FERMILAB-CONF-07-189-E

NON SUSY SEARCHES AT THE TEVATRON

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Recent searches for non-SUSY exotics in $p\bar{p}$ collisions at a center-of-mass energy of 1.96 TeV at the Tevatron Run II are reported. The emphasis is put on the results of model-driven analyses which were updated to the full Run IIA datasets corresponding to integrated luminosities of about 1 fb^{-1}.

1 Introduction

Numerous searches for non Higgs and SUSY extensions of the Standard Model (SM) are conducted at the Tevatron Run II.

In this report we concentrate on the model-driven analyses that were recently updated by the D0 and CDF collaborations to the full Run IIA datasets, representing integrated luminosities slightly in excess of 1 fb^{-1}. Details about these analyses can be found in reference [1].

The SM is constructed with the following ingredients: it's a quantum field theory where the matter fields are replicated into three families of quarks and leptons. This field theory is placed into a four-dimensional space-time. Its lagrangian is invariant under the Poincaré group and under the $SU_C(3) \times SU_L(2) \times U_Y(1)$ gauge group. The electroweak symmetry breaking is provided by the Higgs mechanism.

For about three decades all the experimental tests of the SM have shown no significant deviations with respect to its predictions. However the SM leaves many questions unresolved and is clearly not a full and a satisfactory theory. Therefore many ideas have been proposed to try to extend both predictivity and its domain of validity.

Among these ideas is a possible sub-structure of the particles considered as elementary in the SM. This could explain the replication of the quarks and leptons into three families.

Another path is a possible extension of the SM gauge symmetries. This enables to envisage a unification of the three fundamental interactions described by the SM at a very high energy scale, whilst explaining their differences at low energy as results of different symmetry breakings. One can also postulate the existence of extra space dimensions that could explain the hierarchy between the Planck and the electroweak scales as well as the relative weakness of the gravitational interaction with respect to the three other fundamental interactions.

Searches for fermions sub-structure are reported in section 2, section 3 and section 4 contain searches for hints of extended gauge symmetries and of extra space dimensions respectively. All the exclusion limits are given at the 95% confidence level.

2 Fermions Sub-Structure

In this section, we describe searches driven by two types of models that can be related to a fermions sub-structure. Searches for leptoquarks are presented in the first sub-section and the second sub-section contains searches for fermion compositeness.

2.1 Search for Leptoquarks

The leptoquarks (LQ) carry both a lepton and a baryon quantum number. The relevant phenomenological parameters are M_{LQ} mass for the scalar leptoquarks (simply denoted LQ) and in addition two anomalous couplings for the vector leptoquarks (denoted VLQ).

D0 performed a search for second generation scalar LQ in the $LQ_2 + L\bar{Q}_2 \to \mu\nu + q'\bar{q}$ channel, in a dataset of $\int \mathcal{L}dt = 1.05 fb^{-1}$. Events containing a hard and isolated muon plus jets and large missing transverse energy ($\not{E}_T$) and H_T are selected. The left hand side of figure 1 shows the LQ_2 reconstructed mass where the data are background-like. A limit excluding $M_{LQ_2} < 210$ GeV is set in the hypothesis of this semi-leptonic decay of the LQ_2 pairs.

CDF analysed 322 pb^{-1} to search for third generation VLQ in the channel $VLQ_3 + V\bar{L}Q_3 \to \tau^+\tau^- b\bar{b}$ whith one τ subsequently decaying into hadrons and the other into leptons. An H_T variable summing up the $\not{E}_T$ and the p_T of each reconstructed object in the studied topology is used to discriminate the signal from the background. Its distribution does not reveal any data excess. This enables to set limits excluding $M_{VLQ_3} < 251$ GeV and $M_{VLQ_3} < 317$ GeV for minimal and Yang-Mills couplings respectively as displayed in the right hand part of figure 1.

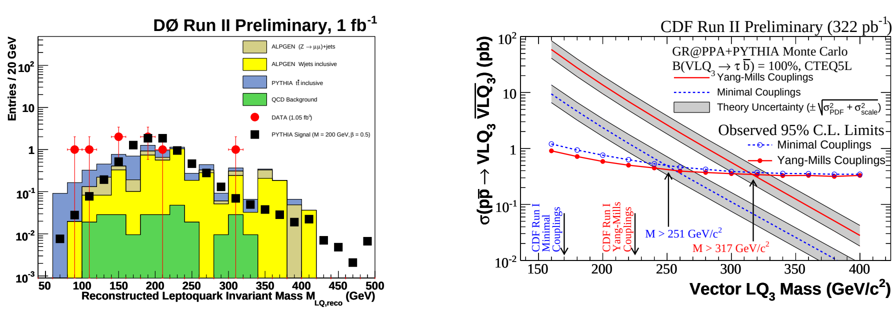

Figure 1: Distribution of the M_{LQ_2} in a $LQ_2 + L\bar{Q}_2 \to \mu\nu + q'\bar{q}$ search performed by D0 (left). Limit on the production cross section of $VLQ_3 + V\bar{L}Q_3 \to \tau^+\tau^- b\bar{b}$ established by CDF (right).

2.2 Search for Leptons or Quarks Compositeness

For the hypothesis of quarks and leptons compositeness as detailed in reference [2], the main parameters are the excited fermion mass M_{f^*} and the compositeness scale Λ.

We report two searches for excited electrons and muons carried by D0 with integrated luminosities of $1 fb^{-1}$ and $0.38 fb^{-1}$ respectively. These excited leptons ($\ell^{*\pm}$) are produced by the following contact interaction process: $q\bar{q} \to \ell^{*\pm}\ell^{\mp}$ and subsequently decay into the $\ell^{*\pm} \to \gamma + \ell^{\pm}$ mode, leading to $\gamma + \ell^{\pm}\ell^{\mp}$ final states. The analyses essentially consist in selecting events with two hard and isolated leptons plus a hard and isolated photon and to search for a resonance in the $M_{\gamma\ell^{\pm}}$ distribution.
Since no excess of data is found with respect to the SM background, exclusion limits are derived in the Λ and M_{ℓ^*} plane. For example, for $\Lambda = 1$ TeV: $M_{e^*} > 756$ GeV and $M_{\mu^*} > 618$ GeV.

We also report that in the measurement of the QCD inclusive jet cross section no deviations with respect to the NLO theory prediction is observed, even up to the highest jet p_T ever probed of about 610 GeV. However, no explicit limit on M_{q^*} is derived from this measurement yet.

3 Extended Gauge Symmetry

If there exists a grand unification of the strong and the electroweak interactions at a high energy scale, then the breakdown of the corresponding gauge group (i.e. $SU(5)$, $SO(10)$, E_6,...) downto the SM gauge group occurs through a cascade of symmetry breakings where extra SU(2) and U(1) factors may appear. Such extra gauge group factors predict the existence of new (and heavy since not observed yet) W and Z bosons that we respectively denote W' and Z'.

We present a D0 search for the $W'^{\pm} \to e^{\pm}\nu$ process in 0.9 fb^{-1} of data. The events are selected if they contain a hard and isolated electron and a significant $\not{E}_T$. The transverse mass $M_T(e^{\pm}, \not{E}_T)$ distribution displayed on the left hand part of figure 2 is scrutinized especially above 150 GeV. No data excess is found on top of the SM background tail. Therefore a $W'^{\pm}$ with a mass below 965 GeV is excluded.

We present a CDF search for the $Z' \to e^+e^-$ process using a data sample of 1.29 fb^{-1}. The analysis selects events with two hard and isolated electrons with at least one in the central part of the calorimeter and with a matching track. Here the signal region is defined as the tail (above 150 GeV) of the dielectron invariant mass shown on the left hand side of figure 2. The data are in good agreement with the SM background causing a Z' with a mass lower than 923 GeV and SM-like couplings to be excluded.

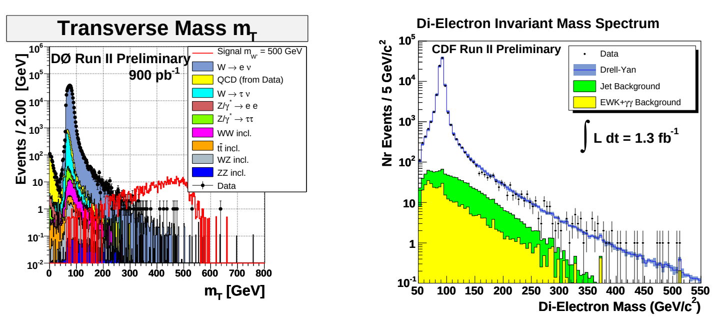

Figure 2: Distributions of the transverse mass (left) and of the invariant mass (right) in searches for W' by D0 and for Z' by CDF respectively.

4 Extended Number of Space Dimensions

The lack of precision measurements of gravity in the sub-millimeter domain leaves some room for possible departures from the Newton's law in this distance range. Such exotic behaviours are obviously predicted in the assumption that space has more than three dimensions because of the

Gauss law. This explains the apparent weakness of the gravitational interaction with respect to the other fundamental interactions.

The Randall-Sundrum (RS) model[3] postulates the existence of a fith dimension separating two branes. The SM fields are localized on one brane. Gravity lives on the second brane where it isn't weak, but can propagate along the fith dimension that has a warped metric. Kaluza-Klein excitations of the gravitons appear as narrow resonances. The relevant parameters are the mass of the first graviton excitation and the $\frac{\kappa\sqrt{8\pi}}{M_{Pl}}$ coupling.

The Arkani-Hamed, Dimopoulos and Dvali (ADD) model[4] also localizes the SM fields on one brane and allows gravity to propagate within a bulk possibly made of up to $N = 7$ large extra dimensions. Here Kaluza-Klein excitations of the gravitons cannot be resolved. And the parameters are the number of extra dimensions N and the effective Planck scale M_D (i.e. the Planck scale in 4+N dimensions).

CDF recycled its $Z' \rightarrow e^+e^-$ search into searches for $G \rightarrow e^+e^-$ and $G \rightarrow \gamma\gamma$. The combination of the two latest yields the exclusion plane displayed at the left hand side of figure 3.

We also report on a CDF search in a $1.1fb^{-1}$ dataset for the $q\bar{q} \rightarrow G + g$ contact interaction process. This process leads to a monojet topology. Hence the analysis requires events with a very hard jet contained in the central part of the calorimeter and confirmed by tracks. In order to allow for a gluon ISR or FSR a second soft jet is accepted. The discriminating variable is the $\not{E}_T$ which is compatible with the expected background. Consequently exclusion limits are derived as a function of the number of extra dimensions and the effective Planck scale as shown at the right hand side of figure 3.

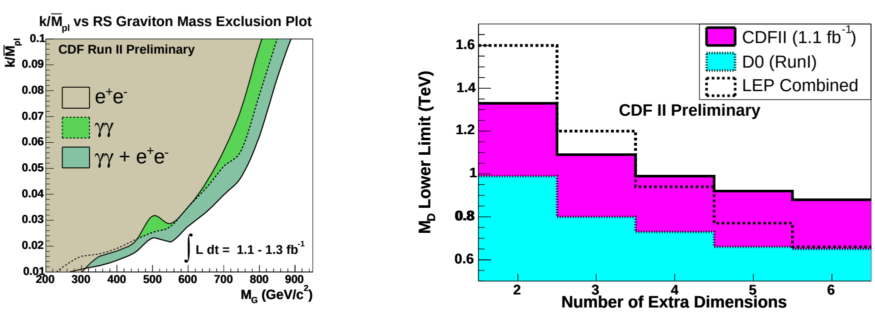

Figure 3: Exclusion plot from the RS CDF search combining the $G \rightarrow e^+e^-$ and $G \rightarrow \gamma\gamma$ channels (left). Limits on large extra dimensions from the CDF monojet search (right).

5 Conclusion

Many searches covering very different topologies have been studied at the Tevatron Run II by the D0 and CDF collaborations. Despite the recent updates of some of these analyses to the full Run IIA datasets of about $1fb^{-1}$, no hints of exotic extensions of the SM have been found and more stringent exclusion limits have been derived.

References

1. http://www-d0.fnal.gov/Run2Physics/WWW/results/np.html
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