FIRST RESULTS OF THE 2006 COLLIMATOR IMPEDANCE MEASUREMENTS IN THE SPS


- **Motivation for these MDs**
  - A new physical regime is predicted for the resistive-wall impedance of the LHC collimators

- **2004 result**
  - Coherent tune shift with a single bunch \( \Rightarrow \text{Im} \left( Z_x \right) \)

- **2006 (preliminary) results**
  - Coherent tune shift with a single bunch \( \Rightarrow \text{Im} \left( Z_x \right) \)
  - Instability rise-time with 72 bunches \( \Rightarrow \text{Re} \left( Z_x \right) \)

Done also with 1 jaw only \( \Rightarrow \text{NEW!} \)

\( \Rightarrow \text{NEW!} \)
This nonlinear wake of FZ will not play an important role in the LHC.

Zimmermann et al., EPAC06

\[ \sim 6 \times 10^{10} \text{ p/b} \]  
\[ \sim 10 \times 10^{10} \text{ p/b} \]
2006 COHERENT TUNE SHIFT with a single bunch \( \Rightarrow \text{Im} \left( Z_x \right) \) (1/3)

Continuous measurement of \( Q_x \)

Tune shift of \( \sim 4 \times 10^{-4} \), with a constant intensity of \( \sim 1.15 \times 10^{11} \) p/b

** Courtesy R. Steinhagen**
2006 COHERENT TUNE SHIFT with a single bunch ⇒ \text{Im} \left( Z_X \right) (2/3)

\[ \Delta Q \left[ 10^{-4} \right] \]

- Rms. bunch length \( \approx 0.4\text{-}0.5 \text{ ns} \)
- Rms. bunch length \( \approx 0.7 \text{ ns} \) in 2004

normalised to:
\[ \Delta Q = \Delta Q_{\text{raw}} \frac{\{n_b\}_{\text{nom}}}{n_b} \]

with:
\[ \{n_b\}_{\text{nom}} = 1.2 \times 10^{11} \text{ protons/bunch} \]

Courtesy R. Steinhagen
2006 COHERENT TUNE SHIFT with a single bunch ⇒ $\text{Im}(Z_x)$ (3/3)

Continuous measurement of $Q_y$

$\text{Im}(Z_x) \approx 20 \text{ M$\Omega$/m}$ (Seems consistent with Helmut’s result)

Courtesy R. Steinhagen
INSTABILITY RISE-TIME with 72 bunches ⇒ Re (Z_x)

Summary of the predicted rise-times (in SPS turns) for 1 batch of 72 bunches (1.15×10^{11} p/b) at 270 GeV/c (See APC 13/10/06)

Without the nonlinear terms of FZ, hoping to see the inductive bypass effect…

Factor ~ 2 difference
MEASUREMENTS (1/24)

Collimator gap (CCV) [mm] ➞ Real one to be confirmed by Stefano

Intensity $[10^{10} \text{ p/b}]$ if 72 bunches...

Relative chromaticity [$\times 10$]

H and V BPM readings (BBQ)

Courtesy B. Salvant
Case 1 (coast 5)  
Collimator out (± 30 mm)

Courtesy B. Salvant
Case 1 (coast 5)

Collimator out ($\pm$ 30 mm)

$\tau_x \approx 35$ ms

$\tau_y \approx 50$ ms

i.e. $\sim 1500$ SPS turns

Courtesy B. Salvant
MEASUREMENTS (4/24)

Case 2 (coast 7)

Collimator in (-2;+2.5 mm)

Courtesy B. Salvant

Elias Métral, CWG meeting, 04/12/06
Case 2 (coast 7)

\[ \tau_x \approx 127 \text{ ms} \]

\[ \tau_y \approx 144 \text{ ms} \]

Courtesy B. Salvant
Case 3a (coast 8)

Collimator out (± 11.5 mm)

MEASUREMENTS (6/24)

Courtesy B. Salvant
MEASUREMENTS (7/24)

Case 3a (coast 8)  Collimator out (± 11.5 mm)

![Graph showing measurements]

$\tau_x \in [40, 138 \text{ ms}]$

$\tau_y \in [81, 131 \text{ ms}]$

_Courtesy B. Salvant_
Case 3b (coast 8)

MEASUREMENTS (8/24)

Courtesy B. Salvant
MEASUREMENTS (9/24)

Case 3b (coast 8)

\[ \tau_x \approx 849 \text{ ms} \]
\[ \tau_y \approx 1008 \text{ ms} \]

Courtesy B. Salvant

Elias Métral, CWG meeting, 04/12/06
Case 4a (coast 11)

Collimator in (± 3 mm)

MEASUREMENTS (10/24)

 Courtesy B. Salvant

Elias Métral, CWG meeting, 04/12/06
Case 4a (coast 11)

\[ \tau_x \in [17, 36 \text{ ms}] \]

\[ \tau_y \approx 37 \text{ ms} \]

Courtesy B. Salvant
MEASUREMENTS (12/24)

Case 4b (coast 11)

Collimator in (± 2 mm)

Courtesy B. Salvant

Elias Métral, CWG meeting, 04/12/06
Case 4b (coast 11)

\[ \tau_x \approx 72 \text{ ms} \]

\[ \tau_y \approx 79 \text{ ms} \]

Courtesy B. Salvant
Case 4c (coast 11)  
Collimator out (± 11.5 mm)

Courtesy B. Salvant

Elias Métral, CWG meeting, 04/12/06
Case 4c (coast 11)

\[
\tau_x \in [286, 545 \text{ ms}]
\]

\[
\tau_y \in [492, 694 \text{ ms}]
\]

Courtesy B. Salvant
Case 5 (coast 12)

Collimator in (± 2 mm)

\[ \tau_x \in [12, 32 \text{ ms}] \]

\[ \tau_y \approx 42 \text{ ms} \]

 Courtesy B. Salvant
Horiz. rise-times normalised to 1.15E11 p/b

- Beams with different history...
- Max. value
- Min. value

Case 1
Case 2
Case 3a
Case 3b
Case 4a
Case 4b
Case 4c
Case 5

Fitted rise-time [ms] vs. Half gap b [mm]

- Max. value
- Min. value
MEASUREMENTS (18/24)

Hor Emit

$\epsilon_h [\mu m]$

- Fitting full profile
- Fitting only core

Time [h]

0 1 2 3 4 5 6 7 8

0 2 4 6 8 10 12 14

norm., $1 \sigma$

Courtesy F. Roncarolo
MEASUREMENTS (19/24)

Hor_Scan@7:53:15 t=0.5sec

Hor_Scan@7:53:15 t=1.5sec

Courtesy F. Roncarolo
MEASUREMENTS (20/24)

Reminder:

- 3.5 μm horiz. rms norm. emitt.
- 1 μm horiz. rms norm. emitt.

[Graph showing the relationship between momentum (p [GeV/c]) and horizontal rms beam size [mm]]

- 26
- 60
- 270
- 450
MEASUREMENTS (21/24)

 Courtesy F. Roncarolo

Fitting full profile
Fitting only core

Elias Métral, CWG meeting, 04/12/06

norm., 1 σ
MEASUREMENTS (22/24)

Collimator OUT, ± 11.5 mm, and $\xi_x = 0.04$ (Anim_07h29)

![Graph](image-url)
MEASUREMENTS (23/24)

Collimator IN, ± 3 mm, and $\xi_x = 0.64$ (Anim_07h33)

Courtesy F. Roncarolo
MEASUREMENTS (24/24)

Collimator OUT, ± 11.5 mm, and $\xi_x = 0.04$ (Anim_07h42)

![Graph showing measurements](image-url)
CONCLUSION

- 2006 tune shifts close to (slightly higher than) the ones from 2004
  - Continuous instead of discrete measurements
  - Shorter bunch length in 2006
  - What about the transverse emittances?
    \[\Rightarrow\text{Still to be analyzed in detail}\]

- Interesting new results (instability rise-times) with 72 bunches with collimator OUT and with collimator IN (several gaps)
  \[\Rightarrow\text{Still to be analyzed in detail}\]