TbT-Data Measurements for SuperKEKB

Acknowledgements
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OMC Meeting
18th December 2019
Overview of Measurements 2019

• 20/05: $\beta^*$ 80 cm / 2 mm
  • HER and LER with IK
  • -400 Hz, -200 Hz, .. 400 Hz
  • $\approx$ 5e3 turns

• 26/06: $\beta^*$ 80 cm / 2 mm
  • HER and LER with PLL H
  • -400 Hz, -200 Hz, .. 400 Hz
  • K-Mod
  • $\approx$ 5e3 turns

• 13/11: $\beta^*$ 80 cm / 1.2 mm
  • HER and LER with IK, PLL H/V
  • -400 Hz, -200 Hz, .. 400 Hz
  • $\approx$ 5e3 turns

• 26/11: $\beta^*$ 80 cm / 1 mm
  • HER and LER with PLL H/V
  • -500 Hz, -400 Hz, .. 500 Hz
  • $\approx$ 5e3 – 5e4 turns

• 03/12: $\beta^*$ 80 cm / 1 mm
  • HER and LER with PLL H+V
  • $\approx$ 5e3 – 5e4 turns

• 05/12: $\beta^*$ 80 (60) cm / 1 mm (HER)
  • LER PLL H+V, - 500 Hz, .. 500 Hz
  • HER PLL H+V 0 Hz
  • $\approx$ 5e3 – 5e4 turns

• 06/12: $\beta^*$ 80 (60) cm / 1 mm (HER)
  • LER IK
  • Rotated sextupole
  • 5000 turns
  • LER PLL H/V
  • PLL frequency different to tune
  • $\approx$ 5e3 turns

• 08/12: $\beta^*$ 80 (60) cm / 1 mm (HER)
  • HER IK
  • -300 Hz, -200 Hz, .. 300 Hz
  • $\approx$ 5e3 turns
Excitation Technique - Injection Kicker

• Only horizontal kicks  • Rather easy to use
• Single kick  • Trigger to start recording data

Orbit X [mm]

MQD3E1: Turn Number [-]
Excitation Technique - PLL

- Continuous excitation, AC-dipole like
- Horizontal and vertical kicks, also simultaneously
- PLL frequency normally not fixed → looks for the natural tune and excites at same frequency with a constant amplitude
- Possible to fix frequency and vary amplitude → tested for LER
- No trigger system:
  - Start PLL excitation
  - Press ‘start’ to record the following e.g. 5000 turns
  - If e.g. amplitude too small → increase PLL amplitude
  - Frequency spectrum looks fine → save these turns
  - No ramping up/down as in LHC
Excitation Technique - PLL

- 13/11/2019
- HER
- PLL horizontal excitation
BPM Synchronisation

- Different BPM synchronisation for IK and PLL excitation → synchronized via code
BPM Issues

- No signal for several BPMs on 03/12
- Could not be explained
- Could not be fixed during measurements

- BPM calibration
- Changes for over time and for on- and off-mom
- No explanation found so far found
PLL Vertical Excitation

13/11/2019

• Improved due to higher kicking amplitude

26/11/2019
PLL Horizontal and Vertical Excitation - ONMOM

- Simultaneous horizontal and vertical excitation tested for the first time in SKEKB
Beta Beating

- $x$: $\Delta \beta_{ph}^{x}/\beta_{mdl}^{x} = 5.7\%$
- $y$: $\Delta \beta_{ph}^{y}/\beta_{mdl}^{y} = 9.5\%$

- $x$: $\Delta \beta_{ph}^{x}/\beta_{mdl}^{x} = 3.6\%$
- $y$: $\Delta \beta_{ph}^{y}/\beta_{mdl}^{y} = 4.5\%$
Main Peaks = PLL Frequency, HER, V+H Excitation

- Main peak drifts over the measurements about $1 \times 10^{-3}$.
- Main peak drifts within one measurement about $1 \times 10^{-4}$. 
PLL Horizontal and Vertical Excitation - OFFMOM

• Off-momentum simultaneous horizontal and vertical excitation tested for the first time in SKEKB
PLL Horizontal and Vertical Excitation - OFFMOM

- Only performed for LER
- Still rather limited lifetime $\rightarrow$ time consuming measurements
  - Inject beam
  - Off-momentum (e.g. +200 Hz)
  - Excite with PLL and save data
  - Beam lost after saving about 3-5 data sets
  - Switch PLL off
  - Move to 0 Hz
  - Inject beam

- HER optics (60 cm / 1 mm) had severe lifetime issues $\rightarrow$ only on-momentum
PLL Horizontal and Vertical - ONMOM

- Natural or driven tune?

![Graph showing Qx and Qy](image)

Amplitude [mm]

MQC1LP: Fractional Tune [-]
PLL Excitation with Fixed Frequency

- Normal mode: PLL frequency looks for tune and excites at tune, not identical between two measurements if tune moves

- Test performed for LER: Fix PLL frequency
  - At the measured tune
  - Off by about 1e-3 compared to tune

- Measured horizontal tune by PLL: 0.47332 (0.52668), Harpy: 0.52379
- Measured vertical tune by PLL: 0.411312 (0.52732), Harpy: 0.52442
- Fixed off-tune horizontal: 0.47268 (0.588688), Harpy: 0.5862
- Fixed off-tune vertical: 0.410708 (0.589292), Harpy: 0.5862
- Difference between measured by PLL and harpy about e-3
PLL Excitation with Fixed Frequency

- Only observed for some BPMs

![Graph showing PLL excitation with two peaks?](image-url)
Some Open Questions

- Why do closed orbit distortion results not agree with Tbt?
- Why do the calibration factors move?
- What is the best value for singular value for harpy?
- How does the result change for different number of turns? (Tune, beta-beating)
- If measured frequency is PLL frequency, how accurate are the measurements if the actual tune is slightly different? (Simulations?)
- Are the maximal possible excitation amplitudes reached?
Merry Christmas..

.. and a happy new year!
Thank you!

Acknowledgements
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