Spin-spin correlations in $\Lambda\bar{\Lambda}$ pairs production

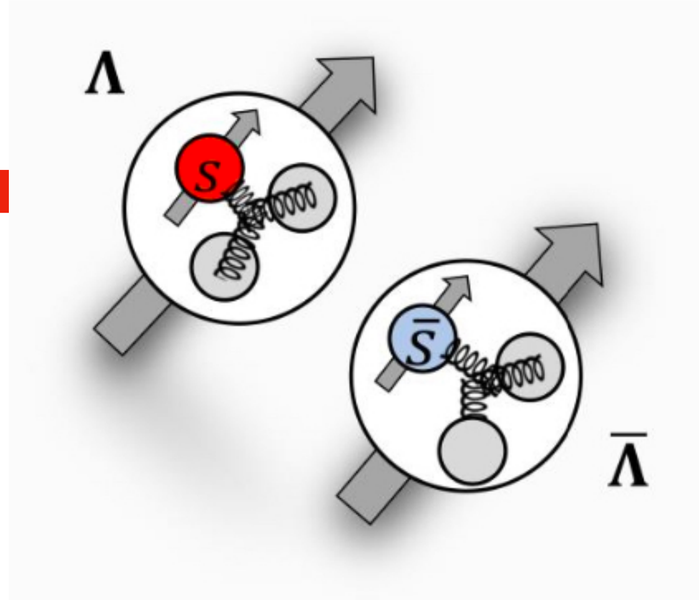
at NICA SPD

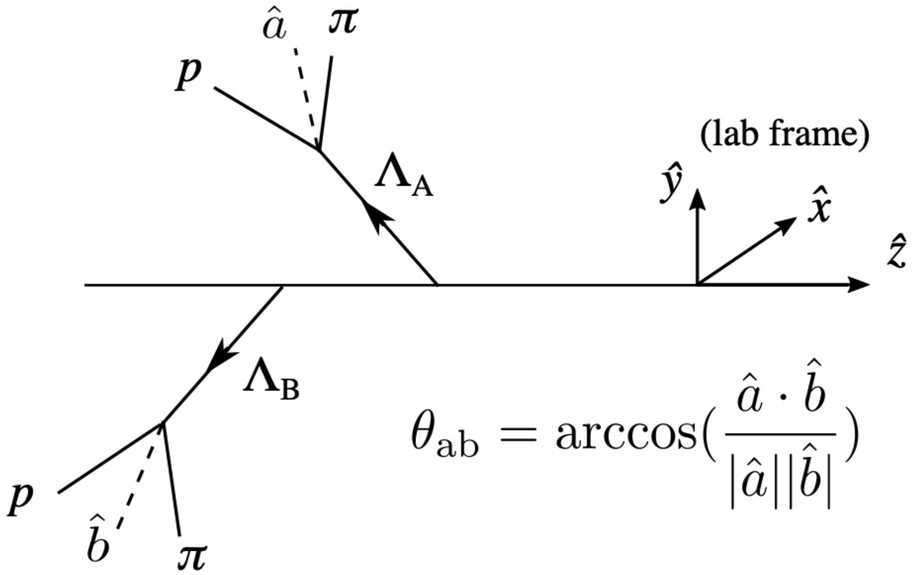
A. Guskov 31.03.2025

Physics case

Spin correlations of $\Lambda\bar{\Lambda}$ pairs produced in pp and dd collisions can provide unique insight into the locality and entanglement effects in hadronization process.







$$\theta_{ab} = \arccos\left(\frac{\hat{a}\cdot\hat{b}}{|\hat{a}||\hat{b}|}\right)$$

$$\sigma = \sigma_0(1 + \alpha_\Lambda \alpha_{\bar{\Lambda}} P_{\Lambda\bar{\Lambda}} \cos\theta_{ab})$$

STAR results

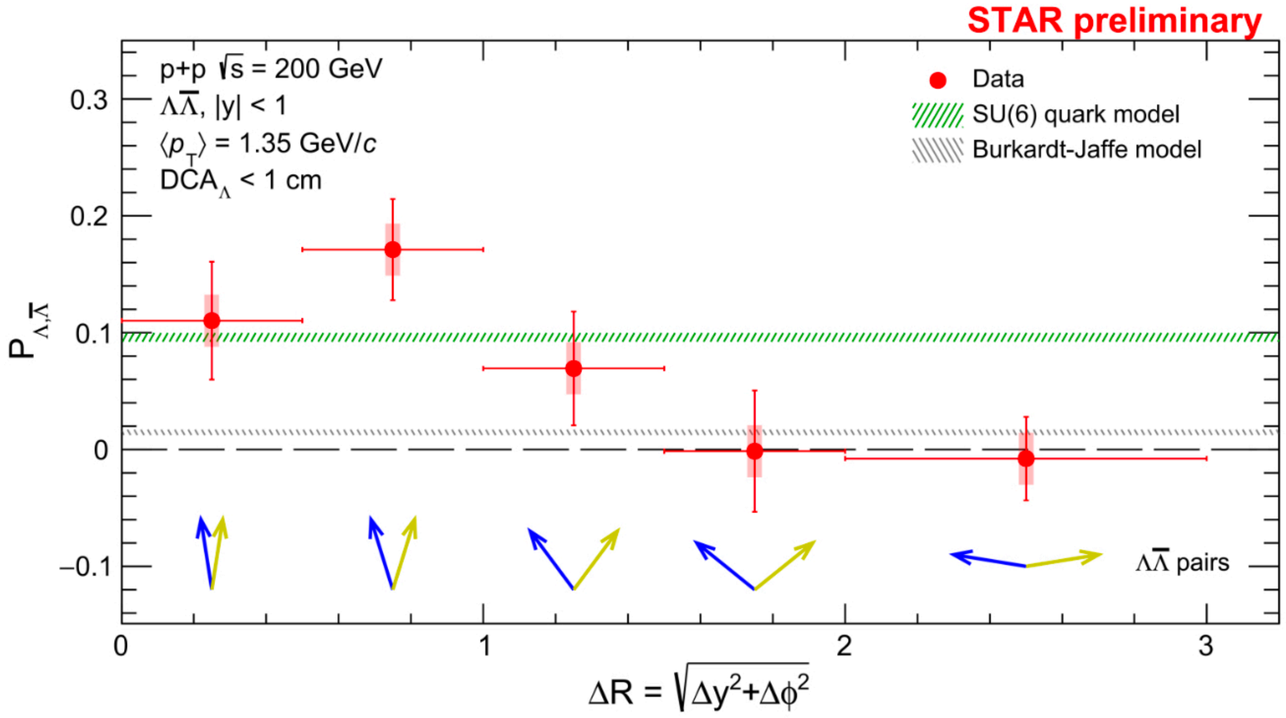
400M of unpolarized MB pp-events at $\sqrt{s}$=200 GeV (2012)

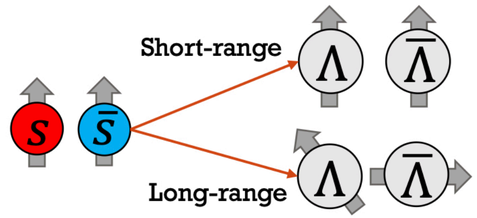
400M MB events

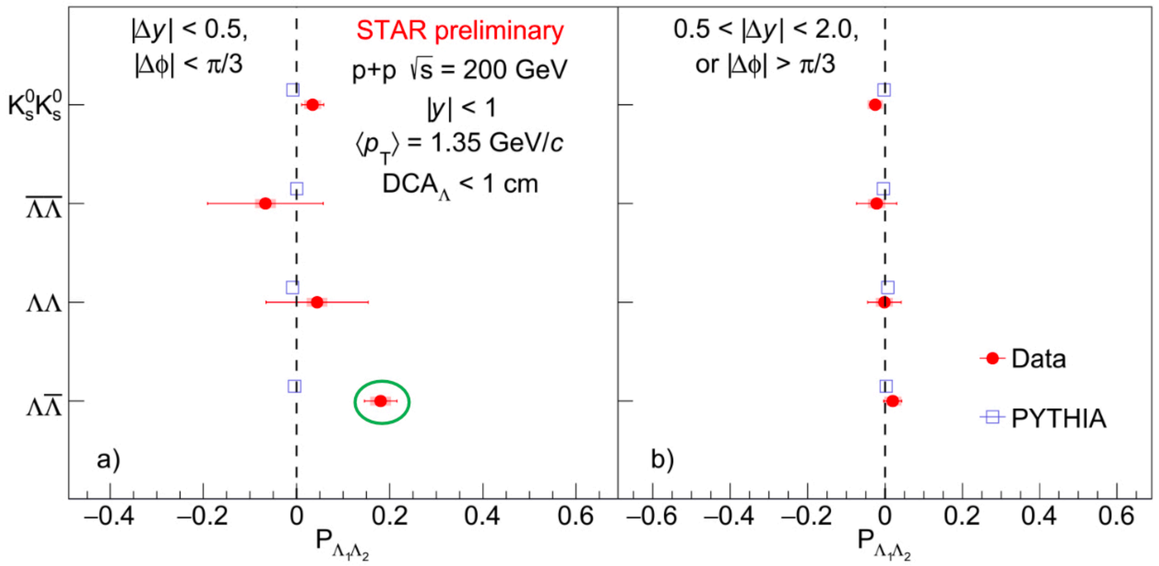
130k $\Lambda-$pairs

$|y| < 1$

$0.5\ GeV/c < p_T < 5.0\ GeV/c$

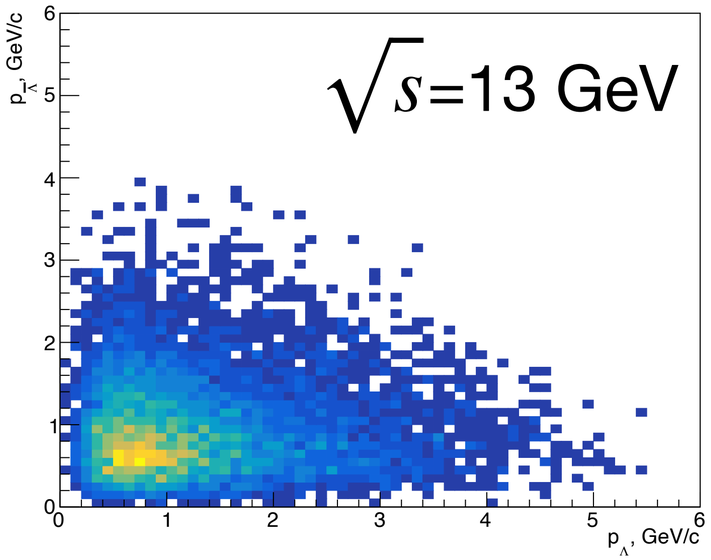


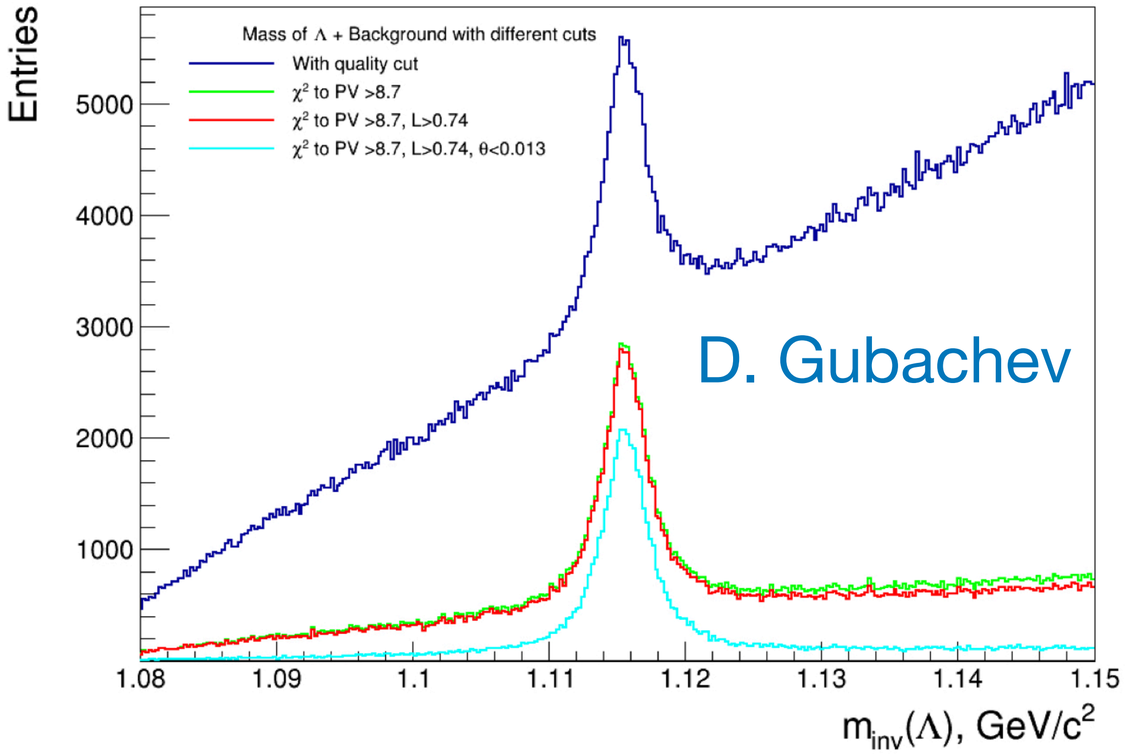




The first evidence of non-zero spin correlations on the hadronic level!

$\Lambda\Lambda$-pairs at SPD





Reconstruction efficiency: ~1% in full range
and ~ 4% for p_T>0.5 GeV/c and |η|<1.2 -D. Gubachev

13M $\Lambda\bar{\Lambda}$ pairs decaying into $p\pi$ per 3 days and 130M per 1 month in dd collision at 13 GeV ($\sigma_{stat} \approx 0.04\,\%$). 1M and 10M for "the STAR range"

No need for MC correction: The normalization can be performed using the angular distribution for pairs taken from mixed events.

General information

Observables: two-particle ($p\bar{p}$) angular correlation function (angle between p and $\bar{p}$ momenta taken in the Λ and $\bar{\Lambda}$ rest frames, respectively
Physics being addressed: possible quantum entanglement and nonlocality effects in hadronization processes
Competitiveness: low-energy collisions at SPD are the optimal tool for the proposed studies
Complementarity: production in e^+e^- , DIS and other hadroproduction experiments
Previous results: STAR
Actuality: actual
Importance: important for understanding hadronization procss

Experimental requirements:

Beam species: **dd**, pp
Collision energy: 5 -13 GeV
Luminosity: 10^{31} cm^{-2} s^{-1} (13 GeV)
Polarization: **preferably** but not necessarily
Involved SPD subsystems: MCT, Straw tracker
Optimal duration of data taking: 1 month
Minimal duration of data taking: 3 days

Expected performance:

Total statistics: 60M pairs for dd collisions at 13 GeV
Statistical accuracy: for $<10^{-3}$
Main sources of systematics: incorrectness of the setup description in MC, combinatorial background subtraction

Backup

per 1 M of pp	10 GeV	13 GeV	27 GeV
LaL events	5 200	8 800	20 800
LaL pairs	5 900	10 000	25 100
LL events	4 300	5 400	9 600
LL pairs	4 400	5 600	10 200
aLaL events	5	50	900
aLaL pairs	5	50	900