Λ_c baryon production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

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Baryon-to-meson yield ratios (p/π, Λ/K^0_S) are observed to be significantly enhanced in central heavy-ion collisions than those in peripheral heavy-ion collisions and p+p collisions at RHIC and LHC. This effect can be explained by taking into account coalescence hadronization that recombine thermalized light and strange quarks in heavy-ion collisions as opposed to fragmentation hadronization in elementary nucleon-nucleon collisions. Several model calculations suggest that coalescence hadronization between charm quarks and light quarks will lead to an enhancement in the Λ_c/D^0 ratio. The possible Λ_c/D^0 enhancement in heavy-ion collisions will introduce additional suppression for charm decay electrons due to smaller semi-leptonic decay branching ratios of Λ_c, which could lead to a different interpretation of the heavy flavor decay electron results.

Λ_c baryons have an extremely small lifetime ($c\tau \sim 60\ \mu$m) and have not been measured in heavy-ion collisions yet. The newly installed STAR Heavy Flavor Tracker (HFT) has shown high efficiency and excellent pointing resolution that can facilitate Λ_c reconstruction in heavy-ion collisions. We report studies of reconstruction of Λ_c baryons via three body hadronic decays into p K and π, using year 2014 Au+Au data at $\sqrt{s_{NN}}$ = 200 GeV .

Λ_c baryon

- Ratios of baryons/mesons (such as p/π, Λ/K^0) in heavy-ion colliusions significantly enhanced compared to p+p collisions – due to quark coalescence.
- Similar enhancement expected in the ratio of Λ_c/D^0.
- This would bring insight into coalescence hadronization of charm quarks.
- The enhancement of Λ_c/D^0 is one of the signatures of the formation of the strongly coupled Quark-Gluon Plasma.

- Challenging to measure, $c\tau \sim 60\ \mu$m.
- Λ_c have never been observed in high energy heavy-ion collisions.

Λ_c branching ratios for three body decay:

- $\Lambda_c^+ \rightarrow p\ K^-\pi^+$ (5.0±1.3)%
  - $\Lambda_c^+ \rightarrow pK^*$ (1.6±0.5)%
  - $\Lambda_c^+ \rightarrow \Lambda(1520)\ \pi^+$ (1.8±0.6)%
  - $\Lambda_c^+ \rightarrow K^-\Delta^{++}$ (0.86±0.3)%
  - Nonresonant (2.6±0.8)%

[Particle Data Group, Chin. Phys. C38 (2014) 090001]

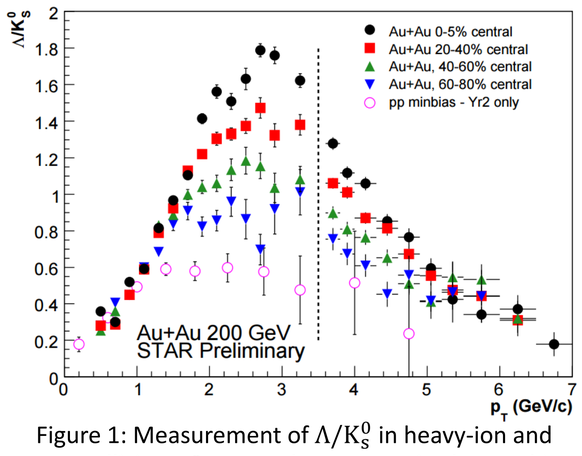

Figure 1: Measurement of Λ/K^0_S in heavy-ion and p+p collisions. Strong enhancement is observed in intermediate p_T [J.Phys.Conf.Ser. 50 (2006) 192].

Detector layout

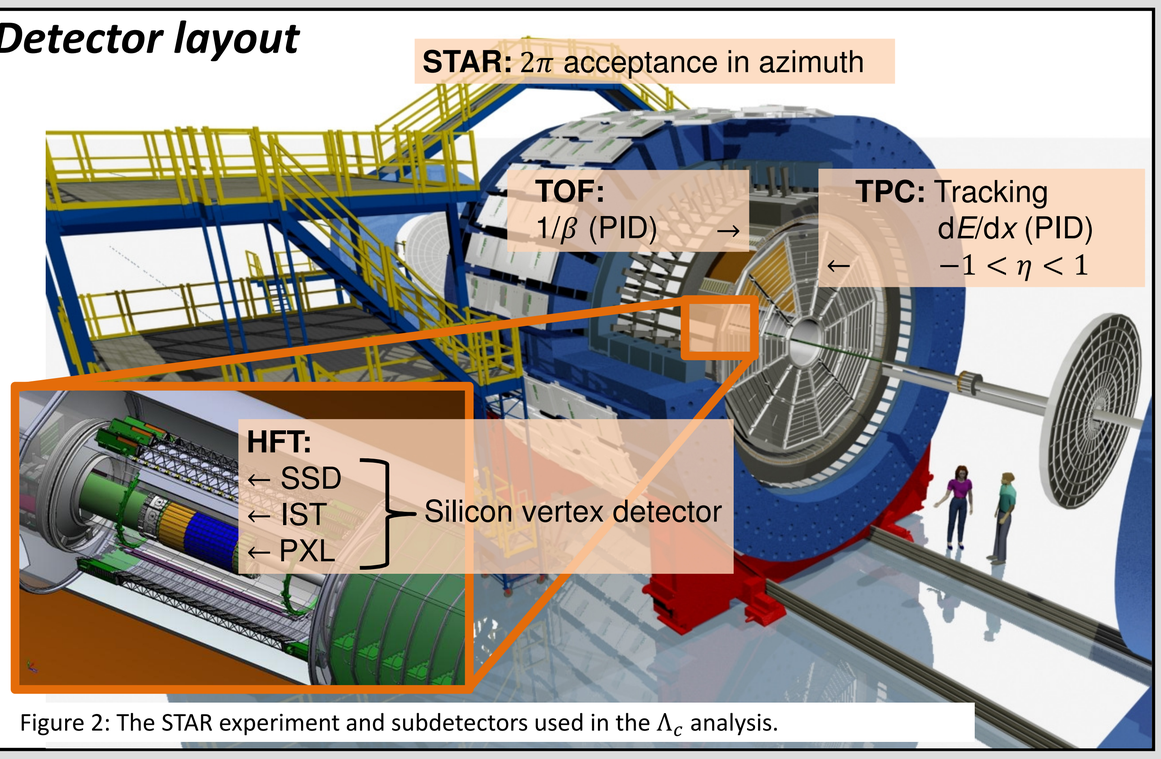

Figure 2: The STAR experiment and subdetectors used in the Λ_c analysis.

Kinematic and topological variables for Λ_c analysis

- **Decay length:** distance of secondary vertex to the primary vertex
- **θ:** angle between Λ_c momentum and position relative to primary vertex
- **Daughter pair DCA:** distance of closest approach (DCA) between the daughter pairs
- **Distance between vertices of daughter pairs**
- **Daughter p_T**

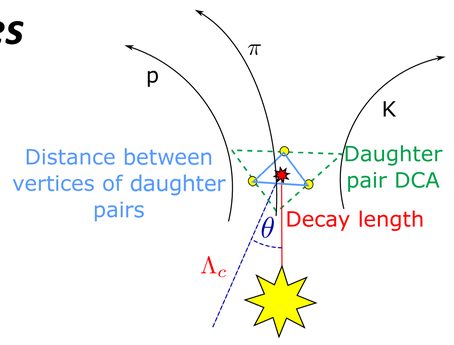

Figure 3: Variables used in topological cuts

Λ_c signal simulation

- Data driven Monte Carlo simulation was used:
  - Λ_c decayed in Pythia.
  - p_T and positions of the daughter particles were smeared, according to resolution observed in data.:
  - Λ_c were generated with flat rapidity distribution within $|y| < 1$.
  - The p_T distribution was obtained from the D^0 minimum bias spectrum from 0–80% centrality Au+Au collisions [Phys. Rev. Lett. **113** (2014) 142301].

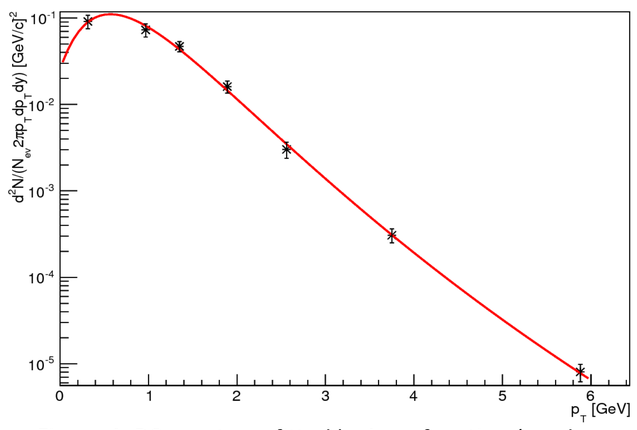

Figure 4: D0 spectrum fitted by Levy function (used as p_T distribution for Λ_c)

- Fragmentation ratio 0.275 between $\Lambda_c$and D^0 was taken from ZEUS data [Eur. Phys. J. C44 (2005) 351].
- Scaling of Λ_c production with the number of binary collisions was used.

Comparison: Simulation and Background from data

- p K π channel – triplets of Λ_c candidates.
- Simulated Λ_c compared to background from 200 GeV Au+Au data.
- Background was selected from p K π triplets with wrong sign combinations of the daughters.
- The same cuts were applied on background and Λ_c from simulation.

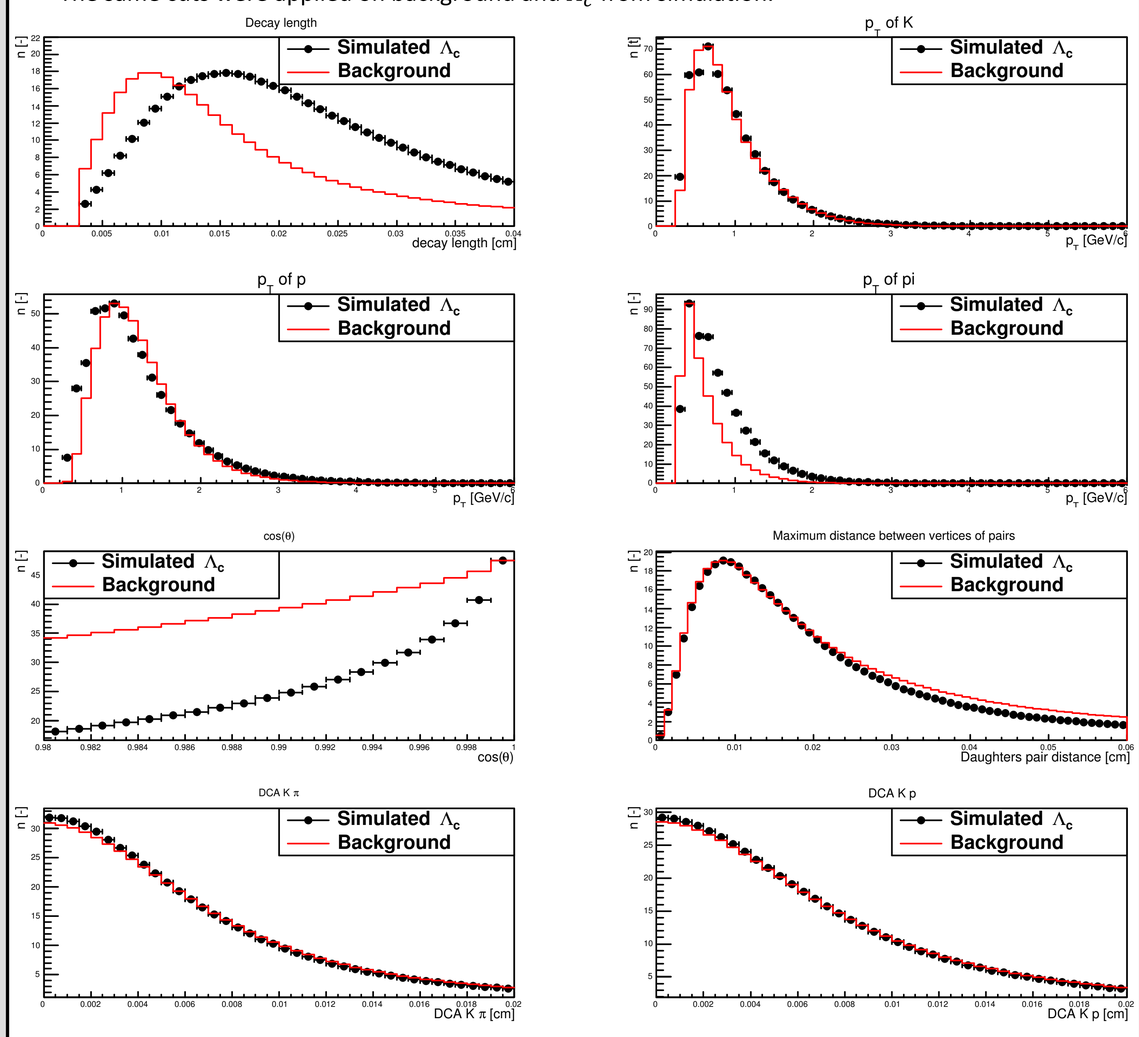

Figure 5: Distribution of variables: Decay length, daughters p_T, cos(θ), distance of pairs vertices, and daughters DCA for signal simulation and background from data. The background is scaled to show the difference in shape.

Run 2016 and future upgrades

- STAR has recorded 1.2 B minimum bias events in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in the year 2014 and plans to take 2 B more in 2016.
- The inner HFT pixel layer will have reduced material budget thanks to changed cable material of the sensors from copper to aluminum.
- The HFT will have higher efficiency because of replacing non-working sensors.
- This increases the pointing and p_T resolution of STAR and increases the efficiency of tracking with HFT.

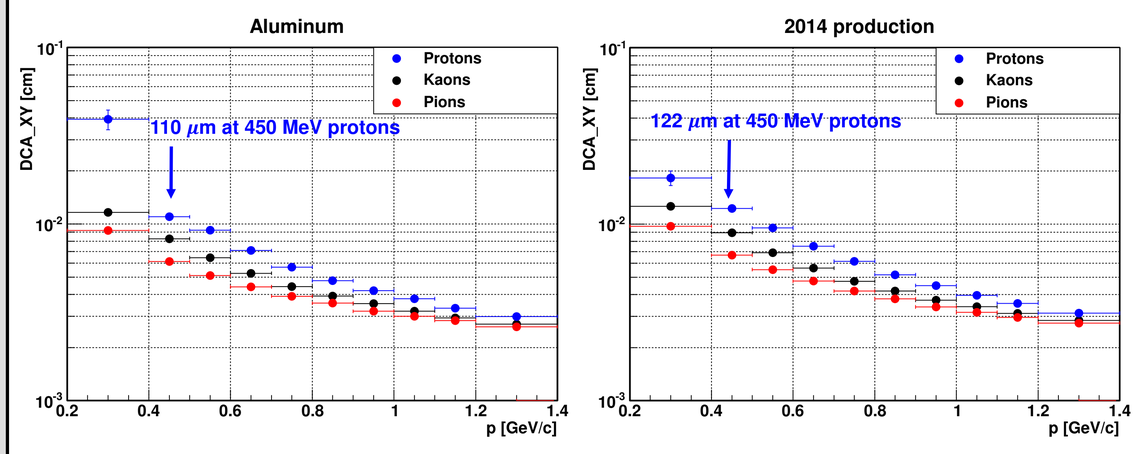

Figure 6: Comparison of the DCA resolution in XY plane with aluminum (left) and copper cables (right).

Conclusion and outlook

- Λ_c measurements are ongoing with the new Heavy Flavor Tracker at STAR.
- Λ_c reconstruction efficiency will increase in run 2016 thanks to reduced mass of the HFT infrastructure and reduced number of dead sensors.
- With the statistics of the future runs, STAR could measure Λ_c baryons for the first time thanks to excellent pointing resolution of the HFT.

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The STAR Collaboration: http://drupal.star.bnl.gov/STAR/presentations