Cold QCD Physics with sPHENIX

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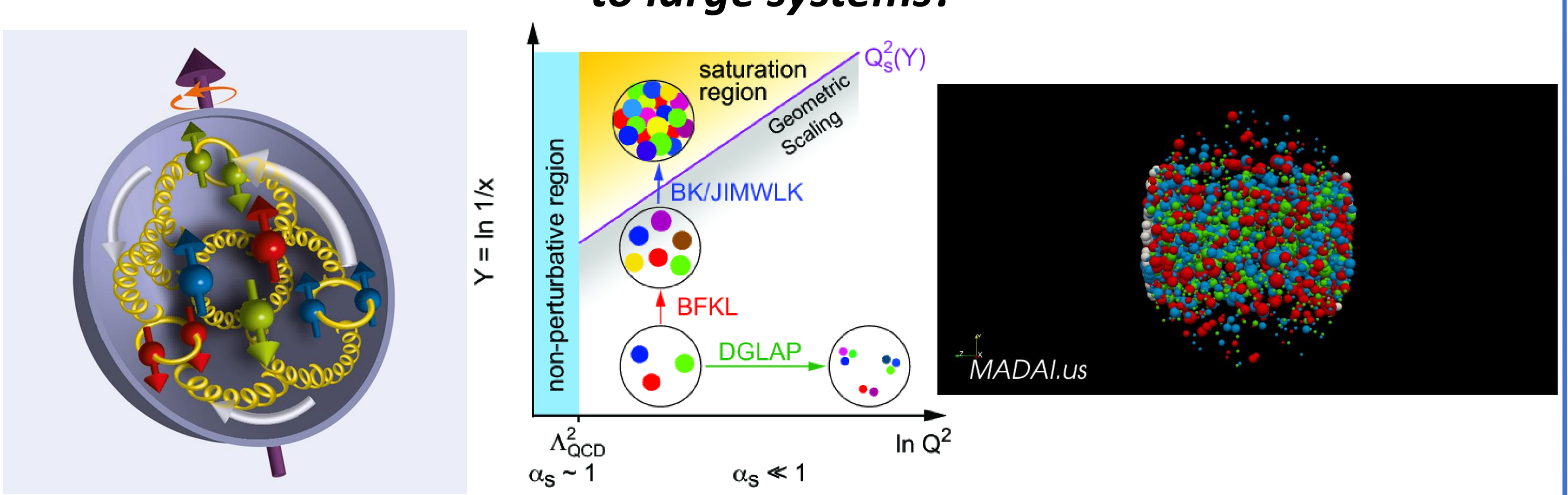
Abstract

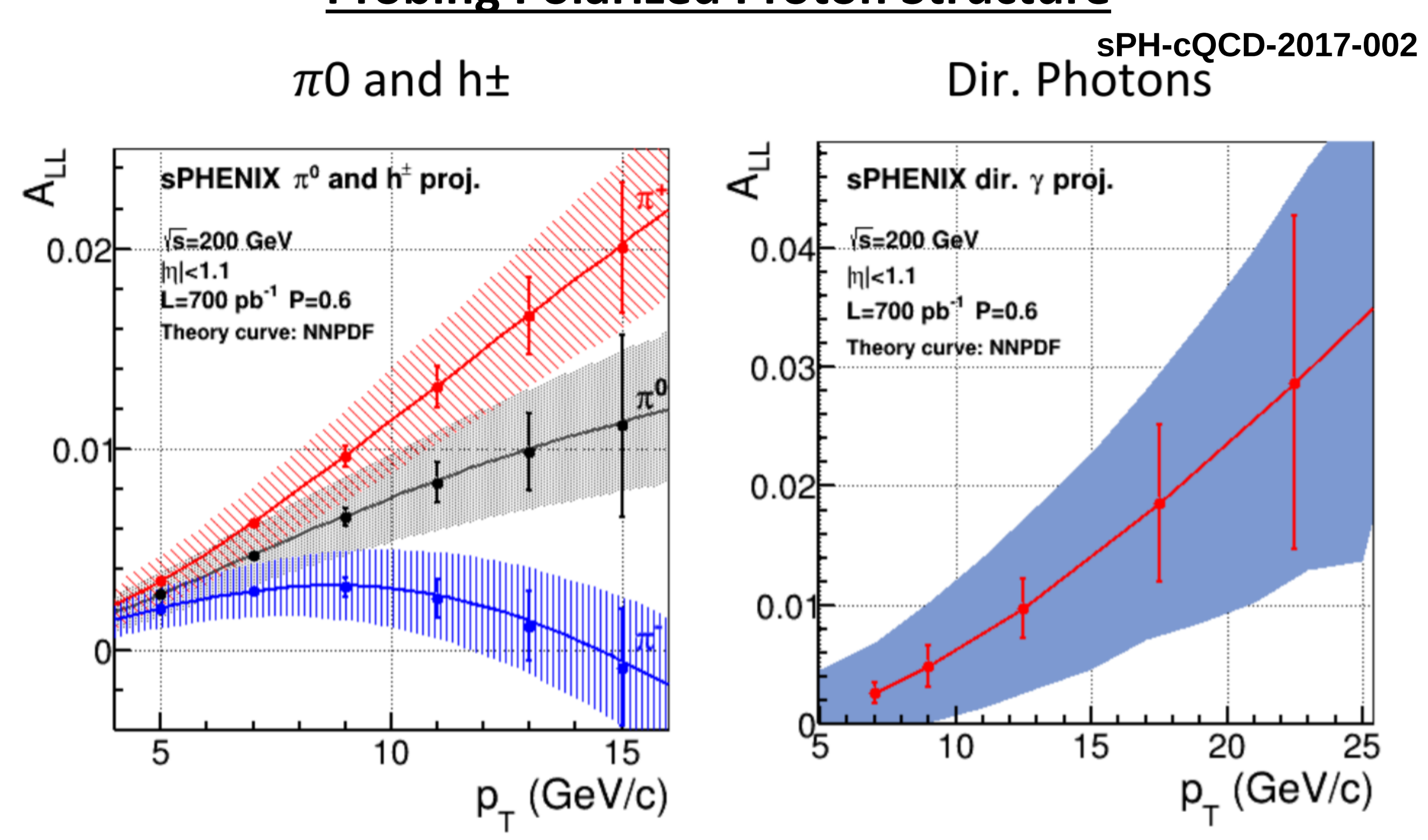
The sPHENIX detector at BNL's Relativistic Heavy Ion Collider (RHIC) will enable a spectrum of new or improved cold QCD measurements, enhancing our understanding of the initial state for nuclear collisions. sPHENIX measurements in proton-proton and proton-nucleus collisions will reveal more about how partons behave in a nuclear environment, inform our understanding of the initial state in heavy-ion collisions, and provide comparative data to investigate modification of fragmentation functions. Measurements will also take advantage of RHIC's unique capability to collide polarized protons on nuclei, which provides novel opportunities to study nuclear effects with spin observables. The cold QCD nuclear physics program for the sPHENIX detector will be presented.

How might collective and many-body behavior arise or evolve from small to large systems?



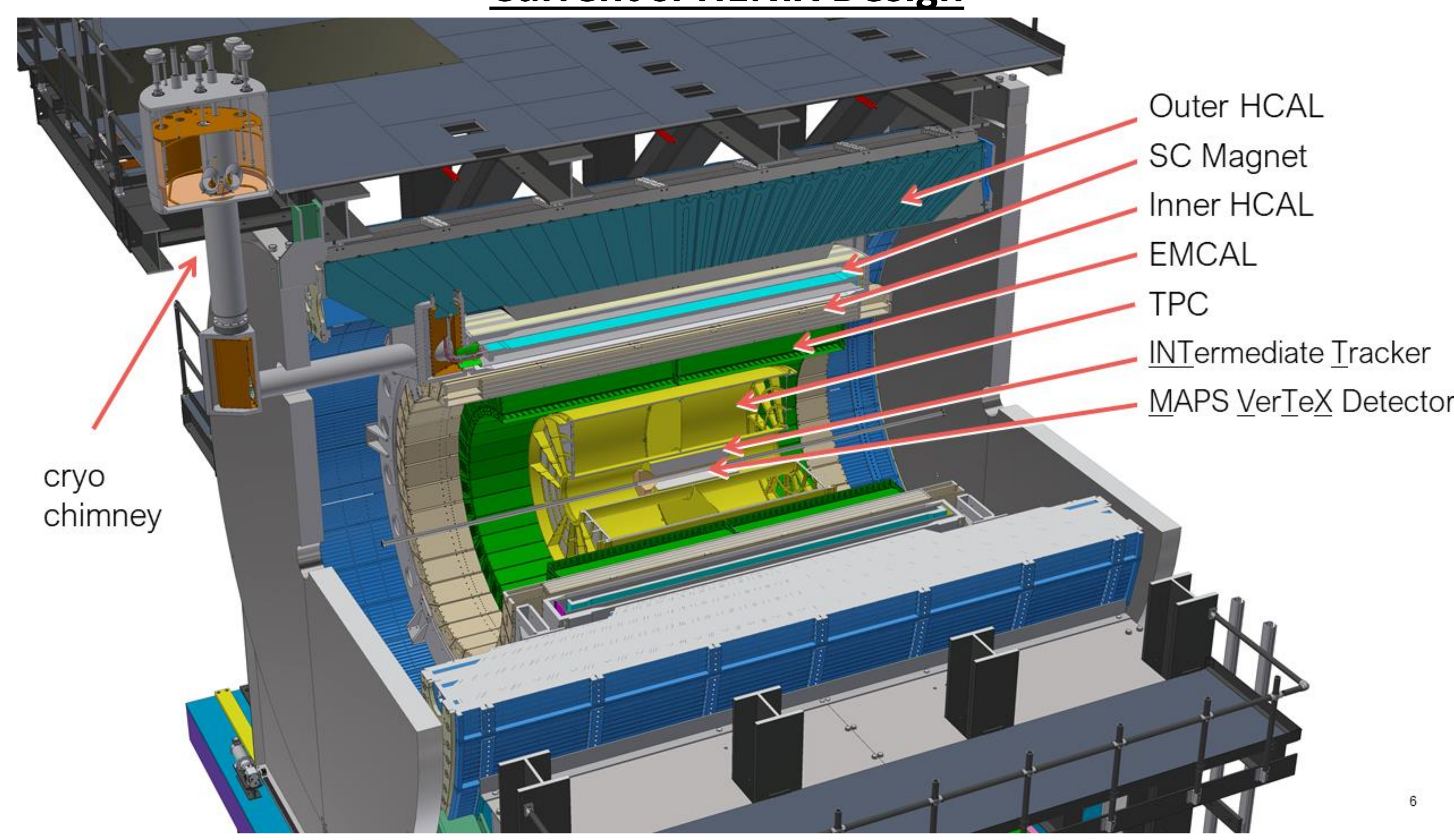
With the EIC on the horizon, the window for exploring the relationships between (polarized) p+p and p+A collisions can be exploited with the sPHENIX detector. These studies will permit an EIC experiment to address universality between p+p(A) and e+p(A) collisions.

Probing Polarized Proton Structure



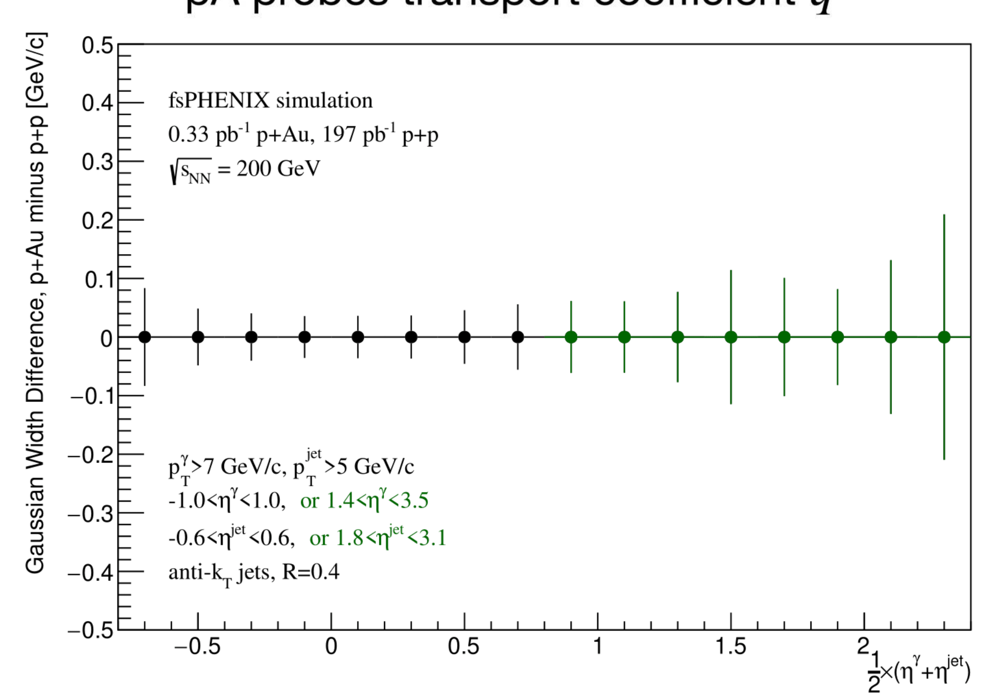
Expected uncertainties on Double-Helicity Asymmetry (A_{LL}) measurements for (Right) direct photon production ($qg \to q\gamma$, $q\bar{q} \to g\gamma$) and (Left) hadron production (gg, qg, qq scattering) projected onto respective DSSV predictions. Note that each probe contains small contributions from non-gluon sensitive channels. These uncertainties are reduced in comparison to previous measurements and are expected to reduce the gluon helicity PDF (ΔG) uncertainty significantly in the region of 0.05 < x < 0.4.

Current sPHENIX Design



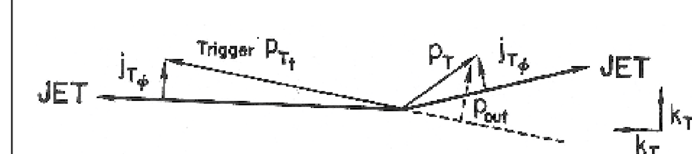
Improving Precision on Transport Coefficient

Transverse momentum broadening in pA probes transport coefficient $\hat{q}$



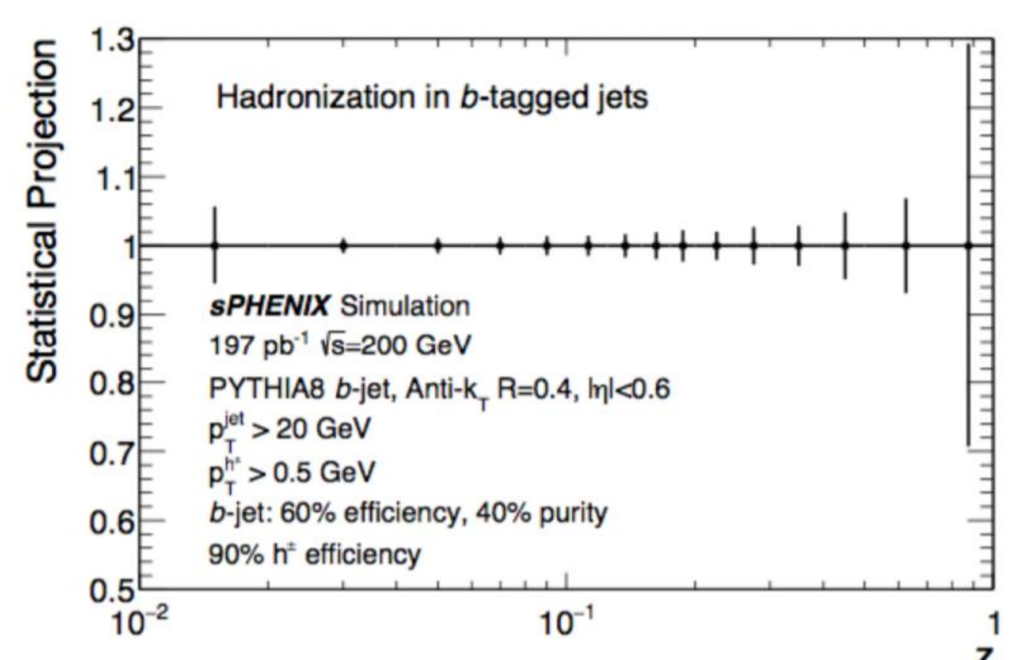
Expected uncertainties for photon-jet pair measurements in p+A vs p+p collisions using the Central Barrel sPHENIX detector (black points). This provides access to the transport coefficient:

$$\langle(\hat{q}L)\rangle/2 \cong \langle p_{out}^2\rangle_{pA} - \langle p_{out}^2\rangle_{pp}$$



Possibility of measuring jet momentum modification in various systems at mid-rapidity is possible with sPHENIX detector.

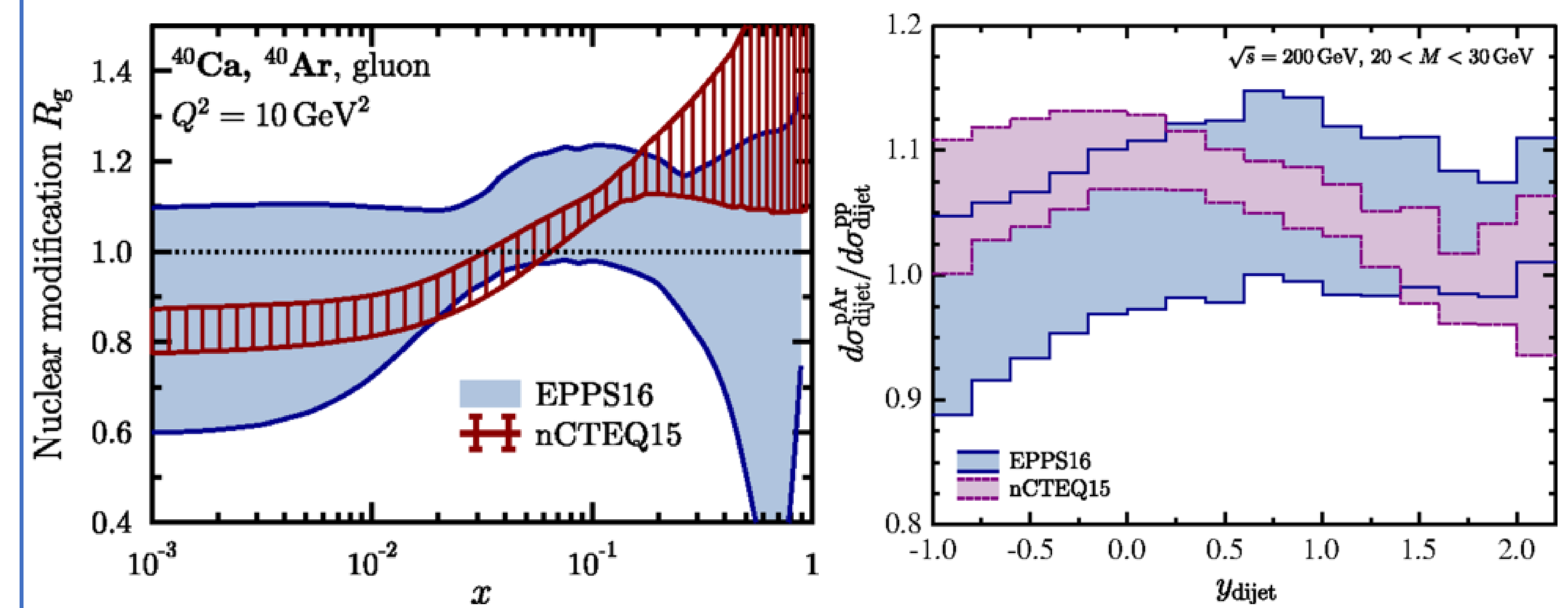
Studying Hadronization in Jets

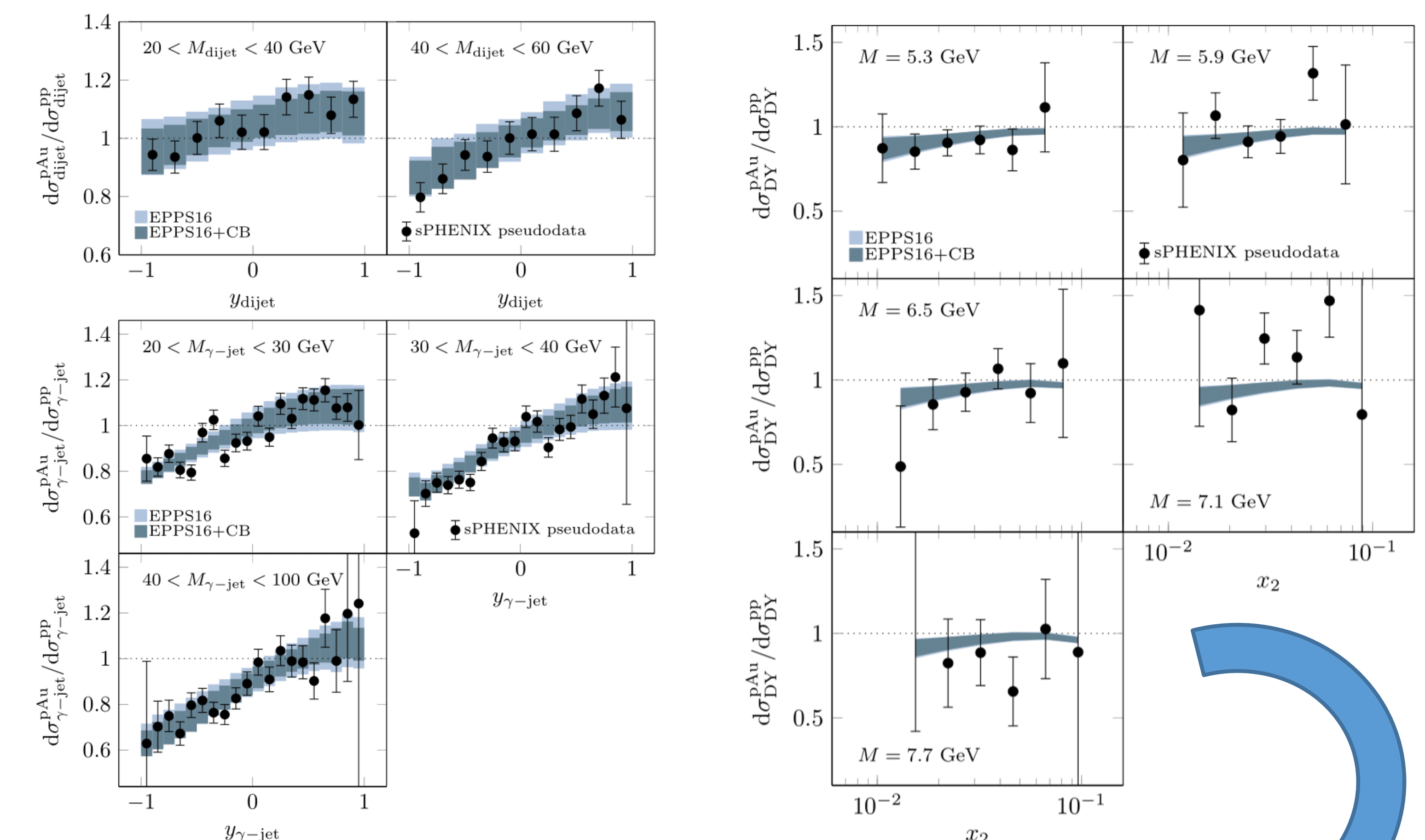


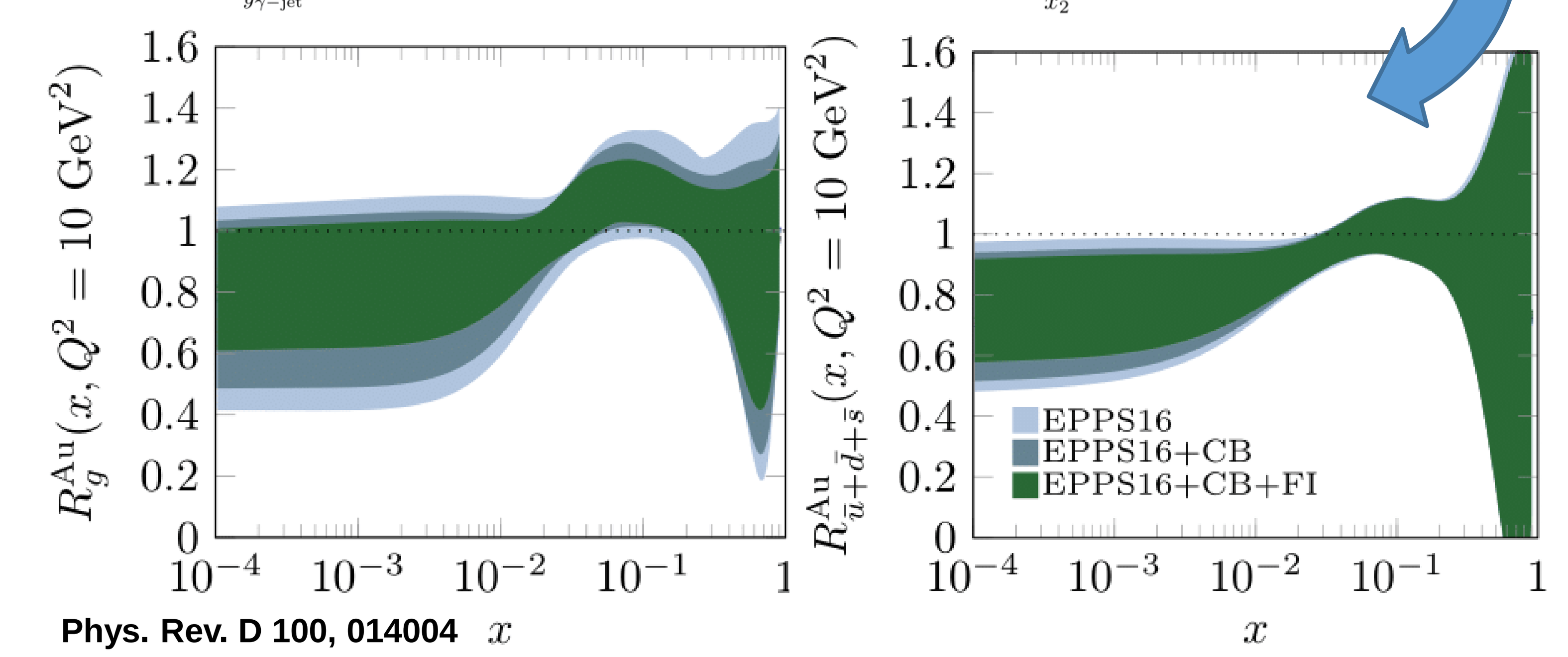
Much remains to be learned about hadronization in jets and modification of hadronization in medium. The sPHENIX MVTX will allow heavy flavor tagging of jets. Expected uncertainties are shown for b-tagged hadronization in jet studies in p+p. Modification of jet hadronization in medium will also be studied in p+A and A+A collisions.

Multiobservable Approach to nPDFs

Current nPDF fits including LHC data display significant uncertainties for the nuclear modification (R_A) of PDFs. This is particularly true for gluon nPDFs and the low-x (shadowing) region. In addition, tension between various models further muddles the picture. Simultaneous measurements of Drell-Yan (DY), and photon-jet correlations are expected to refine the R_A of these observables which will translate to improved nPDF fits.







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Note the improved modification with the inclusion of sPHENIX Central Barrel measurements (dark blue) compared to the current fits (light blue).