Recent Studies on the ILC Main Linac using MERLIN

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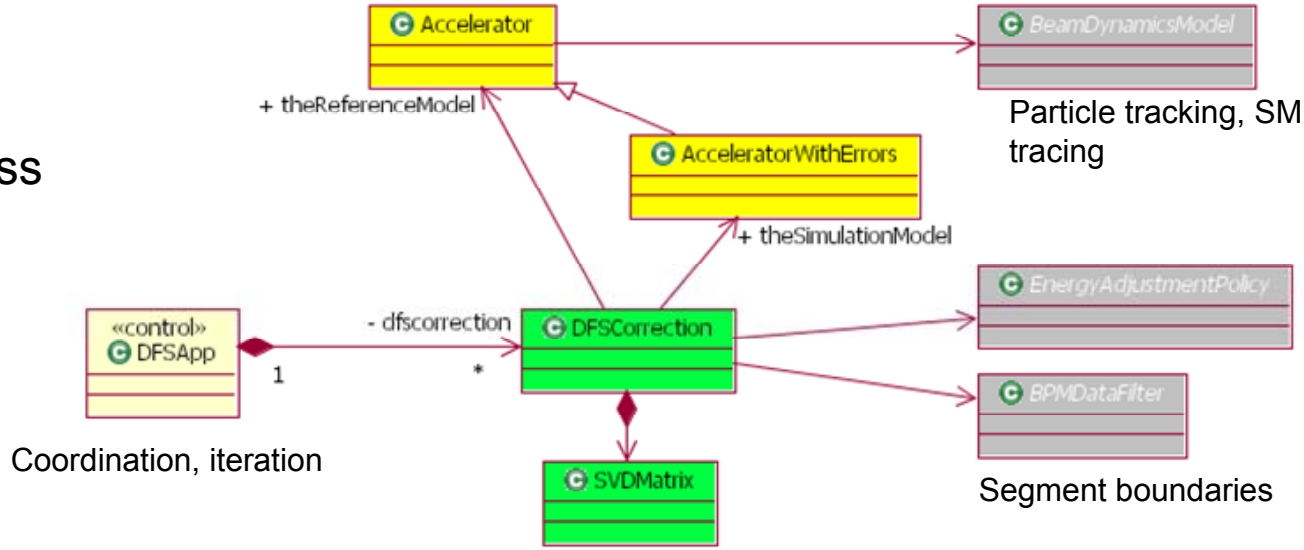
FLC group

- New Package ILCDFS
  - Released at EPAC 2006
  - Allows rapid prototyping of various algorithms.
    - Energy Adjustment Strategy Studies
    - Benchmark with PLACET
- Coupling Correction
- Dynamic Studies for ML with ATL

ILCDFS package

- Development and use of the package ILCDFS(1) based on MERLIN for beam dynamics studies.
  - 2 types of accelerator model:
    - 1) Error-free (or design reference) model
      - Obtain design trajectory
      - Lattice response matrix for DFS
    - 2) Simulation model including alignment (and field) errors
  - Sliced Macro Particle tracking to estimate emittance (includes wakefield)
  - Each model uses the energy adjustment strategy

C++ class diagram

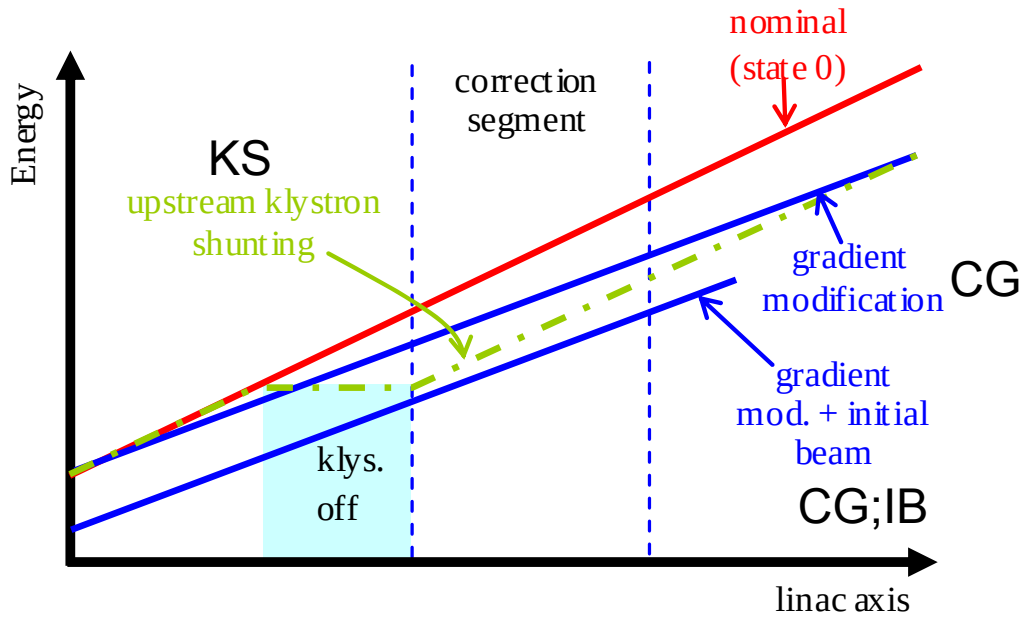


(1) *An ILC main linac simulation package based on MERLIN* EUROTeV Report 2006-076

http://www.desy.de/~merlin

Energy Adjustment Strat^{y}

Study of energy adjustment strategy for off-energy beam along linac for the Merlin based code ILCDFS(1)



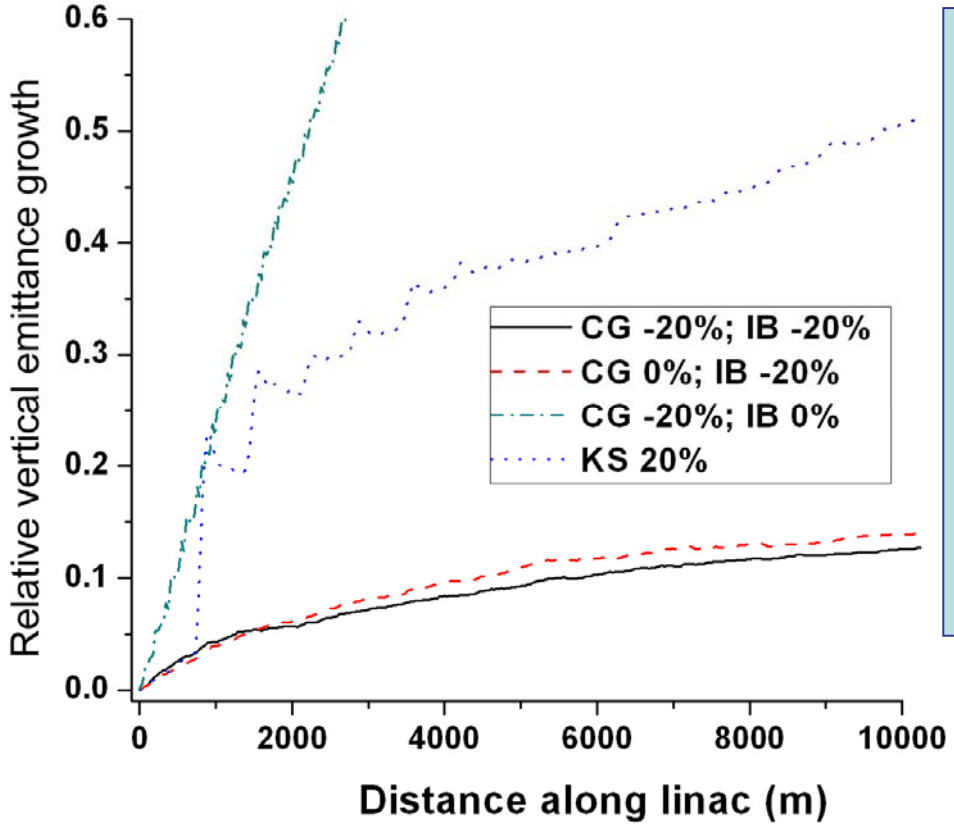
More realistic model (made with Klystron model):

1) CG: systematic adjustment of gradient (energy difference approaches a constant at end of linac)
2) IB: adjustment of initial energy. The energy difference is fixed and kept the same along the linac. Use of bunch compressor.
3) Combination of both
4) KS: Upstream klystron turned off such that the off-energy beam is at a fixed relative change at beg. of corrected segment.

IB and CG implemented & studied also in PLACET, KS in LIAR

(1) An ILC main linac simulation package based on Merlin

Energy Adjustment Result



1) IB: Initial energy is the most effective single adjustment. ($\gamma\varepsilon_{yc}$=22.8 nm)

2) CG: Constant gradient only least effective (59.3 nm)(*)

3) Combination of IB and CG helps to obtain better results (22.5 nm)

4) KS: Klystron Shunting (30.2 nm). Steps probably an artefact of simu. due to steering effect. Decrease with energy

BPM = 1 μm

W_{diff} = 1/(√2*40) μm

W_{abs} = 1 μm

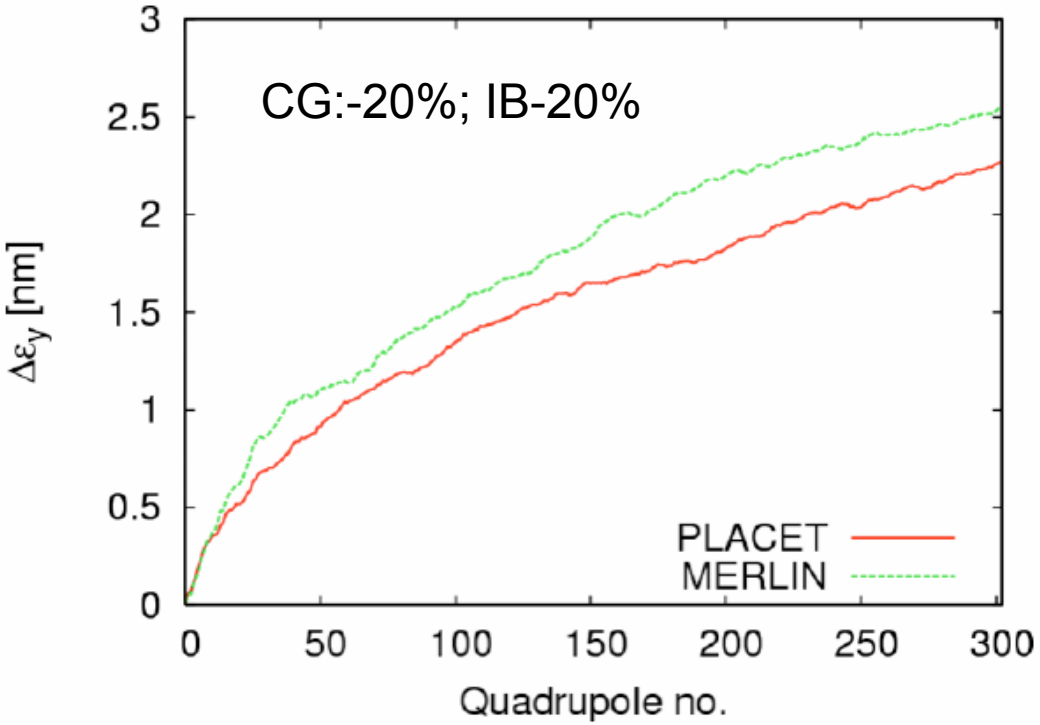
*CG do not effectively correct dispersion at the beginning as relative uncorrelated energy spread is highest.

See: *Energy Adjustment Strategy for DFS at the ILC using the MERLIN Package ILCDFS* – EUROTeV report 2006-106

Benchmarking

The features of the ILCDFS code allowed a benchmark with Placet (CERN) → EPAC/EuroTEV report(2)

→Good agreement



BPM = 1 μm

W_{diff} = 1/(√2*40) μm

W_{abs} = 1 μm

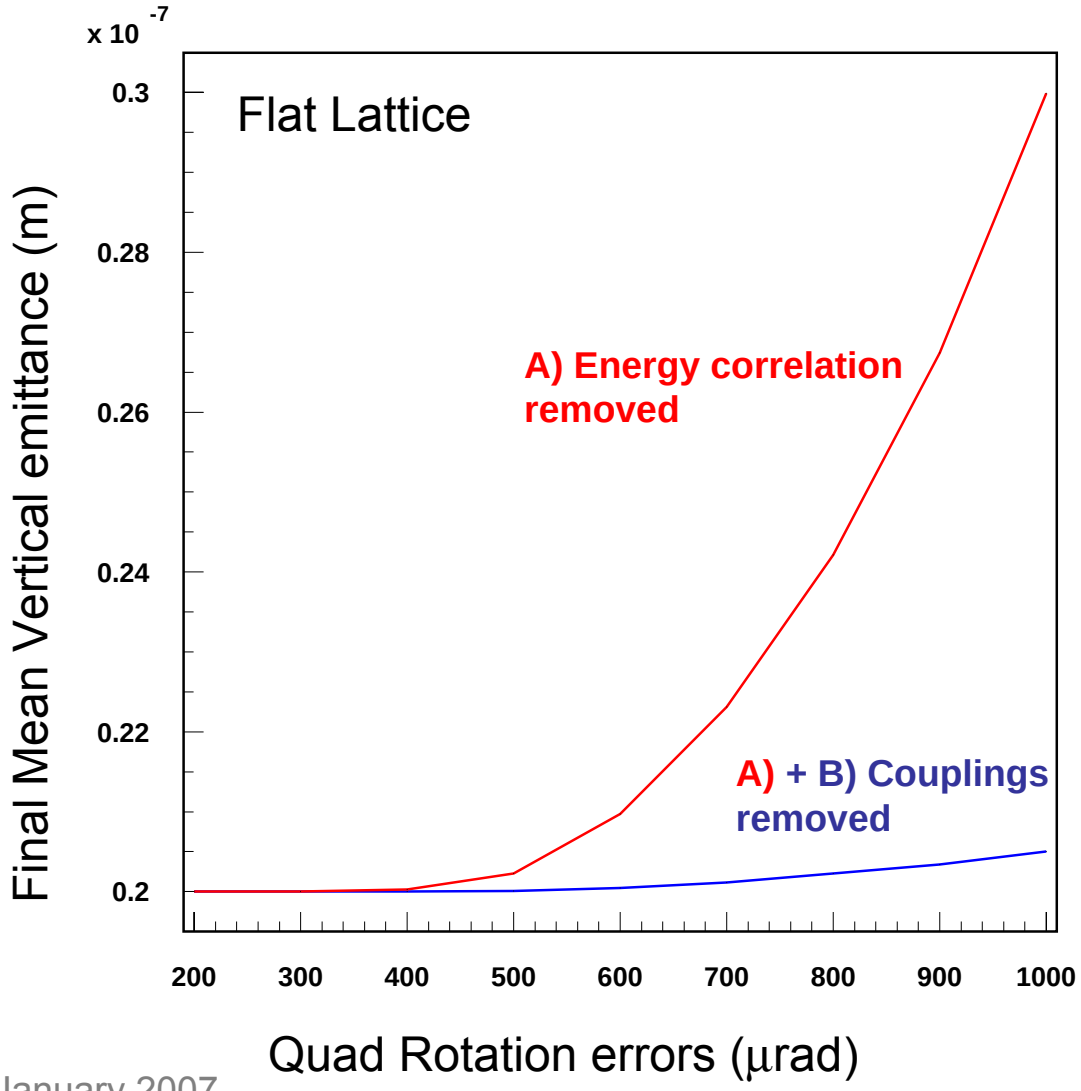
(2) *Study of an ILC Main Linac that follows the Earth Curvature*
EUROTeV Report 2006-50

Effect of Quadrupole Roll

- Rotated quads result in cross-plane (x-y) coupling, resulting in an increase in the vertical (projected) emittance.
- Assuming a full (perfect) coupling correction at the exit of the linac(*), what is the tolerance on the quadrupole rolls?
  - Note: nominal value assumed: 300μrad RMS.

* Instead of local skew-quadrupole correction in the ML

Coupling Correction Results



15 – 250 GeV ILC linac

Only quad roll

100 seeds

BPM resolution = 0μm

For 1 mrad of quad roll, mean $\gamma\varepsilon_{yc}$=~30 nm (50%)

With CC: $\gamma\varepsilon_{yc}$=~20.5 nm

Emittance growth largely reduced by the coupling correction at the end of linac.

Linear x-y correlation are preserved (i.e. little filamentation)

Towards Dynamics Simulation

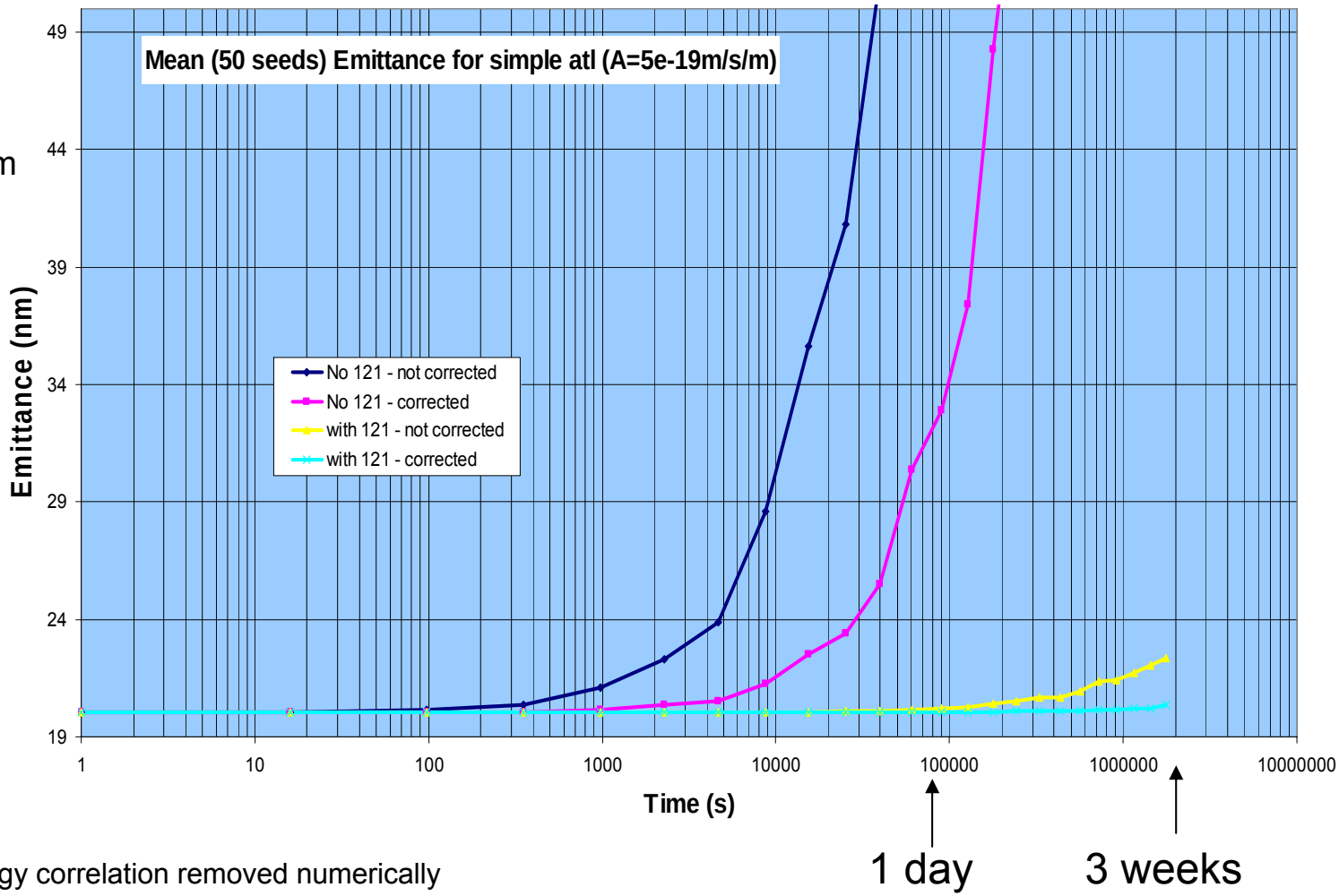
- Simulation Parameters
  - 15 to 250 GeV Main Linac lattice
  - ATL simple model
  - Correction: 1 to 1
  - BPM resolution: 10 μm
  - Dp/p = 1.07%
  - 50 seeds
- Comparison with PLACET
  - T=3 10^6 s
  - A=0.5 e-18 m/s/m

→Preliminary: $\gamma\varepsilon_{yc}$=20.3 nm → ~Good agreement.

Results on ML with ATL

Simulation Parameters
- ATL simple model
- A=5e-19m/s/m
- Correction: 1 to 1
- BPM resolution: 0μm
- Dp/p = 2.8%
- No wakefields
- Straight Linac

$\gamma\varepsilon_{yc}$=20.3 nm at 1.7 10^6 s



Correction= energy correlation removed numerically

Conclusion

- Tools are being refined and more realistic, e.g. ILCDFS package with energy strategy adjustment included.
  - Results show:
    - initial energy beam modification is critical, combined with constant gradient helps
    - Preliminary results (KS) →require inclusion of corrections at segment boundaries
  - Further development is planned to support wider range of machine errors.
- Little filamentation in ML → Coupling corrections at the end decrease drastically emittance
  - Indicates a significant safety margin on the roll tolerance of quads.
- Simple ATL included with 1 to 1 corrections: On-going work