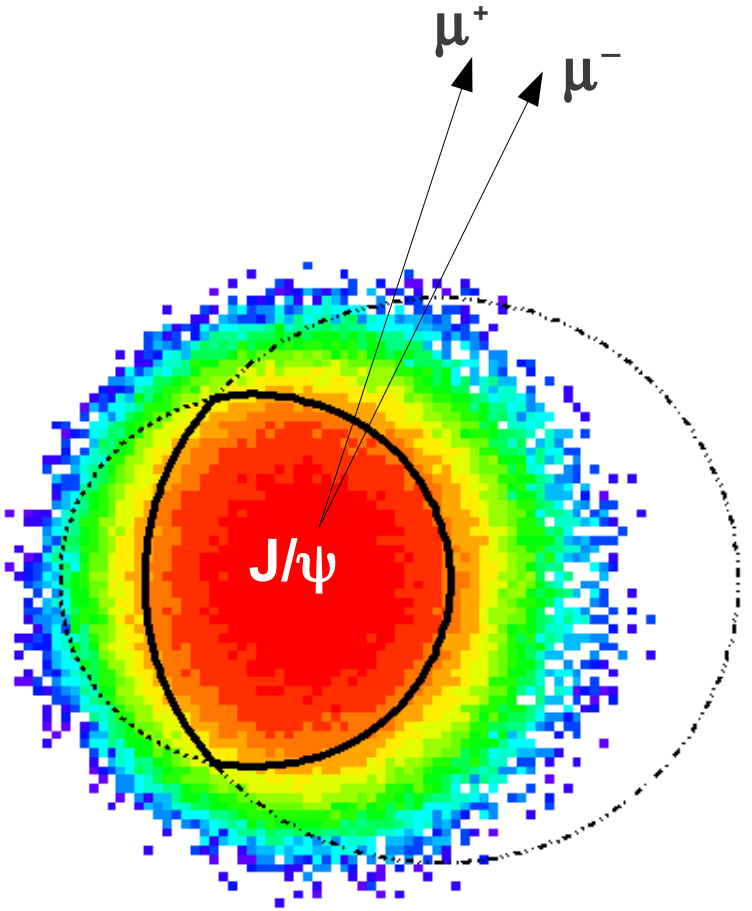
Forward J/$\psi \rightarrow \mu\mu$ production in Cu+Au collisions at PHENIX



Richard Hollis

University of California, Riverside

Winter Workshop on Nuclear Dynamics
Squaw Valley, CA (Feb 2013)

Overview

- Motivation
- Past measurements
  - Tests of hot and cold nuclear matter
- Why CuAu collisions?
- J/ψ measurement in PHENIX
- Results

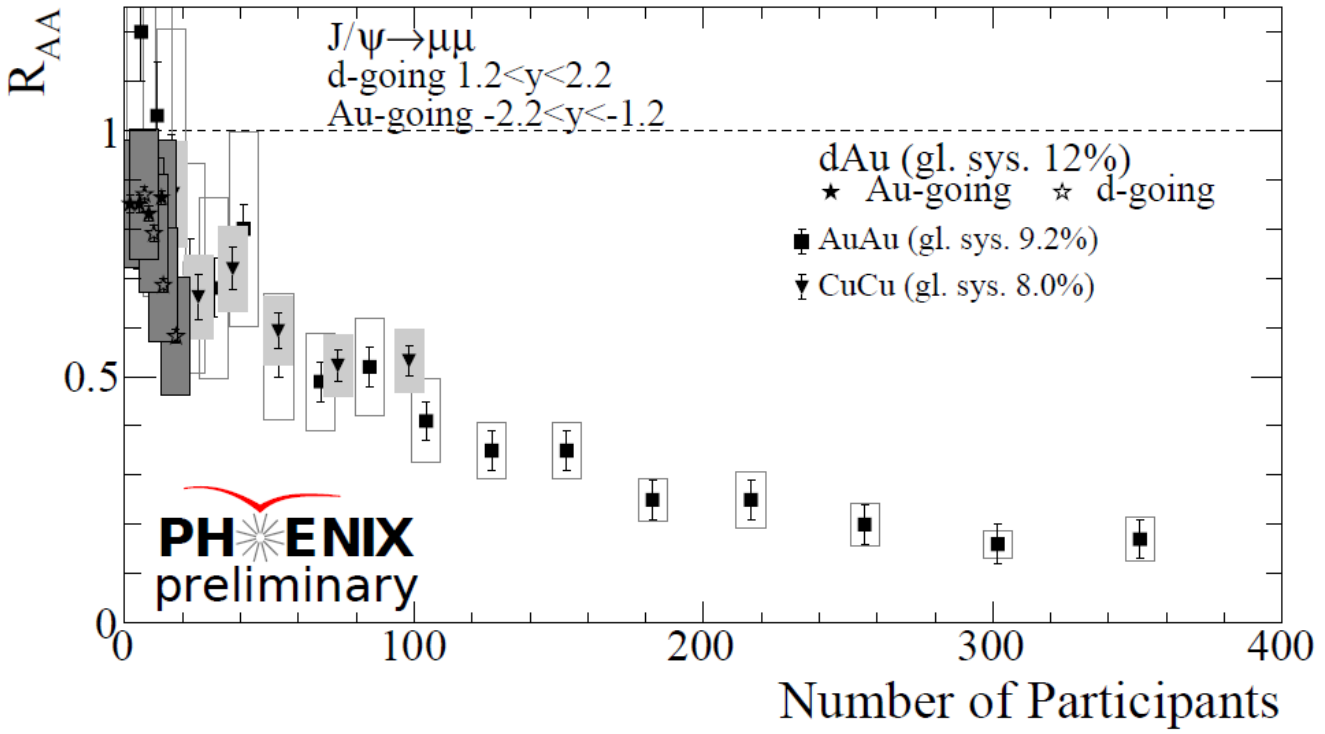
Why measure J/ψ?

- Hard collision product
  - Dominated by gluon fusion
- Loosely bound ccbar state
  - 'Melt' in a QGP?
  - Modification was an initial signature of QGP formation

- Complex interplay between hot and cold nuclear matter … need more variables to disentangle effects

What has been measured: Hot nuclear matter

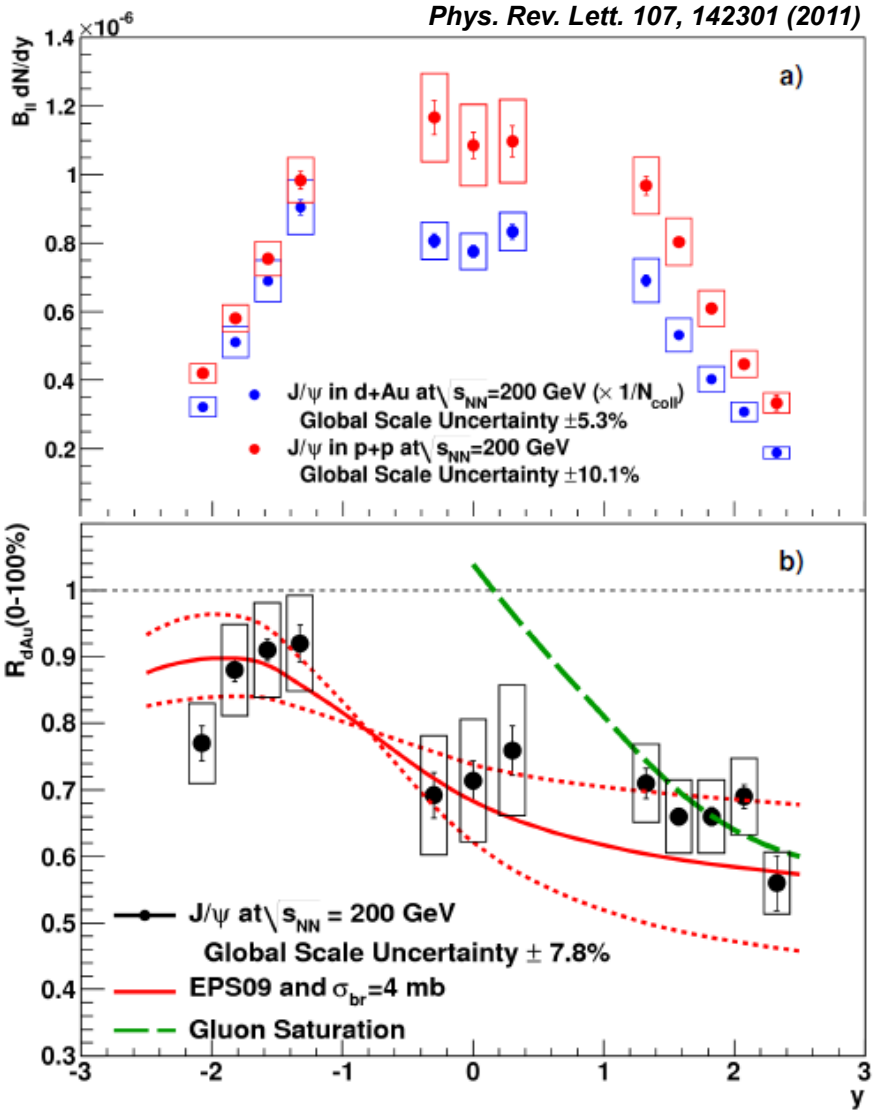
- Au+Au and Cu+Cu collision data
  - Suppression turns on with centrality
  - Similar dependence with overlap volume (N_{part})



What has been measured: Cold nuclear matter

- d+Au
  - Forward/backward asymmetry
  - “suppression” at forward rapidity

- See K. Lee's talk for details



Observational Summary

- J/ψ $\rightarrow$ modified by both hot and cold nuclear matter
- Cold nuclear matter:
  - Shadowing, anti-shadowing, and Cronin
    - Evaluated where these are active, but hot nuclear matter is absent
  - Suppression or enhancement
- Hot nuclear matter, or final state effects
  - Color screening in the hot, dense medium

- Current interpretation needs both hot and cold
  - True relative contribution is difficult to disentangle
  - Colliding different systems, at the same energy, provides additional insight into the relative importance of such mechanisms

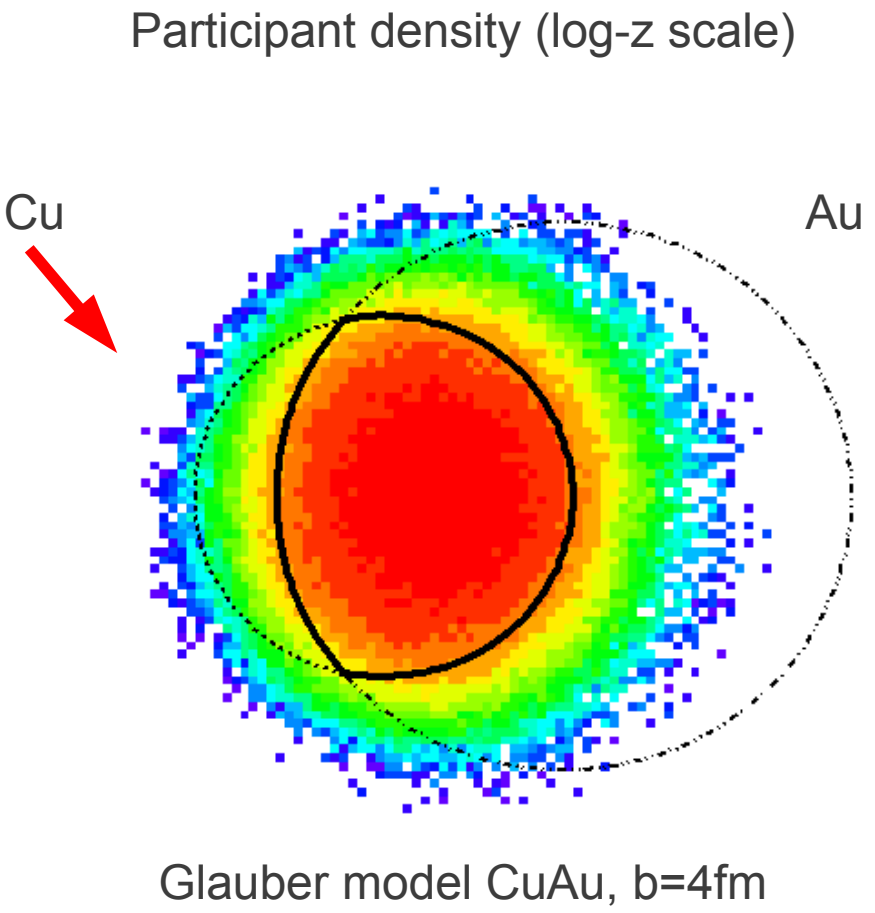
Add more geometrical variation: Cu+Au collisions

- Why CuAu (more details from A.Iordanova's talk)
  - Forward/backward momentum asymmetry (like d+Au, but also includes hot nuclear matter)
  - Left-right asymmetry – test of possible core/corona effects
  - Natural triangularity – is this borne out in data?

- Summary: different geometrical controls
  - Next: test them

CuAu Collisions – Exploiting the flexibility of RHIC

- Why interesting?
  - Naturally odd harmonics
    - Possibility to investigate a “true v3”
  - Large “corona” on Au-side
    - Giving rise to more detailed investigation of it's size
    - “v_1-like” azimuthal dependence
  - Completely swallowed Cu-nucleus in central collisions
    - Cu-going corona vanishes



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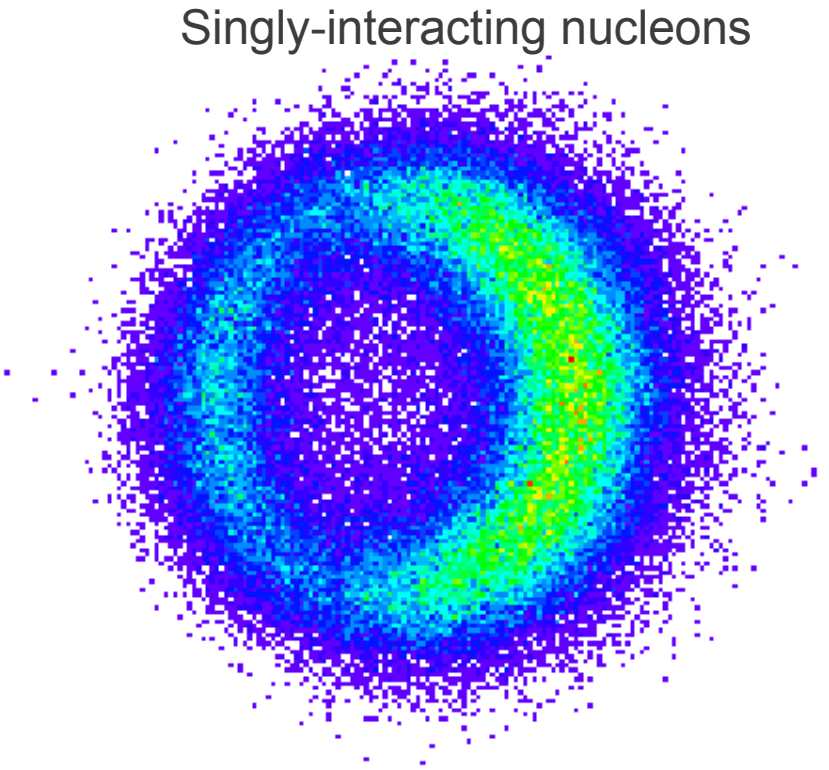

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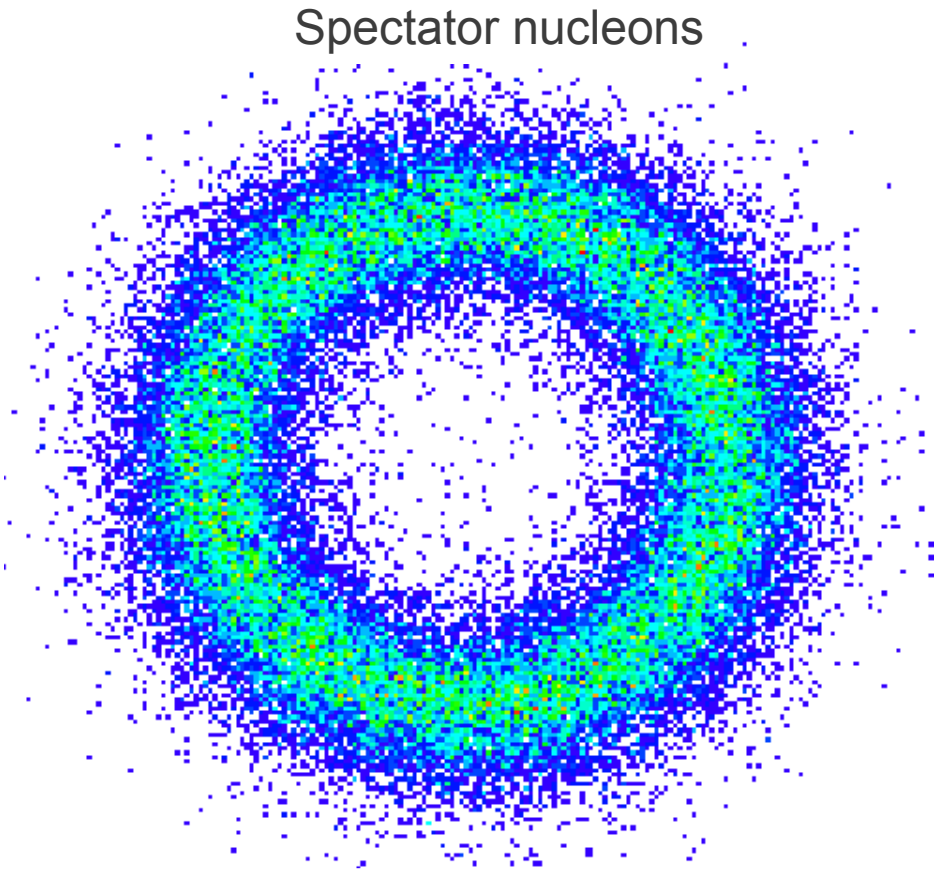
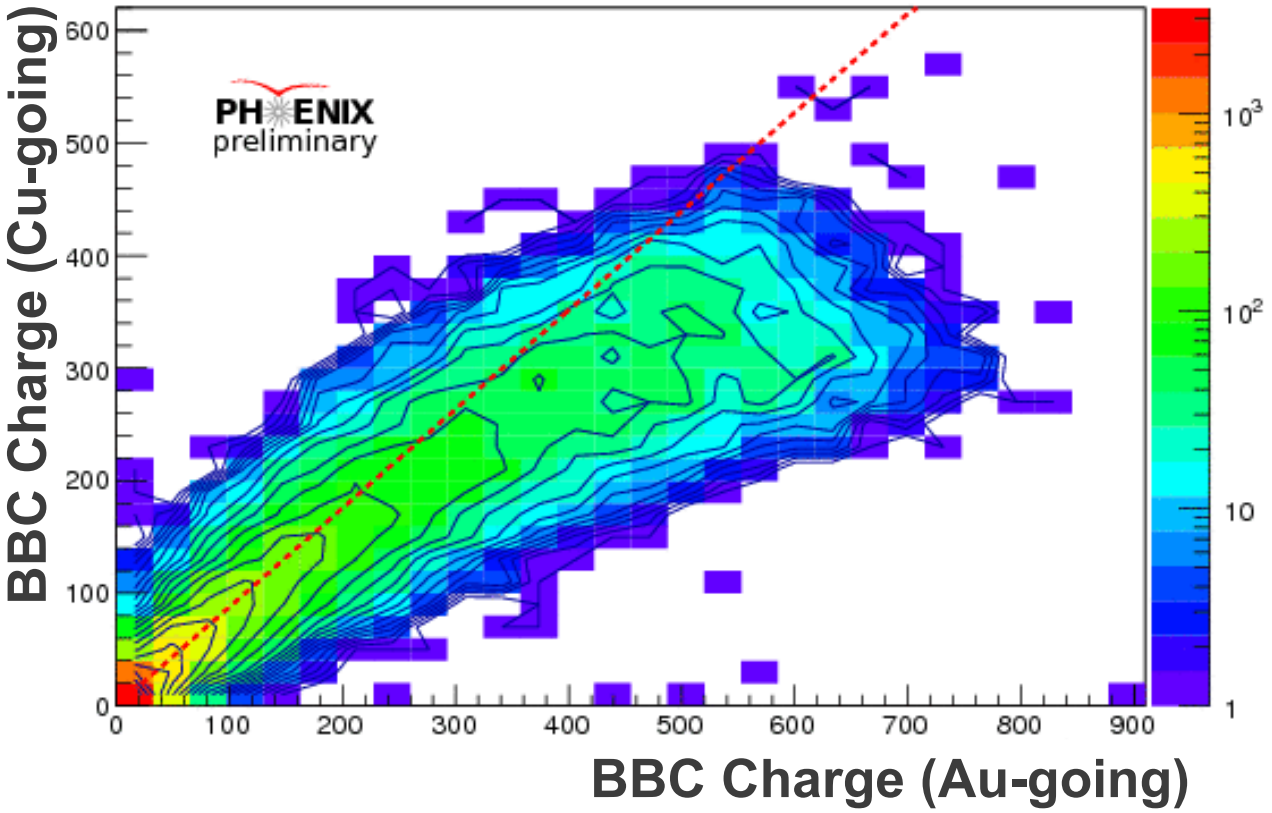
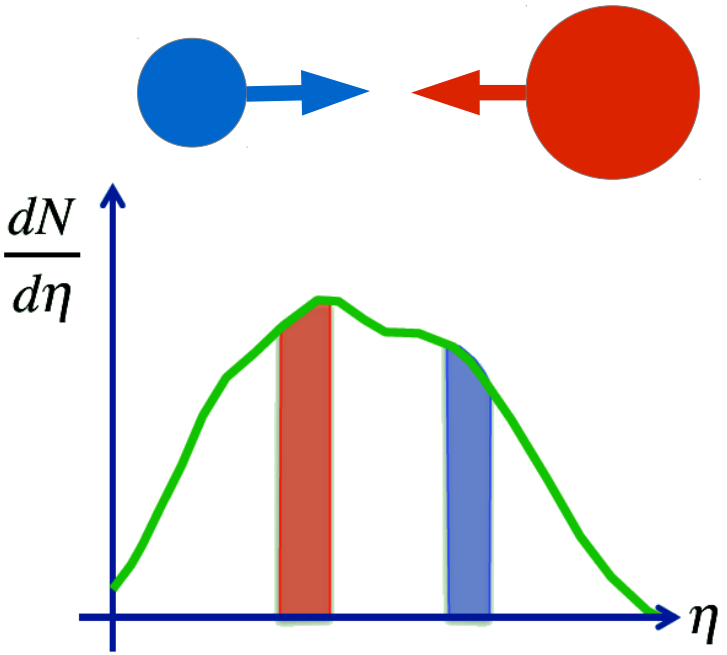


Global observations

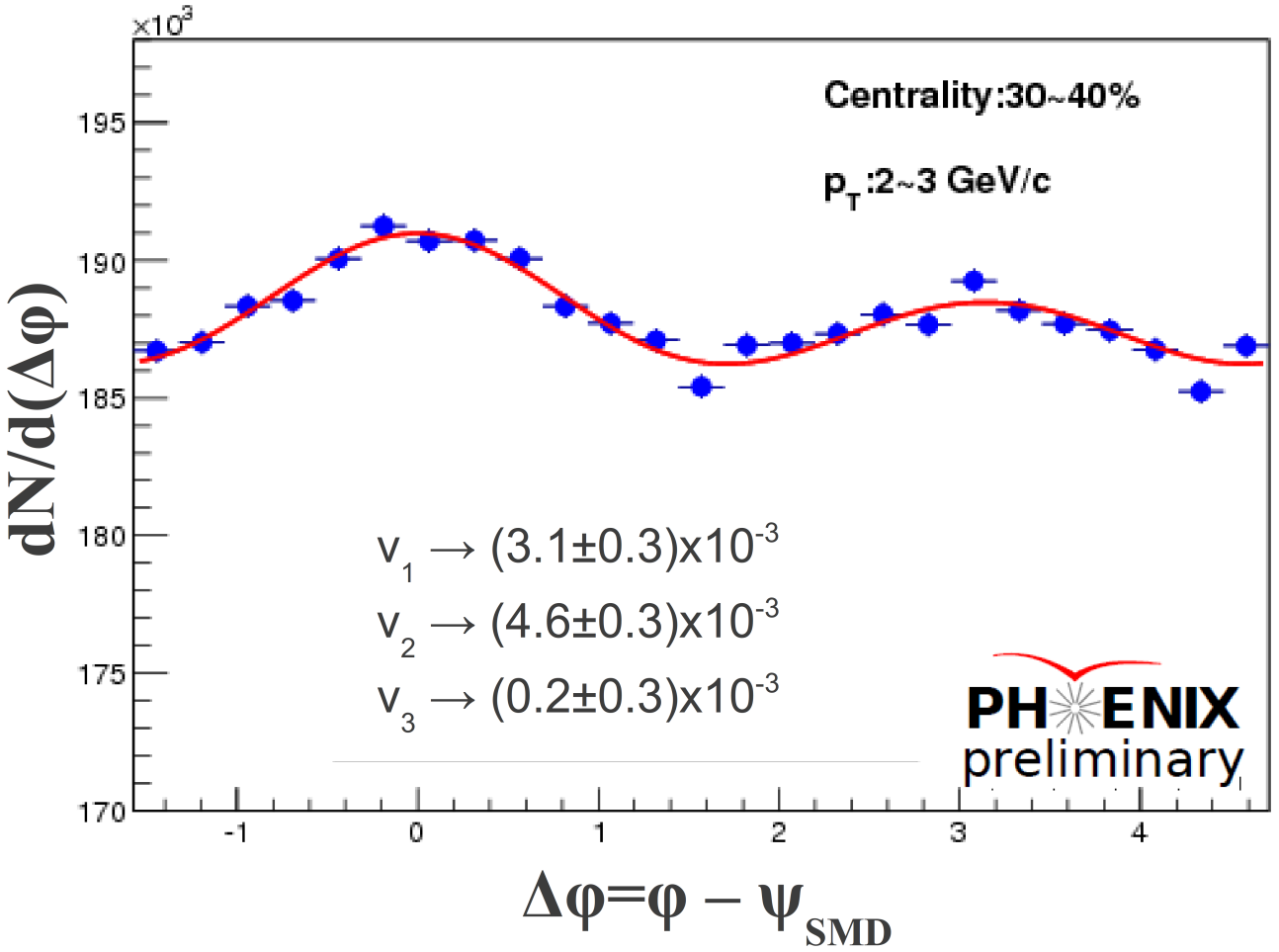
- BBC asymmetry → forward/backward asymmetry in bulk

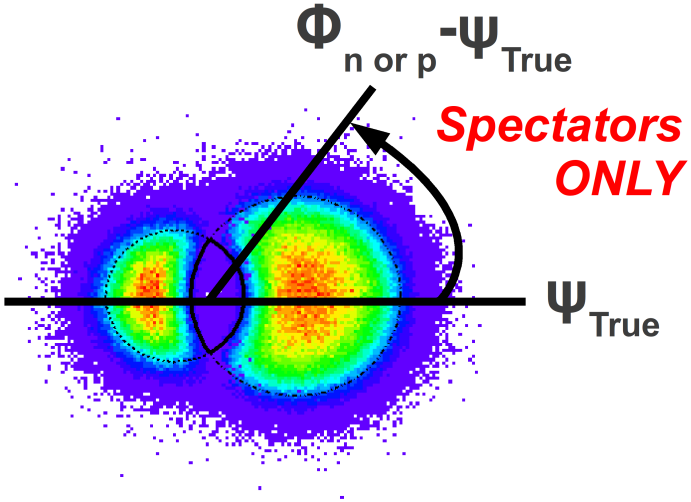




Global observations

- v_1 at mid-rapidity → left/right asymmetry

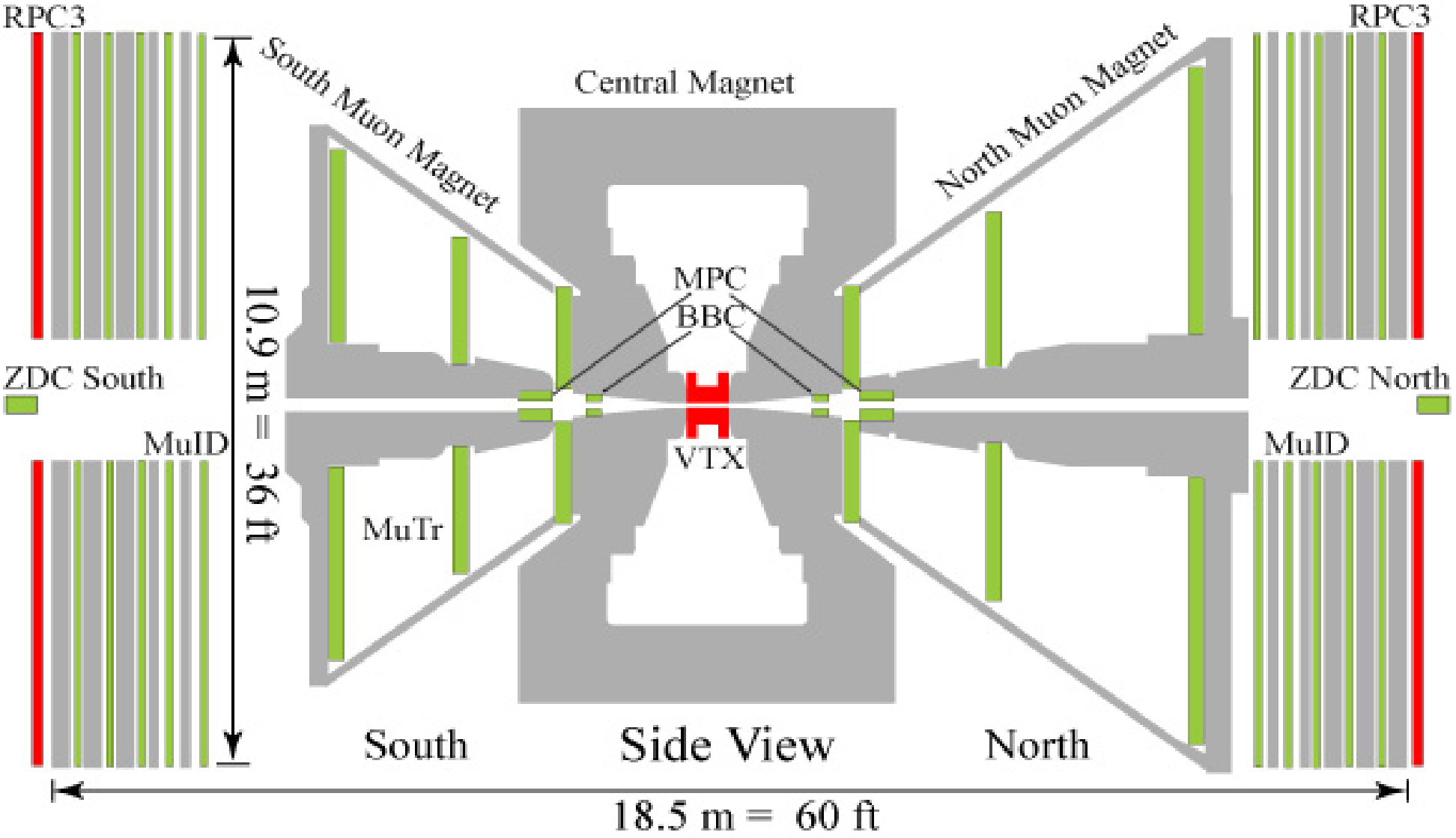




Global observations

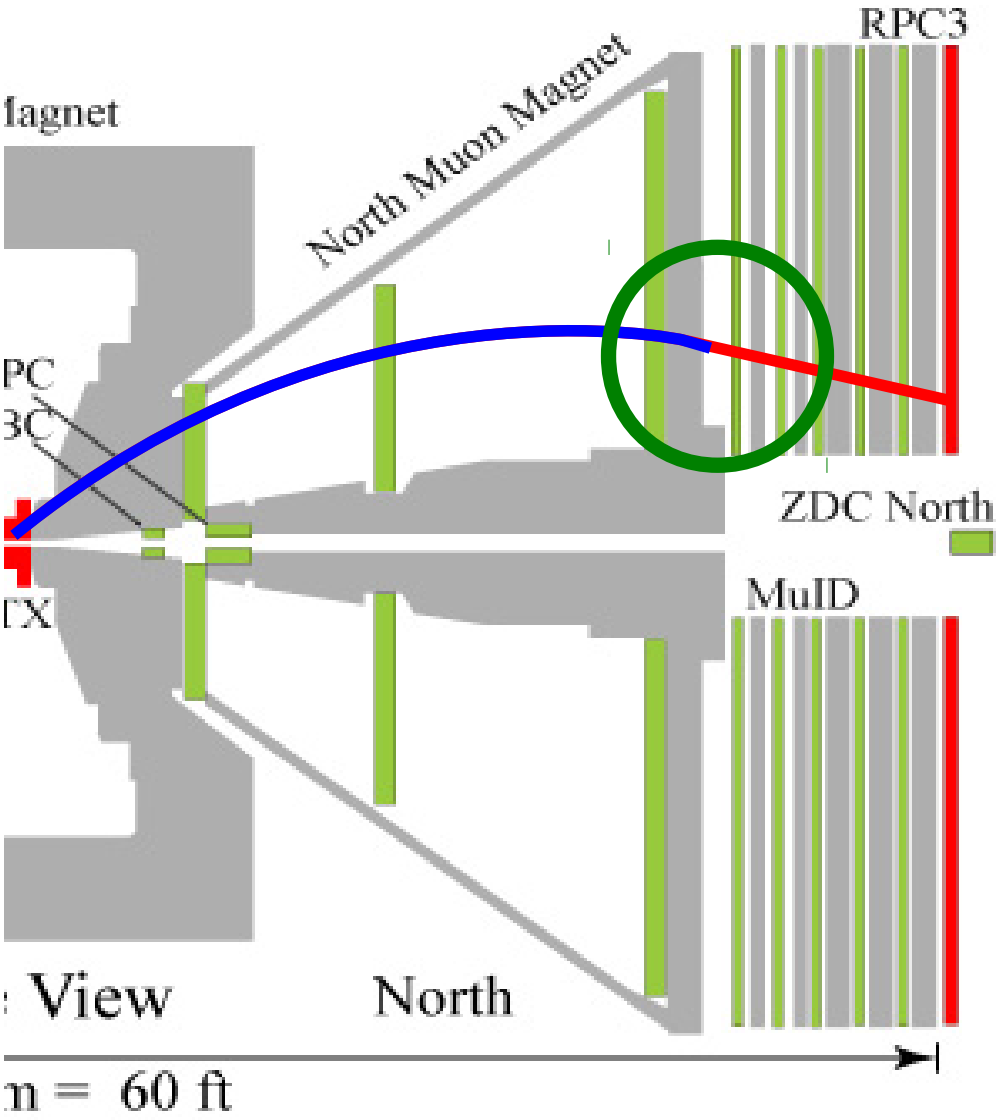
- Geometrical effects are borne out in charged hadrons,
  - What about more hard scatterings?

Measuring J/ψ in PHENIX



Measuring J/ψ in PHENIX

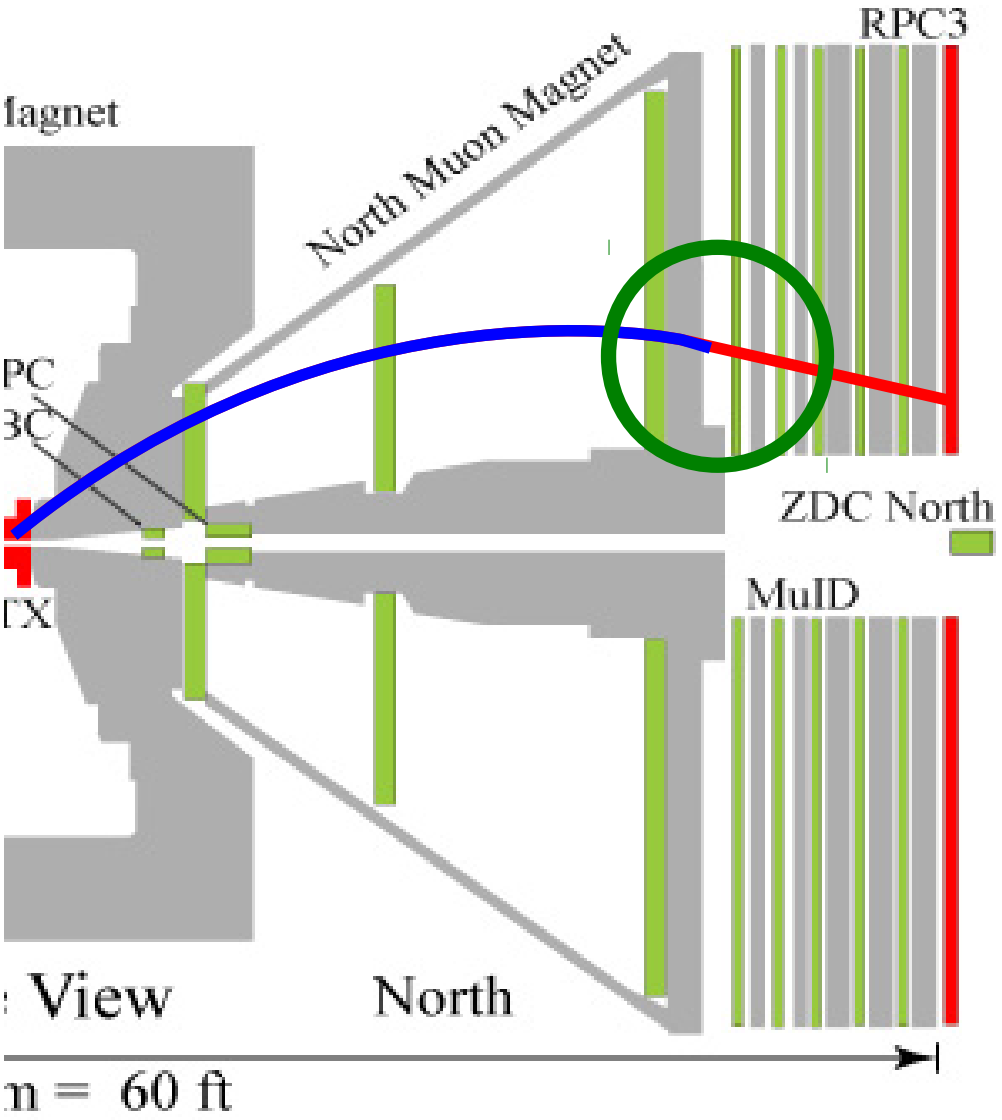
- Three pieces:
  - Tracking
    - In the muon tracker
  - Identification
    - In the MuID (short road through all planes)
  - Match
    - Track pieces to ID
    - Track to vertex



Measuring J/ψ in PHENIX

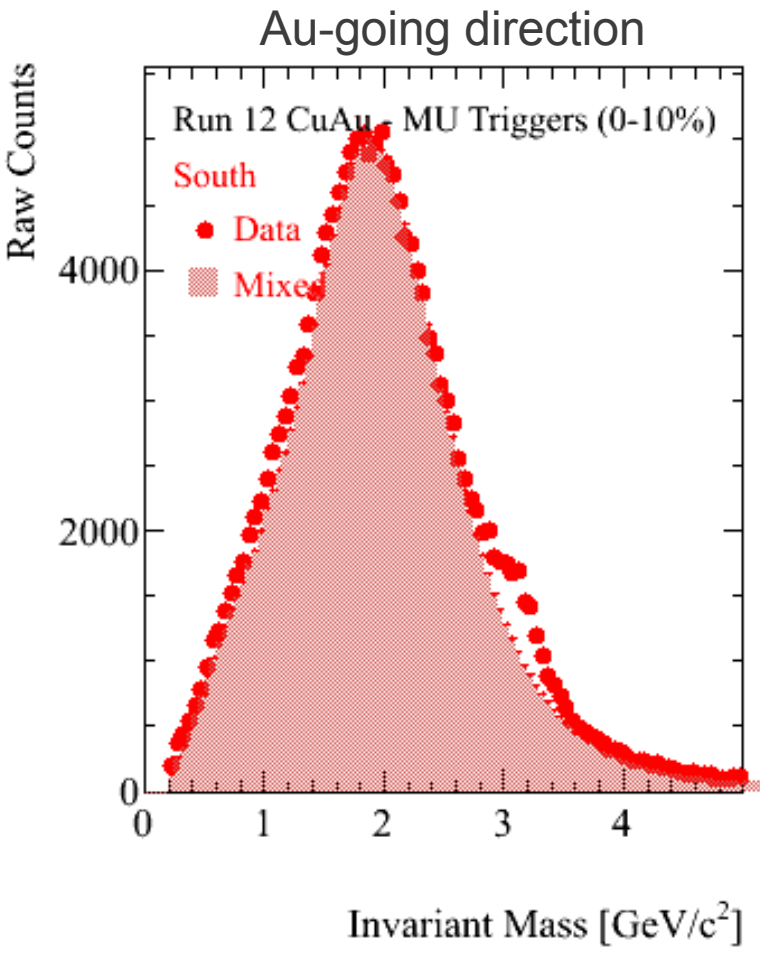
- Tracks: small χ^2 and extrapolate back to vertex
- Identification: must transcend full MuID steel
- Matching requires spatial position and track/road slopes to be similar

- Non-matching tracks are characteristic of hadronic background with larger multiple scattering (or in-flight decay)



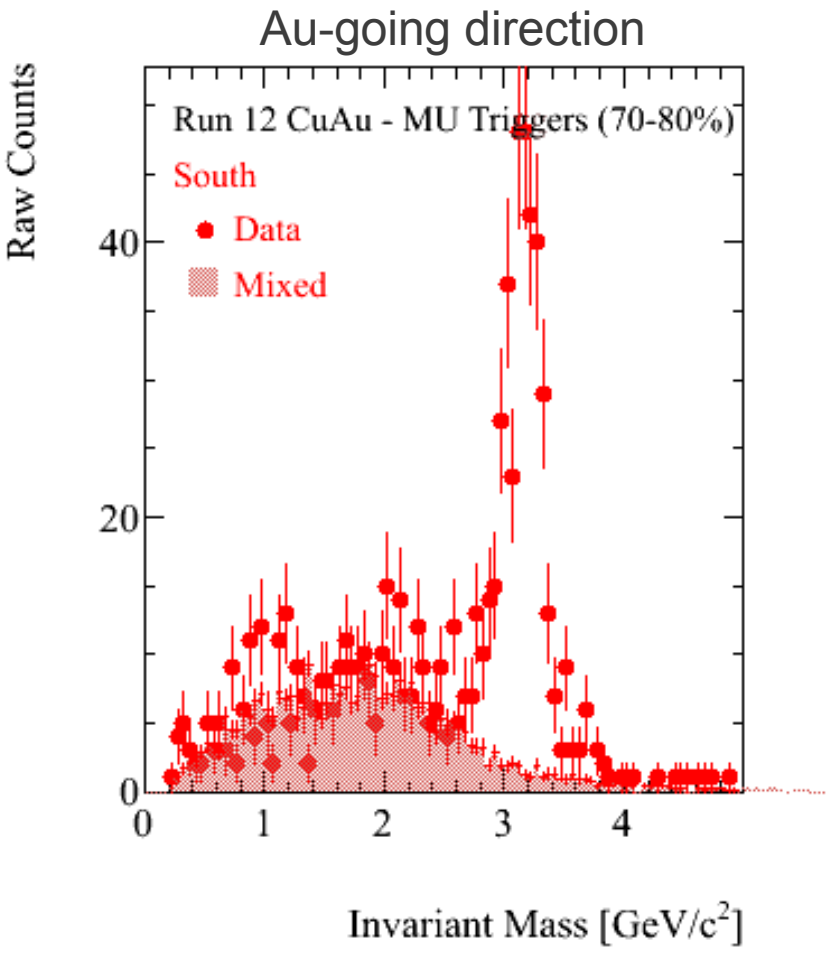
Combinatorics

- Combinatorics form a large background
  - Background estimated from mixed event subtraction
- Central data:
  - Peak visible, but atop a large background



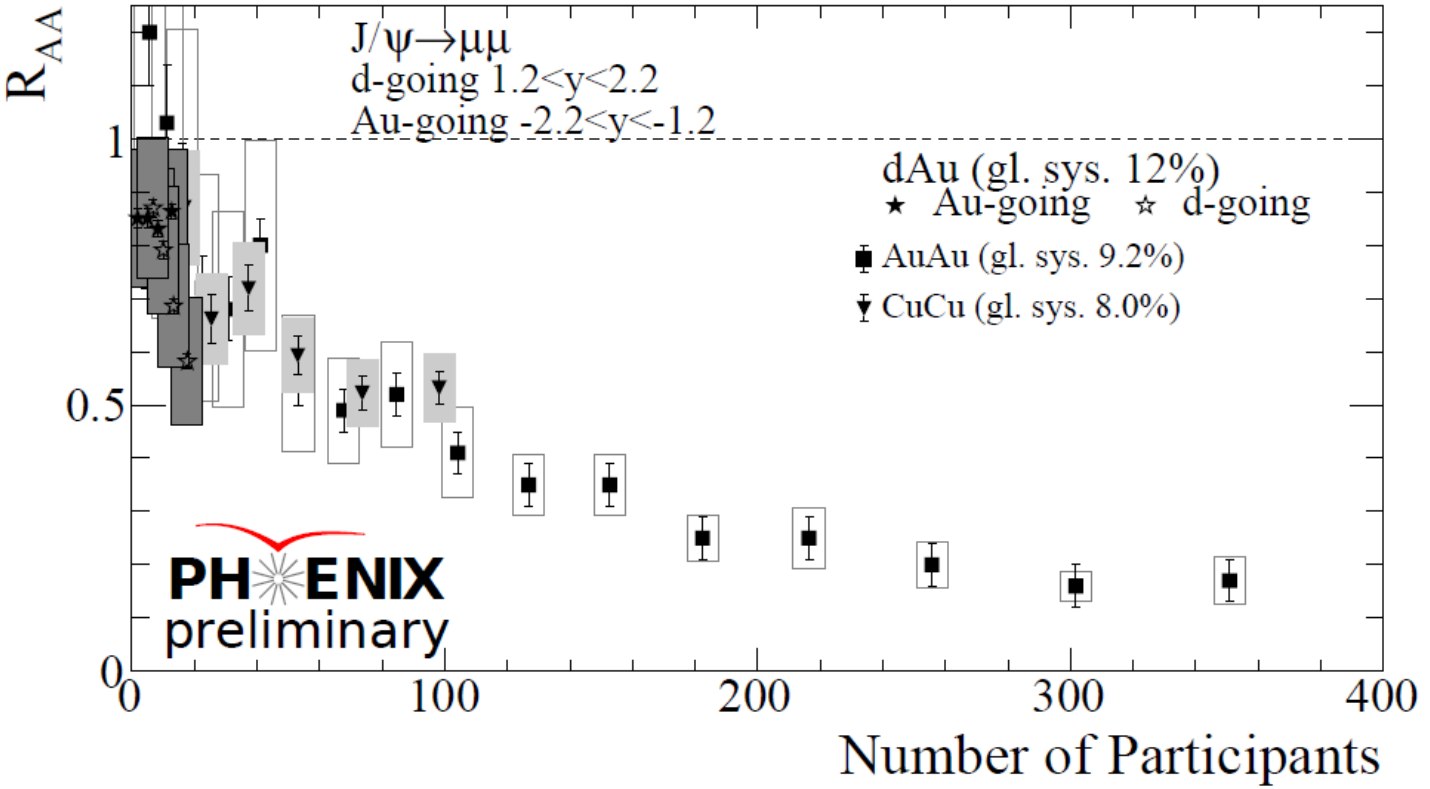
Combinatorics

- Combinatorics form a large background
  - Background estimated from mixed event subtraction
- Central data:
  - Peak visible, but atop a large background
- Peripheral data:
  - Clear peak, little background



Nuclear Modification Factor

- Comparison between particle yields in AA to pp (scaled by the expected number of collisions)
- CuCu and AuAu
  - CNM and final-state effects
  - Suppression observed
  - Independent of collision system



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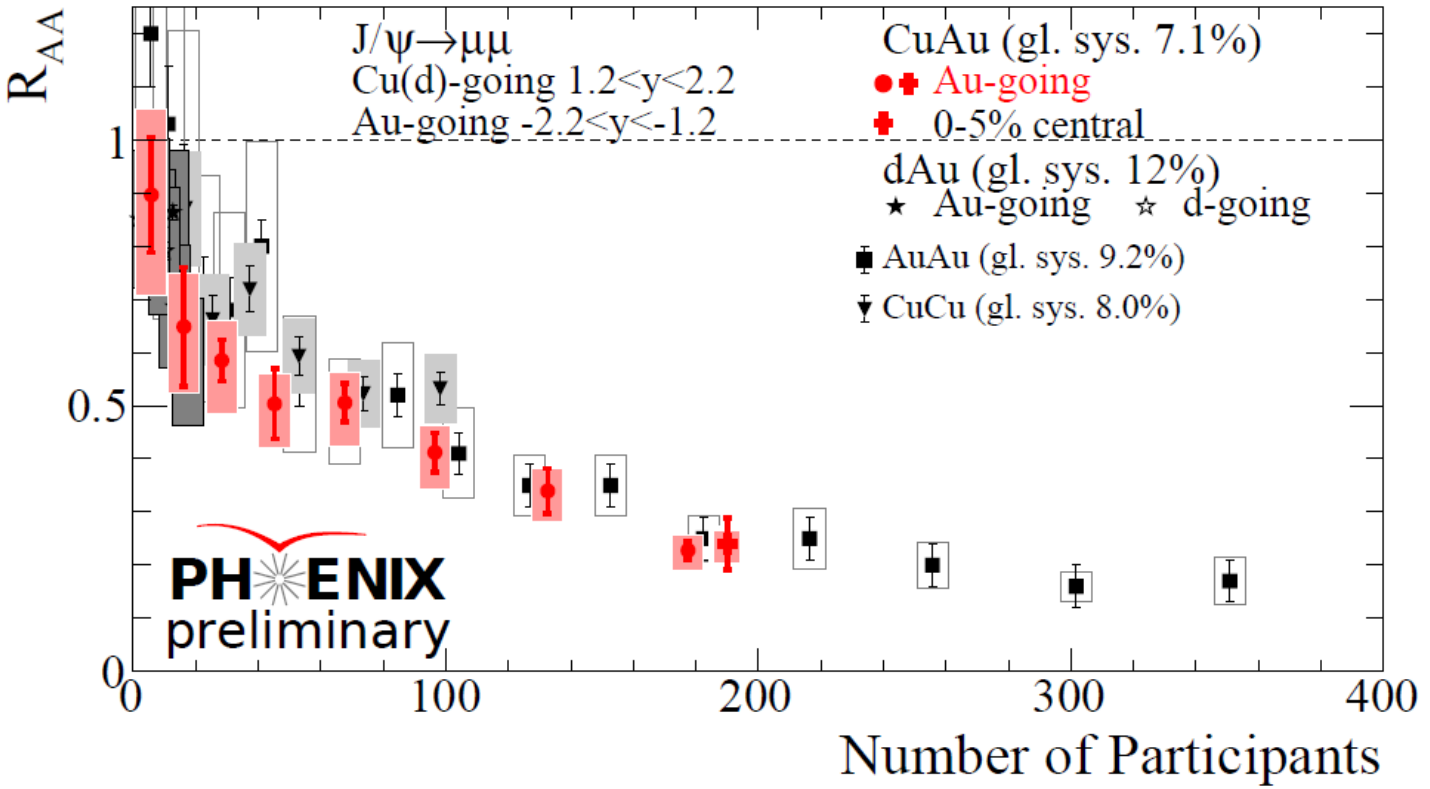

- CuAu collisions
  - Same suppression as AuAu/CuCu measured in the Au-going direction

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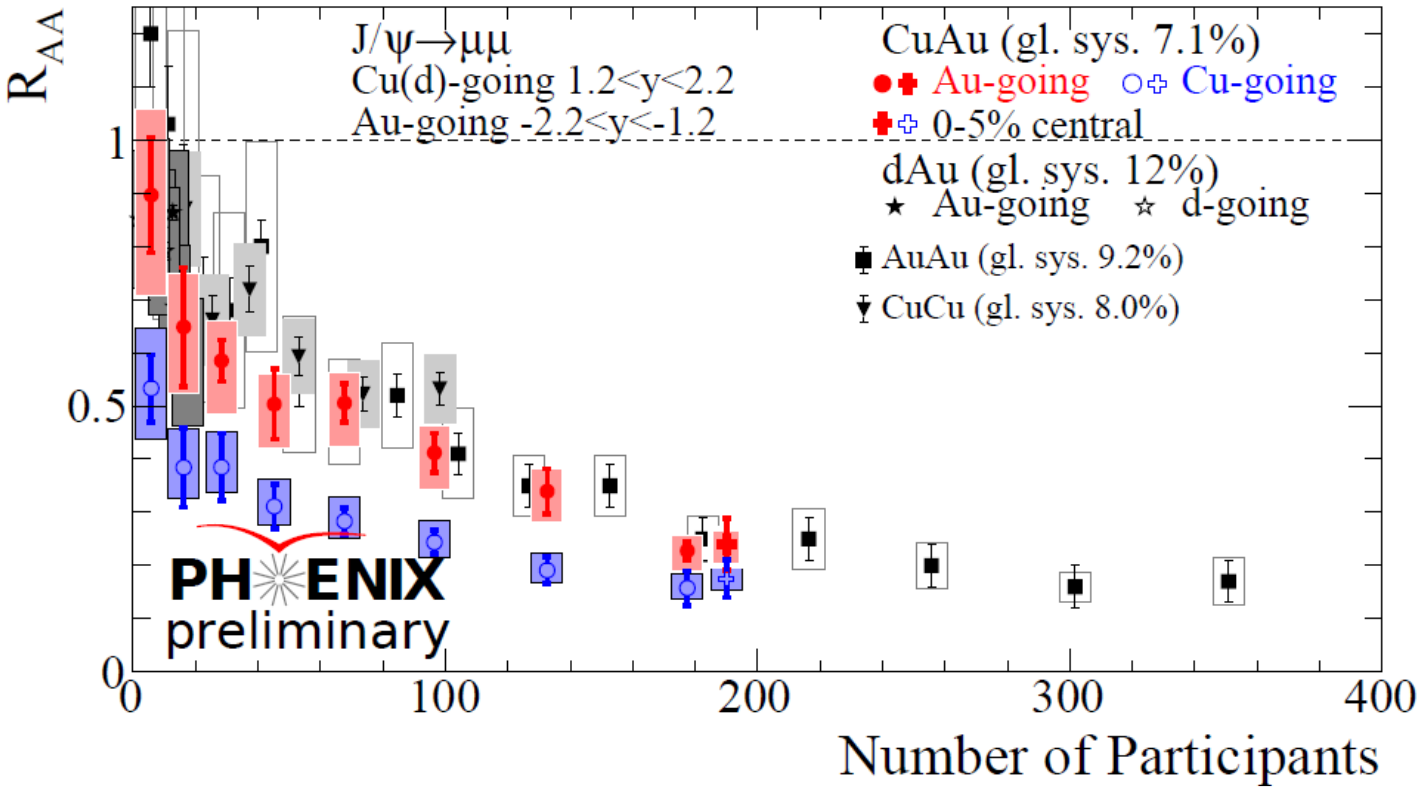
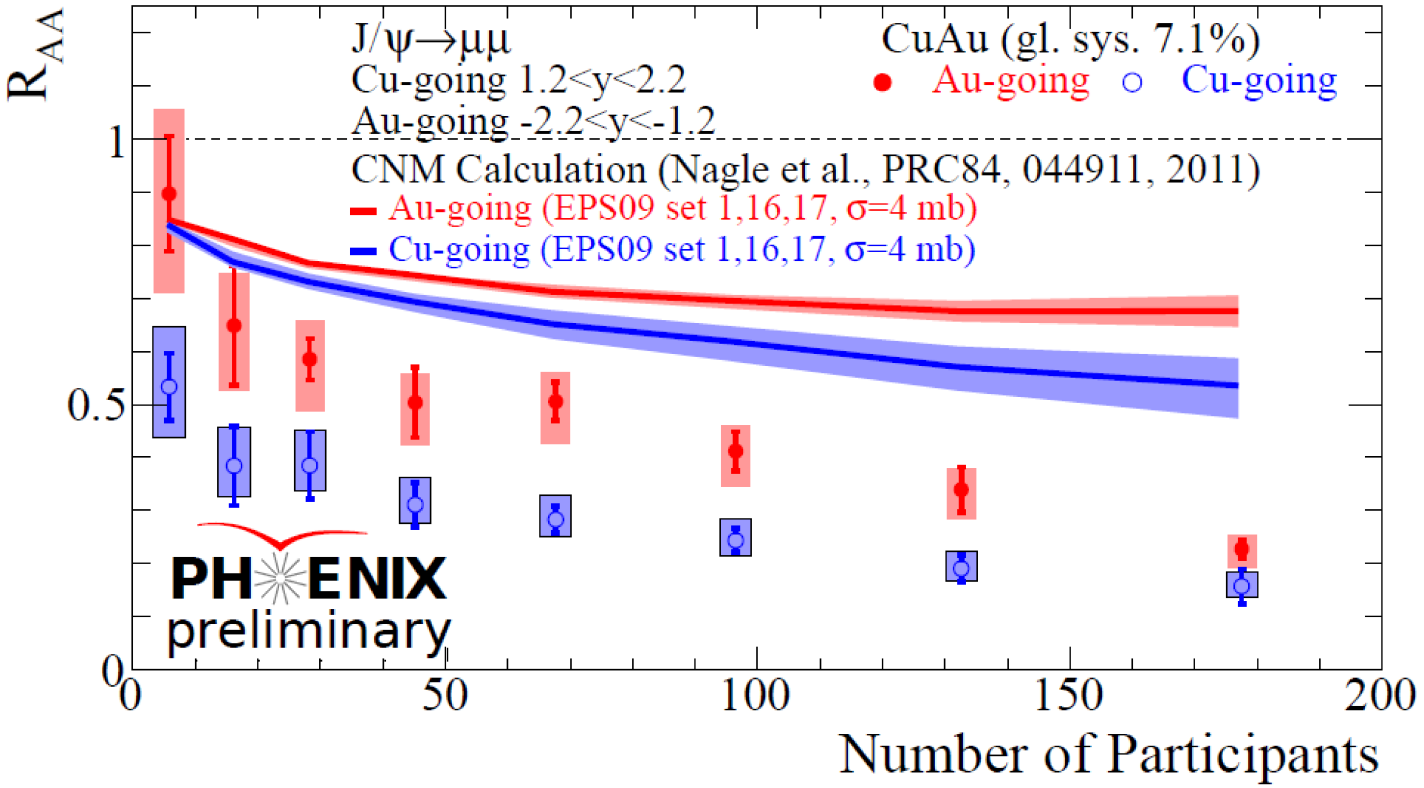


- CuAu collisions
  - Same suppression as AuAu/CuCu measured in the Au-going direction
  - More suppressed in the Cu-going direction
  - J/ψ not significantly more suppressed in completely swallowed-Cu (top 5%) events

Nuclear Modification Factor

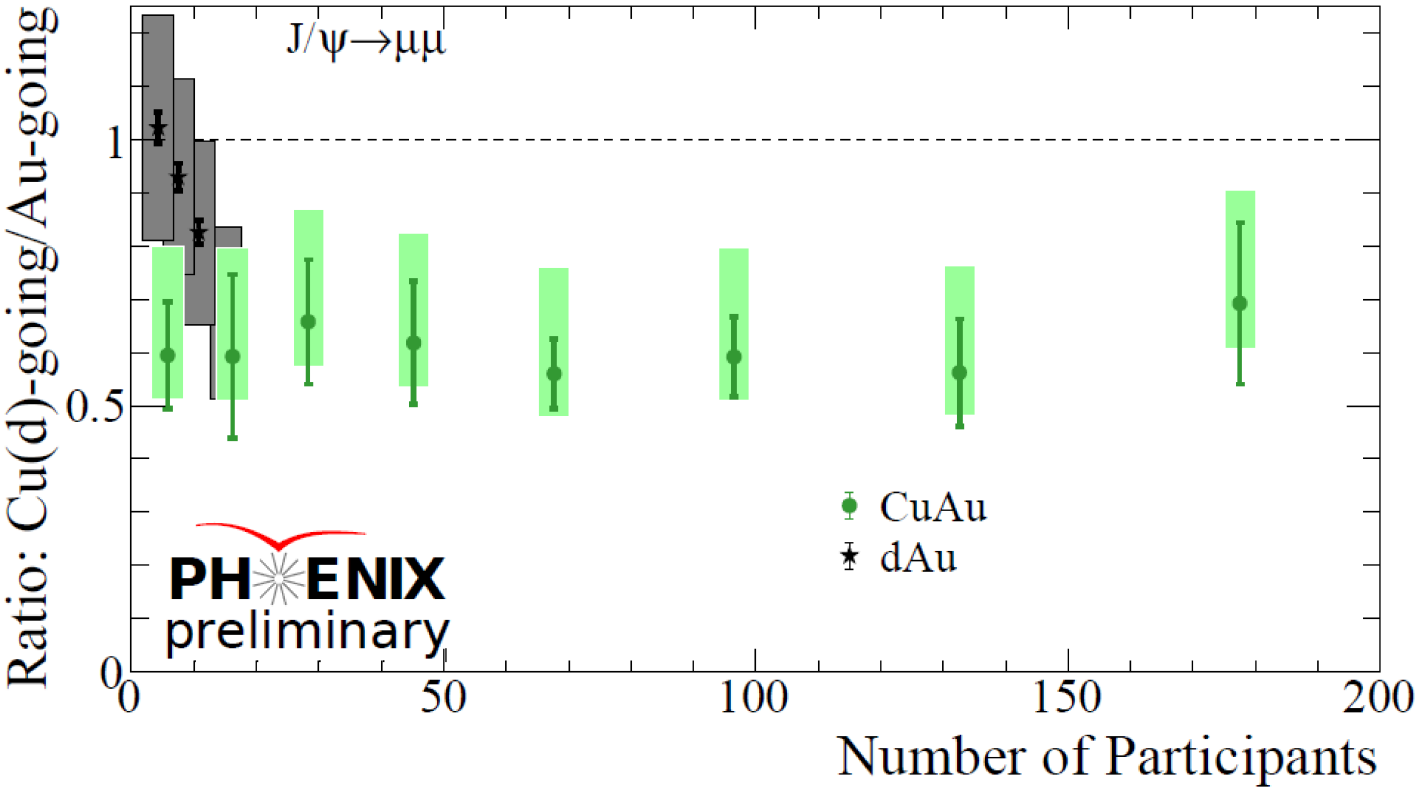
- One example of CNM effects
  - Can partially explain forward / backward difference
  - Final state effects must account for additional suppression
- Similar CNM observations in AuAu collisions



- Model:
  - 4mb break-up cross-section
    - Best describes dAu data
  - Center line → best EPS09 fit
    - Band limits → outer limit of EPS09 nPDFs
  - Linear thickness dependence on shadowing
    - No centrality dependence

Relative Suppression

- Ratios of yields at fixed centrality
- Relative suppression observed forward/backward
- Centrality-independent



Presents a challenge to theories trying to describe the data

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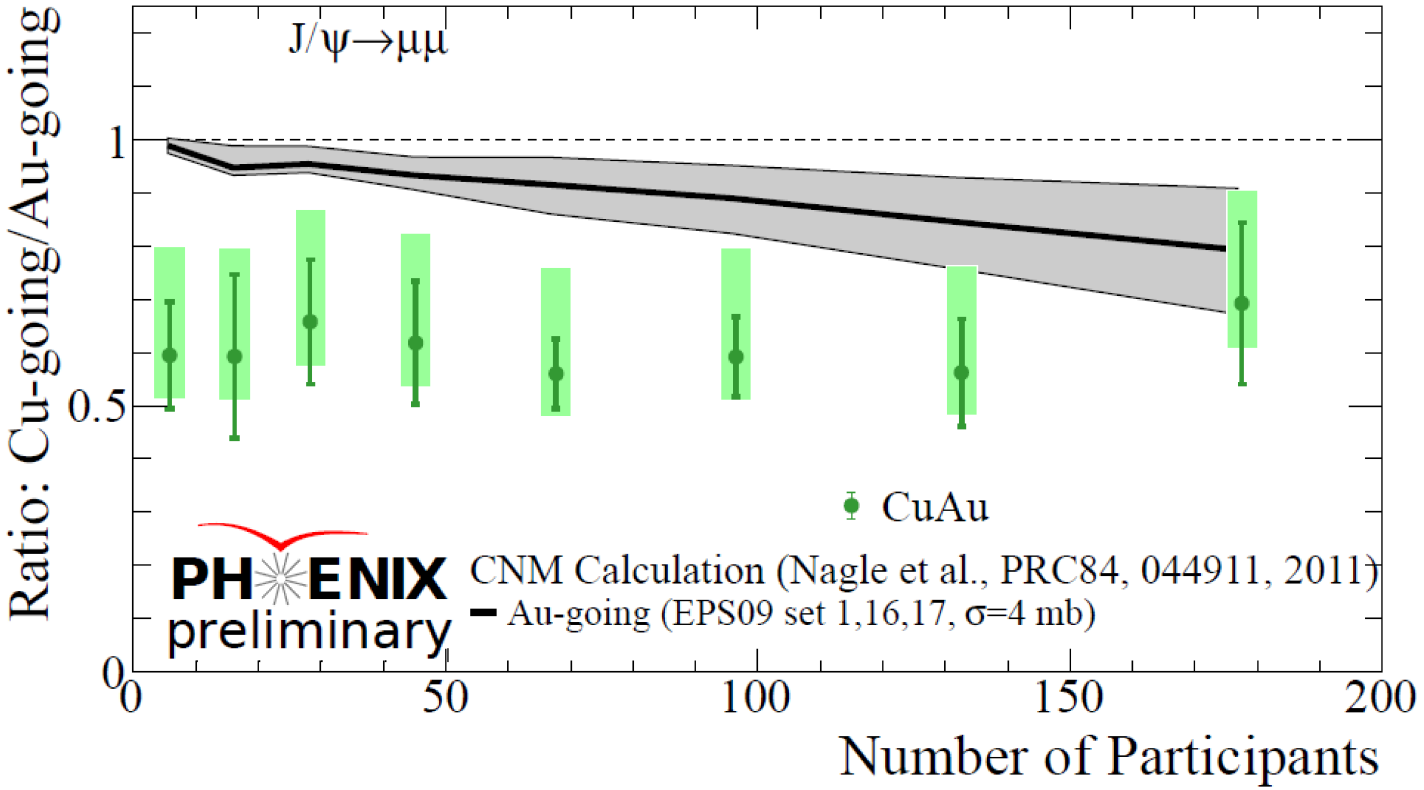
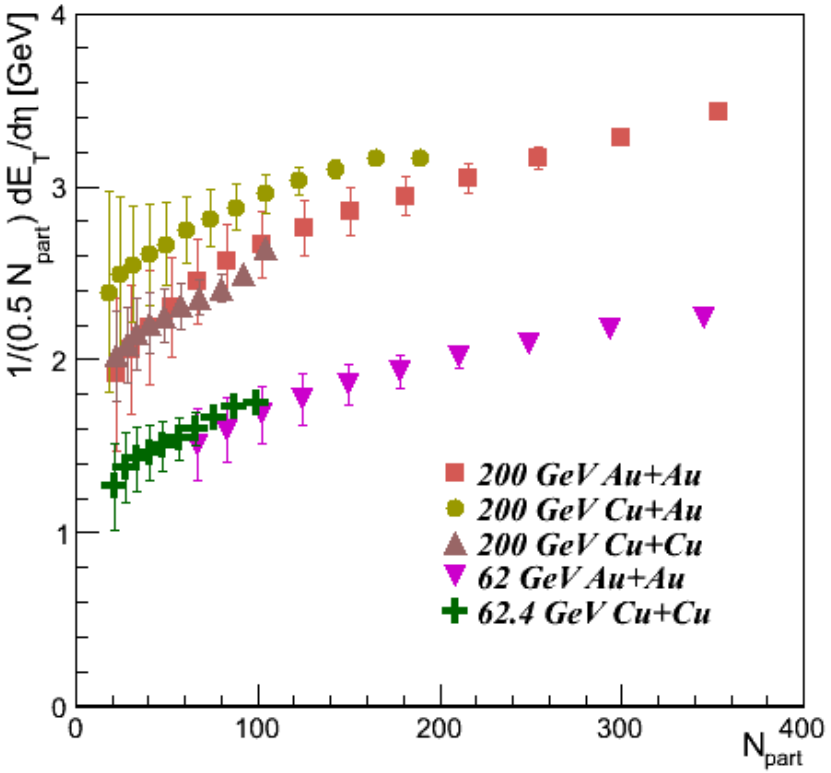


Presents a challenge to theories trying to describe the data

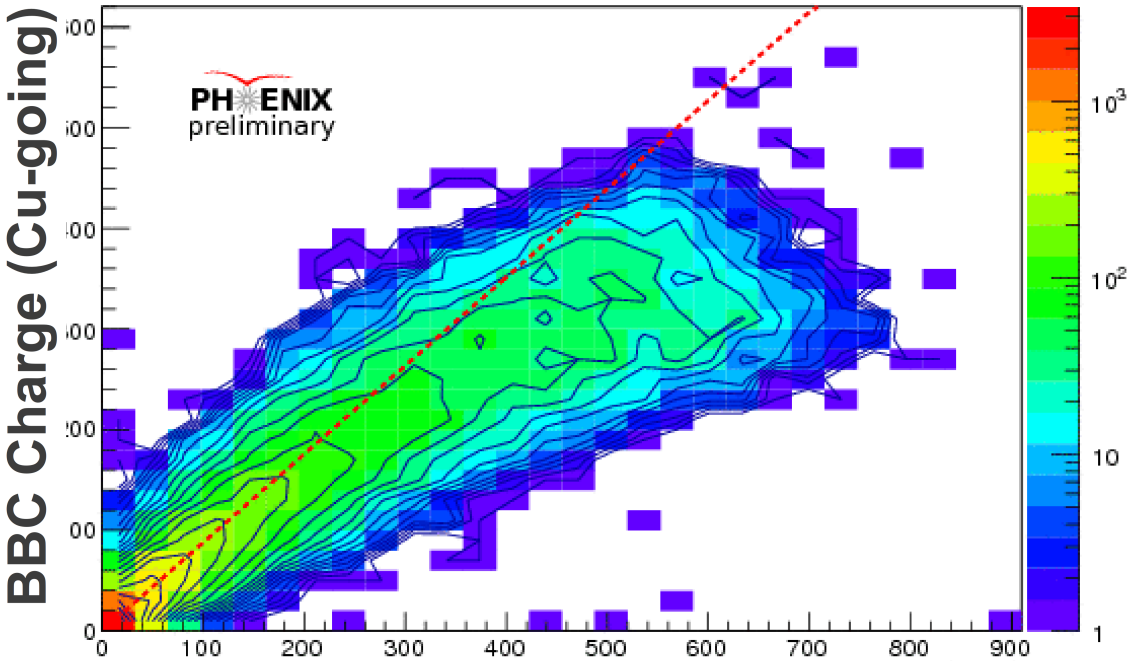
Energy Density

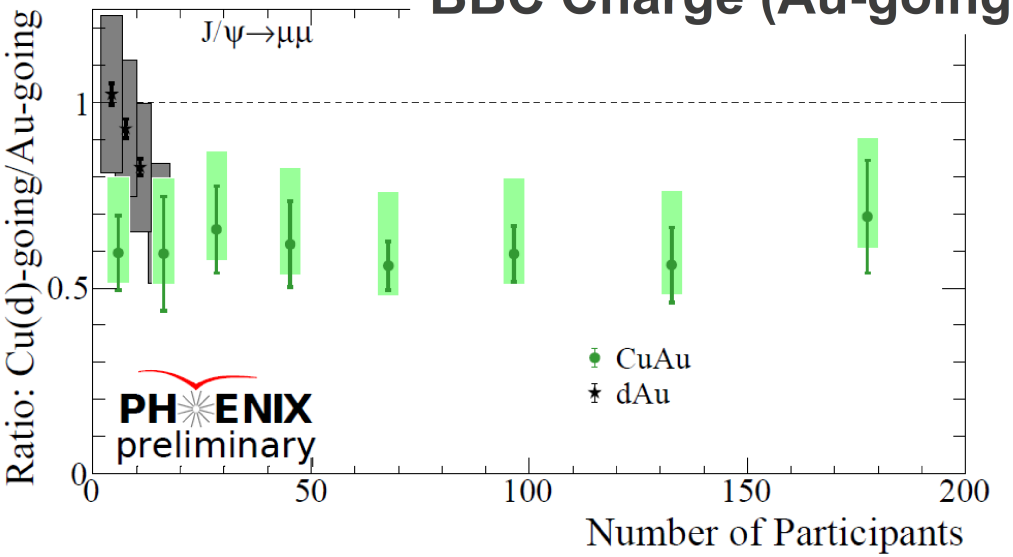
- Reminder
  - CuAu energy density higher than symmetric systems
  - Effect on J/ψ suppression?



Bulk Asymmetry

- Reminder:
  - Bulk forward/backward asymmetry
  - Affects J/ψ suppression?
- More studies are needed
  - Have a large J/ψ dataset from CuAu collisions
  - Reaction plane dependence
  - p_T dependence





Conclusion and Outlook

First measurements of J/ψ CuAu collisions at RHIC

- Similar suppression of Au-going J/ψ's
- Stronger suppression observed in forward (Cu-going) direction for J/ψ
- Further studies to test for reaction plane dependent production underway