CME FROM CHIRAL VISCOUS HYDRODYNAMICS

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in cooperation with:

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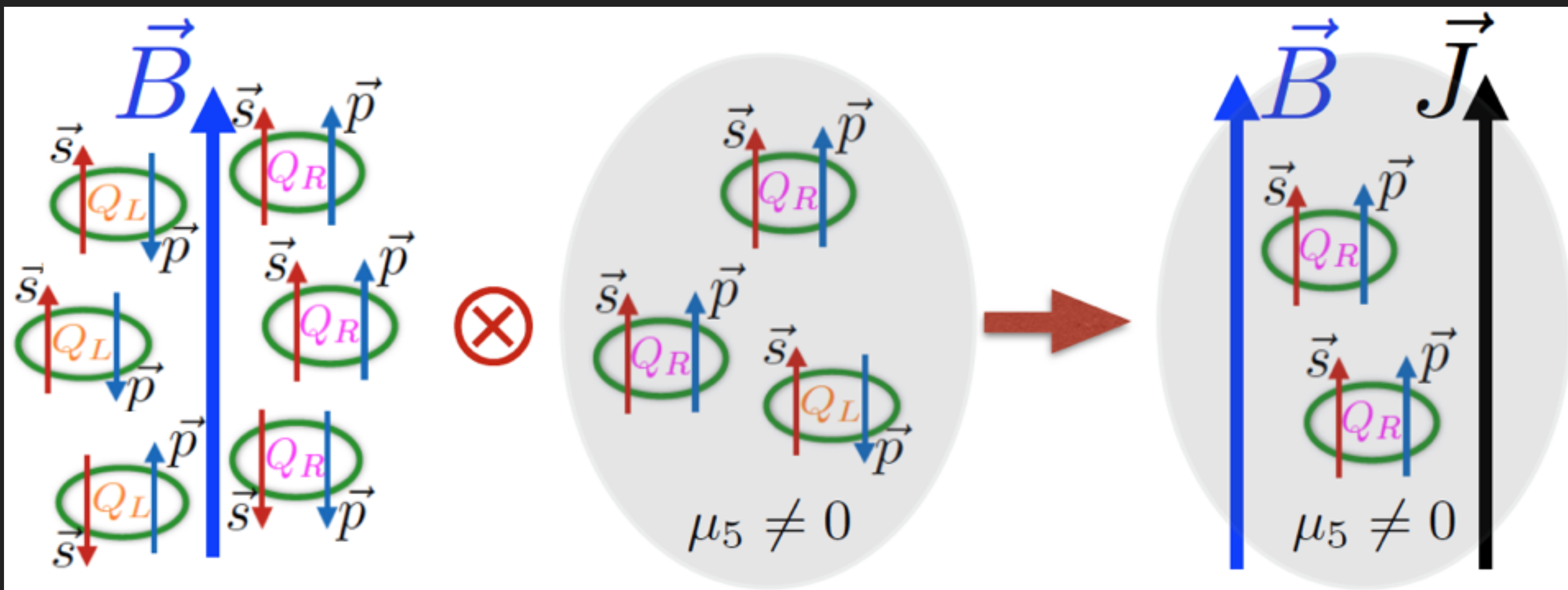
Outline

- How do we study CME quantitatively
- How do different parameters affect CME:
  - viscous parameters
  - axial charge initial condition
  - B field lifetime

Chiral Magnetic Effect



Chiral Magnetic Effect

- B field + μ_A $\Rightarrow$ charge separation

$$dN_{\pm}/d\phi \propto 1 + 2\, a_{1\pm} \sin(\phi - \psi_{RP}) + \ldots$$

- charge separation $\Rightarrow$ two particle correlation

$$\gamma_{\alpha\beta} = \langle \cos(\phi_i + \phi_j - 2\psi_{RP}) \rangle_{\alpha\beta} = \kappa\, v_2\, F - H$$

$$\delta_{\alpha\beta} = \langle \cos(\phi_i - \phi_j) \rangle_{\alpha\beta} = F + H$$

F: Flow Driven Background

H: Possible CME Signal

Chiral Magnetic Effect

- B field + μ_A $\Rightarrow$ charge se

  $dN_{\pm}/d\phi \propto 1 + 2\, a_{1\pm}$ si

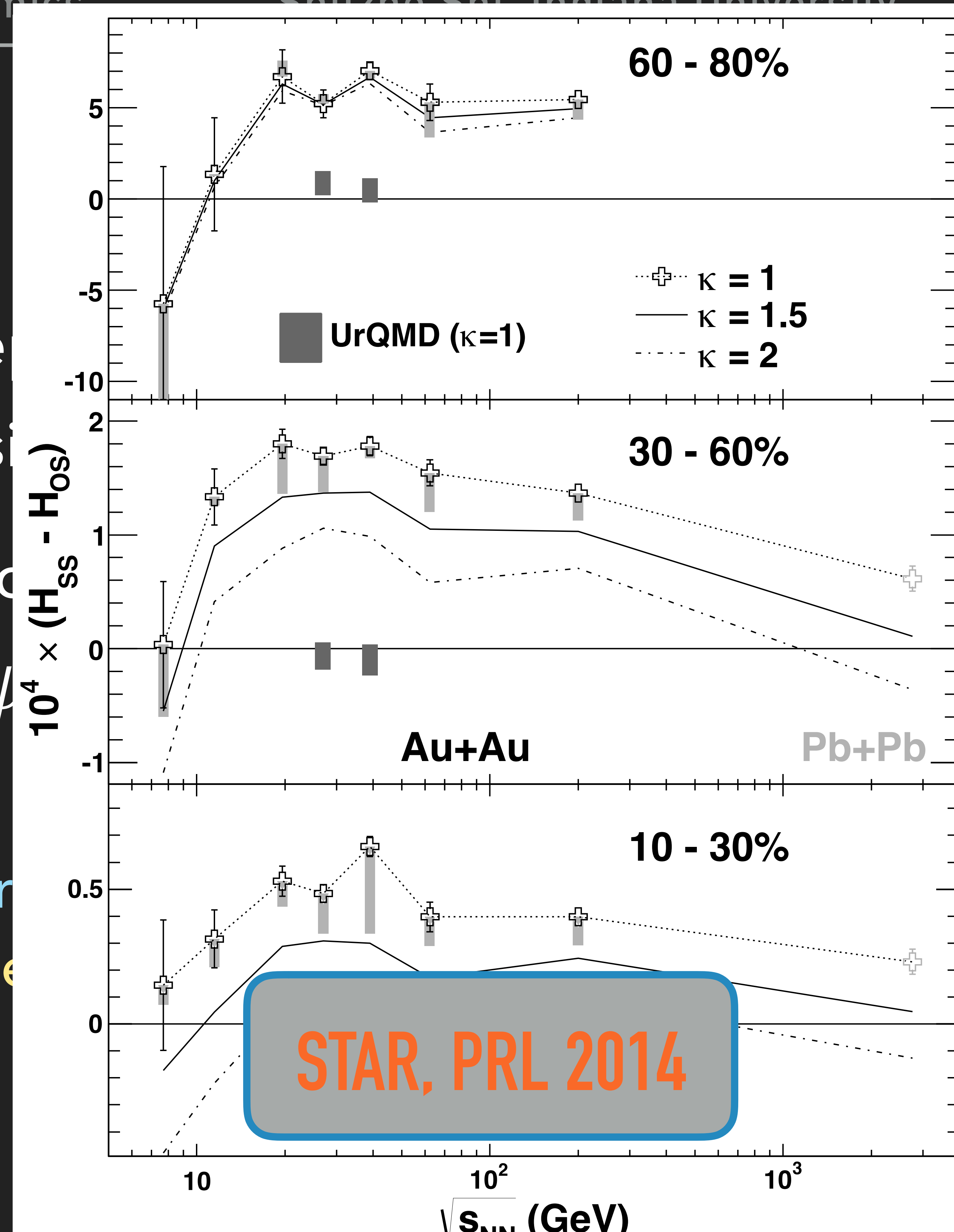
- charge separation $\Rightarrow$ two

  $\gamma_{\alpha\beta} = \langle \cos(\phi_i + \phi_j - 2\psi$

  $\delta_{\alpha\beta} = \langle \cos(\phi_i - \phi_j) \rangle_{\alpha\beta}$

  F: Flow Dr

  H: Possible



Chiral Magnetic Effect

- B field + μ_A $\Rightarrow$ charge se

  $dN_\pm/d\phi \propto 1 + 2\, a_{1\pm} \sin$

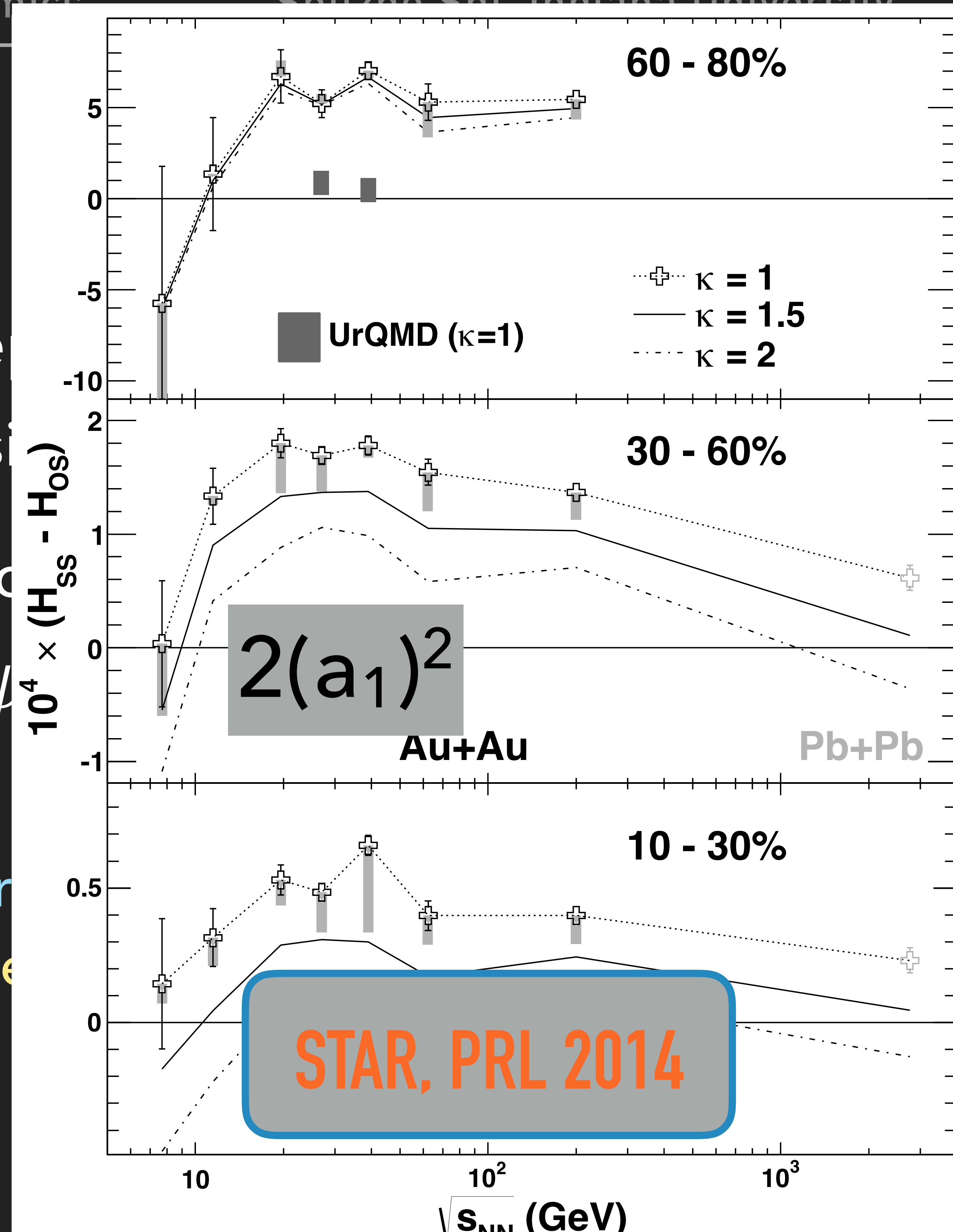
- charge separation $\Rightarrow$ two

  $\gamma_{\alpha\beta} = \langle \cos(\phi_i + \phi_j - 2\psi$

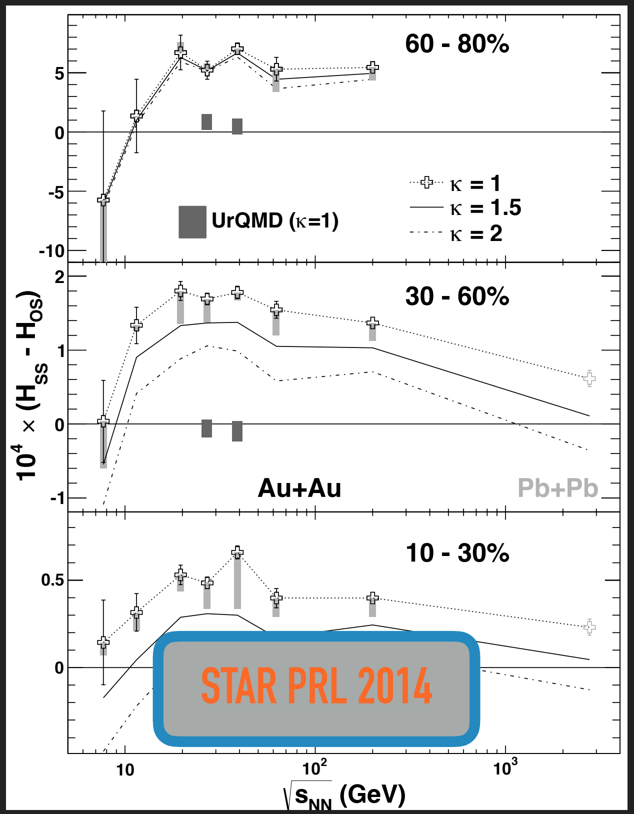
  $\delta_{\alpha\beta} = \langle \cos(\phi_i - \phi_j) \rangle_{\alpha\beta}$

F: Flow Dr

H: Possible



How can we calculate CME quantitatively?



axial & vector charge density

initial condition

\+

driving force

B field

chiral viscous hydro

dynamical evolution

final particle distribution

Anomalous Viscous Hydro

$$D_\mu J_R{}^\mu = +\frac{N_c q^2}{4\pi^2} E_\mu B^\mu \qquad D_\mu J_L{}^\mu = -\frac{N_c q^2}{4\pi^2} E_\mu B^\mu$$

$$J_R{}^\mu = n_R\, u^\mu + \nu_R{}^\mu + \frac{\sigma}{2} E^\mu + \frac{N_c q}{4\pi^2} \mu_R\, B^\mu$$

$$J_L{}^\mu = n_L\, u^\mu + \nu_L{}^\mu + \frac{\sigma}{2} E^\mu - \frac{N_c q}{4\pi^2} \mu_L\, B^\mu$$

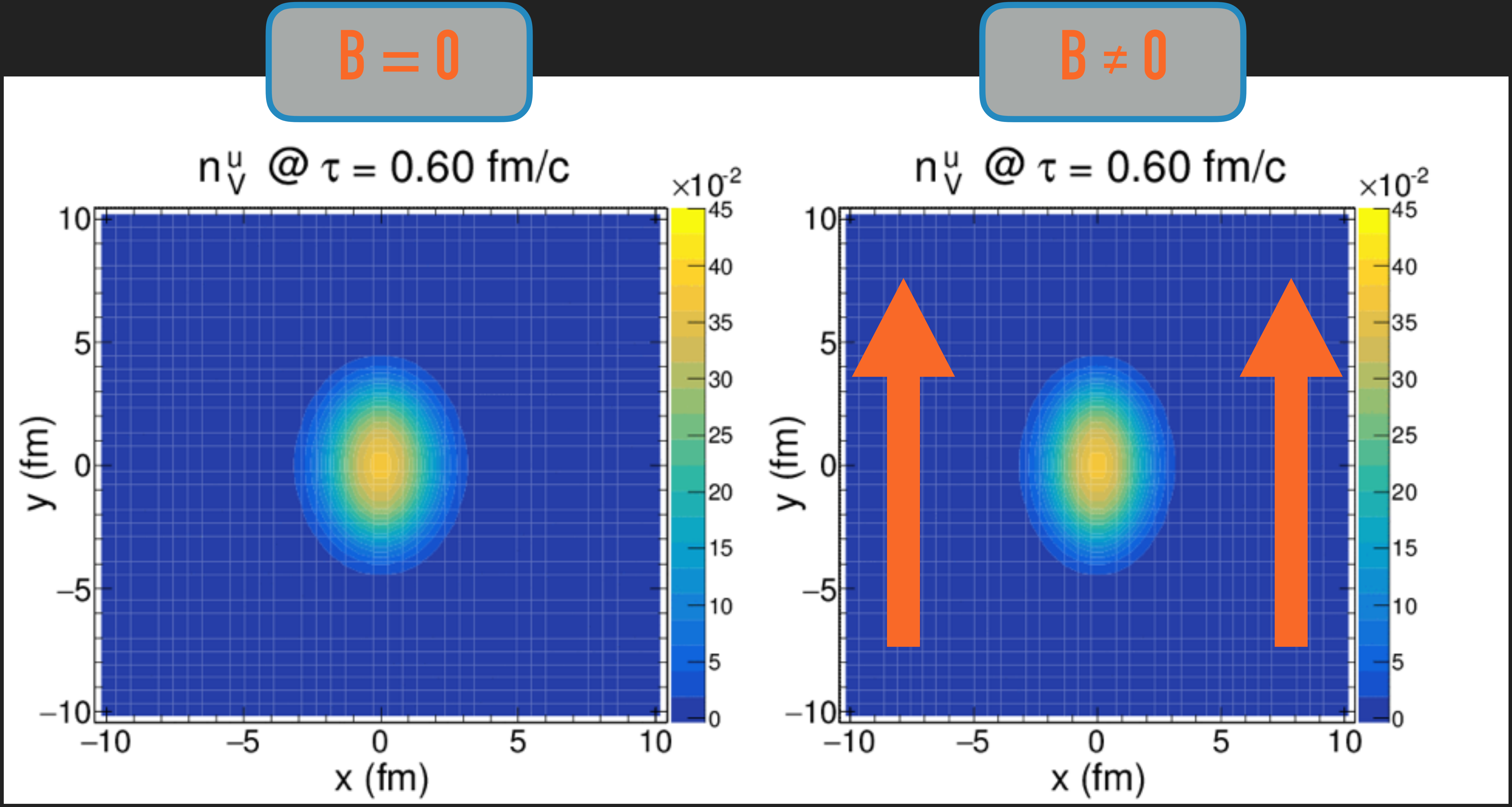
CME

$$d\, \nu_{R,L}{}^\mu = (\nu_{NS}{}^\mu - \nu_{R,L}{}^\mu) / \tau_{rlx}$$

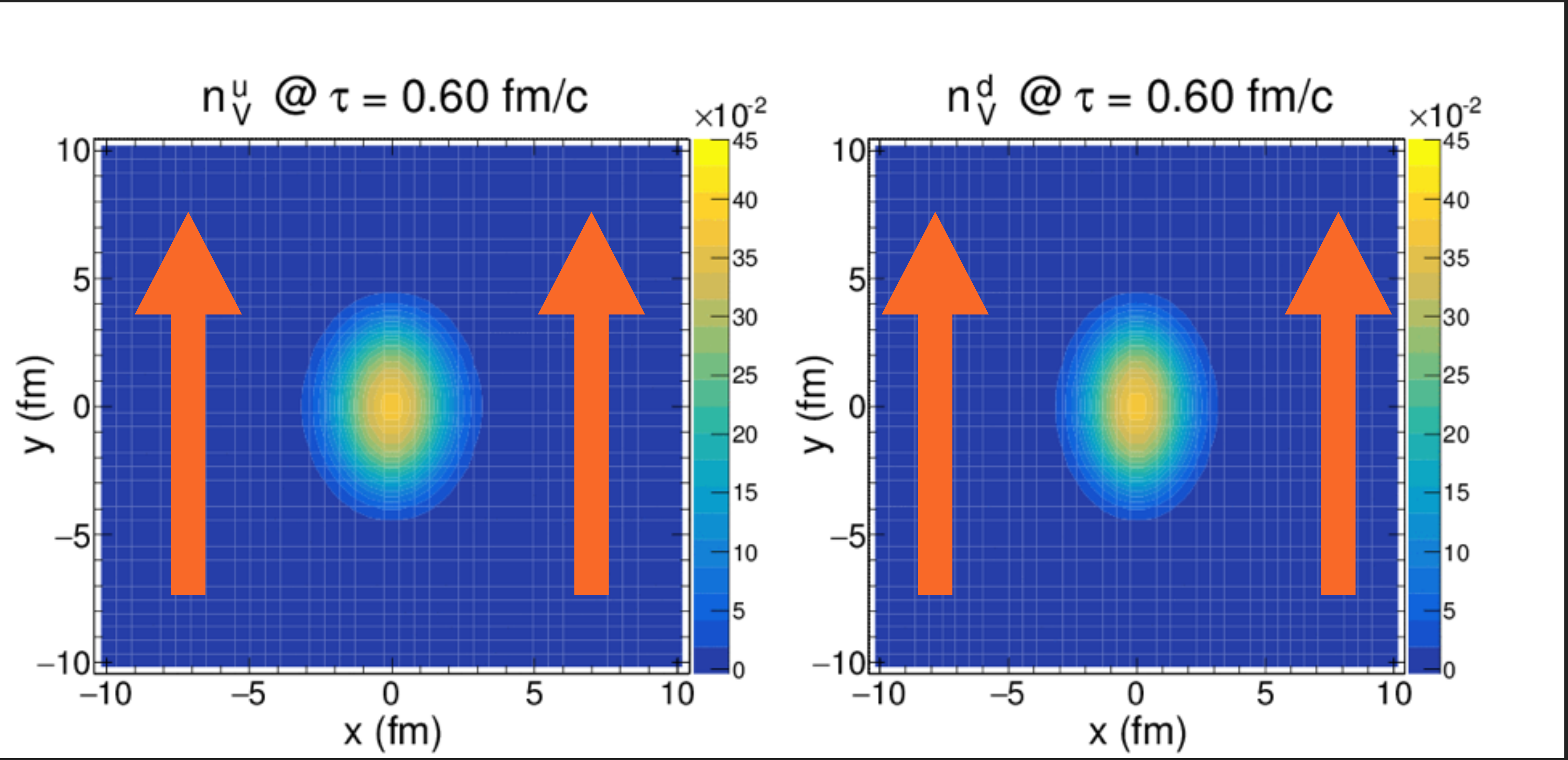
on top of 2+1D VISHNew—– OSU Group

$$D_\mu T^{\mu\nu} = 0 \qquad n = 0$$

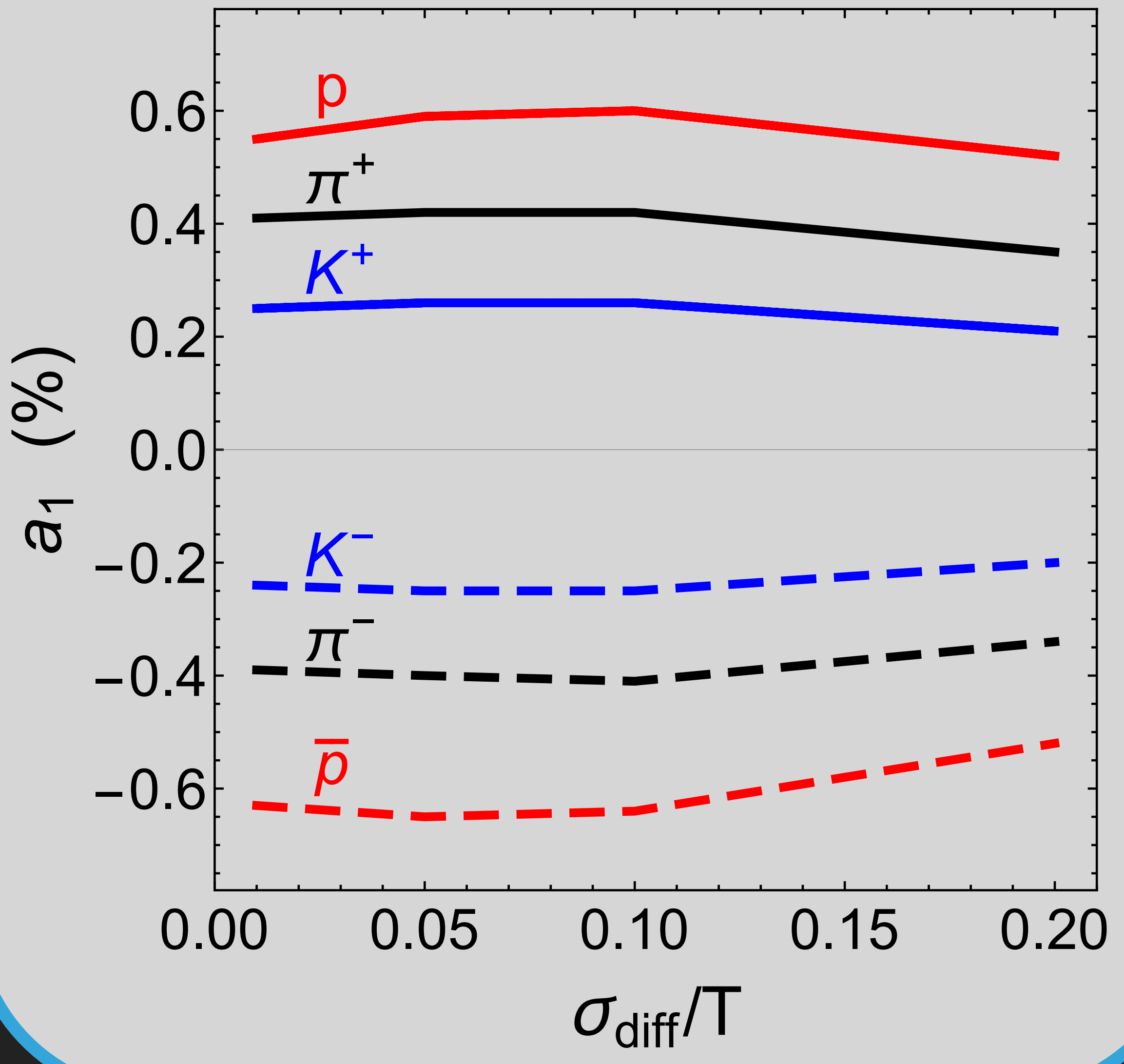
Evolution of number density

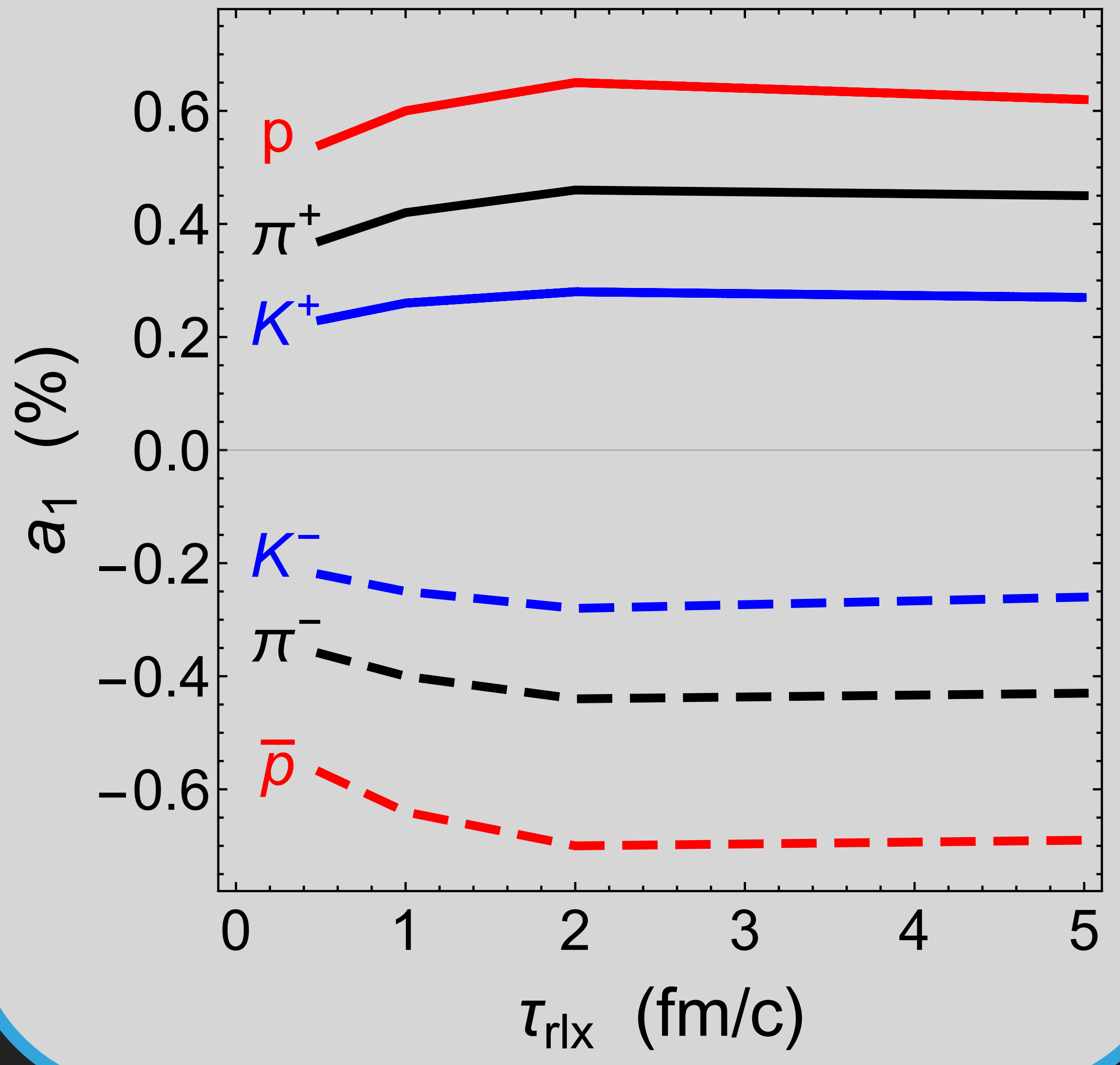


Evolution of number density

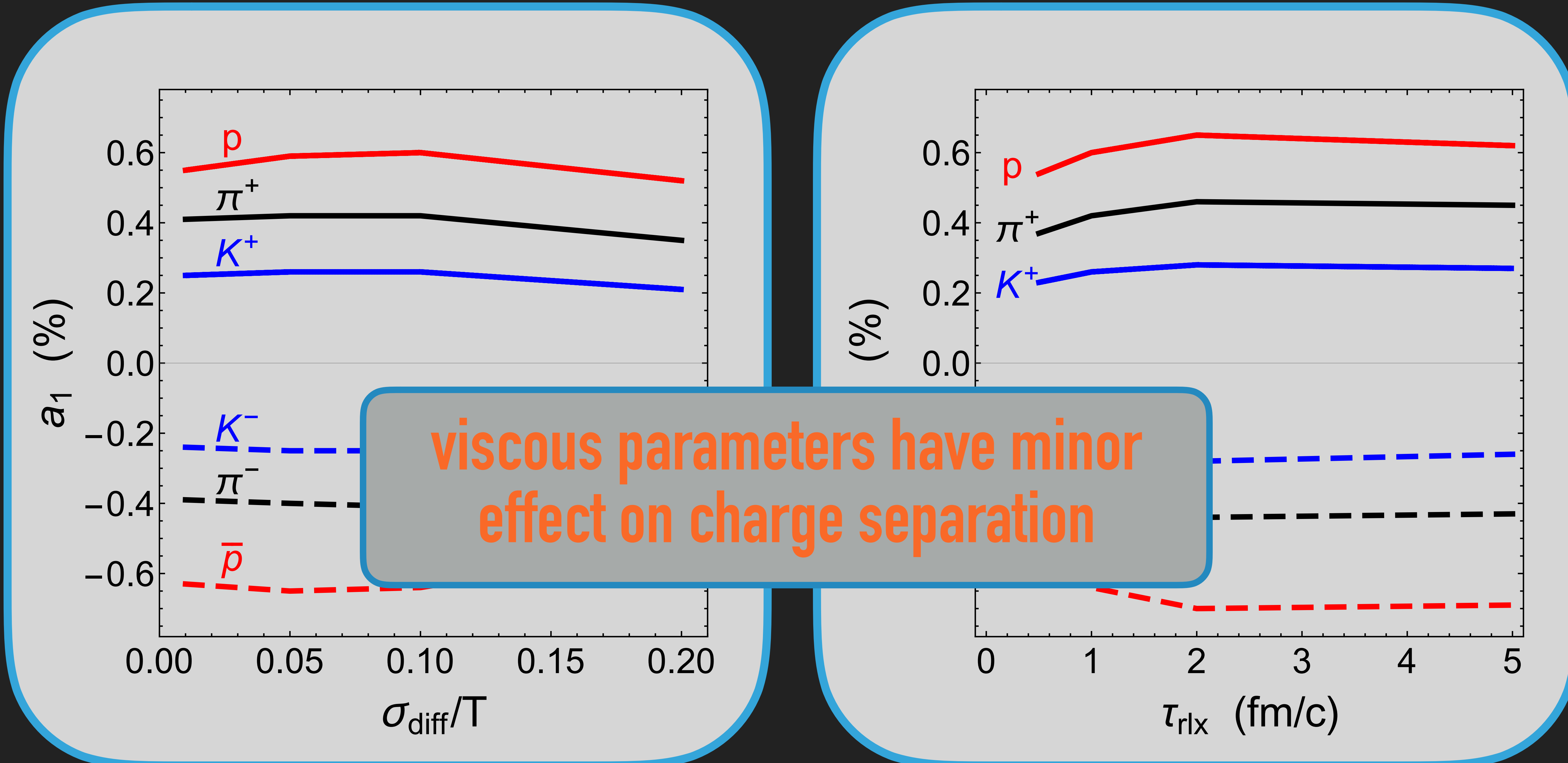


Dependence on Viscous Parameters





Dependence on Viscous Parameters

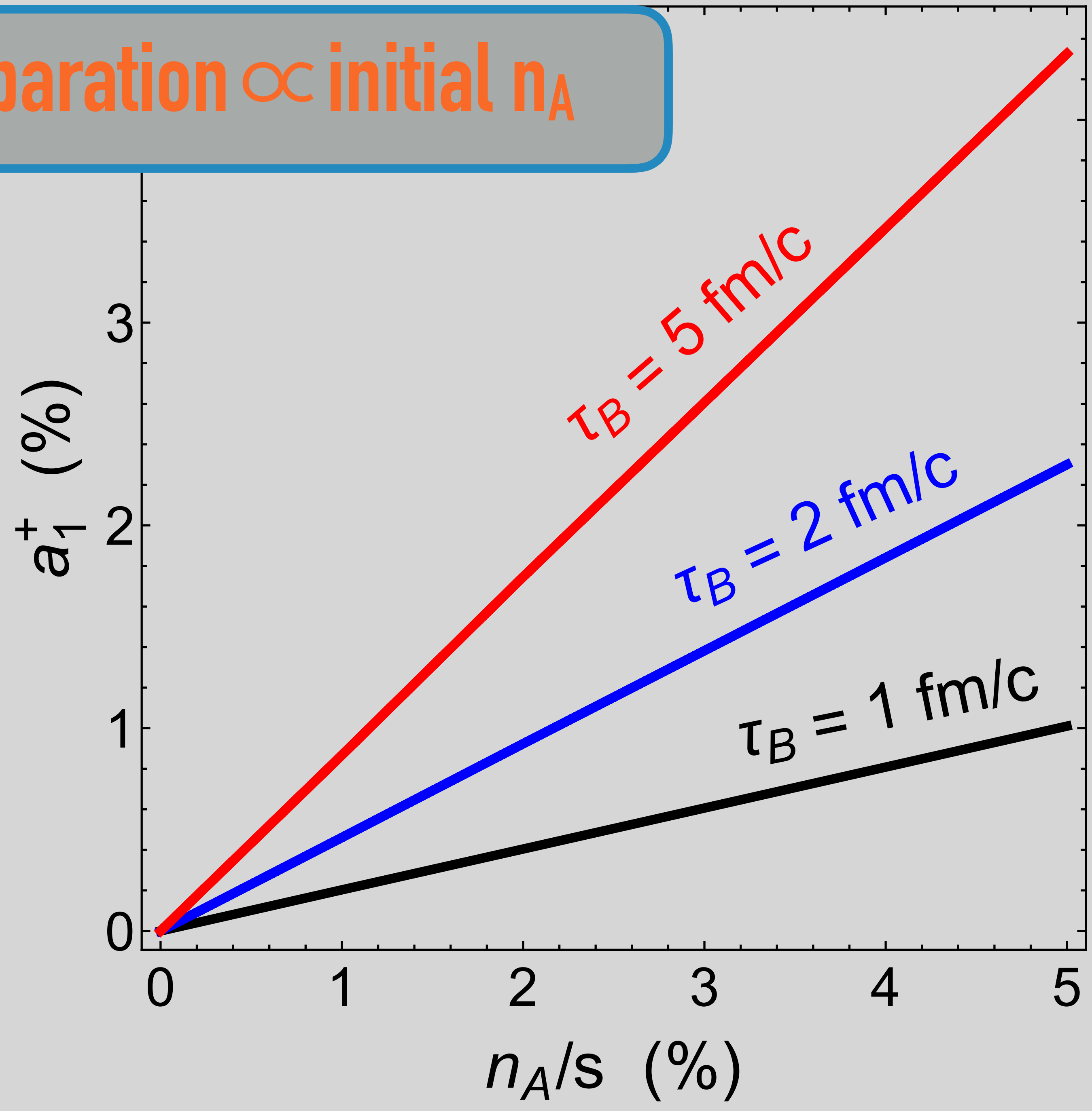


viscous parameters have minor effect on charge separation

Dependence on Initial n_A

$$B = \frac{B_0}{1+(\tau/\tau_B)^2}$$

Charge separation ∝ initial n_A

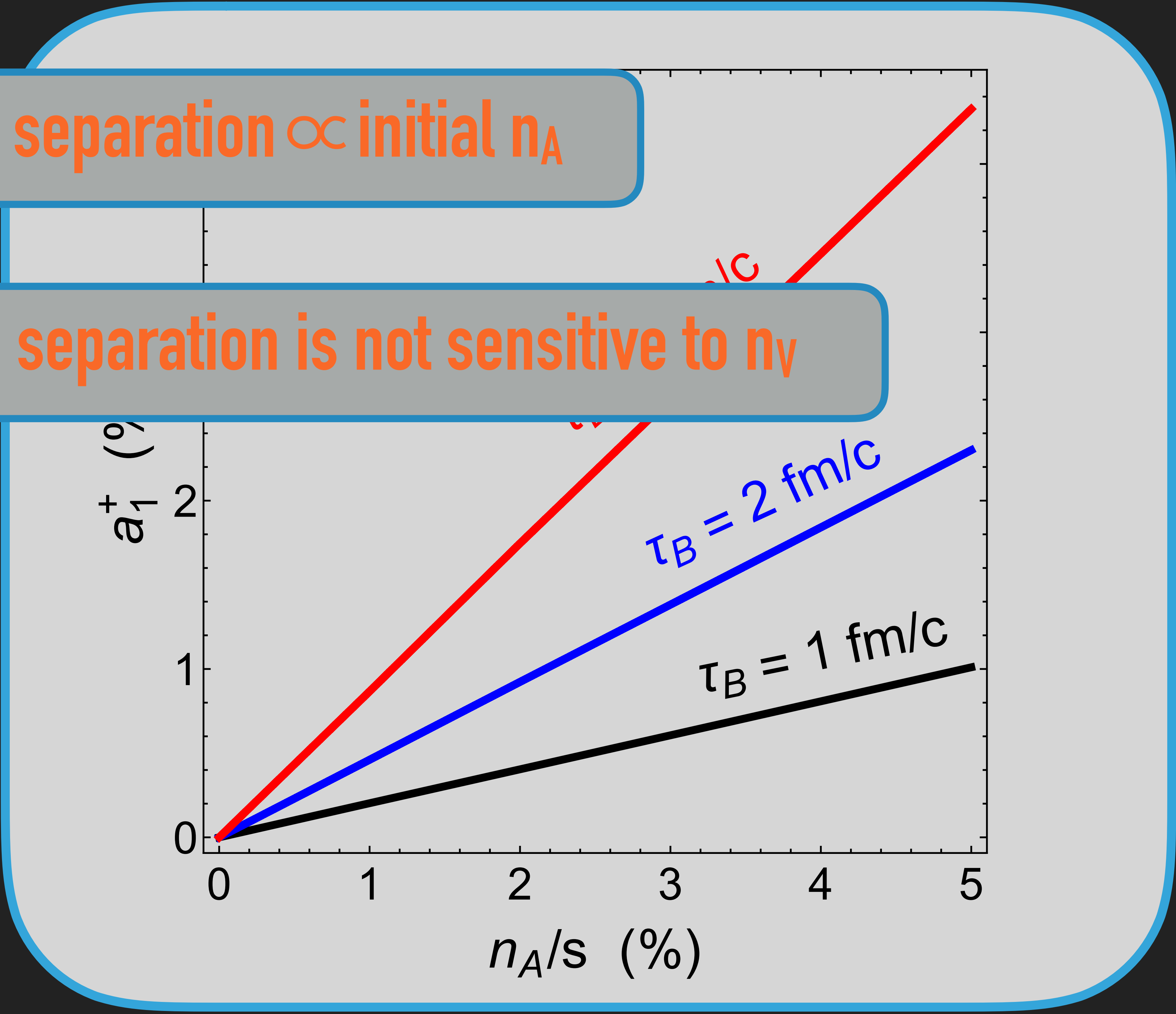


Dependence on Initial n_A

$$B = \frac{B_0}{1+(\tau/\tau_B)^2}$$

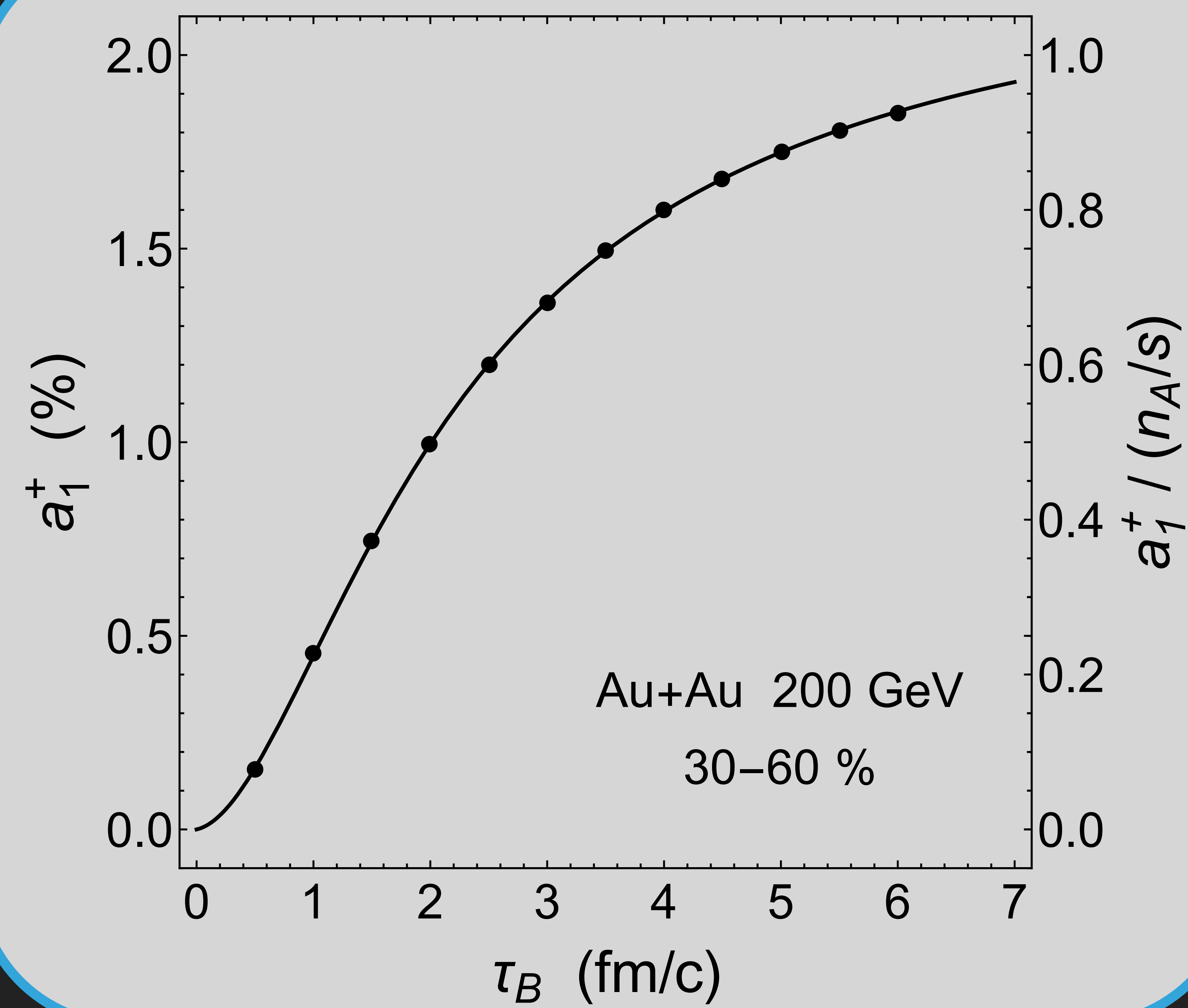
Charge separation ∝ initial n_A

Charge separation is not sensitive to n_V

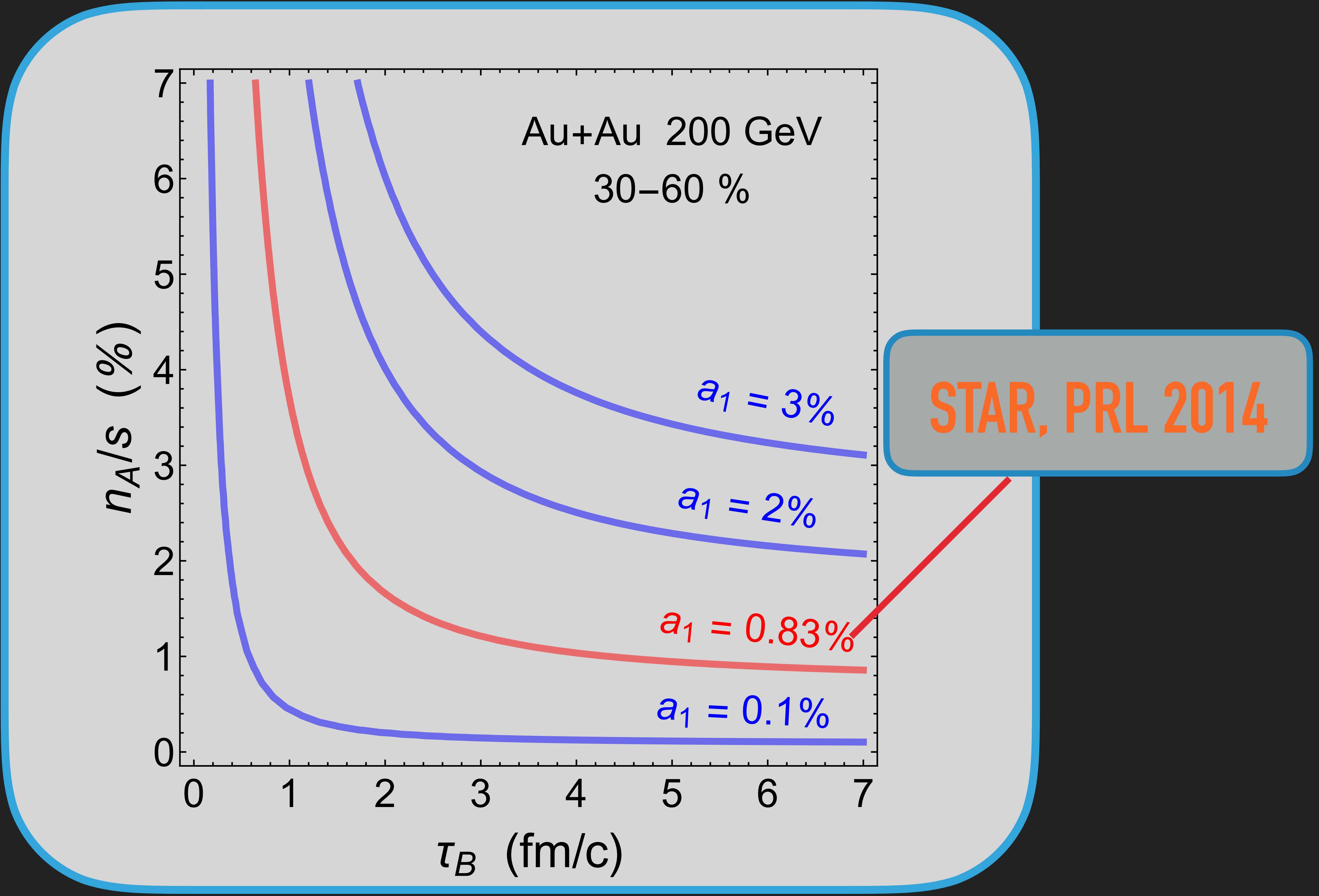


Dependence on B Field Lifetime τ_B

$$B = \frac{B_0}{1+(\tau/\tau_B)^2}$$



Parameters Needed by CME



Parameters Needed by CME

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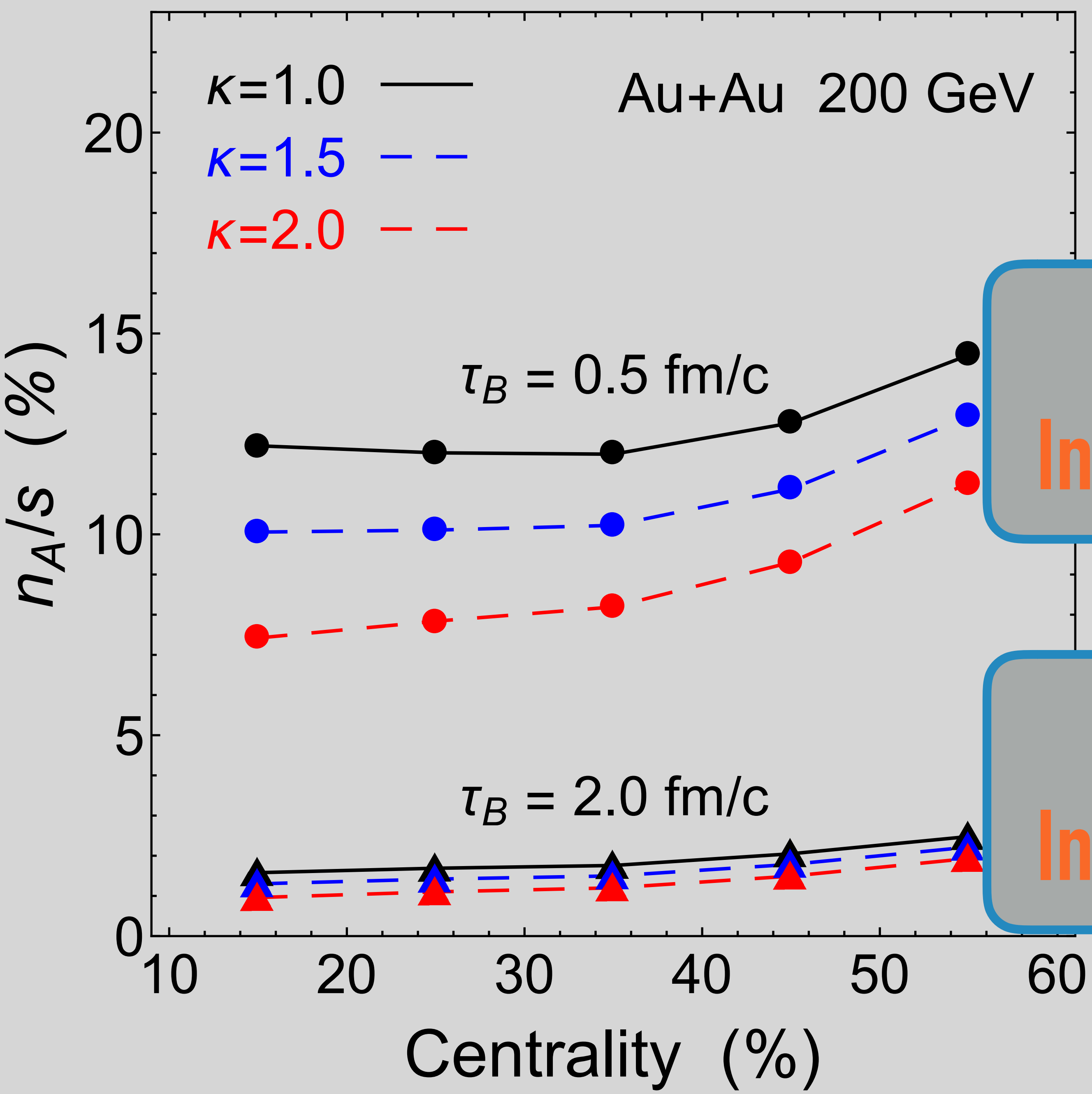
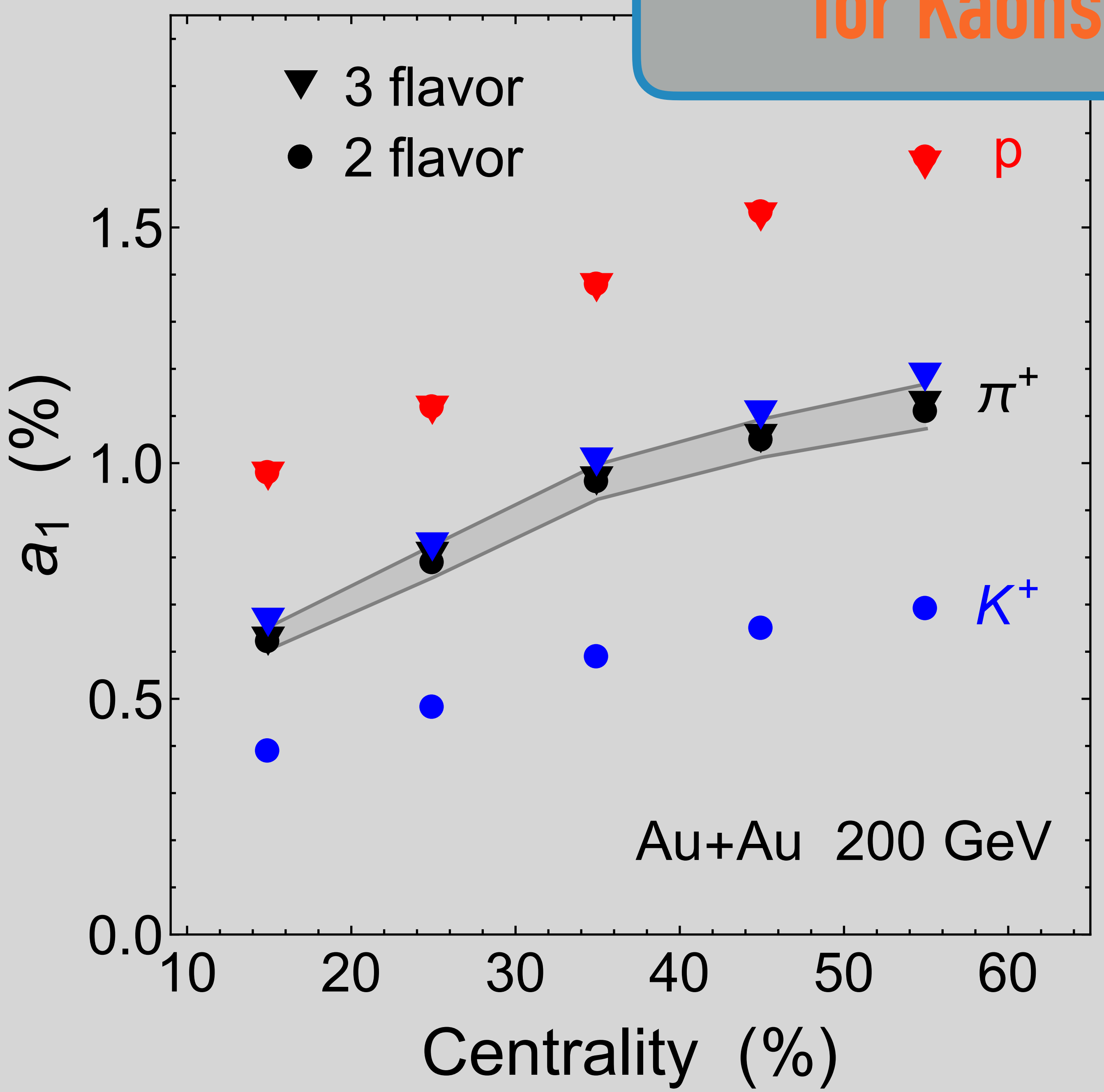


$\tau_B = 0.5$ fm/c,
Initial $n_A \sim (0.4\ \text{GeV})^3$

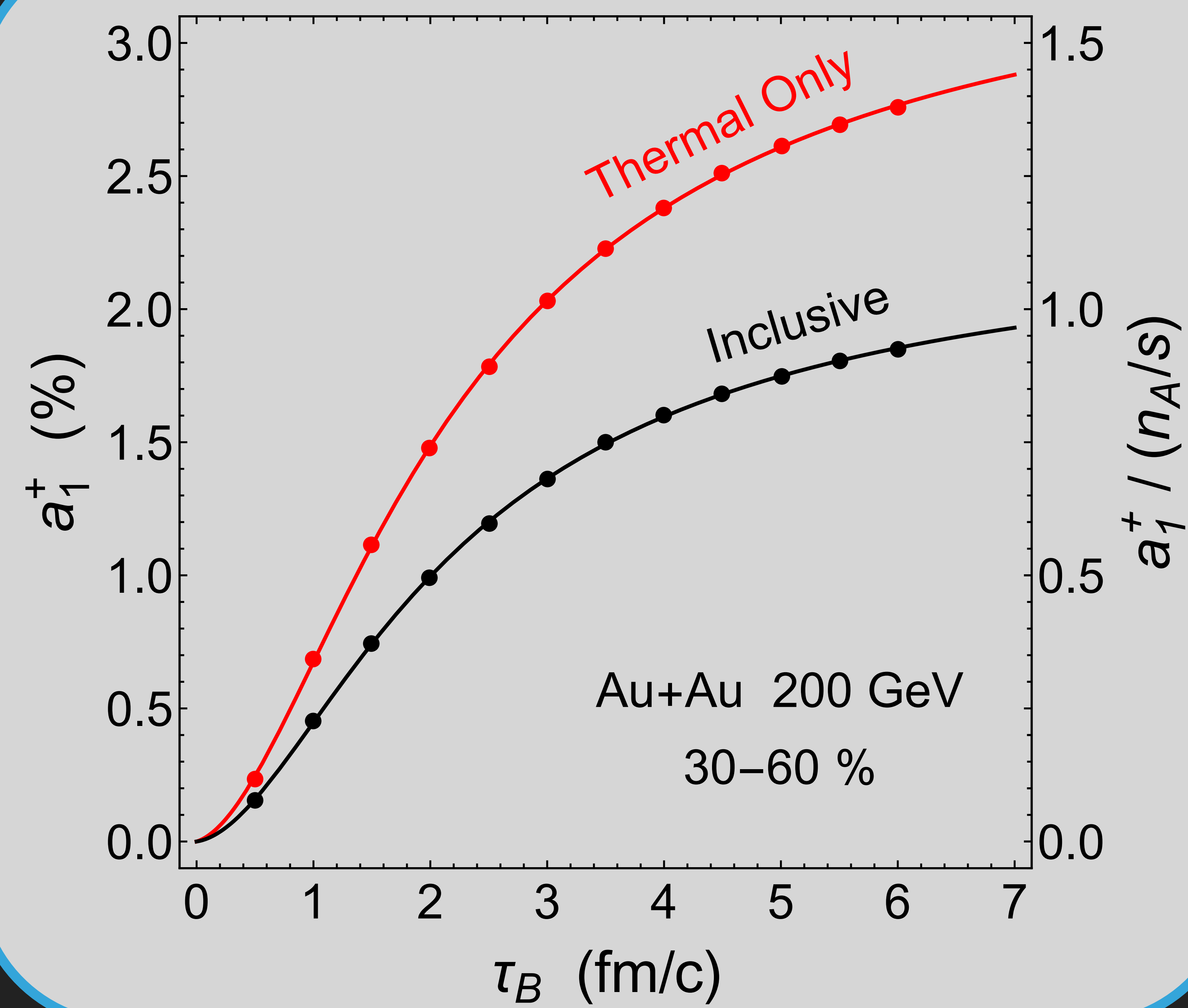
$\tau_B = 2$ fm/c,
Initial $n_A \sim (0.2\ \text{GeV})^3$

Is Strange Quark Axial?

Initial $n_{A,s}$ matters for Kaons

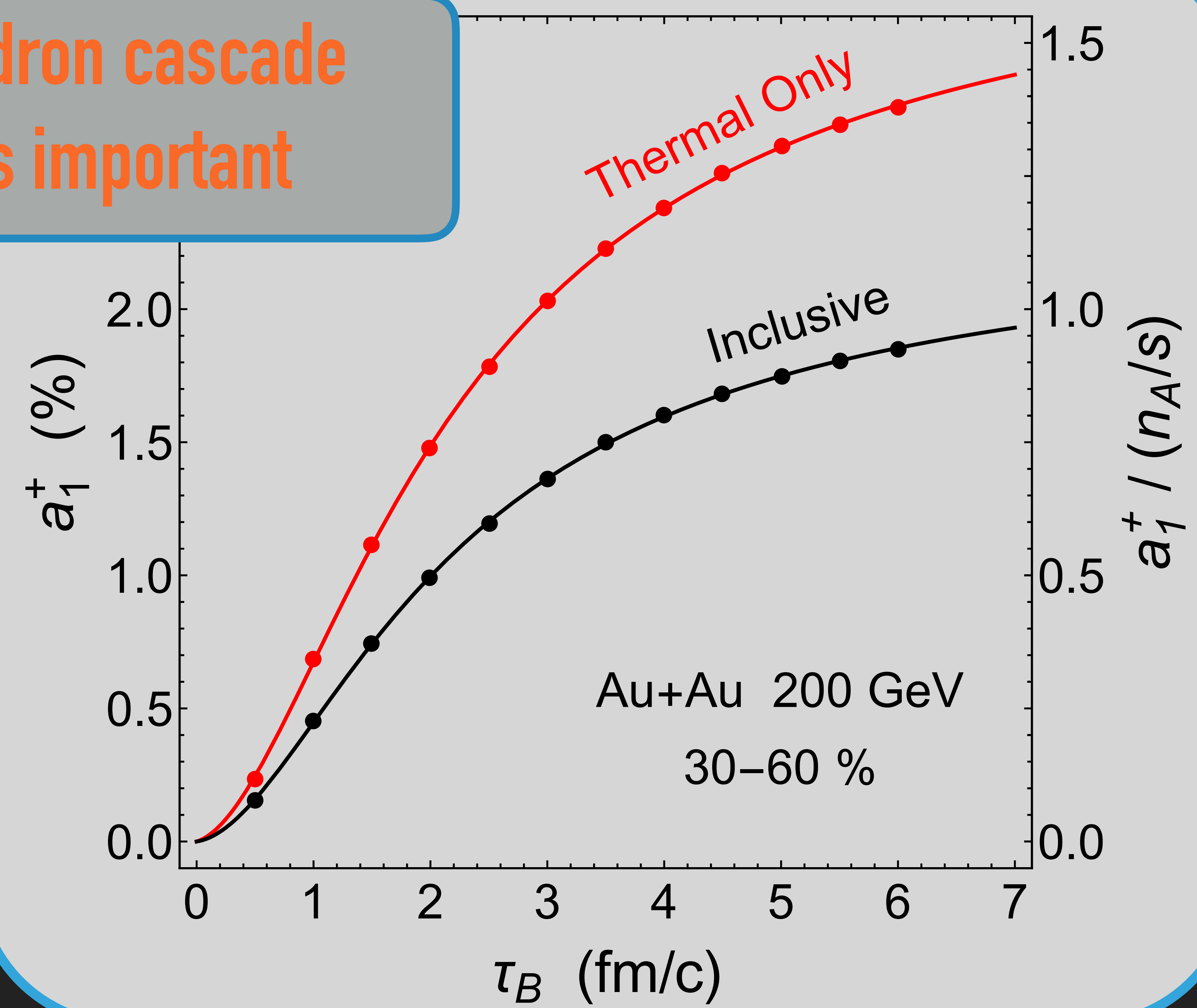


Contribution of Decay from Resonances



Contribution of Decay from Resonances

Hadron cascade
is important



Summary & Outlook

- Experimental signal might be quantitatively explained by CME.
- PHYSICAL axial number density & B field lifetime is needed.
- Initial $n_{A,s}$ can be determined by measuring $K^{\pm}$ asymmetry.

- event-by-event simulation, with hadron cascade
- different type of time-dependent magnetic field
- more anomalous effects, e.g. CMW