讲论文
第二期

平思远

Measurement of transverse polarization of $\boldsymbol{\Lambda}/\boldsymbol{\Lambda}$ within jet in $\boldsymbol{pp}$ collisions at STAR arXiv:2402.01168

Transverse polarization of $\Lambda/\bar{\Lambda}$

- In 1976, the large transverse polarization of hyperon was first observed in unpolarized p+Be scattering, in a direction transverse to the production plane.
- The contributions from the hard scattering of hadronic collisions were found to be close to zero, based on perturbative Quantum Chromodynamics (pQCD) calculations
- Possible contribution could be from polarizing fragmentation functions (pFFs) [10, 11] in the final state, which describe the production of a polarized hadron from the fragmentation of an unpolarized parton.

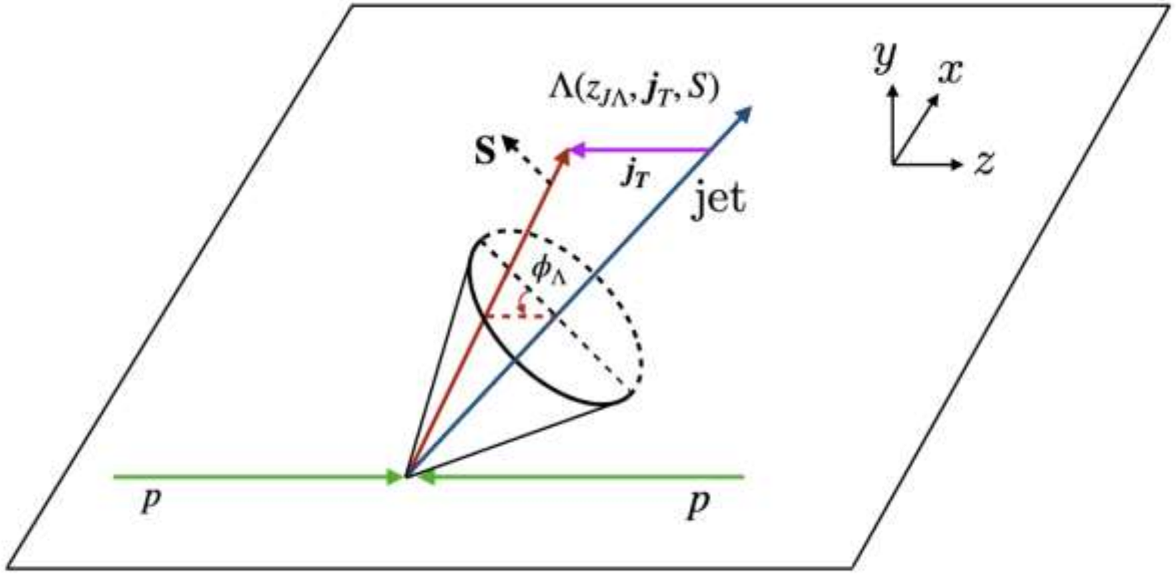

Fig. 1. The illustration of Λ hyperon production inside a jet in pp collisions, vector **S** denotes polarization direction defined by jet and Λ momentum: $\mathbf{S} = \mathbf{p}_{jet} \times \mathbf{p}_{\Lambda}$.

Data used

- The pp collision data at $\sqrt{s}$ = 200 GeV used for this measurement were collected by the STAR experiment at RHIC in 2015.
- Time Projection Chamber (TPC), Barrel Electronmagnetic Calorimeter (BEMC) and Endcap Electron magnetic Calorimeter(EEMC) are used in this analysis.
- In this analysis, only events triggered by JP1, one of the STAR jet-patch triggers with the threshold of 5.4 GeV, are used.
- The $\Lambda(\bar{\Lambda})$ candidates are reconstructed via the weak decay channel: $\Lambda \rightarrow p + \pi-$ ($\bar{\Lambda} \rightarrow \bar{p} + \pi+$).
- Following similar procedure as in Ref. [20] except that the Time of Flight hit matching is not required for the pion track.

TABLE I. Selection cuts for $\Lambda(\bar{\Lambda})$ reconstruction; the upper part is for candidates with daughter $\pi^-(\pi^+)$ matched to a TOF hit, and the lower part is for candidates without a TOF match. Here, "DCA" denotes "distance of closest approach," "PV" denotes "primary vertex," $\vec{r}$ denotes the vector from the primary vertex to the decay vertex of Λ or $\bar{\Lambda}$ and $\vec{p}$ denotes the momentum vector of Λ or $\bar{\Lambda}$.

$\pi^{\pm}$ matches a TOF hit						
$p_{T,\Lambda(\bar{\Lambda})}$ (GeV/c)	<2	2–3	3–4	4–5	5–6	>6
DCA of $p(\bar{p})$ to PV	>0.2 cm	>0.15 cm	>0.05 cm	>0.005 cm	>0.005 cm	>0.005 cm
DCA of $\pi^-(\pi^+)$ to PV	>0.6 cm	>0.55 cm	>0.5 cm	>0.5 cm	>0.5 cm	>0.5 cm
DCA of $p\pi^-$ $(\bar{p}\pi^+)$	<0.75 cm	<0.65 cm	<0.6 cm	<0.5 cm	<0.45 cm	<0.45 cm
DCA of $\Lambda(\bar{\Lambda})$ to PV	<1 cm	<1 cm	<1 cm	<1 cm	<1 cm	<1 cm
Decay length	>3 cm	>3.5 cm	>3.5 cm	>4 cm	>4.5 cm	>4.5 cm
$\cos(\vec{r}, \vec{p})$	>0.995	>0.995	>0.995	>0.995	>0.995	>0.995
$\pi^{\pm}$ does not match a TOF hit						
$p_{T,\Lambda(\bar{\Lambda})}$ (GeV/c)	<2	2–3	3–4	4–5	5–6	>6
DCA of $p(\bar{p})$ to PV	>0.45 cm	>0.3 cm	>0.25 cm	>0.2 cm	>0.15 cm	>0.15 cm
DCA of $\pi^-(\pi^+)$ to PV	>0.65 cm	>0.6 cm	>0.55 cm	>0.55 cm	>0.55 cm	>0.5 cm
DCA of $p\pi^-$ $(\bar{p}\pi^+)$	<0.7 cm	<0.6 cm	<0.55 cm	<0.5 cm	<0.45 cm	<0.45 cm
DCA of $\Lambda(\bar{\Lambda})$ to PV	<0.55 cm	<0.55 cm	<0.6 cm	<0.6 cm	<0.6 cm	<0.6 cm
Decay length	>7 cm	>7 cm	>7 cm	>8.5 cm	>10 cm	>10.5 cm
$\cos(\vec{r}, \vec{p})$	>0.995	>0.995	>0.995	>0.995	>0.995	>0.995

Mathed used

- Anti-K_T algorithm with R = 0.6 and $P_T^{jet} > 5\ GeV$ is used.
- To suppress the edge effects, jet pT is further required to be larger than 8 GeV/c.
- The off-axis method [21] is used to correct for the pile-up events or other background to jet reconstruction.

Result

- The transverse polarization of Λ is extracted via the angular distribution of the daughter particle in the Λ rest frame

$$\frac{dN}{d\cos\theta^*} \propto A(\cos\theta^*)(1 + \alpha_{\Lambda(\overline{\Lambda})} P_{\Lambda(\overline{\Lambda})} \cos\theta^*),$$

where $A(\cos\theta^*)$ is the acceptance function, θ^* is the angle between Λ polarization direction and its daughter p in the Λ rest frame, $\alpha_{\Lambda/\overline{\Lambda}} = \pm\, 0.732$ is the decay parameter [22] and $P_{\Lambda(\overline{\Lambda})}$ is transverse polarization of Λ.

- The detector acceptance function is estimated based on Monte-Carlo simulation by passing the pp events generated by PYTHIA6.4.28 through GEANT3 framework of STAR detector.
- After acceptance correction, the polarization is extracted through fitting cos$\theta*$ distribution by a linear function

Result

- Both Λ and Λbar indicate a hint of negative transverse polarization and also a weak dependence of jet pT at current precision.
- This is the first hint of non-zero transverse polarization of Λ(Λ) inside jet in unpolarized pp collision.

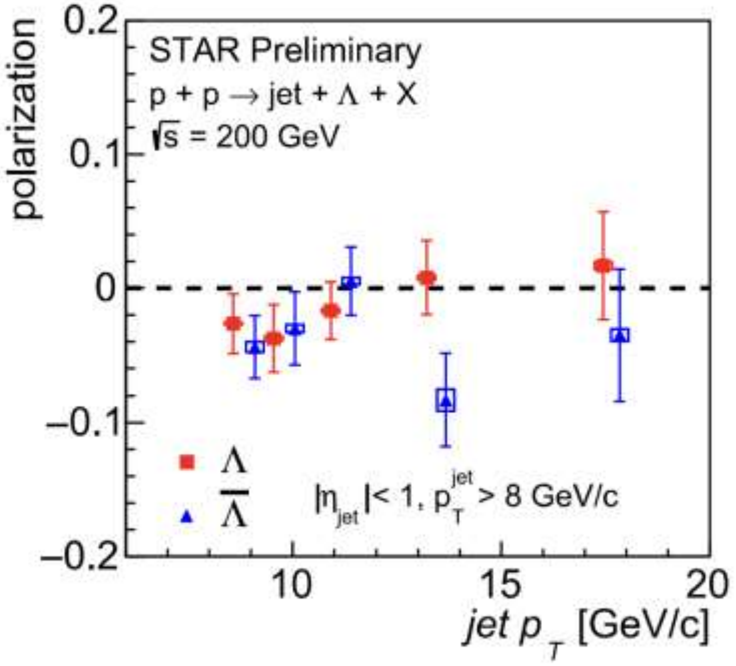

Fig. 2. Preliminary results Λ and $\overline{\Lambda}$ polarization within a jet versus jet p_T in unpolarized pp collisions at $\sqrt{s} = 200$ GeV at STAR.

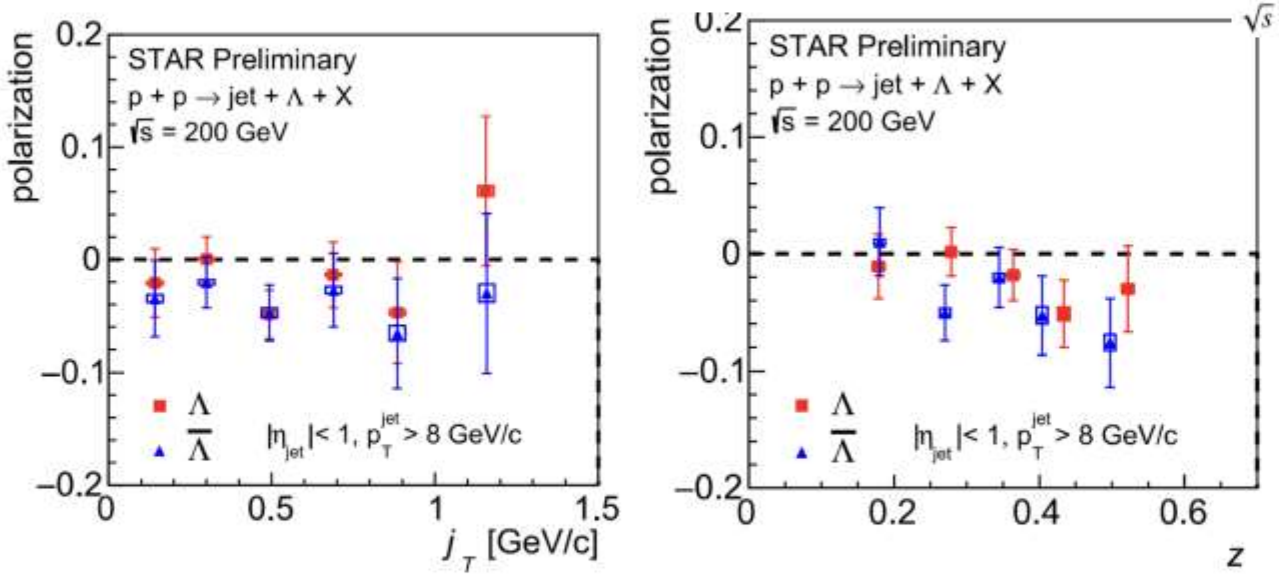

Fig. 3. Preliminary results of Λ and $\overline{\Lambda}$ polarization within a jet as a function of transverse momentum j_T (Left), and jet momentum fraction z (Right) in unpolarized pp collisions at $\sqrt{s} = 200$ GeV.