Introduction to e+e- LC IR Issues

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Snowmass 2001

02 July 2001

Basic Issues

Bunch Structure:

	TESLA-500	NLC-500H	CLIC-3TeV
τ_B	337 ns	2.8ns/1.4ns	0.67 ns
N_B	2820	95/190	154
f	5 Hz	120 Hz	100 Hz

⇨Crossing Angle, Detector Effects, Feedback Design, Extraction

Beam-beam effects & Machine Backgrounds

N	2.0×10^{10}	0.75×10^{10}	0.4×10^{10}
σ_z	300 µm	110 µm	30 µm

⇨IP Backgrounds, Pinch, Disruption, Synchrotron Rad, Neutrons

Small spot sizes:

σ_x	550 nm	245 nm	43 nm
σ_y	5 nm	2.7 nm	1 nm

⇨Control position & motion of final quads and/or the beam

NLC/TESLA Beam-Beam Comparison

$$D_Y = \frac{2 r_e N_e \sigma_Z}{\gamma \sigma_Y (\sigma_X + \sigma_Y)}$$

$$Y = \frac{5 \gamma r_e^2 N_e}{6 \alpha \sigma_Z (\sigma_X + \sigma_Y)} = \gamma \frac{B_{bunch}}{B_c}$$

	NLC500H	TESLA500
D_y	14	25
Y	0.11	0.06
n_γ	1.17	1.6
δ_b	4.6%	3.2%
H_D	1.4	2.1
# pairs/bunch	88,000*	130,000
<E>_pair e	10.5 GeV*	2.8 GeV

* 1 TeV

N_e, σ_x, σ_y, σ_z _

More disruption for TESLA with larger luminosity enhancement (but more sensitivity to jitter) and more, but lower energy photons per bunch (but fewer bunches to integrate over)

Real results come from beam-beam sim. (Guinea-Pig/CAIN) and GEANT3/FLUKA

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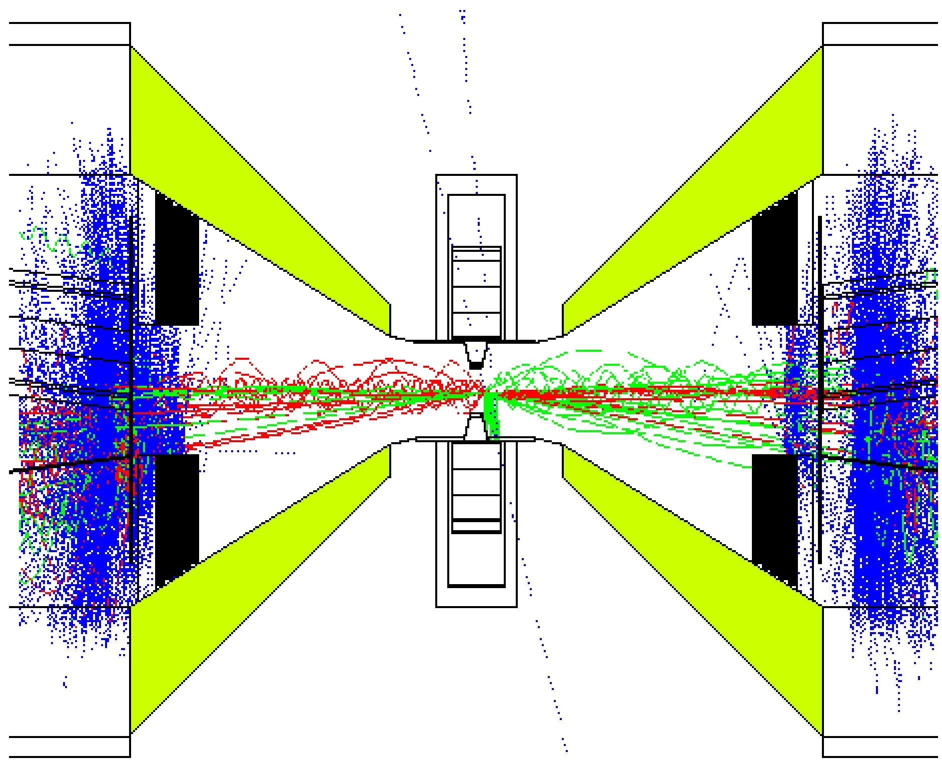
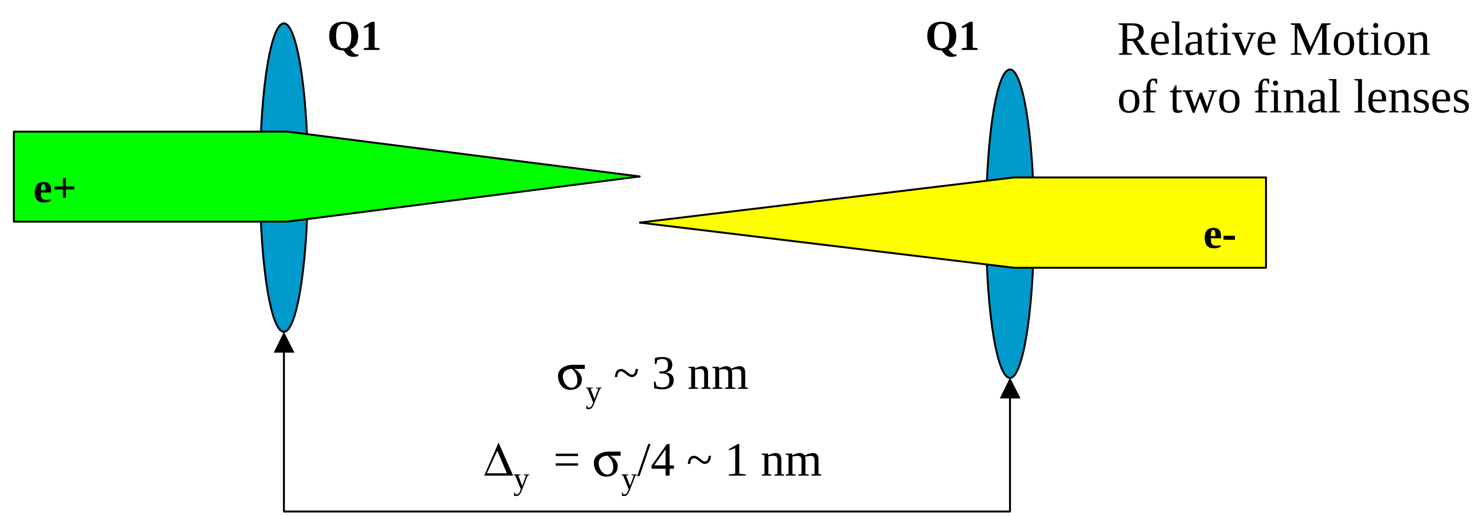
e+,e- pairs from beams. $\gamma\gamma$ interactions

At NLC-1000: 44K per bunch @ <E>=10.5 GeV (0.85 W)



Basic Issue #3

Colliding Small Beam Spots at the IP



Control position & motion of final quads and/or position of the beam to achieve/maintain collisions

- **Get a seismically quiet site**
- **Don’t screw it up: Pumps, compressors, fluids**
- **Good magnet and detector engineering: Light, stiff Q1 in a rigid detector**
- **Tie to “bedrock”: get lenses outside detector as soon as possible**

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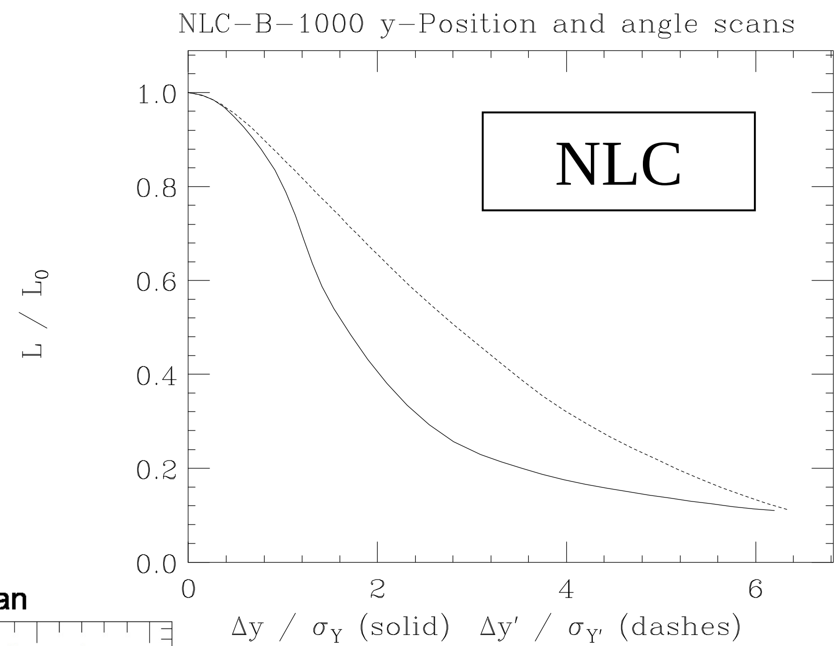
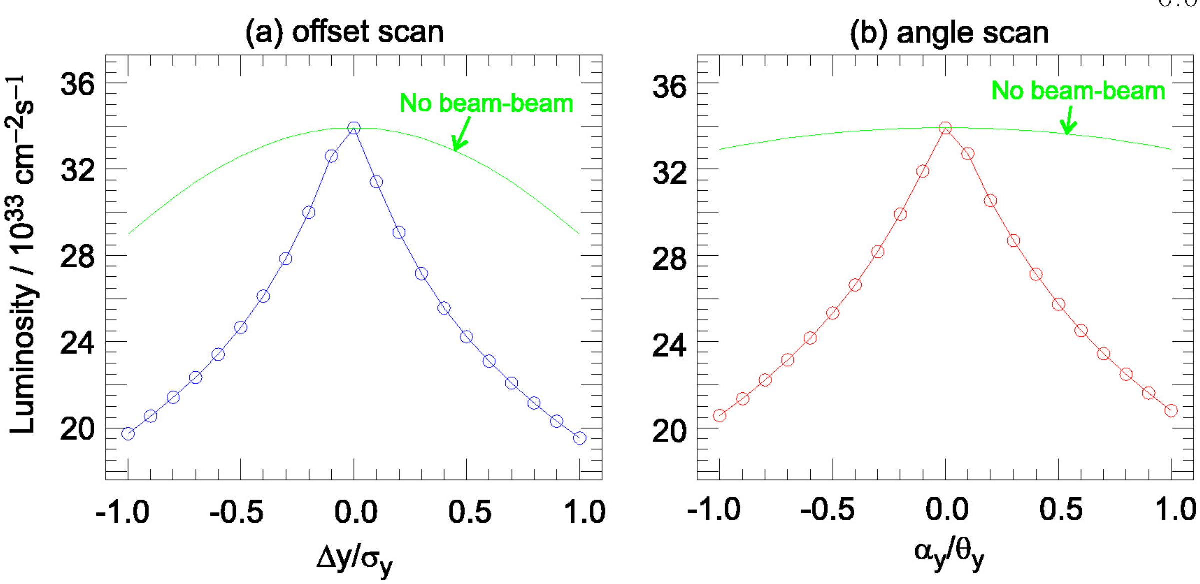
Luminosity Loss vs. Position & Angle Jitter



TESLA

Larger D_y leads to

sensitivity ~0.1σ ~0.5nm



Luminosity Stabilization

Performance of ALL LCs based on feedback systems such as that developed at SLC

"SLOW" feedback based on machine rep rate f and can handle motion of frequencies up to ~f /20 to f /60

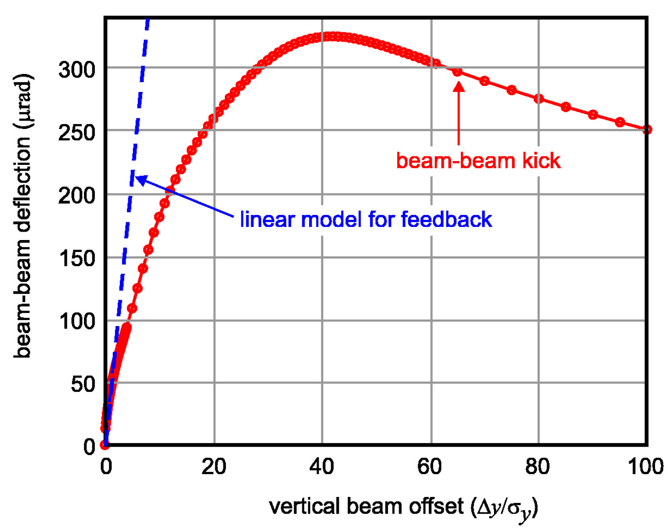
- 0.1-1 Hz at TESLA where f = 5 hz
- 2-5 Hz at NLC where f = 120 Hz

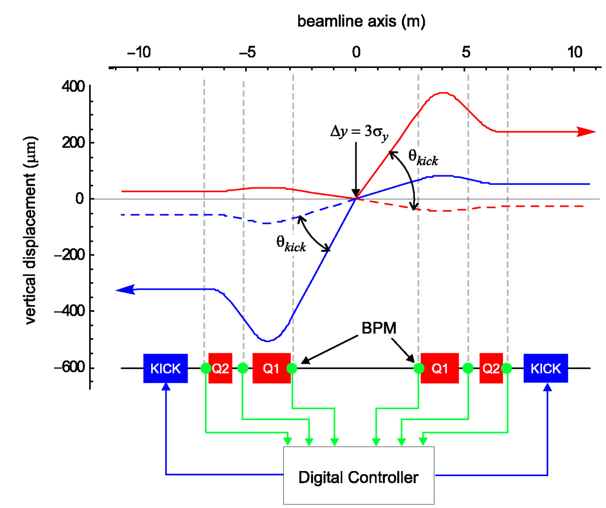
TESLA's long (2820) train of widely (337ns) spaced bunches allows the extension of the technique to frequencies up to ~100 kHz and should handle all correlated noise sources with minimal luminosity loss and little impact to the detector

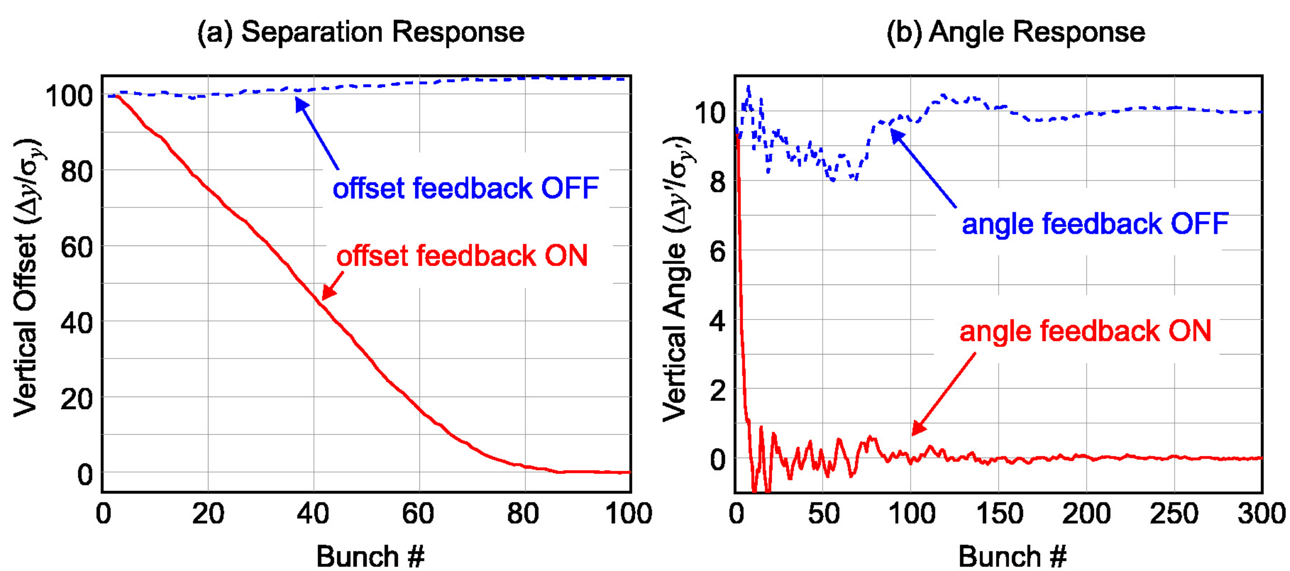
NLC relies on a variety of techniques to stabilize the collisions against jitter above the 2-5 Hz range

In 90 bunches and $\Delta L < 10\%$, bunches are controlled to $0.1\sigma_y$

Intra-train Feedback at TESLA







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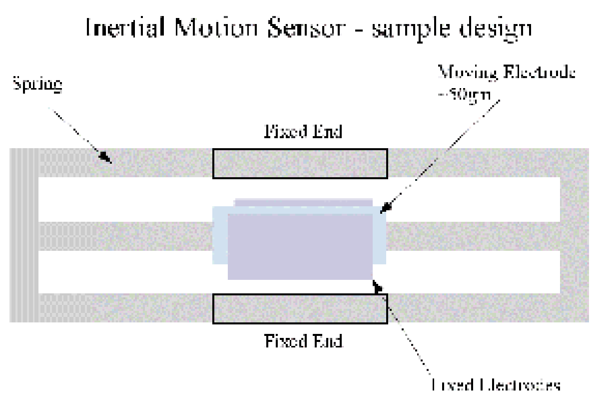
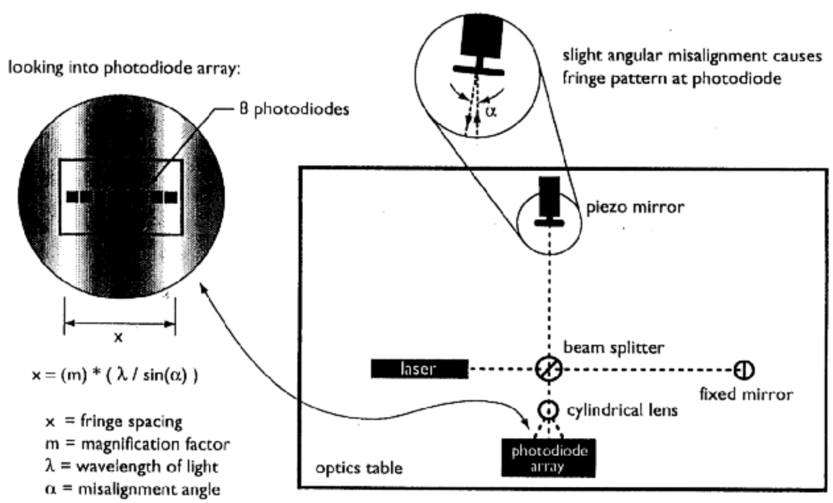
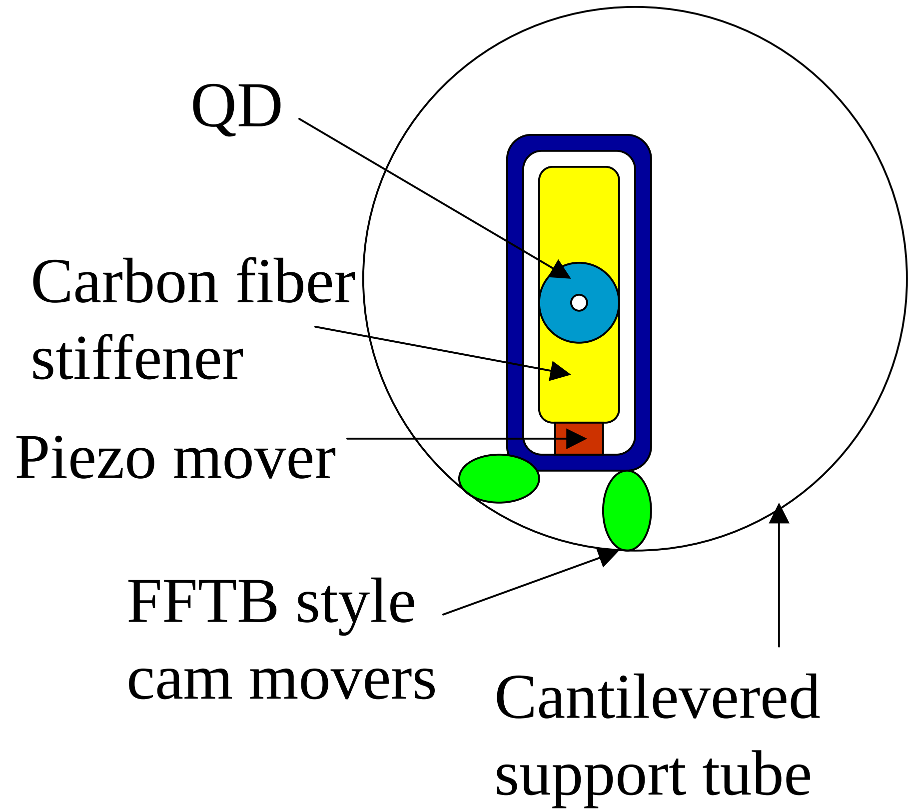
Sensor Driven Active Vibration Suppression at NLC

Inertial Capacitive Sensors

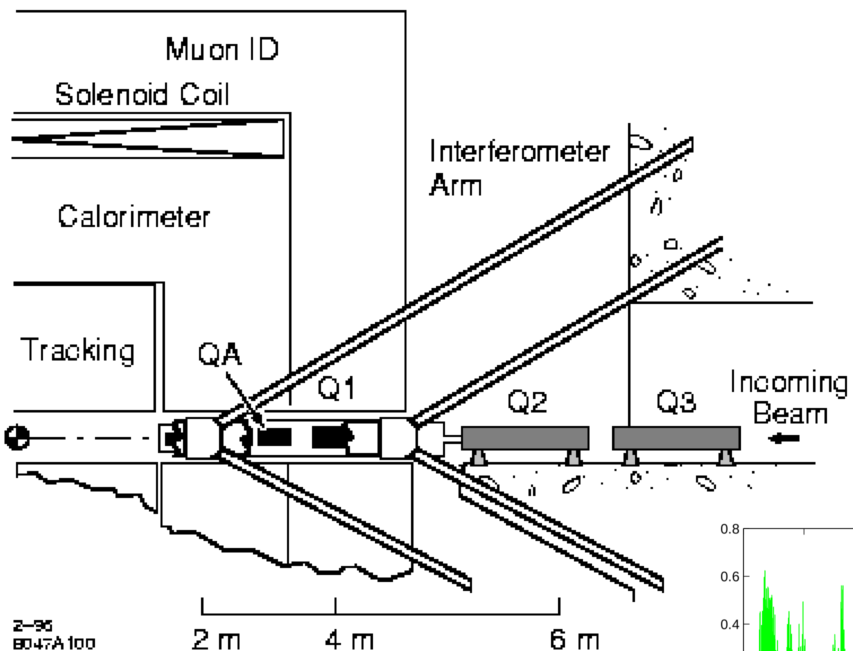


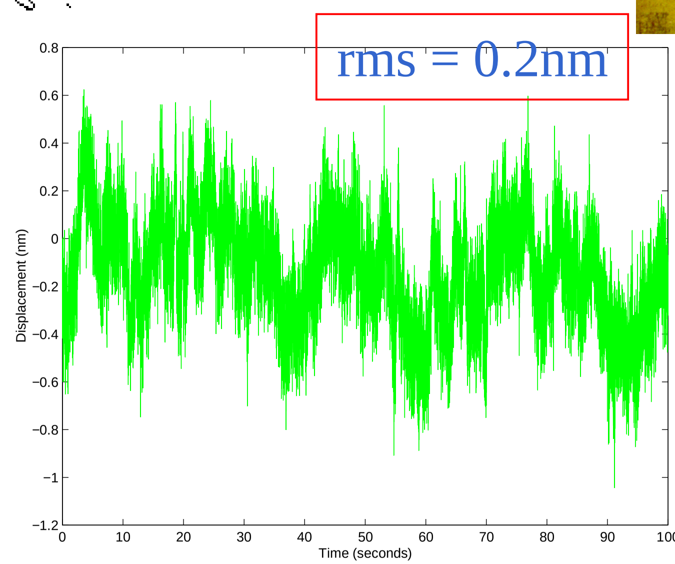
Interferometric Sensors: Optical anchor

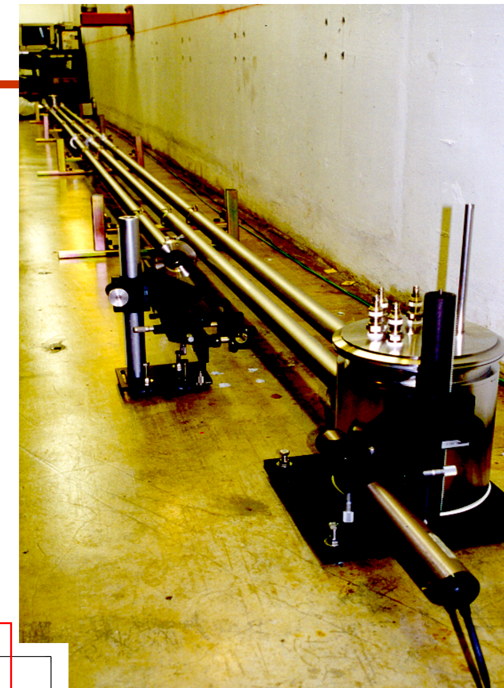




Optical Anchor R&D





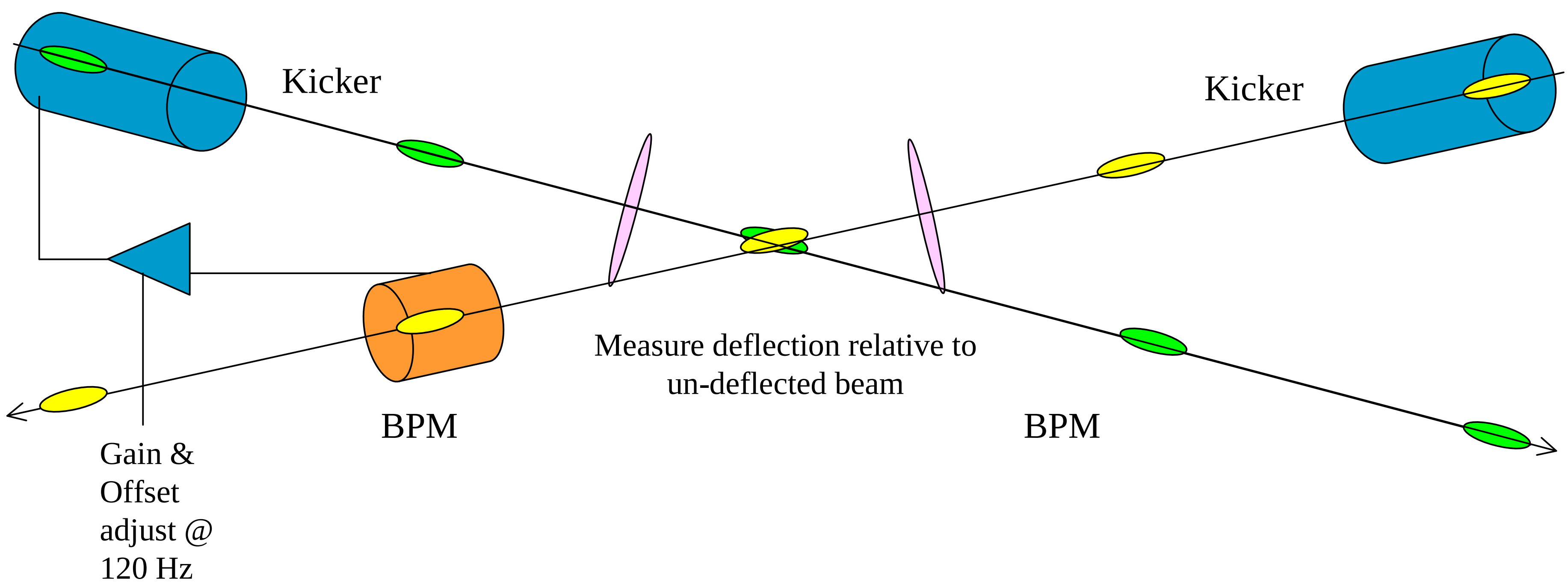


Measured Displacement over 100 seconds

Very Fast IP Feedback

Extend Intra-bunch feedback to 270ns long trains at NLC

- Simulation, Optimization, Layout
- Development of BPM sensors and low current correctors
- ASSET-like beam tests



TESLA IR Summary

- Design exploits large bunch spacing to allow axially symmetric geometry at expense of a possibly more complicated injection/extraction scheme.

- The fact that the detector typically integrates fewer bunch crossings permits larger bunch charges, given similar bunch transverse dimensions, to produce more pinch (and luminosity enhancement) at expense of more backgrounds per bunch and sensitivity to position and angle jitter, neither of which seem to be problems.

- The long trains allow for an extension of the SLC-like beam-beam feedback system to maintain collisions at 0.1σ level without significant luminosity loss and minimal impact on the detector.

NLC/JLC IR Summary

- Bunch spacing requires a 4-40 mrad crossing angle which does not have any apparent problem, permits space for a separate extraction line, is applicable to the $\gamma\gamma$ situation, and can accommodate still smaller bunch spacing if higher frequency machines (CLIC) are the path to the future.

- While the detector typically integrates a full 95/190 bunch train of backgrounds, these appear to be at a low enough level to not impact physics. Inclusion of a device with good timing resolution would further reduce the integrated backgrounds.

- The (reduced) sensitivity to jitter at the IP is handled by a combination of mechanical design, optical, inertial, and fast intra-train feedback.