Impedance study summary

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Acknowledgements:

SuperKEKB commissioning team

SuperKEKB Phase2 summary meeting

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Outline

➤ Bunch lengthening
➤ Tune shift
➤ Summary
1. Bunch lengthening

➤ LER

- Left figure: Streak camera data taken on Jul. 12, 2018 (H. Ikeda, K. Ohmi, et al.) with RF voltage 8.4 MV
- Right figure: MWI simulation with nominal bunch length 4.82 mm

![Graph of LER Bunch Length](image1)

\[ y = 4.7099 + 2.3196x \quad R = 0.99469 \]

From H. Ikeda

![Graph of CWR+CSR+RW+GW](image2)

Fitting: \( y = 4.83 + 0.5635x \)
1. Bunch lengthening

➤ HER

- Left figure: Streak camera data taken on Jul. 10, 2018 (H. Ikeda, K. Ohmi, et al.) with RF voltage 12.8 MV
- Right figure: MWI simulation with nominal bunch length 5.33 mm

From H. Ikeda
1. Bunch lengthening

➤ Phase1 results (June, 2016)
  ● Left figure: LER, nominal bunch length 4.6/5.3/6.8 mm @7.7/5.8/3.8 MV
  ● Right figure: HER, nominal bunch length 5.3/6.2/7.8 mm @12.48/9.3/6.2 MV

\[
\psi(z) = I_0 \cdot e^{-\frac{(z - \bar{z})^2}{2(1+\text{sign}(z - \bar{z})A)^2\sigma^2}} + I_1
\]

\[
\begin{align*}
  f_1(I_b) & = 5.41 + 2.17I_b \\
  f_2(I_b) & = 5.95 + 2.35I_b \\
  f_3(I_b) & = 7.58 + 2.21I_b \\
  f_4(I_b) & = 4.58 + 0.59I_b \\
\end{align*}
\]

LER

\[
\begin{align*}
  f_1(I_b) & = 6.13 + 1.44I_b \\
  f_2(I_b) & = 7.03 + 1.54I_b \\
  f_3(I_b) & = 8.69 + 1.71I_b \\
  f_4(I_b) & = 5.34 + 0.88I_b \\
\end{align*}
\]

HER
2. Tune shift

➤ LER: Horizontal plane

● Left figure: Data taken in Phase 1
● Right figure: Data taken in Phase 2

\[ i Z_{\text{eff}}^{X} = 31 \text{ k}\Omega / \text{m} \]

\[ i Z_{\text{eff}}^{X} = 37 \text{ k}\Omega / \text{m} \]

From K. Ohmi

2. Tune shift

➤ LER: Vertical plane

- Left figure: Data taken in Phase 1
- Right figure: Data taken in Phase 2

\[ iZ_{\text{eff}}^{Y} = 53 \text{ k}\Omega / \text{m} \]

\[ iZ_{\text{eff}}^{Y} = 106 \text{ k}\Omega / \text{m} \]

\[ iZ_{\text{eff}}(\text{k}\Omega / \text{m}) = 33.3 \frac{\Delta \nu}{I_{\text{bunch}}(\text{A})} \]

From K. Ohmi

2. Tune shift

➤ HER: Horizontal plane

- **Left figure:** Data taken in Phase 1
- **Right figure:** Data taken in Phase 2

\[ iZ_{\text{eff}}^{X} = 43 \text{ k}\Omega/\text{m} \]

\[ iZ_{\text{eff}}^{X} = 71 \text{ k}\Omega/\text{m} \]

\[ iZ_{\text{eff}}(k\Omega/\text{m}) = 58.2 \frac{\Delta \nu}{I_{\text{bunch}}(\text{A})} \]

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From K. Ohmi

2. Tune shift

➢ HER: Vertical plane

● Left figure: Data taken in Phase 1
● Right figure: Data taken in Phase 2

\[ iZ_{\text{eff}}(k\Omega/m) = 58.2 \frac{\Delta \nu}{I_{\text{bunch}}(A)} \]

\[ iZ_{\text{eff}}^Y = 145 \text{ k}\Omega/m \]

\[ iZ_{\text{eff}}^Y = 247 \text{ k}\Omega/m \]

3. Summary

➤ Bunch lengthening

● Discrepancy between streak camera and MWI simulations to be understood
  *) Huge discrepancy in LER remains
  *) Discrepancy in HER improves remarkably
● Kind reminding: The re-analysis of KEKB LER data (D.Z. and Karl Bane) showed good agreements between:
  *) HOM power estimates based on MWI simulations and HOM power extracted from RF system log data
  *) RF phase shifts measure by Ieiri-san’s gated BPM method and RF phase shifts extracted from RF system log data
  *) Refer to: http://research.kek.jp/people/dmzhou/BeamPhysics/mwi/kbane_microwave_inst.pdf

➤ Tune shift

● Not serious in Phase2, but can be important in Phase3:
  *) β* squeeze and increasing beta functions at collimators
  *) Number of collimators increases in LER for protection of QCS
● Extrapolation from Phase2 to Phase3 to be done