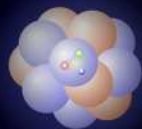


Hadron attenuation at HERMES

T. Falter, W. Cassing, K. Gallmeister, U. Mosel

Contents:

- Motivation
- Model
- Results
- Summary & Outlook

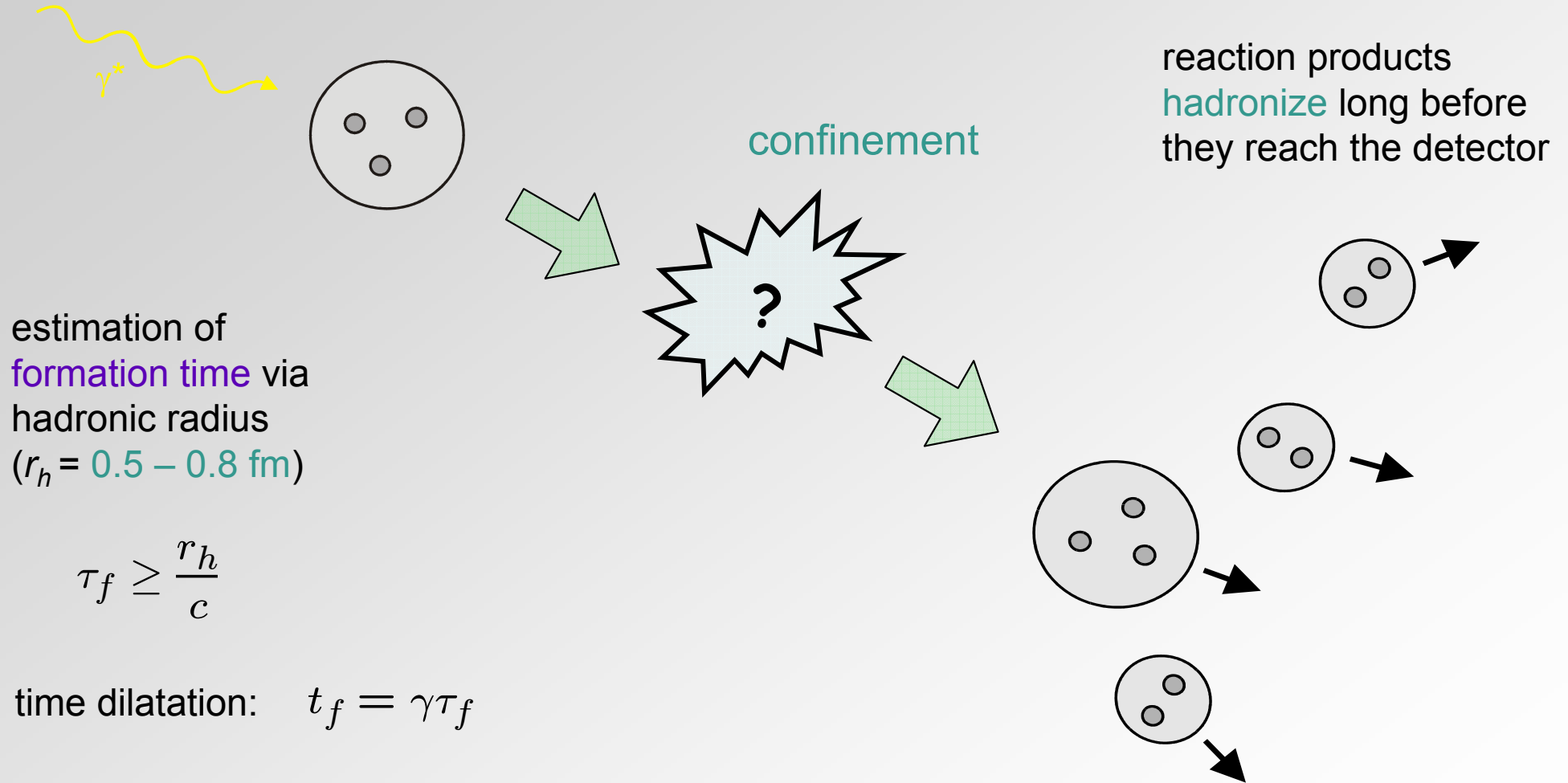


Institut für
Theoretische Physik



Motivation

■ elementary reactions ($eN, \gamma N$):



■ nuclear reactions ($eA, \gamma A$ @ JLAB, HERMES or EMC energies):

interactions with nuclear medium during t_f



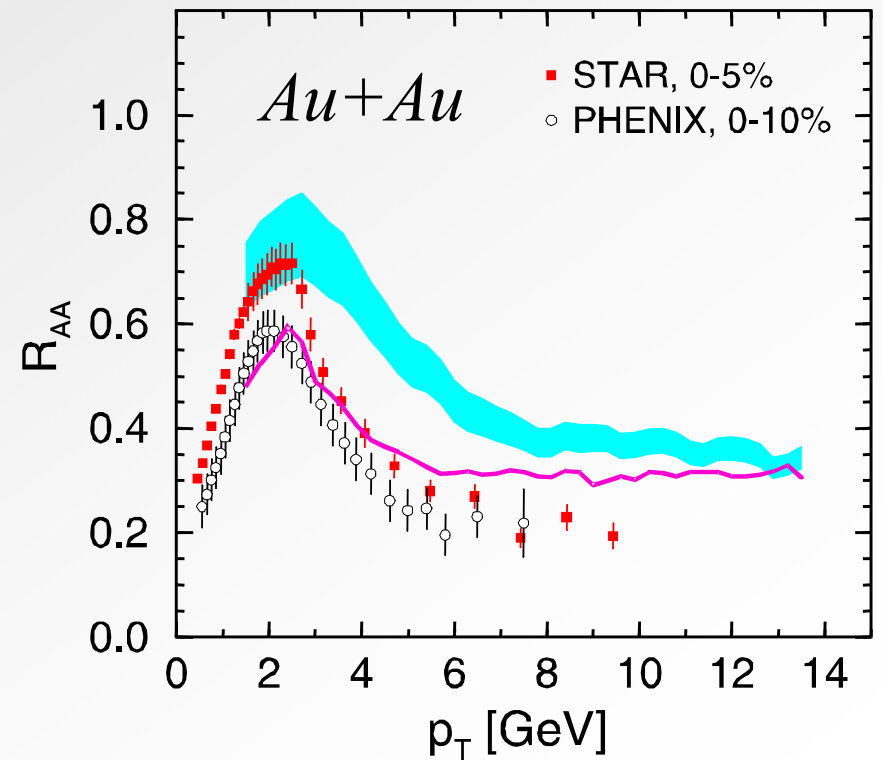
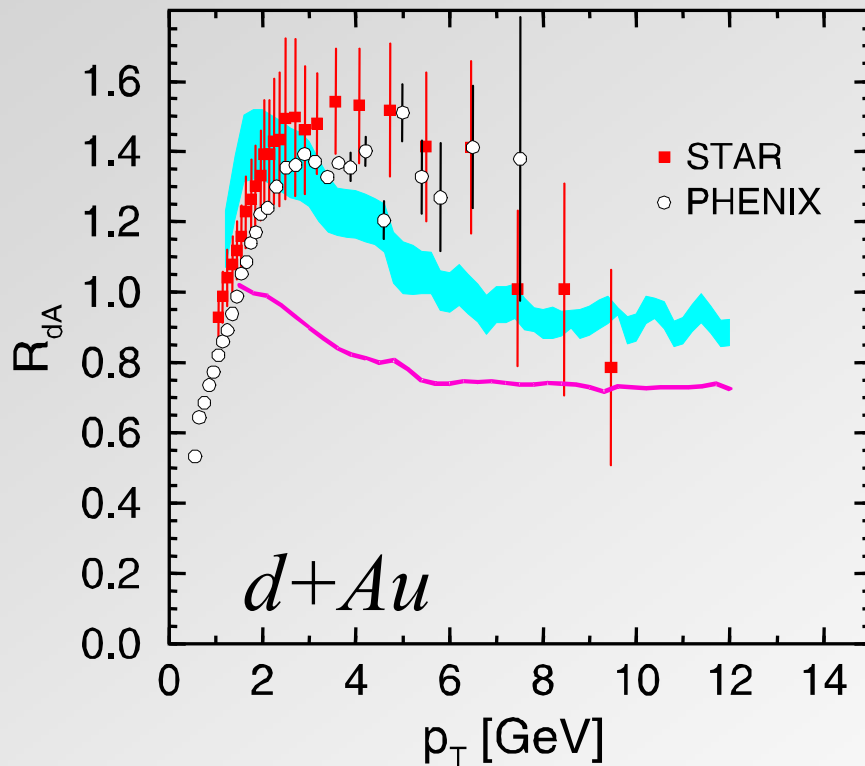
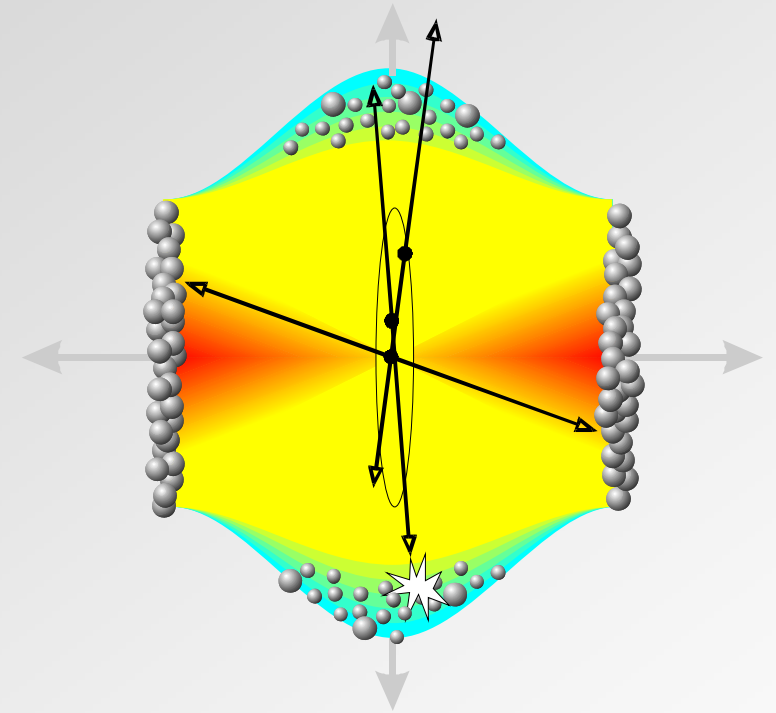
space-time picture of hadronization

■ connection with heavy-ion physics

jet suppression at SpS and RHIC
(partly due) to hadronic FSI ?

W. Cassing, K. Gallmeister, C. Greiner, NPA **735**, 277 (2004).

K. Gallmeister, W. Cassing, hep-ph/0408223.



Model

■ $\gamma A, eA$ reaction splitted into 2 parts :

– $\gamma^* N \rightarrow X$ using **PYTHIA & FRITIOF**

■ consideration of

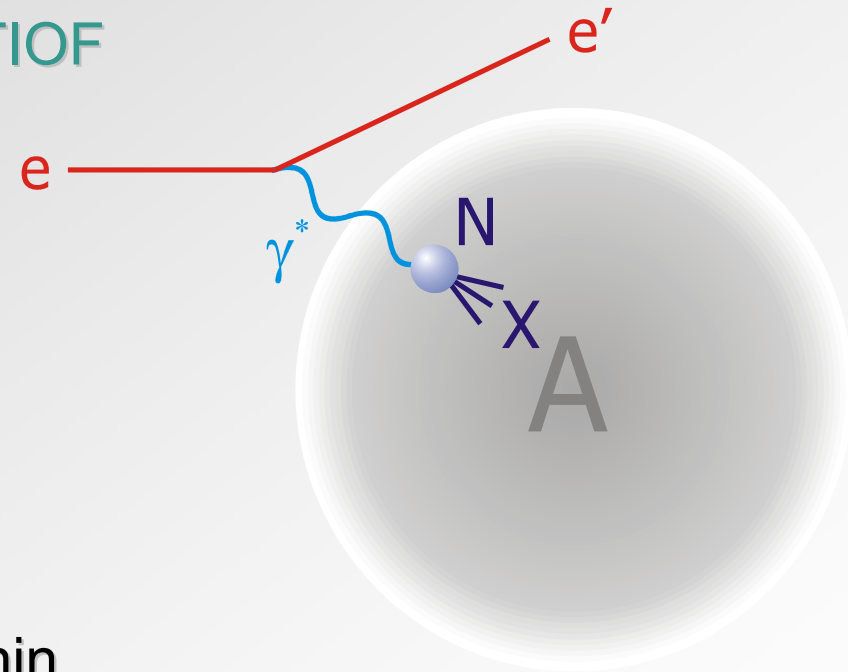
- binding energies
- Fermi motion
- Pauli blocking
- coherence length effects

– propagation of final state X within

BUU transport model

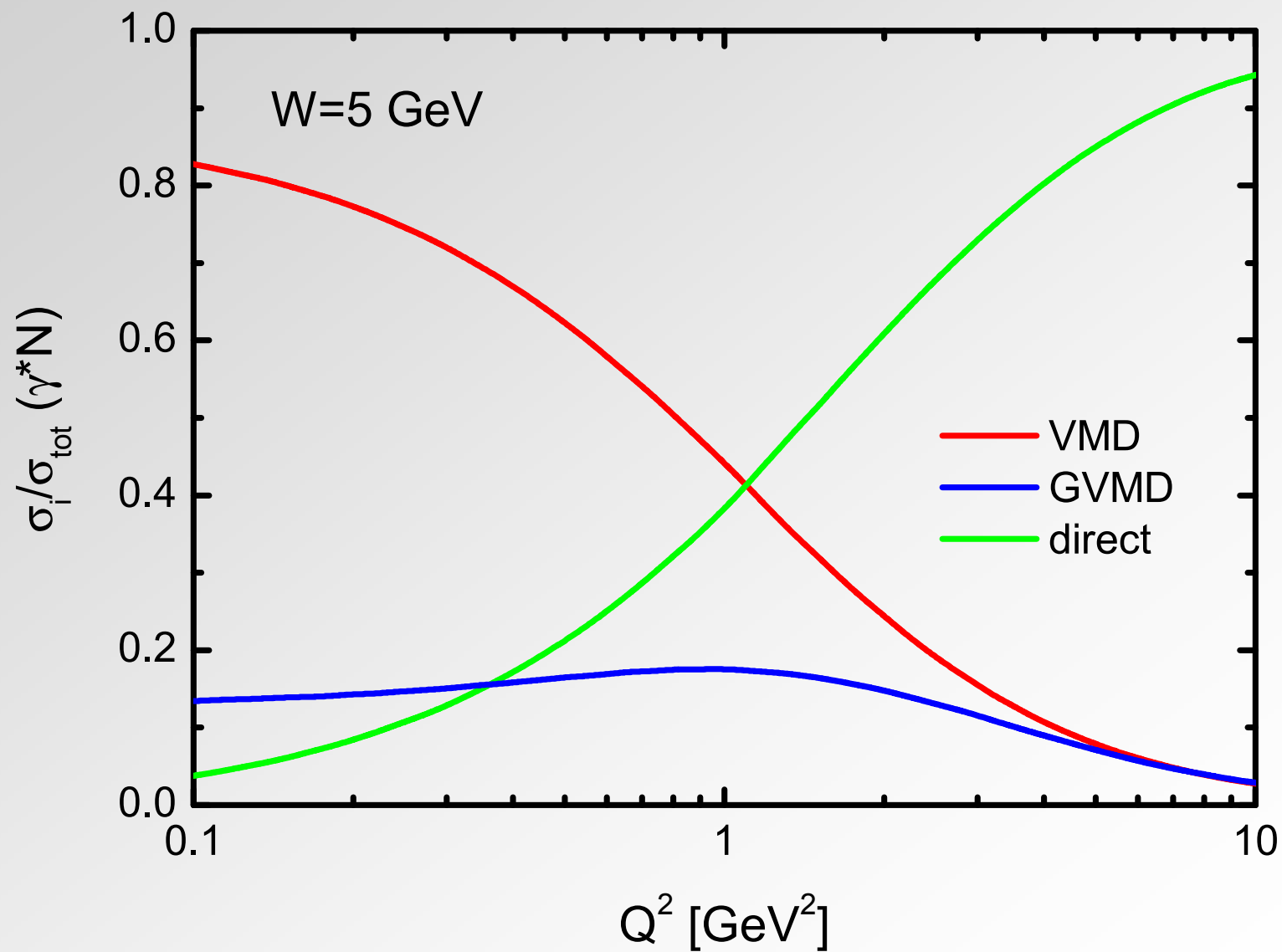
■ consideration of

- elastic and inelastic scattering (coupled channels)



hadronic structure of the photon

$$|\gamma^*\rangle = \text{[green wavy line]} + \text{[red wavy line with } V \text{ and dots]} + \text{[blue loop with } q \text{ and } \bar{q}]$$



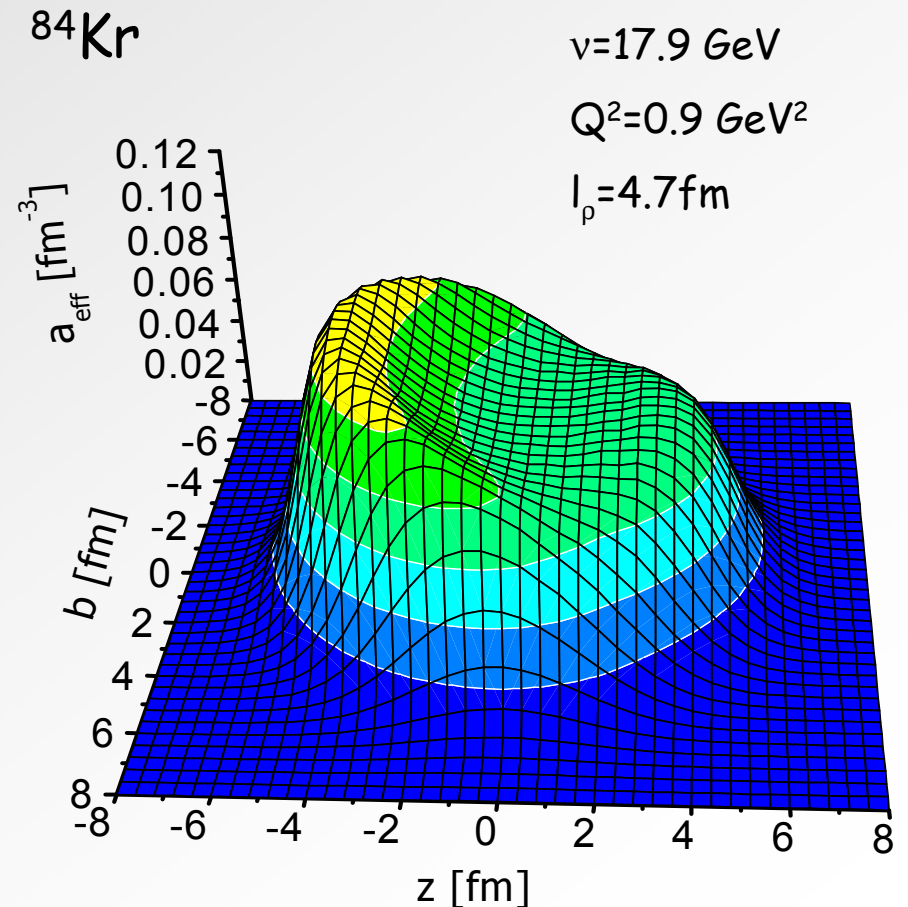
■ shadowing of the vector meson component

- coherence length:
distance that γ^* travels as
a vector meson fluctuation

$$l_V = |k_V - k_\gamma|^{-1} \approx \frac{2\nu}{Q^2 + m_V^2}$$

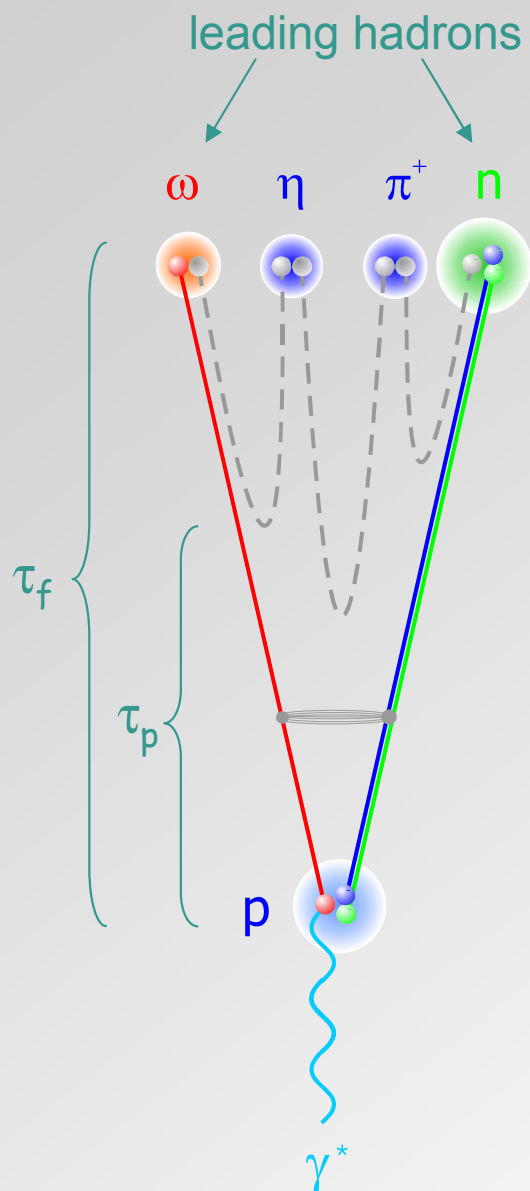
- coherence length $>$ mean free path inside nucleus

- density of nucleons
participating in the
production process
reduced
- influences reactions
triggered by the
vector meson component
(e.g. $\gamma^* N \rightarrow \rho^0 N$)



■ hard interactions (e.g. direct $\gamma^* N$ reaction)

- excitation of hadronic strings

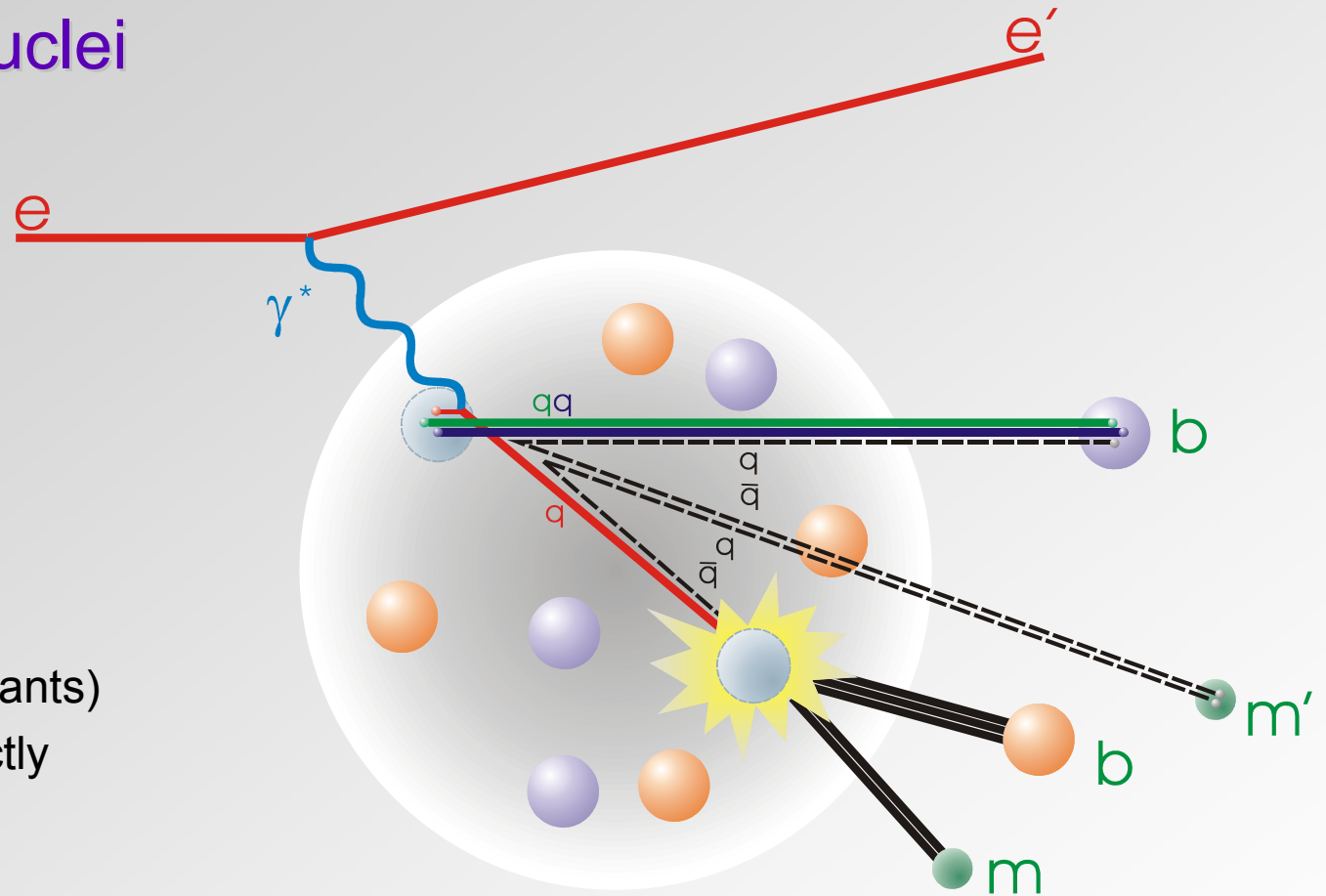


our model assumptions:

- string fragments very fast into colorneutral prehadrons $\tau_p = 0$
- prehadrons need formation time τ_f to build up hadronic wave function
- prehadronic cross section σ^* determined by constituent quark model

$$\sigma_b^* = \frac{\#q_{\text{orig}}}{3} \sigma_b$$
$$\sigma_m^* = \frac{\#q_{\text{orig}}}{2} \sigma_m$$

■ DIS of complex nuclei



- “leading” prehadrons (= target-, beam remnants) can undergo FSI directly after γ^*N interaction
- hadrons that solely contain quarks from string fragmentation start to interact after τ_f

FSI



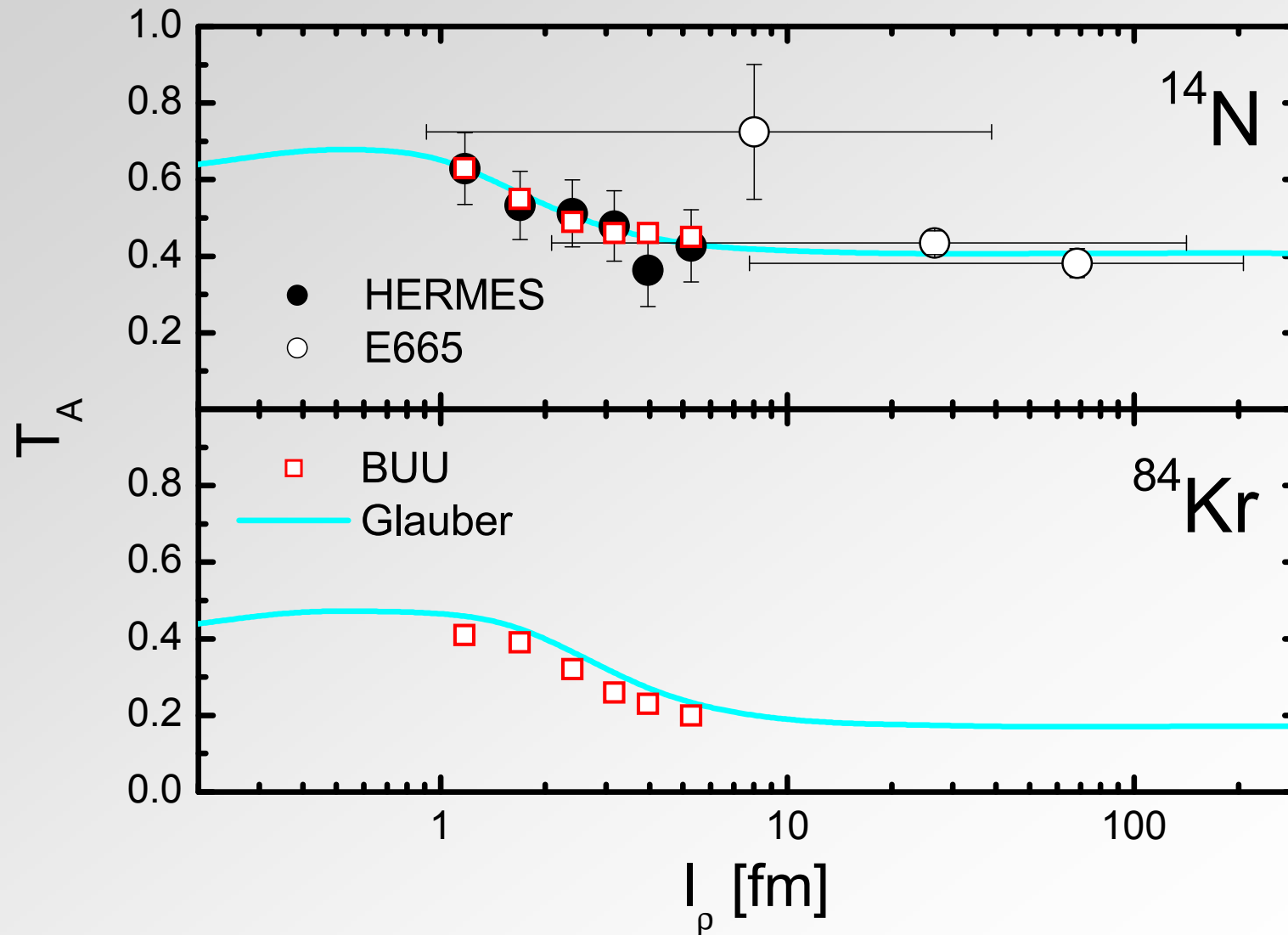
- production of new particles
- redistribution of energy

Results

■ incoherent ρ^0 electroproduction off ^{14}N

– nuclear transparency ratio:

$$T_A = \frac{\sigma_{\gamma^* A \rightarrow \rho^0 A^*}}{A \sigma_{\gamma^* p \rightarrow \rho^0 p}}$$



■ hadron attenuation in DIS off nuclei

- multiplicity ratio:

$$R_M^h(z_h, p_T, \nu) = \frac{\left(\frac{N_h(z_h, p_T, \nu)}{N_e(\nu)}\right)_A}{\left(\frac{N_h(z_h, p_T, \nu)}{N_e(\nu)}\right)_D} \quad z_h = \frac{E_h}{\nu}$$

- Experiments:

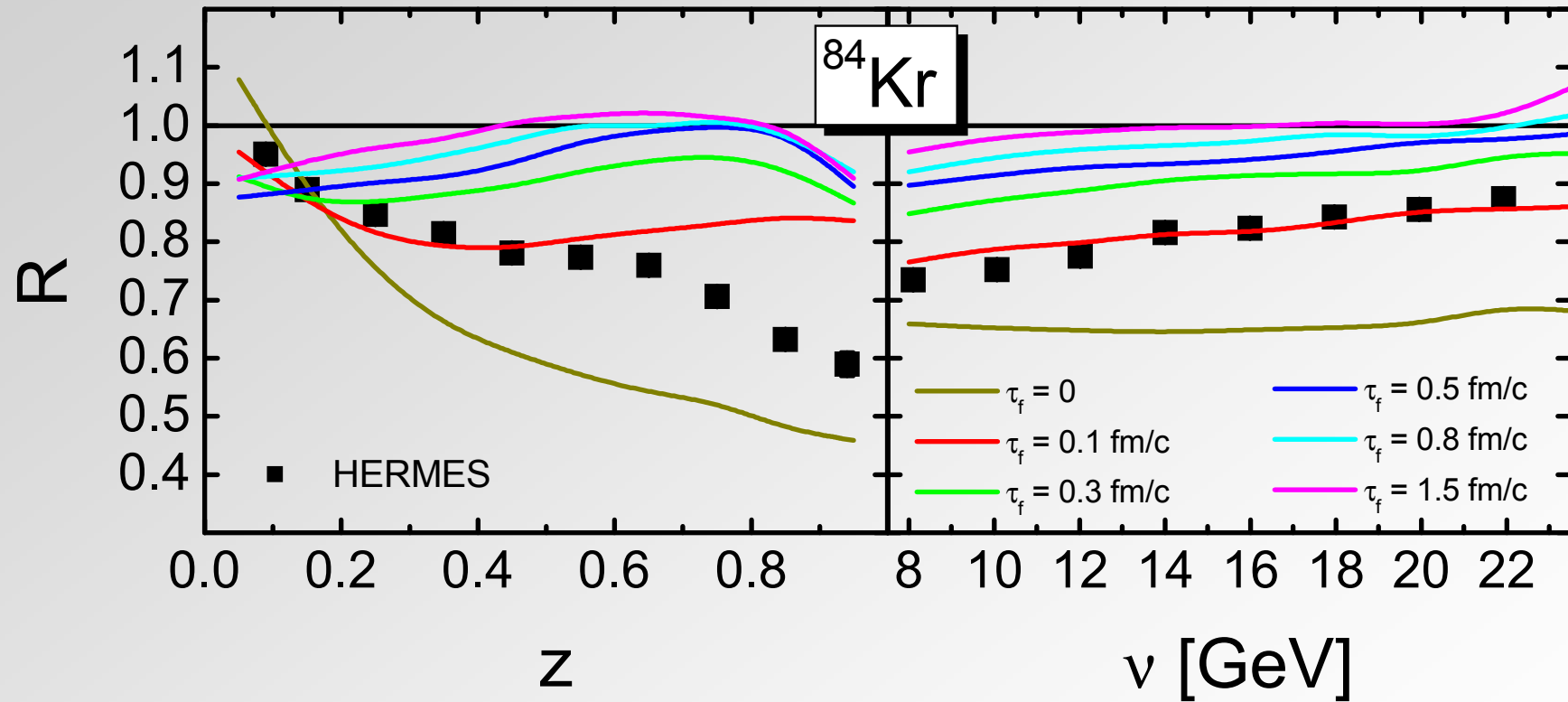
- EMC: 100-200 GeV μ -beam on ^{64}Cu
- HERMES: 27.6 GeV e^+ -beam on ^{14}N , ^{20}Ne , ^{84}Kr
- Jefferson Lab: 5.4 GeV e^- -beam on ^{12}C , ^{56}Fe , ^{208}Pb

- attenuation due to

- partonic energy loss
(X.N. Wang et al., F. Arleo)
- hadronic absorption
(B. Kopeliovich et al., A. Accardi et al.)

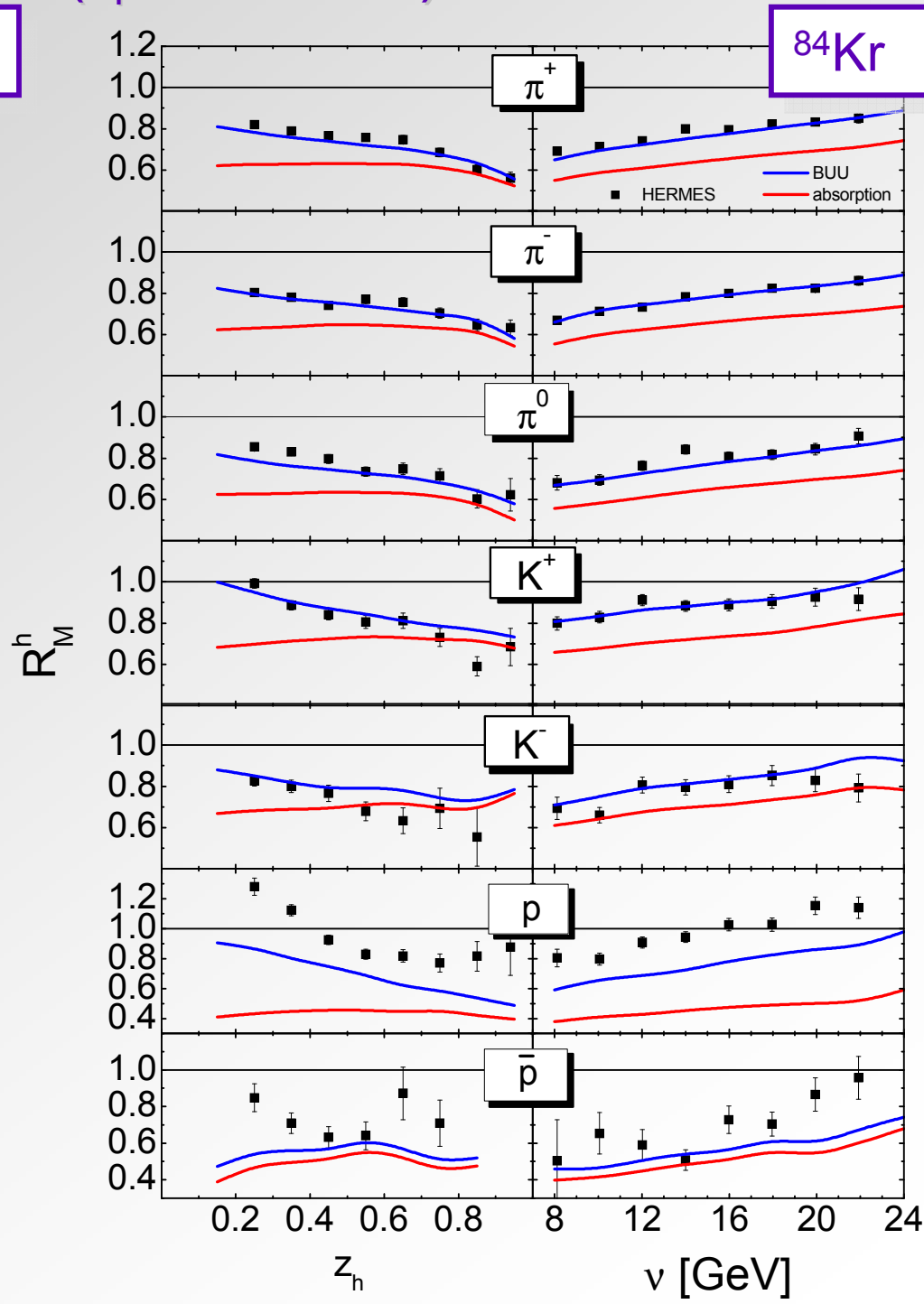
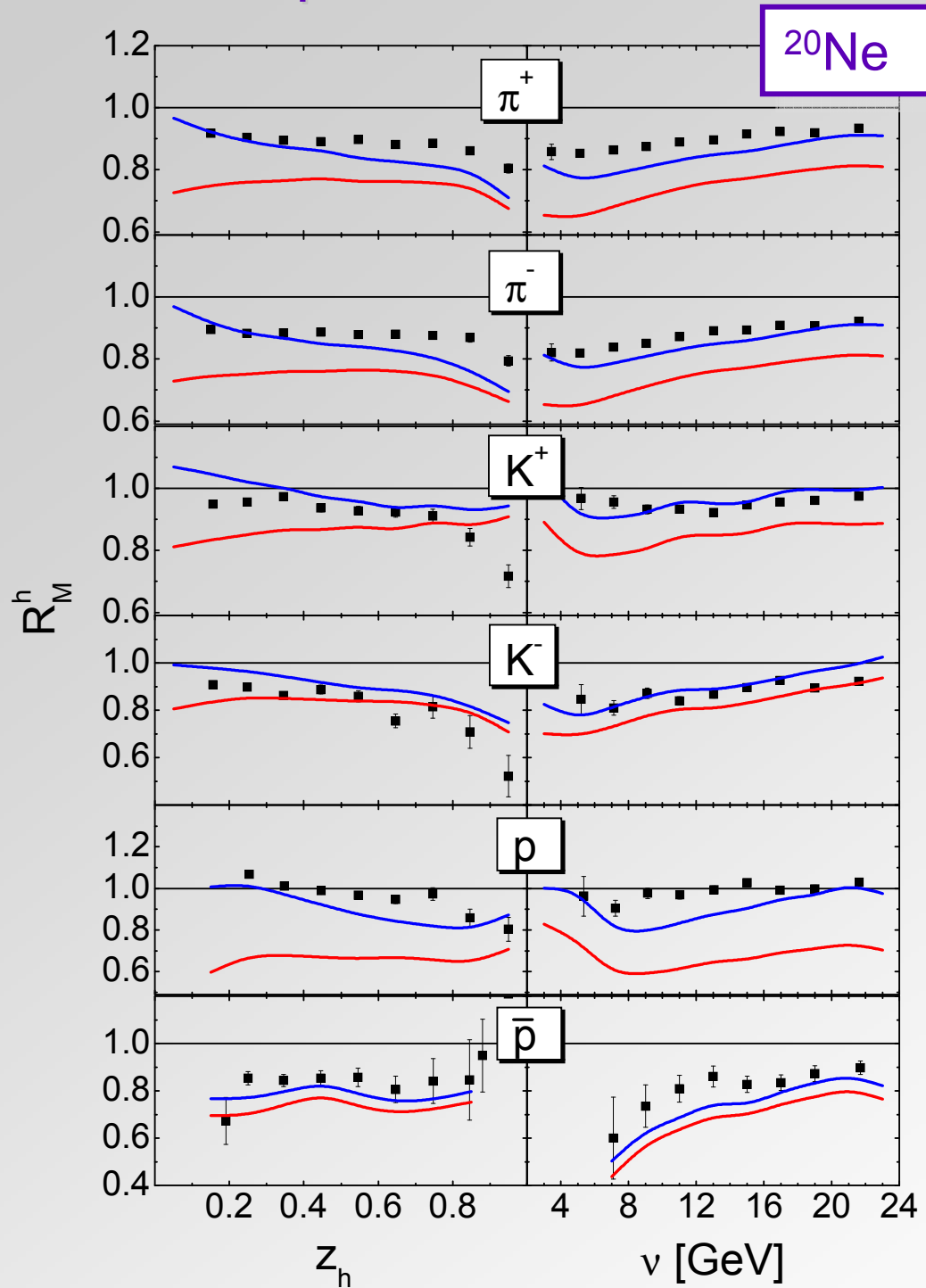
■ multiplicity ratio of charged hadrons

– w/o prehadronic FSI

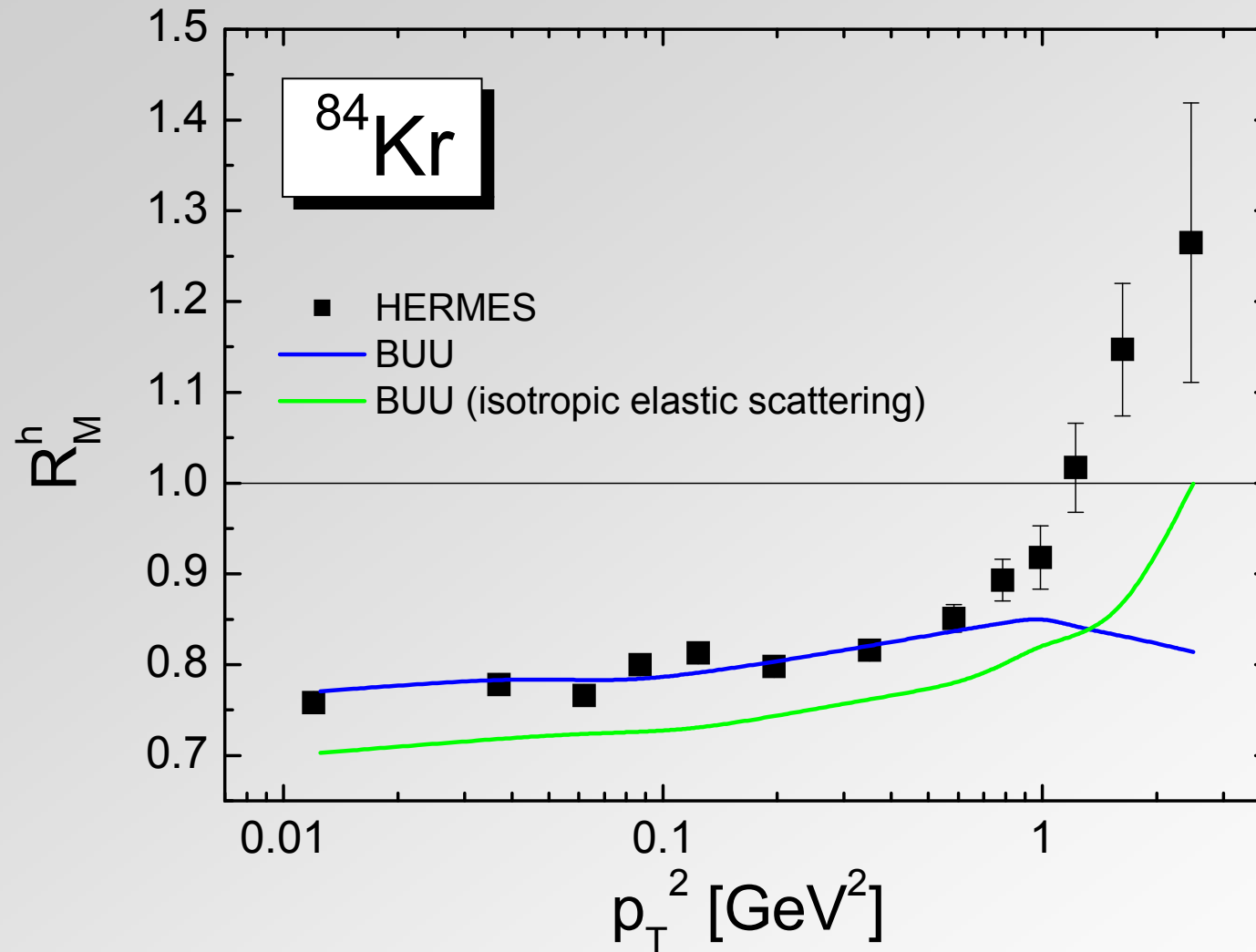


prehadronic interactions needed

■ with prehadronic interactions ($\tau_f = 0.5$ fm/c)



■ p_T -spectrum of charged hadrons ($\tau_f = 0.5$ fm/c)

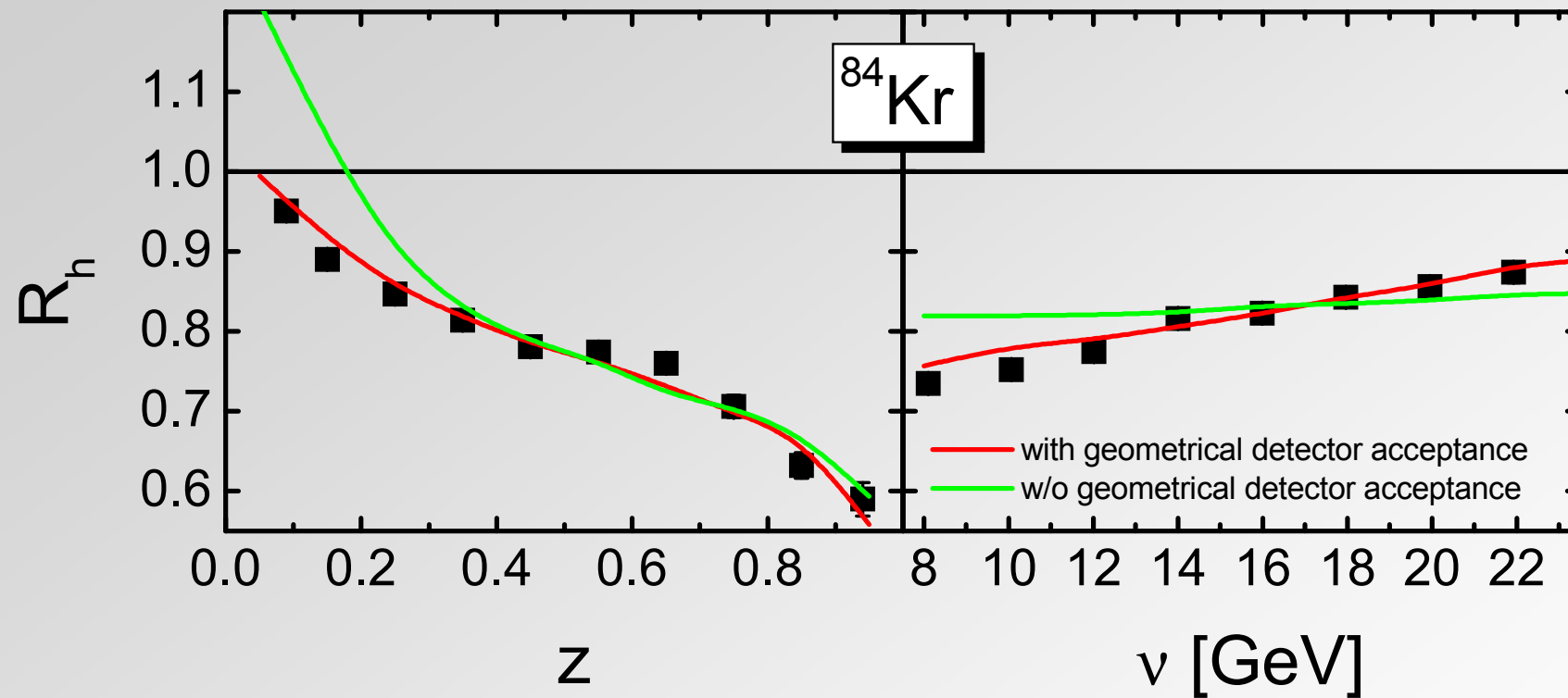


even isotropic elastic
scattering cannot explain
increase at high $p_T > 1$ GeV



Cronin effect

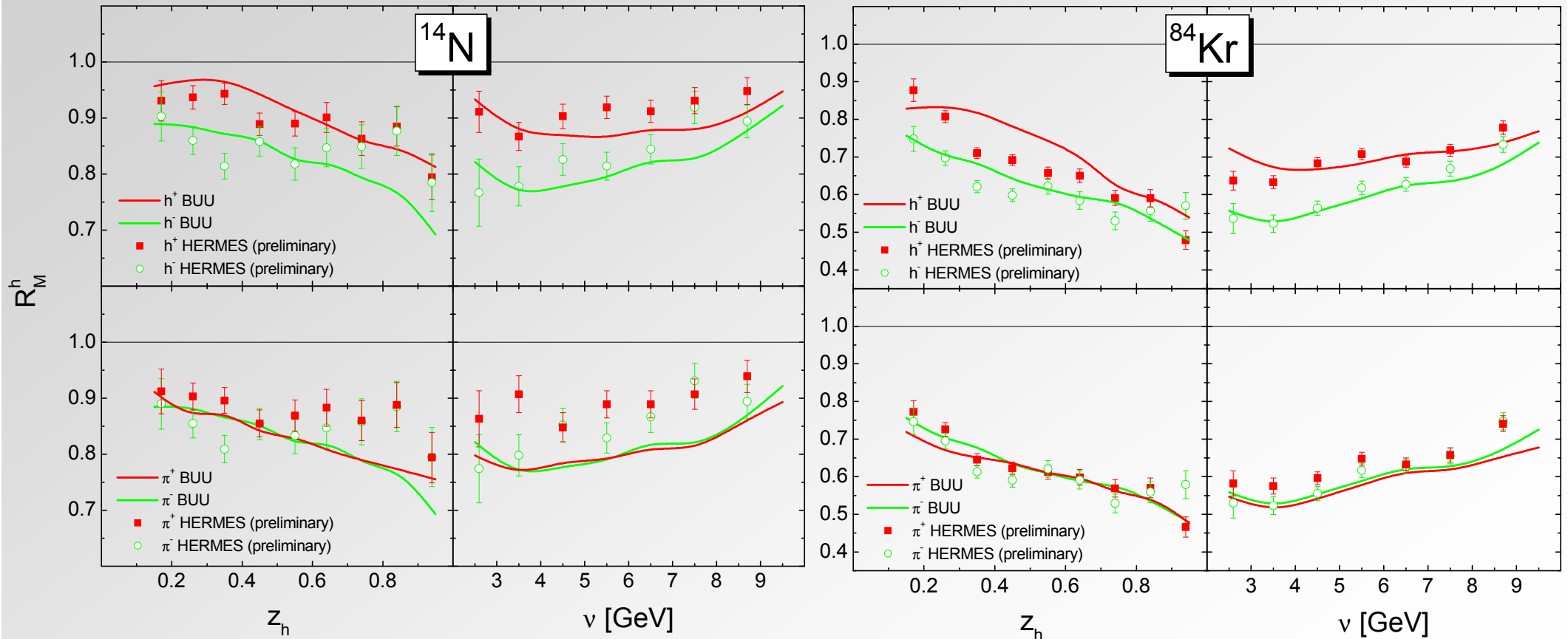
■ influence of detector geometry ($\tau_f = 0.5$ fm/c)



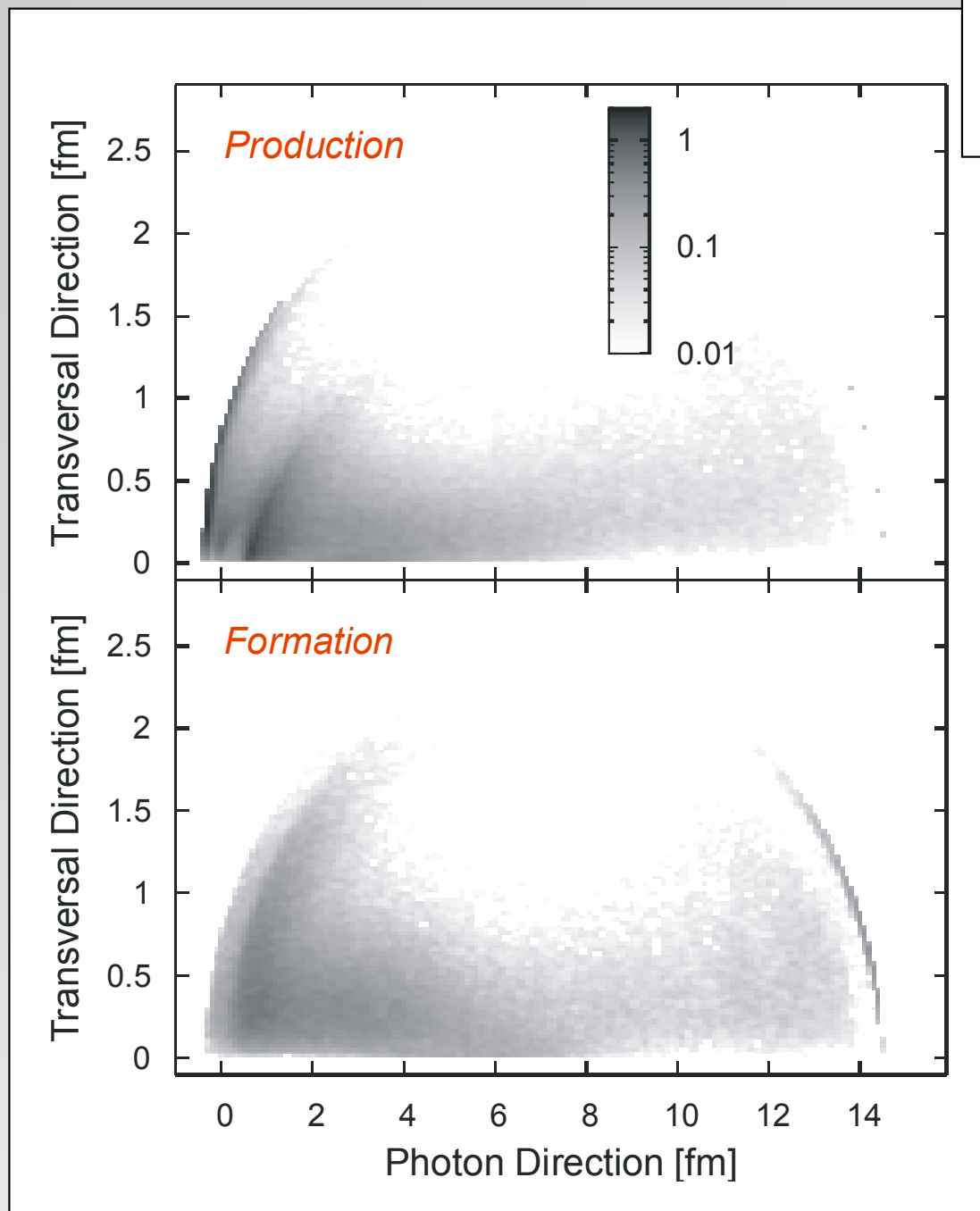
- needs to be accounted for at $z_h < 0.4$
- important for **integrated spectra**

HERMES @ 12 GeV ($\tau_f = 0.5$ fm/c)

– model seems to work also at lower energies



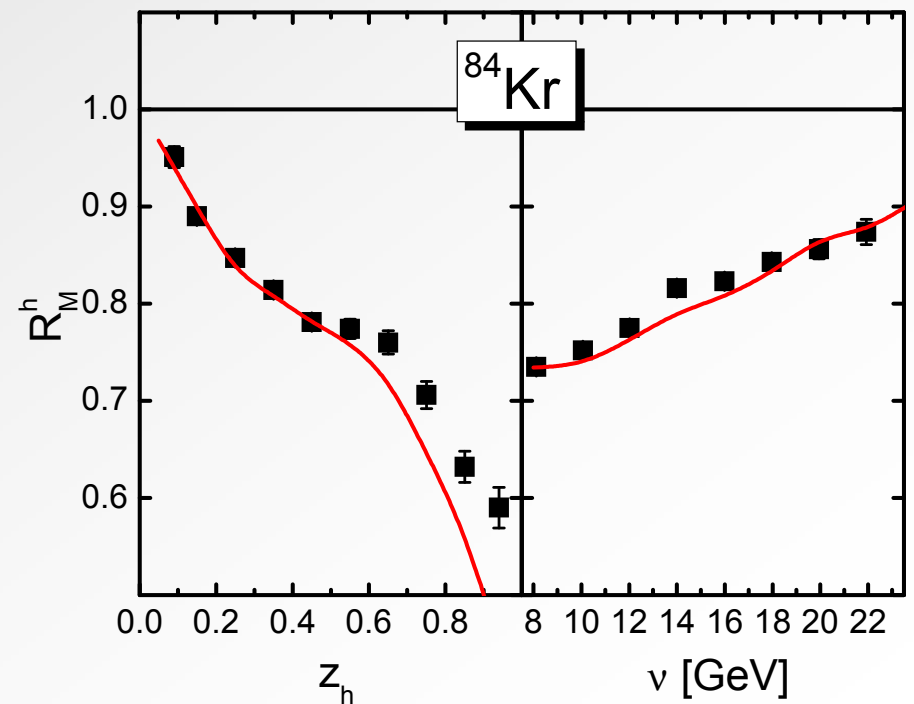
production- and formation times from PYTHIA



$v=15$ GeV

$Q^2=15$ GeV²

HERMES (first shot):



Summary & Outlook

■ model for γ and e induced reactions at GeV energies

– combines:

- qm coherence in entrance channel
- coupled channel transport description of FSI

– can describe

- coherence length effects in exclusive ρ^0 production
- most features observed in hadron attenuation

} at HERMES
energies

– works also for:

- γ and e reactions in resonance region
- πA , pA and AA reactions

} same parameter set

■ future plans:

- Lund model: string propagation and partonic energy loss
- side feeding in photo- and electroproduction of charm
- analysis of future JLab experiments
- higher energies EMC / eRHIC