MOPD73

Study of Beam Size Blowup due to Transverse Bunch Feedback Noise on e^+e^- Collider

Makoto Tobiyama and Kazuhito Ohmi, KEK Accelerator Laboratory, 1-1 Oho, Tsukuba, Japan

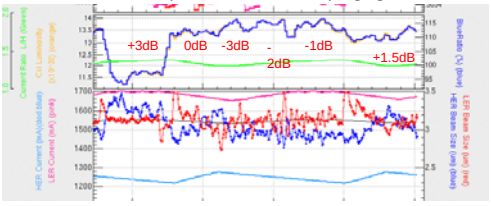
Abstract

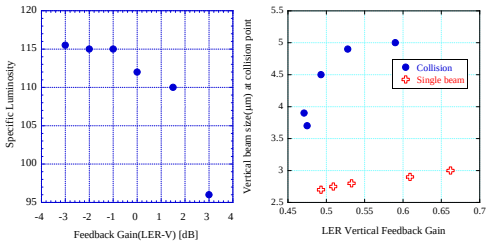
Vertical beam size blowups with the larger gain of the transverse bunch feedback systems have been observed in KEKB B-factory rings. With the numerical simulation, it has been shown that large beam-beam effect enhanced small oscillation induced by the broadband noise of the bunch feedback kick. To examine the simulation, the beam response, the effective beam size and the luminosity change with artificial external noise injected into the transverse feedback system have been measured in KEKB LER ring during collision. The result has been compared with the simulation including beam-beam effect and showed good agreement.

Introduction

Vertical beam-size blowup and luminosity degradation due to exceeded feedback gain was found on KEKB collider.

- Only LER-Vertical feedback gain affected the luminosity.
- Other feedback loops (LER-H, HER-H, HER-V) had no obvious effects on luminosity even with extremely high gain.



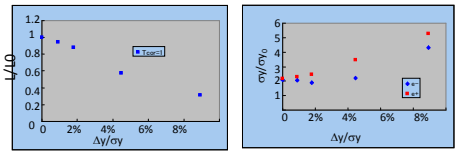


- With V-FB gain of lower than ΔG=-3dB, single beam operation was possible.
- During collision, strong beam-beam effect has completely suppressed the coupled-bunch oscillation, except for the beam-beam oscillation (horizontal only).

- Understanding the effect is necessary for future low emittance, low x-y coupling colliders.

Beam-beam simulation (1)

- Luminosity is sensitive for the offset fluctuation
  - 5% degradation for offset fluctuation of 0.01sy
- Faster noise (turn-by-turn noise, not low frequency) mainly affects.

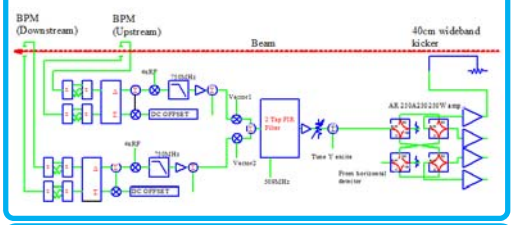


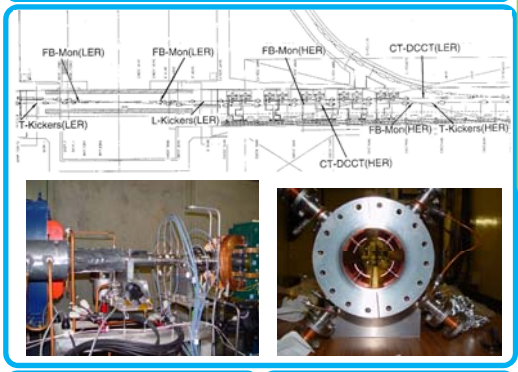
- Examine the simulation by measuring the beam response, the effective beam size and the luminosity change with artificial noise injected into the vertical feedback systems.
- Compare the results with the beam-beam simulations with the same conditions of accelerator.

Main parameters of KEKB rings

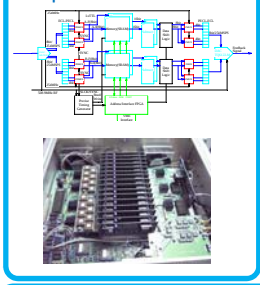
	LER	HER	
Energy	3.5	8.0	GeV
Circumference	3016		m
Revolution freq.	99.39		kHz
RF frequency	508.886		MHz
Harmonic number	5120		
Crossing angle	22 (crab crossing = 0)		mrad
Beam current	1.45	1.0	A
Bunch number	1584	1584	
Betatron tune x/y	45.056/43.558	44.51/41.62	
Total RF voltage	8.0	13.0	MV
IP beta βx*/βy*	120/0.59	120/0.59	cm

KEKB transverse bunch feedback system





2 tap FIR filter

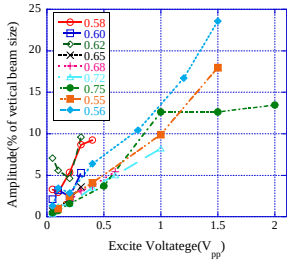


Bunch Oscillation Recorder (BOR)

Accumulate all the bunch positions up to 4096 turns (5120 x 4096 = 20MB)

- Inject excitation signal (sinusoidal wave or white noise) from the Y tune excitation port.
  - The peak-to-peak amplitude was confirmed with the oscilloscope.
  - Excitation tune =(0.55, 0.56, 0.58, 0.6, 0.62, 0.65, 0.68, .72. 0.75)
- Detect the oscillation of the LER beam with the BOR.
  - The recorded value of the BOR was calibrated with the local bumps around the BPMs.
  - FFT the data to find the amplitude of the oscillation corresponding to the excitation.
- Effective beam size was measured using interferometer.
- Luminosity data was delivered by the Belle detector
  - Low latency, slow update rate (<0.1Hz)
  - Beam-beam effect needs long time to settle.

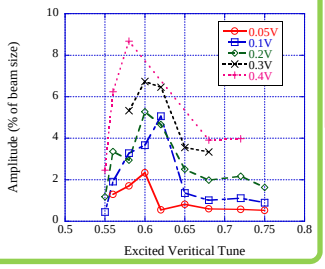
Single frequency excitation voltage vs. amplitude

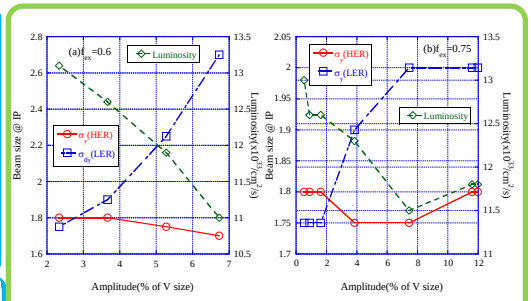


- Response of the beam on the excitation freq. are not the same.
- Beam-beam region (0.58 – 0.63) has larger response.

Excitation frequency (tune) vs. beam amplitude

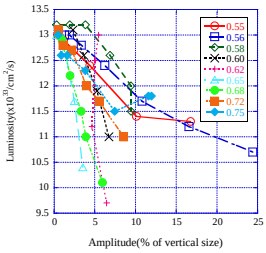
- Response around 0.6 (beam-beam region) is most sensitive starting from small oscillation.
- Response on the out of the beam-beam region is not negligible, especially with larger external excitation.





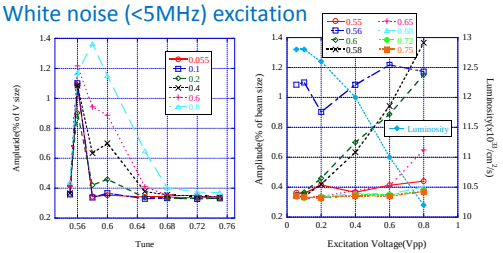
- At the beam-beam region ((a), f_{excite}=0.6), the LER vertical beam size has increased fairly quickly and the luminosity gradually decreased with the excitation amplitude.
- At out of the beam-beam region ((b), f_{excite}=0.75), though the increase of the LER vertical beam size was much slower than that of in the beam-beam region, the drop of the luminosity with the excited amplitude was similar to (a).

Excitation amplitude vs. luminosity



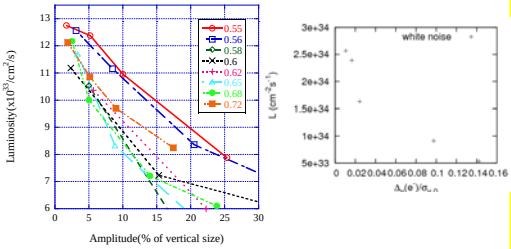
- Drop of the luminosity strongly depends on the excitation frequency.

White noise (<5MHz) excitation



- The shape of the beam response on excitation freq. is similar to the case of single freq. excitation.
- Luminosity has dropped about 5% with the noise amplitude of 0.4Vp-p.
- The noise level of 0.4Vpp is x100 higher than the observed noise level during operation.

Beam-beam simulation (2)



- Roughly consistent with the experimental results.
- Detailed beam-beam simulation are in progress. Expecting to explain the mechanism of enhancement of the oscillation.

Summary

We have studied the effect of the vertical beam size blowups and the luminosity degradation due to externally supplied noise in the feedback systems. The simulation reproduces the amplitude dependences of the effect well. Also the study of the blowup mechanism is in progress with the beam-beam simulation. It is, however, to reproduce the vertical oscillation with white noise, huge noise level which never exist in normal feedback systems is needed. Detailed beam-beam simulation to explore the oscillation and blowup mechanism is in progress.

The authors would like to thank the KEKB commissioning group and the operators for the help during the experiment. This work is supported by the JSPS Grant-in-Aid for Scientific Research(C), contact number 21604010.

mailto:makoto.tobiyama@kek.jp