anti- and hyper- nuclei production

at the LHC with ALICE

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Nuclear matter production

• At the high energies reached in proton-proton (pp), proton-lead (p-Pb) and lead-lead (Pb-Pb) collisions at the LHC a significant production of (anti-)nuclei is observed.

• Two different theoretical models are available to describe the production mechanism of (anti-)hyper-)nuclei:

  Statistical-thermal model

  • The yield of the hadronic species dN/dy is fixed at the chemical freeze-out and depends on the temperature TFO of this collision phase and on the species mass.

  • Since the mass of the nuclei is high, small variations in TFO drastically changes the yield of nuclei.

  Coalescence model

  • The baryons that are close in phase space at the kinetic freeze out can coalesce to form (anti-)nuclei.

  • The probability of producing a nucleus by coalescence can be expressed through the coalescence parameter Bα [3,4].

Nuclei pT spectra

• The transverse momentum (pT) spectra have been measured for (anti-)deuterons and (anti-)He.

• The pT spectra are fitted using different functions to extract the pT integrated yield dN/dy in the unmeasured pT region. In particular:

  • In Pb-Pb and in p-Pb, pT spectra are fitted with a Blast-Wave function [3].

  • Spectra become harder with increasing centrality/multiplicity, due to the radial flow [3].

  • In pp, pT spectra are fitted with a Levy-Tsallis [3].

The ALICE detector

• Inner Tracking System

  • σDCA < 100 μm for pT > 0.5 GeV/c in Pb-Pb

  • Separate primary and secondary vertices

• Time Projection Chamber

  • PID through the specific energy loss dE/dx measurement.

  • o ~ 7% for central Pb-Pb collisions

  • Nuclei identification at low pT

• Time Of Flight

  • PID through the time of flight measurement

  • ~ 85% for central Pb-Pb collisions

  • Deuterons identification up to pT = 5 GeV/c

Experimental data vs models

• The anti-matter/matter ratio is compatible with the unity, independently from the pT and the centrality/multiplicity.

• The yields are compatible with the predictions of the statistical-thermal model, in a range that spans several orders of magnitude.

• The coalescence parameter Bα is pT dependent.

• Explained by space-momentum correlations caused by radial flow in Pb-Pb.

• The dN/dpT vs multiplicity shows an increase in particle multiplicity from pp to Pb-Pb, in agreement with the coalescence picture

The hypertriton lifetime

• The production of (anti-)hypertritons is studied via its two-body weak decay:

  \[ ^3\rm{H} \rightarrow ^3\rm{He} + \pi^- \]

• He and \pi are identified by the TPC, then topological selections are applied

  • DCA between the two prongs

  • DCA to Primary Vertex

  • cos of the pointing angle

• Data are divided in several nbins and the yields are extracted.

• The lifetime is obtained through an exponential fit.

The expected value of the hypertriton lifetime should be close to the lifetime of the free hyperon \[ \Lambda(\bar{\Lambda}) \]

• Some of the previous measurements are shorter than the expected value.

• The latest measurement of the hypertriton lifetime obtained by ALICE is compatible within 1σ with both the world average and the free \( \Lambda \) lifetime.

Bibliography