Intensity Limitiations in LEP

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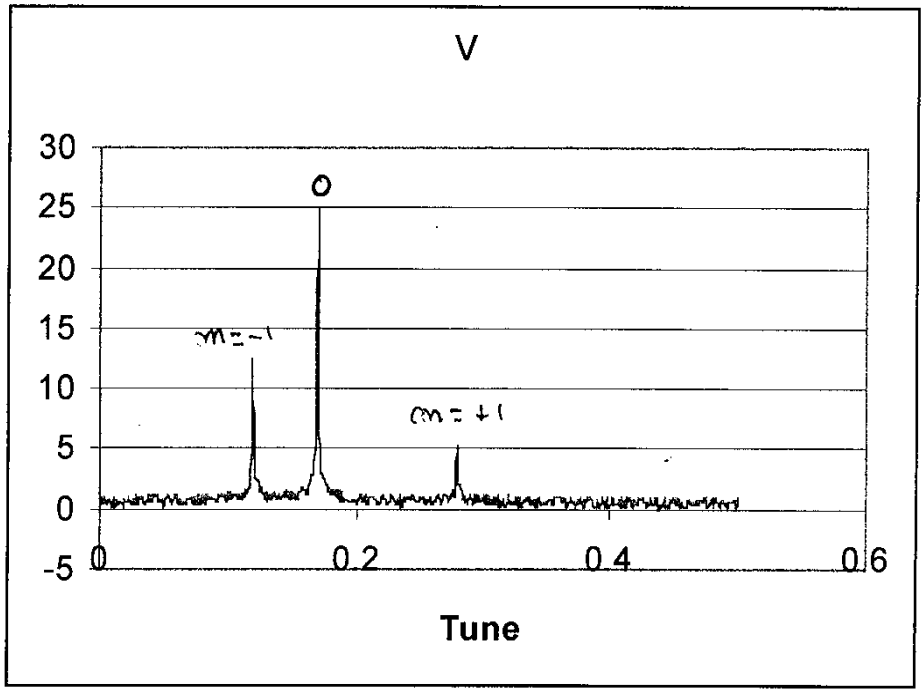
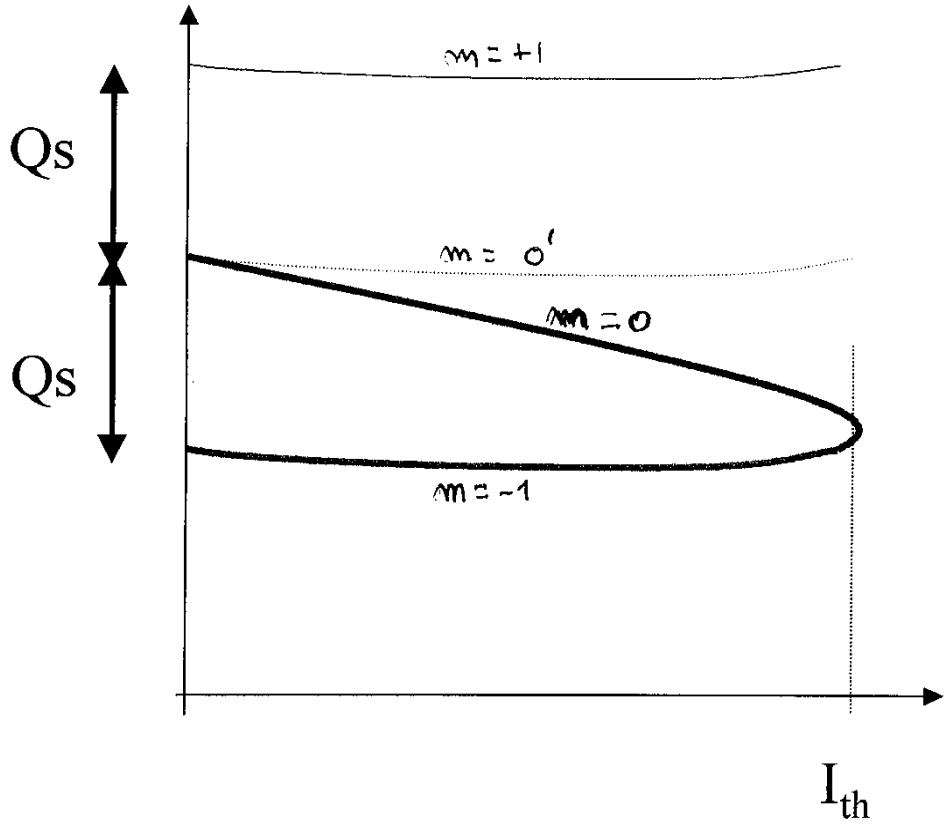
Spectra



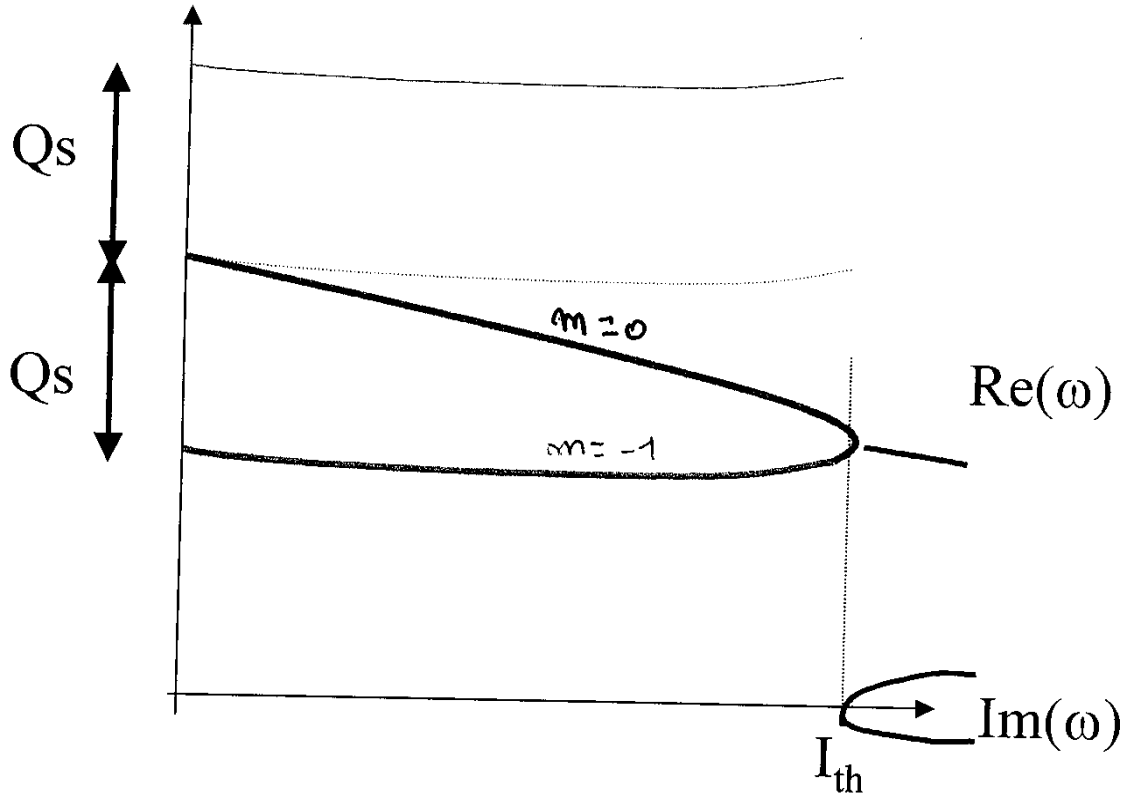
External excitation
High chromaticity (10)
200 μA/bunch

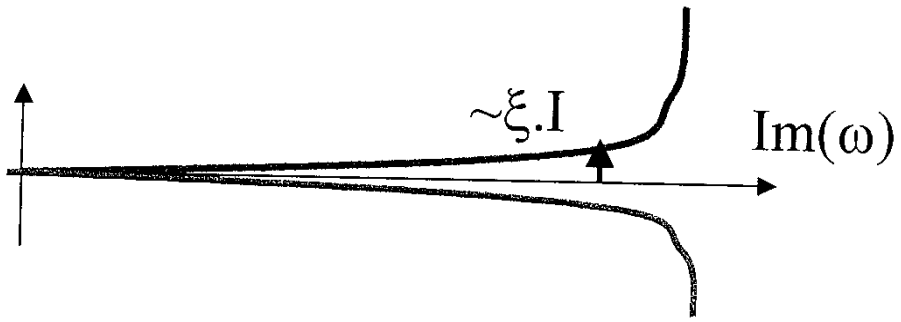
Transverse Mode Coupling



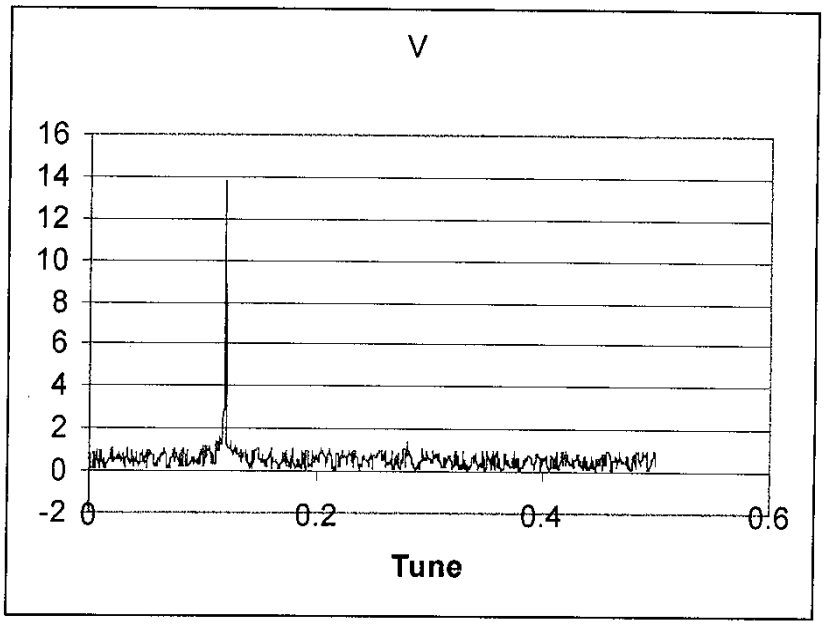
$$I_{th} = \frac{7.88.Qs\ .frev\ .\ E}{e.\Sigma\ \beta_i\ k_i}$$

Chromaticity and head tail damping



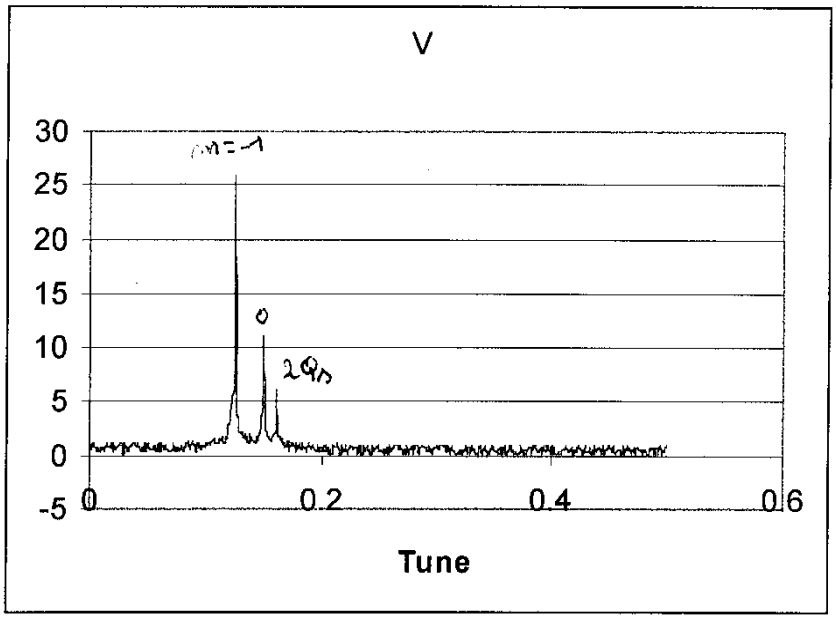


Spectra



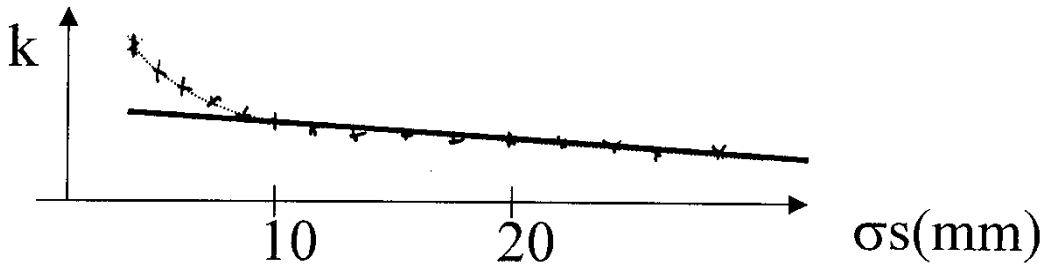
NO External excitation
chromaticity 10
200 μA/bunch

Spectra



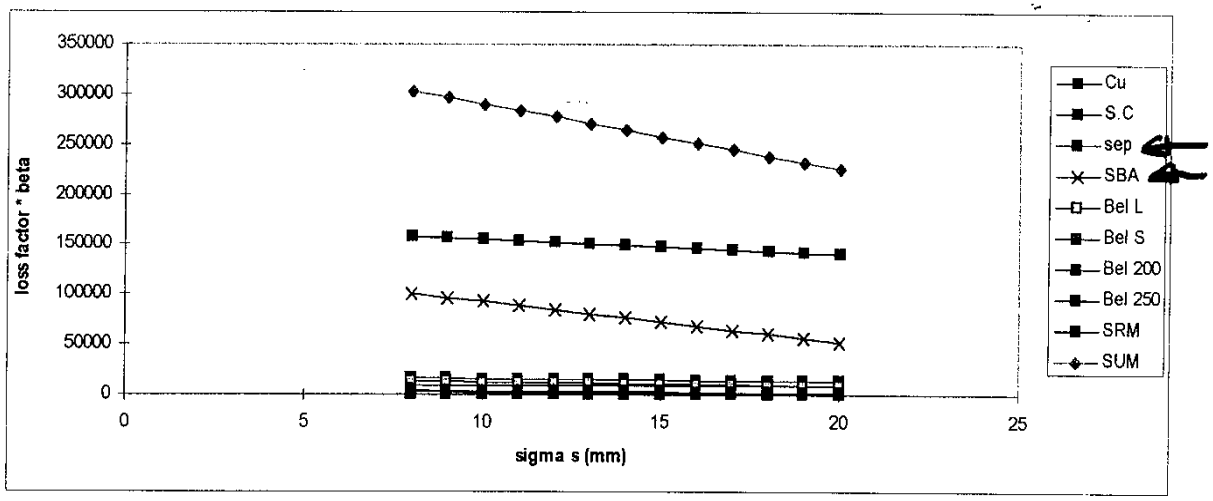
NO External excitation
chromaticity : 1
420 μA/bunch
$Q_s = 0.08$

Loss factors



k in : V/(m.pC)

		CU				S.C.	
beta	n	a	b	beta	n	a	b
40.6	48	0.02703	4.2625	51.3	288	-0.1	11.5



Scaling ?

$$\left(\Sigma k_i . B_i\right)_L = \frac{\langle \beta_{BL} \rangle}{\langle \beta_{Bl} \rangle} \cdot \frac{n_{BL}}{n_{Bl}} \langle \beta k \rangle_{Bl}$$

$$+ \frac{\langle \beta_{cL} \rangle}{\langle \beta_{cl} \rangle} \frac{U_{RFL}}{U_{RFl}} \langle \beta k \rangle_{cl}$$

$$= \langle \beta k \rangle_{Bl} + \frac{U_{RFL}}{U_{RFl}} \langle \beta k \rangle_{cl}$$

$$= \left(\frac{1}{2} + \frac{4}{3} \cdot \frac{1}{2}\right) \langle \beta k \rangle_{len}$$

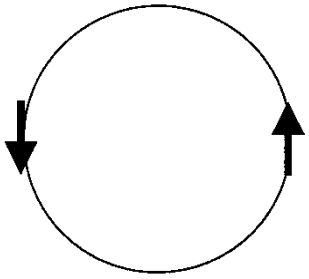
$$= \frac{7}{6} \langle \beta k \rangle_{len}$$

or

$$= \left(5 + \frac{4}{6}\right) \langle \beta k \rangle_{len.}$$

Longitudinal Turbulence

$V=F(\sigma_s)$



$\sigma_s=f(V)$

Leads to shape oscillations, mainly quadrupole.

Less damping of the m=1 mode (depends on longitudinal phase correlation).

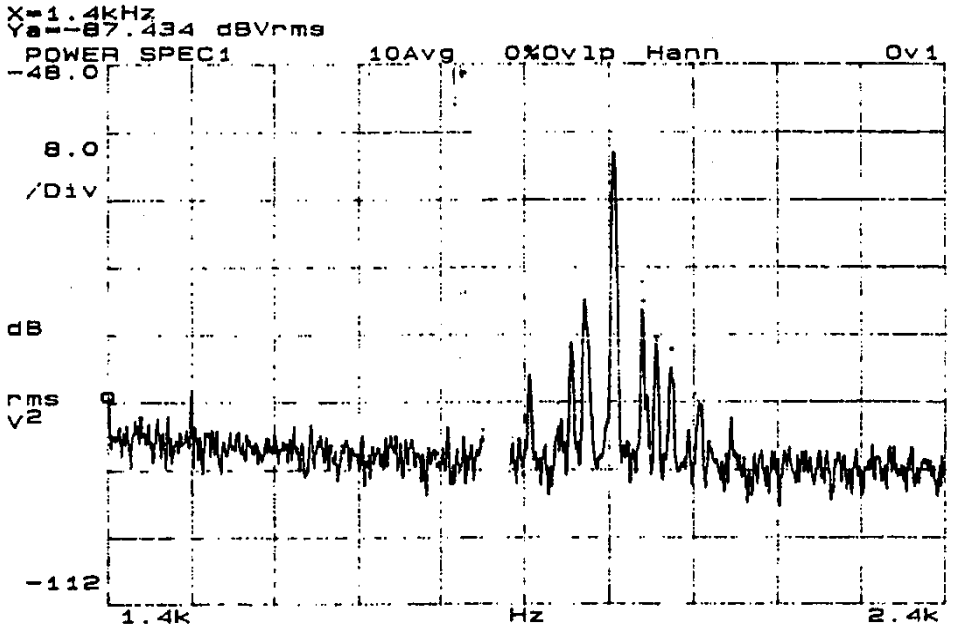


Figure 45.2: Longitudinal spectrum around the $2\times Q_s$ line for a bunch current of 430 μA.

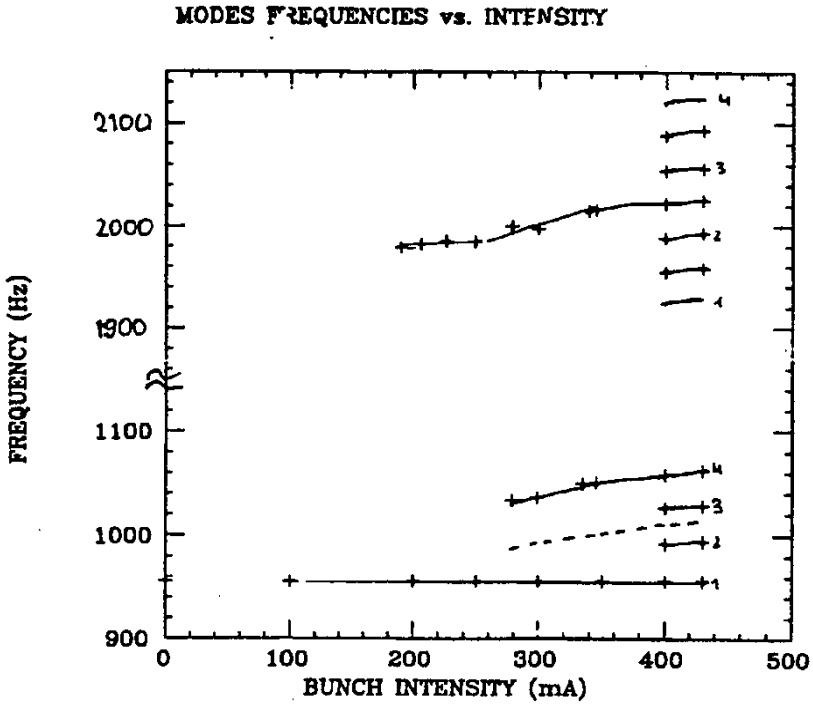


Figure 45.3: Frequency of the longitudinal modes as a function of intensity.

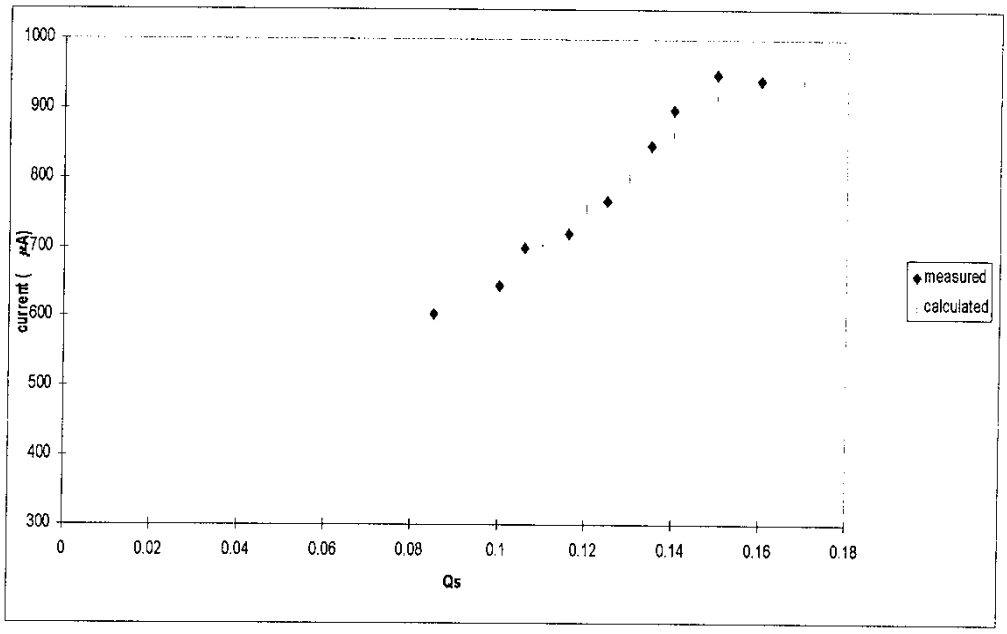
Use of Wigglers

- Dynamic range of storage ring: small emittance at high energy ←→short bunch length at injection.
- Lower beta at impedances <> short bunch length.
- Stronger damping.
- V_{Rf}/V_{beam}
  - No turbulence
  - $\sigma_z > 8$ mm

Bunch length > 8mm

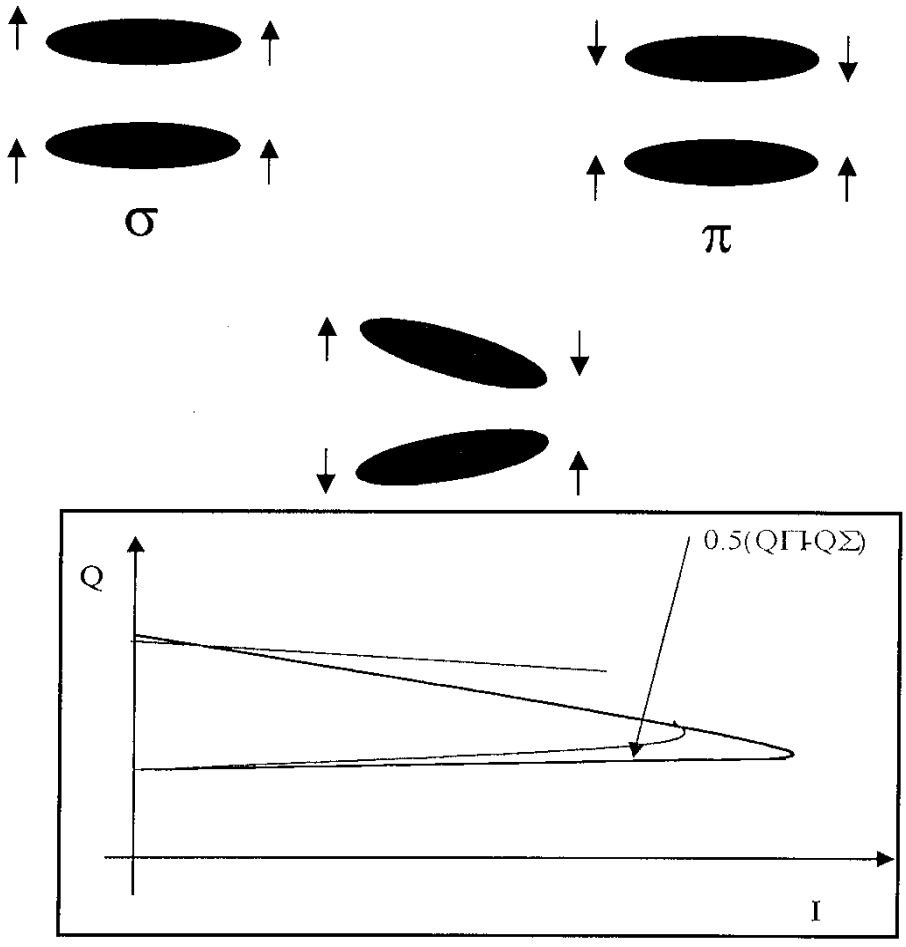
- k-factors increase rapidly
- Longitudinal turbulence (less damping of m=1) + cavity stability
- Splitting of m=0 mode
- Cryogenic losses

Ultimate limit : coherent synchro-betatron resonances



Qs > 0.15 Intensity saturated.

Intensity limit with two beams



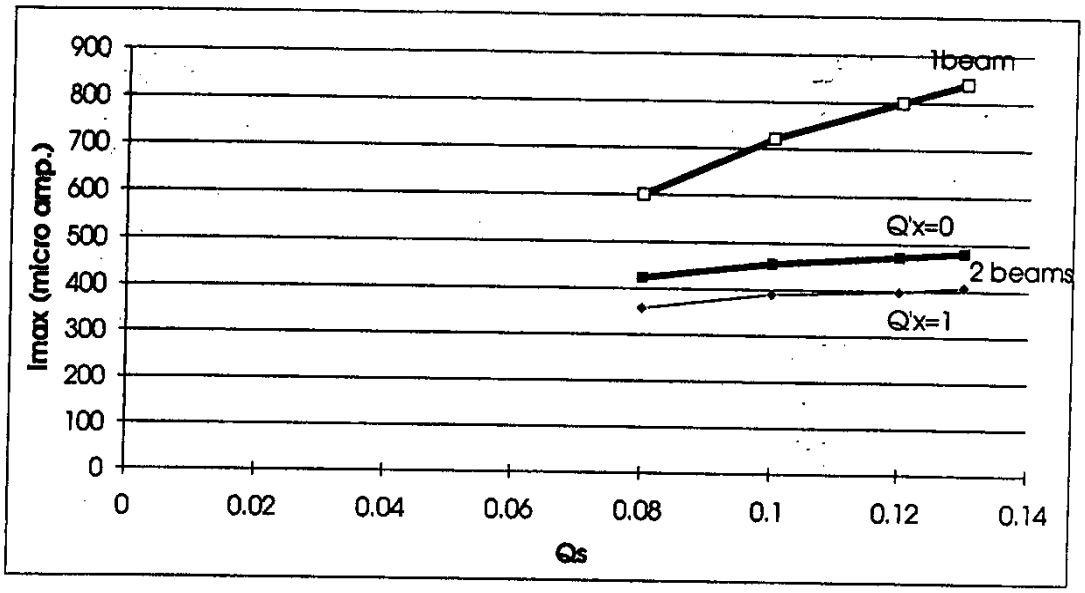
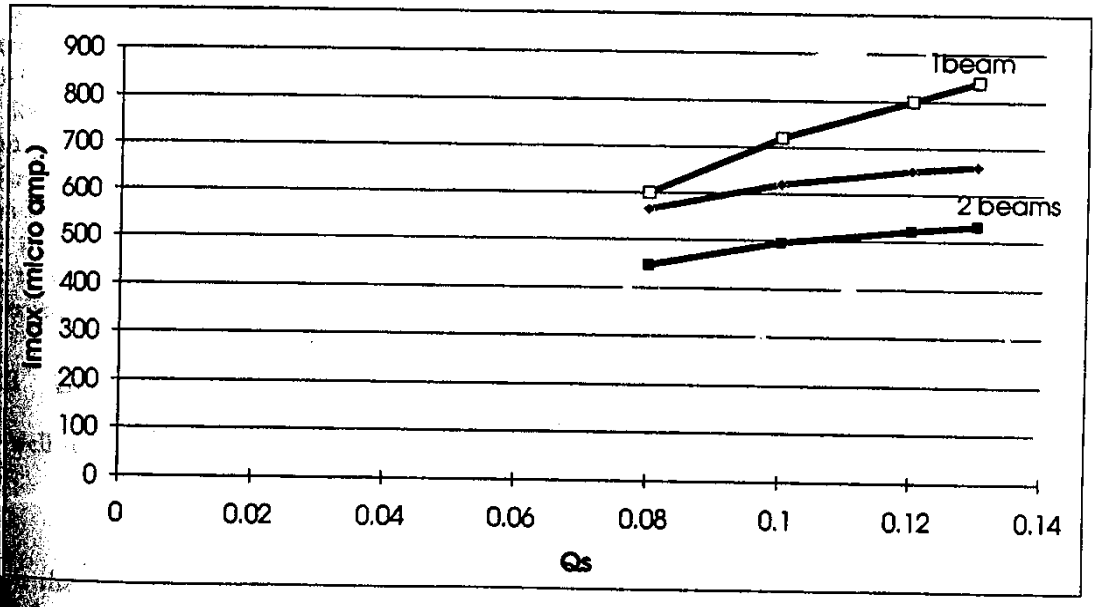


Figure 25.8: maximum currents as function of Q_s for nominal separation



25.9: maximum intensity as function of Q_s with 50% more separation. The lowest curve is =1 the second for Q'_x=0.