1. Requirements

The injector systems supply low emittance ($\varepsilon_y = 3 \times 10^{-8}$ m-rad, $\varepsilon_x = 3 \times 10^{-6}$ m-rad) electron and positron bunch trains respectively to the main linacs. In addition to low emittance, the beams from the injectors are 8 GeV in energy, have a bunch length between 90 and 150 µm and have been collimated. The injector systems provide either 2.8 or 1.4 ns spaced bunches in each train.

2. Technical Description

2.1 Beam Parameters

The Injector System produces electron and a positron beams for injection into the NLC Main Linacs. Table 1 lists the beam parameters delivered by the Injector Systems to the Main Linac.

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Symbol</th>
<th>Injector Output</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunch Spacing</td>
<td>$T_b$</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Energy</td>
<td>$E$</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Bunch Energy Variation</td>
<td>$\delta E/E$</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Single Bunch Energy Spread</td>
<td>$\sigma_{t}/E$</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Horizontal Emittance</td>
<td>$\varepsilon_x$</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Vertical Emittance</td>
<td>$\varepsilon_y$</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Bunch Length</td>
<td>$\sigma_Z$</td>
<td>90</td>
<td>145</td>
</tr>
<tr>
<td>Particles/Bunch</td>
<td>$n_B$</td>
<td>1.5</td>
<td>0.75</td>
</tr>
<tr>
<td>Train Population Uniformity</td>
<td>$\Delta n_T/n_T$</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bunch-to-Bunch Pop. Uniformity</td>
<td>$\Delta n_B/n_B$</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Number of Bunches</td>
<td>$N_b$</td>
<td>95</td>
<td>190</td>
</tr>
<tr>
<td>Repetition Rate</td>
<td>$f$</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Horizontal Beam Jitter</td>
<td>$\Delta \gamma J_x$</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Vertical Beam Jitter</td>
<td>$\Delta \gamma J_y$</td>
<td>0.008</td>
<td>0.008</td>
</tr>
<tr>
<td>Polarization (electron)</td>
<td>$P_e$</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Beam Power</td>
<td>$P_b$</td>
<td>219</td>
<td>219</td>
</tr>
</tbody>
</table>
2.2 Functional Description

The injector system is really two systems, an electron injector system and a positron injector system, each which is divided into three systems: a source system, a damping ring system and a second bunch compression system.

The injector source systems, an electron source system and a positron source system, are where the bunch trains are created, bunched and accelerated to 1.98 GeV, so they can be injected into the damping ring systems.

The two damping ring systems, one for electrons and one for positrons, each reduce the emittances of the beams produced from the source systems. In addition, the electron damping ring system is designed to control and maintain the polarization of the electrons. The damping ring systems are made up of transfer lines, the damping rings themselves and the 1st stage of bunch compression. The damping rings reduce the emittance of the beams, while the transfer lines take the beams to and from them. After the damping rings, the bunch length of each beam must be reduced from 4mm to between 150 and 90 µm, for injection into the main linacs. The compression occurs in two stages, with the first (BC-1) situated at the end of the damping ring system.

The second stage of compression uses a 6 GeV S-Band pre-linac, a 180° turnaround arc, a 600 MeV post-arc X-band linac and chicane, to reduce the bunch length to between 150 and 90 µm. The beams are also collimated in the pre-collimation section between the pre-linac and the 180° turnaround arc.

2.3 Layout Description

2.3.1 Layout models

The electron and positron injectors have two siting layout models. The first is the California cut and cover model where the electron and positron complexes are located at the entrances to the main linacs, approximately 28 ft below grade level. The second is the Illinois deep tunnel model where the electron and positron beamlines are located 100 meters below grade level, near the high-energy ends of the main linacs.

The California injector model assumes that the separated electron and positron injectors are built at low energy ends of the main linacs using cut and cover housing construction methods, such that the beamlines are under tens of feet of dirt. The injectors are assumed to be level with the main linacs.

The Illinois deep tunnel model assumes that all the injector beamlines are located 100 meters below grade level, near the high-energy ends of the main linacs. The location at the exit of the main linacs requires four added beamlines, in comparison to the California model, the long transport lines and the reverse bends. Long transport lines, contained in the main linac tunnels, transport the beams from the pre-linacs to the beginning of the main linacs where they are collimated in the pre-collimation sections and then taken into the 180° BC-2 arcs by the reverse bends.
2.4 Sub-Systems
The sub-systems of the injectors are listed below in beam travel order.

2.4.1 Electron Injector:

2.4.1.1 Electron Source System
1. Electron Polarized Guns and Bunching
2. Electron Booster Linac

2.4.1.2 Electron Damping Ring System
3. Electron MDR LTR
4. Electron MDR
5. Electron BC-1

2.4.1.3 Electron Second Bunch Compression (BC-2) System
6. Electron Pre-Linac
7. Electron Pre-Collimation (California model only)
8. Electron Long Transport Line (Illinois model only)
9. Electron Pre-Collimation (Illinois model only)
10. Electron Reverse Bend (Illinois model only)
11. Electron BC-2

2.4.2 Positron Injector:

2.4.2.1 Positron Source System
1. Thermionic Guns and Bunching
2. Drive Linac
3. Positron Targets
4. Positron Booster

2.4.2.2 Positron Damping Ring System
5. Positron PPDR LTR
6. Positron Pre-Damping Ring (PPDR)
7. Positron Transfer Line
8. Positron MDR
9. Positron BC-1

2.4.2.3 Positron Second Bunch Compression (BC-2) System
10. Positron Pre-Linac
11. Pre-Collimation (California model only)
12. Positron Long Transport Line (Illinois model only)
13. Pre-Collimation (Illinois model only)
14. Positron Reverse Bend (Illinois model only)
15. Positron BC-2
2.5 System Diagrams

e- Injector NLC2001 California Cut and Cover Layout
e+ Injector NLC2001 California Cut and Cover Layout
e- Injector NLC2001 Illinois Deep Tunnel Layout
e+ Injector NLC2001 Illinois Deep Tunnel Layout
LTL, RB and BC-2 NLC2001 Deep Tunnel Layout

2.6 System Boundaries
The Injector systems are the beginning of the NLC beamline systems. The Injector systems end at the beginning or low energy point of the Main Linacs.

2.7 System Optics Decks
Injector Optics Decks

3. Configuration Choice
The choice of configuration layouts for the injector at the California site was made to give the lowest cost while still retaining full functionality. The Illinois sites for the injectors were chosen so that the injectors would remain on Fermi lab property and retain full functionality.