Λ_c Production in Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV at the STAR experiment

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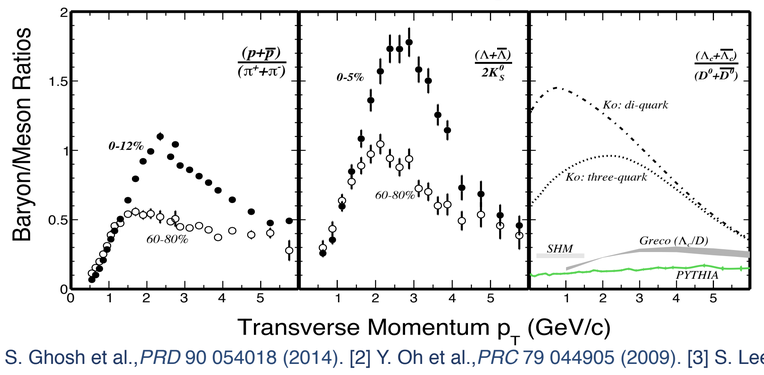
ABSTRACT: Charm quarks, predominantly produced in the early stage of heavy-ion collisions, are believed to provide unique information on the hot and dense medium created in such collisions. At RHIC, an enhancement in baryon-to-meson ratios for light hadrons and hadrons containing strange quarks has been observed in central heavy-ion collisions compared to p+p and peripheral heavy-ion collisions in the intermediate p_T range ($2 < p_T < 6$ GeV/c). This was explained by the hadronization mechanism involving multi-parton coalescence. Λ_c is the lightest charmed baryon with the mass close to D^0 meson, and has an extremely short life time ($c\tau \sim 60$ μm). Different models predict different levels of enhancement in the Λ_c/D^0 ratio depending on the degree of charm quark thermalization in the medium and how the coalescence mechanism is implemented.
In this poster, we will report the first measurement of Λ_c production in heavy-ion collisions using the recently installed Heavy Flavor Tracker at STAR. The Λ_c baryon is reconstructed through the hadronic decay channel ($\Lambda_c \rightarrow pK\pi$) using topological cuts optimized by the Toolkit for Multivariate Data Analysis (TMVA). The invariant yield of Λ_c for $3 < p_T < 6$ GeV/c is measured in 10-60% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The measured Λ_c/D^0 ratio will be compared with different model calculations, and the physics implications will be discussed.

Motivation

- Significant enhancement in baryon-to-meson ratio has been observed in central heavy-ion collisions compared to p+p and peripheral heavy-ion collisions in the intermediate transverse momentum (p_T) range for light hadron and hadrons containing strange quarks, suggesting hadronization through collective multi-parton coalescence.
- Charm baryon-to-meson ratio in heavy-ion collisions is sensitive to the charm quark hadronization mechanism, charm quark thermalization. Different models have quite different predictions for this enhancement and to charm quark thermalization.



[1] S. Ghosh et al.,*PRD* 90 054018 (2014). [2] Y. Oh et al.,*PRC* 79 044905 (2009). [3] S. Lee et al.,*PRL* 100 222301 (2008).

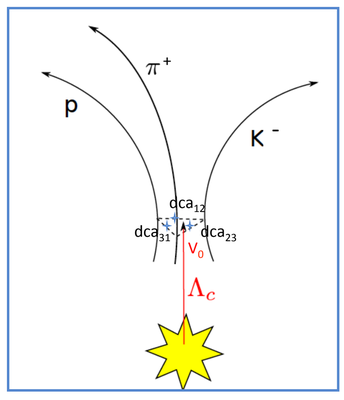
Λ_c Reconstruction

Λ_c^+ (udc), mass ~ 2286 MeV/c^2, $c\tau \sim 60$ μm
D^0 ($c\bar{u}$), mass ~ 1864 MeV/c^2, $c\tau \sim 123$ μm
D^+ ($c\bar{d}$), mass ~ 1869 MeV/c^2, $c\tau \sim 311$ μm

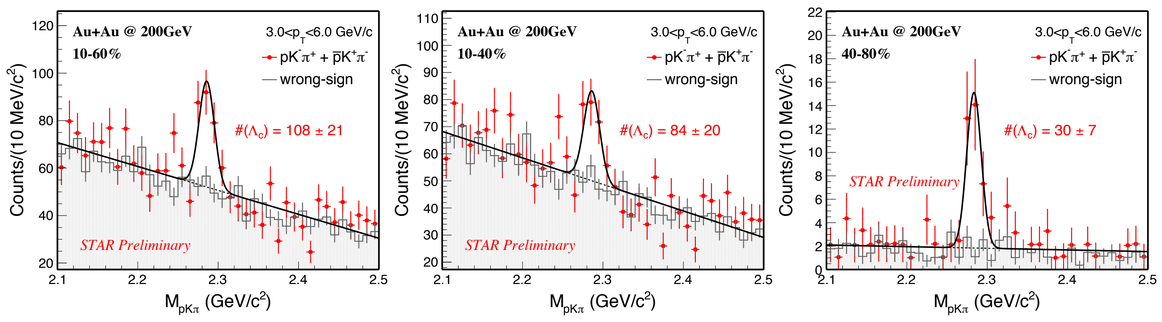
Direct topological reconstruction:
$\Lambda_c^+ \rightarrow p^+K^-\pi^+$ BR ~ 6.35%

- pK* 1.98% * 66.7% = 1.32%
- $\Delta^{++}K^-$ 1.09% * 100% = 1.09%
- $\Lambda(1520)\,\pi^+$ 2.2% * 22.5% = 0.495%
- Non-resonant 3.5%

[4] C. Patrignani et al. *Chin. Phys. C* 40 100001 (2016)

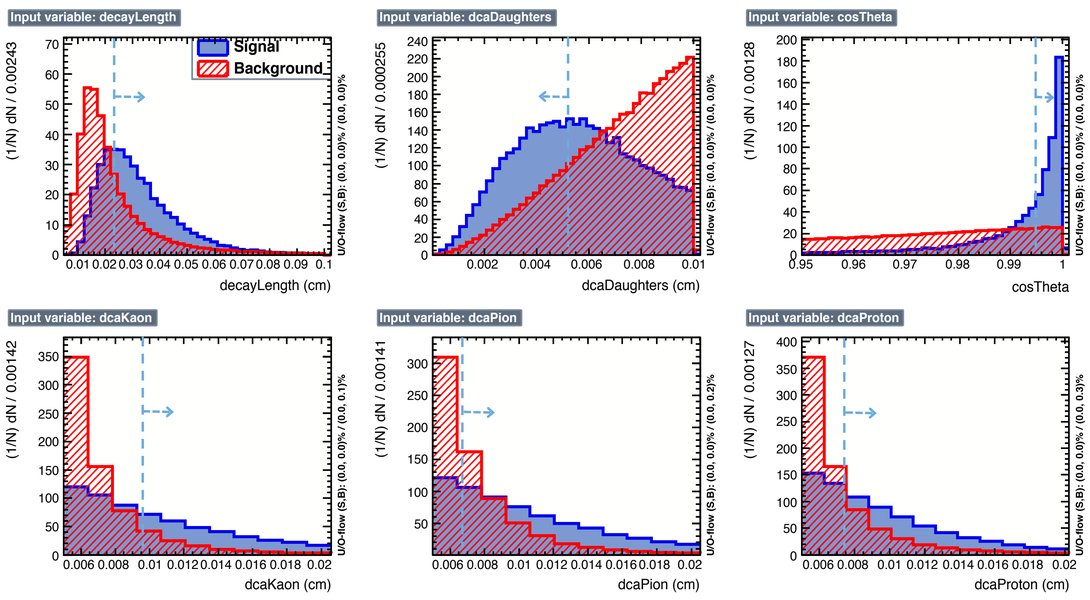


Λ_c signals from different centralities

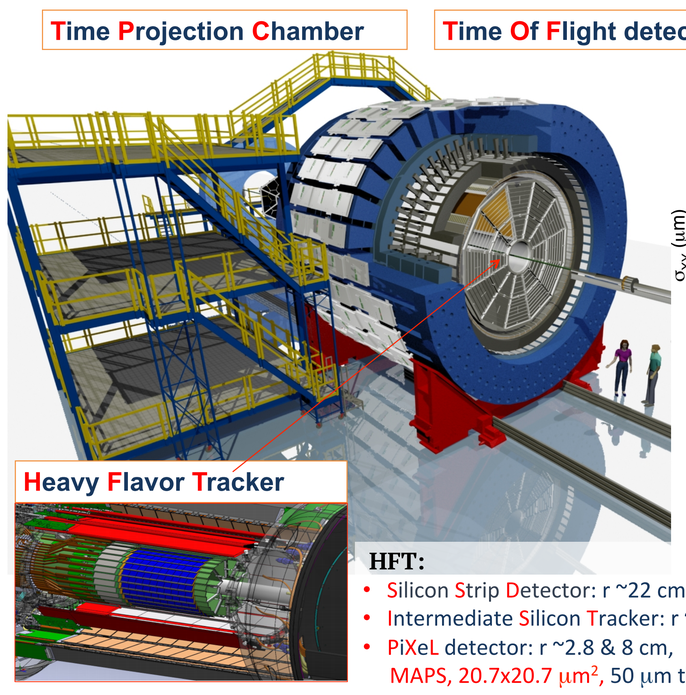


(Rectangular) Topological Cut Optimization using TMVA

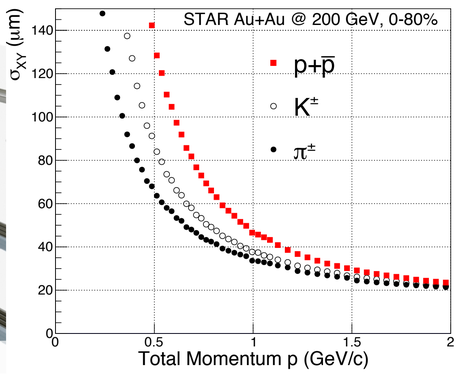
- Background was constructed from real data using wrong-sign method.
- Signal was simulated with data-driven fast simulation.
- The figures below show the comparison between signal and background for $p_T > 3$ GeV/c.



STAR and HFT Performance



Distance of Closest Approach resolution achieved in Run 2014 using Al cables.



HFT:

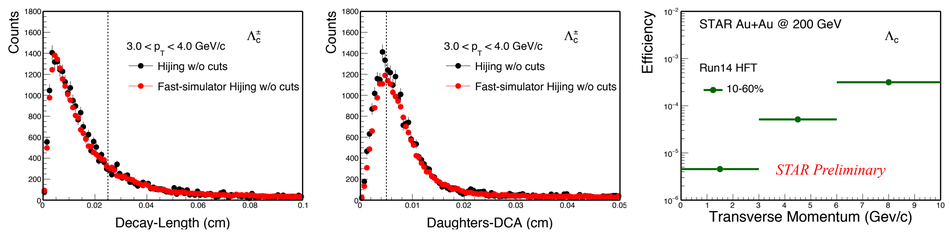
- Silicon Strip Detector: r ~22 cm.
- Intermediate Silicon Tracker: r ~14 cm.
- PiXeL detector: r ~2.8 & 8 cm,
  MAPS, 20.7x20.7 μm^2, 50 μm thick, air-cooled,~0.5%X_0 for the innermost layer.

Efficiency : Data-Driven Fast Simulation

Ingredients:

- Extract centrality-dependent vertex z distributions from data.
- Extract ratio of HFT matched tracks to TPC tracks from data.
- Extract DCA_{XY} - DCA_Z distributions from data.
- Extract TPC efficiency and momentum resolution from embedding.

Validated with full GEANT simulation !

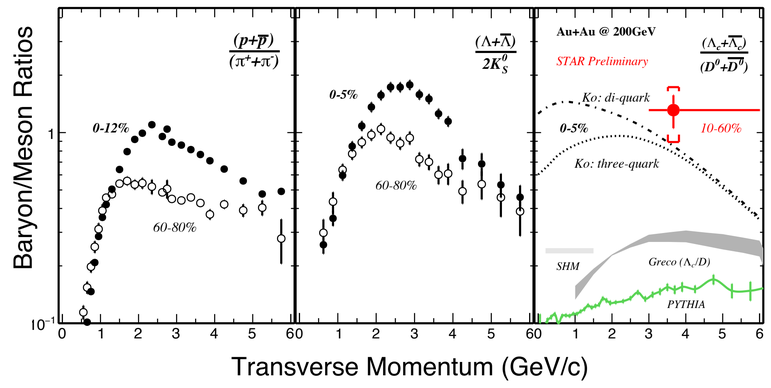


- Comparison of fast simulation and full GEANT simulation
- Λ_c reconstruction efficiency

Results

- The invariant yield of Λ_c for $3 < p_T < 6$ GeV/c is measured in 10-60% central Au+Au collisions.
- The ratio of Λ_c over D^0 ratio in 10-60% Au+Au collisions is significantly enhanced than PYTHIA prediction in proton-proton collisions.

$1.3 \pm 0.3(\text{stat.}) \pm 0.4(\text{sys.})$



Summary and Outlook

- First measurement of Λ_c in heavy-ion collisions by STAR.
- A significant enhancement in the ratio of Λ_c over D^0 has been observed in Au+Au collisions (10-60%) at $\sqrt{s_{NN}}$ = 200 GeV.
- **OUTLOOK**: In run 2016, STAR recorded 2 billion Au+Au events with all inner ladders replaced with Al cables and better operation with more active sensors. More precise measurements of Λ_c production, especially its R_{cp}, will be possible.

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The STAR Collaboration
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