Quenching of High $p_\perp$ Hadrons by (Pre–) Hadronic FSI with Comovers

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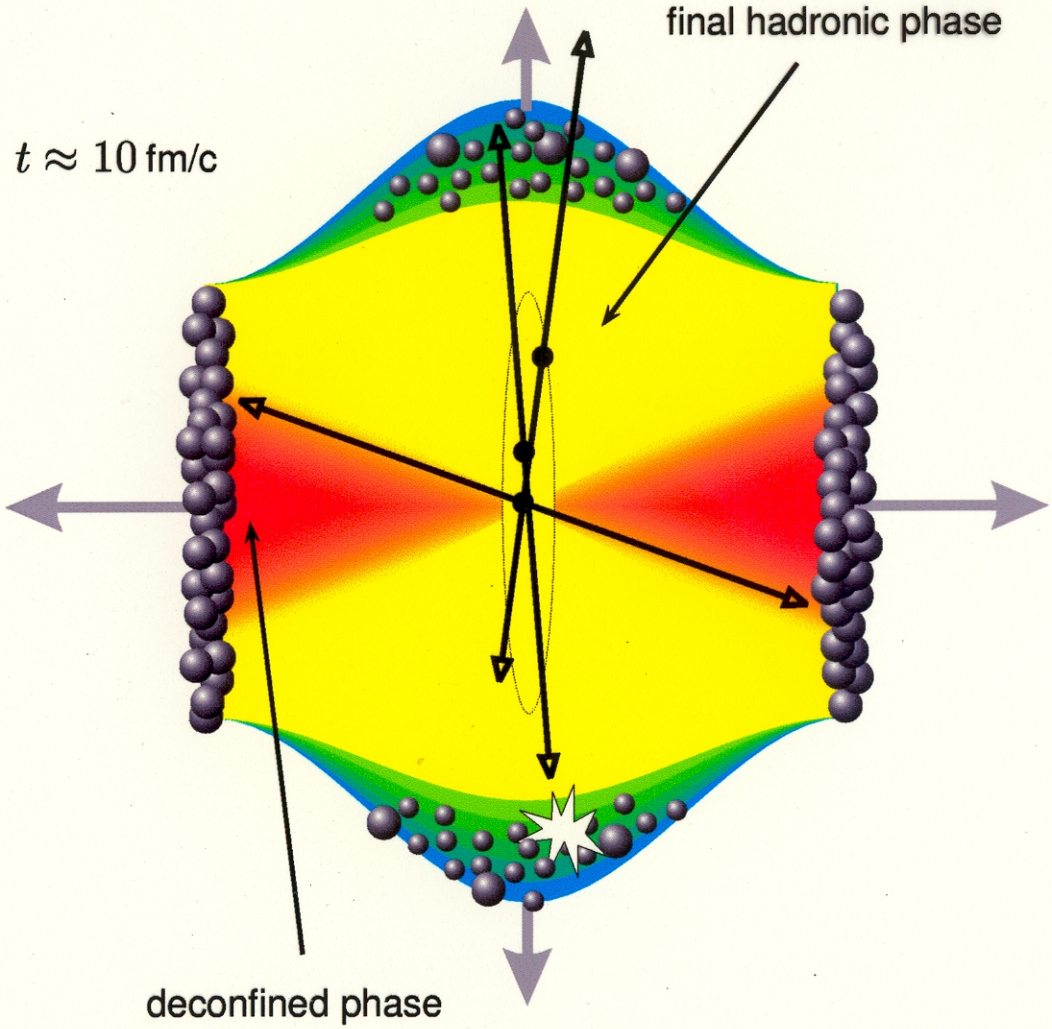
** with W. Cassing, K. Gallmeister (Univ. Gießen)*

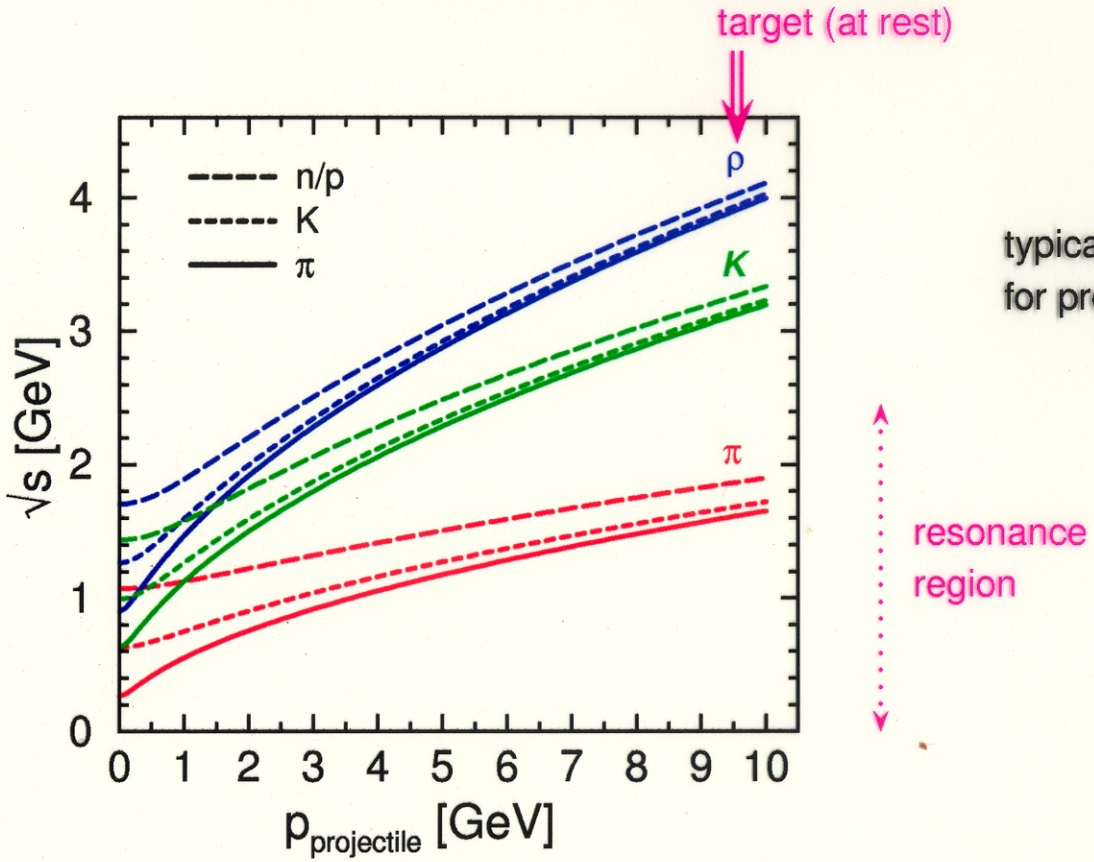
Overview



- Model of FSI
- Implementation into Hadronic Transport Model
- Results & Discussion

K.Gallmeister, C.G., Z.Xu,
PRC 67, 044905 (2003)
W.Cassing, K.Gallmeister. C.G.,
hep-ph/0311358

Available Collision Energy $\sqrt{s}$



typical AGS/SPS regime
for pre-equilibrium collisions

$\Longrightarrow$ model for collision for $\sqrt{s} \geq 2 - 2.5$ GeV: FRITIOF

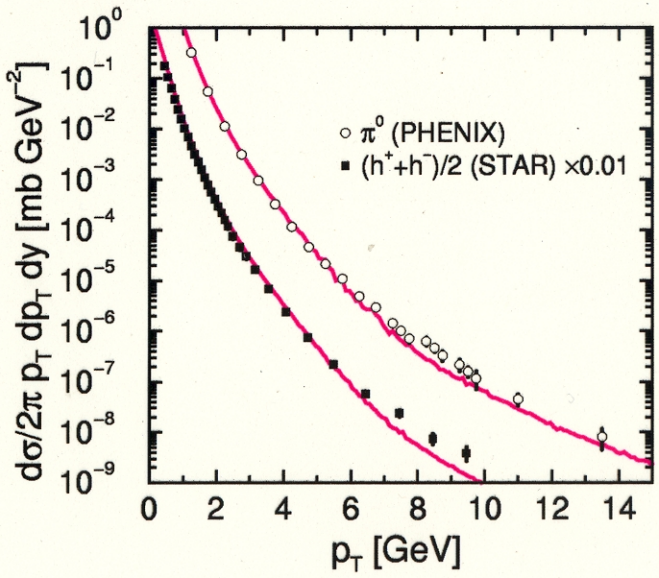
Model of FSI

$$f_j(p_\perp) = \sum_i \int dp_{\perp_0} \; f_i^0(p_{\perp_0}) \; g_{ij}(p_{\perp_0}, p_\perp)$$

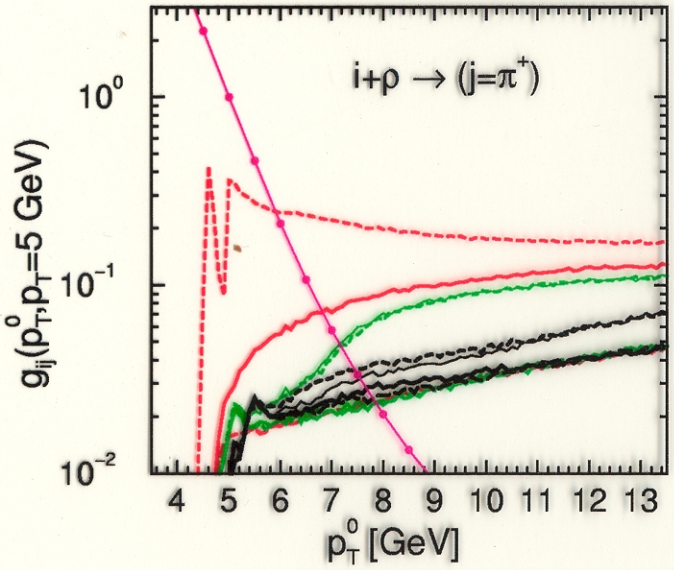
$$i, j = \pi^0, \pi^\pm, K^0, \overline{K}^0, K^\pm, p, \overline{p}, n, \overline{n}$$

- Initial distribution $f_i^0(p_\perp)$:

  PYTHIA v6.2

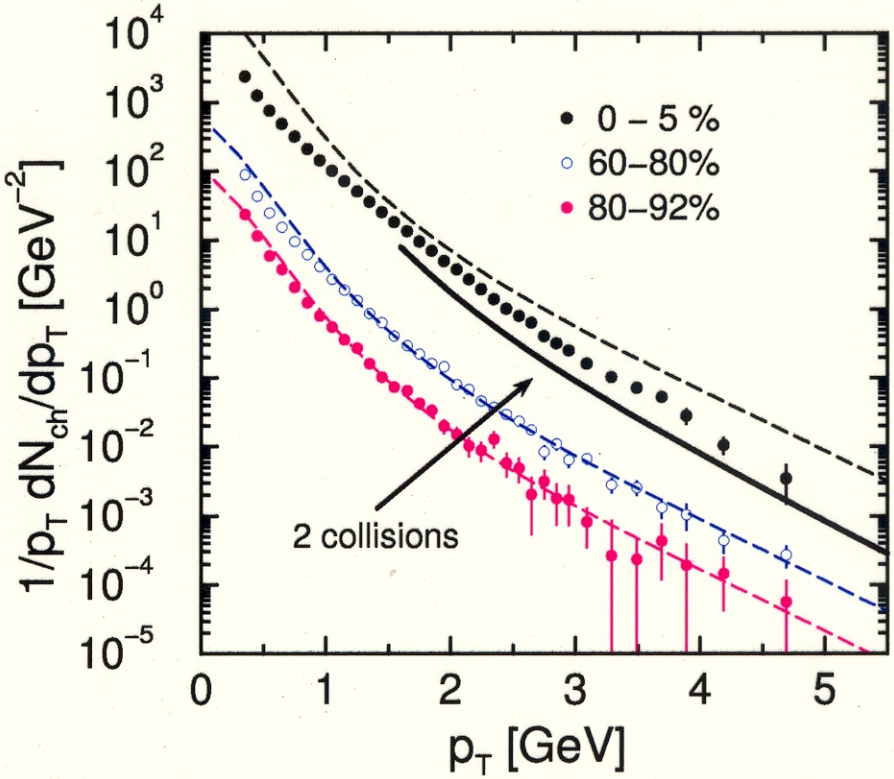


- Folding Matrix $g_{ij}(p_{\perp_0}, p_\perp)$:

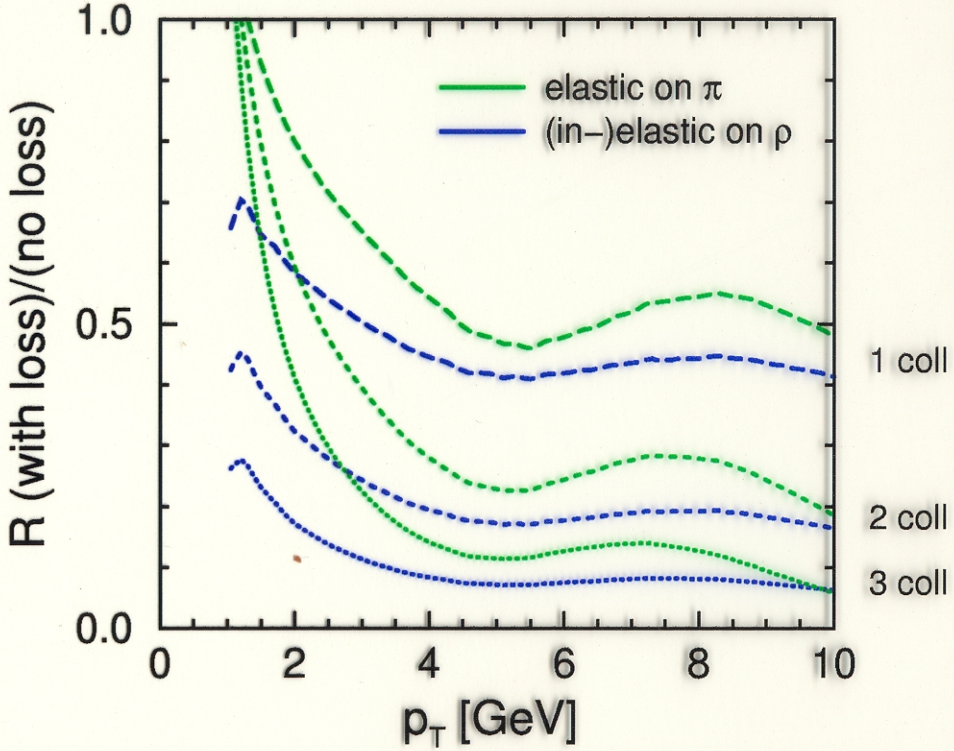


RHIC: Data

$\sqrt{s} = 130$ GeV, charged hadrons:



$\sqrt{s} = 200$ GeV, "predictions":

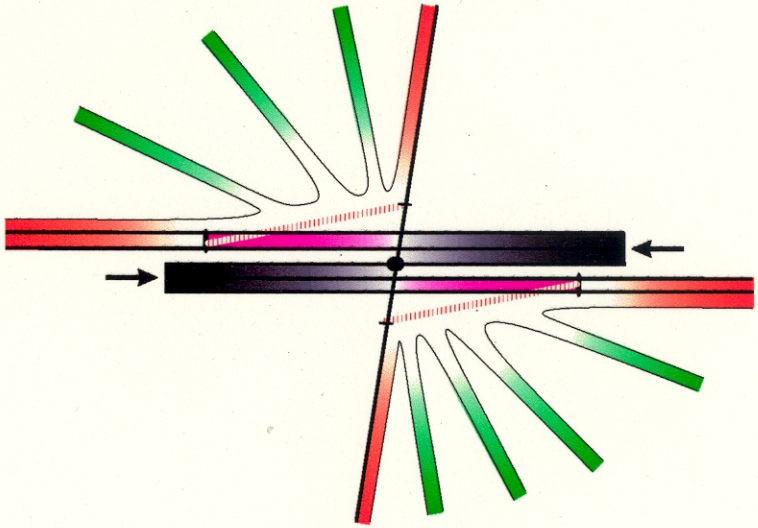


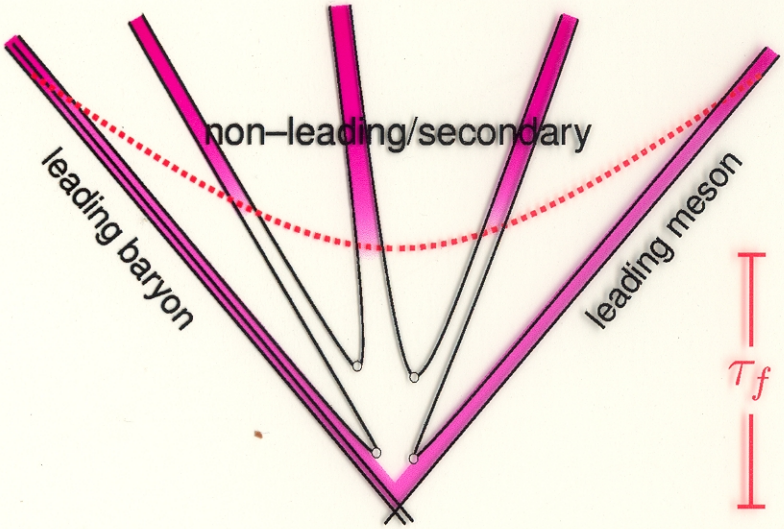
K.Gallmeister, C.G., Z.Xu, nucl-th/0202051, hep-ph/0212295, PRC67, 044905 (2003)

Implementation into Hadronic Transport Model

- Collisions: Transport with HSD

- Concept of Leading Hadrons:

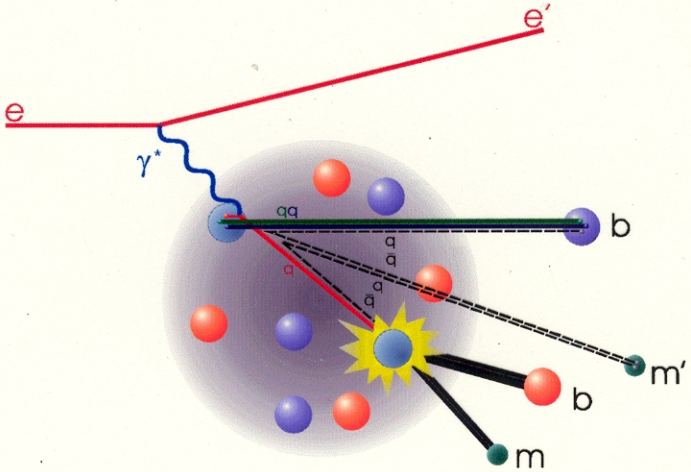




- $\sigma_{\text{lead}} = \frac{1}{2}/\frac{1}{3}\sigma_0$, $\tau_{\text{lead}} \approx 0$ fm/c, $\tau_F = 0.8$ fm/c

Hadron formation in DIS off Nuclei at HERMES

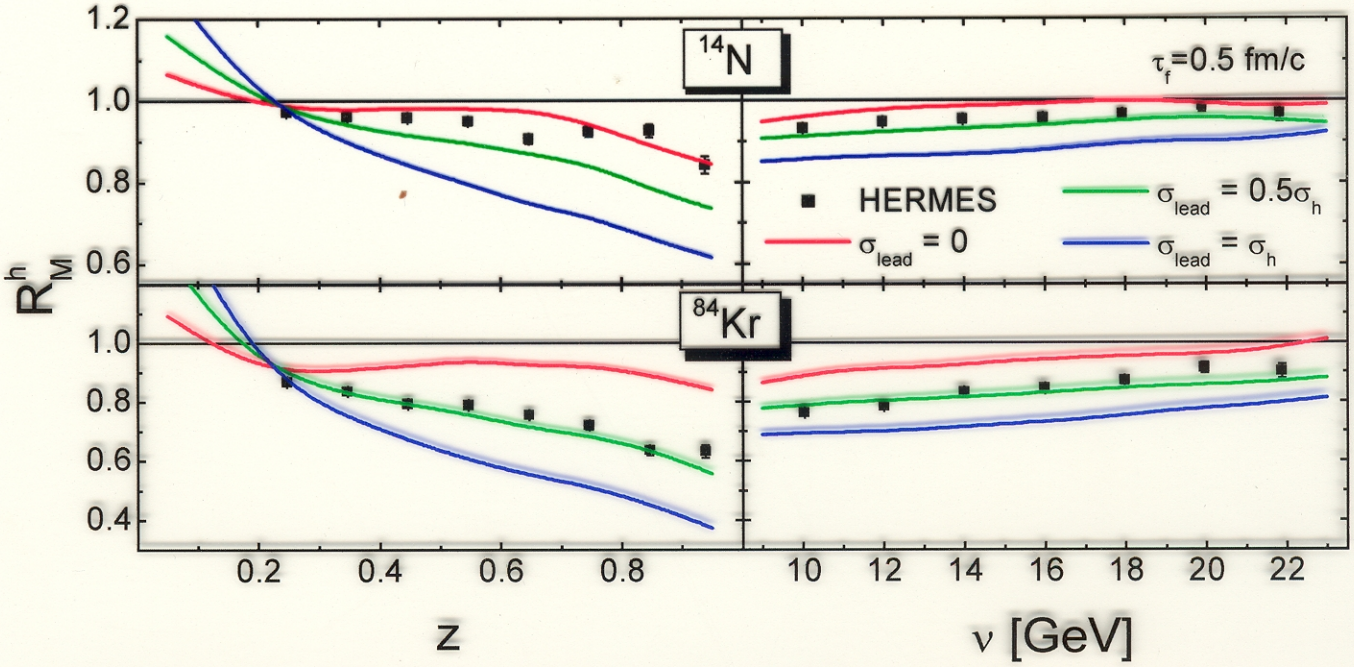
T. Falter, W. Cassing, K. Gallmeister, U. Mosel, *nucl-th/0303011*



$\tau < \tau_f$:
interactions of leading prehadrons

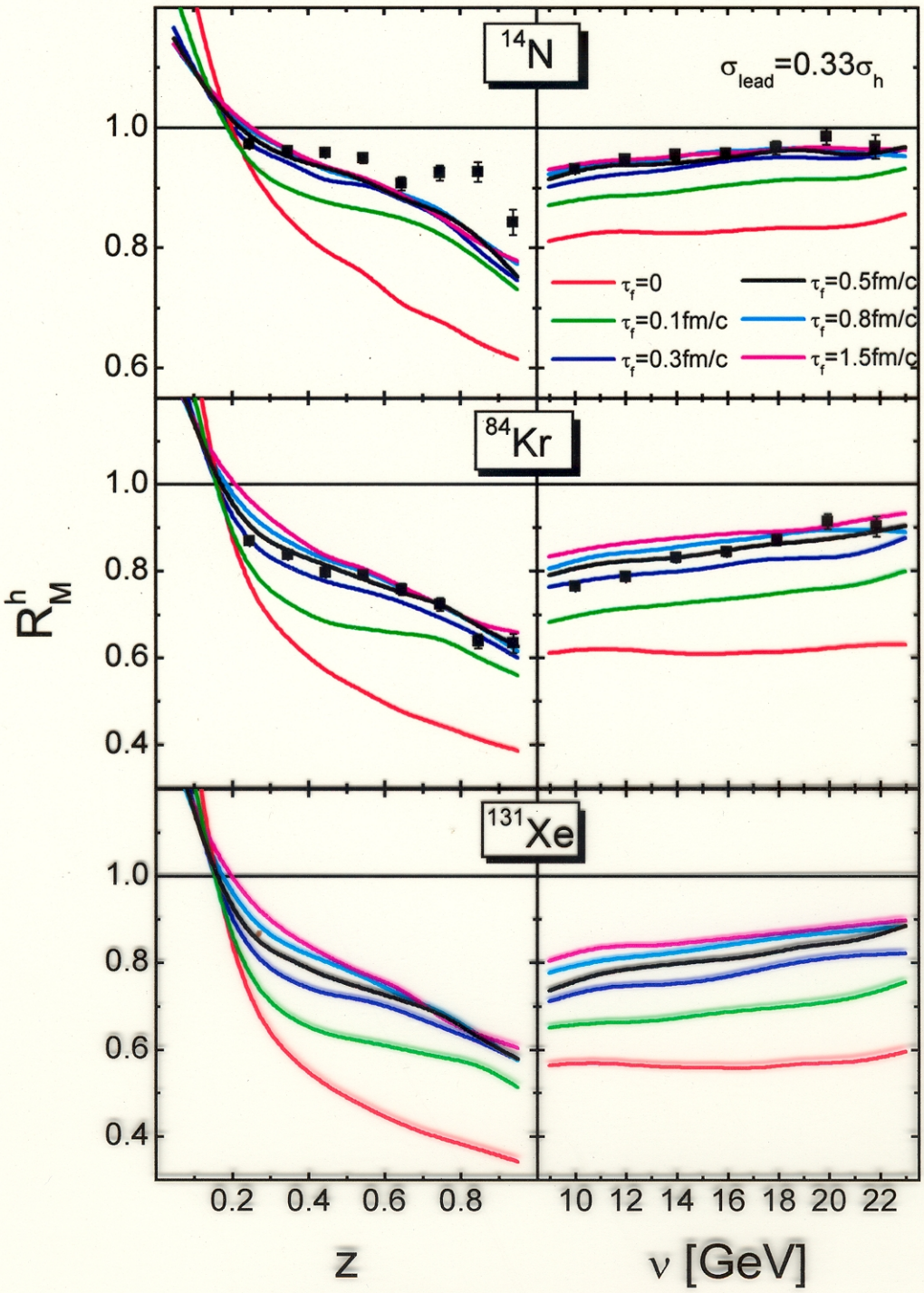
$\tau > \tau_f$:
hadronic rescattering

$$R_M^h(z,\nu) = \left(\frac{N_h(z,\nu)}{N_e(\nu)}\right)_A \Big/ \left(\frac{N_h(z,\nu)}{N_e(\nu)}\right)_D \qquad z = \frac{E_h}{\nu}$$



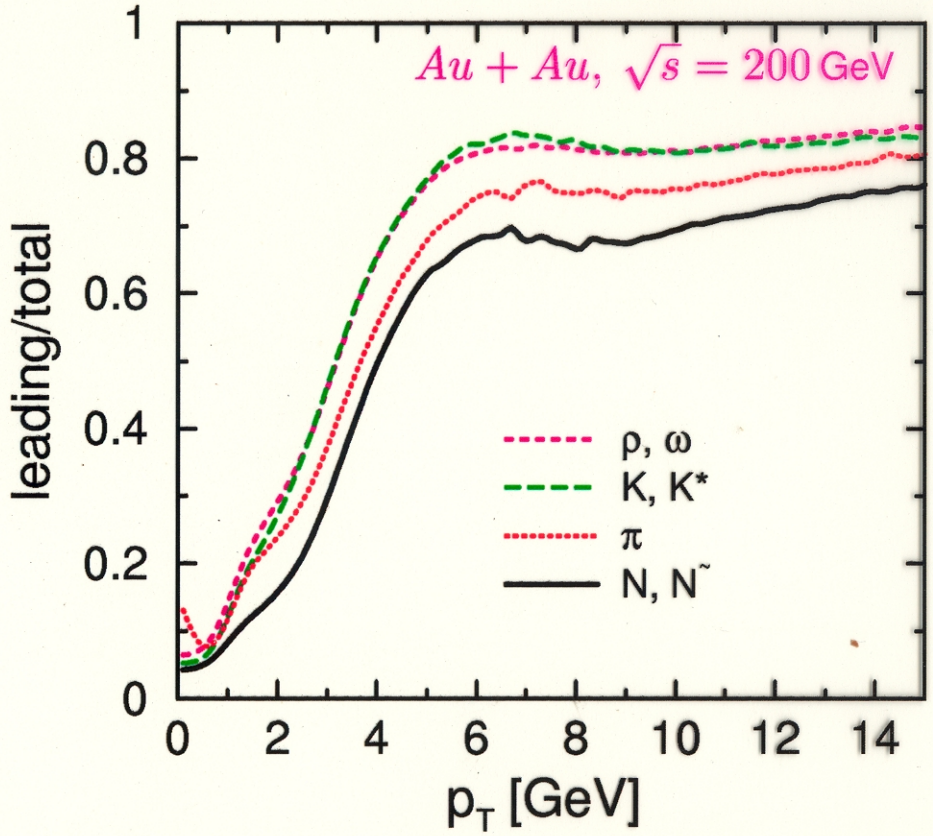
effective prehadronic cross section: $\sigma_{lead} = 0.33 - 0.5\sigma_h$

Sensitivity on formation time τ_f



formation time τ_f > 0.3fm/c

Ratio Leading Hadrons/All Hadrons @ midrapidity



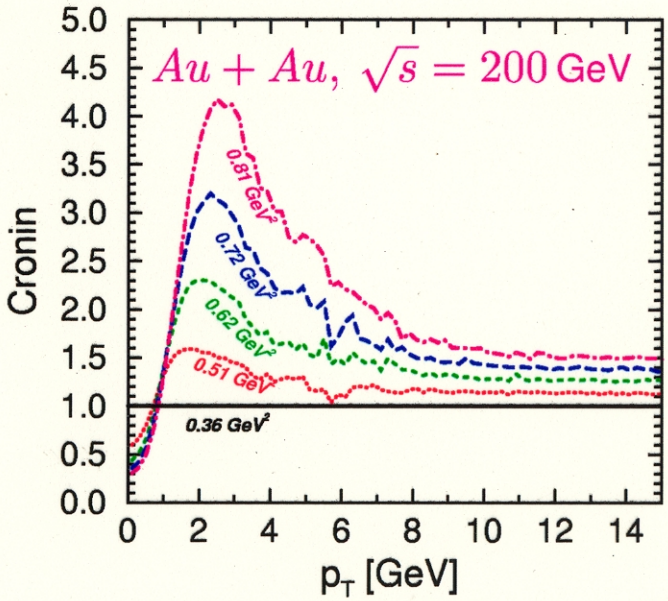
$\Longrightarrow$ leading hadrons for $p_\perp \geq 5\,\mathrm{GeV}$

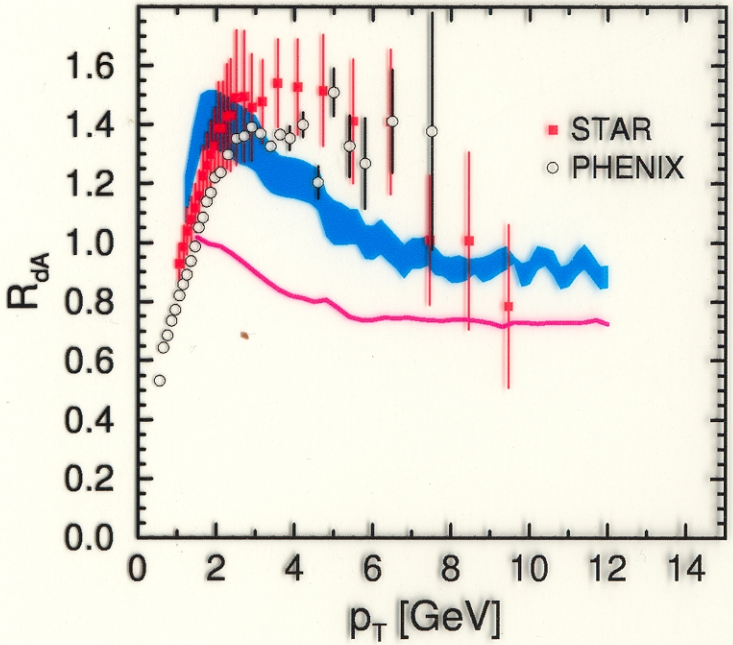
RHIC, d+Au @ $\sqrt{s} = 200$ GeV (charged hadrons)

- Cronin enhancement: phenomenological ansatz

$$\langle k_\perp^2 \rangle = \langle k_\perp^2 \rangle_{NN} (1 + \alpha N_{\rm prev})$$

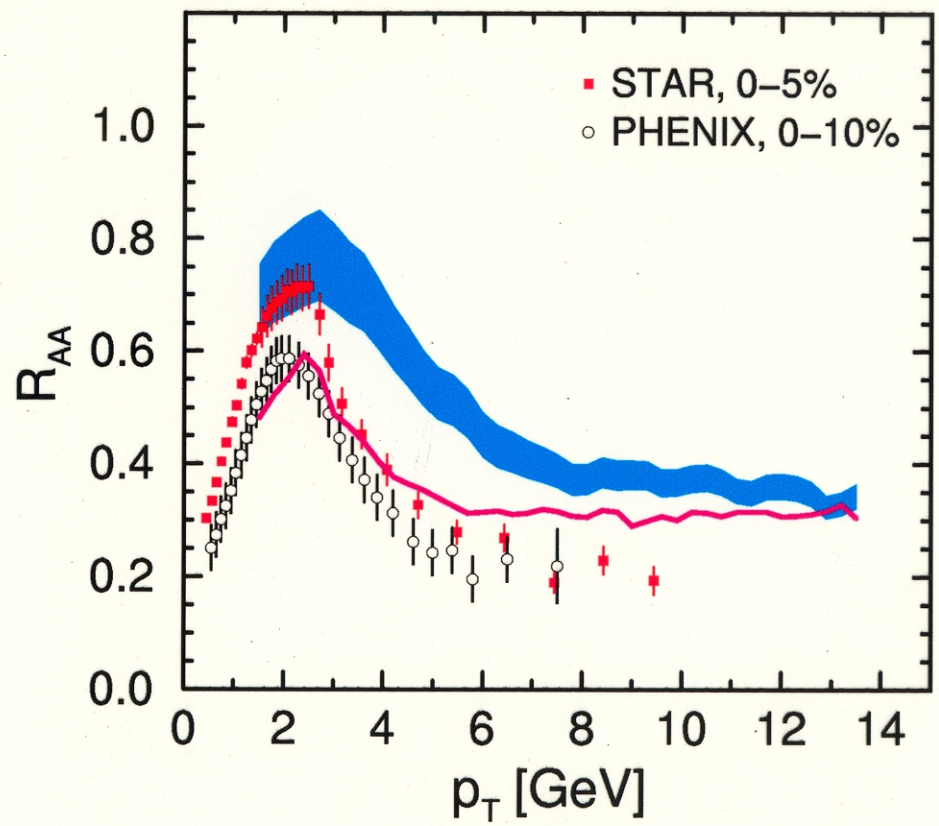
$$R_{dA}(p_\perp) = \frac{1/N_{dA}^{\rm event}\, d^2 N_{dA}/dy dp_\perp}{\langle N_{\rm coll} \rangle / \sigma_{pp}^{\rm inelas}\, d^2\sigma_{pp}/dy dp_\perp}$$





RHIC, Au+Au @ $\sqrt{s} = 200$ GeV, Most Central (charged hadrons)

- leading-secondary collisions only for $\epsilon_{\rm local} \leq 1\,{\rm GeV/\,fm^3}$



particles with $p_\perp > 4\,$GeV:

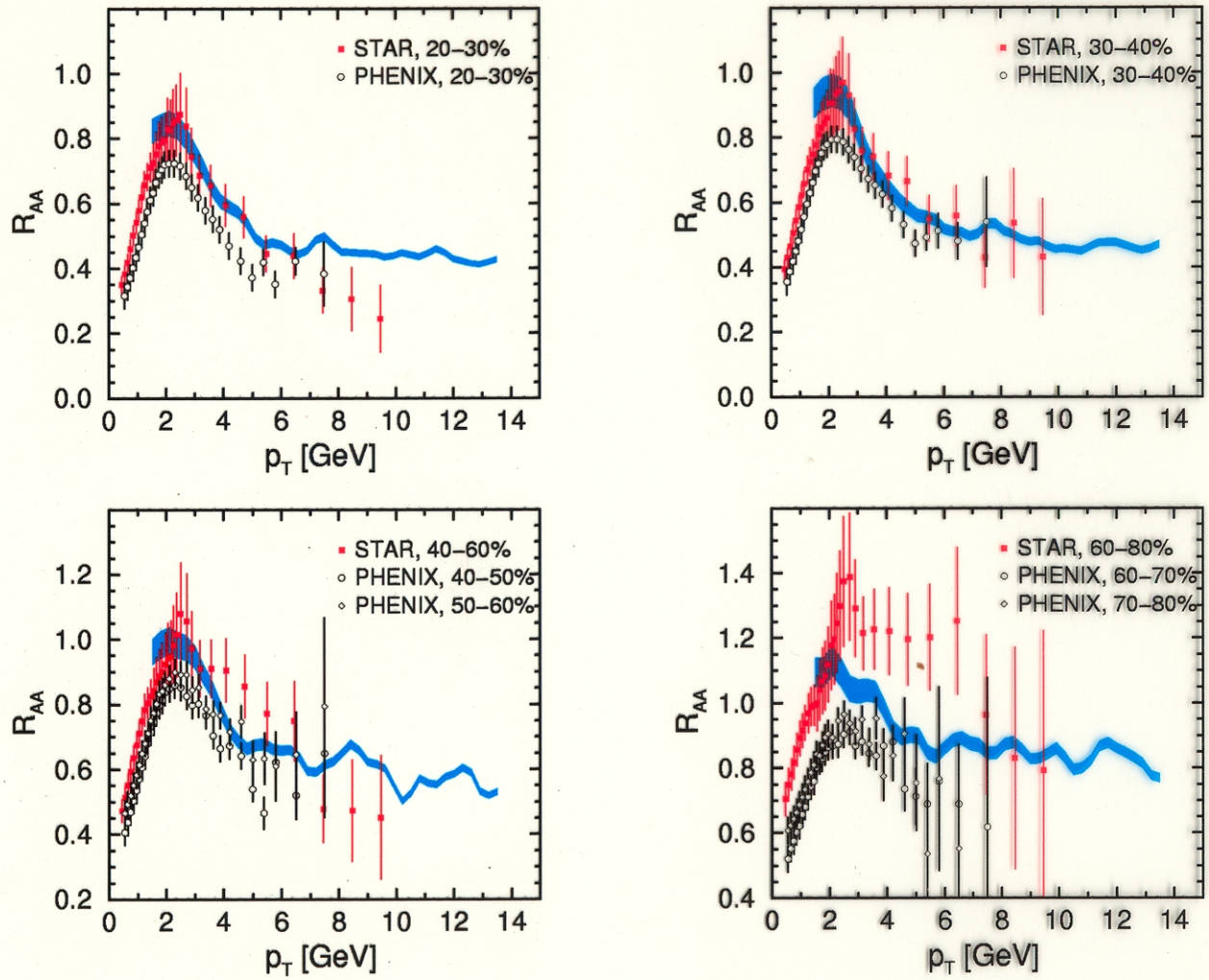
- 2/3 escape without interaction
- 1.4 interactions in average

$\longrightarrow$ Surface Emission

$\Longrightarrow$ Near–Side Correlations unchanged

$\Longrightarrow$ "Fragmentation" as in Vacuum

RHIC, Au+Au @ $\sqrt{s} = 200$ GeV, Centrality Dependance (I)



Hadronization: Within or Without the Fireball?

- color singlet prehadronic production time in DIS (B.Z.Kopeliovich et al., hep-ph/0311220)

$$t_{\rm p.h.} \simeq \frac{E_{\rm jet}}{Q^2}(1-z_h) \overset{Q\approx p_\perp}{\simeq} \frac{E_{\rm jet}}{p_\perp^2}(1-z_h)$$ small

$$\left(\longleftrightarrow \frac{E_{\rm jet}}{K}(1-z_h) \quad \text{string picture}\right)$$

- soft gluon emission incoherence time

$$t_c \simeq \frac{E_{\rm jet}\cdot\alpha}{k_\perp^2} \quad , \quad k_\perp \gtrsim \frac{1}{R_{\rm hadron}} \sim \Lambda_{\rm QCD}$$

- formation time for hadronic wavefunction

$$t_F^q \simeq ER^2 \qquad \text{Pion:} \quad E\cdot(0.5\,\text{fm})^2 = 1.2\,\text{fm}\,\frac{E}{\text{GeV}}$$

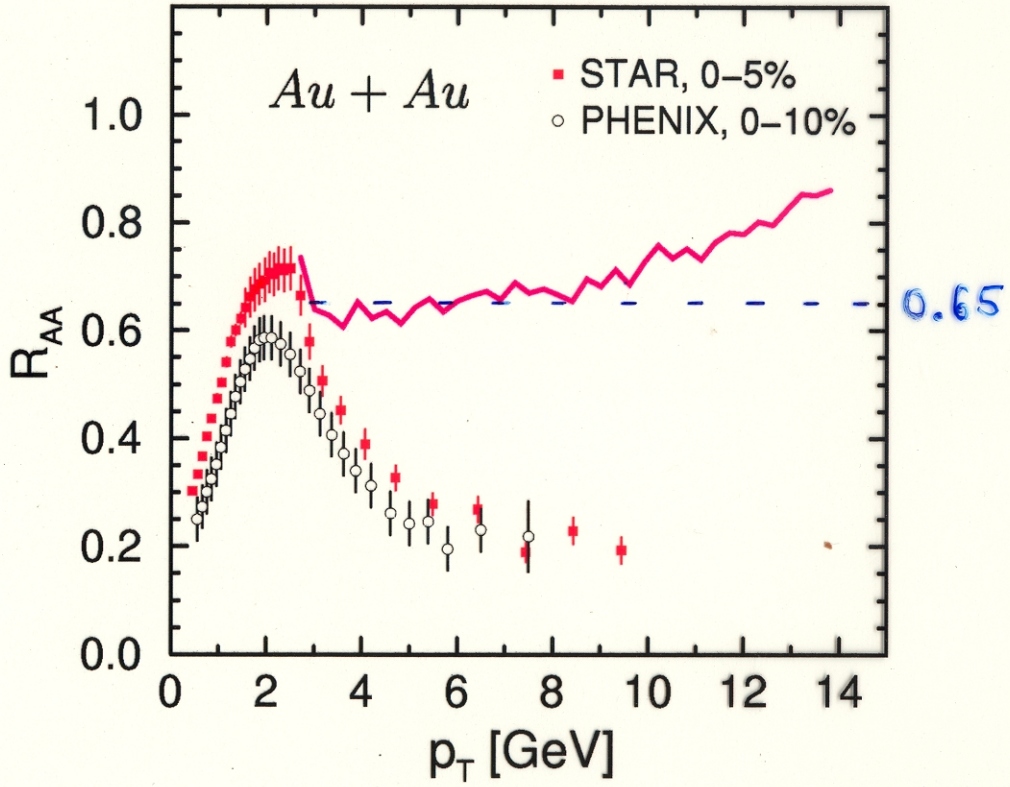
$$t_F^Q \simeq \frac{E}{m_Q}R \qquad \text{Rho:} \quad E/0.8\,\text{GeV}\cdot 0.8\,\text{fm} = 1.0\,\text{fm}\,\frac{E}{\text{GeV}}$$

evolving cross section (color transparency) $\sigma(t) = (t/t_F)\,\sigma_0 \quad , \quad \sigma_0 \simeq 10\ldots15\,\text{mb}$

mean free path $\lambda = \dfrac{1}{\sigma\,\rho} \xrightarrow{\rho\simeq 0.1\ldots1\,\text{fm}^{-3}} 1\ldots10\,\text{fm}$

Alternative Treatment of Leading Particles

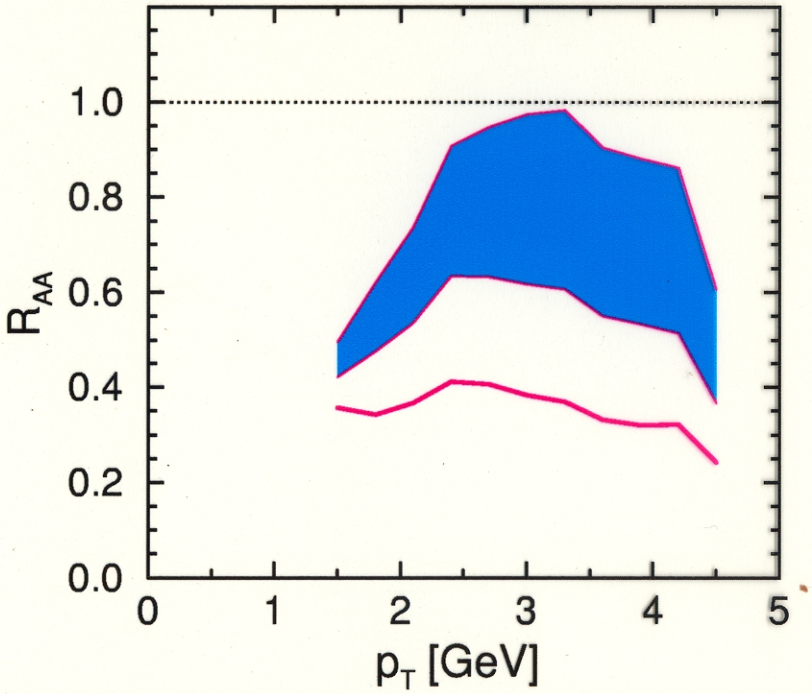
$$\sigma_{\text{lead}}(\tau) = \begin{cases} \frac{\tau}{\tau_F}\sigma_0 & \tau < \tau_F \\ \sigma_0 & \tau > \tau_F \end{cases}$$



⟶ Does not give as high suppression

Hadronic vs. Partonic

- lower energies: e.g. SPS



⟶ controlled pp reference

- Open Charm: should also have some depletion

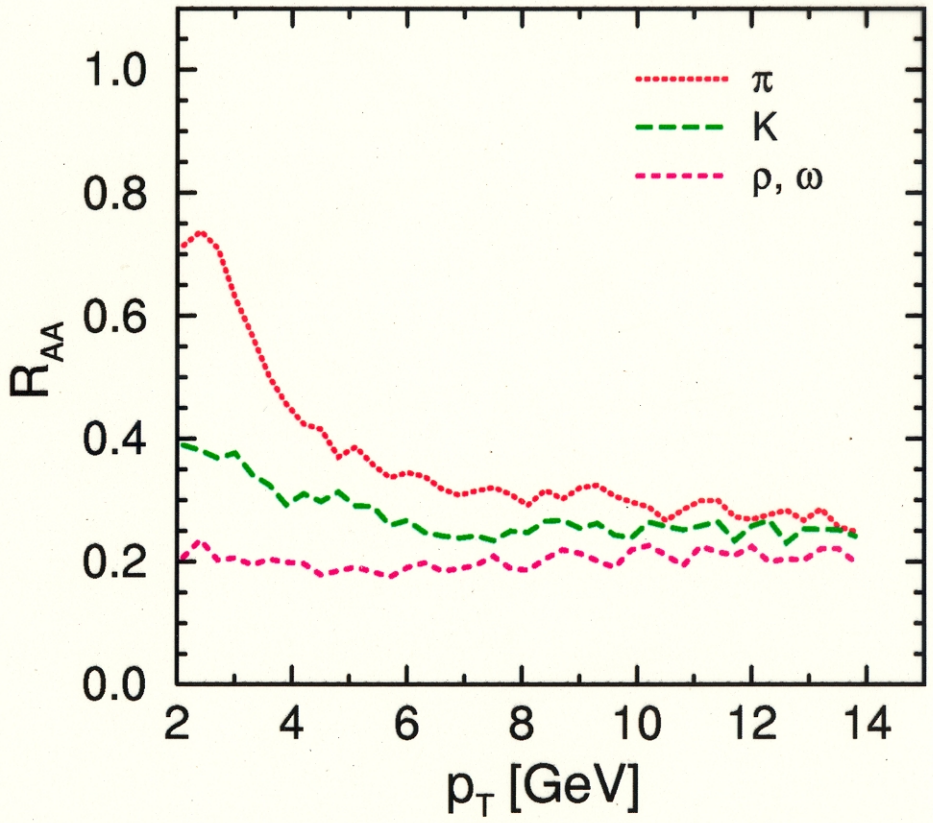
Summary

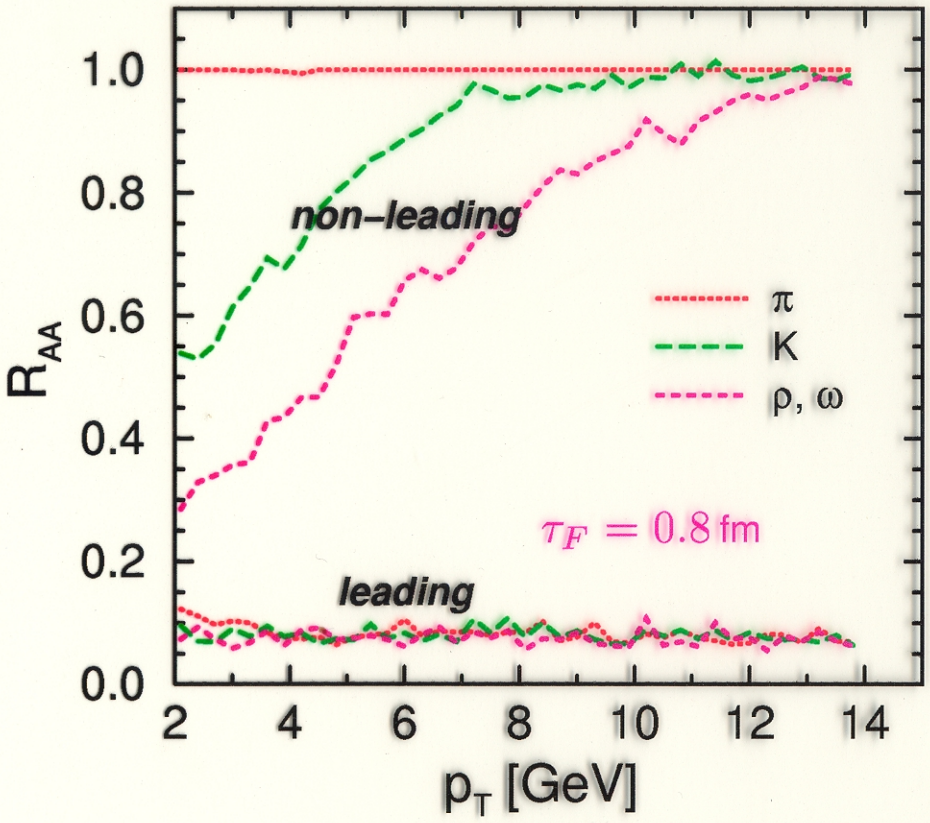
- RHIC, R_{dA}, R_{AA}:
  - pre–hadronic for $p_\perp > 6$ GeV, formed for $p_\perp < 6$ GeV
  - final comover interactions not negligible
  - hadronic FSI can indeed describe data
  - more central AA: need for additional source
- QGP $\longrightarrow$ Jet Suppression $\longrightarrow$ High $p_\perp$ Hadron Attenuation

  QGP $\longleftarrow$ Jet Suppression $\longleftarrow$ High $p_\perp$ Hadron Attenuation $\Longleftarrow$ NO !

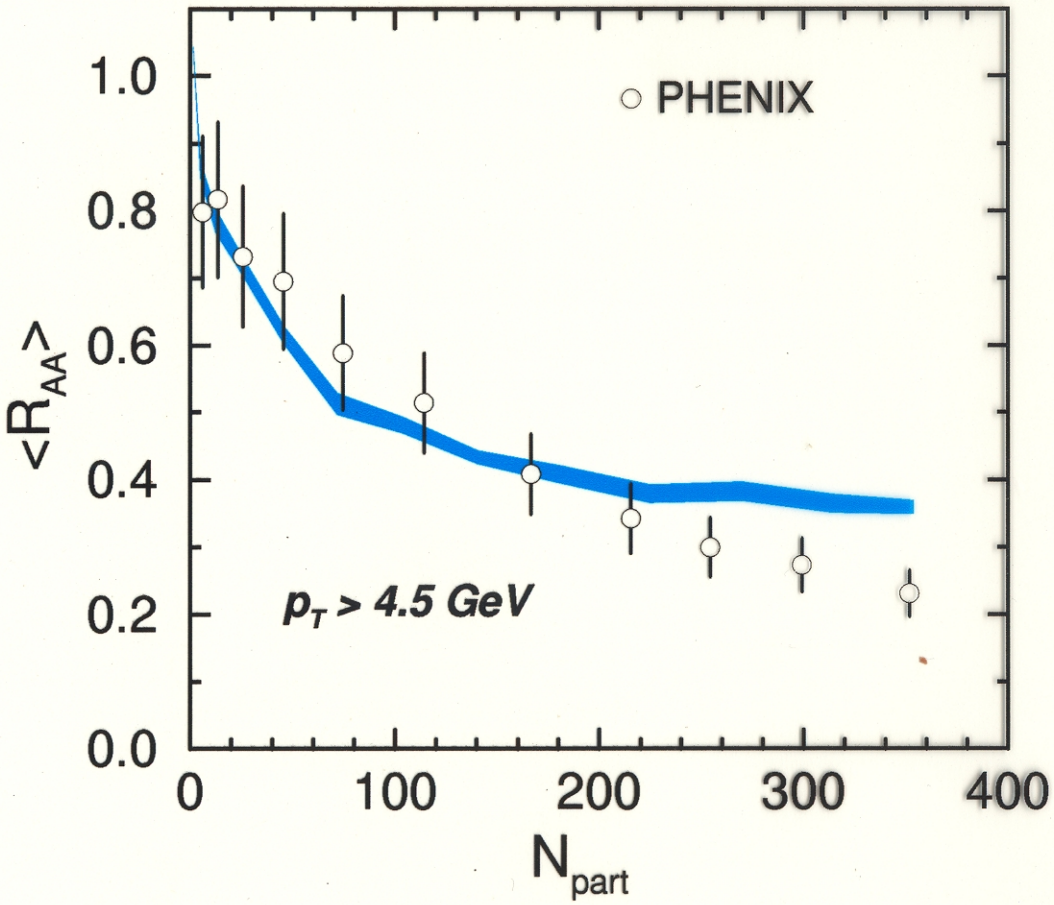
  disentangle sources!
- Not "hadronic vs. partonic", but "hadronic and partonic"
- understand time structure of hadronization and interaction of leading (pre–) hadrons

Contributions to R_{AA}





RHIC, Au+Au @ $\sqrt{s} = 200$ GeV, Centrality Dependance (II)



cf. Drees et al., nucl-th/0310044