The 1992 Polarized Light Source

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Abstract

We describe the Polarized Light Sources used at SLAC during the 1992 runs of the experiments SLD and E142.

I. Introduction

Polarized electron sources utilizing photocathodes are currently in use at many accelerators around the world. Two experiments utilizing polarized beams at SLAC are SLD, run with the SLAC Linear Collider (SLC) at the Z^0 resonance, and E142 which is a fixed target experiment running in End Station A. The Polarized Light Source (PLS) performance for these experiments is summarized in Table I.

II. The PLS for the 1992 SLD Experiment

In 1992, there were a five month SLD run and a two month E142 run at SLAC. The Polarized Electron Source used for the SLD run is shown in Fig. 1. The laser used was a flashlamp-pumped dye laser operating at 120 Hz and 715 nm. A current pulse, 15 J in 1.5 μs, is sent to each of two flashlamps and produces (typically) a 5 mJ laser pulse with a pulse width of 750 ns.

A Laser Pulse Chopper (LPC) system consisting of a Pockels Cell between crossed polarizers is used to produce two 2 ns pulses separated by 60 ns from the initial 750 ns pulse. The first of these pulses produces an electron bunch for e^+e^- collisions, while the second laser pulse produces an electron bunch for positron production. Following the Laser Pulse Chopper, a Bunch Intensity Control (BIC) system consisting of a Pockels Cell between aligned polarizers is used to regulate the intensity of laser light on the photocathode.

The laser beam is linearly polarized through the BIC system. A linear polarizer followed by a Pockels Cell operating at its quarter-wave voltage compose the Circular Polarizer System (CPS) to produce circularly polarized light. A positive HV pulse on the CPS Pockels Cell produces positive helicity light, while a negative HV pulse produces negative helicity light. The sign of the HV pulse is set by a random number pattern generator, which updates at 120 Hz. This effectively eliminates any false asymmetries due to time-dependent behaviour of the accelerator. The absolute helicity of thȩ laser light was determined using total internal relection in a prism to generate a known helicity laser beam.

After the CPS system, the laser beam enters a 20-meter-long vacuum transport line to the photocathode. This transport line contains a 6 m focal length imaging lens approximately midway between the CPS Pockels Cell and the photocathode. It also contains four mirrors to redirect the laser beam to the photocathode while preserving circular polarization.

Table I. PLS Performance

	SLD	E142
Repetition Rate	120 Hz	120 Hz
Pulse Energy	5 μJ	20 μJ
Pulse Length	2 ns	1.2 μs
Circular Polarization	99%	99%
Intensity Jitter	5% rms	2% rms
Helicity Dependent Intensity Asymmetry	$< 10^{-3}$	$< 10^{-4}$

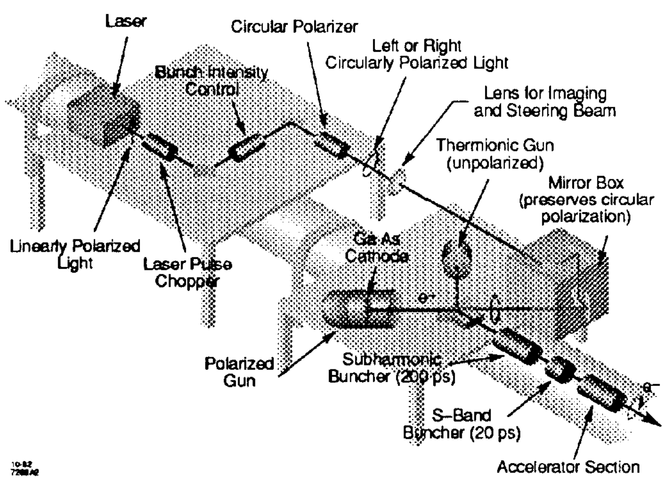

Figure 1. The Polarized Electron Source at SLAC.

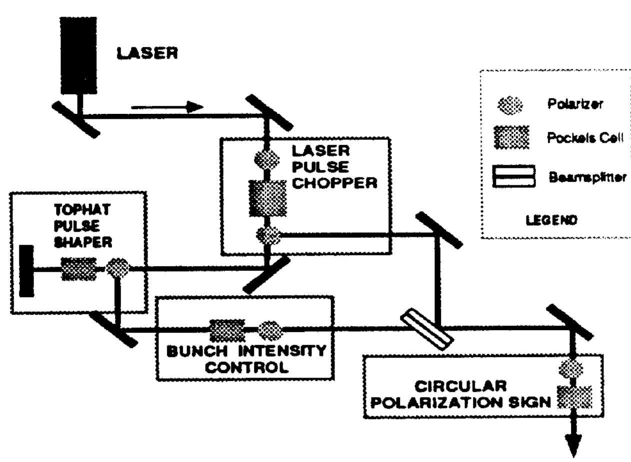

Figure 2. The Polarized Light Source for E142.

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The PLS ran continuously at 120 Hz for the five month SLD run in 1992, with only a four hour scheduled downtime every ten days for dye and flashlamp changes. The PLS delivered usable beams for SLD running with about 95% efficiency for the run, including the scheduled downtime. Typically, 5 μJ in a 2 ns bunch was delivered to the photocathode with 99% circular polarization. The helicity-dependent intensity asymmetry was determined to be less than $5 \cdot 10^{-4}$ from monitoring of the electron beam. The GaAs photocathode used had a typical quantum efficiency of 5% and produced $6{\cdot}10^{10}$ electrons per 2 ns bunch (5 A peak current). The electron beam polarization was 28%.

III. The PLS for the 1992 E142 Experiment

Following the SLD run, the PLS was reconfigured for E142 as shown in Fig. 2. For long pulse operation, the dye laser was modified to produce longer output pulses at lower peak power. Two beams from the pulsed dye laser are produced — a 1.2-μs-long pulse for the experiment, and a 2 ns short pulse for accelerator diagnostics and tuning. Normal operating conditions during E142 were concurrent running of the long pulse at 119 Hz and the short pulse at 1 Hz.

The Laser Pulse Chopper Pockels Cell system is similar to the one described above for the SLD experiment, except that now the Pockels Cell is between aligned polarizers, and only one pulse is produced. The Tophat Pulse Shaper (TOPS) system shapes the dye laser pulse into a 1.2 μs long flattop pulse. A fast feedback system determines a correction voltage to the TOPS Pockels Cell such that a photodiode signal following the TOPS system matches a reference waveform.

After TOPS is the BIC system which serves the same purpose as for the SLD experiment, which is to regulate the laser light on the photocathode and hence the intensity of the long pulse electron beam. After the BIC system, the short and long laser pulses are combined and sent to the CPS system, which is identical to that used for SLD. From the CPS on, the PLSs for E142 and SLD are identical.

The PLS efficiency for E142 is similar to its efficiency for SLD, with typically four hours of scheduled maintenance every 10 days for dye and lamp changes. The PLS delivers about 20 μJ in a 1.2 μs pulse to the photocathode with 99% circular polarization. Helicity-dependent intensity asymmetries as large as $1.5{\cdot}10^{-4}$ have been measured during E142 running. This helicity asymmetry is believed to arise from two effects—residual linear polarization in the laser beam coupled with a small transmission asymmetry in the laser transport optics from the CPS to the photocathode, and steering of the laser beam by the CPS Pockels Cell due to misalignment of the laser beam with respect to the Pockels Cell.[1] For E142, an AlGaAs photocathode was used. It had a typical quantum efficiency of 0.8% and produced $3.5{\cdot}10^{11}$ electrons in a 1.2 μs pulse. The electron beam polarization was 40%.

VI. Conclusions

We have described the Polarized Light Source used to produce a polarized electron beam at SLAC. PLS operation for the 1992 SLD and E142 experiments was very successful, having an uptime efficiency of 95% averaged over seven months of running.

References

1. These effects are described in detail in G. Cates et. al., *Nucl. Inst. Meth. in Phys. Res.* **A278**, 293 (1989). This article points out that the transmission asymmetry in the optics transport line can be minimized by using pairs of phase compensating mirrors, such as is done in the SLAC PLS Mirror Box. The article also points out that steering effects from the helicity Pockels Cell can be minimized by 1:1 imaging of the laser beam from the helicity Pockels Cell to the cathode. This is approximately accomplished in our setup with the 6 m imaging lens between the CPS and photocathode.