FY07 ILC Statement of Work – WBS 3.10.8 Vibration R & D

Work to be Accomplished in FY07

Work will be carried out towards developing a probe to measure the motion of magnetic center in a superconducting quadrupole. The goal is to achieve a sensitivity of ~few nm at frequencies of a few Hz and above for a quadrupole gradient of over 100 T/m.

One of the key components in such a probe is a pick-up coil with sufficient sensitivity, requiring thousands of turns. We have already obtained such a coil on loan from CERN. This coil has a winding area of approximately 125 mm x 13.5 mm with 2500 turns of a 32 micron diameter wire, for an effective surface area of ~4 m^2. The sensitivity of this coil is thus estimated to be ~400 V/(m/s) in a 100 T/m gradient, which is comparable to geophones, and should be adequate for the proposed work.

Since the magnetic probe will only measure the relative motion of the pick-up coil and the quadrupole center, the ultimate resolution obtainable depends on the system electrical noise and the motion of the probe itself. In order to unambiguously measure the motion of the magnetic center, the probe itself must be stabilized as best as possible. The work proposed for FY07 will attempt to produce a working measurement system and study its vibration and electrical characteristics.

As part of the FY07 work, the bare pick-up coil obtained from CERN will be mounted in a suitable support structure and its mechanical motion will be studied using geophones and laser Doppler interferometric techniques. The support structure will be designed to minimize the motion of the pick up coil. It is foreseen that in order to achieve resolutions of a few nm, it will be necessary to actively stabilize the coil support. Commercially available actively stabilized isolation tables will be used for this purpose.

Since no prototype of a superconducting final focus magnet for ILC is likely to be available in the immediate future, it is proposed to study the performance of the magnetic probe in a room temperature quadrupole available in the Superconducting Magnet Division of BNL. This quadrupole has a rather large aperture of ~300 mm and can provide a gradient of 4.9 T/m. The reduced gradient drastically impacts the sensitivity, but the larger aperture allows easier monitoring of the motion of the probe. Furthermore, several other aspects of the technique, such as sensitivity to magnet power supply ripple, can be studied using the available quadrupole. It should also be noted that extensive tests of an initial prototype are far less expensive in a room temperature magnet than in a superconducting magnet.

It is envisioned that the initial coil support design would focus more on the stability of the probe, and may not be suitable for the smaller aperture of the ILC final focus quadrupoles. The FY07 goal will be to demonstrate a “proof-of-principle” probe and gain an understanding of the potential problems in applying this technique to the final focus quadrupoles.

As part of another proposal (WBS 3.10.4; Final Focus Quad Full Length Prototype), BNL is proposing to build in FY07 a room-temperature-only mock-up of the final focus quadrupole from parts that will be used later on for the real prototype. The vibration R&D will be continued using this mock-up and the Laser Doppler Vibrometer at BNL to ascertain the effectiveness of insulating radial supports, and to further develop the techniques for measuring the motion of a cold mass in a geometry closer to the actual final focus magnet design.

Relevance to the FY07 goals of the ILC Global Design Effort

Superconducting quadrupoles for the final focus are part of the baseline design for the ILC. These magnets must meet the stringent vibration control tolerances needed for the ILC. Study of vibration characteristics of superconducting magnets is challenging since most of the conventional vibration sensors cannot be used in the cryogenic and high magnetic field environment. The extremely compact design of the ILC final focus quadrupoles makes the task even more challenging. Some progress has been made at the Superconducting Magnet Division of BNL towards measuring motion of a cold mass at cryogenic temperatures using laser Doppler interferometry. The proposed magnetic probe is expected to provide an alternative method to characterize vibration of the ILC quadrupoles. Furthermore, the magnetic probe will provide a direct measurement of the magnetic field center, as opposed to the mechanical motion of the cold mass, provided the issue of the probe motion can be resolved. The work proposed in FY07 is aimed towards a practical realization of such a probe.

Key Milestones/Personnel

Completion of the prototype probe assembly	November 2006
Study of vibration characteristics of the probe	January 2007
Actively stabilized probe holder with X-Y stage	March 2007
Probe performance in a room temperature quadrupole	May 2007
Effect of power supply ripple on performance	July 2007
Vibration studies in a room temperature mock-up using a Laser Doppler Vibrometer	September 2007

WBS work package leader Animesh Jain

FY07 Deliverables

A prototype probe assembly and study of its mechanical and electrical performance in a room temperature quadrupole.

Vibration measurements using a Laser Doppler Vibrometer in a room temperature mock-up of the ILC quadrupole

Cost

Labor FTE's	Labor $K Direct	M&S $K Direct	Indirect costs $K		Total Costs $K
1.25	94.0	25.0	81.0		200.0

Labor consists of 0.6 FTE graduate student, 0.65 FTE physicists.