Recent Spin Results from

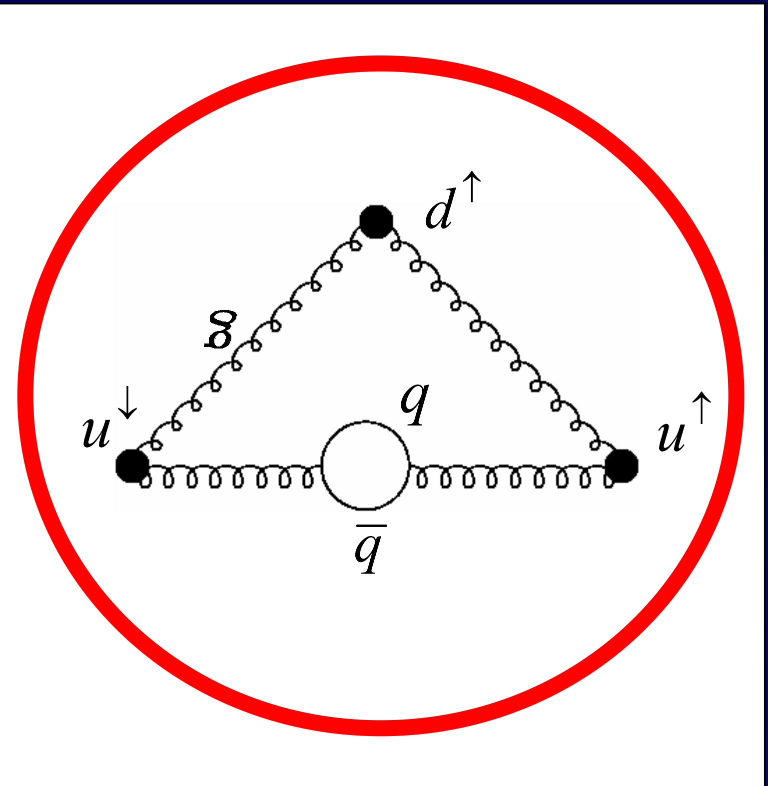
PHENIX

Christine Aidala
Columbia University

CERN
June 23, 2004

Spin Structure of the Proton: Status

Parton Distributions:



$$x = \frac{p_{quark}}{p_{proton}}$$

$q(x,Q^2) \equiv$ quark helicity average

(well known)

$\Delta q(x,Q^2) \equiv$ quark helicity difference

(moderately well known)

$\delta q(x,Q^2) \equiv$ helicity flip

(unknown)

$G(x,Q^2) \equiv$ Gluon Distribution

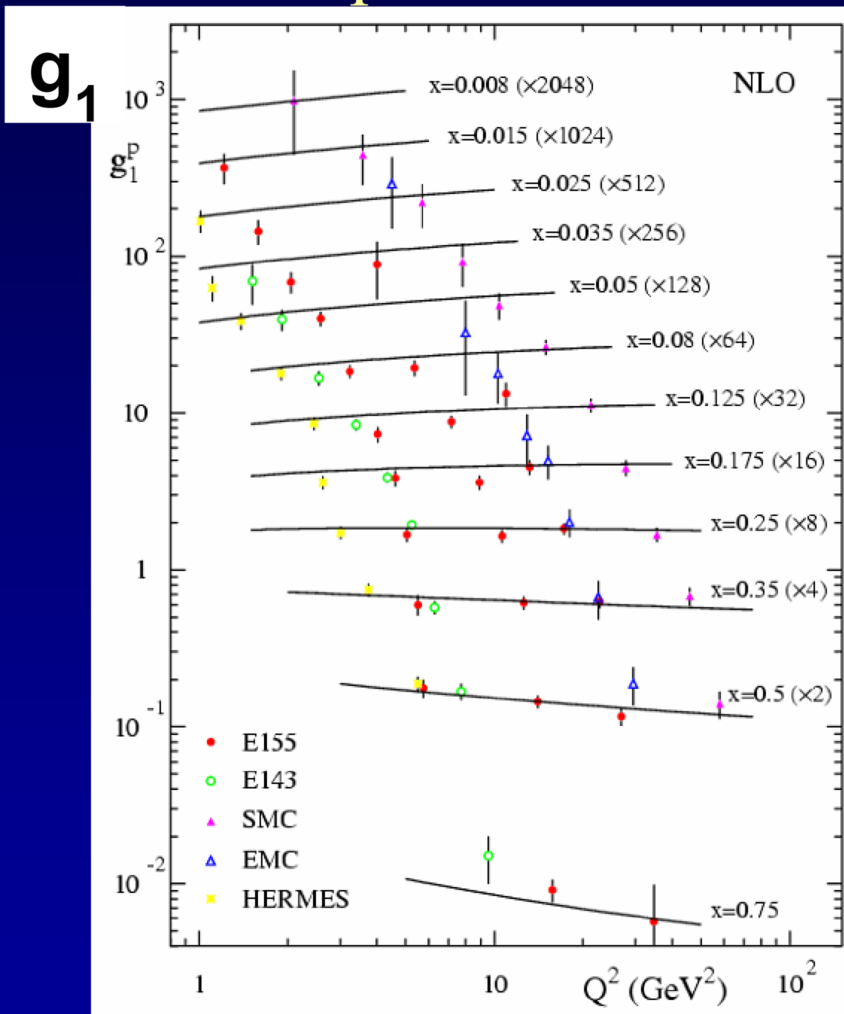
(moderately well known)

$\Delta G(x,Q^2) \equiv$ Gluon Polarization

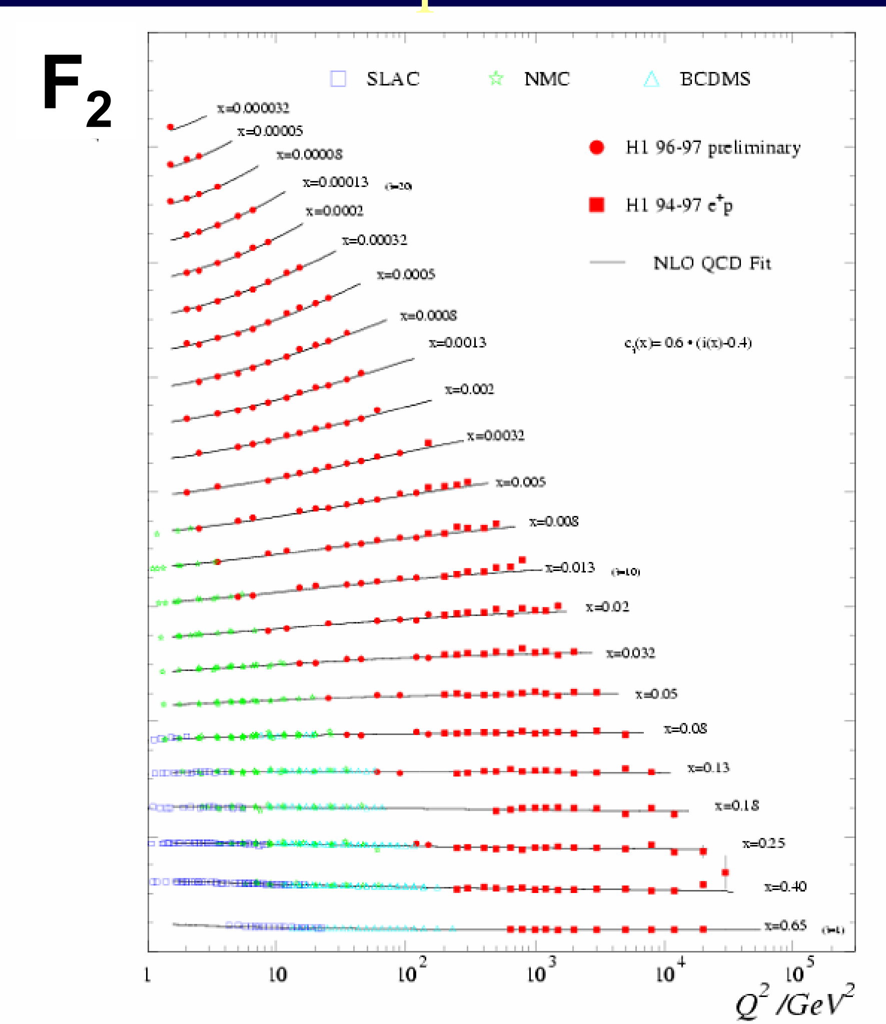
(basically unknown)

Experimental data on proton structure

polarized



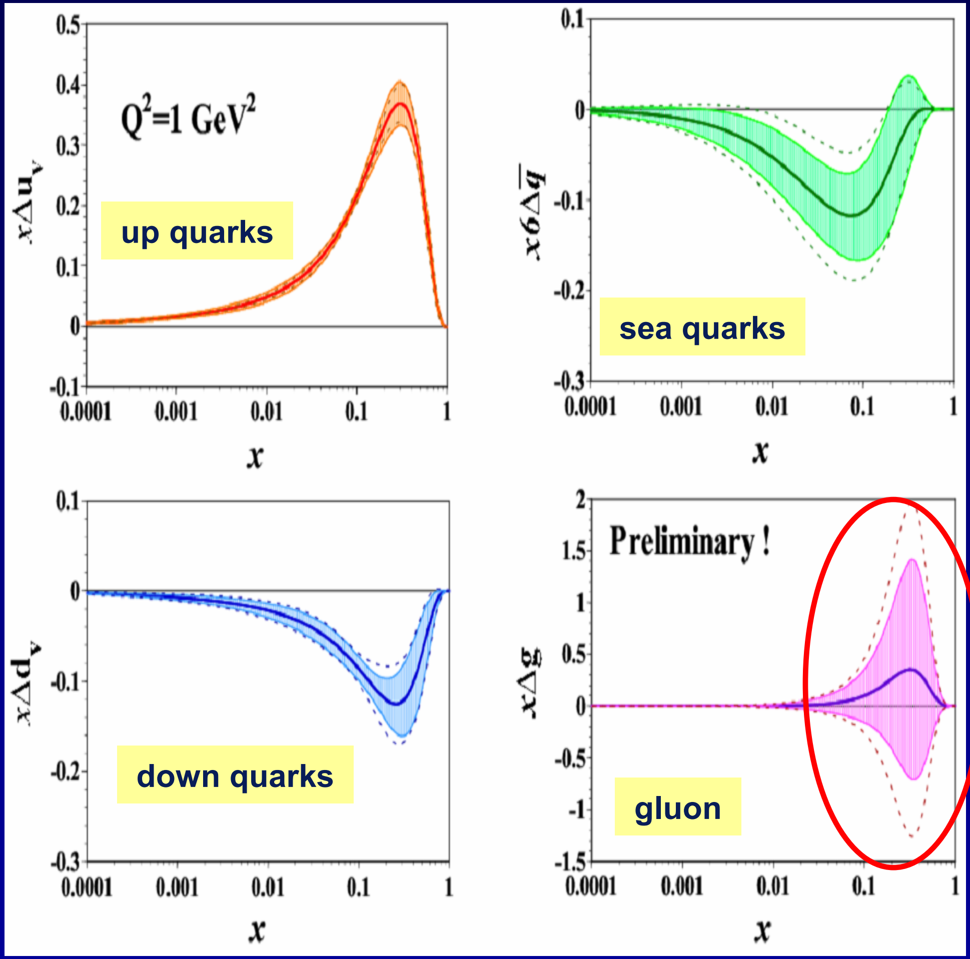
unpolarized



Data points on polarized structure function much sparser!

Polarized quark and gluon distributions

M. Hirai et al (AAC collab)



EMC, SMC at CERN
E142 to E155 at SLAC
HERMES at DESY

$$\Delta\Sigma = \int_0^1 \Delta\Sigma(x,Q^2)dx$$ **is constrained**

$$\Delta G = \int_0^1 \Delta g\left(x,Q^2\right)dx$$ **is largely unknown**

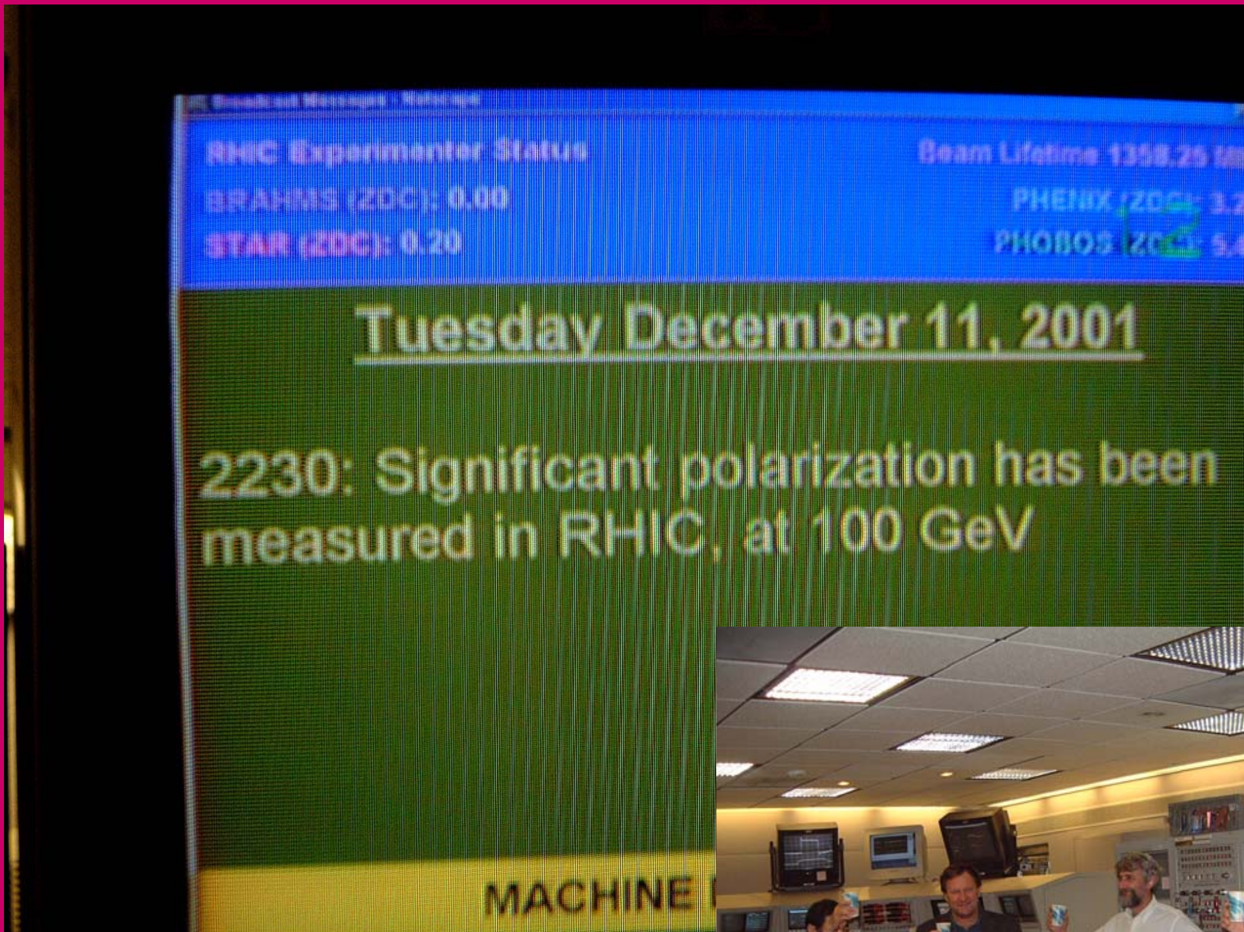
Quark spin contribution to the proton spin: $\Delta\Sigma \approx 30\%$

"Spin Crisis"

Gluon contribution remains unconstrained.

RHIC at Brookhaven National Laboratory

The Relativistic Heavy Ion Collider



RHIC Physics

Broadest possible study of QCD in A-A, p-A, p-p collisions

- *Heavy ion physics*
  - Investigate nuclear matter under extreme conditions
  - Examine systematic variations with species and energy
- *Nucleon structure in a nuclear environment*
  - Nuclear dependence of pdf's
  - Saturation physics
- ***Explore the spin of the proton***
  - In particular, contributions from
    - Gluon polarization (ΔG)
    - Sea-quark polarization $\left(\Delta\bar{u}, \Delta\bar{d}\right)$
    - Transversity distributions (δq)

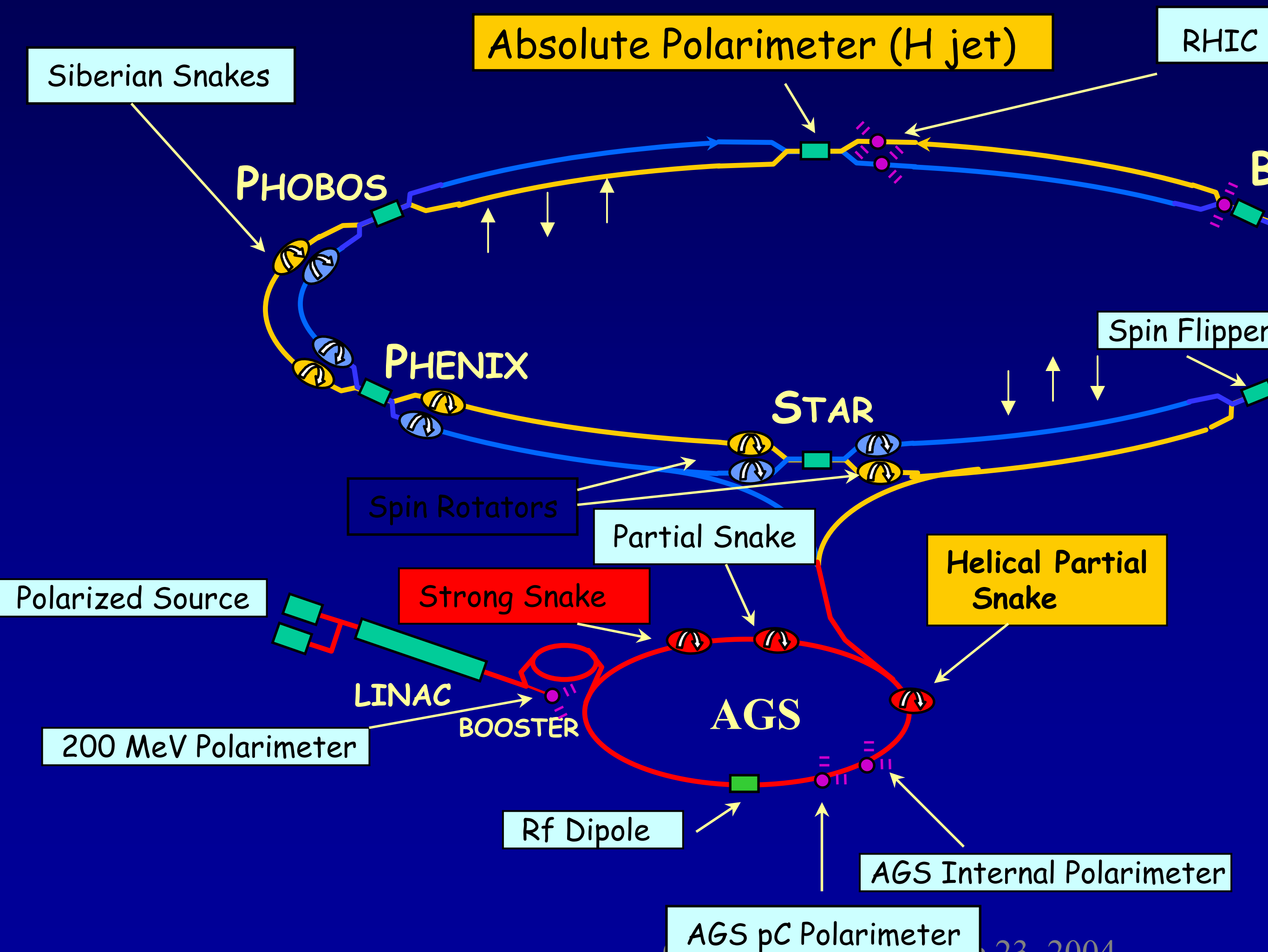
} Continue to explore in eRHIC

RHIC Specifications

- 3.83 km circumference
- Two independent rings
  - Up to 120 bunches/ring
  - 106 ns crossing time
- Energy:
  - ➔ Up to 500 GeV for p-p
  - ➔ Up to 200 GeV for Au-Au (per N-N collision)
- Luminosity
  - Au-Au: 2 x 10^{26} cm^{-2} s^{-1}
  - p-p : 2 x 10^{32} cm^{-2} s^{-1} (*polarized*)

RHIC as a Polarized p-p Collider

source: Thomas Roser, BNL



Run 04 achieved:

$\sqrt{s} = 200\,\text{GeV},\ L_{peak} \sim 6 \times 10^{30}\,\text{cm}^{-2}\,\text{s}^{-1}$

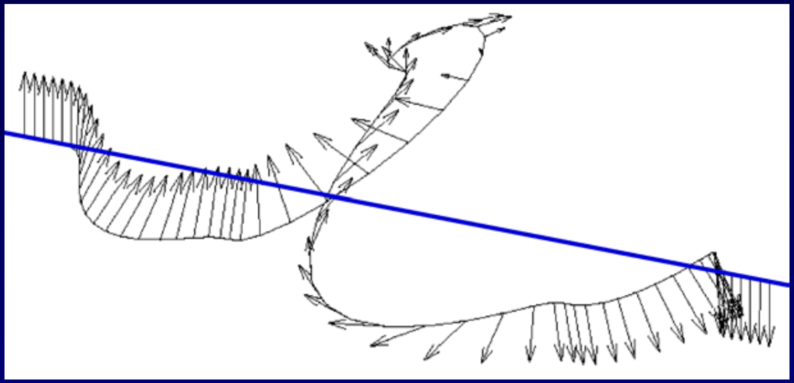
P_b~45% , 55 bunches
New working point with long beam and polarization lifetimes

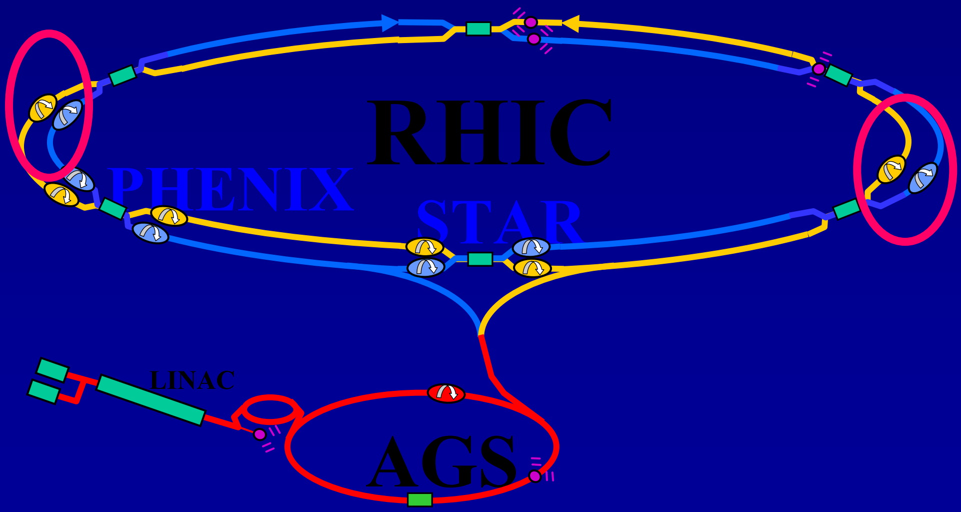
Run 05 planned:

Time to tune accelerator complex
Measure: A_{LL}(jets), $A_{LL}(\pi^0)$
Commission strong supercon-ducting AGS snake

Siberian Snakes

Effect of depolarizing resonances averaged out by rotating spin by 180 degrees on each turn





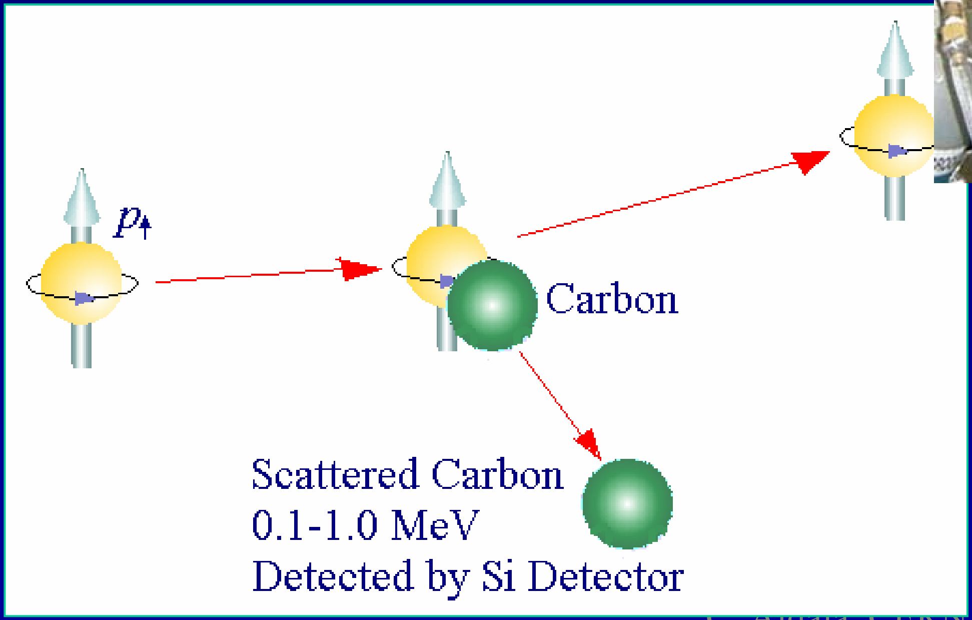
- 4 helical dipoles ➔ S. snake
- 2 snakes in each ring
  - axes orthogonal to each other

RHIC Polarimetry I

Carbon filament target ($5\mu g/cm^2$) in the RHIC beam

Measure recoil carbon ions at $\theta \sim 90^{\circ}$

100 keV < E_{carbon} < 1 MeV



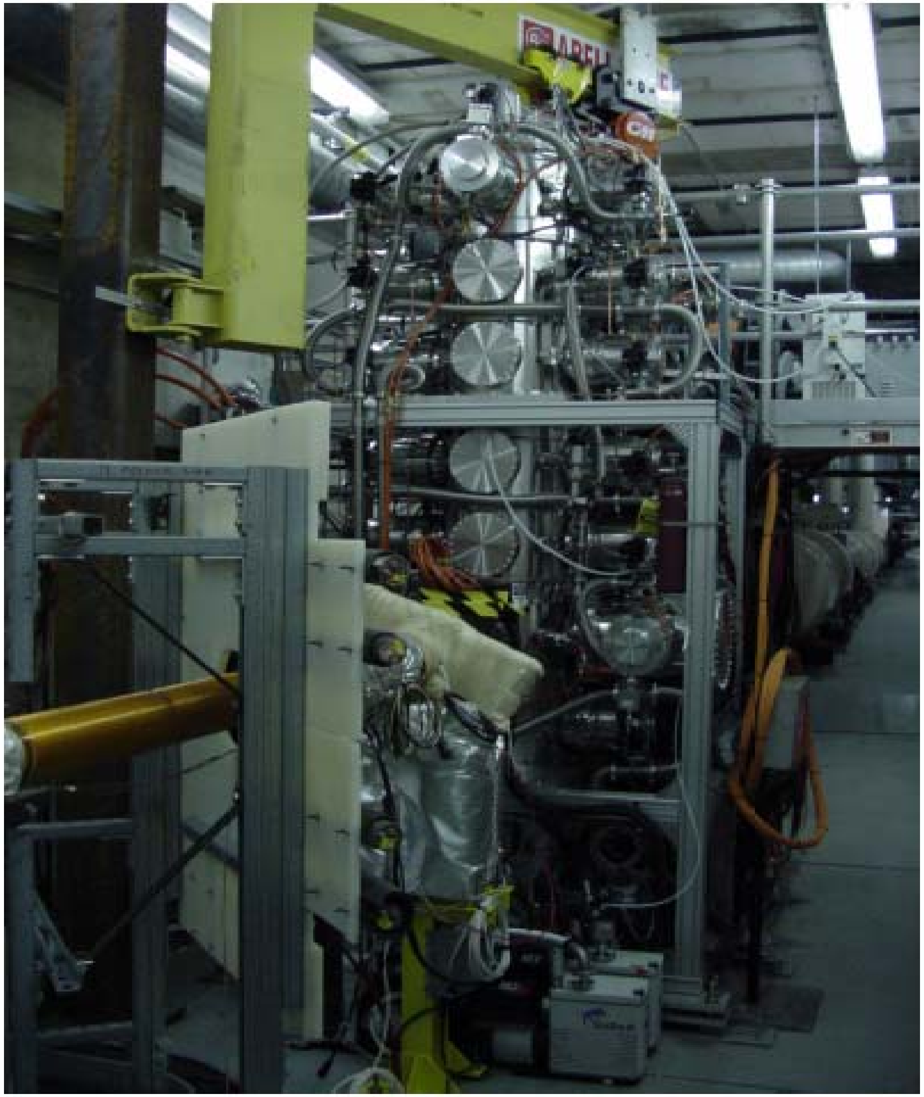
E950 Experiment at AGS (1999)
→→→ RHIC polarimetry now

Allows measurement of beam polarization to within 30%

RHIC Polarimetry II: Absolute Polarimetry Using a Polarized H Jet Target

Courtesy Sandro Bravar, STAR and Yousef Makdisi, CAD

Commissioned April/May 2004!



Polarized Hydrogen Gas Jet Target

thickness of > 10^{12} p/cm^2

polarization = 93% (+1 −2)%!

Silicon recoil spectrometer to:

- Measure left-right asymmetry A_N in pp elastic scattering in the CNI region to $\Delta A_N < 10^{-3}$ accuracy.
- Calibrate the p-Carbon polarimeters

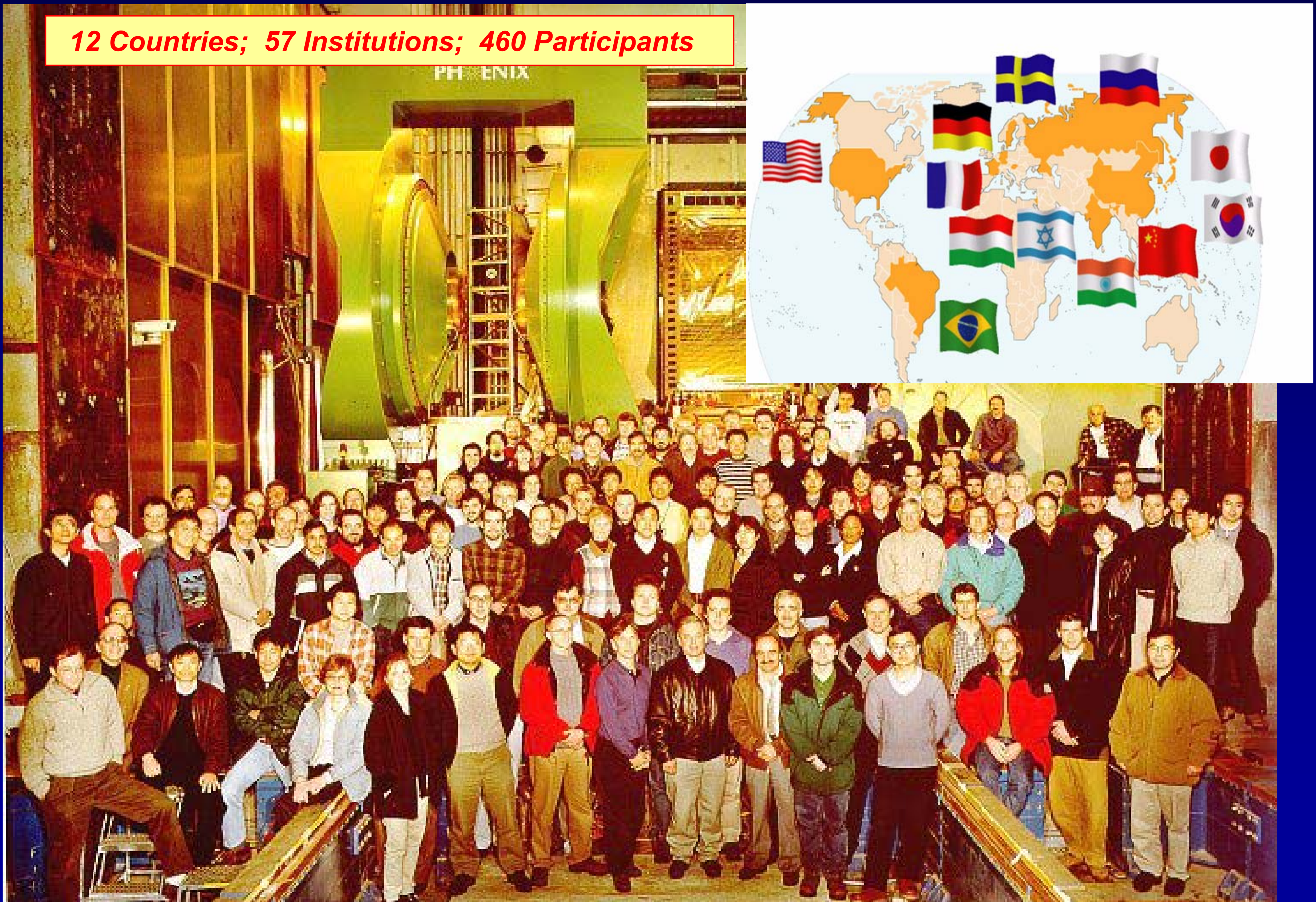
Two large data samples at 24 and 100 GeV

Expect results on P_{Beam} to 10% in the near future!

RHIC's Experiments

PHENIX

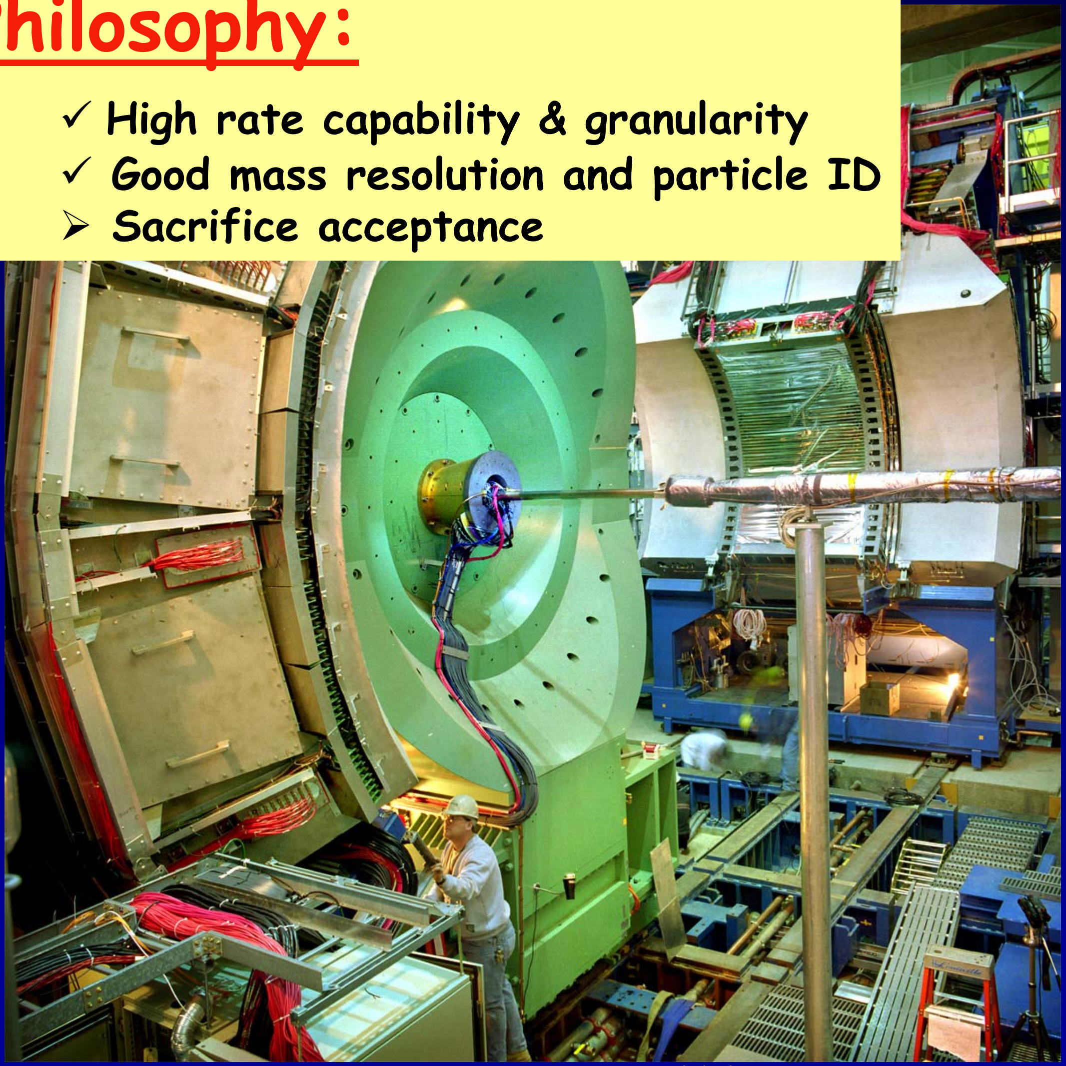
12 Countries; 57 Institutions; 460 Participants



The PHENIX Detector

Philosophy:

- ✓ High rate capability & granularity
- ✓ Good mass resolution and particle ID
- ➢ Sacrifice acceptance



2 central spectrometers

- Track charged particles and detect electromagnetic processes

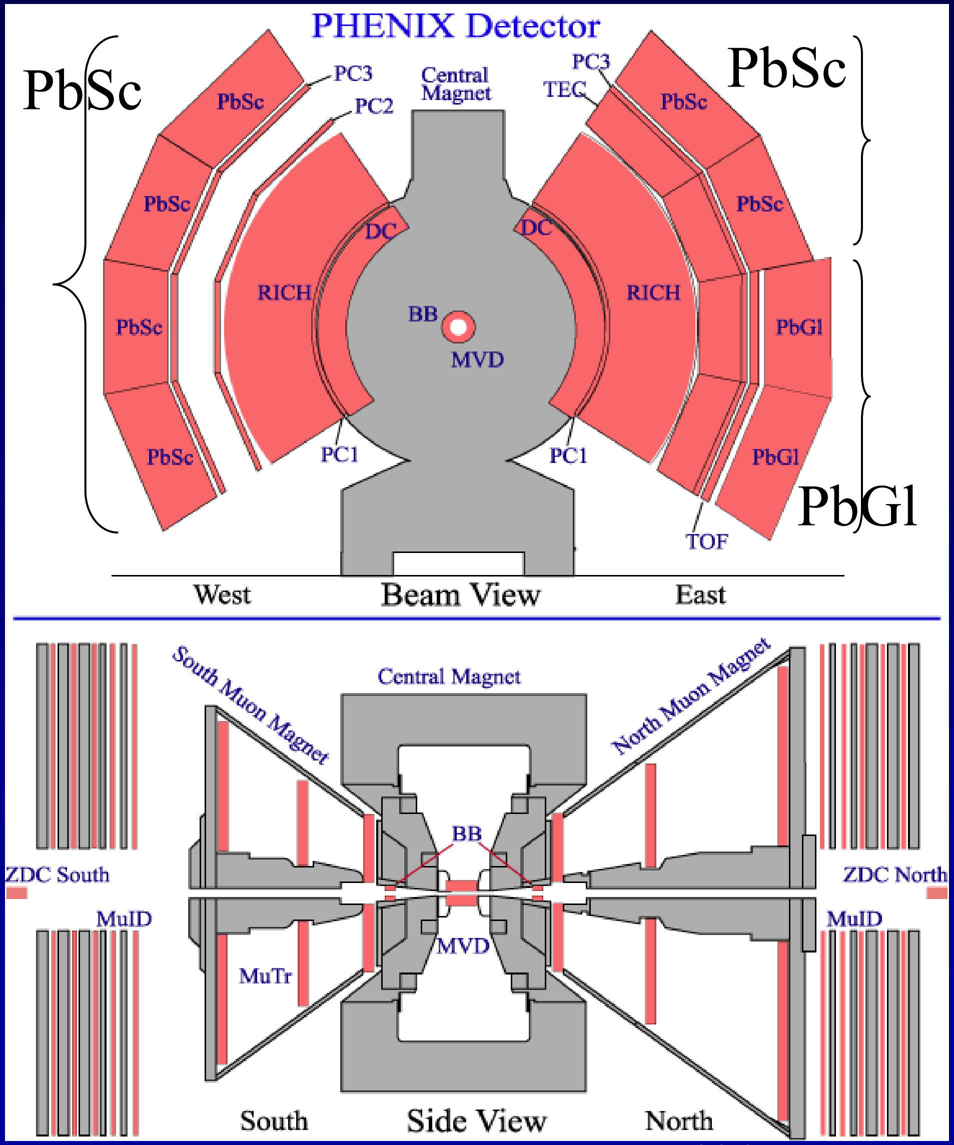
2 forward spectrometers

- Identify and track muons

3 global detectors

- Determine when there's a collision

PHENIX Detector Overview



Central arms

Photons, electrons, identified charged hadrons

$|\eta| < 0.35$

$\Delta\phi = 180$ degrees

Forward muon arms

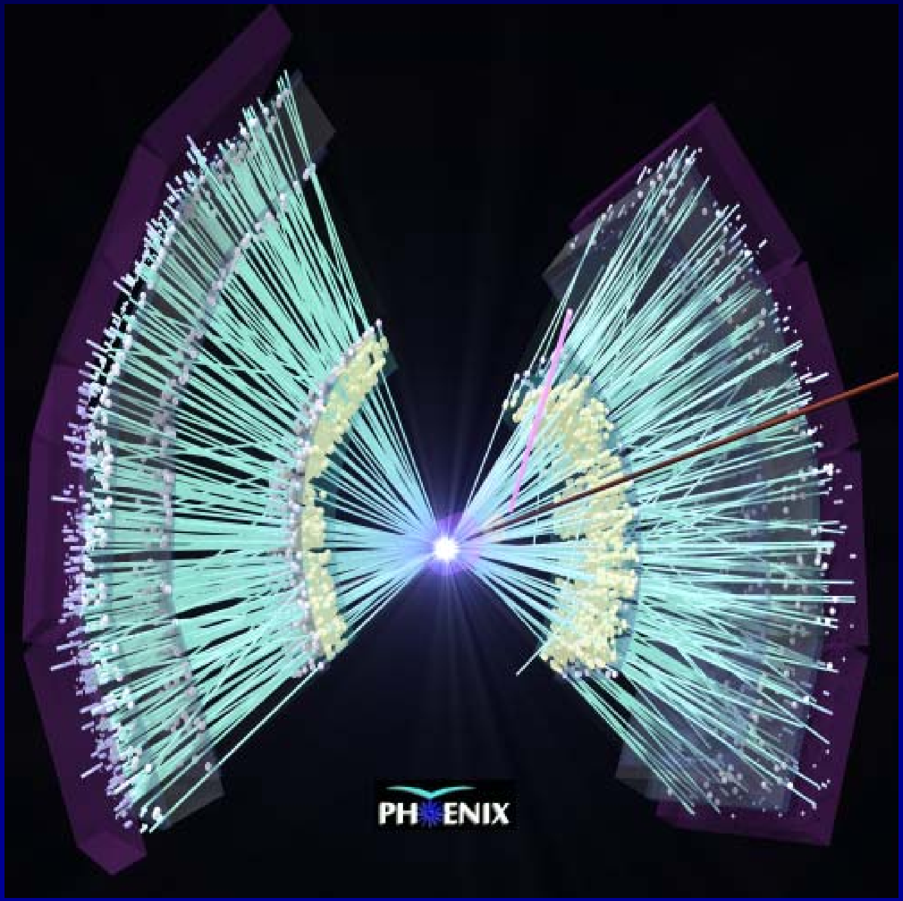
Track and identify muons

$1.2 < |\eta| < 2.4$

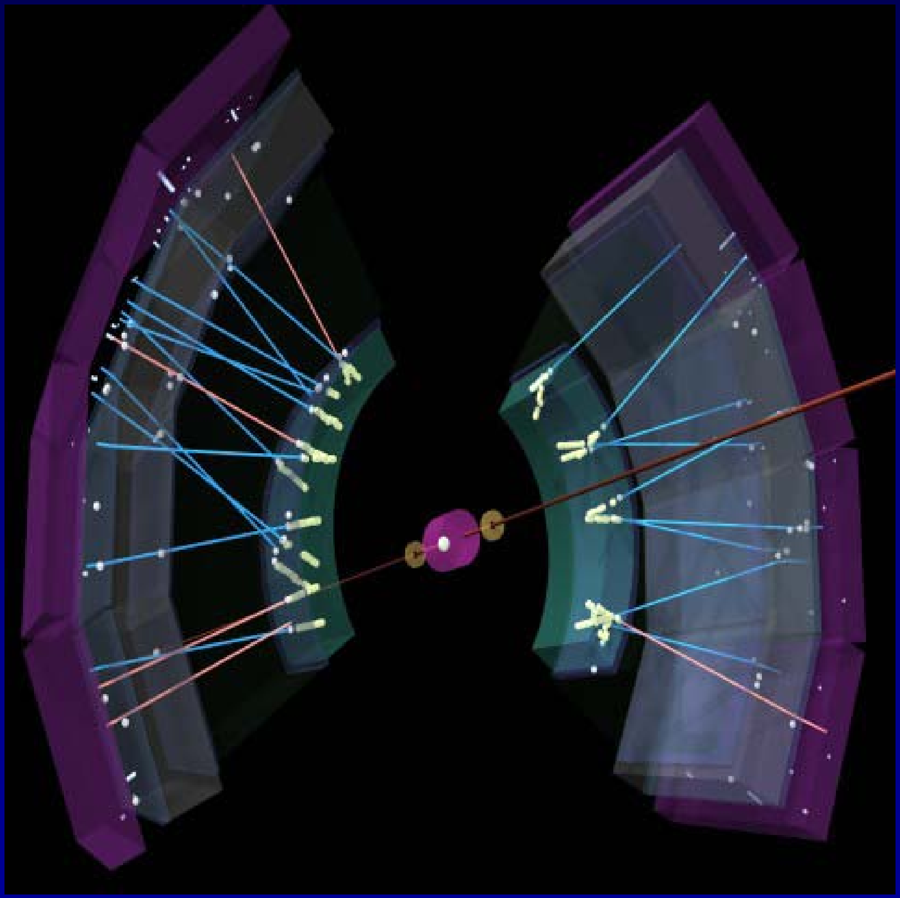
$\Delta\phi = 2\pi$

Detector fully operational for intermediate luminosities. Upgrades planned for high-luminosity running.

Au-Au and d-Au Collisions in the PHENIX Central Arms



2001/2002 Au-Au



2002/2003 d-Au

Goals of the RHIC Spin Program

- Determine the complete spin structure of the nucleon

$$\Delta f(x) = f_{\uparrow}(x) - f_{\downarrow}(x)$$
$$\Delta f \equiv \int_0^1 \Delta f(x)dx$$

$$\frac{1}{2} = \frac{1}{2}\cdot\Delta\Sigma + \Delta G + \Delta L_{G+q}$$

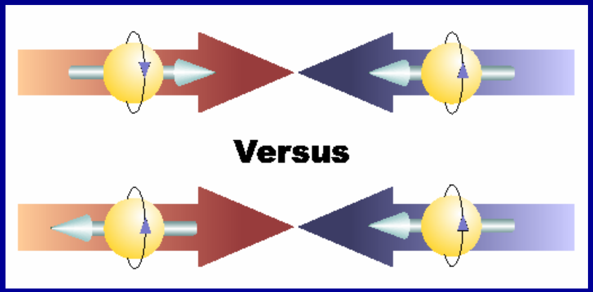
  - In particular, contributions from
    - Gluon polarization (ΔG)
    - Sea-quark polarization ($\Delta\bar{u}$, $\Delta\bar{d}$)

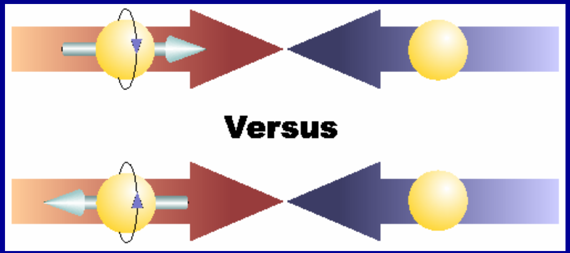
$$\Delta\Sigma = \Delta u + \Delta d + \Delta s = 0.31 \pm 0.04$$
$$\Delta s = -0.10 \pm 0.02$$
$$\left\langle \frac{\Delta G(x)}{G(x)} \right\rangle = 0.41 \pm 0.18 \pm 0.03; \quad \langle x_G \rangle = 0.17$$

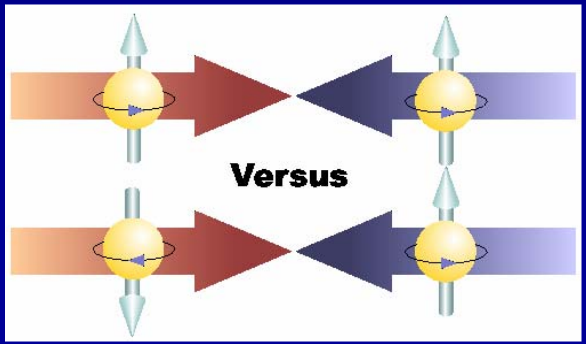
- Why RHIC?
  - High energy → factorization
  - Polarized hadrons → gq, gg collisions
  - High energy → new probes (W's)

Proton Spin Structure at PHENIX

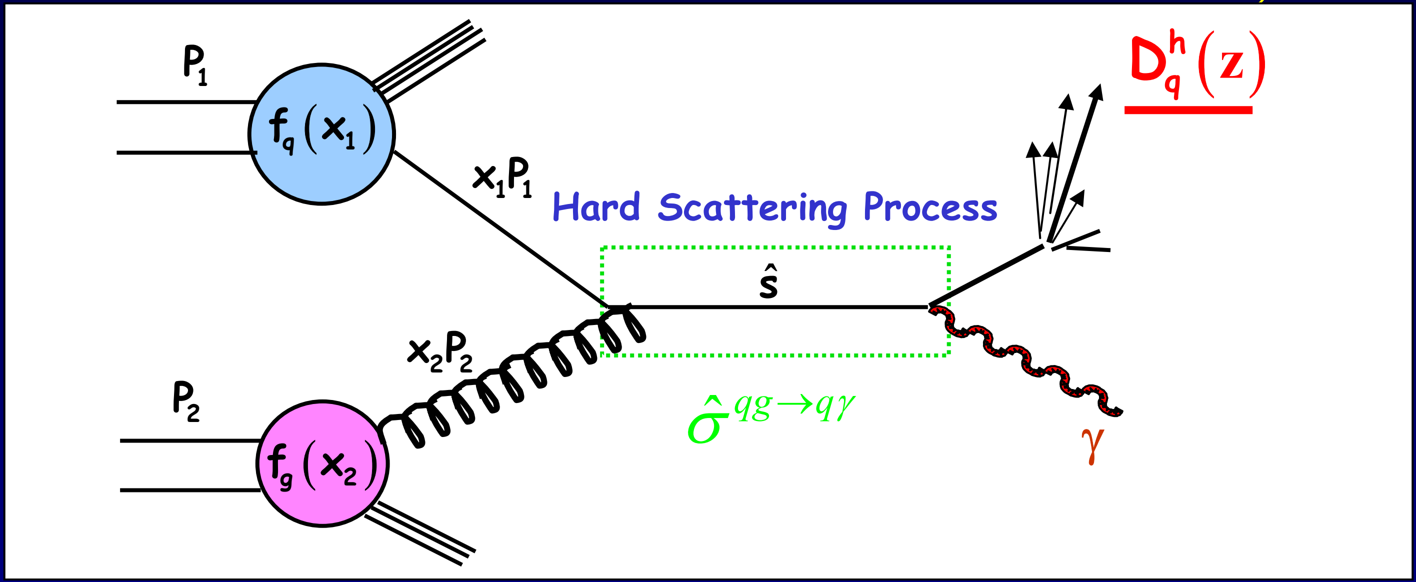
Gluon Polarization ΔG	Flavor decomposition $\frac{\Delta u}{u}, \frac{\Delta \bar{u}}{\bar{u}}, \frac{\Delta d}{d}, \frac{\Delta \bar{d}}{\bar{d}}$	Transverse Spin
π Production $A_{LL}(gg, gq \to \pi + X)$ Prompt Photon $A_{LL}(gq \to \gamma + X)$ Heavy Flavors $A_{LL}(gg \to c\bar{c}, b\bar{b} + X)$	W Production $A_L(u + \bar{d} \to W^+ \to \ell^+ + \nu_l)$ $A_L(\bar{u} + d \to W^- \to \ell^- + \bar{\nu}_l)$	Transversity δq: π^+, π^- Interference fragmentation: $A_T(p_\perp p \to (\pi^+, \pi^-) + X)$ Drell Yan A_{TT} Single Asymmetries A_N







Hard Scattering Processes in p+p: Factorization and Universality



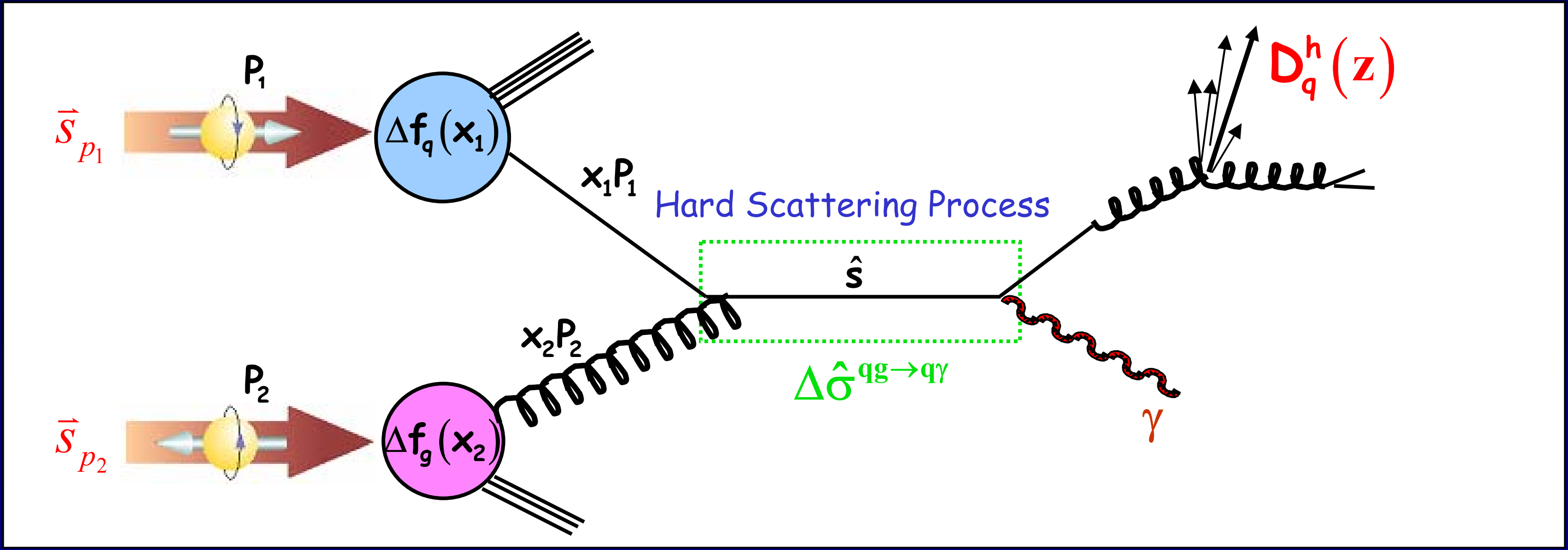
$$\sigma(pp \to \gamma X) \propto f_q(x_1) \otimes f_g(x_2) \otimes \hat{\sigma}^{qg\to q\gamma}(\hat{s})$$

"Hard" probes have predictable rates given:

- Parton distribution functions (need experimental **input**)
- **pQCD hard scattering rates (calculable in pQCD)**
- **Fragmentation functions (need experimental input)**

} Universality

*Hard Scattering in **Polarized** p+p*

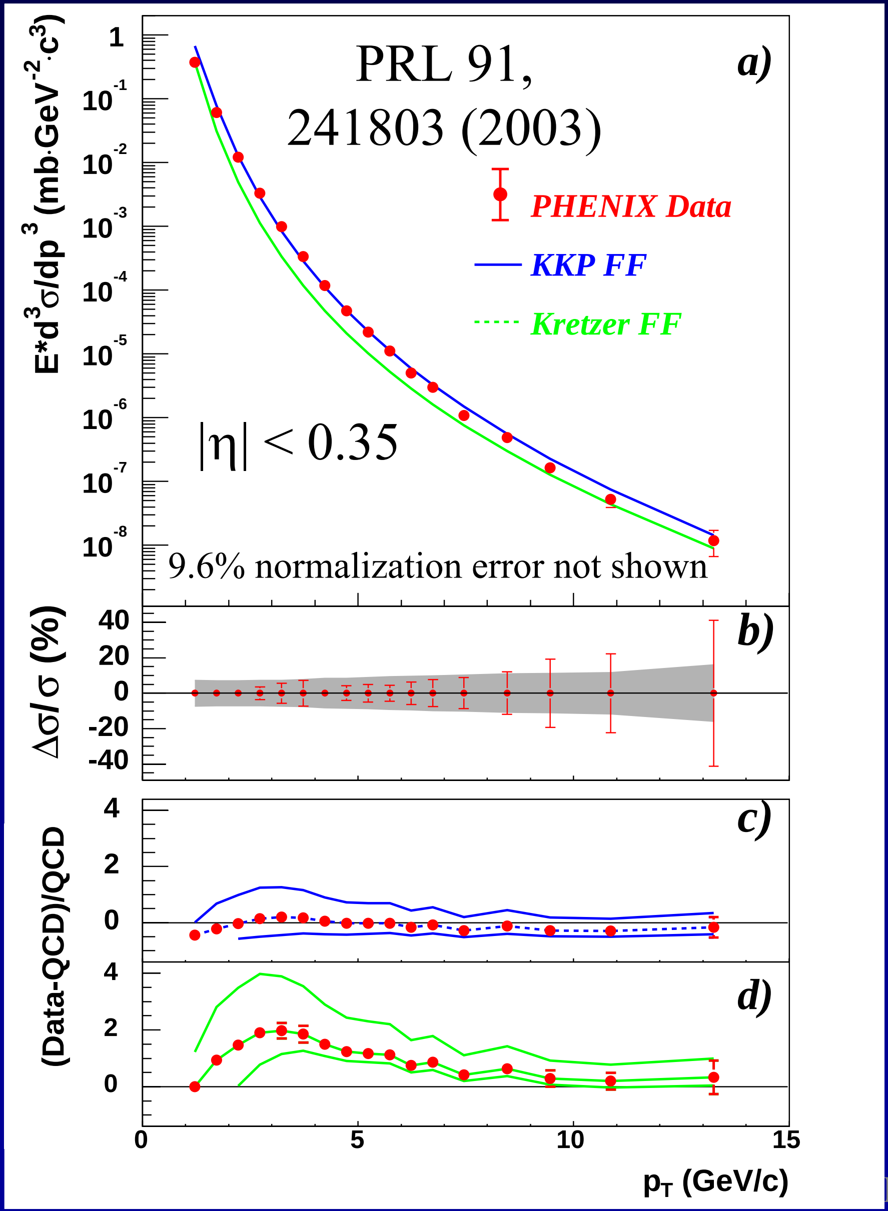


$$\Delta\sigma(pp\to\gamma X)\propto\Delta f_q(x_1)\otimes\Delta f_g(x_2)\otimes\Delta\hat{\sigma}^{qg\to q\gamma}(\hat{s})$$

$$A_{LL}=\frac{\sigma^{\uparrow\uparrow}-\sigma^{\uparrow\downarrow}}{\sigma^{\uparrow\uparrow}+\sigma^{\uparrow\downarrow}}\equiv\frac{\Delta\sigma}{\sigma}=\hat{a}_{LL}(qg\to q\gamma)\otimes\frac{\Delta g(x_1)}{g(x_1)}\otimes\frac{\Delta q(x_2)}{q(x_2)}$$

$\hat{a}_{LL} \to \Delta\hat{\sigma}/\hat{\sigma}$

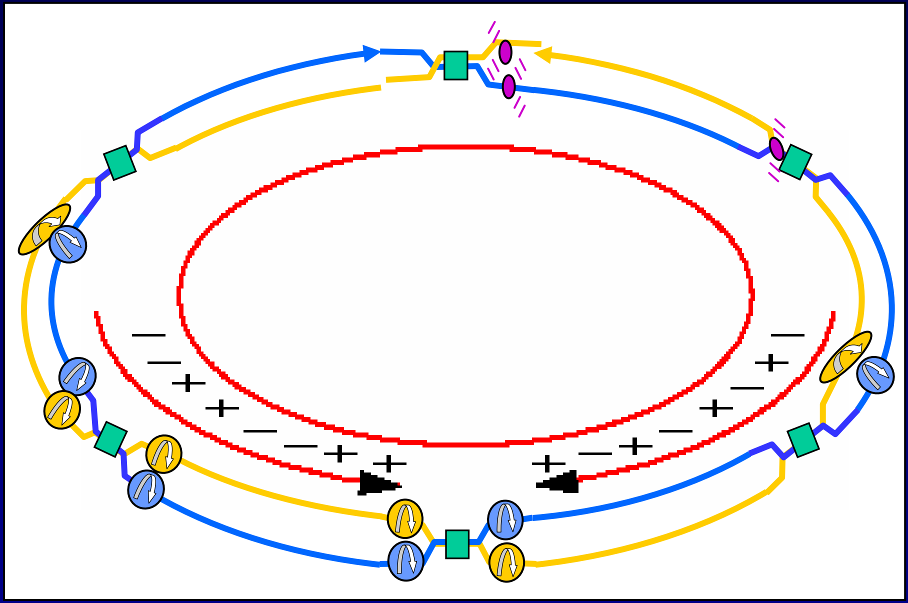
π^0 Cross Section from 2001-2 Run



- NLO pQCD consistent with data within theoretical uncertainties.
  - PDF: CTEQ5M
  - Fragmentation functions:
    - Kniehl-Kramer-Potter (KKP)
    - Kretzer
  - Spectrum constrains D(gluon ➡ π) fragmentation function
- **Important confirmation of theoretical foundation for spin program**
- Data from 2003 run reproduce 2001-2 results and extend the p_T range
  - Will be released soon

Spin Running at RHIC So Far

- 2001-2
  - ***Transversely*** polarized p+p collisions
  - Average polarization of ~15%
  - Integrated luminosity 0.15 pb^{-1}
- 2003
  - ***Longitudinally*** polarized p+p collisions achieved
  - Average polarization of ~27%
  - Integrated luminosity 0.35 pb^{-1}
- 2004
  - 5 weeks polarized p+p commissioning
    - Specifically to work on spin tune and AGS polarization
    - Commission hydrogen jet polarimeter
  - 1 week data-taking
  - Average polarization ~45%



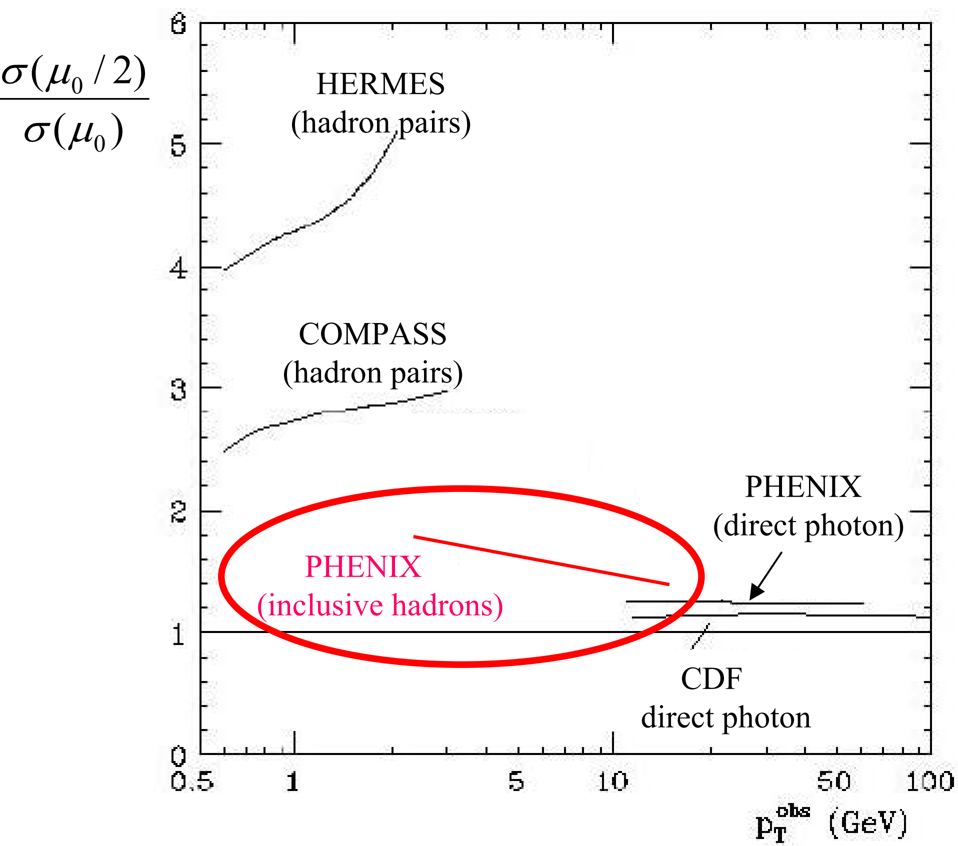
Opposite spin of bunches every ~100 or 200 ns aids in eliminating systematic errors

Recent Results

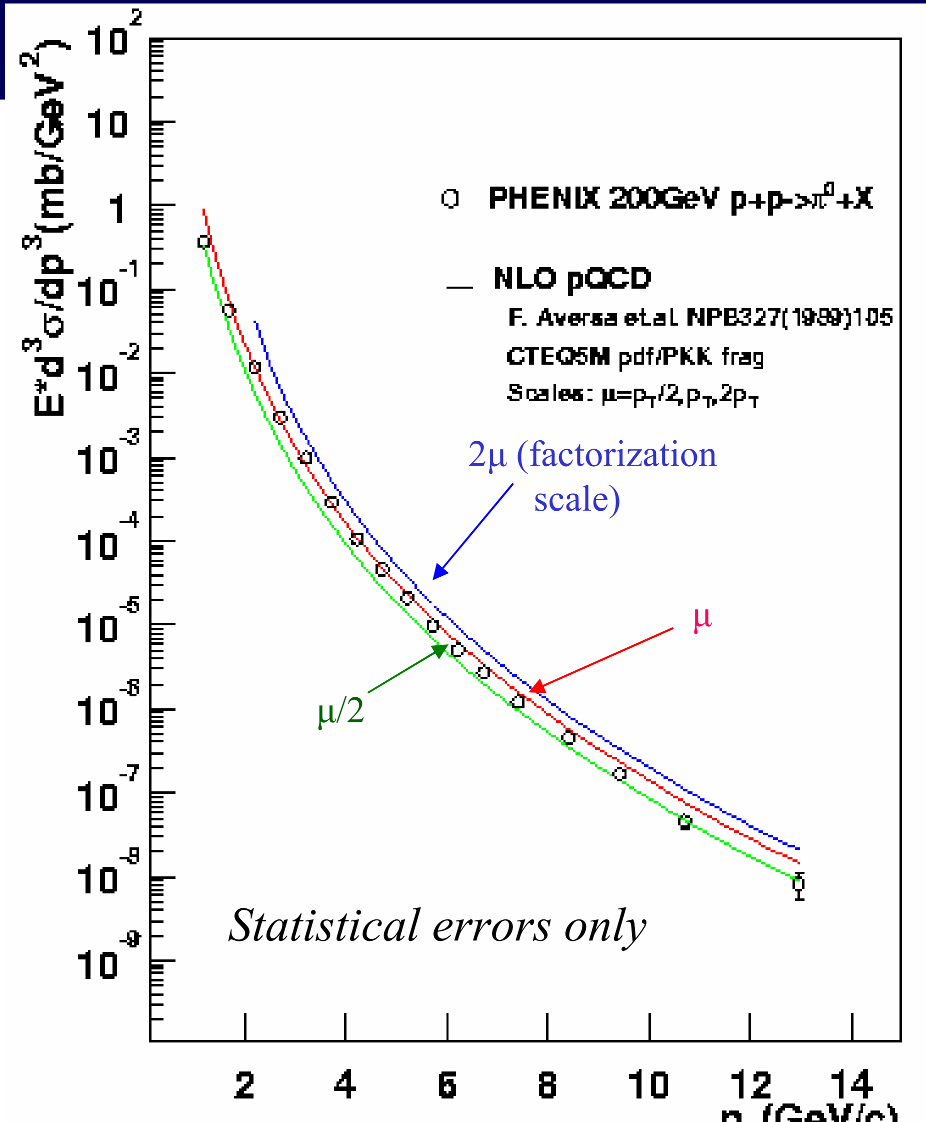
- π^0 A_{LL} from 2003 Run
  - Connections with pQCD
  - Longitudinal polarization
  - Relative luminosity
  - π^0 reconstruction and counting
- π^0 A_N from 2001-2 Run
  - Transversity, Collins, and Sivers effects

pQCD Scale Dependence at RHIC

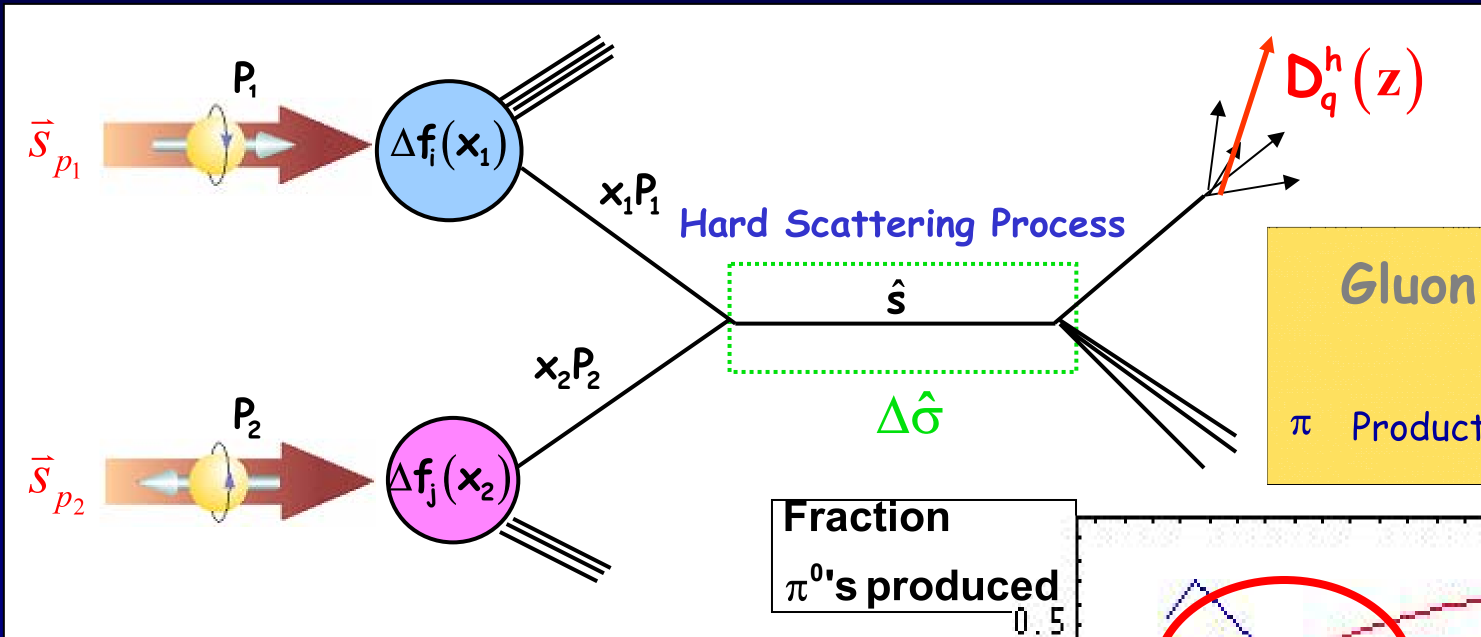
Theoretical uncertainty of pQCD calculations in channels relevant for gluon polarization measurements:



π^0 data vs pQCD with different factorization scales:



Leading hadrons as jet tags

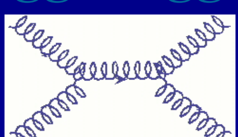


Gluon Polarization

ΔG

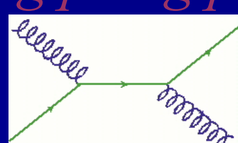
π Production $A_{LL}(gg, gq \to \pi + X)$

$gg \to gg$



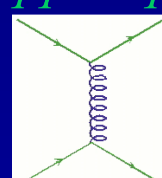
$\propto \frac{\Delta G}{G}\frac{\Delta G}{G}$

$gq \to gq$

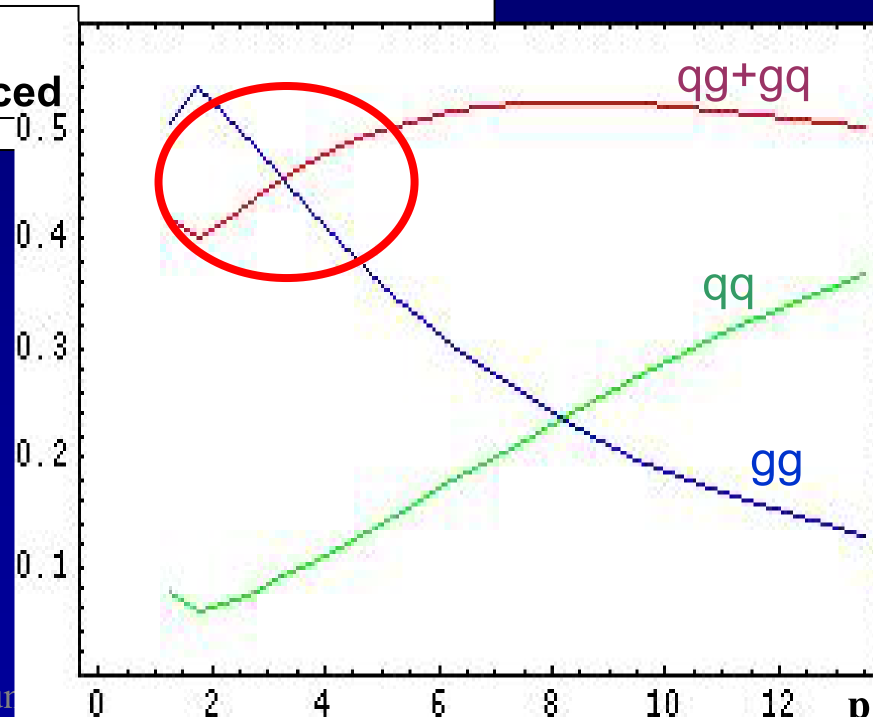


$\propto \frac{\Delta q}{q}\frac{\Delta G}{G}$

$qq \to qq$



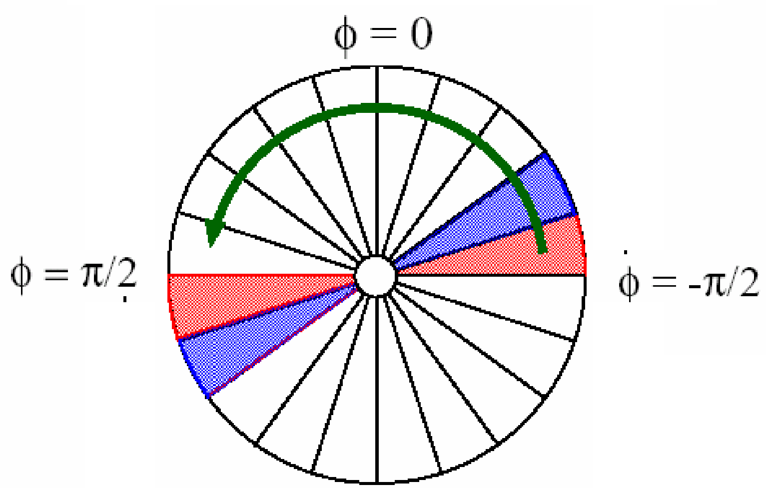
$\propto \frac{\Delta q}{q}\frac{\Delta q}{q}$



PHENIX Local Polarimeter

- ✓ Forward neutron transverse asymmetry (A_N) measurements
  - $A_N \sim -10\%$
- ✓ Shower Max Detector (position) + Zero-Degree Cal. (energy)

ϕ distribution



Vertical → $\phi \sim \pm\pi/2$

Radial → $\phi \sim 0, \pi$

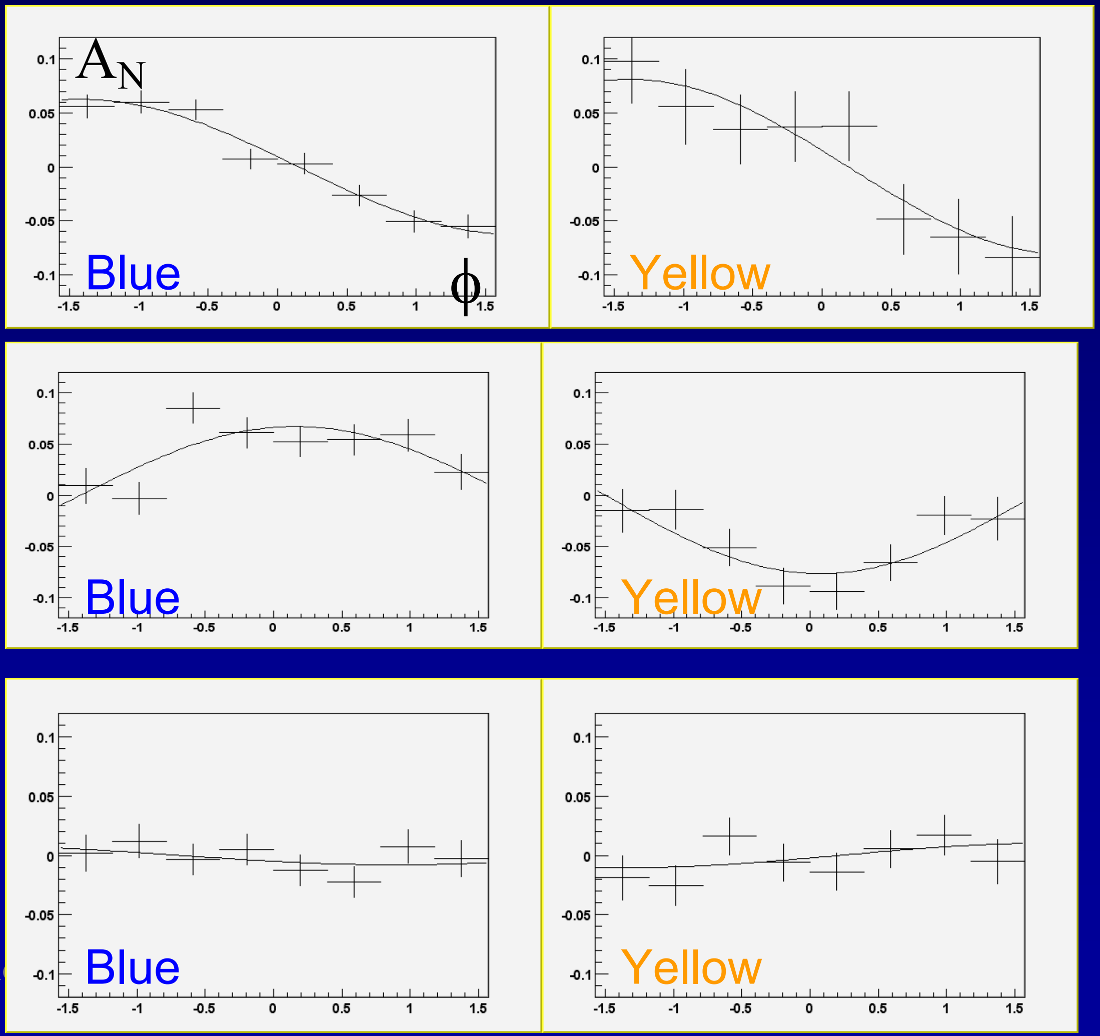
Longitudinal → no asymmetry

Single-Spin Asymmetries for Local Polarimetry: Confirmation of Longitudinal Polarization

Spin Rotators OFF
Vertical polarization

Spin Rotators ON
Current Reversed!
Radial polarization

Spin Rotators ON
Correct Current
Longitudinal polarization!



Data set

Photon ID cuts

- Shower profile
- Time of Flight
- Charge Veto

to maximize Figure of Merit

- Minimize background (combinatorial + hadronic)
- Keeping the π^0 efficiency high (84% to 93%).

hoton trigger

c

tillator used

s (~0.22 pb^{-1})

~27%

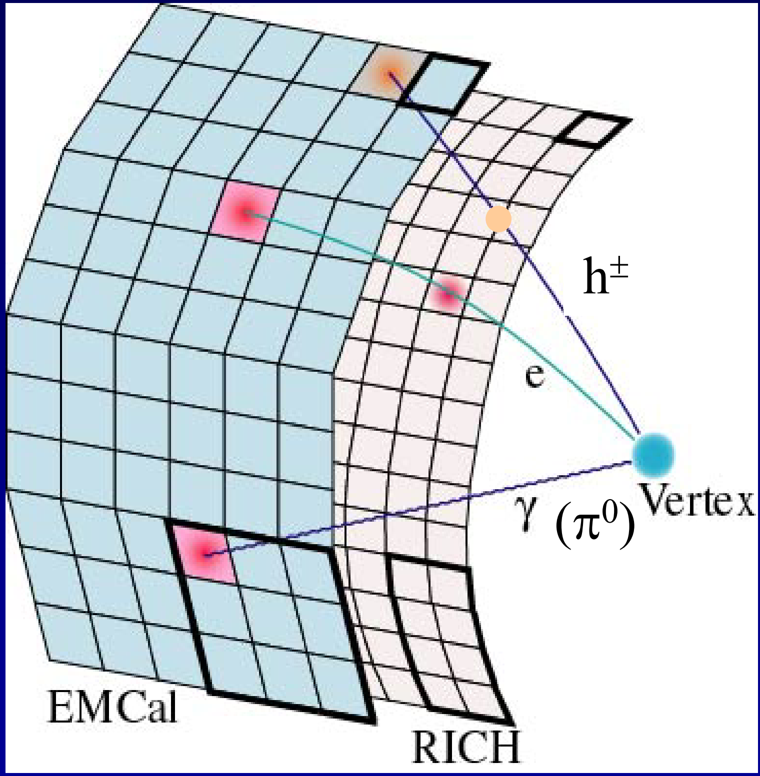
Minimum bias data

To obtain "unbiased" π^0 cross section at low p_T

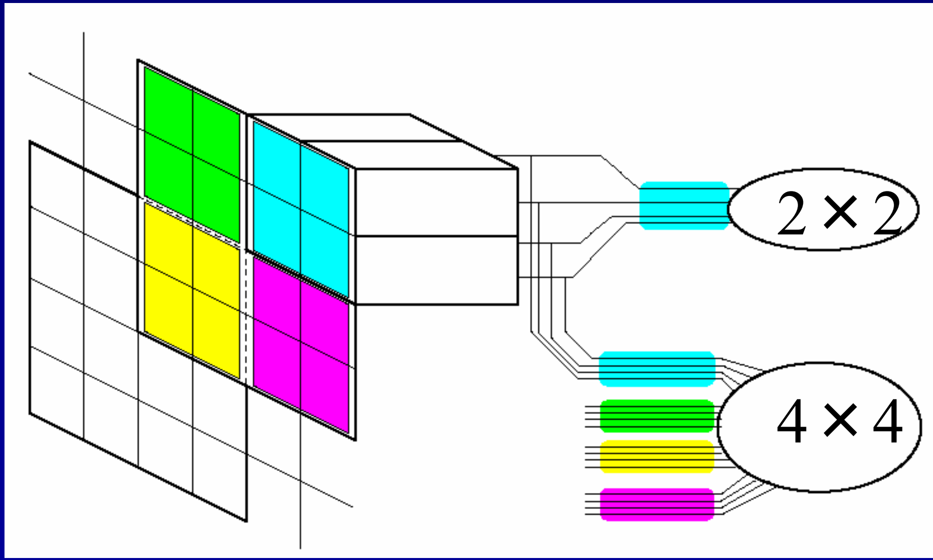
For high-p_T photon trigger efficiency study

High-Energy EMCal trigger

EMCal-RICH trigger



- EMCal part has two sums to collect photon shower
  - 2 × 2 towers non-overlapping sum (threshold at 0.8 GeV)
  - 4 × 4 towers overlapping sum (threshold at 1.4 GeV)



A_{LL} *Measurements*

$$A_{LL} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}} = \frac{1}{|P_B P_Y|} \frac{N_{++} - RN_{+-}}{N_{++} + RN_{+-}}, \qquad \delta_{A_{LL}} = \frac{1}{|P_B P_Y|} \frac{1}{\sqrt{N_{++} + N_{+-}}}$$

++ same helicity

+– opposite helicity

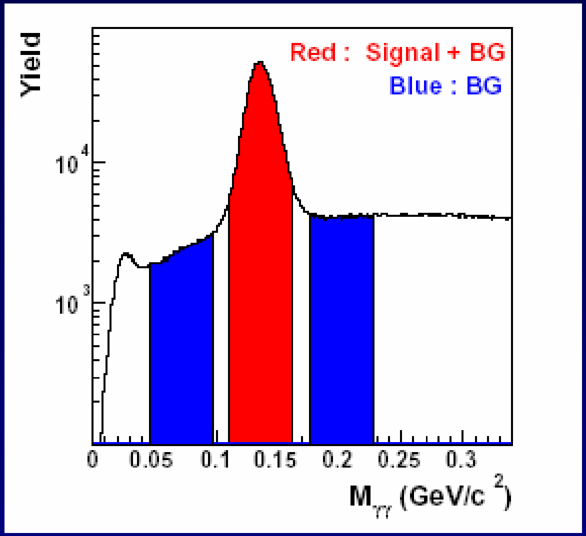
N: # pions

R: luminosity++/luminosity+-

Procedure

1. Count *N* and luminosity for ++ and +– configurations (sum over all crossings) and calculate A_{LL} for each store
2. Average A_{LL} over stores; use χ^2/NDF to control fit quality
3. Perform checks

π^0 Counting for A_{LL}



Background contribution to the physics asymmetry is estimated by measuring the asymmetry of the regions in blue around the π^0 mass peak.

Background in blue region is then normalized to that under the peak (r).

$$A_{LL}^{\pi^0} = \frac{A_{LL} - rA_{LL}^{bkgd}}{1-r} \qquad \sigma_{A_{LL}^{\pi^0}} = \frac{\sqrt{\sigma^2_{A_{LL}} + r^2\sigma^2_{A_{LL}^{bkgd}}}}{1-r}$$

$p_T(GeV/c)$	Trig. Eff. PbSc	Trig. Eff. PbGl	Bkgr. contr.
1 – 2	6%	13%	27%
2 – 3	54%	60%	15%
3 – 4	84%	84%	9%
4 – 5	91%	88%	8%

Relative Luminosity

A collider spin physics issue!

- Must combine yields from *different bunch crossings* to obtain asymmetries
- Important to know that relative luminosity between same-helicity and opposite-helicity bunch crossings is being counted correctly
- Don't get fooled by asymmetries in the luminosity detectors themselves!

Compare relative luminosity measurements from two different detectors situated in two different kinematic regions.
Beam-Beam Counter (BBC): quartz Cherenkov counter
Zero-Degree Calorimeter (ZDC): hadronic calorimeter

Relative Luminosity: Results

- Achieved relative luminosity precision $\delta R = 2.5 \times 10^{-4}$
  - Upper-limit estimation limited by ZDC statistics (30 times less than BBC statistics used in relative luminosity measurements)

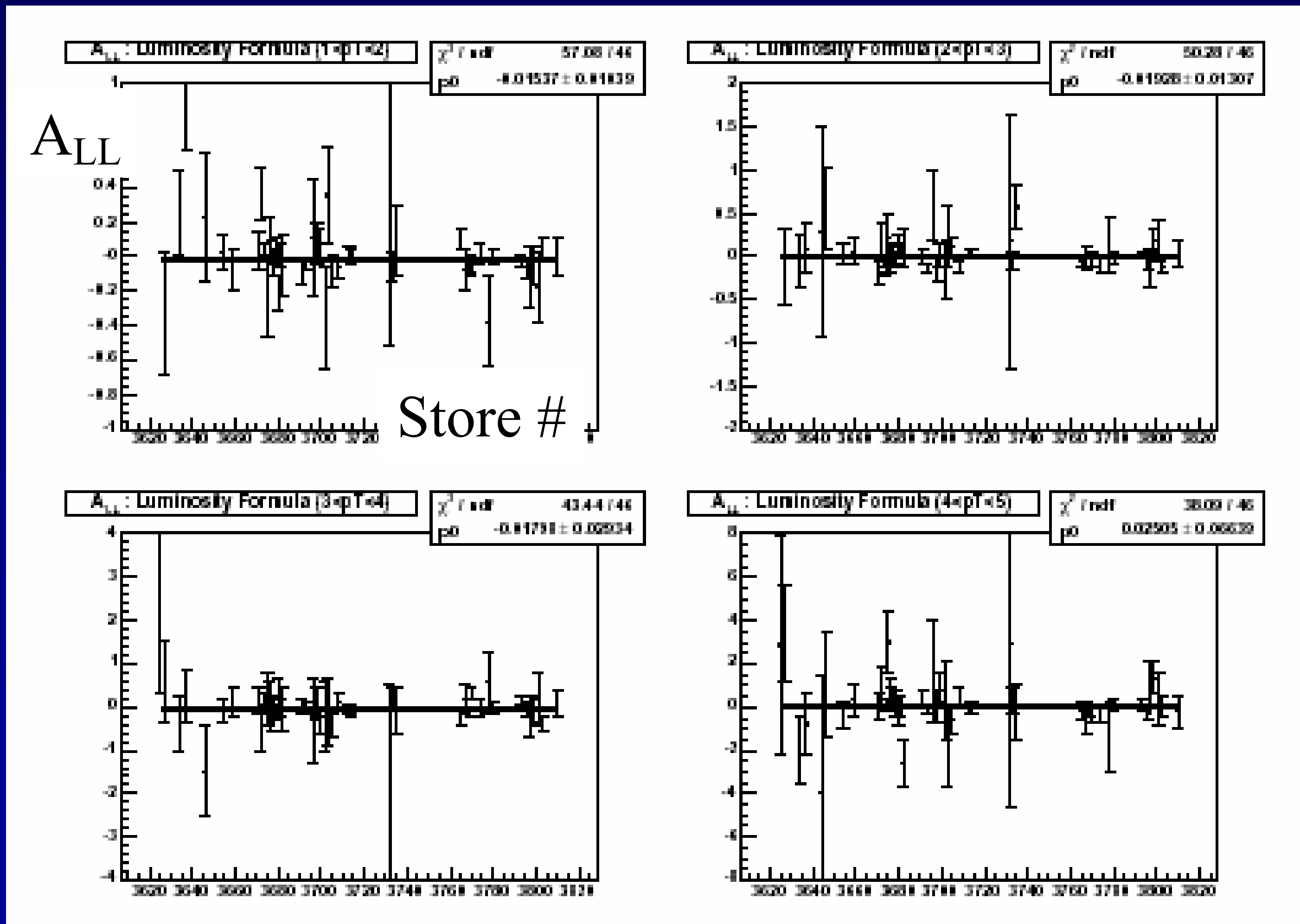
- A_{LL} of BBC relative to ZDC consistent with 0 (<0.2%)
  - Strong indication that asymmetries seen by both detectors are zero (very different kinematical regions, different physics signals)

- A_{LL} measurement currently limited by π^0 statistics

Store-by-Store Stability of Asymmetry

A_{LL} fit to a constant across all stores.

Four different p_T bins *(note y-axes are different)*.



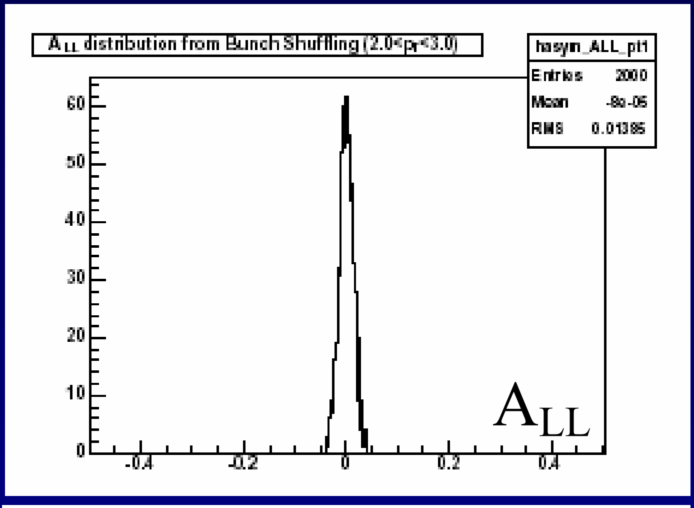
Bunch shuffling to check for systematic errors

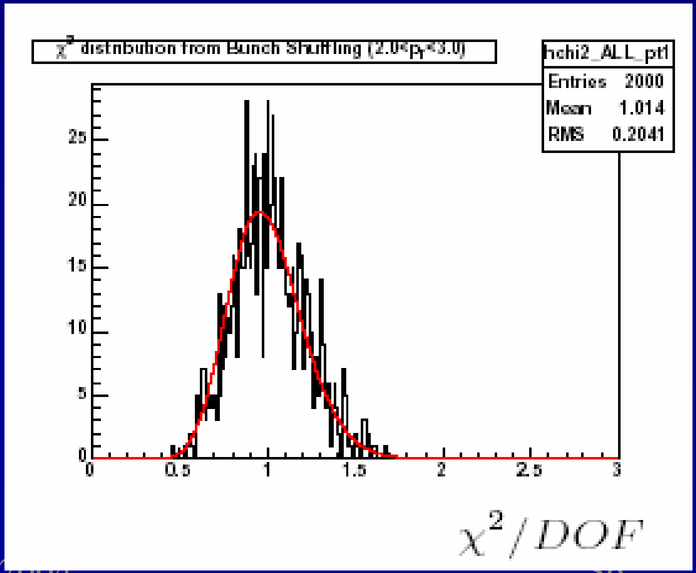
- Randomly assign helicity sign for each bunch

Widths of shuffled A_{LL} distributions are consistent with statistical errors assigned to physics A_{LL}

➢ Indicates that uncorrelated systematic errors are much smaller than statistical errors

distributions for fitted A_{LL} and χ^2





Parity-violating A_L check

$$A_L = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} = -\frac{1}{|P|}\frac{N_+/L_+ - N_-/L_-}{N_+/L_+ + N_-/L_-}$$

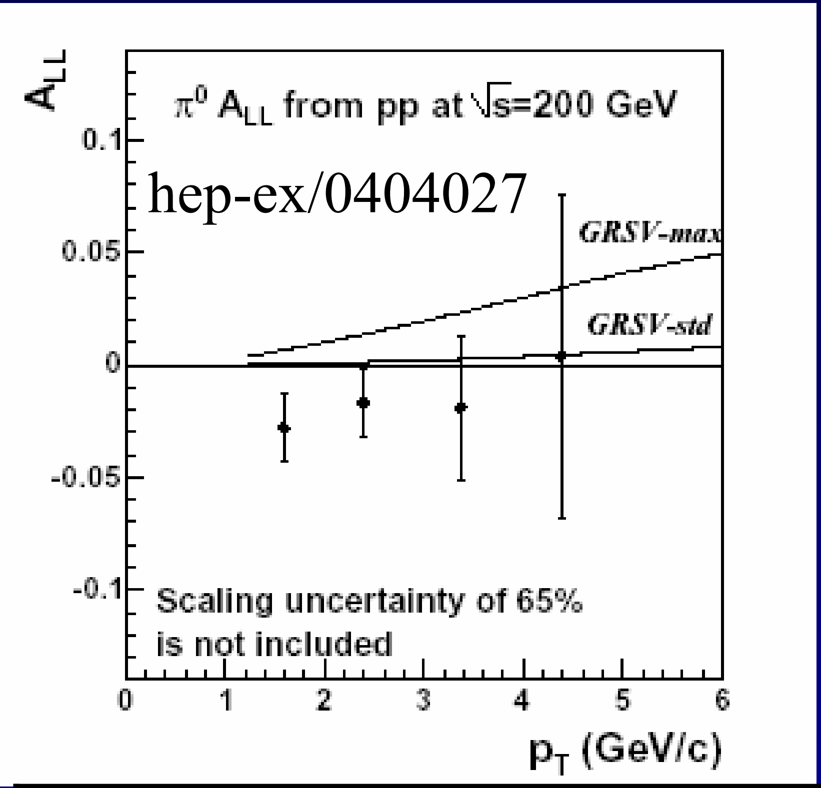
For "yellow" beam:

p_T GeV/c	$A_L^{\pi 0+bck}$ 15 MeV/c²	$A_L^{\pi 0+bck}$ 25 MeV/c²	$A_L^{\pi 0+bck}$ 35 MeV/c²	A_L^{bck1}	A_L^{bck2}
1-2	0.001±0.004	0.000±0.003	0.000±0.003	0.002±0.004	0.000±0.003
2-3	0.001±0.004	0.000±0.004	0.000±0.004	0.002±0.007	0.002±0.005
3-4	0.007±0.009	0.011±0.009	0.008±0.009	-0.033±0.025	-0.010±0.015
4-5	-0.001±0.021	0.004±0.020	0.008±0.020	0.020±0.064	0.050±0.039

All are zero within 1.5σ

Similar results obtained for "blue" beam

π^0 A_{LL} from pp at 200 GeV: Results



Comparison with two NLO pQCD calculations:
M. Glueck et al., PRD 63 (2001) 094005
B. Jaeger et al., PRD 67 (2003) 054005

Consistency with data:
GRSV-std: CL 16-20%
GRSV-max: CL 0.02-5%
(no theoretical uncertainty included)

p_T (GeV/c)	A_{LL}^{raw} (%)	A_{LL}^{bkgd} (%)	$A_{LL}^{\pi 0}$ (%)
1-2	-1.5+-0.9 (27%)	1.6+-1.4	-2.7+-1.3
2-3	-1.5+-1.1 (15%)	-3.0+-2.4	-1.3+-1.3
3-4	-1.8+-2.5 (9%)	-2.4+-6.8	-1.7+-2.8
4-5	2.6+-5.7 (8%)	24+-17	0.7+-6.2

How Could a Negative A_{LL} Be Explained?

- In a naïve analysis, look for a process with a negative partonic asymmetry:

$$gg \rightarrow gg \Rightarrow \hat{a}_{LL} > 0$$

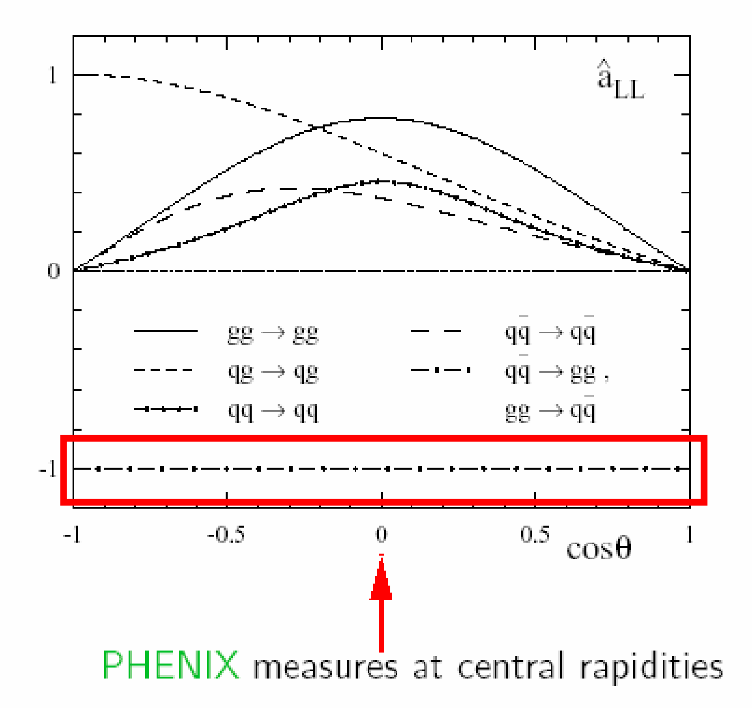
$$gq \rightarrow gq \Rightarrow \hat{a}_{LL} > 0$$

$$gg \rightarrow q\bar{q} \Rightarrow \hat{a}_{LL} = -1$$

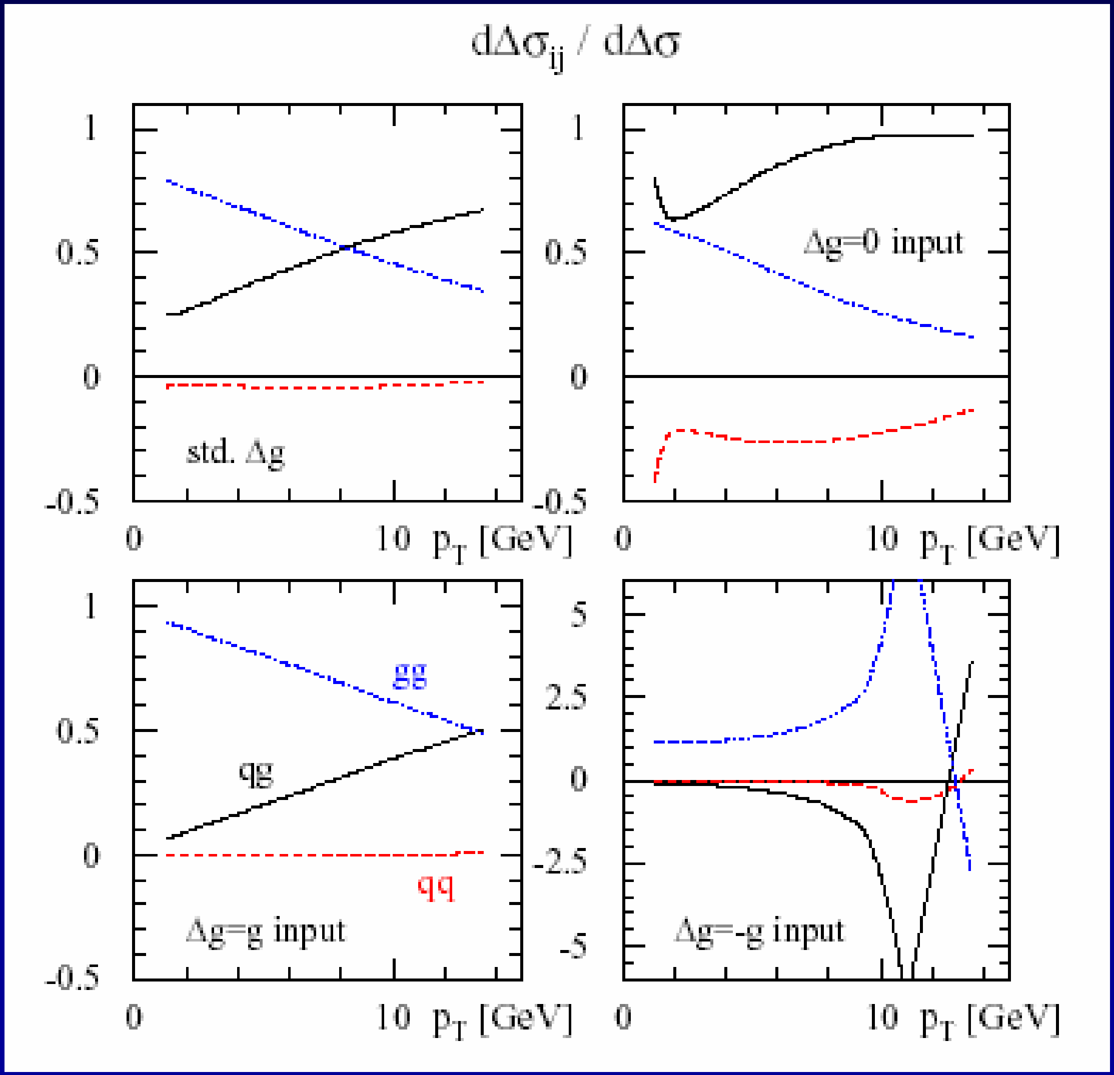
- But

$$\Delta\hat{\sigma}_{gg\rightarrow gg} \underset{(\eta \simeq 0)}{\simeq} 160\ \Delta\hat{\sigma}_{gg\rightarrow q\bar{q}}$$

So this can't account for a negative A_{LL}



Subprocess Contributions to π^0 Production for Four Different Assumptions on Δg



Jaeger, Kretzer, Stratmann, Vogelsang

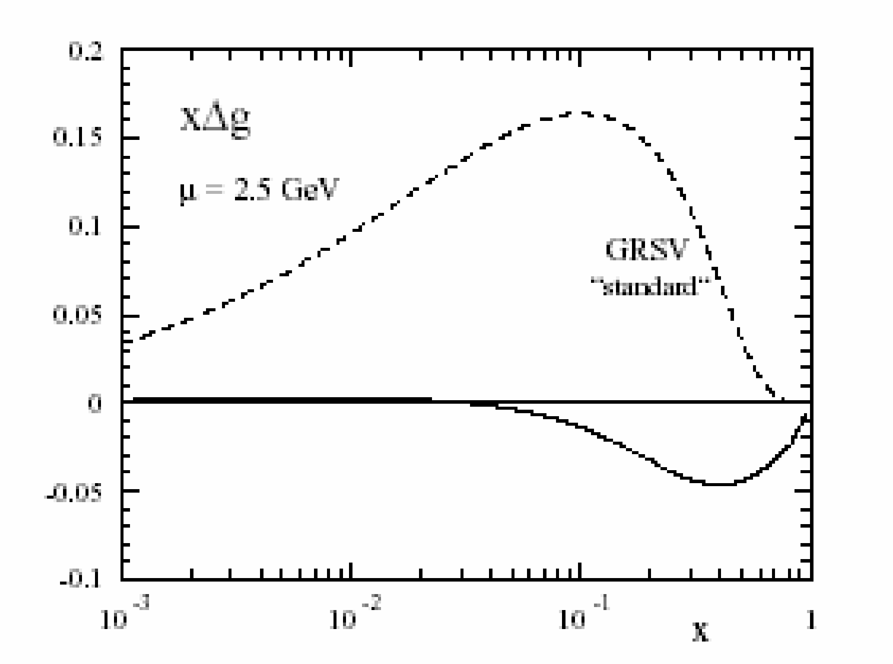
gg scattering dominates for $p_T < 10$ GeV/c in all cases.

This means that Δg will enter squared!

Then for any sign of Δg, a positive partonic asymmetry will give a positive A_{LL}!

One Possibility: A Node in Δg

- Since the gluons aren't necessarily probed at exactly the same *x*, a node in Δg would allow a negative A_{LL}.
- However, analytical calculation of a lower bound on A_{LL} for neutral pions finds
  $$A_{LL}^{\pi}\,|_{\min} \cong O(-10^{-3})$$
- Need more data! Smaller error bars, greater p_T range, and charged pion asymmetries: $\Delta g > 0 \Rightarrow A_{LL}^{\pi+} > A_{LL}^{\pi 0} > A_{LL}^{\pi-}$



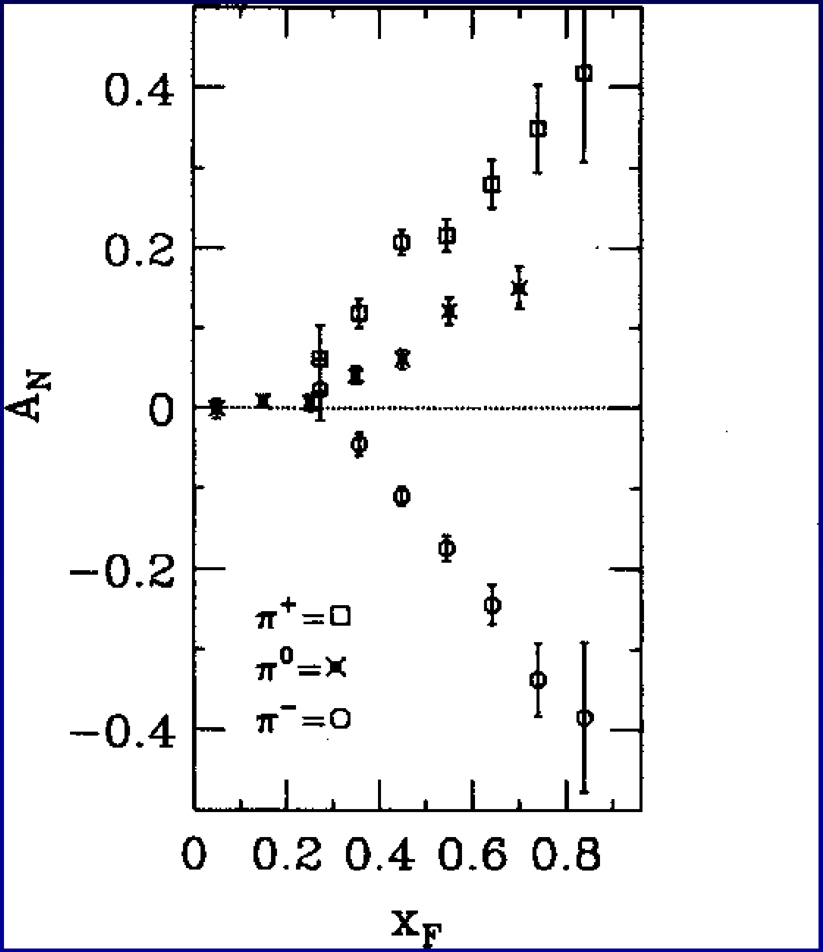
Jaeger et al., PRL 92 (2004) 121803

Single spin asymmetries A_N

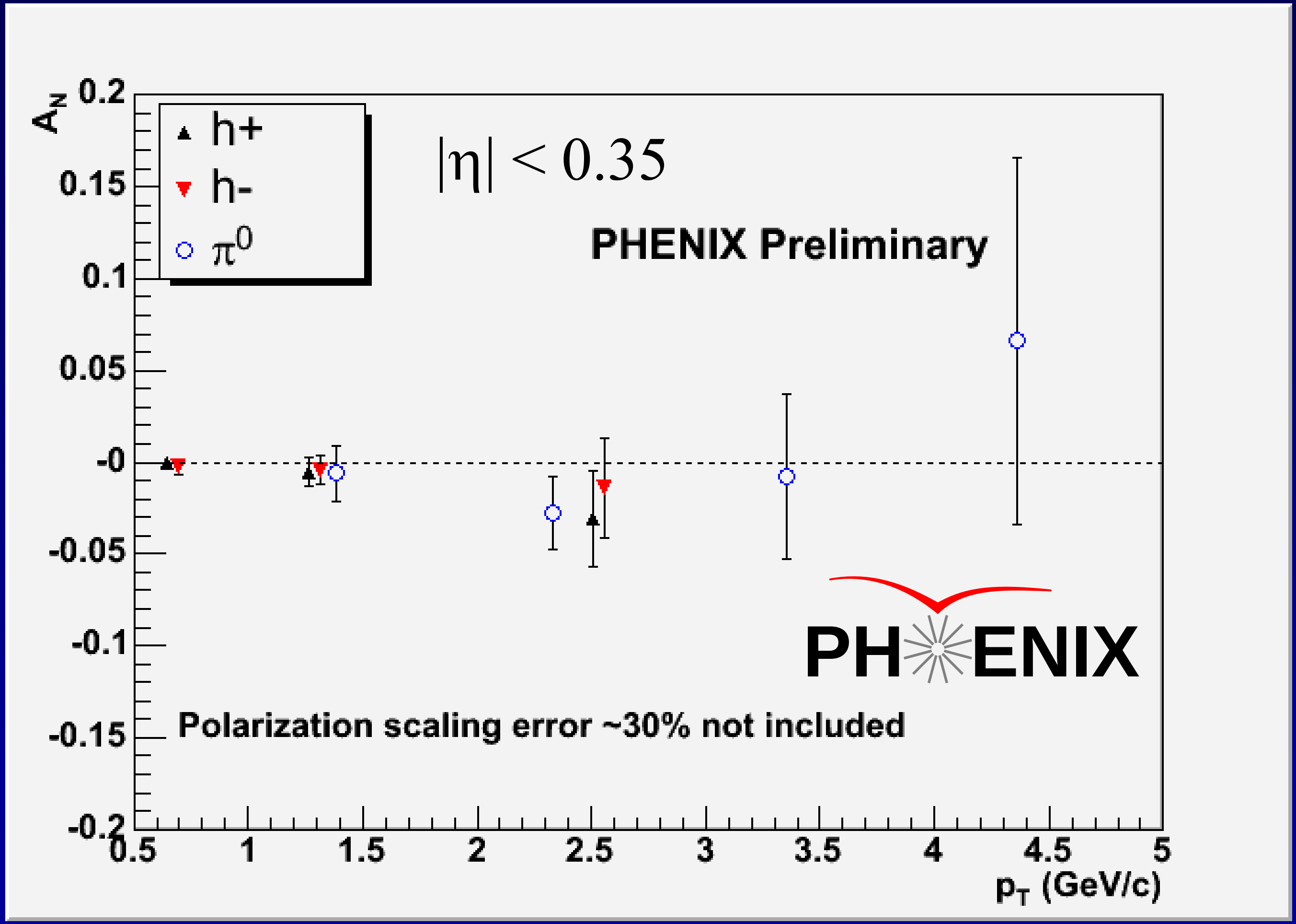
Large left-right asymmetries (~20-40%) seen at lower energies, which various models have tried to explain

- Sivers Effect – Spin dependent initial partonic transverse momentum
- Collins Effect – Spin dependent transverse momentum kick in fragmentation
  - Requires transversity δq non-zero
- Sterman and Qiu – Initial-state twist 3
- Koike – Final-state twist 3

E704 at Fermilab at $\sqrt{s}$=20 GeV, p_T=0.5-2.0 GeV/c:



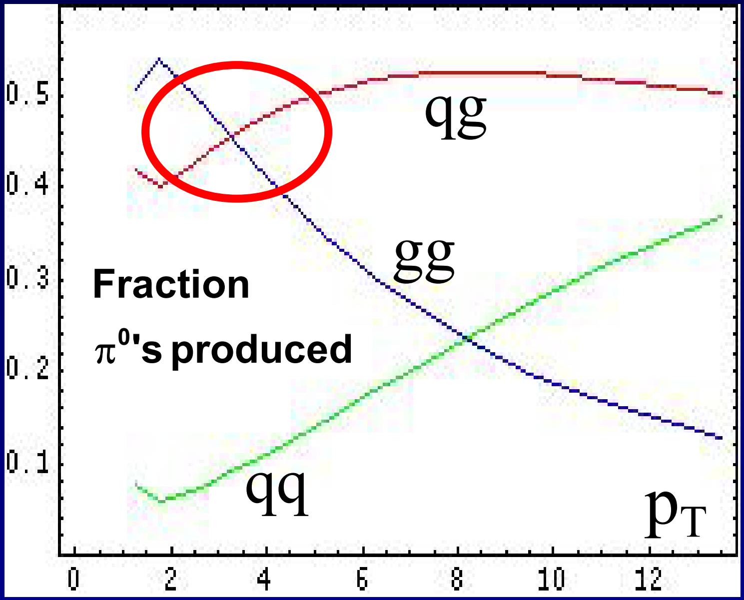
A_N of Neutral Pions and Non-Identified Charged Hadrons at Midrapidity



A_N for both charged hadrons and neutral pions consistent with zero.

A_N at Midrapidity to Probe Sivers and Transversity+Collins

- PHENIX measurement of midrapidity π^0 A_N may offer insight on transversity and the Sivers effect
  - Current data primarily sensitive to Sivers because particle production at midrapidity at these transverse momentum values is mostly from gluon scattering



Future measurements reaching higher transverse momentum will be dominated instead by quark scattering and thus more sensitive to transversity + Collins

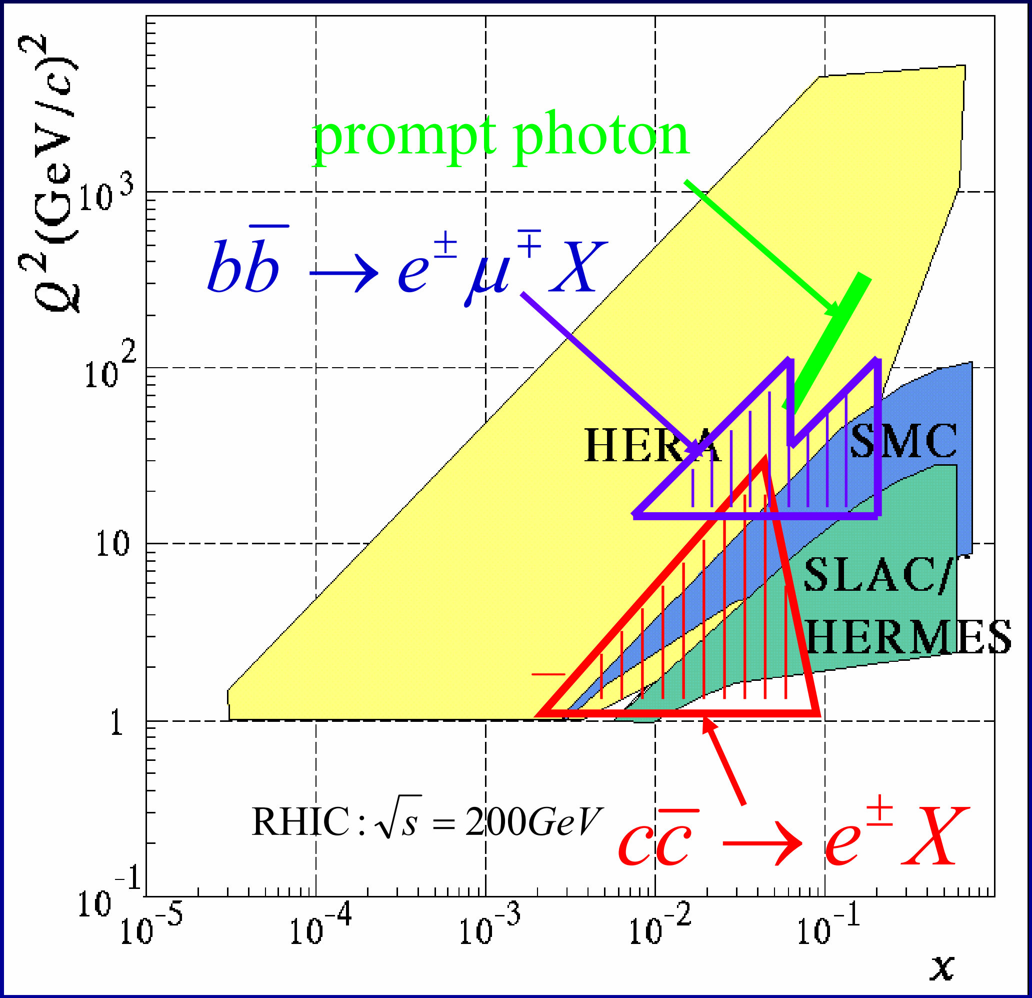
Summary

- RHIC has been successful as the world's first high-energy polarized proton collider, opening up new kinematic regions for investigating the spin of the proton
- The first spin results from PHENIX, including π^0 A_{LL} and A_N for π^0 and h^{+-}, are out and stimulating discussion within the theoretical community
- Proton run of at least 10 weeks at ~50% polarization expected for 2005

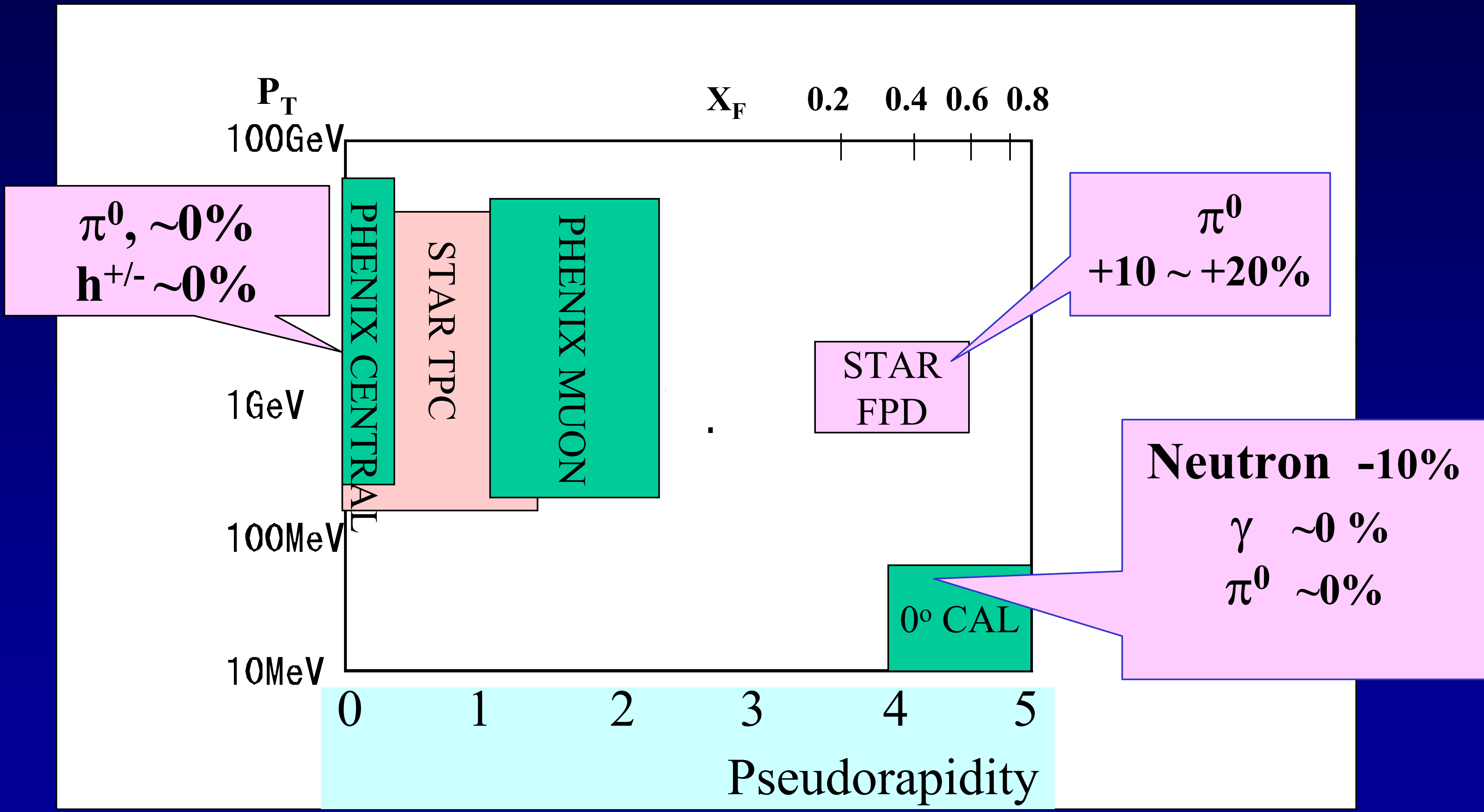
Many more years of exciting data and results to look forward to!

Extra Slides

RHIC vs. DIS Kinematic Coverage



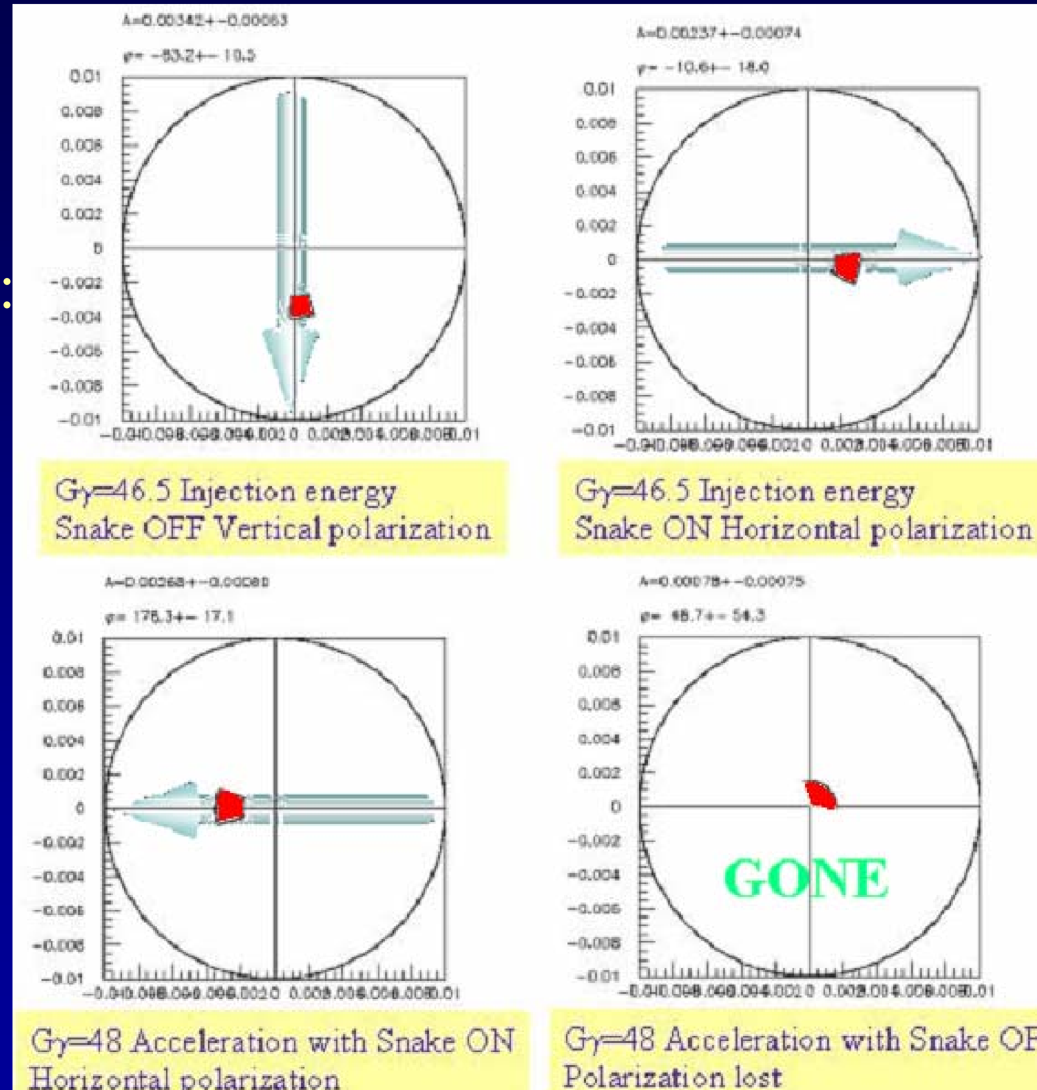
Single-spin asymmetries seen at RHIC so far…



Successful Operation of the Snake

- Injection with Spin Flipped: Asymmetry Flipped
- Adiabatically Snake on: Horizontal polarization
- Accelerate equivalent to 180º rotation: 180º rotated

Successful Single Snake Operation!

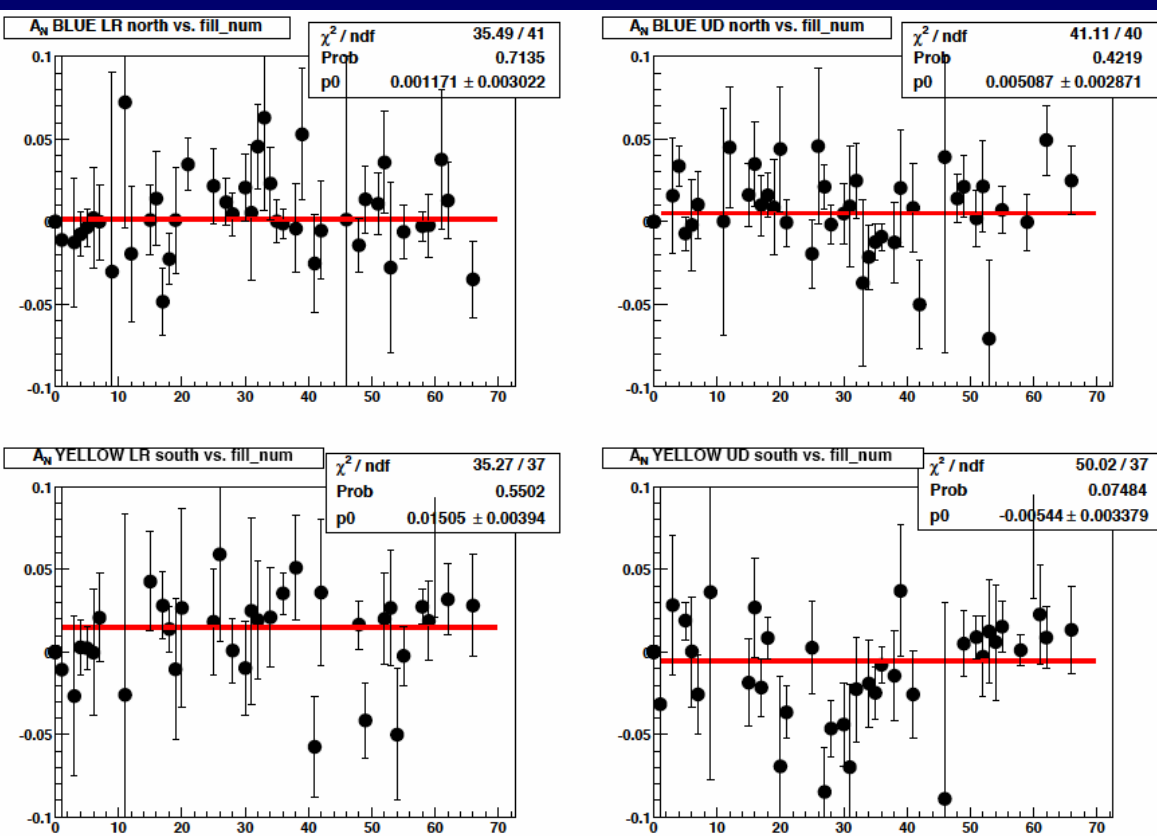


Spin: Longitudinal Component

$$S_L = \sqrt{1 - S_T^2}, \qquad S_T = \sqrt{S_{T-vertical}^2 + S_{T-radial}^2}$$

S_T is measured with PHENIX Local Polarimeter

Left-Right asymmetry Up-Down asymmetry

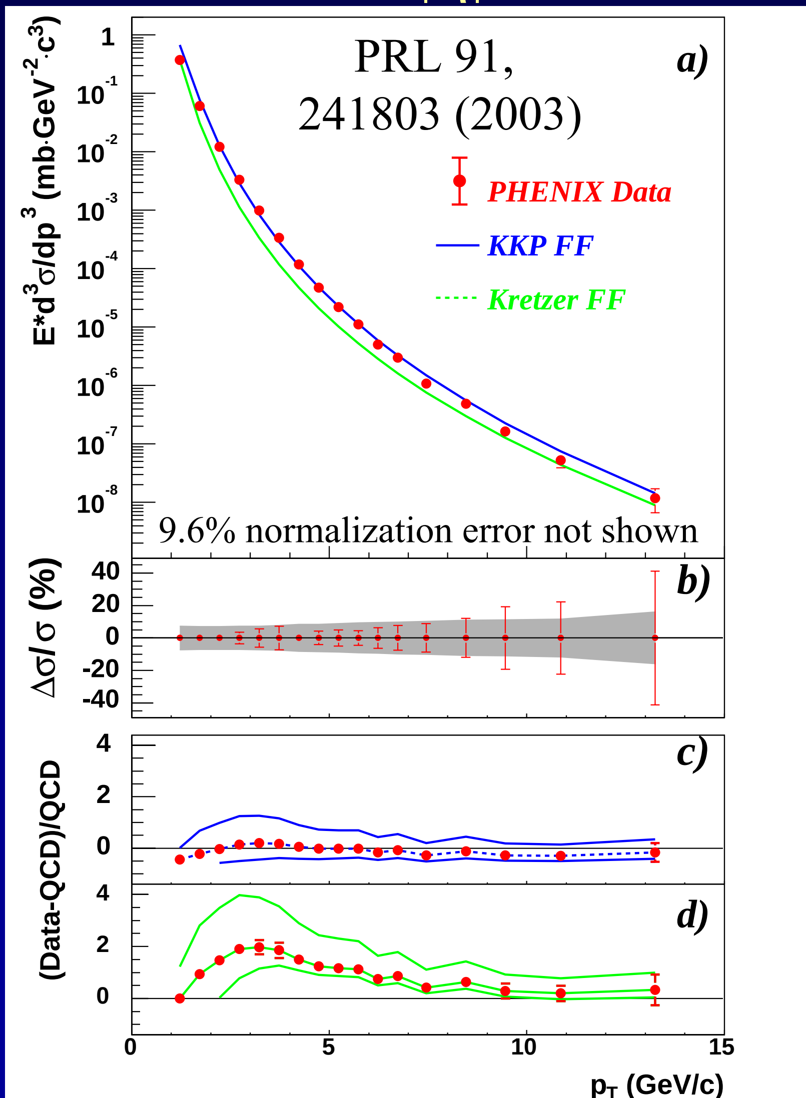


$$S_L(blue) = 99.3^{+0.5}_{-1.4}\ {}^{+0.0}_{-0.9}$$

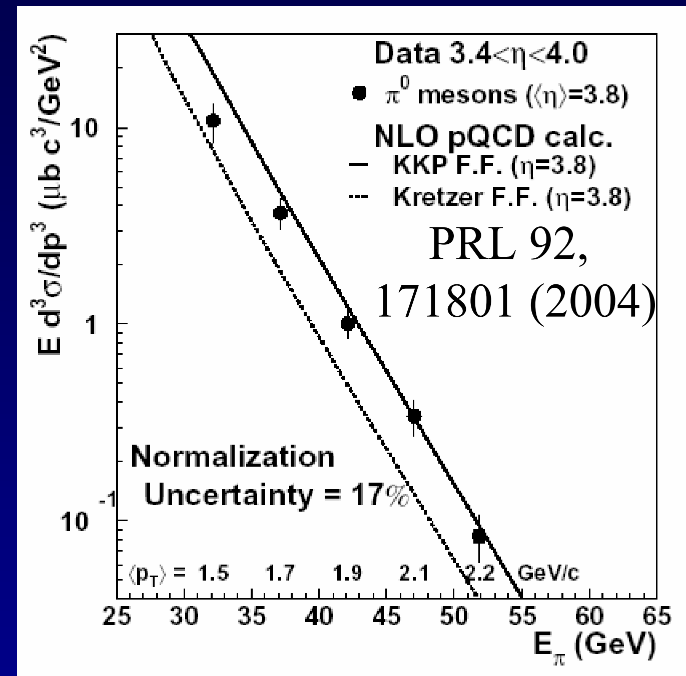
$$S_L(yellow) = 97.4^{+1.3}_{-3.2}\ {}^{+0.1}_{-0.9}$$

π^0 Cross Section from 2001-2 Run

PHENIX, $|\eta| < 0.35$

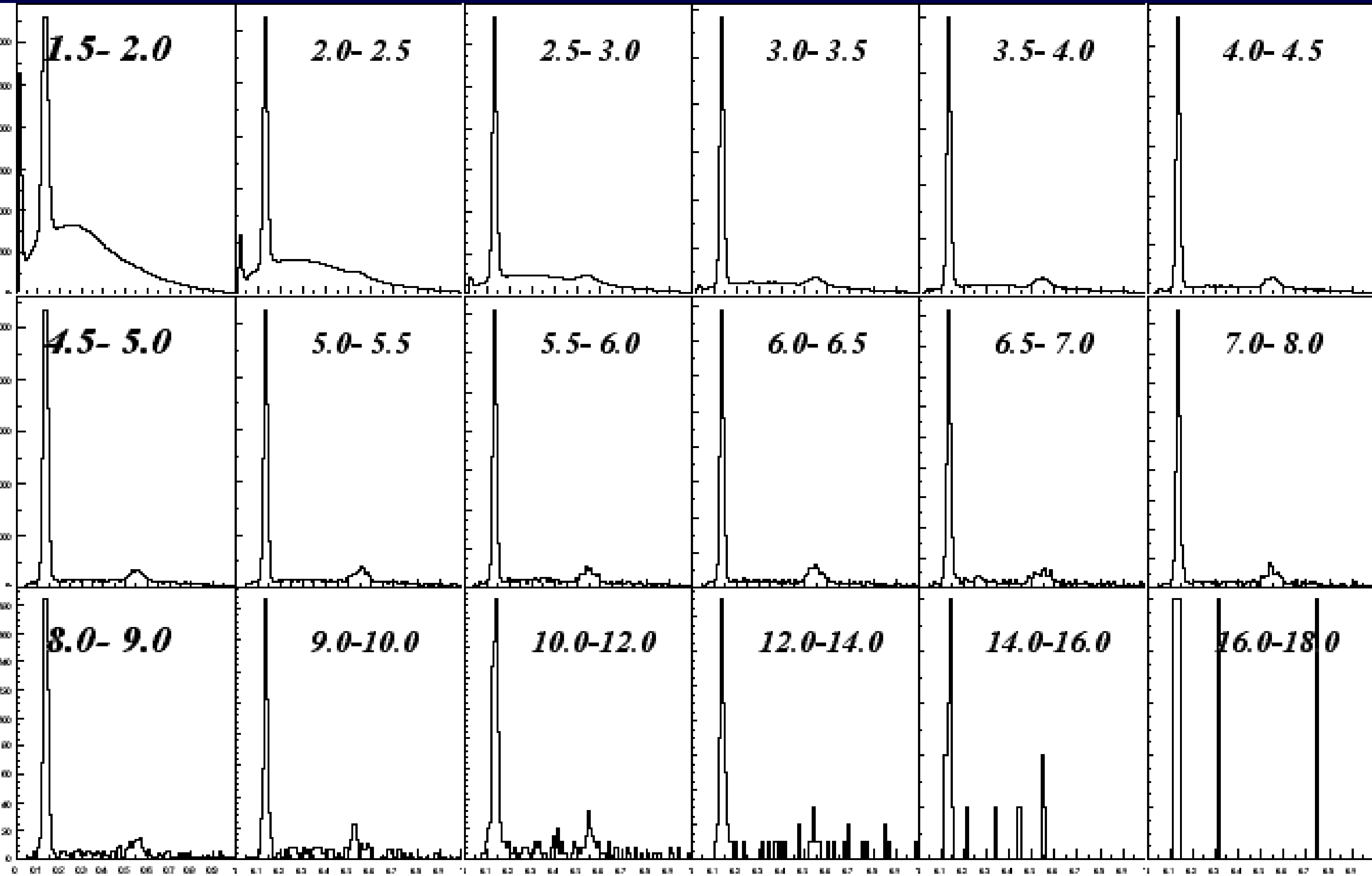


STAR, $3.4 < \eta < 4.0$



- Good agreement between NLO pQCD calculations and experiment
  - Can use NLO pQCD analysis to extract spin-dependent pdf's

σ^{π^0}: π^0 Reconstruction



Parity-violating A_L check

$$A_L = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} = -\frac{1}{|P|}\frac{N_+/L_+ - N_-/L_-}{N_+/L_+ + N_-/L_-}$$

For "blue" beam:

p_T GeV/c	$A_L^{\pi 0+bck}$ 15 MeV/c²	$A_L^{\pi 0+bck}$ 25 MeV/c²	$A_L^{\pi 0+bck}$ 35 MeV/c²	A_L^{bck1}	A_L^{bck2}
1-2	-0.001±0.004	0.001±0.003	0.000±0.003	-0.002±0.004	-0.000±0.003
2-3	0.001±0.004	0.000±0.004	0.002±0.004	0.009±0.007	0.000±0.005
3-4	0.004±0.009	0.006±0.009	0.006±0.008	-0.004±0.024	-0.036±0.015
4-5	-0.024±0.021	-0.016±0.020	-0.016±0.019	-0.011±0.062	0.013±0.038

All are zero within 1.5σ, except

Other A_{LL} Checks

++ vs –– and +– vs –+

p_T GeV/c	$A_{LL}^{\pi 0+bck}$ ++ vs – –	$A_{LL}^{\pi 0+bck}$ + – vs –+
1-2	0.007±0.017	-0.013±0.017
2-3	0.002±0.021	0.005±0.021
3-4	0.061±0.046	-0.027±0.046
4-5	-0.086±0.105	-0.067±0.104

Consistent with 0 within 1.5σ

A_N of Neutral Pions at Forward Rapidity

Large asymmetry seen

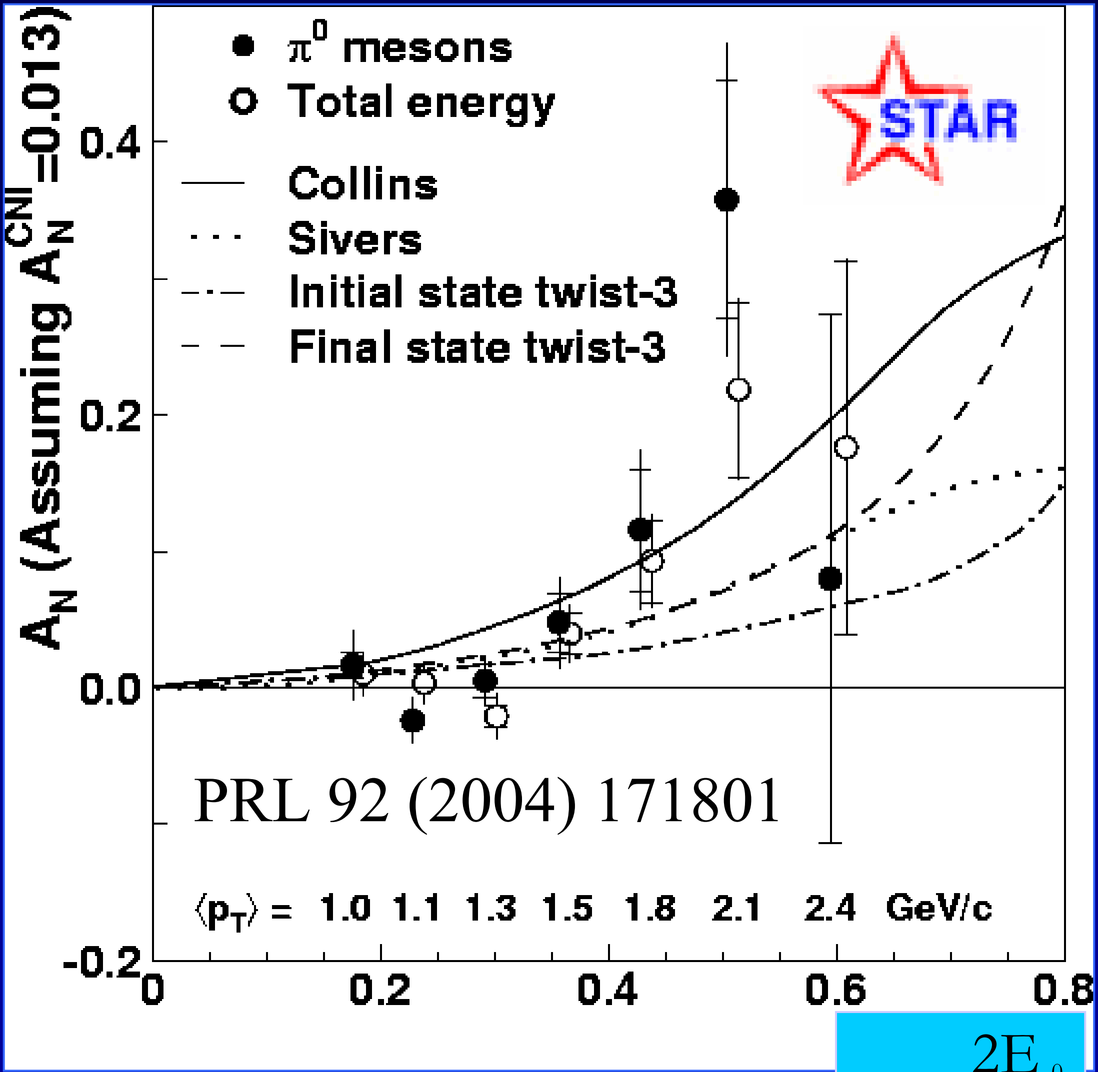
For <η> = 3.7 possible contributions to A_N are:

Sivers Effect – Spin dependent initial partonic transverse momentum

Collins Effect – Spin dependent transverse momentum kick in fragmentation

Sterman and Qiu – Initial-state twist 3

Koike – Final-state twist 3

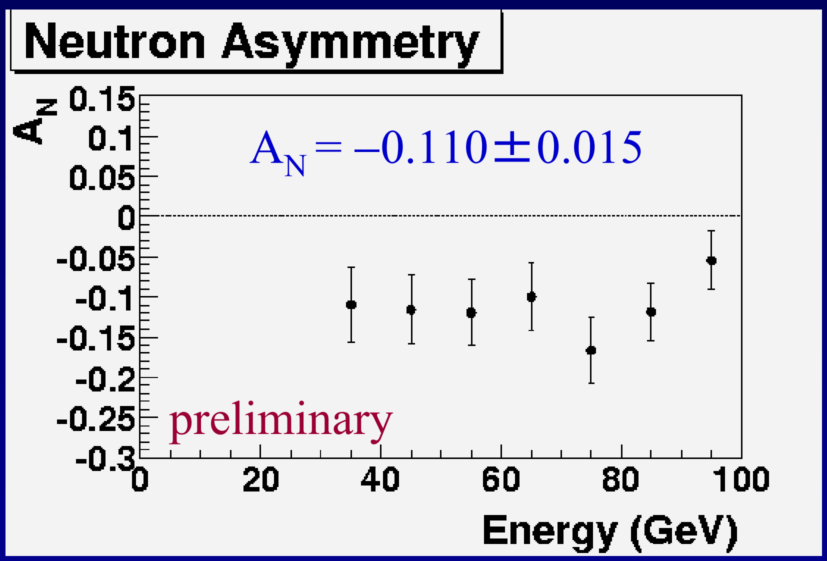


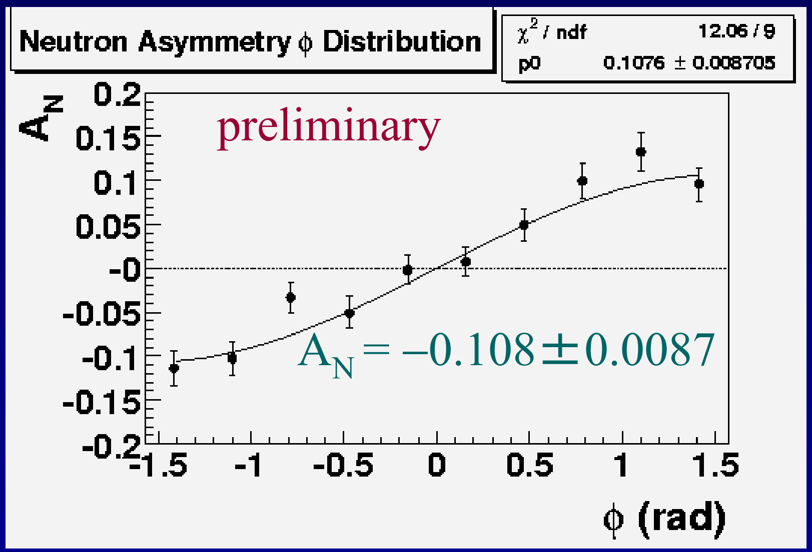
$$X_F = \frac{2E_{\pi^0}}{\sqrt{s}}$$

Neutron A_N at IP12

- A_N measurement at IP12
  - large neutron A_N was discovered

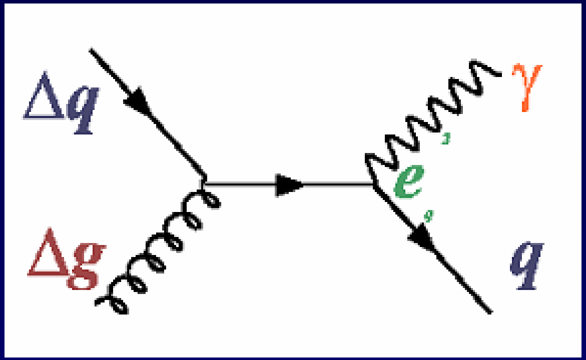
Y. Fukao





➔ Local polarimeter at PHENIX
  - ZDC + position sensitive counters to measure the neutron A_N

Prompt Photon Production

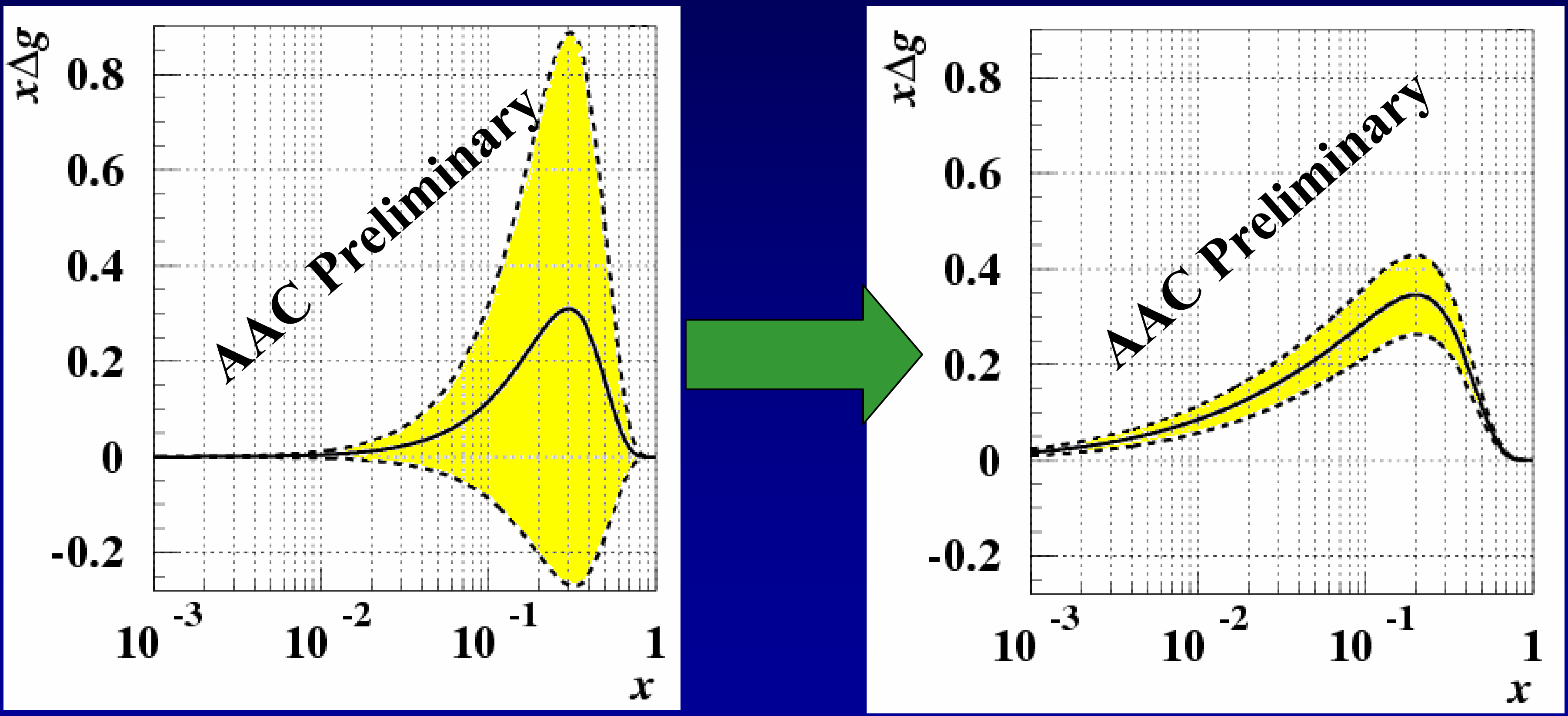


$$A_{LL} = \frac{\Delta g(x_1)}{g(x_1)} \otimes \frac{\sum_{i=u,d,s} e_i^2 \Delta f_i(x_2)}{\sum_{i=u,d,s} e_i^2 f_i(x_2)} \otimes \hat{a}_{LL}(gq \to q\gamma)$$

- A relatively clean channel to access ΔG, but experimentally challenging
  - ✓No fragmentation functions to worry about
  - ➢Small cross section ⇨ need large statistics
  - ✓Good background reduction with fine grained/high resolution EMCal in PHENIX

Impact of RHIC Spin ΔG Measurement

- If the projected PHENIX prompt photon data are included in a global QCD analysis:



M. Hirai, H.Kobayashi, M. Miyama *et al.*