Nuclear Physics B246 (1984) 189–202

SUPERSYMMETRIC PARTICLES AT THE CERN $p\bar{p}$ COLLIDER

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Received 28 May 1984

We explore the experimental missing p_T signatures for squark $\tilde{q}$ and gluino $\tilde{g}$ production at the CERN $p\bar{p}$ collider We present topological cross sections for $\tilde{g}\tilde{g}(\tilde{q}\bar{\tilde{q}})$ production followed by $\tilde{g} \to q\bar{q}\tilde{\gamma}$ ($\tilde{q} \to q\tilde{\gamma}$) decay, applying criteria for the jet trigger and specification modelled on those used by UA1 Gluinos or squarks with masses less than about 40 GeV give events with missing p_T, predominantly one-jet events, fewer two- and multi-jet events We use the observed monojet events as an upper limit implying $m_{\tilde{g}}$ ($m_{\tilde{q}}$) $\gtrsim$ 40 GeV The observed one- and multi-jet events could be due to the production of $\tilde{g}\tilde{g}$ or $\tilde{q}\bar{\tilde{q}}$ with $m_{\tilde{g}}$ or $m_{\tilde{q}} = O(40)$ GeV The small invariant masses of the observed monojets and their hard missing p_T spectrum favour a $\tilde{q}$ interpretation Predictions are presented for $m_{\tilde{g}}$ or $m_{\tilde{q}}$ up to 60 GeV, which could be detectable in forthcoming data from the CERN $p\bar{p}$ collider

1. Introduction

There is currently great interest in phenomenological supersymmetric models which are designed to stabilize the weak interaction scale, and hence predict the existence of supersymmetric partners of the known particles with masses less than about 1 TeV [1]. In most supersymmetric models there is an exactly conserved quantum number called R-parity, which is $+1$ for all sparticles and -1 for all known particles. Conservation of R-parity implies that sparticles must be pair-produced in ordinary particle collisions, that there must be another sparticle among the decay products of any sparticles and hence that the lightest sparticle is absolutely stable. Cosmology suggests that this lightest, stable sparticle is colourless and neutral, with the most likely candidate being the photino $\tilde{\gamma}$ [2]. Therefore a signature for sparticle production in hadron–hadron collisions would be missing energy momentum carried away by weakly interacting photinos. Much experimental effort is now being devoted to searches [3, 4] for such an event signature, and this paper is a phenomenological study of the rates, missing transverse energy p_T^{miss} signature and event topologies to be expected for gluinos $\tilde{g}$ and squarks $\tilde{q}$ pair-produced at the CERN $p\bar{p}$ collider.

Before the collider, the best lower limit on the gluino mass was from beam dump experiments, and was about 3 GeV, depending sensitively on the assumed mass of the squark [5]. The best lower limit on the squark mass was O(20) GeV from e^+e^- experiments [6]. Calculations [7] of the cross sections for $\tilde{g}\tilde{g}$ and $\tilde{q}\tilde{q}$ production at $\sqrt{s} = 540$ GeV suggest that gluinos or squarks with masses less than about 40 GeV could be detectable with the integrated luminosity presently available at the CERN $p\bar{p}$ collider. The UA1 collaboration has reported [4] on a search for events with a large p_T^{miss} signature, finding 5 interesting one-jet events, 1 interesting "photon" event and 1 interesting multi-jet event. The relatively small number of events with large p_T^{miss} could be used to exclude the existence of light gluinos and squarks. It is even possible to interpret the few observed events as sparticle production.

In a previous paper [8] we have investigated quantitatively $\tilde{g}\tilde{g}$ production at $\sqrt{s} = 540$ GeV computing rates, the p_T^{miss} signature assuming $\tilde{g} \to q + \bar{q} + \tilde{\gamma}$ decay, and topological cross sections. We made trigger cuts analogous to those used by UA1, and defined jets in a similar way. We found that gluinos with masses less than about 40 GeV gave predominantly one-jet events, with two- and multi-jet cross sections rather smaller. The UA1 collaboration [4] has used their events and our results to suggest that $m_{\tilde{g}} \gtrsim 40$ GeV [9]. In the second section of this paper we refine our previous analysis, incorporating a closer approximation to the jet trigger conditions used by UA1 and making conservative perturbative QCD calculations of the $\tilde{g}\tilde{g}$ production cross section. In addition to refined versions of the topological cross sections presented earlier, we also compare our calculations in detail with the one- and two- or multi-jet events observed [4] by UA1. We confirm the previous analysis [4, 8] that gluinos with masses less than about 40 GeV seem to be excluded by the UA1 data. We also discuss the possibility that the observed events with large p_T^{miss} are actually due to gluinos with masses O(40) GeV.

In sect. 3 we extend our previous analysis to include $\tilde{q}\bar{\tilde{q}}$ production. Since we infer from sect. 2 that $m_{\tilde{g}} \gtrsim$ O(40) GeV, we assume that squarks with masses less than 40 GeV decay as $\tilde{q} \to q + \tilde{\gamma}$, rather than as $\tilde{q} \to q + \tilde{g}$ which would have been dominant if it were kinematically accessible. Motivated by many models [1], we assume that 5 flavours of squark (u, d, c, s and b) are almost degenerate in mass, and calculate the total cross section for producing all of them. The two-body decay $\tilde{q} \to q + \tilde{\gamma}$ provides a clean p_T^{miss} signature, and we calculate the topological cross sections for one- and two-jet events with large p_T^{miss}, adopting the same cuts modelled on UA1 triggering and jet definition. We also compare our $\tilde{q}\bar{\tilde{q}}$ calculations in detail with the observed [4] one- and two- or multi-jet events. Again we find that squarks with masses less than about 40 GeV seem to be excluded by the UA1 data. The observed events with large p_T^{miss} are however compatible with squarks of mass O(40) GeV.

Although the present data are compatible with gluinos or squarks weighing O(40) GeV, it is not possible to confirm or refute any such interpretation until more events are available. There are however some slight indications which disfavour the gluino interpretation by comparison with the squark interpretation. One is that the observed [4] monojet events seem to contain thin jets with masses $\lesssim O(5)$ GeV. This is compatible with what one might expect from $\tilde{q} \to q + \tilde{\gamma}$ decay:

$$m(\text{q jet}) = O\left(\frac{\alpha_s}{\pi}\right) \times m_{\tilde{q}} = O\left(\tfrac{1}{10} m_{\tilde{q}}\right), \tag{1}$$

but smaller than expected from $\tilde{g} \to q + \bar{q} + \tilde{\gamma}$ decay: if a $q + \bar{q}$ jet pair are coalesced

$$m(q + \bar{q}\ \text{jets}) = O\left(\tfrac{1}{2} m_{\tilde{g}}\right). \tag{2}$$

One of the most dramatic monojet events has an associated muon [4]. If this is a genuine prompt decay muon, it could come from the decay of a heavy quark (c or b) produced either in

$$\tilde{g} \to (c + \bar{c} \quad \text{or} \quad b + \bar{b}) + \tilde{\gamma}, \tag{3a}$$

or in the corresponding squark decay:

$$(\tilde{c} \text{ or } \tilde{b}) \to (c \text{ or } b) + \tilde{\gamma}, \qquad (c \text{ or } b) \to \mu + X. \tag{3b}$$

Squarks give a harder p_T^{miss} spectrum which may be favoured by the data, although the effect is probably not yet statistically significant. We look forward to the light that may be cast on the nature of p_T^{miss} events and their interpretation by forthcoming data from the CERN $p\bar{p}$ collider.

2. Gluino signatures

In this section we refine our previous estimates of topological cross sections for one-, two-, three- and four-jet cross sections from $\tilde{g}\tilde{g}$ production, and make a detailed comparison with the events observed [4] by UA1. There are three essential theoretical ingredients in our calculations:

(i) differential cross sections for the QCD subprocesses $gg \to \tilde{g}\tilde{g}$ and $q\bar{q} \to \tilde{g}\tilde{g}$, which we take from ref. [7];

(ii) parton structure functions in the proton, which we take from the CDHS parametrization evolved using the Altarelli-Parisi equations as described in ref. [10];

(iii) final state distributions for $\tilde{g} \to q + \bar{q} + \tilde{\gamma}$ decay which we compute using a decay matrix element squared:

$$|M|^2 \propto (p_{\tilde{g}} \cdot p_{\bar{q}})(p_{\tilde{\gamma}} \cdot p_q) + (p_{\bar{q}} \cdot p_{\tilde{\gamma}})(p_{\tilde{g}} \cdot p_q), \tag{4}$$

although our results are largely insensitive to this assumption, phase-space decay giving similar results. In evaluating the perturbative QCD cross sections for $\tilde{g}\tilde{g}$ production we assume that $m_{\tilde{g}} = m_{\tilde{q}}$. This is a conservative assumption since another possibility, $m_{\tilde{q}} \gg m_{\tilde{g}}$ leads to higher cross sections due to negative interference between the squark and gluon exchange diagrams. When convoluting (i) and (ii) we take $\Lambda_{QCD} = 0.5$ GeV and assume conservatively that the appropriate momentum scale is

$$Q^2_{eff} = \tfrac{1}{2}\hat{s} = \tfrac{1}{2}(p_{\tilde{g}_1} + p_{\tilde{g}_2})^2 . \tag{5}$$

This is considerably larger than the $Q^2_{eff} = \frac{1}{2}p^2_T$ which reproduces [10] the correct shape for conventional large-p_T jet production, and larger values of Q^2_{eff} lead to smaller perturbative cross sections for $\tilde{g}\tilde{g}$ production. Moreover, it is well known that conventional perturbative QCD calculations of large-p_T jets are a factor $K = O(2)$ lower than the observed cross sections [11]. We have not multiplied our sparticle cross sections by a corresponding fudge factor. In evaluating the decay distributions we have assumed that each gluino jet fragments into a gluino hadron which carries essentially all the jet energy – this seems reasonable for $m_{\tilde{g}} \gtrsim O(5)$ GeV, given the available data on b quark → B hadron fragmentation – and we have neglected the masses of the final state quarks and photino. Most models [1] expect $m_{\tilde{\gamma}} \ll m_{\tilde{g}}$, with the ratio often being

$$\frac{m_{\tilde{\gamma}}}{m_{\tilde{g}}} = \frac{3}{8}\frac{\alpha_{em}}{\alpha_s \sin^2\theta_W} , \tag{6}$$

which is $O(\frac{1}{10})$, so neglecting the photino mass is probably reasonable

Naive perturbative QCD calculations give $\tilde{g}\tilde{g}$ production cross sections which are large enough for $m_{\tilde{g}} \lesssim 40$ GeV to be detectable in principle using the present CERN $p\bar{p}$ collider integrated luminosity of about 100 nb^{-1}. However, the theoretical cross sections can be drastically reduced by experimental cuts. In this section we calculate cross sections with cuts modelled [8] on those used [4] by UA1. They consider events with $p_T^{miss} > 15$ GeV or

$$p_T^{miss} > 4\sigma , \qquad \sigma \equiv 0.7\sqrt{\sum_{event} E_T} , \tag{7}$$

whichever is the larger. The expression in eq. (7) is the calorimeter resolution [12] which depends on the total E_T in the event. We model this by

$$\sum_{event} E_T = \sum_{partons} E_T + 20\ \text{GeV} , \tag{8}$$

thereby making an allowance for the minimum bias background to the large p_T q and $\bar{q}$ partons coming from $\tilde{g}$ decay. The UA1 jet algorithm fuses together in a single jet of particles which have

$$(\Delta\phi^2 + \Delta y^2)^{1/2} \leqslant 1 , \tag{9}$$

and we make a similar ansatz: all q or $\tilde{q}$ partons from $\tilde{g}$ decay which have a small angular separation (9) are coalesced into a single jet Moreover, the UA1 jet algorithm [4, 12] is not efficient when the jet p_T is less than 10 GeV, and we discard all coalesced parton jets which fall below this threshold. The effect of these two procedures is to shift $\tilde{g}\tilde{g}$ events from the naively expected 4-jet event topology due to $(\tilde{g} \to q + \bar{q} + \tilde{\gamma})(\tilde{g} \to q + \bar{q} + \tilde{\gamma})$ down into 3-, 2- or even 1-jet event topologies. Finally, during their 1983 run the UA1 collaboration used a large E_T jet trigger with a nominal threshold which was increased in steps from 5 to 20 to 25 GeV in the course of the run. Whatever the nominal threshold, the trigger efficiency is not a simple step function but varies smoothly between 0 and 100% as the jet E_T is increased. We have modelled the UA1 jet trigger by weighting $\tilde{g}\tilde{g}$ events with an experimentally determined function parametrizing the turn-on of the jet trigger efficiency at each nominal E_T trigger setting, weighted in turn by the fraction of the total integrated luminosity accumulated at each nominal trigger setting [13]. This is a refinement of our previous analysis in which we presented [8] topological cross sections for representative step function thresholds at 20 and 30 GeV.

Fig. 1 shows the topological cross sections for 1-, 2-, 3- and 4-jet events as functions of the gluino mass, using the definitions and cuts specified in the previous paragraph. The cross sections are detectable with the present data if $m_{\tilde{g}} \lesssim O(40)$

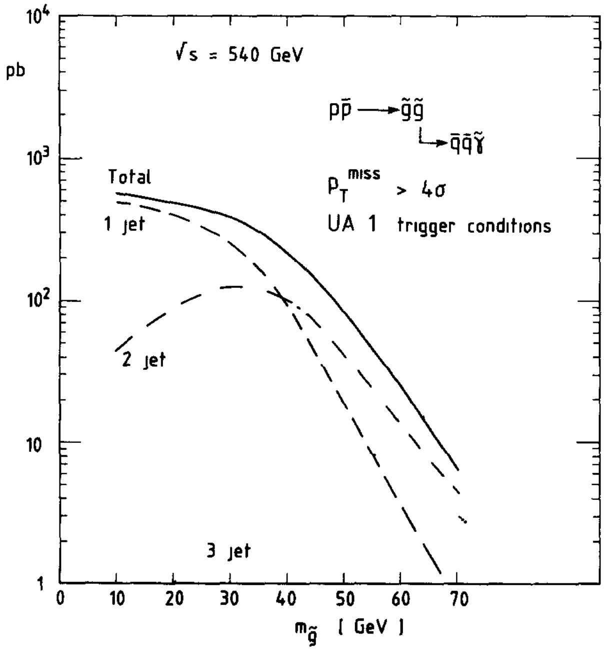

Fig 1 The total and topological cross sections for $\tilde{g}\tilde{g}$ production followed by $\tilde{g} \to q\bar{q}\tilde{\gamma}$ decay giving one-, two- and three-jet final states with $p_T^{miss} > 4$, fullfilling the UA1 trigger requirements described in the text Jets with $[(\Delta\phi)^2 + \Delta y^2]^{1/2} < 1$ have been coalesced and jets with $p_T < 10$ GeV have been discarded

GeV. We see that if $m_{\tilde{g}} \lesssim 40$ GeV one expects the majority of $\tilde{g}\tilde{g}$ production to produce 1-jet final states, whereas 2-jet final states take over above 40 GeV. Events with 3-jet topologies are quite suppressed, while the rate of 4-jet events is negligible The dominance of topologies with a low number of jets is a direct result of the UA1 experimental cuts and definitions which we model. Almost all the produced jets would have rapidities $|y| < 2.5$ and hence fall within the UA1 angular acceptance. One word of caution is in order: we do not include the effects of QCD radiative corrections, and phenomena such as gluon bremsstrahlung may provide an extra jet in O(20%) of the events, though they should not affect the missing p_T event signature.

We deduce from fig. 1 that the UA1 collaboration should have seen O(10) or more $\tilde{g}\tilde{g}$ events if $m_{\tilde{g}} \lesssim 40$ GeV. Perturbative QCD calculations of the cross section and the assumption that all the energy of a gluino jet is carried by the hadron containing the gluino may be bad approximations for $m_{\tilde{g}} < 10$ GeV. Nevertheless, we believe that the cross sections for monojet events due to gluinos weighing less than 10 GeV are likely to be at least as high as those for $m_{\tilde{g}} = 10$ GeV shown in fig. 1. Therefore we do not believe there is any "window of opportunity" for a light gluino between our calculations and the previous beam dump limits [5], though this possibility merits further study. Using the observed events with large p_T^{miss} as an upper limit UA1 has inferred [4] a lower limit of O(40) GeV on the gluino mass. To confirm this limit, we look in more detail at the observed 1-jet events (fig. 2) and 2- or multi-jet events (fig. 3) compared with our calculations of the rates and p_T^{miss} spectra for

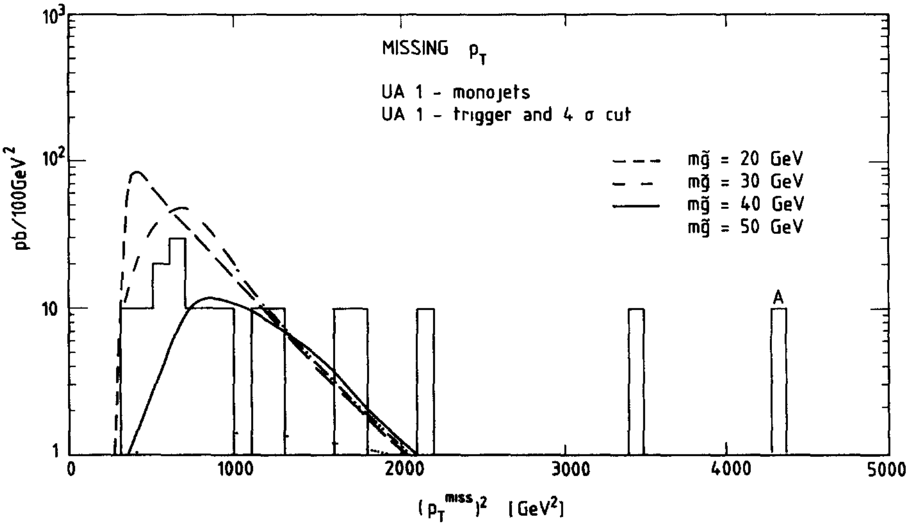

Fig 2 Comparison of the observed p_T^{miss} distribution for the one-jet events taken from fig 2b of ref [4] with expectations from $\tilde{g}\tilde{g}$ production obtained in the way described in the caption to fig 1 Note the events below 1000 GeV^2 are compatible with the estimated background [4]

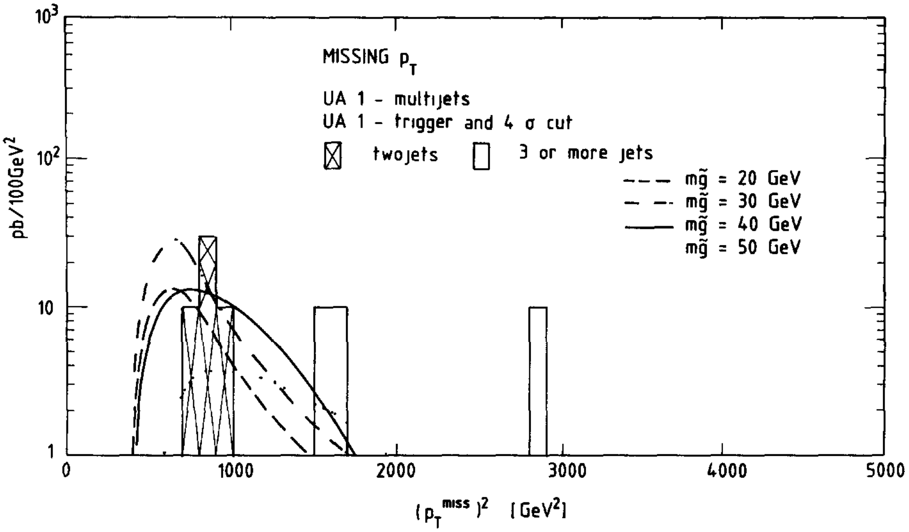

Fig 3 The same comparison as in fig 2, but for events of the multi-jet type

different gluino masses. The events with $(p_T^{miss})^2 < 1000$ GeV^2 in figs. 2 and 3 are probably [4] mainly background, due for example to jet energy fluctuations in the calorimeter. From $m_{\tilde{g}} = 20(30)$ GeV we would have expected 29(15) events to be compared with 0 ± 3 observed in this region after subtraction of the estimated background.

We therefore conclude that $m_{\tilde{g}} \gtrsim O(40)$ GeV. Looking at the 7 events in fig. 2 with $(p_T^{miss})^2 > 1000$ GeV^2, we see that a gluino of mass 40 GeV would reproduce qualitatively the total event rate, whereas a gluino of mass 50 GeV would give too few events. There are however two qualifications to these remarks. One is that the spectrum in $(p_T^{miss})^2$ of the observed events looks harder than the 40 GeV gluino curve, though this discrepancy would be reduced if one reduced the nominal measured momentum of the muon in event A of UA1 by one standard deviation. The second comment is that since we have tried to be conservative in estimating $\tilde{g}\tilde{g}$ production cross sections, the prediction for $m_{\tilde{g}} = 50$ GeV could well be an underestimate by a factor O(2), and the harder p_T^{miss} spectrum associated with a more massive gluino would be welcome. We see from fig. 2 that while $m_{\tilde{g}} \lesssim 40$ GeV is excluded by the UA1 monojet data [4], a gluino of mass 40 to 45 GeV would be compatible with them. Quantitatively, in the region $(p_T^{miss})^2 > 1600$ GeV^2 where UA1 have quoted a heavy quark background of 0.1 event, our calculations for $m_{\tilde{g}} = 40$ GeV yield 1.2 events, with the above-mentioned possibility of augmentation. The multi-jet data shown in fig. 3 neither add nor subtract from these observations. The observed 2-jet events are compatible [4] with jet fluctuation background, but cannot be used to exclude reliably any range of gluino masses. The dramatic 3-jet event at $(p_T^{miss})^2 \approx 2800\ \mathrm{GeV}^2$ is not very probable in $\tilde{g}\tilde{g}$ production, but the existence of such events cannot be excluded, particularly if one takes into account gluon bremsstrahlung.

We conclude that the UA1 data on events with large p_T^{miss} are incompatible with $m_{\tilde{g}} < 40$ GeV, but compatible with $m_{\tilde{g}} = O(40)$ GeV

3. Squark signatures

In this section we repeat for $\tilde{q}\bar{\tilde{q}}$ production the main elements of our $\tilde{g}\tilde{g}$ analysis. In most models [1] the squarks corresponding to the first five quark flavours tend to be almost degenerate:

$$m_{\tilde{q}} = \tilde{m} \pm O(m_q), \tag{10}$$

for q = u, d, c, s, b, where $\tilde{m}$ is an undetermined supersymmetric breaking mass scale. Therefore we include in our $\tilde{q}\bar{\tilde{q}}$ calculations five flavours of squark. The other perturbative QCD assumptions that we make in calculating the cross sections are similar to those used in sect. 2, and hence relatively conservative. We know from the previous analysis that $m_{\tilde{g}} \gtrsim 40$ GeV, and therefore assume that any squark with mass less than 40 GeV will have $\tilde{q} \to q + \tilde{\gamma}$ as its dominant decay mode, the otherwise favoured $\tilde{q} \to q + \tilde{g}$ decay being kinematically excluded. In calculating the $\tilde{q}\bar{\tilde{q}}$ cross sections we assume conservatively that $m_{\tilde{g}} \gg m_{\tilde{q}}$ so as to minimize the cross sections. If indeed $m_{\tilde{g}} \gg m_{\tilde{q}}$, formula (6) raises the possibility that $m_{\tilde{\gamma}}$ may not be negligible compared to $m_{\tilde{q}}$. Therefore we have computed p_T^{miss} signatures, etc. with $m_{\tilde{\gamma}} = \frac{1}{2} m_{\tilde{q}}$ as well as $m_{\tilde{\gamma}} = 0$. There are no qualitative differences and small quantitative differences between the two sets of calculations, so we present results for $m_{\tilde{\gamma}} = 0$ only. We use the same UA1-inspired algorithms for computing interesting values of p_T^{miss} (7, 8), for coalescing jets (9) and for the jet trigger efficiency [13] as we used in sect. 2.

Fig. 4 shows the topological cross sections for 1- and 2-jet events from $\tilde{q}\bar{\tilde{q}}$ production followed by $\tilde{q} \to q + \tilde{\gamma}$ decay, as functions of the squark mass. Again we see that the total cross section is observable if $m_{\tilde{q}} \lesssim O(40)$ GeV, and that 1-jet event topologies dominate in this range, while 2-jet events have comparable rates if $m_{\tilde{q}} \lesssim O(40)$ GeV. We note again that gluon bremsstrahlung could give extra jets in some fraction of the events.

We deduce from fig. 4 that UA1 should have seen O(10) or more $\tilde{q}\bar{\tilde{q}}$ events if $m_{\tilde{q}} \lesssim 40$ GeV. To see in more detail whether the observed events [4] with large p_T^{miss} can be used to exclude $m_{\tilde{q}} < 40$ GeV, let us look at the detailed comparisons between predicted rates and observed events in figs. 5 and 6 As was the case with gluinos in fig. 2 the small number of monojets with $(p_T^{miss})^2 > 1000\ \mathrm{GeV}^2$ in fig. 5 tells us that $m_q \lesssim 40$ GeV can be excluded, since from $m_{\tilde{q}} = 20(30)$ GeV we would have expected 40(22) events to be compared with the observed 0 ± 3. On the other

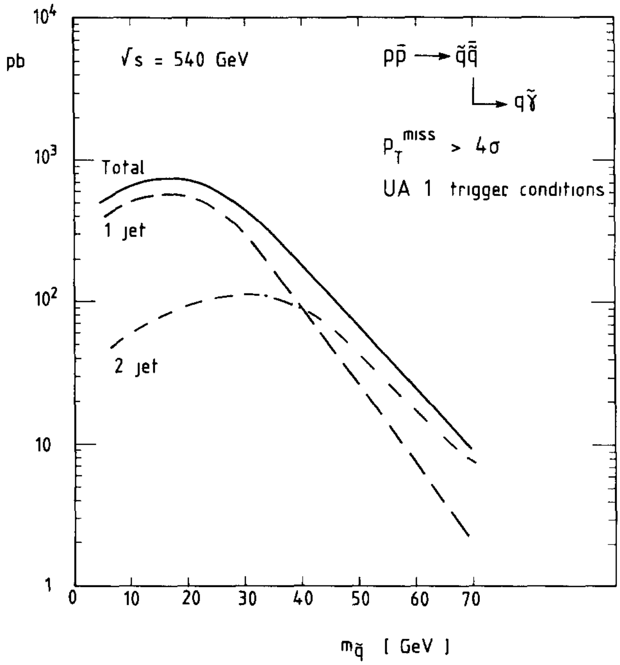

Fig 4 The total and topological cross section for $\tilde{q}\bar{\tilde{q}}$ production followed by $\tilde{q} \to q\tilde{\gamma}$ decay giving one- or two-jet final states with $p_T^{miss} > 4\sigma$, and fulfilling the UA1 trigger conditions as in fig 1

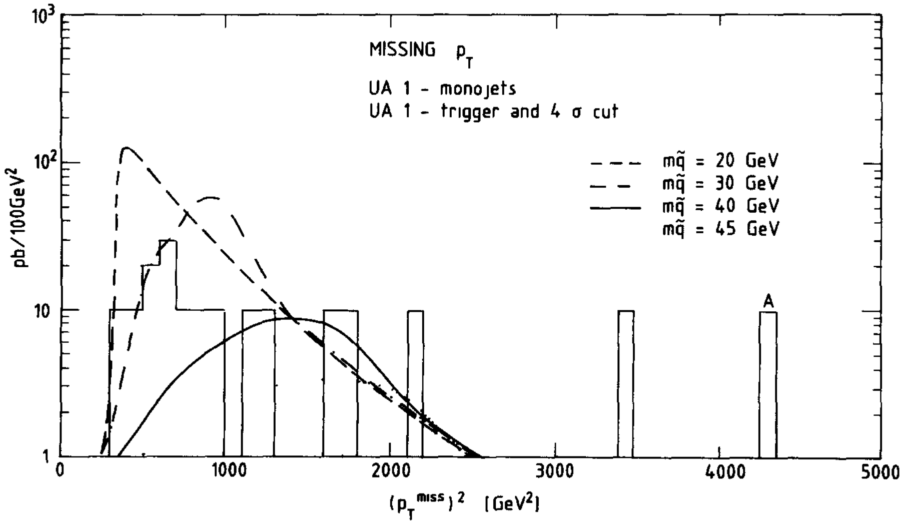

Fig 5 Comparison of the observed p_T^{miss} distribution for the one-jet events taken from fig 2b of ref [4] with expectations from $\tilde{q}\bar{\tilde{q}}$ production Note the events below 1000 GeV^2 are compatible with the estimated background [4]

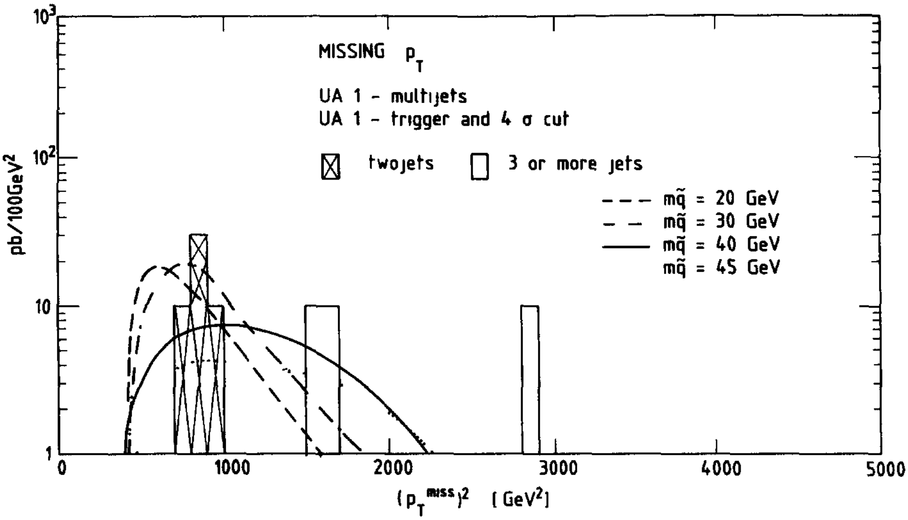

Fig 6 The same comparison as in fig 5, but for events of the multi-jet type

hand, the rate of monojet events with $(p_T^{miss})^2 < 1000$ GeV^2 is compatible with $m_{\tilde{q}} = O(40$ to $45)$ GeV. Comparing figs. 2 and 5 we see that the p_T^{miss} spectrum from $\tilde{q}$ is slightly harder than that from a $\tilde{g}$ of the same mass, an effect which goes in the direction of the data but may not be large enough to be significant. Quantitatively, squarks of mass 40 GeV give 3.3 events with $(p_T^{miss})^2 > 1600$ GeV^2, compared to 1 2 for gluinos of mass 40 GeV, 0.1 events expected from heavy quark background, and 4 events seen. Turning to fig. 6, we see again that the multi-jet events with $(p_T^{miss}) > 1000$ GeV^2 do not by themselves exclude any interesting range of $m_{\tilde{q}}$. If one allows for the possibility of gluon bremsstrahlung, the rate of multi-jet events with $(p_T^{miss})^2 > 1000$ GeV^2 is also compatible with $m_{\tilde{q}} = O(40$ to $45)$ GeV.

We conclude again that the UA1 data on events with large p_T^{miss} are incompatible with $m_{\tilde{q}} < 40$ GeV, but compatible with $m_{\tilde{q}} = O(40)$ GeV.

4. Interpretations and predictions

Are the observed events with large p_T^{miss} due to the production of either $\tilde{g}$ or $\tilde{q}$ with mass O(40) GeV? Both are possible interpretations of the UA1 data, but neither can be confirmed or refuted until more data are accumulated. As was mentioned in the introduction there are indications favouring a $\tilde{q}$ explanation. One is the "smallness" of the observed [4] monojets: typically $m(\text{jet}) \lesssim O(5)$ GeV, to be compared with the $O((\alpha_s/\pi) m_{\tilde{q}}) = O(5)$ GeV (1) expected from $\tilde{q} \to q + \tilde{\gamma}$ decay. We expect larger values from $\tilde{g} \to q + \bar{q} + \tilde{\gamma}$ decay since in most monojet events more than one parton is coalesced, and the invariant mass of the jet has the order of magnitude (2). The muon in monojet event A of the UA1 collaboration could be due either to

$\tilde{g} \to$ heavy $q\bar{q} + \tilde{\gamma}$ or to heavy flavour squark decay (3). Another possible indication in favour of squarks is the fact that they give a slightly harder $(p_T^{miss})^2$ spectrum reflecting the two-body kinematics of $\tilde{q}$ decay: compare figs. 2 and 5 or 3 and 6. However, the differences between these spectra are probably smaller than the statistical errors in the present data.

To proceed further in the elucidation of events with large p_T^{miss} requires more data. The UA1 jet trigger [13] described and modelled in sects. 2 and 3 was not conceived with a search for events with large p_T^{miss} in mind. It may be possible in future runs to trigger directly on p_T^{miss}, selecting interesting events using the criteria (7) and dispensing with the large E_T jet trigger condition. With an eye to this possibility, we present in figs. 7 to 12 calculations with the UA1 jet trigger cut removed. They include topological n-jet cross sections from $\tilde{g}\tilde{g}$ production (fig. 7) and $\tilde{q}\bar{\tilde{q}}$ production (fig. 10), the $(p_T^{miss})^2$ spectrum for $\tilde{g}\tilde{g}$ monojets (fig. 8) and $\tilde{q}\bar{\tilde{q}}$ monojets (fig. 11), and for $\tilde{g}\tilde{g}$ multi-jets (fig. 9) and $\tilde{q}\bar{\tilde{q}}$ multi-jets (fig. 12). We see from these curves that with an order of magnitude increase in integrated luminosity gluinos or squarks with masses up to 60 GeV should be observable.

If either gluinos or squarks have masses O(40) GeV, an order of magnitude increase in statistics should reveal a characteristic p_T^{miss} distribution as a long tail

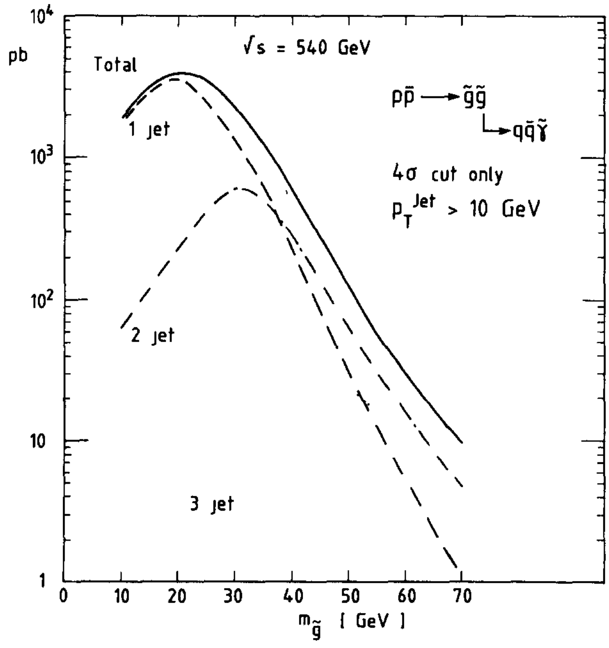

Fig 7 The total and topological cross sections for $\tilde{g}\tilde{g}$ production followed by $\tilde{g} \to q\bar{q}\tilde{\gamma}$ decay giving one-, two-, three-jet final states with $p_T^{miss} > 4\sigma$ The UA1 criteria for jet definition were applied but the UA1 trigger requirements were abandoned

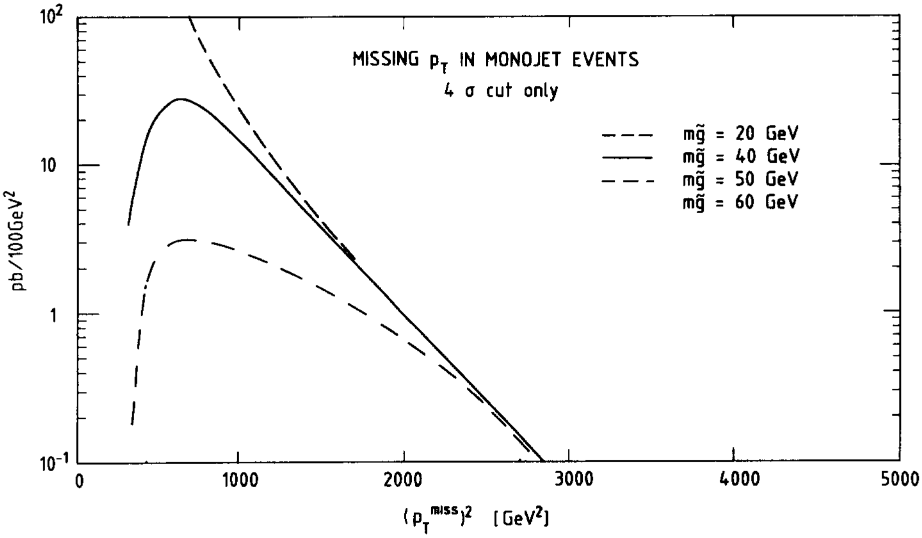

Fig 8 The p_T^{miss} distribution for the one-jet events from $\tilde{g}\tilde{g}$ production evaluated as in fig 7

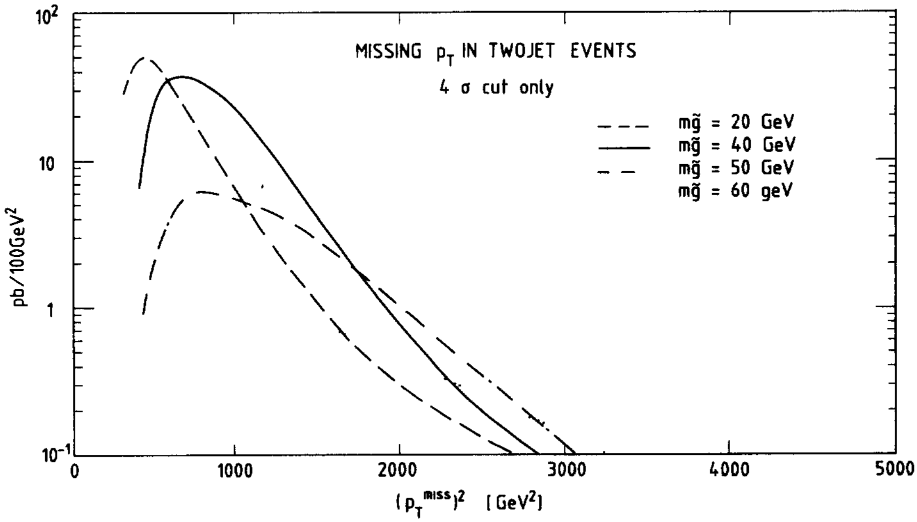

Fig 9 As for fig 8 but for multi-jet events

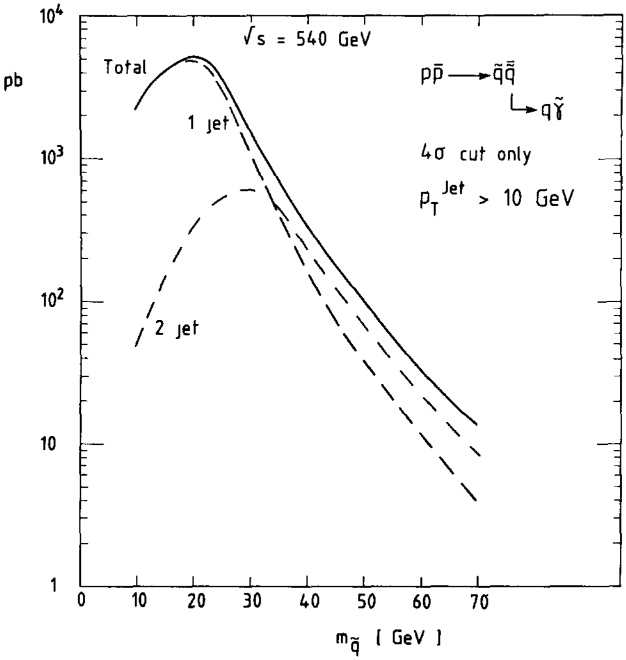

Fig 10 The total and topological cross sections for $\tilde{q}\bar{\tilde{q}}$ production followed by $\tilde{q} \rightarrow q\tilde{\gamma}$ decay giving one- and two-jet final states with $p_T^{miss} > 4\sigma$ The UA1 criteria for jet definitions were applied but the UA1 trigger requirements were abandoned

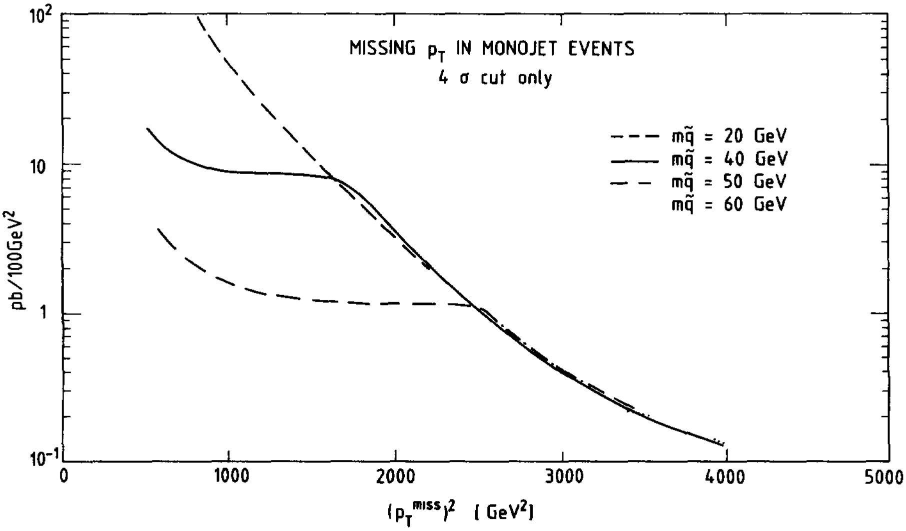

Fig 11 The p_T^{miss} distribution for one-jet events from $\tilde{q}\bar{\tilde{q}}$ production evaluated as in fig 10

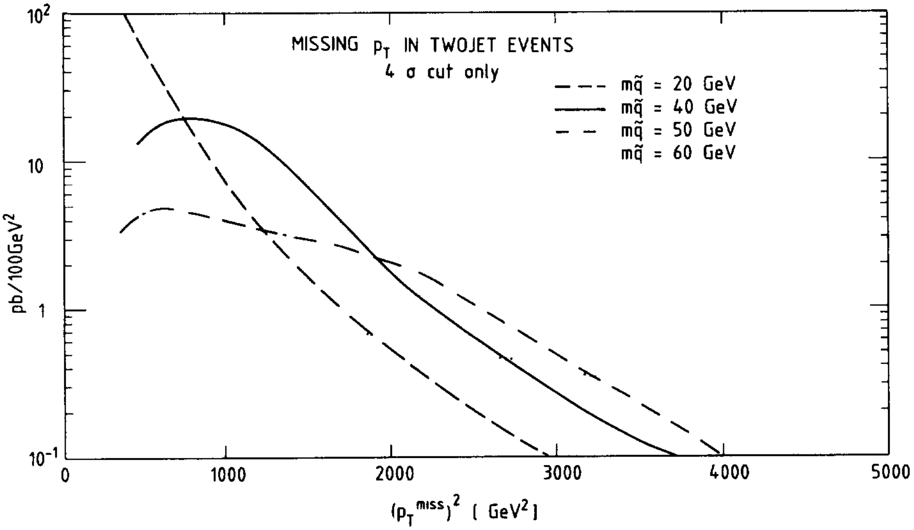

Fig 12 As for fig 11, but for multi-jet events

above the 4σ cut (7). We should soon know whether there are gluinos or squarks in this mass range.

We thank many members of the UA1 collaboration for useful discussions, in particular Michel Della-Negra, Nick Ellis, Witold Kozanecki, Felicitas Pauss, Jean-Pierre Revol, Jim Rohlf, Carlo Rubbia, Jean Sass, Aurore Savoy-Navarro and Charling Tao.

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