

# Understanding and Maximizing Access to Particle Physics at the Undergraduate Level

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## **Introduction**

Undergraduate students are often not exposed to the field of particle physics until after they have matriculated into a graduate program. This is due, in large part, to the fact that undergraduate institutions do not normally include a course in particle physics as part of the required curriculum or as an elective (e.g., see [1]). Since no standard mechanism exists for introducing physics undergraduates to the field, we first propose a survey of undergraduate exposure to particle physics across university programs. With this knowledge, we could then expand upon an existing set of ideas for increasing students' exposure (e.g., through a section in a modern physics course, a freshman seminar, other seminars, electives, etc.) and career preparedness.

## **Access to particle physics careers**

The purpose of the proposed survey and of the ideas we discuss below is to increase access to particle physics at younger ages. Large barriers to entry could exist for the field if students are not empowered to explore it through some portion of their undergraduate education. For example, summarizing the field to students as something only introduced with rigorous mathematics during a Ph.D. program introduces a bias. Students arrive in undergraduate programs with varying levels of math preparedness, resulting in those having been offered calculus and linear algebra in high school feeling less intimidated by their current (and therefore future) physics courses. Another example is that underrepresented identities (e.g., see [2]) in the field can be disproportionately discouraged from pursuing a career in particle physics, and therefore the ways in which the field is presented matter. These are only a couple examples. Indeed, with a broad understanding of the current state of undergraduate particle physics exposure and the avenues to increase exposure and career preparedness, particle physicists will make concrete steps toward becoming a more accessible community.

## **Undergraduate particle physics exposure**

As it is understandable that restructuring a program of study or indeed to force a student to take another course is not ideal for exposing them to this material, we therefore propose some alternatives which can lead to a longer and deeper appreciation of this field. One such option would be to include a small introduction to particle physics at the end of a typical semester or quarter course in modern physics. This class tends to include topics in quantum theory and relativity. Since both of these topics make up the essential prerequisites for understanding particle physics at an introductory level, it would be an easy place for first exposure to that field.

However, there are other ways outside of coursework that students can become exposed to the field of particle physics. One such avenue would be to include a seminar whether it be

lecture-based or laboratory-based, to introduce key research frontiers in this discipline. This concept has already been introduced with great success to Loyola University in Chicago's physics program [3]. Although it is called "Freshman Project," its objective is the same. Namely freshmen physics majors have a chance during one semester to work alongside a faculty member in an area of physics research. While their physics faculty span multiple disciplines besides particle physics, we could use this as an example to concentrate on an area of physics virtually unknown by many undergraduates.

### **Transitioning to a particle physics career**

Beyond the need for exposure to particle physics concepts, undergraduates would benefit from a better understanding of the various career paths of physicists, and in particular particle physicists, before committing to several years of graduate school. Moreover, once in graduate school, rarely do students have time to explore different subfields and their associated career prospects before joining a research group, especially given that this early stage is often occupied with courses and TA requirements. To address this, we propose that the particle physics community provide more formal support for communicating career paths to undergraduates. The avenues for this overlap somewhat with those above, including public online career panels, career sessions at APS meetings, and increased opportunities for undergraduate research, either at the undergraduate institution or as a workshop or summer program such as an REU. We emphasize that undergraduate lab work is a poor model for experimental particle physics research, in that it is rarely structured for open-ended discovery and non-linear problem solving. Opportunities for more realistic lab work can help undergraduates better understand what to expect during their graduate training and thereby increase recruitment and enthusiasm for particle physics.

One such suggestion that would help to prepare undergraduates for a career in the particle physics field would be to set the time for the aforementioned workshops to be held over the summer or winter breaks. As undergraduate studies require packed semesters or quarters of study, this is an ideal time to promote opportunities to engage with scientists, meet other undergraduates exploring the field, and to be given some hands-on research experience. With this in mind, the workshops would give undergraduates a crash-course, over a long weekend or even several weeks, on an introduction to this field and could include short projects related to current research. Although similar to an internship or REU in many respects, it has the added bonus of being easily accessible and open to all. If these are held in person, then students would register for the workshop and the school could sponsor the fees if any undergraduate is unable to pay. They could also be held online, and therefore be accessible to students free of charge, and it would allow aspiring physicists to connect and network from around the world. In either case, having particle physics workshops geared towards undergraduates is an excellent way to promote inclusion and diversity at such an early stage in a student's career.

## References

[1] “What Courses do Physics Majors Take?,” My Majors. <https://www.mymajors.com/college-majors/physics/>

[2] “Physics Degrees by Race/Ethnicity,” APS.  
<https://www.aps.org/programs/education/statistics/degreesbyrace.cfm>

[3] “Freshman Project,” Loyola University Chicago. [https://www.luc.edu/physics/freshman\\_project.shtml](https://www.luc.edu/physics/freshman_project.shtml)