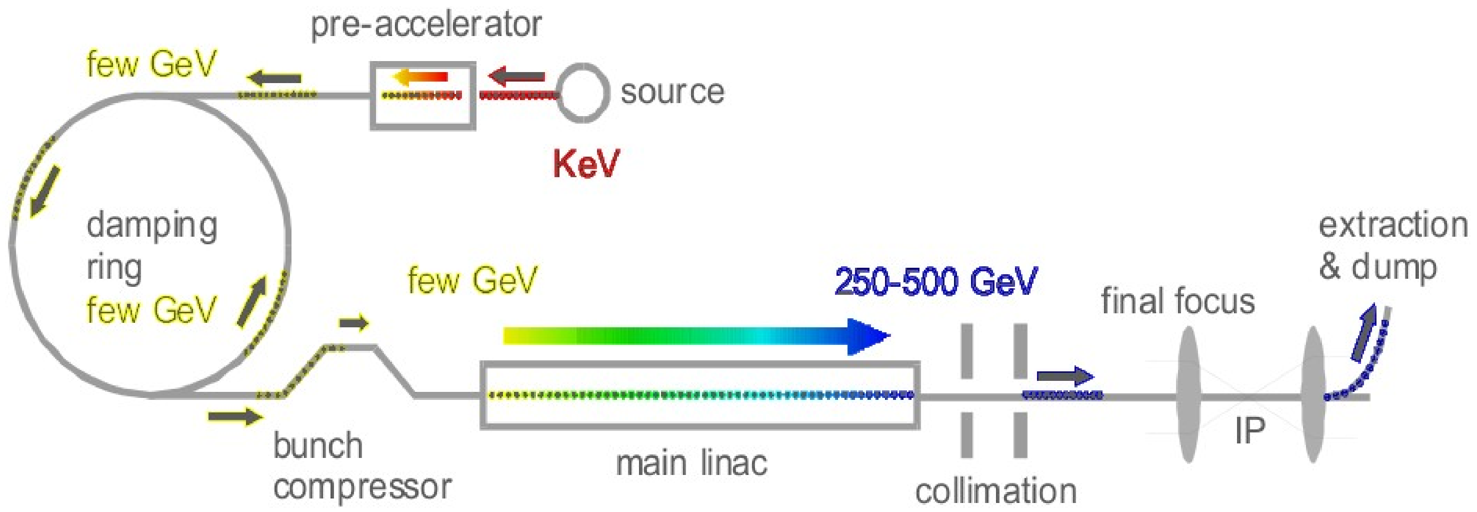
ILC Integrated Simulations

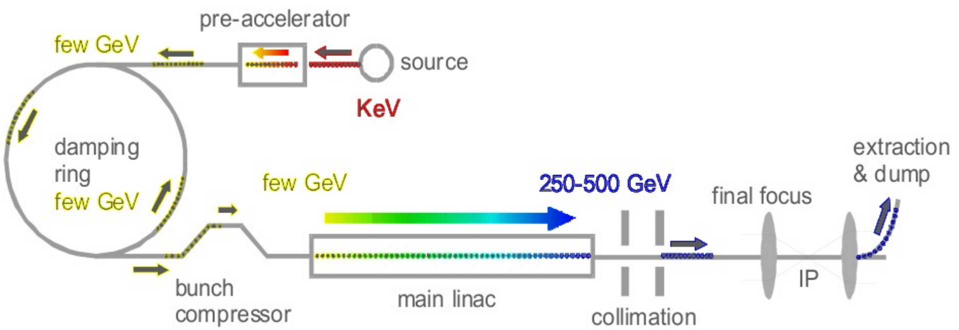


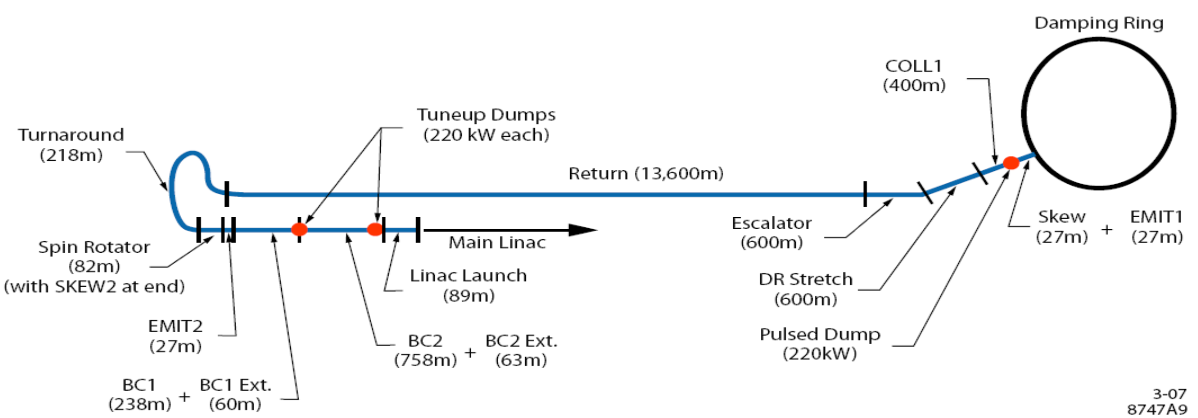
Andrea Latina, Fermilab

IWLC 2010 – CERN, Geneva - Oct 18-22, 2010

Start-to-end Simulations

- S-to-E: usually simulation from Damping Rings to Interaction Point (but it might include sources)
- RTML ~14km
  - Damping Ring Extraction ~200m
  - Escalator / Doglegs / Diagnostics ~1km
  - Return Line following the Earth curvature ~12km
  - Turnaround ~300m
  - Spin Rotator ~125m
  - Bunch Compressor(s) ~350m
- Main Linac ~11km
- Beam Delivery System ~2.5km
  - Collimation
  - Final Focus





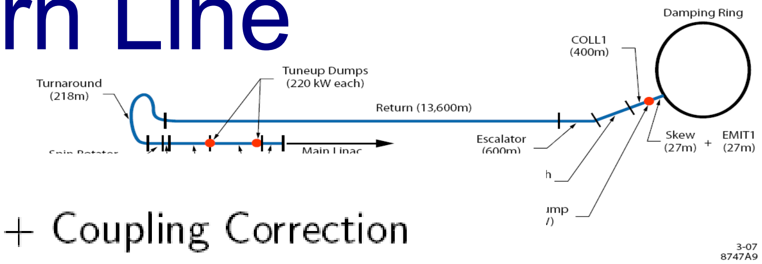
Start-to-end Simulations

- More realistic beam phase-space all along the machine
- More realistic Static / Dynamic Misalignments
- Advanced Static Correction Schemes
  - Example: BC used for DFS in the ML
- Dynamic: Cascade Feedback Loops

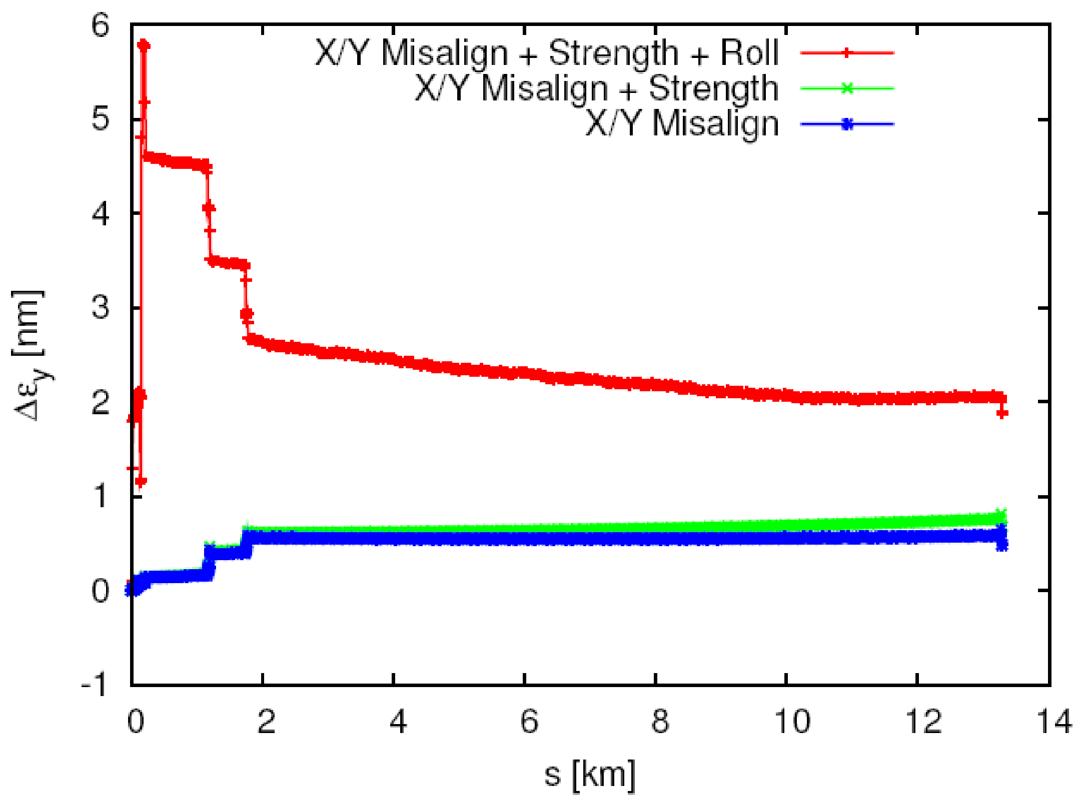
- Interaction Region and Luminosity calculation (GUINEAPIG)

- Encouraged the use of different codes (PARMELA/PLACET-MERLIN-LUCRETIA/GUINEAPIG)

RTML: DRX + Doglegs + Return Line



- Correction: 1-TO-1 + Kick Minimization + Dispersion Bumps + Coupling Correction
- Emittance growth along the line for 1000 seeds:

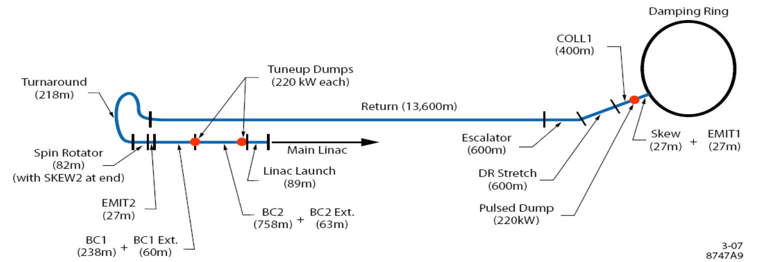


⇒ X/Y Offsets: Final average emittance growth is 0.48 nm (0.52 nm 90% c.l.)

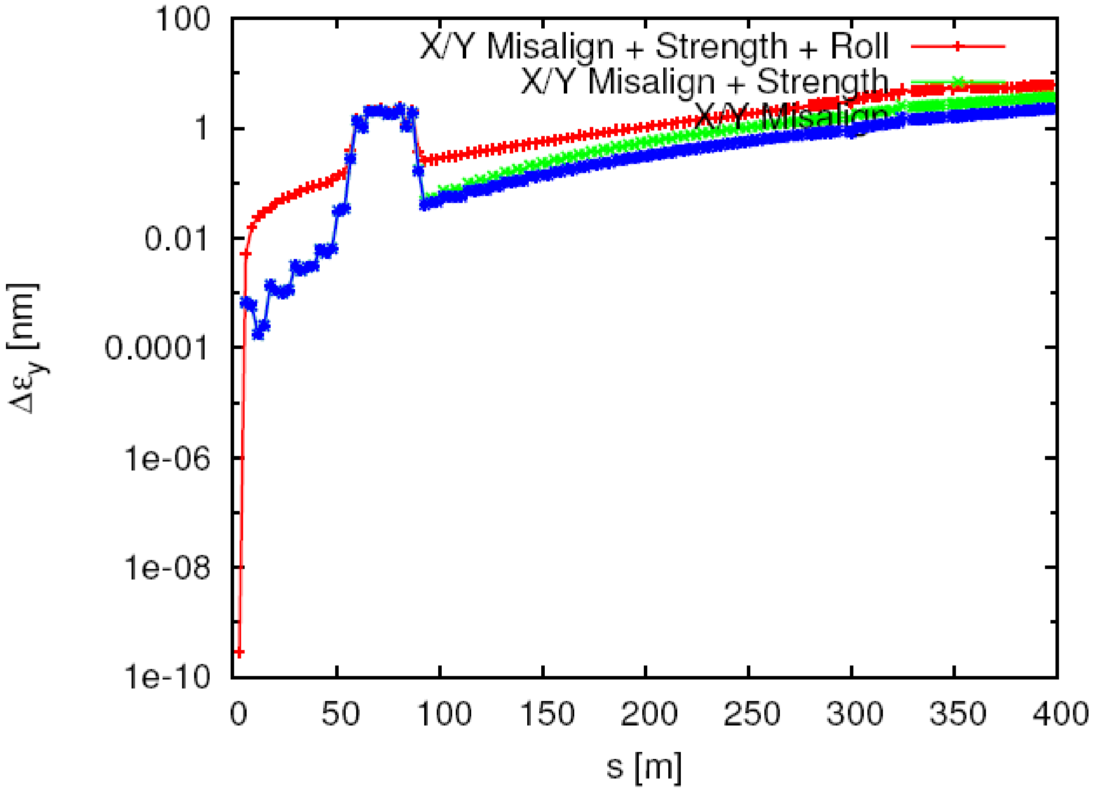
⇒ Add Quad/Sbend Strength: Final average emittance growth is 0.68 nm (1.25 nm 90% c.l.)

⇒ Add Quad/Sbend Roll: Final average emittance growth is 1.87 nm (3.23 nm 90% c.l.)

RTML: Turnaround + Spin Rotator



- Correction: 1-TO-1 + Kick Minimization + Dispersion Bumps
- Emittance growth along the line for 1000 seeds:

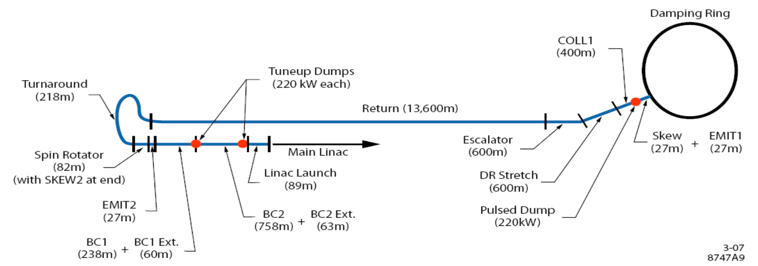


⇒ X/Y Offsets: Final average emittance growth is 2.26 nm (5.33 nm 90% c.l.)

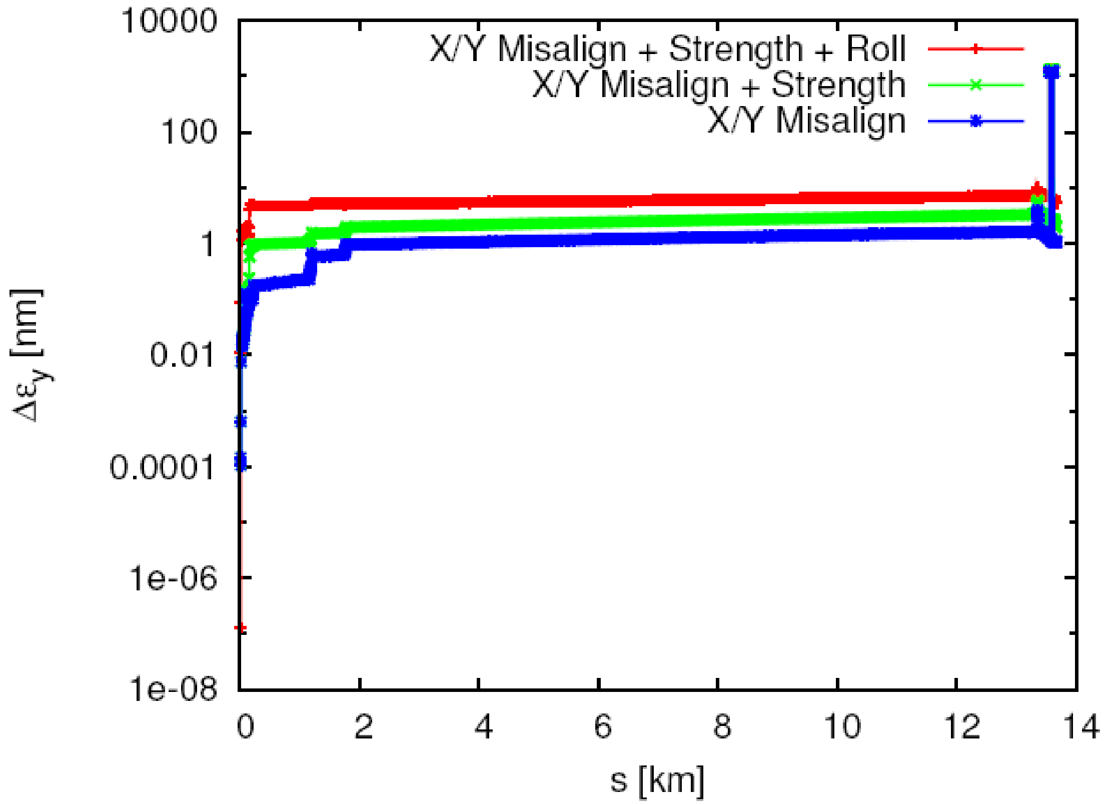
⇒ Add Quad/Sbend Strength: Final average emittance growth is 3.69 nm (8.12 nm 90% c.l.)

⇒ Add Quad/Sbend Roll: Final average emittance growth is 6.11 nm (12.73 nm 90% c.l.)

Entire RTML “Front End”



- Correction: 1-TO-1 + Kick Minimization + Dispersion Bumps + Coupling Correction
- Emittance growth along the line for 1000 seeds:

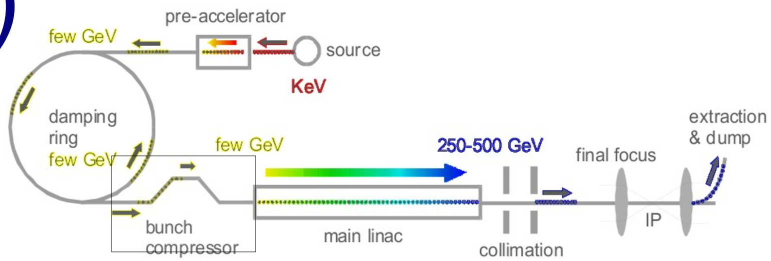


⇒ X/Y Offsets: Final average emittance growth is 1.06 nm (1.58 nm 90% c.l.)

⇒ Add Quad/Sbend Strength: Final average emittance growth is 2.01 nm (3.51 nm 90% c.l.)

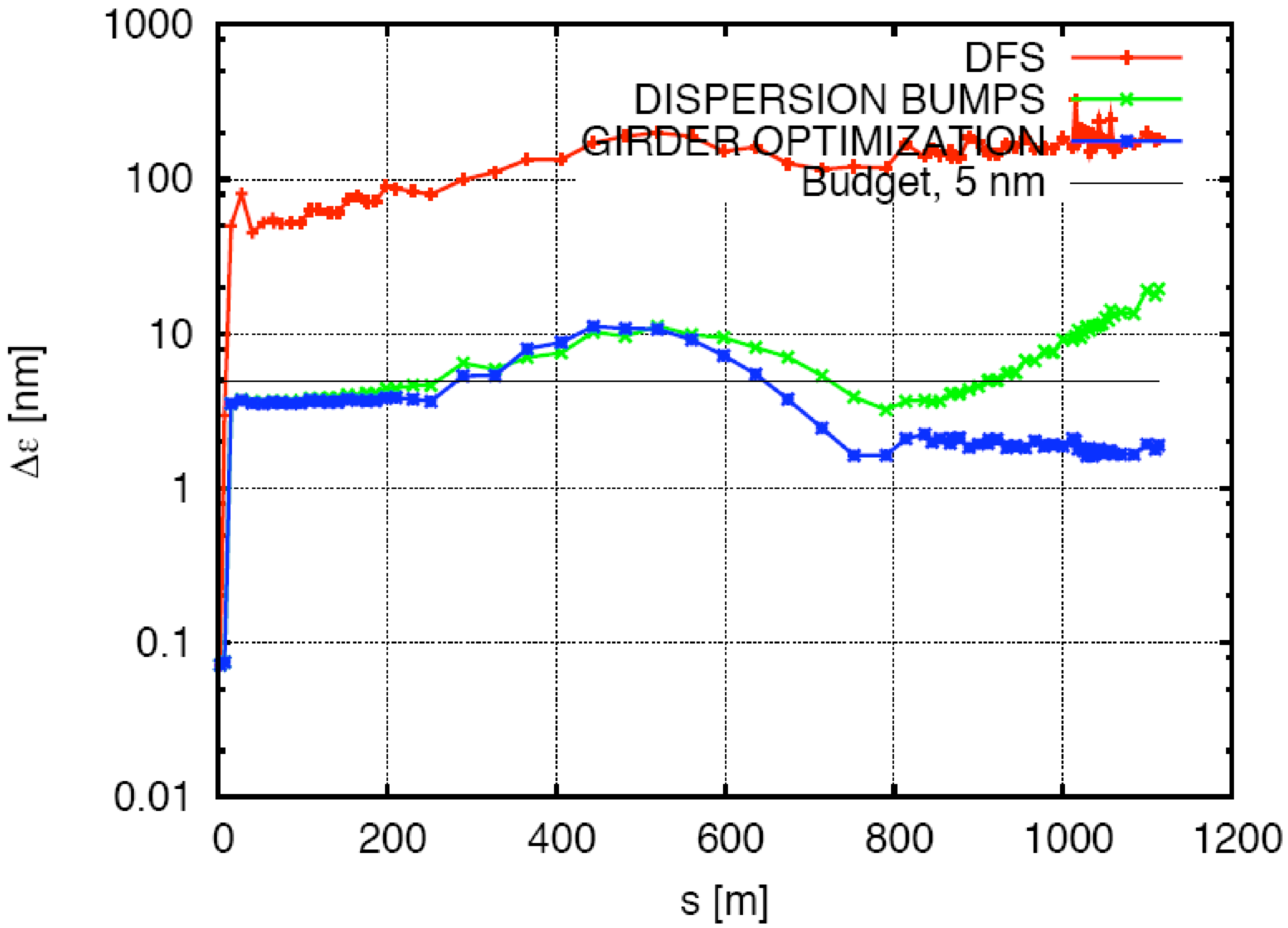
⇒ Add Quad/Sbend Roll: Final average emittance growth is 5.36 nm (9.94 nm 90% c.l.)

Bunch Compressor (ILC-RDR)



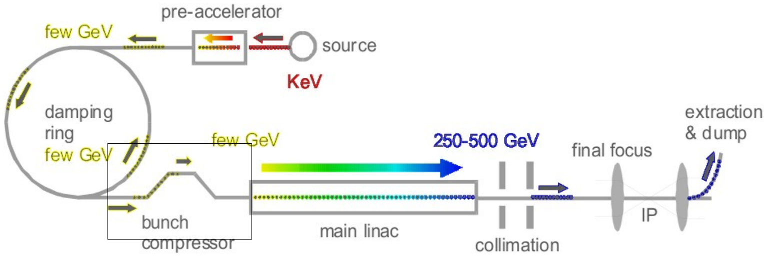
Couplers

- Case B. Emittance Growth along the beamline, for 100 machines, a

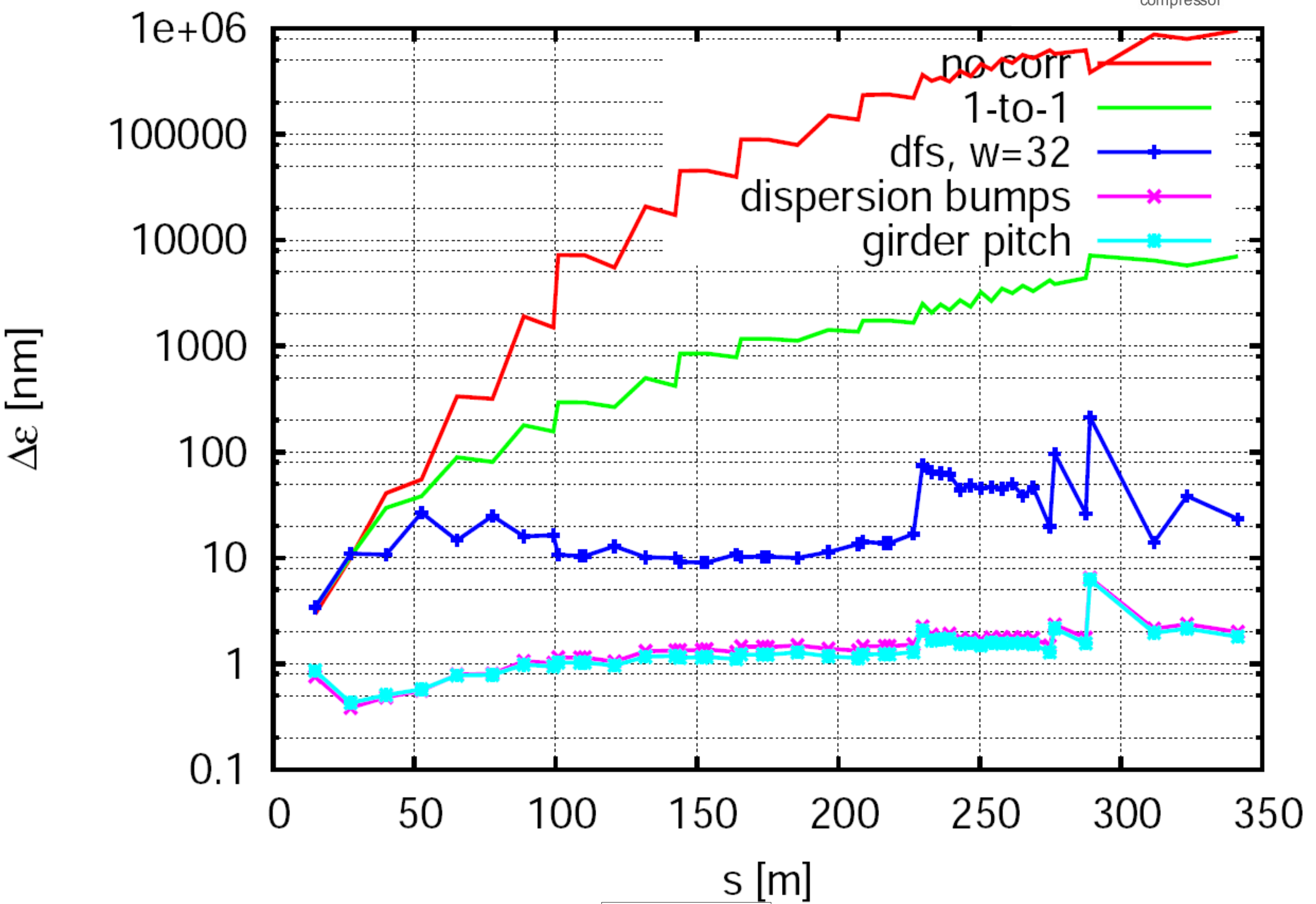


$\Rightarrow$ Final vertical emittance growth is $\boxed{\Delta\epsilon = 1.8 \text{ nm}}$

Bunch Compressor (ILC-SB2009)

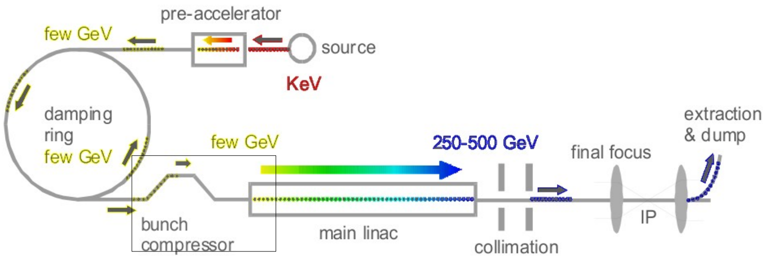


Misalignments+Couplers

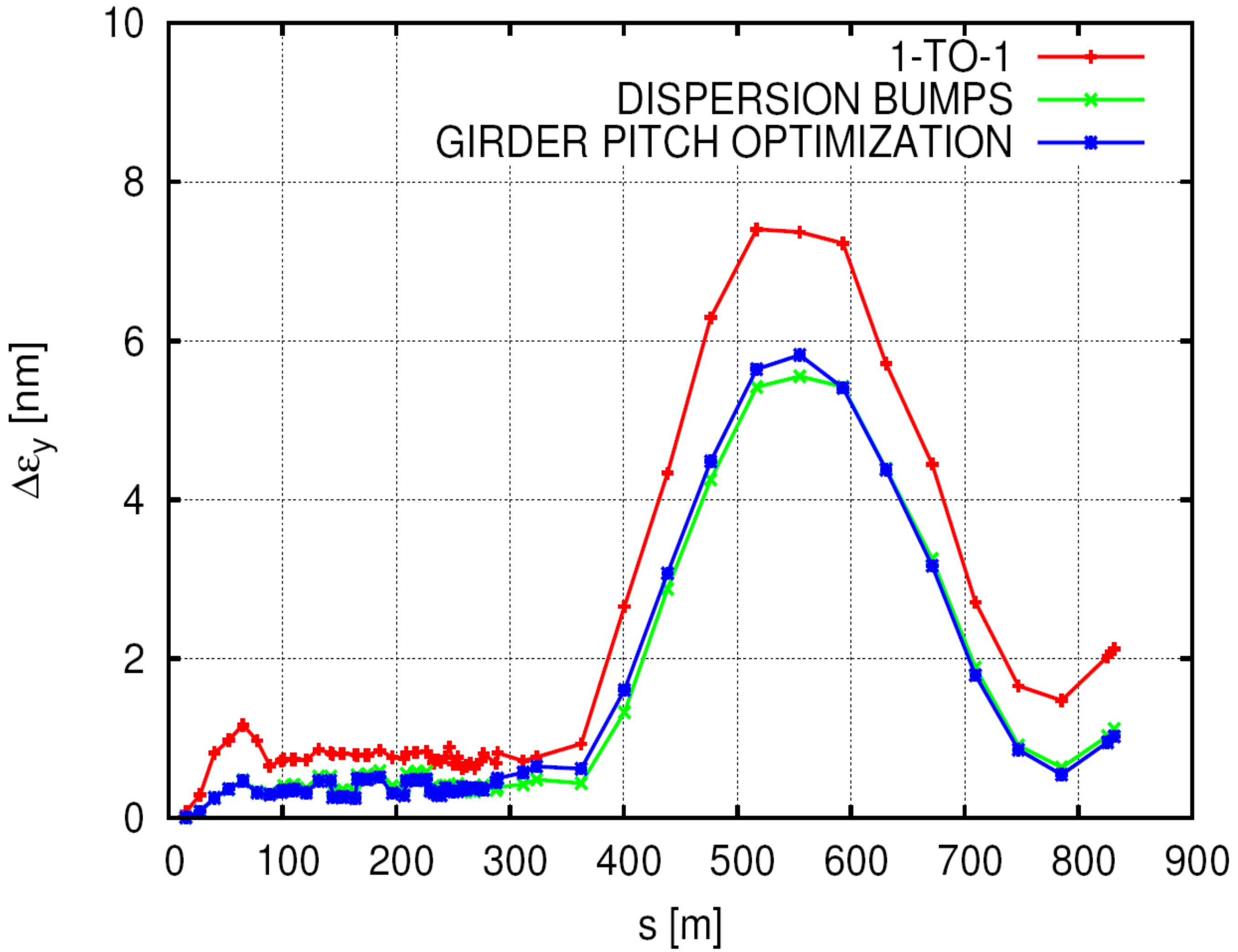
- 

⇒ Final vertical emittance growth is $\Delta\epsilon =$ 1.13.4nm

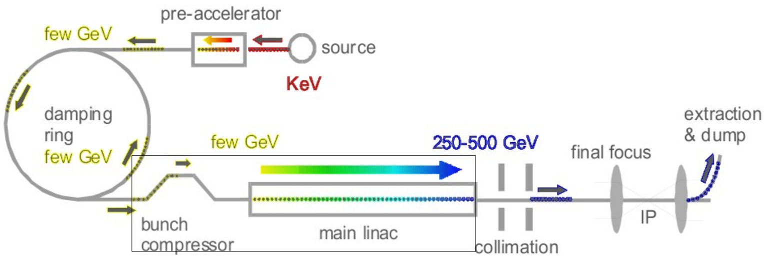
BC1S + ML to 15 GeV



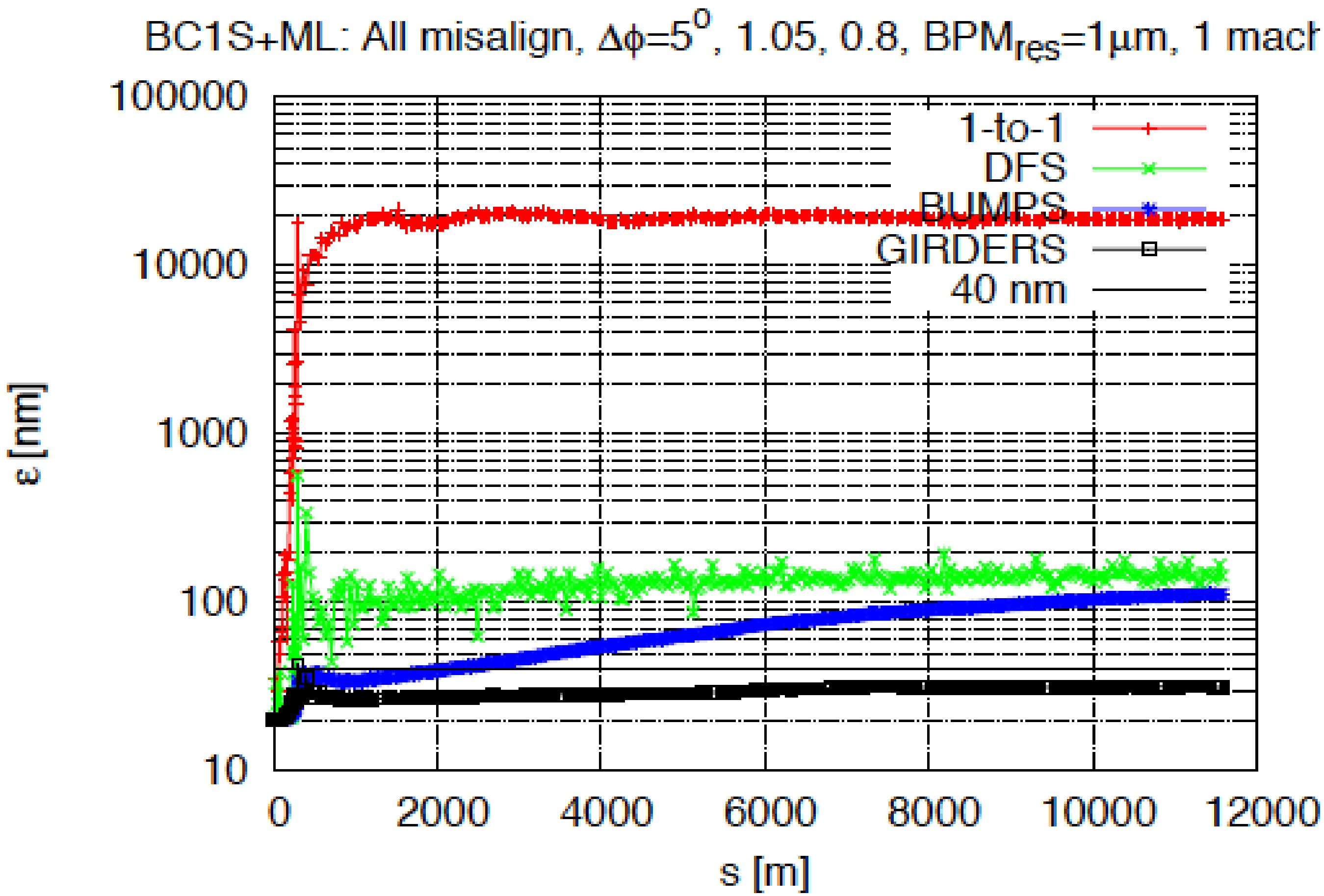
- Couplers



BC1S + ML



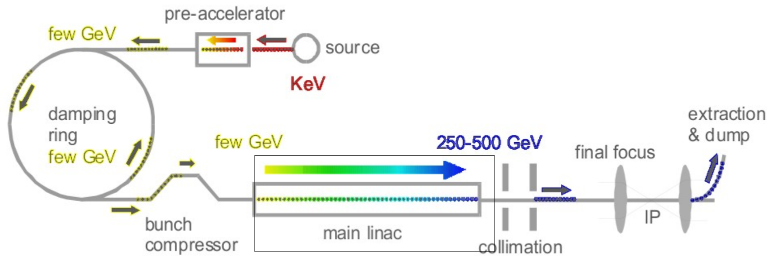
- Vertical emittance along BC1S+ML in case of misalignments
- Couplers kicks are not considered, wakefields are not considered



⇒ final emittance is 31.5 nm

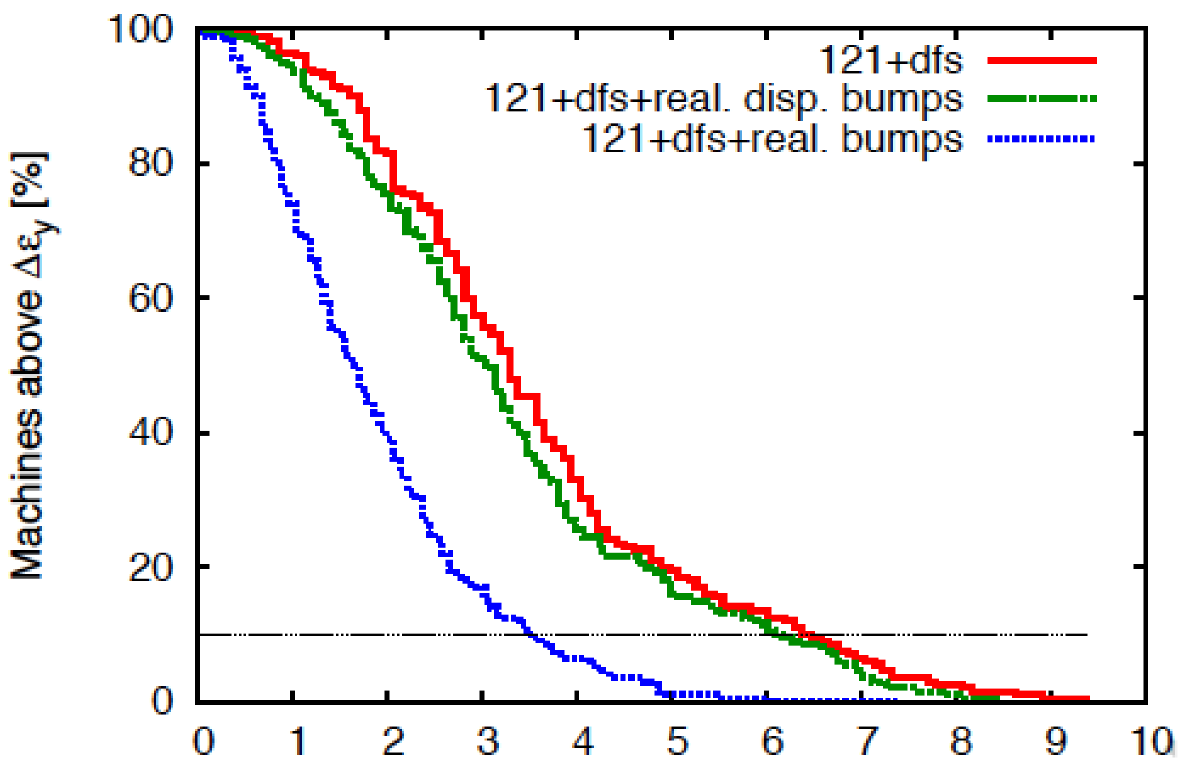
Main Linac

P. Eliasson, EuroTeV 2007



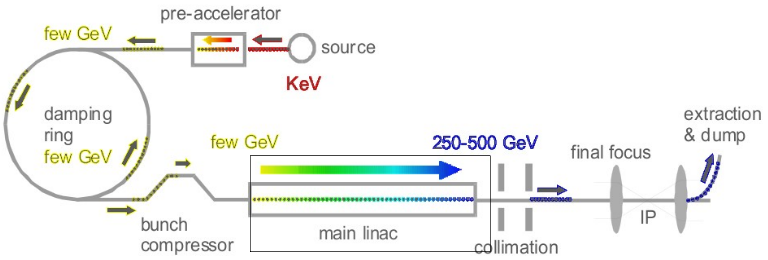
Tuning Knobs in ILC main linac

- Very good results can be obtained using $\Delta E = 0.1$ and $\Delta g \approx 0.01$ (energy difference at undulator stays just below 2%).
- Dispersion Free Steering removes almost all dispersion and there is nothing to be gained by using dispersion bumps. Wakefield bumps on the other hand strongly enhance the emittance.



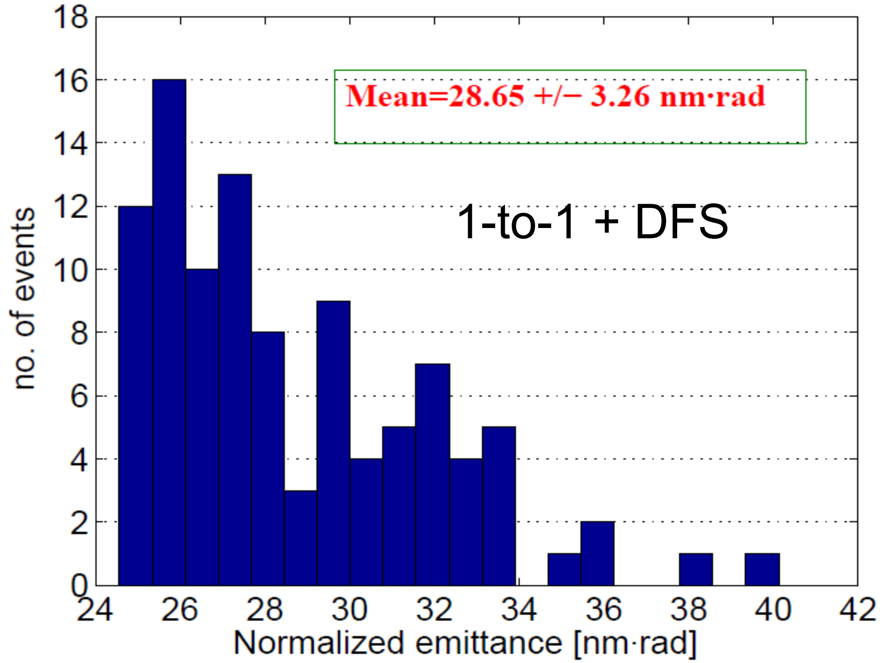
Main Linac

J. Resta-Lopez

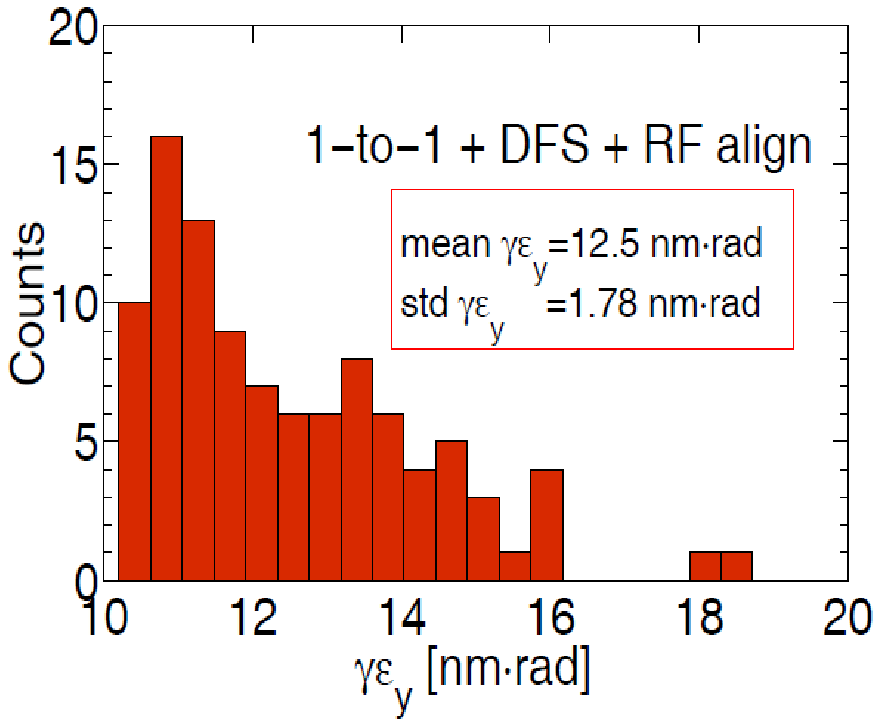


Normalised emittance at the exit of the main linac, after applying survey alignment errors and beam-based alignment correction. Results from simulation of 100 machines.

ILC

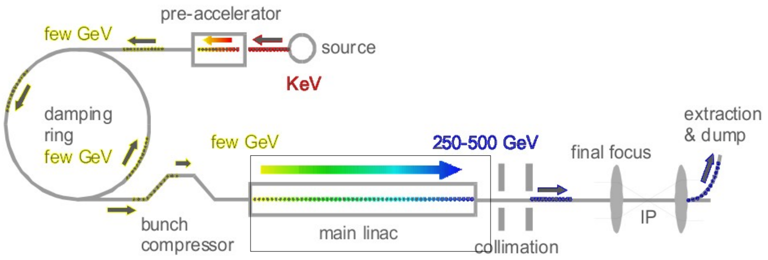


CLIC



Main Linac

D. Kruecker, PAC 2007



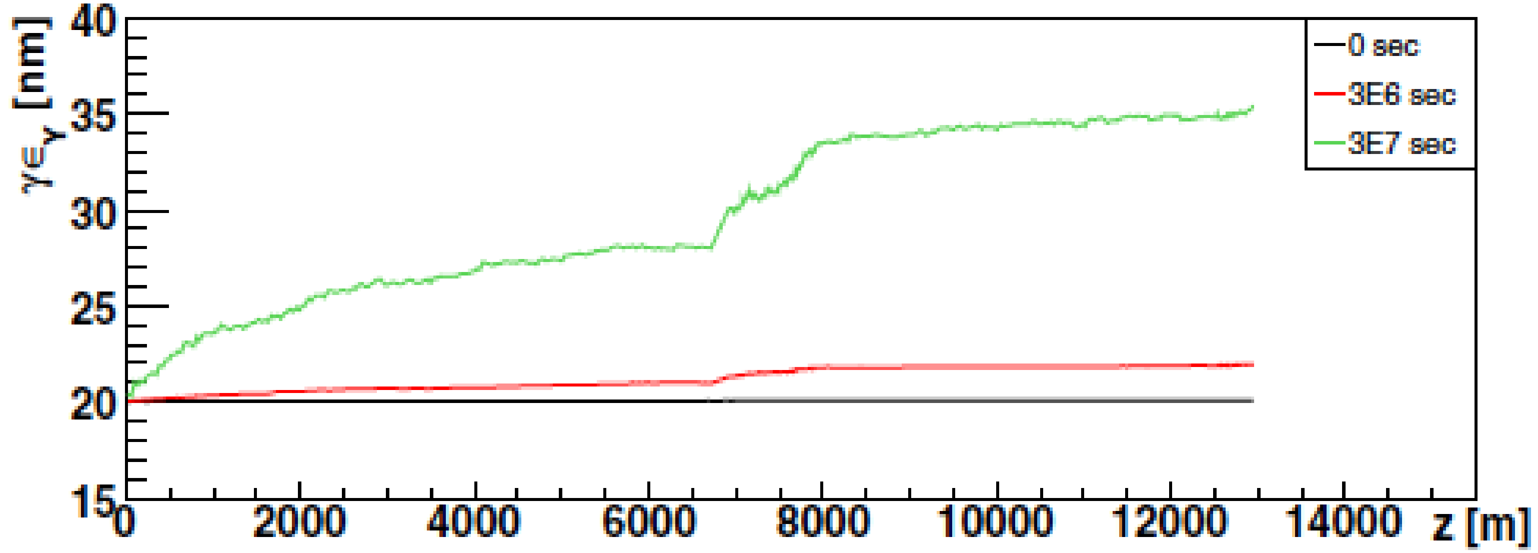
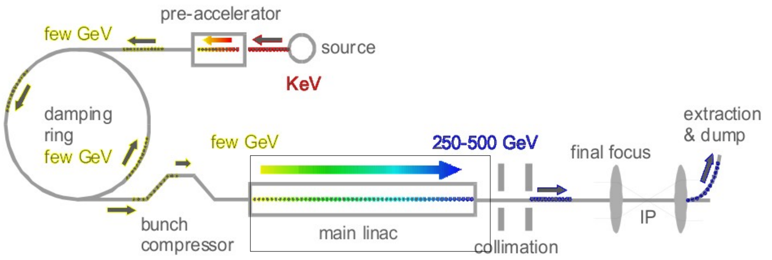


Figure 3: Projected vertical emittance along the electron main linac. ATL ground motion ($A = 4 \cdot 10^{-18}$ m/s) with one-to-one steering. Each point shows the average over 100 random configuration i.e. ground motion seeds. The green line is the emittance after about 1 year. The undulator bypass is clearly visible as a step at 6890 m.

Main Linac

D. Kruecker, PAC 2007



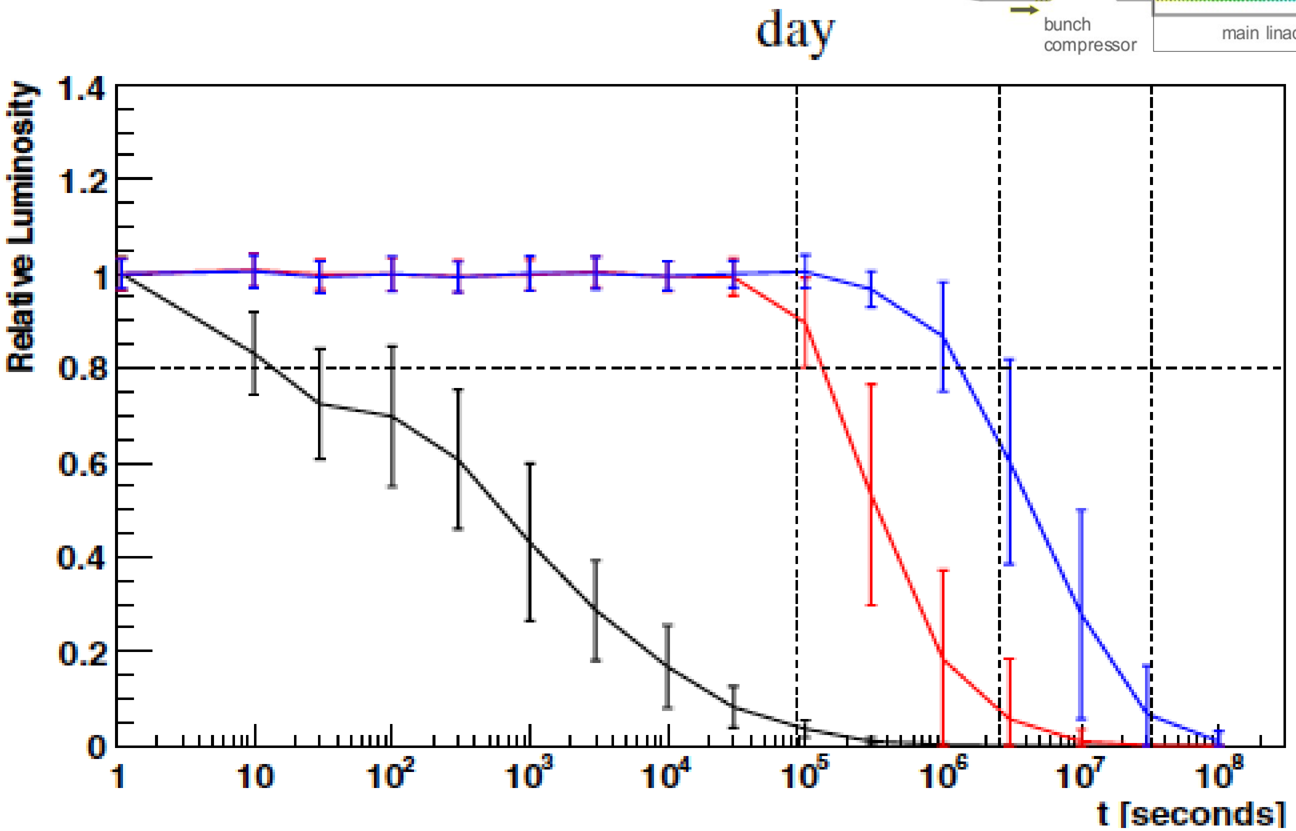
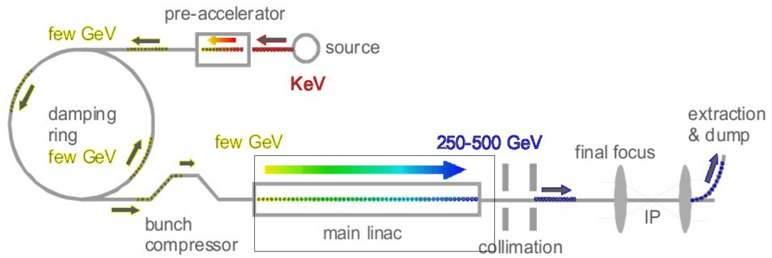


Figure 4: Relative luminosity over time. ATL ground motion ($A = 4 \cdot 10^{-18}$ m/s) with one-to-one steering. Each point shows the average over 80 random configurations i.e. ground motion seeds corresponding to 40 colliding bunch pairs. The error bars show the RMS over these random configurations.

Main Linac

N. Solyak, PAC07



Adaptive Alignment:

$$\Delta y_i = \mathrm{conv} * [A_{i+1} + A_{i-1} - A_i * \{2 + K_i L (1 - \frac{\Delta E}{2E})\}]$$

Ground motion and adaptive alignment:

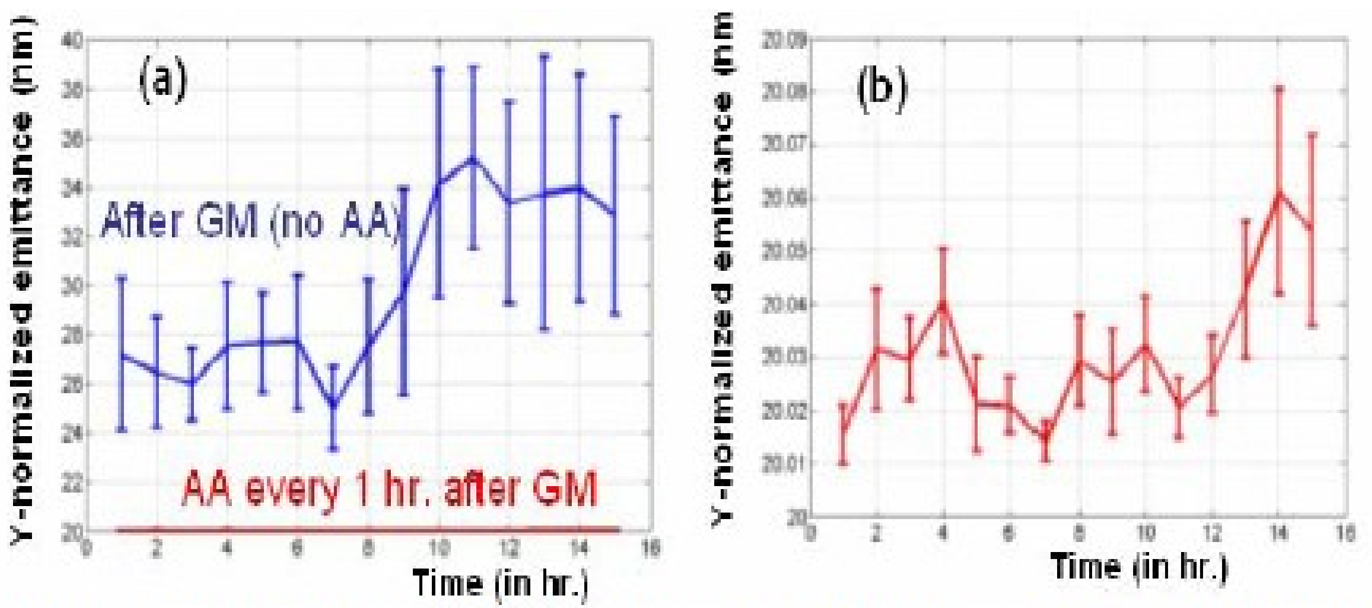
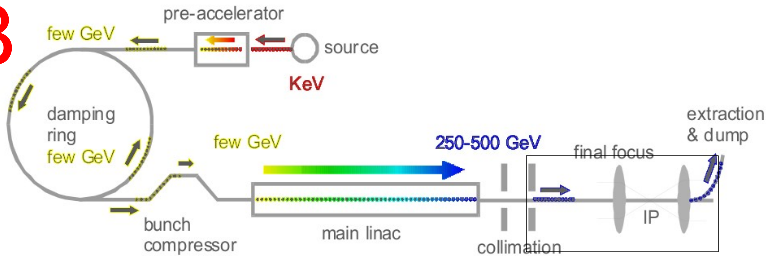


Figure 3: (a) Normalized vertical emittance vs. time in a perfectly aligned linac. AA of 100 iterations and 0.3 convergence factor is implemented after every one hour of GM model 'C'. (b) A blown-up portion of the plot after adaptive alignment.

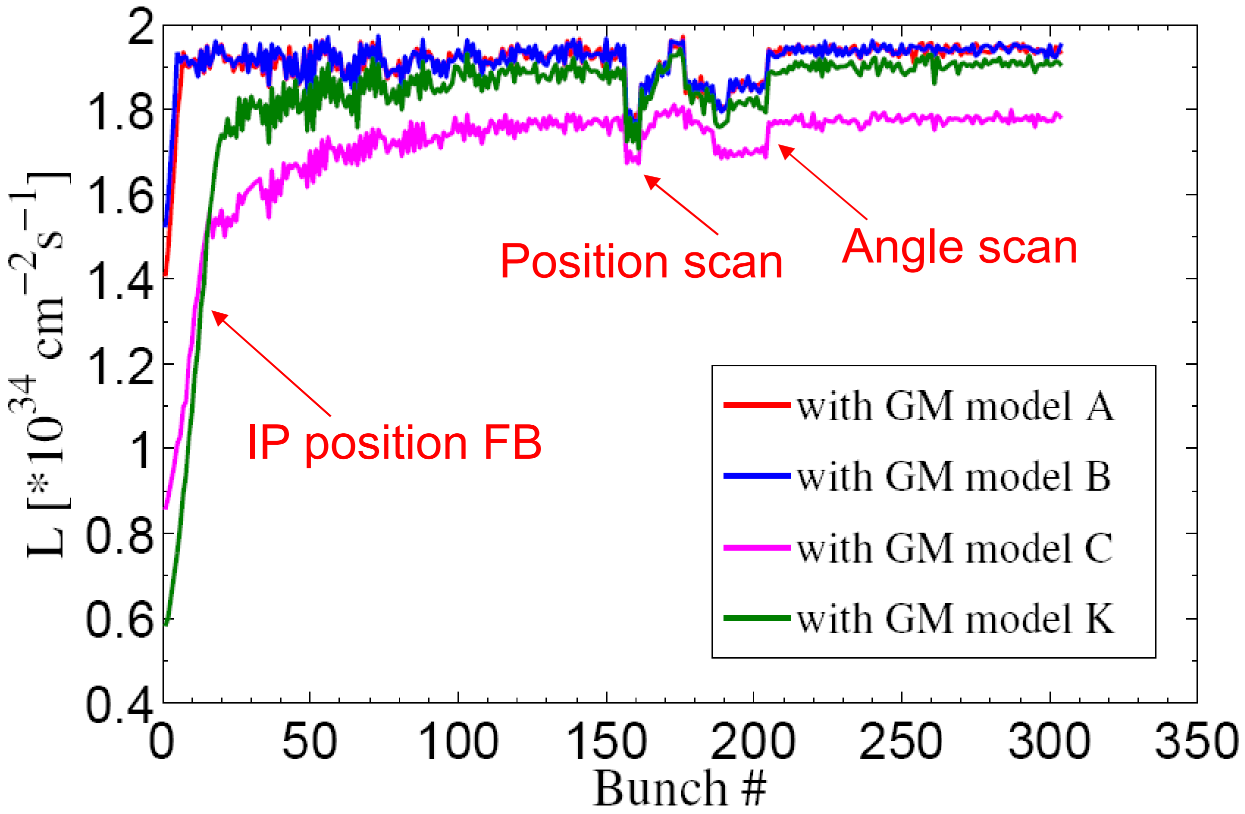
ILC Luminosity Result with IP-FB



Different scenarios of ground motion

G. White, J. Resta-Lopez

- Example for 1 single random seed of GM (0.2 s of GM applied to both main linac and BDS)
- Considering 40 % emittance growth in the main linac



For the noisiest site (model C), applying fast position and angle FB stabilization, a recovery of 85 % of the nominal value is obtained

For quiet sites (model A and B) practically the 100 % of the nominal luminosity would be achievable.

Conclusions and Future Steps

- We aren't far from complete start-to-end simulations
- Integration of the entire RTML “Front End” exists
- Bunch Compressor + Main Linac exists
- Main Linac + Beam Delivery + IP exists (collaboration with JAI-Oxford on intra-pulse IP-FB)
- Need to put together RTML+ML+BDS