Available online at www.sciencedirect.com
SCIENCE DIRECT®
Nuclear Physics B 706 (2005) 325–371
NUCLEAR PHYSICS B

Logarithmic electroweak corrections to gauge-boson pair production at the LHC

E. Accomando [a], A. Denner [b], A. Kaiser [b,c]

[a] *Dipartimento di Fisica Teorica, Università di Torino, Via P. Giuria 1, I-10125 Torino, Italy*
[b] *Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland*
[c] *Institute of Theoretical Physics, University of Zürich, CH-8057 Zürich, Switzerland*

Received 5 October 2004; accepted 11 November 2004

Available online 28 November 2004

Abstract

We have studied the effects of the complete logarithmic electroweak $\mathcal{O}(\alpha)$ corrections on the production of vector-boson pairs WZ, ZZ, and WW at the LHC. These corrections are implemented into a Monte Carlo program for $pp \to 4f(+\gamma)$ with final states involving four or two leptons using the double-pole approximation. We numerically investigate purely leptonic final states and find that electroweak corrections lower the predictions by 5–30% in the physically interesting region of large di-boson invariant mass and large angle of the produced vector bosons.

PACS: 12.15.Lk; 12.15.Ji; 14.70.-e; 13.85.-t

1. Introduction

The production of gauge-boson pairs provides an excellent opportunity to test the non-Abelian structure of the Standard Model (SM). Gauge-boson-pair-production amplitudes involve trilinear gauge-boson couplings. Therefore, the corresponding cross sections depend very sensitively on the non-Abelian structure of the underlying theory. For this reason, vector-boson pair production has found continuous interest in the literature. In the last few

E-mail address: ansgar.denner@psi.ch (A. Denner).

0550-3213/$ – see front matter
doi:10.1016/j.nuclphysb.2004.11.019

years, gauge-boson self-interactions were directly measured at LEP2 and Tevatron. Still, up to now these couplings have not been determined with the same precision as other boson properties, such as their masses and couplings to fermions. Despite of the high statistics reached at LEP2 in producing W^+W^- pairs, the resulting limits on possible anomalous couplings, which parametrize deviations from SM predictions due to new physics occurring at energy scales of order of tens of TeV, are not very stringent. The weakness of the LEP2 measurement is the rather modest centre-of-mass (CM) energy of the produced W-boson pairs. On the other hand, anomalous gauge-boson couplings cause strong enhancements in the gauge-boson-pair-production cross section especially at large values of the di-boson invariant mass $M_{VV'}$ ($V, V' = W, Z$). A significant improvement in the bounds on triple-gauge-boson couplings is expected from measurements at future colliders operating at high energies such as the Large Hadron Collider (LHC). Therefore, in order to achieve a better precision in the determination of these couplings, it will be useful to analyse di-boson production at hadron colliders at the highest possible CM energies.

Vector-boson pairs also constitute a background to other kinds of new-physics searches. One of the gold-plated signals for supersymmetry at hadron colliders is chargino–neutralino pair production, which would give rise to final states with three charged leptons and missing transverse momentum; the primary background to this signature is given by WZ production. Also final states coming from ZZ production could fake that supersymmetry signature if one of the leptons is lost in the beam pipe. Finally, $W^\pm W^\mp$ can dirty the measurements of chargino and slepton pair production, which both give rise to two leptons and missing energy. Leptonic final states, coming from $pp \to VV'$ ($V, V' = W, Z$), could also fake ZZ, WZ, and WW vector-boson scattering signals which are again expected to be enhanced at high CM energies.

In the near future, the LHC will be the main source of vector-boson pairs with large invariant mass $M_{VV'}$. The machine will collect thousands of events, the exact statistics depending on the particular process and luminosity [1]. With LHC approaching its goal of an integrated luminosity of 100 fb^{-1}, a large data sample will be available to start a detailed investigation of the trilinear vertices.

In order to match the experimental precision, theoretical predictions need to have an accuracy of the order of a few per cent to allow for a decent analysis of the data. At lowest order, this demands taking into account all spin correlations and finite-width effects. The easiest way to fulfill this requirement is to go beyond the *production* $\times$ *decay* approach by computing the full processes $pp \to 4f$. The next step consists in a full understanding and control of higher-order QCD and electroweak (EW) corrections. In the past years, a large effort has gone into accurate calculations of hadronic di-boson production (for a review on the subject see Ref. [1]). The $\mathcal{O}(\alpha_s)$ QCD corrections to massive gauge-boson pair production and decay have been extensively analysed by many authors [2–8]. Several NLO Monte Carlo programs have been constructed and cross checked so that complete $\mathcal{O}(\alpha_s)$ corrections are now available [7,8]. QCD corrections turn out to be quite significant at LHC energies. They can increase the lowest-order cross section by a factor of two if no cuts are applied and by one order of magnitude for large transverse momentum or large invariant mass of the vector bosons [2,3]. By including a jet veto, their effects can be drastically reduced to the order of tens of per cent [6,7], but in any case they have to be considered to get realistic and reliable estimates of total cross sections and distributions.