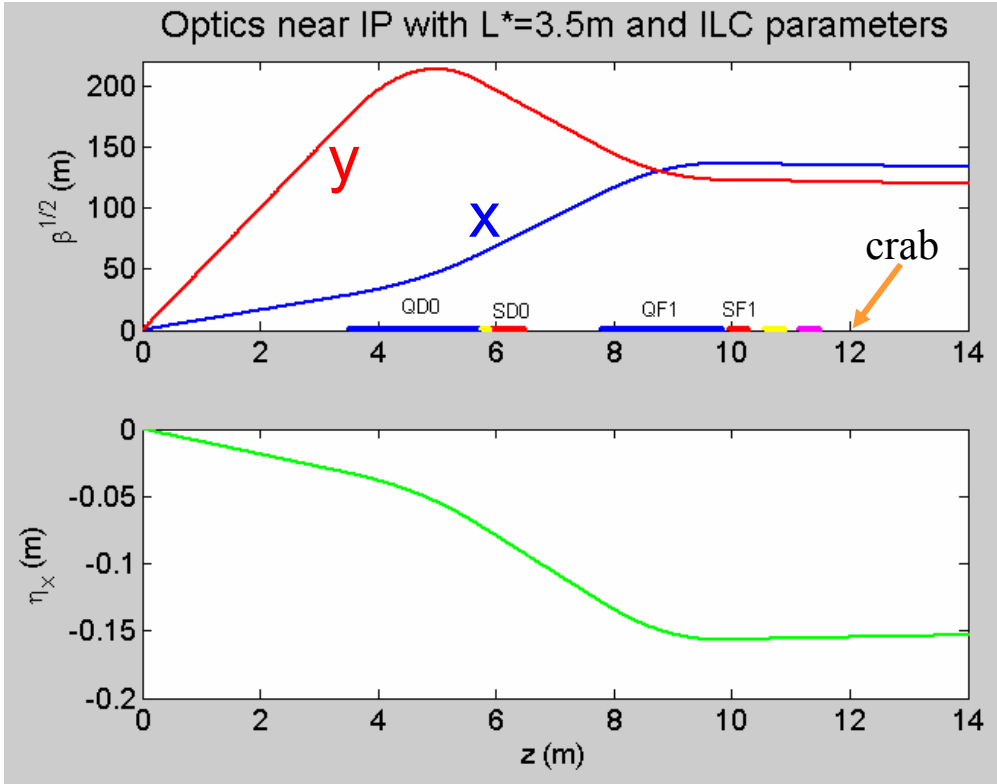
Crab cavity effects on y-beam size for ILC

- Crab cavity produces the x' kick, which creates x orbit through the FD sextupoles
- This will cause yy' and other beam distortions at the IP, correlated with z
- For NLC parameters these distortions were evaluated and found small
- Distortions are proportional to bunch length, so need to make this evaluations again



Parameters:

β^*=15 / 0.4 mm $\gamma\varepsilon$=10e-6 / 3e-8 m

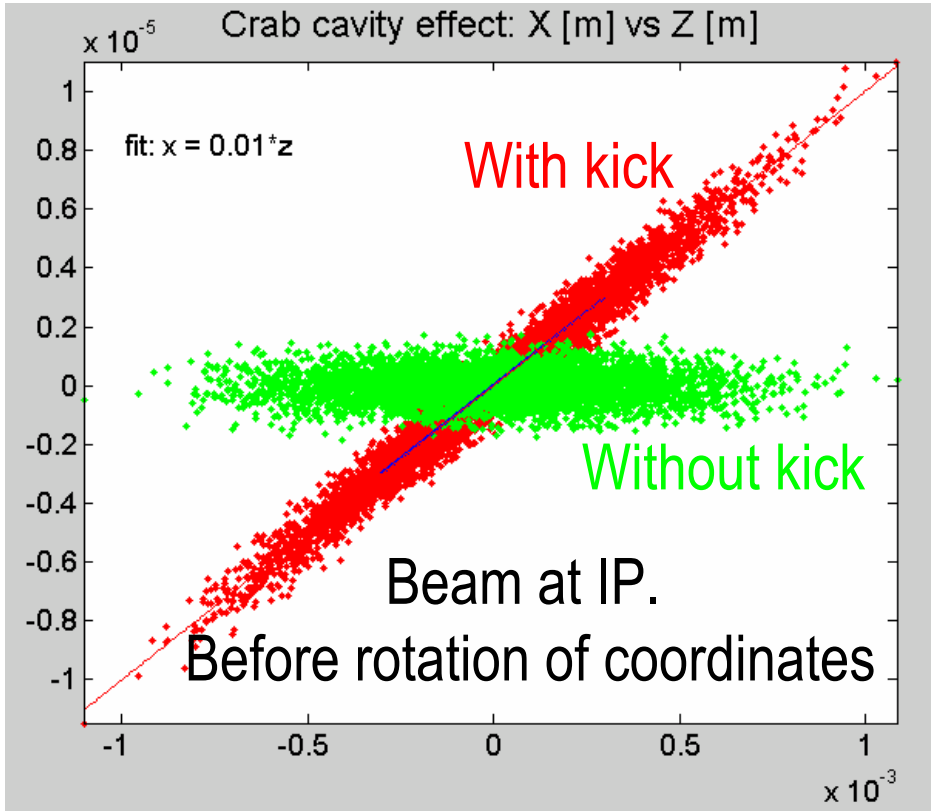
σ^* = 553 / 5 nm

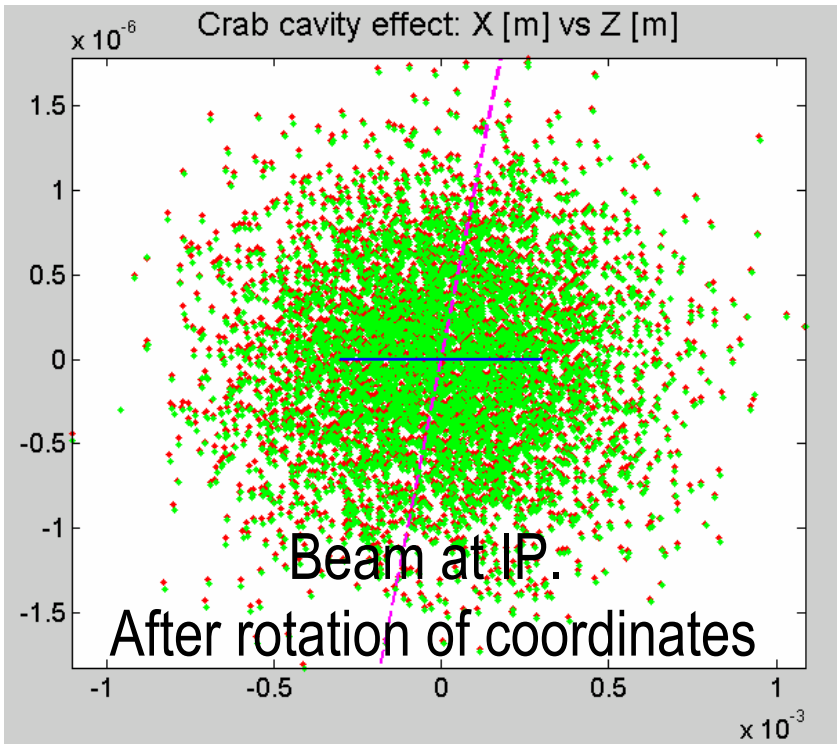
σ_z = 0.3 mm σ_E= 1.5e-3

crab cavity located 12m from IP

Simulation of crab cavity effects

- Use entire BDS optics
- Model crab cavity as x' kick ~z and ~1/E
- Rotate coordinates at IP by θ_c

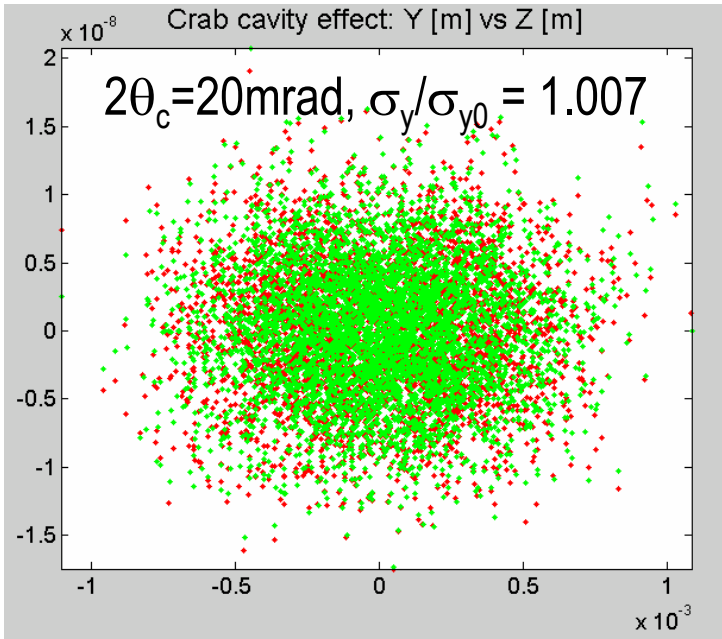


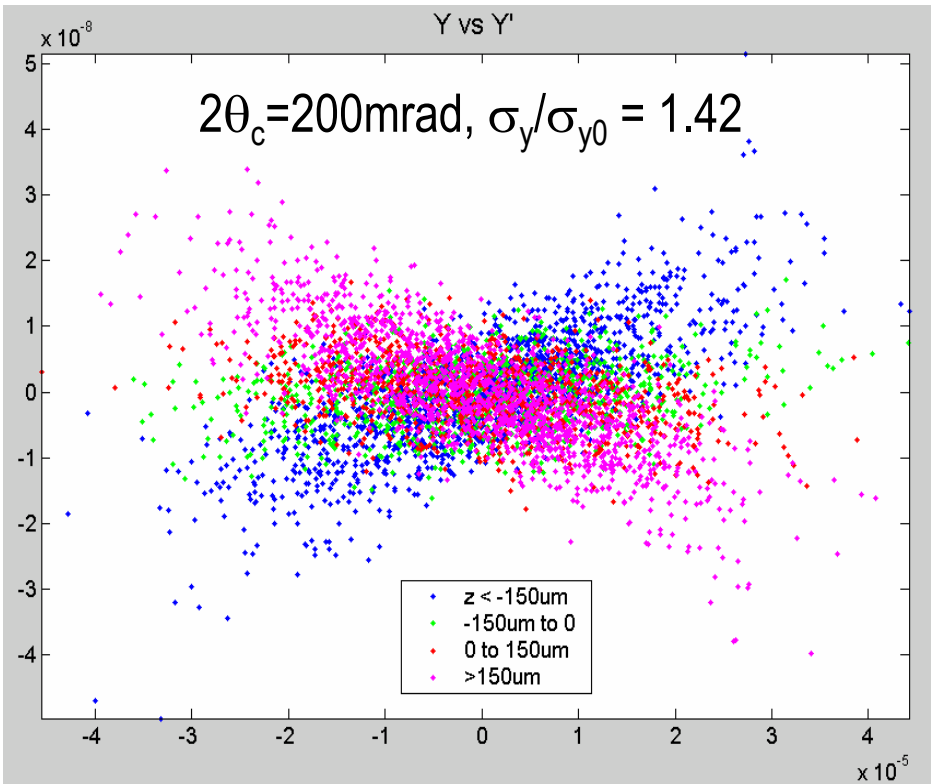


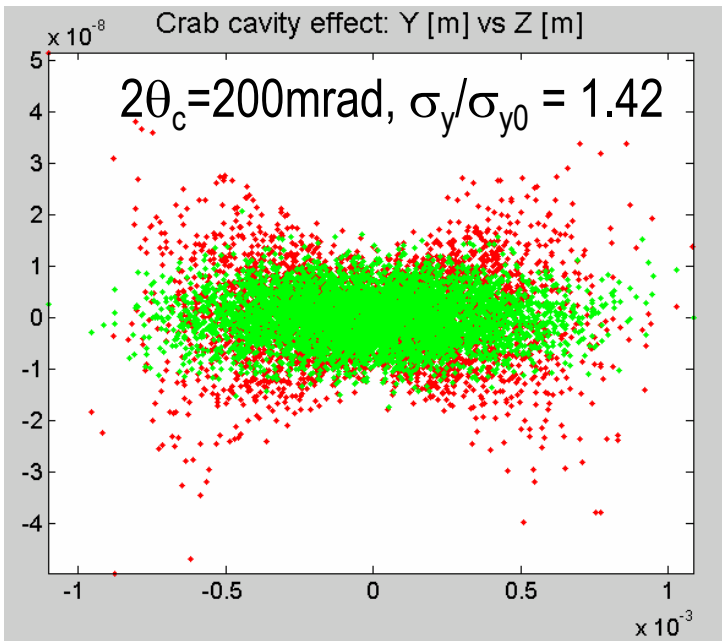
Track 5K particles, compare beams with and without crab kick

Crab cavity effect on the beam

- For 20mrad total crossing angle the effect is barely visible
- For 200mrad, clear effect
- Increase of Y size caused by yy' proportional to z

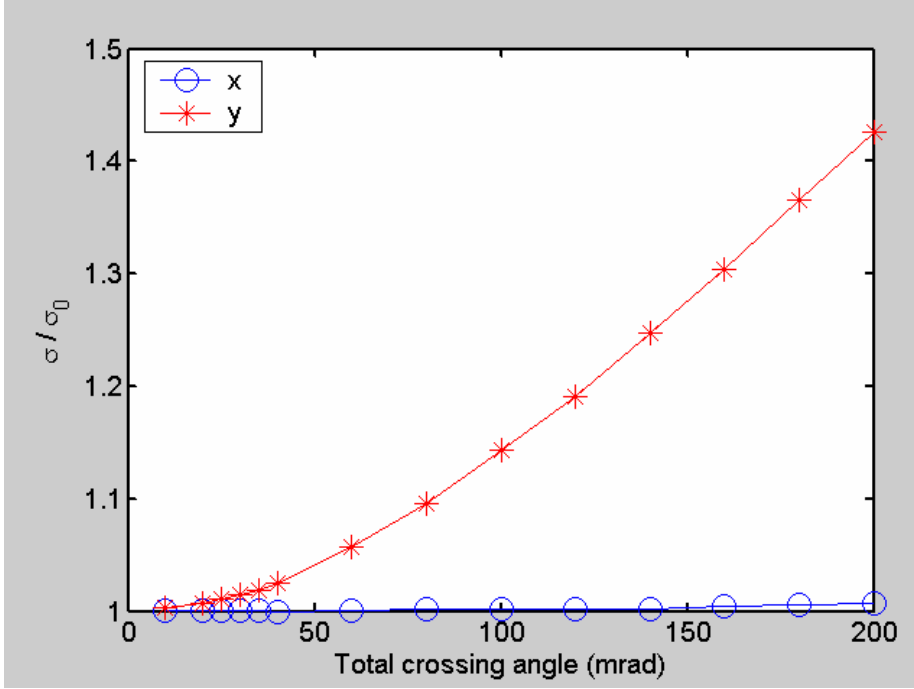


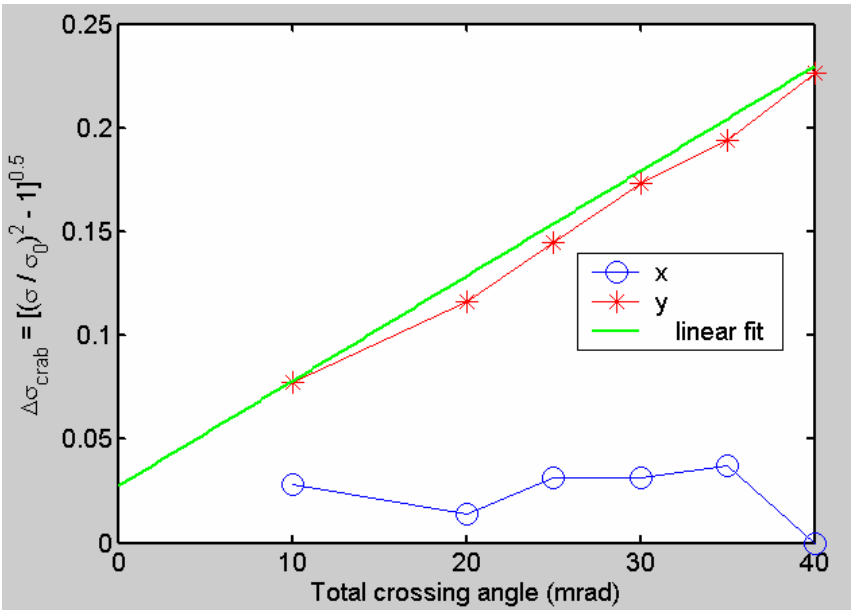


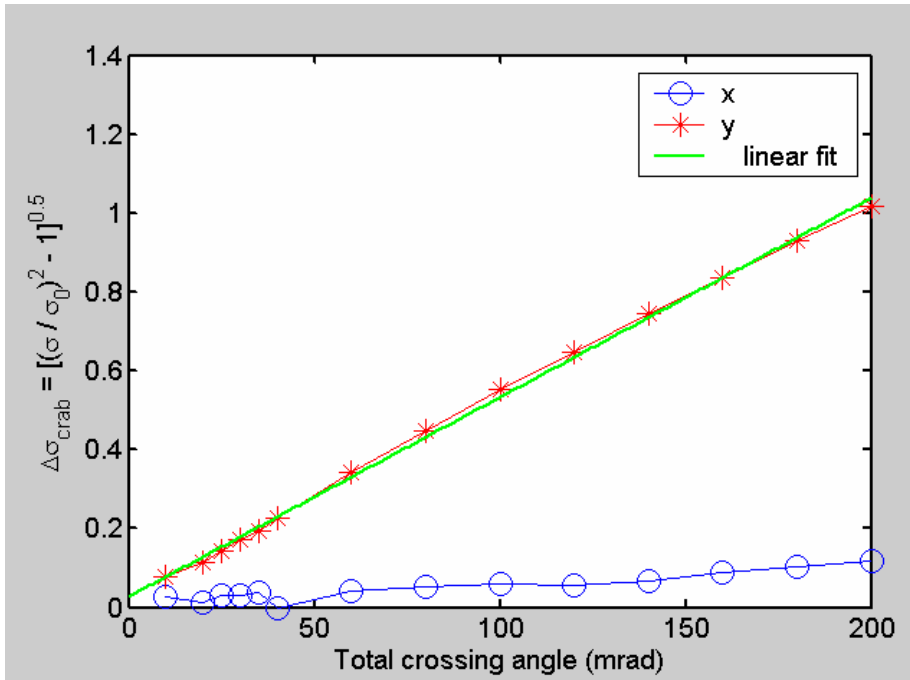


Crab cavity effect versus crossing angle

- With ILC parameters and 20-25mrad crossing angle, the Y size distortion
  $\Delta\sigma_{crab}$ ~ 0.12-0.15
- Effect on the beam size < 1%
- However…







Crab cavity effects vs parameters

- The Y size distortion $\Delta\sigma_{crab}$ ~0.12 with 20mrad, which still gives a small effect (<1%) on the beam size
- There is a factor of 4 of margin, until the effect becomes ~10%
- However, with different parameters the effect can become noticeable.
- Some of the dependencies: $\Delta\sigma_{crab} \sim \theta_c \, \sigma_z \, \sigma_y, / \, (\sigma_y \cdot \eta'_x \cdot L_*^2)$

  things that make this effect worse:

  longer bunch

  smaller beta-Y

  smaller IP dispersion (NLC energy upgrade: reduce η'_x twice)

  shorter L*

- => Need to be careful with choice of parameters for larger angle IR, since we are not far from the edge where this effect may become the dominant one

Compensation of crab cavity effect on Y beam size. First look.

- Install additional crab cavity, ΔL from the first cavity
- Kick of the main cavity $(1+\Delta K)$, kick of the second is $-\Delta K$
- When $\Delta K = T_{323}/ (\Delta L * T_{313})$, then the Y size distortion cancel
  - For our case, T_{323} =54.5, T_{313}=4.39 and if ΔL = 16m, then ΔK=0.75

Tested with $2\theta_c$=200mrad, obtained: σ_x/σ_{x0} = 1.179, σ_y/σ_{y0} = 1.001

(without compensation σ_x/σ_{x0} = 1.007 , σ_y/σ_{y0} = 1.42)

First look have shown that compensation is possible (at least partial – x size distortion is now 18%). This could be improved, but it is better not to have to rely on such exotic compensation, since the crab cavity system becomes more difficult, the needed kick from the first cavity ~doubles, etc.