E-Clouds / TMCI : MD Preparation and Preliminary Results

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

[1]Accelerator Research Division, SLAC
[2]BE-RF Group CERN
[3]BE-ABP Group CERN

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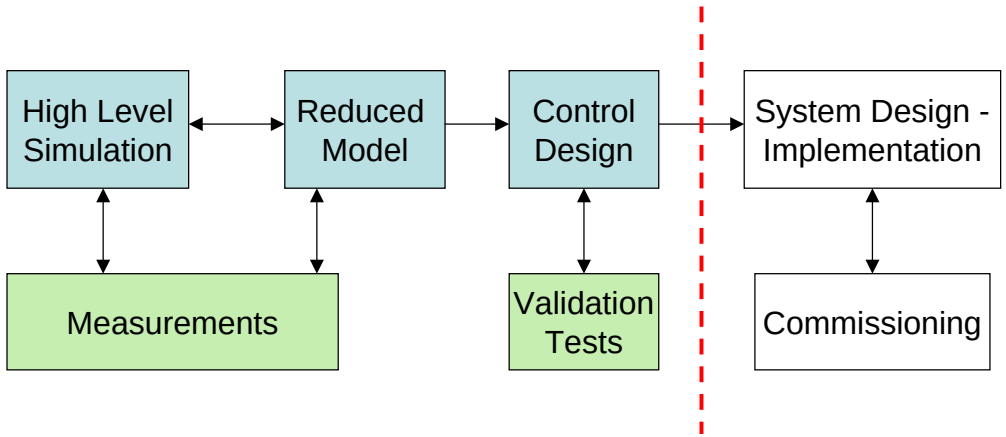
High Bandwidth Feedback Project - (CERN - US LARP)

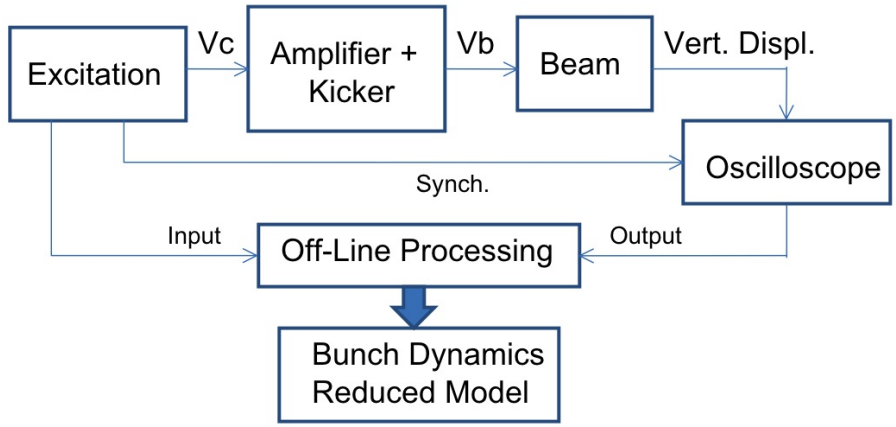
- Motivation: - Control E-cloud and TMCI effects in SPS and LHC via GHz bandwidth feedback
  - Intrabunch Instability: Requires bandwidth sufficient to sense the vertical position and apply correction fields to multiple sections of a nanosecond-scale bunch.
- US LHC Accelerator Research Program (LARP) 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.

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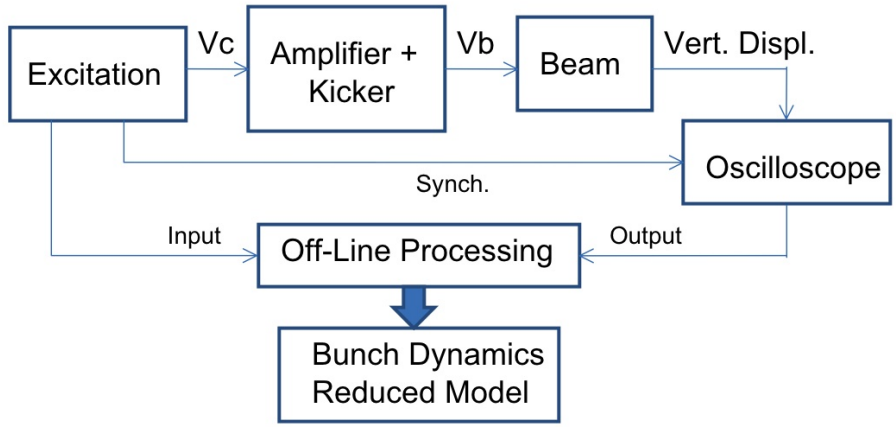

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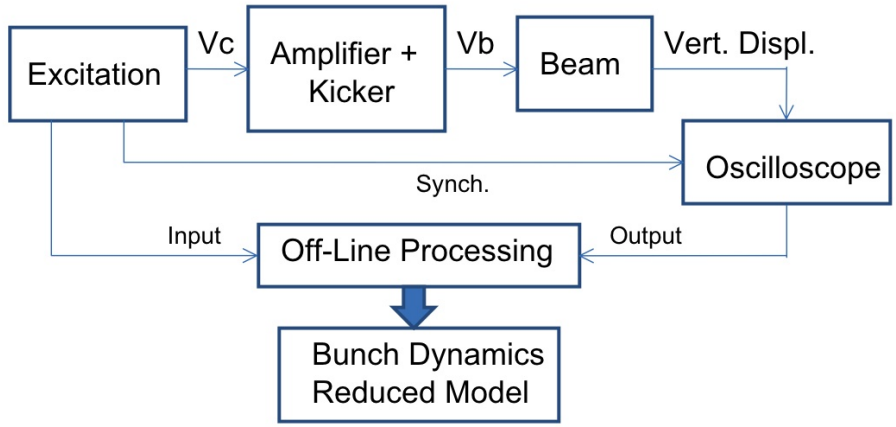

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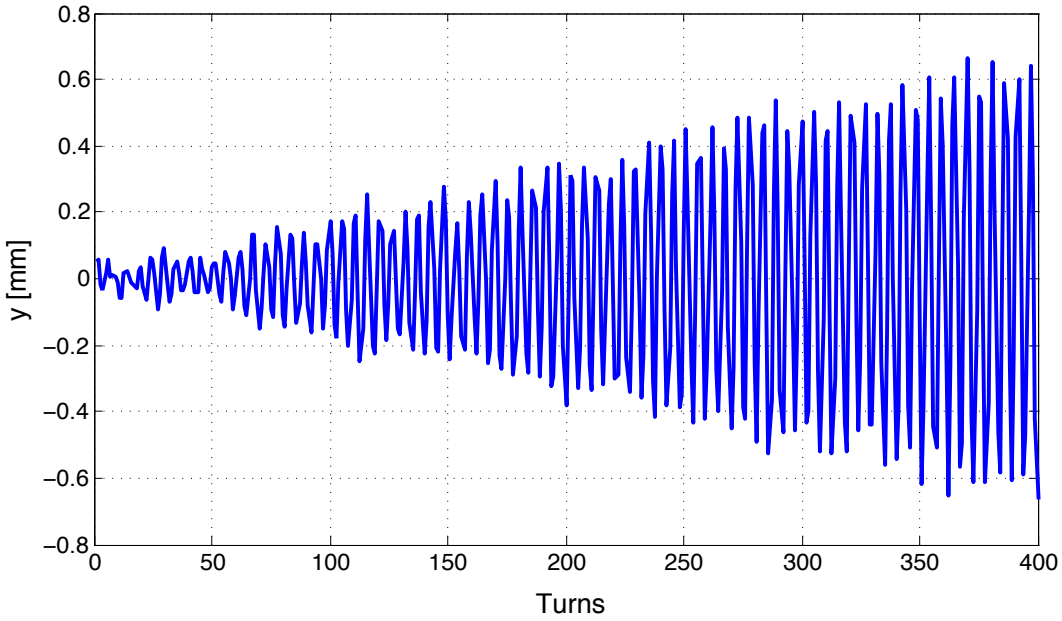
MD preparation

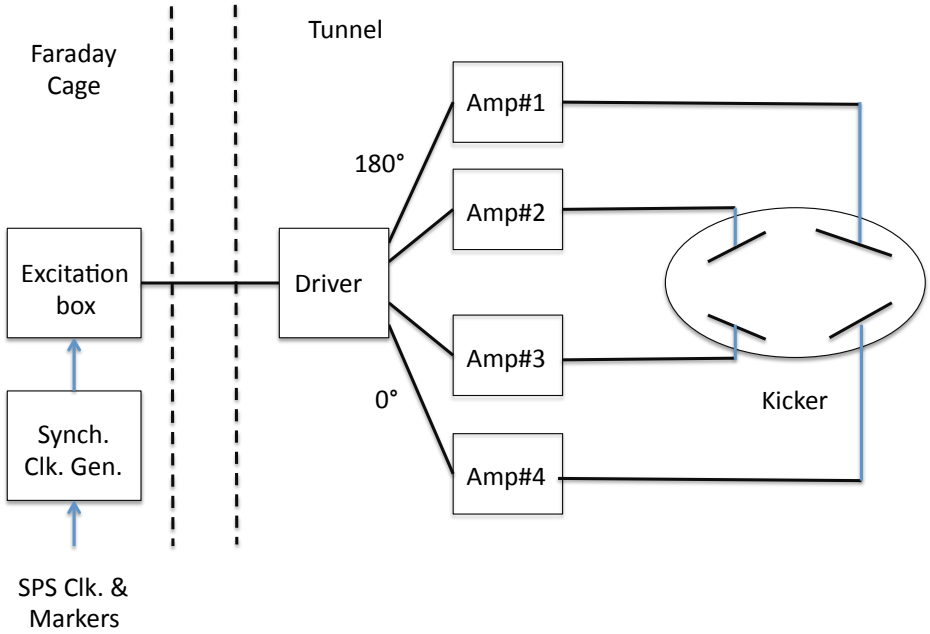
Simulation Results - Estimation of Vertical Displacement.

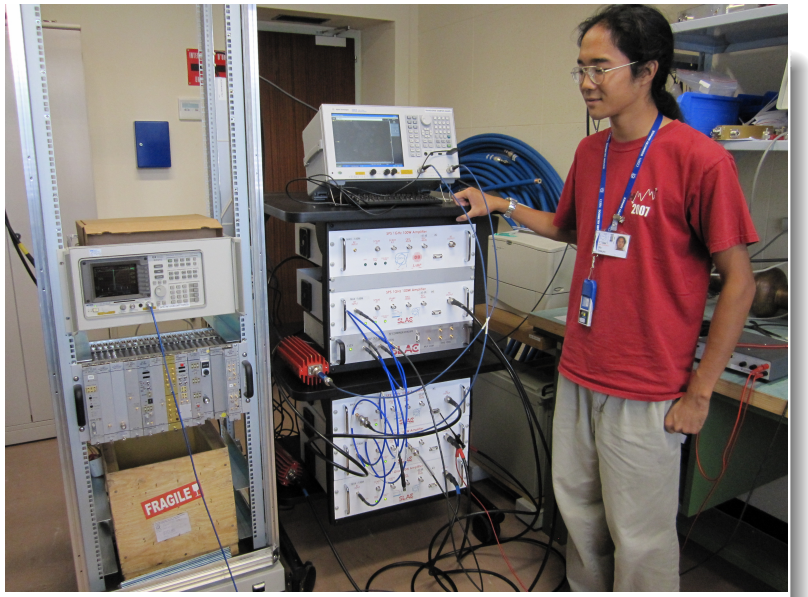
- SPS Kicker: Max. $V_\Delta = 200V$, Max. Momentum $= 4.10^{-6}$ eV.s/m, Kick in single turn $\rightarrow y_{max} = 3.27\mu m$ at 26 GeV
- It is necessary to kick the beam using a periodic excitation near the betatron frequency (frac. tune $= 0.185$)



Kicker signal for all the slices: $V_b = 4.10^{-6} sin(2\pi 0.185\, Turns)$ eV.s/m. C-MAD result: Vertical displacement of center of the bunch.

MD Hardware

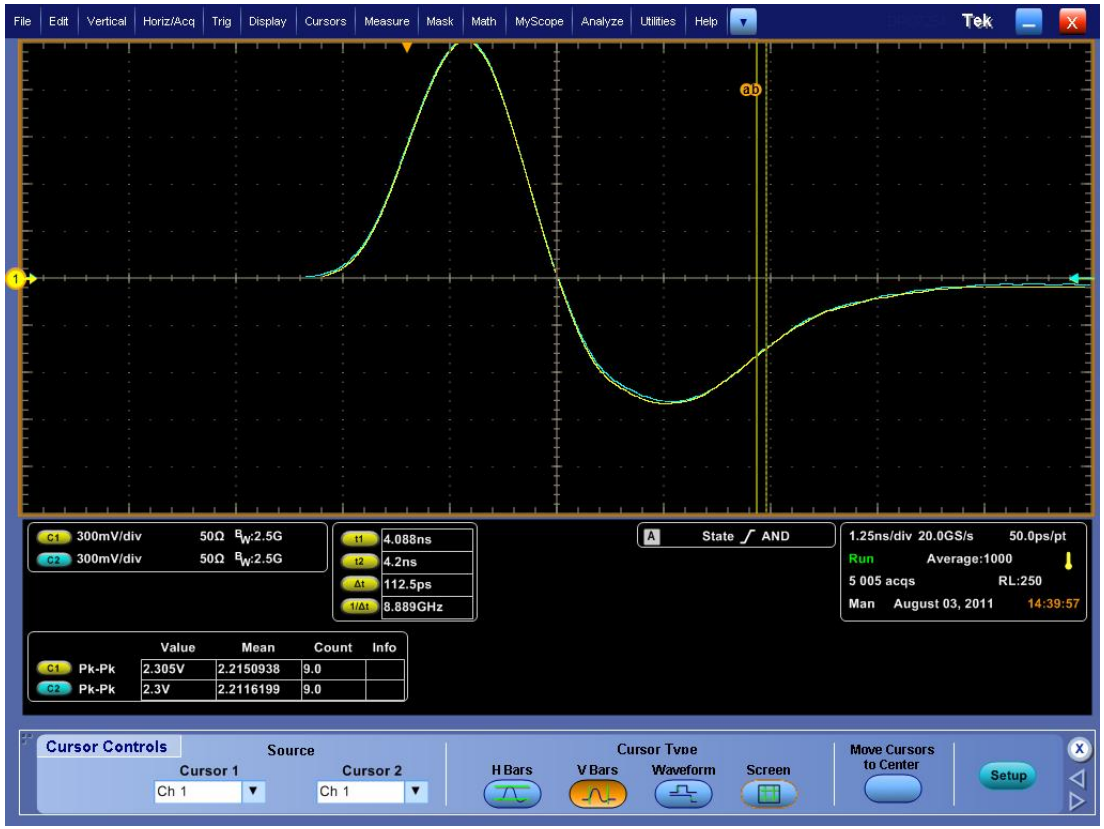

Faraday
Cage
Tunnel
Amp#1
180°
Amp#2
Excitation
box
Driver
Amp#3
0°
Kicker
Synch.
Clk. Gen.
Amp#4
SPS Clk. &
Markers


FRAGILE


K 028

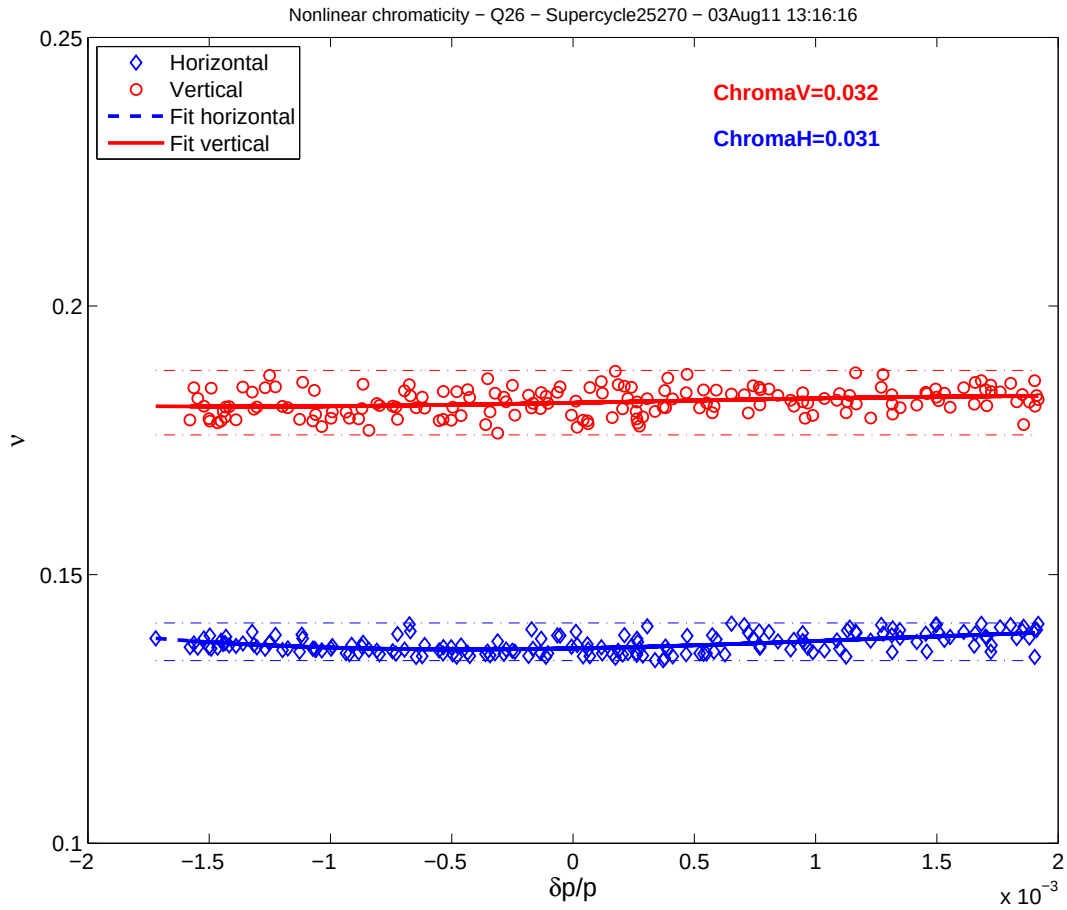
MD Preliminary Results

Matching pick-up signals in time



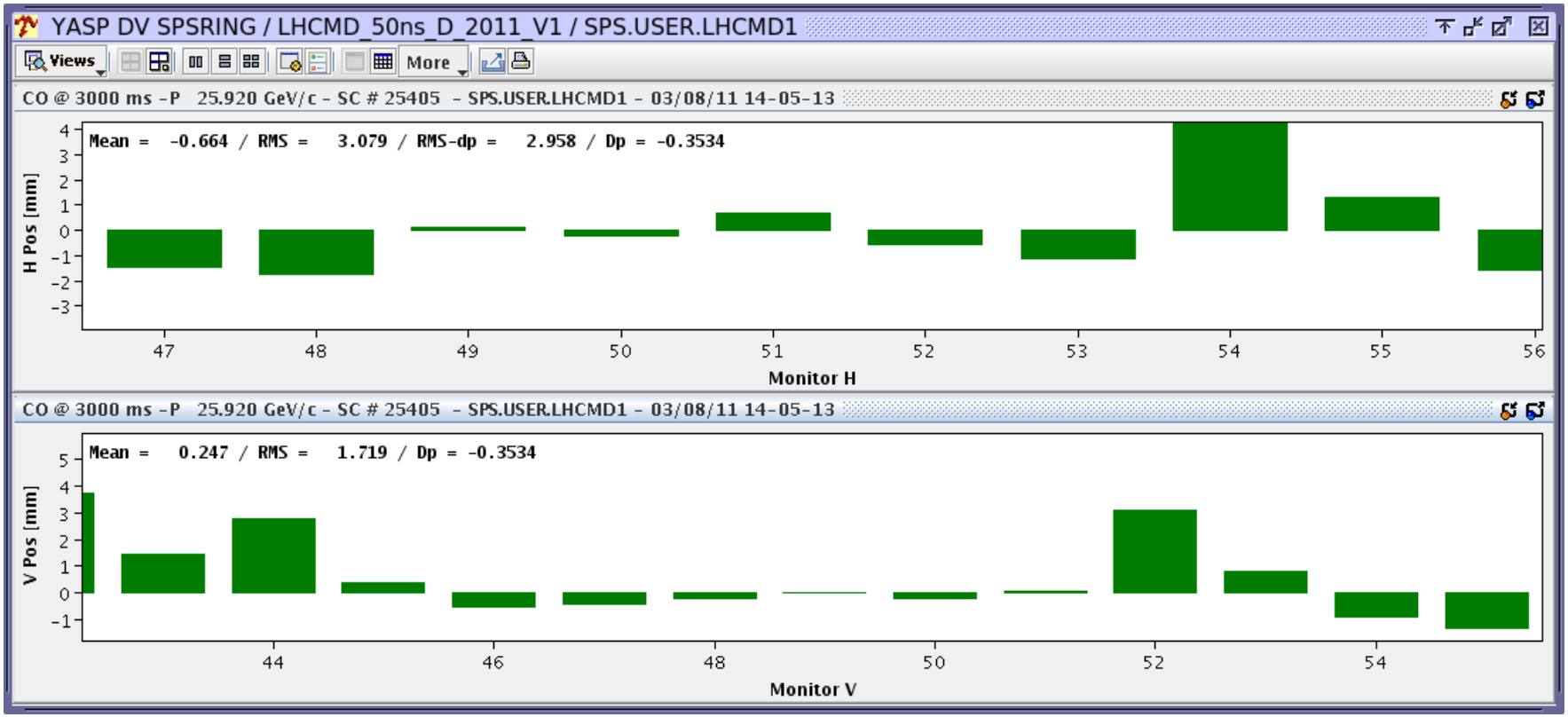
MD Preliminary Results

Chromaticity during the SPS MD



MD Preliminary Results

Orbit adjustment around the pick-up during the SPS MD

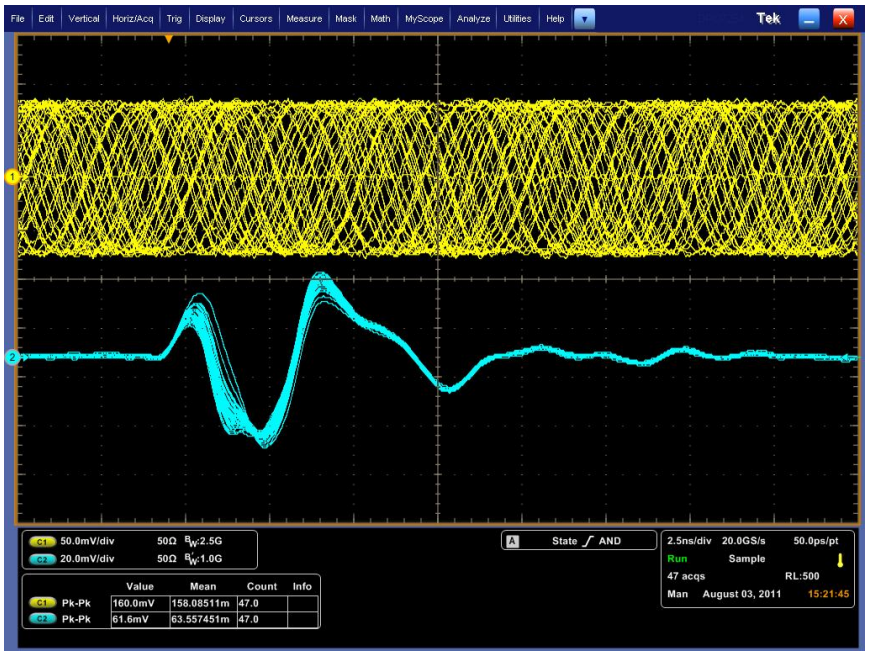


at 3000 ms.png

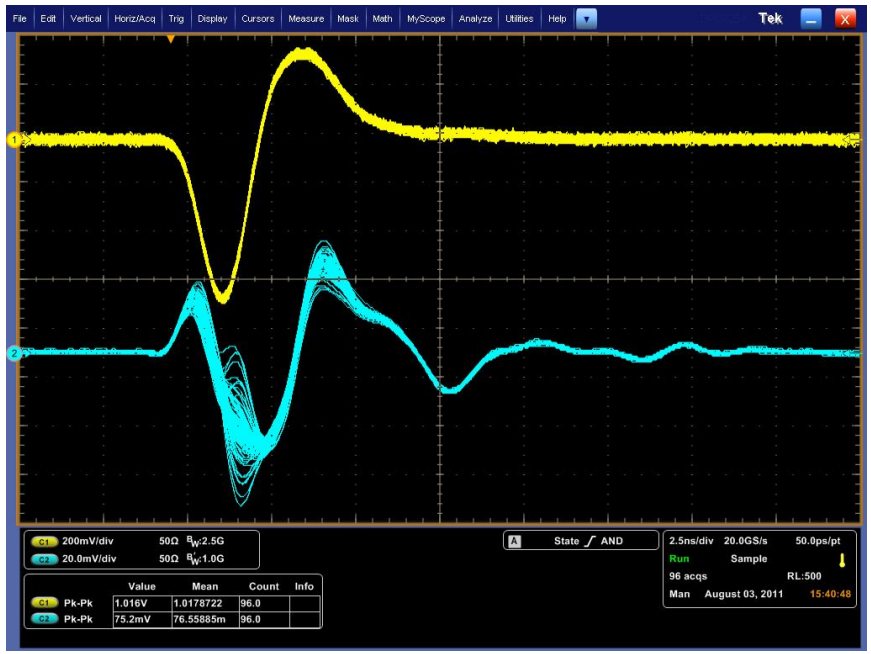
MD Preliminary Results

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



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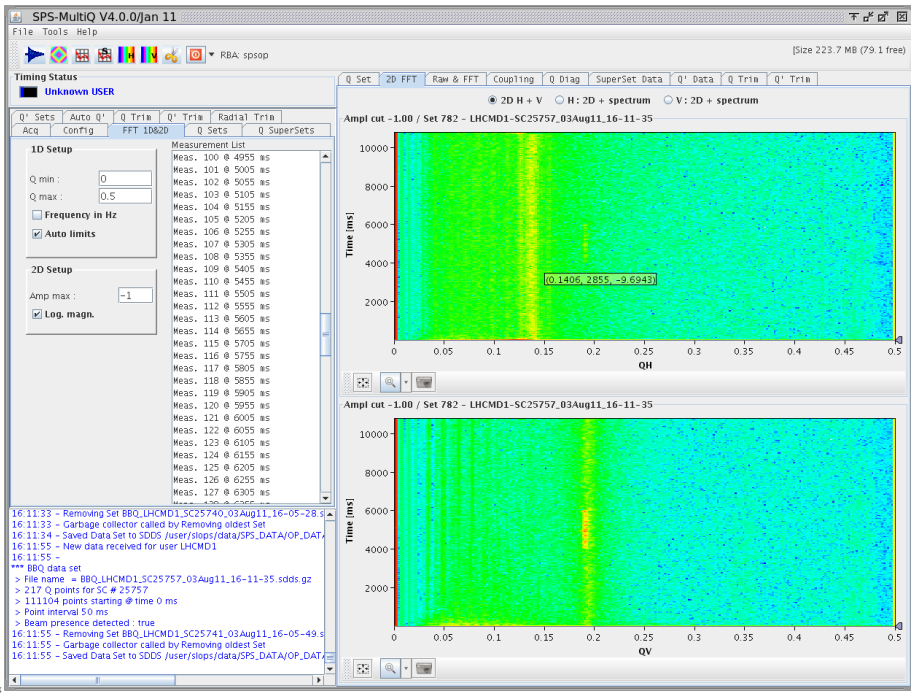
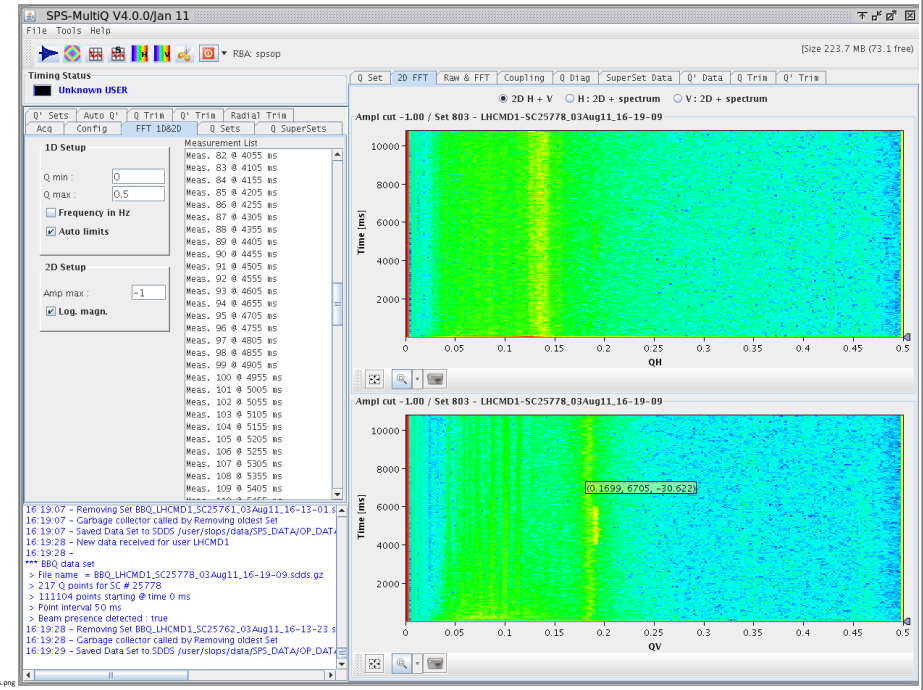
- Signal observed in the BBQ with and without 200.272680 MHz sinewave excitation.

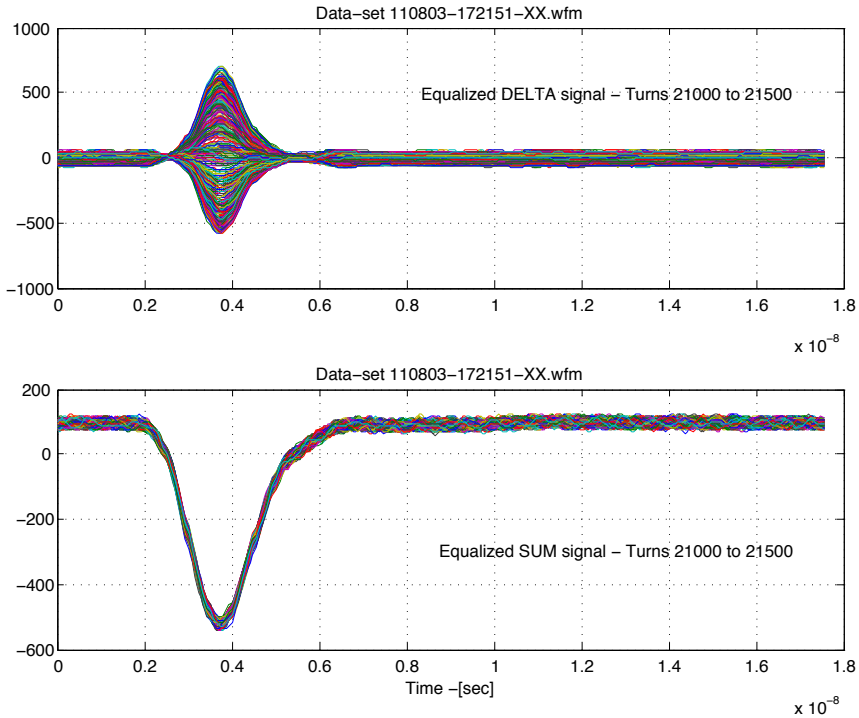




MD Preliminary Results

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

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)