

The University of Michigan Semester Research Program at CERN

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Since 2013, the University of Michigan has hosted a semester-long research program for undergraduate students at CERN. The students are selected from a diverse mix of small and large universities across the USA and are embedded as CERN Users in active research programs on experiments at the laboratory. The program is modelled on the highly successful NSF-funded Research Experience for Undergraduates (REU) program, which brings 15 students each year to participate in the CERN Summer Student Program, but serves to address the very large demand for additional opportunities during the academic year. CERN mentors are selected due to their leadership skills on the experiments, as well as their ability to educate and inspire the students. Projects cover a wide range of activities from detector R&D to software development, trigger design, physics analysis and theoretical methodology, and touch nearly all aspects of the research program at CERN.

Each semester, around six students, selected from diverse backgrounds, often under-represented in our field, spend three months working at the laboratory. They live in apartment facilities in neighbouring St. Genis Pouilly, and enjoy periodic excursions to cultural centres located around Europe. Funding, which covers travel, per diem and a stipend, has come from a variety of sources, including the Richard Lounsbery Foundation, the University of Michigan Department of Physics, and most recently from the United States Mission to the International Organizations in Geneva. We present the growing success of the program, its strategic interest to the USA, and describe our current efforts to expand and improve its diverse reach to all students across the country.

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1. Introduction

Students of all professions often benefit from internships designed to develop their skills and provide them with exposure to current real-life applications with experts in their field. This is especially true for university-level students in the sciences considering careers in research. At this age, students might have obtained essential scientific knowledge from their coursework, but often still lack working environment experience, including complex research-related problem-solving and the rewarding challenges of working in diverse international research teams.

With this in mind, CERN founded a Summer Student program [1] in 1962, offering an opportunity for undergraduate students in the member states to come to Geneva to work with top researchers in physics, engineering and computing for 2-3 months between semesters. The program was instantly successful and has grown in size every summer, since. Typically, around 3000 students apply for entry to the program, which accepts around 280. In 1998, funding was secured through the NSF Research Experience for Undergraduates (REU) program [2] to include U.S. students. This program, administrated by the University of Michigan [3], brings 15 students, selected from across the U.S., to CERN for 9 weeks every summer.

The success of the U.S. CERN REU program is evident by its popularity (300 students apply for 15 places) and by the success rate of students who taken part in the program, as measured through surveys, fraction of students attending graduate studies, and the success of those students in their career path. Growing demand for the program by both students and mentors, as well as a desire by students to experience more in-depth research opportunities – in some cases to satisfy undergraduate research requirements – led the University of Michigan to consider the development of a nation-wide Semester Abroad program at CERN.

This paper describes the University of Michigan Research Semester at CERN program [4] supported by the Richard Lounsbery Foundation [5] and, more recently, an endowment from Prof. Homer Neal. It then outlines a recent partnership between the University and the U.S. State Dept. increasing the participation of women and students from under-represented communities.

1.1 Origin of the program

A national semester program at CERN was first considered in 2008 as a means to address increasing demand from students applying to the summer REU program and from scientists at CERN interested in hosting student research projects during the semester. The goal would be to provide an opportunity for U.S. students unable to attend the summer program, but seeking research experience to complement their studies. Furthermore, it could serve those students in need of a more in-depth research experience than can be provided by the nine-week summer program. Such an opportunity is desired, and often required, as part of their undergraduate studies.

The Richard Lounsbery Foundation, the National Science Foundation, the Department of Energy [6], the American Physical Society (APS) [7], PriceWaterhouseCooper [8], and the University of Michigan held a year-long study of the issues that had to be addressed to bring a CERN research semester into reality. That study, summarized on the webpage of the American Physical Society's Division of Particles and Fields [9], was chaired by Prof. Homer Neal and the membership of the panel included the U.S. heads of the ATLAS [10] and CMS [11] experiments, the LHC Deputy, the head of the University of Geneva Physics Department [12], representatives of the university consortium APLU [13], and several others.

The study addressed questions about housing, transportation, insurance, security, research assignments, on-site coordination and availability of courses. Solutions were put forward and consensus was reached to pursue the program. Subsequently, agreements were reached with representatives from CERN, the registration process was defined, insurance policies were negotiated, housing secured, an on-site coordinator and mentors were identified, and projects were proposed to several students. Feedback from these students, coupled with 12 years of experience from the UM CERN REU Summer program, provided the basis for a for a pilot project proposal.

1.2 UM-CERN Semester Research Pilot (Fall 2013 - Winter 2014)

In 2013, the Richard Lounsbery Foundation awarded the University of Michigan a grant to fund a pilot Research Semester program at CERN in Fall 2013 and Winter 2014. Prof. Jean Krisch and Prof. Thomas Schwarz (author) served as Principal Investigators (PIs) and Steven Goldfarb (author) served as on-site coordinator. Three students were selected to attend from mid-September to mid-December, 2013, and another six attended mid-January to mid-April.

Qualified mentors from LHC experiments proposed research projects, and these were assigned to students according to their expertise and interests. As this came on the heels of the discovery of the Higgs boson, several of the students had the opportunity to work on follow-up measurements, as well as on detector R&D for pending upgrades.

Program participants were asked three times during the semester to give presentations on their projects, describing their experiments, their roles and their progress. As with the summer program, this allowed us to ensure they had a strong understanding of their work at CERN, that communication was clear with their mentors, and to identify and correct any academic or personal issues that might arise. The final presentations were recorded for the students to use as references for their future career pursuits. An informal program evaluation over dinner was complemented with a formal questionnaire and essays on their research and cultural experiences.

As with the REU program, evaluations and results of the pilot were impressive. Registration of the students as CERN Users provided them with access to the same scientific meetings, publications, colloquia and seminars as their collaboration members. The advantage of the 3-month semester over a 2-month summer turned out to be important, as there is a significant learning curve occupying the first few weeks of the projects. The added month effectively doubled the effort the semester students were able to contribute, which was notable in the depth and complexity of their projects, and in the positive feedback given by the mentors.

It is important to note that no students lost time on their academic schedule, one of the concerns raised during the exploratory study. Several students received credit from their home institutes for research carried out in the program. A few students took online courses and had their quizzes and exams proctored by the on-site coordinator at CERN. All of the students agreed that, even if they had to delay graduation, the value of the experience would greatly enhance the value of their applications for postgraduate studies or research jobs following graduation.

1.3 UM-CERN Semester Research Program (Fall 2014 - Winter 2019)

1.3.1 Richard Lounsbery Foundation Grants

Given the positive outcome of the pilot, the Richard Lounsbery Foundation encouraged UM to apply for a 3-year grant to establish a national UM-CERN semester research program. The grant was awarded for five students, each semester, from Fall 2014 to Winter 2017, with the same

team acting as PIs and local coordination. It is the policy of the foundation to provide funding to launch new initiatives, such as the semester research program, in order to establish their value and sustainability before seeking funding elsewhere for the long term. Upon completion of the first grant and the clear establishment of the program's viability, a "Phase 2" extension was awarded to allow us to continue through Winter 2019, while preparing to seek a long-term funding solution.

1.3.2 U.S. State Department Grants

During the Fall semester of 2018, representatives of the U.S. State Department from the U.S. Permanent Mission to the International Organizations in Geneva [14] proposed funding students in a partnership designed to increase the participation of women and minority students in research. Two students were supported that semester and another three were added in Winter 2019.

1.3.3 Student Selection

As with the UM-CERN REU summer program, students were recruited nationally and were selected from a wide variety of colleges and universities. Efforts were made to achieve a balance

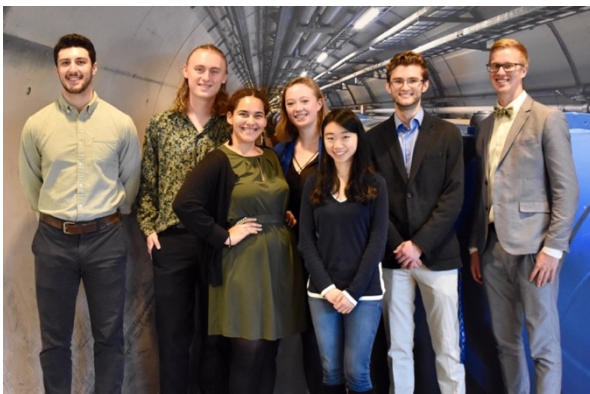


Figure 1. Students from the Fall 2018 program.

between small and large schools, as well as between institutes already involved in CERN research and those that are not. Over the past five years, students were accepted from 33 different universities, representing a very broad spectrum of institutions from across the U.S. and provided the students with the chance to meet and interact with other students of a variety of social and cultural backgrounds. Approximately one-third of the 59 students were women and at least 11 came from under-represented groups

in the field (Hispanic, Asian, Puerto Rican). A recent partnership with the U.S. Mission to the International Organizations in Geneva has focused on increasing these numbers significantly.

1.3.4 Research Projects

The CERN experiments offer a wide variety of potential research projects, from hardware construction and testing to electronics research and development, data acquisition, trigger development, data analysis, computing and software, etc. We make an effort to find challenging and fulfilling projects that are appropriate for the skills and interests of the students. Over the years, we have also identified mentors who are well-suited for proposing interesting projects and overseeing the work of the students in a pedagogical manner that assures they feel a sense of both learning and accomplishment. The three-month duration of the program allows the students and mentors to establish meaningful relationships and to delve deep into the subject matter.

Three times during the semester, the students give presentations to each other about their projects. The on-site coordinator and program leads chair the presentations, and the students are encouraged to ask each other questions about their work. This gives us a chance to check that the students understand the context of their work and that they have been given interesting and challenging problems. On a few occasions, adjustments have been made, including the changing of projects or mentors. Problems are very rare, but can be solved if identified early on.

The final talks are longer and more formal. The students present as if they are at a conference and we record the talks for future reference. Many of the students include links to these talks in their graduate school applications. It is a unique opportunity for all of the students to learn first-hand of the variety of CERN research. Beyond the LHC, students have been engaged in antimatter experiments, medical application research, scientific computing, and data preservation. Agenda of all presentations [15] include slides and videos of the talks. The projects were not only interesting and challenging to the students, but each left CERN knowing that she/he had made a significant contribution to the field of experimental particle physics at the premier high energy laboratory in the world, working alongside other scientists from around the planet.

1.3.5 Housing

Participants were housed in apartments in nearby St. Genis Pouilly, France, about 10 minutes away from CERN via bus or 30 minutes walking. The students were placed in efficiencies, one-bedroom or two-bedroom apartments, depending on the number of men and women in the program. Each apartment is equipped with a kitchen, including stove, refrigerator, and utensils. There is also a television and Wi-Fi, so the students have essentially the same living conditions as they would have at school. They share common laundry facilities and a work out room, and the program paid for the weekly cleaning of their linen, which was also supplied with the apartment.

1.3.6 Cultural Activities

In addition to their research activities, students took advantage of the central location of Geneva to travel on their own or together to various cultural centres, such as Paris, Rome, Barcelona, Berlin and London. To ensure that all students, regardless of their financial status, had an opportunity to take advantage of these cultural opportunities, the program sponsored a trip each semester. The most common choice of destination was nearby Bern, as they could travel by train and visit such locations as the Einstein House and the nearby art museums. In addition, the program sponsored 10 weeks of French lessons designed to improve their abilities to interact with the local population, order food, and shop at the local stores.

2. Measuring the Success of the Program

2.4 Current Status of Past Participants

Each student who participated in the program was contacted in 2019 and asked to describe their current academic/employment plans. Of the 59 students, 26 are already in post-graduate programs, 7 have applied, 10 are still completing their undergraduate studies. Several of the students took on a variety of related employment in the fields of data science, finance, software engineering, data security, management consulting and artificial intelligence, working for businesses, such as Google, Microsoft, Ford, Facebook, NASA and the U.S. Patent Office.

2.5 Testimonials from Students and Mentors

In gathering information from the students on their current status, many shared with us their enthusiasm for the program, as well as their future plans. Here are a few extracts:

“The University of Michigan's Semester Abroad program at CERN solidified my interests in physics and convinced me to pursue graduate-level research in a related field.

I owe a lot of my success to this program. I didn't pursue a bachelor degree in physics because it was

not offered at my undergraduate institution. So I was at a major disadvantage all around for pursuing a career in physics. However, a number of doors opened for me because of the UMich CERN research abroad: I was accepted to two PhD programs to work with two professors I met through the program; I was offered a summer research opportunity at MIT the summer following my CERN semester (I declined in favor of continuing to do research with my CERN advisor at his home institution); and I was employed by Argonne National Lab for a semester to work in their high energy physics group. My experience at CERN made me feel more confident in my ability to do research and I developed a number of invaluable skills, both soft and technical, that have been critical to my graduate studies. Additionally, I made a number of friends with graduate students, post docs, researchers, and professors from all over the world...

Prof. Richard Teuscher, University of Toronto, is one of the regular mentors, offering students interesting and challenging projects. Here are comments from a recent letter:

“Several of the students in this program have gone on to graduate school at leading universities in the US; another received a Barry Goldwater scholarship, one of the most prestigious undergraduate awards in the US; a former student is now a software engineer at Harris Corporation, and another works at Lowell Observatory in Flagstaff, Arizona...Overall this is an outstanding program which provides U.S. students a world-class training in a challenging international environment. I would give it my highest support.”

2.6 Program Evaluation

In 2016, the University’s Research Center for Group Dynamics at the Institute for Social Research reported findings on an independent survey carried out on the first two years of the semester research program. The executive summary from that survey states:

“Based on the findings, there is ample support for continuing the program. Its impact on students is demonstrable, positive, productive, and extensive. A semester-long experience does not have any of the negative impacts some have feared, such as interrupting normal progress toward a four-year timeline to get a degree. The knowledge and insights gained in that semester greatly increase students’ understanding of what a career in physics might entail. This is a view shared by student participants and their advisors.”

2.7 Survey from 2019

Following the Winter 2019 program, a survey was circulated to all past students [16]. We received 35 responses, all of whom expressed enthusiastic support for the program to continue. Below are some key statistics from the report, as well as some comments from the students.

- 94% claim participation in the program had a positive effect on their degree progress/plans;
- 74% intend to continue physical science studies at a postgraduate level;
- 100% feel the program made them more competitive as an applicant to future studies/jobs.

3. Summary and Future Outlook

Since 2013, the University of Michigan has administered an undergraduate research semester program at CERN, modelled after the NSF REU Summer Student program, but providing a longer and more in-depth research experience. By all measures, the program has exceeded its goals. Students not only develop skill sets and gain knowledge about cutting-edge research, but they learn how to work successfully in an international environment, expanding their social and cultural experience, and creating long-lasting ties with colleagues in their field.

The world-wide pandemic put the program on pause in March 2020, cutting short activities by a month. Nevertheless, the six students completed a significant amount of research and were able to report via videoconference in the Spring. The program is expected to resume in Fall 2021 or Winter 2022, depending on health considerations due to the pandemic. Additional resources are being sought to expand efforts to reach more students from under-represented communities.

References

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- [5] Richard Lounsbery Foundation: <https://www.rlounsbery.org>.
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