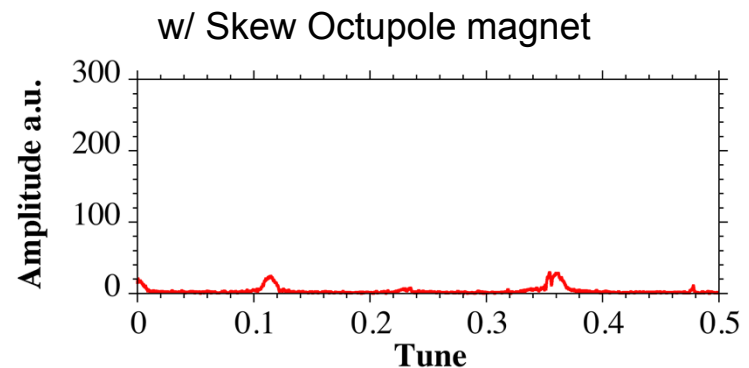
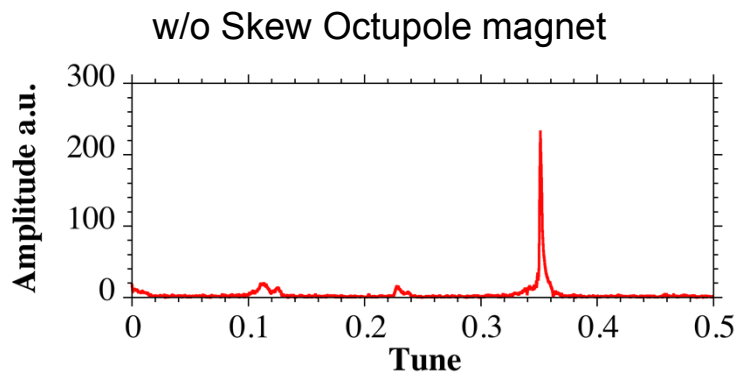


# Correction of Nonlinear Coupling Resonances in the SPring-8 Storage Ring

M. TAKAO,

K. Soutome, K. Fukami, and Y. Shimosaki

JASRI/SPring-8





# Contents

---

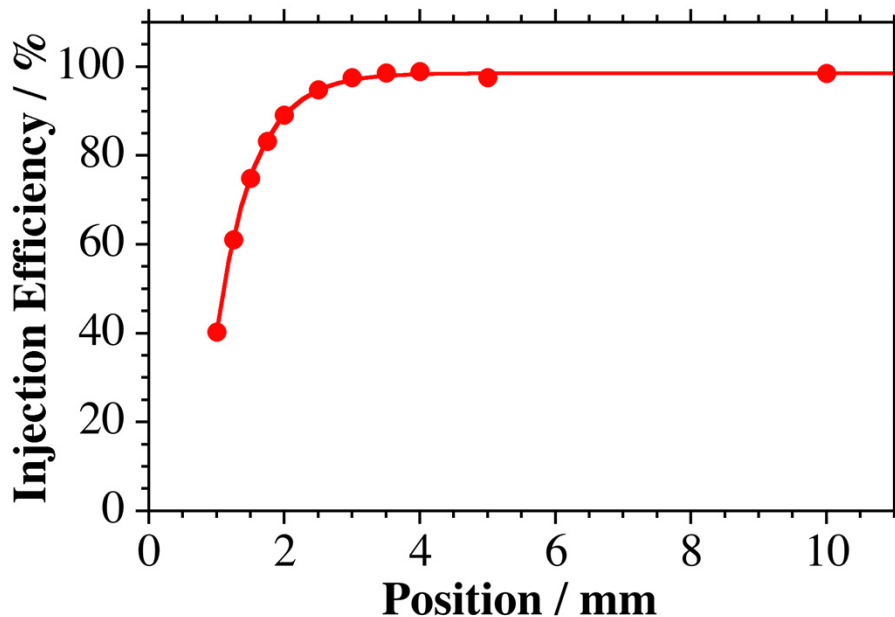
- Introduction
  - Injection Beam Loss
  - Touschek Lifetime
- Coupling Resonance Excited by Insertion Device
- Correction of Coupling Resonance by Skew Octupole magnet
- Summary

# Injection Efficiency vs. Vertical Scraper

Injection beam oscillating in horizontal direction with a large amplitude.

**Nonlinear Coupling**  Converted to vertical oscillation.  
 Lost at narrowest vertical aperture.



**Measured Injection Efficiency**

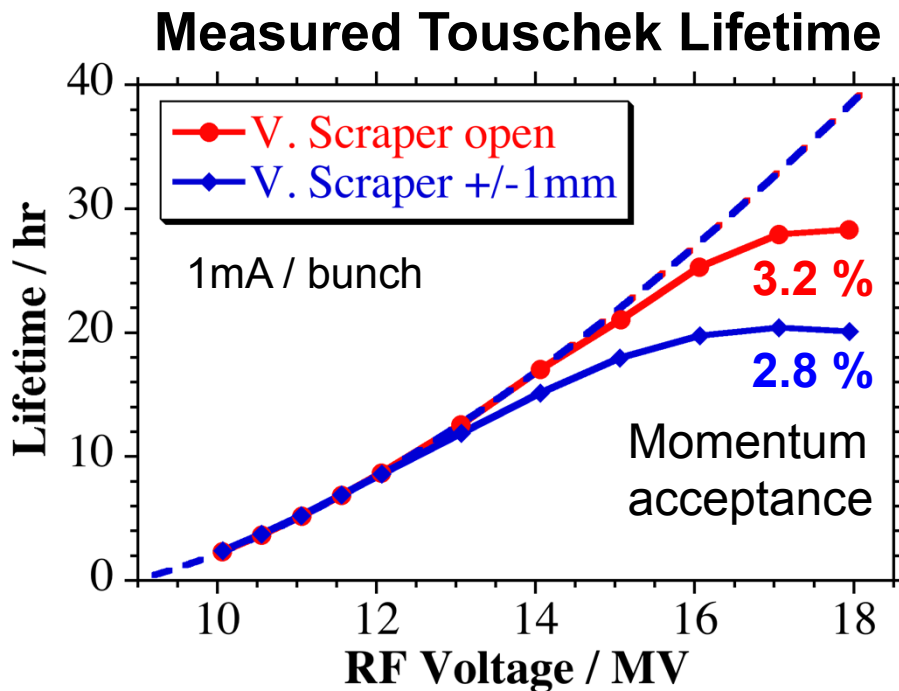


By closing v. scraper, Injection efficiency decreasing.

# Touschek Lifetime vs. Vertical Scraper

Touschek scattered particle at dispersive section starts to **oscillate horizontally with a large amplitude.**

**Nonlinear Coupling**  Converted to vertical oscillation.  
 Lost at narrowest vertical aperture.

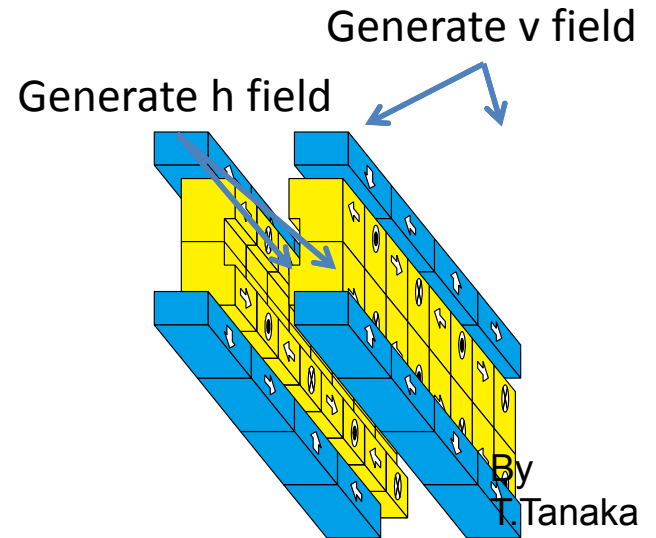
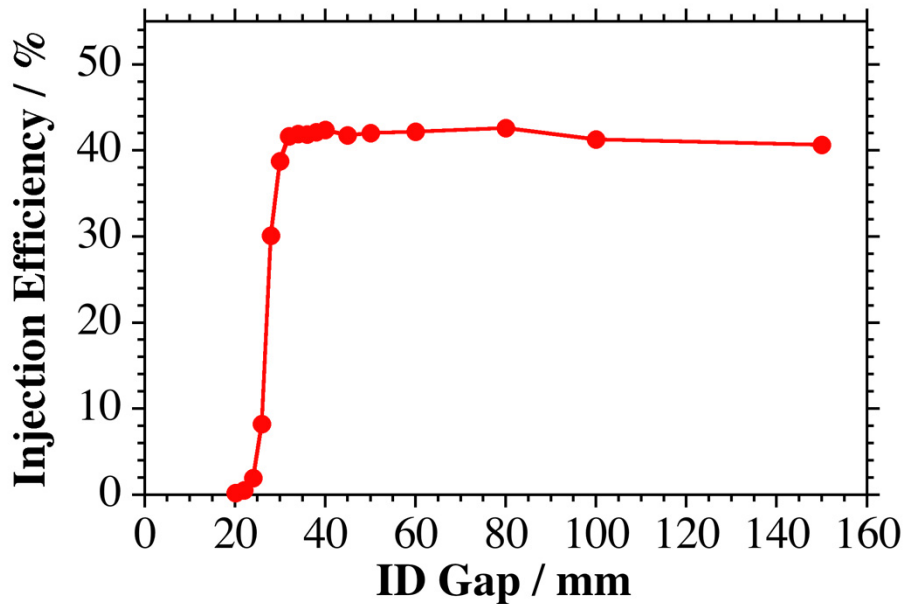


By closing v. scraper, Touschek lifetime decreasing.

# ID Induced Coupling Resonance

- ID07 (**out-vacuum**) has a peculiar magnetic field distribution and generates strong skew octupole field.
- As closing the ID gap, injection efficiency and lifetime are reduced by the effect of ID magnetic field.

**Injection efficiency vs. ID07 gap**  
w/ v. scraper +/-1mm (gap 2mm)

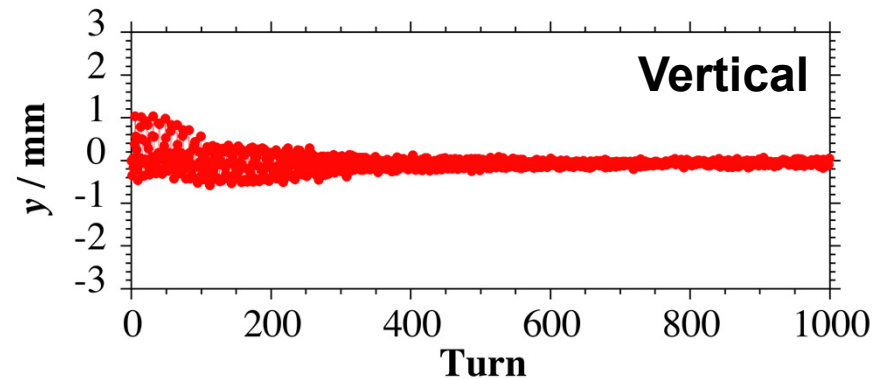
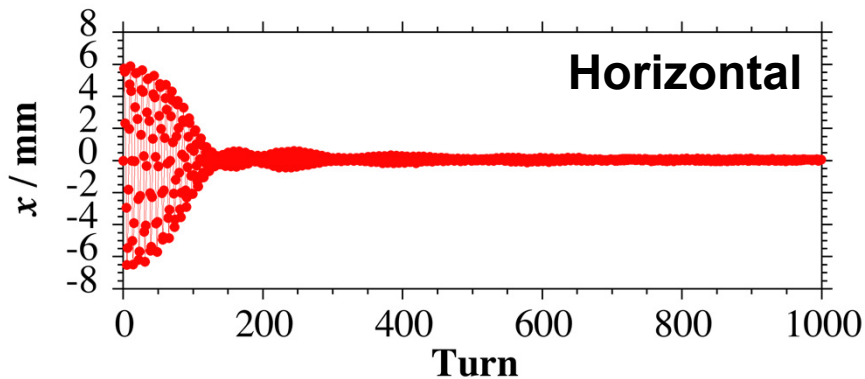


**ID07 magnet array**  
Composed of 4 arrays.  
Period of side arrays is twice of center ones.

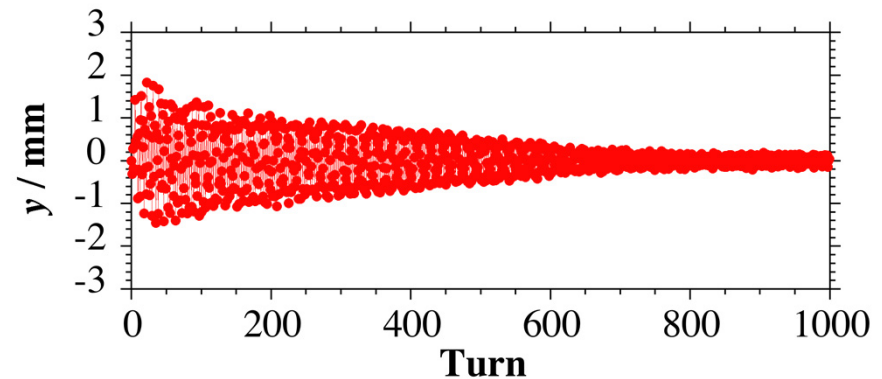
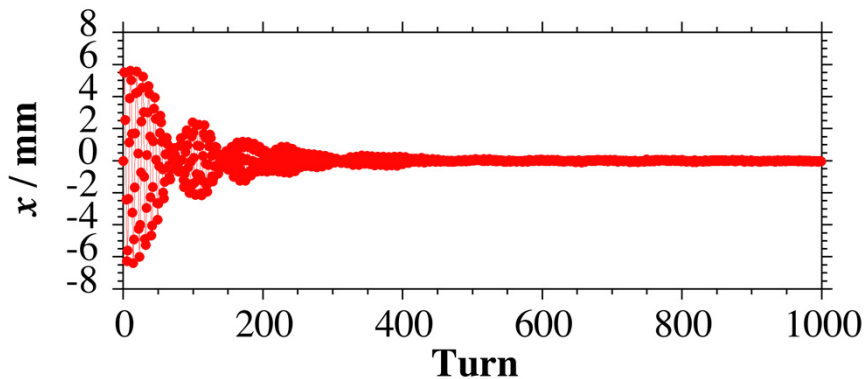
# Beam Oscillation Measurement by Turn-by-Turn BPM

- Measured beam oscillation kicked by injection bump to give an initial amplitude  $x_0$  as injection beam.

Beam oscillation w/ ID07 gap open @  $x_0 = -10\text{mm}$



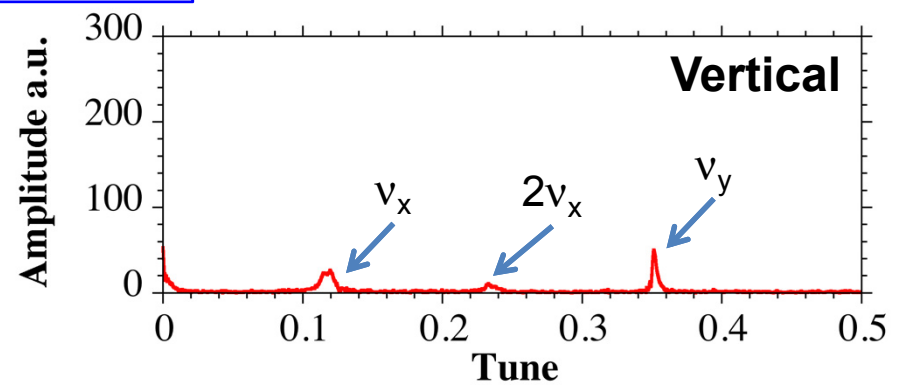
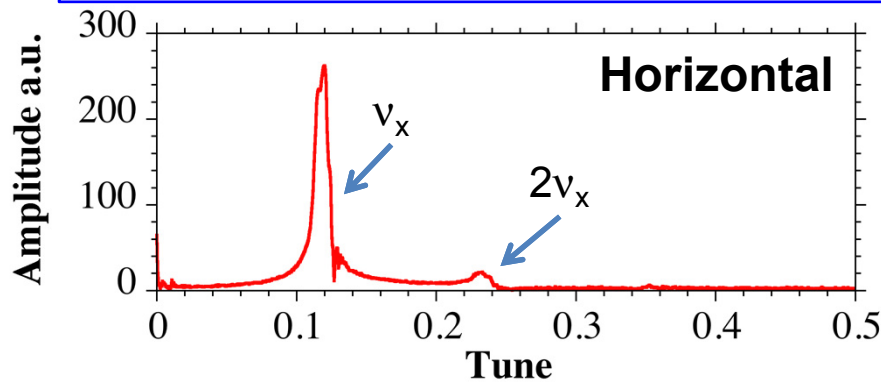
Beam oscillation w/ ID07 min. gap @  $x_0 = -10\text{mm}$



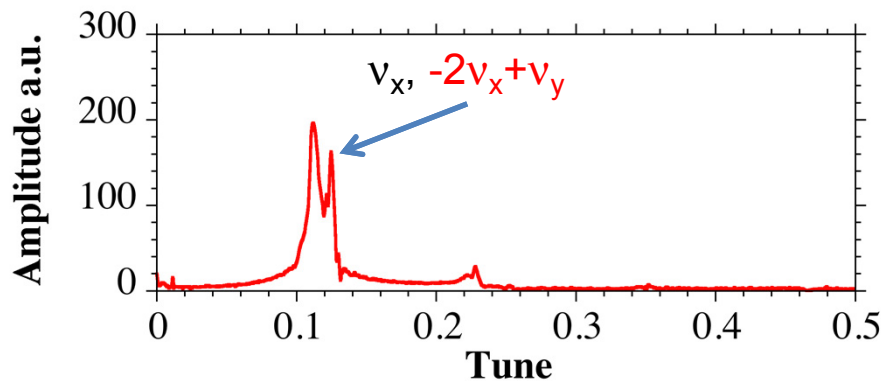
# Mode Analysis from Turn-by-Turn Measurement

- By closing ID07 gap, skew octupole resonance is excited in vertical oscillation.

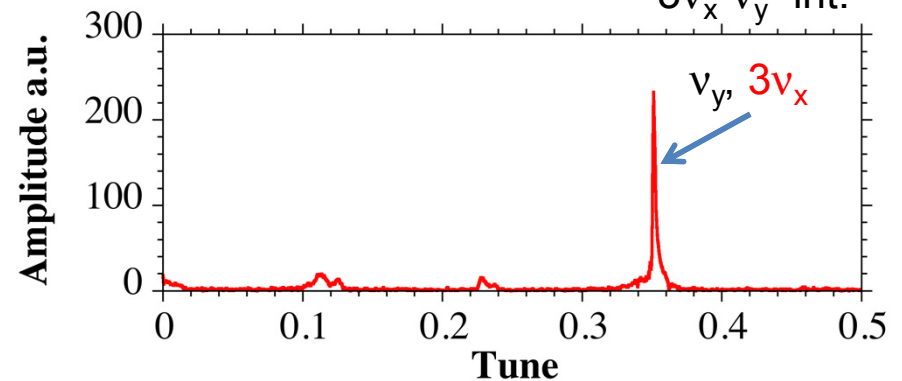
Beam spectrum w/  $x_0 = -10\text{mm}$  in **ID07 gap open**



Beam spectrum w/  $x_0 = -10\text{mm}$  in **ID07 min. gap**



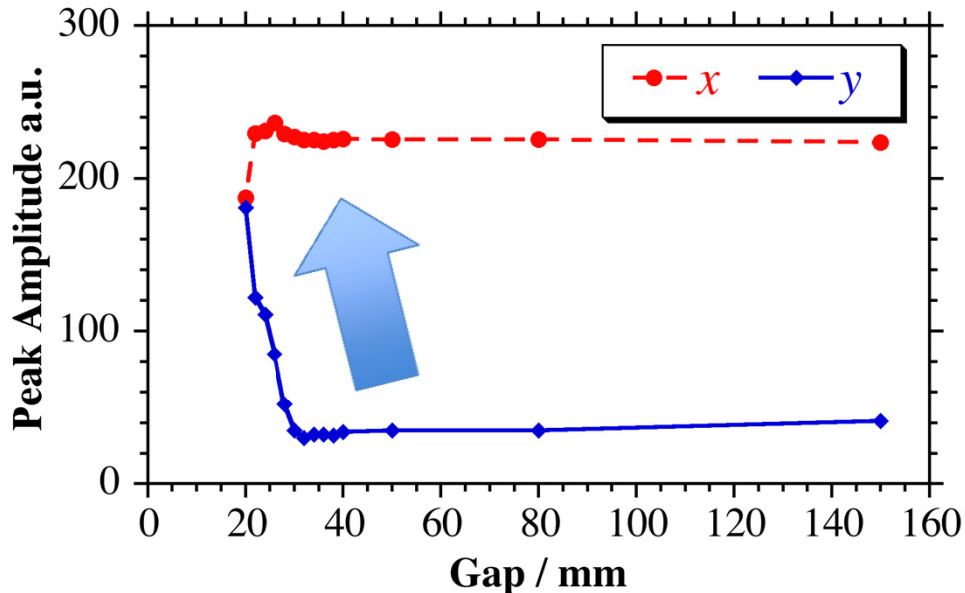
Skew Octupole Resonance  
 $3\nu_x - \nu_y = \text{int.}$



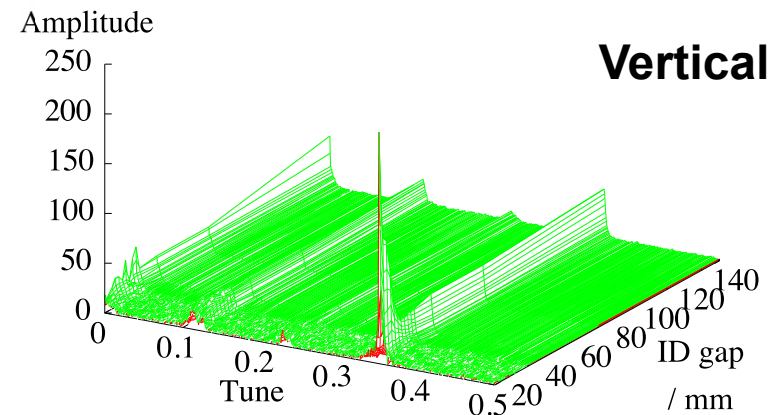
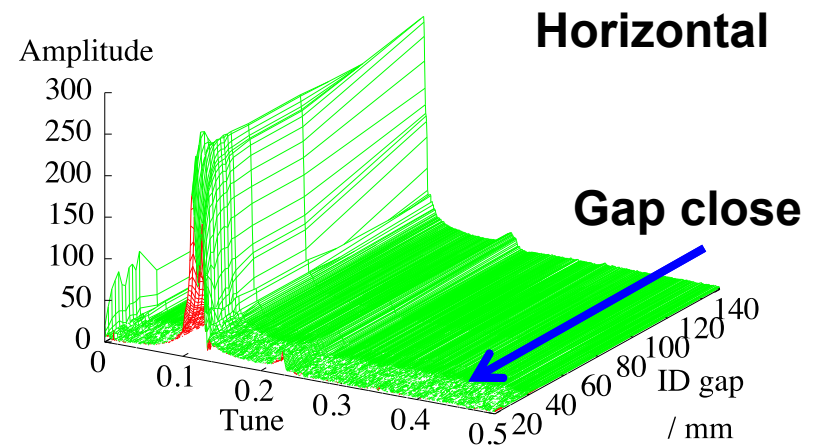
# Coupling Resonance Induced by ID07

- By closing ID07 gap, resonance is excited exponentially near minimum ID gap.

Peak amplitude vs. ID07 gap



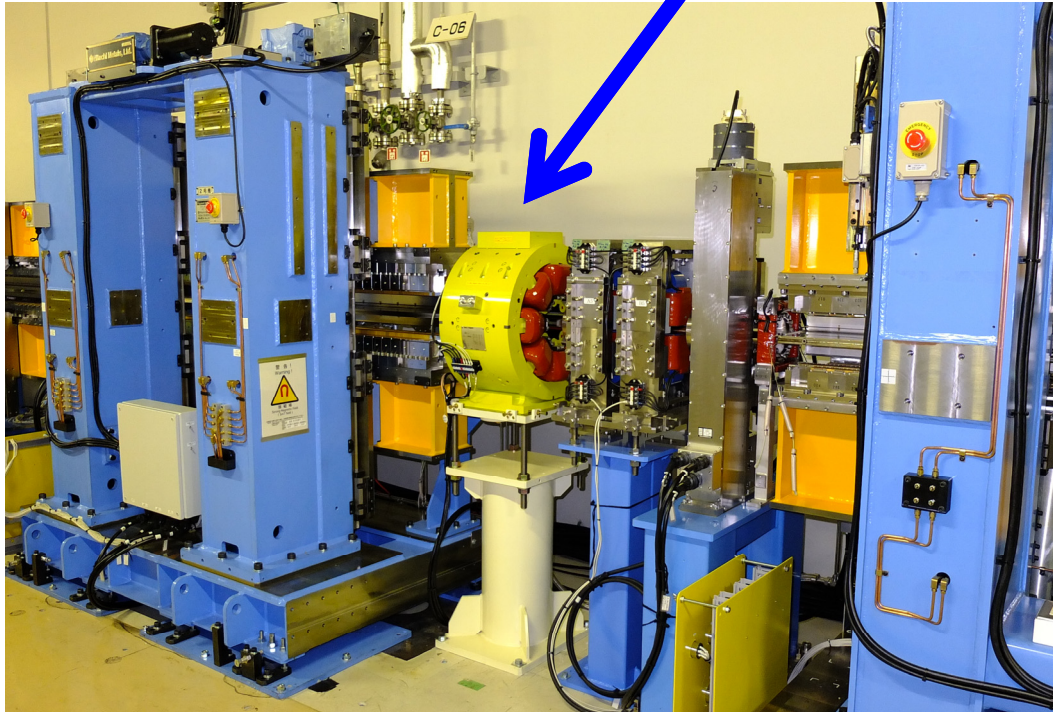
Spectra of Beam Oscillation in ID07 Gap Closing



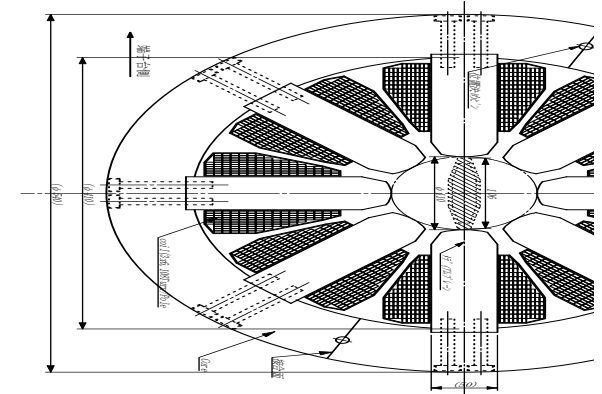


# Skew Octupole Magnets at SPring-8 SR

- 4 skew octupole magnets (SkOCT) are installed adjacent to ID07 to correct the ID induced coupling resonance.

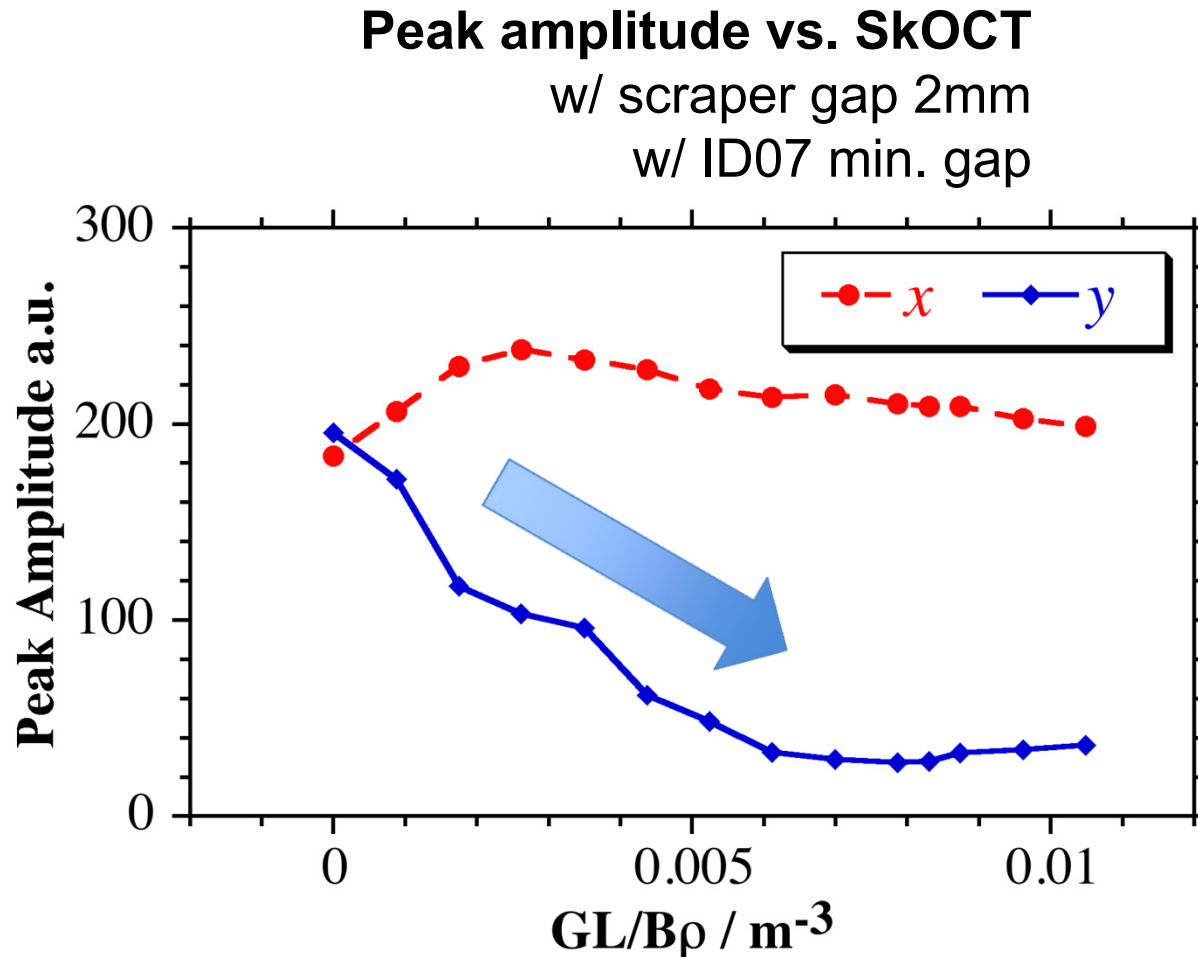


**SkOCT**  
By K. Fukami



# Coupling Correction by SkOCT's

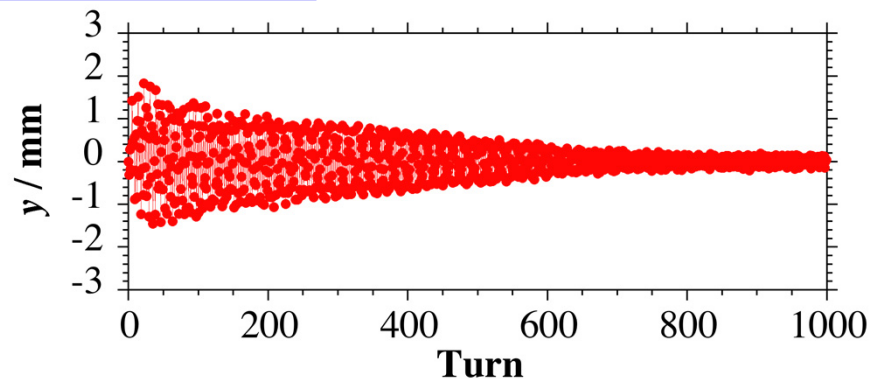
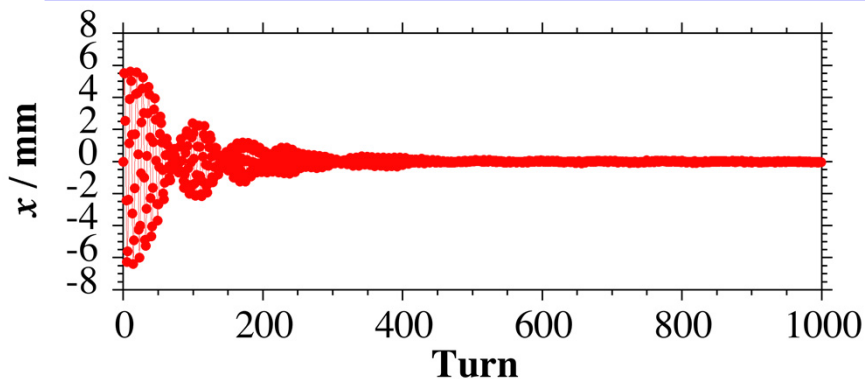
- The SkOCT's suppress the coupling resonance excited by ID07.



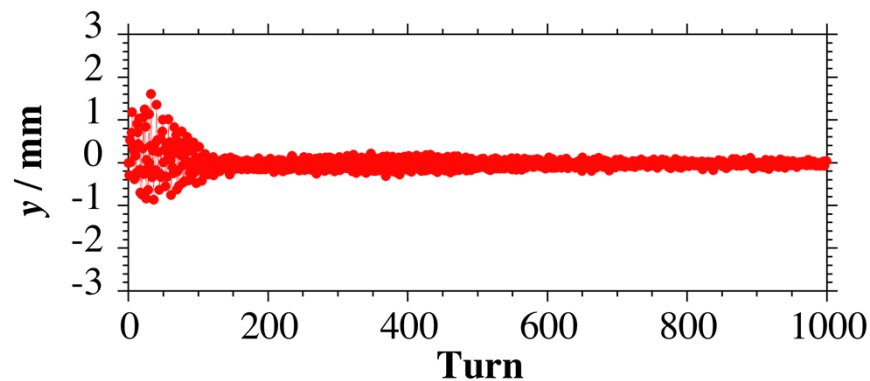
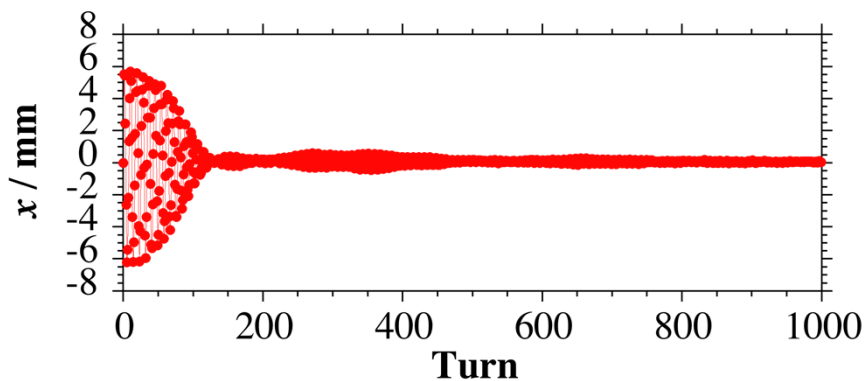
# Suppression of Vertical Oscillation by SkOCT

- Measured beam oscillation w/ and w/o coupling correction by SkOCT.

Beam oscillation w/o SkOCT correction @  $x_0 = -10\text{mm}$



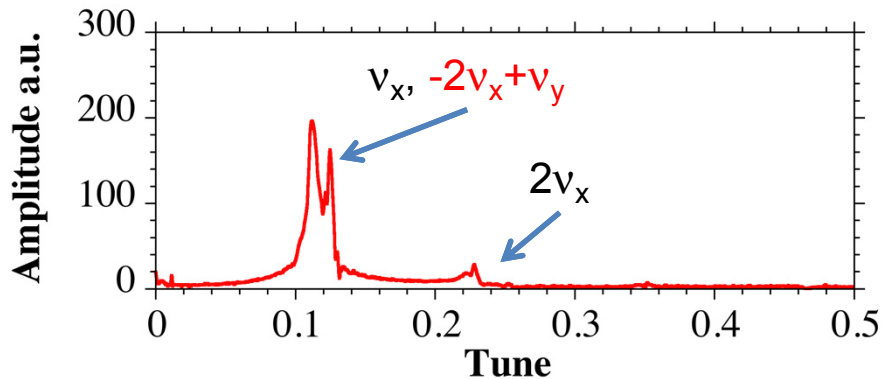
Beam oscillation w/ SkOCT correction @  $x_0 = -10\text{mm}$



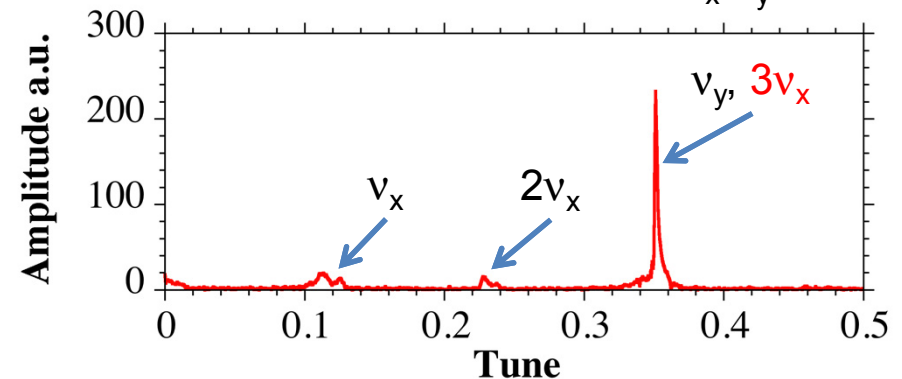
# Correction of Skew Octupole Coupling Resonance

- Peak amplitude of skew octupole coupling resonance is suppressed by exciting SkOCT.

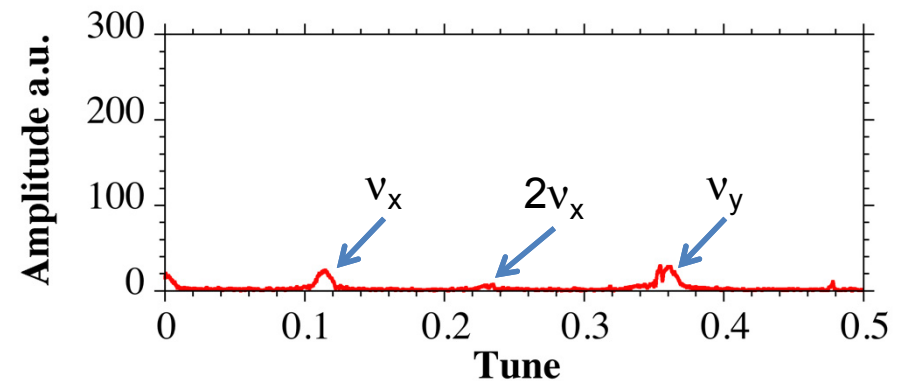
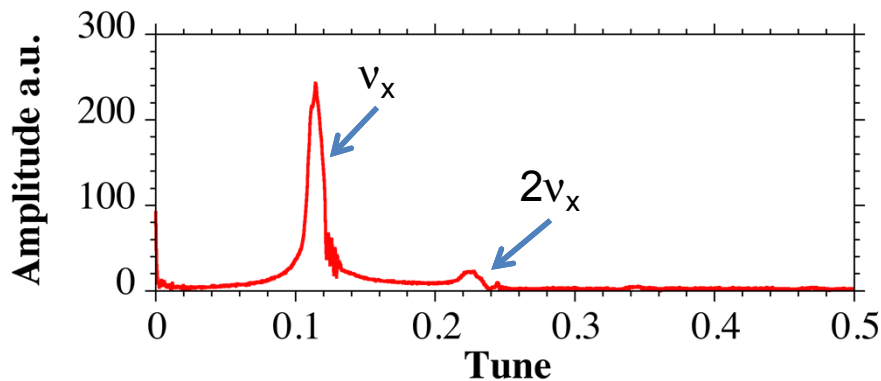
Beam spectrum w/  $x_0 = -10\text{mm}$  w/o SkOCT correction



Skew Octupole Resonance  
 $3v_x - v_y = \text{int.}$



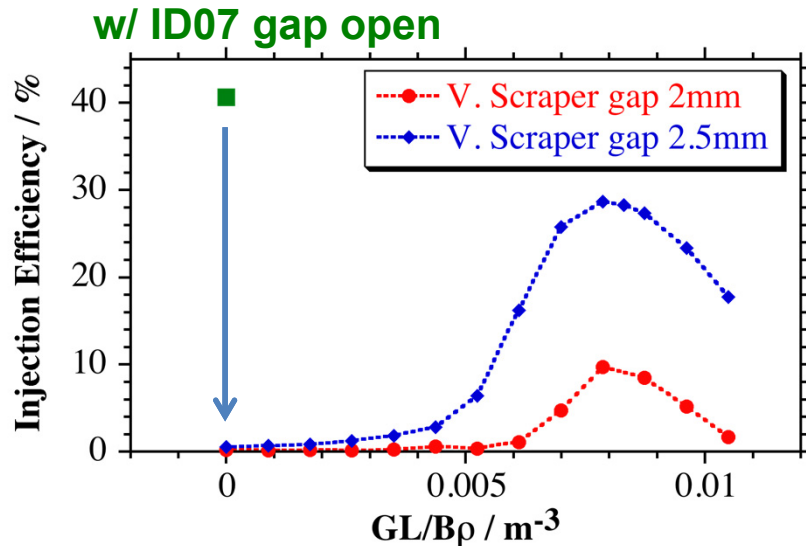
Beam spectrum w/  $x_0 = -10\text{mm}$  w/ SkOCT correction



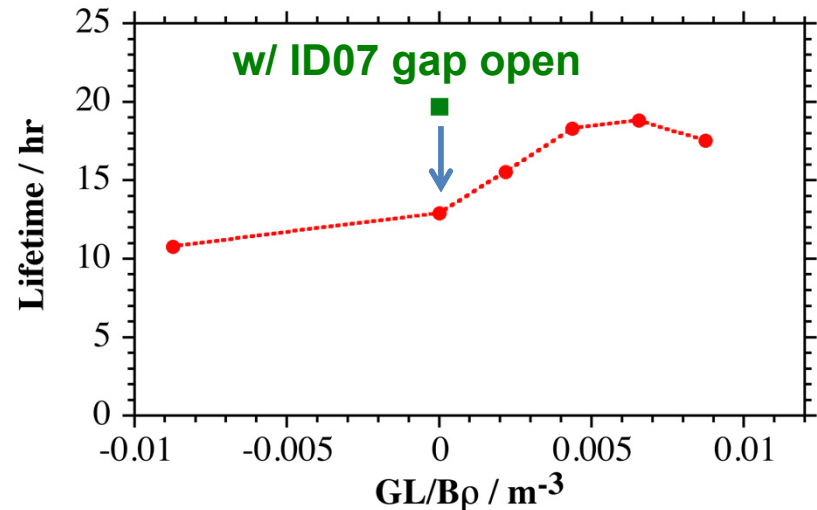
# Effect of SkOCT Coupling Correction

- Injection efficiency and Touschek lifetime are improved by the correction of the coupling resonance by the SkOCT magnets.

Injection efficiency vs. SkOCT  
w/ ID07 min. gap



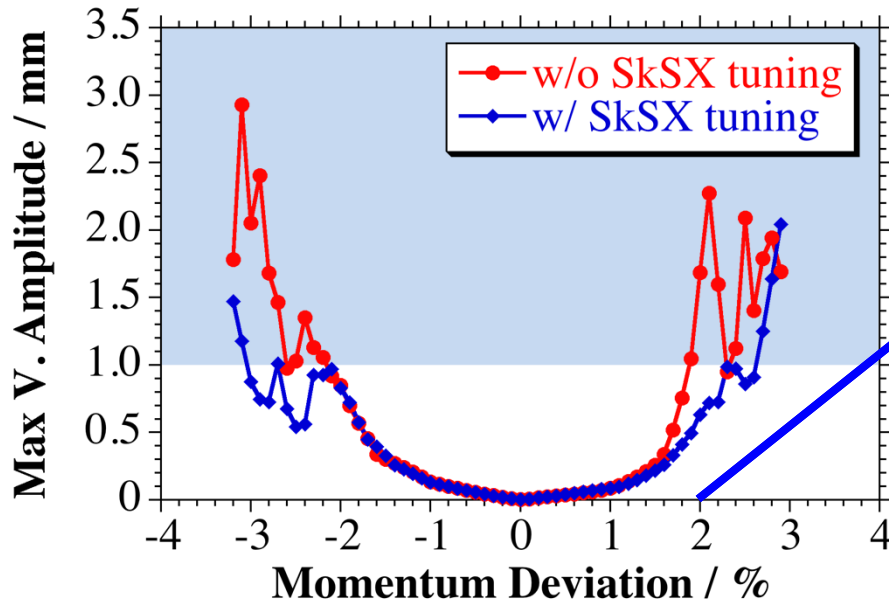
Touschek lifetime vs. SkOCT  
w/ v. scraper gap 2mm  
w/ ID07 min. gap



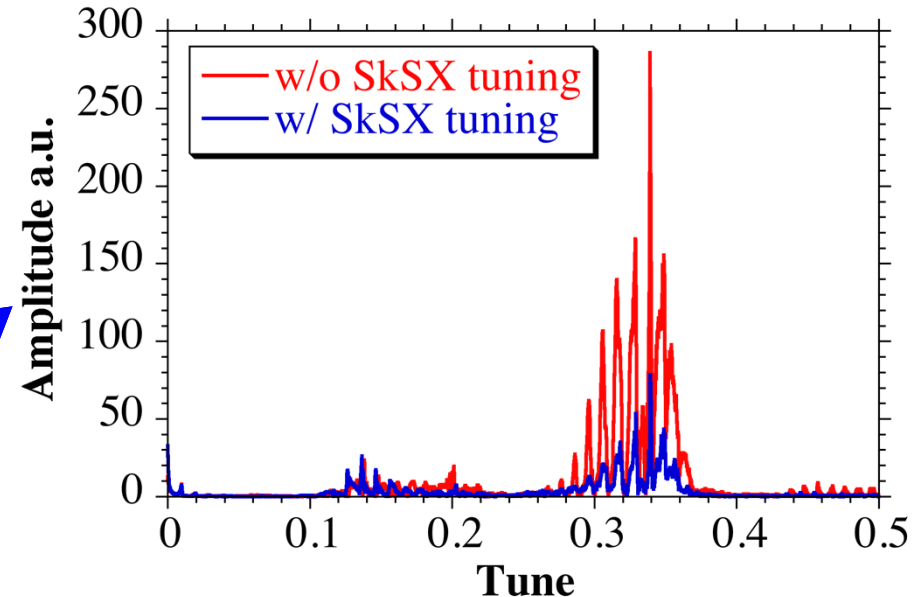
# Study for Correction by Skew Sextupole Magnets

- Study for the correction of the coupling resonance by the skew sextupole (SkSX) magnets is in progress.
- For a single particle motion with a sudden momentum change like Touschek effect, optimizing the strength of the nearest skew sextupole coupling resonance ( $2v_x - v_y = 63$ ) reduces vertical oscillation amplitude.

Calculated max. amplitude of vertical oscillation after Touschek scattering



Spectrum of vertical oscillation w/ momentum deviation +2%



# Summary

---

- The peculiar insertion device (ID07 @ SPring-8) excites strong **skew octupole coupling resonance**.
- The excitation is suppressed by the **skew octupole magnets** installed adjacent to ID07.
- Study of the correction of nonlinear coupling resonance by the skew sextupole magnets is in progress.