Motivation and Overview

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Outline

- Damping ring working group recommendation to GDE
- R&D priorities
- Cesr TA characteristics
- Motivation for R&D
- Program goals of CesrTA
- Measurements
- Other facilities
- Cesr TA Plan
- Program Duration

Damping Ring Group Recommendation

- For the baseline configuration, the damping ring group recommended
  - Two ~ 6km positron rings

  To ensure that there was sufficient circumference so that the beam current would be below the electron cloud induced instability threshold
- A single ~ 6km ring was considered too risky in view of uncertainty about
  - The dependence of the evolution of the electron cloud on
    - Beam current and bunch configuration
    - Vacuum chamber geometry and chamber wall chemistry
    - Local magnetic field (especially high field damping wigglers)
  - Electron cloud instability thresholds
    - Dependence of vertical emittance on cloud density

R&D task force recommendation

- A single ~ 6km ring design is viable if
  - Vacuum chambers for dipoles and wigglers with low SEY can be designed, built and demonstrated
    - Possibilities include TiN or NEG coating, grooves or fins, clearing electrodes, etc.
  - Instability thresholds can be characterized for bunches in the ultra low emittance regime.
    - Measurement of emittance dilution due to the electron cloud of bunches with zero current vertical emittance ~ 5-10pm

CesrTA aims to do both

R&D Priorities

Highest R&D priorities ILC Damping Rings

- Lattice Design for positron ring
- Lattice Design for electron ring
- *Demonstrate < 2pm vertical emittance* *(CesrTA <5-10pm for positrons)*
- Characterize single bunch impedance driven instabilities
- *Characterize electron cloud build up*
- *Develop electron cloud suppression techniques*
- *Develop modeling tools for electron cloud instabilities*
- *Determine electron cloud instability thresholds*
- *Characterize ion effects*
- *Specify techniques for suppressing ion effects*
- Develop a fast high power pulser

- Goal of GDE to produce Engineering Design Report by 2010 and that depends on outcome of R&D

Cesr TA parameter reach, characteristics and capabilities

- Energy 1.5 - 5 GeV
  - Measure energy dependence of collective effects
- Horizontal emittance (geometric) - 2.3nm at 2GeV
- Vertical emittance (geometric) - 5-10pm at 2GeV (ILC design ε_v=2pm)
  - Characterize electron cloud instability thresholds in the ultra-low emittance regime
    Measurements to date at PEP II (ε_v 1.4nm) and KEK-B (ε_v~ 0.4nm)
- Flexible bunch spacing in multiples of 4ns
  - Measure dependence of cloud growth on beam configuration and
  - Vary density & distribution of cloud around the ring as witnessed by trailing bunch
- Maximum beam current ~ 180mA
- Wiggler dominated at 2GeV (90% of radiation in wigglers)
  - As in the damping ring, wigglers are exploited to reduce emittance
- Electrons and positrons in the same vacuum chamber
  - Distinguish electron cloud effects from other intensity dependent phenomena
- Independently powered quadrupoles
  - Flexible optics design
- Superferric wigglers 1.5T < B < 2.1T
  - Measure cloud build up in wigglers that are the baseline for ILC damping ring
- CESR is a well understood machine

Extensively characterized / modeled, in multiple configurations, over 3 decades

R&D Priorities

Calculations and simulation indicate ILC damping ring within a factor of two of instability thresholds for electron cloud

- Simulations depend on prediction of cloud density
  - Codes that calculate cloud growth and density are in reasonable agreement but corroborating measurements are difficult
- Prediction of instabilities and thresholds
  - Instability codes are not altogether consistent
  - To date we depend on measurements at B-Factories which have beam parameters most nearly like ILC
- Anticipated that character of electron cloud instabilities will have strong dependence on vertical emittance
  - B-Factory emittances are greater by 2-orders of magnitude than damping ring.

    A long way to extrapolate
- Experimental program to understand the basic physics in damping ring regime is essential to a realistic engineering design

CesrTA Goals

- Propose to address a number of S3 R&D priorities with CESR configured as a test accelerator
  - Characterize electron cloud build up in dipoles, quadrupoles, drifts and especially ILC-like damping wigglers using RFA and collectors
  - Develop and test e-cloud suppression techniques, finned chambers, coatings, clearing electrodes.
  - Test suppression techniques at 5GeV in ILC-like wigglers under ILC-like synchrotron radiation load
  - Measure dependence of tune shift, emittance dilution, dipole instability, etc. on bunch configuration (bunch spacing, bunch charge, train length), beam energy
  - Measure emittance dilution as a function of electron cloud density.
  - Characterize ion effects by comparison of bunch by bunch mode spectra, tune shifts, emittance dilution, etc. for positrons and electrons
  - Test ion suppression techniques
  - Develop beam based emittance tuning techniques

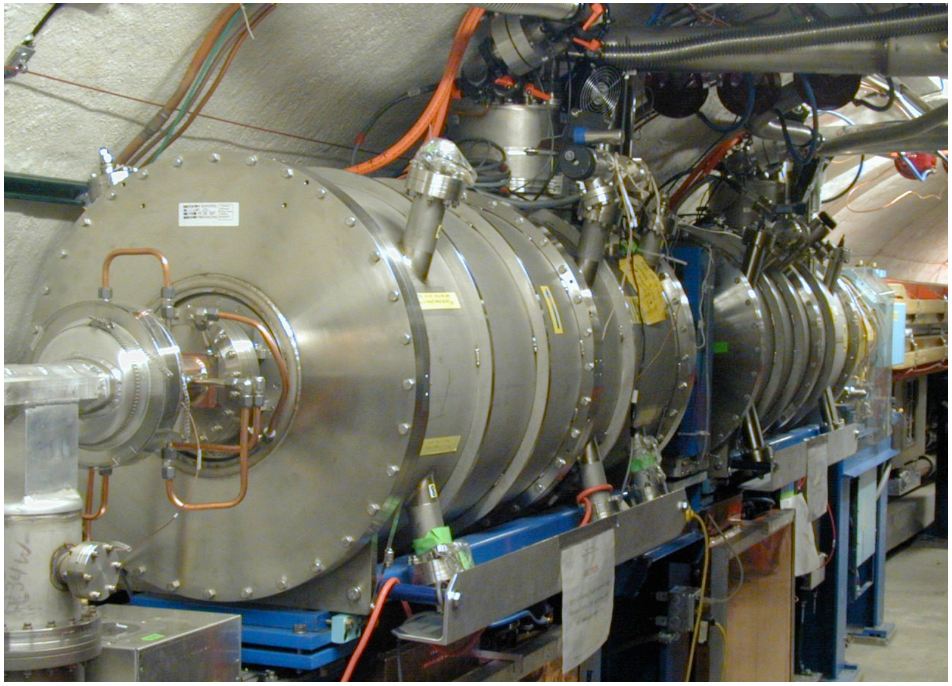
    Demonstrate 5-10pm emittance for both electrons and positrons

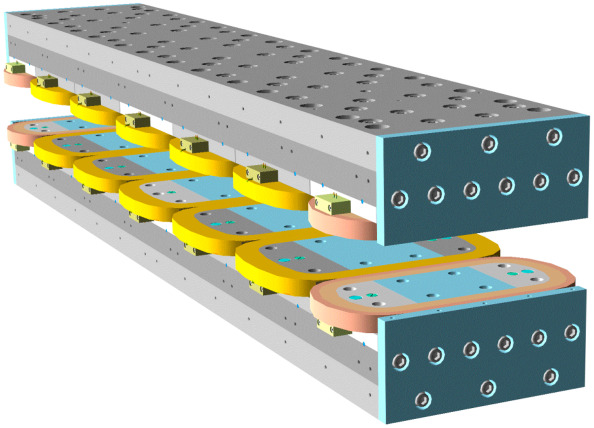
Cesr TA Measurements

- Use RFAs/collectors to measure cloud density in guide field components (and effectiveness of mitigation techniques)
- Exploit extensive experience developing beam based correction techniques in CESR to minimize vertical dispersion, transverse coupling and vertical emittance
- Utilize witness bunch measurements to determine instability thresholds, tune shift and emittance blowup as a function of cloud density
- Control cloud density and density distribution at witness bunch by varying number of bunches in the leading train, and varying the distance of witness bunch from end of the train.
- Repeat with electron beam

CESR is wiggler dominated

- 1.5-2.1T superferric wigglers - well understood
- Nonlinearity characterized in detail
- Modelled and measured effects on beams are in good agreement
- 12 1.9T wigglers account for 90% of synchrotron radiation in CESR-c and CesrTA





Wiggler chambers will be instrumented to measure electron cloud density with trains of electron and positron bunches at 1.5-5GeV

Other Facilities

• Other facilities

Are there other facilities where the equivalent measurements can be made better, cheaper, faster?

KEK-B

Like CESR

- well understood, and well developed diagnostic instrumentation and software and expert staff
- Optics can be reconfigured for low emittance at ~2.3GeV
- Study of low emittance tuning and emittance diluting effects of electron cloud depends on implementing xray beam size monitor

Unlike CESR there are significant drift regions in KEK and all are already wrapped with solenoids which provides a means to control electron cloud density

But

- CESR can circulate electrons and positrons in the same ring. A powerful capability for exploring species dependence of e-cloud, ions, impedances
- CESR has well characterized ILC-like super-ferric damping wigglers
- CESR has flexibility to operate from 1.5 to 5.5GeV to explore energy dependence
- CESR is available for dedicated measurements in 9 months - time scale for GDE

KEK-B not available for dedicated operation as test accelerator until at least 2009

Other Facilities

- HERA
  - Advantages
    - Circumference matches baseline design for DR
    - With modification lattice => low emittance at 5GeV
    - High quality vacuum chamber
    - (Superconducting RF)

    Demonstration of ILC-damping ring like emittance, bunch charge and configuration and beam current is possible - with considerable rebuilding - the real thing
  - Disadvantages
    - Initial tests cannot begin until late 2009
    - Availability of positrons, superferric wigglers, xray beam size monitor, instrumented vacuum chambers, etc., some time later?
- ATF
  - Presently lacks positrons

  Competition with ATF-II

Cesr TA Plan

- Cesr TA
  - Determine threshold for emittance blowup at level of a few pm
  - Test effectiveness of suppression techniques at 2-5GeV in wigglers, bends, quadrupoles
  - Establish that the emittance of positrons, like electrons, can be reduced to the pm level
  - Train today's students in accelerator science so that there will be a work force to build and commission the ILC
- Resources
  - Flexible optics. Energy reach. Superferric wigglers. Electrons and positrons
  - Expertise

    Nearly 3 decades experience building instrumentation for and operating CESR
  - Active leadership in damping rings working group

    Good understanding of R&D objectives

Duration

- Duration of experimental plan
  - We have made a deliberate and systematic plan to carry out the program …
  - Demonstrating acceptable electron cloud densities for positron ring depends on the development of effective suppression techniques.
  - Tuning for ultra-low emittance depends on developing beam based alignment algorithms
  - Developing state of the art, multibunch turn by turn beam size monitor

This is an R&D program. We expect surprises and anticipate new discoveries

Fourth year reduces risk and increases flexibility of program.

Summary

Cesr TA will address most of the highest R&D priorities for the damping rings

- *Demonstrate < 2pm vertical emittance* *(CesrTA <5-10pm for positrons)*
- *Characterize electron cloud build up*
- *Develop electron cloud suppression techniques*
- *Develop modeling tools for electron cloud instabilities*
- *Determine electron cloud instability thresholds*
- *Characterize ion effects*
- *Specify techniques for suppressing ion effects*

- On a timescale consistent with Engineering Design Report in 2010

Presentations

- Outline of presentations
  - Cesr TA configuration and optics for ultra low emittance
  - E-cloud and fast ion program
  - Instrumentation and diagnostics for measuring e-cloud and ion effects
  - Low emittance tuning
    - strategy for achieving pm vertical emittance
  - Advanced instrumentation for low emittance tuning
    - xray beam size monitor
  - Laboratory Plan
  - Integration into ILC GDE
  - Project Management
  - Laboratory Mission