Transverse Single-Spin asymmetries for π^+ and π^- production in pp collisions at $\sqrt{S}$ = 200 GeV

- Introduction
- Experimental setup and considerations
- Preliminary Physics results
- Conclusion and Prospects

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BRAHMS

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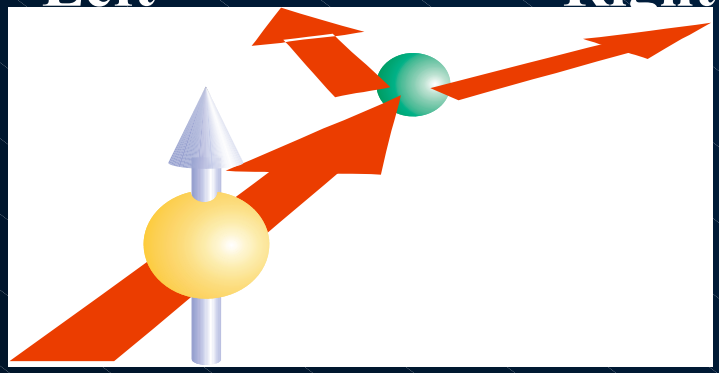
Introduction



$A_n = (\sigma^+ - \sigma^-) / (\sigma^+ + \sigma^-)$

Where the spin cross section is determined with the spin direction defined by $k_b \times k_{pi}$

- Early (naive) QCD predicted this effect to be small
- Non-zero Single Transverse Spin Asymmetry (SSA/ A_n) requires Spin Flip Amplitude and phase difference in intrinsic states
- Such studies may clarify properties of transverse quark structure of the nucleon
- **Sivers effect** **[Phys Rev D41 (1990) 83; 43 (1991) 261]**
  Flavor dependent correlation between the proton spin , momentum and transverse momentum of the un-polarized partons inside the proton.
- **Collins effect** **[Nucl Phys B396 (1993) 161]**
  Correlation between the quark spin, momentum and transverse momentum of the pion.

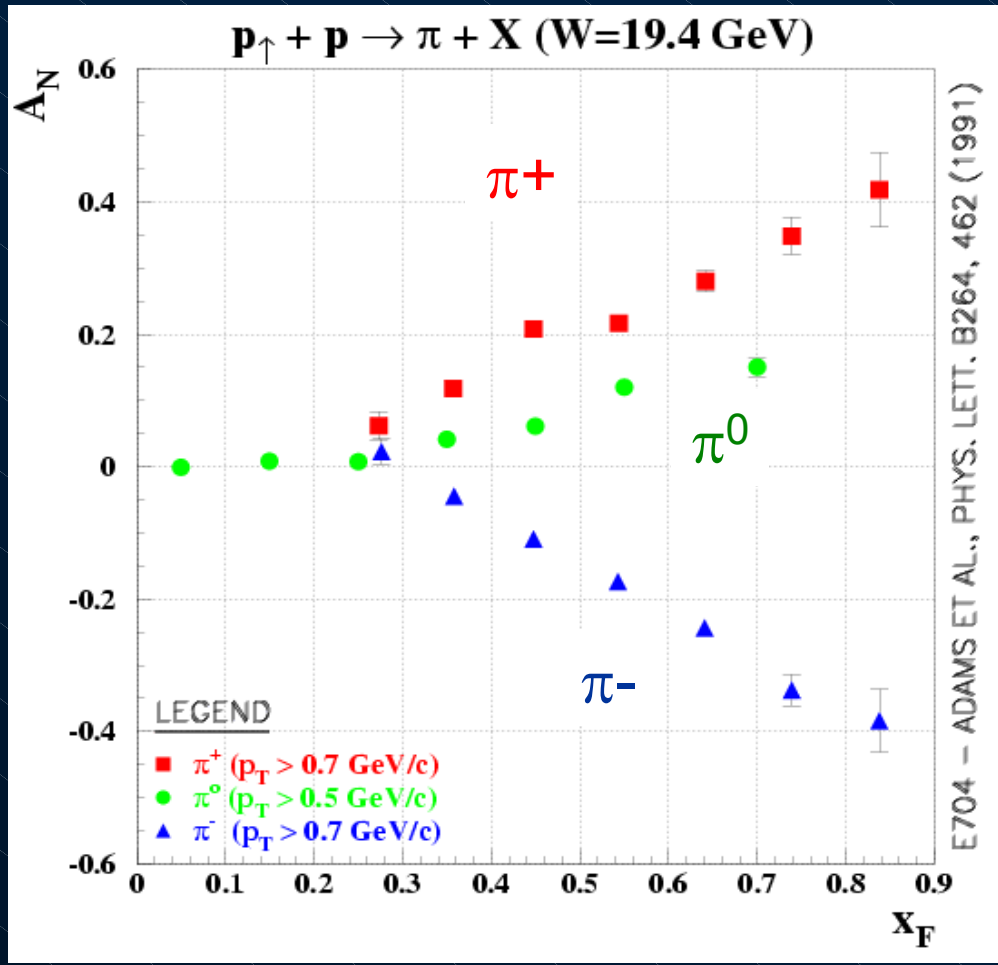
Background

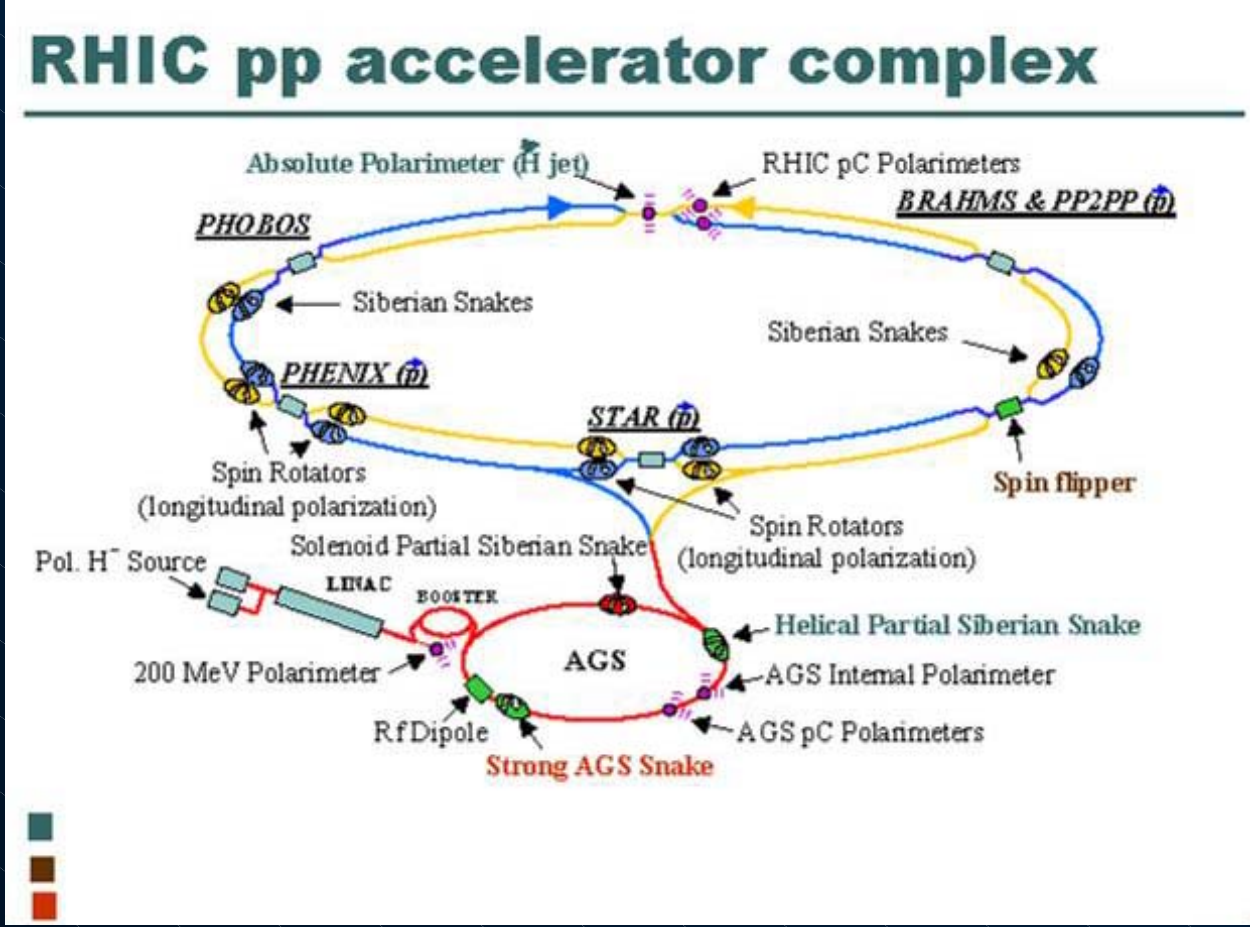
Low energy data (FNAL E704) show clear differences between π^{+-} and π^0.

D.L.Adams (E704) Phys.Lett B264,462(1991);

Phys.Rev. D53, 4747 (1996).

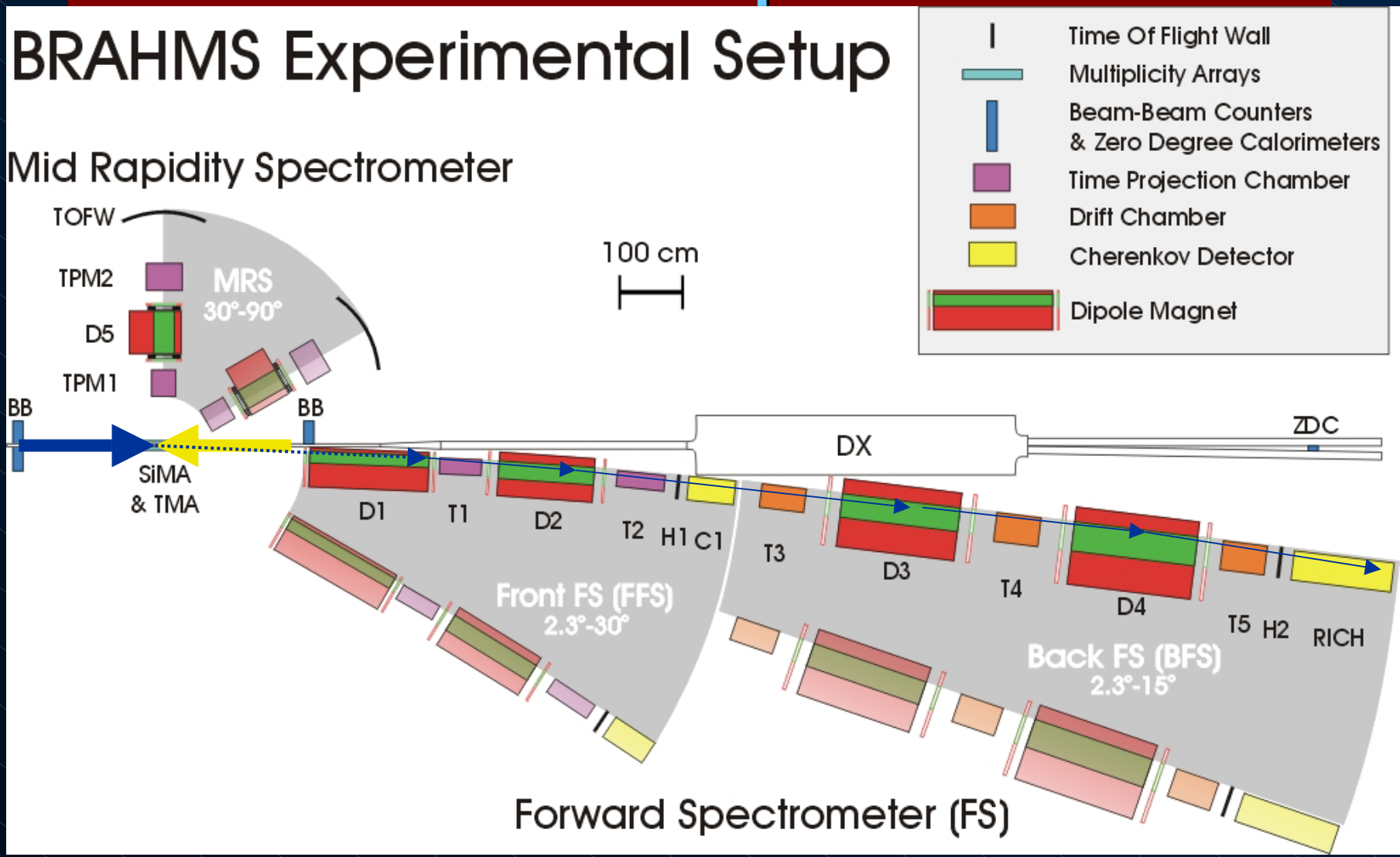
Recent STAR results on π^0 also shows a significant SSA/ A_n at RHIC energies.
Preliminary BRAHMS data was shown at DIS05.





RHIC beam transversely polarized at BRAHMS detector

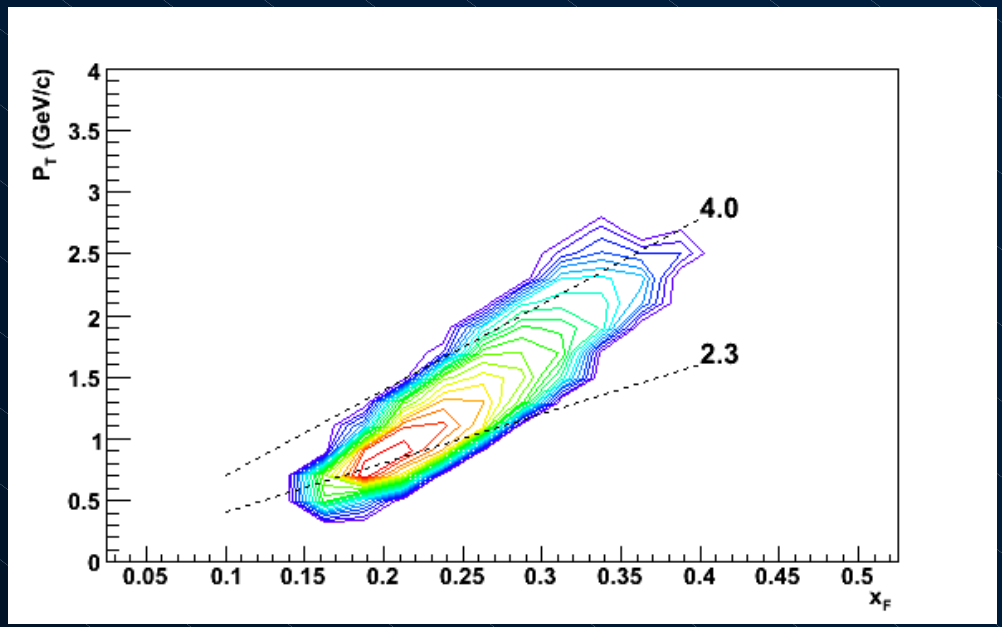
The BRAHMS Spectrometer



Kinematic Variables

- The kinematic variables of interest are Feynman x (x_F) and p_T.
- Shown is the BRAHMS acceptance for the data taken at $\theta = 2.3$ deg and the maximum field setting (7.2 Tm).
- The acceptance is not *straight* in angle or η. Illustrated in this plot. Thus care should be taken when comparing to both other experiments and to theory.

The momentum resolution is $\delta p/p$~1% at 22 GeV/c.



Determination of Asymmetries.

Asymmetries are determined from

$$A_n = (\sigma^+ - \sigma^-) / (\sigma^+ + \sigma^-)$$

Experimentally determined from

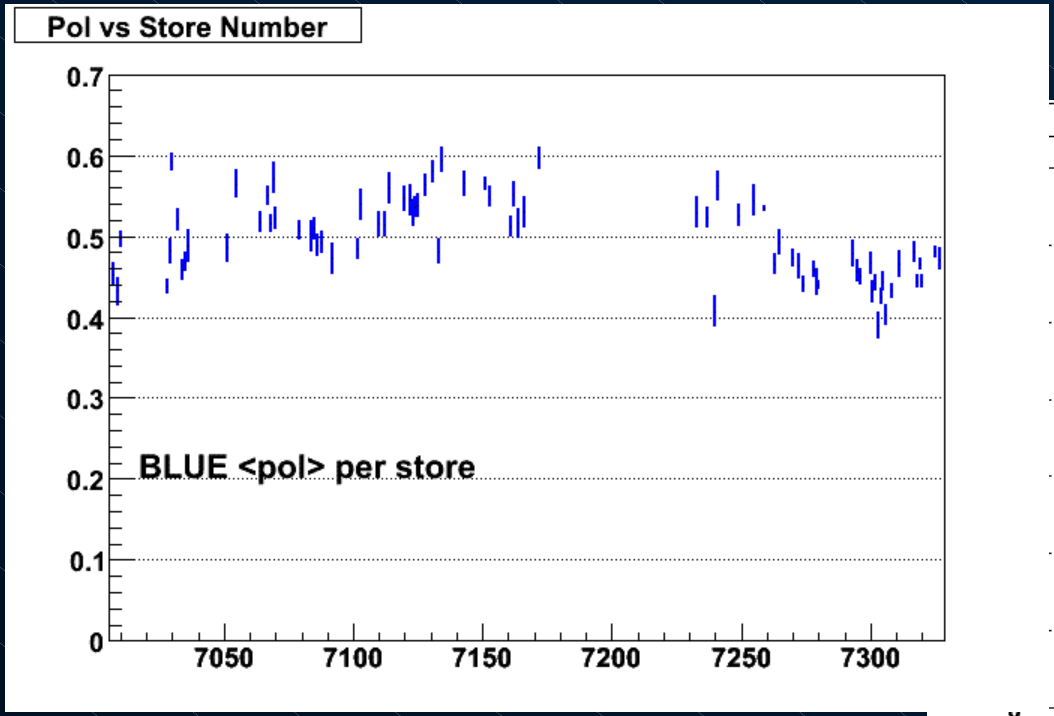
$A_n = 1.0 /P (N^+ - L*N^-) / (N^+ + L*N^-)$,

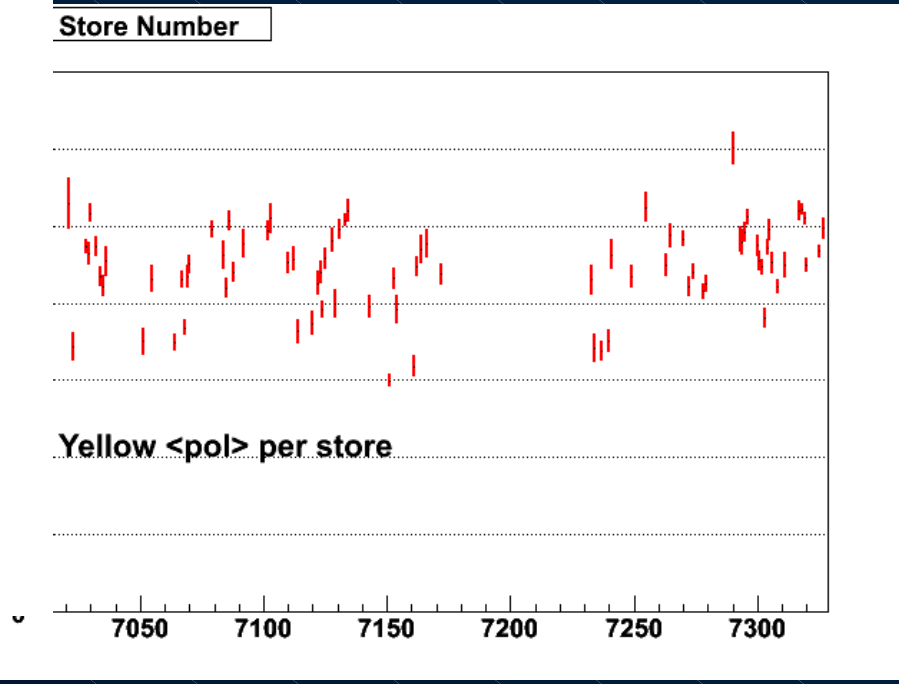
where $L = L^+ / L^-$

Need to know

- **Beam Polarization**
- Bunch Luminosities
- Pion rates in spectrometer

Beam Polarization





These are obtained from the CNI online polarimeter normalized to a Gas Jet Target measurements

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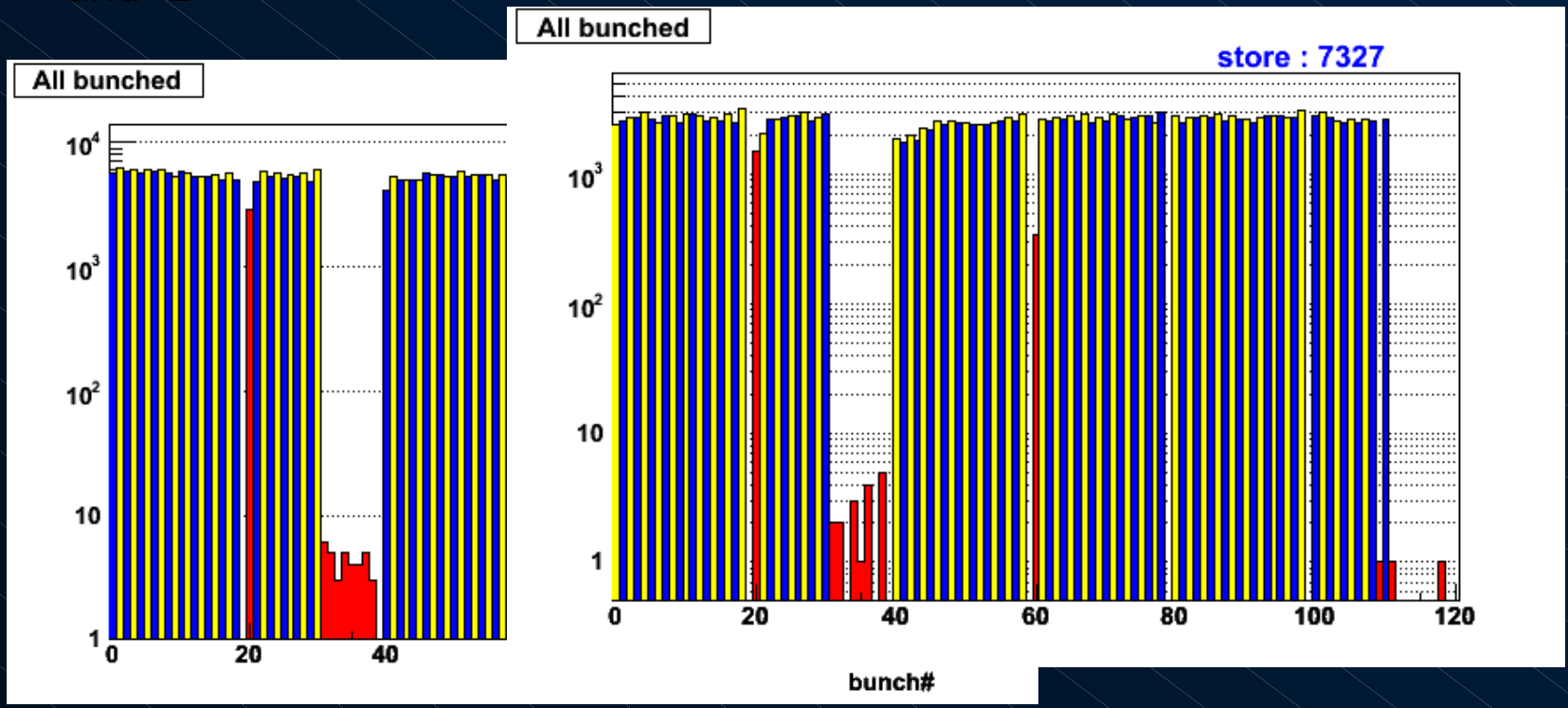
Bunch Luminosities

- Bad bunches with different intensity outside norm is rejected.
- L+/L- ~ 1.05-1.15 typical factors
- Run-5 have more systematic check with varying patterns.

Since the up and down spin patterns alternate most time-dependent systematic errors are small. The main issue is determination of the L^{+} and L^{-}.



Luminosity variation vs. runs

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Need to know

- Beam Polarization
- Bunch Luminosities
- **Pion rates in spectrometer**

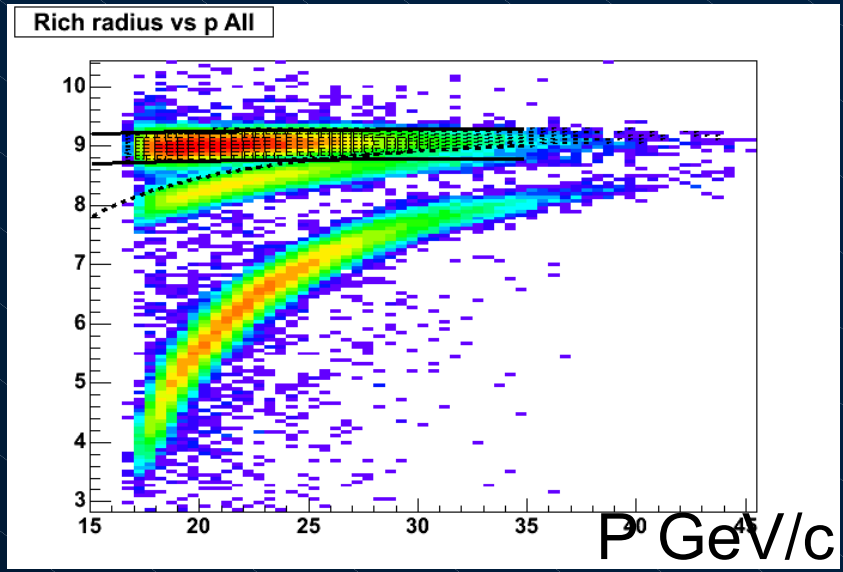
PID using RICH

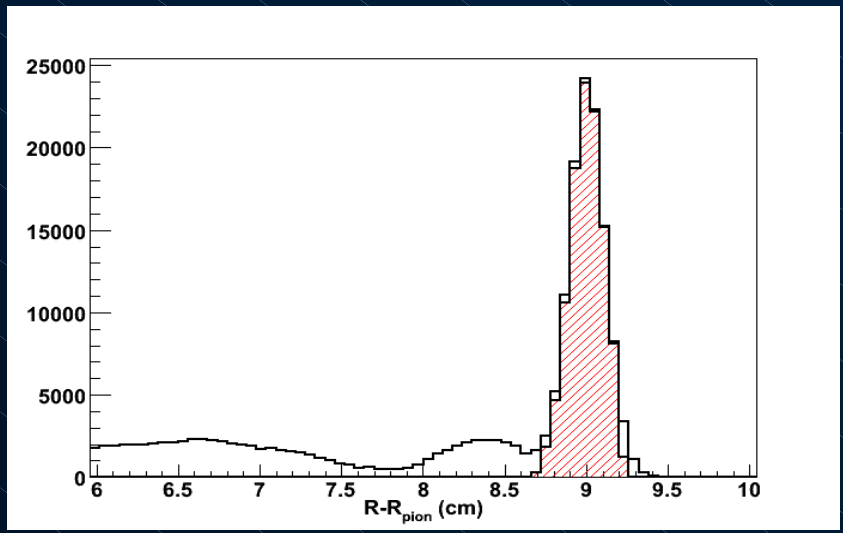
Good track are selected in spectrometer; determining momenta.

Pions identified from momentum and radius measured in a Ring Imaging Cherenkov Counter.

The pion identification is clean up to 35 GeV.

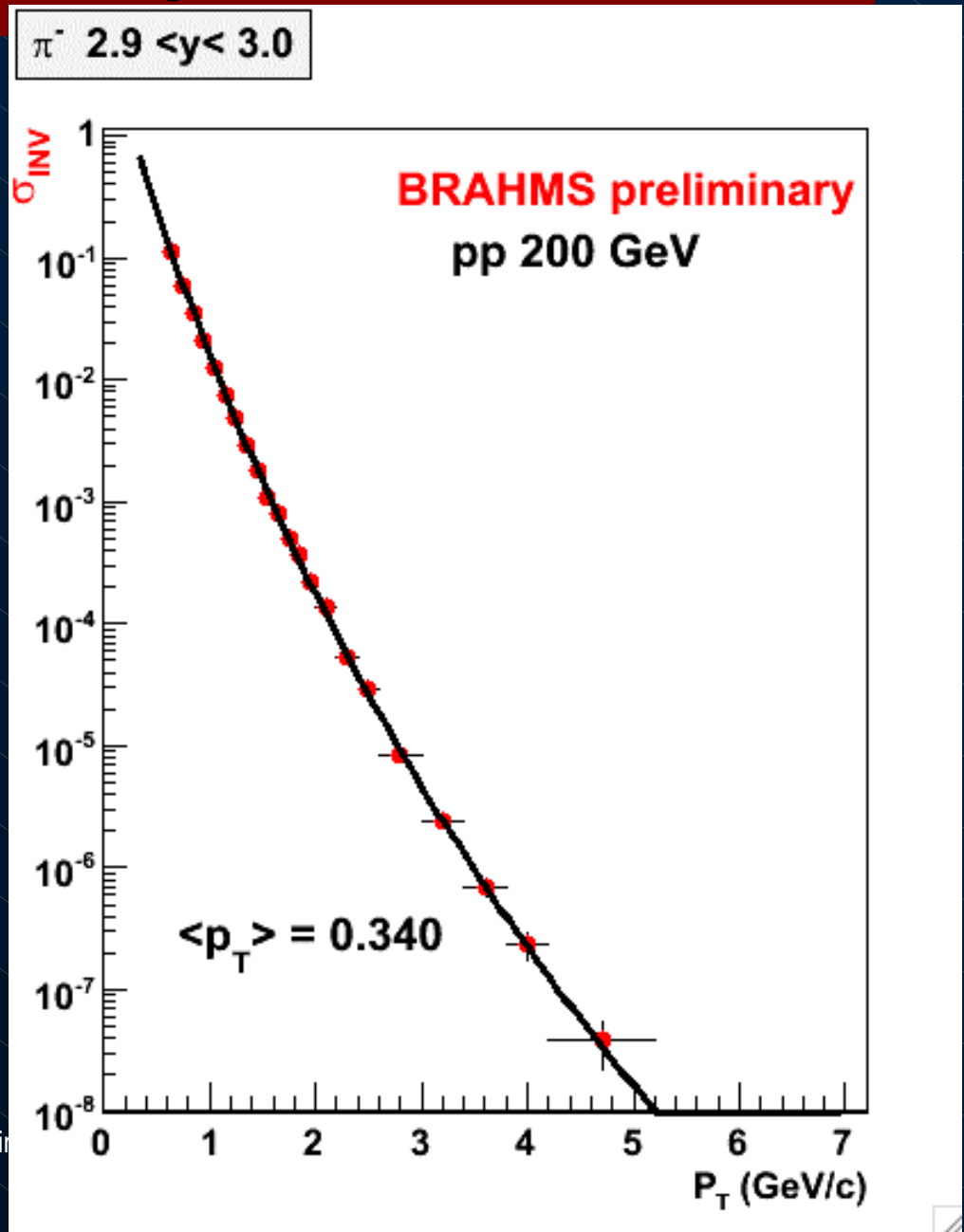
Measured radius vs. calculated showing the selected pions





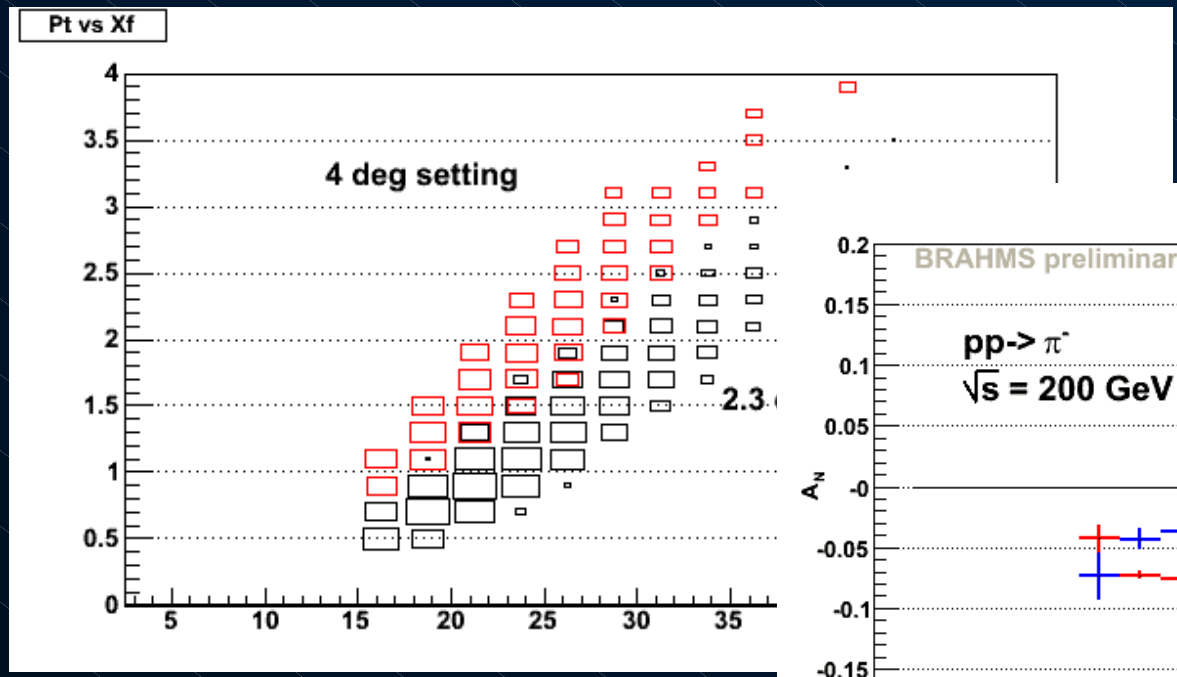
Hadron Spectra

- pp π^- spectrum over 7 orders of magnitude
- Spectra for other charged hadrons are forth coming
- Such spectra will provide a testing ground for pQCD

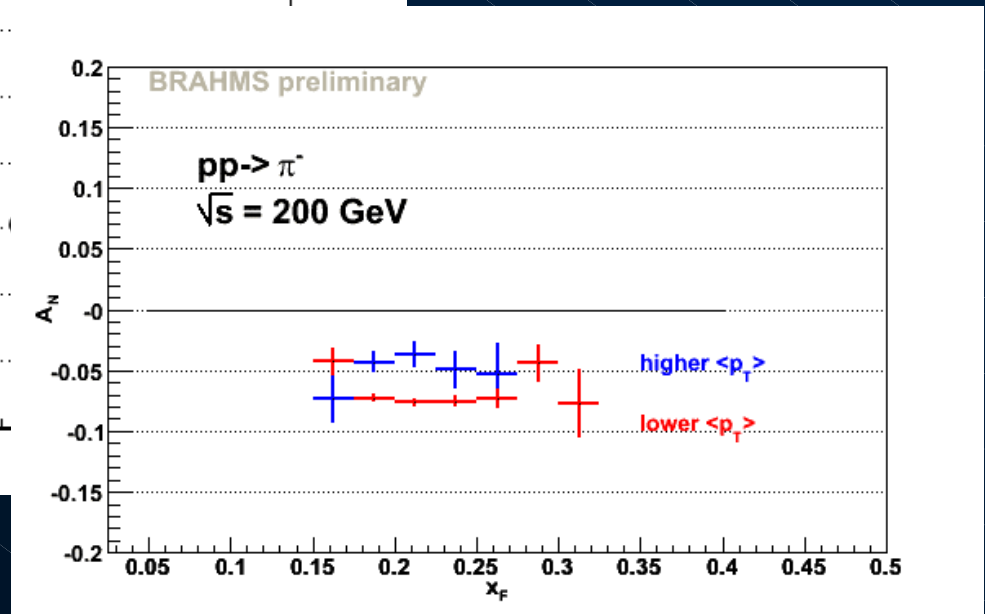


A_N measurements for π^-

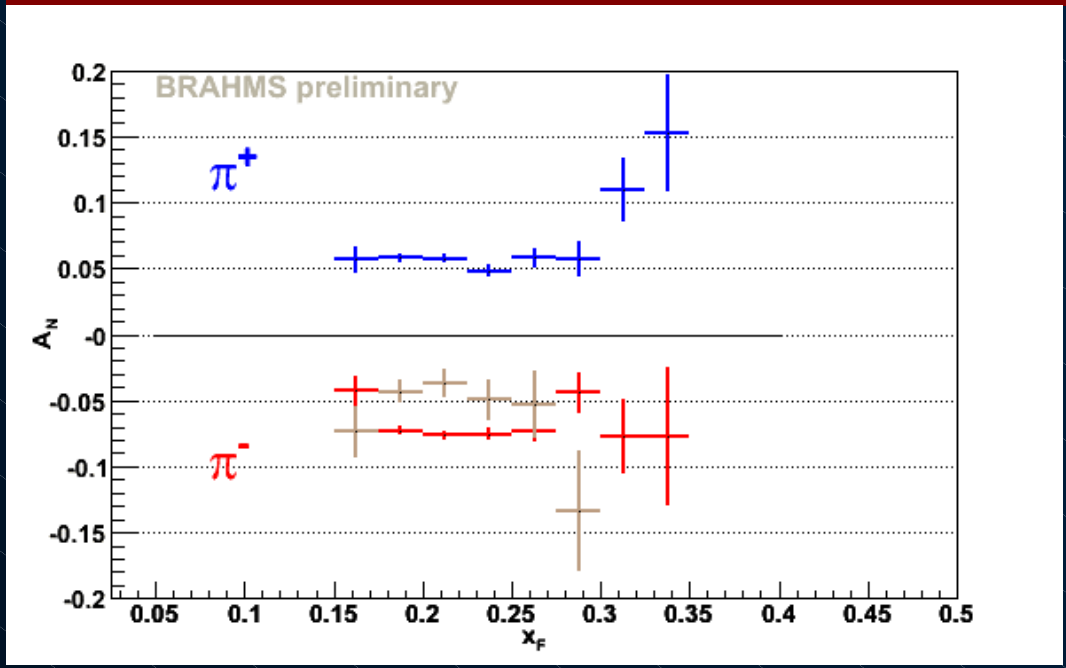
Measurements at 2.3 and 4 degrees.
Results averages of p_T range in each setting.



P_z



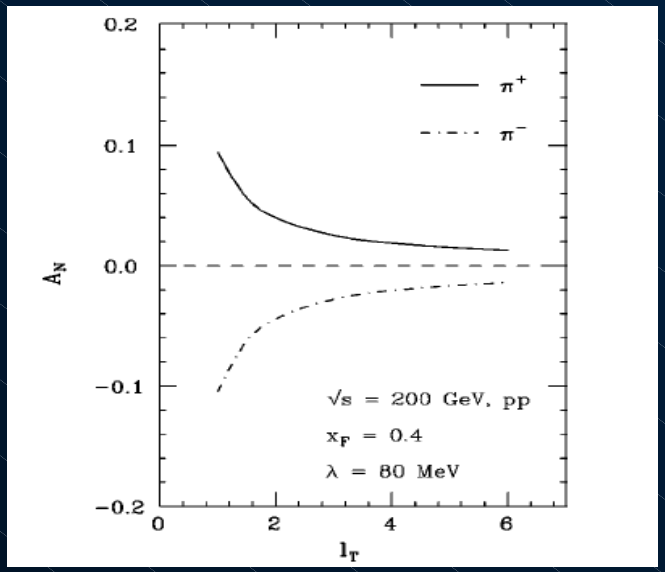
Summary of p_T dependence

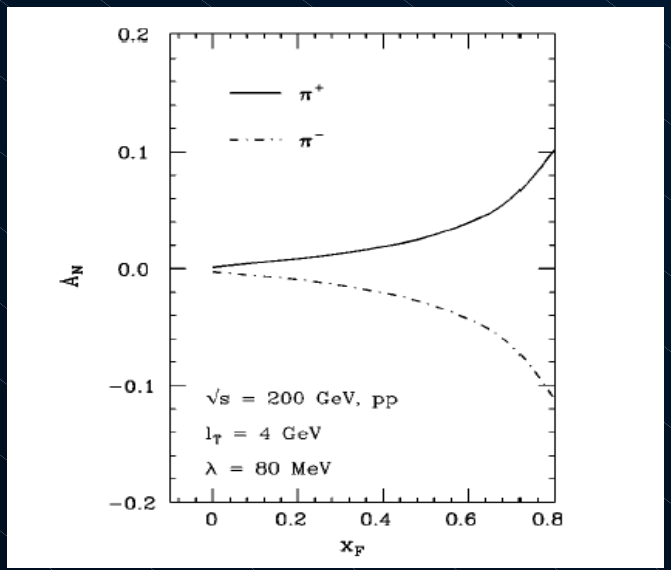


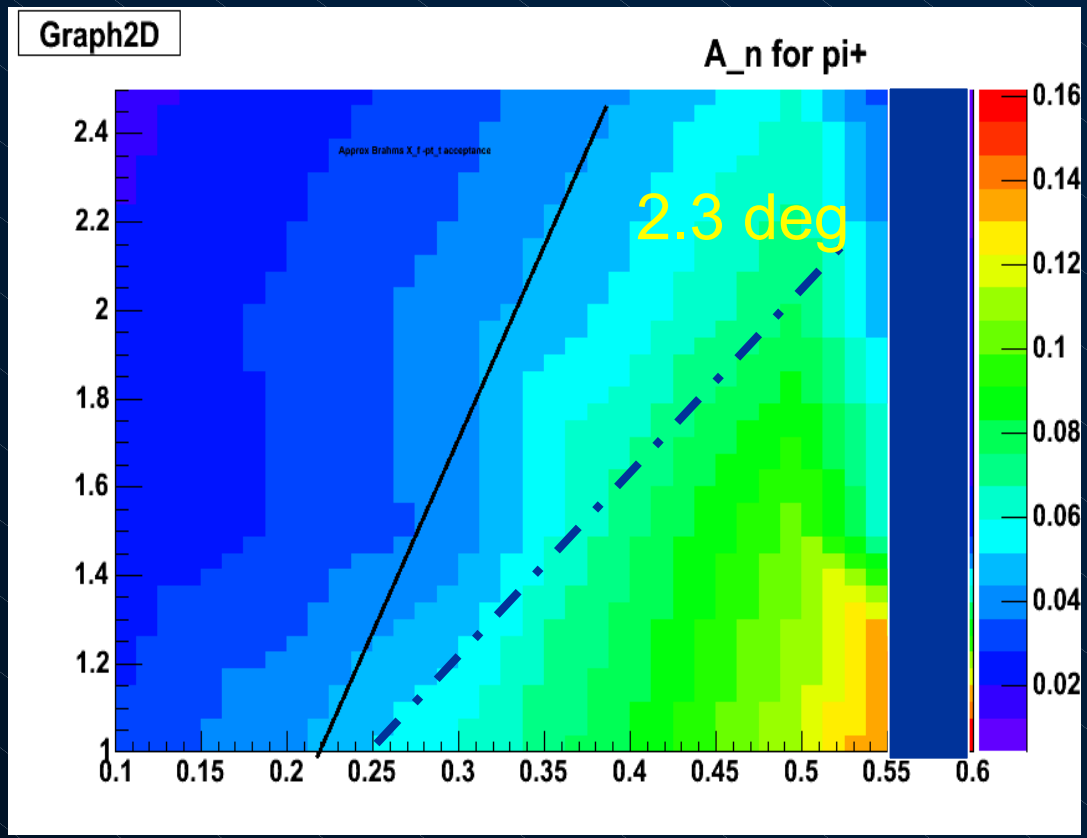
- 0.15-0.30 in Xf
  - A_N(pi-) 0.078+-0.002 low p_T
  - A_N (pi-) 0.045+-0.003 higher p_T
  - A_N (pi+) 0.066+-0.002 low p_T

Systematic errors from online polarization is (presently estimated at ~20% [scale])

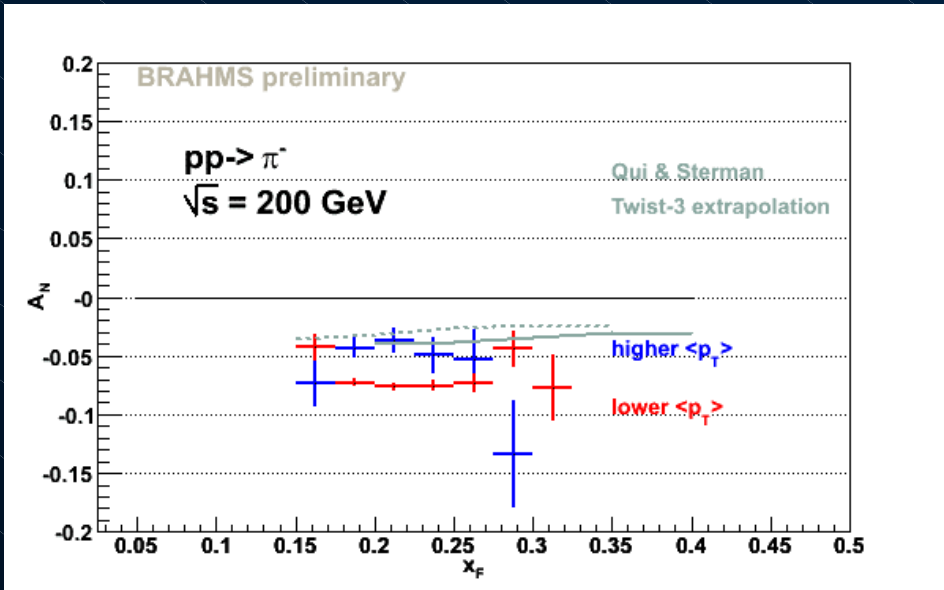
Twist 3 (initial state) calculations by J.Qiu and G.Sterman, Phys.ReV.D59,014004(98) Extrapolated to lower p_T







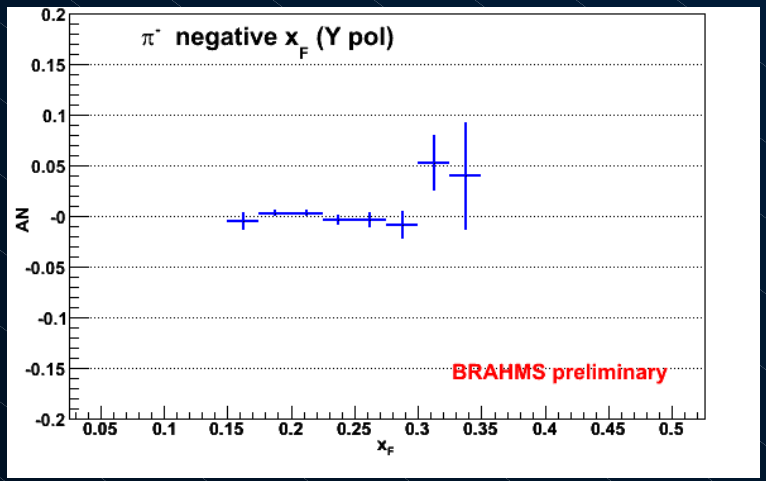
Comparison to data within acceptance.



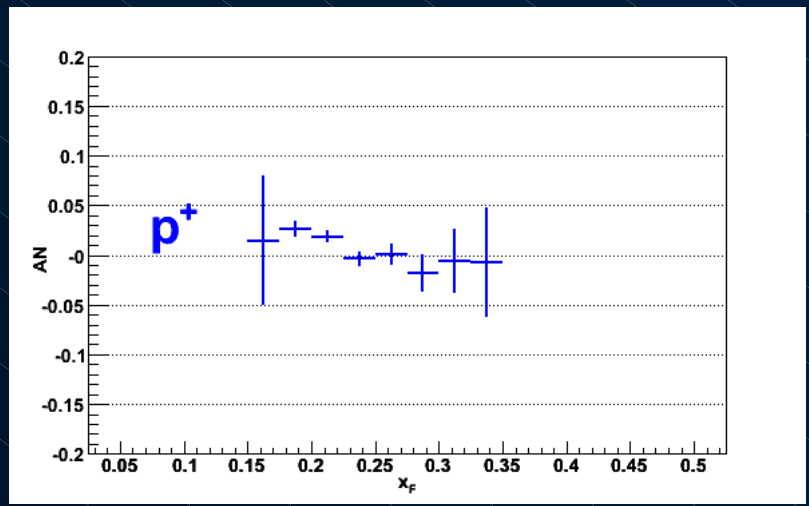
The A_N for π^+ in the theory is ~ A_N for π^- with opposite sign
The theory does predict a lowering at higher p_T and a nearly flat distribution with x_F in the acceptance.

Other results.

- Using polarization from opposite beam (yellow), we obtain A_N equivalent to asymmetries for negative x_F



Brahms will also access other charged hadrons; p+-, K^{+-}.



Conclusions

- BRAHMS has obtained the preliminary result for single spin asymmetries for π^+ and π^- in 200 GeV pp collisions at RHIC in the x_F range of 0.17 to 0.35
- The A_N values for π^+ and π^- are significantly different with opposite sign
- The absolute A_N value for π^- decrease with increasing p_T
- The sign of A_n is consistent with behavior from lower energy data
- A_n at negative x_F for π^+ and π^- are consistent with 0 The protons are found to have A_N ~0

The BRAHMS Collaboration

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