Recent Results of $A_{LL}^{\pi^0}$ measurement at $\sqrt{s} = 510$GeV at Mid-rapidity by PHENIX Experiment

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PHENIX

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1. Motivation

- Spin sum rule: $\frac{1}{2} = \int_0^1 dx\,[\frac{1}{2}\sum_q(\Delta q + \Delta\bar{q})\,(x,\mu^2) + \Delta g(x,\mu^2)] + L$

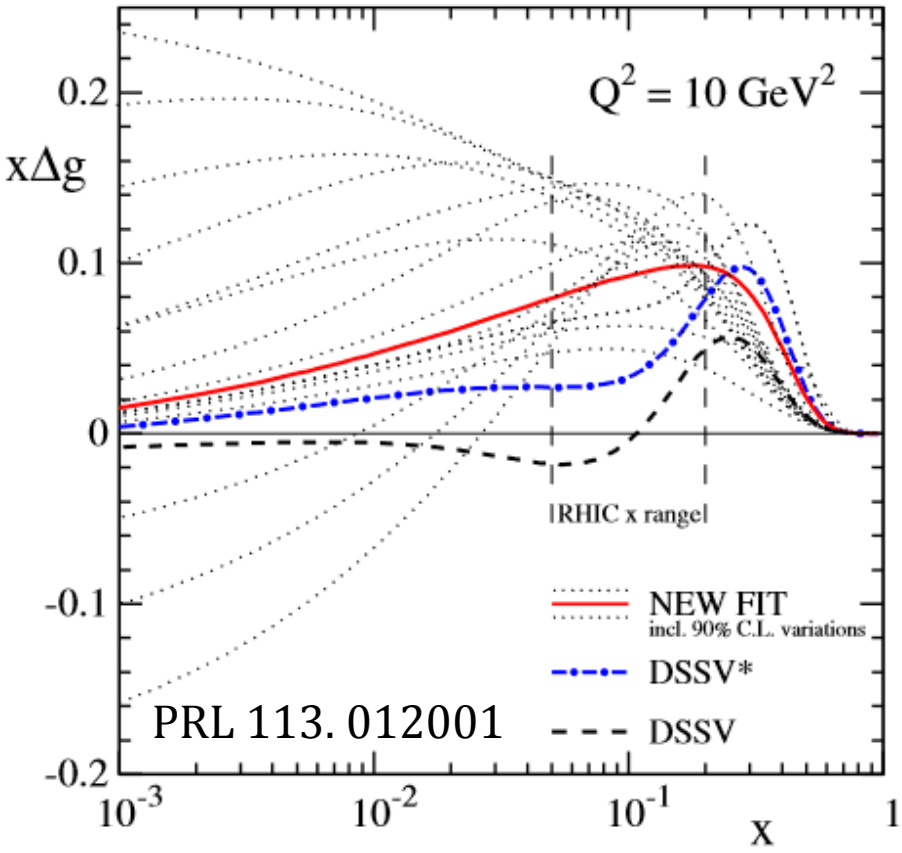
  DIS experiment: quark contribution is only 25~35%.

  Gluon polarization, $\Delta G = \int_0^1 dx \Delta g(x)$

- PP collision provide access to Δg through gg and qg scattering.

- $A_{LL}^{\pi^0}$ measurements give access to Δg

- $A_{LL}^{\pi^0}$ at higher $\sqrt{s} = 510$GeV extends the sensitivity to Δg to lower Bjorken x.

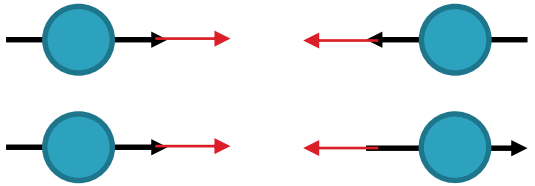


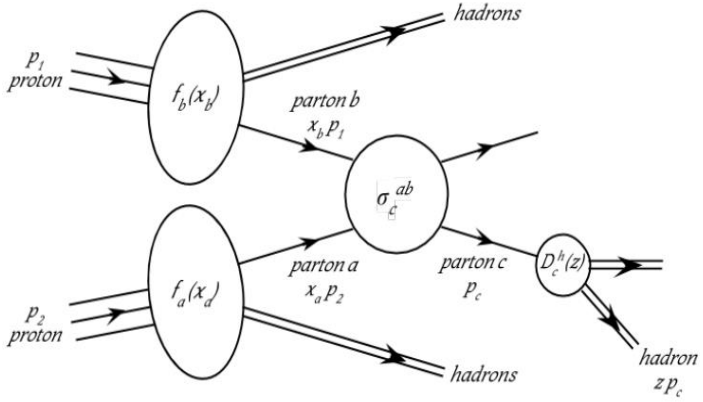
2. $A_{LL}^{\pi^0}$ and its interpretation

- $A_{LL}^{\pi^0} = \frac{1}{P_B P_Y} \frac{\sigma_{++}^{\pi^0} - \sigma_{+-}^{\pi^0}}{\sigma_{++}^{\pi^0} + \sigma_{+-}^{\pi^0}}$

$\sigma_{++}^{\pi^0} : \sigma^{\pi^0}$ from same helicity proton collision.

$\sigma_{+-}^{\pi^0} : \sigma^{\pi^0}$ from opposite helicity proton collision.





$\sigma^{f_a f_b \to f_c X}$: pQCD

$D_{f_c}^{\pi^0}$: e^+e^- experiment

- $A_{LL}^{\pi^0} = \frac{\sigma^{\pi^0}{}_{++} - \sigma^{\pi^0}{}_{+-}}{\sigma^{\pi^0}{}_{++} + \sigma^{\pi^0}{}_{+-}} = \frac{\sum_{f_a, f_b, f_c} \Delta f_a \otimes \Delta f_b \otimes d\hat{\sigma}^{f_a f_b \to f_c X} \otimes D_{f_c}^{\pi^0}}{\sum_{f_a, f_b, f_c} f_a \otimes f_b \otimes \hat{\sigma}^{f_a f_b \to f_c X} \otimes D_{f_c}^{\pi^0}}$

3. Longitudinal Spin Data

Year	$\sqrt{s}$(GeV)	L(Pb^{-1}) (30cm)	P(%)	FoM(P^4L)
2003	200	0.35	27	0.0019
2004	200	0.12	40	0.0031
2005	200	3.4	49	0.2
2006	200	7.5	57	0.79
2006	62.4	0.08	48	0.0042
2009	500	10	40	0.26
2009	200	14	57	1.4
2011	500	16.7	48	0.88
2012	510	30.03	52	2.2
2013	510	150	55	14

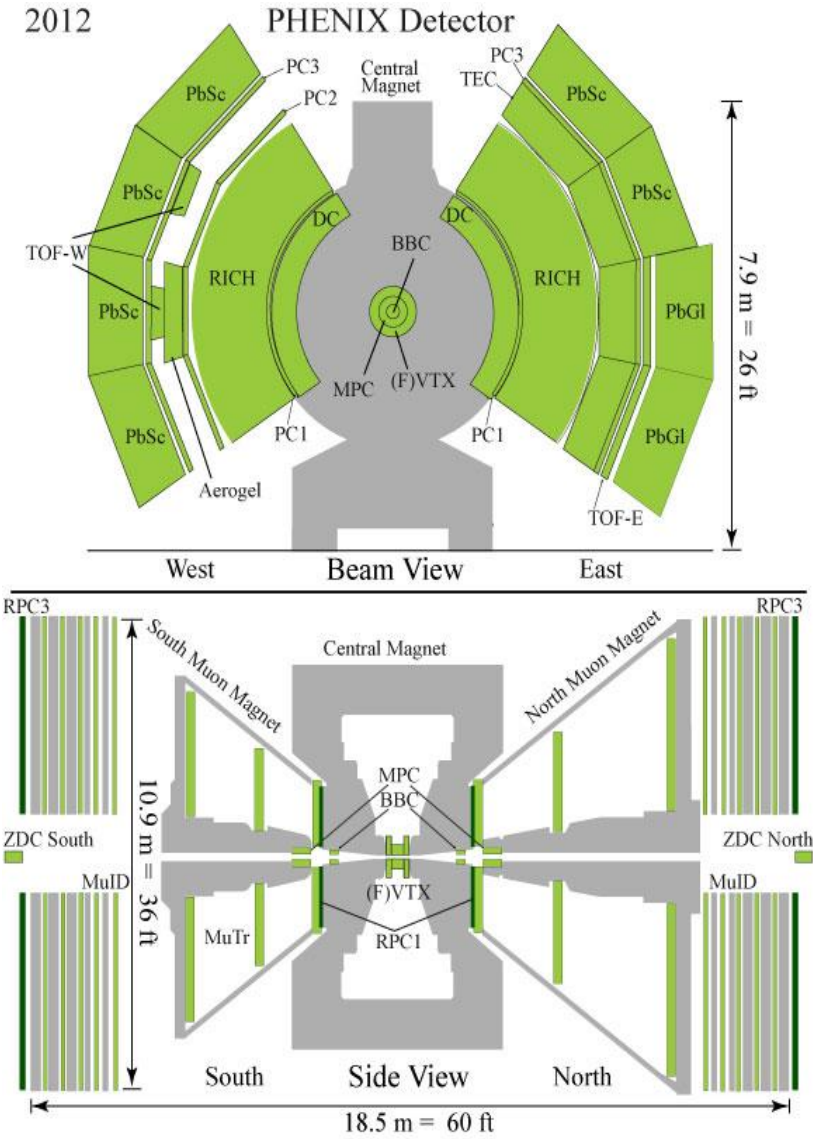
4. Introduction to PHENIX

Central arm: $|\eta| < 0.35, \Delta\theta = \frac{\pi}{2} \times 2$

- Tracking : Vertex detector, DC, PC
- PID : RICH
- EM calorimeter: PbSc and PbGl

Farward Arm:

- Minbias detector : BBC, ZDC
- Muon tracking and ID: Mutr, MuID
- EM calorimeter: MPC



5. Analysis Procedure

- Count yield of signal and side region.

- $A^{Peak(Side)}{}_{LL} = \frac{1}{P_B P_Y}\frac{\sigma_{++}-\sigma_{+-}}{\sigma_{++}+\sigma_{+-}}$

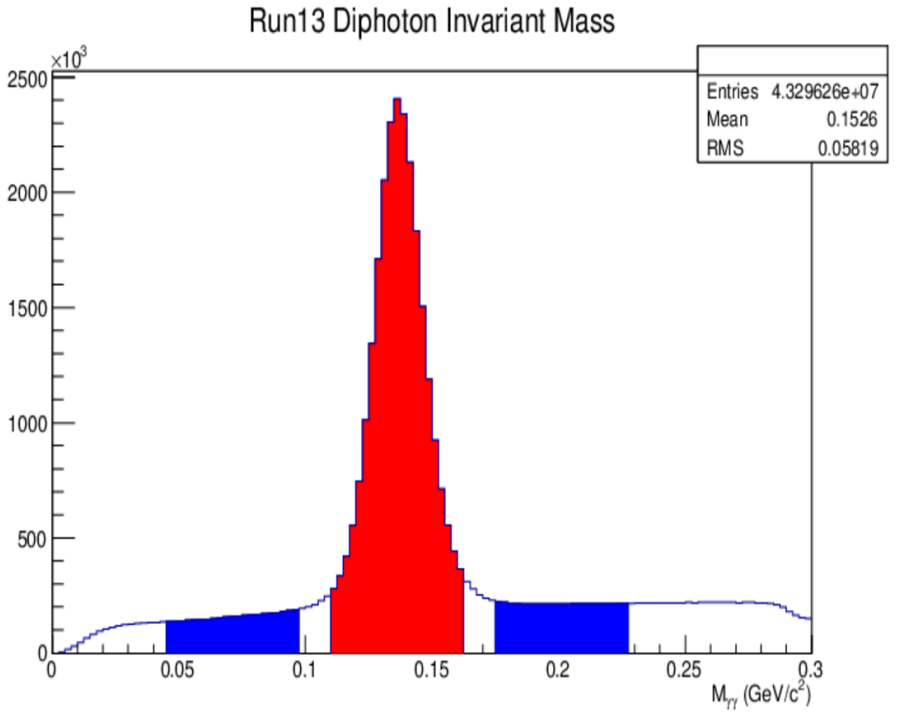
$$= \frac{1}{P_B P_Y}\frac{\frac{N_{++}}{\varepsilon_{++}L_{++}}-\frac{N_{+-}}{\varepsilon_{+-}L_{+-}}}{\frac{N_{++}}{\varepsilon_{++}L_{++}}+\frac{N_{+-}}{\varepsilon_{+-}L_{+-}}}$$

$$= \frac{1}{P_B P_Y}\frac{N^{Peak(Side)}{}_{++}-RN^{Peak(Side)}{}_{+-}}{N^{Peak(Side)}{}_{++}+RN^{Peak(Side)}{}_{+-}},$$

where $R = \frac{L_{++}}{L_{+-}}$. (source of syst.)

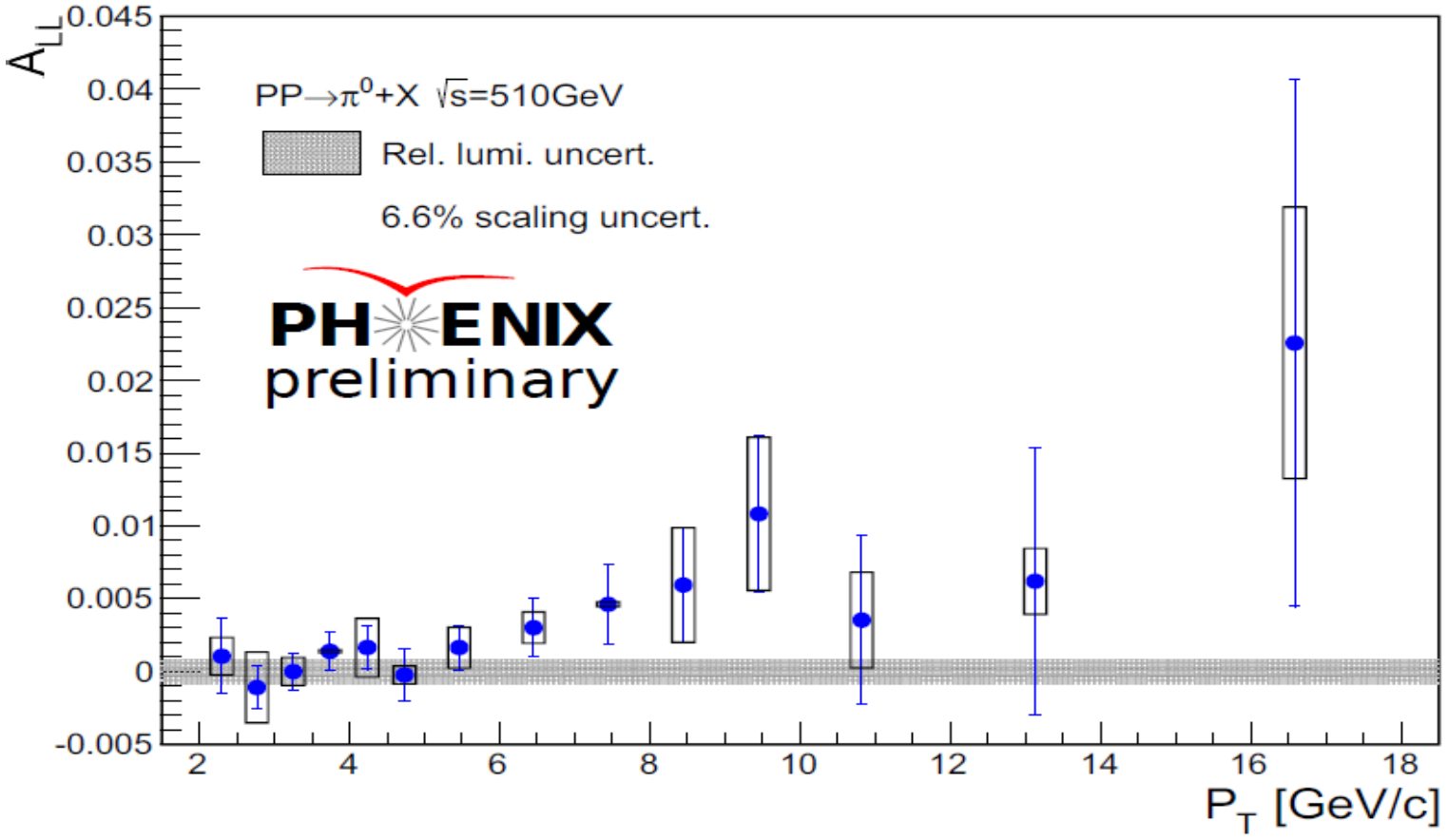
- $A_{LL}^{\pi^0} = \frac{A_{LL}^{Peak}-rA_{LL}^{Side}}{1-r}$,

r = background fraction.

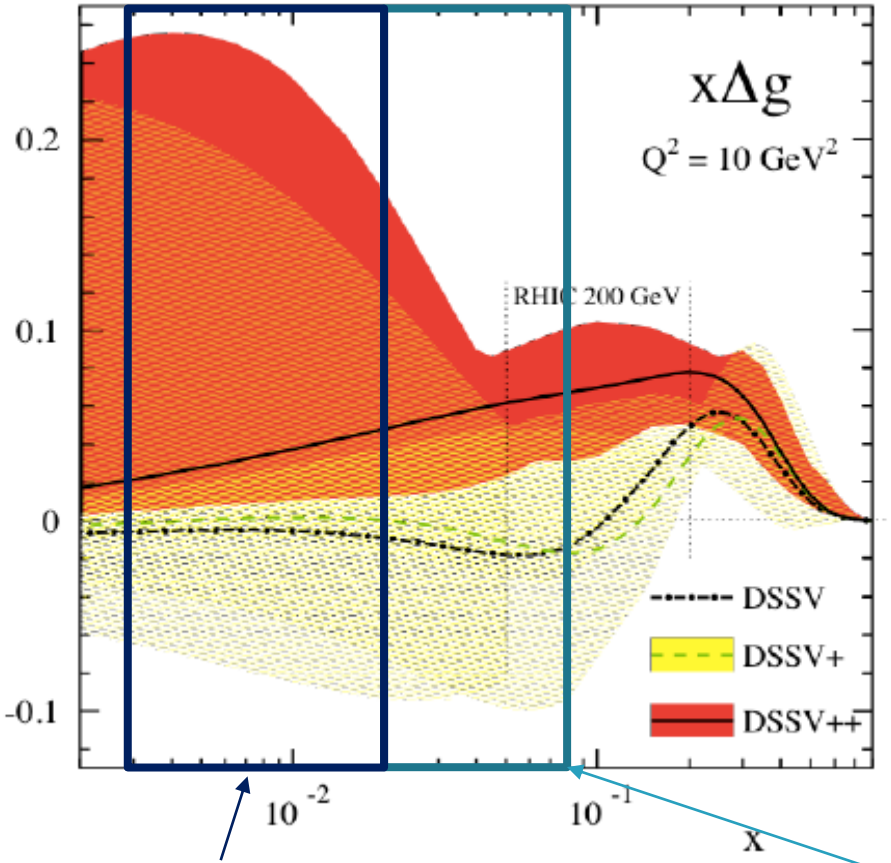


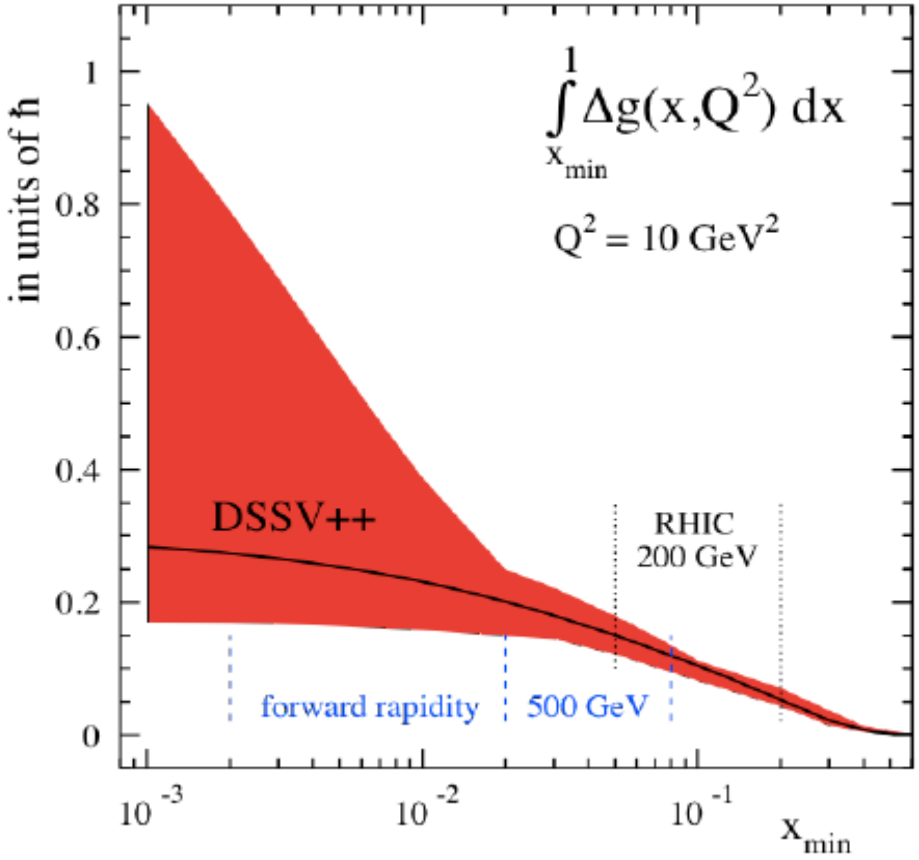
↑. Identifiable mass peak.
Large stat.
Various cuts to minimize uncert.

5. Preliminary Results



5. Preliminary Results - Expected Impact

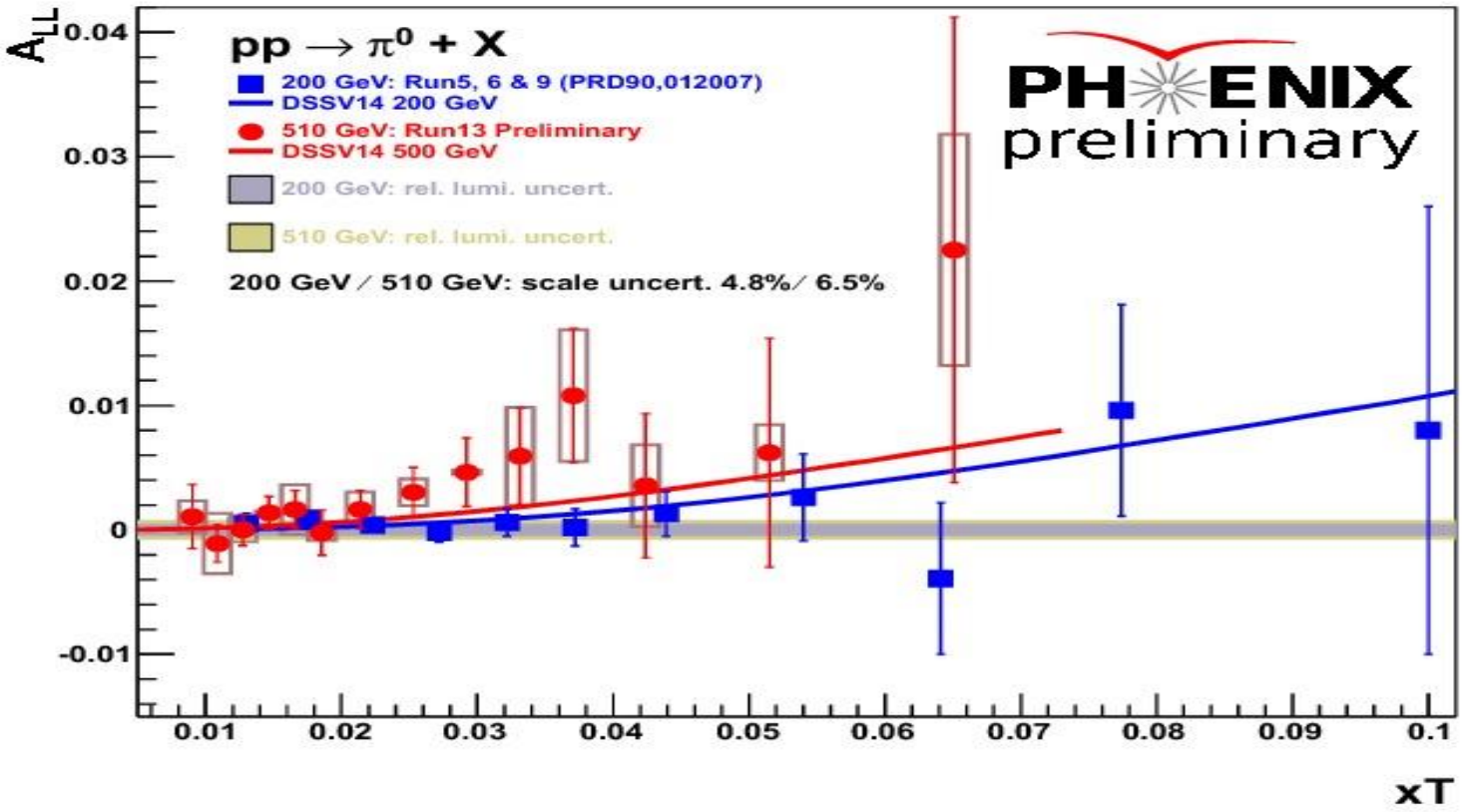




Coverage of A_{LL} measurement with MPC : analysis ongoing with Run12 and Run13 data

510 GeV Region

5. Preliminary Results



- Different scale and ths different size of asymmetries expected.
  Both of data and theory support it. Evolution effect?

$x_T = \frac{2P_T}{\sqrt{s}}$: approximate version of the average x.

6. Summary

- Run13 pp 510GeV data has been taken and analyzed.
  : Integrated Luminosity 150 pb^{-1}, Pol $\sim 56\%$
  Preliminary result is released.

- Larger asymmetry was observed. (cf. Run09 $A_{LL}^{\pi^0}$ at $\sqrt{s} = 200$ GeV)

- We hope the result help global analysis and constrain Δg.

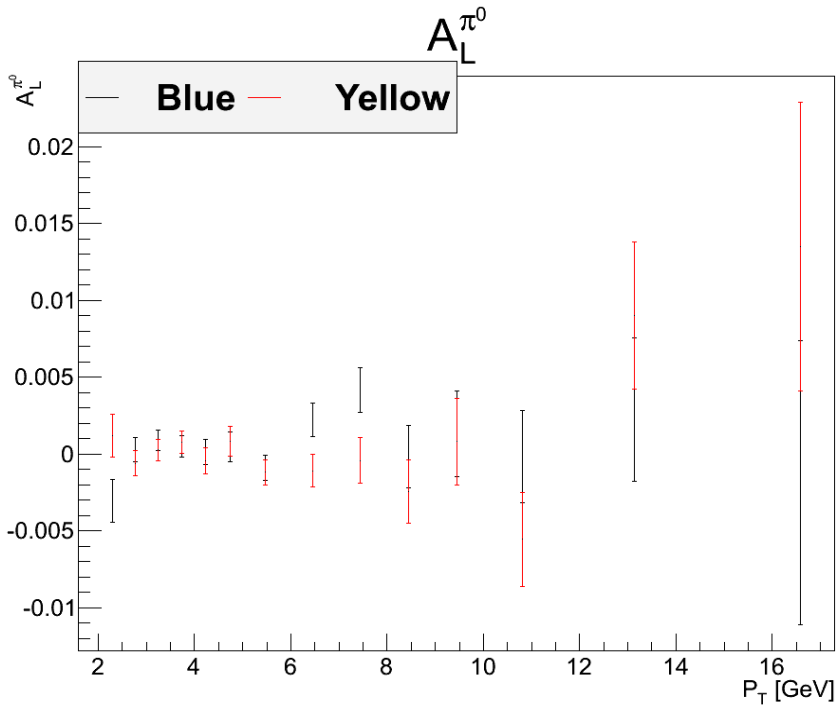
- Analysis is ongoing for final result.
  - Smaller stat. and syst. uncert. will be achieved.

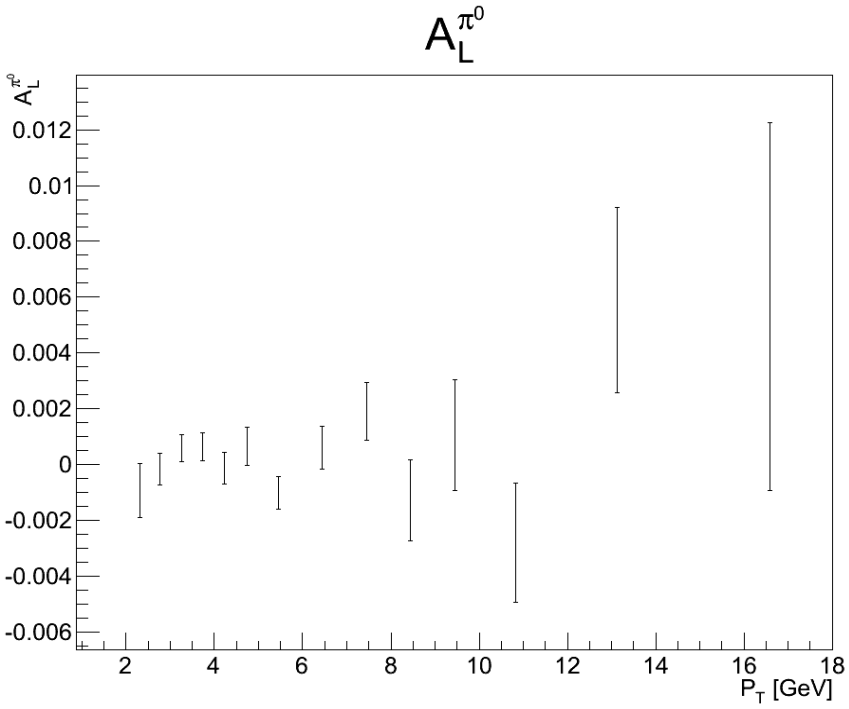
Back Up

Cross Check $A_L^{\pi^0}$

- Zero $A_L^{\pi^0}$ must be obtained.

  ∵ Parity invariant strong interaction.





Bunch Shuffling

- Validity check of stat. eq. and unknown syst. model independently.