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Measurement of spin correlation of Λ-$\bar{\Lambda}$ pairs inside jets in p+p collisions at RHIC

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For the STAR Collaboration
Nov. 18, 2026

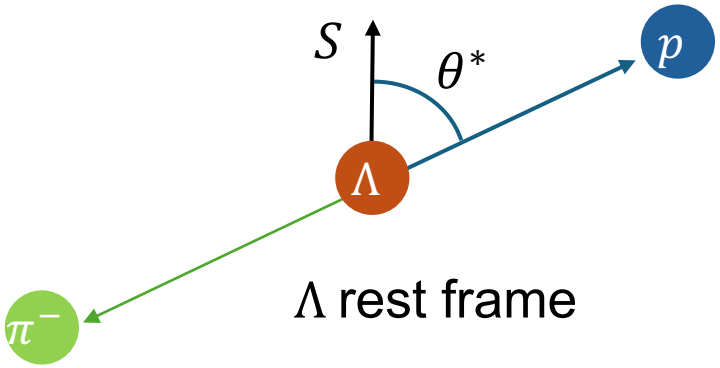
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Outline

- Motivation
- Λ transverse polarization inside jets
- Status of spin correlation inside jets
- Summary

Λ polarization and spin correlation



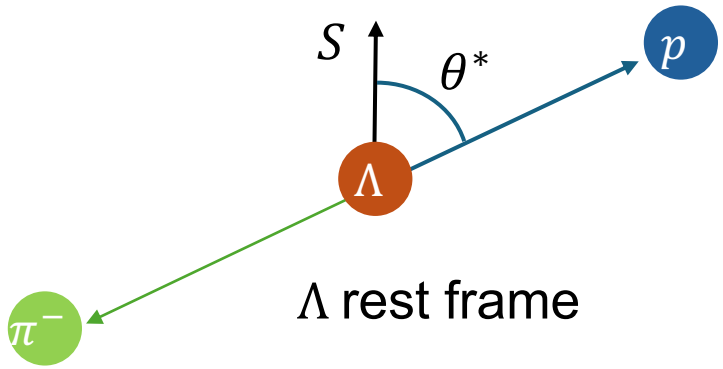
Λ rest frame

$$\frac{dN}{d\cos\theta^*} \propto \mathrm{A}_{(\cos\theta^*)}(1 + \alpha P \cos\theta^*)$$

$A(\cos\theta^*)$: acceptance function
$\alpha_\Lambda = 0.747 \pm 0.009$, $\alpha_{\bar{\Lambda}} = -0.757 \pm 0.004$
P: Λ polarization
θ^*: angle between p and spin direction in the Λ rest frame

Λ hyperon is a self-analyzing probe of spin polarization due to its decay daughter tracks carrying original spin direction

Λ polarization and spin correlation

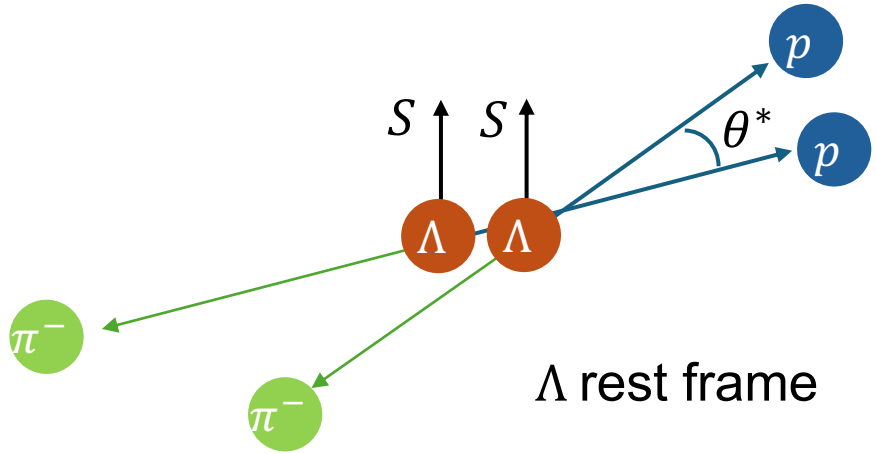


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Λ rest frame

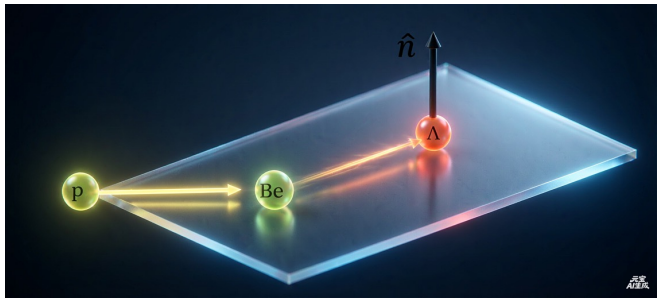
$$\frac{dN}{d(cos\theta^*)} \propto A_{(\cos\theta^*)}(1 + \alpha_1\alpha_2 P_{\Lambda_1\Lambda_2} cos\theta^*)$$

$P_{\Lambda_1\Lambda_2}$: spin correlation
θ^*: angle between two p in the rest frame of their mother hyperon respectively

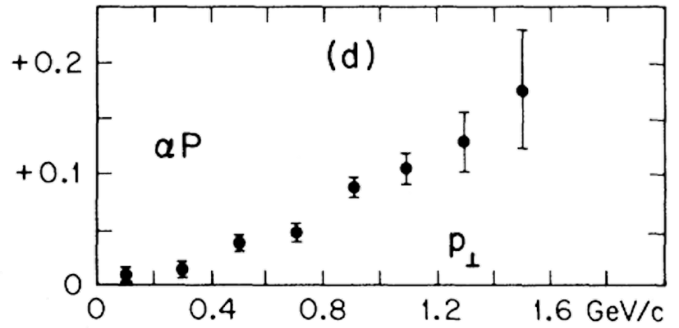
The correlation between two protons of Λ hyperon pairs carry original $s\bar{s}$ spin correlation information

Λ transverse polarization

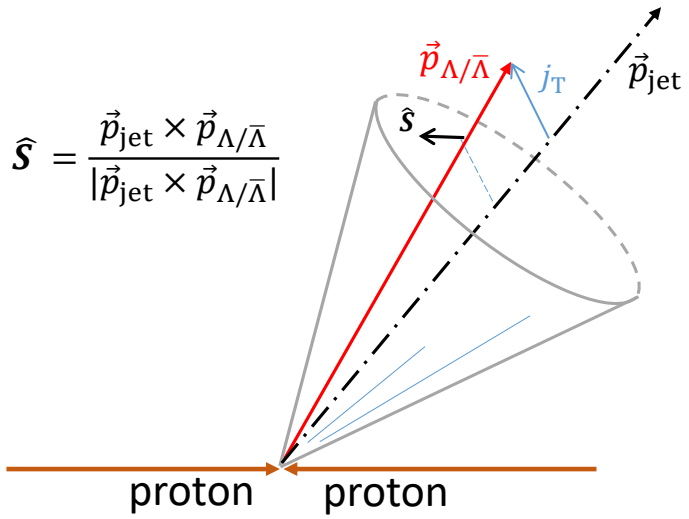
- Large transverse polarization of Λ hyperon in unpolarized hadron scatterings, along the normal to the production plane, first observed in 1976



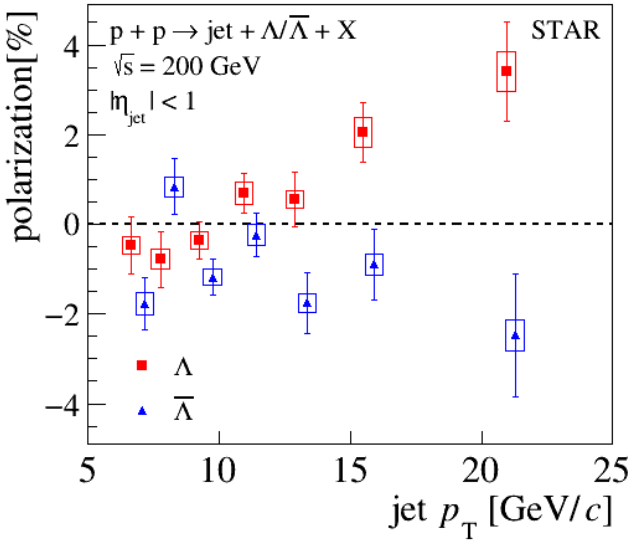
G.Bunce et al. PRL 36, 1113 (1976)



- **Polarizing Fragmentation Function (PFFs)**, one possible source, can be accessed by transverse polarization of Λ-in-jet
- First measurement of Λ polarization in jets in pp collisions
- Indication of jet p_T dependence of Λ transverse polarization

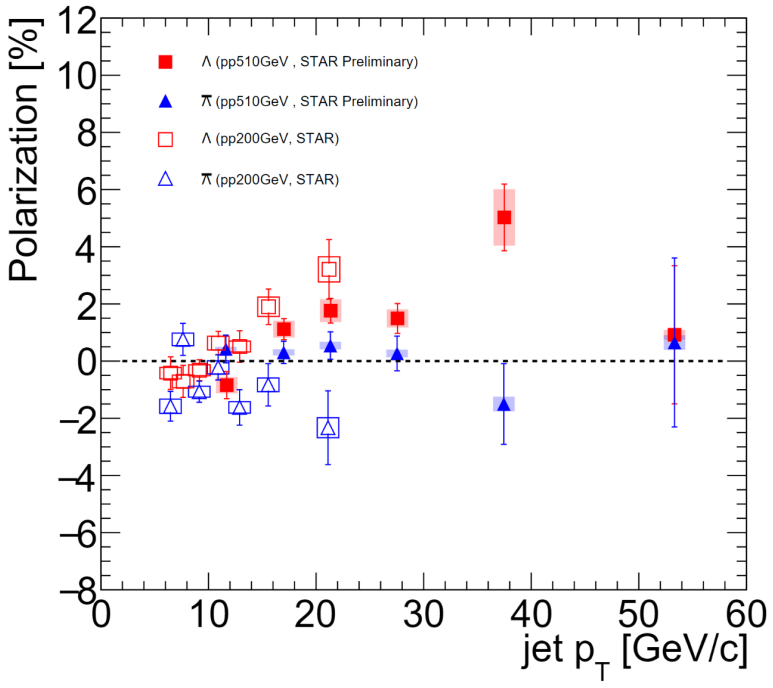


STAR JHEP 06 (2026) 050



Λ transverse polarization in jets

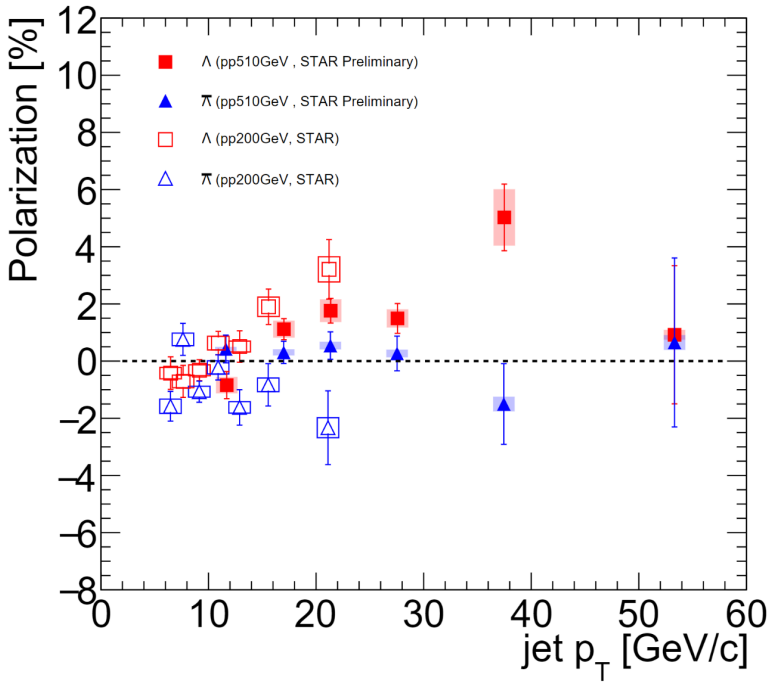
pp collisions at 510 GeV



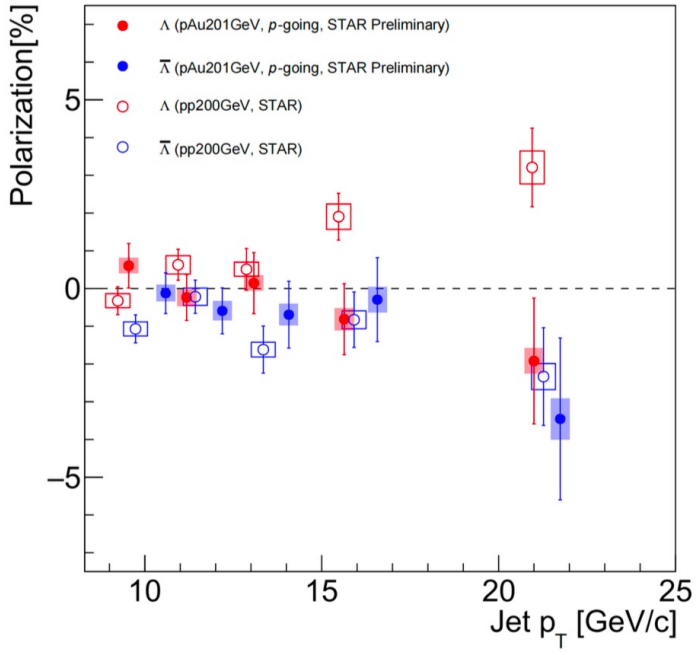
- Jet p_T dependence of Λ polarization is consistent between $\sqrt{s} = 200$ and 510 GeV
- No significant transverse polarization is observed in p-Au collisions
- An indication of possible nuclear effects relative to pp in p-Au collisions

Λ transverse polarization in jets

pp collisions at 510 GeV



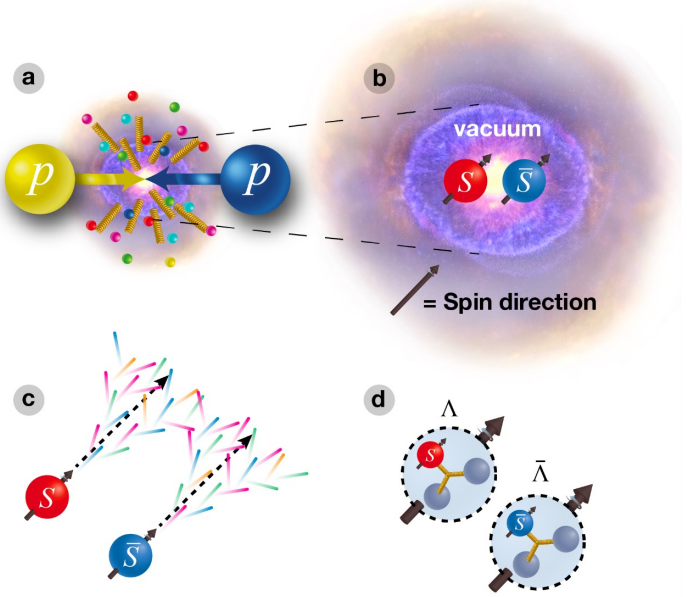
pAu collisions at 200 GeV



- Jet p_T dependence of Λ polarization is consistent between $\sqrt{s} = 200$ and 510 GeV
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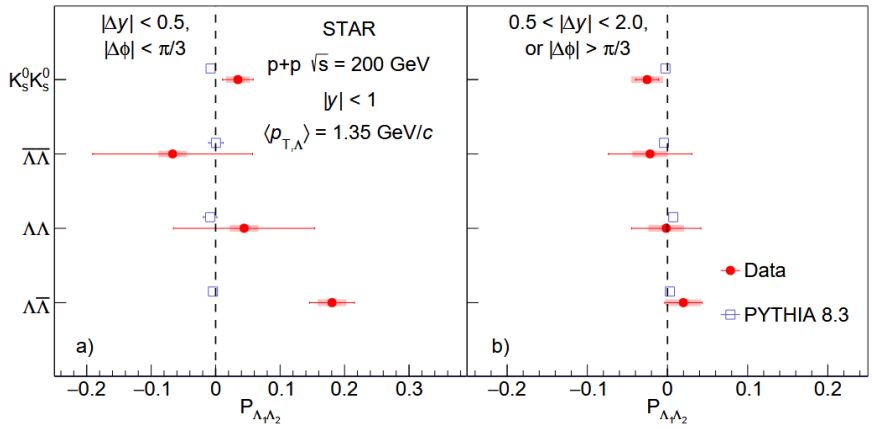
Spin correlation at STAR

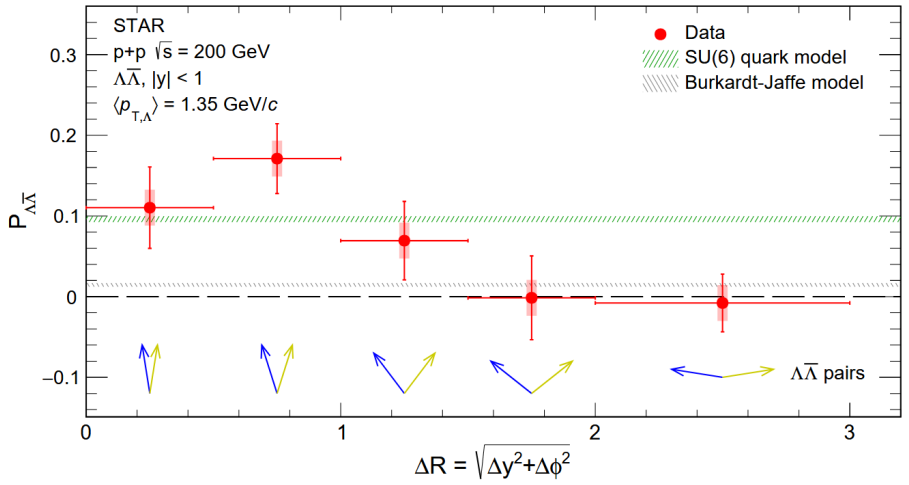
- The first evidence of a positive spin correlation of $\Lambda\overline{\Lambda}$ pairs is observed in the short range from p+p collisions at 200 GeV
- Spin-correlation signal decreases with $\Delta R(\Lambda\overline{\Lambda})$



STAR Nature 650, 44-45 (2026)

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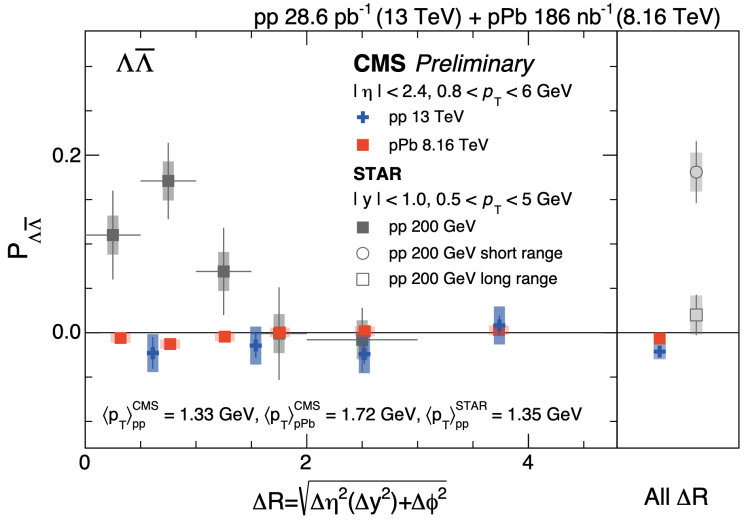


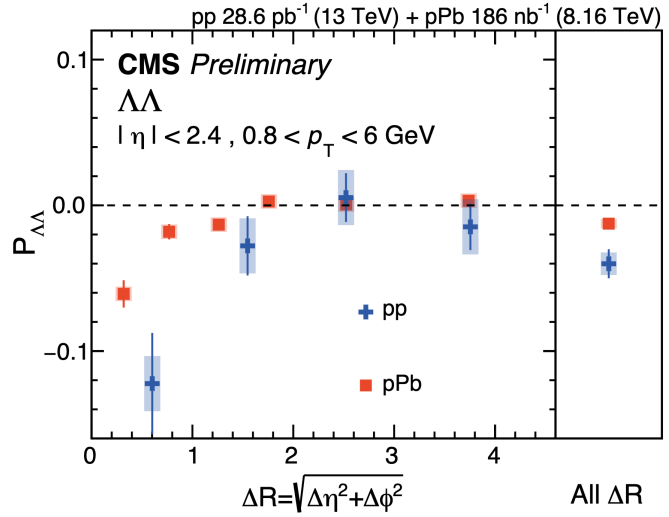
Spin correlation at LHC

Zhenyu's and Jieke's talk

CMS results

- Spin correlation of $\Lambda\overline{\Lambda}$ pairs consistent with zero
- Negative spin correlation of same hyperon pairs are observed at small ΔR

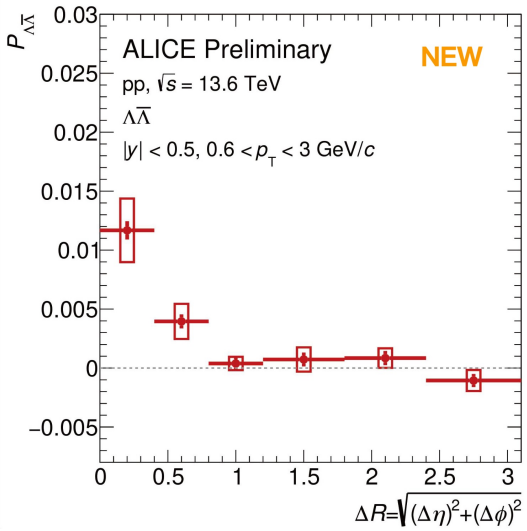


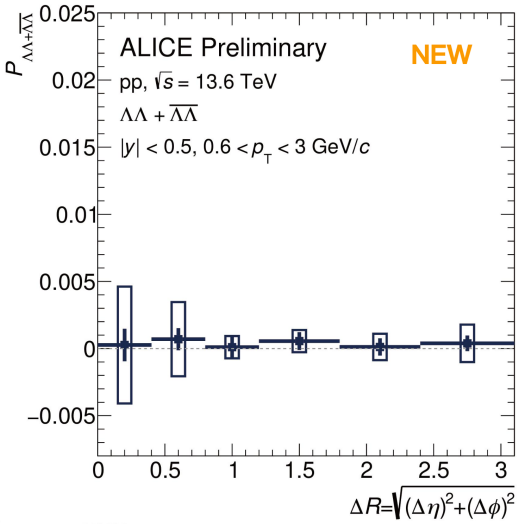


ALICE results

- The spin correlation of $\Lambda\overline{\Lambda}$ pairs decrease as ΔR
- Zero spin correlation for same hyperon pairs

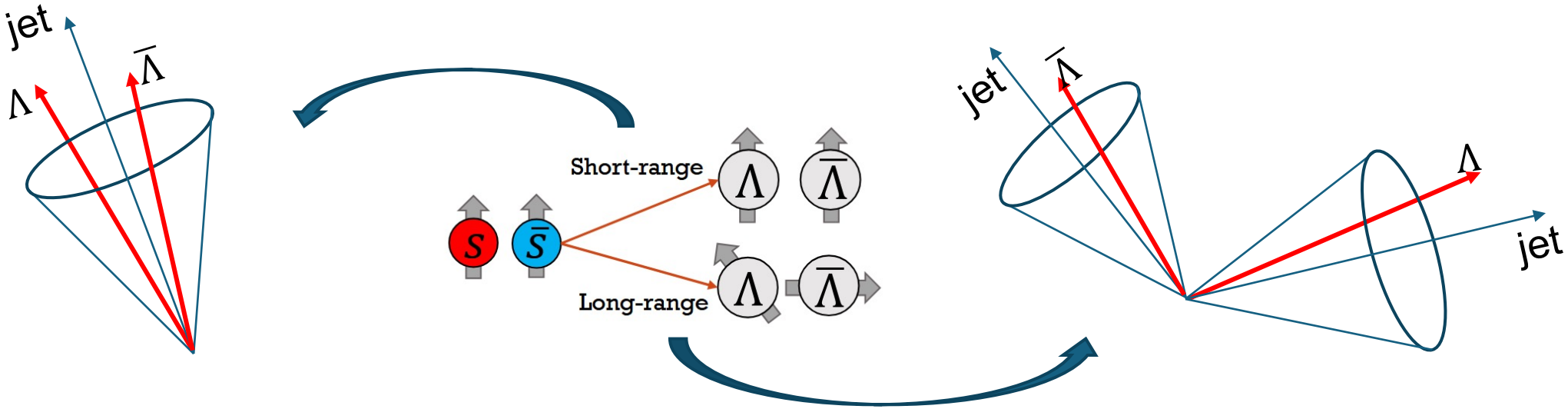
Xiaoming's talk





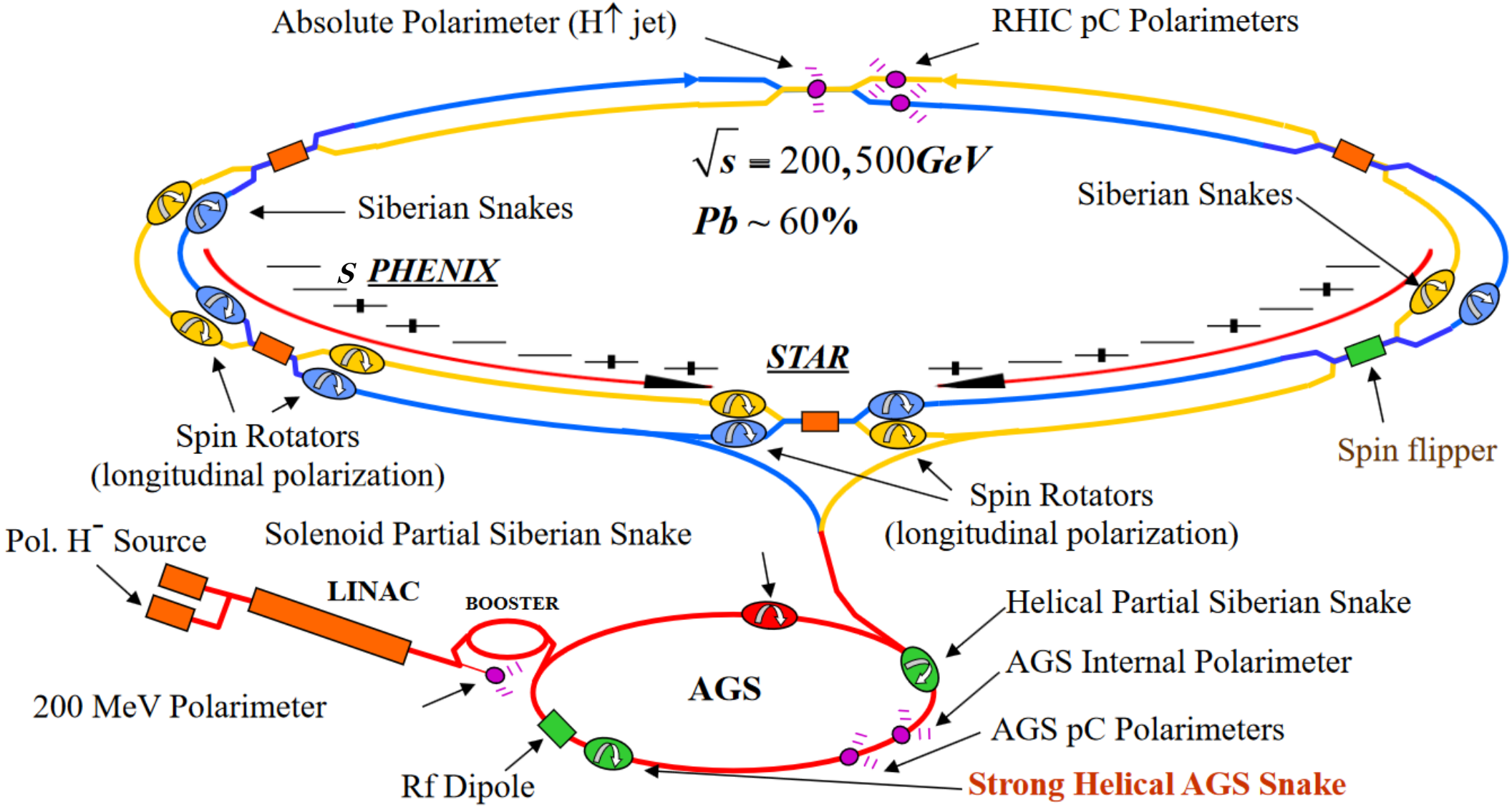
Spin correlation inside jet

- Extending inclusive measurements to measurements within jets
- The measurement of spin correlation of $\Lambda(\overline{\Lambda})$ inside jet provide an interesting insight to the new observations
- Separating $\Lambda\overline{\Lambda}$ pairs into two types
  - same jet
  - different jets
- Probing jet p_T dependence of spin correlation

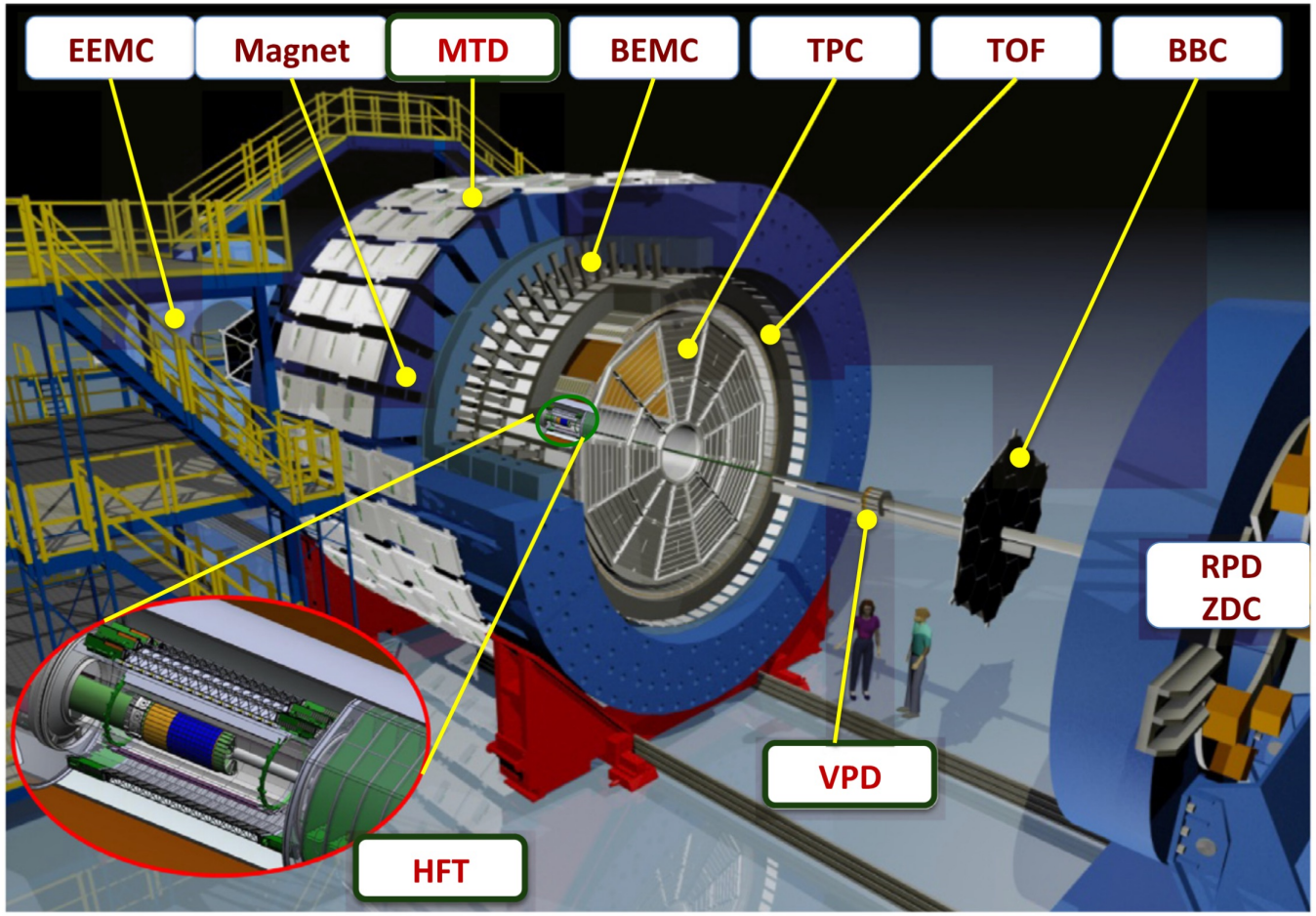


Relativistic Heavy Ion Collider (RHIC)

The world's first and only polarized proton collider



Solenoidal Tracker At RHIC(STAR)



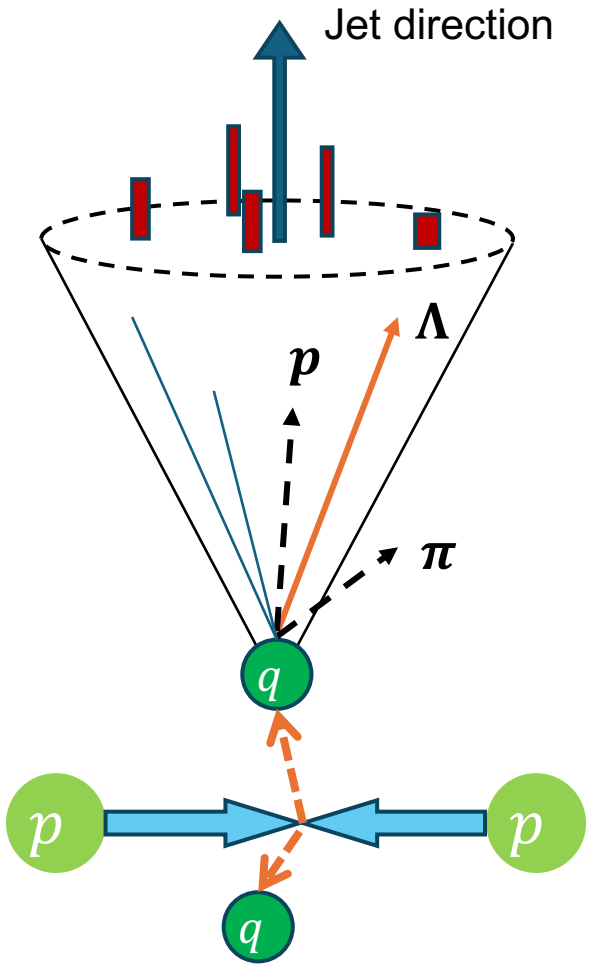
TPC (Time Projection Chamber)**:**

- Track momentum detection
- PID of TPC tracks
- $-1 < \eta < 1, \phi \in [0,2\pi]$

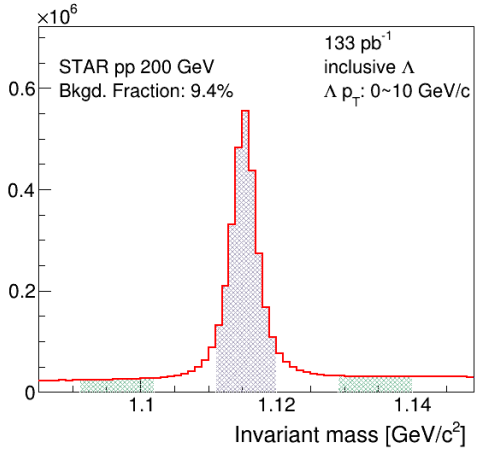
Barrel and Endcap E.M. Calorimeter :

- BEMC coverage: $-1 < \eta < 1, \phi \in [0,2\pi]$.
- EEMC coverage: $1.086 < \eta < 2, \phi \in [0,2\pi]$.
- EM energy detection
- Trigger system

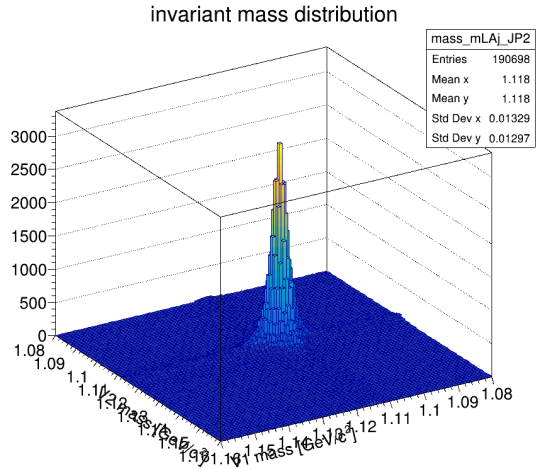
Analysis procedure



- Λ reconstruction:
  - ✓ $\Lambda \to p + \pi^-$; $\quad \overline{\Lambda} \to \bar{p} + \pi^+$
  - ✓ Track reconstruction and PID by TPC
  - ✓ Topological criteria



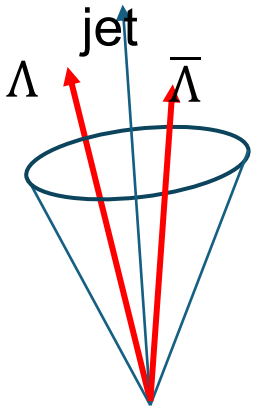
- Jet reconstruction
  - ✓ Anti-k_T with $\mathrm{R} = 0.6$
  - ✓ Reconstructed $\Lambda, \overline{\Lambda}$ as inputs
  - ✓ Including tracks and tower energies

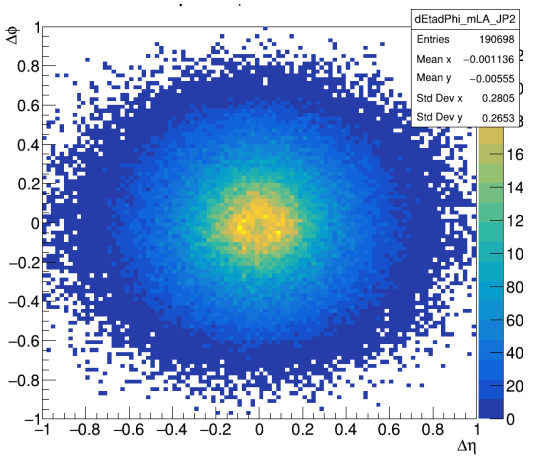


$\Lambda\overline{\Lambda}$ inside same jet

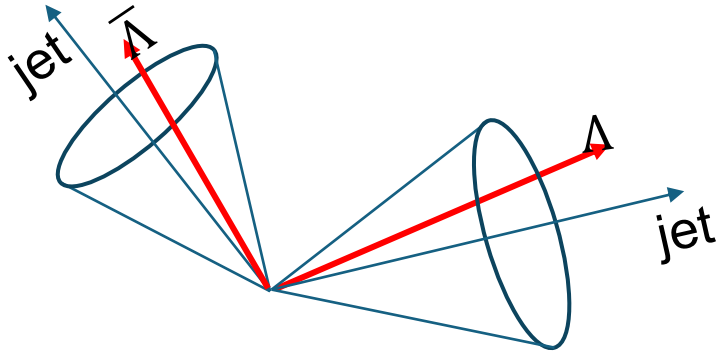
$\Lambda\bar{\Lambda}$ pairs inside jets

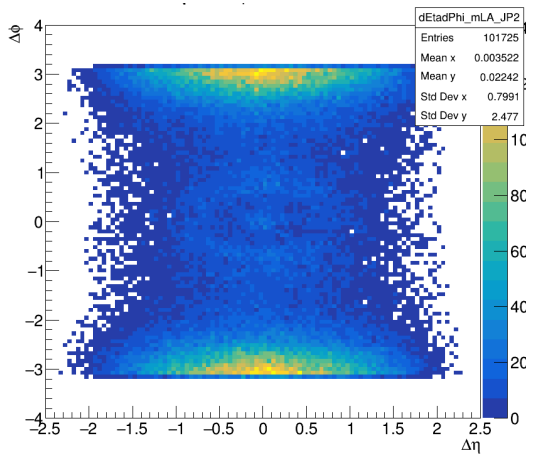
Same jet





Different jets





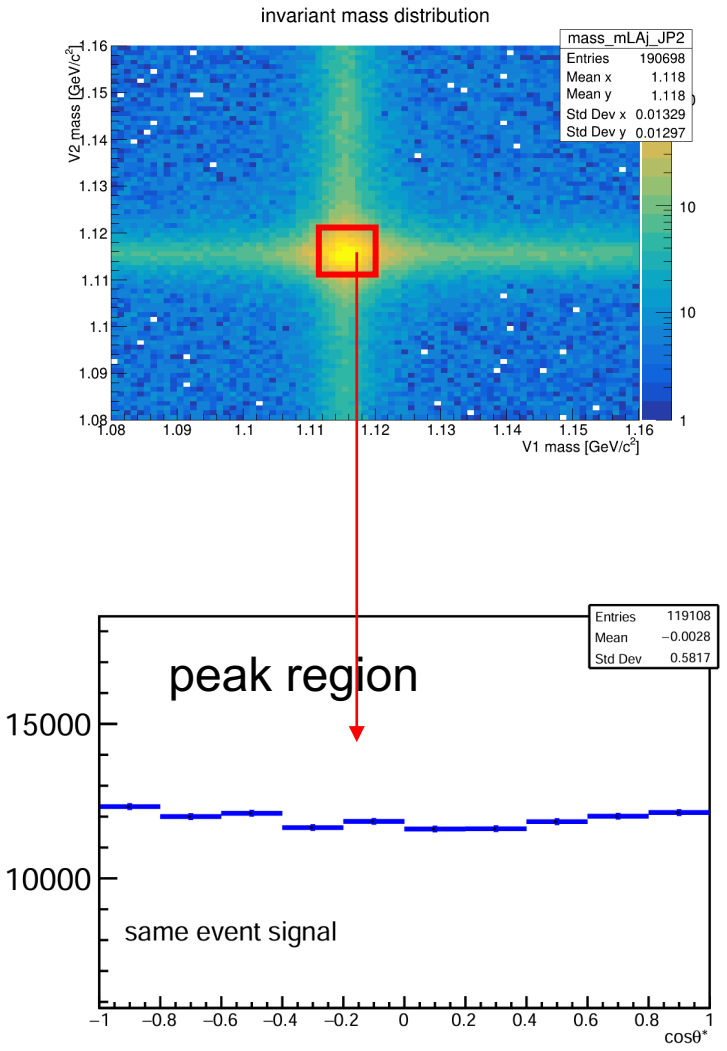
- The $\Delta\eta$ and $\Delta\phi$ correlation of $\Lambda\bar{\Lambda}$ pairs resulted by jet kinematic correlation
- $\Lambda\bar{\Lambda}$ pairs in the different jets mostly come from back-to-back jets

Raw cosθ^* distributions

$$\frac{dN}{d(cos\theta^*)} \propto 1 + \alpha_1\alpha_2 P_{\Lambda_1\Lambda_2} cos\theta^*$$

- θ^* is angle between p and $\bar{p}$ momentum in the rest frame of their mother hyperon respectively
- Signal range of Λ and $\overline{\Lambda}$: $1.112 \sim 1.120$ GeV/c^2
- Background subtraction via 2D side-band method

$\Lambda\overline{\Lambda}$ inside same jet

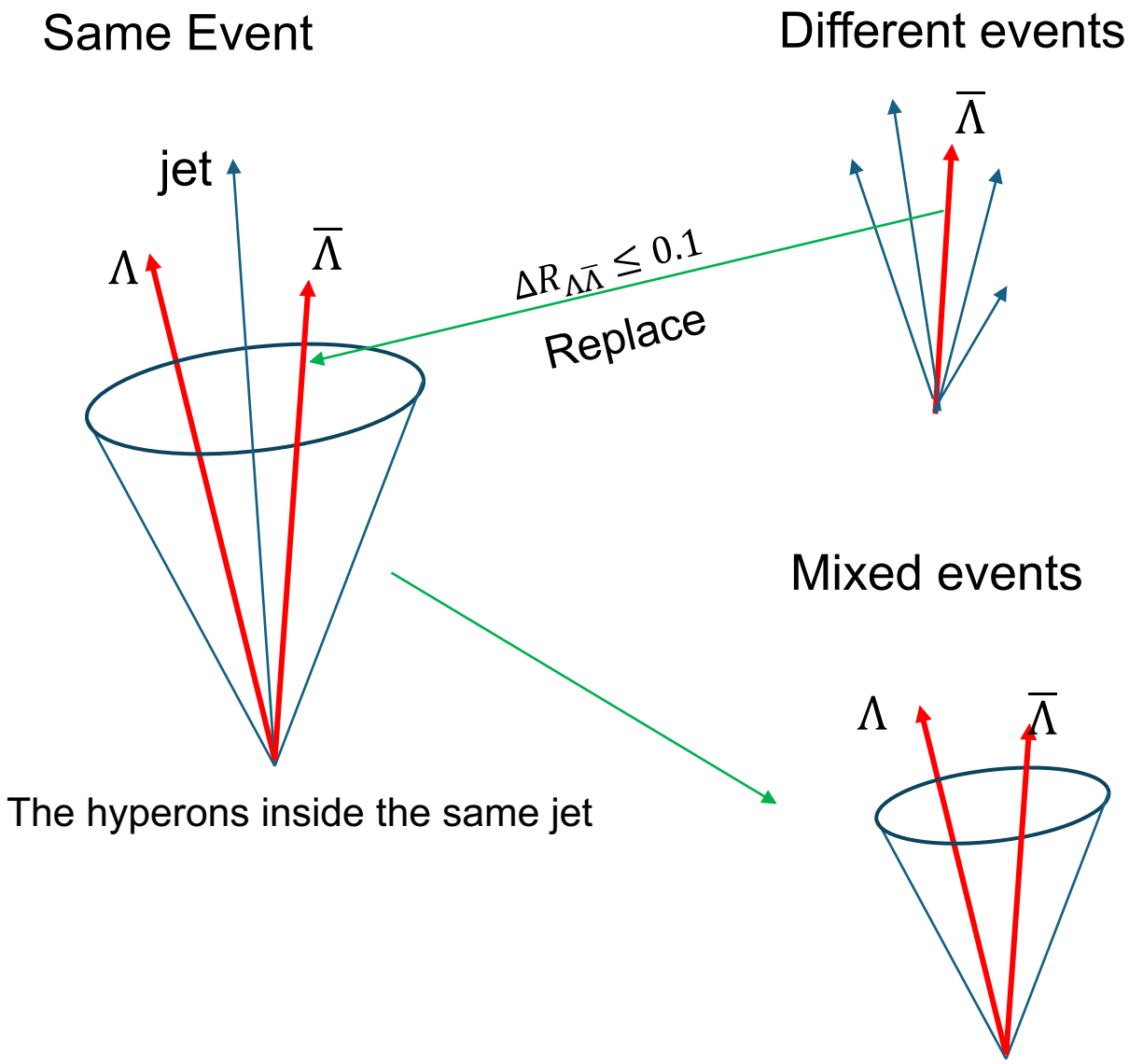


Mixed events method

- Replacing one Λ by another Λ from different events after kinematic filtering

- Cuts:
  - $|\Delta V_z| < 5$ cm
  - $|\Delta p_T| < 0.1$ GeV/c
  - $|\Delta R| < 0.1$

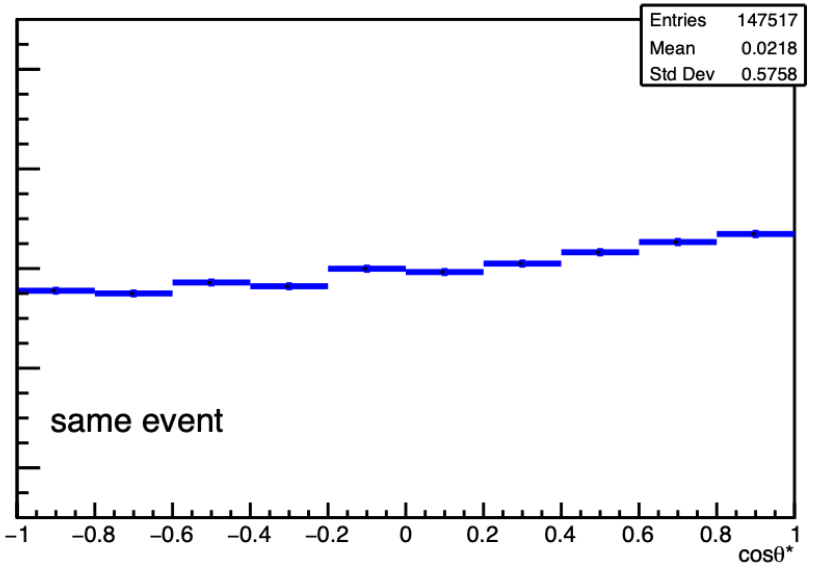
- The method is also applied to the $\Lambda\Lambda$, $\Lambda\overline{\Lambda}$ or $\overline{\Lambda}\overline{\Lambda}$ pairs in the different jet

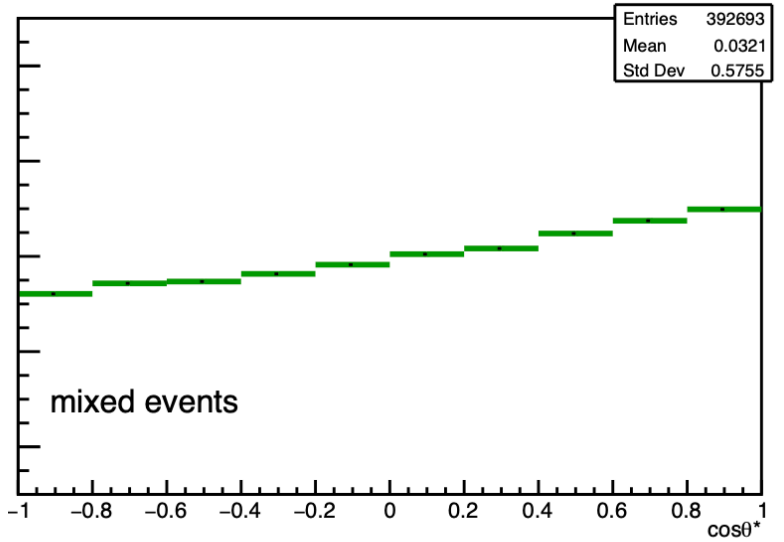


Acceptance correction

$$\frac{dN_{same}}{d(cos\theta^*)} \Big/ \frac{dN_{mix}}{d(cos\theta^*)}$$

- Normalize $\frac{dN}{d(cos\theta^*)}$ distributions of the same-event and mixed-event separately
- Divide the separately normalized distributions to correct detector acceptance effects
- Spin correlation $P_{\Lambda_1\Lambda_2}$ is extracted by fitting corrected $cos\theta^*$ distributions

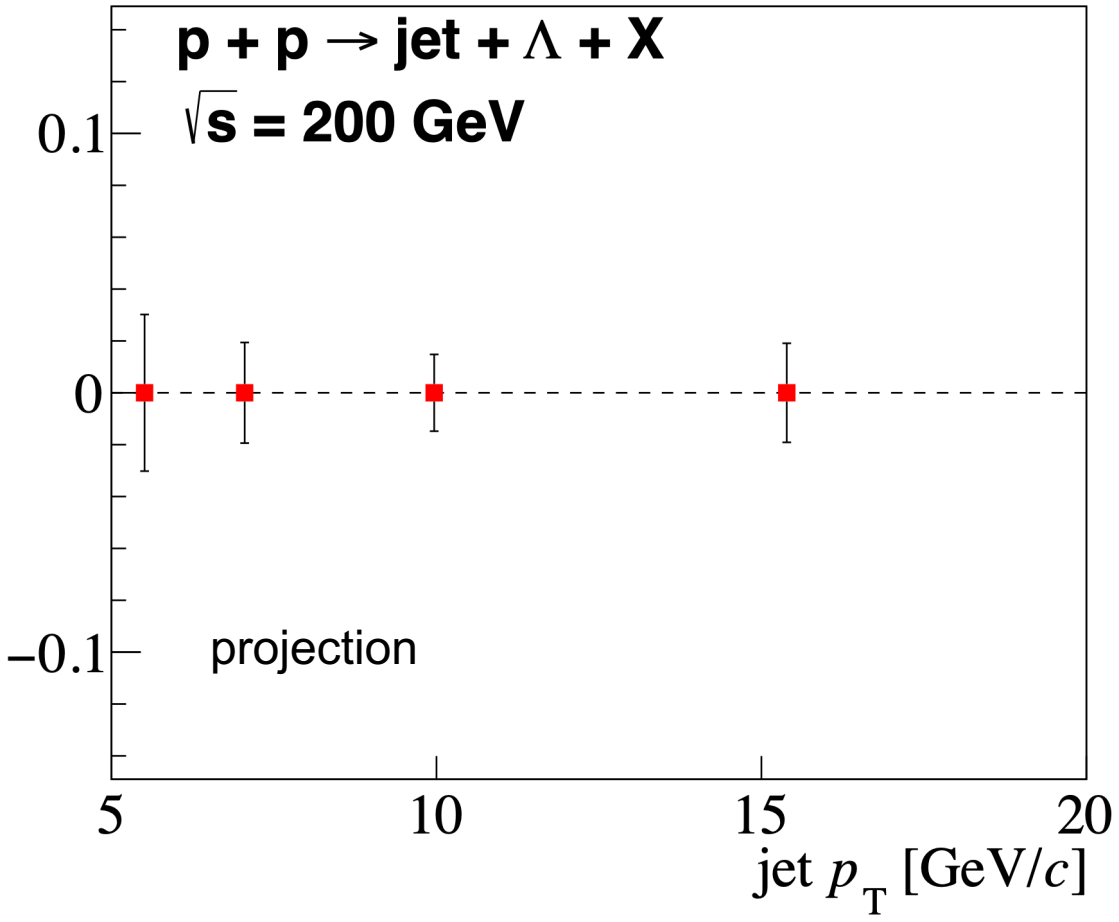




Projection of spin correlation inside jets

Projected precision of $\Lambda\overline{\Lambda}$ spin correlation inside jets in pp collisions

- Integrated luminosity: 133 pb^{-1}
- Same jet: ~1%(stat.)
- Different jets: ~1.6%(stat.)



Summary

Λ transverse polarization inside jets

- First measurements inside jet and indication of jet p_T dependence in pp collisions

$\Lambda\bar{\Lambda}$ spin correlation inside jets

- Providing new insight into underlying mechanism of spin correlation
- ~1% statistic uncertainties in the same jet and ~1.6% in the different jets are expected

To do

- Analysis ongoing, expect to report results at QM2027
- Extending measurement into pA collision system

Chirality 2026

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