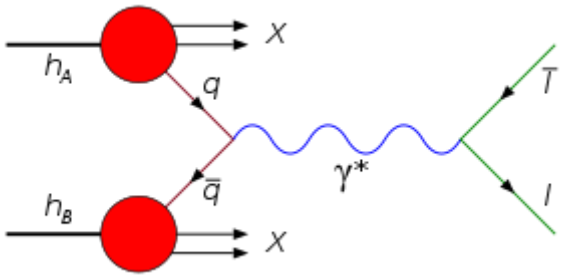
Drell–Yan process

The **Drell–Yan process** occurs in high energy hadron–hadron scattering. It takes place when a quark of one hadron and an antiquark of another hadron annihilate, creating a virtual photon or Z boson which then decays into a pair of oppositely-charged leptons. Importantly, the energy of the colliding quark-antiquark pair can be almost entirely transformed into the mass of new particles. This process was first suggested by Sidney Drell and Tung-Mow Yan in 1970[1] to describe the production of lepton–antilepton pairs in high-energy hadron collisions. Experimentally, this process was first observed by J.H. Christenson *et al.*[2] in proton–uranium collisions at the Alternating Gradient Synchrotron.



Drell–Yan process: a quark from one hadron and an antiquark from another hadron annihilate to create a pair of leptons through the exchange of a virtual photon.

Contents

Overview

The Drell–Yan process is studied both in fixed-target and collider experiments. It provides valuable information about the parton distribution functions (PDFs) which describe the way the momentum of an incoming high-energy nucleon is partitioned among its constituent partons. These PDFs are basic ingredients for calculating essentially all processes at hadron colliders. Although PDFs should be derivable in principle, current ignorance of some aspects of the strong force prevents this. Instead, the forms of the PDFs are deduced from experimental data.

Drell-Yan process and deep inelastic scattering

PDFs are determined using the world data from deep inelastic scattering, Drell-Yan process etc. The Drell-Yan process is closely related to the deep inelastic scattering:Feynman diagram of the Drell-Yan process is obtained if Feynman diagram of the deep inelastic scattering is rotated by 90°. A time-like virtual photon or Z boson is produced in s-channel in the Drell-Yan process while a space-like virtual photon or Z boson is produced in t-channel in the deep inelastic scattering.

Sensitivity to light sea quark flavor asymmetry in the proton

It had been naively believed that the quark sea in the proton was formed by quantum chromodynamics (QCD) processes that did not discriminate between up and down quarks. However, results of deep inelastic scattering of high energy muons on a proton and a deuteron targets by CERN-NMC[3][4] showed that there are more $\bar{d}$'s than $\bar{u}$'s in the proton. The Gottfried sum deduced by NMC was 0.235 ± 0.026 which is smaller than the expected value of 0.33. This suggests the $\bar{d}$ dominance over $\bar{u}$ in the proton. Recent

measurements using Drell-Yan scattering probed the flavor asymmetry of the proton.[5][6][7] To leading order in the strong interaction coupling constant, α_s, the ratio of the Drell-Yan cross section from a proton beam on a deuterium target to a proton beam on a proton target is given by

$$\frac{\sigma^{pd}}{2\sigma^{pp}} = \frac{1}{2}\left[1 + \frac{\bar{d}(x)}{\bar{u}(x)}\right]$$

where $\bar{d}(x)$ and $\bar{u}(x)$ are the anti-down and anti-up quark distributions in the proton sea and x is the Bjorken-x scaling variable (the momentum fraction of the target quark in the parton model).[5]

Z boson production

The production of Z bosons through the Drell–Yan process affords the opportunity to study the couplings of the Z boson to quarks. The main observable is the *forward–backward asymmetry* in the angular distribution of the two leptons in their center-of-mass frame.

If heavier neutral gauge bosons exist (see Z' boson), they might be discovered as a peak in the dilepton invariant mass spectrum in much the same way that the standard Z boson appears by virtue of the Drell–Yan process.

See also

- Fermilab E-906/SeaQuest

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