The DOE High Energy Physics SBIR/STTR Superconductivity Program

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***Abstract*—The U.S. Department of Energy has over a 35-year history in the support of superconducting devices. Superconductivity is an enabling technology for its major installed particle accelerators as well as planned projects. The Small Business Innovation Research (SBIR) Program has played a most significant role in the industrial development of advanced superconducting materials and devices. This paper will give a short history of the program as well as its accomplishments in the field of superconductivity. Current development needs of the Department in High Energy Physics will be explored. Suggestions for participation in this program will be discussed.**

***Index Terms*—History, proposals, SBIR, STTR, superconductivity.**

I. Introduction

IN THE Division of High Energy Physics (HEP) at the U.S. Department of Energy (DOE) the Small Business Innovation Research (SBIR) program and the similar Small Business Technology Transfer (STTR) program are used to leverage base funding in technology research and development. This paper will give an overall history of the SBIR/STTR programs and will discuss how current needs in HEP research are integrated with the development needs of the various HEP national laboratories and funded grants at universities.

II. History of the SBIR/STTR Program

Congress set up the SBIR program with an annual set aside of federal research and development program funds starting in fiscal year (FY) 1983. The most recent reauthorization of the SBIR program was by Public Law 106-554 in 2000. The similar STTR program has been in place for nine years beginning in FY 1994, pursuant to Public Law 102-564 of 1992.

Details on these programs can be found at the Small Business Administration (SBA) web site: http://www.sba.gov/sbir/indexsbir-sttr.html. In particular, small businesses must meet certain eligibility criteria set by the SBA to participate in the SBIR/STTR program:

- American-owned and independently operated
- For-profit
- Principal researcher employed by the small business
- Company size limited to 500 employees.

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SBIR and STTR projects are awarded in two phases, each of which is competed separately. The purpose of Phase I is to demonstrate the feasibility of the small business's proposed idea and prepare the Phase II proposal. Phase I has a duration of nine months (recently increased from 6 months in order to synchronize the SBIR and STTR schedules), and grants can be up to $100 000. Phase I awardees may apply in the following year for Phase II, which is the principal R&D effort. For both SBIR and STTR, Phase II grant awards are expected to be in amounts up to $750 000 and to cover a period of up to 24 months. There is a Phase III, in which nonfederal capital is used by the small business to pursue commercial applications of the R&D effort. Also under Phase III, federal agencies may award follow-on grants or contracts for: 1) products or processes that meet the mission needs of those agencies, or 2) further research or development.

Federal agencies with extramural R&D budgets over $100 million are required to administer SBIR programs. The annual set-aside is 2.5 percent of extramural R&D. Federal agencies with extramural R&D budgets over $1 billion are also required to administer STTR programs. In an SBIR project, a subcontractor may perform up to 1/3 of the work in Phase I and up to half the work in Phase II. In STTR, which is funded in a similar way to SBIR, the small business must collaborate with a nonprofit research institution that serves as a subcontractor on the project. For both Phase I and Phase II STTR projects, at least 40% of the work must be performed by the small business and the nonprofit research institution must perform at least 30% of the work. Such institutions include federally funded research and development centers (DOE national laboratories, for example), universities, nonprofit hospitals, and other nonprofits. The funding for STTR is much smaller than that for SBIR with the percentage reserved presently at 0.15 percent. By recent legislation, the STTR set-aside rate will increase to 0.3 percent in FY 2004.

Over the years, DOE has provided approximately $1 billion under SBIR, including about $95 million in FY 2002. The amount for STTR in FY 2002 is approximately $5 million. The DOE HEP has contributed approximately $165 million to these programs, currently at about $15 million per year.

Different federal agencies have different processes and schedules for making SBIR and STTR awards. Information about the DOE SBIR and STTR programs, the subject of this paper, is posted on the web site: http://www.science.doe.gov/sbir/. In DOE, the two programs are advertised under one solicitation, and firms may apply to either or both programs with a single grant application (proposal). DOE selects awards to fully subscribe both programs.

III. SBIR/STTR Selection Criteria

It is important for a firm proposing a project to address the selection criteria following the guidelines in the solicitation. At DOE, external peer reviewers are used to evaluate the proposals with respect to three criteria—**Scientific/Technical Quality, Ability, and Impact**—each with equal weight.

Scientific/Technical Quality is evidenced by:

- Strength and innovativeness of the idea;
- Strength and innovativeness of the approach;
- Significance of the scientific or technical challenge; and
- Thoroughness of the presentation.

Ability is evidenced by:

- Qualifications of the Principal Investigator, other key staff and/or consultants;
- Soundness of the work plan to show progress toward proving the feasibility of the concept; and
- Adequacy of equipment and facilities (in Phase I), or
- Degree of Success of Phase I objectives at time of Phase II proposal (for Phase II).

Impact for Phase I and Phase II is evidenced by:

- Significance of the technical and/or economic benefits for the proposed work;
- Likelihood that the proposed work could lead to a marketable product or process; and
- Likelihood that the project could attract further development funding after the project ends.

Taking into account the comments of at least three peer reviewers, an HEP staff member rates each criterion as positive (strong endorsement), negative (has reservations), or neutral (somewhere between the two extremes).

For a Phase II proposal, the **Impact** criterion is divided in weight *equally* between the rating described above and the **Commercial Potential**, which is determined by the SBIR Program Office based on information provided in the proposal.

In accordance with the requirements in Public Law 102-564, **Commercial Potential** is evidenced by:

- The small business's record of commercializing SBIR or other research;
- Phase II funding commitments from private sector or non-SBIR funding sources; and
- Phase III follow-on funding commitments.

For Commercial Potential, neutral ratings in these three elements are assigned, 1) if the small business has achieved Phase III funding for previous projects on the order of one-fourth of the amount requested to fund the proposed project, or if the proposing firm has never attempted to commercialize technology; 2) if the Phase II funding commitment from non-SBIR sources is on the order of 10 percent of the requested amount; and 3) if the Phase III funding commitment is on the order of one-fourth the requested amount. The three ratings for Commercial Potential are combined into a single rating, which, in turn, is combined with the Impact rating from the HEP staff member into an overall rating for the Impact criterion.

In order to be a candidate for funding, a proposal may not receive a negative rating on any of the three criteria. In addition, candidates for funding must receive positive ratings on at least two of the three criteria. This latter requirement allows DOE technical program offices to de-emphasize one of the three criteria. For the DOE High Energy Physics program, the Commercialization Potential rating often leads to neutral, rather than positive rating on the Impact criterion. A project's applicability to HEP research is considered to be of paramount importance, and DOE may be the sole buyer for a particular product. Although many HEP technologies are not readily commercialized, experience has shown that a poor rating on Commercial Potential may not be fatal for a proposal if the ratings on the other criteria are sufficiently high.

IV. High Energy Physics Needs

We have previously presented the technical challenges and prospects for both current and next generation HEP colliders [1]. The Large Hadron Collider is under construction in Europe on the French/Swiss border. Even at this time plans are underway for upgraded superconducting components. Projected projects for new machines and upgrades to present machines will require high field superconducting materials and magnets as well as improvements to their support technologies. The technical decision regarding the use of superconducting radio frequency cavities for an international linear collider collaborative project has not been made.

The Division of High Energy Physics presently has a national program to improve the properties of Nb_3Sn superconducting cable. The goal of this program is Nb_3Sn strand operating at 4.2 K and 12 Tesla with a critical current of 3000 A/mm^2. Part of this research and development is directly funded to the larger manufacturers who do not qualify in the SBIR/STTR program. These firms are working at providing Nb_3Sn with improved performance and quantities needed to build full sized accelerator magnets. A significant amount of funding is channeled through the SBIR program. This area of development is well coordinated with the end users in the national laboratories who provide recommendations regarding the solicitation language and also provide time at headquarters to assist us in choosing and recruiting reviewers. All proposals are given to at least three independent reviewers. The SBIR/STTR solicitations include in the Technical Topic descriptions a useful list of references to help identify our needs.

There is a large effort at Brookhaven, Lawrence Berkeley and Fermi National Laboratories to construct dipole bending magnets and quadrupole focusing magnets that have magnetic fields at the superconductor of well above 12 Tesla. The goals for the highest fields are greater than 15 Tesla. The three national laboratories have agreed on unified goals for the superconductor of critical current in the noncopper area of 3000 A/mm^2 at 4.2 K and 12 Tesla. To improve the magnetic quality of the magnets at low fields a goal of an effective filament diameter of 8 μm has been established. Just over four years ago industrially available Nb_3Sn had the following properties of critical current density of 1800 A/mm^2 at 4.2 K and 12 Tesla. Recent results indicate that 2800 A/mm^2 can be met. This improvement in current density parallels the improvements in NbTi technology during the R&D period of the Superconducting Super Collider. At that time NbTi current density improved by almost the same amount but measured at 5 Tesla.

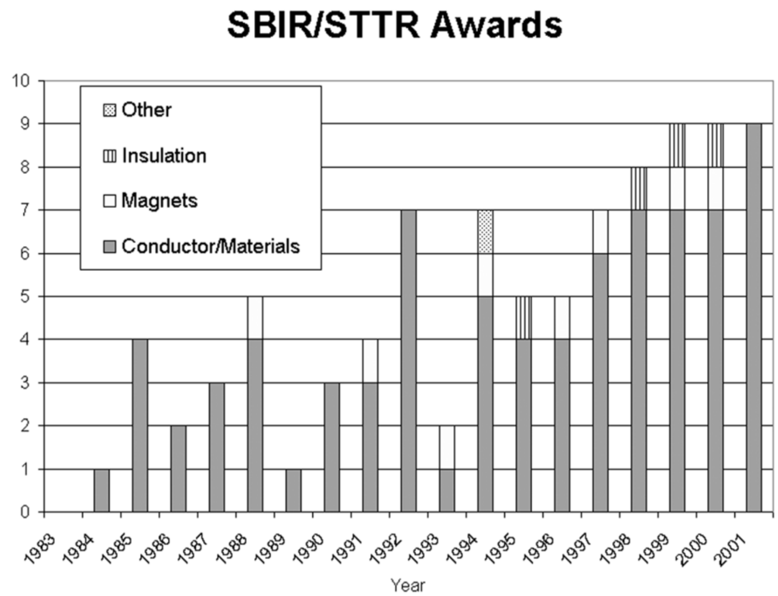

Fig. 1. The distribution of SBIR Phase I grants among subcategories in superconductivity since 1983.

High effective current density, J_e, and small filaments are absolutely required for high field magnets used in particle accelerators. The requirements for HTS conductors in our solicitations have reflected this. The specifications in the last SBIR/STTR solicitation asked for a minimum current density of 1200 A/mm^2 (not cm^2) in the superconductor itself and a minimum current density of 250 A/mm^2 over a total conductor cross section, at 12 Tesla minimum and 4.2 K. This performance is very different from that required for applications in power transmission or other utility applications. In addition the challenges of long length, large volume industrial production for practical applications were required to be addressed. While not specifically stated in the solicitation potential proposers should be aware of the needs for filamentary geometry with small, twisted individual filaments.

In each of the past five years we have averaged at least nine Phase I grants in the area of superconductivity and its applications. About half of these are usually converted to Phase II grants. At the present funding levels this represents $3.7 million in new grants each year. Along with improvements in Nb_3Sn, we have supported work in Nb_3Al as well as other LTS and HTS materials. We have also supported grants for electrical insulation systems that could be co-processed in the very long diffusion heat treatments required to form the Nb_3Sn conductors in the assembled magnets. In this last case SBIR developments have had almost immediate application to current magnet development projects at the national laboratories. Fig. 1 shows the distribution of SBIR grants in sub-categories of superconductivity applications since 1983.

In 2001 nine Phase I grants were awarded for superconducting materials processing. In the same year five Phase II awards were made including one in insulation systems and one in magnet winding techniques. This year twelve grants in Phase I and five grants in Phase II are expected to be awarded for superconductivity applications. Grants from the former Superconducting Super Collider division are included. Grants from other organizations in DOE, such as Fusion Energy, Nuclear Physics and Energy Efficiency, are not included.

While we have awarded grants for RF superconductivity in the past we have not done so in the past few years. Other groups within DOE have done so to support current projects. For example groups at Basic Energy Sciences and Nuclear Physics have recently awarded grants in RF superconductivity to support work at the Spallation Neutron Source and at Jefferson Laboratory. Our colleagues in Fusion also support development in A-15 conductors and insulation systems that are specific to their needs. These requirements are presented elsewhere at this conference.

V. Recommendations for Proposers

In order to have a very competitive SBIR/STTR proposal, it is very useful for firms to contact scientists at DOE national laboratories. At DOE headquarters we obtain information about the needs of the physics program from the universities and national laboratories that are pushing the limits of science and technology in our Advanced Technology R&D subprogram within High Energy Physics. It is our goal that R&D at the laboratories be leveraged by development in the SBIR/STTR program. Potential proposers to the SBIR/STTR program are permitted and encouraged to contact laboratory personnel for assistance in preparing proposals and for letters of support to DOE. More importantly, contact with the laboratories is contact with the end users of SBIR development. Small firms will be able to target their marketing and proposals to defined specific needs.

There are a couple of snags to avoid in laboratory/university interactions. One is that in very specialized technologies, such as superconductivity, there is a relatively small pool of peer reviewers. Despite this, applicants are encouraged to form the best team possible to carry out their project. It may be advantageous to have a laboratory or university scientist write a letter of support or to be a partner, a consultant, or a subcontractor in a project. It is important to note that laboratory or university individuals or their institutions can develop a conflict of interest that must remove that person or possibly their institution from the pool of reviewers. Another snag is possible for STTR proposals, in which not-for-profit institutions can be major partners in a proposal. A person or institution that provides language for a technical topic to DOE in a solicitation cannot participate in a project or in the selection process for that competition. While DOE and its consultants in selecting potential reviewers attempt to screen them carefully to avoid conflicts of interest, potential reviewers must recuse themselves when they are determined to have a conflict. As an extreme consequence, it is possible for a firm to have an award canceled, if it is found that a consultant on the project performed a peer review in a particular Phase I or Phase II competition.

Another recommendation for small businesses is that it is often advantageous for a small company to link up with another small or large firm. Relationships involving rights, licenses, etc. can be made which provide the small business with access to the larger firm for marketing a new product or process.

VI. DOE Support to SBIR/STTR Awardees

DOE provides two alternate services to SBIR awardees. There is a formal process, the Commercialization Assistance Program (CAP) that provides consulting assistance with business planning and presentations to potential investors. The process culminates in a Commercialization Forum where awardees make presentations to venture capitalists and large company representatives. Fifty percent of previous participants in the program have received over $400 million in increased sales or investments. The other option has been provided since FY 1998 for those who do not wish to invest the time and effort in the formal CAP. The Technology Niche Assessment identifies possible partners for SBIR Phase II companies.

References

[1] D. F. Sutter and B. P. Strauss, "Next generation high energy physics colliders: Technical challenges and prospects," *IEEE Trans. Applied Superconductivity*, vol. 10, pp. 33–48, March 2000.