SEVERAL RECENT MONITORING EFFORTS IN NSLS-II

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Abstract

Monitor the changes of accelerator components and tunnels are one of the major efforts when the machine is running. Several recent monitoring efforts in NSLS-II will be discussed.

Long term measurements above truck tunnel will be updated. Besides, a new wire position system is installed. The system, data processing and results will be shown.

The circumference changes of storage ring in one year are also measured in month long intervals and are compared with beam data. This is a topic that didn't get covered a lot. The approach and results will also be reported.

INTRODUCTION

Along with new projects of beam line installation, the monitoring of the facility is ongoing. Some efforts were presented during last workshop [1].

In the past two years, several more efforts have been performed. Firstly, a wire positioning system is installed and running above the truck tunnel. The result will be compared with long- and short-term trend observed before. Secondly, the circumference of storge ring have been monitored monthly for the during of one year. The correlation of circumference change, and beam energy were published in the paper [2]. Some details will be discussed here including an unsuccessful attempt.

TRUCK TUNNEL MOVEMENT

The picture of truck tunnel is shown in Figure **1**. It facilitates the transportation from outside to the courtyard. However, much large changes have been observed.

Seasonal changes of about 0.5 mm and daily changes of about 0.06 mm have been observed. Considering that a very tight tolerance of ±100 micron for girders, it's hard to see those large numbers.

Long-term monitoring

Laser tracker is used to take measurements of monuments and girder fiducials around truck tunnel. When processing data, the two adjacent multiple girders were hold as datum and the changes of the C17G2 girder was checked.

The monitoring effort continues during each long during shutdown, and the graph is updated in Figure **2**.

As can be seen, the long-term yearly change trend still exists. The impact from construction gets smaller after the first year (2019).

Figure 1 : Truck tunnel.

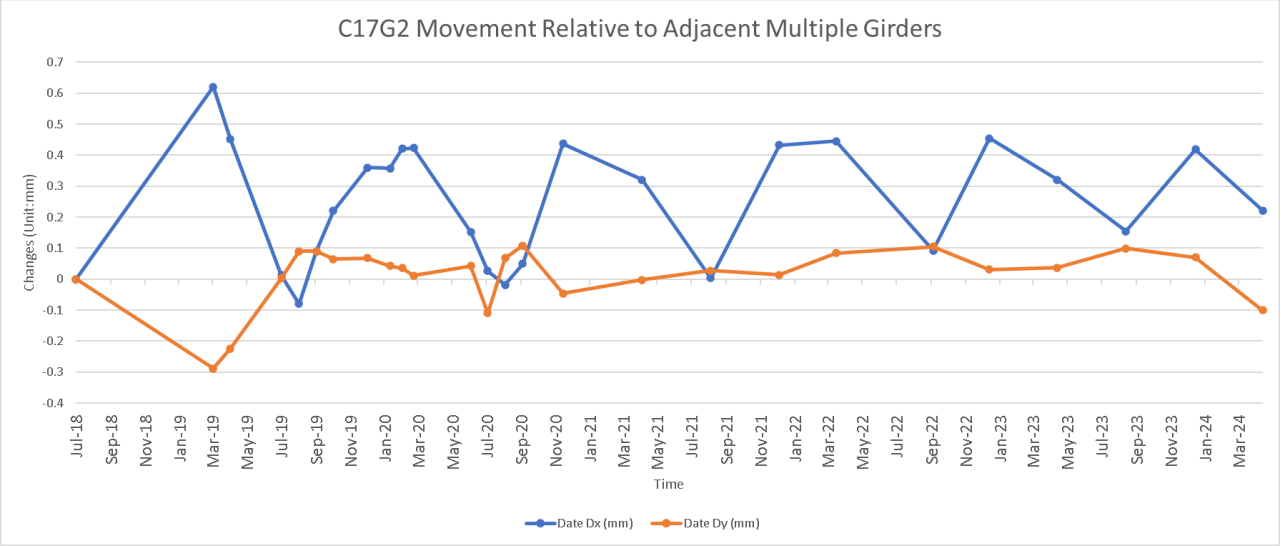

Figure 2 : Truck tunnel movement along with time.

Wire positioning system

A wire positioning system is installed to monitor the change in real time. It can only provide the long-term trend but also show the short-term trend in real time.

Installation

The hardware and data collection software were purchased from Fogale Nanotech.

An engineering drawing was produced and supporting hardware were made or purchased. There are 5 sensors in total. The two ends are outside of the truck tunnel and will be set as datum. The middle point corresponds to the location of girder C17G2.

The sensors are installed in the storage ring tunnel and cables are connected to the rack above the mezzanine. The sensors and protection are shown in Figure 3. The cracks on the floor can be seen clearly.

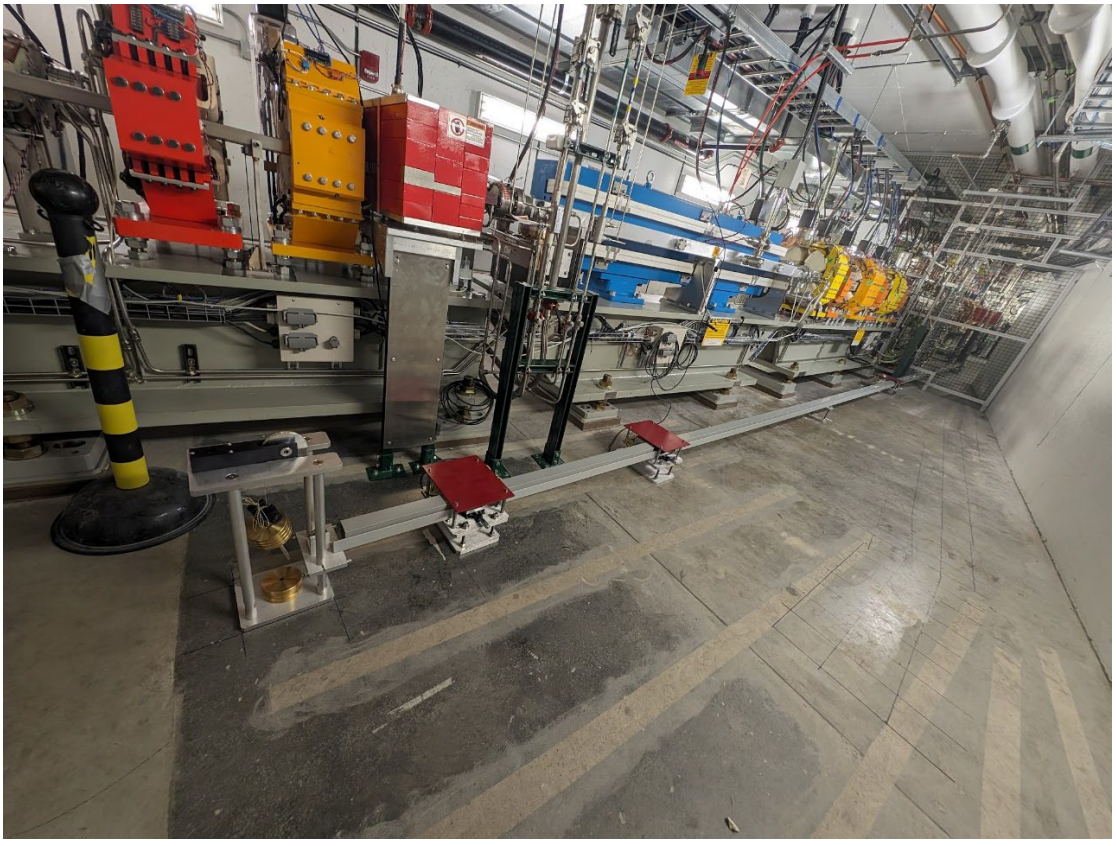

Figure 3: Monuments and instruments layout for monitoring floor changes above truck tunnel.

Data collection

The system is up and running since May 2024.

The raw data was collected with the software provided by the vendor.

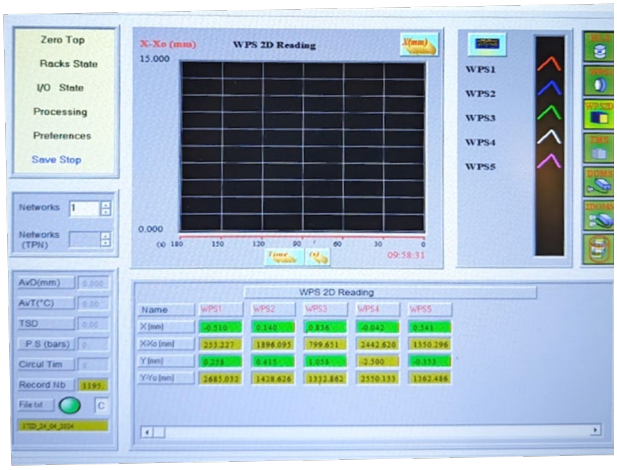

Figure 4: Software interface

The data are saved day by day. Each day there is *.txt file generated.

Data processing

Scripts were created to connect the data together. For each set of measurements, a line will be established with two ends as datum. Then the data was shown as a graph.

The scripts were written with Python and the Measurement Plan of Spatial Analyzer.

Trends

The long-term (more than two months) and short-term (one day) changes in X direction can be seen in Figure 5.

As can be seen, the change in about two months is about 0.17 mm. In one day, the changes are in the order of 10 micron. This generally agrees with the measurement result of laser trackers with smaller amplitude. This probably is because laser tracker is more sensitive to air and temperature and hence there is larger noise.

Future

The beamline scientist needs to reset their alignment daily. The data from WPS can be compared with beam data in the future to see the correlation.

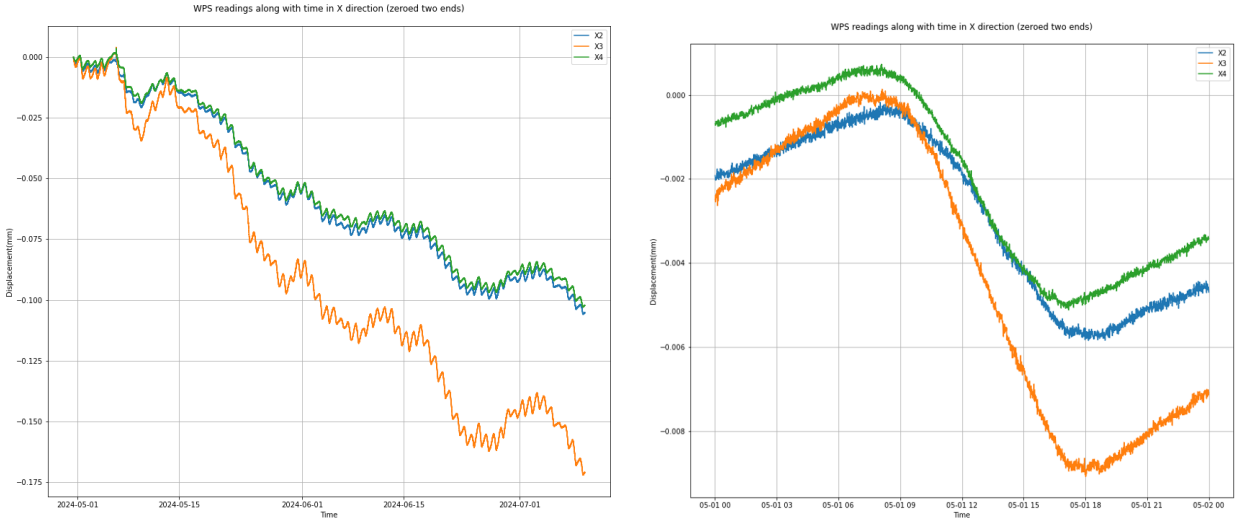

Figure 5 :Long and Long-term trends in X directions (Unit: mm).

SR CIRCUMFERENCE MEASUREMENT

Accelerator Physicists observed large long-term variations of the measured amplitude-dependent tune shifts and suspect that seasonal variations of the storage ring circumference and energy could be the culprit. Therefore, the circumference changes monitoring work is scheduled.

Circumference changes have been observed in several facilities, such as like Spring-8 [2] and ALBA [3]. However, there is little direct measurement examples of the circumference by survey techniques recently.

We performed two kinds of circumference measurements since May 2022. The first approach is measuring radius changes and is proven to be inaccurate and will be discussed shortly.

Radius measurement approach

During the construction of NSLS-II, several primary monuments were set to establish the relative location of different accelerator tunnels. Deep concrete pillars, as shown in Figure 6, in the center of the facility and doors and penetrations were reserved to make observation possible. There are 5 primary monuments can be used. The plan is shown in Figure 7.

It's convenient to use those monuments to take radius measurements and calculate the circumference with C=2*R*pi.

Figure 6: Central monuments

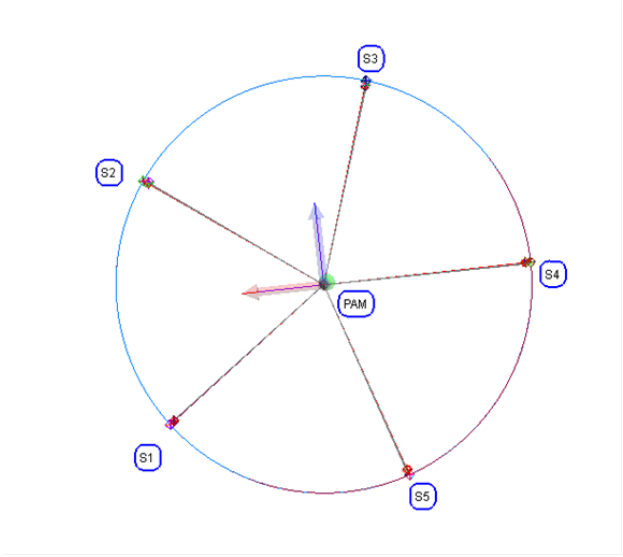

Figure 7: Radius measurement

However, it didn't work out due to the following reasons:

- Probably due to the aging of laser tracker, it could not take direct measurement at around 125 m all the time. A temp setup above the mezzanine is employed so that the measurement can be taken.
- Due to significant temperature difference between outdoor and the controlled building, the distance measurement accuracy is low.

After several rounds of measurements, this approach is abandoned.

Arc measurement approach

A new plan must be developed. Ideally, the monuments and measurement should be taken place in the storage ring tunnel. However, there is only limited access to storage ring tunnel when the machine is in operation. Therefore, the monuments are set on the mezzanine.

Comparing with the previous approach, both the monuments and instrument are under controlled temperature. Therefore, the measurement accuracy can be improved significantly.

Monument location

The distances between monuments were measured periodically to compute the circumference changes. There are totally fifteen monuments and their locations are shown in Figure 8.

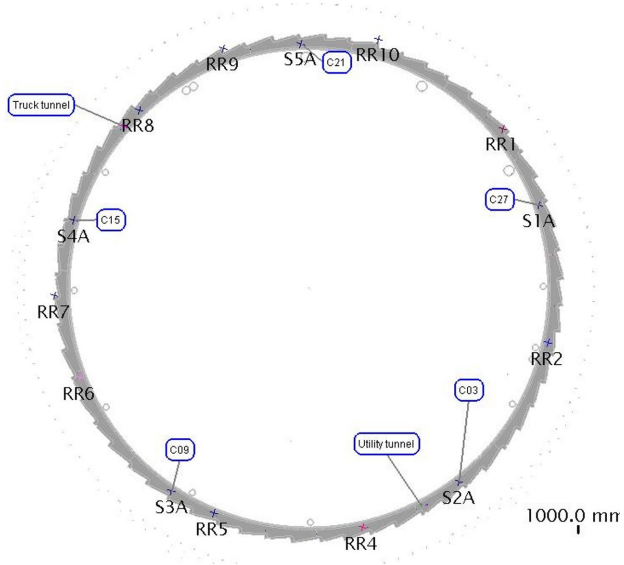

Figure 8: Arc measurement

Instrument and accuracy estimate

A Leica AT401 laser tracker was used to measure the distances between two monuments. Each monument will be measured three times and then the distance between the monuments was computed and averaged. Based on the instrument's specifications, the instrument provides a distance accuracy of 0.010 mm and an angular accuracy of 1 arcsecond. The estimated distance measurement accuracy is about 0.07 mm, and the circumference accuracy is about 0.28 mm.

In 2023–2024, a total of 16 sets of data had been collected.

Distance measurement comparison between mezzanine and storage ring tunnel

The purpose of this comparison measurement is to calibrate the factor between the measured value in two areas. The major difference is that the accuracy of temperature control is in significant level. In the storage ring tunnel, the temperature change is much lower than the one in experimental area and hence the changes should be much smaller.

Two laser trackers were set up and took measurement simultaneously. In storage ring, the distance between two measured points is 34346mm. On mezzanine, the distance between two points is 53256mm.

When doing comparison, the distance difference is considered.

The measurements duration were about two weeks.

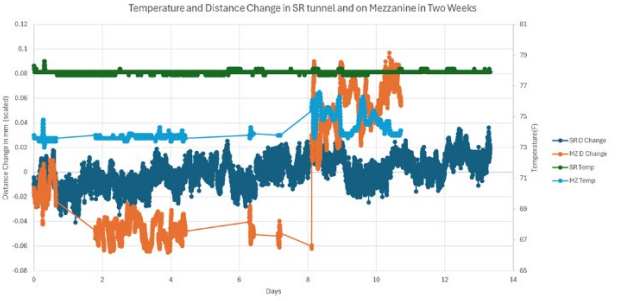

Figure 9: Distance and temperature changes in about two weeks at mezzanine and in storage ring tunnel

Figure 9 shows the raw measurements of temperature and distance changes. People or object in the way makes the collected data set is smaller on the mezzanine.

The temperature change in the storage ring and on the mezzanine is 0.9 °F and 3.6 °F respectively. The distance change range in the storage ring and on the mezzanine is 0.07 mm and 0.16 mm (scaled to 34.3 meter) respectively. This corresponds a scale factor of 0.44 for the distance value measured above mezzanine.

Storage ring circumference and outside temperature changes

With the scale factor applied, the measurement is shown in Figure 10. As one can see, the circumference follows the temperature with a significant time lag caused by the thermal capacity of the large amount of material.

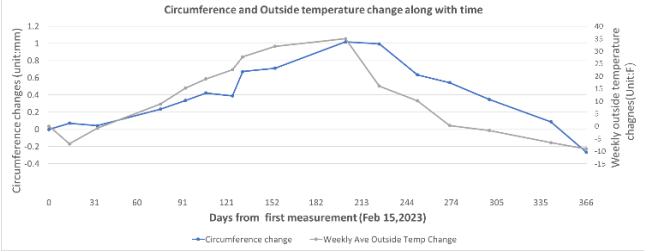

Figure 10: SR Circumference (corrected) and outside temperature changes in about one year

As can be seen in Figure 10, the circumference change follows the temperature with a significant time lag caused by the thermal capacity of the large amount of material. Considering the discontinuity of measurement, the estimated yearly peak-to-peak circumference change is about 1.5 mm.

Storage ring circumference and energy

Paper [4] summarized the circumference measurement along with other data including RF frequency changes, sum current of power supplies feeding quadrupole magnets, IVU gap changes, and energy changes.

The conclusion is that the seasonal variations of the ring circumference and energy seem to be the main reason for the lattice reproducibility issues observed at NSLS-II.

SUMMARY

The seasonally monitoring survey of the changes above truck tunnel shows that the changing trend is like previous years. Nothing is to be alarmed.

The newly installed WPS can provide real time data. It agrees with the trend from regular survey and could provide much more detailed information.

The storage ring circumference measurement campaign is not ideal since it's not measured in the tunnel directly. However, with careful designed plan and corrections, the estimated 1.5mm peak to perk yearly change is reliable.

NSLS II has been running for about 10 years. Although the machine is running well, potentially more problems will occur. Monitoring the changes of equipment could be helpful and the efforts will continue.

ACKNOWLEDGEMENT

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