

Undergraduate Research at CERN Programmes for U.S. and Ukrainian Students

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Since 1999, universities in the United States associated with major particle physics experiments at CERN have coordinated summer and semester programmes bringing undergraduate students to perform research at the laboratory. This includes participation in the CERN Summer Student Programme, as well as other programmes supported by national funding agencies, foundations or the universities themselves. They typically include a 2-month summer programme or longer stays over the Fall or Winter semesters. All of them provide access to CERN's cutting-edge research facilities to a diverse mixture of students coming from small, large, public and private colleges and universities from across the nation. In one particular case students from Ukraine or other countries in times of conflict have also been invited through a U.S. initiative.

These proceedings will discuss the motivation and origin of these programmes with a focus on the University of Michigan programs, for which the author has served as the local programme coordinator. These include the Research Experience for Undergraduates (REU) summer student programme supported by the National Science Foundation (NSF), a semester/summer programme supported by the University's Physics Department, and a complementary programme recently initiated by the U.S. State Department through the U.S. Permanent Mission to the international organisations in Geneva. We will also discuss growing demand from the students and experiments to increase both the size and diverse reach of these opportunities for the future.

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1. Introduction

The role of apprenticeship as a valued component of education is as old as humanity, itself. In fact, it most likely dates back to earlier apes, as tool-making was prevalent at least 3 million years ago [1]. Today, students of all professions benefit from internships that provide them with exposure to real-life application of their studies under the mentorship of experts in their field. For university-level students in the sciences, considering careers in research, this can be particularly important for several reasons: it gives them experience with current tools and methodologies in their field, it bridges abstract concepts in textbooks to actual real-life application, and it exposes them to the daily life of the career they might (or might not) consider pursuing.

The impact of undergraduate research experiences has been the subject of a variety of academic studies. A 2019 Colorado State University study [2], found that “if students do not feel engaged, they are at high risk for leaving their institution prematurely. Among high impact practices, undergraduate research has been shown to have the most positive effects with regard to promoting student engagement.” Results from a 2023 study by Florida Atlantic University and Lynn University [3] “indicated that experienced students had significantly higher graduating GPAs than novice or control students, and both research groups had significantly lower time to graduate than the control group. Findings also indicated experienced student researchers are significantly more likely to progress to graduate school.”

In the field of experimental particle physics, opportunities for undergraduate students to participate in research exist in a variety of national and international laboratories and research institutions around the globe. CERN, the European Laboratory for Particle Physics, has run a highly successful and prestigious Summer Student programme [4] since 1962. It began by offering undergraduate students in the member states an opportunity to compete for short-term projects, working alongside top researchers in physics, computing and engineering for 2-3 months between semesters, during the European summer. The programme has grown in size and global reach every summer since, with the current number of applications exceeding 3000 for around 280 positions and with students participating from every inhabited continent around the planet.

These proceedings will describe U.S. participation in the CERN Summer Student Programme, as well as a number of additional summer and semester programmes initiated by the University of Michigan to address increasing demand from U.S. students and researchers.

2. The U.S. CERN REU Summer Student Programme

2.1 Programme Origins

In 1998, funding was first secured through the National Science Foundation (NSF) [5] Research Experience for Undergraduates (REU) programme [6] to include U.S. students in the CERN programme. U.S. participation in the programme was pioneering, as past participation had depended on national status as a CERN member or associate member, and the U.S. is an observer state. However, following discussions between then CERN Director General Chris Llewellyn Smith, Prof. Homer Neal of the University of Michigan and Prof. Stephen Reucroft of Northeastern University, it was decided that participation in the programme would be a positive means to encourage the participation of American institutions in the U.S. to experiments on the Large Hadron Collider (LHC) at CERN. The NSF solved the issue of funding.

Beginning in the summer of 1999, The University of Michigan and Northeastern University split the task of advertising the programme, selecting students and matching them to projects and mentors at CERN. Student projects covered a range of activities, including detector construction and operation, software development and testing, data acquisition, trigger development, theory and analysis. In 2001, the University of Michigan received complementary funding through the Ford Foundation to support additional students, citing the need to address a national shortage of young STEM-educated employees (or potential employees) with international experience, willing to serve in its offices and factories overseas.

2.2 Current Implementation

The University of Michigan took over the REU programme in 2005 and has administered it ever since. Currently, the programme [8] brings 15 students, selected out of roughly 250-300 applicants from large and small colleges and universities across the U.S., to CERN for 9 weeks (mid-June to mid-August) every summer. Given the large number of highly-qualified applicants, it is possible to seek students coming from a diverse cross-section of communities and to include gender balance in its final list of participants, a very positive aspect of the programme.

Currently, projects and mentors are selected by CERN, as the U.S. students are integrated into its programme. This means the students are given the same opportunities and experiences as the other international students and participate in their events, including the Summer Student Lectures, detector visits, social events, poster sessions and more. Important additions organised by the university include a video orientation with the principal investigators, flight arrangements, insurance, greeting at the Geneva airport, pizza dinner orientation in Geneva, three short presentation sessions by the students, and a final dinner debriefing with the local coordinator.

The short presentation sessions are key to the success of the REU programme. The first set of talks helps to ensure the students are well-equipped for their projects and that they understand what is expected of them by their mentors and research teams. The second set provides a more complete picture of the progress being made by the student over the summer and allows for any necessary adjustments to lead to a successful conclusion. The final talks are slightly longer and more formal, so they can be recorded on video for the students to keep for their CV and future career applications. At the end of the summer, the students are asked to hand in short descriptions of their work and evaluations of the programme.

3. The University of Michigan Semester Research Programmes

3.1 Motivation

A national semester programme at CERN was first considered in 2008 as a means to address increasing demand from students to participate in research and from our colleagues at CERN to host projects during the semester. It was also seen as an opportunity to recruit students from under-represented communities and to offer a more in-depth research experience than that provided by the nine-week summer programme. Furthermore, such a programme could also fulfil some university requirements for research experience as a part of an undergraduate degree.

3.2 Pilot Programme

Following discussions with the NSF, U.S. Department of Energy [9], U.S. State Department [10], American Physical Society [11], leadership from the LHC experiments and others, the Richard Lounsbery Foundation [12] 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 served as Principal Investigators (PIs) and Dr. 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, 2014. [13]

The semester programme was modelled on the summer programme, albeit with a longer timeframe, allowing the students a more in-depth research experience. The programme PIs selected a diverse group of students from across the nation, ensuring representation from a large variety of colleges and universities. Projects and mentors were procured from the broad spectrum of experiments at CERN, then mapped to the students, often providing the latter with an opportunity to select the projects that interested them most. The students were expected to make three presentations during the programme, just as with the summer students, with a formal talk at the end, followed by a dinner and debriefing. Travel funds, a per diem and a stipend were provided, allowing the students to live off-campus in nearby St. Genis Pouilly in well-equipped apartments within walking distance or a short bus ride to CERN.

The results of the pilot were very positive. 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.

Furthermore, no students lost time on their academic schedule, a concern raised during early discussions, and several received credit from their home institutes for research carried out in the program. A few of the students took online courses and had their 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 enhanced the value of their applications for postgraduate studies or research jobs following graduation.

3.3 Semester Programmes

3.3.1 Nationwide Programme

The University of Michigan was awarded a grant from The Richard Lounsbery Foundation for five students, each semester, from Fall 2014 to Winter 2017. Upon completion of the first grant and establishment of the programme's viability, a "Phase 2" extension was awarded to allow continuation through Winter 2019, while seeking a long-term funding solution.

During a visit to CERN in 2017, representatives of the U.S. State Department from the U.S. Permanent Mission in Geneva [14] were impressed by the student programme and the efforts being made to bring in students from communities traditionally under-represented in the field, including women (who currently make up only 24% of the personnel at CERN). They proposed boosting these efforts by funding two students in Winter 2018 selected from those communities.

A search was launched through the online platforms of the Society of Physics Students (SPS) and the APS and two students were supported that semester. Following that semester, the U.S. Permanent Mission in Geneva provided support for 2-3 students each year, either attached to the Lounsbery Foundation programme or on their own, once that programme had concluded.

3.3.2 University Programmes

In addition to the national programmes described above, several U.S. universities host or have hosted semester programmes for undergraduate research at CERN. A partial listing includes Boston University [16], Duke University (with the Triangle Universities Nuclear Laboratory) [17], in addition to the University of Michigan [18]. The University of Michigan programme is funded by a grant bequeathed by Prof. Homer Neal, founder of the initial REU and semester programmes at CERN. Additional funding provided by the Physics Department brings 4-5 students to CERN each year.

The University of Michigan students follow a programme that is very similar to the national programme described above, spending around 80 days embedded in CERN research. The programme was originally held during the semester, but the long summer recess at the university makes it possible for them to come early in the summer, so as to avoid clashing with their semester courses. Although the students are selected from within the university, their research projects also span the wide range of CERN's experimental programme.

3.3.3 Ukrainian Programme

Following the unprecedented invasion of Ukraine by Russia in 2022, organisations all over the world sought means to aid endangered Ukrainians not only to continue a “normal” life in safer locations, but to help them to prepare for the eventual rebuilding of their country. A fellow LHC colleague, Prof. Chris Tully of Princeton University, obtained funding through a grant by the Simons Foundation to support three young Ukrainian physics students who had escaped the war to come to CERN to do research.

The students continued their studies online at the Taras Shevchenko National University of Kyiv, while embedded in research projects at CERN. In autumn 2022, the University of Michigan secured funding through its Physics Department to support these students through the 2022-2023 school year, allowing them time to apply to universities outside of Ukraine to continue their undergraduate studies. The Ukrainian students joined the University of Michigan students in the autumn and completed a similar program, embedded in research projects and giving periodic presentations of their work, before leaving for U.S. and U.K. universities to complete their studies.

The success of this programme prompted the U.S. Permanent Mission in Geneva to provide funding in winter 2024 and winter 2025 to support three students each semester. This has been an invaluable contribution. It has allowed Ukrainian students a chance to escape war, to complete their studies, to gain valuable research experience, and to pursue future educational opportunities in safety, thus helping to prepare a new generation of leaders for the rebuilding of their homeland.

4. Future Perspectives

The NSF-funded University of Michigan CERN REU programme has been a resounding success and has led the way as an example for U.S. undergraduate research opportunities at CERN. The expansion to semester programmes has been similarly successful, providing students

with the opportunity to be embedded in cutting-edge research, offering them a chance to expand their horizons with an international cultural experience, and even giving some the possibility to escape war while continuing education. What remains is securing long-term funding to establish a continual presence of U.S. undergraduate researchers at CERN. Future efforts will attempt to persuade potential funding providers of the value of this pursuit for the nation and the world.

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