ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-MOPRO094

TPS COMMISSIONING EXERCISE PERFORMED ON THE TLS

Fan-Hsin Tseng#, Ho-Ping Chang, Mau-Sen Chiu and Szu-Jung Huang
National Synchrotron Radiation Research Center,
101 Hsin-Ann Road, Hsinchu Science Park, Hsinchu 30076, Taiwan, R.O.C.

Abstract

Taiwan Photon Source (TPS) commissioning exercise by using the high-level accelerator physics application programs (HL-APAP) [1-2] has been performed on the operational 1.5 GeV Taiwan Light Source (TLS) storage ring. It includes steering the injection beam in the first turn to achieve multi-turns and storing beam with the help of the RESOLVE [3] analysis. The orbit correction programs using different algorithms such as SVD, Householder transformation and local bumps were applied to reduce the closed orbit distortion of the stored beam and to adjust the beam orbit to pass through those field centers of quadrupoles indicated by the corresponding BPMs. The golden orbit defined by the measured data of BPMs corresponding to each quadrupole field center was based on the Beam Based Alignment (BBA) [4]. After approaching the stored beam orbit to the golden orbit, we save all the BPMs data as the target orbit for machine operation. The lattice calibration is then performed by the LOCO [5]. The detail of the commissioning exercise is described in this report.

INTRODUCTION

For the coming TPS beam commissioning in 2014, we have been trying to take some exercises on the 1.5 GeV TLS in order to achieve as much as possible experiences. Our exercises include the commissioning of TLS low emittance lattice to achieve the experiences from beam injection to beam stored, beam steering of the BTS with design optics, and the tests of those HL-APAP on the TLS storage ring. We describe these exercises in the following sections.

LOW EMITTANCE LATTICE COMMISSIONING ON TLS STORAGE RING

A low emittance lattice had been studied for the TLS storage ring at 1 GeV [6]. It was performed as an exercise on the TLS to achieve the experience for the coming TPS beam commissioning. In 1993 when we commissioned the TLS storage ring, there were some screen monitors used to check the beam steering around the ring. At that time the turn-by-turn BPMs or the single pass BPMs were not available. In this exercise, we tried to learn the first beam commissioning without any screen monitors and we assumed the beam signals could be obtained from the turn-by-turn BPM system. Following describes the experiment results.

Experiment was starting from downloading the linear part of the low lattice, i.e. the settings of bending and quadrupole magnets, setting all other power supplies of magnets to be zero and turning off the RF system.

On-Axis Beam Injection

The purpose of on-axis beam injection test is used to check the possible critical errors of beam trajectory, the approach of closed orbit, caused by the beam energy mismatching and those misalignments of bending and quadrupole magnets. Due to the difficulty of fine-tuning of the on-axis condition, it requested stronger field strength of the kicker #4 and the launching conditions before the injection septum on the BTS transfer line (see the Fig. 1a), and the combined function bending magnets used in the six TBA cells lattice of TLS storage ring. We did not get much benefit except the experience of the on-axis injection exercise. But it is still important for the TPS beam commissioning.

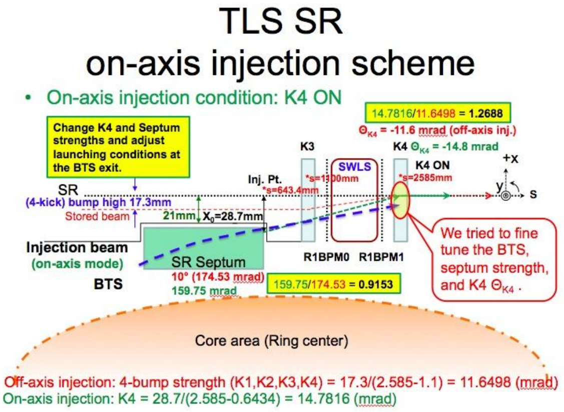


Figure 1a: The on-axis injection scheme of the TLS storage ring.

Off-axis Beam Injection

Used the design of TLS injection scheme (Fig. 1b), we got the first 1/6 turn beam signals. With the help of RESOLVE analysis, we might tune the injection septum or the horizontal corrector R1HCSF1 to achieve the one-turn beam (Fig.2). Then we simulated the 2nd turn beam trajectory by using the data of injection kickers (Fig.3), which pulse width is 5 times of the revolution time (400 ns). We adjusted the knob of corrector pair R6HCSF1 and R6HCSF2, it helped to reduce the amplitude of beam trajectory after the first turn and we obtained the multi-turns beam trajectory.

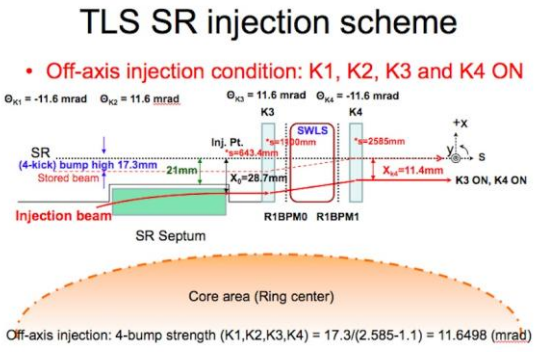
After turning on the sextupole magnets and the RF system and then lightly scanning the injection conditions

---

#tseng.fanhsin@nsrrc.org.tw

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-MOPRO094

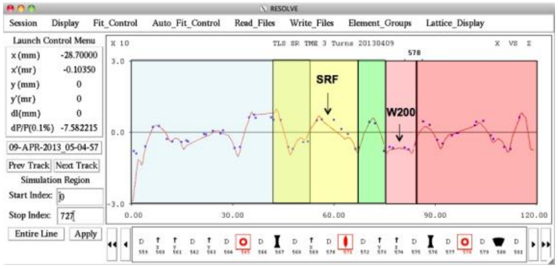
and working tune, we could store the beam although the injection efficiency was not good (Fig. 4). Figure 5 shows the closed orbit of the stored beam with the low emittance lattice of TLS storage ring.


TLS SR injection scheme

- Off-axis injection condition: K1, K2, K3 and K4 ON

Off-axis injection: 4-bump strength (K1,K2,K3,K4) = 17.3/(2.585-1.1) = 11.6498 (mrad)

Figure 1b: The off-axis injection scheme of the TLS storage ring.



Launch Control Menu

x (mm) -28.70000
x'(mr) -0.10350
y (mm) 0
y'(mr) 0
dl(mm) 0
dP/P(0.1%) -7.582215

09-APR-2013_05-04-57

Simulation Region

Start Index: 0
Stop Index: 727

Figure 2: The first turn beam trajectory.

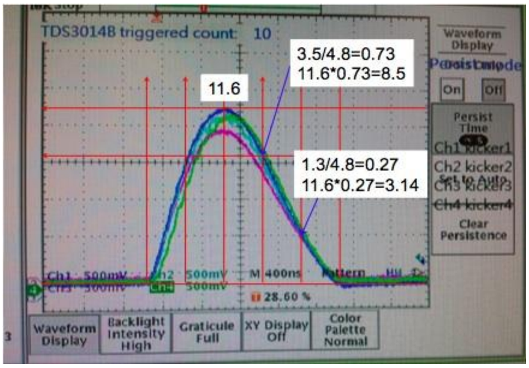
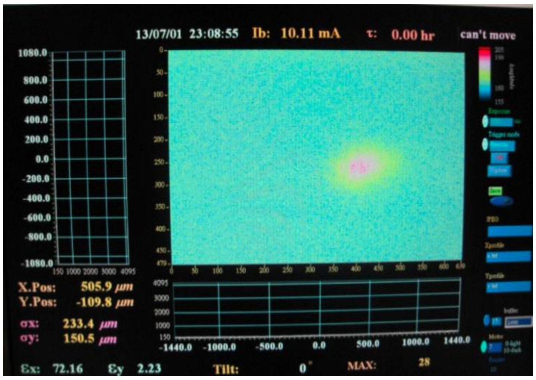
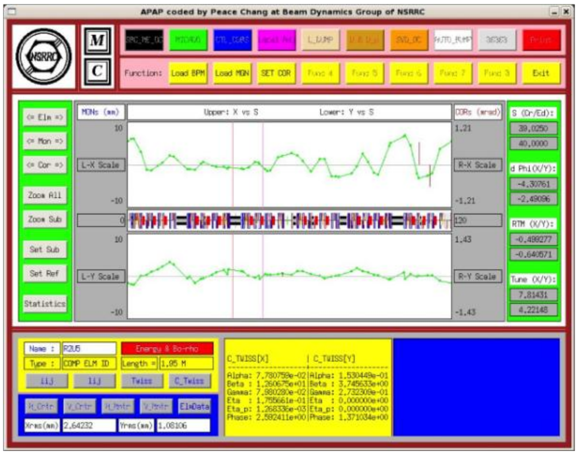


Figure 3: Waveform of the injection kickers of the TLS storage ring.



X.Pos: 505.9 µm
Y.Pos: -109.8 µm
σx: 233.4 µm
σy: 150.5 µm
Ex: 72.16 Ey 2.23 Tilt: 0°

Figure 4: Stored beam of the TLS storage ring using the low emittance lattice.



Function:

S (Cr/Ed): 39.0250 40.0000
d Phi(X/Y): -4.30761 -2.49096
RTM (X/Y): -0.499277 -0.640571
Tune (X/Y): 7.81431 4.22148

Name : R2U5
Type : COMP ELM ID
Length = 1.95 M

Xrms(mm) 2.64232
Yrms(mm) 1.08106

```
C_TWISS[X]              | C_TWISS[Y]
Alpha: 7.780759e-02 |Alpha: 1.530449e-01
Beta : 1.260675e+01 |Beta : 3.745633e+00
Gamma: 7.980280e-02 |Gamma: 2.732309e-01
Eta  : 1.755661e-01 |Eta  : 0.000000e+00
Eta_p: 1.268336e-03 |Eta_p: 0.000000e+00
Phase: 2.582411e+00 |Phase: 1.371034e+00
```

Figure 5: The closed orbit of the stored beam with the low emittance lattice of the TLS storage ring.

BEAM BASED ALIGNMENT

The purpose of BBA is to measure the BPM offsets relative to the nearest quadrupole field centers. In the TLS, the power supplies of quadrupoles are not independent so we use the build-in quadrupole trim coils to adjust the quadrupole strengths. We have measured two times of the BBA data to compare the reliability. Figure 6 shows the measurements between two different days are almost the same and offsets are around 1 mm. But the reliability of a few data is not good, and it may be due to the noise of BPMs in the measurement or other reasons. Figure 7 shows the reproducible results those are 79 micron (RMS) at horizontal plane and 69 micron (RMS) at vertical plane.

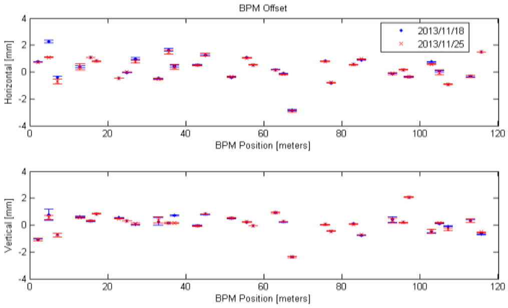


Figure 6: BBA results measured on different days.

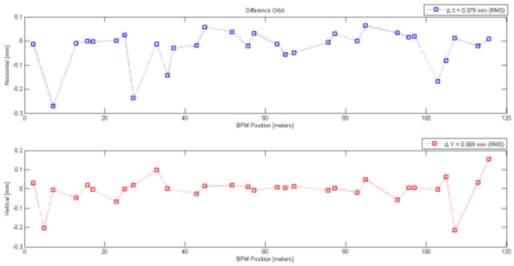


Figure 7: The difference of BBA results.

With the BBA measurement results, we define the golden orbit. We use different orbit correction methods (including SVD, Householder transformation and local orbit bumps) to correct the present orbit to approach the golden orbit. Then we define the achievable target orbit. Figure 8 shows the reliability of target orbits and we can control the differences in both planes under 7 micron (RMS).

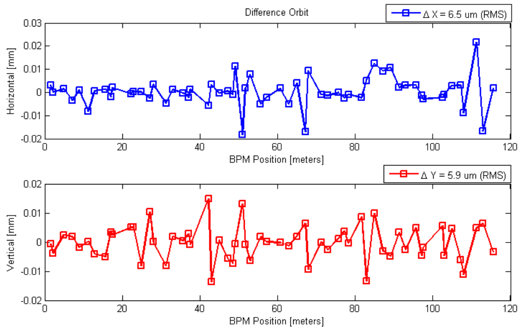


Figure 8: The reliability of golden orbit.

OPTICS CALIBRATION

In the TLS, the vertical betatron function is distorted due to the vertical focusing effects of the 9 insertion devices (IDs). We try to study the optics restored by using the LOCO. Figure 9 shows the beta functions between model, measurement and LOCO fitting. The results are very close, but the horizontal beta function of the LOCO fitting is distorted. This is maybe due to the feed-down effect of the sextupoles or others.

Figure 10 shows the dispersion data and the vertical dispersion caused by the coupling may be due to the quadrupole roll error or the misalignment of sextupoles. The fourth BPM in the section 4 is bad because the crunch value of this BPM is large (see Fig. 11) and the vertical dispersion of this BPM location is larger than others. So we can also dig out the BPM status by using LOCO. Besides, the gain and roll of BPMs or correctors also can be fitted.

We do not apply the LOCO result to restore the optics because the power supplies of the quadrupoles are not independent. In this stage, we just calibrate the optics without applying it to the real machine. However it is taken as an exercise for the TPS commissioning.

SUMMARY

We have described the major part of the TPS beam commissioning exercises on the available 1.5 GeV TLS in this report. Most of the application programs have been tested on the TLS and we already have learned much of how to commission a new accelerator. From this commissioning exercises performed on the TLS, we are also encouraged and become more self-confident to face the coming TPS commissioning with these precious experiences.

ACKNOWLEDGMENT

We would like to thank our Accelerator Operation Group and Instrumentation and Control Group for their helps during the exercises.

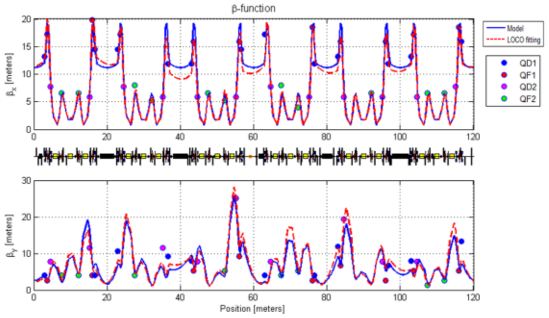


Figure 9: The comparison of the beta function between model, measurement and LOCO fitting.

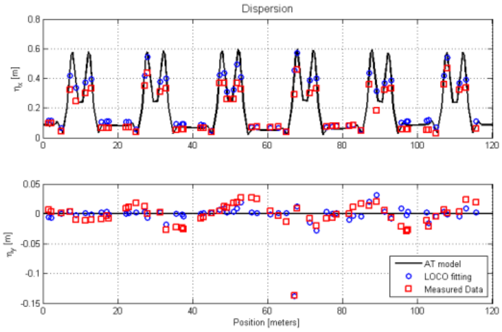


Figure 10: The comparison of the dispersion function between model, measurement and LOCO fitting.

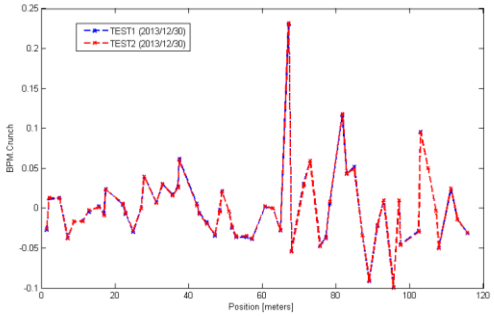


Figure 11: The comparison of the crunch of BPMs in two times LOCO fitting data.

REFERENCES

[1] F. H. Tseng, et al., “MATLAB-based Accelerator Physics Applications for the TPS Commissioning and Operation at NSRRC,” IPAC’10.
[2] F. H. Tseng, et al., “High-Level Application Programs for the TPS Commissioning and Operation at NSRRC,” IPAC’11.
[3] M. Lee, “RESOLVE User’s Guide.”
[4] C. Steier, et al., “Beam Based Alignment in Synchrotron Light Sources,” ICFA Dynamics Newsletter Vol. 44, pp. 193-202, December 2007.
[5] J. Safranek, et al., “Matlab-Based LOCO,” EPAC2002.
[6] C. Y. Lee, et. al., “Design Study of Low Emittance Lattice for Taiwan Light Source at 1 GeV”, IPAC’11.