



JOINT MARCH MEETING AND APRIL MEETING
Global Physics Summit

March 16–21, 2025, Anaheim, CA and virtual



Probing Baryon Transport Dynamics and Strangeness Production with Hyperon-kaon Correlations

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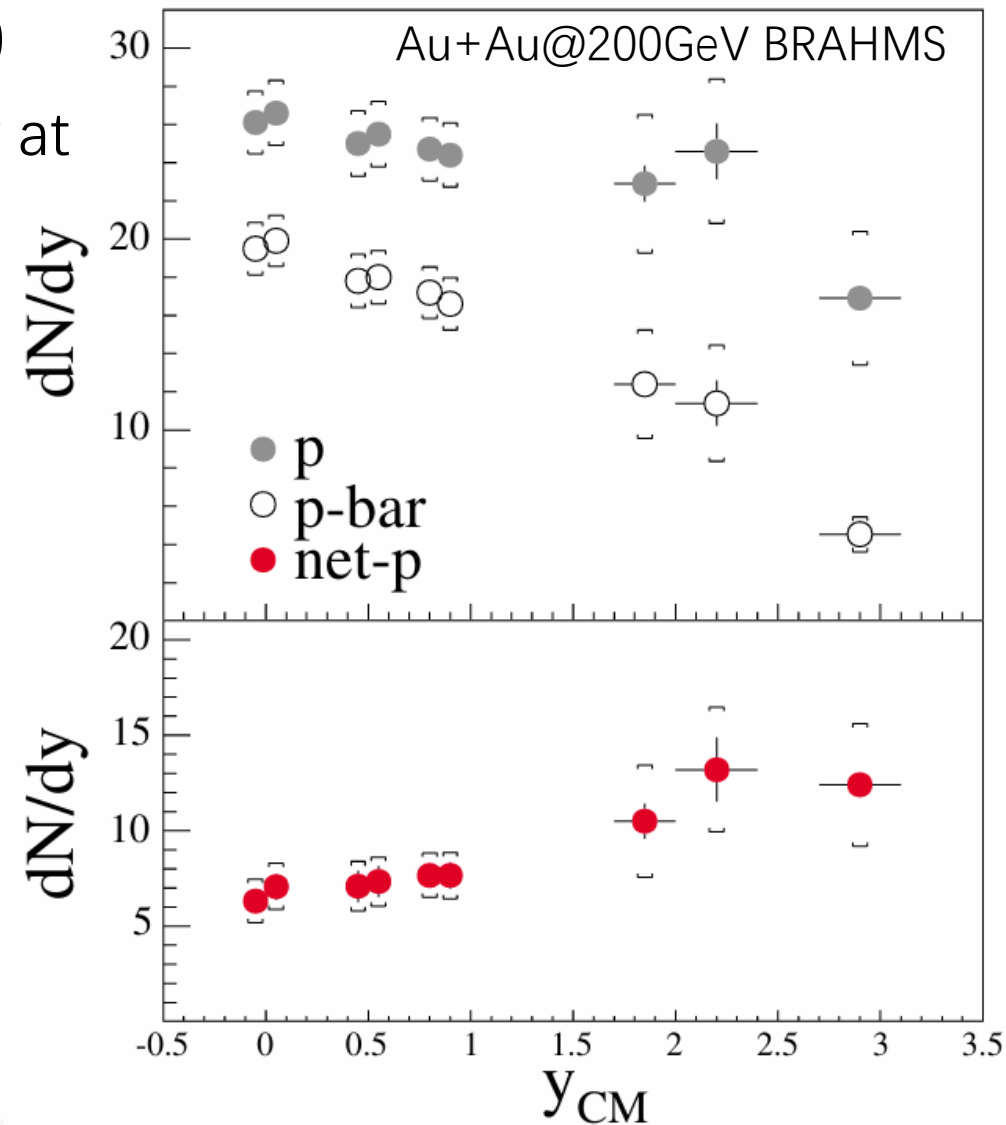
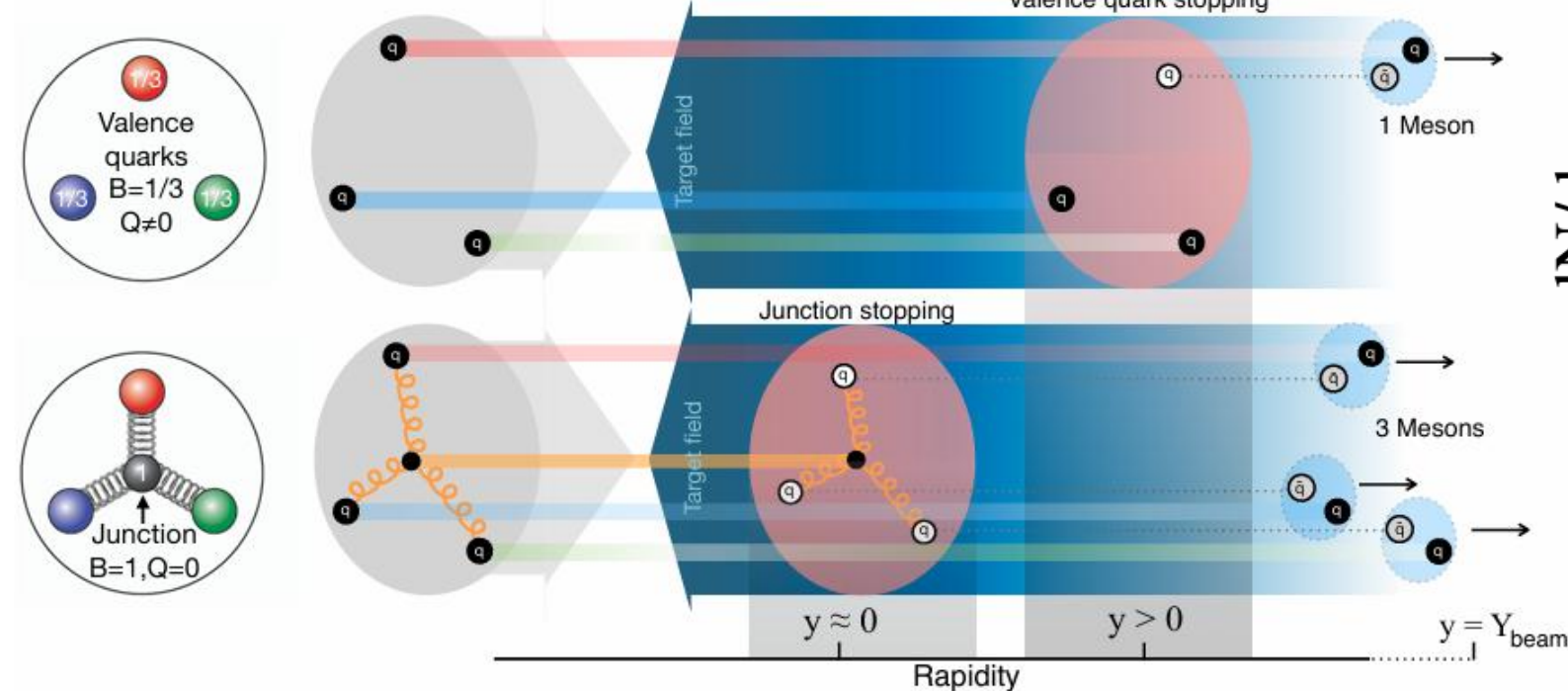
Outline

1. Baryon Number Transport
2. Hyperon-Kaon Correlation
3. p(d) + Au Collision
4. Hyperon reconstruction in STAR data
5. AMPT Result
6. Summary and Outlook

Baryon Number Transport

- Baryon number transport from $|y_{Beam}|$ to $y \sim 0$
 - Significant $N_{Baryon} > N_{anti-Baryon}$ at mid-rapidity at RHIC energies.
- Stopping scheme
 - Valence quark picture
 - Gluon-junction model

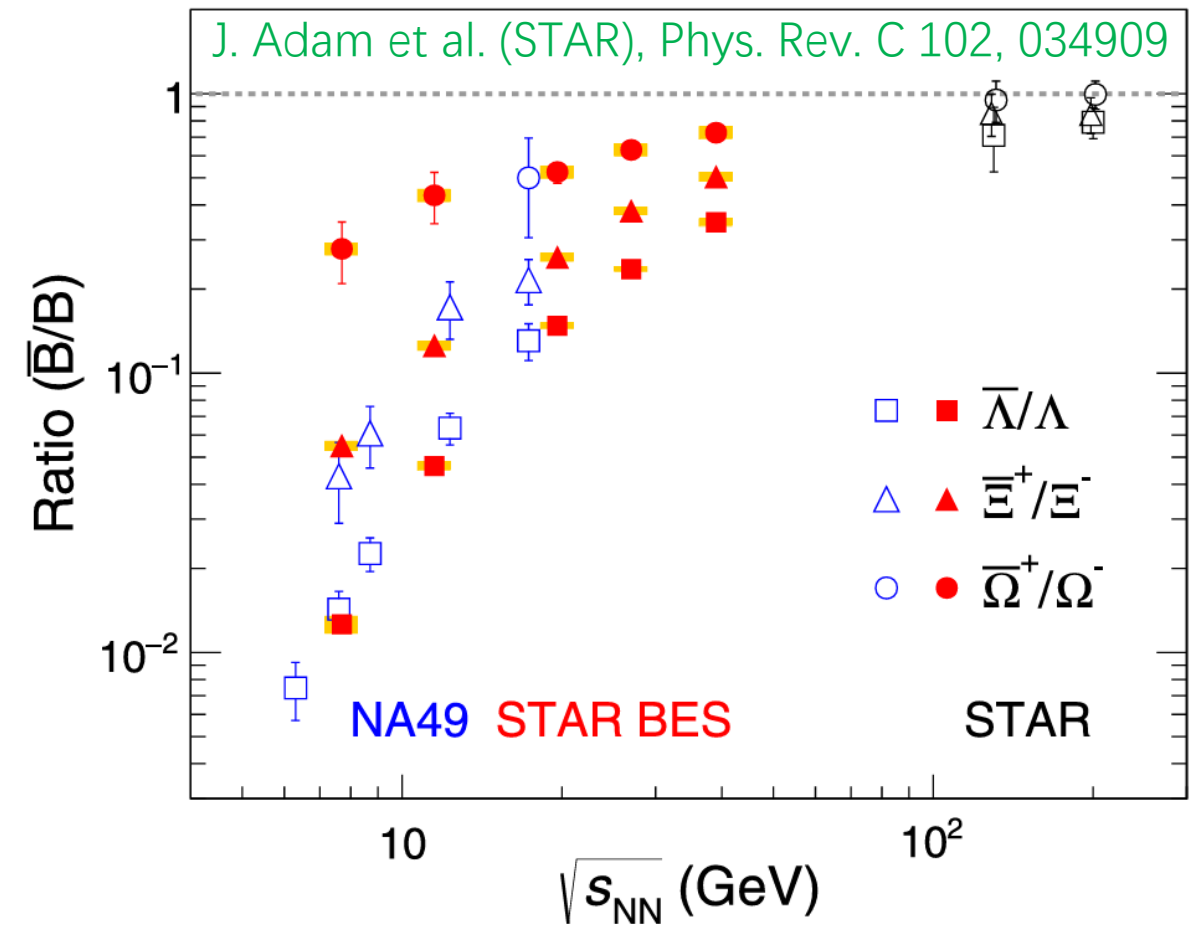
STAR Collaboration, arXiv:2408.15441



I. G. Bearden et al. (BRAHMS), *Phys. Rev. Lett.* 2004, 93(10):102301

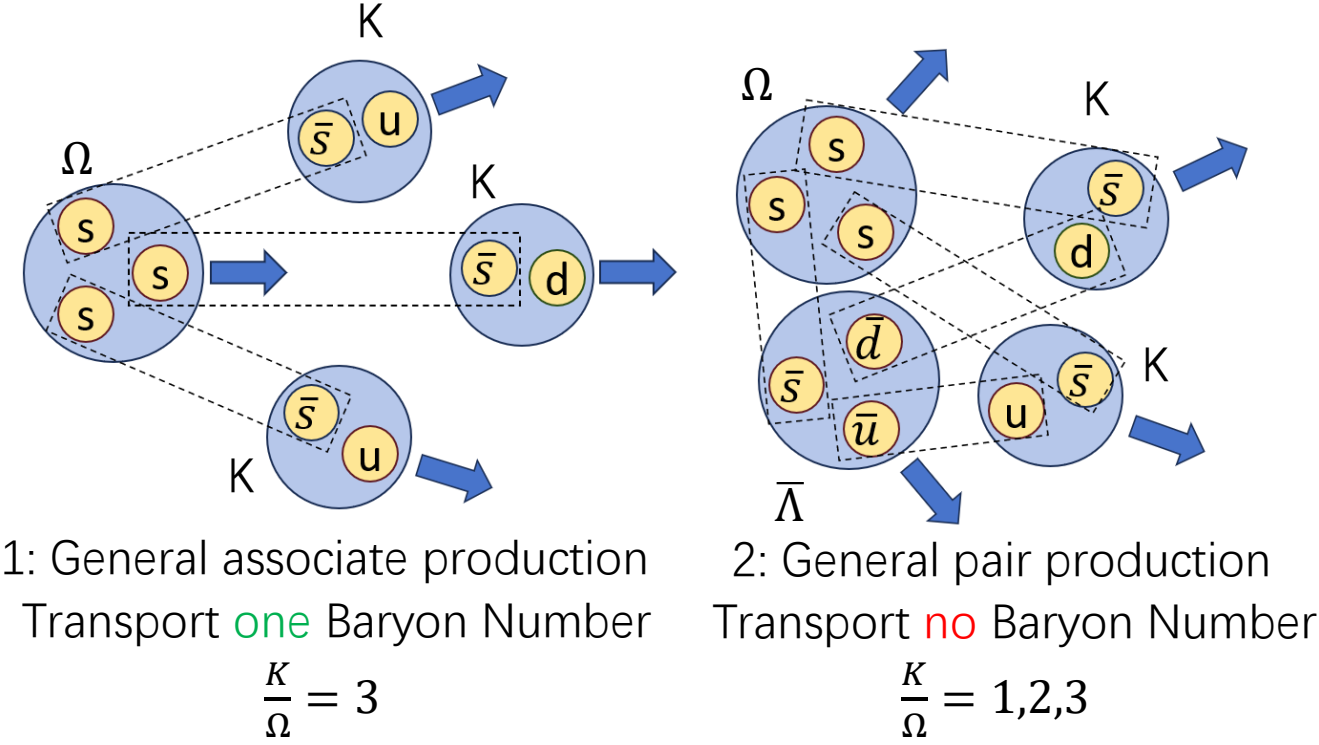
Hyperon-Kaon Correlation

- Baryon number transport from Proton/Neutron to Hyperon
 - Ratio Anti-Hyperon/Hyperon < 1
 - Strangeness conservation: Strange – Anti-Strange quarks are pair-produced



Kaon-Hyperon Correlation:

*particles containing at least one valence strange quark:
More primordial production than from weak decays
compare to π and p*



p(d) + Au Collision

• What do we expect in p(d)+A asymmetric collisions?

• In Gluon-junction scheme:

• Baryon number may be carried by the gluon junction

• Valence quark jets emerge with leading mesons

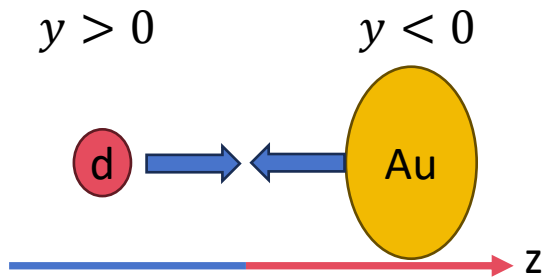
D. Kharzeev, Phys. Lett. B 378 (1996) 238-246

• Hyperon in initial p/d hemi-sphere more likely carry baryon number from initial p/d

• Clearer K-Hyperon correlation for hyperon with $y > 0$

• Different pair Δy distribution between $hyperon_{y > 0}$ and $hyperon_{y < 0}$.

W.J. Dong, X.Z. Yu, S.Y. Ping, X.T. Wu, G. W, H.Z. Huang, Z.W. Lin, Nucl. Sci. Tech. 35 (2024) 120



$$C_{K\Lambda}(\Delta y) = \frac{1}{N_{\Lambda}} \frac{dN_{K+\Lambda}^{pairs}}{d\Delta y} - \frac{1}{N_{\bar{\Lambda}}} \frac{dN_{K+\bar{\Lambda}}^{pairs}}{d\Delta y}$$

$$\Delta y = \theta(y_{\Lambda})(y_K - y_{\Lambda}) + \theta(-y_{\Lambda})(y_{\Lambda} - y_K)$$

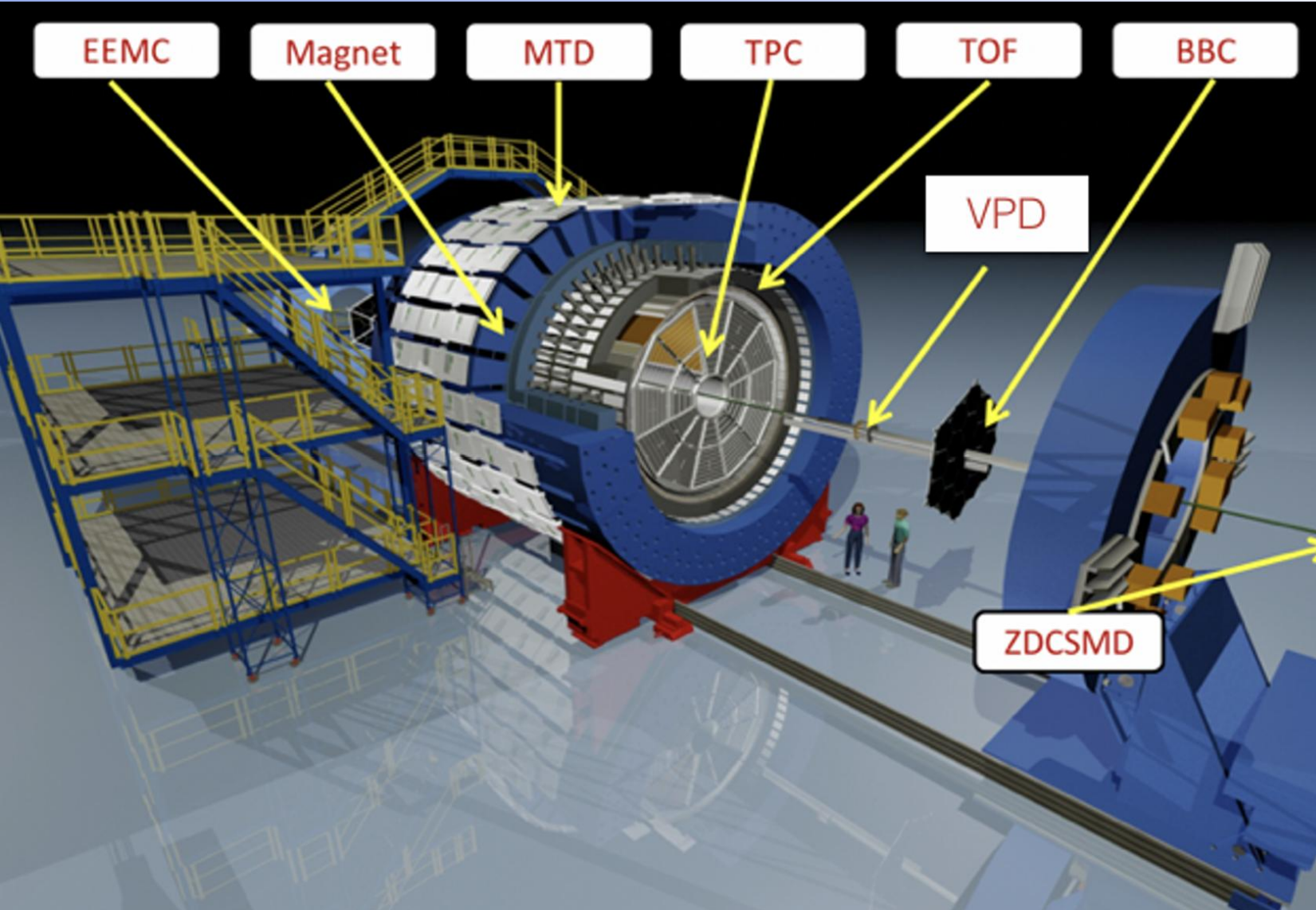
$$\theta(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x < 0 \end{cases}$$

$\Delta y > 0$: Kaon emit faster; $\Delta y < 0$: Λ emit faster

Yielding information of average Kaon number per Lambda

Combinatorial background subtraction

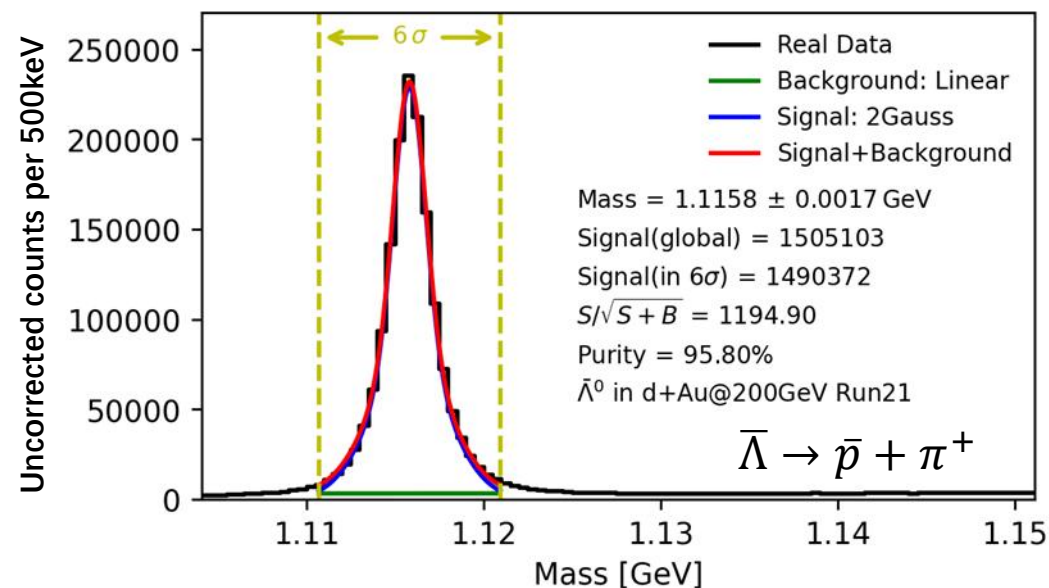
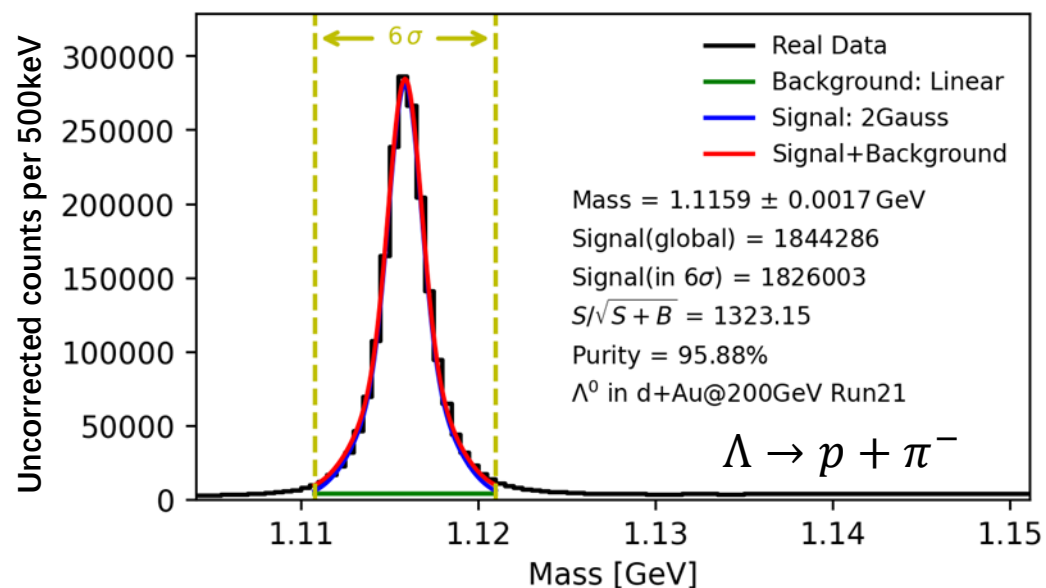
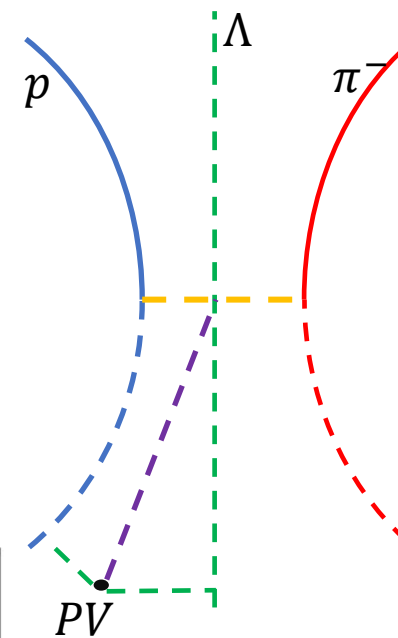
Hyperon reconstruction in STAR data



- Dataset:
 - d+Au@200GeV Run 21
- STAR Acceptance
 - TPC & TOF are used
 - $|\eta| < 1$

Hyperon reconstruction in STAR data

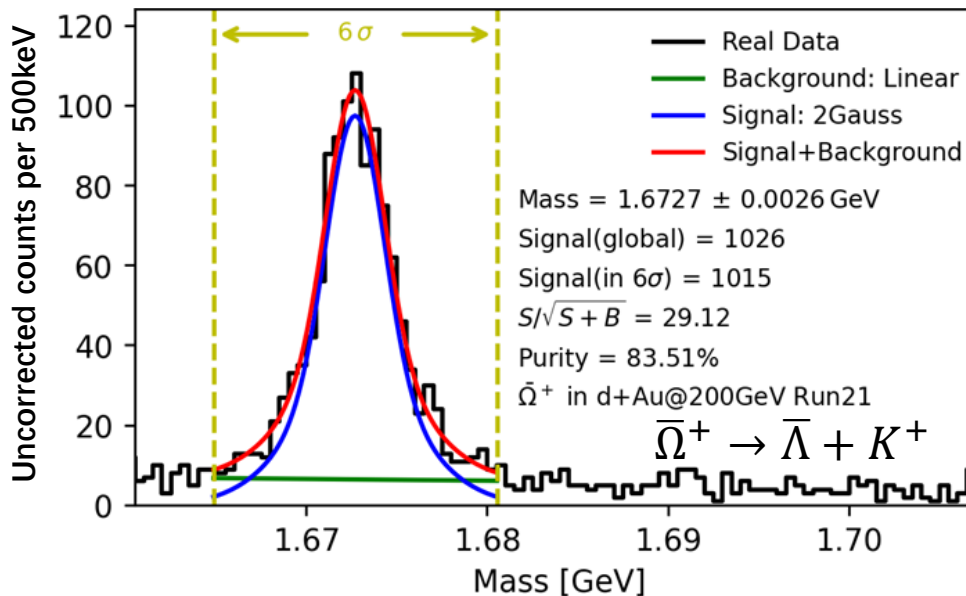
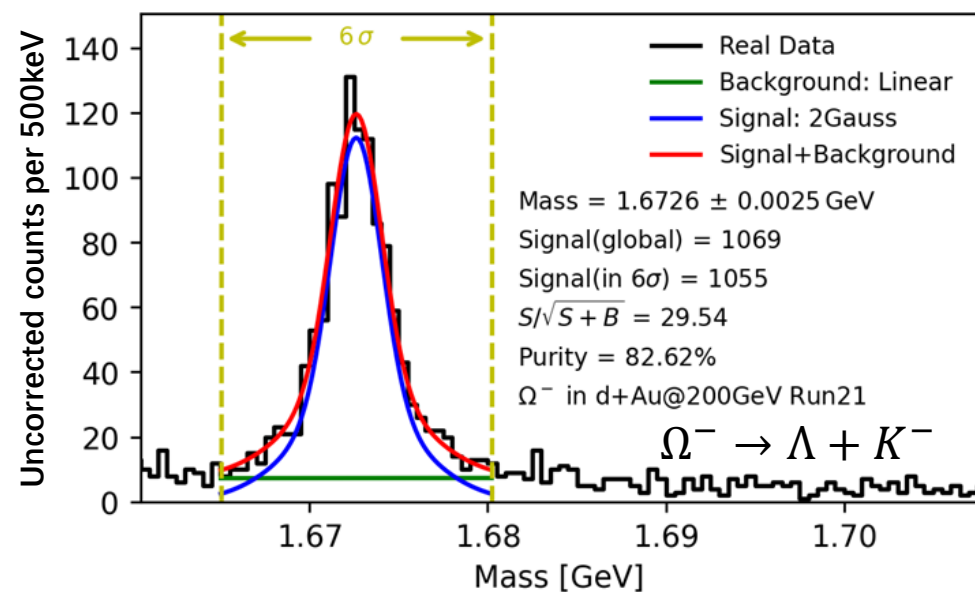
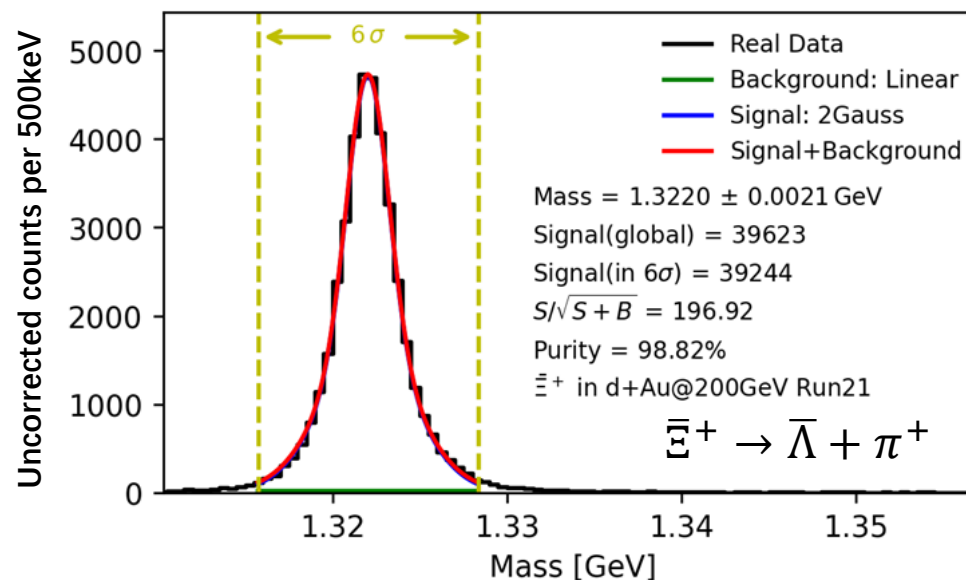
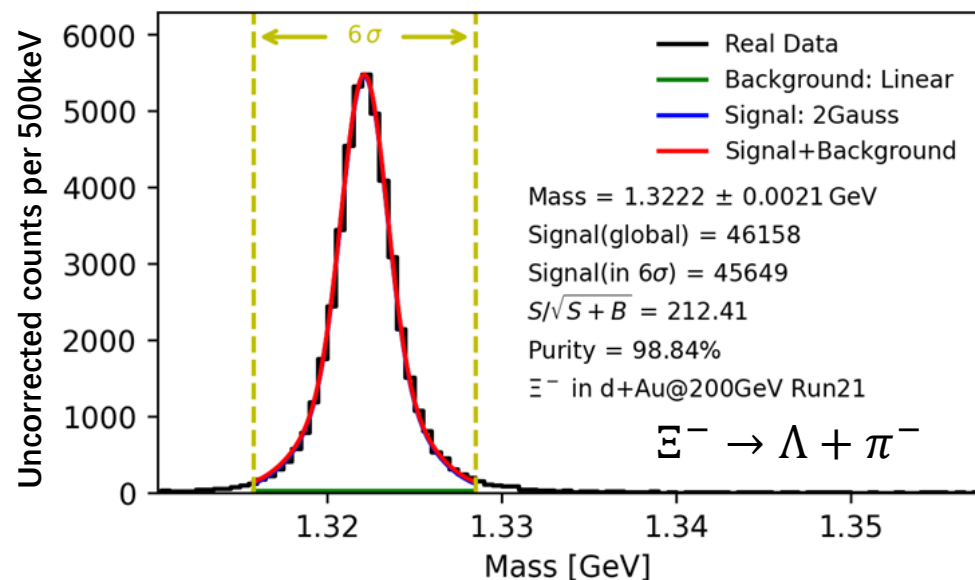
- KFParticle Package was used in d+Au@200GeV Run 21:
 - Using dE/dx in the TPC for particle identification
 - **DCA** between daughter particles **< 0.5 cm**
 - the **distance** to the primary vertex from the decay vertex **> 1.0 cm**



For more KFP introduction:

<https://publikationen.uni-frankfurt.de/opus4/frontdoor/deliver/index/docId/29538/file/GorbunovThesis.pdf>

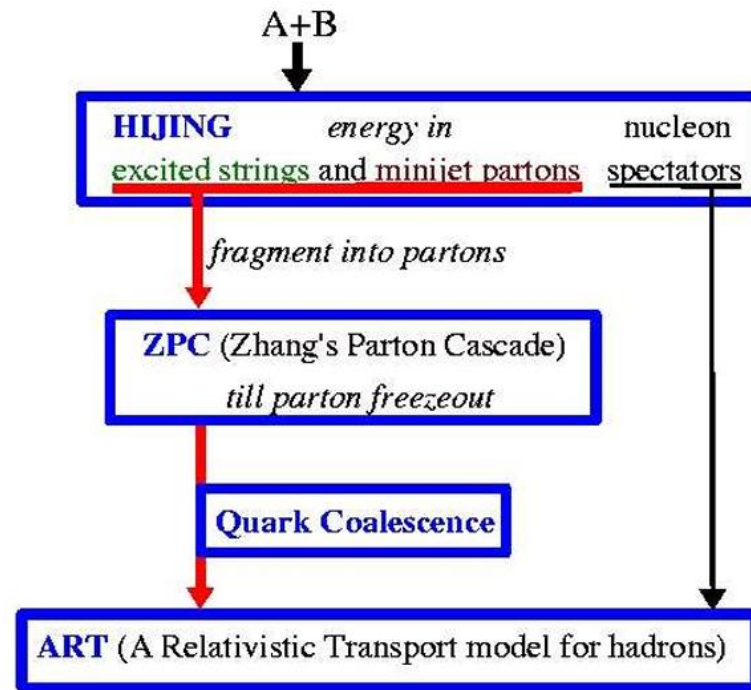
Hyperon reconstruction in STAR data



AMPT Result

- Simulation for reference:
 - A Multi-Phase Transport Model (AMPT)
 - Version: 2.25t7cu (StringMelting)
 - Transport models treat chemical and thermal freeze-out dynamically
- Data Generated:
 - d+Au@200GeV
- Guiding the experimental investigation
 - STAR acceptance adopted
 - $|\eta| < 1$
 - AMPT has no Baryon junction:
 - As a benchmark for experimental studies

Structure of AMPT model with string melting



Z.W. Lin, C.M. Ko, B.A. Li, B. Zhang, S. Pal, Phys.Rev.C72:064901,2005

AMPT Result

• d+Au@200GeV

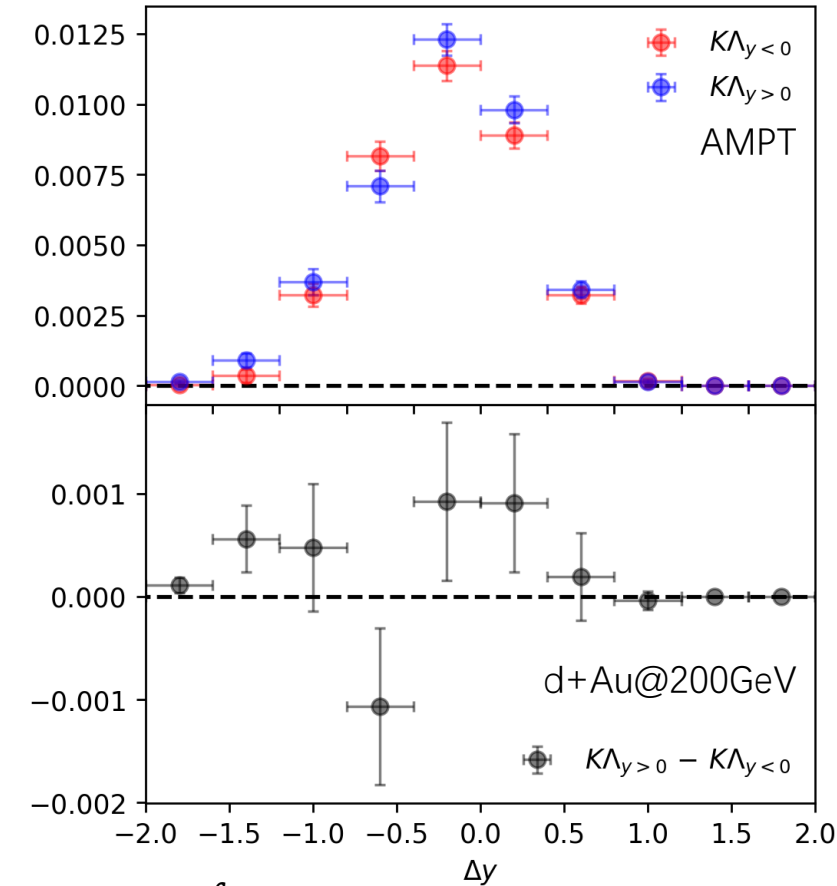
$$\Delta y = \theta(y_{Hyperon})(y_K - y_{Hyperon}) + \theta(-y_{Hyperon})(y_{Hyperon} - y_K)$$

$\Delta y > 0$: Kaon emit faster; $\Delta y < 0$: Hyperon emit faster

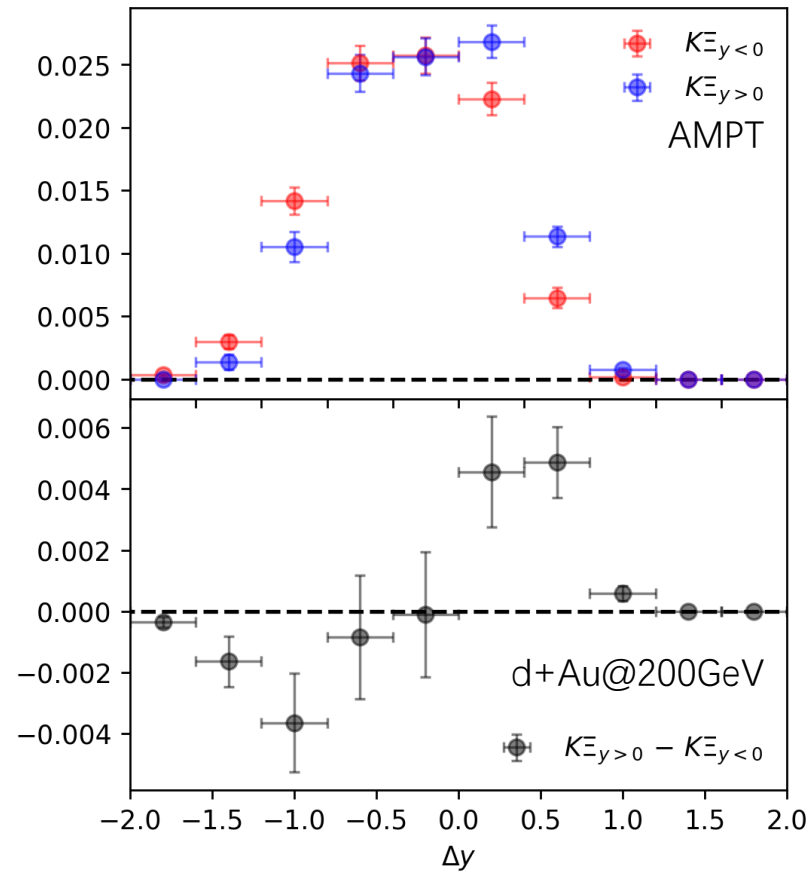
$$C_{K\Lambda}(\Delta y) = \frac{1}{N_\Lambda} \frac{dN_{K^+\Lambda}^{pairs}}{d\Delta y} - \frac{1}{N_{\bar{\Lambda}}} \frac{dN_{K^+\bar{\Lambda}}^{pairs}}{d\Delta y}$$

$$C_{K\Sigma}(\Delta y) = \frac{1}{N_\Sigma} \frac{dN_{K^+\Sigma}^{pairs}}{d\Delta y} - \frac{1}{N_{\bar{\Sigma}}} \frac{dN_{K^+\bar{\Sigma}}^{pairs}}{d\Delta y}$$

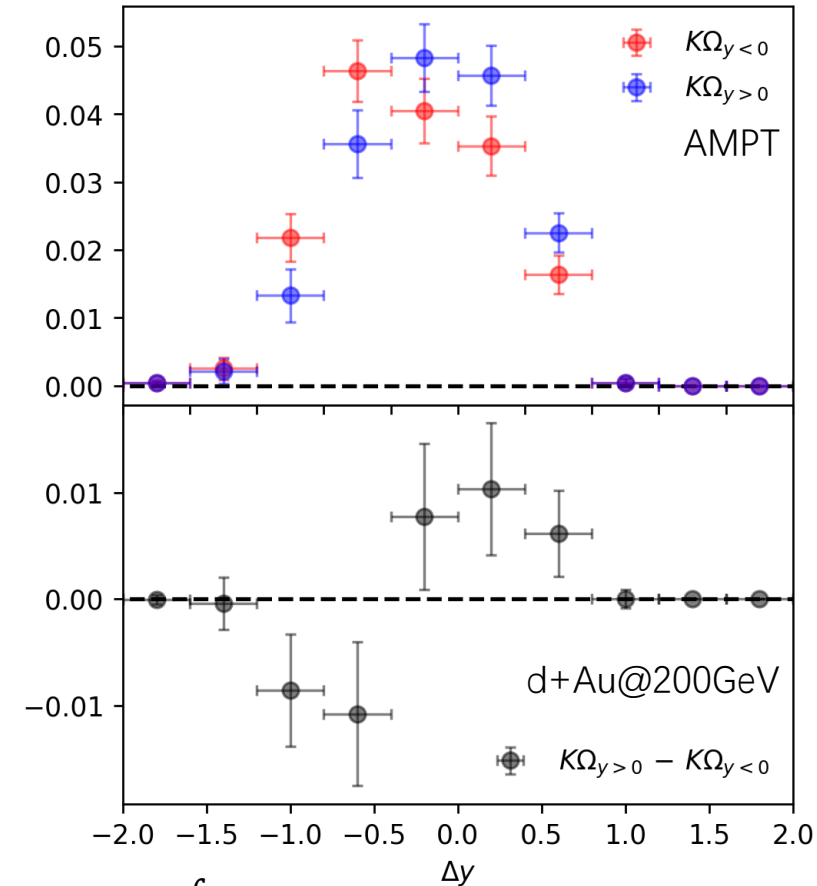
$$C_{K\Omega}(\Delta y) = \frac{1}{N_\Omega} \frac{dN_{K^+\Omega}^{pairs}}{d\Delta y} - \frac{1}{N_{\bar{\Omega}}} \frac{dN_{K^+\bar{\Omega}}^{pairs}}{d\Delta y}$$



$$\int C_{K\Lambda}(\Delta y) d\Delta y = 0.037 \pm 0.001$$



$$\int C_{K\Sigma}(\Delta y) d\Delta y = 0.099 \pm 0.002$$



$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.166 \pm 0.007$$

Summary and Outlook

- p(d)+A collision:
 - A new way to study baryon stopping and possible baryon junction interactions.
- Hyperon-Kaon correlation:
 - Sensitive probe of baryon number transport dynamics
- AMPT simulation:
 - StringMelting version
 - Hyperons with positive rapidity correlate faster emitted Kaons
 - Indicates stronger baryon stopping for initial deuteron.
 - Positive $\int C_{K-Hyperon}(\Delta y) d\Delta y$:
 - $\int C_{K\Omega}(\Delta y) d\Delta y > \int C_{K\Xi}(\Delta y) d\Delta y > \int C_{K\Lambda}(\Delta y) d\Delta y$
 - Baryon number transport to hyperons
- Analysis of d+Au STAR dataset is ongoing (Stay tuned!)

Thank you!

Back Up

