Update* on J/ψ cold nuclear matter R_{AA} estimates from fits to dAu R_{CP} data

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CATHIE – INT workshop
June 17, 2009

*Update of results presented in "Looking for the cold nuclear matter baseline for J/ψ production at RHIC" at the quarkonium workshop at ECT, Trento, May 2009.

Estimating the cold nuclear matter R_{AA} from fits to d+Au data

This is an extension of work (reported at the quarkonium workshop in Trento) to estimate the R_{AA} for heavy ions that would be expected from cold nuclear matter effects **alone**, using measured d+Au J/ψ data.

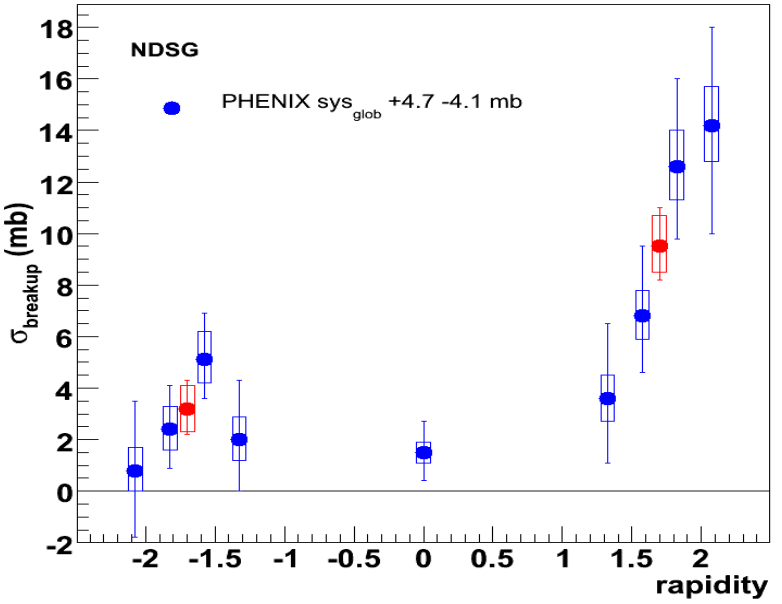
I will not describe the calculation details here, please see my Trento slides for those. **Briefly**, the R_{AuAu}(CNM) calculations there were made by:

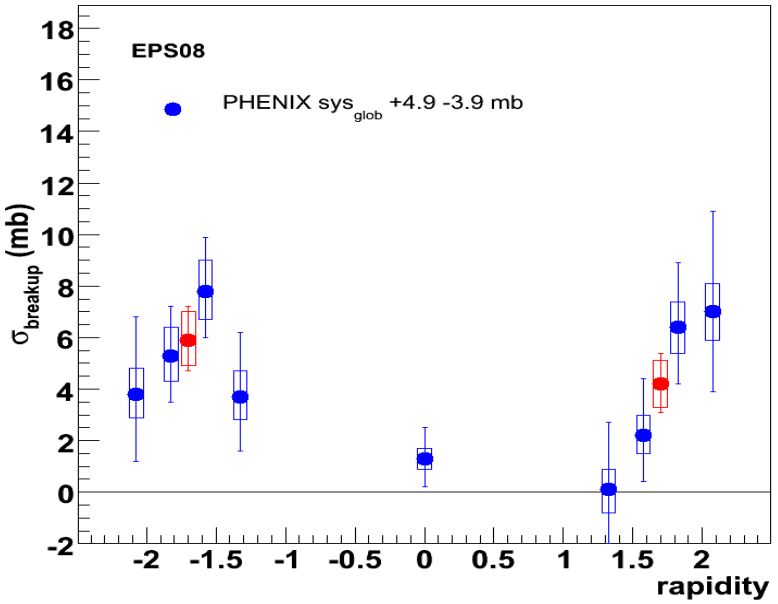
- Fitting PHENIX d+Au R_{CP} data with R_{dAu} vs impact parameter calculations by **Ramona Vogt** ($\sigma_{breakup}$ + a shadowing model – EKS98, nDSG, or EPS08).
- Parameterizing the d+Au R_{CP} data **independently at y= -1.7, 0, +1.7**.
- Using the parameterizations in a Glauber calculation for Au+Au to calculate **for each nucleon-nucleon collision** the R_{dAu} for each colliding nucleon in its target nucleus.
- Accumulating R_{AuAu} (CNM) vs centrality for 250,000 Glauber AuAu events.
- Dividing the measured R_{AA} by R_{AA}(CNM) to get **"survival probability"**.

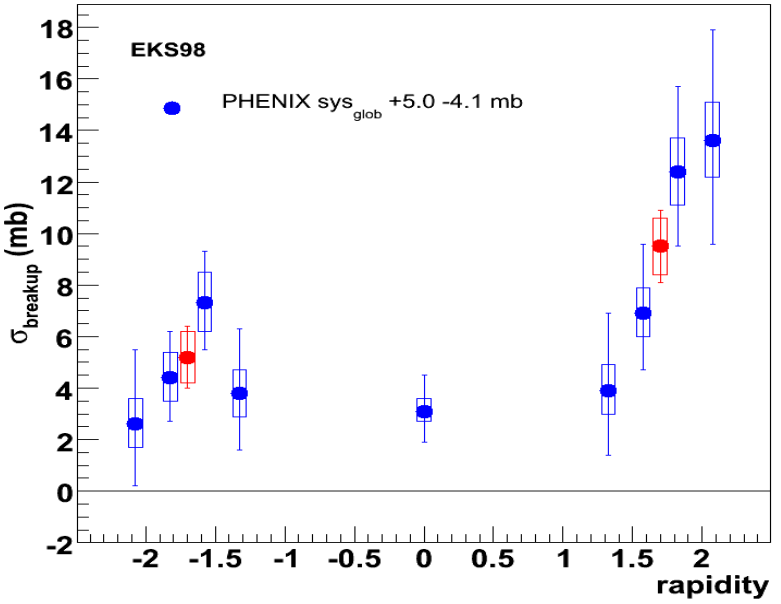
The effective absorption cross sections from fits of Ramona's calculations to PHENIX d+Au R_{CP} data are shown for each shadowing model.

This is **not** an attempt to extract physics from the d+Au R_{CP}! This is just a parameterization of the data that is independent at each rapidity.

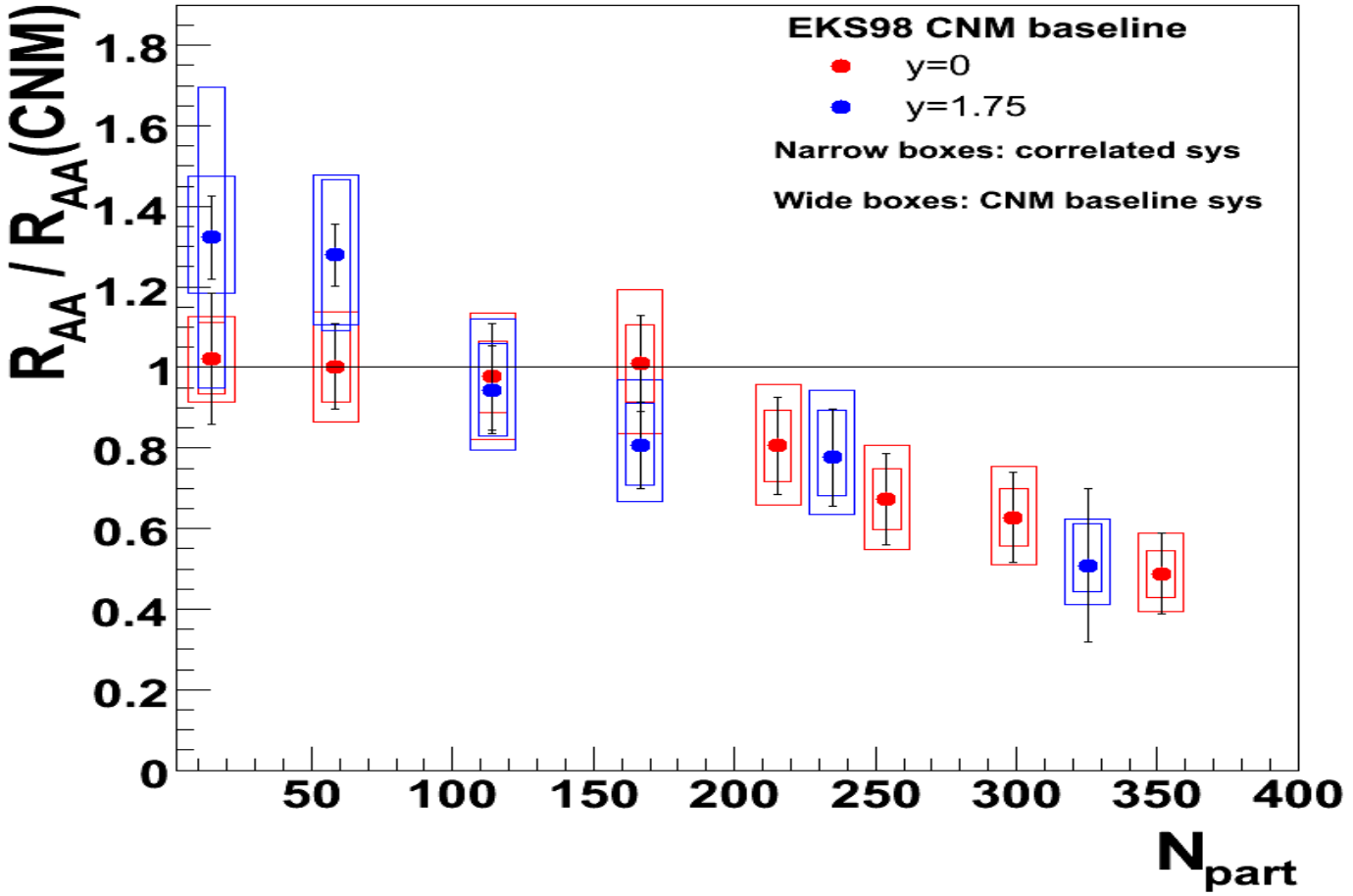
The red points are the averages at y = -1.7 and +1.7.







The resulting "survival probability" for PHENIX data on J/ψ production in Au+Au collisions shown at the ECT in May was:

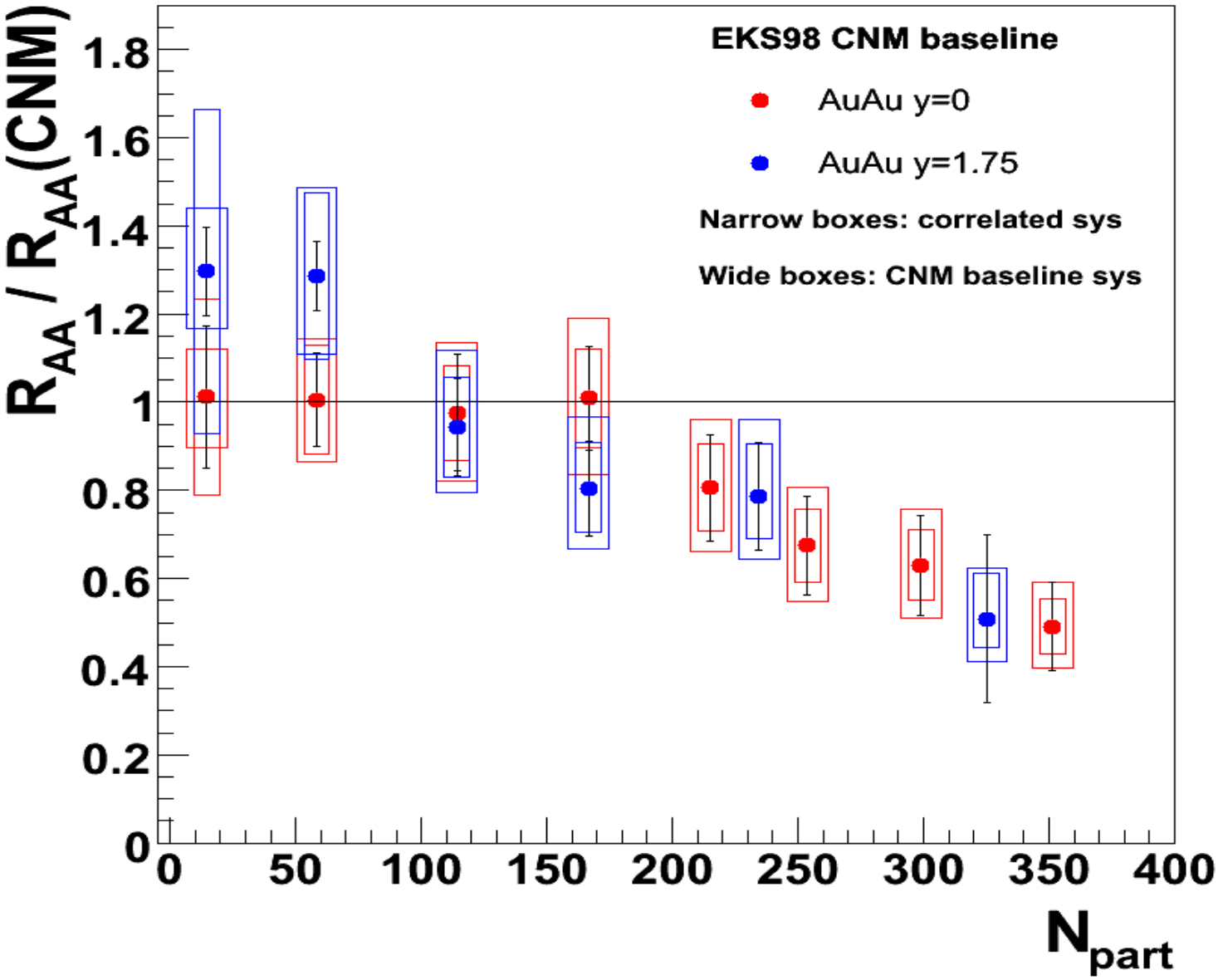


This is a brief **update** describing minor improvements to the estimates of R_{AA}(CNM) for Au+Au, and the addition of **new estimates for Cu+Cu**.

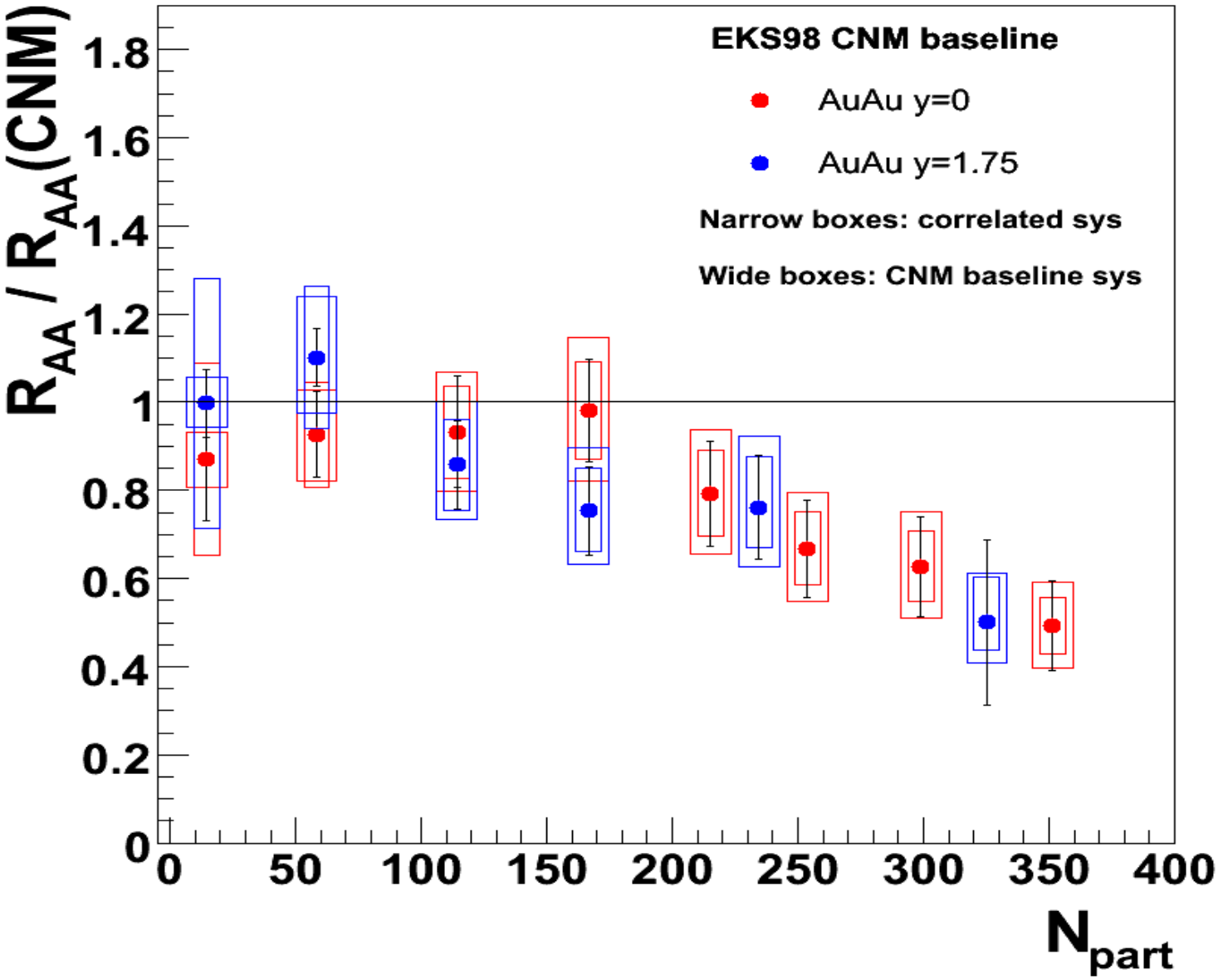
Changes since May

- The R_{AuAu}(CNM) calculation presented in May was made using theoretical **R_{dAu}** values vs impact parameter, instead of R_{pAu}, in the Glauber model.
- I have now replaced the R_{dAu} theory curves used to calculate R_{AA}(CNM) with new **R_{pAu}** calculations from Ramona. It turns out that the difference is **significant for the most peripheral** bins (only).
- I have added a calculation of R_{CuCu}(CNM) made using **R_{pCu}** calculations by Ramona.

Effect of using R_{pAu} instead of R_{dAu} in Glauber calculation



Effect of using R_{pAu} instead of R_{dAu} in Glauber calculation



R_{CuCu}(CNM) estimates

The Cu+Cu calculations use the **same** breakup cross sections as those for Au+Au, namely the independent **best fit** cross sections at each rapidity from the d+Au R_{CP} data with EKS98, nDSg and EPS08 shadowing calculations of R_{dAu} by Ramona (see slide 4).

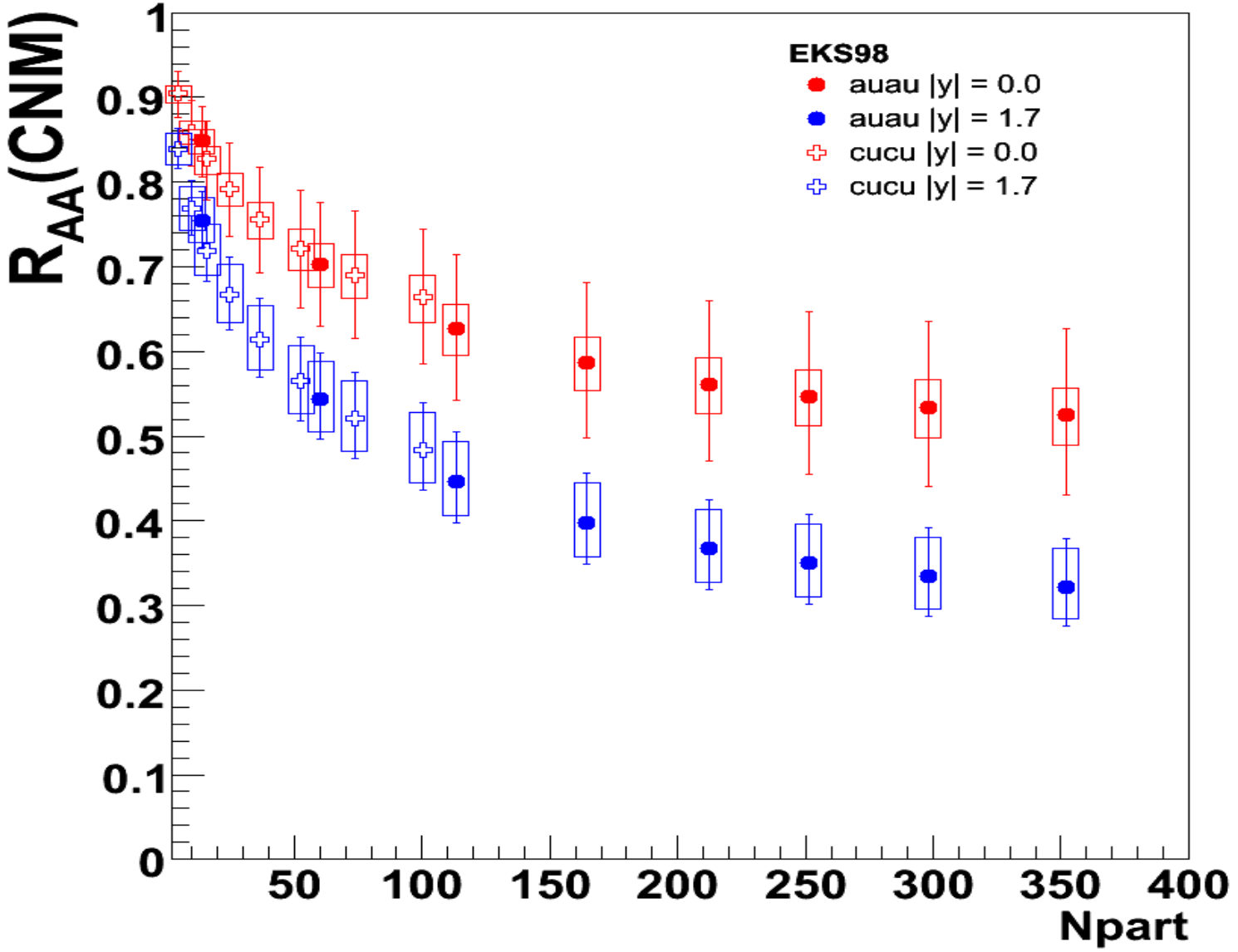
The R_{CuCu}(CNM) calculations are identical to those for Au+Au with two exceptions:

- The Glauber calculation is for CuCu collisions.
- The shadowing model (EKS98, nDSg, EPS08) for CuCu is used .

We will start by looking at the **R_{AA}(CNM) values** obtained for the three shadowing models for AuAu and CuCu.

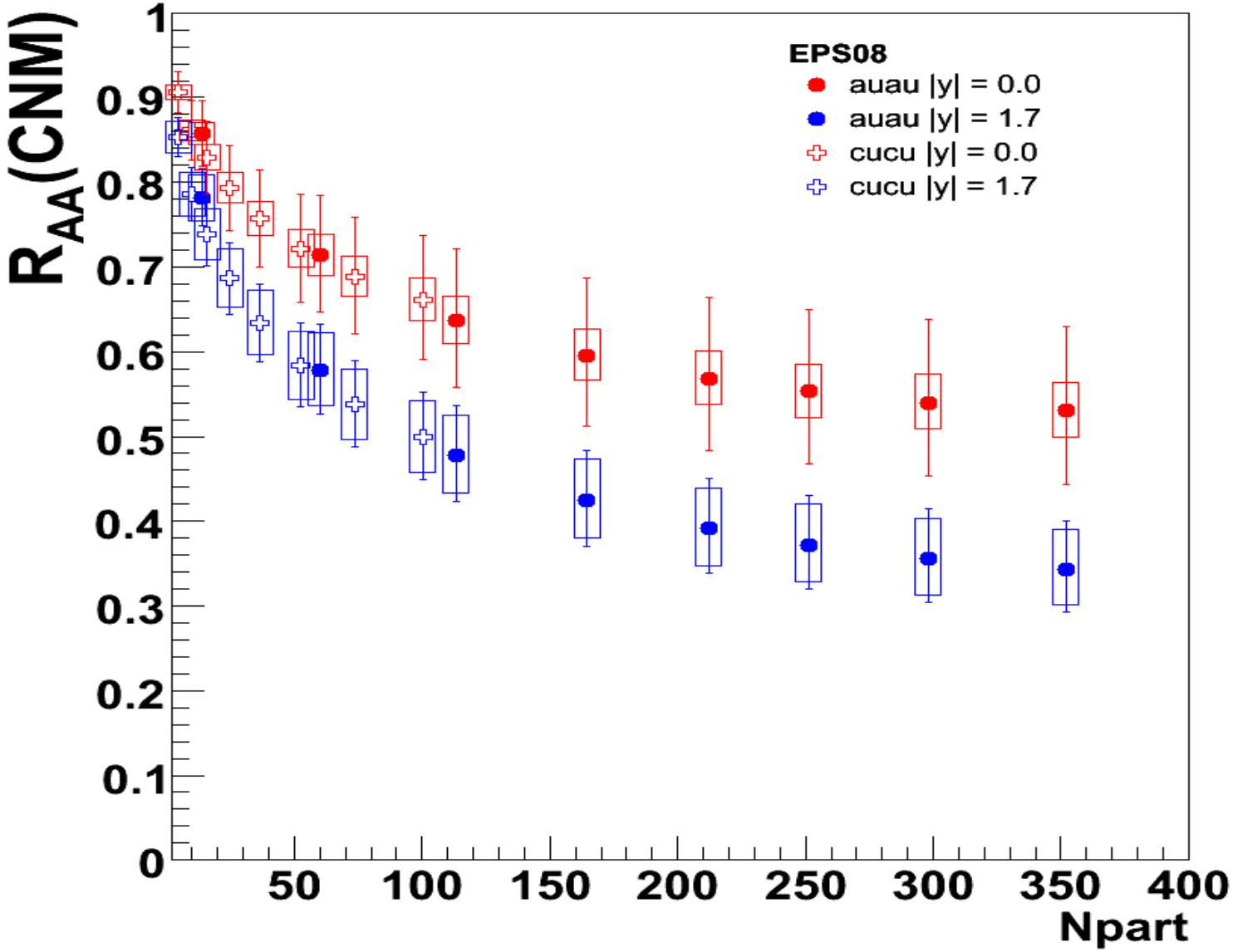
R_{AA}(CNM) for Au+Au and Cu+Cu made with the **EKS98** shadowing model and the d+Au best fit breakup cross sections.

Nice agreement of the Npart dependence!



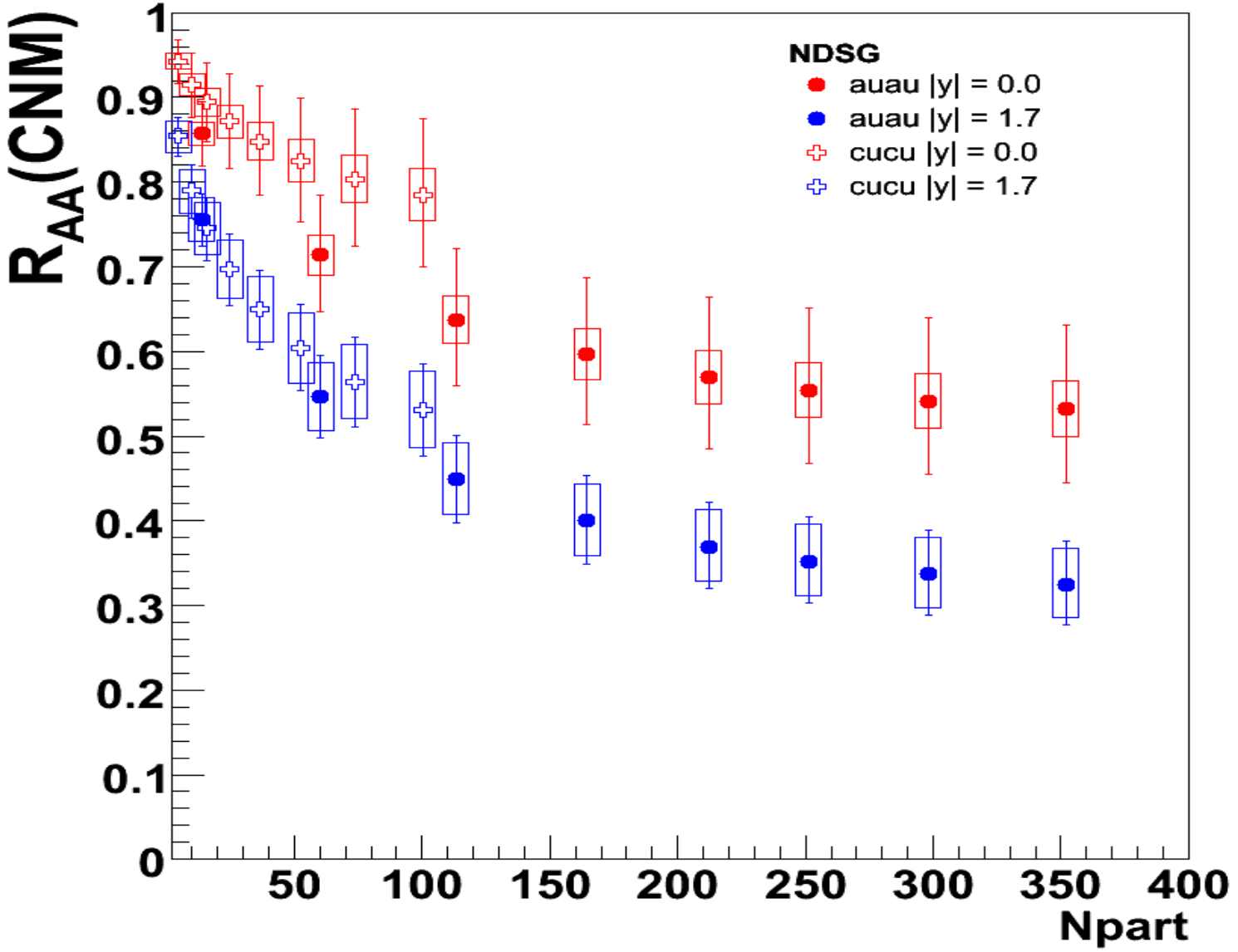
R_{AA}(CNM) for Au+Au and Cu+Cu made with the **EPS08** shadowing model and the d+Au best fit breakup cross sections.

Again, nice agreement of the Npart dependence.



R_{AA}(CNM) for Au+Au and Cu+Cu made with the **nDSg** shadowing model and the d+Au best fit breakup cross sections.

Different Npart dependence for AuAu and CuCu for the nDSg case! **Why?**

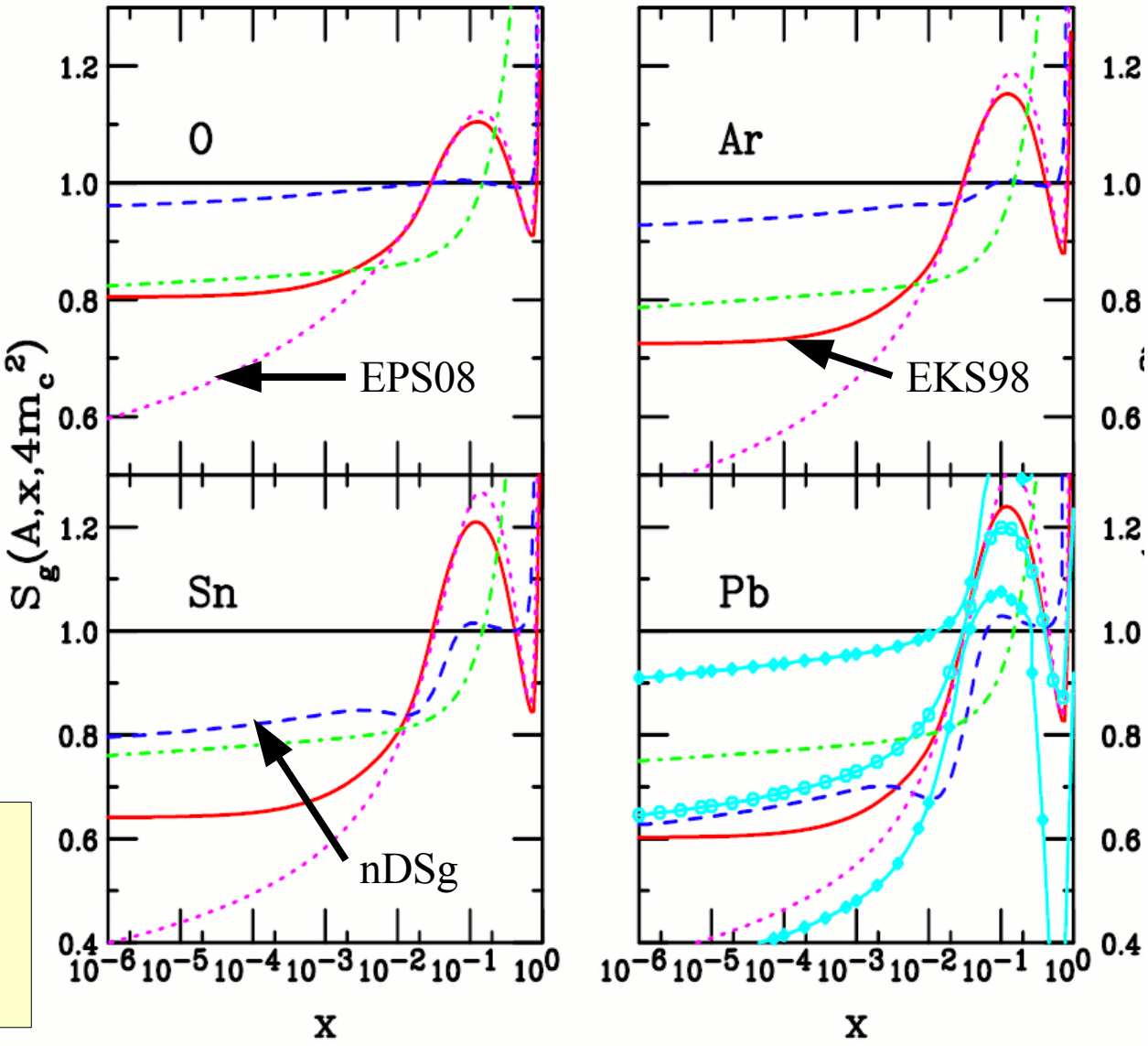


Ramona Vogt pointed me to slide 49 of her Trento presentation, showing the x dependence of various gluon shadowing parameterizations for J/ψ for different nuclear sizes.

Note the smooth behavior of the EKS98 and EPS08 parameterizations with nuclear size, and the **non - smooth** behavior for nDSg.

Given that the PHENIX Cu+Cu and Au+Au data show reasonable agreement for R_{AA} vs Npart, it seems to me that the nDSg result for Cu+Cu is unlikely, **so I will not use it**.

This makes clear that there is some **model dependence** in the R_{CuCu}(CNM) estimates.



Results for "survival probability"

The R_{AA}(CNM) values shown on slides 7 and 8, calculated with the EKS98 and EPS08 parameterizations of the d+Au data, have been used to make plots of **R_{AA}/R_{AA}(CNM)** for the published PHENIX J/ψ R_{AA} data:

PHENIX **Au+Au** data: Phys. Rev. Lett. 98, 232301 (2007).

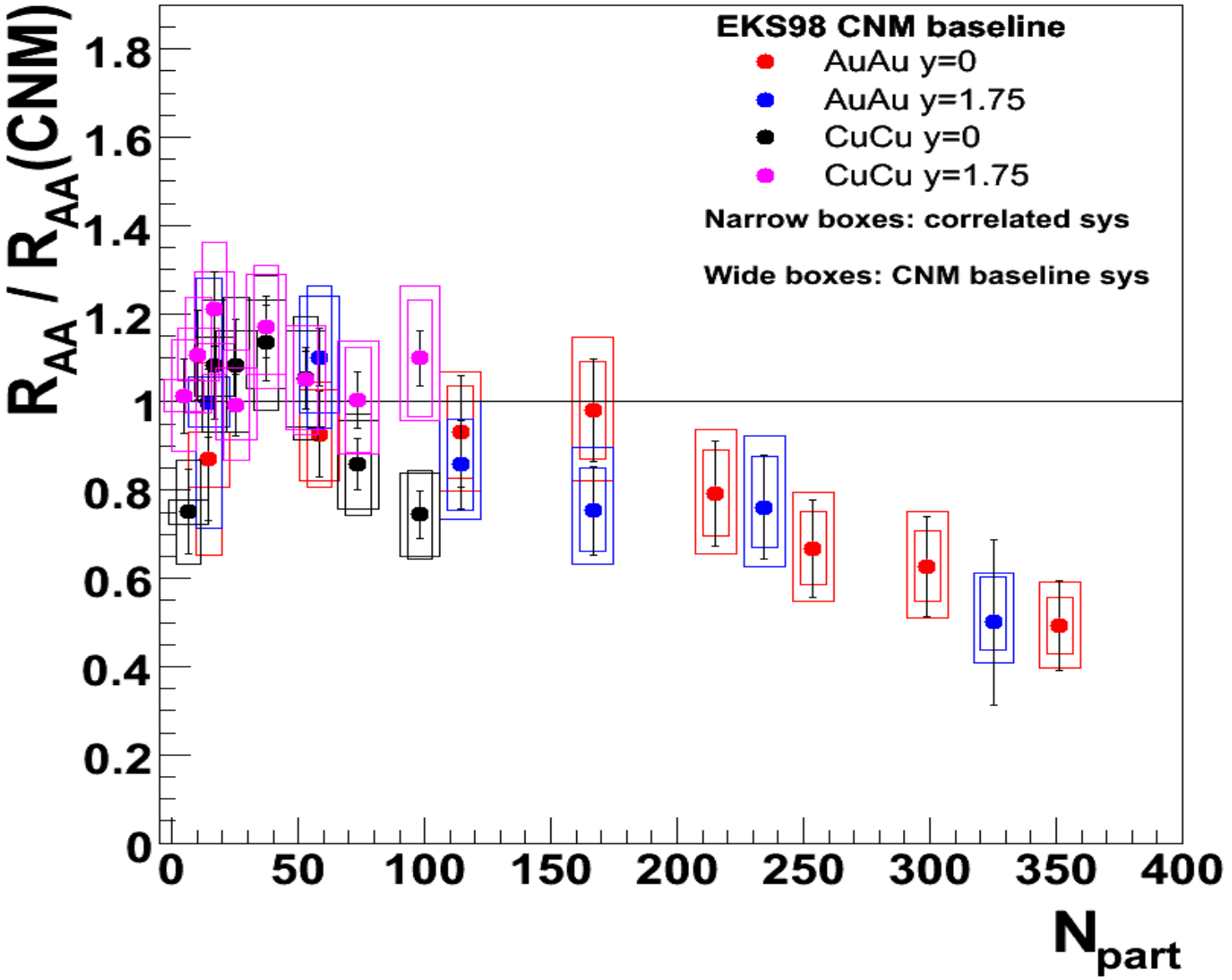
PHENIX **Cu+Cu** data: Phys. Rev. Lett. 101, 122301 (2008).

Of course, calling it a **"survival probability"** implies a particular mechanism for J/ψ production that may not be correct or complete.

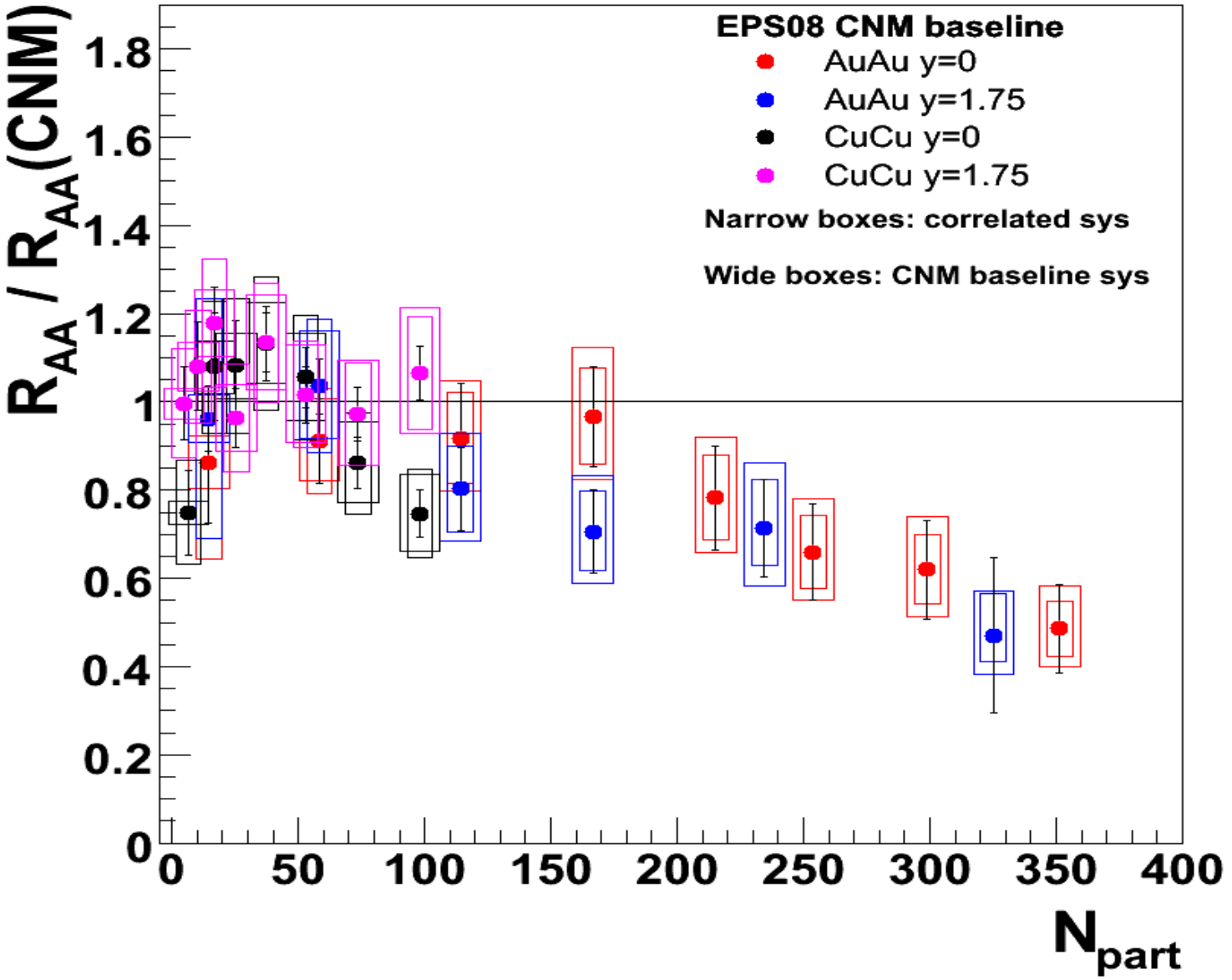
It is more accurate to think of R_{AA}(CNM) as **"folded pA"** - an estimate of what we would see if there were no additional effects in AA collisions.

BUT: If the rapidity dependence of the effective absorption cross section in d+Au is due to changes in **charm pair** production (as distinct from destruction of forming J/ψ), the R_{AA}(CNM) reference will work as the baseline for any production mechanism – including statistical hadronization.

R_{AA}/R_{AA}(CNM) for Au+Au and Cu+Cu made with the **EKS98** shadowing model and the d+Au best fit breakup cross sections.



R_{AA}/R_{AA}(CNM) for Au+Au and Cu+Cu made with the **EPS08** shadowing model and the d+Au best fit breakup cross sections.



Aside

If a larger fraction of the ψ' and χ_c are destroyed by **cold nuclear matter effects**, which seems very likely, then the $R_{AA}/R_{AA}(CNM)$ will not reflect the destruction of those mesons – they are **already** gone in our d+Au measurements.

We should try to **quantify** this at RHIC using our d+Au data.

My point is: be careful about looking for evidence of excited charmonia destruction in $R_{AA}/R_{AA}(CNM)$.
$\rightarrow$ in the limit where they were **all** destroyed in the initial collision, they would have **no** effect in $R_{AA}/R_{AA}(CNM)$.

Summary and conclusions

The suppression **beyond "folded pA"** is **very similar** for y=0 and y=1.7, even though R_{AA} is quite different.

There is very little dependence of R_{auAu}(CNM) on the shadowing model used in the parameterization of d+Au. Not surprising, since the d+Au R_{CP} was fitted with a **Au** shadowing model.

But caution: There is significant model dependence of the calculated R_{CuCu}(CNM) when using a parameterization of d+Au data.

Even though the EKS98 and EPS08 R_{CuCu}(CNM) look **reasonable** next to the R_{AuAu}(CNM) it is important to remember that there is still some model dependence there – the data were fitted using a Au shadowing parameterization, **not** a Cu one, since we do not have d+Cu data.

I should stress that these are **my conclusions** - I am not speaking for PHENIX here.

Backup slides

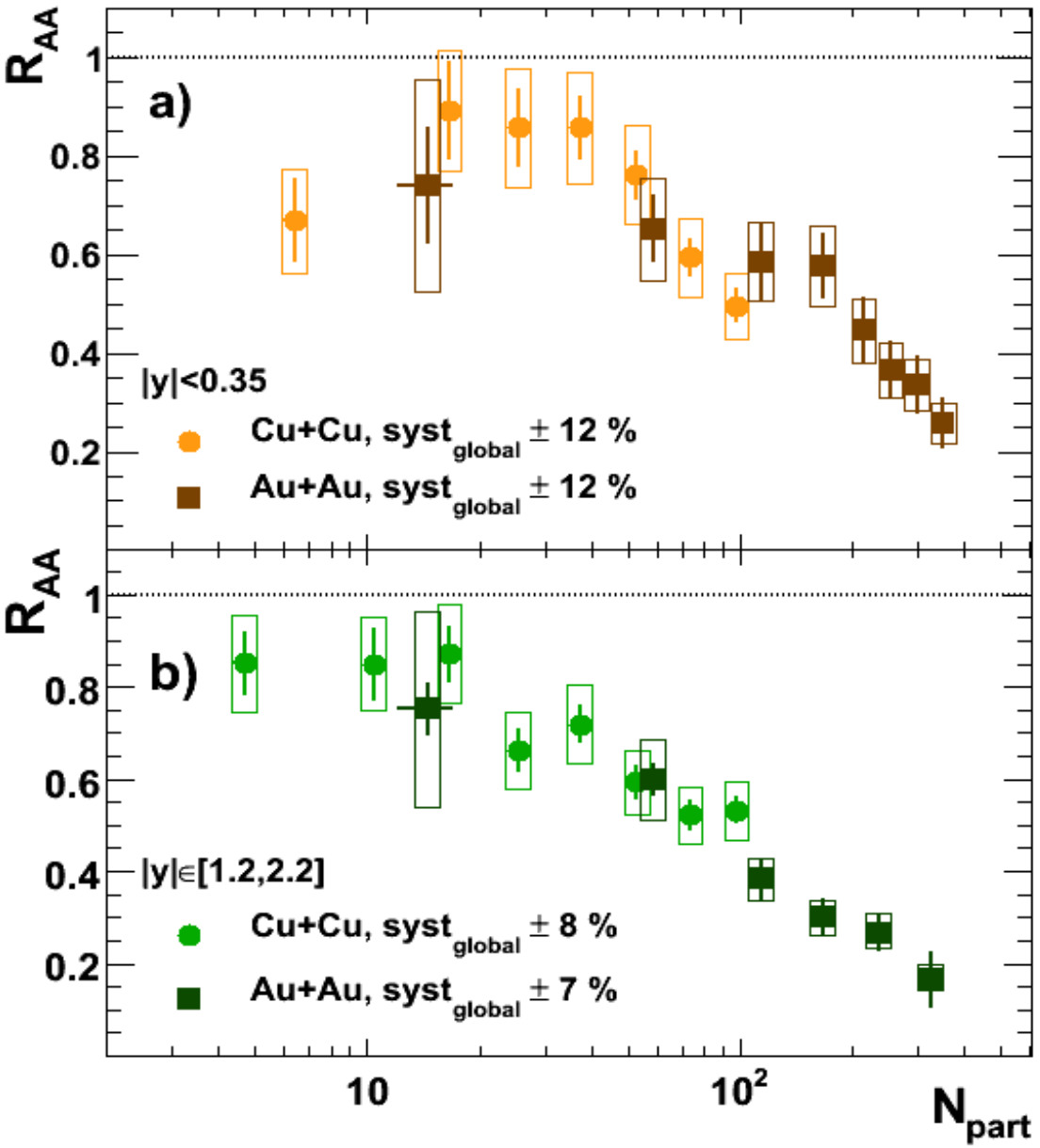
Cu+Cu and Au+Au R_{AA}

The Npart dependence of Au+Au and Cu+Cu is consistent.

Note the smaller systematic uncertainties for the Cu+Cu data. This is primarily due to smaller uncertainties on **Ncoll** from the Glauber calculation.

Thus the Cu+Cu data will be much better for studying the **onset** of hot nuclear matter effects.

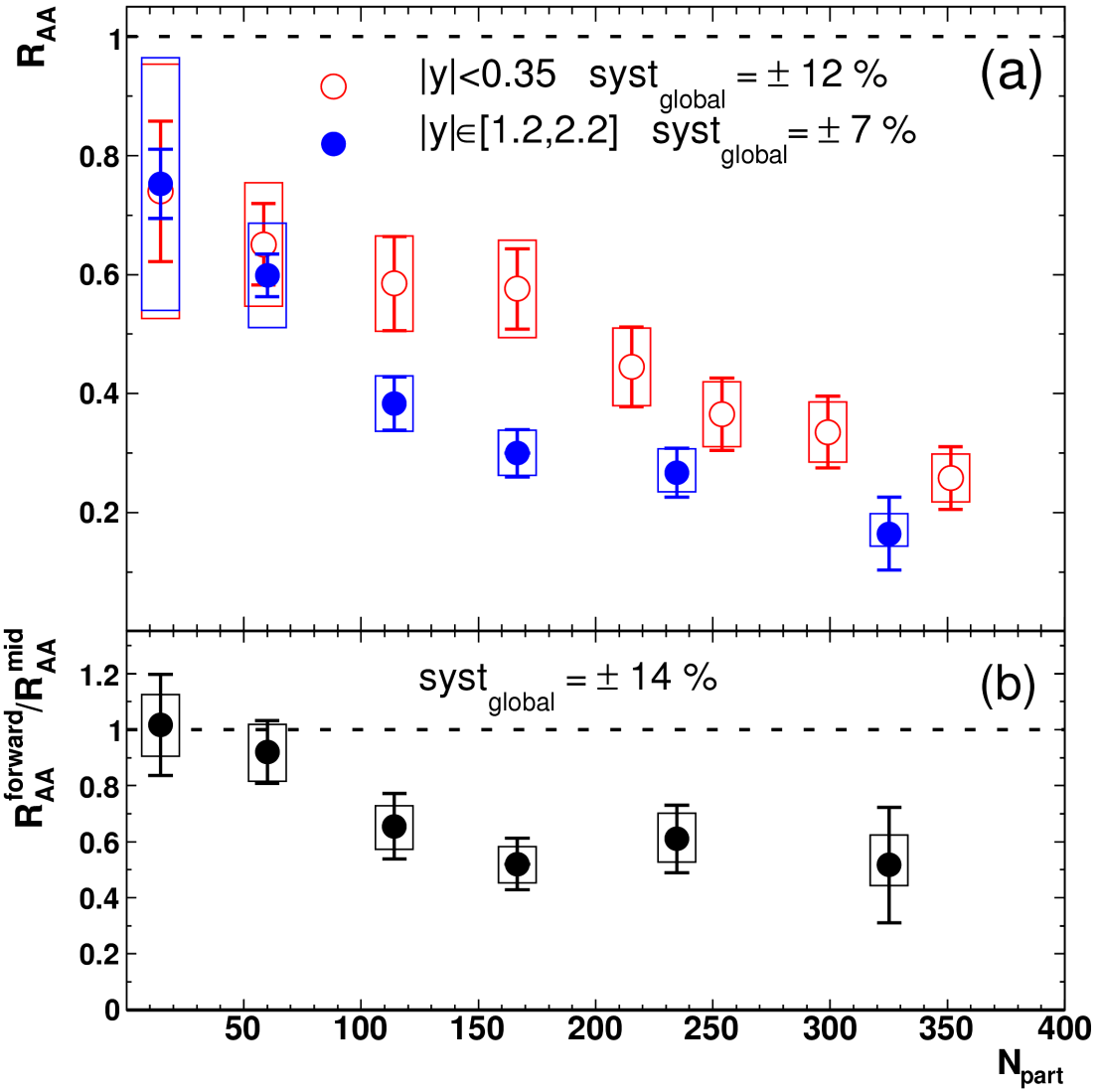
Phys. Rev. Lett. 101, 122301 (2008)

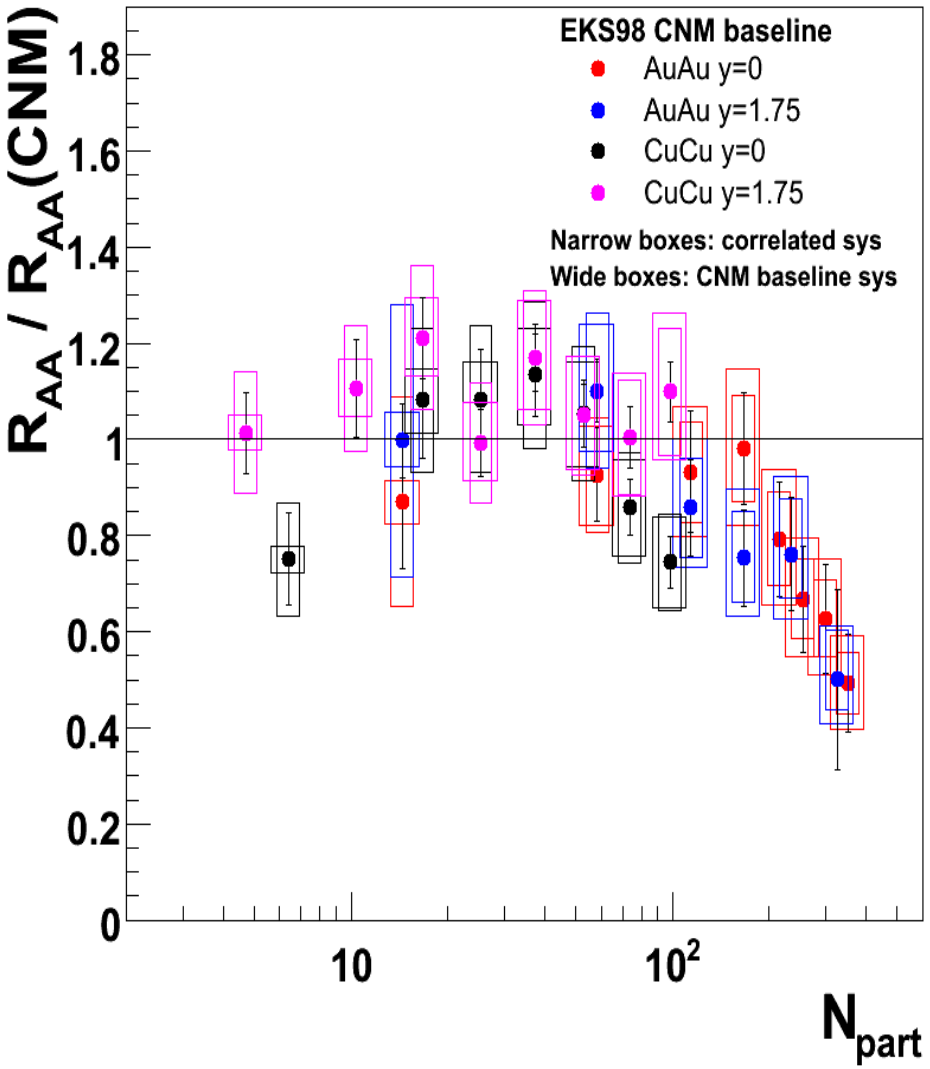


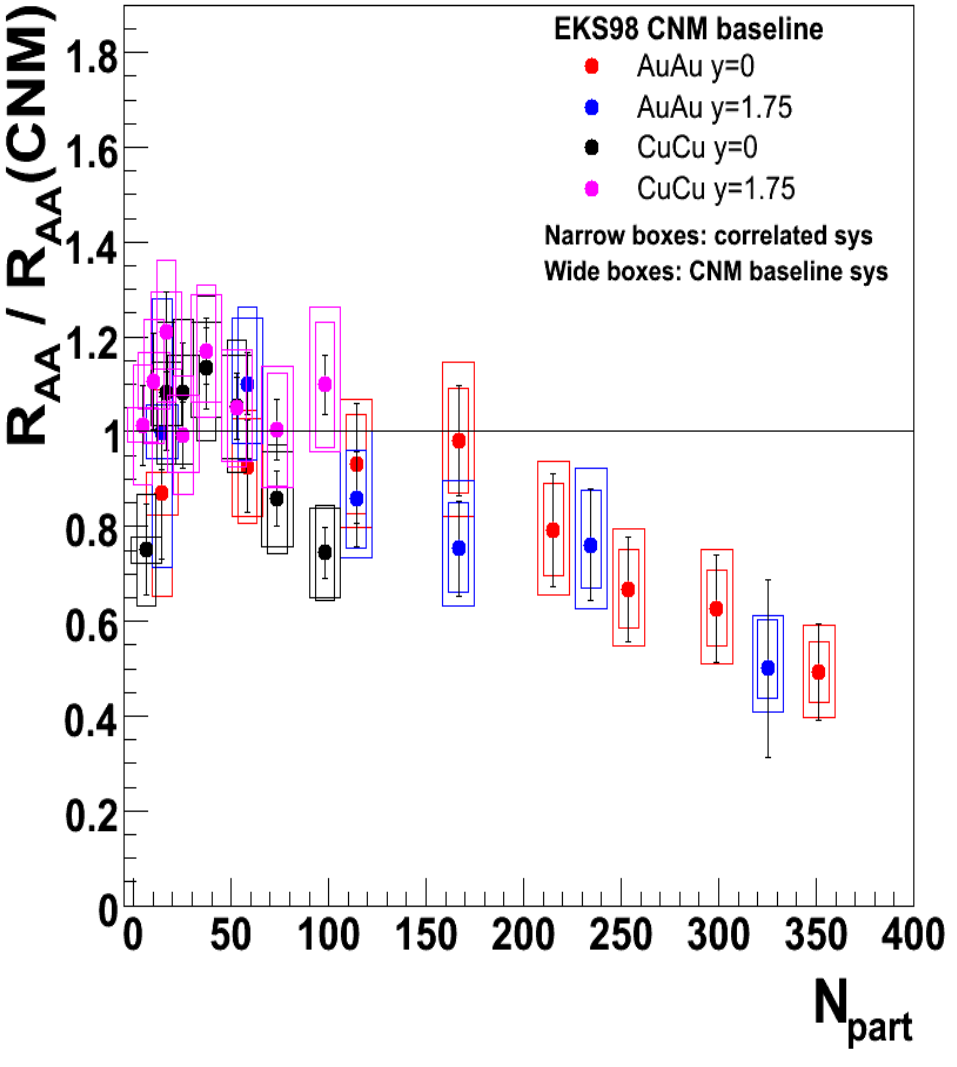
Au+Au R_{AA}

The stronger Au+Au suppression at forward/backward rapidity has generated considerable interest.

But what is the expected suppression due to **cold nuclear matter effects**?




EKS98 CNM baseline
AuAu y=0
AuAu y=1.75
CuCu y=0
CuCu y=1.75
Narrow boxes: correlated sys
Wide boxes: CNM baseline sys
R_{AA} / R_{AA}(CNM)
N_{part}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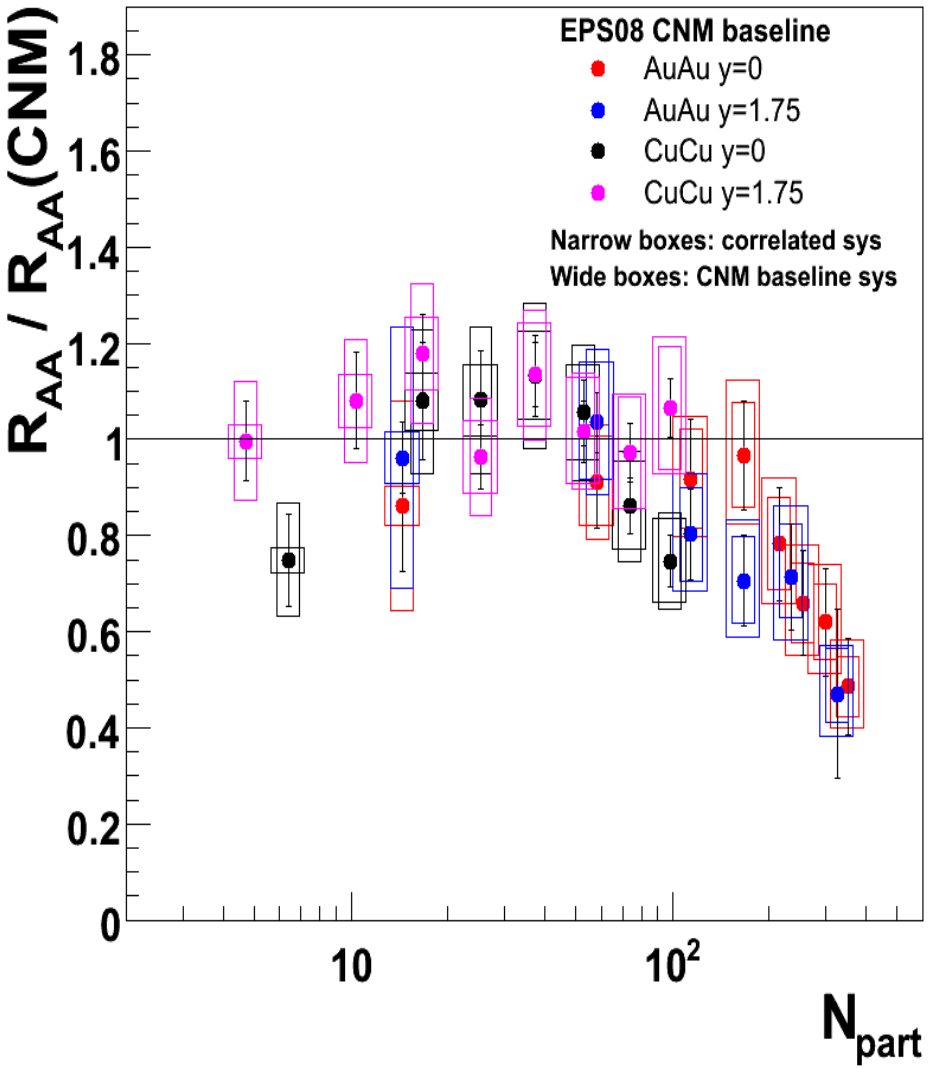
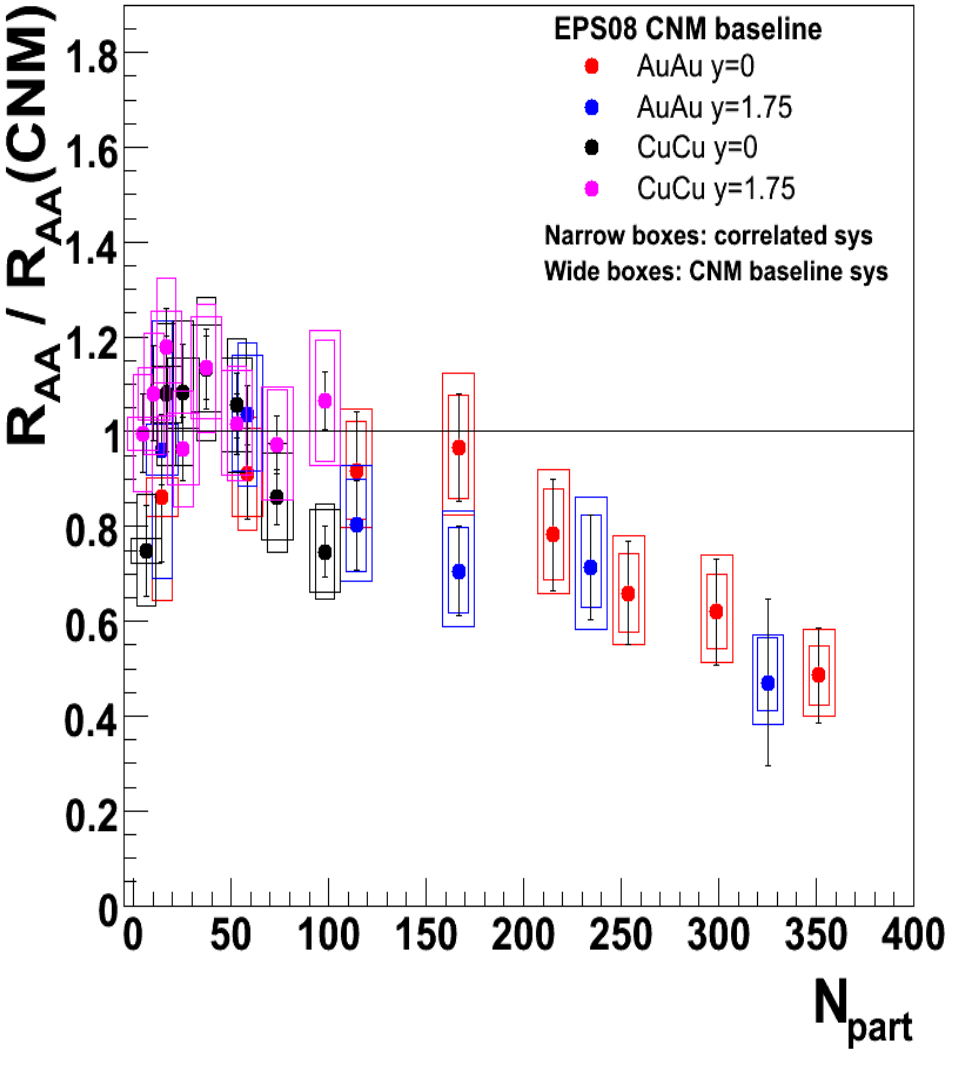
N_{part}


EPS08 CNM baseline
AuAu y=0
AuAu y=1.75
CuCu y=0
CuCu y=1.75
Narrow boxes: correlated sys
Wide boxes: CNM baseline sys
R_{AA} / R_{AA}(CNM)
N_{part}


EPS08 CNM baseline
AuAu y=0
AuAu y=1.75
CuCu y=0
CuCu y=1.75
Narrow boxes: correlated sys
Wide boxes: CNM baseline sys
R_{AA} / R_{AA}(CNM)
N_{part}