DAMPING RING STUDIES FOR THE LC

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Abstract

The goals for the beam emittances of the proposed Linear Collider (LC) are far smaller than those achieved at existing accelerators. Thus, the obstacles to be encountered will be substantial, although hopefully not insurmountable. A major limitation on the performance the LC will be the damping rings and the emittances achieved there. Experiments have been performed, or are planned, at a number of facilities, including the ATF at KEK and CESR at Cornell. We propose to travel to the ATF for a two-week period and to CESR for a two-week period to assist in gaining a theoretical understanding of the results of their experiments.

INTRODUCTION

Achieving the design performance of the Linear Collider will depend strongly on the performance of the damping rings. The design normalized horizontal emittance coming out of the damping ring is 3 mm-mrad, with the normalized vertical emittance being two orders of magnitude smaller. The beam charge is about 10^{10} particles per bunch. Some of the most urgent issues that need to be addressed in order to achieve these emittances are the following:

1. Electron cloud build-up that could limit the performance of the positron damping ring. There is a need to understand better this phenomenon, and specifically taking into account the influence of the magnetic field from the wiggler. Ideally, one would want to design systems that minimize the effect of the electron cloud.

2. Residual gas ionization caused by the passage of a bunch train that could lead to tune spread and coherent betatron oscillations towards the end of the bunch train. A theory exists but more experimental studies are required to elucidate the physics limitations here.

3. The effect of intrabeam scattering at high beam intensities. The ultimate limitation on the achievable emittance will be determined by intrabeam scattering. Already, ATF has conducted experiments [1] and soon CESR will start its experiments. The initial results from ATF are somewhat inconclusive when compared to the theory. Although good agreement is achieved for the horizontal emittances and for lower beam intensity vertical emittances, the discrepancies are significant between theory and experiment for vertical emittances at higher beam intensities ~ 10^{10} particles per bunch. Thus, more theoretical and experimental work is crucial for achieving design LC damping ring performance.

4. The injection efficiency of the damping rings, which have limited momentum acceptance. There is a great need to improve both the dynamic aperture and momentum acceptance of the damping rings.

5. The interaction of the beam with radiation in the damping ring, leading to such effects as coherent synchrotron radiation and particle loss due to Thompson scattering. More theory needs to be done on this effect.

6. Injection of a new pulse train leading to the emittance growth of stored trains. This could be caused by wake field effects or the feedback system that damps injection transients.

TASKS

The vertical emittance in a damping ring is largely determined by vertical dispersion and horizontal-vertical coupling; thus, one wants to minimize these effects in the accelerator lattice design. Even so, the operating regime of the ATF demands a better understanding of the coupling among the three degrees of freedom and its effects on intrabeam scattering. An excellent start in this direction is contained in Reference [2], where they extended the theory contained in Reference [3]. We propose to analyze this effect further.

Intrabeam scattering involves multiple small-angle Coulomb scattering of particles within a bunch. The theory in Reference [3] does not specify the precise minimum scattering angle of the particles and only estimates it. Some work on this effect is contained in Reference [2]. We propose more work on this issue.

Finally, the discrepancy between the data and theory at the ATF may involve other issues, such as those enumerated above. We will study whatever seems to make the biggest impact on reconciling the data with the theory.

ANNUAL BUDGET

Tuition for 1 graduate student	$30,000
Stipend for 1 graduate student	12,000
Travel to ATF for two weeks	4,000
Travel to CESR for one week	2,000
Total Requested Budget	$48,000

REFERENCES

1. K. Kubo *et al.*, Phys. Rev. Lett. **88** (2002) 194801.
2. K. Kubo and K. Oide, Phys. Rev. ST Accel. Beams **4** (2001) 124401.
3. J. Bjorken and S. Mtingwa, Part. Accel. **13** (1983) 115.