SLAC MEMORANDUM

21 May 2002

To: Distribution

From: Roger Erickson

Subject: **Photon Beam Dump Magnets**

This memo proposes a set of parameters for the four magnets we plan to use as the dump magnets for the A-Line photon beam project. Specifically, we propose to deflect the electron beam by a total of 7.0 degrees using the four original dump magnets with additional coils. The magnets will be powered in series with the power supply originally built for the SLC arcs.

Starting Assumptions

1. We removed the four original dump magnets from the BSY last year, expecting to refurbish them for this project. They will be re-installed in the same z-positions as before, but their y-positions and pitch angles will be adjusted to match a shallower dump angle. A new dump will be installed to intercept the deflected beam.

2. The dump line must handle any beam energy up to 48.4 GeV. This energy corresponds to an electron spin precession of 15π, resulting in longitudinal polarization at the diamond target. The next higher energy point for longitudinal polarization is approximately 52 GeV, which is near the upper limit of both the linac and the A-Line.

3. The new total dump line angle must be large enough to ensure that muons generated in the new dump pass into the ground below the experimental apparatus, and do not constitute a significant source of background radiation in End Station A. L. Keller has carried out a set of calculations that indicate that a total bend angle of 6 degrees is adequate, although some muon trajectories could still come up through the floor of End Station A. His calculations show some improvement with larger dump angles up to about 7 degrees. Angles larger than 7 degrees offer little benefit, because other sources of backgrounds dominate.

4. A special detector is being designed to monitor the over-bent degraded electrons that have lost energy in the diamond radiator. These electrons provide a non-invasive method for monitoring the energy spectrum of the photon beam. Preliminary calculations by R. Arnold have shown that these electrons will exit

the lower surface of the vacuum chamber in the first two dump magnets. The exact distribution of these electrons along the longitudinal dimension depends on the bending strength of the dump magnets, as well as the geometry of the vacuum chamber and detector elements. The bending strength, and hence the total dump angle, should be chosen to accommodate a reasonable design for this beam monitoring apparatus, although the calculations indicate only a weak dependence of the monitoring resolution on the dump angle, over the full range of practical angle choices.

5. The deflection angle should be chosen to simplify the overall dump-line (and photon beam line) mechanical design and minimize the project cost, but not to the extent that it compromises the issues in points 3 and 4 above. Preliminary design work indicates that angles less than 6 degrees would lead to mechanical interference problems, but larger angles can be accommodated.

6. The deflection angle should be chosen to be as small as possible to minimize electric power costs and temperature rise in the magnets, but not to the extent that it compromises points 3 and 4 above, or creates significant design problems.

Magnet Options

We propose a total bend angle of 7.0 degrees (1.75 degrees per magnet). This will require an integrated field strength of 49.31 kG·m for each of the four magnets. A conservative design approach requires that we add an additional coil to each pole of each magnet (for a total of six coils per magnet). With this configuration, the current requirement for the four magnets (powered in series) is approximately 761 amps. Assuming a resistance of 0.14 ohms per magnet, the voltage drop across the four magnets will be 426 volts, and the power dissipated in the coils will be 325 kW. Note that the highest voltage above ground of any point in the circuit will be half the total, or 213 volts.

It is interesting to note that this configuration could reach the next longitudinal polarization energy of 51.6 GeV, which would require 52.57 kG·m per magnet. This bending strength would require a total of 855 amps at 479 volts, for a total power requirement of 410 kW (not counting cable losses).

If we were to try to achieve the same dump angle with just four coils per magnet, we would need a current of 1142 amps to reach the 48.4 GeV point, and this would dissipate 488 kW. On the other hand, if we were to design for a maximum current of 1000 amps, but stay with four coils per magnet, we would have to reduce the dump angle to 6.43 degrees or less, and higher energies would be impractical.

A comment about power costs:
The difference in power requirements between the proposed "cool" 6-coil configuration and the simpler, but "stressed" 4-coil configuration is about 163 kW at the 48.4 GeV point. If we assume 12 months of operation spread over four years, this difference corresponds to a little more than 1400 MW-hours. At an incremental power cost of $100/MW-hr, the 6-coil configuration saves $140K in power costs, compared to the 4-coil configuration.

Power Supply

A large DC power supply was built at SLAC to power the SLC arcs. This power supply, which is built in to the south end of Building 136, consists of four sub-units connected in a series-parallel arrangement. Two of these four sub-units, connected in series, would be adequate to power the new A-Line dump magnets. Martin Berndt has examined this possibility and concluded that the power supply can be reconfigured relatively easily with some internal bus-bar changes. This could be done in such a way that the power supply could be changed back to power the SLC arcs in a few hours. In the new configuration, the system could supply up to 2800 amps at up to 800 volts.

Cables

Six runs of 500MCM cable (three per circuit leg) from the original BSY installation can be re-used for part of the circuit. These cables run from a point inside the Cableway 3 tunnel, where the cut ends are lying in a cable tray, through Cableway 4 and the BSY, to the location of the dump magnets. These cables are adequate to handle any current up to about 1300 amps, which is more than the magnet coils could handle. New cable extensions will be needed between the power supply in Building 136 and the cut ends in Cableway 3. The ESED Cable Group has looked at this issue and recommended that water-cooled aluminum cables be installed along the existing support structures that run along the north side of the walkway from MCC to Building 136. This recommendation was based partly on the assumption that we have suitable water-cooled aluminum conductor on site that could be used with no additional cost to SLAC.