

Spin physics at PHENIX

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for the PHENIX collaboration

05/16/03 RHIC/AGS users meeting

Outline

- The goals of spin physics at PHENIX
- PHENIX experiment
- **Past:** summary of the first run
- **Present:** status of the ongoing run
- Summary

PH[✶]ENIX



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The goals of spin physics at PHENIX

- Polarized proton collider
→ Study of spin structure of proton
 $1/2 = 1/2\Delta\Sigma + \Delta G + L$ ($\Delta\Sigma \sim 0.25$)

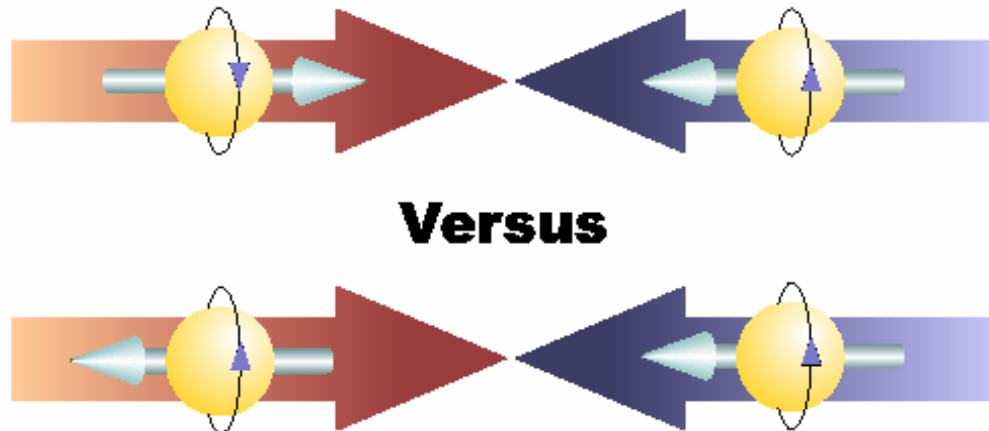
- How to study?

A_{LL} -- double spin asymmetry

$$= \frac{\sigma(++)-\sigma(+-)}{\sigma(++)+\sigma(+-)}$$

$$= (\text{parton pol.})^2 \times$$

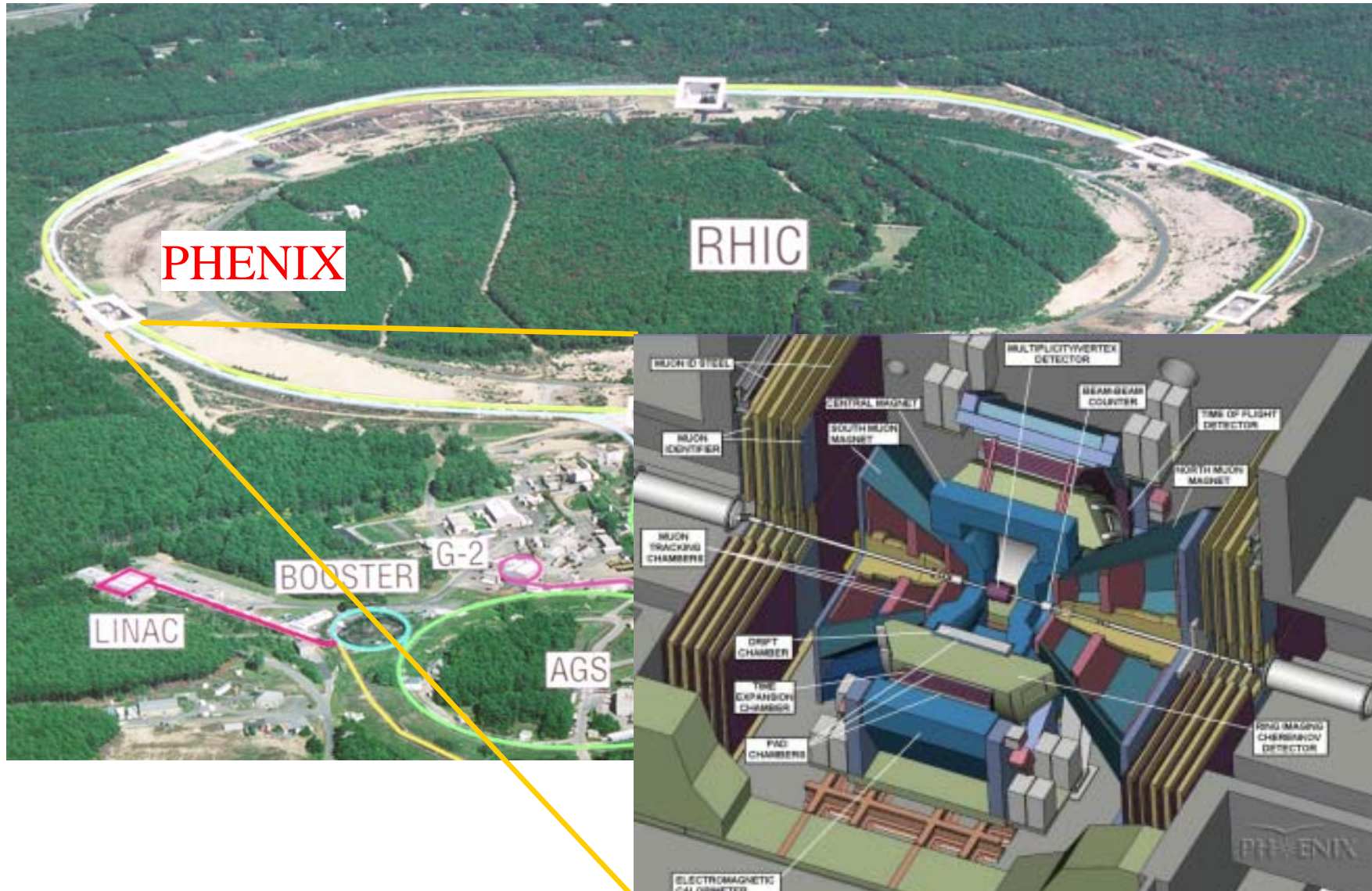
(a_{LL} in parton reaction)



Examples of reaction channels

- Direct photon: $g + q \rightarrow \gamma + q$
 - ~10% contribution from other processes
(e.g. $\bar{q}q \rightarrow \gamma\gamma$)
→ golden channel for gluon polarization
 - Need high luminosity ($> 100 \text{ pb}^{-1}$).
- Inclusive high- p_T hadron production
 - mix of various processes, $q+q$, $g+g$, $g+q$, ...
 - feasible at relatively small luminosity ($\sim \text{pb}^{-1}$)
→ important channel at early stage
- Heavy flavor
- W -- spin-flavor structure

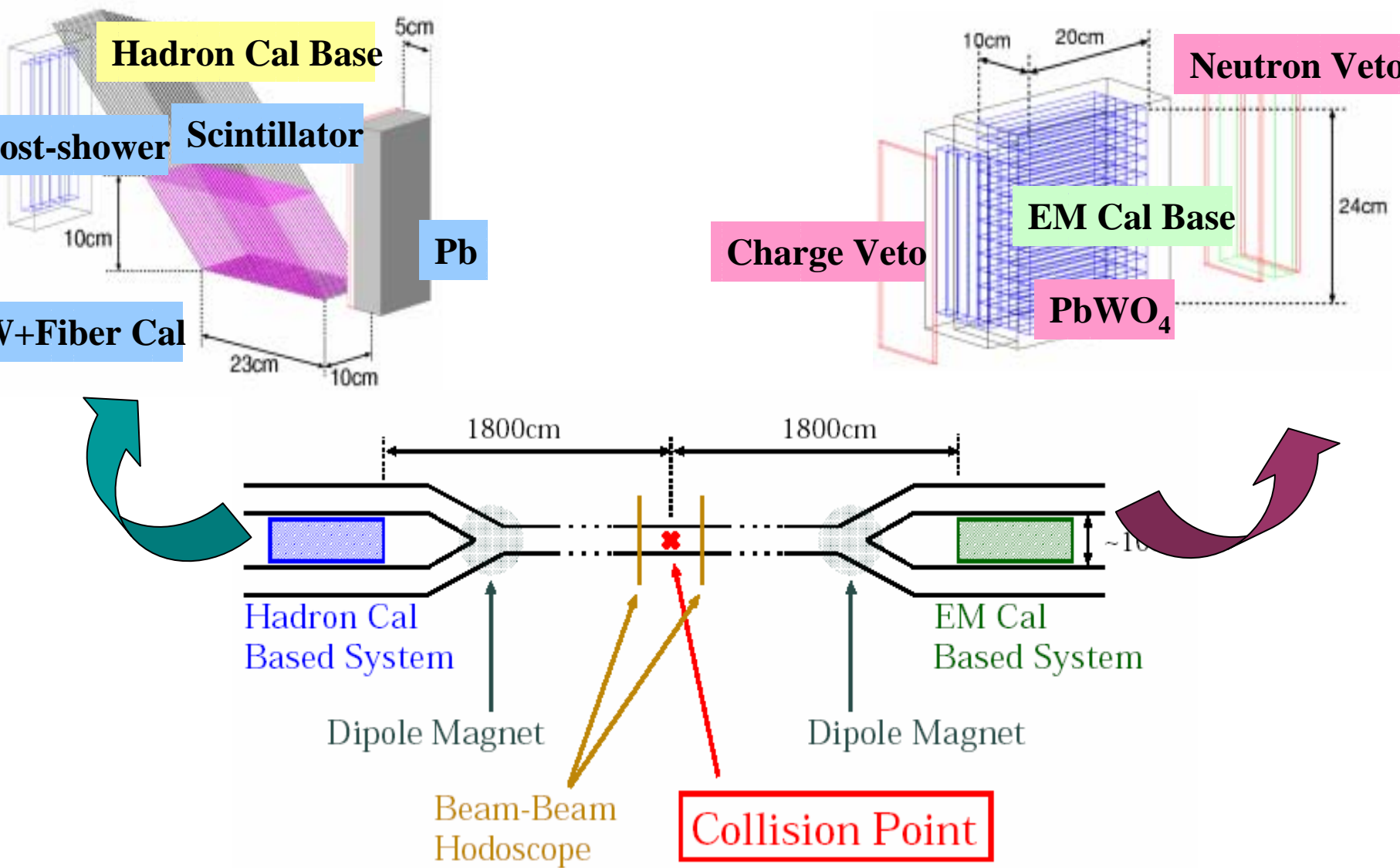
PHENIX experiment

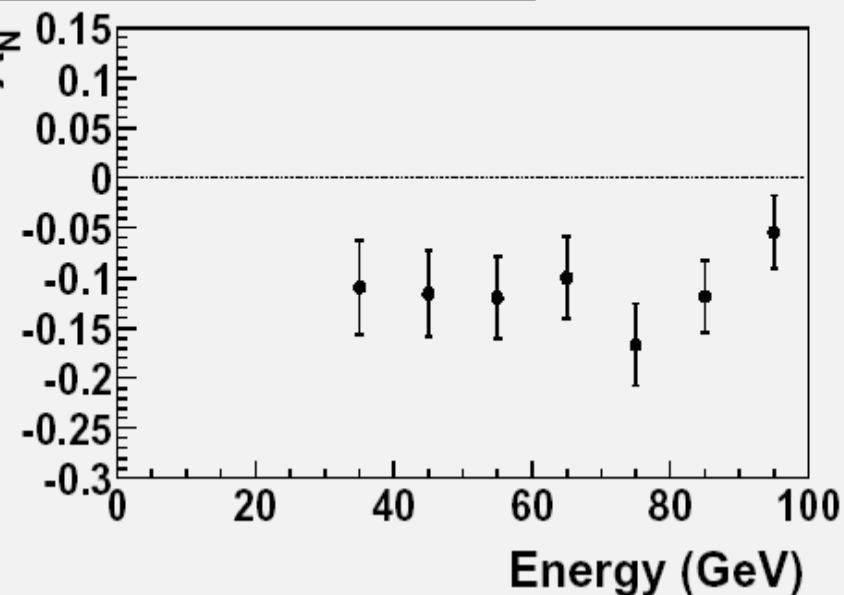
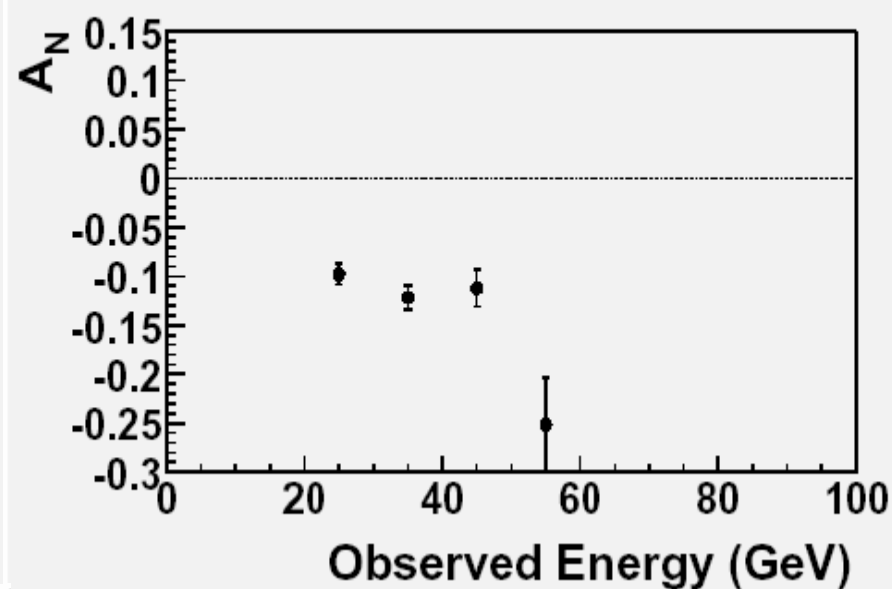
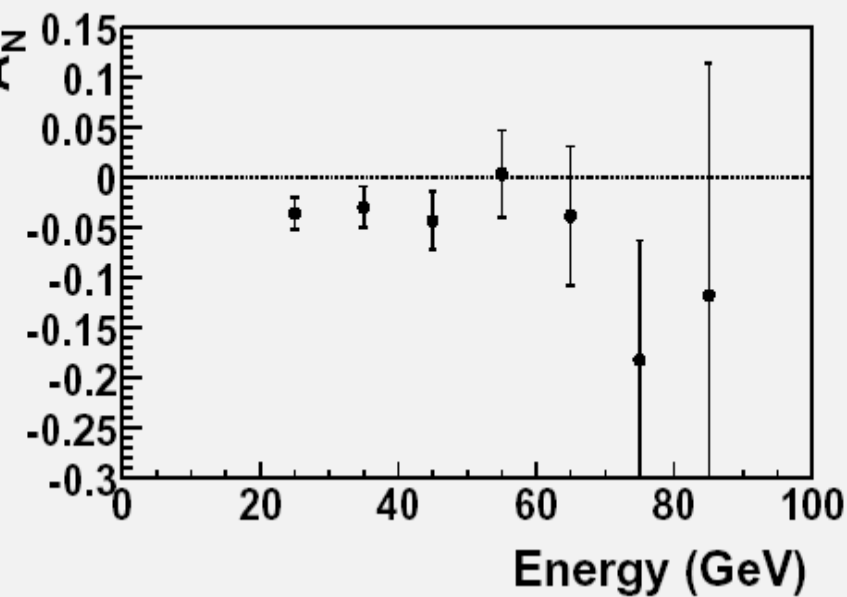
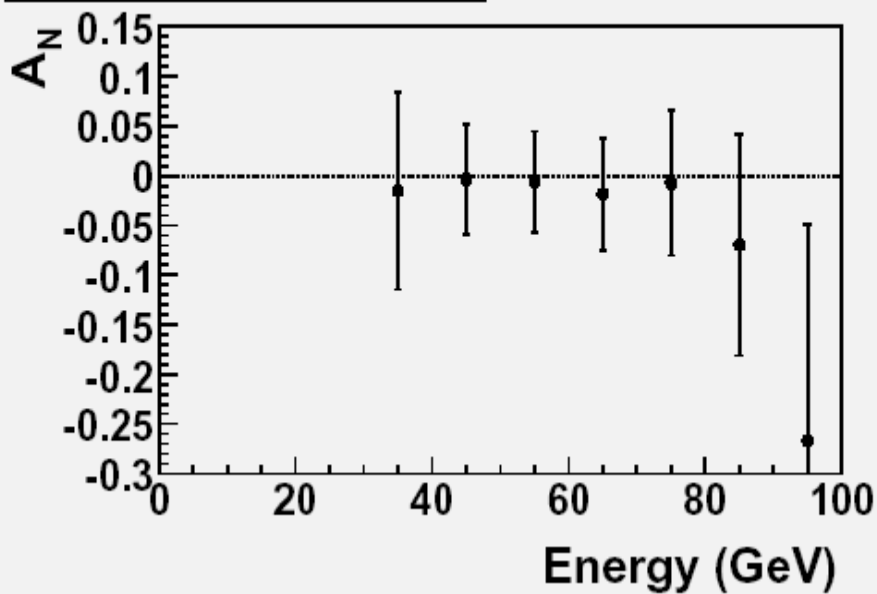


Summary of the first run

- Dec. 2001 - Jan. 2002
- $\sqrt{s} = 200 \text{ GeV}$
- Beam polarization: $\sim 15\%$
 - ran with transverse polarization to measure A_N
- Integrated luminosity: 150 nb^{-1}
- Development of Local Polarimeter
 - discovery of large A_N in forward neutron production
- Physics outputs:
 - π^0 cross section measurement
 - J/ψ cross section measurement
 - ...

LocalPol test @IP12



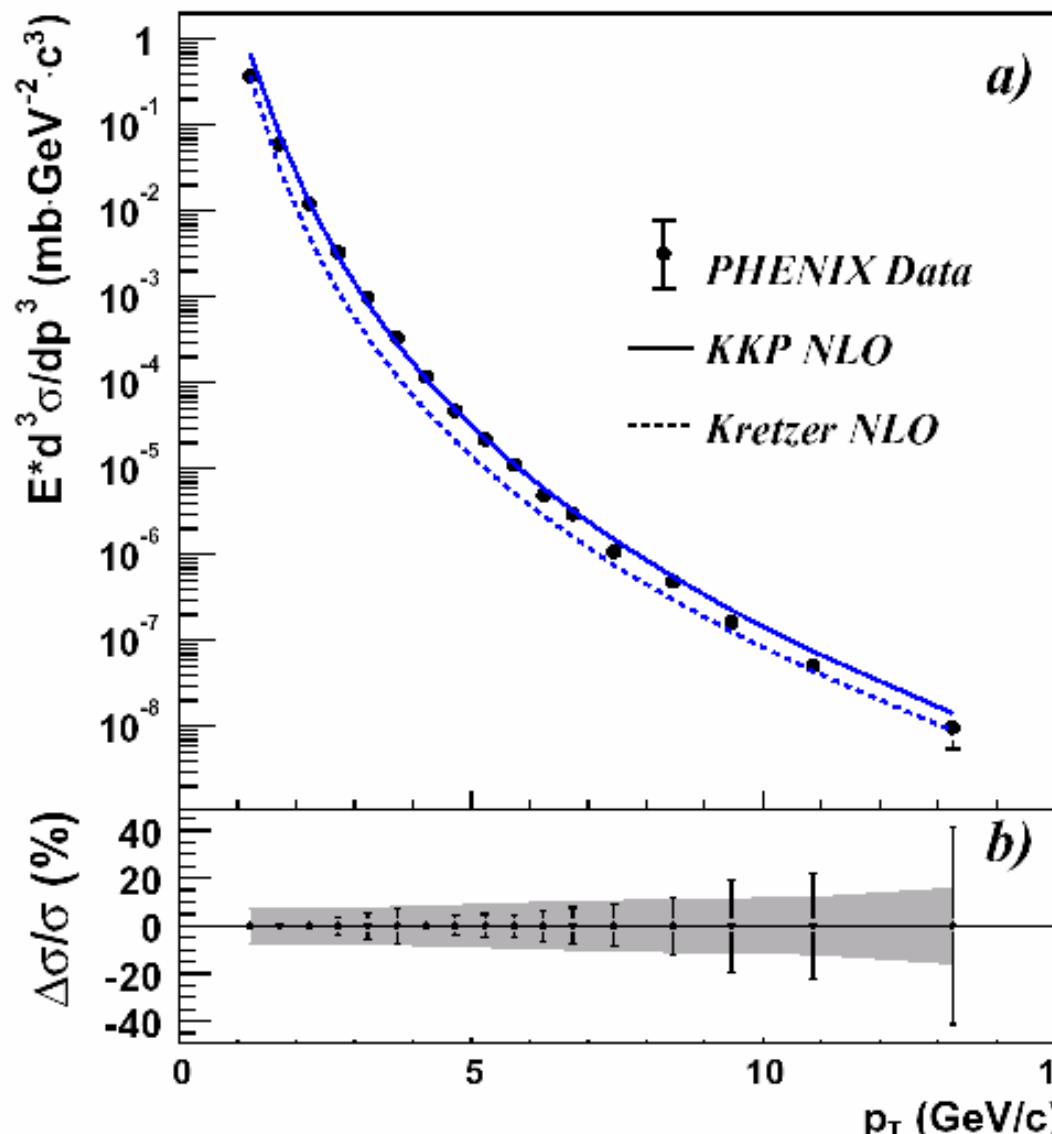
Neutron Asymmetry**Neutron Asymmetry****Photon Asymmetry** **π^0 Asymmetry**

π^0 cross section

hep-ex/0304038,
submitted to PRL

- p_T Spectrum over 10^8 magnitude
- NLO pQCD calculation consistent with data

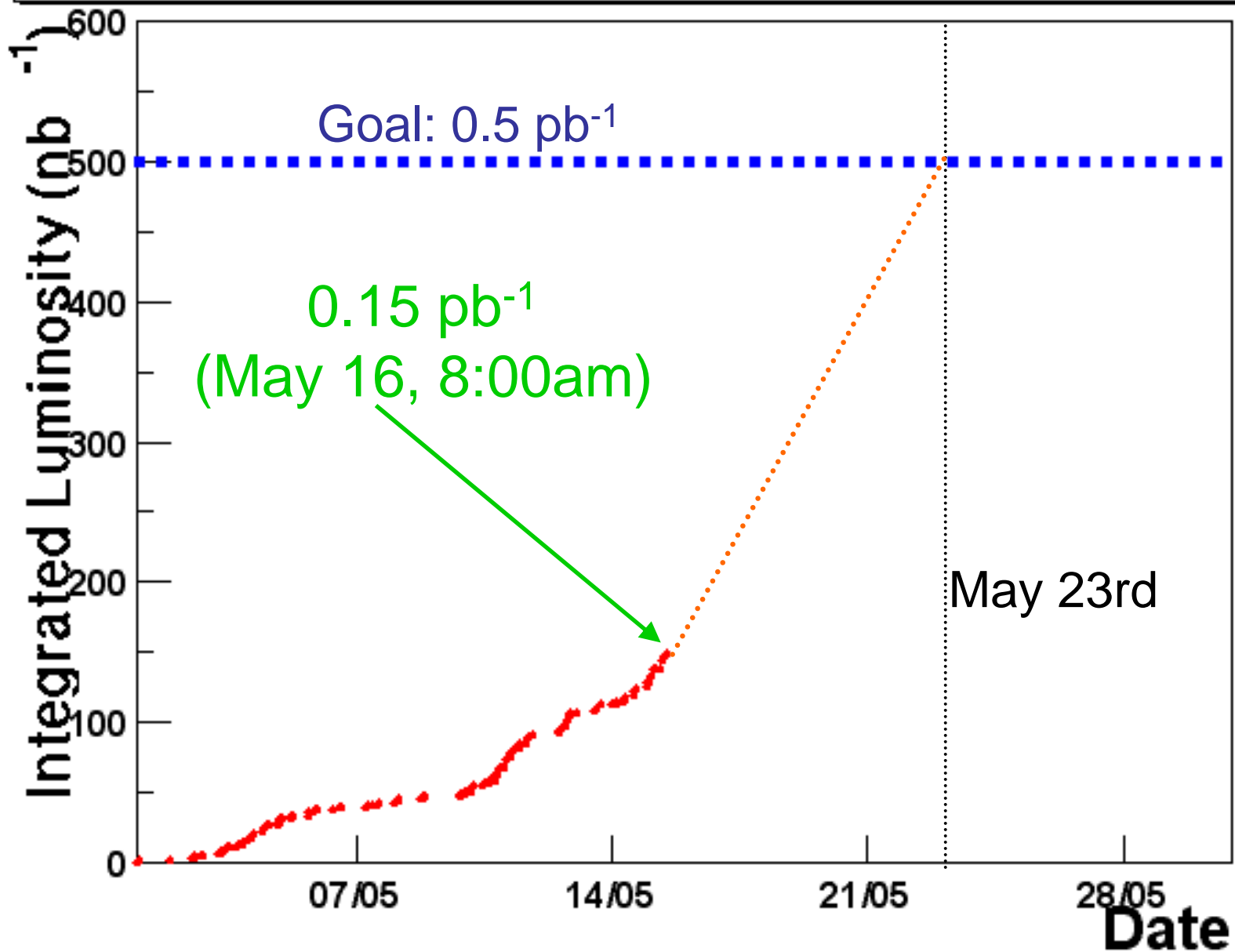
→ OK to extract
gluon
polarization
using pQCD.



Status of the ongoing run

- Physics data taking started May. 1st.
Expected until May. 23rd.
- Polarization: $\sim 15\% \rightarrow \sim 30\%$
 \rightarrow running with longitudinal polarization
- Luminosity: 0.15 pb^{-1} accumulated so far within
 $\pm 30\text{cm}$ vertex cut. (goal: 0.5 pb^{-1})
- Spin rotator commissioning
 \rightarrow LocalPol feedback was important
- Fast analysis started
 - study of relative luminosity
 - π^0 cross section and A_{LL}
 - ...

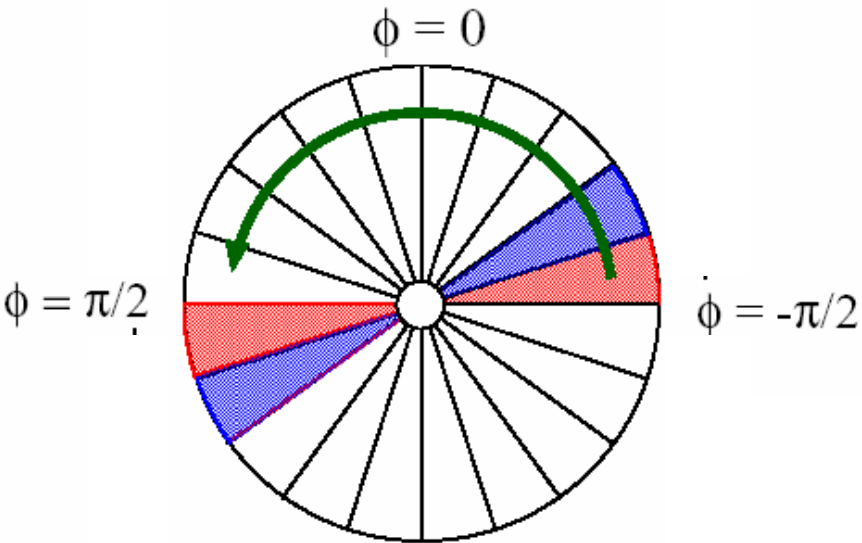
Integrated Luminosity



LocalPol in the present run

- SMD (position) + ZDC (energy)

ϕ distribution



Vertical $\rightarrow \phi \sim \pm \pi/2$

Radial $\rightarrow \phi \sim 0$

Longitudinal

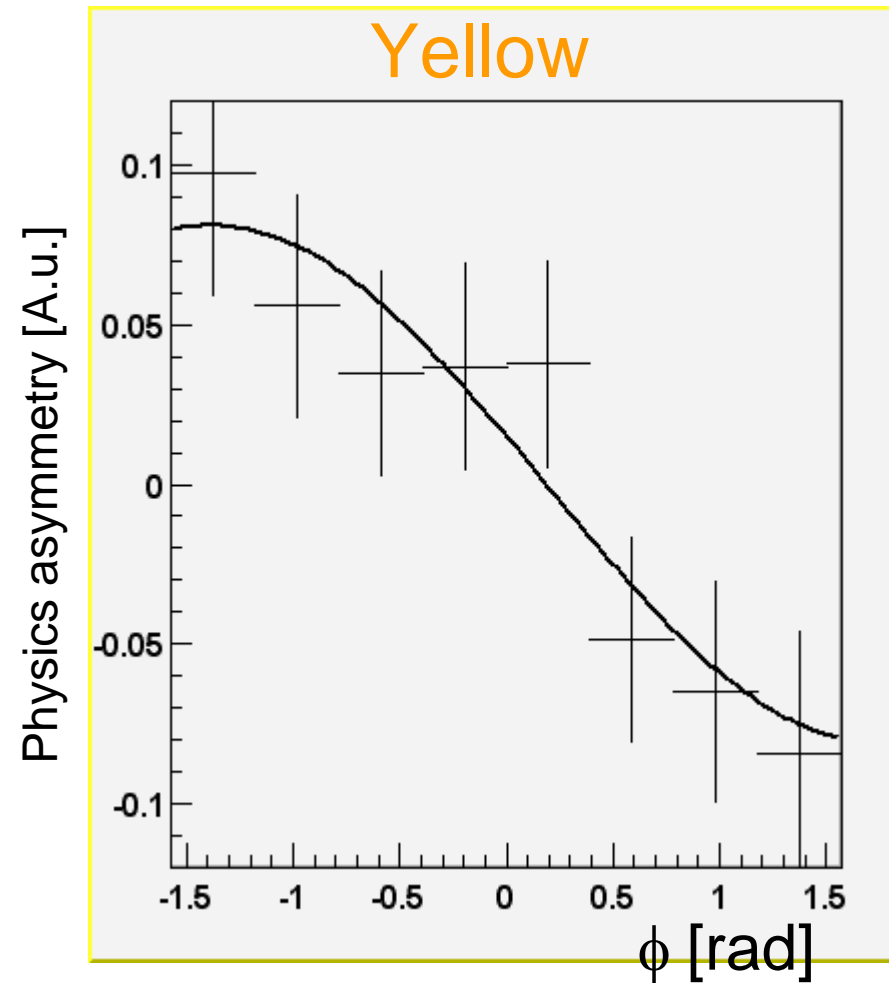
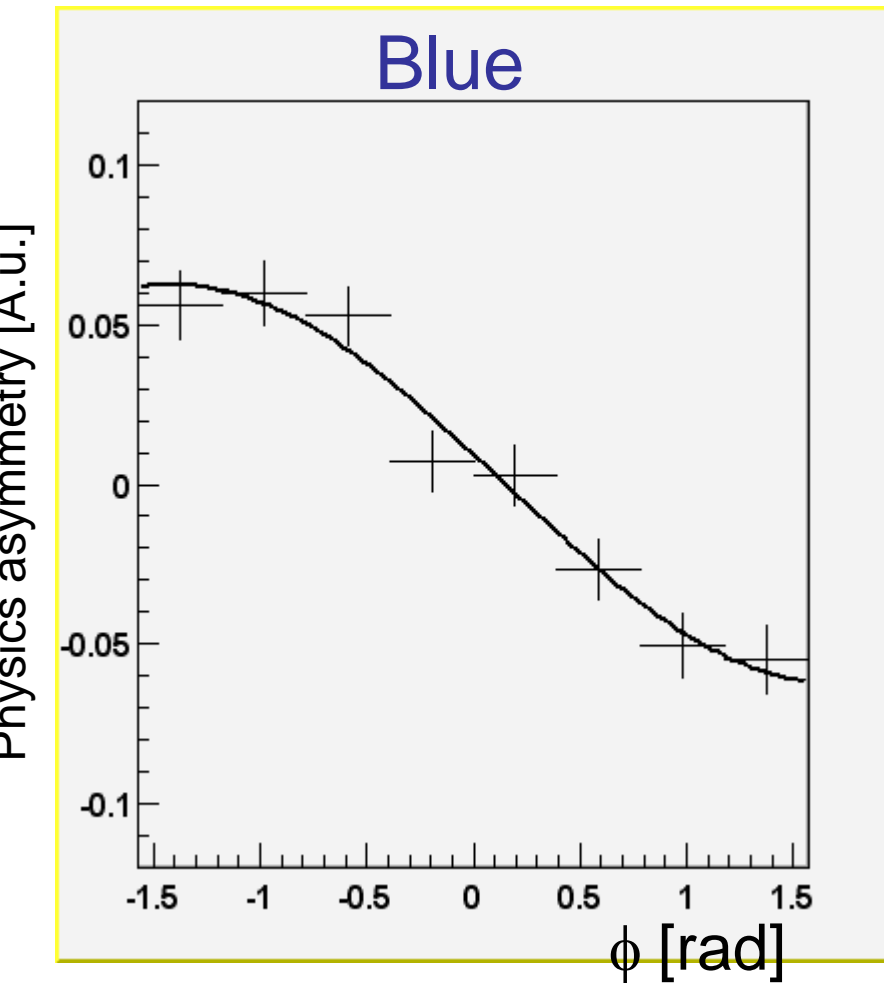
\rightarrow no asymmetry

SMD



ZDC

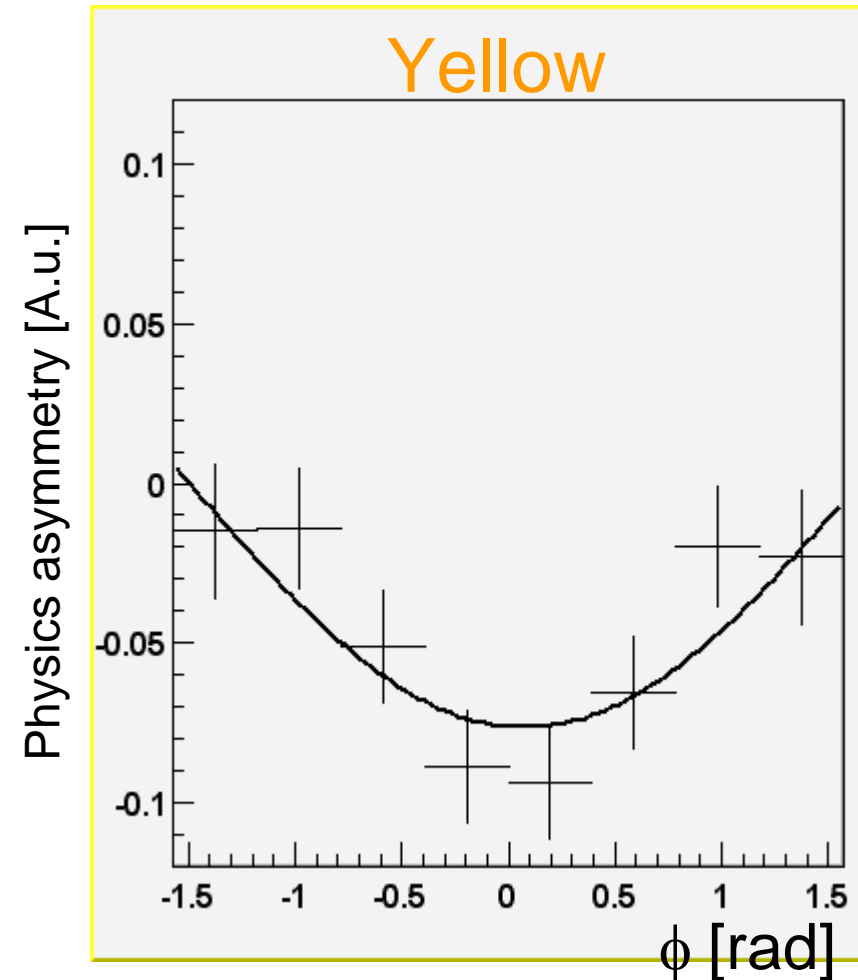
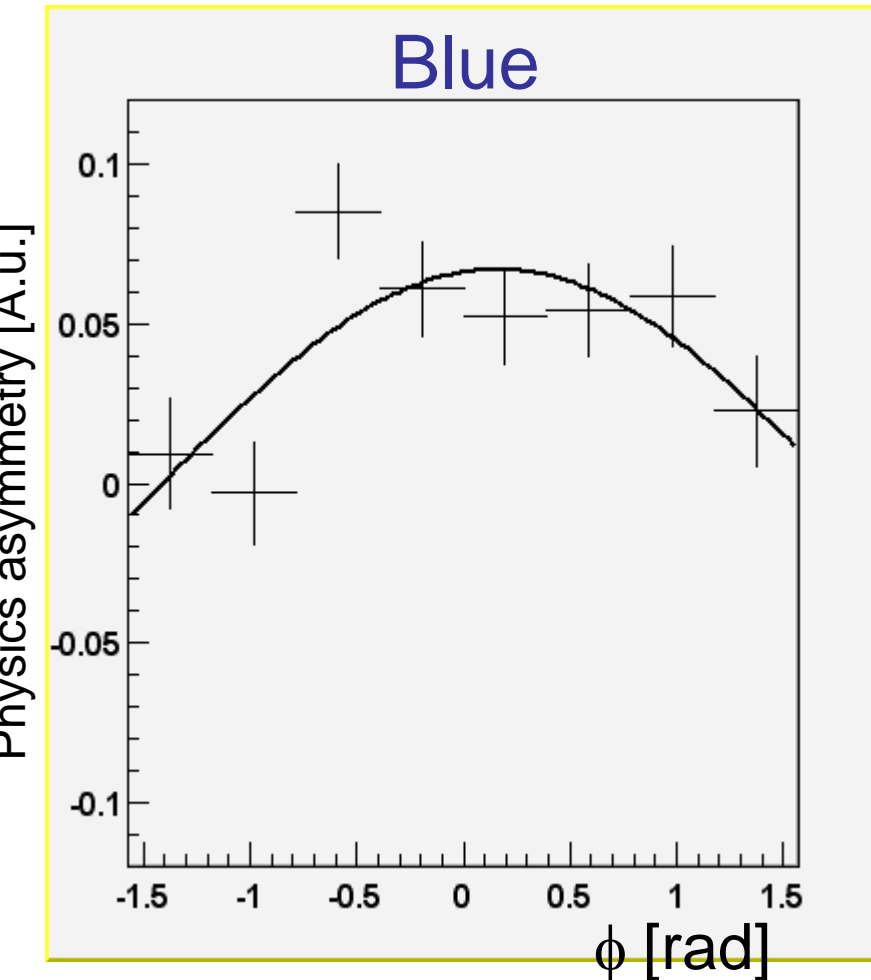
Spin rotator commissioning



Vertical w/ rotator off (Apr.12th)

1st try (Apr 25th)

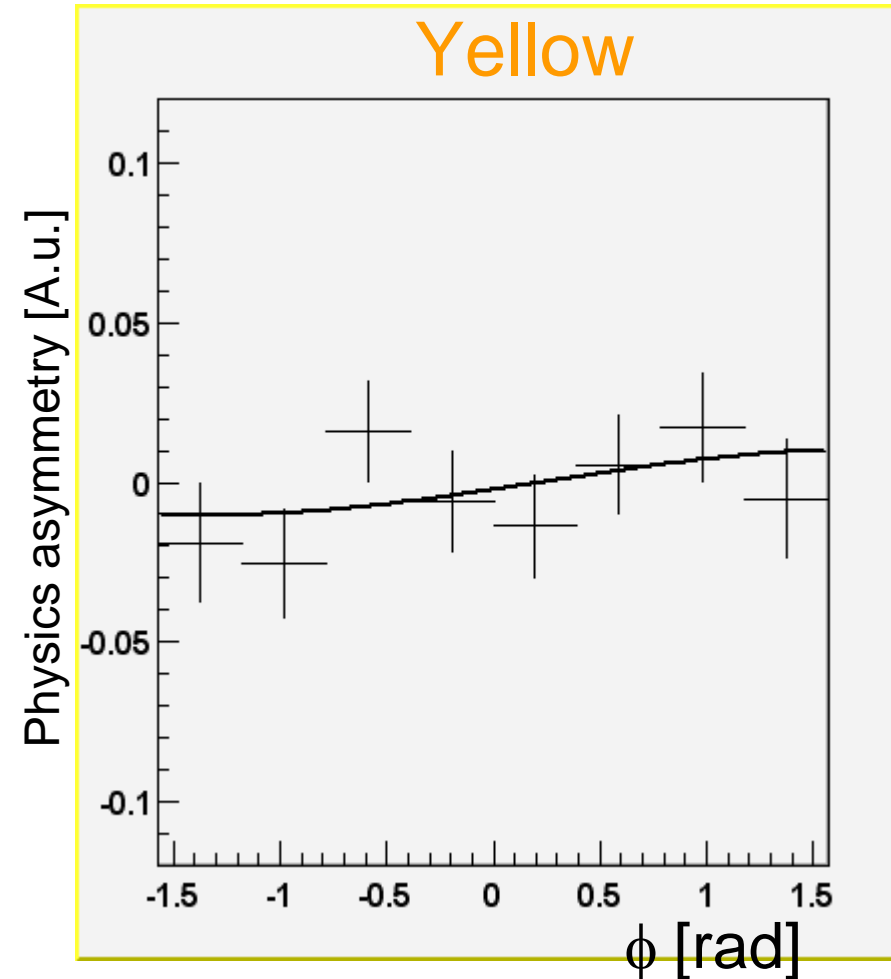
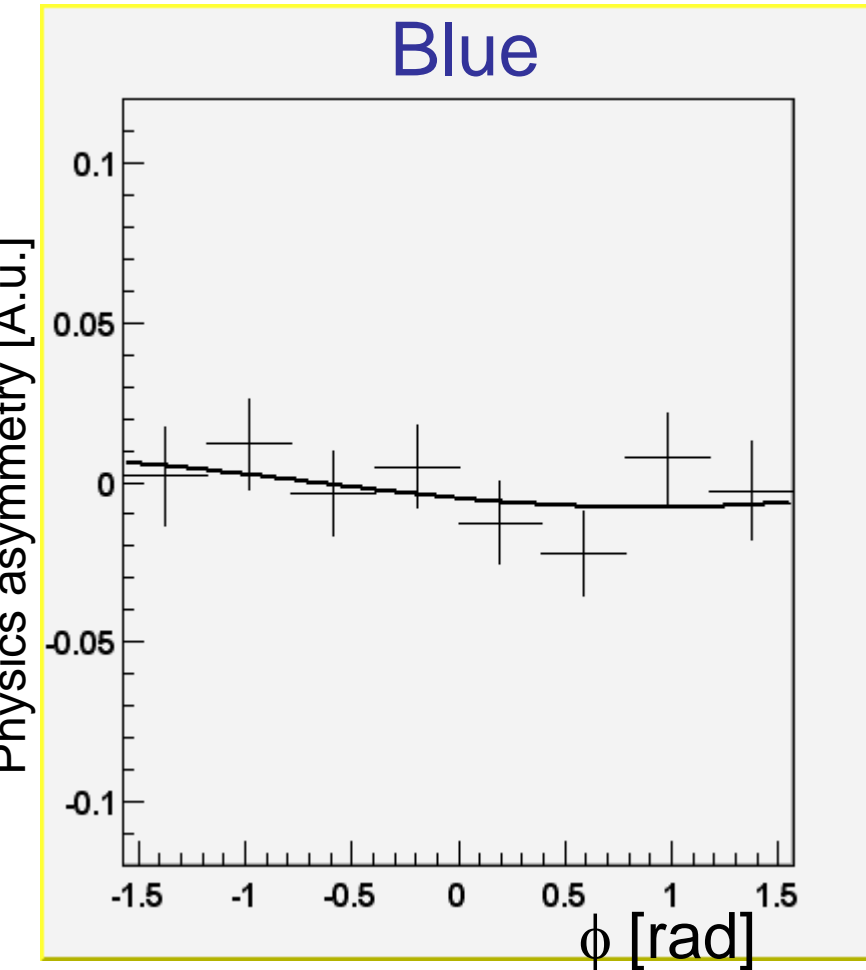
- Vertical polarization → Radial



ratator magnet polarity was wrong

4th try (May. 1st)

- Vertical polarization \rightarrow Radial \rightarrow ... \rightarrow Longitudinal



$P_L/|P|=0.99 \pm 0.01 \rightarrow \text{OK}$

Relative luminosity

$$A_{LL} = \frac{\sigma(++)-\sigma(+-)}{\sigma(++)+\sigma(+-)} = \frac{1}{P^2} \frac{N(++)-RN(+ -)}{N(++)+RN(+ -)}$$

$R = L(++)/L(+ -)$: relative luminosity

- Our Goal: $\delta R/R < 2 \times 10^{-4}$ ($\delta A_{LL} < 2 \times 10^{-3}$)
- Fill by fill measurement

Blue: $+ - + - + - + - \dots$

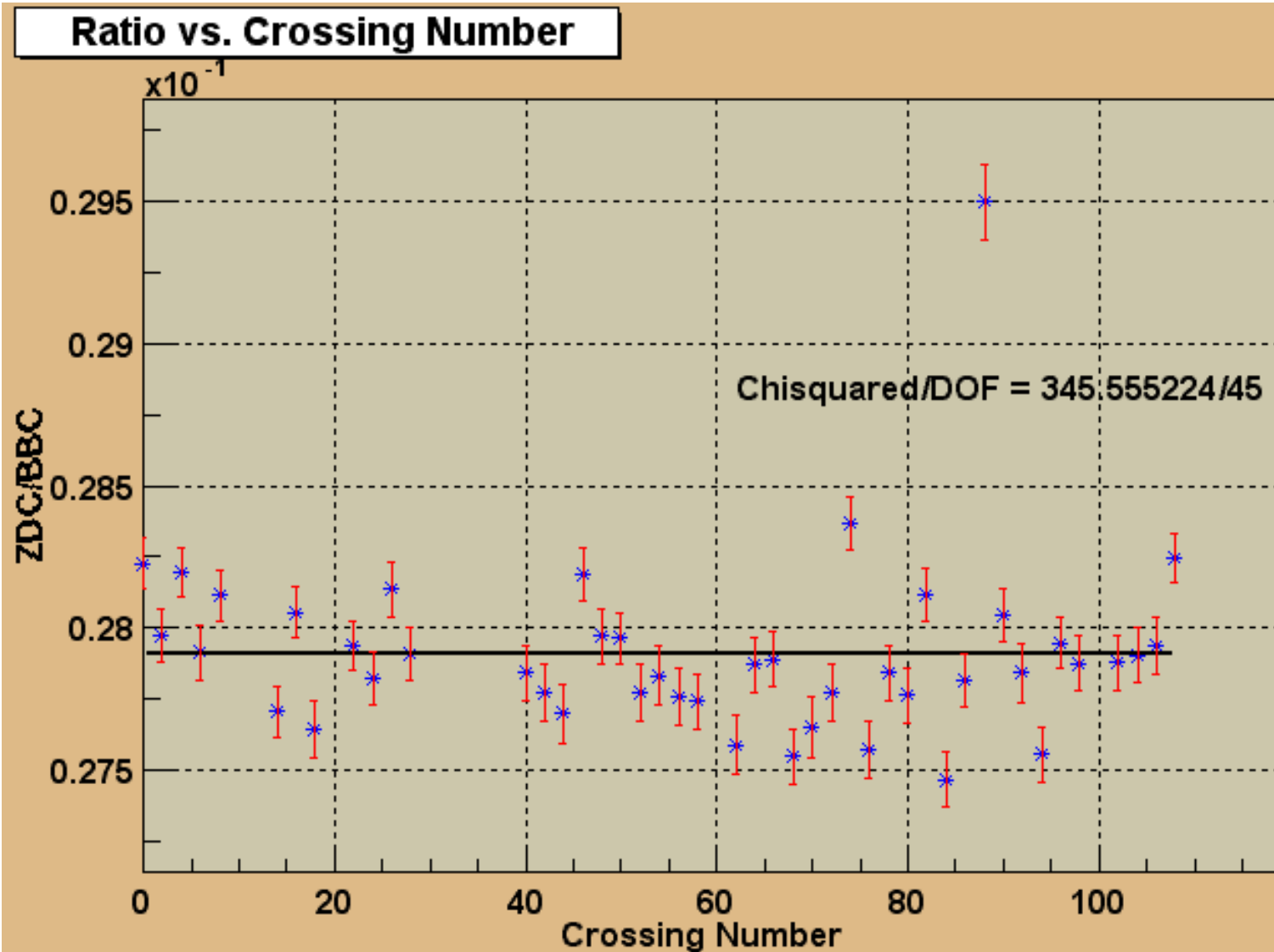
Yellow: $++--++-- \dots$ \rightarrow check within a fill: 1×10^{-3}

- This check was done by taking crossing-by-crossing ratio of two counters,

$$N_A(i)/N_B(i) = L(i)\Omega_A/L(i)\Omega_B = \text{constant}$$

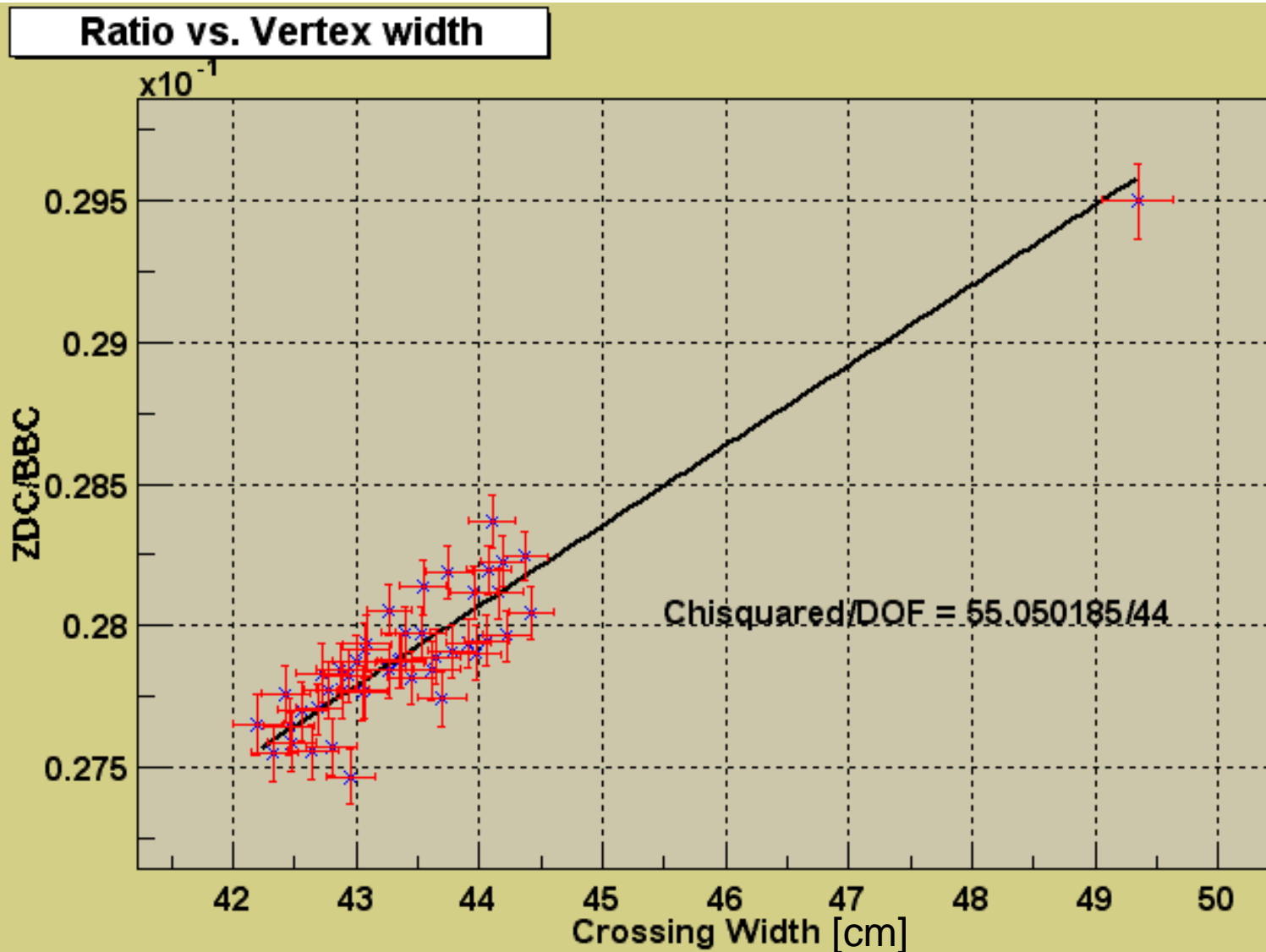
\rightarrow to what extent is this correct?

crossing-by-crossing ratio



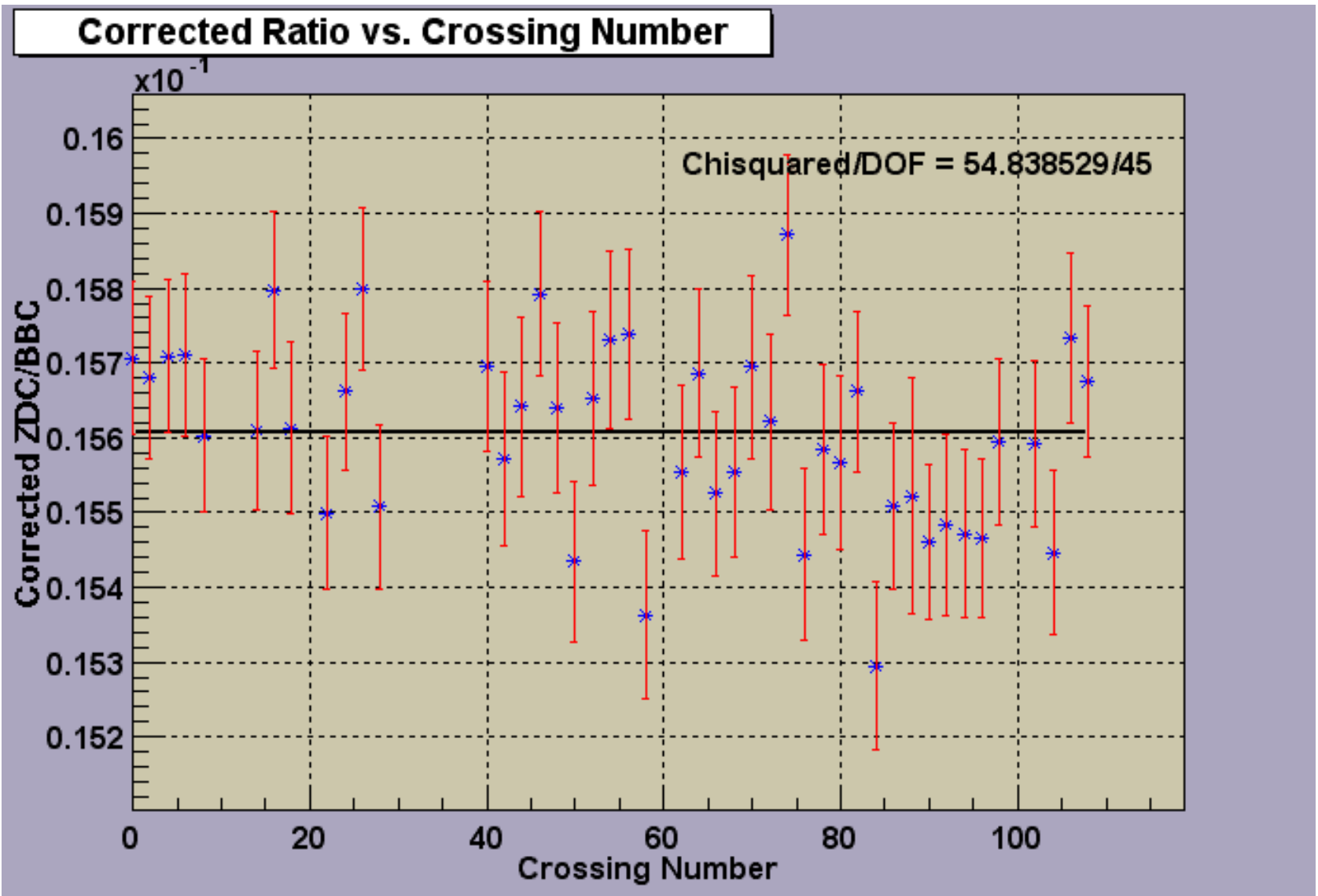
Significant deviation from constant. Why?

Correlation with Z-vertex width



We understand the reason now → correction

After correction

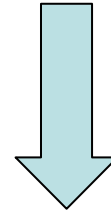
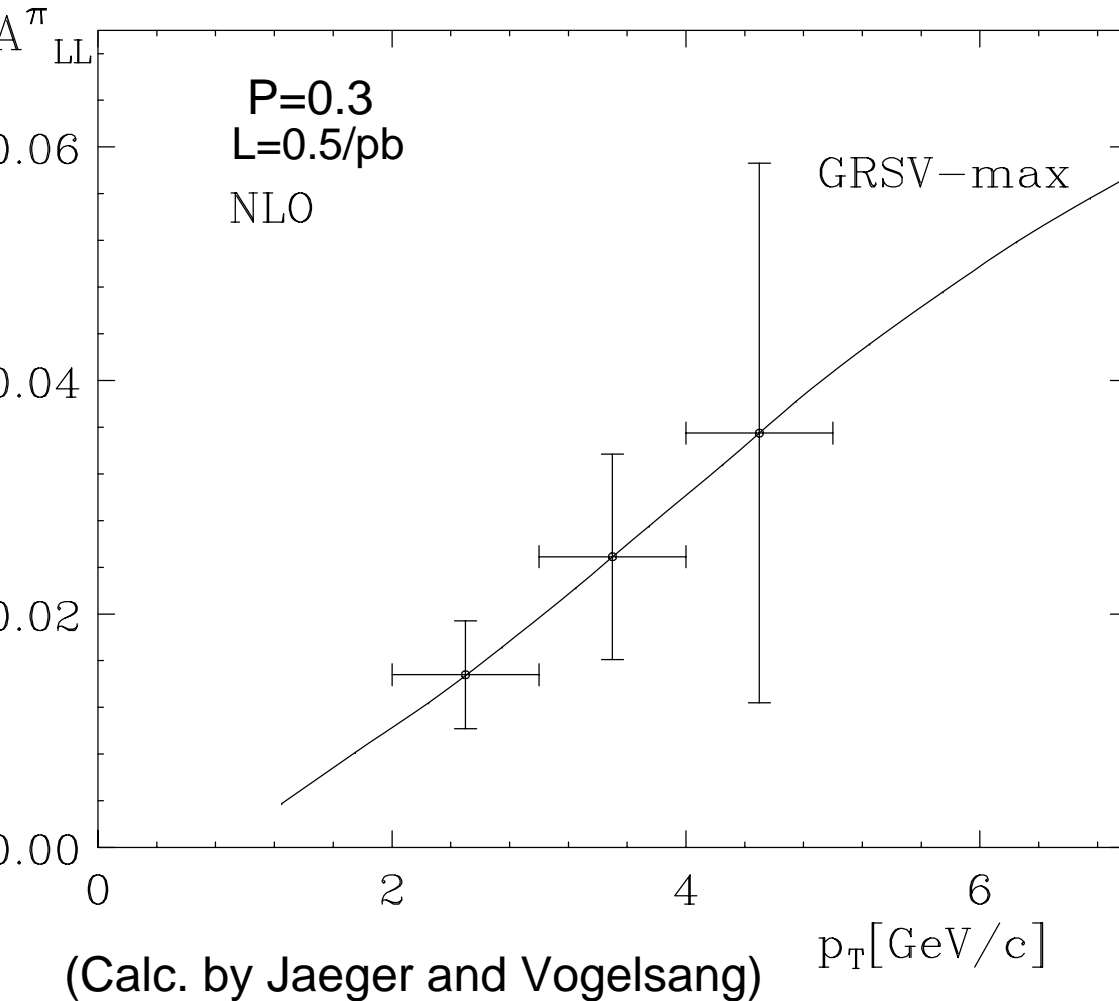


Relative luminosity accuracy < 0.09% (stat. limited)

Expected signal for π^0

- Integrated luminosity goal: 0.5 pb^{-1}

5.6M counts expected for $2.0 < p_T < 3.0 \text{ GeV/c}$

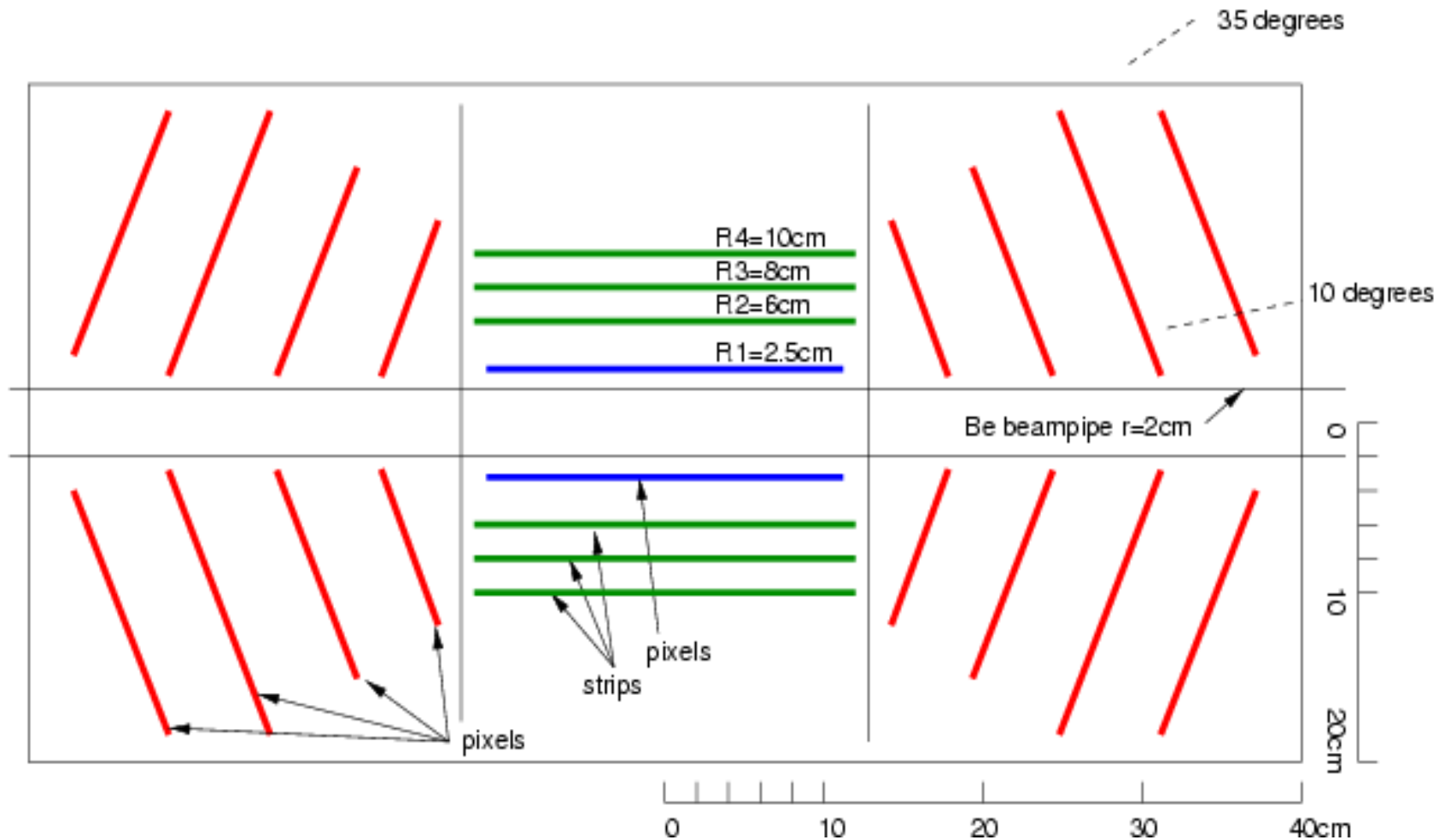


$$\delta A_{LL} = 4.6 \times 10^{-3}$$

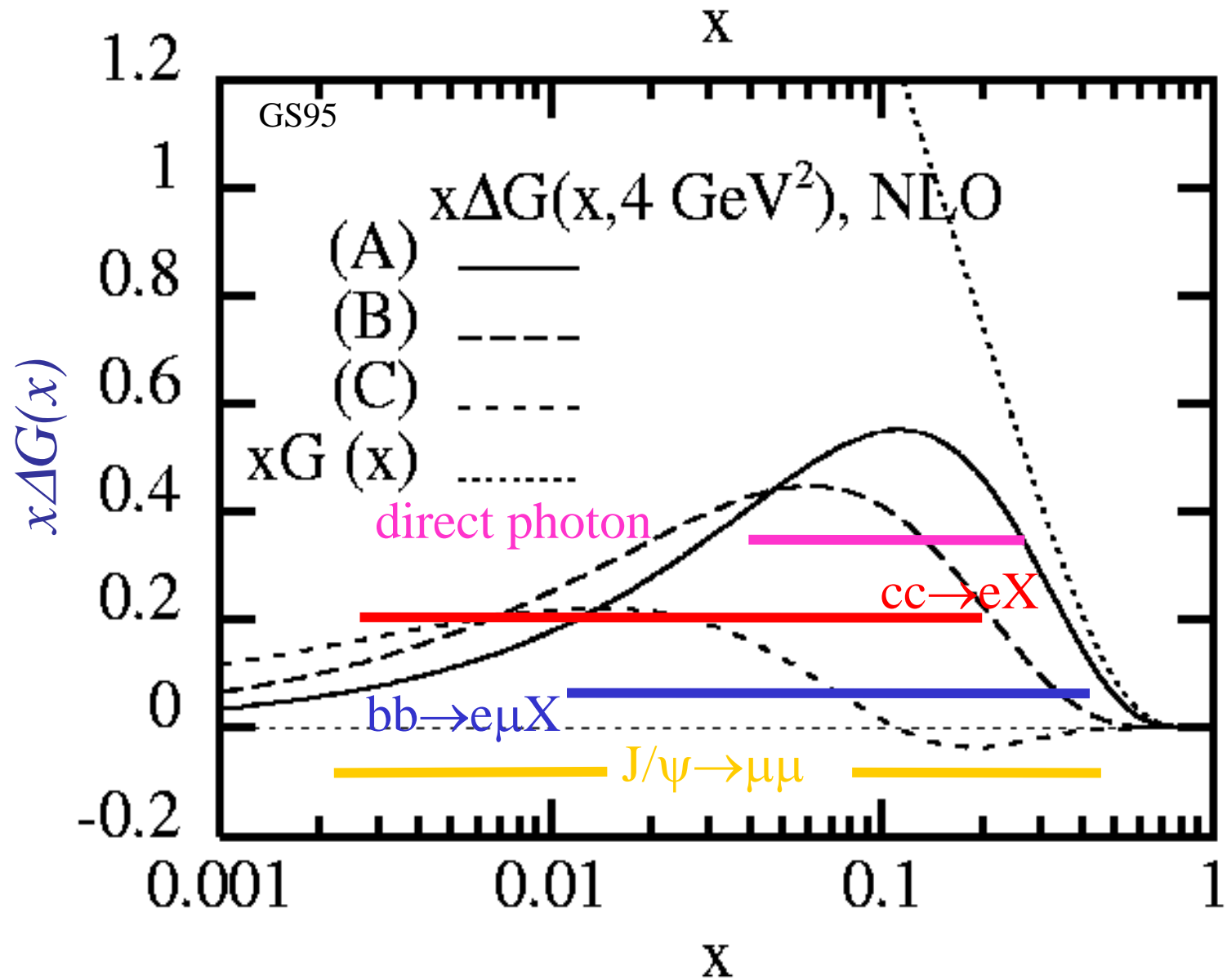
We are sensitive
for large ΔG

Plans for PHENIX upgrade

- Detection of heavy flavors (charm, bottom)
→ Silicon strip/pixel detectors



Extended x region for ΔG measurement



Summary

- Spin physics at PHENIX
 - spin structure (especially gluon) of proton
- 1st run: transverse spin, low luminosity/polarization
- 2nd run: ongoing
 - polarization: ~ 30%
longitudinal spin ← Local Polarimeter confirmed
 - integrated luminosity: 0.15pb^{-1} so far, goal 0.5pb^{-1}
 - at this goal, we have sensitivity for large ΔG
- Future runs [$\sqrt{s} = 200, 500 \text{ GeV}$]:
 - direct photons with higher luminosity
 - heavy flavors, W and more