Linear Collider Accelerator Research

D. Rubin, Cornell University

- Main linac - simulation
- Polarized positron source - design study and model wigglers
- Fast kicker - design study and prototype
- Damping rings - measurement and simulation

Cornell University

Research

Linear Collider Accelerator
With low emittance optics, CESR-c is a damping ring.

\( \frac{E^w}{E^t} \sim 90\% \), \( L \sim 18m \), \( B \sim 2.1T \)

As it is in CESR-c

TESLA - \( \frac{E^w}{E^t} \sim 95\% \), \( L \sim 300m \), \( B \sim 1.8T \)

NLC - \( \frac{E^w}{E^t} \sim 66\% \), \( L \sim 46m \), \( B \sim 2.15T \)

In linear collider damping rings, energy loss and radiation damping time are dominated by wigglers.

Wigglers

Damping Rings
included nonlinearities in optimization of lattice for dynamic aperture
- Incorporate detailed field in simulation
- Model and measure wigglers fields
- We have developed techniques to etc.
  - Manufacturing misalignments
  - Nonuniformity in iron
  - Finite width of pole
  - Horizontal and vertical nonlinearity due to interactions with longitudinal field at edges
  - Cubic nonlinearity (vertical) resulting from wigglers beam
  - Nonlinearities with high field wigglers and low energy beam

Wigglers

Damping Rings
We will begin to test our understanding of the effect of damping wigglers with the installation of the first next week. LC damping ring studies will require a low emittance lattice. All quadrupoles and sextupoles are independently powered and optics are very flexible. Effect on dynamic aperture and lifetime vs pulsed bump amplitude and tune / coupling vs displacement. We will begin to test our understanding of the effect of damping wigglers with the installation of the first next week.
resolve existing discrepancies between theory and measurement.

With a complementary effort to model IBS, we will try to

- RF voltage
- Transverse coupling

and as a function of

to degrade emittance by measuring beam size vs bunch current.

- We can study the intra beam scattering that introduces

In low emittance mode

Collective Effects

Damping Rings
Damping Rings

Collective Effects - Space Charge

Space Charge in Low Emittance Beams Will Induce a Tune Shift That Is Greatest Near the Core of the Bunch and Falls to Zero For Particles in the Tail.
Damping Rings

Collective Effects

In low emittance mode we can measure thresholds for

Electron cloud effect

Fast ion instability

Impedance driven instabilities associated with short bunches
Collaboration with SLAC, DESY, LBL

- Detectors for measuring size of stored beams and in a single pass
- Algorithms for correcting guide field errors to minimize vertical emittance
- Algorithms for correcting dispersion and vertical dispersion
- Techniques for precise measurement of coupling that we develop
- Techniques for precise measurement of coupling

Operation of CESR in low emittance mode will require

Coupling/dispersion/emittance correction

Damping Rings
Just getting started with (REU) summer students

- Extended to include intra-beam scattering and

- Extended wigglers fields

- Flexibility for integration or mapping through optics/orbits/complex/complex dispersion

- Based on code extensively tested against measurements in CESR and used to diagnose and correct CESR

Develop modeling tools to support the measurements on CESR

Damping Rings
Optical functions at transition to long straight Tesla Damping Ring

A.Amsel and plots courtesy W.Decking Lattice file
Lattice file courtesy A. Wolski and plots V. Borum

NLC Damping Ring Optical functions

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HEPAP

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We have confirmed documented tolerances to misalignments that generate vertical dispersion and transverse optics. We will recompute and then explore optimization of dynamic aperture by experimenting with alternative optics.

We will measure and correct vertical dispersion and BPM resolution required to adequately dispersive resolution required. We recovered dependence of vertical emittance on vertical. We have generated vertical dispersion and transverse coupling. Confirmed documented tolerances to misalignments that damping ring.
- The size of the TESLA damping ring is determined by the large number of bunches in the train and the bunches 20ns apart. The 2820 bunch train requires a 17kM damping ring.

- A reduction in the pulse width translates to a smaller ring.

- With bunches spaced 20ns apart, the 2820 bunch train with injection and extraction kicker.

- The baseline TESLA design calls for a 20ns pulse.

- The minimum spacing depends on the width of the pulsed spacing.

- The size of the TESLA damping ring is determined by the bunch spacing.

Fast Kicker
Fast Kicker

We plan to investigate designs

- For conventional kickers with narrower pulses
- Schemes using electron beams to provide very fast kicks, including evaluation of jitter

Collaboration with FNAL, DESY, Illinois

And to build a prototype of a promising design
High energy electron beam in a helical undulator produces circularly polarized photons, which are then converted to $e^+e^-$ pairs in a thin target. Proposed by TESLA and now being considered for both superconducting and warm linear collider designs.

Planned Cornell R&D:
- Design study for target and transport.
- Short undulator model achieving magnetic field specifications.
- Design study for target and transport.

$\frac{1}{2} \text{ cm at } 250 \text{ GeV}, \frac{1}{2} \text{ mm at } 50 \text{ GeV}$

**Polarized Positron Source**
Polarized Positron Source
Polarized Positron Source
Main Linac - Simulation

- Effective beam-based techniques for correction through Linac
- Preservation of small vertical emittance during acceleration
- Elaborate simulations have been developed at SLAC, DESY and CERN which can incorporate static and dynamic alignment errors, including BPM resolution and feedback mechanisms
- Permit tests of correction algorithms and feedback
- Preservation of small vertical emittance during acceleration through Linac

And both depend on modeling of beam transport.

Are both critical to collider performance.
Main Linac - Simulation

and other issues that are likely to emerge
Spin transport
Beam halo transport
Investigate

In collaboration with experts, identify inadequacies of existing
on guide field errors, RF phase errors, misalignments...

Exercise with already solved problems
(Merlin - Walker, LAR - Tennebaum et al.)
Assemble existing simulation tools at Cornell

See for ourselves how emittance depends

Examine existing simulation tools at Cornell
Main Linac - Simulation

Flexible modeling tools will be critical to the timely commissioning of the new machine

Simulations are a powerful tool for educating ourselves and our students with respect to design choices

-> Develop the expertise that will be so important to the commissioning and operation of the collider
Collaboration

Summary of main linac

Polarized position production

Simulation of fast kicker designs

Investigation of fast kicker designs

Short damping time ring

All aspects of wiggler dominated low emittance,

Measurement and supporting simulation for nearly

Damping ring study

Summary