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 \(4 \times 10^{13} p^+\) 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, 25 ns & 72 bunches, \(9 \times 10^{12} p^+\)) 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


- 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:
  $$\left(1 - \left[Q_x\right]\right)f_{rev} = 16 \text{ kHz in 1999 vs. } 38 \text{ kHz now}$$
  $$\left(1 - \left[Q_y\right]\right)f_{rev} = 18 \text{ kHz in 1999 vs. } 35 \text{ kHz now}$$

- At those frequencies:
  $$\Re\left[ Z_x \left(1 - [Q_x]f_{rev}\right) \right] = 100 \text{ M}Ω/m \text{ in 1999 vs. } 50 \text{ M}Ω/m \text{ now}$$
  $$\Re\left[ Z_y \left(1 - [Q_y]f_{rev}\right) \right] = 190 \text{ M}Ω/m \text{ in 1999 vs. } 100 \text{ M}Ω/m \text{ now}$$

- 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 ($\sigma_{z,\text{rms}}=0.19$ m, Nb part/bunch=$1e11$, $\gamma=27.7$, zero chromaticities) we get:
  - At the 1999 working point:
    \[ \tau_x = 24 \text{ turns} \]
    \[ \tau_y = 13 \text{ turns} \]
  - At the current working point:
    \[ \tau_x = 48 \text{ turns} \]
    \[ \tau_y = 23 \text{ turns} \]

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