Impedance study summary

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Acknowledgements:

SuperKEKB commissioning team

SuperKEKB Phase2 summary meeting

KEK, 06 September, 2018

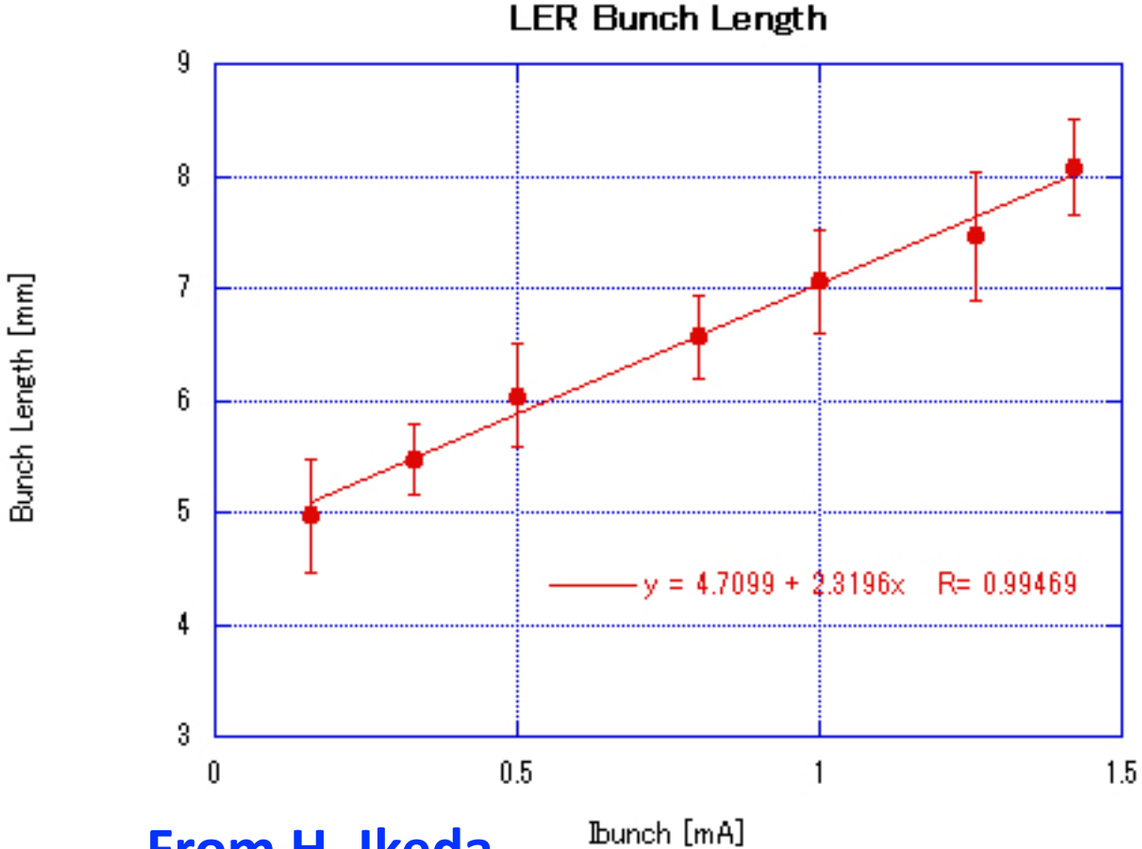
Outline

- ➤ Bunch lengthening
- ➤ Tune shift
- ➤ Summary

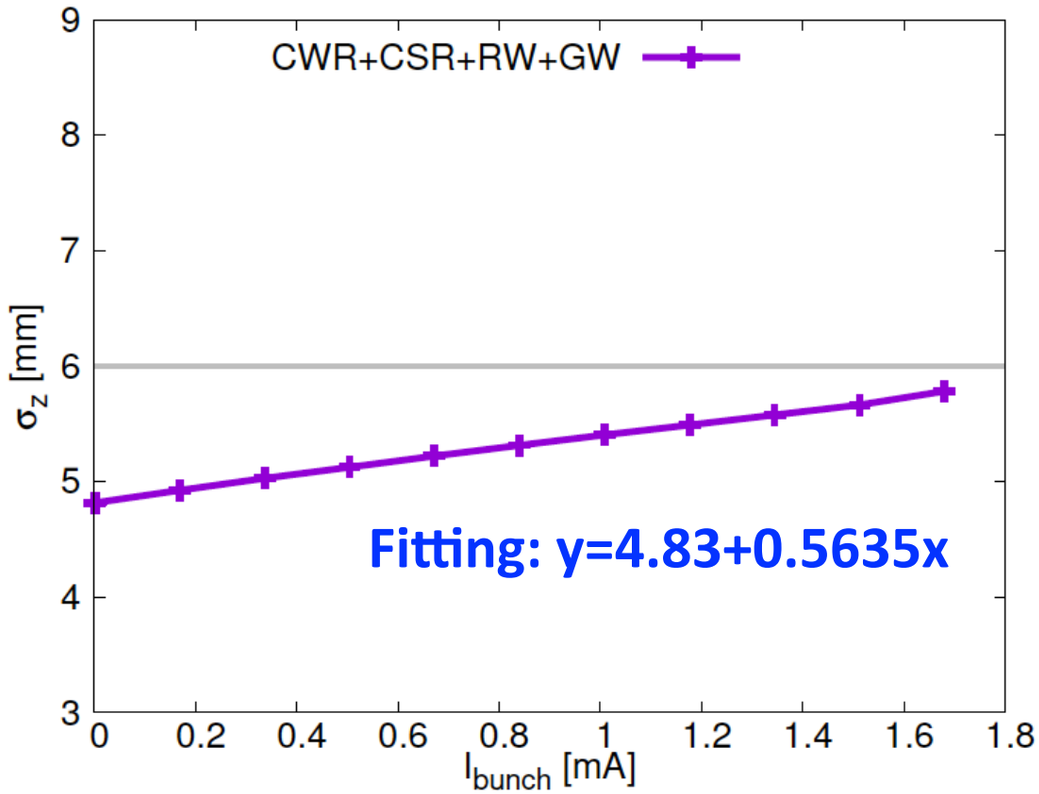
1. Bunch lengthening

➤ **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**



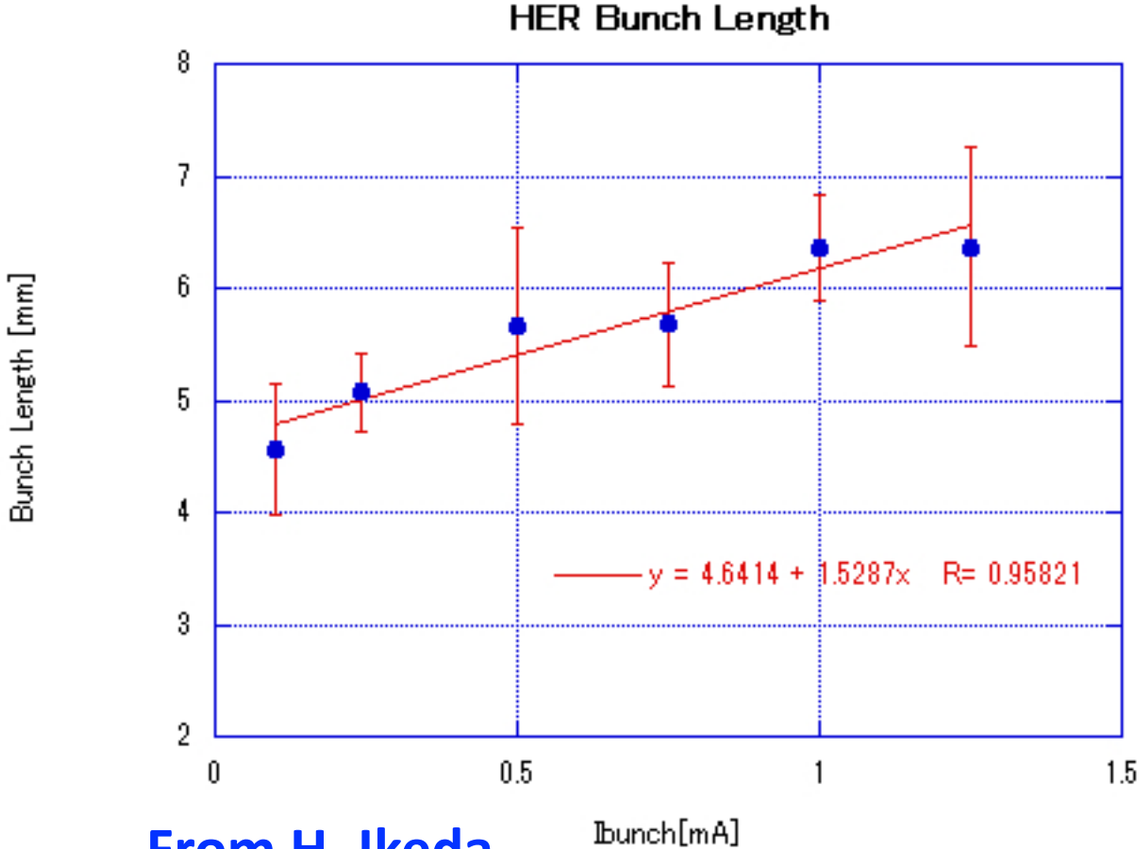
From H. Ikeda



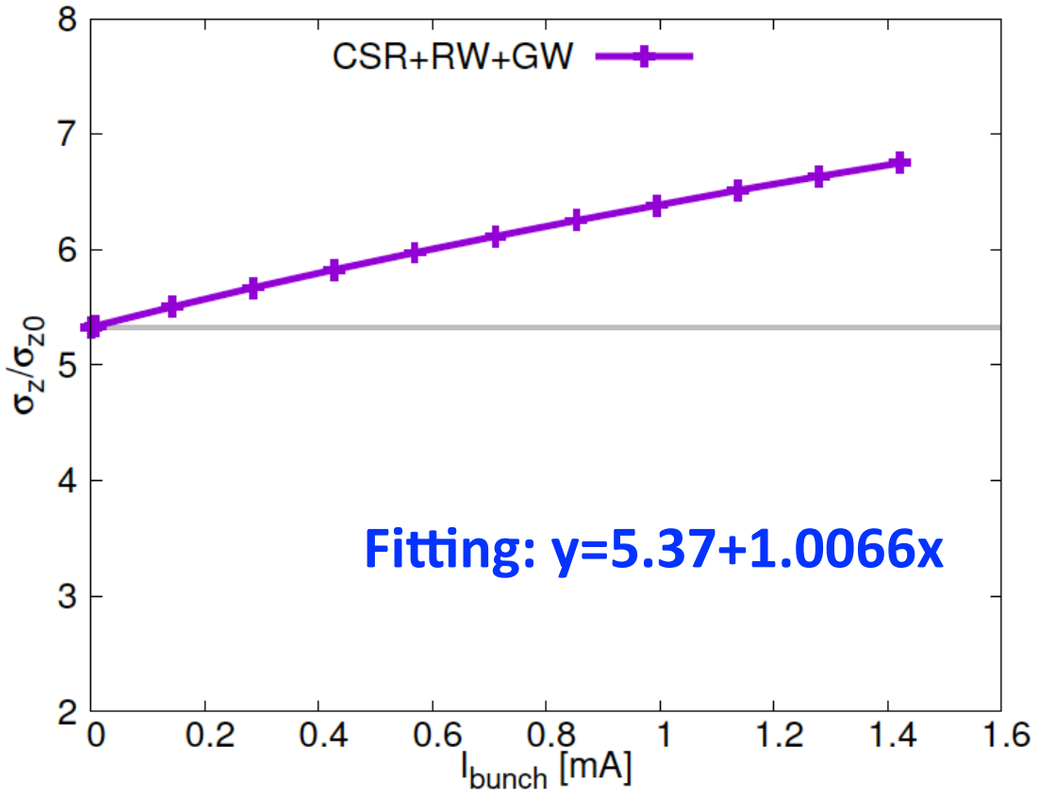
1. Bunch lengthening

➤ 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



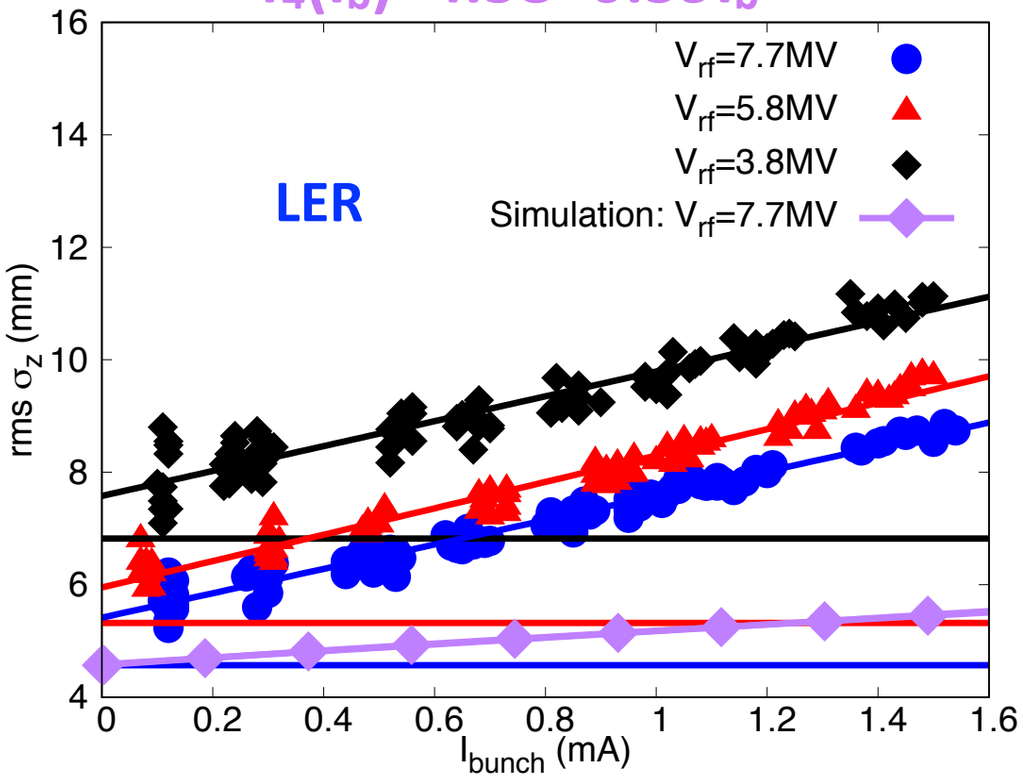
1. Bunch lengthening

➤ **Phase1 results (June, 2016)**

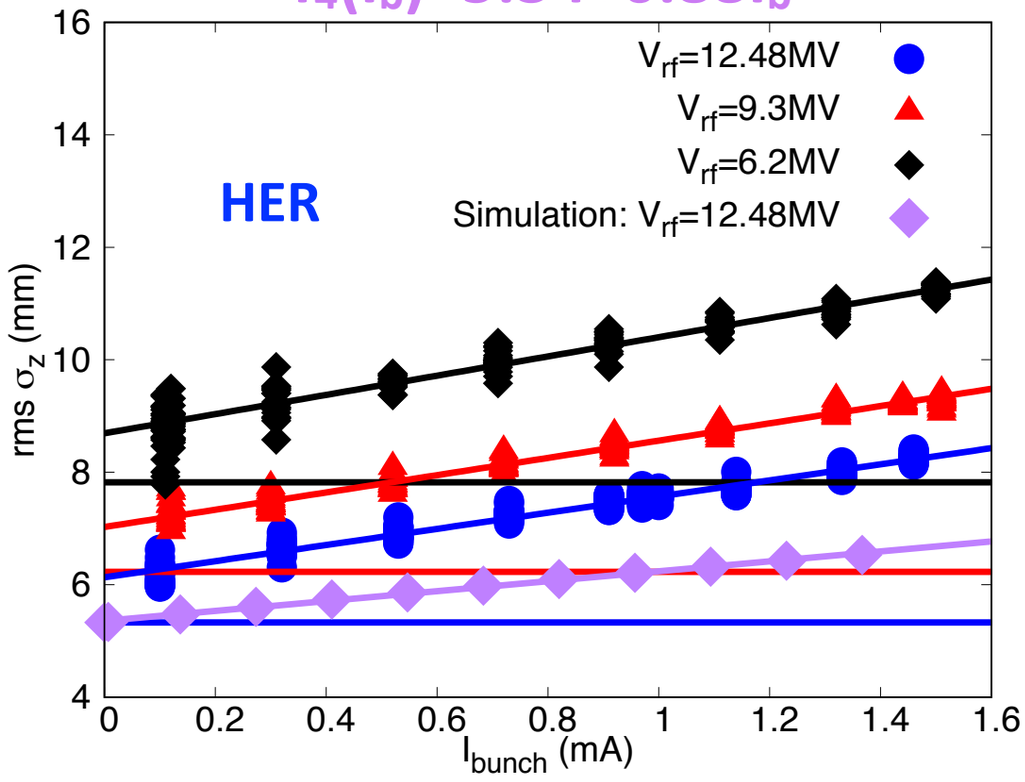
$$\psi(z) = I_0 * e^{-\frac{(z-\bar{z})^2}{2[1+\mathrm{sign}(z-\bar{z})A]^2\sigma^2}} + I_1$$

- **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**

$f_1(I_b)=5.41+2.17I_b$
$f_2(I_b)=5.95+2.35I_b$
$f_3(I_b)=7.58+2.21I_b$
$f_4(I_b)=4.58+0.59I_b$



$f_1(I_b)=6.13+1.44I_b$
$f_2(I_b)=7.03+1.54I_b$
$f_3(I_b)=8.69+1.71I_b$
$f_4(I_b)=5.34+0.88I_b$



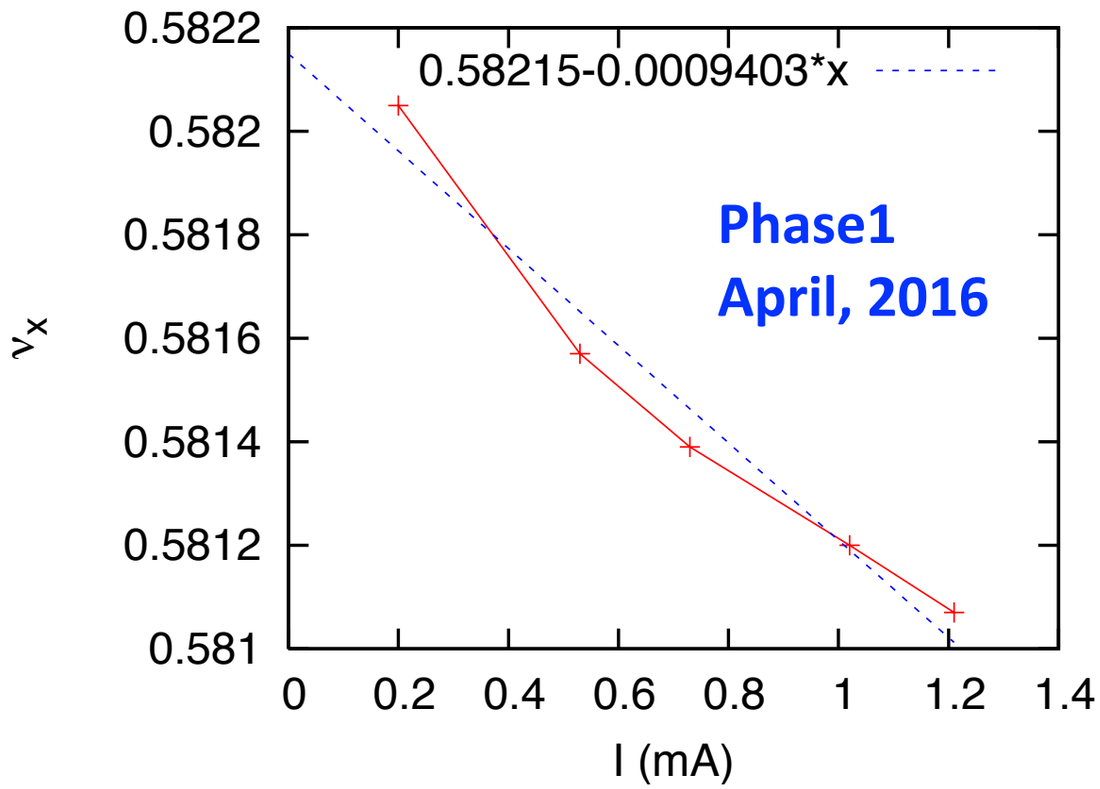
2. Tune shift

➤ LER: Horizontal plane

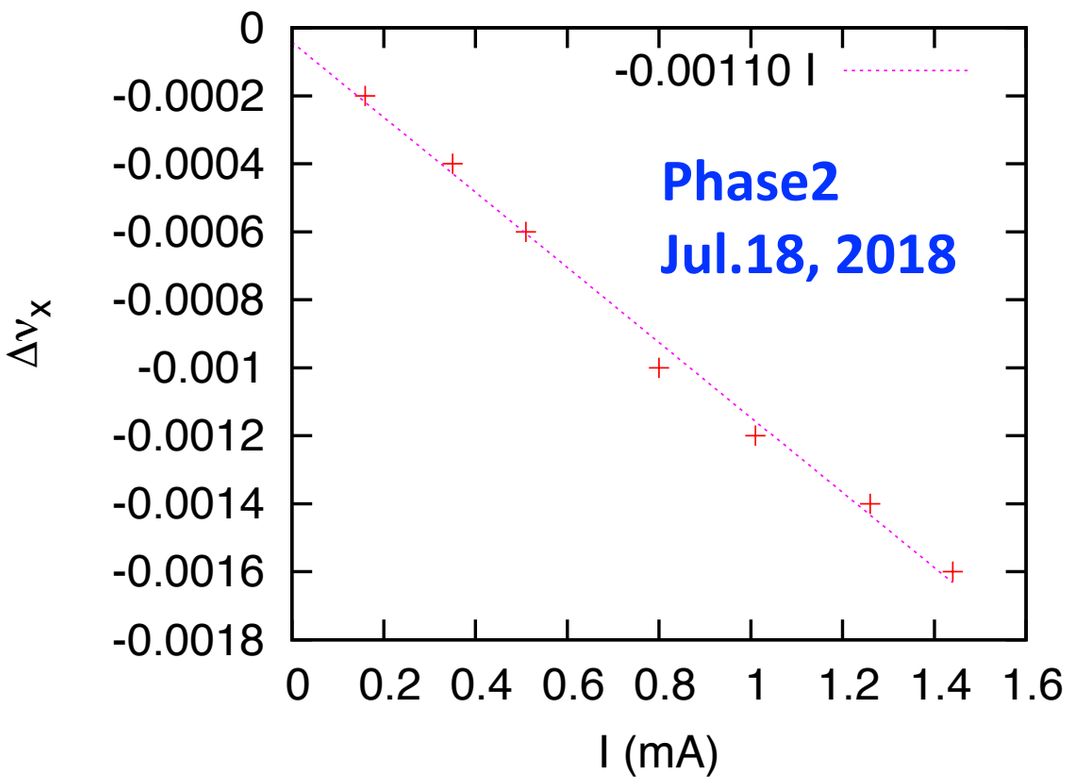
- **Left figure: Data taken in Phase 1**
- **Right figure: Data taken in Phase 2**

$$iZ_{\rm eff}({\rm k}\Omega/{\rm m}) = 33.3\frac{\Delta\nu}{I_{\rm bunch}({\rm A})}$$

$$iZ^X_{\rm eff} = 31\ {\rm k}\Omega/{\rm m}$$



$$iZ^X_{\rm eff} = 37\ {\rm k}\Omega/{\rm m}$$



From K. Ohmi

Ref. http://www-kekb.kek.jp/MAC/2018/Report/Ohmi.pdf

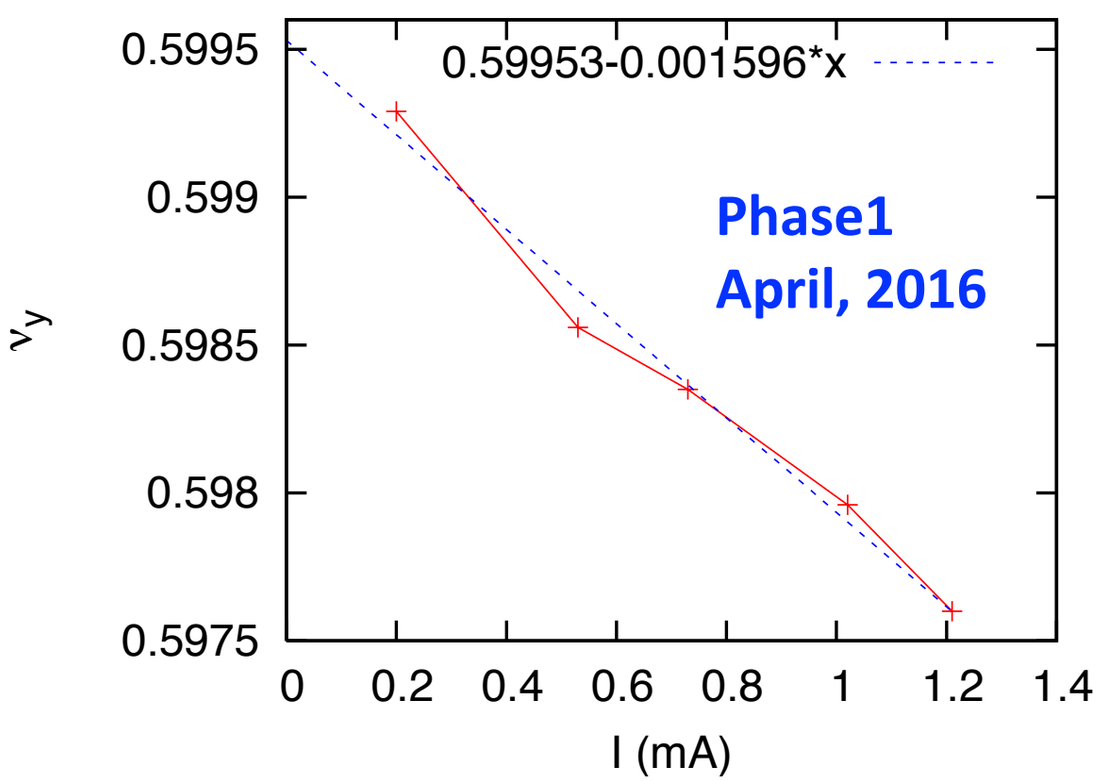
2. Tune shift

➤ LER: Vertical plane

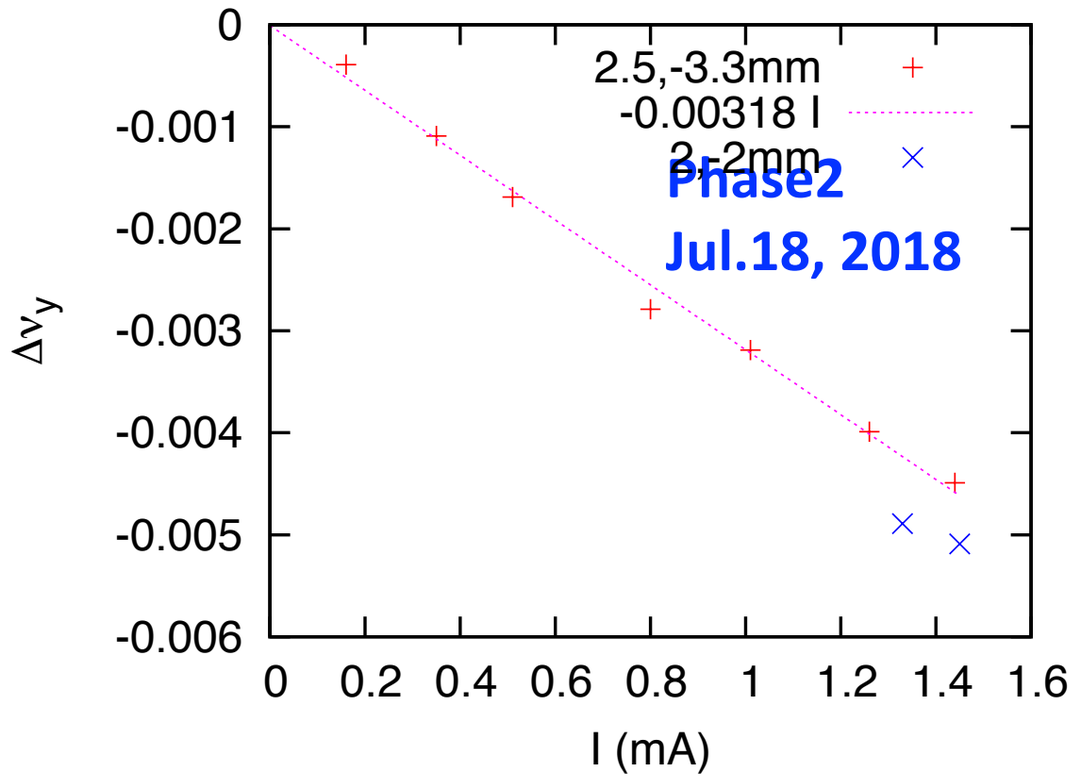
- **Left figure: Data taken in Phase 1**
- **Right figure: Data taken in Phase 2**

$$iZ_{\rm eff}({\rm k}\Omega/{\rm m}) = 33.3\frac{\Delta\nu}{I_{\rm bunch}({\rm A})}$$

$$iZ^Y_{\rm eff} = 53\ {\rm k}\Omega/{\rm m}$$



$$iZ^Y_{\rm eff} = 106\ {\rm k}\Omega/{\rm m}$$



From K. Ohmi

Ref. http://www-kekb.kek.jp/MAC/2018/Report/Ohmi.pdf

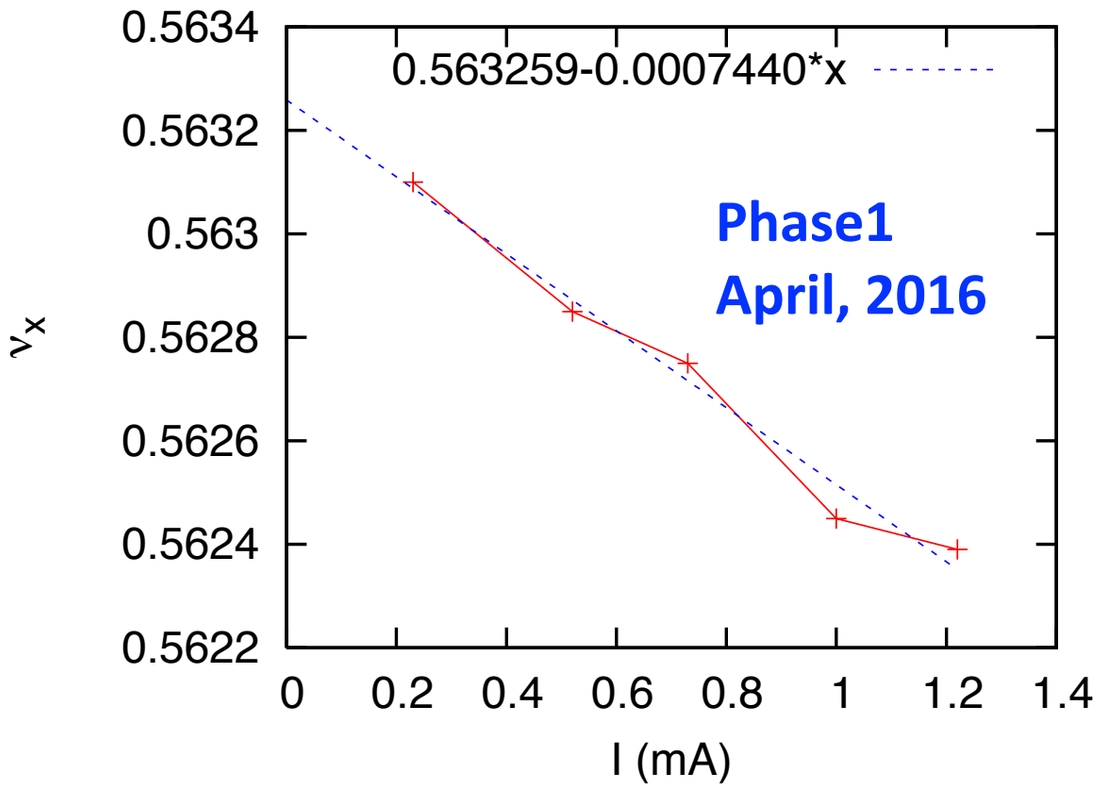
2. Tune shift

➤ HER: Horizontal plane

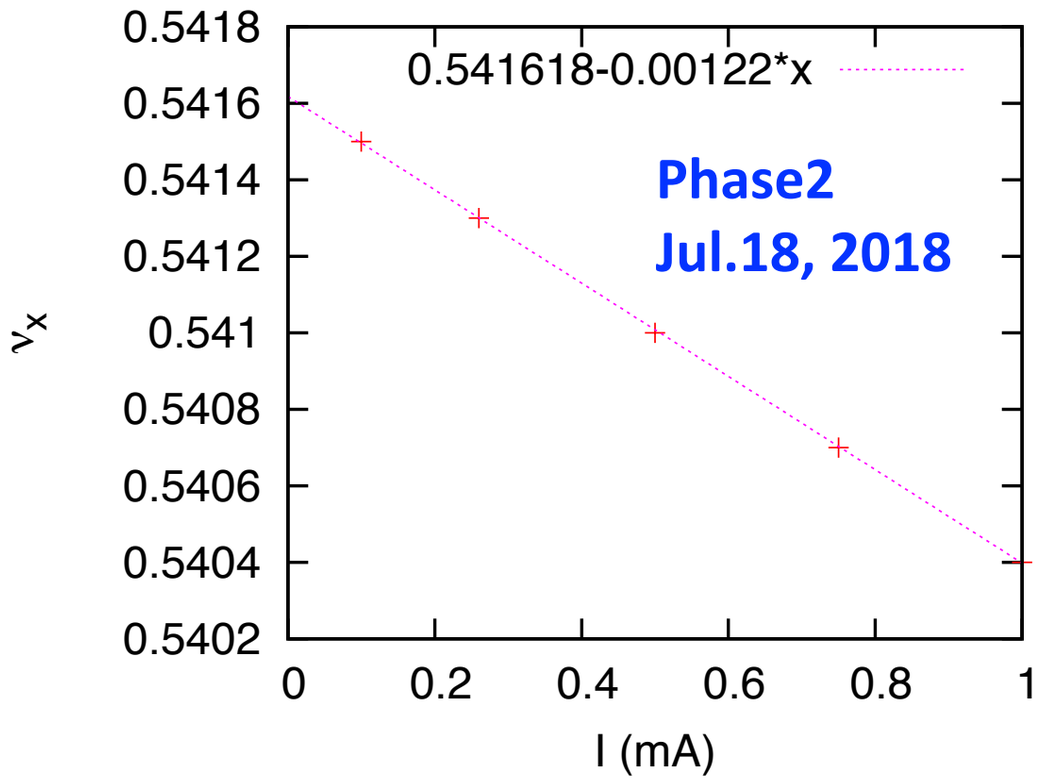
- **Left figure: Data taken in Phase 1**
- **Right figure: Data taken in Phase 2**

$$iZ_{\rm eff}({\rm k}\Omega/{\rm m}) = 58.2\frac{\Delta\nu}{I_{\rm bunch}({\rm A})}$$

$$iZ^X_{\rm eff} = 43\ {\rm k}\Omega/{\rm m}$$



$$iZ^X_{\rm eff} = 71\ {\rm k}\Omega/{\rm m}$$



From K. Ohmi

Ref. http://www-kekb.kek.jp/MAC/2018/Report/Ohmi.pdf

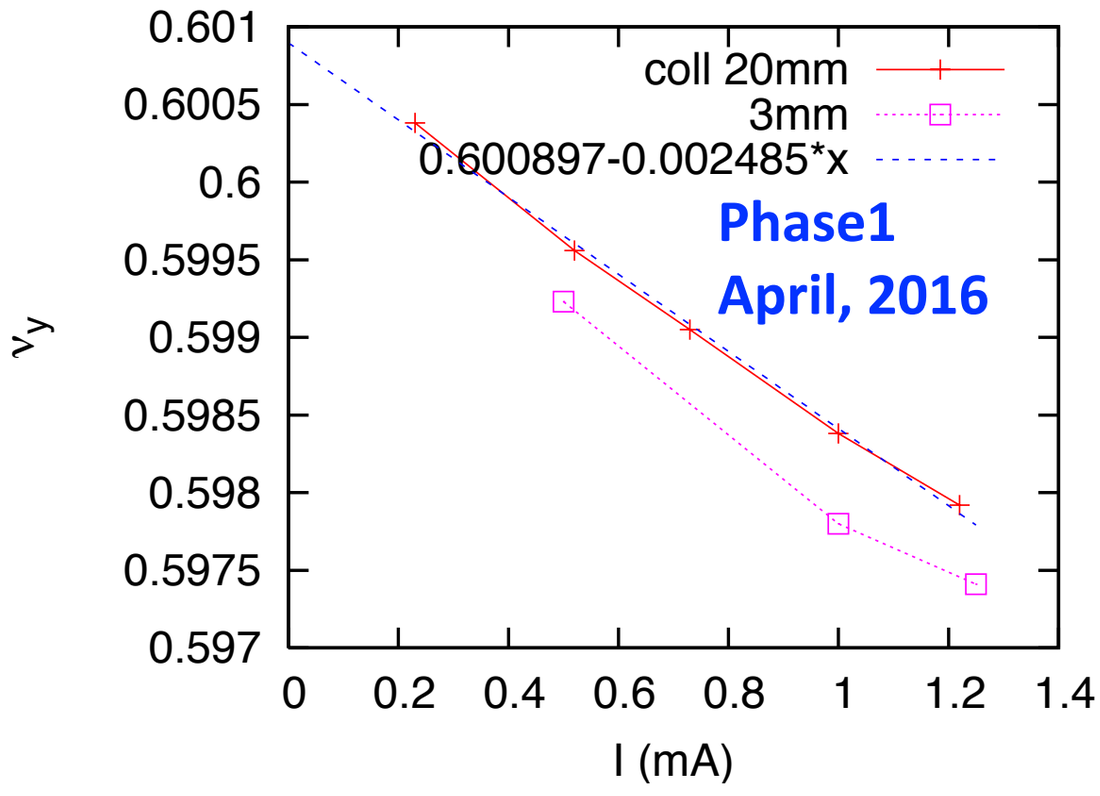
2. Tune shift

➤ HER: Vertical plane

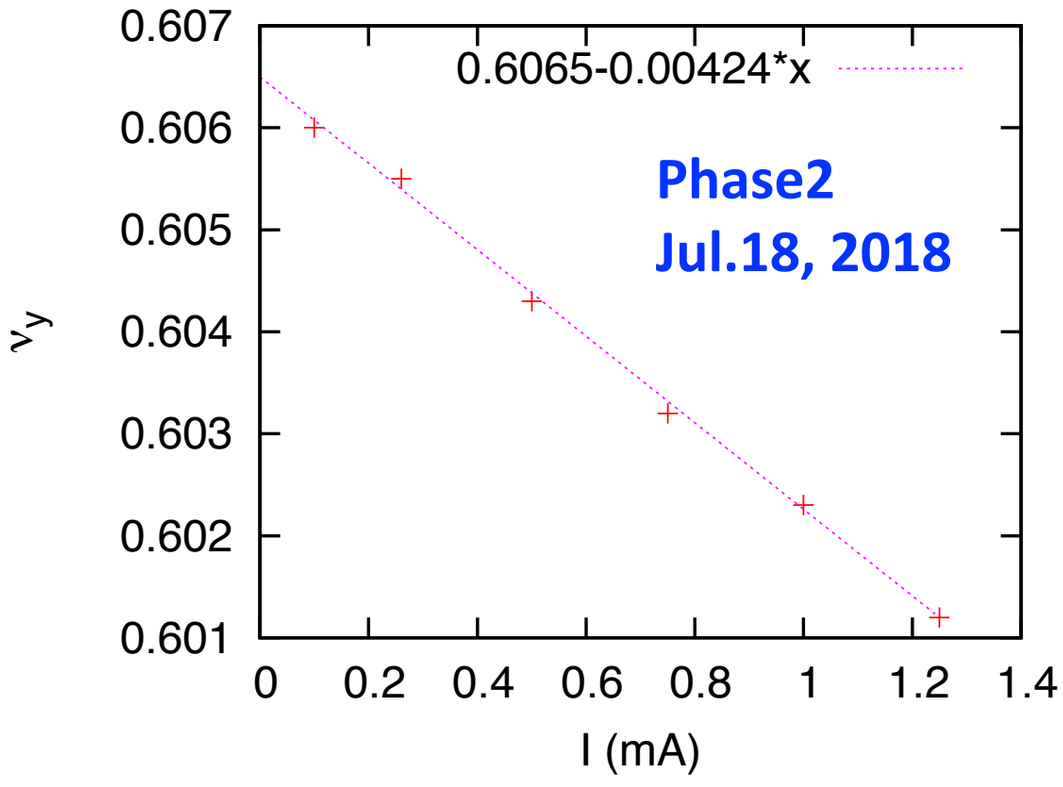
- **Left figure: Data taken in Phase 1**
- **Right figure: Data taken in Phase 2**

$$iZ_{\rm eff}({\rm k}\Omega/{\rm m}) = 58.2\frac{\Delta\nu}{I_{\rm bunch}({\rm A})}$$

$$iZ^Y_{\rm eff} = 145\ {\rm k}\Omega/{\rm m}$$



$$iZ^Y_{\rm eff} = 247\ {\rm k}\Omega/{\rm m}$$



From K. Ohmi

Ref. http://www-kekb.kek.jp/MAC/2018/Report/Ohmi.pdf

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**