PROGRESS REPORT FY06
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Continuing Research and Development of Linac and Final Doublet Girder Movers

Personnel and Institution(s) requesting funding

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Project Description:

Every magnet and structure girder in the ILC beam delivery system will sit on movers to allow them to be positioned accurately. Depending on the requirements of the component in question, the movers must position the beam components in either three degrees of freedom (two linear positions and one angle) or five degrees of freedom (two linear positions and three angles). Beam delivery system movers will typically be adjusted every few minutes, and must have a resolution or "step size" of approximately 50nm. It is not required that each step be precisely 50nm, simply that the average step size over a series of 10-20 steps achieve this average. The movement will be relative, with the motion required by the mover and achieved in operation determined by beam position monitors. Since approximately 1,000 movers will be required, cost reduction, manufacturability and reliability are important for this component.

Gordon Bowden developed and produced movers used in the FFTB while not achieving the required precision (they were measured to achieve a position resolution of approximately 300nm) and cost (a 5-degree of freedom mover would probably cost at least $5000 each to manufacture in their current design, at least in small quantities) have provided the fundamental design concept for our mover. These FFTB movers are mechanical, utilizing a kinematic support concept providing motion by rotation of bearings mounted on an eccentric shaft, which are in contact with wedge-shaped anvils supporting the linac component.

Status Report

Several changes have been made to the magnet mover design over the last year. The most significant of these changes is the evolution from a three axis system to a five axis system. We have also incorporated a new motor with a 10:1 gear reduction box attached in order to achieve higher torque required for the increased load requirement (~1000 kg load). The connection mechanism for the gear reducer to the shaft has been redesigned completely, paying special attention to reducing thermal contact between the motor/gear reducer and the chassis. Lastly we have switched to a new self-aligning ball bearing, which is fully sealed, improving the long-term reliability of the mover.

Designing and producing the five axis mover is the most significant change in the mover project that has taken place over the last year. The five axis design is comprised of five single axis chassis that were modeled after the single axis chassis of the old 3 axis design (See Fig 1 below. See Appendix B for close up of chassis with gearbox attached). With the new five axis system the mover has 5 degrees of motion, being motion in the x-direction, y-direction, pitch, yaw and roll. We are currently working on a prototype for a 5 axis mover to be used in manufacturing, which accounts for lessons learned in production of the first 5 axis mover and works toward a simpler manufacturing procedure to be used in mass production.

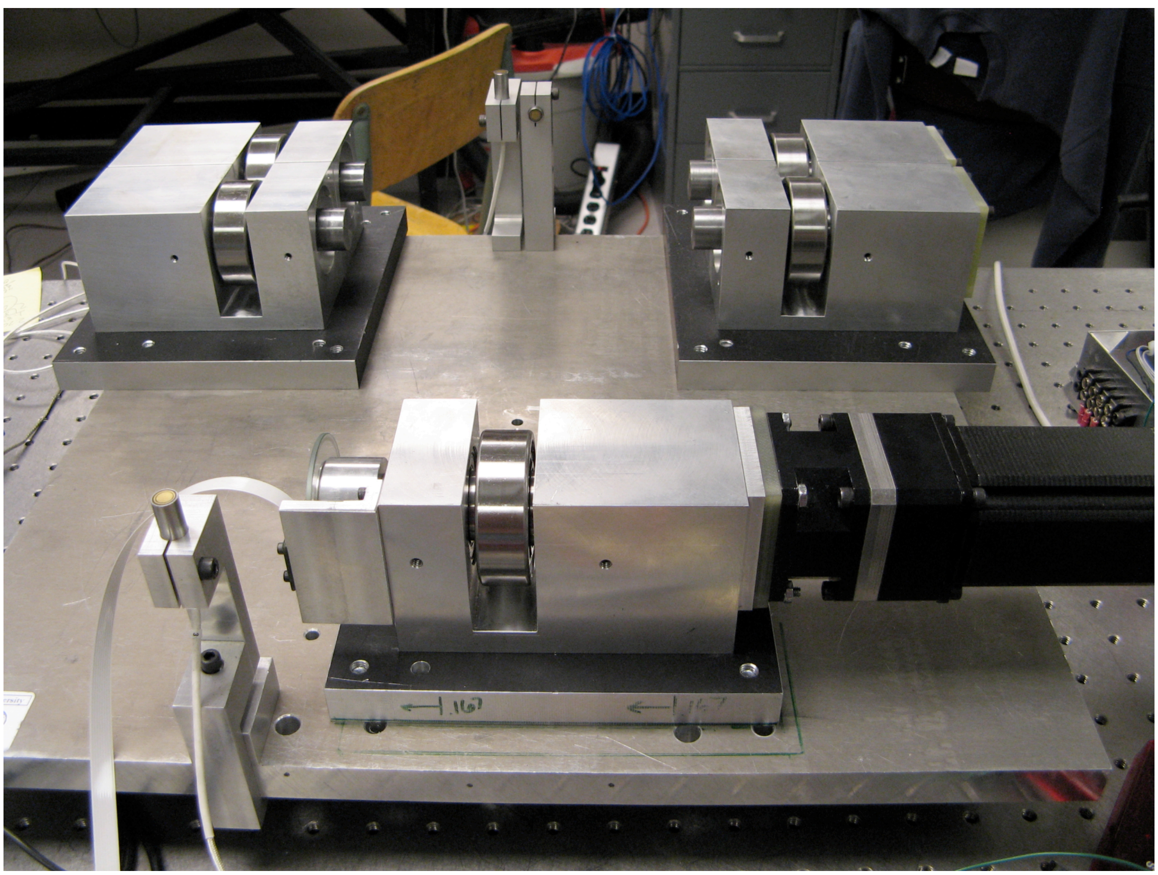

Fig 1. Five axis Mover without load bearing top plate

The new mover design incorporates a larger motor and a planetary gear box, as seen in Fig 1. The new motor and gearbox give us 1400 oz-in torque as compared to the 60 oz-in with the old motor. The resolution of the new motor with the gear box is 0.0007 degrees/step, which is higher than the resolution we were able to achieve with the old motor (0.002 degrees/step). The only significant performance cost for the increase in both torque and resolution was a factor of ten decrease in the speed at which the shaft turns, which limits the new speed of rotation for the shaft to approximately one revolution per minute. With the new motor we are able to achieve more precise resolution than before, approximately 40nm/step at 90 degrees shaft rotation from the zero point (The zero point is defined to be where the point on the offset cam where the thickness of the cam is smallest is normal to the support for the load bearing plate that rests on the bearing). Figure 2 shows motion for 6 separate series over 250 steps through 90 degrees plotted versus motion of the support platform.

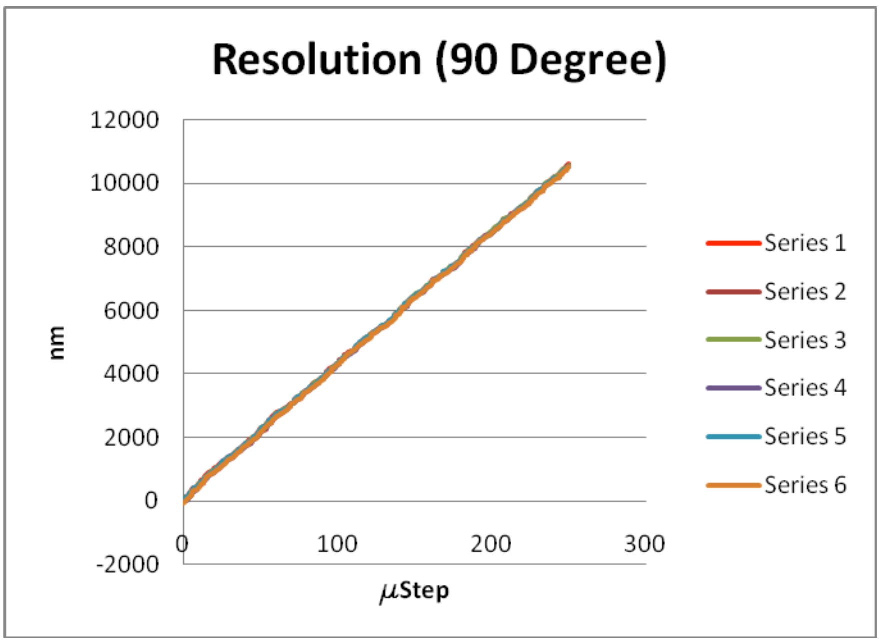

Fig 2. Plot of resolution at 90 degrees from zero

While designing the new chassis for the five axis system special attention was paid to thermally isolating the motor/gearbox from the chassis. A piece of G-11 was machined to connect the shaft of the gear box to the shaft of the chassis and a plate of G-10 was machined to sit between the mounted gear box and the chassis (as seen in Fig 3). Temperature data were taken showing the thermal isolation of the G-11 and G-10 pieces by measuring the temperature of the motor and measuring the temperature of the chassis, where the G-11 and G-10 pieces separated the two (as seen in Fig 4). Both motor and chassis temperatures increase exponentially at first until a plateau is reached at 300 minutes, at this point fluctuations in room temperature are seen to dominate. It is seen that the chassis temperature is always below the temperature of the motor, which is a direct result of the insulation. The chassis temperature is still affected by the motor, although it is easy to see that once the plateau is reached the temperature change is dominated by changes in ambient room temperature.

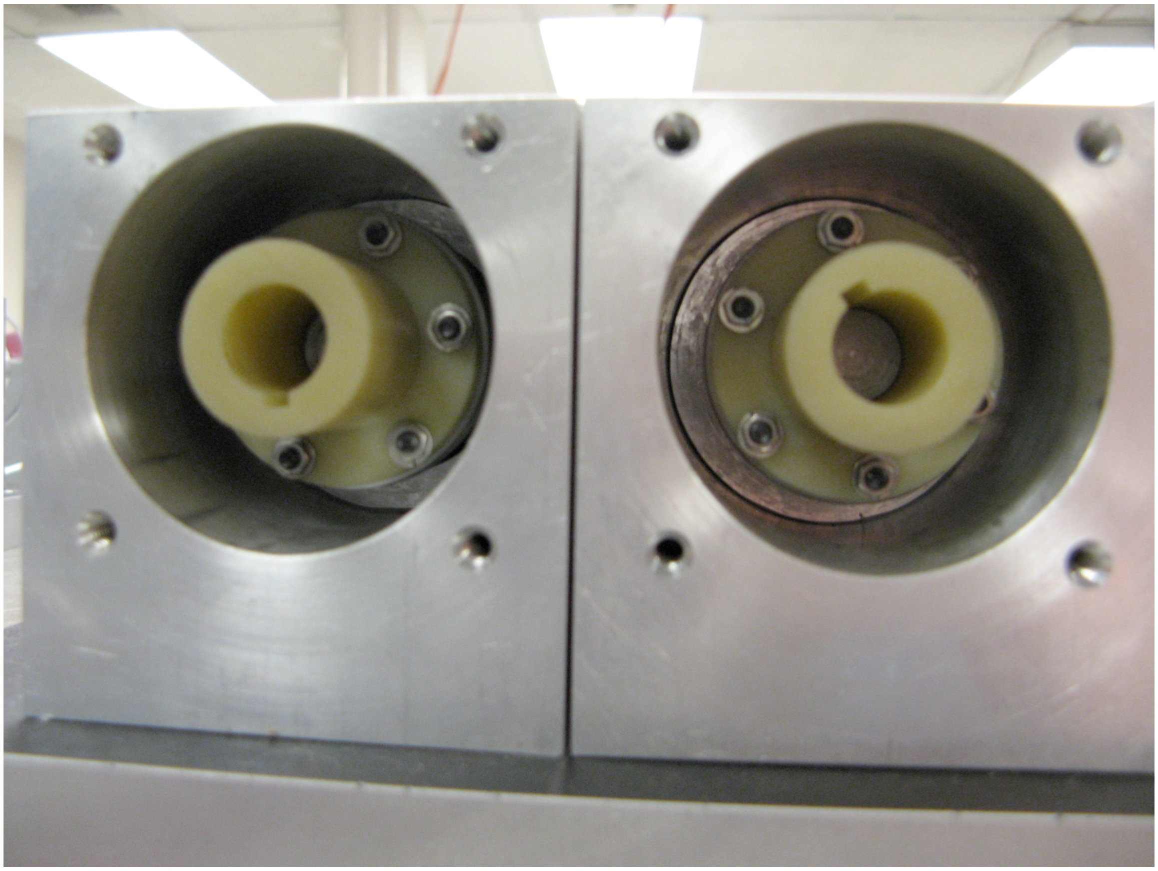

Fig 3. Edge on view of chassis showing thermal isolation

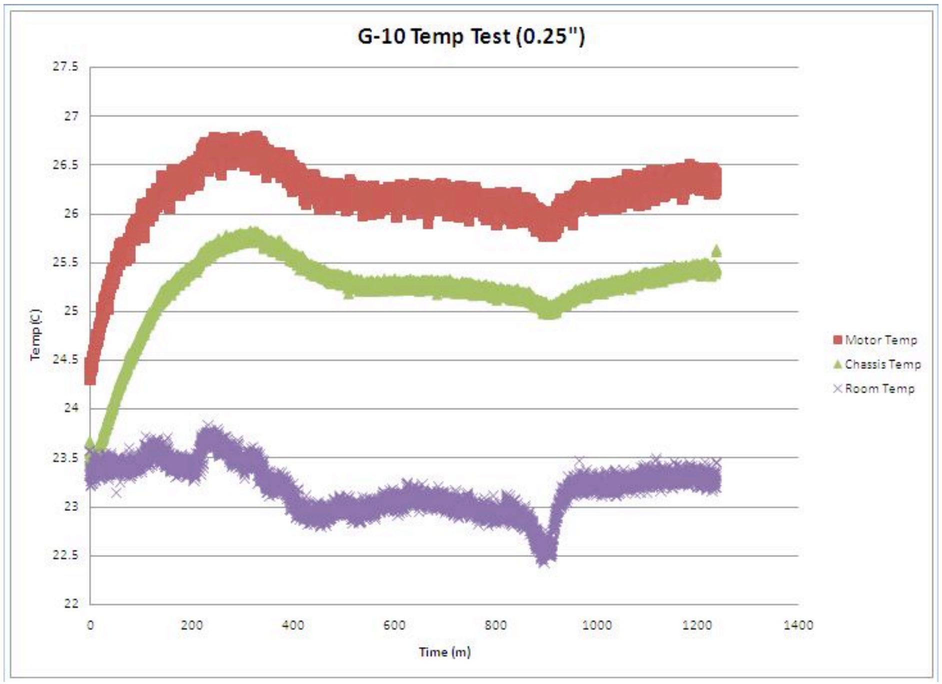

Fig 4. Plot of Temp Test with G-10 and G-11

The software for the magnet mover has also evolved over the last year. We have developed an automated zeroing program which is able to locate the zero point of the cam with repeatability to within 20nm. This program works for both the single chassis, which has block support to the load bearing plate, and the conjoined chasses which have triangular support to the load bearing plate. Furthermore, once the zero point has been located the program locates an index mark on the quadrature encoder for that axis and measures how many steps and in what direction absolute zero is from the index. In this way once zero is located once it is known as long as the glass grating with the index mark stays fixed to the main shaft.

FY 2007 Project Activities and Deliverables

In FY07, the project will move towards manufacturability of the beam delivery system mover at a low price, involving redesign of the components in collaboration with manufacturing firms to reduce price and to determine the most cost effective option for the driver system. Year three will also include development of any special mounts required for the final focus girder cryostat.

Deliverables:

-An optimized-for-manufacturability design report for the beam line movers, including an optimized shaft driving system, measurements of system performance, and projected costs

-A design for a final focus element mover.