Measurement of $\frac{\Lambda_c^-}{\Lambda_c^+}$ ratio in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV with the STAR experiment

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Abstract

The yield ratios of strange anti-baryons to baryons have been measured in heavy-ion collisions and exhibit a trend that is getting closer to unity with increasing number of valence strange quarks. This ratio has, however, never been measured for charm baryons, and it is important to establish if they exhibit a similar amount of baryon-to-anti-baryon enhancement as strange baryons. $\Lambda_c$ is the lightest baryon containing a charm quark and, as such, presents a unique probe to study the hadronization of charm quarks in the hot and dense QCD medium created in ultra-relativistic heavy-ion collisions. $\Lambda_c$ has, however, an extremely short lifetime ($\tau \sim 60 \mu$m) which makes the reconstruction experimentally challenging. The Heavy Flavor Tracker, installed at the STAR experiment between the years 2014 – 2016, has shown a high efficiency and an unparalleled track-pointing resolution that can facilitate the $\Lambda_c$ reconstruction in heavy-ion collisions. In this poster, we present the reconstruction of $\Lambda_c$ baryons via hadronic decays and the studies on the measurement of the yield ratio of $\frac{\Lambda_c^-}{\Lambda_c^+}$ utilizing the high-statistics data samples of Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV recorded with the STAR experiment in 2014 and 2016.

Motivation

- Ratios of strange anti-baryons to baryons grow towards unity with increasing number of strange valence quarks in the baryon.
- This ratio has never been measured for charm baryons and anti-baryons in heavy-ion collisions.
- $\frac{\Lambda_c^-}{\Lambda_c^+}$ can bring important insights into the hadronization of charm quarks.

Solenoidal Tracker at RHIC: 2π acceptance in azimuth

- Time of Flight Detector: $\delta E/\delta x$ (Particle Identification)
- Time-Projection Chamber (TPC): Tracking $dE/dx$ (PID)
- Heavy Flavor Tracker: SSD, IST, PXL

Figure 2: The STAR experiment and the main subdetectors used in the $\Lambda_c$ analysis.

Figure 1: Ratios of anti-baryons to baryons [1].

Figure 3: DCA resolution in the transverse plane of identified tracks with the HFT [2].

- Short life time of $\chi_c$ = 60 μm.
- Three-body decay channel $\Lambda_c \rightarrow \pi^+K^-\pi^+$ used.
- Topological reconstruction thanks to the excellent tracking resolution of the HFT.
- Cut on topological variables optimized via the Toolkit for Multi-Variate Analysis (TMVA – [3]) package, using the Boosted-Decision Trees method.

Data-driven fast simulation:

- The $\Lambda_c$ were decayed using the EvtGen simulator [4].
- HFT- and TOF—matching efficiencies were obtained from data.
- TPC efficiency was obtained from embedding of simulated tracks in real data.
- The positions of the daughter particles are smeared according to the DCA resolution extracted from data. 
- Moments are smeared according to detector simulation.

Outlook: Efficiencies will be applied separately for $\Lambda_c^-$ and $\Lambda_c^+$ to obtain the final $\frac{\Lambda_c^-}{\Lambda_c^+}$ ratio.

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References


The STAR Collaboration

Time-Projection Chamber (TPC):
Tracking $dE/dx$ (PID)

$\delta E/\delta x$ (Particle Identification)

Figure 5: $\Lambda_c$ invariant mass spectrum from 2014 and 2016 data. Red points are right-sign and blue points wrong-sign pK+ triplets.

Figure 6: Projection of the statistical uncertainty projection of the $\frac{\Lambda_c^-}{\Lambda_c^+}$ ratio using the high-statistics data samples of Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV recorded with the STAR experiment in 2014 and 2016.

Figure 7: Difference in the TOF-matching efficiency.

Figure 8: Difference in the TPC efficiency.

Figure 9: Difference in the HFT-matching efficiency.

Figure 10: Maximum daughter pair DCA from the data-driven fast simulation.

Figure 11: DCA between $\Lambda_c$ and the primary vertex from the data-driven fast simulation.

Charge dependent reconstruction efficiency

- There is an observable charge dependence of detector efficiencies.

Figure 4: Topological reconstruction of the $\Lambda_c$ secondary vertex.