Low Emittance Guns for the ILC Polarized Electron Beam

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Polarized electron beams generated by DC guns are routinely available at several accelerators including JLAB, Mainz and SLAC. These guns operate with a cathode bias on the order of -100 kV. To minimize space charge effects, relatively long bunches are generated at the gun and then compressed longitudinally external to the gun just before and during initial acceleration. For linear colliders, this compression is accomplished using a combination of rf bunchers. For the basic design of the International Linear Collider (ILC),[1] a 120 kV DC photocathode gun is used to produce a series of nanosecond bunches that are each compressed by two sub-harmonic bunchers (SHBs) followed by an L-band buncher and capture section. The longitudinal bunching process results in a significantly higher emittance than produced by the gun alone. While high-energy experiments using polarized beams are not generally sensitive to the source emittance, there are several benefits to a lower source emittance including a simpler more efficient injector system and a lower radiation load during transport especially at bends as at the damping ring. For the ILC, the SHBs could be eliminated if the voltage of the gun is raised sufficiently. Simulations using the General Particle Tracer (GPT) package indicate that a cathode bias voltage of at least 500 kV is required to eliminate the lower frequency SHB and 700 kV to eliminate both SHBs. Simulations can be used to determine the minimum emittance possible if the injector is designed for a given increased voltage. Operational problems expected at increased voltage levels are discussed and relevant R&D proposed. A possible alternative to the DC gun is to use an rf gun. Several projects already underway for both normal and superconducting rf guns for polarized beams are described. The uncertainties of operating an activated GaAs-type photocathode using an rf gun are discussed.

[1] See *Electron Source* at http://www.linearcollider.org/wiki/doku.php?id=bcd:bcd_home .