Q1: Please provide us with an update to Figure 8 of your BUR, listing which of these measurements, at which energies, were shown at QM23.

Physics Analysis	Status of Analysis (orig)	QM23?	motivation
R_{CP} up to p_T=5GeV/c	Physics Working Group	no	no change
Elliptic Flow	Published 3 and 27 GeV, QM2023 3.0-3.9, 7.7-19.6GeV	partial	7.7GeV: centrality not ready in time for analysis 9.2,11.5GeV: centrality/embedding not ready
Chiral Magnetic Effect	Published 27GeV, QM2023 7.7, 14.6, 19.6	yes	no change
Directed Flow	Published 3GeV, QM2023, 3.0-7.7, 7.7-27GeV	partial	4.5GeV: analysis not ready 4.5-7.7(FXT): centrality/embedding not ready 9.2, 11.5GeV: centrality/embedding not ready
Femtoscopy	QM2023 3.0-4.5 GeV	yes	no change
Net-proton Kurtosis	Published 3GeV, QM2023 7.7, 14.6, 19.6	no	STAR prefers to include 9.2, 11.5, and 17.3GeV 9.2, 11.5GeV: embedding not ready 17.3: production just finished
Di-leptons	Published 27GeV, QM2023 14.6, 19.6GeV	yes	also include 7.7GeV 27GeV paper in GPC
Lambda Polarization	Published 3, 19.6 and 27GeV	yes	no change
Multi-strange Baryons	Published 3 GeV, QM2023 3.2GeV	no	3.2GeV analysis not finalized 14.6 and 19.6GeV were added
Hyper-nuclei	Published 3GeV, QM2023 3.2-4.5 and 7.7-19.6GeV	partial	9.2, 11.5GeV: centrality/embedding not ready
Rapidity dependent Spectra	In-prep 3.0GeV, QM2023 3.2, 7.7-54.4GeV	partial	3.2GeV analysis not finalized 7.7GeV: centrality not ready in time for analysis 9.2,11.5GeV: centrality/embedding not ready
J/psi production	QM2023 14.6, 19.6, 27GeV	yes	no change

Q1: Please provide us with an update to Figure 8 of your BUR, listing which of these measurements, at which energies, were shown at QM23.

Figure 8 update

Physics Analysis	Status of Analysis
R_{CP} up to p_T=5GeV/c	Physics Working Group
Elliptic Flow	Published 3 and 27 GeV; QM2023: 3.0-3.9, 14.6-19.6GeV
Chiral Magnetic Effect	Published 27GeV; QM2023: 7.7, 14.6, 19.6GeV
Directed Flow	Published 3GeV; QM2023: 3.0, 7.7, 14.6, 19.6, 27GeV
Femtoscopy	QM2023: 3.0-4.5GeV
Net-proton Kurtosis	Published 3GeV; Near completion: 7.7, 14.6, 27GeV
Di-leptons	In-prep 27GeV; QM2023: 7.7, 14.6, 19.6GeV
Lambda Polarization	Published 3, 19.6, and 27GeV
Multi-strange Baryons	Published 3 GeV; QM2023: 14.6, 19.6GeV
Hyper-nuclei	Published 3GeV; QM2023: 3.2-4.5 (FXT) and 7.7, 14.6, 19.6GeV
Rapidity dependent Spectra	In-prep 3.0GeV; QM2023: 14.6-54.4GeV
J/psi production	QM2023: 14.6, 19.6, 27GeV

Q2: If there were five weeks of pAu running with statistics comparable to those in Run15 and the anticipated level of polarization, please specify what advantages the forward upgrade would yield (for both polarized and unpolarized measurements), and which of the measurements Lijuan presented could be completed.

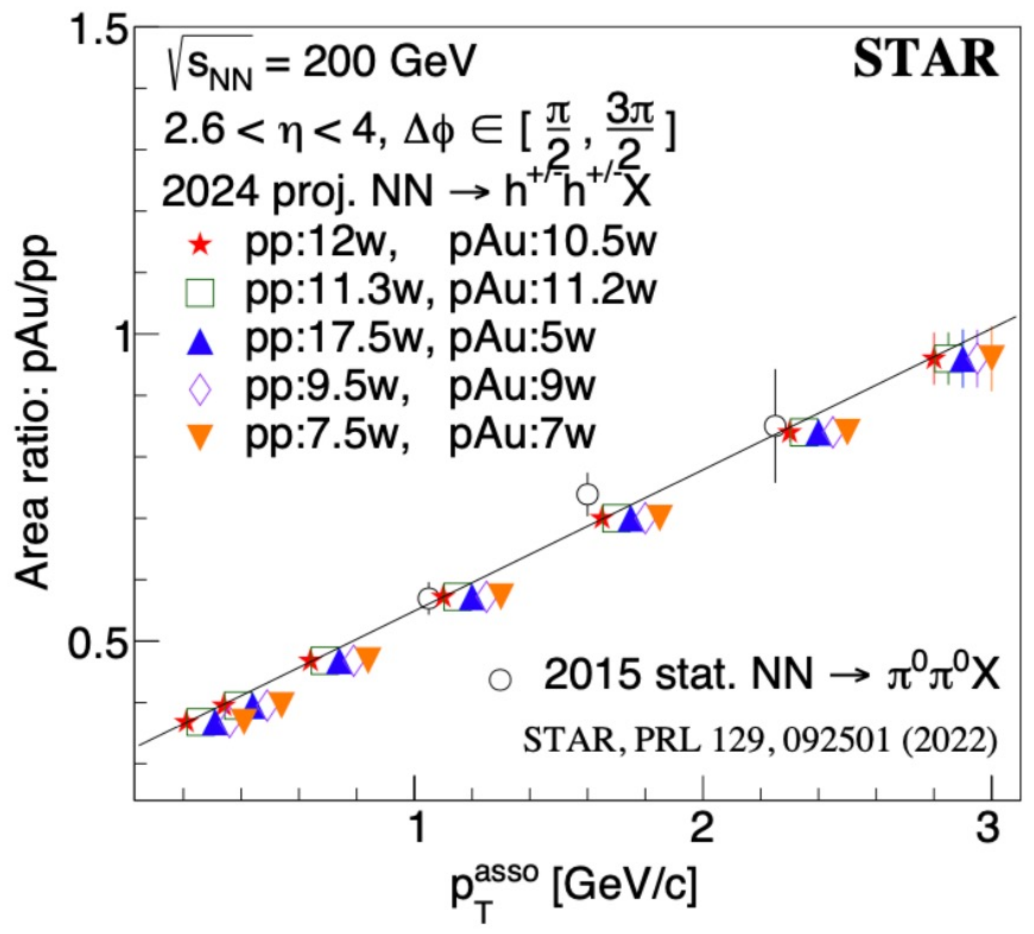
New capabilities of the STAR forward upgrade

- charge hadron identification down to p_T of 0.2 GeV/c
- full jet reconstruction at forward rapidities $2.5 < \eta < 4$
- extended reach to high x at high Q^2 for TMD physics
- extended reach to low x at low Q^2 for Saturation physics

From Lijuan's slide 37 & 38 the following physics can be completed / addressed

- First look at gluon GPD Eg through A_{UT} for J/Ψ in UPC
  forward upgrade allows to low W where asymmetry is largest (see slide 10)
- Nuclear dependence for A_N of inclusive charged hadrons
  forward upgrade allows a larger kinematic dependence and a much cleaner measurement
  because of reduced backgrounds
- nuclear dependence of TMDs → Sivers and Collins effect through tagged hadrons in jet
  forward upgrade allows to extend x-reach to lower and higher x (slide 7)
- non-linear QCD effects
  forward upgrade extends reach to lower x and Q2 and provides with di-charged hadrons
  a combinatorial free probe (slide 14)
  additional new probes: γ-jet and di-jets

Example of new physics reach with fSTAR



STAR forward upgrade provides charged hadron detection down to p_T of 0.2 GeV/c

→ 2024 data:

- Scan more complete x-Q^2 phase space, compared to the 2015 data
- could not study p_T dependence for the 2015 data, limited statistics for di-π0
- Access lower p_T, which is closer to the saturation region → strongest suppression is expected!

  Can reach $\widehat{Q^2}$ = 1.5 GeV^2 for x_1 =0.152 and x_2 = 0.025
- Much larger statistic at high p_T, to test evolution of Q_s with x

Q3: Is STAR formulating a strategy for data preservation? If so, could you briefly summarize the current state of your plans?

Strategy for Data Preservation

Recent Efforts

- integrate **HEPdata** submission in STAR's publication workflow
  - used STAR's shift-credit mechanism to handle backlog of older papers
- move STAR software repository to **GitHub**
  - use industry standards
  - keeps documentation of software developments/updates close to the code
- automatic generation of "**software containers**"
  - allows virtualization of the OS and STAR-specific libraries to run anywhere, anytime
- **document** internal GPC discussions
  - next: enabling collaboration access to these dedicated and archived mailing lists

Past Efforts

- all STAR analysis accompanied with a STAR note (knowledge preservation) duly reviewed, all papers uploaded with comments and revision, all presentations as well since the early 2000
- Web service virtualized / containerize [migration to a facility based support possible]
- dynamic content useful during runs made static (no long-term maintainability risks): ESL, online information
- database snapshots (no server required) demonstrated to work as expected (1:1 comparison made, used at NERSC)
- containers based workflows validated (DOI 10.1088/1742-6596/898/8/082023)

Efforts in preparation:

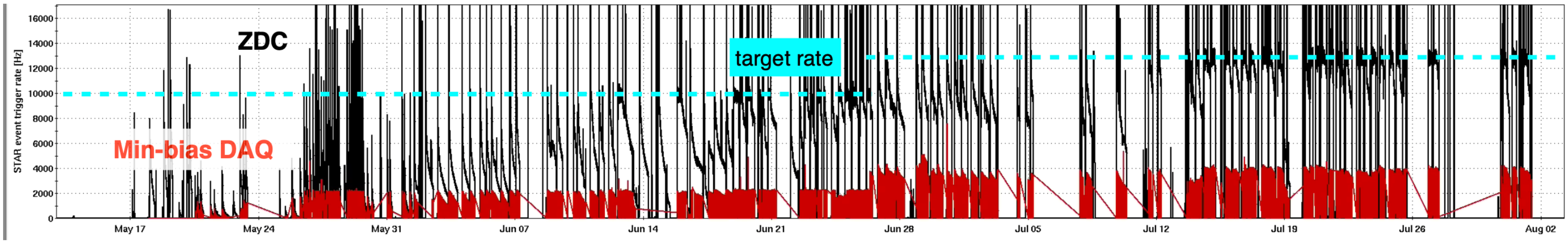
- **documentation preservation**:
  - transition STAR's old drupal server (v6) to newer version (v9+)
    - take advantage of BNL's resources to further enable common preservation efforts
    - careful since STAR is still very active (e.g. detector operations)
- **software sustainability**:
  - transition STAR's ROOT 5.34 environment to ROOT6
    - allow STAR production & analyses to take advantage of latest libraries
    - allow incremental changes in software stack to easier integrate with common preservation efforts
- database virtualized, migration to a facility based support (from a STAR in-house support)

Next steps:

- create "buy-in": **engage whole collaboration**
  - use shift-credit mechanism
- improve **workflow documentation** (calibrations, analyses, etc)
- look for **commonalities** with other BNL collaborations
  - seeking strong support from BNL

Q4: Question to C-AD (and STAR): Can STAR take physics data with p-Au (or Au-Au or p-p) while sPHENIX is commissioning?

A: Yes, within the constraints of the beams requested by sPHENIX. STAR took 6.5B high-quality minimum-bias (MB) data from Run 23 while sPHENIX was commissioning, as discussed by JH Lee in his talk. It's true that we couldn't take data when sPHENIX was running with a single beam or was doing studies without beam. But for changes of luminosities, crossing angles, etc., IP-8 (sPHENIX) and IP-6 (STAR) are largely independent. Significant downtime in Run 23 was attributed to STAR magnet issues due to missing maintenance of heater exchangers by BNL support group. We appreciate the collaborative efforts between STAR, sPHENIX, and CAD to optimize the RHIC physics program in the coming runs.

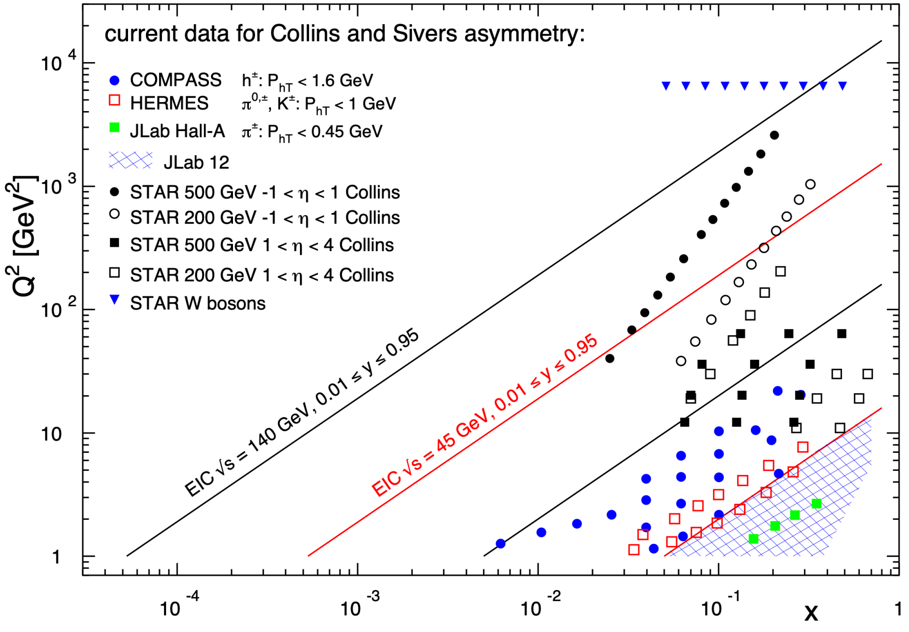


Q5: Question to STAR and sPHENIX: Please provide us with the plots (from the literature? from recent conference talks by theorists? or from your own efforts?) that support what you see as a crisp example of how a specific pAu measurement (either polarized or unpolarized) made in the closing years of the RHIC program can be compared to which specific future eA measurement from the EIC, and what this comparison can teach us. Which is to say please share what you see as "the money plot" making the case that a specific pAu measurement is particularly important to enhancing the science impact of the future EIC program.

To test Universality, one needs to separate interaction dependent phenomena from intrinsic nuclear properties → different complementary probes are critical

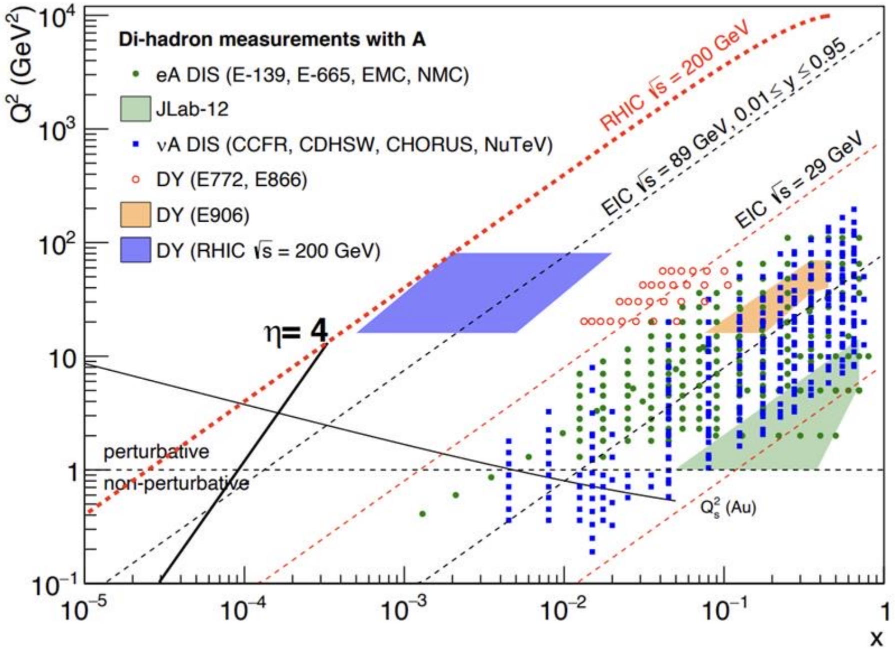
RHIC and EIC have very similar kinematics

TMD Kinematics pp vs ep



The STAR pp data have a wide range of overlap with the EIC ep kinematics and reach to even higher Q^2 then the EIC

Kinematics pA vs eA

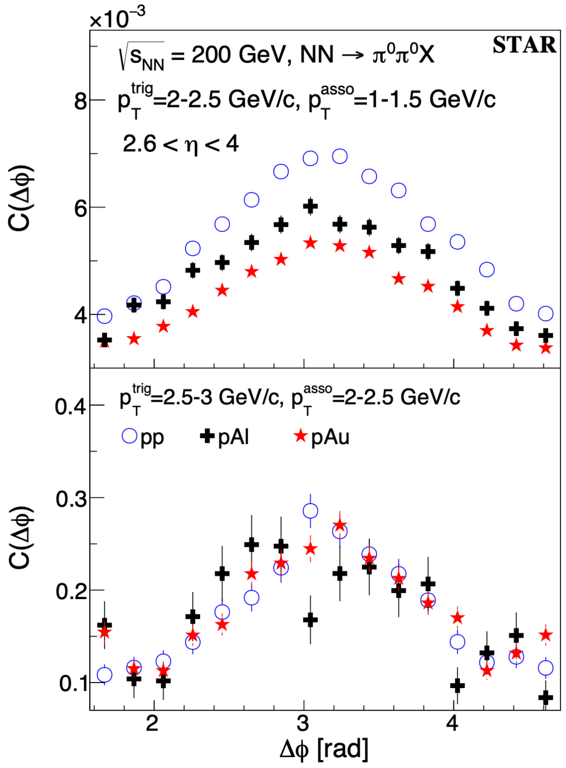


The STAR data have a wide range of overlap with the EIC kinematics and reach to lower x at low Q^2
→ critical for saturation

It has been shown that studying polarized observables helps to tease out effects hidden in unpolarized observables like cross sections, i.e. TMDs

Unpolarized pA and eA

pA | eA



$\widehat{Q^2}$ = 2.5 GeV²

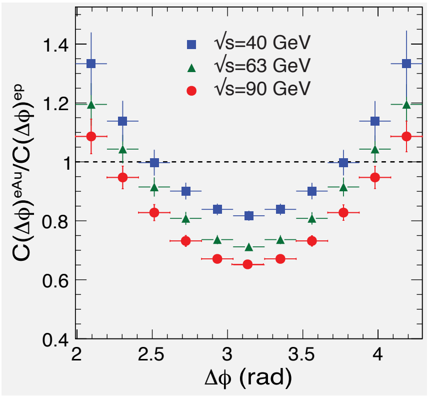
x_1 =0.39

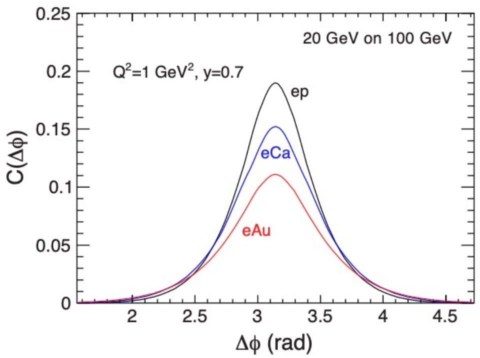
x_2 = 0.06

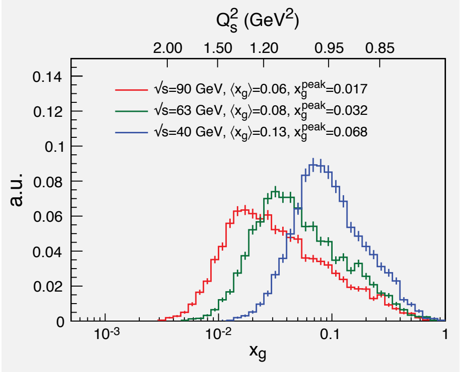
$\widehat{Q^2}$ = 3.8 GeV²

x_1 =0.53

x_2 = 0.09







Can test universality of A-dependence and evolution of Q_s as fct of x

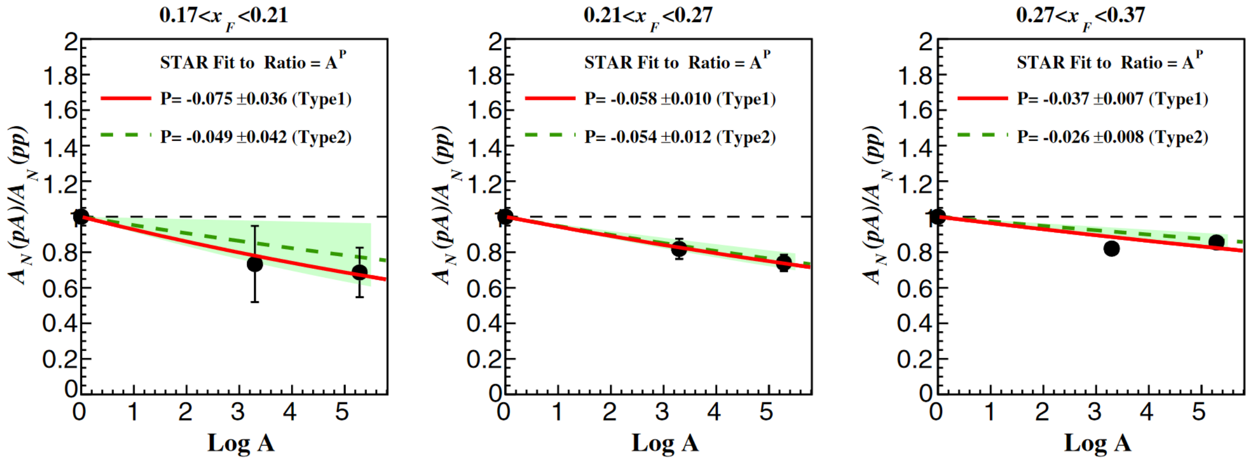
can study universality of IS and FS radiation in eA and pA studying the near side peak in di-hadron correlations

→ all critical to proof or disproof broadening prediction from saturation models

Polarized pA and eA

RHIC is and will be the only polarized hadron collider

→ so what is not measured now will never be measured



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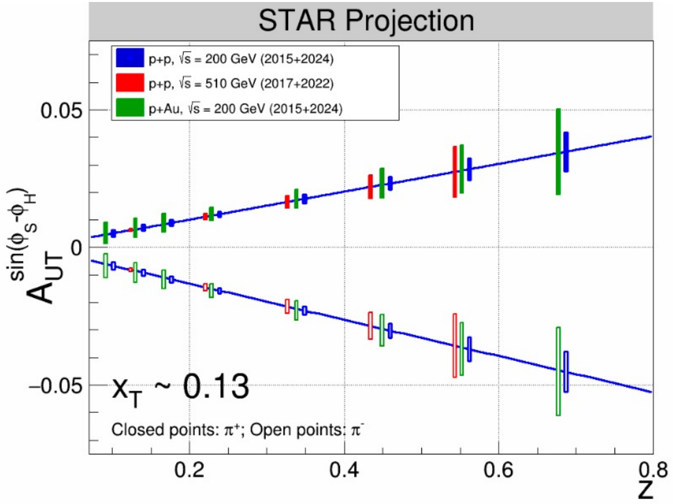
suppression increases at low x_F similar as di-hadron correlations

→ Unpolarized observables, i.e. di-hadron correlations initial state TMDs are the driving force for suppression

→ Polarized observables: → TMD fragmentation functions, i.e. Collins FF



Golden probe to measure Collins FF: hadrons in jet

→ several results published and released for pp

Important Question: is the non-pertubative part in TMD evolution the same for ep & eA (compared to pp & pA), whether the evolution part and nuclear effects are universal between pA and eA?

polarized eA: till now few studies

→ Elliptic Anisotropy in eA Di-Jet Production driven by linearly polarized gluons → STAR can inspire program

nuclear FF

Inspired by HERMES results, nuclear effects in FF at EIC → but LHC no suppression
→ current understanding LHC hadronization happens outside nuclear medium ?

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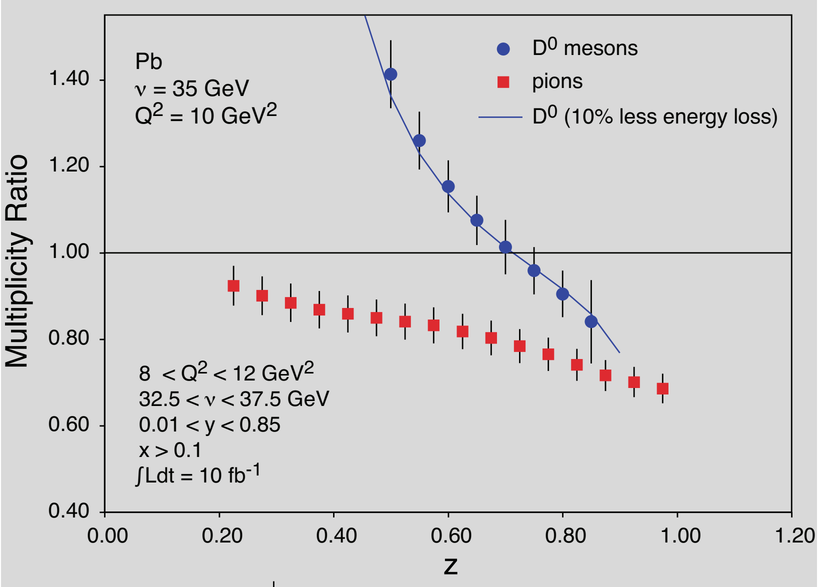

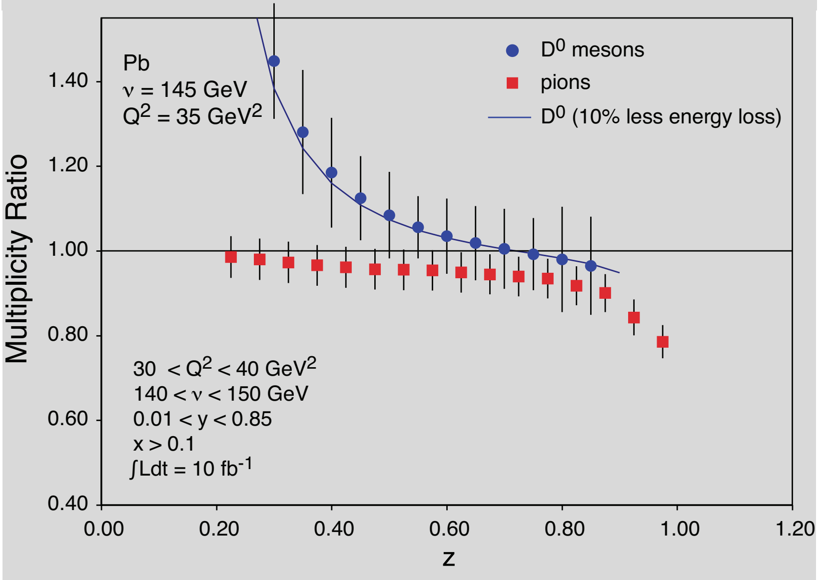

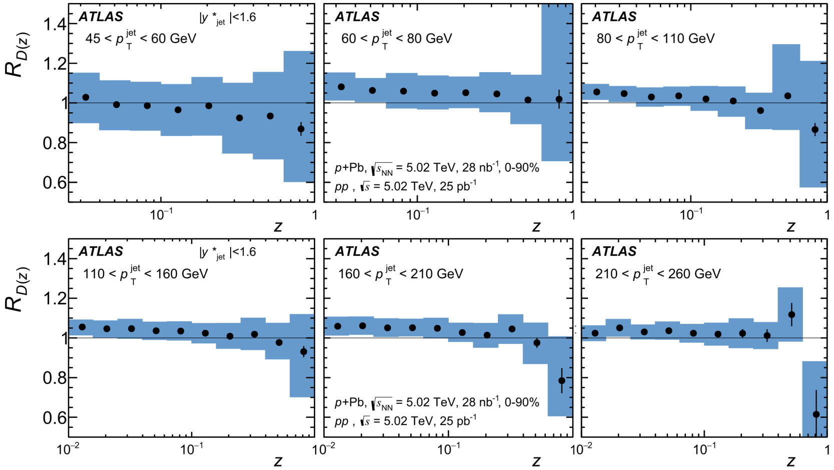

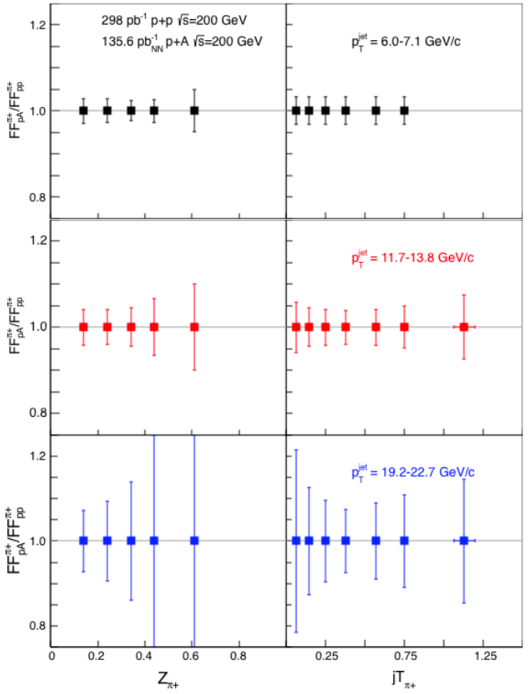

STAR and EIC have identical kinematics
→ such one can verify
- scale dependence for nFF is universal
- observed nuclear effects are universal

Impact of STAR science goals with no pAu data in Run 2024

- Quantitative comparisons of the validity and the limits of factorization and universality in lepton-proton and proton-proton collisions for initial and final state TMDs

  Test of Sivers non-universality: $Sivers_{SIDIS}$ = -- $Sivers_{DY, W+/-, Z0;}$ Full jet and dijet Sivers asymmetry

  Probe final state TMDs: Collins asymmetry for hadrons in jet
  - Requirement:
    - large data sets √s = 200 and 508 GeV p↑p
      → low to high x, highest and lowest x with fSTAR
    - A_{UT} for $W^{+/-}$ Z^0, A_{UT} for hadrons in jet
- ~~First look at gluon GPD → E_g~~
  - Requirement:
    - data sets √s = 508 GeV p↑p and √s = 200 GeV p↑A
    - A_{UT} for J/ψ in UPC
- Physics driving the large A_N at forward rapidities and high x_F
  - Requirement:
    - large data sets √s = 200 and 508 GeV p↑p
      → low to highest x_F → fSTAR
    - charge hadron A_N at forward rapidities
- ~~Nuclear dependence of PDFs, FF, and TMDs~~
  - Requirement:
    - large equal data set of √s = 200 p↑p and p↑Au
      → low to high x, highest and lowest x with fSTAR
    - R_{pA} direct photons and DY, hadrons in jet A_{UT}
- ~~Non-linear effects in QCD~~
  - Requirement:
    - large equal data set of √s = 200 p↑p and p↑Au
      → lowest-x through fSTAR
    - correlations for $h^{+/-}$, γ-jet, di-jets

Without pAu data, STAR's forward upgrade will not be fully utilized for its discovery potential and RHIC will lose important physics opportunities on the following:

- First look at gluon GPD → E_g
- Probe Nuclear dependence of PDFs, FF, and TMDs
- Study Non-linear effects in QCD
- Discover a novel vortical configuration