Effect of the working point on the resistive wall multibunch instabilities in the SPS

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Thanks to W. Höfle

SPS RW multibunch instability

- With a 25 ns beam of 4e13 p^+ at 26 GeV/c (details to be checked), in 1999 W. Höfle found instability rise times of (SPSU 14/04/2011):

$$\tau_x = 30 \text{ turns and } \tau_y = 18 \text{ turns}$$

- Recently (2009 & 2010 MDs, 25ns & 72 bunches, 9e12 p^+) we found much larger rise times:

with $\xi_x = -0.25$, $\tau_x \sim 500$ turns,

with $\xi_y = -0.1$, $\tau_y \sim 230$ turns.

- Such a large discrepancy not so surprising: intensity is different, and many things have changed in the machine, as well as beam parameters.
- We investigate here the part of the discrepancy due to a change in working point.

Effect of the working point

- In 1999, $Q_x = 26.62$ & $Q_y = 26.58$, vs. resp. $Q_x = 26.13$ and $Q_y = 26.18$ nowadays (with LHC beam).
- Resistive-wall impedance of the SPS beam pipe gives instability rise times mainly related to the real part of the impedance at the first unstable betatron line, which is located at:

$$\left(1-\left[Q_x\right]\right) f_{rev} = \text{16 kHz in 1999 vs. 38 kHz now}$$

$$\left(1-\left[Q_y\right]\right) f_{rev} = \text{18 kHz in 1999 vs. 35 kHz now}$$

- At those frequencies:

$$\Re\left\{Z_x\left(\left(1-\left[Q_x\right]\right) f_{rev}\right)\right\} = \text{100 M}\Omega\text{/m in 1999 vs. 50 M}\Omega\text{/m now}$$

$$\Re\left\{Z_y\left(\left(1-\left[Q_y\right]\right) f_{rev}\right)\right\} = \text{190 M}\Omega\text{/m in 1999 vs. 100 M}\Omega\text{/m now}$$

- W. Höfle obtained resp. 120 & 200 MΩ/m.
  NOTE: THIS IS NOT THE EFFECTIVE IMPEDANCE.

Effect of the working point

- Exemple: with Sacherer formula, for 924 equidistant bunches separated by 25ns ($\sigma_{z,rms}$=0.19 m, Nb part/bunch=1e11, γ=27.7, zero chromaticities) we get:
  - At the 1999 working point:

    $\tau_x = 24$ turns

    $\tau_y = 13$ turns
  - At the current working point:

    $\tau_x = 48$ turns

    $\tau_y = 23$ turns

→ ~ a factor 2 can be explained from the change in working point ...