W AND TOP QUARK PHYSICS AT THE TEVATRON

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Abstract

We review some of the latest results on W boson and top quark physics at the Tevatron and show prospects for Run IIa.

1 Introduction

In this paper we present some of the most recent results obtained by CDF and DØ during Run I, analysing about 110 pb^{-1} of data. In addition we report on the improvements foreseen in the current run (Run IIa), which is expected to collect about 2 fb^{-1} by the year 2004. Till now the Standard Model (SM) had a remarkable success in describing the elementary particle interactions. The Higgs sector however remains unexplored. The precise measurement of the mass of the W boson (M_W) and of the top quark (M_t) is expected to provide a constraint on the Higgs mass (M_H).

2 W Physics

Many W properties were measured at the Tevatron [1] [2] [3] [4] . Combined CDF and DØ values for the M_W and the directly measured W width Γ_W were recently released: M_W = 80.456 ± 0.059 GeV/c^2 and Γ_W = 2.115 ± 0.105 GeV [5]. The direct measurement of Γ_W is made by analysing W boson candidate events with transverse mass above the Jacobian peak near 80 GeV. The directly measured Γ_W has been combined with the width extracted from the ratio of W and

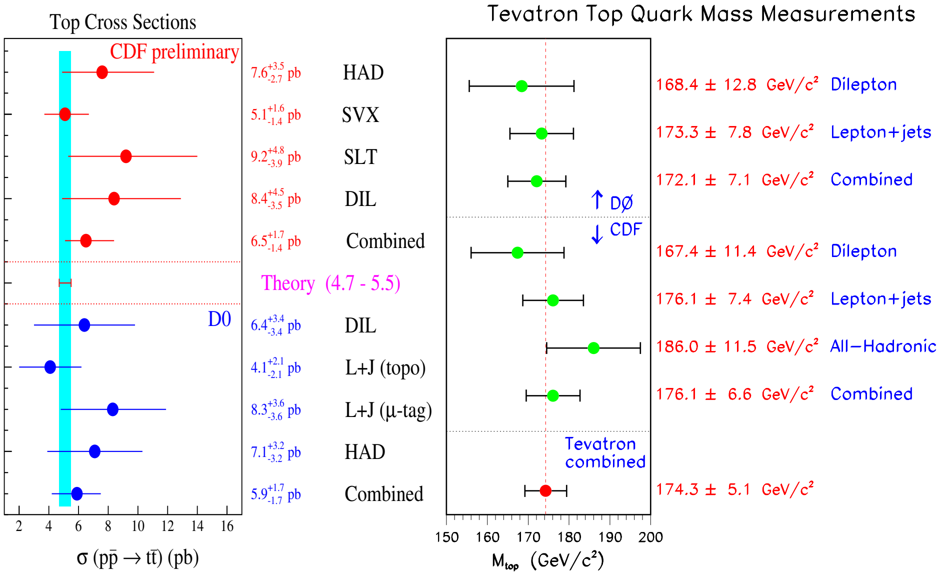

Figure 1: Cross section (left) and mass (right) measurements by CDF and DØ .

Z boson leptonic partial cross sections. The combined result for the Tevatron is $\Gamma_W = 2.160 \pm 0.047$ GeV [5].

Run IIa with 2 fb^{-1} will provide each Tevatron experiment with over 3 x 10^6 W's (e and μ channel) therefore allowing a precise determination of many electroweak parameters. Since most of the M_W systematic uncertainties depends upon the size of the control samples, we will greatly benefit from the larger data set. The biggest contribution to the uncertainty comes from the momentum scale determination. This is obtained by fitting the l^+l^- invariant mass spectrum. W asymmetry is used to constrain PDF and the Z P_T spectrum is the input to the W P_T spectrum. With 2 fb^{-1} we expect to reduce the overall uncertainty on M_W to 40 MeV/c^2, with 30 MeV/c^2 as a possible target.

3 Top Physics

After the top discovery the Tevatron experiments moved to detailed studies of its properties. The $t\bar{t}$ production cross section $\sigma_{t\bar{t}}$ and top mass M_{top} were measured in as many channels as possible to test the SM predictions in great detail.

In Fig. 1 (left) we show the results of the CDF and DØ $t\bar{t}$ cross section measurements [6] [7]. Direct top mass measurements were made by CDF [8] and DØ [9] in several channels, and are summarized in Fig. 1 (right).

The two collaborations produced also a Tevatron average top mass, taking into account the correlations in the systematic errors:

$$M_{Tevatron}^{top} = 174.3 \pm 3.2(stat) \pm 4.0(syst) GeV/c^2. \tag{1}$$

Both experiments investigated the top candidate events kinematic properties and the decay vertex. CDF did an indirect measurement of the V_{tb} vertex [10], studied the W boson helicity in top decays [11], the top P_T distribution [12] and the $t\bar{t}$ system invariant mass [13]. DØ studied the top-antitop spin correlations and other kinematic features [14]. Both experiments set upper limits on single top production cross section [15] [16]. Most of these studies were statistically limited. However, they can be viewed as a preview of possibilities for the Tevatron in Run II. In table 1 we summarize the projection of top quark measurements for Run II.

Top quark Property	Run I measurement	Precision	
		Run I	Run IIa
Mass (CDF + DØ)	174.3 ± 3.2 ± 4.0	2.9 %	1.2 %
$\sigma_{t\bar{t}}$ (CDF 175 GeV)	$6.5^{+1.7}_{-1.4}$	25 %	10 %
$\sigma_{t\bar{t}}$ (DØ 172 GeV)	5.69 ± 1.21 ± 1.04	28 %	10%
W helicity, F_0	0.91 ± 0.37 ± 0.13	0.4	0.9
W helicity, F_+	0.11 ± 0.15 ± 0.06	0.15	0.03
$\lvert V_{tb}\rvert$	$0.97^{+0.16}_{-0.12}$(3-gen) $\lvert V_{tb}\rvert > 0.61$ 90% CL	15%	3%
σ(single top)	$<$ 14 pb	-	20 %
$\Gamma(t \to Wb)$	-	-	25 %
$\lvert V_{tb}\rvert$ (direct from σ)	-	-	12 %
BR($t \to \gamma q$) 95% CL	0.03	0.03	2 x 10^{-3}
BR($t \to Zq$) 95% CL	0.30	0.30	0.02

Table 1: Summary of achieved precision for top quark measurements and projections for Run IIa.

4 Conclusion

The Tevatron Run IIa started in spring 2001 and it is offering one of the most exciting physics program for the next decade. The accelerator and the two experiments have undergone major improvements. Over the course of last year enormous progresses have been made in terms of detector commissioning. The integrated luminosity delivered until june 2002 is about 54 pb^{-1}. 32 pb^{-1} are on tape and about 10 pb^{-1} have been analyzed. New top mass and W mass measurements will be done on a scale of about one year from now, because we need to deeply understand b tagging and the new detector systematics. However, preliminary results are encouraging and indicate that the two upgraded detectors will be able to fully exploit the available physics opportunities. Top physics will be a rich field of study. The uncertainties expected in Run IIa on M_W and M_{top} should lead to a constraint of about 40 % on M_H.

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