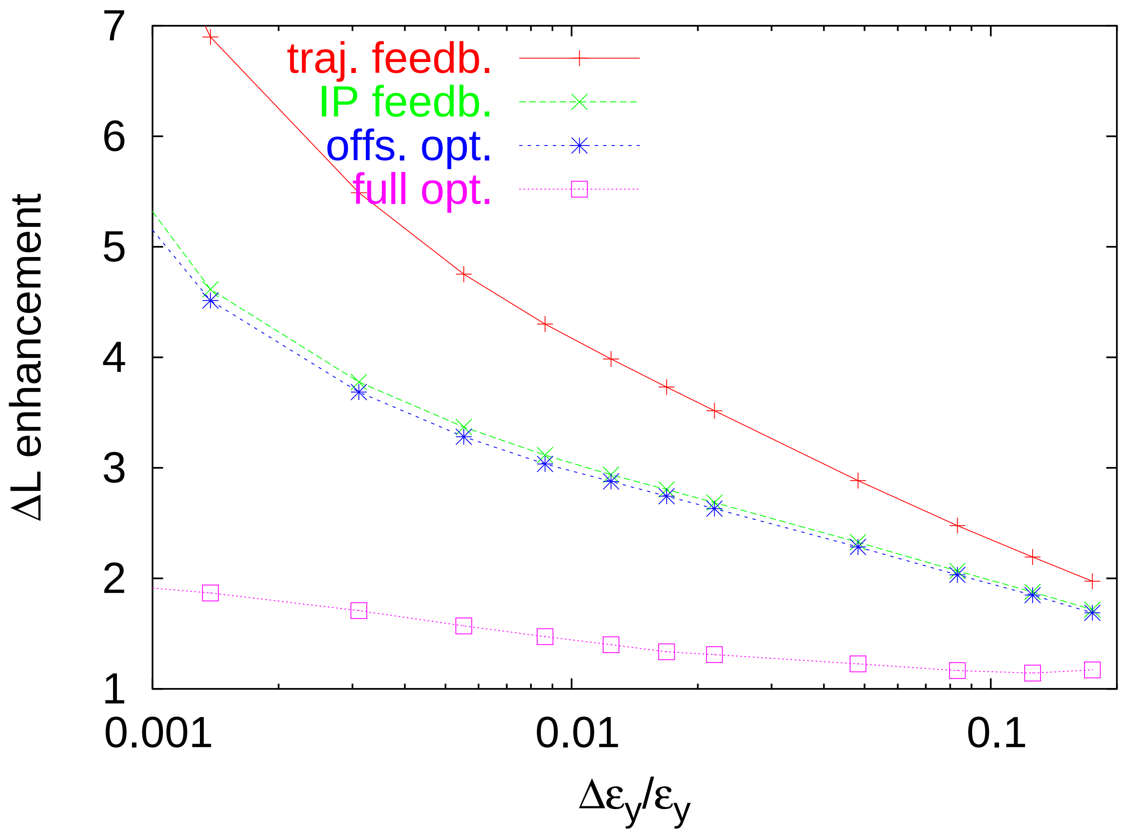
- Simulation procedure

  - emittance growth in main lianc with PLACET
  - simplified trajectory feedback at end of ML
  - simple transfer matrix to IP
  - beam-beam with GUINEA-PIG



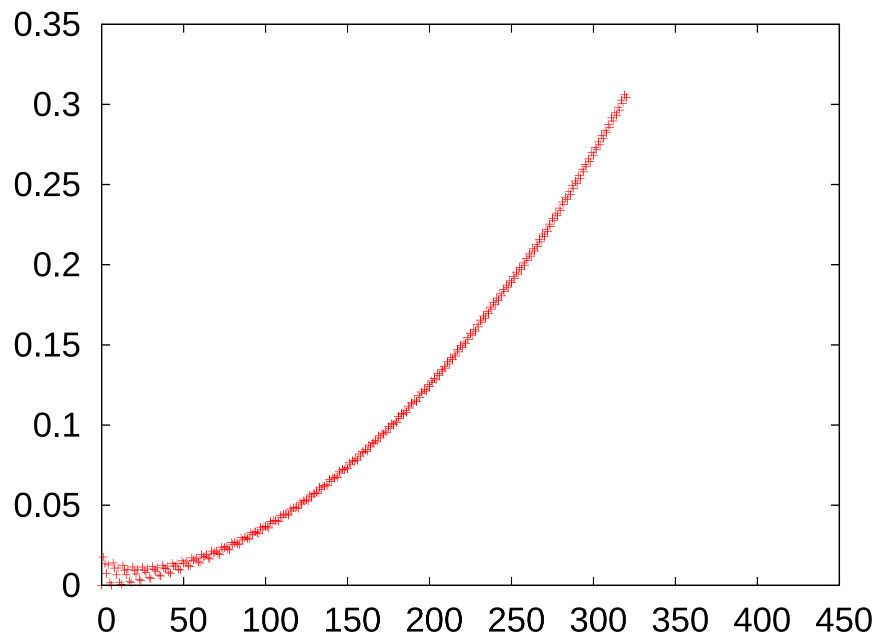
Luminosity Loss Enhancement

- ⇒ Luminosity loss is enhanced with respect to expectation from emittance growth
- ⇒ Offset optimisation does not improve beam-beam feedback a lot
- ⇒ But angle optimisation does
- ⇒ For larger emittance growth loss enhancement is reduced



ILC Main Linac Quadrupole Jitter

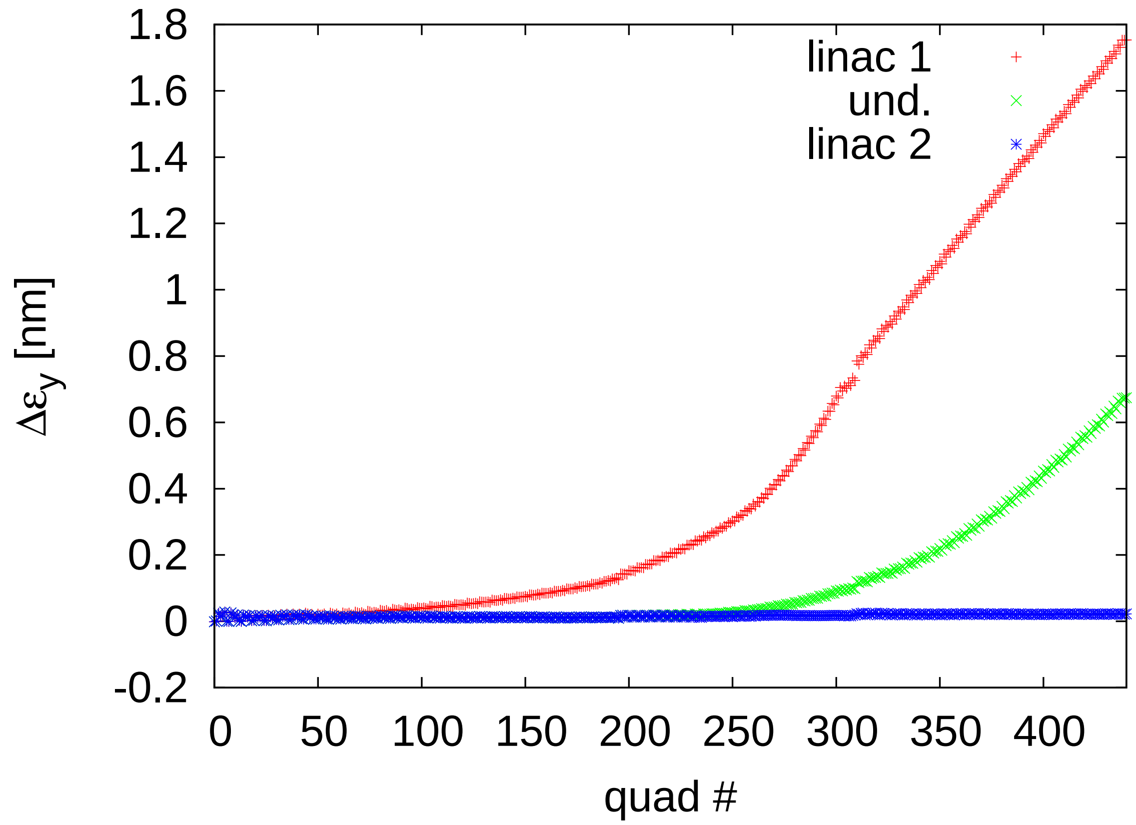
- Simplified new lattice
  - 24 cavities per quadrupole
  - simulate quadrupole jitter in main linac
  - use emittance as a measure



⇒ Emittance growth is larger than in old lattice since more quadrupoles and smaller beta-functions

ILC Full Lattice Simulations

- Electron linac simulated, contains undulator section
  - undulators are modeled as elemetns that generate energy spread, full spectrum is used
- Quadrupole jitter in three regions
  - linac before undulator
  - undulator
  - linac after undulator



$\Rightarrow$ Significant emittance growth due to jitter in first part of linac

$\Rightarrow$ Much worse than simplified lattice

$\Rightarrow$ Need to verify automatic translation but expect result to be correct

Impact of BDS

- Additional emittance growth can be expected in BDS

  ⇒ an intra-pulse feedback at the end of the linac should help

- Simplified model of intra-pulse feedback used in simulation

- Observed growth

	end of linac	IP no traj. feedb.	IP with traj. feedb.
linac	1.7nm	2.3nm	1.8nm
und.	0.6nm	1.2nm	0.7nm

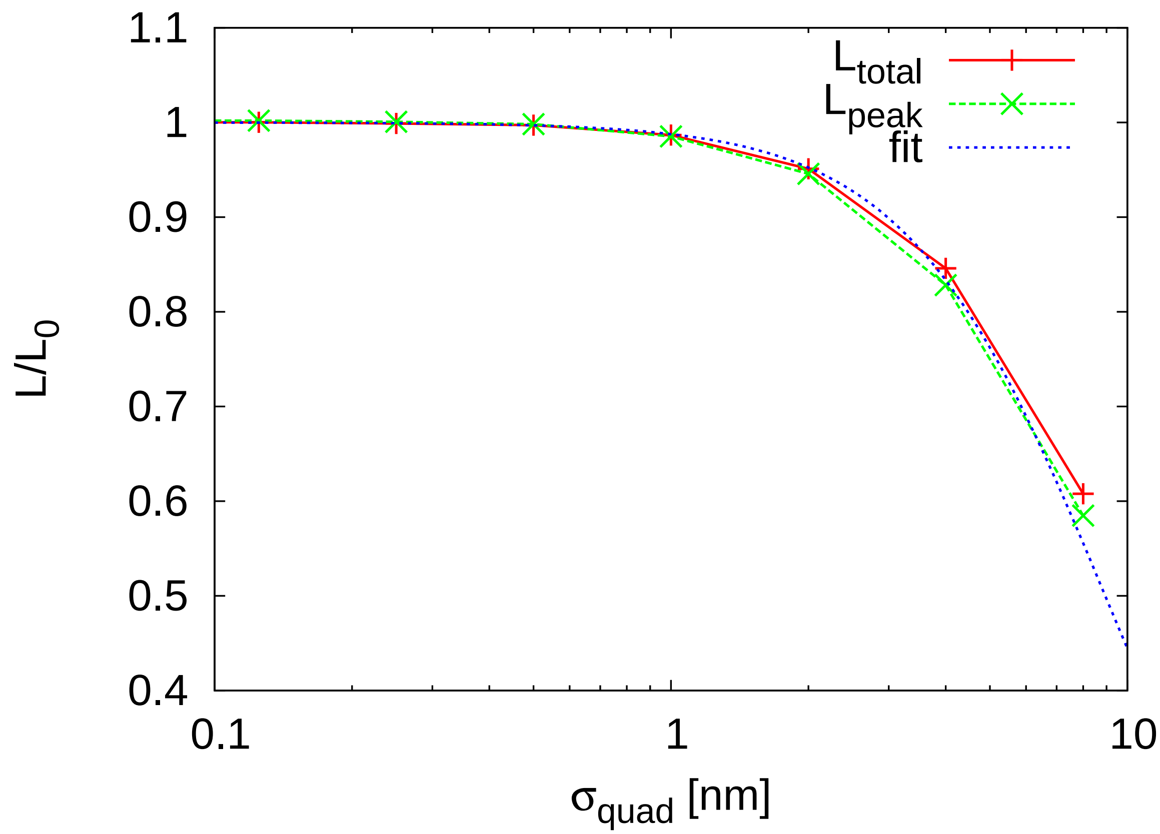
⇒ Intra-pulse feedback helps somewhat

⇒ Little additional emittance growth in BDS

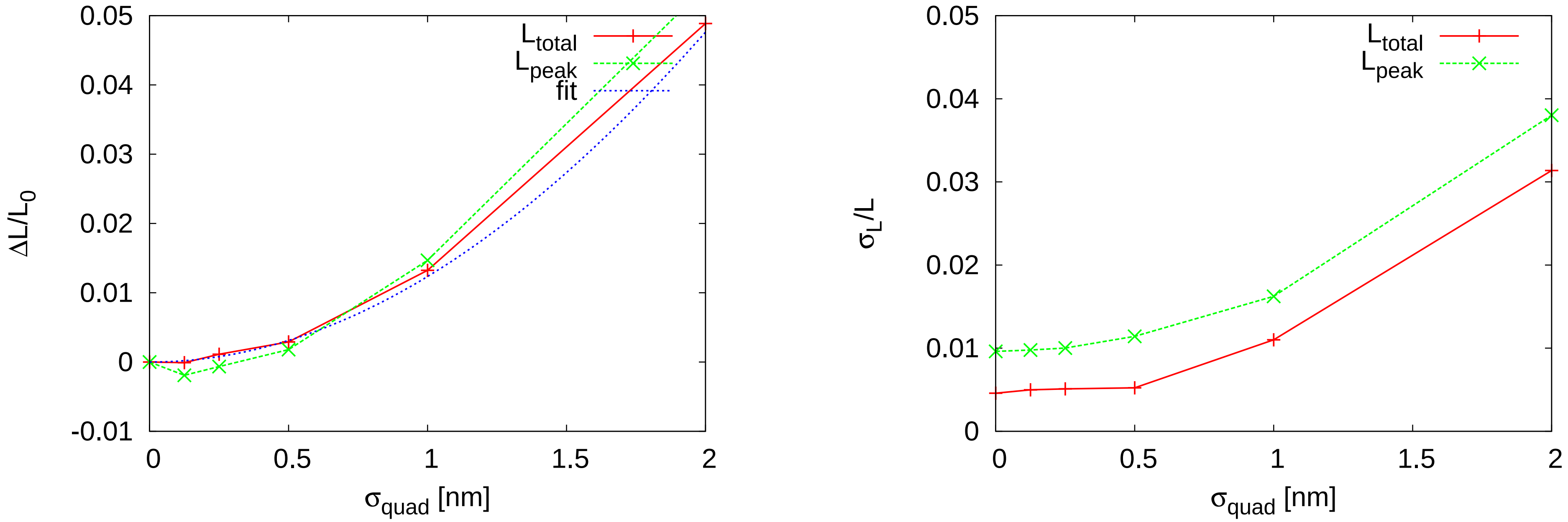
- But need to include collimators

Main Linac Quadrupole Jitter in CLIC

- Full lattice used
- No intra-pulse feedback exists
- Pulse to pulse beam-beam feedback is running
- Other feedback systems are switched off



Jitter Tolerance

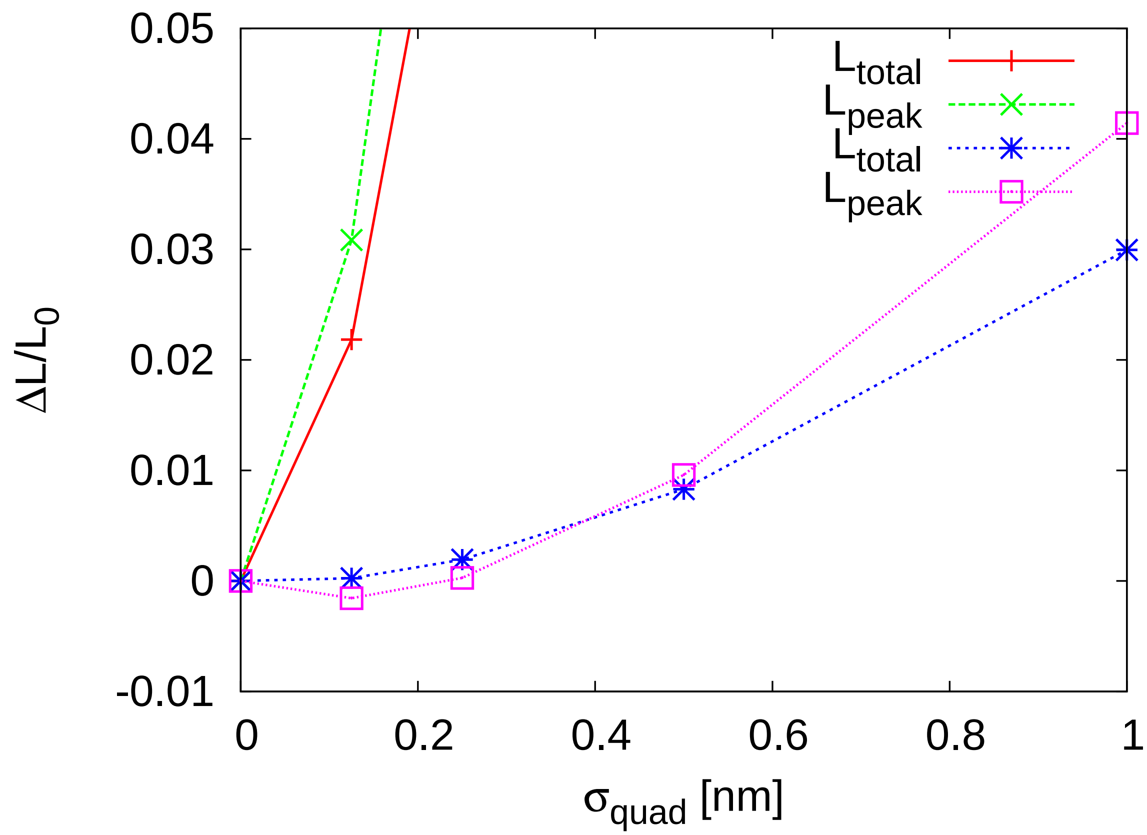


$\Rightarrow$ Luminosity loss for 1nm jitter $\approx 1.25\%$

- Stabilisation has been demonstrated to better than 1nm with comercial equipment
- Pulse-to-pulse luminosity jitter already from beam-beam simulation

Quadrupole Jitter in CLIC BDS

- Two cases
  - all quadrupoles jitter
  - all but the final quadrupoles jitter
- Beam-beam feedback is running

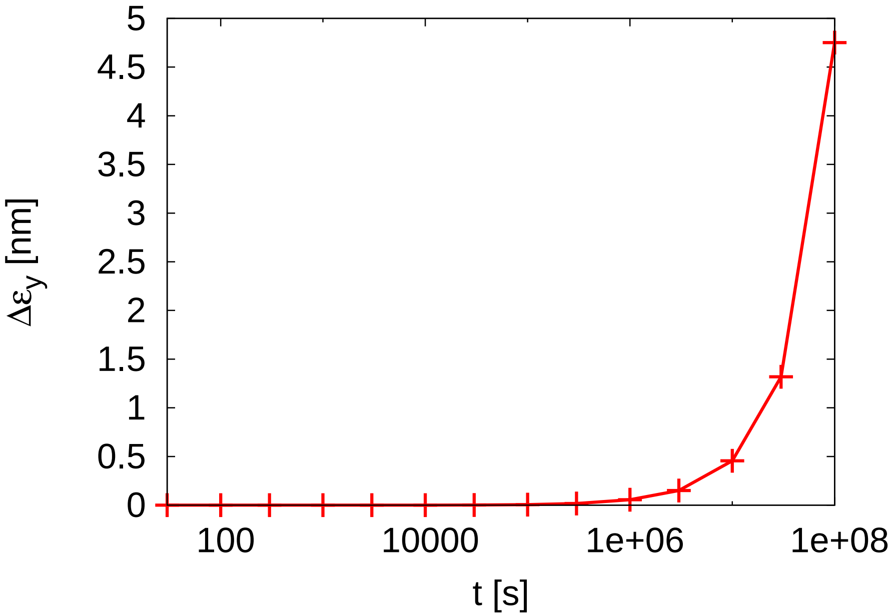


$\Rightarrow$ Stability of 0.5nm for quadrupoels and 0.1nm for final double quadrupoles

Main Linac Feedback Options

- Local (cascaded) feedback
  - could use special equipment
  - relatively large residual emittance growth
- Permanent one-to-one (implemented as few-to-few)
  - acceptable for long time
  - mover steps can become quite small

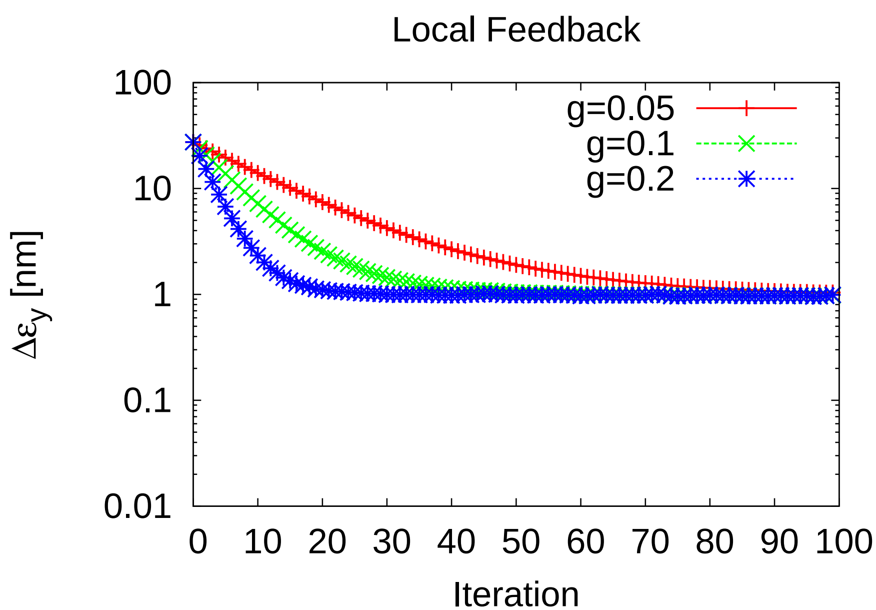
  ⇒ need to find algorithm to solve this
- MICADO style correction
  - converges as one-to-one
  - typically larger step sizes
- Adaptive alignment
  - local algorithm

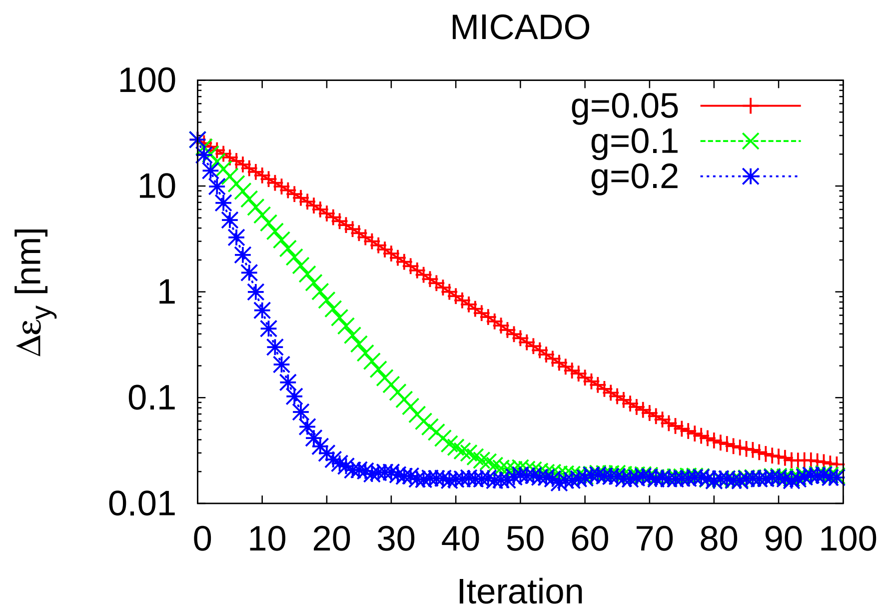


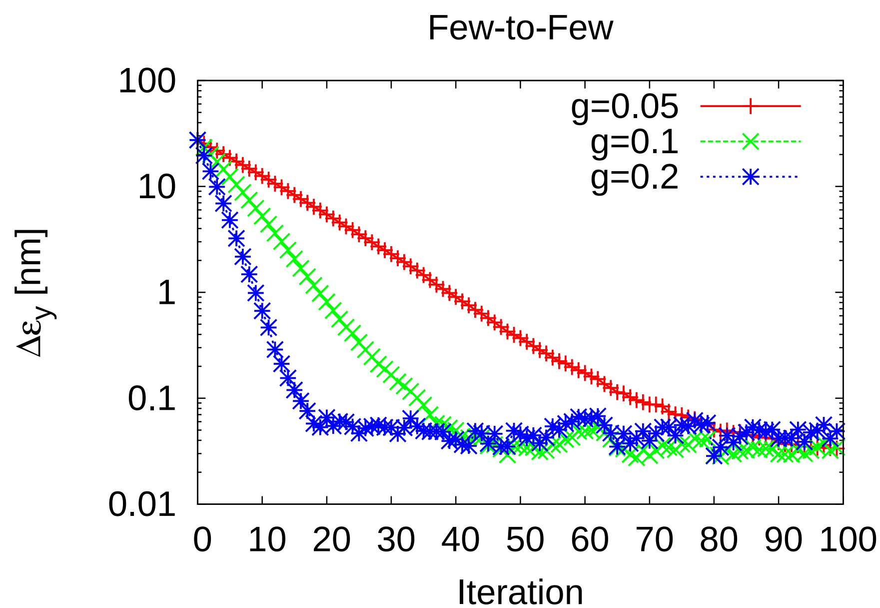
- Perfect one-to-one alignment after ATL-type ground motion
  - simplified lattice used

  ⇒ no signifciant growth before a month
- But dynamics of alignment not modelled

Results





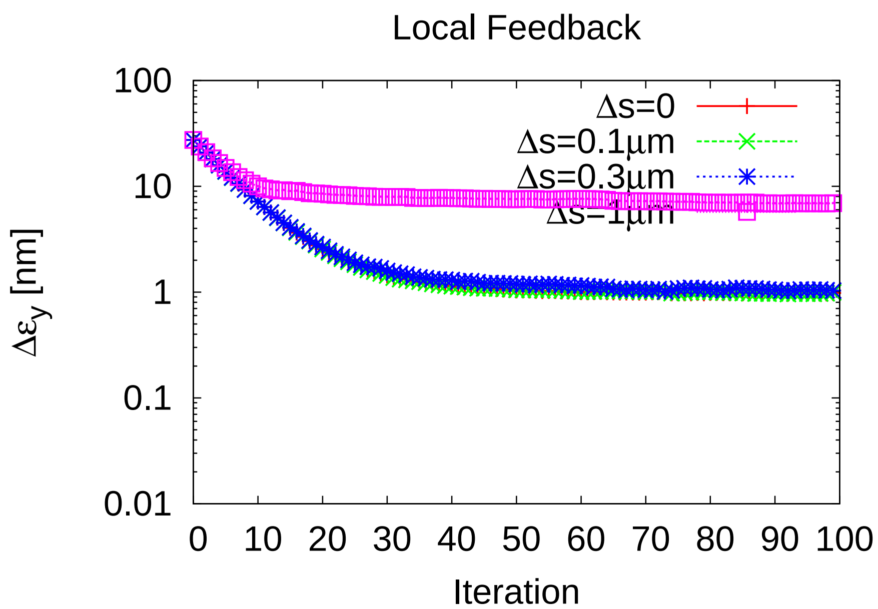


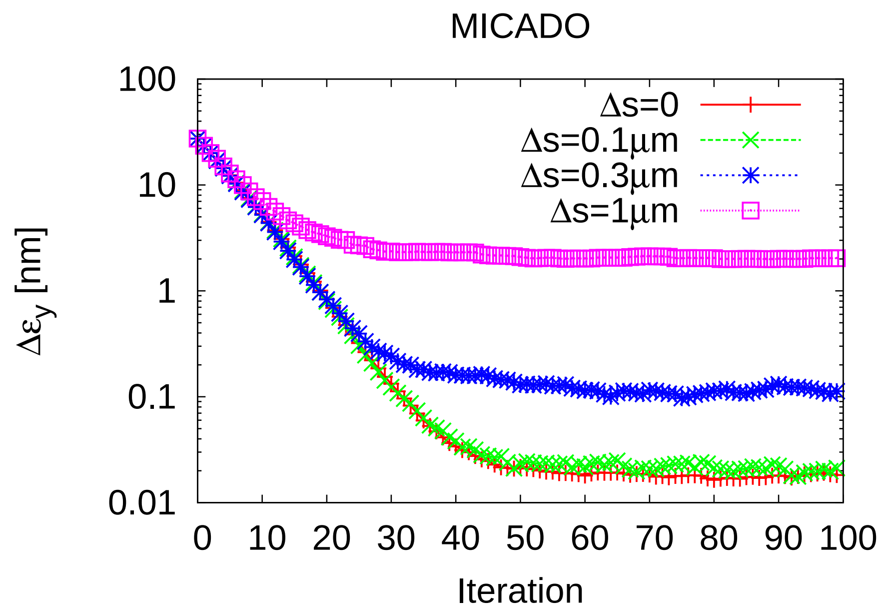
- Local feedback, MICADO and few-to-few correctin used after $3 \times 10^5\mathrm{s}$ of ATL-type ground motion

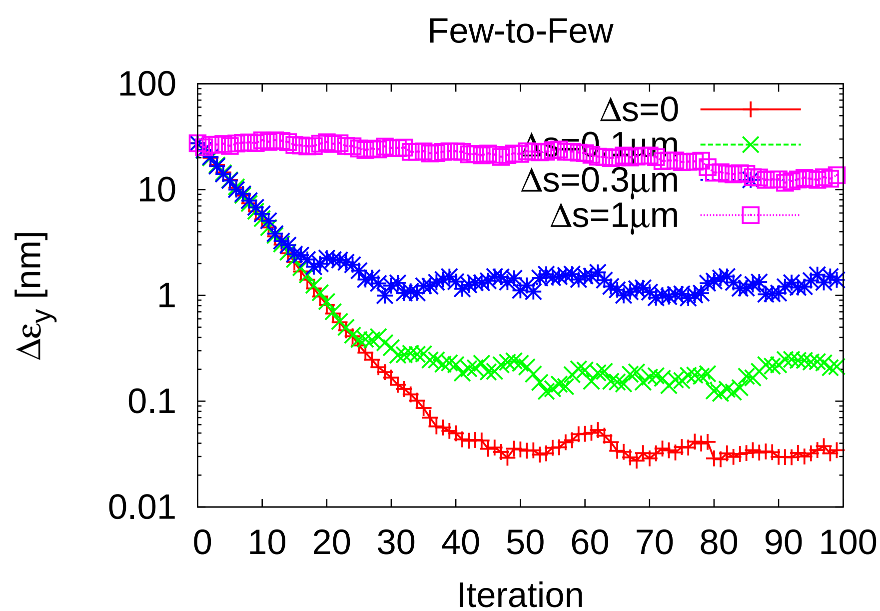
$\Rightarrow$ Residual growth for local feedback

$\Rightarrow$ Should use full ground motino model

Impact of Corrector Step Size







$\Rightarrow$ MICADO is best

$\Rightarrow$ local feedback can employ high resolution equipment

Dynamic Effects During Alignment

- Dispersion free steering uses beams at different energies to align quadrupoles
- They can be obtained using different gradients or bunch compressor settings
- Beam jitter during alignment fakes dispersion
  - either accept
  - or try to fit incoming beam trajectory
  - or use different energies within single pulse
- Simulations done using simplified ILC lattice

- Nominal misalignments are used
  - 1.5% RMS gradient jitter from RF unit to RF unit
  - 5% RMS random scale error of BPMs
- Needs to be redone with full lattice

- Small energy difference used
  - gradient difference 1%
  - first two units are off

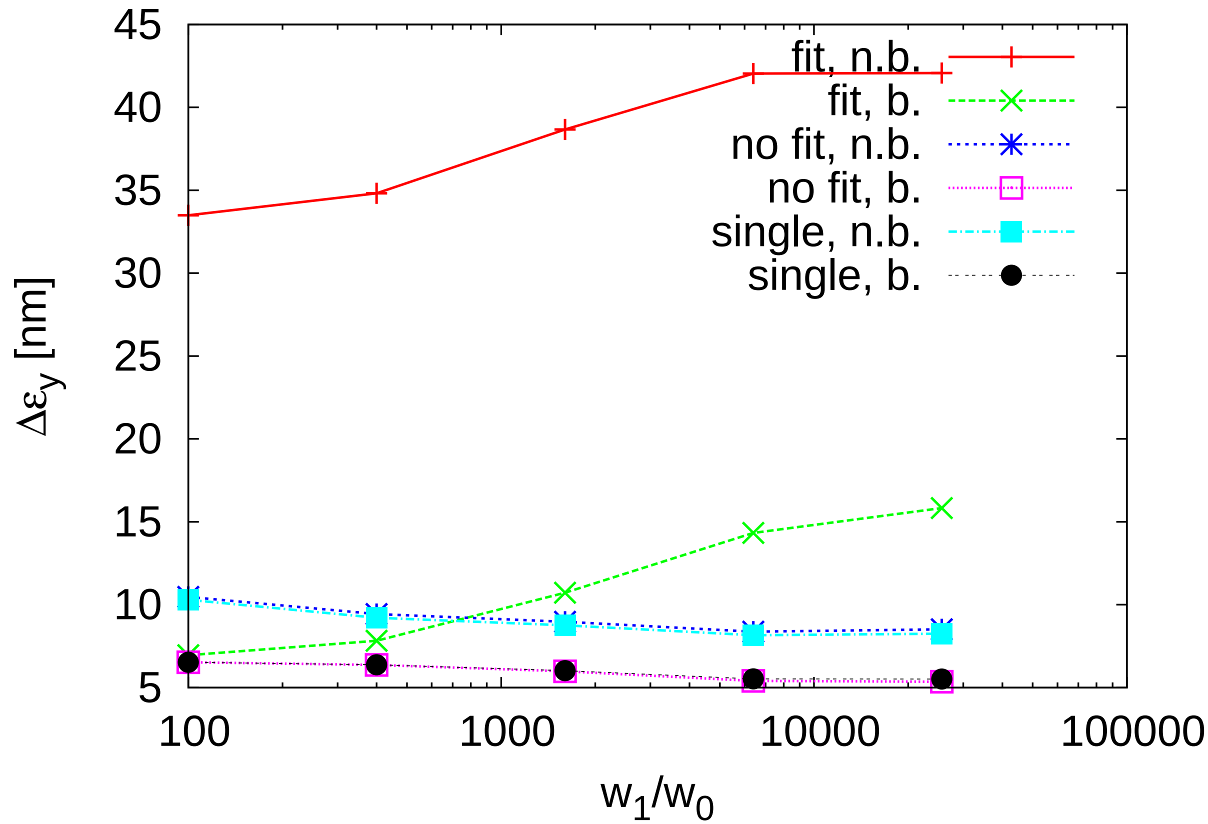
  $\Rightarrow$ alignment of first six quadrupoles not treated

Emittance Growth

- Dispersion tuning knobs used at beginning and ending of linac
- Resulting emittance growth depends on weight on trajectory difference
- Incoming beam trajectory is fit using two BPMs before the correction bin

$\Rightarrow$ Fit of incoming beam pushes to low weigths on differences

$\Rightarrow$ Better fit procedure could be developed



- Propose to use bunches at different energies from a single pulse (as suggested for CLIC)

Quadrupole Jitter

- Very large quadrupole jitter of 500nm added

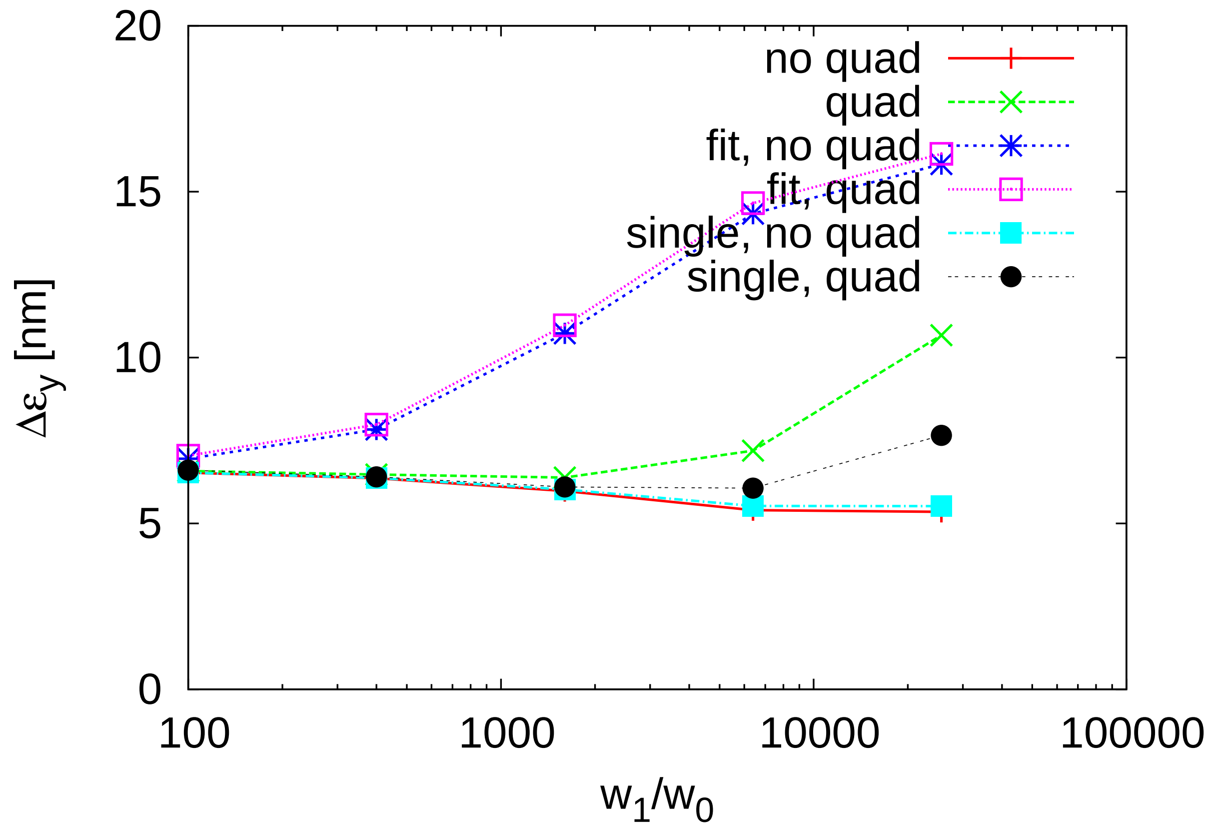
⇒ Procedure with no fit suffers most

⇒ Fit of incoming beam helps a bit

⇒ Use of different energies in single pulse is best

⇒ But could try better fit

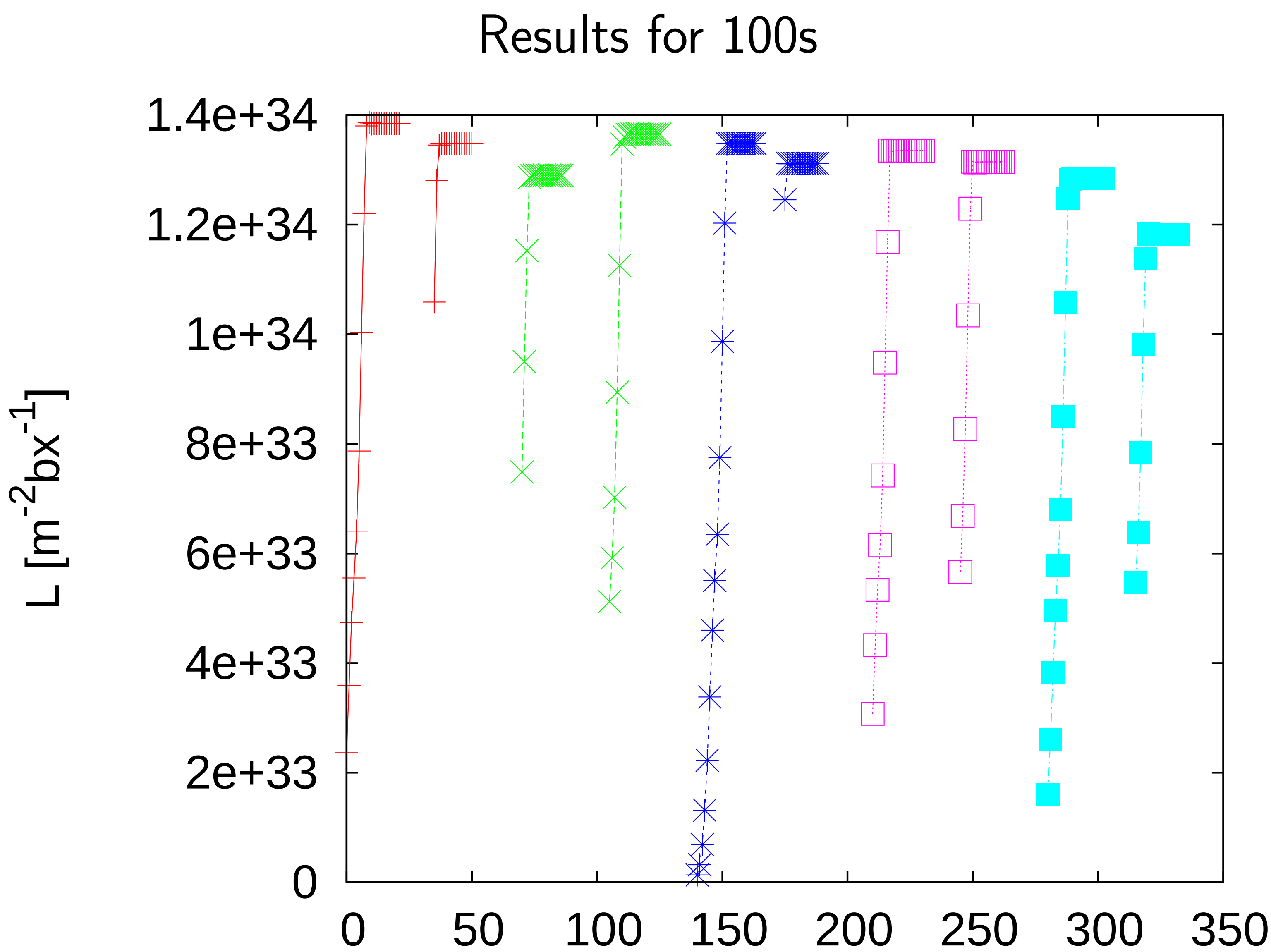
⇒ Recommend to use energy difference within a single pulse

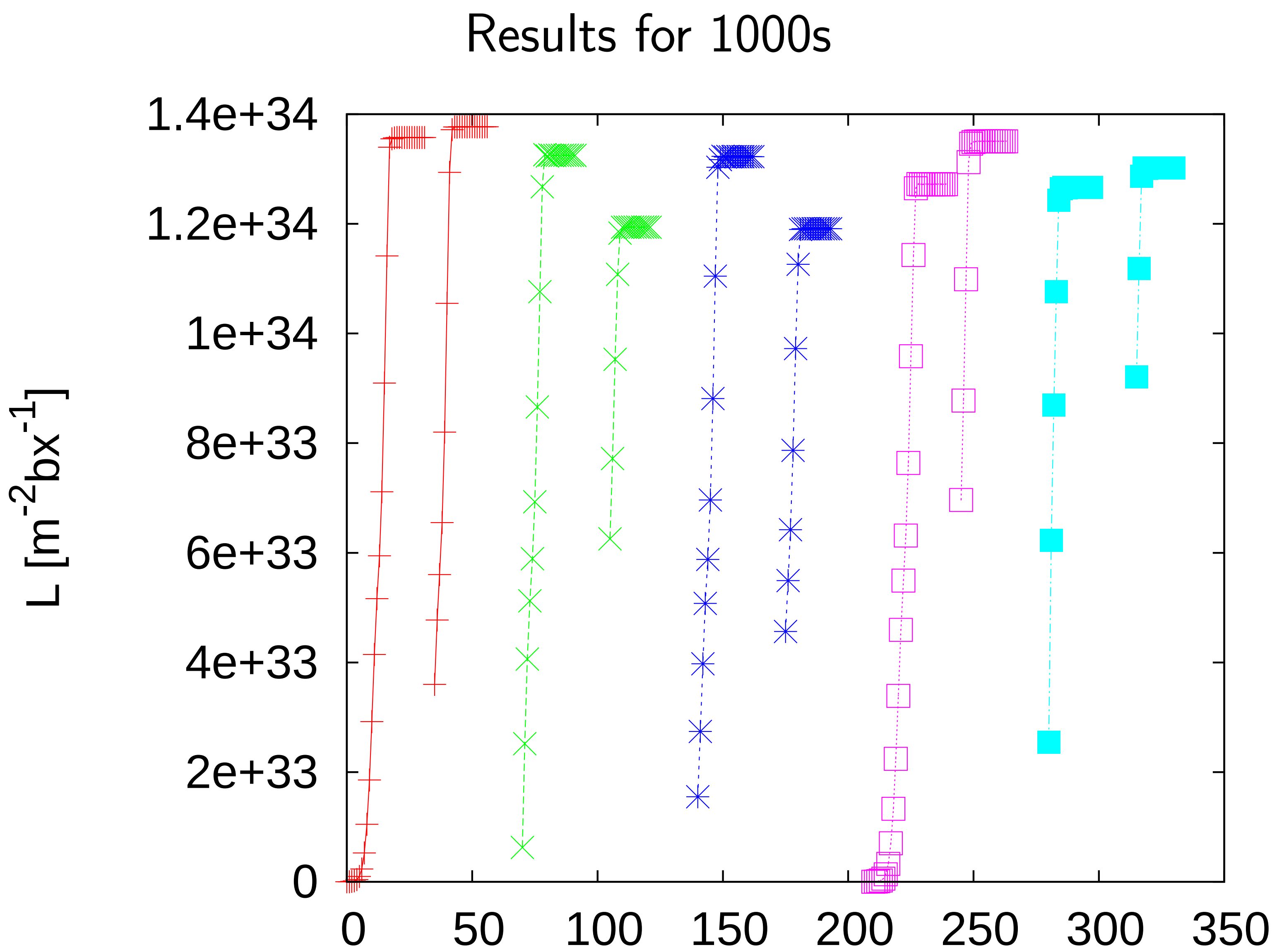


- correction can be performed with stable machine
- if spread can be reduced (better BPM resolution/averaging) or test bunches are used (after main pulse) one could align during luminosity operation

Full Integration of Feedback (ILC Example)

- Studies just started
- Quite time consuming
- Example:
  - use only BDS and beam-beam
    PLACET and GUINEA-PIG
  - assume all bunches in a pulse are equal
  - use ground motion of noisy site (model C) for a given time
  - run 49 pulses with orbit feedback only
    orbit feedback is not optimised
  - run beam-beam feedback using BPMs
    no luminosity optimisation feedback included
  - run next pulse using initial beam-beam feedback as starting value


Results for 100s
L [m-2bx-1]
1.4e+34
1.2e+34
1e+34
8e+33
6e+33
4e+33
2e+33
0
0
50
100
150
200
250
300
350


Results for 1000s
L [m^-2bx^-1]
1.4e+34
1.2e+34
1e+34
8e+33
6e+33
4e+33
2e+33
0
0
50
100
150
200
250
300
350

⇒ Luminosity loss with time seems not too dramatic

  - orbit feedback not yet optimised

⇒ Pulse-to-pulse luminosity variations would make tuning knobs quite slow

- Stabilisation of elements will help
- Or choice of a quiet site
- Further studies with
  - more cases
  - intra-pulse luminosity optimisation
  - improved orbit feedback
  - pulse-to-pulse luminosity optimisattion
  - inclusion of main linac and RTML

Conclusion

- The tools to perform integrated simulations of dynamic effects have been largely provided
  - integration of PLACET and GUINEA-PIG
- Started to define the feedback strategy
  - probably MICADO in the main linac (but more tests)
- Started to investigate impact of dynamic effects on beam-based alignment
  - seems not desastreous
  - studied simple way to recude impact of effects

$\Rightarrow$ Need to run many cases and verify results