# RECENT PROGRESS AT KEKB

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*Abstract*

We summarize the machine operation of KEKB during past one year focusing on progress for this period.

## INTRODUCTION

The KEKB B-Factory is an electron-positron double ring collider working at KEK which has the world highest luminosity. In this reports, we summarize the machine operation of KEKB mainly after the summer-shutdown in 2004. A status report before this was written elsewhere [1]. Fig. 1 shows 5-year's history of the KEKB luminosity and beam currents. Table 1 shows present machine parameters of KEKB compared with those of about one year ago.

Table 1: KEKB Machine Parameters.

| | **June 2004** | | **May 2005** | | |
|---|---|---|---|---|---|
| | LER | HER | LER | HER | |
| Energy | 3.5 | 8.0 | 3.5 | 8.0 | GeV |
| Circumference | 3016 | | 3016 | | m |
| $I_{\rm beam}$ | 1650 | 1220 | 1730 | 1261 | mA |
| # of bunches | 1294 | | 1387 | | |
| $I_{\rm bunch}$ | 1.28 | 0.94 | 1.25 | 0.909 | mA |
| Ave. Spacing | 2.35 | | 2.1 | | m |
| Emittance | 18 | 24 | 18 | 24 | nm |
| $\beta_x^*$ | 59 | 56 | 59 | 56 | cm |
| $\beta_y^*$ | 5.2 | 6.5 | 6.5 | 6.2 | mm |
| Ver. Size@IP | 2.1 | 2.1 | 2.1 | 2.1 | $\mu$m |
| RF Voltege | 8.0 | 14.0 | 8.0 | 15.0 | MV |
| $\nu_x$ | .505 | .513 | .505 | .511 | |
| $\nu_y$ | .535 | .582 | .535 | .577 | |
| $\xi_x$ | .113 | .072 | .110 | .073 | |
| $\xi_y$ | .074 | .057 | .092 | .056 | |
| Lifetime | 152 | 178 | 140 | 179 | min. |
| Luminosity | 13.92 | | 15.62 | | /nb/s |
| Lum/day | 0.944 | | 1.178 | | /fb |
| Lum/7 days | 6.01 | | 7.36 | | /fb |
| Lum/30 days | 24.00 | | 29.02 | | /fb |

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## HIGH BEAM CURRENTS

AT KEKB, the beam current of HER (High Energy Ring) is mainly limited by RF power, while the LER (Low Energy Ring) beam current is mainly limited by tolerance of vacuum components against a high beam current. To increase the beam currents, the following three works were done during the summer shutdown in 2004. 1) One of superconducting cavities (SCC) (named D10C) in HER, which had been removed from the ring due to vacuum leak at the beginning of 2003, was reinstalled in the ring. 2) Input couplers of two ARES cavities (named D4C #1 and #2), which had had a multipacting problem, were replaced with a refined type. 3) Cooling channels were installed to the vacuum chambers of the septum magnets in both rings, which had had a heating problem at high beam currents.

After the summer shutdown in 2004, we tried to increase the beam currents of both rings. In the course of increasing, we encountered several vacuum troubles related to the high beam currents. In November 2004, we had a trouble with a bellows in IR section. Due to anomalous temperature rise and bad vacuum pressure, we had to reduce the LER current to about 60 % of the usual operation in order to avoid a disastrous breakdown of the bellows as is seen in Fig. 1. Since we had no spare replacement for the broken bellows, which made the trouble serious, we had to postpone the work of the replacement until the end of December. In the work, we found that a cramp of the RF fingers come off and the fingers got broken maybe by heating due to leakage HOM field. Since the beginning of Feb. 2005, we have been annoyed with frequent beam aborts due to somewhat mysterious beam loss of LER. The direct triggers of the aborts are detections of beam loss by beam loss monitors in the ring or a request from the physics detector (Belle) which detects intolerable beam background. The features of the beam aborts are in the followings. 1) No transverse oscillations are accompanied by the aborts. 2) Beam phase shifts are observed in the direction of time delay, which means that the beam lost its energy before the beam loss. 3) No vacuum pressure rise is observed. 4) No other unusual behaviors of the beam such as abrupt tune changes are observed. From these observations we suspected that the beam loss is induced by collisions of the beam parti-

 

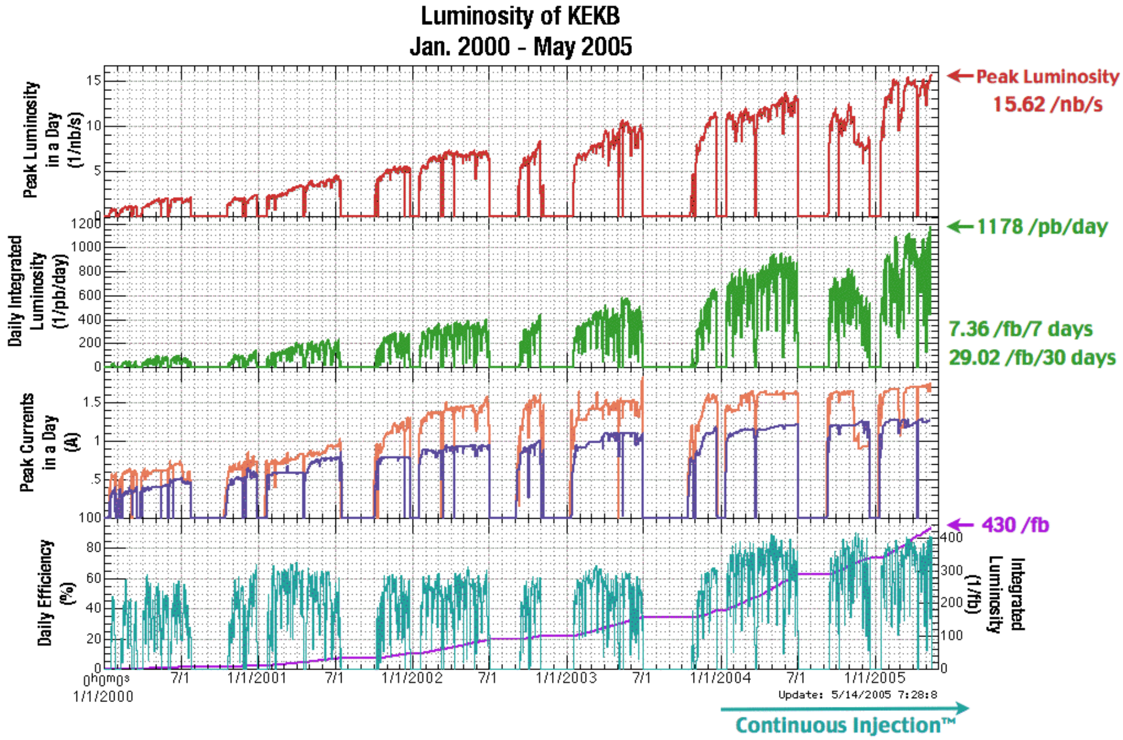


Figure 1: History of KEKB.

cles (positrons) from some dust-like particles in the vacuum chamber. Although we installed several PIN-diodes in the ring to detect bremsstrahlung due to the collisions, we could not identify the vacuum component responsible for the beam abort. After a long struggle with the problem, we found that a bellows in the downstream of the wiggler magnets had a problem which is a very similar RF finger problem to the case of IR bellows mentioned above. After replacing the troubled bellows with a straight pipe, the problem disappeared. Although the precise mechanism is not understood, it is thought that spattered material from the bellows fingers (Be-Cu) might be responsible for the beam loss. We experienced this kind of troubles twice with different bellows. As for the LER beam current, there has been another problem that the luminosity did not increase with a higher LER beam current than some value. Although we have not yet fully understood the reason for this, we suspect the effect of the electron cloud in LER. During the summer shutdown, we installed additional solenoid magnets, whose effective length is about 50m in total, in the straight section of LER. In addition, we installed permanent solenoid magnets at the NEG ports where the solenoid coils are not possible to be installed. The number of the permanent solenoid magnets is about 2000 and their effective length is around 200m in total. At the present level of the LER beam current around 1700mA, we do not observe saturation of the luminosity as function of the LER current. We are increasing the HER beam current gradually with carefully observing RF trip rates. The present problem with the RF system is that one of klystrons (D4C) for the ARES cavities is frequently down due to crowbar works. The target beam currents of LER and HER before summer shutdown in 2005 are 2000mA and 1400mA, respectively.

As a part of efforts to increase the beam currents, we have been trying to increase the number of bunches stored in the rings by decreasing the bunch spacing. This increase in the number of bunches is requested to mitigate the stress of the vacuum components by high beam currents. As the first step, we tried to decrease the averaged bunch spacing from 3.77 RF buckets to 3.5. The results are described below.

## SPECIFIC LUMINOSITY

Fig. 2 shows progress of the specific luminosity. There are four data in the graph. Of the four, the green(March 19 2005) and black(May 13 2005) dots are data taken in this year. The bunch spacing of only the back is 3.5 RF buckets, which means that 3 and 4 RF buckets repeat alternatively, while the averaged bunch spacing of the other three is 3.77 RF buckets (mixture of 3 and 4 RF buckets). The red and blue dots denote data on June 03 2004 and on May 09 2003, respectively. The peak luminosity record of KEKB so far was set on May 13 2005. However, when we compare the present performance with one year ago, we should use the data with the same bunch spacing (green and red). In the comparison, the beam current correction is needed, since the beam current increased during the past one year as seen in the figure. For this purpose, we usually use a somewhat old data of the blue dots. This data was taken before starting the continuous injection scheme and the beam current span is wider than the others. The black line is the fitted curve of the blue dots. One should take notice that the KEKB bunch currents are above the beam-beam limit and the specific luminosity decreases as function of the beam current. Calculating ratios between given data and the black reference line (at corresponding beam currents), improvement during past one year (between the green and red data) is about 10%. It is not easy to say what brought this improvement, since it was brought by accumulation of many efforts such as the installation of BPM displacement monitors at the local chromaticity correction sections in LER, where a very small change of the beam positions affects the optics seriously, the installation of the solenoid magnets, fine tuning of the gain of the feedback system and so on.

Another big progress at KEKB is a successful transition from 3.77 bucket spacing to 3.5. As is described in the earlier paper[1], the specific luminosity with 3.5 bucket spacing was by about 15% lower than that with 3.77 in the last trial in June 2004 as in shown in Fig. 3 . Although from the viewpoint of hardware protection against high beam currents, increasing the number of bunches is desirable, the degradation of the specific luminosity has prevented us from adopting shorter bunch spacing. As is seen in Fig. 2, however, they are comparable in the recent trial. One possible reason of this improvement is the installation of the additional solenoids in LER. Another possibility is fine tuning of the gain of the bunch-by-bunch feedback system. Recently, we found that the luminosity decreases with higher feedback gain. Only the LER vertical gain affects the luminosity. We found that the luminosity degrades by about 15 % with 3 dB higher feedback gain than the usual value. The reason why the feedback gain affects the luminosity has not been understood yet. Roughly speaking, the growth rate of the coupled bunch instability is proportional to the total beam current, while the damping rate by the feedback is proportional to the bunch current with the same gain. Then, usually the feedback gain is needed to be raised with shorter bunch spacing. This might have degraded the luminosity with shorter bunch spacing, although we need further study. In near future, we will try even shorter bunch spacing such as 3.27 RF buckets.

## STABLE BEAM OPERATION

In parallel with the efforts to raise the peak luminosity, lots of efforts have been devoted to keep the highest luminosity as much as possible. These efforts include realization of the continuous injection scheme[1], decreasing the beam abort rate, quick recovery of performance after breaks and so on. As a part of these efforts, we describe in the following an effort to decrease day-night difference of the luminosity. We have been long troubled about the problem and recently made progress. The problem became first conspicuous in March 2003. The problem has the following features. 1) The luminosity degrades in the daytime. The difference in the luminosity between day and night is about 20 % at the worst. 2) The difference seems to depend on the temperature difference between day and night. The difference is not remarkable in winter or on a rainy day. 3) When the luminosity drops in the daytime, the HER beam blowup is observed. Tuning on the x-y coupling parameters at the IP is somewhat effective to mitigate the luminosity drop, although its effectiveness is insufficient. A lot of efforts have been devoted in vain to solve the problem. Recently we found that the BPM consistency also shows the day-night difference. The consistency is defined as the standard deviation of four BPM readings by using four different combinations of BPM electrodes (choice of three electrodes out four). Orbit corrections based on changing BPM offsets bring optics deformation and may result in the luminosity degradation. The mechanism that we found is that a part of BPM cables goes through the outside of buildings and is affected by the day-night temperature change. To solve the problem, we installed thermal insulator sheets to the BPM cables in the outside. After the installation, the day-night change of the BPM consistency error decreased by 30 or 50 % and the day-night difference in the luminosity became almost invisible.

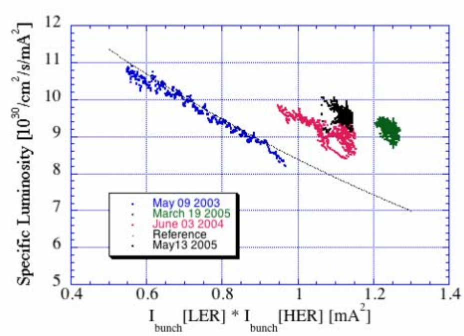


Figure 2: Progress of specific luminosity.

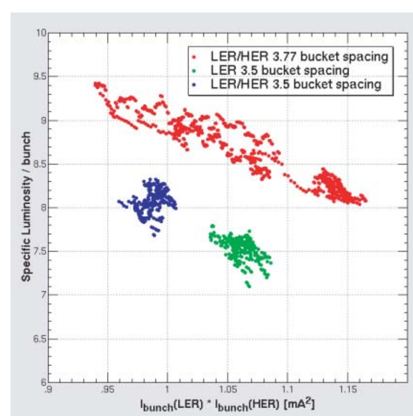


Figure 3: An old experiment showing lower specific luminosity with shorter bunch spacing. This data was taken on June 19 2004.

## REFERENCES

[1] Y. Funakoshi et al., “KEKB PERFORMANCE”, EPAC’04, Lucerne, July 2004.



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