



QCD@LHC

Measurements of Λ hyperon spin correlation in pp and pPb collision at CMS

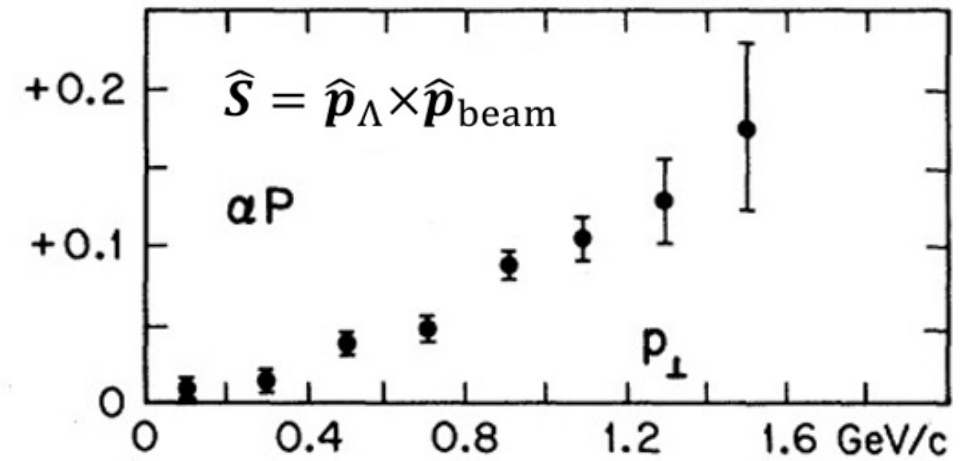


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Spin and polarization

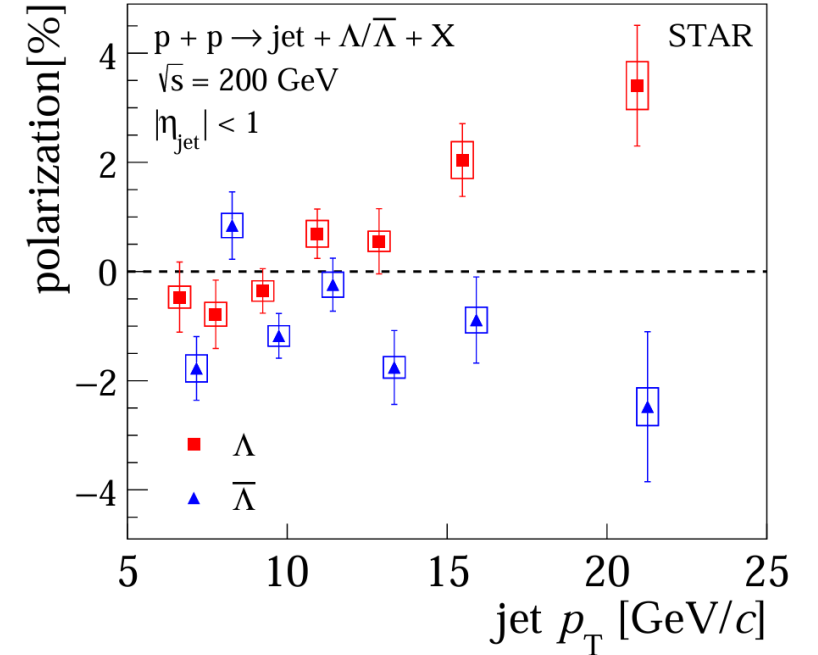
PRL 36,1113(1976)



A diagram illustrating the production of a hyperon (H, red circle) and a jet (P, blue circle) from a collision. The hyperon's spin vector $\vec{n}$ (red arrow) is shown at an angle θ^* relative to the jet direction. The differential cross-section is given by:

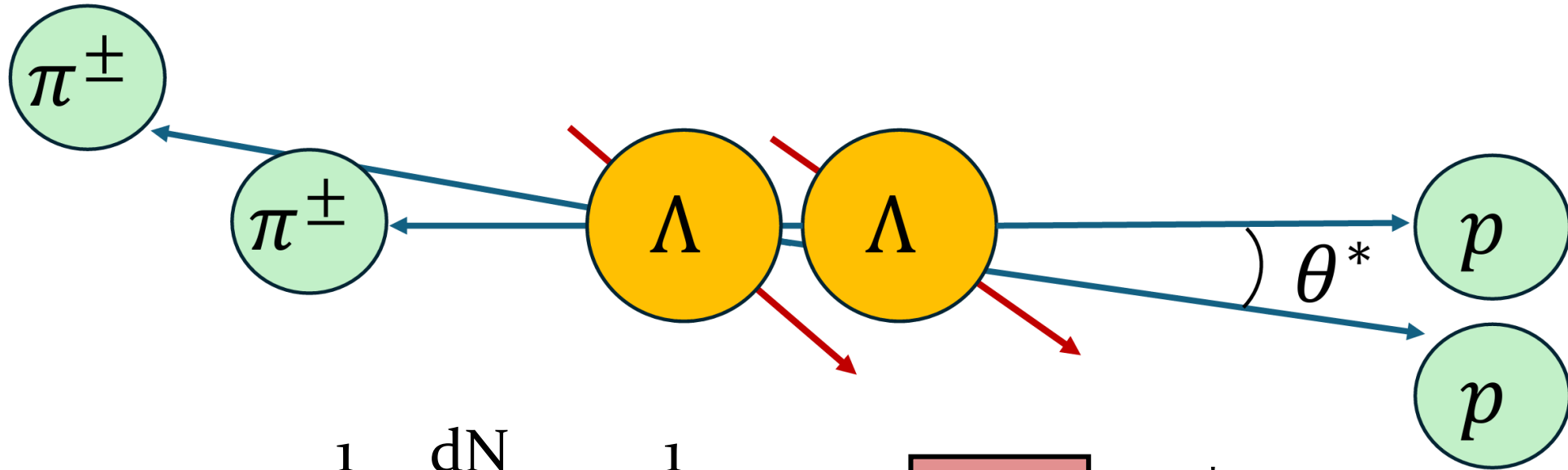
$$\frac{dN}{d \cos(\theta^*)} = 1 + \alpha P_{\Lambda} \cos(\theta^*)$$

arXiv:2509.17487



Origin of polarization is a long standing puzzle
 Λ hyperon is a self-analyzing probe of spin polarization
 Recent measurements focus mainly on single Λ observables

Λ spin correlation



$$\frac{1}{N} \frac{dN}{d\cos\theta^*} = \frac{1}{2} (1 + \alpha_1 \alpha_2 P_{\Lambda_1 \Lambda_2} \cos\theta^*)$$

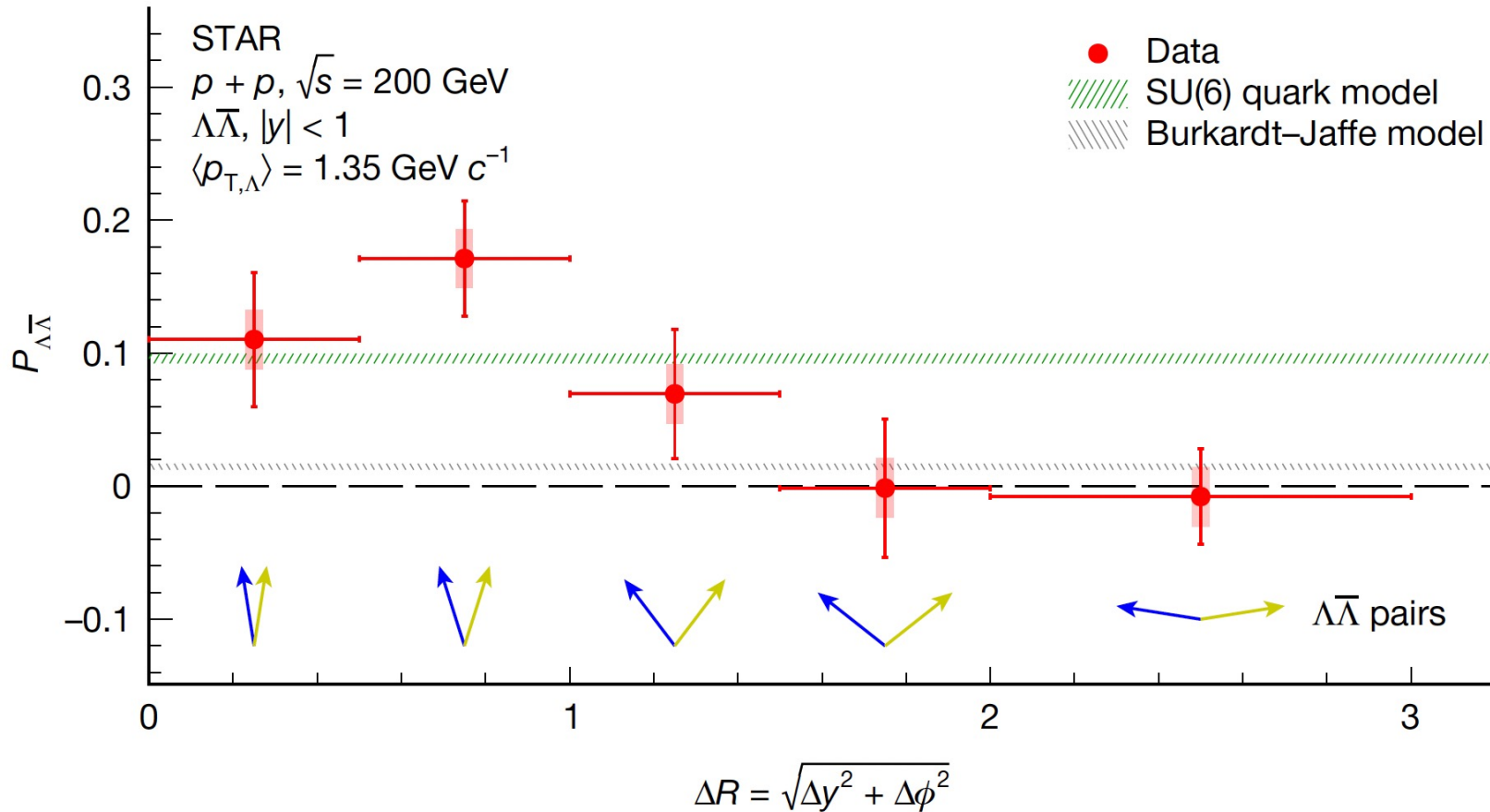
Picture : Zhoudunming Tu

Correlation of $\Lambda s'$ spin

Correlation of two Λ 's spin can be probed
by the angle between (anti-)protons in the rest frames of Λs

Λ spin correlation

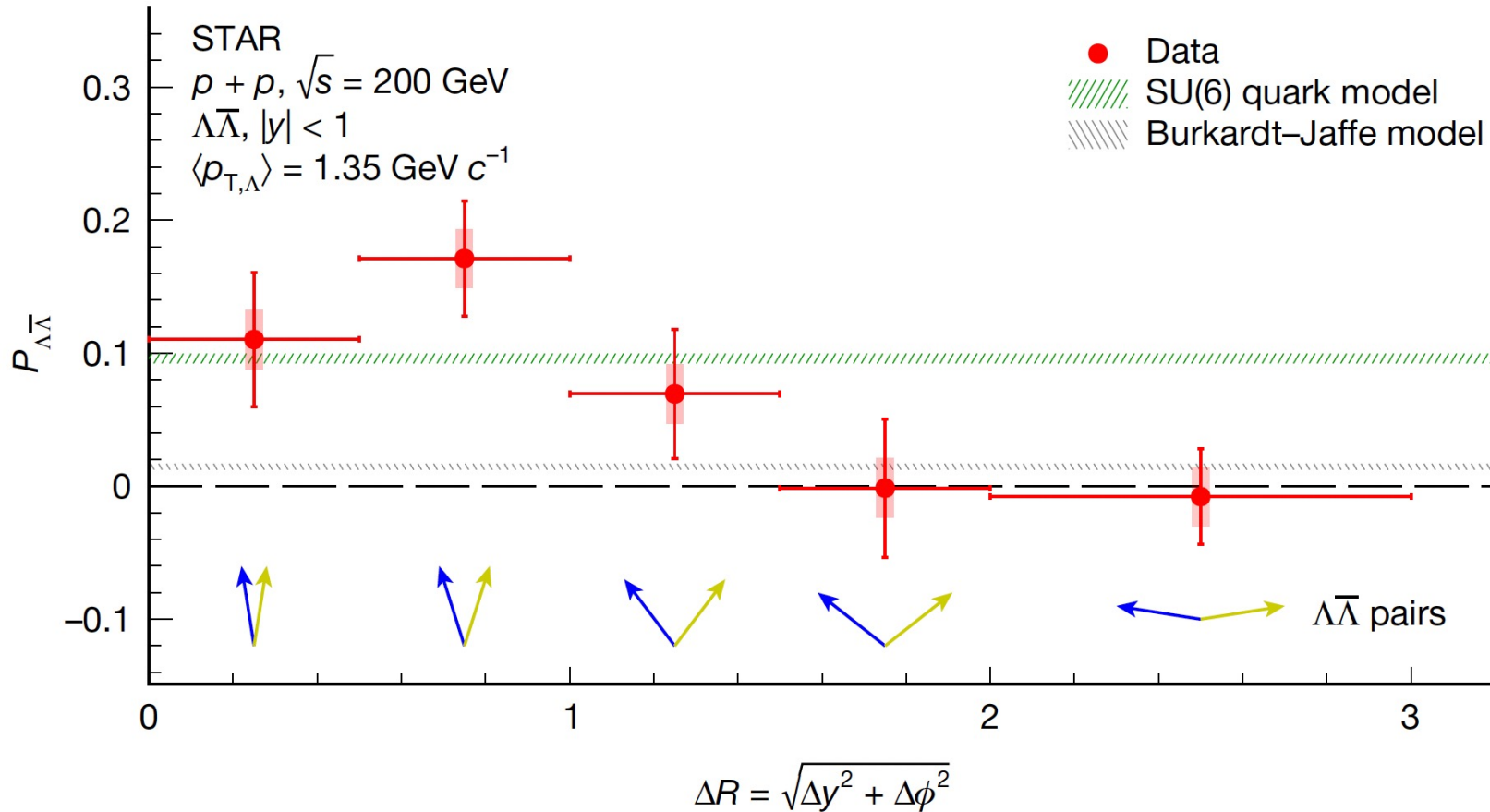
Nature 650 (2026) 65-71



Significant $\Lambda\bar{\Lambda}$ correlation at small ΔR

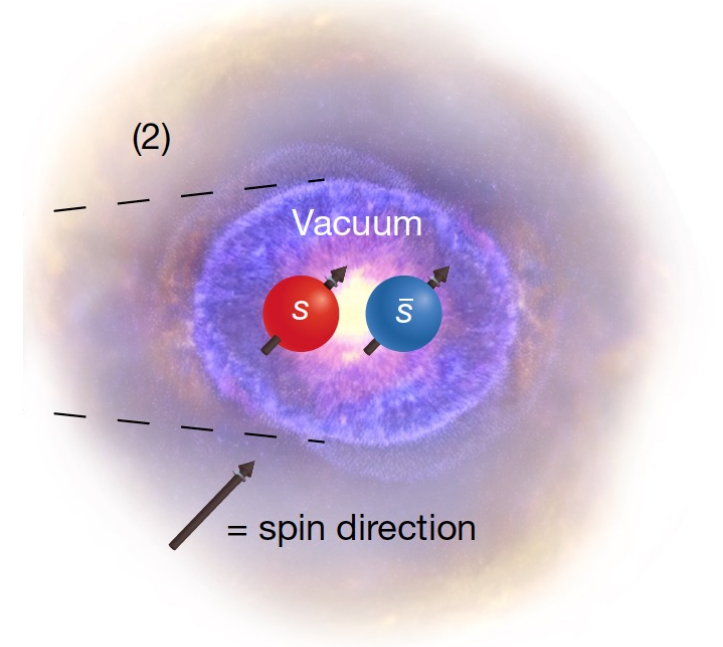
Λ spin correlation

Nature 650 (2026) 65-71



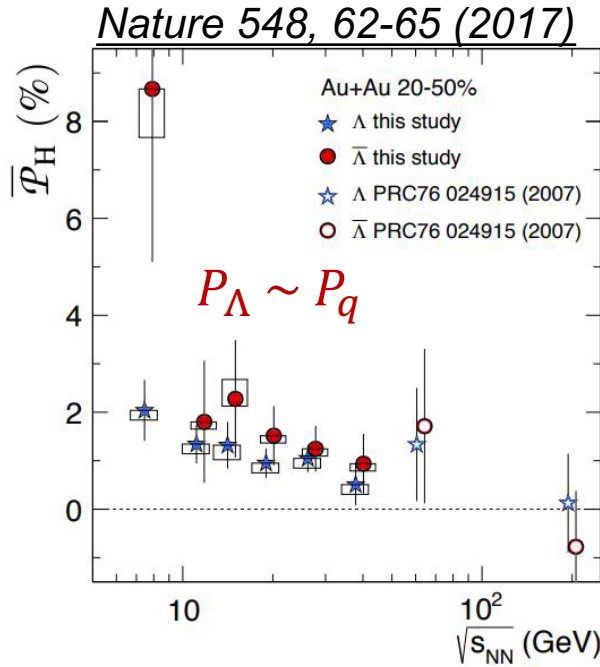
Significant $\Lambda\bar{\Lambda}$ correlation at small ΔR

Nature 650 (2026) 65-71

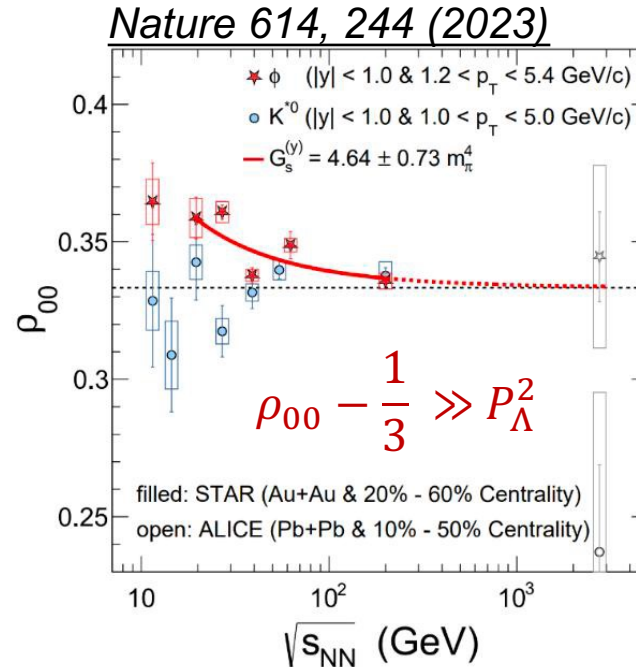


vacuum production : $J^{PC} = 0^{++}$
 $s\bar{s}$ in spin triplet state

Spin correlation in Heavy Ion Physics

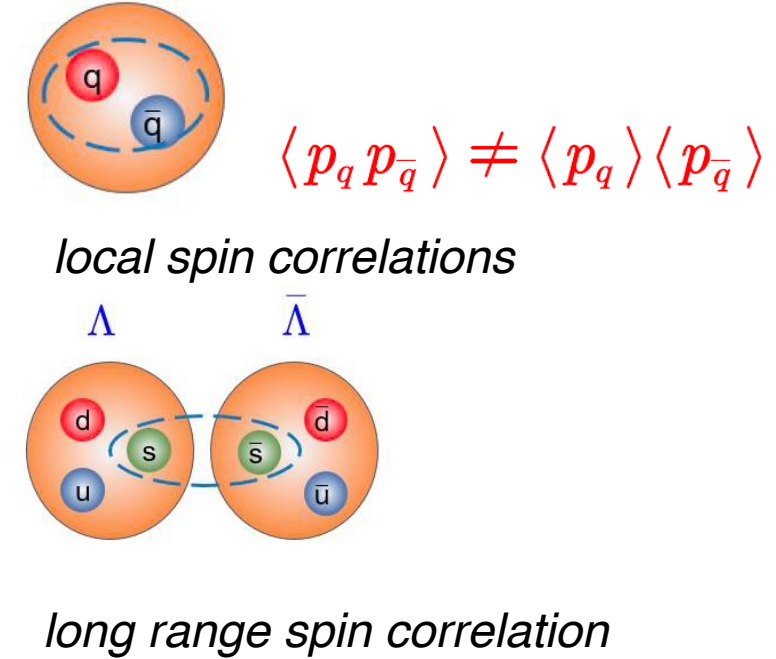


$$P_H = P_{\bar{H}} = P_q = P_{\bar{q}}$$



$$\rho_{00}^V = \frac{1 - P_{q1} \bar{q}_2}{3 + P_{q1} \bar{q}_2} \sim \frac{1}{3} \left(1 - \frac{4}{3} P_q^2 \right)$$

PRD 109 (2024) 11, 114003



Spin correlation proposed to simultaneously explain global polarization & spin alignment

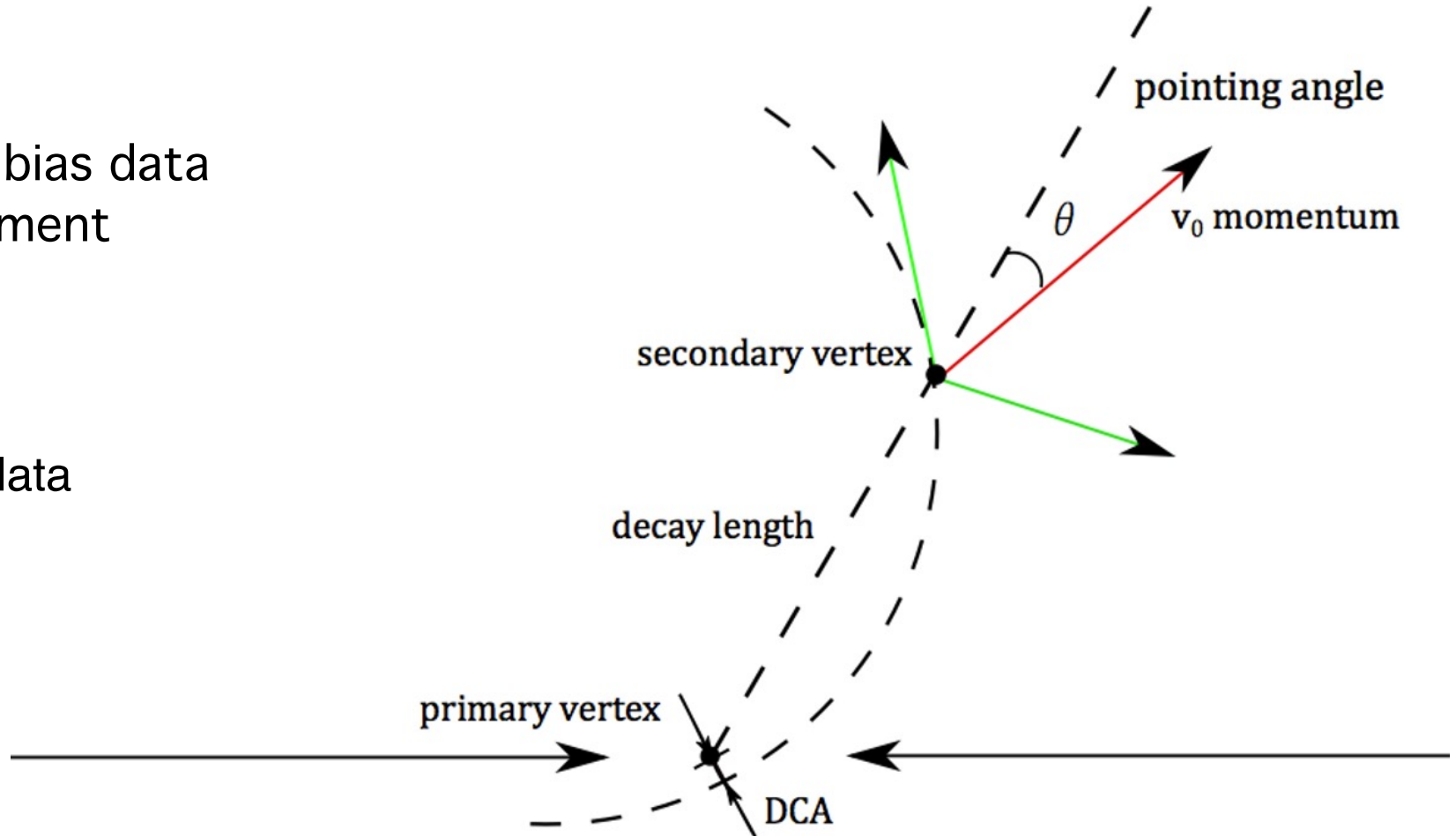
Λ spin correlation measurement at CMS in pp and pPb collisions

- Energy and collision system dependence
- Baseline for measurements in heavy ion collisions

Dataset and Λ reconstruction

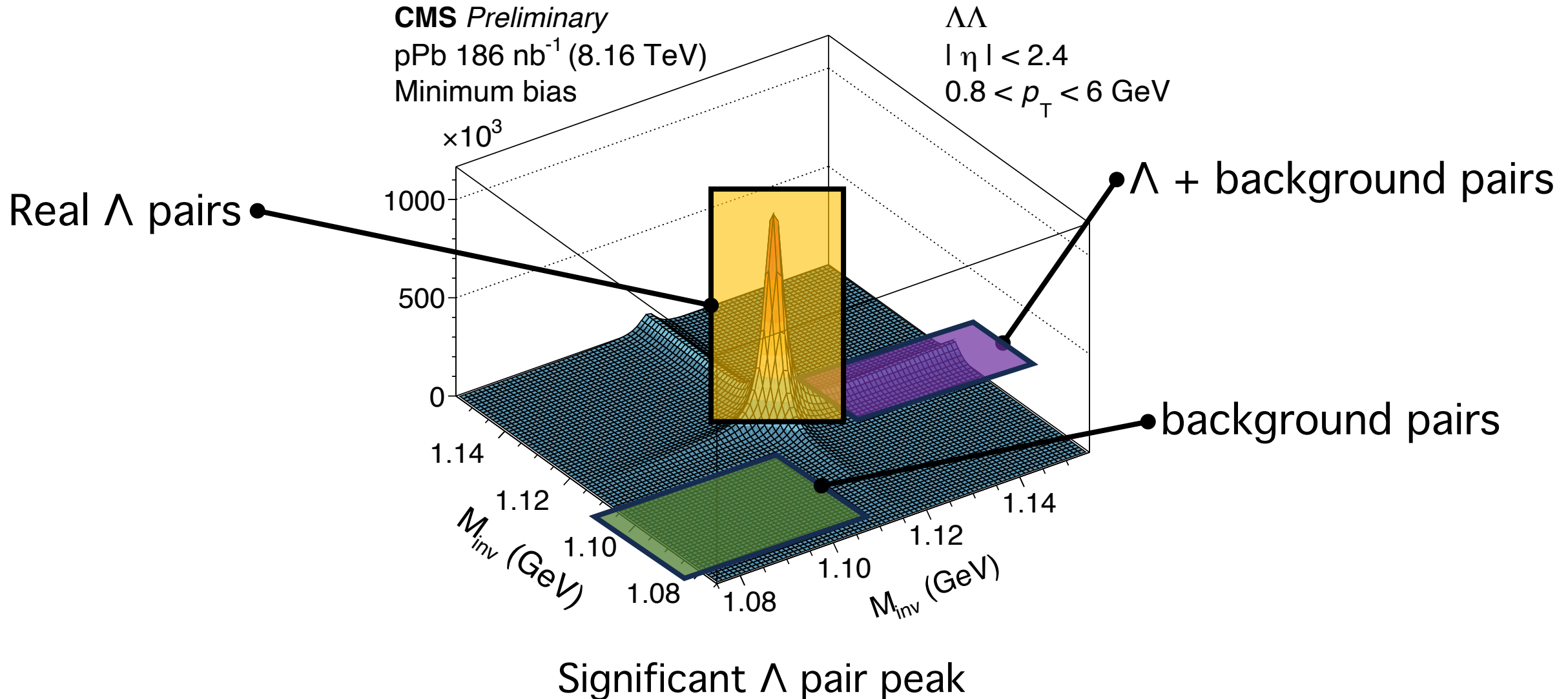
● 8.16 TeV pPb minimum bias data collected by CMS experiment

● 13 TeV pp minimum bias data

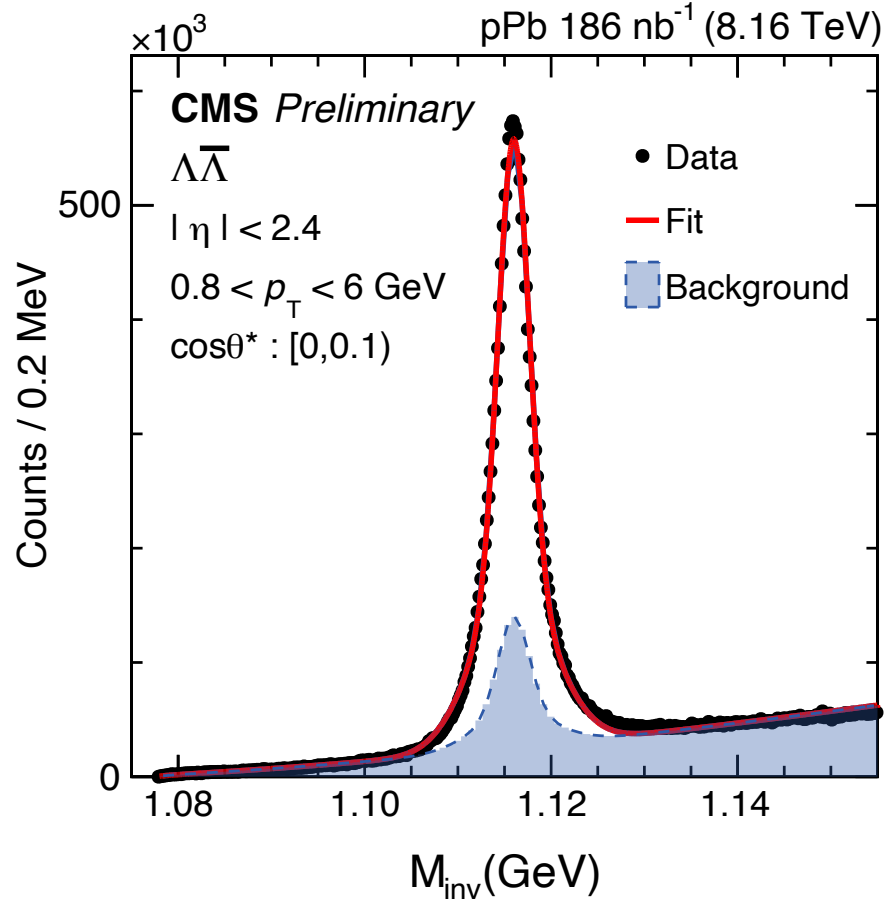


Λ reconstruction

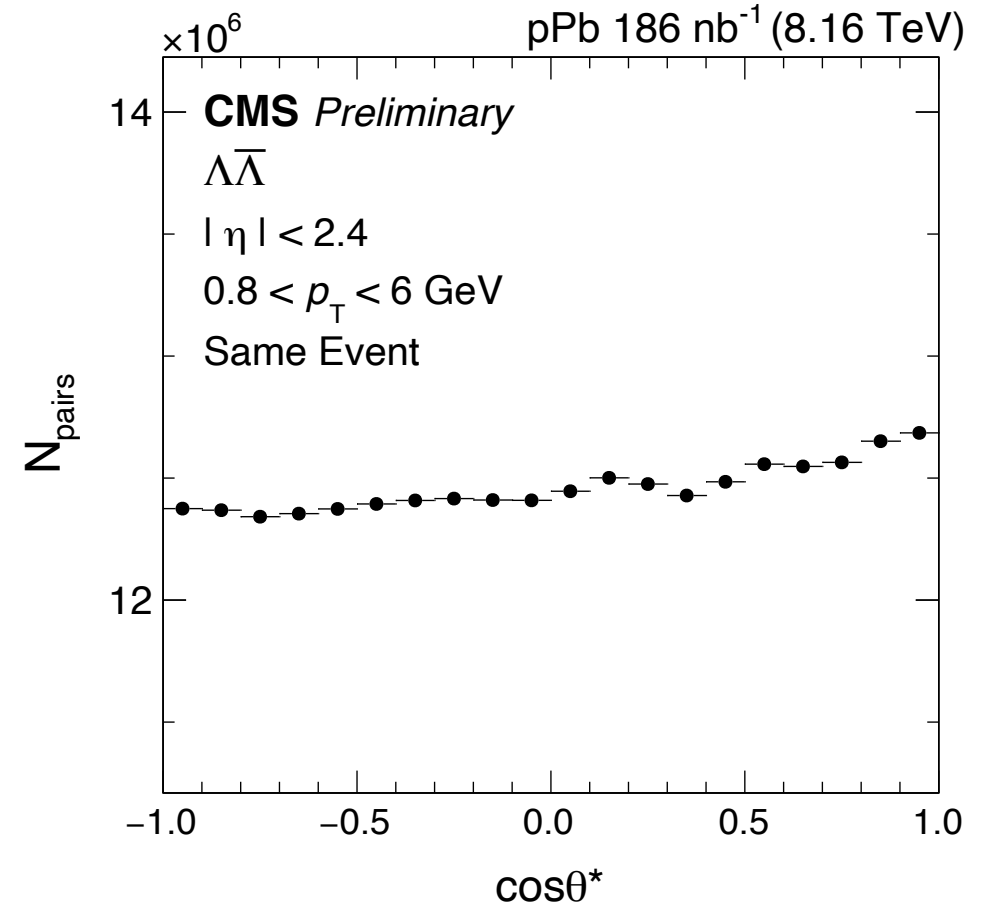
Λ pair reconstruction



Pair yield extraction



Fit the projected distribution to
extract yield of real Λ pairs



Need to correct detector effect
for the $dN/d\cos\theta^*$ distribution

Mixed event correction

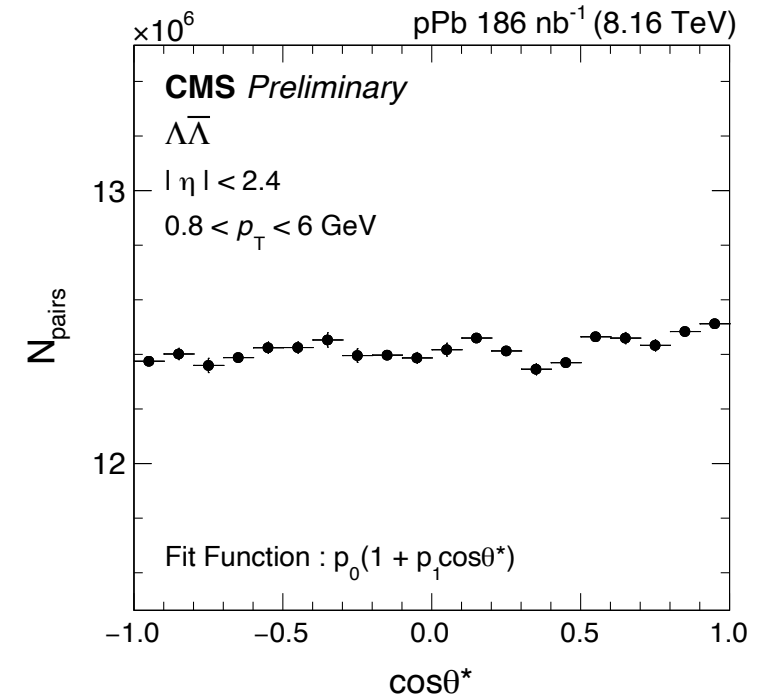
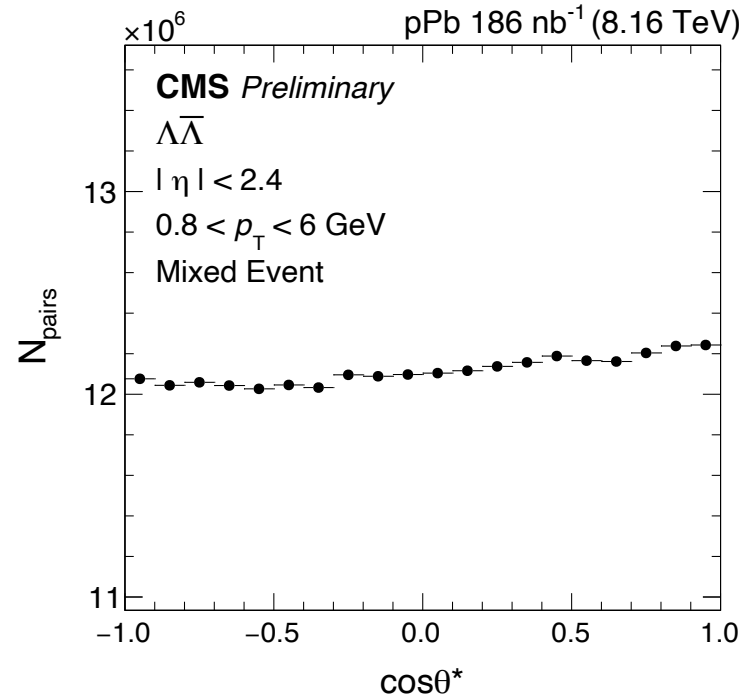
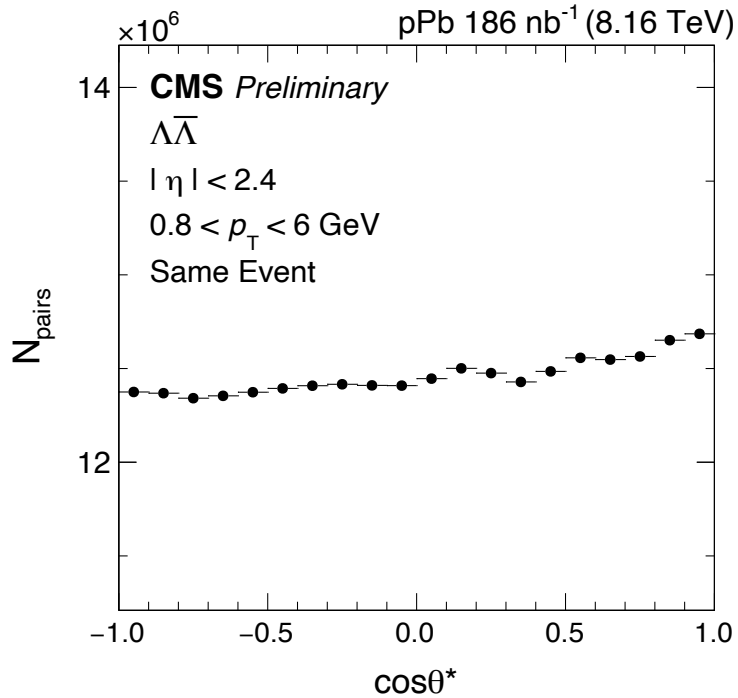


Replace one Λ with another Λ from random events with requirements

$$|\Delta v_z| < 2cm, |\Delta N_{trk,offline}| < 5$$

$$|\Delta p_T| < 0.1, |\Delta \eta| < 0.1, |\Delta \phi| < 0.1$$

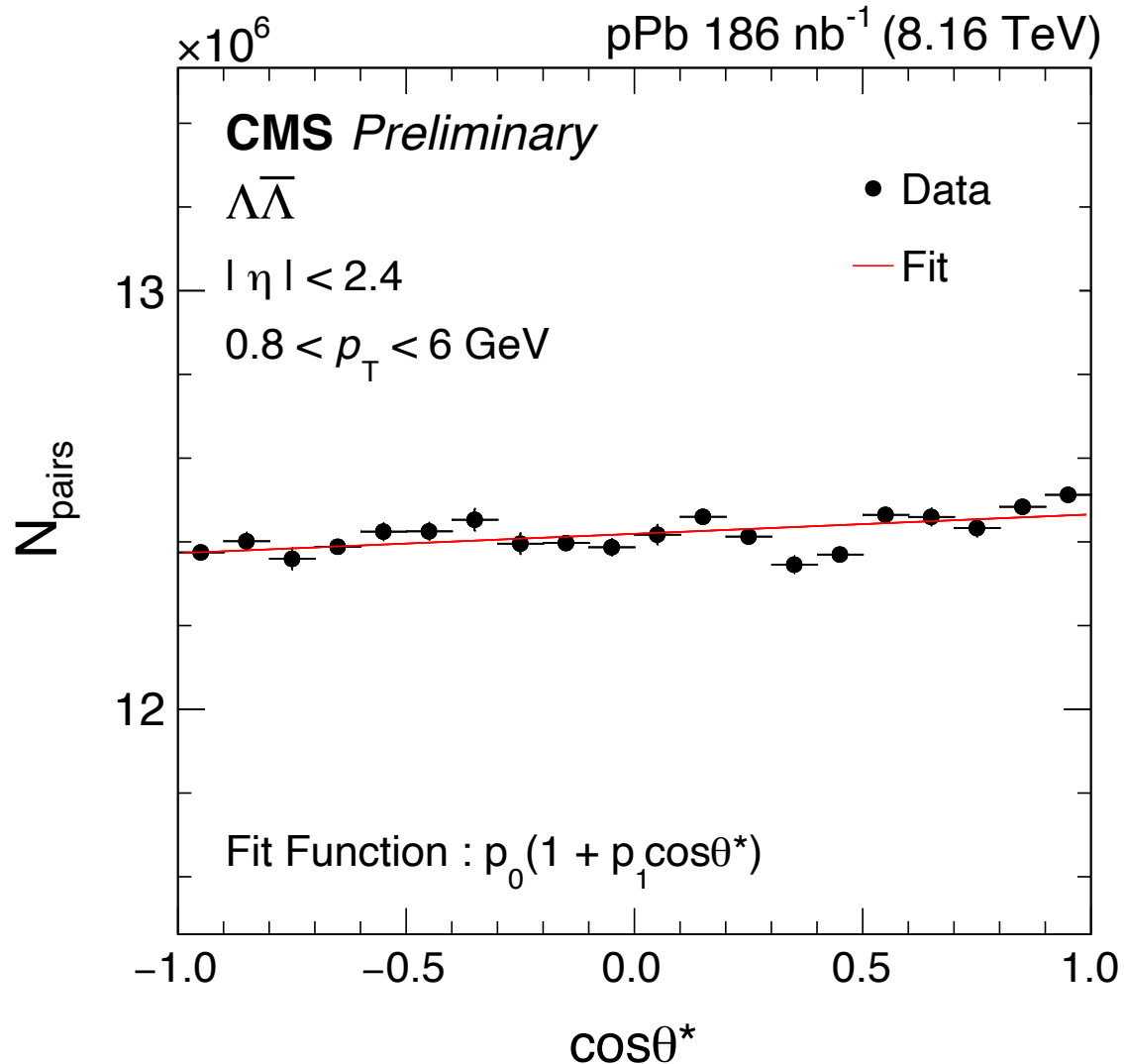
Mixed event correction



Same event / Mix event = Final $\cos\theta^*$ distribution

Correct the same event $\cos\theta^*$ with mixed event

Spin correlation $P_{\Lambda\Lambda}$ extraction



$P_{\Lambda\Lambda}$ is extracted by the fitting to the Final $\cos\theta^*$ distribution

$$N_{\text{pairs}} = p_0(1 + p_1 \cos\theta^*)$$

$$p_0 = N_{\text{pairs}}/2$$

$$p_1 = \alpha_1 \alpha_2 P_{\Lambda\Lambda}$$

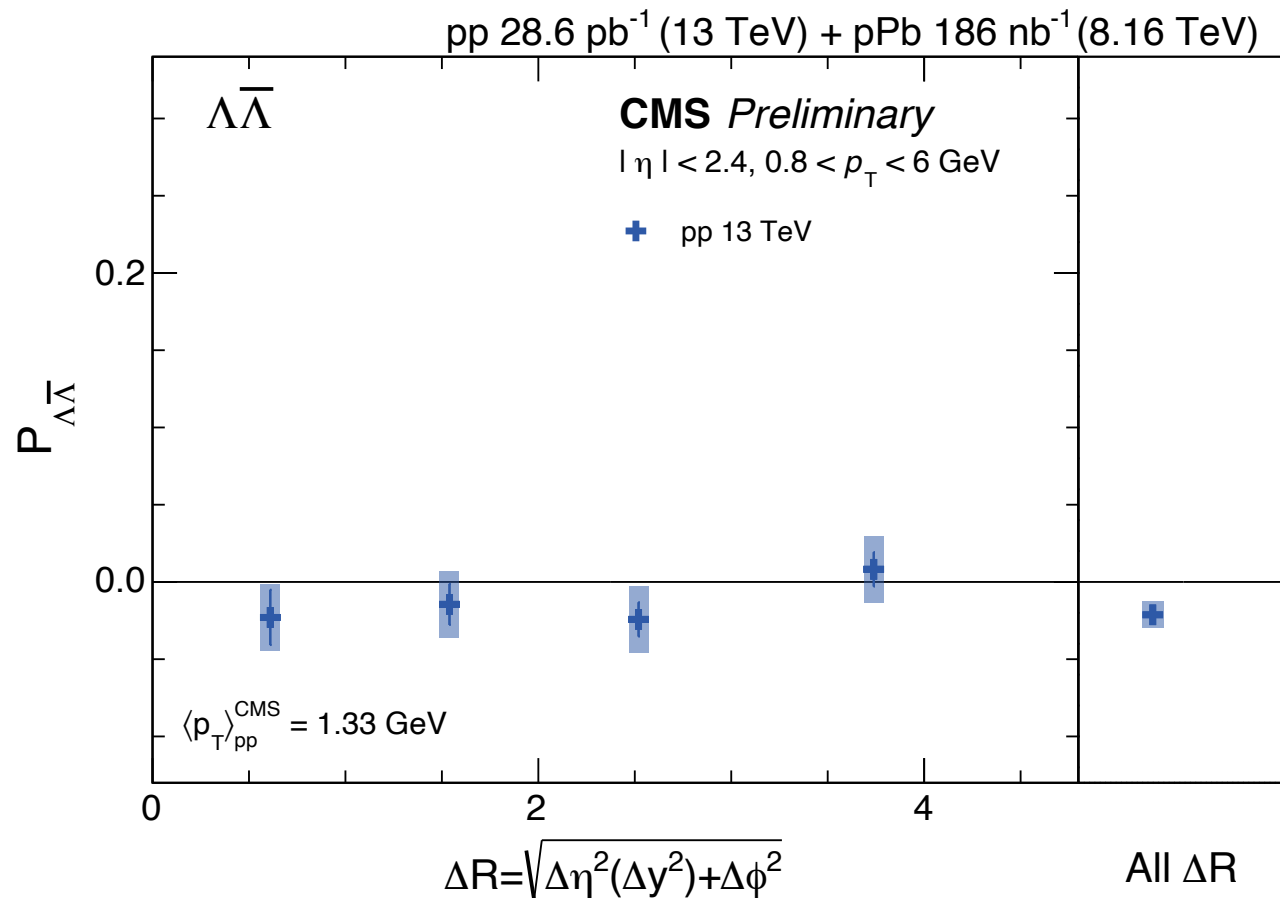
$$\alpha_{\Lambda} = 0.750 \pm 0.009,$$

$$\alpha_{\bar{\Lambda}} = -0.758 \pm 0.010$$

(*Nature Phys.* 15 (2019) 631)

Spin correlation of $\Lambda\bar{\Lambda}$ pairs

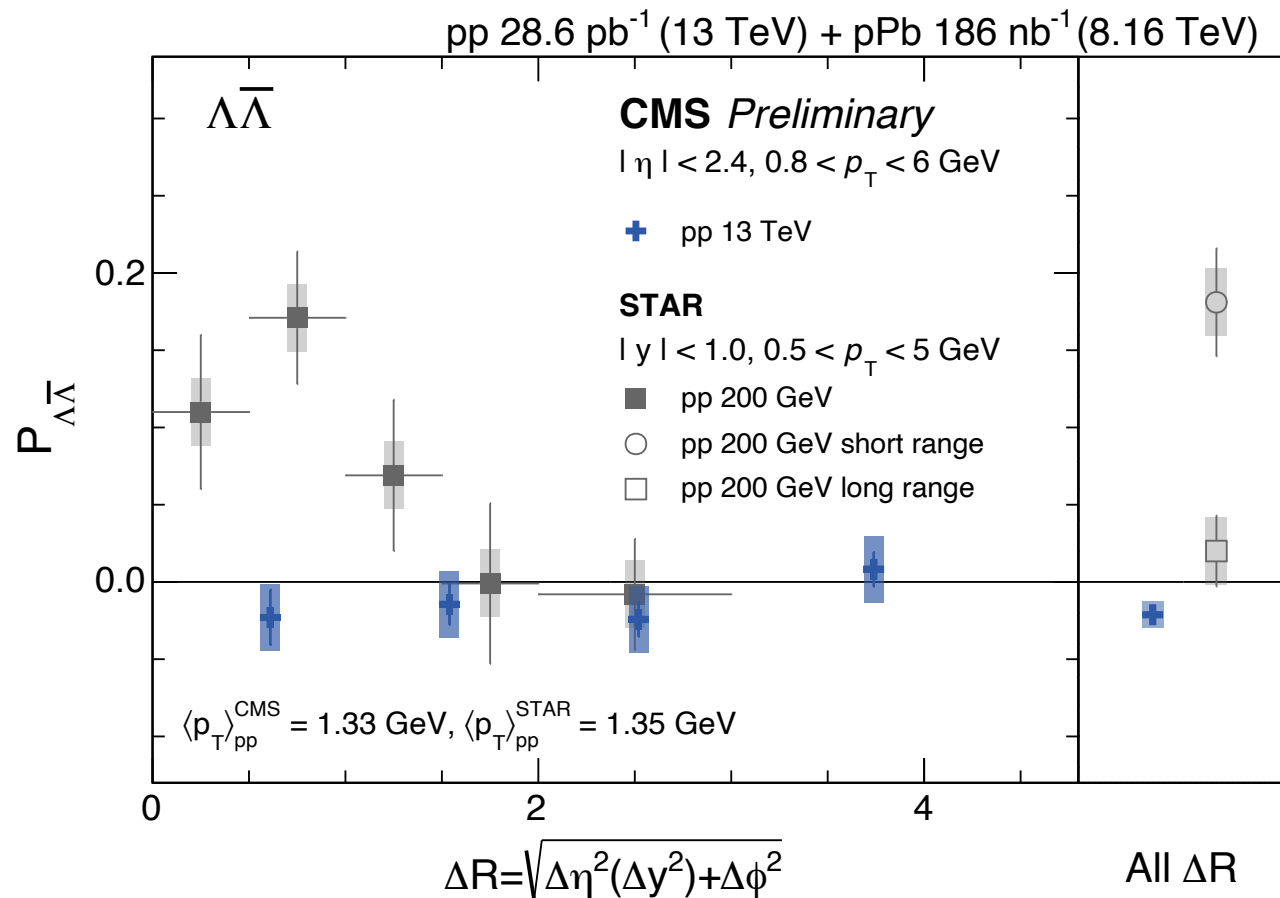
pp 13 TeV



ΔR differential results are consistent with zero within uncertainties
Integrated result shows a hint of negative value

Spin correlation of $\Lambda\bar{\Lambda}$ pairs

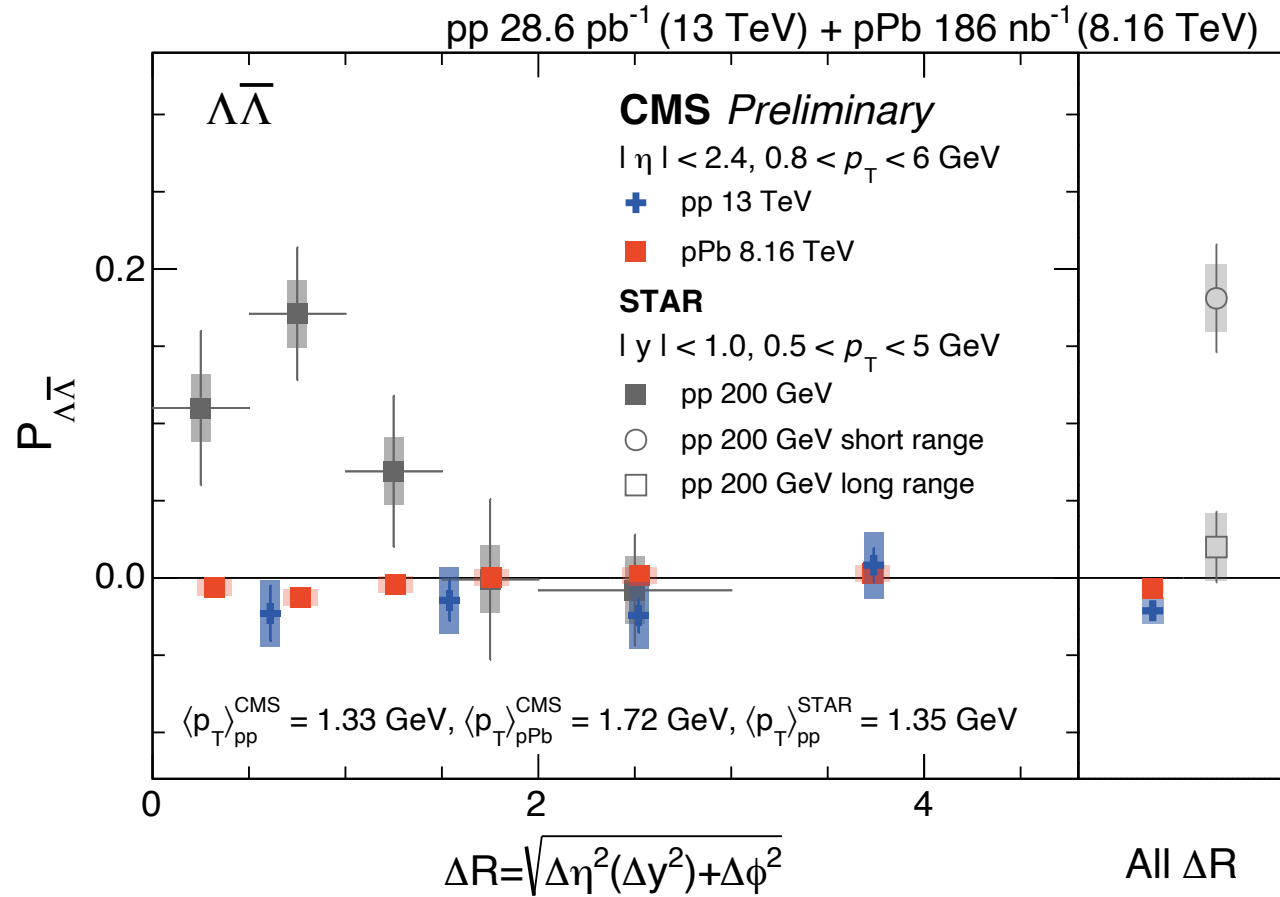
pp 13TeV
pp 200GeV



Different behavior from STAR measurements at 200GeV
Might be due to different production mechanism at RHIC and LHC energies

Spin correlation of $\Lambda\bar{\Lambda}$ pairs

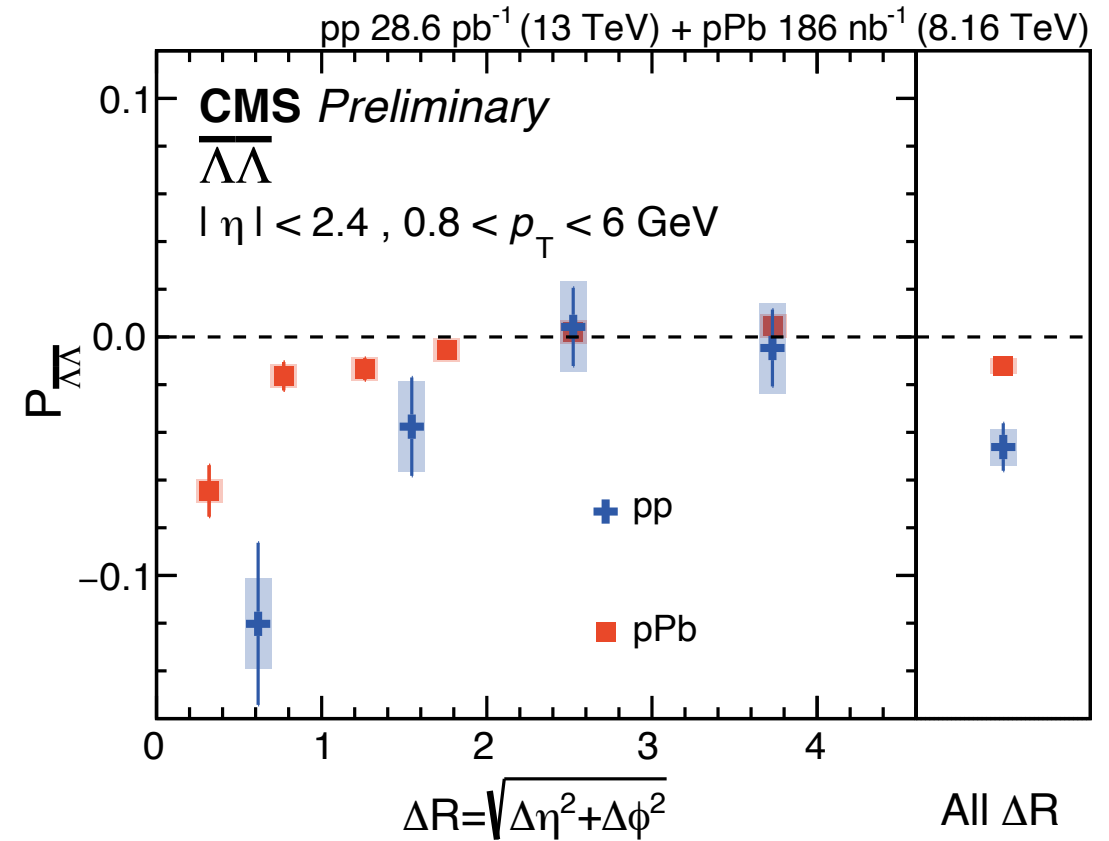
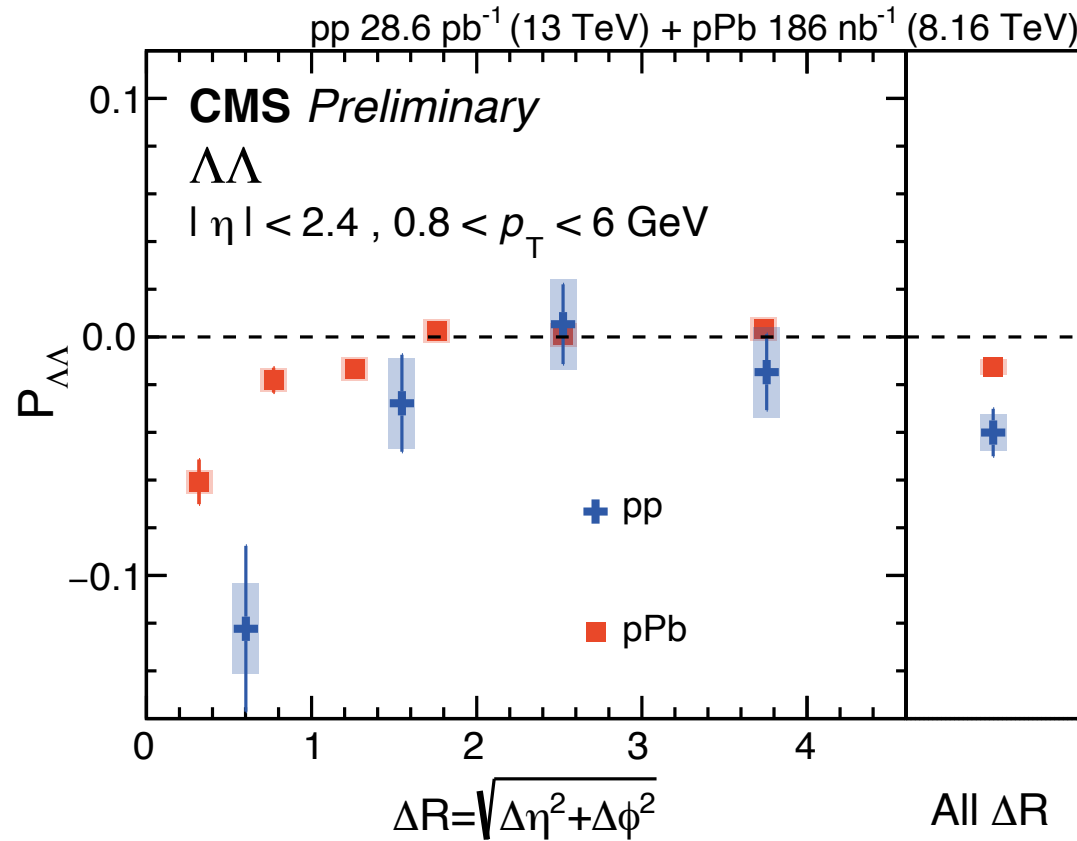
pp 13TeV
pp 200GeV
pPb 8.16TeV



pPb results similar to pp

Average multiplicity for pPb ~ 101 , where collectivity behavior emerges

Spin correlation of $\Lambda\Lambda$ and $\bar{\Lambda}\bar{\Lambda}$ pairs

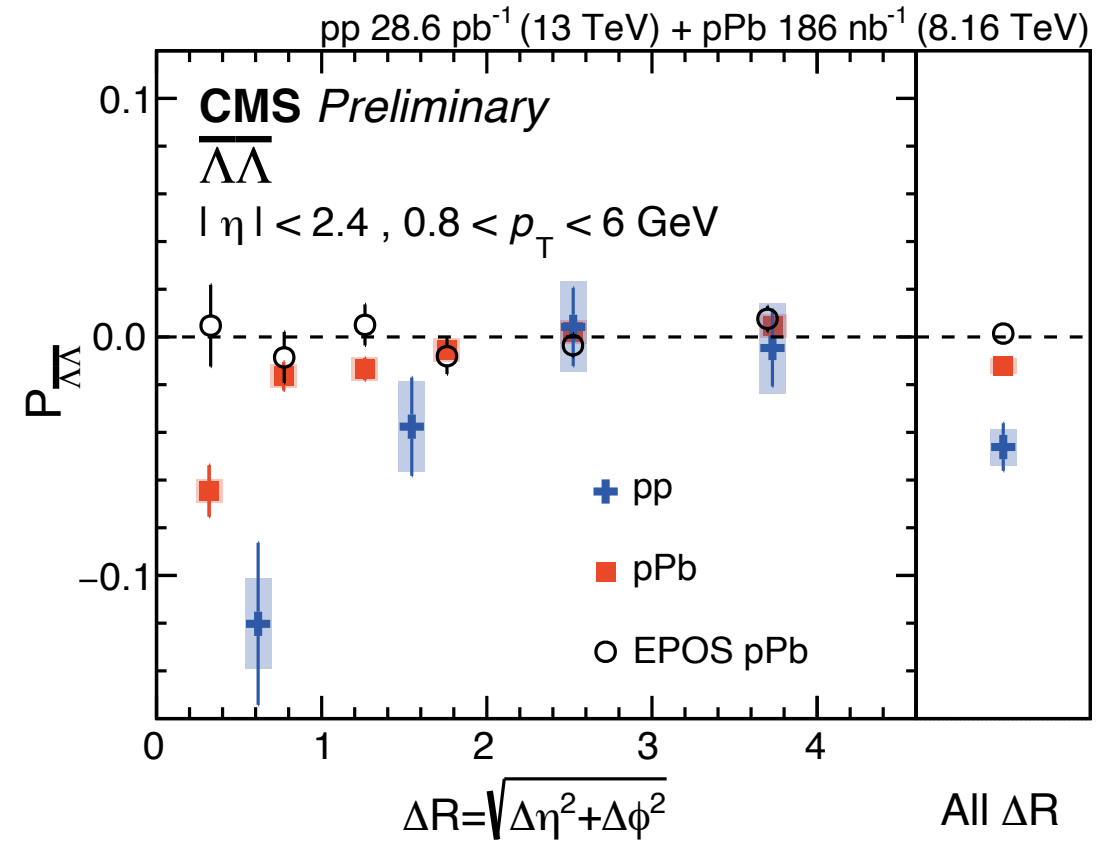
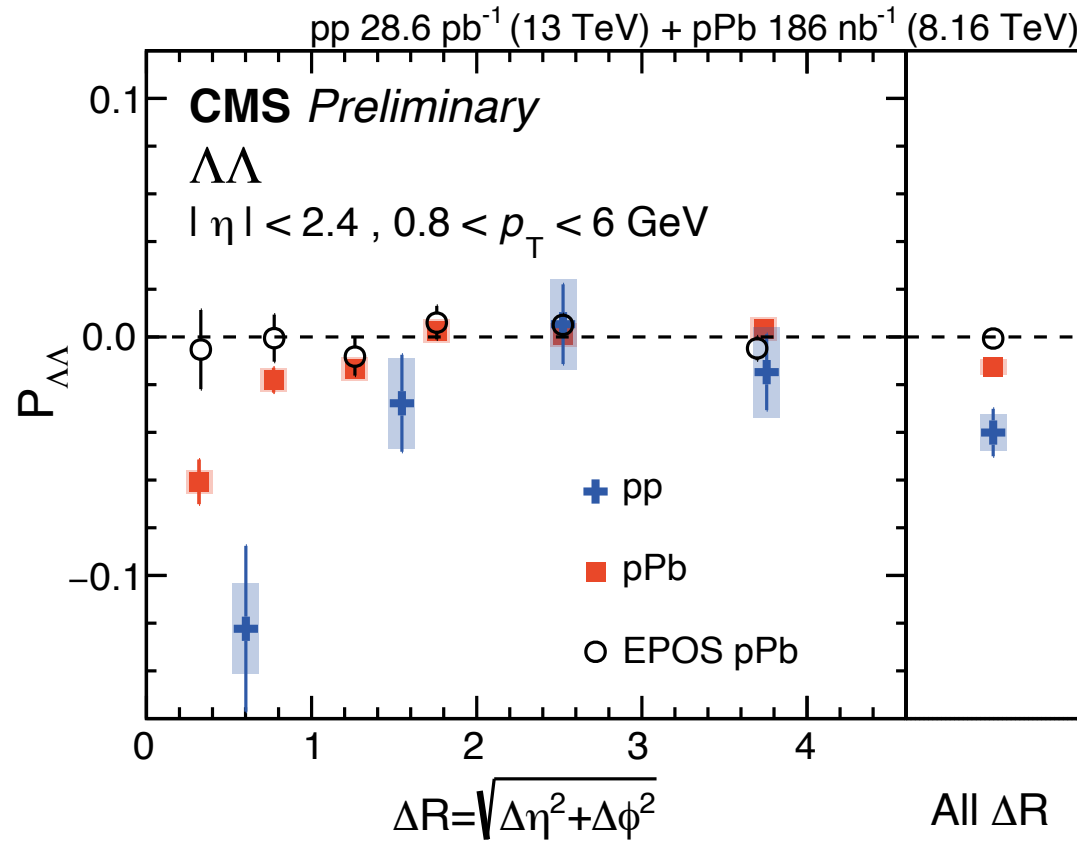


Negative spin correlation observed at small ΔR for $\Lambda\Lambda$ and $\bar{\Lambda}\bar{\Lambda}$ pairs

Converge to zero at large ΔR value

A hint of larger magnitudes in pp than pPb

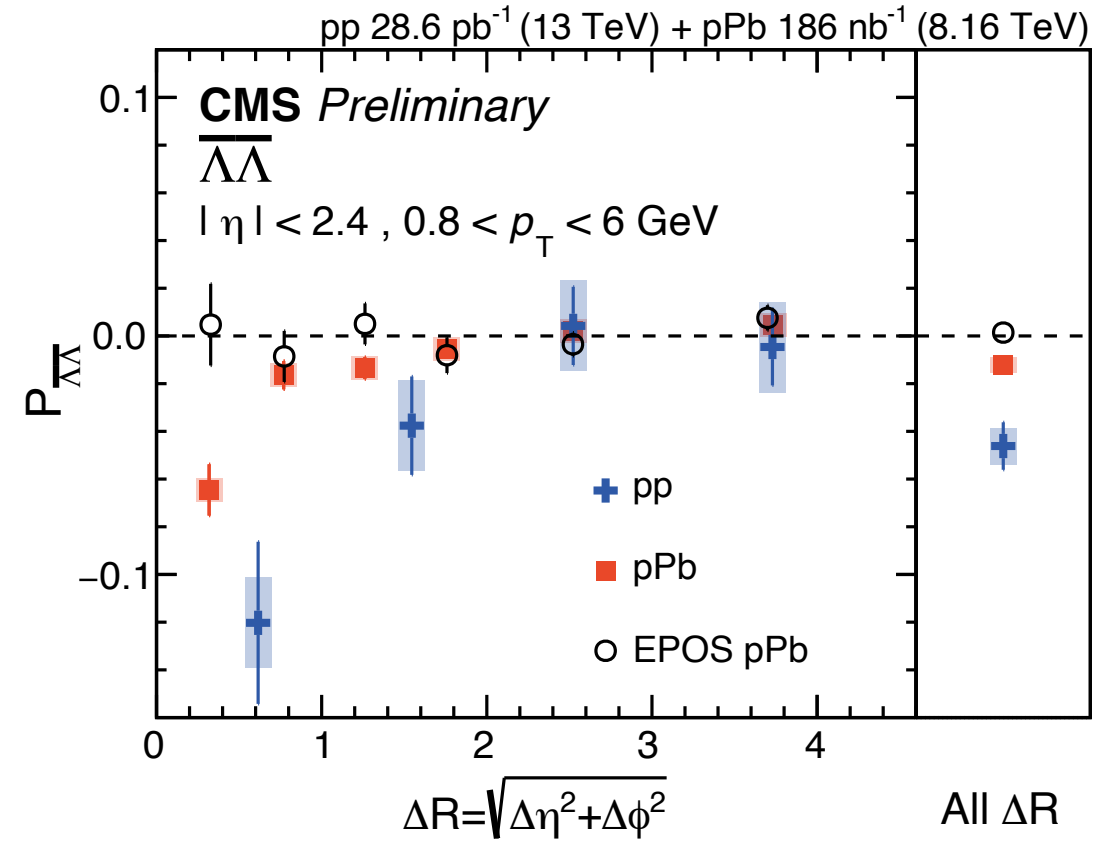
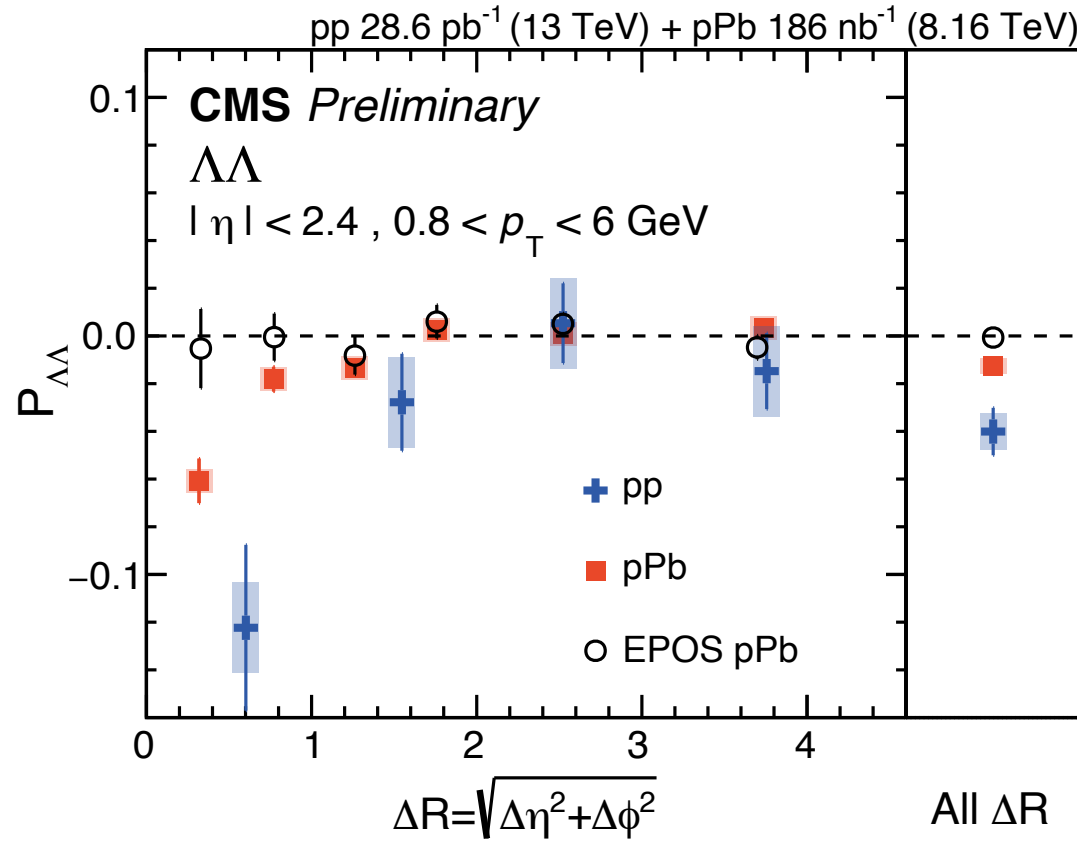
Spin correlation of $\Lambda\Lambda$ and $\bar{\Lambda}\bar{\Lambda}$ pairs



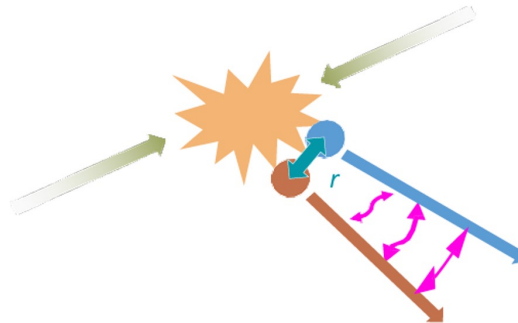
Same observables in EPOS LHC are consistent with zero as expected

↗
No spin degree of freedom

Spin correlation of $\Lambda\Lambda$ and $\bar{\Lambda}\bar{\Lambda}$ pairs

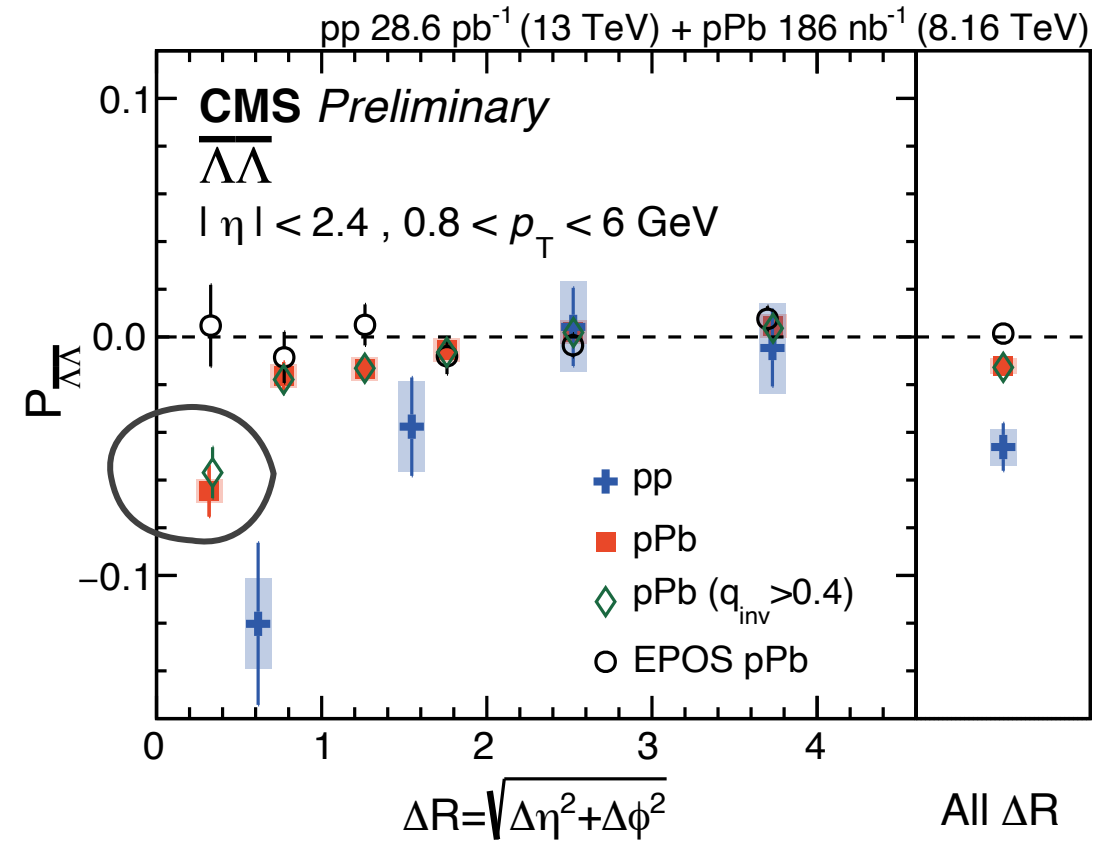
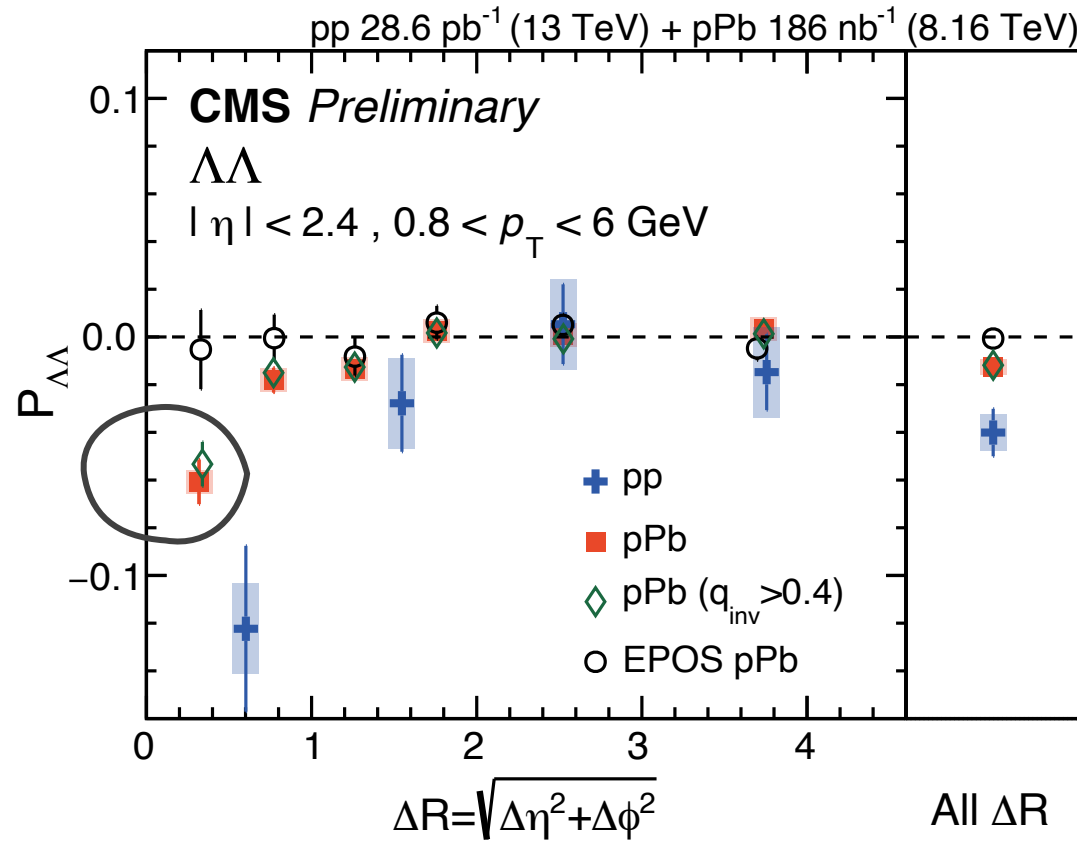


HBT (Hanbury-Brown-Twiss) effect



$$q_{inv} = \sqrt{M_{\Lambda\Lambda}^2 - 4m_{\Lambda}^2}$$

Spin correlation of $\Lambda\Lambda$ and $\bar{\Lambda}\bar{\Lambda}$ pairs



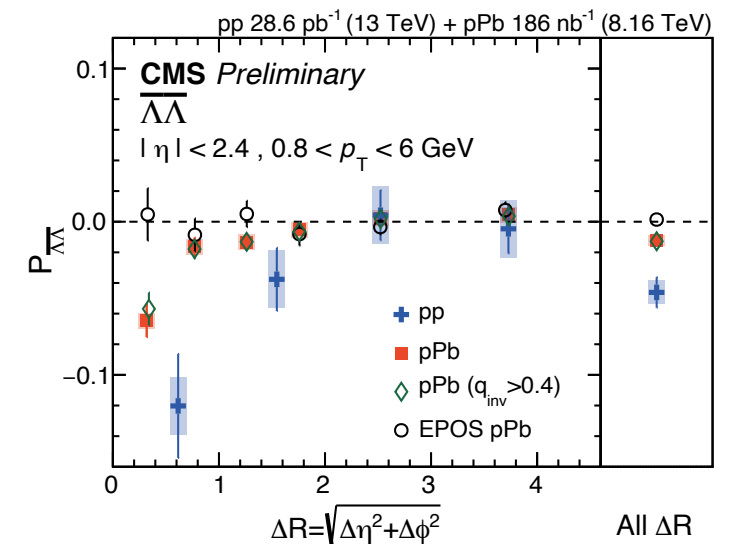
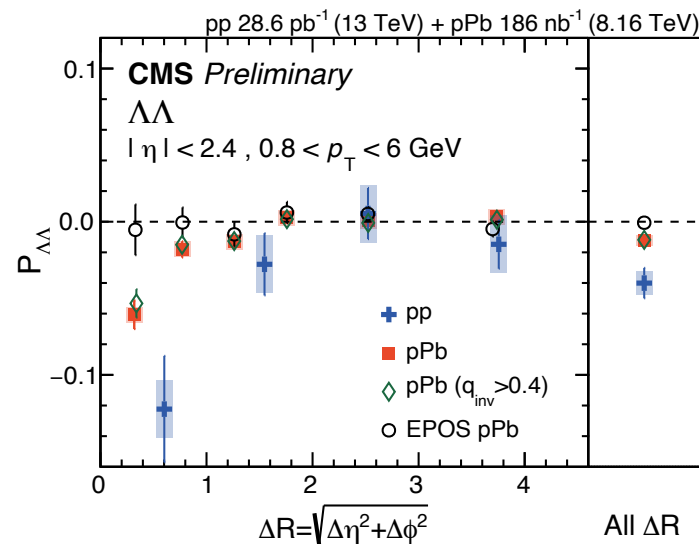
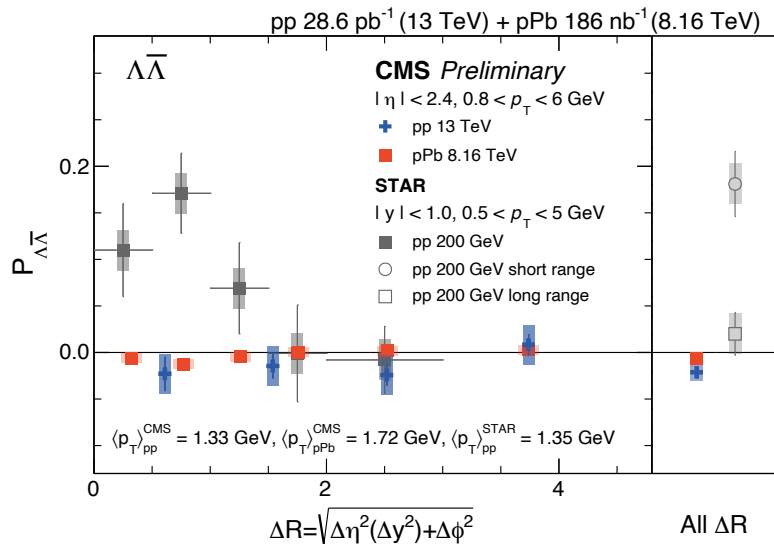
Same observables in EPOS LHC are consistent with zero as expected

Results with $q_{inv} > 0.4 \text{ GeV}$ consistent with default

Indicate the signal is not dominated by simple HBT effects

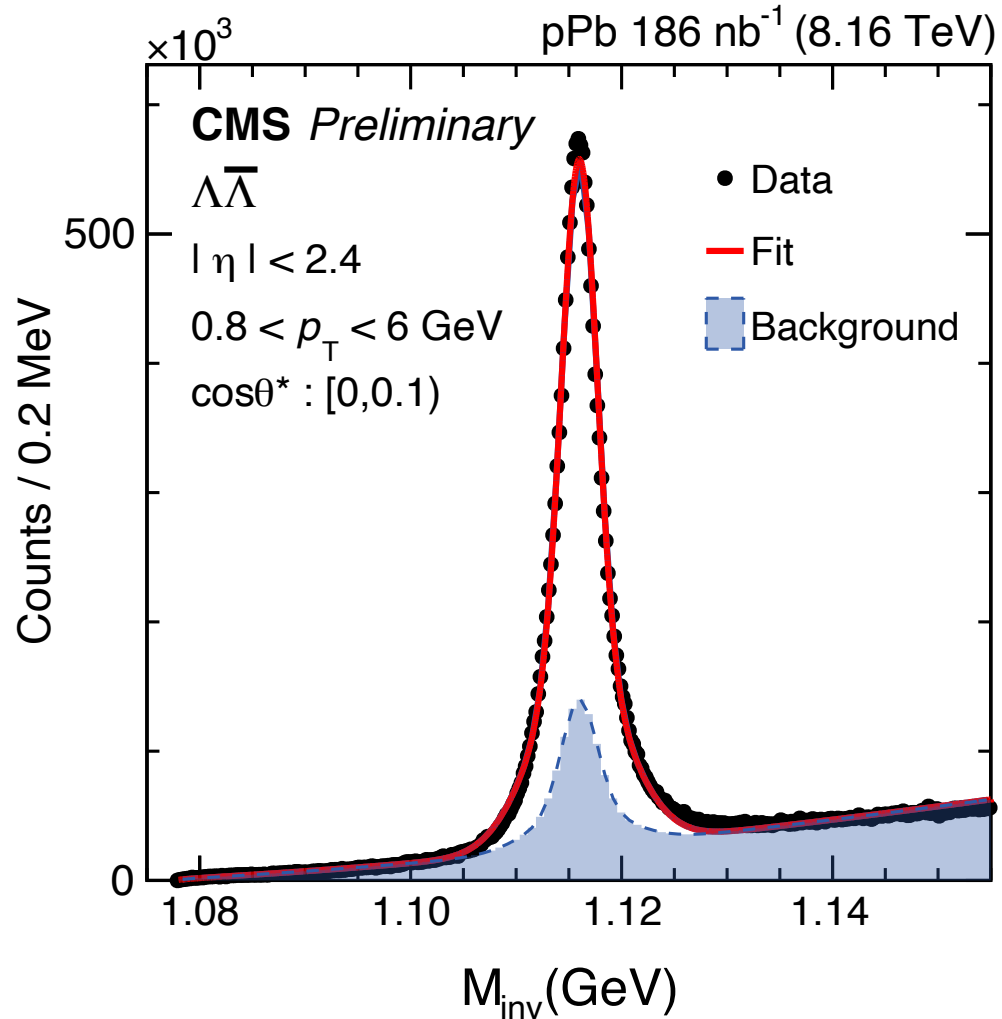
Summary

- First Λ spin correlation measurement in pp and pPb at LHC
- $\Lambda\bar{\Lambda}$ spin correlation consistent with zero, with a hint of negative value
 - difference with STAR hints at different production at RHIC v. LHC
- Negative correlations found for $\Lambda\Lambda$ and $\bar{\Lambda}\bar{\Lambda}$ at small ΔR
 - converge to zero for large ΔR
- The underlying mechanism remains an open question
- Stay tuned for future measurements in AA collisions



Backup

Pair yield extraction



● For single Λ candidates

$$f(m) = f_{\text{signal}} + f_{\text{background}}$$

f_{signal} : Double Gaussian function

$$f_{\text{background}} : Aq^{\frac{1}{2}} + Bq^{\frac{3}{2}}, q = m - (m_{\pi} + m_p)$$

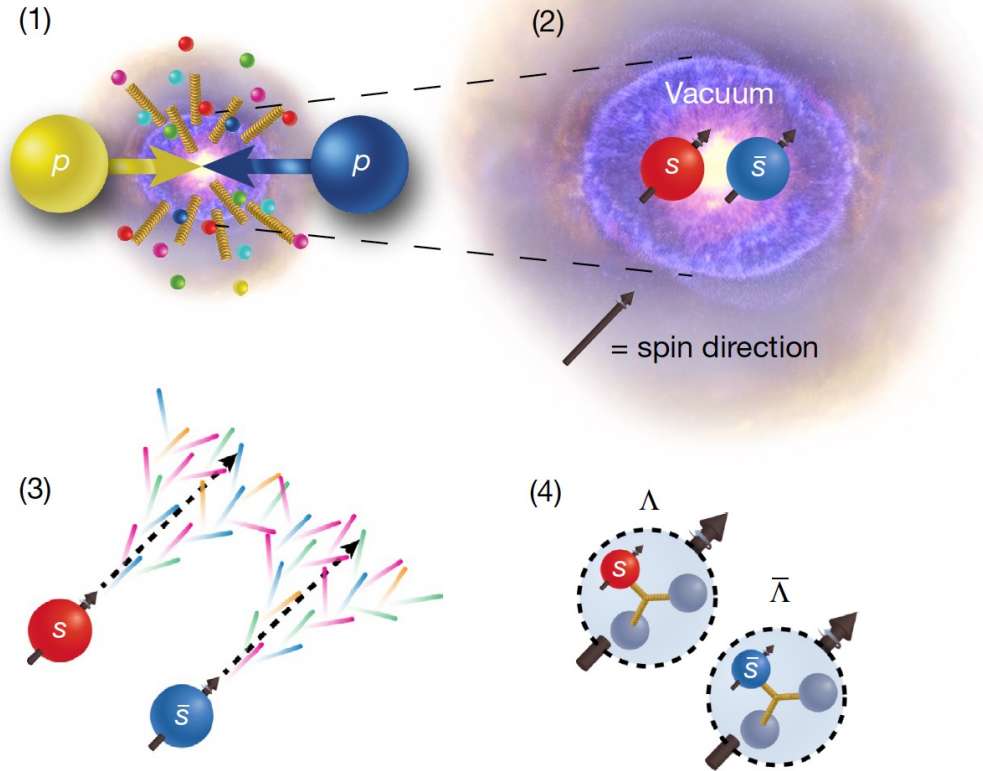
● For Λ pair candidates

$$f(x, y) = f(x) \times f(y)$$

Fit the projected distribution to extract yield of real Λ pairs

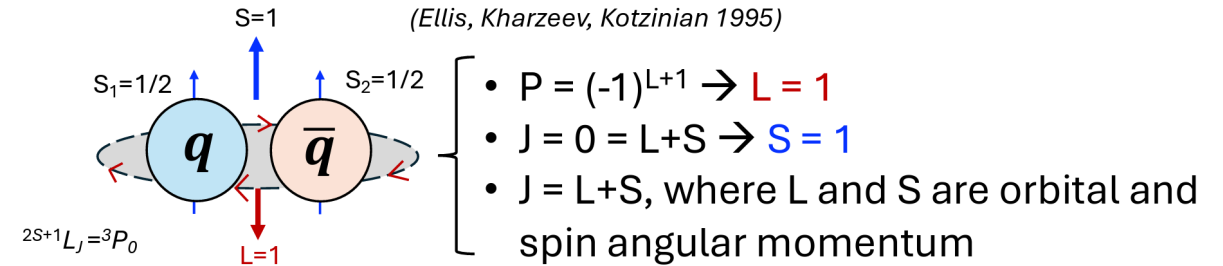
Hepyon spin correlation

Nature 650, 44-45 (2026)



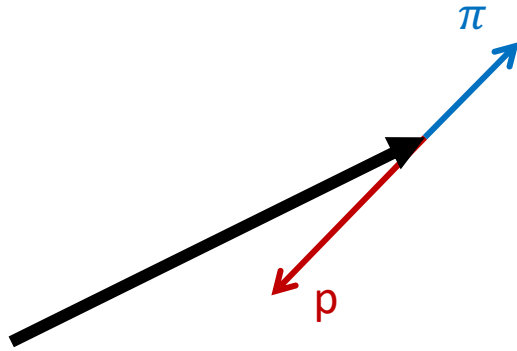
$$J^{PC} = 0^{++}$$

(Ellis, Kharzeev, Kotzinian 1995)



Impact of acceptance effect

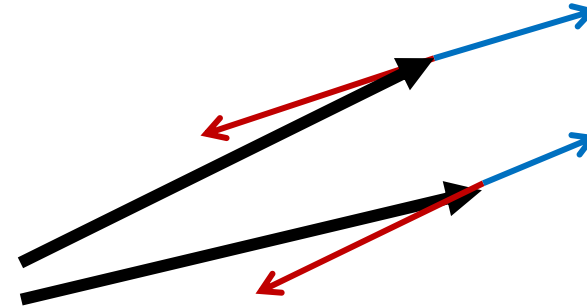
Single Λ decay



Λ decay (rest frame)

π will gain a boosted p_T in lab frame, resulting higher reconstruction efficiency of this π and this Λ

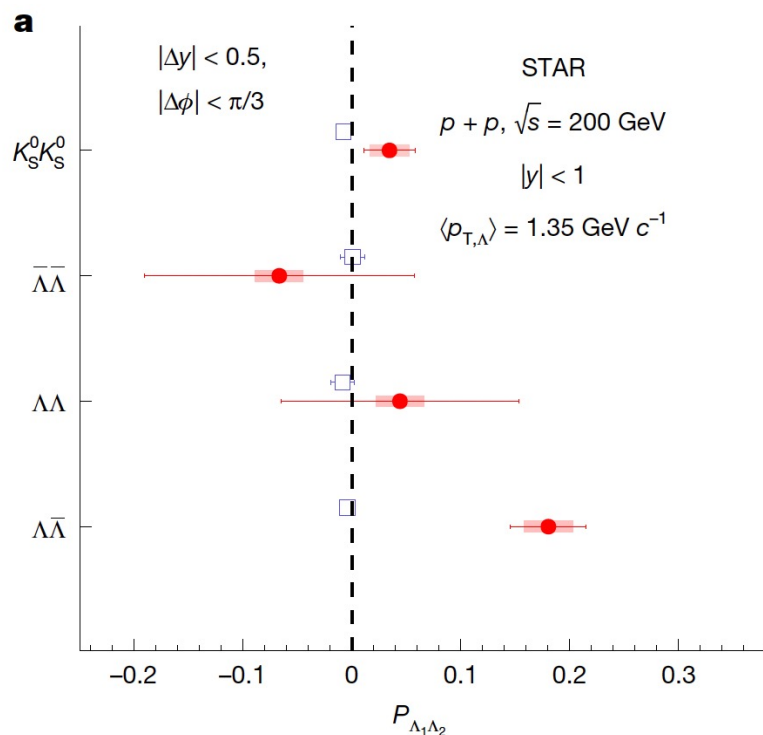
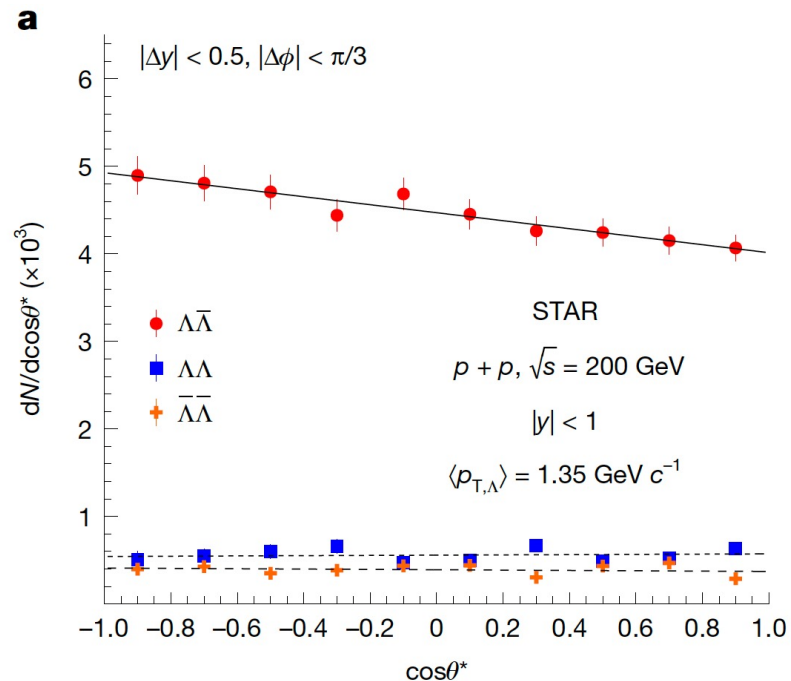
Λ pairs decay



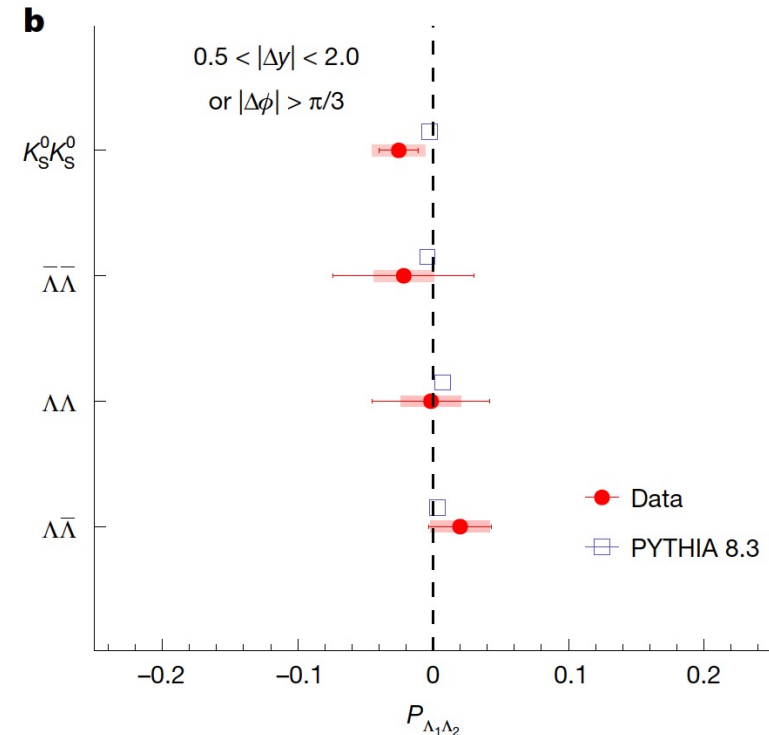
Λ pairs decay (in both rest frame)

Considering the effect, if you pick close Λ s, their proton tend to have the same momentum direction in rest frame, thus $\cos\theta^* \sim 1$

STAR Results

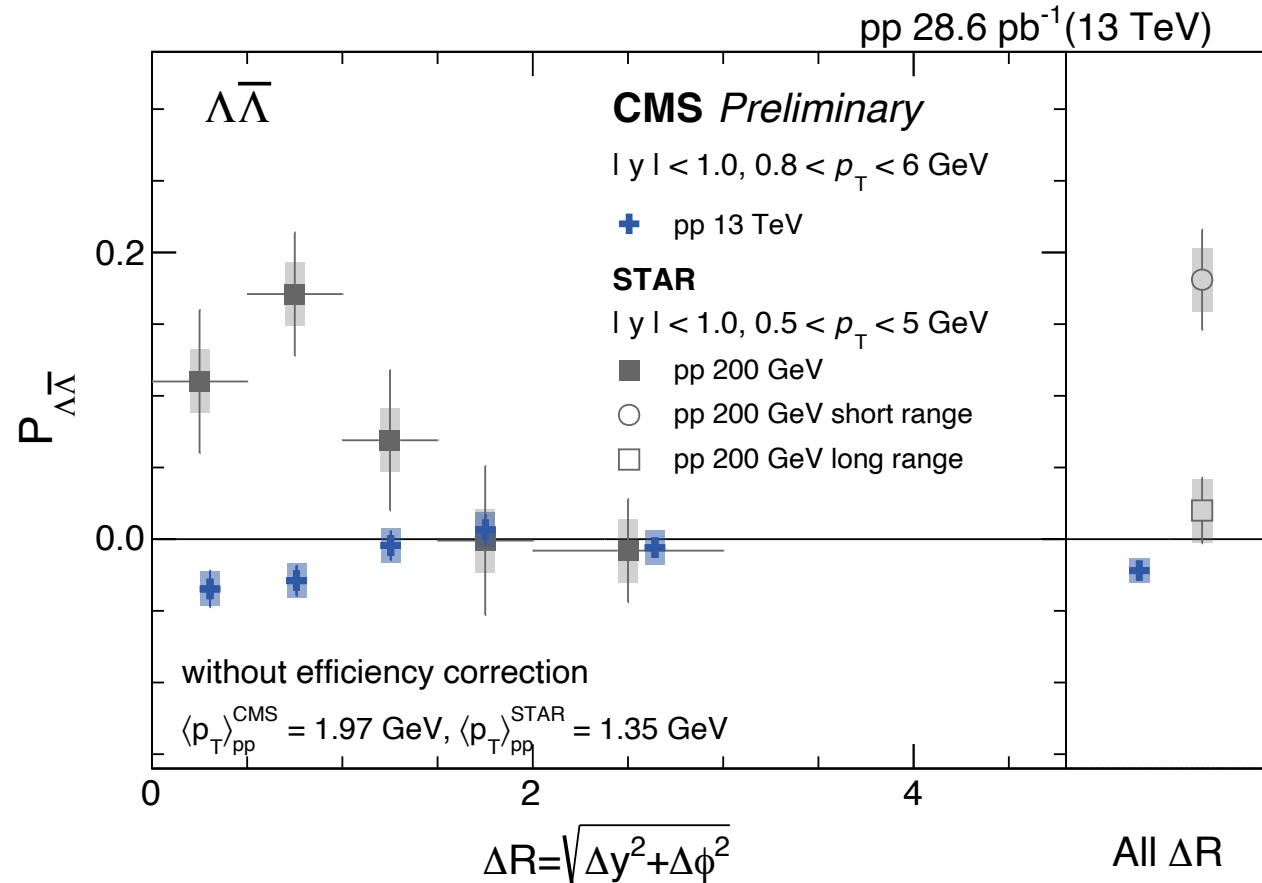


Short range



Long range

Comparison with STAR(w/o eff corr)



Comparison with STAR $\Lambda\Lambda$ and $\bar{\Lambda}\bar{\Lambda}$

