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Precise Measurement of Di-Pion ($\pi^+\pi^-$) Azimuthal Correlation Asymmetry (A_{UT}) Using $p^\uparrow p$ Data At $\sqrt{s}$ = 510 GeV At STAR

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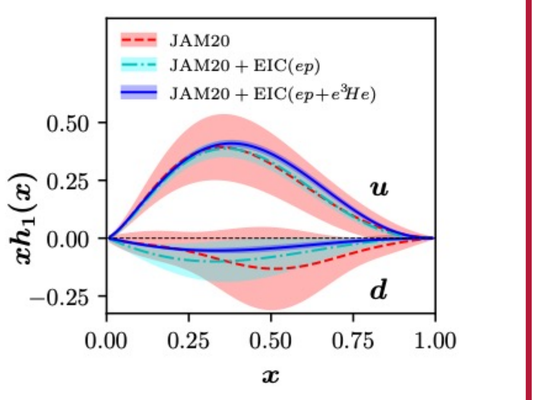
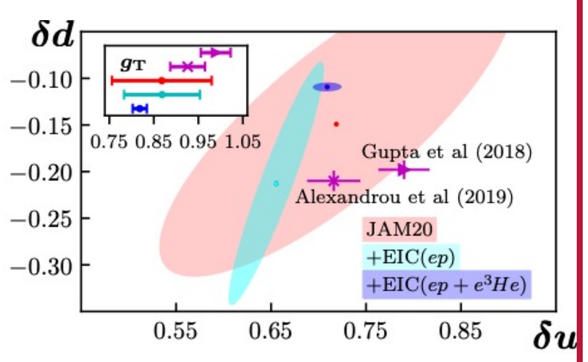
Motivation : Transversity ($h_1^q(x)$)

- $h_1^q(x)$ is the leading-twist parton distribution function (PDF) which describes the transversely polarized quarks inside a transversely polarized nucleon.
- $h_1^q(x)$ is the least known leading-twist PDF due to its chiral-odd nature and is accessible only when coupled with another chiral-odd function, such as interference fragmentation function(IFF), $H_1^\sphericalangle(z, M^2)$, in $p^\uparrow p$ collisions.
- Coupling of transversity with IFF gives rise to experimentally observable azimuthally correlated asymmetry (A_{UT}) of di-pion ($\pi^+\pi^-$) in the final state of $p^\uparrow p$ collisions.
- A precise measurement of $h_1^q(x)$ is necessary to measure the nucleon tensor charge (g_T) .

$$g_T = \int_0^1 dx[h_1^q(x) - h_1^{\bar{q}}(x)]$$

- The study of A_{UT} using the new STAR 2017 ($L_{int} = 350\, pb^{-1}$) provides a more precise measurement than the previous STAR 2011 ($L_{int} = 25\, pb^{-1}$) results.





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STAR Detector :

- **R**elativistic **H**eavy **I**on **C**ollider (**RHIC**) is capable of colliding polarized proton beams up to a center-of-mass energy, $\sqrt{s}$ = 510 GeV.
- The **STAR** (**S**olenoidal **T**racker **A**t **R**HIC) experiment, located within the RHIC ring, consists of various subsystems, including TPC, BEMC, TOF.
- Particle identification in STAR primarily relies on the combination of TPC and TOF.
- STAR has a long-standing history measuring A_{UT}.
- This analysis is based on the STAR 2017 dataset, which enhances the statistical precision by a factor of 4.

Detector	Acceptance	Use
TPC	$-1<\eta<1,\ 0<\phi<2\pi$	Tracking, PID
TOF	$-1<\eta<1,\ 0<\phi<2\pi$	PID
BEMC	$-1<\eta<1, 0<\phi<2\pi$	Event triggering

A_{UT} Extraction :

- Reaction channel: $p^\uparrow + p \rightarrow h^+h^- + X$
- Di-hadron azimuthal correlation asymmetry:

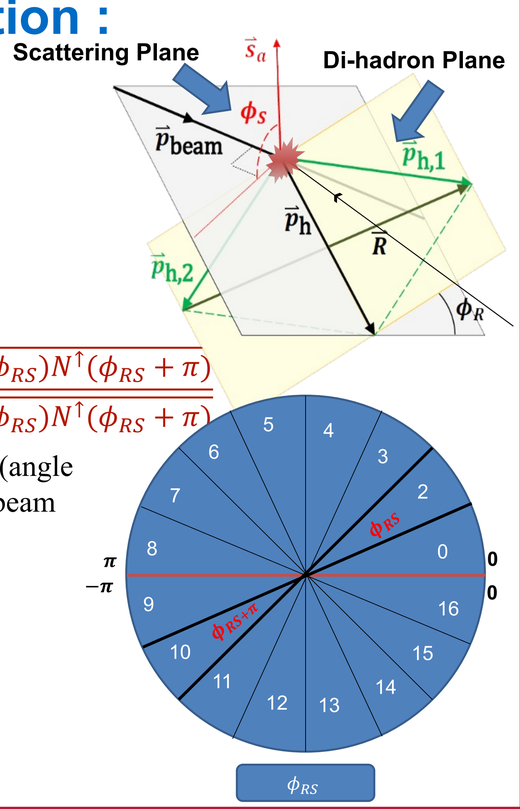
$$A_{UT} = \frac{d\sigma^\uparrow - d\sigma^\downarrow}{d\sigma^\uparrow + d\sigma^\downarrow} \propto h_1^q(x)H_1^\sphericalangle(z, M^2)$$

- For a symmetric detector like STAR A_{UT} can be extracted using cross-ratio formula,

$$A_{UT} \cdot sin(\phi_{RS}) = \frac{1}{P}\frac{\sqrt{N^\uparrow(\phi_{RS})N^\downarrow(\phi_{RS}+\pi)} - \sqrt{N^\downarrow(\phi_{RS})N^\uparrow(\phi_{RS}+\pi)}}{\sqrt{N^\uparrow(\phi_{RS})N^\downarrow(\phi_{RS}+\pi)} + \sqrt{N^\downarrow(\phi_{RS})N^\uparrow(\phi_{RS}+\pi)}}$$

where, $N^{\uparrow(\downarrow)}$ is the number of $\pi^+\pi^-$ in respective ϕ_{RS} (angle between scattering and di-hadron plane) bin when the beam polarization is ↑ (↓).

- This method is free from effects related to detector efficiencies and spin-dependent luminosity.



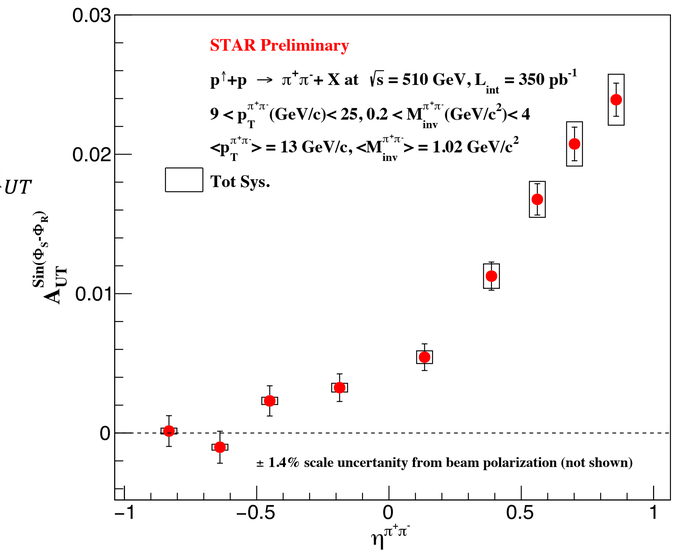
Summary and Outlook :

- STAR's new result from the 2017 data set precisely measures the $\pi^+\pi^-$ azimuthal correlation asymmetry A_{UT} at $\sqrt{s}$ = 510 GeV.
- A_{UT} is larger for $\eta^{\pi^+\pi^-} > 0$ due to higher x (where $h_1^q(x)$ is sizable) whereas A_{UT} is smaller in $\eta^{\pi^+\pi^-} < 0$ due to low-x.
- Interference between the different $\pi^+\pi^-$ production channels causes a strong A_{UT} signal around ρ meson mass (~ 0.8 GeV/c^2).
- A_{UT} signal increases linearly with $p_T^{\pi^+\pi^-}$.
- This result, together with precise unpolarized $\pi^+\pi^-$ cross-section measurement, will help improve our current understanding of transversity.
- Results of this analysis will help in probing transversity at much higher Q^2 than SIDIS and test the universality of the mechanism which produces azimuthal correlations amongst SIDIS, e^+e^-, and $p^\uparrow p$ collisions.

Results :

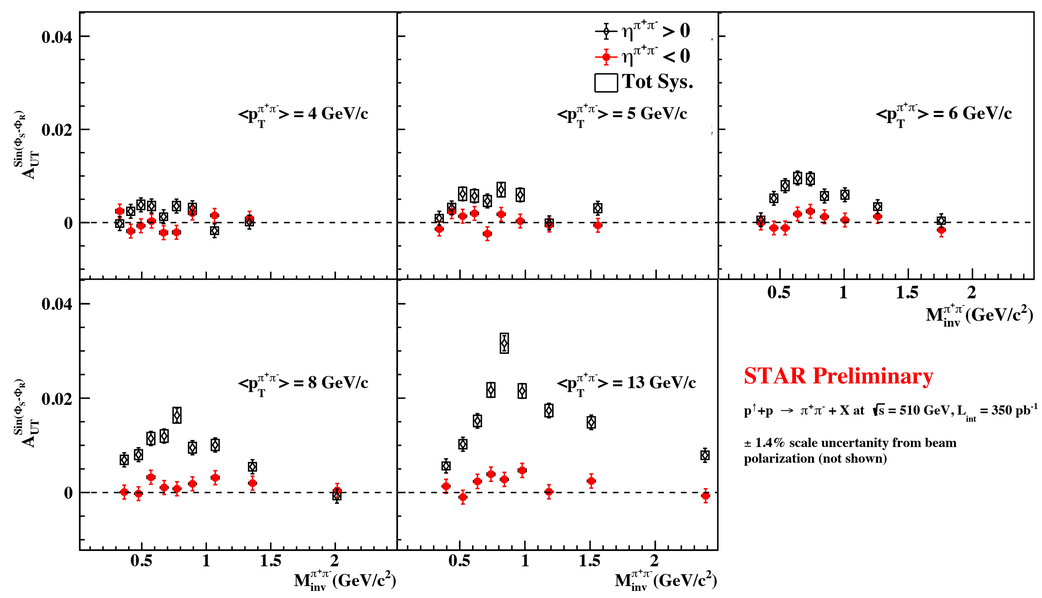
A_{UT} as function of $\eta^{\pi^+\pi^-}$

- $\eta^{\pi^+\pi^-} > 0$ probes higher x, valence region, where $h_1^q(x)$ is sizable, hence A_{UT} is large.
- $\eta^{\pi^+\pi^-} < 0$ probes lower x from backward propagating transversely polarized particles resulting lower A_{UT} signal.



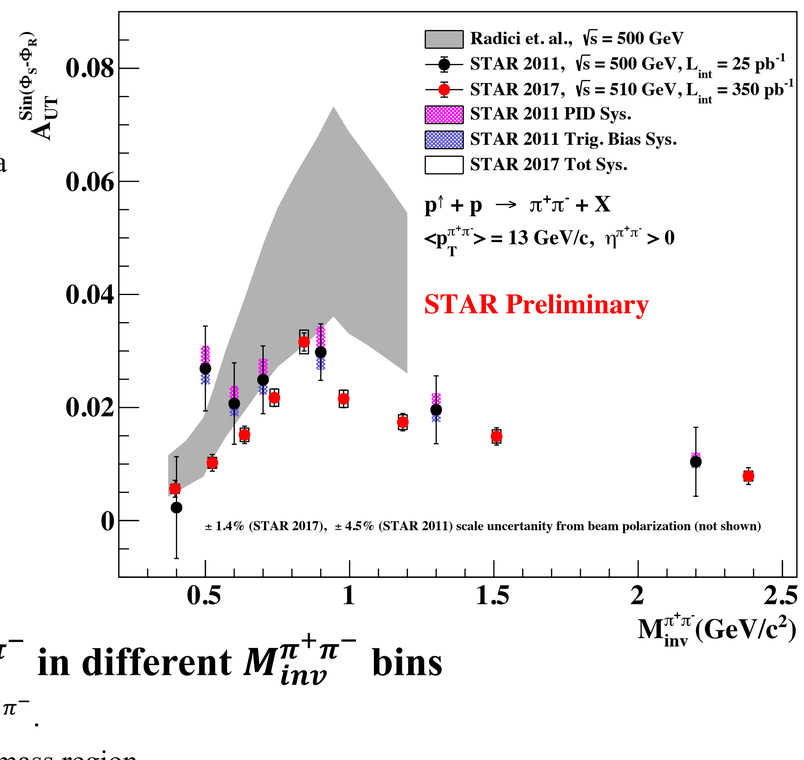
A_{UT} as function of $M_{inv}^{\pi^+\pi^-}$ in different $p_T^{\pi^+\pi^-}$ bins

- The enhancement of A_{UT} signal around the ρ meson mass (~0.8 GeV/c^2) is due to the interference between the different $\pi^+\pi^-$ production channel.
- The A_{UT} signal increases with increasing $p_T^{\pi^+\pi^-}$.



A_{UT} as function of $M_{inv}^{\pi^+\pi^-}$ for highest $p_T^{\pi^+\pi^-}$ bin and $\eta^{\pi^+\pi^-} > 0$

- STAR's latest measurement of A_{UT} from 2017 dataset exhibits a notably higher level of precision and is consistent with previous STAR measurement and theory prediction from SIDIS, e^+e^- data.



A_{UT} as function of $p_T^{\pi^+\pi^-}$ in different $M_{inv}^{\pi^+\pi^-}$ bins

- A_{UT} increases linearly with $p_T^{\pi^+\pi^-}$.
- Stronger rise in A_{UT} around ρ mass region.