

UNDERGRADUATE OUTREACH

Introduction

The National Underground Science Laboratory (NUSL) will become a unique scientific facility within the U.S. Along with this comes an excellent opportunity to blend a world-class research environment with a diverse range of outreach activities, and it is critical to make these an integral part of NUSL from the outset. While broad in scope, a major component of NUSL's outreach program surrounds the undergraduate academic community. Both undergraduate students and faculty at predominantly undergraduate institutions constitute a valuable and under-represented segment of the scientific community. The programs and recommendations presented here offer mechanisms for strengthening the connection between the research performed at a national laboratory facility and the undergraduate academic community.

The Panelists

A group of panelists was invited to discuss, develop, and propose a set of programs designed to encourage participation of undergraduate institutions at the National Underground Science Laboratory. Panelists were drawn from both national and regional institutions including tribal colleges. Given the multi-disciplinary potential of NUSL, care was taken to select representatives from the fields of physics, chemistry, and engineering. In this way, a fuller discussion of the spectrum of research and outreach opportunities was possible, as well as their impediments. The panelists are listed at the end of this document.

Benefits of/to NUSL

The benefits that undergraduate students and faculty can bring to NUSL is many and varied, and reciprocated by the wealth of opportunities provided by a multi-disciplinary, cutting-edge research facility.

Benefits of Undergraduate Students:

The panel on Undergraduate Outreach envisions participation at NUSL by a broad variety of undergraduate students. Amongst these are science majors, science education majors, and non-science majors. An important constituency is represented by undergraduates from local tribal colleges. Each of these distinct groups will form a section of society that is both important and complementary to the other.

Today's science majors represent tomorrow's researchers and engineers, and will form the backbone of our technological society. Also, our majors in science education soon will be in a position to introduce and expose young people to the wonders and beauty of science and acquaint them with humanity's quest to understand the universe. Finally, non-science majors will move on to various roles ranging from parents to members of congress and corporate leaders. For all these students, the role of scientific research and its value to society will be formed through their college experiences. For many, this is their final formal interaction with the sciences and therefore, it is vital to create experiences that reflect the positive and creative nature of research.

In addition to the future impact that undergraduates can have for science in society, their presence and participation in the activities of NUSL bring immediate positive effects. As has been evidenced at other national laboratories, undergraduate summer interns inject a freshness and enthusiasm to the members of the Lab. Their probing questions serve to create a healthy and challenging environment for all who work with them, and enhance the vitality of the laboratory staff. The presence of undergraduates at a national facility can have a strong, positive impact.

Benefits of Undergraduate Faculty:

Faculty at predominantly undergraduate institutions provide a valuable experience and a unique perspective to both research and mentorship at a national laboratory facility. In addition to enhancing the diversity of experimental collaborations, they are best suited to quickly realize the full potential of undergraduate students while understanding their limitations. Undergraduate faculty are in a good position to bring a multi-disciplinary perspective to the collaboration and at the same time, bring the activities and goals of NUSL back to the classroom and their home institutions.

Benefits of NUSL to the Undergraduate Community:

The benefits to the undergraduate community are expressed through the valuable opportunity to collaborate in “big science” at a world-class, national science facility. Through this collaboration, undergraduates are introduced to the field of research, the culture of graduate students, postdoctoral fellows, university researchers and career scientists and engineers. At the same time, they are exposed to the highly active environment of a multi-disciplinary national lab, sponsoring a broad spectrum of seminars and workshops at various levels. Also, NUSL will provide a venue for undergraduates to meet fellow undergraduates who share their interest in science and research. NUSL will act to broaden the research horizons for undergraduate faculty and allow them to explore collaborative work at a national laboratory.

In order to best utilize this potential resource, it is important to appreciate the circumstances of faculty at undergraduate institutions and develop programs that are consistent with these conditions. Typically, undergraduate faculty teach at smaller institutions having student populations between 500 and 5000. These institutions are distinguished from research universities which sponsor graduate programs and enjoy the vitality and productivity that the presence of graduate students and post doctoral fellows can provide. Teaching loads for undergraduate faculty are more substantial and range from three to five courses each semester. This fact alone concentrates much of their research activity over the summer. It is also important to note that the size of the undergraduate institutions demands departments to be small and diverse, and rarely with more than one faculty member in a given research specialty. However, this can be a strength in building cross-disciplinary areas of research interest which ties in well with the breadth of NUSL’s research interests.

The research activities of the NUSL facility will encompass both short- and long-term experiments and involve collaborations ranging from a few researchers to many-hundred member groups. We present a set of programs that builds on the benefits of undergraduate students and faculty in a manner that is sensitive/compatible to the unique conditions of the undergraduate community.

The Key: An Office of Outreach

A thread, common to the success of all the programs proposed by the panel, is the need for a *well-supported Office of Outreach integrated into the organizational structure of the Laboratory from the very beginning*. Four distinct but related branches to this office are envisioned:

- outreach to the general public;
- outreach to the K–12 community;
- outreach to the undergraduate community;
- outreach for young scientists.

Responsibilities of the Office associated with the undergraduate program include the:

- co-ordination of student experiences at the Lab (*i.e.* housing, orientation, social activities, etc.);
- assistance in facilitating collaborations between undergraduate faculty and Laboratory experiments;
- establishment of a liaison with regional institutions and tribal colleges;
- seeking out partnerships with science education programs at regional institutions; and
- cultivating a relationship with the Council on Undergraduate Research (CUR).

The Office of Outreach will establish a continuity for successful programs which will allow for the streamlining of activities in future years, and thereby provide opportunities for further program development. The Office of Outreach will also serve as a resource for new outreach proposals while maintaining a record of past successes and positive experiences.

Overview

The Panel on Undergraduate Outreach proposes a series of programs designed to foster the relationship between NUSL and undergraduate institutions. Programs fall naturally into categories designed for undergraduate students and those directed at supporting research faculty from predominantly undergraduate institutions, although schemes which incorporate elements of both are also proposed.

PROGRAMS:

It is perceived that strong benefits can be provided to students of various backgrounds and interests. As such, programs have been developed which identify and build on the objectives designed for each group. These programs separate into summer and academic year opportunities. For science and engineering majors, summer and semester-long research internship programs that parallel the co-operative experience common to engineering training are proposed.

A: Summer Research Internships

Description: A summer research internship program provides a vital connection between our future researchers and NUSL. Given the multi-disciplinary nature of NUSL, summer internships are proposed for physics, chemistry, and engineering majors. This program is modeled from the successful *Fermilab Internship Program for Undergraduate Physics Majors*, and proposes to award approximately 8–12 internships to talented undergraduates in each of the three fields. The program will target outstanding undergraduate students from regional and tribal colleges, as well as national institutions, who seek an opportunity to participate in the research activities of a national laboratory. The program will be open to both U.S. and foreign students who have completed at least a year of undergraduate studies up to the end of their senior year. To maximize the opportunity for all undergraduates to participate in research at NUSL, the internship can be awarded only once to each undergraduate.

Administration: While administered by the Office of Outreach, the program will be managed by resident NUSL researchers. Program leaders will be associated with each of the different disciplines, and they will be the primary contacts throughout the program. The Program leaders will solicit potential student projects from both experiments and divisions within the Lab. Student projects will be selected on the basis of their suitability for the program; more favorable projects will be ones that provide good opportunities for the student to make a contribution to the research while learning the methods and goals of the research. It is envisioned that projects are closely related to ongoing experiments or ones that deal with computing issues relevant to work carried out at the Lab.

Organization: The interns and their projects are monitored closely after the internship begins. Should a project fail to meet the goals of the program, or should the project prove to be unsuitable for the intern, the program leaders will attempt to correct the problem by changing the project or by moving the student to a more suitable project. To facilitate these corrective actions it is important that intern salaries be budgeted to the internship program rather than having the research programs supplying the projects for the program. This also improves the competition among the research programs to provide good projects that will be beneficial to the interns.

Important to the cohesiveness of the group and the success of the program is the regular interaction amongst all interns and with the program leaders. Program leaders will meet weekly with the interns as a group to discuss individual projects, topics of interest, and concerns. Underpinning the internship program is a set of additional (extra-curricular) activities that serve to complement the undergraduate's experience at the Lab. A schedule of tours of experiments and facilities will be organized where students can gain a better appreciation for the larger scope of the laboratory. In addition, a series of special summer lectures aimed directly at the undergraduate level will be organized. (This incentive is described later in the document.) At the same time, students will be encouraged to attend lab-wide colloquia and seminars where they will be exposed to the nature of communication in research. Various social activities will also be planned including nature hikes and visits to local historic sites which introduce them to the background of the Black Hills region and its history.

Assessment: Students will complete their summer internships with a presentation describing their research project. Program leaders, mentors, and all interns will attend this event. Moreover, it is envisioned that a formal undergraduate summer research symposium be organized which brings together not just undergraduates and their mentors from the internship program, but all undergraduates participating in research throughout the Lab. (This incentive is described later in the document.) The NUSL Undergraduate Research Symposium may then represent the culmination of each undergraduate's summer internship and allow the members of the Lab to view the achievements and quality of work that can be performed by well-supervised undergraduates. NOTE: Such a symposium would also benefit prospective NUSL undergraduate faculty by introducing them to the character of student research projects and provide a forum in which future collaborations can be discussed.

Costs: Each intern will be supported by a stipend. This salary may be based on the seniority of the undergraduate, as is done in the Fermilab internship program. Housing will be factored into the overall cost for each internship as will the cost for travel to the Lab and transportation during the program. The latter may be arranged through the sharing of a rental car by several students. The provision for computing facilities and other research equipment will be supplied by the individual research programs.

Staffing: For the administration, co-ordination, and support of 12–15 undergraduates, it is envisioned that each discipline will require two program leaders, each committing approximately 15% of their time during the summer. Administrative support, through the Office of Outreach, will also require 10–15% time allocation during the summer with a further 5% committed throughout the remainder of the year.

Estimated cost: \$6000 per student.

B: Academic Semester of Research

The Academic Semester of Research program provides undergraduates with the opportunity to participate in a semester of research experience at NUSL. While models are in place for similar programs at other national laboratories, the panel proposes two distinct programs:

I: Academic Semester of Research Fellowships

Description: This program supports the intellectual and professional development of students with a strong desire to become involved in an intensive scientific research project with a mentor. Under the guidance of NUSL scientists or engineers, undergraduates will complete a 16-week program during the Fall or Spring semesters, culminating in a technical research report or final presentation. Emphasis will be given to recruiting from a diverse pool of applicants.

In addition to their research commitments, lectures, tours, and group activities will be scheduled around the Lab and in the surrounding environment, both historically and culturally rich. These activities will be of a similar nature to the ones described in the Summer Research Internship program.

Costs: This model is taken from the fellowships sponsored by the Department of Energy through the ERULF program. This program provides a student stipend, travel and transportation, as well as a housing allowance. The anticipated costs include a stipend of

approximately \$400 per week, travel to NUSL at \approx \$500, and transportation costs during the program (in the form of shared student cars, etc.).

II: CoURSEs at NUSL

Description: This program describes an initiative to strengthen the impact of predominantly undergraduate institutions at national laboratory facilities. CoURSE (Consortium for Undergraduate Research and Science Education) brings together faculty and students from predominantly undergraduate institutions in a way that enhances the scholarly opportunities of the faculty while offering a unique academic experience for their students. This is achieved through a carefully constructed semester curriculum involving both undergraduate faculty and students. NUSL collaborators from undergraduate institutions and working in similar fields are provided with an opportunity to participate in a joint, semester-long program that brings together two students from each institution for a semester of coursework and lab experience centered about a particular research topic.

Faculty from 3–4 undergraduate institutions unite to design a set of courses compatible with the sequence of the typical junior/senior major, and through this consortium assign one of the members to direct it each semester on a rotating basis. Courses considered for a junior physics major may include quantum mechanics (or advanced classical mechanics), extensive advanced laboratory work in the form of a research project related to a NUSL experiment, a seminar series on the consortium’s general field of interest, and finally, a course in “communicating science.” In this way, interested majors can remain “on track” with their degree programs while participating in research at a world class laboratory. At the same time, undergraduate faculty can increase their participation and visibility in their collaboration during the semester at NUSL while maintaining their teaching responsibilities and engaging in faculty/course development through the design and implementation of the novel course in communicating science. Undergraduate faculty will provide a stronger impact on their research experiments and heighten the visibility and perception of undergraduate institutions in the area of science at a national laboratory – both through the work of the faculty and the students.

Costs: It is anticipated that the primary funding will come from a granting agency external to NUSL, such as the National Science Foundation. Based on the proposal of a similar program at Fermilab, the NUSL contribution will consist of the following:

1. \$10,000 per year for contribution toward NSF grant
2. assurance of student housing
3. agreement and support of the Office of Public Affairs
4. access to suitable meeting rooms

It is also understood that each of the collaborating experiments will ensure computer facilities as well as access to all appropriate research equipment. In addition, it is envisioned that individual institutions will provide a level of support to enable consortium members to visit member institutions, etc. at a level of \$1,500 to \$2,500 per year.

C: Student Organizations

Description: A Student Organization program provides a means of extending an undergraduate's experiences at NUSL beyond the length of the program. Achieved via the World Wide Web, participants in a particular program initiate and develop a community web page during their time at NUSL which then acts as a focus for future activities.

Student organizations, through simple nurturing, create a valuable asset to NUSL at minimal administrative cost. Drawn primarily from undergraduates participating in a particular program, a student society provides a network for advice, information, and experiences cutting across all scientific disciplines and geographic locations. Fermilab has an established record of success in seeding student organizations from participants in their Summer Internships programs.

Administration: By providing simple resources such as access to a web site, students can maintain their connection to each other after returning to their home institutions. The relationships that formed during the intense summer of research which included weekly meetings, various social activities, and shared living arrangements, can be sustained and developed. A vital network of undergraduates tied by their experiences at NUSL is a strong reinforcement of the positive impact that a facility such as NUSL can make.

Cost: Central to the success of sustained student organizations is the active involvement of the program leaders. Their efforts to establish a *community* amongst the students must be supported by the Laboratory Administration through the Office of Outreach. Such support may be in the form of sponsored social activities (which already have been factored into the cost of the existing program), and the hosting of a student organization web site. The cost of this program is minimal.

Extensions to program: Possible extensions of this program include NUSL sponsorship for students to attend and present talks at national conferences. The NCUR conference (National Conference on Undergraduate Research) is an opportunity for students to reunite, as well as showcasing the work performed at NUSL to a wider academic community.

D: Site Visits

Description: The science being done at this facility will be of great interest to all students at the institutions of higher education in the region. Students from surrounding institutions will be eager to visit the lab and get a first-hand view of the equipment being used and the experiments being conducted at NUSL. The role of the Office of Outreach will be as liaison between the facility and regional schools to assist in the planning of the visit. However, as exciting and entertaining as these visits can be, experience has shown that they do not always create a lasting impact on the students. The students come in to the facility, see the equipment and the experiments, and then leave, having no further connection with the facility. A lasting impression from these visits can be achieved by providing supporting materials, both to students and their teachers. Curricular materials can be used before the visit to NUSL to provide background information and after the visit to provide follow-up information. These resources, coupled with the willingness of NUSL staff to work with instructors, will lay the foundation for an excellent opportunity to explore the science performed at NUSL. The Office of Outreach will be responsible for creating and disseminating the supporting materials for these field trips. This program will complement similar programs designed for students in regional K-12 schools.

E: Virtual Seminars

Description: We envision that NUSL will have an active seminar program, and one that could benefit faculty and students at all academic institutions in South Dakota. Unfortunately, the large physical distance between the academic institutions in the eastern portion of the state and the laboratory precludes regular attendance by faculty and students from these institutions. However, South Dakota has an extensive network, the Dakota Digital Network (DDN), which links all of the state-funded institutions of higher education and has been used to deliver upper-division physics courses, along with courses in many other programs. Facilities to connect to this network should be included in the Lab from the start and scheduled seminars should be held in this facility. The Office of Outreach should be responsible for sending a schedule of available NUSL programs and activities to all institutions of higher education and ensuring that these programs are available to as large an audience as possible.

F: Visiting Lecturers

Description: Scientists participating in research activities at the laboratory will be valuable resources to South Dakota students. They should be encouraged to visit regional institutions for short talks and longer extended stays. These visits may serve a variety of purposes. First, these talks will provide information to the general student population about the work occurring at NUSL. Even though these students may not be science majors, it is important that they have knowledge of the activities occurring at NUSL. Second, by bringing information about the research occurring at the lab, these scientists will be encouraging active participation in research activities at the lab by undergraduate science majors at all of the institutions in South Dakota.

G: Remote Experiments and Data Access

Description: The computational and networking capabilities of NUSL experiments adapt well to the realm of remote experiments and the opportunity for data access and analysis. This opens avenues for distance learning utilizing the Dakota Digital Network within the state as well as the WWW throughout the country and beyond. The large physical separation between the population centers in the eastern and western portions of the state will limit the access students in the east can have to the laboratory. Fortunately, South Dakota has an extensive high capacity fiber optic network throughout the state. With this network in place, the transfer of large amounts of information from the lab to various institutions in the state becomes a reality. When possible, every effort should be made to make data collected from experiments at the facility accessible to everyone.

Concluding Remarks

The Panel recognizes the importance of outreach in the responsibilities of the National Underground Science Laboratory (NUSL) and recommends that outreach be considered an essential and indispensable component of this facility. To accomplish this, we recommend that the Laboratory include a well-funded office of outreach in its organizational structure from the onset, with efforts related to outreach beginning at the earliest stages of the Lab's development. The Office of Outreach should be well staffed, with an associate director that reports directly to the head of the Laboratory, and sufficient support staff to allow the programs described above to be accomplished.

The key to the success of all aspects of outreach is the Office of Outreach, integrated into the organizational structure of the Laboratory and incorporated from the very beginning. The Office of Outreach will serve as the hub for all outreach activity supporting a diverse community from K-12, and the public, to young scientists.

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