



JOINT MARCH MEETING AND APRIL MEETING

Global Physics Summit

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

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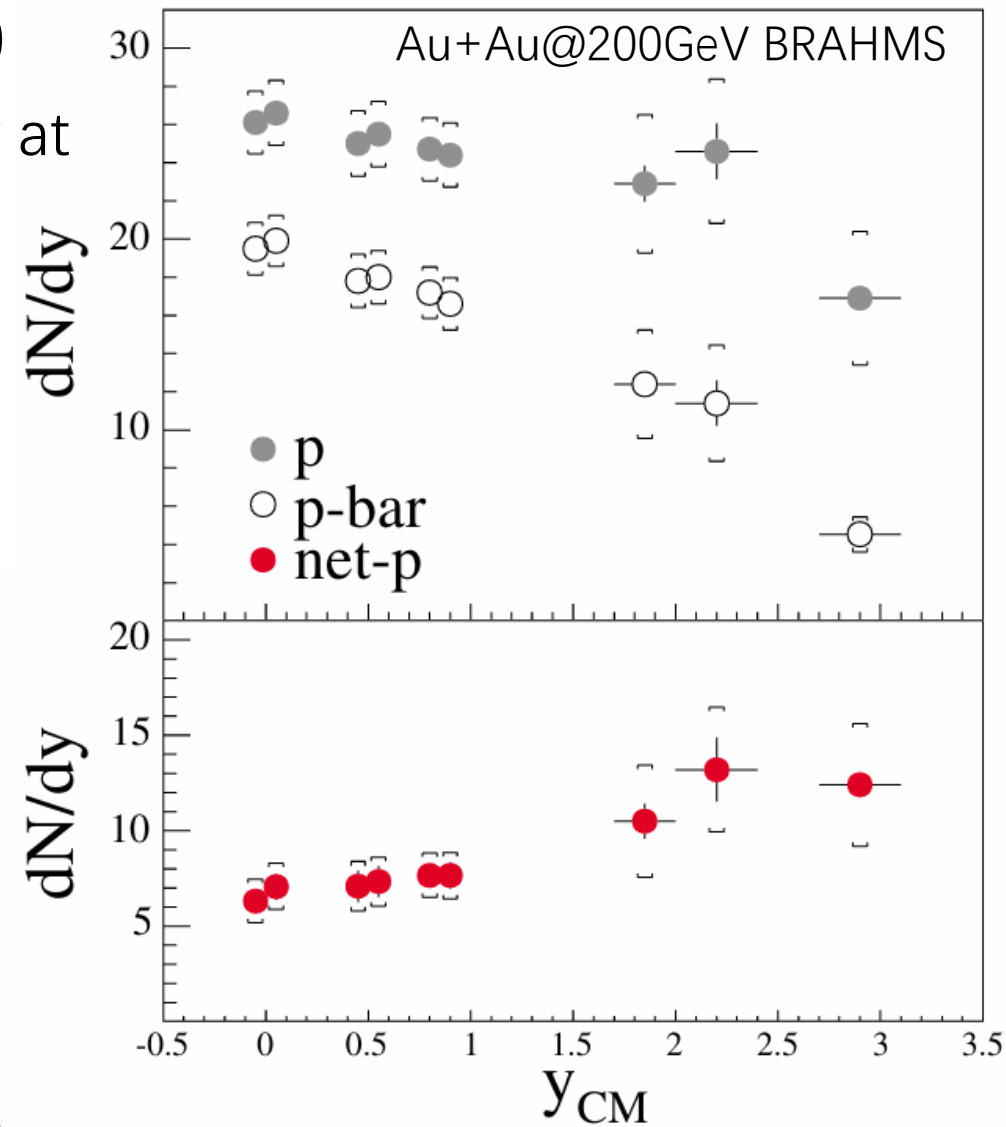
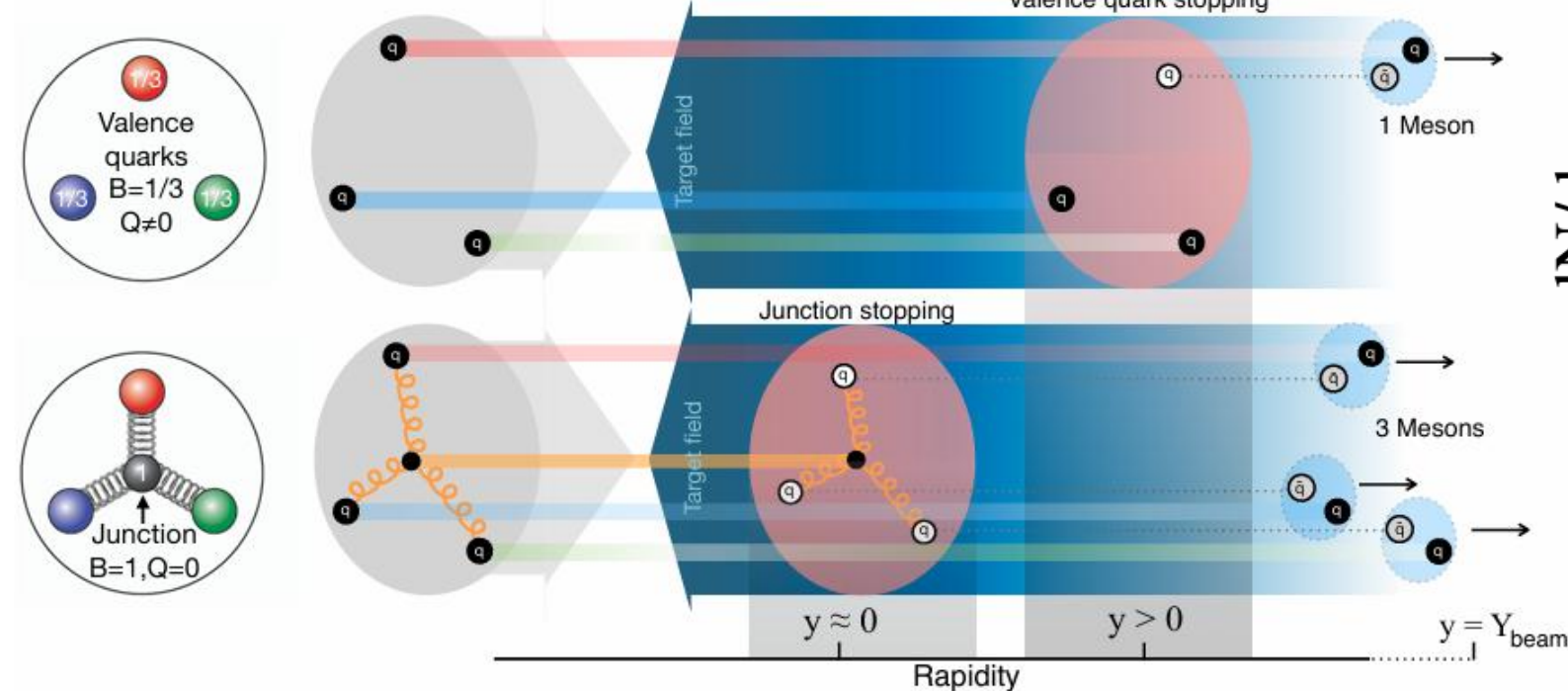
# Outline

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

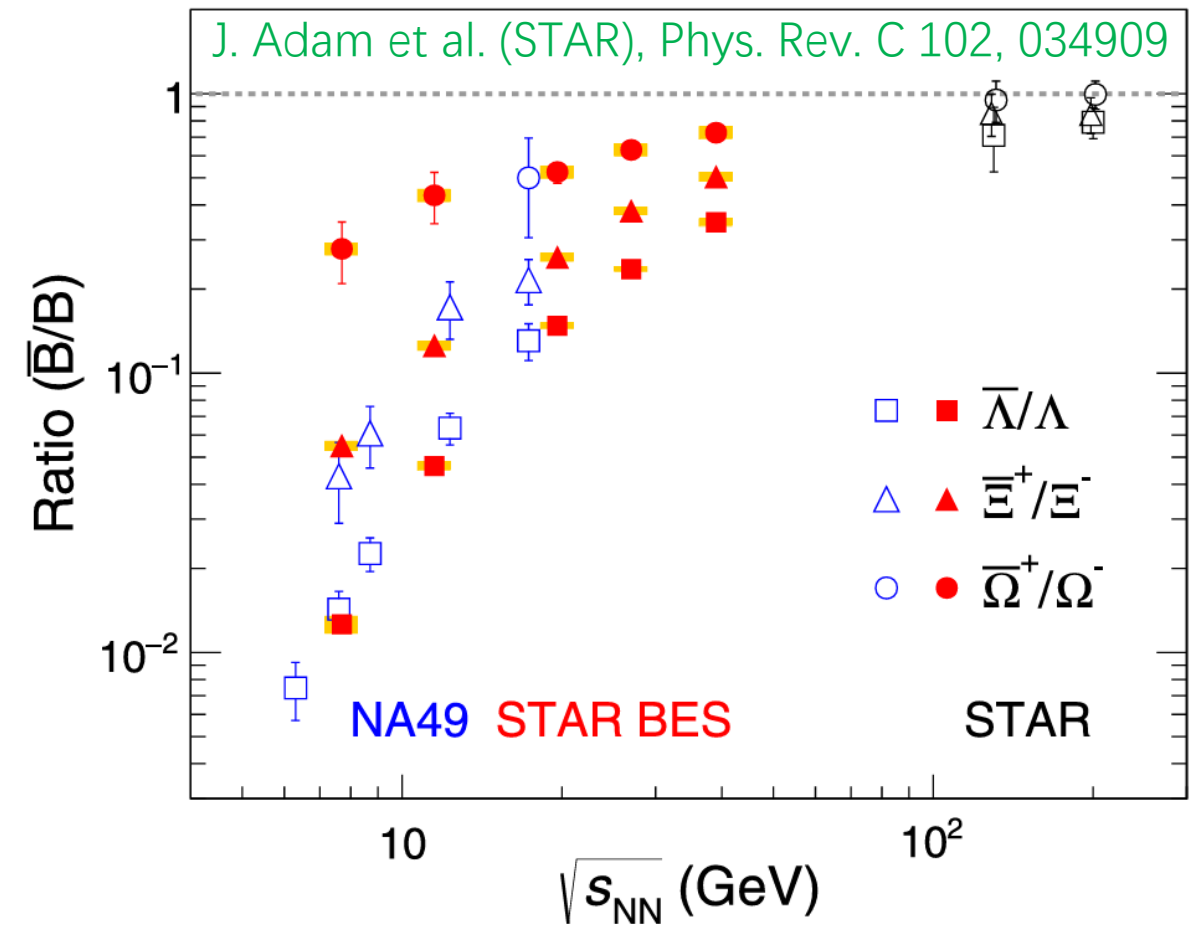
STAR Collaboration, arXiv:2408.15441



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

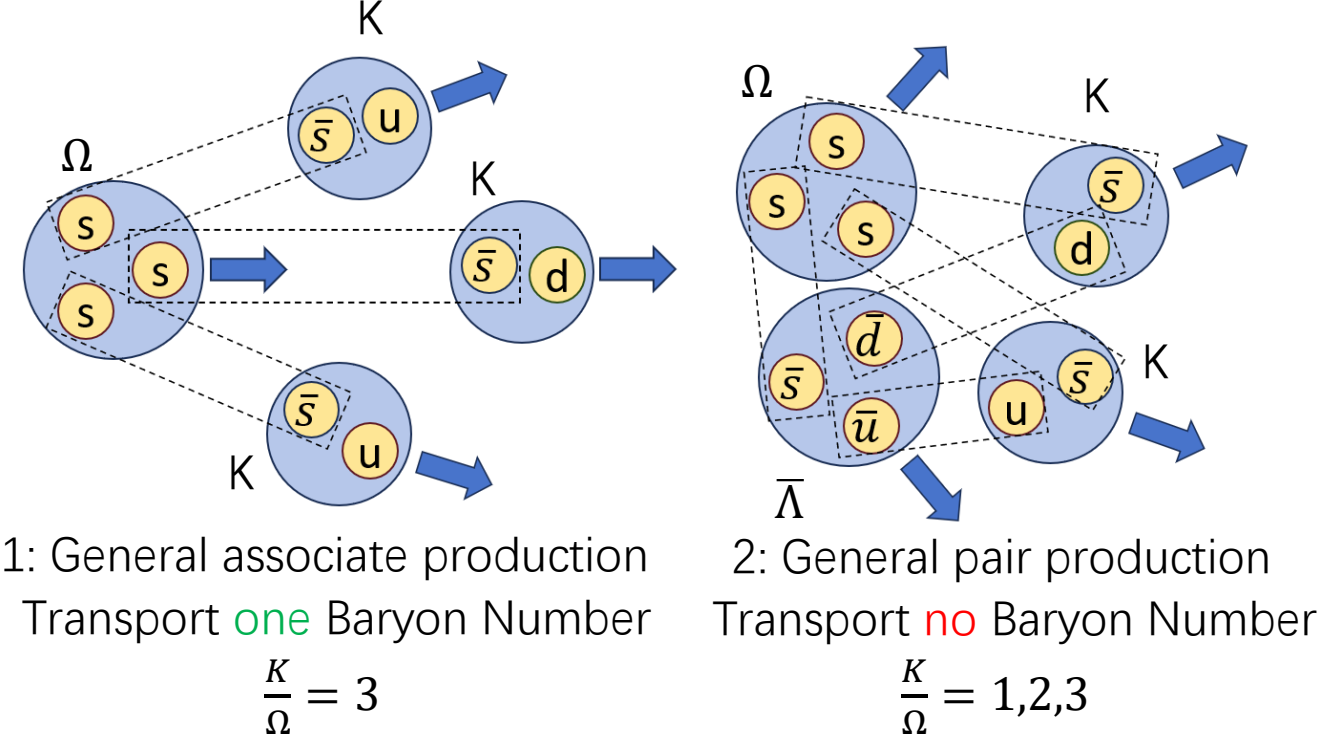
# Hyperon-Kaon Correlation

- 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:

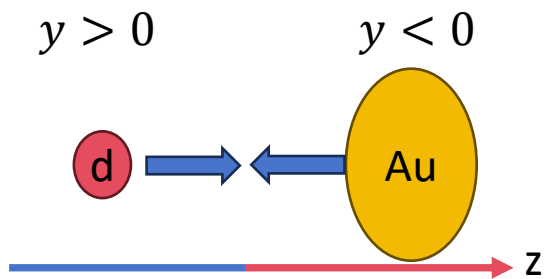
*particles containing at least one valence strange quark:  
More primordial production than from weak decays  
compare to  $\pi$  and  $p$*



# 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  $\Delta y$  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



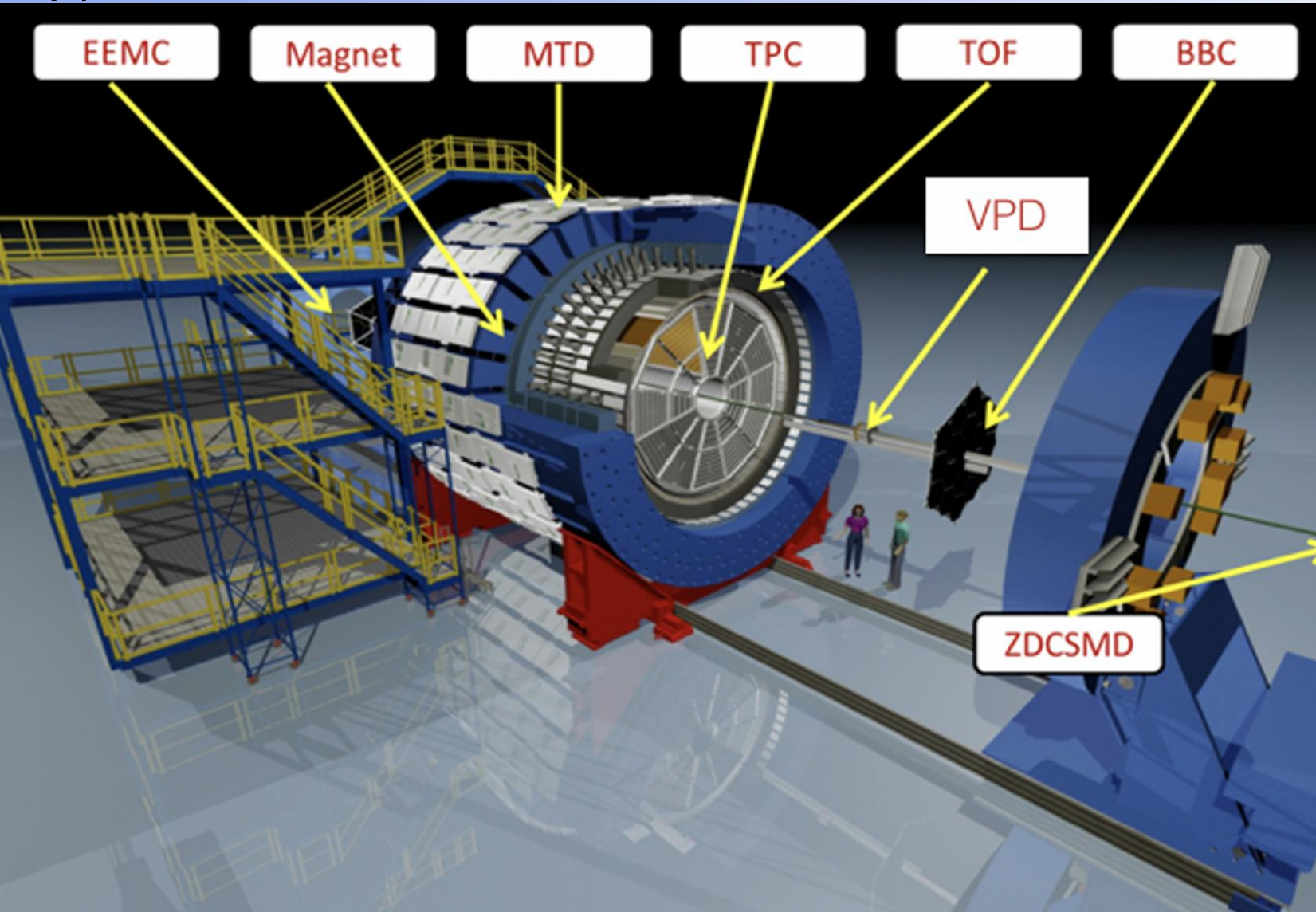
$$C_{K\Lambda}(\Delta y) = \frac{1}{N_{\Lambda}} \frac{dN_{K+\Lambda}^{pairs}}{d\Delta y} - \frac{1}{N_{\bar{\Lambda}}} \frac{dN_{K+\bar{\Lambda}}^{pairs}}{d\Delta y}$$

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

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

$\Delta y > 0$ : Kaon emit faster;  $\Delta y < 0$ :  $\Lambda$  emit faster  
 Yielding information of average Kaon number per Lambda  
 Combinatorial background subtraction

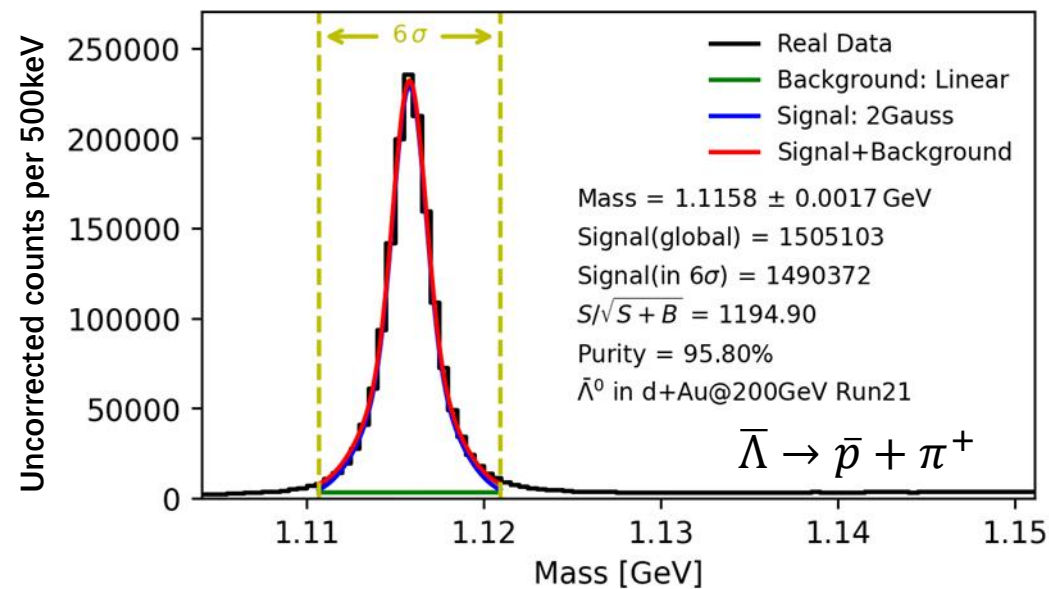
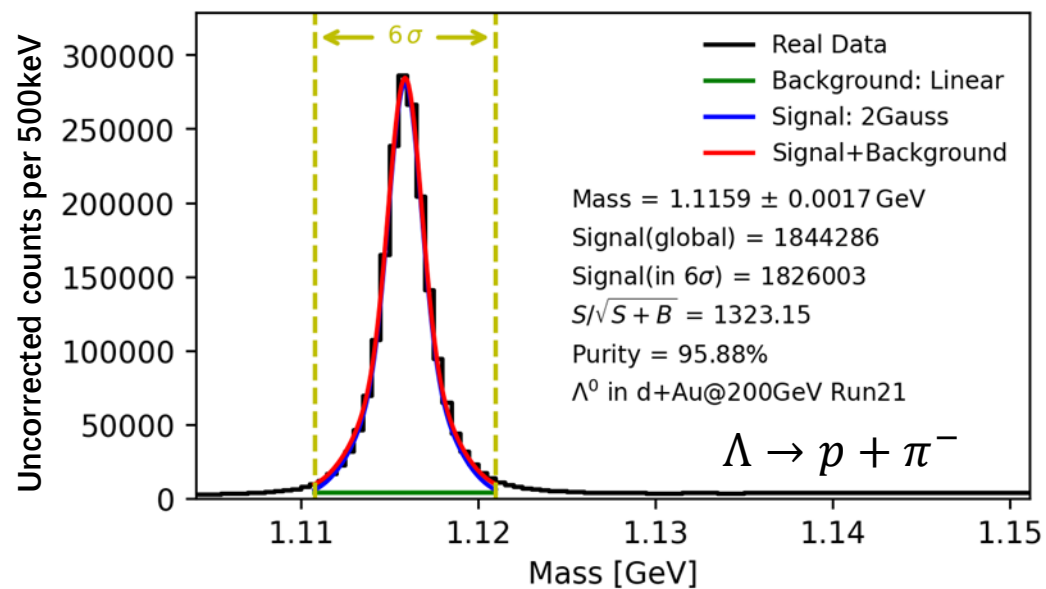
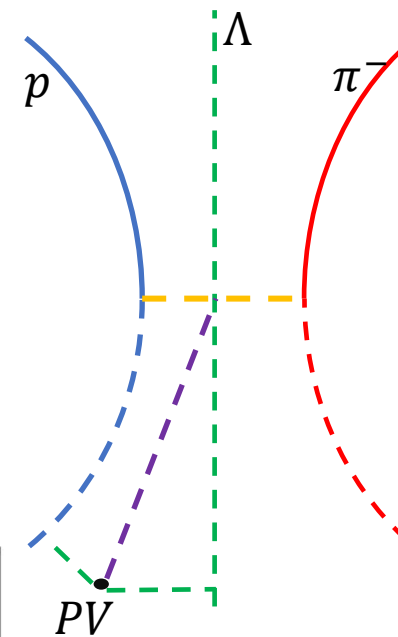
# Hyperon reconstruction in STAR data



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

# Hyperon reconstruction in STAR data

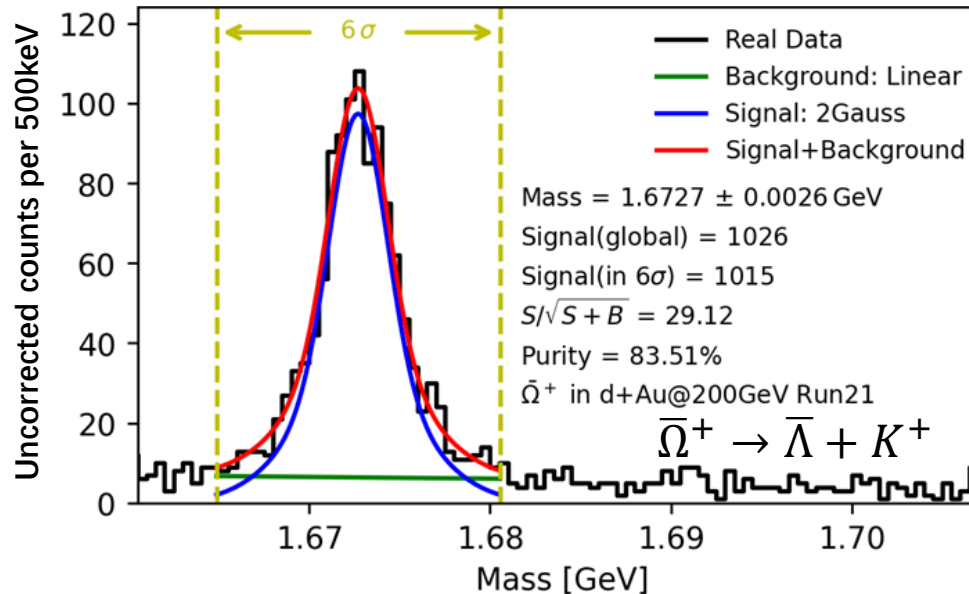
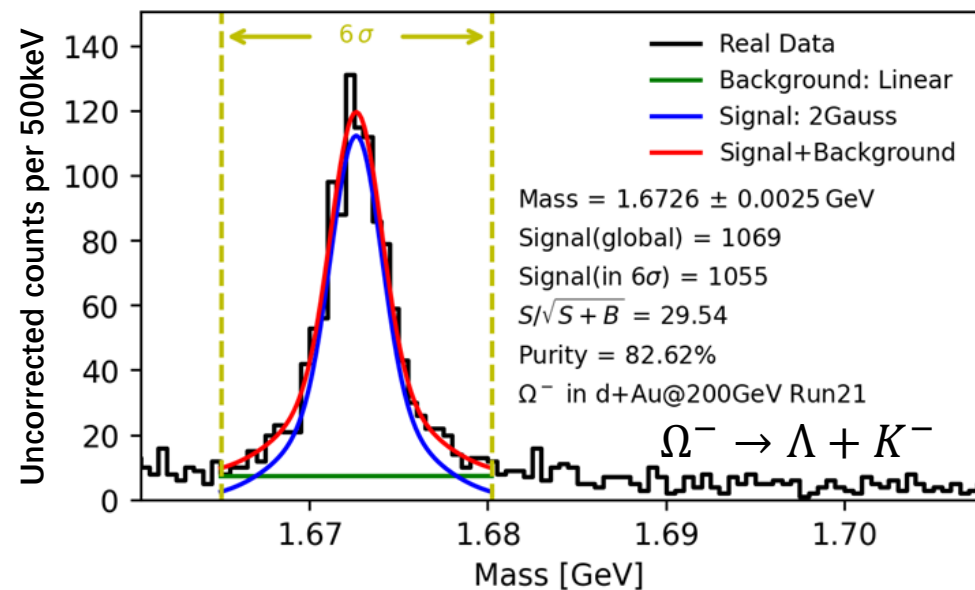
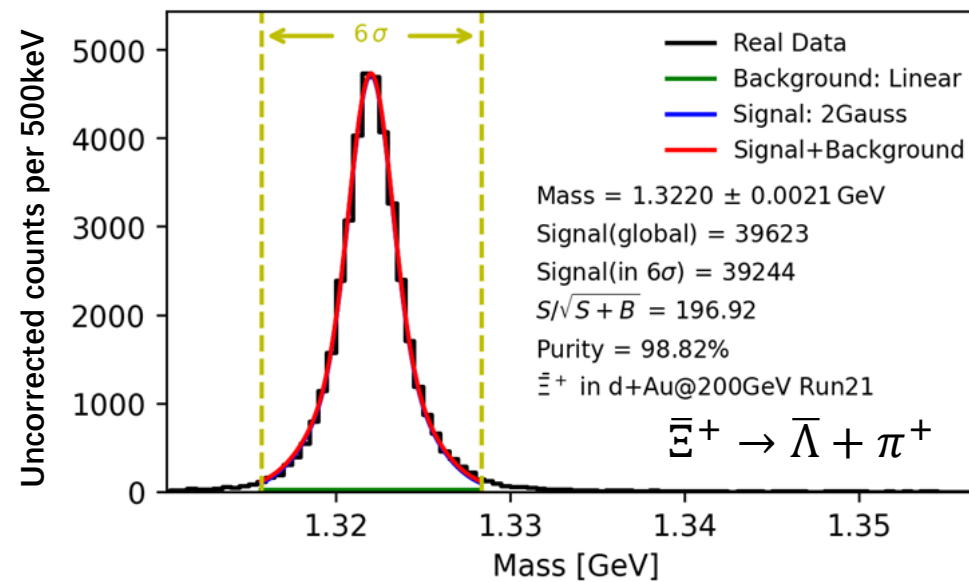
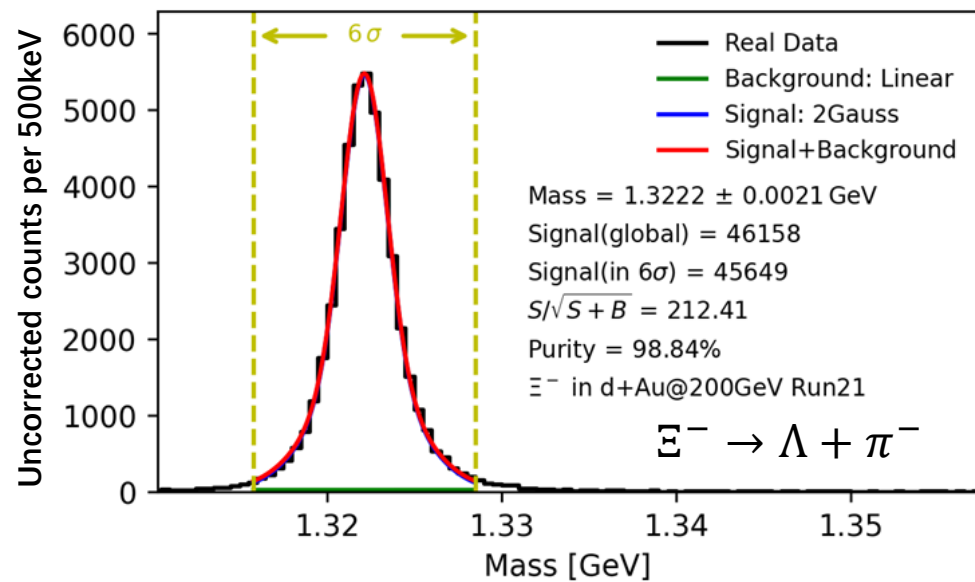
- KFParticle Package was used in d+Au@200GeV Run 21:
  - Using  $dE/dx$  in the TPC for particle identification
  - **DCA** between daughter particles **< 0.5 cm**
  - the **distance** to the primary vertex from the decay vertex **> 1.0 cm**



For more KFP introduction:

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

# Hyperon reconstruction in STAR data

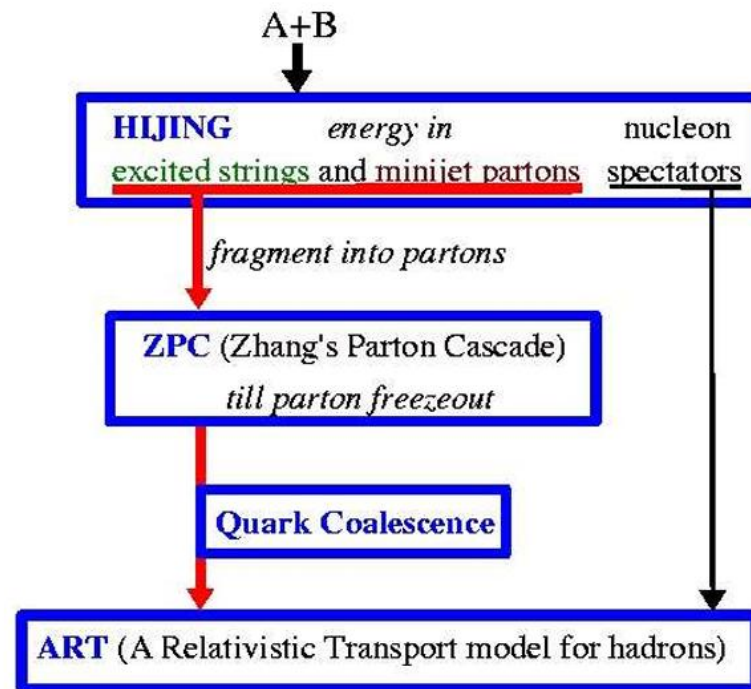




# AMPT Result

- 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

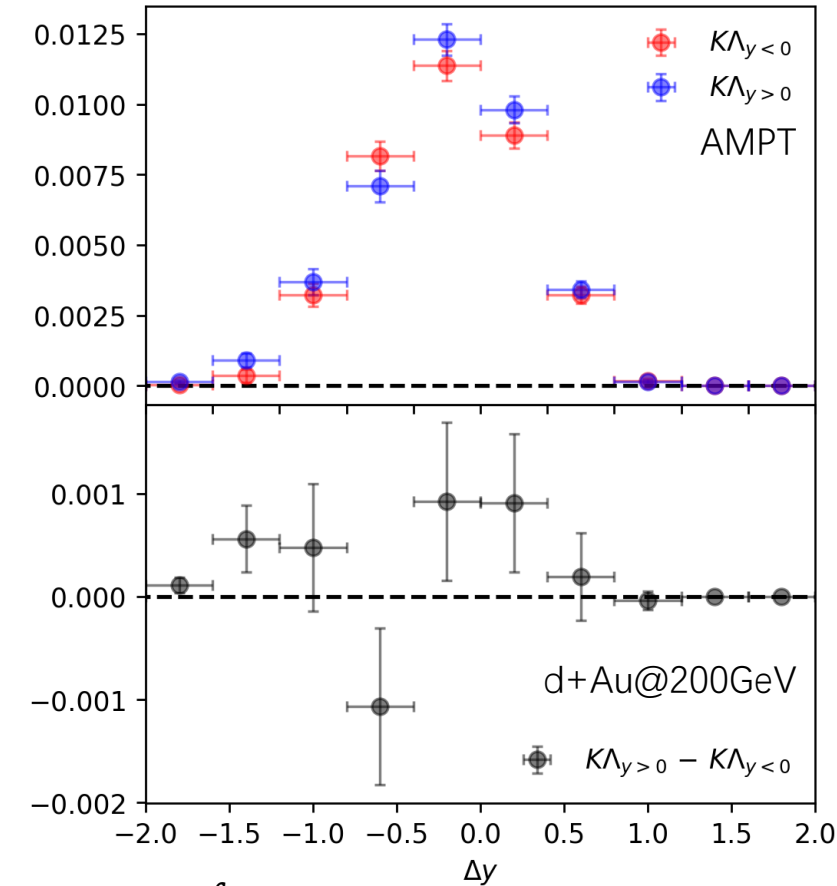
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$\Delta y > 0$ : Kaon emit faster;  $\Delta y < 0$ : Hyperon emit faster

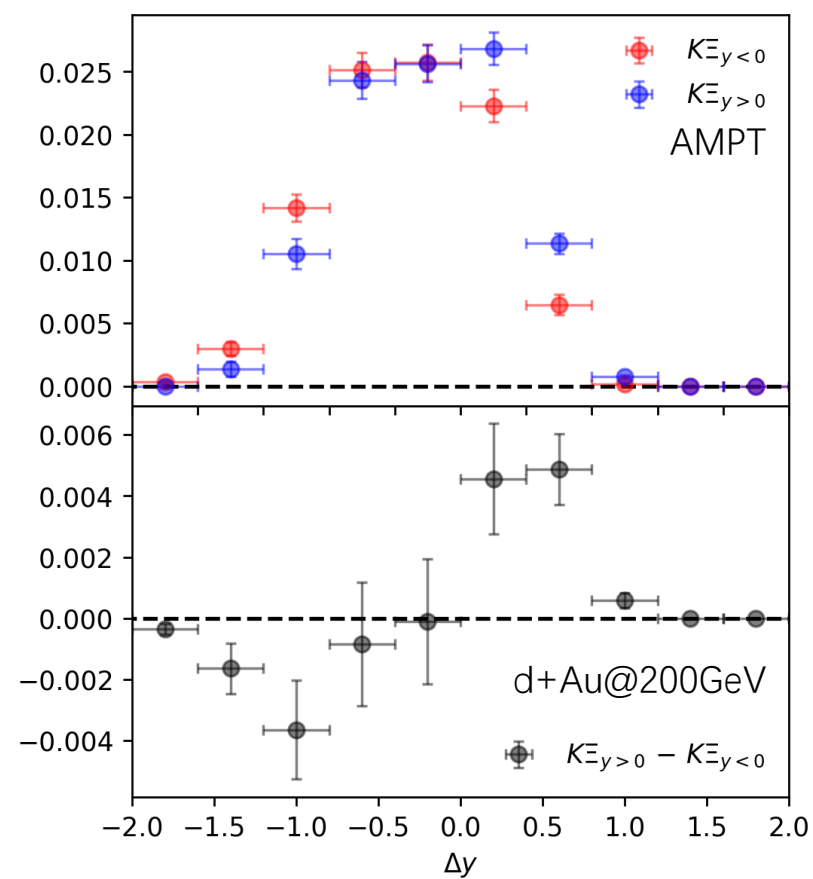
$$C_{K\Lambda}(\Delta y) = \frac{1}{N_\Lambda} \frac{dN_{K^+\Lambda}^{\text{pairs}}}{d\Delta y} - \frac{1}{N_{\bar{\Lambda}}} \frac{dN_{K^+\bar{\Lambda}}^{\text{pairs}}}{d\Delta y}$$

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

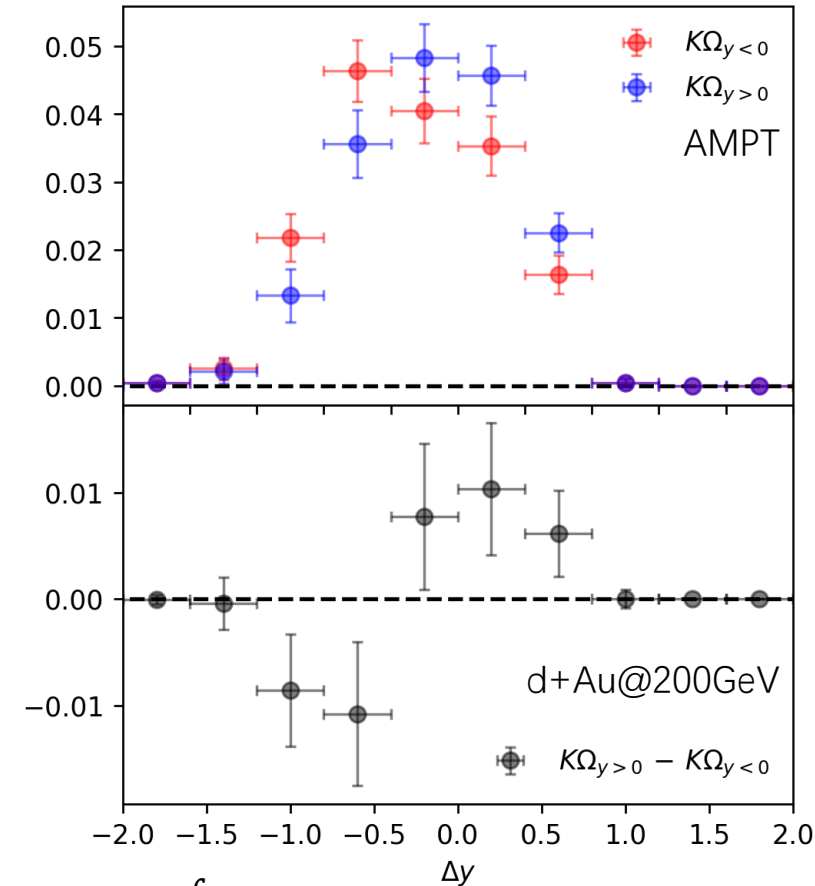
$$C_{K\Omega}(\Delta y) = \frac{1}{N_\Omega} \frac{dN_{K^+\Omega}^{\text{pairs}}}{d\Delta y} - \frac{1}{N_{\bar{\Omega}}} \frac{dN_{K^+\bar{\Omega}}^{\text{pairs}}}{d\Delta y}$$



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



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



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

# 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  $\int C_{K-Hyperon}(\Delta y) d\Delta y$  :
    - $\int C_{K\Omega}(\Delta y) d\Delta y > \int C_{K\Sigma}(\Delta y) d\Delta y > \int C_{K\Lambda}(\Delta y) d\Delta y$
    - A hint of baryon number transport to hyperons
- Analysis of d+Au STAR dataset is ongoing (Stay tuned!)

Thank you!

# Back Up

