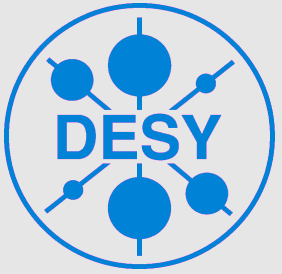
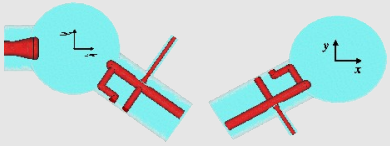


Coupler Wakefield and RF Kick Simulations

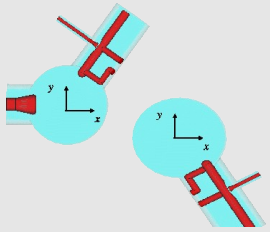
Dirk Krücker

Status of MERLIN since SLAC meeting

old design



new design



Bugs in 1st MERLIN implementation

- RF kicks for the new design had been wrong
  - k_t in y becomes larger
  - sign was wrong

Differences between RF calculations

- kick is tiny effect
  - orders of mag smaller then acc. field)
  - cancellation between upstream and downstream coupler
- Sensitive to RF coupler pen depth (Q)
  - different between calculations

Summary formula and numerical input

Numerical calculation RF Kicks

- MAFIA
- Omega3P
- HFSS

- I did not manage to collect all results

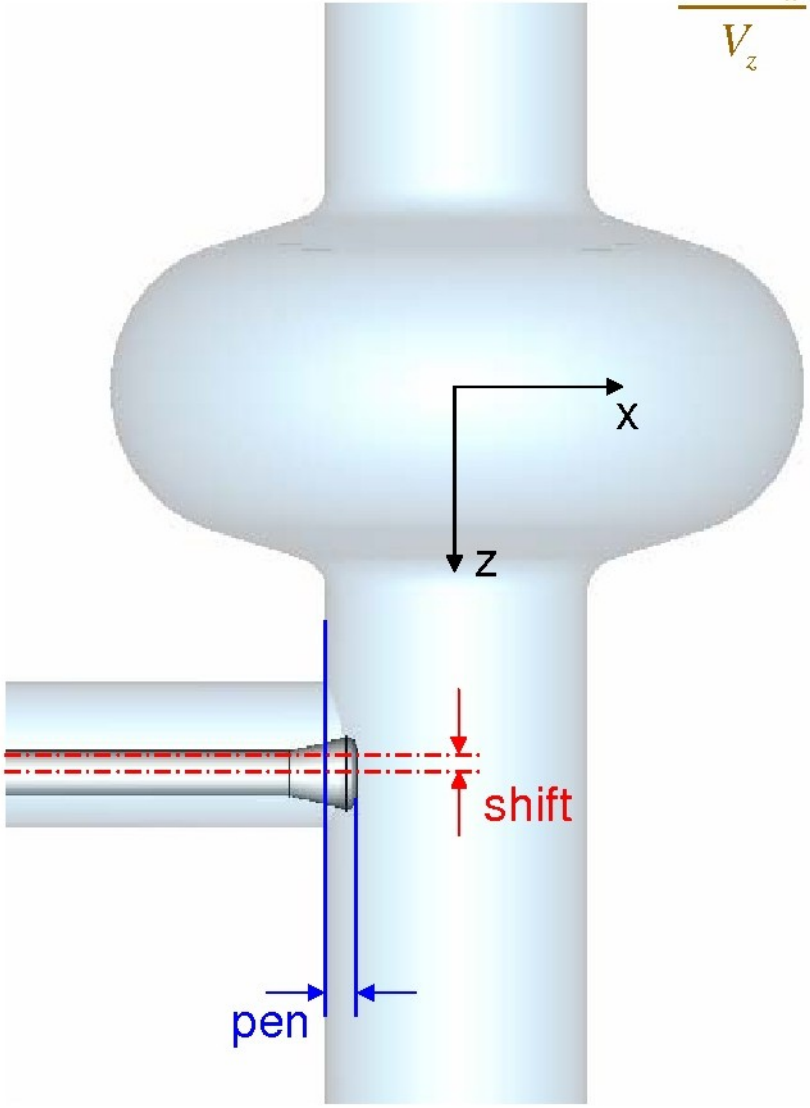
kick of main coupler

$$\frac{Q_{ext}}{10^6}$$

$$\frac{10^6 \cdot V_x}{V_z}$$

scaled for TTF 9 cell cavity

problem: field asym. caused by asym. MWS mesh



MWS-discretization: 30lines@2GHz

pen/mm \ shift/mm	-5	0	5
4.5	3.347 19.9+j35.9	4.490	
6	2.466 47.6+j40.9	3.384 30.6+j54.3	
7.5	1.781 84.5+j50.0	2.4482 58.7+j65.0	3.987 37.4+j68.1
9	1.272 130.3+j56.9	1.940 93.4+j83.3	3.464 65.1+j88.9
10.5	0.9662	1.663	2.583 100.9+j86.5
12		1.351	2.099 141.1+j65.0

MWS-discretization: 50lines@2GHz

pen/mm \ shift/mm	-5	0	5
4.5	3.405		
6	2.488	3.423	
7.5	1.857 83.7+j14.2	2.623 59.1+j31.7	4.242 37.1+j35.5
9		2.008	3.237
10.5		1.570	2.542
12			

old values!

RF Kicks in Merlin

see EPAC08 -TUPP047
M.Dohlus I.Zagorodnov LCWS/ILC2007 in paper wrong signs! talk is OK
6mm

Sum of upstream and downstream couplers

$$\mathbf{v} = (v_x, v_y) := 10^6 \cdot \mathbf{V}/V_{||}$$

x,y [m]

$$\mathbf{v}(x,y) \overset{old}{=} \begin{bmatrix} -82+58i \\ -9.2+1.8i \end{bmatrix} + \begin{bmatrix} -29-27i & 63+5.1i \\ 63+7.0i & 28+24i \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$\mathbf{v}(x,y) \overset{new}{=} \begin{bmatrix} -82+58i \\ -74-8.7i \end{bmatrix} + \begin{bmatrix} -29-27i & 63+5.1i \\ 4.9+2.9i & -48-12i \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

e.g.:

$$\Delta y' = \frac{\Delta E |v_y|}{E} \Re\left\{ e^{i(\phi_c - \varphi - k\Delta z)} \right\}$$

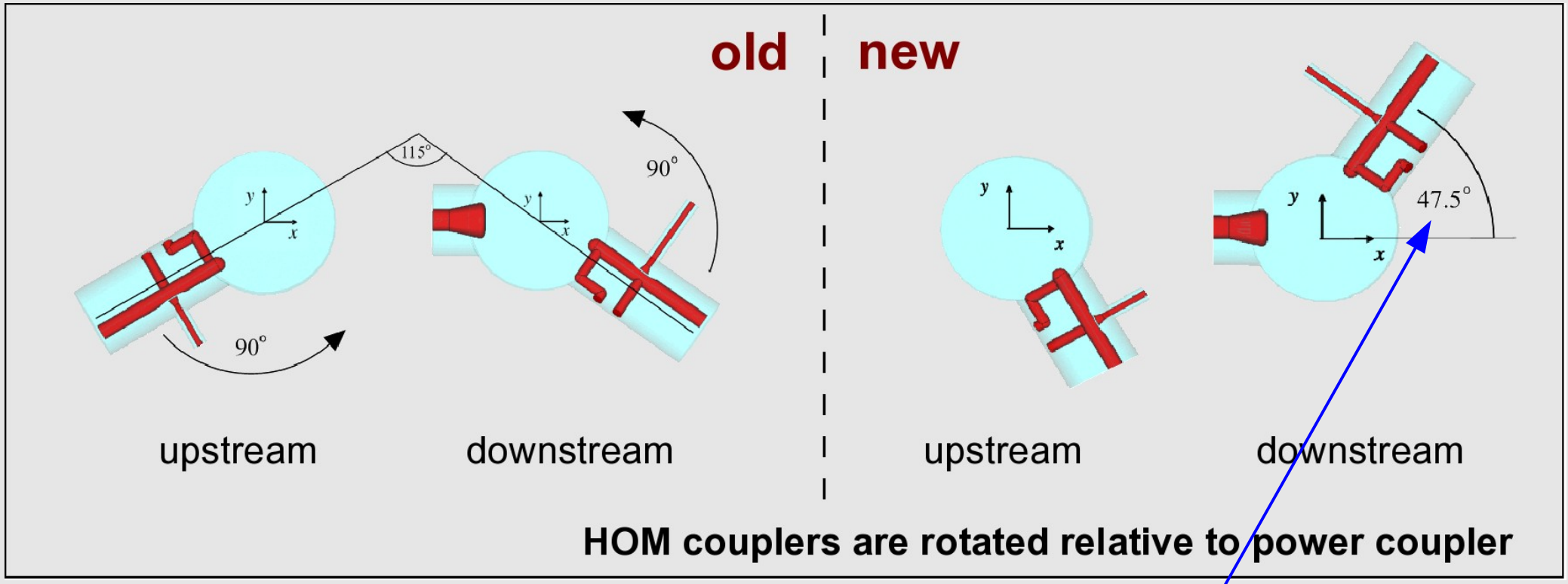
on axis (0,0) for 31.5GeV

|Vy(0,0)|:
old 300 V
new 2415 V

$\Delta z = -\Delta ct$, longitudinal position of a particle at φ
ϕ_c coupler phase, φ RF phase $= 5.3°$, $k = 2\pi f/c$,
$f = 1.3\,\mathrm{GHz}$
$\Delta E = 31.5\,\mathrm{GeV/m} \cdot l$, $E = 15 \cdots 250\,\mathrm{GeV}$
$l = 1.036$ m

Similar in Zenghai Li,
talk Wakefest 07
TDR 785 V
TDRM 2621 V <- larger
(downstream rotated by 180°)

Approximation for New Design



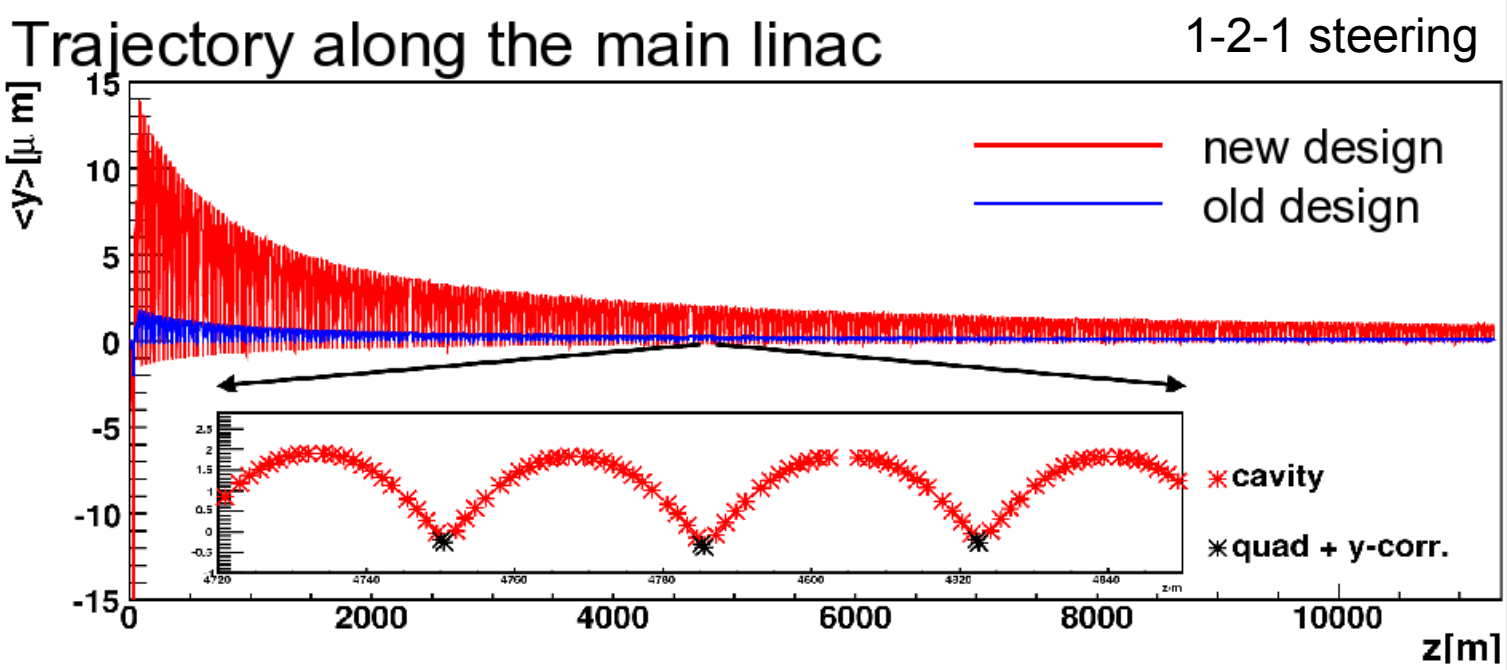
There is no MAFIA field calculation for the modified design.
- Approximated in MERLIN by

downstream coupler: $V_y \rightarrow -V_y$

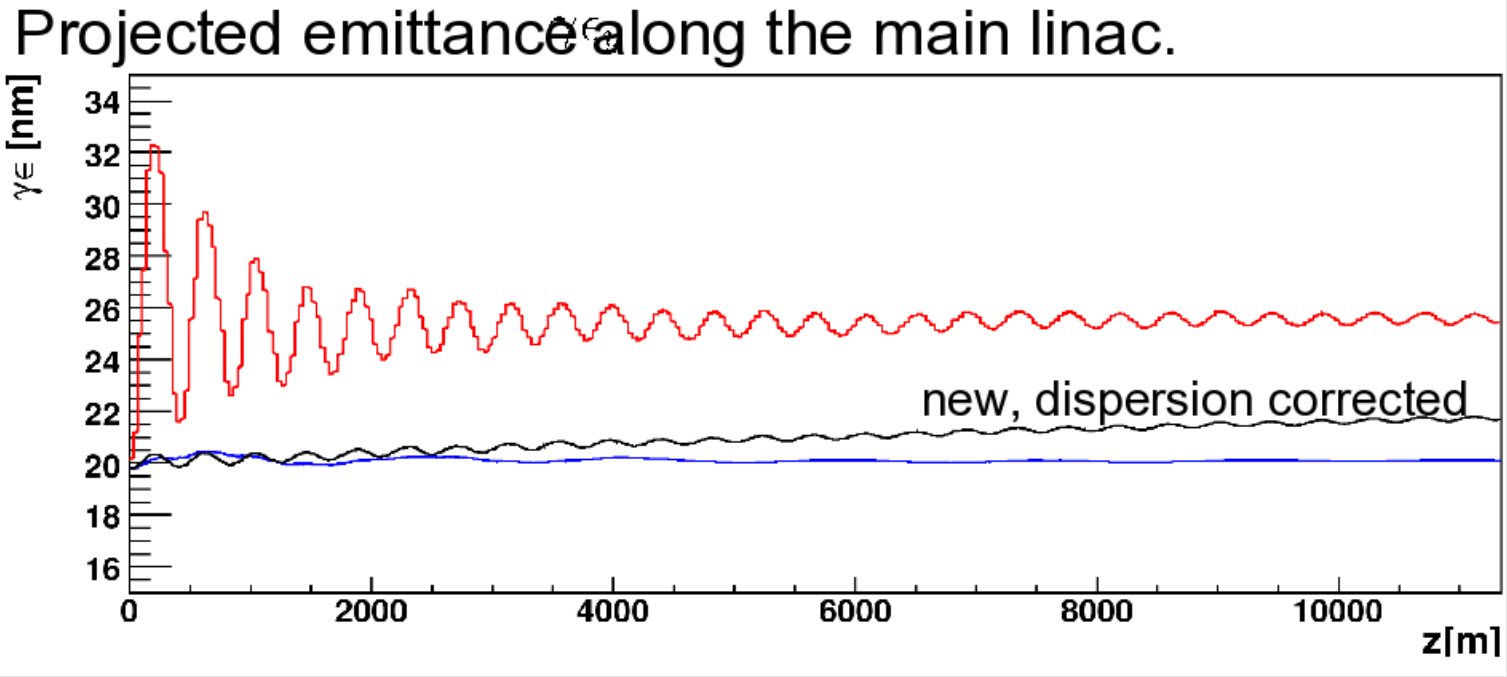
The angle between HOM coupler and x-axis is only 42.5° in this case.

- The kick: 8 times larger for the new design.

MERLIN simulation - RF Kicks (DK et al., EPAC08 - TUPP047)



RF stability?



21.5 nm

Wakefield Kicks in Merlin

Numerical approximation of the coupler transverse wakefield kicks [V/nC] near the cavity axis (x,y[m]):

$$\mathbf{k}(x,y) \overset{old}{=} \begin{bmatrix} -21 \\ -19 \end{bmatrix} + \begin{bmatrix} 4300 & 70 \\ 30 & -900 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$\mathbf{k}(x,y) \overset{new}{=} \begin{bmatrix} -2.5 \\ -0.2 \end{bmatrix} + \begin{bmatrix} 2330 & 40 \\ -20 & 1100 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

A particle in a bunch with distribution $\lambda(s)$ sees the transverse bunch wake potential:

$$\mathbf{W}(s) = 2\mathbf{k} \int_{-\infty}^{s} \lambda(s) ds$$

- Assumed to be purely capacitive → upper limit
- Added to cavity wakefield

Transverse cavity wakefield in MERLIN Tesla Report 2003-18

$$w_\perp(s) = 121\left(1-\left(1+\sqrt{\frac{s}{0.92\cdot 10^{-3}}}\right)e^{-\sqrt{\frac{s}{0.92\cdot 10^{-3}}}}\right) \quad \left[\frac{V}{pC\cdot m\cdot m}\right]$$

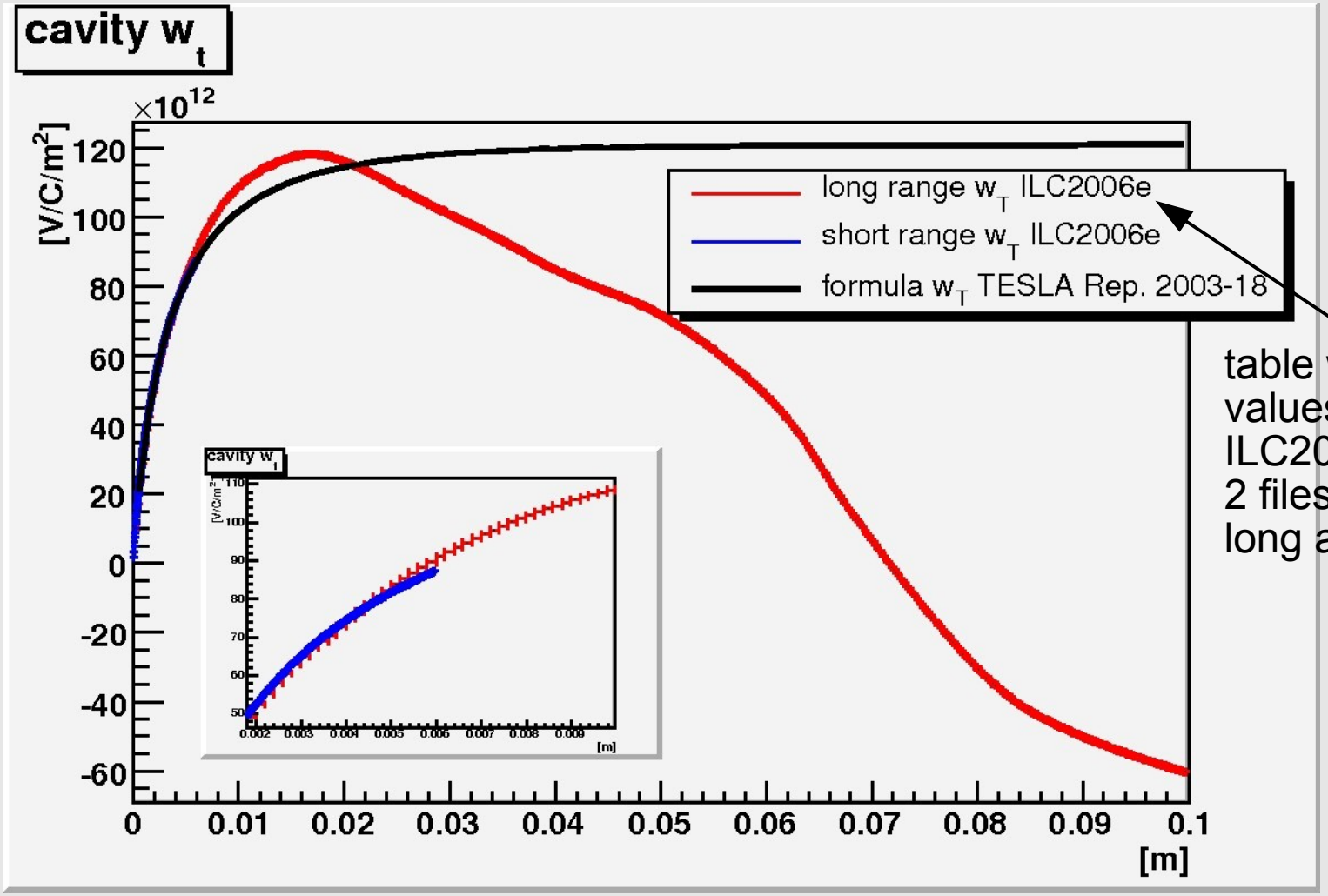


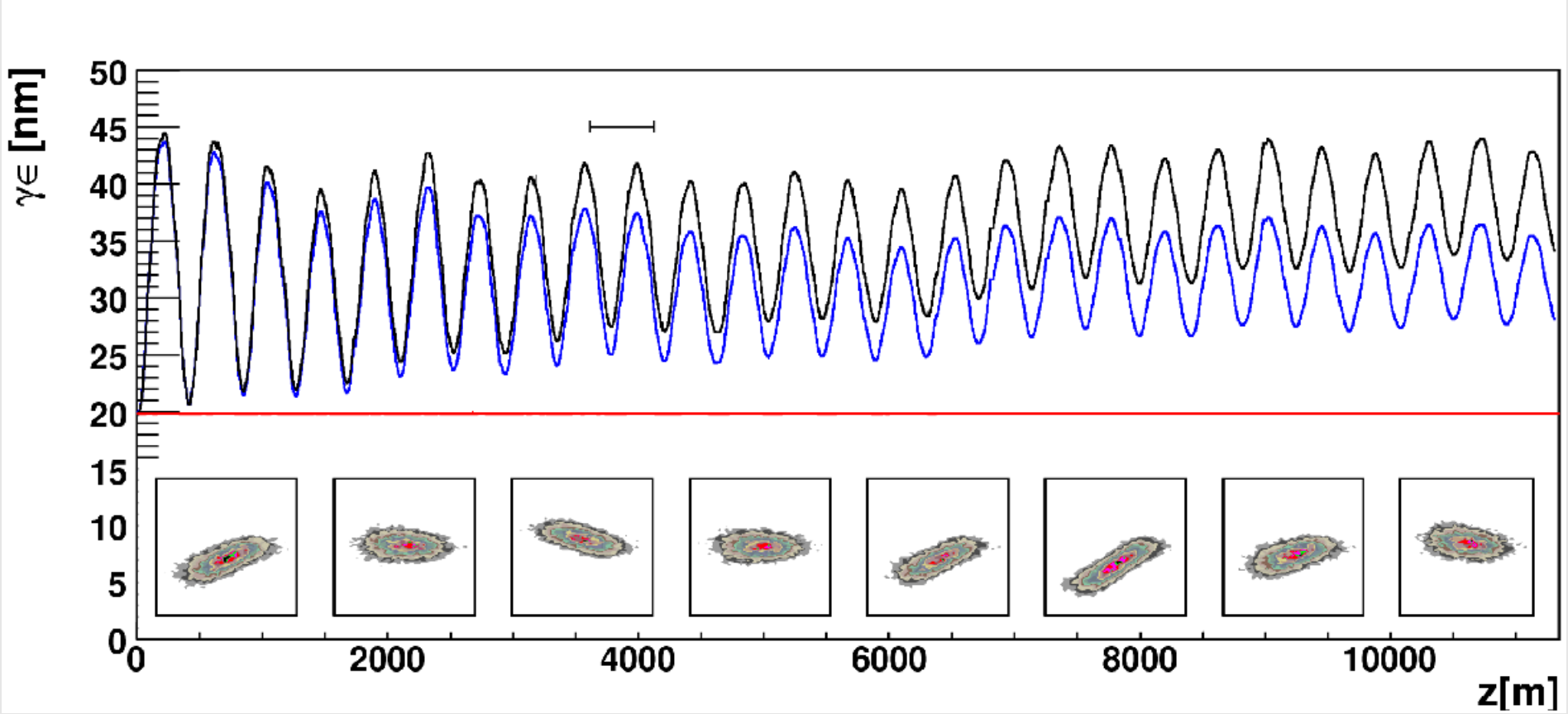
table with numerical values in ILC2006e/auxfiles/wakes
2 files:
long and short range

Questions by Kiyoshi

- Purely capacitive wake - is this a good approximation?
  - I do not have anything better, but fine as upper limit
- Usually wake potential as a linear function of distance, disappeared at 0?

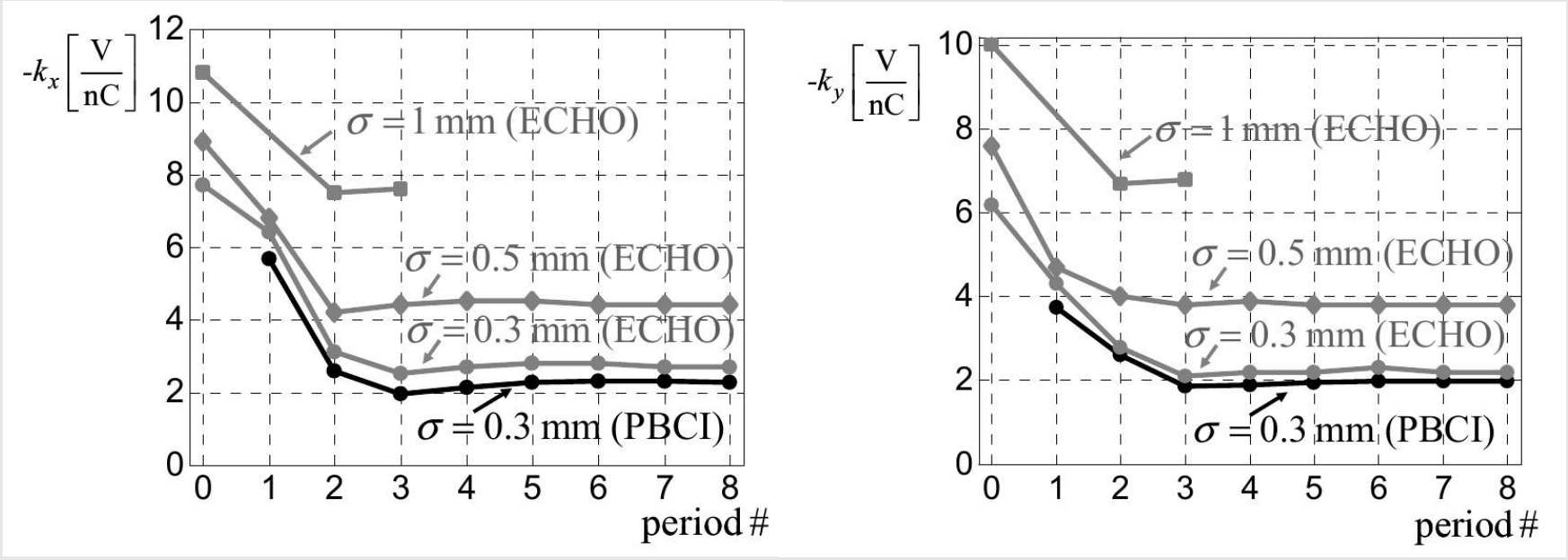
  $W_{x,y}(s=0)=0$ <- $\mathbf{W}(s) = 2\mathbf{k}\int_{-\infty}^{s} \lambda(s)ds$ $\qquad \mathbf{W}(s) \propto \mathrm{erf}(s/\sqrt{2}\sigma_z)$
- Can the coupler wake be inckuded in the cavity wake?
  - It is added as a separate term. It cannot be absorbed into the cavity wake
  - W_T cavity only depends on r while for the coupler the dependence on the distance is different in x and y
- References, see above and talk by Igor Zagorodnov, LCWS/ILC07 and EPAC08: TUPP019, MOPP013

MERLIN simulations - Coupler Wakefield (DK et al., EPAC08 - TUPP047)



old
old 1-2-1
new

Size of Transverse Coupler Wakefield in Periodic Structure



M. Dohlus et al., MOPP013

Compared to 21 V/nC , 19 V/nC in my simulations

Significantly smaller now! 1/10

Summary

- RF kick in new design would be 8x larger
  - stability issue (phase, voltage)?
- Transverse coupler wakefield in periodic structure looks much smaller.
  - Is it still a problem?
- It would be useful to collect all numerical RF kick calculations.

- Plans:
  - Simulations with smaller wakefield kick.
    - I do not have the numerical values, yet.
  - RF stability.