Project Summary / Abstract

Company Name: Particle Beam Lasers, Inc.

Project Title: Overpass/Underpass coil design for high field dipoles

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Topic Number/Subtopic Letter: 33b

Abstract: We propose to develop and demonstrate the overpass/underpass (also called cloverleaf) end design for high field block coil dipole magnets made with Nb_3Sn Rutherford cable. Block coil dipole designs are appealing for their simplicity in the body of a magnet, but less so in the ends of certain blocks that must be lifted to clear the beam tube. This lifting — which typically is in the hard direction of the broad cable — must be very gradual, to avoid conductor degradation from excessive strain, making for ends that are undesirably long.

We propose to develop and demonstrate a new and innovative coil end design for high field block coil dipoles. The new geometry, the overpass/underpass or the cloverleaf, clears the bore tube by replacing the hard-way bends by a gentle twist in a 270° turn. The design produces ends that are much shorter in length. Moreover, the strain on the cable in the ends also remains low, although the geometry of the ends becomes more complex. We will demonstrate this design for the pole coils of 2-in-1 common coil dipoles while also developing a good field quality design.

The Phase I work plan will include winding a few practice coils either with NbTi or with the unreacted Nb_3Sn Rutherford cable. We will also perform magnetic and mechanical analysis of the 3-d ends of the overpass/underpass design for a "Proof-of-Principle" ~10.5 T dipole. Such a high field demonstration is possible within the Phase II budget thanks to the unique geometry of the BNL common coil dipole, which has a large, easily accessible open space in which the R&D coils can be inserted and tested as an integral part of the magnet without any need to disassemble and reassemble the original magnet. The Phase I work plan also includes a basic structure design of the "Proof-of-Principle" magnet.

In Phase II we plan to carry out a preliminary engineering design of a 16 T Nb_3Sn dipole based on the overpass/underpass ends in addition to performing the critical proof-of-principle demonstration of this end design. If successfully designed and demonstrated, this design can also be applied to other block coil dipoles as well, whether made of HTS or Nb_3Sn superconductor and to high gradient block coil quadrupole designs.

Commercial Applications and Other Benefits: Block coil dipoles with end windings based on the overpass/underpass design are appealing for a variety of accelerator applications, and for other scientific research needs. The overpass/underpass design, if successfully demonstrated, will reduce both the stored energy and length of the magnet and may improve performance in machines such as the Future Circular Collider (FCC), which in itself offers a market of several billion dollars.

Key words: Block coil dipoles, high field dipoles, common coil dipoles, Nb3Sn dipole magnets.

Summary for members of Congress: The next generation "atom smashers" will require dipole magnets of very high magnetic field. This proposal will explore innovative block coil designs that can be used to make magnets shorter and more reliable.