Probing gluon saturation with dihadron correlations

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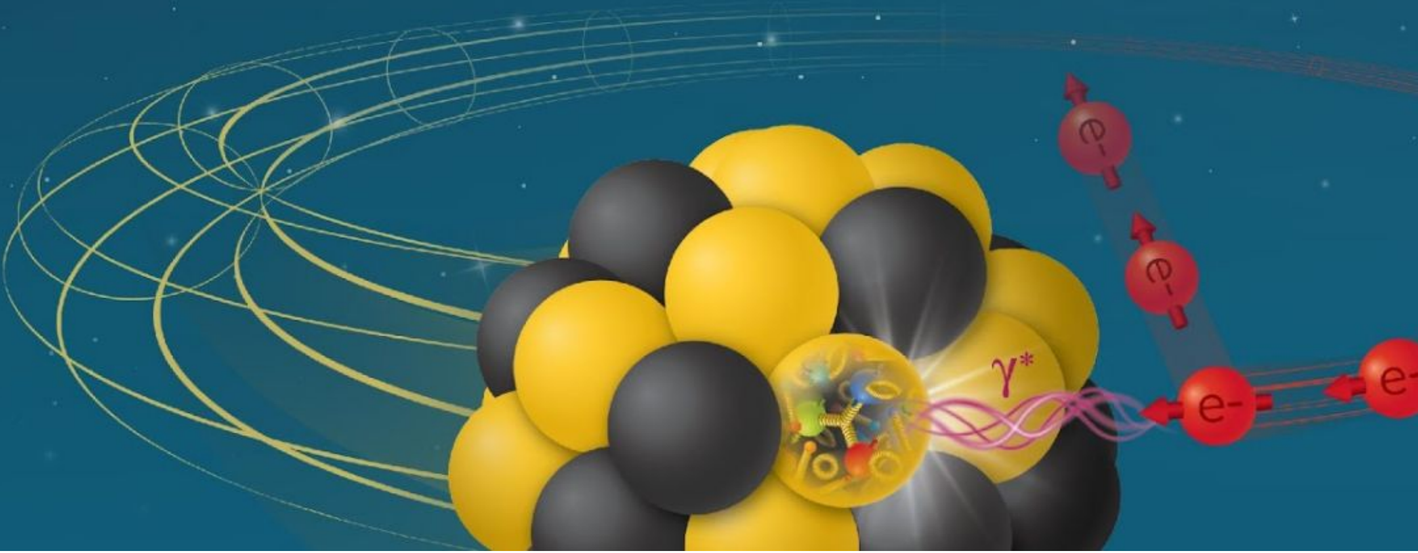
ePIC - SIDIS WG
June 23th, 2026



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Summary

❖ **Previous presentations**
Readiness workshop - London 2025 (link)
Readiness workshop - Calabria 2026 (link)
SIDIS WG - 04/21/2026 (link)

❖ **Methodology - Updates**

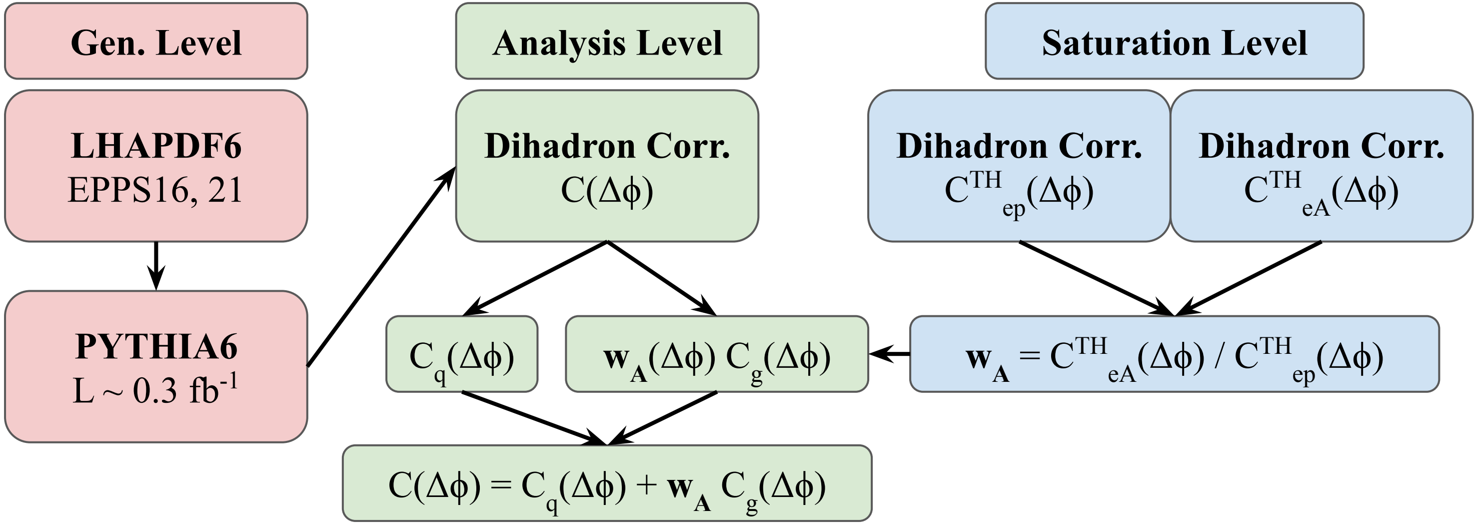
z_{h1} and z_{h2} dependency

Current results: **Correlation function in *x* bins**

Analysis note sketch (link)

❖ **Next steps**

Methodology



Generation Level

- ❖ PYTHIA6 + LHAPDF6:

https://gitlab.com/eic/mceg/PYTHIA-RAD-CORR/-/tree/lhapdf6test?ref_type=heads

- ❖ Collision systems: e+p, e+Ag, e+Au
  - ➢ Luminosity: **e+p = 0.25 fb^{-1}**, **e+Ag = 0.38 fb^{-1}**, **e+Au = 0.40 fb^{-1}**
  - ➢ Energy: 10 x 100 GeV
  - ➢ Kinematic range: $1 \leq Q^2 < 9$ GeV^2, $10^{-4} < x < 0.9$
  - ➢ Nuclear PDFs: EPPS16 and EPPS21

    https://arxiv.org/pdf/1612.05741, https://arxiv.org/pdf/2112.12462

Saturation Level - z_{h1}, z_{h2} dependence

- Coincidence probability calculated within the saturation formalism

$$C(\Delta\phi) = \frac{1}{\frac{d\sigma_{\text{SIDIS}}^{\gamma^*+A\to h_1+X}}{dz_{h1}}} \frac{d\sigma_{\text{tot}}^{\gamma^*+A\to h_1+h_2+X}}{dz_{h1}dz_{h2}d\Delta\phi} \longrightarrow \frac{d\sigma_{\text{tot}}^{\gamma^*+A\to h_1+h_2+X}}{dz_{h1}dz_{h2}d^2p_{h1\perp}d^2p_{h2\perp}} = C\int_{z_{h1}}^{1-z_{h2}} dz_q \frac{z_q(1-z_q)}{z_{h2}^2 z_{h1}^2} d^2p_{1\perp}d^2p_{2\perp}\mathcal{F}(x_g,q_\perp)\mathcal{H}_{\text{tot}}(z_q,k_{1\perp},k_{2\perp}) \times \sum_q e_q^2 D_q(\frac{z_{h1}}{z_q},p_{1\perp})D_{\bar{q}}(\frac{z_{h2}}{1-z_q},p_{2\perp}),$$

- $$\boxed{w_A(\Delta\phi) = \frac{C_{eA}(\Delta\phi)}{C_{ep}(\Delta\phi)}}$$

- **Weight is calculated across phase space and applied event by event, for each hadron pair**

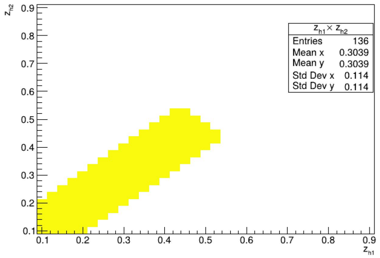
Phase space is now: (Q2, x, z_{h1}, z_{h2})

- New fixed parameters: 2.0 GeV/c $\leq p_T^{trig}$ and 1.0 GeV/c $\leq p_T^{asso} < p_T^{trig}$

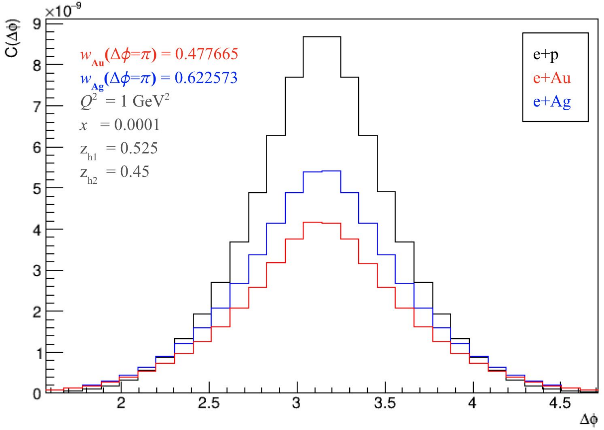
L. Zheng, E.C. Aschenauer, J.H. Lee, Bo-Wen Xiao, Phys. Rev. D 89, 074037 (2014)

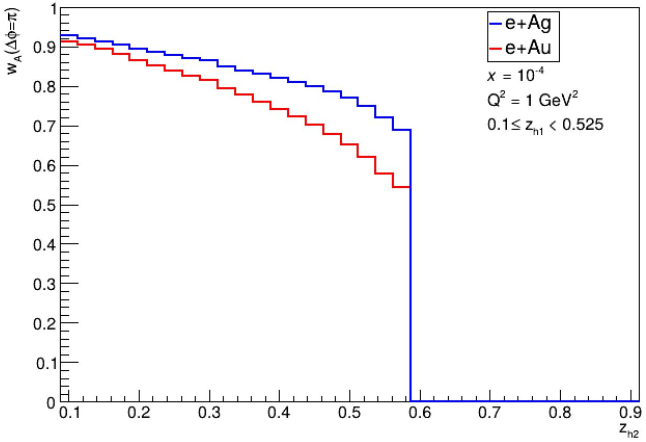
Saturation Level - z_{h1}, z_{h2} dependence

- Selected region for zh1, zh2:
  - $z_{h1} + z_{h2} < 1$
  - $|z_{h1} - z_{h2}| < 0.1$



- Maximum away side suppression and Saturation weight dependence





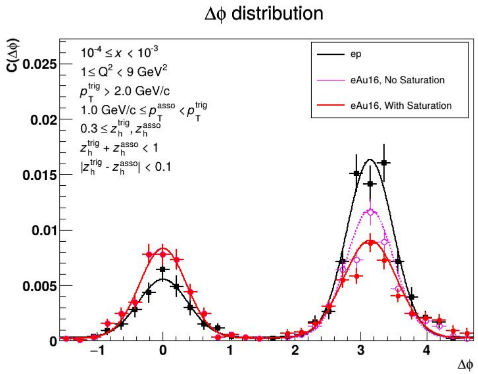
Analysis Level

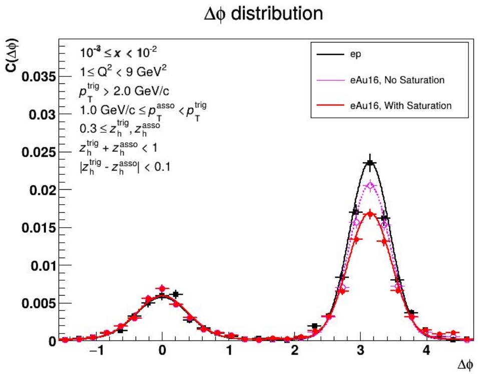
- Events initiated with gluon involving processes (e.g. PGF) have it's dihadron correlation weighted by $w_A(\Delta\phi)$

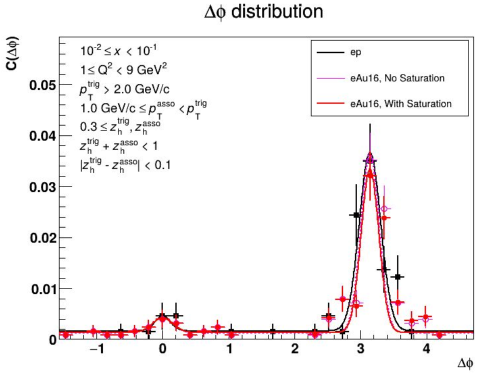
- Analysis cuts:
  - $|\eta| < 4.0$ (ePIC)
  - $1 < Q^2 < 9$ GeV^2
  - $0.3 \leq z_{h1,h2}$ within $z_{h1} + z_{h2} < 1$ and $|z_{h1} - z_{h2}| < 0.1$
  - 2.0 GeV/c $\leq p_T^{trig}$
  - 1.0 GeV/c $\leq p_T^{asso} < p_T^{trig}$
  - x bins: $[10^{-4},10^{-3})$, $[10^{-3},10^{-2})$ and $[10^{-2},10^{-1})$

Results: e+Au (EPPS16)

- ❖ Suppression of away-side peak observed in e+A *vs* e+p
- ❖ Lower x more suppressed
- ❖ Away-side area **suppression ~40%** in lowest x bin of e+Au relative to e+p





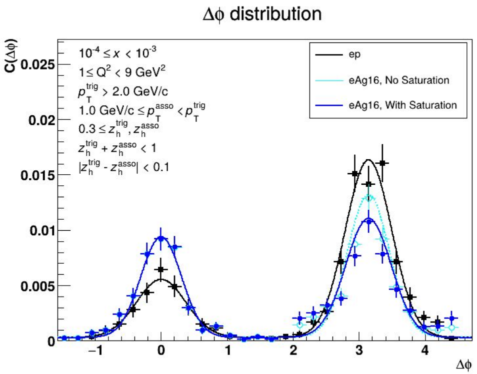


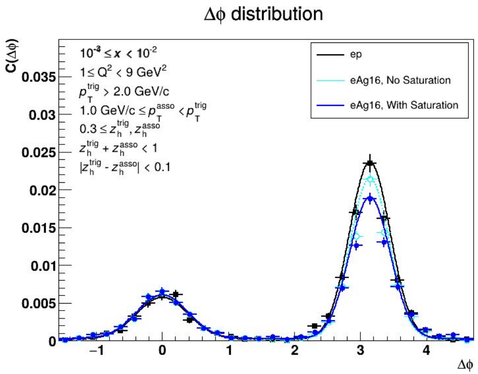
Results: e+Ag (EPPS16)

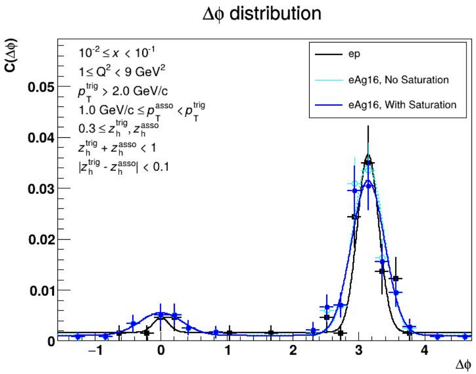
- Suppression of away-side peak observed in e+A *vs* e+p

- Lower *x* more suppressed

- Difference between Ag and Au reflects nuclear size dependence

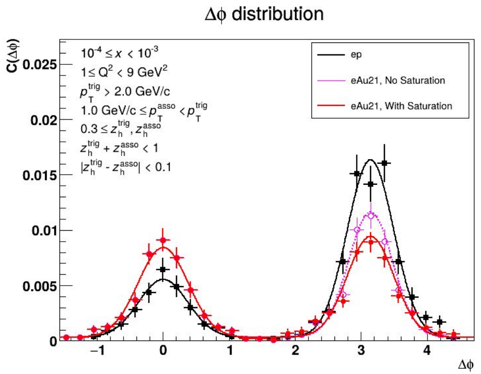


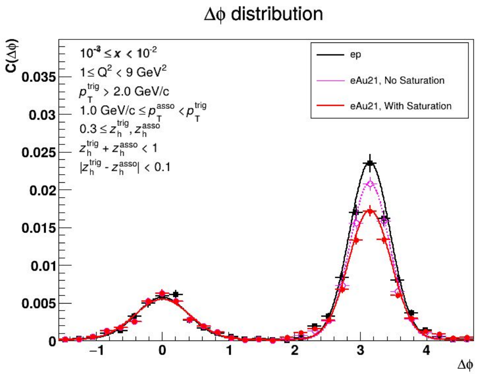


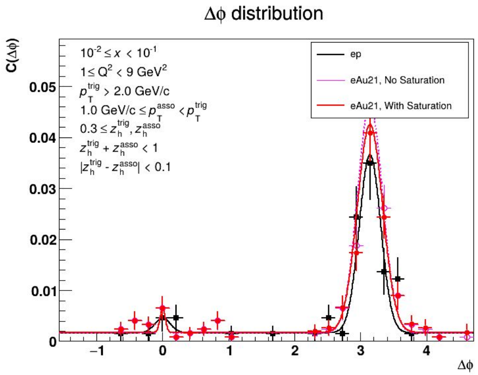


Results: e+Au (EPPS21)

- Suppression of away-side peak observed in e+A *vs* e+p
- Lower x more suppressed
- Difference between Ag and Au reflects nuclear size dependence
- EPPS16 *vs* EPPS21: results consistent within uncertainties

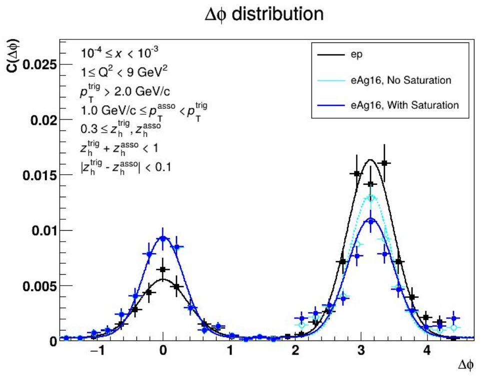


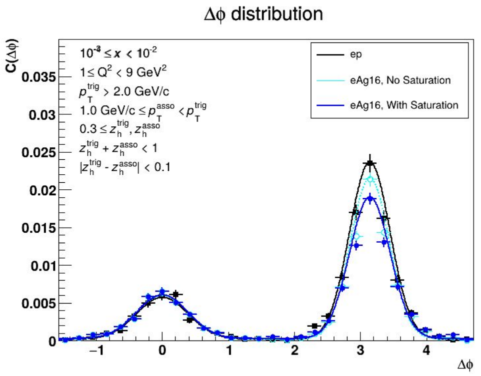


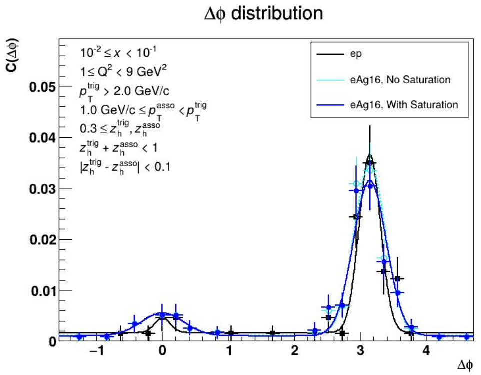


Results: e+Ag (EPPS21)

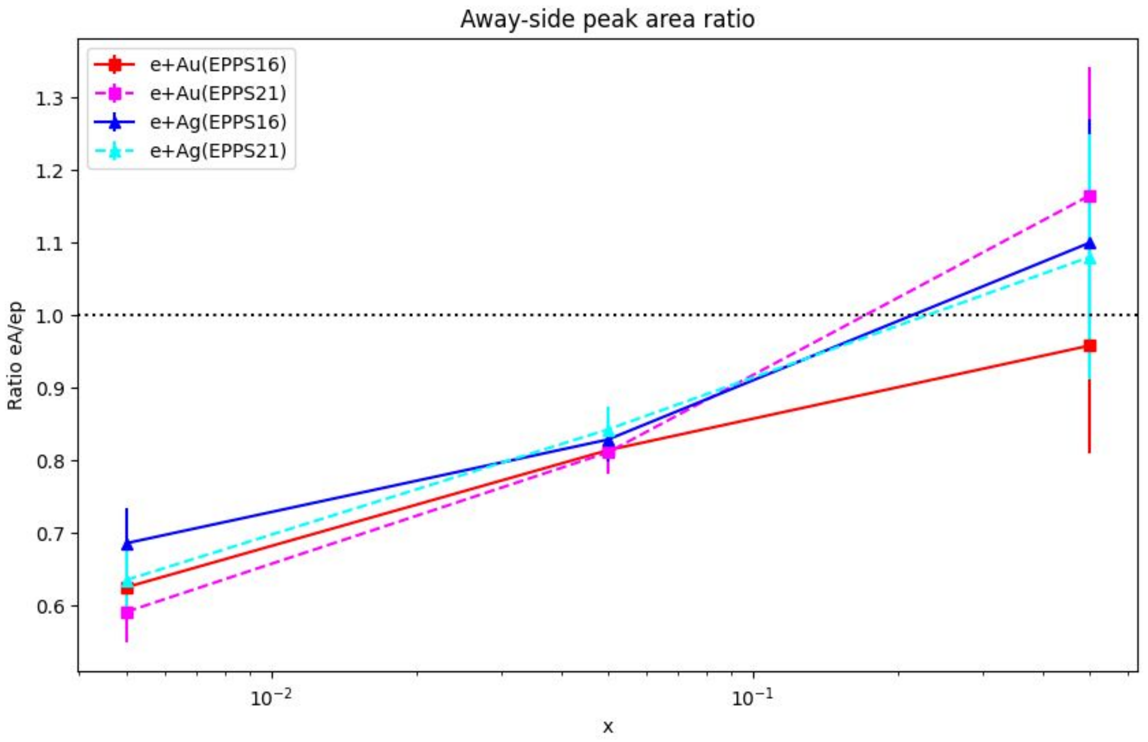
- Suppression of away-side peak observed in e+A *vs* e+p
- Lower *x* more suppressed
- Difference between Ag and Au reflects nuclear size dependence
- EPPS16 *vs* EPPS21: results consistent within uncertainties







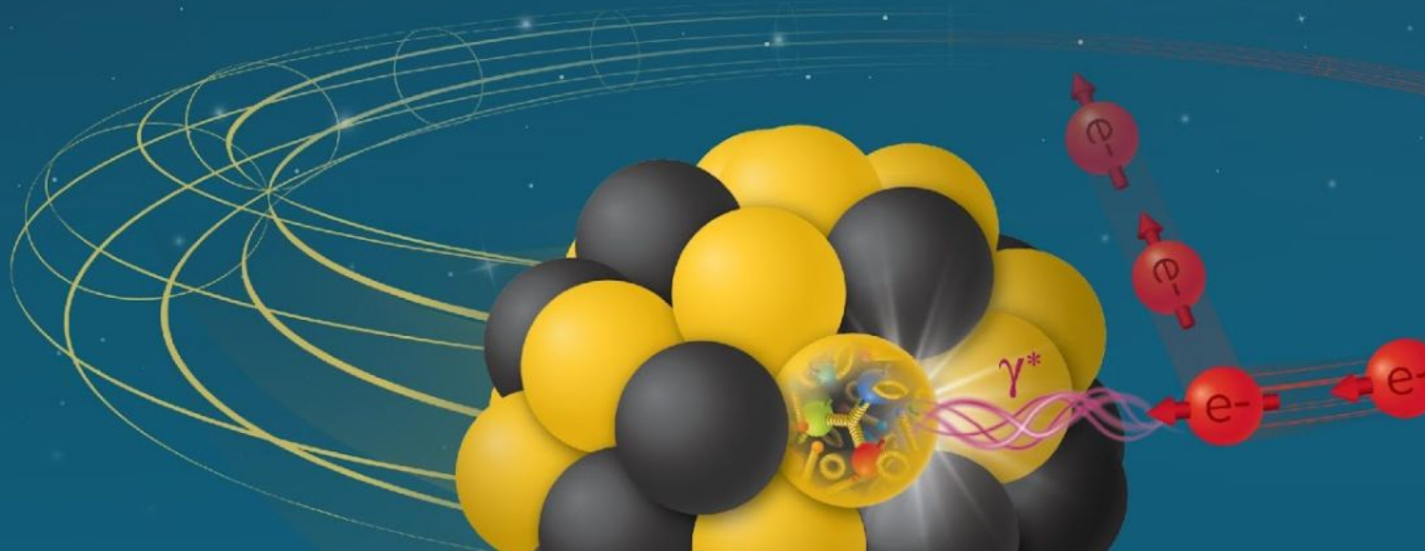
Results: Away-side area



Next steps

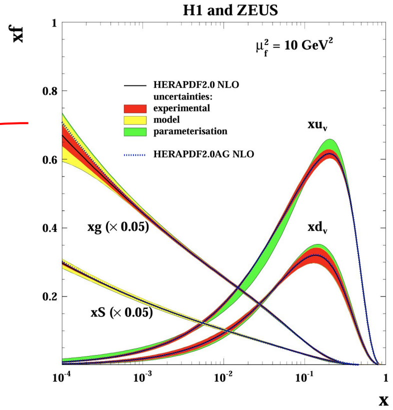
- Last x bin $[10^{-2},10^{-1}) \rightarrow [10^{-2},1)$ to improve statistics
- Generation level with updated energies
- Sea quark saturation contribution → Require $C^{TH}(\Delta\phi)$ for sea quarks
- LHAPDF6 + PYTHIA + BeAGLE → Introduce final state nuclear effects
- Detector effects

Thank you!



BKP

Motivation



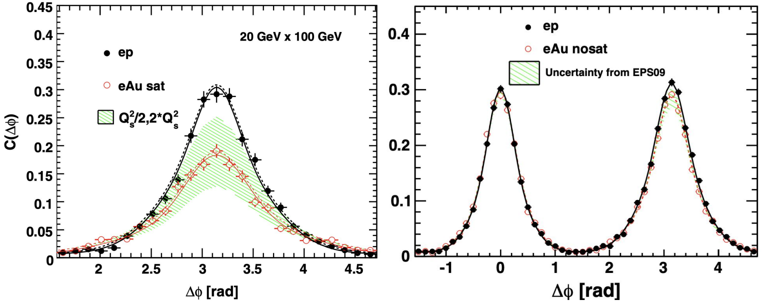
- **Saturation**

  Low-x behaviour of PDF threatens unitarity

  Nonlinear effects become relevant

- **Dihadron correlation**

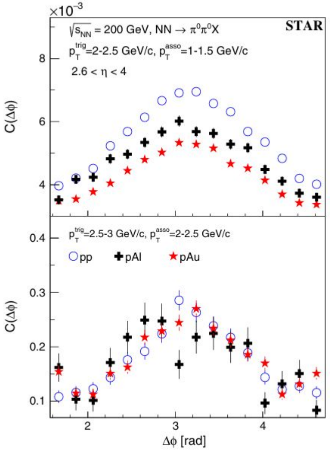
  Gluons k_T at a scale of $Q_s > Q \rightarrow$ Smear away side

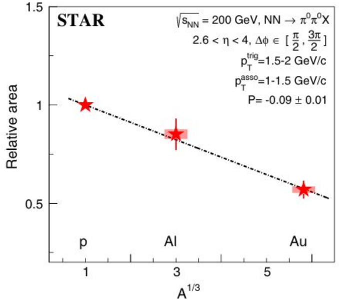


L. Zheng, E.C. Aschenauer, J.H. Lee, Bo-Wen Xiao, Phys. Rev. D 89, 074037 (2014)

- **Evidence of nonlinear gluon effects: STAR**

  Saturation scale $Q_s^{\,2} \sim A^{1/3}$





STAR, Phys. Rev. Lett. 129, 092501

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First years of EIC

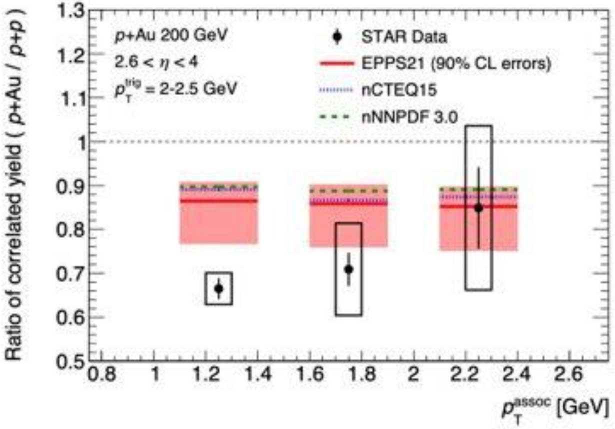
- Early science matrix (the e+A luminosity is per nucleon)

Species	Beam energy (GeV)	Integrated luminosity (fb^{-1})	Electron-beam polarization	Hadron-beam polarization
e+Ag	9×115	1.0	NO	N/A
e+D	9×130	1.5	LONG	NO
$e+p$	9×130	1.0	LONG	TRANS and/or LONG
$e+p$	9×275	2.5	LONG	TRANS and/or LONG
e+Au	9×100	1.0	LONG	N/A
$e+{}^{3}$He	9×166	1.5	LONG	TRANS and/or LONG

- Dihadron correlations identified as an early EIC physics goal
- Observable sensitive to gluon saturation effects
- In this work we compare the dihadron correlation from e+p, e+Ag and e+Au
  - Two different nPDFs: EPPS16 and EPPS21

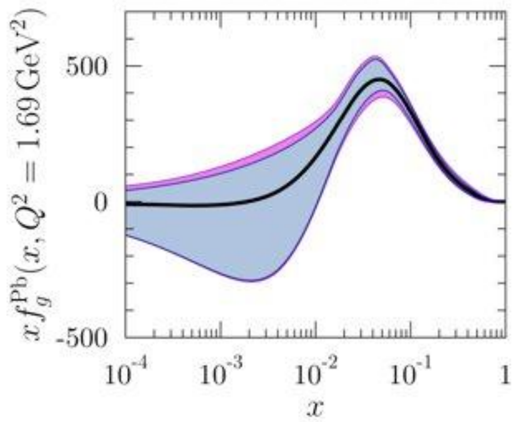
nPDF at small Q^2

D. Perepelitsa, PRC 111 (2025), 054901



- No p_T dependence, overshoot low p_T data
- The vanishing gluon density at small Q^2 is used

K. Eskola et al., EPJC 82 (2022) 413



- Gluon density is 0 with largely negative error