

# Damping Ring R&D Activities at Cornell and Minnesota (UCLC Progress Report)

R. Poling, A. Smith, B. Rancourt, *University of Minnesota*

G. Dugan, M. Palmer, **J. Rogers**, D. Rubin, D. Sagan, R. Helms, J. Urban,  
A. Wan, *Cornell University*

Collaborators:

W. Decking, *DESY*

S. Mtingwa, *MIT*

M. Ross, *SLAC*

J. Urakawa, *KEK*

A. Wolski, *LBNL*

## R&D goals over 3 years

- Studies of wiggler-related dynamic aperture limitations\*
- Studies of beam-based alignment and emittance correction algorithms
- Studies of intrabeam scattering (IBS)
- Studies of space charge effects
- Investigation of collective effects relevant for damping rings  
(electron cloud and ion instabilities, impedance-driven instabilities)
- Development of simulation and modeling tools\*
- Review of TESLA damping ring design and optics\*
- Investigation of the superferric option for NLC and TESLA damping ring wigglers

These are a combination of experimental studies in CESR-c and simulation and design studies.

\* primary areas of activity in FY03

## ILC-TRC 2003 Report R&D Rankings

Rank 2 items: R&D needed to finalize design choices and ensure reliability of the machine

Our program addresses four of these items, which include: refined modeling of the TESLA DR dynamic aperture; electron cloud experiments; fast ion instability experiments; and simulation and experimental studies of emittance correction.

Rank 3 items: R&D needed before starting production of systems and components

We will address two of these items, which include: refined modeling of the JLC/NLC dynamic aperture; and experiments to determine the validity of theoretical models of IBS.

## Activities in FY03

- We have completed the inclusion of wiggler tracking into the particle tracking code BMAD.
- We have run damping ring lattices in BMAD and have overcome the problem of running a large lattice (TESLA).
- We are in the process of porting BMAD to the Minnesota machines. Minnesota has received approval from the DoE for a new computer simulations farm (90% CLEO-c, 10% LC).
- We are in the process of developing a Frequency Map Analysis tool for dynamic aperture studies.
- We are in the process of upgrading the low-emittance diagnostics with integration into the CESR control system.
- We are investigating two alternatives to the TESLA dogbone damping ring design.

## Further activities planned for FY03

- We plan to do NLC and TESLA dynamic aperture studies on the Minnesota simulation farm, with a simplified wiggler model followed by a realistic wiggler model.
- We plan to produce a space charge element for BMAD for space charge simulation studies.

## Wiggler-related dynamic aperture limitations

- Cornell's CESR-c is the first machine operated in the regime where synchrotron radiation damping is dominated by wiggler magnets.
- The linear collider damping rings will be wiggler-dominated.
- Dynamic aperture can be severely restricted by nonlinearities from wigglers.
- Studies in the wiggler-dominated CESR-c:
  - Incorporate wiggler tracking into the particle tracking code.
  - Perform particle tracking calculations.
  - Compare particle tracking with measurements of dynamic aperture, tune shifts, decoherence, and phase space distortion in CESR-c.
  - Apply the wiggler/lattice design algorithm and particle tracking to LC damping ring designs to demonstrate or optimize dynamic aperture.

## Space charge tune shift

Incoherent space charge tune shift,  $\epsilon_x \gg \epsilon_y$ :

$$\Delta\nu_{sc,x}^{\max} \approx \frac{Cr_e N_e}{(2\pi)^{3/2} \gamma^2 \epsilon_{x,n} \sigma_s}$$

$$\Delta\nu_{sc,y}^{\max} \approx \frac{Cr_e N_e}{(2\pi)^{3/2} \gamma^2 \sqrt{\epsilon_{x,n} \epsilon_{y,n}} \sigma_s}$$

vertical tune shift

NLC MDR: 0.05

TESLA (no coupling bump): 0.26 (!)

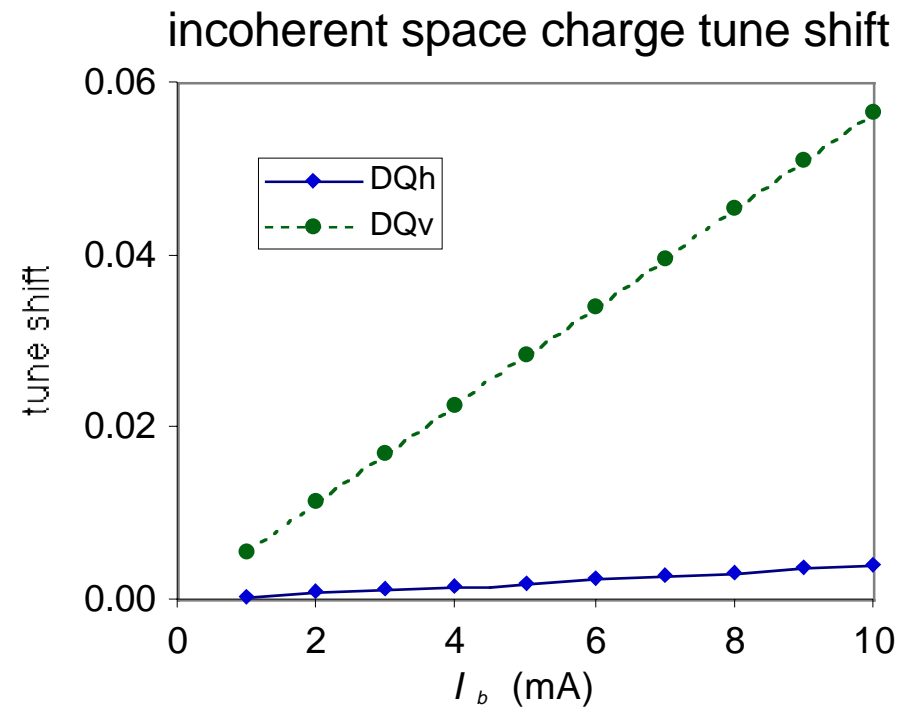
TESLA (with coupling bump): 0.06

Are these values safe? What should operating tunes be?

## Space charge tune shift

With special optics we can measure the effects of space charge in CESR-c, and compare with our simulation results

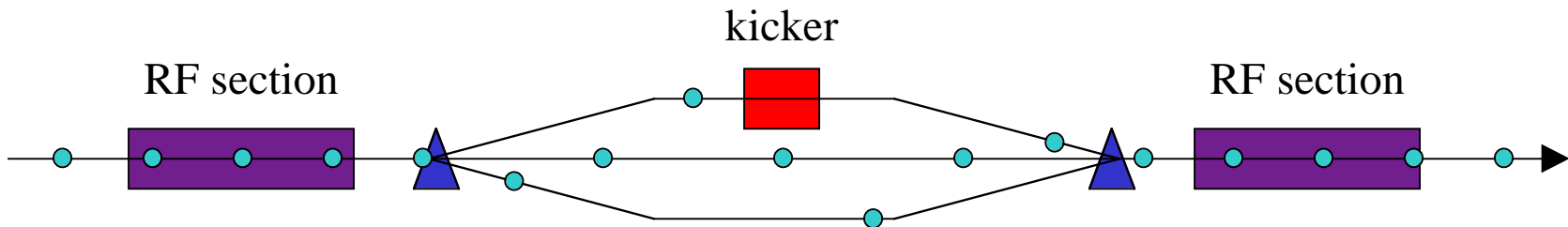
CESR-c  
 $E = 1.55$  GeV  
emittance coupling ratio = 0.0045  
 $\eta_{y,rms} = 0.045$  m  
 $\sigma_s = 1.0$  cm  
no wigglers



## Alternatives to the TESLA dogbone damping ring (1)

(R. Helms, D. Rubin)

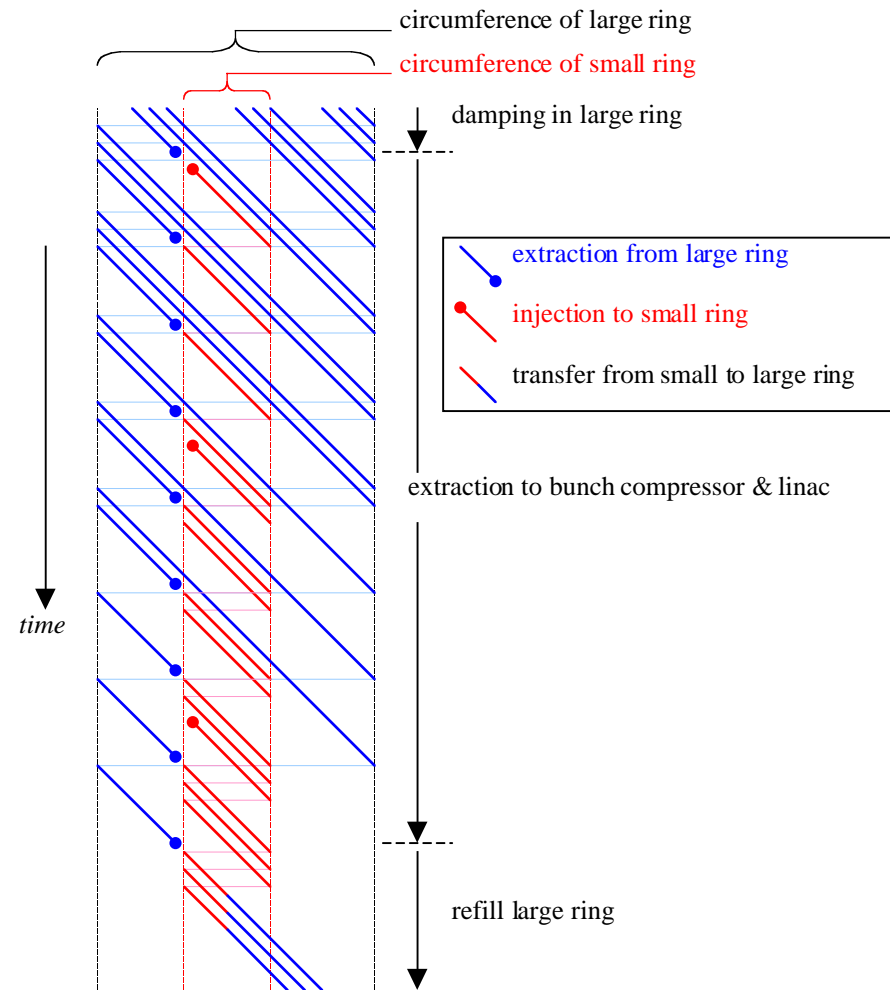
- A secondary RF system with a different frequency is used to separate the beam dispersively, bunch by bunch, into different channels.
- One such channel contains the injection/extraction kicker.
- Bunch spacing can be made smaller than the kicker rise/fall time, allowing for a smaller ring.



## Alternatives to the TESLA dogbone damping ring (2)

(J. Rogers)

- Uses two rings (one large, one small) with a common RF section.
- Bunches are always extracted and injected at the end of a bunch train, so the injection/extraction kickers need only have a fast rise time.
- Large ring can be much smaller than the dogbone design.
- Positron bunch production rate is greatly reduced, allowing use of a conventional positron source.



## Conclusions

- We're now laying the groundwork for future work by getting our simulation tools and diagnostics in place.
- Several of our FY03 goals have been met.
- We're starting on tasks for which we currently have expertise.
- We're looking forward to finding solutions for damping ring issues together with the linear collider community.