# Proposal to the
# University Consortium for a Linear Collider

August 23, 2002

**Proposal Name**

Damping ring studies for the LC

**Classification (accelerator/detector: subsystem)**

Accelerator: damping rings

**Personnel and Institution(s) requesting funding**

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**Collaborators**

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**Project Overview**

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 of 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 per year for the next three years to assist in gaining a theoretical understanding of the results of their experiments.

The NLC/JLC design normalized horizontal emittance coming out of the damping rings 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. The most important limitation on achieving the design emittances in the damping rings is that of intrabeam scattering (IBS). Thus, it will be important to understand more fully the challenges that intrabeam scattering will present. With James Bjorken, we developed the theory of IBS for strong focusing accelerators and spent a number of years at Fermilab analyzing beam emittance growth rates from IBS in the Antiproton Source's Accumulator Ring. Also, we worked with David Finley and Alvin Tollestrup in analyzing IBS growth rates for the Tevatron upgrade. In this project, we will revisit IBS within the context of the LC damping rings. The results will be important for the TESLA design as well.

**FY 2003 Project Activities and Deliverables**

Intrabeam scattering involves multiple small-angle Coulomb scatterings of particles within a bunch. The theory in Reference [2] does not specify the precise minimum scattering angle of the particles and only estimates it. Some work on this effect is contained in Reference [3]. During the first year, we propose to work more on this issue. Also, we will begin our studies of the data from prototype damping ring experiments at ATF, CESR, and the Advanced Light Source. Our results will be written in a detailed report and published.

**FY 2004 Project Activities and Deliverables**

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 [3], where they extended the theory contained in Reference [2]. During the second year, we propose to analyze this effect further and compare with the data from the prototype experiments. Our results will be written in a detailed report and published.

**FY 2005 Project Activities and Deliverables**

Armed with a better understanding of the predictions of intrabeam scattering, during the third year, we will concentrate on the wealth of data that should have been collected by that time and fine tune our understanding of the ability to achieve the small design emittances of the various linear collider designs. Others are studying various other effects that could compromise the damping rings' performance. These include such effects as electron cloud build-up, residual gas ionization, the injection efficiency of the damping rings, the interaction of the beam with radiation, and the influence of newly injected pulse trains on ones previously stored. During the third year of this project, we plan to use the results from those other studies to achieve a quantitative understanding of how to unravel those other effects from that of intrabeam scattering. Our results will be written in a detailed report and published.

**Budget justification**

The entire project will consist mainly of theoretical and computational calculations. The first year's budget will mainly support one graduate student and travel for the Principal Investigator (PI) to spend two weeks at the ATF in Japan and two weeks at CESR at Cornell University. Computational equipment will be purchased for the graduate student.

During the second year, we include the same funds as requested the first year, increased mostly for inflation. Also, computational equipment will be purchased for the PI.

During the third year, we include the same funds as requested the second year, increased mostly for inflation. Also, additional computational equipment will be purchased for the PI.

Indirect costs are calculated at North Carolina A&T's 41% rate on modified total direct costs, which excludes tuition.

**Three-year budget, in then-year K$**

**Institution:** North Carolina A&T State University

| Item | FY 2003 | FY2004 | FY 2005 | Total |
|---|---|---|---|---|
| Graduate student (RA) | 12 | 13 | 14 | 39 |
| Undergraduate Students | 0 | 0 | 0 | 0 |
| Total Salaries and Wages | 12 | 13 | 14 | 39 |
| Fringe Benefits | 0 | 0 | 0 | 0 |
| Total Salaries, Wages & Fringe Benefits | 12 | 13 | 14 | 39 |
| Equipment | 3 | 3 | 3 | 9 |
| Travel | 8 | 9 | 10 | 27 |
| Materials and Supplies | 1 | 2 | 3 | 6 |
| Other direct costs (Tuition) | 12 | 13 | 14 | 39 |
| Total direct costs | 36 | 40 | 44 | 120 |
| Indirect costs | 10 | 12 | 13 | 35 |
| Total direct and indirect costs | 46 | 52 | 57 | 155 |

## References


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