VARIATION OF THE CIRCUMFERENCE OF THE KEKB RING AFTER THE GREAT EAST JAPAN EARTHQUAKE

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Abstract

At the time of The Great East Japan Earthquake, which took place on March 11, 2011, the alignment of magnets in the KEKB ring was deformed in the order of some millimeters. In the construction of the KEKB ring, the tolerance for the ring circumference was as tight as ±10 mm, 3 ppm of the KEKB circumference. So the circumference of the ring was measured after the earthquake with a laser tracker and a mekometer. Results of this measurement are reported.

1. INTRODUCTION

The [*]KEKB ring [1] is a high luminosity electron-positron two-ring collider constructed in 10m deep underground tunnel. The energy of electron and positron beams was 8 GeV (HER) and 3.5 GeV (LER) respectively. This KEKB is now reconstructed as a higher luminosity B-factory, SuperKEKB [2]. The layout of the KEKB ring is shown in Figure1. The KEKB ring is divided into four arc sections, and these arc sections are connected with 200 m long straight sections. Its circumference is about 3km. The electron and positron beams circulate in the opposite direction. They collide at the Tsukuba experimental hall in the north area, and cross over each other in the Fuji experimental hall in the south area.

In the construction of the KEKB ring, the tolerance for the ring circumference was as tight as ±10 mm, 3 ppm of the KEKB circumference. The error of the circumference was less than 5mm in the preceding project, TRISTAN and KEKB. But the Great East Japan Earthquake took place on March 11, 2011, and the alignment of magnets in the KEKB ring was lost in the order of some millimeters [3]. The circumference of the ring was thought to be also changed and the error of the circumference might have become larger than 10 mm. So the circumference of the ring was evaluated with a laser tracker and a mekometer.

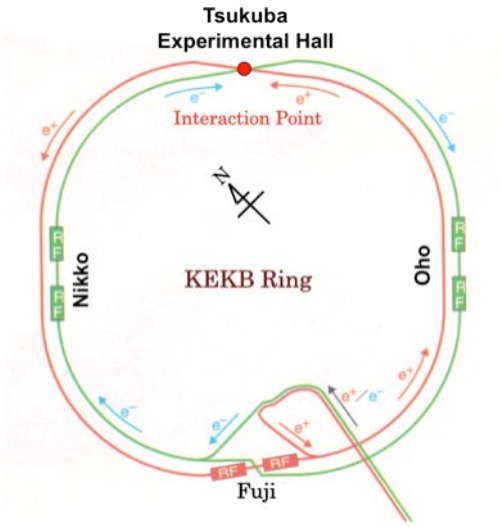

Figure 1: Layout of the KEKB ring

2. INSTRUMENTS AND MEASUREMENT

Two instruments were used, a laser tracker for the arc sections and a mekometer for the 200 m straight sections. The laser tracker is ION™ of FARO, and the mekometer is ME5000 of Leica. The precision and the range are as follows in the makers' specifications:

Laser tracker, ION™

Precision:

8 μm + 0.4 ppm for distance (ADM mode)
(10 + 2.5/m) μrad for angle

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Range:

0 – 30 m with 1/2” SMR

Mekometer, ME5000

Precision:

0.2 mm + 0.2 ppm for distance

Range:

20 – 1,000 m in low range

The position of magnets mainly in the high-energy ring (HER) was measured at the spatial interval of 40 m in the arc section. The position of magnets at both edges was measured. At the 200 m straight section, the position of magnets at both ends of the straight section was measured. Measurement was carried out counter-clock wise starting from the Tsukuba straight section. The edge magnet was overlapped in the next measurement. The distance between the left and the right magnets was calculated in the horizontal plane, and compared with the designed value in the lattice. dL is defined as follows:

dL = (measured distance) – (designed value)

dL was accumulated from the starting point till the final point. The final value of this accumulation provides an estimation of the error for the circumference. Measurements were carried out 5 times from July 2011 till June 2012 as shown in Table 1. Only the measurement #3b was performed with a total station for an instrument test [4]. First three measurements were performed every about two months. And the last measurement was performed for two months, from April till June, 2012. A set of the circumference measurement consists of 55 measurements in the arc sections and 4 measurements in the straight sections.

Table 1. Period of measurements

Year	Duration	No.	Instruments
2011	7/28 - 8/24	#1	LT+Mekometer
	9/21 - 9/30	#2	LT+Mekometer
	12/2 - 12/7	#3a	LT+Mekometer
	12/7 - 12/19	#3b	TS
2012	4/11 - 6/7	#4	LT+TS

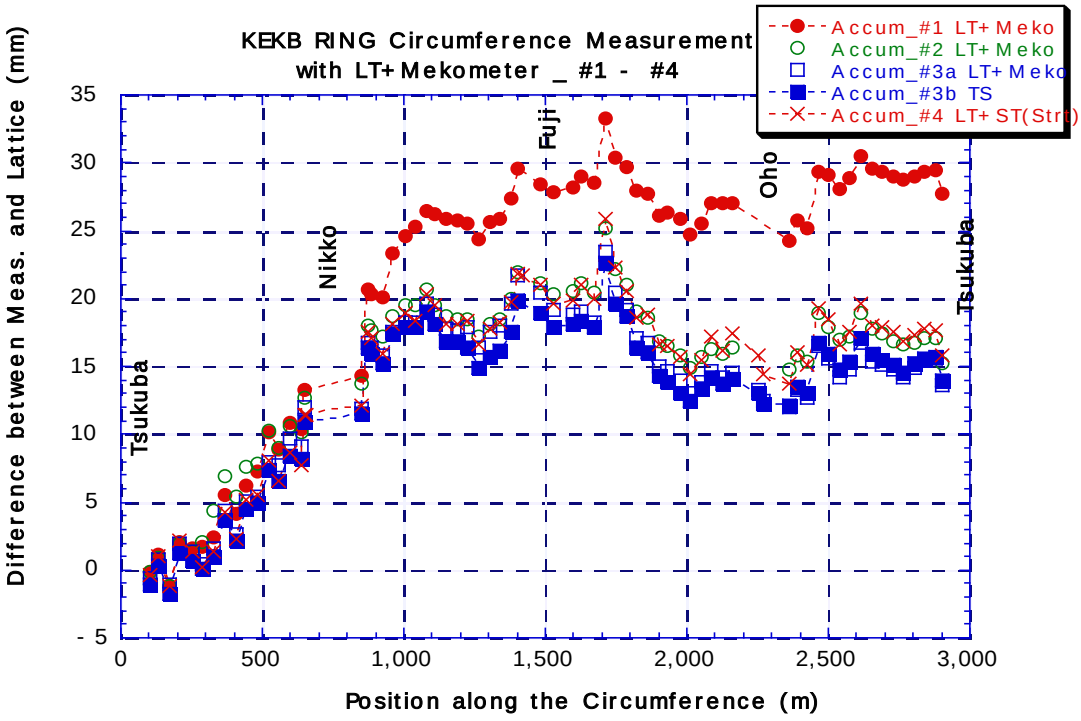

Figure 2: Accumulation of dL (difference between measurement and designed value)

The precision for the circumference measurement is estimated to be about 2 mm based on the precision listed in the makers' specifications.

3. MEASUREMENT RESULTS

Accumulation of dL is shown in Figure 2. The error of the circumference is about +28 mm in the first measurement performed in early August 2011. Then it became about +15mm in the second measurement. Since then the error stayed around +15 mm.

4. COMPARISON WITH THE ERROR DERIVED FROM THE RF FREQUENCY

The error for the circumference of the ring derived by A. Morita from the change of the ring RF frequency is shown in Figure 3. The error stayed between +8 and +10 mm since January 2003 till the end of 2010, although the error was reported to be less than +5 mm in the TRISTAN operation and the beginning of the KEKB operation.

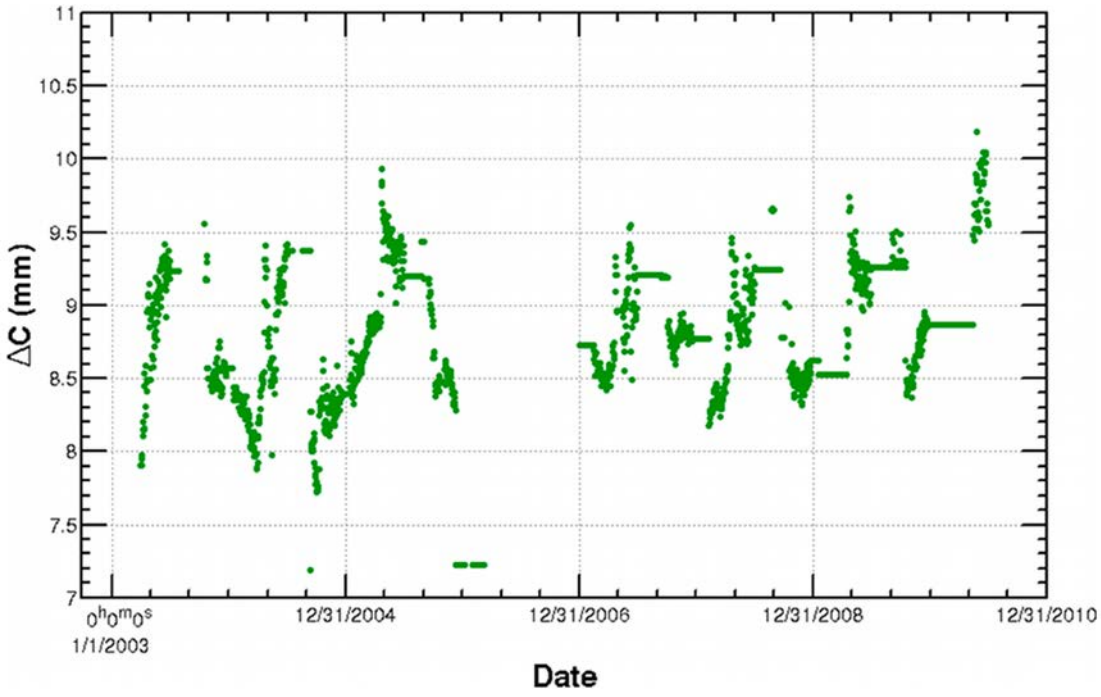

Figure 3: The error for the circumference of the KEKB ring derived by A. Morita from the change of the RF frequency of the KEKB main ring.

SUMMARY

The error of the circumference of the KEKB ring was reported to be less than +5 mm in the beginning of the KEKB operation. And it looks shifted to around +9 mm on the way of the KEKB operation. This change is under investigation on when and how it took place. Then the KEKB alignment was deformed in the Great East Japan Earthquake. The circumference was thought to be changed largely at that time. And it returned to about +28 mm in August 2011, and about +15 mm in the end of September. It looks settling down around +15 mm since then. It is said that the extension of the circumference of the ring by +15 mm can be managed by lowering the RF frequency in the linac and the ring as well. But the circumference of the LER and the HER ring should match within 3 mm which is the range of the beam passage adjusting chicane system.

It will be decided soon how to manage this error of the circumference in the discussion

between KEKB hardware groups and the beam optics group.

REFERENCES

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