Wakefield of cavity BPM In ATF2

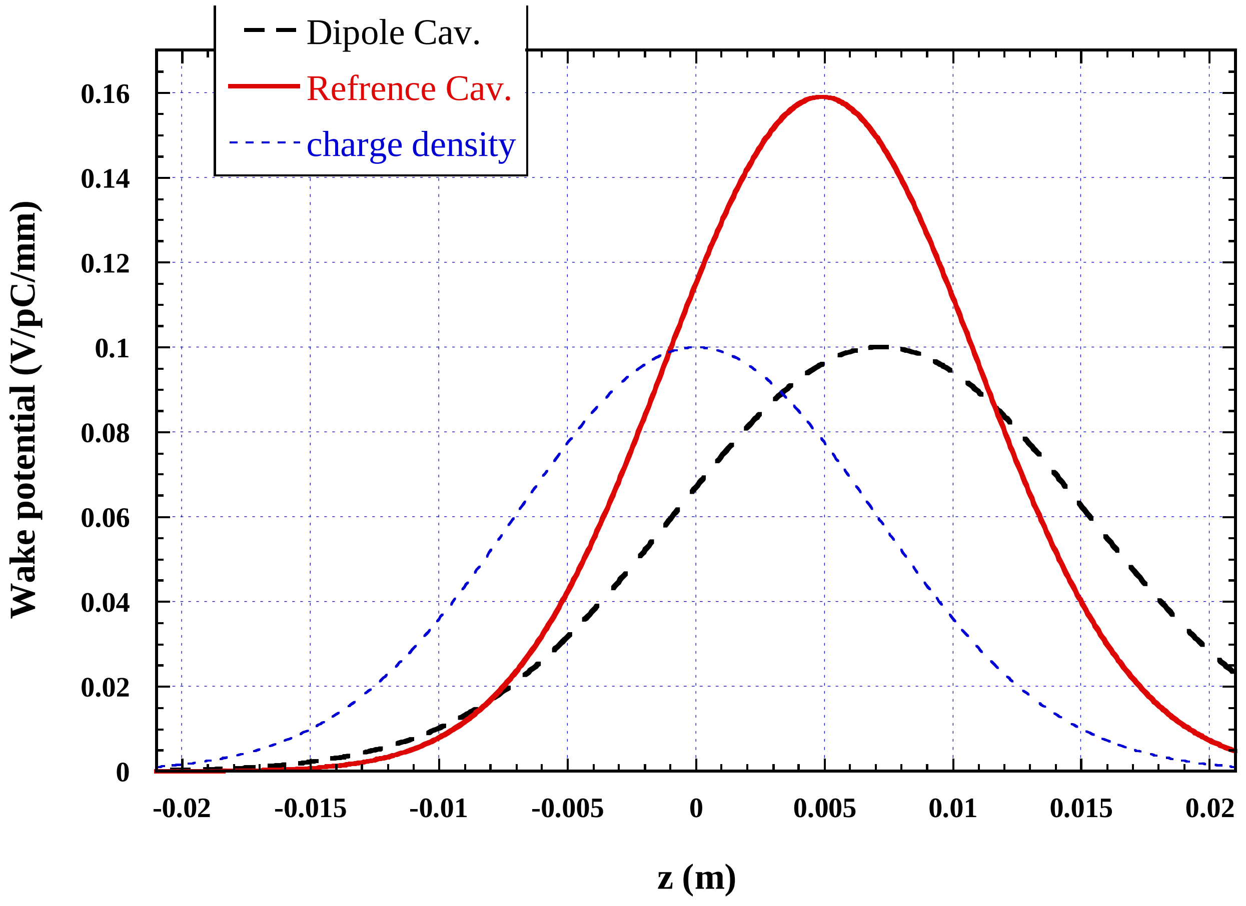
ATF2 Project Meeting

2013.01.23 K.Kubo

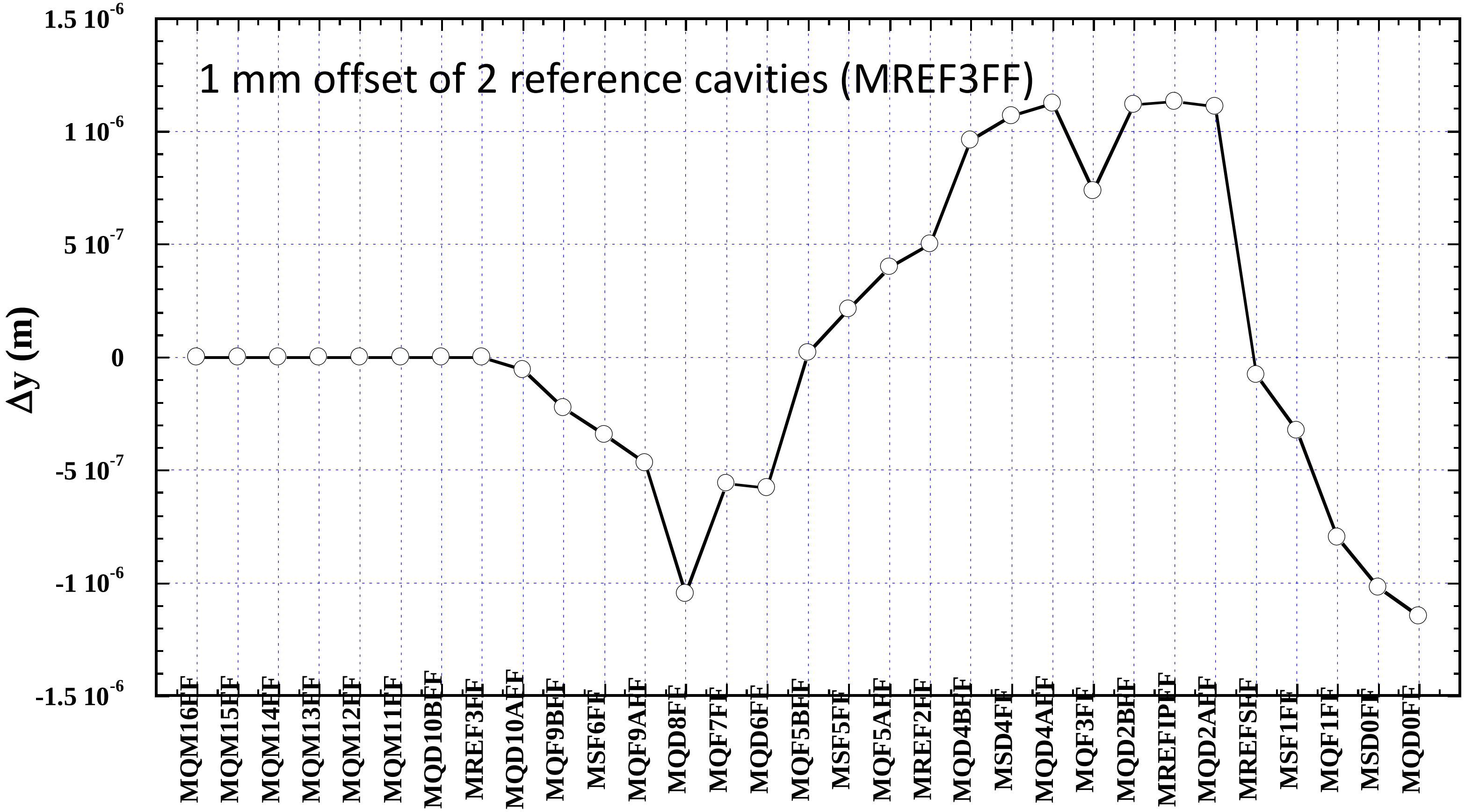
Simulations

- Use wakepotential based on caclulations by A. Lyapin
- Tracking simulation using SAD, emity=12 pm, sigmaE/E=0.008, sigmaZ=7 mm
- Looked RMS beam size at IP, and Modulation by IPBSM

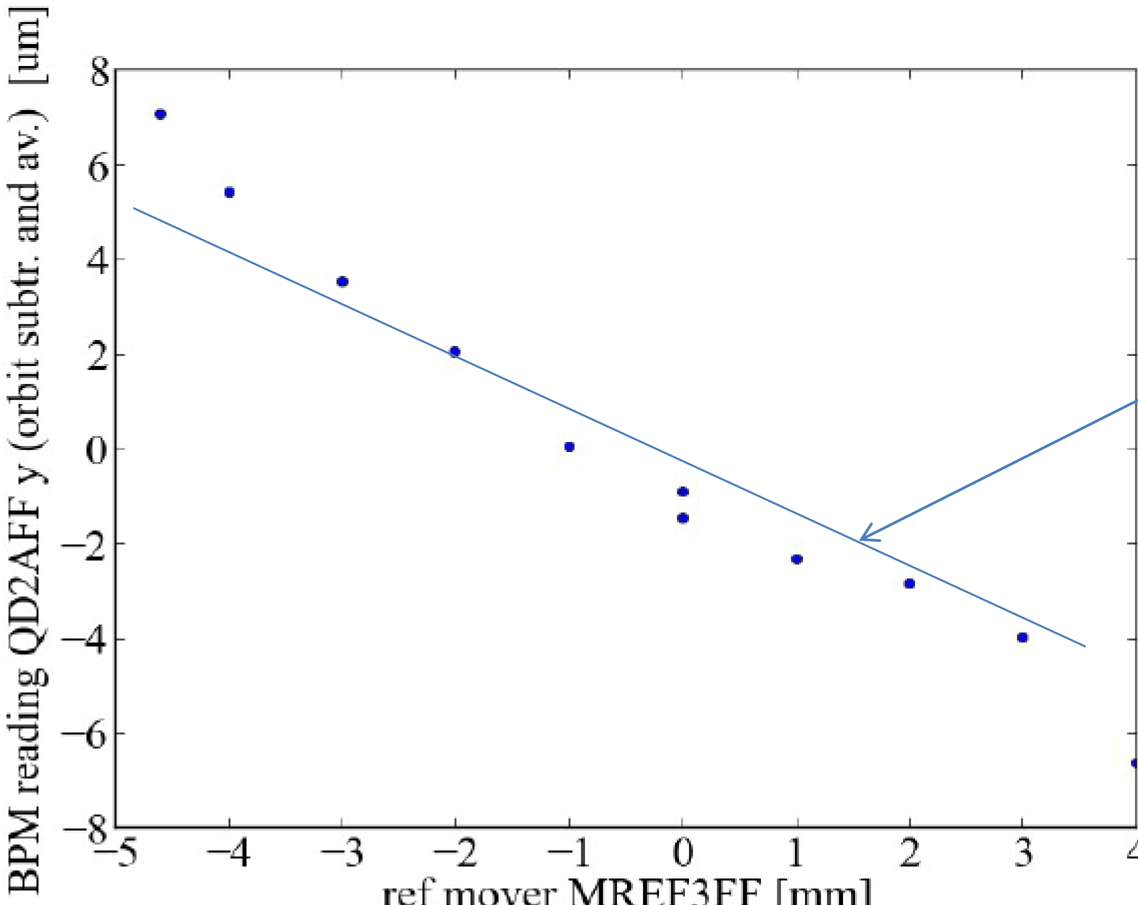
Wake potential used in simulations



Orbit response to MREF3FF position



Comparison with experiment

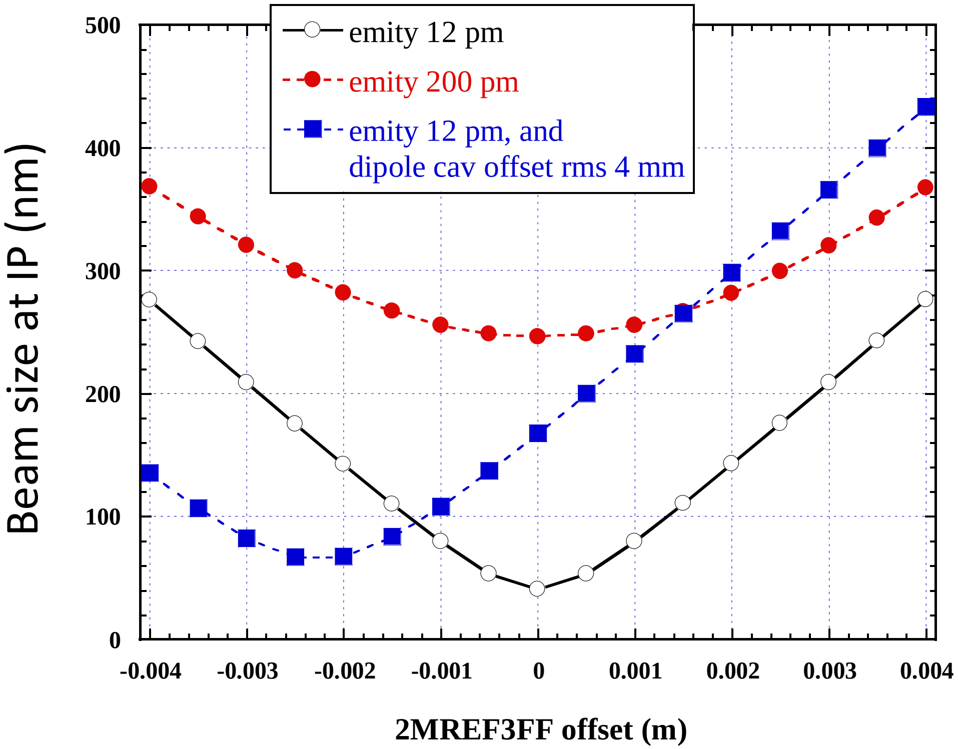


Calculation Assuming dipole wake. There may be quadrupole wake?

Jochem Snuverink, etc. 20121207 ATF operation meeting

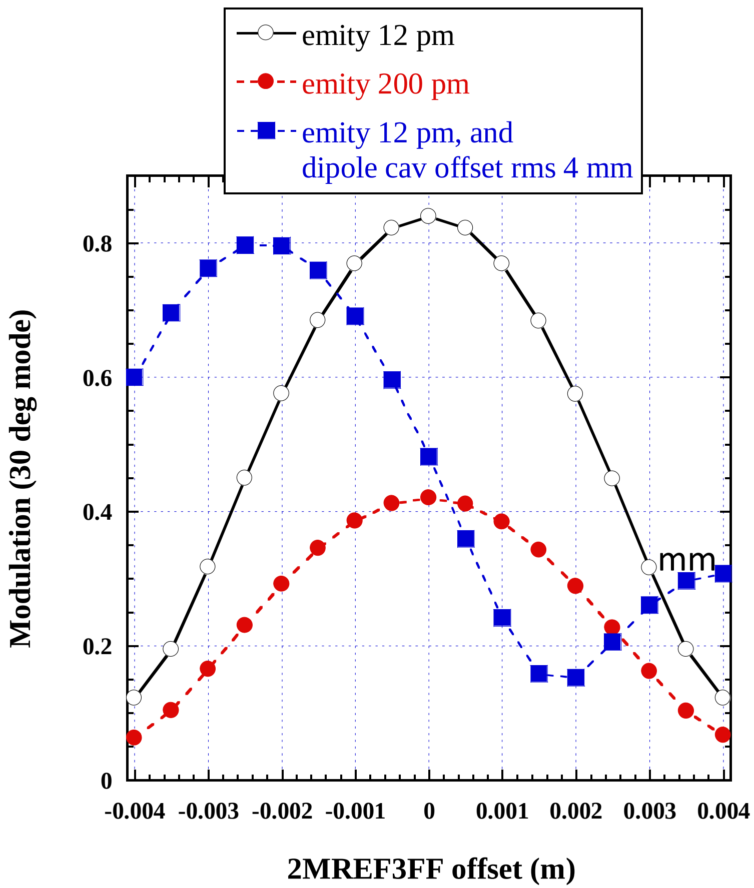
Beam size vs. ref cav offset

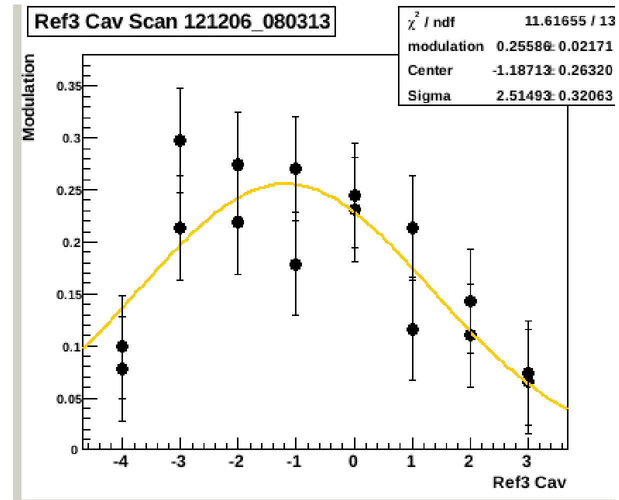
Black: No other errors
Red: Large emit_y (200 pm)
Blue: Large dipole cavity BPM random offset (rms 4 mm)

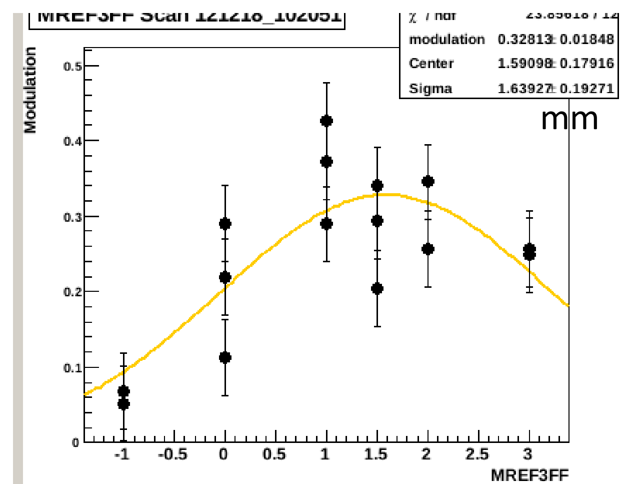


Dipole cavity wake can be mostly compensated by reference cavity wake.

Modulation vs. ref cav offset, simulation and experiment



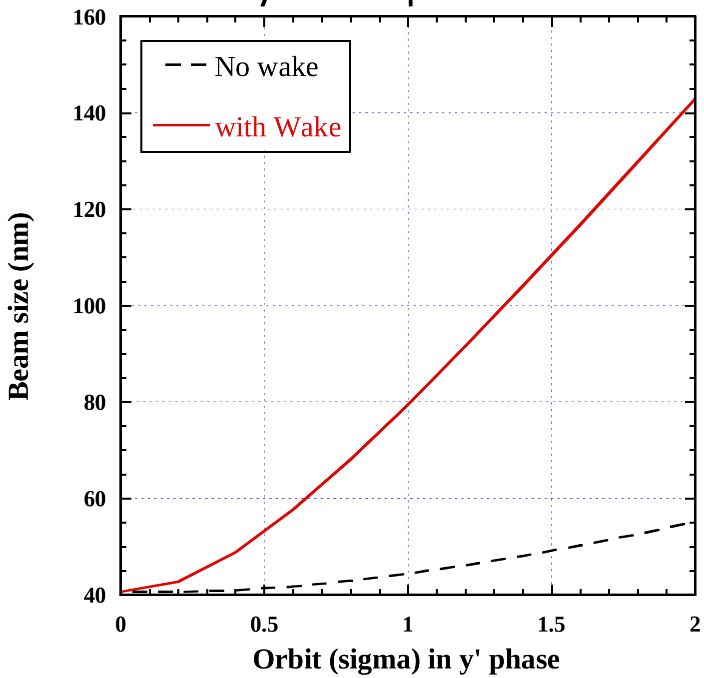




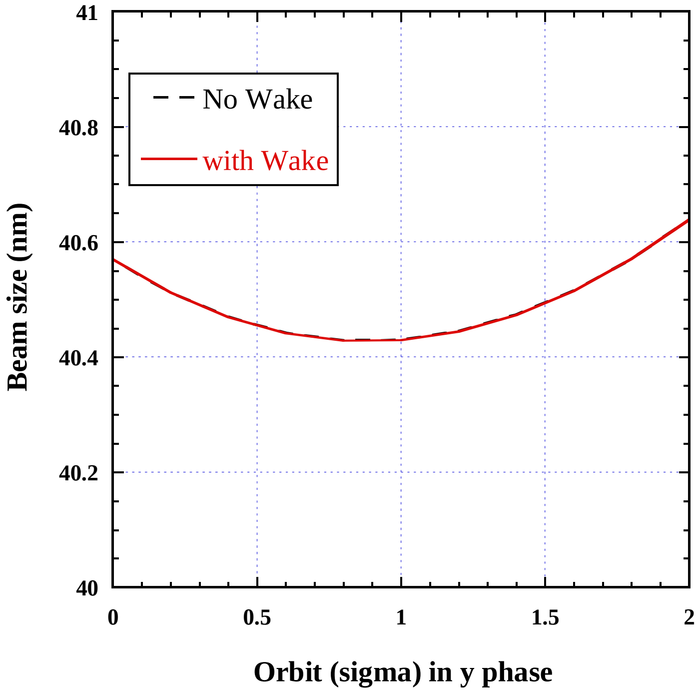
Cavity BPM wake cannot explain low modulation.
(If so, should have been corrected by reference cavity offset.) ???

Beam size vs. orbit

y'-at-IP phase

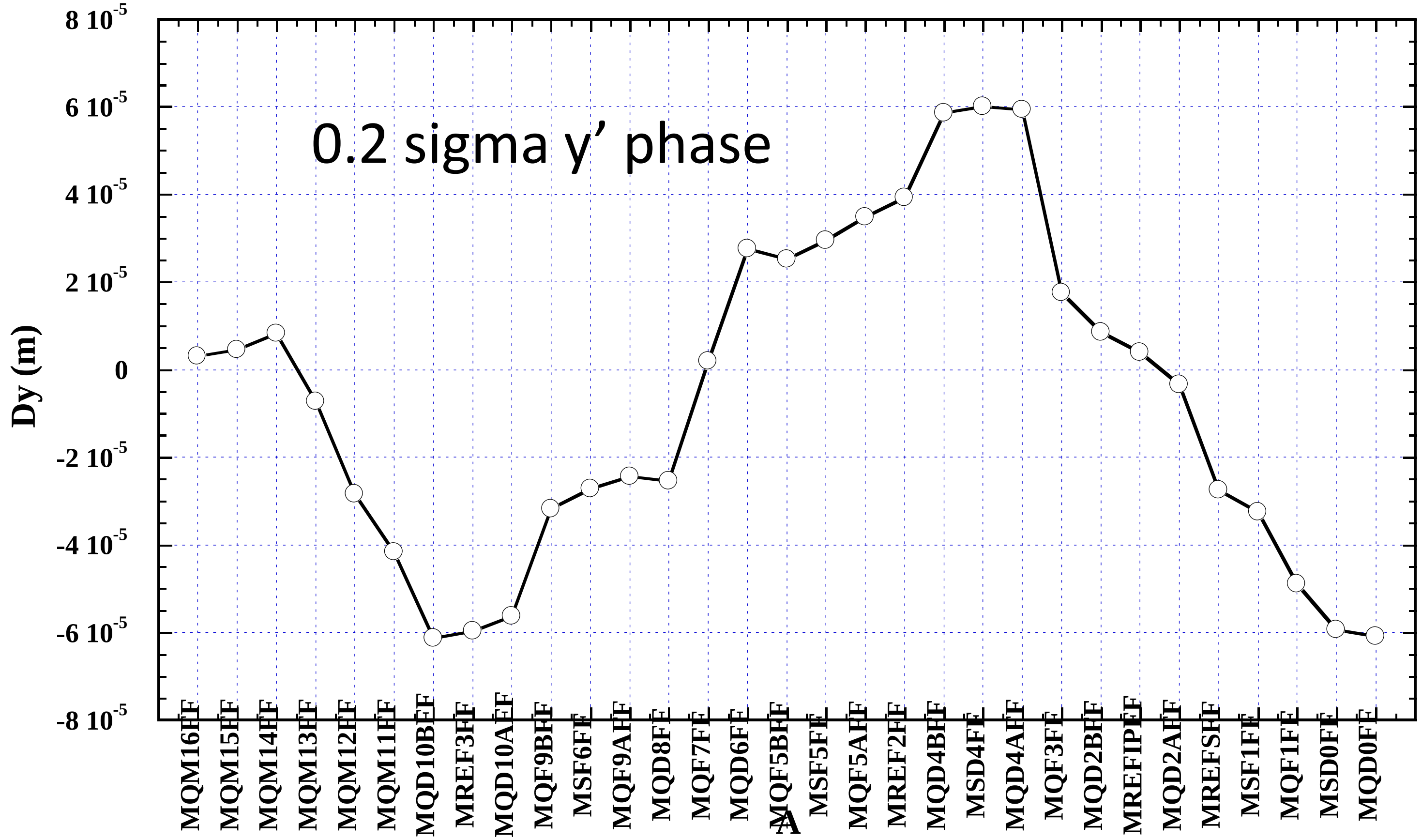


y-at-IP phase

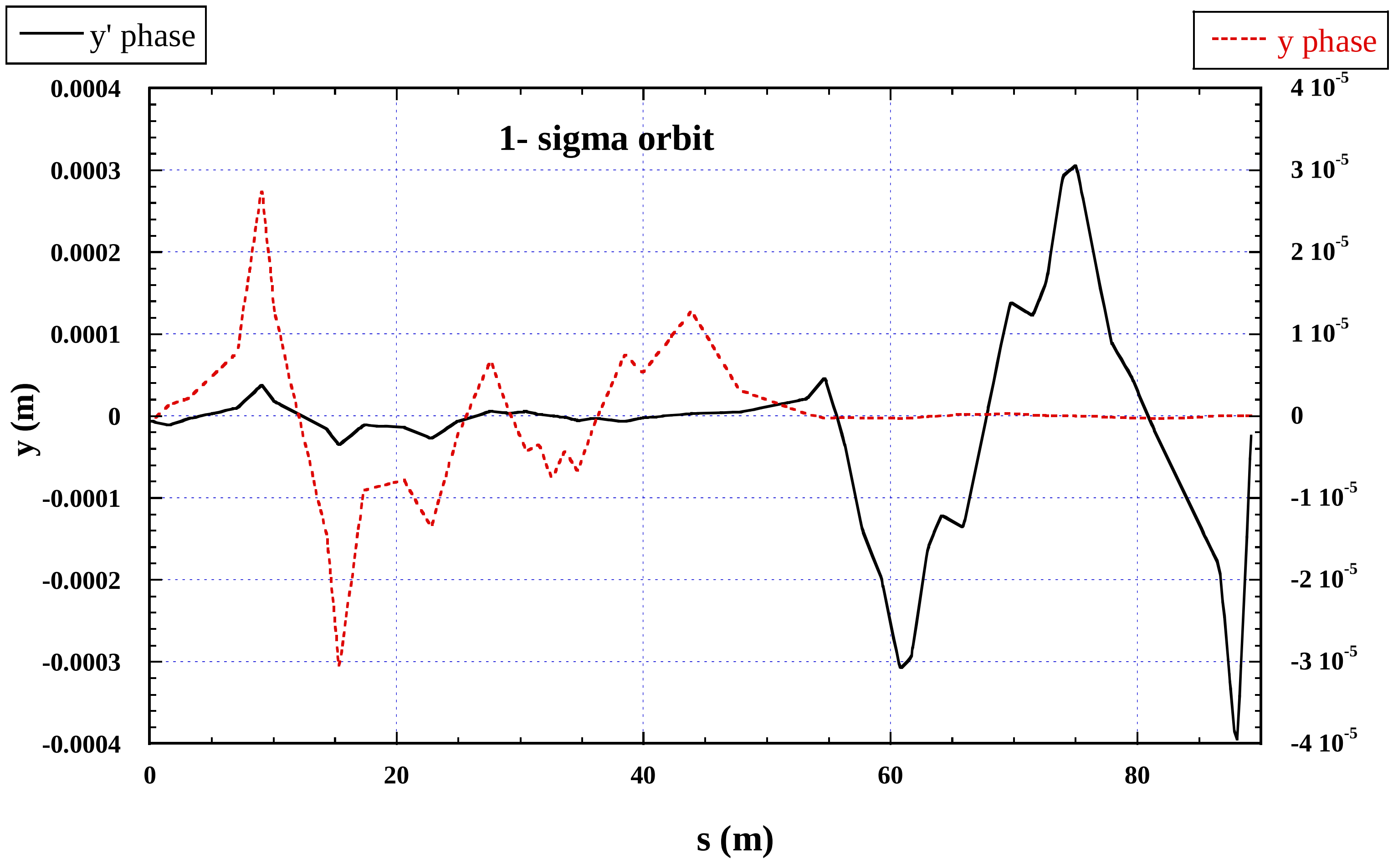


1-sigma orbit of y' (at IP) phase significantly affect beam size.
This will require small orbit jitter.

Orbit of y'-at-IP phase, in FF



Orbit of y’-at-IP phase, and y-at-IP phase in EXT-FF



SUMMARY, Discussion

- Experiment and calculation of orbit change vs. reference cavity offset seems consistent.
  - For small offset.
  - Higher order wake is significant for large offset (?)
- Experiment showed reference cavity offset had stronger effect to beam size than calculation. (?)
- Large beam size at large intensity
  - cannot be explained by wakefield of cavity BPMs. (?)
  - From something cannot be compensated by wakefield of reference cavities.
    - Wake of other structures?
    - Non-linear field?

Rough comparison of Effect of Wakefield ILC BDS, ILC RTML and ATF2

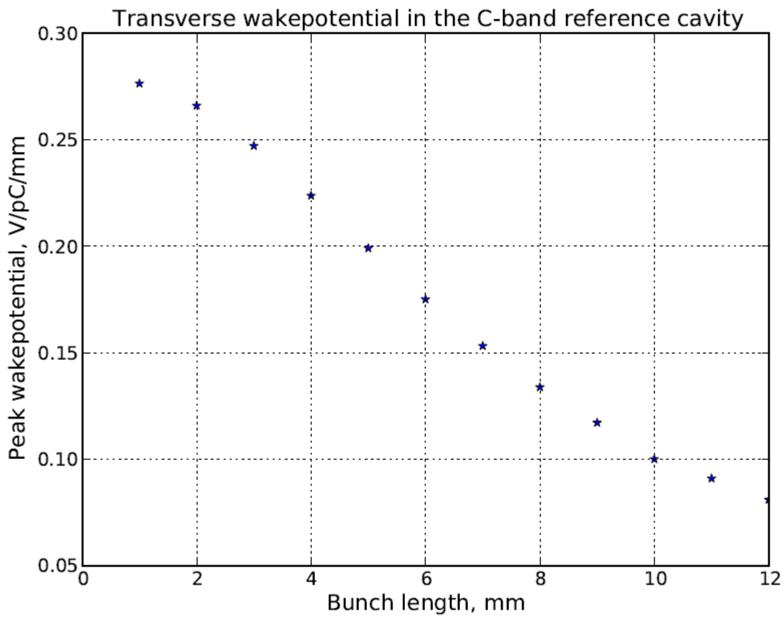
Proportional to

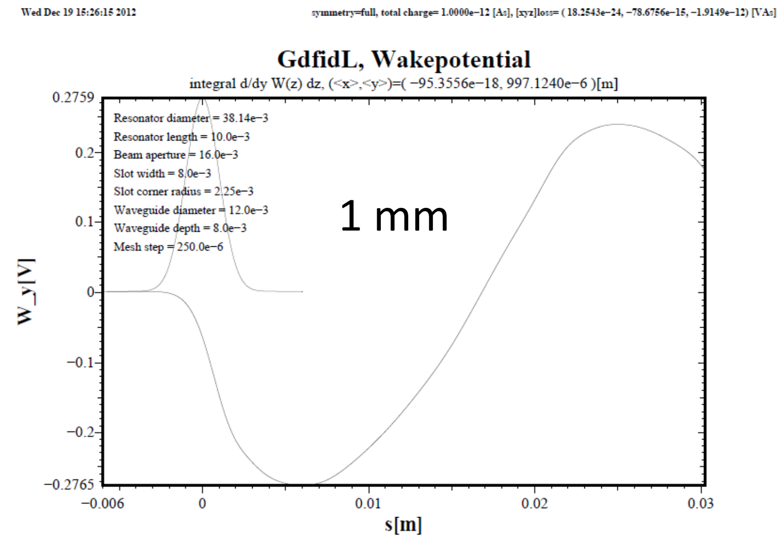
- 1/E_beam
- 1/σ' (angular divergence)
- offset of beam center – wake source center
  - Assume constant (misalignment) or,
  - Assume proportional to beam size (beam jitter)
- Length and/or Number of wake source
  - Number of Q magnets, or
  - Beam line length for resistive wall

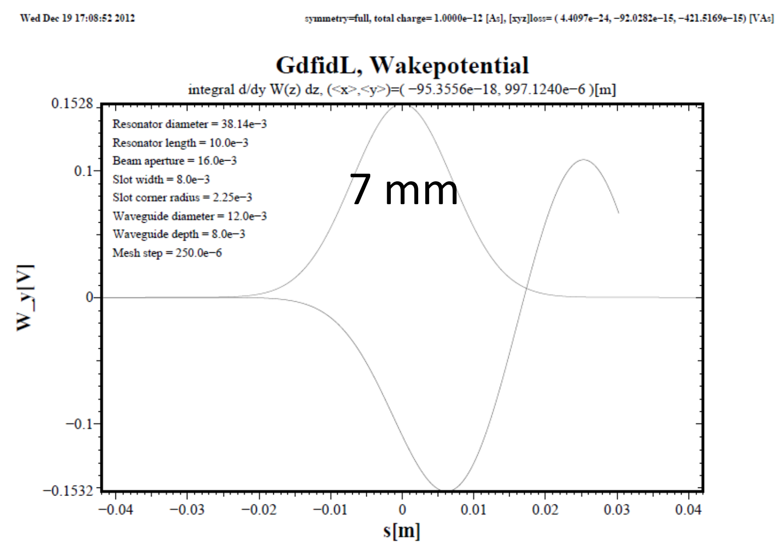
Depend on bunch length

- Cavity BPM (W_ILCBDS ~ W_ATF x 0.3 ~ W_ILCRTML x 0.3) (?)
- Resistive wall ~ 1/(bunch length) (?)

Peak vs. bunch length

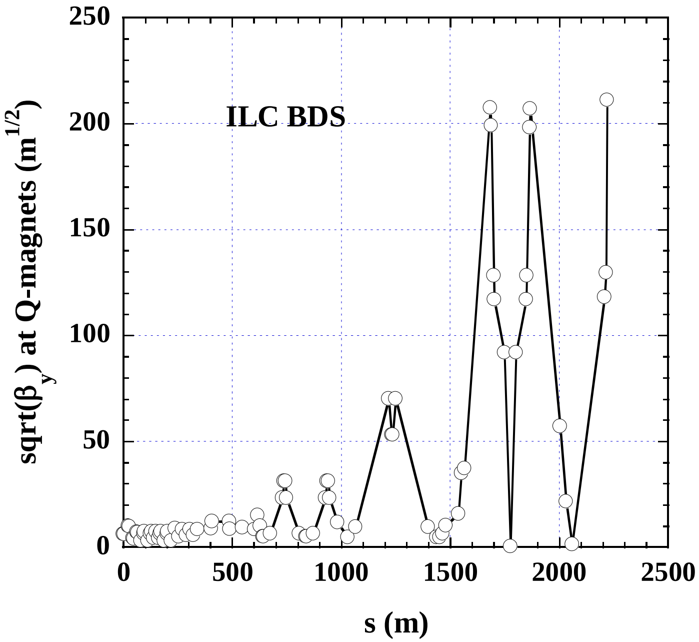






By A. Lyapin

Beta_y in ILC BDS and ATF2



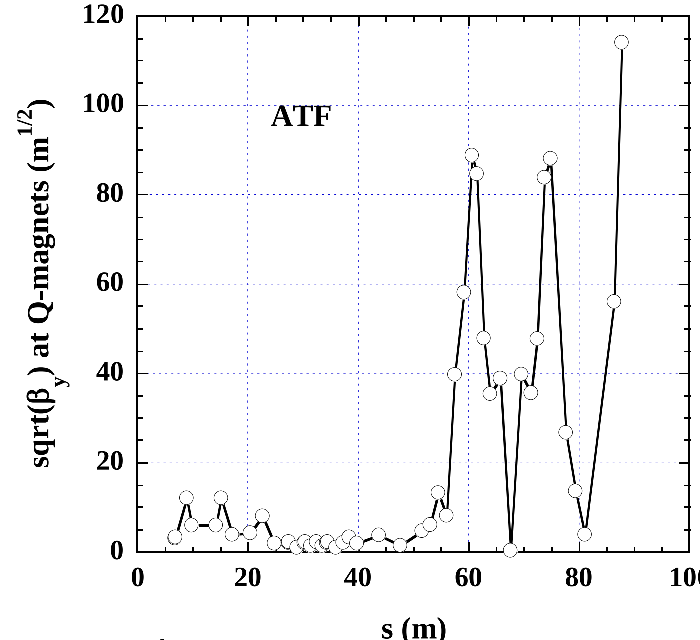
85 quads

$$\sum_{\text{Q-mag.}} \sqrt{\beta_y} = 2{,}939 \ \text{m}^{1/2}$$

$$\sum_{\text{Q-mag.}} \beta_y = 347{,}216 \text{m}$$

$$\int ds \sqrt{\beta_y} \sim 89{,}000 \ \text{m}^{3/2}$$

$$\int ds \beta_y \sim 8{,}900{,}000 \ \text{m}^2$$



46 quads

$$\sum_{\text{Q-mag.}} \sqrt{\beta_y} = 1{,}024 \ \text{m}^{1/2}$$

$$\sum_{\text{Q-mag.}} \beta_y = 62{,}660 \text{m}$$

$$\int ds \sqrt{\beta_y} \sim 4{,}000 \ \text{m}^{3/2}$$

$$\int ds \beta_y \sim 1{,}100{,}000 \ \text{m}^2$$

ILC RTML Return Line

- Beta ~ 100 m,
- Beam line length ~ 15 km,
- Beam energy 5 GeV,
- Bunch length ~ 6 mm,
- Number of Q-magnets ~800

Wake effect comparison.
Assume Same wake source at every Q-magnet. Same bunch charge.

Same beam – wake source offset

	ILC BDS	ILC RTL	ATF EXT/FF
1/E_beam (1/GeV)	1/250	1/5	1/1.3
Effect of bunch length	0.3 ?	1	1
$1/\sqrt{\varepsilon_y}$ (m^(-1/2))	$1/\sqrt{8\times10^{-14}}$	$1/\sqrt{2\times10^{-12}}$	$1/\sqrt{1.2\times10^{-11}}$
$\sum_{\text{Q-mag.}}\sqrt{\beta_y}$ (m^(1/2))	3,000	8,000	1,000
Total (Relative to ATF)	0.057 ?	5.1	1

Beam – wake source offset scale as beam size

	ILC BDS	ILC RTL	ATF EXT/FF
1/E_beam (1/GeV)	1/250	1/5	1/1.3
Effect of bunch length	0.3 ?	1	1
$\sum_{\text{Q-mag.}}\beta_y$ (m)	350,000	80,000	63,000
Total (Relative to ATF)	0.0087 ?	0.33	1

Wake effect comparison.

Resistive wall, assume same aperture and material. Same bunch charge

Same beam – pipe center offset

	ILC BDS	ILC RTL	ATF EXT/FF
1/E_beam (1/GeV)	1/250	1/5	1/1.3
Effect of bunch length	20 ?	1	1
$1/\sqrt{\varepsilon_y}$ (m^(-1/2))	$1/\sqrt{8\times10^{-14}}$	$1/\sqrt{2\times10^{-12}}$	$1/\sqrt{1.2\times10^{-11}}$
$\int ds\sqrt{\beta_y}$ (m^(3/2))	89,000	150,000	4,000
Total (Relative to ATF)	28 ?	24	1

Beam – pipe center offset scale as beam size

	ILC BDS	ILC RTL	ATF EXT/FF
1/E_beam (1/GeV)	1/250	1/5	1/1.3
Effect of bunch length	20 ?	1	1
$\int ds\beta_y$ (m^2)	8,900,000	1,5000,000	1,100,000
Total (Relative to ATF)	0.84 ?	0.35	1

Back up

Y at IP distribution with reference cavities 2.5 mm offset