IP Prototype Concept and Plans

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SLAC
5/10/02

MAC Report from October 2001

"While it is important to demonstrate stabilization at this level before committing to the final design of the final focus system, this is not an issue that affects the fundamental viability of the NLC project. Thus, given the scarcity of resources, it is not necessary to pursue this problem vigorously at this point."

NONETHELESS

This presentation constitutes a proposal to vigorously pursue exactly this problem

GOAL

On the time scale of a 2004 CDR, to have **a realistic IP prototype** that or will effectively address both our critic's and our own personal concerns that 1nm vibration suppression is achievable.

The Final Doublet Jitter Issue

TESLA: Perceived as clean, simple and guaranteed to work

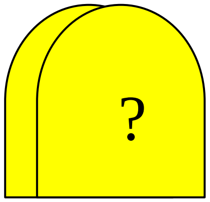
- Digitally processed feedback loop suppresses high frequency vibration at minor cost in luminosity

X-Band: Perceived as not clean, not simple, and not guaranteed

- 120 Hz feedback algorithm frequency response
- Sensor noise and frequency response
- Ground motion amplitude and correlations as a function of frequency in detector environment with seismic and "cultural" noise sources
- Options for interferometric, inertial, and feedback based systems
- Options for hard or soft magnet supports
- Coupling of proposed solutions to detector design, detector access, optical lattice, geology (site & tunnel depth choices) and final doublet magnet technology choice

Independent of perceptions, WE feel R&D demo is both important and do-able even with current level of support

LINX - R.I.P.



"The demonstration of the stabilization of the beam spot at the collision point in a real accelerator environment is one of the main goals of the LINX proposal. While this is a desirable goal, it is not necessary to achieve this in the immediate future. From this standpoint the only urgency of pursuing the LINX proposal at this time is to ensure that the SLC infrastructure is not allowed to decay to the extent that it will be impossible later to implement LINX."

STATUS

All work stopped as of 4/12/02:

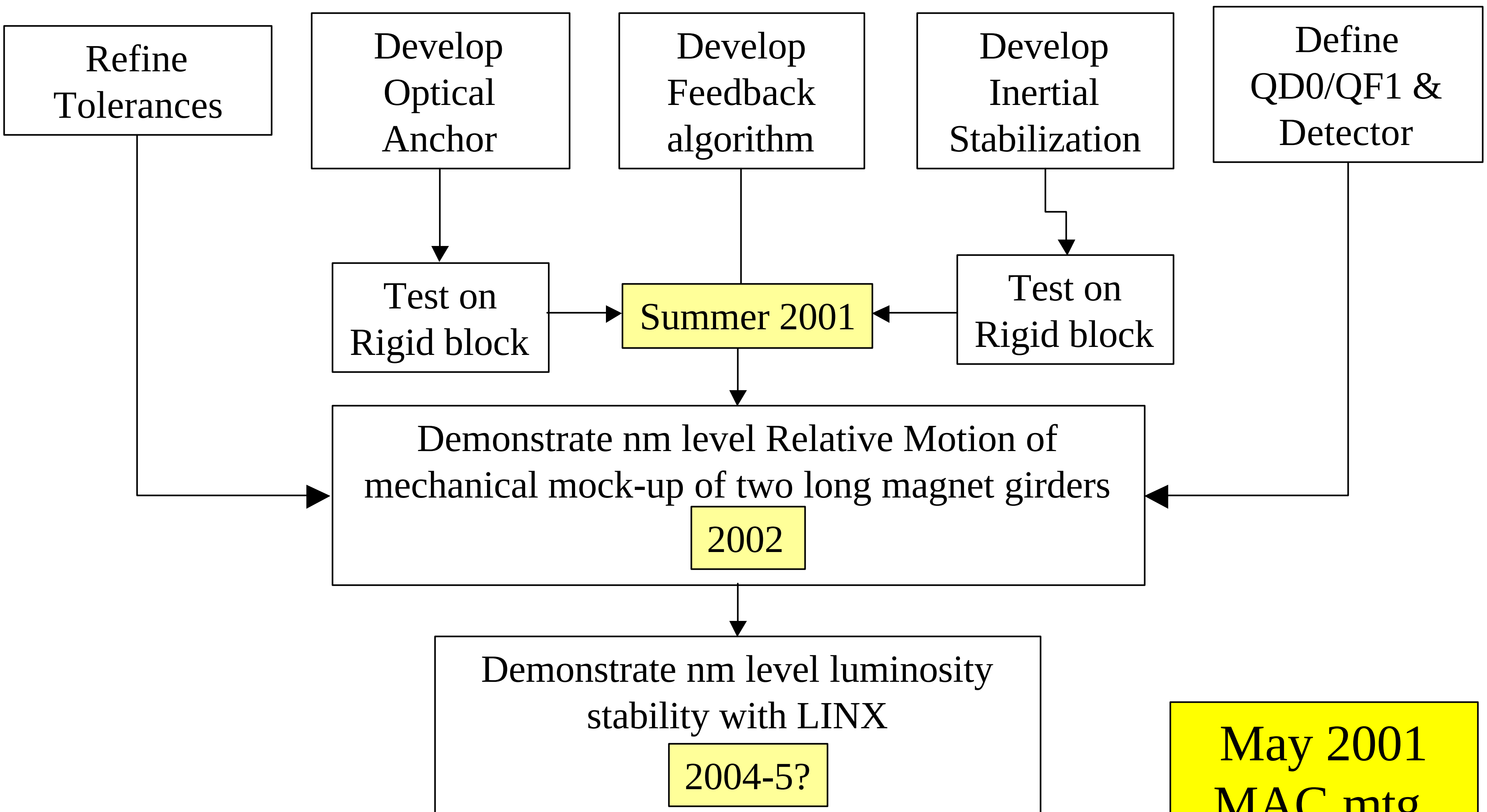
SARC & SFF vacuum re-established

All Proposals to proceed with limited scope rejected: No lab resources

LINX Phase I→SARC Octupole → SARC Beam Transport → Maintain SARC vac

Current proposal will not try to create a LINX-useable doublet

Active Vibration Suppression Plan



May 2001
MAC mtg.

Beam Delivery R&D Plan

A reprogramming of effort and a redefinition of the goal, as opposed to a new crash initiative

Stop:

- Rotating Collimator Work
- Liquid metal collimation work
- Wakefield experiment
- Vacuum outgas-sing
- LINX / SLC

Project	M&S+SS	FTE
Collimator R&D	$28,000	1.1
Wakefield Expt	$25,000	0.3
Vacuum Outgassing	$30,000	0.1
LINX	$50,000	0.1
Inertial Sensor	$129,500	3.3
IntraTrain Feedback	$25,000	0.3
Optical Anchor	$20,000	0.0

Continue FY02 Plan

- SLAC based work on inertial systems & UBC work on Optical Anchor
  - Simple block & sensor
  - Long steel beam
  - Relative motion of two simple blocks
- Fast Feedback demonstration in NLCTA

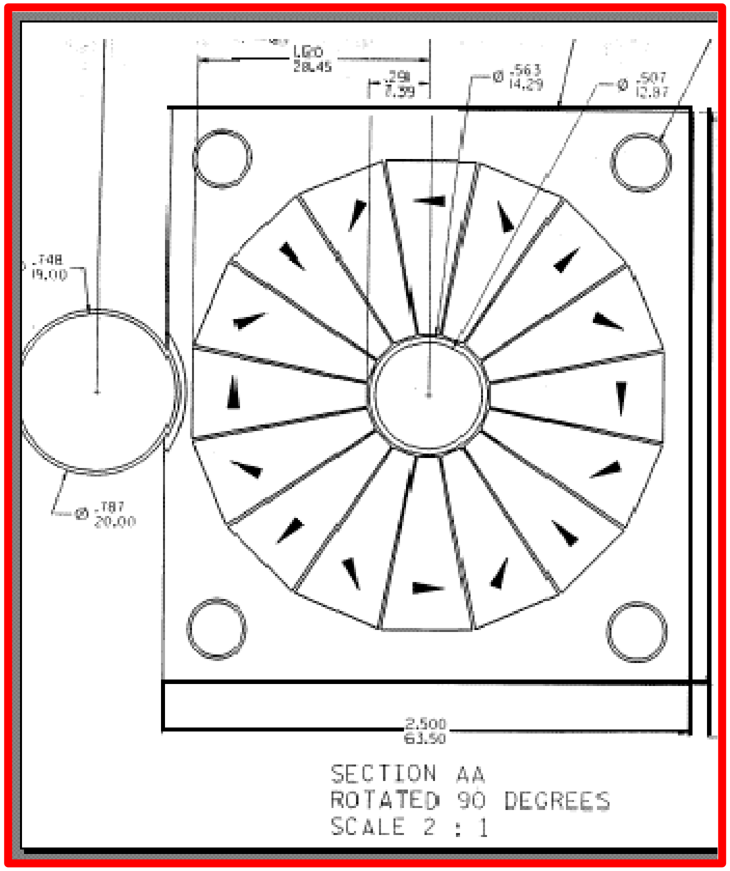
Begin

- 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

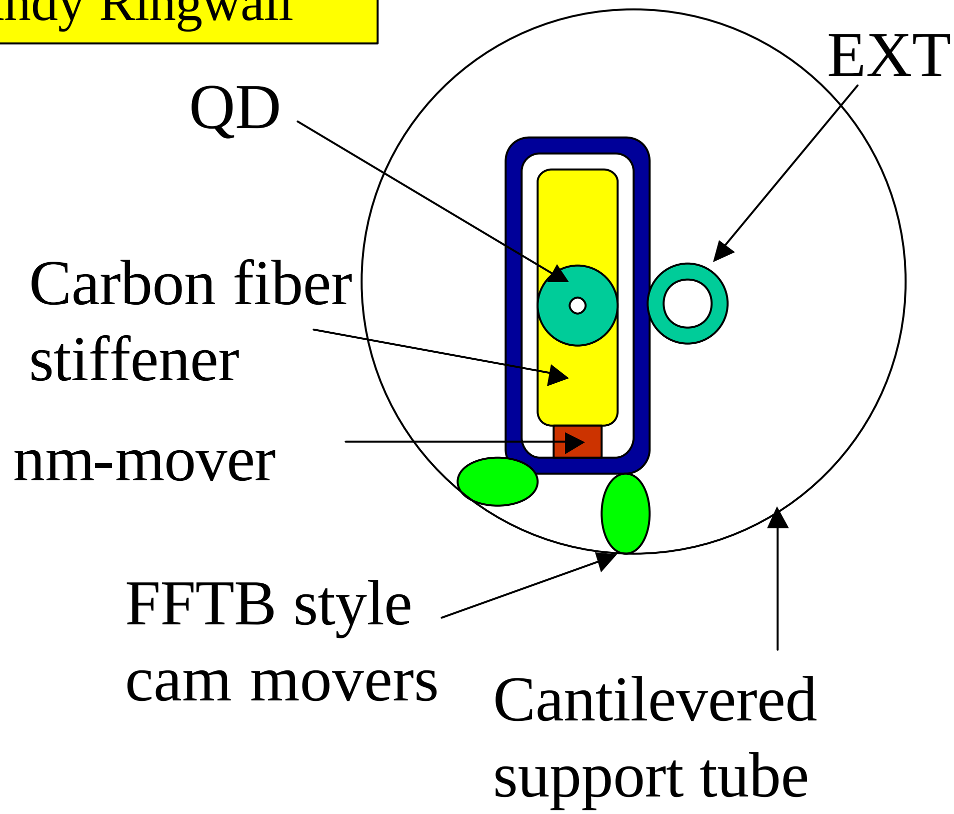
NLC Baseline: Permanent Magnet Quad

Compact, Stiff, Connection Free

Control B by controlling magnet position in Closed-Loop FB



Andy Ringwall



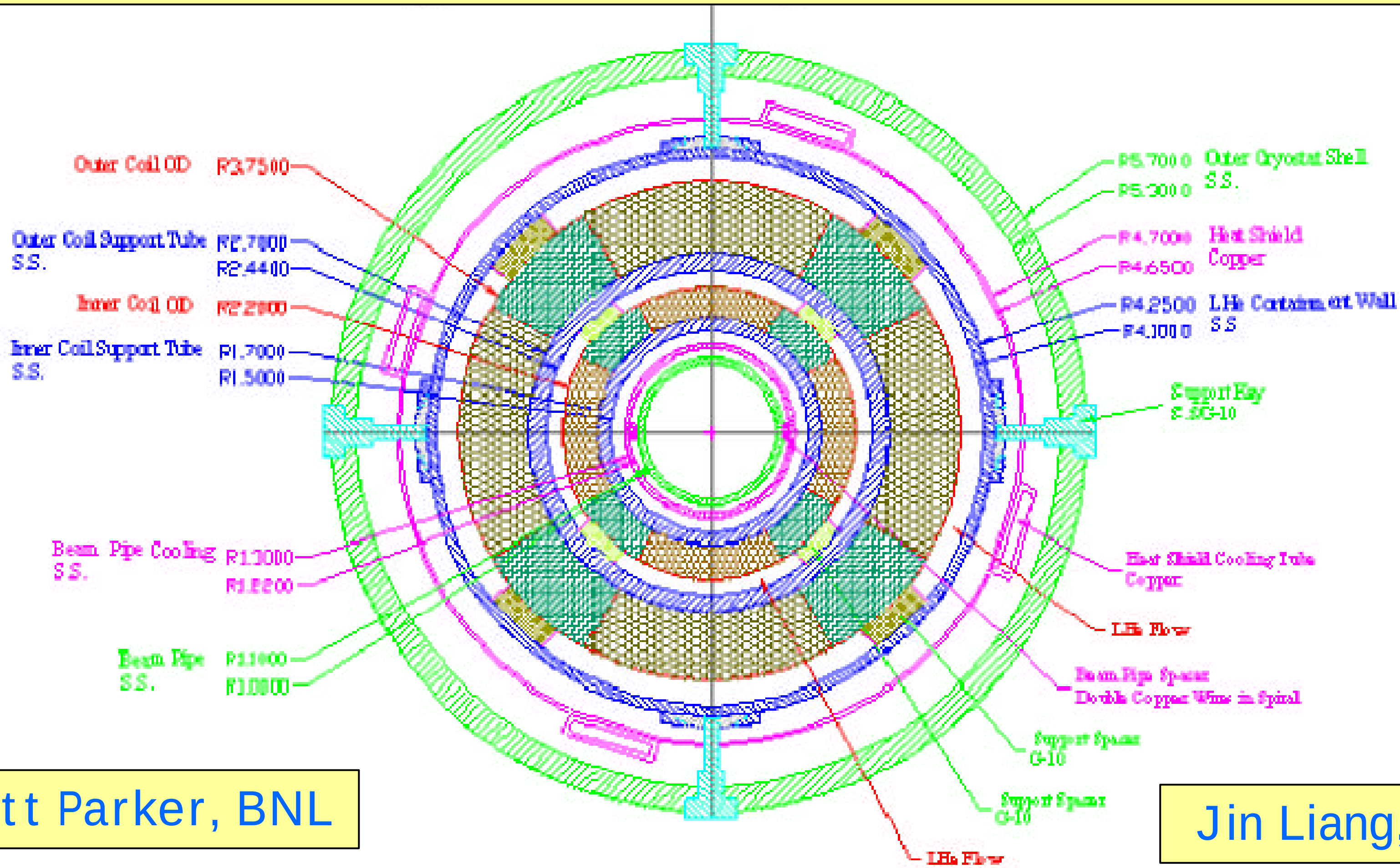
Magnet	Aperture	Gradient	Rmax	Z_ip	Length
QD0	1.0 cm	144 T/m	5.6cm	3.81 m	2.0m
QF1	1.0 cm	36.4 T/m	2.2cm	7.76 m	4.0 m

Knut Skarpaas

NLC Future? SC Final Doublet

based on HERA & BEPC technology

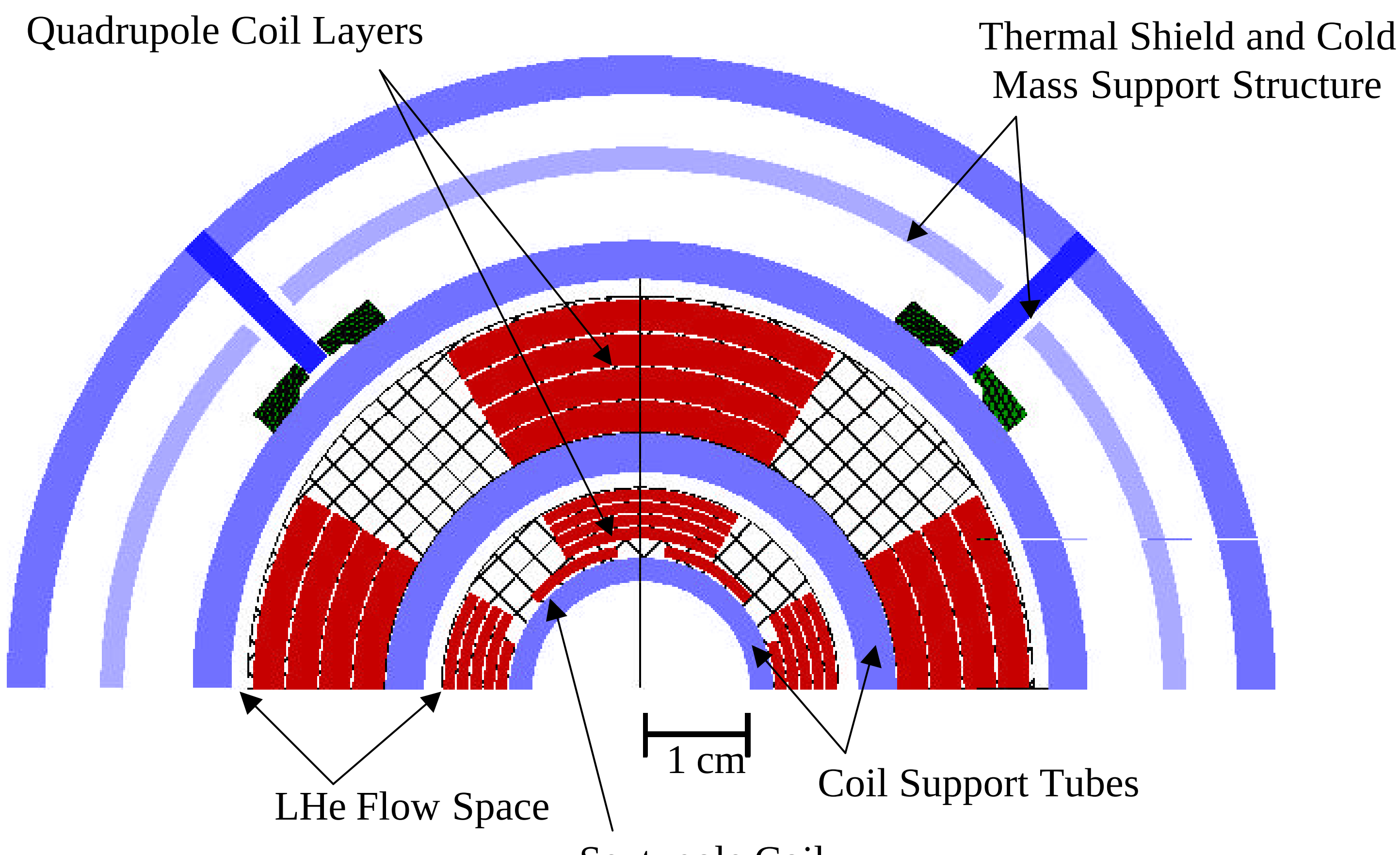
Compact 5.7cm Radius Warm Bore Design



Brett Parker, BNL

Jin Liang, BNL

Cold Bore NLC SC Quadrupole w/ Integrated Sextupole Windings



Brett Parker, BNL

Jin Liang, BNL

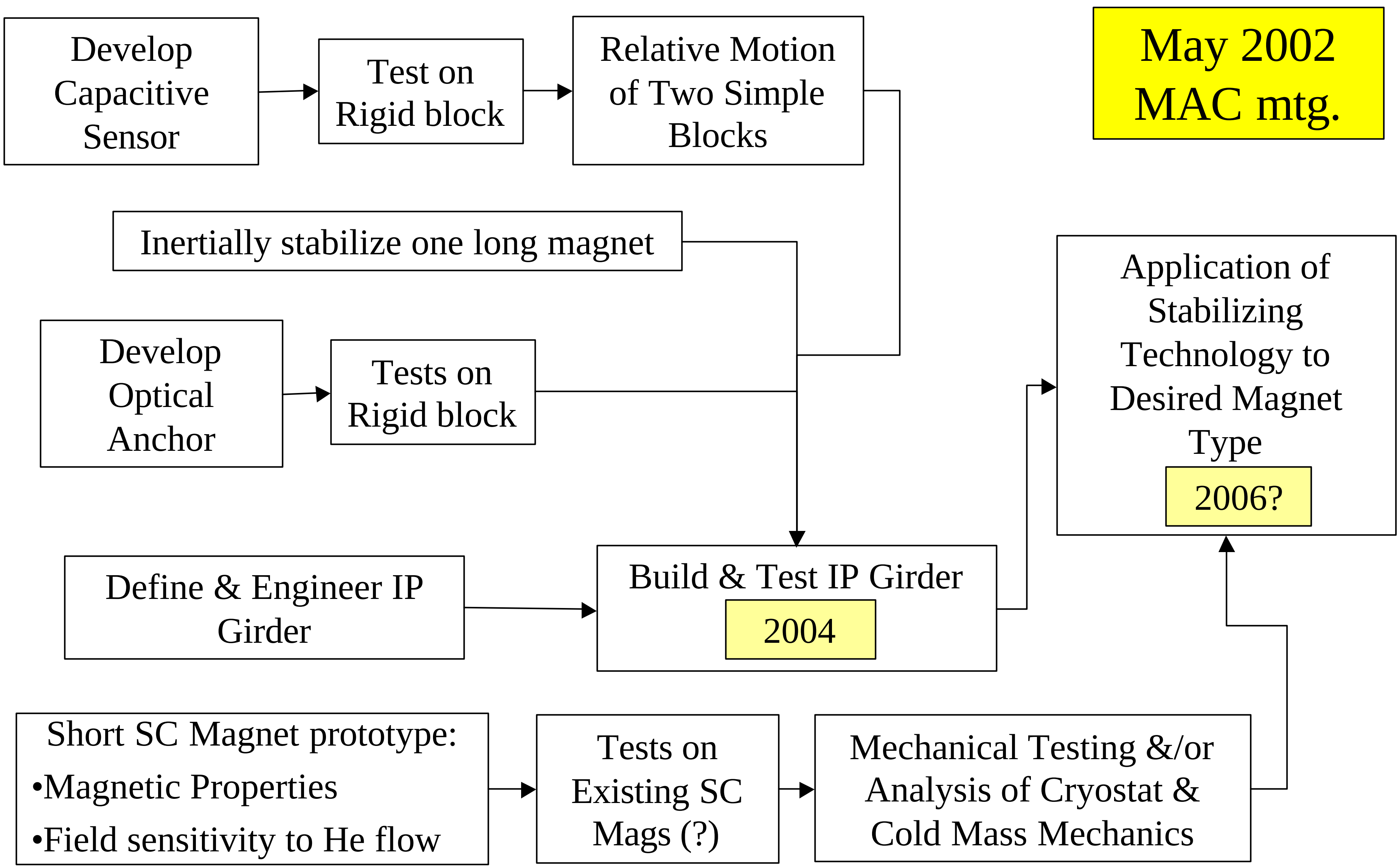
How does SC Quad Fit into R&D Plan?

- Consensus is that compact Superconducting Quads is the most likely candidate for the Final Doublet because operational flexibility
- R&D in SC Quads is still in conceptual stage and inconsistent with a proof-of-stability demonstration in 2004
  - Short Prototype of cold mass w/w.o. cryostat
  - 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
  - Effect of helium and power supply connections on vibration

Vibration suppression team will

- **Continue with the baseline permanent magnet model for the IP Girder Prototype under the assumption that a demonstration in important in the stated time scale and that making ANY viable technology work will teach us valuable lessons applicable to any final solution**
- **Work with BNL & others to develop a SC magnet vibration program and to design a SC magnet whose field can be assumed to be as stable as the position of its cryostat and then adapt the vibration suppression technology to it when (and if) it is ready**

Active Vibration Suppression Plan

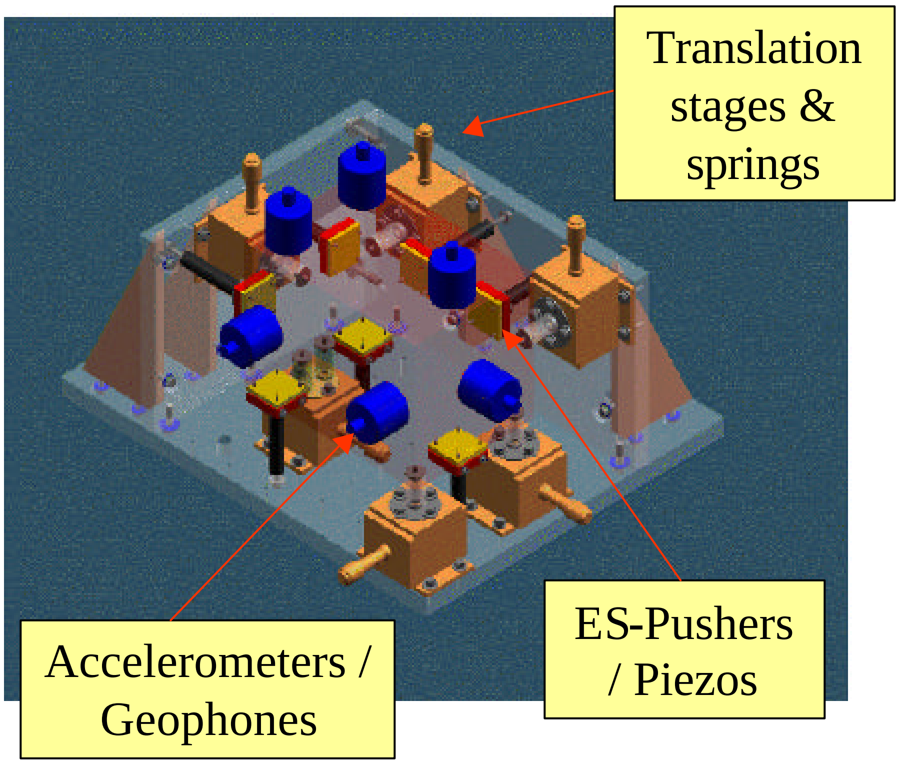


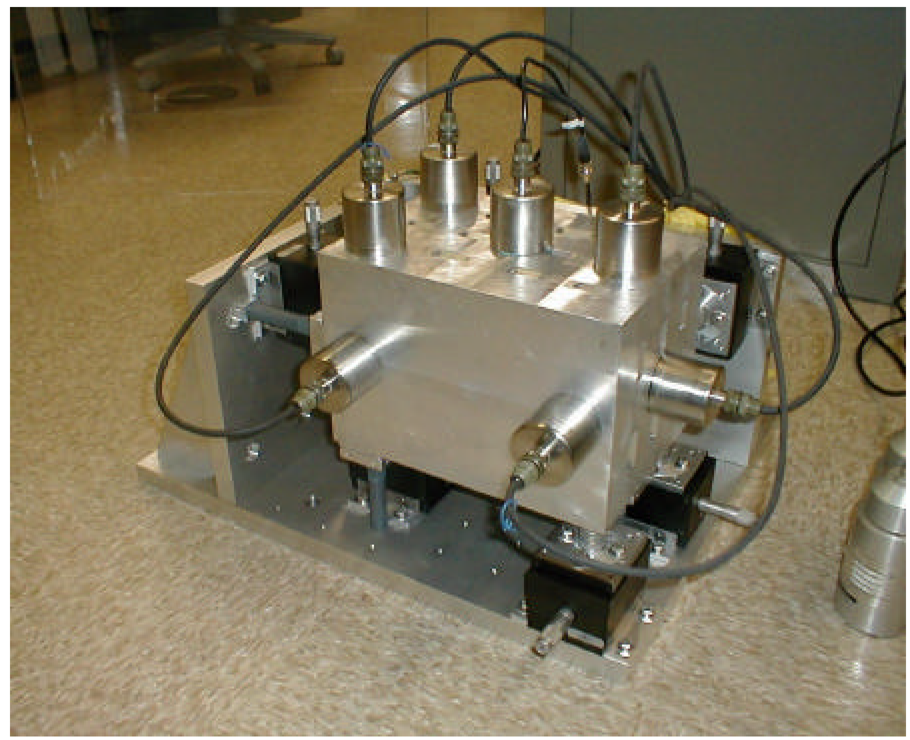
Inertial Vibration Damper Block Test

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

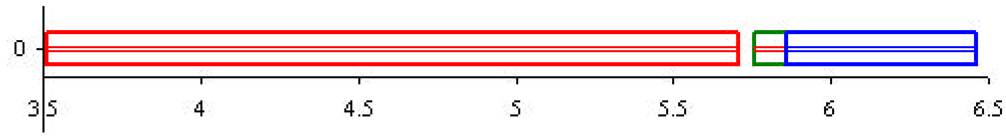




Long Magnet Test: Begin Now

Quantify problems of internal modes and stiffness requirements

- Support scheme
  - Generally analogous to single simple block
  - One extra sensor/activator to get lowest bending mode in y
- Specification of “Magnet”
  - 3m x 11cm x 11cm solid steel box beam
- Electrostatic pushers
  - As for single block



To Scale

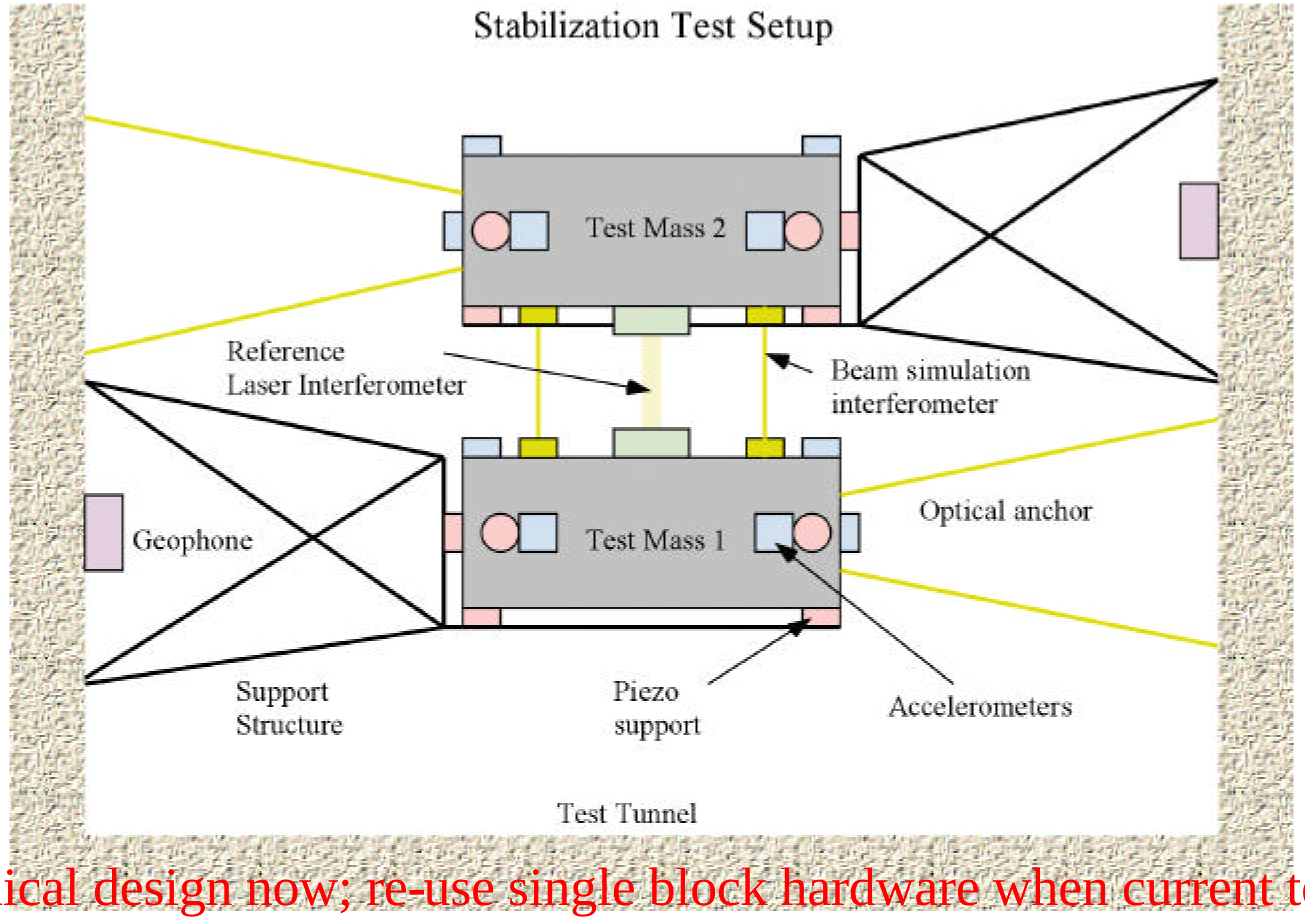
- Sensors
  - Capacitive sensors under construction for single block
- DAQ
  - Same computer, new ADC/DAC channels
- Location
  - CRYO lab with single block

Direct Dy Measurement of Two Simple Masses [Frisch ~4/1999]

–Witness laser interferometer measures exact quantity of interest

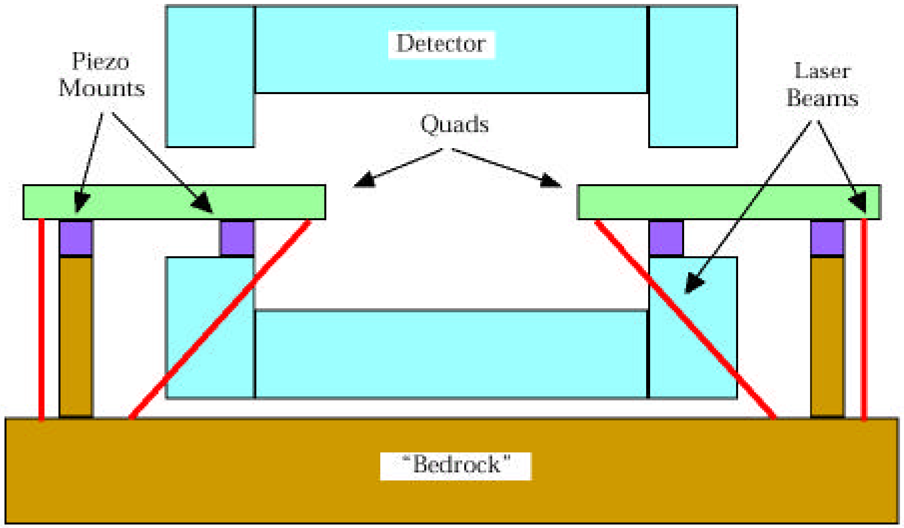
–One laser interferometer sampled at 120Hz simulates “slow” Beam-Beam feedback

–Currently done off-line in software

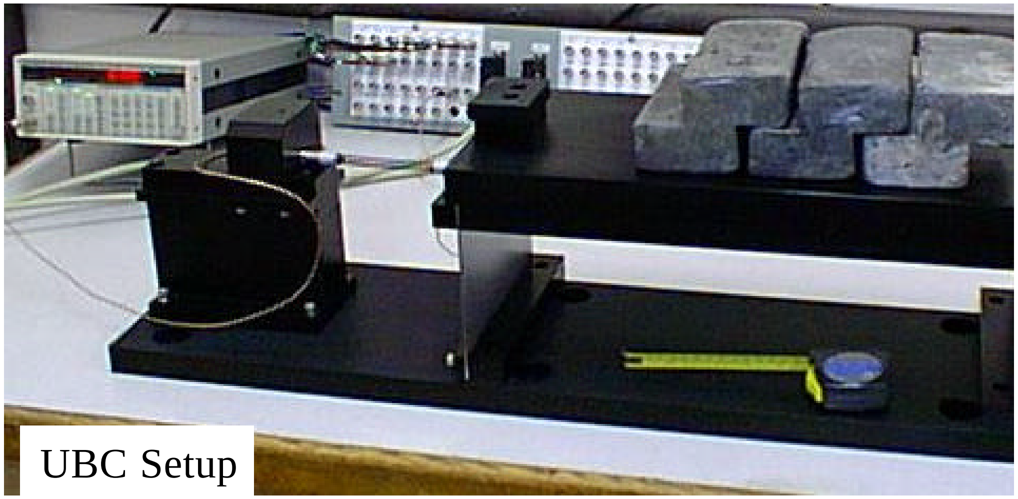


Begin mechanical design now; re-use single block hardware when current test done

UBC R&D on Interferometers

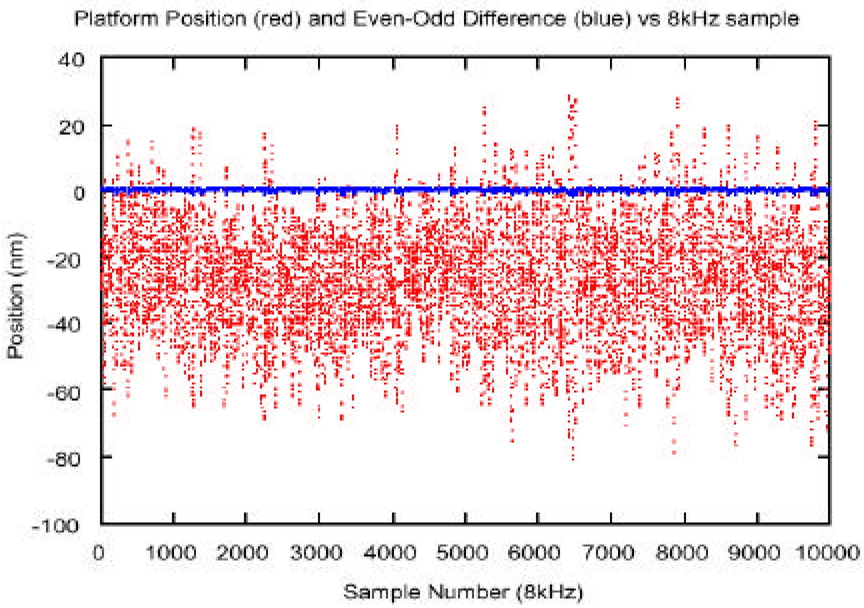


Sub-nm resolution measuring fringes with photodiodes ⇒ drive piezos in closed loop



UBC Setup

Platform Displacement & Sensor Value



IP Girder Prototype

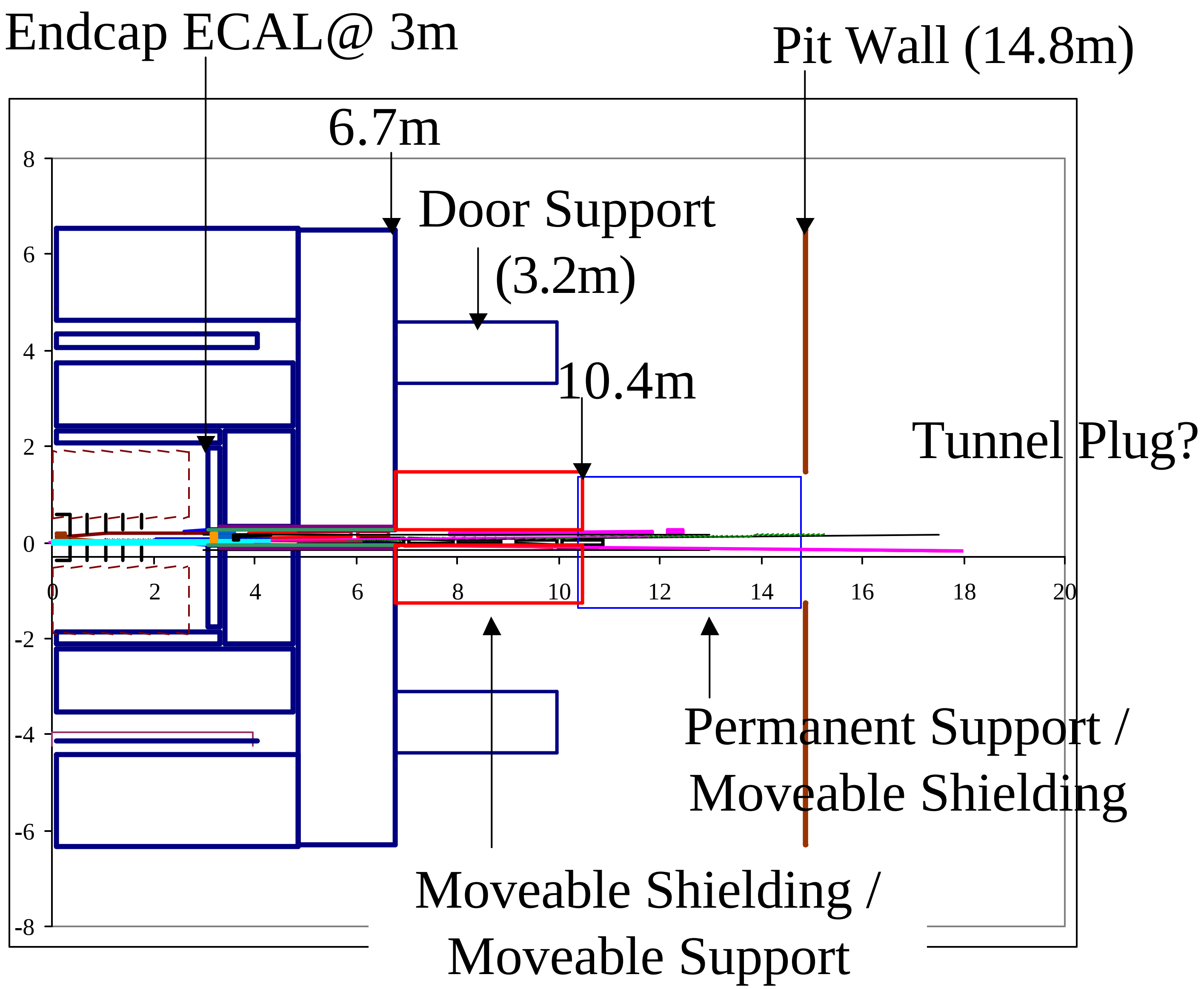
- Must look like the final girder
  - Successfully test relative/absolute nm-y stability when realistically mounted in a quiet but realistic experimental environment without a lot of hand waving to explain away deficiencies of prototype, site or frequency range of interest.
- Explore conceptual solutions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

IP Girder Design Issues and Working Consensus

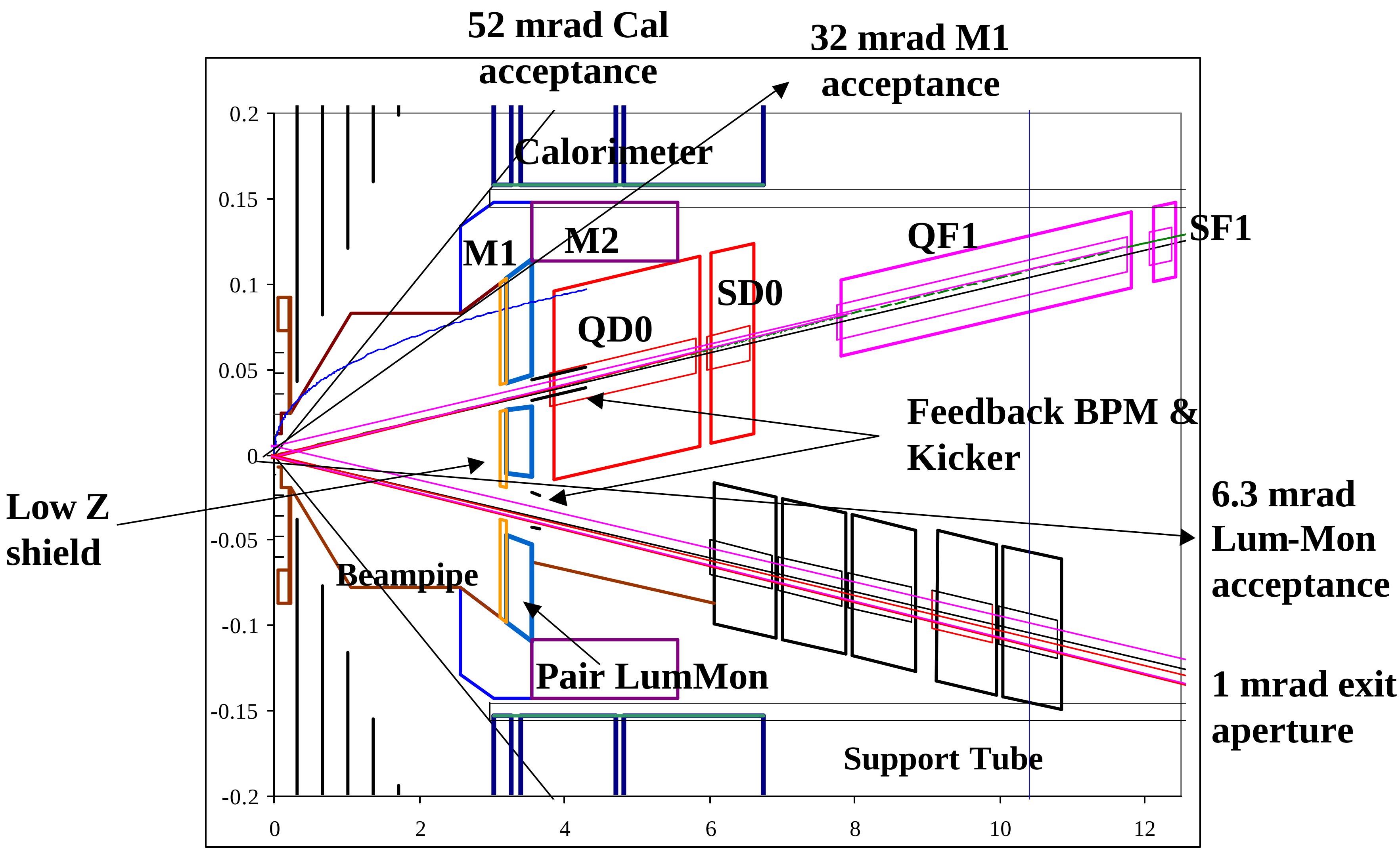
Detector Interface

- "Large Detector" with endcap $3.0<z<6.7$m
- 4.5m long 50cm diameter tube carrying one 3m magnet with the pair-lum monitor and low Z shield grabbed so as to fix one end firmly to floor with other 3.7m cantilever free of detector door
- Other heavy W masks assumed hung from detector
- Assume that even for "Silicon" detector, where $1.85<z_{DOOR}<5.21$, that optics require L*=3.5m so that there is NO solution where QD0 is outside detector

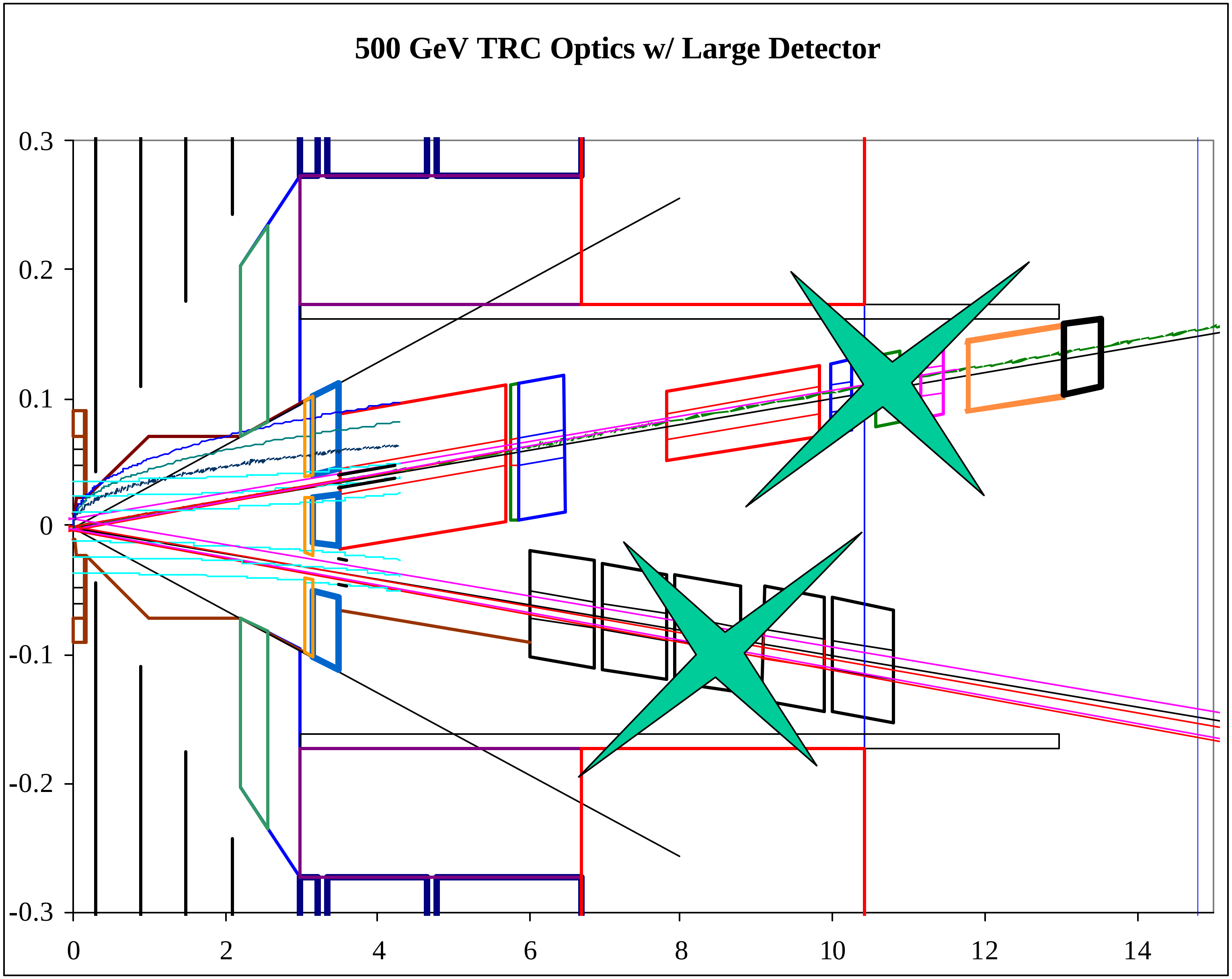
Large Detector in Pit



LCD-L2 (3T) with 3.8m L* Optics



Current Final Doublet with New Masks



Success is Zero-Motion as measured by Ideal Sensor

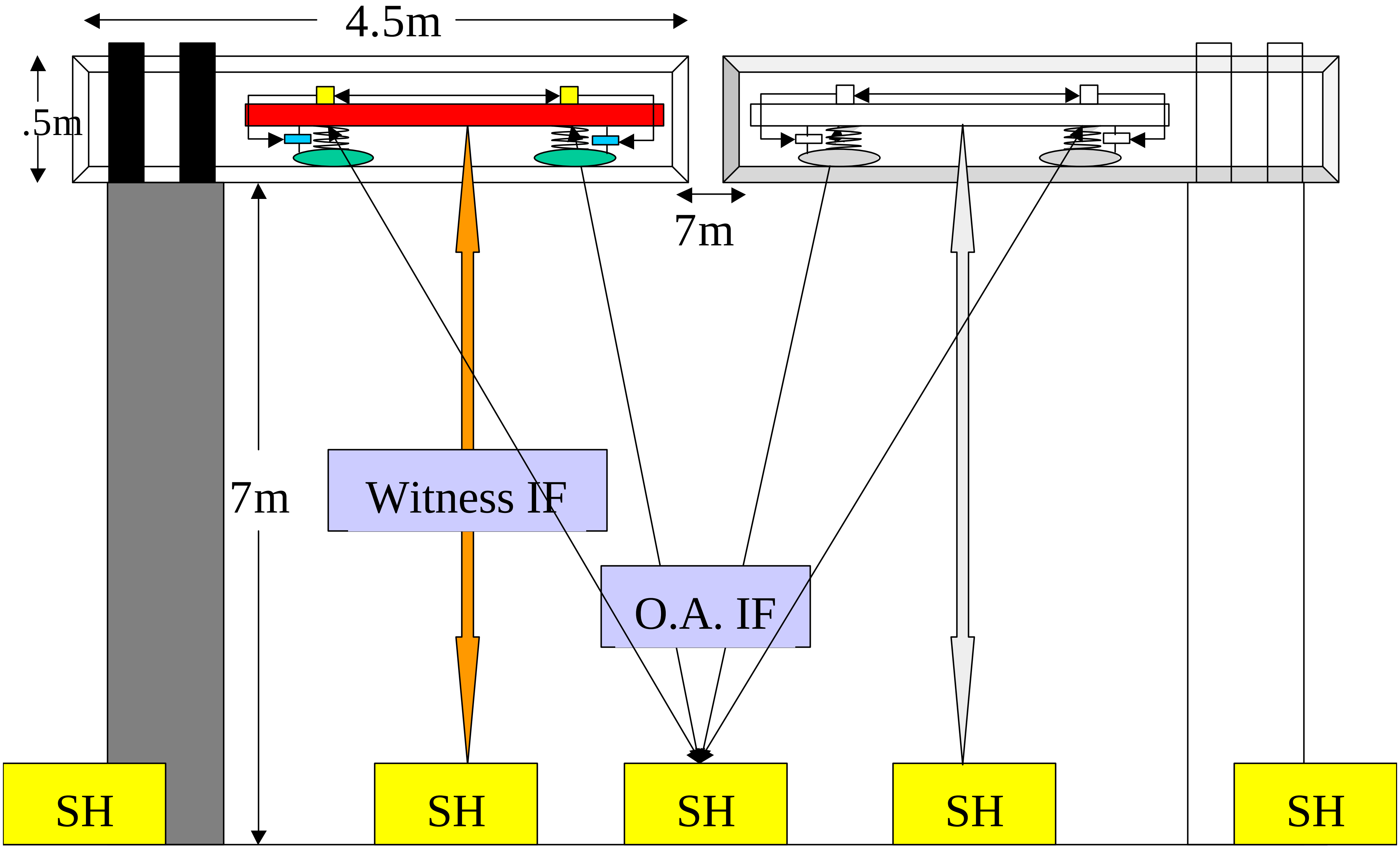
Adequate number of Struckheisen geophones

- Together with laser interferometer, serve as substitute for **ideal inertial reference frames** or measure magnet relative to ground that sensor sits on
- Measure surrounding ground motion well enough to input into simulation spectra and coherence for seismic & cultural disturbances

Probably no need for two identical girders

- If measurements are relative to pseudo-inertial frame no need for two unless, for example, one is equipped with O.A. and stiff supports while other uses soft supports and inertial sensors
- Concern expressed that correlation length for cultural noise sources together with low frequency cutoff of inertial sensor and effective vibration reduction of 120Hz system

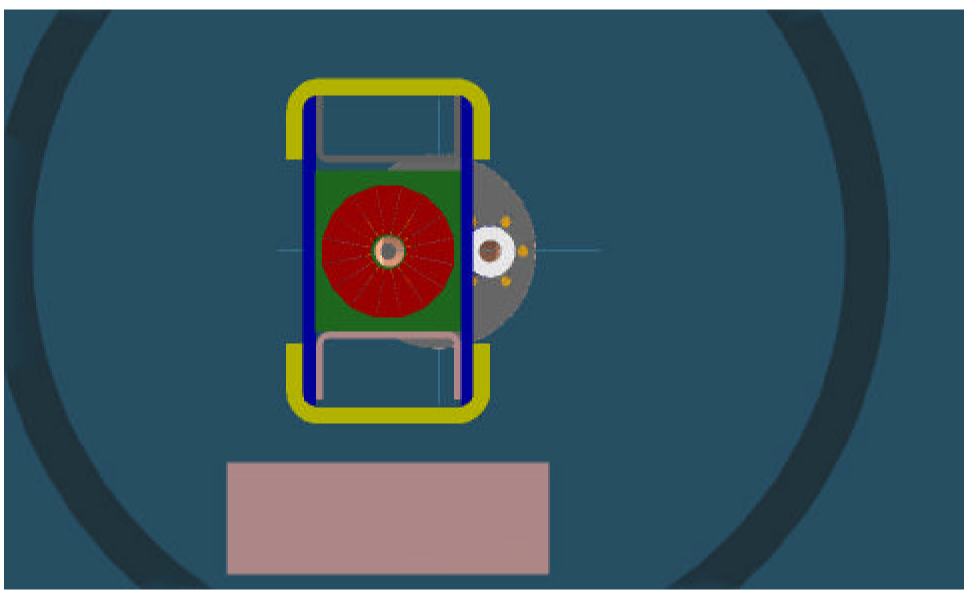
IP Girder Test Concept



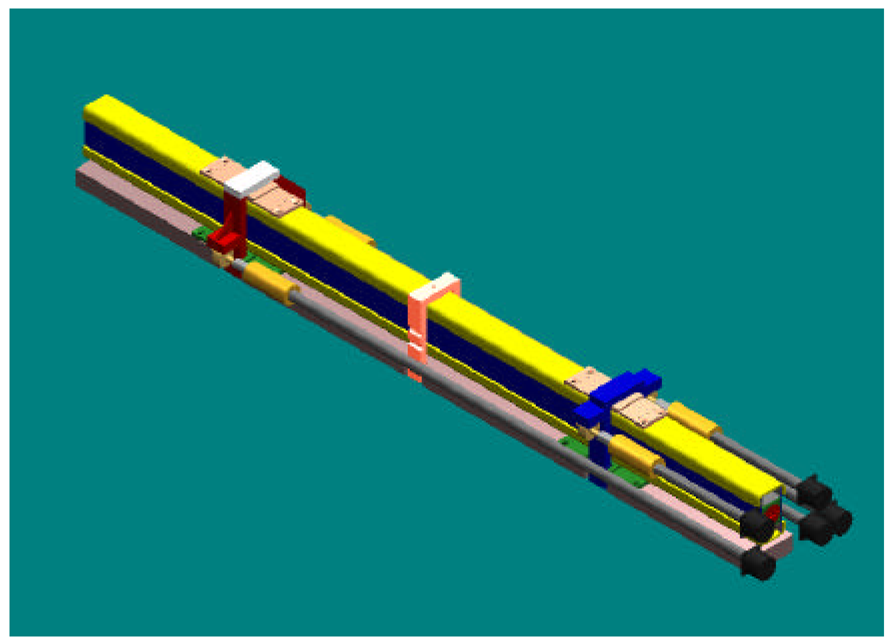
The QD0 Magnet

- 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

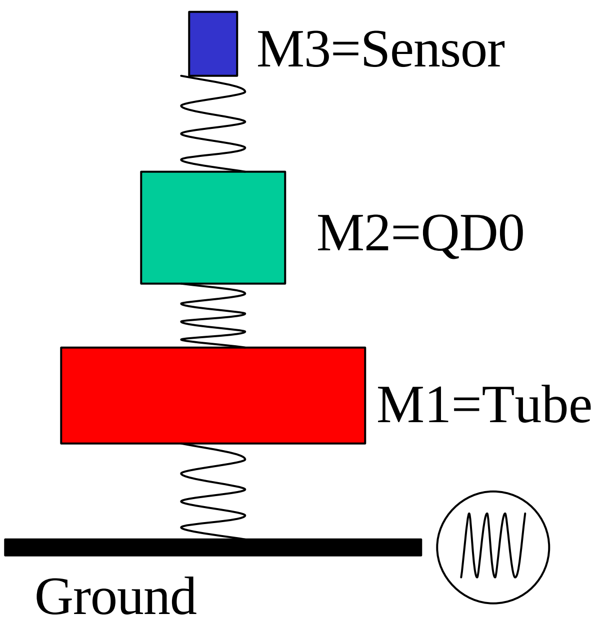


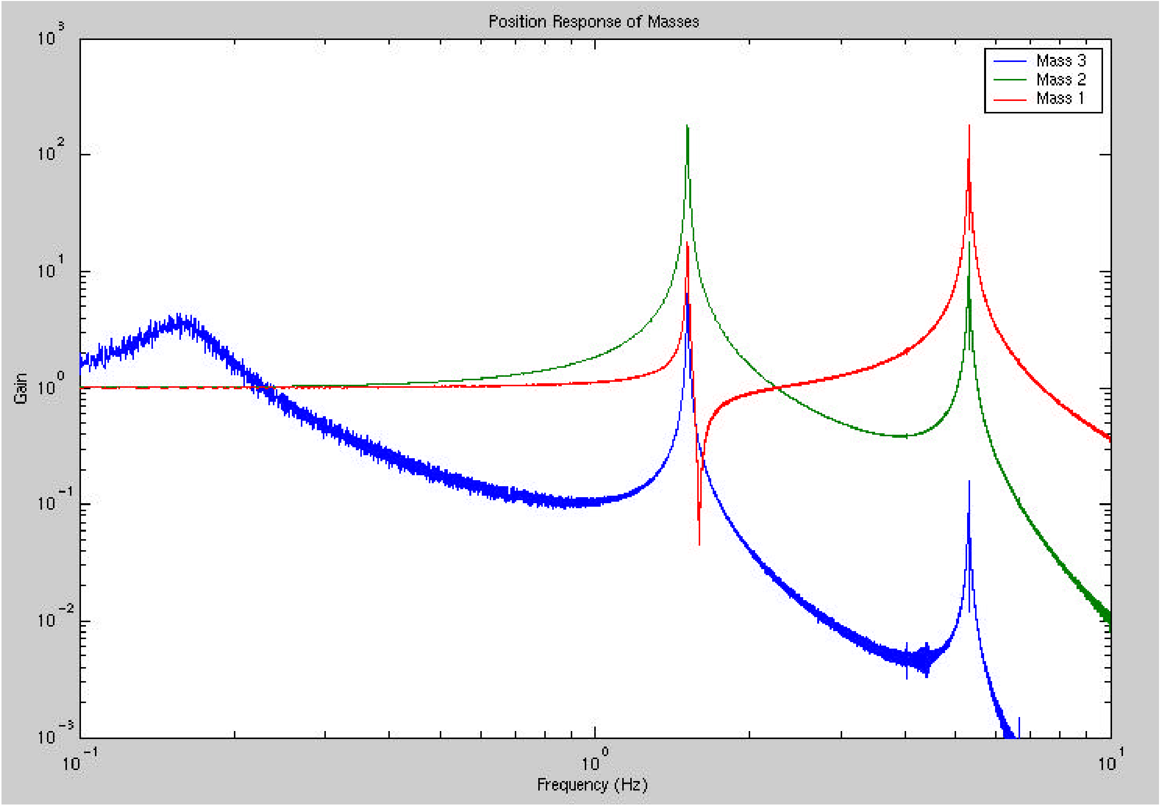
Q1 with stiffener & movers



Support Tube Details

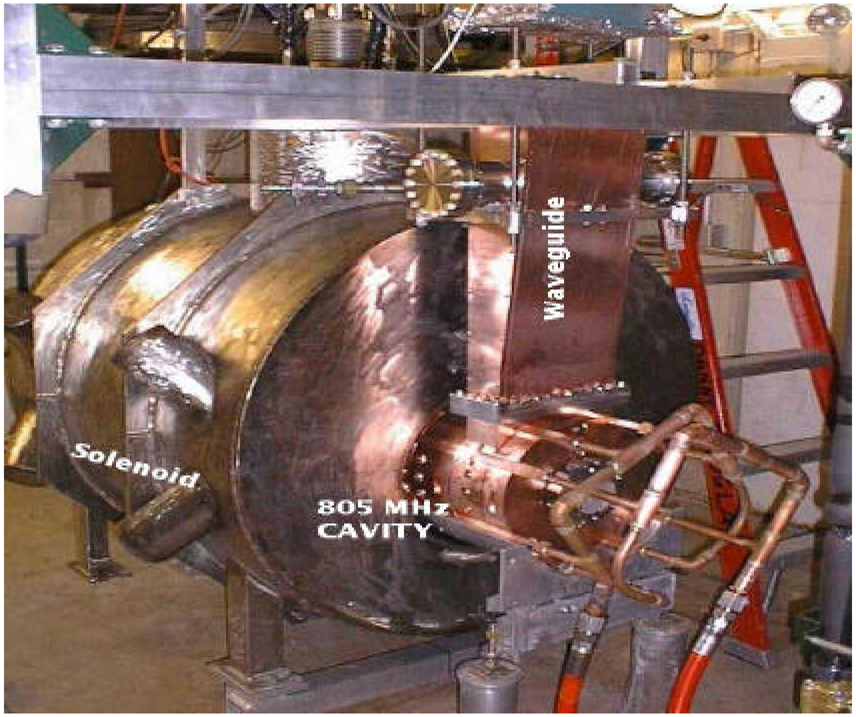
- Stiffness and mass of 50cm diameter tube: material, wall, …
  - –For inertial, depends on performance of sensor under design





Magnetic Coupling of QD0 to Detector Solenoid Fringe Field

- ~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

- **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?
- **……**

Questions for MAC

- Our perception is that a proof of principle vibration system demo, rather than incrementally assuring R&D is required. Is this correct?
- Our feeling is that, eventually, flexibility of compact SC magnet will make it the desired technology? What do you think?
- Our working decision is to continue to pursue inertial and optical closed loop feedback to stabilize permanent magnets that are assumed not to have internal degrees of freedom, as SC magnets might. While some knowledge gained will be generally useful, detailed engineering experience will probably not be applicable. Is this necessary?
- First part of plan assumes a 2004 time scale. Is this a pipe dream?
- Detailed design of IP Girder needs much more work. Comment on level of realism needed: vacuum, external field, similarity to real magnet, etc.