### Effect of Chromaticity on the Emittance Growth caused by the E-C

#### HEADTAIL simulation for LHC at injection

Elena Benedetto

Effect of Chromaticity on the Emittance Growth caused by the E-C

- Q'=2 ec-density?
- Fixed ec-density chromaticity?
- Resonator model for the E-C wake field

# Chromaticity Q'=2



Horizontal (Left) and Vertical (Right) Emittance growth Vs Time for different values of ec-density (from 3 10<sup>11</sup> to 3 10<sup>12</sup> m<sup>-3</sup>)



#### **Rise time of the instability**



 $\tau$  is the time during which the emittance increases from 7.82 10<sup>-8</sup> m (initial value) to 8 10<sup>-8</sup> m (~2,3%)

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# Chromaticity Q'=2



The ec-density "allowed"(\*) for 30min operation in LHC (parameters at injection! & Q'=2) is ~3  $10^{10}$  m<sup>-3</sup>

(\*) The time to reach 8  $10^{-3}$  is lower then < 30min

### Fixed ec-density. Which chromaticity?

#### Ec-density =

- 6 10<sup>-11</sup> m<sup>-3</sup> → Q'>20
- 9 10<sup>-11</sup> m<sup>-3</sup>  $\longrightarrow$  Q'>30
- $1.2 \ 10^{-12} \,\mathrm{m}^{-3} \longrightarrow ?$
- 1.5 10<sup>-12</sup> m<sup>-3</sup> ...
- 3 10<sup>-12</sup> m<sup>-3</sup> ...

Maybe a number of kicks/turns larger then 10 is needed...

# Ec-density = $6 \ 10^{-11} \ \text{m}^{-3}$



Horizontal (Left) and Vertical (Right) Emittance growth Vs Time for different values of chromaticity (from Q'=2 to Q'=40)

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# Ec-density = $1.2 \ 10^{-12} \ m^{-3}$



Horizontal (Left) and Vertical (Right) Emittance growth Vs Time for different values of chromaticity (from Q'=2 to Q'=80)

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# Resonator model

- $\rightarrow$  see Elias+Frank presentation at LCE meeting 6/02/04
- According to Frank, Ohmi and Perevedentsev's broadband impedance model for the ec-interaction with the bunch (\*):

$$f_{res} = \frac{1}{2\pi} \sqrt{\frac{2r_e c^2}{2\sigma^2}} \sqrt{\frac{N_b}{\sqrt{2\pi\sigma_z}}} \frac{1}{\sqrt{k}}$$
$$cR \qquad \lambda r^{1/2}$$

$$\frac{cR_s}{Q} = H_{emp} \frac{\lambda_c r_e^{1/2}}{\sigma^3 k^{3/2} \lambda_b^{1/2}} L$$

(\*) K.Ohmi, F.Zimmermann, E.Perevedentsev, "Wake field and fast head-tail instability caused by an electron cloud", Phys. Rev. E 65, 016502 (2002).

### Resonator model



Resonator model (continuous line) and ec-simulations (dashed lines) for ec-density =  $6 \ 10^{-11} \text{ m}^{-3}$ . (f=1.194 GHz; Q=1; Z=43.48 MOhm/m)

# Conclusions

- Cromaticity is a cure for the fast headtail instability, **but** maybe for very large electron cloud density is not any more efficient.
- To be done: check the eventual dependence of the simulations on the number of kicks/turn
- To be done: study the effect of octupoles as a cure of the instability