Hadronization in Nuclei – Multidimensional Study

Inti Lehmann[1] on behalf of the HERMES Collaboration
Department of Physics and Astronomy
University of Glasgow
Glasgow, G12 8QQ, Scotland/UK

Hadron multiplicities in semi-inclusive deep-inelastic scattering were measured on neon, krypton and xenon targets relative to deuterium at an electron-beam energy of 27.6 GeV at HERMES. These ratios were determined as a function of the virtual-photon energy ν, its virtuality Q^2, the fractional hadron energy z and the transverse hadron momentum with respect to the virtual-photon direction p_t. Dependences were analysed separately for positively and negatively charged pions and kaons as well as protons and antiprotons in a two-dimensional representation. These results will help to constrain mechanisms and models of hadronization much more decisively than by the use of integrated results as traditionally done. A few features particular to the two-dimensional representation are highlighted in this contribution.

Semi-inclusive production of hadrons in deep-inelastic lepton nucleus scattering (SIDIS) provides a way to study quark fragmentation or hadronization. Lepto-production of hadrons has the virtue that the energy and momentum transfered to the hit parton are well determined, as it is "tagged" by the scattered lepton. In these studies the nucleus is basically used as a scale probe of the underlying hadronization mechanism: by using nuclei of increasing size one can investigate the the space(time) development of hadronization.

The ratio of normalised yields Y_A^h on neon (Ne), krypton (Kr) and xenon (Xe) targets, denoted by A, compared to the same quantity on a deuterium D target: $R_A^h = Y_{\mathrm{A}}^h / Y_{\mathrm{D}}^h$ was measured with the HERMES spectrometer [1] at DESY, where h indicates positively and negatively charged pions ($\pi^{+/-}$) and kaons ($\mathrm{K}^{+/-}$), protons (p) and antiprotons ($\overline{\mathrm{p}}$). For the first time a two-dimensional representation is chosen for all hadrons separately. This allows to observe features that are hidden when integrating over large kinematic ranges. Details, references to previous measurements and theoretical studies can be found in Ref. [2].

The results show, for example (see Fig. 1), that π^+ and π^- behave similarly. However, their dependences with the virtual-photon energy ν change with the fraction carried by the hadron z. K^+ show different features compared to K^- which could be due to their different quark content. Particularly striking is the behaviour of protons, which show completely different trends in different ranges of z. Presumably, this is due to a sizable contribution of final-state interactions, such as knock-out processes, in addition to the fragmentation process.

[1] inti.lehmann@glasgow.ac.uk

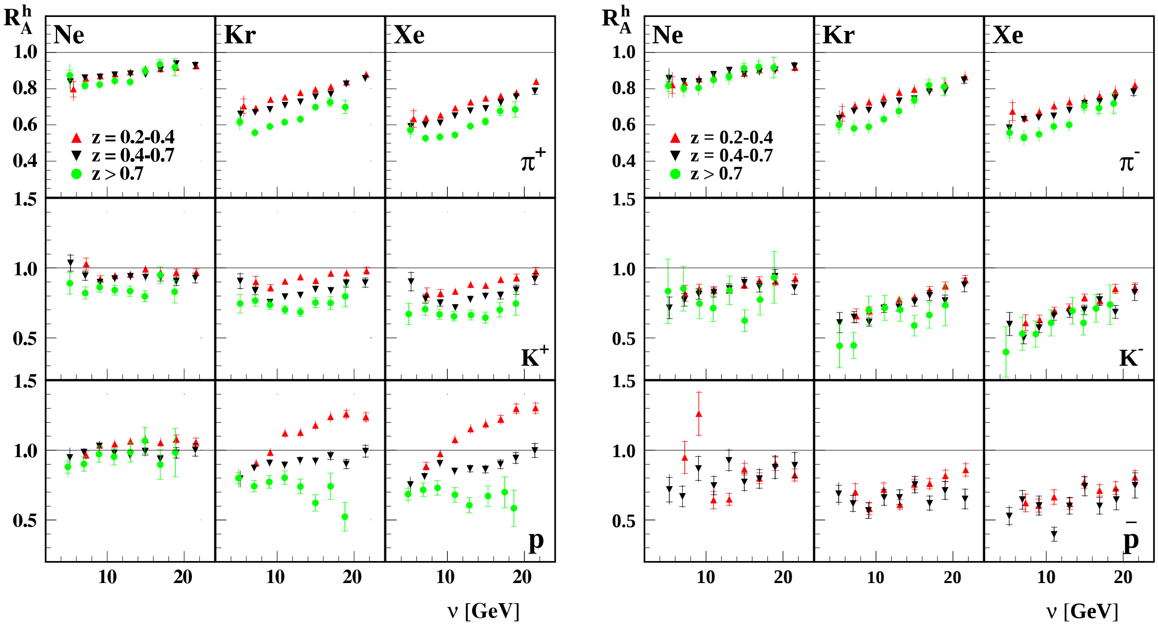

Figure 1: Dependence of R_A^h on ν for positively and negatively charged hadrons for three slices in z as indicated in the legend. The inner and outer error bars indicate the statistical and total uncertainties, respectively. For the latter the statistical and systematic bin-to-bin uncertainties were added in quadrature. In addition, scale uncertainties of 3%, 5%, 4%, and 10% are to be considered for pions, kaons, protons and antiprotons, respectively.

In conclusion, the two-dimensional distributions of R_A^h for identified π^+, π^-, K$^+$, K$^-$, protons and antiprotons, measured at HERMES [2], provide detailed information which is generally not accessible in the one-dimensional distributions (in which all kinematic variables except one are integrated over, as has been traditionally done). These new detailed data are expected to be an essential ingredient for constraining models of hadronization and, hence, improving our understanding of hadron formation.

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References

[1] K. Ackerstaff *et al.* [HERMES], NIM A417 (1998) 230.

[2] A. Airapetian *et al.* [HERMES], Eur. Phys. J. A 47 (2011) 113.