RESISTIVE-WALL INSTABILITY FOR THE

(1) BEAM SCREEN

(2) WARM PIPE

(3) TCDS = Target Collimator Dump Septum

E. Métral

- **"Effective" impedance**
- **Coherent tune shift**
- **Heat load**

And comparison with the results of L. Vos in the LHC design report

BEAM SCREEN (1/3)

- **Length** $L = 23.6\ \mathrm{km}$
- **Half gaps** $b_x = 22\ \mathrm{mm}$ $b_y = 18\ \mathrm{mm}$
- **It is maintained at 5 to 20 K**
- **The Yokoya factors for the LHC beam screen geometry are derived from "a geometry halfway between square and elliptical"**

$$Y_x = 0.63 \qquad Y_y = 0.87$$

BEAM SCREEN (2/3)

- **3-layer formula used**
  - 1 = Cu $s_1 = 50\ \mu\text{m}$
  - 2 = SS $s_2 = 1\ \text{mm}$
  - 3 = Vacuum

- **Resistivity**

$$\rho_1\left(\text{high}-\text{B}\right) = 5.5\times 10^{-10}\ \Omega\text{m}$$

$$\rho_1\left(\text{low}-\text{B}\right) = 1.8\times 10^{-10}\ \Omega\text{m}$$

$$\rho_2 = 5\times 10^{-7}\ \Omega\text{m}$$

- **Skin depth**

$$\delta_1\left(\text{high}-\text{B}, 8\ \text{kHz}\right) = 0.13\ \text{mm}$$

$$\delta_1\left(\text{low}-\text{B}, 8\ \text{kHz}\right) = 0.08\ \text{mm}$$

$$\delta_2\left(8\ \text{kHz}\right) = 4\ \text{mm}$$

BEAM SCREEN (3/3)

- **Low B**
  - "Effective" impedance $Z_y^{eff} = -27 + 10.2\ j\ \ \mathrm{M\Omega/m}$
  - Coherent tune shift $\Delta Q_{m=0} = -\left(0.8 + 2.2\ j\right) \times 10^{-4}$
  - Heat load $P_{loss} \approx 30\ \mathrm{mW/m}$

$\times \dfrac{s_b}{2\sqrt{\pi}\ \sigma_z} \approx 16$

$\mathrm{Re} \Rightarrow -8\,\%$

$\mathrm{Im} \Rightarrow +19\,\%$

- **High B**
  - "Effective" impedance $Z_y^{eff} = -80 + 19.5\ j\ \ \mathrm{M\Omega/m}$
  - Coherent tune shift $\Delta Q_{m=0} = -\left(0.1 + 0.4\ j\right) \times 10^{-4}$
  - Heat load $P_{loss} \approx 110\ \mathrm{mW/m}$

$\times \dfrac{s_b}{2\sqrt{\pi}\ \sigma_z} \approx 28$

$\mathrm{Re} \Rightarrow -5\,\%$

$\mathrm{Im} \Rightarrow +97\,\%$

exactly the same value

WARM PIPE (1/3)

- **Length** $L = 2.4\ \mathrm{km}$
- **Half gap** $b = 40\ \mathrm{mm}$
- **It is at room temperature**

WARM PIPE (2/3)

- **2-layer formula used**
  - **1 = Cu** $s_1 = 2 \text{ mm}$
  - **2 = Vacuum**

- **Resistivity** $\rho_1 = 1.5 \times 10^{-8} \ \Omega\text{m}$

- **Skin depth** $\delta_1 \left(8 \text{ kHz} \right) = 0.7 \text{ mm}$

WARM PIPE (3/3)

- **Low B**
  - "Effective" impedance $Z_y^{eff} = -1.6 + 2.6\ j\ \ \mathrm{M\Omega/m}$
  - Coherent tune shift $\Delta Q_{m=0} = -\left(0.22 + 0.13\ j\right) \times 10^{-4}$
  - Heat load $P_{loss} \approx 110\ \mathrm{mW/m}$

$\times \dfrac{s_b}{2\sqrt{\pi}\ \sigma_z} \approx 16$

$\mathrm{Re} \Rightarrow -54\ \%$

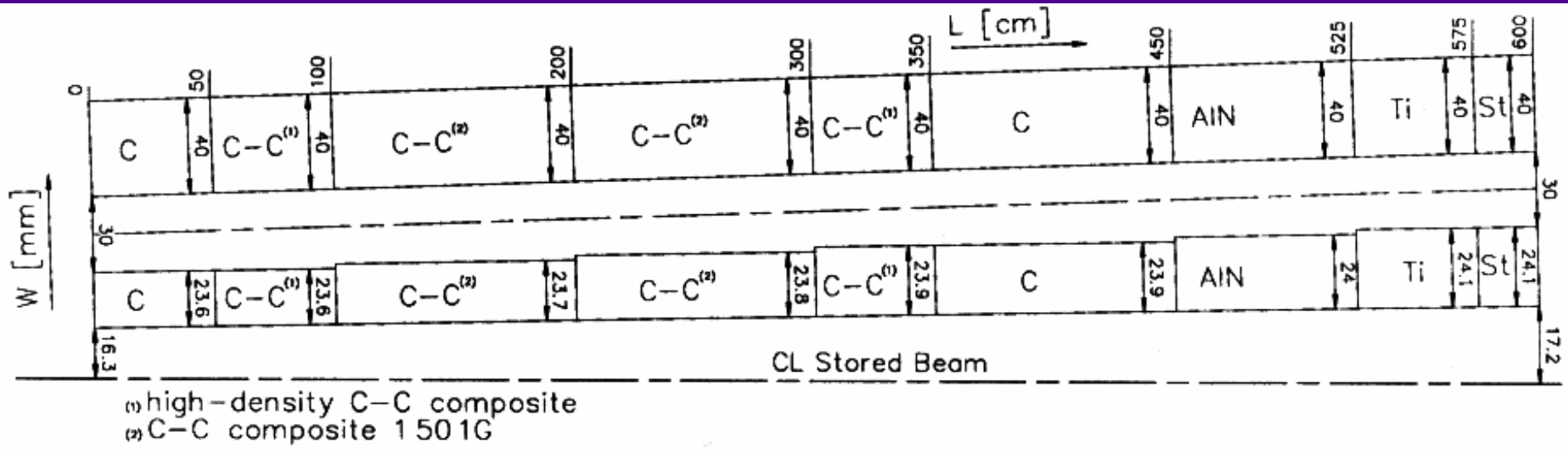
$\mathrm{Im} \Rightarrow -10\ \%$

- **High B**
  - "Effective" impedance $Z_y^{eff} = -1.6 + 2.7\ j\ \ \mathrm{M\Omega/m}$
  - Coherent tune shift $\Delta Q_{m=0} = -\left(1.4 + 0.9\ j\right) \times 10^{-6}$
  - Heat load $P_{loss} \approx 260\ \mathrm{mW/m}$

$\times \dfrac{s_b}{2\sqrt{\pi}\ \sigma_z} \approx 28$

TCDS (1/6)

- The TCDS is a fixed diluter block, just upstream of the MSD magnets (Lambertson septum magnets, which deflects the beam vertically to the TDE dump absorber block)
- The purpose of the TCDS is to protect the MSD magnets from destruction in the event of an asynchronous firing of MKD kickers, which would cause the beam to sweep over the septum
- The TCDS is not part of the collimation system



TCDS (2/6)

- **Blocks 1,2,3,4,5**
  - **2-layer formula**
    - 1 = C
    - 2 = Vacuum
  - **Betatron function** $\beta_y \approx 240\ \mathrm{m}$
  - **Resistivity** $\rho_1 = 6 \times 10^{-5}\ \Omega\mathrm{m}$
  - **Skin depth** $\delta_1\left(8\ \mathrm{kHz}\right) = 4.4\ \mathrm{cm}$

TCDS (3/6)

- **Block 6**
  - **2-layer or 3-layer (for copper coating, which is necessary) formulae**
    - **1 = Cu** $s_1 = 5\ \mu\text{m}$
    - **2 = Aluminium Nitride**
    - **3 = Vacuum**
  - **Betatron function** $\beta_y \approx 240\ \text{m}$
  - **Resistivity** $\rho_1 = 1.5 \times 10^{-8}\ \Omega\text{m}$

    $\rho_2 = 10^{12}\ \Omega\text{m}$

TCDS (4/6)

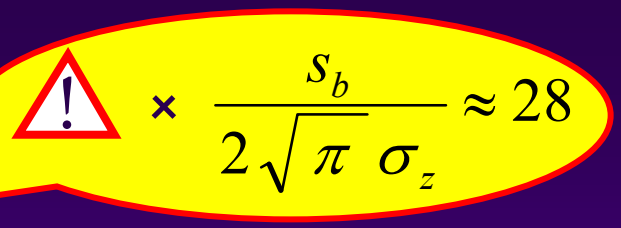
- **Block 7**
  - **2-layer formula**
    - 1 = Ti
    - 2 = Vacuum
  - **Betatron function** $\beta_y \approx 240$ m
  - **Resistivity** $\rho_1 = 5.5 \times 10^{-7}\ \Omega\text{m}$

TCDS (5/6)

- **Block 8**
  - **2-layer formula**
    - 1 = SS
    - 2 = Vacuum
  - **Betatron function** $\beta_y \approx 240$ m
  - **Resistivity** $\rho_1 = 7.4 \times 10^{-7}\ \Omega\text{m}$

TCDS (6/6)

- 7 TeV
  - "Effective" impedance $Z_y^{eff} = -1.3 + 5.9\ j\ \ \mathrm{M\Omega/m}$
  - Coherent tune shift $\Delta Q_{m=0} = -\left(3.2 + 0.7\ j\right) \times 10^{-6}$
  - Heat load $P_{loss} \approx 185\ \mathrm{W}$



Estimation by L. Vos (2003-04-07)
~ 260 W ⇒ A cooling system with a capacity of ~1kW is foreseen