NSLS-II TRANSPORT LINE PERFORMANCE*

R. P. Fliller III#, G. Wang, W. Casey, H. Fernandes, R. Faussete, G. Ganetis, R. Heese, H.-C. Hseuh, P. Job, B.N. Kosciuk, R. Meier, D. Padrazo, B. Parker, I. Pinayev, J. Rose, T. Shaftan, O. Singh, J. Skaritka, C. Spataro
NSLS-II Project, Brookhaven National Laboratory, Upton, NY 11973

Abstract

The NSLS-II injection system consists of a 200 MeV linac and a 3 GeV booster synchrotron and associated transport lines. The transport lines need to transport the beam from the linac to the booster and from the booster to the storage ring in a way that provide high injection efficiency. In this paper we discuss progress on specifying and prototyping the NSLS-II transfer lines including diagnostics, magnet specifications, and safety systems. Commissioning plans are also discussed.

INTRODUCTION

The NSLS-II is a state of the art 3 GeV synchrotron light source under construction at Brookhaven National Laboratory. The injection system consists of a 200 MeV linac and a 3 GeV booster synchrotron. The injection system needs to provide 7.3 nC in 80-150 bunches every minute for top off operation. The injector overall design is discussed in other publications. [1]

The linac to booster and booster to storage ring transfer line are an integral part of the injection system. Their initial design has been discussed on other publications. [2] In this paper we discuss progress on the transport lines and highlight significant milestones in their development.

LINAC TO BOOSTER TRANSFER LINE

General Layout

The linac to booster transfer (LtB) line layout is shown in Figure 1. It consists of a short triplet section, an achromatic bend section that allows energy selection via an energy slit, and a matching section into the booster. There are also two diagnostic beamlines for linac commissioning, troubleshooting and studies. The straight beamline can be used for emittance measurements while the other diagnostic line is used for energy and energy spread measurements. These beamlines allow the linac to operate while maintenance activities are ongoing in the booster vault. Installation is scheduled for 2011.

Diagnostics

The linac to booster transfer line is equipped with sufficient diagnostics to commission the linac and monitor its operation while injecting into the booster. Table I shows the available diagnostics for the linac to booster transfer line.

Table 1: Diagnostics available in the transfer lines

Diagnostic	LtB	BSR
Integrating Current Transformer	2	2
Fast Current Transformer	2	2
Faraday Cup	2	1
Beam Position Monitor	6	8
Flag	9	9

An integrating current transformer (ICT) is located at the exit of the linac and the entrance of the booster to measure the charge of the bunch train. This will also be part of the Loss Control and Monitoring System (LCM). A fast current transformer (FCT) is located after the energy slit and prior to the entrance to the booster to measure the fill pattern. Each beam dump also serves as a faraday cup to have a redundant measure of the charge coming from the linac.

Beam Position Monitors (BPM) are located at strategic points in the beamline to allow trajectory correction, matching into the booster, and energy measurement. Flags are placed to allow for commissioning of the linac and fast commissioning of transport to the booster. Three flags are located in the straight beamline at the exit of the

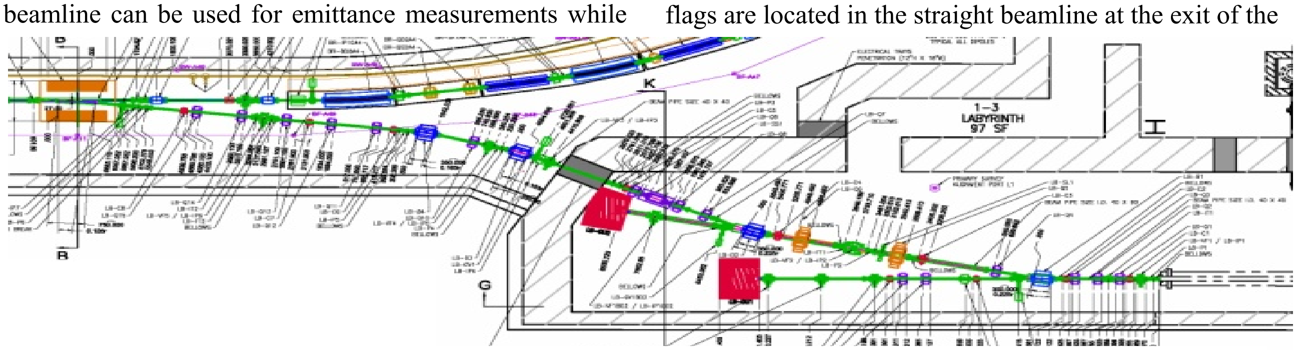

Figure 1: Linac to Booster Transfer Line.

* This manuscript has been authored by Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy.
#rfliller@bnl.gov

linac for measuring the emittance of the linac via a three screens measurement. Quads are also available for a quadrupole scan. One flag is placed in the dispersive dump beamline for energy spread measurement.

The beamline also has an energy slit to limit the energy acceptance of the transport line. It is located after the fifth quadrupole, at the highest dispersion location. The blades will be coated with a scintillator, and a camera allows imaging of the scraped beam on the blades.

Trajectory correction is performed using 8 dual plane corrector dipoles. Two more are located in the straight diagnostic beamline. Figure 2 shows the results of trajectory correction after including the effects of misalignment, field errors, and power supply ripple. Only 5 correction dipoles were used in this case showing sufficient flexibility in the system.

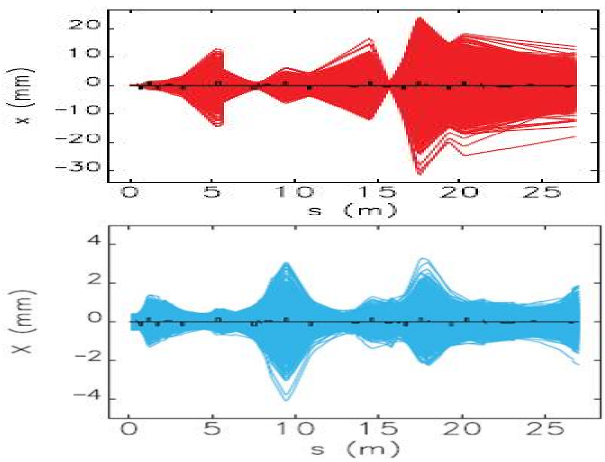

Figure 2: Before (above) and after (below) trajectory correction in the linac to booster transfer line. Beam position variation at the end of the transfer line improved a factor of 5.

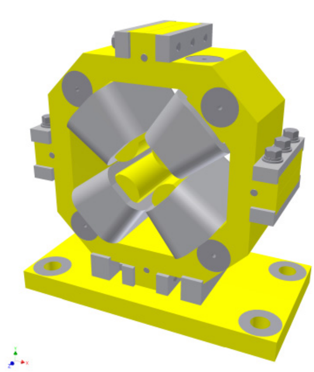

Figure 3: Design of the 52 mm aperture quadrupole for the linac to booster transfer line.

Magnets

Reference magnet designs are nearing completion for all elements of the transfer line. Table 2 shows the specifications for the transport line magnets. One unique feature of this transport line is the wide aperture magnets in the dispersive section. The energy spread of the linac is 0.5% rms, which means that the beam is 5 mm rms at the high dispersion area. After leaving sufficient good field region for the beam to move about in, the magnet has a aperture of 134 mm.

Table 2: Magnet Specifications for the transfer lines

Transport Line	Magnet	Field (T) or Gradient (T/m)	Length (cm)	Gap (mm)
LtB	Dipole	0.64	35	48
LtB	Normal Quadrupole	12.01	15	52
LtB	Wide Aperture Quadrupole	4.50	25	134
LtB	Normal Corrector	0.01	15	45
LtB	Wide Aperture Corrector	0.01	20	100
BSR	Booster Extraction DC Septum	1.01	100	20
BSR	Storage Ring Injection Septum	0.89	135	20
BSR	B Dipole	1.16	140	35
BSR	Quadrupole	25.22	35	52
BSR	Corrector	0.04	20	100

BOOSTER TO STORAGE TRANSFER LINE

General Layout

The booster to storage ring transfer line layout is shown in Figure 4. It consists of the extraction section, an achromatic transport section, and the matching section in to the storage ring. There is a diagnostic beamline that will allow for commissioning, troubleshooting, and studies. This will also allow for the booster to operate with maintenance activities are ongoing in the storage ring vault. Installation is scheduled for 2012.

Diagnostics

The booster to storage ring transfer line is equipped with sufficient diagnostics to commission the booster and monitor its operation while injecting into the storage ring. Table I lists the available diagnostics for the transfer line.

An ICT in the diagnostic beamline will monitor the extracted charge from the booster during operations to the dump. Another ICT is located near the injection septum of the storage ring. These will be combined with the DCCT in the booster to measure the extraction efficiency. These are also part of the LCM.

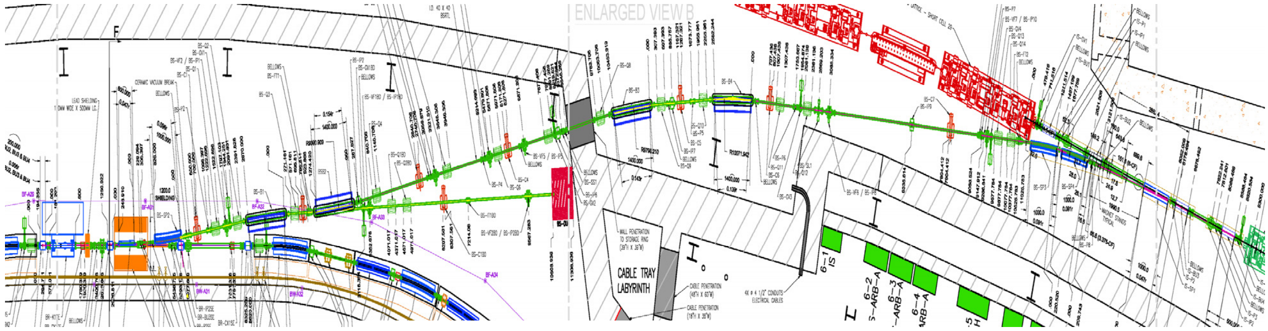

Figure 4: Booster to Storage Ring Transfer Line

An FCT in the extraction section and near the storage ring injection septum allow for comparison of the bunch to bunch charge through the transport line. The beam dump incorporates a faraday cup to provide a redundant charge measurement.

Nine beam position monitors are strategically placed throughout the transport line. Special attention was paid to matching the beam into the storage ring. There is a beam position monitor located immediately upstream of the injection septum to the storage ring. Seven dual plane corrector magnets allow for sufficient flexibility to steer the beam past the septum and into the storage ring.

Nine flags are placed through the transport line for commissioning and beam studies. Four of them are available for booster commissioning and studies.

At extraction the booster emittance is 39 nm and the energy spread is 0.1%, determined by radiation damping. The optics of the diagnostic beamline are such that the contribution of dispersion and emittance to the beam size is always comparable and cannot be decoupled. In order to commission the booster and measure the extracted emittance and energy spread, the transport matrix from the booster through the transport line needs to be measured and the beam size sampled at multiple locations in the transport line. Reference 3 details the procedure.

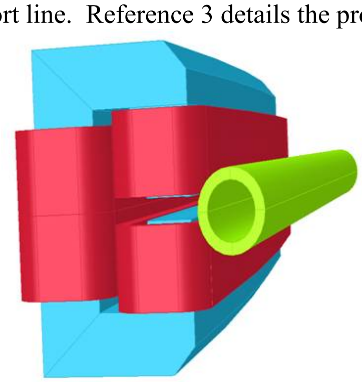

Figure 5: DC extraction septum showing the magnet and the mu metal shielding around the circulating beam pipe.

Magnets

Reference magnet designs are nearing completion for all elements of the transfer line. Table 2 shows the specifications for the transport line magnets. One unique feature of this transport line is the DC septum magnets. The booster extraction DC septum and the injection DC septum are specially designed to have low fringe field. This is particularly important for the booster where the fringe fields can disturb the beam at injection energy. The fringe field is reduced by having half of the coils wrap around the backleg of the magnet. Mu metal shielding around the beam pipe in the booster keeps the fringe field below 5 Gauss in the beam pipe. Figure 5 shows the design of booster extraction DC septum. The storage ring injection DC septum is the same design with a longer length.

CONCLUSION

The NSLS-II transfer lines are nearing final design. The transfer lines are instrumented to commission and study the linac and booster. They also leave open the possibility to perform studies of the linac or booster without interfering with maintenance in the downstream machines.

Diagnostics and magnets are in the procurements stage. Supports and supplemental shielding are in the design stage. Installation of the linac to booster transfer line will occur in 2011 in time to commission the linac. The booster to storage ring transfer line will be installed the following year.

REFERENCES

[1] T. Shaftan, R. Alforque, Alexei Blednykh, W. Casey, L. Dalesio, M. Ferreira, R. P. Fliller III, G. Ganetis, R. Heese, H.-C. Hseuh, P. Job, E. Johnson, Y. Kawashima, B. Kosciuk, S. Kowalski, S. Krinsky, Y. Li, H. Ma, R. Meier, S. Ozaki, D. Padrazo, B. Parker, I. Pinayev, M. Rehak, J. Rose, S. Sharma, O. Singh, P. Singh, J. Skaritka, C. Spataro, G. Wang, F. Willeke." Status of the NSLS-II Injection System" these Proceeding WEPEA082.

[2] R. P. Fliller III, R. Alforque, R. Heese, R. Meier, J. Rose, O. Singh. "Beam Transport and Diagnostics for the NSLS-II Injection System." Proceedings of the Particle Accelerator Conference 2009, Vancouver, CA, TU5RFP006.

[3] G. Wang, R. P. Fliller III, W. Guo, R. Heese, T. Shaftan, L.-Hua Yu, Y.-C.Chao. "Study of Beam Emittance and Energy Spread Measurements using SVD and Multiple Flags in the NSLS-II Booster Extraction Beamline". these Proceedings WEPEA084.