

π^0 -Charged Particle Correlations at $2.5 < \eta < 4.0$ from $p^\uparrow + p$ Collisions at $\sqrt{s} = 200$ GeV

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For the  **STAR** collaboration

OUTLINE

- Background
- STAR
- Correlations: current status
- Summary

Setting the Stage: E704

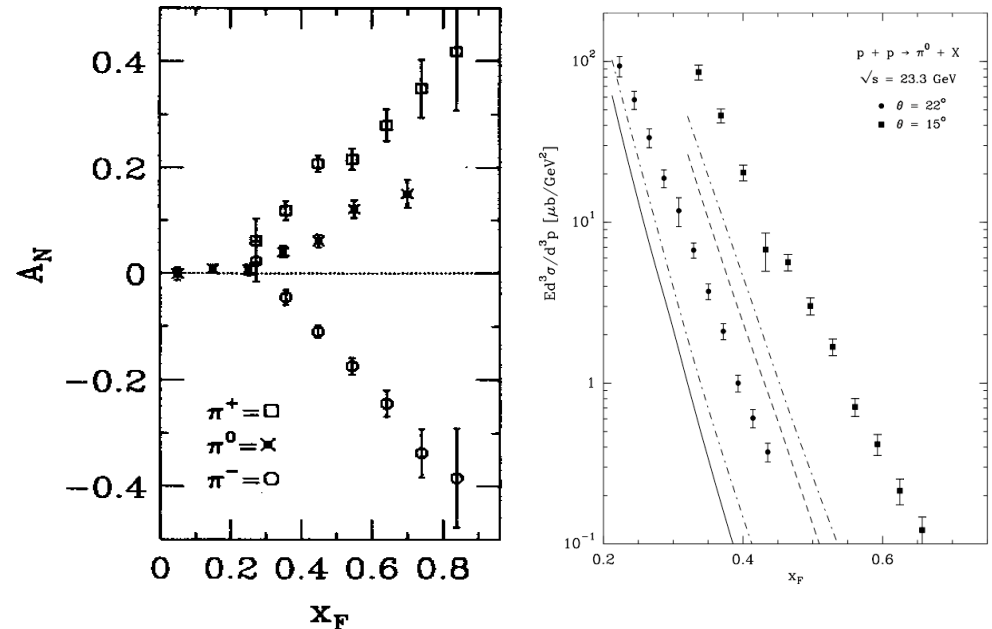
Beyond the first Born approximation, for non-zero

quark mass, m_q

$$A_N \sim \frac{\alpha_s \times m_q}{p_T}$$

So, pQCD estimates for single-spin asymmetries are **very small** (proportional to the quark mass!)

Phys. Rev. Lett. 41, 1689 (1978)



E704 showed **large** A_N for large x_F pion production at $\sqrt{s} = 20$ GeV.

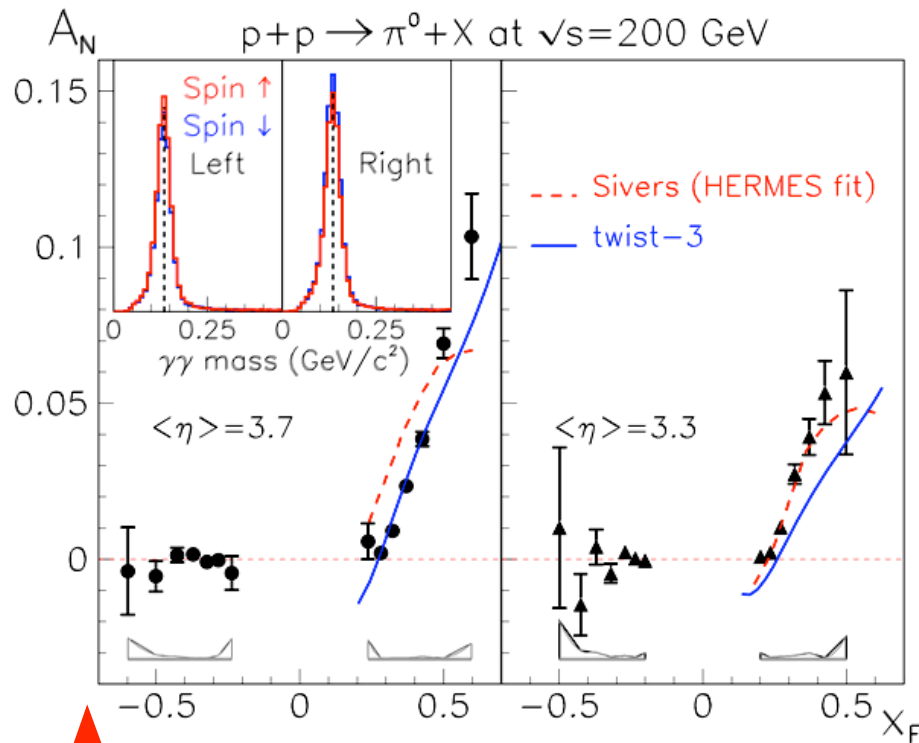
Observed cross-sections large compared to pQCD predictions

Phys. Lett. B 261, 201; 264, 462 (1991)

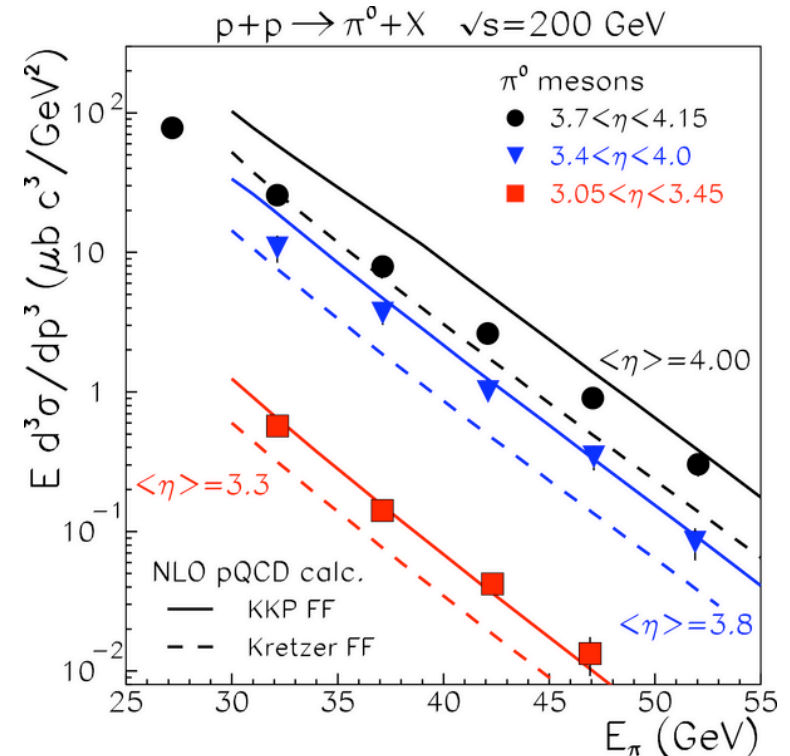
Eur. Phys. Journ. C 36, 371 (2004)

Setting the Stage: STAR

Likewise, STAR has observed **large A_N** for $p+p \rightarrow \pi^0 + X$ at forward angles



STAR Phys. Rev. Lett. **101**, 222001 (2008)

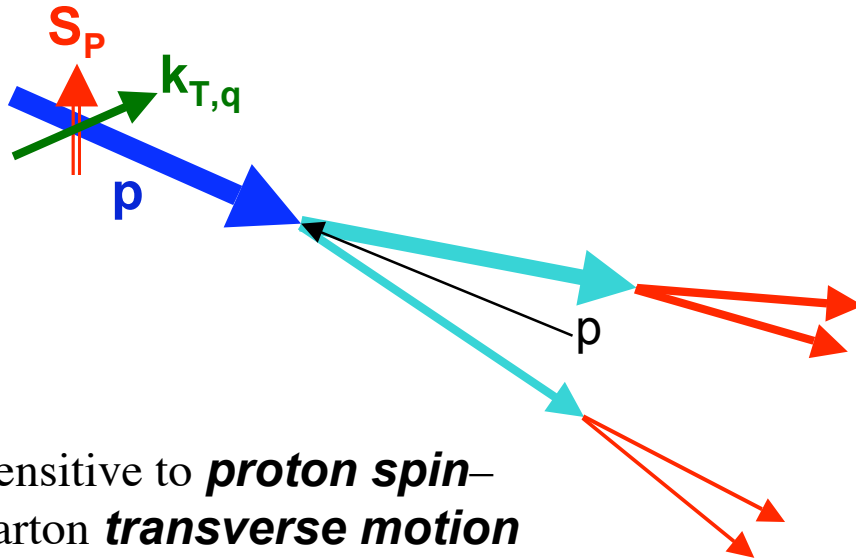


In this case, the measurements were taken in a region where the pQCD cross-section provides a **reasonable description of the data**

STAR Phys. Rev. Lett. **97**, 152302 (2006)

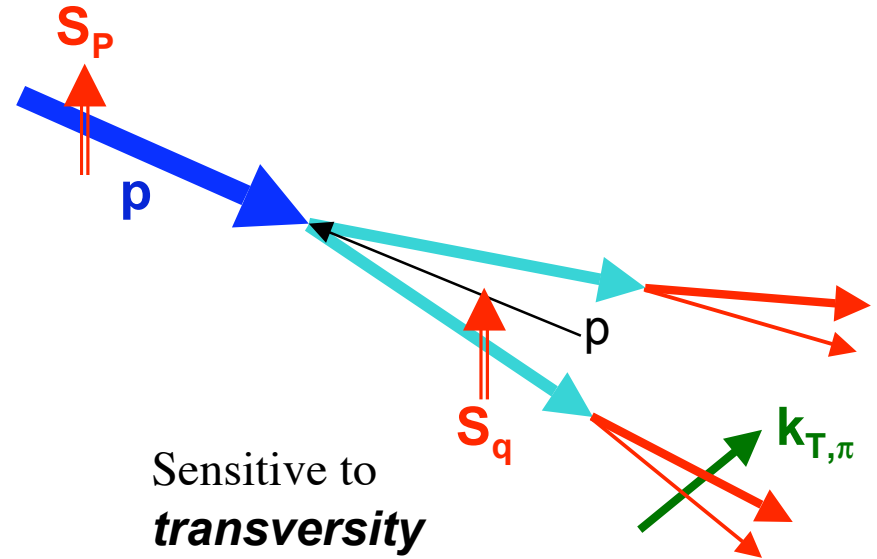
Separating Sivers and Collins Effects

Sivers mechanism: asymmetry in the forward jet *production*



Sensitive to *proton spin*–
parton *transverse motion*
correlations

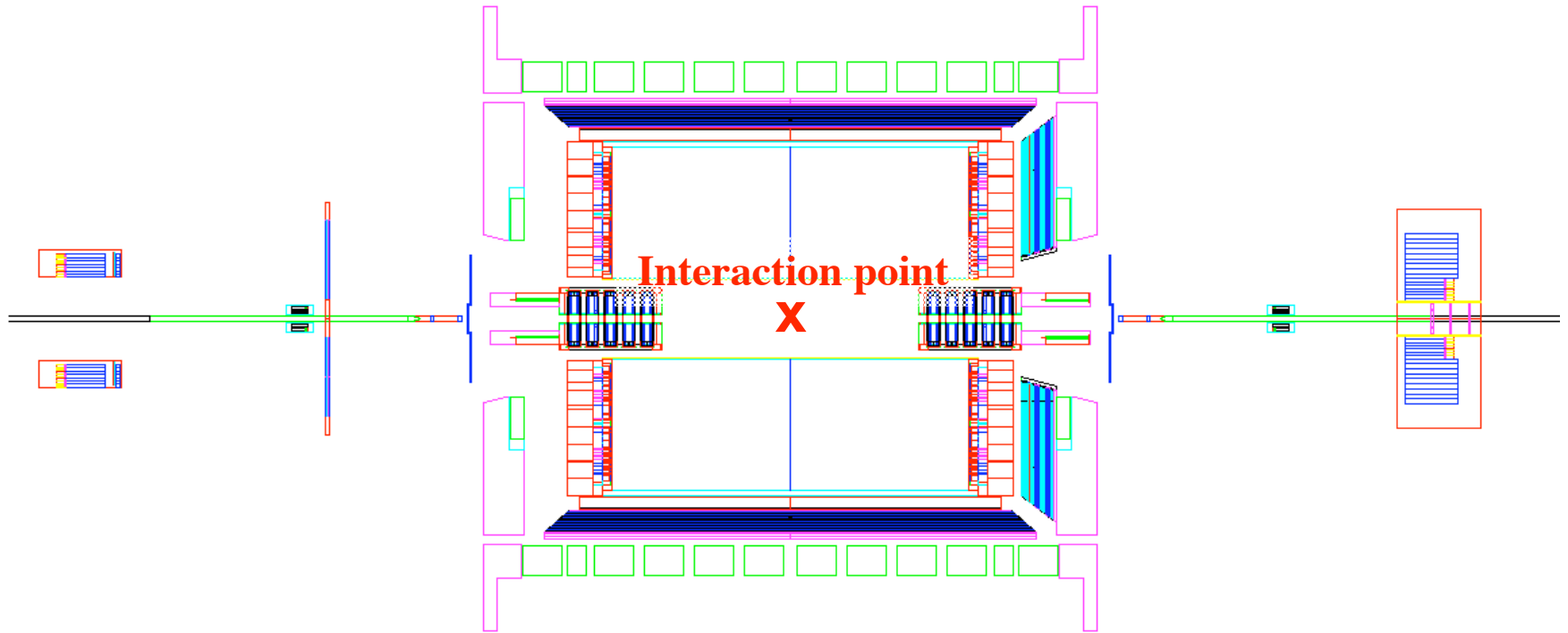
Collins mechanism: asymmetry in the forward jet *fragmentation*



Sensitive to
transversity

To discriminate between the two effects we need to go beyond π^0 detection. This talk focuses on *correlations*

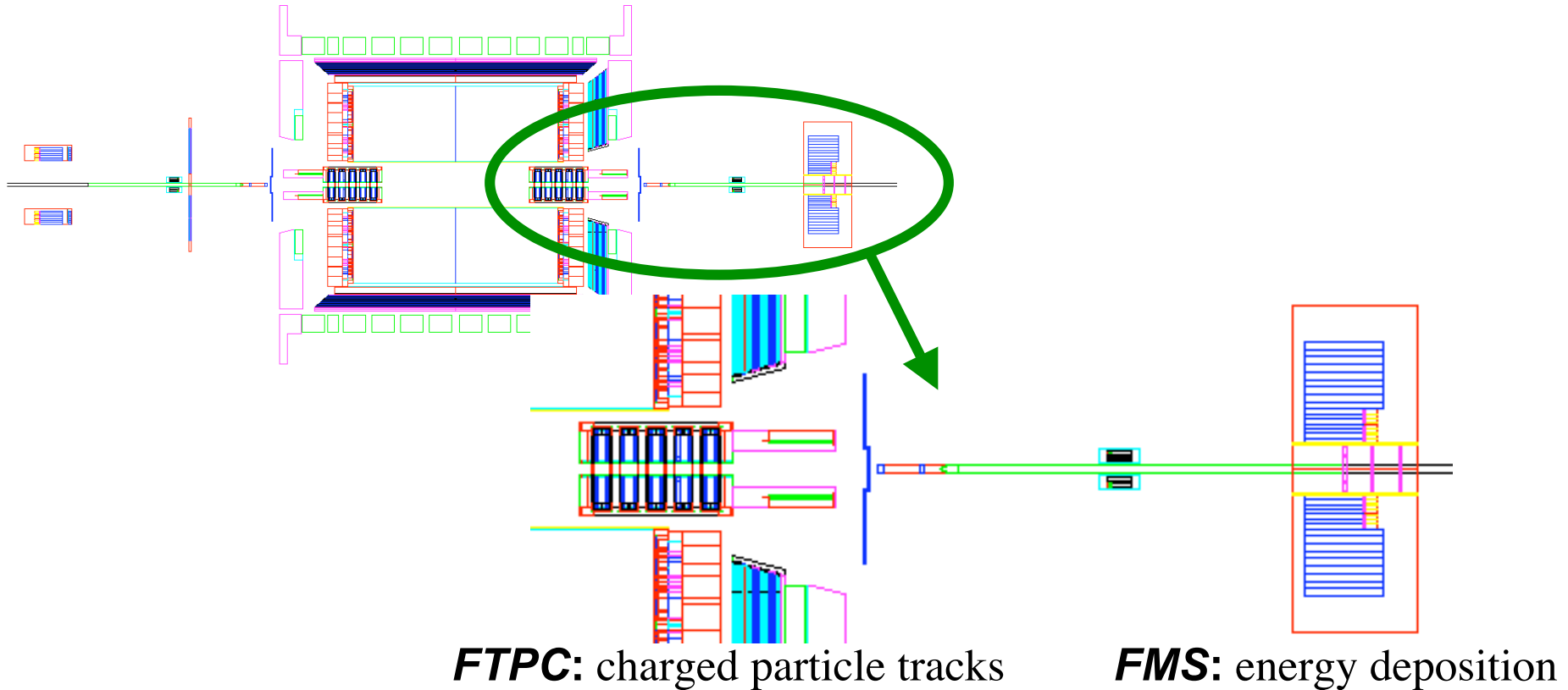
Solenoidal Tracker at RHIC



STAR (2008 geometry)

Charged-particle tracking and electromagnetic calorimetry over large solid-angle

Solenoidal Tracker at RHIC



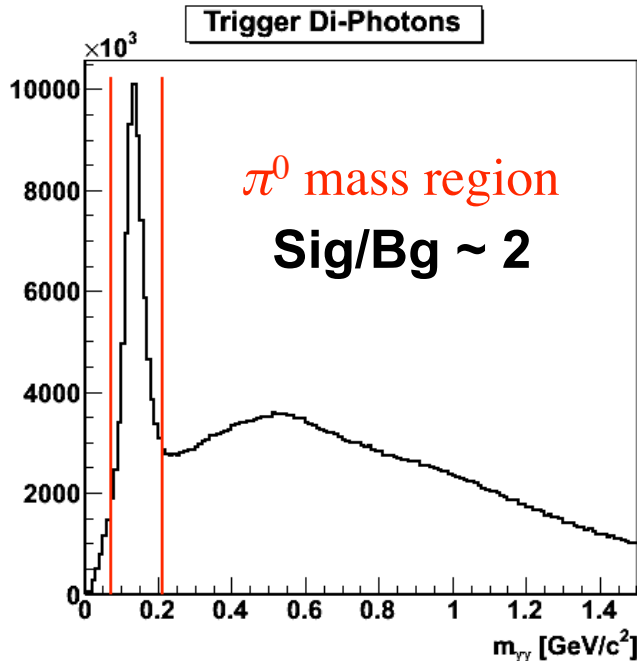
FMS and FTPC subtend $2.5 < \eta < 4.0$

Look at correlations in a region with large π^0 asymmetries

Event Cuts

- Transversely polarized $p+p$ runs at $\sqrt{s} = 200$ GeV (Average polarization ~ 0.50)
- Trigger: single FMS tower ADC above threshold
- Software-level cuts:
 - Good event vertex with $|z_{\text{vertex}}| < 50$ cm
 - Summed energy in FMS < 200 GeV
- Photon cuts:
 - **Calibration:** tower-by-tower gains; corrected for energy-dependent shift in π^0 mass
 - **Fiducial volume:** 1/2-cell from detector edge; 3/4-cell from dead tower

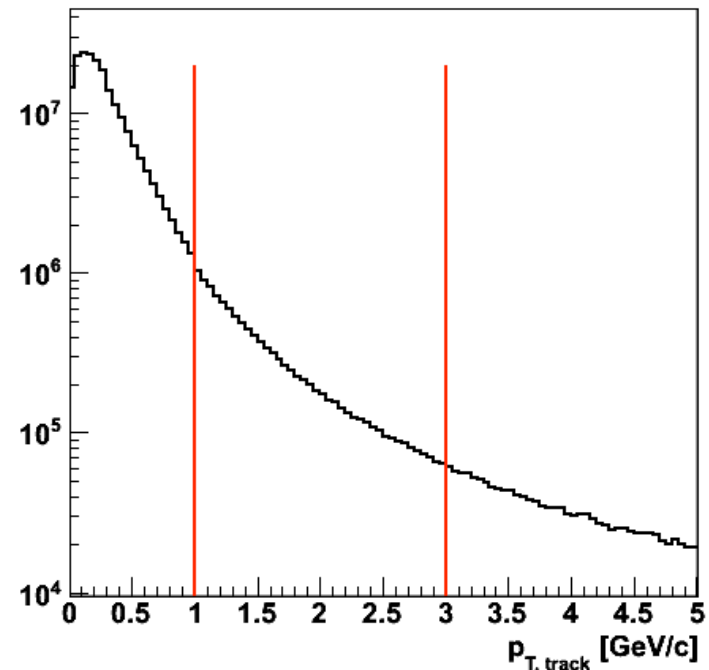
Trigger π^0 's and Correlated Tracks



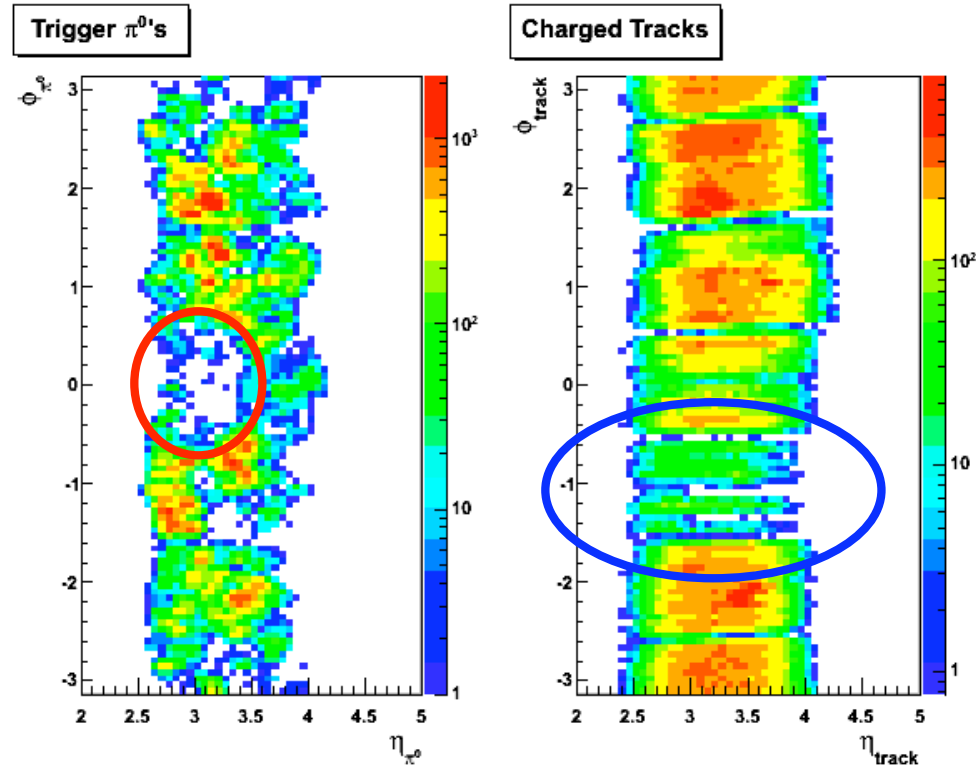
- At least one γ which could fire trigger
- $0.07 < m_{\gamma\gamma} < 0.21$ GeV/c²;
($E_{\gamma_1} - E_{\gamma_2}$) / ($E_{\gamma_1} + E_{\gamma_2}$) < 0.80
- Choose highest energy remaining π^0
- $2.0 < p_T < 5.0$ GeV/c

Track quality cut based on fit points

- Distance of closest approach (DCA) to collision vertex within 0.85 cm
- $1.0 < p_{T, \text{track}} < 3.0$ GeV/c



Correlation Acceptance

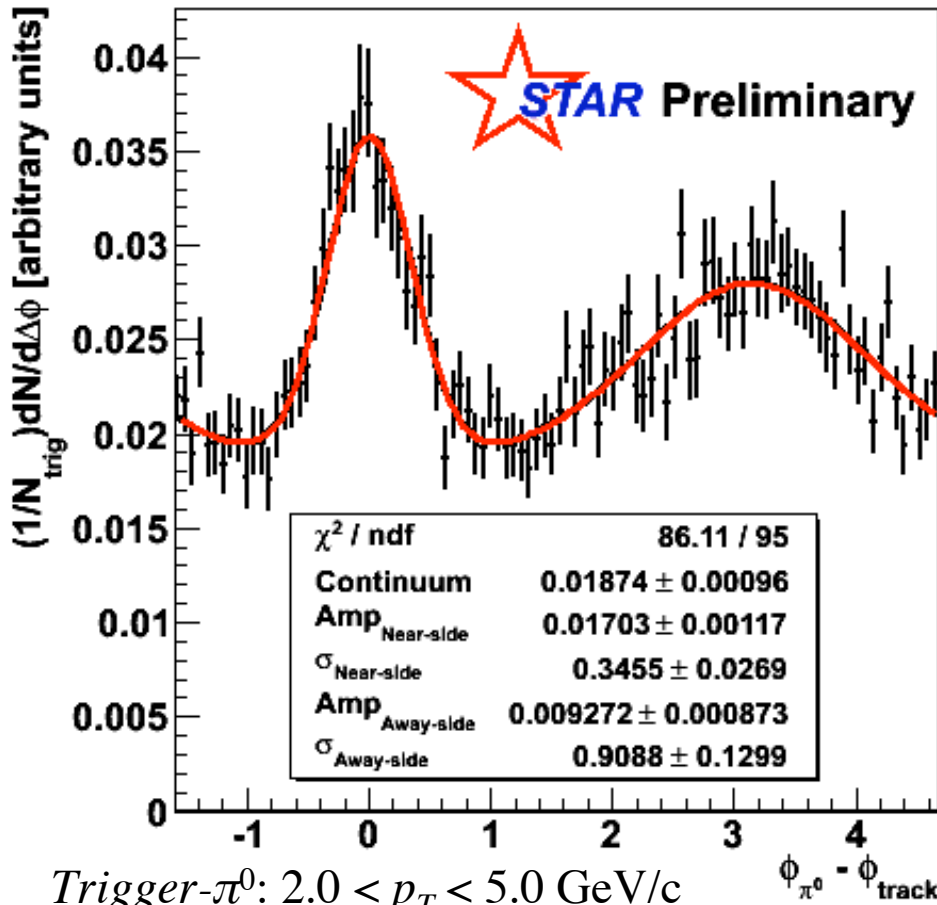


Correlations cover the range of $2.5 < \eta < 4.0$

Acceptance holes due to **gain non-uniformity** and **electronics failures** are corrected with a *mixed-event technique*

π^0 -Charged-particle Correlations

p+p at $\sqrt{s} = 200$ GeV



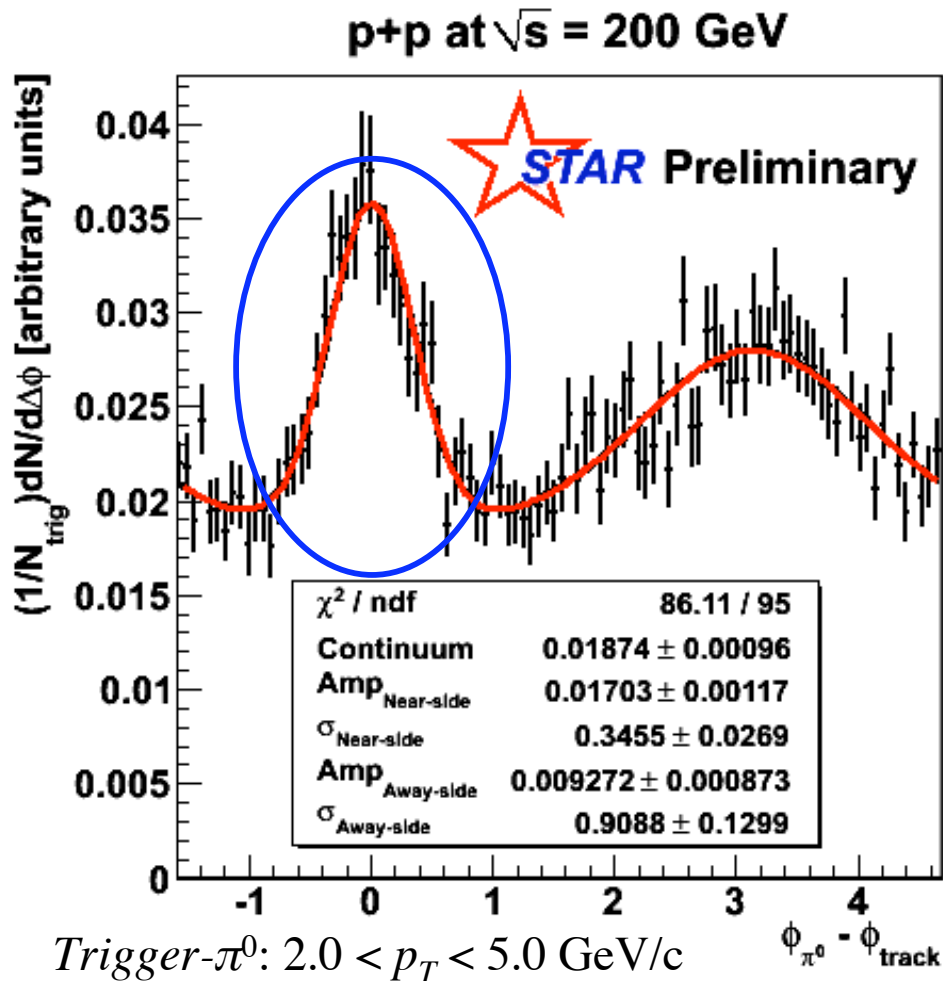
Trigger- π^0 : $2.0 < p_T < 5.0$ GeV/c

Assoc.-Chg. Part.: $1.0 < p_T < 3.0$ GeV/c

Normalization based on *estimated* tracking efficiency (Embedding studies to quantify tracking efficiency are ongoing)

Luminosity-dependent studies show a “physics” continuum of 0.016 ± 0.001

π^0 -Charged-particle Correlations

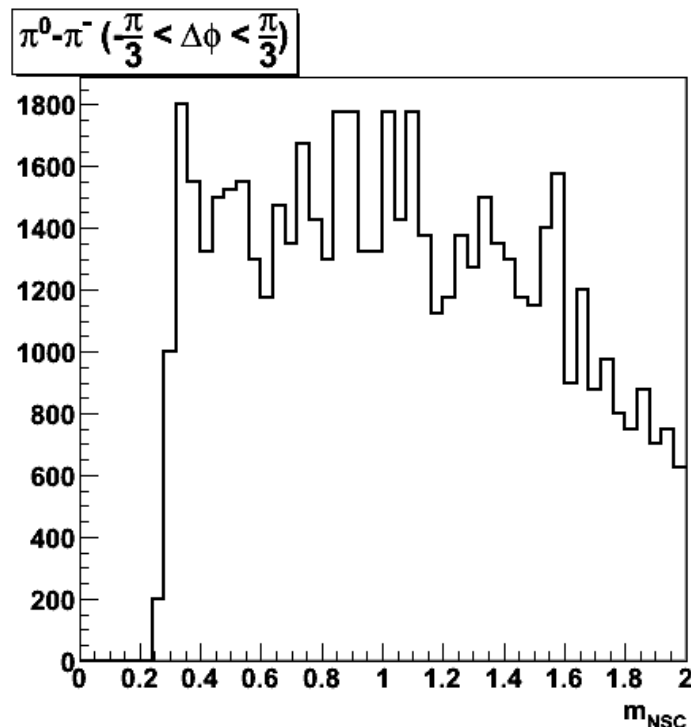
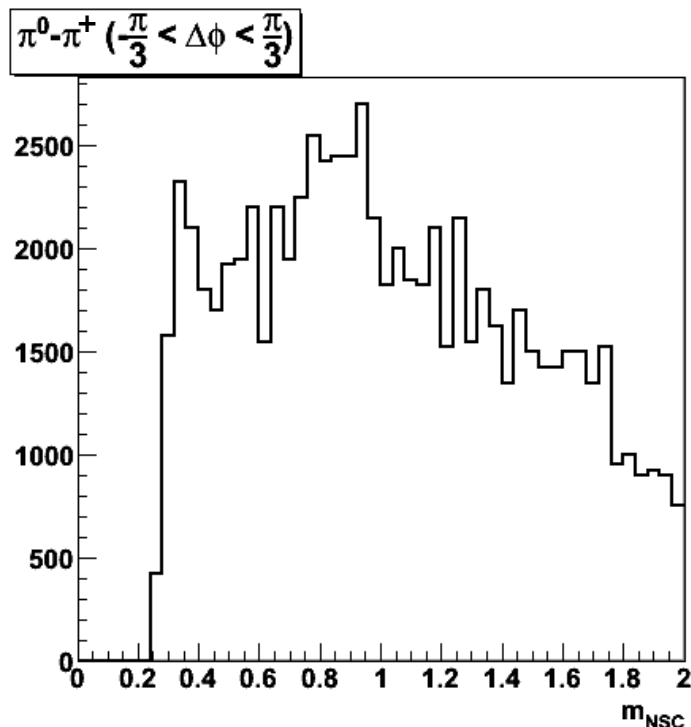


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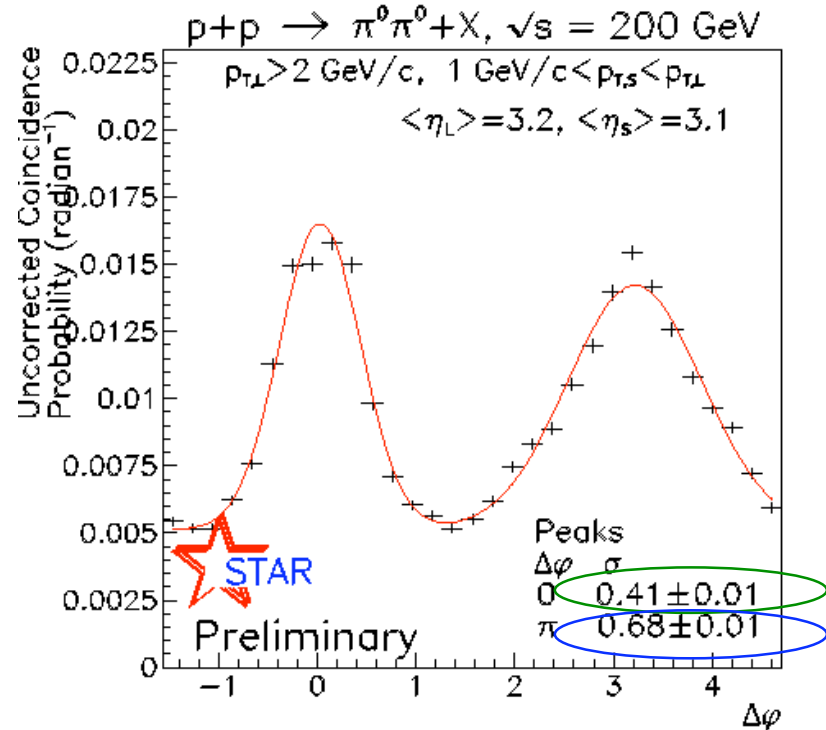
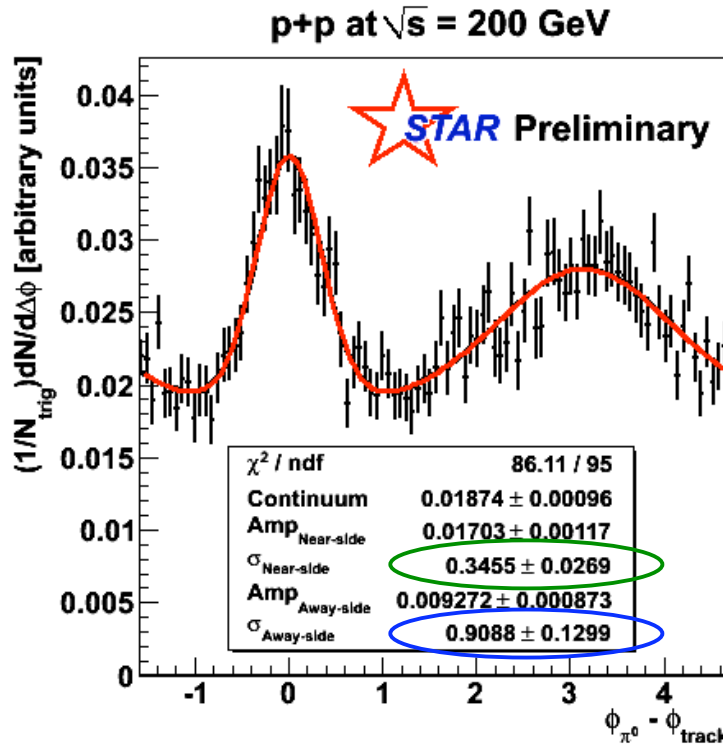
Focus on near-side correlations (NSC)

Near-side Correlations



- Near-side invariant mass shows signal for ρ^+
- ρ^- not visible at these statistics
- Events are not dominated by ρ -production suggesting sensitivity to “jet-like” events

Comparison to π^0 - π^0 Correlations



- Near-side and away-side widths consistent to within 2σ
- Integrated near-side to away-side relative yields roughly consistent ($\sim 10\%$)
- $\langle \eta_{ch} \rangle = 3.3$ vs. $\langle \eta_{\text{sub-}\pi^0} \rangle = 3.1$
- Largest apparent difference is relative size of peaks compared to the continuum

Summary

- **Detector effects** *removed* from 2008 dataset
- **Correlations signal** obtained with random contribution estimated
- **Near-side correlations** exhibit *jet-like* behavior
- To do:
 - *Quantify tracking efficiency with embedding*
 - *Begin spin-dependent measurements (including Interference Fragmentation Functions)*