DESIGN STATUS OF TRANSFER LINES IN TPS

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Abstract

The booster design of Taiwan Photon Source (TPS) has been significantly revised. Therefore, the transfer line from linac to booster (LTB) and the one from booster to storage ring (BTS) have been redesigned accordingly. The design of LTB transfer line has been simplified to reduce the number of magnets. The length of BTS transfer line has been greatly reduced. The design goal of transfer lines is achieve high efficiency for beam injection. The status of current progress will be reported.

INTRODUCTION

The design of TPS booster has been significantly revised since October 2008. The dipole length of TPS booster is reduced from 2 meter to 1.6 meter. There is a need to increase the length of straight section in order to install two units of 5-cell PETRA cavities. The number of modified FODO cells per period is reduced from eight to seven. As a result of this new booster design, the natural emittance of TPS booster is increased to 10 nm-rad [1]. The transfer lines from linac to booster and booster to storage ring have been redesigned accordingly.

The LTB transfer line is redesigned to work with the new layout of booster. In the downstream of LTB transfer line, the beam line splits into two branches as show in Fig. 1. A diagnostic beam line which also serves as the beam dump is included. Since the TPS booster is a concentric design sharing the same tunnel with the storage ring, the extraction point in the TPS booster has to be relocated. The optimum beta function at the injection point of storage ring has been recalculated and the lattice of BTS transfer line re-matched. The length of revised BTS transfer line is shorter than the previous version by five meters approximately [2]. The revised lattice design and orbit correction scheme for LTB and BTS are reported. Preliminary results of injection simulation for the BTS transfer line are also presented.

LTB TRANSFER LINE

TPS low energy LTB transfer line guides the beam from the 150MeV linac to the 3GeV booster ring. Due to the concentric booster and storage ring to share the same tunnel and the linac location, the arrangement of LTB transfer line is similar to the SLS and ALBA. According to the revision of booster, a revised LTB transfer line has been worked out, which is different with the previous TPS LTB version [3]. The updated LTB contains a sub-branch particle beam line from linac to a beam dump (LTD) for linac diagnostic purpose. The schematic layout of the LTB is shown in Fig. 1.

Design Philosophy

Generally, the LTB design is not the key point of an accelerator complex. However, one may find some useful design considerations such as:

- Transportation
  It must not be a bottleneck of the whole accelerator complex.
- Beam parameters measurement
  The beam parameters at the linac exit can be measured by the design of LTD linac diagnostic sub-branch.
- Optics matching
  The optical functions should be matched as good as possible for smooth connection to the booster.
- Energy control
  The quality control of the electron beam energy can be performed with a pair of horizontal slits (HS) located at a region with high dispersion and low beta functions.
- Flexibility
  Tuning the quadrupoles of the LTB, it should be easy to fit the booster target optical functions with different initial linac beam parameters.

Design Results

A simplified TPS LTB transfer line constructed with one bending magnet and one booster injection septum has been worked out. The on-axis injection scheme is used for the TPS booster. A long straight section in the booster will be used for injection.

Figure 2 shows the optical functions of the LTB transfer line. The first five quadrupoles are used to control the required low beta and high dispersion area near the Q2C quadrupole. The last five quadrupoles in the LTB transfer line can provide tuning flexibility to accommodate different beam conditions from the linac and matching of optical functions into the booster. The maximum beta functions in both horizontal and vertical planes are designed within 40 m and the horizontal dispersion is within 1.3 m. The effects due to uncertainties in initial linac beam parameters are studied by scanning optical functions within certain ranges. The ranges for beta functions are scanned from the low beta (2 m) to the high beta (15 m), and the alpha function from -1.5 to 1.5 respectively.

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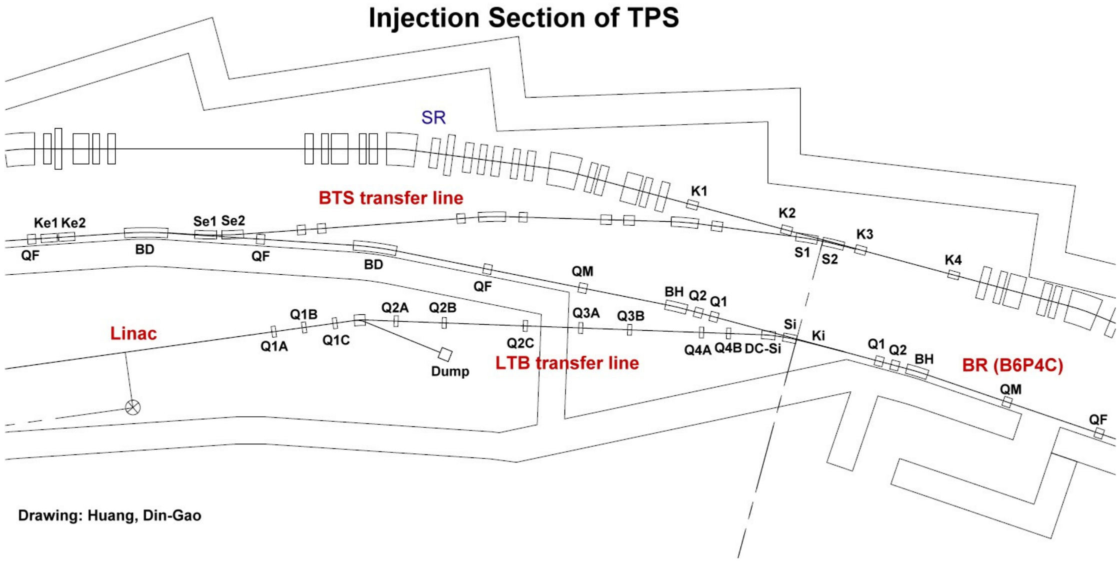

Figure 1: A schematic layout of transfer lines from linac to booster and booster to storage ring.

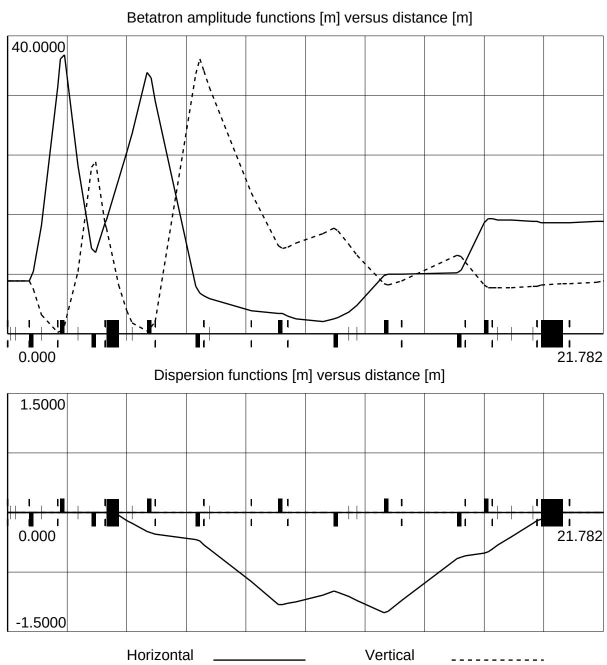

Figure 2: Optical functions of LTB transfer line.

The uncertainties in the initial linac beam parameters can be measured by scanning the first quadrupole triplet and fitting the set of beam size measured on the screen monitor SMA before the bending magnet. An optional screen monitor SMB is suggested to monitor the electron beam directly from the linac. That can be also used to confirm the beam parameter measurement of the linac. The energy calibration can be done by the measurements of horizontal displacement and horizontal beam size on the screen monitor SME located at the high dispersion and low beta region of LTD linac diagnostic beam line. And there is a horizontal energy pair of slits (HS) located at a high dispersion (η_x) and low beta (β_x) area of the LTB to accurately deliver the electron beam energy.

The trajectory correction scheme includes five horizontal and seven vertical correctors. Seven BPMs and 5~6 screen monitors will be used to measure the electron beam trajectory. The simulation results of beam steering by correctors are below 2.5 mm along the LTB with possible alignment errors, field errors, and the launching beam conditions. The same error set is assumed as in the previous LTB design [3]. Simulated results of particle trajectories after correction are shown in Fig. 3.

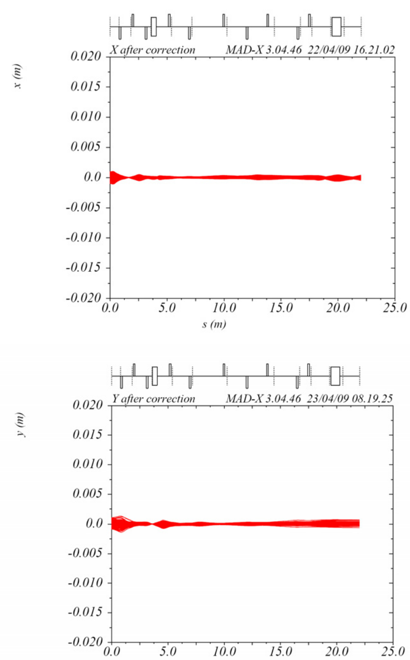

Figure 3: The simulated particle trajectories with random errors after correction in LTB transfer line. Top: horizontal orbit, bottom: vertical orbit.

BTS TRANSFER LINE

The design of BTS transfer line is subject to several constraints set by engineering requirements. A clear path must be reserved for personnel and equipment passage in routine maintenance. In addition, there are four trenches on the floor for purpose of water piping and electrical cabling. The space available for placing magnets in the BTS transfer line is somewhat limited. The resulting lattice of BTS transfer line is shown in Fig. 4. The maximum value of horizontal beta function is within 55 m, the vertical beta function within 50 m, and the dispersion function is within 0.55 m. The last three quadrupoles near the injection septum SI require a longer length (0.4 m) in order to have large enough tuning capability and keep the strength within engineering limit as well. The proposed scheme for beam diagnostics and correction comprises of 6 BPMs, 6 corrector magnets, and 3 screen monitors. These screen monitors can also be used for the optimization of orbit correction. The same error set as the LTB transfer line is assumed for the BTS correction simulation. The results of corrected orbits are shown in Fig. 5.

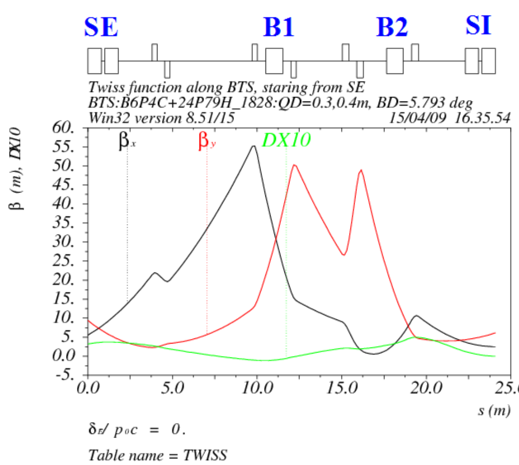

Figure 4: The lattice of BTS transfer line. The dispersion function has been magnified by 10 times for view purpose.

The injection simulation of BTS transfer line has been performed with a Gaussian beam and a storage ring lattice with random errors in magnets. The tentative design of vacuum chambers in BTS transfer line will contain two beryllium windows of thickness 127 µm, one kapton foil of thickness 40 µm, and an air gap of 17.5 cm. The beam emittance will be increased after passing through these vacuum windows and air gap due to multiple Coulomb scattering. According to this tentative design, the beam emittance at the exit of BTS transfer line is increased from the design value 10 nm-rad to 62 nm-rad. The injection simulation is carried out by assuming an injected beam of emittance 62 nm-rad. An improved design of vacuum chamber is in progress in order to reduce the emittance blow-up. A preliminary result of injection simulation is shown in Fig. 6.

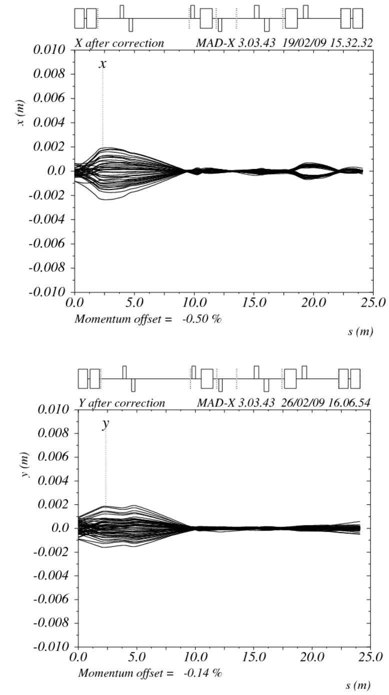

Figure 5: The particle trajectory after correction when random errors are assumed for magnets in BTS transfer line. Top: horizontal orbit, bottom: vertical orbit.

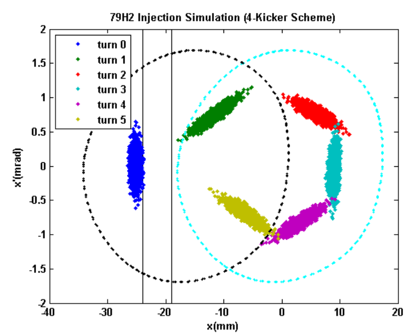

Figure 6: The horizontal phase space at the injection point of storage ring. The injected beam is depicted by blue color, and the beam distribution in subsequent turns in the storage ring are labeled by other color as shown in the legend.

SUMMARY

The LTB and BTS transfer lines have been redesigned for TPS injector system. The revision of related engineering design is under way. Detailed studies of injection simulation are in progress.

REFERENCES

[1] H.C. Chao, et al., "Current Design of TPS 3GeV Booster Synchrotron", these proceedings.

[2] Taiwan Photon Source Design Handbook (June 2008)

[3] H.P. Chang et al., "Design Considerations of the TPS Linac-to-Booster Transfer Line", EPAC'08, WEPC005 (2008); http://www.JACoW.org