Searches beyond the standard model at high-energy colliders

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Recent searches for physics beyond the standard model at high-energy colliders are reviewed, with emphasis on supersymmetry, additional space dimensions, extra gauge bosons, leptoquarks, and model-independent searches. The results reported are based on data samples of up to 0.5 and 2.5 fb^{-1} collected at HERA and at the Tevatron, respectively.

1. INTRODUCTION

This review covers results presented in three parallel sessions (SUSY, and Exotics I and II) during which 21 experimental talks were delivered, of which ten reported results from the Tevatron, four from HERA, one from the B factories, and six gave prospects at the LHC. In addition, there were twelve theoretical talks, for which the reader should consult Refs. [1] and [2]. Furthermore, in view of the limited amount of time allocated to this review, hard choices had to be made, for which I apologize. In particular, only actual results, i.e., no prospects, will be reported here.

There are many ways in which the standard model (SM) can be extended. Supersymmetry (SUSY) is the only non-trivial extension of the Poincaré group, and it naturally incorporates gravity in its local form. String theories suggest that there could be a number of compact space dimensions in addition to the three usual ones. The SU(3)×SU(2)×U(1) gauge group can be seen as resulting from the breaking of a larger, more unified, gauge group. Alternatives to the Higgs mechanism can be considered to break the electroweak symmetry. The quark-and-lepton structure in three generations is at the origin of many ideas such as compositeness.

Among those many possibilities, the choice was made in this review to address supersymmetry, additional space dimensions, new gauge bosons, and leptoquarks. Searches for new phenomena not motivated by any specific model will also be reported. In the following, all limits will be given at 95% C.L., and evidences or discoveries will be reported only if their significance exceeds three or five sigmas, respectively.

2. SUPERSYMMETRY

The general concepts of supersymmetry, as well as details of the minimal supersymmetric extension of the standard model, the MSSM, can be found in Ref. [1]. Briefly, the MSSM is built from the minimal field content, with squarks, sleptons, gluinos, charginos and neutralinos, and with two Higgs doublets. In the absence of a specific SUSY breaking scheme, more than a hundred new parameters are introduced, which are reduced to a manageable level by invoking some unification of the soft SUSY-breaking terms at the GUT scale. In what is usually called "standard SUSY", additional assumptions are made: in order to avoid fast proton decay, R-parity is assumed to be conserved, and the lightest supersymmetric partner, the LSP, is a neutralino. As a consequence, SUSY particles are produced in pairs, and they decay to SM particles and to the LSP; since the LSP is stable and weakly interacting, the final state exhibits missing energy. Models in which R-parity is not conserved are not considered in this review.

The most widely studied model is minimal supergravity, mSUGRA. Only five parameters are needed to fully specify the model: a common scalar mass m_0, a common gaugino mass $m_{1/2}$, and a common trilinear coupling A_0, all defined at the GUT scale, the ratio $\tan\beta$ of the vacuum expectation values of the two Higgs doublets, and the sign of μ, the supersymmetric Higgs mass term. The absolute value of μ is determined from the renormalization group equations, by imposing electroweak symmetry breaking at the proper scale. The typical mSUGRA spectrum contains a light Higgs boson, a neutralino LSP, sleptons substantially lighter than squarks, and the following relation holds approximately among the gaugino masses: $m_{\tilde{g}}/3 \sim m_{\tilde{\chi}^{\pm}} \sim 2m_{\tilde{\chi}_1^0}$.

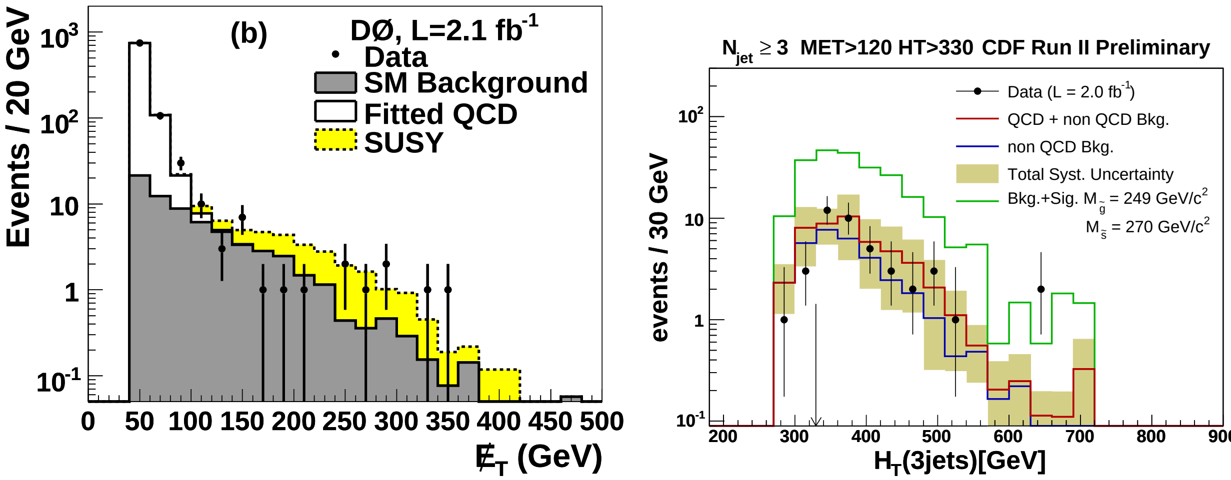

Figure 1: Left: Final $\not\!\!E_T$ distribution in the DØ search for squarks and gluinos [6] in the three-jet topology, after $H_T > 375$ GeV; the final cut is $\not\!\!E_T > 175$ GeV. Right: Final H_T distribution in the CDF search for squarks and gluinos [7] in the three-jet topology, after $\not\!\!E_T > 120$ GeV; the final cut is $H_T > 330$ GeV.

2.1. Standard SUSY

Some of the most constraining limits on SUSY particles still result from the searches performed at LEP. Mass limits of about 100 GeV were obtained for sleptons and charginos [3]. In the MSSM with sfermion and gaugino mass unification, a mass lower limit of 47 GeV was set on the LSP at large $\tan\beta$ [4], somewhat tighter at lower $\tan\beta$ and in mSUGRA [5].

There are two main streams for standard-SUSY searches in $p\bar{p}$ collisions at the Tevatron: squarks and gluinos in jets+$\not\!\!E_T$ final states, and electroweak gauginos in the trilepton topology.

2.1.1. Squarks and gluinos

Colored SUSY particles, squarks and gluinos, are expected to be the most copiously produced at the Tevatron via the strong interaction, up to phase space suppressions at large masses. If squarks are much lighter than gluinos, the most relevant production channel is $p\bar{p} \to \tilde{q}\bar{\tilde{q}}$. In that configuration, the $\tilde{q} \to q\tilde{\chi}_1^0$ decay mode is expected to be dominant. If gluinos are much lighter than squarks, the $p\bar{p} \to \tilde{g}\tilde{g}$ production channel and the $\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$ decay mode are expected to be the most relevant. If the squark and gluino masses are similar, both production processes contribute, as well as squark-gluino associated production, $p\bar{p} \to \tilde{q}\tilde{g}$. The above processes lead to topologies of at least two, four, or three jets with $\not\!\!E_T$, respectively, and the CDF and DØ collaborations have both optimized three analyses accordingly, the results of which are combined in the end. The simple picture outlined above is in practice complicated by the possibility of cascade decays such as $\tilde{q} \to q'\tilde{\chi}^{\pm} \to q'\ell\nu\tilde{\chi}_1^0$, so that a specific model is needed to interpret the search results.

In the searches in jets+$\not\!\!E_T$ topologies, the main backgrounds are of two types: instrumental from standard QCD multijet production, where the $\not\!\!E_T$ arises from jet energy mismeasurements, and (W/Z)+jets production, with real $\not\!\!E_T$ due to the neutrinos from $W \to \ell\nu$ or $Z \to \nu\bar{\nu}$. The instrumental background is reduced by the requirement that the $\not\!\!E_T$ should not be aligned with the direction of a jet, while the W+jets background (including from top quark decays) is reduced by vetoing events with isolated leptons. The background from $(Z \to \nu\bar{\nu})$+jets is irreducible. The final discrimination is achieved by requiring large $\not\!\!E_T$ and H_T, where H_T is the scalar sum of the jet transverse momenta. Final distributions of these variables in the CDF and DØ three-jet analyses are shown in Fig. 1.

In the DØ analysis [6] based on 2.1 fb^{-1}, 11, 9, and 20 events were selected in the two, three, and four-jet topologies, respectively, to be compared with background expectations of 11.1 ± 2.9, 10.7 ± 2.8, and 17.7 ± 4.5 events, respectively.

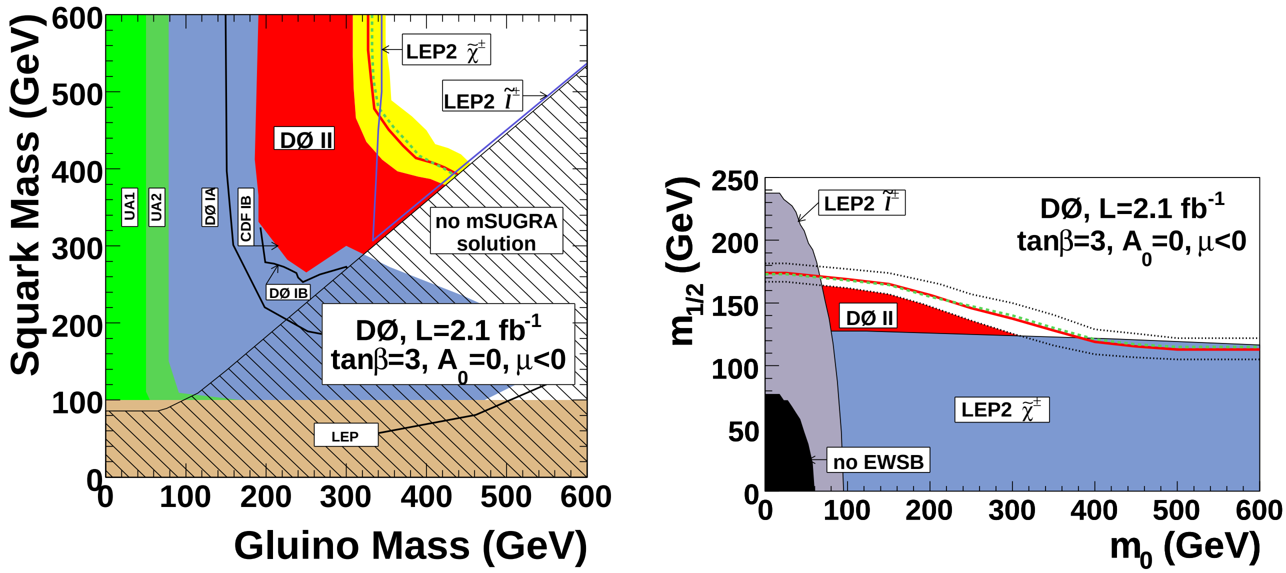

Figure 2: Left: Region in the $(m_{\tilde{g}}, m_{\tilde{q}})$ plane excluded by DØ [6] and by earlier experiments. The red curve corresponds to the nominal scale and PDF choices. The yellow band represents the uncertainty associated with these choices. The blue curves represent the indirect limits inferred from the LEP chargino and slepton searches. Right: Region in the $(m_0, m_{1/2})$ plane excluded by the DØ search for squarks and gluinos [6] and by the LEP experiments.

These results were turned into an exclusion domain in the $(m_{\tilde{g}}, m_{\tilde{q}})$ plane, within the mSUGRA framework with $\tan\beta = 3$, $A_0 = 0$, and $\mu < 0$, as shown in Fig. 2-left. The exact boundary of the exclusion domain depends on the choice of renormalization and factorization scale, and on the parton distribution functions chosen, as shown by the yellow band in Fig. 2-left. For the nominal choice, indicated by the red curve, squark masses below 392 GeV and gluino masses below 327 GeV are excluded. The lower limit for equal squark and gluino masses is 408 GeV. An alternative presentation can be given in terms of the mSUGRA parameters, as shown in Fig. 2-right, where it can be seen that the domain excluded by gaugino and slepton searches at LEP is extended. Similar results have been obtained by the CDF collaboration [7].

2.1.2. Electroweak gauginos

Although chargino and neutralino production in $p\bar{p}$ collisions is mediated by electroweak interactions, while squarks and gluinos are produced via the strong interaction, the search for electroweak gauginos at the Tevatron is nevertheless quite relevant for two reasons. In a framework with gaugino mass unification, a similar fraction of the parameter space is probed for electroweak-gaugino masses a factor of three smaller than the gluino mass, thus reducing the impact of the phase space suppression. Second, if sleptons are sufficiently light, leptonic decays of the electroweak gauginos such as $\tilde{\chi}^{\pm} \to \tilde{\ell}^{*}\nu \to \ell\nu\tilde{\chi}^0_1$ and $\tilde{\chi}^0_2 \to \tilde{\ell}^{*}\ell \to \ell^+\ell^-\tilde{\chi}^0_1$ are enhanced. As a result, associated $\tilde{\chi}^{\pm}\tilde{\chi}^0_2$ production leads to the very clean signature of three leptons and $\not{E}_T$ in an otherwise quiet environment. The final state leptons tend however to carry little energy, because the LSP mass is roughly half the chargino or $\tilde{\chi}^0_2$ mass.

The search strategy is therefore to require two isolated leptons, with minimum transverse momenta as low as possible, and some $\not{E}_T$ due to the escaping neutrino and neutralinos. The third lepton can either be explicitly identified, or simply be an isolated charged particle track, thus providing some sensitivity to hadronic τ decays. Since this third lepton may be too soft to be part of the analysis, an alternative strategy is also used, based on only two identified leptons, but with the requirement that they should have the same electric charge, a configuration for which the SM backgrounds are greatly reduced.

In the CDF search [8] based on 2.0 fb^{-1}, one trilepton event survived all stages of the selection, with a background

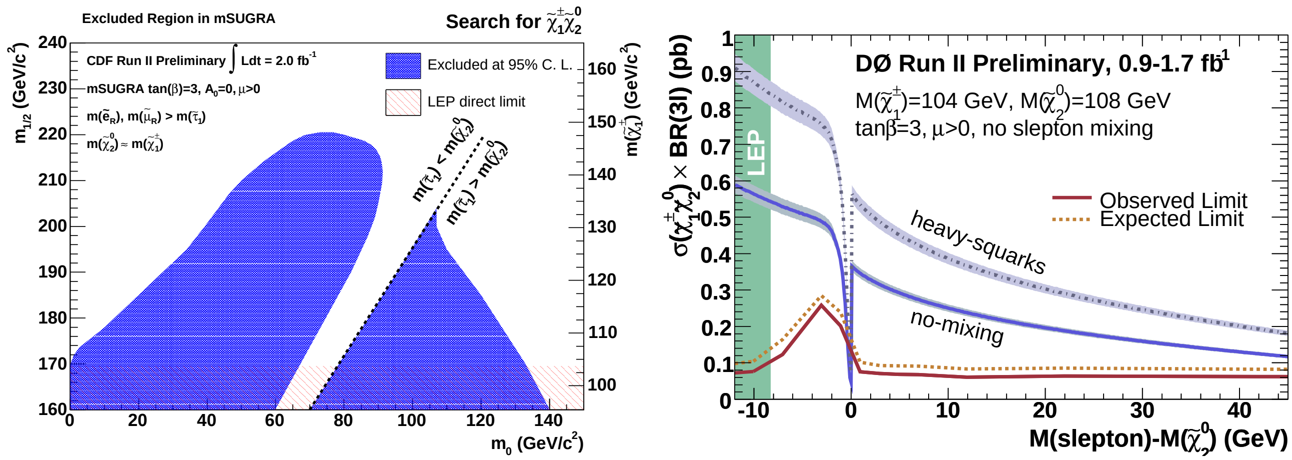

Figure 3: Left: Regions in the $(m_0, m_{1/2})$ plane excluded by the CDF search for trileptons [8]. Right: Upper limit obtained by DØ on the product of the cross section of associated $\tilde{\chi}^{\pm}\tilde{\chi}_2^0$ production times the branching fraction into three leptons, as a function of the slepton $-$ $\tilde{\chi}_2^0$ mass difference, compared with the MSSM expectation without slepton mixing ("no-mixing" curve) [9].

expectation of 0.88 ± 0.14 events. In the less pure selection where the third lepton is identified simply as an isolated track, six events were selected, with 5.5 ± 1.1 expected from backgrounds. These results were translated into an exclusion domain in the mSUGRA parameter space, as shown in Fig. 3-left for $\tan\beta = 3$, $A_0 = 0$, and $\mu > 0$. Two lobes can be observed. The left one corresponds to two-body decays such as $\tilde{\chi}^{\pm} \to \tilde{\ell}\nu$, while the right one corresponds to three-body decays such as $\tilde{\chi}_2^0 \to \ell^+\ell^-\tilde{\chi}_1^0$. For $m_0 = 60$ GeV, a chargino mass lower limit of 145 GeV is obtained; the limit is 127 GeV for $m_0 = 100$ GeV. These values exceed the chargino mass lower limit set at LEP. The DØ collaboration has not yet performed such a full mSUGRA scan. They investigated the configuration where the slepton mass is just above $m_{\tilde{\chi}_2^0}$, along the edge of the right lobe, and obtained a chargino mass limit of 145 GeV in that configuration [9]. The gap between the two lobes corresponds to the case where two-body decays are just open, so that one of the leptons arising from the $\tilde{\chi}_2^0 \to \tilde{\ell}\ell$ decay is too soft to be detected. This is the configuration where the search for same-sign dileptons comes to rescue. A search for same sign dimuons was performed by DØ, which allows the gap to be reduced, as shown in Fig. 3-right.

2.2. Non-standard SUSY

2.2.1. Gauge mediated SUSY breaking

In models where SUSY breaking is mediated by gauge interactions, the scale of SUSY breaking is lower than in supergravity, and the gravitino becomes the LSP. The phenomenology depends on the nature of the NLSP, the next to lightest SUSY particle, and on its lifetime. In most viable models, the NLSP is a stau or a neutralino. A stau NLSP was excluded at LEP with masses below 87 to 97 GeV, depending on its lifetime [10]. These remain the tighter limits to date.

In the mass range relevant for searches at LEP and at the Tevatron, a neutralino NLSP decays as $\tilde{\chi}_1^0 \to \gamma\tilde{G}$, where the very light gravitino $\tilde{G}$ escapes detection. The final state arising from the pair production of SUSY particles therefore involves two photons and missing energy carried away by the gravitinos. Inclusive searches for this topology were performed at the Tevatron under both assumptions of prompt and delayed NLSP decays. The distribution of the $\not{E}_T$ significance in the CDF search with prompt decays is shown in Fig. 4-left [11], where the resolutions on the energies of the objects involved in the calculation of the $\not{E}_T$ are folded into the significance. A clear separation is observed between processes with fake and with real $\not{E}_T$. Based on an analysis of 1.1 fb^{-1}, the DØ collaboration interpreted their results within the framework of a minimal model, the "Snowmass slope" [12], where

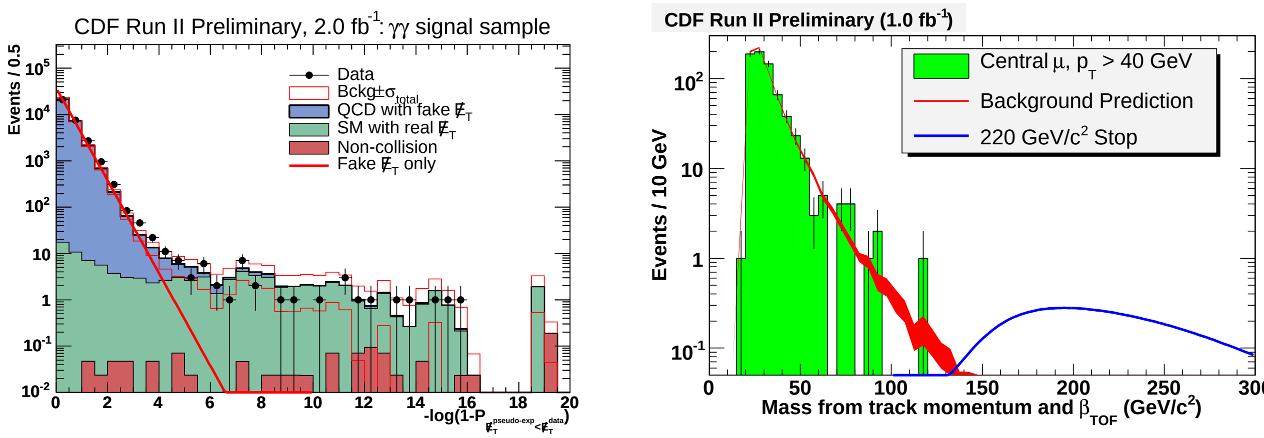

Figure 4: Left: Distribution of the $\not\!\!E_T$ significance in the CDF search for diphotons and $\not\!\!E_T$ [11]. Right: Distribution of the mass of charged particles, calculated by CDF from the momentum and time of flight [15].

the dominant process is associated $\tilde{\chi}^{\pm}\tilde{\chi}^{0}_{2}$ production. A chargino mass lower limit was set at 229 GeV [13].

2.2.2. Charged massive stable particles

Long-lived charginos are expected in some models with anomaly-mediated SUSY breaking. The reason is that, in such models, the LSP is wino-like, so that the $\tilde{\chi}^{\pm} - \tilde{\chi}^{0}_{1}$ mass difference is very small. Such long-lived charginos would appear in a Tevatron detector like slowly moving muons with large momenta. The DØ collaboration made use of the timing information of their muon detectors to set a chargino mass lower limit of 185 GeV, based on 1.1 fb^{-1} [14]. The CDF collaboration made use of their time-of-flight detectors in 1 fb^{-1}, as shown in Fig. 4-right, and excluded masses below 250 GeV for a long-lived stop [15], as would be the case in the MSSM for a small stop–LSP mass difference.

3. EXTRA-DIMENSIONS

Models with additional space dimensions come in many flavors: large, TeV^{-1}, universal, warped... The results reported in this review pertain to the model of large extra-dimensions (LED) within which only gravity propagates in the bulk, and the Kaluza-Klein (KK) excitations of the graviton cannot be resolved.

Such KK gravitons can be produced together with a quark, a gluon, or a photon in $p\bar{p}$ collisions, and escape into the bulk. The corresponding final states are a monojet or a mono-photon, with $\not\!\!E_T$. The analysis of these processes provides direct information on the fundamental Planck scale M_D. In the simplest model, M_D is related to the Planck scale by $M_{Pl}^2 = 8\pi M_D^{n_D+2} R^{n_D}$, where R is the radius of the n_D additional compact dimensions. A search for such monojets was performed in 1.1 fb^{-1} by CDF [16]. As can be seen in Fig. 5-left, the spectrum of jet p_T for events with $\not\!\!E_T > 120$ GeV does not show any excess at large p_T, above the SM expectation dominated by $(Z \to \nu\nu)$+jet, that could be attributed to the effects of LEDs. In addition to the SM $(Z \to \nu\nu) + \gamma$ background, the search for single photons suffers from a large background from cosmics and from the beam halo. The CDF analysis based on 2 fb^{-1} [16] makes use of the timing information of the calorimeter, while the DØ collaboration takes advantage of the fine segmentation of their electromagnetic calorimeter and of their preshower detector to verify that the photon candidates originate from the interaction vertex [17]. The CDF collaboration combined the results of their seraches for monojets and for single photons to extract limits on M_D as a function of the number of extra dimensions (Fig. 5-right). For $n_D = 4$, $M_D > 1.04$ TeV.

Virtual KK gravitons can also be exchanged in the production of fermion or boson pairs, thus modifying the SM cross sections for these processes. Here, the sensitivity is expressed in terms of a cutoff, the effective Planck scale M_s, which is expected to be close to M_D. The DØ collaboration combined in a single analysis the search in 1.05 fb^{-1}

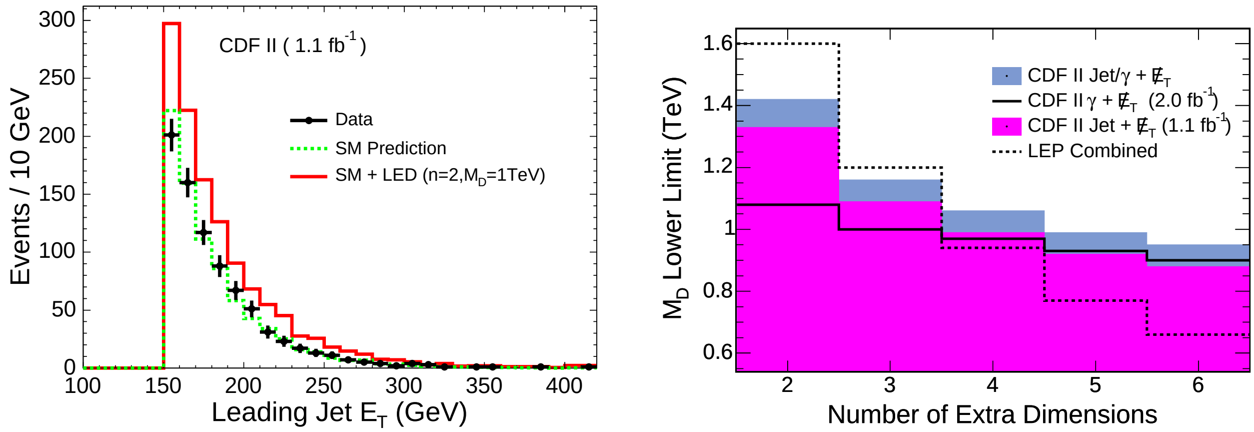

Figure 5: Left: Distribution of the jet p_T in the CDF search for monojets [16]. Right: Limits on the fundamental Planck scale M_D as a function of the number of extra dimensions [16].

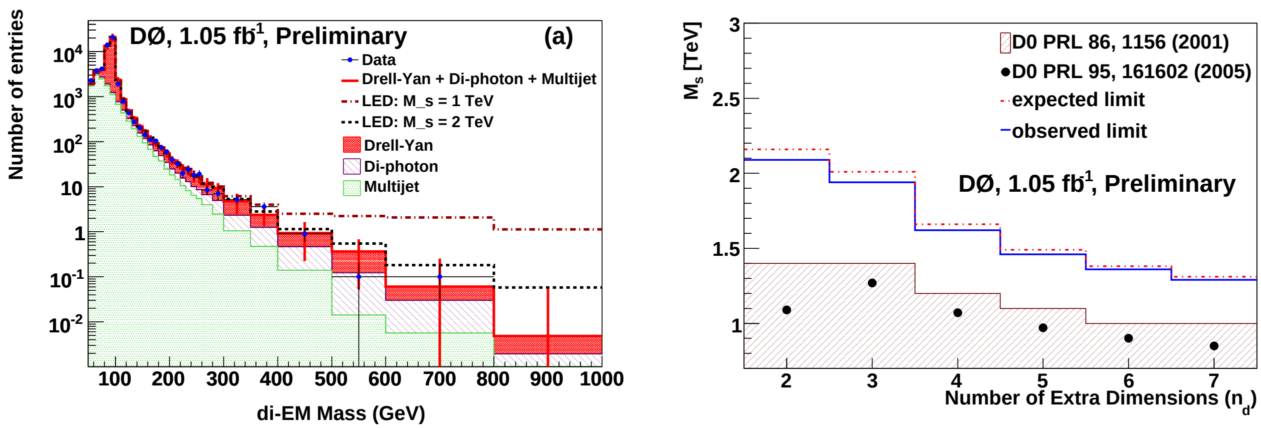

Figure 6: Left: Distribution of the diEM mass in the DØ search for LEDs [18]. Right: Limits on the effective Planck scale M_s as a function of the number of extra dimensions [18].

for LEDs in electron and photon pair production. The combined dielectron and diphoton (diEM) mass spectrum showed in Fig. 6-left does not exhibit any excess at large diEM mass above the SM contribution, from which limits on M_s are derived as a function of n_D as shown in Fig. 6-right [18]. For $n_D = 4$, $M_s > 1.62$ TeV.

A search for LEDs in high p_T dijets was performed by DØ [19] in 0.7 fb^{-1}. Given the uncertainties on the jet energy scale, the most sensitive variable is the angular distribution in the center-of-mass of the hard process, parameterized in terms of χ =exp($|y_1 - y_2|$) $\sim (1 + \cos\theta^*)/(1 - \cos\theta^*)$, where y_1 and y_2 are the rapidities of the two jets. The χ distribution would be uniform for Rutherford scattering, and the deviations are accurately predicted by perturbative QCD. Additional deviations are predicted in LED models, which would build up at large dijet masses and small values of χ. The absence of such deviations allows a lower limit of 1.49 TeV to be set on M_s for $n_D = 4$.

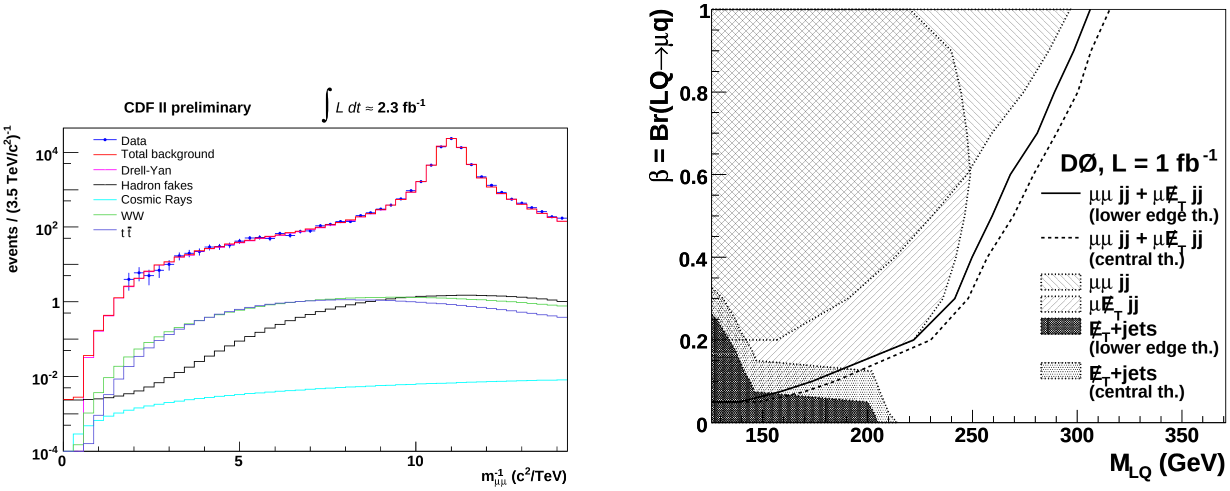

Figure 7: Left: Distribution of the dimuon inverse mass at CDF [21]. Right: Exclusion domain in the (m_{LQ}, β) plane from the DØ search for second generation leptoquarks in the $\mu\mu qq$ and $\mu\nu qq$ topologies [25]; the low β region is excluded by a search in the acoplanar jet topology [26].

4. OTHER MODEL-INSPIRED SEARCHES

4.1. Extra gauge bosons

Neutral bosons associated with extra U(1) gauge groups appear in many extensions of the standard model. Recent searches were performed by CDF for such extra Z' bosons in the dielectron [20] and dimuon [21] channels, based on 2.5 and 2.3 fb^{-1}, respectively. They would show up as a peak in the dilepton mass distribution. The dimuon mass spectrum is shown in Fig. 7-left, presented in terms of $1/m_{\mu\mu}$, a variable better fit to the trackers resolution which is Gaussian in inverse momentum. In the absence of any excess over the SM expectation, a lower limit of 1.03 TeV was set on the mass of a sequential Z', i.e., with couplings identical to those of the standard Z boson. Somewhat lower limits were obtained in various canonical E(6) models. In the dielectron channel, an excess is seen around 240 GeV, the significance of which is however only 2.5σ, once the trial factor is taken into account.

Extra W' bosons are also expected in extensions of the SM such as the left-right symmetric model based on $\mathrm{SU(2)}_L\times\mathrm{SU(2)}_R\times\mathrm{U(1)}$. A DØ search for $W' \to e\nu$ in 1 fb^{-1} excluded a sequential W' with mass below 1.00 TeV [22].

4.2. Leptoquarks

The apparent symmetry between the structures of the lepton and quark representations in the SM leads to the conjecture that bosons carrying lepton and quark quantum numbers could mediate transitions between quarks and leptons. Indeed, such leptoquarks appear naturally in, e.g., grand unified theories. In order to avoid flavor changing neutral currents, it is commonly assumed that a given leptoquark couples to a single generation. Leptoquarks decay into a quark and a charged or neutral lepton, with branching fractions β and $(1-\beta)$, respectively. In the following, only scalar leptoquarks are considered.

At the Tevatron, leptoquarks can be pair produced by the strong interaction, $p\bar{p} \to LQ\overline{LQ}$. Depending on the way they decay, the final state is $\ell^+\ell^- q\bar{q}$, $\ell\nu q\bar{q}$, or $\nu\bar{\nu}q\bar{q}$, with respective branching fractions β^2, $2\beta(1-\beta)$, or $(1-\beta)^2$. Searches were recently performed by DØ for leptoquarks of all three generations. The search for first generation leptoquarks was performed in the $e^+e^-q\bar{q}$ channel, from which a mass lower limit of 299 GeV was derived for $\beta = 1$ [23]. The search for third generation leptoquarks was performed in the $\tau^+\tau^-b\bar{b}$ channel, with one τ decaying as $\tau \to \mu\nu\nu$, and the other as $\tau \to$ hadron(s)$+\nu$. A mass lower limit of 210 GeV was obtained for $\beta = 1$ [24]. The

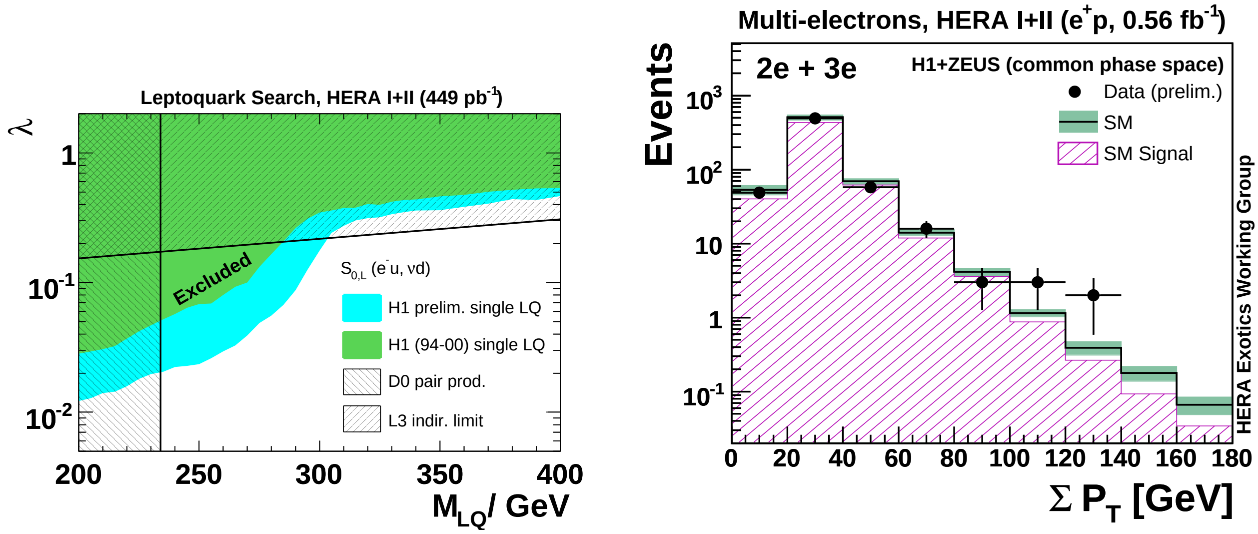

Figure 8: Left: Domain excluded in the (m_{LQ}, λ) plane by the H1 search for first generation leptoquarks with $\beta = 0.5$ [28]. Right: Distribution of the scalar sum of the transverse momenta of the electrons in the two and three-electron final states in e^+p collisions at HERA (combined H1 and ZEUS result) [31].

search for second generation leptoquarks was performed in both the $\mu^+\mu^- q\bar{q}$ and $\mu\nu q\bar{q}$ channels, thus allowing an exclusion domain to be determined in the (m_{LQ}, β) plane, as shown in Fig. 7-right [25]. For $\beta = 1$, a mass lower limit of 316 GeV was obtained. All these searches were performed in a data sample of 1 fb^{-1}. A search for acoplanar jets, relevant for $\beta = 0$, was performed in 2.5 fb^{-1} [26]. It is similar to the search for squarks reported earlier in this review, and allowed first and second-generation leptoquarks to be excluded with masses below 214 GeV for $\beta = 0$. The contribution of this search at low β is shown in Fig. 7-right. A tighter limit of 229 GeV was obtained previously for third generation leptoquarks decaying into $\nu\bar{\nu}b\bar{b}$, in which case heavy flavor tagging increases the sensitivity [27].

First generation leptoquarks can also be resonantly produced in ep collisions at HERA, $eq \to LQ$. The production cross section is however dependent on the a priori unknown $eqLQ$ coupling λ, so that the resulting mass limit depends on the value of λ. Searches were performed by H1 [28] in the eq and νq final states in 0.45 fb^{-1}. The excluded domain obtained for $\beta = 1$ is almost entirely covered by the search for first generation leptoquarks reported above, and by the indirect limits from LEP. For $\beta = 0.5$, however, a substantial domain is excluded only by the H1 analysis, as shown in Fig. 8-left.

5. SEARCHES FOR THE UNEXPECTED

Up to here, the searches reported were all motivated by some theoretical model. It is also possible to look for deviations from the standard model, without any specific a priori motivation.

5.1. Anomalies at HERA

In the HERA I data taking period, the H1 collaboration observed an excess of events with an isolated lepton, missing transverse energy, and a high p_T hadronic jet, in e^+p collisions only. The SM process leading to this topology is the photoproduction of a W boson, $\gamma q \to q'W$, with $W \to \ell\nu$. The full HERA I+II statistics was reanalysed by both H1 and ZEUS, with similar selection criteria [29]. For $p_T > 25$ GeV, an excess is still observed by H1 in their e^+p data, 17 events for 7.1 ± 0.9 expected, while ZEUS selects six events for 7.5 ± 1.1 expected. The significance of the excess in the combination of the two experiments, 23 events vs. 14.6 ± 1.9 expected, is only at the level of 1.8σ.

An excess was also observed by H1 in the topology with two or three high p_T leptons. The SM process leading to this final state is the two-photon interaction $\gamma\gamma \to \ell^+\ell^-$, with possibly in addition the beam electron deflected at large angle. In their full HERA I+II e^+p dataset, five events were observed by H1 with two or three electrons or muons and with a sum of lepton transverse momenta larger than 100 GeV, while only 0.96 ± 0.12 were expected [30]. No such excess was seen in the e^-p data. The H1 and ZEUS collaborations agreed on a common selection to combine their results in the multilectron channel [31]. For Σp_T(leptons)$>$ 100 GeV, they observe five events in e^+p collisions, for 1.8 ± 0.2 expected (Fig. 8-right). In e^-p collisions, one event is selected, in agreement with the 1.2 ± 0.1 expected. The full combination, including final states with muons, is currently underway.

5.2. Global, model-independent analysis

In a model-independent approach all events are categorized in terms of their content in high p_T objects: electrons, muons, τ leptons, photons, jets, b jets, and neutrinos, i.e. $\not{E}_T$. A comparison is then performed between the numbers of events in each class and the expectations from all SM processes. Such an approach was pioneered by H1 at HERA I, who repeated their analysis with the HERA II dataset. Excellent agreement was observed, except for the known excess in the $\mu\nu$+jet final state in e^+p collisions [32].

The CDF collaboration considered 399 final states in a 2 fb^{-1} data sample. After adjusting a few normalization and correction factors, no significant anomaly was uncovered. A total of 19650 kinematic distributions was next analysed using the VISTA package, of which a few hundred were found to be discrepant with respect to their SM expectation. All these discrepancies could however be traced to an inadequate modeling of soft QCD effects in the simulation, and none was found to be suggestive of any new physics. They next proceeded to investigate, with the SLEUTH algorithm, more specifically the high p_T tails, where new physics is expected to be more likely to show up. They also performed a search for mass bumps. Taking into account the trial factor, no excess was found beyond what is expected from statistics [33]. A similar investigation was performed by H1, reaching the same conclusion [32].

Although the sensitivity of such a model-independent approach does not compete with that of dedicated searches, it is important to make sure that no stone was left unturned, in case the right new physics model has not yet been considered...

6. FINAL REMARKS

One year after the end of the HERA II run, the H1 and ZEUS collaborations are delivering their final results, including combinations corresponding to an integrated luminosity of almost 1 fb^{-1}. A couple of intriguing anomalies in the H1 e^+p data will most likely remain with us in the foreseeable future.

Broad searches for phenomena beyond the standard model are being pursued by the CDF and DØ collaborations at the Tevatron, with steadily increasing integrated luminosities. Currently, results are reported by the individual experiments with data samples corresponding to up to 2.5 fb^{-1}. Unfortunately, no sign of new physics has been uncovered until now. With 4 fb^{-1} on tape per experiment, it is time to update the existing searches, and to reach a sensitivity corresponding to 8 fb^{-1} by combining the CDF and DØ results. And with the LHC imminent start-up, time is running short for the Tevatron collaborations...

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