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1 Introduction

Despite its overwhelming experimental success, there is compelling reason to believe that the Standard Model is not the final word. DØ has been actively pursuing many possible extensions to the Standard Model, and we report on several of our searches in this paper.

All of the searches on which we report are based on the data sample collected during Tevatron Run 1a (August, 1992 to May, 1993). A full description of the DØ detector appears elsewhere.[1]

2 Supersymmetry

Supersymmetry (SUSY), a space–time symmetry that relates bosons to fermions, is being rigorously studied to explain the fermion mass hierarchy of the Standard Model. We report on several searches for R–parity conserving SUSY.

2.1 *Squarks and Gluinos*

At the Tevatron we can have pair production of squarks ($\tilde{q}$) and gluinos ($\tilde{g}$) or associated production of $\tilde{q}\tilde{g}$. We search for the hadronic decay of these sparticles[2] and identify two event signatures: $\geq$ 3–jets plus $\not{E}_T$; and $\geq$ 4–jets plus $\not{E}_T$. The integrated luminosity for this search is 13.5 ± 0.7 pb^{-1}. Since this analysis relies on a good determination of the $\not{E}_T$ and the jet E_T's we restrict our search to events involving only a single interaction. This reduces the integrated luminosity to a single–interaction equivalent of 7.2 ± 0.4 pb^{-1} where the uncertainty includes the probability of mis–identifying a multiple interaction as a single interaction.

In the 3–jet analysis we require 3 jets with $E_T > 25$ GeV and $\not{E}_T > 75$ GeV. We apply quality cuts to the jet selection and cuts to the events to reject Standard Model sources of large $\not{E}_T$. Finally, we hand–scan the remaining 17 events and remove 3 events with anomalous $\not{E}_T$ resulting in 14 candidate events. In the 4–jet analysis we apply the same quality cuts to the jets and require 4 jets with $E_T > 20$ GeV and $\not{E}_T > 65$ GeV. After applying the cuts to reject Standard Model sources of large $\not{E}_T$ we have 5 candidate events remaining.

For both analyses the Standard Model sources of background are gauge boson production associated with one or more jets with the gauge boson decaying leptonically and the lepton being either missed or mis–identified. This results in 14.2 ± 4.4 events for the 3–jet analysis and 5.2 ± 2.2 events for the 4–jet analysis. In addition to these sources of background there are also QCD multi–jet events where jet fluctuations can result in large $\not{E}_T$; this results in 0.4 ± 0.4 events expected for the 3-jet analysis and 1.6 ± 0.9 events for the 4–jet analysis. For neither analysis do we subtract the QCD multi–jet background, thus producing a more conservative limit. We present our limit in Fig. 1 as an exclusion contour and set a limit of $m_{\tilde{g}} > 173$ GeV/c^2 for large squark masses and $m > 229$ GeV/c^2 for equal mass squarks and gluinos.

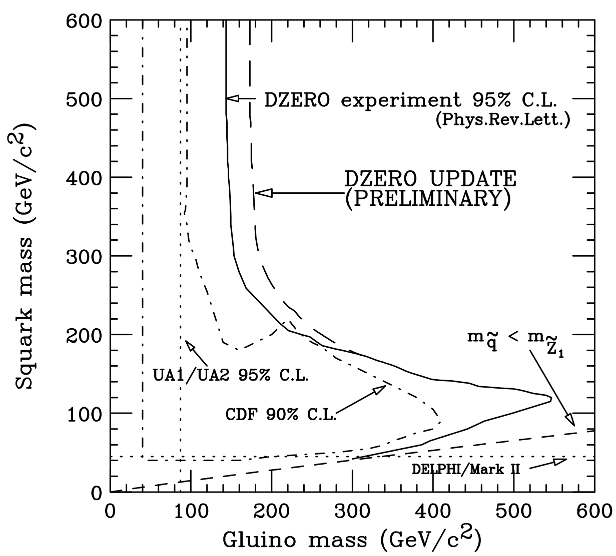

Figure 1: DØ preliminary exclusion contour for $\tilde{q}\,\tilde{g}$ production.

2.2 *Light Stop*

The squarks are assumed to be mass degenerate with the exception of the stop. With the top quark so much more massive than the other quarks, the Yukawa interaction drives the mass of the stop below the other squarks. We search for a light $\widetilde{t}_1$, where the dominant 2–body top–like decay $\widetilde{t}_1 \rightarrow \widetilde{W}_1 + b$ along with the dominant three–body decay mode $\widetilde{t}_1 \rightarrow W + b + \widetilde{Z}_1$ are kinematically forbidden. This leaves the decay mode $\widetilde{t}_1 \rightarrow c + \widetilde{Z}_1$ and results in a two–parameter search $(m_{\widetilde{Z}_1}, m_{\widetilde{t}_1})$. The event signature is 2 acollinear jets plus $\not{E}_T$. The single interaction equivalent integrated luminosity for this search is 7.2 ± 0.4 pb^{-1}. We apply cuts to reduce the Standard Model sources of $\not{E}_T$ and find 2 candidate events. The Standard Model sources of background for this search are gauge boson production in association with jets. This gives 2.86 ± 0.93 events. The contribution from QCD multi–jet events is determined to be negligible. We interpret our lack of excess events as an exclusion contour in Fig. 2.

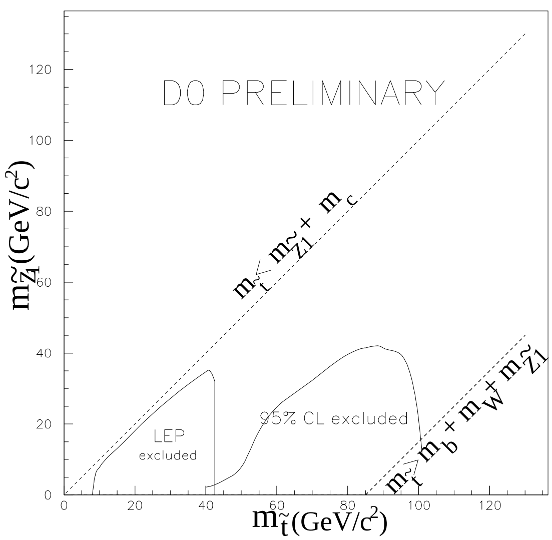

Figure 2: DØ preliminary limit on $m_{\widetilde{t}_1}$ vs $m_{\widetilde{Z}_1}$

2.3 Wino – Zino

A promising alternative supersymmetric search is to look for $\widetilde{W}_1\widetilde{Z}_2$ production. The subsequent decay involves quarks and/or leptons plus the LSP. We report preliminary results of a search for the tri–lepton final state which is the cleanest event signature with negligible Standard Model backgrounds. In certain super–gravity inspired models, the branching ratio to 3ℓ is actually enhanced. We search for the final states, eee, $ee\mu$, $e\mu\mu$, and $\mu\mu\mu$. After applying cuts to reduce the background we are left with 0 candidate events in any of the channels. The backgrounds are due to mis–identification of jets as leptons and di–boson and heavy quark production. We determine a preliminary upper limit of $\sim$ 1 event/channel. We interpret the lack of excess events as a 95% CL upper limit on $\sigma \times BR(\ell\ell\ell)$ as shown in Fig. 3. Here we have assumed $BR(eee) = BR(ee\mu) = BR(e\mu\mu) = BR(\mu\mu\mu)$.

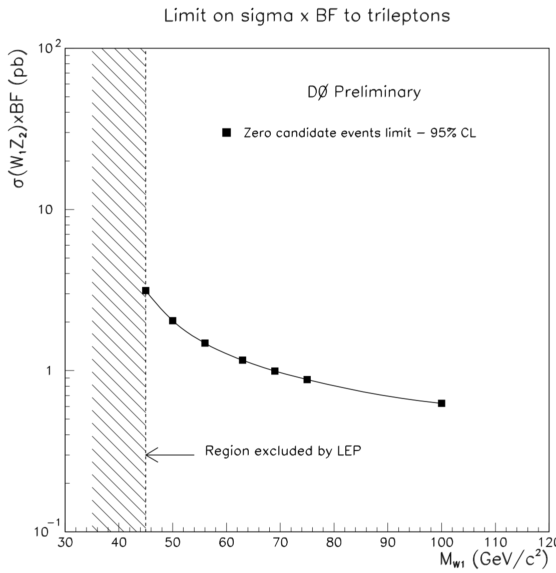

Figure 3: DØ preliminary 95% CL upper limit on $\sigma \times BR(\ell\ell\ell)$

3 Heavy Right–Handed W

Left–right extensions of the Standard Model yield new SU(2) gauge groups with heavy gauge bosons $(W_R^{\pm}, Z_R)$ and massive right–handed neutrinos. We search for a heavy right–handed W through its decay to a heavy right–handed neutrino $(W_R \rightarrow e + N)$, assuming $m_{W_R} > m_{N_R}$. We also assume no difference in coupling or CKM matrix elements for the W_R. The decay of the neutrino proceeds through $N_R \rightarrow e + jet + jet$. We allow for left–right mixing so that the above decay can be through either a virtual W_R (no mixing), a real W (large mixing), or a combination of the two. The event signature depends on the mass of the N_R. If it is very large, then we can resolve the two electrons and the two jets resulting in a counting experiment. If, on the other hand, the N_R is not so massive, then we cannot resolve its decay products, and we look at the E_T spectrum of the single electron data for evidence of the Jacobian peak from the two–body decay of the W_R.

For the counting experiment, we look for two electrons and at least two jets with $E_T^e > 25$ GeV and $E_T^j > 25$ GeV. In addition, we apply cuts to remove events due to Z decay and find 1 candidate event remaining based on an integrated luminosity of 13.5 ± 1.6 pb^{-1}. The background is due to Drell–Yan production, top quark decay, and QCD multi–jet events and totals 0.48 ± 0.08 events. We do not subtract this background thus producing a more conservative limit.

For the shape analysis, we trigger on a single high–E_T electron and apply quality cuts to the electron candidates. This event sample yields the signal sample (strict quality cuts) as well as the background sample. We simultaneously fit both the E_T^e and $m_T^{e\nu}$ distributions, where we calculate $m_T^{e\nu}$ using the electron and $\not{E}_T$ of the event.

We combine the results of our two analyses to produce a contour limit in Fig. 4. For the counting experiment we show two contours to show the limits of no mixing and maximal mixing.

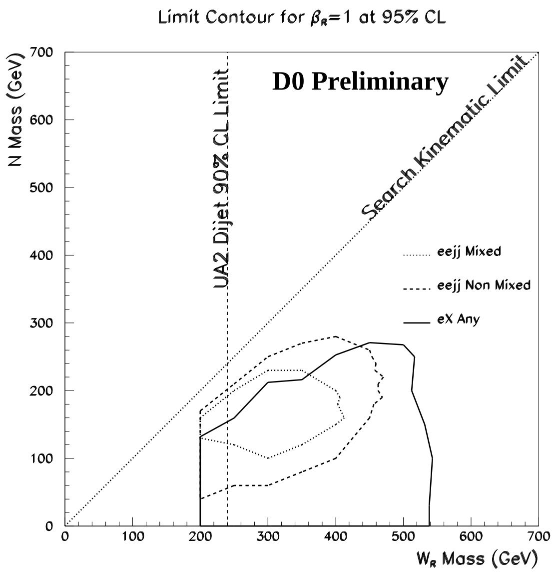

Figure 4: DØ preliminary limit on m_{W_R} vs m_{N_R}

4 Second Generation Scalar Leptoquarks

Leptoquarks are bosons appearing in many SUSY, GUT, and composite models and carry both color and lepton quantum numbers. For masses of leptoquarks that can be produced at the Tevatron, the coupling to fermions is strictly generational. We search for leptoquarks in both the $\ell\ell$ + jets and $\ell\nu$ + jets channels. We report results of our search[3] for second generation scalar Leptoquarks in a data sample of 12.7 ± 0.7 pb^{-1}. In the $\mu\mu$ + jets analysis we require 2 isolated muons with $p_T > 25$ GeV/c and 2 jets with $E_T > 25$ GeV and find no candidate events. In the μ + jets + $\not{E}_T$ analysis we require 1 isolated muon with $p_T > 20$ GeV/c, 2 jets with $E_T > 25$ GeV/c, and $\not{E}_T > 25$ GeV and again find no candidate events. We present our results in Fig. 5 as a 95% CL lower limit on the mass of the leptoquark as a function of β, the BR to the muon final state.

5 Bosonic Higgs

In the Standard Model there is a single scalar Higgs boson which is responsible for giving mass to both the vector bosons (EW symmetry breaking) as well as the fermions

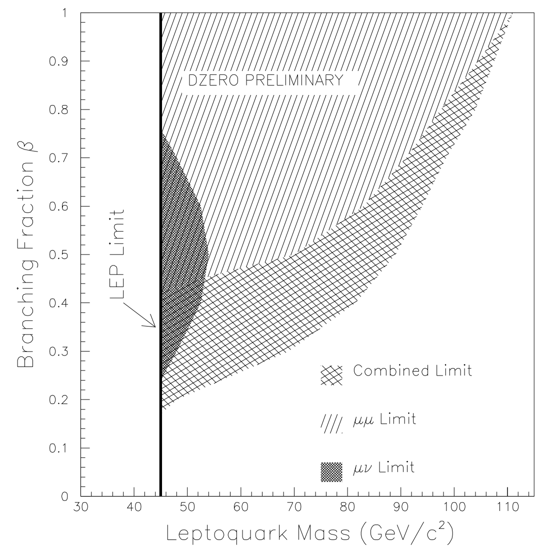

Figure 5: DØ preliminary limit on $m_{L_q^\mu}$ vs β

(flavor symmetry breaking). In Multi–Higgs–Doublet models we can have one Higgs boson that couples via Standard Model coupling to the vector bosons with suppressed coupling to the fermions (the "Bosonic" Higgs) and one that couples predominantly to the fermions. This Bosonic Higgs will decay mainly to $\gamma\gamma$ if $m_H < 90$ GeV/c^2; otherwise, it decays to WW^*. We search for the associated production of the Higgs with a gauge boson; the event signature is $\gamma\gamma$ + 2 jets. We require 2 photons with $p_T > 20$ GeV/c and 2 jets with $E_T > 15$ GeV/c and 65GeV/c$^2 < m_{jj} <$ 105GeV/c^2. We find 4 candidate events with $m_{\gamma\gamma} \geq 45$ GeV/c^2 and calculate a 90% CL upper limit on σ which translates into a 90% CL lower limit on the mass of the Higgs of 73 GeV/c^2.

6 Conclusion

We have reported results from several searches for new particles with the DØ detector based on the Tevatron Run 1a data sample. This does not cover all of the searches currently underway at DØ as many interesting and novel studies are in progress. With the addition of the Run 1b data we expect ~100 pb^{-1} in the total data sample. This should allow us to set some stringent limits on New Physics at the Tevatron energy scale.

References

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