Measurement of the anti-nucleus $^{4}\text{He}$ with the ALICE apparatus at the LHC

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Heavy-ion collisions at the LHC give the opportunity to measure all known particles in higher abundances than it was possible before, like for example light (anti-)nuclei. These heavy particles are rarely produced, because the production probability decreases with increasing mass. But the energy regime reached at the LHC leads to large production probabilities even for these particles, as described for example by thermal models [1, 2]. So far, data of Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV were taken in the years 2010 and 2011.

Furthermore, the unique particle identification capabilities of the ALICE detector [3] allow for the measurement of rarely produced states created in Pb–Pb collisions. In fact, ALICE has already observed four anti-alpha candidates [4] in the data set of 2010, whereas the first anti-alphas were detected by the STAR Collaboration at RHIC in Au–Au collisions [5].

Anti-matter studies have the advantage that the antiparticles suffer only from annihilation when detector material is crossed, whereas on the matter side a substantial background is created via knockout from the material.

The excellent performance of the Time-Projection Chamber (TPC) [6] and the Time-Of-Flight detector (TOF) [3] allows for the clear identification of all stable particles over a wide range in rigidity $R = p/z$, where $p$ is the track momentum and $z$ is the charge number. Here results for 38 million Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, recorded in the heavy-ion run of November 2011 are presented, where a trigger mix of minimum bias, semi-central and central events was applied. Furthermore an offline trigger selecting all $^{4}\text{He}$-nuclei or heavier candidates using the TPC $dE/dx$ measurement is used. For a clear identification of the $^{4}\text{He}$ the velocity $\beta$ measurement of the TOF detector is required in addition, as shown in figure 1.

The resulting measured production yield $dN/dy$ for $^{4}\text{He}$ is plotted in figure 2. In addition the production yields $dN/dy$ for protons, deuterons and $^{3}\text{He}$ are shown. An exponential fit is performed (blue line). This leads to a penalty factor of $\sim 330$ for each additional nucleon, which means for example that $^{4}\text{He}$ a factor 330 less produced than $^{3}\text{He}$.

References