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Production of charged hadrons in muon deep inelastic scattering

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A B S T R A C T

The production of charged hadrons, in muon deep inelastic scattering (DIS), at light and heavy target is presented. The particles produced by the interaction with Xenon (Xe) are compared with those produced by the interaction with Deuteron (D), to obtain information on cascading process, forward–backward productions, and the rapidity distribution in different bins of the invariant mass of the interacting system W. It is clear that particle production due to the projectile (muon) fragmentation is substantially less than those in the target fragmentation (nucleons), because of the diversity of their internal structures.

1. Introduction

The hadronization process, during Lepton Deep Inelastic Scattering (LDIS), is amongst the most striking phenomena in the particle physics. Its importance is to search for new physics of hadron production. The topic of the production of charged hadrons have been covered by several models [1–4]. Furthermore, the particle production, during muon DIS, has been studied in early experiments, using a free nucleon [5,6] and bound nucleons (nucleus) targets [7,8]. Moreover, there are very modern research works [9–12] that study the production of charged hadrons by lepton as projectile. The general features of collision may be understood in the framework of quark-parton model (QPM), in which one or multi photons, emitted by the incident muon, interact with the parton of the target nucleon. In Fig. 1, this process is described as seen in the center of mass system.

The struck parton is emitted into the forward direction, while the remnant of the target travels into the backward direction. Both of these fragments hadronize, to form the forward and backward jets [13].

In our pervious paper [14], we investigated the structure of the nucleon in this process and showed how the hadronic and the leptonic stages. This led us to enrich understanding the inner structure of the nucleon target. In this paper, we are going to study the production of the charged hadrons and their correlation in the rapidity space, and in a forthcoming one, we will study the phase transition from QGP to the hadron state in this process.

The production of charged hadrons is discussed in rapidity space. We use Deuterium, as a light nucleus or free nucleon target, and Xenon as a heavy nucleus or bound nucleon target [15]. The results of the two cases will be compared to share some light on the phenomenon of the cascading process.

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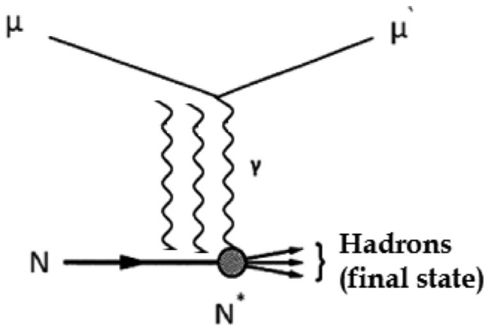

Fig. 1. Deep inelastic muon-nucleon scattering.

Table 1
Main parameters of targets.

Target	A	Z	Density [gm/cm^3]	Length [m]	Number of interactions	Number of radiation
H_2	1.01	1	0.071	1.15	0.16	0.13
D_2	2.01	1	0.162	1.15	0.34	0.15
Xe	131.29	54	0.085	1.13	0.06	1.13

The layout of the paper is as follows: Section 2 describes the experimental setup and Systematic errors. The rapidity distributions are explained in Section 3 for both muon – Deuteron and muon - Xenon interactions. In Section 4, we compare the particle production in muon-Nucleus and that of muon nucleon interactions. Finally the concluding remarks are given in Section 5.

2. Experimental setup and systematic errors

2.1. The experiment

The data were taken from the E665 spectrometer for the muon beam line of the Fermi lab Tevatron. The muon beam has an average energy of 490 GeV with a dispersion of approximately 60 GeV. The muon beam impinged on a target filled either with liquid hydrogen (H), deuterium (D) or gaseous Xenon (Xe). Only the D and Xe data sets are used in the present analysis. The main parameters of the targets are listed in Table 1.

A streamer chamber (SC), surrounding the target and located inside a 4.3 Tm vertex magnet (CVM), provides momentum measurement of nearly all low momentum charged hadrons ($0.2 < p < 10$ GeV/c). The scattered muon and high momentum ($p > 10$ GeV/c) charged hadrons are reconstructed and measured by a forward spectrometer (FS) which comprises of a second magnet (CCM with - 6.7 Tm) and several sets of proportional and drift chambers. Photons are detected with an electromagnetic calorimeter. Downstream of an iron absorber for the hadrons, the scattered muon is detected and reconstructed by several sets of proportional tubes and scintillation counters.

The requirements of the trigger used in the present analysis can be described as follows: a well defined beam track, no signal in the halo veto counters, signals in 3 (out of 4) muon scintillator planes (implying a cut in the muon scattering angle of approximately $\Theta > 3$ mr) and no signals close to the beam axis in the veto counters of the muon detector. In addition, in order to enhance the fraction of deep-inelastic events in the SC pictures, at least two hits are required in the non-bending planes of the PCN detector (outside the beam region), which is a proportional chamber located in the field free region between the two magnets.

2.2. Systematic errors

The systematic errors $\Delta_{\bar{n}}$ for the Xe and D data sets have different origins and in addition do not necessarily cancel in Xe/D ratios; therefore they are studied separately in [16], for both targets the systematic error $\Delta_{\bar{n}}$ due to uncertainties in the simulation of the trigger, in particular the requirement on PCN hits, is estimated to be 0.10. The overall systematic error of the average total multiplicity of charged hadrons is 0.43(0.40) for the D (Xe) target, after adding the individual contributions in quadrature (Table 2).

If not stated explicitly, all errors drawn in the figures and quoted in the text and in the tables are statistical only.

3. The rapidity distribution

The lab and cms rapidity are given by

$$y_{lab} = \frac{1}{2} Ln \frac{E_h + p_l}{E_h - p_l} \qquad (1.a)$$

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