8. Project Narrative

Cover Page

Company Name & Address:	Particle Beam Lasers, Inc. 18925 Dearborn Street Northridge, CA 91324-2807
Principal Investigator:	Ronald M. Scanlan
Project Title:	Development of an accelerator quality high field common coil dipole magnet
Topic No: 27	Superconductor Technologies for Particle Accelerators
Subtopic: (b)	Superconducting Magnet Technology

Proprietary data legend: This narrative contains no proprietary data.

Identification and Significance of the Problem or Opportunity, and Technical Approach

This proposal concerns the development of high field dipole magnet technology for a future high energy physics colliding beam accelerator. This proposal is consistent with many of the recommendations put forth by both the 2014 Particle Physics Project Prioritization Panel (P5) and a recent High Energy Physics Advisory Panel (HEPAP) subpanel [1].

The P5 recommended that US DOE research efforts should "Participate in global conceptual design studies and critical path R&D for future very high-energy proton-proton colliders and continue to play a leadership role in superconducting magnet technology focused on the dual goals of increasing performance and decreasing costs". The HEPAP subpanel on Accelerator R&D has recommended to "Aggressively pursue the development of Nb_3Sn magnets suitable for use in a very high-energy proton-proton collider". The subpanel also called for "simplicity in design for cost reduction" and "development of R&D platforms that reduce turn-around-time". The common coil design discussed below satisfies the guiding principles laid out in the reports by P5 and by the HEPAP subpanel.

PBL Inc. will develop an alternative to the traditional cosine theta dipole that will be more compatible with Nb_3Sn and HTS-class superconductors, which are more fragile than NbTi. The basic concept of this alternative approach, called the common coil magnet [2], which was used in the Very Large Hadron Collider (VLHC) proposal [3] in the USA, has been successfully demonstrated in model coil work at several DOE Labs [4, 5, 6, 7], including BNL, FNAL, and LBNL. Although the basic concept was demonstrated with the main coils, these earlier efforts have not produced a magnet or a design that can provide the required high field homogeneity for accelerator magnets in a simple and cost-effective manner. We propose a solution to the field quality issue based on the development of new and innovative designs using auxiliary coils or pole turns. In the common coil design, the term "pole turns" or "pole block" refers to the turns above and below the beam tube. These are analogous to those used to shape the field in traditional cosine theta dipoles. Pole turns are technically challenging in common coil magnets because simple racetrack coils do not clear the beam pipe. Therefore, the coil ends must be shaped to avoid the beam pipe, yet at the same time have good mechanical support to resist the large Lorentz forces, all while producing good field quality. In addition, these pole turn coils must be reasonably easy to fabricate and assemble.

The proposed work will combine the advances in coil winding techniques that our PBL/BNL team has made in prior SBIR/STTR-supported projects, together with the use of powerful analytical tools such as ROXIE, OPERA, ANSYS, COMSOL and other CAD/CAM programs, to design pole turn coils in Phase I. The focus of this proposal is the development of a simpler and a lower cost very high field Nb_3Sn dipole magnet. The coils designed in Phase I will be constructed in Phase II. Testing will be in the background field of an existing common coil Nb_3Sn dipole magnet, in order to maximize the demonstration of the design and technology within the budget of an SBIR/STTR Phase II program.

Anticipated Public Benefits

The common coil design is expected to provide a lower cost and technically attractive solution to the high field dipoles required for a Future Circular Collider (FCC). Lower costs are expected because of (a) the simpler geometry and (b) the reduction in the number of coils by a factor of two since the same coil serves both beam apertures. The common coil design is technically attractive for high field magnets because the coil modules move as a unit against the large Lorentz forces and therefore the relative motion and internal strain on the conductor is minimized by this approach.

Since the proposed project aims to benefit the science of building colliding beam accelerators, the most immediate beneficiaries are researchers working in High Energy Physics around the world. The market for colliding beam accelerators is small when measured in number of units – typically only one or two such devices are constructed every 10 to 20 years. However, the market as measured in dollars can be significant, with project costs in the range of tens of billions of dollars. The high field magnets used in such colliders is a significant portion of this cost.

The public benefit from High Energy Physics may prove to be great, but it is hard to specify in advance. It is the nature of the enterprise that advances cannot be predicted; one can only speculate. Greater knowledge over the particles and forces that make up our world may be used to enable devices that are unforeseen at the present time. Past experimentation led to understanding and control of the electromagnetic force with revolutionary benefits accruing to mankind. Future experimentation may lead to understanding and control of other forces such as the nuclear and gravitational forces, and such gains could be revolutionary as well. One thing is certain – if we stop experimenting progress in these areas will cease.

However, the proposed project can also contribute to more immediate practical advances in an indirect way. Compact, high field superconducting magnet technology may find use in the fields of magnetic resonance imaging (MRI), Superconducting Magnetic Energy Storage (SMES), proton and ion therapy accelerators, and wind power generation. Although these fields are unlikely to need the common coil geometry of a colliding beam accelerator, the advances in superconducting technology gained during the project may prove very important for superconducting magnet technology in general. (For instance, advances in the area of stabilizing coils against the Lorentz Forces can be important for many applications.) As discussed more fully in the Commercialization Plan attached as part of this proposal, the MRI and SMES markets are in the billion-dollar range, which is indicative of a significant public market.

Technical Objectives

Magnets based on a common coil design have been successfully built at LNBL, BNL and FNAL (see Fig. 1). The very first common coil test magnet at LBNL, designed and built [4, 5] while the P.I. was Program Head and Dr. Gupta was the chief designer, reached the short sample limit with no training quench. Several subsequent magnets reached the short sample critical current limit with few or no training quenches. Further tests showed that the change in pre-stress causes no degradation in performance. At BNL, magnet DCC017 was built with essentially no vertical and horizontal pre-stress, and it reached over 10 T, slightly exceeding the short sample performance that was predicted by computation. A noteworthy feature of the BNL magnet was that it tolerated a computed overall deflection of about 200 microns, indicating the possibility for a significant reduction in structural material required for this type of magnet. FNAL also successfully demonstrated a magnet based on this design.

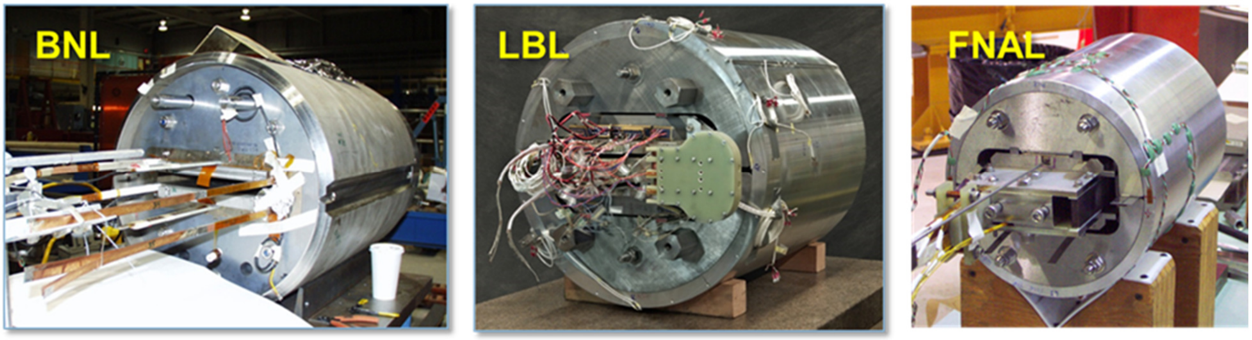


Figure 1: Proof-of-principle common coil magnets built and tested at BNL, LBNL and FNAL.

Further work on this type of magnet was, however, suspended despite the initial successes – not for technical reasons but because of changing project needs. Subsequent magnets were single aperture quadrupoles or dipoles, whereas the common coil design is for 2-in-1 dipoles. With the growing interest of the high energy physics community for proton colliders with a center of mass energy of 100 TeV, and with the tunnel limited to a certain size (for geographic or other reasons), interest has returned for designs that can produce a lower cost high field magnet (16 T or above). CERN hosted a seminar on "Common Coil Magnet Design for High Energy Colliders [8]" for possible use in the proposed Future Circular Collider (FCC) [9]. The common coil design is also the baseline design in the proposed Super proton-proton Collider (SppC) [10] in China.

The primary technical objectives of this proposal are: (a) to develop an engineering design for a lower cost, more reliable, higher field (16 T) 50 mm aperture 2-in-1 accelerator quality dipole primarily based on Nb_3Sn conductor and (b) to demonstrate the basic design and technology within the budget of Phase II by using the existing coil and support structure at BNL. The exact design parameters may evolve during the course of work based on the feedback from machine physicists.

Work Plan – Common Coil Design Concept

In the common coil design, the coils are common between the two apertures, providing a natural 2-in-1 configuration with fields in opposite directions as needed in particle colliders (Fig. 2 left). It offers a conductor-friendly design based on simple racetrack coils with large bend radii which is particularly suitable for high field magnets made with brittle conductor (Nb_3Sn and HTS). Large bend radii in the common coil design allow both "wind & react" and "react & wind" technology to be used. Structure design used in the common coil magnet built at BNL is shown in Fig 2 (middle).

The simple coil geometry (Fig. 2 left) becomes more complicated with the addition of pole blocks (Fig. 2 right) which are required to produce the good field quality needed in accelerator magnets. Whereas the conductors in the simple flat racetrack coils automatically clear the bore in going from one aperture to another aperture, conductors in the ends of the pole blocks do not. Pole block conductors must either be shifted sideways (breaking the simple racetrack coil geometry) or return away from the aperture. In order to avoid this complication, these pole blocks were left out of the successful first generation R&D programs, including the one built and tested at BNL (Fig. 1 right).

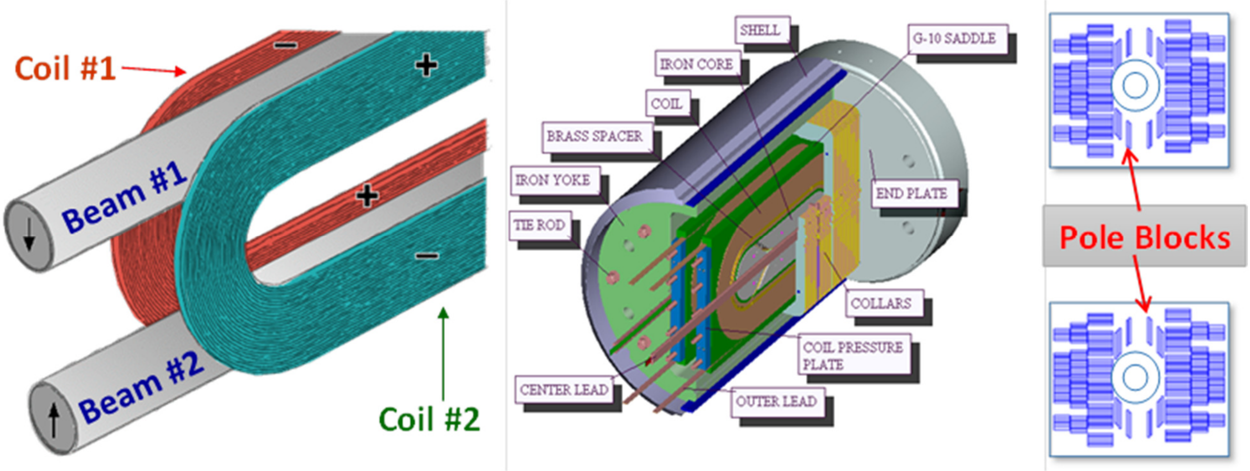
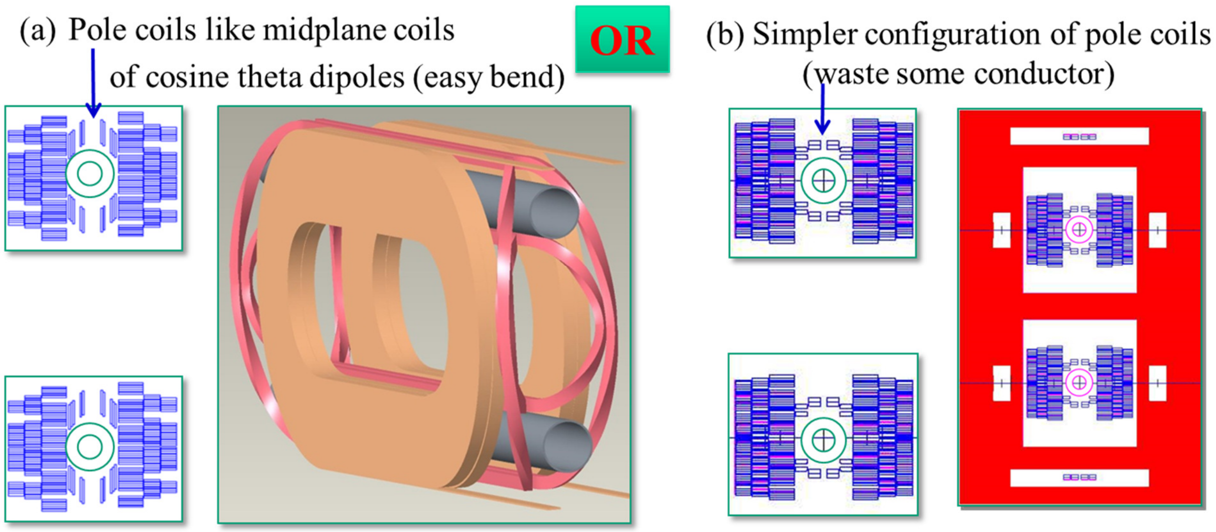


Figure 2: Basic common coil design concept (left), structure design (middle) used in the magnet built at BNL (Fig 1 left), and a possible field quality magnetic design with pole coil blocks (right).

The demonstration of the design is, of course, not complete without the inclusion of pole blocks. The purpose of this proposal is to leverage the resources and unique common coil magnet that BNL has built, and to produce a cost-effective demonstration of the basic design with improved dipole field quality. Two possible groups of solutions are shown in Fig. 3.


(a) Pole coils like midplane coils of cosine theta dipoles (easy bend)

(b) Simpler configuration of pole coils (waste some conductor)

Figure 3: Possible options for pole coil blocks needed to obtain good field quality. Option (a) (left) uses less amount of conductor but has slightly more complicated ends than those used in option (b) (right).

It may be pointed out that both of these options allow coil blocks to move as a whole, which minimizes the stress and strain on the conductor at the ends. As shown in Fig 4 (left), in cosine theta (and also in conventional block designs), large forces put excessive stress/strain on the conductor in the end region. However, as shown in Fig 4 (right), in a common coil design, coils move as a whole, thus producing much smaller stress/strain on the conductor in the end region despite the large motion of the coil. In fact, the BNL common coil dipole tolerated ~200 microns displacement, which is significantly larger than the typical ~25-50 microns allowed in cosine theta magnets. This, in principle, reduces the need for the amount of support structure required in the common coil design, as long as it is permitted by the field quality. One would therefore expect lower cost magnets due to less structure and better performance due to less strain. This could be a key technical and cost issue in high field magnets in which the magnet structure is a major issue.

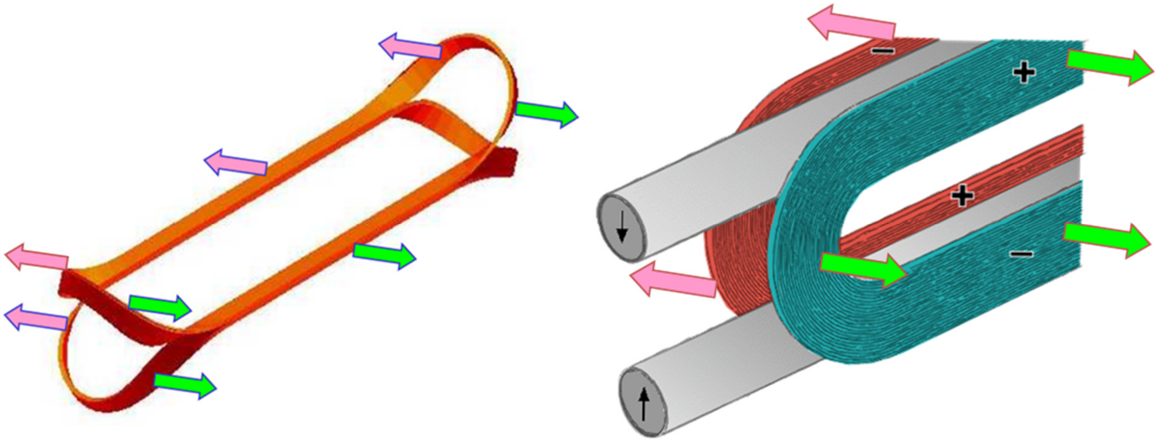


Figure 4: In cosine theta or conventional block design magnets, large horizontal Lorentz forces in high field magnets put significant stress and strain on the conductor in the end region (left), which is significantly lower in a common coil design, because the coil layers move as a block (right).

The simpler geometry of a common coil design allows faster and less expensive R&D, particularly because of simpler coil winding and simpler support structure. In various laboratories where R&D magnets based on this design were built and tested [4, 5, 6, 7], the first test results were obtained in a relatively short period of time. In addition, the structure could be modular, and individual parameters (such as coil aperture, particular coil module) could be changed while retaining most of the other hardware, which allowed rapid-turn-around and versatile R&D. For example, the same coils built for certain aperture magnets could be used for testing zero aperture magnets, allowing them to be tested at a much higher field level. In fact, many common coil R&D magnets have been built with zero gaps for various testing [4, 5]. This rapid-turnaround and low cost R&D remains a major attraction of common coil design for systematic and versatile R&D and is in line with the recommendation of P5 and its subpanel on accelerator R&D [1].

Another advantage of the common coil design is that it also allows easier segmentation of coil layers in a hybrid design (consisting of either Nb_3Sn and NbTi or HTS and LTS), because of the way the field naturally decreases between inner and outer layers.

Work Plan – Field Quality Optimization in a Common Coil Design

Field quality optimization in LTS magnets is mostly associated with minimizing geometric harmonics, saturation-induced harmonics and harmonics in the end region. Minimization of persistent-current induced harmonics that are typically associated with the choice of conductor (or some special techniques), is not part of this proposal.

Minimization of geometric harmonics to the level needed in accelerator magnets, in a design optimized to reduce conductor, requires pole blocks. Developing accelerator quality dipole designs with the magnets which are easier and cheaper to build is the major part of this Phase I proposal, and demonstrating them in a proof-of-principle design is the major part of an envisioned Phase II effort. Several configurations (see Fig. 5) were examined earlier [11] in a series of designs for a 40 mm aperture dipole design optimized using the code ROXIE [12]. These designs were also optimized for low saturation induced harmonics [11].

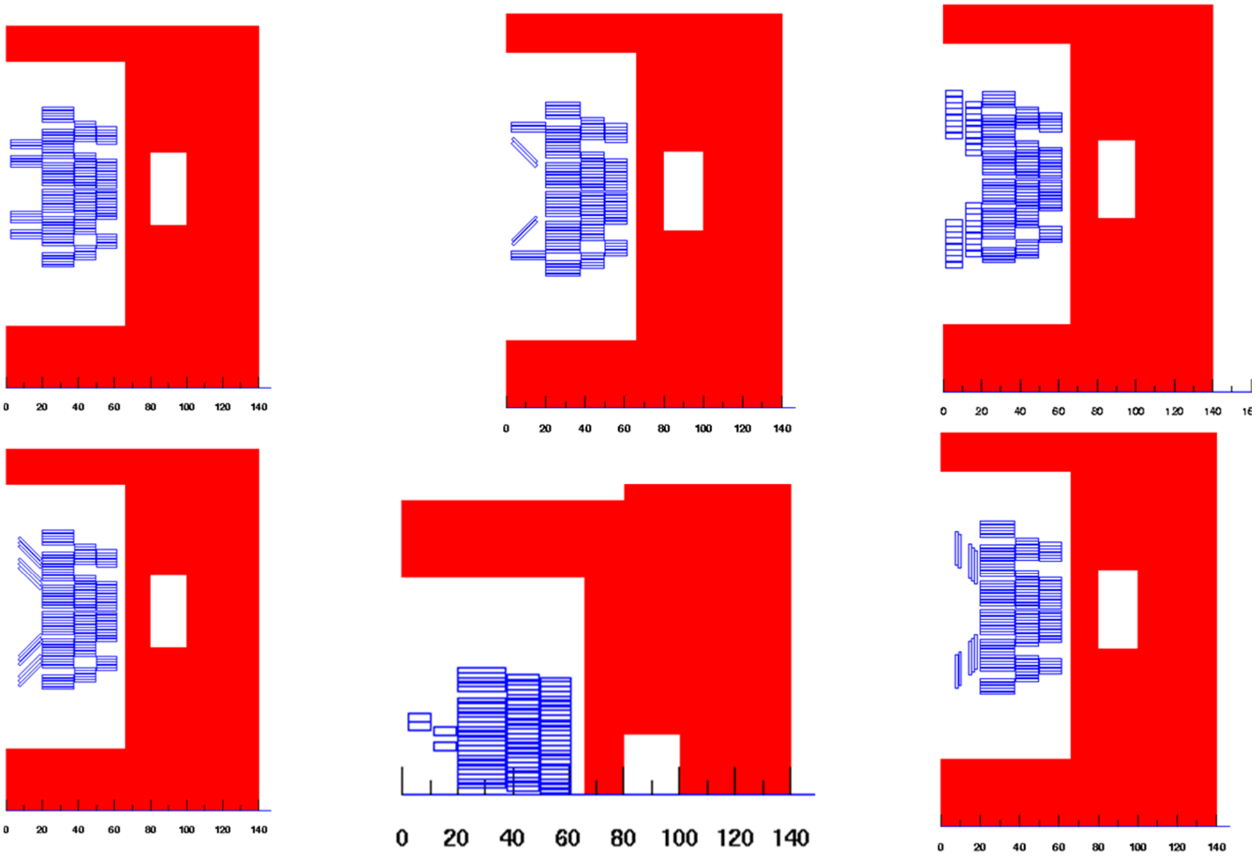


Figure 5: Optimized magnetic design for a 40 mm aperture dipole [11], all producing the generally accepted uniformity in accelerator dipoles.

Another challenge in common coil design is obtaining low end harmonics. The geometry of ends in a common coil is different from normal designs, since all turns from one aperture must return to another aperture. Using the code ROXIE, we were able to obtain low harmonics [11] despite this asymmetry (see Fig. 6).

End harmonics in Unit-m

n	Bn	An
2	0.00	0.00
3	0.01	0.00
4	0.00	-0.03
5	0.13	0.00
6	0.00	-0.10
7	0.17	0.00
8	0.00	-0.05
9	0.00	0.00
10	0.00	-0.01
11	-0.01	0.00
12	0.00	0.00
13	0.00	0.00
14	0.00	0.00
15	0.00	0.00
16	0.00	0.00
17	0.00	0.00
18	0.00	0.00

Contribution to integral (a_n, b_n) in a 14 m long dipole ($<10^{-6}$)

n	bn	an
2	0.000	0.001
3	0.002	0.000
4	0.000	-0.005
5	0.019	0.000
6	0.000	-0.014
7	0.025	0.000
8	0.000	-0.008
9	-0.001	0.000
10	0.000	-0.001
11	-0.001	0.000
12	0.000	0.000

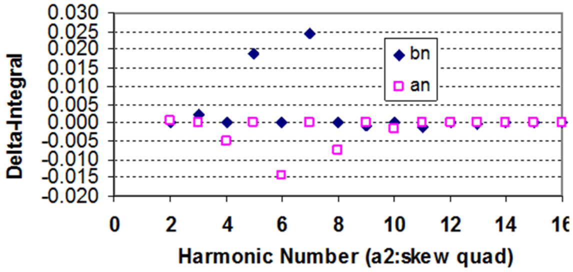


Figure 6: Optimized magnetic design for ends of a 40 mm aperture common coil dipole.

Work Plan – Principal Investigator and Other Key Personnel

Ronald M. Scanlan will serve as Principal Investigator for the proposed project. Dr, Scanlan has had 35 years of experience in the field of superconducting magnets and materials at General Electric R&D Laboratory, Lawrence Livermore National Laboratory, and Lawrence Berkeley National Laboratory. From 1999 until his retirement from LBNL in 2003, he was the Group Leader for Superconducting Wire and Cable Development. He was responsible for the U. S. Department of Energy, Division of High Energy Physics, Conductor Development Program. The goal of this program is industrial development aimed at developing a cost-effective, high field superconductor for accelerator magnet applications. During this time, his team at LBNL developed the technology for cabling the new HTS wire, Bi-2212, and made many thousands of meters of this cable in collaboration with the wire manufacturers (Oxford Superconducting Technology and Showa). From 1995 to 1999, he was Program Head for Superconducting Magnet Development at LBNL, during which time a world-record 13 T Nb_3Sn dipole magnet was built and tested. Earlier in his career, he was responsible for development of Nb_3Sn conductor for the MFTF fusion magnet (a 14 T solenoid) at the Lawrence Livermore National Laboratory. He is the author or co-author of over 100 publications in the field of superconducting magnets and materials. In 1991, he shared the IEEE Particle Accelerator Conference Award with Dr. David Larbalestier for “the development of NbTi superconducting material for high current density application in high field superconducting magnets”, and in 2011 he received the IEEE Council on Superconductivity award for “Continuing and Significant Contributions in the Field of Applied Superconductivity”.

Robert J. Weggel will be the PBL magnet designer for this Phase I project. He has been PI for PBL on several recent SBIR/STTR projects (see related research section). Mr. Weggel has had over 50 years of experience as a magnet engineer and designer at the Francis Bitter National Magnet Laboratory at MIT and Brookhaven National Laboratory and as a consultant in magnet design. In the course of his career he has authored over 100 peer-reviewed articles concerning resistive and superconducting magnets as well as hybrid high-field versions. He has had extensive experience optimizing magnets for various uses including solid-state research, accelerator and medical applications. He has contributed extensively to the book *Solenoid Magnet Design* by Dr. D. B. Montgomery and was principal proofreader for the 682-page textbook *Case Studies in Superconducting Magnets*, 2nd edition, by M.I.T. Prof. Y. Iwasa.

Dr. Erich Willen, a PBL employee, will contribute his expertise in the areas of magnet design and magnetic field quality. Recently, he served as PI on a related SBIR entitled "Magnet Coil Designs Using YBCO High Temperature Superconductor." His experience on this previous SBIR will be useful in evaluating the design options being explored in this new SBIR.

Dr. Ramesh Gupta will be sub-grant Principle Investigator (PI) for the work performed in the Superconducting Magnet Division (SMD) at the Brookhaven National Laboratory (BNL). The R&D at BNL will focus on the design, construction and the test of the superconducting coils. Dr. Gupta, aided by his BNL colleagues, has led the development of the common-coil 2-in-1 dipole design for hadron colliders as well as the open mid-plane dipole design when it was considered for the luminosity upgrade for the Large Hadron Collider (LHC) in the "dipole first optics". In addition, Dr. Gupta has more than two decades of experience in the design of superconducting accelerator magnets for various applications. His current interest includes developing and demonstrating HTS magnet designs and technology for particle accelerators and beam lines. Over the last decade he has developed several new innovative designs such as the common-coil dipole, the HTS quadrupole for RIA and FRIB, and a low-cost medium-field HTS dipole. He has developed a cost-effective, rapid-turnaround and systematic magnet R&D approach that is now being adopted by BNL, LBNL and Fermilab and will be employed in this proposal. Dr. Gupta is the PI or sub-grant PI of several HTS R&D grants. He is sub-grant PI of two previous Particle Beam Lasers, Inc. SBIRs on a HTS solenoid for a muon collider and the open-midplane dipole. He is also PI for the development of HTS magnets for RIA, FRIB and sub-grant PI of a HTS Superconducting Magnetic Energy Storage (SMES) effort. Dr. Gupta has also worked on conventional Low Temperature Superconductor cosine-theta magnet designs (an area that he still continues to pursue) for RHIC and the SSC. Dr. Gupta has taught several courses on superconducting magnets at U.S. Particle Accelerator Schools.

Work Plan – Managerial controls for a successful project.

To ensure a successful project, PBL will hold regular technical meetings and compare progress made against the performance schedule below. Four times during the course of the project the technical staff will meet to ensure that important milestones are being met in a timely way. In the final meeting, PBL senior management will also travel to participate. At the final meeting, held approximately six weeks prior to project completion, the team will identify any problems as well as ensure ways to solve them. We will also plan for the Phase I final report and Phase II proposal at that final face to face meeting.

Work Plan – Task List.

Task 1: Prepare a magnetic design of pole blocks to improve field quality of the DCC017 common coil magnet. The basic magnetic performance of this magnet has been demonstrated in previous tests at BNL. The task at hand involves the use of design tools (ROXIE, OPERA, and COMSOL) to design pole blocks that will improve the field quality of the existing magnet so that the field quality will rise to accelerator magnet standards. The position and size of the pole block coils will be optimized in order to provide the necessary field quality with a minimum of conductor and with coils that can be assembled within the common coil structure. This will be a joint task involving both PBL (Scanlan, Weggel, Willen) and BNL staff (Gupta, BNL mechanical engineers).

Task 2: Selection of conductor and cable for common coil magnet. This task will involve choosing the proper strand and cable for various magnetic designs for Task 1 above, as well as for the coils proposed to be built in Phase II. The cable to be used in Phase II will use Nb_3Sn strands developed for the LARP (Large Hadron Collider Accelerator Research Program) project and, to reduce cost even more, the cable developed for LARP may be used. This task will be led by Scanlan.

Task 3: Prepare a mechanical design of pole blocks to withstand large Lorentz forces and to reduce conductor movement. The design tools listed above will be used to design a structure that will satisfy the structural support requirements of the pole blocks while at the same time considering the constraints of the existing DCC017 magnet. Whereas the magnetic design (Task 1 above) is primarily an optimization effort using established design tools and procedures, the mechanical design task requires more technical input. The combination of the high Lorentz forces on the pole block coils, together with the brittle nature of the high field superconductor required in this high field region, require innovative solutions to provide for mechanical support and to allow for assembly. This will be a joint task between PBL and BNL teams and will involve the use of sophisticated design and analysis tools such ANSYS, COMSOL and other CAD/CAM programs. Both teams will provide input into the technical approaches for coil support. The BNL team will take the lead on adapting the coil support plan to the specific interface with the DCC017 common coil magnet at BNL.

Task 4: Develop a conceptual design for the assembly and operation of the pole block coils in a common coil dipole. The simple racetrack geometry and the direction of the Lorentz forces make the mechanical support of the main common coils reasonably straightforward. However, the pole block coils present more of a challenge due to the very large Lorentz forces (these coils are in the highest field region of the magnets) and the limited space for structural support. Innovative support and assembly techniques must be developed for the pole block coils. Techniques that will be investigated include the use of bladders that can be used to increase the preload on these coils after assembly. Also, operating modes that compensate for the relatively large movements of these pole block coils and the main coils will be investigated.

Task 5. Model the coil winding tests. In order to verify that the coils designed in Tasks 1 and 3-5 can indeed be wound and supported, model coils will be fabricated using existing Nb_3Sn cable.

Filler pieces, where required, will be made using 3-D printing techniques for fast turnaround. The BNL technical staff, with input from the PBL team, will take the primary responsibility for this task. As a part of another program, the PBL/BNL team performed some practice winding that is relevant to this proposal. Please see Fig. 7, where the model on the right shows the schematic of clearing the bore in the ends with end spacers (filler pieces) made of Nomex in the right, and the practice coil wound in the middle. We plan to use a 3-D printer with appropriate material to obtain well-supported ends which satisfy both mechanical and magnetic requirements. Once optimized, the actual spacer to be used in the coil will be metallic.

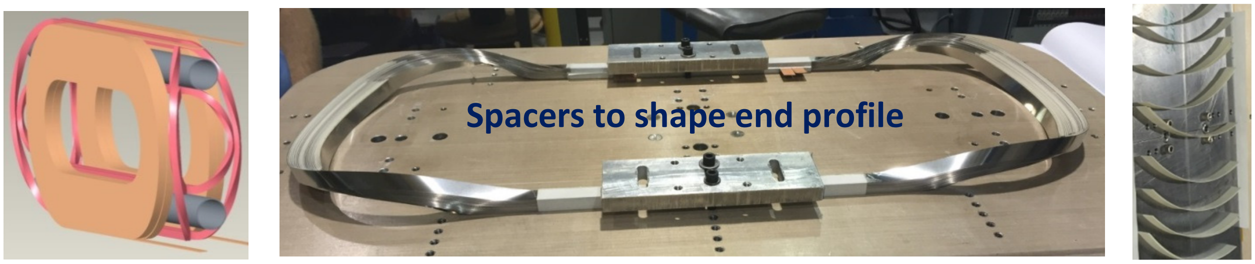


Figure 7: Schematic of a possible pole block design that clears the beam tube (left), practice windings (middle) made with spacers of Nomex sheet (right) that will be replaced by parts with better conforming geometry made with 3-d printer during the course of proposed work.

Task 6. Plan the basic steps required for proof-of-principle tests. Construction and testing of actual pole block coils is beyond the scope of a Phase I effort. However, the basic steps required for proof-of-principle tests will be presented in a subsequent Phase II proposal. BNL built its Nb_3Sn common coil dipole DCC017 with a unique design and structure so that it has a large open space between the coils (~30 mm horizontal and ~220 mm vertical). This large open space allows coils or coil blocks to be inserted and become part of this magnet without requiring disassembly of the entire magnet. The primary goals of a Phase II will be to first examine several configurations of Nb_3Sn coil blocks using the conductor available and then build and integrate a set of coils with the existing structure of DCC017. A special support structure for the ends will be required. With this, DCC017 will turn into a complete common coil magnet having both main coils and field shaping auxiliary coils. The envisioned Phase II effort is expected to be a low-cost, fast turnaround proof-of-principle demonstration, primarily because DCC017 was designed and built such that it requires no major disassembly and reassembly for insert coil testing. Field measurements, at least the warm measurements, will also be performed in Phase II. Whereas attempts will be made to develop a design that does not require any disassembly, the designs will also be examined that would need DCC017 disassembly while still utilizing most of the components of this magnet. The Phase II proposal will be for a particular choice (disassemble the magnet DCC017 or not) and will be based on technical and budget considerations.

Task 7. Plan for the design of a 16 T, 50 mm aperture common coil for a future proton collider. A secondary but strategically important task of the Phase II effort will be to develop magnetic, mechanical and preliminary engineering design of a 16 T, 50 mm aperture common coil for a future proton collider. The final design will, of course, be developed as a part of subsequent funding (which is expected to be much larger). However, the further development of the common coil R&D design to a more advanced level is essential to place this design in a technically competitive position with cosine theta and canted cosine theta designs, which have benefited from significant funding over a period of years to increase their maturity.

Task 8. Prepare the Phase I Final Report and identify the key components for a Phase II proposal. Both PBL and BNL teams will participate in identifying the key components for a Phase II proposal and for writing the Phase I final report.

Performance Schedule

Task 1: Develop a block pole coil design that produces accelerator field quality. Weeks 1-17.

Task 2: Develop strand and cable parameters for model coils and future magnets. Weeks 1-36.

Task 3: Develop a block pole coil mechanical support system. Weeks 10-26.

Task 4: Develop a conceptual design for the assembly of the block pole coils within the main common coil system. Weeks 10-26.

Task 5: Wind model coils to demonstrate that the block pole coils can be fabricated. Weeks 22-35.

Task 6. Plan the basic steps required for proof-of-principle tests. Weeks 32-36.

Task 7. Plan for the design of a 16 T, 50 mm aperture common coil magnet for a future proton collider. Weeks 32-36.

Task 8: Prepare a final report and identify the key components for a Phase II proposal. Weeks 35-39.

Facilities/Equipment

The PBL PI will be responsible for the overall direction of the program. The PBL Senior Mechanical Engineer, Bob Weggel, will be responsible for the overall magnetic and mechanical efforts. The Superconducting Magnet Division (SMD) at BNL working in collaboration with the PBL Principal Investigator and Senior Mechanical Engineer, will have responsibility for the detailed magnetic and mechanical design tasks. In addition, the SMD will be responsible for winding the block pole test coils. The Division has extensive facilities for winding demonstration coils and for testing these coils. It also has access to simulation and engineering software tools that will aid in the design of coils and magnets. The design software available includes ROXIE, OPERA2d, OPERA3d and in-house software for magnetic design, ANSYS for mechanical design, and Pro/ENGINEER and AutoCAD for engineering design. The BNL Magnet Division has been a major player in the development of conventional superconducting magnets over the last four decades and of HTS magnets for over a decade. It has dedicated coil winding machines, cryo-coolers and other equipment. The Division has a staff of about 40 scientists, engineers, technicians, administrative staff and others. Construction and testing of coils will be carried out in a 55,000 ft^2 multipurpose complex at the Division. The facility allows testing of a variety of superconductors, coils and magnets from 2 K to 80 K. The infrastructure (space, tools, test equipment, etc.) that are part of the Division will be made available for the Phase I and Phase II work. The value of the infrastructure at BNL is well over $1 million; this infrastructure is a very valuable "in-kind" contribution crucial to the project.

American-Made

To the extent possible in keeping with the overall purposes of the program, PBL and BNL will work to ensure that only American-made equipment and products will be purchased with the funds provided by the financial assistance under DOE Phase I grants.

Research Institution (RI)

This grant application involves a formal collaboration between Particle Beam Lasers, Inc. and a research institution, Brookhaven National Laboratory (BNL). As can be found in more detail in the attachments found in block 12, what follows is the requested identifying information for this collaboration:

Name and address of the institution:

Brookhaven National Laboratory
Building 460
P.O. Box 5000
Upton, NY 11973-5000
Phone: (631) 344-2103

Name, phone number, and email address of the certifying official from the RI:

Michael J. Furey
(631) 344-2103
mfurey@bnl.gov
Total dollar amount of the subcontract:

$45,000

Other Consultants and Subcontractors

BNL will be a subcontractor for the Phase I effort. There will be no other consultants or subcontractors on the Phase I effort.

Bibliography & References Cited

1. The Particle Physics Project Prioritization Panel (P5) and its subpanel on Accelerator R&D, http://science.energy.gov/hep/hepap/
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