Reference measurements at CERN for indirect dark matter searches

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Dark matter is a highly elusive and mysterious form of matter. Although it does not interact electromagnetically nor emits light, the universe would look very different without it. Recent measurements confirm that dark matter is roughly five times as numerous in the universe as visible matter. Exploring the properties of dark matter is important for the understanding of the origin and a potential end of the universe, and thus investigating dark matter is among the most important questions in physics.

Albeit little is known about dark matter, theoretical predictions for its nature are being discussed. Many theories predict a stable heavy particle – the weakly interacting massive particle (WIMP), which is capable of annihilating with other WIMPs into Standard Model particles. In other models, WIMPs can decay into Standard Model particles on very long time scales. In these processes, particles and antiparticles would be produced. Investigating antiparticles is especially interesting because they do not have sizable astrophysical sources. Among the produced antiparticles would be antiprotons and antideuterons (nuclei consisting of an antiproton and an antineutron). Many theoretical models predict the antiparticle flux to be high enough to be detected experimentally. However, there are also secondary sources of antiparticles in the Galaxy (different than from interactions of dark matter), e.g. spallation of cosmic rays on the interstellar matter. Therefore, in order to detect dark matter signals in the total particle flux it is necessary to precisely determine the contribution coming from sources other than dark matter interactions. The current flagship experiment in the field is AMS-02, which is a particle spectrometer based on the International Space Station.

For a more powerful dark matter interpretation, uncertainties connected with antiproton and antideuteron formation should be reduced. In order to reduce uncertainties connected with the measurements of the cosmic-ray antiparticles, well-tuned hadronic events generators are necessary. Hadronic generators like EPOS-LHC have to be optimized with antiproton, deuteron and antideuteron cross section measurements. To this end, data from heavy ion experiments is used. Such data can be provided by the NA61/SHINE experiment at CERN.

The goal of this proposal is to perform systematic data analyses on proton-carbon collisions to further the understanding of antiproton, deuteron and antideuteron production. This is planned to be performed in close collaboration with Philip von Doetinchem's cosmic-ray group at the University of Hawaii at Manoa. Measurements of proton-carbon collisions are of high importance for the AMS-02 experiment, which analyzes cosmic rays at the International Space Station.

The importance of the proposed project is stressed by the final report on *Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context*, which states that "... there is a robust and well-defined target in all indirect detection experiments: the value of the cross section that leads to the observed dark matter abundance.". The project is an opportunity to start dark matter searches in Poland. There is no similar activity currently ongoing in Poland. Because of its mysterious nature, shedding light on dark matter has great potential to attract public interest.