

Run-8 p+p

**optimizing the goals of the Spin Program
with 6 weeks of p+p**

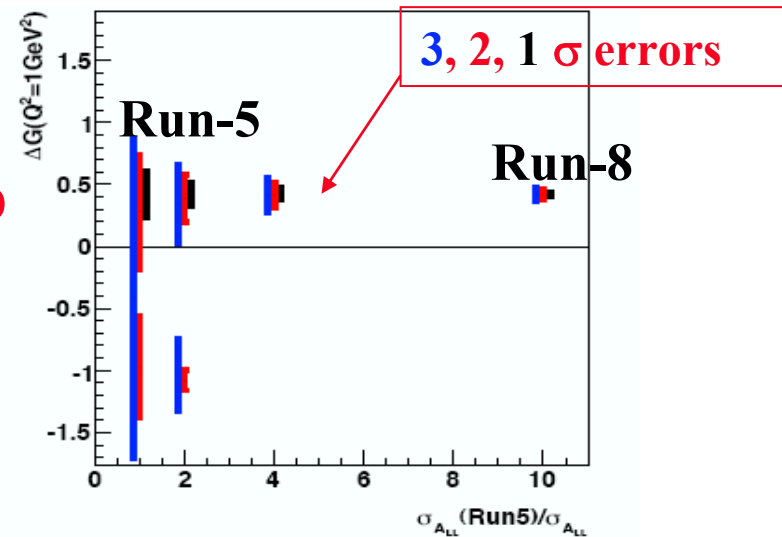
**→ a little more of the same
vs. a first look at something new**

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for the PHENIX Collaboration
January 8, 2008**



Long term goals of PHENIX Spin Program

- **Measure ΔG**
must add $\geq 71 \text{ pb}^{-1}$ 200 GeV p+p
NB: DOE milestone in 2008



- **Precision measurement + flavor separation of $\Delta q(x)$, $\Delta q(x)$ in W-production**
requires 500 GeV polarized p+p
NB: RIKEN milestone for first W observation in 2011



for 6 week run: 500 GeV p+p

- **Best for long-term health of Spin Program**
develop machine, experimental capabilities
allow some new measurement
- **Operational Goals**
 - demonstrate 500 GeV collisions
 - establish 250 GeV polarimetry in both p-C and H-Jet polarimeters
 - develop new EMCAL gains
- **Physics goals (3 pb⁻¹/week recorded, P = 0.5)**
 - measure cross section for neutral pions & photons
compare to pQCD, publish!
 - first look at $W \rightarrow e\pm$
 - measure J/ψ and Y
 - first look at muon backgrounds for W



some numbers

- **assumptions**

 - 2 weeks machine setup + studies at 200 GeV**

 - 1 week machine setup at 500 GeV**

 - 2 weeks “physics” includes some experiment setup time
projections for 1 week of data taking**

- **performance**

 - 3 pb⁻¹/week recorded**

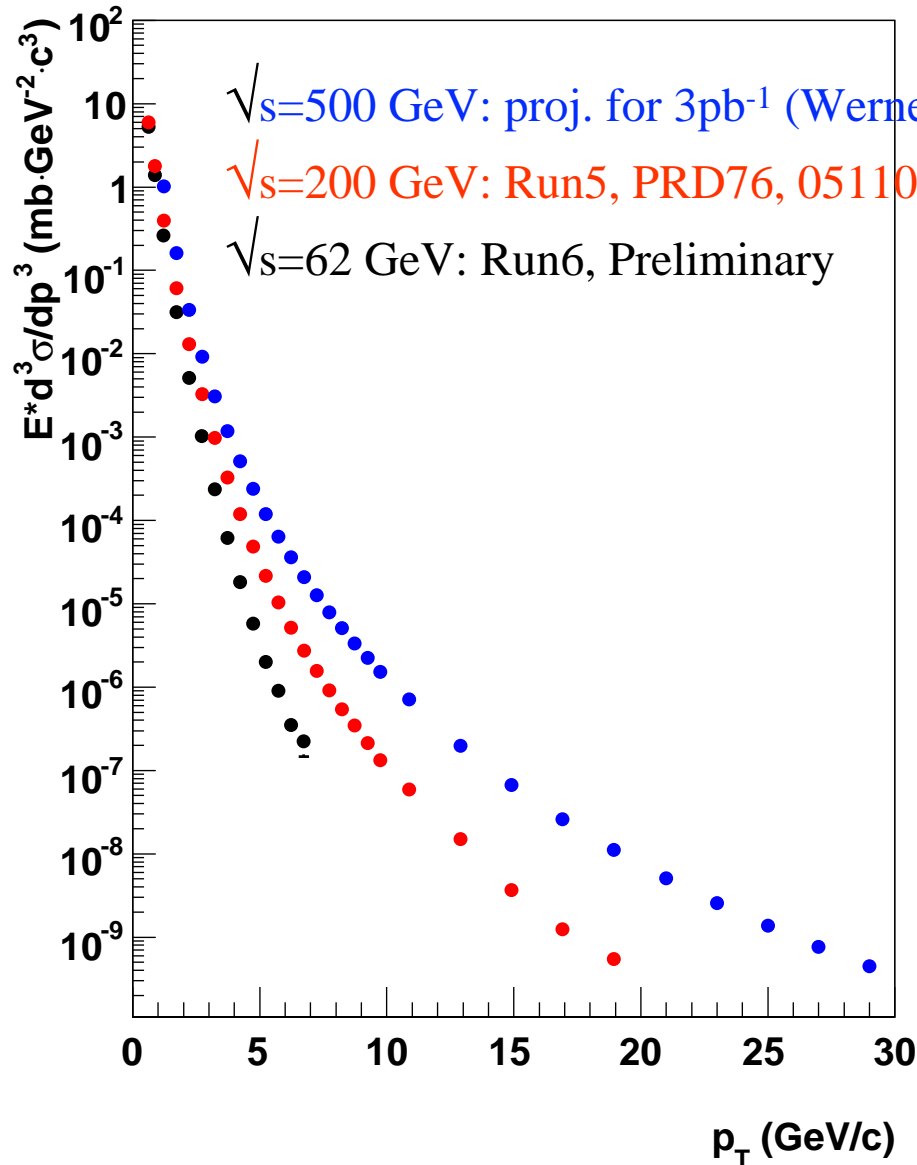
 - 200 GeV luminosity x 2.5 for emittance shrinkage**

 - with “efficiency factor” = 25%**

 - Polarization = 0.5**



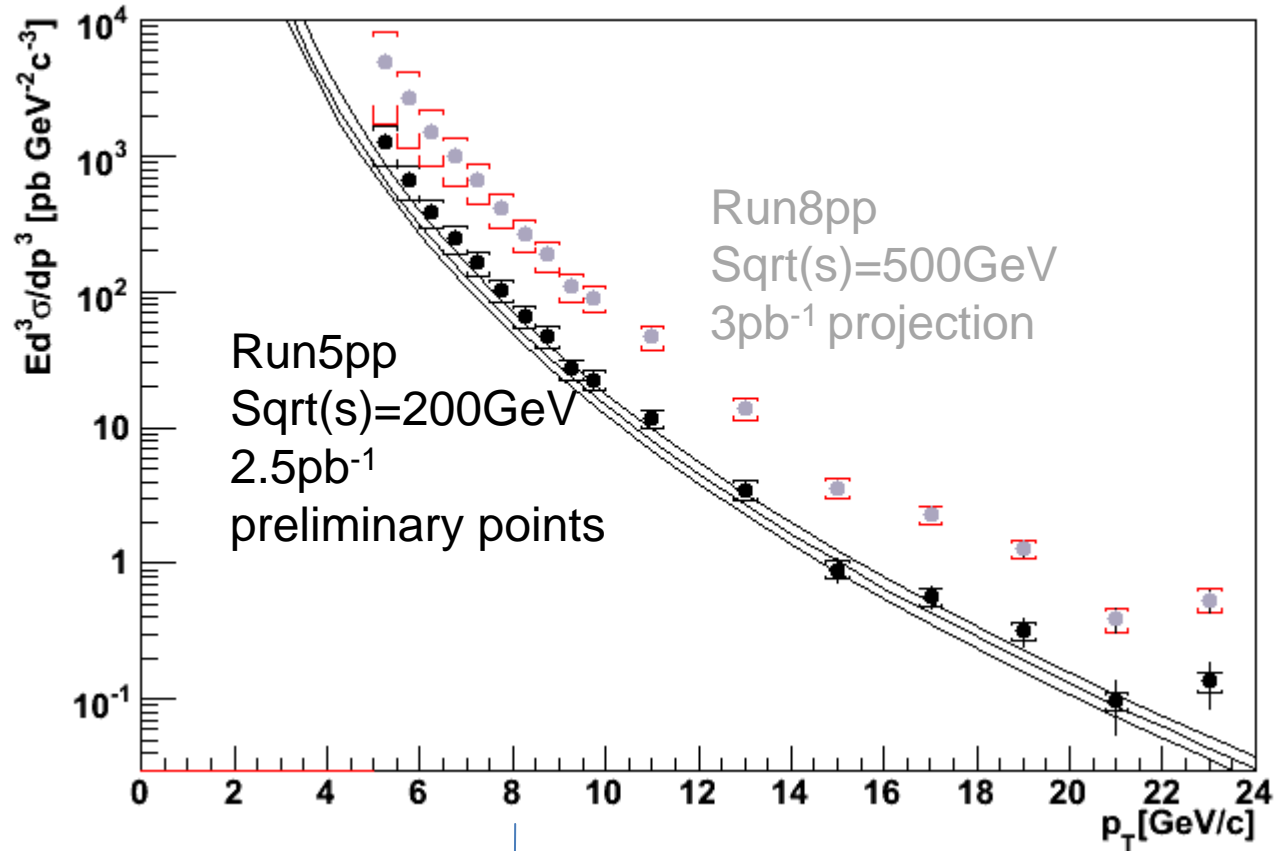
$\sqrt{s}=500$ GeV: π^0



**Projection for
1 week of data taking
error bars < symbol size**

- *Cross section measurements up to $p_T \sim 30$ GeV/c*
- *pQCD test*
- *x_T scaling test*

$\sqrt{s}=500$ GeV: direct γ



Projection for 1
week of data
taking

Signal to (signal+background)
ratio may be less than 15%.

For higher p_T ,
We need to study
merged π_0 contribution
more carefully.

$\sqrt{s}=500$ GeV: heavy quarkonium

(COM + CTEQ PDF calculations)

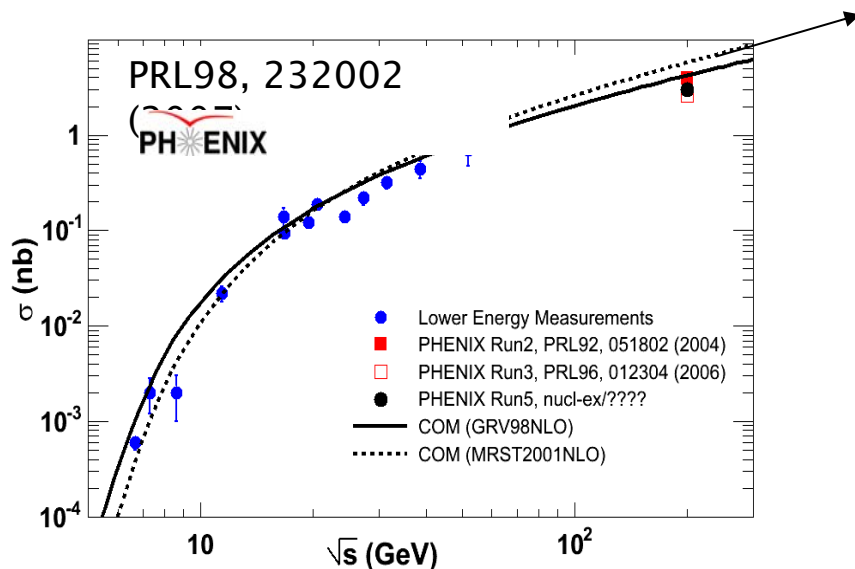
• J/Psi expectation

Same arm dimuons; scale run-5

$$\sigma(J/\psi) = 2x \sigma(200 \text{ GeV}) = 5.2 \mu\text{b}$$

$$1.2 < |\eta| < 2.4$$

$$16\text{K } J/\psi \rightarrow \mu+\mu^- \text{ for } 3 \text{ pb}^{-1}$$



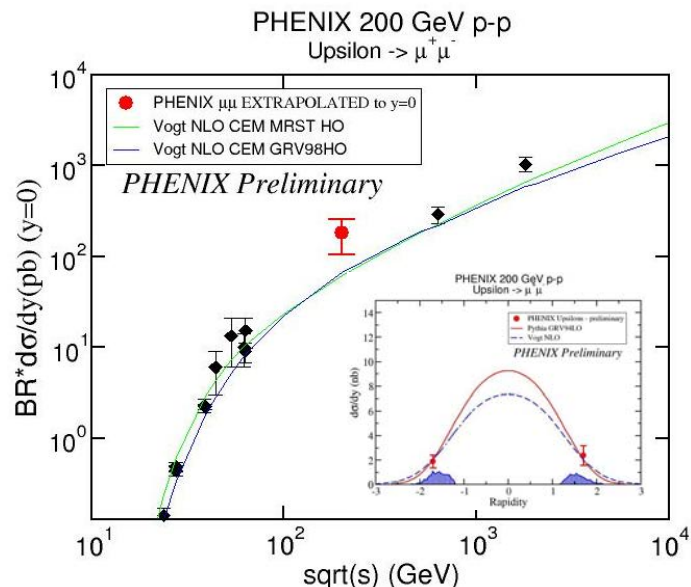
• Upsilon expectation

Same arm and back-to-back dimuons

$$\sigma(Y) = 2x \sigma(200 \text{ GeV}) = 4 \text{ nb}$$

$$4 \text{ nb} \times 2.2\%(\text{BR}) \times \text{accept} \cdot \text{eff} \rightarrow 5 Y \text{ pb}^{-1}$$

$$15 Y \rightarrow \mu+\mu^- \text{ for } 3 \text{ pb}^{-1}$$



Projection for 1 week of data taking

$\sqrt{s}=500$ GeV: $W \rightarrow e$

RHICBOS MC:

~ 20 W^+ and 3 W^- / pb^{-1} in PHENIX Central Arm ($W \rightarrow e$)

1 week (**3 weeks**) of physics: recorded 3 pb^{-1} (**9 pb^{-1}**) with $P=0.5$

✓ ~ 60 (**180**) W^+ \Rightarrow cross section measurement

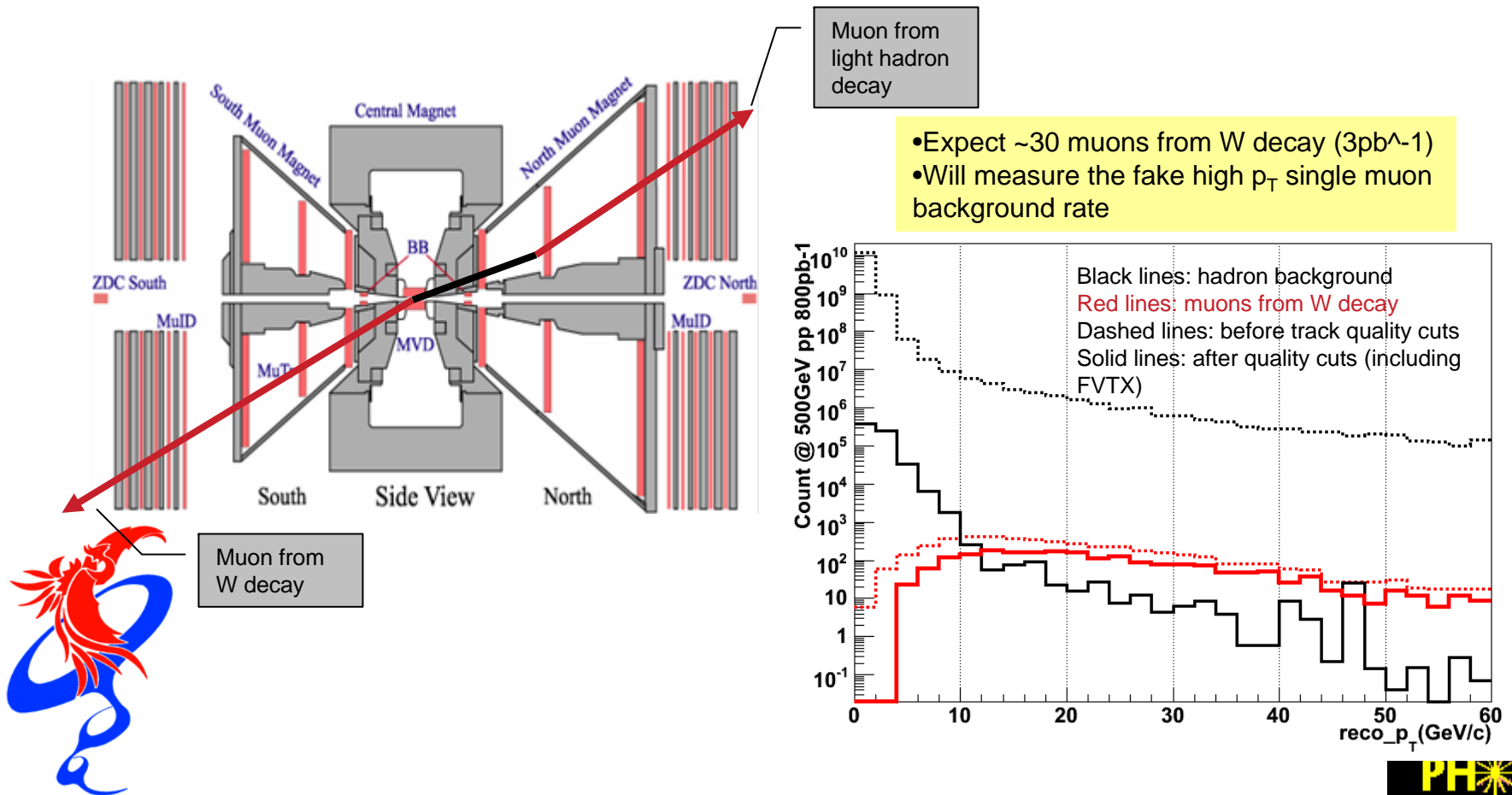
PV asymmetry expectation $A_L \sim 0.25-0.40$;

statistical $\delta(A_L) \sim 0.18$ (**0.10**), based on event generator



$\sqrt{s}=500 \text{ GeV}: W \rightarrow \mu$

- Many fake high p_T tracks due to muons from light hadron decays inside the tracker.
- Critical to study how to reduce this background for W measurements.



200 GeV p+p in Run-8?

- **assume: 1.2 pb⁻¹/week recorded, P = 0.5**
3-4 weeks data taking → 3.6 – 4.8 pb⁻¹
insufficient to impact A_{LL} goal
- **how about transversely polarized running?**
 - **forward physics with MPC**
 π^0 in both MPC's, but don't see how to
add anything compelling to existing knowledge
 - **charged pion single spin asymmetry**
Run-6 2.5 pb⁻¹ is currently being analyzed
 - **Sivers, Interference Fragmentation Function**
some numbers follow



$\sqrt{s}=200$ GeV: Sivers

- **Central-Central correlations**
 - Run-6 analysis uses 1.9 pb^{-1}
 - ERT triggers
 - Run-8 expects 2.4 pb^{-1} sampled (2 week projection)
 - Not really much of a help
- **Central-Muon correlations**
 - Run-6 analysis uses 1D muon triggers
 - New for Run-8 – “1H” hadron trigger
 - Should be a better jet trigger
- **No good argument for central-central correlations**
 - Sensitivity is still below STAR’s PRL99, 142003

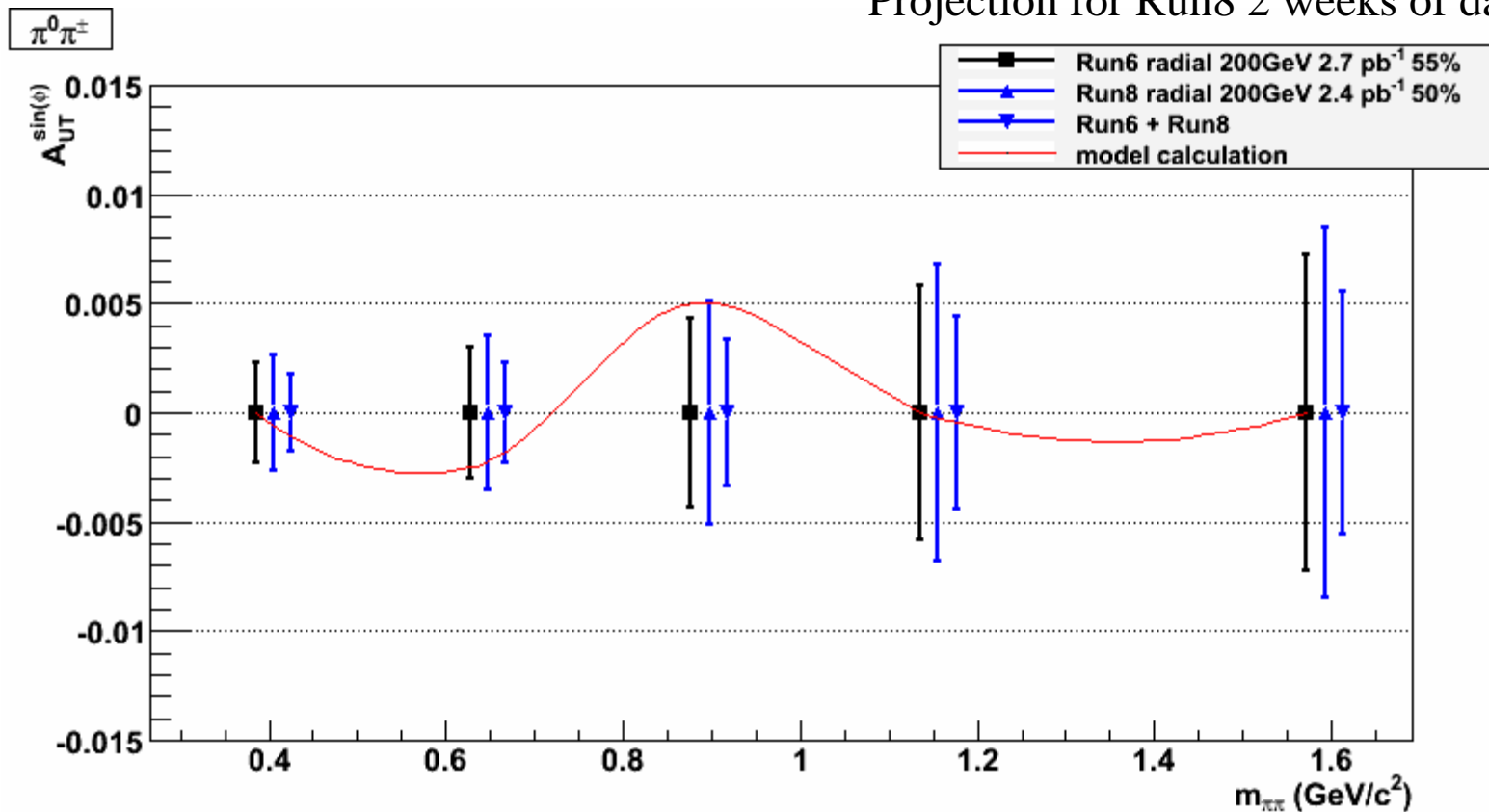
\therefore Only benefit: central-muon correlations

 - 1H trigger adds benefit beyond additional statistics
 - Needs more study to quantify improvement
 - Not compelling reason for 200 GeV running



$\sqrt{s}=200$: Interference Fragmentation Fn.

Projection for Run8 2 weeks of data taking



Estimate of asymmetries based on:

- ✓ Transverse distribution from global analysis: Anselmino et al hep-ph/0701006
- ✓ Interference Fragmentation Function (IFF) modeled by Tang/Jaffe: PRL 80 (1998) 166

Summary

- **PHENIX Spin physics goals**
best addressed by 6 weeks of p+p at 500 GeV
- **Driven by where the compelling measurements are**
- **200 GeV goals Spin starved for luminosity**
not possible to address in Run-8, without 9MHz cavity
so, let's provide opportunity for some new
measurements by running at 500 GeV
- **How about splitting the time?**
we are happy to switch over to p+p earlier than Feb.1!
need ≥ 2 weeks physics running at 500 GeV
usable 200 GeV run would also need ≥ 2 weeks physics
this would imply 7 weeks of p+p! seems unlikely

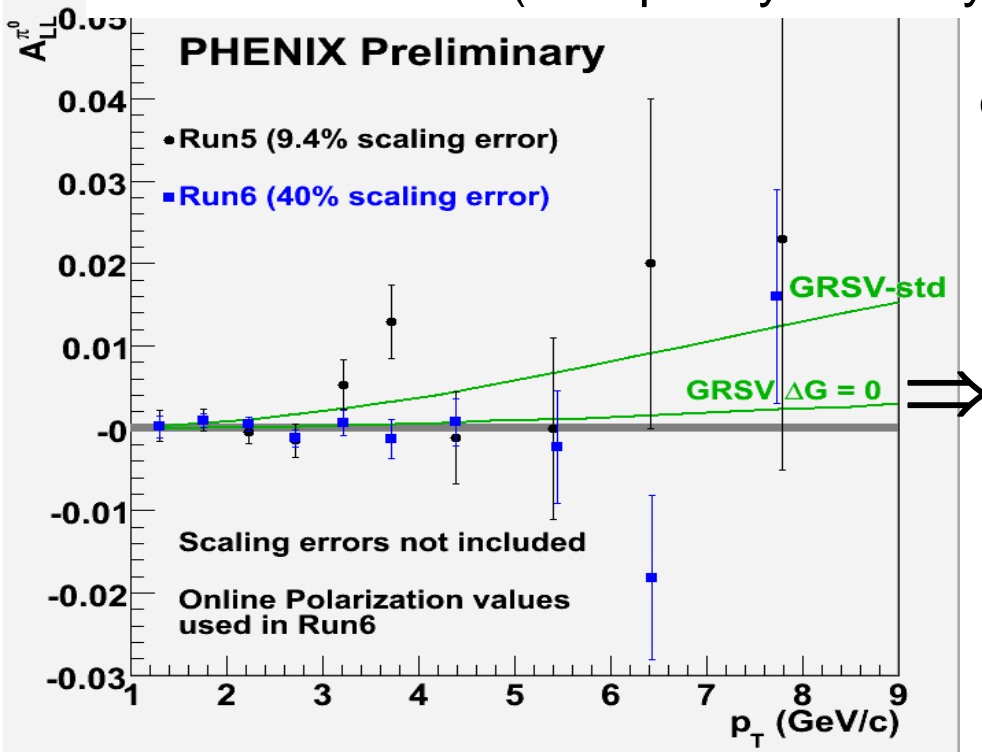


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- **backup slides**

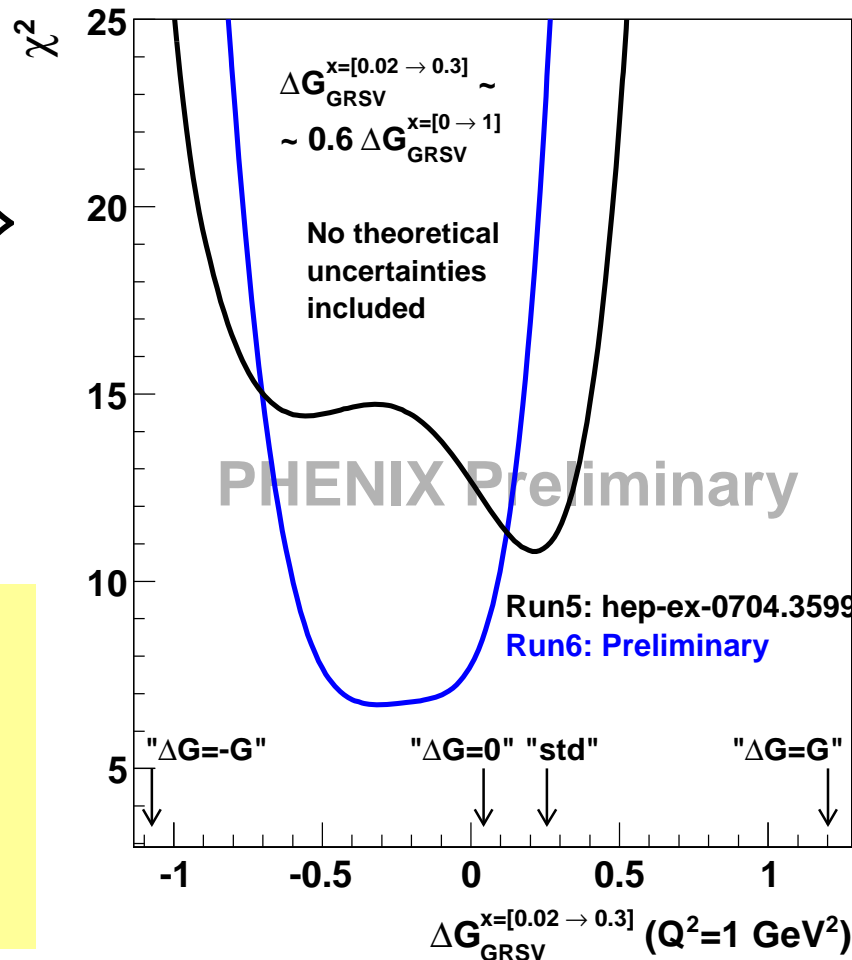


Spin: the surprises continue!

arXiv 0704.3599 (accepted yesterday)



Calc. by W.Vogelsang and M.Stratmann



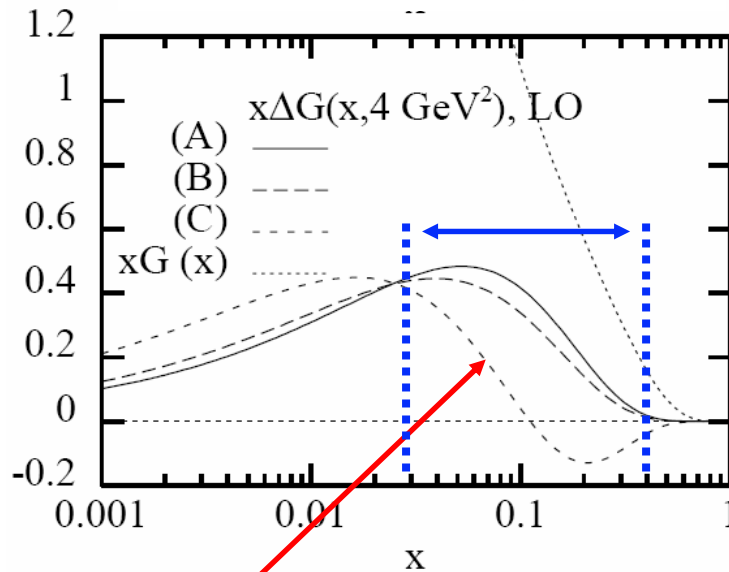
“std” scenario, $\Delta G(Q^2=1\text{ GeV}^2)=0.4$, is excluded by data on >3 sigma level:

$$\chi^2(\text{std}) - \chi^2_{\min} > 9$$

✓ **Uncertainties from functional from $\Delta G(x)$ are not included. Reducing these requires measure at lower x .**

node or no node?

Gehrmann-Stirling models

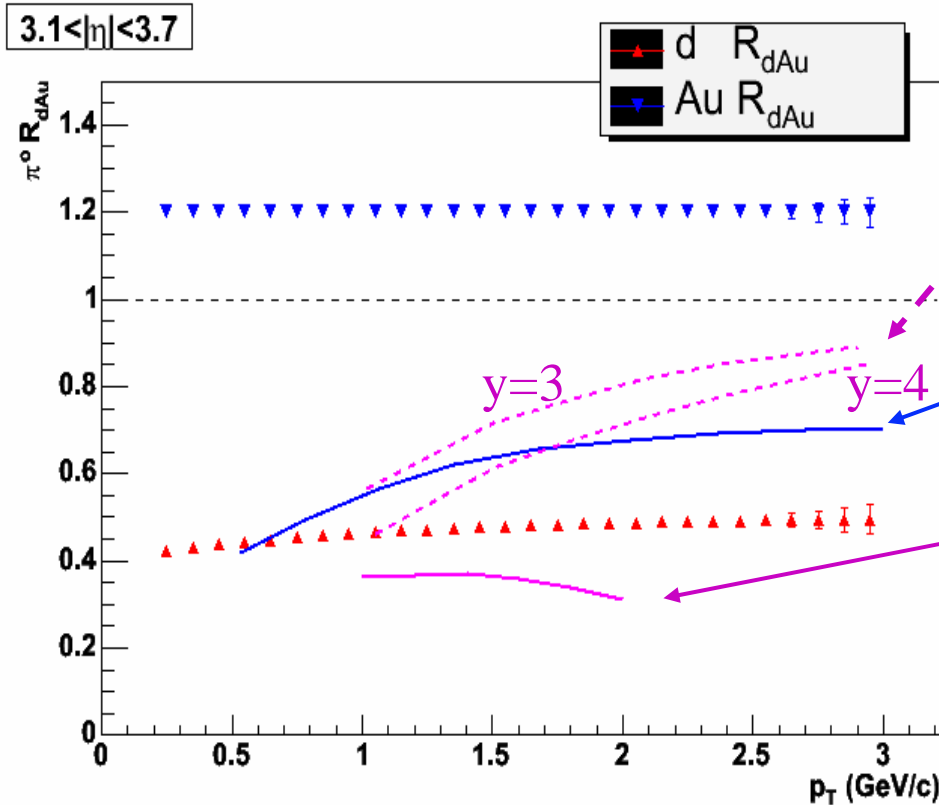


will be useful
to run at
lower \sqrt{s}

- GSC: $\Delta G(x_{\text{gluon}} = 0 \rightarrow 1) = 1$
 $\Delta G(x_{\text{gluon}} = 0.02 \rightarrow 0.3) \sim 0$
- GRSV-0: $\Delta G(x_{\text{gluon}} = 0 \rightarrow 1) = 0$
 $\Delta G(x_{\text{gluon}} = 0.02 \rightarrow 0.3) \sim 0$
- GRSV-std: $\Delta G(x_{\text{gluon}} = 0 \rightarrow 1) = 0.4$
 $\Delta G(x_{\text{gluon}} = 0.02 \rightarrow 0.3) \sim 0.25$



forward π^0 R_{dAu} with the MPC

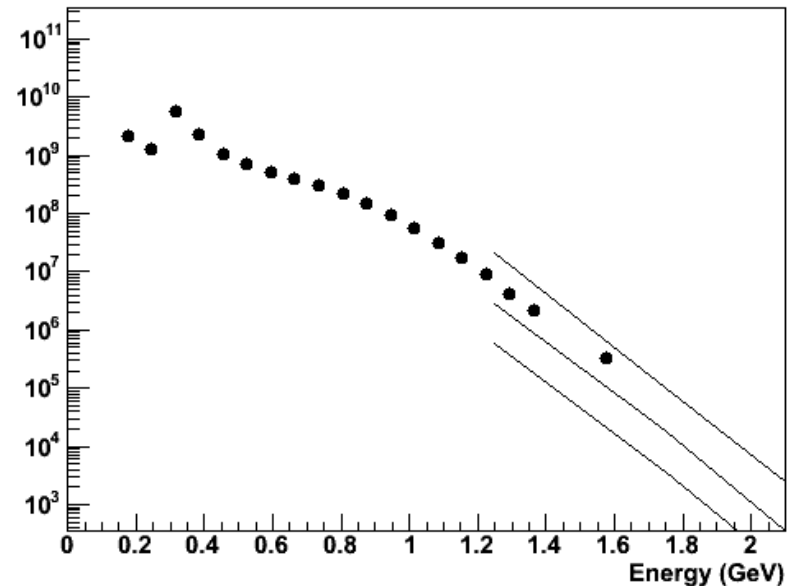


Qiu/Vitev, PLB 632, 507 (2006)
coherent multiple scattering

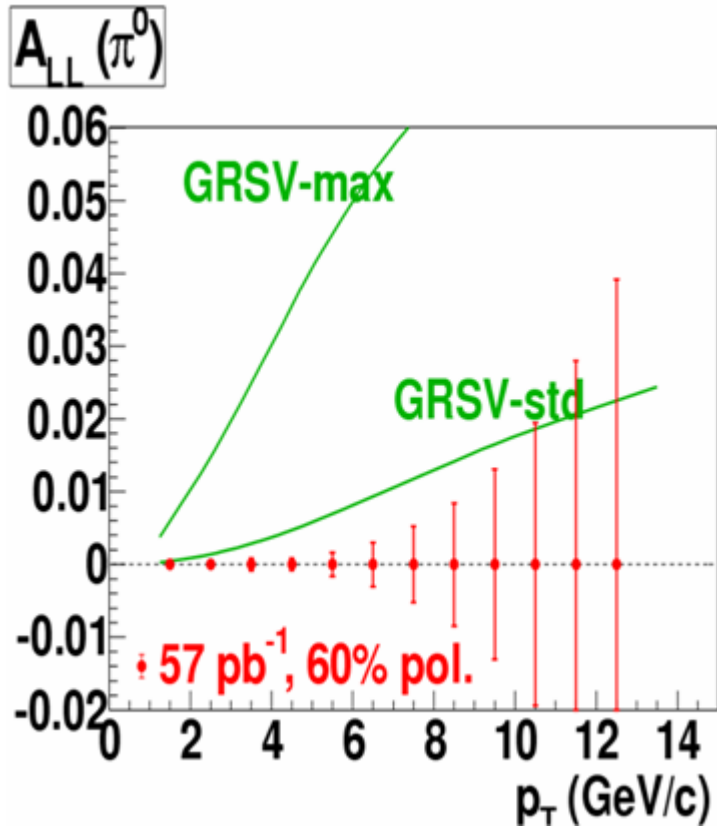
Kharzeev, et al, PLB599
CGC

Vitev, hep-ph/0609156
+ initial state energy loss

π^0 spectrum
in MPC south



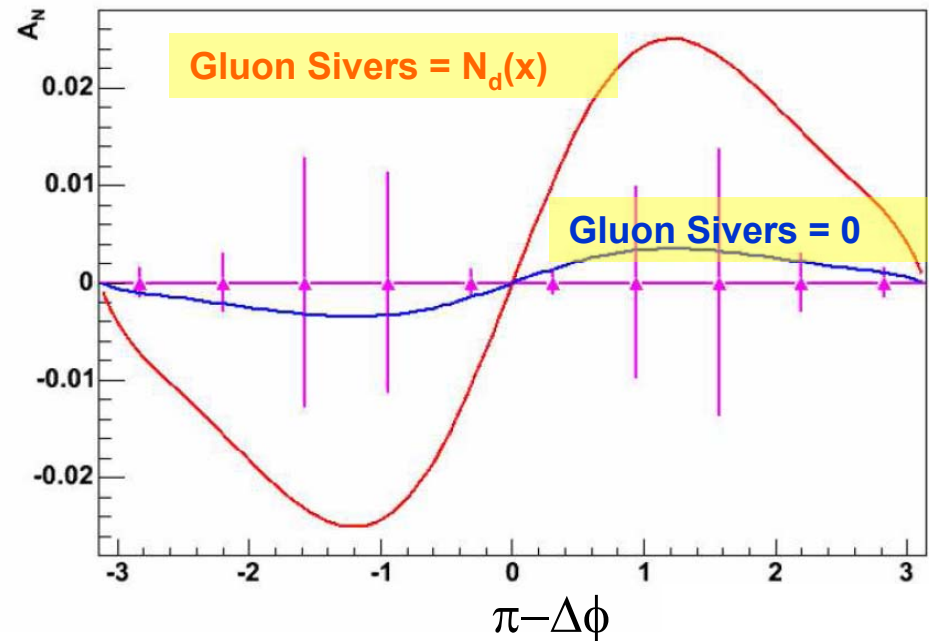
From our previous Run-7 request



approximately
what's expected
for Run-8

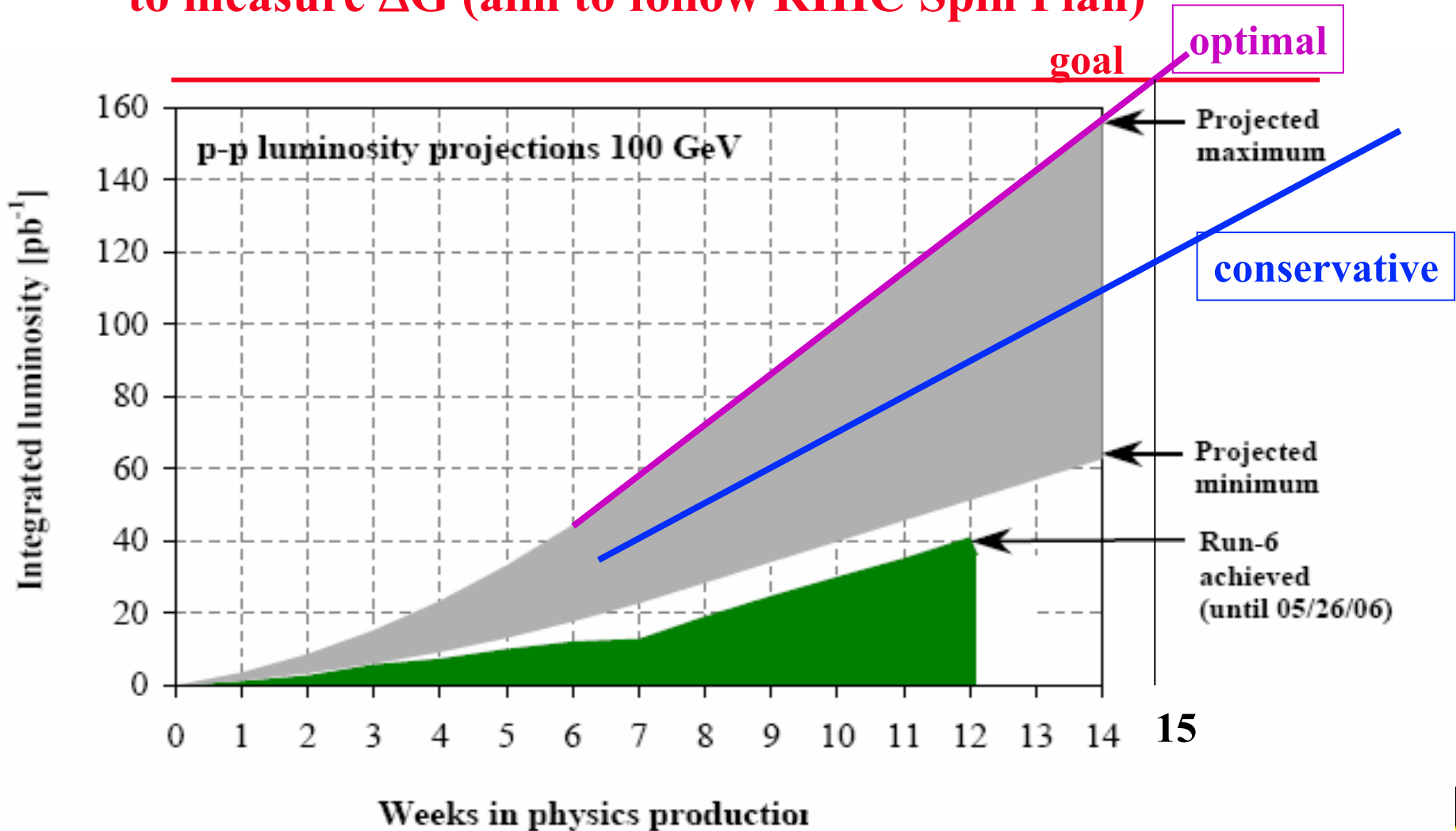
for 2.7 + 6.0 pb^{-1} transverse
pol. recorded (<Run-8)
di-hadron (+ singles)
measurement

[Boer and Vogelsang, hep-ph/0312320](#)



Run-8 polarized p+p

- 71 pb⁻¹ recorded (167 delivered)
to measure ΔG (aim to follow RHIC Spin Plan)

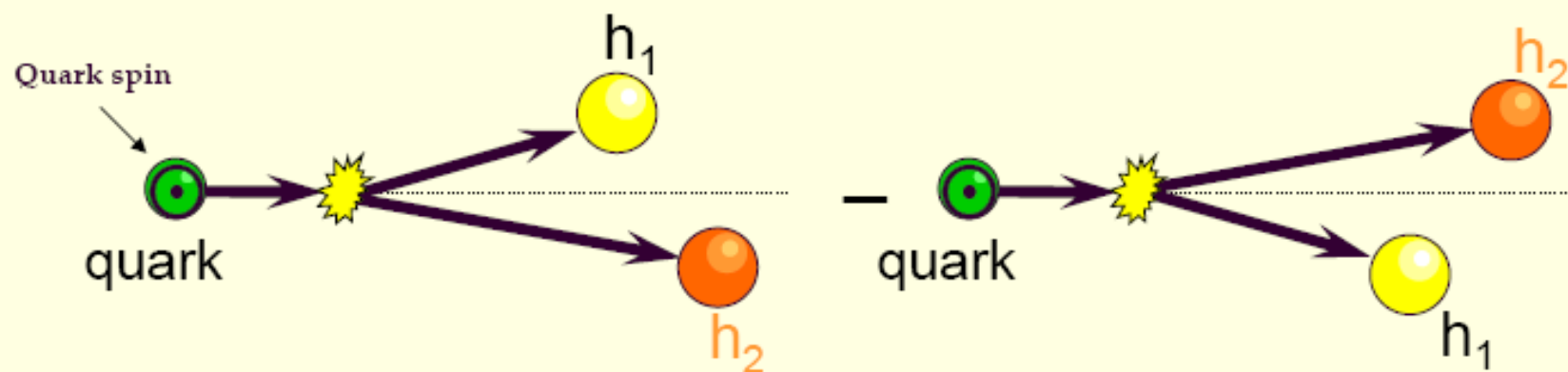


Comparison of IFF and Collins FF

Interference fragmentation function $H_1^{\triangleleft}(z, M_{\pi\pi}^2)$

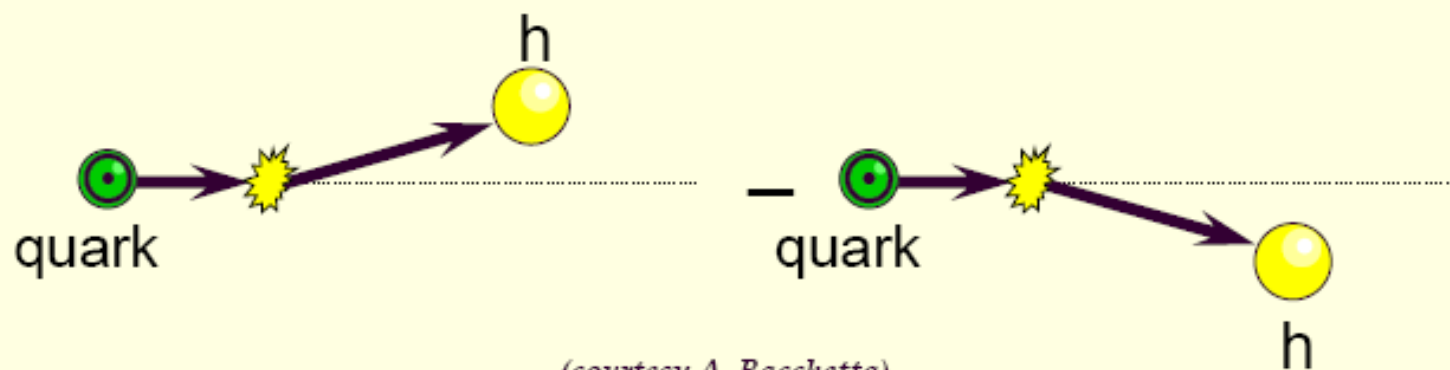
J. Collins S.Heppelmann, G. Ladinsky, Nuclear Physics B, 420 (1994) 565

R. Jaffe, X. Jin, J. Tang, Physical Review Letters, 80 (1998) 1166



Collins fragmentation function H_1^{\perp}

J. C. Collins, Nucl. Phys. B396, (1993) 161



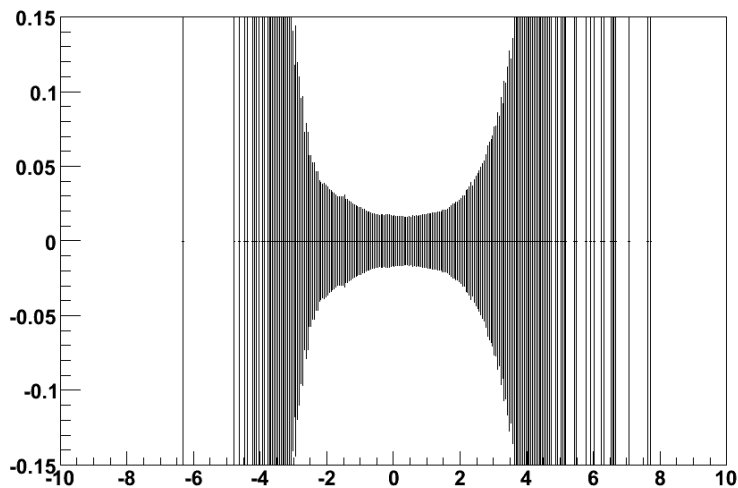
(courtesy A. Bacchetta)



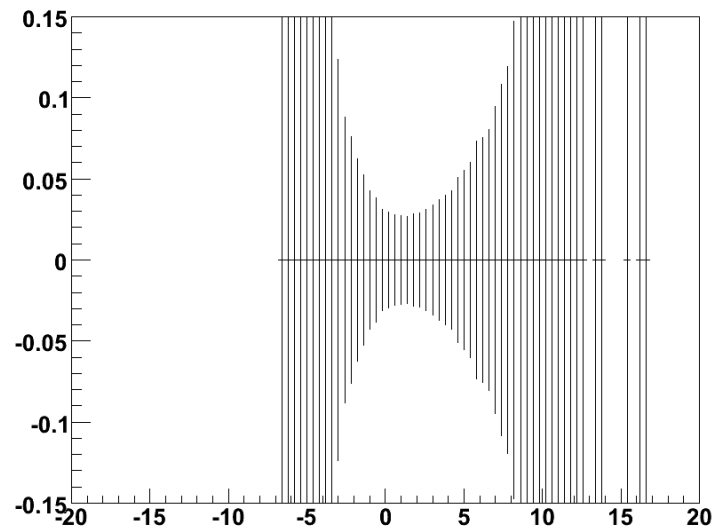
$\sqrt{s}=200$ GeV: Sivers

- Central-Central correlations
 - Plots show projected errors on raw qty asymmetry
 - Errors assume combining Run-6 and Run-8

2-particle correlations
qty raw asymmetry



dijet correlations
qty raw asymmetry



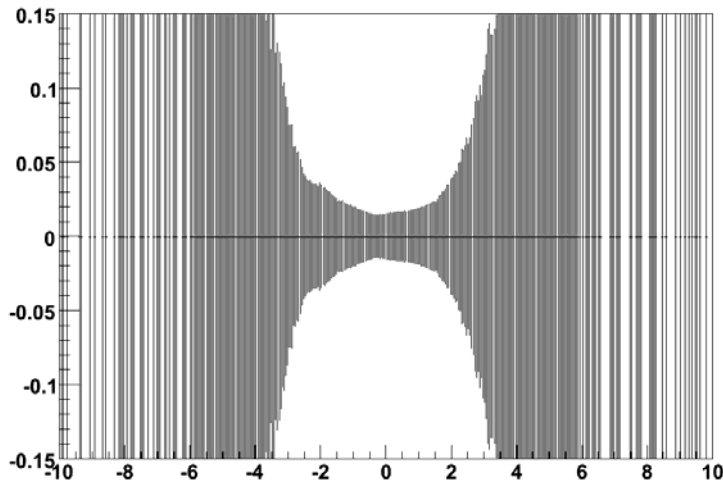
GeV
21



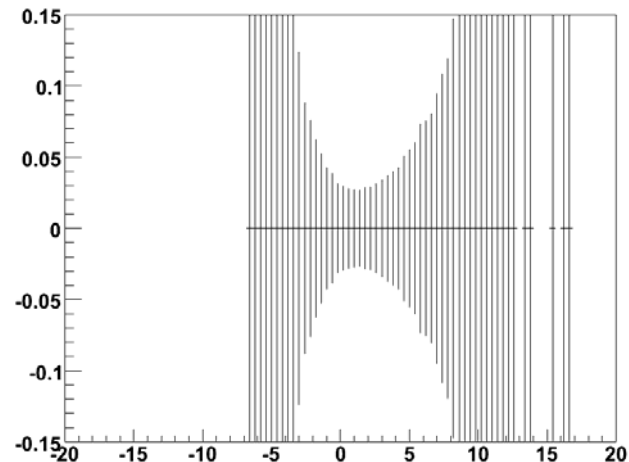
$\sqrt{s}=200$ GeV: Sivers

- Central-Muon correlations
 - Errors assume combining Run-6 and Run-8
 - No enhancement assumed for 1H trigger
 - Needs further study, could be significant

2-particle correlations
qty raw asymmetry



dijet correlations
qty raw asymmetry



GeV