Production of antihelium in pp collisions at the LHC

The research fellow is expected to contribute to the measurement of the production of antihelium-3 in pp collisions at LHC energies using Run 3 data and the ALICE experiment. The objective of the project is to measure the production rate, the matter-to-antimatter ratio, and the yield ratio relative to that of antiprotons and other light antinuclei. Thanks to the availability of large data samples collected by ALICE from 2022 to 2024, these measurements could be complemented by a study of the multiplicity and rapidity dependence of antihelium production, for which scarce and no measurement are available, respectively. The fellow is expected to carry out data analysis using the ALICE O2Physics framework and distributed computing. Due to the key role of particle identification based on the Time-of-Flight (TOF) detector information for the observables of interest, a significant involvement in online (data taking) and offline (data quality control, calibration) activities for ALICE-TOF and the data preparation is foreseen. By the end of this project, we expect the analysis results to be released in a public note or the publication process to have started in coordination with the ALICE Collaboration working groups.
In addition, the research fellow is expected to contribute to the study of cluster formation mechanisms via detailed comparison of the obtained results with state-of-the-art models of coalescence and statistical hadronization. Further insights on the formation mechanisms will be obtained by comparing simulations obtained with a dedicated coalescence afterburner developed withing the project to be run in cascade to the QCD-inspired PYTHIA event generator. Additional developments of the software may be necessary to include a realistic description of antihelium production, to which the fellow will contribute.

The research programme is framed in the H2020-ERC-STG CosmicAntiNuclei project, finalized to the study of nucleosynthesis mechanisms in hadronic collisions, with applications for cosmic ray physics and indirect dark matter searches in space. The research fellow will join the ALICE-TOF group at DIFA-INFN, and the team involved in the CosmicAntiNuclei project.

In summary, the activities include:
- participation to online activities of the ALICE-TOF detector at CERN
- detector calibration and quality control activities, evaluation of detector performance
- data analysis
- software development (C++/Python, ALICE O2Physics framework)
- modelling of production of antinuclei (coalescence, statistical hadronization)
- application of the results obtained within the context of the CosmicAntiNuclei project.

Activity plan
The fellow, expected to have experience with the ALICE O2Physics software framework, is foreseen to analyze the existing 2022 and 2023 data sample, and possibly, validate the 2024 dataset for analysis. Using the analysis software developed within our group for the measurement of antihelium-3 in inelastic pp collisions at $\sqrt{s}$ = 13.6 TeV, the fellow is expected to extend that analysis to investigate the multiplicity and/or rapidity dependence. The software will be further developed if necessary. We expect the analysis to be the focus of the first nine months of the project, whereas the remaining time should be devoted to preparing for the public release of the results. As part of the study, the fellow will compare the new results with predictions from the most commonly employed models of coalescence and statistical hadronisation. The predictions will be extracted working on modelling in parallel to the data analysis and will be released at the same time as data.
During the duration of the project, the fellow will participate to the ALICE-TOF detector-related activities, including data taking shifts at CERN, as well as to collaboration meetings. The fellow will participate to international workshops and conferences and contribute to the publications by the CosmicAntiNuclei team and the ALICE Collaboration.