Observation of the anti-nucleus $\overline{^4\mathrm{He}}$ 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 as 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 $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$ per nucleon–nucleon pair was taken in the years 2010 and 2011.

Further, the unique particle identification capabilities of the ALICE detector [3] allow for the measurement of rarely produced states created in Pb–Pb collisions. Anti-matter studies have the advantage that the anti-particles suffer only from annihilation when detector material is crossed, whereas on the matter side a substantial background is created via knockout reactions within the detector material.

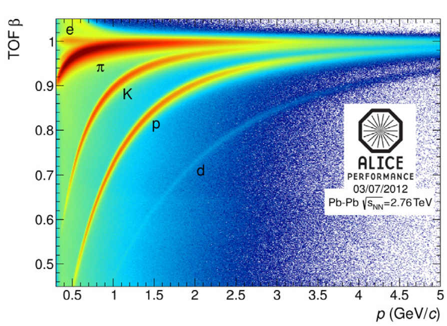

Figure 1: TOF β versus p, a clear seperation of hadrons is visible.

The excellent performance of the Time-Projection Chamber (TPC) [4] 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. In figure 1 the TOF performance is shown exemplarily. Here β measured with the TOF detector is plotted as function of p. Combining the specific energy loss (dE/dx) in the TPC and the TOF information, we identified 10 anti-alpha nuclei. Here we present results for 23 million Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$ per nucleon–nucleon pair, recorded in the heavy-ion run of November 2011 where a trigger mix of minimum bias, semi-central and central events was applied.

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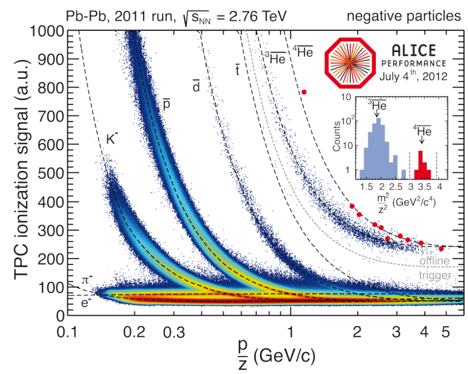

Figure 2: TPC dE/dx spectrum, the inlet shows the m^2/z^2 distribution. The 10 anti-alphas clearly identified by TPC and TOF are indicated with larger markers.

We further apply an offline trigger selecting all $^3\overline{\mathrm{He}}$-nuclei or heavier candidates. Figure 2 shows the dE/dx versus rigidity distribution for candidates after the offline selection for negative particles in the region where the bands of $^3\overline{\mathrm{He}}$ and $^4\overline{\mathrm{He}}$ are clearly visible. Below a rigidity of $p/z \approx 2\,\mathrm{GeV}/c$ three candidates are clearly identified based on the dE/dx information only. At higher p/z the energy-loss information of the candidates is combined with mass determination performed with the TOF detector following $m^2/z^2 = R^2/(\gamma^2-1)$. The inlet in Fig. 2 shows the m^2/z^2 distribution for all tracks within a 2σ-band around the expected dE/dx for $^4\overline{\mathrm{He}}$. The 10 identified anti-alphas are highlighted in both the m^2/z^2 and the dE/dx versus rigidity plot. A similar analysis had been performed for the 2010 data, which led to four anti-alpha candidates [5]. The first anti-alphas were detected by the STAR collaboration at RHIC in Au–Au collisions [6]. The work on the extraction of the corrected particle yield is currently ongoing.

References

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