Longitudinal Double-Spin Asymmetry and Cross Section for Inclusive π^0 Production in Polarized p+p Collisions at RHIC

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Motivation

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma(Q^2) + \Delta G(Q^2) + L_q(Q^2) + L_g(Q^2)$$

Proton spin puzzle:

quark spins carry only a small fraction of proton spin $\Delta\Sigma \approx 0.3$

The gluon spin contribution ΔG is less constrained

Polarized proton collisions at RHIC probe gluon polarization by measuring the observable double spin asymmetry A_{LL} of particle production

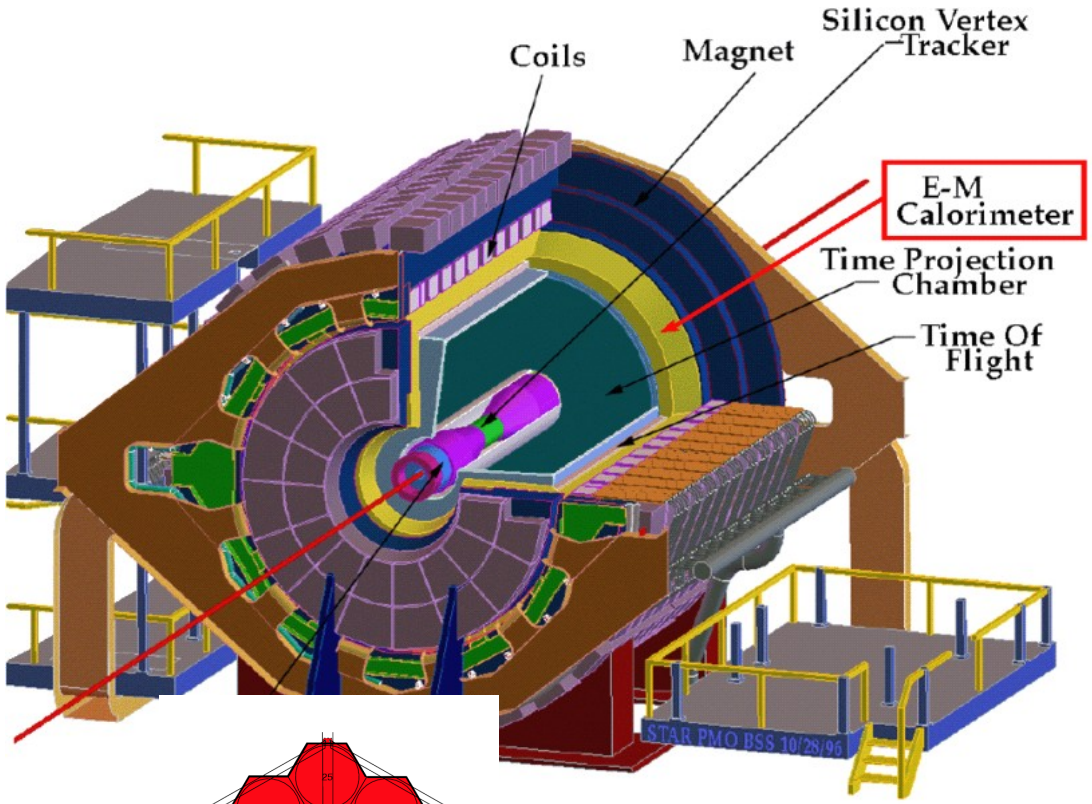
$$A_{LL} = \sum_{ABC} \frac{\Delta f_A \Delta f_B \times \Delta\sigma_{AB\to CX} \times D_C}{f_A f_B \times \sigma_{AB\to CX} \times D_C}$$

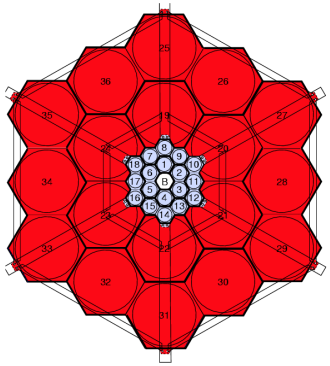
Motivation

Why measure π^0?

- Produced abundantly and provides supplemental information to jets measured by STAR
- Measured statistically independent from jets with different systematic uncertainties
- In most cases leading particle in a jet and carries most of its momentum
- Can be reconstructed in a calorimeter up to high momenta

STAR Detector



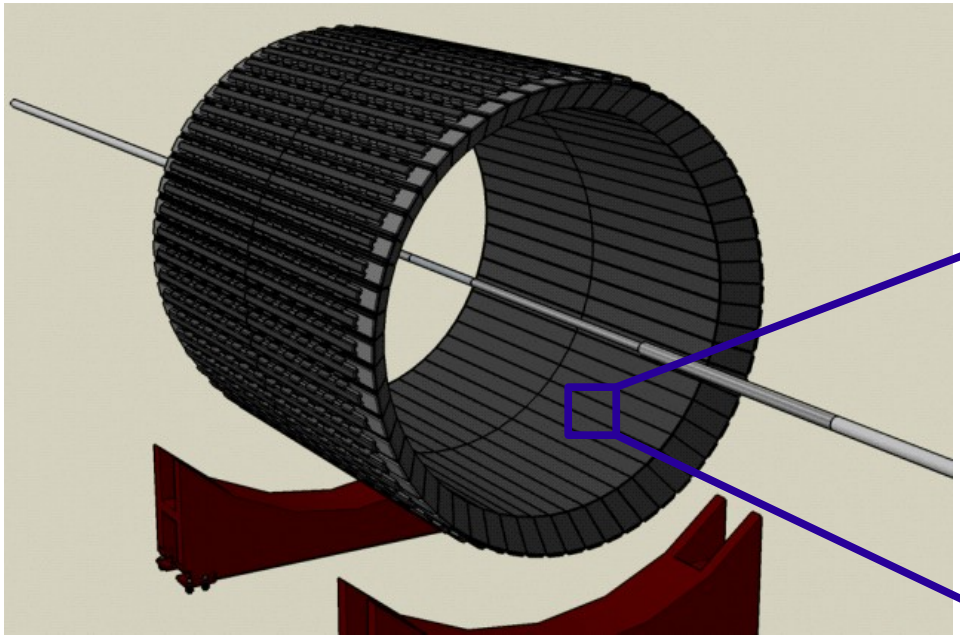


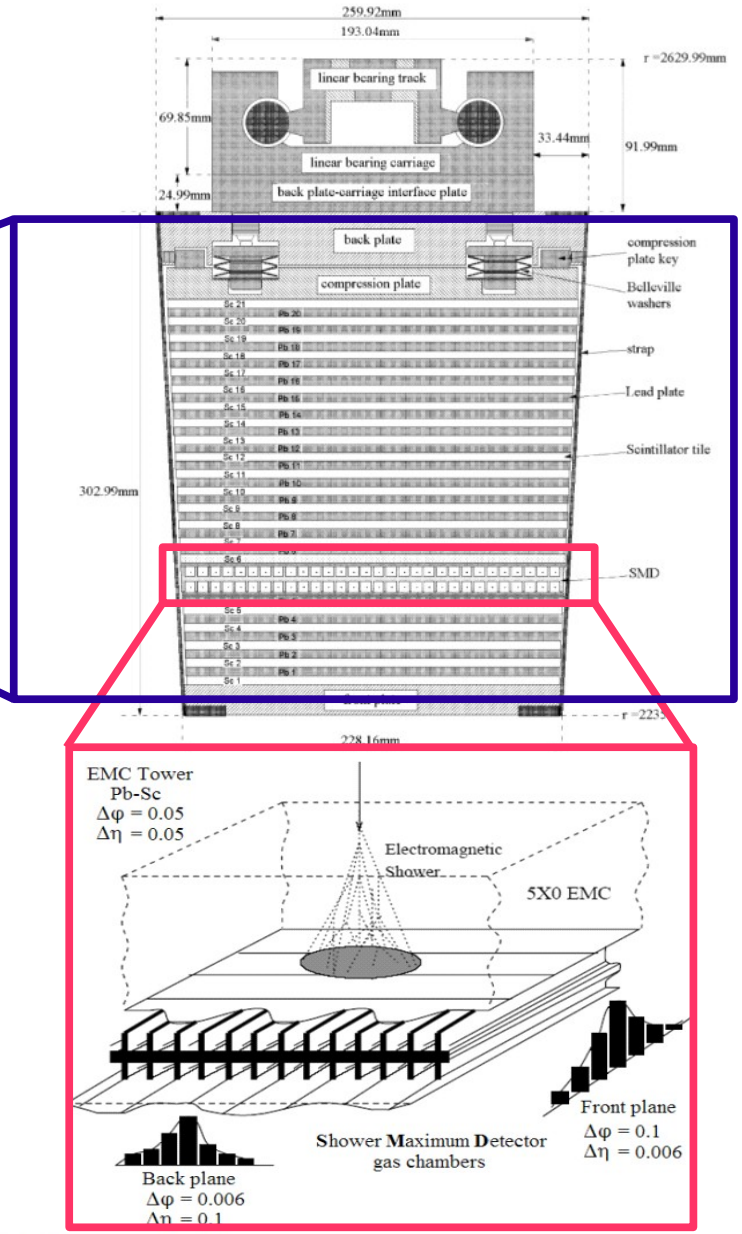
Beam-Beam Counter

Subsustems used in this analysis:

- Beam-Beam Counters triggering and luminosity
- Barrel Electromagnetic Calorimeter triggering and final state reconstruction
- Time Projection Chamber central tracking and vertexing

STAR EMCal





Lead-scintillator sampling calorimeter ($\approx 20 X_0$)

- 2π azimuthal coverage
- $-1 < \eta < 1$ (Run 6)
- Segmented into 4800 towers $\Delta\eta \times \Delta\varphi = 0.05 \times 0.05$
- Shower Max Detector located at a depth of $\approx 5 X_0$

π^0 reconstruction

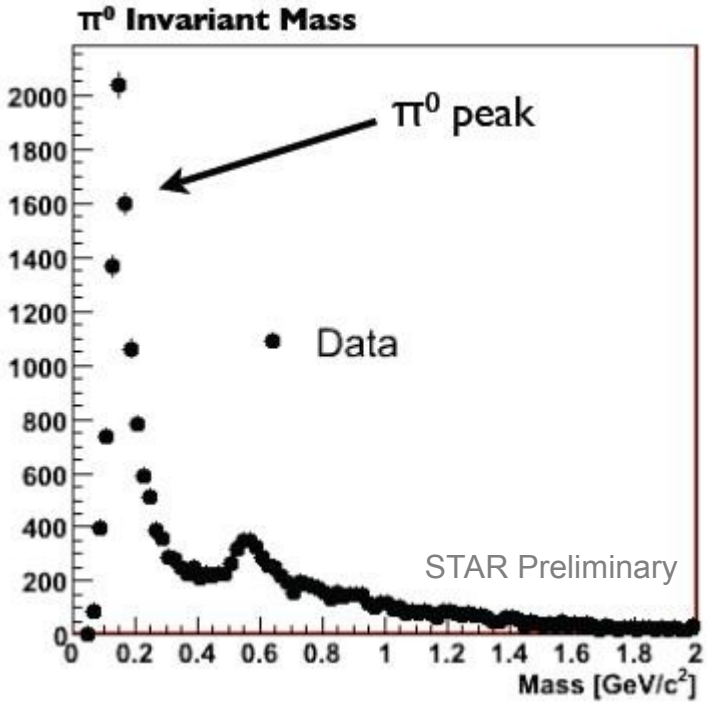
$\pi^0 \rightarrow \gamma\gamma$

New trigger in 2006: two stage triggering

L0 High Tower + L2 Trigger Patch

High energy in one cell + some in 3x3 surrounding cells

Triggered luminosity 3.7 pb^{-1}

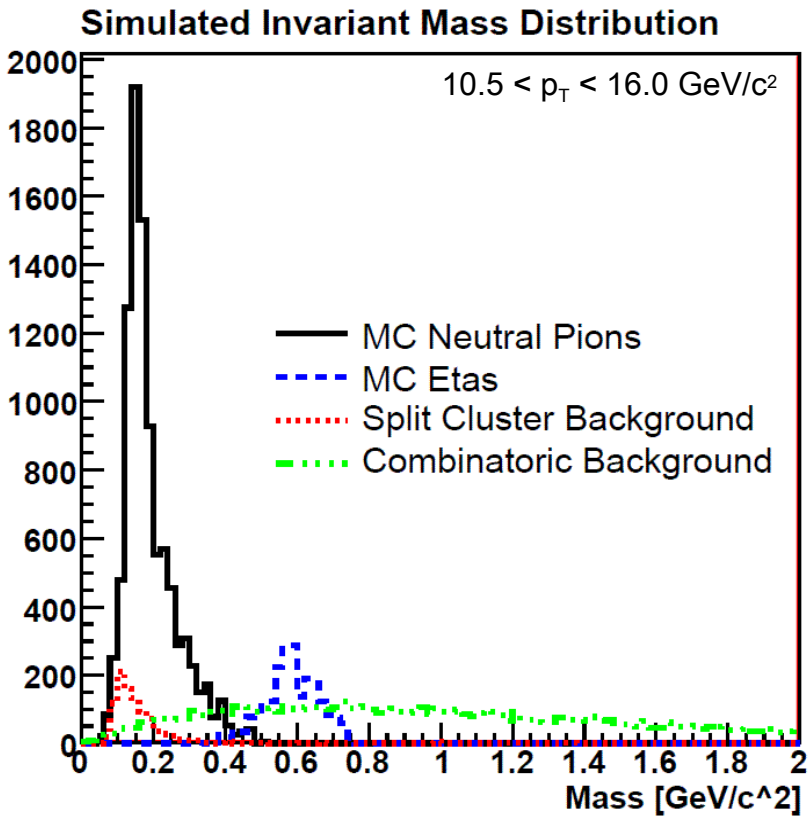


Data selection:

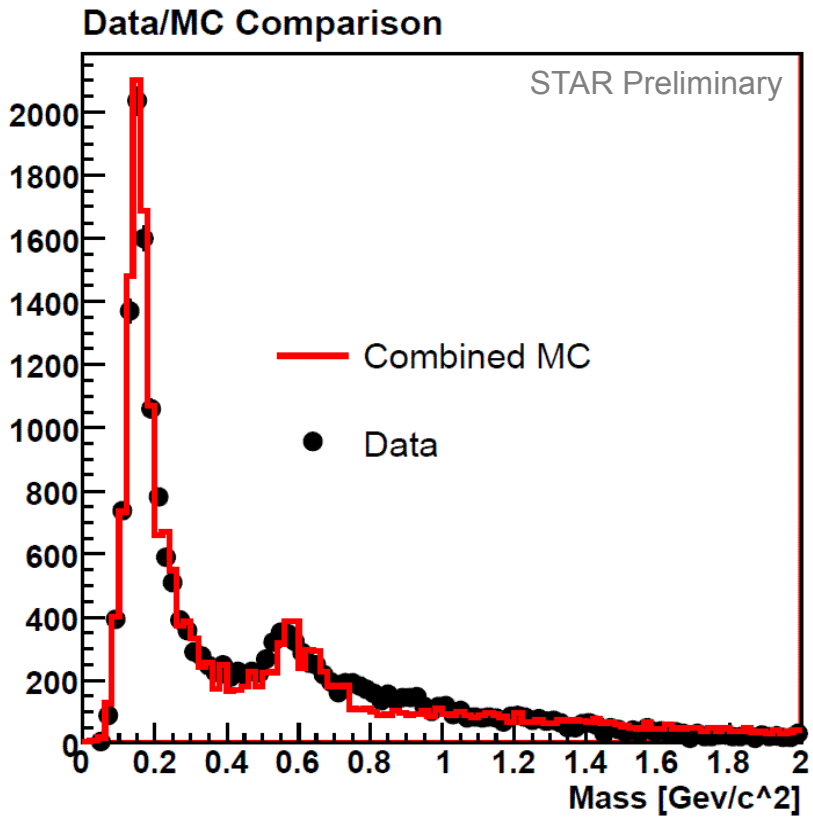
- Vertex required
- SMD information in both dimentions required
- TPC veto if charged track points to a cluster
- π^0 reconstruced with p_T above 5.2 GeV/c (above trigger threshold)
- π^0 invariant mass: $M^2 = 2E_1E_2(1-\cos\theta)$
- $-0.95 \leq \eta \leq 0.95$ (stay away from edges)
- $Z_{\gamma\gamma} \leq 0.8$ (reject very asymmetric decays)
- Yield counted in window $0.08 \leq M \leq 0.25$ GeV/c^2

π^0 reconstruction

Data to Monte Carlo comparison

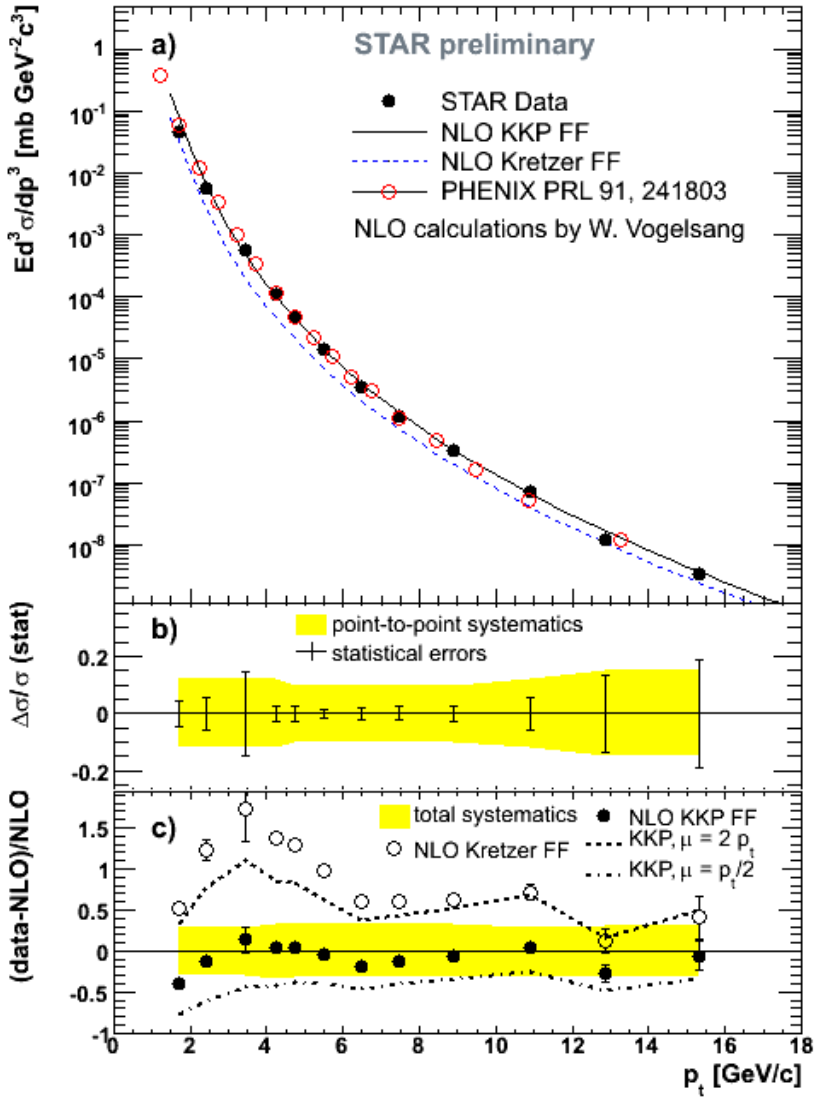


Single π^0, single η and backgrounds



Mass spectrum is well described by simulation

π^0 cross section



Cross section measured on 2005 data

Sampled luminosity:
0.4 pb^{-1} (High Tower), 44 μb^{-1} (Min Bias)

One half of BEMC used only: $0.1 \le \eta \le 0.9$

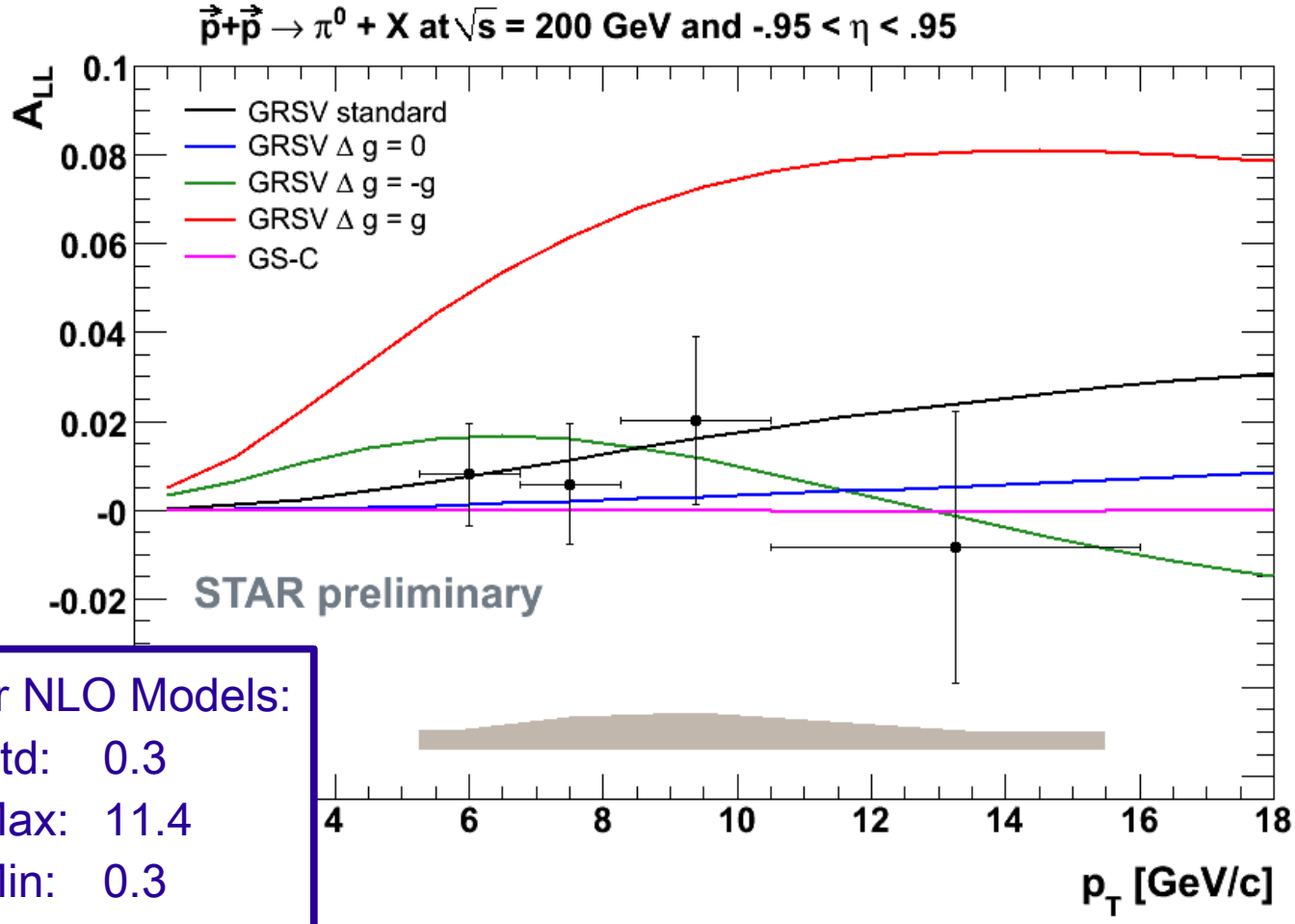
Systematic uncertainties dominated
by 5% uncertainty in BEMC energy calibration

Good agreement with NLO pQCD calculation
and with PHENIX measurement

Good agreement between different triggers

2006 Preliminary A_{LL}

$$A_{LL} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}} = \frac{1}{P_1 P_2} \times \frac{N_{++} - R N_{+-}}{N_{++} + R N_{+-}}$$



χ^2/ndf for NLO Models:

GRSV Std: 0.3

GRSV Max: 11.4

GRSV Min: 0.3

GRSV Zero: 0.4

GS-C: 0.5

Results consistent with PHENIX 2006 preliminary

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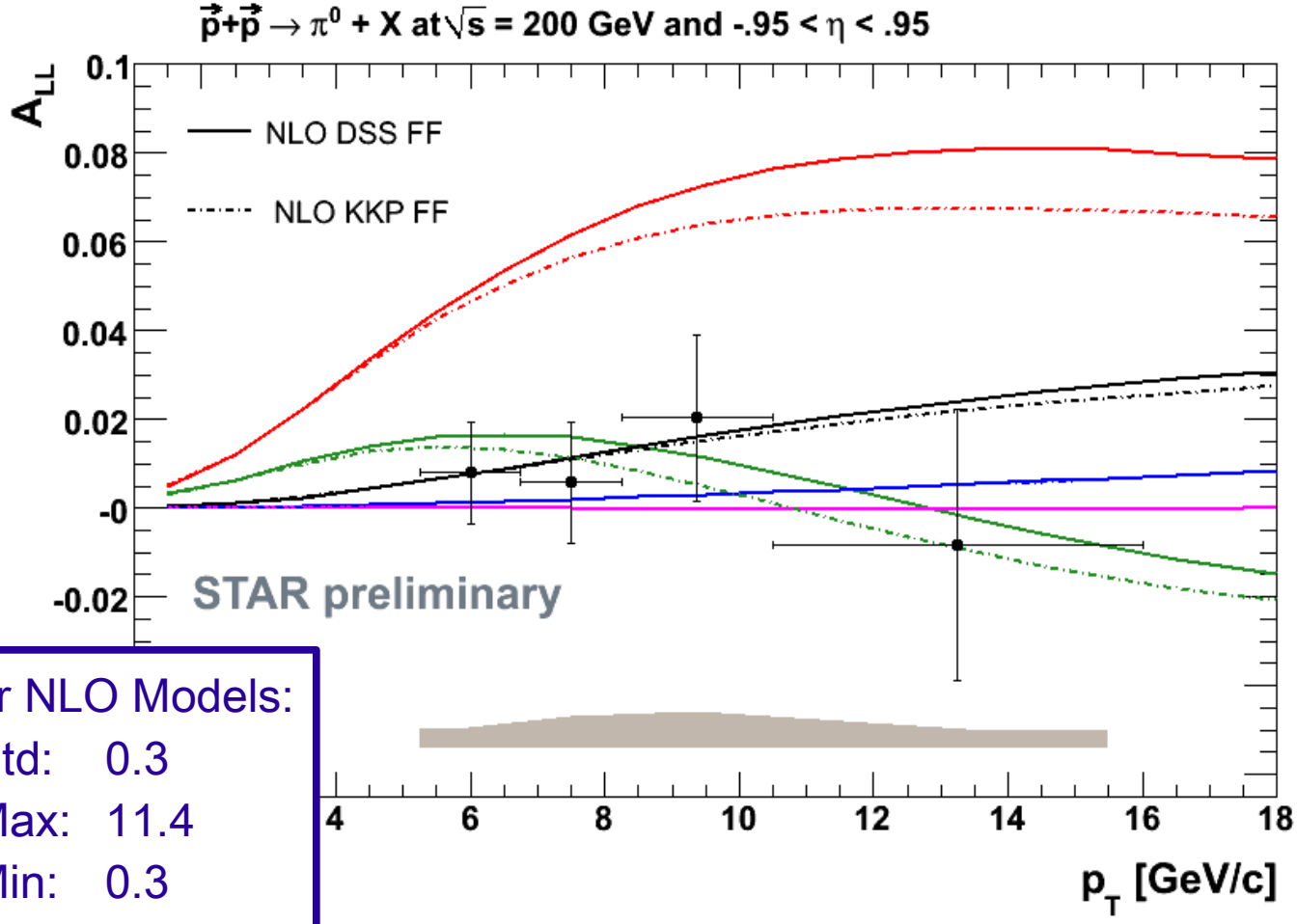

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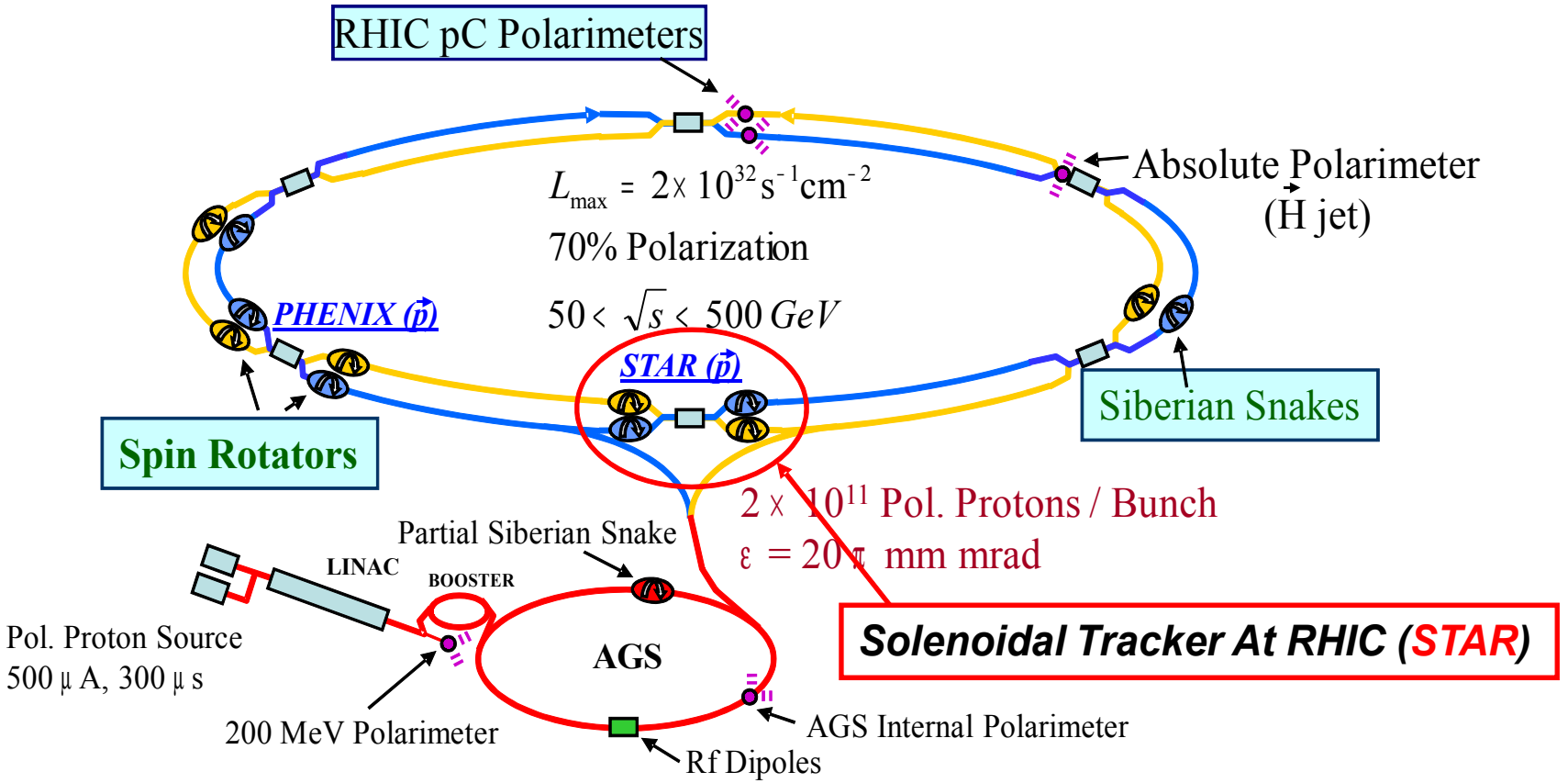
Summary

- Most recent measurement of A_{LL} and the cross section for inclusive π^0 production have been presented
- Maximum gluon polarization scenario is excluded, but measurement cannot at this time distinguish between other scenarios.
- STAR is planning for a long p+p run in Run 9. Expecting large increase in FOM with 60% polarization and 50 pb^{-1}

The End

RHIC



Collider capabilities:

- Polarized p+p collisions at 200 and 500 GeV
- Bunch-to-bunch spin control
- Siberian snakes maintain vertical polarization
- Spin rotators flip to longitudinal at two experiments
- Polarimetry

A_{LL} measurement

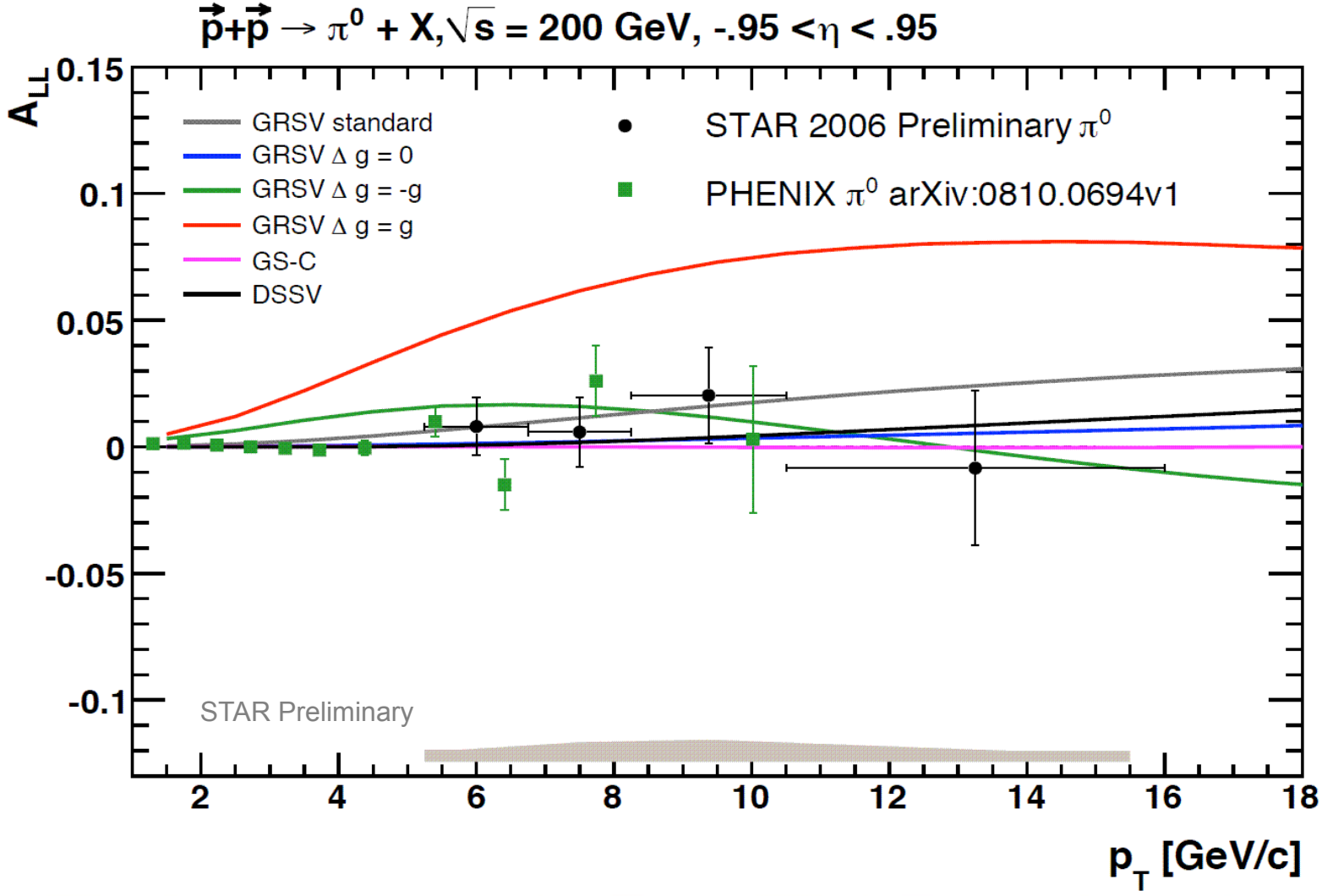
$$A_{LL} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}} = \frac{1}{P_1 P_2} \times \frac{N_{++} - R N_{+-}}{N_{++} + R N_{+-}}$$

- Polarization measurement P:
  Coulomb-Nuclear Interference (CNI)
  and H-jet polarimeters
  Average polarization $P \approx 55\%$

- Relative luminosity R:
  Measured locally to 10^{-3} precision at STAR
  by Beam-Beam Counters
  Varies by 1 ± 0.15 between fills

Summary

Results consistent with PHENIX 2006 preliminary



Summary

The Run 6 π^0 result sees a significant increase in statistical precision as well as a greater reach in p_T compared to Run 5