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Recent Results From the Search for New Phenomena at DØ

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RECENT RESULTS FROM THE SEARCH FOR NEW PHENOMENA AT DØ

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Abstract

We present results from several new searches for physics beyond the Standard Model. We describe a search based on the scalar sum of the transverse energy of the event, a global quantity nearly independent of the event topology. We summarize our searches for first generation leptoquarks into all three decay channels, $eq\bar{e}q$, $eq\bar{\nu}q$, and $\nu q\bar{\nu}q$ and note that this is the first time that the triumvirate of decay channels has been searched. We do not find any evidence for production of first generation leptoquarks and set a lower limit on the mass of the leptoquark of 175 GeV/ c^2 , assuming the decay is exclusively into $eq\bar{e}q$. We also present results from the first search for a third generation leptoquark with charge = $\pm 1/3$. Again, we find no evidence for its existence for a mass less than 80 GeV/ c^2 . Finally, we discuss one of our searches for supersymmetry, specifically the pair-production of \tilde{e} , $\tilde{\nu}$, and $\tilde{\chi}_2^0$ where the decay yields final states with two photons plus missing transverse energy (\cancel{E}_T). We set limits on the production cross section ranging from 1 pb to 400 fb, depending on the mass. This analysis also sets a model-independent limit of $\sigma \cdot B(p\bar{p} \rightarrow \gamma\gamma + \cancel{E}_T + X) < 185$ fb at the 95% CL for $E_T^{(\gamma)} > 12$ GeV and $|\eta| < 1.1$ and $\cancel{E}_T > 25$ GeV.

1 Introduction

The successes of the Standard Model are legendary and numerous; however, the model is not complete as it leaves several questions unanswered, for example, what is the origin of the mass hierarchy and why are there three generations of fermions, thus opening the door for extensions to the model. Many extensions to the Standard Model include new, heavy particles while others introduce new interactions. We report new results from a few of the searches presently underway at DØ. The first is an analysis of events with large scalar transverse energy where we are looking for evidence of contact interactions. The next topic includes updates to two searches for first generation leptoquarks decaying to electrons plus quarks and first results from searches for first generation leptoquarks decaying to neutrinos plus quarks and third generation leptoquarks decaying to neutrinos plus b quarks. Finally, we summarize some newly published results from an analysis of events with two photons plus missing transverse energy searching for pair-production of \tilde{e} , $\tilde{\nu}$, and $\tilde{\chi}_2^0$. We note that this is only a small subset of the total package of active searches that we are pursuing.

2 Large Scalar Transverse Energy as a Window on New Physics

As noted above, many extensions to the Standard Model involve additional, heavy particles or new interactions. The clearest evidence for new particles would be an invariant mass peak due to on-shell production, but no such peaks have been found. Therefore, if new massive particles exist, the mass must be larger than $\sqrt{\hat{s}}$, the parton-parton CM energy available at the Tevatron. Indirect evidence of their existence can then be inferred from an increase in the cross section with increasing $\sqrt{\hat{s}}$ over that predicted by the Standard Model. For the case of new interactions the characteristic energy scale is usually larger than the electro-weak scale.

We are developing a generic search strategy to look for evidence of new physics. We define the quantity

$$H_T \equiv \sum_{i=1}^N |E_T^{(i)}|,$$

where N is the number of jets with transverse energy $E_T \geq 20$ GeV (with no requirement on the jet multiplicity). Thus, H_T has only a weak dependence on the event topology. To demonstrate a “proof of principle” of the sensitivity of the H_T analysis to new physics, we apply it to a specific extension to the Standard Model, composite quarks. Previous searches for quark sub-structure used the inclusive jet cross section. Recently, an

alternative analysis based on the angular correlation between the leading two jets (two highest E_T jets) in the event has published a limit on the compositeness scale, Λ^* , of 1.8 TeV assuming all six flavors of quarks are composite and destructive interference in the Lagrangian[1]. $D\bar{O}$ presented a preliminary limit at this conference[2]. Because the H_T analysis uses a more global quantity it complements the inclusive jet and di-jet angular correlation measurements.

H_T has the following advantages. It is the best measure we have of the transverse component of \sqrt{s} since it sums over most of the jets in the event, omitting only the low- E_T jets where the reconstruction efficiency begins to drop, the jet energy scale is not well-determined, and underlying event uncertainties are large. One of the problems inherent in any jet analysis is the details of the jet algorithm used to define the jets. For example, when using a cone algorithm which employs a fixed cone size, one question that arises is how to resolve two nearby energy clusters. If they cannot be resolved then they are merged to produce a single jet, and if they can be resolved they are split with some prescription for how to partition the energy. This decision of merge/split can easily populate/depopulate the high energy regime of the inclusive jet cross section, exactly where one expects to find evidence of new physics. For the cross section as a function of H_T , this is not a concern so long as the jet energy scale is well-behaved. Final-state radiation can also depopulate the high energy regime of the inclusive jet cross section when a high- E_T jet radiates a moderate- E_T jet; once again, we find the H_T distribution is robust.

The H_T analysis uses a shape comparison between the measured and the predicted cross section and is therefore insensitive to the overall normalization. There are several input parameters that are needed for the QCD calculation, such as choice of parton distribution function and renormalization scale, which can result both in normalization and shape differences from one choice to the next. We find that the shape of the H_T cross section does not depend on the choice of renormalization scale. We show an example of this in the lefthand plot in Fig. 1 where each curve is the ratio between the cross sections for two different choices of renormalization scale. The Monte Carlo cross section is generated using the NLO generator, Jetrad[3], with renormalization scale, $\mu = 0.5, 1.0,$ or $1.5 \times E_T$ where E_T is the transverse energy of the leading jet of the event. Here we use the CTEQ2ML[4] parton distribution functions. The small variation in shape of each curve as a function of H_T is due to the ansatz function (an exponential whose argument is a polynomial in H_T) used to smooth the Monte Carlo distributions,

$$\frac{d\sigma}{dH_T} = \exp\left[\sum_{i=0}^3 (a_i \times H_T^i)\right],$$

where the a_i are coefficients determined in the fit.

In general, changing the order of the QCD calculation, from leading-order (LO) to

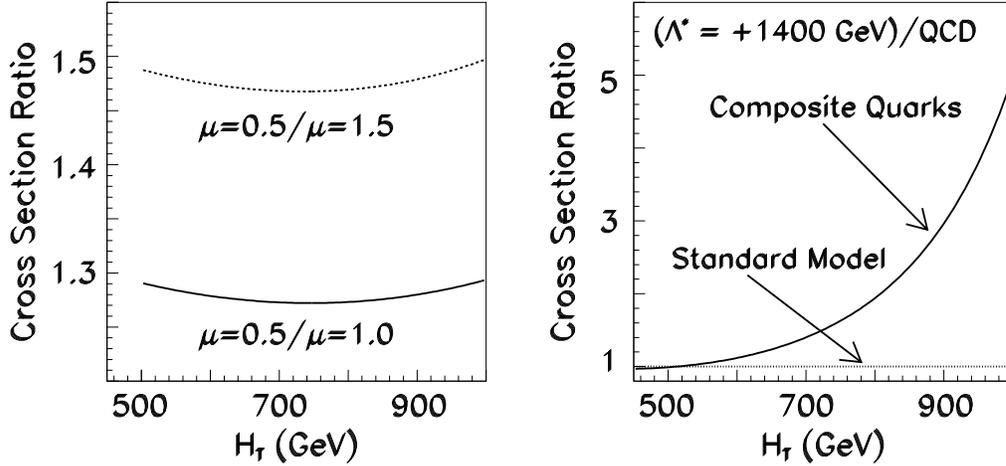


Figure 1: Lefthand plot: The ratio of NLO QCD cross sections for various choices of renormalization scale, μ . Righthand plot: The ratio of LO cross sections for composite quarks ($\Lambda^* = 1400$ GeV and destructive interference in the lagrangian) and QCD.

next-to-leading-order (NLO), results in both a normalization as well as a shape change in the cross section. The more inclusive quantity experiences less shape change, an important consideration since the models for new processes are implemented as LO processes in the event generators. Another important aspect of doing a shape analysis is that it minimizes some of the systematic errors, such as the uncertainty in the jet energy scale, and eliminates others, such as the uncertainty in the integrated luminosity.

The model for quark sub-structure that we employ is from Eichten, *et al.*, [5] with all six quarks allowed to be composite and both signs of the interference term possible. This model is implemented in the LO generator, PYTHIA, [6] but we use for comparison the QCD cross section generated with Jetrad. Therefore, we make the a priori assumption that the ratio between QCD and quark compositeness generated at LO is identical to what we would find at NLO if the model was implemented there. This ratio we term the K-factor; an example is shown in the righthand plot in Fig. 1. We apply this ratio to the QCD cross section generated by Jetrad to simulate quark compositeness at NLO. For our Monte Carlo event generation we use $\mu = 0.5 \times E_T$ of the leading jet and the CTEQ3M parton distribution functions, consistent with the $D\emptyset$ inclusive jet analysis [2].

Here we report preliminary results from an analysis of $90.4 \pm 4.9 \text{ pb}^{-1}$ of data taken in Run 1b, the 1994–95 run. The trigger used was a multi-jet trigger which was fully efficient for $H_T \geq 500$ GeV. Because the cross section decreases by several orders of magnitude for $500 \leq H_T \leq 1000$ GeV, we linearize the comparison with the Monte Carlo generated cross section by taking the difference between the two and normalizing to the Monte Carlo cross

section. As noted above, we are doing a shape analysis, so we normalize the generated cross section to match the data in the bin $H_T = 500$ GeV. The results are shown in Fig. 2 where for the lefthand plot we generated QCD ($\Lambda^* = \infty$) and for the righthand plot we generated composite quarks with $\Lambda^* = 1400$ GeV and destructive interference in the Lagrangian (+ sign of the interference term). The error bars are statistical only with the systematic errors due to the jet energy scale shown as the dotted and dashed lines. The extraction of a limit on the scale of quark sub-structure is still underway, but Fig. 2 indicates that the data are in good agreement with NLO QCD up to the highest energies probed and that the H_T analysis is sensitive to contact interactions. With the new jet energy scale and its concomittantly smaller uncertainty reported at this conference[2], we expect to extract a very competitive limit on the scale of quark compositeness. Finally, we note that even though we used quark compositeness as a specific example for the preceding discussion we have a “proof of principle” of the sensitivity of the H_T analysis to new interactions at scales much higher than the electro-weak scale.

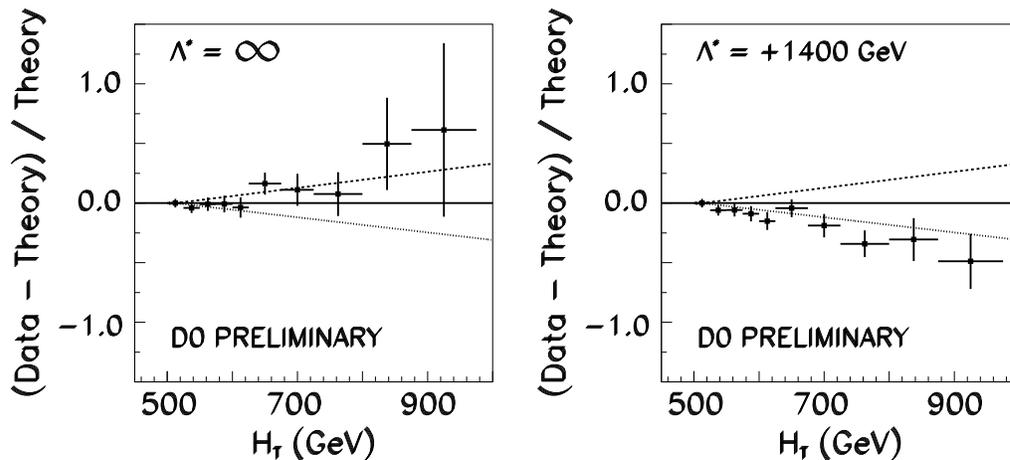


Figure 2: Lefthand plot: Data comparison with NLO QCD, where theory refers to the Monte Carlo cross section generated using Jetrad, see text for details. Righthand plot: Data comparison with NLO quark sub-structure ($\Lambda^* = 1400$ GeV and destructive interference in the Lagrangian). The error bars are statistical, and the error band is the systematic uncertainty due to the jet energy scale.

3 Leptoquarks

Leptoquarks are particles that carry both lepton number and color, and, therefore, they couple both to leptons and quarks. These arise in many extensions to the Standard

Model[7]. They couple with an unknown coupling strength which is usually parameterized in terms of the electro-weak coupling

$$g^2 = 4\pi\alpha k,$$

where α is the fine structure constant and k is an unknown constant. We find that we are fully efficient for $k \geq 10^{-12}$. This cutoff arises from the requirement that the leptoquark decays within the DØ beam pipe. Rare decay experiments set strict limits on contributions from flavor-changing neutral currents which translate into very high limits on the masses of the leptoquarks. If we require that the leptoquarks couple to a single Standard Model generation only, these limits are considerably lower allowing direct searches at present day colliders. There is renewed interest in leptoquark searches at the Tevatron following the recent report of an excess of events at high- Q^2 by the H1[8] and ZEUS[9] collaborations at DESY. Leptoquarks are produced at the Tevatron via strong pair-production. They can be either scalar or vector particles; we report here on searches for scalar leptoquarks. We define β as the branching fraction of the decay of the leptoquark to the charged lepton, ℓ , plus a quark. Three basic final states arise: (1) both leptoquarks decay to ℓq with branching fraction, β^2 ; (2) one leptoquark decays to ℓq and the other to νq , with branching fraction, $2\beta(1 - \beta)$; (3) both leptoquarks decay to νq , with branching fraction $(1 - \beta)^2$.

3.1 First Generation Leptoquarks – $eq\bar{e}q$ channel

For this analysis, we select events that have two high- E_T electrons ($E_T > 25$ GeV) and two high- E_T jets ($E_T > 30$ GeV), consistent with the event topology. The electrons must pass stringent quality cuts[10]. To reduce the background from $Z + \text{jets}$ events, we veto events where the di-electron mass lies within ± 15 GeV/ c^2 of the nominal mass of the Z . The overall efficiency for detecting first generation leptoquarks in this channel depends on the mass of the leptoquark and ranges from 0.21% for a mass of 40 GeV/ c^2 to 24.1% for a mass of 250 GeV/ c^2 . The analysis is optimized for a leptoquark mass of 160 GeV/ c^2 . The full Run 1 data sample (117.7 ± 6.4 pb $^{-1}$) yields 3 events which pass our selection criteria.

Five sources of events contribute to the background for this analysis. The largest is Drell-Yan production of $Z/\gamma + \text{jets}$. The second largest contribution is from $t\bar{t}$ pair-production with subsequent decay to di-electron final states. Smaller contributors to the background are $Z + \text{jets}$, where $Z \rightarrow \tau\bar{\tau} \rightarrow e\bar{e}$, $W^+W^- + \text{jets}$, where $W^+W^- \rightarrow \bar{\nu}e\nu\bar{\nu}$, and QCD multi-jet events where two of the jets fluctuate to mimic electrons. We predict 2.9 ± 1.1 events from these backgrounds.

Our search is a null search since the number of events that pass our analysis criteria in the data are well described by the predicted background. Therefore, we interpret the

results as a 95% CL upper limit on the cross section as a function of the mass of the leptoquark. An example of such a limit is presented in Fig. 3 where we have assumed $\beta = 1.0$ and find a lower limit on the mass of $175 \text{ GeV}/c^2$. The theoretical cross section is a LO calculation from Ref. [11]; this calculation yields a smaller cross section than we had used previously[12] resulting in a somewhat lower mass limit.

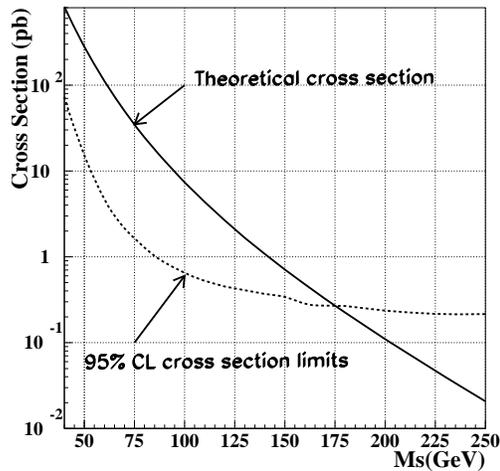


Figure 3: 95% CL upper limit on the cross section for production of first generation scalar leptoquarks as a function of the mass, $\beta = 1.0$.

3.2 First Generation Leptoquarks – $eq\bar{\nu}q$ channel

The event selection requirements for this channel are a single high- E_T electron ($E_T > 25 \text{ GeV}$), two high- E_T jets ($E_T > 25 \text{ GeV}$), and large missing transverse energy ($\cancel{E}_T > 40 \text{ GeV}$), consistent with the event topology (the \cancel{E}_T is due to the presence of the neutrino). To reduce the background from $W + \text{jets}$ we require the transverse mass, m_T , of the electron and \cancel{E}_T satisfy $m_T > 100 \text{ GeV}/c^2$. We discriminate against background from $t\bar{t}$ pair-production by requiring $H_T > 170 \text{ GeV}$, where $H_T \equiv \sum |E_T^{(j)}(> 15 \text{ GeV})| + |E_T^{(e)}|$, and vetoing events containing a reconstructed muon with $p_T > 4 \text{ GeV}/c$. The overall efficiency again varies as a function of the leptoquark mass and ranges from 0.03% for a leptoquark mass of $40 \text{ GeV}/c^2$ to 14.5% for a leptoquark mass of $250 \text{ GeV}/c^2$. As with the $eq\bar{e}q$ channel, this analysis is optimized for a leptoquark mass of $160 \text{ GeV}/c^2$. Analysis of $103.7 \pm 5.6 \text{ pb}^{-1}$ of data yields 3 events passing the requirements outlined above.

There are two main sources of background. The first is $t\bar{t}$ pair-production with subsequent decay to a single electron in the final state; this is the largest residual source of background. The second is W plus two jets, where $W \rightarrow e\bar{\nu}$. Both of these sources of

Standard Model background exhibit large missing transverse energy. We predict 4.0 ± 1.1 events from these sources.

Once again, the number of data events passing our selection criteria is well-modeled by the background. We interpret our null search result as a 95% CL upper limit on the cross section as a function of the leptoquark mass. An example of this is shown in Fig. 4 where we have assumed $\beta = 0.5$ and find a lower limit on the mass of $132 \text{ GeV}/c^2$. The theoretical cross section is from the calculation of Ref. [11].

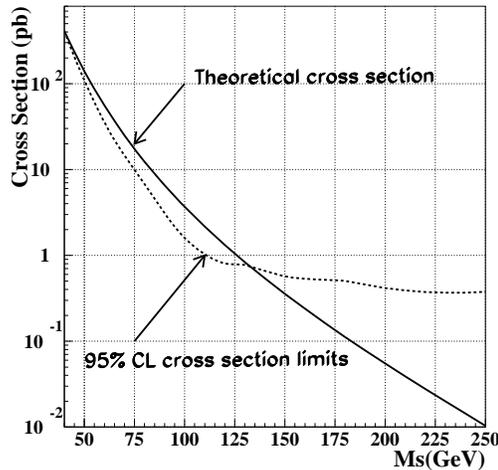


Figure 4: 95% CL upper limit on the cross section for production of first generation scalar leptoquarks as a function of the mass, $\beta = 0.5$.

3.3 First Generation Leptoquarks – $\nu q \bar{\nu} \bar{q}$ channel

The preliminary analysis of this channel completes the triumvirate of searches for first generation leptoquarks and is the first result from this channel. While this is in actuality a mixed-generational search since we are not able to tag the flavor of the neutrinos, we note that this analysis is valid for all three generations as long as we obtain a null result. We also stress that the analysis we present here is not optimized to search for first generation leptoquarks, rather it is a simple application of our previously published light top squark analysis[13] to this search.

The event requirements are two high- E_T jets ($E_T > 30 \text{ GeV}$) and large missing transverse energy ($\cancel{E}_T > 40 \text{ GeV}$). To reduce the vector boson contribution to the background, we veto events containing charged leptons. To minimize ambiguity in the \cancel{E}_T determination we also require only single interactions which yields an effective integrated luminosity of $7.4 \pm 0.4 \text{ pb}^{-1}$ from Run 1a, the 1992–93 run. We find 3 events surviving our selection

criteria. The main source of background is vector bosons + jets for which we predict 3.5 ± 1.2 events. Once again, we find the number of events passing our event selection is well-modeled by the background resulting in a null search. We interpret this null result as a 95% CL upper limit on the cross section as a function of the leptoquark mass. We present this limit in Fig. 5 where $\beta = 0.0$ and find a lower limit on the mass of 71 GeV/c^2 . The theoretical cross section is calculated from Ref. [11].

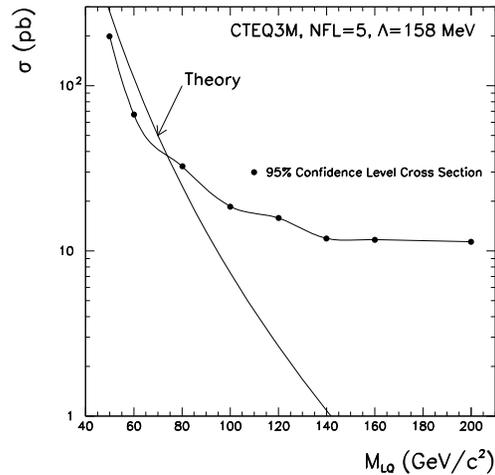


Figure 5: 95% CL upper limit on the cross section for production of first generation scalar leptoquarks as a function of the mass, $\beta = 0.0$.

3.4 First Generation Leptoquarks – combined channels

We then vary β over the allowable range $0.0 \leq \beta \leq 1.0$ for the three analyses presented above to produce limits of leptoquark mass versus β and combine all three channels to determine the limit on first generation leptoquark production as a function of β as shown in Fig. 6. We also include in Fig. 6 for comparison the LEP I direct search limit of 45 GeV/c^2 and our previously published limit[14]. For $\beta = 1.0$ we find a lower limit on the first generation scalar leptoquark mass of 175 GeV/c^2 , while $\beta = 0.5$ and 0.0 yield lower limits of 147 and 71 GeV/c^2 , respectively.

3.5 Third Generation Leptoquarks – $\nu b \bar{\nu} \bar{b}$ channel

The search for third generation leptoquarks decaying to $\nu b \bar{\nu} \bar{b}$ is optimized for a leptoquark with mass less than that of the top quark. As opposed to the searches for first generation leptoquarks where both quark species were kinematically allowed in the final state, here

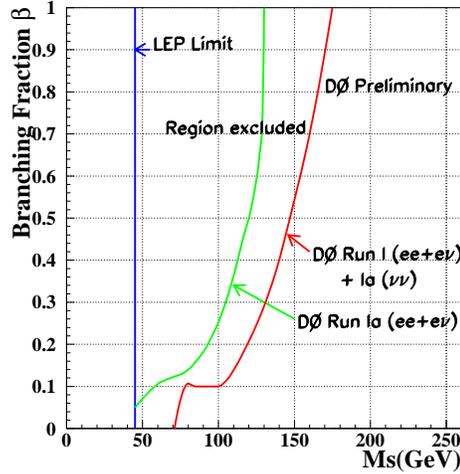


Figure 6: First generation leptoquark mass limit versus β . The present limit contour is labelled DØ Run I ($ee + e\nu$) + 1a ($\nu\nu$).

we are restricted to b quarks only. Therefore, this search is not a search in terms of β but rather is a search for a leptoquark with charge = $\pm 1/3$.

The event selection requires large missing transverse energy, $\cancel{E}_T > 35$ GeV, and two jets, where one or both of the jets is tagged as a b quark jet due to the presence of a μ -tag, consistent with the event topology. For a tagged jet, we require $E_T > 10$ GeV, while untagged jets must satisfy $E_T > 25$ GeV. We apply additional topological constraints to enhance the b quark decays of the leptoquarks and reduce mismeasurement sources of \cancel{E}_T . To enhance the b quark decays we require that the di-jet system carry most of the energy since μ 's from b quark decays tend to be softer than μ 's from W decay. We veto events where there is too much energy in an annular cone around the tagging muon thus reducing contributions from gluon splitting, $g \rightarrow b\bar{b}$. Finally, to reduce mismeasurement sources of \cancel{E}_T , we require that the \cancel{E}_T vector not be aligned or anti-aligned with either of the two leading jets. The effective total acceptance varies as a function of the leptoquark mass and ranges from 0.41% for a mass of 60 GeV/ c^2 to 3.4% for a mass of 150 GeV/ c^2 . Analysis of 85.6 ± 4.6 pb $^{-1}$ of data yields 2 events that satisfy the event requirements outlined above.

The sources of background for this channel are Standard Model sources of b quarks, such as $t\bar{t}$ pair-production, $W/Z \rightarrow b$, and QCD b quark events. The QCD events are difficult to estimate with an expectation of 4 ± 4 , so we arbitrarily set this contribution to zero resulting in the most conservative limit we can set. We predict 2.8 ± 0.7 background events from the other two sources. The number of events passing our selection criteria is consistent with the background, so we interpret the null result as a 95% CL upper limit on

the production cross section as a function of the leptoquark mass. The limit is plotted in Fig. 7 where we find for third generation leptoquarks with charge = $\pm 1/3$ a lower limit on the mass of 80 GeV/c². We include in Fig. 7 the LEP I direct search limit of 45 GeV/c². The theoretical cross section shown in Fig. 7 is based on our earlier calculation[12].

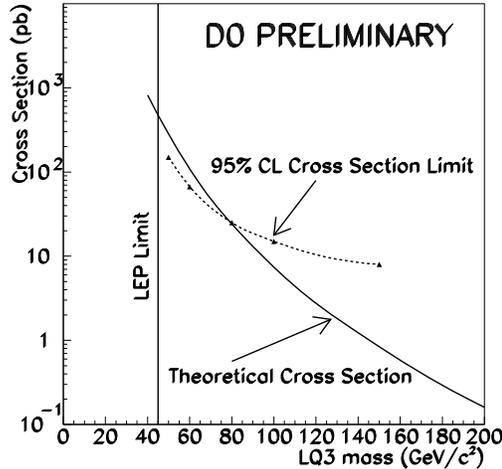


Figure 7: 95% CL upper limit on the cross section for production of third generation scalar leptoquarks with charge = $\pm 1/3$ as a function of the mass.

4 Supersymmetry

Supersymmetry is one of the most elegant extensions to the Standard Model since it generalizes the space-time symmetry without altering the gauge symmetry. It also provides the framework for unification with gravity which occurs at a sufficiently high enough mass scale, like the Planck scale. The Minimal Supersymmetric Standard Model, MSSM, consists of adding a super-partner to every Standard Model particle and results in a plethora of undetermined parameters, such as the masses and mixings of the particles.

Recent models of low-energy supersymmetry suggest signatures involving one or more photons plus missing transverse energy[15]. One feature common to these models is the prediction of tens of events in the $> 100 \text{ pb}^{-1}$ of data taken in Run 1. The photon plus \cancel{E}_T final state arises from pair-production of \tilde{e} , $\tilde{\nu}$, and $\tilde{\chi}_2^0$, where the \tilde{e} and $\tilde{\nu}$ decay to $\tilde{\chi}_2^0$ which subsequently decays to $\tilde{\chi}_1^0$ and a photon. This analysis is recently published[16], and we summarize the search for these signatures. The event requirements are two central ($|\eta| < 1.1$) photons with $E_T > 12 \text{ GeV}$ and large missing transverse energy ($\cancel{E}_T > 25 \text{ GeV}$). To minimize the contribution from $Z \rightarrow ee$ where the two electrons are reconstructed as

photons, we veto events with a di-photon invariant mass within ± 10 GeV/ c^2 of the nominal Z mass. To reduce the background from radiative W decays ($W(e\nu)\gamma$ and $W(e\nu\gamma)$) we require an azimuthal separation of the photons ($\Delta\phi_{\gamma\gamma} > 90^\circ$). Analysis of 93.3 ± 11.2 pb $^{-1}$ of data yields no event satisfying the selection criteria.

The largest source of background comes from QCD multi-jet events where two of the jets are misidentified as photons and mismeasurement provides the large \cancel{E}_T . Lesser sources of background are processes like $W \rightarrow e\bar{\nu}$, $\tau \rightarrow eX$, and $t\bar{t} \rightarrow eX$, where the e is misidentified as a photon, in combination with either a photon or a jet misidentified as a photon. We predict 2.0 ± 0.9 background events in our event sample. In the lefthand plot of Fig. 8 we show the \cancel{E}_T distribution measured in the event; the points are the background prediction, and the data are shown in the histogram. As can be seen from this plot, there is no visible excess in the data. Detecting zero events with $\cancel{E}_T > 25$ GeV is consistent with the background model, so we interpret this null result as a 95% CL upper limit on the production cross section which is shown in the righthand plot of Fig. 8 as a function of the neutralino mass difference. We find that the mean photon E_T and the mean \cancel{E}_T of these events is typically given by the neutralino mass difference. We examine several masses for the pair-production of \tilde{e} , $\tilde{\nu}$, and $\tilde{\chi}_2^0$. The cross section limit ranges from 1 pb to 400 fb for neutralino mass differences > 20 GeV/ c^2 , almost independent of the species and mass being pair-produced.

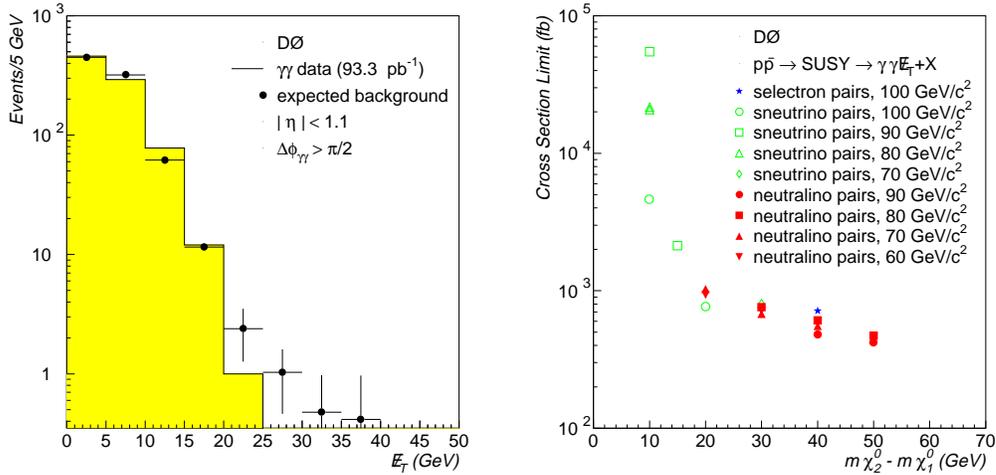


Figure 8: Lefthand plot: The \cancel{E}_T distribution for $\gamma\gamma$ data (histogram) and background (black circles). Righthand plot: 95% CL upper limits on the pair-production cross section where the decay $\tilde{\chi}_2^0 \rightarrow \gamma + \tilde{\chi}_1^0$ has been forced.

The weak dependence of the cross section limit on the neutralino mass difference above 20 GeV/ c^2 arises from the near independence of the event efficiency (trigger plus

reconstruction) for the kinematic requirements above. Therefore, we extend the analysis to set a model-independent upper limit on the cross section for final states satisfying our event selection criteria of two central ($|\eta| < 1.1$) photons with $E_T > 12$ GeV and $\cancel{E}_T > 25$ GeV of $\sigma \cdot B(p\bar{p} \rightarrow \gamma\gamma + \cancel{E}_T + X) < 185$ fb at the 95% CL. The reason that this model-independent limit is better than the supersymmetry search limit is that typically only 25–50% of the supersymmetric events satisfy our kinematic requirements. The effect of this model-independent limit on some of the recently proposed models is to exclude a considerable fraction of their parameter space.

5 Summary and Future Prospects

We have shown preliminary results from the H_T analysis and have argued the efficacy of this analysis for searching for physics beyond the Standard Model. We use quark compositeness as our example of new physics to describe the search. We have presented preliminary results and find that the cross section as a function of H_T is consistent with NLO QCD up to the highest energies probed. We do not set a limit on the compositeness scale at this time as we are still working on this phase of the analysis; however, we do find that this analysis is sensitive to contact interactions, as required in the quark substructure model. The future for this analysis is very bright as we incorporate the new jet energy scale and begin to map out the rich array of proposed extensions to the Standard Model.

We have presented new results from our search for first generation leptoquarks which, for the first time, covers the triumvirate of decay channels ($eq\bar{e}q$, $eq\bar{\nu}q$, and $\nu q\bar{\nu}q$). The results from the two decay channels containing an electron are updates to what we have previously shown. The analysis employs a new calculation of the production cross section which has resulted in a somewhat decreased mass limit. We have presented the first results from an analysis of the $\nu q\bar{\nu}q$ channel. Even with a non-optimized analysis of a limited data set, we set a limit of $71 \text{ GeV}/c^2$ on the mass of the leptoquark for $\beta = 0.0$. Combining all three channels we find lower limits on the mass of first generation leptoquarks of $175 \text{ GeV}/c^2$ ($\beta = 1.0$), $147 \text{ GeV}/c^2$ ($\beta = 0.5$), and $71 \text{ GeV}/c^2$ ($\beta = 0.0$). This is not the last word we will have to say regarding the search for first generation leptoquarks as we plan to re-optimize the analysis for higher leptoquark masses, such as $200 \text{ GeV}/c^2$. We are also exploring invariant mass constraints on the eq pairs in both the $eq\bar{e}q$ and $eq\bar{\nu}q$ channels. We are examining a NLO cross section calculation which will result in higher mass limits. We will be adding the entire Run 1 data set to the $\nu q\bar{\nu}q$ analysis and optimizing for searching for leptoquarks. Finally, we are searching for vector leptoquarks, where the production cross section is substantially larger than for scalar leptoquarks.

We have presented the first results from a search for a third generation scalar lepto-

quark with charge = $\pm 1/3$ decaying to $\nu b\bar{\nu}b$. We find a lower limit on the leptoquark mass of $80 \text{ GeV}/c^2$. The future for this analysis involves re-optimizing for masses greater than the limit quoted above, employing the NLO cross section calculation, and searching for vector leptoquarks.

We have presented results from one of our searches for supersymmetry, the pair-production of \tilde{e} , $\tilde{\nu}$, and $\tilde{\chi}_2^0$. We force the decays of \tilde{e} and $\tilde{\nu}$ to $\tilde{\chi}_2^0$ plus a photon with the subsequent decay of $\tilde{\chi}_2^0$ to $\tilde{\chi}_1^0$ plus a photon. We find 95% CL upper limits on the production cross section that range from 1 pb to 400 fb for neutralino mass differences $> 20 \text{ GeV}/c^2$, nearly independent of the mass or the species of the particles being pair-produced. This weak dependence allows us to set a model-independent 95% CL upper limit on the cross section for producing any final state satisfying our kinematic requirements (two central photons with $|\eta| < 1.1$ and $E_T > 12 \text{ GeV}$ plus $\cancel{E}_T > 25 \text{ GeV}$) of $\sigma \cdot B(p\bar{p} \rightarrow \gamma\gamma + \cancel{E}_T + X) < 185 \text{ fb}$ at the 95% CL. The effect of this model-independent limit on some of the recently proposed models is to exclude a considerable fraction of their parameter space.

We have reported on a variety of searches for new physics, none of which has resulted in any unexpected production. The Standard Model is still viable today. With many more exciting analyses underway at DØ we continue the search. We thank the organizers of this conference for the opportunity to present some of our latest results.

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