Study for fragmentation and fructure functions in the hard processes

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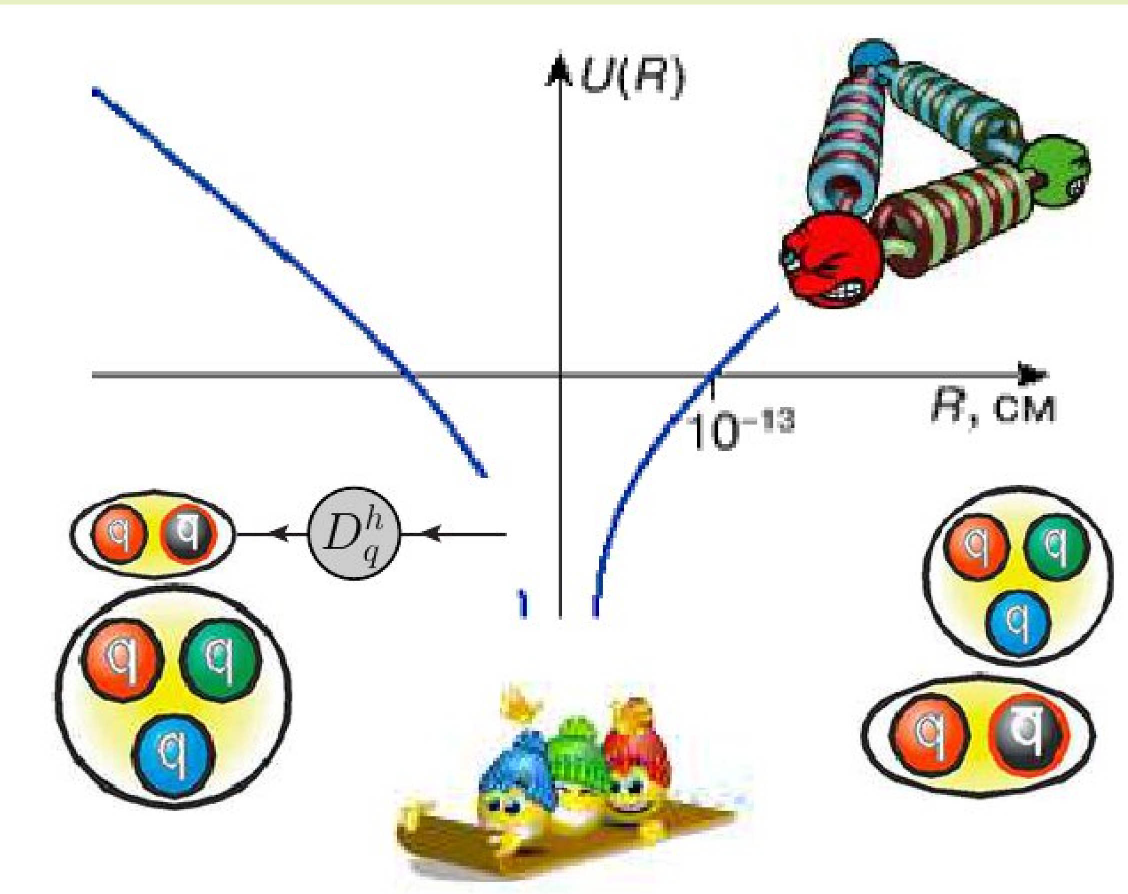
Abstract

We discuss a process of hadronization of light quarks into charged pions in e^+e^- annihilations and in deep inelastic scattering of charged leptons and neutrino off nucleons. The corresponding hard cross-sections of pions production we write in terms of quark fragmentation and fracture functions. We suggest a new method of measurements of fragmentation and fracture functions based on analysis of the hard processes. Simulation program for these processes has been developed.

Quark fragmentation

Quark fragmentations (or hadronization) in hard scattering processes are determined in terms of **fragmentation and fracture functions**.

While due to strong interaction quarks are free at the small distance and they have huge potential for a distance larger than size of the hadrons, theory can not calculate dynamic properties of the hadronization processes.

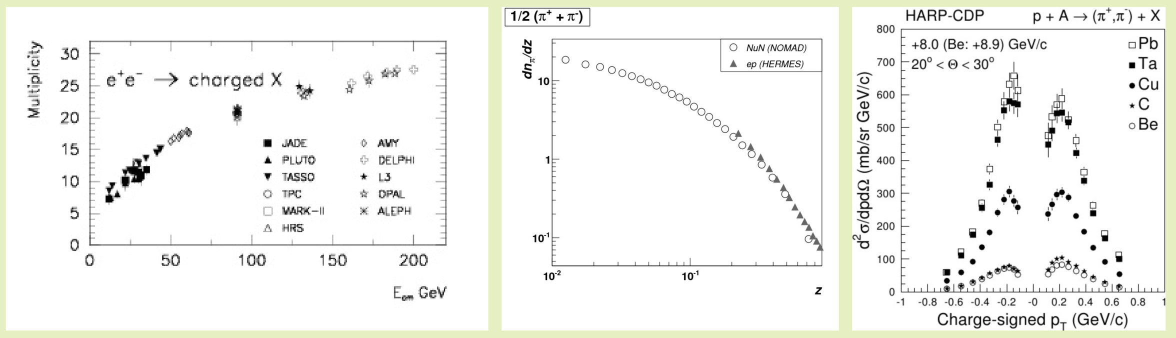


Such a quark transfer to hadrons is defined by fragmentation functions that describe the final-state single-particle energy description in hard scattering processes like e^+e^- annihilation.

$$F^h(z,s) = \frac{\sum_q e_q^2 \left[D_q^h(z,s) + D_{\bar{q}}^h(z,s)\right]}{2\sum_q e_q^2}.$$

Experimental data

Data selection for the analysis is based on measurements of the hadron production or full fragmentation functions F^h.



@ Durham HepData project
http://hepdata.cedar.ac.uk/

Analysis Scheme

Our analysis extracts quark fragmentation functions D_q^h and fracture functions $M_{q,N}^h$ from measurements of hadron productions F^h in different hard processes. In what follows we restrict our considerations of final hadrons to charged pions only.

$$\underline{F_{ee}^{\pi^\pm}} = \frac{1}{\sigma_{ee}}\left[(C_d + C_u)(D_u^{\pi^+} + D_d^{\pi^+}) + 2C_s D_s^{\pi^+}\right]$$

$$D_u^{\pi^+} = D_{\bar{d}}^{\pi^+} = D_d^{\pi^-} = D_{\bar{u}}^{\pi^-},$$

$$D_d^{\pi^+} = D_{\bar{u}}^{\pi^+} = D_u^{\pi^-} = D_{\bar{d}}^{\pi^-},$$

$$D_s^{\pi^+} = D_{\bar{s}}^{\pi^+} = D_s^{\pi^-} = D_{\bar{s}}^{\pi^-}$$

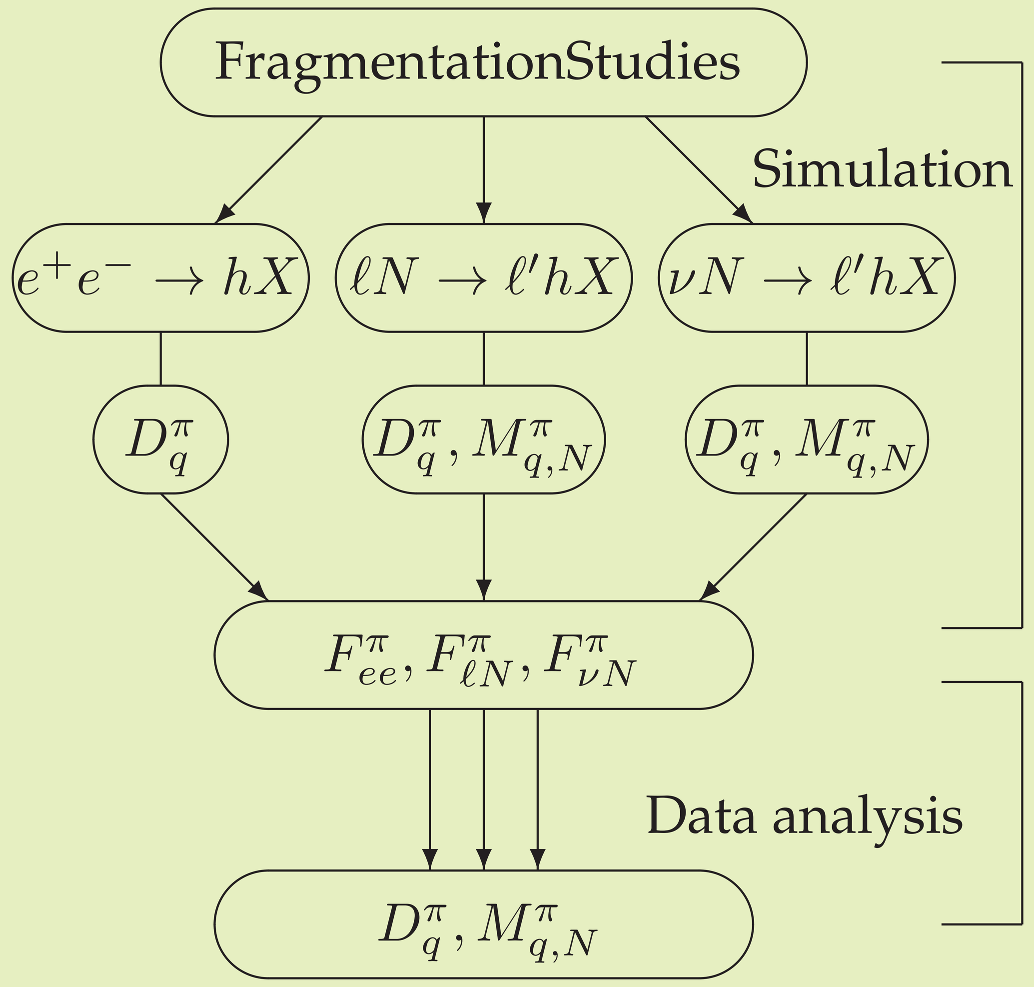
$$\underline{F_{\ell N}^{\pi^\pm}} = \frac{1}{\sigma_{\ell N}}\sum_q e_q^2\left[x\left(f_q^N D_q^{\pi^\pm} + f_{\bar{q}}^N D_{\bar{q}}^{\pi^\pm}\right)\right] + \frac{1}{\sigma_{\ell N}}\sum_q e_q^2\left[(1-x)\left(M_{q,N}^{\pi^\pm} + M_{\bar{q},N}^{\pi^\pm}\right)\right]$$

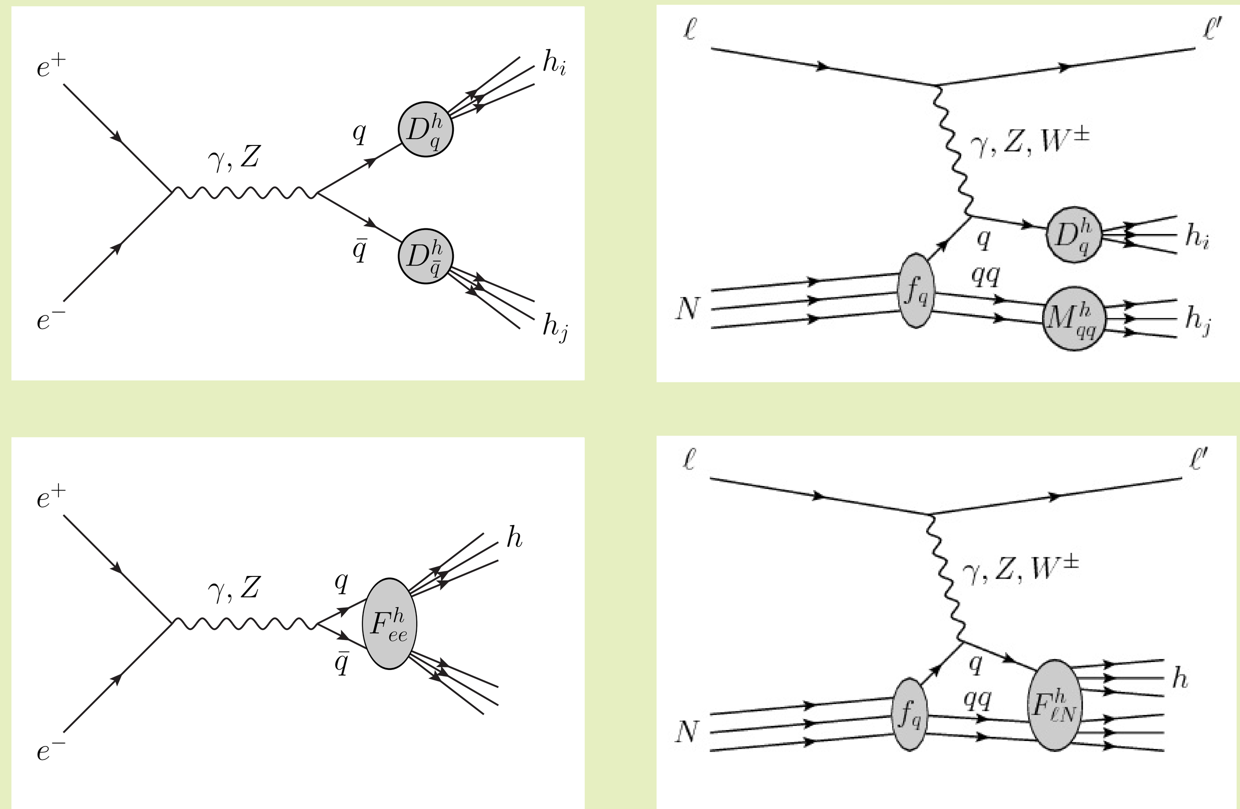
$$M_{d,p}^{\pi^+} \simeq M_{uu}^{\pi^+},\quad M_{u,p}^{\pi^+} \simeq M_{ud}^{\pi^+},\quad M_{\bar{d},p}^{\pi^+} \simeq M_{uudd}^{\pi^+},$$

$$M_{\bar{u},p}^{\pi^+} \simeq M_{uuud}^{\pi^+},\quad M_{\bar{s},p}^{\pi^+} \simeq M_{uuds}^{\pi^+}$$

Simulation program

Our program provides to fit experimental data given an access to fragmentation and fracture functions.

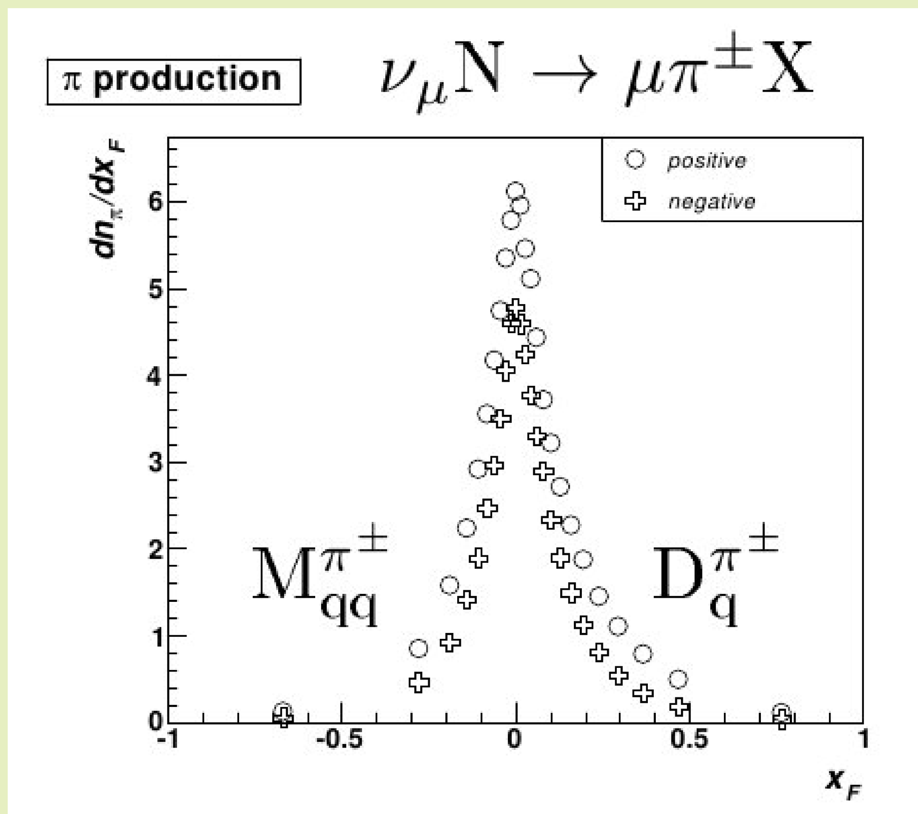




We observe (and this is the principal result of our work) that combining one observable $F_{ee}^{\pi^\pm}$ from e^+e^- annihilations, four observables $F_{\ell N}^{\pi^\pm}$ and eight observables $F_{\nu N}^{\pi^\pm}, F_{\bar{\nu} N}^{\pi^\pm}$ one has in total 13 observables which are linear combinations of 13 unknown fragmentation and fracture functions.

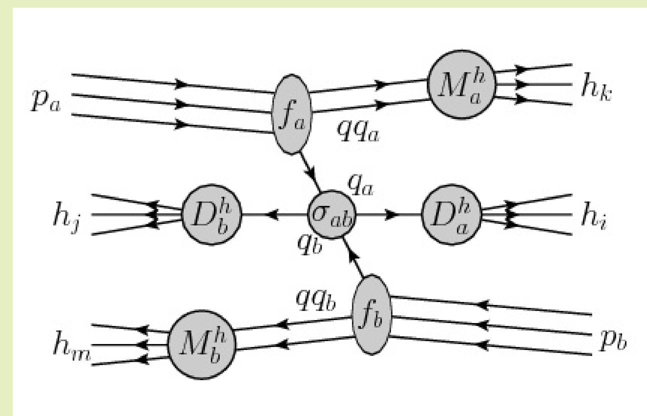
Relevance of experimental measurements

In additional to Durham experimental data we have an opportunity to precisely measure fragmentation functions from neutrino-nucleon interactions in the NOMAD experiment. Those neutrino data is sensitive to type of the quarks due to Cabbibo angle. We have large statistics for different x-Bjorken and Q^2 intervals.



Sensitivity to fragmentation parameters

Such method is free from assumptions about a functional form of the fragmentation and fracture functions. Thus in general it has a potential to measure these functions with smaller uncertainties (*A.K. Edemskaya, D.V. Naumov, O.B. Samoylov, Phys.Part.Nucl.Lett. 8:772-775, 2011*). Analysis can predict hadron production in hard hadron-hadron collisions.



Acknowledgements

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