Follow-up of last week's action on the change in the longitudinal intensity limitations due to the kickers

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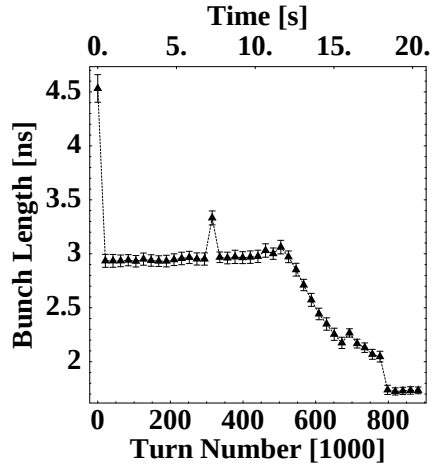
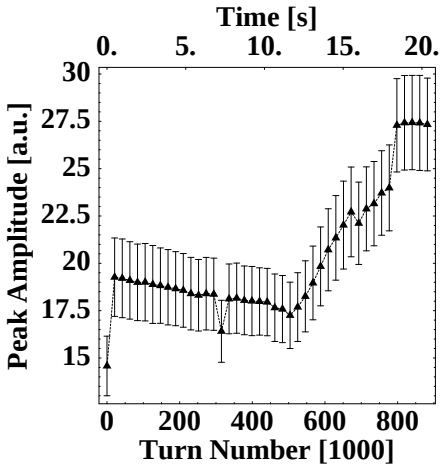
"Residual" longitudinal impedance after MKE shielding (*F. Caspers and T. Kroyer*)**:**

resonant peak at $f_r = 48$ MHz with

$R_{sh} = 0.9\ \mathrm{k\Omega/m} \times 8 \times 2.2\ \mathrm{m} \simeq 16\ \mathrm{k\Omega}$

Coupled-bunch instability of LHC beam





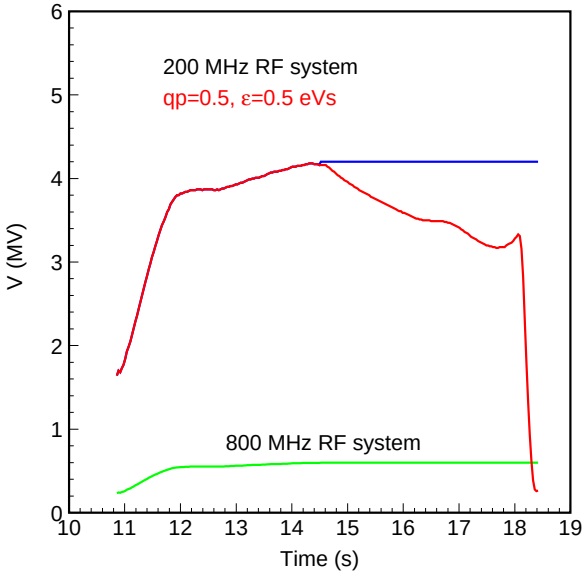
T. Bohl et al.

- **Threshold:** single batch with 2×10^{10} ppb is unstable at ~ 280 GeV
- **Source:** fundamental and HOMs of 200 MHz RF system (629, 912 MHz...)
- **Cures:**
  - the 800 MHz RF system in bunch-shortening mode through the cycle
  - controlled emittance blow-up by
    (1) mismatched voltage at injection: $\varepsilon_{2\sigma} = 0.35$ eVs $\rightarrow$ 0.45 eVs
    (2) beam excitation at 200 GeV with band-limited noise: $\rightarrow$ 0.6 eVs

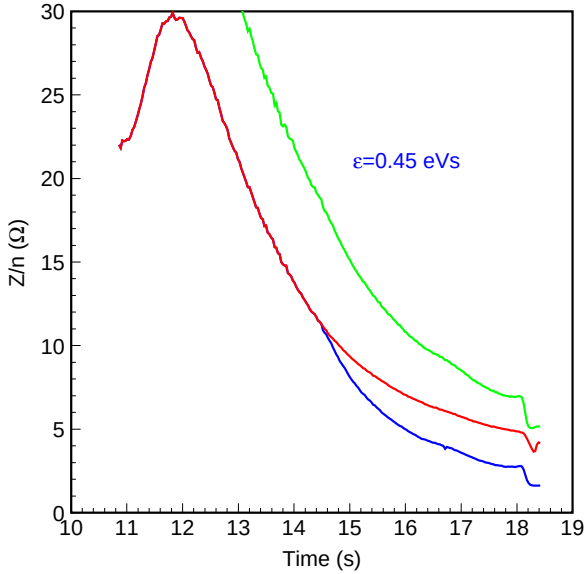
Intensity limitations

Threshold impedances for nominal intensity in the SPS

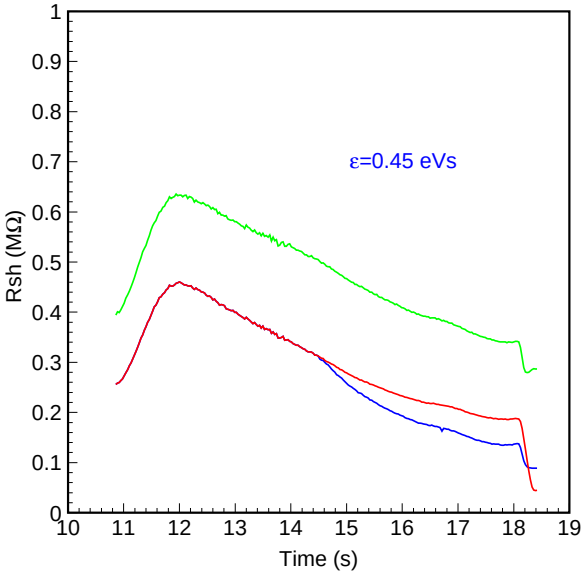
Voltage (MV)



ImZ/n (Ω)



R_{sh}^{min} (MΩ)



- **Controlled emittance blow-up: $\varepsilon \propto \sqrt{I_A}$ $\Rightarrow$ nominal LHC intensity: $\varepsilon = 0.6$ eVs at 450 GeV, ultimate: $\varepsilon = 0.73$ eVs.**
- **200 MHz RF system: HOM at 629 MHz, $R_{sh} \simeq 380$ kΩ, $Q \sim 500$**

Dependence on resonant frequency

Threshold for coupled-bunch instability (equally spaced bunches) due to resonant impedance with frequency

$$f_r = f_0 n_r = pMf_0 + nf_0 + mf_s$$

$$R_{sh} < \frac{|\eta|E}{eI_0}\left(\frac{\Delta p}{p}\right)^2 \frac{\Delta\omega_s}{\omega_s}\frac{F}{f_0\tau} xG(x),$$

I_0 is the average beam current, $F \sim 0.3$

Minimum threshold at $f_r^{min} \simeq 0.43/\tau$

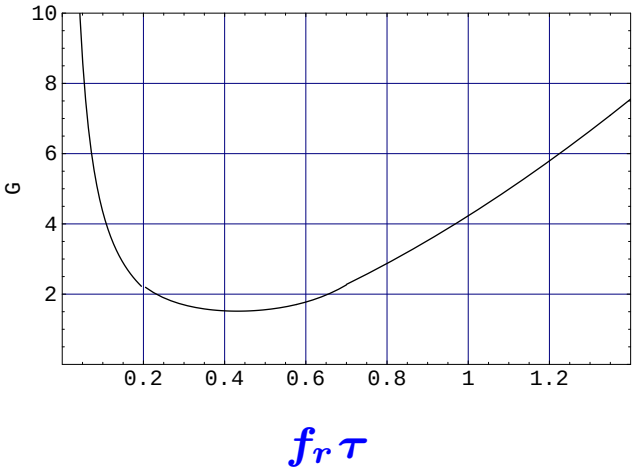
$\Rightarrow$ For $f_r = 48$ MHz and $\tau = (2-4)$ ns

factor 2-3 better

Function

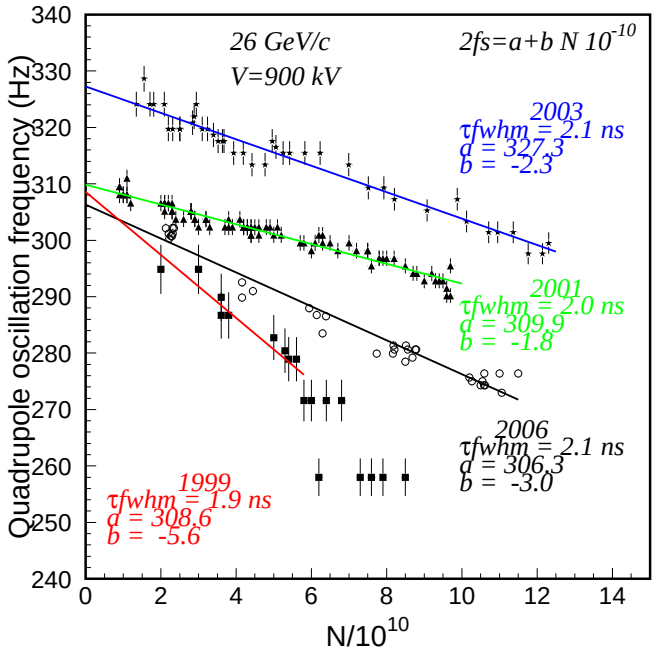
$$xG(x) = x \min\{J_m^{-2}(\pi x)\},$$

$$x = f_r\tau$$

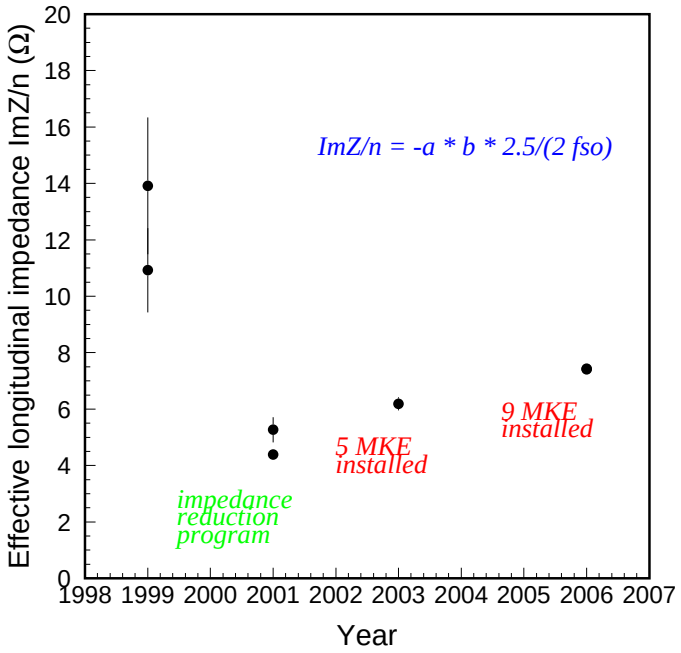


Broad-band longitudinal impedance

Quadrupole frequency shift



Effective ImZ/n



Summary

- **Very good overall result for longitudinal impedance of MKE with shielding**
- **The resonant peak is not a limitation even for the ultimate LHC intensity**
- **Nevertheless the low-frequency resonant peak should be minimised, if possible...**