High Precision Measurement of Transversity using Di-hadron Correlations in $p^{\uparrow}+p$ Collisions at $\sqrt{s}$ = 500 GeV at STAR

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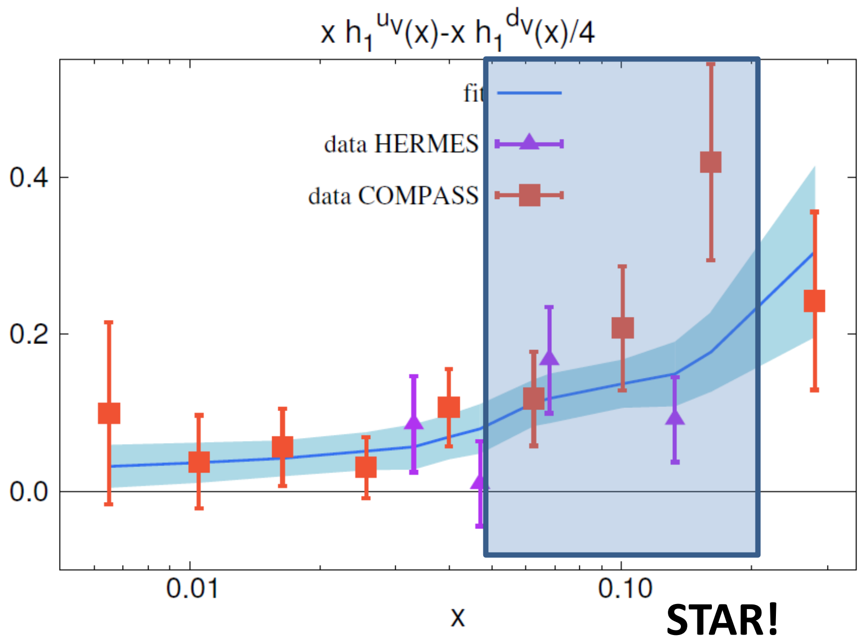
Overview

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

Motivation

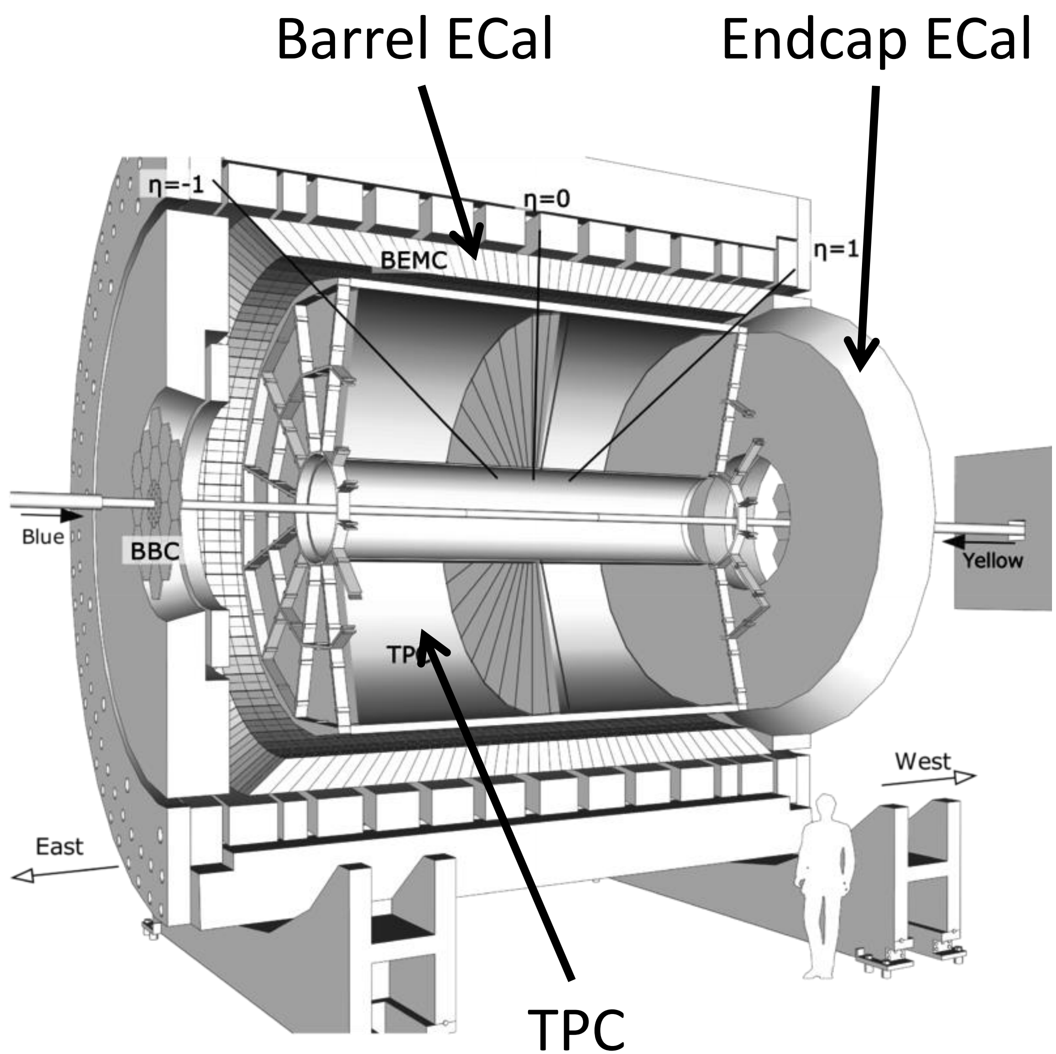
Bacchetta, Courtoy, Radici, JHEP **1303** (2013) 119



- Di-hadron correlations allow point-to-point transversity measurements in SIDIS
- High precision data lacking at relatively high x
- 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

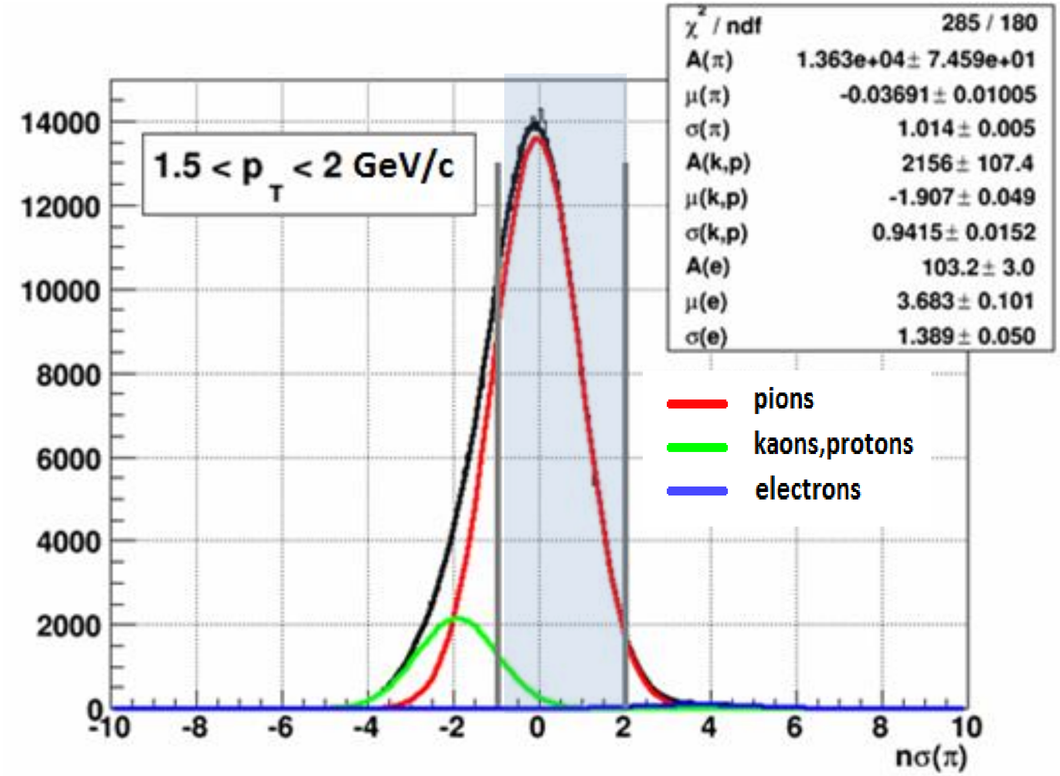
STAR

- 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



Charged Pion Purity Estimates

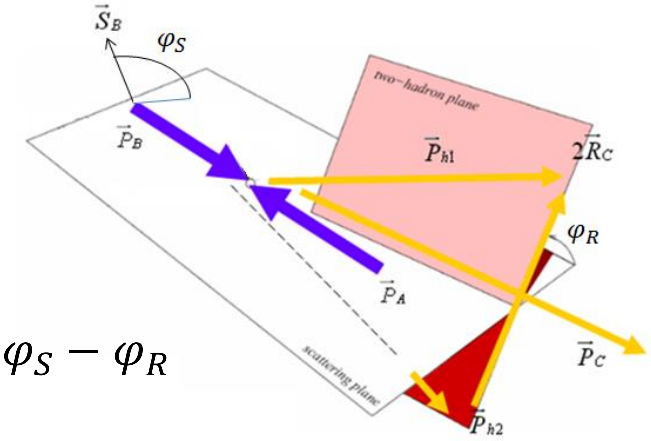
p_T range (GeV/c)	Pion purity
1.5 – 2.0	0.97
2.0 – 3.0	0.94
3.0 – 4.0	0.88
4.0 – 6.0	0.83
6.0 – 8.0	0.86
> 8.0	0.97



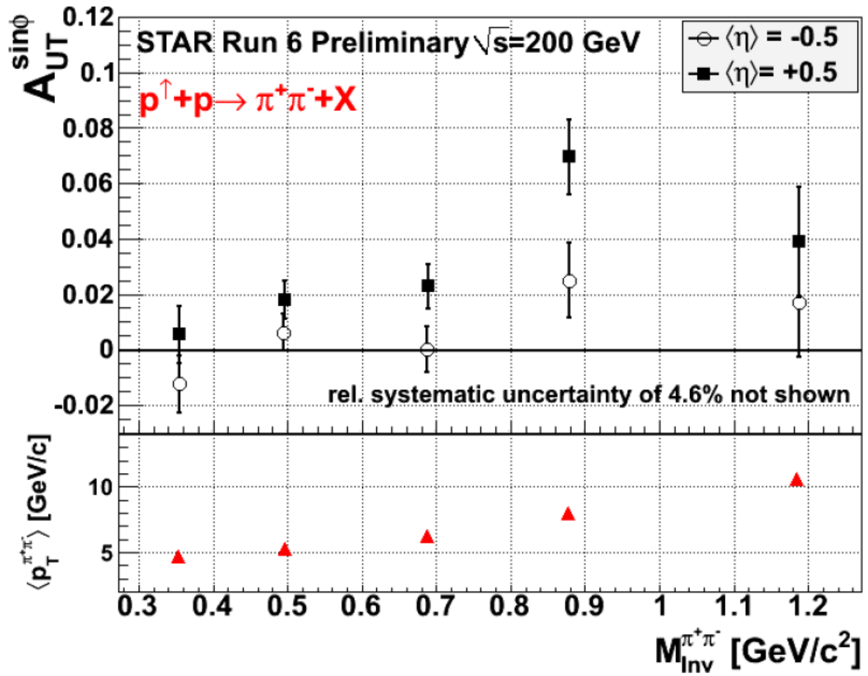
- Use dE/dx to identify pions
- nσ(π) ≈ # of σ in $z = \ln\left(\frac{dE/dx_{measured}}{dE/dx_{parameterized}}\right)$ distribution
- Excellent pion purity samples

Asymmetry Observable

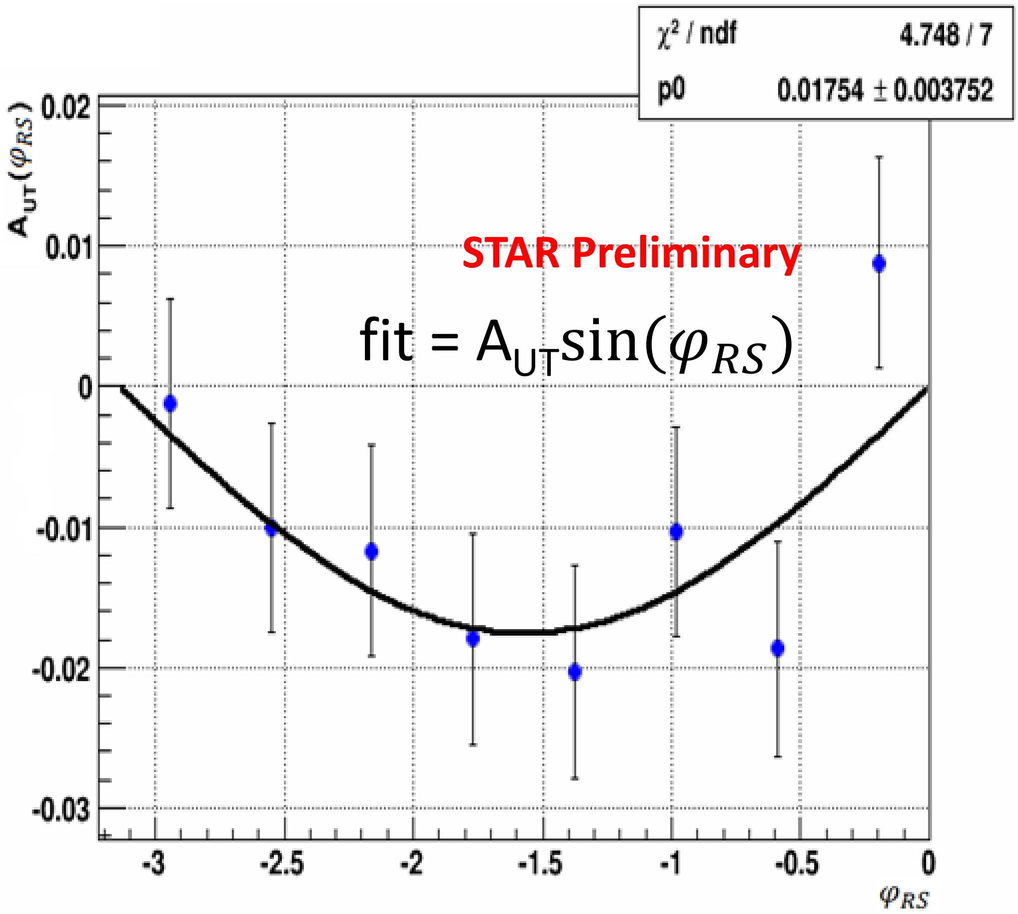
- Calculated for $\boldsymbol{P_B}$ as incident beam, $\boldsymbol{P_A}$ as target
- Incident beam is polarized and target unpolarized by summing over bunches
- Pion separation = $\sqrt{(\Delta\eta^2 + \Delta\phi^2)} < 0.7$
- $A_{UT} \propto h_1 \cdot H_1^{<}$
  - Transversity (h_1)
  - Interference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



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



Extract A_{UT}



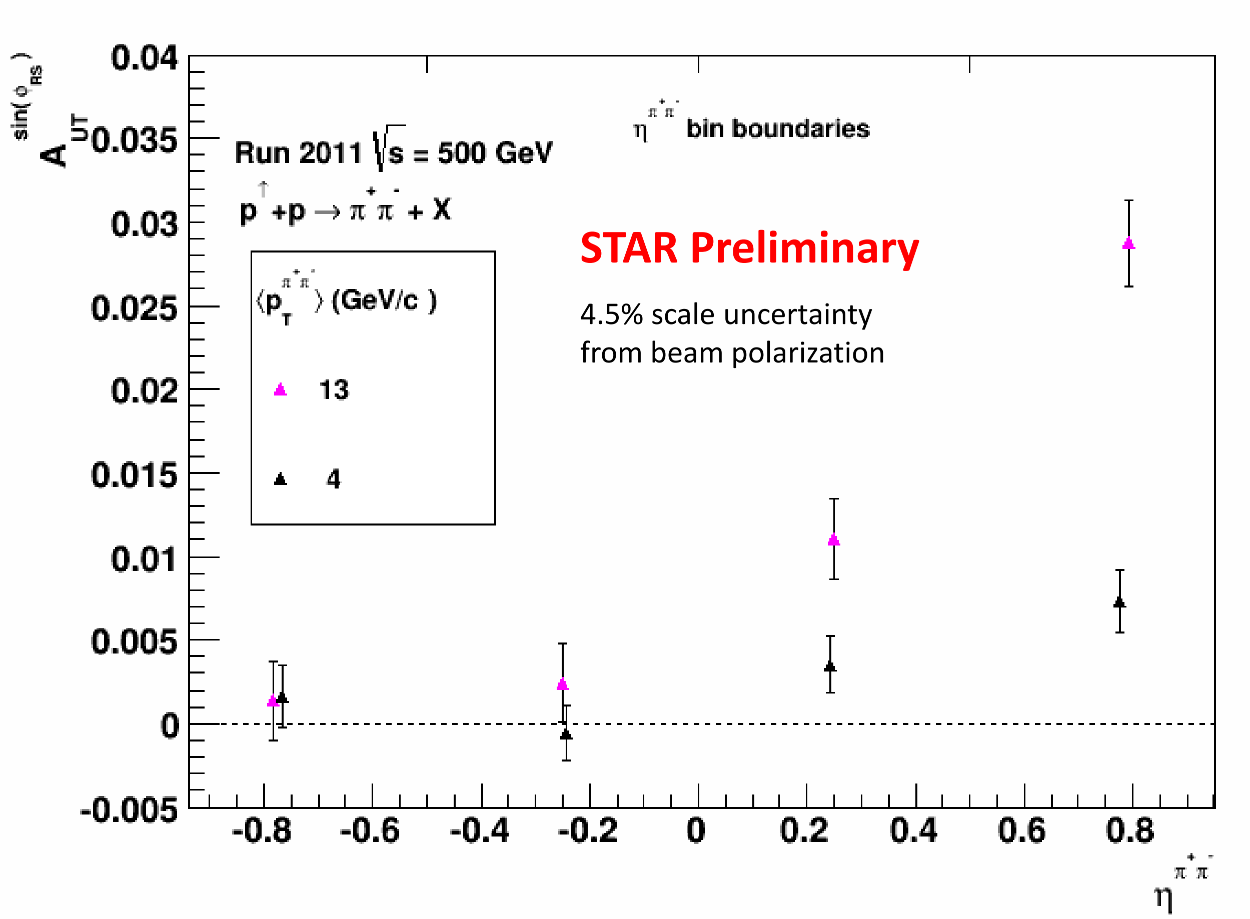
- Particle $p_T > 1.5$ GeV/c
- Pair $p_T > 3.75$ GeV/c
- For a given M_{Inv}, p_T bin the asymmetry is calculated for 8 ϕ_{RS} bins
- The asymmetry is the amplitude extracted from a single-parameter fit
- Example shown here is one M_{Inv}, p_T bin

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

Asymmetry (η ,p_T)

- A_{UT} as a function of η plotted for 5 p_T bins

- Significant asymmetry seen at high η and high <p_T>



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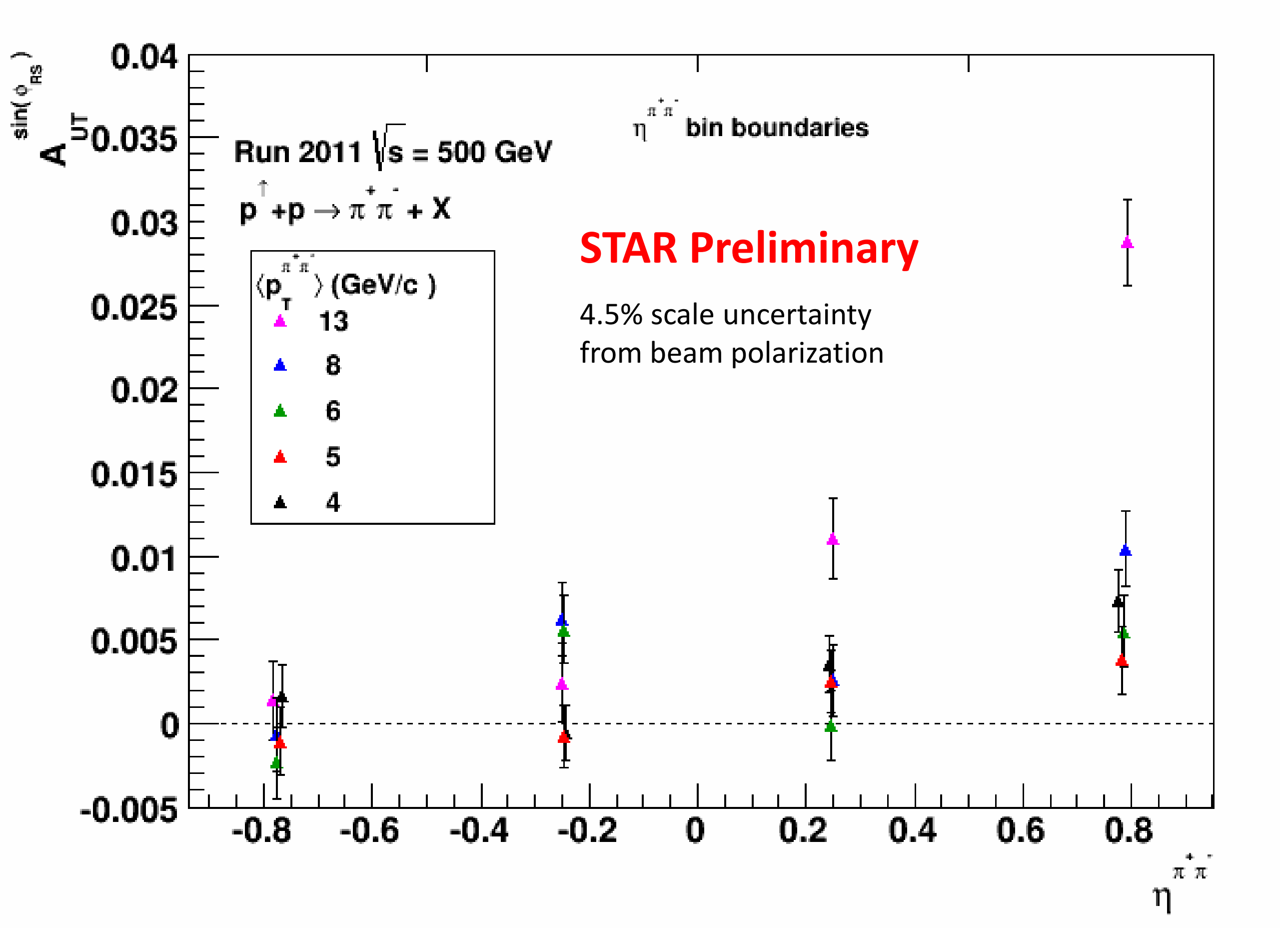
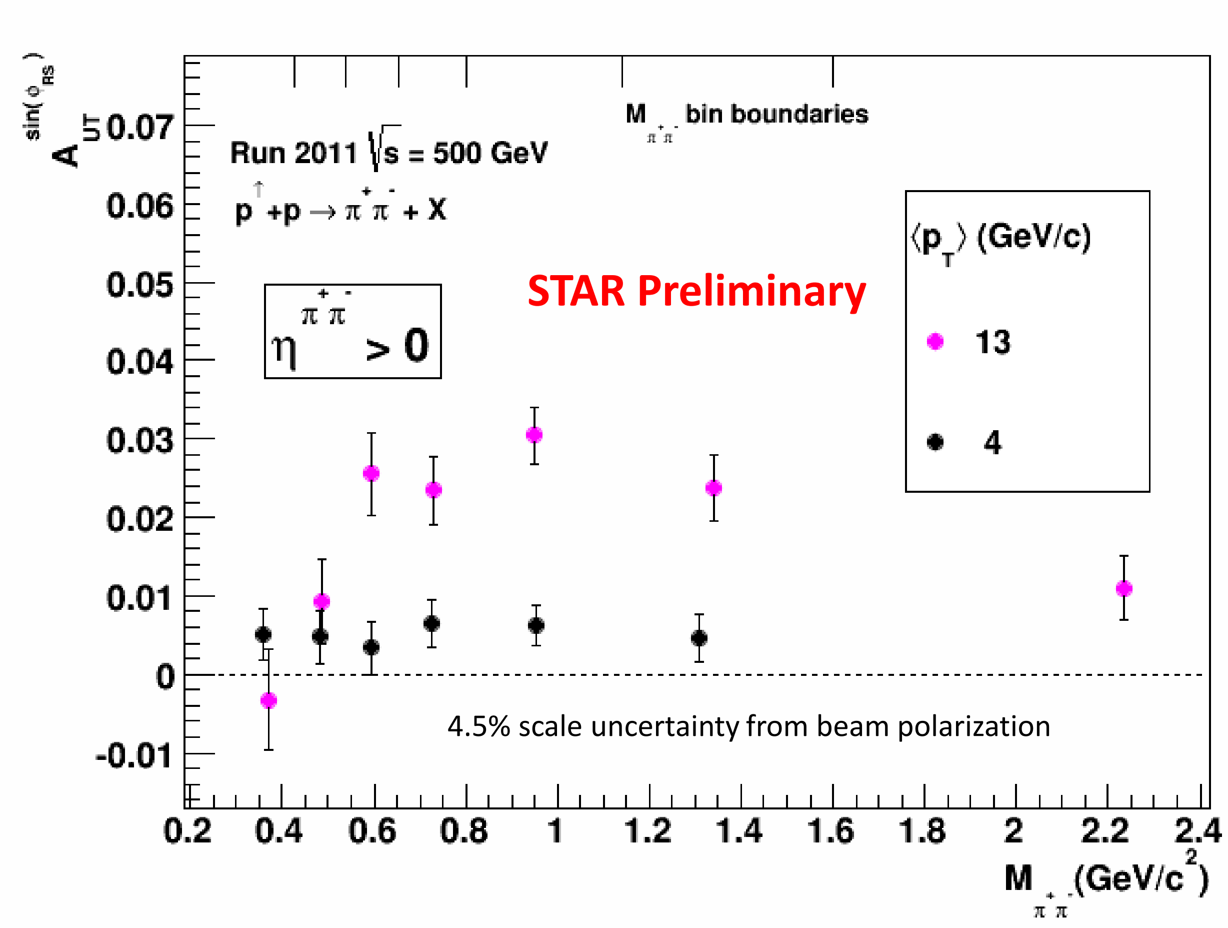


Asymmetry (M_{Inv}, p_T)

- 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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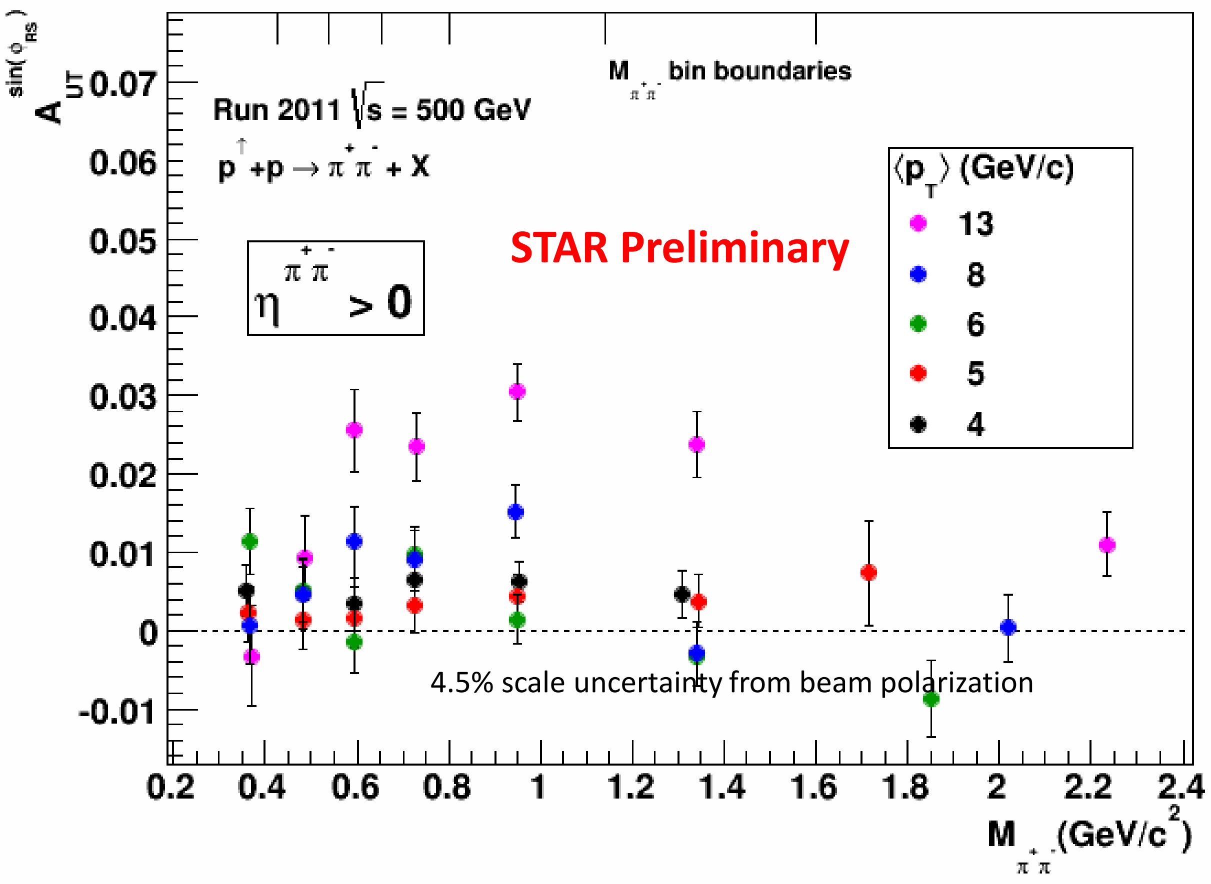
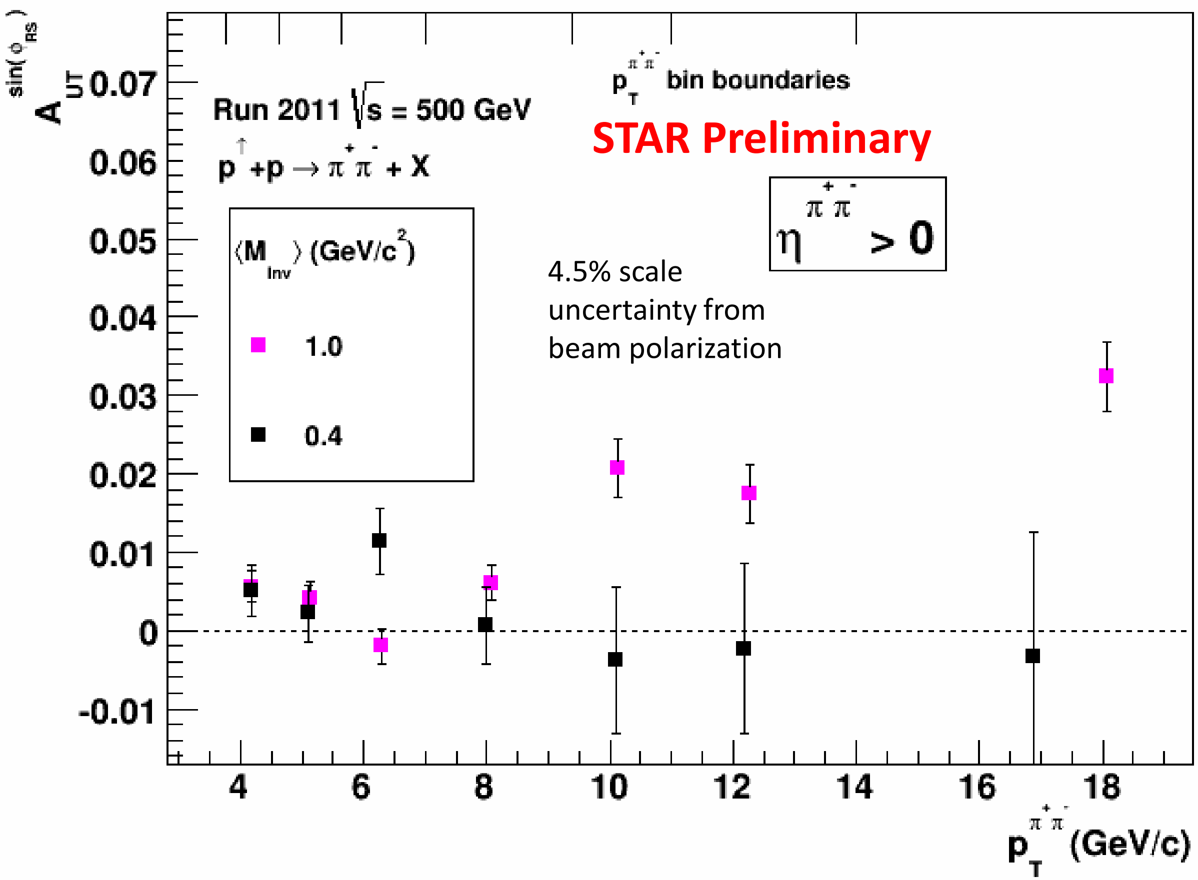


Asymmetry (p_T ,M_{Inv})

- 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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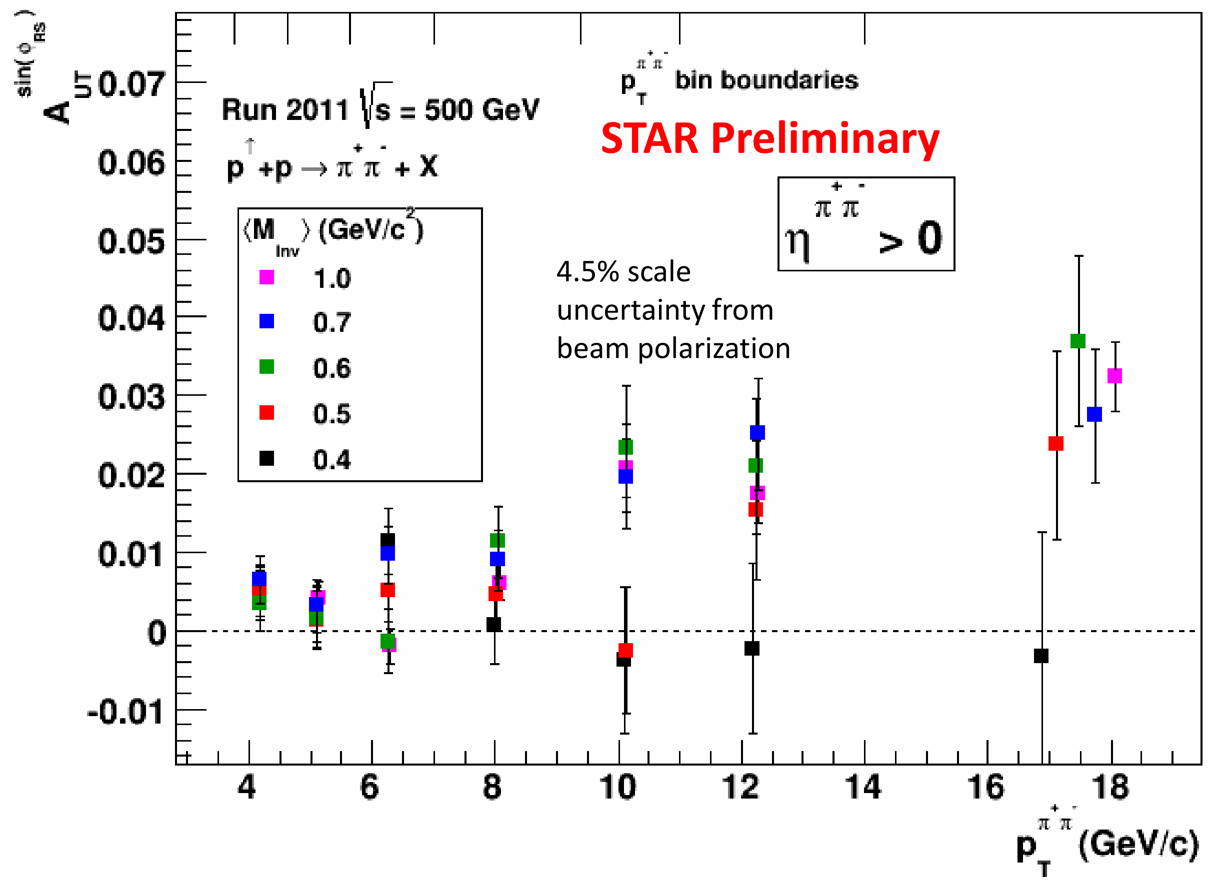
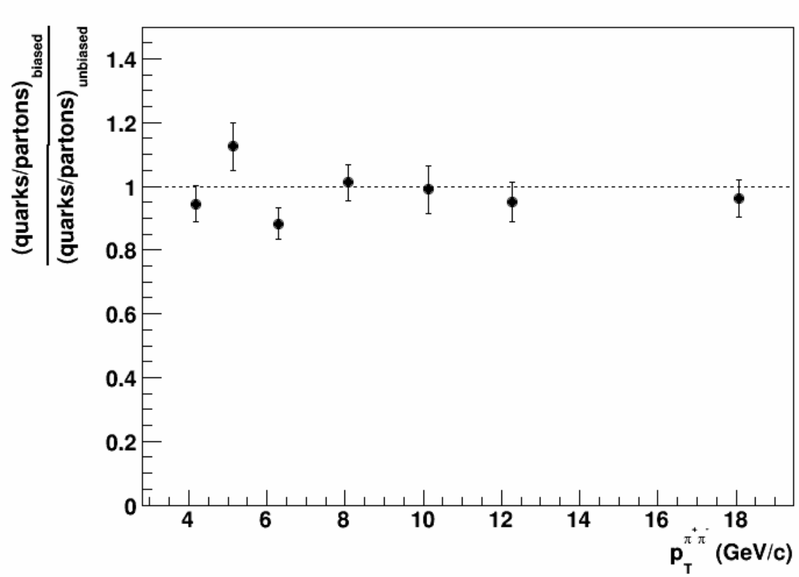
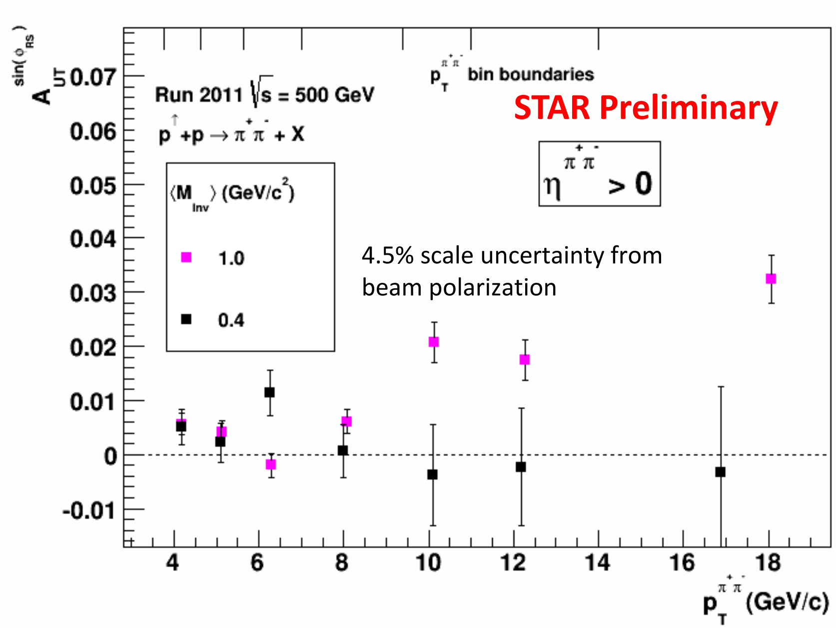


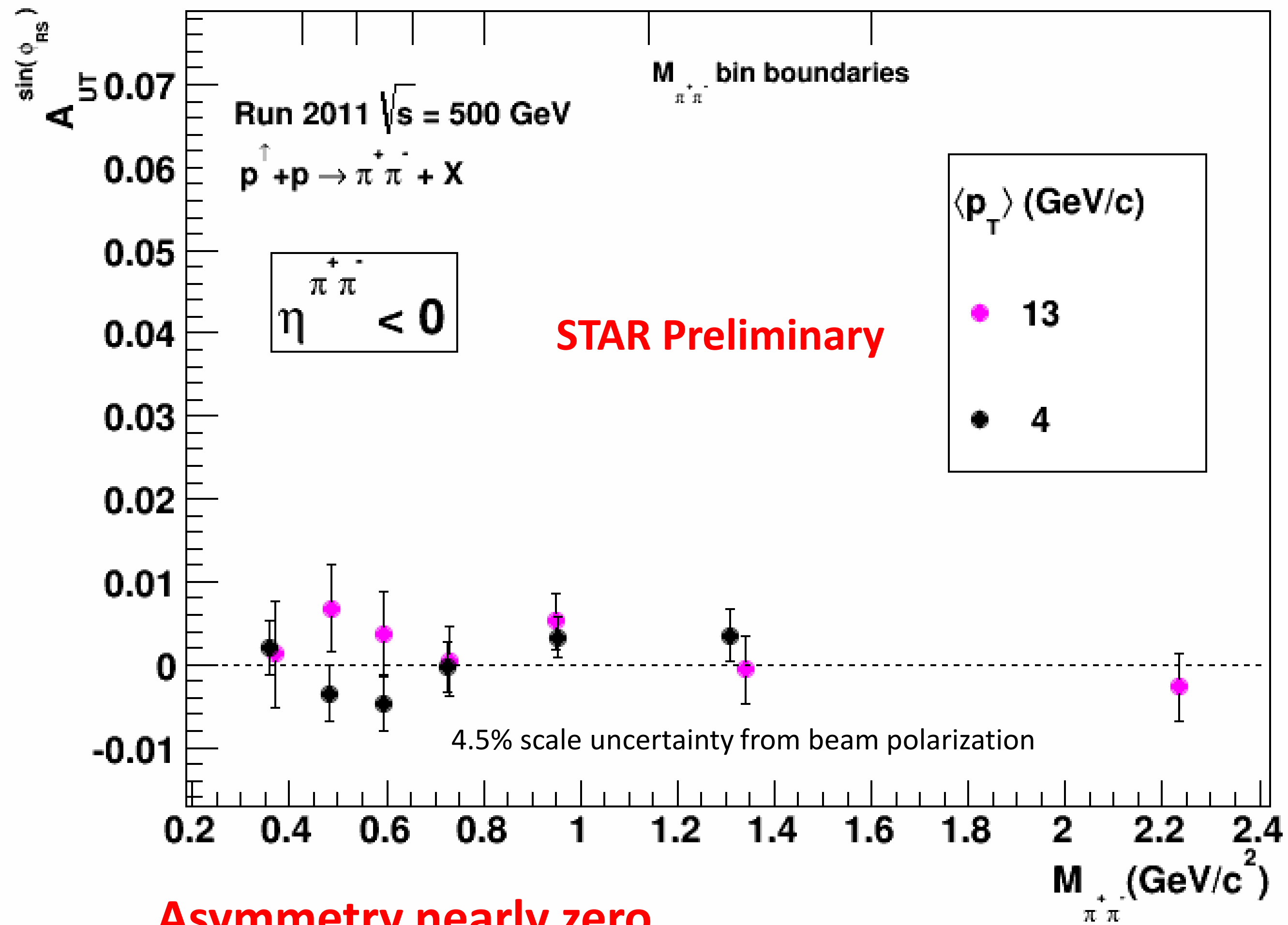
Measurement Bias





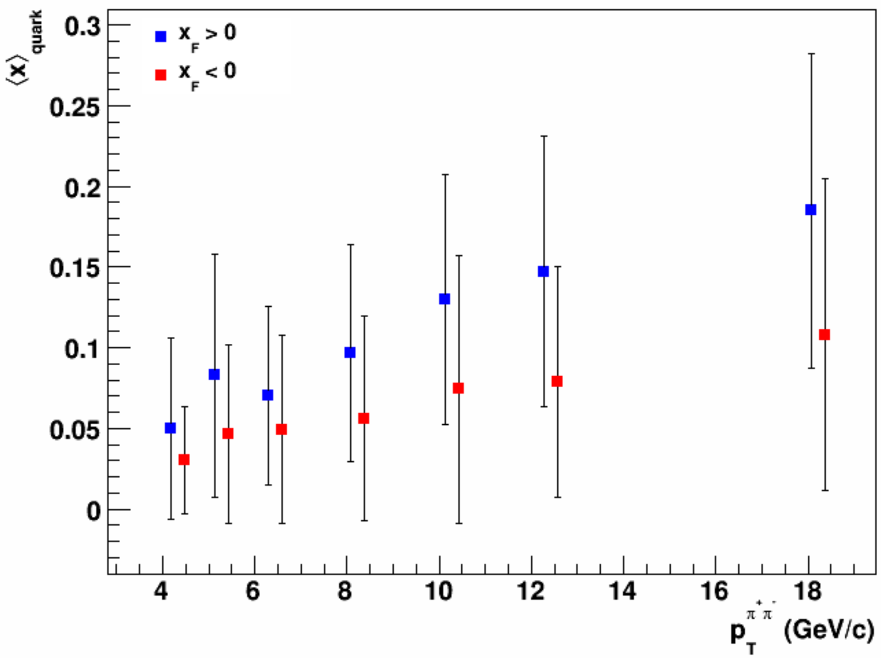
- The events we choose to record are biased towards pions that fragment from quarks
- There should be no asymmetry for pion pairs that come from gluons
- To account for the bias a dilution correction is estimated in the top panel
  - Quarks/partons ratio of biased data over the quarks/partons ratio of unbiased sample
- Correction not applied to data

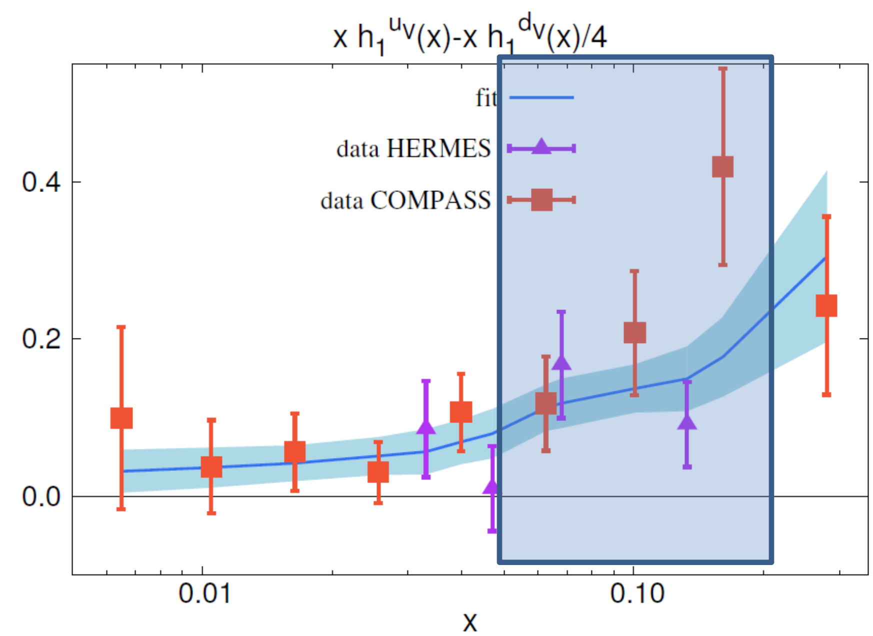
Results for $\eta^{\pi^+\pi^-} < 0$



Asymmetry nearly zero

<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)
- STAR results from 2012 polarized p+p collisions at $\sqrt{s}$ = 200 GeV coming soon (higher precision than 2006)