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Combination of CDF and DØ Results on the W-Boson Width

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Abstract

The results on the direct measurements of the W-boson width, based on the data collected by the Tevatron experiments CDF and DØ at Fermilab during Run-I from 1992 to 1996 and Run-II since 2001 are summarized. The combination of the published Run-I and preliminary Run-II results, taking correlated uncertainties properly into account, is presented. The resulting preliminary Tevatron average for the total decay width of the W boson is: $\Gamma_{\mathrm{W}} = 2078 \pm 87$ MeV, where the total error consists of a statistical part of 62 MeV and a systematic part of 60 MeV.

[1]WWW access at `http://tevewwg.fnal.gov`
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1 Introduction

The experiments CDF and DØ, taking data at the Tevatron proton-antiproton collider located at the Fermi National Accelerator Laboratory, have made several direct experimental measurements of the total decay width Γ_{W} of the W boson. The published measurements [1, 2, 3] are based on Run-I data (1992-1996) while the results from Run-II are preliminary [4]. They utilize the electron [1, 2, 3, 4] and muon [2] decay topologies arising in W-boson decay. The recently presented preliminary measurement in the electron channel [4] by the DØ collaboration is based on a large Run-II data set with correspondingly well controlled systematic uncertainties.

This note reports on the combination of these measurements, using the published Run-I measurements [1, 2, 3] combined earlier [5] and in particular including the preliminary Run-II measurement from DØ [4]. The combination presented here takes into account the statistical and systematic uncertainties as well as the correlations between systematic uncertainties, and replaces the previous combination [5]. The new preliminary Run-II DØ measurement [4] is the single most precise W-boson width measurement and has the largest weight in this new combination.

2 Measurements

The five measurements of Γ_{W} to be combined are listed in Table 1. Besides central values and statistical uncertainties, the systematic errors arising from various sources are reported in Table 1. For each measurement, the individual error contributions are combined in quadrature. The sources of systematic errors considered here are the same as in the previous combination [5]:[2]

- Lepton energy scale (E-scale)
- Lepton E or p_T non-linearity (Non-lin)
- Detector response to QCD radiation and underlying event p_T (Recoil)
- Transverse momentum distribution of the W bosons ($p_T(W)$)
- Backgrounds (BG)
- Detector modeling and lepton ID (DM, ℓ-ID), including distribution of the primary vertex, calorimeter position resolution, recoil momentum biases and efficiencies along lepton direction, and the selection bias

[2]The labels in parenthesis are those used in Table 1.

	Run-I				Run-II
	CDF			DØ	DØ
	e (Ia)	e (Ib)	μ	e	e
Result	2110	2175	1780	2231	2011
Stat.	280	125	195	142	93
E-scale	42	20	15	42	23
Non-lin	-	60	5	-	-
Recoil	103	60	90	59	80
$p_T(W)$	127	55	70	12	29
BG	17	30	50	42	3
DM, ℓ-ID	-	30	40	10	16
Resol.	13	10	20	27	51
PDF	15	15	15	39	27
QED RC	28	10	10	10	3
M_{W}	10	10	10	15	15
Syst.	173	114	135	99	108
Total	329	169	237	173	142

Table 1: Summary of the five measurements of Γ_{W} performed by CDF and DØ. All numbers are in MeV. For each measurement, the corresponding column lists experiment and channel, central value and contributions to the total error, namely statistical error and systematic errors arising from various sources defined in the text. Overall systematic errors and total errors are obtained by combining individual errors in quadrature.

- Lepton resolution (Resol.)
- Parton distribution functions (PDF)
- QED radiative corrections (QED RC)
- W-boson mass (M_{W})

The details on these sources of systematic uncertainties are given in Reference [5] and the individual publications of the two experiments [1, 2, 3, 4]. Note that the error source called "parton luminosity slope as a function of Q^2 (PLS)" considered in the previous combination [5] for the DØ Run-I measurement [3] is combined in quadrature with the PDF uncertainty.

Further studies on the systematic errors are necessary to achieve better understanding and will be pursued in the future. The described procedure with the quoted numbers represent our current understanding of the various error sources and their correlations, adequate for the precision of the current measurements and their combination presented here.

3 Combination

In the combination, the error contributions arising from different sources are assumed uncorrelated between measurements. The correlations of error contributions arising from the same source are the same as in the previous combination [5]:

- uncorrelated between any two measurements: statistical error, energy scale, non-linearity, recoil model, $p_T(W)$, background, detector modeling and lepton ID, lepton resolution, parton luminosity slope;
- 100% correlated between any two measurements: parton distribution functions, QED radiative corrections, W-boson mass.

The resulting matrix of global correlation coefficients is listed in Table 2.

		Run-I				Run-II
		CDF			DØ	DØ
		e (Ia)	e (Ib)	μ	e	e
CDF-Ia	e	1.00				
CDF-Ib	e	0.01	1.00			
CDF-I	μ	0.01	0.01	1.00		
DØ-I	e	0.02	0.03	0.02	1.00	
DØ-II	e	0.01	0.02	0.02	0.05	1.00

Table 2: Matrix of global correlation coefficients between the measurements of Γ_{W}.

The measurements are combined using a program implementing a numerical χ^2 minimization as well as the analytic BLUE method [6, 7]. The two methods used are mathematically equivalent, and are also equivalent to the method used in the previous combination [5], and give identical results for the combination. In addition, the BLUE method yields the decomposition of the error on the average in terms of the error categories specified for the input measurements [7].

4 Results

The combined value for the W-boson width is:

$$\Gamma_W = 2078 \pm 87 \text{ MeV}\,, \tag{1}$$

where the total error of 87 MeV contains the following components: a statistical error of 62 MeV; and systematic error contributions of: energy scale 14 MeV, non-linearity 15 MeV, recoil model 36 MeV, $p_T(W)$ 21 MeV, background 14 MeV, detector modeling and lepton ID 11 MeV, lepton resolution 19 MeV, parton distribution functions 25 MeV, QED radiative corrections 9 MeV, W-boson mass 13 MeV, for a total systematic error of 60 MeV.

The χ^2 of this average is 2.99 for 4 degrees of freedom, corresponding to a probability of 56%, showing that all measurements are in good agreement with each other which can also be seen in Figure 1. The pull of each measurement with respect to the average and the weight of each measurement in the average are reported in Table 3.

	Run-I				Run-II
	CDF			DØ	DØ
	e (Ia)	e (Ib)	μ	e	e
Pull	+0.10	+0.67	−1.35	+1.02	−0.59
Weight [%]	6.3	24.6	12.4	22.3	34.4

Table 3: Pull and weight of each measurement in the average.

5 Summary

A preliminary combination of measurements of the total decay width of the W boson, Γ_W, from the Tevatron experiments CDF and DØ is presented. The combination includes the four published Run-I measurements and one preliminary Run-II measurement. Taking into account statistical and systematic errors including their correlations, the preliminary Tevatron result is: $\Gamma_W = 2078 \pm 87$ MeV.

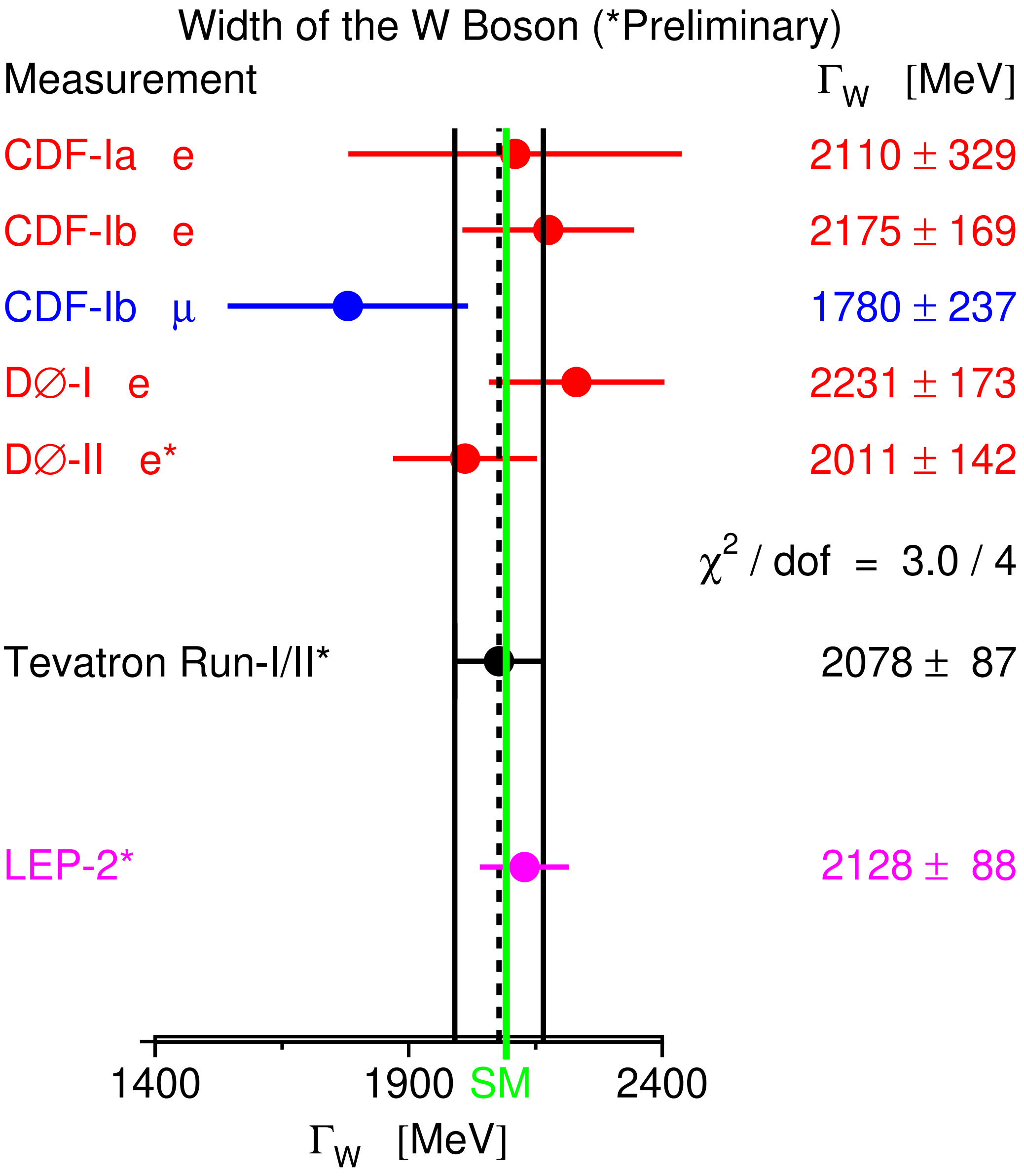

Figure 1: Comparison of the measurements of the W-boson width and their average. The most recent preliminary result from LEP-2 [8] and the Standard Model prediction are also shown.

References

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