PROCEEDINGS OF SCIENCE

Electron structure function at LEP energies

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The hadronic part of the Electron Structure Function (ESF) has been measured for the first time, using e^+e^- data collected by the DELPHI experiment at LEP, at electron scattering energy from $\sqrt{s} = 91.18 - 209.5$ GeV. The data analysis is simpler than that of the measurement of the photon structure function. The ESF data are compared to predictions of phenomenological models based on the photon structure function. The GRVLO and SAS parameterisations do not seem to reproduce the data at high virtualities of the probing photons. It is shown that the quasi-real photon virtuality contribution is significant. The presented data can serve as a cross-check of the photon structure function analyses and help in refining existing parametrisations.

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1. Introduction

Single tag $e^+e^- \mapsto e^{\pm}X$ collisions can be used to determine both the photon [1] and electron [2, 3] hadronic structure functions. Although both analyses start from the same set of events the

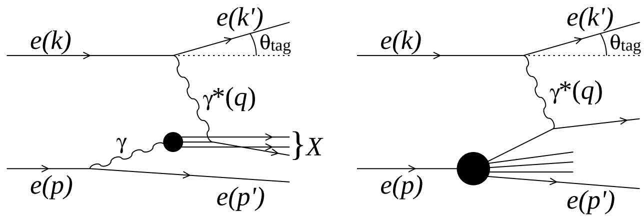

Figure 1: Deep inelastic scattering on a photon target (1a - left), and on an electron target (1b - right); $p,\ p',\ k$ and k' denote the corresponding four-momenta and q is the four-momentum of the radiated photon.

procedures are quite different mainly due to different kinematics. In the photon case (Fig. 1a) the spectrum of virtual photons emitted by the (untagged) electron is strongly peaked at small virtualities P^2 (this quantity can be expressed in terms of the untagged electron four-momenta, $P^2 = -(p-p')^2$), approximating the photon to be real. In the electron case (Fig. 1b) the photon scatters on a real particle so the problem does not appear. Another difference is the determination of the Bjorken variables x (z) representing the fraction of the struck parton momentum with respect to the photon (electron). In the first case, since the photon momentum is not known, the total hadronic mass W must be used to determine *x*,

$$x \cong \frac{Q^2}{Q^2+W^2}\ , \tag{1.1}$$

where $Q^2 = -(k-k')^2$ is the negative momentum squared of the deeply virtual (probing) photon. The z variable for the electron is determined simply - as in the classical deep inelastic scattering i.e. from the scattered electron variables only (see below).

The case of the electron structure function is illustrated in Fig. 1b. The upper (tagged) electron emits a photon of high virtuality $Q^2 = -q^2$ and scatters off the target electron constituents. The cross-section for such a process under the assumption that $Q^2 \gg P^2$, is:

$$\frac{d^2\sigma_{ee\to eX}}{dzdQ^2} = \frac{2\pi\alpha^2}{zQ^4}\left[\left(1+(1-y)^2\right)F_2^e(z,Q^2) - y^2F_L^e(z,Q^2)\right], \tag{1.2}$$

where

$$y = 1-(E_{\text{tag}}/E)\cos^2(\theta_{\text{tag}}/2), \tag{1.3}$$

with E, E_{tag} and θ_{tag} being the beam electron initial, final energy and scattering angle, respectively. $F_2^e(z,Q^2)$ and $F_L^e(z,Q^2)$ are the electron structure functions related to the transversal and longitudinal polarization states of the target photon. The parton momentum fraction, *z*, is defined in the standard (deep inelastic) way:

$$z = \frac{Q^2}{2pq} = \frac{\sin^2(\theta_{\text{tag}}/2)}{E/E_{\text{tag}} - \cos^2(\theta_{\text{tag}}/2)}\ , \tag{1.4}$$

and is measured, by means of the tagged electron variables only. The virtuality of the probing photon can be also expressed in terms of E_{tag}, θ_{tag} as follows:

$$Q^2 = 4EE_{tag}\sin^2(\theta_{tag}/2). \tag{1.5}$$

In [2, 3] the construction of the electron structure function has been presented together with the Q^2 evolution equations and their asymptotic solutions. Although the determination of the electron and photon structure functions is quite different the functions are simply interrelated:

$$F_2^e(z,Q^2,P^2_{\max}) = \int_z^1 dy_\gamma \int_{P^2_{\min}}^{P^2_{\max}} dP^2 f_\gamma^e(y_\gamma,P^2)\, F_2^\gamma(z/y_\gamma,Q^2,P^2), \tag{1.6}$$

where $P^2_{\min} = m_e^2 y_\gamma^2/(1-y_\gamma)$. The above formula enables any existing parametrisation of the photon structure function, both real ($P^2 = 0$) and virtual (integrated over P^2), to be tested on the measured electron structure function.

2. Experimental procedure

2.1 Event Selection

The analysis has been carried out with the data samples collected by DELPHI at both LEPI and LEPII centre-of-mass energies ranging from 92.5 GeV up to 209.5 GeV and corresponding to integrated luminosities of 72 pb^{-1} at LEPI and 487 pb^{-1} at LEPII. In order to suppress backgroud the following cuts were imposed: the vector sum of the transverse momenta of all charged particles, normalised to the total beam energy had to be greater than 0.12 for LEPI (0.14 for LEPII data taking); the normalised (like above) sum of the absolute values of the longitudinal momenta of all charged particles (including tagged electron) had to be greater than 0.6; the angle between the transverse momenta of the tagged electron and of the charged particles system had to be greater than 120°; The maximum of the visible invariant mass was 40 GeV for LEPI (60 GeV for LEPII data taking).

3. Determination of the Electron Structure Function

The ESF can be extracted as a function of two variables z and Q^2 from formula (1.2) under assumption that the longitudinal term F_L^e is negligible and reads

$$F_2^e(\xi,Q^2) = C\frac{Q^4}{(1+(1-y)^2)}\frac{d^2\sigma_{ee\to eX}}{d\xi\, dQ^2}\ , \tag{3.1}$$

where $\xi = log_{10}(z)$ and C is the product of all constant factors.

The measured function $F_2^e(\xi,Q^2)$ was corrected in each $\Delta\xi_i\Delta Q_k^2$ bin by the corresponding detector response function $E(\xi,Q^2)$, yielding the reconstructed ESF $F_2^e(\xi,Q^2)$.

Such a procedure is justifi ed since the migration effect of events generated in any of the (ξ,Q^2) bins to neighbouring bins, after passing the detector simulation, is small.

4. Conlusions

The hadronic part of the electron structure function has been measured and has been found to agree with the predictions based on the photon structure function. The proposed method is explicit and simpler than the photon structure analysis as it does not use the unfolding procedure. It allows the virtuality of the probed photon to be taken into account correctly. It is shown that the migration of events between z-bins (electron) is much smaller than between x-bins (photon). The statistical uncertainties are well understood since in each bin of the measured ESF they reflect a Poisson error whereas statistical uncertainties obtained from the unfolding procedure for the photon analysis have never been discussed.

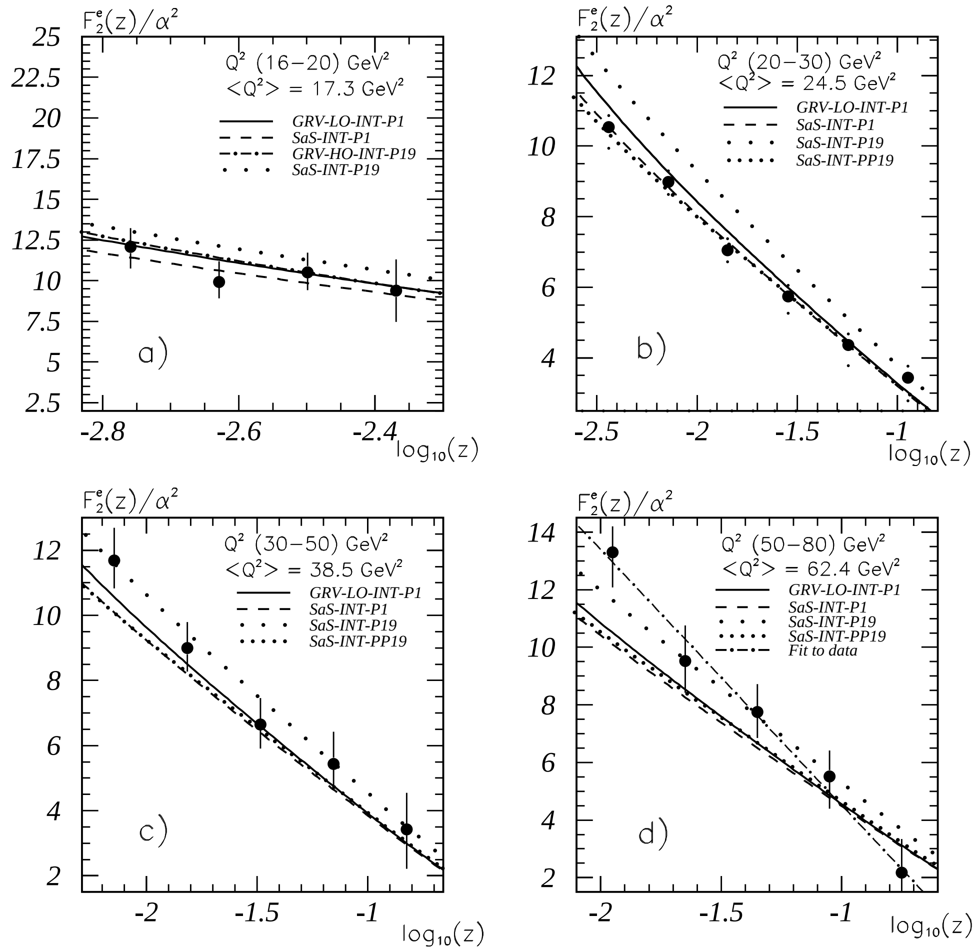

Figure 2: LEPII data.The electron structure function measured for (a) $Q^2 \in (16,20)\,\mathrm{GeV}^2$, (b) $Q^2 \in (20,30)\,\mathrm{GeV}^2$, (c) $Q^2 \in (30,50)\,\mathrm{GeV}^2$, (d) $Q^2 \in (50,80)\,\mathrm{GeV}^2$.

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