

Source-size dependent production of light nuclear clusters in high-energy collisions

The research activity is framed in the context of the H2020-ERC-STG CosmicAntiNuclei project, aiming at constraining production mechanisms of light antinuclei in high-energy collisions with measurements at the LHC, 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.

Results from the ALICE experiment at the Large Hadron Collider based on Run 2 data provide evidence that the production of light bound systems as deuterons and helium nuclei, depends smoothly on the final-state charged particle multiplicity from pp, where the particle emitting source characteristic radius is about 1 fm, to Pb-Pb collisions, where the source is collectively expanding and its radius is as large as a few femtometers. The proposed research aims at understanding the source-size dependence of the production of light (anti)nuclei with $A=3$ in high-energy collisions at the LHC. This will be achieved by combining simultaneous measurements of nucleus yields and nucleon-emitting source via state-of-the-art techniques. The researcher is expected to carry out the analysis of large data samples of pp and/or Pb-Pb collisions collected with the ALICE detector during the LHC Run 3, contributing to the optimization of tracking as well as particle identification for light antinuclei. Participation in the operations, calibration and data quality monitoring of the ALICE Time-Of-Flight are foreseen, as functional to the data analysis. The obtained results will be combined with existing measurements and compared to model predictions to provide input for the calculation of expected cosmic antinuclei flux in AMS and GAPS, possibly during the project of the fellow.

In summary, the activities include:

- participation to data taking with the ALICE detector at CERN
- detector calibration and quality control activities, evaluation of detector performance
- data analysis for physics measurements
- software development (C++/Python, ALICE O2Physics framework)
- application of the results obtained to modelling of nuclei formation

Activity plan

The research fellow will join the ALICE-TOF group at DIFA-INFN, and the team involved in the CosmicAntiNuclei project.

During the first semester of the project, the fellow will validate the ALICE 2024 data for physics analysis, contribute to the calibration of TOF and develop the analysis software within the official framework of the ALICE Collaboration.

The analysis will be conducted on the existing Run 3 data sample and will be the focus of the second and third semester of the project. During this time, the fellow will report to the relevant ALICE Physics Working Groups regularly. The last semester of the project will be devoted to the finalization of the data analysis and preparation of the publication, including a participation in the modelling activities ongoing within the research team.

During the entire duration of the project, the fellow is expected to participate to the ALICE-TOF detector-related activities, including data taking shifts at CERN, as well as to collaboration meeting that also might take place at CERN or at the partner institutes in the ERC project. The fellow will participate to international workshops and conferences and contribute to the publications by the CosmicAntiNuclei team and the ALICE Collaboration.