BEAM TRANSPORT AND DIAGNOSTICS FOR THE NSLS-II INJECTION SYSTEM*

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Abstract

The NSLS-II is a state of the art 3 GeV synchrotron light source being developed at BNL. The injection system will consist of a 200 MeV linac, 3 GeV booster synchrotron, and associated transfer lines. The transport lines between the linac and booster (LtB) and the booster and storage ring (BSR) must satisfy a number of requirements. In addition to transporting the beam while maintaining the beam emittance, these lines must allow for commissioning, provide appropriate diagnostics, allow for the appropriate safety devices and in the case of the BSR line, provide a stable beam for top off injection. Appropriate diagnostics are also necessary in the linac and booster to complement the measurements in the transfer lines and to allow for fast commissioning. In this paper we discuss the design of the transfer lines for the NSLSII along with the incorporated diagnostics and safety systems. Necessary diagnostics in the linac and booster are also discussed.

INTRODUCTION

The NSLS-II is a state of the art 3 GeV synchrotron light source being developed at BNL. The injection system will consist of a 200 MeV linac, a 3 GeV booster synchrotron, and associated transfer lines.

In this paper we discuss the design of the transfer lines for the NSLS-II along with the incorporated diagnostics and safety systems. We also discuss the diagnostics in the linac and booster to provide a comprehensive diagnostics suite for staged commissioning of the injection system.

LINAC DIAGNOSTICS

The NSLS-II linac is specified to have an output energy of 200 MeV, energy spread of 0.5%, bunch length of 20 ps, and normalized emittances of $4\gamma\beta\sigma_x\sigma_x'$= 55 mm-mrad. The linac will be capable of operating in single bunch mode with a charge of up to 0.5 nC, or in multibunch mode with a bunch train of 80-150 bunches separated by 2ns with a charge per train of 15 nC.[1]

The linac will have a 100 kV electron gun with thermionic cathode, subharmonic prebuncher, 3 GHz prebuncher, 3GHz buncher section, and a 3 GHz acceleration section. Linac diagnostics will consist of a wall current monitor (WCM) after the gun, and another before buncher. There will be a WCM, flag, and beam position monitor before each linac tank. This will provide sufficient diagnostics to determine bunch charge, length, transverse size and position. The WCMs will also provide a measure of the beam losses in the linac.

LINAC TO BOOSTER (LTB) TRANSFER LINE

The layout of the LtB line is shown in Figure 1. It consists of 3 sections, a linac to achromat section, an achromat, and a matching section into the booster. In addition there are two beam dumps located in the linac vault that will be used for commissioning, tune up and diagnostics.

Table 1 shows the available diagnostics in the LtB. There are flags at the start of the LtB, after the energy slit, and prior to booster injection that will be used for

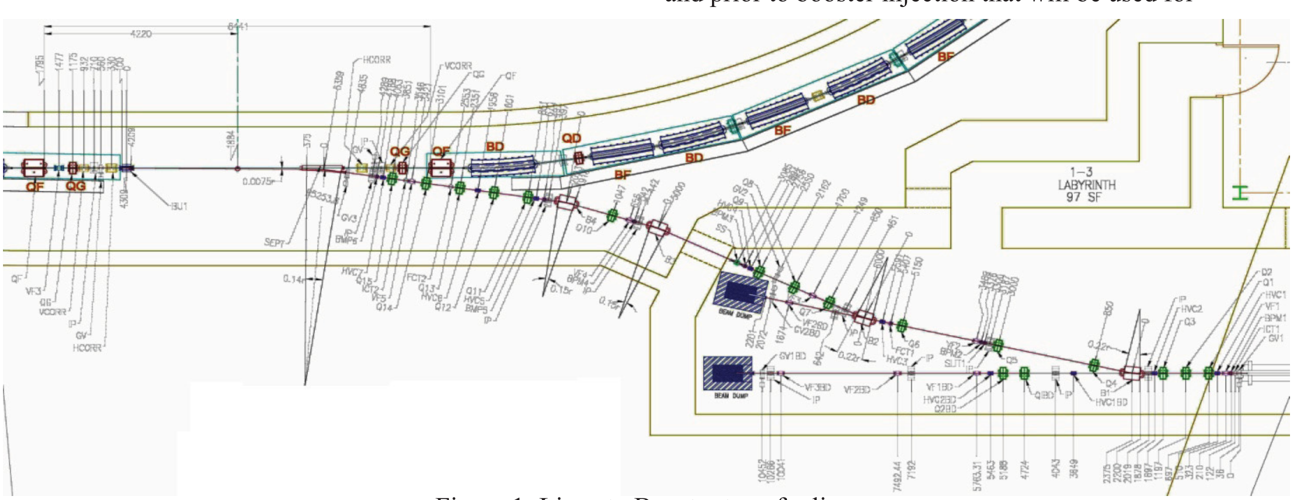

Figure 1: Linac to Booster transfer line.

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Table 1: Diagnostic and Safety System List for Injection System

Diagnostic	Linac	LTB	Booster	BSR
ICT		2		2
FCT		2	1	2
DCCT			1	
WCM	5			
BPM	3	6	24	7
Flag	3	9	6	9
Energy slit		1		1
Stripline			2	
Streak Camera			1	
Safety Shutter		1		1
Beam Dumps		2		1

commissioning. There is an integrating current transformer (ICT) and a fast current transformer (FCT) to measure the beam charge and the bunch train at each end of the LtB. An energy slit will be placed at the maximum dispersion location in the achromat, to remove any low energy particles. Six BPMs are placed through the line. The first is located at the end of the linac. One exists after the energy slit for online energy jitter measurement. Four BPMs are in the matching section for matching into the booster. Lastly, there is a safety shutter placed before the exit of the linac vault that will allow safe operation of the linac independent of the status of the booster.

The beam dumps are equipped with flags. There are 3 flags in the "straight ahead" beam dump for a three screens emittance measurement. The second beam dump will have sufficient dispersion to perform an energy spread and energy jitter measurement. A flag is located in this line for this purpose. These beam dumps can be used to fully characterize the linac independent of the booster. This will allow us to commission the linac while booster installation is in progress.

BOOSTER DIAGNOSTICS

The NSLS-II booster is a 158 m combined function for magnet synchrotron with an extraction energy of 3 GeV for top up injection. The beam emittance will be damped below 50 nm-rad, with a train up to 150 bunches. The bunch length will be 15 ps, and an energy spread of 0.08% when fully damped. The expected total charge out of the booster is estimated to be 10 nC when the linac operates in multibunch mode.

The booster diagnostics are chosen for commissioning and robust operation. The booster will have 24 BPMs placed at strategic points in the ring to allow for robust orbit correction. Six flags will be located in the booster for commissioning, injection matching and transverse profile measurements. Beam current will be measured with a DCCT. An FCT will monitor the bunch train pattern. A pair of stripline kickers will be available for tune and chromaticity measurements. They can also serve in a beam cleaner system. Synchrotron light will be used in conjunction with a streak camera to measure the bunch length. The streak camera will be shared with the storage ring.

BOOSTER TO STORAGE RING (BSR) TRANSFER LINE

Extraction from the booster is performed with a four bump scheme. A kicker imparts a 5 mrad angle, which is then followed by thin pulsed septum, and a large DC septum into the BSR line. The BSR line consists of 3 main sections, the booster extraction section, an achromatic transport section, and the matching section. There is also a beam dump located in the booster vault for commissioning and tuning up. Figure 2 shows the layout of the BSR line.

The current baseline storage ring injection scheme is a standard four bump scheme and pulsed septum.[1] A pulsed sextupole injection scheme is also under consideration and will be discussed in the next section.[2] The design of the storage ring injection straight is discussed in these proceedings [2].

Table 1 shows the planned diagnostics for the BSR line. The BSR line has nine flags. Two flags are placed before the first dipole to commission booster extraction. Three flags are in the achromat section for emittance measurements. Three flags are in the matching section for injection matching. The last flag is prior to the beam dump to allow for energy spread measurements. There is an FCT in the booster extraction section and near the

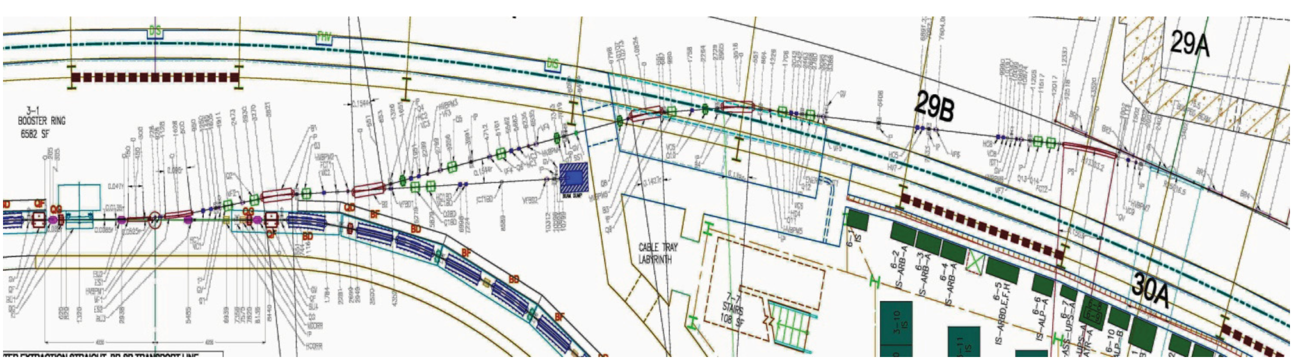

Figure 2: Baseline booster to Storage Ring transfer line.

Figure 3: BSR transport line with sextupole injection. Changes to the beamline occur near the section labeled 29B.

injection point to measure the bunch train distribution. There is an ICT near injection point to measure the bunch charge. Seven BPMs are placed in the beamline. Two BPMs are placed in the booster extraction section, three are in the achromat, and the remainder are in the matching section. There is an energy slit near the maximum dispersion location to limit the energy spread going into the storage ring. A safety shutter near the exit of the booster vault will allow operation of the booster independent of the storage ring.

The booster beam dump is equipped with a flag for energy spread measurements. It also has and ICT for bunch charge measurements. This beam dump will be used for booster commissioning and tune up. This setup allows for complete characterization of the booster independent of the storage ring status.

SEXTUPOLE INJECTION

The possibility of using a pulsed sextupole for injection in to the storage ring is being discussed. The pulsed sextupole is discussed in these proceedings, as are the modifications to the injection straight.[2,3] This paper will discuss the impact on the BSR line. The modified BSR line is shown in Figure 3.

The injected beam will enter the sextupole 8.5mm from the center. The stored beam will pass through the sextupole center. The sextupole will be 0.5m long and will have a gradient of 1550 T/m^2. This gives the desired 56mT field at 8.5 mm. There is an effective quadrupole gradient of 13 T/m. This gradient is similar to other quadrupoles in the transfer line.

The changes to the BSR line have to do with trajectory modifications and matching the beam into the sextupole. The tradjectory modifications are done by moving the thick septum as far from the sextupole as possible. An additional weak dipole is needed to meet the constraints of the building. Two quadrupoles will need to be added to the BSR to be able to provide the proper focusing. No additional diagnostics will be needed.

Figure 4 shows the beam sizes through the BSR for the baseline case and the sextupole injection case. The large horizontal beam size for the sextupole case is because a large dispersion and beta function are needed to

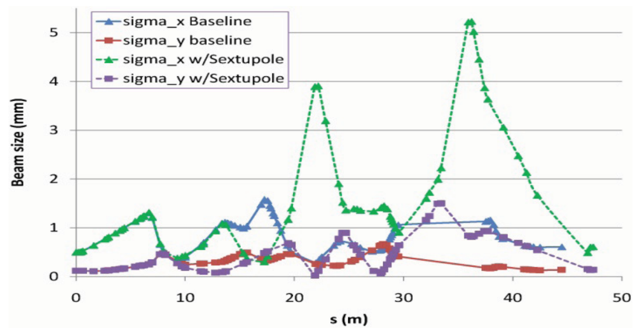

Figure 4: Beam Sizes through BSR transfer line for both injection options.

compensate for the focusing in the sextupole. This will require some large aperture quadrupoles for these areas.

CONCLUSION

The diagnostics for the NSLS-II injection system have been discussed along with the layout of the transfer lines. The diagnostics are adequate for staged commissioning of the NSLS-II injectors and allow for sufficient beam diagnostics during top up operations. The transfer lines contain enough flexibility to be able to operate the linac and the booster separate from the rest of the machine. This will allow us to take advantage of the early beneficial occupancy of the building, install and commission the injectors prior to finishing the storage ring installation.

REFERENCES

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[3] T. Shaftan, et.al., “Alternative Designs of the NSLS-II Injection Straight Section”, these Proceedings TU5RFP012.