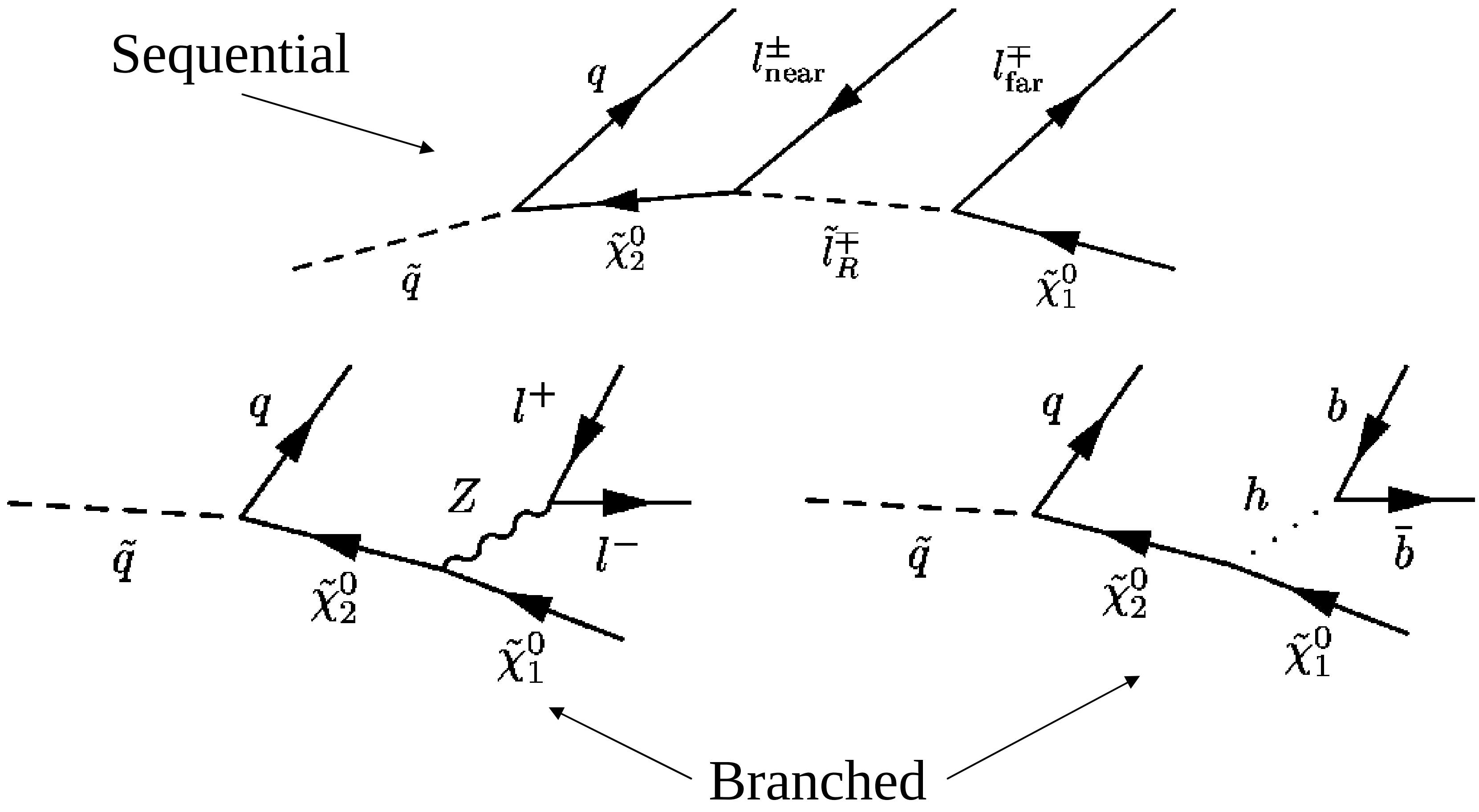
Edges and things, and what experimenters do in HEP.

Christopher Lester

What's this all about?

Decay chains used

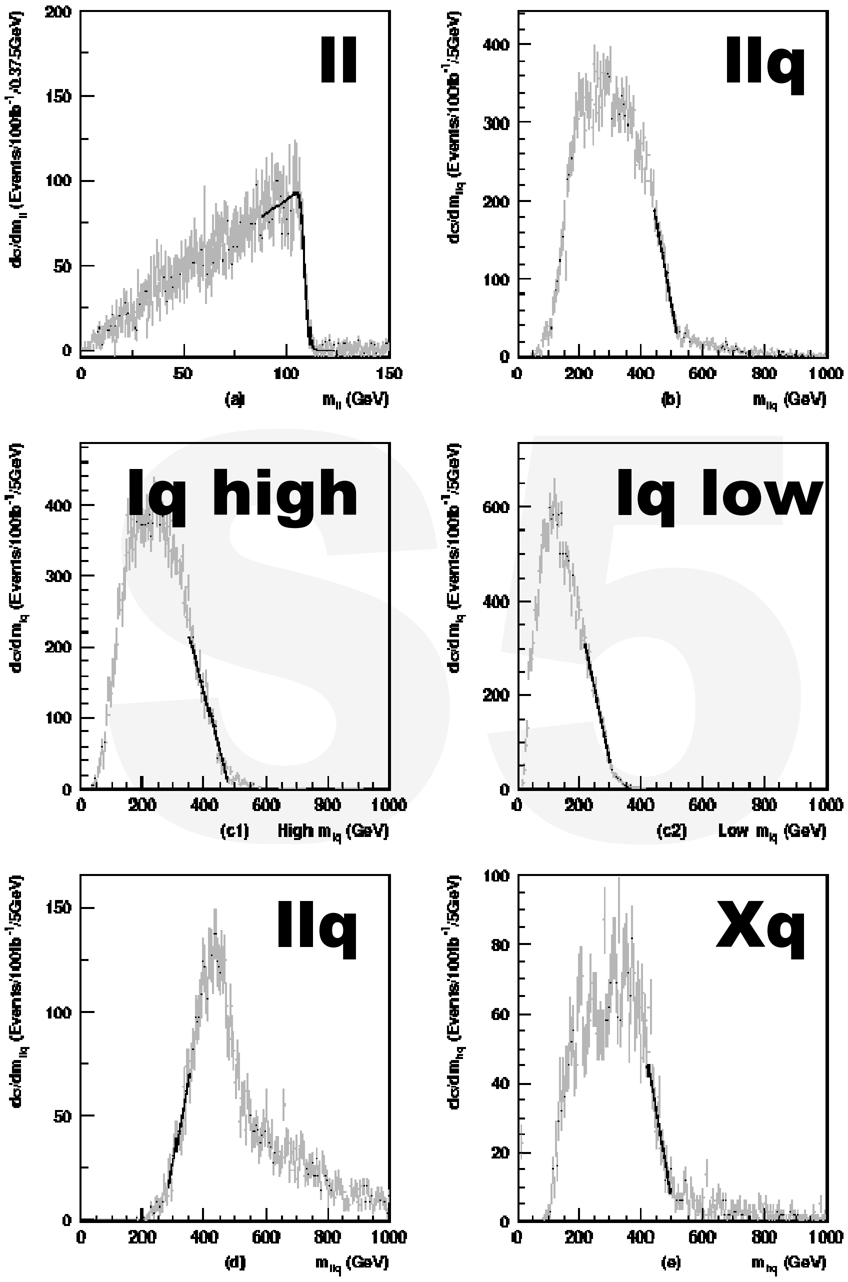


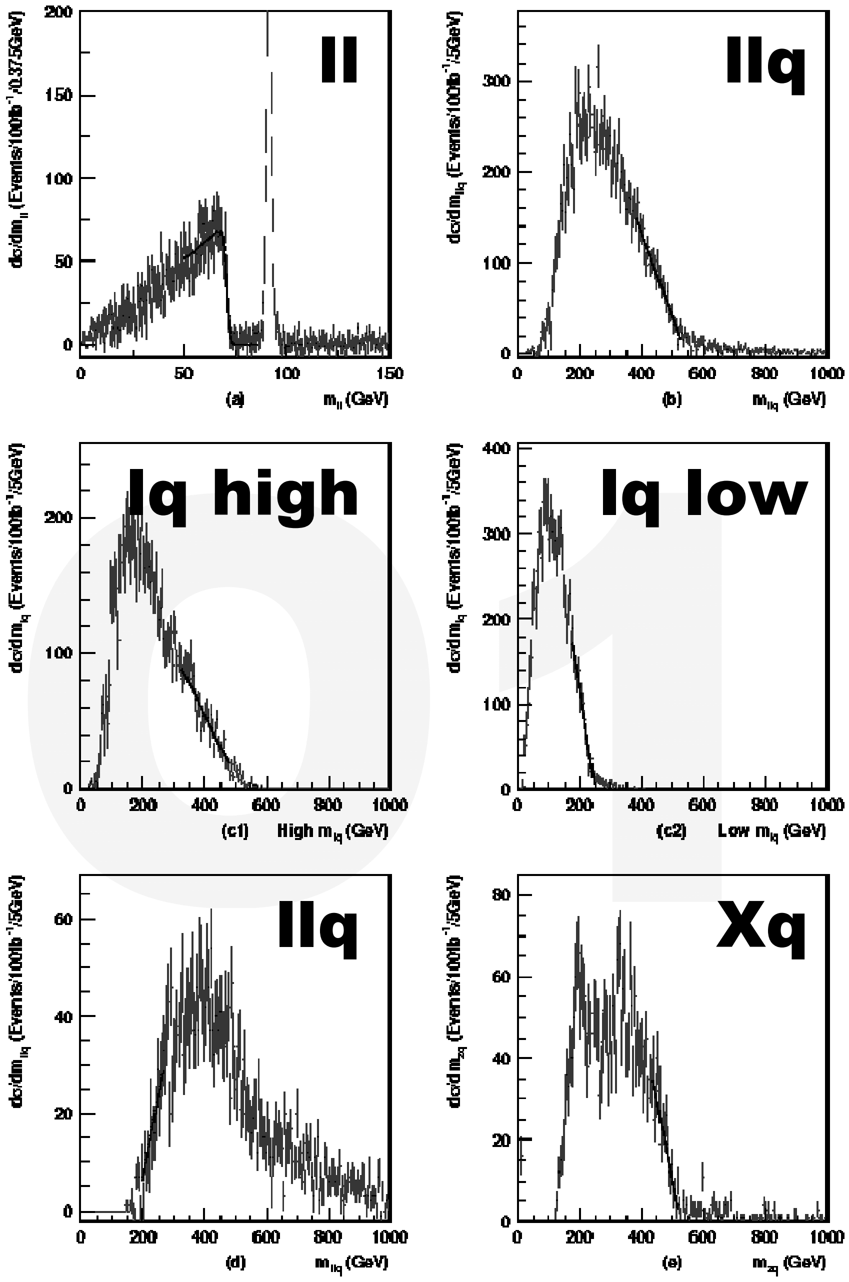
Edge positions

Related edge	Kinematic endpoint
l^+l^- edge	$(m_{ll}^{\max})^2 = (\tilde\xi - \tilde l)(\tilde l - \tilde\chi)/\tilde l$
l^+l^-q edge	$(m_{llq}^{\max})^2 = \begin{cases} \max\left[\frac{(\tilde q-\tilde\xi)(\tilde\xi-\tilde\chi)}{\tilde\xi}, \frac{(\tilde q-\tilde l)(\tilde l-\tilde\chi)}{\tilde l}, \frac{(\tilde q\tilde l-\tilde\xi\tilde\chi)(\tilde\xi-\tilde l)}{\tilde\xi\tilde l}\right] \\ \text{except for the special case in which } \tilde l^2 < \tilde q\tilde\chi < \tilde\xi^2 \text{ and} \\ \tilde\xi^2\tilde\chi < \tilde q\tilde l^2 \text{ where one must use } (m_{\tilde q} - m_{\tilde\chi_1^0})^2. \end{cases}$
Xq edge	$(m_{Xq}^{\max})^2 = X + (\tilde q - \tilde\xi)\left[\tilde\xi + X - \tilde\chi + \sqrt{(\tilde\xi - X - \tilde\chi)^2 - 4X\tilde\chi}\right]/(2\tilde\xi)$
l^+l^-q threshold	$(m_{llq}^{\min})^2 = \begin{cases} [\ 2\tilde l(\tilde q-\tilde\xi)(\tilde\xi-\tilde\chi) + (\tilde q+\tilde\xi)(\tilde\xi-\tilde l)(\tilde l-\tilde\chi) \\ \ -(\tilde q-\tilde\xi)\sqrt{(\tilde\xi+\tilde l)^2(\tilde l+\tilde\chi)^2 - 16\tilde\xi\tilde l^2\tilde\chi}\ \ ]/(4\tilde l\tilde\xi) \end{cases}$
$l^\pm_{\text{near}}q$ edge	$(m_{l_{\text{near}}q}^{\max})^2 = (\tilde q - \tilde\xi)(\tilde\xi - \tilde l)/\tilde\xi$
$l^\pm_{\text{far}}q$ edge	$(m_{l_{\text{far}}q}^{\max})^2 = (\tilde q - \tilde\xi)(\tilde l - \tilde\chi)/\tilde l$
$l^\pm q$ high-edge	$(m_{lq(\text{high})}^{\max})^2 = \max\left[(m_{l_{\text{near}}q}^{\max})^2, (m_{l_{\text{far}}q}^{\max})^2\right]$
$l^\pm q$ low-edge	$(m_{lq(\text{low})}^{\max})^2 = \min\left[(m_{l_{\text{near}}q}^{\max})^2, (\tilde q - \tilde\xi)(\tilde l - \tilde\chi)/(2\tilde l - \tilde\chi)\right]$
M_{T2} edge	$\Delta M = m_{\tilde l} - m_{\tilde\chi_1^0}$

Table 4: The absolute kinematic endpoints of invariant mass quantities formed from decay chains of the types mentioned in the text for known particle masses. The following shorthand notation has been used: $\tilde\chi = m^2_{\tilde\chi_1^0}, \tilde l = m^2_{\tilde l_R}, \tilde\xi = m^2_{\tilde\chi_2^0}, \tilde q = m^2_{\tilde q}$ and X is m^2_h or m^2_Z depending on which particle participates in the "branched" decay.

Fitted distributions





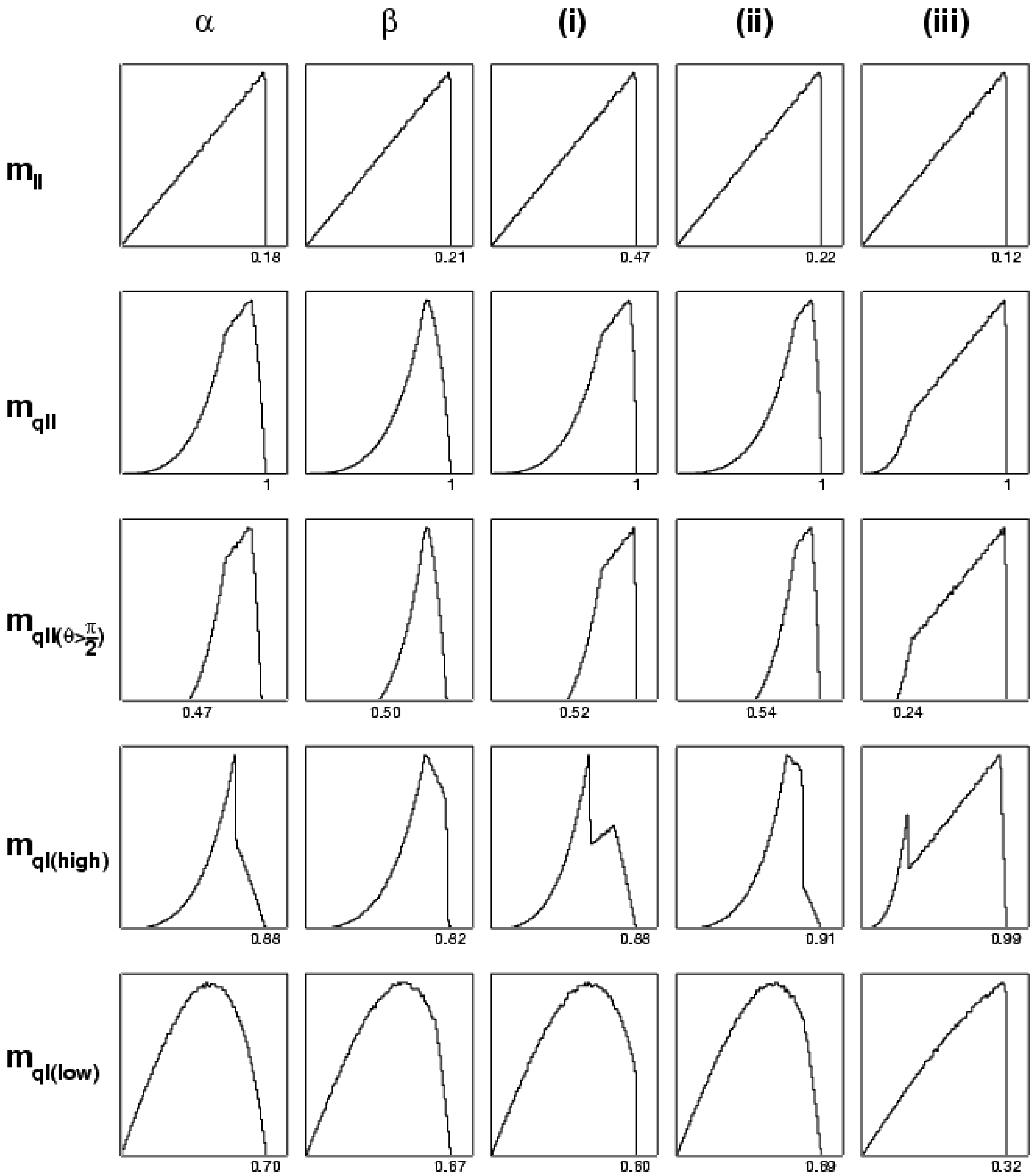


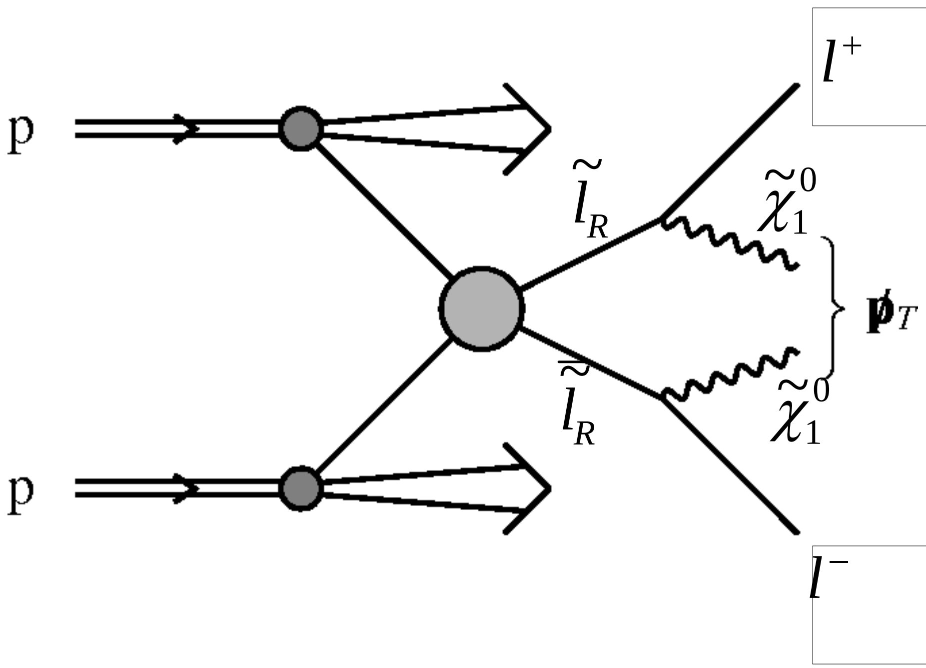
Figure 10: Theoretical mass distributions for SPS 1a (α) and (β), as well as for three other mass scenarios, denoted (i), (ii) and (iii). Kinematic endpoints are given in units of the squark mass. (More details will be given in [43].)

What the different invariant mass distributions look like for a selection of plausible supersymmetric models.

From Miller et. al.

hep-ph/0410303

$\Delta M = M_{T2}(X) - X$



Given:

- the lepton momenta
- the missing transverse momentum
- an estimate "X" of the neutralino mass

Deduce:

- lower bound $M_{T2}(X)$ on slepton mass
- slepton-neutralino mass difference ΔM

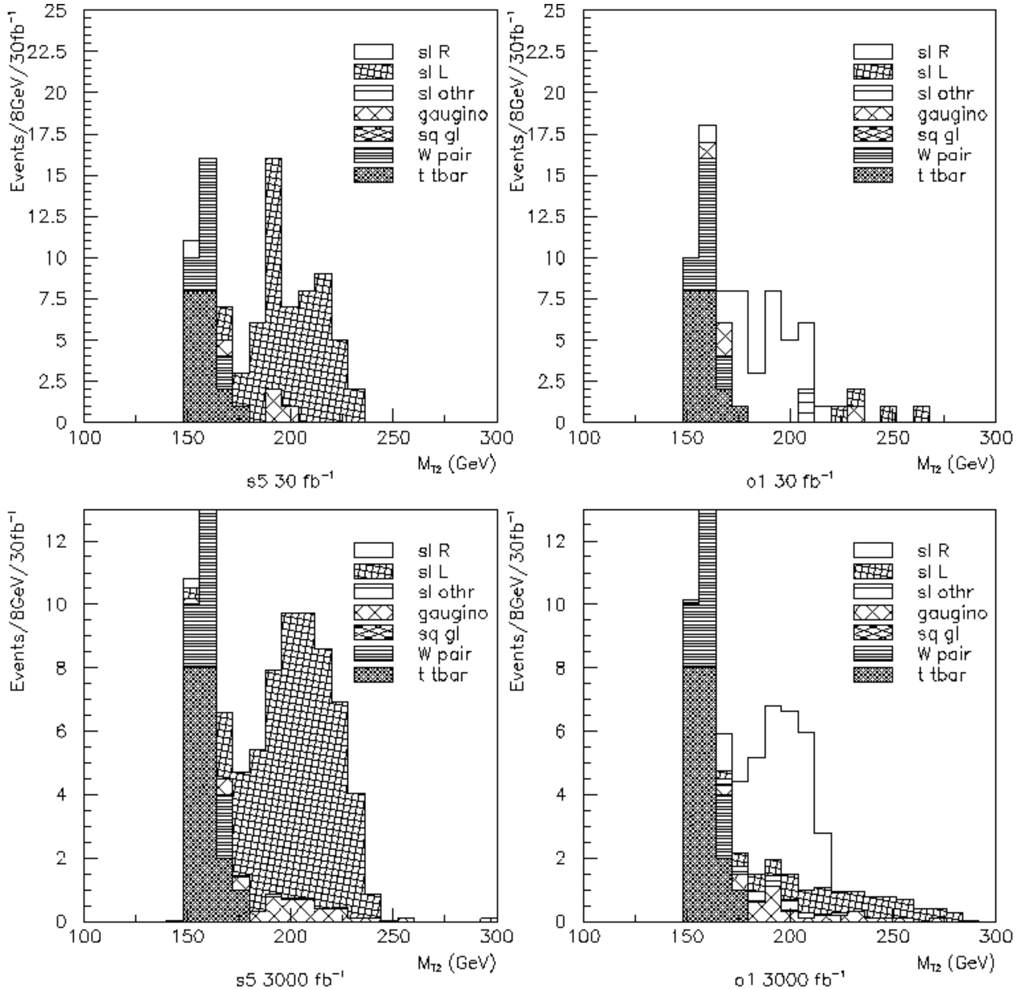
How does this m_{T2} work?

- For each event you want a lower bound for $m_{slepton}$
- You get this by trying ALL POSSIBLE neutralino momenta, k, consistent with
  - observed missing momentum,
  - identical (unknown) slepton masses,
  - Hypothesised neutralino mass.
- For each of these momenta, k, “that might have been” there is an “$m_{slepton}$(k) that might have been”.
- There is a least such $m_{slepton}$(k) (call it m_{T2}) which cannot be bigger than the true value of $m_{slepton}$, because one of the k’s is acutally right!
- Hence m_{T2} is a lower bound for $m_{slepton}$.

So summarising:

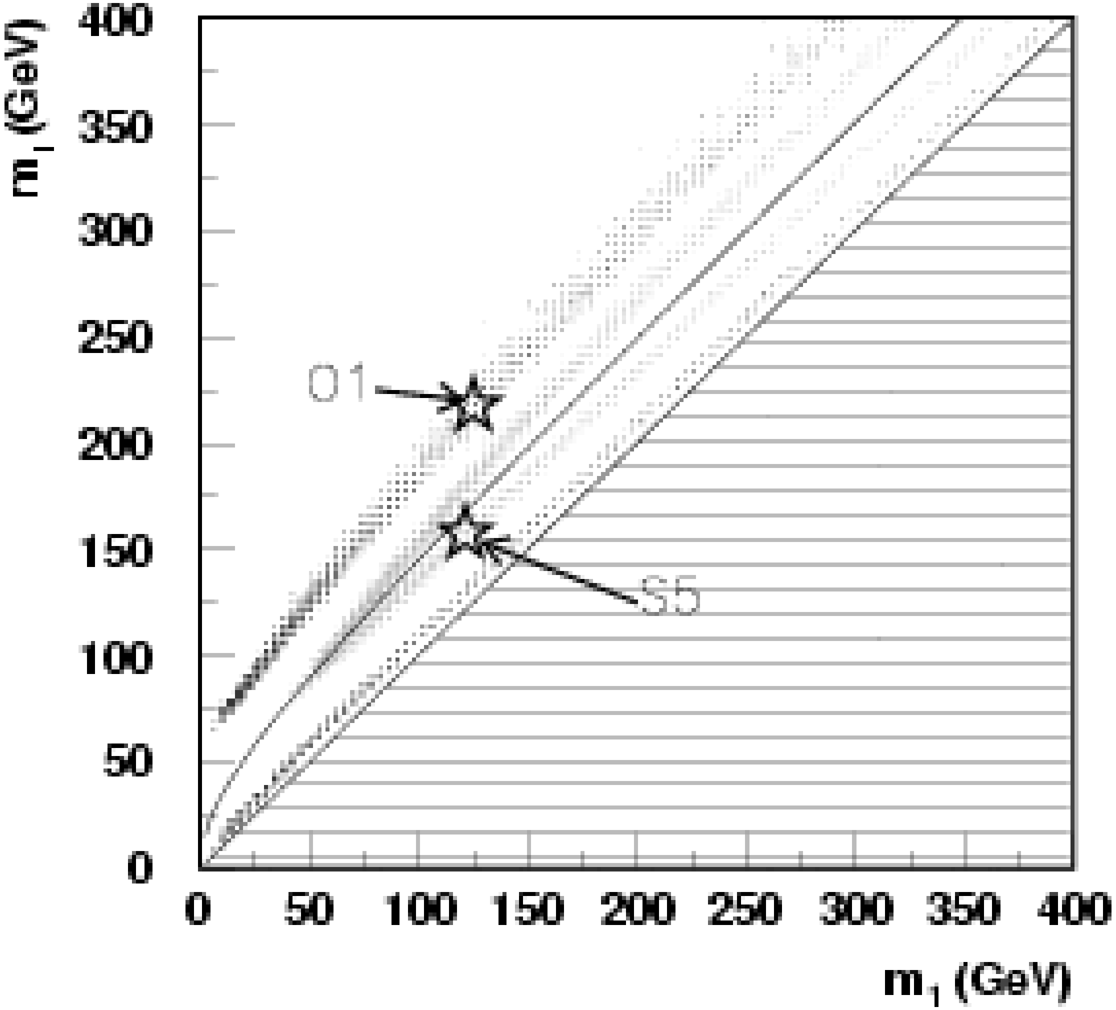
- In each event:
  - $m_{T2} <= m_{slepton}$.
- Can show that:
  - there exist events for which $m_{T2} = m_{slepton}$.
- So:
  - the endpoint of the m_{T2} distribution is $m_{slepton}$!

Example m_{T2} distributions

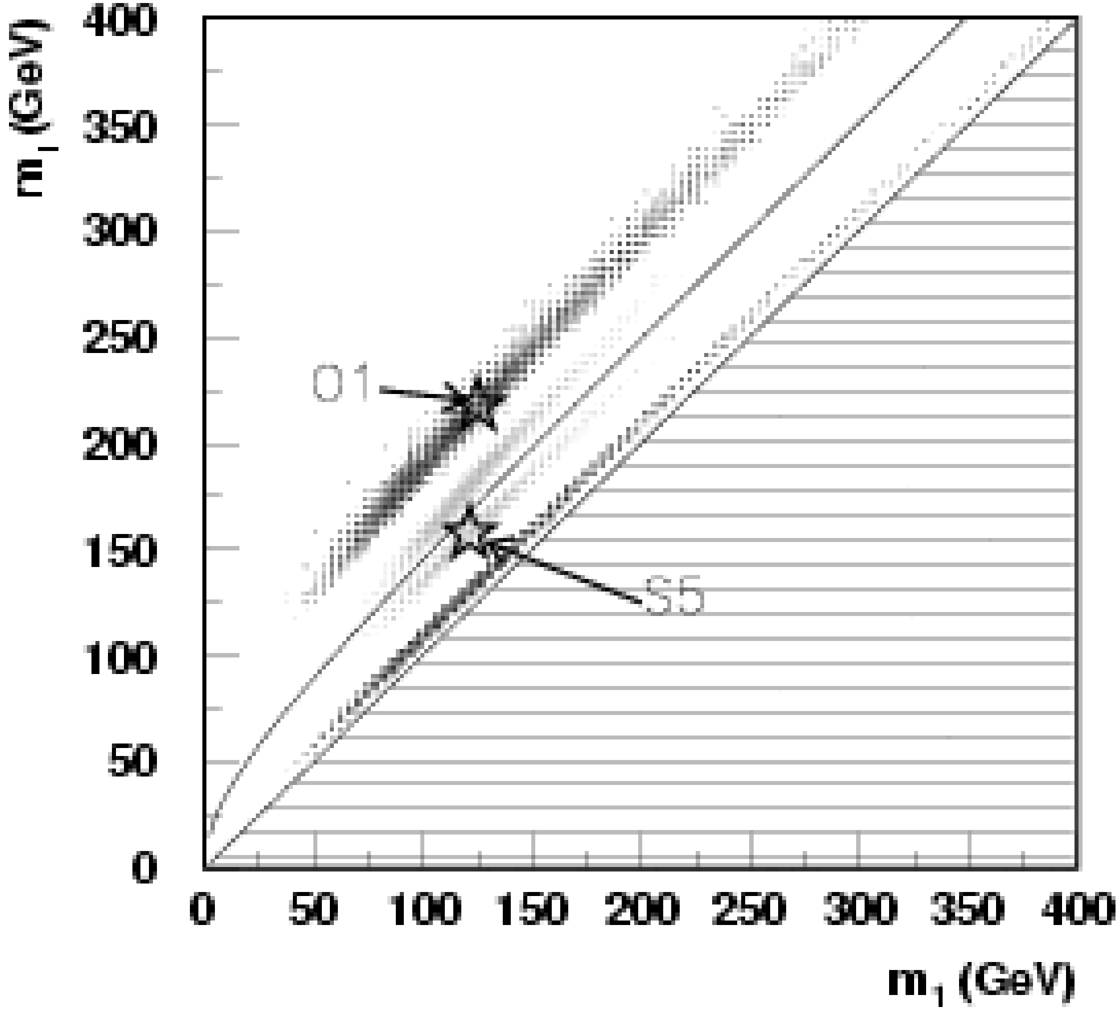


(This old plot underestimates SM backgrounds)

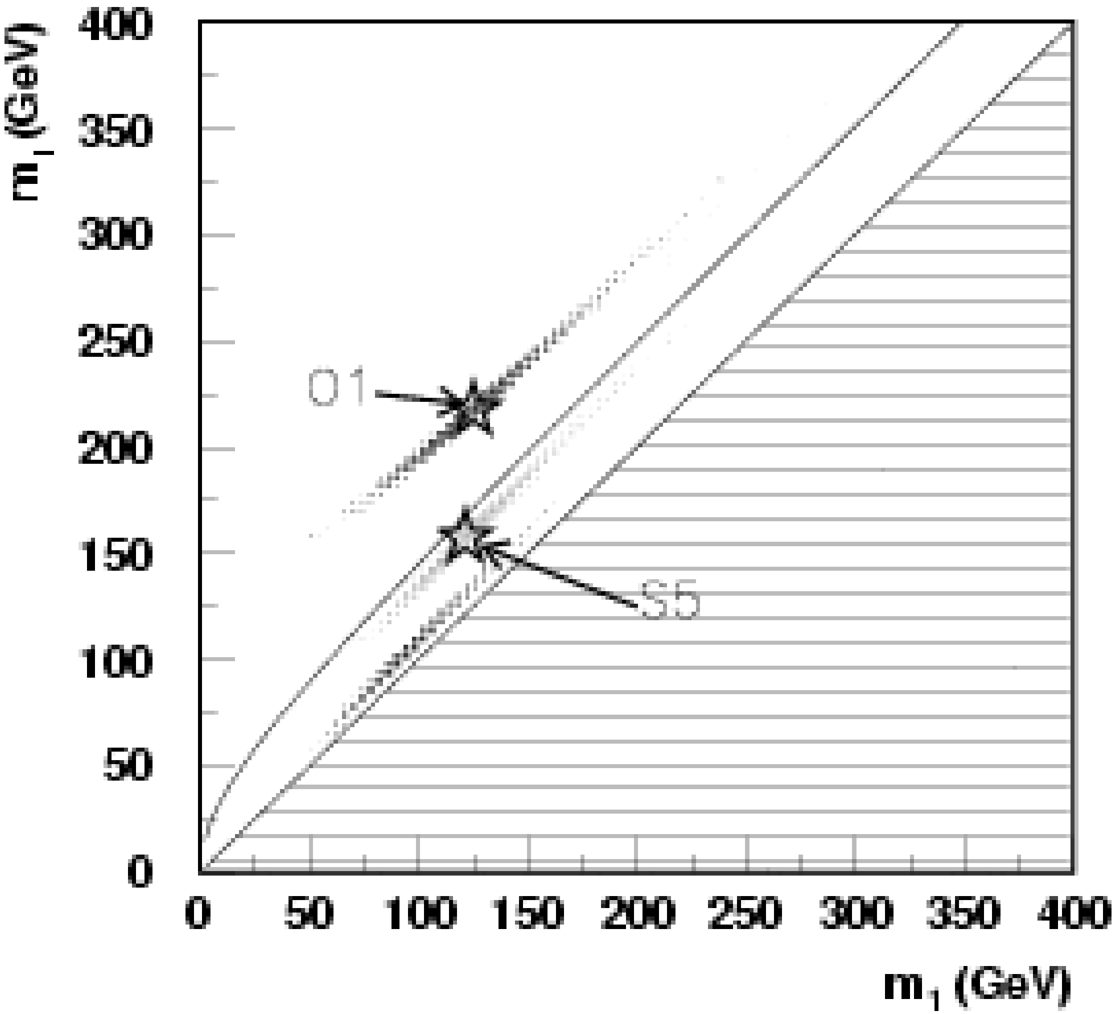
No m_{qll}-thresh, no m_{lq}-low, no m_{T2}



No m_{lq}-low, no m_{T2}

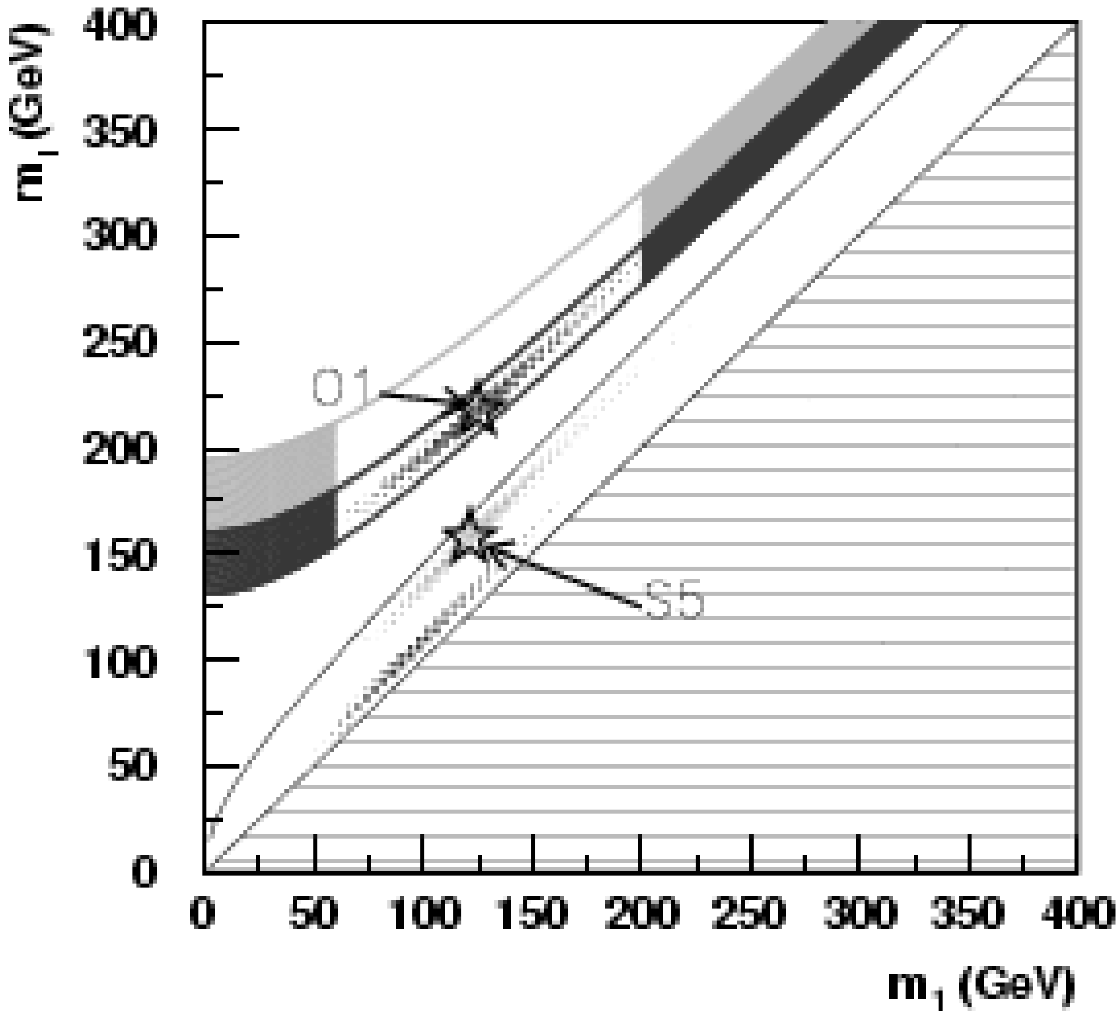


No m_{T2}



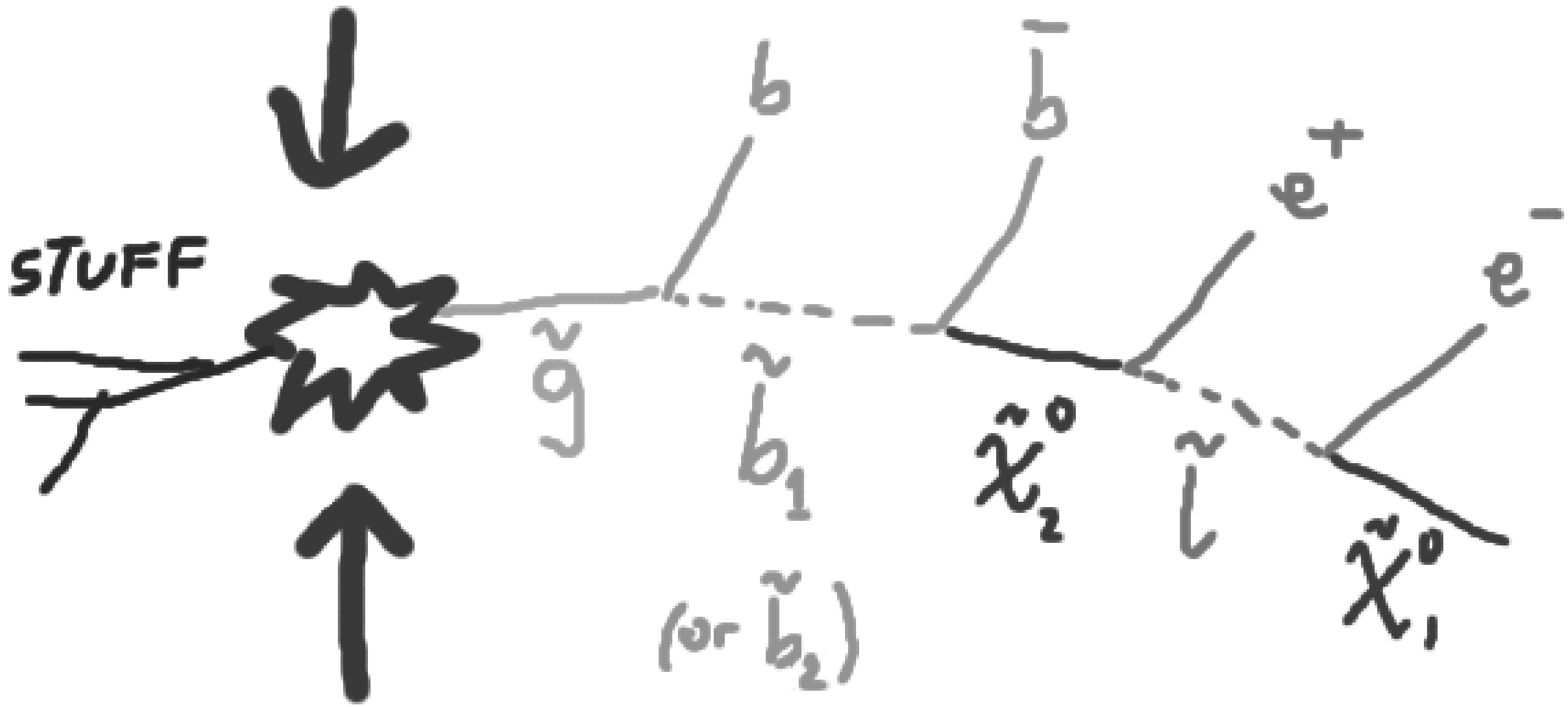
400
350
300
250
200
150
100
50
0
m_l (GeV)
O1
S5
0
50
100
150
200
250
300
350
400
m_1 (GeV)

Everything!



m_l (GeV)
400
350
300
250
200
150
100
50
0
O1
S5
0
50
100
150
200
250
300
350
400
m_1 (GeV)

A long cascade decay from pp



Mass Relation Method Results