PERFORMANCE TEST OF LASER TRACKERS OF FARO

Ryuhei Sugahara [A)], Mika Masuzawa [A)], Yasunobu Ohsawa [A)]

[A)] *High Energy Accelerator Research Organization (KEK)*
1-1 Oho, Tsukuba-shi, Ibaraki, 305-0801, Japan

Abstract

Results on performance test of laser trackers of FARO are reported. Test was performed on the following items: (1) drift of output after power on, (2) long term variation of output, (3) reproducibility of point measurement, and (4) comparison between measurement with a laser tracker and the one with WPS (Wire Positioning Sensor).

1. INTRODUCTION

Three laser trackers of FARO were purchased by the KEKB magnet group in December 2009. The model name is Laser Tracker ION™. Each of these three trackers is called Blue, Red and White. As they are not familiar with FARO LTs (Laser Trackers), performance test was carried out. There are two control software systems for FARO LTs, CAM2 and Insight. The CAM2 was developed from the control system for Arms, free arm measuring system, and it is a bit inconvenient for the survey people. So the KEKB magnet group adopted the Insight system.

Figure 1 shows a picture of a FARO LT. The coordinate system is defined that +X is the horizontal axis stretched from the front face near to the HP (Home Position), +Z vertical upward, and +y the horizontal axis to make right hand system with X and Z axis. Horizontal angle (Φ) is measured from X toward Y axis. Vertical angle (Θ) is from +Z axis toward downward.

Two coordinate systems are used in the measurement. One is the Machine System sticking on to the machine, and the other the Level System which is created in the level plane measured with the LT.

There are two ways to measure distance, IFM

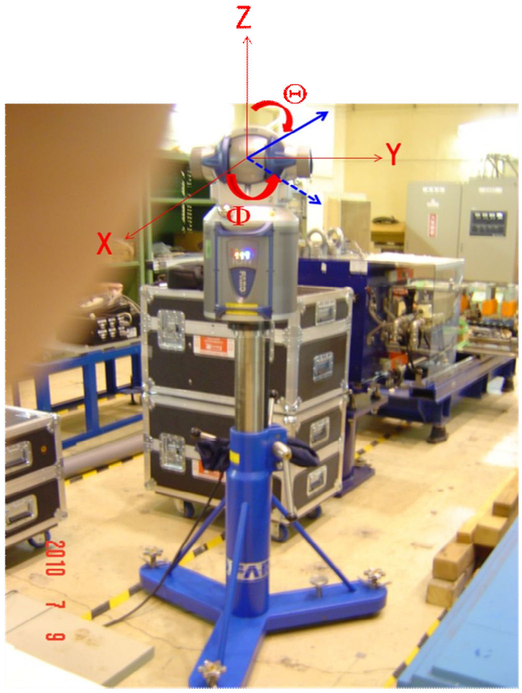

Figure 1: Picture of a FARO Laser Tracker. Definition of the coordinate system is shown in the figure.

(InterFoeroMeter) and ADM (Absolute Distance Measuring system). The "ADM only" mode was used except for the case that the "IFM only" mode was mentioned to be used.

2. WARM-UP TEST

LT becomes ready after machine warm-up in 20-25 minutes. Output data were sampled after the machine ready with 1Hz scanning mode in order to see how much time we have to wait to get stable output. Figure 2 shows variation of R (distance) (a) at HP, (b) at a point 5m far, and (c) in case of IFM (InterFeroMeter) mode.

It can be seen from the figure that we have to wait two hours or longer after machine ready to

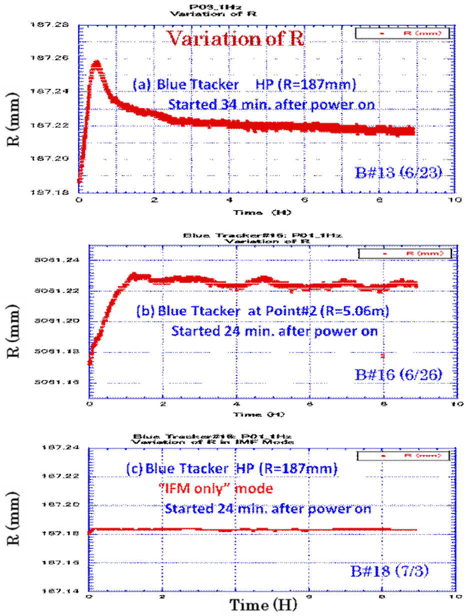

Figure 2: Drift of R (distance) data after machine ready (a) at HP (Home Position), (b) at a point about 5m far, and (c) drift in case of IFM (InterFerometer Mode).

get stable R output, although it becomes stable only in about 10 minutes in case of IFM (InterFerometer Mode).

Figure 3 shows the drift of angle data (a) for White tracker and (b) for Blue tracker. Both data taking was started almost at the same time. A big and slow drift is seen in White tracker output about 6 hours after data taking was started. The same phenomena were observed in other runs for White tracker.

3. LONG TERM VARIATION

Figure 4 shows a long term variation of angle data (a) for White tracker and (b) for Blue tracker. Data were sampled with 0.1Hz scanning mode. The line width of horizontal angle plot is as large as 0.1mrad and several jumps are observed in the White tracker data. It looks something wrong in the angle measurement in White tracker.

4. REPRODUCIBILIT OF POINT MEASUREMET

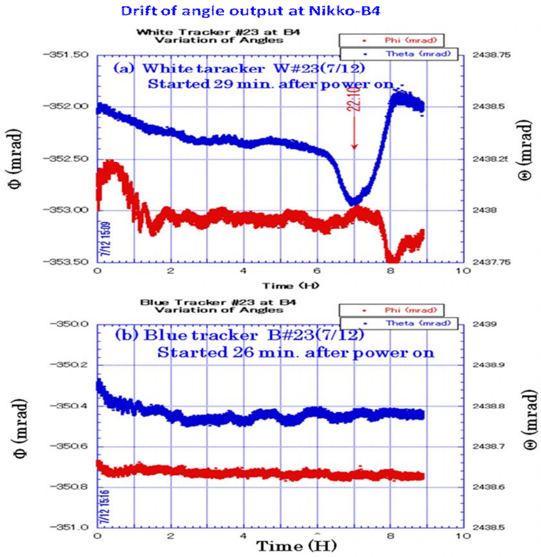

Figure 3: Drift of horizontal angle (Φ, red plot) and vertical angle (Θ, blue plot) for (a) White tracker and (b) for Blue tracker.

Blue tracker was brought in the KEKB Oho straight section, monument points on the wall in about 70m long area were measured five times, and reproducibility of measurements was

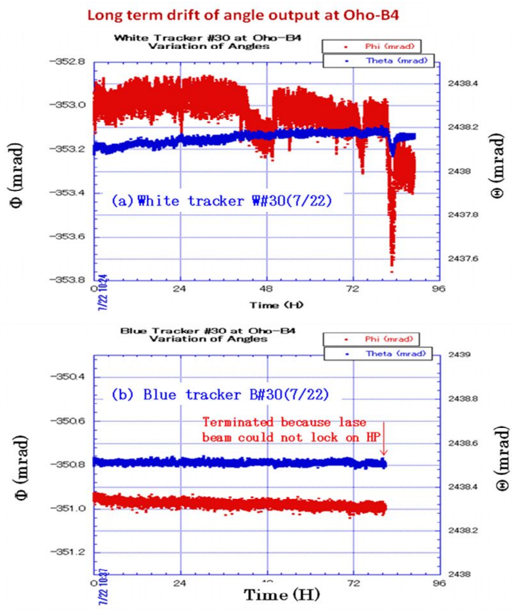

Figure 4: Long term variation of horizontal angle (Φ, red plot) and vertical angle (Θ, blue plot) (a) for White tracker and (b) for Blue tracker.

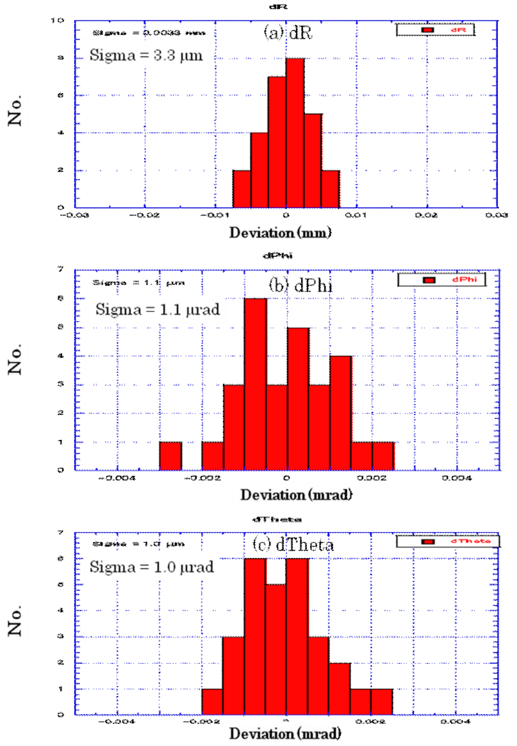

Figure 5: Histograms for RMS for measurement at each monument, (a) for R, (b) for Φ and (c) for Θ.

observed. One measurement is an average of 500 Front-Back samplings. Figure 5 shows histograms for RMS for measurement at each monument point, (a) for R values, (b) for Φ values, and (c) for Θ values. The standard deviations of distributions are 3.3µm for R, 1.1µrad for Φ and 1.0µrad for Θ distributions. These results are satisfactorily small.

5. COMPARISON BETWEEN TRACKER AND WPS MEASURE-MENT

A semi-conducting wire was stretched on wiggler magnets for about 60m long area in the KEKB Oho straight section. And the position of upstream holes for alignment target insertion was measured with WPS (Wire Positioning Sensor). These positions were also measured with the Blue tracker, and both measurements were compared. Here, one tracker measurement is an average of 500 Front-Back samplings.

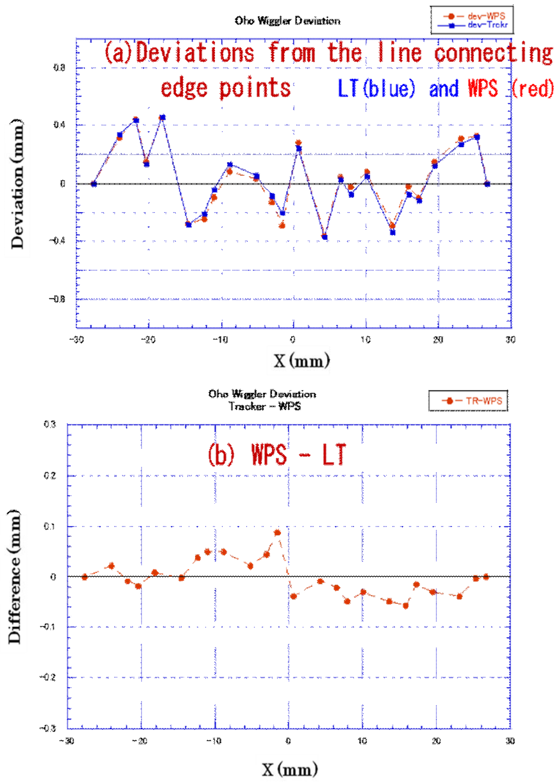

Figure 6: Comparison between WPS and Blue tracker measurements of positions of holes for alignment target insertion on the KEKB wiggler magnets. (a) Deviations of each measurement from the line connected both edge points for WPS (red) and Blue tracker (blue). (b) Differences between WPS measurement and Blue tracker measurement.

Figure 9(a) shows the deviation of each measurement from the line connecting both edge points, where the red curve is for the WPS and blue for tracker measurement. Figure 9(b) shows the differences in deviation values between WPS and tracker measurements.
Differences are less than 0.1mm. And no bending of a straight beam line was observed in the tracker measurement as seen before in the measurement with a Leica LT [1].

SUMMARY

●Warm-up test

- Machine warm-up is finished in 20-25 minutes. But it was found that users have to wait for two hours or longer to get stable output, although the IFM output becomes stable in about 10 minutes.

- In the White tracker measurements, slow deviations in the angle output larger than 0.1mrad were observed after about 7 to 8 hours after data taking was started.

This problem is under investigation

●Reproducibility of measurements

- RMS in 5 time measurements of monument positions in about 50m long area was 3.3μm for R, 1.1μrad for Φ and 1.0μrad for Θ. These results are satisfactorily small.

●Comparison between tracker measurement and WPS measurement

- A semi-conducting wire was stretched on the wiggler magnets in about 60m long area in the KEKB Oho straight section. Upstream position of holes for alignment target insertion was measured with WPS. These positions were also measured with the Blue tracker. Both measurements agree well within 0.1mm. And the bend in the straight line measurement was not observed as observed in the previous measurement with a Leica tracker [1].

●In general

- Three laser trackers were purchased in December 2009 by the KEKB magnet group. But the Red tracker was down in this March and returned to Singapore to be repaired. It had to be sent back again after coming back to KEK because the laser beam happened not to lock to the Home Position. And the White tracker is suspicious now because of a big slow jump in the angle measurement in the warm-up test and long term test. The FARO laser trackers look fragile.
- The reproducibility of measurement in a short time looks excellent.

REFERENCES

[1] R. Sugahara, M. Masuzawa, Y. Ohsawa and H. Yamashita, “Installation and Alignment of KEKB Magnets”, KEK Preprint 99-131, November 1999; Proceedings of the 6th International Workshop on Accelerator Alignment, Grenoble, France (1999).