Medium-energy Nuclear Physics with sPHENIX

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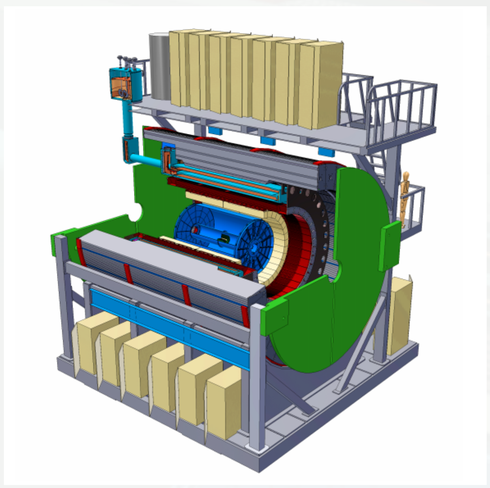
Abstract

A potential upgrade with forward instrumentation of the proposed sPHENIX detector at the Relativistic Heavy Ion Collider (RHIC), together with RHIC's unique capabilities to collide polarized protons and heavy nuclei, will open the door to exciting new measurements to enhance our understanding of quantum chromodynamics (QCD). These measurements will reveal more about how partons behave in a nuclear environment, explore spin-spin and spin-momentum correlations in the nucleon in a new kinematic regime, and investigate high-temperature QCD systems over a range of baryon densities. In addition, they will probe early times in the formation of the strongly coupled quark-gluon plasma. This poster focuses on the measurements enabled by the sPHENIX forward upgrade, as well as the medium-energy nuclear physics program for the sPHENIX mid-rapidity detector itself.

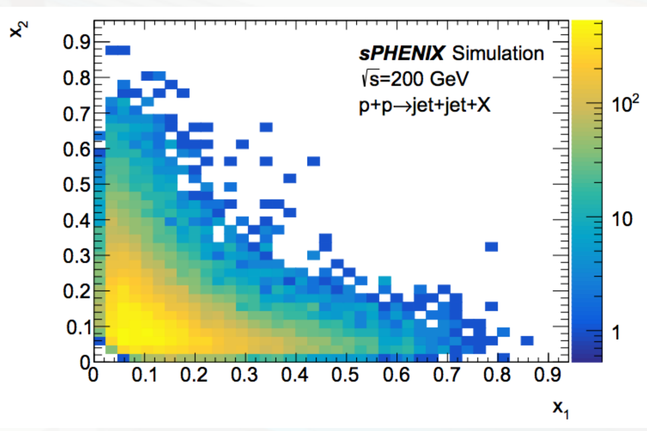
sPHENIX Detector

- The sPHENIX detector is designed to have full azimuthal coverage and pseudorapidity coverage $|\eta|<1.1$ around an approximately 1.4 Tesla solenoidal magnet.
- The detector consists of a central tracking system, an electromagnetic calorimeter, and two hadronic calorimeters situated around the solenoid.
- sPHENIX will record a variety of high p_T processes including, but not limited to, jets and photon-jet correlations in p+p, p+Au, and Au+Au collisions between the years 2022-2026.



Nuclear Modification of Parton Distribution Functions and Hadronization

- Inclusive jets and jet correlations will be measured at large longitudinal momentum fraction x over a large range of x in both p+p and p+A collisions, as shown to the right.



- The sPHENIX barrel will improve our knowledge of nuclear PDFs via measurements of inclusive hadrons, jets, direct photon-jet correlations, dijets, and Drell-Yan in p+A compared to p+p collisions.
- These data together will cover an x range from several times 10^{-2} for inclusive hadron measurements up to 0.4 as shown above for dijets.
- The sPHENIX tracking capabilities will also allow robust studies of hadronization in p+A compared to p+p collisions, multi-differential in the longitudinal and transverse momentum of the hadron with respect to the jet. Direct photon-jets and dijets will also provide different mixes of quark and gluon hadronization.

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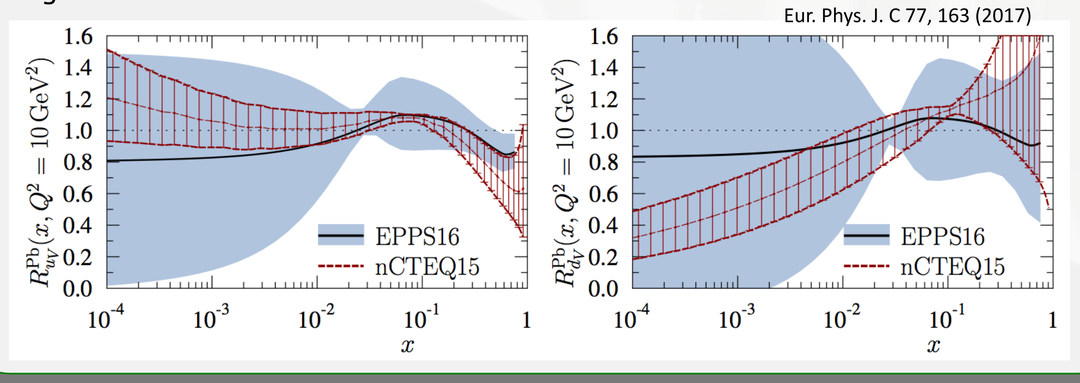

Heavy Quarkonium Production

- Heavy quarkonium production mechanisms are still largely not well understood.
- One of the main goals of the sPHENIX physics program is to measure the three lightest upsilon states in p+p and Au+Au collisions.

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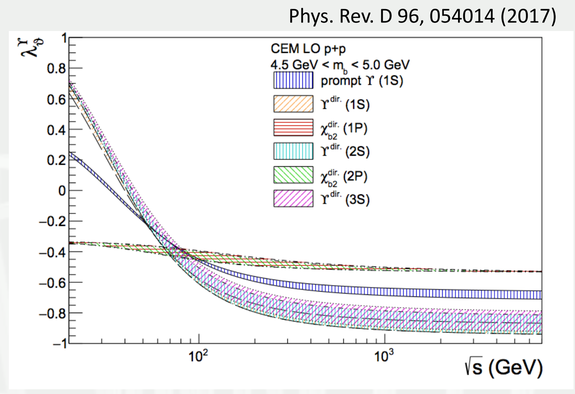
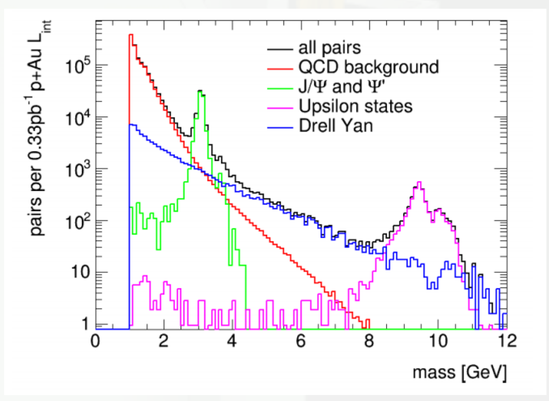
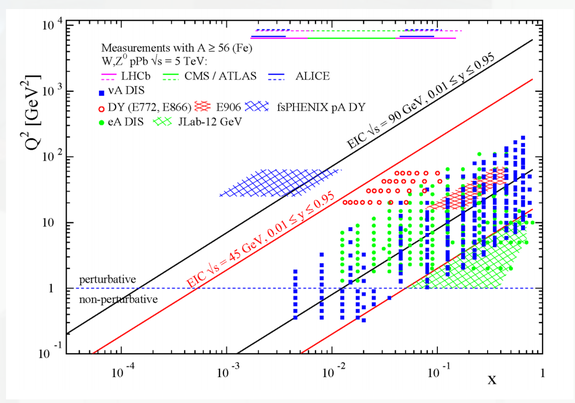


- Large longitudinal upsilon polarizations have been predicted within the color evaporation model, which can be measured with the decay products of the quarkonium state.
- Measurements of upsilon and J/ψ polarization, as well as their p_T dependent cross sections, will provide information on heavy quarkonium production mechanisms as well as gluon transverse-momentum-dependent PDFs.

Forward Detector Upgrade

- A forward upgrade with tracking and both electromagnetic and hadronic calorimetry has been proposed to cover $1.1<\eta<4$.
- The additional coverage would allow for transverse spin phenomena with jets to be studied where large azimuthal asymmetries have been measured.

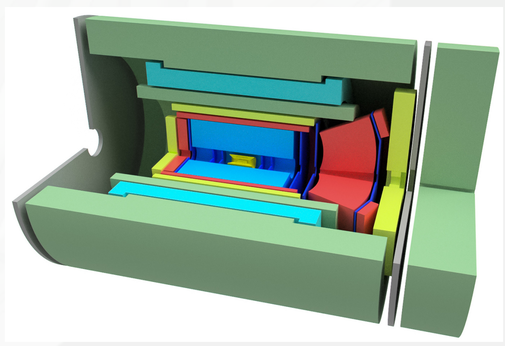




- Drell-Yan measurements, shown with full detector simulations above, will also be feasible in p+Au to constrain nuclear parton-distribution-functions.
- The forward sPHENIX kinematic coverage covers a unique phase space in x-Q^2 compared to other world experiments, shown to the left.

Evolution Towards an EIC Detector

- The path of sPHENIX will lead to a capable day-1 Electron Ion Collider (EIC) detector with large coverage of tracking, calorimetry, and particle identification.
- A model of an EIC detector based around the sPHENIX detector is shown to the right.



References

1. Medium-Energy Nuclear Physics Measurements with the sPHENIX Barrel https://www.sphenix.bnl.gov/web/sph-cqcd-2017-002
2. sPHENIX Forward Instrumentation LOI https://www.sphenix.bnl.gov/web/node/450
3. sPHENIX Proposal, arXiv:1501.06197
4. Concept for an EIC Detector Around the BaBar Solenoid, arXiv:1402.1209

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