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## International Collaboration in Physics Research: A Summer at CERN

—Herbie Smith (Editor: Jennifer Lee)

During the summer of 2014, after my junior year as a physics major at the University of New Hampshire, I took part in a nine-week Research Experience for Undergraduates sponsored by the University of Michigan and the National Science Foundation. During the program, I lived and worked at the European Organization for Nuclear Research (CERN) just outside of Geneva, Switzerland. CERN is home to the largest particle collider in the world, the Large Hadron Collider (LHC), and is the world's leading particle physics laboratory. As a summer student, I attended daily lectures on particle physics from leading experts in the field, carried out research under the supervision of a staff scientist, and networked with students and scientists from around the world. This experience has informed both my professional goals and my view of myself as a student in a global community. I was amazed by the collaboration between individuals who were from diverse countries and cultures and spoke different languages, but were able to set aside their differences to pursue a common goal.

### CERN: History and Vitality

While CERN has facilities in both Switzerland and France, its main campus, where I lived, is in Switzerland, adjacent to the Franco-Swiss border. The campus has many of the amenities of a small town, including a post office, a bank, restaurants, hostels, and plenty of office space. CERN rests in a valley and has a climate similar to that of New England.

That summer, CERN was celebrating its 60<sup>th</sup> anniversary. The organization was founded in 1954 by twelve original member states. The goal of the organization was and still is to restore European science to world-class status and to foster international cooperation in the wake of World War II through the pursuit of fundamental physics. By bringing together the resources of many European countries, CERN hoped to improve international relations and the quality of research being done throughout Europe (CERN History). Today, 21 member states support CERN. The United States is not a member state, but still participates as an observer state (Member States).

The scientists, engineers, support staff, and students at CERN are from all around the globe. Every year about 300 undergraduate and graduate students in computer science, engineering, and physics are chosen to participate in the summer student program, and dozens more come to work on projects with their research advisors. To facilitate cooperation, English and French are both used as official languages.



*The author in front of the ATLAS detector.*

All are united by the pursuit of fundamental research in physics. Despite a world of strained international relations, national differences and difficulties are set aside for the purpose of pushing back the frontiers of

knowledge. Because every member of the collaboration comes from a different background, each scientist brings a unique perspective on the work being done. This allows opposing viewpoints to challenge one another, which strengthens final results and adds a sense of vitality to the CERN research community difficult to find elsewhere.

### **International Collaboration: Students and Scientists**

The students and scientists collaborated in a number of ways, both officially and informally. There were numerous regular meetings of large groups with broad focuses and small groups working on particular projects. For example, my research advisor, Dr. Clement Helsen, attended weekly meetings with the very large data analysis group for the ATLAS particle detector. Another student and I were part of a small working group for the Future Circular Collider (FCC) study. Dr. Helsen met with us to define our projects. After that he and I worked independent of the group although we kept the others updated on our progress.



*The mural inside Building 40 is a full scale depiction of the ATLAS detector.*

A centrally located coffee shop and nearby restaurant made it easy for members of a working group to meet informally over coffee or lunch to discuss their research. Casual talk among the students often led to surprising insights in our work. For example, one friend who had experience with ROOT, a data analysis software package, was able to give me advice on how to carry out some details of my work much more efficiently.

Dr. Helsen is a French national and connected me with the scientists at CERN. Early in my stay, he organized a meeting with several theoretical physicists, where we decided I would focus on understanding the difference between the decays of two types of particles, the top quark and the bottom quark, as a subset of the FCC study and an extension of his work. The FCC is a five-year design study to understand the facilities and new physics needed to produce and understand particle collisions in a proposed future collider seven times as powerful as the LHC. Most of my work was done in a shared office with Dr. Helsen. As a result, we communicated frequently and worked very closely on my research and on presentations of my work to other summer students. He also spent a great deal of time teaching me about the particle physics I needed to know for my project.

detect that they are indeed separate particles. For my project, I used computer simulations to study the properties of the jets to find how to tell them apart and to determine the requirements for particle detectors that would be able to do so. Understanding the differences between the decay of top and bottom quarks tells physicists, in part, the minimum resolution of the detectors needed to be able to discriminate between the two particles' jets. If the top quark and bottom quark jets cannot be told apart by the detector, important physics could not be studied. Over the course of the summer, we found several

When these particles decay, they each create a cascade of decay products called a jet, which would look similar for these two particles in the FCC because the particles that compose them would be very close together, making it difficult to

methods of discriminating the two types of the particles' jets, but further work is needed to determine the detector resolution required for those methods.

## International Friends and Travels

While at CERN, I lived in an on-campus hostel, adjacent to Building 40 where many of the scientists working on ATLAS, including myself, worked. My single hostel room had a full size bed, a desk, a wardrobe, and a bathroom with a shower. For the sake of frugality, I usually bought and cooked my own food in the hostel kitchen. However, on nights when I chose not to cook, the rotating menu at Restaurant 1 usually had a very tasty substitute!

Of course, work was not my only activity while at CERN. I made many friends among the other summer students. The first group of students I met was the fourteen other American summer students, about two-thirds male and one-third female, who were part of the Research Experience for Undergraduates. We often had lunch or dinner together and traveled together during the weekends. In addition, I made friends from Ecuador, Germany, France, Austria, and other countries. The kitchens and Restaurant 1, where many of the students ate dinner, were common mingling places, and chats over dinner often led to group hikes, visits to Geneva, and other activities. One friend, Sebastian, took it upon himself to organize weekly Tuesday night dinners where all of the summer students were invited to contribute ingredients and partake in a huge, communal feast.

The summer grant provided by the University of Michigan and the NSF covered all of the American students' expenses while at CERN, as well as airfare to and from Switzerland and some additional funds to allow traveling around Switzerland and nearby countries. I visited several towns in Switzerland and spent a great deal of time in Geneva, and my wife and I visited Paris and Ascoli Piceno, Italy.

The time I spent at CERN was the most important formative experience of my years as an undergraduate. While there, I grew a tremendous amount as a scientist and as a person. Networking with scientists and students from around the world and being part of a diverse workplace community helped me understand the importance of an international experience to becoming a globally aware citizen and scientist.

*I am grateful to my advisor at CERN, Dr. Clement Helsens, for all of his help throughout my stay during summer 2014. None of my work could have been done without his guidance. I would also like to thank my research advisor at UNH, Dr. Per Berglund, without whom I would not have known about or been prepared to apply for the program. His support has been instrumental in my success throughout my undergraduate career. Finally, this wonderful program would not be possible without generous funding from the University of Michigan and the National Science Foundation and the hard work of the staff at CERN, who organize the summer student program each year.*

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## Author and Mentor Bios

Originally from Rocky Face, Georgia, **Herbie Smith** says he has adopted nearby Newmarket as his hometown since coming as a freshman to the University of New Hampshire. A senior and member of the University Honors Program, Herbie will graduate in May with a bachelor of science in physics with a minor in mathematics. Herbie has won a three-year graduate research fellowship from the National Science Foundation, which will allow him to pursue a doctorate in theoretical physics at the University of Texas at Austin. He plans then to use his knowledge and experience to inspire students and aspiring young physicists. When his research advisor, Professor Per Berglund, told him of *Inquiry*, Herbie decided to write a commentary to share his CERN experience with students at UNH and around the world. This summer experience, he said, “contributed to my growth as a physicist” and helped point him to topics for his graduate work.

Professor **Per Berglund** is a member of the Department of Physics at UNH. He has encouraged many undergraduate physics majors to apply for research experiences abroad.

Dr. **Clement Helsens** is a Research Fellow at CERN in particle physics. He supervised Herbie’s research project during the summer student program. Dr. Helsens said, “I was pleased to work with Herbie on this small project and hope he will have a successful career as a physicist.”

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