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A Request for Planning Funds for a Research and Study Abroad Facility in Geneva, Switzerland in Affiliation with the European Laboratory for Particle Physics

Final Technical report

Objective:

To create a research and study abroad program that would allow U.S. undergraduate students access to the world-leading research facilities at the European Organization for Nuclear Research (CERN), the World Health Organization, various operations of the United Nations and other international organizations based in Geneva.

Project Description:

The proposal is based on the unique opportunities currently existing in Geneva. The Large Hadron Collider (LHC) is now operational at CERN, data are being collected, and research results are already beginning to emerge. At the same time, a related reduction of activity at U.S. facilities devoted to particle physics is expected. In addition, the U.S. higher-education community has an ever-increasing focus on international organizations dealing with world health pandemics, arms control and human rights, a nexus also centered in Geneva.

But perhaps most important, students based in Geneva would have the rare opportunity to participate in cutting-edge research at CERN and other international organizations. While being exposed to the people, tools and activities surrounding the LHC and other complex international programs, they will also be offered academic credit for their research contributions; these students, in other words, will contribute directly to the research program of the LHC and will learn by so doing. The program thus differs from traditional study abroad programs, whose curriculum plans are created for educational purposes alone.

This initiative builds on the National Science Foundation (NSF)–funded Research Experience for Undergraduates (REU) program operated by the University of Michigan at CERN, which has been highly successful in introducing young students to the excitement of LHC research and, in many cases, drawing them into high energy physics in their subsequent postgraduate studies. Although the program typically receives approximately 250 outstanding applications each year, it can only accommodate 15 students for two months each summer. This level of involvement is far below the needs of the 97 U.S. institutions participating at CERN and far below student demand. Creating year-round research and study abroad opportunities would both address this unmet need and increase the pipeline of future physicists. Similarly, broadening the program to include other Geneva-based organizations would help to achieve a wider national goal of increasing the number of U.S. students studying abroad and having access to cutting edge facilities wherever they are.

A Proposal for a U.S. Research and Study Abroad Program in Geneva, Switzerland

Planning Document

Prepared by the Planning Advisory Council

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U.S. Research and Study Abroad Program in Geneva, Switzerland
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Executive Summary

This document describes plans and the rationale for the establishment of a U.S. research and study abroad program in Geneva, Switzerland, in affiliation with the European Laboratory for Particle Physics and other international organizations.

Objective: To create a research and study abroad program that would allow U.S. undergraduate students access to the world-leading research facilities at the European Organization for Nuclear Research (CERN), the World Health Organization, various operations of the United Nations and other international organizations based in Geneva.

Cost: The annual operating expenses of the program when fully subscribed are projected to be US\$2.14M, based on 60 students participating in each of two semesters each year. In addition, start-up costs are estimated at US\$580,000, assuming that a potential relationship with CERN concerning use of a residential facility comes to fruition. Start up funding would include support for a senior staff person and administrative assistant responsible for initiating the program (fundraising, recruitment, logistics, etc.)

Direct personal expenses for each student are estimated at US\$8,800 per semester, excluding tuition or its equivalent and fees. It is expected that some operating expenses and student costs will be shared among members of the university consortium that manages the program, and some costs will be funded through grants from U.S. federal research agencies, foundations and other sources. In addition, students may be able to have their financial aid packages adjusted by their home institutions to reflect the higher costs associated with spending a semester in Geneva.

Need: As globalization increases, the size, scope and duration of international research projects require that more and more of the world's frontier research establishments be located in other nations (e.g., ITER in France, LHC in Switzerland). As a result, new modalities are required to continue to provide opportunities for U.S. undergraduates to participate in cutting-edge research. Many students choose their careers based on research experiences they have as undergraduates, thus making our proposed initiative central to the very future of U.S. technological leadership in key areas.

An added benefit would be to enhance the intercultural skills of the U.S. scientific community—of increased importance in many disciplines. It is important for our most promising science students to be placed in a facility that offers both scientific training and an opportunity for broader cultural experiences.

Project Description: The proposal is based on the unique opportunities currently existing in Geneva. The Large Hadron Collider (LHC) is now operational at CERN, data are being collected, and research results are already beginning to emerge. At the same time, a related reduction of activity at U.S. facilities devoted to particle physics is expected. In addition, the U.S. higher-education community has an ever-increasing focus on international organizations dealing with world health pandemics, arms control and human rights, a nexus also centered in Geneva.

But perhaps most important, students based in Geneva would have the rare opportunity to participate in cutting-edge research at CERN and other international organizations. While being exposed to the people, tools and activities surrounding the LHC and other complex international programs, they will also be offered academic credit for their research contributions; these students, in other words, will contribute directly to the research program of the LHC and will learn by so doing. The program thus differs from

traditional study abroad programs, whose curriculum plans are created for educational purposes alone.

This initiative builds on the National Science Foundation (NSF)–funded Research Experience for Undergraduates (REU) program operated by the University of Michigan at CERN, which has been highly successful in introducing young students to the excitement of LHC research and, in many cases, drawing them into high energy physics in their subsequent postgraduate studies. Although the program typically receives approximately 250 outstanding applications each year, it can only accommodate 15 students for two months each summer. This level of involvement is far below the needs of the 97 U.S. institutions participating at CERN and far below student demand. Creating year-round research and study abroad opportunities would both address this unmet need and increase the pipeline of future physicists. Similarly, broadening the program to include other Geneva-based organizations would help to achieve a wider national goal of increasing the number of U.S. students studying abroad and having access to cutting edge facilities wherever they are.

The planning phase of the program has been overseen by an advisory council comprised of representatives from the international physics and study abroad communities, as well as a major international consulting firm. This phase is currently managed by the University of Michigan, which will turn over the development and operation of the program to a consortium of universities as the initiative progresses to insure broad national representation in its establishment and oversight.

Student Selection: Approximately 60 students would be selected for participation in the program through an application process yielding a highly qualified, diverse group of students from across the country. Although the focus for a CERN-based program would be primarily on students majoring in physics, other related fields, such as mathematics or computing, would also be included. Indeed, students who could benefit from performing research at CERN might also include those studying collaboration science, journalism or even social or political science.

For an expanded program featuring participation with the other international centers in Geneva, students from an even broader spectrum of fields, including health sciences, medicine, economics and international policy studies, would participate.

Residence: A physical facility will be secured in the Geneva area to house the students in a safe environment in close proximity to transportation lines linking them to CERN, the World Health Organization (WHO) and other major international organizations. The facility would be patterned after the hostels now on site at CERN, which have been used by the University of Michigan during its REU summer program. Students would have access to kitchenette facilities, seminar rooms, computer networks and collaborative tools that would permit their participation in classes at their home institutions as necessary. CERN management has recently indicated its readiness to help make available facilities at competitive rates to accommodate up to 60 students, including interim housing for smaller numbers during the program's ramp-up period.

Instruction: The thrust of the program is to provide research opportunities to motivated students—opportunities they would likely not have in the United States. We anticipate that some students will have completed all of their required coursework at their home institution, or will do so upon their return to the United States. However, the program will also include the option for students to take courses during their time in Geneva. This instruction would be provided through an appropriate combination of courses either

offered at a Geneva-area university, through videoconferencing with students' home institutions and/or at the students' residence. The last option could be arranged by inviting visiting U.S. faculty to teach a standard course such as "Introduction to High Energy Physics," possibly through an NSF/Department of Energy LHC fellowship. Clearly, many details of credit repatriation, course offerings and instruction will need to be worked out as the program is developed, but there is every expectation that they will be.

Research Projects: The Michigan REU program has, for the past decade, brought approximately 15 students to the CERN Summer Student Program every year, each of whom is assigned to an LHC research project team. This experience has firmly established that the research projects available to students are of the highest quality: they are not artificially created for the students. Rather, after a general matching of research group needs and student background and interest, students are expected to jump in alongside CERN researchers, in small group settings, and help solve the real problems facing CERN scientists. Pedagogically, this is a very effective way to train students to be future scientists. Students see firsthand how research problems are attacked and what must be done to validate solutions. Too, mentors affirm the numerous examples of students who make lasting contributions to the work of research groups, despite only being able to work on projects for a few weeks in the summer. Indeed, such observations—of the significant contributions students have made in even a limited capacity—have provided much of the motivation for seeking to increase student involvement by implementing semester-long opportunities and serving a larger number of individuals through the proposed research and study abroad program.

Financial Framework: As noted above, the estimated annual operating expense of the U.S. research and study abroad program is US\$2.14M, with start-up costs of approximately US\$580,000. Partial funding will come from fees collected from students, either as tuition and/or special fees. It is anticipated that a portion of the program operating support will also come from university contributions, agency contributions and private foundation contributions. We hold open the possibility that a single foundation or agency may wish to become the lead contributor. Appropriate auditing oversight would be incorporated into the program structure.

Governance and Management: The research and study abroad program would have a director and two associate directors, located on-site in Geneva, responsible for the academic and research components of the program. One facility manager and two resident assistants would live in the housing facility along with the students and be available for counselling and emergencies. The director would have overall responsibility for the integrity of the program, ranging from daily operations to student recruitment and selection, and would report to an external oversight board. The Geneva-based staff would be augmented by several U.S.-based faculty and staff responsible for student recruitment and admission, financial management and building relationships with participating U.S. institutions. Much of this support would be provided as in-kind contributions by these institutions, given the alignment of the program mission with university goals.

1 Introduction

The purpose of this proposal is to describe the goals and proposed organization of a research and study abroad program in Geneva, Switzerland, to allow U.S. undergraduate students access to the world-leading research facilities at the European Organization for Nuclear Research (CERN), the World Health Organization, the various operations of the United Nations and other international organizations, and to motivate the process to make the program a reality. A residential facility is envisioned that would house approximately 60 U.S. students in the greater Geneva community, providing them with proper supervision and security. The program will also provide a structure for repatriating course credit to the students' home institutions for their work in cutting-edge data collection and analysis efforts at the participating research facilities and for any approved courses they take during their study abroad period.

This proposal is based on the unique opportunities currently existing in Geneva. The Large Hadron Collider (LHC) has already begun operations at CERN, concurrent with an expected related reduction of activity in particle physics at U.S. facilities. In addition, the U.S. higher-education community has an ever-increasing focus on international organizations dealing with world health pandemics, arms control and human rights, a nexus also centered in Geneva.

This proposal highlights an additional, and especially challenging, situation now facing U.S. higher education. As globalization increases, the size, scope and duration of international projects require that more and more of the world's frontier research establishments be located in other nations (e.g., ITER in France, LHC in Switzerland). As a result, new modalities are required to continue to provide opportunities for U.S. undergraduates to participate in cutting-edge research. Many students choose their careers based on the research experiences they have as undergraduates, thus making our proposed initiative central to the very future of U.S. technological leadership in key areas.

This proposal derives from an initiative of the high energy physics community. In pursuing the needs in high energy physics, it has been found that similar needs exist in other areas (e.g., mathematics, computing, collaboration science, journalism, social science, political science, health sciences, medicine, economics, international policy studies). While the overall Geneva-based research and study abroad program will definitely include these other areas as key components, the factual details presented below derive from the early and critical needs identified specifically for physics.

Elementary particle physics questions range from understanding the basic building blocks of Nature to how the universe began and how it evolves. Such a broad intellectual landscape requires many varied experimental techniques which are strategically deployed among nations and consortia of nations. These experiments vary from utilizing large, expensive colliding beams (such as protons colliding with protons or antiprotons), to high intensity specialized beams (such as neutrinos or muons), to sophisticated surface, subterranean, and orbiting astrophysical sources.

The cost and complexity of the first of these – large colliding beam laboratories – are so great that more than one international facility is now impossible. The CERN LHC is that facility in the world and offers the best chance for exciting discoveries which is why more than 1,700 physicists from 97 U.S. universities and laboratories currently participate in Geneva-based LHC experiments.

Like the Fermilab facility in the United States, the LHC is just beginning a multi-decade lifetime of fruitful research and the U.S. has to become accustomed to more than half of the particle physics community working off-shore. The challenge we face is broadening our educational and training experiences to include these international opportunities. CERN has a very large U.S. presence and will be welcoming of U.S. student colleagues.

The current University of Michigan NSF-funded REU program at CERN has been highly successful in introducing young students to the excitement of LHC research and, in many cases, drawing them into high energy physics in subsequent postgraduate studies. However, while this program typically receives approximately 250 outstanding applications each year, it can only accept 15 students for two months each summer. This amount of involvement is far below both the needs of participating U.S. institutes and the demand of the students themselves. Unless decisive action is taken soon, the United States will miss the important opportunities available through this extraordinary endeavor by not having provided for an adequate level of involvement of outstanding U.S. undergraduate physics students.

Numerous studies support the concept that one of the most successful strategies for training science students is to involve them in real scientific studies. With the projected closure of facilities at the leading high energy physics facilities in the United States, we are losing opportunities to train students in this field, a field often cited as one of the most fundamental of all the sciences. Moreover, the damage may go well beyond the loss of training opportunities, the broader and more significant loss is the lack of student interest in a field that they can never experience.

Additionally, it is clear that a semester or yearlong experience for underrepresented students can be pivotal in the development of their professional futures. In a world where more and more corporations and academic institutions are zeroing in on international experience as they seek to fill key leadership positions, it is extremely important that groups that are already underrepresented not be additionally disenfranchised because students lack the opportunity for such experiences. Indeed, the current state of physics departments in the nation's Historically Black Colleges and Universities gives major cause for concern (Quinton L. Williams, *Physics Today* 63 (6), 47 (2010)). Providing underrepresented students exciting physics opportunities can only help to keep the physics pipeline open for them.

The United States has the option of ignoring the risks of depriving its students of easy access to frontier facilities. Clearly, some students will find their way to where the research action is occurring. But counting on happenstance and individual initiative as national science policy would be very unwise. Another option is to try to bridge the current period, with its paucity of frontier facilities, to reach the point at which the situation is better balanced, with the understanding that sea changes of this type may take two decades or even more. The program we are proposing here is intended to provide just such a bridge.

This whitepaper lays out the issues that must be addressed before a study and research center can be established in Geneva. It addresses the benefits and challenges of study and research abroad programs by drawing upon existing experiences, explaining the rationale for a U.S. national program and describing the details of the proposed initiative.

2 Detailed Description of the Proposed Program

2.1 Introduction

This section presents a potential structure for the proposed program, including size, scope, logistics, management scheme and financial model. The primary focus is on the format of the final, full-scale program, although a several-year ramp-up period is foreseen. A certain degree of flexibility in size and scope will be required to allow for adaptation to available housing and other necessary infrastructure.

2.2 Program Size and Composition

Defining the size of the research and study abroad program depends on the following major factors:

- Student demand for participation
- The existence of suitable projects and qualified mentors
- The ability to absorb students in local courses
- The capacity of housing and other necessary infrastructure
- The willingness of CERN and other international organizations to absorb students into existing facilities, and
- Project management and funding

It is our belief that a program accommodating around 60 students per semester would be both satisfactory and appropriate, given these factors, and would have a powerful impact on the current lack of U.S. undergraduate research opportunities in high energy physics, simultaneously providing international research opportunities in a variety of other disciplines.

Around 250 highly qualified U.S. students apply each year for the 15 available positions in the REU summer student program at CERN. The vast majority of the students applying fit the necessary criteria to both contribute to and profit from the REU program, but most are turned away. Interviews with these interested and motivated students, and with undergraduates belonging to local physics societies, indicate a very high level of demand for a semester- or yearlong - program to both allow more opportunities at CERN and to prolong the duration of the existing program. Further, those students fortunate enough to participate in the current REU program do express one common disappointment at the program's end: that their time at CERN was too short.

The LHC experiments taking place at CERN involve the participation of thousands of physicists, representing hundreds of institutes from around the world. Most of these institutes have at least a few senior faculty members, research scientists and postdoctoral associates performing research at CERN. The proposed U.S. program would receive project proposals from this large international pool of potential mentors. Even if only half of the 97 U.S. institutes participating in the LHC each proposed one or two projects, it would suffice for a program of this size, and we would expect interest on the part of many non-US research teams as well.

Concerning course capacity, the University of Geneva has already expressed interest in establishing a relationship with a future program that would bring students to its campus

to participate in physics and other classes. In fact, it has already established exchange programs with some U.S. institutes, such as the University of Michigan and Boston University, with no written limits on the number of students who can be exchanged. Officials from the University of Geneva, in principle, see no roadblock to the acceptance of the 60 students proposed here. It might also be desirable to bring U.S. faculty to CERN to teach specific physics courses, as part of a fellowship for LHC research faculty. This would provide a means to both share the effort necessary to sustain the program in a very positive manner and provide an enhanced educational opportunity for the students.

Regarding housing, CERN management has indicated its readiness to help make available facilities to accommodate up to 60 students, including interim housing for smaller numbers during the program's ramp-up period. CERN may be able to act as the necessary legal entity. Such facilities would offer services similar to those already provided through the REU summer student program, including cleaning and security, and would be located close to CERN and to high-speed transportation lines linking students with the University of Geneva and other international organizations.

Clearly, students would need to be hosted for the research aspect of the program, and CERN has also expressed a strong interest in the creation of the necessary substructure in this area. All parties recognize that certain sensitivities exist regarding the use of laboratory facilities by nonmember state residents. However, CERN management has stated its full support for the proposed program at the level of 60 students and has agreed to work with program administrators to address any concerns that may arise. As with the other laboratory users, contributions toward the fulfillment of CERN's program goals must be weighed against costs incurred. The program proposed here is premised on the assumption that similar agreements can and will be reached with other participating international organizations, given that they operate under similar constraints and conditions.

The last major factor determining program size is funding. We are confident that between student tuition and fees, support from participating U.S. universities and funding from U.S. federal research agencies and foundations, the cost of a program supporting 60 students is manageable.

2.3 Program Scope

The Geneva area hosts a number of international programs and organizations working at the frontiers of a wide variety of disciplines, including the World Health Organization, the International Labour Organization and several United Nations entities. Each of these organizations hosts year-round internship programs that allow students to take on important roles in research and the implementation of key projects.

The United States has a strong historical interest in the success of the international organizations centered in Geneva and maintains an ambassador who heads the U.S. mission dedicated to their operation. U.S. students already participate in the many internship programs located in Geneva, and officials at the U.S. mission have indicated their interest in the creation of a program that would support the permanent presence of U.S. physics students in Geneva.

Further, while the need for a program supporting undergraduate participation in the LHC physics program at CERN is well established, it is our opinion that the United States—and the research and study abroad program itself—would also benefit from student participation in the research and programmatic activities of the many other international organizations headquartered in Geneva. Example research foci include studies in world health promotion, pandemic prevention, international labor law, resource sustainability, worldwide communication and human rights.

In addition, interactivity and the development of lasting relationships among students living together under the same roof are often among the most important and positive outcomes of any research and study abroad program. Our experience with the REU summer student program at CERN has clearly demonstrated this. For this reason, we believe that the presence of students working across a broad range of research topics would not only support the U.S. presence in Geneva but would benefit students by fostering both a diverse and stimulating atmosphere and lifelong personal and professional relationships.

2.4 Student Accommodations

The significant economies of scale, security considerations and short- and long-term social benefits described above lead to the conclusion that securing a single residence for all participating students is the preferred approach. The optimal arrangement would be to use or share an existing structure at CERN under a long-term lease or another arrangement with the organization.

Fortunately, CERN is already engaged in agreements with nearby off-site facilities and has offered to make them available for immediate use by this program. An existing structure in nearby St. Genis (France), for example, offers clean, secure living facilities in a studio apartment-like setting. Such a location, coupled with an arrangement for frequent shuttle service, could serve during a two- to three-year ramp-up period, easily accommodating up to 20 students.

In the long term, CERN is currently negotiating the rights to reserve a significant number of residences in a building to be constructed in nearby Meyrin (Switzerland). This project, which is to be completed in two to three years, will offer student housing for CERN, a number of other international organizations, the University of Geneva and others. It is located within walking distance of the laboratory and is very close to a tramline that provides quick, direct access to Geneva. The University of Geneva's interest in this facility underlines both the convenience of the available transportation and the fact that this building will be shared by an international mix of students, thereby enhancing the positive cultural aspects of the program. CERN is prepared to consider requesting the reservation of an additional 60 rooms at this site, specifically for this program.

Alternatively, the program could lease a single structure or adjacent structures in close proximity to public transportation serving CERN, other international organizations and the University of Geneva. The only clear advantage of this option is that an off-site location would more easily accommodate students performing research in one of the other international organizations, which are typically located closer to the city.

The option of purchasing or constructing a building in the Geneva area is not presented here, as it is assumed that potential U.S. funding agencies would be reluctant to make such a major investment abroad. It is possible, however, that a foundation or some other funding source might regard such an investment as both interesting and within the scope of its mission. In that case, potential administrators of the program should seriously consider such an option, as it might represent a significant overall savings in operations.

2.5 Student Security

The security of the students participating in the research and study abroad program must receive the highest priority. Since the beginning of the REU summer student program at CERN, there have been no events causing concern for the security of the students at CERN, in Geneva or even during occasional voyages outside the region. The REU students, however, have spent the vast majority of their time within the CERN walls, living in an on-site residence and working in office buildings that are protected by a 24-hour security service.

The proposed program will require that students spend a significant amount of time outside of CERN, on public transport around the city, in and around the university, and perhaps living in the center of Geneva. In addition, the group will be significantly larger and thus have a higher profile than the current group of 15 summer students.

In the event that the students are housed external to CERN, we recommend that the residence be protected by a dedicated professional security service to be procured by the program. The students should have a 24-hour phone number that accesses transportation, advice or anything else that is needed. The residence itself must be well secured, requiring keys and/or codes for entrance.

2.6 Student Personal Insurance

CERN requires that all of its users, including students, provide proof of health and accident insurance while working in the laboratory. In addition, the Swiss authorities do not recognize standard U.S. health insurance policies as providing the level of coverage that is required for people working in the country. For these reasons, and to simplify claims for medical fees, we expect that students will be required to purchase health and accident insurance from a local provider.

Purchasing local insurance would also make it easier for students to continue their normal schedule of health and dental checkups, without the concern of added costs. This can be a factor in long-term trips abroad, as negligence can lead to serious health problems. It is reasonable to expect that the program would be able to negotiate group rates for participating students, either on its own or within agreements already negotiated by CERN or the University of Geneva.

2.7 Student Expenses

Major student expenses will include housing, transportation, food and institutional fees and/or tuition, depending on arrangements made with the local universities. Additional non-negligible costs associated with working and studying abroad include health and

accident insurance; visas and other legal fees; banking fees for new accounts, transfers and exchanges; and communication costs. The cost of living in Geneva is significantly higher than in most U.S. cities. These costs and the added costs of relocation should not be neglected in the realization of a typical student budget for the program.

2.8 Course Credit Repatriation

In those cases where a student needs additional academic credit at their home institute, we envision at least three ways in which a Study Abroad opportunity in High Energy Physics can be facilitated: (1) taking a course given at the Geneva site by a U.S. professor in residence, (2) taking a course at a local Geneva university, and (3) using collaborative tools to remotely take a needed course back at the student's home institution. (See Appendix C for a discussion of the value and current use of collaborative tools at CERN and elsewhere.)

Essentially every university and college in the United States has a study abroad program, each of which has evolved in ways that fit the institution's culture and its academic and student needs. While managing the transfer of credit and the evaluation and matching of courses among participating institutions seems at first to be a complicated problem it has already been solved by every U.S. institution, and the process does not need to be reinvented here. Many U.S. colleges and universities already have Web-based databases that allow students to quickly match courses at a given foreign institute with courses at their home institutions and to assign appropriate credit to their home institutions. At most U.S. universities, when a new foreign institution becomes of interest, the relevant home academic departments match the new institution's courses for inclusion in this database. This problem of credit transfer, then, is a local responsibility and one that U.S. institutions are already managing. Department chairs regularly sign off on such transfers; this is the level where decision-making rightly belongs.

In addition, several aspects of the research and study abroad program proposed here make it uniquely amenable to the transfer of credits. First, physics is taught in very similar ways around the world. For junior and senior physics students, course offerings in Geneva will be familiar, some even using the same textbooks that are used in the United States. Second, the centralized management of this program will allow local staff to become familiar with University of Geneva courses and to thus act as a source of easily accessible information for U.S. institutions seeking to create credit matches.

2.9 Student Mentoring

The unique feature of this program is its identification with the premier international research laboratory in the world and the opportunities that this offers for undergraduate participation in exciting scientific work. Hand in hand with their academic programs, students will also participate in real-time research with mentors chosen from among the CERN-based U.S. scientific community as well as scientists from other participating nations.

Matching students and their research advisors at CERN has a considerable body of experience behind it and will be modeled after the successful approach used in the REU summer program at CERN. In the REU process, suggestions for possible research

projects are solicited from the CERN scientific teams, with priority given to those projects that include exposure to leading-edge scientific research; offer the opportunity to learn new, valuable skills; allow the student to contribute to an important and interesting aspect of the experiment; and can be completed in the allotted time, thus providing the student with a sense of value and accomplishment. Mentors proposing such projects are interviewed and selected according to their commitment to teaching and their ability to communicate with and encourage students to succeed.

A larger, year-round program will require a significant increase in the effort required to identify projects and mentors of sufficient quality. To ensure an appropriate pool of projects and to enhance the international, diverse and cultural experience of the students, it would be beneficial to draw from all of the hundreds of institutional research groups currently working at CERN or the other international organizations participating in the program, regardless of nationality. That the United States alone supports 97 groups at CERN should ensure that sufficient projects can be found to support 60 students year-round. However, the program would encourage research proposals from the entire CERN community in order to increase the cross-cultural opportunities for the students. (See Appendix B for a list of REU student research projects.)

As with the REU program, frequent individual interviews and group presentations will help to monitor students' progress and ensure that they are on the right track to complete their projects in a timely and positive manner. The research program coordinator and the local program director will be expected both to select student research projects and to oversee student monitoring, including communication with project mentors and changes to particular mentoring arrangements, should any problems occur.

Similar to current REU practice, students will be expected to make periodic project presentations to their peers and mentors. In addition, each student will be expected to prepare a research document related to his or her research project (similar or equivalent to a senior thesis) by the end of the program. This research paper will provide the student with an important sense of accomplishment, proof of having made a significant contribution to CERN's scientific program, and will provide program coordinators with a key metric for measuring the success of the program's research component.

2.10 Faculty Recruitment and Support

An important component of the U.S. research and study abroad program will be the participation of qualified U.S. faculty to help participating students stay on track to graduation by teaching one or more classes and generally contributing to the program's academic environment. The program's faculty would teach classes at the residential facility, the University of Geneva and/or the CERN campus.

The program's operating consortium—responsible for identifying and recruiting potential faculty—might want to consider establishing a nationwide competition for two university faculty fellowships. These fellowships would be prestigious awards and might be funded by U.S. federal research agencies and/or foundations. Fellows would be expected to teach at least one course during one academic term, as part of a sabbatical or some other arrangement with their home institution. The fellow's other time would be devoted to his or her own research program at CERN, as well as possibly mentoring students' research efforts at CERN.

Support for fellows would include salary and benefits, housing, international travel, local transportation, location adjustment assistance and so on.

2.11 Language Requirements

Undergraduate courses at the local universities are taught in French. Although students may ask questions and receive replies in English during lectures and discussion sessions, they will need to have a certain basic level of French to be able to understand the material.

Students attending the Boston University (BU) program in Geneva this past year were required to complete one semester of basic French (101) in Boston and also received three weeks of special training in “French for Scientists” before taking courses in Geneva. The BU students found that this training was adequate for following the physics courses, but admitted that more training would have been helpful.

For students planning to take courses at the University of Geneva, we would advocate at least one full semester of basic French, but advise a full year, if possible. A targeted preparatory course to be taken by all students upon arrival in Geneva, similar to BU’s, could be further supplemented through the presence of one or more resident French tutors hired to help students throughout the course of the program. Students might also be encouraged to complement this training by taking an additional course at the university or elsewhere in Geneva, provided their course load is not too heavy and preferably if credits can be repatriated to their home institutions.

Fluency in French is not required for students conducting research at CERN as normal scientific work at the facility is conducted in English. This practice is also common at the international non-governmental organizations where non-physics students may intern in later years. However, some level of French language ability is highly recommended for any student participating in the study abroad program.

2.12 Cultural Components

Geneva is famous for its international environment. It also happens to be located at Europe’s geographical center, connected to all the continent’s major cities via short flights or train rides. Even students attending the eight-week REU summer student program find the time to visit one or more of the important nearby cultural centers, thus broadening their experience tremendously.

For many of the students coming to Geneva, this will be their first long-term travel abroad. Indeed, for some, it might very well be their first trip outside of the United States. It is our experience that students who spend at least a few of their weekends traveling—visiting historical locations, participating in cultural activities or simply meeting people from different parts of the world—benefit a great deal. The opportunity helps broaden their perspective on world affairs, leads them to envision how their studies and research fit in to the global environment and points them toward the many opportunities that exist for their future careers.

As with the REU summer student program, we would encourage participating students to visit important cultural centers and discuss their experiences with their fellow students. In most cases, the students themselves organize their own travel and take care of planning, although someone is always available to assist with suggestions and solutions to various logistical issues. For the proposed program, one or two organized events might be offered, such as a group tour of United Nations facilities, a visit to Einstein's home study in Bern or a cultural event, if there is time and interest.

It is important to note that working in an international organization such as CERN provides the students with an important multicultural experience even without travel. The pool of potential mentors for students includes representatives from institutes around the globe, and nearly all of the research teams that the students join comprise a variety of nationalities and cultures. Students cannot help but gain exposure to the world of international research, providing them with positive experiences and lasting relationships that will benefit them far into the future.

2.13 Program Management

A program of this size and scope requires several levels of management:

- Daily management of student activities, advice and counseling
- Daily operation and maintenance of facilities
- Research program planning
- Educational program planning
- Student recruitment
- Resource management
- Overall coordination and oversight, and
- Administrative support

Experience with the REU summer student program at CERN underlines the importance of maintaining close continual contact with students. We recommend the recruitment of responsible individuals, such as graduate-level students or young postdoctoral fellows involved in research at CERN, to live and interact with the students on a daily basis. Persons filling this position would be similar to *residential advisors* in a university dormitory. It would be preferable to recruit at least one male and one female advisor to help students with any personal issues that might arise.

Concerning the daily operation and maintenance of facilities, much depends on the location and type of residence to be constructed or rented. For any facility, periodic cleaning and maintenance will be required, as well as the preparation of meals and/or the provision and maintenance of cooking facilities for the students. Although such services might well be included in an agreement with CERN, other facilities might require the hiring of maintenance, cleaning and cooking services. Regardless, we advise that a *resident facility coordinator* be hired to address any problems the students might have with housing, transport or security and to help communicate with local services.

Both research and educational program planning should be managed by senior faculty. Research planning will require both the recruitment of mentors with suitable projects and the matching of these projects with appropriate students. The program's *research*

coordinator should also maintain periodic communication with students and their mentors to ensure that projects are appropriate, that there is clear communication among students and mentors, and that progress is being made at a reasonable rate.

The program's *educational planning coordinator* will need to plan curriculum and to arrange for students' participation in courses at the local university, with U.S. faculty in Geneva and/or with their home institutions via remote participation using dedicated communication facilities. We expect that an initial investment of effort will be required to develop a seamless process for the repatriation of course credit. This will require coherent planning long before students initially arrive in Geneva. However, the coordinator will also help with any necessary case-by-case adjustments that may arise during the school year, acting as a point of contact with the home institutions and the students.

Student recruitment should be coordinated by a dedicated senior faculty member based in the United States. This person would communicate with existing universities and consortia and nationwide teaching and research programs and would design and use Web tools, flyers and posters to advertise the program across the country. Responsibilities would include a targeted effort to recruit students from underrepresented populations and areas of the country in order to seek a broad and diverse group of the nation's most outstanding students.

The program's *resource manager* would ensure sound planning, usage and accounting of program finances and provide the necessary contact with the institutions providing capital and human resources. The resource manager would coordinate capital for housing, transportation and other major investments and establish long-term plans for program funding via student tuition and fees and agency, consortia and foundations funds. The resource manager will also require expertise in international issues, such as local tax codes, labor law, general legal issues and housing regulations. Program accounts should be subject to an annual independent external audit by a qualified organization.

Overall coordination of the program will require experience in all aspects of the initiative, including research and educational planning and project management. A *program director* located in Geneva will coordinate student activities, oversee resource management and maintain contact with local institutes and organizations. Coordination in the United States could be provided either through senior faculty attached to a single university or through a consortium. The advantage of coordinating through a consortium comes from the existence of support staff and facilities, as well as experience in program management.

Administrative support will be required for Geneva-based and U.S.-based personnel to assist in program management and logistical issues. It would be desirable for this support to come from existing entities, such as a consortium, and to include staff with experience in international program management.

2.14 Budget Model

As noted above, the estimated annual cost of operating the research and study abroad program is US\$2.14M. This figure is a rough estimate derived from the expenses

associated with several existing study abroad programs and the University of Michigan's REU summer program. Revenue sources for the program that will offset expenses are anticipated from a combination of student tuition and fees; financial and in-kind contributions from universities participating in the management consortium; fees paid by institutions sending students to Geneva; and grants from U.S. federal agencies, foundations and other non-profit organizations. The amount of annual contributions from these various sources will most likely change as the program goes through the ramp-up period necessary to bring it to the full complement of 60 students per semester.

The program budget should be designed to minimize any student fees paid in addition to the home institution's tuition in order to maintain accessibility for a broad and diverse cross-section of students. Special attention will be required to ensure that adequate funding is available for students involved in work-study programs and/or receiving other forms of financial aid. Some institutions may be able to adjust financial aid packages in order to ensure equal access to the program. Foundations might be called upon to play a special role in providing scholarships, grants or travel funds to support financially challenged students.

Major program expenditures include housing rent and maintenance, insurance and legal fees, program staff salaries and expenses, faculty expenses, university or institutional fees, transportation, communication and general program management costs. Students can reasonably be expected to pay similar amounts for housing and food as they would at their home institutions. Geneva's high cost of living, however, might require that additional funding be provided either through the program or via the home institutions' financial support systems. (See Appendix D for a detailed budget model.)

3 Program Launch Timetable

Implementation of the program outlined in this document will require a significant increase in effort, organization and funding, in comparison to the existing REU summer student program. Although the new program's size, scope and duration are based in part on existing student programs that have already proven successful, including both the University of Michigan REU Summer experience and the Boston University Geneva Internship Program, it would be advisable to implement the program in stages.

We advocate that each new program stage follow an evaluation of the effects of previous changes, especially concerning the program's ability to successfully handle the increased size and scope of its research and educational elements. Given the growing need for undergraduate programs to accommodate the current increased activity at the LHC and the subsequent curtailing of activities in the United States, however, it is advisable that the program launch its first stage as soon as possible.

The additional requirements for housing and related logistical matters are substantial. It is thus reasonable to expect that locating appropriate housing for 60 students will take some time. In the interim, as the program ramps up, suitable housing could be located in the form of studios, apartments or similar accommodations in and around CERN. Concerning the program's educational aspects, the University of Geneva signed a student exchange agreement with the University of Michigan in 2010. We anticipate that a broader agreement could be fashioned with the University of Geneva that would

apply to all students participating in this program. Students could thus begin to attend courses at Geneva as soon as credit repatriation issues are resolved with their home institutions.

The identification of mentors with suitable research projects for students is a task with which administrators of the REU summer student program already have significant experience. In addition, CERN administration has expressed its full support for initiating the new program as soon as possible. No major obstacles are thus foreseen for integrating students immediately into research teams located at CERN.

Given the situation described above, we advocate launching the program as soon as possible, preferably by September 2012. The University of Michigan has already begun a small, semester-long pilot program with one UM physics undergraduate living in Geneva, working on a CERN research project and earning credit toward his undergraduate degree in Fall 2010, with another student scheduled to do the same in Fall 2011. Assuming the commencement of a more comprehensive program, Table 1 presents a potential timeline for ramping up the program over the next four years.

Term	No. of Students	Ramping Requirements (R) and Goals (G)
Sept. 2012	5–10	R: Local housing, projects, local courses, project management, staff G: Test basic concepts; identify challenges of larger scale and management
Sept. 2013	10–20	R: As above, plus more formalized program, increased infrastructure, staff G: Test program scale; check project quality, management model and funding strategy
Sept. 2014	20–30	R: As above, plus large-scale recruitment and non-CERN projects G: Check ability to recruit students in large numbers and of diverse backgrounds; research topics
Sept. 2015	40–60	R: Finalize housing and full-scale research and study program G: Check all aspects of program continually, through formal review process; check that numbers are neither too large (insufficient facilities, projects) nor too small (many rejections of quality students, projects)

Table 1. Recommended Staging Timetable for the Research and Study Abroad Program
Dates indicate the beginning of the semester affected. Student numbers are approximate ranges and are dependent on the project's ability to satisfy the goals of the previous stage, as well as the requirements of the current stage.

The dates in Table 1 indicate the beginning of a term (typically January–June and September–January) and might vary slightly according to the course schedules to be followed. The number of students is an estimated range, dependent on whether the goals of the previous stage have been met and whether the requirements of a particular stage can be met on time.

With the exception of the first stage (September 2012), all stages include two terms. We believe this is necessary to make sure that anomalies do not bias decisions regarding whether or not to proceed with the next planned stage. In addition, significant planning time (at least six months) will be necessary for coordinating increases in the recruitment of students and projects and the planning of class sizes.

4 Prospects for Program Enlargement Involving Other Fields

The initial and primary focus of the research and study abroad program is to engage U.S. undergraduate students in the significant research and education opportunities at CERN. As noted earlier, however, Geneva also offers a myriad of research and experiential opportunities that could appeal and be of value to students in a wide range of other disciplines, including health, the environment and human rights. Below, we describe a few of these opportunities and suggest organizational possibilities for expanding the program for their inclusion.

4.1 Health, the Environment and Human Rights

Beyond CERN, Geneva is home to an enormous range of other global research activity, providing unequalled opportunities for hands-on learning in an international environment. We envision the research and study abroad program expanding over time to include opportunities for applied study, research and development in many areas:

- *Health.* The World Health Organization, which has its headquarters in Geneva, provides leadership in setting global health policies and shaping research agendas. It takes a broad view of health policy, paying attention to social, economic and environmental factors, as well as medical practice.
- *The environment/climate change.* Geneva is home to a wide range of organizations studying the environment and climate change, including the World Meteorological Organization; the Secretariat for the Convention on International Trade in Endangered Species (CITES); and the Geneva Environment Network, a consortium of more than 50 nongovernmental organizations intergovernmental organizations and academic institutions.
- *Human rights.* Geneva is a center of international human rights activity, anchored by the world headquarters of the United Nations High Commissioner for Refugees (UNHCR); the International Labour Organization (ILO); the International Committee of the Red Cross; and the United Nations Office at Geneva, which is the second-largest UN office, after New York. UNICEF has its European regional office in Geneva, and dozens of smaller organizations centered in the city also work on a variety of human rights issues.

Many of these organizations have formal internship programs, for either undergraduates or graduate-level students. Arrangements can be made with smaller organizations on a case-by-case basis. Our vision is not simply to place students in organizations, but to create opportunities for cross-domain exchange, synergy and cooperation among students in the program and other relevant individuals, through seminars and mentorships.

4.2 Programmatic Vision

Key characteristics of an expanded program would include:

- A focus on research, both basic and applied, with an emphasis on students making real contributions to knowledge and applied scholarship in international communities of practice
- A cross-disciplinary view emphasizing connections and understanding between scientific and humanistic modes of understanding
- An explicit goal to have an impact on others outside of the program and its partner organizations
- Support for long-term projects and community building in a broad network of scholars and educators

At the core of this expanded vision is the mandate for students to take their research and extend its reach to others who could benefit from it in a meaningful way. There will be an emphasis on using custom-built or appropriate existing technologies to do this effectively. In addition to internships and content-area study, students will participate in seminars on technology design and social entrepreneurship. Online tools will be used to facilitate communication among stakeholders, including faculty and graduate student mentors in other locations.

4.3 Connections with Older and Younger Students

Undergraduates working at CERN will enjoy naturally occurring opportunities to work with graduate students and researchers at various points in their careers, and we envision building in parallel opportunities for students working in the fields listed above.

For example, students could collaborate with teams of graduate students in the University of Michigan–Flint’s Technology in Education Global Program, a master’s degree program that includes intensive residencies in Geneva. Like the vision described here, the Global Program emphasizes applied research and development in conjunction with internationally oriented partner organizations, with a focus on designing new models of education and social entrepreneurship in an increasingly globally interconnected world.

In addition, undergraduates in the program will have opportunities for leadership development in connection with secondary and early college students at institutions such as the International School of Geneva, traveling secondary programs such as THINK Global School, and emerging study abroad programs for students in Early College High Schools.

5 Advantages of a National Program

The primary arguments for the creation of a national U.S. research and study abroad program in Geneva, as opposed to individual institutional efforts, include a reduction in effort and resource replication; the advantage of scale in securing housing, transport and other accommodations; and the facilitation of student security. Certain issues, such as

course repatriation, elective requirements and the recognition of independent research as part of the undergraduate curriculum, will need to be addressed at an institutional level. However, the development of common strategies to handle these issues, in addition to the larger logistical challenges, will be greatly facilitated through a single coherent organization and could foster lasting agreements at a national level.

It is our opinion that the following components of the program would benefit substantially from the creation of a single national entity to administer the program:

- A national student recruitment strategy
- Research project solicitation and follow-up
- Local university course agreements
- Housing accommodations and security arrangements
- Relations with the host laboratory
- International legal agreements
- Insurance arrangements
- Cooperation with individual university programs

5.1 Recruitment Strategy

The current NSF-sponsored REU program benefits from a coherent nationwide recruitment strategy. As a national entity, the proposed program will have the freedom to utilize existing educational networks, without facing competition from others seeking the same student profile. This will allow the program to reach a very broad base of students, which is essential for locating and recruiting top-notch candidates from diverse backgrounds.

The circulation of publicity, in the form of Web-based announcements, email, posters and other printed material, will also be facilitated by central organization, and program costs will be significantly reduced in comparison to individual initiatives. Further, maintenance of a central location for information and registration will decrease the burden on students applying to or seeking information on the program.

5.2 Research Projects

The solicitation, scrutiny and approval of research projects for students should also benefit significantly from a central nationwide structure. Experience with the REU summer student program has already proven the value of maintaining a coherent set of criteria for the type and quality of proposed projects, as well as the qualifications, availability and dedication of potential supervisors.

5.3 Coordination of Local Courses and Aiding Credit Repatriation

An essential criterion of the program is that students will be able to obtain sufficient course credits through a combination of research equivalents or by taking courses at a local institute so that they can participate without delaying graduation. It is thus necessary for a relationship to be created between the program and a local university that will allow students to attend courses and to transfer credits to their home institutions.

The exact value of credits applied toward each student's academic record will need to be evaluated on a case-by-case basis. However, the establishment of the types of courses requested and the allotment of resources required to support increased student participation at local institutions will be best coordinated through a single channel of communication.

One key argument for coordination is simply the logistics involved in defining such agreements. Negotiations would be facilitated by the presence of a single line of communication presenting a single set of requirements. A local institution might shy away from the creation of numerous heterogeneous agreements, each of which would affect only a few students each term. The effort required to define and follow up on each agreement would increase substantially over that required for a single agreement with a program or a consortium of universities that has already agreed internally on the necessary requirements. In addition, a large program would be able to guarantee the number of students attending the courses from year to year, making it possible for the local university to plan for and acquire the necessary teaching staff and facilities. This can be especially important for equipping physics labs and establishing discussion sessions in English.

5.4 Housing and Security

The housing market in Geneva is very tight, and even with adequate resources, acquiring housing in a suitable location, in proximity to CERN, a local college or university and public transportation, is difficult. A nationwide program would benefit from economy of scale, in that a variety of options would be made available that could not otherwise be considered. CERN's readiness to facilitate the availability of housing for the research and study abroad program is a case in point. Under alternate off-site scenarios, owners or realtors are more likely to be willing to enter into long-term leases for a large facility. It may even be possible for a dedicated structure to be built for the program, given an agreement guaranteeing payments for an extended period of time.

A large single program would also create opportunities to equip the residence with meeting and teaching facilities designed for the student program. Videoconferencing and remote teaching/learning facilities can also be installed to allow students to communicate with their research groups and home institutions. Finally, security arrangements for a large single complex would be easier to arrange and cost significantly less per student than they would for a variety of independent housing locales.

5.5 Relations with CERN and Other Host Institutions

The creation of a single national research program would provide a single point of contact for communication and organizational coordination with CERN and other organizations hosting student interns or research assistants. As noted previously, CERN administration has in fact already voiced support for the creation of a national U.S. program. A number of students from non-U.S. countries already participate in research projects associated with national research programs. Their activities are coordinated through the CERN Academic Training Program or other agreements, but they are

typically handled on the national level, rather than through independent institutes. This facilitates coordination and reduces the burden on CERN staff.

A U.S.-based program may face the additional issue that the United States is a non-member state at CERN. CERN member states contribute significantly to the operating costs of the laboratory, including the organizational and logistical issues related to supporting a group of student researchers. While it is uncertain at present whether CERN would require any administrative or management fees, having a single national program would make it possible to better negotiate costs and to determine a standardized set of rules of engagement.

5.6 International Legal Agreements and Insurance Issues

International agreements for large-scale programs can be somewhat challenging, as slight changes to law or protocols are common and cause unforeseen problems, affecting many people. A good example is the recent changes to banking agreements that forced many U.S. citizens working in Geneva to remove their funds from the largest and most popular bank in the region. Complications arose due to a variety of related issues, including salary pay arrangements, and a significant effort was required to resolve the issue.

A national research program would maintain close contact with the U.S. State Department and other appropriate U.S. entities in Geneva and back in the United States, providing representation for all members of the program. Agreements with health, accident and other insurance providers are also best handled via centrally organized negotiations, as many of the issues that would concern the students have national commonalities. Financially, large-scale agreements can also significantly reduce costs and ensure that all students are properly and legally covered, according to local requirements.

5.7 Cooperation with Individual University Programs

The existence of a national research program would not exclude the possibility for smaller institutional programs to exist in parallel. Universities with large commitments to international study might already have existing structures through which they would prefer to offer a similar experience to students in Geneva, separate from the proposed program. Boston University, for example, currently runs a program in Geneva that supports students studying international affairs, health and, more recently, physics. This program receives its support entirely from within the university and is offered as a standard part of the curriculum.

A national program, on the contrary, would offer a unique opportunity to a broad and diverse spectrum of students from the entire nation. Many of these students would not have access to a similar program at their local institution. A nationwide program would have the additional advantage of allowing students from diverse backgrounds to come together to share a common international learning experience. The experience of the REU summer program has demonstrated that such opportunities for interaction create ties among students that are invaluable for their future careers in physics or other fields.

Finally, it should be noted that a national program could facilitate existing institutional programs by providing appropriate assistance in the negotiation of state-level issues, such as visa agreements or banking arrangements. It could also serve as a point of contact with the local university and local partners concerning issues that might have a national or large-scale impact on all program participants, such as cost-of-living adjustments or national security issues.

6 Future Program Management and Oversight

While the University of Michigan is leading the effort to develop the preliminary concept for the research and study abroad program, the program will ultimately be managed by some other entity, most likely a consortium of U.S. universities. The Advisory Council believes that creating a management structure for the program is the single highest priority moving forward and has begun identifying institutions and organizations that might consider assuming this responsibility.

Regardless of what group of universities ultimately manages the program, an external oversight body will need to ensure the program's proper management and operation. Such details will be established by the operating entity, but they should include a certified external audit of program funds on an annual basis.

7 Summary

The proposed U.S. national research and study abroad program in Geneva presents an extraordinary opportunity to provide U.S. undergraduates with an international research and learning experience that will change lives, influence careers and address a looming national deficit in qualified and passionate physicists. The program will ultimately provide similar opportunities for students in an ever-widening array of disciplines and fields. This planning document is designed to provide the outlines of such a program based in large measure on the highly successful REU Summer Student Program at CERN.

We are hopeful that an appropriate consortium of U.S. universities will share our passion and commitment and come together to make this program a reality. We are also hopeful that U.S. federal agencies, foundations and other non-profit organizations will recognize the importance and value of this initiative and join with us to make it a reality.

Appendix A. The Benefits, Challenges and Logistics of Study Abroad Programs

The Benefits of Education Abroad for Students of Science

International education has moved far beyond the old model of providing a high-culture finish and exposure for cosmopolitan humanists. Being able to operate skilfully and effectively in the real world across cultural differences is now a requirement for success in a large number of professional fields. This development is especially true for cutting-edge scientific research and knowledge production. It is essential for young scientists and potential scientists to be able to communicate and interact comfortably and effectively with strangers in a variety of cultural contexts in order to engage fully with colleagues in their areas of expertise. High-tech research and its applications are just as likely to take place today in Brazil, India or China as in the research labs of the United States or Western Europe.

The young student of science needs to master not simply the work of science itself, but also a set of essential skills: the ability to adapt to the individuals in any scientific context, the ability to communicate effectively across cultural boundaries and the ability to function successfully amid various work styles and structures and approaches to knowledge. It is also imperative that the student be able to manage everyday life outside the lab in varied contexts and to keep his or her social identity beyond science healthy and balanced. Expert knowledge is always embodied in the context of the self and the research team, and the ability to engage others across human and cultural differences leads to far more successful and productive scientific practice, insight and results, as demonstrated by many scholars, including Scott Page in *The Difference: How The Power of Diversity Creates Better Groups, Firms, Schools, and Societies* (Princeton University Press, 2007).

Living and studying in a diverse multicultural environment outside one's own nation, with the explicit intention of intercultural learning, is a particularly effective way to gain these essential skills. The habits of mind necessary to function effectively while surrounded daily by linguistic and cultural diversity, and to engage with this diversity, embrace it and both learn and be understood, are complex and invaluable. Too often, the functioning of virtual worlds and mediated encounters hinders the progress and success of young scientists who must be able to collaborate, synthesize, communicate and adapt. Real world immersion through an international education experience that moves students across several domains of knowledge and social contexts—crossing boundaries of lab, institutions, daily life and personal interests—is a critical part of a global higher education. We expect that linking CERN, the University of Geneva and the life of the city and its surrounding environs will provide just such a rich, intercultural, skills-building experience for the students participating in this program. They will become better scientists through becoming more fully engaged and skilled global citizens.

The Current Practices and Challenges of Education Abroad

Education abroad is currently undergoing transformation, as institutions and programs recognize that while exposure is a necessary condition for students' success in

enhancing intercultural skills, it is not sufficient. Studies by psychology and business professor Fiona Lee of the University of Michigan demonstrate that simple exposure without deep reflection or skill development can result in participants who are even more critical or close-minded about cross-cultural situations than those who have never travelled.³⁴ Increasingly, institutions are offering both preparatory and debriefing courses, as well as reflective exercises on site, in order to maximize and build on students' experiential learning. Furthermore, programs are now being designed specifically to take advantage of the field location, incorporating home stays and internships and other experiences that are unique to the site, rather than simply having students attend a university abroad with their U.S. peers.

One of the past cohorts of the NSF-funded Research Experience for Undergraduates (REU) program at CERN was also part of the Global Intercultural Experience for Undergraduates at the University of Michigan, under the direction of professors Homer Neal and Jean Krisch. These students not only carried out their scientific research but also studied the culture of science at CERN and reflected on it through comparing the historical careers of Einstein in Switzerland and Galileo in Italy. One of their observations was that the labs with lights on after 5 P.M. invariably belonged to U.S. scientists. While those U.S. scientists might believe their diligence positive, the students found that European scientists viewed it as antisocial, since they normally engaged in social, team-building activities immediately after 5 P.M.

This new awareness and understanding allowed the students to adapt more readily to the CERN environment, advise future REU participants and become more effective members of their research teams. The cultural, contextual and historical study, discussion and reflection around the field trips gave purpose and dimension to the students' understanding of what being a scientist, and being a scientist in Europe, fully means. The life of a scientist became real during the students' brief summer exposure, not just the profession's technical aspects.

This need for deeper local engagement runs up against the challenges of fluency, especially for students whose academic focus is in an area other than language, and the fact that students are only temporary residents of the communities they visit. The need for solid, and in some cases intensive, preparation courses becomes ever clearer if students are going to hit the ground running with local home stay hosts, conversation partners, internship mentors and colleagues and academic peers. Access to institutions, such as the University of Geneva's language courses and student population, is essential to a successful and engaged experience.

Programs do not necessarily need to structure each activity and encounter; in fact, it is better if they do not. But programs must equip students to be proactive about finding, setting up and participating in meaningful intercultural interactions. They also need to be structured in such a way that each individual student is engaged, rather than involving students in a group experience that maintains their outsider status by perpetuating an "us and them" structure. One advantage of programs like the one proposed here is that the students themselves will be drawn from a wide range of institutions and backgrounds,

³ Cheng, C., & Lee, F. (in review). Travelling abroad and creative performance: A mediation model.

⁴ Cheng, C., Sanchez-Burks, J., & Lee, F. (2010). Increasing Innovation through Identity Integration. Paper presented at the Academy of Management Meetings, August 2010, Montreal, Canada

while their research teams are already intercultural. Finding the time and the motivation to draw on Geneva's rich cultural and community setting effectively remains the student's challenge. Nevertheless, the program's partnership with the University of Geneva would provide students some entrée to the city's many civic and interest-based organizations.

Funding Needs and Mechanisms

Operating such programs around the globe with advanced and effective practices and structures obviously demands resources, typically provided by the individual participants, institutions and outside funders. With a base of transient participants, a local professional staff who can confidently handle housing, visas, personal and personnel issues, government and community relations, and so on, is essential. University offices focused on study abroad typically operate in one of two ways: either as self-funded operations entirely financed through program fees, where participants do not pay normal tuition, or as tuition-funded programs, where some portion of normal tuition follows the students to their study site.

A program involving multiple universities needs to be able to accommodate both models, typically by charging a study abroad office at each home university a fee that separates housing/board and personal expenses from program/academic expenses. Participating universities typically provide faculty and staff and the administrative support of departments and study abroad offices, as well as financial aid packages that allow for the participation of all qualified students. Travel and personal expenses are normally the responsibility of individual students; this is an area where outside funders can be of great assistance to talented students with need, since these costs are not negligible in a location like Geneva.

Consortial arrangements are common when universities jointly sponsor or participate in an off-site project. The division of central on-site staffing and recurring costs across multiple institutions, or a standard participation fee to cover such costs, is typical. Outside funding for start-up and capital expenses is often crucial to getting such ambitious programs off the ground and into a position where universities are willing to join such a consortium.

Building on Success: The REU Summer Program at CERN

Perhaps the most relevant template for the program being proposed herein is the NSF - funded Research Experience for Undergraduates (REU) summer program at CERN, operated for the past decade by the University of Michigan. Indeed, the difference between that program and what is being proposed here is primarily that the former program is able to accommodate too few students and for too short a time (the summer only). The CERN/Michigan REU program is limited to 15 students who live and work at CERN for a period of only ten weeks during the summer. Indeed, with nearly 100 U.S. universities participating in the research program at CERN, statistically each university would need to wait more than six years just to be able to send one of its undergraduates to CERN for the summer. The U.S. students join approximately 150 European physics students who participate in the formal CERN Summer Student Program.

The U.S. student candidates for the CERN/Michigan program are recruited nationally through NSF Web postings and literature distributed to all U.S. universities. Efforts are made to achieve a balance among students from small and large colleges, schools involved with the LHC and those that are not, with attention to the diversity requirements stipulated in the NSF REU guidelines. Student selection is based on grade achievement, computational abilities, letters of recommendation and student essays. It is noteworthy that of the approximately 250 applications received each year, roughly one-third of the students have perfect 4.0 GPAs.

There are many ways in which the effectiveness of an REU site can be evaluated. One is to conduct longitudinal studies of the students who have participated. Alternatively, students can be asked to directly evaluate the program, or a formal evaluation by social research professionals can be conducted. In the ten years of the CERN/Michigan REU program, all three of these evaluation instruments have been used. The results highlight the program's value for students: the vast majority of those selected go on to graduate study in physics, mathematics or engineering. The 15 students in the 2010 program are still in school. The 30 students who participated in 2008–9 are in some of the best science/math graduate programs in the United States and around the world, including:

California Polytechnic	University of California, Davis
Cambridge University	University of California,
University of Cincinnati	Santa Barbara
Cornell University	University of California,
Harvard University	Los Angeles
Massachusetts Institute of	University of Chicago
Technology	University of Colorado
Princeton University	University of Illinois
Rice University	University of Maryland
Stanford University	University of Michigan
University of California,	University of Pennsylvania
Berkeley	Vanderbilt University

These 30 students have also garnered an impressive number of awards: seven NSF Fellowships, four NSF honorable mentions, one DOE, one IGERT, one NDSEG, one Churchill and one Marshall Award. In addition, one was selected as one of the 20 outstanding Academic All-stars by *USA Today*.

The National Science Foundation recognized the CERN/Michigan program as exemplary, featuring it on the Web page of NSF International Programs for an extended period. Indeed, the CERN/Michigan/REU program clearly demonstrates the value of having bright U.S. undergraduates exposed to research and study at CERN. During their summer in Geneva, students in the program attend lectures in the prestigious CERN Summer Lecture Program in the mornings and work on specific research projects with mentors for the rest of the day. The problems they attack are real ones faced by the research groups in which they are embedded; they are not artificially constructed to serve as adjunct student training activities, but instead are the very problems that are being pursued as part of the process of preparing experiments and analyses to be conducted at the Large Hadron Collider, the proton collider that is now the world's largest operational research facility of its type. In addition to lectures and research, students have the opportunity to explore the enormous cultural offerings that are accessible within a few hours of Geneva.

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Students also get the chance to observe how modern research is done in large, international collaborations.

It is also worth noting that CERN's acceptance of 15 U.S. students among the approximately 150 overall participants in the CERN Summer Student Program is quite a generous and significant gesture, particularly given the fact that the United States is not a CERN member state. At the same time, CERN has provided for a significant increase in summer students from non-member states, currently hosting 70 or so from countries ranging from Argentina to Vietnam.

Appendix B. Sample REU Student Projects 2008-2010

2008

- Kristen Beck (U Rochester)-Track Selection Performance of the CMS CSC Track Finder and Level 1 Trigger
- Brice Cannon (Norfolk State University)-REX-ISOLDE: Design of Beam Line for Ion Transport at Low Energies
- Joseph Clappitt (Purdue)-Deploying Beam Radiation and Monitoring Displays
- Sam Espabodhi *(U Michigan) Diboson Signatures of High Mass Neutral Resonances at the LHC
- Lu Feng (Penn State)-ATLAS dashboard: monitoring the flow
- Christopher Flores (St. Mary's (Texas))-ATLAS commissioning: liquid argon calorimeter calibrations
- Amanda Fort (West Point)-The Final Countdown: FDR 2 Data Analysis
- Ayah Massoud (Penn State)-Convergence in proton reconstruction algorithm and final reference tests of Roman pots before installation in LHC
- Brandi McVety (Otterbein)-LHCb Web Site Development and Online Display Panels
- Cen-bi Liu (Loyola)-ATLAS Remote Monitoring System Framework
- Nathaniel Roth (Yale)-Beamline Position Measurements for the ATLAS Trigger System
- Meghan Shanks (Drake University)-A Study of the ATLAS Time Calorimeter LASER Calibration System Dynamic and Spin Studies at the LHC
- Jake Skrabacz(Notre Dame)-Structure Proposal for Re-circulating Race-track Design of the LHeC e-Linac
- Adam Sypniewski (Alma College)-Site mapping in DIRAC.
- Jeremy Ticey (Hampton)-Distributed Data Management
- Mingming Yang *(UMichigan)-Experiencing ATLAS Muon Spectrometer Endcap MDT Commissioning

2009

- William Boyd (Georgia Inst. Of Tech)-Testing Dynamic Data Allocation Algorithms Within a GRID simulator.
- Javier Duarte (MIT)-Comparison of mSUGRA and GMSB Super symmetry in ATLAS using Z (II) Final States
- Giulia Fanti (Olin College of Engineering)-Alice PC Cooling System Sensor
- Jennifer Grab (Lafayette College) –CMS Tracker Commissioning
- Emily Grace (Purdue)-Validation and Monitoring of the CMS E-Gamma High Level Trigger
- Philip Hebda Purdue)-Trigger Software Validation and DQM Development in SUSY and Exotica Analysis at CMS
- Jason Hindes *(U Michigan)-B-Field Corrections to Gas Monitor RT Functions
- Monica Lacy (U Dallas)-Refinements of Positron Accumulation Technique at ATRAP

- Tim Lou (Rutgers)-Next to Minimal Super Symmetric Model
- Steven Moses (U Michigan)-Designing a Laser Interface for ATRAP
- Jessica Muir (Michigan State U)-Noise Validation in ATLAS' Tile Calorimeter
- Alexander Palmer (U Texas)-ATLAS High Level Trigger System
- James Stankowicz (U Florida) –ATLAS Live and Higgs Search
- Jiri Stehlik (SUNY-Binghamton)-Exploring Lambda B Spin Effects through Toy Monte Carlo and Event Displays
- Jeremy Ticey (Hampton)-ATLAS Calorimeter Commissioning and Missing Transverse Energy
- Alexander Tuna (Duke)-Understanding LHC Splice Resistances and Quench Protection

2010

- Aram Apyan (Ill. Inst. Tech)-CMS Dashboard System
- David Bjergaard (Johns Hopkins)-Semileptonic Boosted Top Decays
- Len Evans (UNorth Carolina)-Stability in VPT signal in the ECAL Endcap of the CMS Detector
- Gustavo Gandara-Montano *(U North. Ariz.)-Magnetic Shielding and Creation of homogeneous magnetic field for a Radio Frequency Cavity
- Michael Glidden (U South Fla)-Data Analysis of a Low Momentum Detector Prototype for NA61/Shine
- Alex Ji (Stanford)-CMS Cathode Strip Chamber Track Finder
- Jason Locke (Florida Inst. Tech.)-Missing Transverse Energy and Jet Selection in ATLAS Collisions
- Adam Lowery (Lincoln)-Z Boson reconstruction with Monte Carlo Simulations and ATLAS Data
- Tim Olson (Valparaiso University)-ATLAS Level 1 Muon Central Trigger Processor Interface Monitoring
- Rebecca Pankow (Org. St)- Updating the Syntax of Template
- Elliot Schneider (CalTech)-Search for Diphoton Resonances Using the CMS ECAL
- Dayton Thorpe (U.South. Cal)-HCAL SiPM Calibration
- Natasha Woods (U Texas)-Study of Gamma+Jets production and first CMS data
- Ray Zhang (U Michigan)-Data analysis of lambda-0 polarization
- Kat Ziegler (Purdue)-COMPASS Trigger System Hodoscopes

*non-NSF funding

Appendix C. The Role of Collaborative Tools

Introduction

Two of the authors of this document are leading experts in the development and deployment of collaborative tools for large-scale, global scientific research. Homer Neal created the ATLAS Collaboratory Project⁵ to explore technological and sociological solutions to the challenges of the LHC. Steven Goldfarb chaired a requirements and technical assessment group⁶ to advise on LHC policy and is currently serving as the ATLAS collaborative tool coordinator. With this background, we believe we have a clear understanding of the important role these tools could play in aiding students, in particular, in their completion of required courses at their home institutions and their continued communication with research teams at home and elsewhere.

Remote Class Participation

Most undergraduate students in their junior or senior year have completed their peripheral course requirements and are focused on the topic of their selected major. A student, however, may still need to participate in and pass a course that is unavailable at the local university in Geneva for several reasons. It could be that the student has changed his or her field of study, is attempting multiple majors or has transferred from a different institution. Or perhaps a specific course in the student's field of study is only available during the time he or she would like to participate in the Geneva program. For whatever reason, every effort ought to be made to allow such students to come to Geneva without fear of missing a required course.

We thus advocate the installation of remote learning and teaching facilities on or near the site of the student residence. These facilities would be equipped with high-quality Internet-based videoconferencing installations, including cameras, flat-panel displays and interactive white boards. To effectively address the needs of all the students, several small facilities (1–4 occupants) and at least one meeting-room-sized facility (15–30 occupants) would be required. In addition, a small fund should be available to provide basic equipment (camera, microphone, PC and codec) for U.S. institutions lacking similarly equipped classrooms.

It is our opinion that expecting an institution to provide this service for a program participant is both reasonable and acceptable. Over the past ten years, the concept of remote learning has flourished in the United States, with the development of Web-based tools and accompanying methodology, and institutions across the country already offer a wide range of courses on the Internet. In addition, nearly all students are accustomed to using e-learning facilities of some sort as a part of their everyday curriculum.

⁵ **ATLAS Collaboratory Project:** A University of Michigan project supporting research and development for large-scale collaborative research experiments: <http://atlascollab.umich.edu>.

⁶ **Report of the LHC Computing Grid Project RTAG 12: Collaborative Tools**, S. Goldfarb *et al.*, [CERN-LCG-PEB-2005-007](http://cern-lcg-peb-2005-007) (2005).

Remote Research Group Participation

It is possible that participating students might already be involved in research back on their home campuses. That research could be tied into the Geneva-based project, or it might simply need to be completed as a part of degree requirements. It would be desirable for these students to be able to maintain communication with their remote research group via regularly scheduled phone or videoconferences or occasional ad-hoc call-ins.

The facilities constructed for remote learning, described above, could also be designed to address these needs. In addition, each student should be equipped with individual computing, cameras, microphones and/or headsets for personal one-to-one communication with their mentors. Although most students already possess this equipment and are familiar with communication applications, such as Skype, a small supply of additional equipment should be on hand to ensure that all students have the necessary capability.

Continued Program Participation

Students who have completed their stay in Geneva and returned to their home institutions might wish to keep in touch with their research teams back at Geneva. In some cases, this might be necessary for the completion of a project requiring more than a full semester; for the benefit of the Geneva research teams, which might gain knowledge from the student's new expertise; or simply due to the student's continued interest in the project. For this purpose, we advocate the installation of at least one small videoconferencing facility at CERN and the other participating organizations in Geneva.

The Presentation Archive

The current REU summer student program requires that each student present his or her project to peers, several times, in the form of slide presentations. Each student's final talk, at the end of the summer, is a formal presentation that is recorded in the form of an electronic Web-based archive. This practice has proven extremely useful: it maintains a record of the students' work and progress that can be viewed by mentors, project coordinators, funding providers and potential future recruits. It also allows each student to assess the strengths and weaknesses of his or her own presentation, a valuable tool in improving public speaking skills. We highly recommend the continuation of this practice and urge that at least one local facility be equipped with the required tools to archive presentations: camera, microphone, lighting, PC, cabling, converters and other associated hardware and software.

Appendix D. Detailed Budget Model

Many of the budgetary assumptions for an extended U.S. national program made in other sections of this proposal and below are based on direct experiences with the CERN/Michigan REU program. Calculations of per diem expenses (food/lodging) are based on 60 student participants in each of two semesters per year (130 days per semester). Salaries for Geneva and U.S. staff and contracted support services (e.g., food service, housekeeping, maintenance, security) are calculated on an annual basis.

Item	Specifications	Annual Cost US\$
STAFF EXPENSES		
GENEVA		
Research Program Coordinator (GVA) Senior faculty/researcher -recruit mentors and research projects for students; monitor student progress	Senior Faculty Salary	112000
	Travel Expenses	4000
Academic Program Coordinator (GVA) Senior faculty - plan curriculum; liaise with local university; manage transfer of credit issues with U.S. institutions; recruit U.S. faculty "LHC Fellows"	Senior Faculty Salary	112000
	Travel Expenses	4000
Visiting US Teaching Faculty (GVA) "LHC Fellows" - Senior faculty funded by U.S. federal agency and/or foundation - 2 per semester	Senior Faculty Salary	112000
	Travel Expenses	8000
	Living expenses including apartment	72000
Local Program Coordinator (GVA) Associate faculty - coordinate student activities; oversee research and education programs; oversee residence operations and resource management	Faculty Salary	189000
	Travel Expenses	4000
Resident Assistants (GVA) Graduate students (one male/one female); live in residence; conduct research at CERN	Grad Student Salary+COLA	62000
	Travel Expenses	8000
	Health & Accident Insurance	624

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Facility Manager (GVA) Oversee operation and maintenance of residence; on-call 24 hrs.	Salary	105000
Housekeeping Staff (GVA)	Salary (2 staff/day)	52000
Cooking Staff (GVA)	Salary (or service) (2 staff/day)	65000
Local Administrative Support (GVA)	Salary	70000

UNITED STATES

Program Coordinator (US) Senior faculty - coordinate overall planning with Local Coordinator (GVA); oversee faculty and student recruitment (US); oversee resource management; oversee transfer of credit planning and management; coordinate fundraising efforts; liaison to U.S. institutions and management consortium.	Senior Faculty Salary	112000
	Travel Expenses	10000
Admissions Officer (US) Associate faculty - manage student recruitment and selection process; liaise with U.S. institutions	Faculty Salary	38500
	Travel Expenses	6000
Resource Coordinator (US) Associate faculty or accountant - budget management; oversees annual external audit	Accountant or Faculty Salary	77000
	Travel Expenses	6000
Resource Oversight (US) External auditor - conduct annual audit of programs funds; report to oversight board	Auditor	15000
	Expenses	2500
Administrative Support (US)	Salary	15750
Subtotal Staff Expenses		\$1,262,374

FACILITY/PROGRAM EXPENSES

Residence	Annual Rent (students)	624000
	Annual Rent (grad Students)	31200
	Maintenance (service - per month)	12000
	Building & Liability Insurance	TBD
	Security Service (per month)	12000
Offices & Classroom (depends on physical arrangement)	Annual Rent (if different from Residence)	TBD
	Maintenance Expenses	TBD
	Installation (one-time costs)	TBD
	Building & Liability Insurance	TBD
	Office and Faculty Supplies	10000
Transportation Service	Airport	2000
	Car Rental (lease, insurance, gas, maintenance) - staff only	12000
Communication	Phone/Fax/Internet/Email	36000
Computer	Maintenance/upgrades (annual)	5000
	Maintenance/upgrades (annual)	2000
Remote conferencing	Mobile units (U.S.) (one-time cost)	4000
Legal Services (annual)		12000
Miscellaneous Costs	Other Supplies/Equipment	20000
Currency/Expenses Reserve	Buffer against currency fluctuations	100000
Subtotal Facility/Program Expenses		\$882,200
TOTAL EST. FACILITY/PROGRAM OPERATING EXPENSES		\$2,144,574

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EST. ANNUAL FACILITY/PROGRAM OPERATING EXPENSES PER STUDENT	<i>60 students/semester; 2 semesters; assumes no external support</i>	\$17,871
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ESTIMATED REVENUE

Student Tuition	TBD
Student Fees	TBD
Institutional Contributions	TBD
Federal Grants	TBD
Foundation Grants	TBD

START-UP FACILITY/PROGRAM EXPENSES

STAFF EXPENSES

Initial Program Coordinator (US)

Associate/senior level faculty member
responsible for identifying and securing
start-up funds for program

Senior/Associate Faculty Salary	189000
Travel Expenses	8000

Administrative Support (US)

Salary	31500
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FACILITY UPFIT

Remote conferencing	Installation (one-time costs)	30000
Residence Renovation (painting/floors/plumbing/electrical)		100000
Residence furnishings	Installation (one-time costs) Capital improvements	150000

ADDITIONAL EXPENSES

Legal/Permits/Licenses/Regulatory	TBD	50000
Miscellaneous Costs	Staff recruiting, administrative	25000

Subtotal Start-Up Facility/Program Expenses

\$583,500

**INDIVIDUAL STUDENT EXPENSES
(PER SEMESTER)**

Food & Transport (per day)	6500
Health & Accident Insurance (per day)	163
Round Trip Travel (per term)	2000
Group Activities (per student)	100
	\$8,763