Progress Report on LHC Collimator Impedance

- Update on thin metallic coatings
- Transverse impedance of the collimators during beta-squeeze
  - Resistive impedance
  - Geometric impedance
  - Implications/constraints from transverse feedback
  - Implications/constraints from Landau octupoles
- Implications/guidelines for the collimators

Thin metallic coatings

The spec of $3\,\mu$m Ti coating for the TDI is confirmed. The effect of the coating on the inductive surface impedance is remarkable.

In case of graphite collimator jaws, for ultimate LHC beam intensity and collimators around $6\,\sigma$ we estimate a beam induced heating of 106 W/m at injection and 970 W/m at top energy. The latter drops to 730 W/m for a $3\,\mu$m Ti coating.

Depending on the heat deposition, the uncoated graphite may outgas and create vacuum problems, in addition to dust.

We assume $\rho_{\mathrm{C}} = 14 \times 10^{-6}\Omega$m and $\rho_{\mathrm{Ti}} = 90 \times 10^{-8}\Omega$m. The heat deposition scales approximately with the square root of the graphite resistivity.

Transverse resistive impedance of LHC collimators versus impedance of cold beam screen: rough scaling

$$\frac{Z_\perp^{\rm coll}}{Z_\perp^{\rm arc}} \sim \frac{(L^{\rm coll}/L^{\rm arc}) \times \sqrt{\rho^{\rm coll}/\rho^{\rm arc}}}{(a^{\rm coll}/a^{\rm arc})^3} \sim$$

$$\sim \frac{(20\,{\rm m}/20\,{\rm km}) \times \sqrt{{\rm RRR} \sim 30}}{(1.8\,{\rm mm}/18\,{\rm mm})^3} \sim$$

$$\sim \frac{10^{-3} \times 5}{10^{-3}} \sim 5!$$

$$a^{\rm coll} \sim n_{\rm coll}\sqrt{\beta_{\rm coll}\,\epsilon} \sim n_{\rm coll}\sqrt{\beta_{\rm coll}}$$

$$\tau^{-1}_{\rm resist-wall} \propto < \beta\, Z_\perp^{\rm coll} > \sim \frac{1}{n^3_{\rm coll}\sqrt{\beta_{\rm coll}}}$$

Performance of the LHC transverse feedback system at 7 TeV

W. Höfle and T. Linnecar, see also 17th LCC on January 30, 2002

We can accommodate an impedance increase at top energy of a factor 3 (1.5 from higher beta functions times factor 2 margin in the vertical plane) to 4.5 (with restriction for the tune $\longrightarrow$ 8 kHz).

A more detailed study is required to evaluate the effects of an increased gain. In order to do this one would need to make some assumptions:

- What is the relevant tune spread for blow-up at top energy?
- What is the orbit excursion in the pick-up used for the transverse feedback system, bunch to bunch (+/- 0.3 sigma due to Pacman), and is it reasonable to assume that a slow orbit feedback system can center the beam in the pick-up for the transverse feedback system to better than +/- 0.1 sigma?

Experimental studies foreseen in the SPS for 2003. Additional money for lower noise electronics and processing with a higher number of bits.

Guidelines for the collimator design

Increasing the collimator aperture will drastically reduce the resistive transverse impedance. For example going from 6 to 8 σ the reduction factor is already 2.4. This may be possible by a local tertiary collimation system near the triplets?

Reducing the total length of the collimators will linearly decrease the impedance. I think this option should be seriously considered.

Thin metallic layers (say 3 μm Ti) give only marginal gains on the impedance. A lower bulk collimator resistivity helps.

A sizable increase of the LHC impedance budget by the collimators requires further studies on emittance growth, feedback system, and Landau damping of multi-bunch modes (with octupoles and/or large chromaticity).