TWC 200 MHz Beam Loading At Injection (pLHC Beams)

2016-12-01

Contents

Introduction

Comparison of beam loading with 8b4e and standard 25 ns pLHC beam at injection.

- ▶ cycle MD_26_28_3inj_L21600_Q20, ID: 9754
- ▶ $V_{200} = 4.5$ MV, $V_{800} = 450$ kV, $\gamma_t = 17.95$, $p = 26$ GeV/c
- ▶ 8b4e beam, 48 bunches, between 17:00 and 17:30
  - ▶ $N_Q = 1.8 \times 10^{11}$, $N_{Q,\text{tot}} = 8.6 \times 10^{12}$
  - ▶ $l_{\text{batch}} = 1.675$ μs
- ▶ standard 25 ns beam, 72 bunches, between 18:30 and 18:45
  - ▶ $N_Q = 1.3 \times 10^{11}$, $N_{Q,\text{tot}} = 9.1 \times 10^{12}$
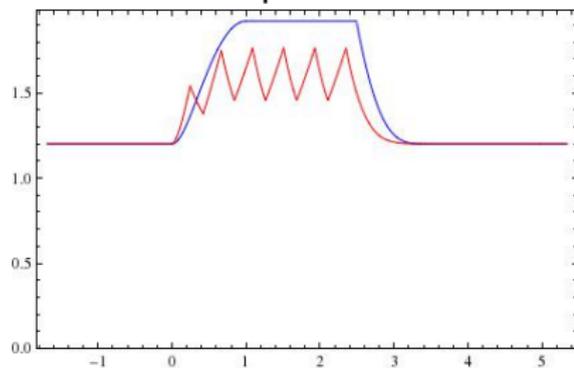 - ▶ $l_{\text{batch}} = 1.775$ μs

Measurements of power at RF Power Amplifier Final Hybrid and cavity voltage at Cavity Return for TWC200-4 (5 Sections) at various time scales (μs to 10 ms).
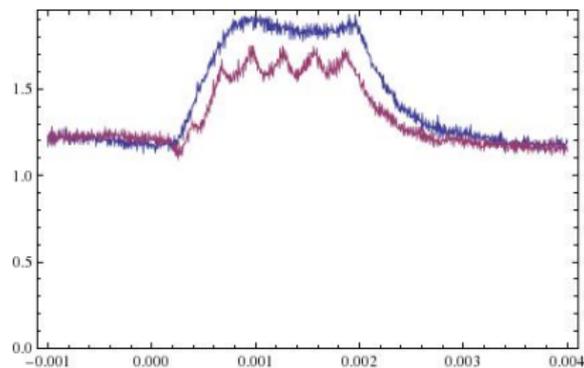
Observations with TWC200-4 (5 Sections)
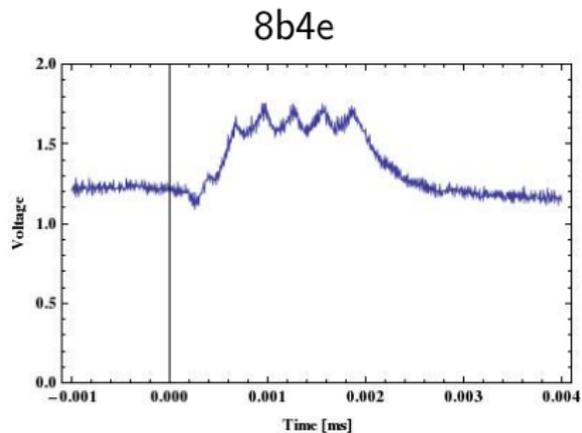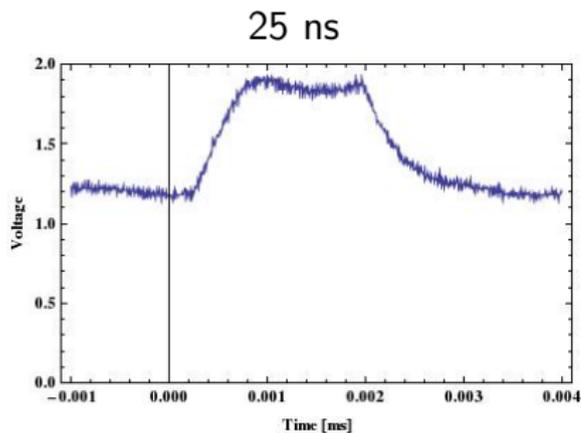
First turn, total voltage

Voltage

Observations with TWC200-4 (5 Sections)

First turn, μs time scale

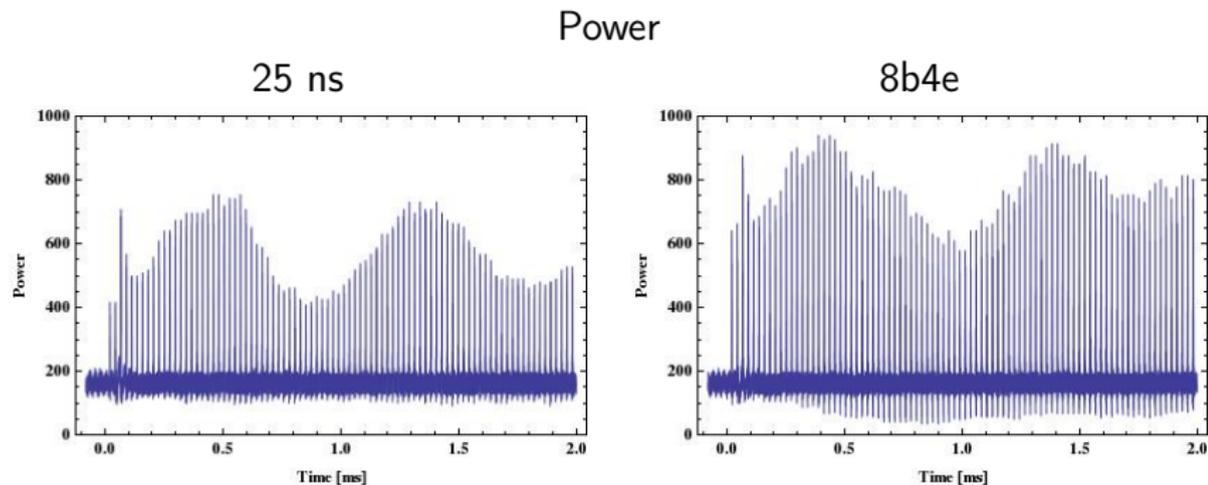Voltage

- harmonic content

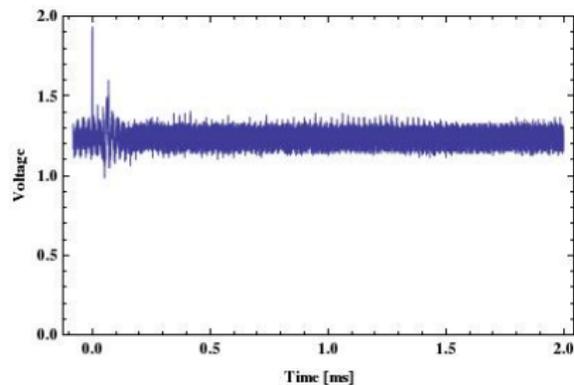# Observations with TWC200-4 (5 Sections)

First 2 ms

Power

25 ns   8b4e

- 0.4 ms, $2f_s$

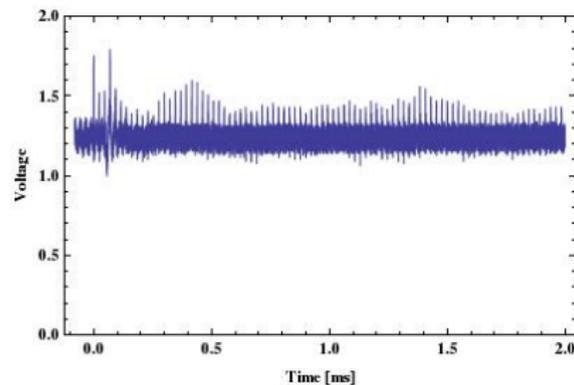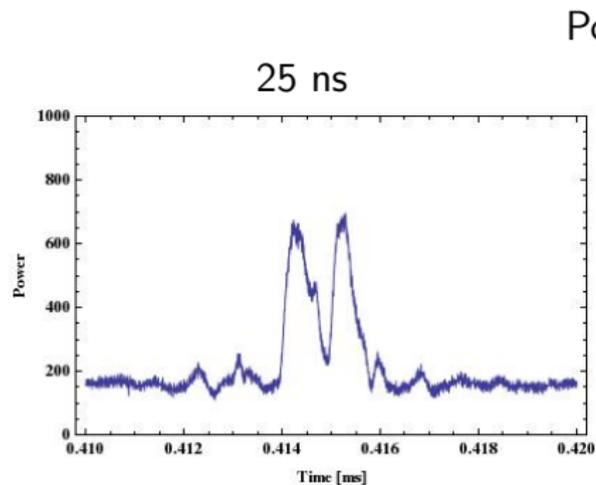# Observations with TWC200-4 (5 Sections)
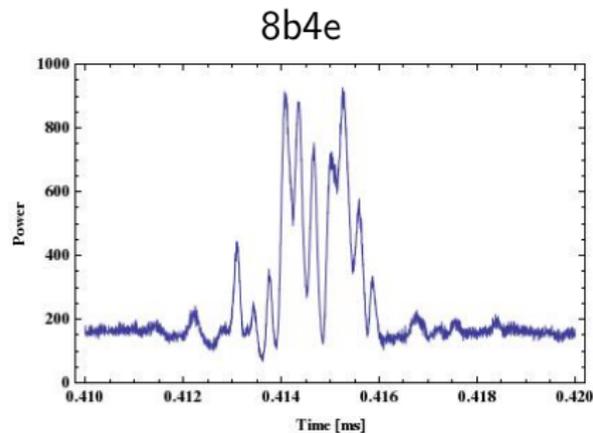
First 2 ms

Voltage

25 ns   8b4e

▶ uncompensated beam loading voltage

Observations with TWC200-4 (5 Sections)

One turn at 0.4 ms

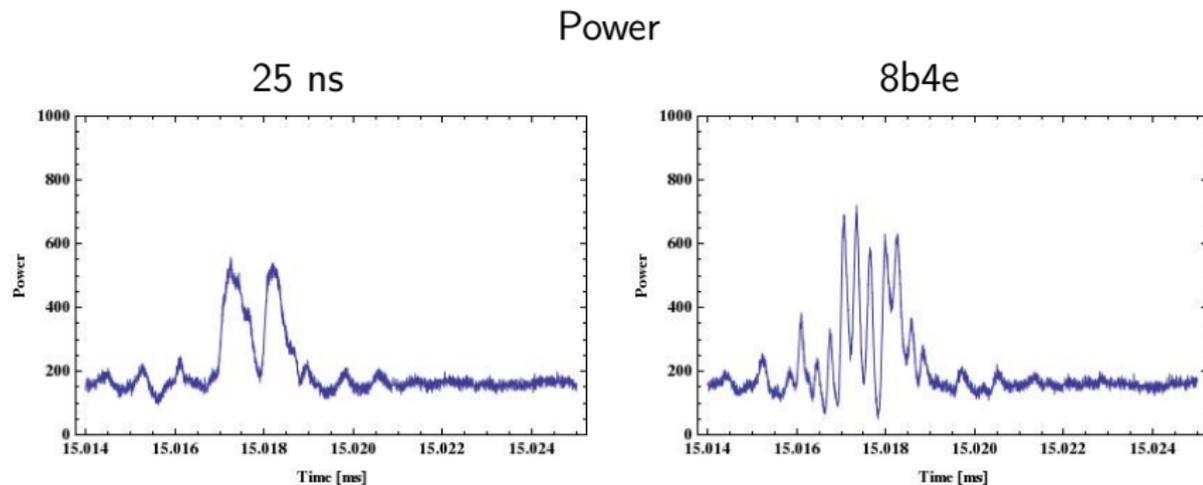Power

25 ns   8b4e

- power, I_{batch}
- harmonic content

Observations with TWC200-4 (5 Sections)

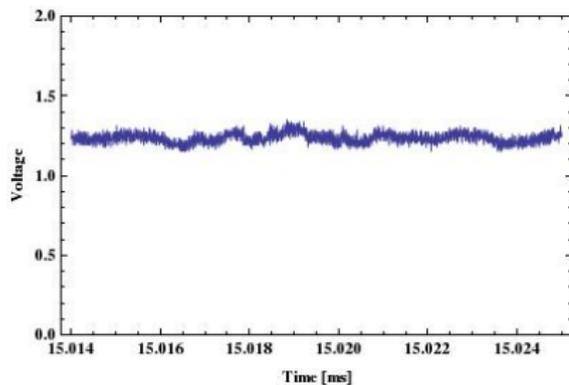Steady state, one turn at 15 ms

Power

25 ns

8b4e

- power, I_{batch}
- harmonic content

Observations with TWC200-4 (5 Sections)
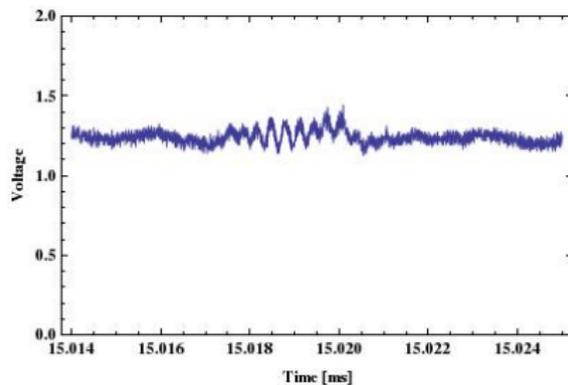
Steady state, one turn at 15 ms

Voltage

25 ns

8b4e
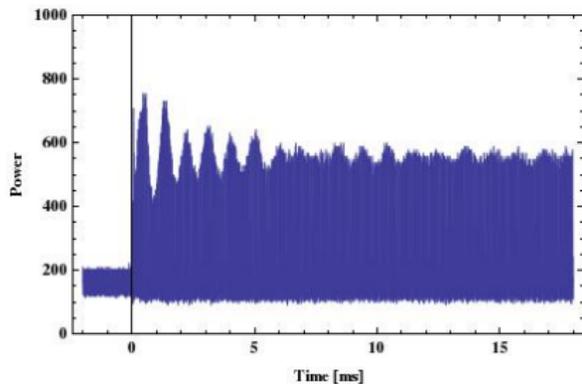
- uncompensated beam loading voltage
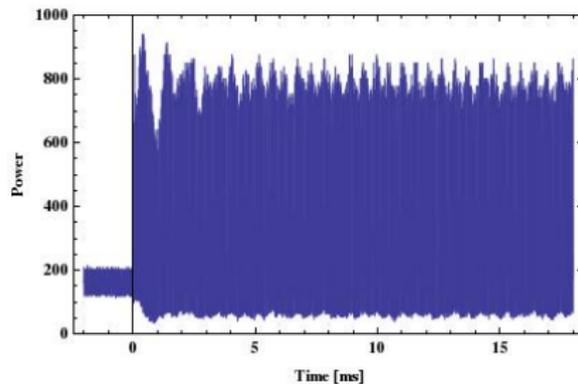
Observations with TWC200-4 (5 Sections)
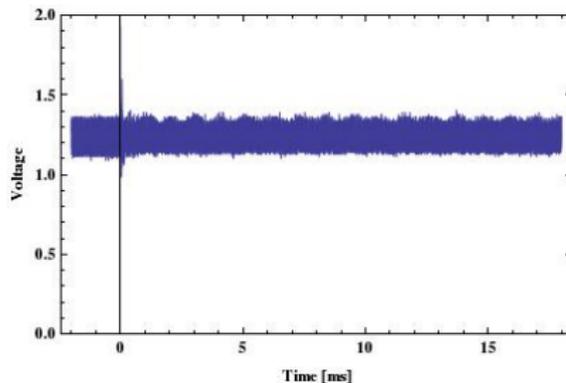
Total acquisition time

Power

25 ns   8b4e
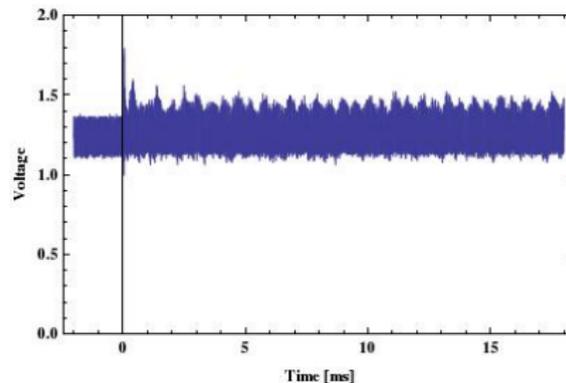
Observations with TWC200-4 (5 Sections)

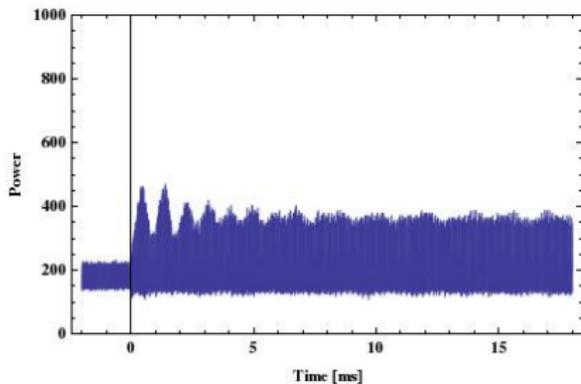Total acquisition time

Voltage

- ▶ uncompensated beam loading voltage

Comparison 4 Sections - 5 Sections
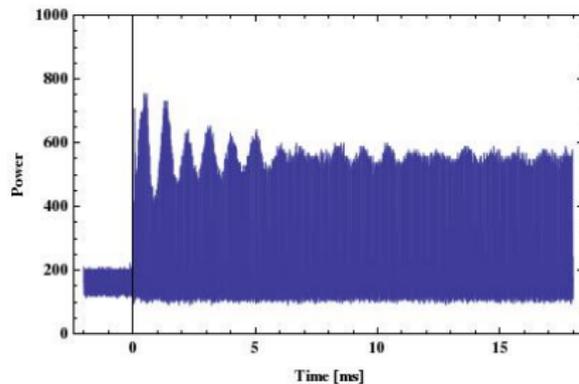
25 ns beam, full acquisition time

Power

4 Sections   5 Sections

Comparison 4 Sections - 5 Sections

25 ns beam, full acquisition time

Voltage
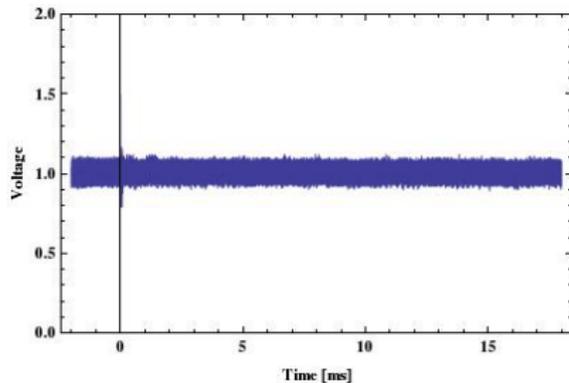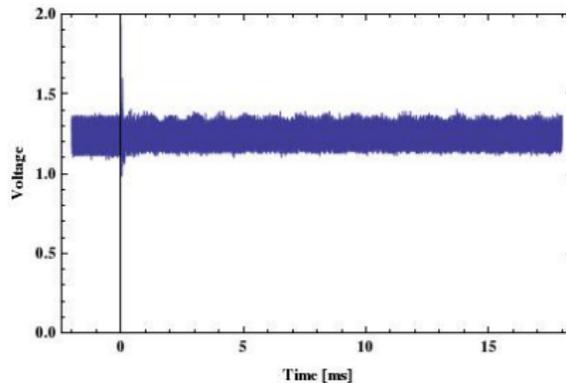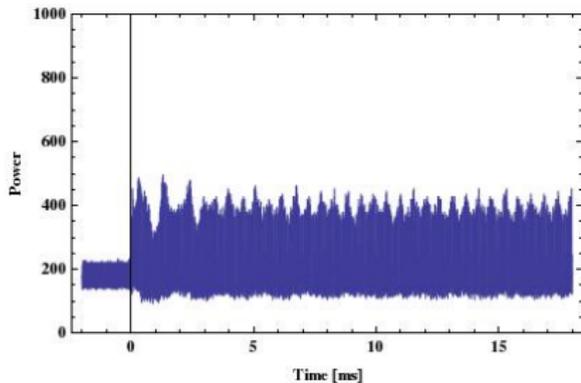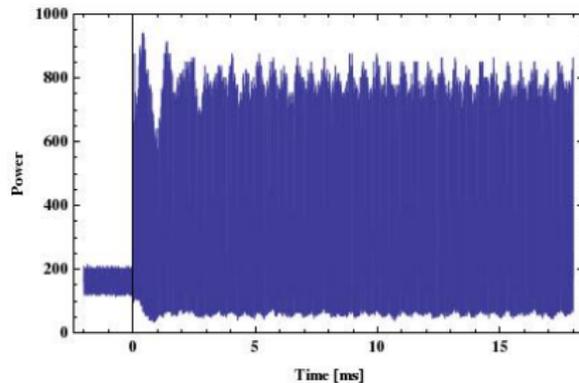
Comparison 4 Sections - 5 Sections

8b4e beam, full acquisition time

Power

4 Sections

5 Sections

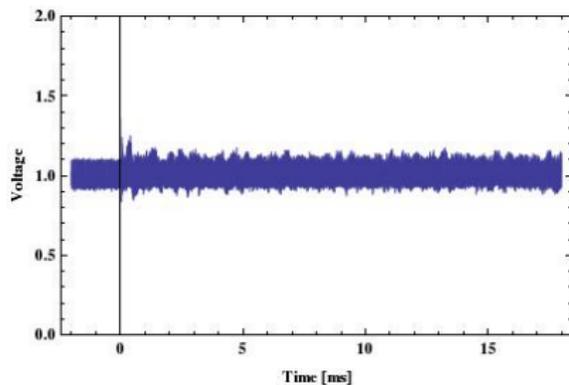## Comparison 4 Sections - 5 Sections

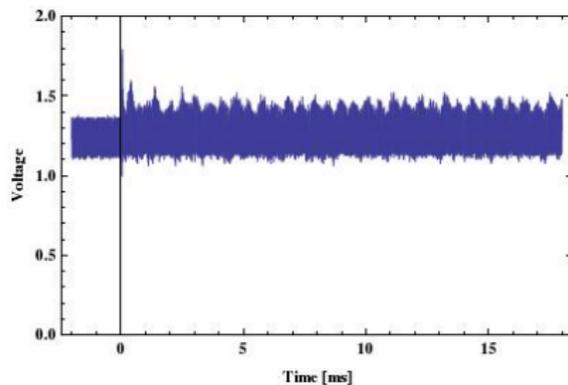8b4e beam, full acquisition time

Voltage

Voltage Partition

Voltage Partition

- partition of total requested RF voltage, V_Σ to the 4 travelling wave structures according to $\{V_1, V_2, V_3, V_4\} = v_{\mathrm{p}} V_\Sigma$

- $v_{\mathrm{p}} = \{f_1, f_2, f_3, f_4\} / \sum\limits_{i=1}^{4} f_i$, $f_i \in \mathbb{R}^+$, for power balancing

- $v_{\mathrm{p}} = \{4, 4, 5, 5\}/18$ for zero beam current, other values for high voltage and high beam loading

- if P requirement is dominated by beam loading, gain with changing v_{p} is marginal

- if uncompensated beam loading voltage is not due to lack of P, change of v_{p} does not reduce P demand

Summary

- observations of 2016-11-22 in line with previously made measurements
- observations of TWC200-4 shown in detail, correspondingly similar results for TWC200-2
- no benefit of voltage partition
- no beam loading compensation if lack of power
- no beam loading compensation if lack of bandwidth
- beam induced voltage less for 8b4e than for standard 25 ns beam
- beam loading compensation worse for 8b4e than for standard 25 ns beam