

SLC POLARIZED BEAM SOURCE ULTRA-HIGH-VACUUM DESIGN*

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This paper describes the design of the ultra-high vacuum system for the beam-line from the 160-kV polarized electron gun to the linac injector in the Stanford Linear Collider (SLC). The polarized electron source¹ is a GaAs photocathode, requiring 10^{-11} -Torr-range pressure for adequate quantum efficiency and longevity. The photocathode is illuminated by 3-nsec-long laser pulses. Photocathode maintenance and improvements require occasional substitution of guns with rapid restoration of UHV conditions. Differential pumping is crucial since the pressure in the injector is more than 10 times greater than the photocathode can tolerate, and since electron-stimulated gas desorption from beam loss in excess of 0.1% of the 20-nC pulses may poison the photocathode. Our design for the transport line contains a differential pumping region isolated by a pair of valves. Exchange of guns requires venting only this isolated region which can be restored to UHV rapidly by baking. The differential pumping is performed by non-evaporable getters (NEGs) and an ion pump.

The design of the polarized beam source transport-line vacuum system is nearly complete. We are beginning to fabricate two identical systems. One system is to be installed in the SLC this summer for operation this autumn. A copy is to be installed in a polarized gun test laboratory this summer, in order to test the SLC polarized source prior to operating the source in the SLC, and for future tests of new photocathode guns.

In the present configuration, shown in Figure 1, two guns can be mounted on the SLC injector. One gun has a GaAs photocathode suitable for producing a polarized electron beam. The other gun, which has a thermionic cathode, has produced the unpolarized beams used in previous SLC operations. Both of these guns aim into a "Y"-shaped vacuum chamber inside a DC bend magnet that can bend the beam from either gun into the SLC injector.

Isolation of the photocathode gun vacuum from the "Y" region is necessary for two reasons: (1) It will be necessary occasionally to remove the photocathode gun from the accelerator and to replace it with a spare. When swapping guns, it is desirable to maintain vacuum in the guns and in the "Y" chamber. (2) The photocathode demands pressure below 10^{-10} torr for adequate quantum efficiency and lifetime. The best pressure attained in the "Y" chamber is of order 10^{-9} torr.

The goal of photocathode vacuum isolation is met by a pair of all-metal straight-through valves with low magnetic permeability.² The valves have 2.9-cm-diameter aperture and are 18-cm long. One valve seals-off the gun. The other valve seals-off the "Y" chamber.

The pumping configuration is intended to reduce the pressure from 10^{-9} torr in the linac injector to less than 10^{-10} torr in the photocathode gun. This pressure drop is to be accomplished by pumping in the injector, in the "Y" chamber, in a pump-out between the photocathode-isolation valves, and in the gun.

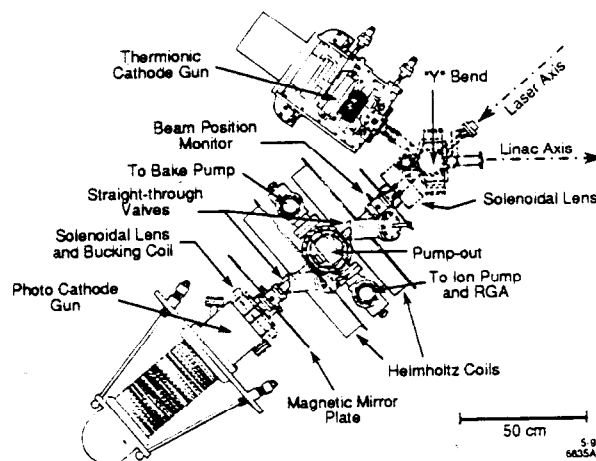


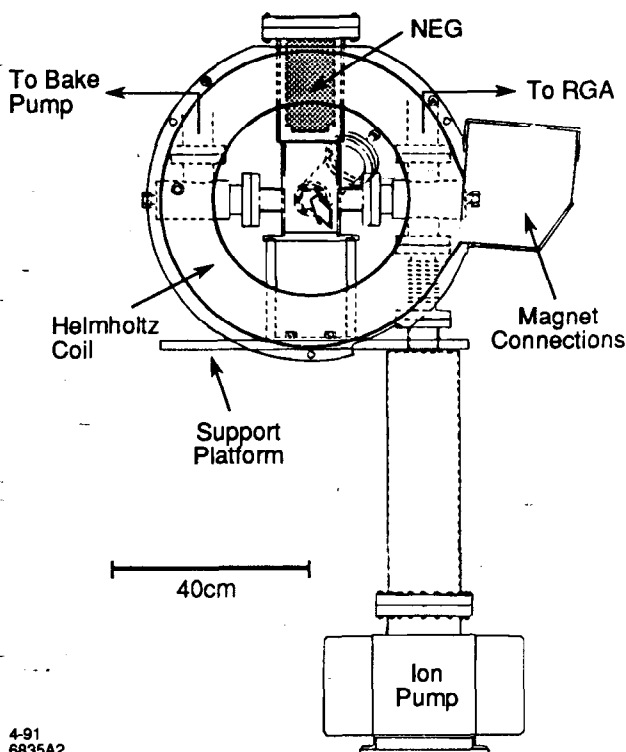
Figure 1: Plan view of the SLC gun region. The polarized electron beam emerges from the photocathode gun (at lower left), passes through a pair of straight-through valves and Helmholtz coils, and is bent through the "Y" chamber into the linac injector. The upper beam-line is the (unpolarized) thermionic gun.

A potential source of gas load comes from beam loss. The total charge in the 3-nsec pulse is 20 nC. We estimate that the effect of electron-stimulated gas desorption will be negligible if beam losses are kept less than 0.1% before the bend, and less than 1% after the bend.

The optics design that accomplishes these criteria is described elsewhere in these proceedings.³ The focusing fields necessary to transport the beam through the pair of valves is provided by the Helmholtz coils and iron-encased solenoidal magnetic lenses shown in Figure 1. The 2500-amp-turn lens mounted on the gun has a water-cooled inner spool-piece to minimize thermally-stimulated desorption of gas molecules near the gun. The lenses are bakeable to 250°C.

The pump-out region between the photocathode-isolation valves is pumped by an ion pump and by a non-evaporable getter (NEG) pump, as shown in Figure 2. The ion pump is Perkin-Elmer's 220-liter/second differential ion pump. The NEG pump is SAES Getters' model GP500, with an ST707 (zirconium-vanadium-iron) NEG

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Figure 2: Beam's eye view of the pump-out region between the straight-through valves in Figure 1. The non-evaporable getter (NEG) is commercially available as SAES Getters' model GP500.

cartridge mounted on an eight-inch flange. The NEG provides high pumping speed for hydrogen, CO, and CO₂ at very low pressures. CO and CO₂ are particularly bad for the photocathode.

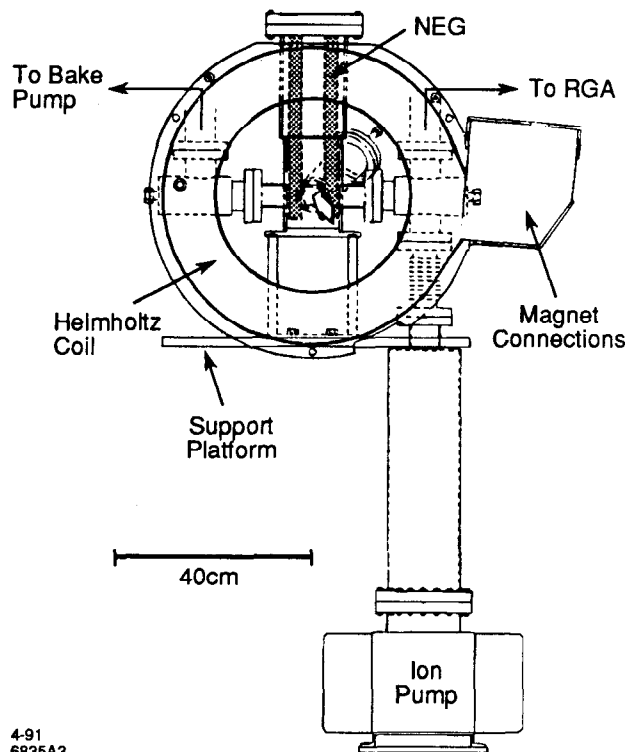
A possible upgrade to the NEG pumping, shown in Figure 3, is to replace the GP500 unit with a pair of SAES Getters' NEG double-wafer modules (model WP1250/2) specially designed to straddle the beam-line. The pump-out chamber was designed to accommodate either NEG configuration.

A Tee valve connects the pump-out chamber to the ion pump and to a residual gas analyzer. A right-angle valve connects the pump-out chamber to a bake pump. Both of these valves are all-metal, and of low magnetic permeability.²

The photocathode gun is pumped by a 120-liter/sec differential ion pump and a NEG (SAES Getters' GP200 with ST707 cartridge).

The pump-out chamber between the valves was designed to permit restoration of ultra-high-vacuum conditions within several hours after swapping photocathode guns. Tests of a small prototype pump-out chamber pumped by an ion pump and a NEG indicate that such rapid turnaround is possible.

The rapid-turnaround bake system we are designing for the pump-out region implements complete coverage of all vacuum components between the isolation valves with clamp-on band-type heaters of low magnetic permeability.



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Figure 3: Beam's eye view of the pump-out region between the straight-through valves in Figure 1. The non-evaporable getter (NEG) shown is a possible future upgrade in which a pair of NEG double-wafer modules straddle the beam-line to increase the pumping speed for molecules traveling along the beam-line.

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References

1. J. E. Clendenin, "The SLC Polarized Electron Source" (SLAC-PUB-5368), presented at the Workshop on Polarized Electron Sources and Electron Spin Polarimeters, Bonn, Federal Republic of Germany, September 6-7, 1990.
2. The straight-through, right-angle, and Tee valves are Vacuum Generators' models CSD32, CR64, and CR64T, respectively. All are being fabricated with special low magnetic permeability movement mechanisms.
3. K. R. Eppley, T. L. Lavine, R. A. Early, W. B. Herrmannsfeldt, R. H. Miller, D. C. Schultz, C. M. Spencer, and A. D. Yeremian, "SLC Polarized Beam Source Electron Beam Optics Design" (SLAC-PUB-5453, May 1991), published in these proceedings.