E-Clouds / TMCI: MD Preparation and Preliminary Results

W. Hofle
Ecloud / TMCI CERN US-LARP Contributors:
C. Rivetta\textsuperscript{1}, J. D. Fox\textsuperscript{1}, O. Turgut\textsuperscript{1}, S. Uemura\textsuperscript{1}, M. Pivi\textsuperscript{1}, I. Rivetta\textsuperscript{1}, T. Bohl\textsuperscript{2}, U. Wehrle\textsuperscript{2}, Y. Papaphilippou\textsuperscript{3}, G. Rumolo\textsuperscript{3}

\textsuperscript{1}Accelerator Research Division, SLAC
\textsuperscript{2}BE-RF Group CERN
\textsuperscript{3}BE-ABP Group CERN

August 12, 2011
1 Introduction

2 MD Preparation
   - Goals and Estimation of Bunch Vertical Displacement
   - Preliminary Results

3 Conclusions
High Bandwidth Feedback Project - (CERN - US LARP)

- Motivation: - Control E-cloud and TMCI effects in SPS and LHC via GHz bandwidth feedback
  - Intrabunch Instability: Requires bandwidth sufficient to sense the vertical position and apply correction fields to multiple sections of a nanosecond-scale bunch.
- US LHC Accelerator Research Program (LARP) has supported a collaboration between US labs (SLAC, LBNL) and CERN
MD preparation

Goal: Drive individual sections of the bunch - Estimate Models

- Hardware development - Excitation - Power Stage - Vertical displacement measurement.
- Analyze and estimate using macro-particle simulation codes the signal levels and outcomes of MD measurements.
- Estimate bunch reduced dynamical model in open loop - Below TMCI / e-cloud instability threshold.

- Drive individually different areas of the bunch (Excitation - Amplifier - Kicker)
- Measure with scope the receiver signals $\Delta - \Sigma$. Estimate vertical displacement for different sections of the bunch.
- Based on Input-Output signals, estimate bunch reduced model.
Goal: Drive individual sections of the bunch - Estimate Models

- Hardware development - Excitation - Power Stage - Vertical displacement measurement.
- Analyze and estimate using macro-particle simulation codes the signal levels and outcomes of MD measurements.
- Estimate bunch reduced dynamical model in open loop-Below TMCI / e-cloud instability threshold.

- Drive individually different areas of the bunch (Excitation - Amplifier - Kicker)
- Measure with scope the receiver signals $\Delta - \Sigma$. Estimate vertical displacement for different sections of the bunch.
- Based on Input-Output signals, estimate bunch reduced model.
Goal: Drive individual sections of the bunch - Estimate Models

- Hardware development - Excitation - Power Stage - Vertical displacement measurement.
- Analyze and estimate using macro-particle simulation codes the signal levels and outcomes of MD measurements.
- Estimate bunch reduced dynamical model in open loop - Below TMCI / e-cloud instability threshold.

- Drive individually different areas of the bunch (Excitation - Amplifier - Kicker)
- Measure with scope the receiver signals $\Delta - \Sigma$. Estimate vertical displacement for different sections of the bunch.
- Based on Input-Output signals, estimate bunch reduced model.
MD preparation

Simulation Results - Estimation of Vertical Displacement.

- SPS Kicker: Max. $V_{\Delta} = 200 \, V$, Max. Momentum $= 4.10^{-6} \, eV.s/m$, Kick in single turn $\rightarrow y_{\text{max}} = 3.27 \, \mu m$ at 26 GeV
- It is necessary to kick the beam using a periodic excitation near the betatron frequency (frac. tune $= 0.185$)

Kicker signal for all the slices: $V_b = 4.10^{-6} \sin(2\pi 0.185 \text{Turns}) \, eV.s/m$. C-MAD result: Vertical displacement of center of the bunch.
Matching pick-up signals in time
MD Preliminary Results

Chromaticity during the SPS MD

![Graph showing chromaticity during the SPS MD](image)

- ChromaH = 0.031
- ChromaV = 0.032
MD Preliminary Results

Orbit adjustment around the pick-up during the SPS MD
**MD Preliminary Results**

**Single bunch driven by sine wave**

- Bunch was driven by continuous sine waves at 200.272680MHz, 300.404676MHz and 400.537404MHz (no phase synchronization between excitation signal and SPS ring).
- Pictures: SUM (SIGMA) signal and DIFF (DELTA) signal for multiple turns

**SUM/DIFF signals when bunch is driven by 200.272680 MHz sinewave**

**SUM/DIFF signals when bunch is driven by 200.272680 MHz sinewave**
MD Preliminary Results

Single bunch driven by sine wave

- Signal observed in the BBQ with and without 200.272680 MHz sinewave excitation.
MD Preliminary Results

Single bunch driven by sine wave

- Movies: SUM (SIGMA) and DIFF (DELTA) signals are processed by equalizing the frequency response of the pick-up and cables and subtracting the mean value along the turns. e.g. Equalized SUM/DIFF signals for turns 21000 to 21500

- Movies: (top) RMS value of the vertical dipole motion, (bottom) sliding window showing the Vertical dipole motion of 25 turns. (Driven by 200.272680MHz sinewave)
MD to be conducted in a few days

**Excitation Box**

Injection trigger- (magenta), Rev-Markers (yellow), Excitation signal (light blue ), 200MHz reference signal (SPS ring - green)
Conclusions - Further plans

- Amplifiers were installed on Aug 03 and preliminary tests were conducted to measure beam motion when driven by external excitation.
- Continue with the preparation of SPS MD and drive the bunch with different modal signals to analyze the vertical motion of the bunch in response to those signals.
- First steps toward more specific MDs based on driving the bunch: Identification of bunch dynamics, bunch dynamic behavior near e-cloud instability and TMCI thresholds, effects of synchrotron motion of bunch centroid, etc..
- Reserve space for new pick-up / kicker installation in sector 3/5 (LSS 3/LSS 5)