PHENIX

Overview of Recent PHENIX Results

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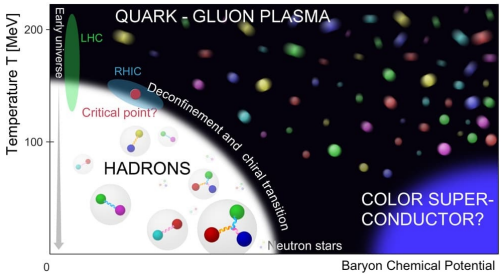
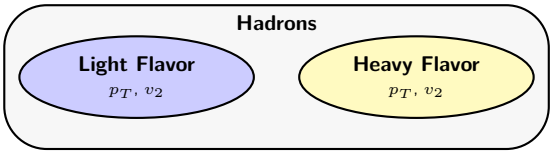
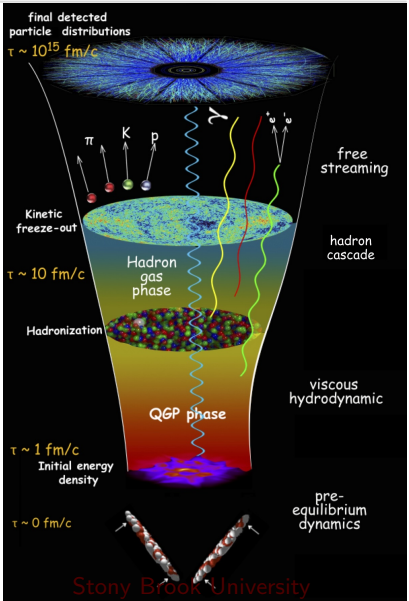
May 13, 2026

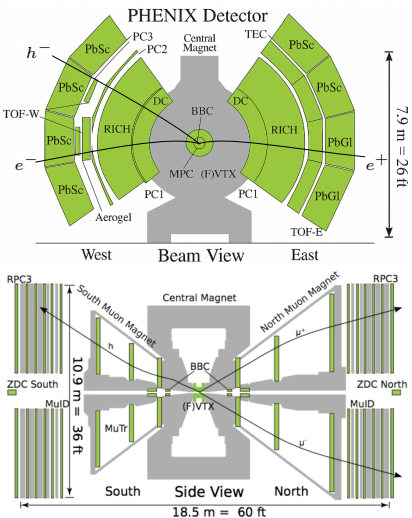
Motivation: studying QCD matter with different probes







PHENIX Detector



Xiaochun He, Hard Probes 2016

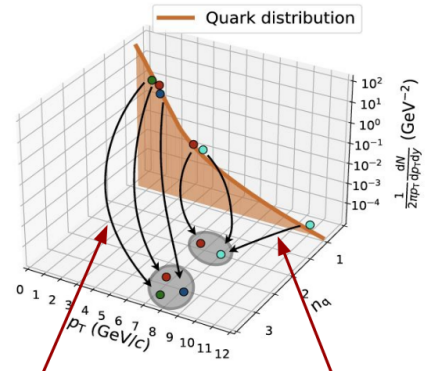
PHENIX Data Taking Mission Completed

Email from the PHENIX spokesperson (Dr. Yasuyuki Akiba) on 6/27/2016

"This morning at 7:42, we ended RUN459344. The beam was dumped at ~7:50. This is the end of RUN16 and the end of PHENIX data taking. We had the first collision of Au+Au at 56 GeV on June 15, 2000."

PHENIX data production and analyses continue !

Hadronization at RHIC: recombination to fragmentation



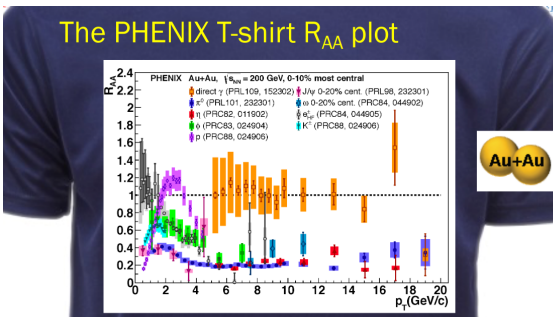
Recombining quarks:

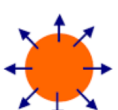
$p_{meson} = p_{q1} + p_{q2}$

$p_{baryon} = p_{q1} + p_{q2} + p_{q3}$

Fragmenting parton:

$p_h = z \cdot p_q$ with $z<1$

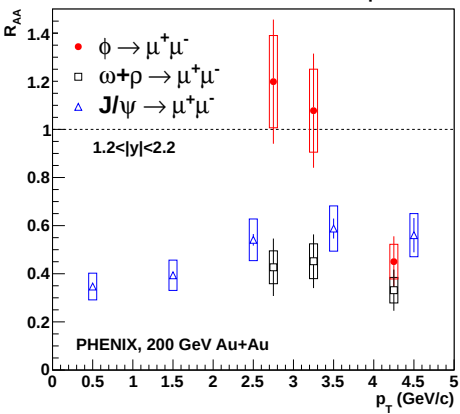




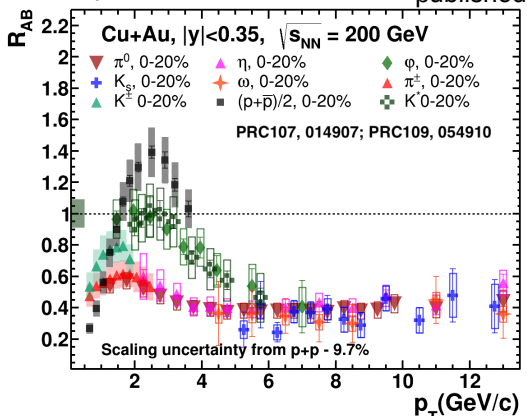
$$R_{AB} = \frac{1}{N_{coll}} \cdot \frac{A + B}{p + p}$$

Soft Probes: Hadronization System&Species Dependence

Phys. Rev. C 112, 064918 published

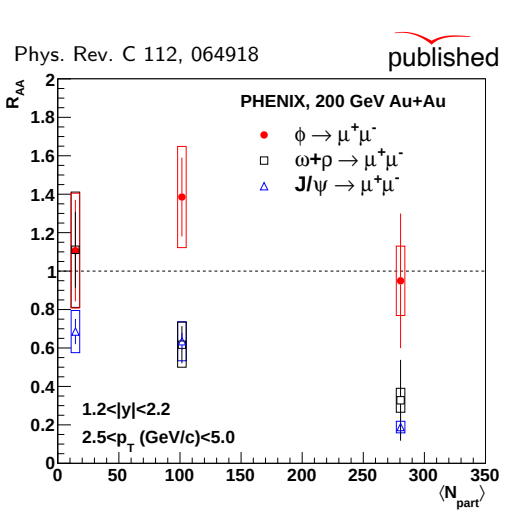


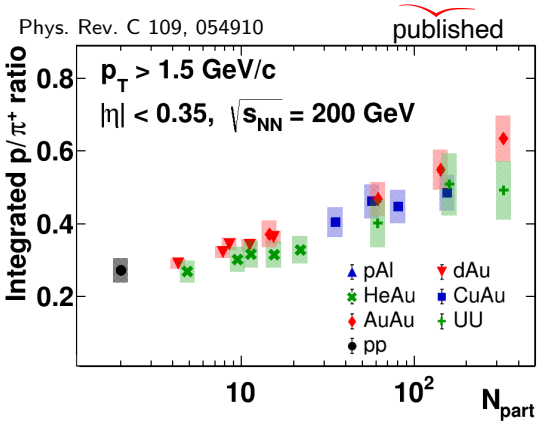
Phys. Rev. C 109, 054910 published



p+p p+Al p+Au d+Au ^{3}He+Au Cu+Cu Cu+Au Au+Au U+U

System Size Dependence of ϕ and Baryon Enhancement

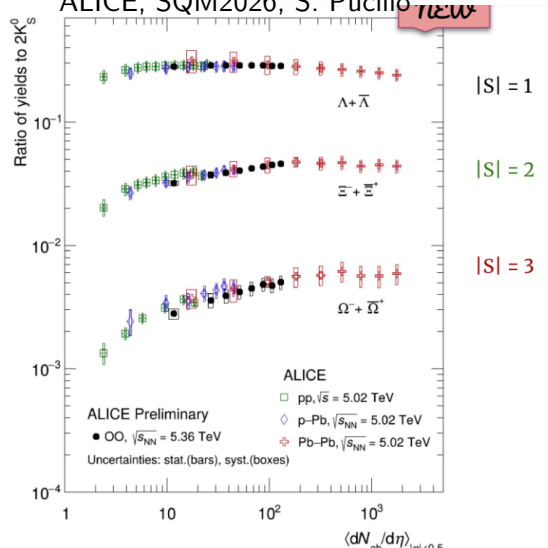




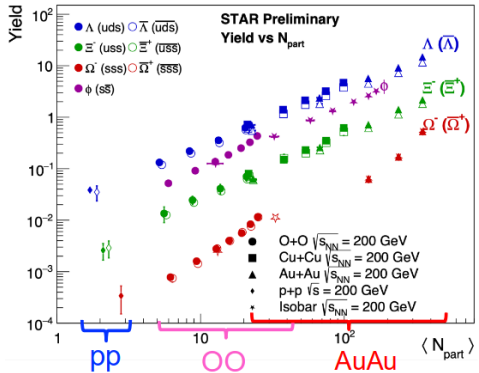
- The intermediate-p_T enhancement grows smoothly with system size.

Strange Baryon to Meson Ratio from ALICE and STAR

ALICE, SQM2026, S. Pucillo



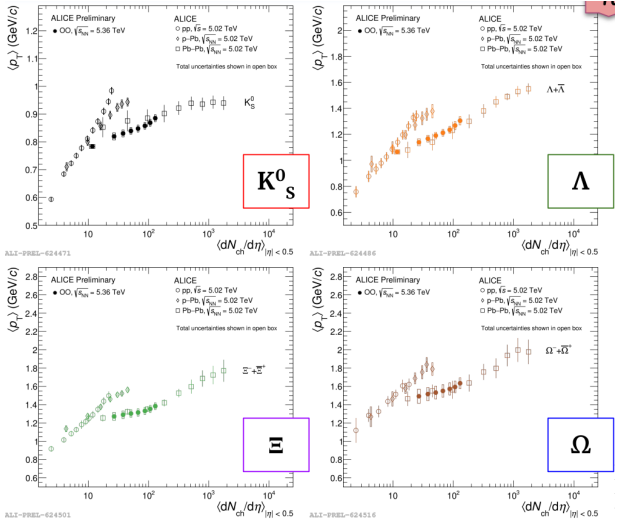
STAR, SQM2026, I. Ponce



- Similar results from ALICE and STAR.

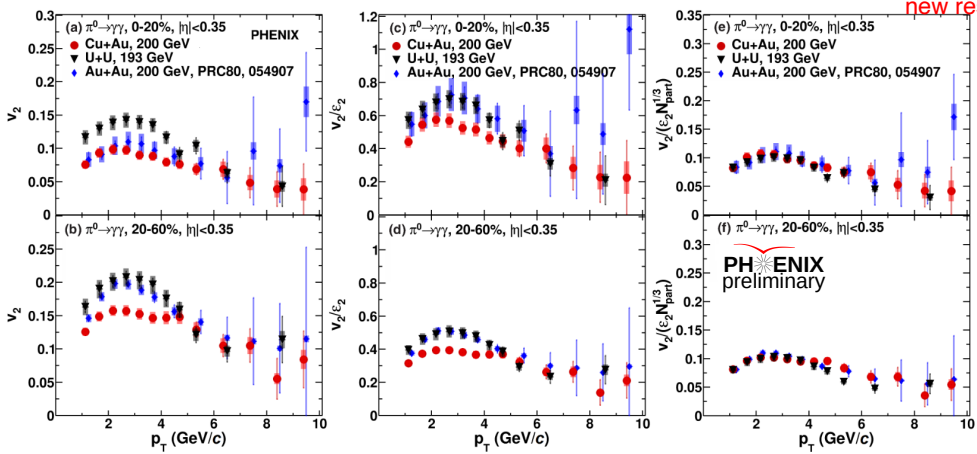
Mean p_T of Strangeness from ALICE

ALICE, SQM2026, S. Gami



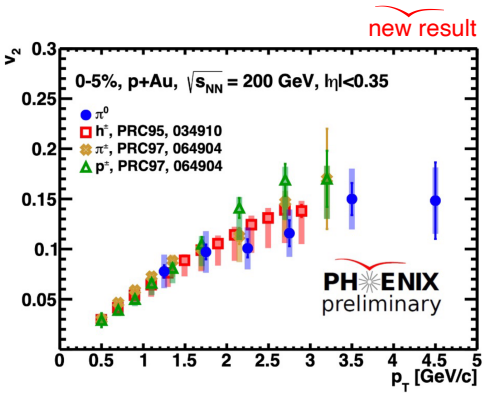
- The average p_T is sensitive to radial flow, which pushes particles to higher p_T with a stronger effect for heavier hadrons.
- Since radial flow is driven by the system pressure gradients and energy density, the multiplicity dependence provides information on how collective expansion develops across different collisions.
- The observed dependence on charged-particle multiplicity is non-trivial and qualitatively follows the type of mass ordering expected from collision geometry and collective expansion.

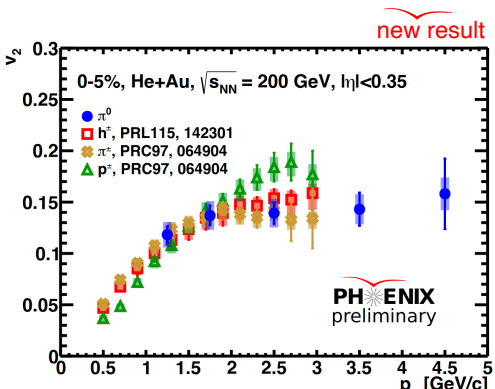
High-p_T π^0 v_2 in Cu+Au, Au+Au, and U+U



- The low-p_T π^0 v_2 scales with the initial eccentricity and $N_{\rm part}^{1/3}$.
- The high-p_T π^0 v_2 provides input for path-length dependent energy loss studies.

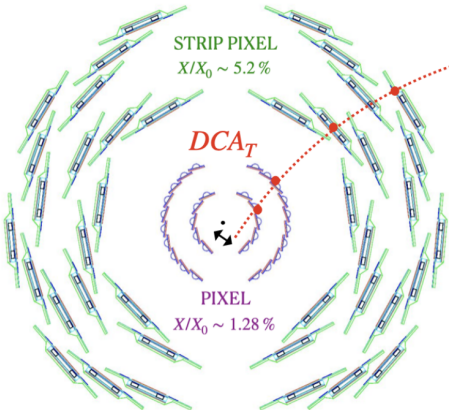
High-p_T π^0 v_2 in p+Au and ^{3}He+Au

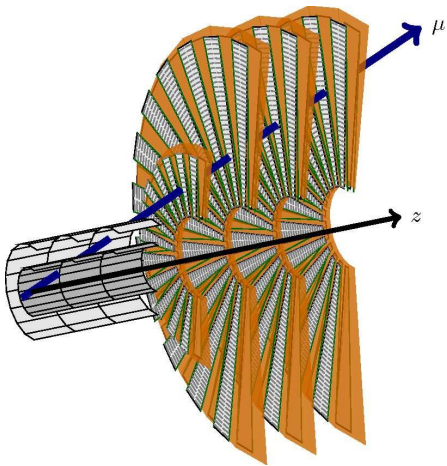




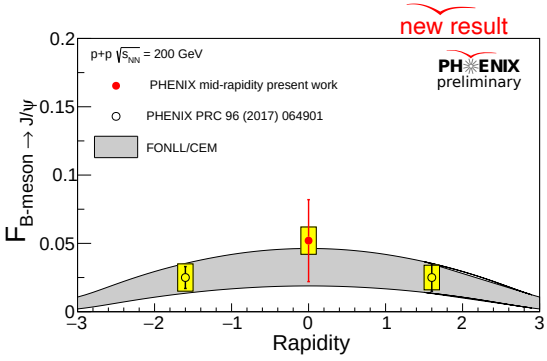
- The high-p_T π^0 v_2 in small systems can provide insight on energy loss and non-flow contributions to azimuthal anisotropy.

Heavy Flavor at PHENIX

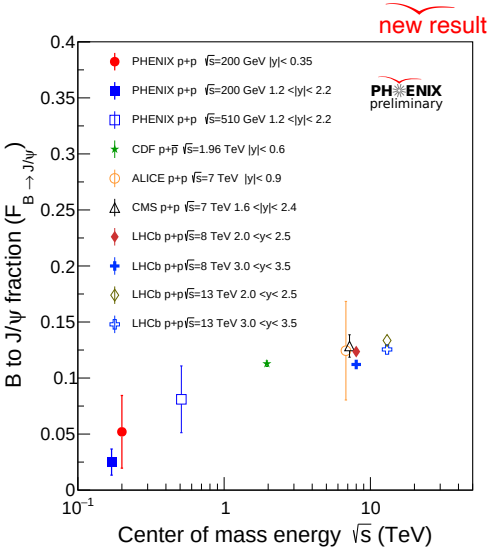




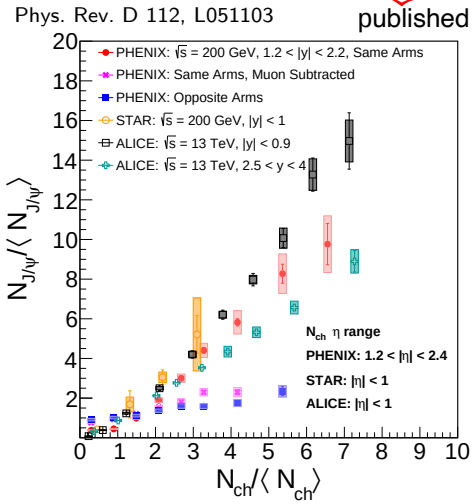
Bottom Quark Production in p+p Collisions

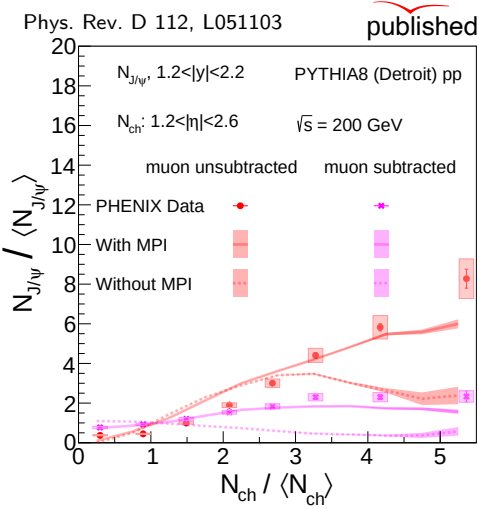


- Fraction of J/ψ from B decays evolves with $\sqrt{s}$ and rapidity, consistent with FONLL predictions.



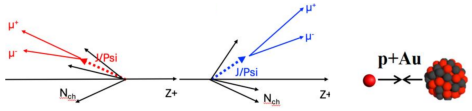
Charmonium Production vs. Event Activity in p+p

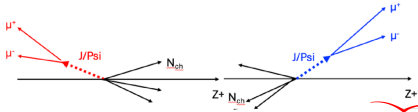




- J/ψ production versus charged-particle multiplicity in p+p is described by PYTHIA with MPI.

Charmonium Production vs. Event Activity in p+Au

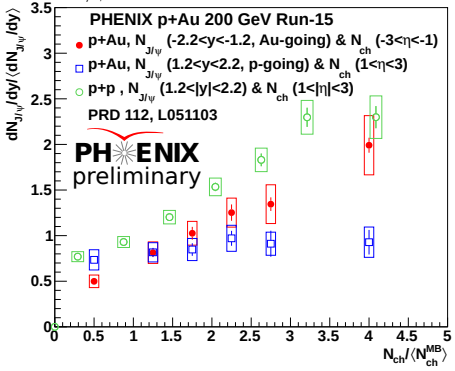


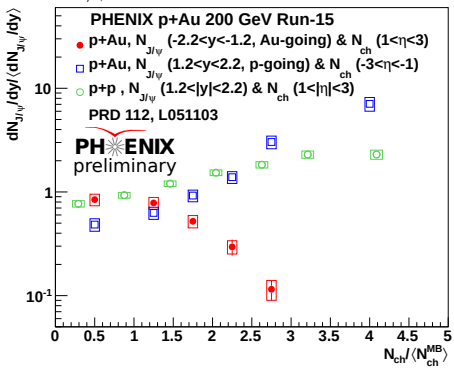


$|y_{J/\psi} - \eta_{\rm ch}| \approx 0$

$|y_{J/\psi} - \eta_{\rm ch}| > 2.2$

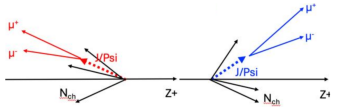
new result

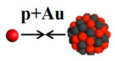


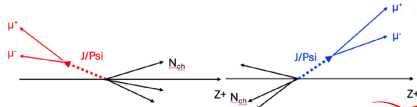


- Short-range correaltion similar to p+p. More pronounced long-range correlations.

Charmonium Production vs. Event Activity in p+Au







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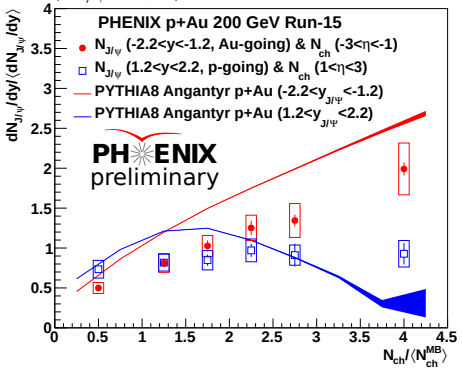
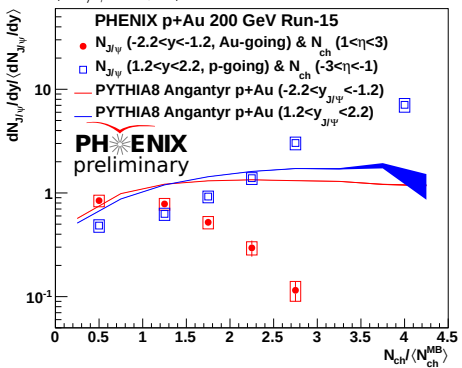
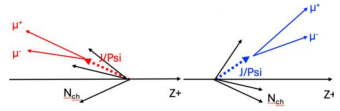
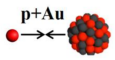


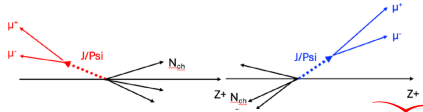


- Pythia8/Angantyr with MPI does not describe this large-separation pattern.

Charmonium Production vs. Event Activity in p+Au







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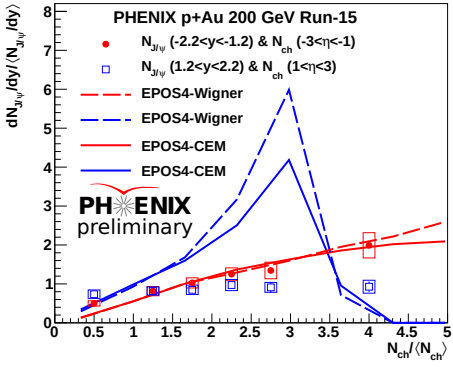
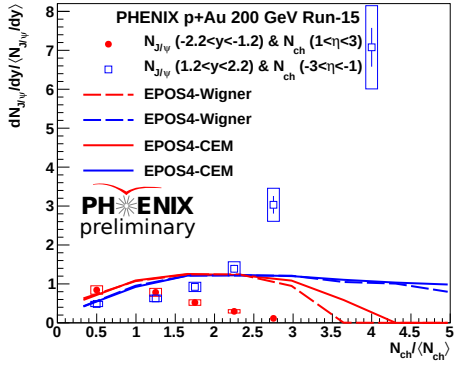
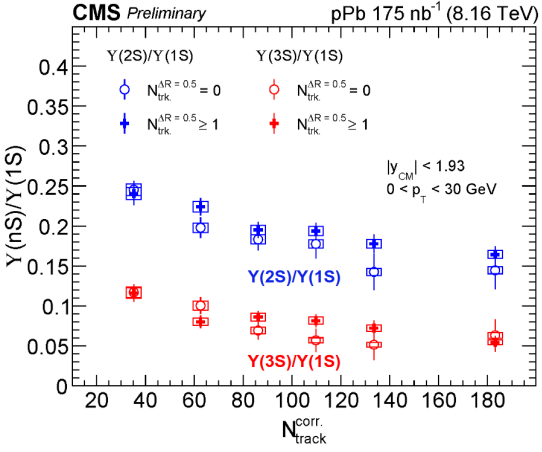


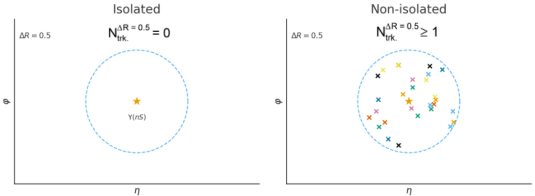


- EPOS4 can also only describe short-range correlations in Au-going direction

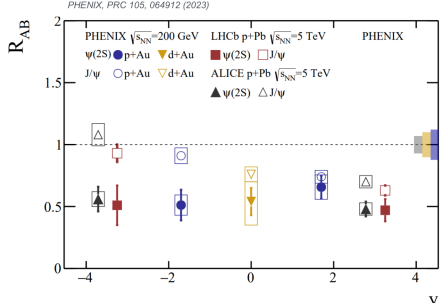
Challenging Comover Models

CMS, SQM2026, S. Nanda

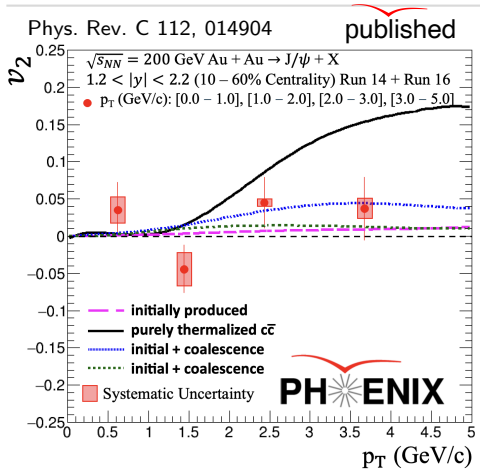


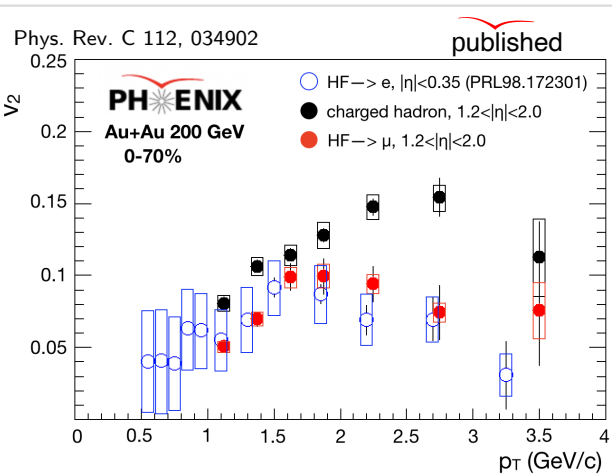


PHENIX, PRC 105, 064912 (2023)



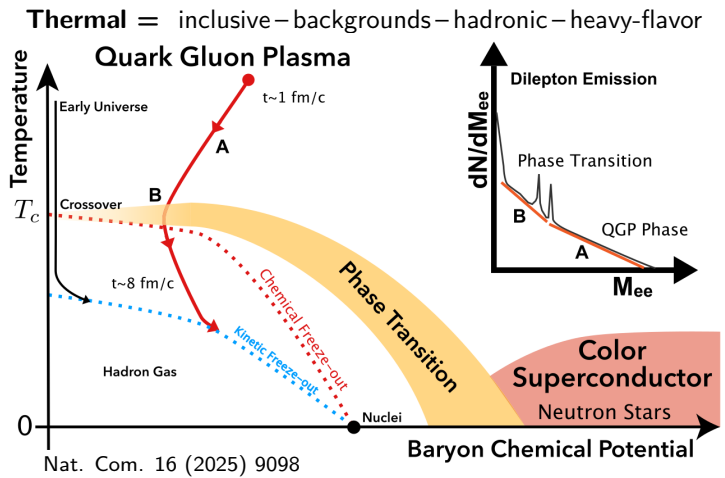
Heavy-Flavor Flow in Au+Au Collisions

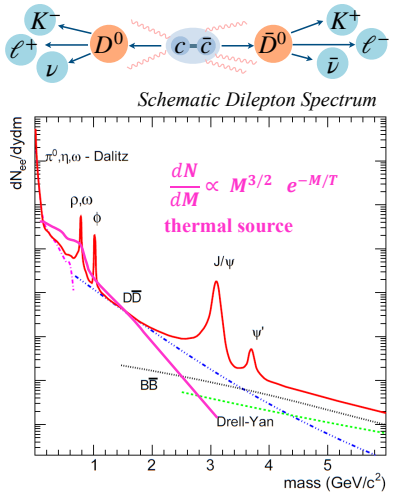




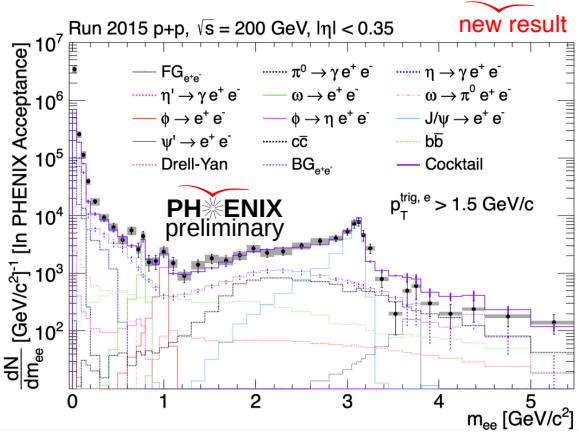
- PHENIX observes open heavy-flavor flow, providing evidence for strong heavy-quark interactions with the medium.

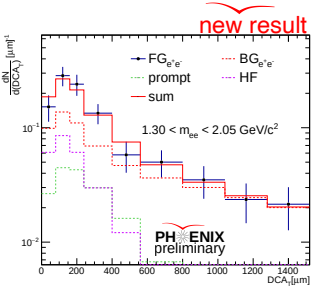
From Heavy Flavor to Thermal Dielectrons in Au+Au

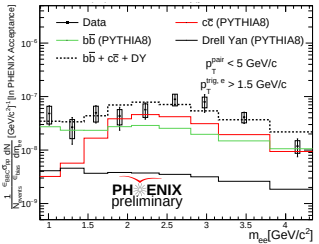




Dielectrons in p+p Collisions

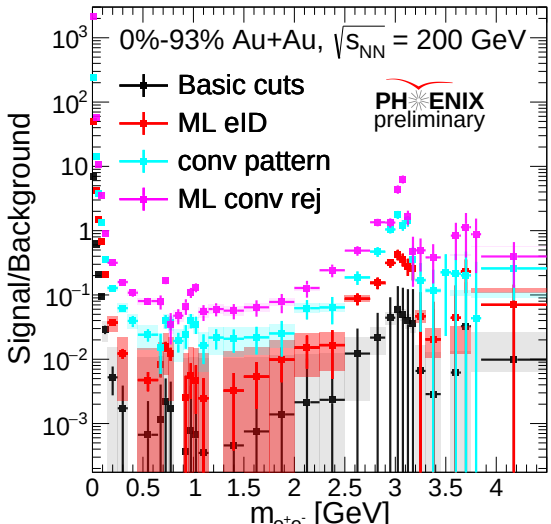






- The hadronic cocktail and the Pythia Detroit tune describe the data well.

Au+Au: Signal-to-Background Improvements

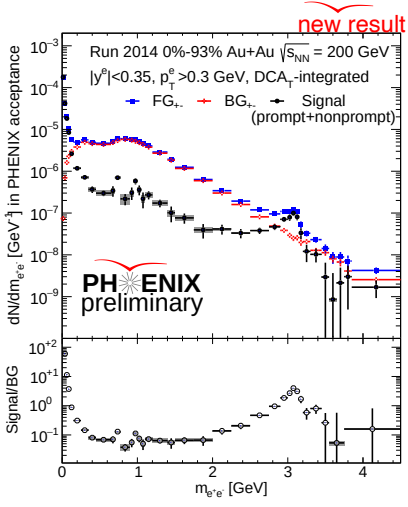


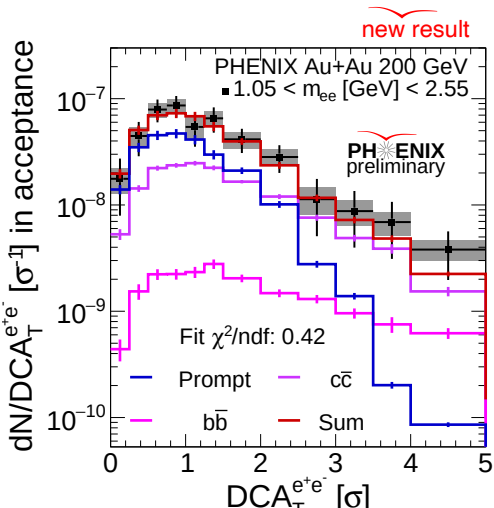
Because background constraints are limited, higher S/B is key for smaller systematics and precision.

- Black: PRC93 014904 baseline.
- Red: BDT electron ID.
- Cyan: Partner-based conversion rejection.
- Magenta: ML conversion-pattern rejection.

Takeaway: much higher significance and much smaller systematics.

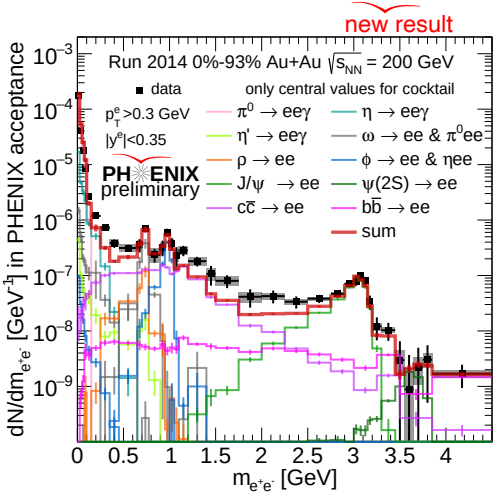
Au+Au Dielectrons: separating HF and extracting the excess

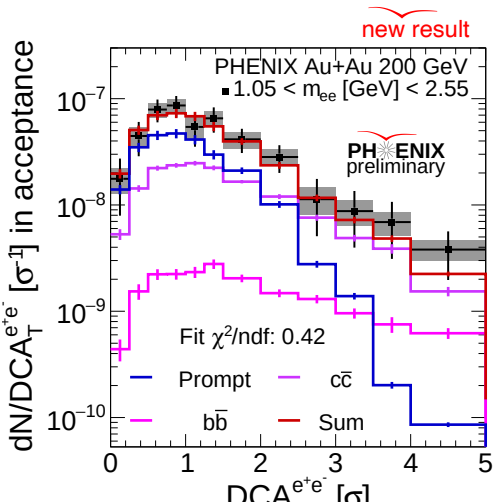




$$DCA_T^{e^+e^-} = \sqrt{\left(DCA_T^{e^+}/\sigma_{e^+}\right)^2 + \left(DCA_T^{e^-}/\sigma_{e^-}\right)^2}$$

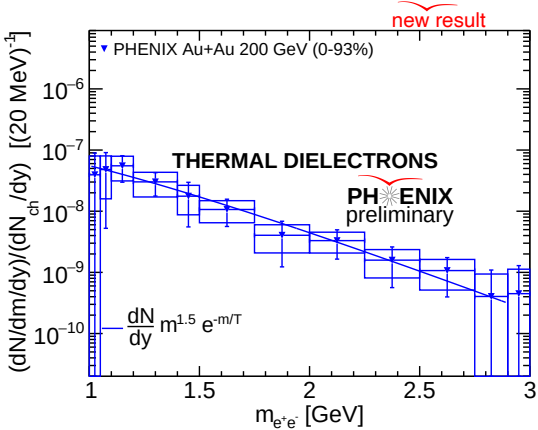
Au+Au Dielectrons: separating HF and extracting the excess

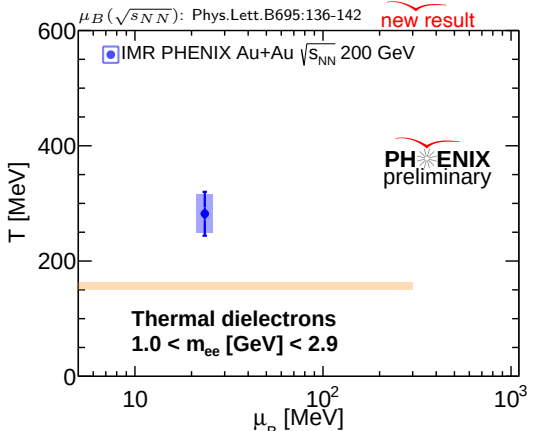




- Pair-DCA constrains heavy flavor directly in data, allowing us to isolate the excess in the IMR.

Thermal Dielectrons: Mass Spectra and Measured T





- **First** direct measurement of the QGP temperature at top RHIC energy in Au+Au collisions, enabled by the extraction of the prompt IMR component using DCA.
- Only a slight increase in T_{IMR} is observed from SPS.

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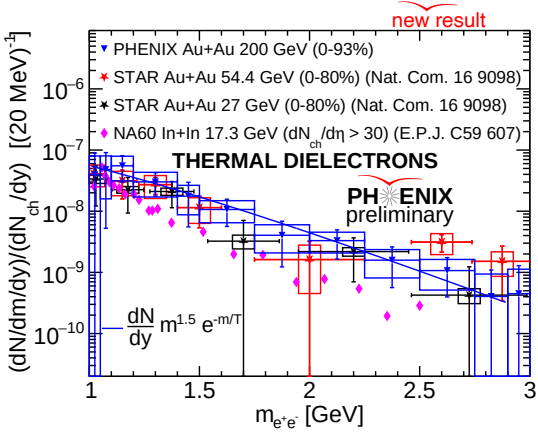

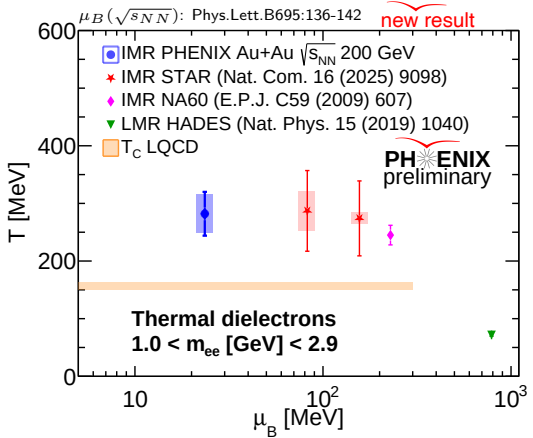

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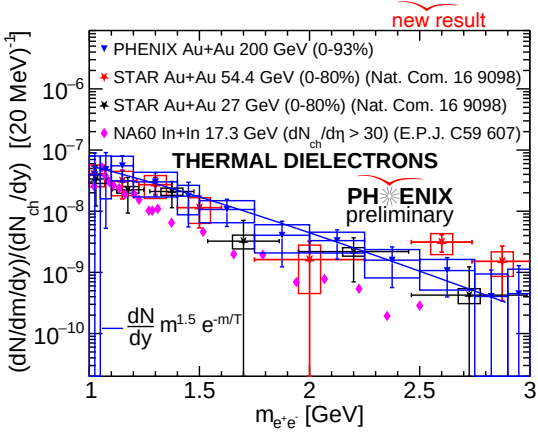
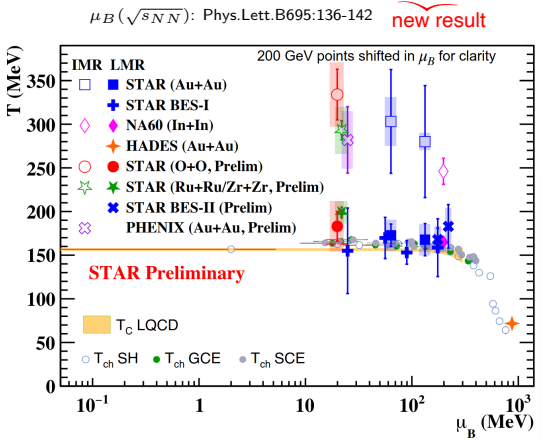
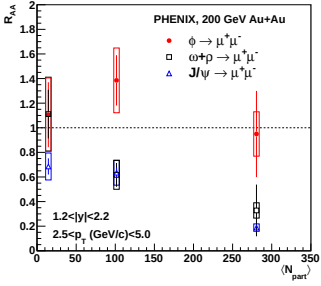


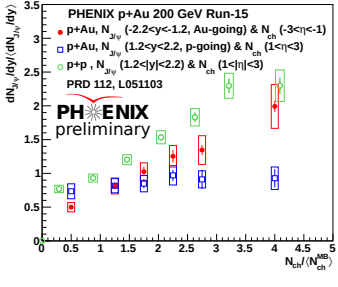


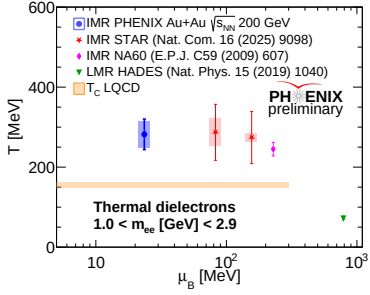
- **First** direct measurement of the QGP temperature at top RHIC energy in Au+Au collisions, enabled by the extraction of the prompt IMR component using DCA.
- Great agreemnt with the STAR results using a cocktail-based approach

Summary

- Interplay of recombination and fragmentation evolves smoothly with system size.
- J/ψ production in p+p and p+Au shows a strong dependence on event activity: MPI describes the p+p, while in p+Au additional mechanisms to explain the long-range correlation are needed.
- IMR dielectrons in p+p are well described by HF contributions from the PYTHIA Detroit tune; in Au+Au, after isolating the HF component, a clear prompt excess is observed, consistent with thermal radiation at temperatures similar to those extracted at lower collision energies.

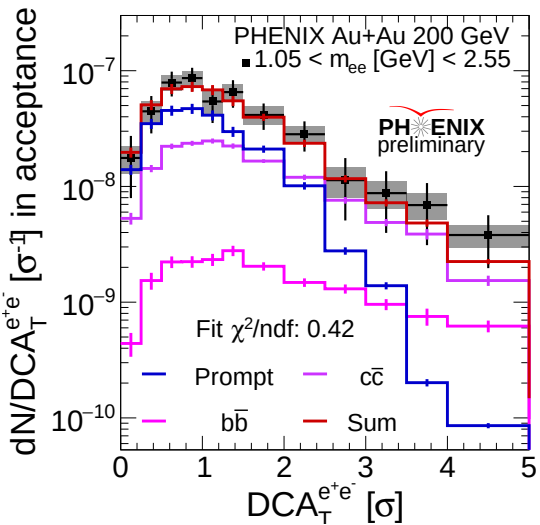


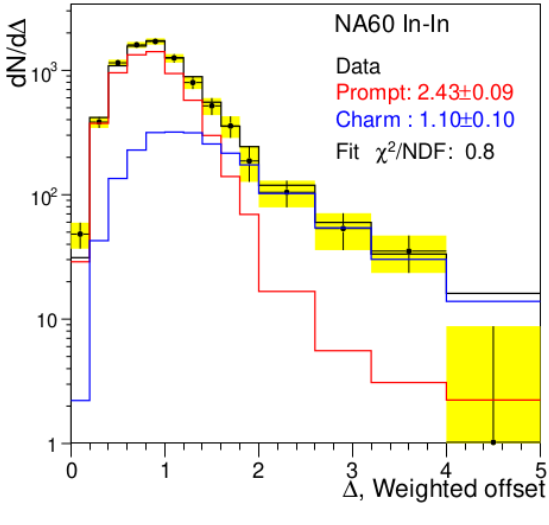




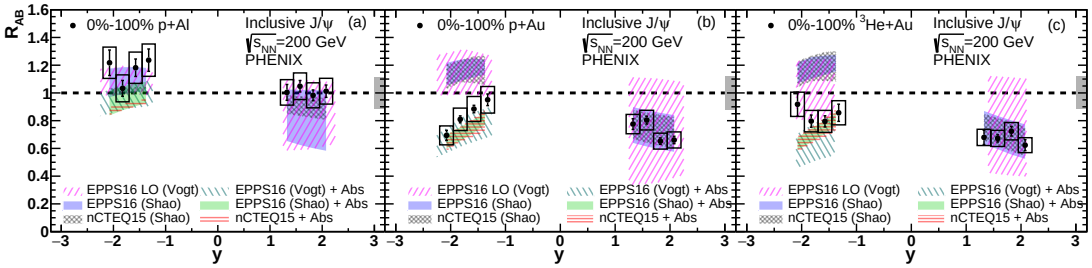
Backup Slides

PHENIX and NA60 DCA Template Fit Comparison





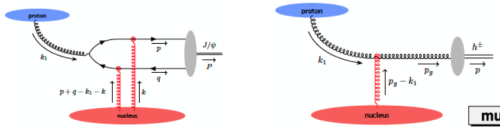
Nuclear Modification of J/ψ in p+Al/Au and He+Au Collisions

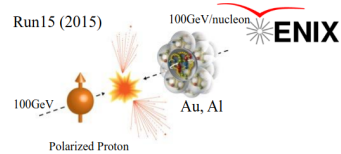


- J/ψ is suppressed at both forward and backward rapidity.
- The suppression in p+Al collisions is consistent with nuclear PDF modifications (shadowing)
- The stronger suppression in p+Au and He+Au is consistent with additional nuclear absorption effects.

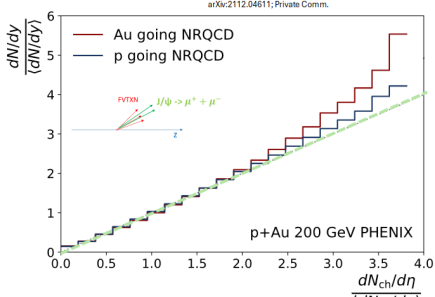
CGC-based Model for J/ψ vs. $N_{\rm ch}$ Correlations

Probe CGC in p+Au?



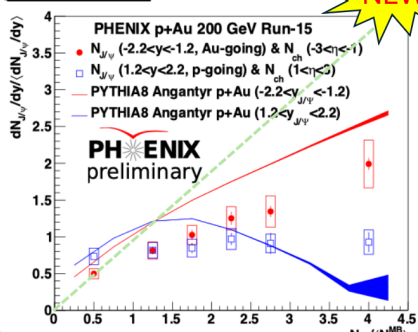


Farid Salazer, Bjorn Schenke and Alba Soto-Ontoso
arXiv:2112.04611; Private Comm.

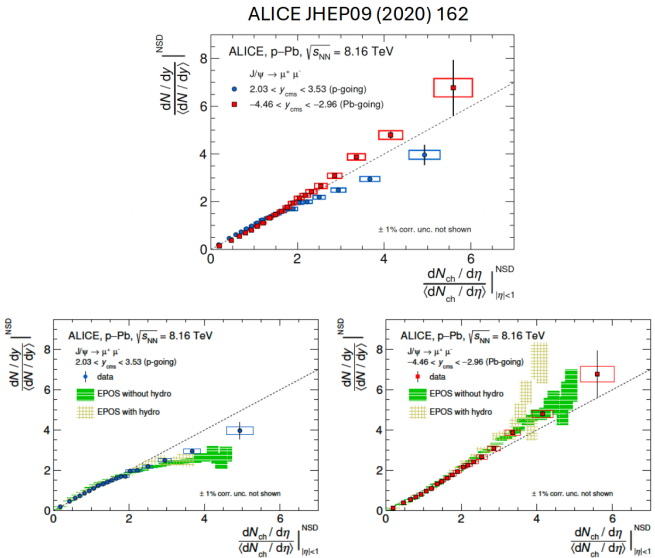


muon subtracted

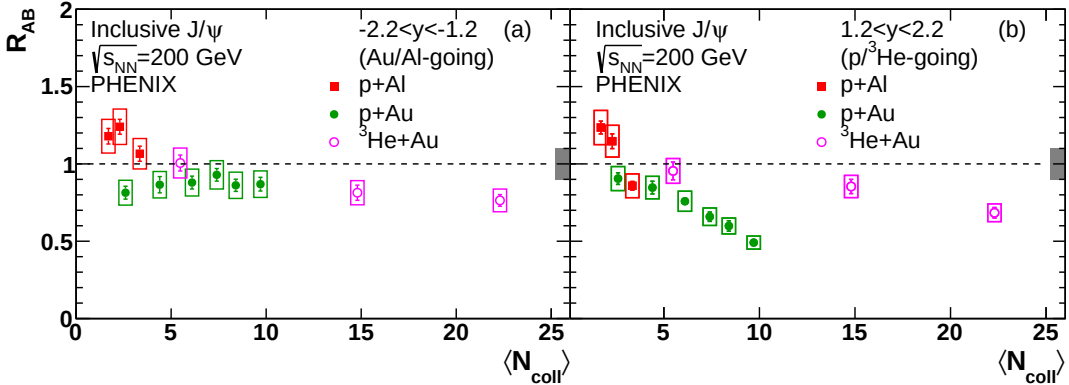
NEW



ALICE J/ψ vs. $N_{\rm ch}$ in p+Pb



Nuclear Modification of J/ψ in p+Al/Au and He+Au Collisions



- The suppression in the p-going direction is inversely proportional to N_{coll}.
- The same trend is observed in the Au-going direction, but with a smaller magnitude.