experiment observing edges like those of S5 would also find only one region of the $m_{\tilde{\chi}_1^0}$-$m_{\tilde{l}_R}$ plane consistent with the edge positions. Effectively this means that, for S5, the analysis can stop at this point. This is not to say that the smallest possible sparticle mass errors have been achieved yet; the point is only that the probability distribution for reconstructed masses is now approximately gaussian (and centred on the correct values) rather than spread over two disconnected regions. Indeed, it will shortly be seen that further analysis at S5 (using $\Delta M^{\max}$) can in fact produce a valuable new result. Nevertheless, the difference in character between the "single consistent region" of S5 and the "pair of consistent regions" of O1, mean that the way subsequent analysis is *interpreted* will differ in the two cases. It will be possible to make stronger claims when faced with edges like those of S5.

In order to remove the ambiguities associated with the correct evaluation of $m_{\tilde{l}_R} - m_{\tilde{\chi}_1^0}$, it is necessary to introduce the $\Delta M^{\max}$ observable.

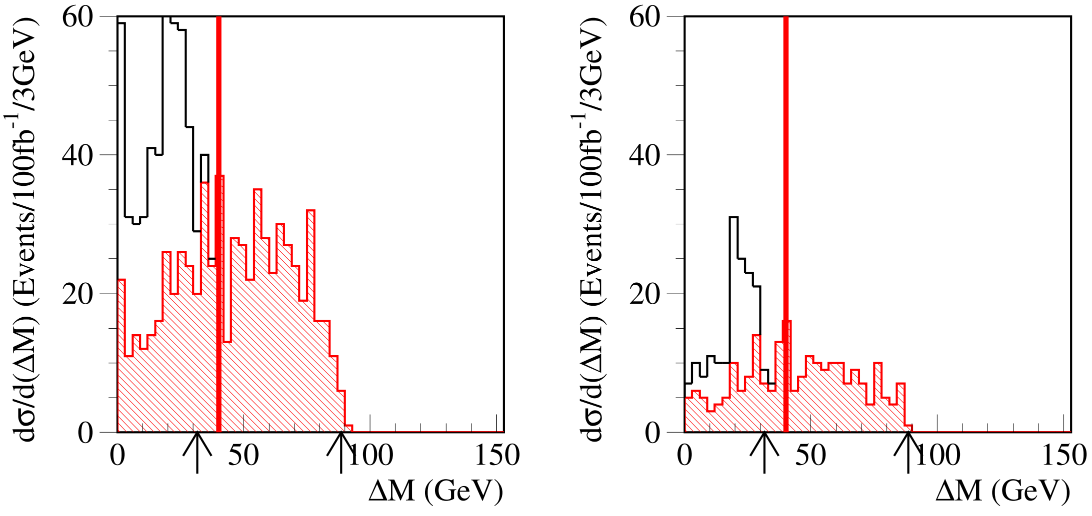
5.14 Reconstruction using $\Delta M^{\max}$

5.15 ΔM edge resolution

XXX FINISH!! XXX

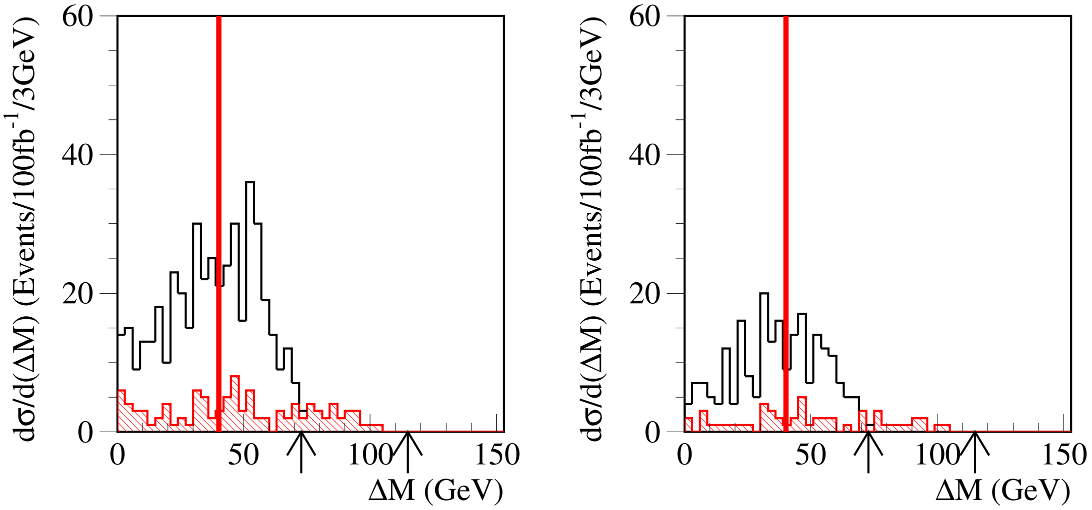
XXX This part should ONLY deal with the resolution of the principal mttwo edge, not with interpretation issues, which come later when mttwo is used to resolve the heavy/light slepton conflict. XXX

Figure 5.11 shows the ΔM distributions obtained at S5 and O1 after applying the cuts listed in Section 5.9.1 to a 100 fb^{-1} sample of signal dislepton events. Events from lighter sleptons ($\tilde{e}_R$ and $\tilde{\mu}_R$) occupy the unhatched region in each plot, while the events



(a) S5, soft cuts

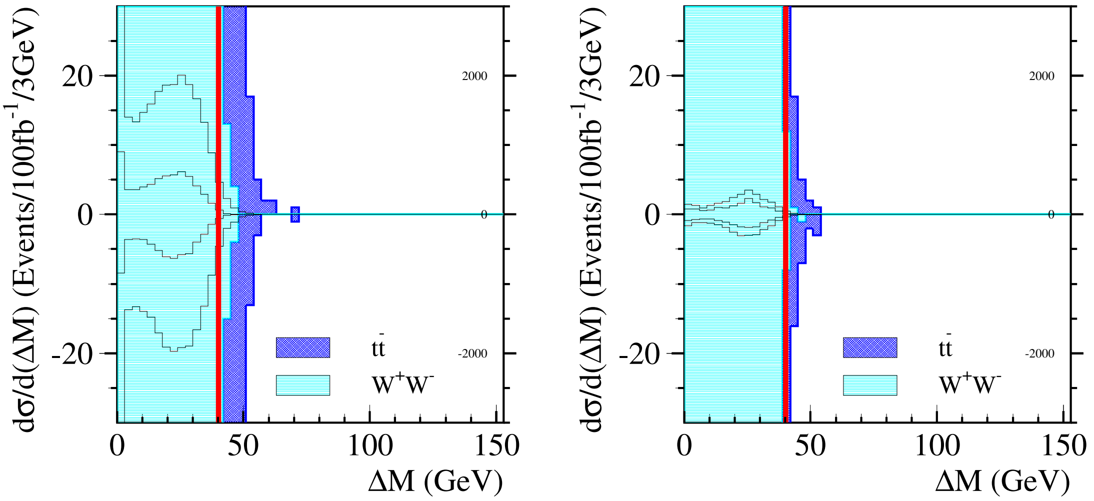
(b) S5, hard cuts



(c) O1, soft cuts

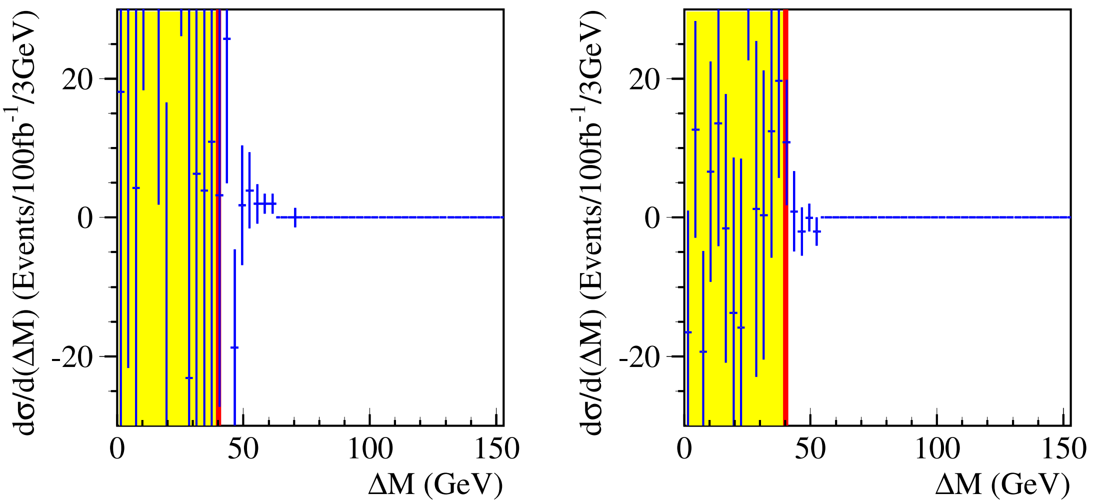
(d) O1, hard cuts

Figure 5.11: *ΔM distributions obtained at S5 and O1 after applying the cuts listed in Section 5.9.1 to a* 100 fb^{-1} *sample of $\tilde{e}_R\bar{\tilde{e}}_R$, $\tilde{\mu}_R\bar{\tilde{\mu}}_R$, $\tilde{e}_L\bar{\tilde{e}}_L$ and $\tilde{\mu}_L\bar{\tilde{\mu}}_L$ dislepton events. Events from light right-sleptons (unhatched) are stacked on top of those from heavier left-sleptons (hatched). Only events from OSSF leptons combinations are shown. The plots are generated without OSDF background subtraction, but were it to be performed, no significant differences would be apparent as only 4 (12) signal events are able to pass OSDF soft cuts at S5 (O1). Arrows indicate the values of $\Delta M^{\max}$ predicted by theory for the two types of slepton in each model. A red vertical line is drawn through each plot at half the W mass.*



(a) SM backgrounds, soft cuts

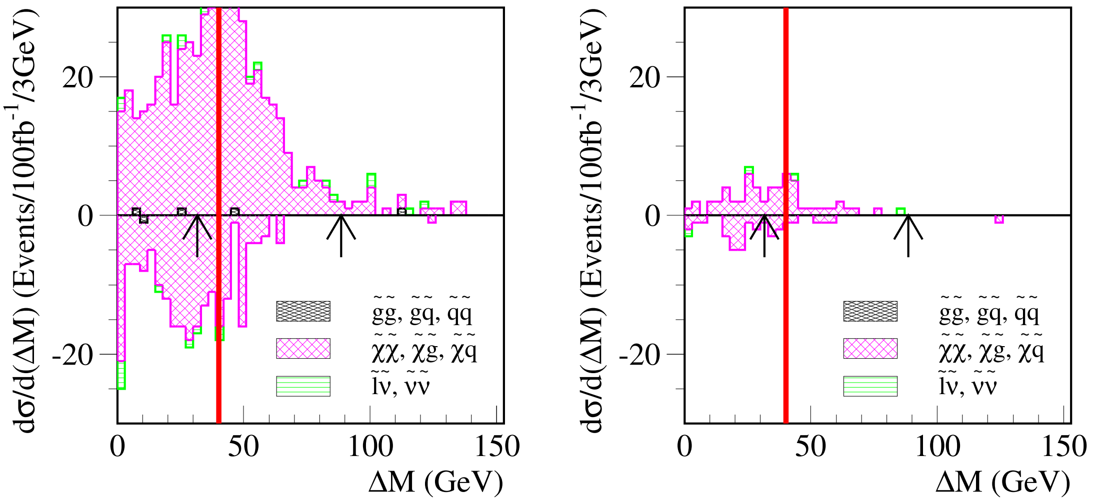
(b) SM backgrounds, hard cuts



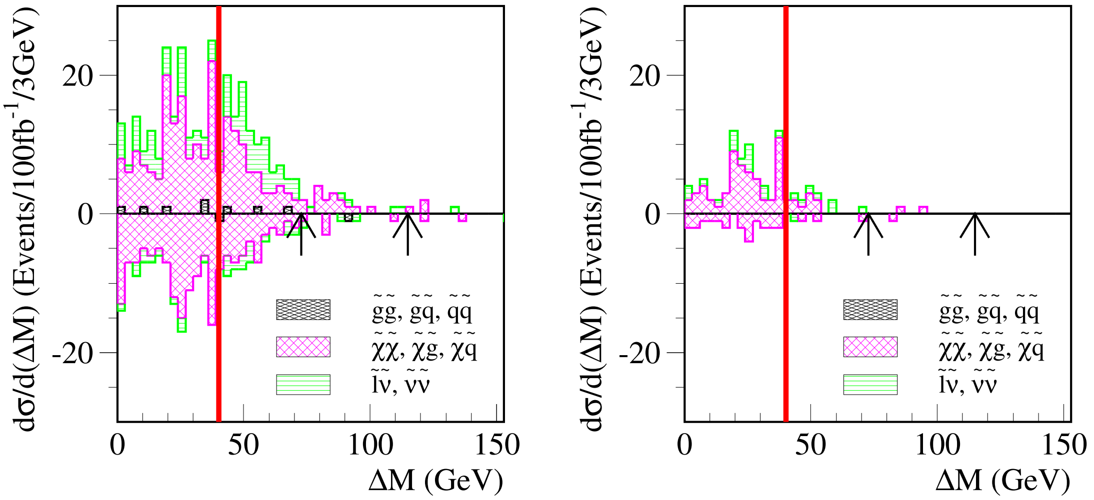
(c) SM (OSSF-OSDF), soft cuts

(d) SM (OSSF-OSDF), hard cuts

Figure 5.12: *SM background to* ΔM *measurement. The plots above show the* ΔM *distributions obtained after cuts from* 100 fb^{-1} *of* W*-pair and* $t\bar{t}$ *background samples. In (a) and (b), events passing the OSSF cuts are stacked with positive weight, while events passing the OSDF cuts are stacked with negative weight. Because number of events passing cuts in (a) and (b) is very large, the outlines of the stacked histograms are overlapped after being downscaled by a factor of 100 (see scales on right hand side of each plot). Plots (c) and (d) show the result of subtracting the OSDF events passing the cuts from the OSSF events passing the cuts. A red vertical line is drawn through each plot at half the* W *mass. Plots (c) and (d) are shaded to the left of this line in order to draw attention to the performance of the background subtraction* above *this point.*

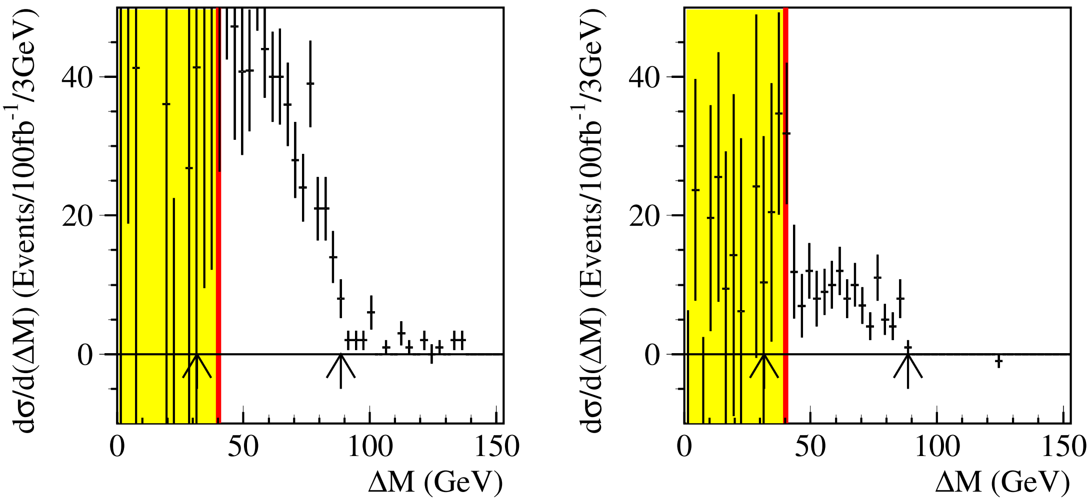


(a) S5, soft cuts (b) S5, hard cuts



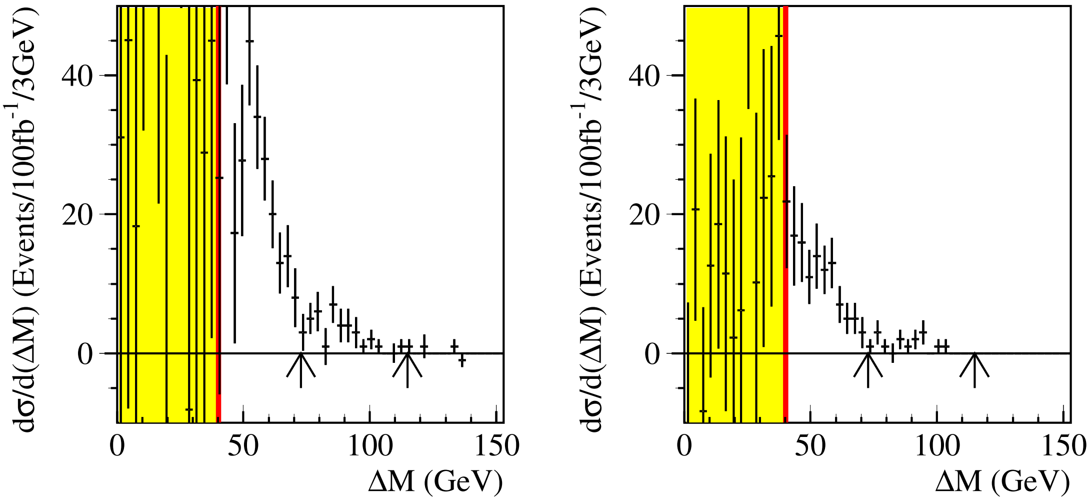
(c) O1, soft cuts (d) O1, hard cuts

Figure 5.13: *ΔM distributions obtained at S5 and O1 after applying the cuts listed in Section 5.9.1 to the remainder of the supersymmetric cross section not generated for Figure 5.11. Events passing the OSSF cuts are stacked by primary parton pair with positive weight, while events passing the OSDF cuts are stacked with negative weight. A red vertical line is drawn through each plot at half the W mass.*



(a) S5, soft cuts

(b) S5, hard cuts



(c) O1, soft cuts

(d) O1, hard cuts

Figure 5.14: *Flavour-subtracted ΔM distributions for combined signal and background at S5 and O1 after applying the cuts listed in Section 5.9.1. A red vertical line is drawn through each plot at half the W mass. Plots are shaded to the left of this line in order to draw attention to the events which reconstruct* above *this point. Compare these plots with those of Figure 5.11 which contain only signal events.*

from heavier left-sleptons are cross hatched. It will be noted that events from both light and heavy sleptons succeed in passing the cuts in both models. In principle, then, there are two edges to be observed in each of the models: one for the lighter slepton and one for the heavier. We note, however, that the slepton masses increase, their production is strongly suppressed, and so there are very few heavy slepton events at O1 where there are in fact none within 10 GeV of the kinematic limit. It is readily observed that at the three remaining edges, where statistics are higher, there is good agreement between the theoretical prediction and the observed endpoint of each distribution.

Looking next at the SM backgrounds in Figure 5.12(a) and Figure 5.12(b) we see that the number of $t\bar{t}$ and W^+W^- events passing the "soft" cuts is about two orders of magnitude larger than the number of signal events passing cuts. Fortunately, although large in number, these events are under control. As the source of leptons and missing energy in these events are not sleptons but W-bosons, we expect the edge of the SM background to fall at half the W mass (as this is the modulus of the three momentum of the decay products of the W in its rest frame). From the "zoomed out" histograms in Figures 5.12(a) and 5.12(b) it may be seen that the W-pair background does indeed have an endpoint at $m_W/2$. The same is true of the $t\bar{t}$ background passing the hard cuts, although under the soft cuts the $t\bar{t}$ edge does begin to wander up to 50 GeV, probably due to the worsening of the $\not{p}_T$ resolution when more hadronic energy is admitted to the event as well as the effect of allowing a larger range of transverse boosts for the W-bosons. Nevertheless, the sheer number of SM events passing both sets of cuts, combined with the finite detector resolution, allows significant numbers of events to reach 50 GeV (hard cuts) or 60 GeV (soft cuts). This leakage threatens to further restrict the minimum position at which a supersymmetric edge in ΔM might be observed. Fortunately, the OSSF SM background may be seen to be well modelled by its OSDF counterpart. Since the signals from dislepton pair production are expected to be purely OSSF (because of lepton-number conservation) there is a strong motivation for using different-family background subtraction. The quality of this subtraction may be seen in Figures 5.12(c) and (d). Across the whole range of $\Delta M > 0$ the SM background is consistent with zero after subtraction. If these Figures are compared with the signal distributions shown in Figure 5.11, it may be seen that after subtraction, the SM backgrounds have been reduced to a level where they are very much less than the signal in all bins above $m_W/2$, except perhaps in the two lowest bins in the case of the soft cuts. It is reasonable to assume, therefore, that in the real experiment the OSDF ΔM distribution (or indeed montecarlo) could be used to place limits on the number of OSSF events which would be required to occur above a given value of ΔM, for there to be significant evidence of physics beyond the SM. Beacause of the interplay between signal edge position and signal cross section, one cannot make a definitive statement of the form "if a supersymmetric model has a dislepton edge above X GeV then it will be observable" however it is clear that observation of dislepton edges below $m_W/2$ is not to be expected, while observation of edges in the range $m_W < \Delta M < 50$ GeV will be possible if the number of signal events is significant over the SM background, while observation of an edge above 50 GeV is only likely to be limited by signal cross section itself. From these considerations we see that the light slepton edge at S5 is rendered unobservable by the presence of the SM background, but that the observability of the other edges (including those of O1) remains unaffected.

Having looked at the signal and the SM processes, there remains only the supersymmetric backgrounds to consider. Figure 5.13 shows the remaining non-signal events from supersymmetric production processes, after both the OSSF and the OSDF versions of the cuts. We notice here that, with the single exception of the soft cuts at S5, the OSSF distributions are well modelled by the OSDF events passing the same cuts. Even where the background subtraction is not perfect, we again see that the supersymmetric backgrounds remain small in comparison with the signal distributions (see Figure 5.11) and are either absent or constant in the vicinity of the slepton edges. **XXX I'm not**

too concerned about this, but why would we expect the *unsubtracted* mixed bg at S5 to be quite as large as it is, as after all, the BF for (Ntlino2-¿Ntlino1 lepton antilepton) is only twice as big at S5 as at O1. Since the excess disappears in the hard cuts, it presumably comes from associated production of NtlinoTwo and (quark or gluon). Persumalbly there is some argument about how the ntlinotwo's gaugino/higggsino components favour its production in assoc with the light left-squarks at S5 whereas in O1 they probably only get made with the heavier right-squarks. How about this Peter? XXX

XXX And here comes the old blurb ... XXX

The ΔM distributions obtained after the cuts listed in Section 5.9.1 are shown in Figure 5.15. The signal dislepton region having the desired edge is the unhatched region on each plot. Conveniently, most of the other supersymmetric events passing the cuts (mainly events containing gauginos) are also distributed with an edge located at a similar position to the disleptons'. This is due to the fact that such events often include pairs of slepton decays, and these may sometimes occur in combination with low jet activity and without additional leptons being produced inside detector acceptance. Consequently, for much of the supersymmetric background which passes cuts, the cuts are accepting M_{T2} values which do not degrade edge performance significantly. Note that $\Delta M(\chi) = M_{T2}(\chi) - \chi \geq 0$ is plotted evaluated at $\chi = m_{\tilde{\chi}_1^0}$, so this should have an edge at $\Delta M_{\max} = m_{\tilde{l}} - m_{\tilde{\chi}_1^0}$. Of course, $m_{\tilde{\chi}_1^0}$ is not actually known *a priori*, so generating this graph in a real experiment requires an estimate of $m_{\tilde{\chi}_1^0}$ to be obtained by other means. For our purposes it will be sufficient if the position of the edge of the distribution can be measured to about 10%, and this determines the accuracy required of the neutralino mass estimate χ. The width $\Delta M(\chi) = M_{T2}(\chi) - \chi$ remains approximately stable at the 10% level for $m_{\tilde{\chi}_1^0}/2 < \chi < 2m_{\tilde{\chi}_1^0}$. To illustrate the relative insensitivity of $\Delta M_{\max}(\chi)$ to χ near $m_{\tilde{\chi}_1^0}$, plots generated from the same data as before but with $\chi \approx m_{\tilde{\chi}_1^0} \pm 50$ GeV