Diffraction and low-x 2024

Measurements of unpolarized cross section and transverse single spin asymmetry of Z^0 in 500/510 GeV p+p collisions

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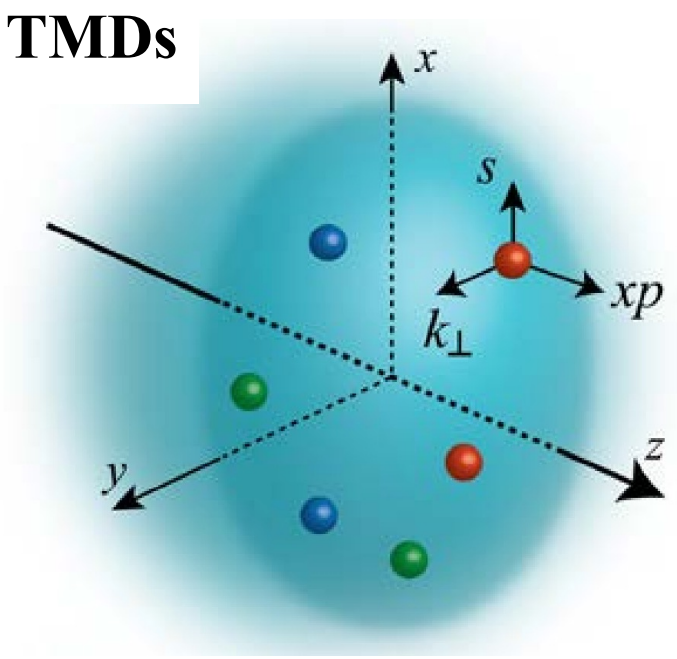
Diffraction and Low-x

Cross section of Z^0



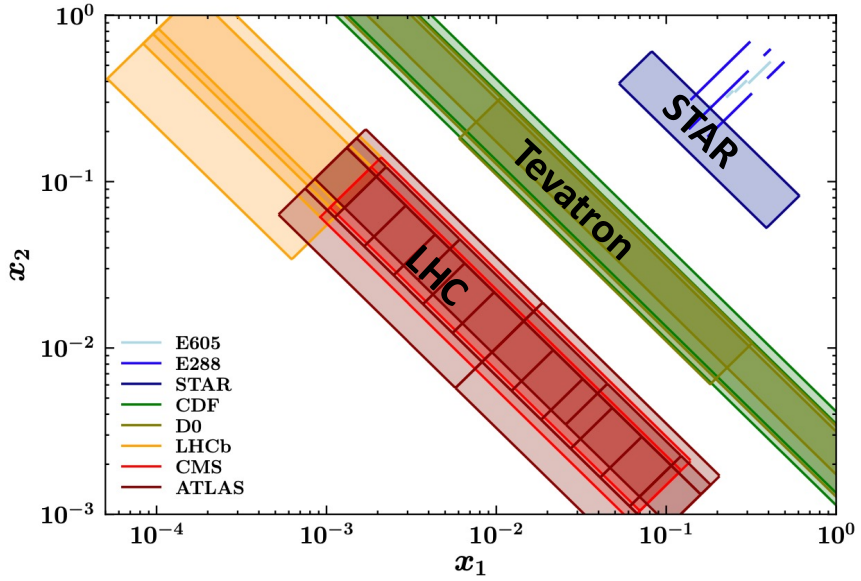
- **Motivation:** Understanding the internal structure of nucleons is an important topic in nuclear physics.
- **TMD Physics:** TMDs encode both the parton's longitudinal momentum fraction (x) and its intrinsic transverse momentum (k_T), depicting the density of partons in 3D.
- **Method:** Unpolarized TMDs extracted from Z^0 p_T spectrum from p+p→ Z^0 +X; $\frac{d\sigma}{dQdydp_T} \propto \int f(x, k_T, Q^2)dk_T$, $k_T \ll Q \sim M_{Z^0}$ makes Z^0 an ideal observable.

*Transverse momentum dependent parton distribution functions (TMDs): $f(x, k_T, Q^2)$

Why Z^0 from RHIC-STAR

RHIC serves as an intermediate energy range:

- Complementary to other experiments with higher x
- Allowing studies in TMD evolution on x



$$x \propto \frac{1}{\sqrt{s}}: \; x_{1,2} = Qe^{\pm y}/\sqrt{s}$$

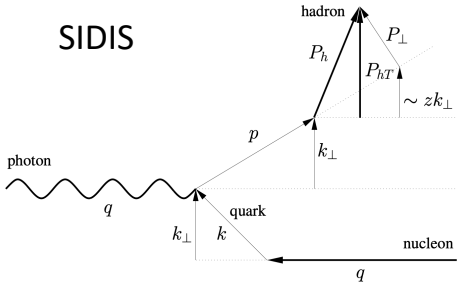
A. Bacchetta et al., JHEP 07(2020) 117

Z^0 channel at STAR:

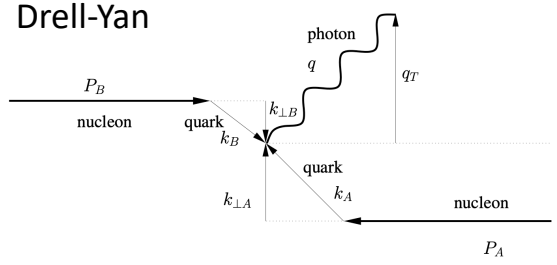
- Test property of TMDs from different processes
- Allowing studies in TMD evolution on Q

Channels	Experiments	Q
Z^0 boson	STAR, CDF, D0 ATLAS, CMS, LHCb	$\sim M_{Z^0}$
SIDIS	Hermes, Compass	Virtuality of γ^*
Drell-Yan	E288, E605, E772 PHENIX, ATLAS, D0	$\sim M_{ll}$

SIDIS



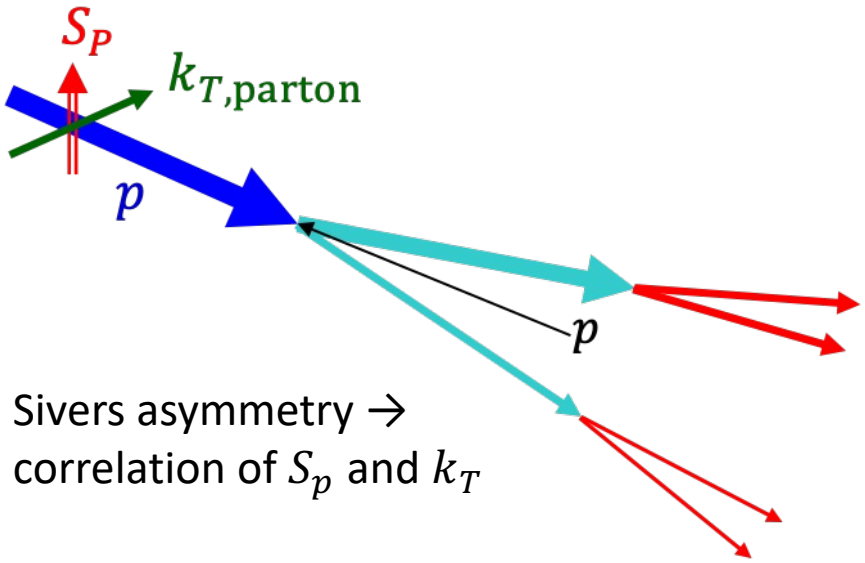
Drell-Yan



A. Bacchetta et al., JHEP 06(2017) 081

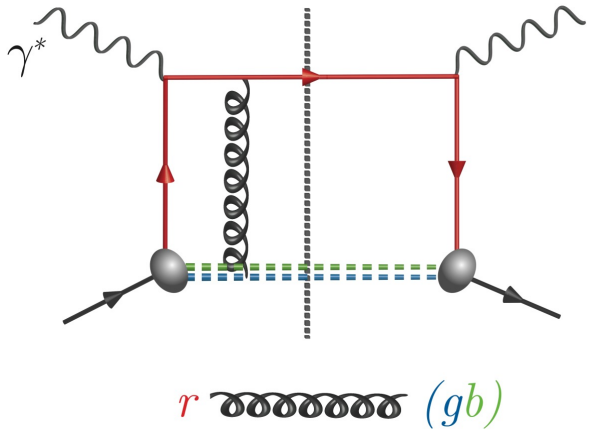
TSSA of Z^0

- Transverse single spin asymmetry (TSSA) of Z^0 is sensitive to Sivers function; RHIC is the world's only polarized pp collider who can make this measurement possible in p+p.
- TSSA of Z^0 is needed to test the non-universality of the Sivers function: **$\text{Sivers}_{\text{DIS}} = -$ ($\text{Sivers}_{\text{DY}}$ or $\text{Sivers}_{\text{W,Z0}}$).**

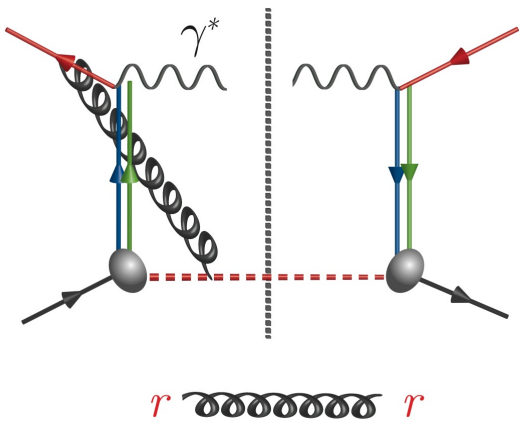


Sivers asymmetry → correlation of S_p and k_T

DIS: Color attractive

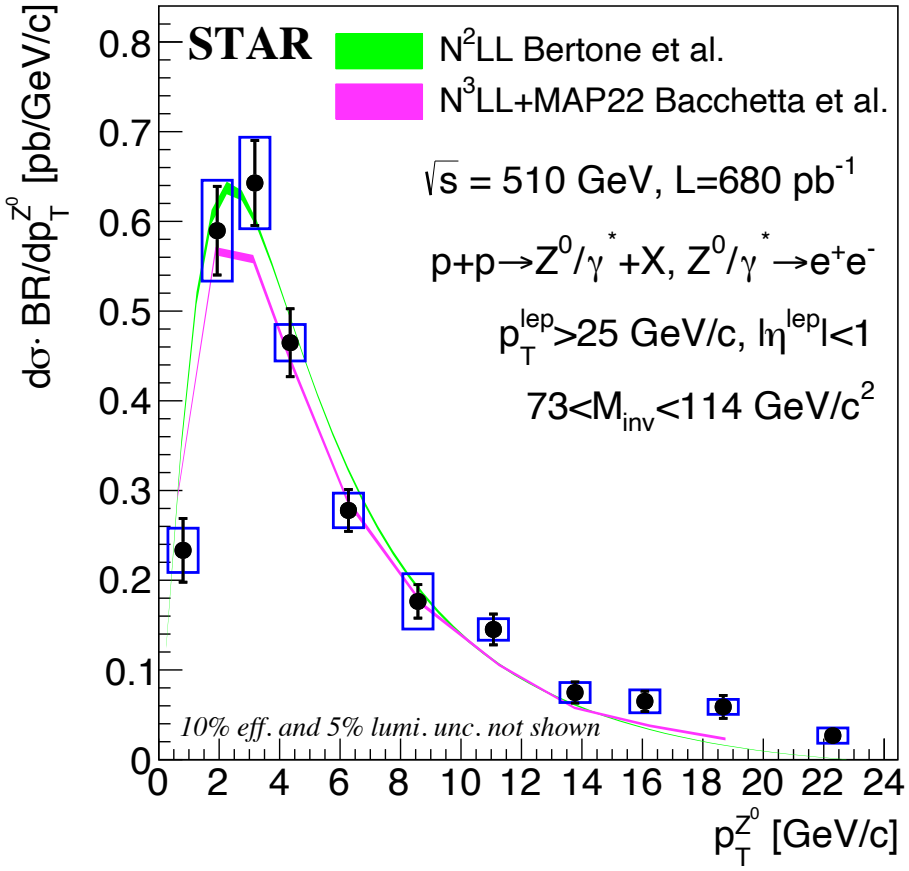


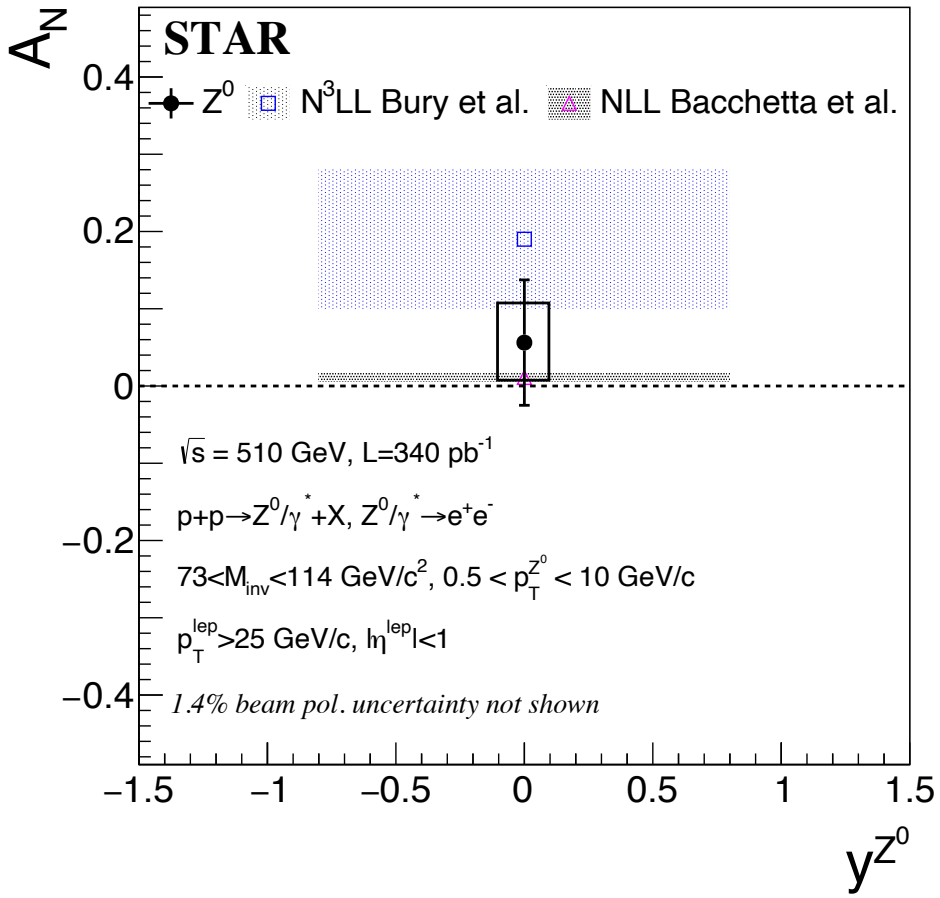
DY, W, Z^0: Color repulsive



RHIC Spin Collaboration, RHIC Spin Plan

Results from STAR





- First measurement of the Z^0 differential cross section as a function of its p_T in p+p collisions at STAR.
- Cannot conclude sign change with STAR data; higher precision measurement (2022 data) is coming.

Please check out the poster!

STAR published these results in May 2024!

STAR, Phys. Lett. B 854 (2024) 138715

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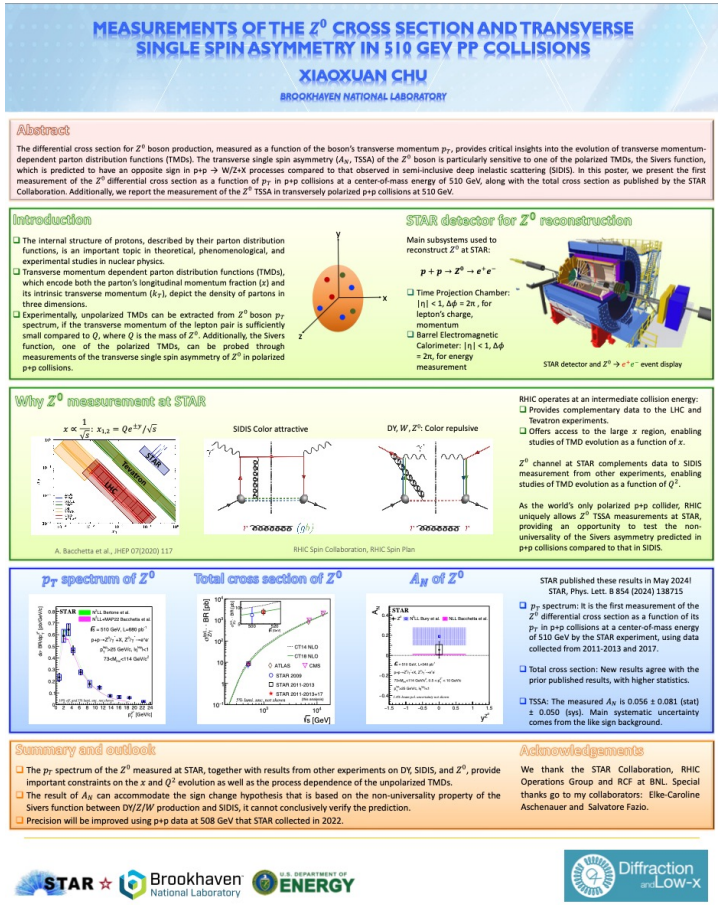
Letter

Measurements of the Z^0/γ^* cross section and transverse single spin asymmetry in 510 GeV $p+p$ collisions

The STAR Collaboration



Thank you!