impedance of flanges

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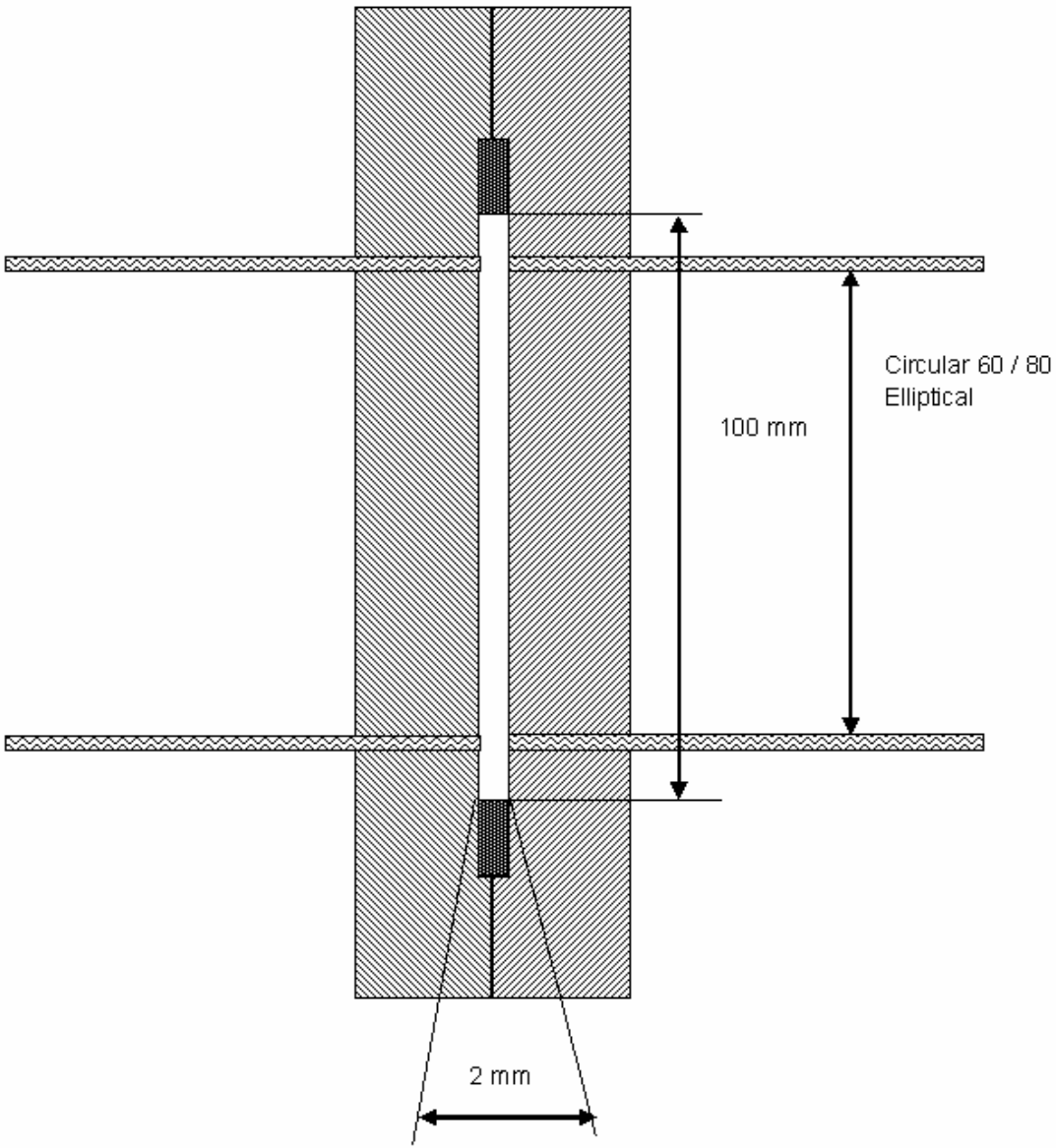
RLC meeting
14.01.2005

impedance of flanges



LHC will have several 1000 flanges

Question from M. Jimenez:

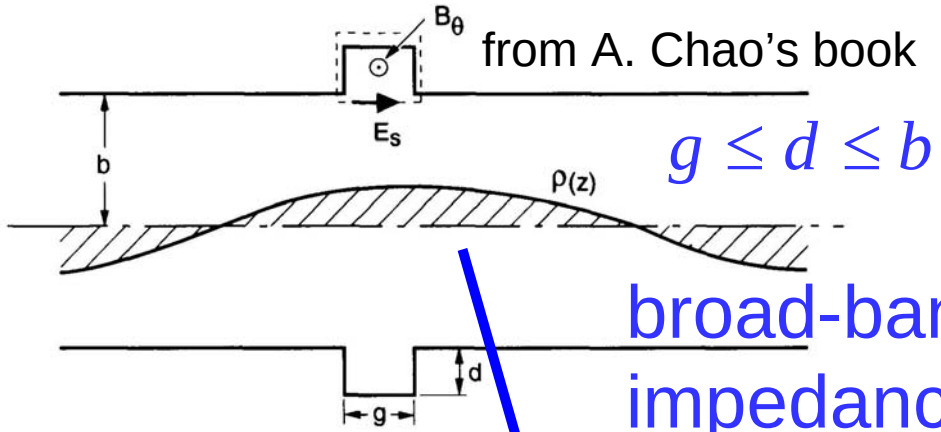
“We will shortly start the procurement of the seals for the LHC, but before that we need to clarify some rumours.

As you probably know, when two flanges are assembled, a small gap remains between the flanges. The depth depends on the inner diameter of the chambers with respect to the inner diameter of the seal i.e. 100 mm (see figure).

The gap length is 2 mm maximum. If compared to the length of the bunches, it should not, isn’t it?

The CtC assumes standard seals and if these gaps are not acceptable, we (you and us) shall issue an ECR to request additional money.”

impedance of flanges? *corrected*



from A. Chao's book

$g \le d \le b$

Figure 2.17. The impedance of a small cavity ($g \le d \ll b$) is predominantly inductive at low frequencies ($\omega \ll c/b$). The voltage across the cavity gap can be obtained by applying Faraday's law to the dashed circuit.

resonances & trapped modes?

broad-band impedance model

lowest resonant frequency
f ~ c/(4d)~4 GHz
for d=2 cm

Schnell-Sacherer relation

Estimate of longitudinal impedance

$$\frac{Z}{n} \approx N_{flanges} \frac{g}{2\pi b} \frac{\omega_0}{c/g} Z_0 \approx 2000 \frac{0.002}{2\pi \times 0.03} \frac{2\pi\, 0.002}{C} Z_0 \approx 4\,\mathrm{m\Omega}$$

LHC total longitudinal BB impedance ~ 70 mΩ

Estimate of transverse impedance

$$Z_1 \approx N_{flanges} Z_0 \frac{g^2}{\pi b^3} \approx 35\,\mathrm{k\Omega/m}$$

LHC total transverse BB impedance ~ 2 MΩ/m

→ *contribution to broadband impedance is ~6% longitudinally, ~4% transversely*

K.Y. Ng, “Impedance Issue of Corrugated Beam Pipe from CDF”, FERMILAB-TM-1847 (1993)

$$\left|\frac{Z}{n}\right|_{Ng} \approx \frac{N_{flanges}\, g}{C} Z_0 \ln\frac{b+d}{b} \approx \frac{N_{flanges}\, g}{C} Z_0 \frac{d}{b} \approx \frac{d}{g}\left|\frac{Z}{n}\right|_{Chao}$$

!

~40 mΩ

if we accept this estimate, the flange impedance is about half the total LHC broadband impedance from the design report!

$$Z_1 \approx N_{flanges} Z_0 \frac{gd}{\pi b^3} \approx 360\ \mathrm{k\Omega/m}$$

the transverse flange impedance is about 20% of the total

above numbers assume $N_{flanges}$~2000 (exact number not known)

impedance of flanges

literature on impedance of PS & PS booster flanges
received from Karl-Heinz Schindl & Christian Carli:

G.R. Rufer, W. Unterlerchner:
“Low cost vacuum hardware developed for the CERN PS Booster”,
CERN/SI/Int. ME/71-2 (1971)

R. Cappi, “RF Bypass on the Proton Synchrotron Vacuum Chamber Flanges”,
PAC 1989 Chicago (1989)

G.C. Schneider, “Beam Coupling Impedances of the Booster Vacuum Flanges,”
PS/RF/Note 89-5 (1989)

F. Pedersen, “PSB Vacuum Flange Impedance,” email dated 23.02.98 (1998)

A. Blas, M. Chanel, C. Carli, C. Lacroix, “Reduction of the Impedance Created by the Insulated Vacuum Flanges in the PS Booster,” EPAC 2000 Vienna (2000)