
UMONS
Université de Mons

# $\Upsilon$ production in dAu and AuAu collisions at RHIC

**N. Matagne**
University of Mons

**Workshop Annecy nPDF**
**February 22, 2010**

In collaboration with E. G. Ferreiro, F. Fleuret, J. P. Lansberg and A. Rakotozafindrabe

# Outline

# Introduction and motivations

- Extend to $\Upsilon$ the study of CNM effects (shadowing + absorption) on production of quarkonia

# Introduction and motivations

- Extend to $\Upsilon$ the study of CNM effects (shadowing + absorption) on production of quarkonia
- Glauber Monte Carlo model to simulate dAu and AuAu collisions at RHIC

# Introduction and motivations

- Extend to $\Upsilon$ the study of CNM effects (shadowing + absorption) on production of quarkonia
- Glauber Monte Carlo model to simulate dAu and AuAu collisions at RHIC
- Two main production schemes ($1 \longrightarrow 2$, $2 \longrightarrow 2$)

# Introduction and motivations

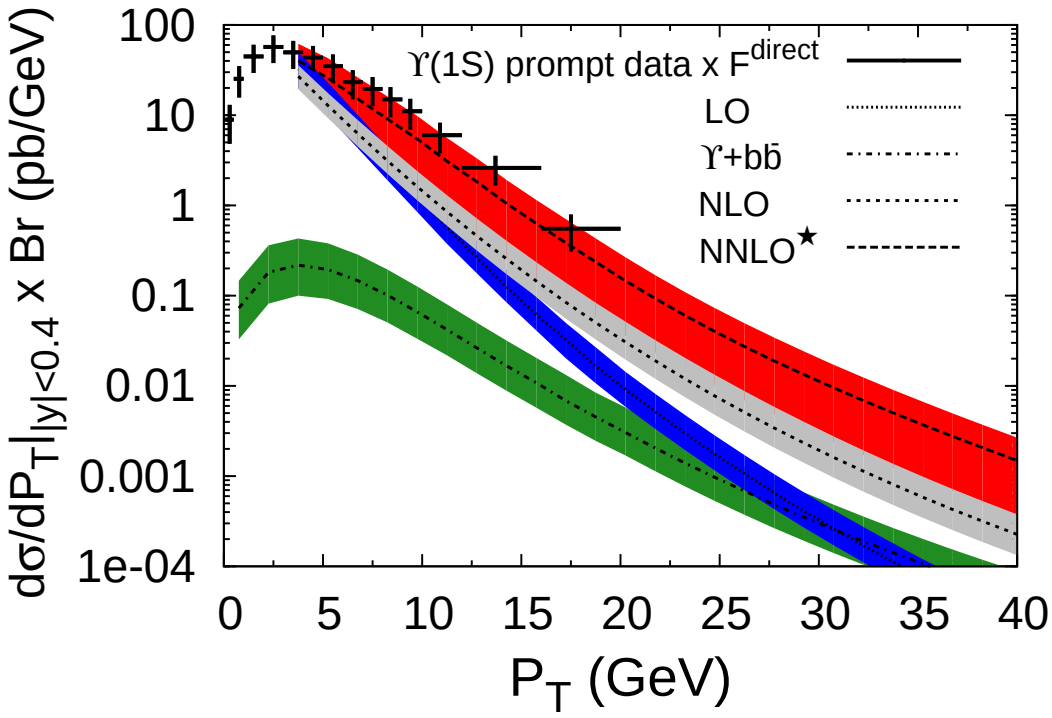
- Extend to $\Upsilon$ the study of CNM effects (shadowing + absorption) on production of quarkonia
- Glauber Monte Carlo model to simulate dAu and AuAu collisions at RHIC
- Two main production schemes ($1 \longrightarrow 2$, $2 \longrightarrow 2$)
- Comparison of three differents shadowing parametrisations

# Introduction and motivations

- Extend to $\Upsilon$ the study of CNM effects (shadowing + absorption) on production of quarkonia
- Glauber Monte Carlo model to simulate dAu and AuAu collisions at RHIC
- Two main production schemes ($1 \longrightarrow 2$, $2 \longrightarrow 2$)
- Comparison of three differents shadowing parametrisations
- Three absorption cross sections

# Experimental situation

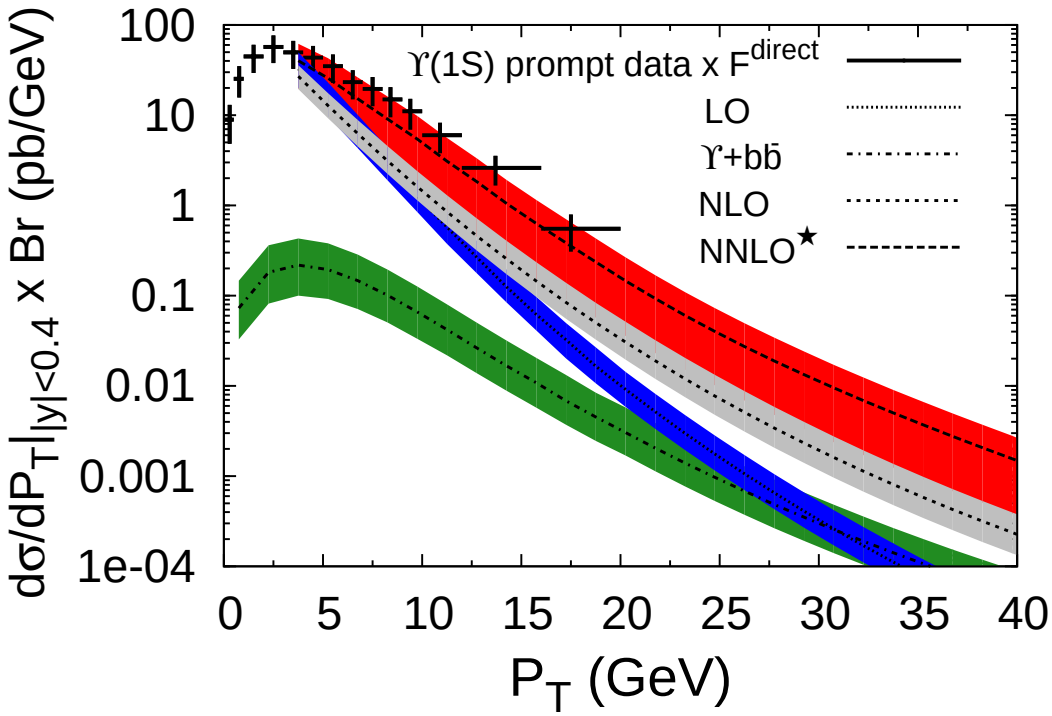
Results at 1.8 TeV




- CSM describes well the data at NNLO$^\star$

# Experimental situation

Results at 1.8 TeV

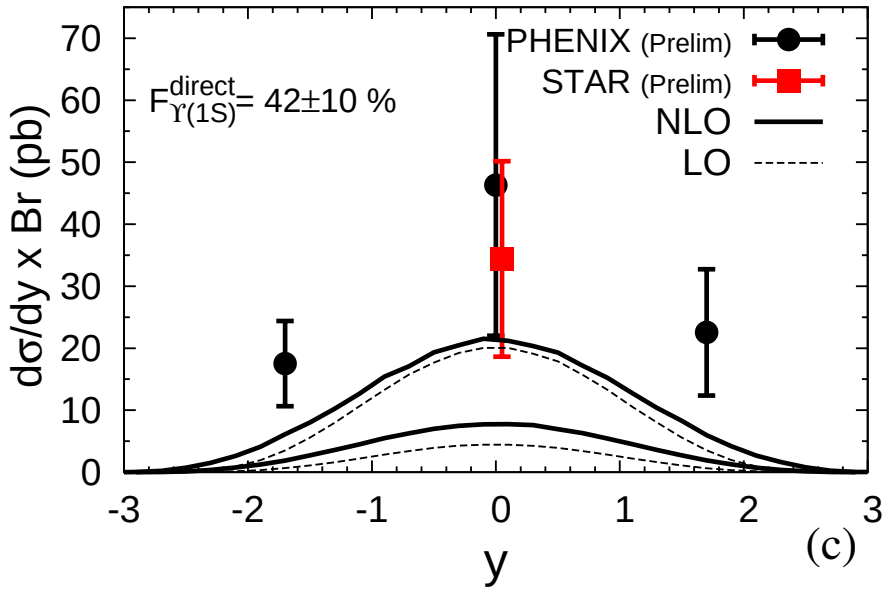



- CSM describes well the data at NNLO$^\star$
- However LO CSM is sufficient to describe low pT data

# Experimental situation

S. J. Brodsky and J. P. Lansberg, arXiv:0908.0754 [hep-ph].

Results at 200 GeV




- Upper dashed line, $m_\Upsilon = 4.5$ GeV,
- Lower dashed line, $m_\Upsilon = 5.0$ GeV,

$m_\Upsilon = 4.5$ GeV, taken in the following plots

# On the kinematics of $\Upsilon$ production

If $\mathcal{F}_g^A(x, \vec{r}, z, \mu_f)$ gives the distribution of a gluon of mom. fract. $x$ at a position $\vec{r}, z$ in a nucleus $A$, the differential cross-section reads:

$$\frac{d\sigma_{AB}}{dy\, dP_T\, d\vec{b}} =$$

| $\mathbf{2 \to 1}$ kinematics with intrinsic $p_T$ | $\mathbf{2 \to 2}$ kinematics with extrinsic $p_T$ |
|---|---|

# On the kinematics of $\Upsilon$ production

If $\mathcal{F}_g^A(x, \vec{r}, z, \mu_f)$ gives the distribution of a gluon of mom. fract. $x$ at a position $\vec{r}, z$ in a nucleus $A$, the differential cross-section reads:

$$\frac{d\sigma_{AB}}{dy\, dP_T\, d\vec{b}} =$$

| $\mathbf{2 \to 1}$ kinematics with intrinsic $p_T$ | $\mathbf{2 \to 2}$ kinematics with extrinsic $p_T$ |
|---|---|
| $\int d\vec{r}_A\, dz_A\, dz_B$ | $\int dx_1\, dx_2 \int d\vec{r}_A dz_A dz_B$ |
| $\times\ \mathcal{F}_g^A(x_1^0, \vec{r}_A, z_A, \mu_f)\mathcal{F}_g^B(x_2^0, \vec{r}_B, z_B, \mu_f)$ | $\times\ \mathcal{F}_g^A(x_1, \vec{r}_A, z_A, \mu_f)\mathcal{F}_g^B(x_2, \vec{r}_B, z_B, \mu_f)$ |
| $\times\ \sigma_{gg}^{\mathrm{Intr.}}(x_1^0, x_2^0)$ | $\times\ 2\hat{s}P_T \frac{d\sigma_{gg\to\Upsilon+g}}{d\hat{t}} \delta(\hat{s} - \hat{t} - \hat{u} - M^2)$ |
| $\times\ S_A(\vec{r}_A, z_A)\, S_B(\vec{r}_B, z_B)$ | $\times\ S_A(\vec{r}, z_A) S_B(\vec{r}_B, z_B)$ |

# On the kinematics of $\Upsilon$ production

If $\mathcal{F}_g^A(x, \vec{r}, z, \mu_f)$ gives the distribution of a gluon of mom. fract. $x$ at a position $\vec{r}, z$ in a nucleus $A$, the differential cross-section reads:

$$\frac{d\sigma_{AB}}{dy\, dP_T\, d\vec{b}} =$$

**$2 \to 1$** kinematics with intrinsic $p_T$

$$\int d\vec{r}_A\, dz_A\, dz_B \times \mathcal{F}_g^A(x_1^0, \vec{r}_A, z_A, \mu_f)\mathcal{F}_g^B(x_2^0, \vec{r}_B, z_B, \mu_f) \times \sigma_{gg}^{\text{Intr.}}(x_1^0, x_2^0) \times S_A(\vec{r}_A, z_A)\, S_B(\vec{r}_B, z_B)$$

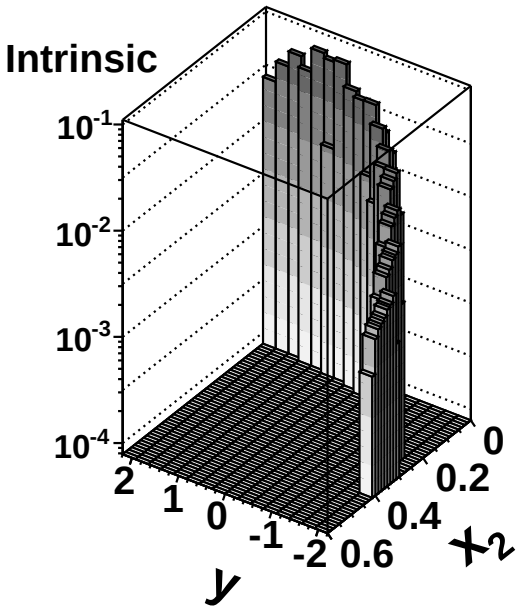
$$x_{1,2} = \frac{m_T}{\sqrt{s_{NN}}} \exp(\pm y) \equiv x_{1,2}^0(y, P_T)$$

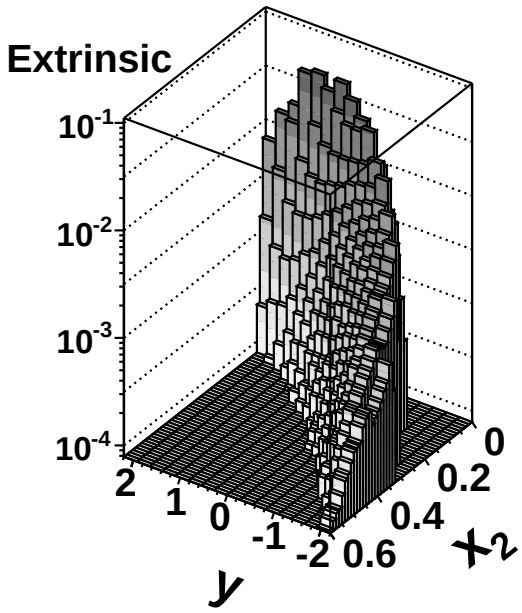
**$2 \to 2$** kinematics with extrinsic $p_T$

$$\int dx_1\, dx_2 \int d\vec{r}_A dz_A dz_B \times \mathcal{F}_g^A(x_1, \vec{r}_A, z_A, \mu_f)\mathcal{F}_g^B(x_2, \vec{r}_B, z_B, \mu_f) \times 2\hat{s}P_T \frac{d\sigma_{gg\to\Upsilon+g}}{d\hat{t}}\delta(\hat{s} - \hat{t} - \hat{u} - M^2) \times S_A(\vec{r}, z_A)S_B(\vec{r}_B, z_B)$$

$$\delta(..) \to x_2 = \frac{x_1 m_T \sqrt{s_{NN}} e^{-y} - M^2}{\sqrt{s_{NN}}(\sqrt{s_{NN}} x_1 - m_T e^{y})}$$

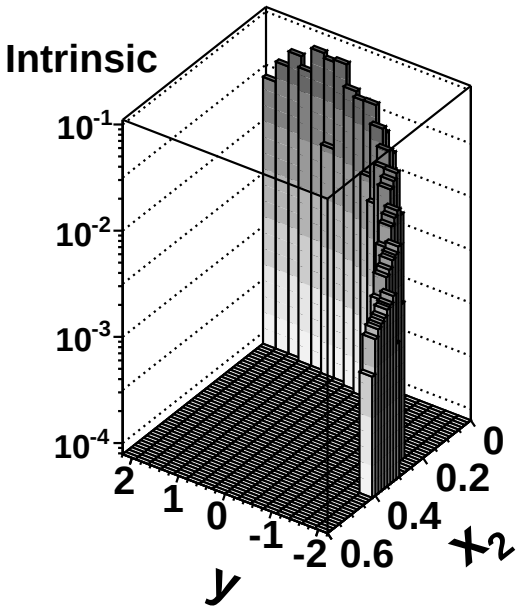
# On the kinematics of ϒ production

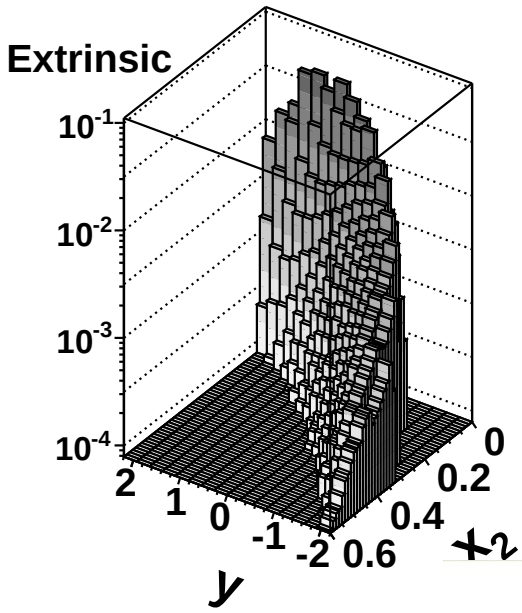



For a given couple $(y, p_T)$, $x_2$ is larger in the extrinsic scheme

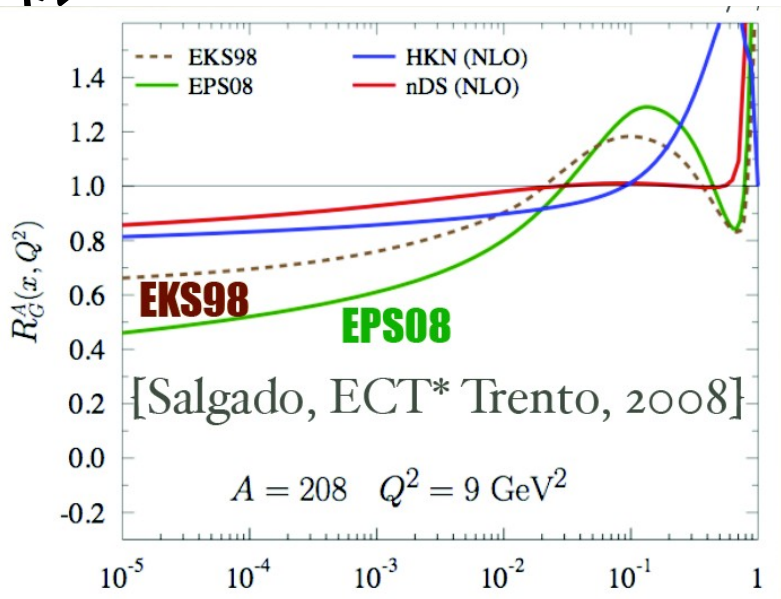
# On the kinematics of ϒ production



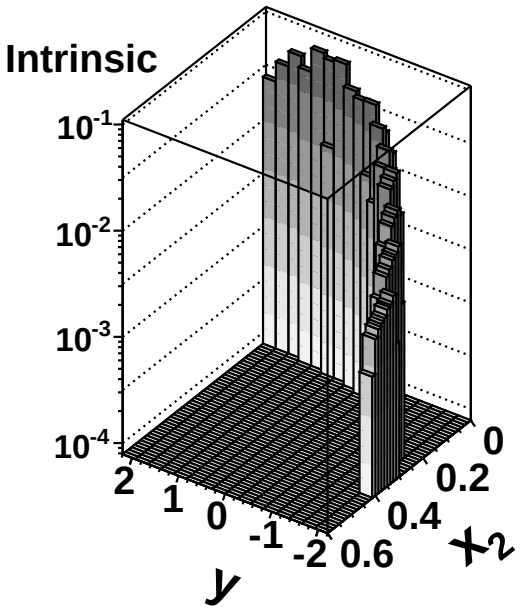



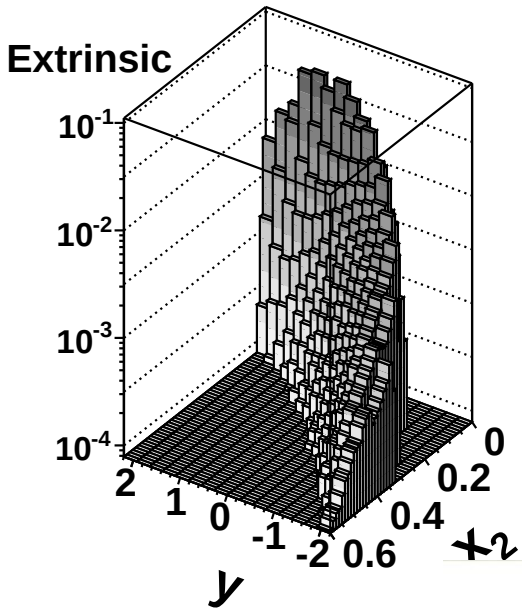

For a given couple $(y, p_T)$, $x_2$ is larger in the extrinsic scheme

Antishadowing peak at $\sim 10^{-1}$



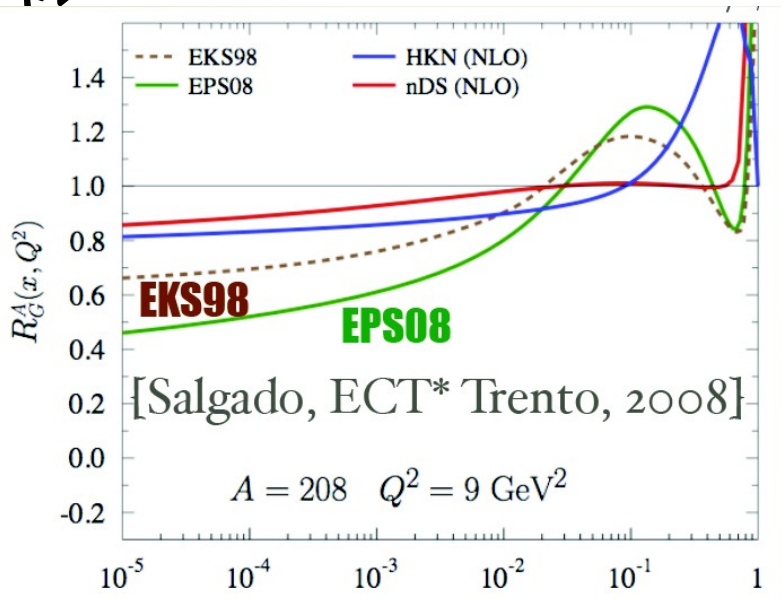
# On the kinematics of ϒ production




For a given couple $(y, p_T)$, $x_2$ is larger in the extrinsic scheme

Antishadowing peak at $\sim 10^{-1}$




We expect different shadowing effects in both cases.

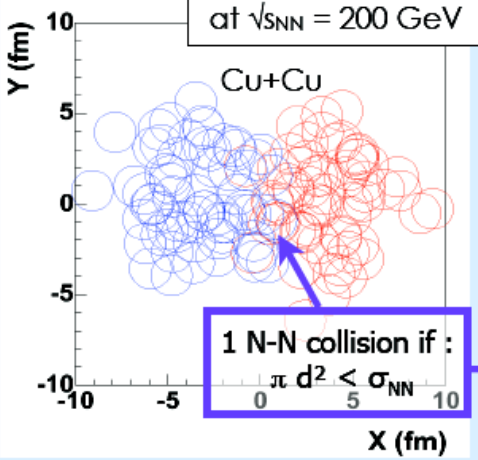
# The Glauber Monte Carlo

## Our Monte-Carlo approach for J/Ψ production

1 → 2 → 3

### Glauber MC

$\sigma_{NN}$ = 42mb
at $\sqrt{s_{NN}}$ = 200 GeV



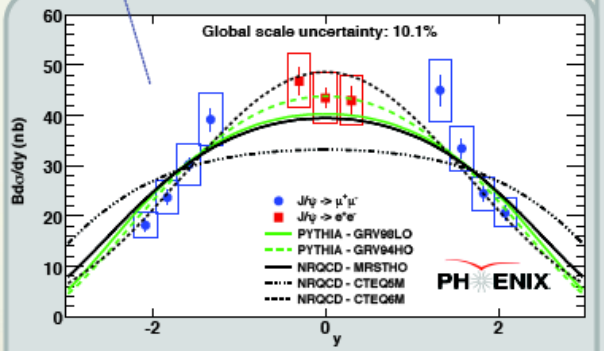

Random :
- b according to 2π b db
- position of nucleons ∈ A, B according to Woods-Saxon

### For each N-N collision

J/Ψ?

**J/Ψ candidate produced**
- according to $\sigma_{J/\psi} \leq \sigma_{NN}$

with random :
- y and $p_T$ according to p+p data
- random $p_T$ orientation φ uniformly distributed in [0, 2π]



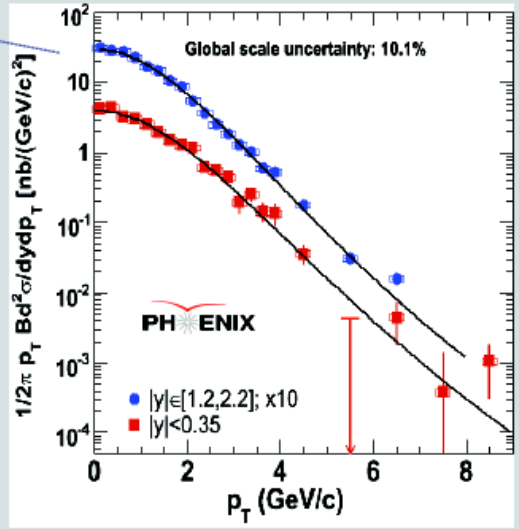

**Kinematics for J/Ψ candidate:**
**y, $p_T$, φ, M ⇒ $p_x$ , $p_y$ , $p_z$ , E**

### J/Ψ canditate ⇒ real J/Ψ if :

**random[0,1] < $R_{shadow}$ × $\sigma_{J/\psi}$ / $\sigma_{NN}$**

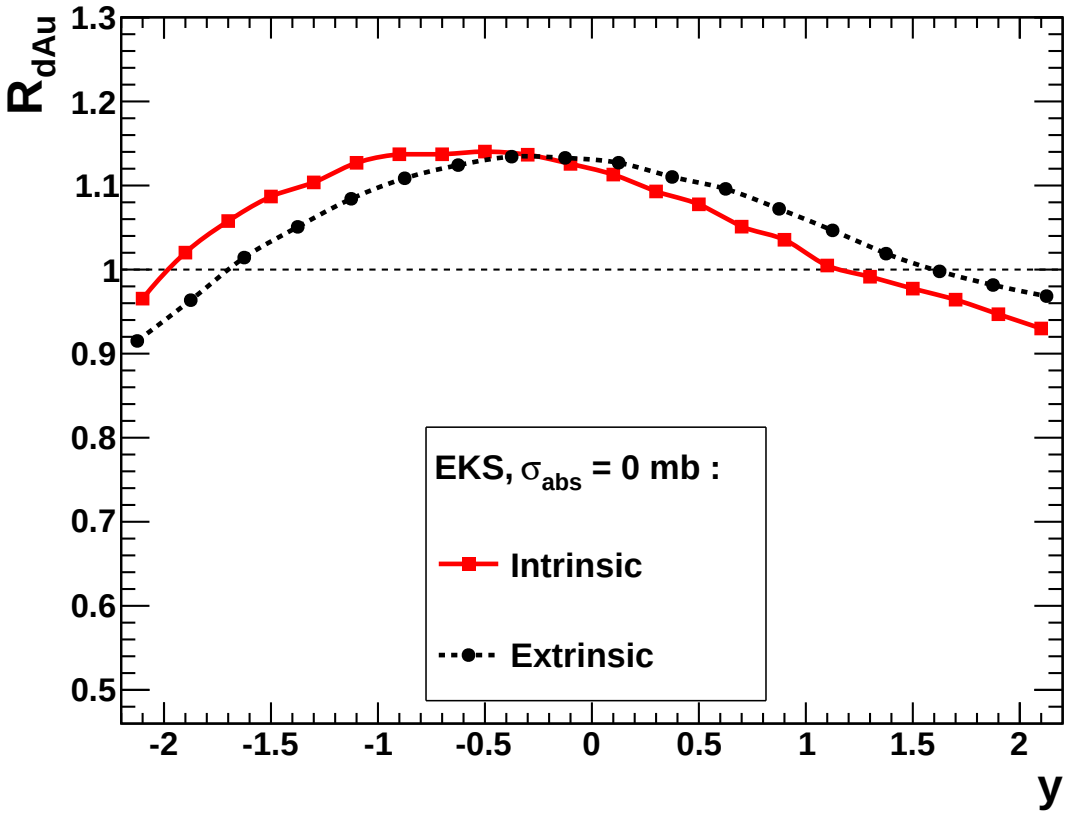
computed using CF or EKS

**Nuclear modif. factor =**
**dN real J/Ψ / dN J/Ψ canditate**



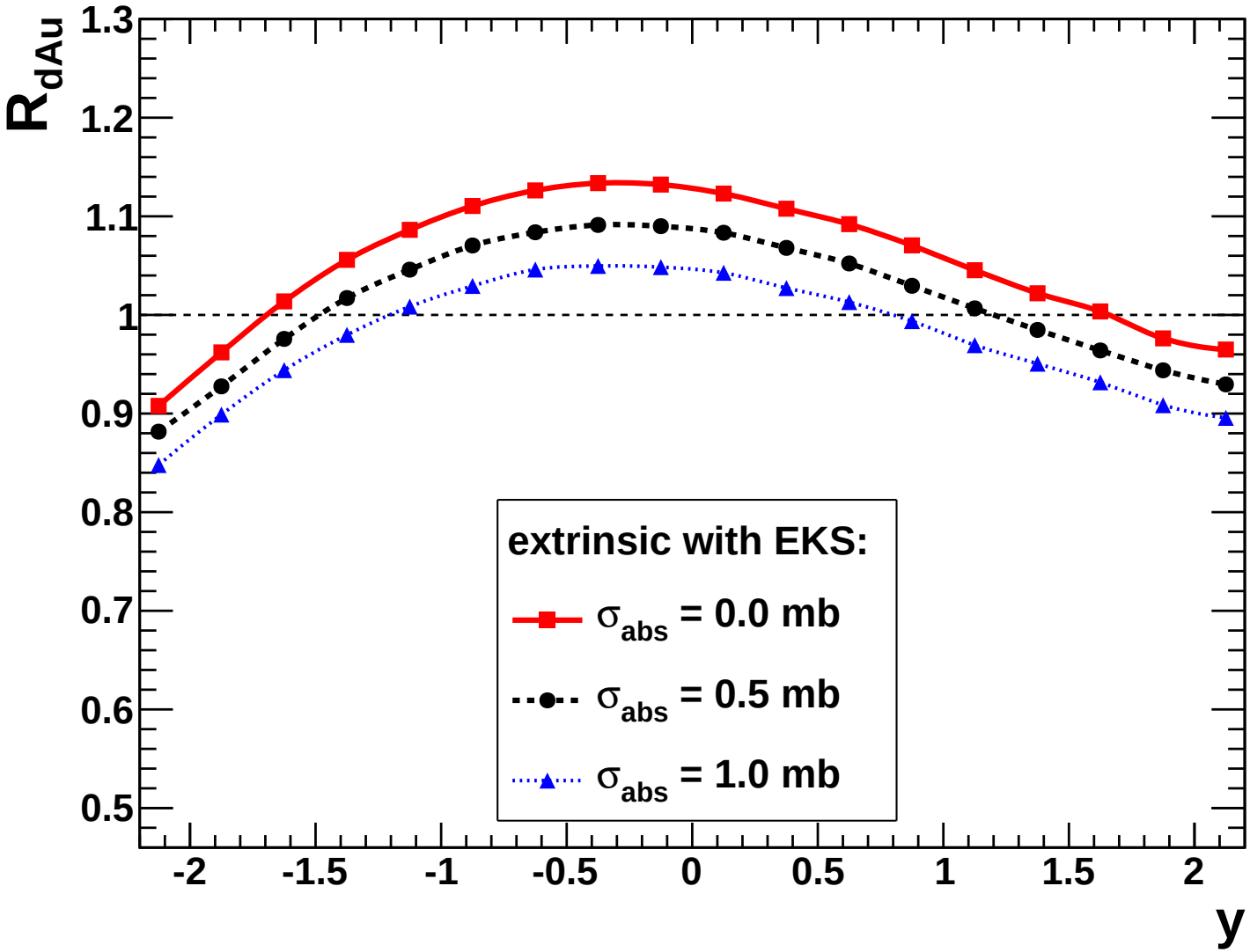
# Results for dAu collisions

Illustration of the differences between intrinsic and extrinsic $p_T$

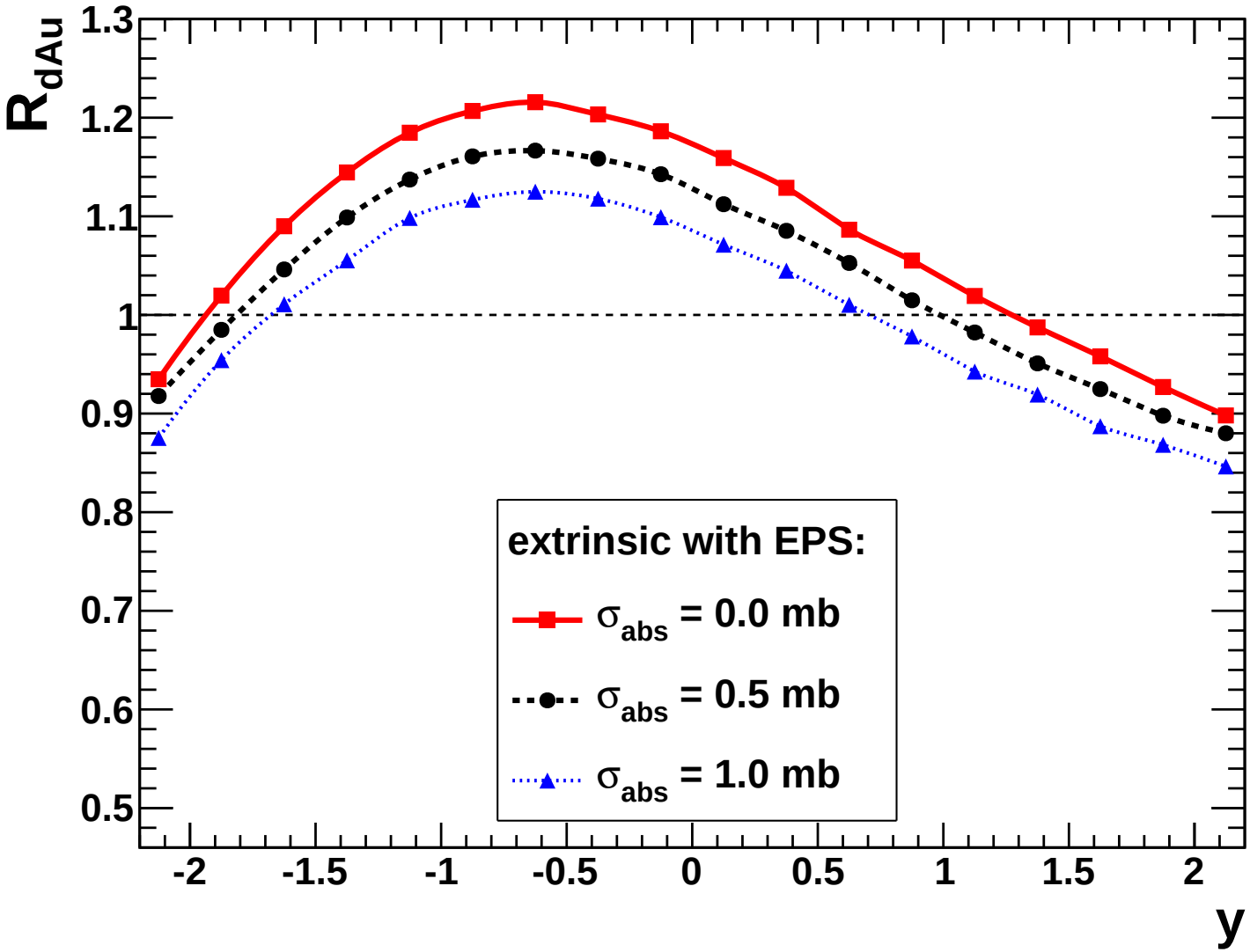



See Andry's talk

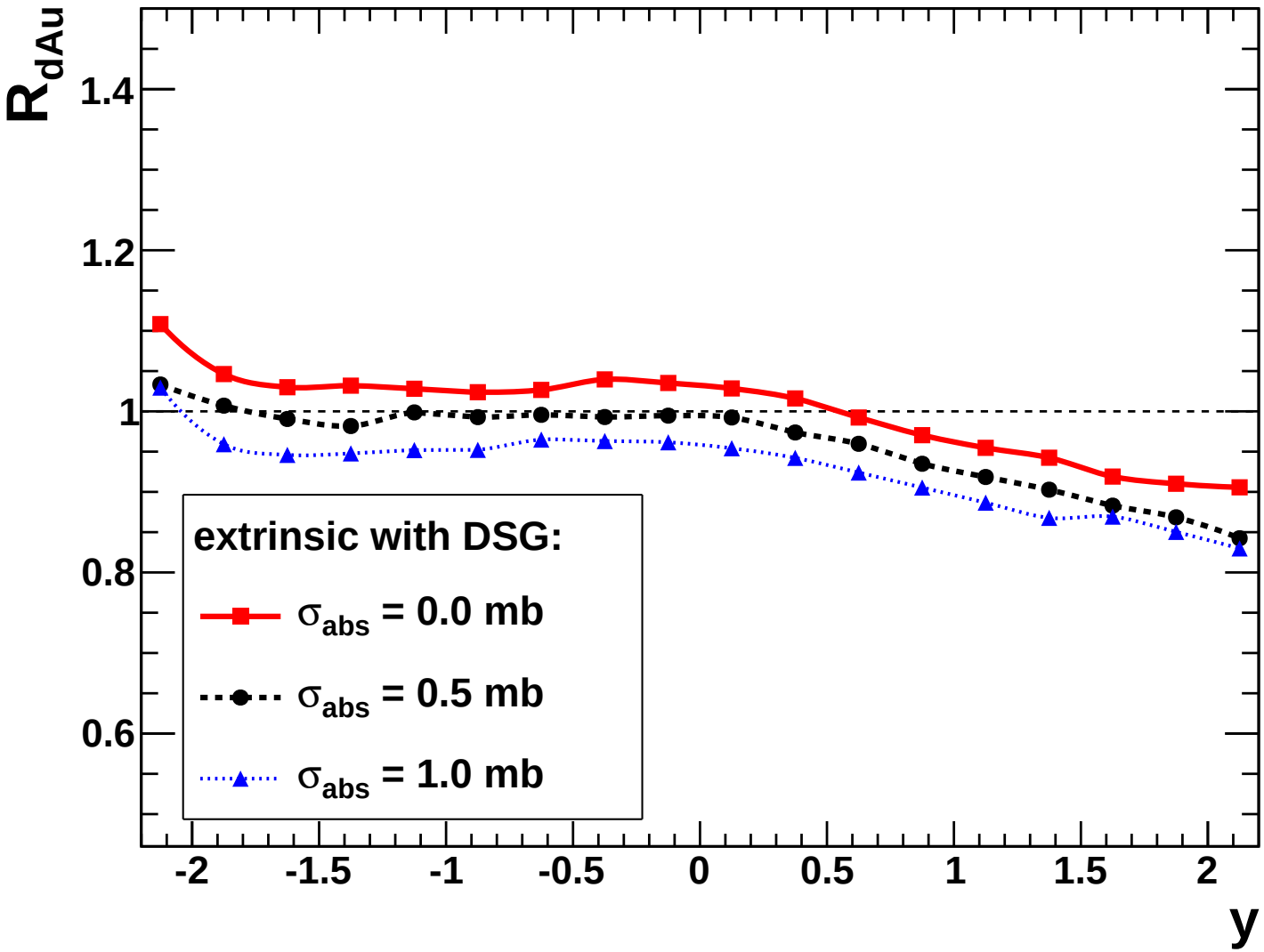
# Results for dAu collisions



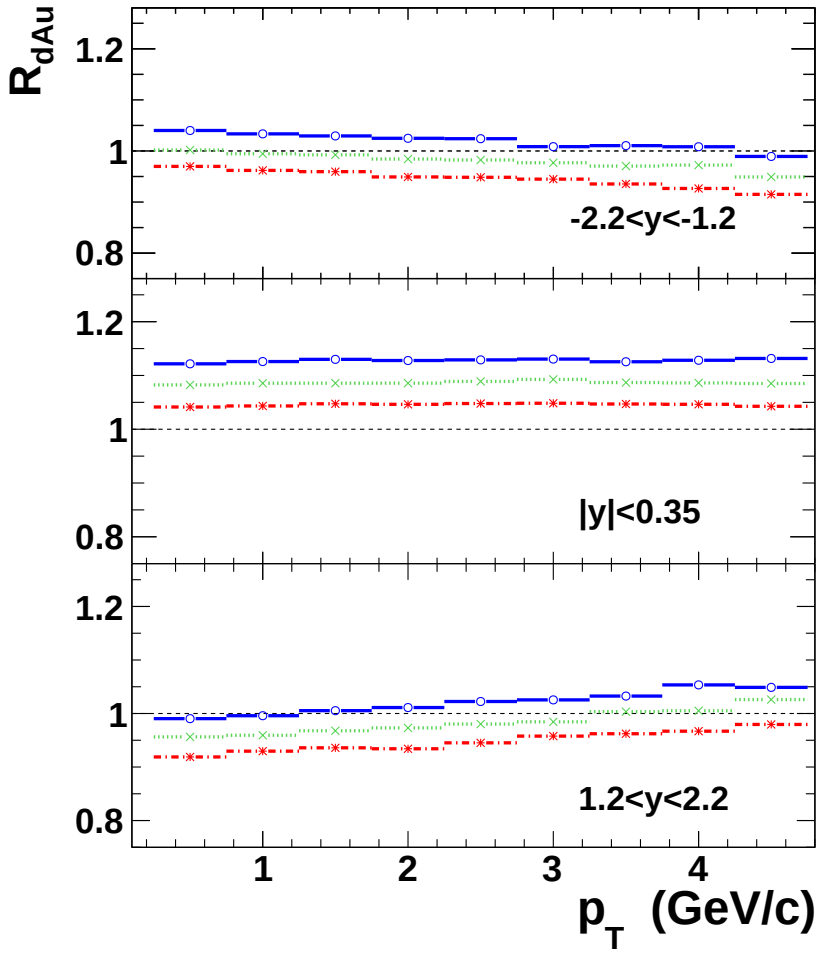
# Results for dAu collisions



# Results for dAu collisions



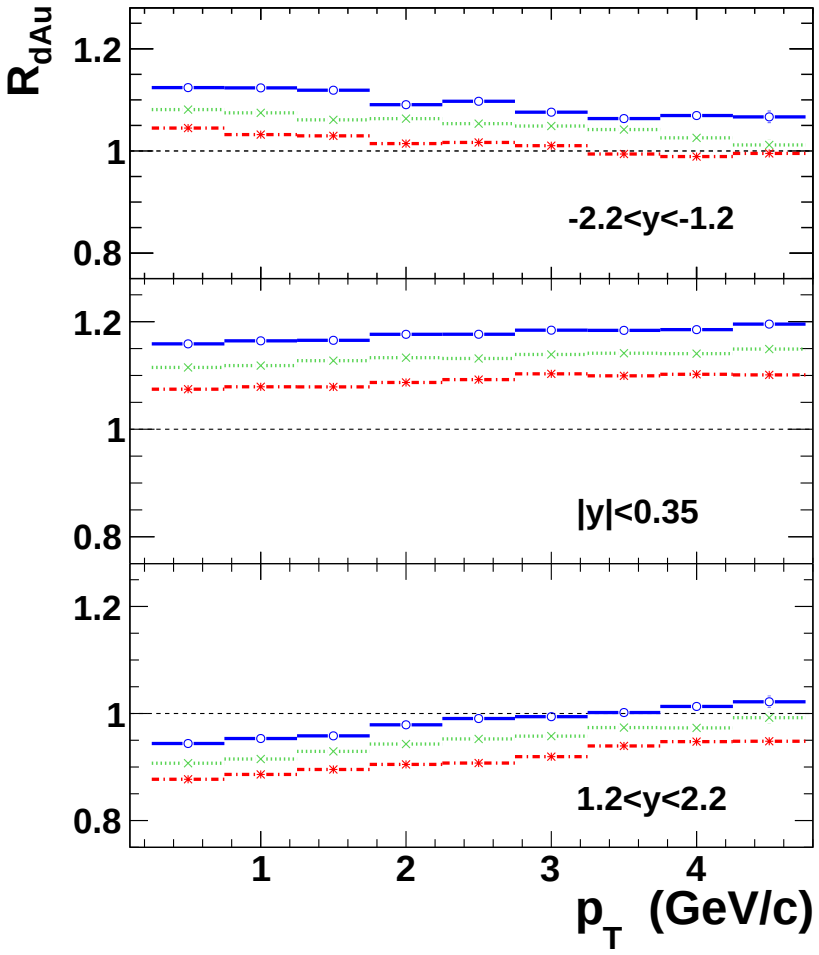
# Results for dAu collisions




- In blue, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

EKS

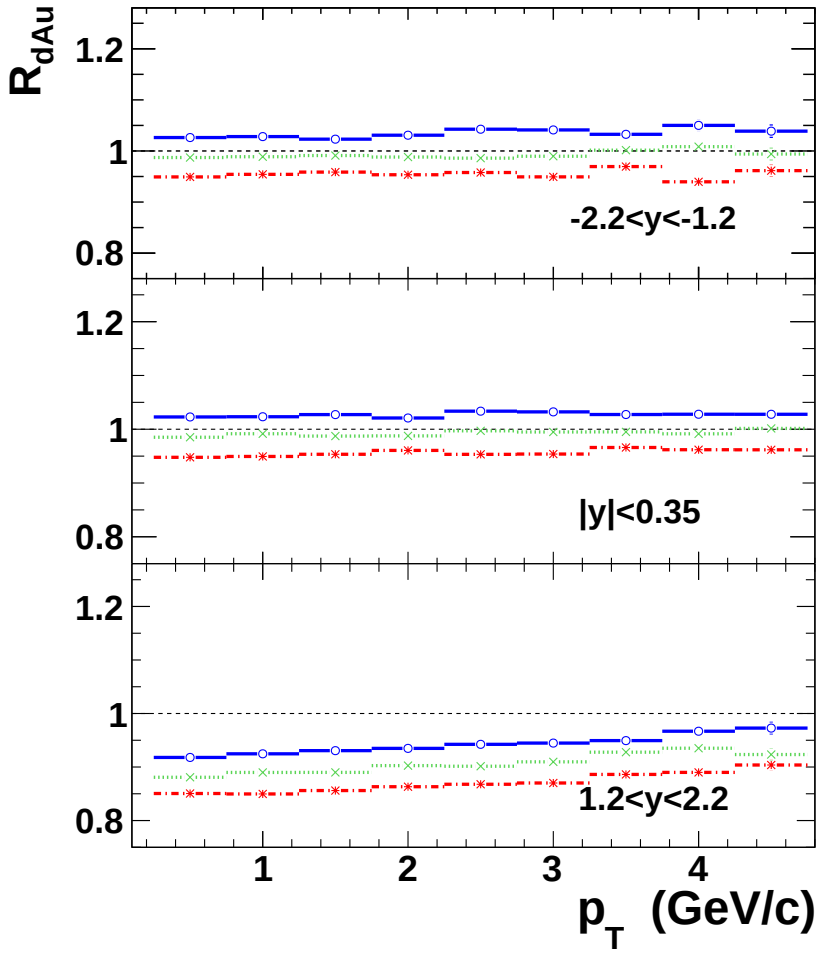
# Results for dAu collisions




- In blue, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

EPS

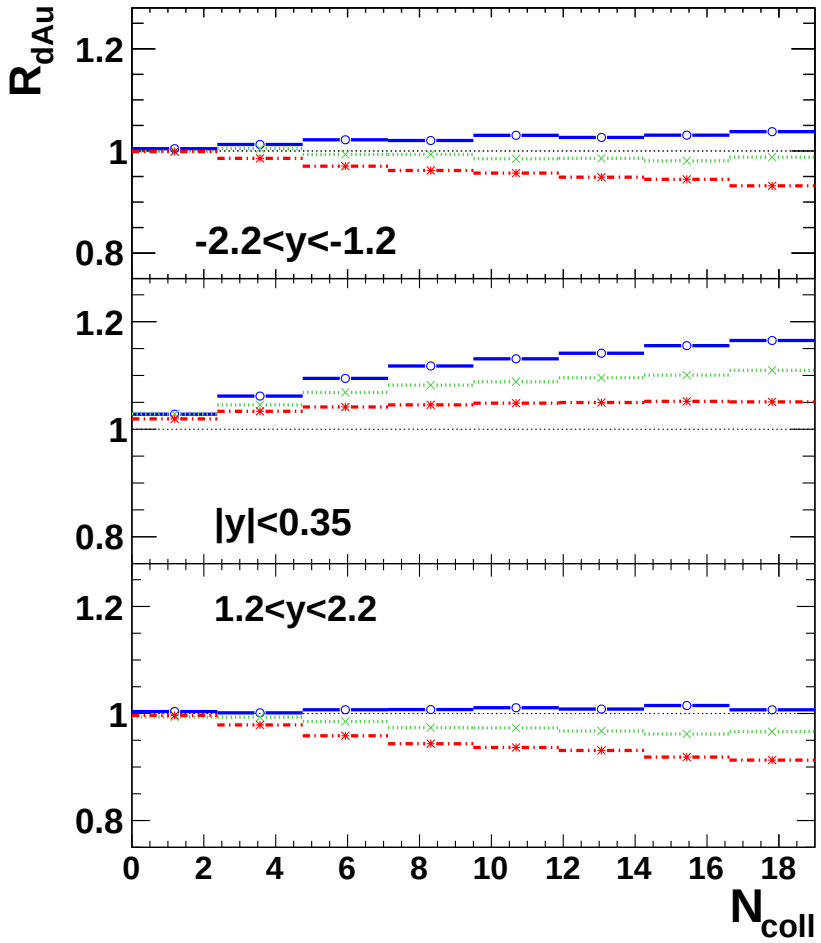
# Results for dAu collisions




- In blue, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

nDSg

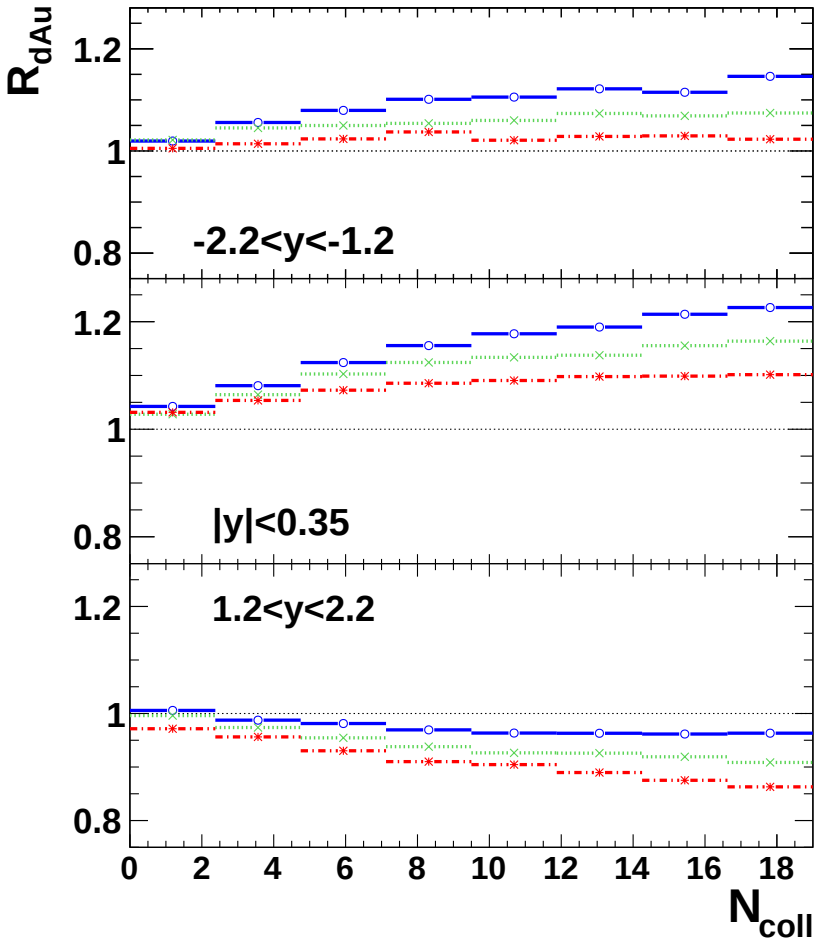
# Results for dAu collisions




- In blue, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

EKS

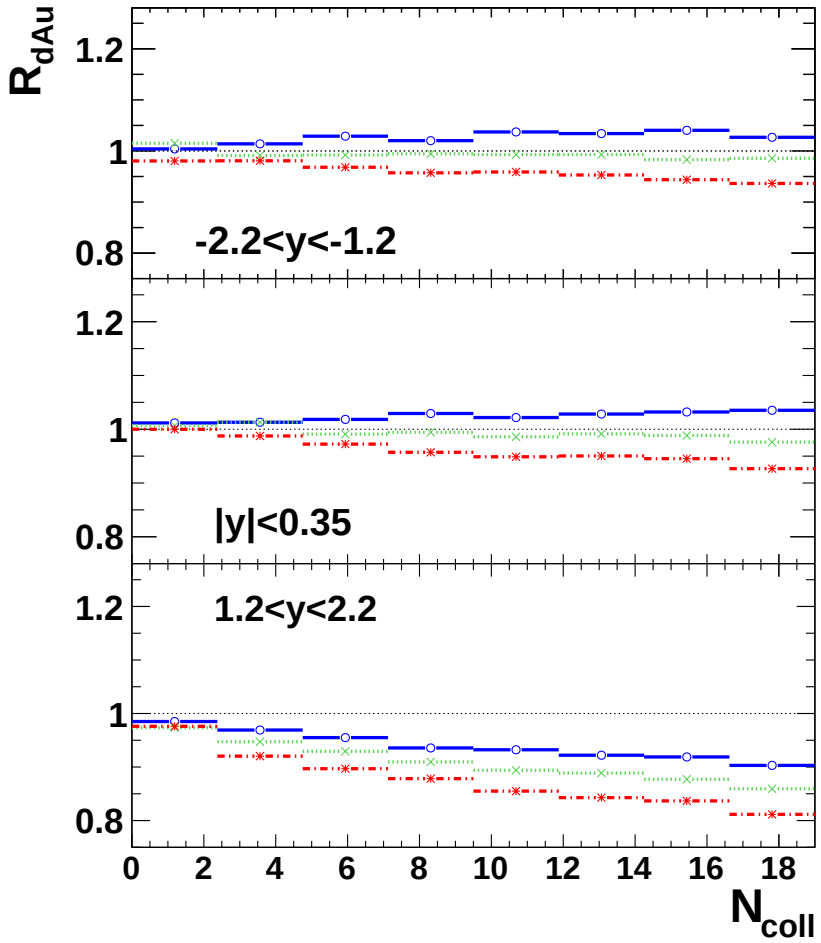
# Results for dAu collisions




- In blue, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

EPS

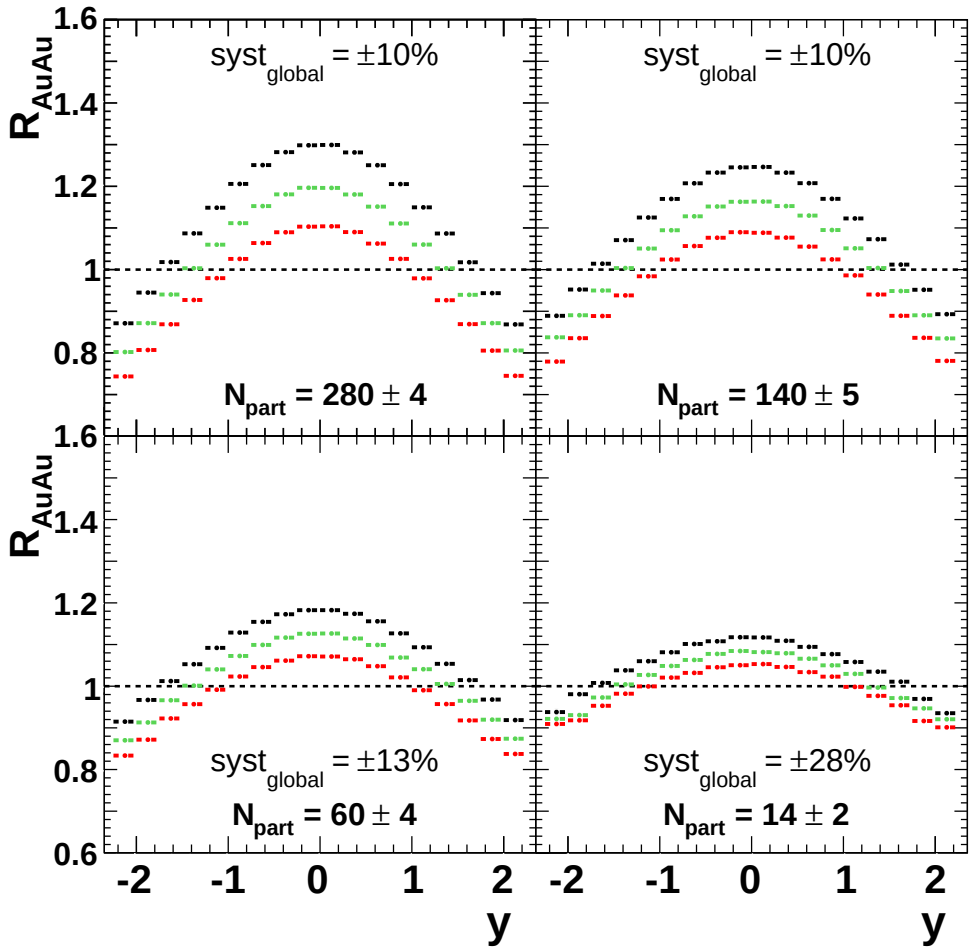
# Results for dAu collisions




- In blue, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

nDSg

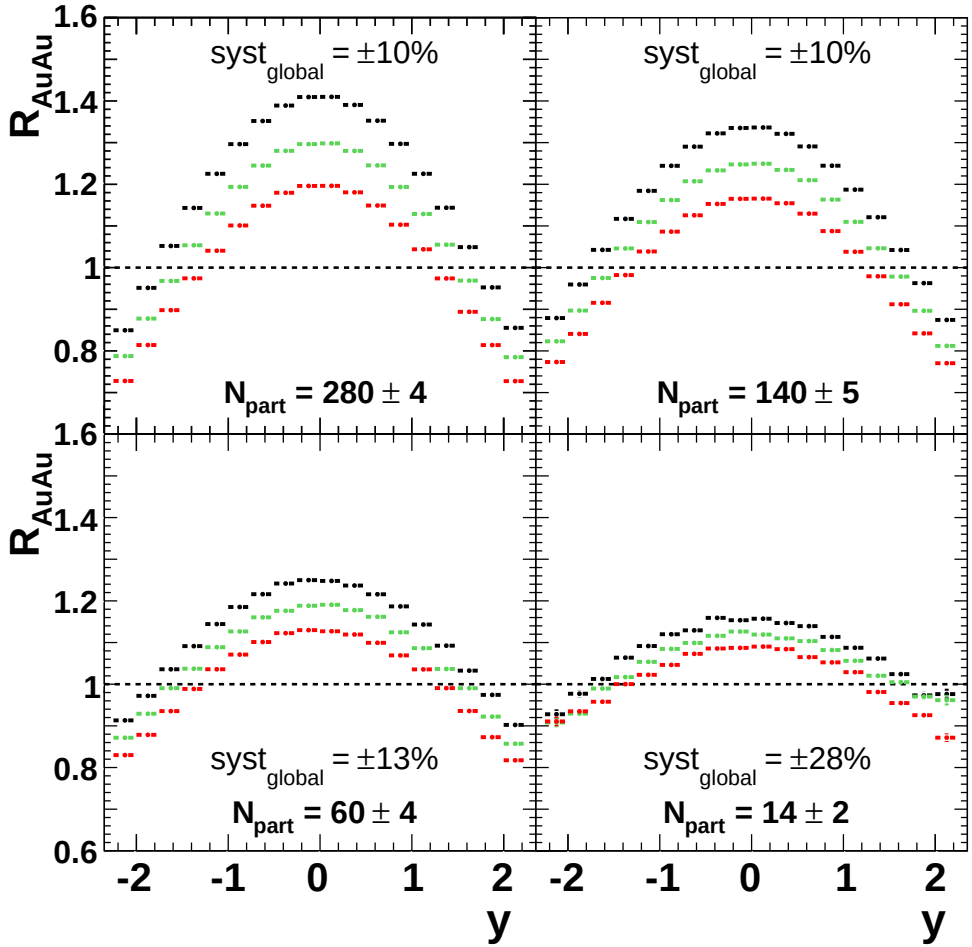
# Results for AuAu collisions




EKS

- In black, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

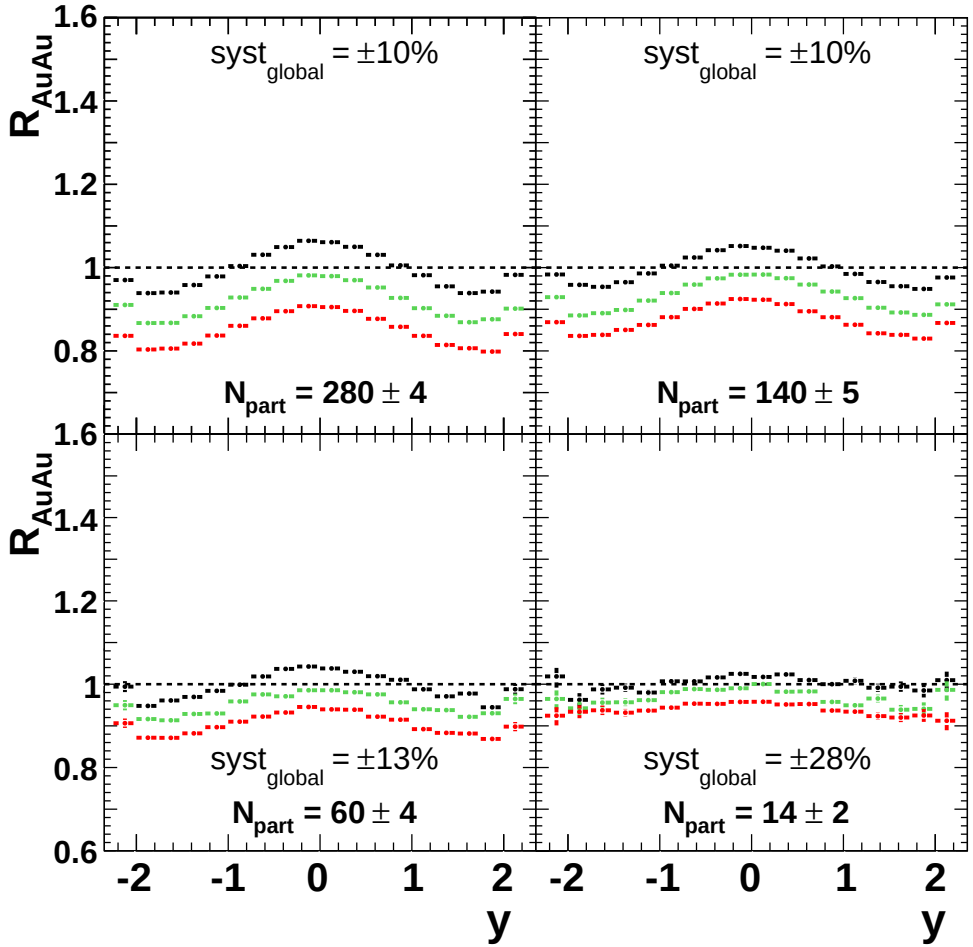
# Results for AuAu collisions




- In black, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

EPS

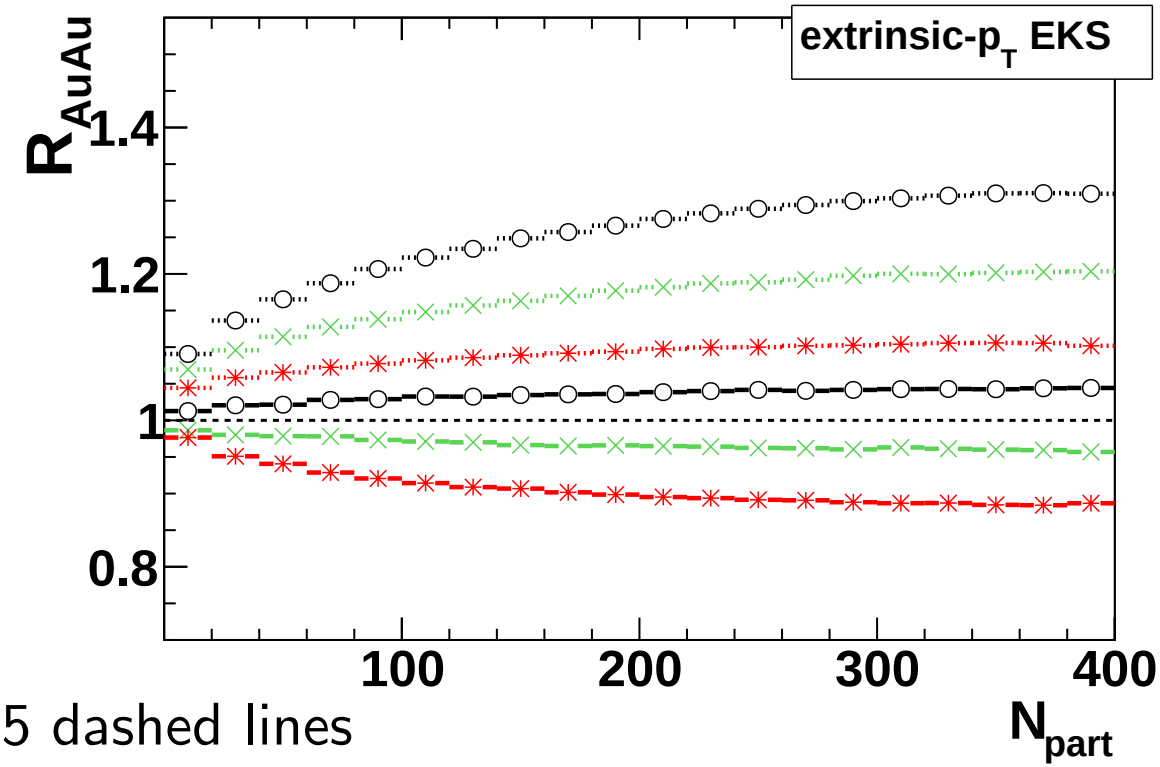
# Results for AuAu collisions




- In black, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

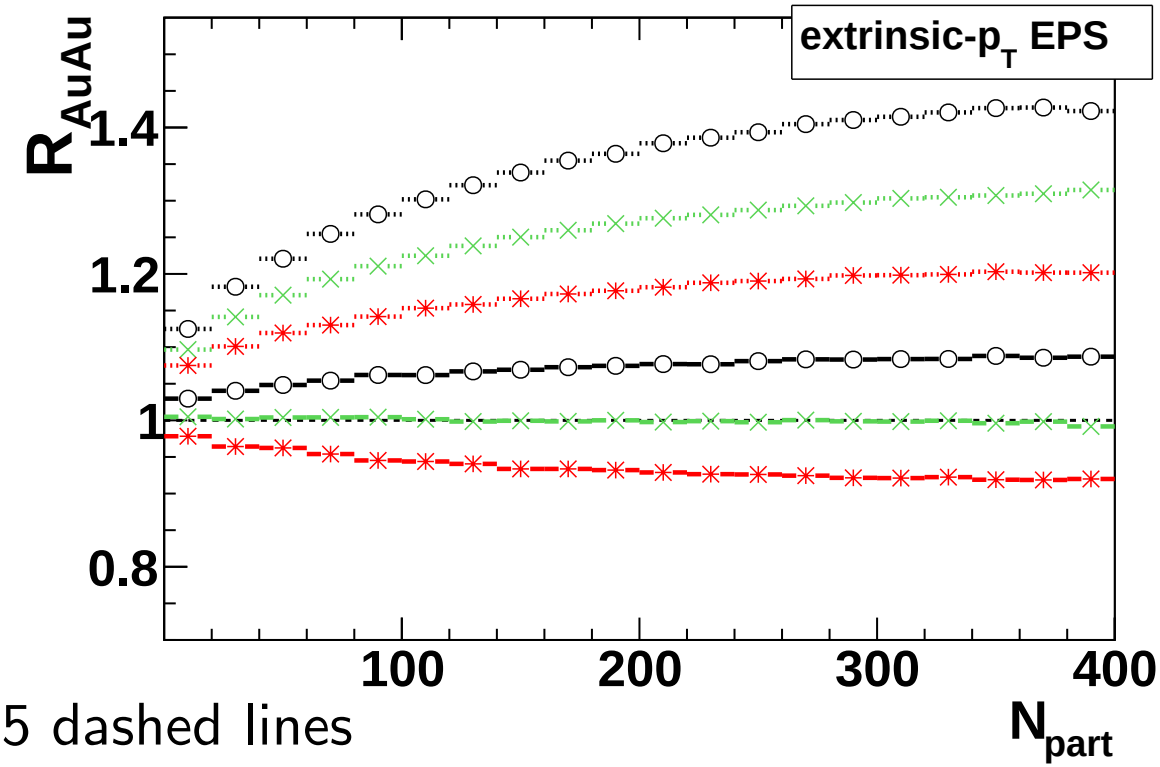
nDSg

# Results for AuAu collisions



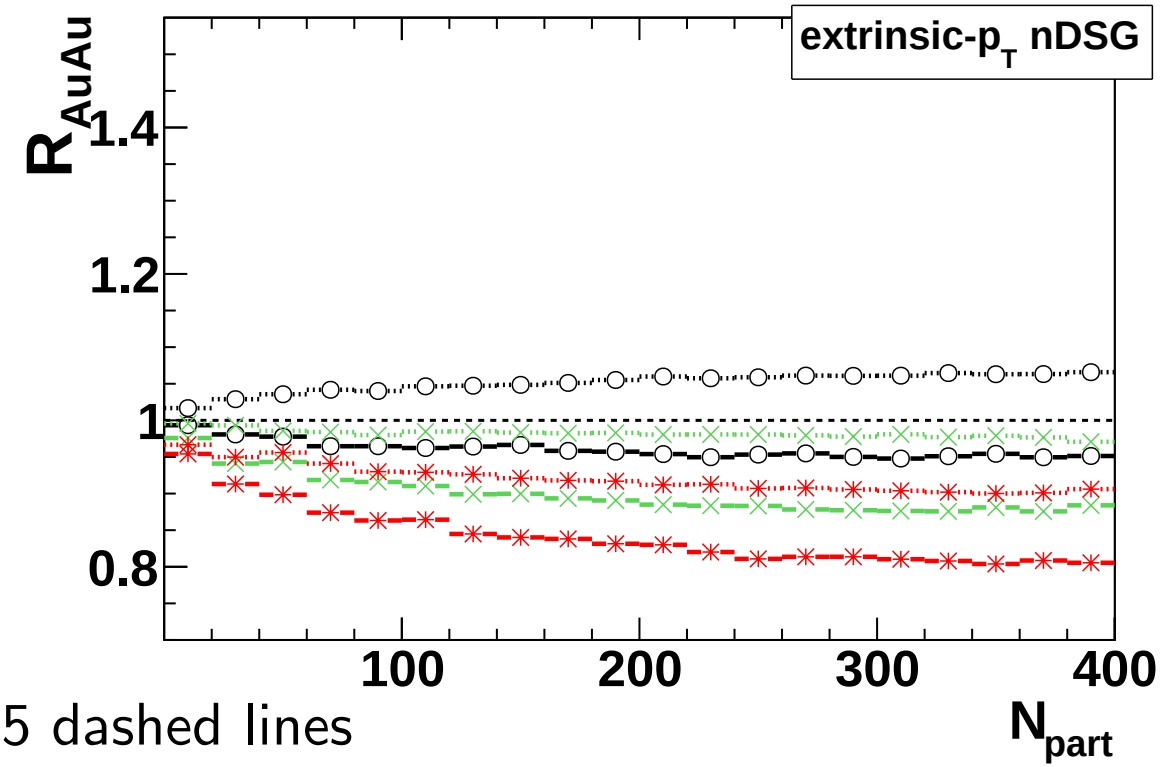

- $|y| < 0.35$ dashed lines
- $1.2 < y < 2.2$ solid lines
- In black, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

# Results for AuAu collisions




- $|y| < 0.35$ dashed lines
- $1.2 < y < 2.2$ solid lines
- In black, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

# Results for AuAu collisions




- $|y| < 0.35$ dashed lines
- $1.2 < y < 2.2$ solid lines
- In black, $\sigma_{abs} = 0.0$ mb
- In green, $\sigma_{abs} = 0.5$ mb
- In red, $\sigma_{abs} = 1.0$ mb

# Conclusions and perspectives

- Production of Upsilon sits in the antishadowing region at RHIC energy

# Conclusions and perspectives

- Production of Upsilon sits in the antishadowing region at RHIC energy
- Only very forward (backward) region shows $R_{dAU} < 1$ due to shadowing

# Conclusions and perspectives

- Production of Upsilon sits in the antishadowing region at RHIC energy
- Only very forward (backward) region shows $R_{dAU} < 1$ due to shadowing
- Within the commonly accepted $\sigma_{abs}$, one should expect an excess of $\Upsilon$

# Conclusions and perspectives

- Production of Upsilon sits in the antishadowing region at RHIC energy
- Only very forward (backward) region shows $R_{dAU} < 1$ due to shadowing
- Within the commonly accepted $\sigma_{abs}$, one should expect an excess of $\Upsilon$
- ... unless there is no antishadowing (see nDSg)