On the electroproduction on nuclei

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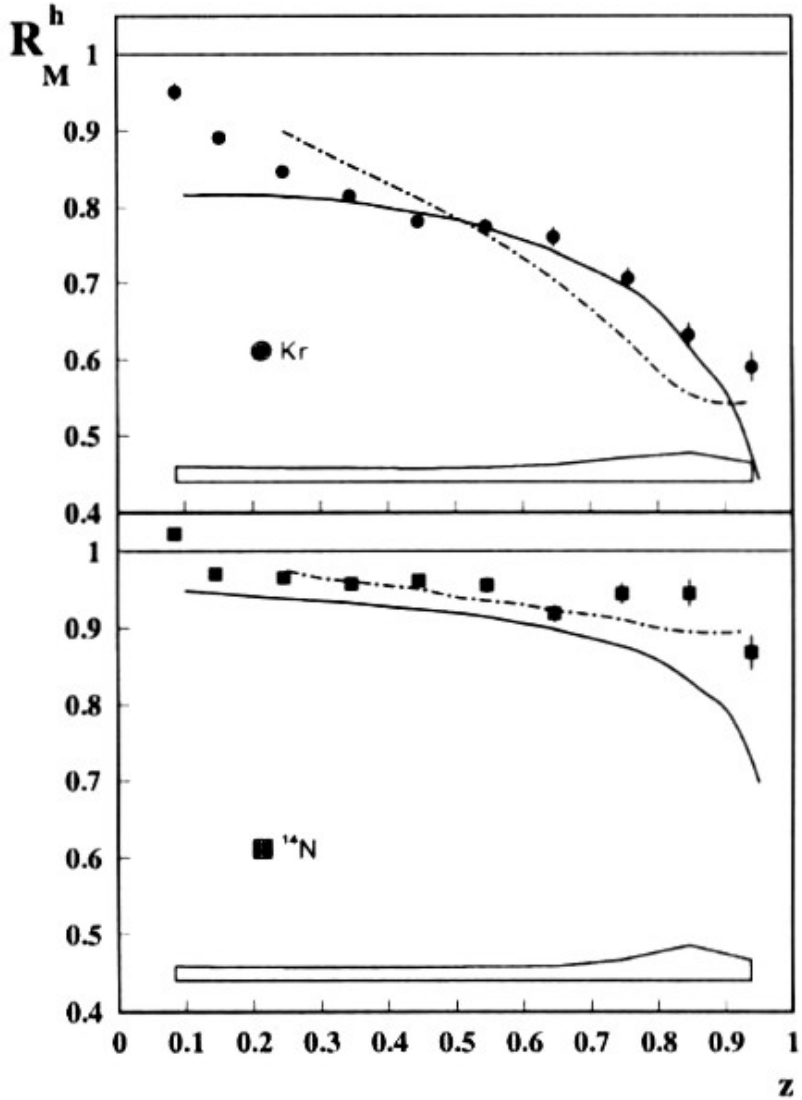
Why?

- Absorption effects in nuclei allow for tests of the space-time development of the hadroproduction process.
- Lund Model yields a well-defined example, for which the electroproduction is a simplest production process (one string formation).
- History: Białas-Gyulassy-Chmaj-Czyżewski-Sawicki; later Accardi-Muccifora-Pirner, Wang, Falter-Gallmeister etc.
- General feature: Lund +/- OK., except of small z, where absorption is not enough; to add extra production? Unified description by transport eq.?

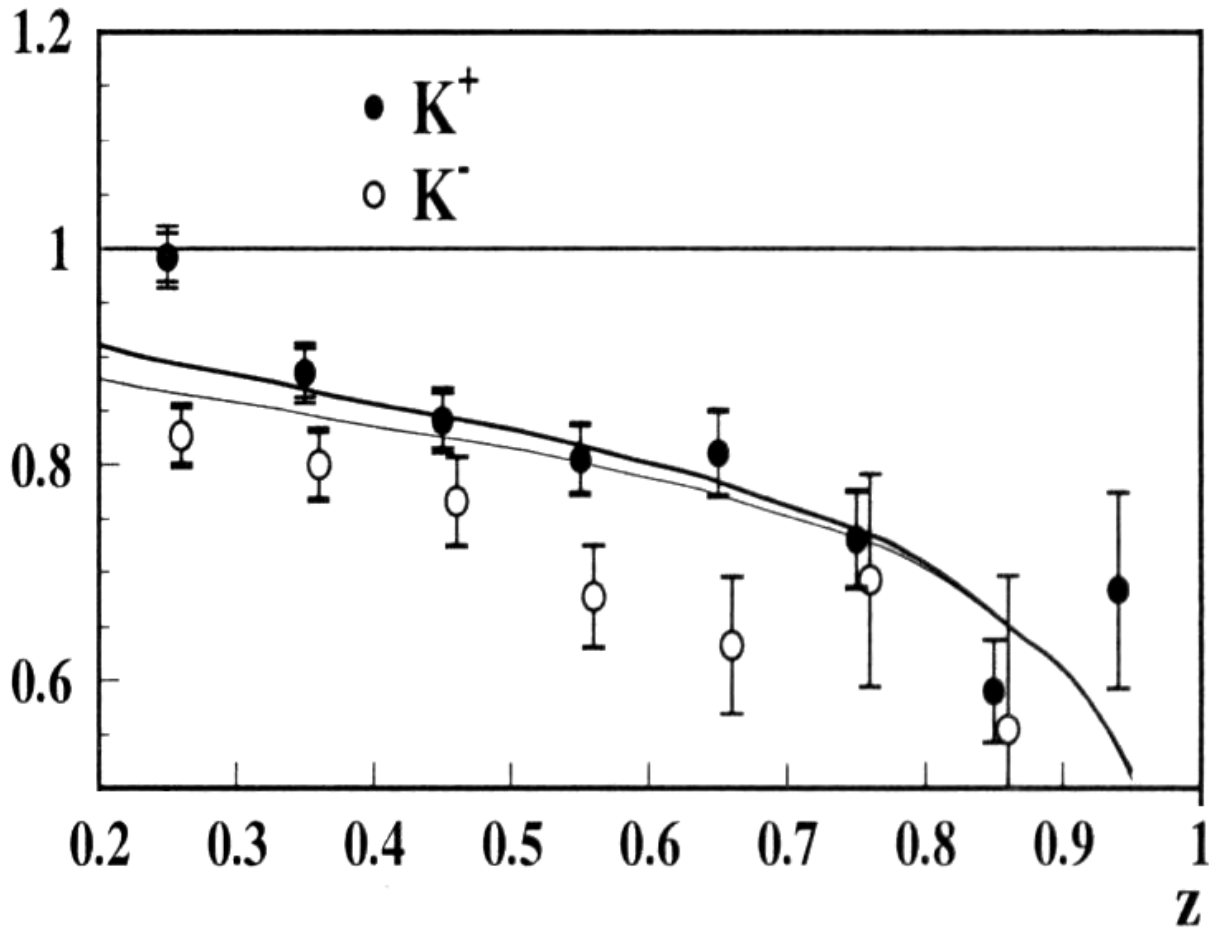
HERMES data < 2007

- One-particle spectra for charged hadrons for N, Kr, Xe (ratio to d) as functions of z=E/W, Q^2, ν: Eur. Phys. J. C20 (2001) 479, Phys. Lett. B577 (2003) 37; some data for identified particles.
- Two-particle spectra („second" hadron for the events with z_1>0.5): Phys.Rev.Lett. 96 (2006) 162301.

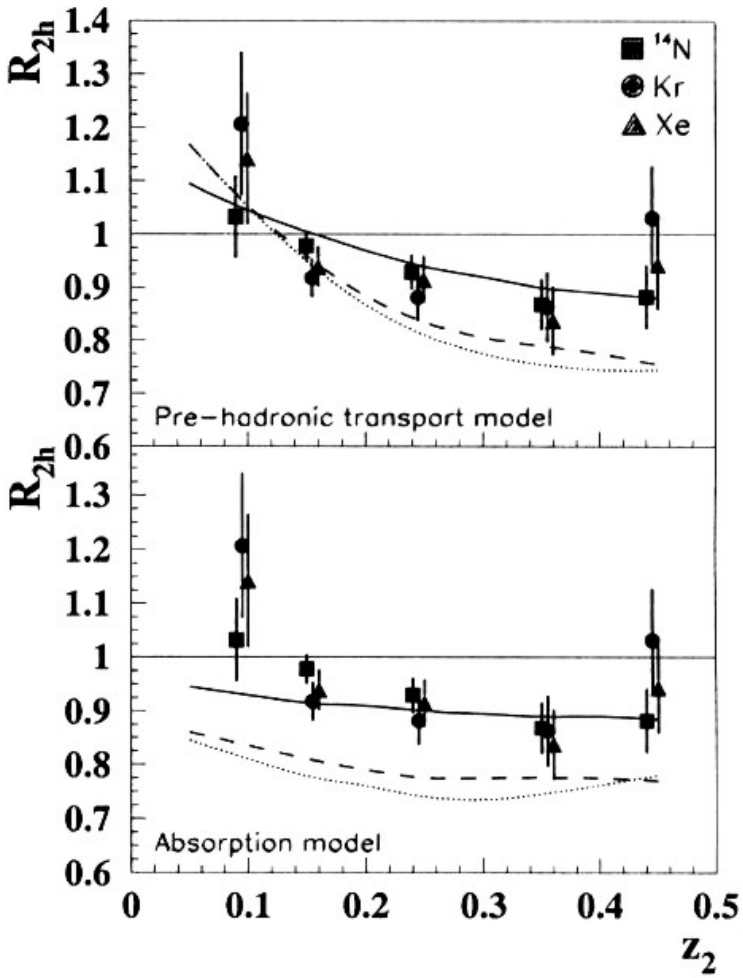
1-particle data and models



Kaon data and models



2-particle data and models



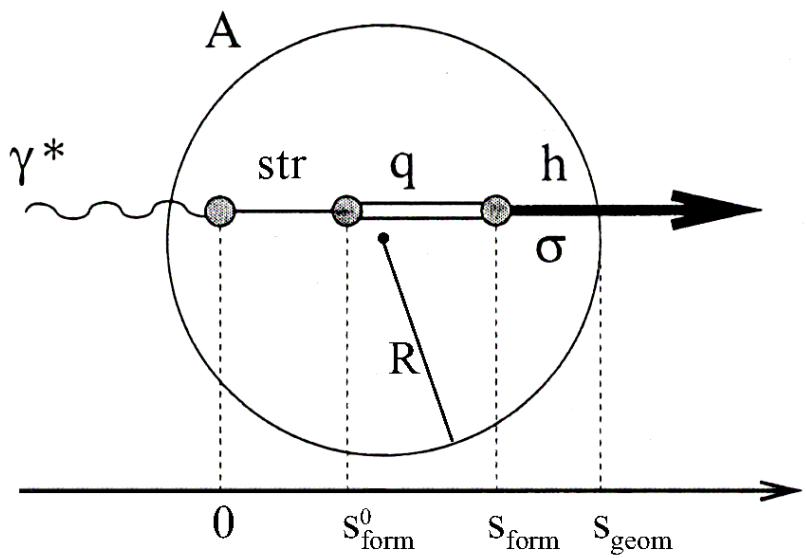
Proposal

- To use systematically new PYTHIA.
- Absorption model as simple as possible.
- To analyze the HERMES data for 1- and 2-particle spectra in $z_h=E_h/W$ (for which even the complicated transport equations do not give really good description).
- In particular: why the spectra of „second hadron” (for events with $z_1>0.5$) are almost identical for N, Kr, Xe, and for $z_2 \rightarrow 0.5$ absorption effects seem to vanish?

Model

- Standard PYTHIA with one extra information: proper time between the string formation and its breaking (GAM(3) parameter of PYSTRF) as τ; $s^0_{form}=\tau\gamma_{str}\beta_{str}c$.
- Full formation length $s_{form}=(\tau+t_h)\gamma_{str}\beta_{str}c$.
- Geometrical path s_g – from the string creation point (random inside the nucleus) to the border of the nucleus.
- Absorption: weight $w=exp[(s_f-s_g)\theta(s_g-s_f)/L]$

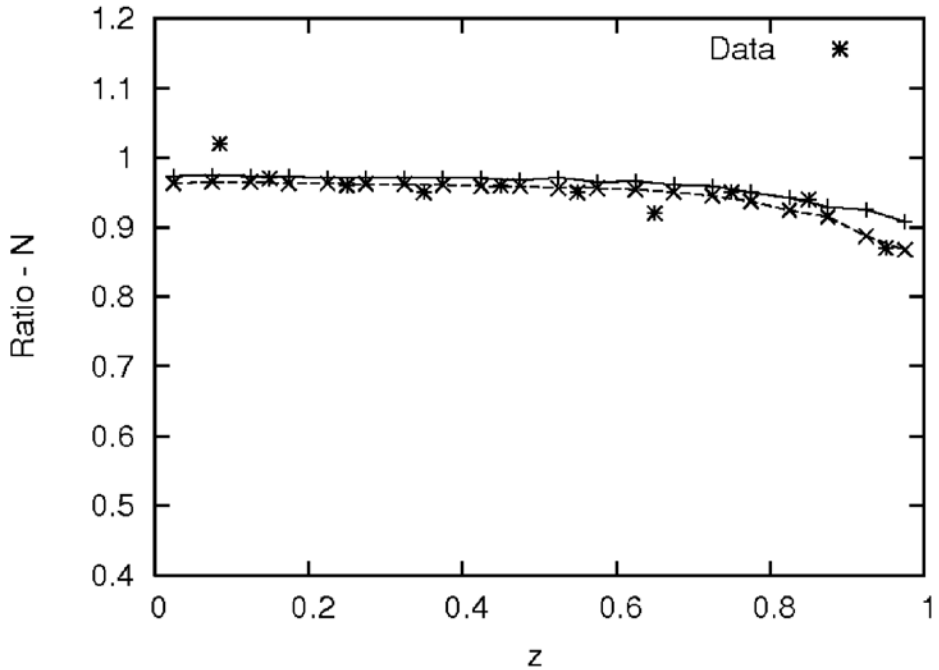
Production scheme in the model



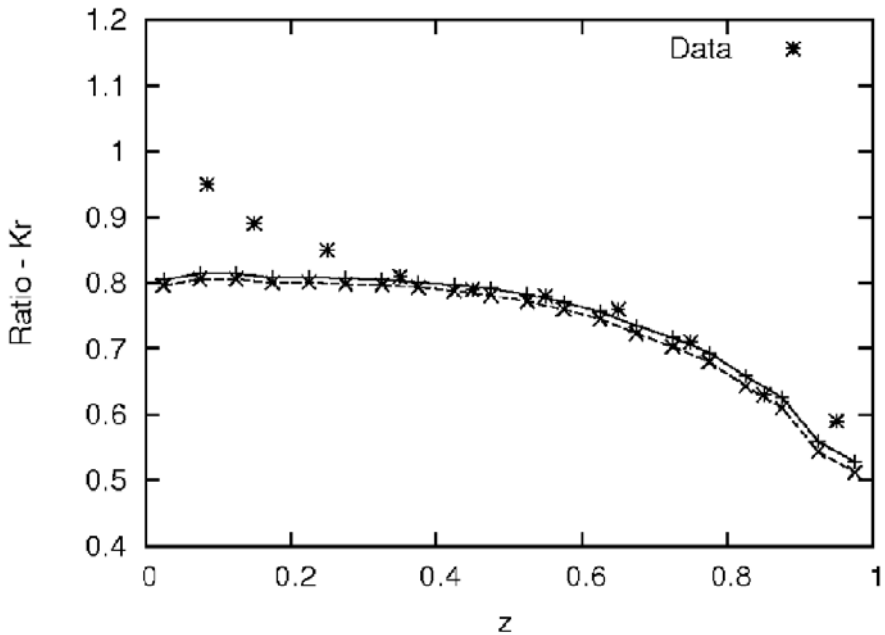
Comparison with data

- To compare with 1-particle data: the ratio of the distributions in *z* with- and without weight.
- Results: reasonable description of data for charged hadrons on N for *z>0.1,* Kr for *z>0.3* (with only one free parameter t_h *=0.7÷0.8* fm/c), compatible with K data for t_h*=0.4* fm/c.

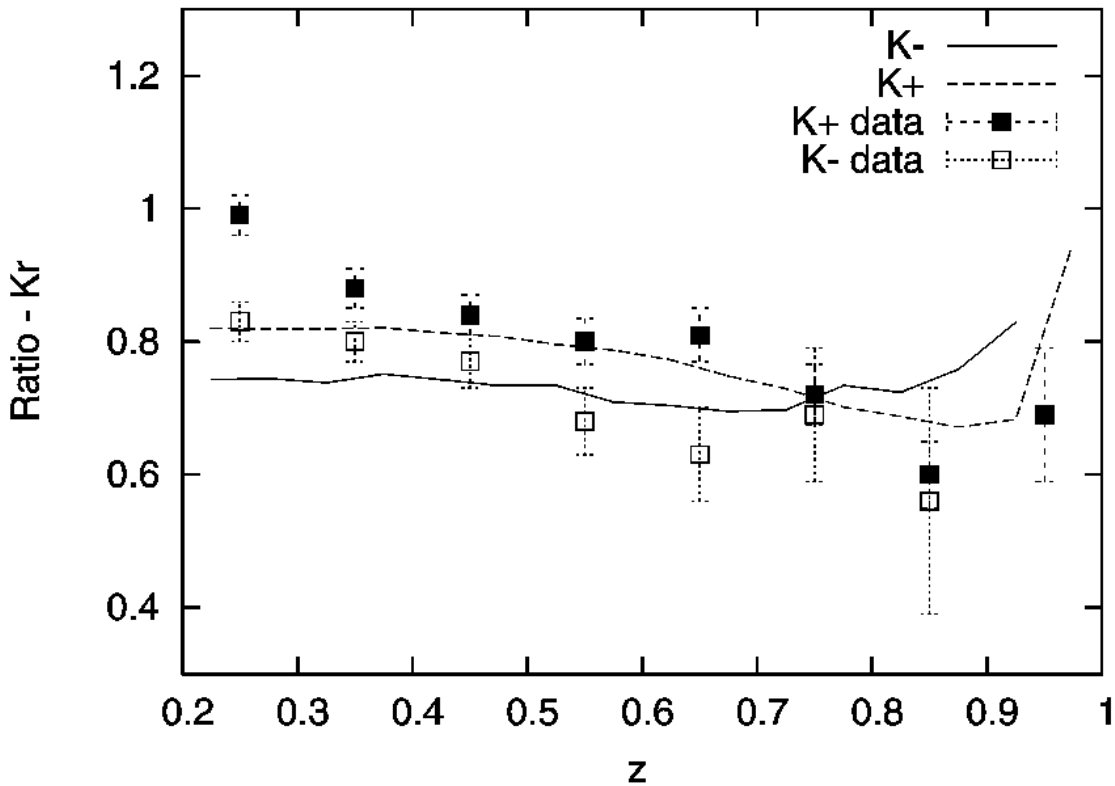
N data and the model



Kr data and the model



Kaon data and the model



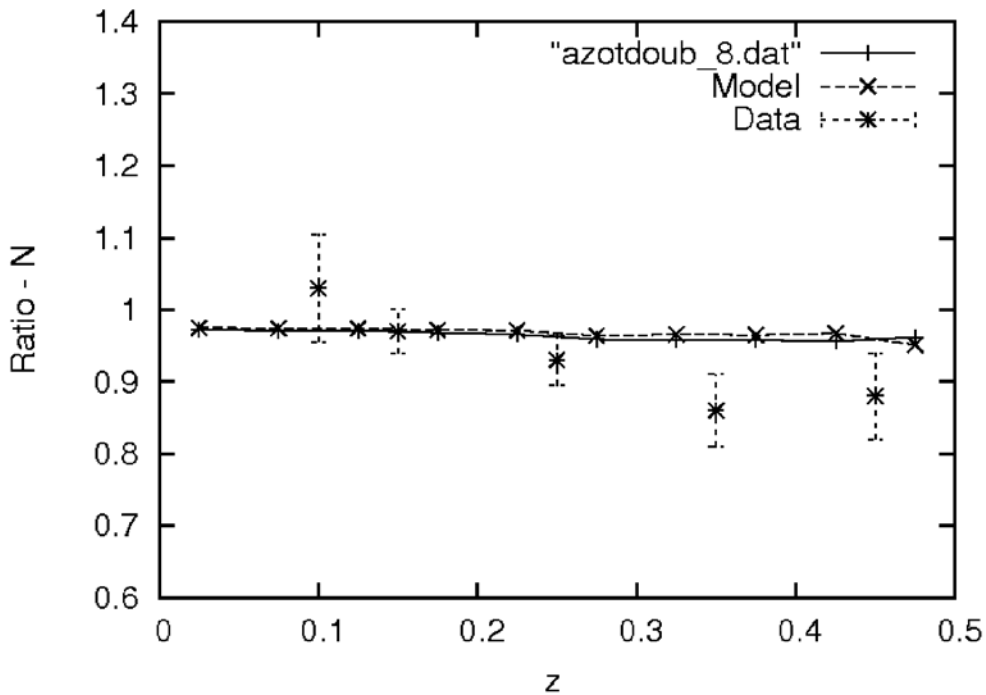
2-particle distributions

- Selecting events with z_1>0.5 and using the same prescription to calculate ratios of the distributions in z_2 gives too strong absorption for Kr i Xe (as already seen for the models used by HERMES).
- Probable reason: neglected correlations. Since both in the Lund models and in the data absorption grows with z, the events with z_1>0.5 on Kr and Xe should have small s_g to „survive” absorption despite small s_f. This suppresses the absorption effects for the „second” hadron.

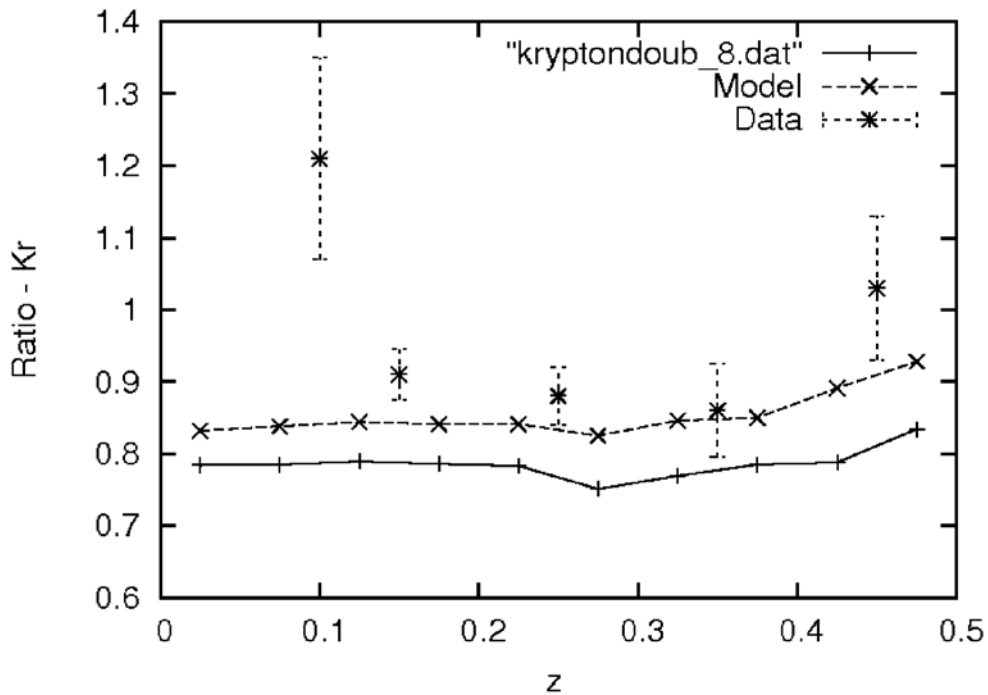
Proper modelling

- One should add the condition that a random number $w \in (0,1)$ is smaller than the weight of the fastest particle (the one with $z_1>0.5$): $w<w_1$. This takes into account the correlation described above.
- Results: compatible with the HERMES data for N, a dla Kr, Xe przy $z_2>0.2$, poprawne maximum przy $z_2 \rightarrow 0.5$.
- Note: no new free parameter!

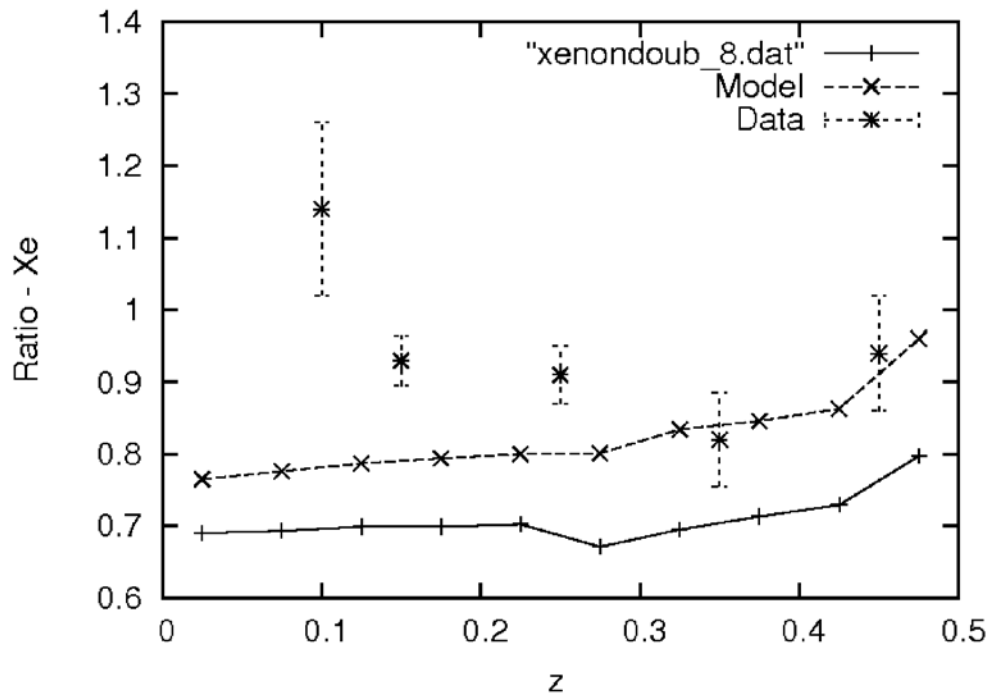
N data and the model



Kr data and the model



Xe data and the model



Provisional conclusions

- The Lund description of the elektroproduction on nuclei gives the absorption effects compatible with the old data from HERMES (apart from small *z*, where the secondary productionmay be more important than the absorption).
- The agreement of data is much better than for the absorption models used by HERMES (using Lund model as well, but without MC and/or with different prescription for $s_{form)}$.
- 2-particle distributions do not discriminate models much better than the 1-particle data.

Published as

K. Fiałkowski, R. Wit:

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hep-ph/0702058v2,

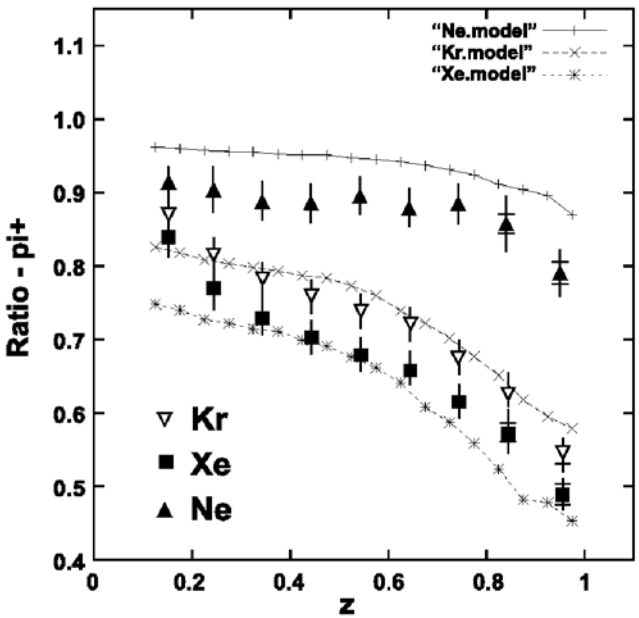
Eur. Phys. J. A32 (2007) 213.

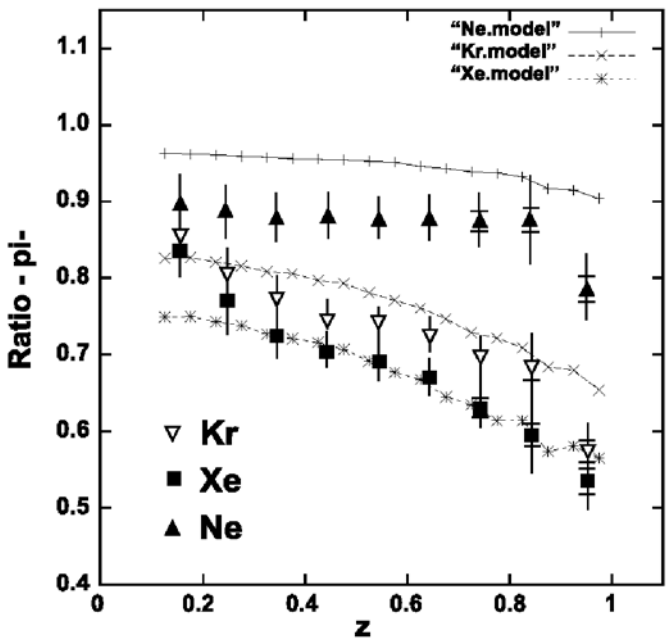
Everything seems OK., but…

New HERMES data

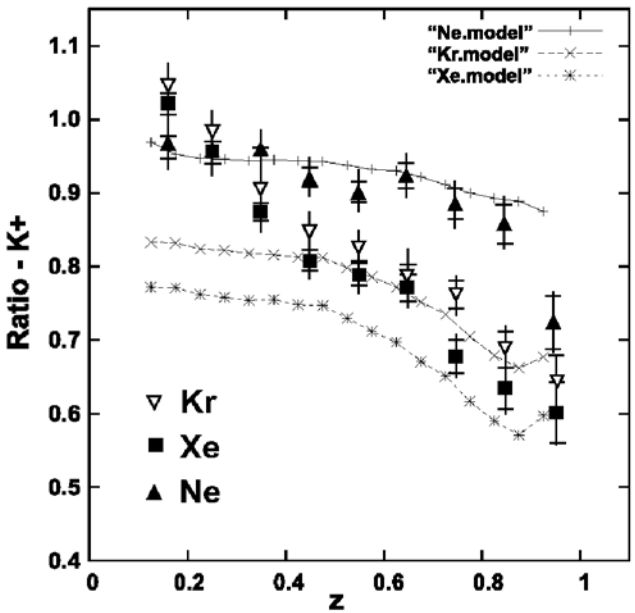
- A. Airapetian et al. hep-ex/0704.3270v1:
- He, Ne, Kr, Xe (/d); π^+, π^-, K^+, K^-, p, pbar: ratios of spectra in z, Q^2, ν
- For He no significant absorption (both in the model and data); p spectra unreliable in a purely absorptive model; application range in Q^2, ν unclear;
- thus only Ne, Kr, Xe (/d); π^+, π^-, K^+, K^- spectra in *z* compared with the model.

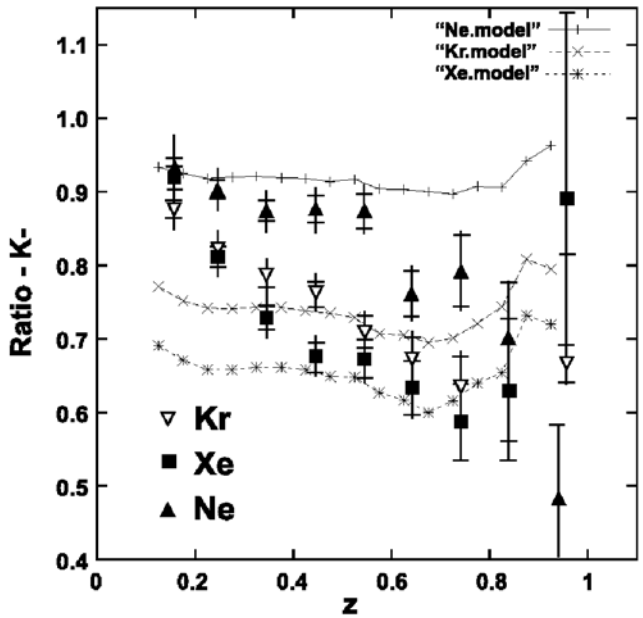
Data and the model for pions





Data and the model for kaons

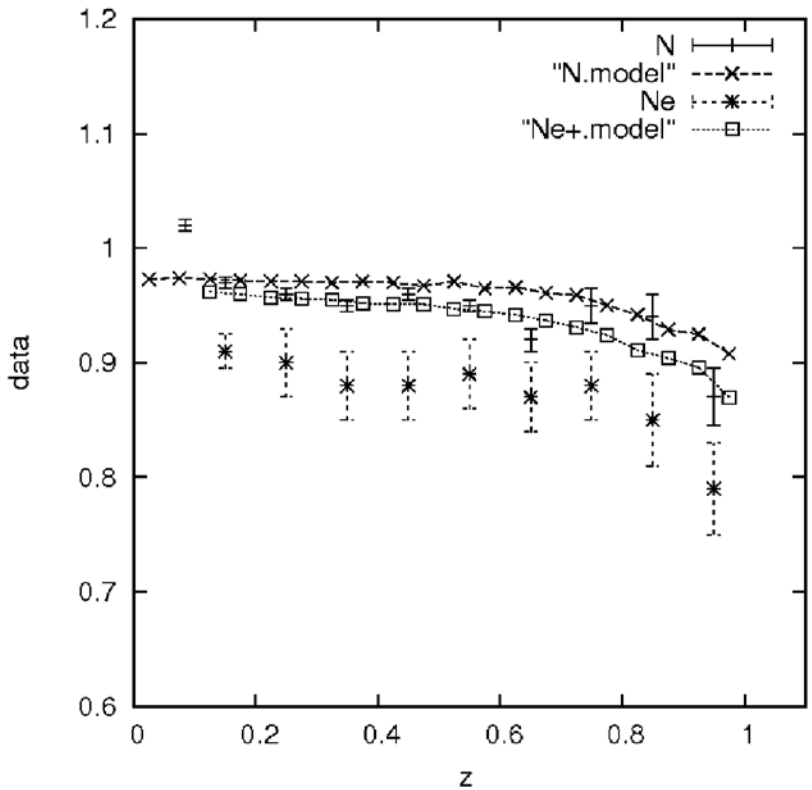




The reasons for discrepancy?

- Pions: absorption for Ne much bigger than in the model; changing the value of the only free model parameter τ_h would shift all curves downwards, and thus spoil the agreement for the heavier nuclei.
- For kaons a similar effect: either the Ne data too low, or the Kr and Xe data too high.
- Since for the old data (comparing N and Kr) model was OK., let us compare now the N data (*A=14*) and the Ne data (*A=20*)

Data and the model for N and Ne



Results

- Changing N to Ne, thus the value of the nuclear radius by less than 15%, seems to double the absorption effects (from R>0.95 to R<0.9)!
- Note: we compared „charged hadrons” for N with „π^+” for Ne, but this should not matter - pions dominate among hadrons, and for both signs data look the same.

Suggestion

- Model (and the common sense) predicts minimal difference between N i Ne, and the data?
- Before claiming the disagreement with any models, it would be wise to check the internal consistency of data!
- Reference: KF+RW hep-ph/0705.4354