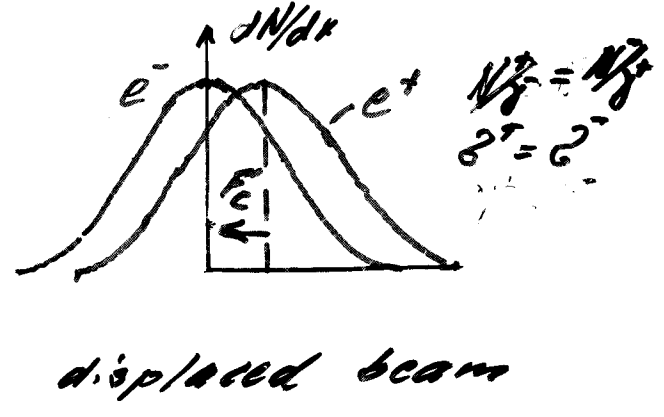
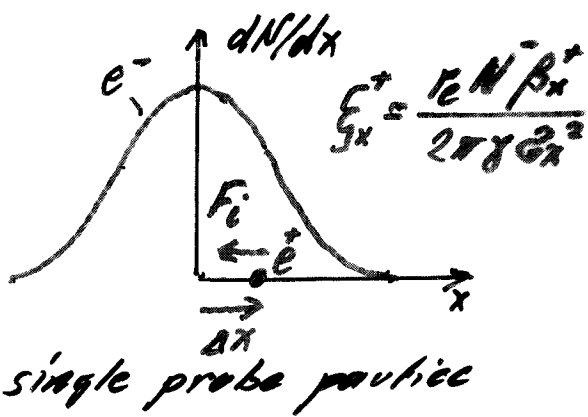


Measuring beam-beam mode frequencies for diagnostics.

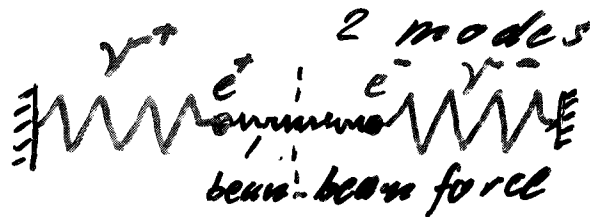
Beam-beam force ( $e^+, e^-$ ), rigid bunches, small effect



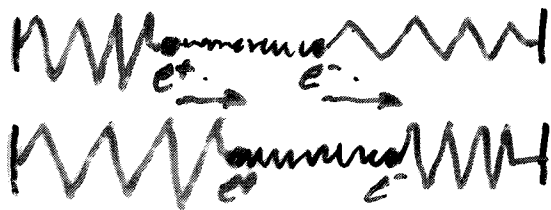
$$F_c = \frac{1}{2} F_i$$

Beam-beam modes

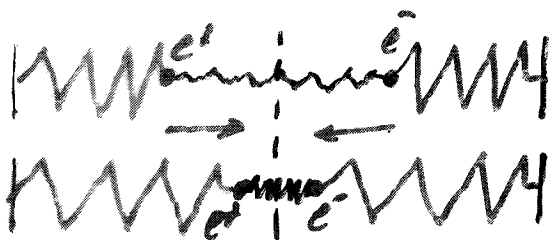
1 rigid bunch per beam  
1 interaction point



$$\gamma_0^+ = \gamma_0^- = \gamma_0$$

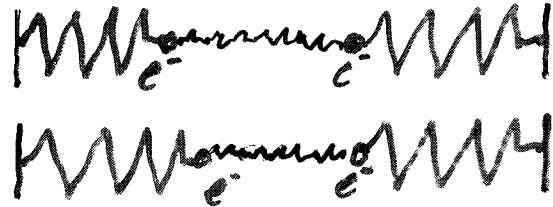


$$\gamma_{\beta 0} = \gamma_0, \Delta \gamma = 0$$



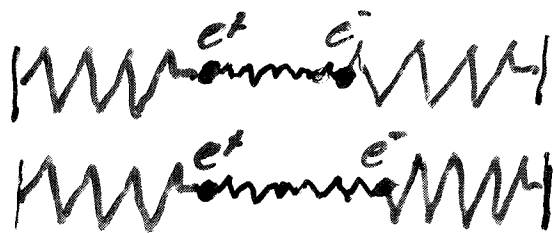
$$\gamma_{\beta 0} = \gamma_0 + \xi, \Delta \gamma = \xi$$

$$\gamma_0^+ \neq \gamma_0^-, |\gamma_0^+ - \gamma_0^-| \gg 5$$



excite at  $\gamma \approx \gamma^+$

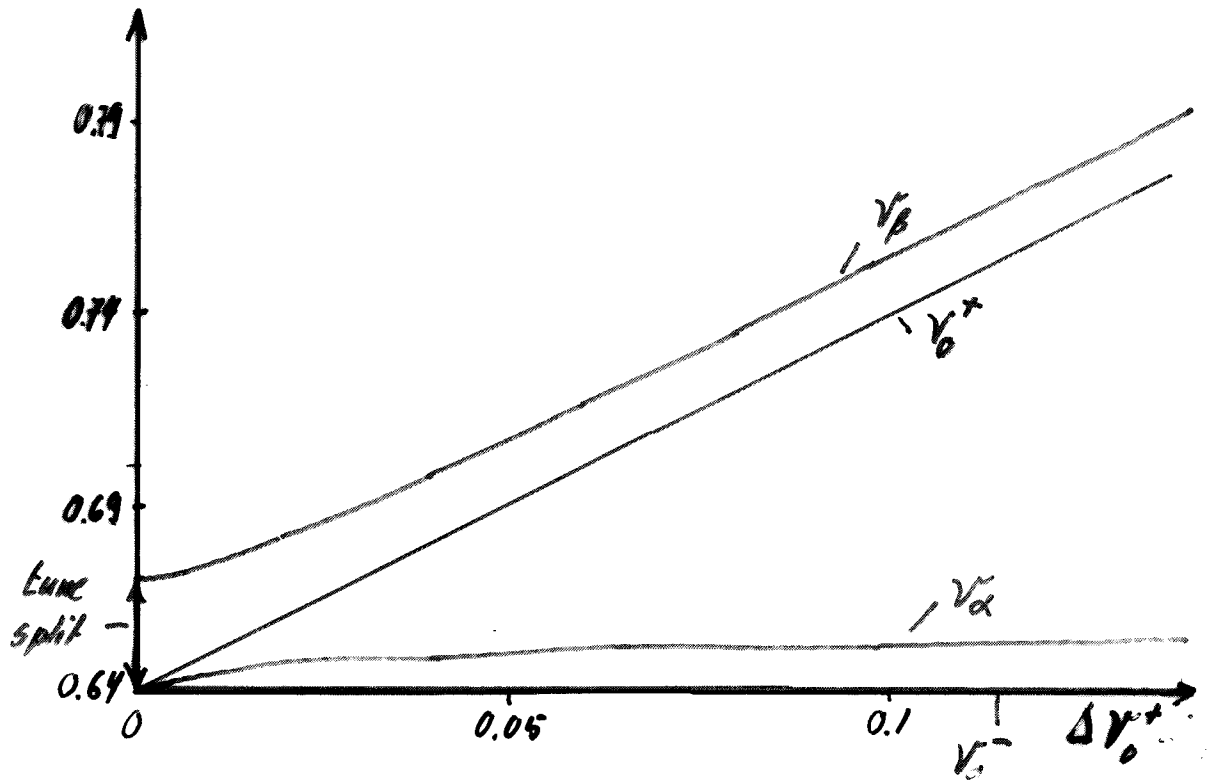
$$\gamma_{\alpha} = \gamma^+ + \frac{1}{2} \xi$$



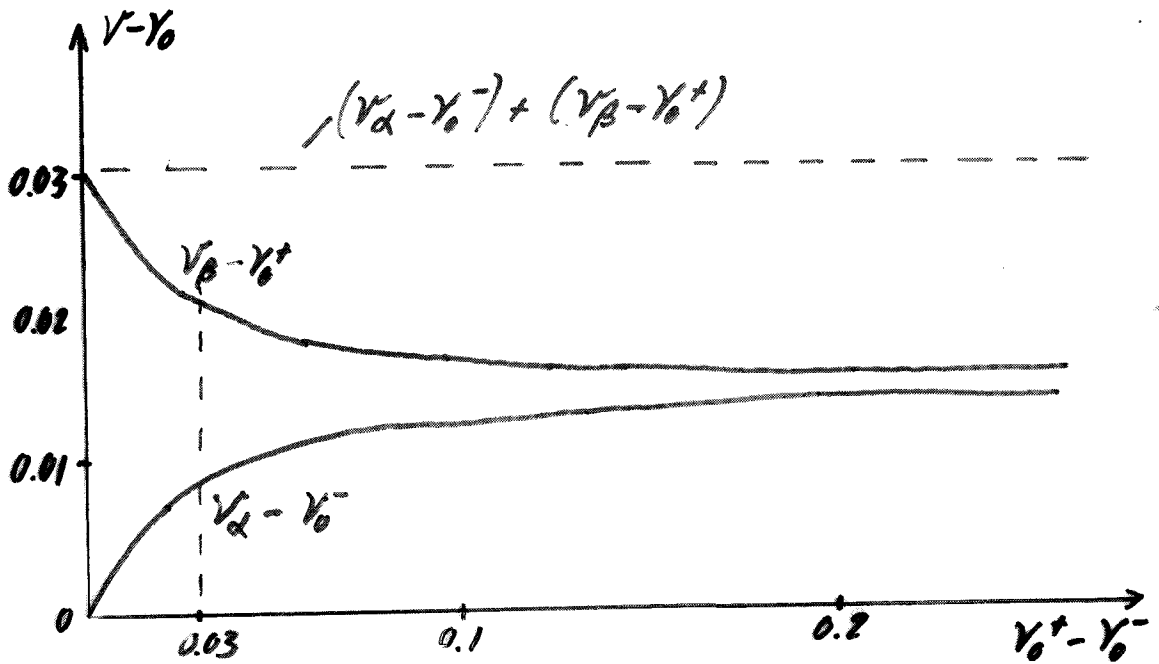
excite at  $\gamma \approx \gamma^-$

$$\gamma_{\beta} = \gamma^- + \frac{1}{2} \xi$$

Beam-beam mode tunes as a function of tune difference HER-LEP  
 $\xi = \Delta\nu = 0.03$  for both beams  $\xi^+ = \xi^-$  assumption



ref SPEAR group 1974



Refinement: no-rigid beam, Yokoyama factor  
 larger effect,  $\nu_0$ -dependence, dynamic  $\beta^*$

9 Dec 88

Moving HER nu $\gamma$  up by 0.0037 to match LER nu $\gamma$

Measurements

Unshifted  $\nu$ 's

	X	Y
LER	79.062	87.680
HER	76.609	87.703

Shifted  $\nu$ 's (w/ 1 mA LER on 0.35 mA HER colliding)

LER	LER	$f_8 = 87.909$	$f_7 = 89.2906$
LER	HER	$f_2 = 87.9219$	$\sim$

We see  $\beta$  and  $\pi$  modes on LER- $\gamma$  we find  $\Delta\nu_{\beta-\beta} = .0096$

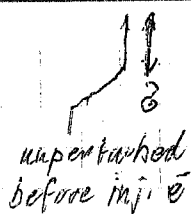
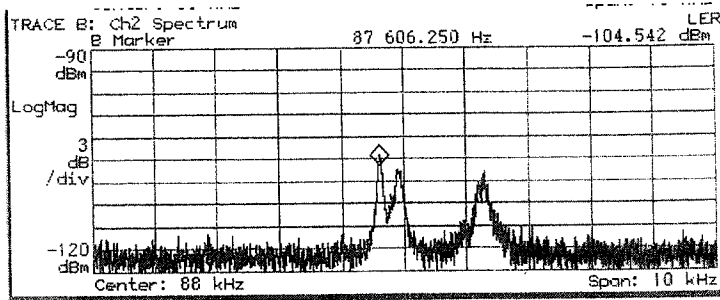
$$\xi \approx \frac{\nu_{\pi} - \nu_{\beta}}{1.25} = 0.0077$$

Dump HER

$$\text{LER } f_{\gamma} = 87.606$$

-4 mV

We fill  $e^-$  again,  $\beta$  mode moves a little, and  $\pi$ -mode appears



PEP-II

$$\nu^+ = \nu^-$$

measure  $\Delta\nu$   
by comparing  
with pilot bunch

$$\xi_x = 0.0167$$

$$\xi_y = 0.0091$$

For comparison

$$\nu^+ \approx \nu^-$$

$$\xi_y = .0073$$

'good' agreement with expectations

Yokoya factor used 1.25