Accelerator R&D Opportunities:

Damping Rings, Beam Delivery, and Interaction Region

J. Rogers, Cornell University

- Emphasis on projects with high priority which need attention.
- Please also see detailed list compiled by Tom Himel, *et al*. (http://www-project.slac.stanford.edu/lc/Project_List/intro.htm)

Functions of the LC damping rings

- **Damp the emittance** of the beam from the electron and positron sources prior to injection into the linac
- Damp the jitter (from the source) of the beam.
- (Delay bunches so that downstream feedback systems have time to compensate for bunch errors).

Design of the damping rings depends on the bunch pattern required by the linac:

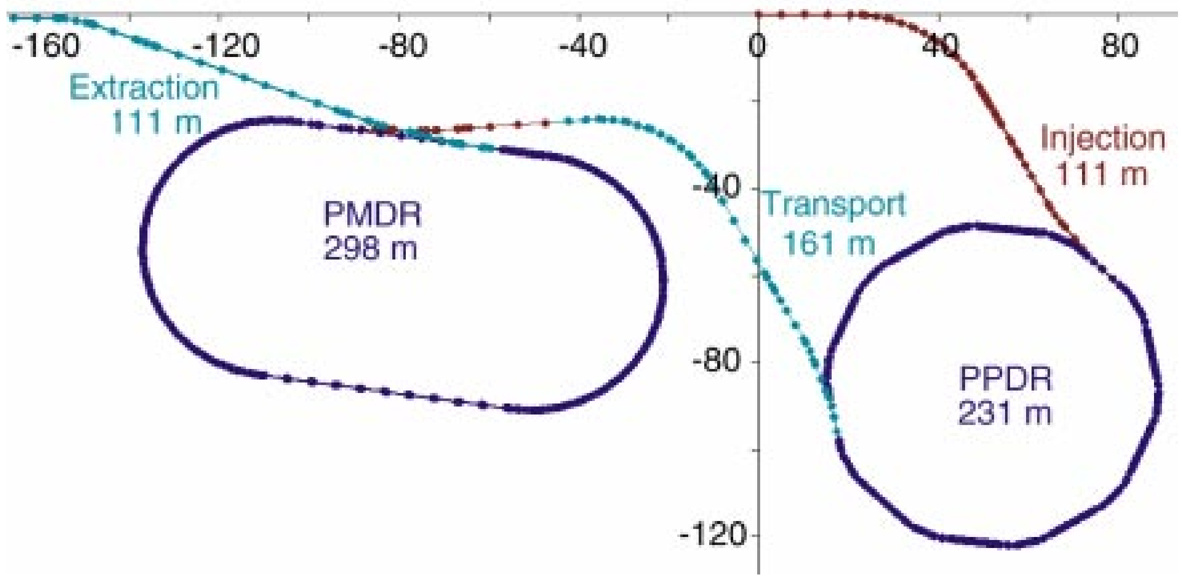
Machine	TESLA	NLC	CLIC
number of bunches per pulse	2820	192	154
bunch spacing (ns)	337	1.4	0.67
bunch train length (μs)	950	0.267	0.102
pulse repetition rate (Hz)	5	120	200

NLC: train length·c = 80 m. 3 trains fit into a small DR.

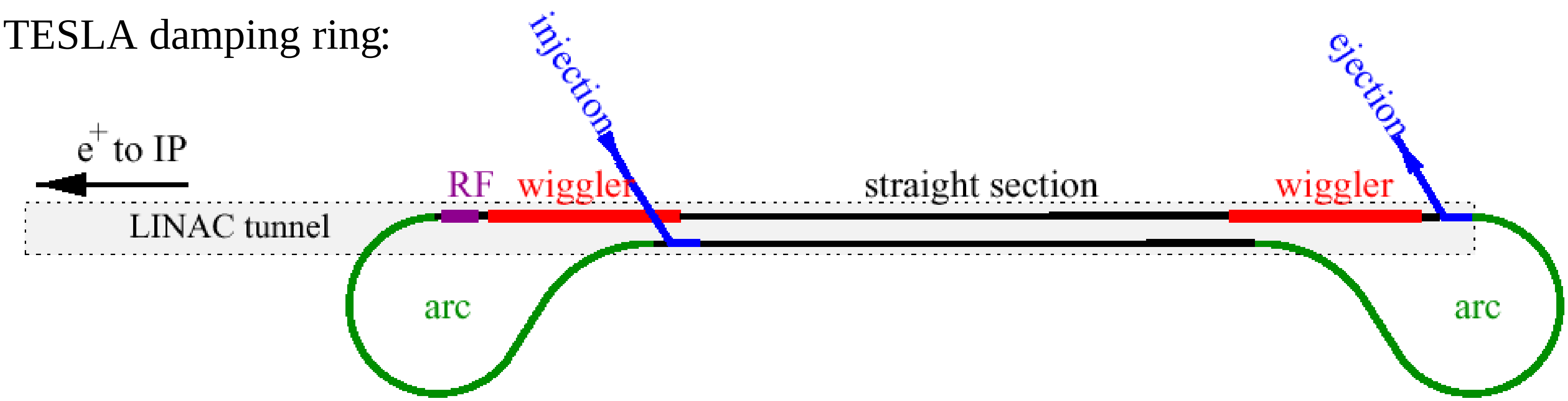
TESLA: train length·c = 280 km. Will *not* fit into a DR. Need to eject bunches individually. Bunch spacing in DR (determined by ejection kicker bandwidth) is 20 ns, so DR circumference is 17 km (beam folded on itself ×17).

Damping Rings— Introduction

NLC positron pre-damping ring and damping ring:



TESLA damping ring:

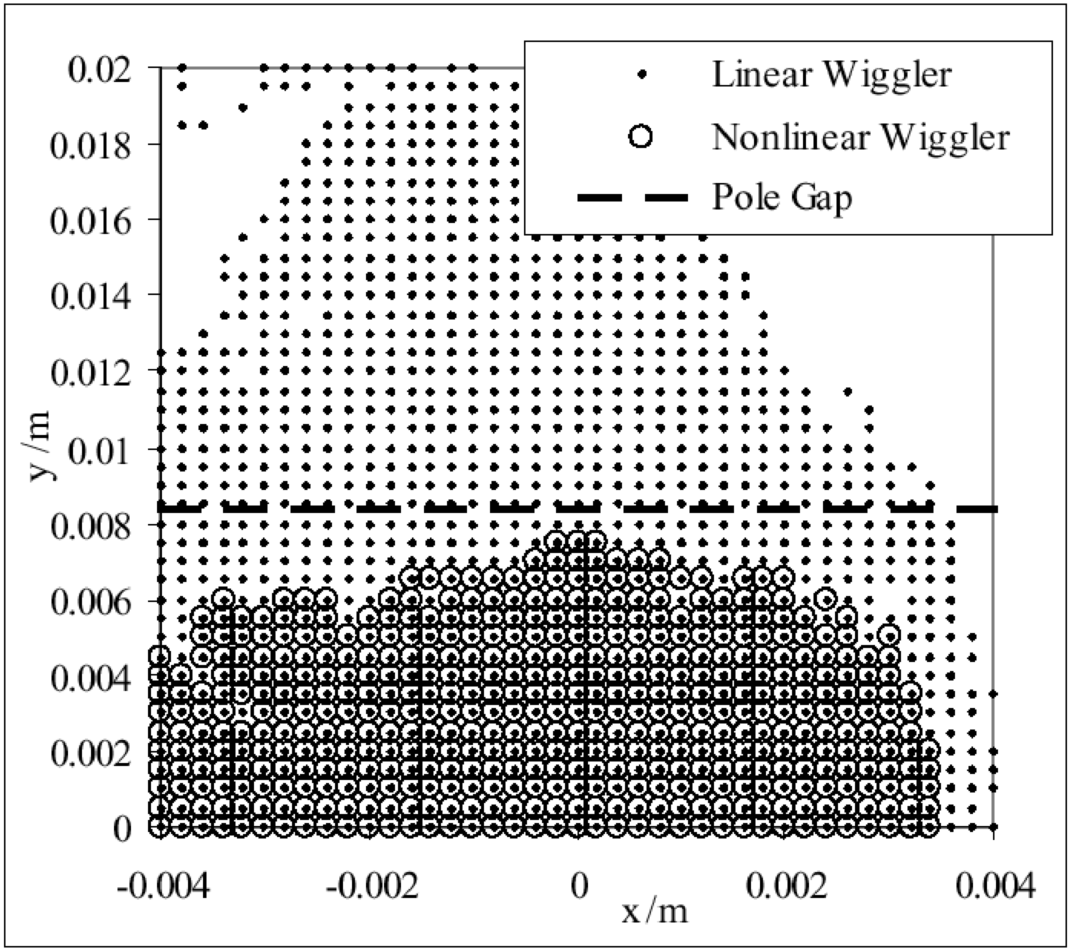


• Damping wiggler prototype and test. High priority.

The linear collider damping rings will be loaded with damping wigglers. Even small magnetic nonlinearities will reduce the useable aperture of the machine. *(Figure: A.Wolski, J.N. Corlett, Y. Wu, PAC01)*

Wiggler designs exist for NLC and TESLA, but no prototypes or analyses of tolerances.

Permanent magnet and superconducting wigglers are being considered.

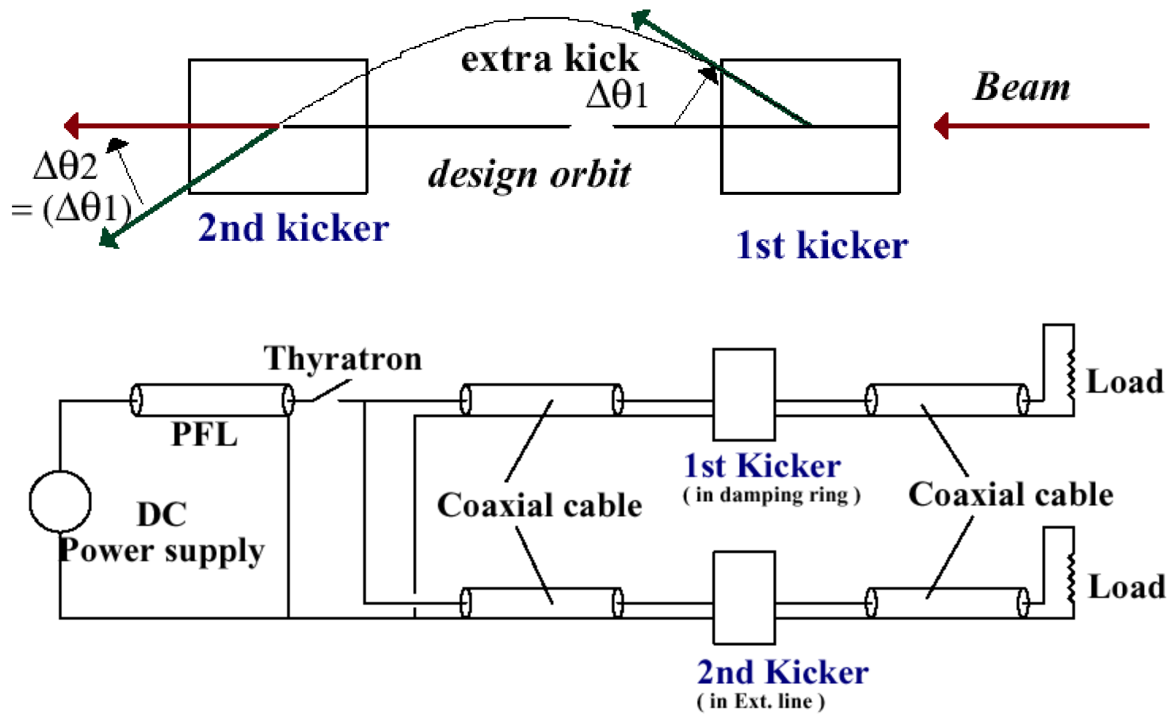


• Extraction kicker and kicker compensation development. High priority.

TESLA must extract individual bunches from the damping ring, which has a bunch spacing of 20 ns. Fast rise- and fall-time required from extraction kicker.

NLC and JLC extract long trains of bunches. Extraction kicker must be very flat.

For any project extraction kicker must be very reproducible.



ATF prototype extraction kickers *(T. Imai et al., 2000)*

Component/subsystem development

• Beam size monitor development. High priority.

Laser wire *(figure: Y. Honda)*

Optical interferometer

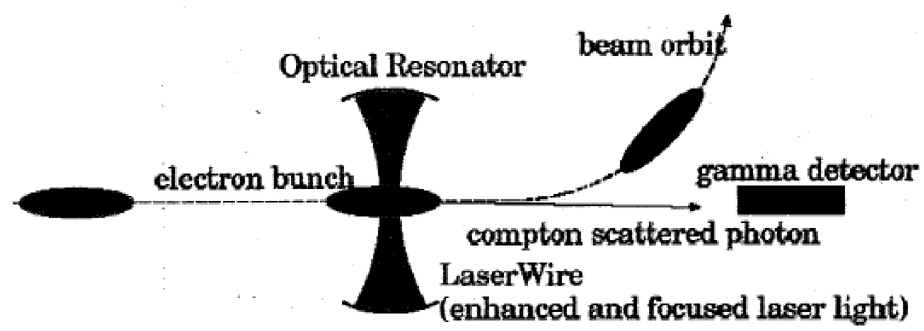
X-ray synchrotron radiation monitor

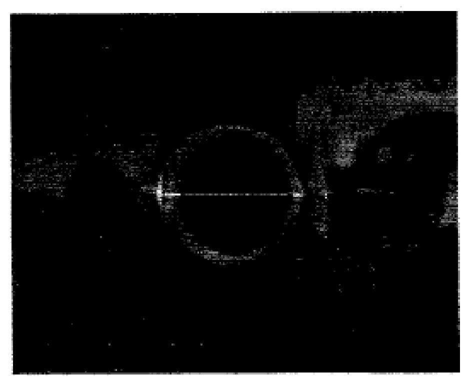
Optical diffraction radiation monitor

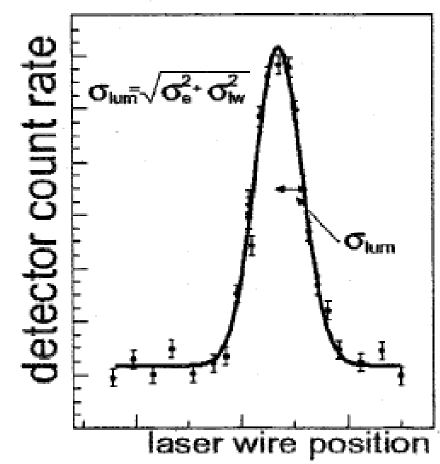
Other ideas?…

• Polarimeter for the damping ring. Medium priority.

Could be combined with laser wire monitor.







Damping Rings— R&D

Computer simulation and machine experiment

• Nonlinear, wiggler-dominated beam dynamics. High priority.

Particle-tracking simulations needed to maximize dynamic aperture, minimize emittance growth. CESR-c will be the first storage ring in which synchrotron radiation damping is dominated by wigglers, and experiments will be done here.

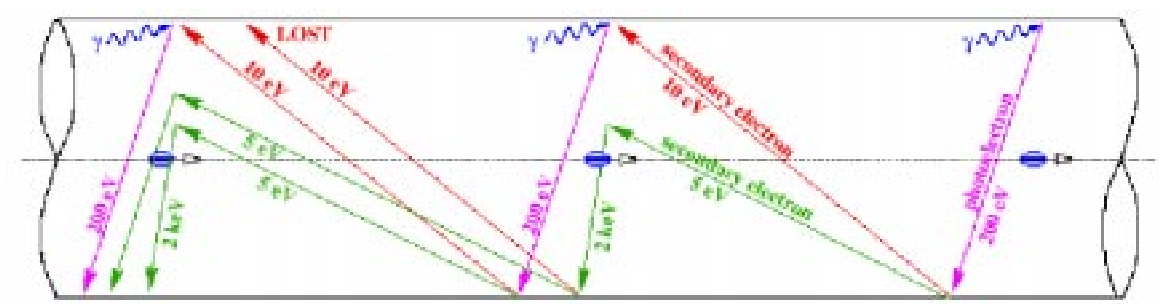
• Dispersion and coupling correction algorithms. High priority.

Beam-based alignment of magnets and beam position monitors will be required. Ground motion and temperature changes move magnets, requiring continuous correction of the orbit and coupling. The most obvious alignment/correction algorithms sometimes fail to converge. Requires careful thought, simulation, and test.

•Electron cloud instability and tune spread (e^+ rings). High priority.

Electron cloud results in a very strong multi-bunch instability, single-bunch instability, and tune spread. Requires improved simulation, remediation, and monitoring.

F. Ruggiero, CERN



Damping Rings— R&D

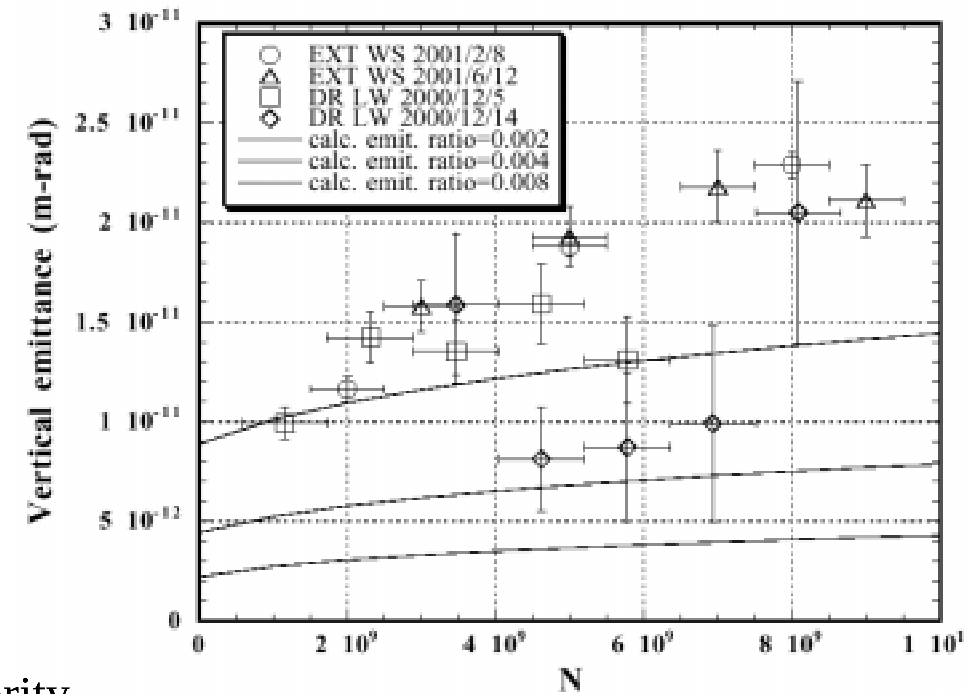
Computer simulation and machine experiment

• Fast ion instability, ion trapping and tune spread (e^- ring). High priority.

Ions can be trapped by the beam, creating a large tune spread and a fast multi-bunch or single-bunch instability. Much better simulation and further beam experiments are needed.

• Intrabeam scattering. Medium priority.

Intrabeam scattering increases the vertical emittance. Experiments in ATF may show stronger IBS than predicted by theory. Could require changes in NLC MDR design. Experiments in other rings are needed.

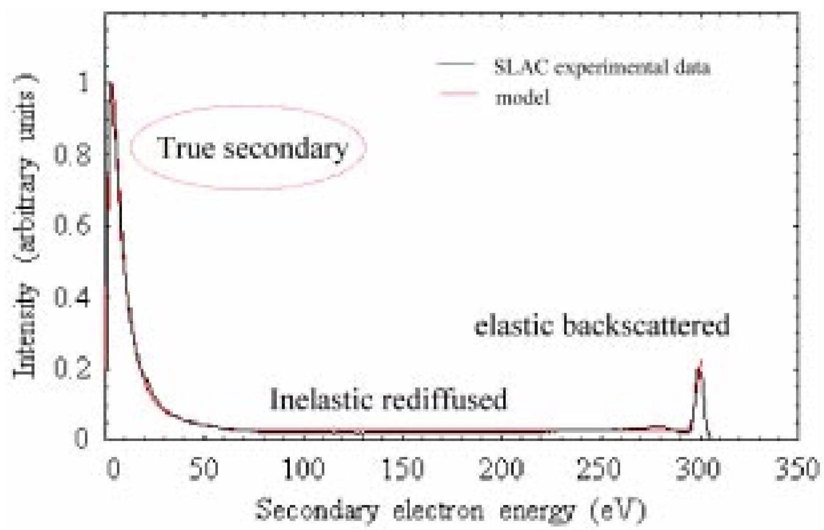


• Space charge tune shift. Medium priority.

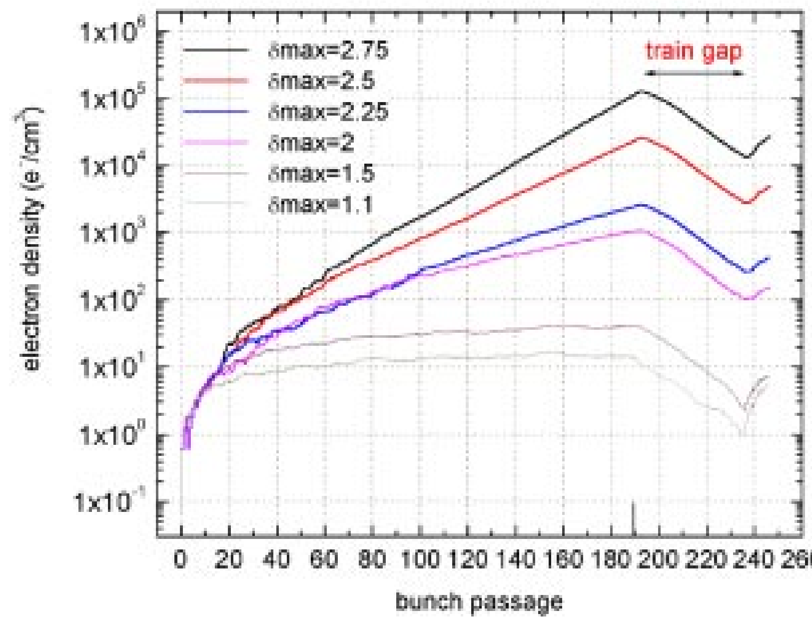
Beam self-defocusing produces a tune spread. Simulations needed to find effect on emittance and particle loss and to determine optimum tunes. Experiments desirable.

• Suppression of the electron cloud. High priority.

Electron density grows exponentially when the effective secondary emission yield exceeds 1. Low SEY, UHV-compatible surfaces must be developed to suppress the electron cloud.



Measured SEY, high-purity Al, degreased, NaOH etched and rinsed. (R. Kirby, SLAC).



Simulation of electron density (M. Pivi, M. Furman, LC02).

Functions of the LC beam delivery system and interaction region:

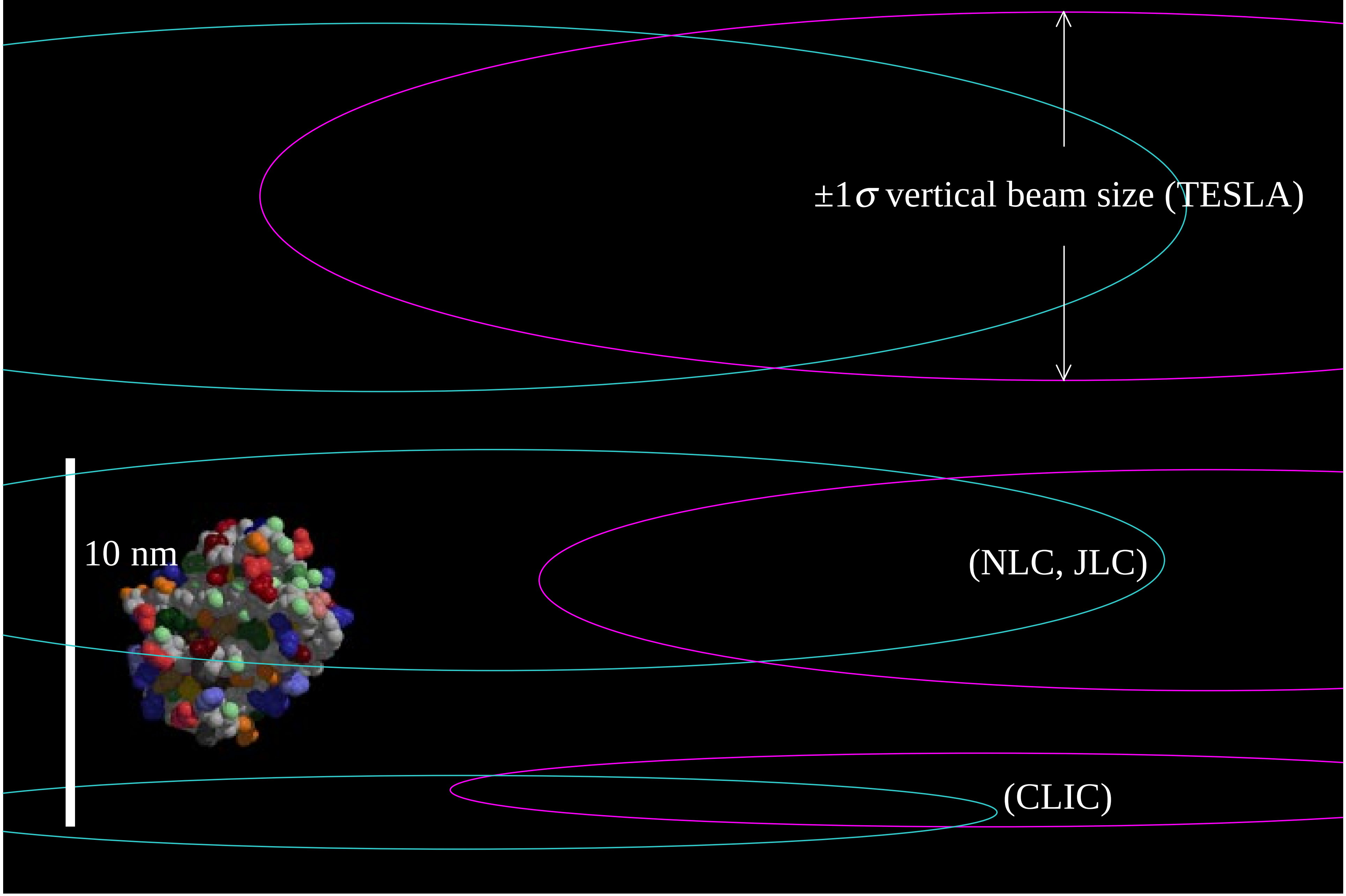
• Focus the beams to a several nanometer (vertical) size at interaction point with well-controlled aberrations.

• Keep beams in collision in the presence of ground motion and vibration.

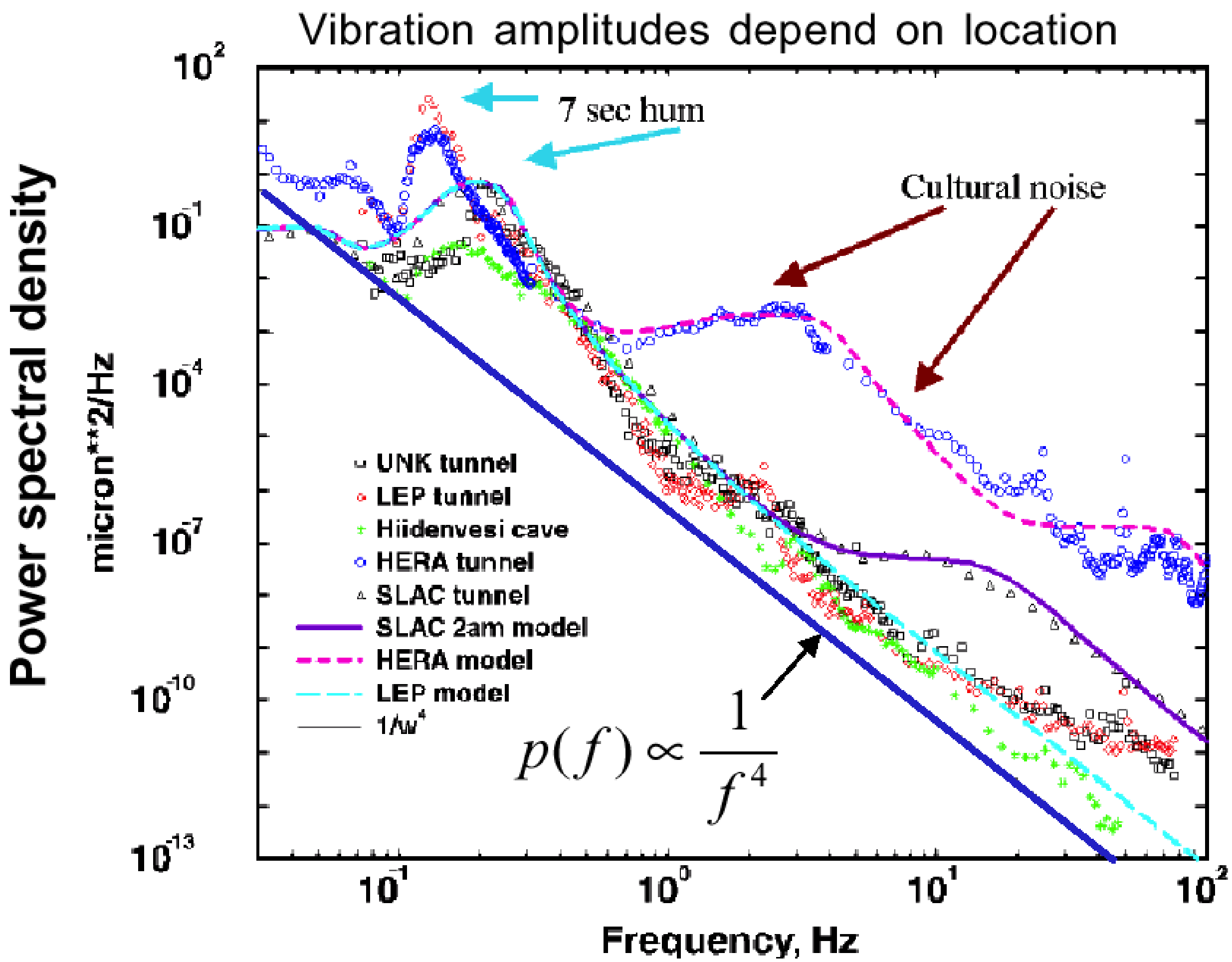
• Minimize/collimate backgrounds.

• Monitor beam, luminosity, polarization.

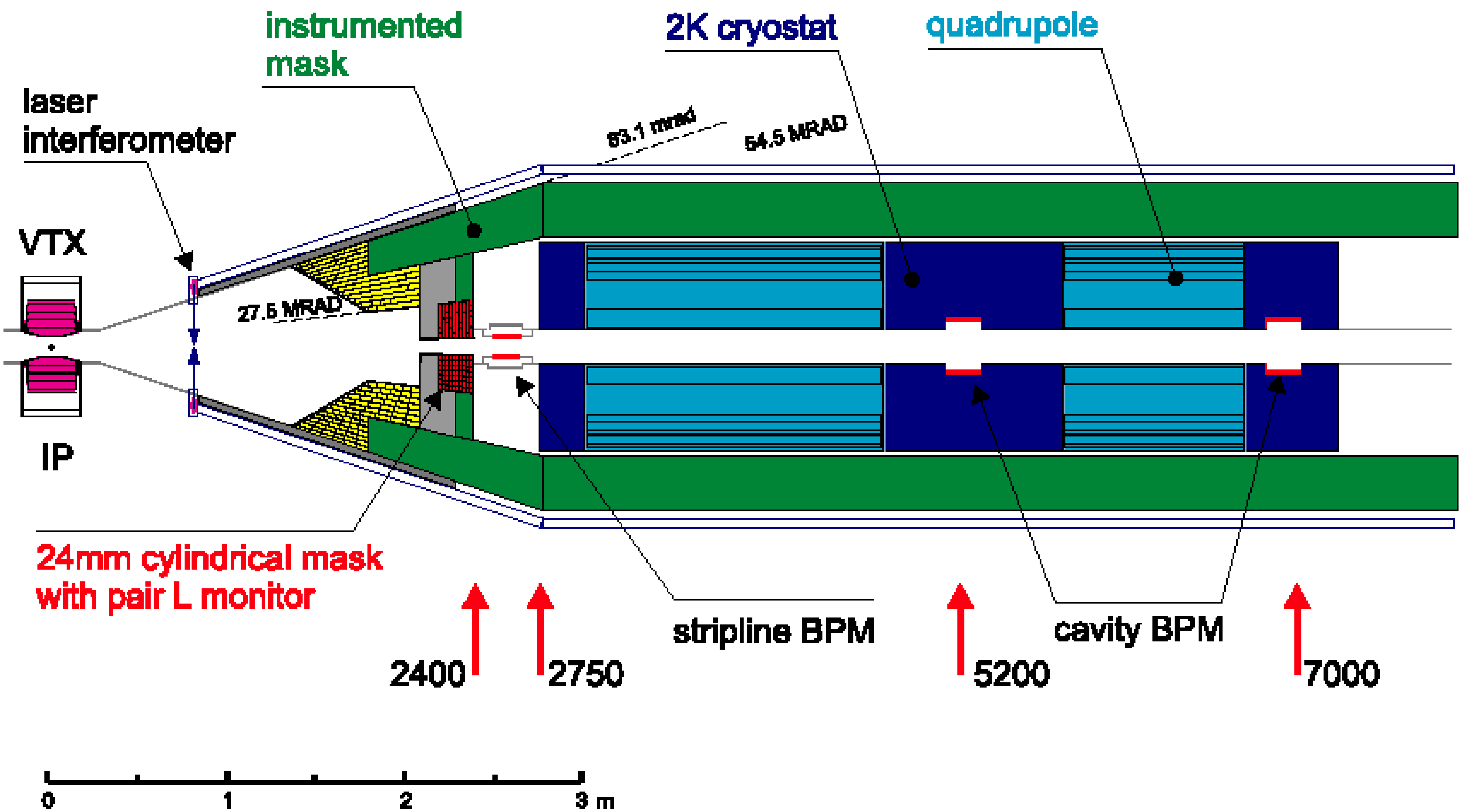
Beam Delivery System & Interaction Region— Introduction



Ground motion *(data and fits: A. Seryi)*

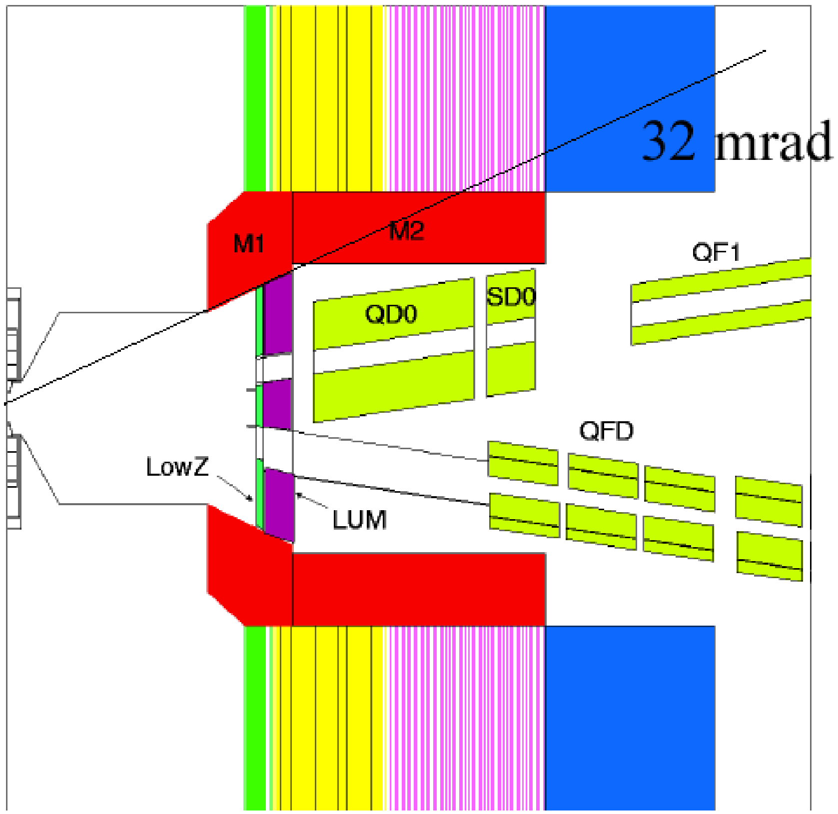


TESLA interaction region

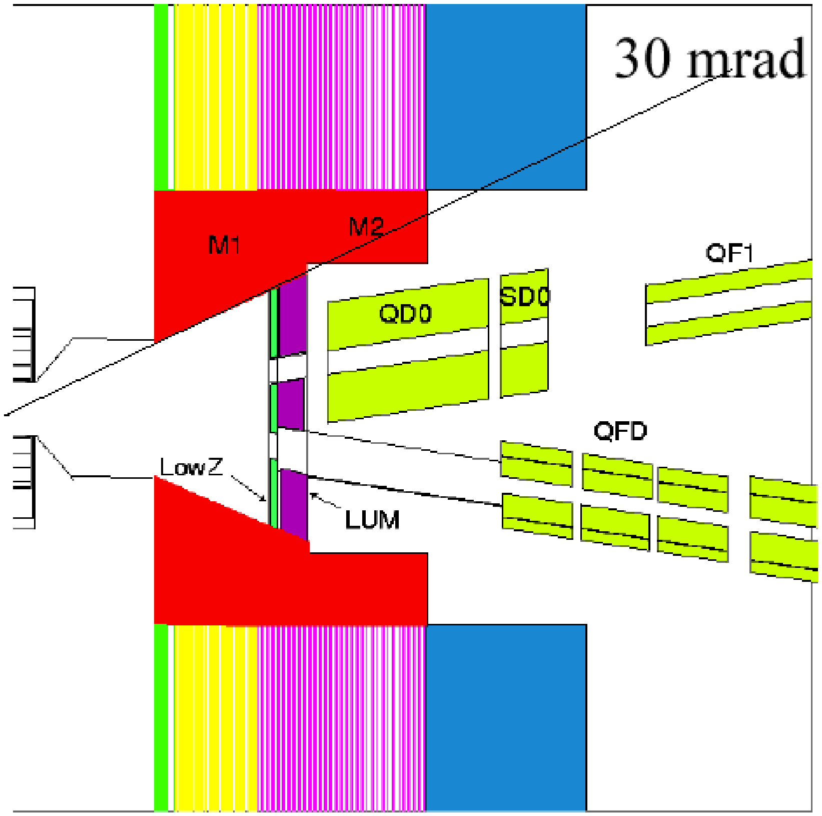


NLC interaction region

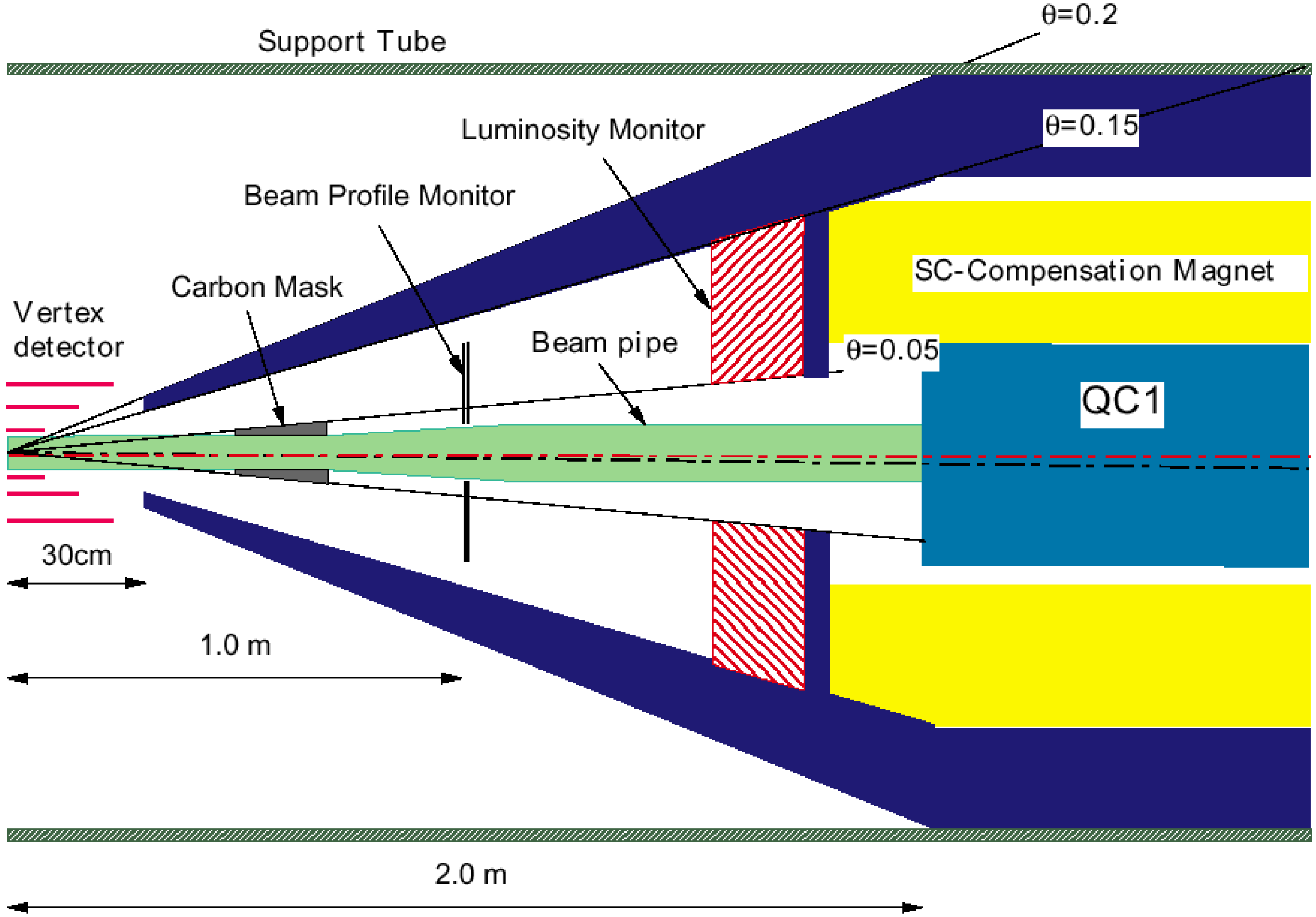
Large Det.- 3 T



Silicon Det.- 5 T



JLC interaction region

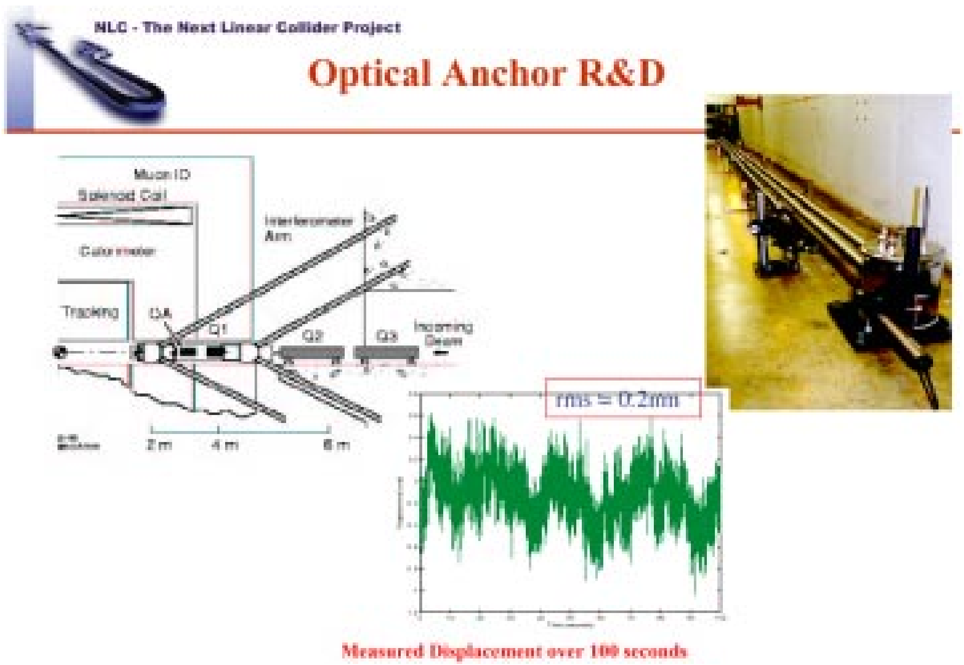


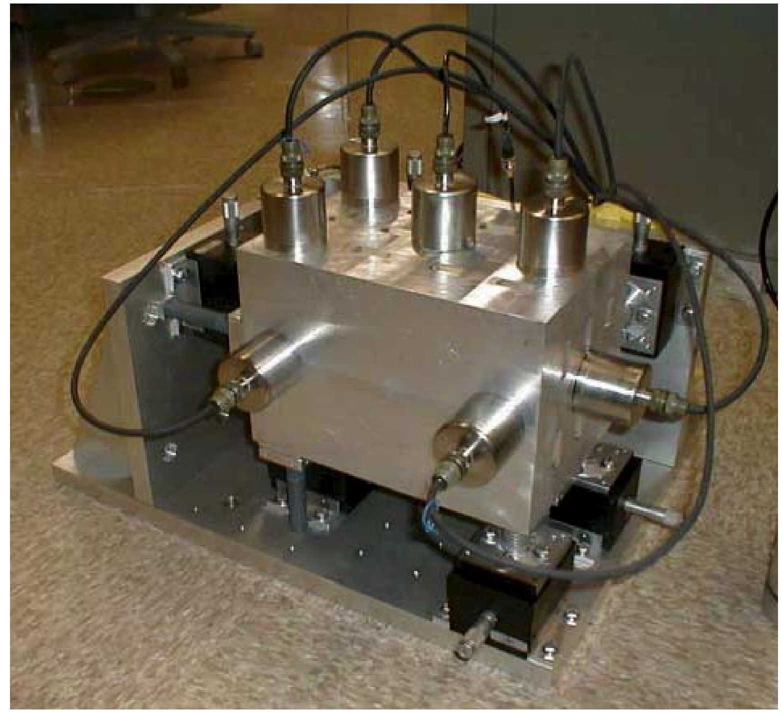
Component/subsystem development

• IP magnet stabilization. High priority.

Inertial stabilization and "optical anchor" considered. Preliminary R&D has started.

(T. Markiewicz, Snowmass 2001)





Inertial stabilization test (J. Frisch, LC02)

• Final doublet magnets. Medium priority.

Permanent magnets (NLC): compact, allow exiting beam to pass; no internal source of vibration; few external connections; fixed field.

Superconducting magnets (TESLA): Adjustable; large bore; massive. Is LHe flow a source of vibration?

Fe/Cu magnets (JLC): Adjustable; massive; requires cooling water (source of vibration?); requires shielding from detector solenoid.

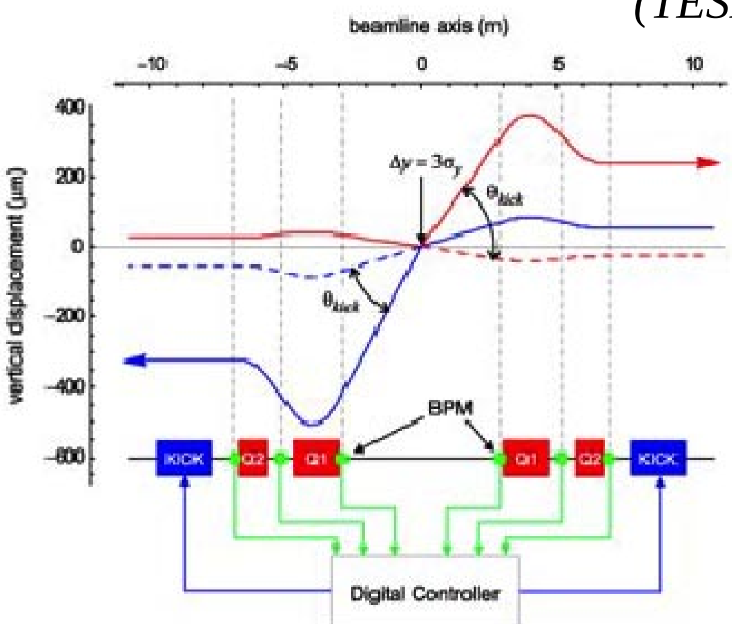
Mock magnets for vibration testing and full design/prototypes needed.

Instrumentation development

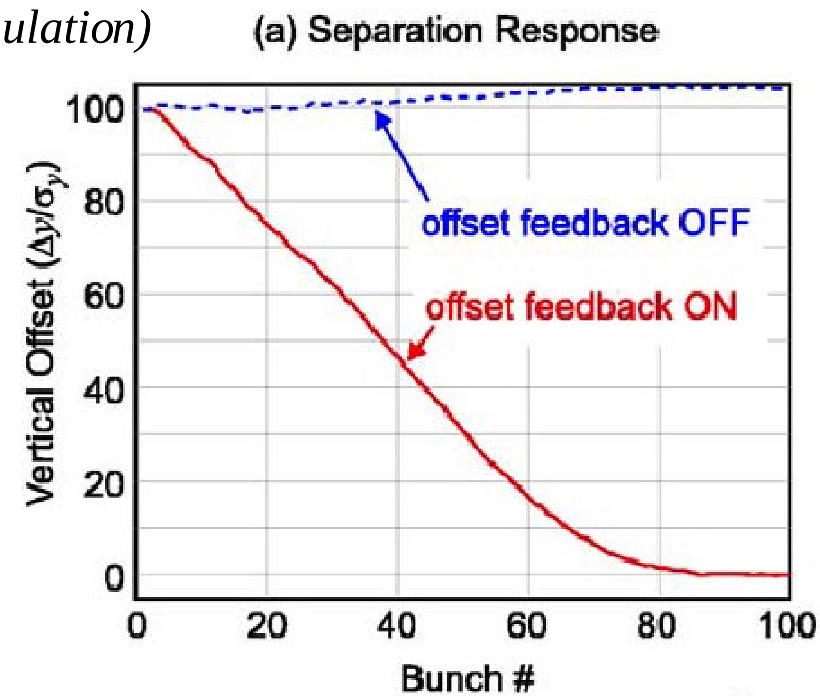
Beam feedback system design. High priority.

NLC and JLC: short (8 ms) interval between trains, and short train. Use train by train feedback (with possible intra-train feedback).

TESLA: long (200 ms) interval between trains, but long train. Use intra-train feedback.



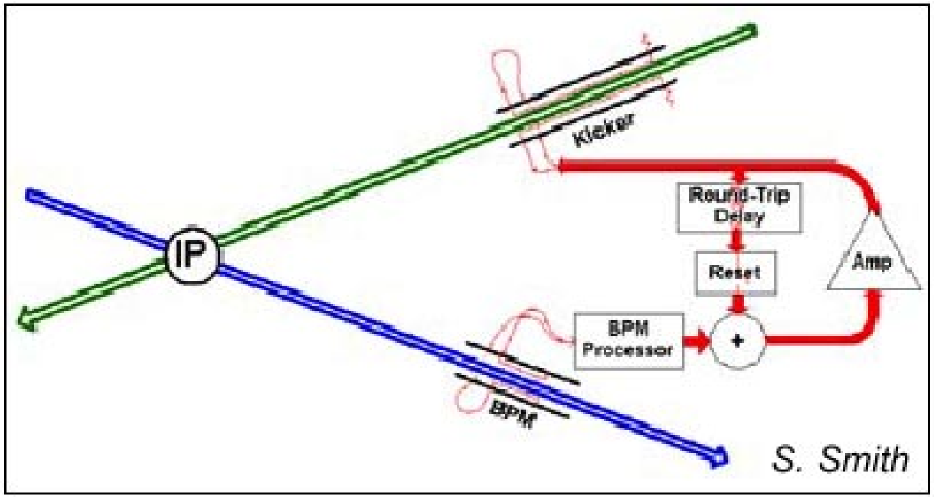
(TESLA simulation)



Instrumentation development

Status of NLC fast (intra-train) feedback

(reported by Philip Burrows and Glen White,
10/5/01, CERN, see also note LCC _ 0056 03/01, Steve Smith)



Initial offset	Start of steering	Full luminosity	
8 nm (3 σ_y)	after 36 ns	after 42 ns	(16 % of bunches)
100 nm (37 σ_y)	after 36 ns	after 120 ns	(45 % of bunches)

Beneficial for NLC and CLIC as well but not sufficient.

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Instrumentation development

• Luminosity monitor design. High priority.

Suppression of secondaries from pairs hitting luminosity monitor is a major issue. Can the monitor be fast enough to measure the luminosity from each collision?

• IP beam size monitor. High priority.

Probably based on Compton scattering. How can this be incorporated into the IR/detector geometry?

• Polarimeter design. Medium priority.

Ideally want to measure polarization both before and after IP.

Monte Carlo optimization of IR design

- Shielding and absorber design. High priority.

Backgrounds produced by the machine in the IR:

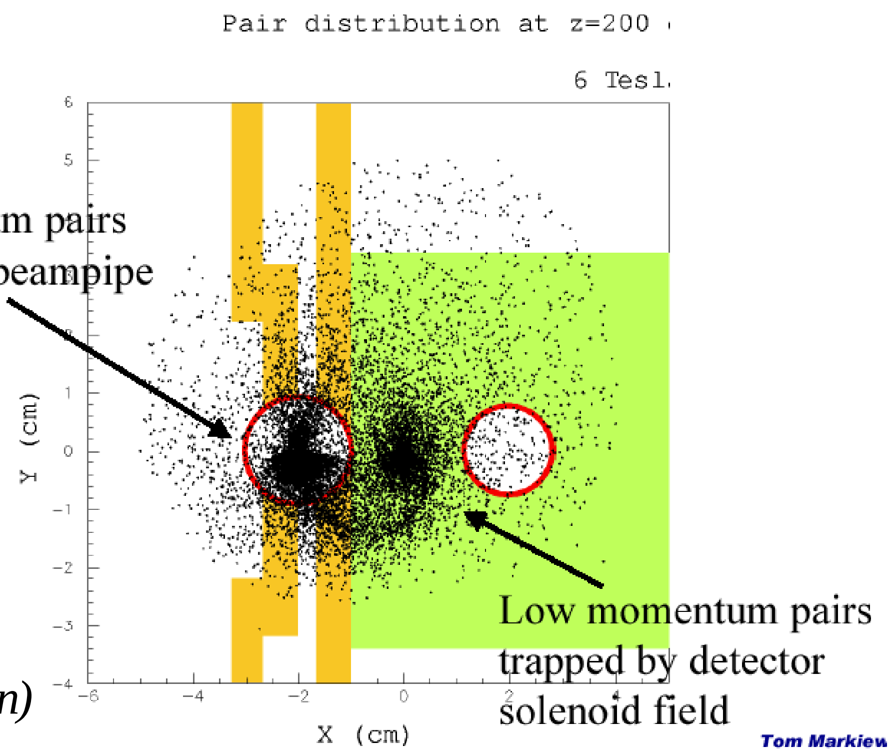
Synchrotron radiation from beam “tails” in IR quads;

Pairs produced in field of opposing bunch during collision;

Hadrons produced by beam-beam gamma-gamma processes;

Beamstrahlung photons;

Secondaries (photons, neutrons, electrons) produced when pairs hit material near IP.



(T. Markiewicz, LC02 presentation)