TOPICS IN W^+W^- PHYSICS MEASUREMENTS WITH DELPHI

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LEP2 collider proves to be an excellent scientific environment for $W^\pm$ physics measurements. Analyses and recent results on production cross-section, branching ratios, mass reconstruction and triple gauge boson couplings obtained on data recorded by the DELPHI experiment are presented.

1 Introduction

Large Electron Positron Collider (LEP) operating in European Organization for Nuclear Research (CERN) delivered in 1998 to the four adjoint experiments an integrated luminosity of about 150 pb^{-1} of data at the centre-of-mass energy $E_{\mathrm{CMS}} \approx$189 GeV. A $W^\pm$ pair production proceeds through the processes shown in fig. 1. From the recorded e^+e^- collisions, the DELPHI

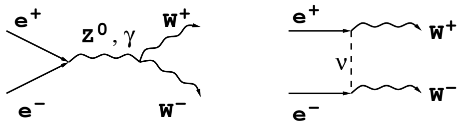

Figure 1. Processes contributing to a $W^\pm$ pair production in e^+e^- collisions at LEP energies.

experiment[1] reconstructed about 2400 W^+W^- pairs decaying into 4 fermions. Generally these events are divided into three categories, depending on the subsequent $W^\pm$ boson decays: hadronic events with both $W^\pm$ decaying into quarks, semileptonic events with one $W^\pm$ decaying into quarks and the other into leptons and leptonic events, where both bosons decay into leptons. In 1999 the integrated luminosity raised to approximately 230 pb^{-1} collected at energies between 192 GeV and 204 GeV. A large sample of reconstructed $W^\pm$ pair events in a clean e^+e^- collision environment enables a number of precision measurements and tests of the Standard Model. Results presented in next sections are mostly based on data collected by DELPHI in 1998 and 1999 and are to be considered preliminary.

2 Cross-section and branching ratios

Selection of W^+W^- events exploits topological and kinematical properties of different decay channels mentioned in section 1. For hadronic events a neural net was fed by several observables discriminating signal from the background. For semileptonic and leptonic events sequential cut analyses were used[2].

A maximum likelihood fit to the binned neural net output distribution (hadronic channel) and to the number of observed events (semileptonic and leptonic channel) was performed leaving the total $\sigma(e^+e^- \to W^+W^-)$ production cross-section and individual leptonic branching ratios as free parameters. The results[2] are consistent with lepton universality. For the data at $E_{\rm CMS} \leq 189$ GeV measurements yield a value $Br(W^\pm \to \ell\nu) = 10.71 \pm 0.24(\text{stat.}) \pm 0.14(\text{syst.})$ %, in good agreement with the SM prediction of 10.8%. The hadronic branching ratio, calculated as $1 - 3Br(W^\pm \to \ell\nu)$, obtained at different e^+e^- collision energies, is shown in fig.2. $\sigma(e^+e^- \to W^+W^-)$ was ob-

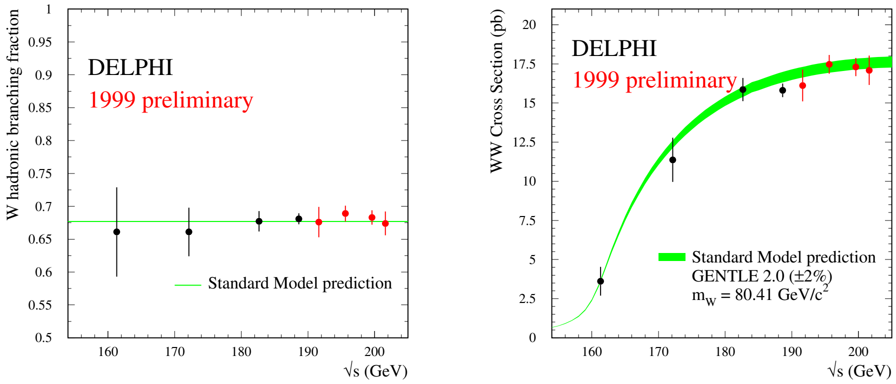

Figure 2. $W^\pm$ hadronic branching ratio (left) and total $W^\pm$ pair production cross-section (right) obtained from the fit to the data at different e^+e^- CMS energies. Shaded band is the SM prediction[3].

tained by fixing $Br(W^\pm \to \ell\nu)$ to the SM value. At 189 GeV the cross-section amounts to $15.83 \pm 0.38(\text{stat.}) \pm 0.20(\text{syst.})$ pb, and its energy dependence is compared to the prediction in fig.2.

3 $W^{\pm}$ mass measurements

The invariant mass reconstruction of $W^{\pm}$ boson decay products enables tests of the SM (through comparison to indirect measurements of this quantity). M_W is also sensitive to the mass of the SM Higgs boson. Hadronic and semileptonic events were used in the performed analysis, while leptonic events have a lower sensitivity due to a presence of at least two undetected neutrinos.

The invariant mass was calculated from the measured momenta of hadronic jets and leptons, after a kinematically constrained fit requiring a 4-momentum conservation[4]. In the semileptonic sample the likelihood function for the event-by-event fit was constructed as a convolution of the theoretical signal distribution with the resolution function plus the simulated background distribution. For $W^+W^- \to 4q$ decays an ideogram[5], giving a probability for a given event kinematics to be a product of two objects of independent masses, was calculated and convoluted with the expected signal and background mass distributions.

Combining measurements at $E_{\rm CMS} \leq 189$ GeV, the $W^{\pm}$ mass was found to be[6] $M_W = 80.316 \pm 0.076(\text{stat.}) \pm 0.047(\text{syst.}) \pm 0.017(\text{LEP})$ GeV/c^2, where the last error comes from the uncertainty on the LEP collision energy. Values obtained at different $E_{\rm CMS}$ are summarized in table 1. Fig. 3 illustrates the

Table 1. Left: results on M_W obtained at different e^+e^- CMS energies. The first row shows an indirect measurement derived from the total W^+W^- production cross-section just above the threshold. Errors include statistical and systematical uncertainties. Right: results of TGC measurements combining all decay channels used on data at $E_{\rm CMS} \leq 189$ GeV.

M_W		TGC	
σ 161+172 GeV	80.33 ± 0.31 GeV/c^2	Δg_1^Z	$-0.02\,^{+0.07}_{-0.06}$
direct 172 GeV	80.22 ± 0.42 GeV/c^2	$\Delta\kappa_\gamma$	0.23 ± 0.16
direct 183 GeV	80.24 ± 0.16 GeV/c^2	λ_γ	0.02 ± 0.08
direct 189 GeV	80.33 ± 0.10 GeV/c^2		
Combined	80.316 ± 0.091 GeV/c^2		

limits on the SM Higgs boson mass imposed by direct measurements of M_W and top quark mass[7].

4 TGC measurements

Since the processes, leading to a $W^{\pm}$ boson production at LEP, include vertices with three gauge bosons ($W^+W^-V; V \equiv \gamma, Z^0$) it is possible to measure the triple gauge couplings (TGC's). Beside the diagrams, shown in fig.1, also

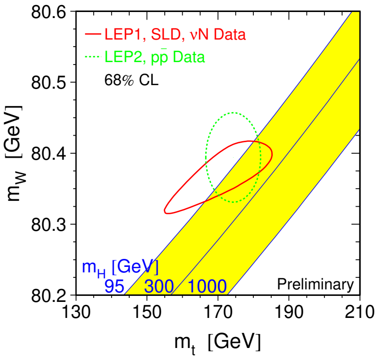

Figure 3. Results of direct (dotted line) and indirect (full line) M_W and top quark mass reconstruction compared to the SM Higgs boson mass prediction[7].

single $W^{\pm}$ and γ productions are exploited. Under reasonable assumptions[8] TGC's can be described with three parameters: an overall $W^+W^-Z^0$ coupling g_1^Z, dipole $W^+W^-\gamma$ coupling κ_γ and quadrupole $W^+W^-\gamma$ coupling λ_γ. Results for these parameters are presented in the form of deviations from the SM predictions($\Delta g_1^Z = 0$, $\Delta\kappa_\gamma = 0$, $\lambda_\gamma = 0$).

TGC parameters affect the total $W^{\pm}$ pair production cross-section, the $W^{\pm}$ production angle distribution, as well as the polarization of charged gauge bosons and by that the angular distribution of final state fermions. In hadronic and semileptonic W^+W^- events two observables with maximal sensitivity to the TGC's were constructed from the reconstructed kinematics of an event (Optimal Observables - OO[9]) and compared to the expected distributions. In leptonic $W^{\pm}$ pair decays and in single $W^{\pm}$ and γ events only a single most sensitive variable was used in the fit (total cross-section, inter-jet angle and the photon energy, respectively). Results[10] are presented in table 1 and show no significant discrepancy from the SM.

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