# KFParticle for reconstruction of Λ anisotropic flow in the MPD experiment

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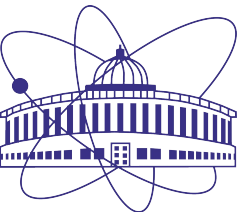
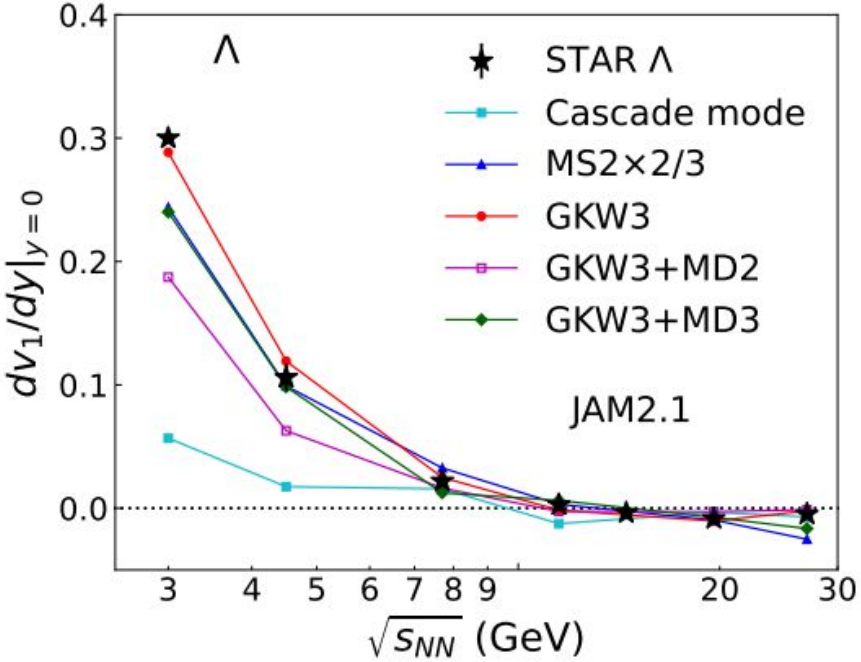


# Outline

- Motivation
- Reconstruction and selection
- Comparison and results
- Summary and Outlook

# Motivation

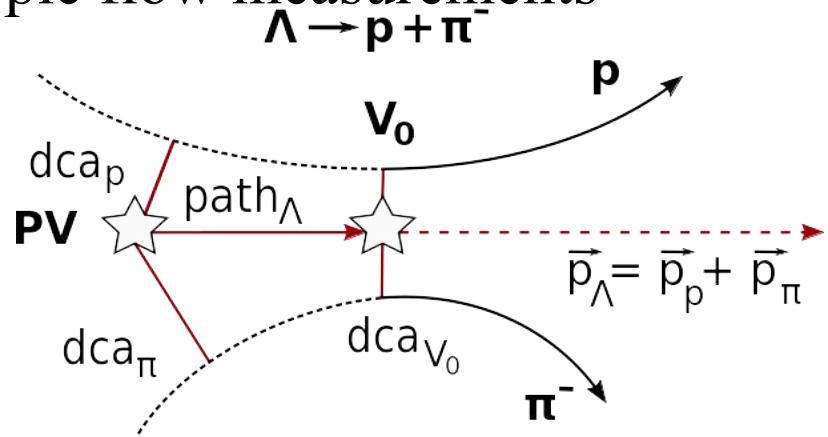



Yasushi Nara et al. *Phys.Rev.C* 106 (2022) 4, 044902

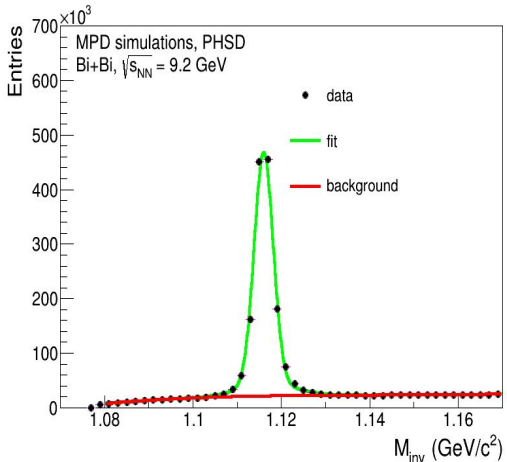
- Λ potential is important to explanation of existence of two-solar-mass neutron stars
- Constrained by $v_1$
- Models cannot fully describe anisotropic flow for NICA energy range
- Best agreement with model includes interactions with hyperons

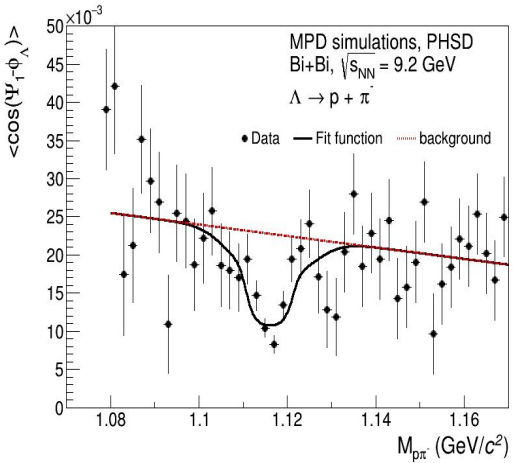
# Λ hyperon reconstruction and anisotropic flow measurements

1. Track selection
2. Build Λ from p and $\pi^-$
3. Selection of Λ candidates
4. Fitting the $m_{inv}$ distributions
5. Fitting $v_n$ as a function of $m_{inv}$




$$v_n^{SB}(m_{inv}, p_T) = v_n^S(p_T)\frac{N^S(m_{inv},p_T)}{N^{SB}(m_{inv},p_T)} + v_n^B(m_{inv}, p_T)\frac{N^B(m_{inv},p_T)}{N^{SB}(m_{inv},p_T)}$$

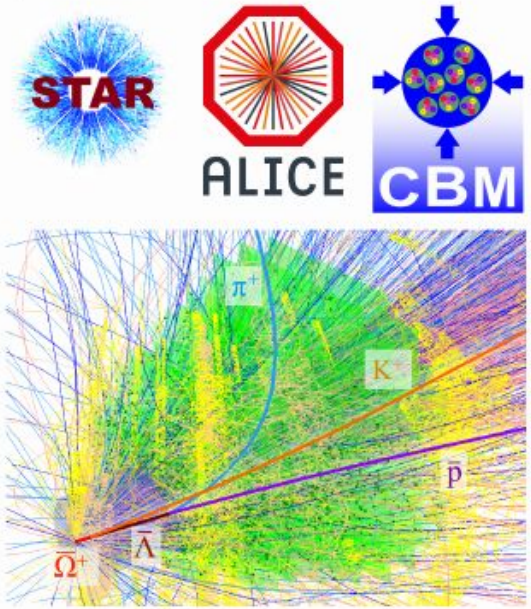



- PV — primary vertex
- $V_0$ — vertex of hyperon decay
- dca — distance of closest approach
- path — decay length

# KFParticle formalism

## Particles in heavy-ion collision:



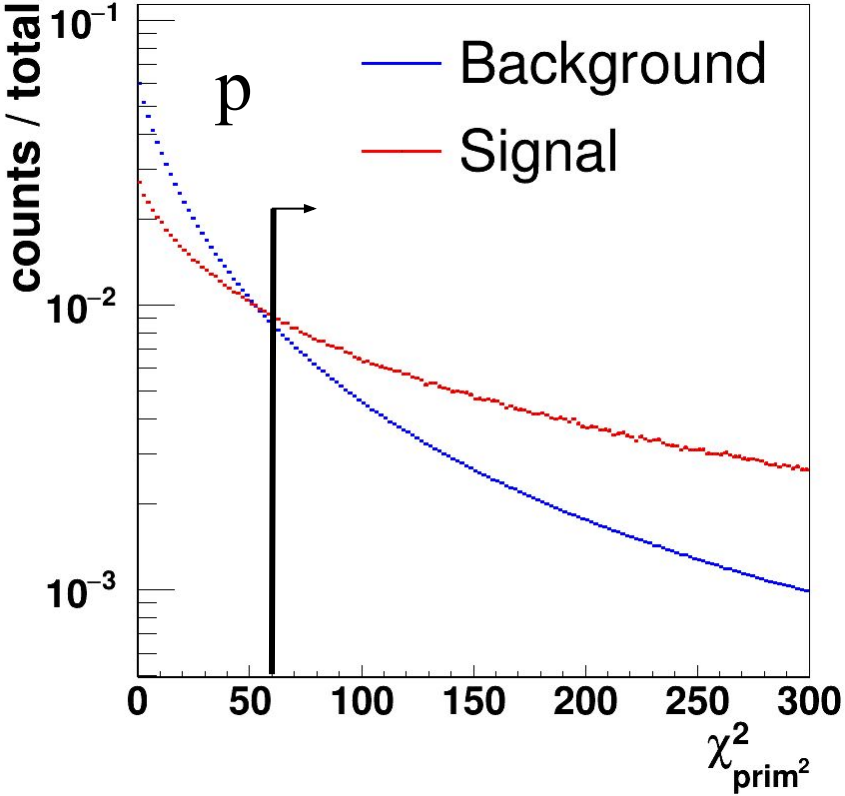

## KFParticle:

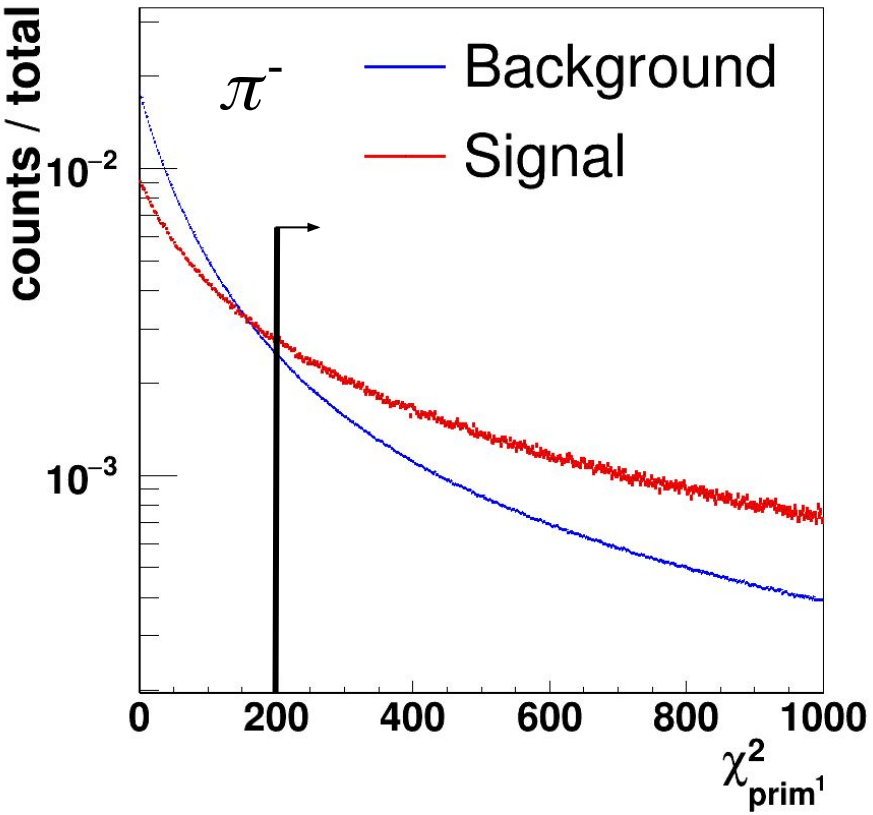
- developed for complete reconstruction of short-lived particles with their $P$, $E$, $m$, $c\tau$, $L$, $Y$

## Main benefits:

- based on the Kalman filter mathematics
- idependent in sense of experimental setup (collider, fixed target)
- allows one reconstruction of decay chains (cascades)
- daughter and mother particles are described and considered the same way
- daughter particles are added to the mother particle independently

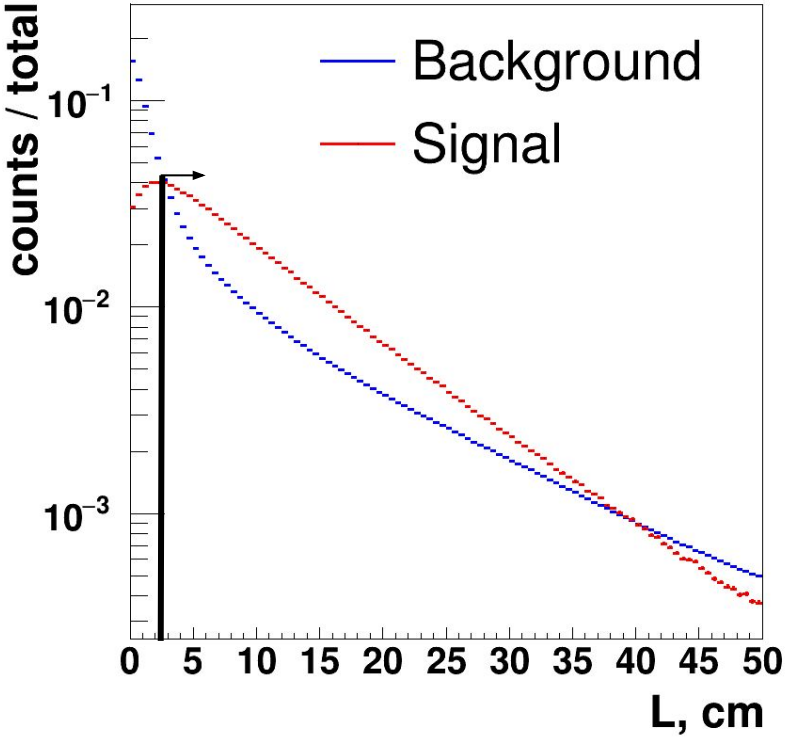
# $\chi^2$ of daughters to primary vertex in PHSD model

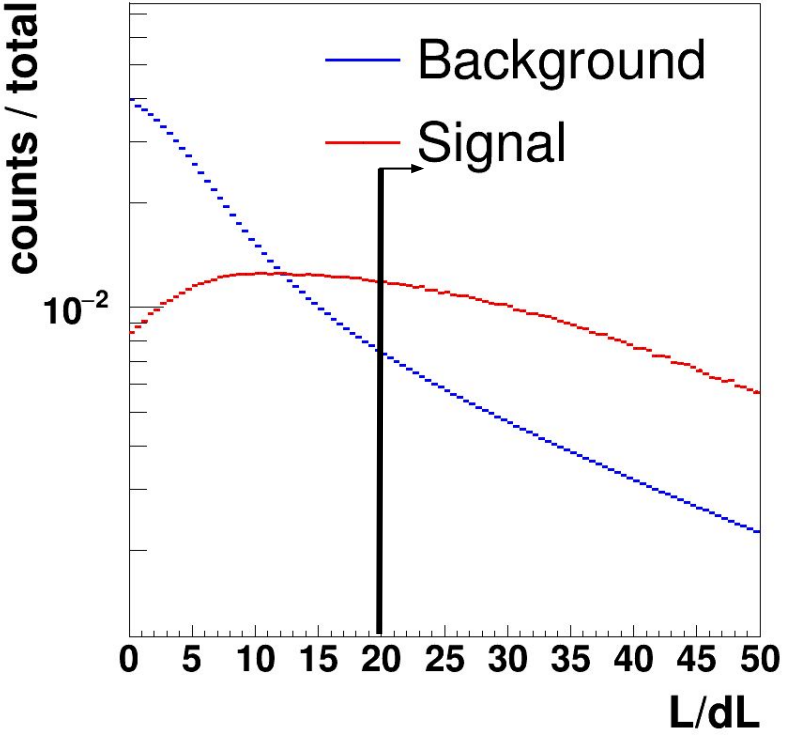



Most of the background created by primary tracks

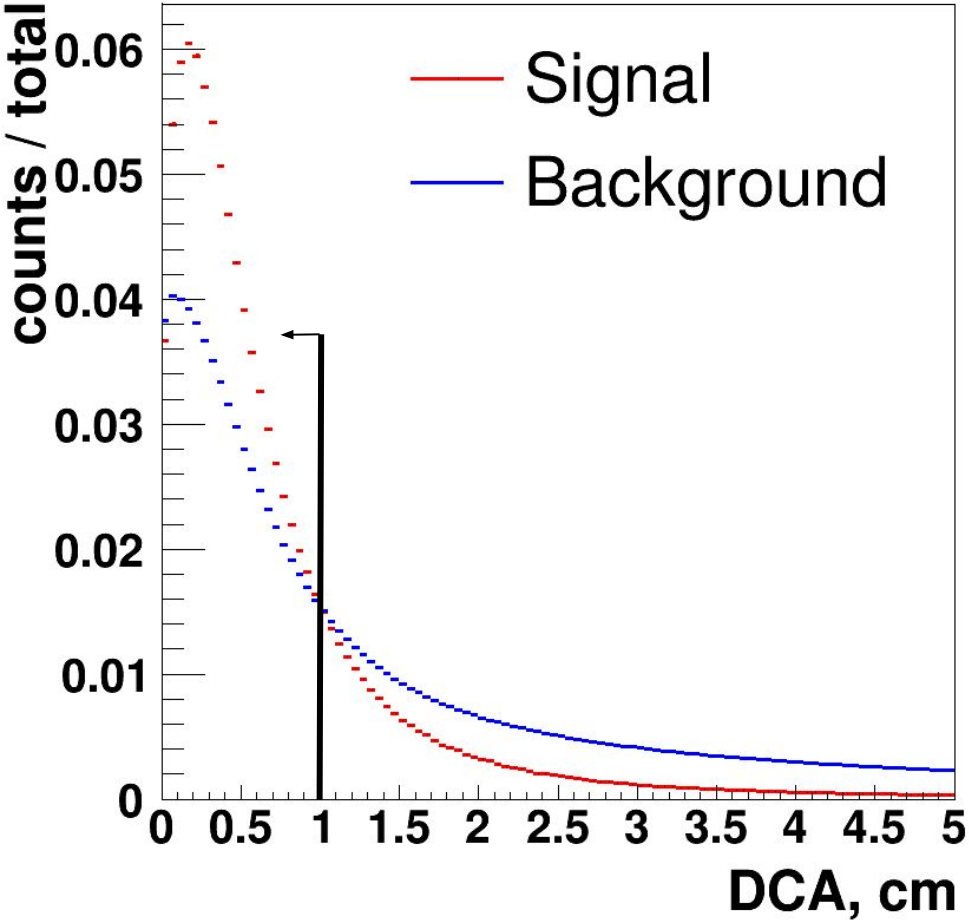
# Length of interpolated track from secondary to primary vertex



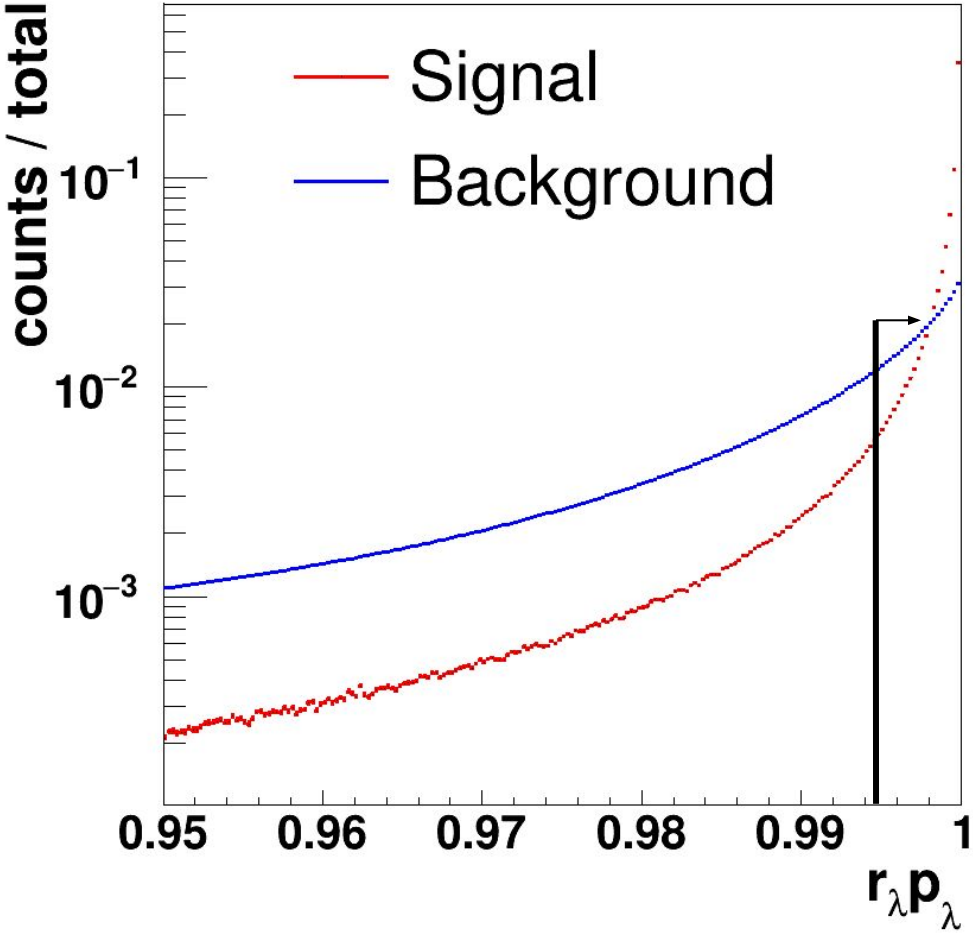

Most of the background created by candidates “decayed” near primary vertex

# Distance between daughter tracks in their closest approach



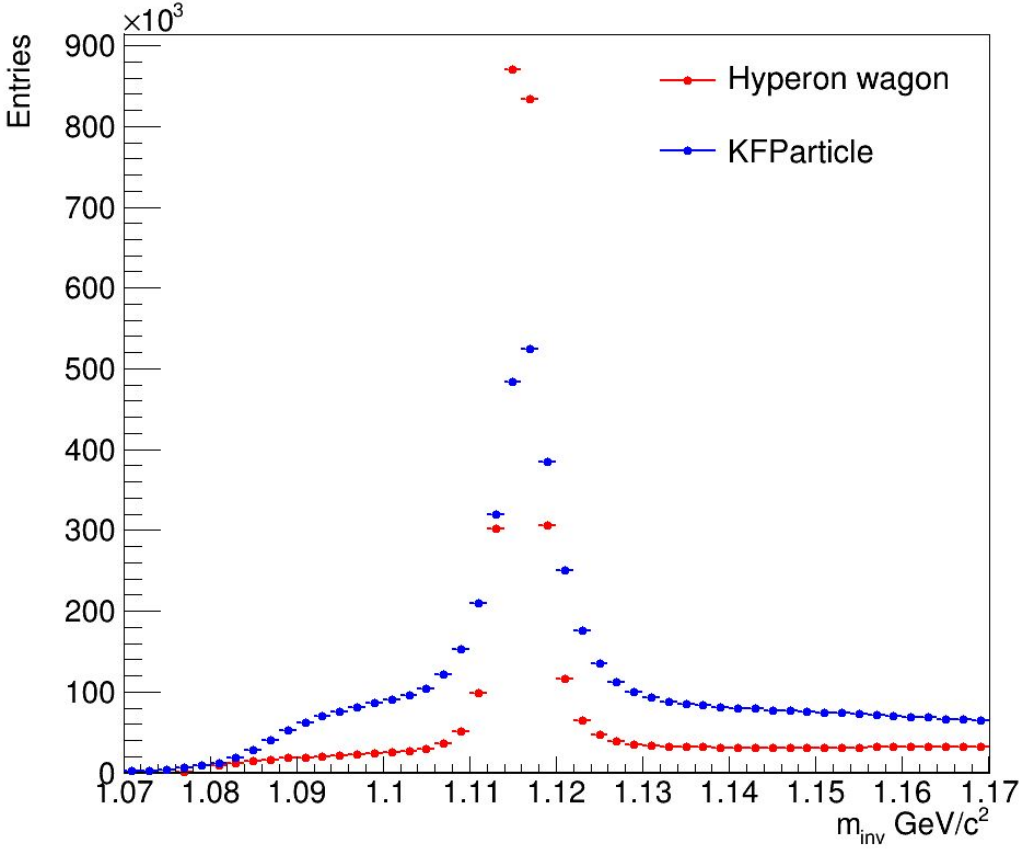

Most of the background created by candidates with daughters with large distance between them

# Cosine of the angle between mother's momentum and radius vector




Quality cut on mother particle: the momentum and radius vector from primary vertex to secondary vertex should be close to the same direction

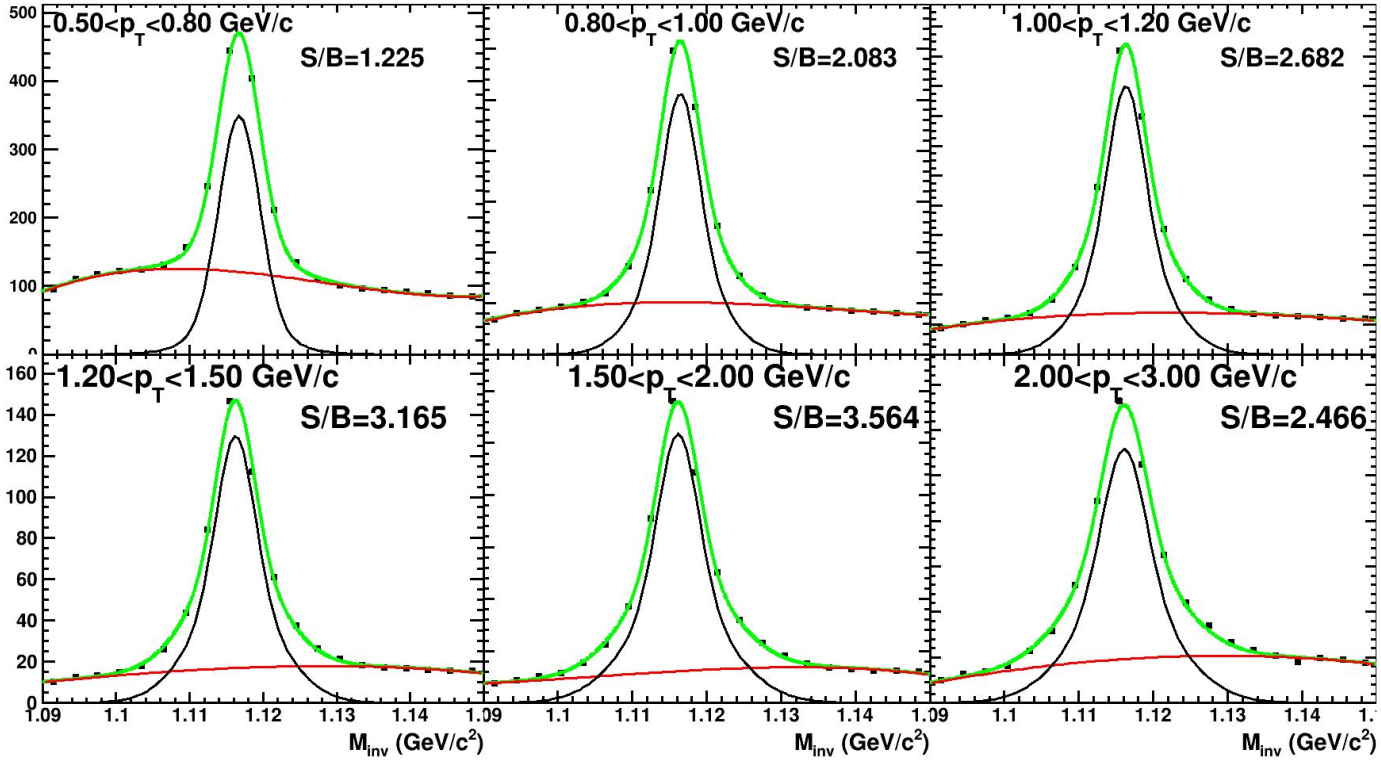
# Comparison between MPD Hyperon wagon and KFParticle




| | Hyperon wagon $\omega_2 = \ln \frac{\sqrt{\chi_\pi^2 \chi_p^2}}{\chi_\Lambda^2 + \chi_{V_0}^2}$ | KFParticle<br><br>Plenty of cuts |
|---|---|---|
| S/B | 12.34 | 2.11 |
| S | $6.17*10^6$ | $6.45*10^6$ |
| σ | 0.002 | 0.0036 |

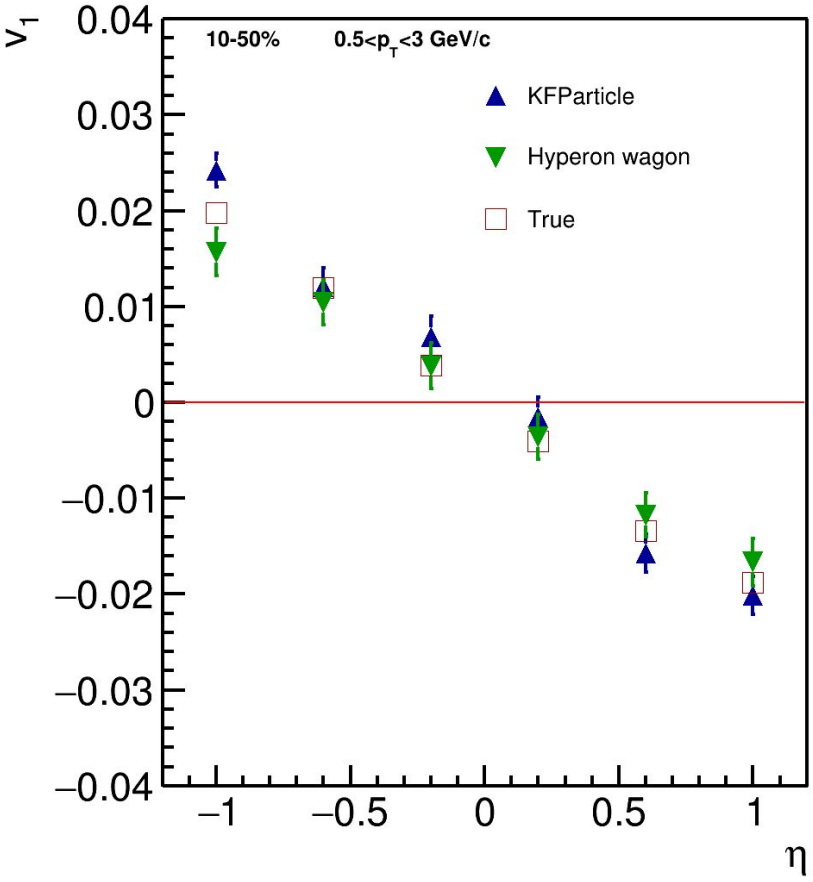
Refit of daughters with mass hypothesis is not conducted in KFParticle at this moment, that might worsen S/B ratio

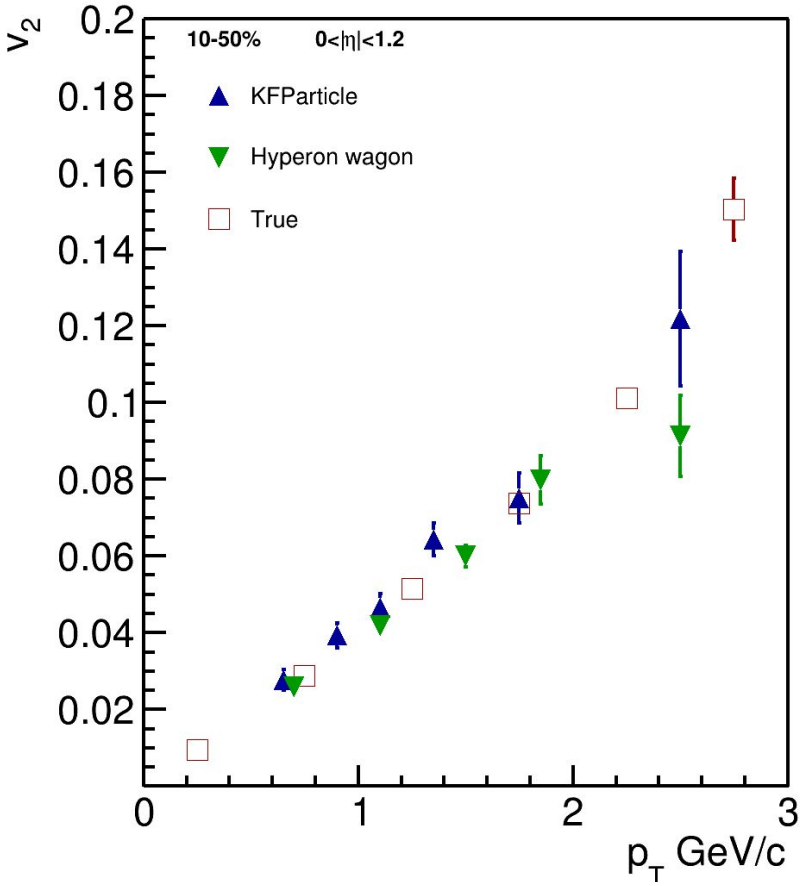
# Fitting the $m_{inv}$ distributions of $\Lambda$ in $p_T$ bins




Fitted by 2 gaus functions + 5-degree polynomial
Good fit quality for all bins

# $v_1(\eta)$ and $v_2(p_T)$ of $\Lambda$ for Bi+Bi at 9.2 GeV in PHSD model

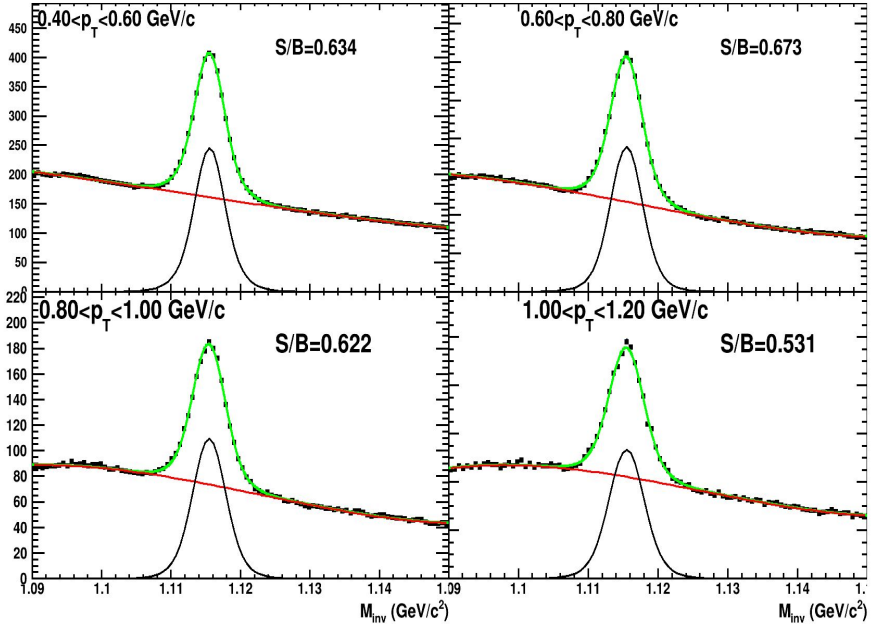


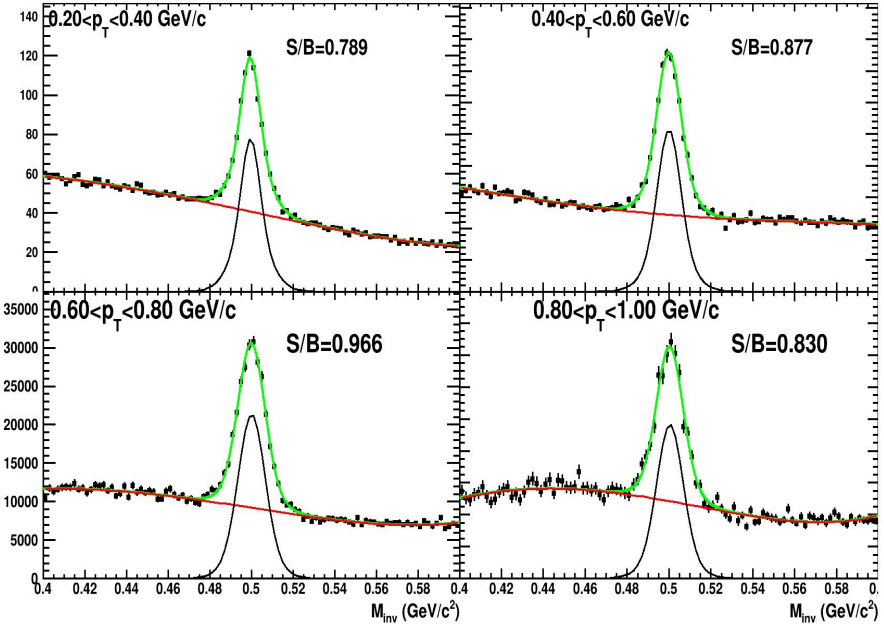

Hyperon wagon and KFParticle provides good agreement with Monte-Carlo and each other

# Fitting the $m_{inv}$ distributions of Λ and $K^0_S$ in $p_T$ bins in BM@N Xe+Cs(I) at 3.26 GeV

Λ hyperons

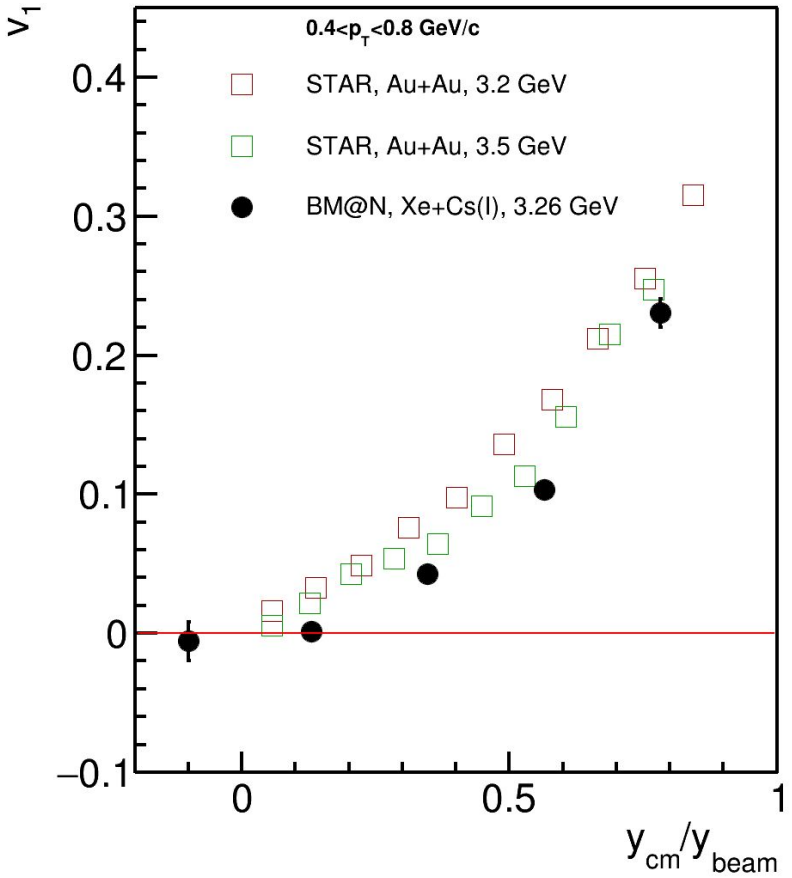



$K^0_S$ mesons




KFParticle provides good peak quality in experimental data

# $v_1(y)$ of Λ for STAR Preliminary Au+Au at 3.2 and 3.5 GeV and BM@N Xe+Cs(I) at 3.26 GeV




Centrality: 5-40%
$p_T$: 0.4-0.8 GeV/c

The results are systematically lower, maybe because of the difference in system of the collision

# Summary

- KFParticle for Λ reconstruction and selection for anisotropic flow is used
- Comparison with Hyperon wagon is shown
  - Peak is wider with KFParticle probably because the mass hypothesis is not used.
  - Comparison between procedures for anisotropic flow measurements shows good agreement
- Example results from BM@N experimental Xe+Cs(I) at 3.26 GeV are shown.

# Outlook

- Study about implementation of refitting the daughter particles with mass hypothesis
- Improving selection criteria

# BACKUP

# Cut's dictionary

| $\chi^2_{prim}(1;2)$ | dca | L | L/dL | $\chi^2_{geo}$ | $\chi^2_{topo}$ | $cos_{topo}$ |
|---|---|---|---|---|---|---|
| $\chi^2$ of daughter particle to primary vertex<br>----------<br>Cut off primary tracks | Distance between daughter tracks in their closest approach<br>----------<br>Cut off candidates are built from tracks located far away from each other | Length of interpolated track from secondary to primary vertex<br>----------<br>Cut off short-length candidates | Distance between primary and secondary vertices divided by error<br>----------<br>Cut off short-length candidates | $\chi^2$ of daughters' tracks in their closest approach<br>----------<br>Cut off candidates are built from tracks located far away from each other | $\chi^2$of the mother's track to the primary vertex<br>----------<br>Cut off very distant secondary vertex | Cosine of the angle between reconstructed mother's momentum and radius vector beginning in the primary vertex<br>----------<br>Quality of candidate |
| $\Lambda$ $\chi^2(p)>60$<br>$\chi^2(\pi^-)>200$ | dca<1 cm | L>2.5 cm | L/dL>20 | $\chi^2_{geo}$ <100 | $\chi^2_{topo}$ <100 | $cos_{topo}$>0.995 |

KFParticle provides plenty of cuts for candidates selection