Single transverse spin asymmetry of single electrons from heavy flavor decay at RHIC-PHENIX experiment

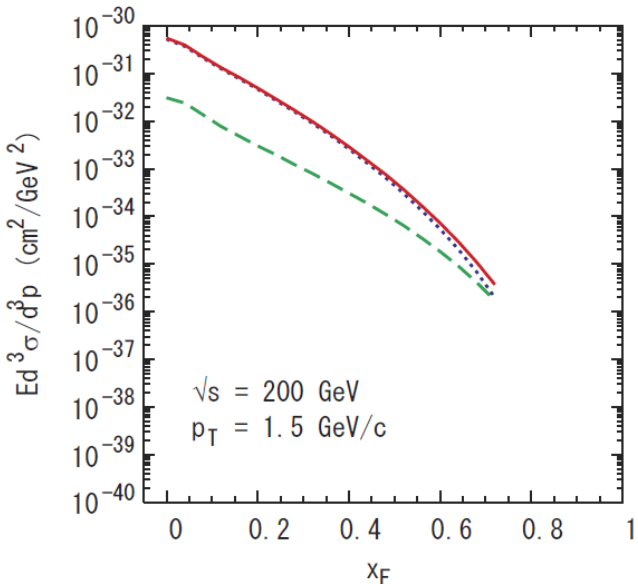
Seishi Dairaku

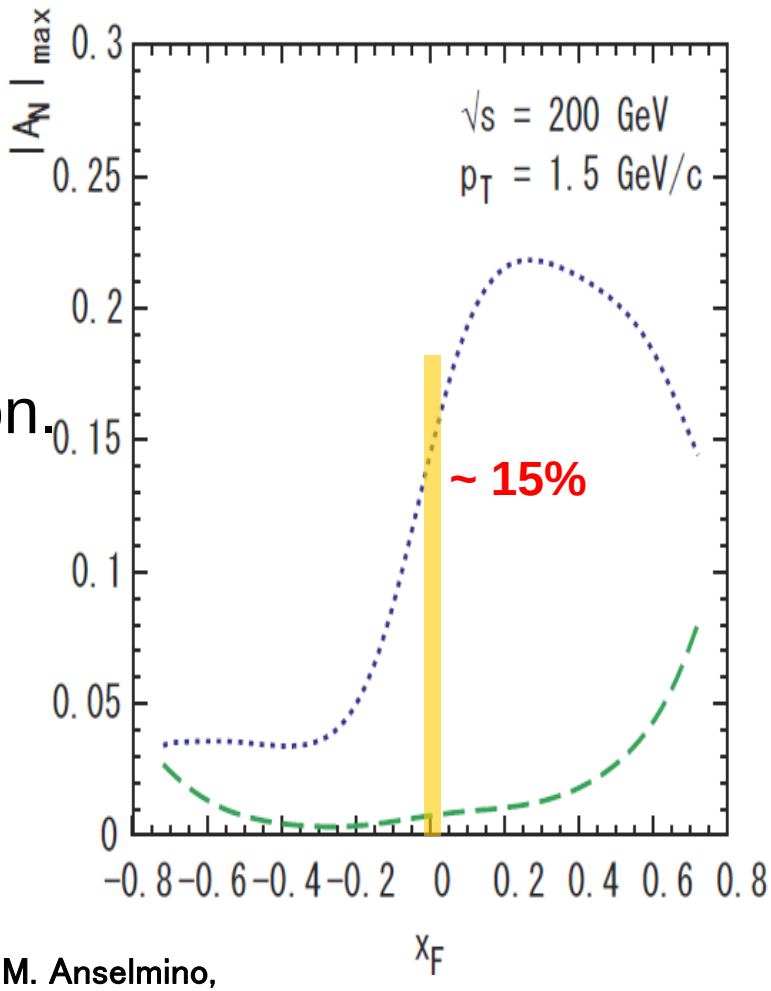
for the PHENIX collaboration

Kyoto university / RIKEN

A_N of heavy flavor at RHIC ($p^{\uparrow}p \rightarrow$ DX) --- Probe of gluon Sivers function

- ✓ Gluon fusion is a dominant process in heavy flavor production at RHIC kinematic region.
- ✓ A_N of heavy flavor
- ➡ a good probe of gluon Sivers function.
- ✓ A_N of electrons from heavy flavor decay in PHENIX central arm.

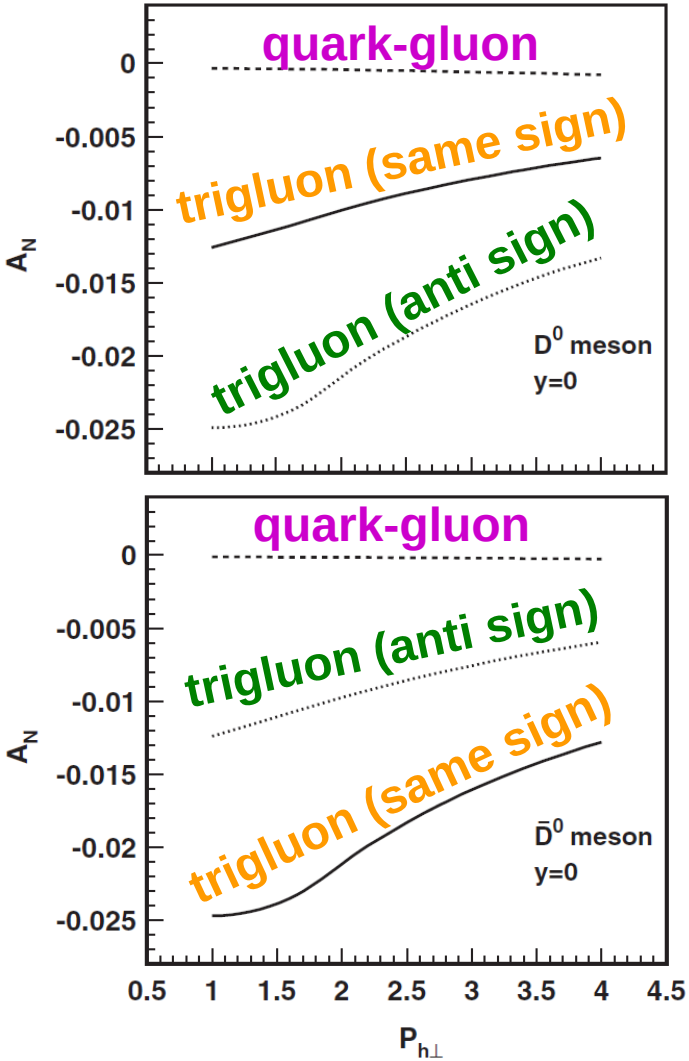




M. Anselmino,
M. Boglione, U. D'Alesio, E. Leader, and
PRD 70, 074025

A_N of heavy flavor at RHIC ($p^{\uparrow}p \rightarrow DX$) --- Probe of trigluon correlation function

Z-B Kang, J-W Qui, W Vogelsang and F Yuan
PRD 78, 114013



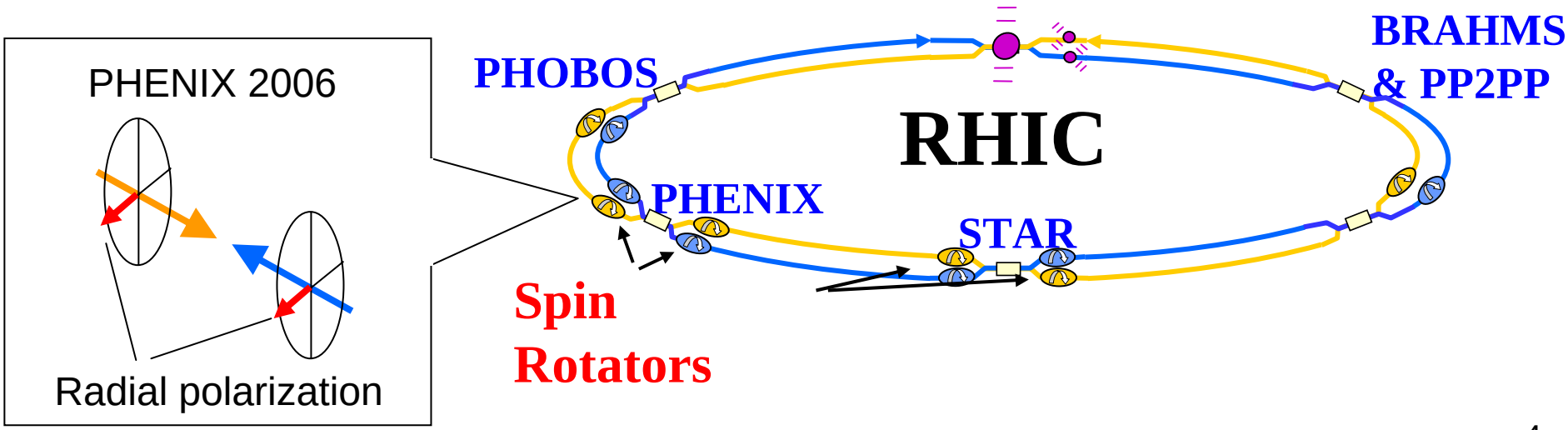
- ✓ Twist 3 correlation functions.
  - ✓ quark-gluon correlation.
  - ✓ trigluon correlation.
- ✓ The quark-gluon correlation functions generate a very small asymmetry.
- ✓ The observation of any significant A_N
  ➡ Indication of trigluon correlation?

Furthermore ,

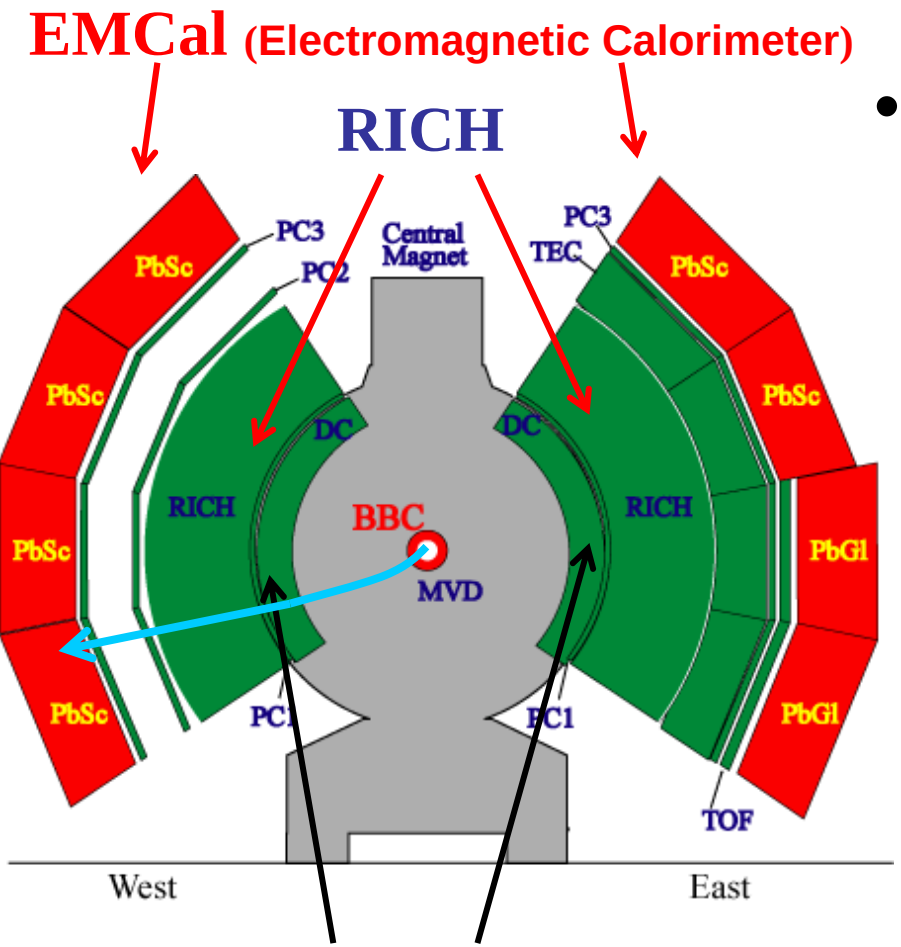
- ✓ The trigluon contribution could be very different for D and $\bar{D}$ production.

Transverse spin running at RHIC

Year	√s [GeV]	Recorded L	Pol [%]	FOM (P^2L)
2001 (Run 2)	200	.15 pb^{-1}	15	3.4 nb^{-1}
2005 (Run 5)	200	.16 pb^{-1}	47	38 nb^{-1}
2006 (Run 6)	200	2.7 pb^{-1}	51	700 nb^{-1}
2006 (Run 6)	62.4	.02 pb^{-1}	48	4.6 nb^{-1}
2008 (Run 8)	200	5.2 pb^{-1}	46	1100 nb^{-1}



Electron ID at RHIC PHENIX



Momentum spectrometer
(Drift chamber
Pad chamber)

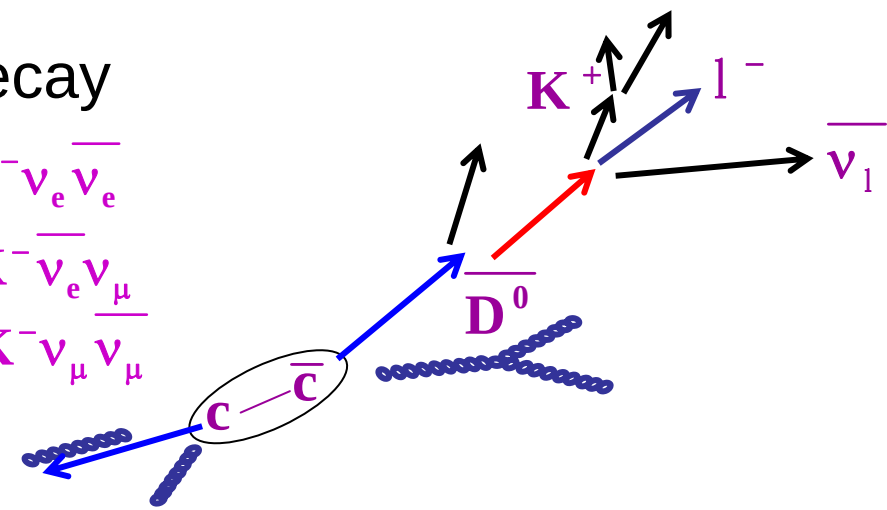
- Electrons were detected by central arm.
  - Momentum spectrometer
  - EMCal (Electromagnetic Calorimeter)
  - RICH (**R**ing **I**maging **CH**erenkov)
    - CO_2, n = 1.000410
    - Threshold
      - For electron : 0.02 (GeV/c)
      - For pion : 4.9 (GeV/c)
    - For momentum < 4.9 GeV : Only electrons generate a signal in the RICH.

Sources of electrons

- Electrons from heavy flavor decay

$$D^0 \to K^- l^+ \nu_e$$
$$\overline{D^0} \to K^+ l^- \overline{\nu_l}$$

$$\begin{cases} D^0\overline{D^0} \to e^+e^- K^+K^- \nu_e \overline{\nu_e} \\ D^0\overline{D^0} \to e^-\mu^+ K^+K^- \overline{\nu_e} \nu_\mu \\ D^0\overline{D^0} \to \mu^+\mu^- K^+K^- \nu_\mu \overline{\nu_\mu} \end{cases}$$



- Photon conversions : $\pi^0 \to \gamma\gamma$, $\gamma \to e^+e^-$
- Dalitz decays of $\pi^0, \eta, \eta', \omega, \phi$ ($\pi^0 \to ee\gamma$, $\eta \to ee\gamma$, etc)
- Kaon decays

} Background

Dominant background : electrons from π^0 decay.

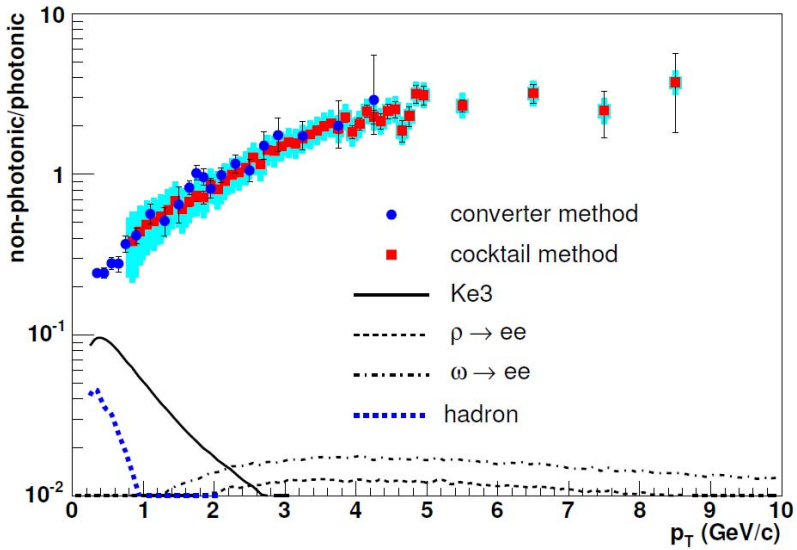
Background correction

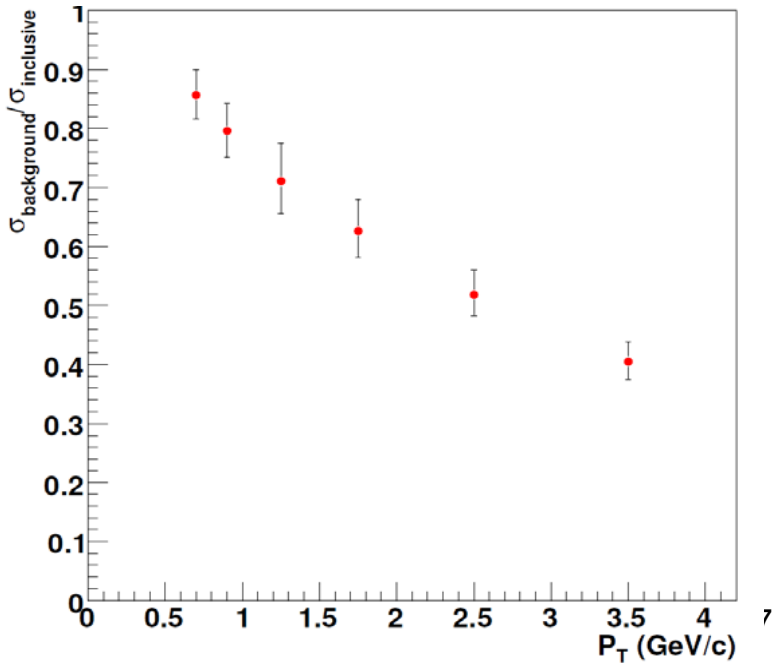
- ✓ Extract A_N of Heavy flavor from A_N of inclusive electrons.

$$A_N^{HF} = \frac{A_N^{inclusive} - r A_N^{bg}}{1 - r}$$

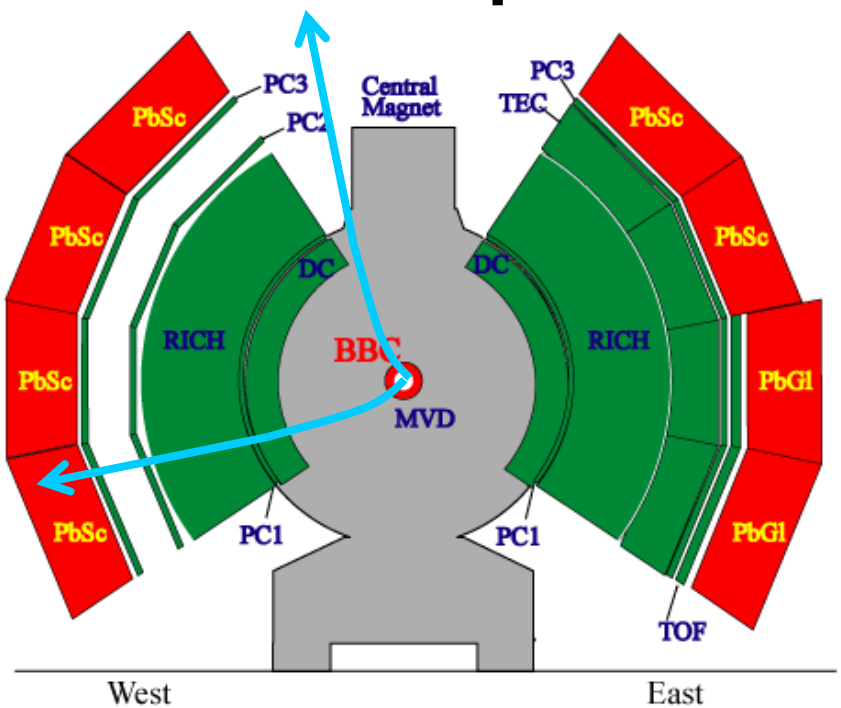
- ✓ Dominant background is π^0, but π^0 A_N from PHENIX data is negligible compare to the present electron A_N accuracy.

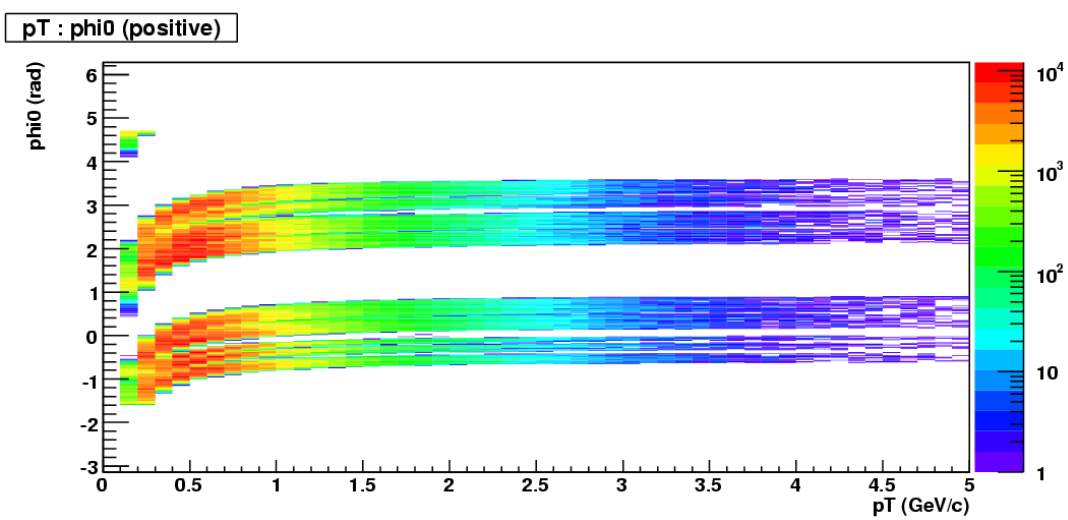
$$\Rightarrow \quad A_N^{HF} = \frac{A_N^{inclusive}}{1 - r}$$





Acceptance correction





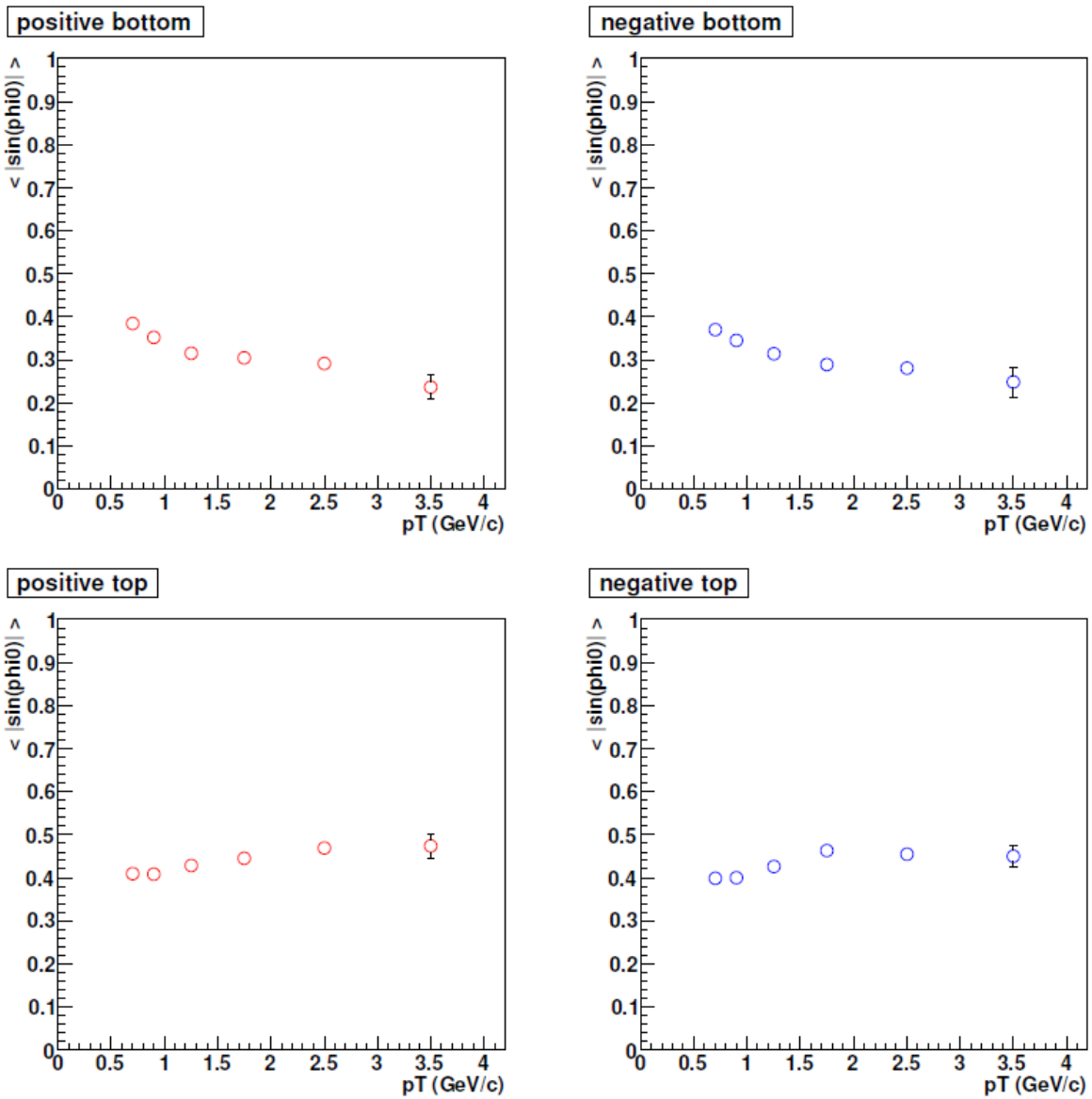
- ✓ Sine modulation should be taken into account.

$$A_{sqrt} = \frac{f}{P}\frac{\sqrt{N_l^{\uparrow}N_r^{\downarrow}} - \sqrt{N_l^{\downarrow}N_r^{\uparrow}}}{\sqrt{N_l^{\uparrow}N_r^{\downarrow}} + \sqrt{N_l^{\downarrow}N_r^{\uparrow}}}$$

- ✓ Correct asymmetries for the limited acceptance of the PHENIX central arm.

$$\frac{1}{f(\phi)} = \frac{\int |\sin\phi| d\phi}{\int d\phi}$$

Acceptance correction factor



- ✓ Correction factor

$$\frac{1}{f(\phi)} \simeq \frac{1}{< f(\phi) >} = \frac{\sum_{i=1}^{N} |\sin\phi|}{N}$$

- ✓ Botttom, Top, Positive charge and Negative charge

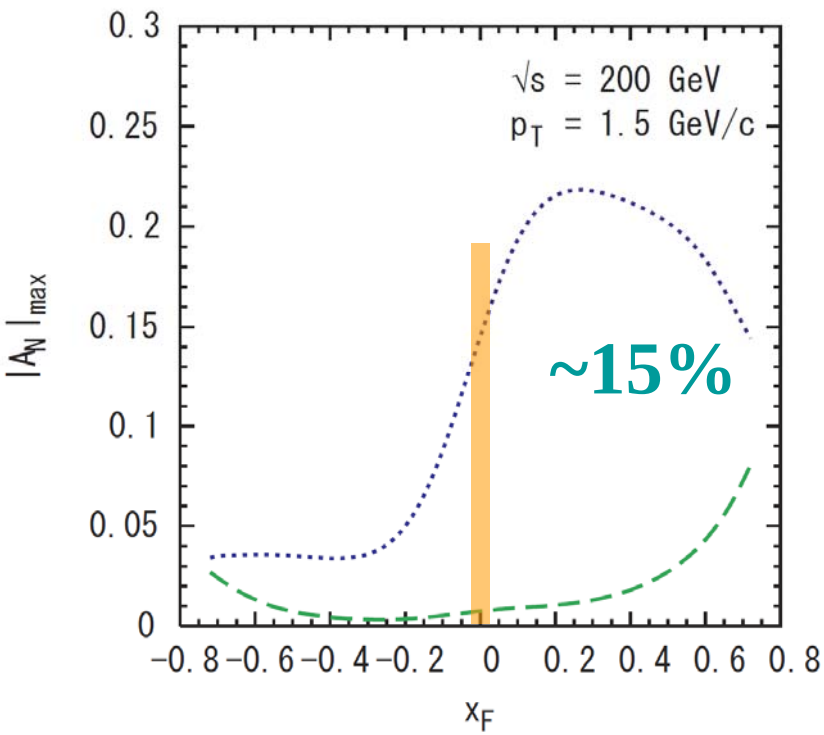
- ✓ Radial Polarization.

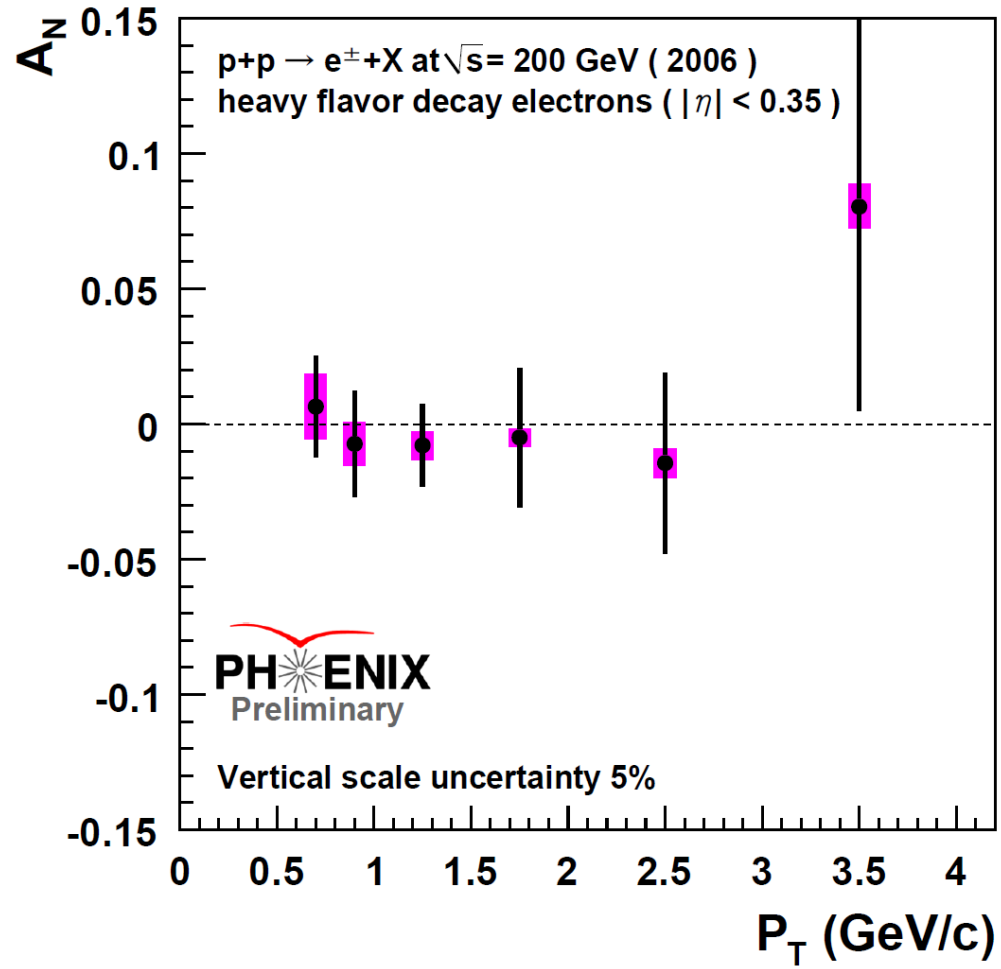
Left Right ⟷ Top Bottom

Results (1)

- A_N of heavy flavor (charm) is small.

➡ Maximum value of gluon Sivers function could be excluded.

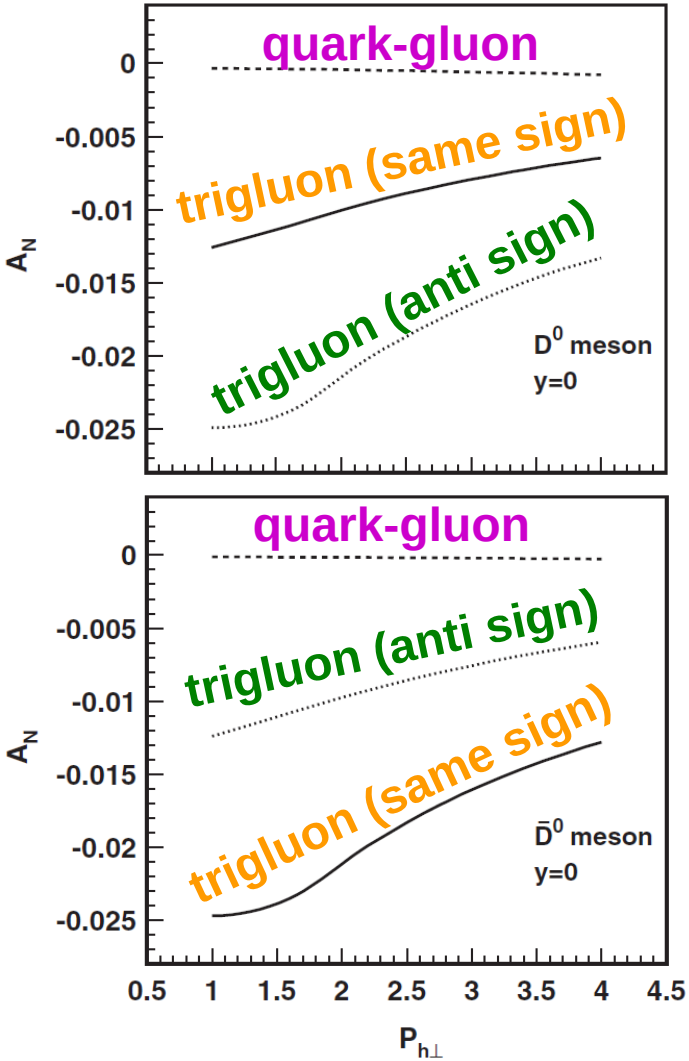




M. Anselmino,
M. Boglione, U. D'Alesio, E. Leader, and
PRD 70, 074025

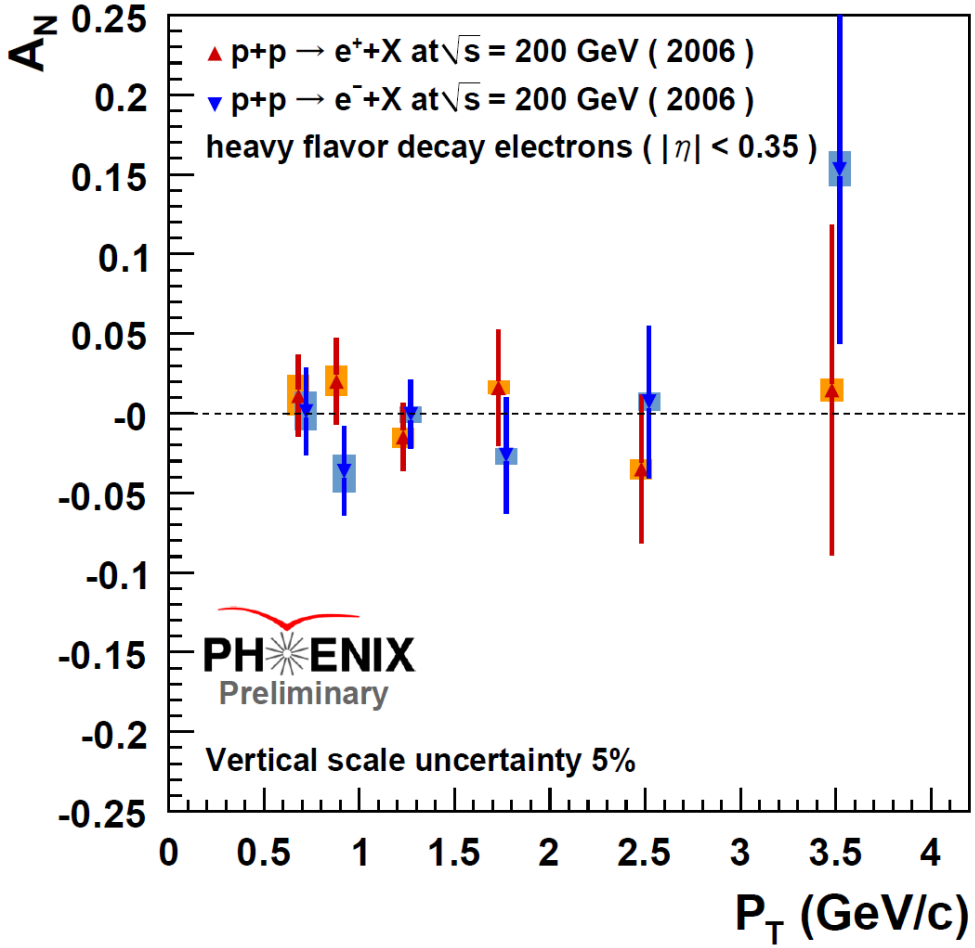
Results (2)

Z-B Kang, J-W Qui, W Vogelsang and F Yuan
PRD 78, 114013



- A_N difference between D^0 and $\overline{D}^0$ is small.

➡ Constraint to trigluon correlation.

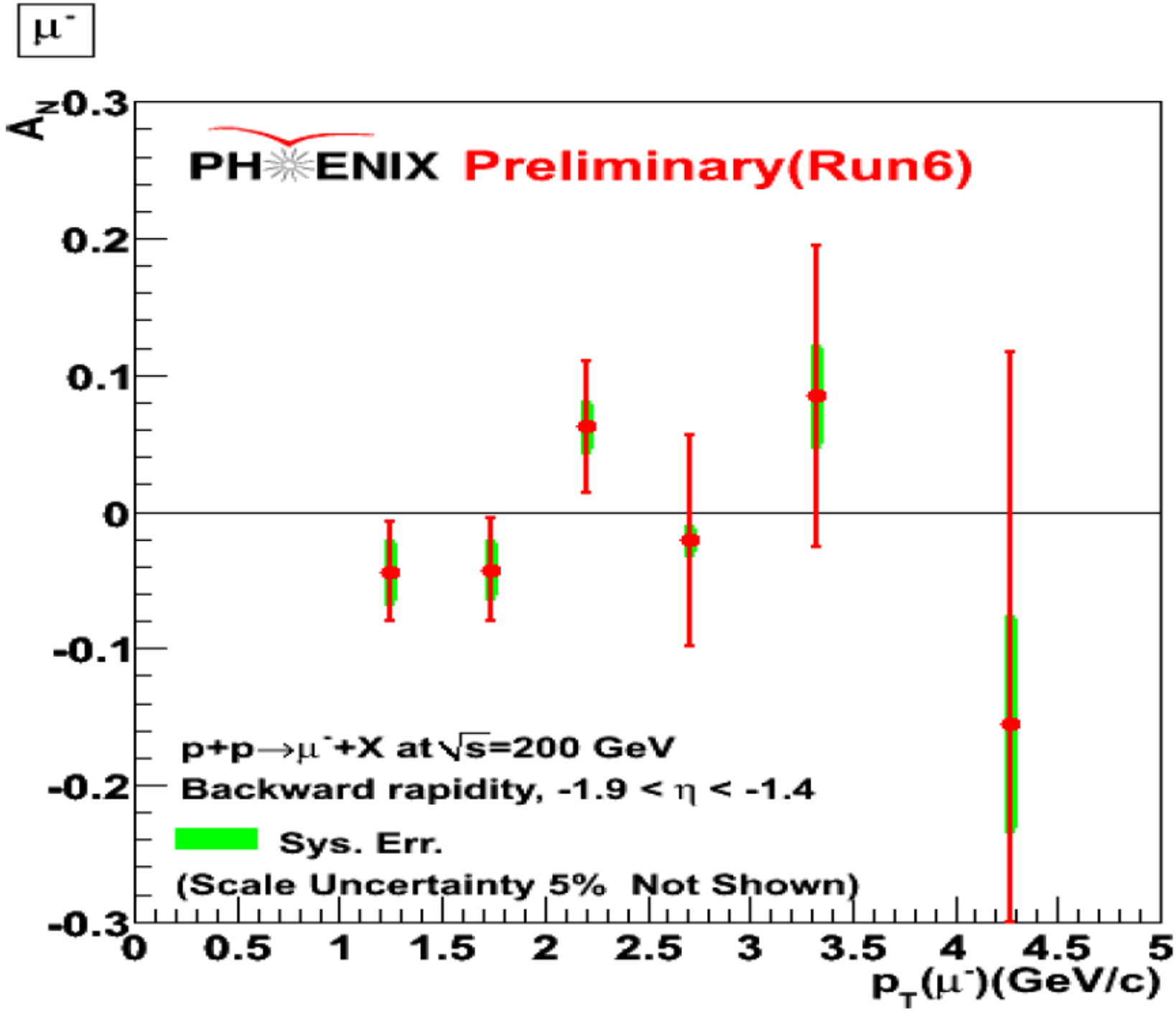


Summary

- ✓ We measured A_N of single electrons from heavy flavor decay in pp collisions at RHIC PHENIX experiment.

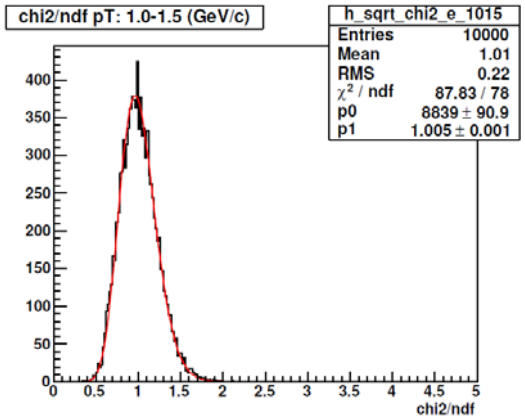
  - ✓ The A_N is a good probe of "gluon sivers function" and "trigluon correlation function".
  - ✓ Our results can exclude maximum Sivers gluon function, and could give a constraint to trigluon correlation functions.

Backup

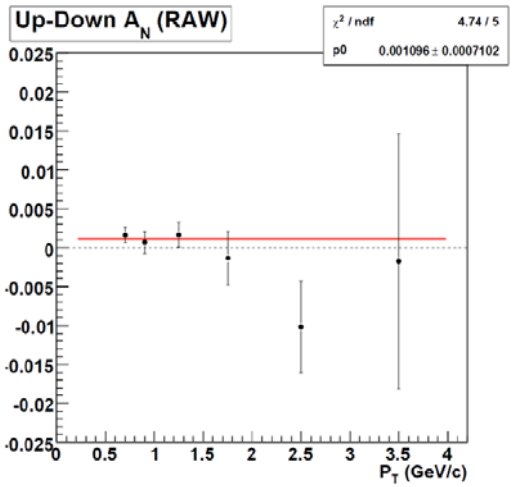

μ⁻
PHENIX Preliminary(Run6)
A_N
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
p+p→μ⁻+X at √s=200 GeV
Backward rapidity, -1.9 < η < -1.4
Sys. Err.
(Scale Uncertainty 5% Not Shown)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
$p_T(\mu^-)$(GeV/c)

Systematic checks

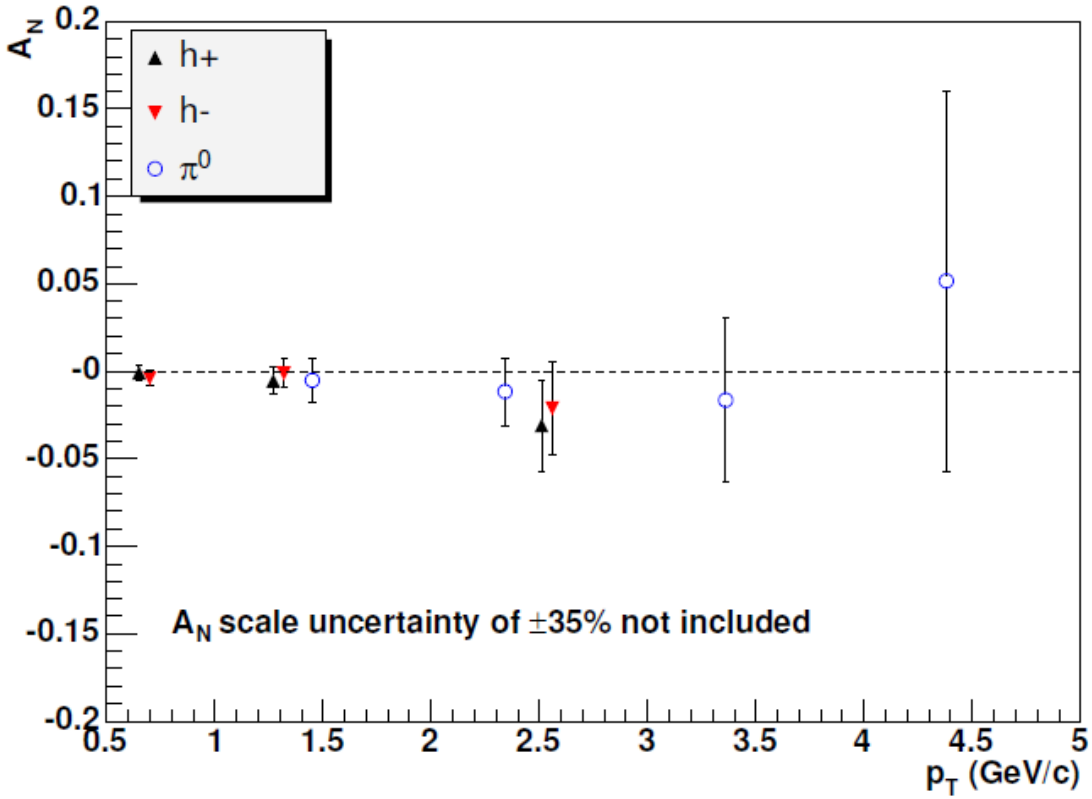
- **Bunch shuffling**



- **Up-down asymmetry**



- **Systematic error from background**
  - **Background ratio : r**
  - **Background A_N : π^0 A_N**



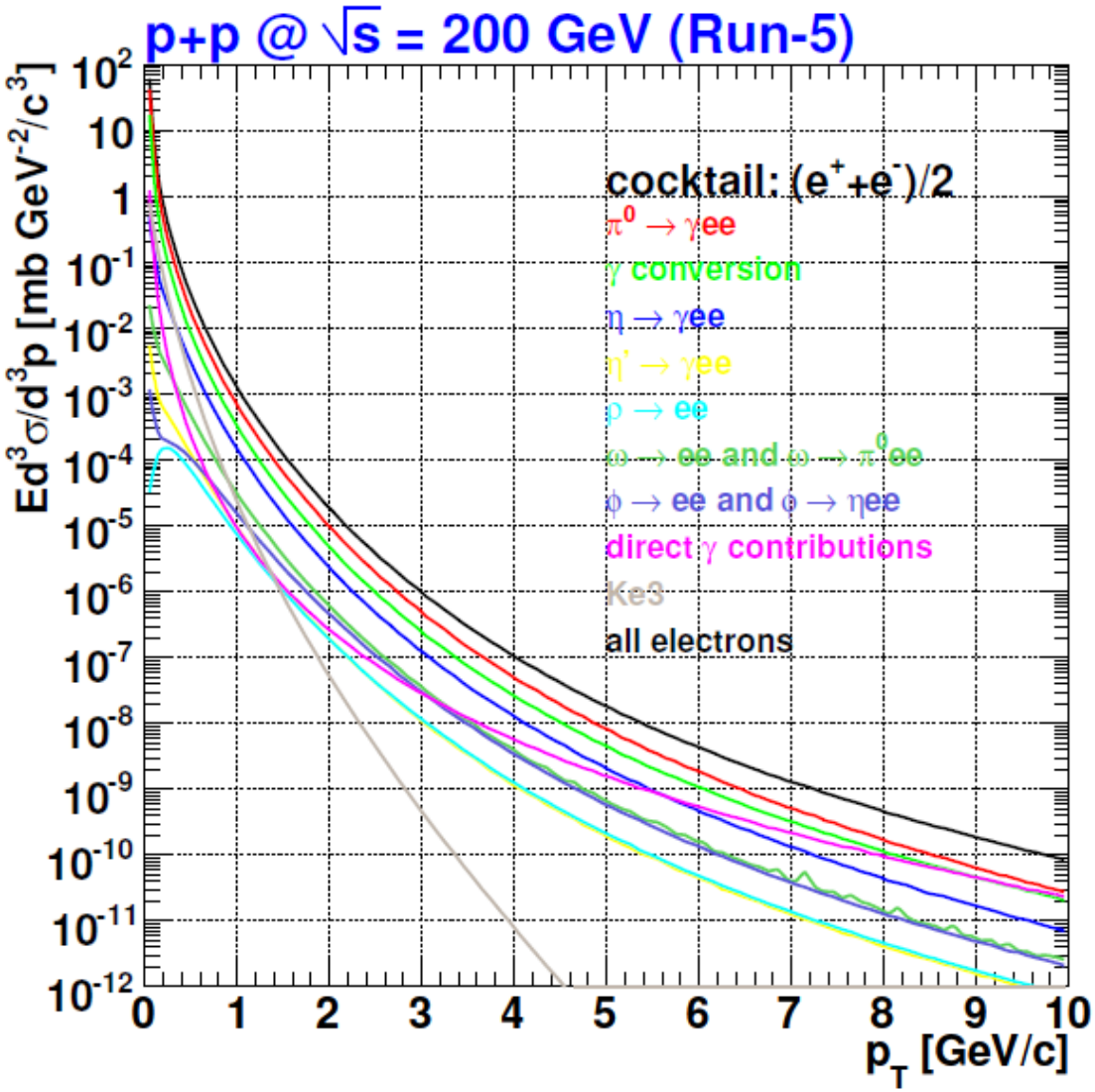


Figure 33: Invariant differential cross section of electrons from all sources considered in the p+p Run-5 cocktail.