# INTRODUCTION OF PLS HLS SYSTEM

*Y. C. Kim, K. W. Seo, B. I. Moon, M. S. Hwang, C. W. Chung, I. S. Ko*
*PAL, POSTECH, San 31, Hyoja-Dong, Pohang, Kyungbuk, 790-784, Korea*

## 1. INTRODUCTION

Pohang light Source (PLS) with beam energy of 2.5 GeV has provided the stable photon beam to the users during last 10 years. As the number of beamline requiring the micro-spot high resolution photon beams such as U7, EPU and U10, has been increased, the stabilization of the electron beam orbit drift is strongly required. Hence efforts to improve the beam stability have been conducted in various related fields such as RF, magnet power supply, diagnostics of electronic device, etc. Among those efforts the suppression of movements of mechanical components, which are normally due to thermal effects and vibration, had been known to be very important. Thermal problem in the storage ring tunnel has been cured sufficiently by improving the air handling units including the sensors and its control. As for the mechanical vibration, the measured amplitude in the frequency range of a few hertz and a few tens of hertz were very small so far in view of the effect on the beam orbit drift. However, the mechanical motions of main storage ring machine components such as girder, magnet, vacuum chamber, etc., have been known very important factors having potent influence on the beam trajectory. Therefore, it is necessary to measure and understand the real time movement behaviour of the storage ring components and its base, i.e., the tunnel floor. As was reported before, there has been a big amount of uneven settlement at the storage ring floor slab along its circumference. These measurements are shown in Fig. 1. The amounts were almost 3 mm per year at the beginning stage of measurement and it tends to converge to 2 mm per year. These measurements were performed by the conventional optical surveying method at every machine shutdown period (2 times a year). To understand the real impact of this floor uneven settlement on the beam operation, we planned to measure the continuous vertical movement of storage ring floor by use of hydrostatic levelling system (HLS, Fogale Nanotech, France).

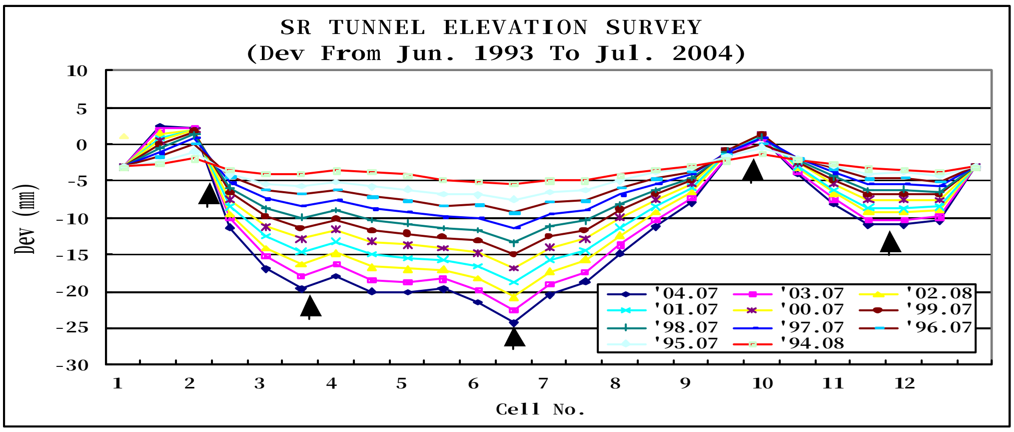


Fig. 1 Elevation survey of storage ring tunnel floor for last 11 years

## 2. INSTALLATION OF THE HLS ON THE STORAGE RING FLOOR

For the record of the real time floor movement and to compare it with the optical measurement data shown in the above Fig.1, 24 HLS were installed near the optical survey benchmarks in equidistance along the circumference of the storage ring. The installation map is shown in Fig. 2. Two numbers of HLS correspond to a cell in Fig. 1, with the same point of cell #1 and HLS#1. At first we believed that the HLS we purchased from the maker were the 2nd generation HLS or more improved ones. The 2nd generation HLS has been reported in some papers to have very good accuracy with small amount of standard deviation for a few months data collections [1][2]. Later, we knew that the sensors of HLS were later generation ones, which were found to have bigger error bound than the 2$^{nd}$ generation HLS. For the fluid medium we used LCW(low conductivity water) that were used for the cooling of all the mechanical components of the PLS (Pohang Light Source) without any additives. The water tank was installed outside the storage ring tunnel for the filling up the evaporation amount of water at first installation, but later it was moved to near the HLS water network inside the storage ring tunnel.

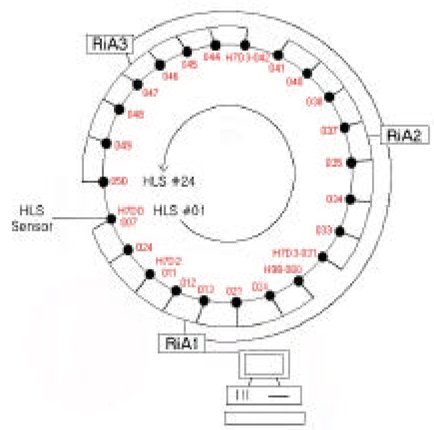


Fig. 2 HLS installation map

## 3. DATA ACQUISITION AND ANALYSIS

As soon as the installation completed, we began to collect the data from the sensors. The first data collected for a little more than one month from the 5$^{th}$ Feb. 2004 to 10$^{th}$ Mar. 2004 are shown in the Fig. 3. In this graph, the values represent the relative readouts of the other 23 HLS in reference to the readout of HLS#1 (zero line) and with the reference time of 0:00 of 6$^{th}$ Feb. for your easy understanding of the readout development. The blank portions in the data lines are due to fail in data acquisition.

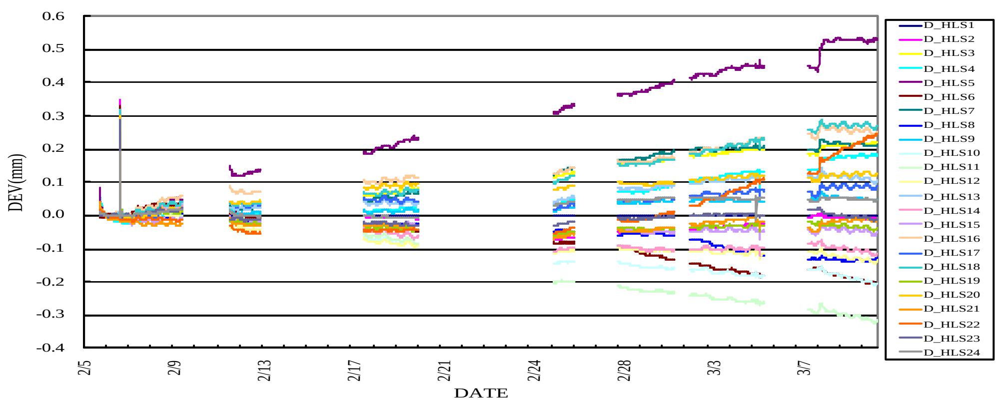


Fig.3 Relative level readout for about 34 days

Because of complexity of graph a few representative locations i.e., HLS#3, #6, #12, #19 and #23 were selected to compare these HLS data with the data from the digital level measurement as shown in Fig.1 (arrow mark). The comparison between the simplified HLS data for the representative locations and the calculated movements of the marked locations for the same period (34 days) and for a year are shown in Fig.4. The calculation was done with the assumption of linear movement for a year. There are big differences in between those two data. This are considered that the assumption is not correct and/or the sensors have a big errors.

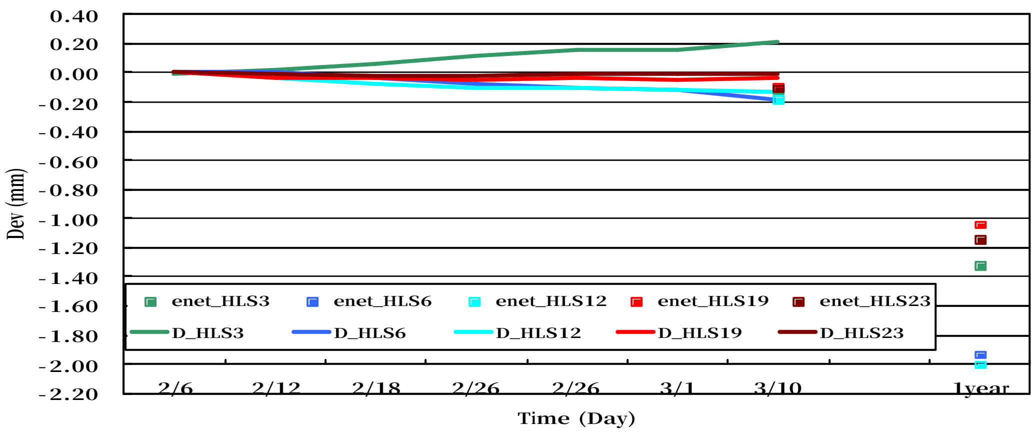


Fig. 4 Relative level readout for about 34 days for 5 HLS (HLS#3, 6, 12, 19, 23)

During operation and maintenance of HLS, there were many jumps of different amounts among the 24 HLS in the readings whenever water filling or cleaning of sensor surfaces were done. Hence, the level differences in the whole HLS between before and after the bubble removal and water filling were checked and are shown in Fig. 5. Through analyzing the data of this graph we found there could be some factors which might degrade the accuracy or damage

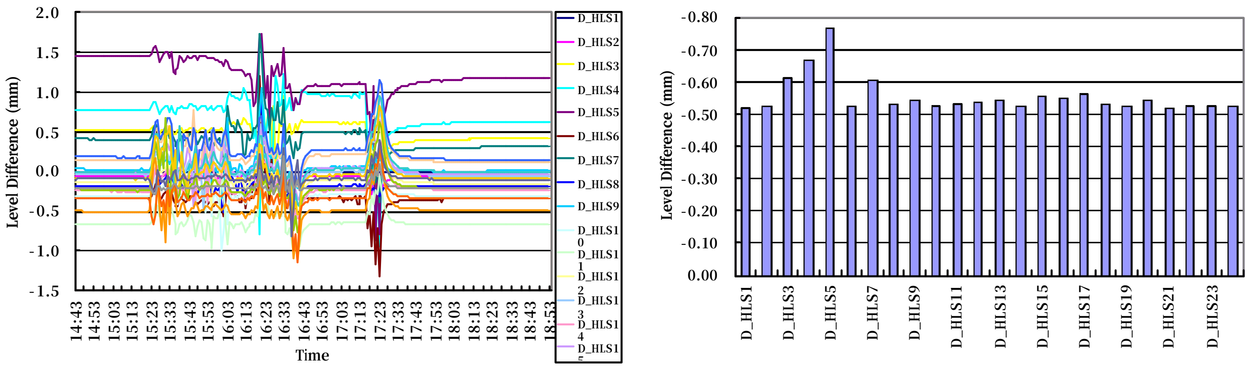


Fig. 5 Difference in readings before and after water filling

the reliability of HLS, such as power off to the HLS, thermal source near the network, contamination of the sensor surface with water or dirt, etc.

With consideration of all factors, we moved the water tank near to the water network, removed/blocked the heat source from the network, and cleaned all the sensor surfaces so as to get reliable data. Continuous measurements from the first measurement setup in the storage ring were done for about 6 months and the simplified graphs for the representative points are shown in Fig. 6. The calculated digital survey values of the same points for the same period are also

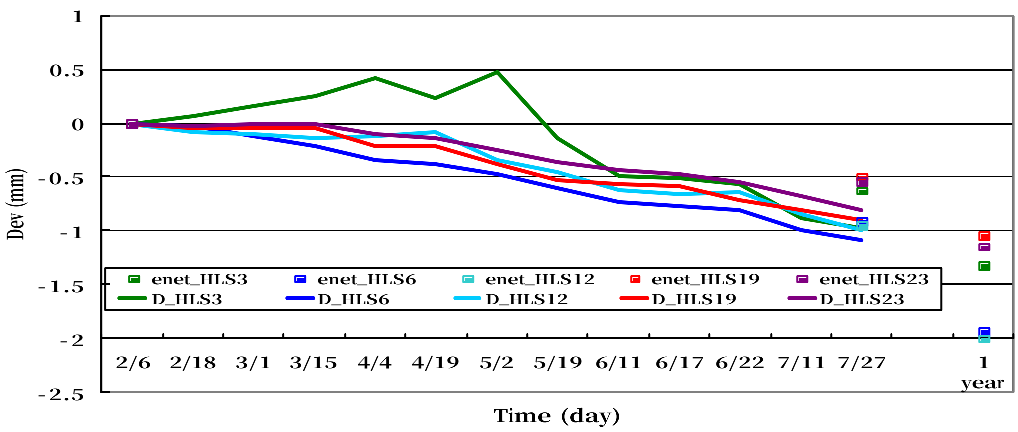


Fig. 6 Movement trend of the representative locations for almost 6 months (1)

marked in Fig. 6. The data from the HLS show the bigger movements than the digital survey data. This kind of comparison between the HLS data for 6 months and the assumed digital survey data

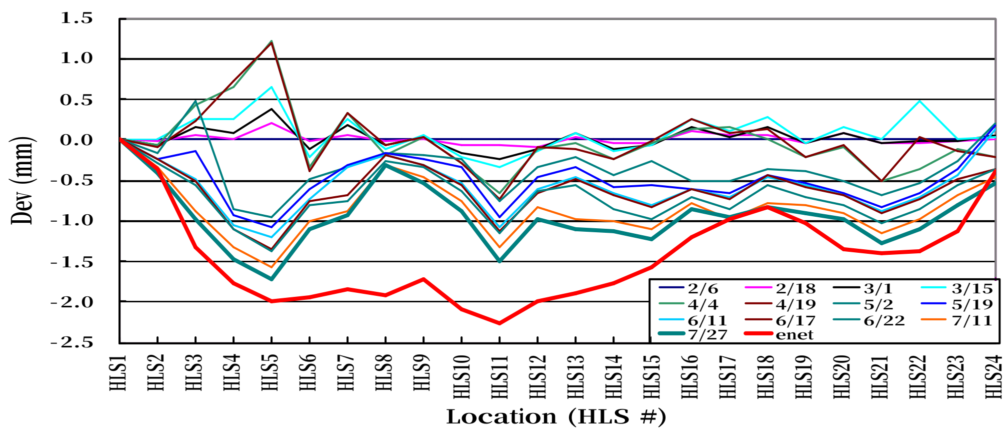


Fig. 7 Movement trend of the representative locations for almost 6 months (2)

for a year along the circumference of storage ring are also shown in Fig. 7 for rough review of accuracy of HLS measurement. The ‘enet’ in the legend of Fig. 7 represent assumed movements in the specific locations for a year.

## 4. TEST MEASUREMENT

During the summer maintenance period the test measurement for the whole HLS were performed in the laboratory. The 24 HLS captors were arranged on a marble table as shown in Fig. 8. The size of marble table is about 2 m by 1.5 m. The room in which the test is performed is air conditioned with the temperature fluctuation of 0.2℃ in day and night. The humidity is also controlled in a bit rough manner. The filling /purging test was performed first and the results are shown in Fig. 9. The test was started with 5 steps of water filling of about 0.5 mm height per step and purge of water of about the same height followed. Sufficient times were given for the water to be stabilized after the filling or purging of water and the following step proceed. In principle, the differences among the amount of changes of reading from the initial values in every HLS after a filling/purging should be the same. But, in reality the values vary almost 0.05 mm near the edge of sensing range. After finishing the test, the reading values still show the different values from the initial ones by 0.01

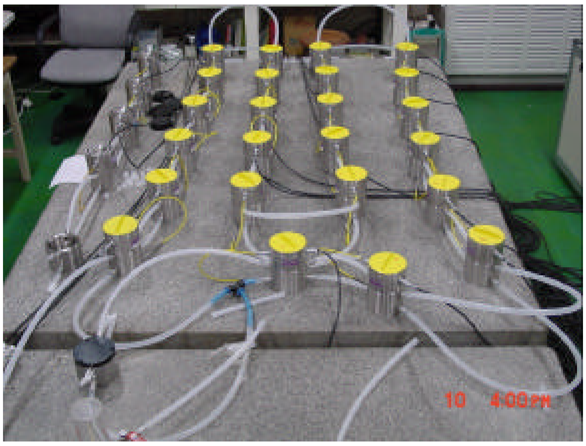


Fig. 8 Setup for test measurement

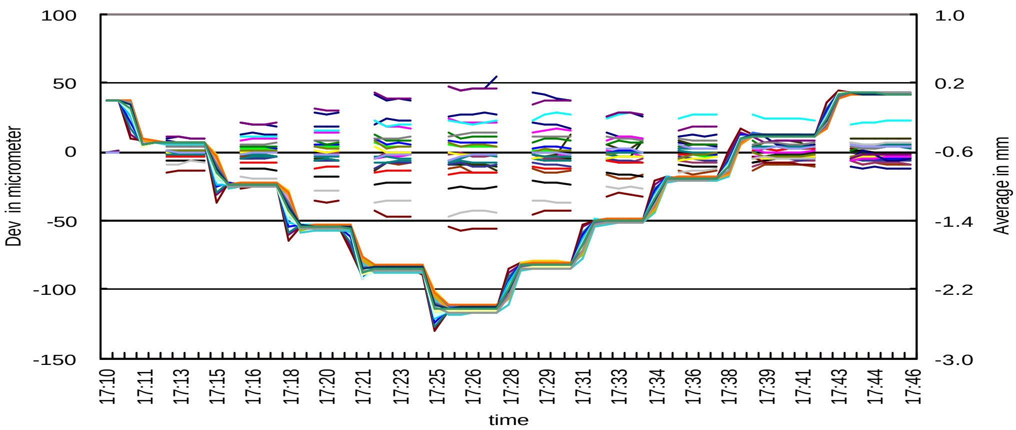


Fig. 9 Filling/Purging test for 24 HLS

mm at most. The standard deviation of the readings of 24 HLS after the test i.e., after 30 minutes operation, is about 0.07 mm. After the test we recorded data in a quiet circumstance without any actions to the test setup for more than a month. The typical graph for the readings of 24 HLS for 10 days and the variation of the standard deviations are shown in Fig. 10 and 11. As shown in the graphs, the changes in the data reading are quite bigger than expectation and the changes in the standard deviation also rapidly increased at the beginning stage. It was found that there was no such big increase in the standard deviation (SD) after 2 weeks from the first date of recording and the SD is maintained in the value of 0.040 mm to 0.050 mm. Those figures are still too big for our measurement to be used for the understanding of motion behaviour and for the final improvement of beam stability.

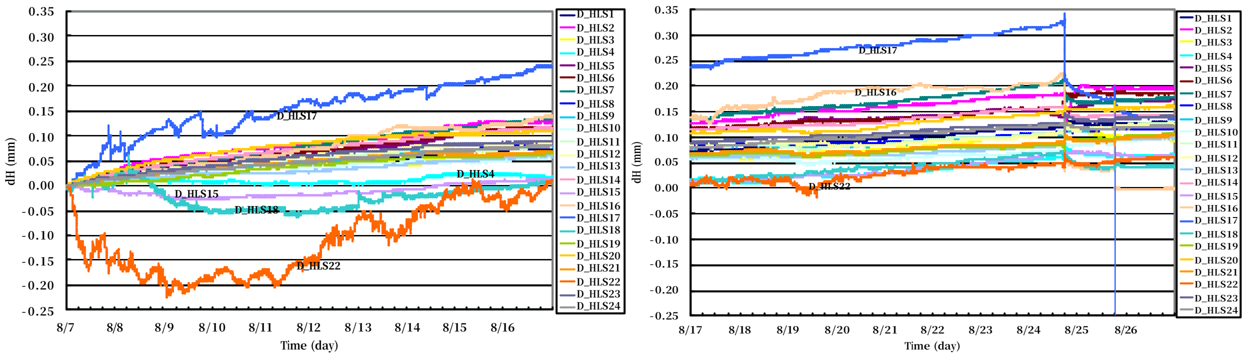


Fig. 10 Records of test measurement for 10 days each

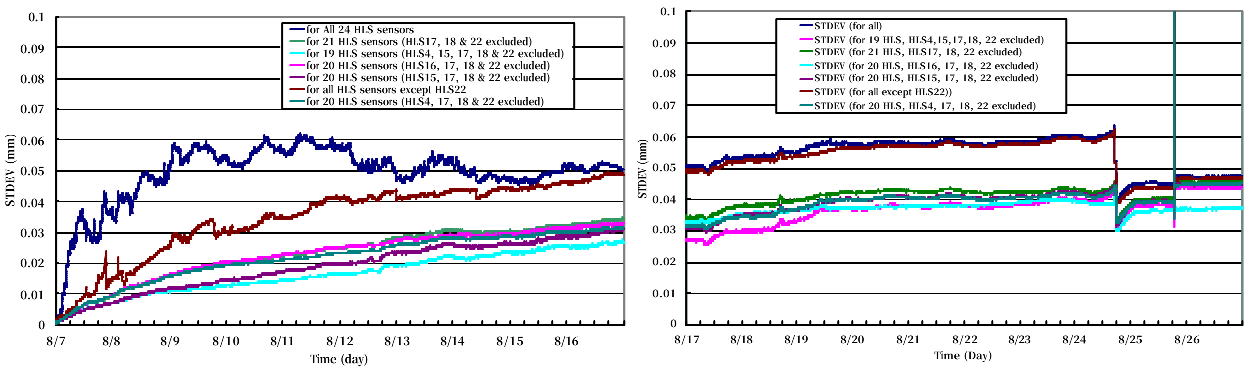


Fig.11 Standard deviation of test measurement

## 5. CONCLUSION

The 3rd generation HLS were used to monitor the real-time vertical movement of the storage ring tunnel floor to understand the behaviour of its motion. From the test measurement, the error bounds of these HLS were found to be bigger than those of 2nd generation ones. During the operation, many factors were found to be harmful to the accuracy of the data, such as dirt or condensing water on the surface of sensor, sensor electronic drift we guess, etc. With many test measurements after removal of the possible error reading sources, the sensor electronic drift is suspected to be the biggest error source. However, the trend of the movement for a little bit long time seems to be correct. Since this is the first operation of HLS in the PAL (Pohang Accelerator Laboratory), we need more test and analysis on the accuracy of the 3rd generation HLS and are still testing for the long term parameters of these HLS. Though the test results of 4 numbers of 4th generation HLS were not introduced in this paper, it showed us a good confidence in the accuracy.

Since we got approval for the construction of 4th generation accelerator from the government, we are in the beginning stage of conceptual design of the machine. It is well known that for the machine alignment of 4th generation accelerator, which has more severe tolerance than that of 3rd generation one, HLS with high accuracy and high stability is necessary. Therefore, we need confidence in the use of HLS not only for the improvement of orbit stability of the PLS but for our next 4th generation accelerator.

**References**

[1] D. Martin, "The European Synchrotron Radiation Facility Hydrostatic Levelling System-Twelve Years Experience with a large Scale Hydrostatic levelling System", Proceedings of the 7th International Workshop on Accelerator Alignment, Spring-8, 2002

[2] David Martin, "Deformation Movements Observed at The European Synchrotron Radiation Facility", Proceedings of the 22nd Advanced ICFA Beam Dynamics Workshop on Ground Motion in Future Accelerators, SLAC, 2000