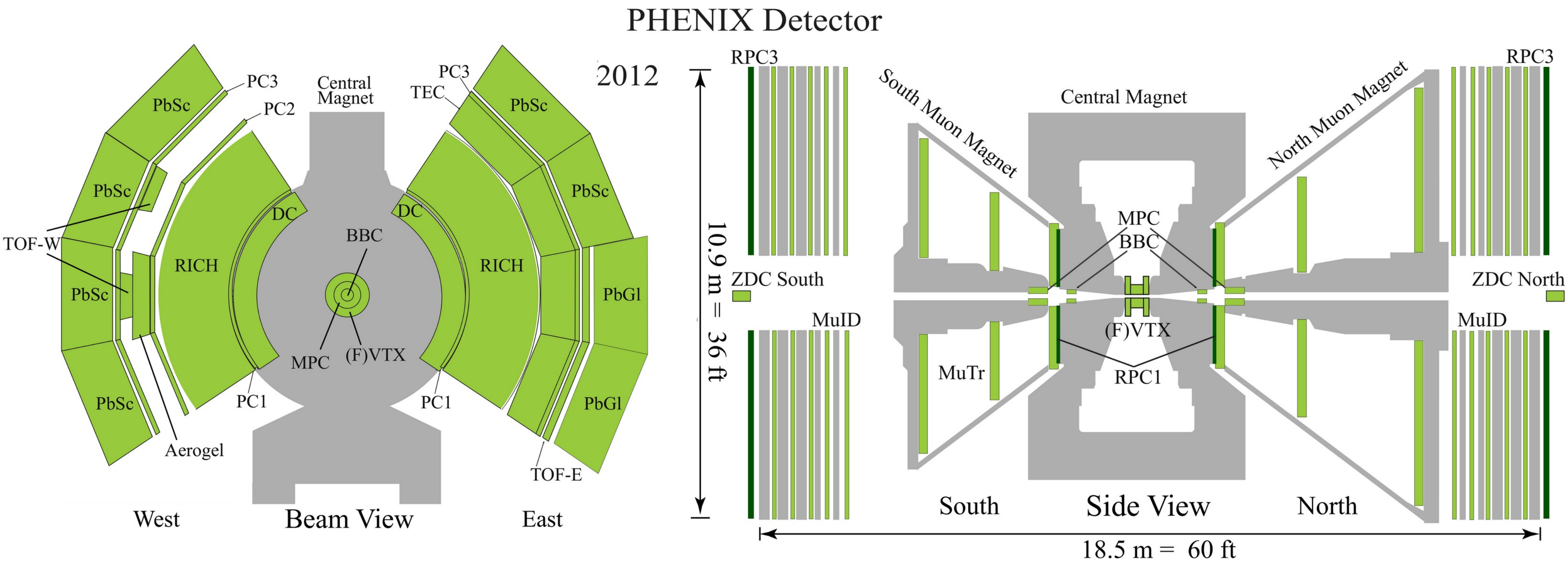
https://www.colorado.edu/physics/2013/12/09/quark-gluon-droplets-discovered-bnls-phenix-experiment

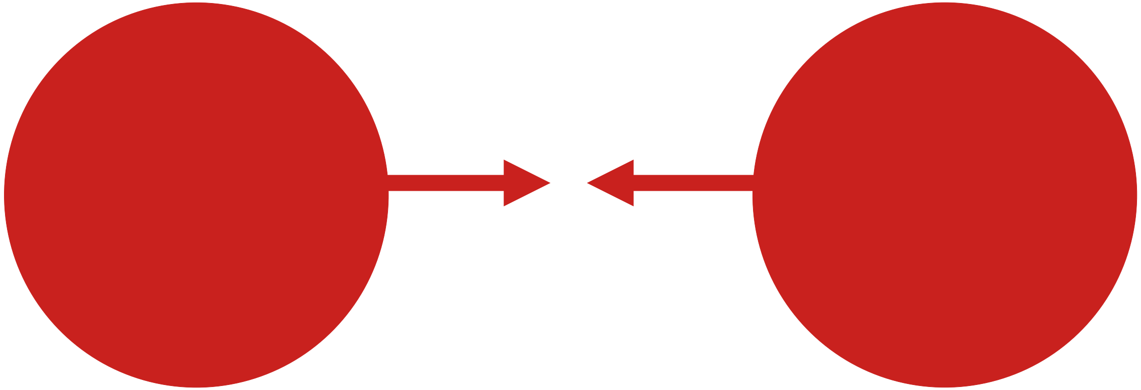
Results from PHENIX

Christine Nattrass
University of Tennessee, Knoxville



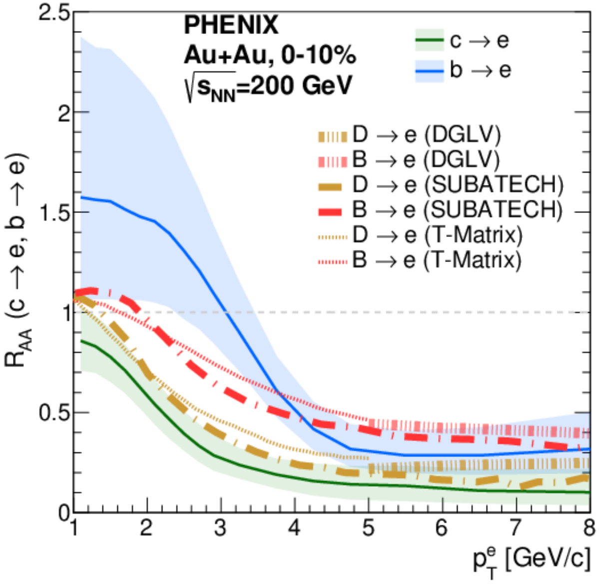
4-spectrometer arms
• Central detector $|\eta| < 0.35$
• Forward/backward detector $1.2<|\eta| <2.2$

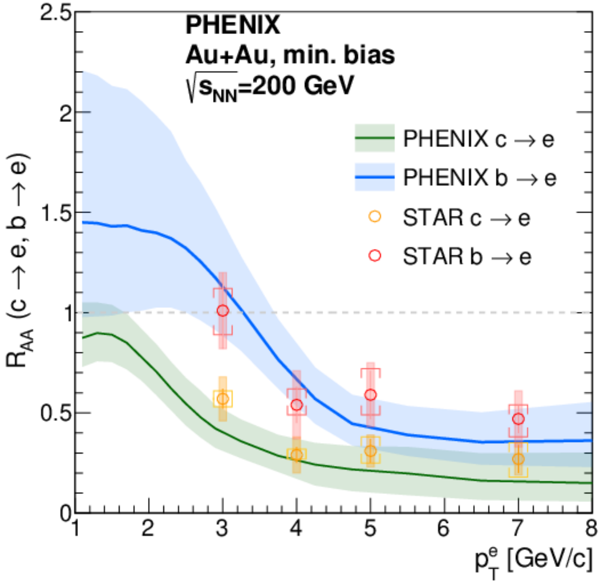
Ended operations in 2016 but still produce new results from the large data acquired during its final years



Au+Au

b/c quark R_{AA}

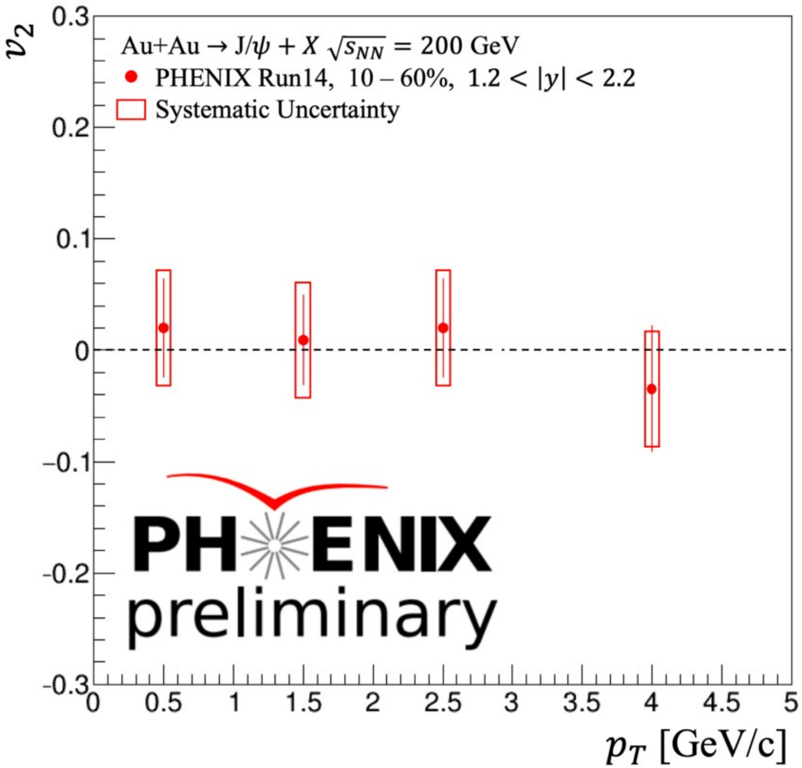




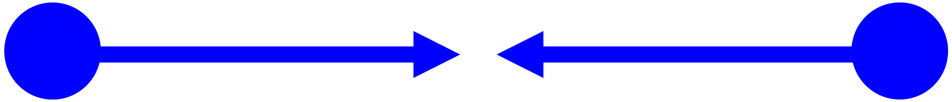
- arXiv:2203.17058 (submitted to Phys. Rev. C)
- Beauty is less suppressed than charm

J/ψ v_2 in Au+Au

Au+Au



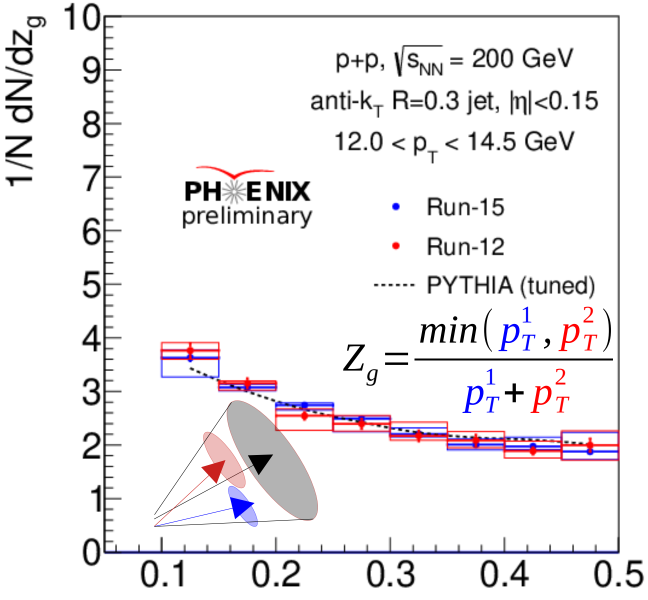
- Consistent with zero at forward rapidity, different from the LHC results
- May indicate absence of charmonium regeneration in the forward rapidity region at RHIC energies



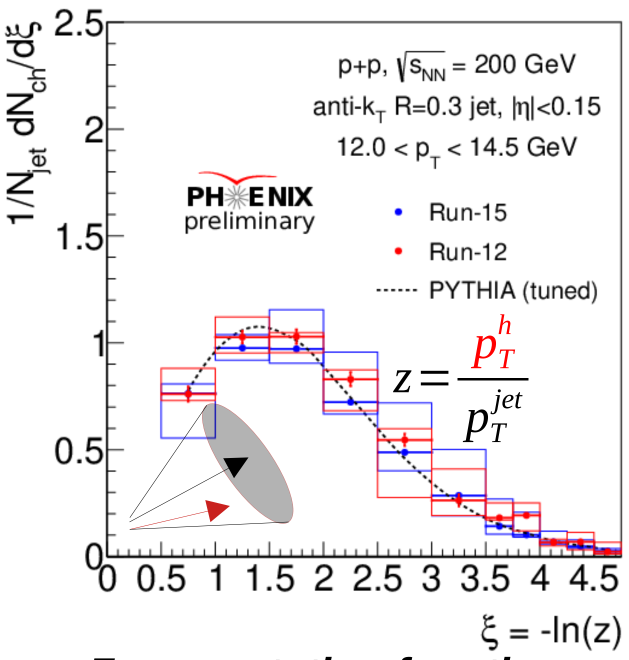
p+p

Jet substructure

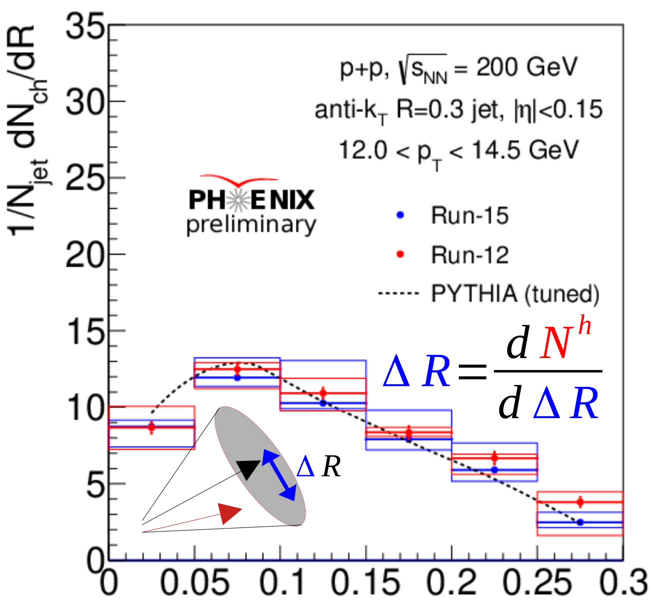
p+p



Jet splitting function



Fragmentation function

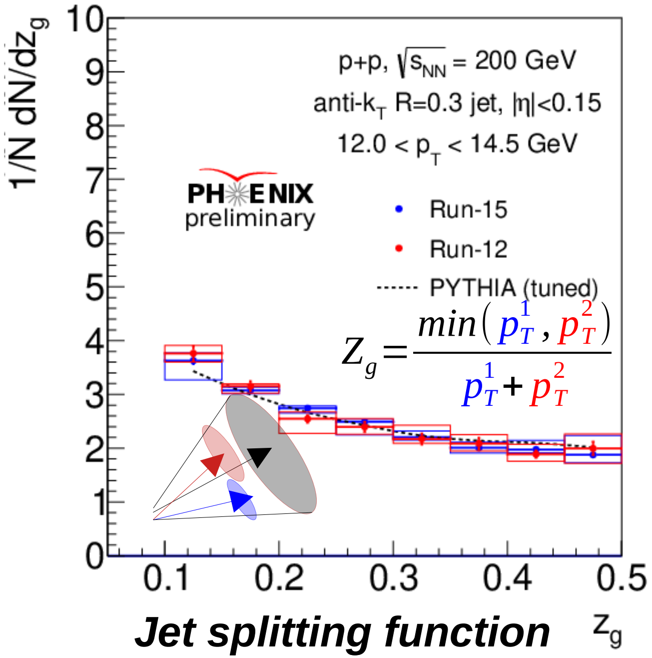


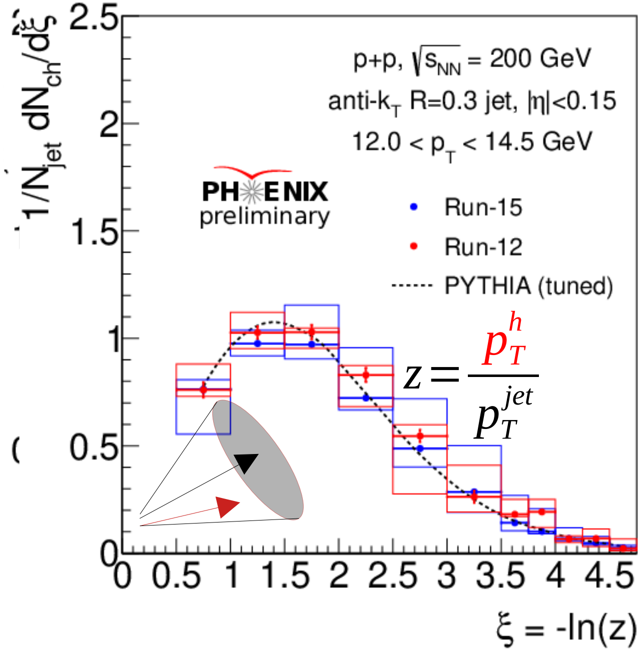
Radial profile

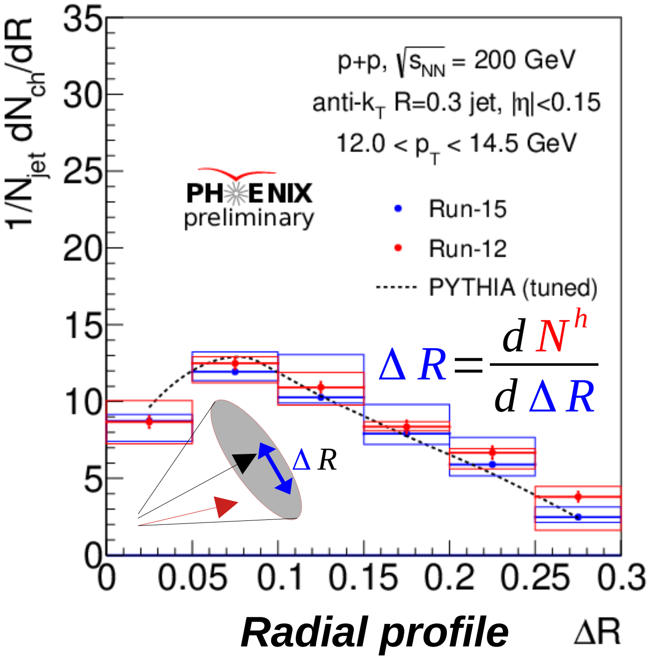
- New analysis of jet substructure
  - R = 0.3
  - **12.0 GeV/*c* < p_T < 14.5 GeV/*c***
- Analysis ongoing with p+Au, results coming soon!

Jet substructure

p+p



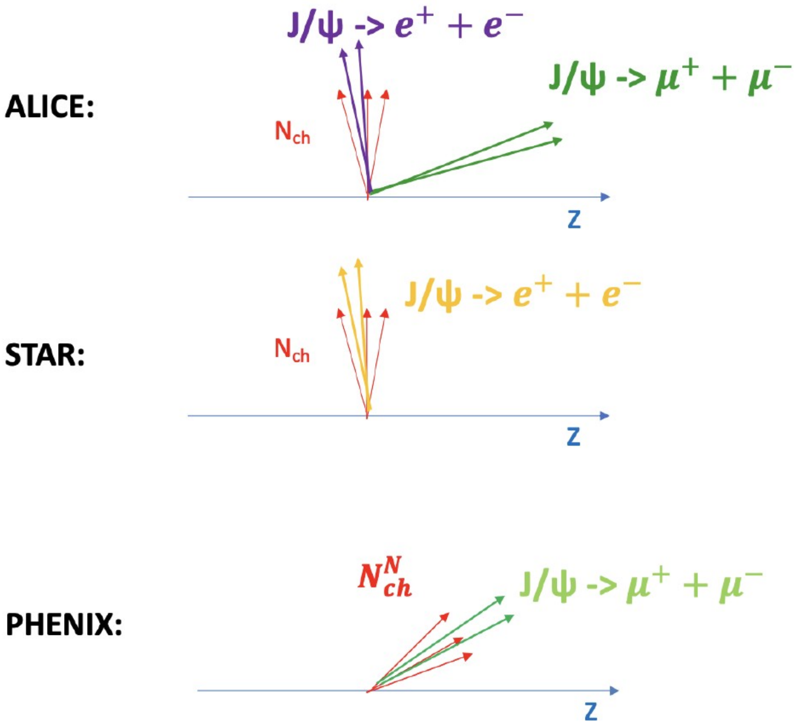


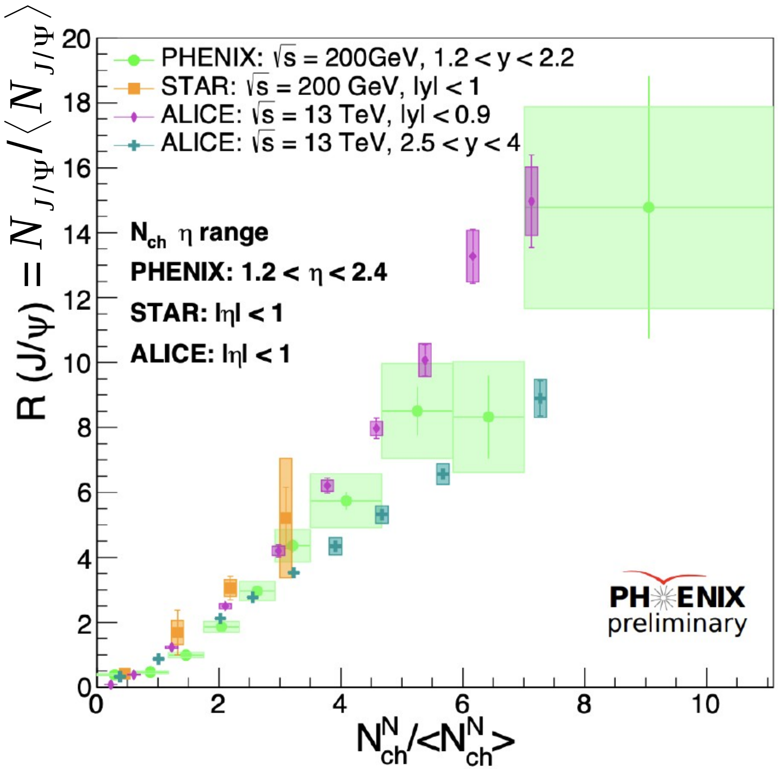


- New analysis of jet substructure
  - R = 0.3
  - **20.5 GeV/*c* < p_T < 24.5 GeV/*c***
- Analysis ongoing with p+Au, results coming soon!

J/ψ yield in p+p

p+p



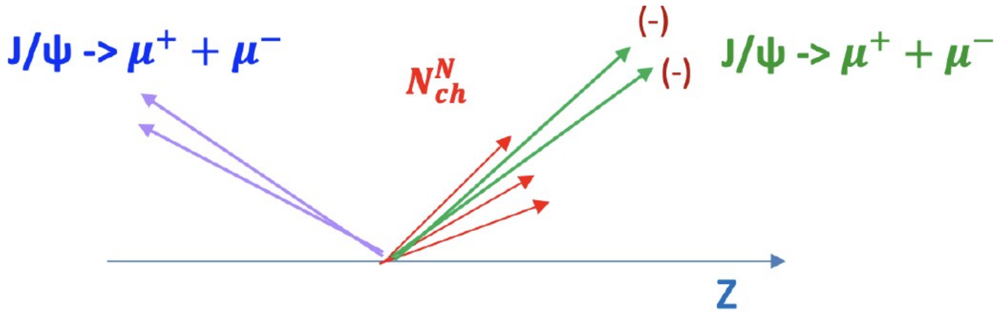


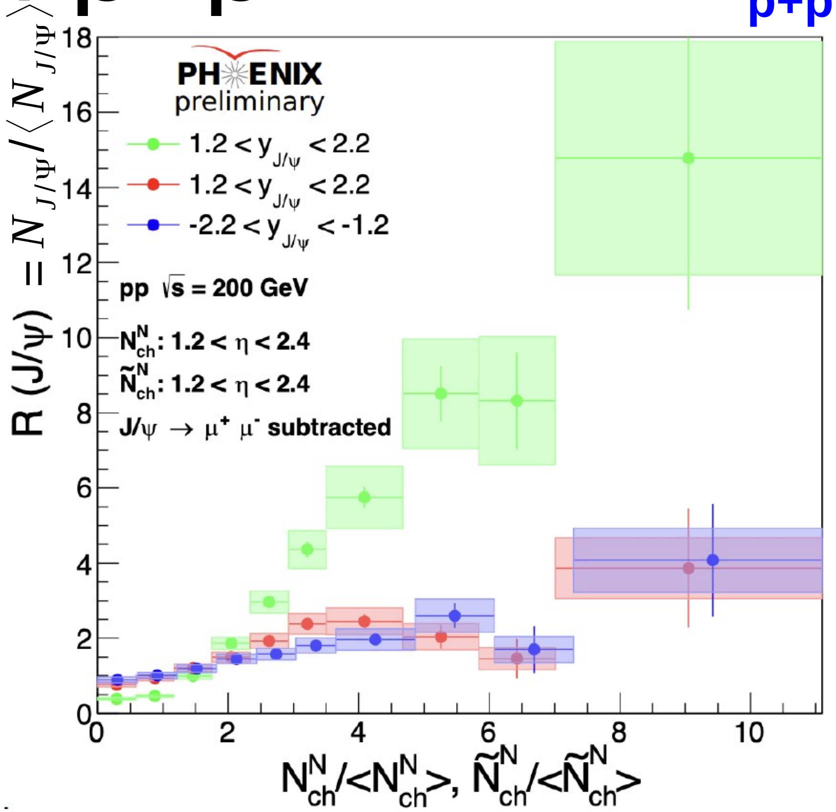
- J/ψ yield exhibits large dependence on local track multiplicity
- Usually attributed to multi-parton interactions

J/ψ yield in p+p

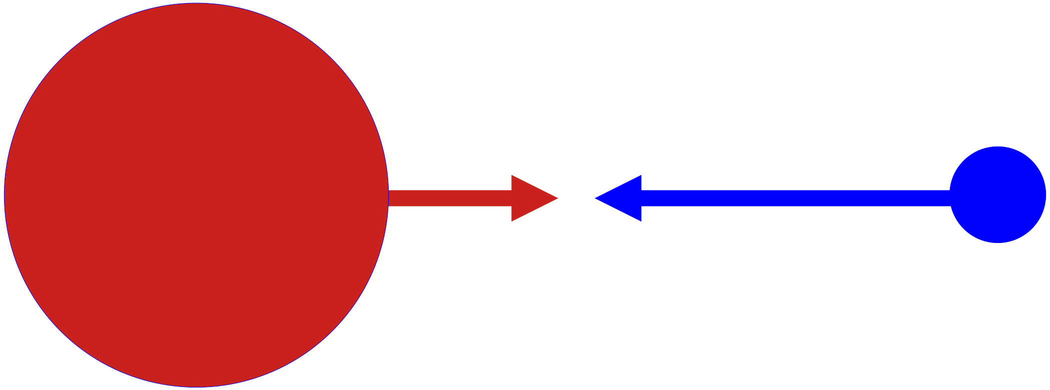
p+p

RED = Tracklets $N_{ch}^{N}(1.2 < \eta < 2.4)$ [inclusive, dimuon subtracted]
Green = J/ψ (1.2 < y < 2.2)
Blue = J/ψ (-2.2 < y < -1.2)



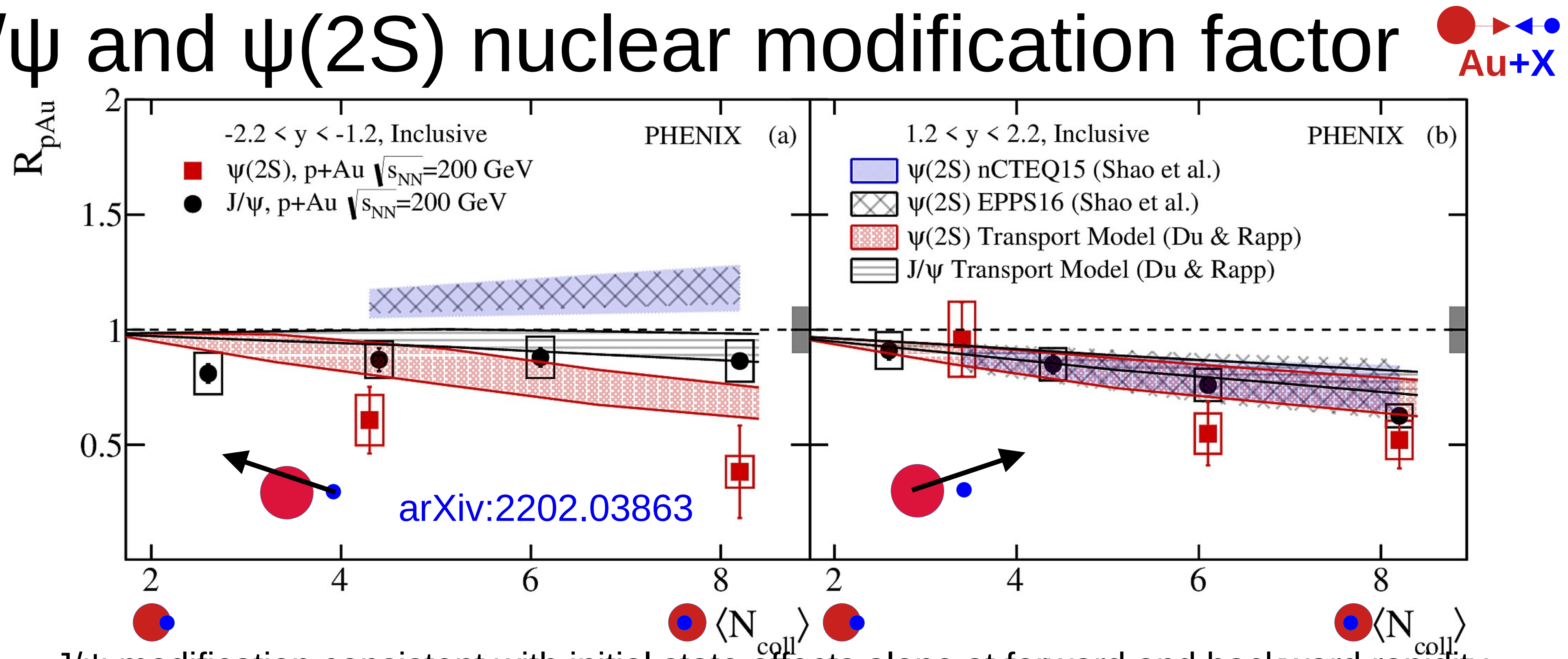


- J/ψ yield vs multiplicity significantly reduced when Looking at J/ψ and multiplicity in separate rapidity windows
  - Looking at J/ψ and multiplicity in the same rapidity window but removing the μ+ μ− from the multiplicity
- Important implications for MPI picture



Au+p,X

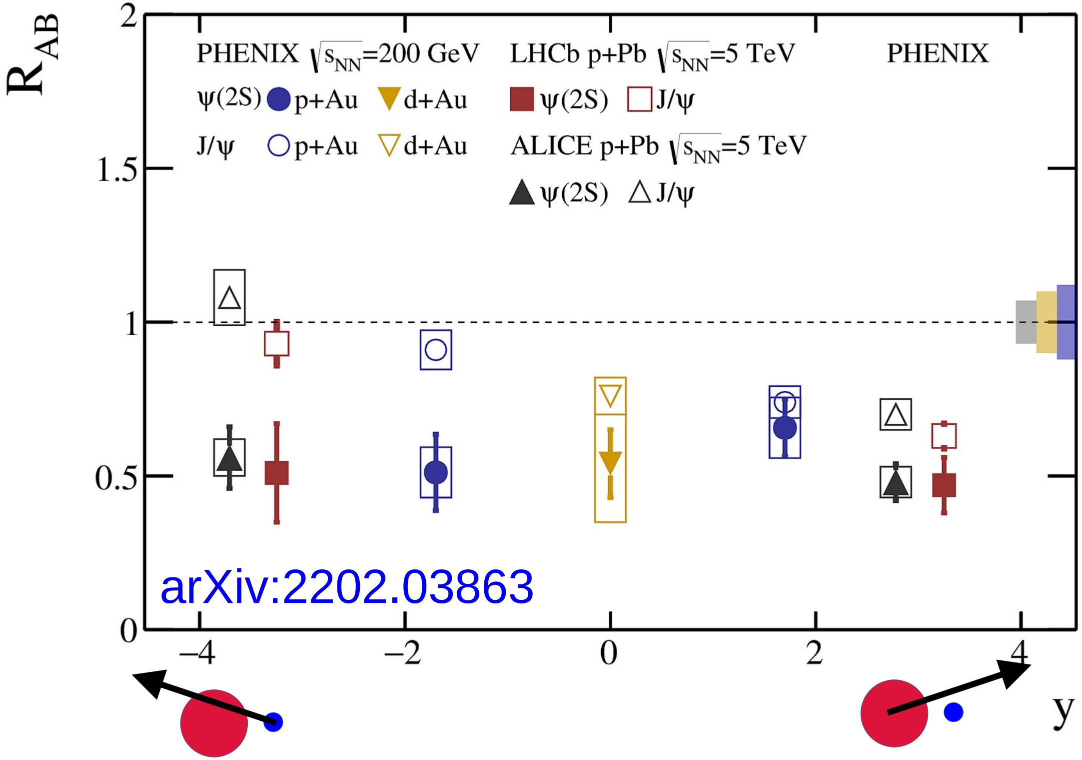
J/ψ and ψ(2S) nuclear modification factor



- J/ψ modification consistent with initial state effects alone at forward and backward rapidity
- ψ(2S) modification indicates presence of final state effects at backward rapidity
  - Presence of co-movers? QGP?

J/ψ and ψ(2S) nuclear modification factor

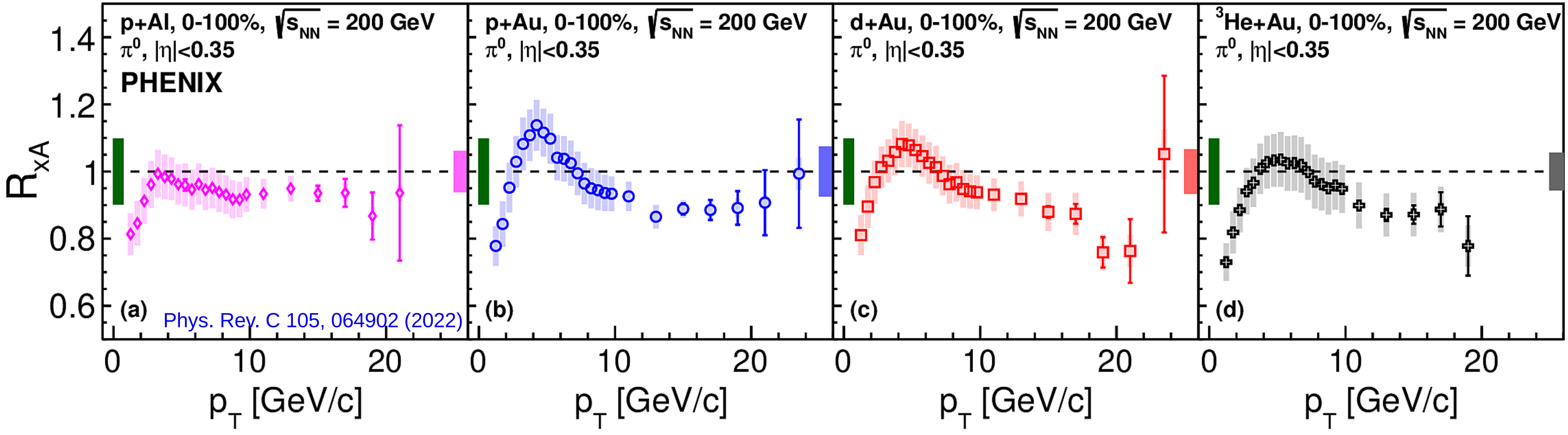
Au+X



- Similar patterns for J/ψ and ψ(2S) found at RHIC and LHC

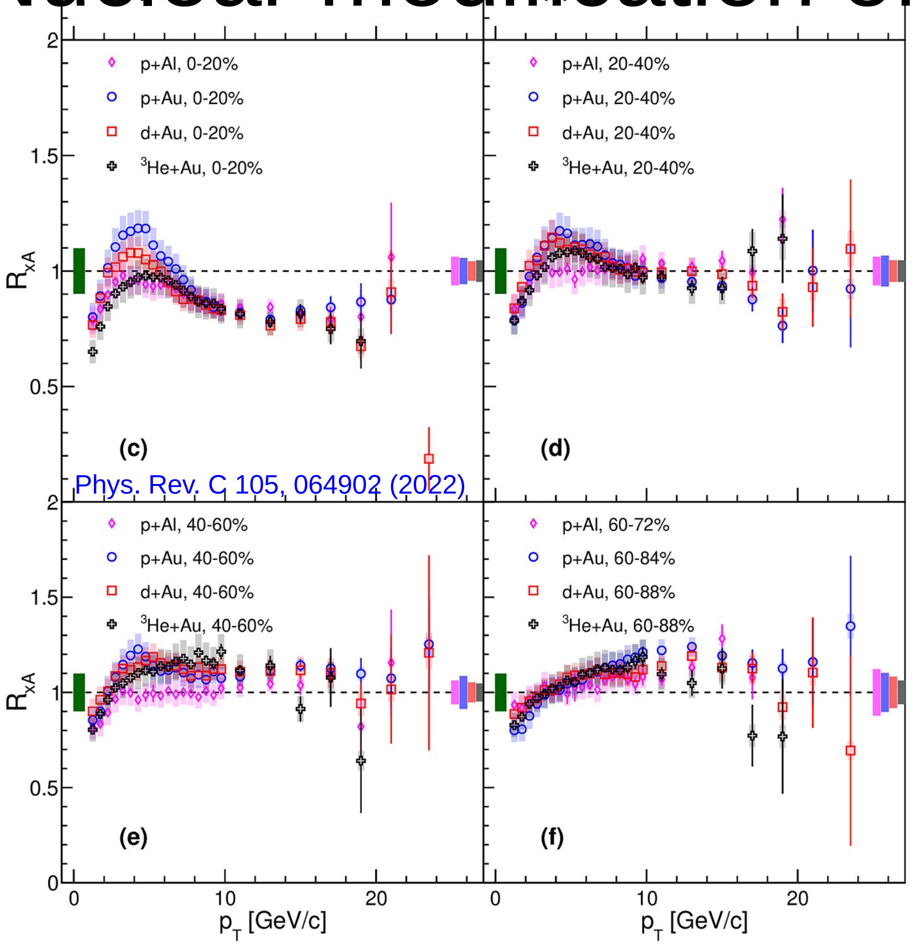
Nuclear modification of π^0 in small systems

Au+X



- Minimum bias collisions shown
- Cronin enhancement at intermediate p_T
  - Lighter target shows smaller enhancement (p+Al < p+Au)
  - Heavier projectile shows smaller enhancement (3 He+Au < d+Au < p+Au)

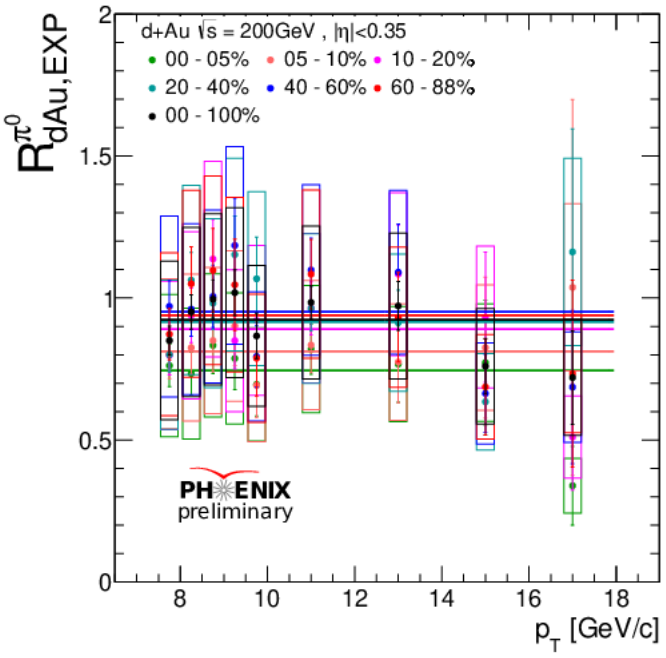
Nuclear modification of π^0 in small systems

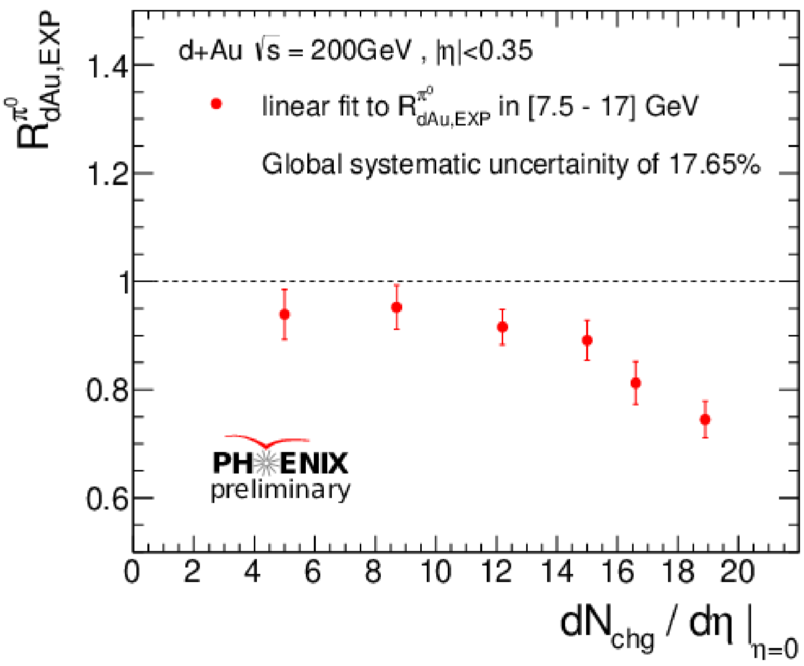


- Considerable centrality dependence—suppression in central, enhancement in peripheral
- Peripheral enhancement not new, but still difficult to understand...

Direct photons and π^0 in small systems

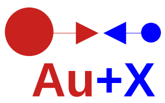
Au+X

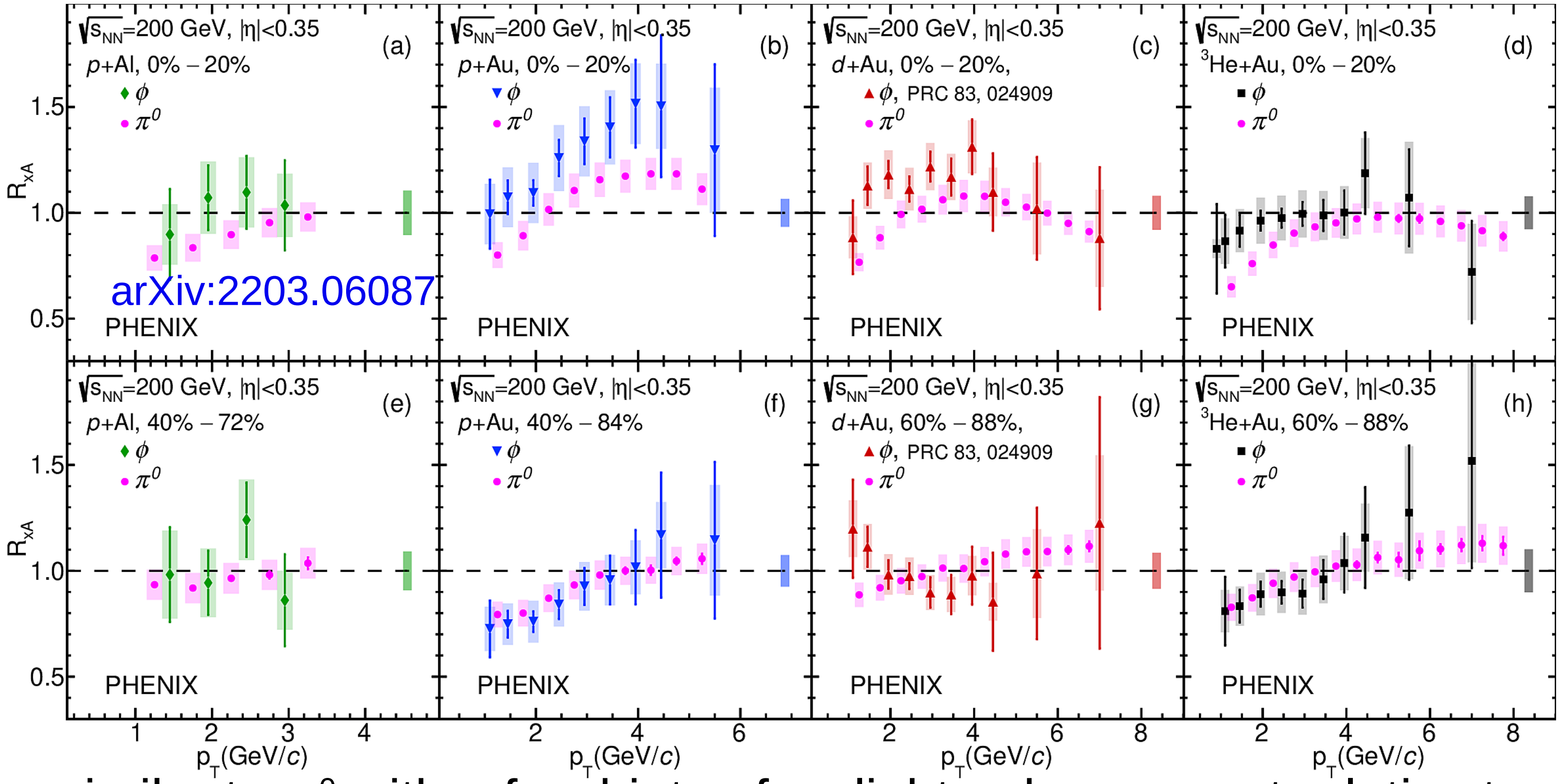




- Can use non-modification of photons to correct for bias in N_{coll} determination
- Resolves a decade-long mystery of apparent enhancement in peripheral collisions
- Small but non-negligible suppression in central collisions
  - EMC effect? QGP?

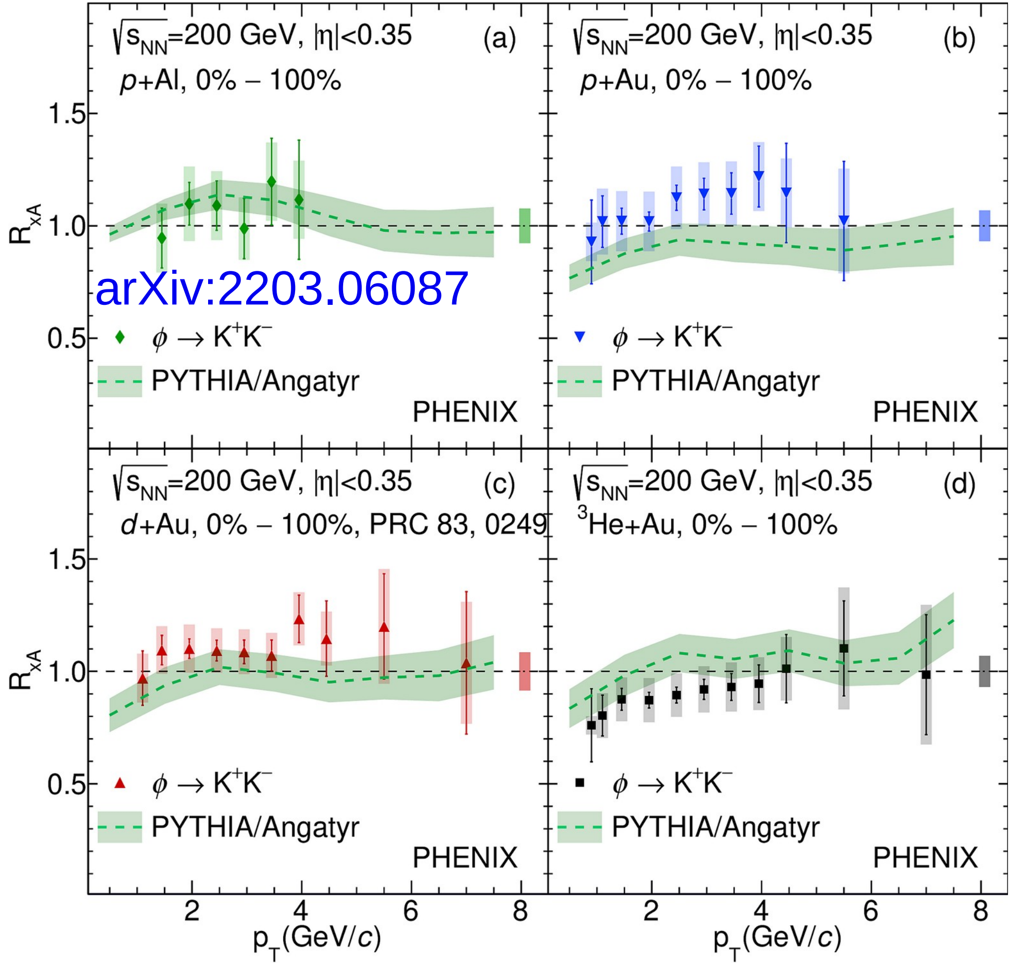
φ meson in small systems





- φ similar to π^0 with a few hints of a slight enhancement relative to π^0

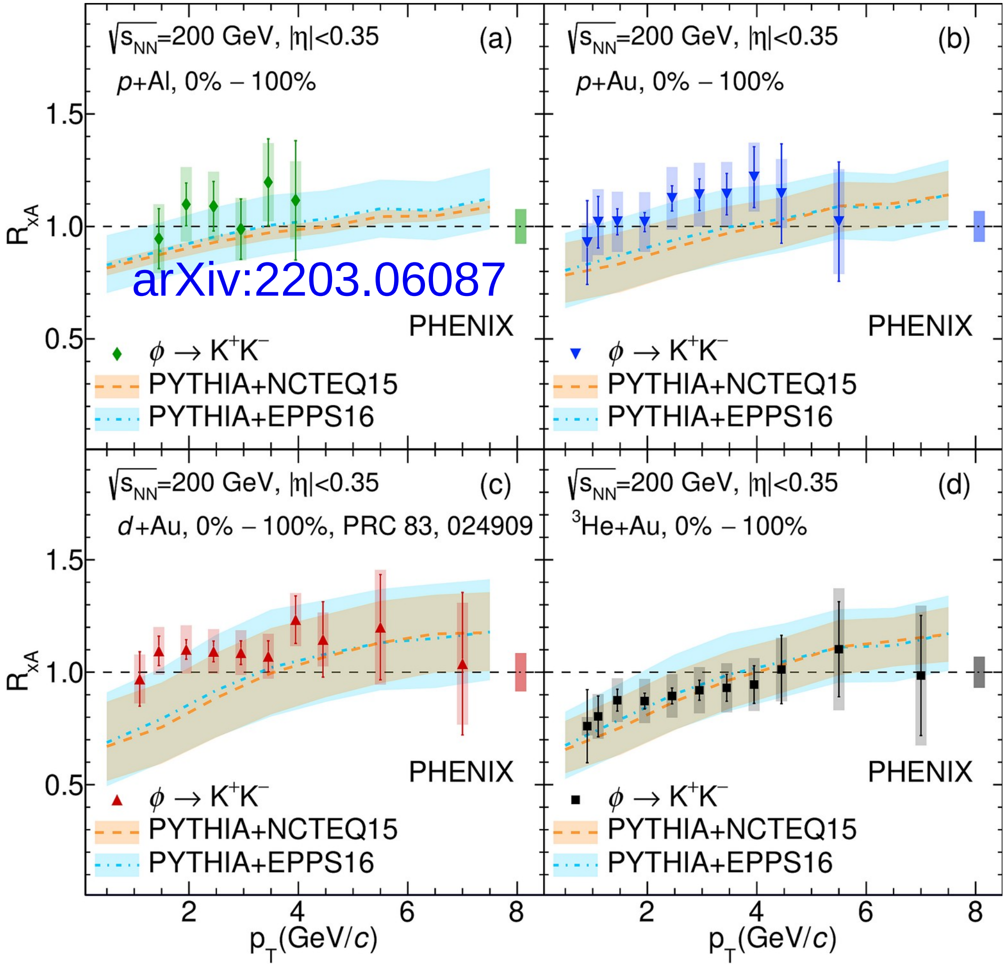
φ meson in small systems



- φ nuclear modification reasonably well-described by PYTHIA Angantyr, but overall system size ordering is missed

φ meson in small systems

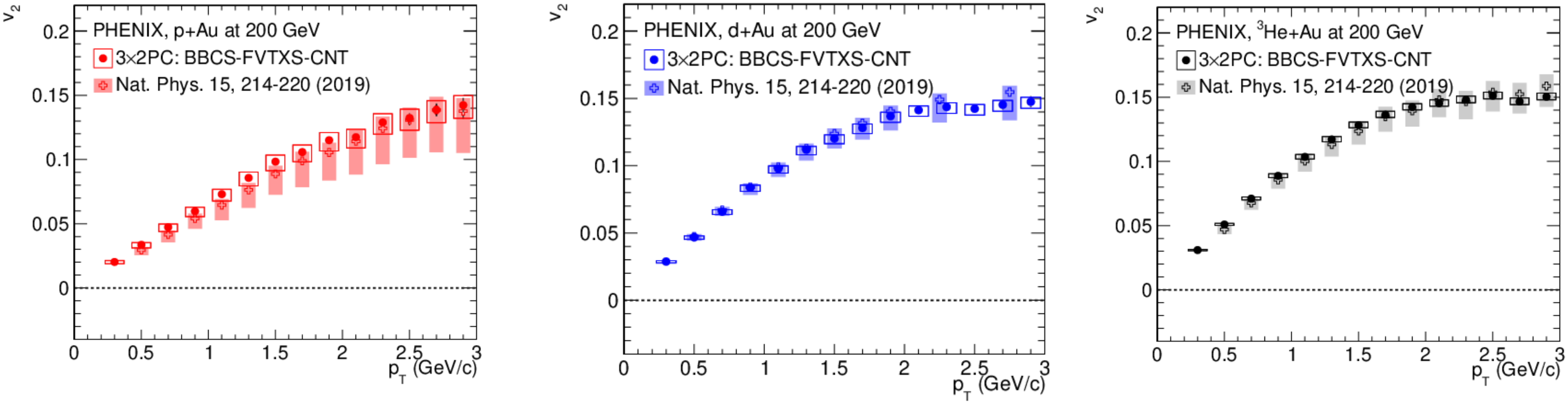
Au+X



- Also reasonably well-described by PYTHIA with nPDFs, but overall system size ordering is missed

v_n in small systems

Au+X



- All new analysis using two-particle correlations with event mixing instead of event plane method used in Nature Physics publication
  - Very different sensitivity to key experimental effects (beam position, detector alignment)
- Uses same detector combination as used in Nature Physics publication

Data and Analysis Preservation (DAP)

- Knowledge management: analysis preservation is more than just software preservation
- Minimum goal: reproducibility of (newly) published result (in principle “forever”)
  - new, standardized analysis notes (template-based), mandatory since 2020
  - all analysis codes, macros, auxiliary files stored in HPSS since 2020
  - published data uploaded in HEPData (since 2020)
  - older publications uploaded retroactively – ***undergraduate assistants hired at UTK!***
  - currently 62 uploads from about 200 PHENIX publications, growing
- Maximum goal: making re-analysis (with different conditions) possible “forever”, in principle even for “outsiders”
  - Docker/REAna (“Reproducible Analysis”)
  - high p_T direct photons in d+Au already implemented
  - Plan to do the same with at least one of each signature PHENIX analysis (muons, dielectrons, spin asymmetry, hadron flow, etc.)
- Availability: everything in github (private access) and Zenodo (public access)
- First from RHIC to publish data and simplified analysis tools on CERN OpenData for the general public
- All info available from the new “DAP website” https://www.phenix.bnl.gov/ in Analysis tab

Conclusions

- A still vibrant PHENIX collaboration despite competing efforts
- PHENIX physics program still unique in several studies of QCD and QGP
- Students who came after PHENIX ended of operation are a vital part of PHENIX collaboration and responsible for many more discoveries

Many more interesting and important measurements from PHENIX coming soon!