Recent J/ψ results measured with PHENIX

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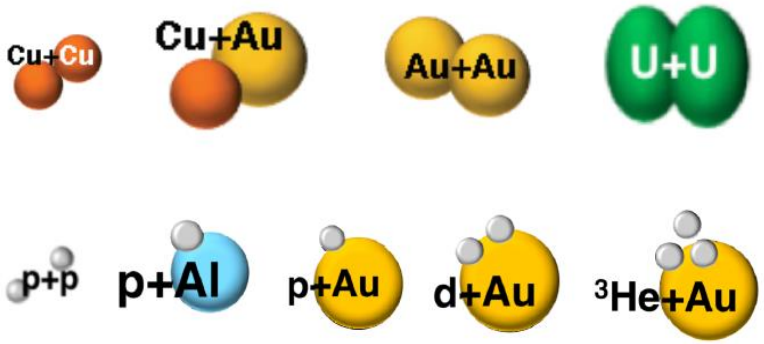
PHENIX

MATE

PHENIX Run History

Accomplished 16 years of operation with 9 collision species and 9 collision energies



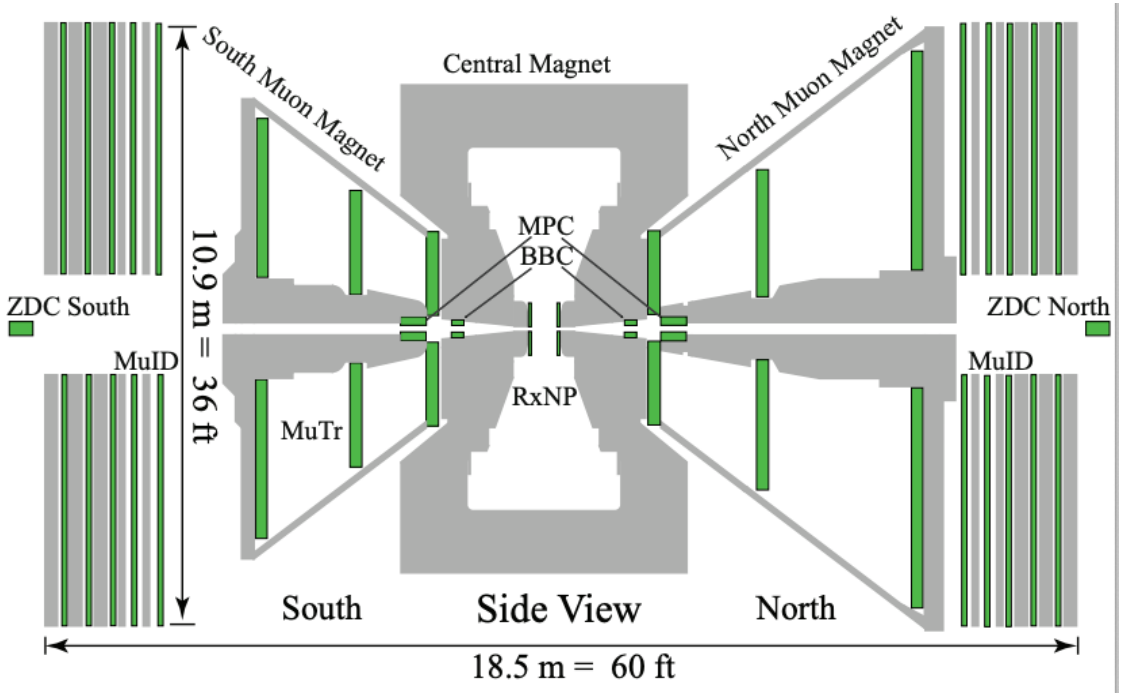
Results from the recorded data are still coming out.

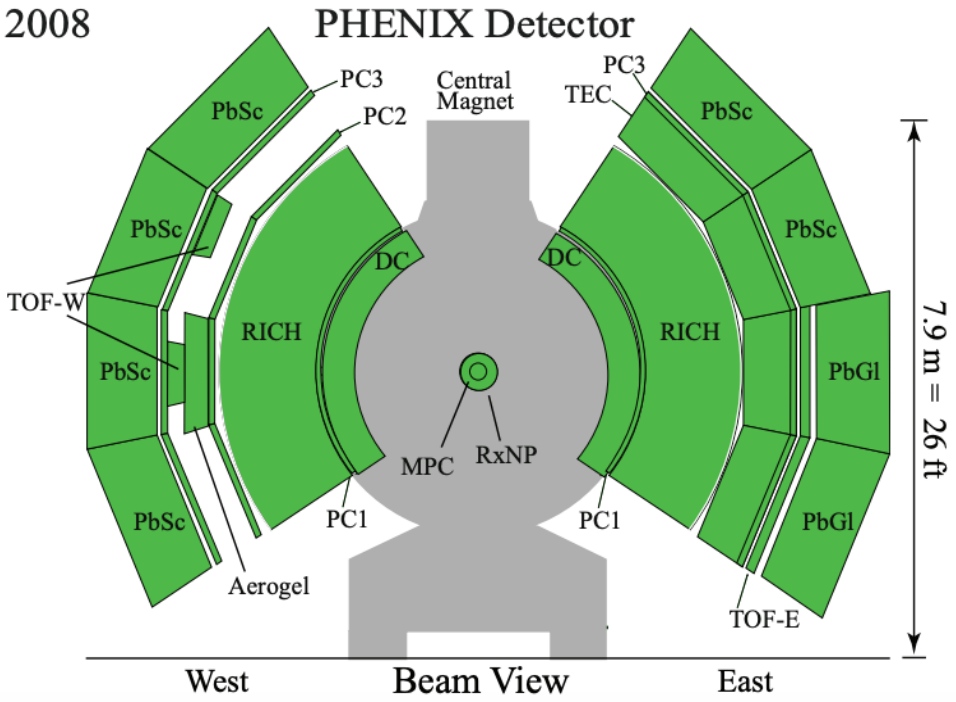
Progresses from larger systems to smaller systems

Species	Run Year
Au+Au	2001, 2002, 2004, 2007, 2008, 2010, 2011, 2014, 2016
d+Au	2003, 2008, 2016
Cu+Cu	2005
U+U	2012
Cu+Au	2012
^{3}He+Au	2014
p+Au	2015
p+Al	2015

Muon Arms

- Rapidity coverage: 1.2<|y|<2.2
- Muon Tracking followed by Muon Identifier
  - *Stainless steel and copper absorbers for hadron rejection*
- BBC measures collision vertex along beam axis





Central Arms

- Rapidity coverage: |y|<0.35
- Charged particle tracks and momentum – pad and drift chambers
- Ring Imaging Cherenkov detector for pion rejection
- Energy / momentum matching of charged particles using EMCal clusters

Small Systems Results

CNM Effects

- **Gluon Shadowing/Anti-Shadowing:**

Modification (suppression/enhancement) of heavy quark cross section due to modifications of the gluon structure function

- **Parton Energy Loss:**

The projectile gluon experiences multiple scattering while passing through the target before J/ψ production, reducing the rapidity of the J/ψ

- **Cronin Effect:**

Modification of the J/ψ p_T distribution due to multiple elastic scattering of partons

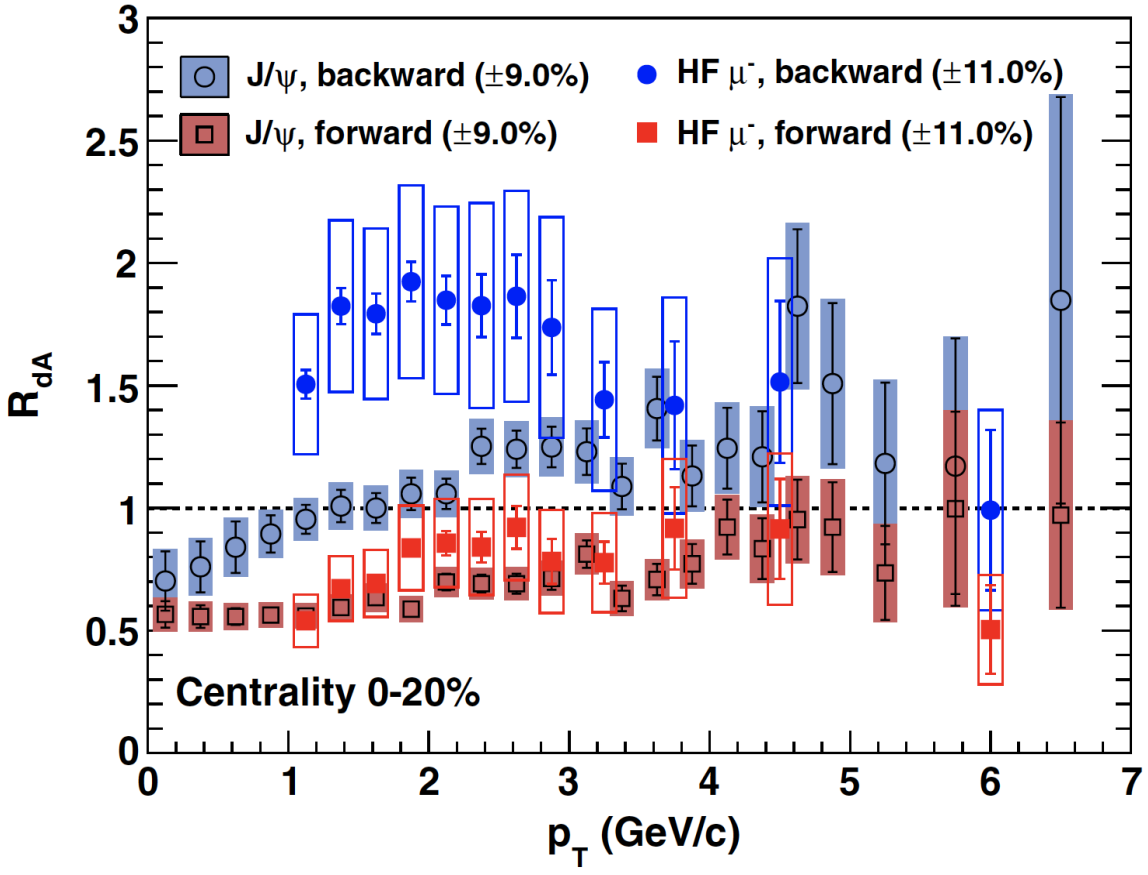
- **Nuclear Break-Up:**

The break up of the bound J/ψ (or precursor state) in collisions with other target nucleons that pass through J/ψ production point

- **Co-Movers Break-Up:**

Final state break up of the J/ψ through interactions with produced partons

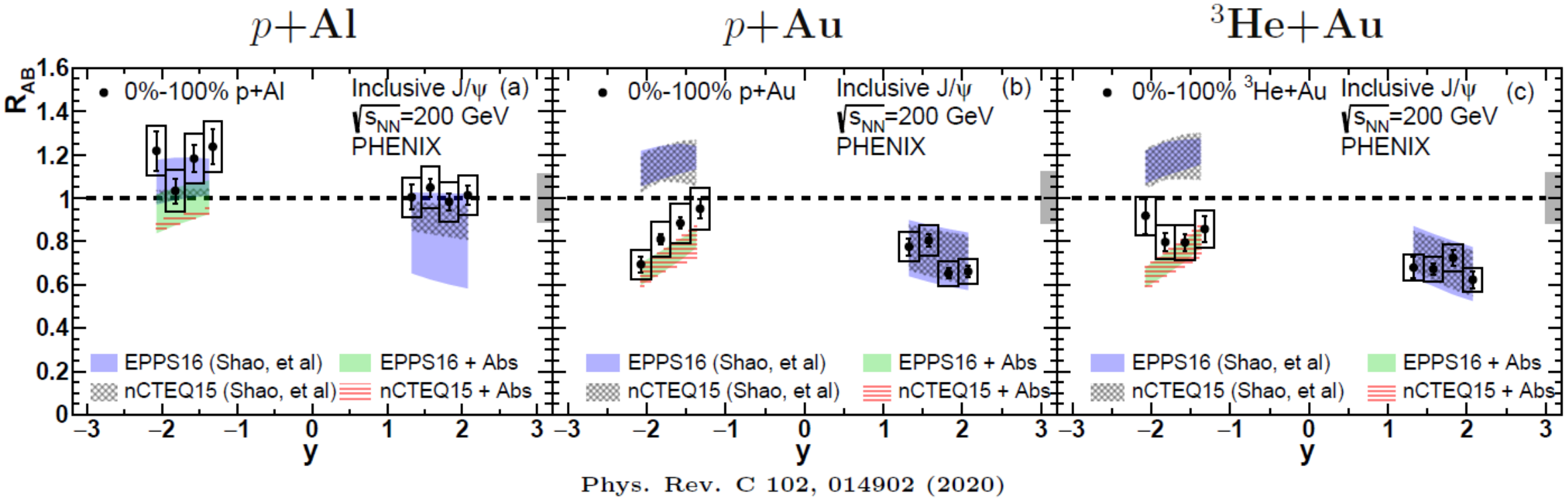
J/ψ Nuclear Modification (2014)



- Forward rapidity: J/ψ suppression similar to open charm suppression
  - Consistent with shadowing and/or parton energy loss
- Backward rapidity: J/ψ suppressed relative to open charm
  - Expect open charm enhanced by anti-shadowing
  - J/ψ suppression consistent with absorption from collisions with nucleons in target
  - Possible contribution also from co-movers

Phys. Rev. Letters 112, 252301 (2014)

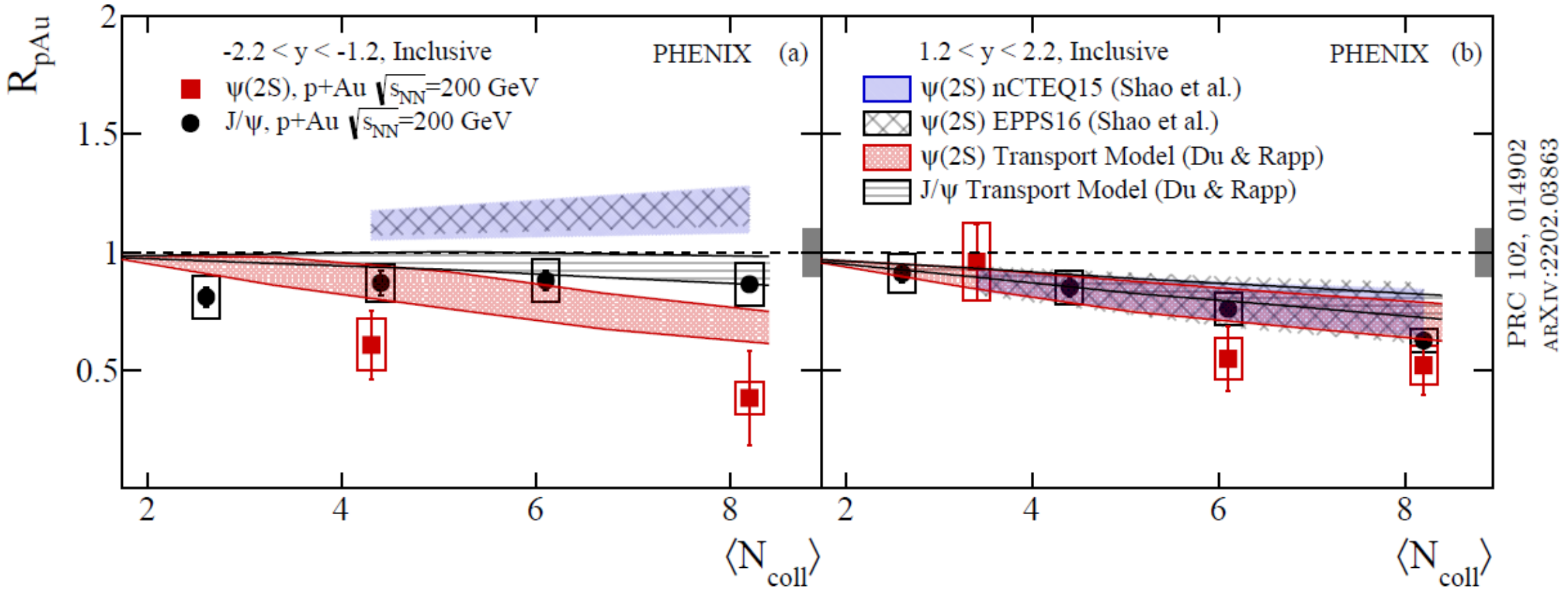
J/ψ Nuclear Modification (2020)



Phys. Rev. C 102, 014902 (2020)

- **Predictions for *p*/^{3}He+Au based on Bayesian reweighting method using J/ψ constraints from *p*+Pb data at the LHC**
- **Added PHENIX nuclear absorption estimate at backward rapidity**

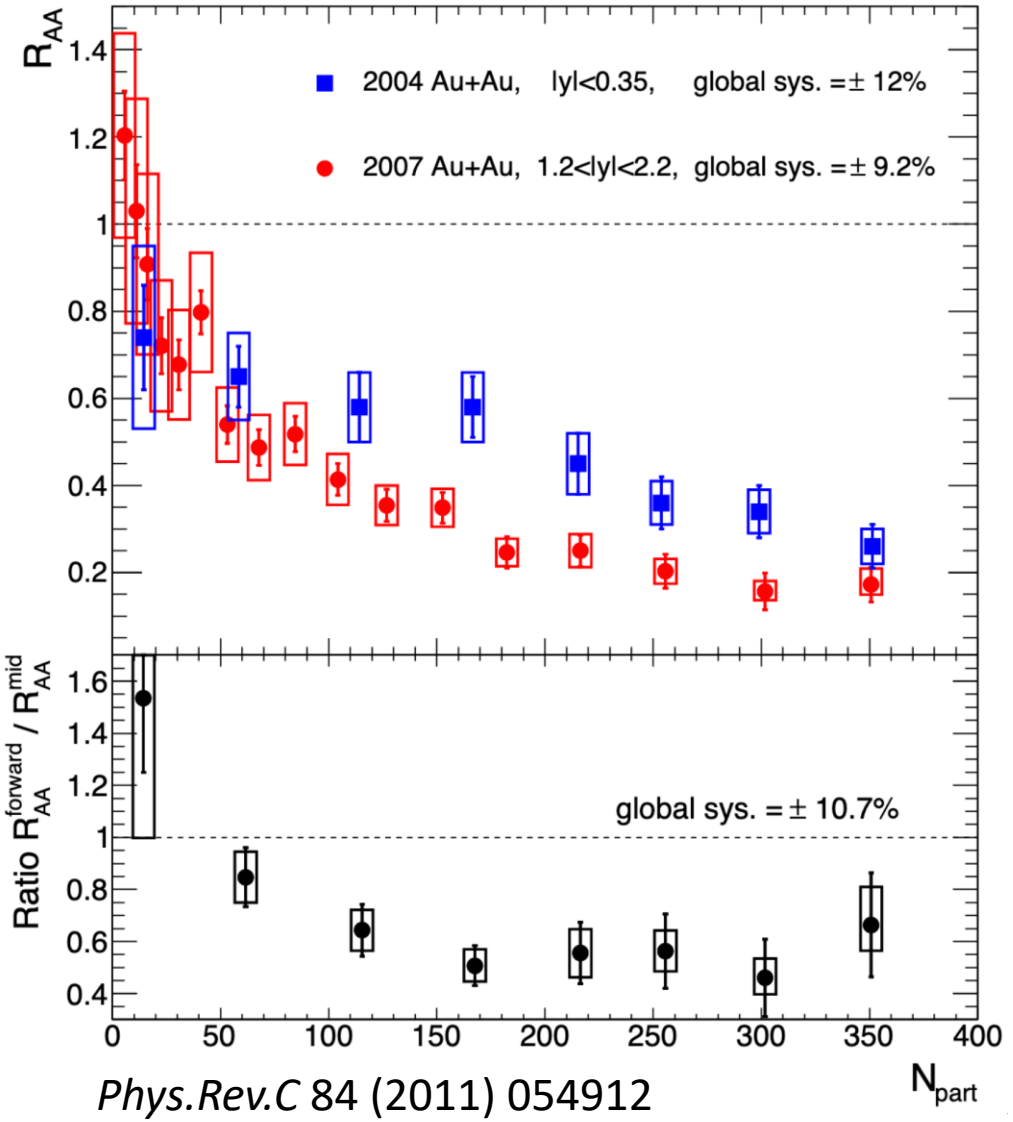
Charmonia Nuclear Modification in *p*+Au Collisions



- At forward rapidity, J/ψ and ψ(2S) modification well described by shadowing models
  - Consistent with cold nuclear matter effects
- At backward rapidity, charmonium modification inconsistent with shadowing effects alone

Large Systems Results

J/ψ Suppression puzzle

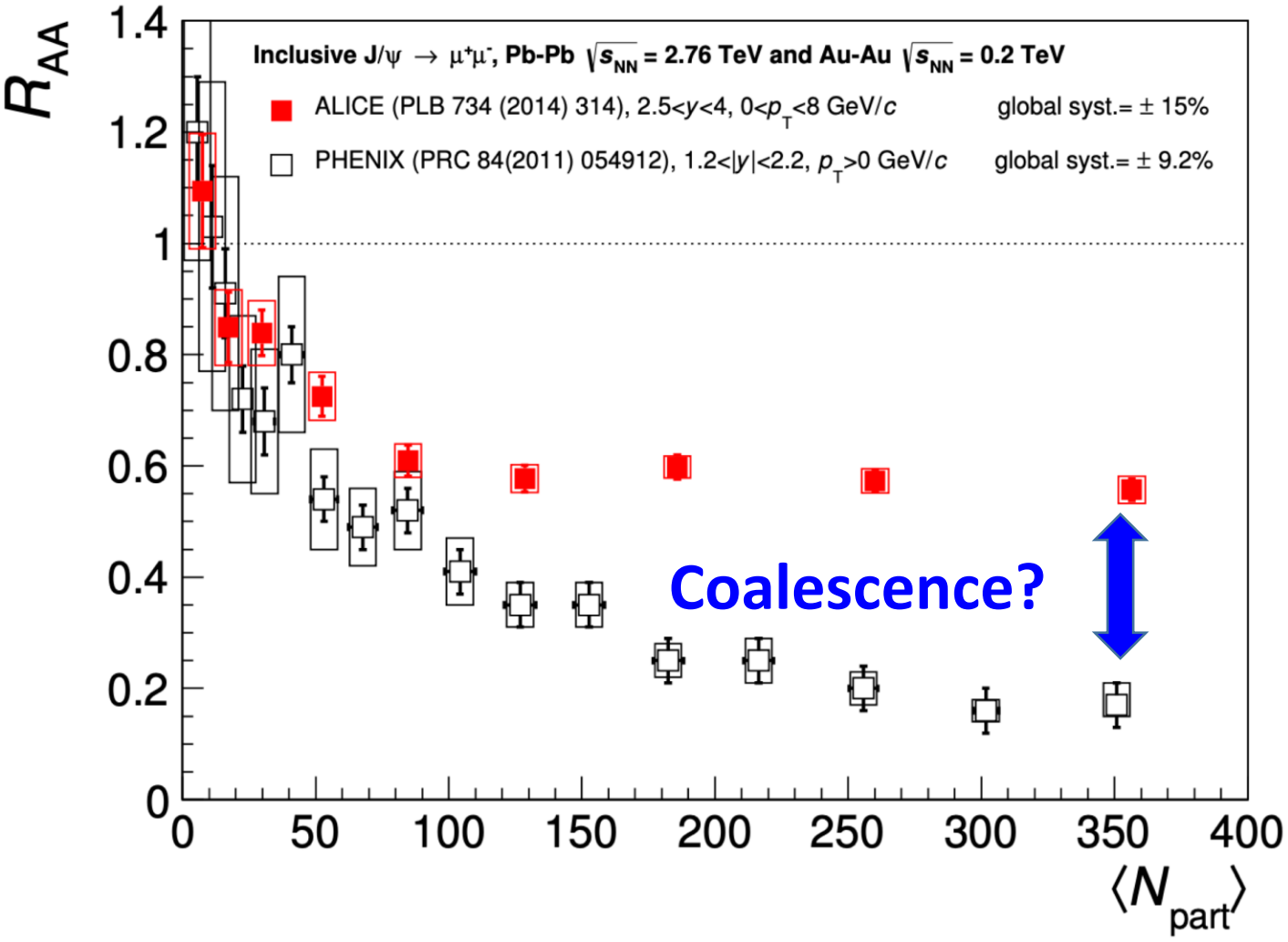


Phys.Rev.C 84 (2011) 054912

- $R_{AA}^{\mathrm{Fwd}} < R_{AA}^{\mathrm{mid}}$, **contrary to expectation**
- **~20 $c\bar{c}$ pairs in collisions at RHIC (mostly at mid-rapidity)**

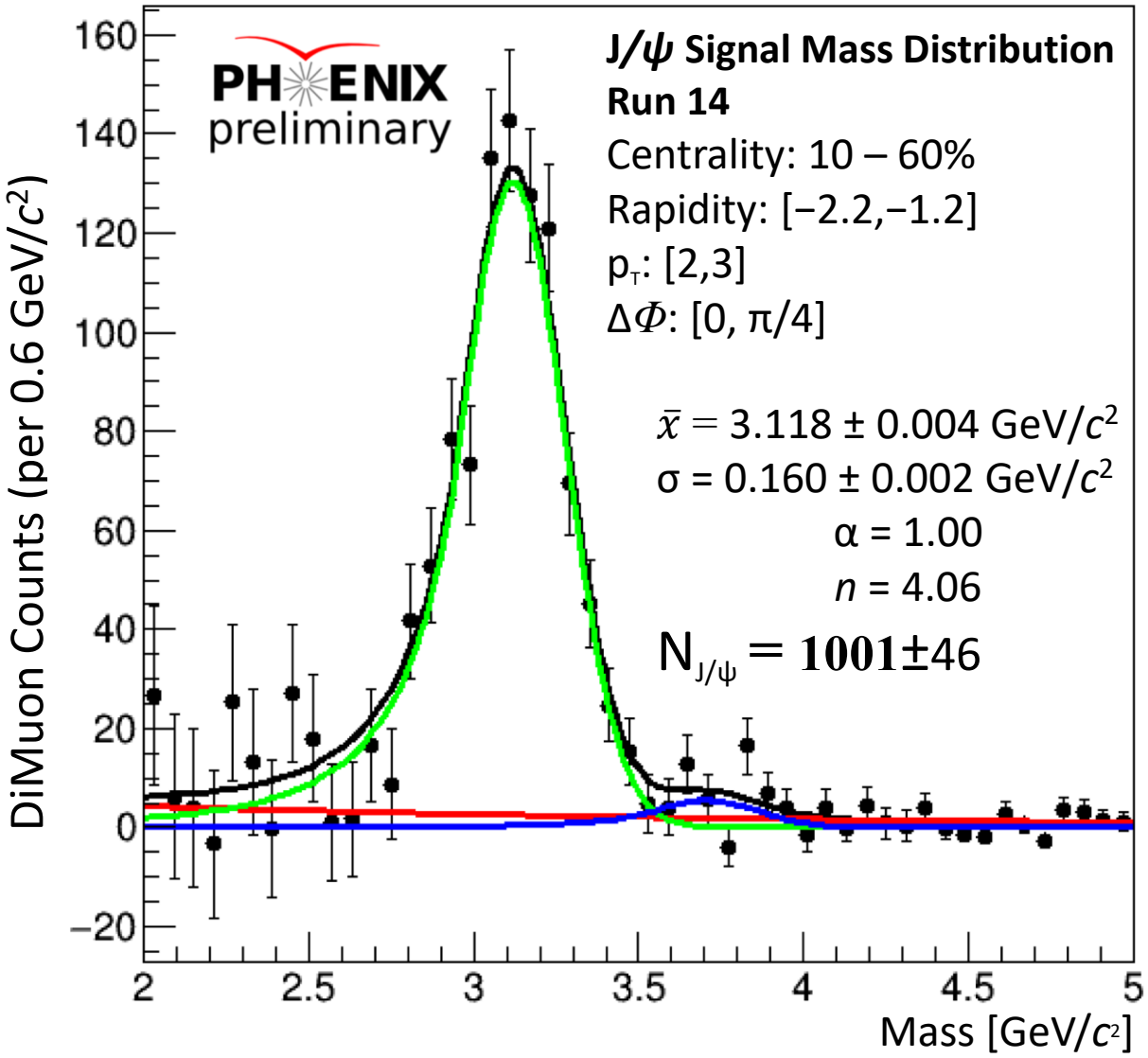
Can we attribute this significant difference in J/ψ R_{AA} to regeneration of J/ψ from $c\bar{c}$ pairs at mid-rapidity?

Coalescence as the solution



- $R_{AA}^{\mathrm{LHC}} > R_{AA}^{\mathrm{RHIC}}$
- **Greater J/ψ suppression predicted at higher T**
- **~200 $c\bar{c}$ pairs at LHC**
- **Coalescence increases R_{AA}**

J/ψ Reconstruction



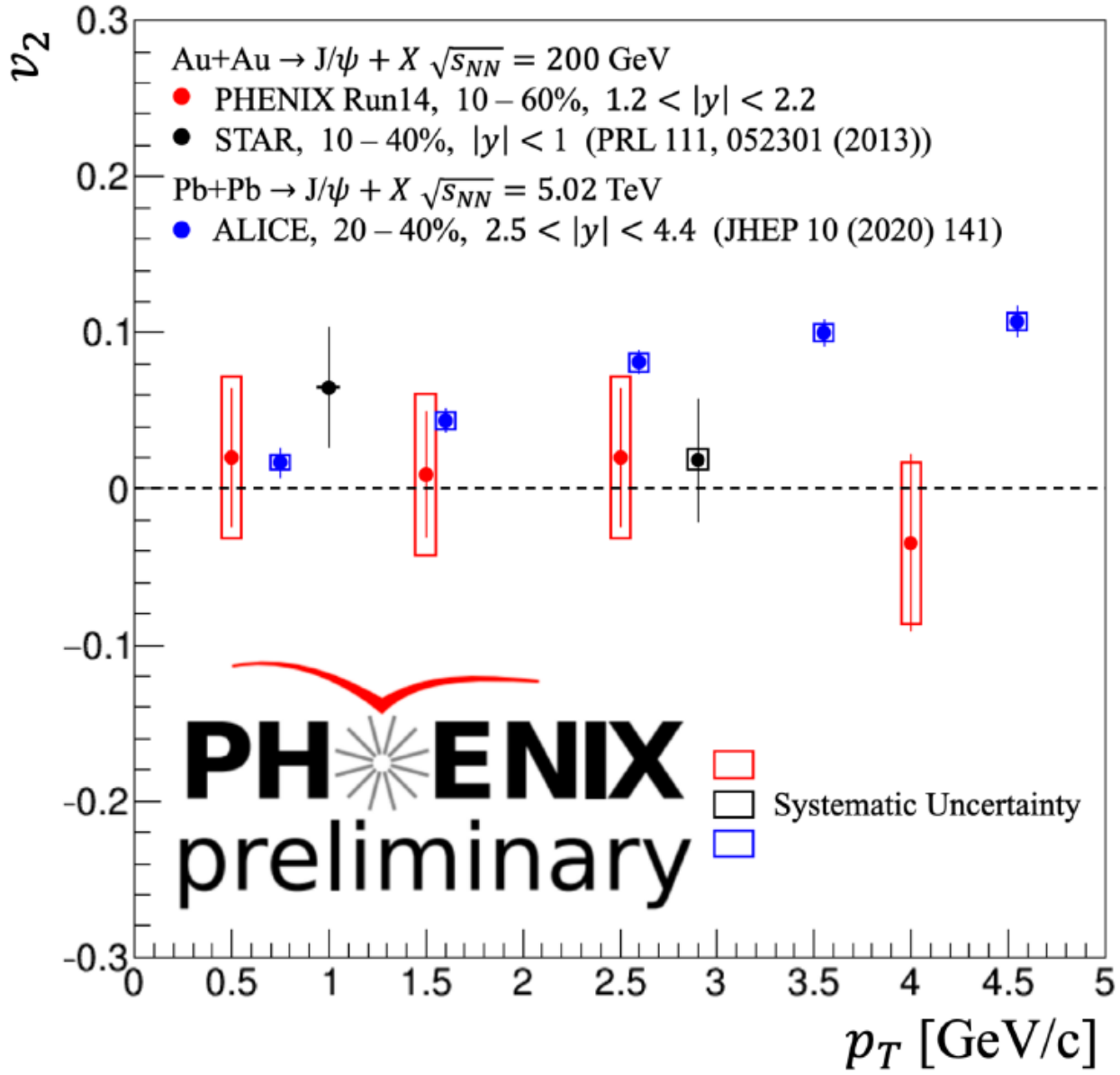
J/ψ simulated with PYTHIA embedded in Au+Au data

- Obtain Crystal Ball fit parameters

Constructing the signal and fit

- Crystal Ball function (J/ψ)
- Crystal Ball function (ψ(2S))
- Exponential (residual background)

J/ψ v_2 measurement



- **PHENIX J/ψ v_2 at forward rapidity is consistent with zero**
- **Forward and mid-rapidity results at RHIC are consistent, but the uncertainties are large**
- **The ALICE nonzero result is different from our measurement**

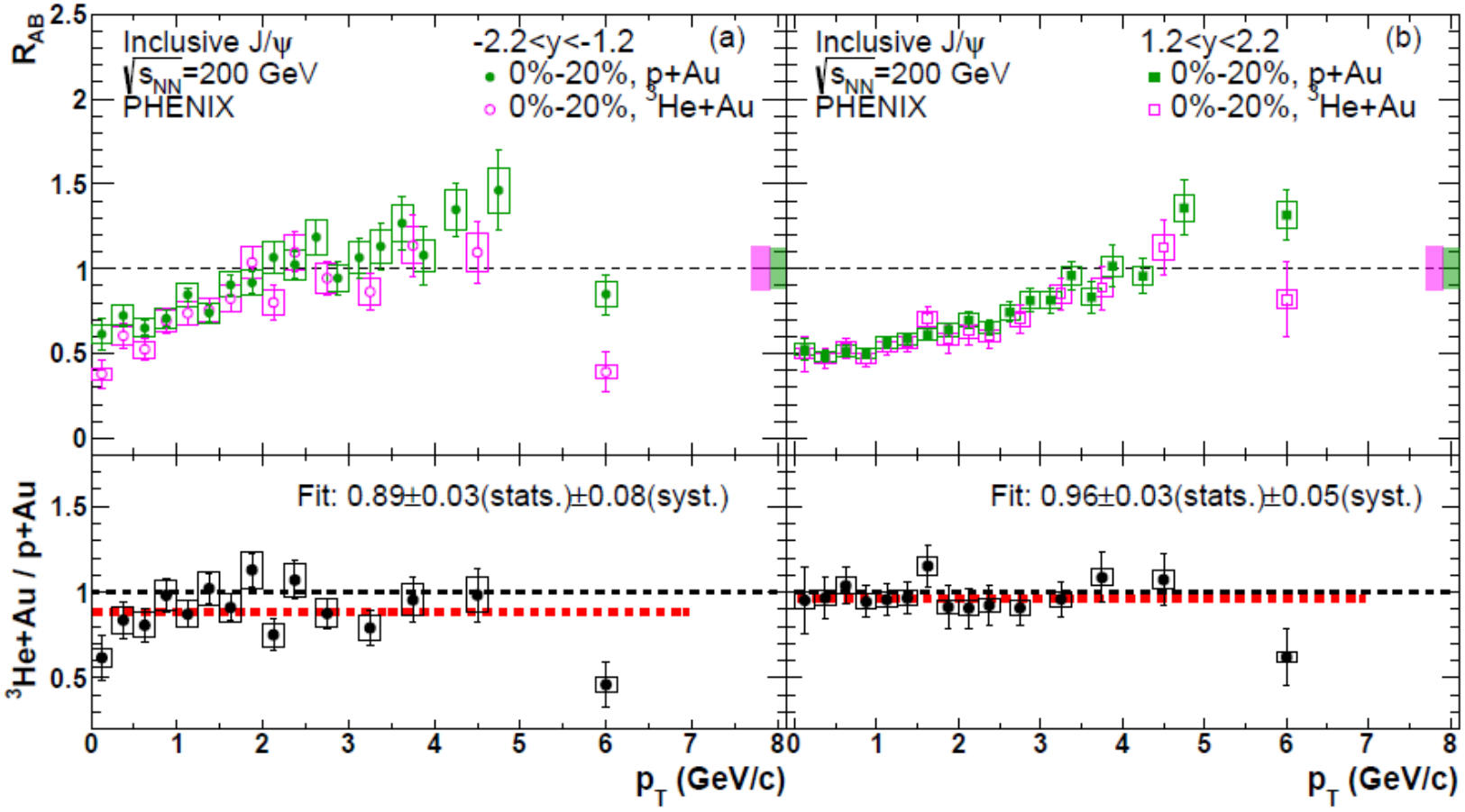
Summary

- Small systems
  - Large enhancement seen in open heavy flavor decays at backward rapidity
  - J/ψ R_{AA} suppression at backward rapidity consistent with nuclear absorption effects
  - ψ(2S) modification at backward rapidity consistent with final state effect
- Large systems
  - Forward rapidity J/ψ R_{AA} slightly more suppressed than mid-rapidity results
  - Data at forward rapidity suggests little to no coalescence effects
  - J/ψ v_2 measurements consistent with zero

Thank you for your attention!

Back up

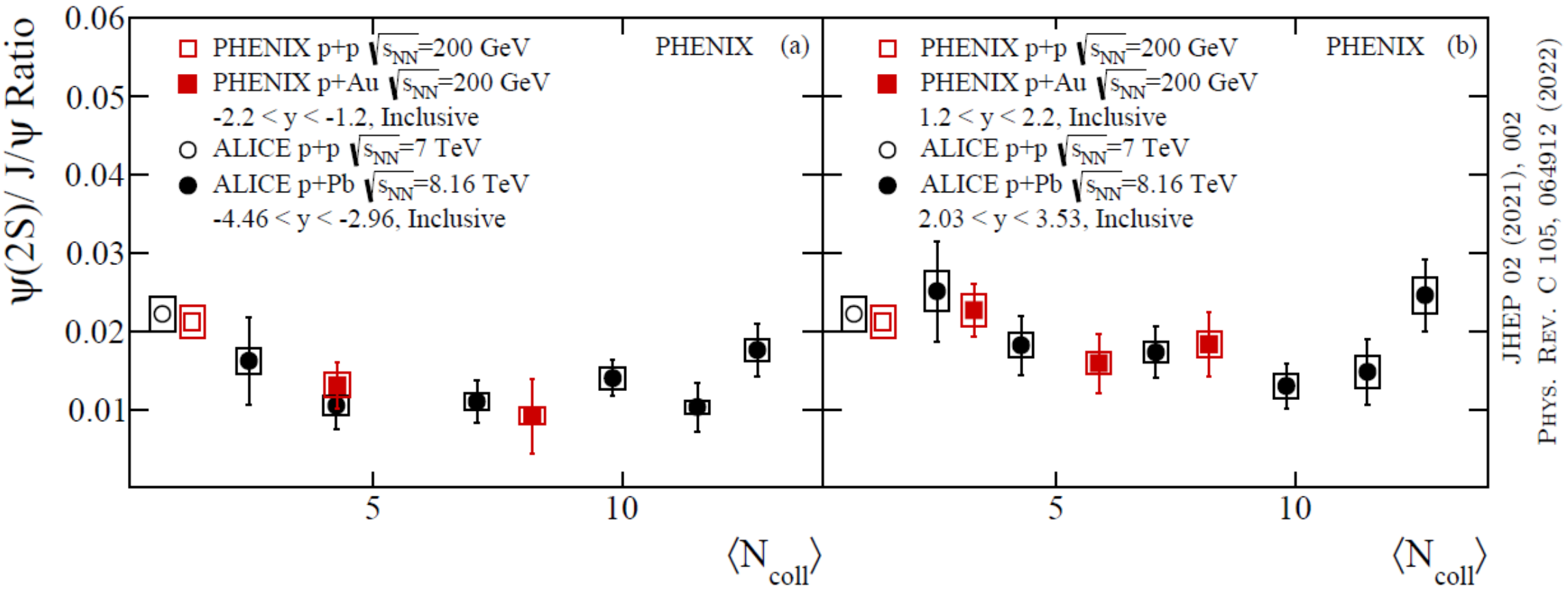
J/ψ Modification Ratio for ^{3}He+Au to p+Au (0-20%)



Phys. Rev. C 102, 014902 (2020)

- **Stronger suppression in ^{3}He+Au than *p*+Au at bkwd rapidity with signicance 1.3σ**
- **No final state effect at fwd rapidity, small final state effect at bkwd rapidity**

ψ(2S) to J/ψ Ratio in *p*+A Collisions at RHIC and LHC



- The ψ(2S) to J/ψ ratio in *p*+*p* collisions at RHIC, LHC show no clear energy dependence
- Comparison of the *p*+A to *p*+*p* ratio strongly suggests the presence of final state effects in *p*+A collisions at backward rapidity, as initial state effects expected to largely cancel