Effects of Magnetic Non-adiabaticity and Measurement of the Energy Distribution of a Solid Neon Moderated Positron Beam*

S. Ghosh,# J. R. Danielson, C. M. Surko
Department of Physics, University of California San Diego, La Jolla, CA 92093 USA

High quality, trap-based positron beams typically operate in the regime in which particle transport is adiabatic. In this regime, the quantity ($E_\perp/B$) is a so-called adiabatic invariant (AI), where $E_\perp$ is the energy in cyclotron motion in the direction perpendicular to magnetic field B. Adiabaticity requires the parameter $\gamma = (2\pi v_\parallel/\omega_c)\ (1/B)(dB/dz) < 1$, where ω_c is the cyclotron frequency and $v_\parallel$ is the parallel positron velocity [1].

Discussed here is a positron beam from a ^{22}Na source and a cone-shaped solid neon moderator. For all beam transport energies ≤ 100 eV, invariance holds quite well for the beam from the buffer gas trap (BGT) to the test-gas cell [2]. However, upstream of the BGT, breaking of AI is observed for transport energies ≥ 60 eV. This has been identified to be due to the low magnetic field and strong gradients at front end of the beam tube separating the solid-Ne moderator source stage and the BGT. The principle effect of the breaking is that it scrambles the parallel ($E_\parallel$) and perpendicular energy ($E_\perp$) beam distributions, leading to broadening of both, while the total particle energy is conserved. Experimental results for a fixed source magnetic field show increases in mean perpendicular energy with increased moderator bias in the range 60 – 80 V, in the regime where $\gamma \geq 1$.

The result of these studies is that the mean total energy of the positrons from the solid neon moderator could be measured with the result that, in the adiabatic regime, mean $E_\perp \sim 0.8$ eV, mean $E_\parallel \sim 1.6$ eV (relative to the moderator bias), and the parallel energy spread is ~ 2 eV FWHM. Measurement of the spatial distribution of positrons from the cone-shaped surface of the neon moderator will also be discussed, as will implications of these observations for BGT-based beam systems.

* Work supported by the U. S. NSF, grant PHY-1702230.

References

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Corresponding author, Email: soumen@physics.ucsd.edu