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Analysis of Bunch Oscillation in KEKB LER

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INTRODUCTION

Motivation

- **Effect of electron cloud by observing transverse dipole oscillation**

Objectives

- ⇒ **Coupled bunch instability by the electron cloud**
- ⇒ **Focussing by the electron cloud**
- ⇒ **Head-tail oscillation - synchrotron sideband**

MEASUREMENTS AND ANALYSIS

- Filling pattern 1/1153/4/different beam current
- Bunch oscillations were recorded by BOR
(a high-speed data recording system, KEKB)
- Recorded turn-by-turn for 4096 turns after feedback off
- ν_β - bunch by bunch ffts of the bunch oscillation data
- Correction to those transformed data - $e^{-i\omega\beta\Delta t}$
- Snapshot-like data - inverse fft
- Mode spectrum - turn-by-turn ffts of snapshot data after zero padding
- Growth rates - fits to the growth part

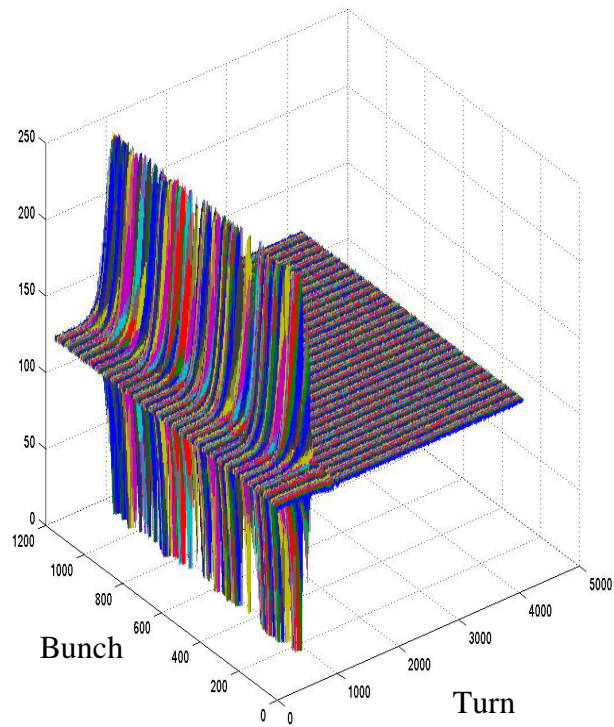


Figure Bunch oscillation recorded by BOR

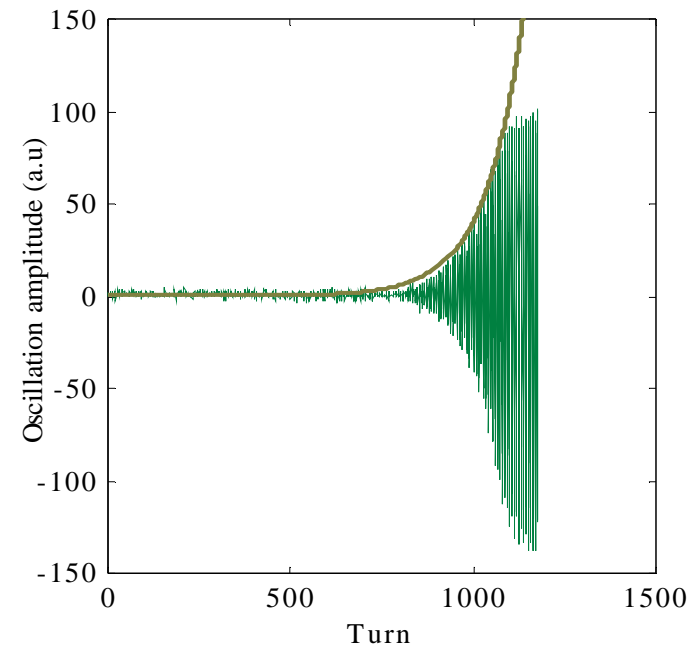


Figure Growth rate fit of a bunch oscillation

RESULTS

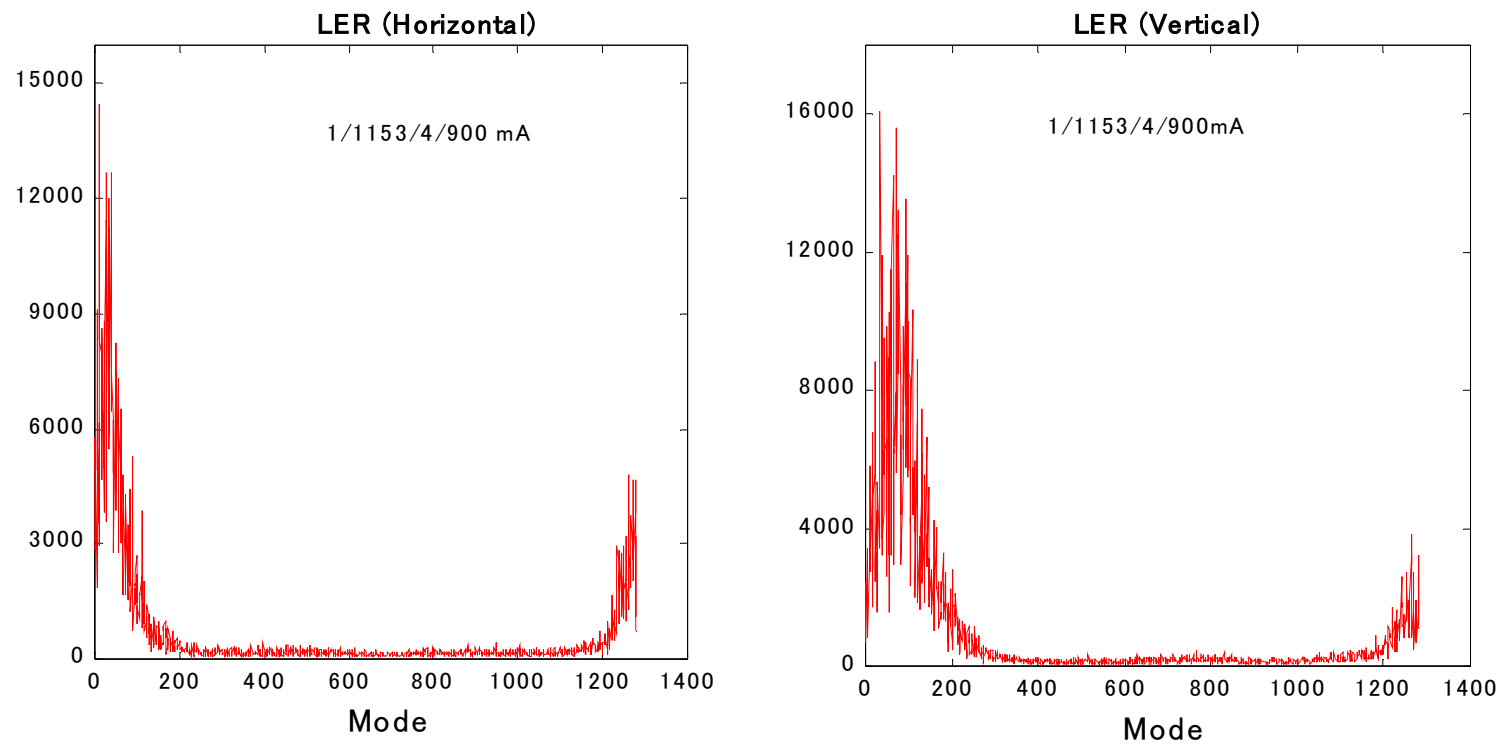
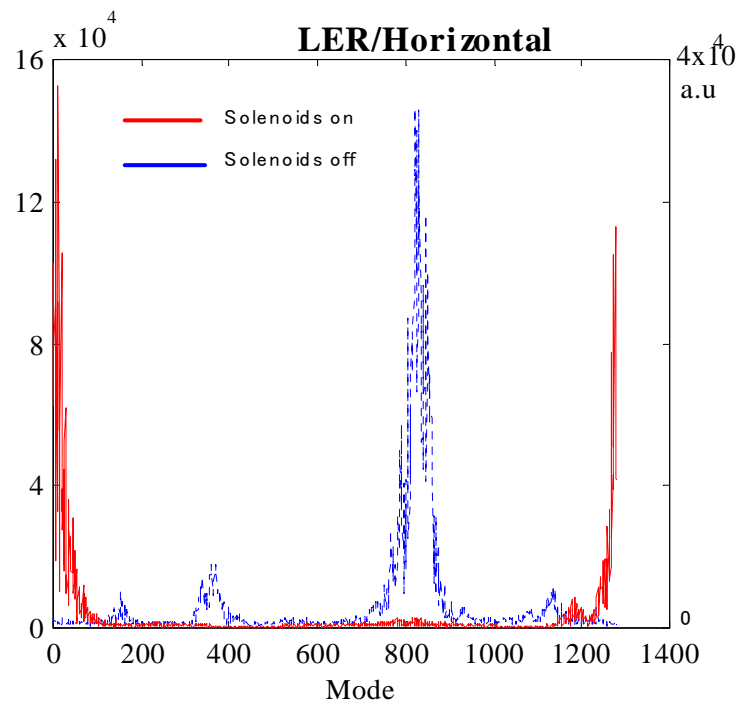
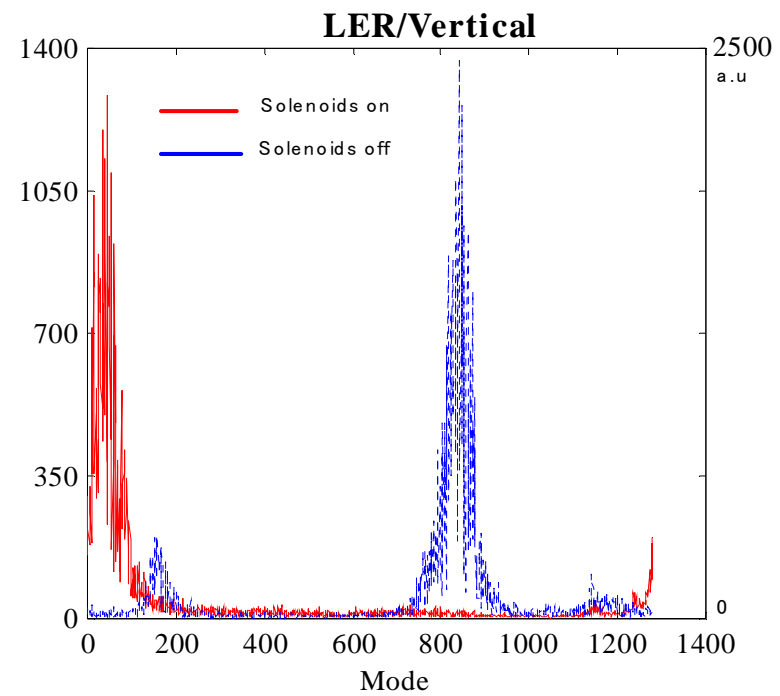


Figure Mode spectrums observed in LER when solenoids on a) Horizontal and b) Vertical



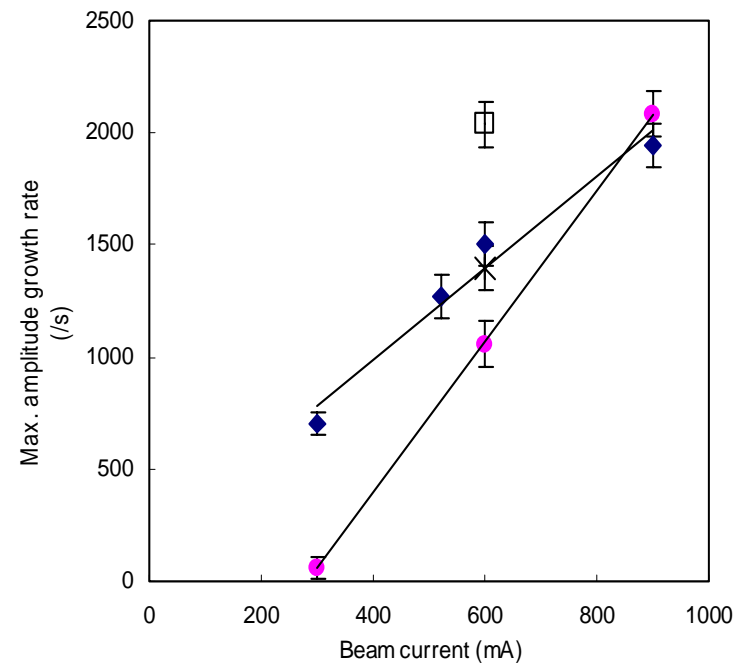
1/1153/4/600 mA



1/1153/4/600 mA

Figure Comparison of mode spectrums in solenoids on and off cases at 600 mA beam current

Growth rate changes with beam current in LER



◆ Horizontal (solenoids on) ● Vertical (solenoids on)
□ Horizontal (solenoids off) ✕ Vertical (solenoids off)

SUMMARY 1

- Mode spectrums are different in solenoids on and off.
- Growth rates linearly increase with beam current.
- Growth rates improve ~ 35% due to solenoids on.

Table Mode of instability

<i>Beam current</i>	<u>Horizontal</u>	
	Solenoids ON	Solenoids OFF
300 mA	12	-
600 mA	12	822
900 mA	35	-

	<u>Vertical</u>	
	Solenoids ON	Solenoids OFF
300 mA	-	-
600 mA	43	840
900 mA	35	-

Table Growth rates

<i>Beam current</i>	<u>Horizontal</u>	
	Solenoids ON	Solenoids OFF
300 mA	701	-
600 mA	1506	2037 (35%)
900 mA	1942	-

	<u>Vertical</u>	
	Solenoids ON	Solenoids OFF
300 mA	59	-
600 mA	1059	1397 (32%)
900 mA	2083	-

HORIZONTAL

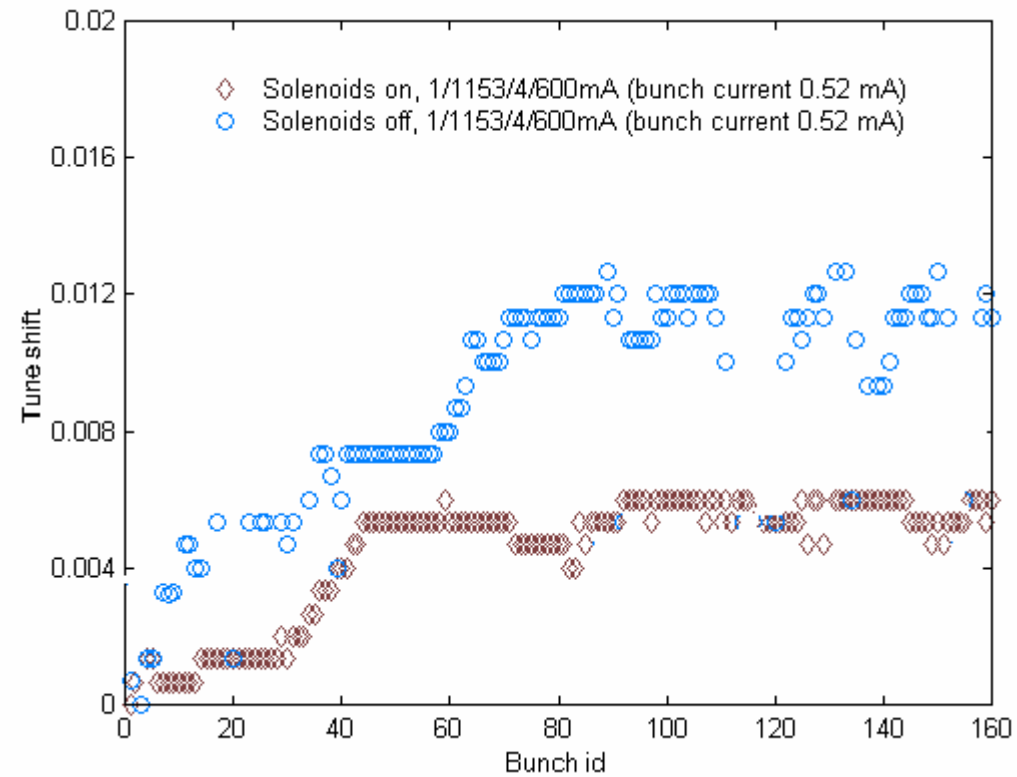


Figure Horizontal tune shift changes along positron bunch train

VERTICAL

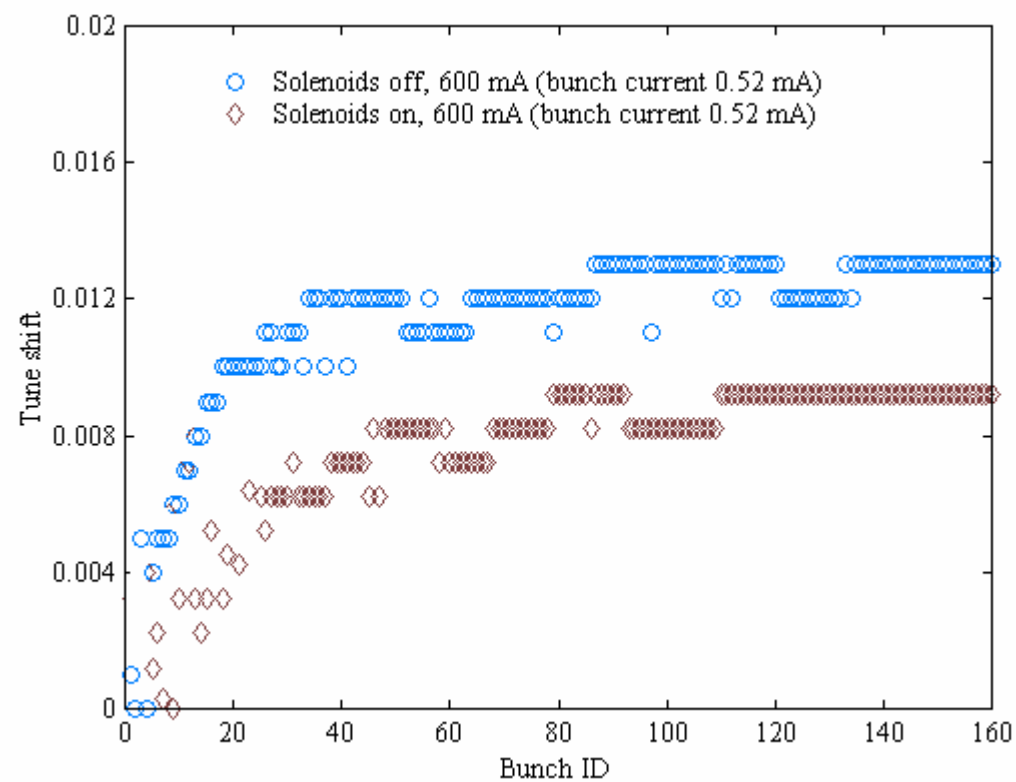


Figure Vertical tune shift changes along positron bunch train

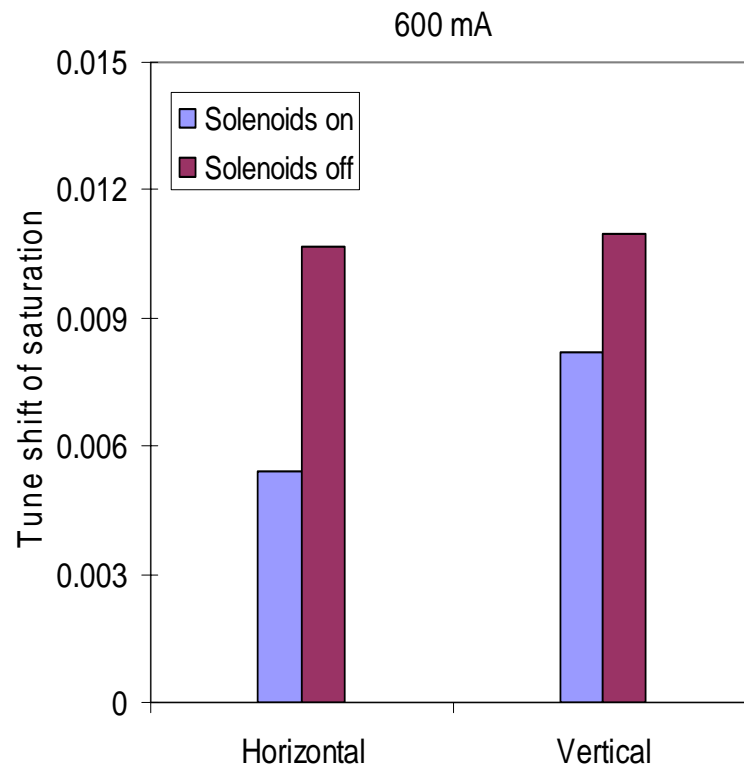


Figure Horizontal and vertical tune shifts (600 mA)

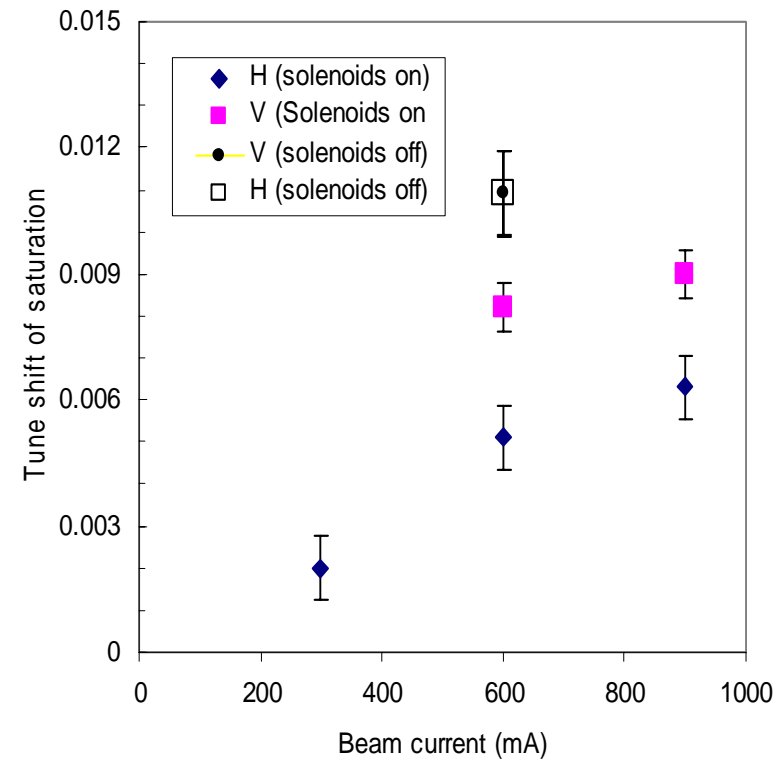


Figure Tune shift versus beam current

SUMMARY 2

- ➔ For both cases of solenoids on and off, the horizontal and vertical tune shifts increase with bunch id and tends to saturate.
- ➔ The saturated tune shift increases with increasing beam current both in horizontal and in vertical directions.
- ➔ Both vertical and horizontal tune shifts of saturation are higher when solenoids are off.
- ➔ Vertical tune shift of saturation is higher than horizontal one in solenoids on case.
- ➔ Horizontal and vertical tune shifts of saturation are approximately the same when solenoids off.

HORIZONTAL

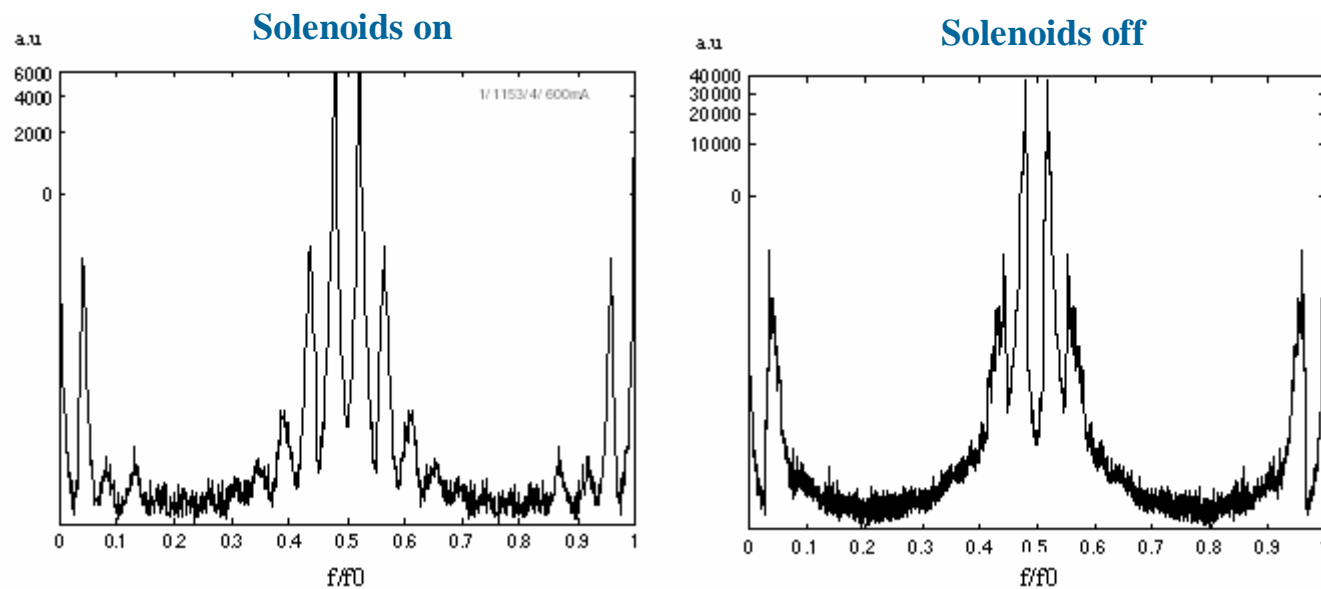


Figure Bunch-by-bunch ffts of LER Horizontal a) solenoids on, b) solenoids off

VERTICAL

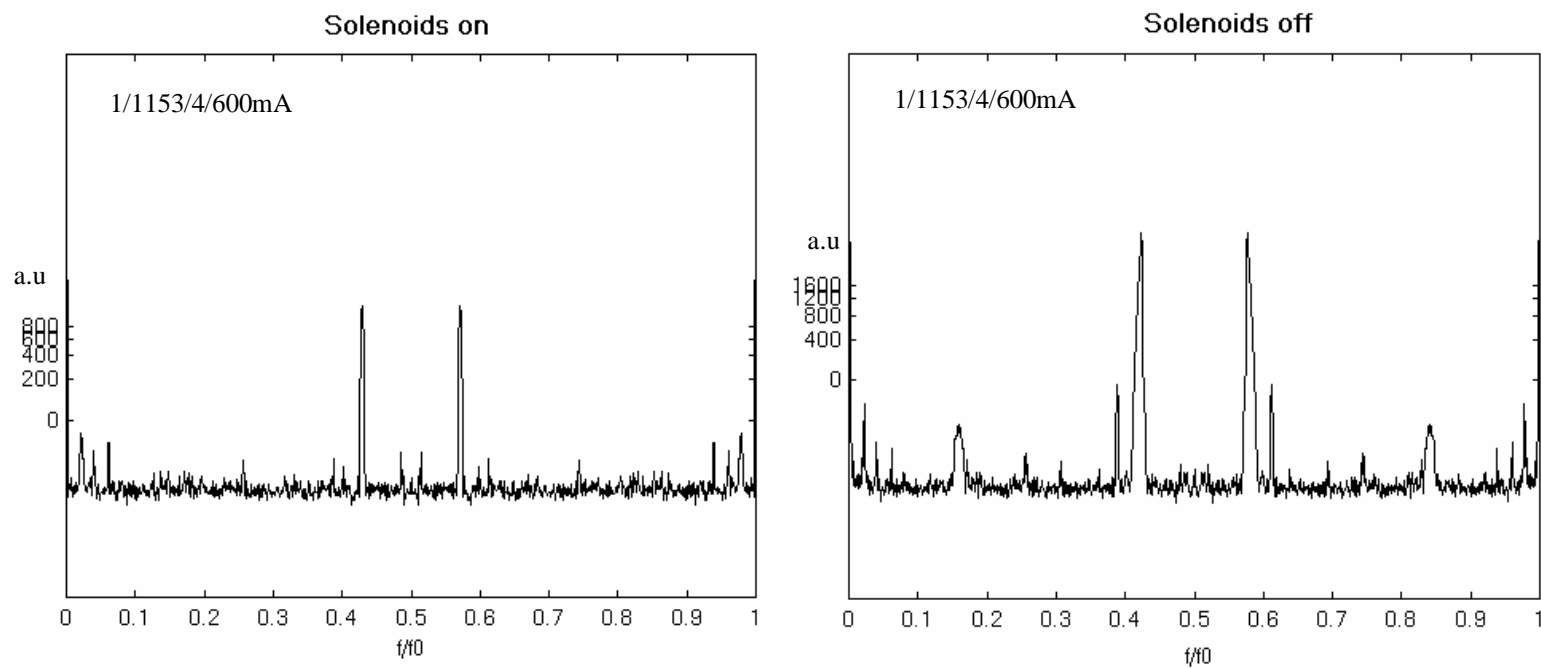


Figure Bunch by bunch fft of LER (Vertical) / solenoids on and off

HORIZONTAL

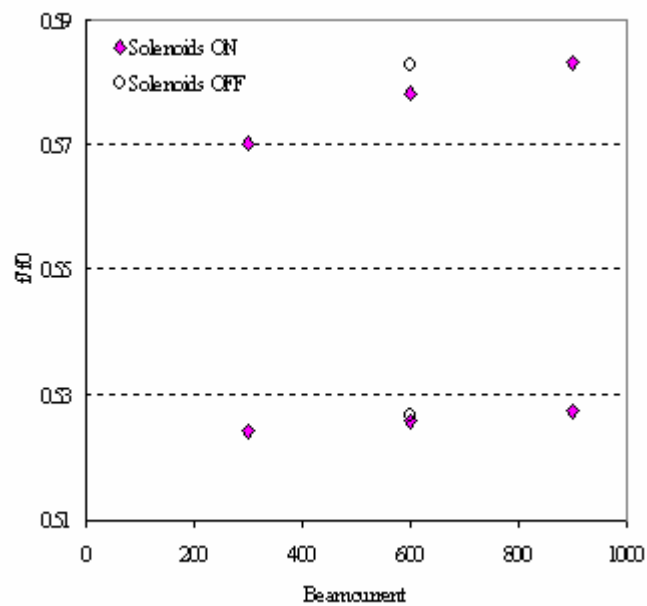
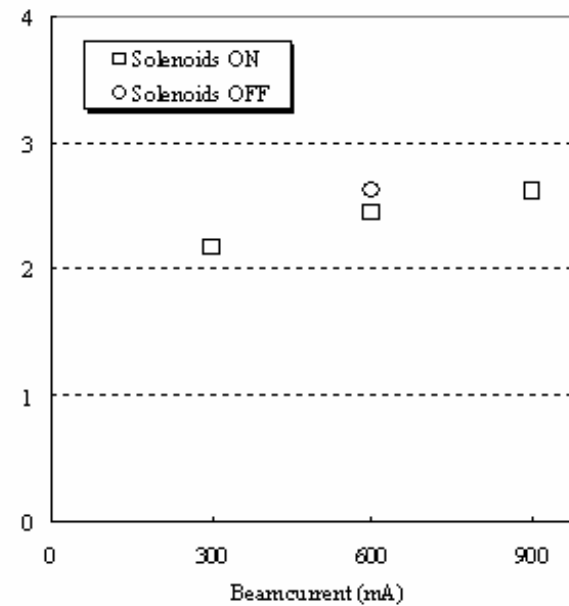


Figure Tune with beam current



*Figure Synchrotron side band frequency
 $(\omega - \omega_\beta) / \omega_s$*

VERTICAL

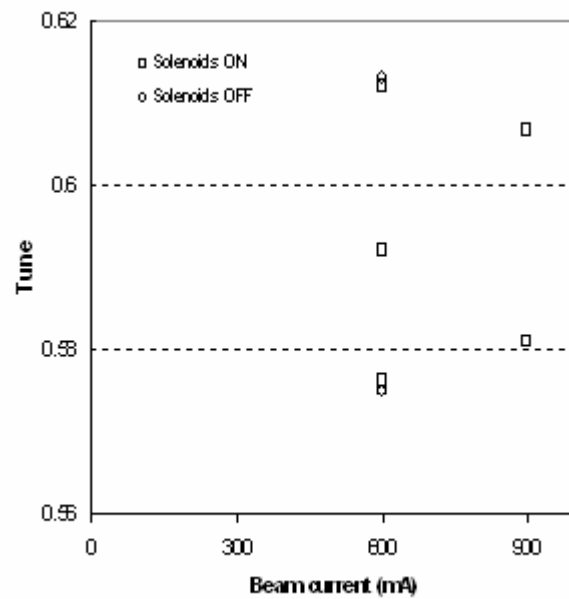


Figure Tune with beam current

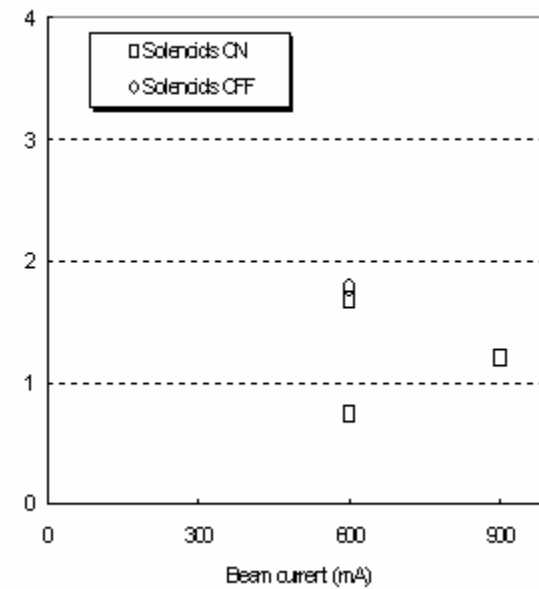


Figure Synchrotron side band frequency
 $(\omega - \omega_\beta) / \omega_s$

SUMMARY 3

- Synchrotron side band appearance

<i>Beam current</i>	<u>Horizontal</u>	
	Solenoids ON	Solenoids OFF
300 mA	~ 2	-
600 mA	~ 2	~ 2
900 mA	~ 2	-

	<u>Vertical</u>	
	Solenoids ON	Solenoids OFF
300 mA	-	-
600 mA	~ 1 & 2	~ 2
900 mA	~ 1	-

Discussion

- ♦ It is certain that solenoids have removed the portion of electron cloud due to the observation of
 - the difference in mode spectrums between solenoids on and off,
 - the improvement of amplitude growth rates due to solenoids on, and
 - the reduction in tune shift of saturation due to solenoids on.
- ♦ Although the saturated tune shifts are approximately equal in solenoids off case, the vertical tune shift is higher than horizontal one when solenoids are on.
The electron cloud density distribution might have been disturbed by solenoids.
- ♦ Naively, we can say that
there is head-tail instability from the observation of synchrotron side bands near $\bullet \sim 2$ in horizontal for solenoids on and off, near $\bullet \sim 1$ & 2 in vertical for solenoids on, near $\bullet \sim 2$ in vertical for solenoids off.

- ♦ **However, at the moment we found no systematic relation of synchrotron side band appearance with beam current.**
- ♦ **Further study should be done by changing the rf voltage and study the synchrotron side band appearance at various beam currents.**

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