Transverse Spin-dependent Azimuthal Correlations of Charged Pion Pairs Measured in $p^{\uparrow}+p$ Collisions at $\sqrt{s}$ = 500 GeV at STAR

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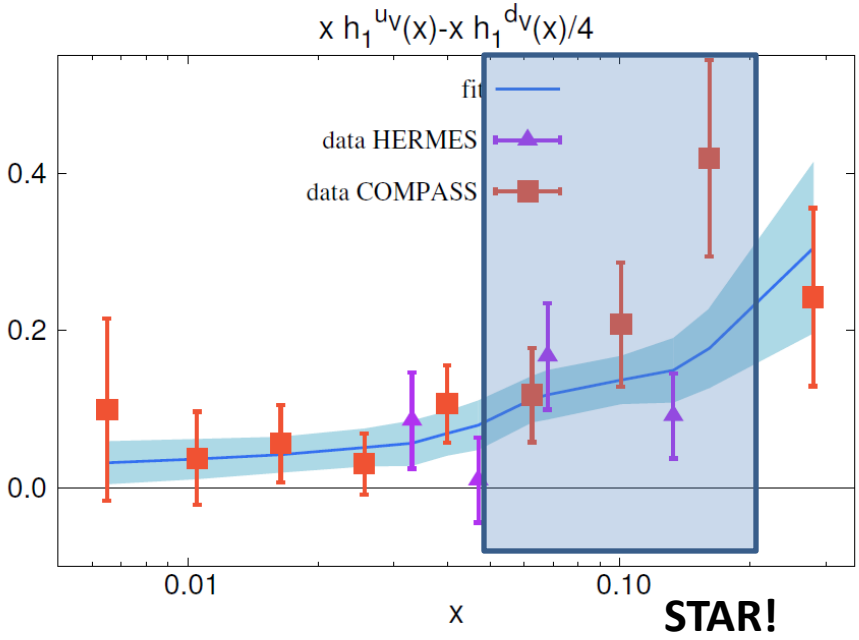
Overview

- Why measure $\pi^+\pi^-$ correlations?
- Some analysis details
- Asymmetry measurements vs η, p_T and M_{Inv}
- Conclusions

Motivation

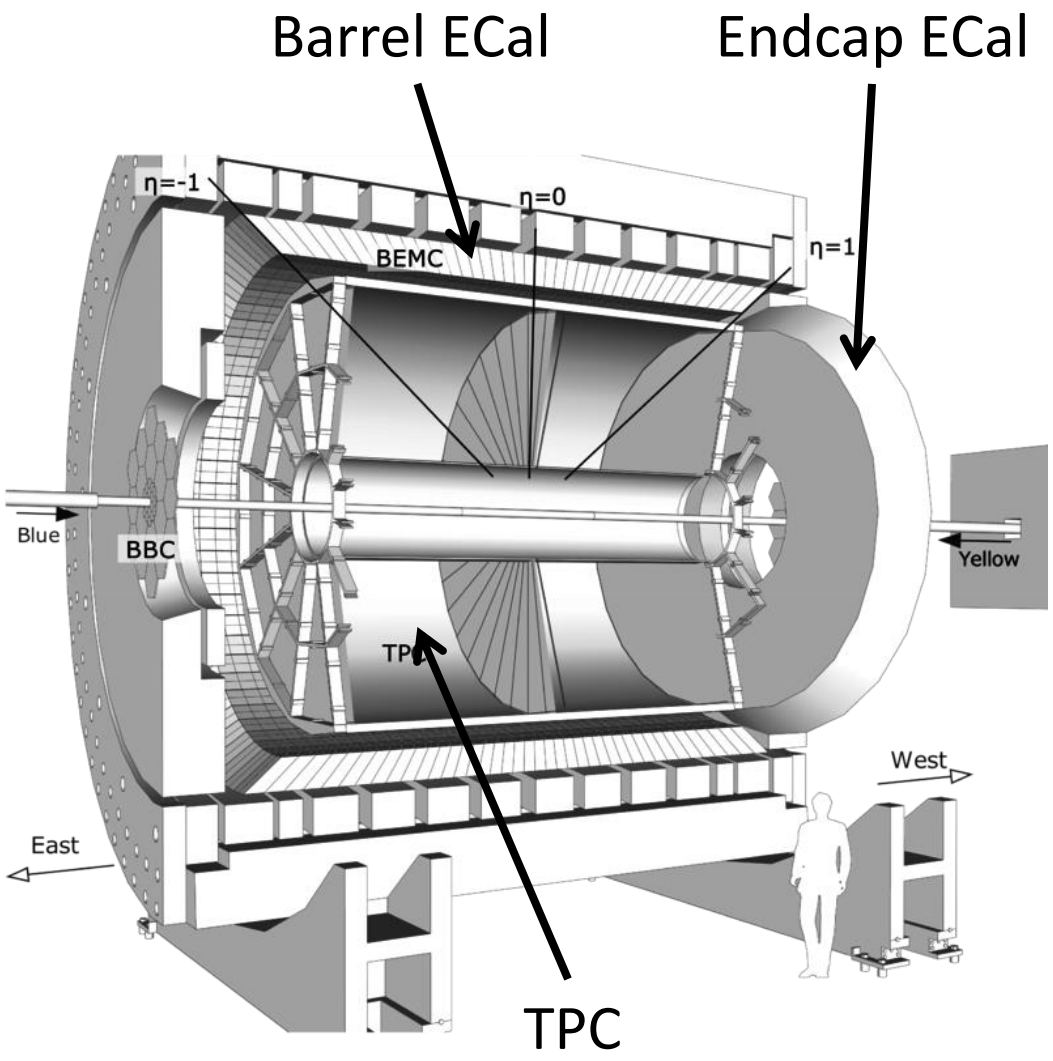
Bacchetta, Courtoy, Radici, JHEP **1303** (2013) 119



- Di-hadron correlations allow point-to-point transversity measurements in SIDIS
- Measuring transversity from polarized p+p data
  - collinear framework
  - high precision, reduced u-quark dominance
  - test of universality (SIDIS vs p+p)
  - new kinematic regime

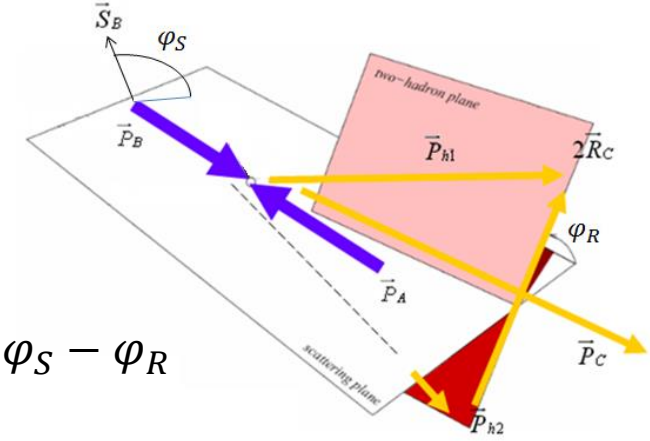
STAR

- 2011 polarized p+p collisions at 500 GeV with 25 pb^{-1} integrated luminosity
- P_{beam} = 53%
- Solenoidal Tracker at RHIC (STAR)
- Charged pions measured in Time Projection Chamber
  - 2π azimuthal coverage
  - $-1 < \eta < 1$
- Endcap and Barrel electromagnetic calorimeters and vertex position detector used to select events

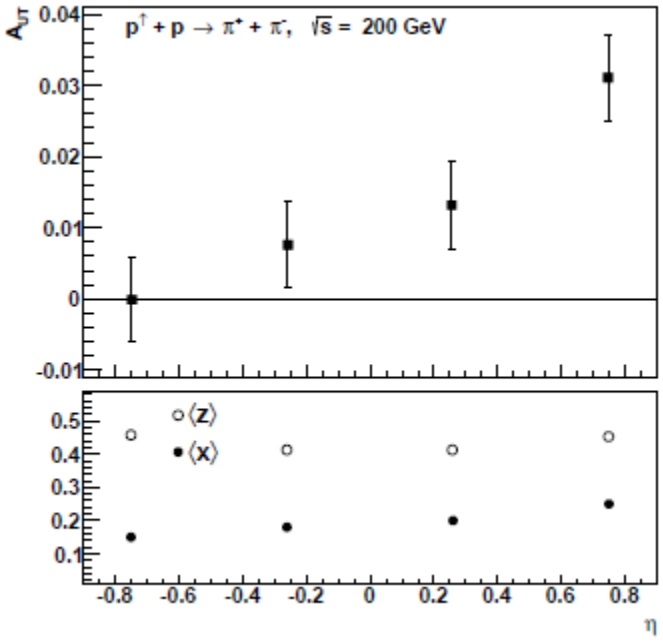


Asymmetry Observable

- Calculated for $\boldsymbol{P_B}$ as incident beam, $\boldsymbol{P_A}$ as target
- Incident beam is polarized and target unpolarized by summing over bunches
- Pion separation = $\sqrt{(\Delta\eta^2 + \Delta\phi^2)} < 0.7$
- $A_{UT} \propto h_1 \cdot H_1^{<}$
  - Transversity (h_1)
  - Interference Fragmentation Function ($H_1^{<}$)
- A_{UT} is expected to depend on the invariant mass (M_{Inv}) and p_T of the pion pair

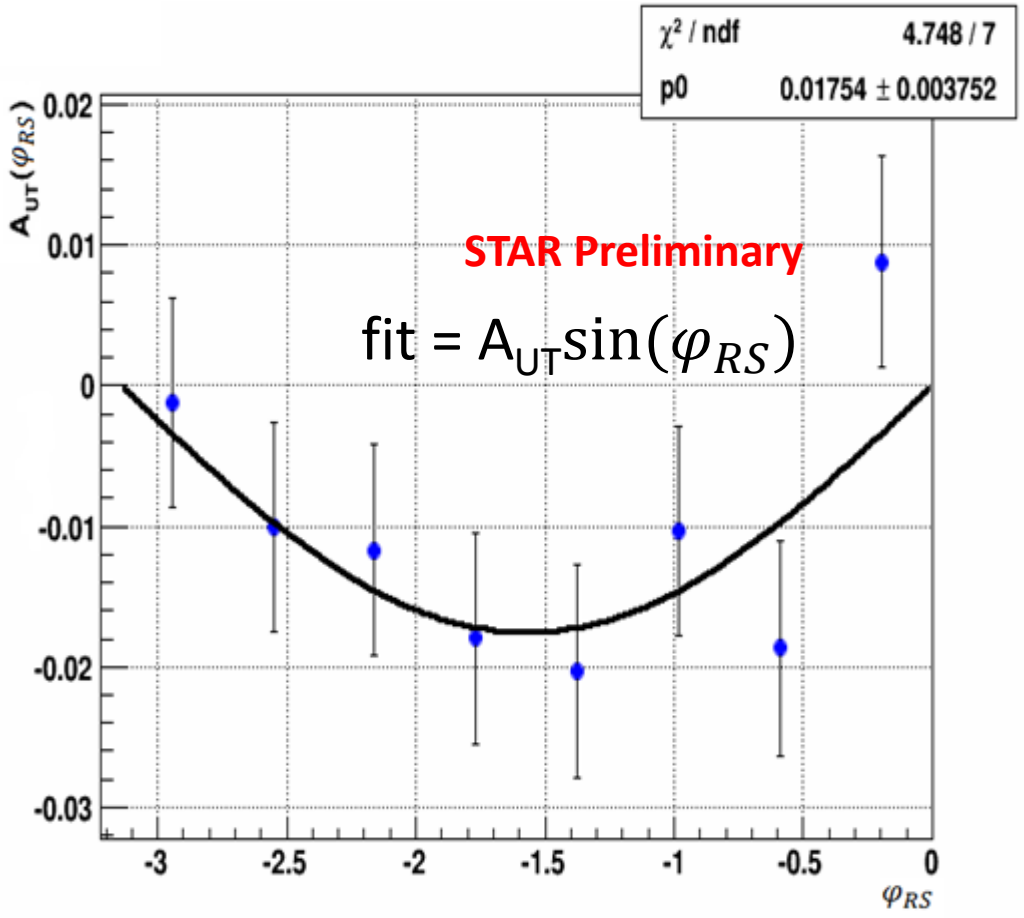


$$\varphi_{RS} = \varphi_S - \varphi_R$$



STAR Collab. PRL **115**, 242501 (2015)

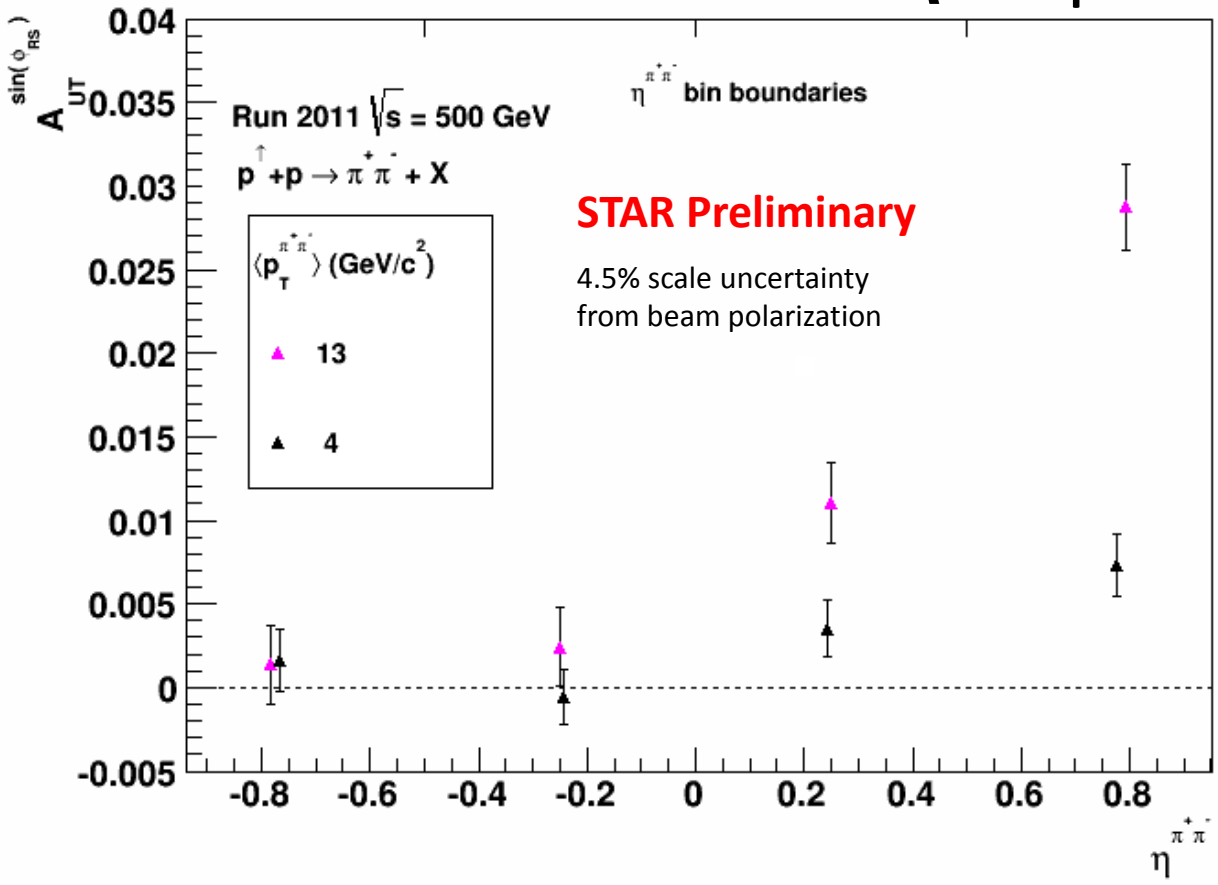
Extract A_{UT}



- Particle p_T > 1.5 GeV/c
- Pair p_T > 3.75 GeV/c
- Use dE/dx to identify pions
- For a given M_{Inv} , p_T bin the asymmetry is calculated for 8 ϕ_{RS} bins
- The asymmetry is the amplitude extracted from a single-parameter fit
- Ex: M_{Inv} = 1 GeV/c^2 p_T = 12 GeV/c

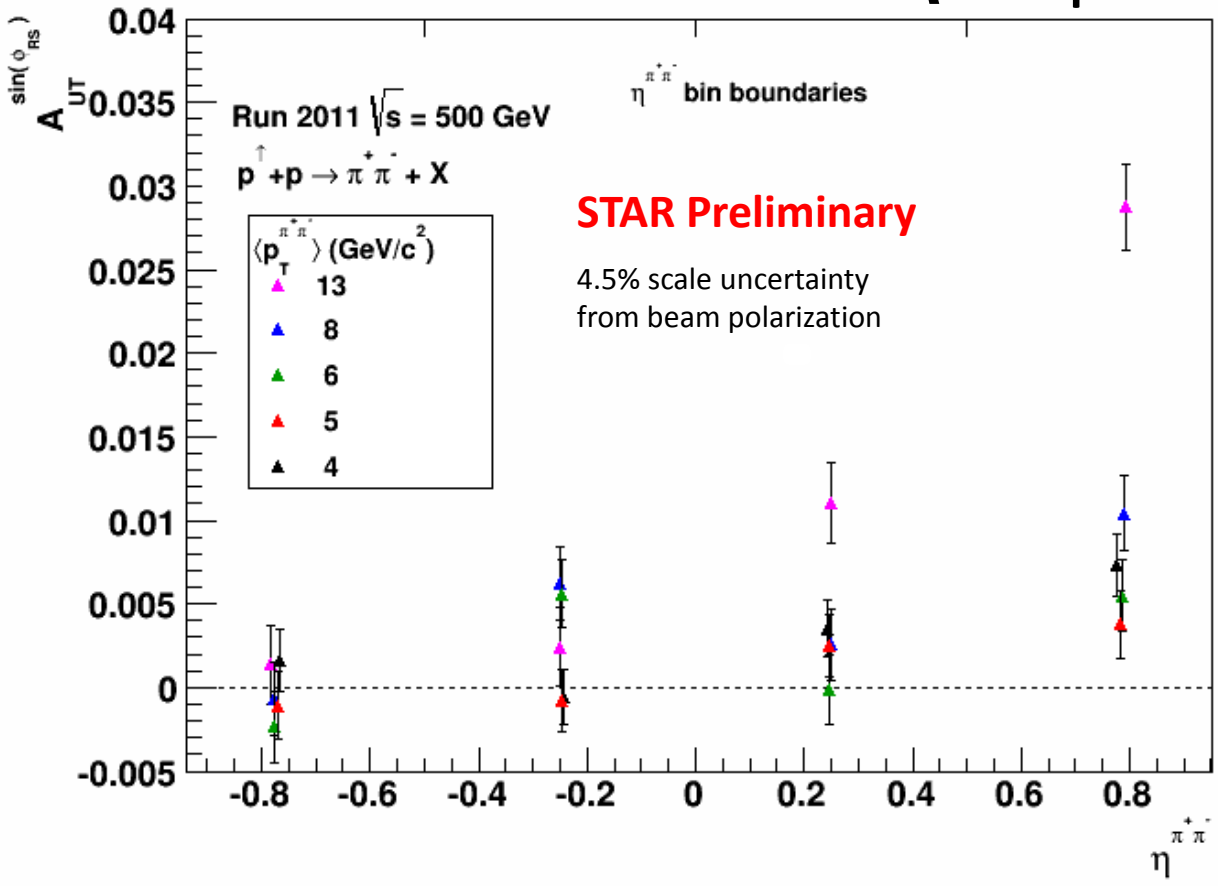
$$A_{UT}(\varphi_{RS}) = \frac{1}{P}\frac{\sqrt{N\uparrow(\varphi_{RS})N\downarrow(\varphi_{RS}+\pi)} - \sqrt{N\downarrow(\varphi_{RS})N\uparrow(\varphi_{RS}+\pi)}}{\sqrt{N\uparrow(\varphi_{RS})N\downarrow(\varphi_{RS}+\pi)} + \sqrt{N\downarrow(\varphi_{RS})N\uparrow(\varphi_{RS}+\pi)}}$$

Asymmetry (η ,p_T)



- Transversity is manifested in forward pion pairs due to large x valence quarks of the incident proton
- Due to event selection bias, the signal may be enhanced up to 66% of the statistical uncertainty

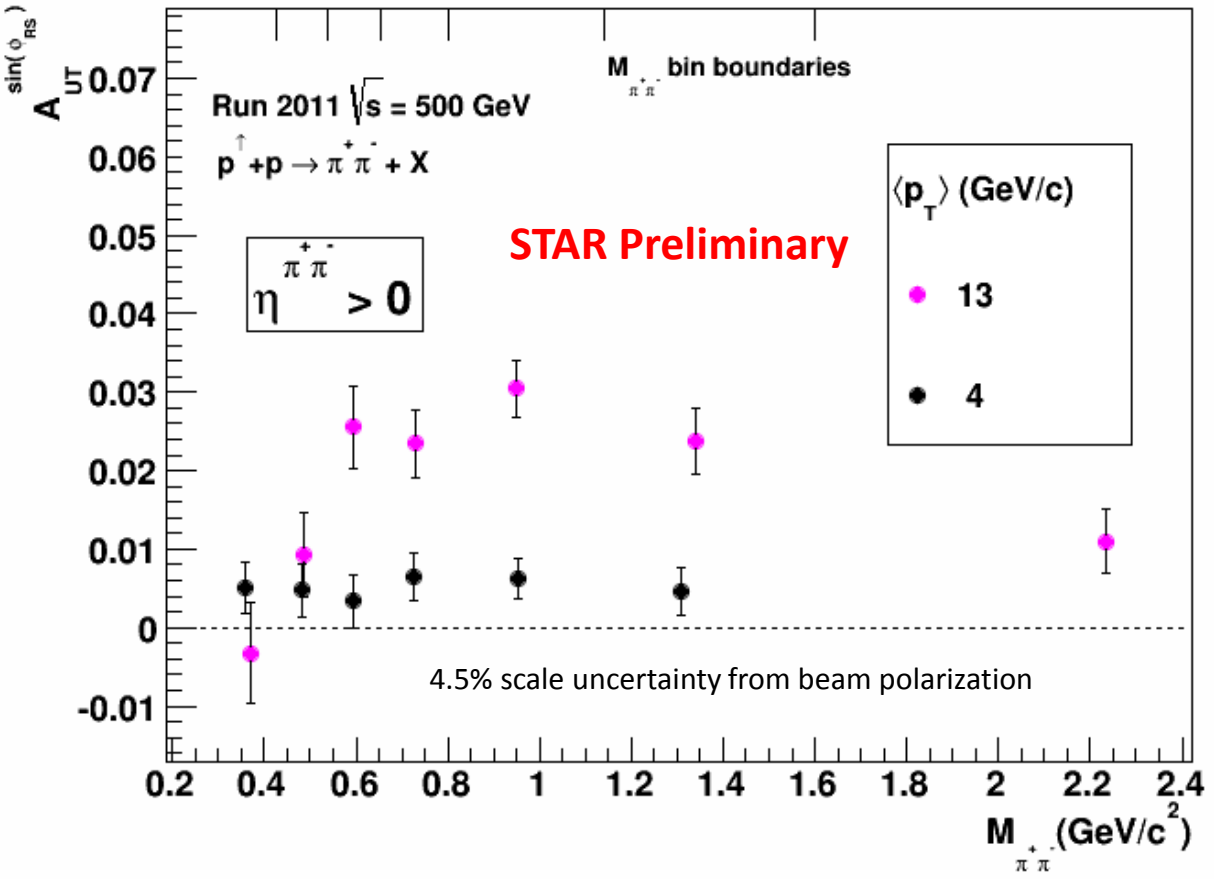
Asymmetry (η ,p_T)



- A_{UT} as a function of η plotted for 5 p_T bins
- Significant asymmetry seen at high η and high $\langle p_T \rangle$

Asymmetry (M_{Inv}, p_T)

- A_{UT} as a function of M_{Inv} plotted for 5 p_T bins
- Avg M_{Inv} in each M_{Inv} bin decreases with decreasing $<p_T>$
- Significant asymmetry seen at mid-M_{Inv} and high $<p_T>$



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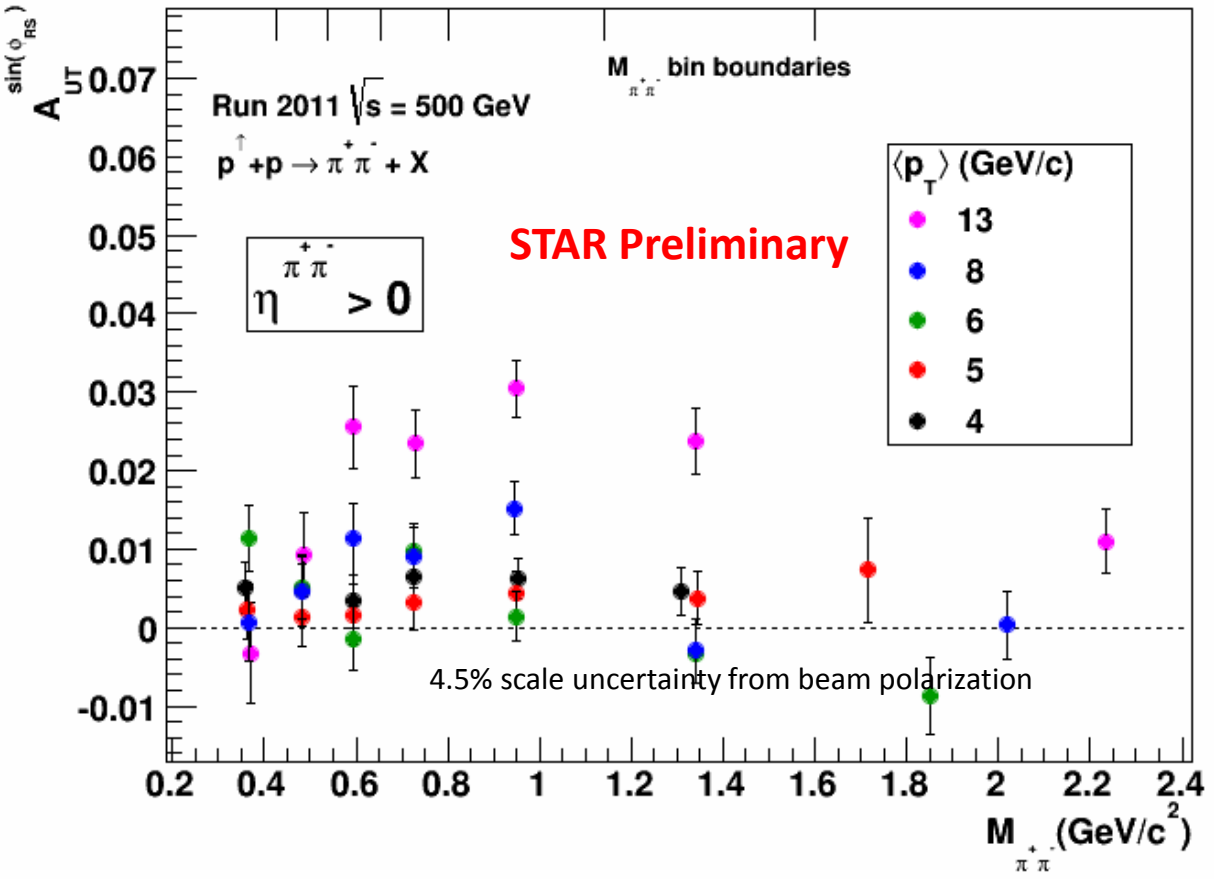
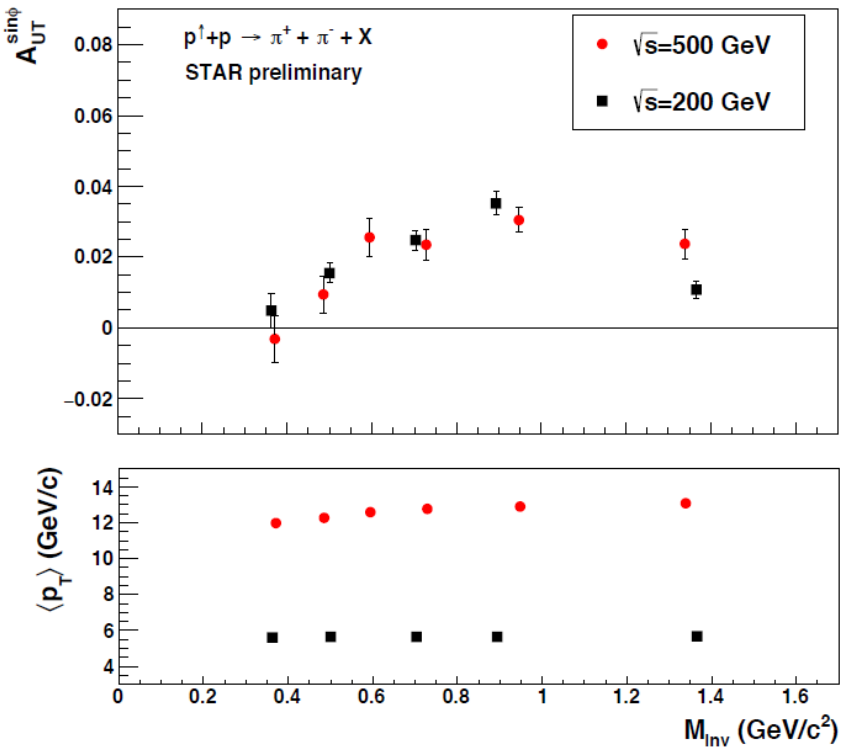
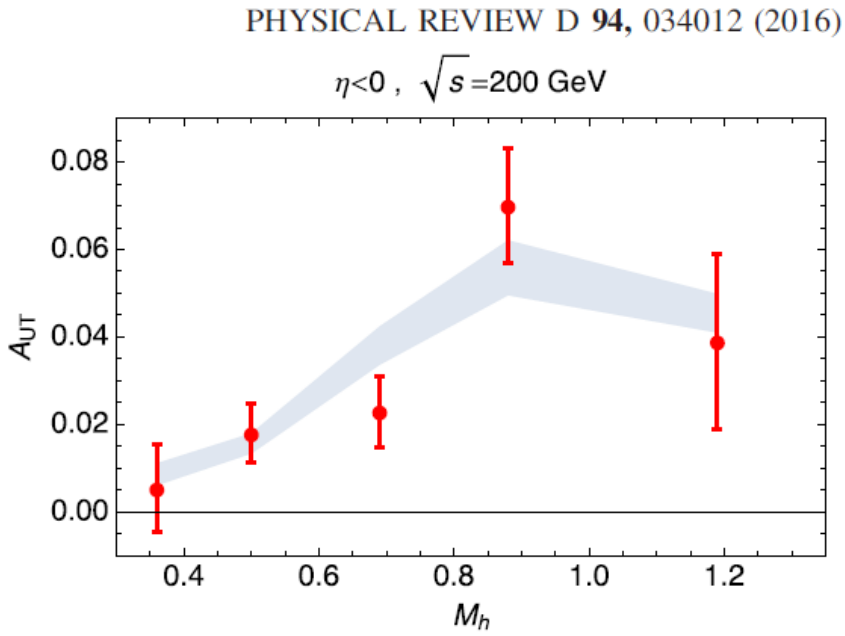


Theoretical Comparison



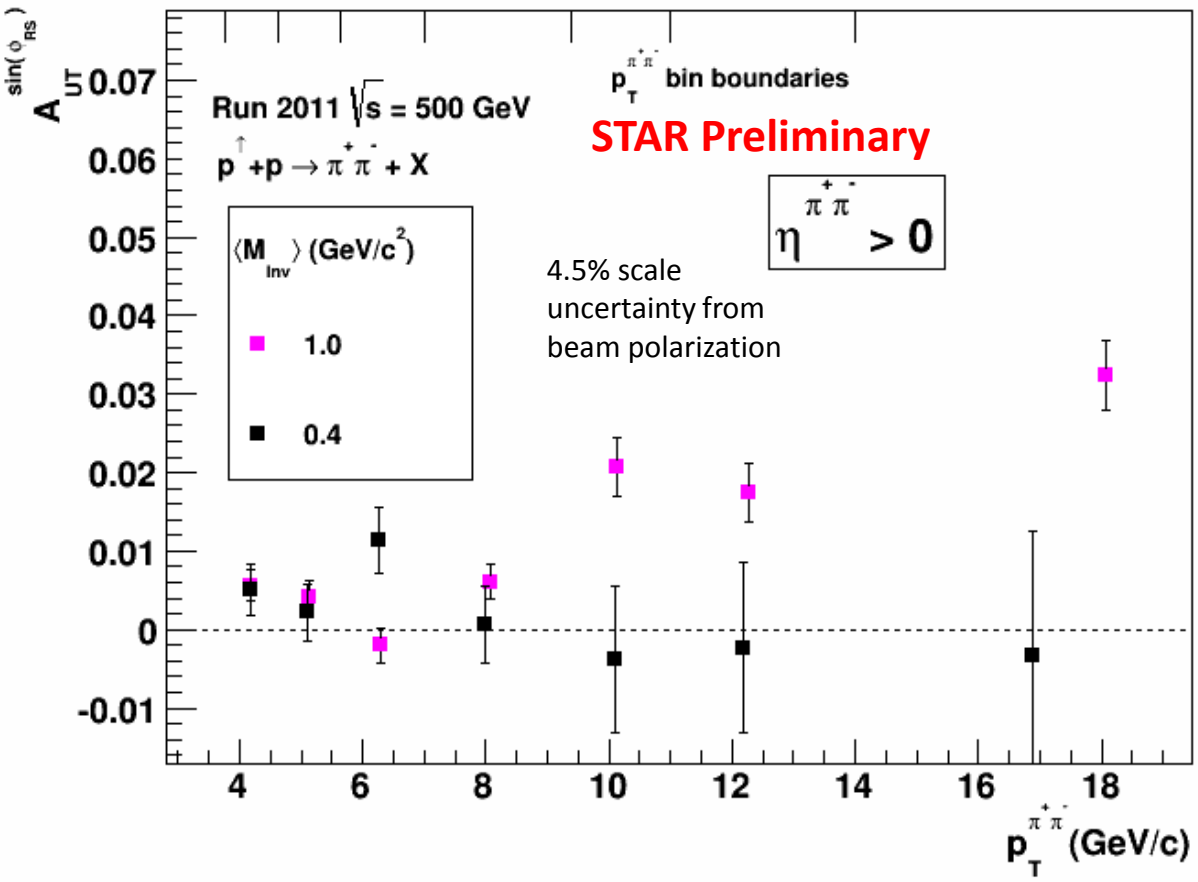
- p_T ranges sample similar $x_T = 2\ p_T/\sqrt{s}$
- 500 GeV: $\langle p_T \rangle$ = 13 GeV/c
- Run 2012, 200 GeV: $\langle p_T \rangle$ = 6 GeV/c
- 200 GeV sensitive to higher x



- Theoretical prediction from fitting SIDIS and e^+e^- data
- Above convention $\eta < 0$ corresponds to $\eta > 0$ for STAR
- Large increase around the ρ mass
- $3 < p_T < 13$ GeV/c

Asymmetry (p_T ,M_{Inv})

- A_{UT} as a function of p_T plotted for 5 M_{Inv} bins
- Avg p_T in each p_T bin slightly decreases with decreasing $<M_{Inv}>$
- Asymmetry rises significantly for high p_T and high M_{Inv}



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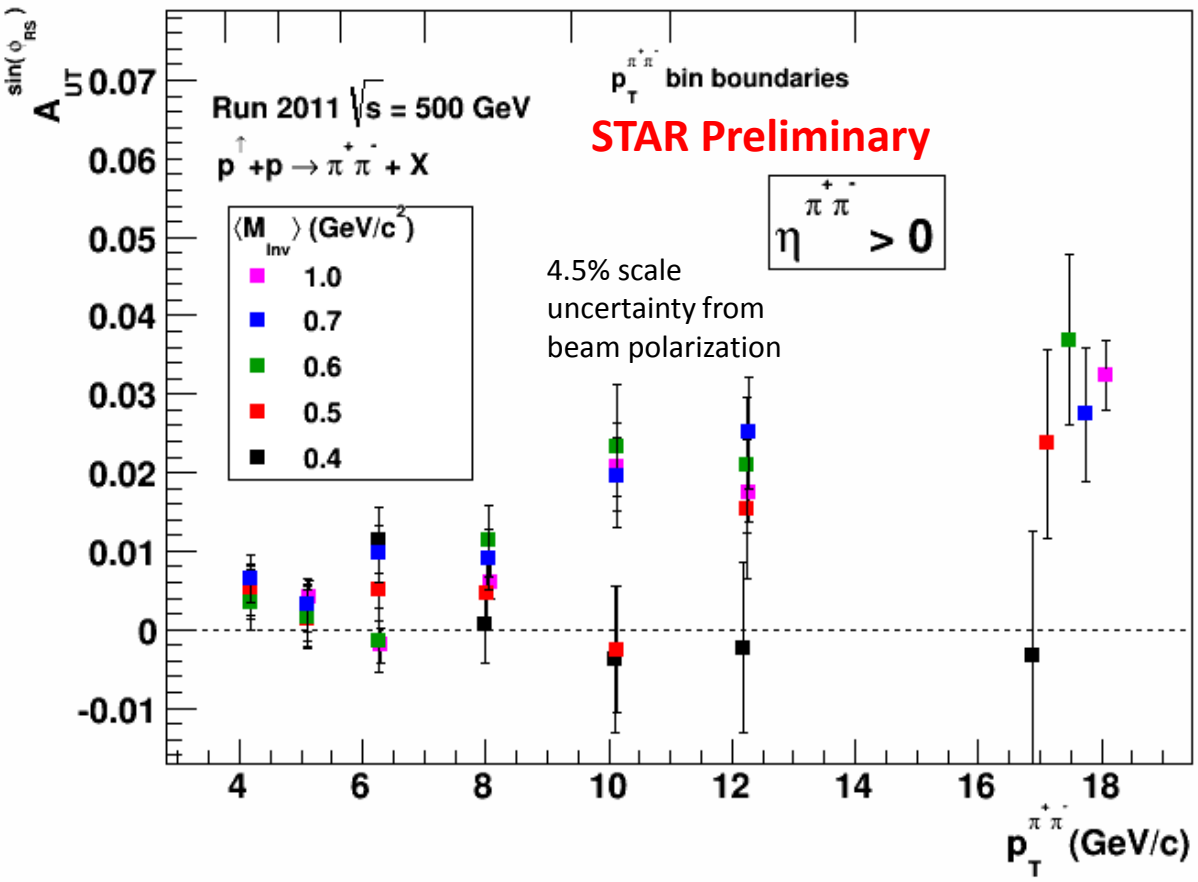
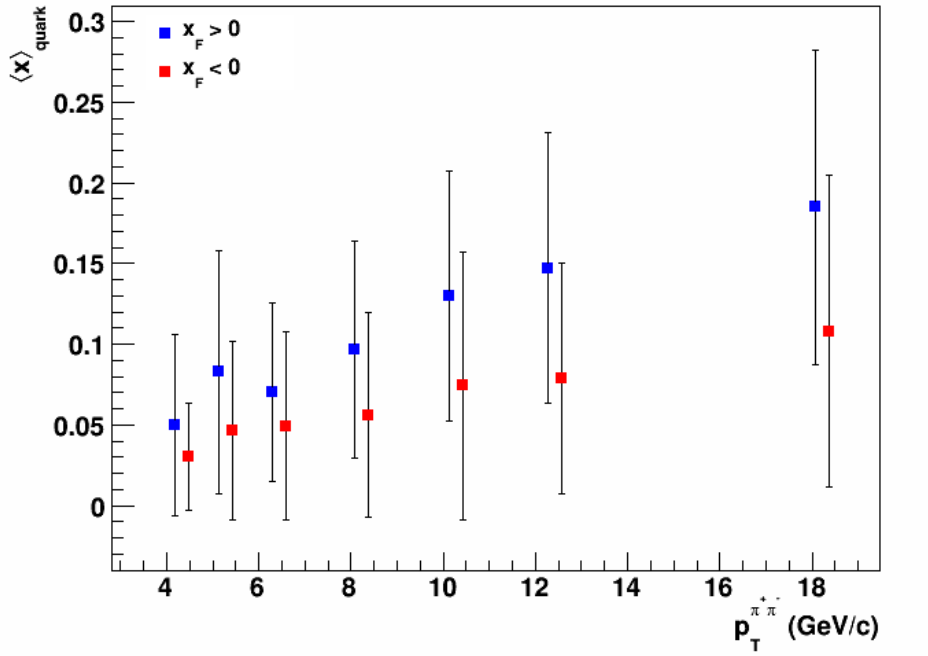
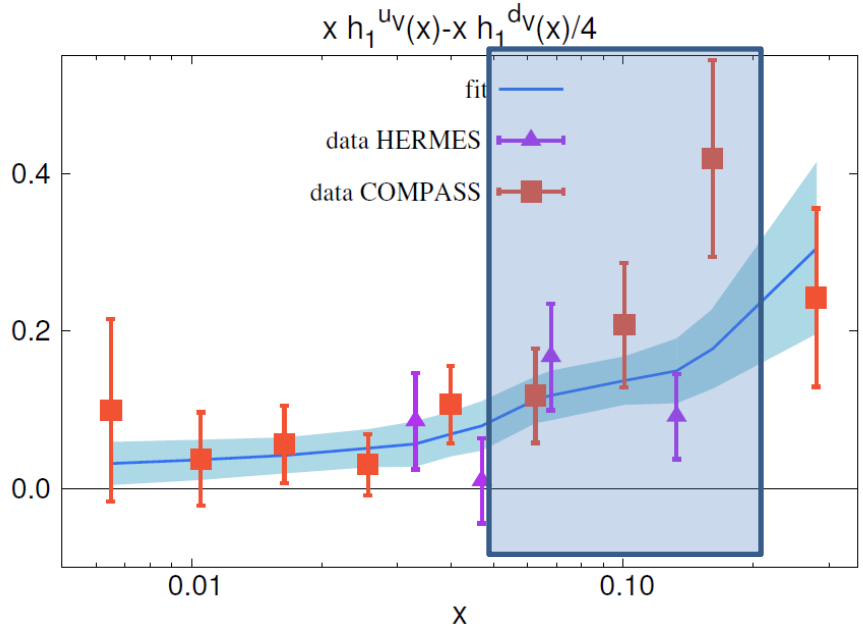


<x> Coverage at STAR





Bacchetta, Courtoy, Radici, JHEP **1303** (2013) 119

- High precision asymmetries measured at relatively high <x> and high effective Q^2

Conclusions

- Preliminary STAR data show high precision pion pair correlation asymmetries at large p_T and M_{Inv} for $\eta^{\pi+\pi-} > 0$

- These results are at much higher Q^2 and sample a different mixture of quark flavors than SIDIS

- Results may be used to test universality of transverse polarization dependent quantities (SIDIS vs p+p)

- Recorded twice the 2012 figure of merit during 2015 for $\sqrt{s}$ = 200 GeV. Errors will be reduced by sqrt(3) once the 2012 and 2015 data are combined

Backup

Results for $\eta^{\pi^+\pi^-} < 0$