Wiggler-dominated beam dynamics simulation and experiment

•Effect of wiggler magnetic nonlinearities on single-particle dynamics

CESR-c wigglers will be *very* similar to the LC damping ring wigglers:

	Type	$\int B^2 dl$ (T^2m)	B_{max} (T)	Total length (m)	λ_w (m)	E (GeV)	x_{max} (mm)	θ_{max} (mrad)	K
NLC MDR	PM	106	2.15	46	0.27	1.98	8.2	14	54
TESLA DR	PM	592	1.67	432	0.40	5.0	2.5	6.4	62
CESRc (hi)	SC-Fe	~52	2.1	~18.2	~0.40	5.3	3.0	7.6	79
CESRc (lo)	SC-Fe	~52	2.1	~18.2	~0.40	1.55	10.3	26	79

Need to do wiggler design correctly!!!

Experiments to validate LC DR design tools:

• Compare measured dynamic aperture with particle tracking simulations of dynamic aperture.

• Measure tune shift *vs*. orbit bump.

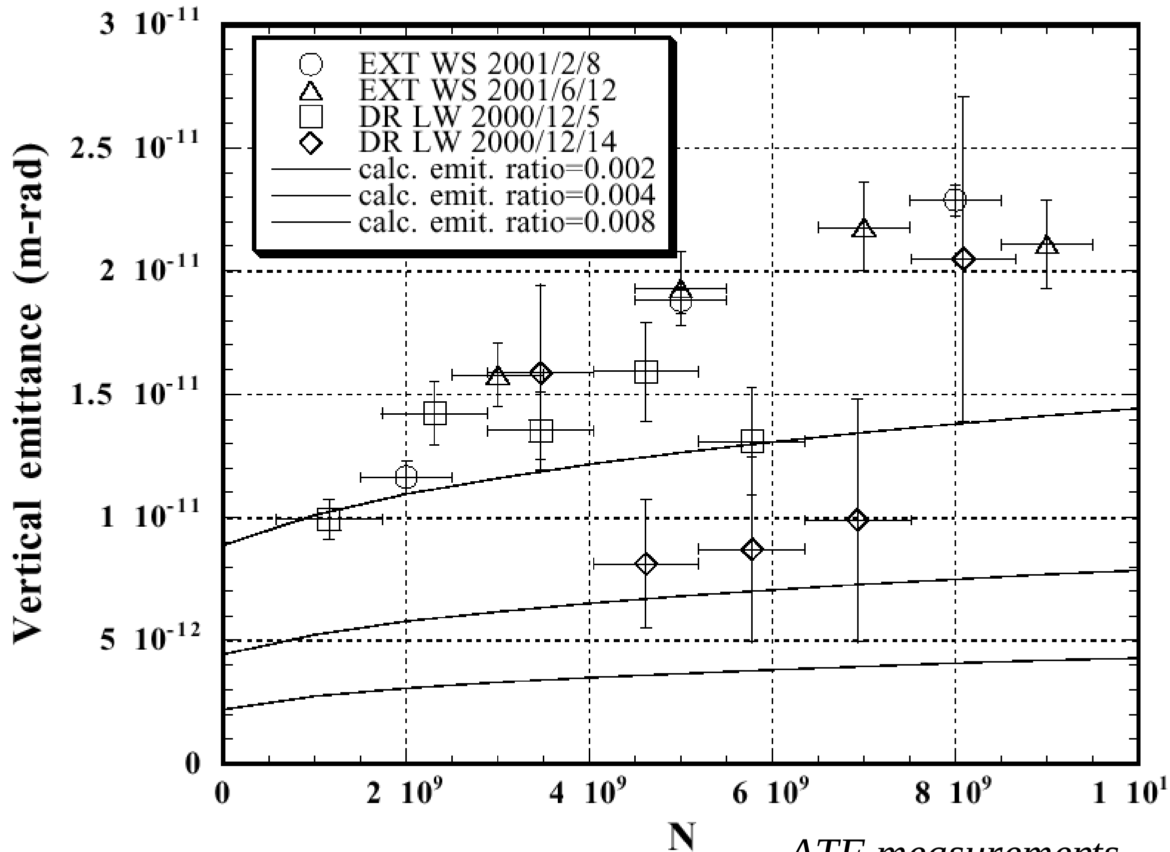
• Measure tune shift, decoherence, and phase space distortion with pulsed bump.

Intra-beam scattering

- Measure σ_E/E as σ_y (and σ_x) are varied by coupling; measure σ_x, σ_y, and σ_E/E as a function of bunch current.
- Discrepancy of ATF IBS measurements with Piwinski, Raubenheimer, and Bjorken-Mtingwa theory (measurements ≈ 2 to $1.5 \times$ theory. Theory needs to be reconciled with observations.
- Some observations in ALS. More quantitative comparisons with theory needed. Further experiments in ALS may be difficult or not possible with recent installation of "superbends"
- No other suitable electron (*i.e.*, flat-beam) machines exist, yet (CESR-c can be used).

$$\frac{1}{T_p} \approx \frac{r_0^2 c N}{32\gamma^3 \varepsilon_x \varepsilon_y \sigma_s (\sigma_p / p)^2} \left(\frac{\varepsilon_x \varepsilon_y}{\langle \beta_x \rangle \langle \beta_y \rangle} \right)^{1/4} \ln\left(\frac{\langle \sigma_y \rangle \gamma^2 \varepsilon_x}{r_0 \langle \beta_x \rangle} \right)$$

$$\frac{1}{T_{x,y}} \approx \frac{\sigma_p^2 \langle \mathcal{H}_{x,y} \rangle}{\varepsilon_{x,y}} \frac{1}{T_p}$$



ATF measurements

Space charge tune shift

- Present in ATF and ALS at level of LC damping rings and at somewhat lower level in KEKB LER.
- Increased tune footprint may lead to particle loss.
- Single-bunch lifetime tune scan, and comparison with simulation, may be the best way to determine whether space charge tune shift is a problem for damping rings.
- Can be checked in CESR-c at low energy.

Local coupling (Derbenev) technique for reducing space charge effects

- Thorough particle tracking with space charge and optics errors is needed.
- Is there a long transfer line somewhere where this could be tested?

Demonstration of required ε_y

- Nearly achieved in ATF.
- Demonstration of continuous operation with low ε_y is needed! Continuously operating emittance diagnostics are essential!
- Not likely to be achieved in any other existing machine.
- Operating emittance ratio is below LC DR specs for several operating machines. These demonstrate that required *coupling* can be maintained.
  - Better than TESLA DR spec: NSLS X-ray, Spring-8, MAX II, NSLS VUV, ESRF (in machine studies)
  - Better than NLC MDR spec: all of the above, ESRF (in operation), LNLS, CESR, PLS

Electron cloud instability

- Simulations needed for LC DR chambers.
- Excellent relevant data from PEP-II LER, KEKB LER, APS,… already exists.

Fast ion instability

- Experimental data exists for ALS, PLS,… which requires comparison with LC DR parameters.

Control of circumference

- Requires a dedicated but straightforward experiment on a machine with a long enough straight for the installation of a chicane.

Beam size measurement techniques

- ATF is the *only* existing machine with ε_y approaching NLC MDR and TESLA DR requirements.
- Faster (higher optical power) laser wire technique for stored beams.
- Understand limitations of interferometer technique.
- Is ALS X-ray optical technique adaptable to ATF?

Impedance-driven collective effects

- LC DR regime similar to existing machines (SR light sources, B-factories, LEP).

Beam diagnostics: ATF laser wire (Y. Honda)

7.5 um waist size; laser intensity must be improved for fast scans