NLC Vibration Program & LINX

Tom Markiewicz/SLAC

Session #9, Nanobeams 2002, Lausanne, CH

5 September 2002

Beam Delivery R&D Plan

NLC

In Progress:

- SLAC based work on inertial systems
  - Simple block & sensor (J. Frisch)
  - Long steel beam
- UBC work on Optical Anchor (T. Mattison)
- Fast Feedback demonstration in NLCTA (FONT) (G.White,S.Smith)

Think about:

- Measuring relative motion of two simple blocks

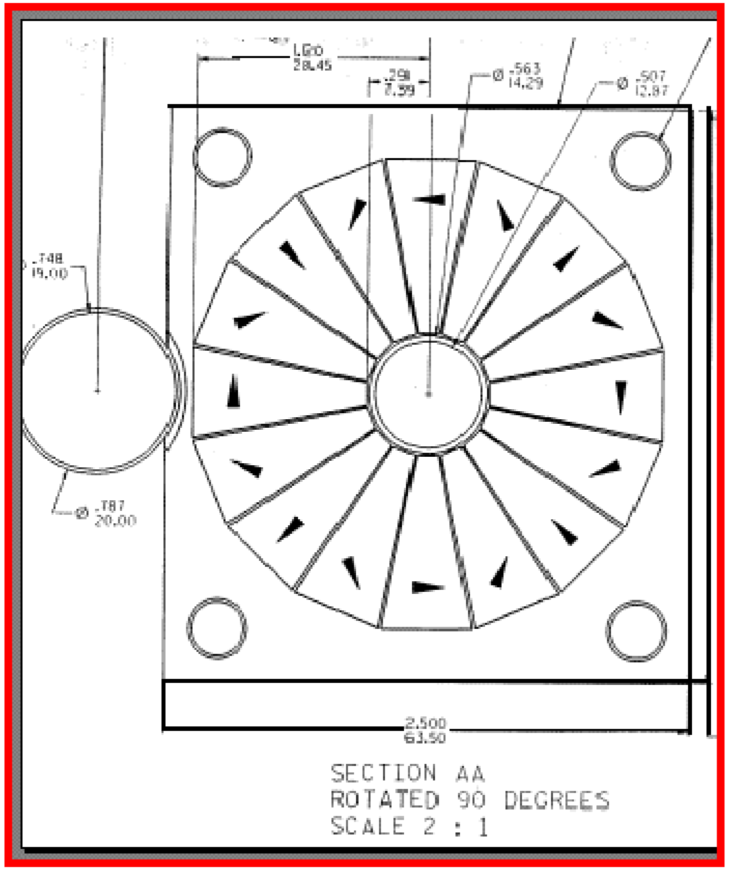
Planned:

- Realistic design of IP Girder prototype as a proof-of-principle in the stated time frame and start to lead to down-selection of options
- Discuss alternative solutions that might require longer R&D time
  - SC quad (B. Parker)
- Dovetail into LINX-like beam tests if warranted

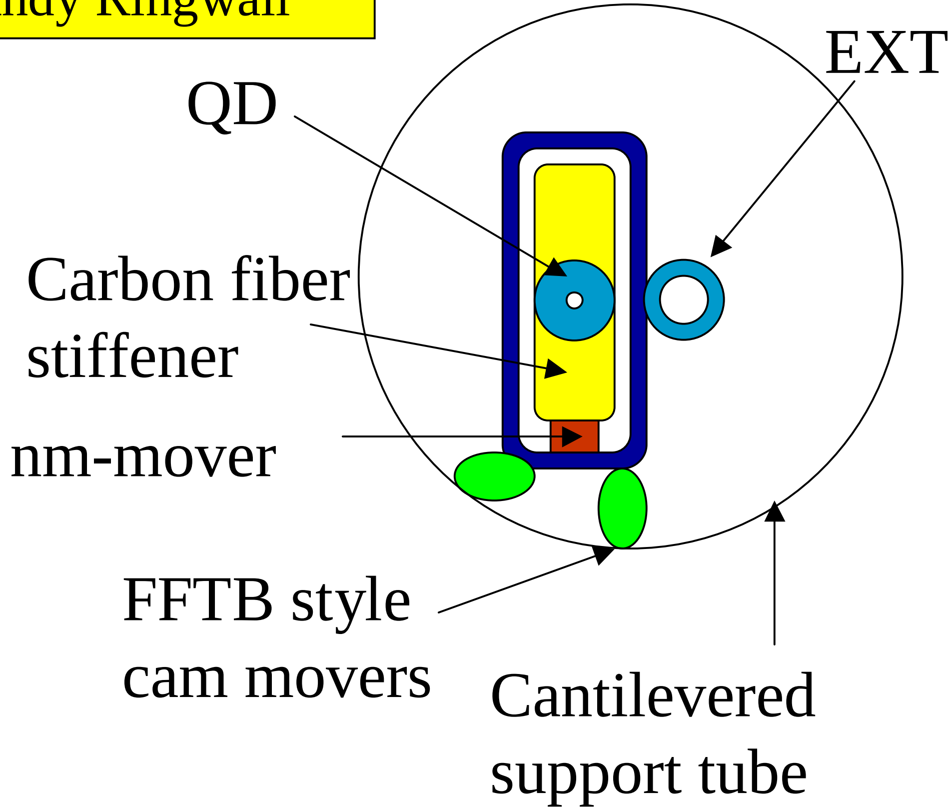
NLC Baseline: Permanent Magnet Quad

Compact, Stiff, Connection Free

Control B by controlling magnet position in Closed-Loop FB



Andy Ringwall



Magnet	Aperture	Gradient	Rmax	Z_ip	Length
QD0	1.0 cm	144 T/m	5.6cm	3.81 m	2.0m
QF1	1.0 cm	36.4 T/m	2.2cm	7.76 m	4.0 m

Knut Skarpaas

Tom Markiewicz

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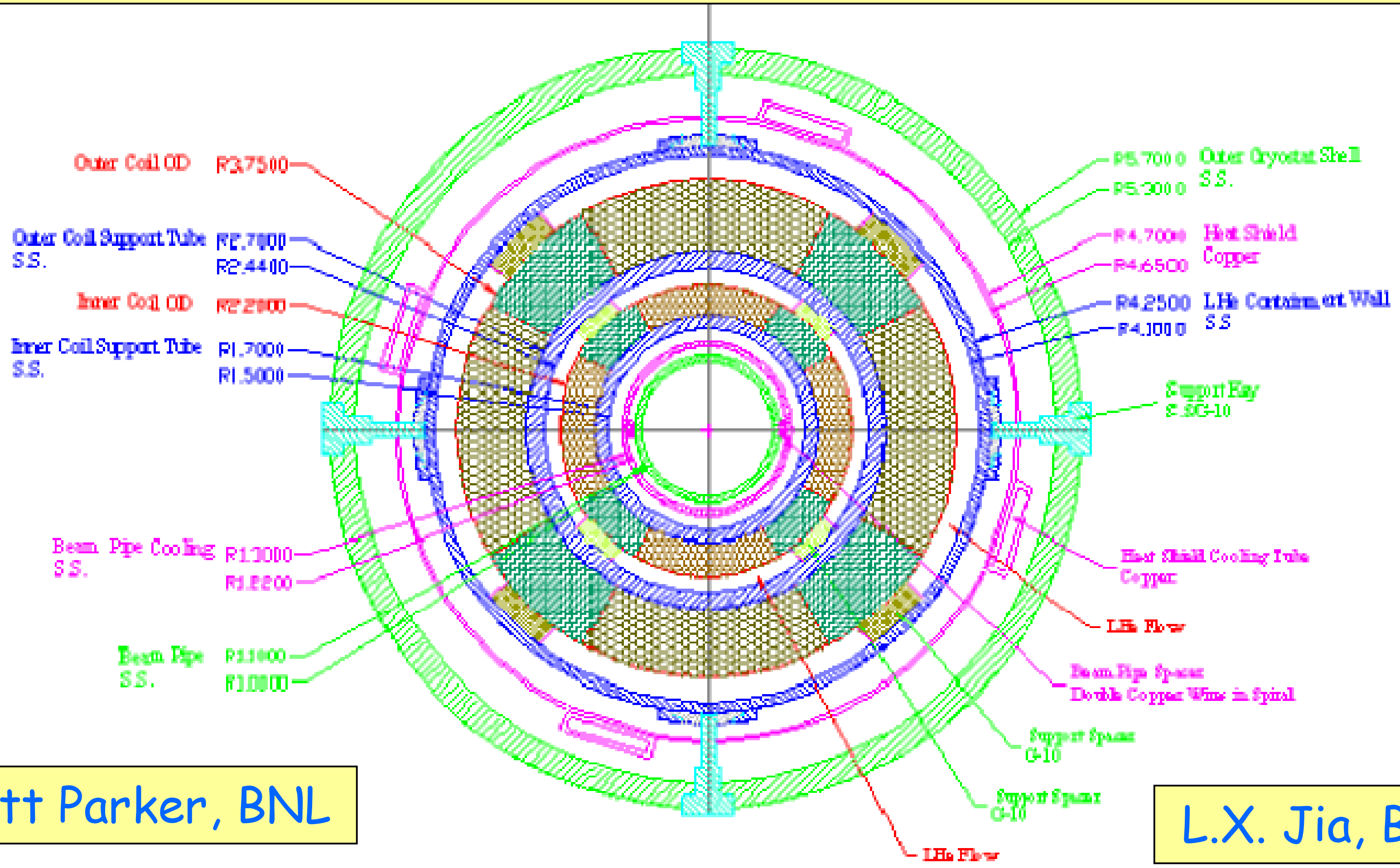
NLC Future? SC Final Doublet based on HERA & BEPC technology

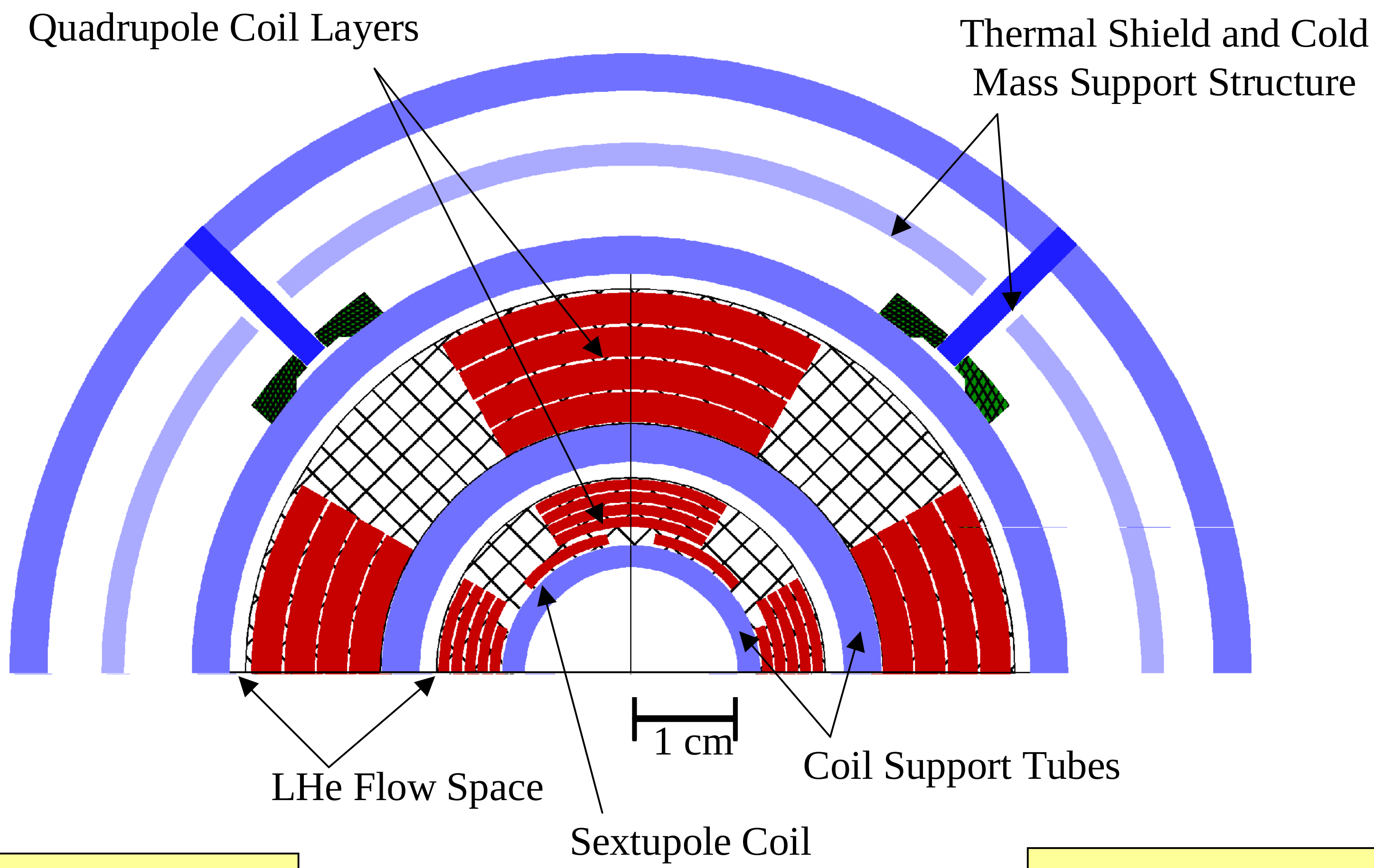
Compact 5.7cm Radius Warm Bore Design



Brett Parker, BNL

L.X. Jia, BNL

Cold Bore NLC SC Quadrupole w/ Integrated Sextupole Windings



Brett Parker, BNL

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How does SC Quad Fit into R&D Plan?

- SC Quad the most likely candidate for the FD because operational flexibility
- But vibration R&D in SC Quads is still in conceptual stage. Plans/Ideas:
  - Short Prototype of cold mass w/w.o. cryostat **(BNL Funds approved)**
  - Magnetic field measurements on new prototypes or existing SC quads
    - SQUIDs?
  - Mechanical stiffness of cryostat w/ multiple wound coils, supports, etc.
    - Modelling?
    - Full scale warm mechanical prototypes? **(HERA Magnets?)**
  - Effect of helium and power supply connections on vibration

SLAC vibration suppression team will

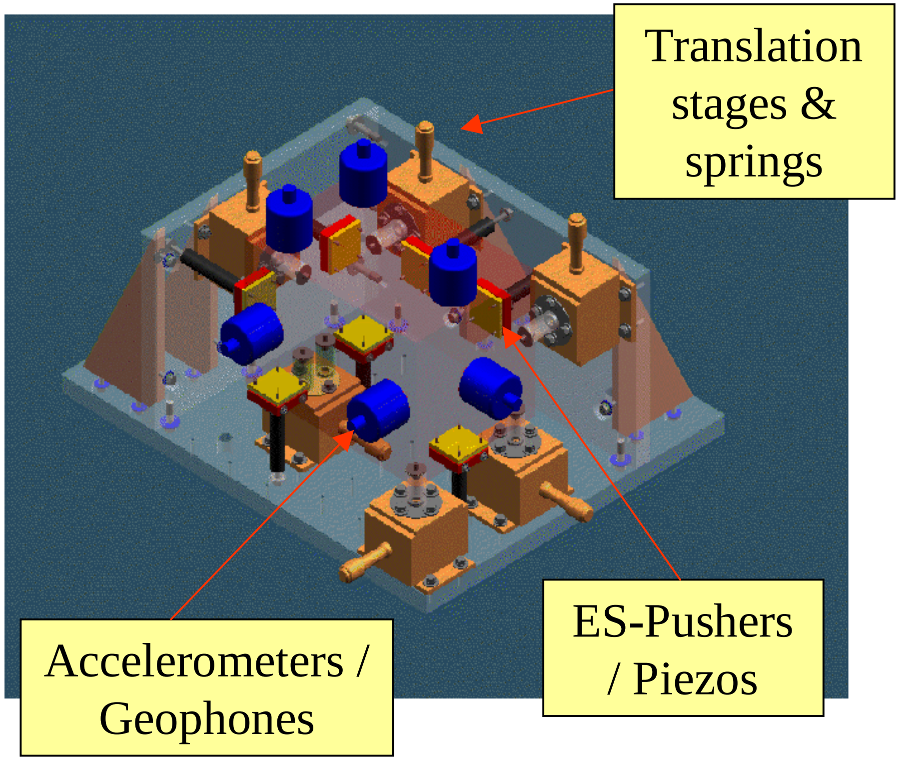
- Use baseline permanent magnet model for the IP Girder Prototype
  - a demonstration in important in the ~2004 time scale
  - making ANY viable technology work will teach us valuable lessons
- Work with BNL & others to develop a SC magnet vibration program
  - design a SC magnet whose field can be assumed to be as stable as its cryostat
  - adapt the vibration suppression technology to it when it is ready

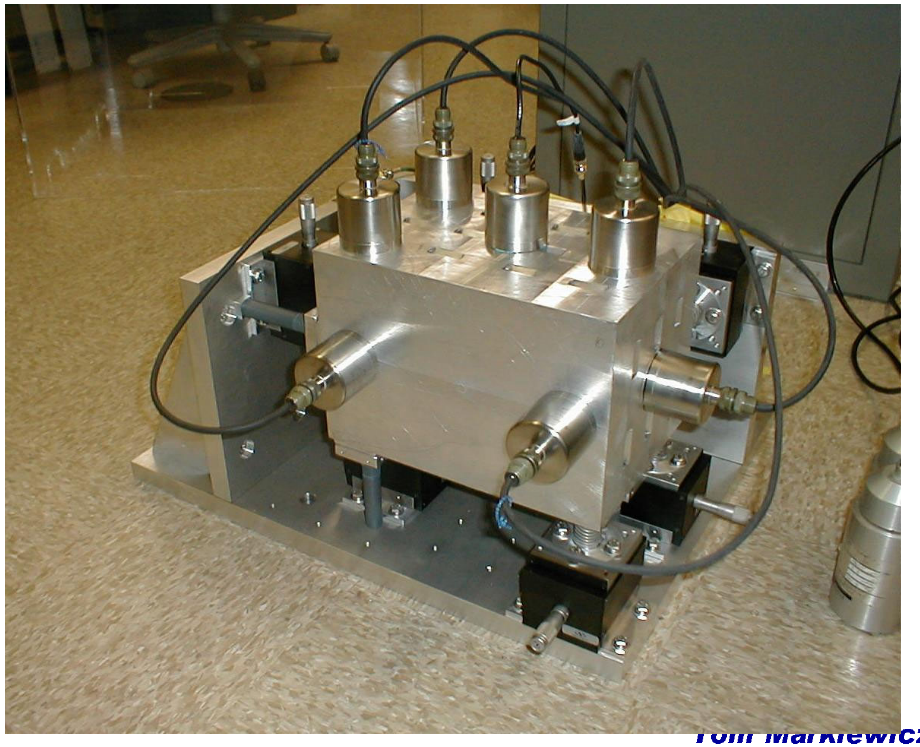
Inertial Vibration Damper Block Test

Joe Frisch, Tom Himel
Eric Doyle, Leif Eriksson, Linda Hendrikson

Status: Developing non-magnetic inertial sensor with adequate sensitivity, noise, and low frequency response

Goal: Stabilize Single Bock in all 6 axes





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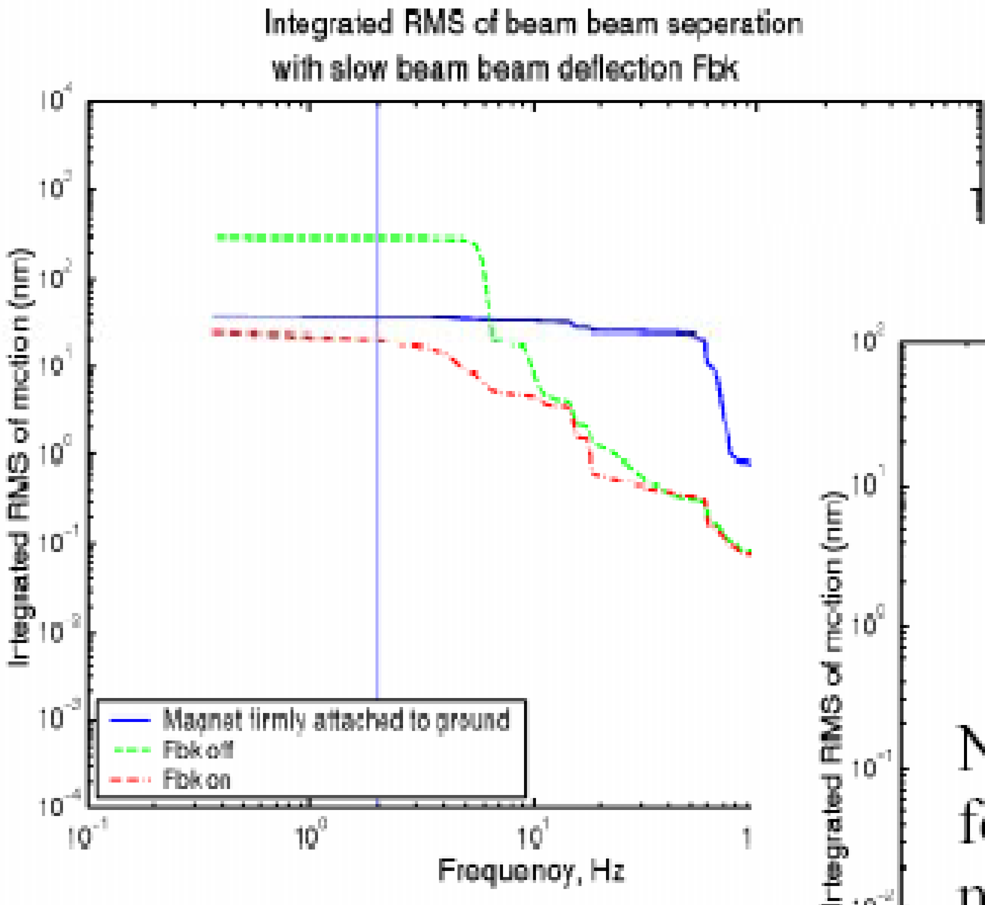
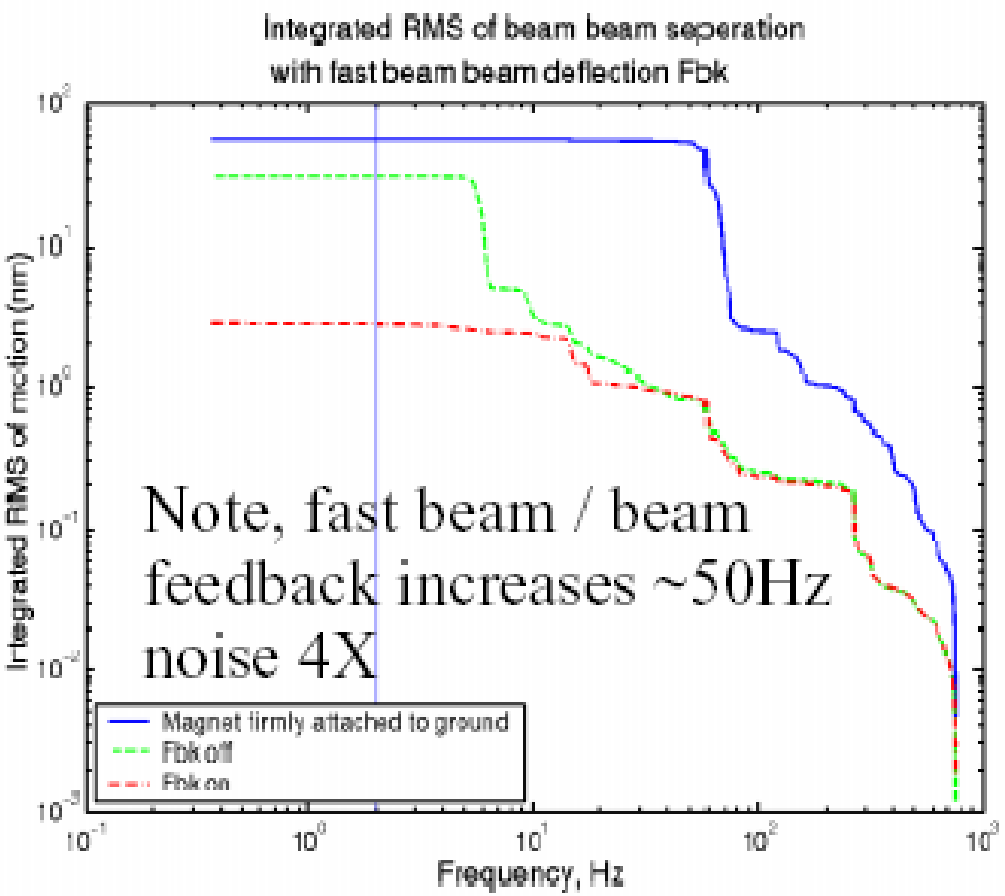
System Performance

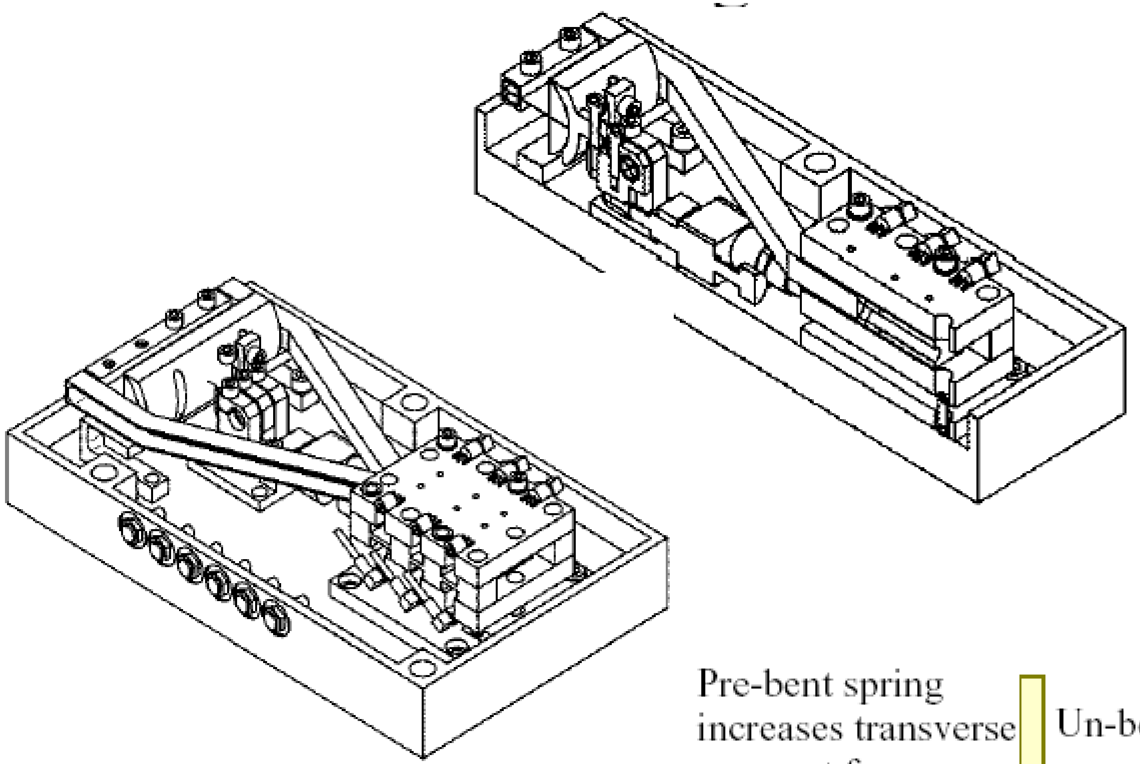


HS-1 geophone integrated rms noise ~1000nm at 0.1 Hz



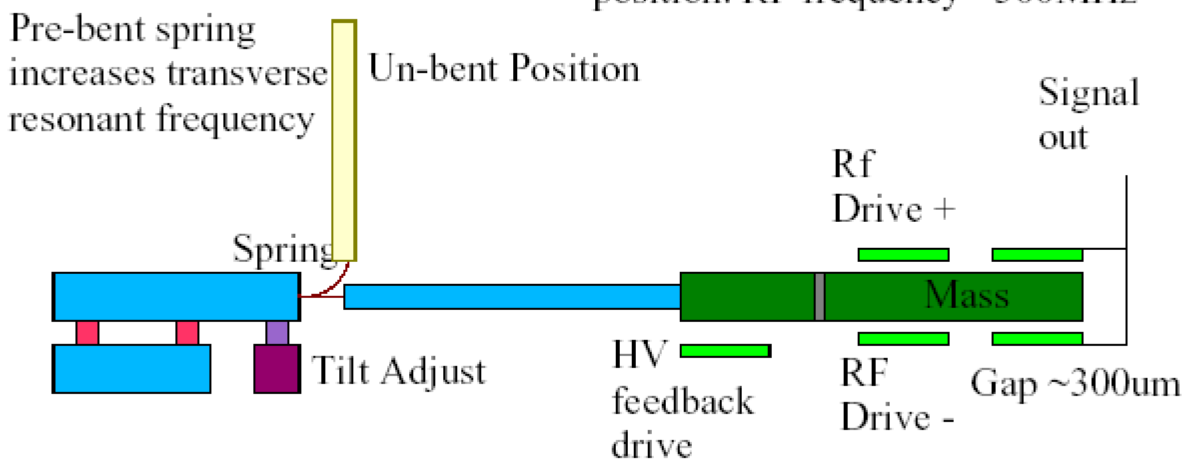
Note, fast beam / beam feedback increases ~50Hz noise 4X

Sensor Development



Goal:
Compact non-magnetic capacitive sensor with 0.1nm integrated rms noise to 0.1 Hz

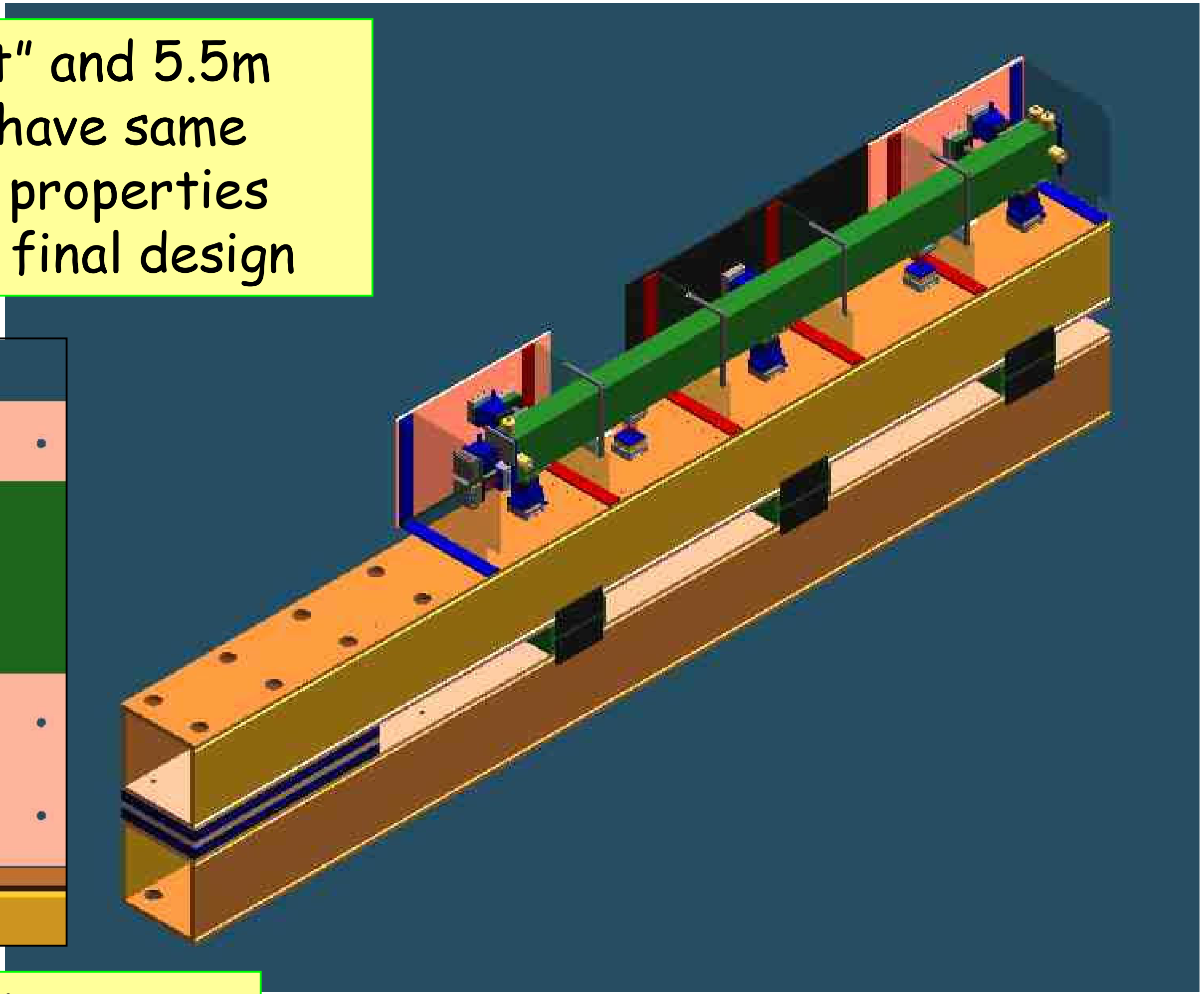
Output signal is mixed against RF drive to measure mass position. RF frequency ~300MHz

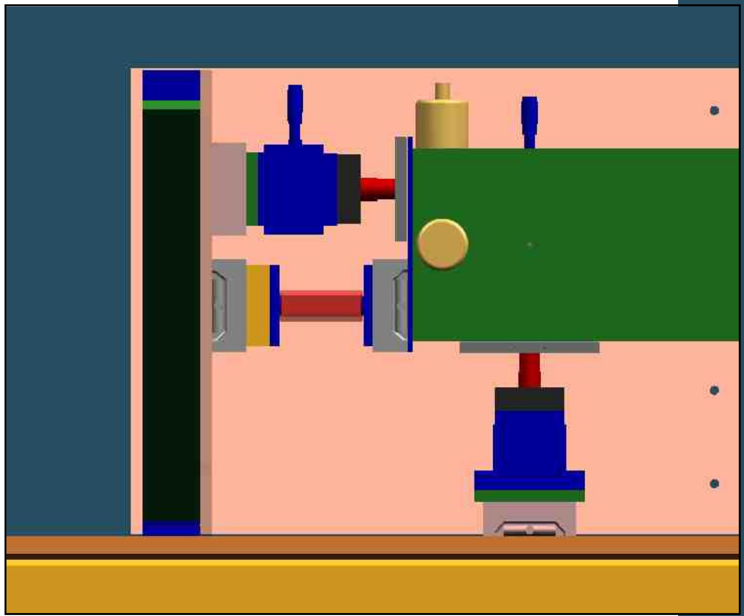


Long Magnet Stabilization Test Fixture

Study internal modes and stiffness in a more realistic system

3m “magnet” and 5.5m “support” have same mechanical properties (mass, ω) as final design





Elevation View w/springs, Electrostatic Pushers, & Sensors

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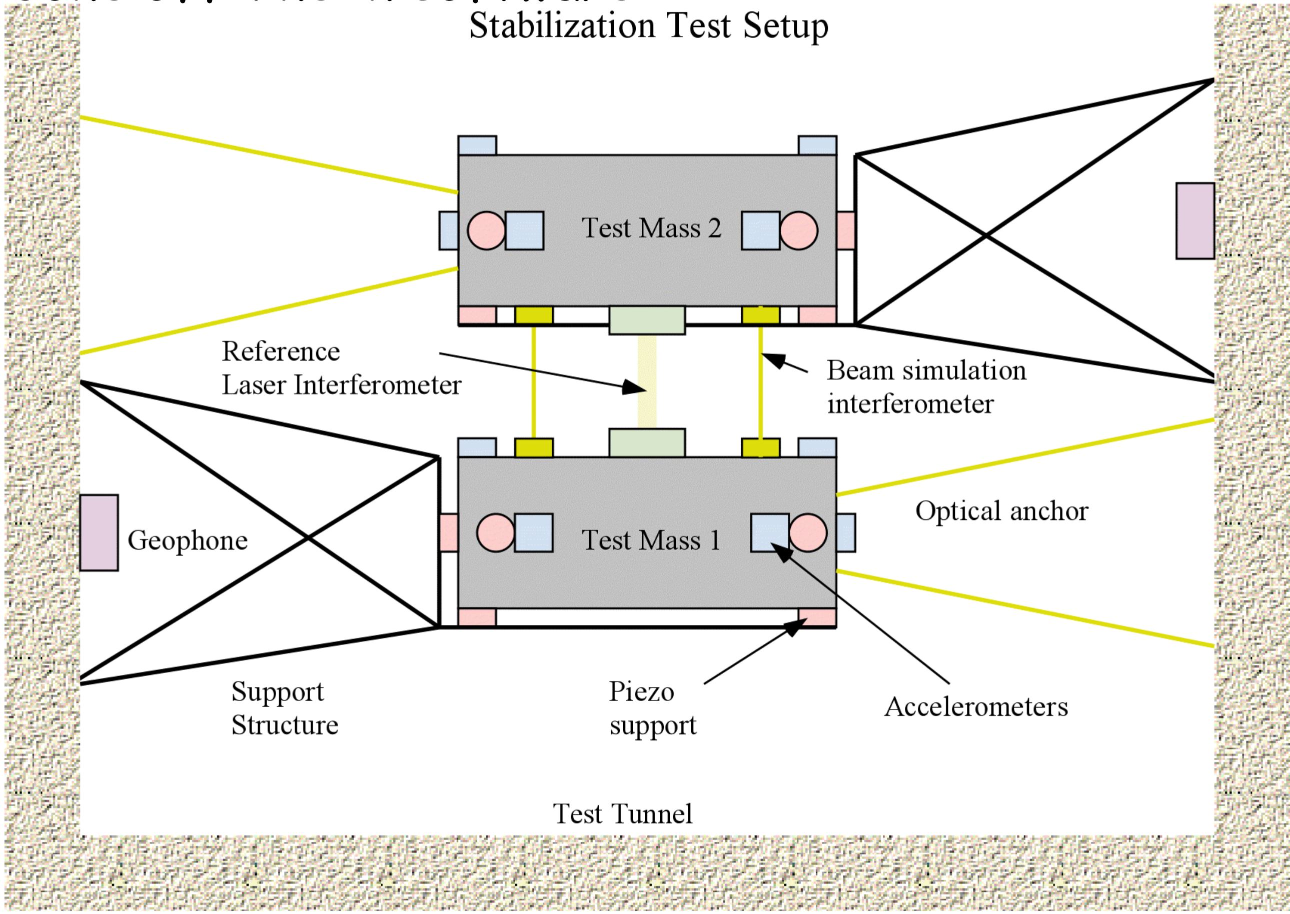
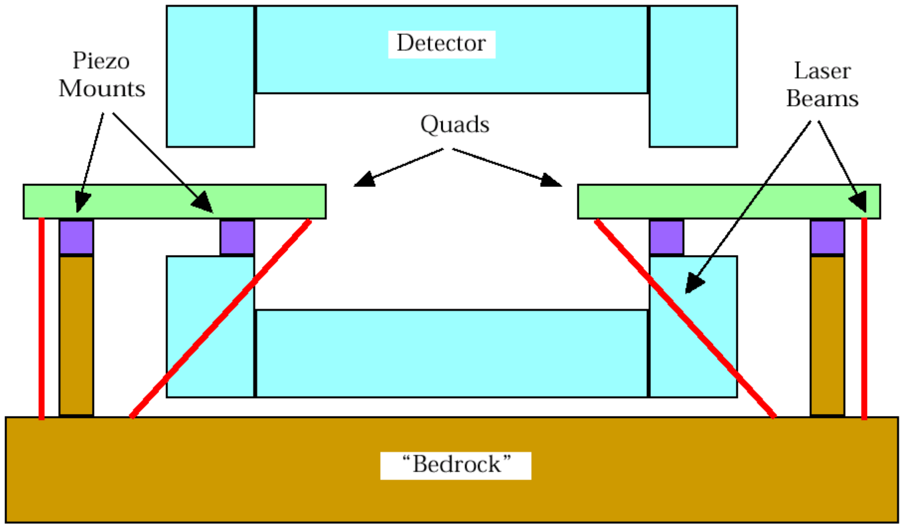
Direct Δy Measurement of Two Simple Masses

Suggested by Frisch ~4/1999, Is it needed?

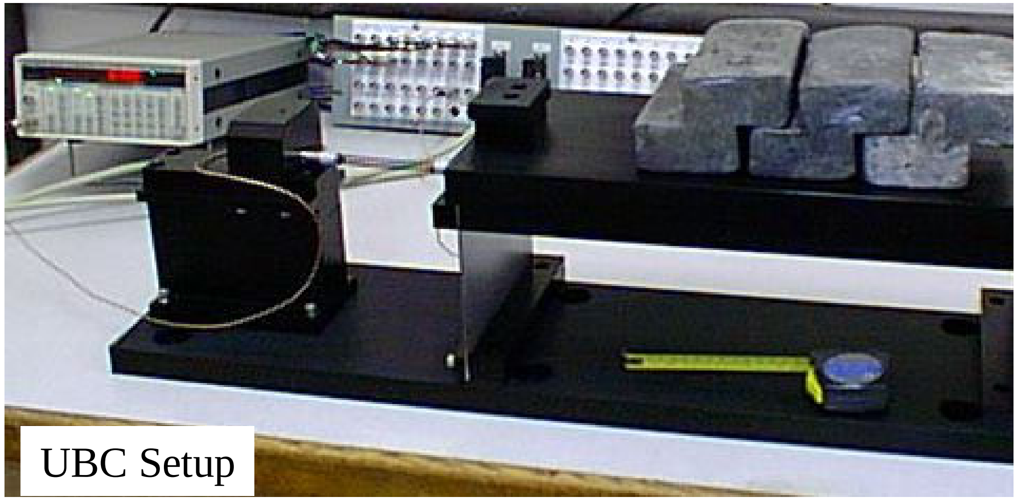
-"Witness" laser interferometer measures exact quantity of interest
-2nd laser interferometer sampled at 120Hz simulates "slow" feedback
- -Currently done off-line in software



UBC R&D on Interferometers

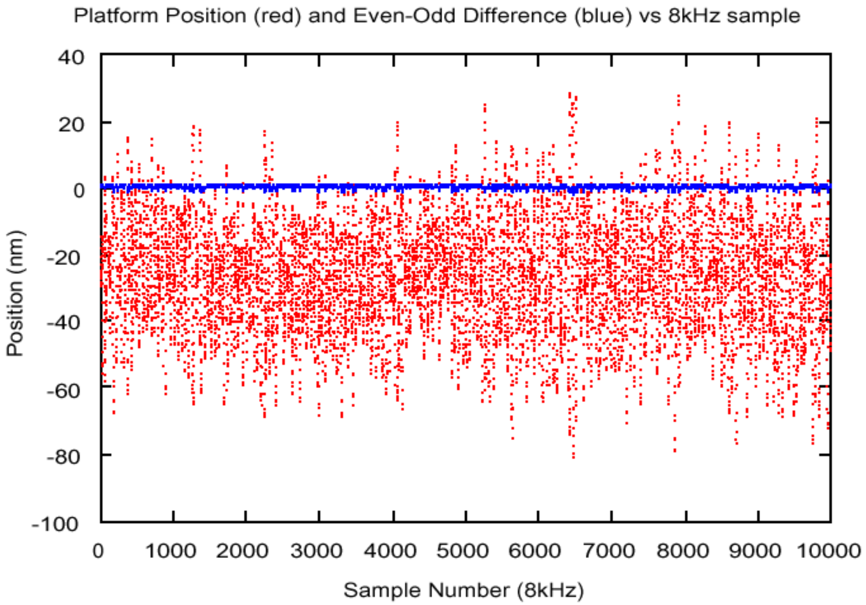


Sub-nm resolution measuring fringes with photodiodes ⇒ drive piezos in closed loop



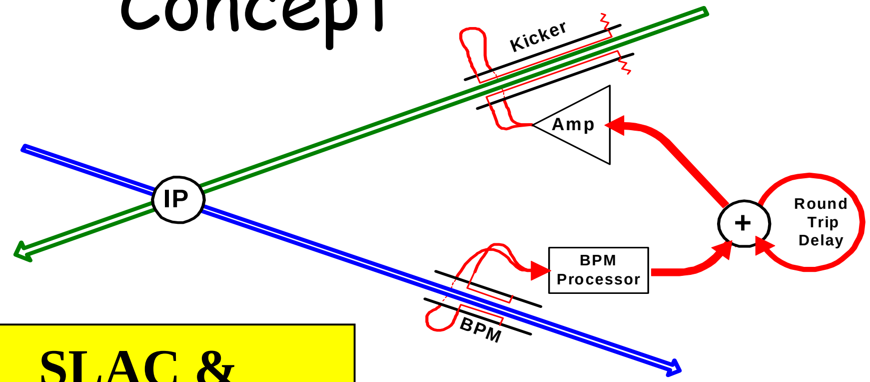
UBC Setup

Platform Displacement & Sensor Value



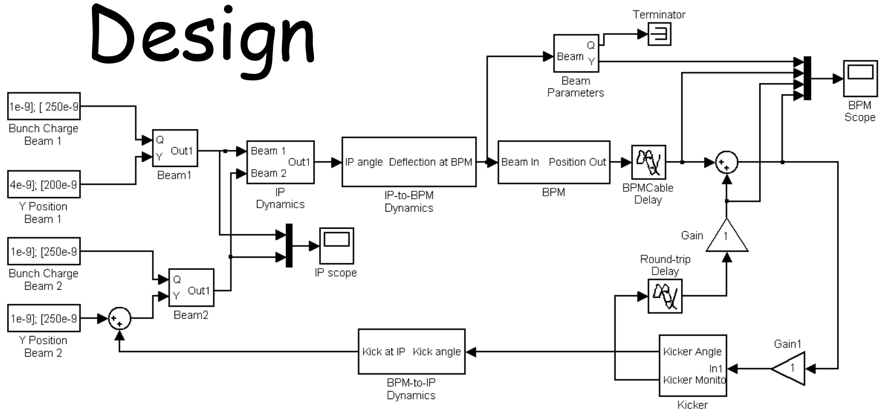
Very Fast Intra-train IP Feedback at NLC limits jitter-induced ΔL

Concept

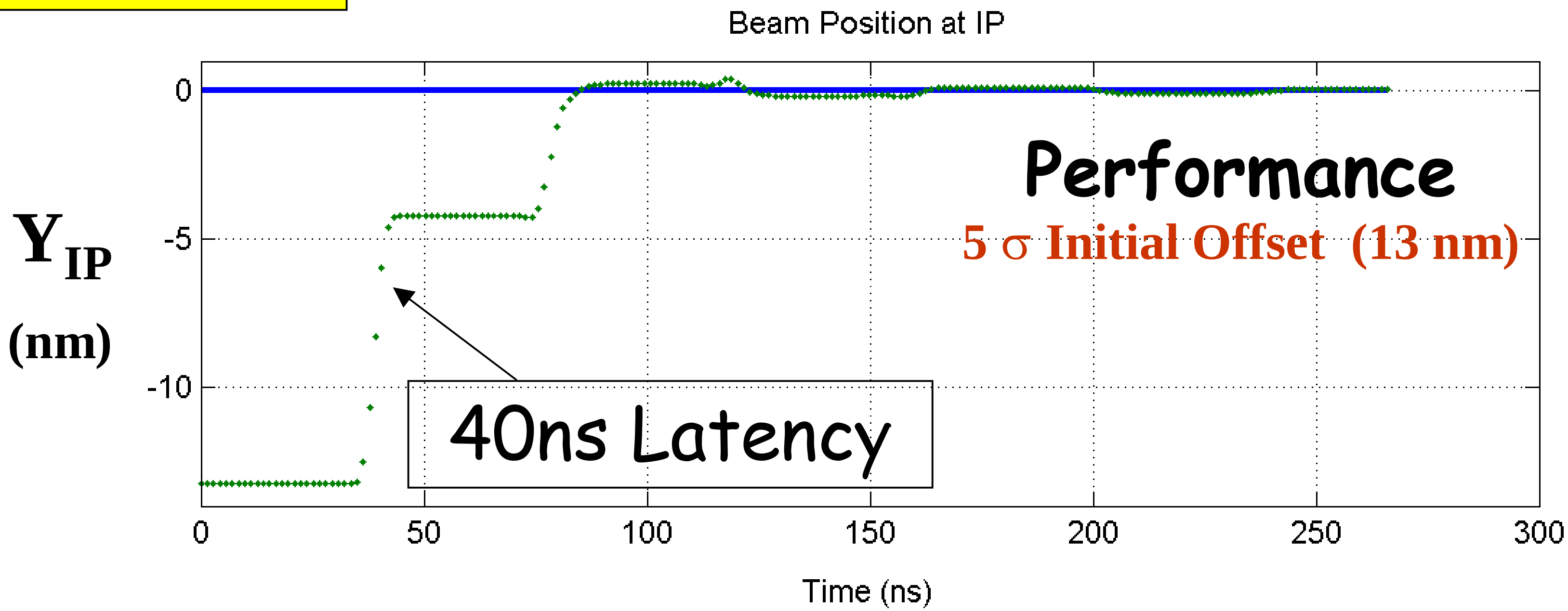


SLAC & Oxford/QMC

Design



Performance



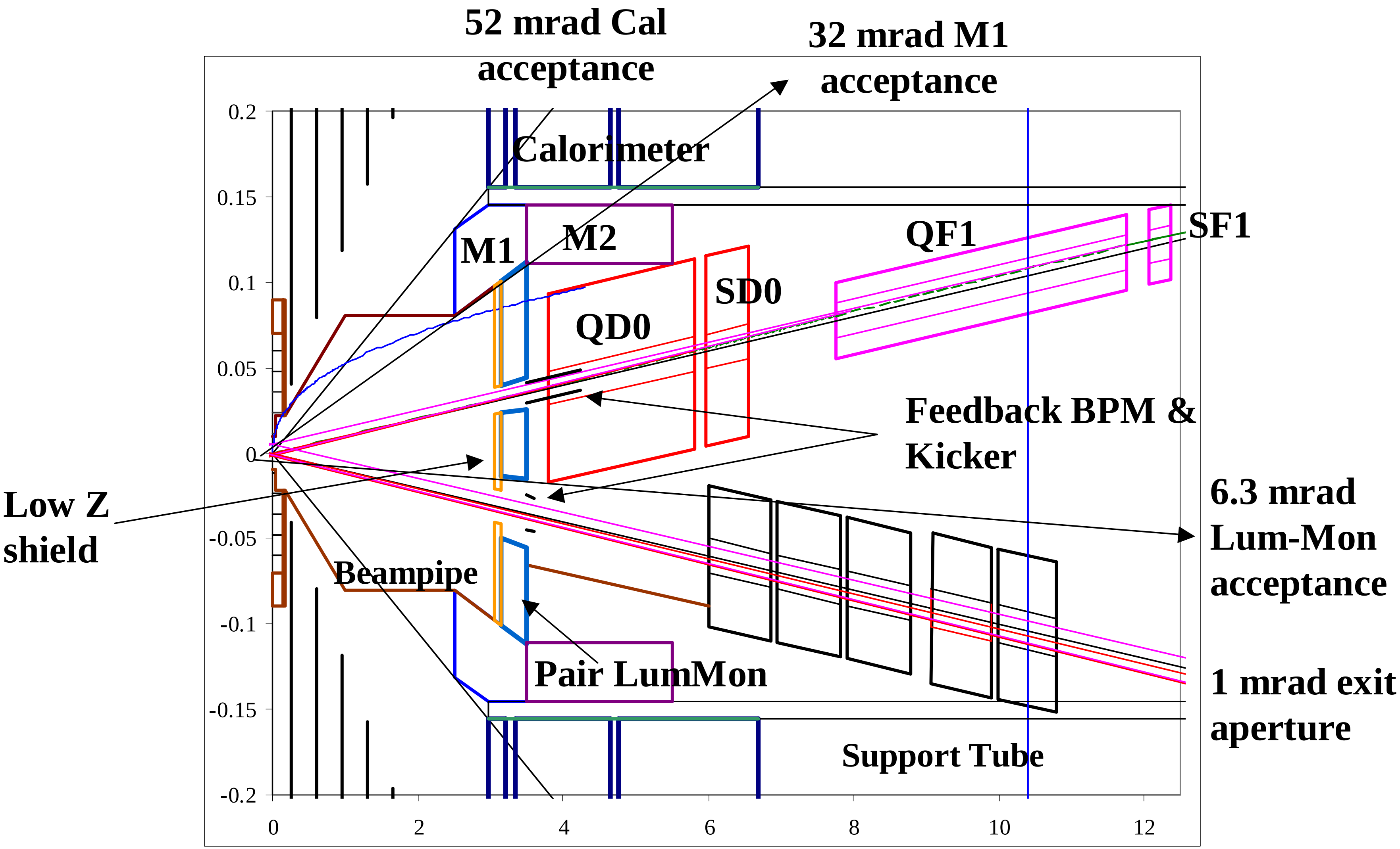
CZ

IP Girder Prototype

- Must look like the final girder and include any mechanical feature that may be a “got-cha”
  - Successfully test relative/absolute nm-y stability when realistically mounted in a realistic experimental environment without a lot of hand waving to explain away deficiencies of the prototype, site or frequency range of interest.
- Explore conceptual solutions under consideration
  - Inertial vs. Optical sensors
  - “Soft” vs. Hard mounts
  - Incorporate slow feedback directly or measure environment adequately to simulate performance in a lattice

Should we make this a centerpiece program?
Is this a Project Worthy of Intl. Effort?

LCD-L2 (3T) with 3.8m L* Optics
Cantilevered Support Tube Support Model



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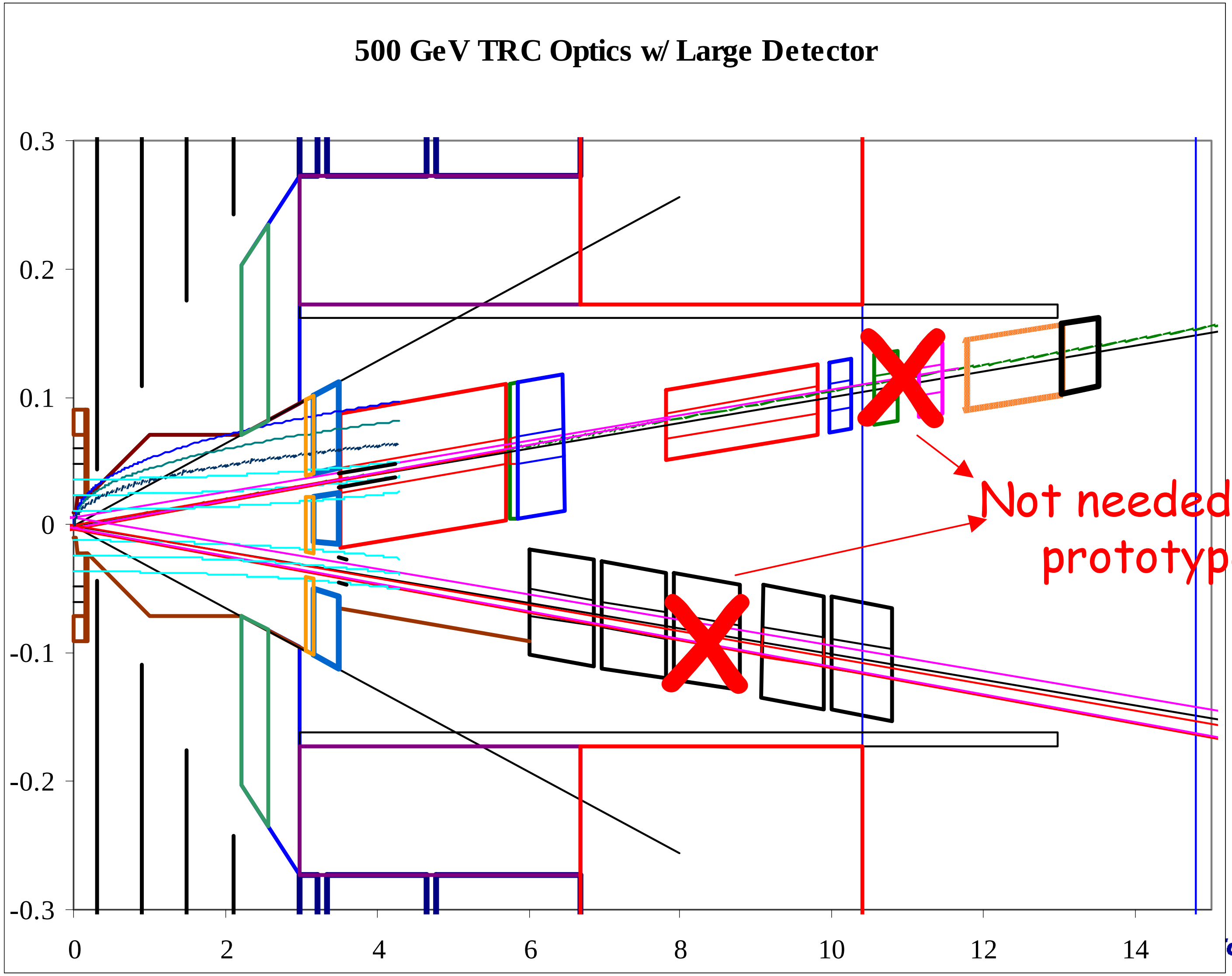
Current Final Doublet with New Masks

Support Masks From Detector



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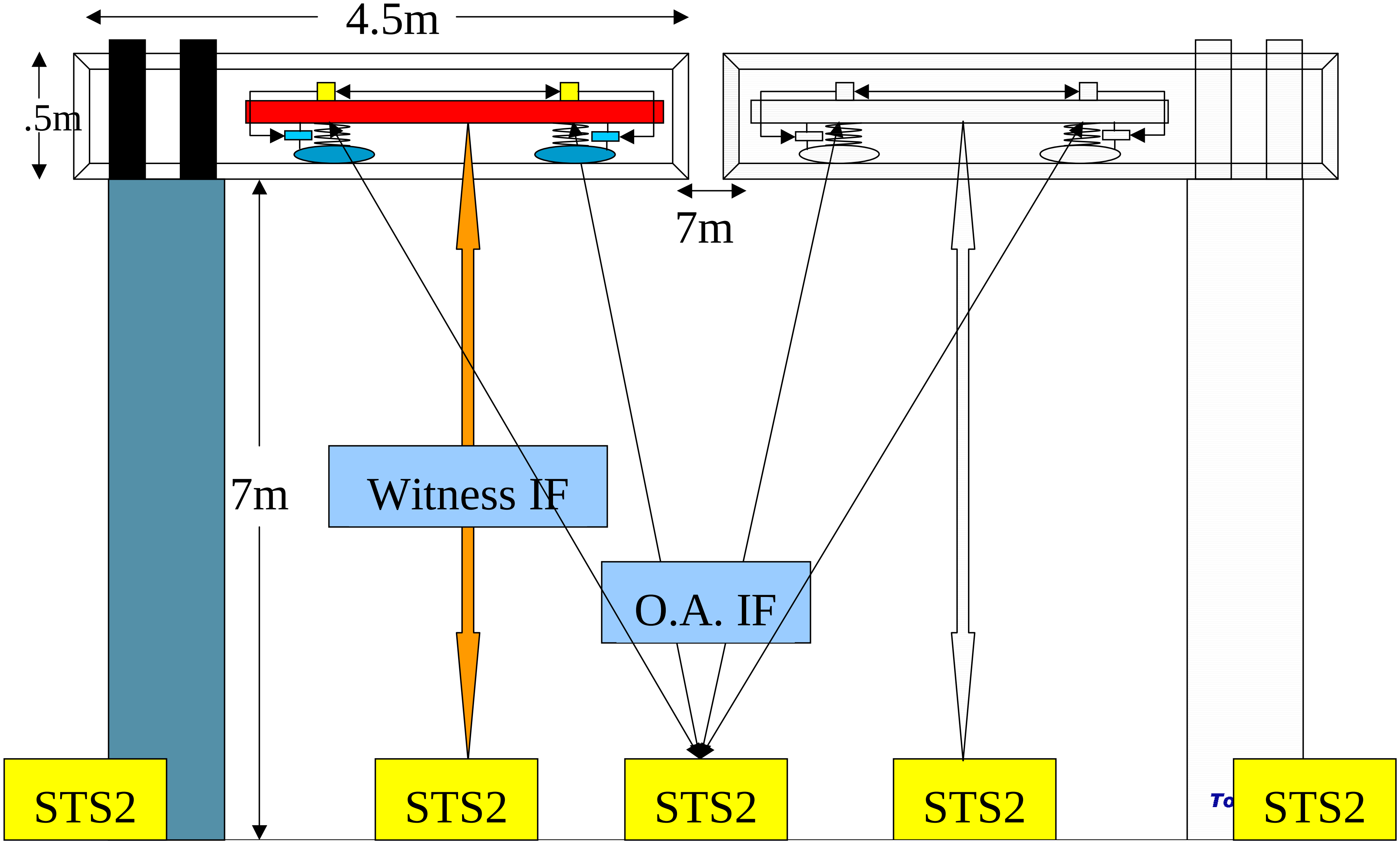
IP Girder Test Concept



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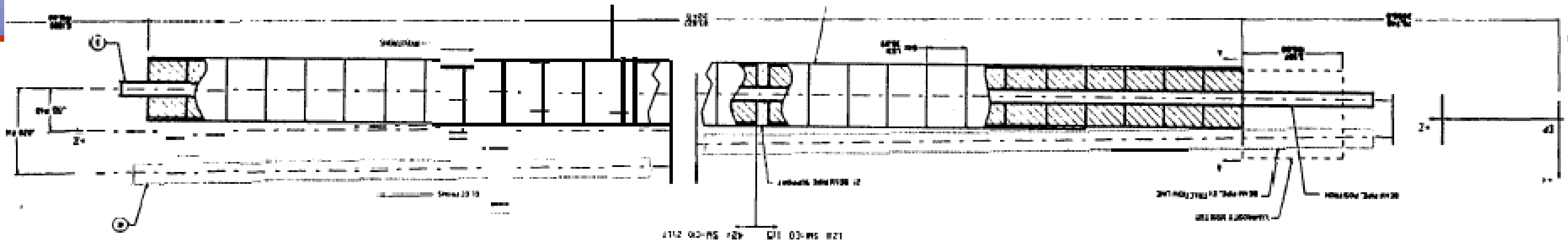
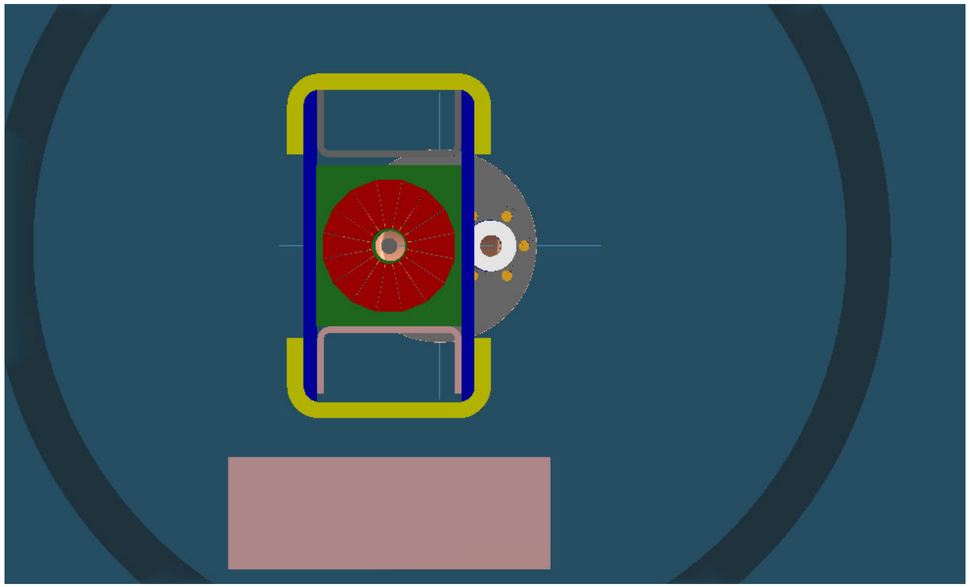
The QD0 Magnet

Epoxy Wedges & Disks in Stiffening Structure

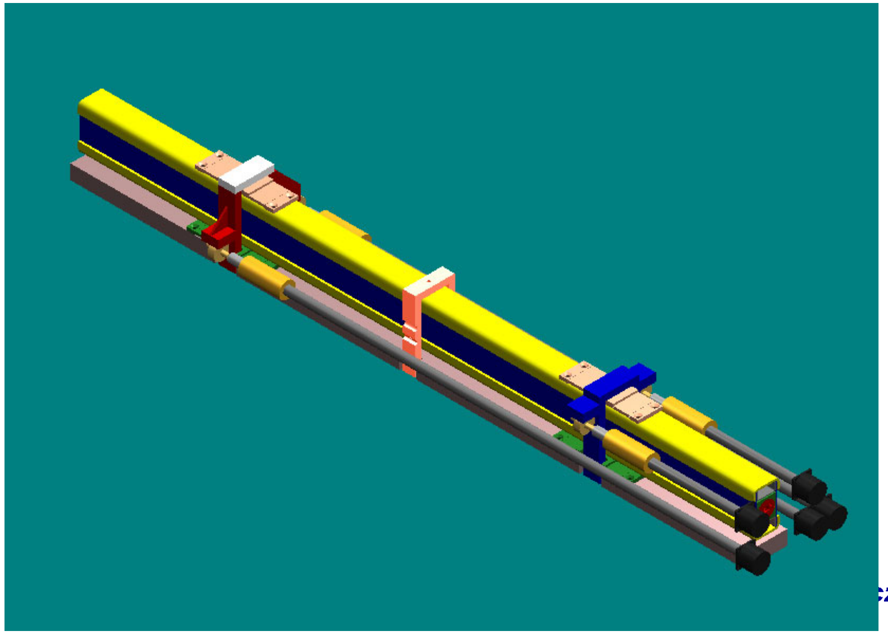


- Stiffened as per 1998 K. Skarpaas design
- Epoxied carbon fiber assembly of 1-2cm thick steel disks tuned to have weight/stiffness of SmCo

Q1 End View

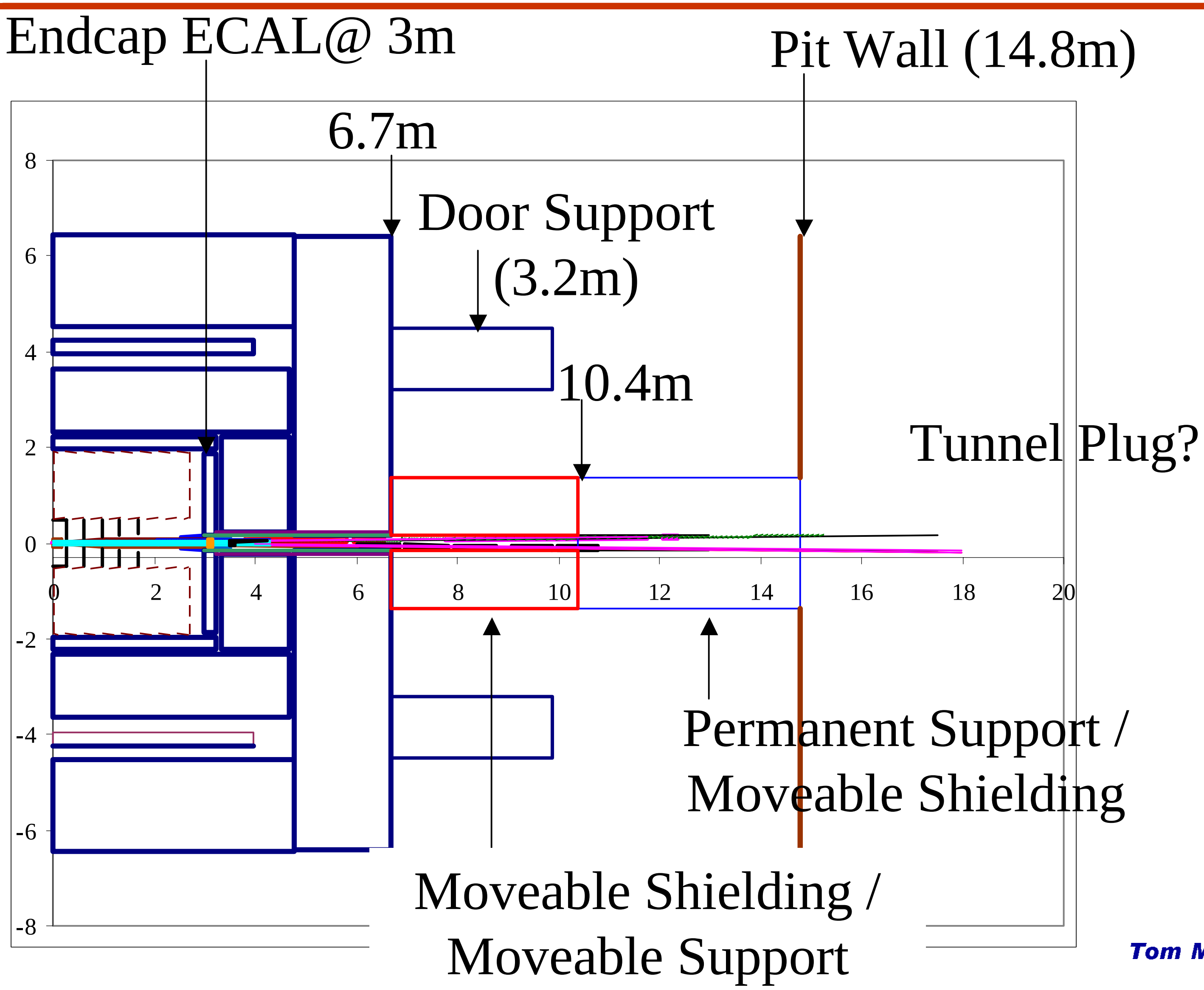


Q1 with stiffener & movers



Large Detector in Pit

Access to detector determines length of cantilever



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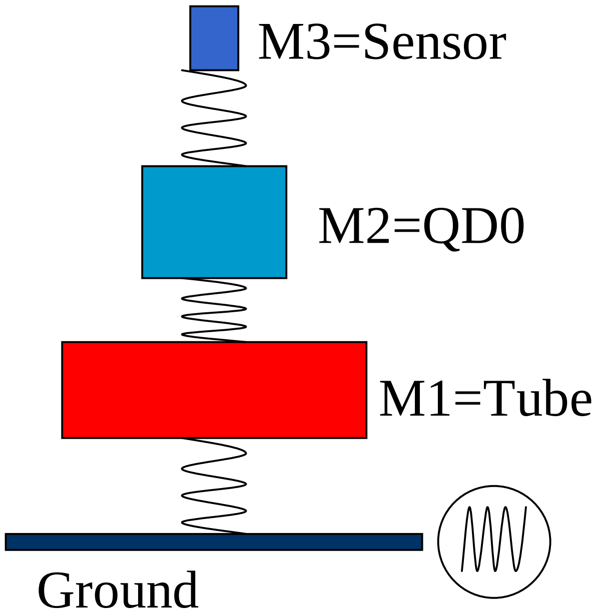
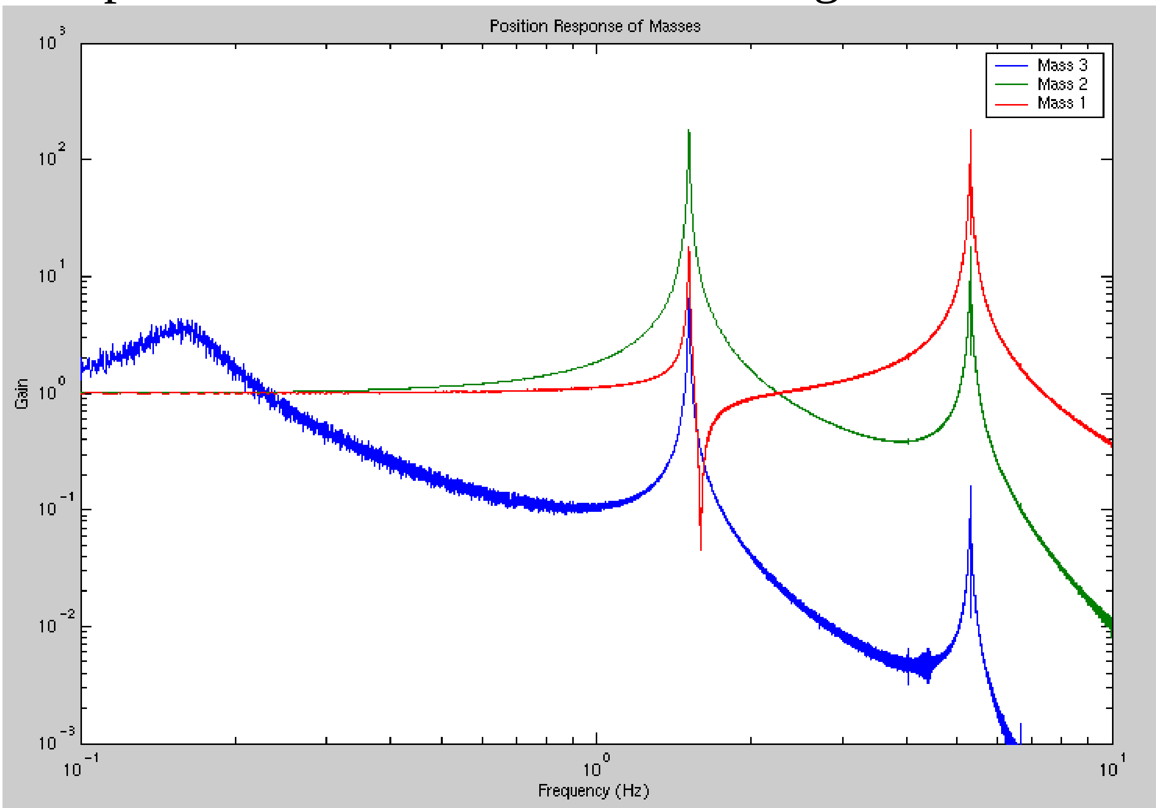
Support Tube Details

Design Support Tube for Test as for Final System

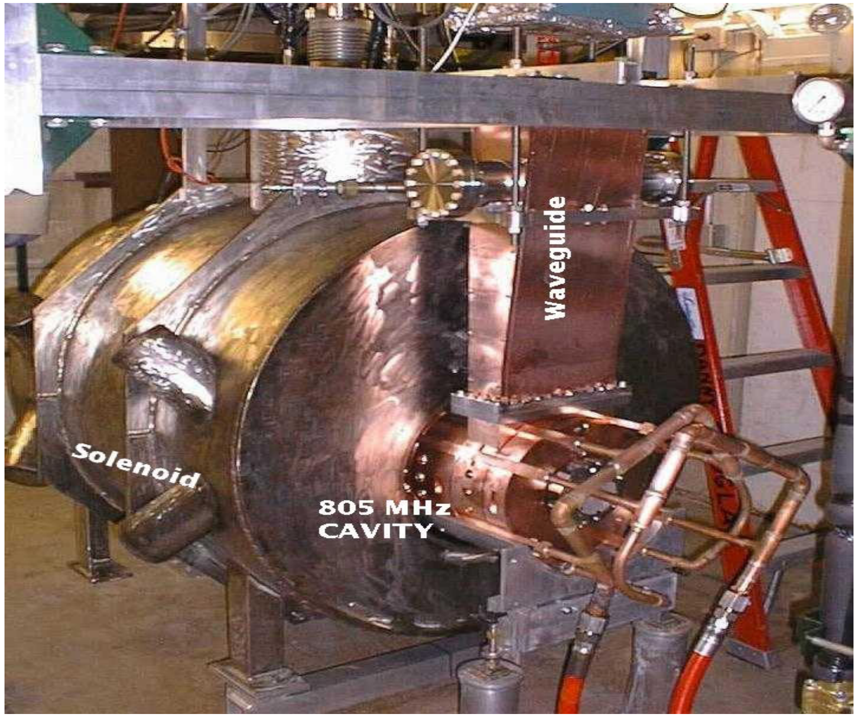
- Stiffness and mass of 50cm diameter tube: material, wall, …
  Carbon Fiber, Stainless, Aluminum,….
  - For inertial, depends on performance of sensor under design





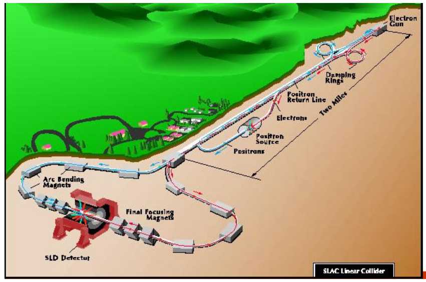
Magnetic Coupling of QD0 to Detector Solenoid Fringe Field
Include? Divided Opinion!

- ~1000 lb. non-linear off-axis load on PM
- Consensus is that this cannot be ignored, but it complicates test considerably
- "Discovery" of Fermilab 5 Tesla solenoid will be folded into planning



More Engineering Issues
How Real do we have to be?

- **Vacuum**
  - Implement mechanical design consistent with vacuum requirement (1 nTorr?) and 1cm radius beam pipe
  - May mean that 3m magnet is broken into pieces
  - Decide whether beam pipe hangs free of magnet or not
- **Nature of contact between QD0 magnet and the support tube**
  - Static FFTB cams as opposed to a fully functional FFTB mover
- **Assembly**
  - Joints and flanges which allow assembly and servicing must be designed and included
  - Do we need to support IP end of cantilever with a vibrating detector endcap door?
- ……



LINX Engineering Test Facility

Address x10^4 Luminosity Issue!!

e+e- collisions at SLC with ~50nm beams

	SLC	NLC
Beam Energy:	30 GeV	250 GeV
DR emittances:	$\gamma\varepsilon_{x,y}$=1100/50E-8 m-rad	300 / 2
FF emittances:	$\gamma\varepsilon_{x,y}$=1600/160E-8 m-rad	360 / 3.5
IP Betas:	β_x=8mm β_y=0.1 mm	same
Bunch length:	σ_z=0.1 - 1.0 mm	0.11 mm
IP spot sizes:	$\sigma_{x,y}$=1500/55 nm	245/2.7nm
Beam currents:	$N^{\pm}$= 6E9	7.5E9

1. Test stabilization techniques proposed for future linear colliders and demonstrate nanometer stability of colliding beams
2. Investigate new optical techniques for control of beam backgrounds
3. Provide a facility where ultra-small and ultra-short beams can be used for a variety of other experiments

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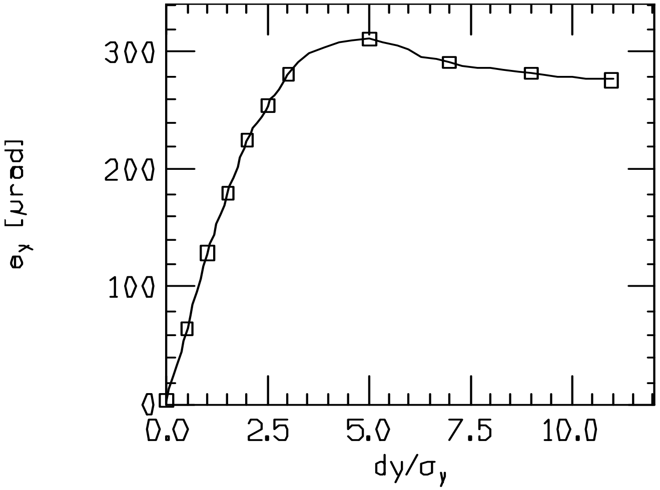
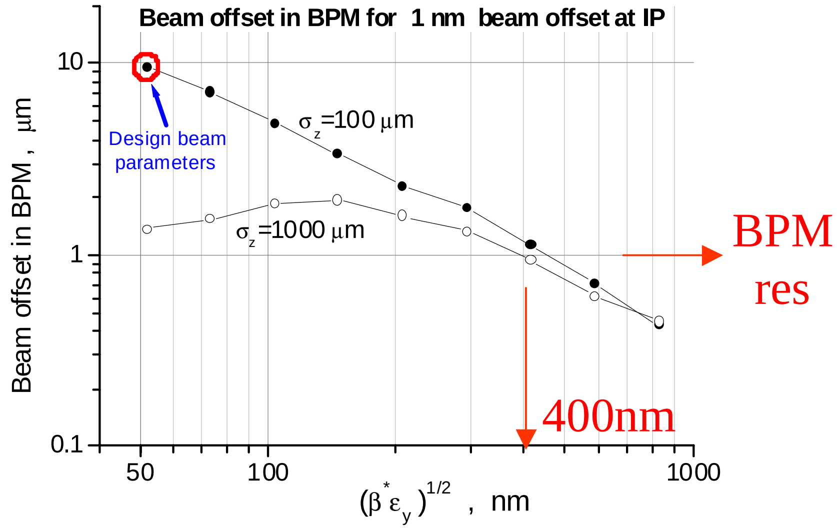
Nanometer Stability of Colliding Beams

Beam-Beam Deflection gives **1nm stability resolution**
for beam spots from 1-400nm





Colliding beams provide a Direct Model-Independent Test **of any engineering solution to the final doublet stability problem**

Not possible in FFTB

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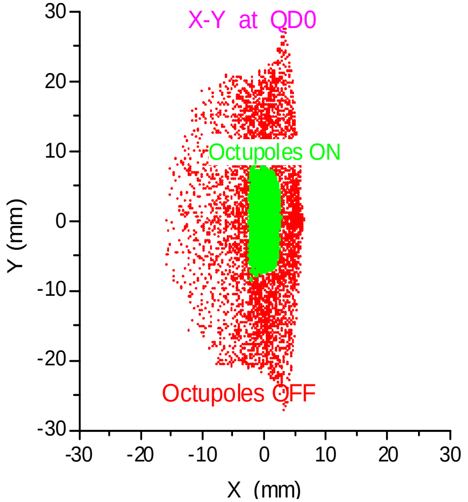
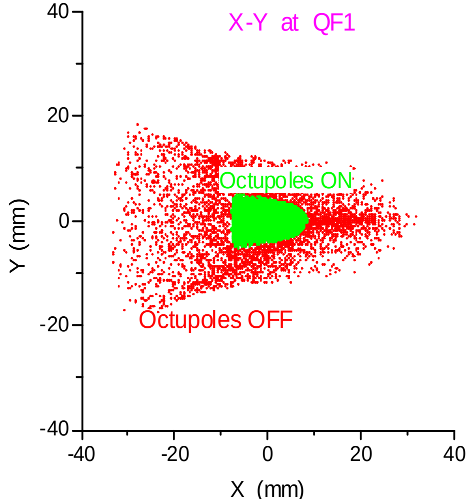
LINX Secondary Goal

Verify that Local Chromaticity Correction Plus Octupoles can Fold Beam Tails, Decrease Sensitivity to Backgrounds, and Ease Constraints on the Collimation System

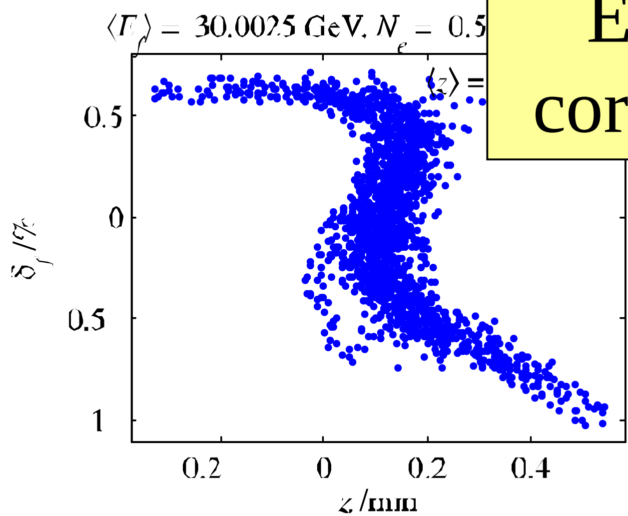




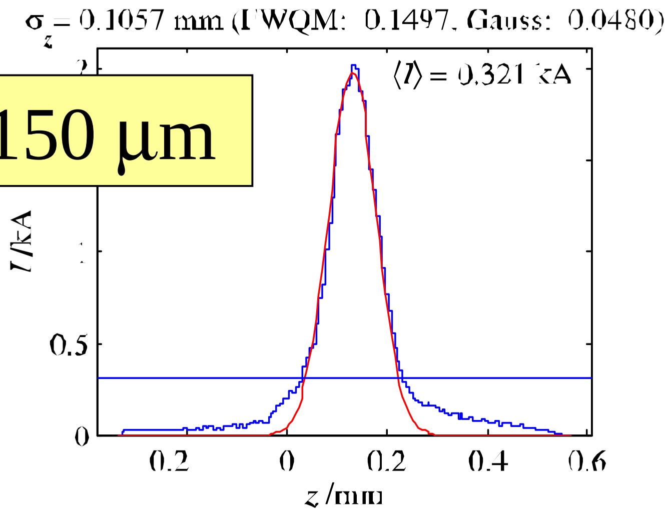
Backgrounds at SLC Limited Luminosity

Confidence that comes from an Actual Demonstration may permit a great savings in collimator design, and pps and muon shielding

Ultra-short & -low emittance beams



Energy correlation



σ_z=150 μm

Producing NLC-like beams cannot help but increase confidence in the program

Various tests relevant to NLC or exploiting the short bunches may be performed:

- Plasma wakefield acceleration studies
- Traveling focus study
- Low latency Feed-forward orbit correction
- Collimator tests
- Instrumentation test-bed

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Technical Feasibility for LINX

Parasitic to PEP-II Operation: 30 HZ, 30 GeV

Damping Rings:

- Typical SLC running: $\gamma\varepsilon_{x,y}$=2900/150E-8m-rad
- Typical FFTB $\gamma\varepsilon_y$= / 90E-8m-rad
- "Best" SLC $\gamma\varepsilon_y$= / 70E-8m-rad

} need x2-3 improvement

- LINX: Reduced rep rate allows "long store" AND simple rewiring allows shift of magnetic center of QFs in ring to act as combined function magnets and to decrease $\varepsilon_{x,y}$ by x3

Linac: No different than 1994-1997 FFTB runs and recent (E150,E157) FFTB plasma experiments

Arcs: 30 GeV running reduces SR emittance growth to ~0

Final Focus: Optics are "EASY"; need only:

- New doublet w/ sextupoles
- New octupole pair to investigate tail control

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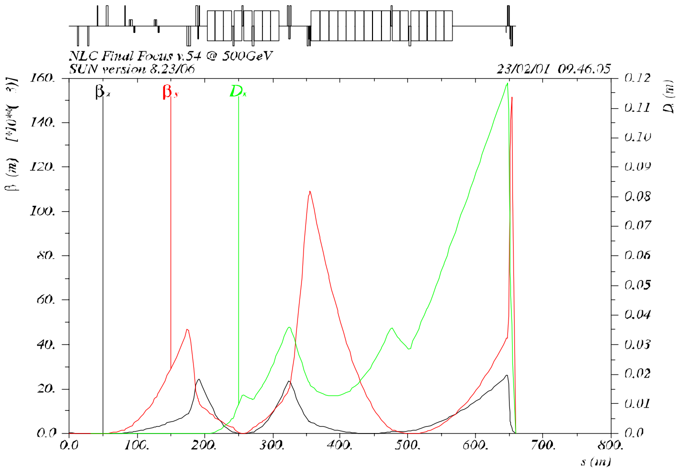
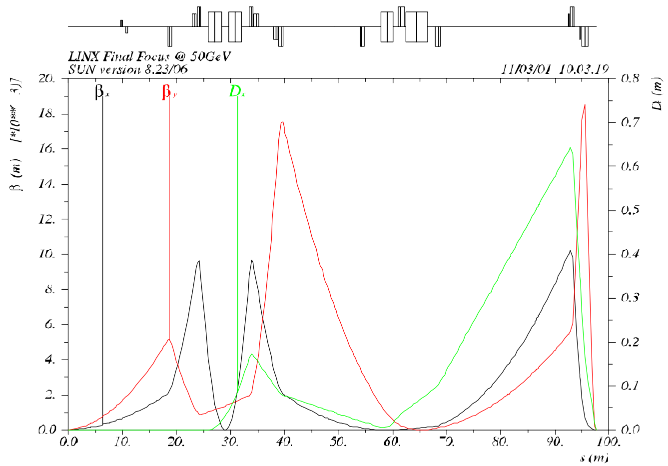
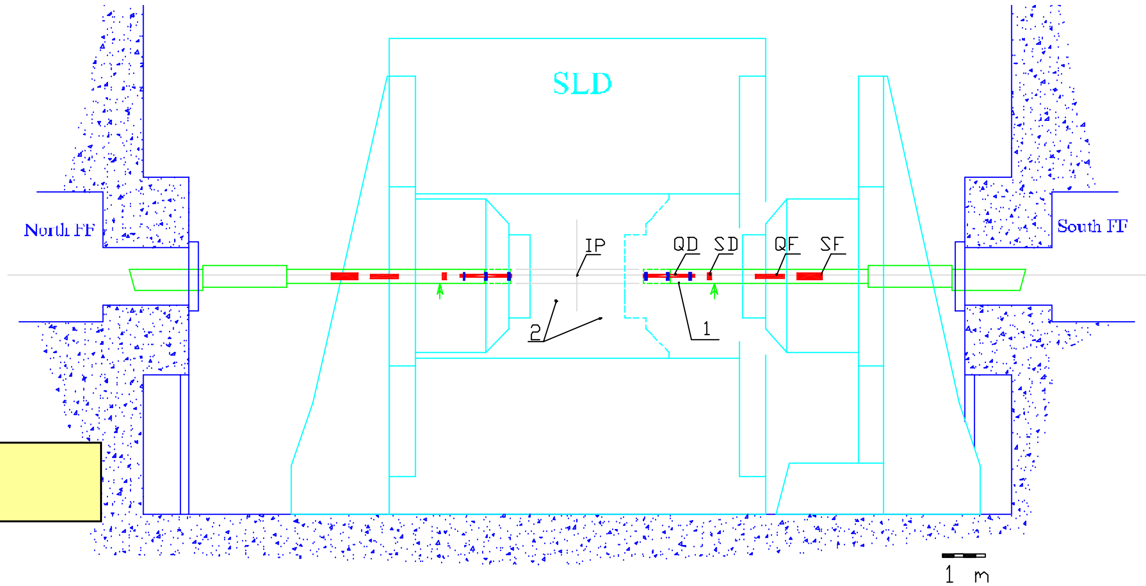
LINX IR and OPTICS

NLC FF



LINX FF





LINX IR

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LINX Stages

Step 1: **Successfully transport e+ and e- beams to the north and south beam dumps respectively.**

Step 2: **Demonstrate that the SLC beamlines can still deliver high quality colliding beams.**

DECISION POINT TO PROCEED & CONSTRUCT DOUBLET

Step 3: **Produce ultra-short beams.**

Step 4: **Evaluate the effectiveness of background suppression with the new Final Focus optics.**

Step 5: **Produce ultra-low emittance beams.**

Step 6: **Develop fast intra-pulse feedback hardware**

INSTALL NEW DOUBLET

Step 7: **Produce < 100 nm vertical beam size at the IP.**

Step 8: **Demonstrate nanometer stabilization at the IP.**

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LINX Status

> DRAFT
>
> **Letter of Intent for the LINX Test Facility at SLAC**
>
> NLC Collaboration
>
> *Stanford Linear Accelerator Center*
> *Lawrence Livermore National Laboratory*
> *Lawrence Berkeley National Laboratory*
> *Fermi National Laboratory*

Bureaucratic:

- A DRAFT Letter of Intent distributed
- Expressions of Interest
  - DESY offers to build Octupoles
  - Substantive effort financial support from LLNL & Northwestern for development of LINX and its eventual use in the prototyping of a $\gamma\gamma$ collider
- An independent "Preliminary Cost Estimate for the LINX Test Facility at SLAC" MADE
- SLAC VETOES spending $ more until LC funding appears

Hardware: ~$100K spent by SLAC shops

- Both N & S Arc/FF Leak checked & problem areas identified
- SARC & SFF vacuum re-established & left filled with N_2
- All work on ARC/FF stopped as of 4/12/02