When I started studying at the Pennsylvania State University, I was curious about research and wanted to experience it as early as possible. I was invited to spend time observing various labs in the Department of Mechanical and Nuclear Engineering during my sophomore year. I found that I enjoyed the environment of a research lab, filled with knowledgeable individuals considering fundamental science questions. I settled in the Intense Laser Laboratory, where I worked on was Direct Laser Acceleration, an acceleration scheme that uses the electromagnetic field from an intense laser pulse to rapidly accelerate electrons over a short distance. The motivation of the project was to realize a compact, portable accelerator with potential applications to medicine and nuclear security.

During this time, I was responsible for a variety of tasks. I started by designing and constructing unconventional breadboard supports and an adapter to fit the experiment into a constrained space and reduce the number of cables in our vacuum chamber. I helped design and construct a laser compressor and shutter system capable of withstanding the laser intensity. I also programmed the user interface to position the gas jet used to generate a plasma waveguide and simulated the generation of bremsstrahlung from relativistic electrons using Geant4. While working on the Direct Laser Acceleration project, we were able to generate plasma filaments. It was exciting for me to observe the creation of this plasma, and the experience helped me realize my interest in pursuing an experimental degree where it is possible to generate and observe phenomena that has otherwise only existed as a hypothesis.

This past summer, I gained significant research experience in another field, participating in the University of Michigan REU at CERN. There, I spent nine weeks working with scientists of the CMS detector, working with jets. My task was to compare different quark jet reconstruction algorithms used to characterize a hadronic W boson. These jet characteristics were identified as functions of the transverse momentum of the parent W and amount of pileup in a given event. This project had the goal of identifying the algorithm that had the most stable characteristics and best invariant mass resolution, so that future searches with jets can be made with higher precision. The results of my study will be used in negotiations between the CMS and ATLAS experiments to determine a common cone size and grooming algorithm for future runs. My results showed that the current CMS default grooming algorithm, pruning, consistently produced the worst resolution of all the considered algorithms. Smaller cone sizes tend to produce better resolution, and considering smaller substructures when grooming leads to more stable jet characteristics. I had presented these results to multiple groups within CMS and was frequently met with surprise. However, recent studies using different phenomena have since confirmed my conclusions and helped me gain confidence in my work.

I enjoyed the environment at CERN, where I worked with researchers from a variety of countries, and everyone I met was excited by the big research questions being posed. This experience helped me to select my area of study in graduate school. I have decided to attend graduate school for experimental high-energy physics. Through my majors in Nuclear Engineering and Physics, I have been able to approach modern physics in different ways. Studying nuclear engineering teaches me how to apply modern physics, while studying physics allows me to understand these applications in terms of fundamental models. Between the two, I am particularly drawn to the physicists' approach of attempting to unify a wide range of phenomena using as few distinct theories as possible.

To this end, I have taken advantage of the opportunity to continue working under my

summer advisor, Philip Harris. One of the ultimate goals of my summer project is to apply knowledge of jet characteristics in future searches for dark matter. I recently started work to characterize the jets for events that include Z or $Z + W$ production. The missing energy from $Z \to \nu + \bar{\nu}$ will be the dominant background in the search for dark matter, with the signal being characterized by $H + W$ events. Hopefully, the Higgs will couple with dark matter, making the upcoming run of the LHC a particularly exciting time to be attending graduate school. I hope to be involved with this search.

I feel that I am well qualified to participate in high energy physics experiments. The comparisons I made over the summer had never been done before by CMS, making me one of the youngest people to have worked on fundamental research with jets. In addition, my curriculum in Nuclear Engineering gave me an unusual focus on the design and application of detectors. I have also gained experience in simulating particle transport through deterministic and stochastic means.

In addition to my research activities and studies, I have experience educating the public about science. Primarily, I have been involved in the outreach activities of the American Nuclear Society (ANS). Through ANS, boy scouts visit Penn State's research reactor, the Breazeale Reactor, to learn basic principles and applications of reactors and nuclear science, earning their Nuclear Science merit badge. Westinghouse also runs a program bringing high school students to the Breazeale Reactor. Through numerous outreach events, over 300 students visit each year. I enjoy volunteering for these events because the students find the subjects exciting, and they challenge me by asking difficult questions. I make an effort to explain advanced nuclear science topics using basic concepts by punctuating my explanations with questions about what they have already learned. It is rewarding when students approach me after a presentation to thank me. In addition to short-lived weekend activities, I have had experience with long-term teaching commitments through tutoring. Helping students gain deeper understanding of fundamental science is something I hope to continue doing in the future.

I have also had the opportunity to reach out to a larger audience through the media. Onward State, a student-run blog that is popular among Penn State students, conducted an interview of me about my summer at CERN. The title of the published piece was "Penn Stater Returns from CERN: 10 Questions with Dan Abercrombie." During the interview I tried to convey what it was like working at such a large facility.

Attending graduate school for experimental high-energy physics would enable me to build upon my intellectual and outreach experiences in college. I would like to learn about the most fundamental questions that are being asked by particle physicists and be involved with addressing the challenges of creating and observing the predicted effects. Many members of the public are also interested in learning about the physics that is studied at the LHC. After gaining experience there, I look forward to spending time teaching others. Through tutoring, study groups, and outreach, I found great joy helping people understand topics that they are curious about. I hope that attending graduate school will allow me to realize my ultimate goal of becoming a professor of physics.