Sequential Regeneration of Charmonia in Heavy-Ion Collisions

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Strangeness in Quark Matter
Berkeley

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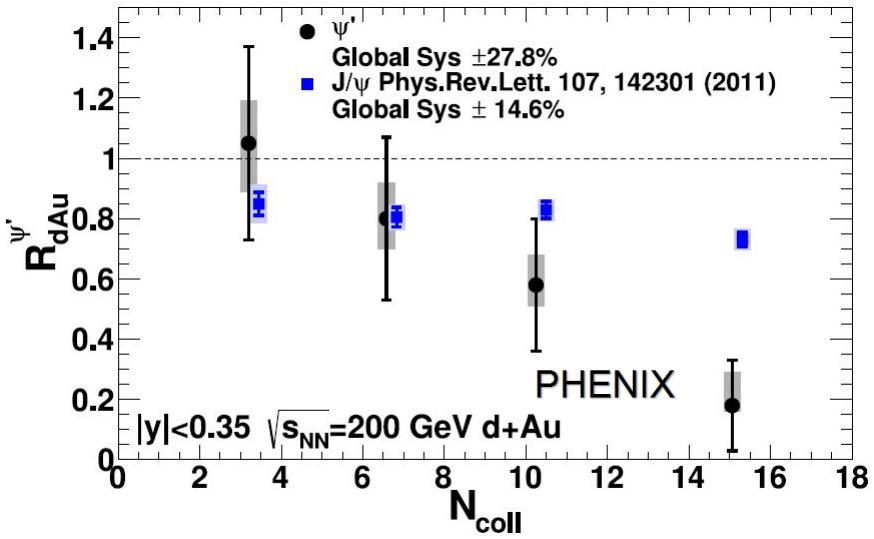
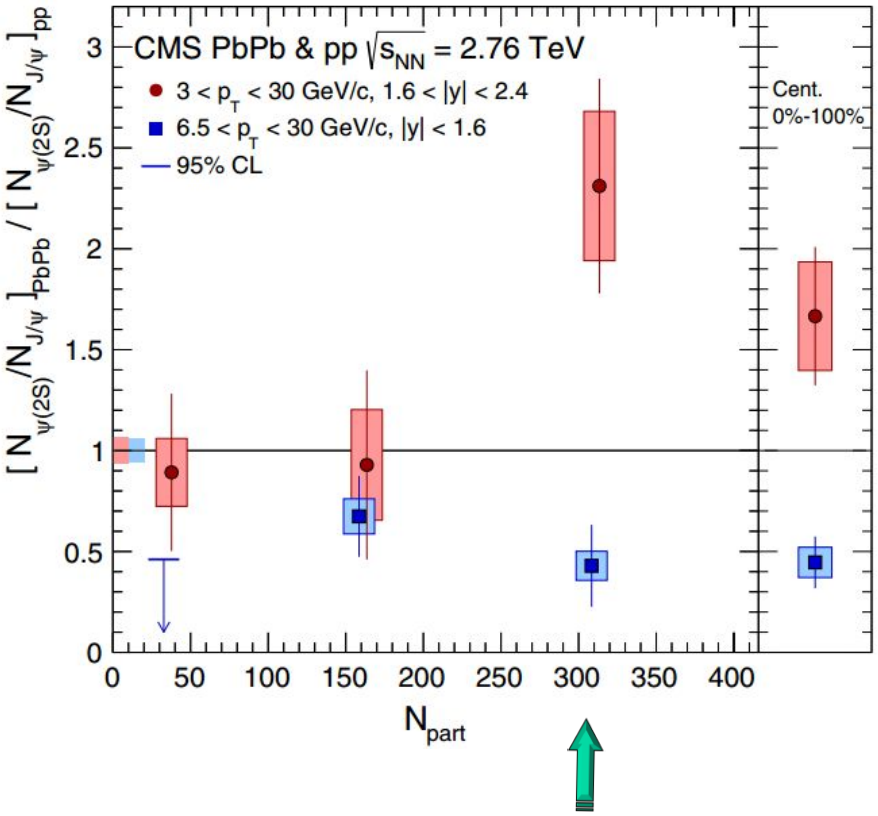
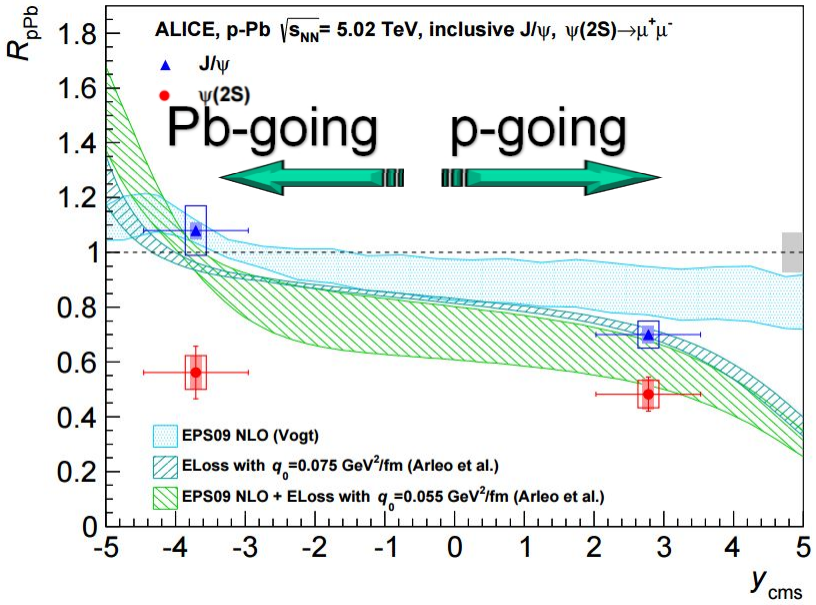
1. Introduction







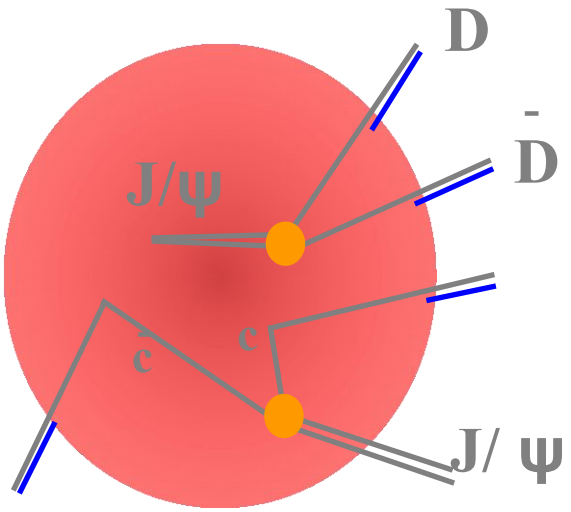
- Large Enhancement for ψ'

- Large Suppression for ψ'

2. Quarkonium Transport in Heavy-Ion Collisions

- **Rate Equation**

$$\frac{dN_\psi}{d\tau} = -\Gamma_\psi \left(N_\psi - N_\psi^{eq}\right)$$



- **Transport coefficients**

  Chemical relaxation rate Γ_Ψ

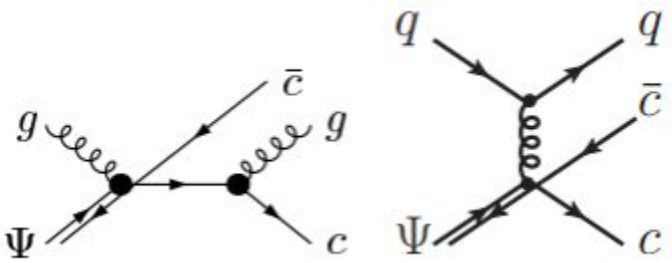
  Equilibrium limit N_Ψ^{eq}

- **Inelastic Reactions**

Hadronic dissociation:

$$J/\psi + \pi \rightarrow D + \bar{D}^* \,,\, \bar{D} + D^*$$
$$J/\psi + \rho \rightarrow D + \bar{D}$$
$$J/\psi + \rho \rightarrow D^* + \bar{D}^*$$

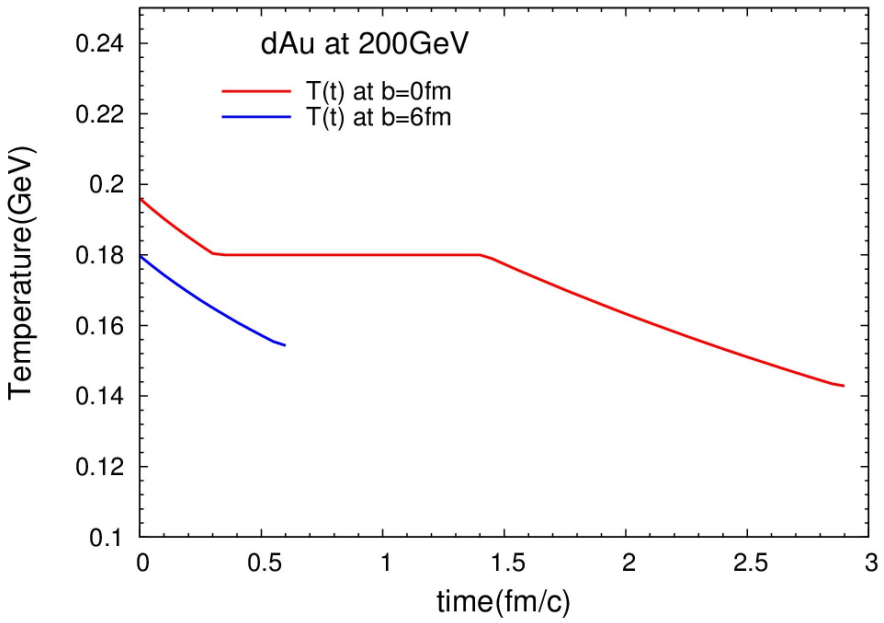
QGP dissociation: $J/\psi + q(g) \rightarrow c + \bar{c} + q(g)$



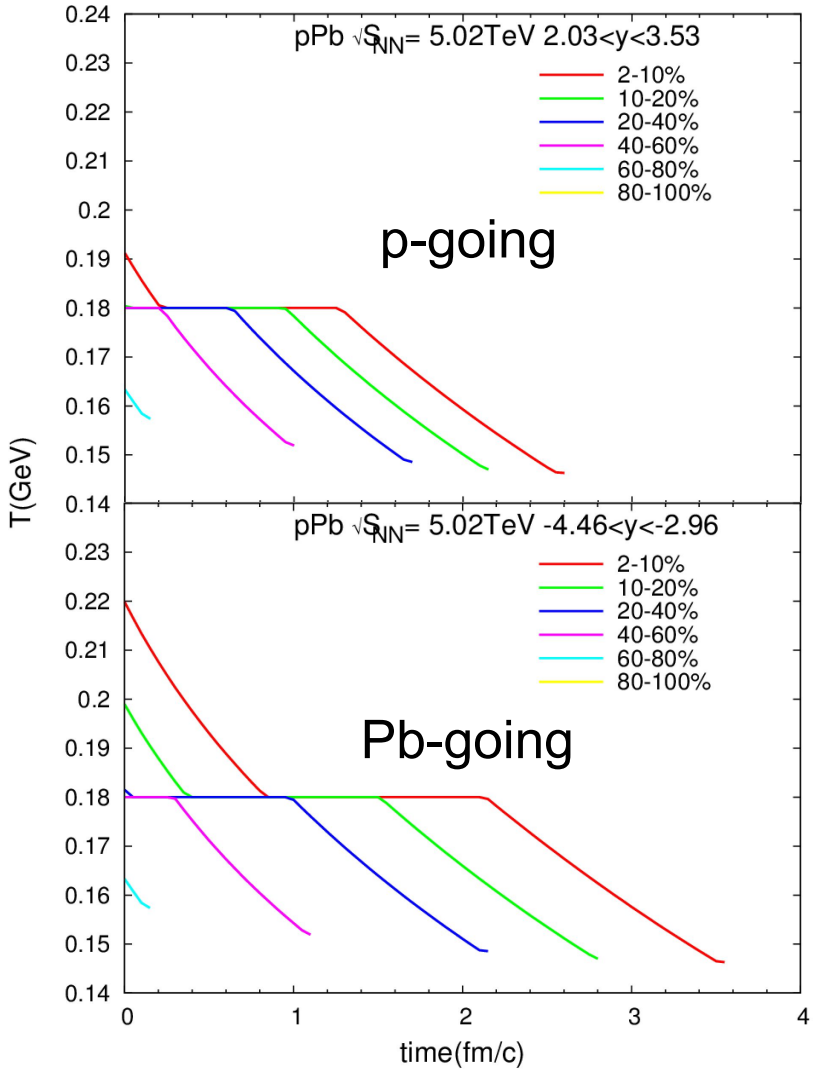
- **Evolve rate equation over expanding fireball evolution in heavy-ion collisions**

3.1 Fireball in pA/dA collisions

dAu at RHIC



pPb at LHC



- QGP formation time:

  AuAu RHIC~0.6fm

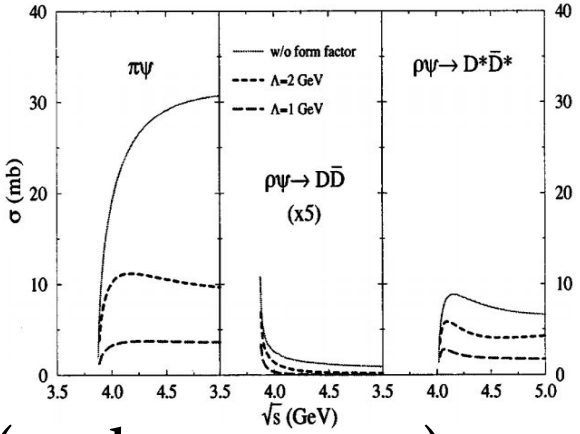
  dAu RHIC~0.9fm

  pPb LHC~0.9fm

3.2 Hadronic Dissociation Rates for Charmonia

- SU(4) meson-exchange model [Lin+Ko, PRC 62 (2000)]

$$J/\psi + \rho \to D + \bar{D}$$
$$J/\psi + \rho \to D^* + \bar{D}^*$$
$$J/\psi + \pi \to D + \bar{D}^*, \bar{D} + D^*$$

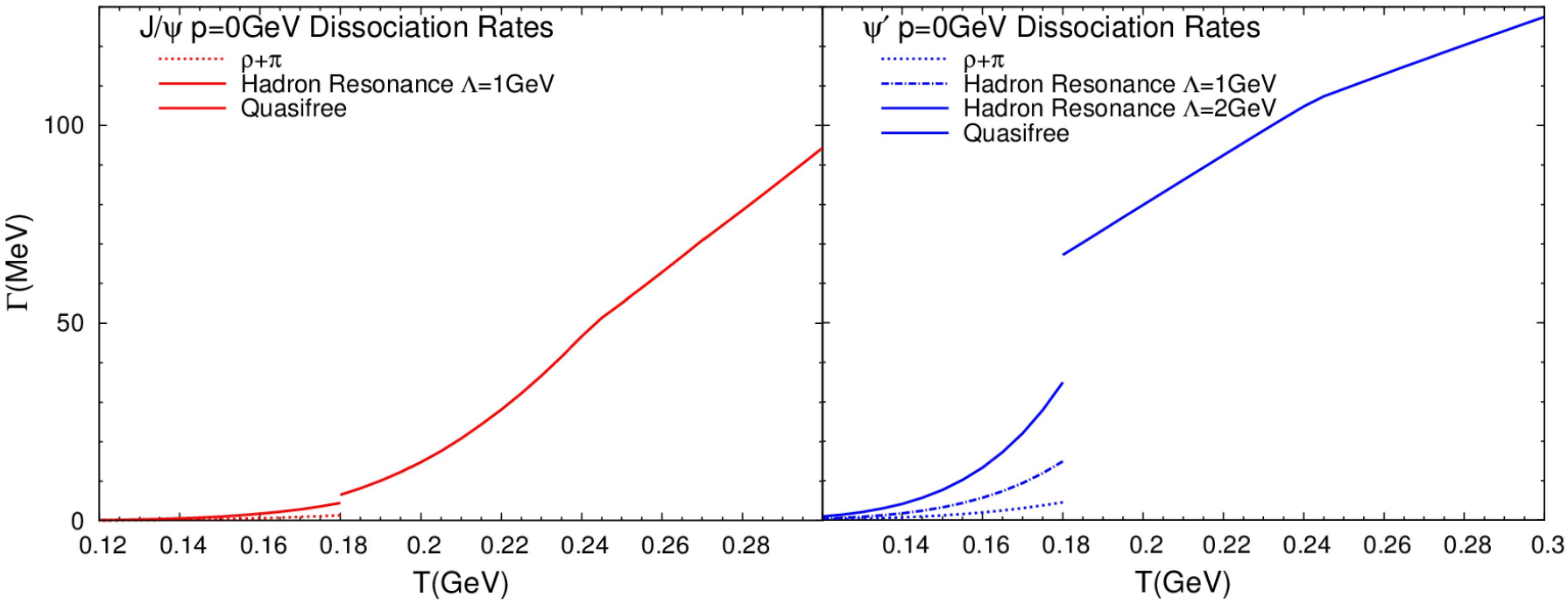


- Contributions from 52 mesons (no baryon yet)

$$\Gamma^{\rm diss}_{X+J/\psi}(T) = \int \frac{d^3k}{(2\pi)^3} f^X(E_X(k);T)\sigma^{\rm in}_{X+J/\psi}(s, s^X_{\rm thr})v_{\rm rel}$$

- Rate scaled by geometric size from J/ψ to ψ'

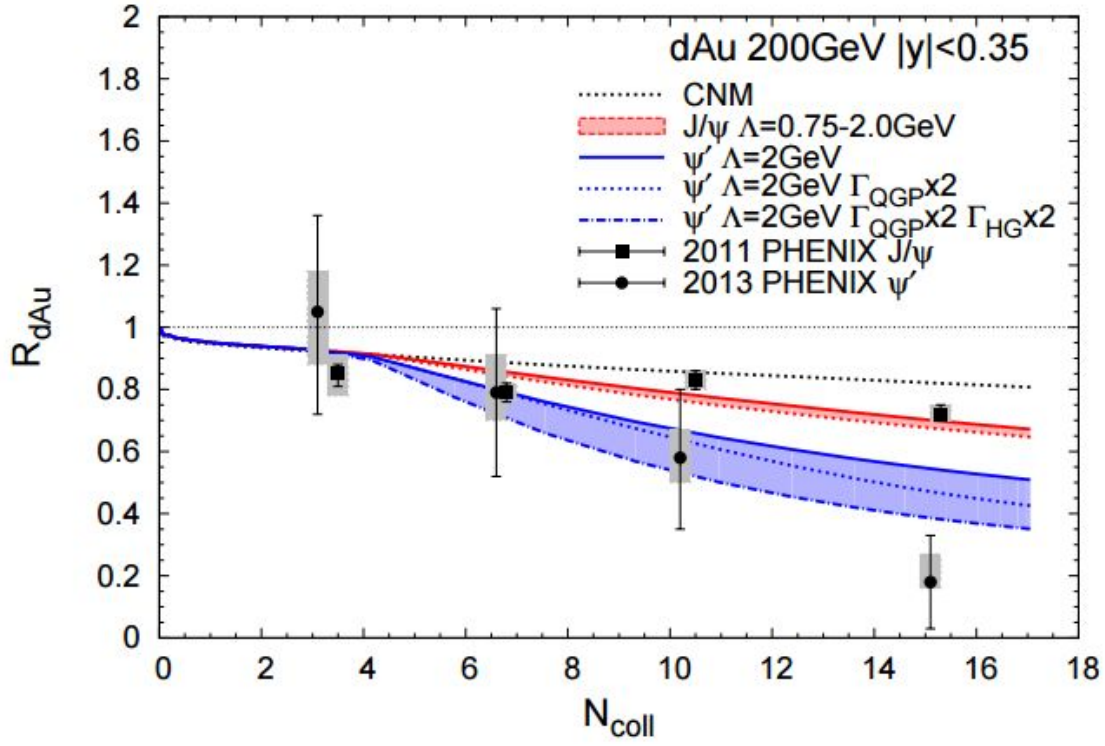
3.2 Dissociation Rates for Charmonia



- Small hadronic rate for J/ψ
- Sizeble hadronic rate for ψ'

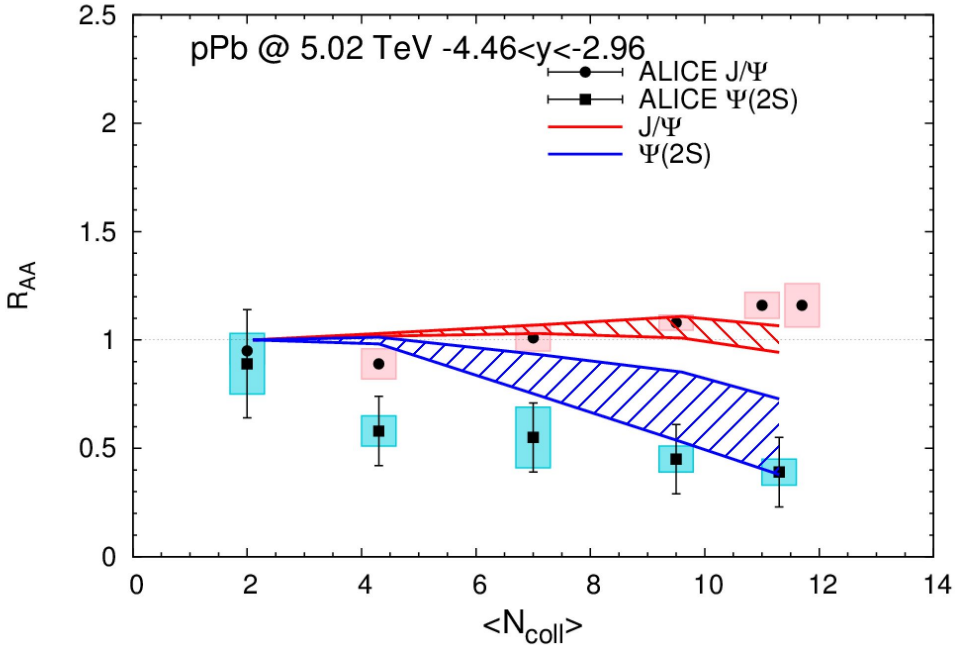
Du+Rapp, NPA 943 (2015)

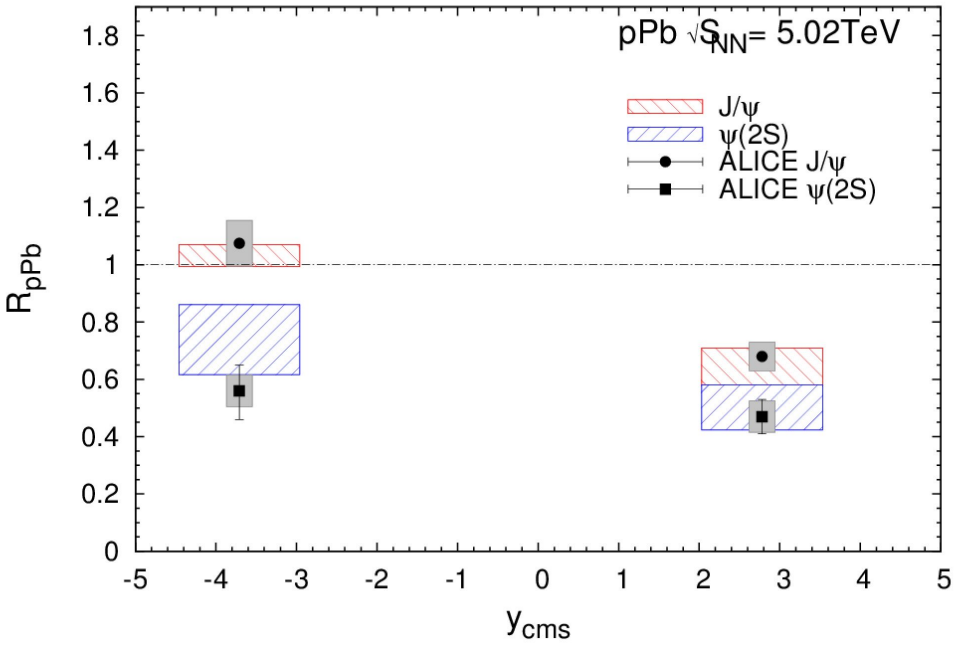
3.3 Charmonia in dAu at RHIC



- For J/ψ, hadronic rate negligible
- For ψ', both QGP and hadronic rates relevant

3.3 Charmonia in pPb at LHC

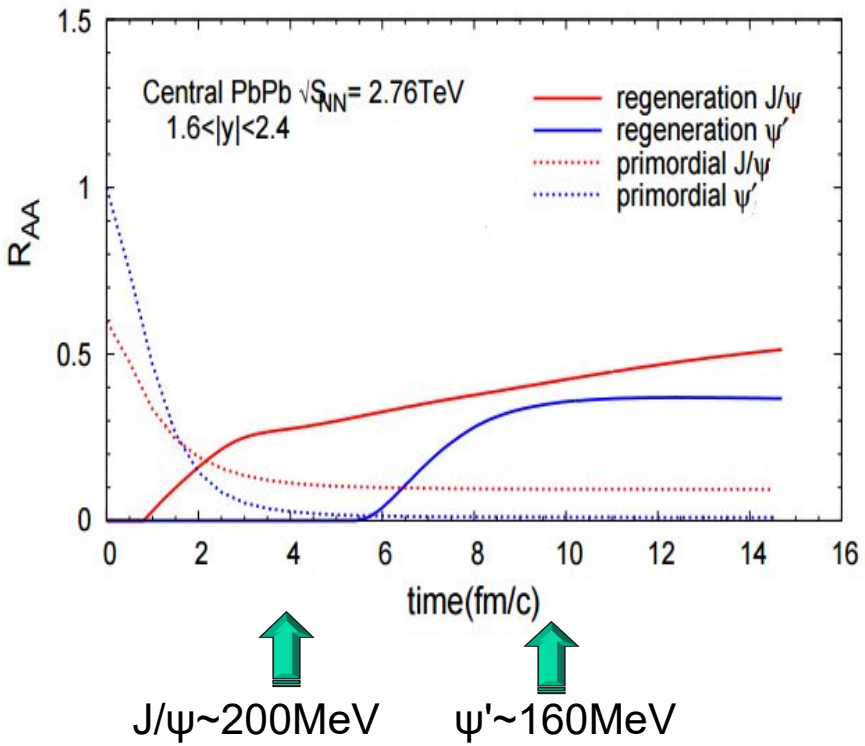




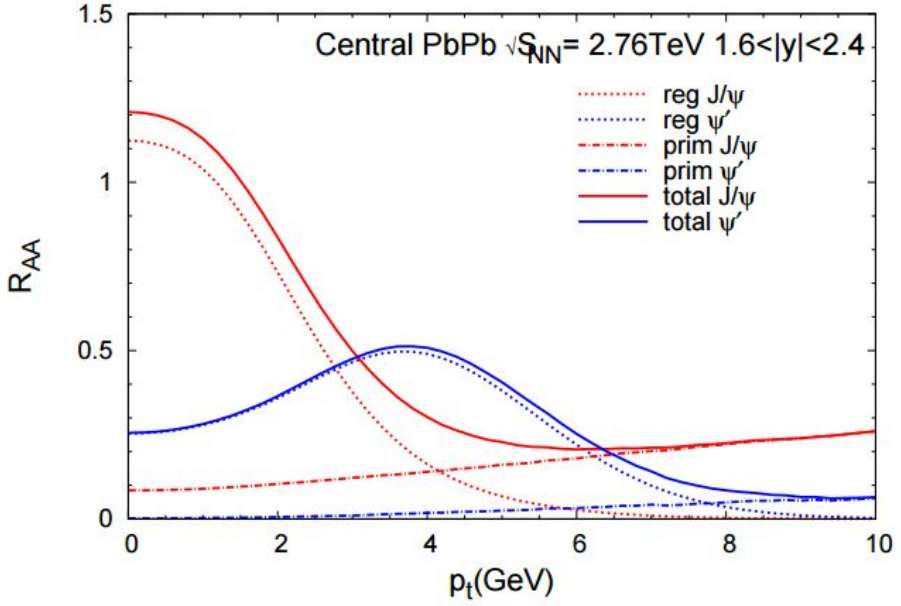
- ψ' much more suppressed than J/ψ due to hot medium

4.1 Charmonia in PbPb collision: Sequential regeneration

RAA time evolution



p_T dependent RAA



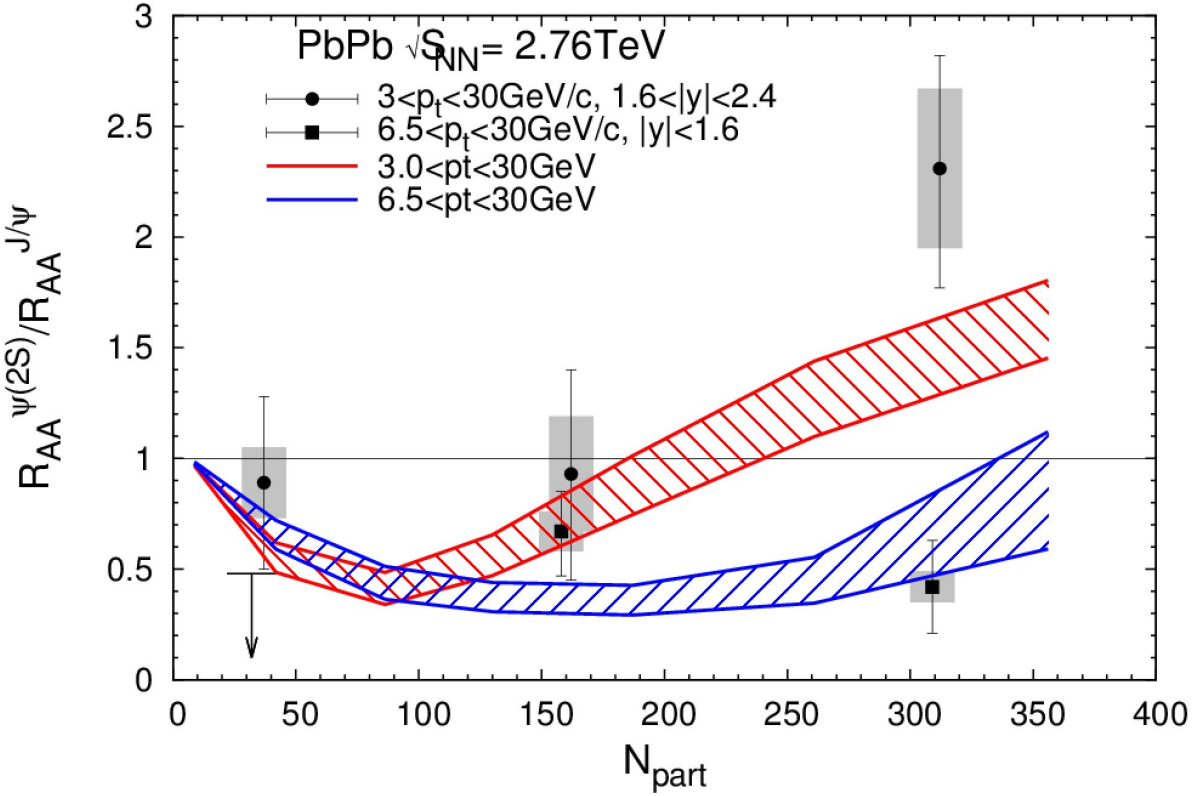
- ψ' regenerated later than J/ψ
- blastwave description for J/ψ and ψ':

$$\frac{dN^{reg}}{p_t dp_t} = N_0(b) m_t \int_0^R r dr K_1\left(\frac{m_t ch\rho(r)}{T}\right) I_0\left(\frac{p_t sh\rho(r)}{T}\right)$$

- Flow pushes ψ' to higher p_T

4.2 Sequential regeneration of charmonia and the ψ' puzzle

Rate Equation+Fireball Approach



- Trend of sequential regeneration caluclation consistent with data

5. Conclusion

- Revisited hadronic dissociation rates of charmonia, including more complete set of reactions

- Larger hadronic dissociation rate for ψ' generates larger suppression of ψ' than J/ψ in dA/pA collisions

- Sequential regeneration mechanism with large hadronic rate can qualitatively explain the enhanced ψ' over J/ψ double ratio in PbPb

Thanks!