MTGEN –

– SUSY MASS SCALE

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(Christopher Lester)

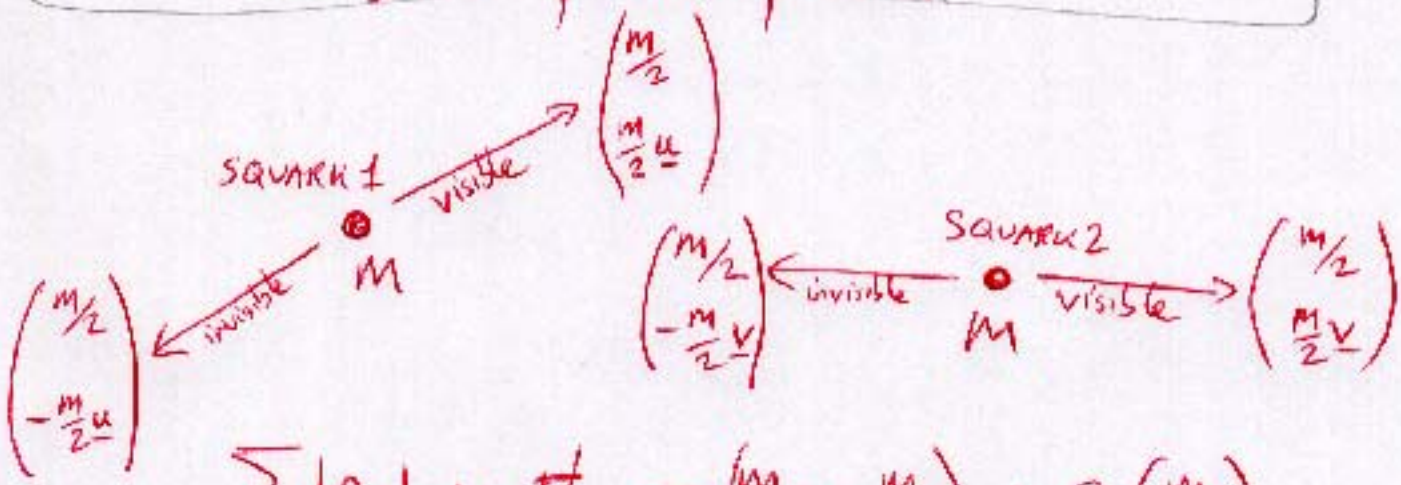
Often pair production is dominated by production "at threshold".

eg: Produce di-squark predominantly with both squarks "at rest"

IDEA:

MEFF (Effective Mass)

"Add up most of the energy you can see or infer, and you will have about the mass of the particles produced

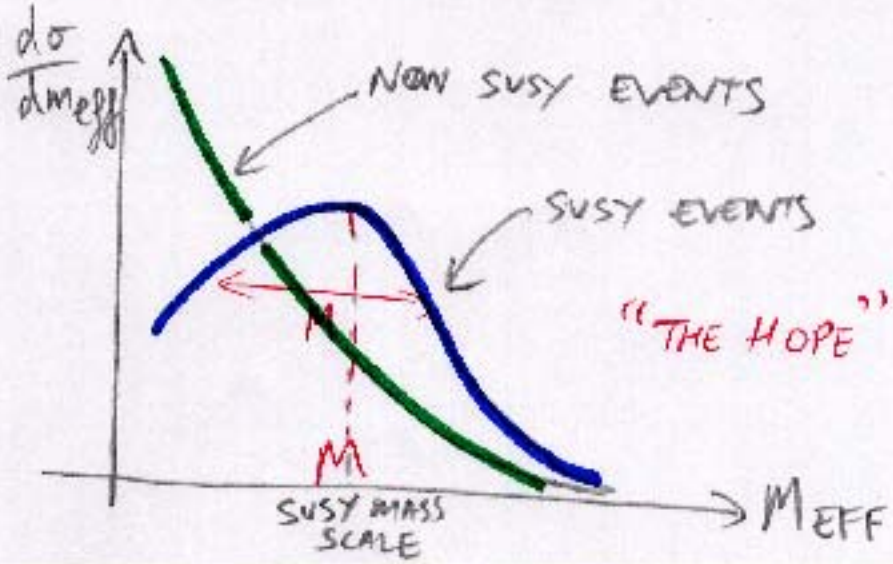



$$\sum_j |p_{Tj}| + \not{E}_T = \left(\frac{m}{2} + \frac{m}{2}\right) + O\left(\frac{m}{2}\right)$$

$$= M + O\left(\frac{m}{2}\right)$$

ALL A BIT VAGUE ☹

ALL VERY SIMPLE ☺



Many suggestions for new physics involves <u>pair production</u> of particles of similar or identical mass. eg:

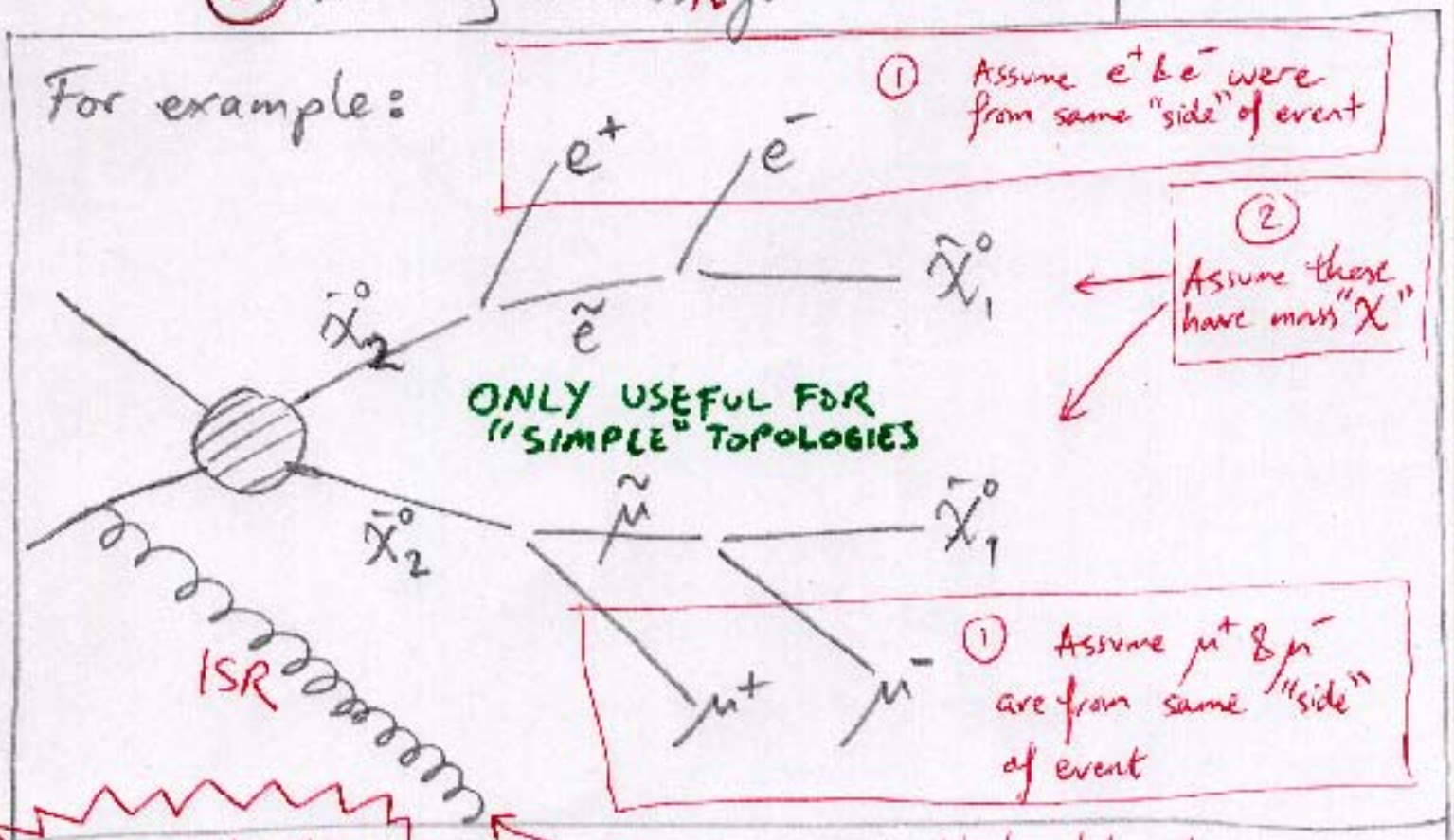
$$pp \to \tilde{e}^+ \tilde{e}^-$$
$$pp \to \tilde{u}\, \bar{\tilde{d}}$$
$$pp \to \tilde{g}\, \tilde{g}$$

hep-ph/9906349
hep-ph/0304226
hep-ph/arXiv:0705.0486

Old variable **MT2** has provided an event-by-event ~~estim~~ lower bound for the mass of the particle which was pair-produced, assuming:

1. Assuming the visible decay products were correctly identified,
2. Assuming a mass "$\chi$" for the invisible particles.

For example:




Given all the above:

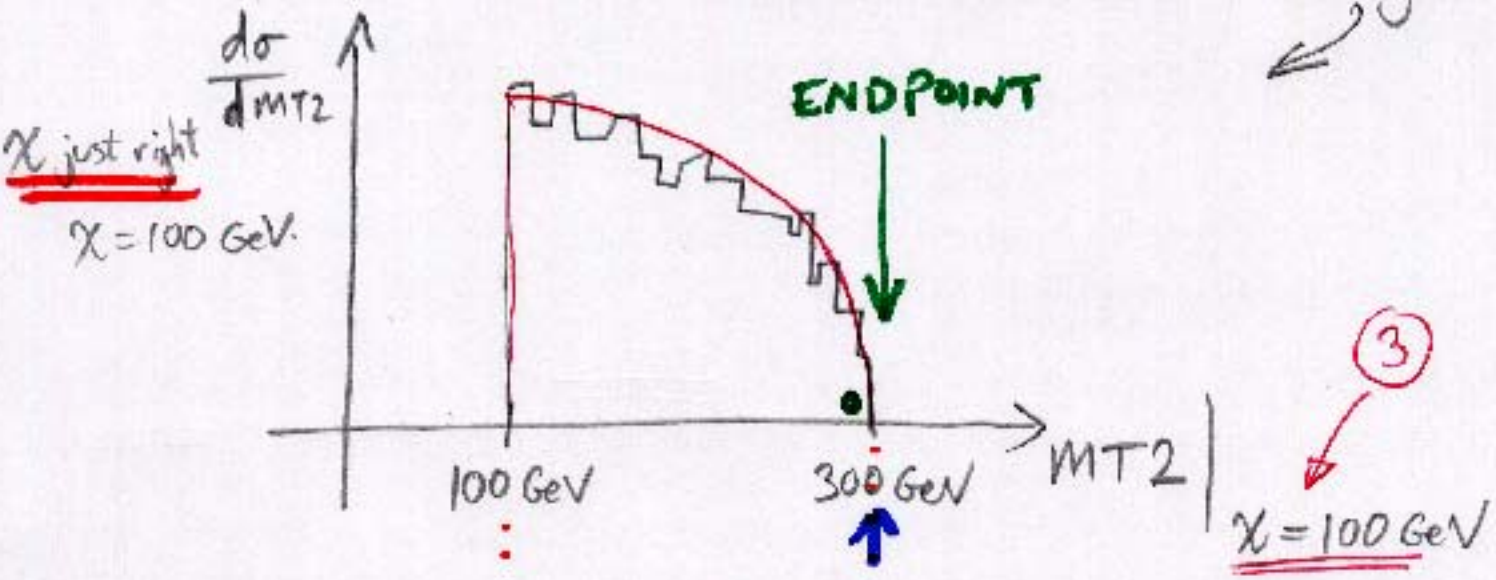
$$M_{T2} \leq M_{\tilde{\chi}^0_2}$$

Assume ISR seen in detector, but not confused with the "interesting visible final state particles $e^+, e^-, \mu^+, \mu^-$.

(If $\chi$ is correct!)

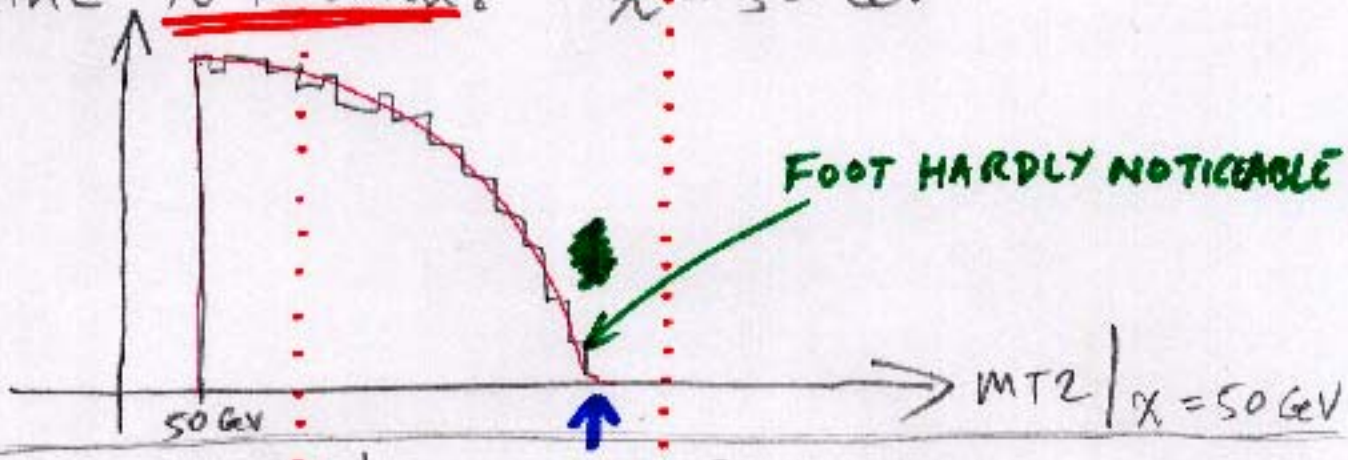
Suppose $m_{\tilde{\chi}_1^0} = 100$ GeV, and $m_{\tilde{\chi}_2^0} = 300$ GeV.

Then plot MT2 <u>over many events</u>. Get this histogram

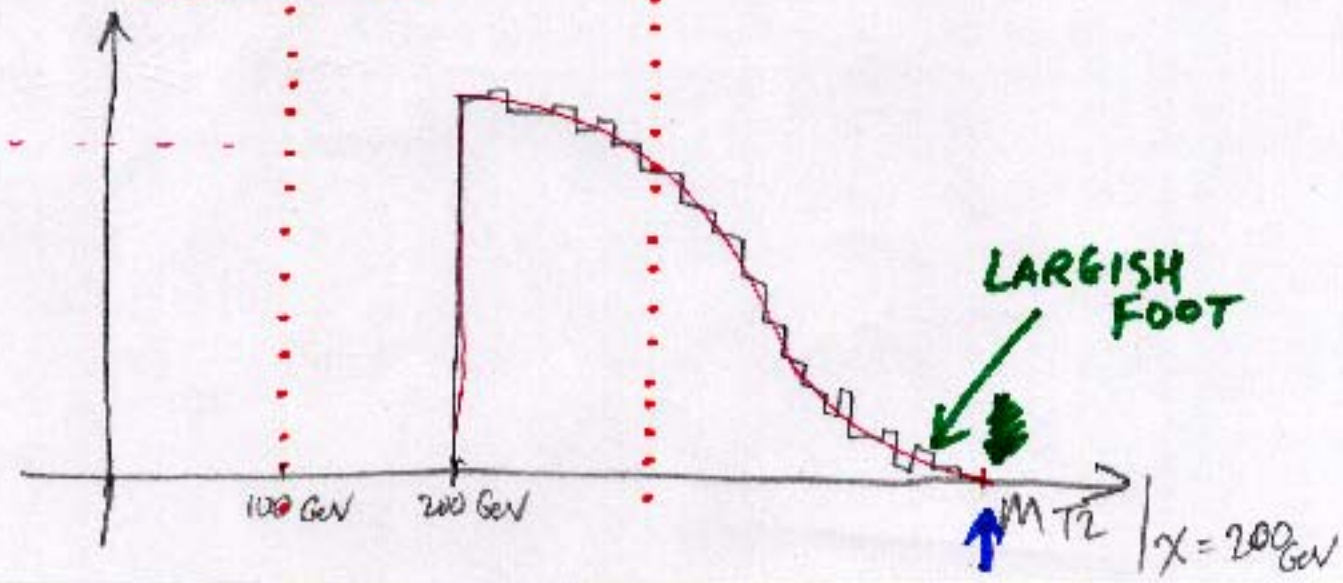



What if we try the same thing again, but:

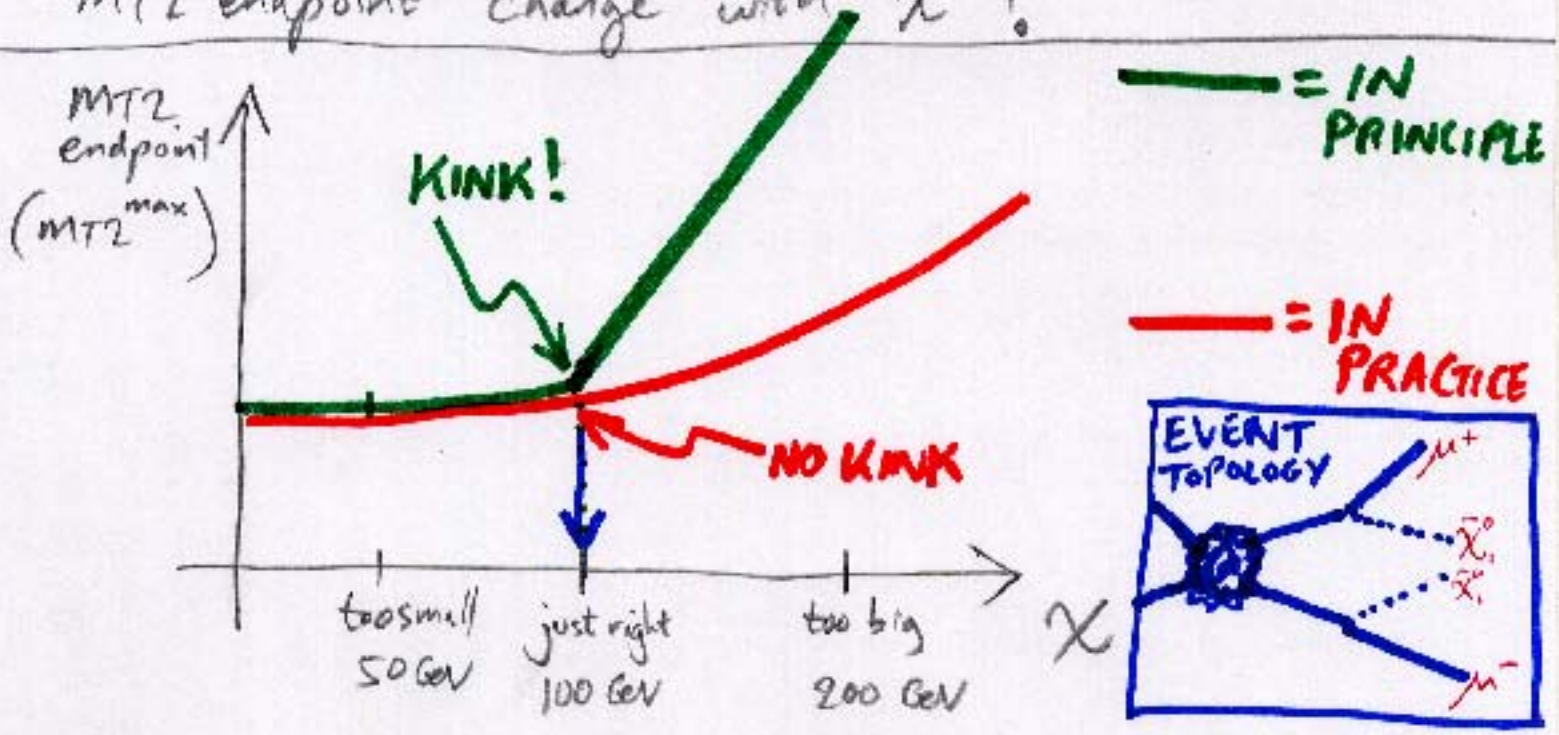
* MAKE $\chi$ too small: $\chi = 50$ GeV

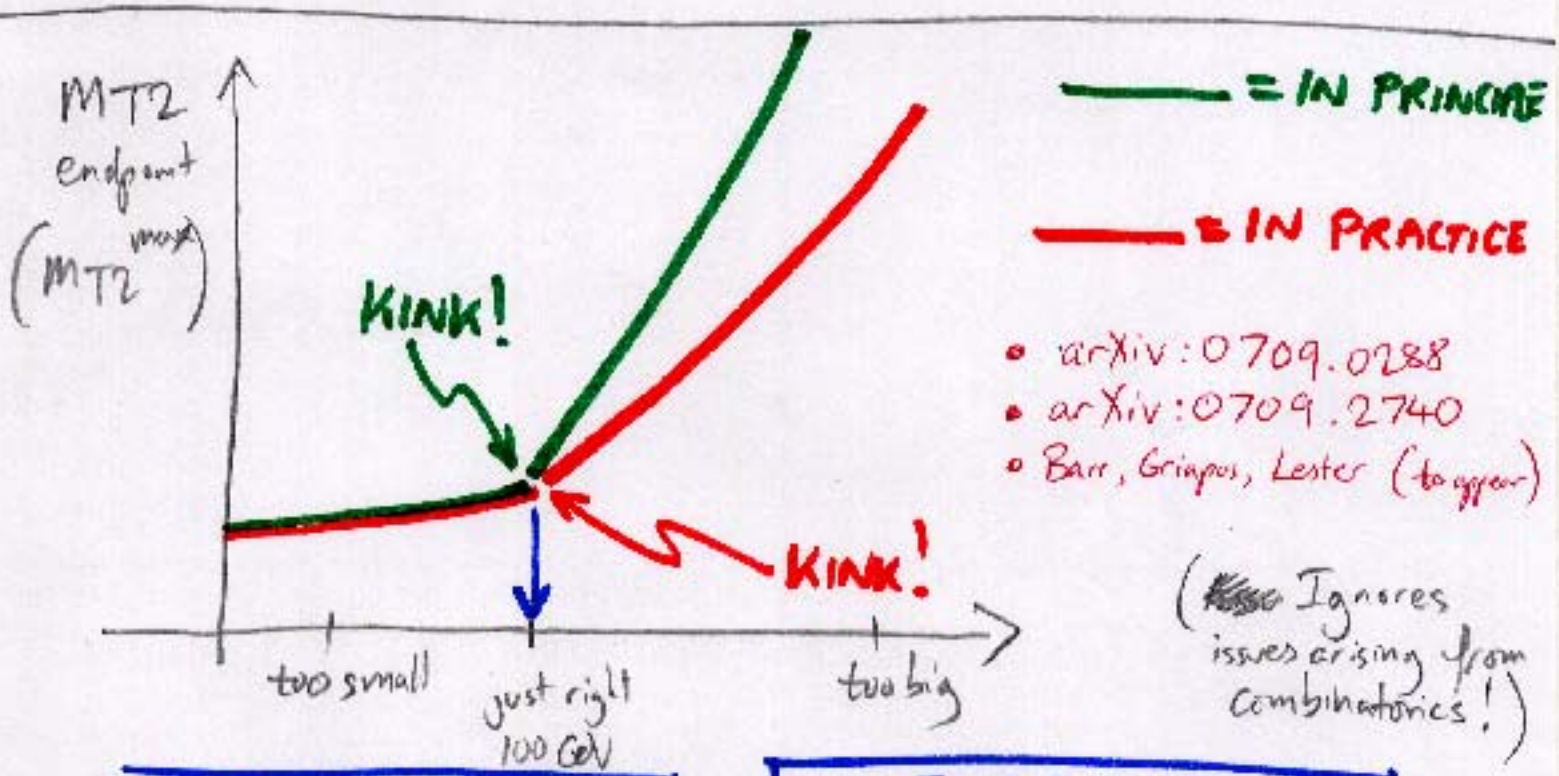



* MAKE $\chi$ too big: $\chi = 200$ GeV



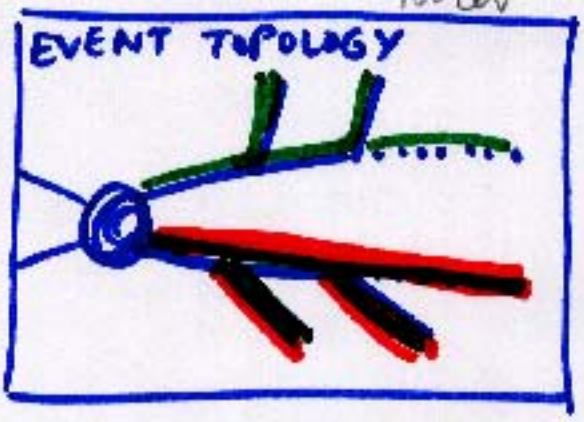
Where does the little blue arrow ↑ move?
How does the posn of the little blue arrow ↑ – the "MT2 endpoint" change with $\chi$?

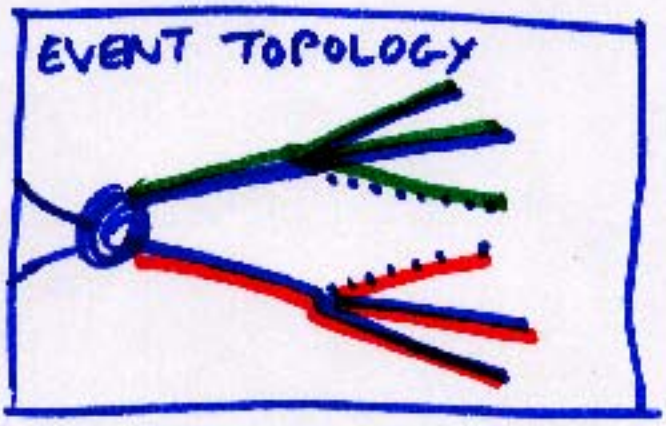



- arXiv:0709.0288
- arXiv:0709.2740
- Barr, Grinpas, Lester (to appear)

(Ignores issues arising from combinatorics!)



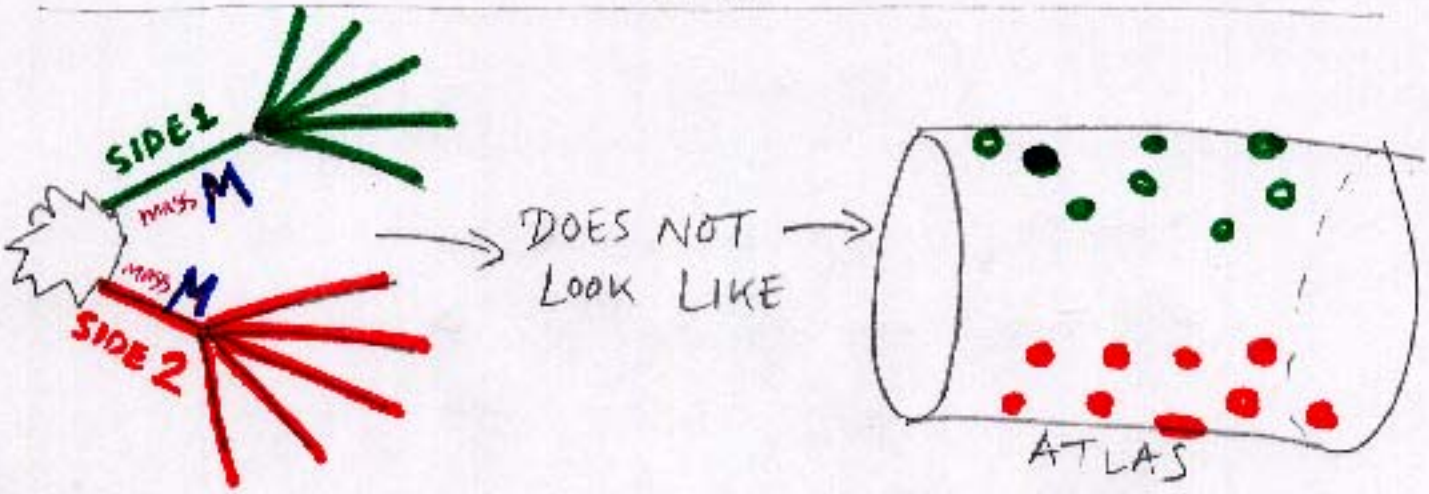



Recent different IDEA:

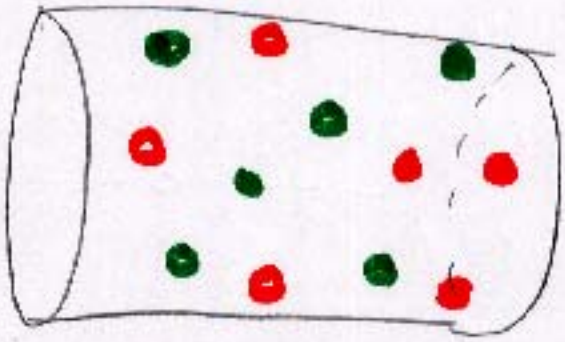
# MTGEN

arXiv:0705.0486 Lester + Barr

"Adapts MT2 to work in the sort of complicated events which have previously been the territory of MEFF."




IT LOOKS LIKE



i.e. you can't usually tell in complicated events which "side" each jet came from.

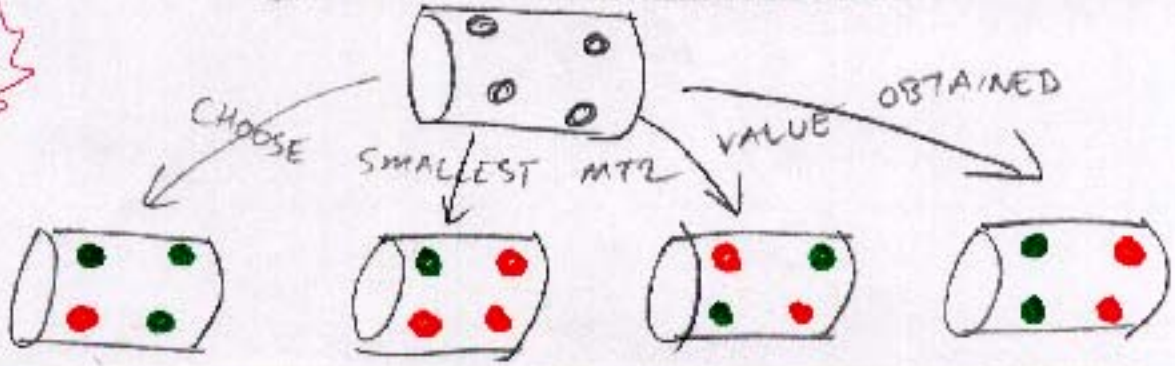
MTGEN says:

Definition

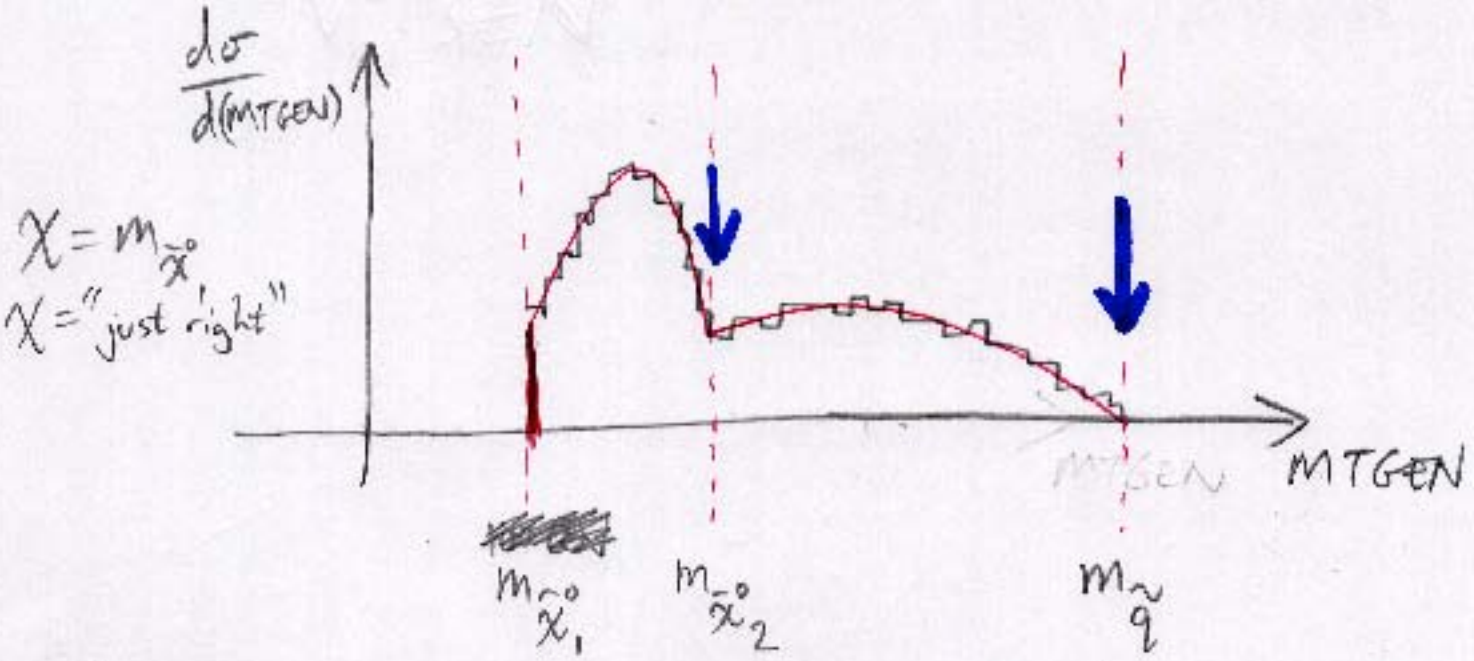
1. "TRY SPLITTING OBSERVED JETS / MOMENTA INTO TWO "SIDES" IN ALL POSSIBLE WAYS".
2. CALCULATE MT2 FOR EACH.
3. REMEMBER THE SMALLEST MT2 VALUE FOUND AND CALL IT MTGEN.

CAN PROVE

MTGEN ≤ M



Over many events, generate histogram of MTGEN:




(just like MT2, the MTGEN histogram slides ⟷ and gains feet if evaluated at $\chi$ too big or too small).

| | MTGEN | MEFF |
|---|---|---|
| Easy to calculate? | [redacted] No ☹ (need to download ATLAS MTGEN library) | Yes ☺ |
| Precision measurement? | Yes ☺ (precision limited by combinatorics, statistics, fit to endpoint) | No ☹ (can only interpret by comparison with montecarlo ...) |
| Affected by ISR? | ☹ a bit | ☹ a bit |
| Affected by PT distro of produced particles | No ☺ | Yes ☹ |

Executive summary:

If you are happy to calculate it, it looks like MTGEN IS NOT WORSE THAN MEFF AND MAY IN FACT BE THEORETICALLY MORE DESIRABLE

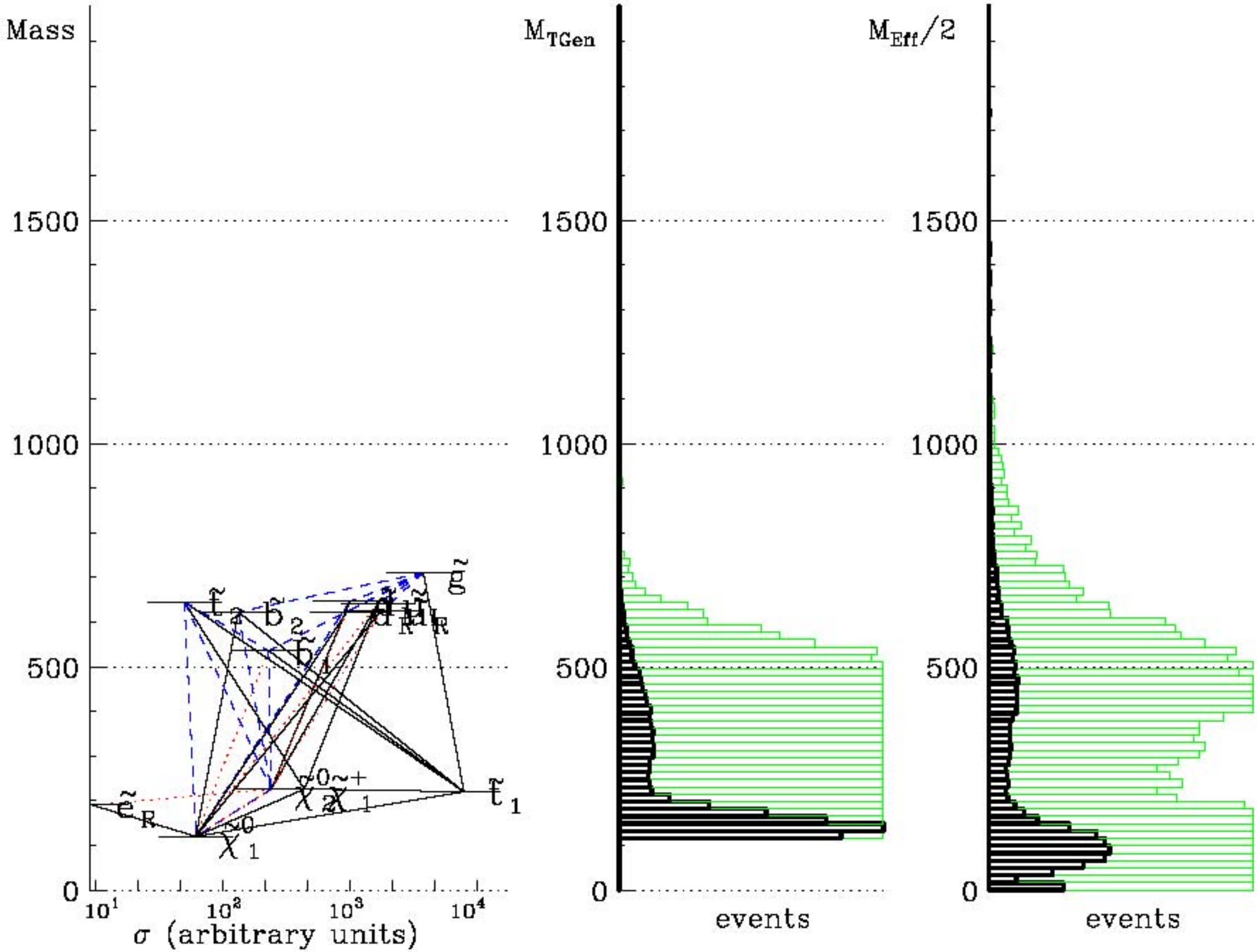



Figure 2: As for figure 1, but for Snowmass point 5.

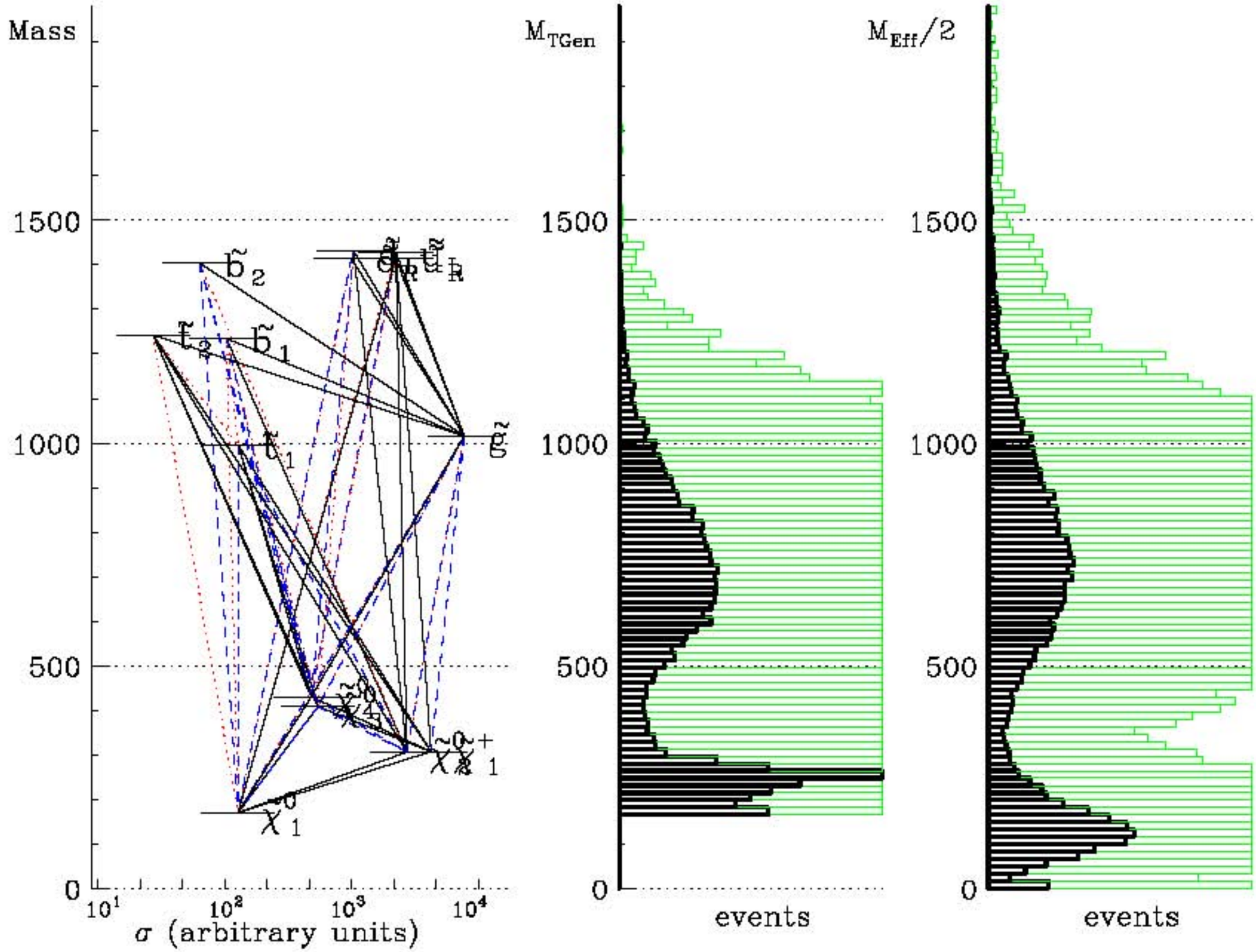



Figure 3: As for figure 1 but for a (non-Snowmass) point with a heaver sparticle spectrum, defined by the mSUGRA parameters: $\{m_0 = 1200$ GeV, $m_{\frac{1}{2}} = 420$ GeV, $\tan\beta = 10$, $m_t = 174$ GeV, $\mu < 0\}$ and with a spectrum generated using `Isajet`[15] version 7.58.

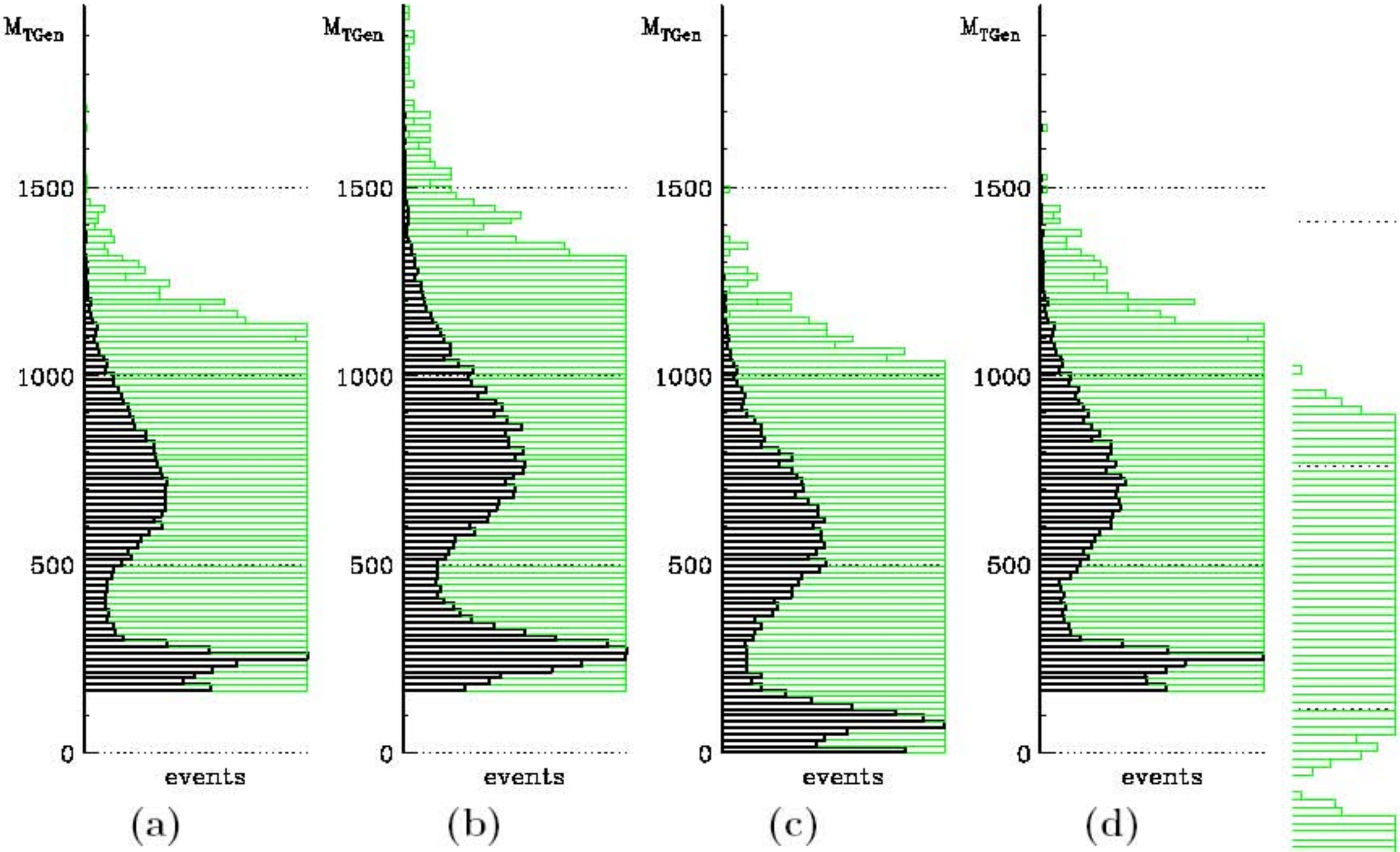



Figure 4: $m_{TGen}$ distributions for the same sectrum as for figure 3, but with different assumptions. **(a)** The idealised case, as described in text. **(b)** As for (a) but now with initial state radiation and the underlying event, and including particles from both categories $F$ and $G$ ("interesting" and "ISR/underlying event") to form jets. **(c)** As for (a) but with the parameter, $\chi$, (corresponding to the mass of the invisible particle) set to zero. **(d)** As for (a) but using the sum of the transverse momenta of the invisible particles for the missing transverse momentum.

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# SUMMARY

**MTGEN** histograms look like
**MEFF** histograms but "WITHOUT THE TAILS".

(But ISR may soften the above statement)

# SUGGESTION:

You might like to consider plotting MTGEN whenever you also plot MEFF to see if one works better for you than the other .....