



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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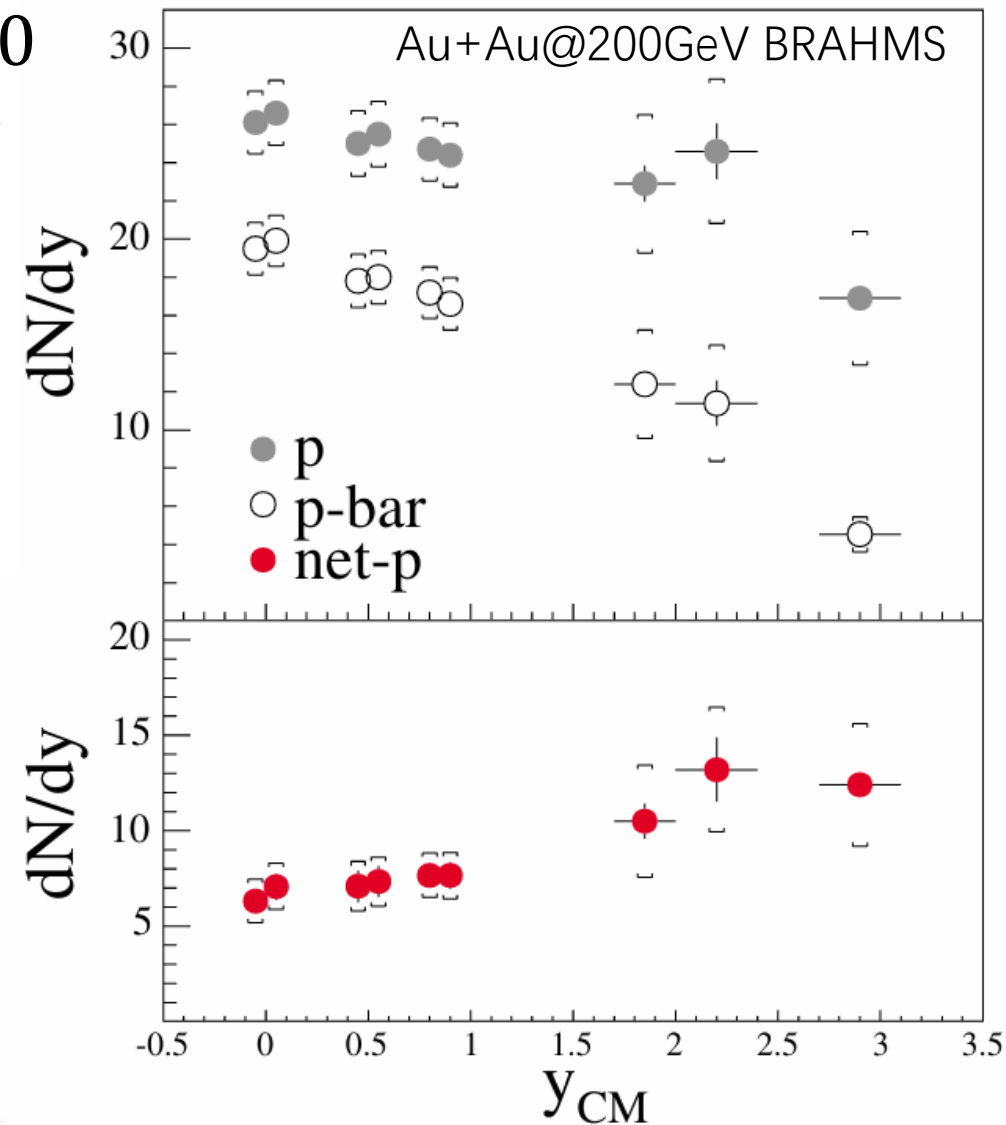
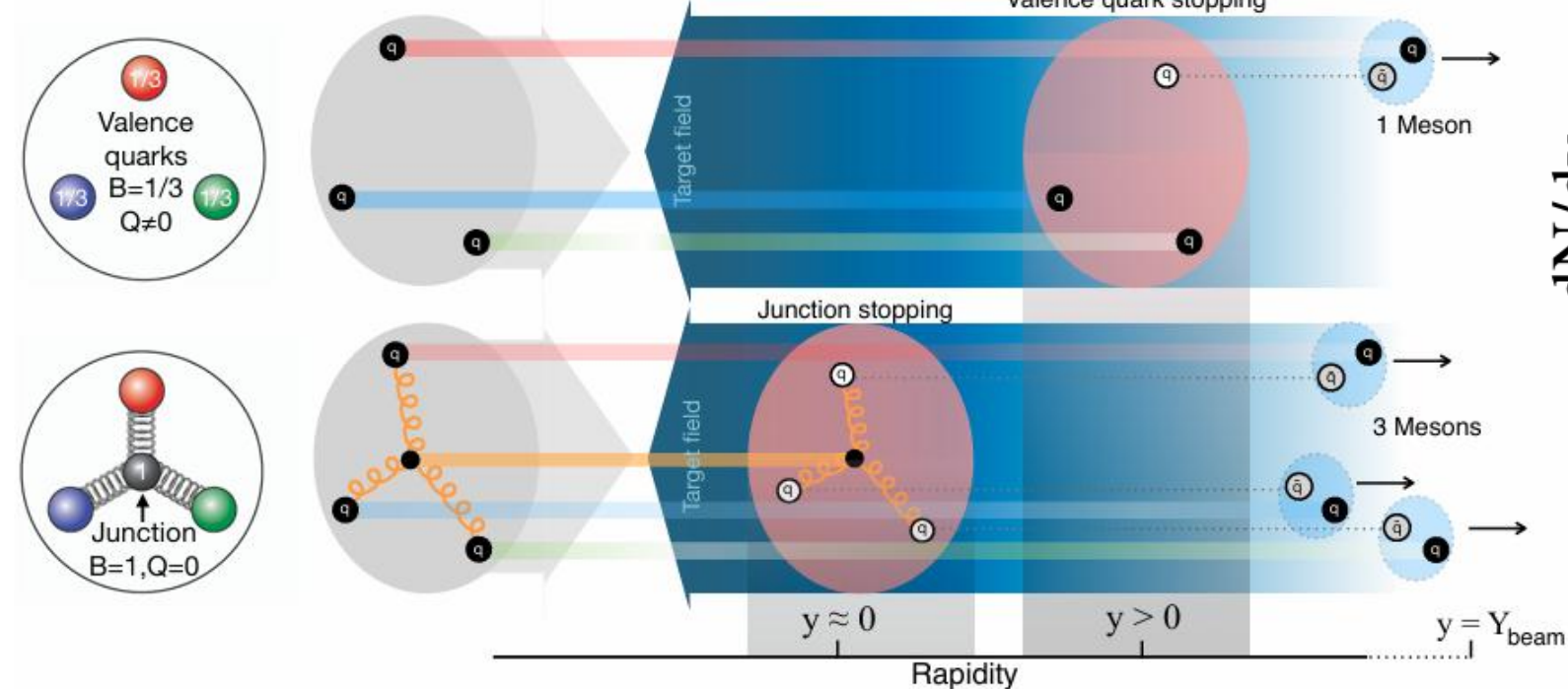
# Outline

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

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

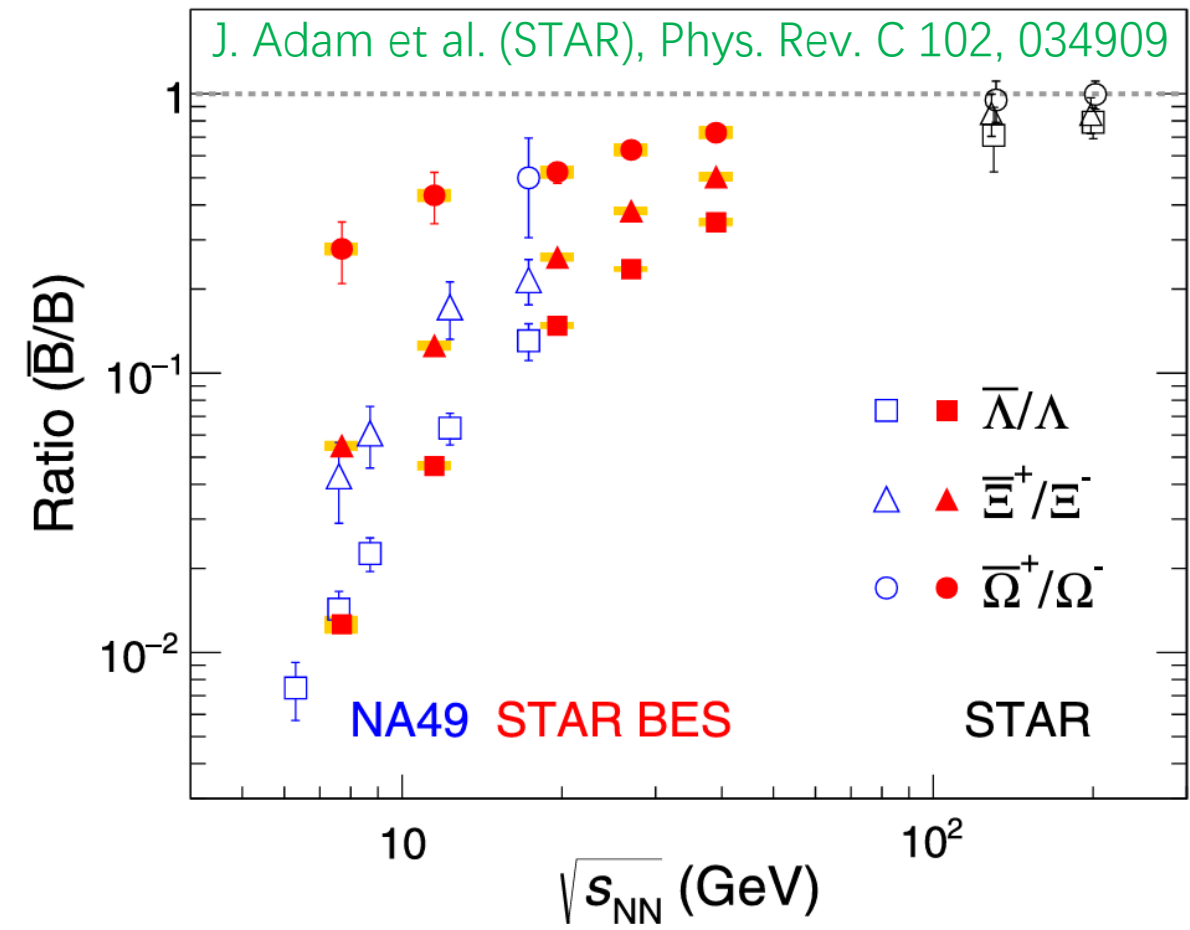
STAR Collaboration, arXiv:2408.15441



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

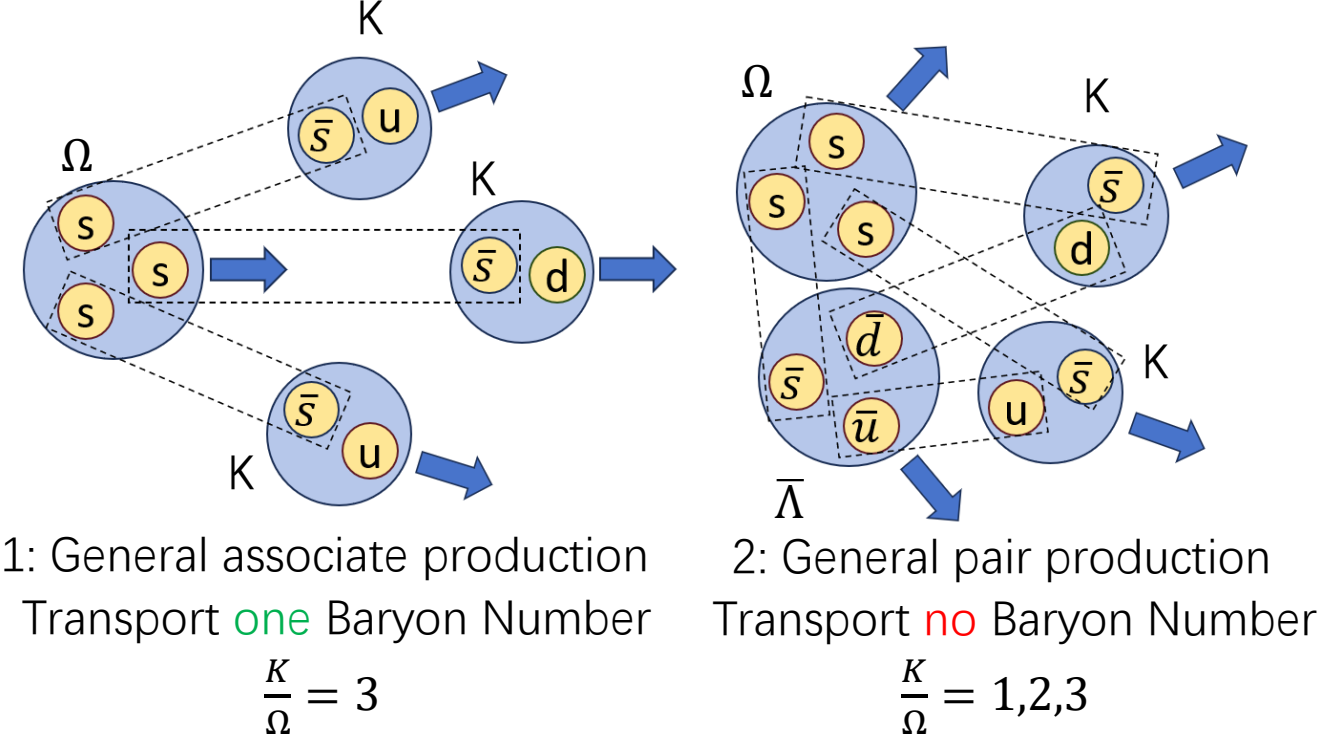
# Hyperon-Kaon Correlation

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



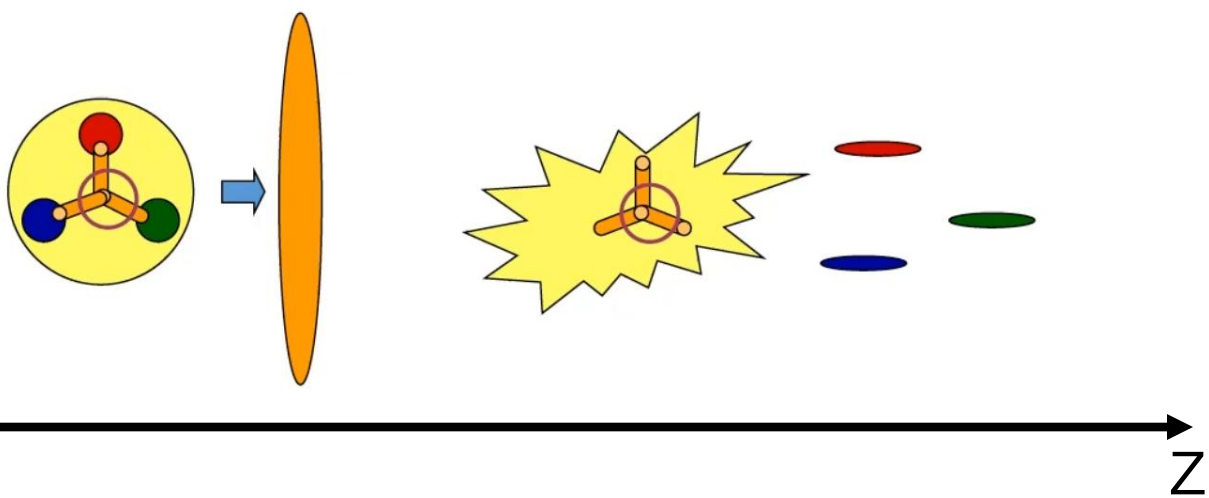
## Kaon-Hyperon Correlation:

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



# p(d) + Au Collision

- Asymmetric collisions
  - The rapidity shift depends on the target A thickness
  - Baryon number is carried by the gluon junction during the interaction
  - Valence quark jets emerge with leading mesons
  - Hyperons in initial p/d hemi-sphere more likely carry baryons number from initial p/d
  - Clearer K-Hyperon correlation for hyperon which  $y > 0$



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

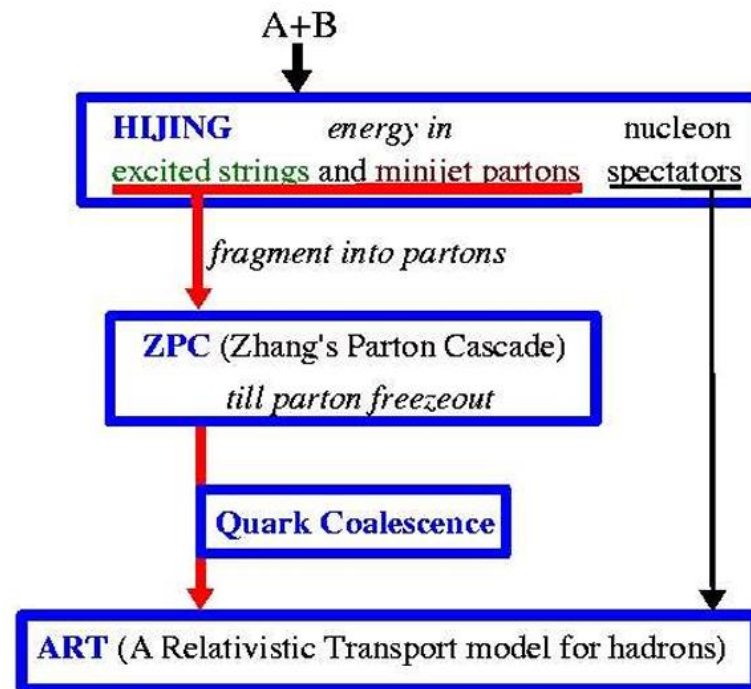
$\Delta y = \theta(y_{\Lambda})(y_K - y_{\Lambda}) + \theta(-y_{\Lambda})(y_{\Lambda} - y_K)$   
 $\Delta y > 0$ : Kaon emit faster;  $\Delta y < 0$ :  $\Lambda$  emit faster

Yielding information of average Kaon number per Lambda  
 Combinatorial background subtraction

# 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:
  - p+Au@39/62GeV
  - d+Au@200GeV
- Guiding the experimental investigation
  - STAR acceptance adopted
    - $|y| < 1$
    - $|\eta| < 1$

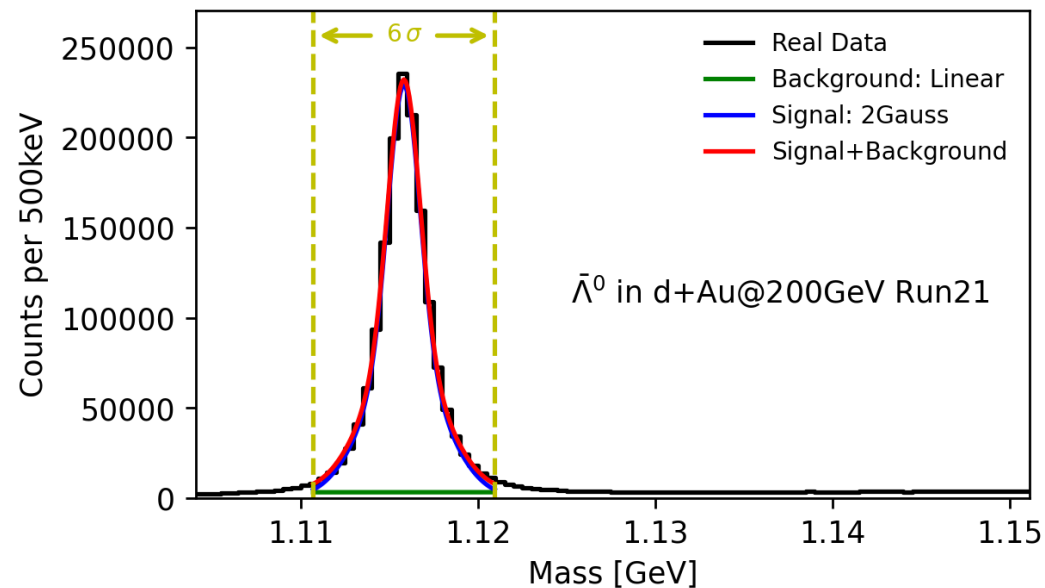
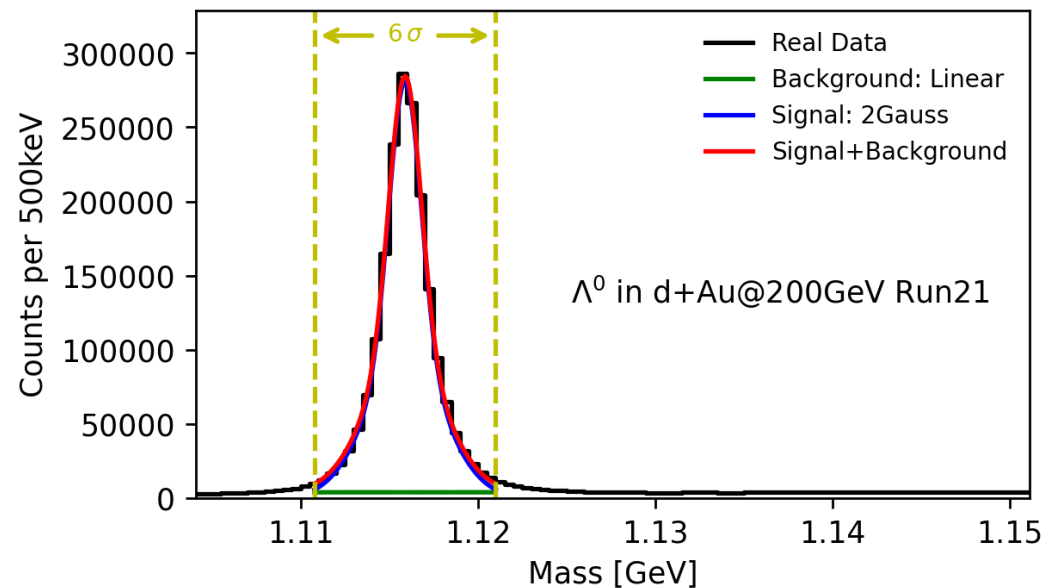
*Structure of AMPT model with string melting*



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

# Hyperon reconstruction in STAR data

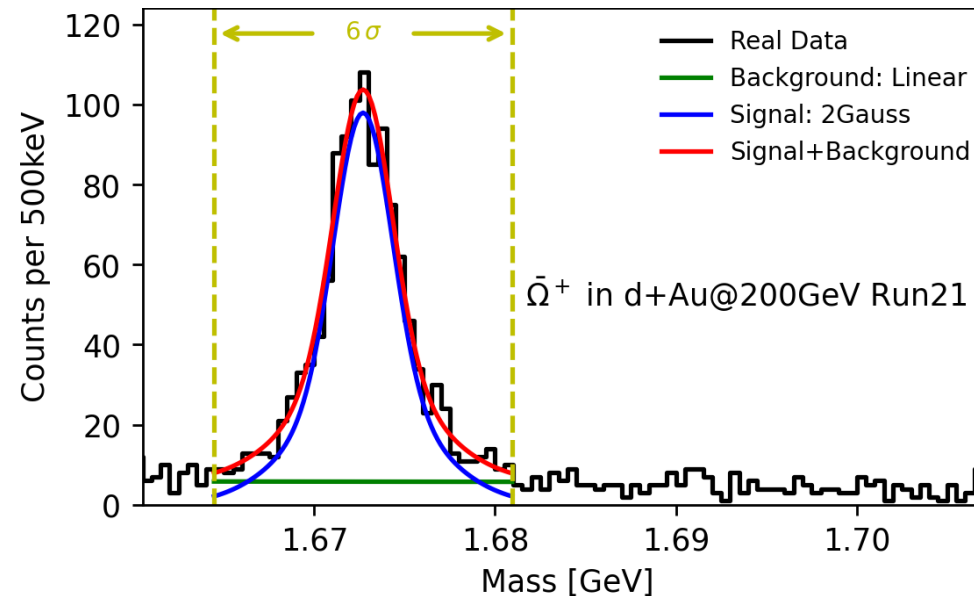
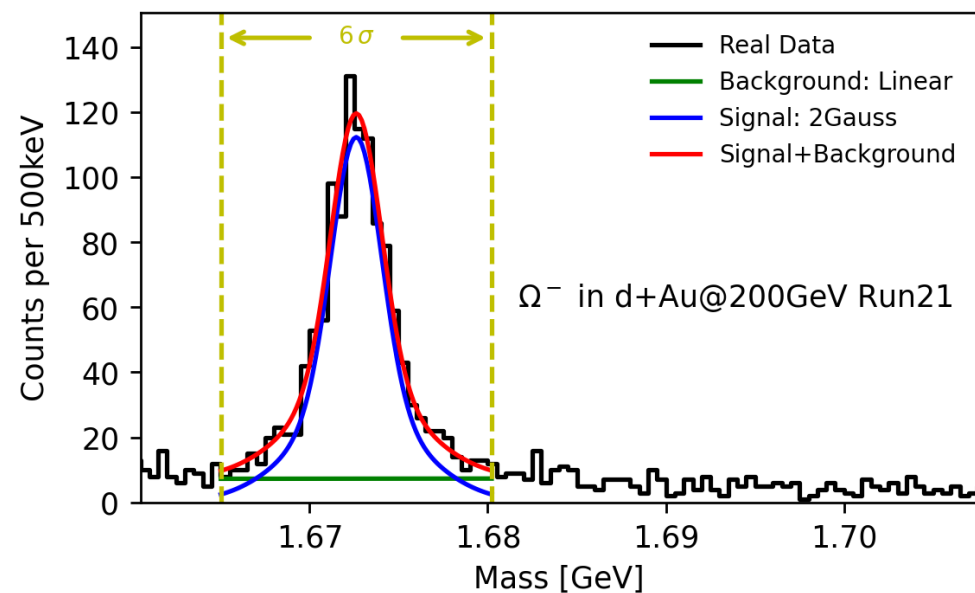
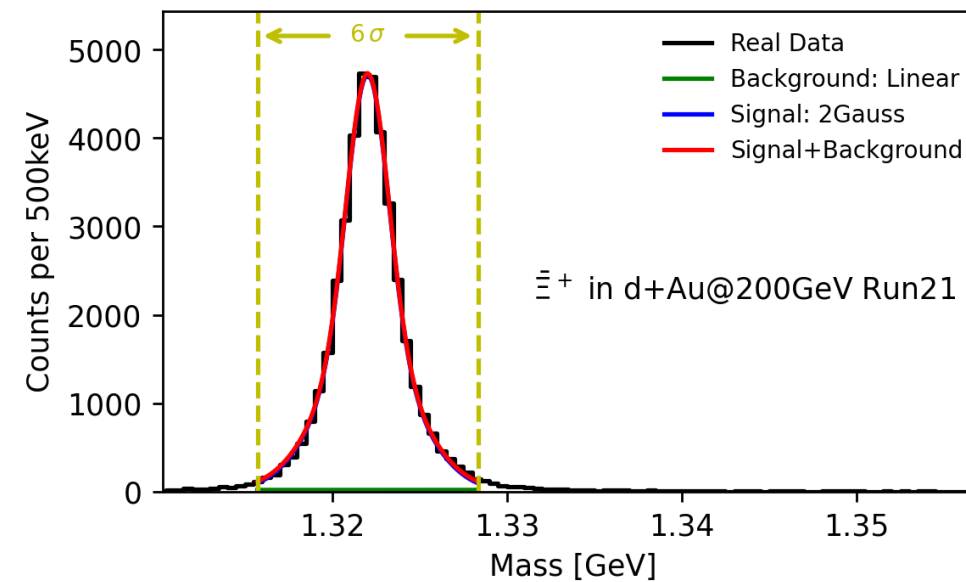
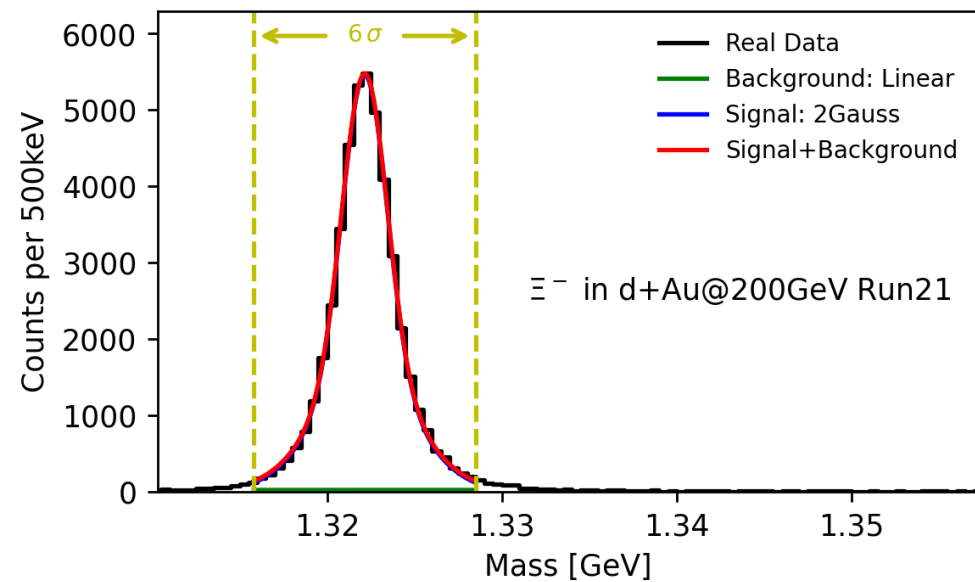
- KFParticle Package was used in d+Au@200GeV Run 21:
  - $\sigma_p, \sigma_K, \sigma_\pi < 3$
  - **DCA** between daughter particles **< 0.5 cm**
  - the **distance** to the primary vertex from the decay vertex **> 1.0 cm**



For more KFP introduction:

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

# Hyperon reconstruction in STAR data



Too low  $\Omega$  statistics



# AMPT Result

- p+Au@39GeV

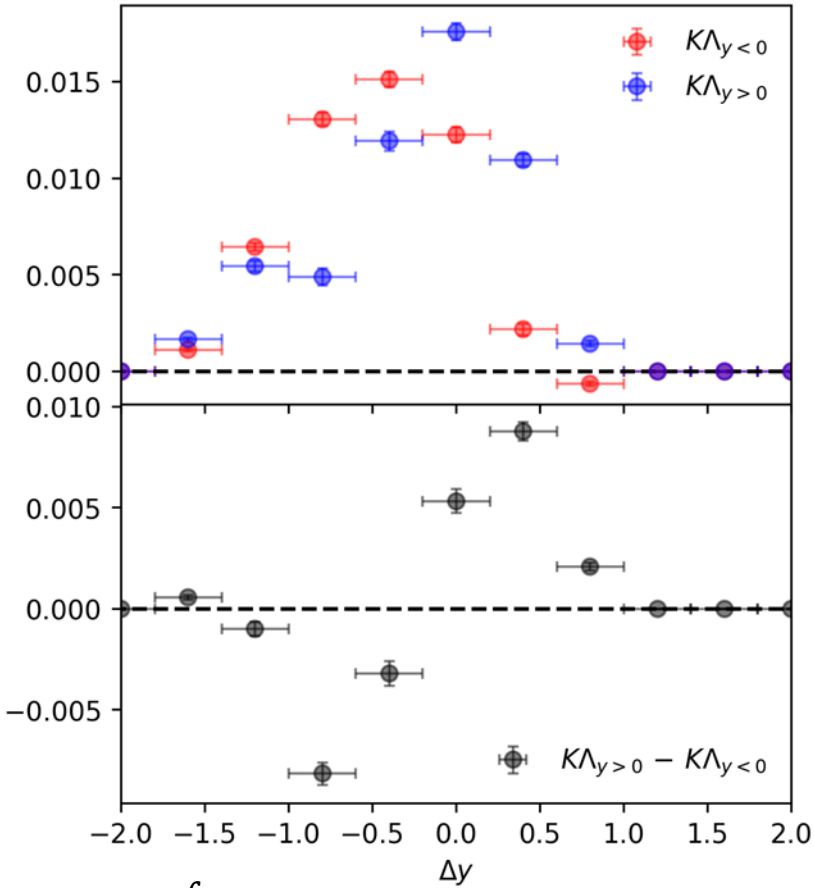
$$\Delta y = \theta(y_{\text{Hyperon}})(y_K - y_{\text{Hyperon}}) + \theta(-y_{\text{Hyperon}})(y_{\text{Hyperon}} - y_K)$$

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

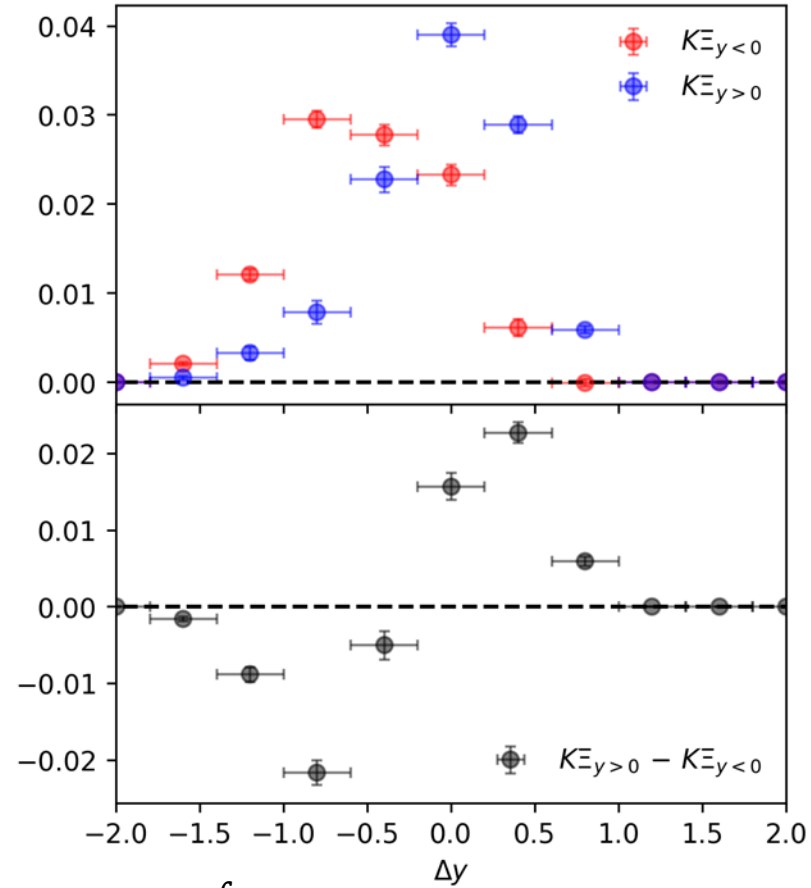
$$C_{K\Lambda}(\Delta y) = \frac{1}{N_\Lambda} \frac{dN_{K^+\Lambda}^{\text{pairs}}}{d\Delta y} - \frac{1}{N_{\bar{\Lambda}}} \frac{dN_{K^+\bar{\Lambda}}^{\text{pairs}}}{d\Delta y}$$

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

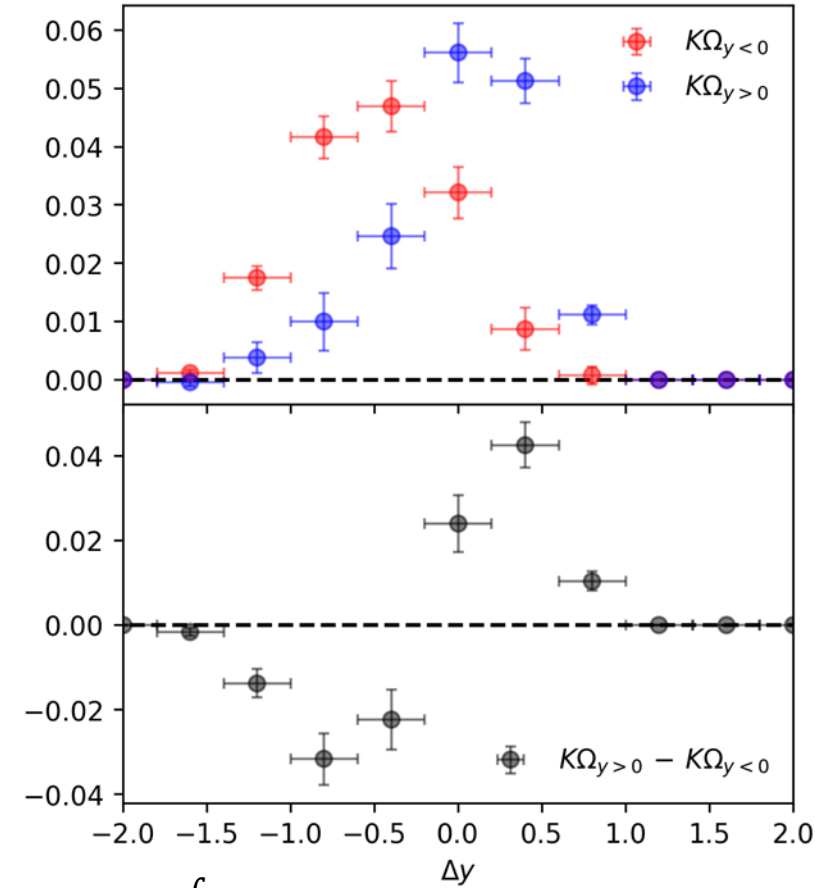
$$C_{K\Omega}(\Delta y) = \frac{1}{N_\Omega} \frac{dN_{K^+\Omega}^{\text{pairs}}}{d\Delta y} - \frac{1}{N_{\bar{\Omega}}} \frac{dN_{K^+\bar{\Omega}}^{\text{pairs}}}{d\Delta y}$$



$$\int C_{K\Lambda}(\Delta y) d\Delta y = 0.051 \pm 0.001$$



$$\int C_{K\Sigma}(\Delta y) d\Delta y = 0.104 \pm 0.002$$



$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.152 \pm 0.007$$

# AMPT Result

- p+Au@62GeV

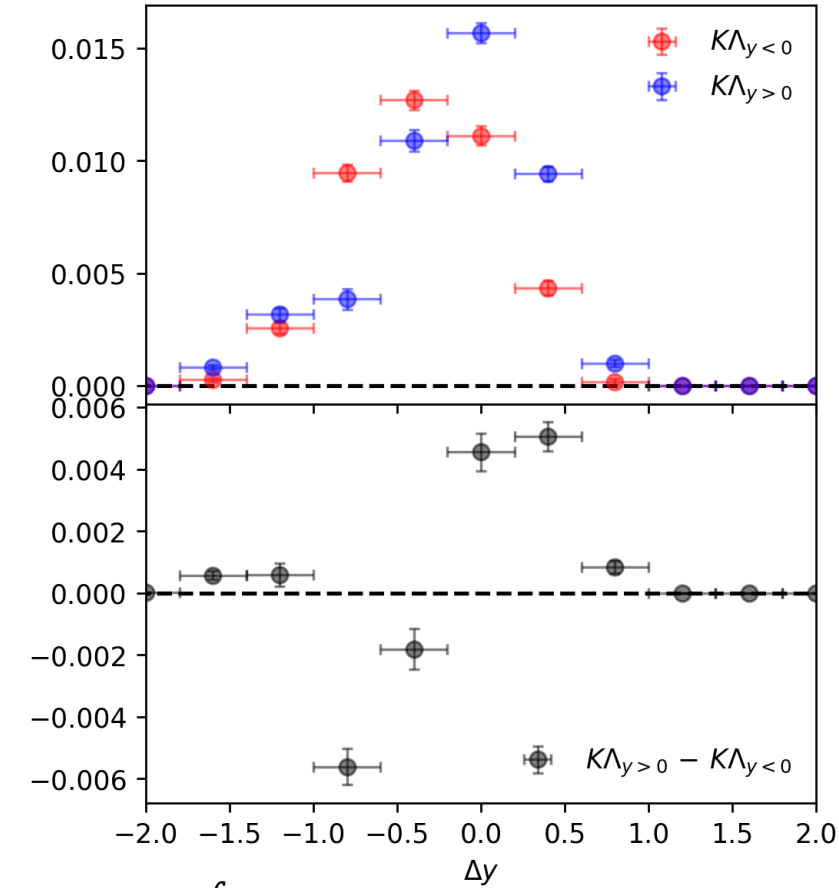
$$\Delta y = \theta(y_{\text{Hyperon}})(y_K - y_{\text{Hyperon}}) + \theta(-y_{\text{Hyperon}})(y_{\text{Hyperon}} - y_K)$$

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

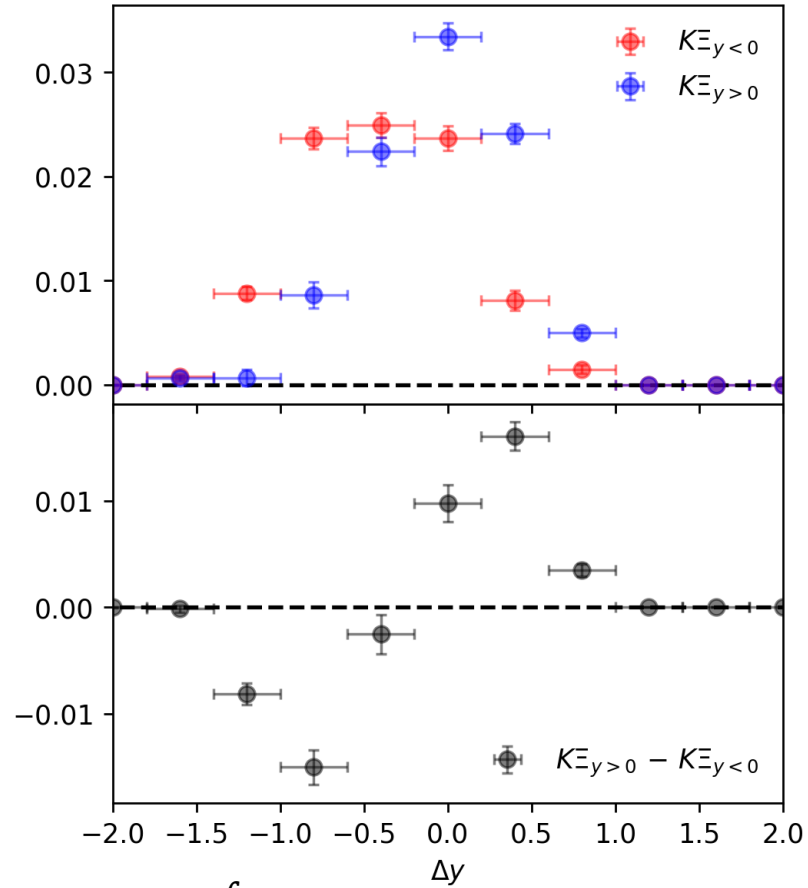
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$$C_{K\Sigma}(\Delta y) = \frac{1}{N_\Sigma} \frac{dN_{K^+\Sigma}^{\text{pairs}}}{d\Delta y} - \frac{1}{N_{\bar{\Sigma}}} \frac{dN_{K^+\bar{\Sigma}}^{\text{pairs}}}{d\Delta y}$$

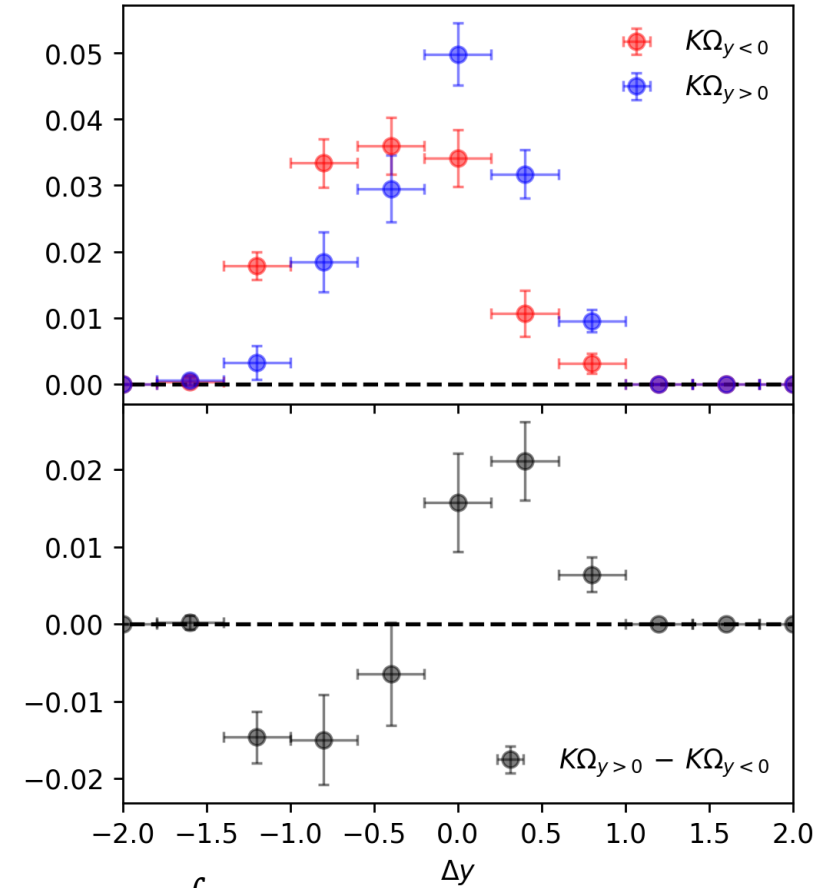
$$C_{K\Omega}(\Delta y) = \frac{1}{N_\Omega} \frac{dN_{K^+\Omega}^{\text{pairs}}}{d\Delta y} - \frac{1}{N_{\bar{\Omega}}} \frac{dN_{K^+\bar{\Omega}}^{\text{pairs}}}{d\Delta y}$$



$$\int C_{K\Lambda}(\Delta y) d\Delta y = 0.042 \pm 0.001$$



$$\int C_{K\Sigma}(\Delta y) d\Delta y = 0.093 \pm 0.002$$



$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.138 \pm 0.006$$

# AMPT Result

- d+Au@200GeV

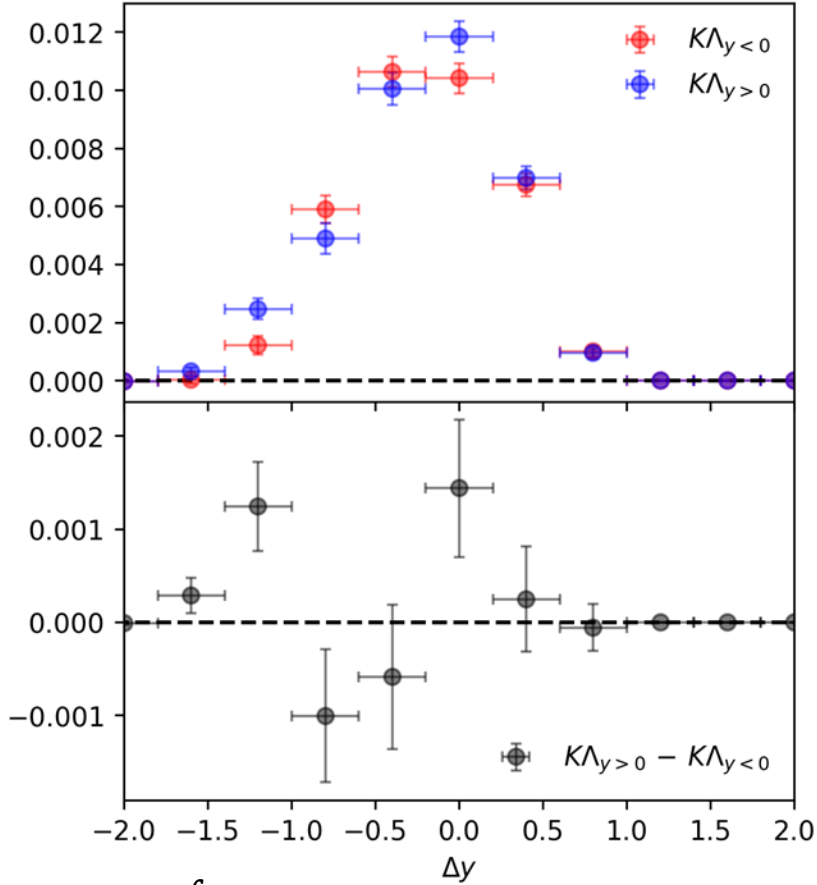
$$\Delta y = \theta(y_{\text{Hyperon}})(y_K - y_{\text{Hyperon}}) + \theta(-y_{\text{Hyperon}})(y_{\text{Hyperon}} - y_K)$$

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

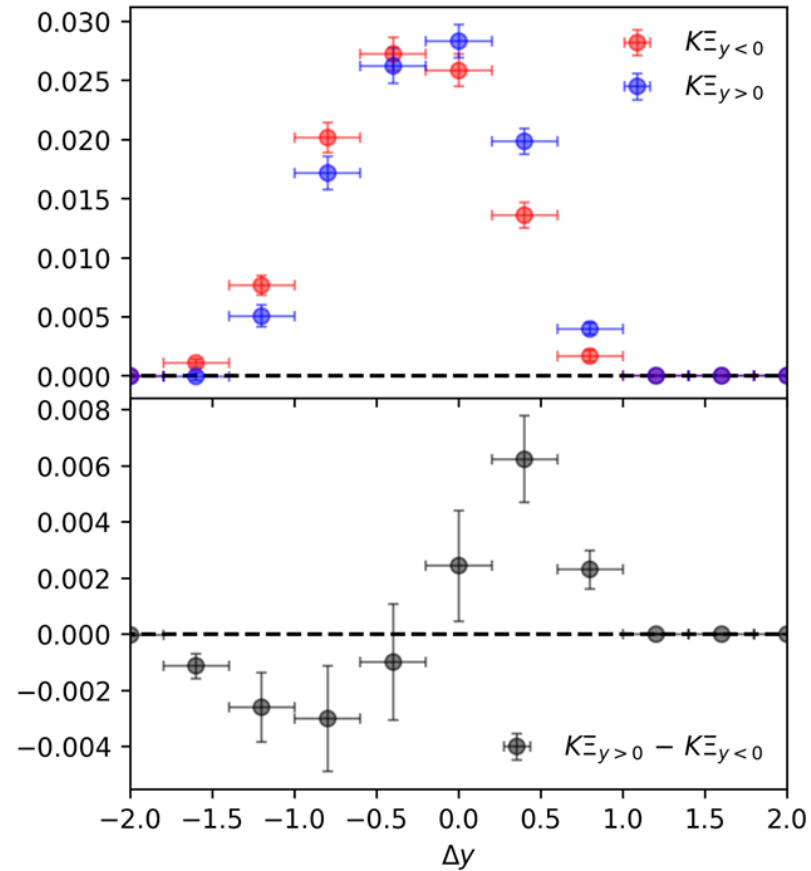
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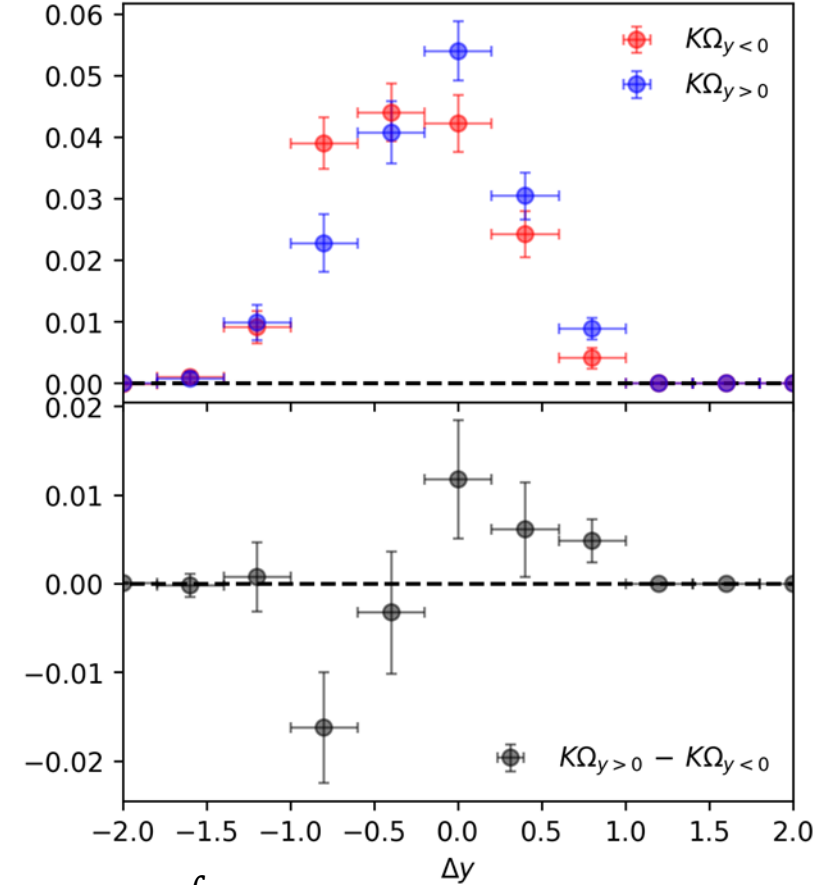
$$C_{K\Omega}(\Delta y) = \frac{1}{N_\Omega} \frac{dN_{K^+\Omega}^{\text{pairs}}}{d\Delta y} - \frac{1}{N_{\bar{\Omega}}} \frac{dN_{K^+\bar{\Omega}}^{\text{pairs}}}{d\Delta y}$$



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



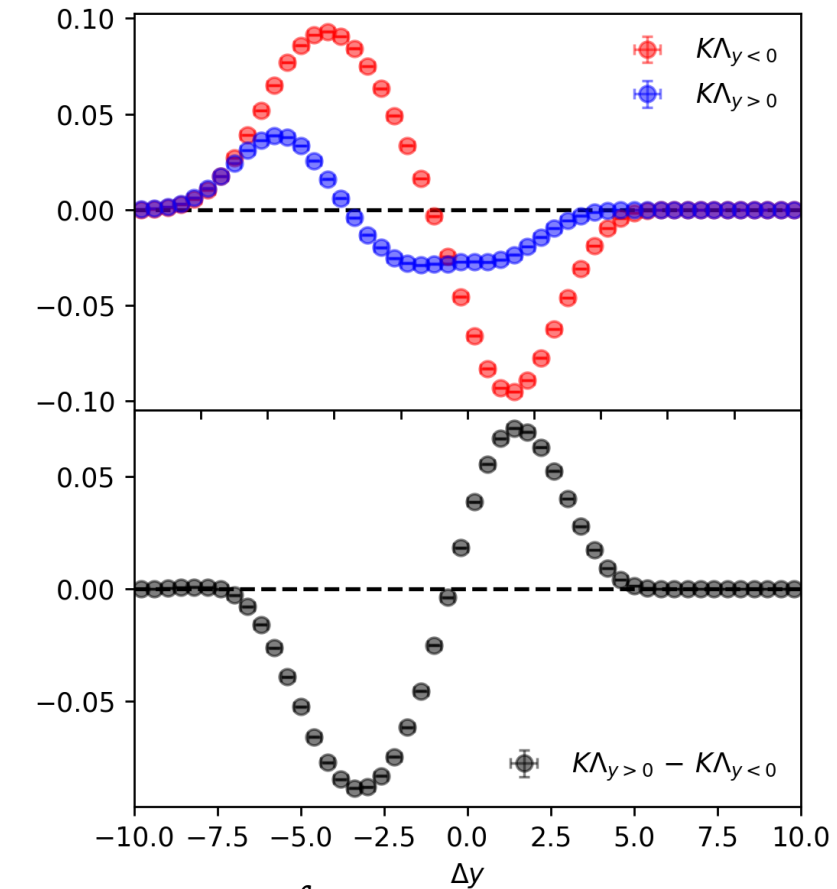
$$\int C_{K\Sigma}(\Delta y) d\Delta y = 0.099 \pm 0.002$$



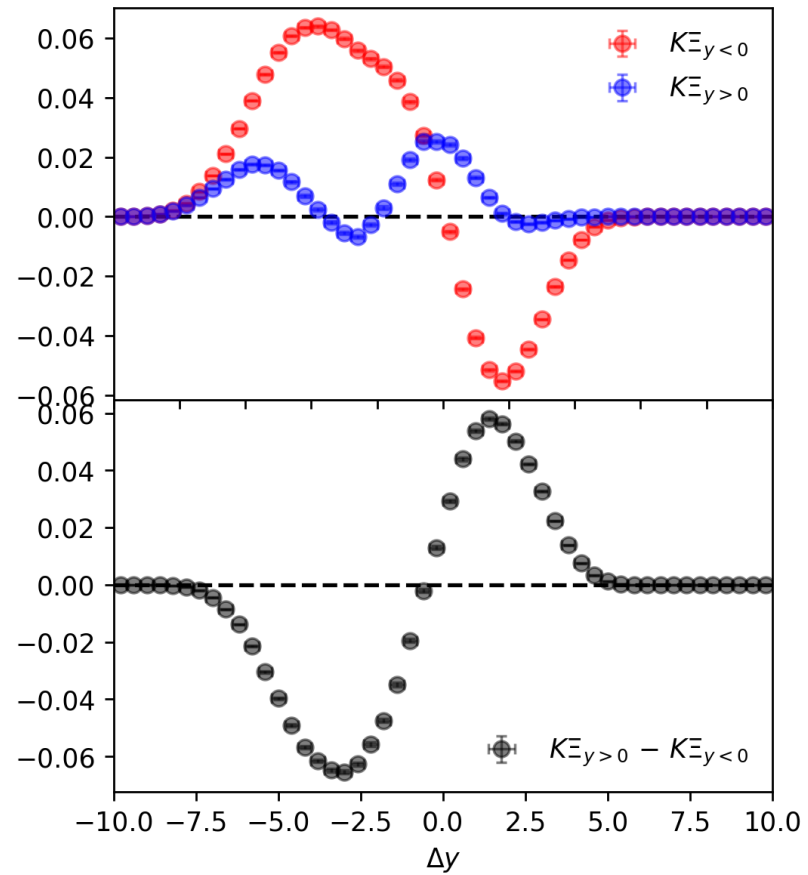
$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.166 \pm 0.007$$

# AMPT Result

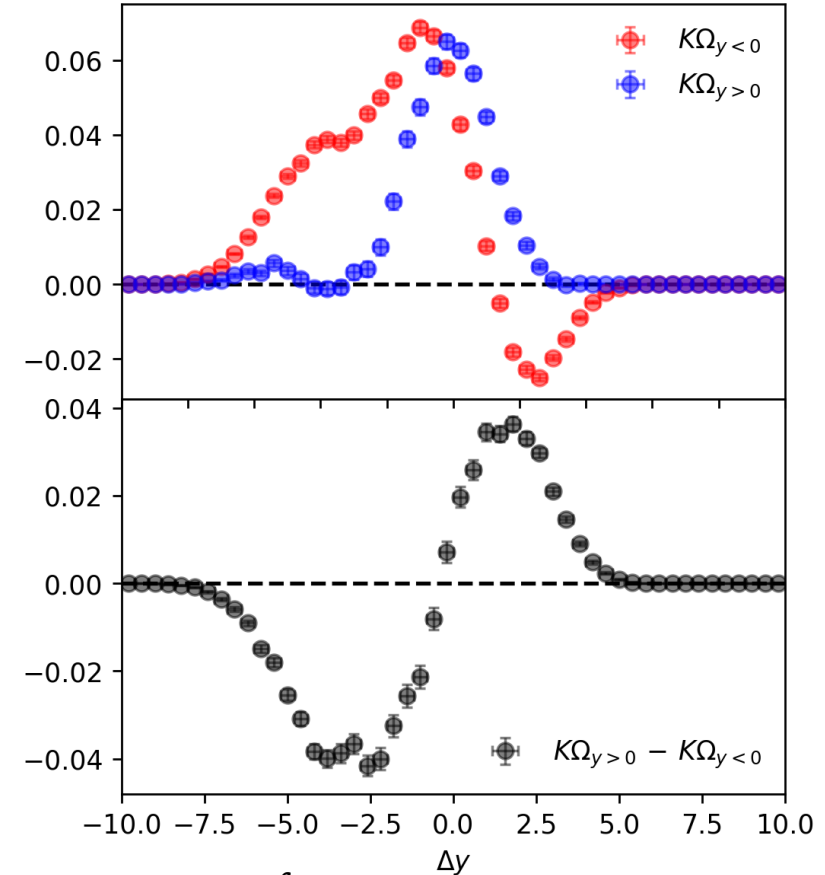
- d+Au@200GeV Full Acceptance, estimate the detector acceptance effects in preparation for STAR data analysis



$$\int C_{K\Lambda}(\Delta y) d\Delta y = 0.174 \pm 0.000$$



$$\int C_{K\Xi}(\Delta y) d\Delta y = 0.417 \pm 0.001$$



$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.619 \pm 0.005$$

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

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

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

# Summary and Outlook

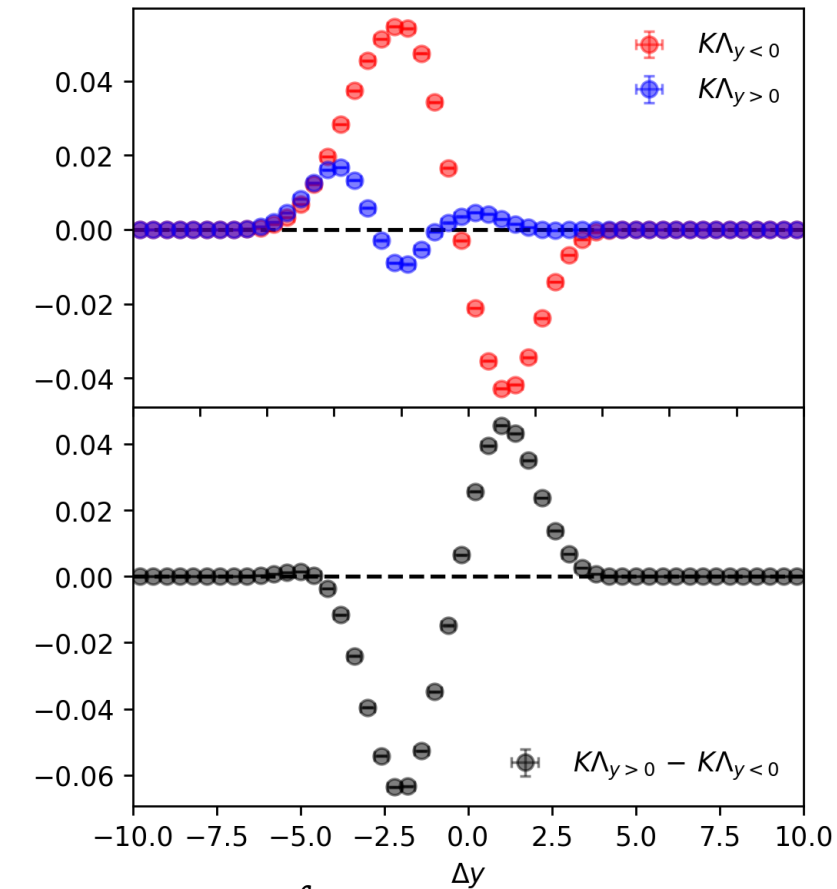
- p(d)+A collision:
  - A new way to study possible baryon junction interactions
- Hyperon-Kaon correlation:
  - Sensitive probe of baryon number transport dynamics
- AMPT simulation:
  - StringMelting version
  - Hyperons with positive rapidity correlate faster emitted Kaons
    - A hint of baryon junction?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

Thank you!

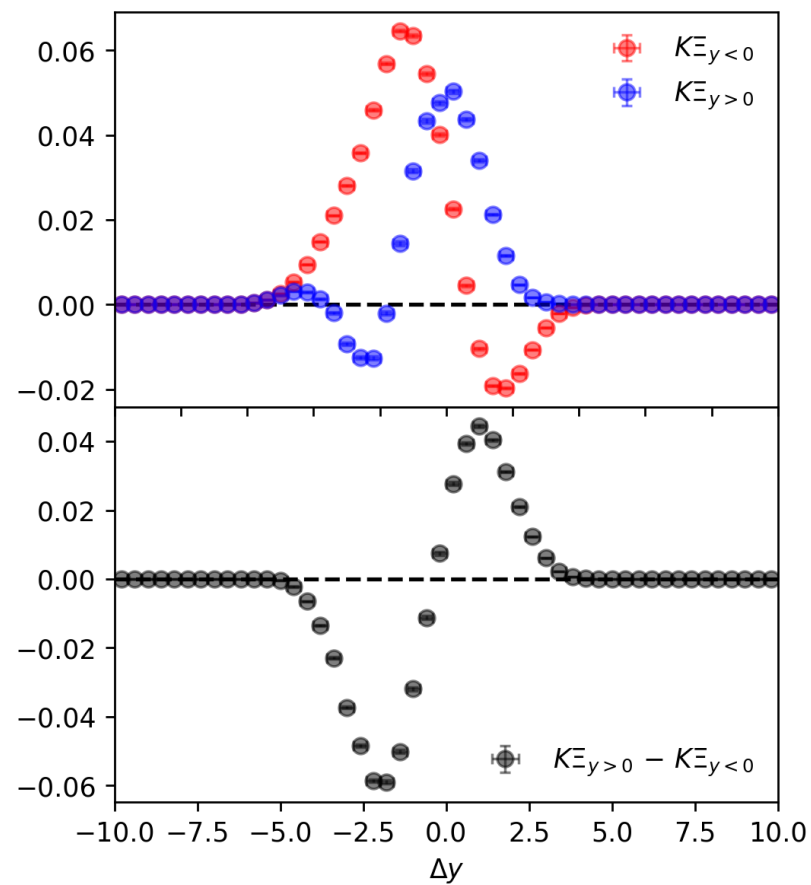
# Back Up

# AMPT Result

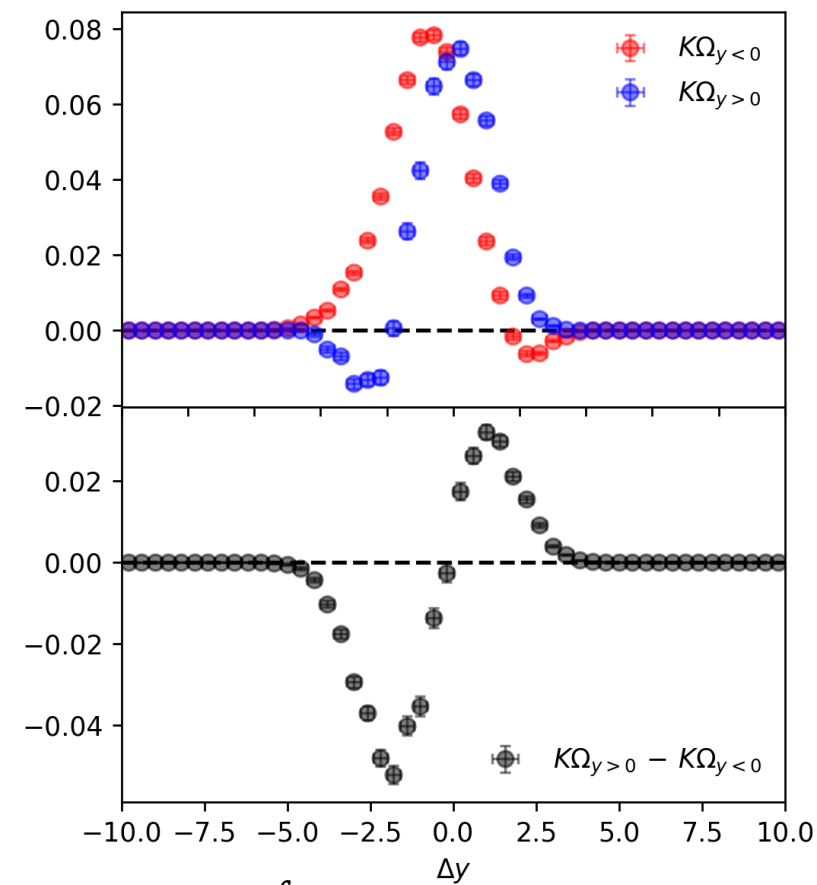
- p+Au@39GeV Full Acceptance



$$\int C_{K\Lambda}(\Delta y) d\Delta y = 0.172 \pm 0.000$$



$$\int C_{K\Xi}(\Delta y) d\Delta y = 0.373 \pm 0.001$$



$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.536 \pm 0.003$$

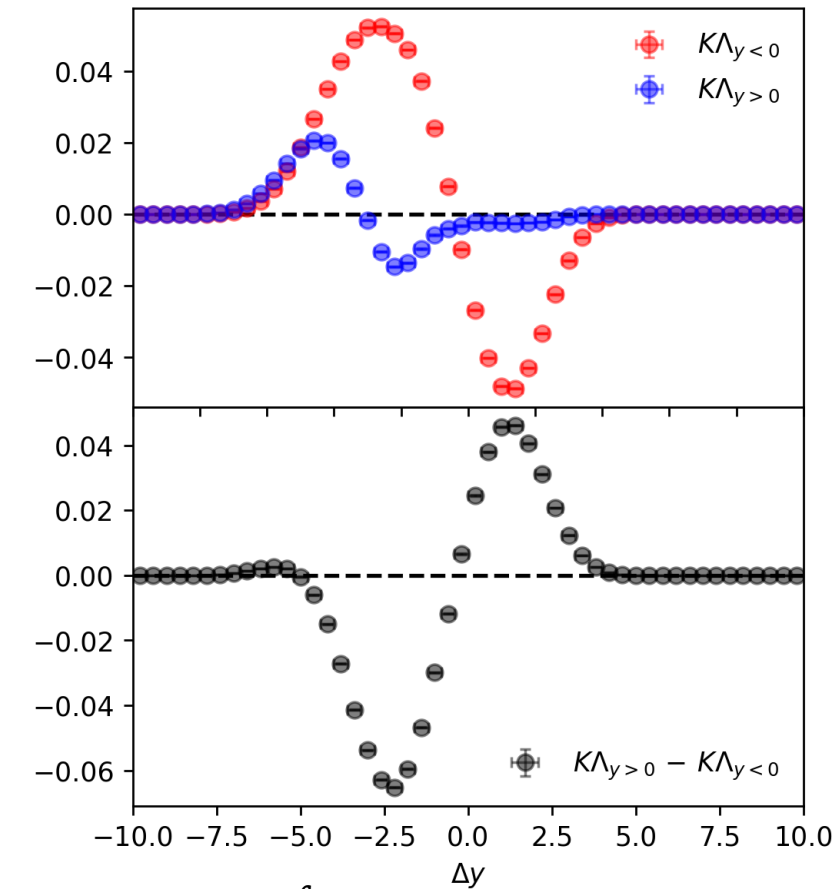
STAR Acceptance:  $\int C_{K\Lambda}(\Delta y) d\Delta y = 0.051 \pm 0.001$

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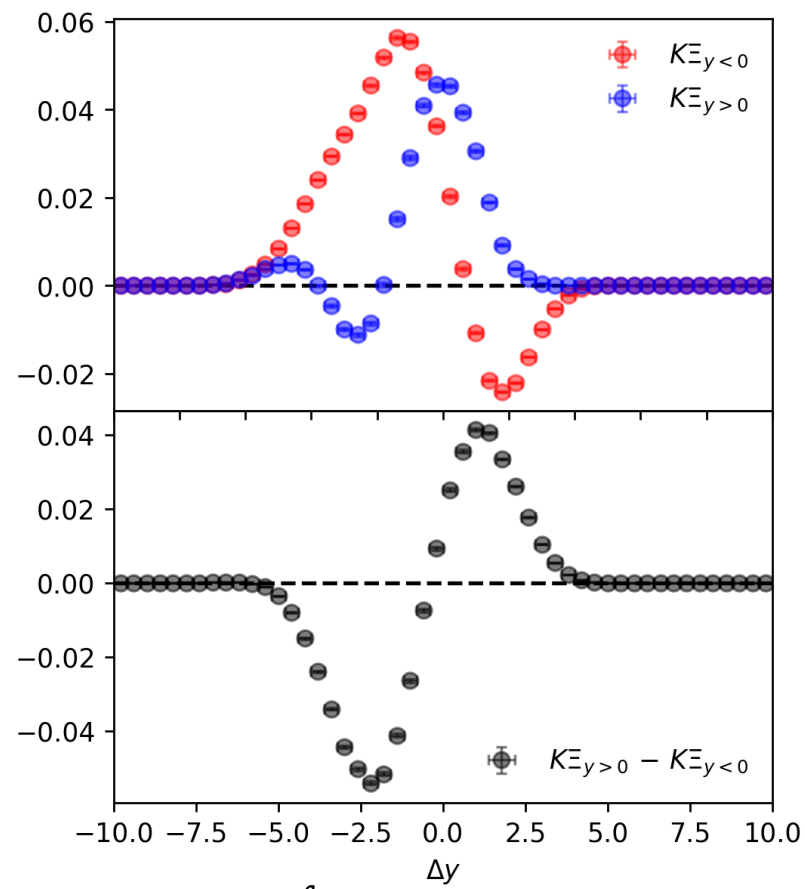
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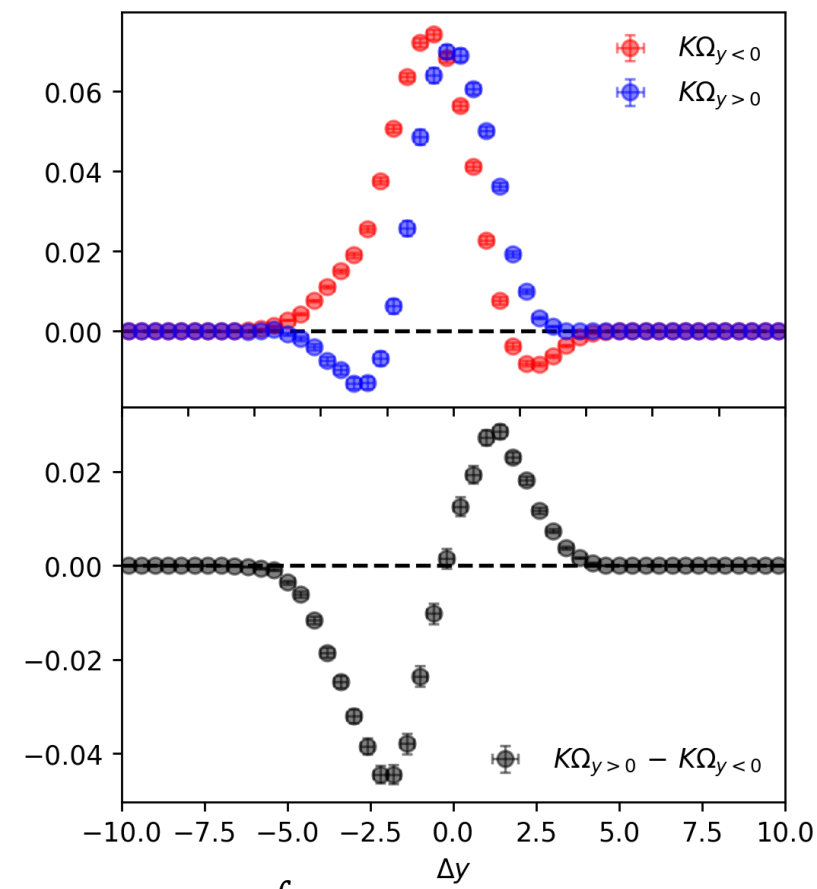
- p+Au@62GeV Full Acceptance



$$\int C_{K\Lambda}(\Delta y) d\Delta y = 0.153 \pm 0.000$$



$$\int C_{K\Xi}(\Delta y) d\Delta y = 0.367 \pm 0.001$$



$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.525 \pm 0.003$$

STAR Acceptance:  $\int C_{K\Lambda}(\Delta y) d\Delta y = 0.042 \pm 0.001$

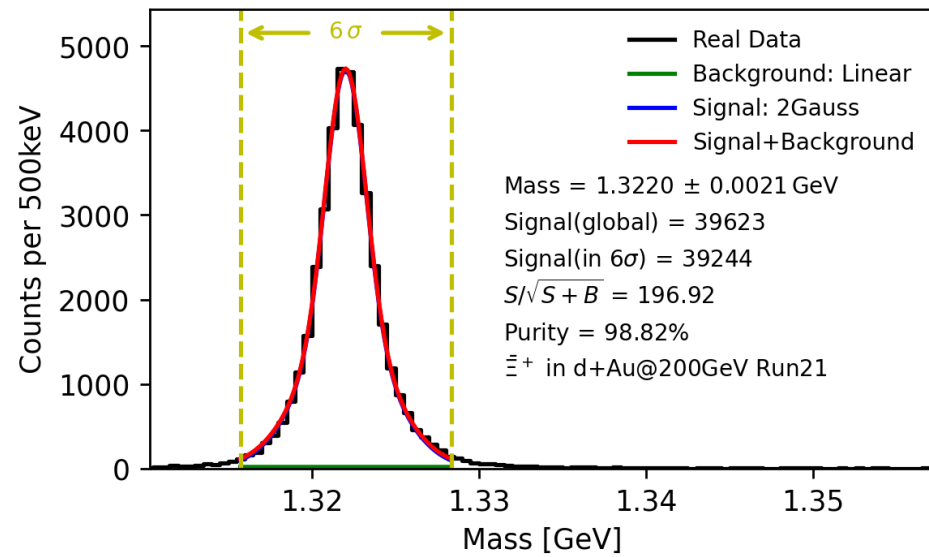
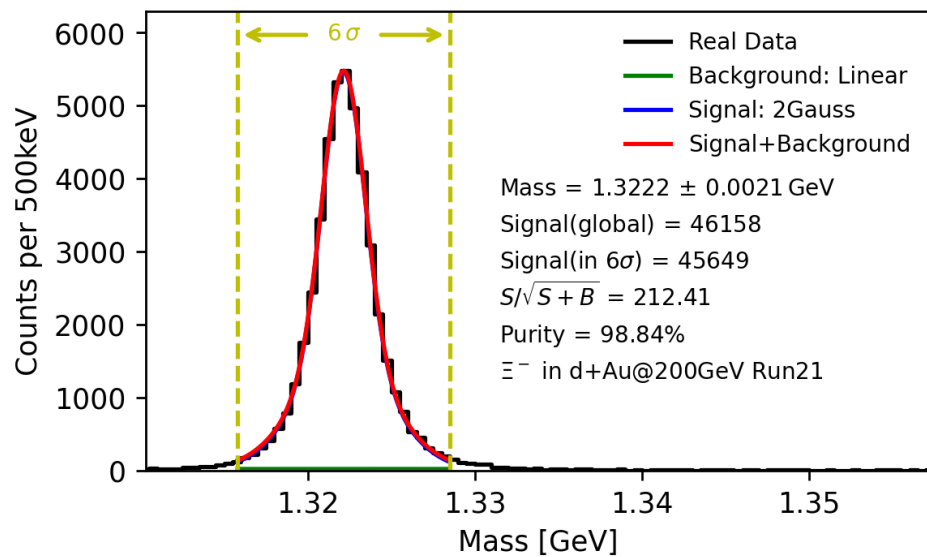
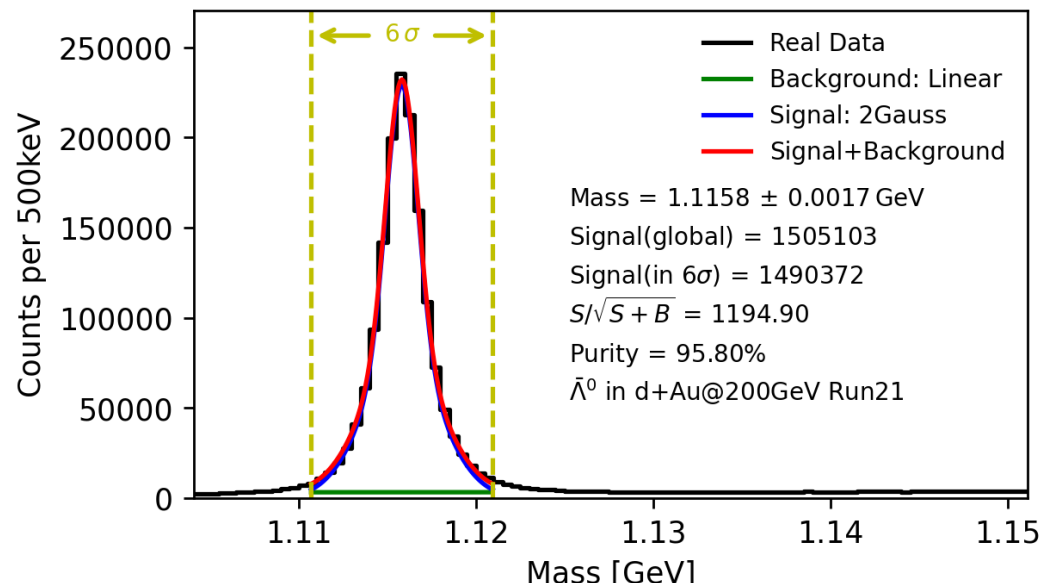
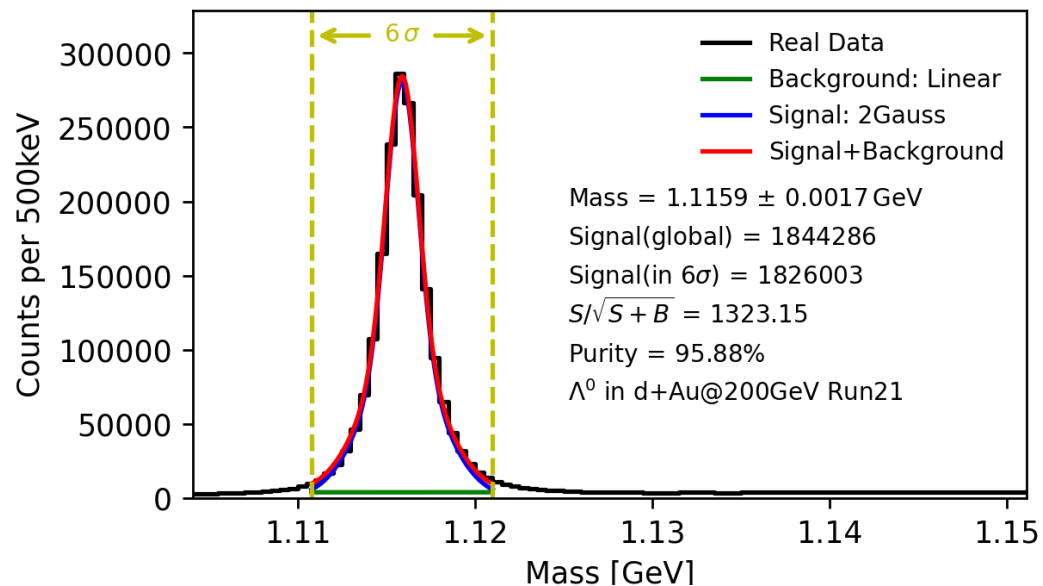
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$$\int C_{K\Omega}(\Delta y) d\Delta y = 0.138 \pm 0.006$$



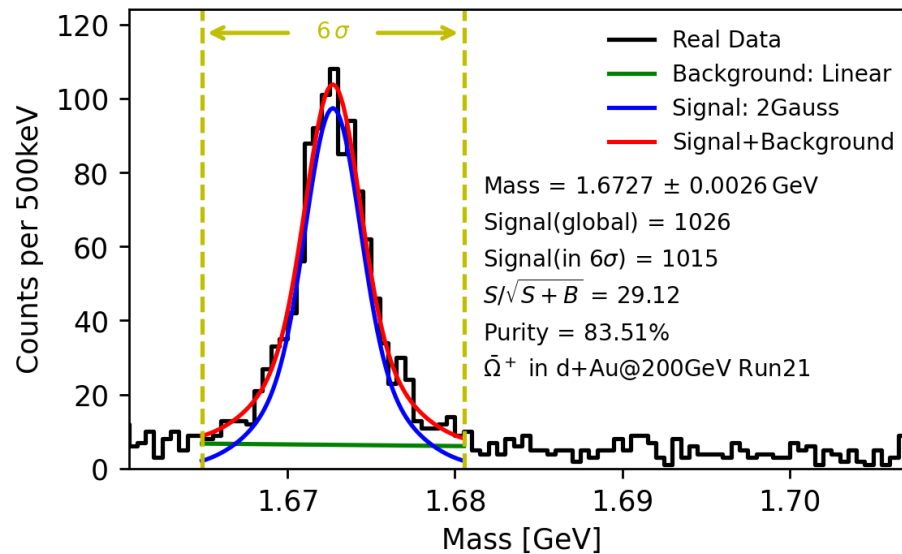
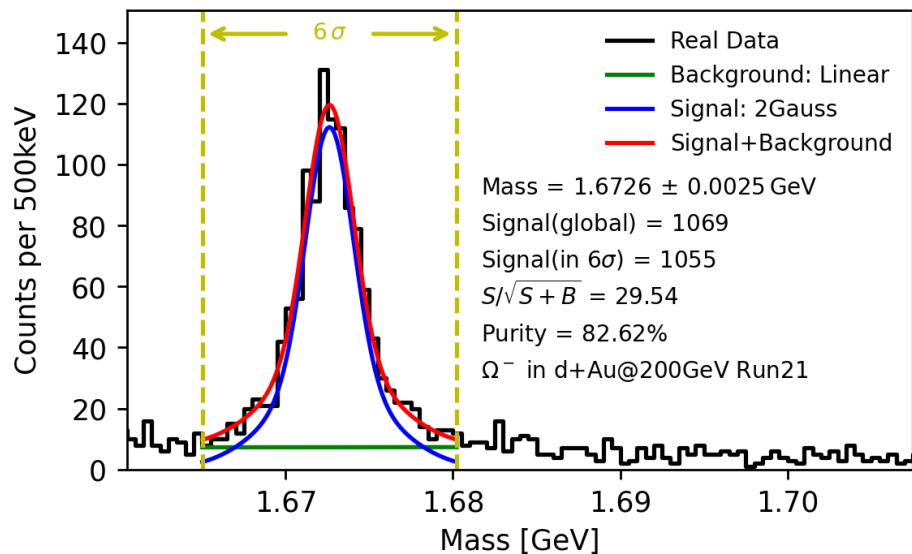
# Hyperon reconstruction in STAR data

- KFParticle Package was used to reconstruct hyperons:



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Too low  $\Omega$  statistics

