PROCEEDINGS OF SCIENCE

Searches for b' and W' at the Tevatron

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We present the results for two searches for massive particles in $p\bar{p}$ collisions at the Tevatron collider: the search for a massive quark decaying to W boson and another quark, and the search for the production of a heavy W$'$ gauge boson that decyas into a top and a bottom quark. In the former, we focus on a fourth generation b$'$ quark decaying into a top quark and a W boson, and set lower limits on its mass, and on a heavy vector-like quark decaying to W boson and a first generation quark. In the latter, we analyze the final state invariant mass distribution and set upper limit on W$'$ production cross section times branching ratio. Lower limits on W$'$ mass are also derived for different hypotheses on the helicity of the heavy boson.

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1. Introduction

Despite its great success in the prediction of the phenomena observed in the high energy physics experiments carried on in the last forty years, the standard model of the elementary particles can not be considered a fundamental theory. Many possible extensions of the standard model have been proposed, a number of which predict a fourth generation of fermions, or additional heavy gauge bosons.

In this paper, we describe the latest searches for massive quarks and heavy charged bosons at the CDF [1] and D0 [2] experiments of the Tevatron collider. In Section 2, two CDF searches for heavy quarks are presented. In the first one, the pair production of a fourth generation b′ quark decaying into a top quark and a W boson is considered [3, 4], while in the second one, the single production of a massive vector-like quark decaying into W boson plus a first generation quark is investigated [5]. In Section 3, the latest CDF and D0 results for the searches of a heavy charged boson W′ decaying into top and bottom quarks are discussed [6, 7] for several hypotheses on the new boson helicity.

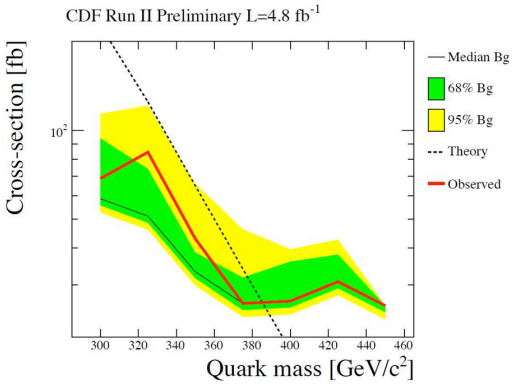

Figure 1: Upper limits at 95% C.L. on the production cross section of a fourth generation quark b′.

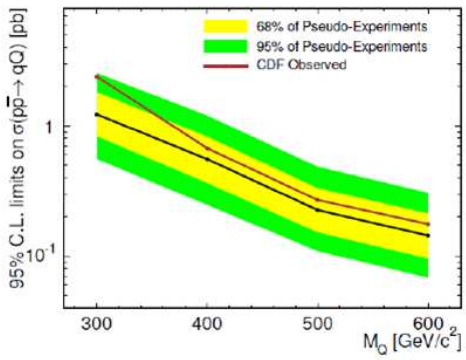

Figure 2: 95% C.L. limit on productio cross section of new heavy quarks as a function of their mass.

2. Searches for a Fourth Generation Quark b′

A fourth generation of fermions is predicted by several theory beyond the standard model. Since a low mixing with light quarks is suggested from constraints from the CKM matrix, fourth generation quarks b′ in $p\bar{p}$ collisions are expected to be produced mainly in pairs $b'\bar{b}'$ and to decay into a top quark and a W boson. After top decay, four W bosons are present in the events. CDF searched b′ production evidence in 2.7 fb^{-1} of data for final states with two W decaying into opposite sign leptons and two W decaying into quarks, and in 4.8 fb^{-1} of data where only one W boson decay into leptons. The jet multiplicity and the total transverse energy of jets, leptons and neutrinos (measured by the missing transverse energy in the event) are used to discriminate the signal production from background processes and derive upper limit on its cross section. Figure 1 shows the results for the lepton+jets channel. Finally, a lower limit on the mass pf the b′ is set at 385 GeV/c^2.

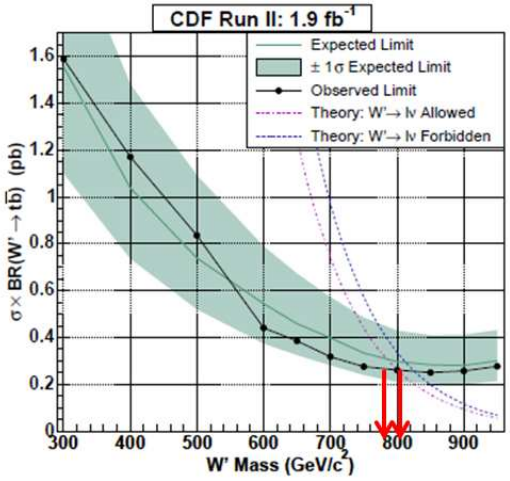

Figure 3: Observed upper limits on W′ production cross section times branching ratio at CDF.

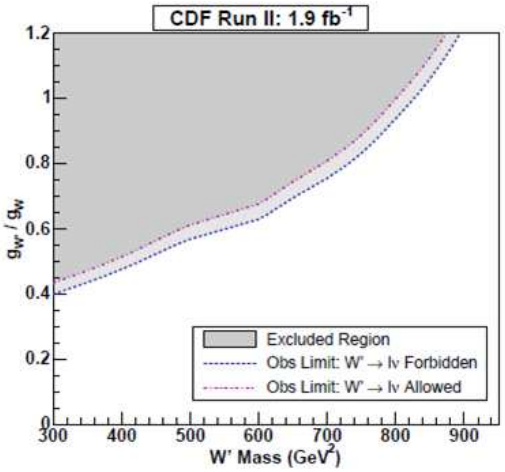

Figure 4: Observed limits on the $g_{W'}/g_W$ ratio as a function of W′ mass. The region in gray is excluded.

Heavy quarks with vector-like couplings to the W boson are exploited by some theories to avoid mass limits from perturbativity in Yukawa couplings. Recent models with warped extra dimensions allow sizable mixing between these quarks and the first generation ones [8]. The CDF collaboration searched for vector-like quarks decaying into a W boson plus a light quark in 5.7 fb^{-1} of data, by selecting events with one isolated lepton plus large transverse energy from the leptonic decay of the W boson, and two jets. The invariant mass of the reconstructed final states is used to discriminate signal from background events. The upper limits on single heavy quark production cross section are shown in Figure 2.

3. Searches for Heavy Charged Bosons W′

Heavy charged bosons W′ are predicted by many theories beyond the standard model. The decay to a top and a bottom quark is sensitive to both left and right-handed couplings to fermions and has been exploited by the CDF and D0 collaborations to search for massive charged boson production by using the same data selection as for the observation of single top production [9]: one isolated high-p_T lepton, large missing transverse energy and two or more jets, one of which identified as a jet from b quark hadronization.

CDF set upper limits on a right-handed W′ production by fitting the observed invariant mass distribution of the tb system (see Figure 3). When standard model couplings are assumed ($g_{W'} = g_W$), a lower limit on the W′ mass is also set at 800 (825) GeV/c^2 if the mass is greater (lower) than the right-handed neutrino mass. Finally, the assumptions on the W′ couplings are relaxed and lower limits on the $g_{W'}/g_W$ ratio are derived as a function of the W′ mass (see Figure 4).

D0 analysis uses a multivariate discriminant based on boosted decision trees to enhance the sensitivity to W′ production. Eleven values for the left(right)-handed coupling parameter $a^{L(R)} = g^{L(R)}_{W'}/g_W$ are scanned from 0 to 1 in steps of 0.1 to set upper limits on the W′ production cross section. Results for a pure right-handed W′ are shown in Figure 5 as an example: a lower limit on the W′ mass is correspondingly set at 885 (890) GeV/c^2 if the mass is greater (lower) than the

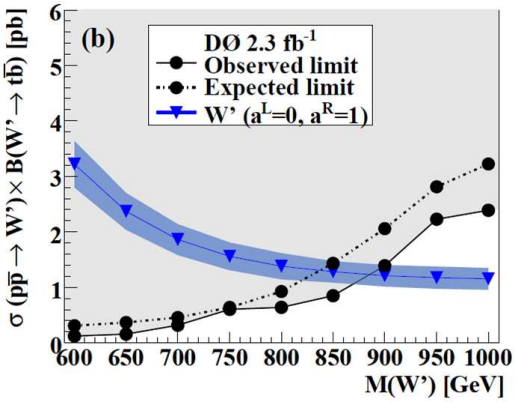

Figure 5: Observed 95% C.L. limits on a right-handed W′ production cross section at D0.

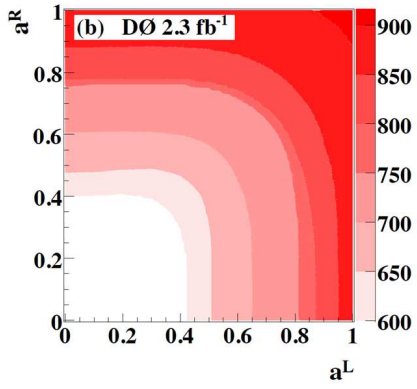

Figure 6: Contour plot of 95% C.L. lower limits on W′ mass in the (a^L,a^R) plane.

right-handed neutrino mass. Finally, the lower limits on the heavy boson mass for all the values of couplings considered are summarized in Figure 6.

4. Conclusions

We presented the latest searches for heavy quark and charged boson production beyond the standard model at the Tevatron collider. World's strongest limits have been set on the masses of a fourth generation quark b′ ($m_{b'} > 385$ GeV/c^2) and massive charged boson W′ ($M^R_{W'} > 885$ GeV/c^2, $M^L_{W'} > 863$ GeV/c^2). There is still a great potential to exploit for future searches, more statistics to analyze and more channels to investigate, which could eventually lead to new physics discovery in the next years.

References

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