Annual Report

Design Studies for Converting CESR to a Damping Ring Test Facility

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Major Findings

CesrTA lattice

We have considered modifications of the machine layout compatible with a very low emittance lattice. This requires that all 12 CESR-c wigglers be located in zero dispersion regions and that the coupling elements associated with our compensation scheme for the CLEO solenoid be removed. 6 of our wigglers are presently located in straights which can already be configured for zero dispersion. The remaining 6 wigglers will need to be relocated to the CLEO interaction region straight.

In addition to this baseline configuration, we have explored our emittance reach for a number of machine configurations. These studies have varied the number of wigglers and the wiggler fields, the machine energy, and also considered the possibility of low emittance operations in the CESR-c configuration before any machine modifications can be made.

The dynamic aperture for the various sets of optics has been evaluated for fractional energy offsets of 0.5% and 1%.

Low emittance tuning

The vertical emittance that can be obtained in CesrTA will be sensitive to alignment errors around the ring and to the emittance coupling that can be obtained. Magnet misalignments in CESR create vertical dispersion and couple horizontal and vertical emittance. In order to achieve the target vertical emittance, the sensitivity to misalignments has been characterized and algorithms for correcting misalignments have been evaluated.

X-ray beam size monitor

We are developing a fast x-ray camera for bunch by bunch beam size measurements. We plan to build two cameras and install two x-ray lines so that we can measure both electron and positron beams. We have preliminary designs for the layout and optics of the beam lines.

Touschek/IBS studies

Intrabeam scattering (IBS) will play a significant role in the emittance that can be attained in CesrTA with a bunch charge corresponding to the ILC bunch charge. We have incorporated IBS physics in the BMAD library of accelerator software tools so that the effects of intrabeam scattering can be evaluated for the various configurations without approximations.

Electron cloud simulation and measurements

Measurements of bunch by bunch tune shift and beam size indicate the presence of an electron cloud. In one set of measurements we store a ten bunch train of positrons with 14ns spacing. We then inject a witness bunch, one at a time, at integral 14ns intervals beyond the end of the train. The development of the cloud is evident from the increasing tune shift along the 10 bunch train. The decay distance of the cloud is extracted from the tune shift of the witness bunches. Measurements of a similarly configured electron beam suggests the presence of an electron cloud as well, but with a somewhat lower density. We are beginning to use simulations growth of electron cloud in the CESR guide field so that we can eventually make comparisons with the measurements.

We have designed and built a set of retarding field analyzers (RFA) for installation in May 2007. We will use the RFAs to study the local evolution and lifetime of the electron cloud.

4ns transverse feedback

CESR operates in a colliding beam mode with a bunch spacing of 14ns and with bunch by bunch digital feedback for electrons and positrons in horizontal, vertical and longitudinal planes. The 500MHz RF system can accomodate bunch spacing of 4ns. We have developed an analog system, that utilizes the same amplifier and kicker as the digital system, but with the capability of damping trains of bunches with 4 ns spacing. In recent tests, we have stored a 21 bunch train, with bunch charge of 2×10^{10} particles, (1.4mA/bunch) with 4ns spacing.

Training and development

We further the teaching mission of Cornell University and expose undergraduates to the field of accelerator physics by creating research opportunities for students. Four undergraduate students have been involved in the project, specifically with respect to the design and evaluation of the CesrTA lattice. Graduate students are responsible for developing the low emittance tuning algorithms and evaluating effects of the damping wigglers. The training of new accelerator physicists is expected to have a significant impact on a range of fields which presently depend on particle accelerators for their research.

Publications

1. D. Sagan, J. Crittenden and D. Rubin, "A Magnetic Field Model for Wigglers and Undulators", Proc. 2003 Particle Accelerator Conference, Portland, Oregon (2003), p. 1023.

2. R. W. Helms and D. L. Rubin, "A Compact Damping Ring Using RF Deflectors for the International Linear Collider," Proc. 2005 Particle Accelerator Conference, Knoxville, Tennessee (2005).

3. J. Urban and G. Dugan, "CESR-c Wiggler Studies in the Context of the International Linear Collider Damping Rings," Proc. 2005 Particle Accelerator Conference, Knoxville, Tennessee (2005).

4. M.A. Palmer, *etal.*, "A Bunch-by-Bunch and Turn-by-Turn Instrumentation Hardware Upgrade for CESR-c", Proc. 2005 Particle Accelerator Conference, Knoxville, Tennessee (2005).

5. M.A.Palmer,*etal.*, " The Proposed Conversion of CESR to an ILC Damping Ring Test Facility", Proc. 2006 European Particle Accelerator Conference.

6. J.Shanks, "CESRc as a Test Facility for the International Linear Collider",
   http://www.lepp.cornell.edu/public/reu/2006reports/shanks.pdf

Web Site

CesrTA Wiki https://wiki.lepp.cornell.edu/ilc/bin/view/Public/CesrTA

Contrbutions

(a) Development of the principal discipline

The project has contributed to the body of accelerator science, by the development of basic theory, modeling tools, and beam instrumentation, and to the understanding of ILC damping ring physics in particular.

(b) To other disciplines

Bunch by bunch instrumentation designed and tested for the CesrTA has application to other accelerator projects including xray light sources. The training of new accelerator physicists is expected to have a significant impact on a range of fields which presently depend on particle accelerators for their research -this includes the materials sciences, medicine, solid state physics, and biophysics, as well as nuclear and high energy physics.

(c) Development of human resources

Work on the project has been the basis of the development of the technical skills of the LEPP accelerator physics staff as well as training of students.

(d) Physical institutional and information resources ...

(e) To the public welfare

As noted above, particle accelerators are essential tools in the fields of medicine, materials sciences, solid state physics and biophysics. Work on the CesrTA project contributes to the development of accelerator technology, and therefore to the public welfare.