# Coupler's RF-Kick and Wakefields PLACET Simulations

in ML, BC1 and BC2

A. Latina, A. Lunin, K. Ranjan,
N. Solyak, V. Yakovlev

# RF kick for Main Linac, BC1 and BC2

- Asymmetries of couplers generate transverse RF field in the accelerating cavities

$$\vec{V}(s) = aGLe^{i(\varphi+\psi+ks)}$$

Kick is $\alpha$ to bunch length

- Period:

**upstream rf-kick – drift1 – accelerating cavity – drift1- downstream rf-kick - drift2**

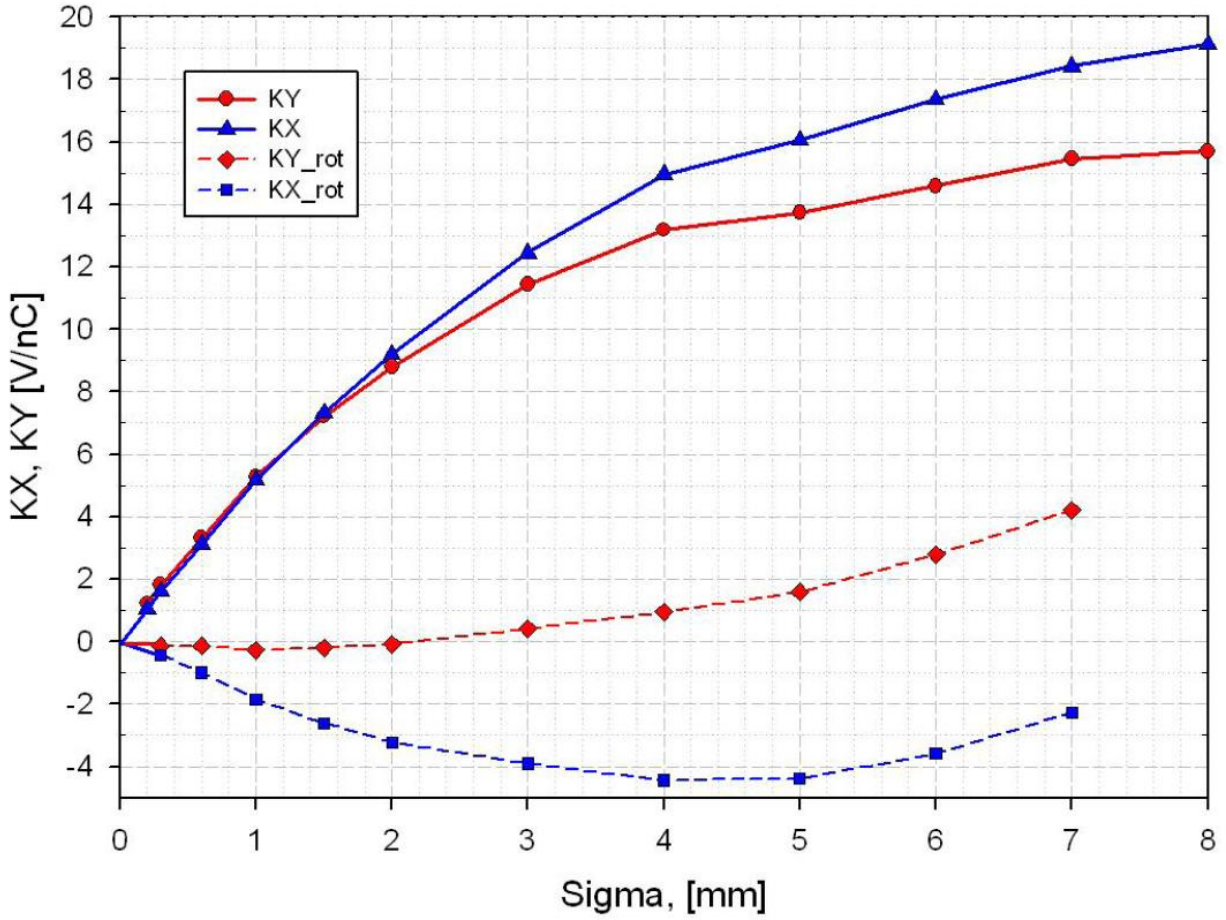
- Parameter "a" (calculated using HFSS):

| | | | |
|---|---|---|---|
| Main linac, φ=-5.1° | Upstream | $10^6 V_x / V_a$ | -82.2+9.8i |
| | | $10^6 V_y / V_a$ | -48.4+0.9i |
| | Downstream | $10^6 V_x / V_a$ | -30.5+60.1i |
| | | $10^6 V_y / V_a$ | 42.1+10.8i |
| BC1, φ=-105° | Upstream | $10^6 V_x / V_a$ | 21.4+65.5i |
| | | $10^6 V_y / V_a$ | 9.2+47.5i |
| | Downstream | $10^6 V_x / V_a$ | 73.3+18.1i |
| | | $10^6 V_y / V_a$ | 3.4-43.4i |
| BC2, φ=-27.6° | Upstream | $10^6 V_x / V_a$ | -56.3+35.2i |
| | | $10^6 V_y / V_a$ | -44.4+19.3i |
| | Downstream | $10^6 V_x / V_a$ | -1.7+75.5i |
| | | $10^6 V_y / V_a$ | 43.1-16.2i |

**Imaginary** part was simulated using a CrabCavity , **real** part was simulated *ad hoc*

# Coupler's Wakefields

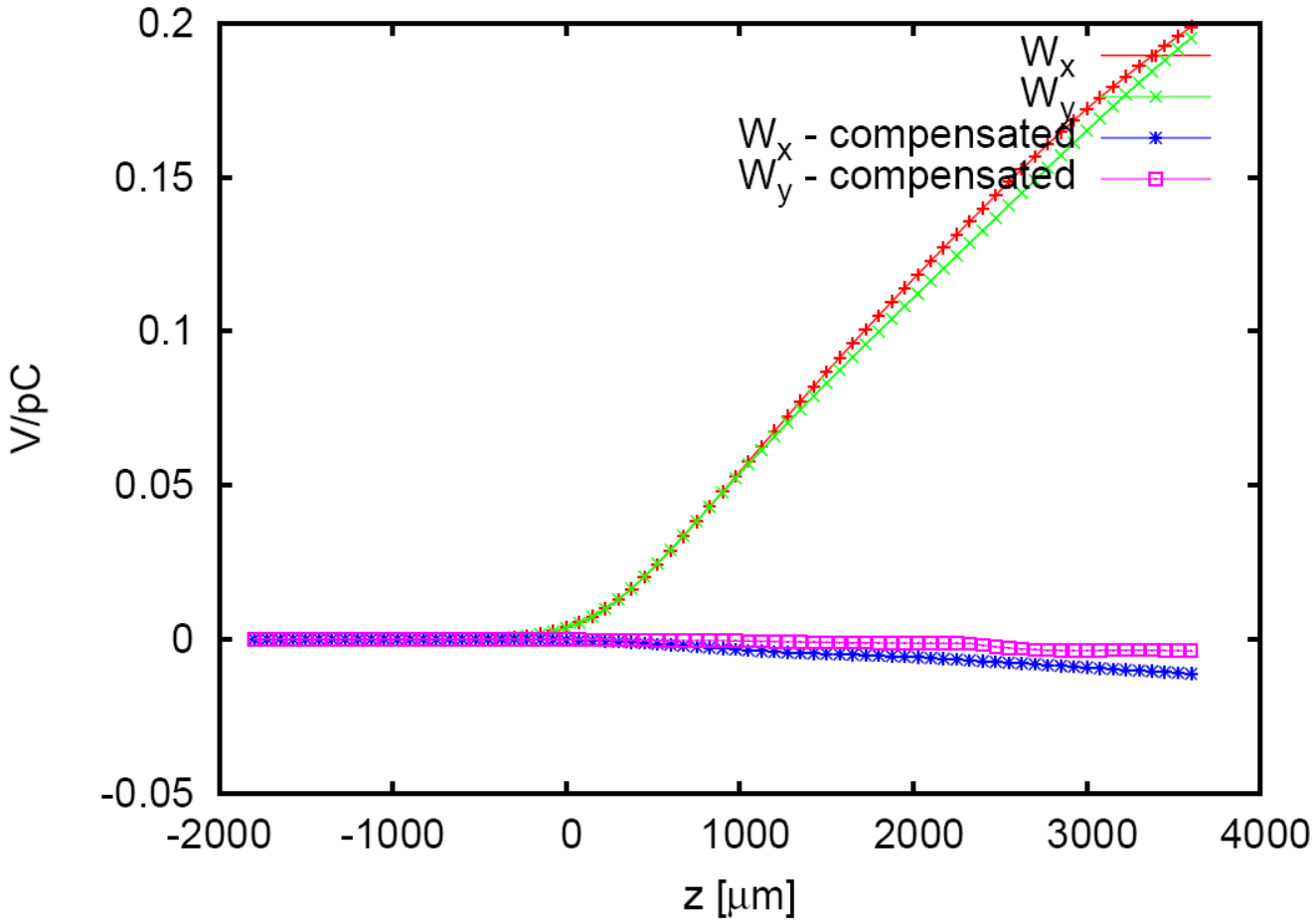
- Wakes calculated by A. Lunin using Gdfid




…Kick goes with square root of the bunch length

# Coupler's Wakefields

- Calculations by A. Lunin using GdfidL




"Compensated" configuration: downstream coupler is tilted by 180 degrees around the beamline axis

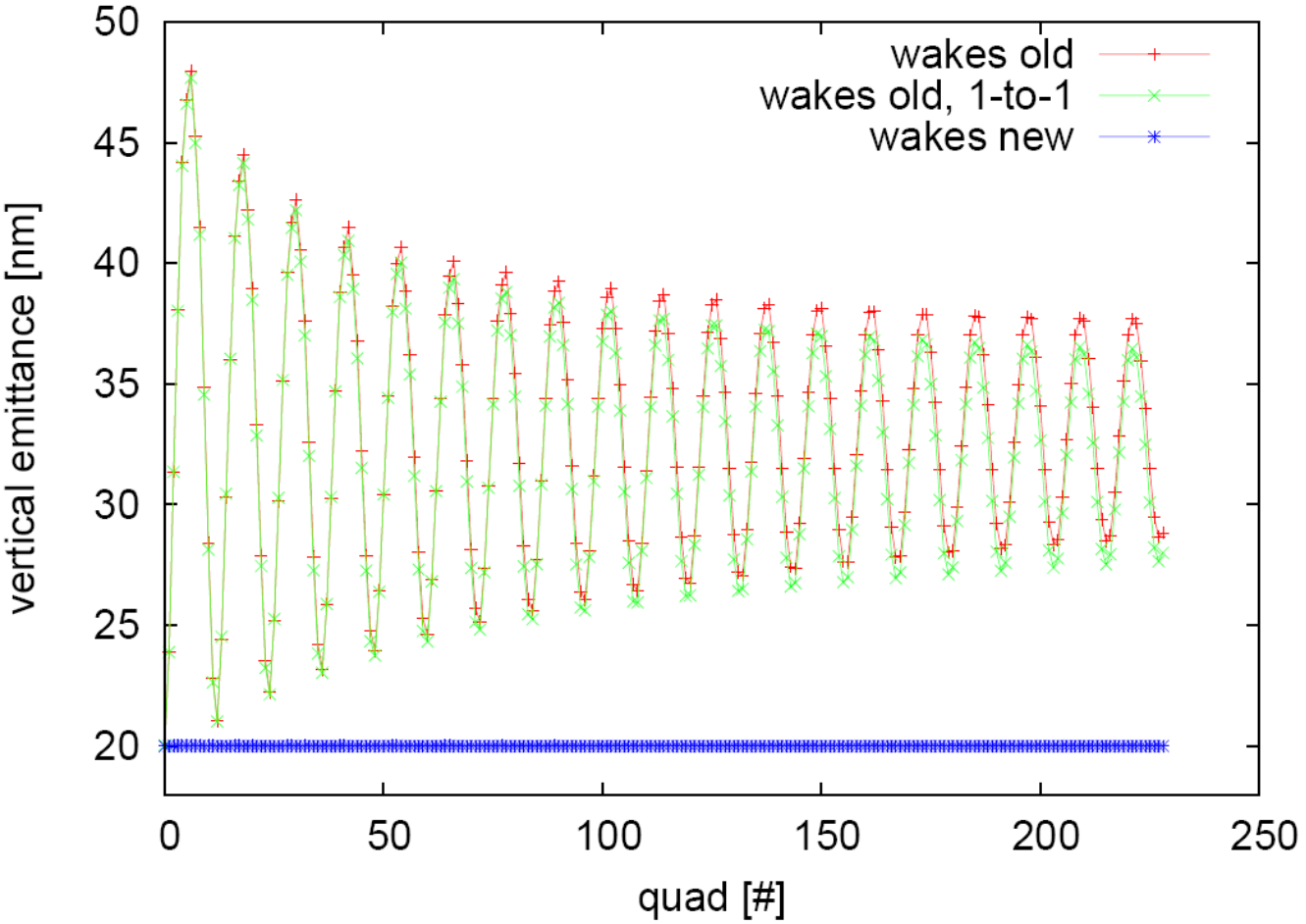
# Simulation Setup

- All simulations performed using PLACET
- Lattice: ILC2007b
- ML: positron line

| | BC1 | BC2 | ML |
|---|---|---|---|
| charge | $2 \cdot 10^{10}$ e | $2 \cdot 10^{10}$ e | $2 \cdot 10^{10}$ e |
| b.length | 9 mm | 1 mm | 300 μm |
| e.spread | 0.15 % | 2.5 % | 1.07 % |
| initial energy | 5 GeV | 4.88 GeV | 15 GeV |
| Emittance x/y | 8 μm / 20 nm | 8 μm / 20 nm | 8 μm / 20 nm |

# Main Linac: Coupler's Wakefields

- first 100 FODO cells
- Wakefields only, "old" configuration vs "new"

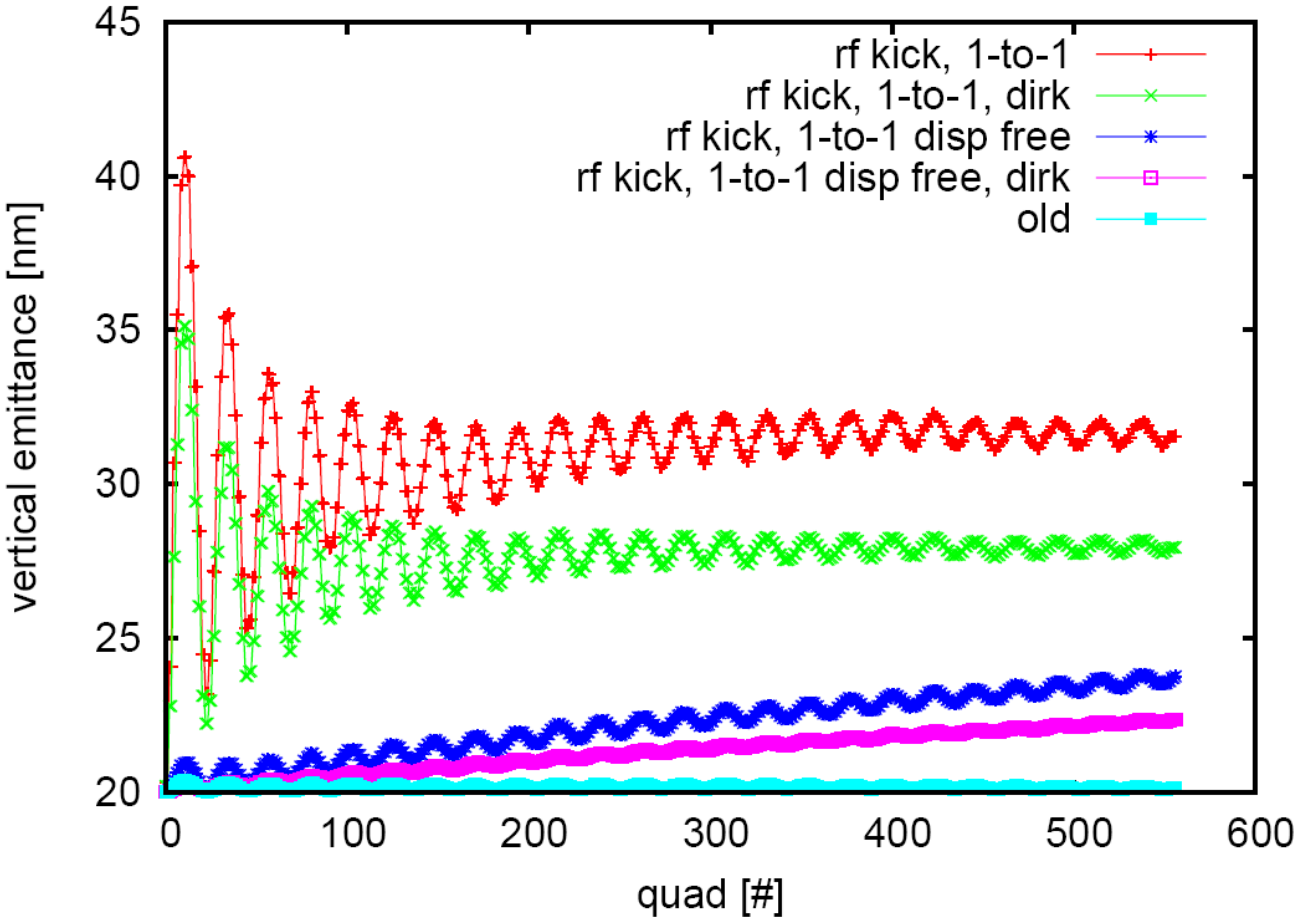



(*)"old" means *not compensated*; "new" means *compensated* configuration

"new" is manifestly better…

# Main Linac: RF-Kick

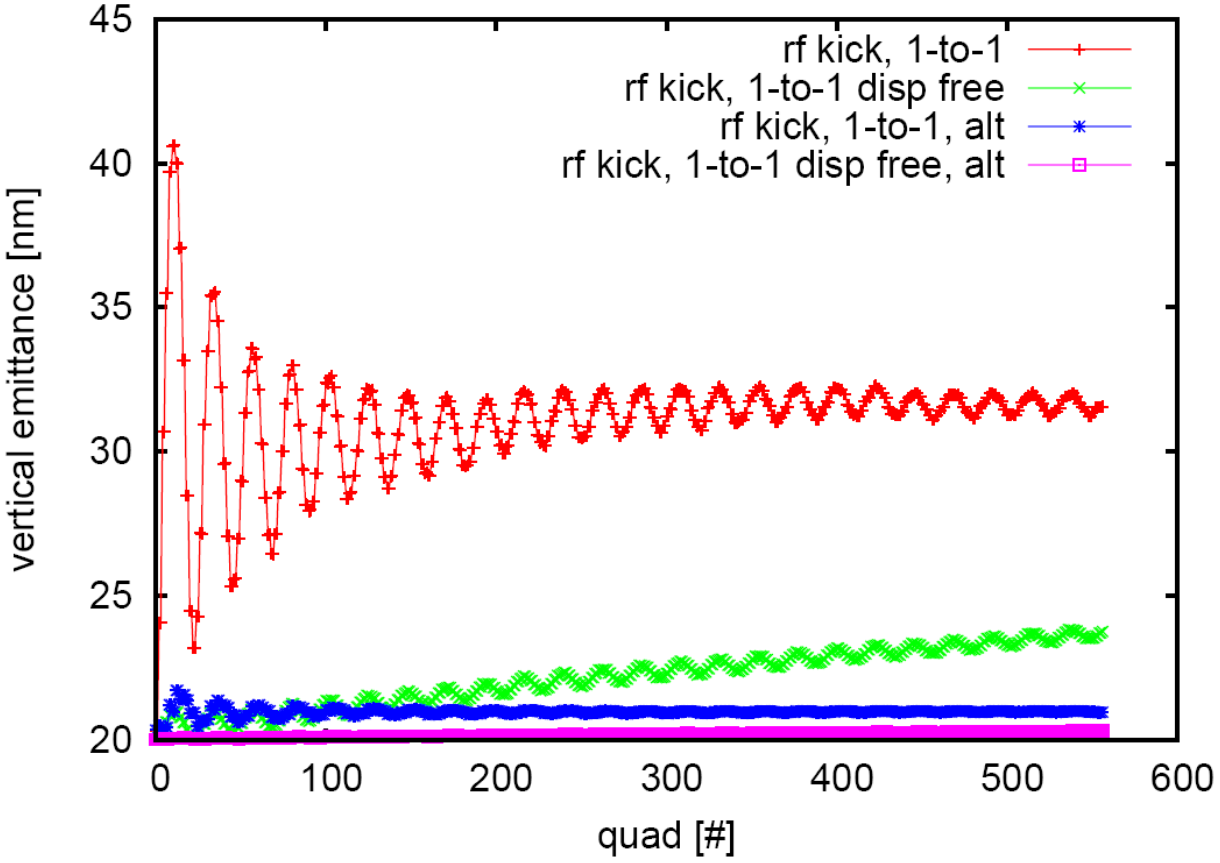
- ILC2007b, positron linac
- The opposite of the wakes: *old* is better, *new* is much worse
- Comparison: “new”, “old”, Dirk’s result




- “old” is better for RF-Kick (but not for wakes).

# Main Linac: RF-Kick, alternate configuration

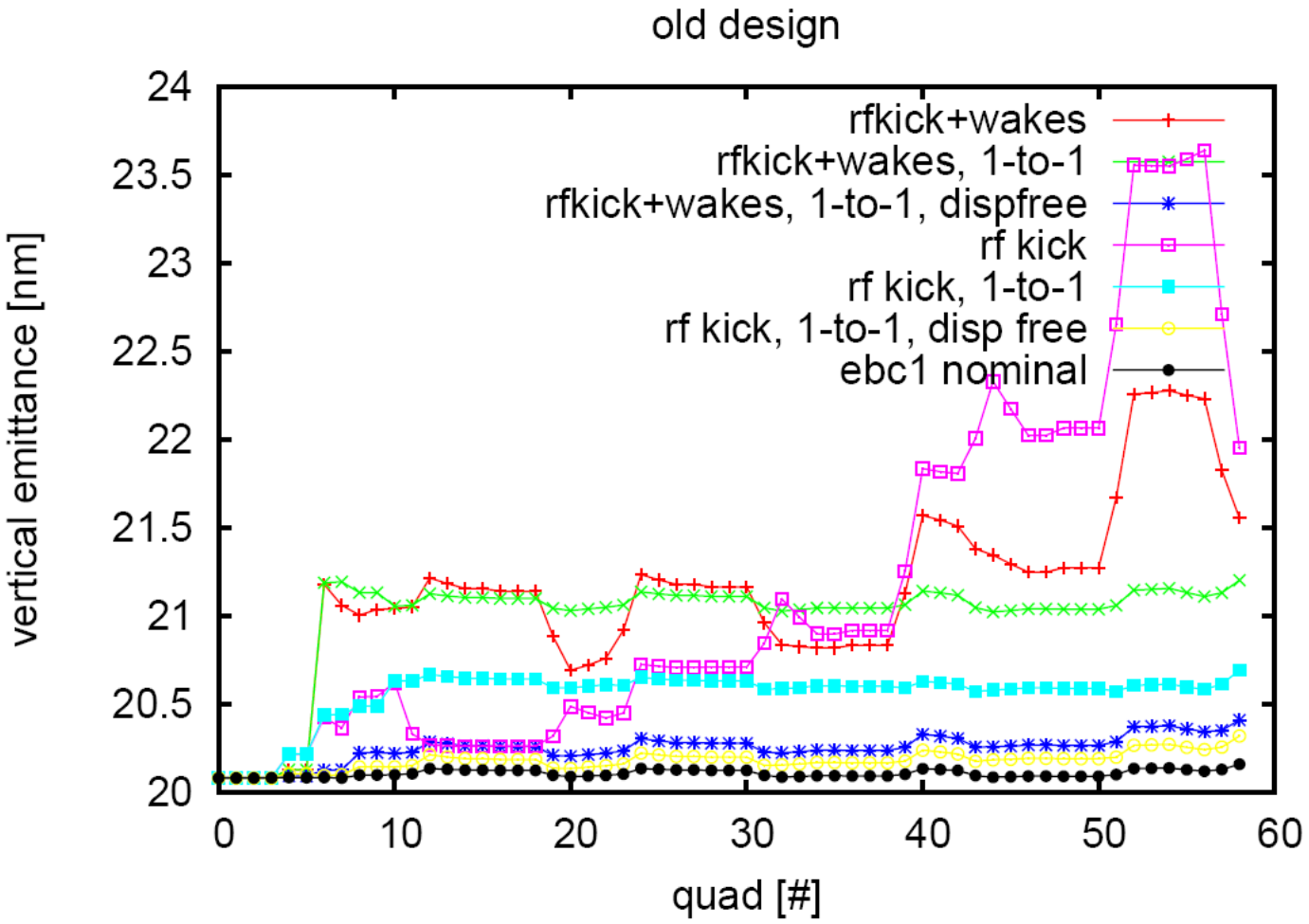
- like “new” but the cryomodules are flipped by 180 degrees, in triplets
  (so the RF-kick is flipping between *up* and *down*)
- RF-Kick only; “new” vs. “alternate”
- alternate, final emittance is 20.26 nm




- “alternate” reduces the RF-Kick and allows to use the “new” configuration, that compensates the wakes.

# BC1: *old* configuration

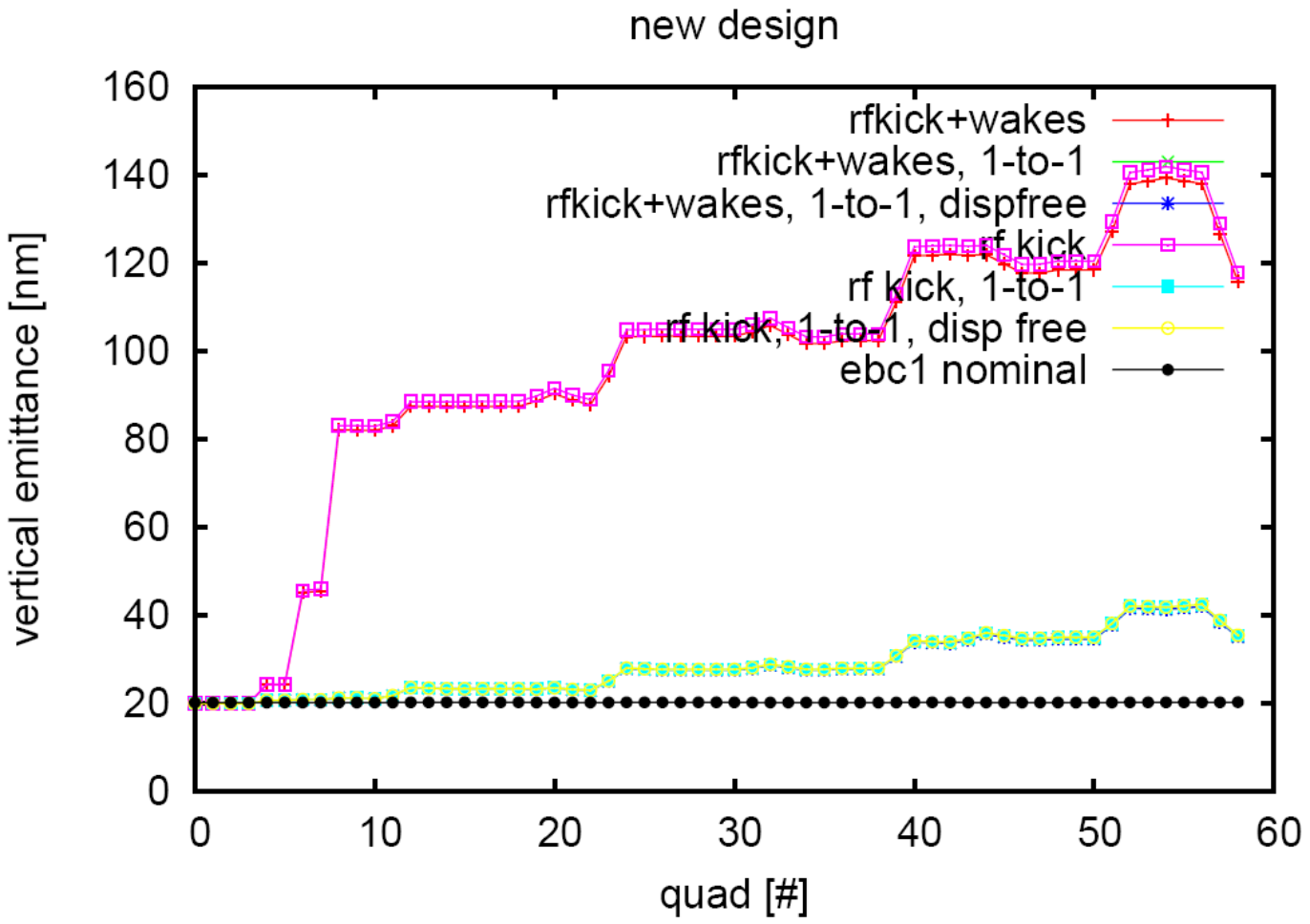
- Simulated both RF-Kick and Wakes
- ILC2007b / RTML (24 cavities) – initial bunch length: 9 mm




- Final emittance is 20.4 nm.

# BC1: *new* configuration

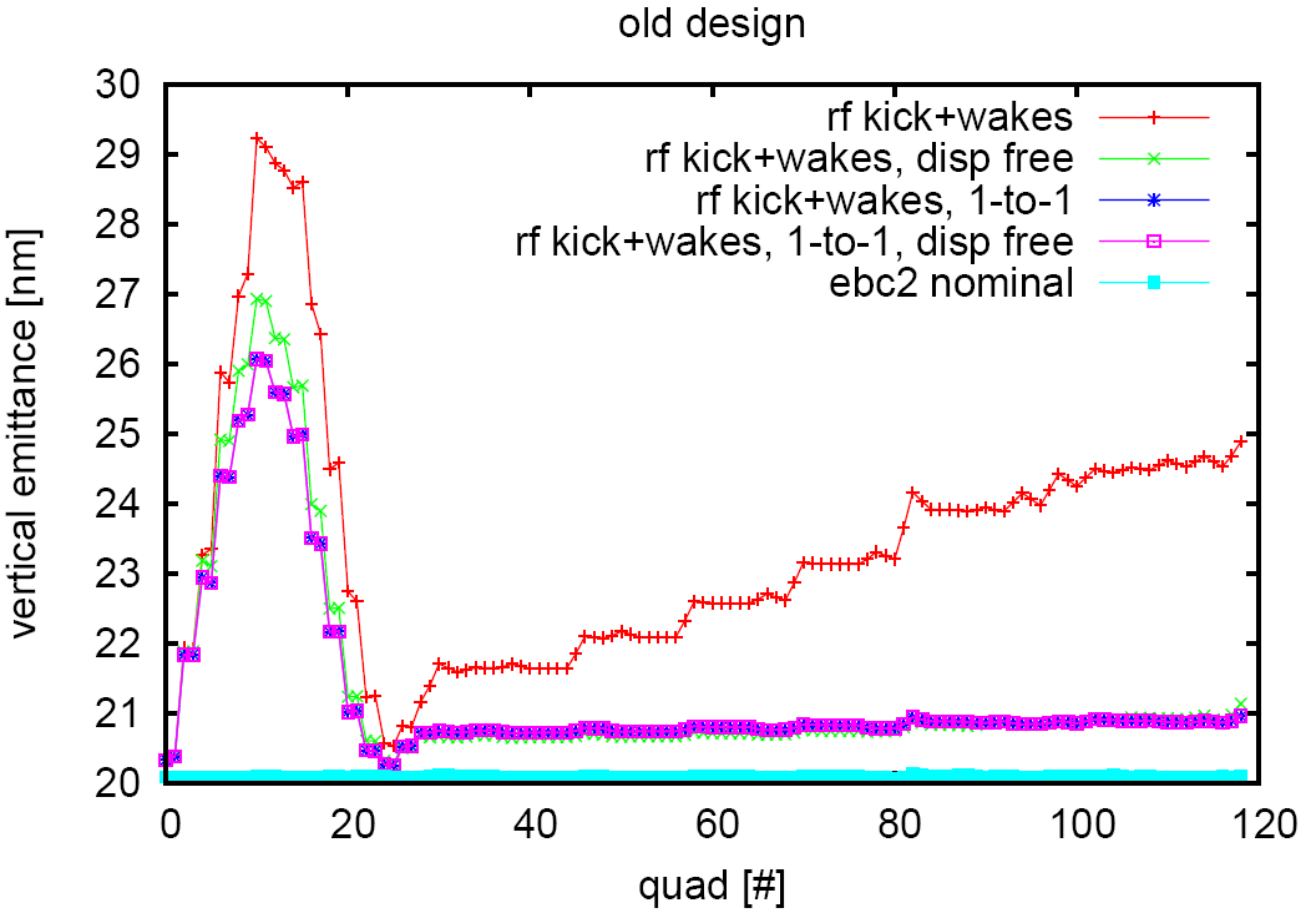
- Wakes are negligible in the new configuration




- Final emittance is 35.4 nm.

# BC2: old configuration

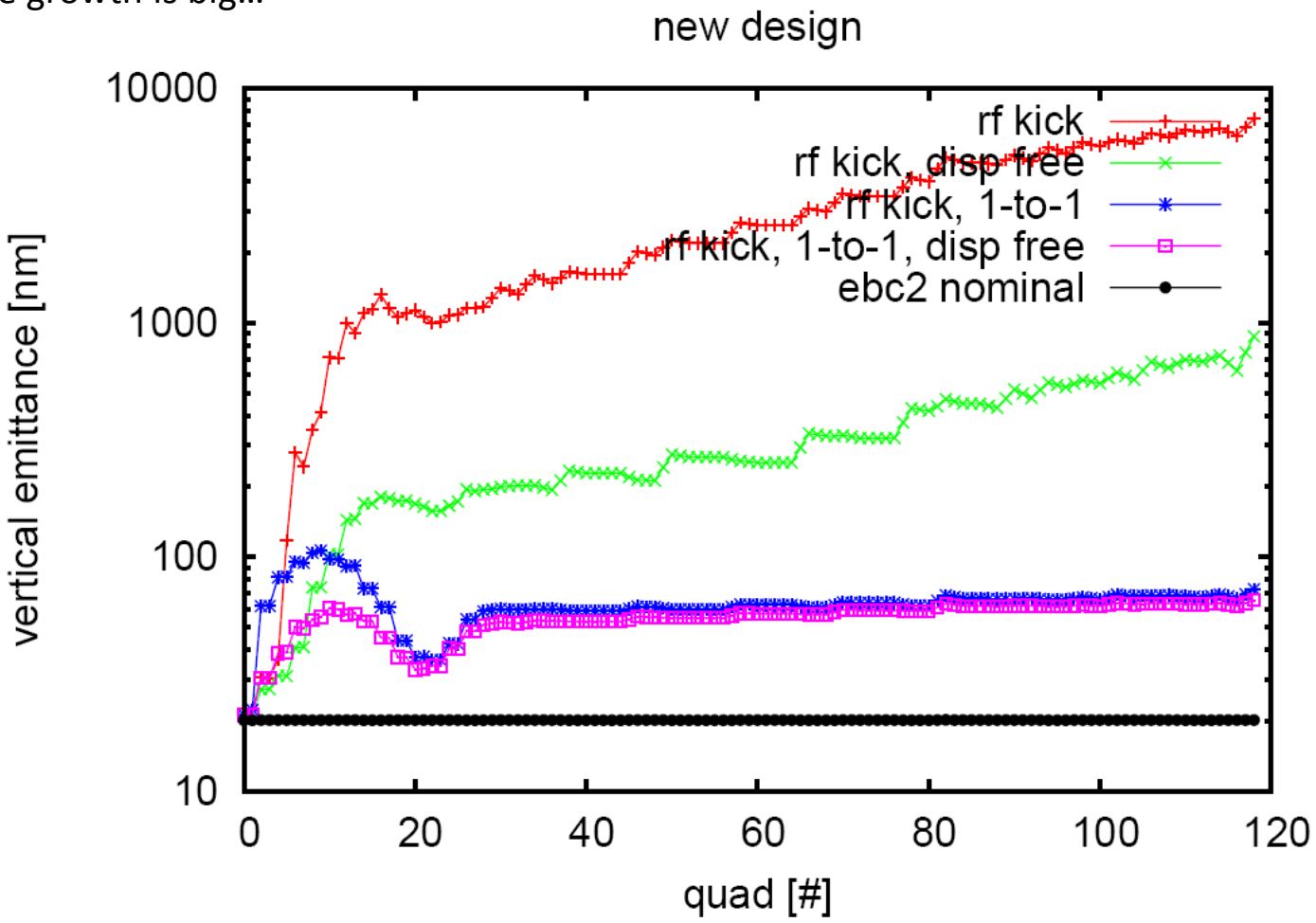
- RF-Kick and wakes simulated
- ILC2007b / RTML (364 cavities)




- Final emittance is 20.95 nm

# BC2: new configuration

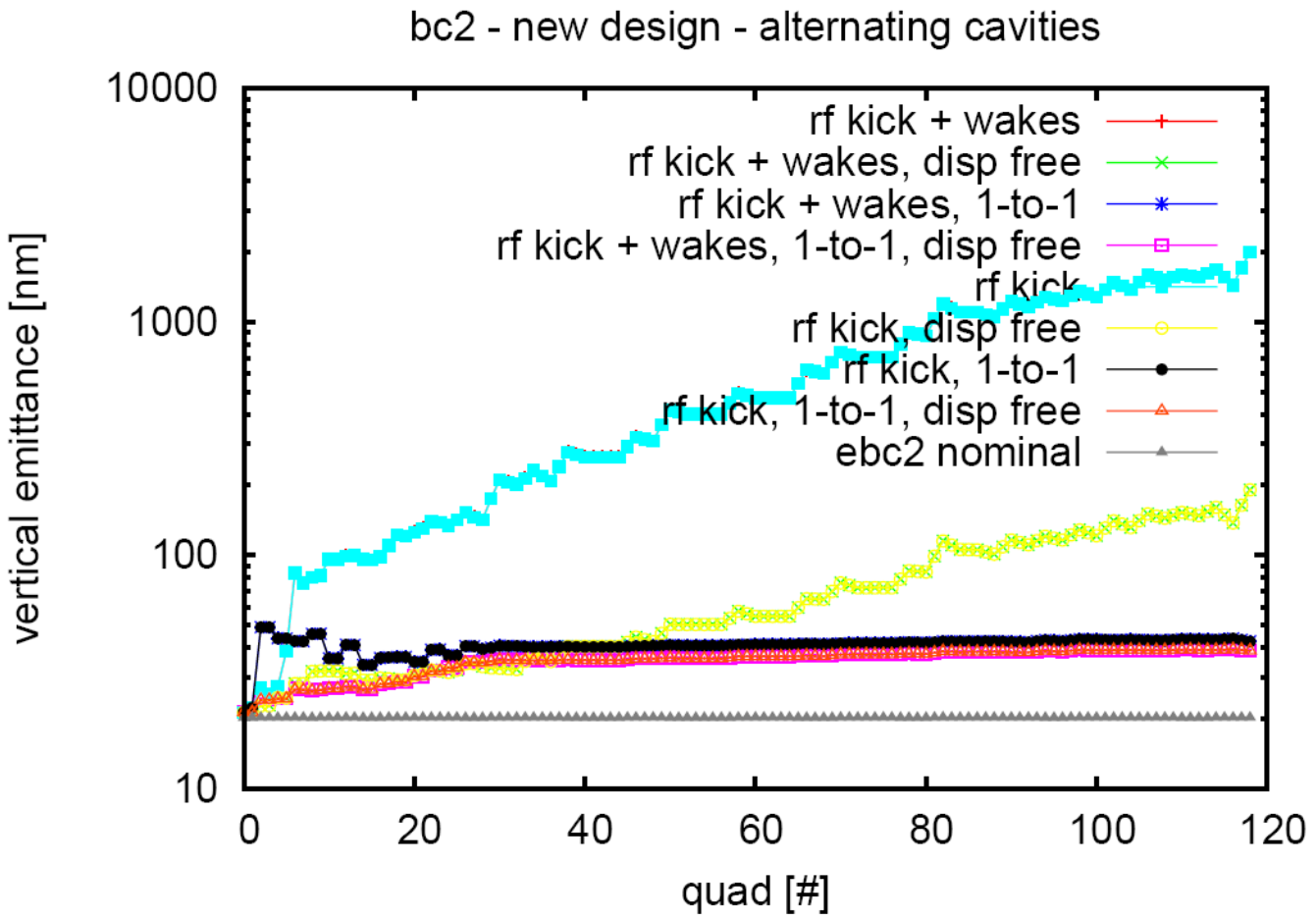
- only RF-Kick simulated
- emittance growth is big…




- Final emittance is 65.2 nm

# BC2: alternate configuration

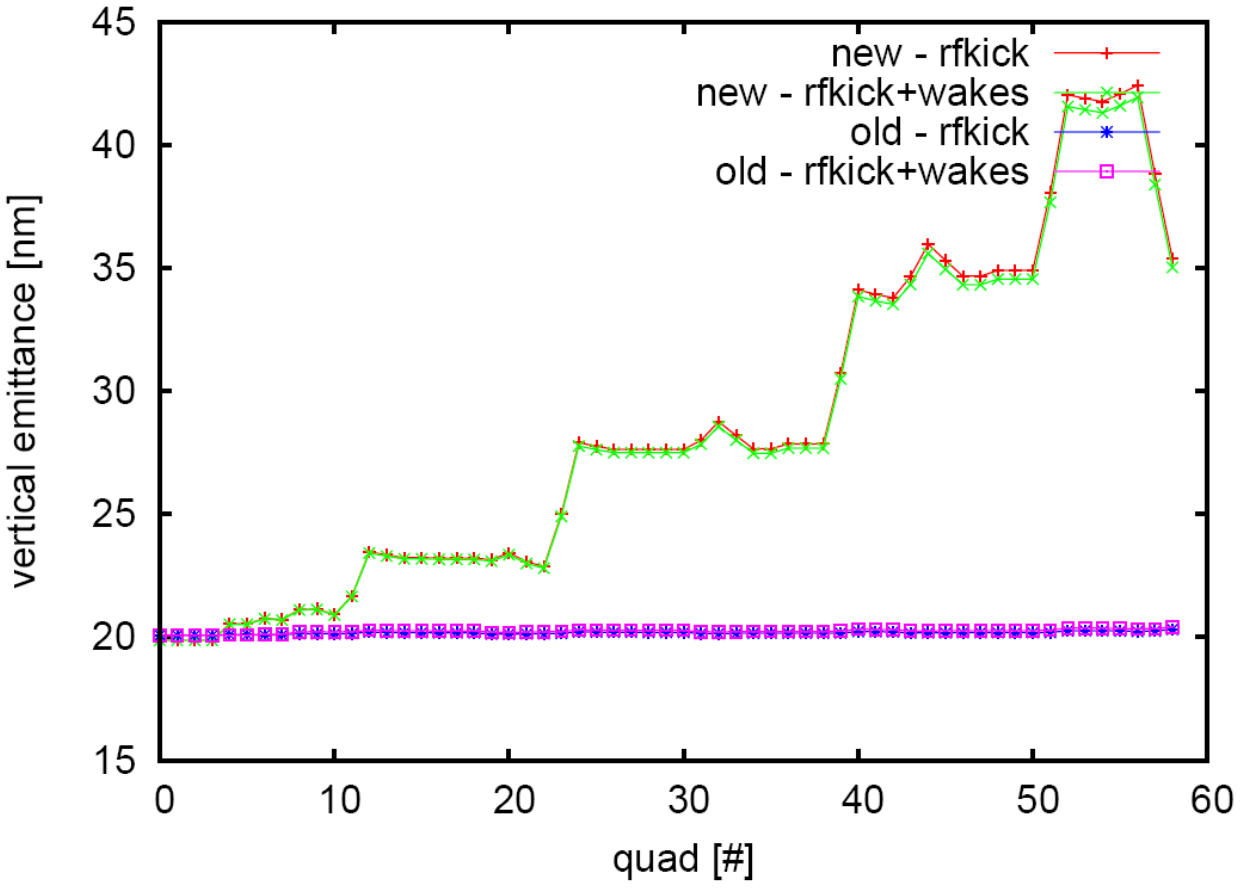
- Cryomodules are tilted by 180 degrees, one every two
- RF-Kick and wakes are simulated
- final emittance growth is less than 2 nm




- Final emittance is 38.91 nm

# BC1: summary

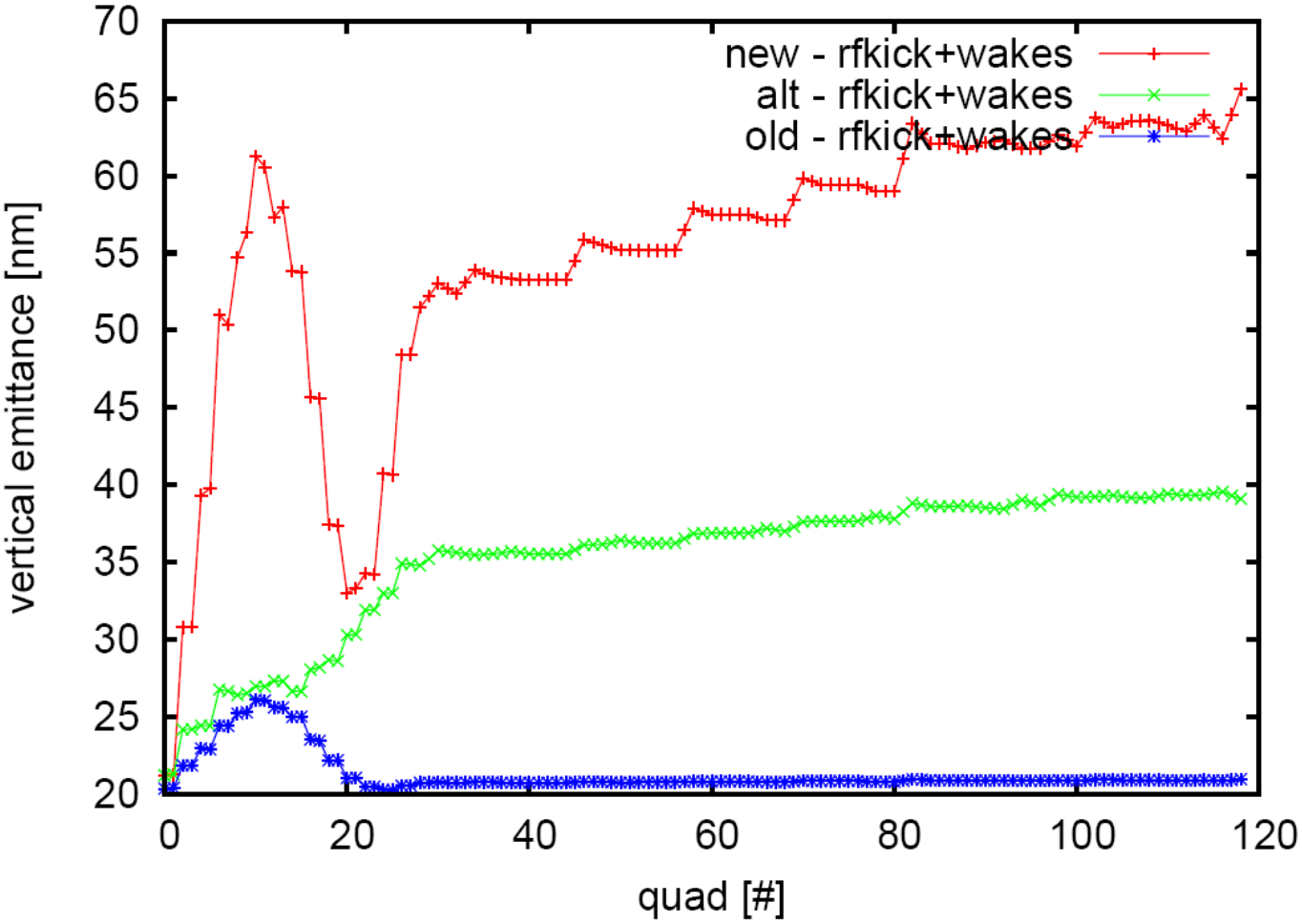
- RF-Kick and wakes are simulated
- with old config emittance growth is labout 0.4 nm




- OLD Config: Final emittance is 20.4 nm.

# BC2: summary

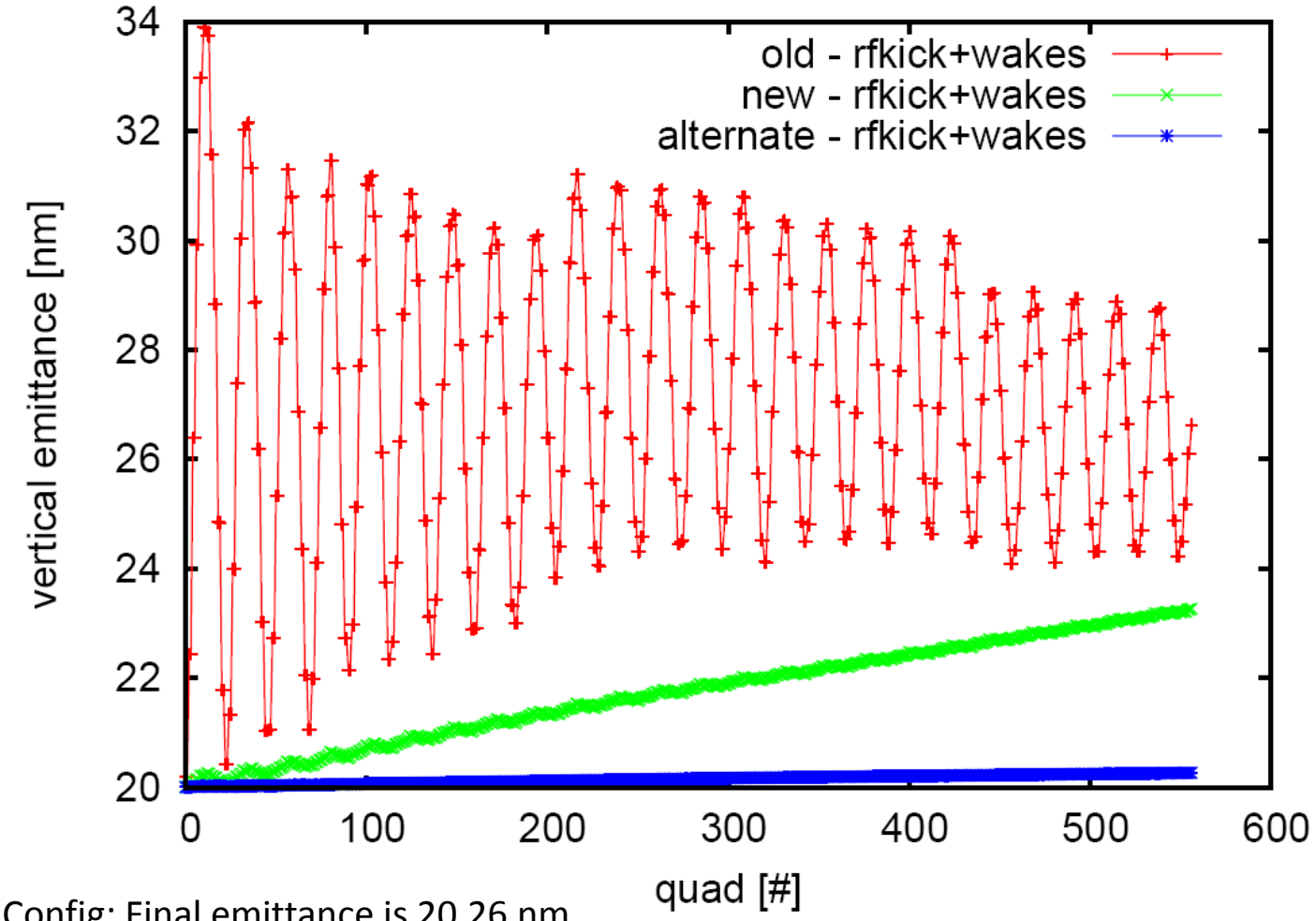
- RF-Kick and wakes are simulated
  "old" config performs better; final emittance growth is 0.95 nm




- OLD Config: Final emittance is 20.95 nm

# ML: summary

- RF-Kick and wakes are simulated
- “alternate” config performs better; final emittance growth is 0.26 nm




- ALTERNATE Config: Final emittance is 20.26 nm

# Summary tables and conclusions

RF-Kick + Wakes

| | BC1 | | BC2 | | | ML | | |
|---|---|---|---|---|---|---|---|---|
| | old | new | old | new | alt | old | new | alt |
| no correction | 21.55 | 115.88 | 24.89 | 7430.1 | 1991.2 | 91.53 | 7425.25 | 654.6 |
| 1-to-1 correction | 21.20 | 35.03 | 20.95 | 73.06 | 42.68 | 26.8 | 31.63 | 20.96 |
| 1-to-1 disp free | 20.40 | 35.03 | 20.95 | 65.59 | 39.08 | 26.6 | 23.26 | 20.26 |

- Old configuration works better in BC1 and BC2
- Alternate configuration works better in ML

# ML: tables

RF-Kick

| | ML | | | | |
|---|---|---|---|---|---|
| | old | new | alt | DESY/old | DESY/new |
| no correction | 68.7 | 7427.3 | 654.7 | - | - |
| 1-to-1 correction | 20.2 | 31.65 | 20.96 | - | 25.5 |
| 1-to-1 disp free | 20.0 | 23.28 | 20.26 | 20.0 | 21.8 |

Wakes

| | ML | | | |
|---|---|---|---|---|
| | old | new | DESY/old | DESY/new |
| no correction | 29.4 | 20.0 | 34.0 | 20.0 |
| 1-to-1 correction | 28.3 | 20.0 | 28.0 | 20.0 |
| 1-to-1 disp free | 28.3 | 20.0 | 28.0 | 20.0 |

# BC: tables

RF-Kick

| | BC1 | | BC2 | | |
|---|---|---|---|---|---|
| | old | new | old | new | alt |
| no correction | 21.95 | 117.9 | 21.81 | 7428.74 | 1991.3 |
| 1-to-1 correction | 20.69 | 35.39 | 20.32 | 72.73 | 42.59 |
| 1-to-1 disp free | 20.31 | 35.39 | 20.32 | 65.23 | 38.91 |

Wakes

| | BC1 | | BC2 | | |
|---|---|---|---|---|---|
| | old | new | old | new | alt |
| no correction | 21.65 | 20.3 | 21.9 | 20.2 | 20.2 |
| 1-to-1 correction | 21.61 | 20.2 | 21.3 | 20.2 | 20.2 |
| 1-to-1 disp free | 20.3 | 20.2 | 21.3 | 20.2 | 20.2 |

# References @ EPAC08


1. **RF Kick in the ILC Acceleration Structure** MOPP042.PDF

   *V. P. Yakovlev, I. V. Gonin, A. Latina, A. Lunin, K. Ranjan, N. Solyak (Fermilab, Batavia, Illinois)*

2. **Transverse Wake Field Simulations for the ILC Acceleration Structure** MOPP043.PDF

   *V. P. Yakovlev, A. Lunin, N. Solyak (Fermilab, Batavia, Illinois)*

3. **Simulation Studies on Coupler Wakefield and RF Kicks for the International Linear Collider with MERLIN** TUPP047.PDF

   *D. Kruecker, I. Melzer-Pellmann, F. Poirier, N. J. Walker (DESY, Hamburg)*