Describing the Structure of New Physics on "The Day After"

Natalia Toro

with J. Alwall, P. Schuster

Reminder: Simplified Models

- Small number (4) of topological models tailored to "SUSY-like" excesses in X+MET searches
  - Cover a broad range of phenomenology
  - Baseline from which to build evidence for complex new-physics structure from data

don't need to study one simplified model per idea/theorist

Physics Assumptions

- Working with validated, stable, large excesses
- Signals in multiple channels
- Not Z' (easy)

These are <u>reasonable:</u>

- SUSY predicts many channels
- Naturalness suggests low masses, big xsec's

Case Study:

A SUSY Model with Complicated Decay Chains, at 500 pb^{-1}

- What kinds of physics we can learn from different distributions
- Why we need more than distributions (and why simplified models help)
- Deduction
- Implications of Limited Model-Resolution

Discovery!

(Our starting point)

- ≥3 Jet, 1 Lepton+MET

$E_T^{\text{miss}} > 100$ GeV

$N_{jet} \geq 3$

$p_T(j_{1,2,3}) > 75$ GeV

$H_T > 350$ GeV

- ≥2 Jet, 2 Lepton+MET

$E_T^{\text{miss}} > 80$ GeV

$N_{jet} \geq 2$

$p_T(j_{1,2}) > 75$ GeV

$H_T > 350$ GeV

(combination of ee, eμ, μμ searches)

(In each case, Lepton=e or μ with pT>10 GeV, plus isolation etc.)

1100±100 events

420±50 events

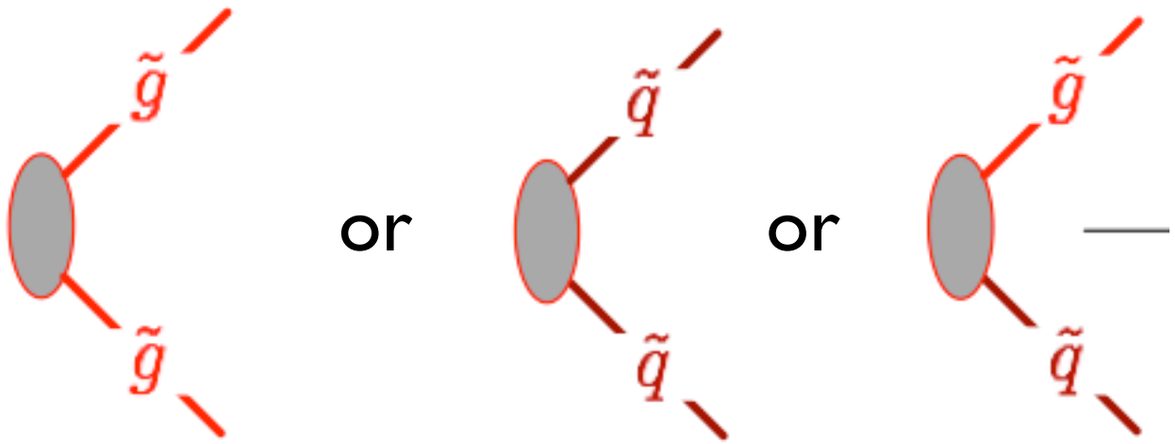
+ distributions in each case.

Relative rates of 2-lepton, 1-lepton events are important, but we don't know yet!

- count 2l events with tighter cuts (lose statistics!)
- divide by efficiencies of decay chain for some model (which one?)

Models that populate these final states?

- Have SUSY-like topologies in mind



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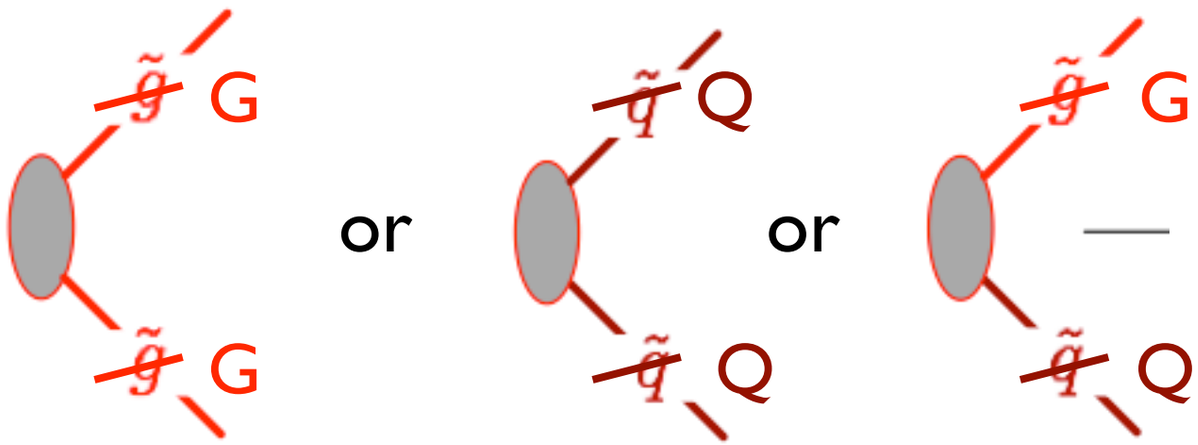

not ready to measure spins & <u>for now</u> don't care whether SUSY or other partners w/ same decays (little higgs, UED, ...)

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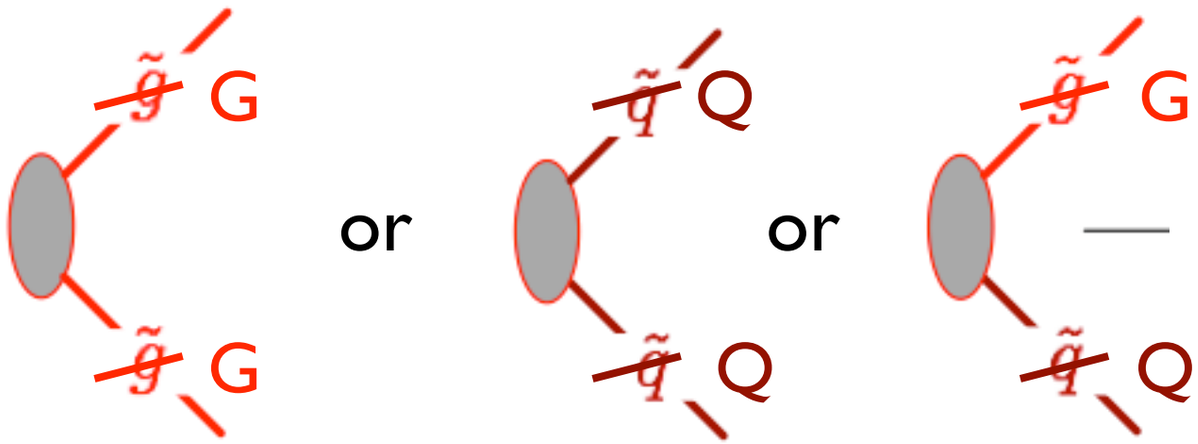

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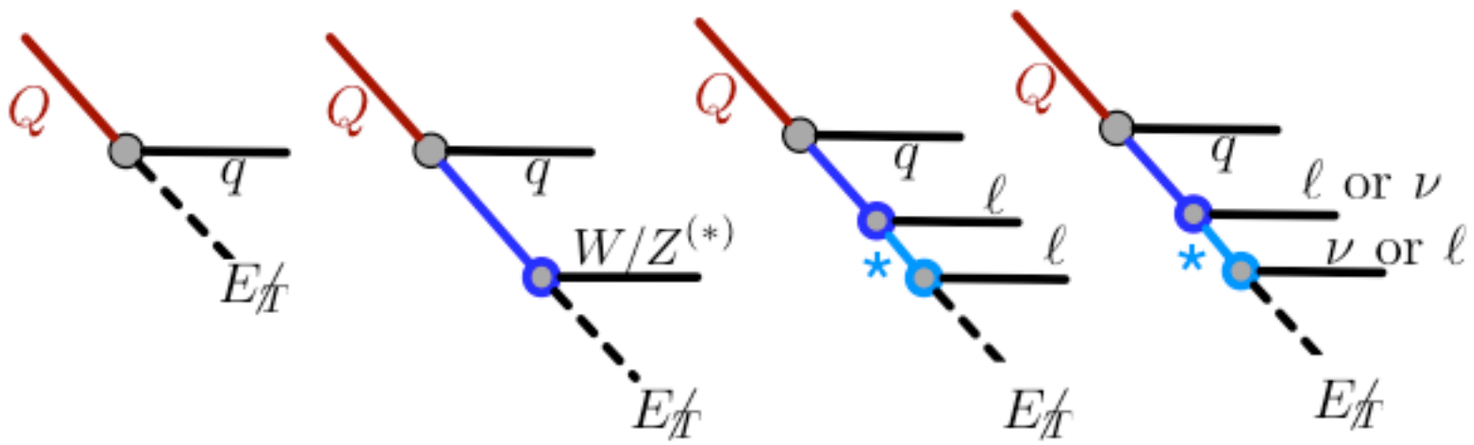
- Leptons imply cascade decays:

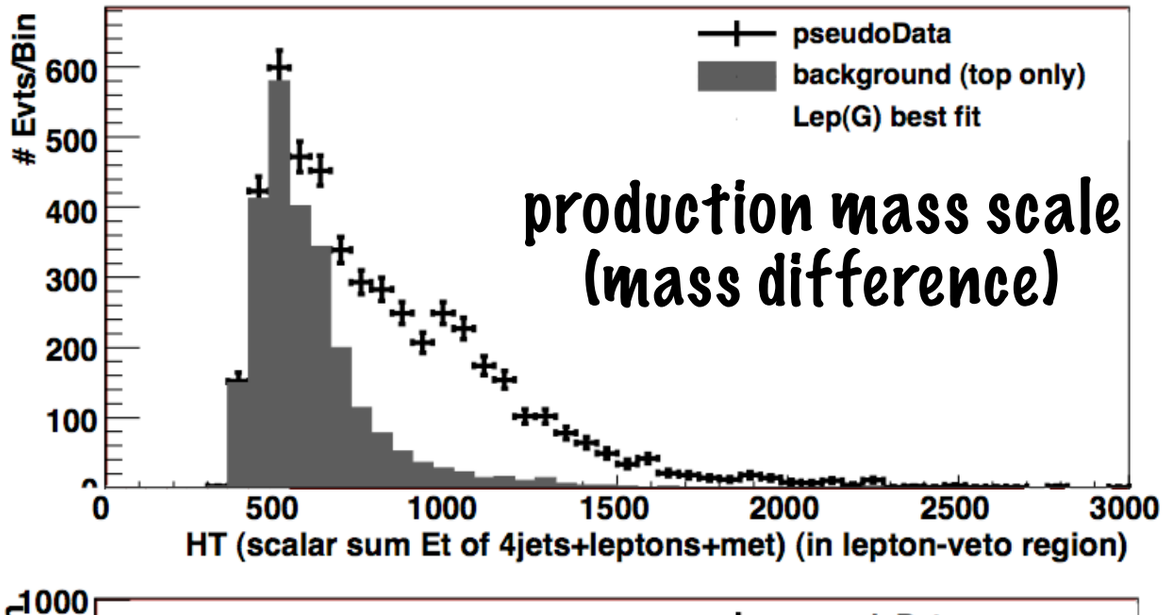


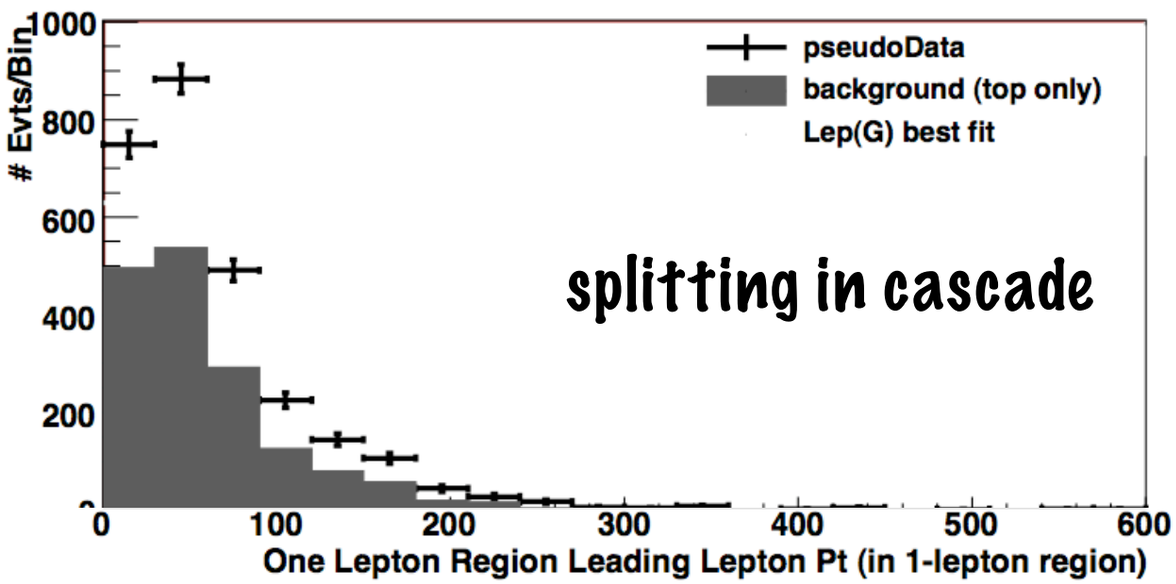
-How do we distinguish?
-What are masses?
-Are one or multiple modes present?

+ perhaps longer cascades ...or top quarks?

Distributions

- ≥3 Jet, 1 Lepton+MET

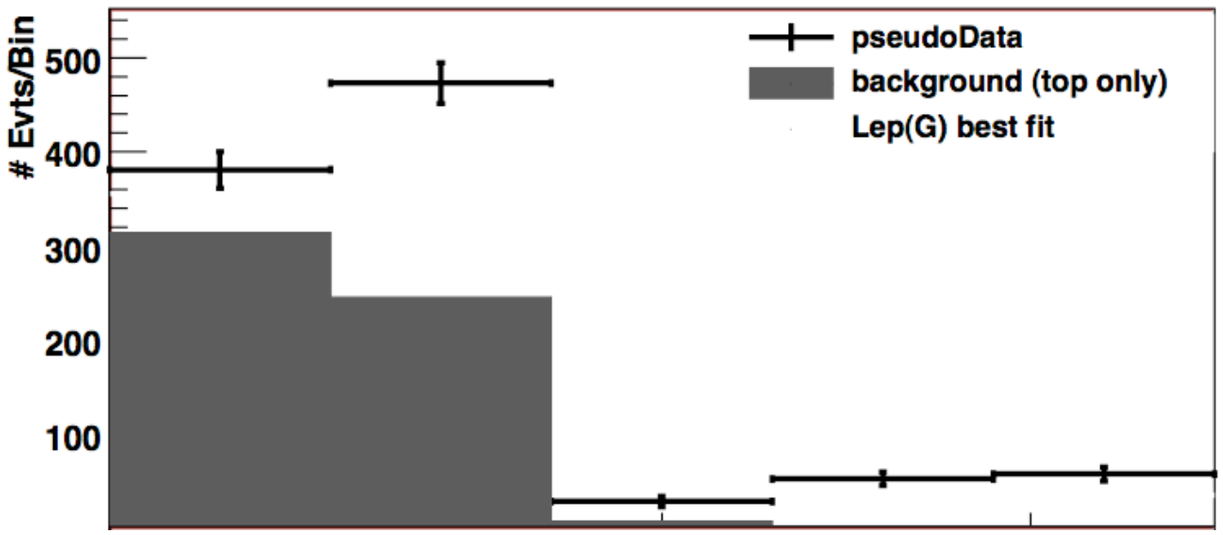




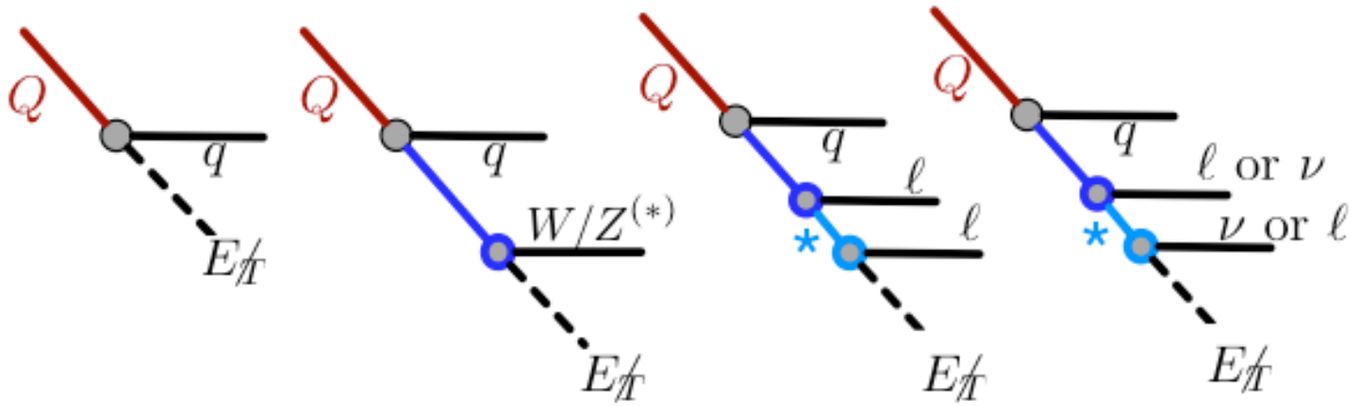
MET, jet p_T's, ... jet multiplicity

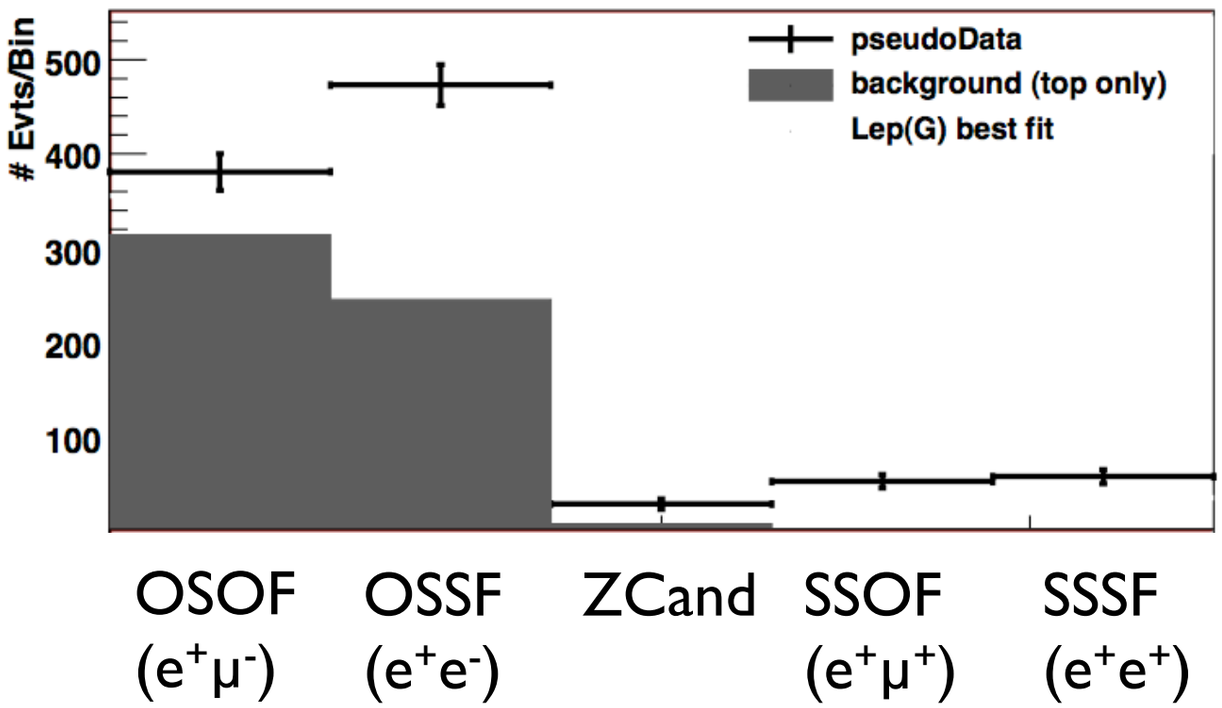
- ≥2 Jet,2Lepton+MET

Same kinematic plots,
dilepton mass, ...



Branching Ratios





5 params and 3 independent counts in 2-lepton data (under-constrained)

Additional constraint from 0-, 1- or 3-lepton data

AMBIGUITY:

W goes to 1 lepton (30%) or 0 leptons (70%).

Hard to distinguish W's from combination of direct and one-lepton cascade

Branching Ratios (Best Fits)

Parameters that fit counts, HT, p_T(lepton):

Model / Limit	$M_{Q/G}$-M_I-M_L^*-M_{LSP}	$\sigma(pb)$	B_{ll}	$B_{\nu l+l\nu}$ $(\frac{B_{\nu l}}{B_{\nu l+l\nu}})$	B_{LSP}	B_W	B_Z
Lep(Q) / $B_W = 0$	500-440- – -100	46.1	0.0151	0.4155/–	0.5274	–	0.0420
Lep(Q) / $B_{\ell\nu} = 0$	650-440- – -100	12.8	0.0485	–	0.0	0.9244	0.0270
Lep(G) / $B_W = 0$	650-440- – -100	13.6	0.0507	0.2928/–	0.5840	–	0.0725
Lep(G) / $B_{\ell\nu} = 0$	700-440- – -100	11.5	0.0636	–	0.0	0.8710	0.0654

ambiguity – affects conclusions!

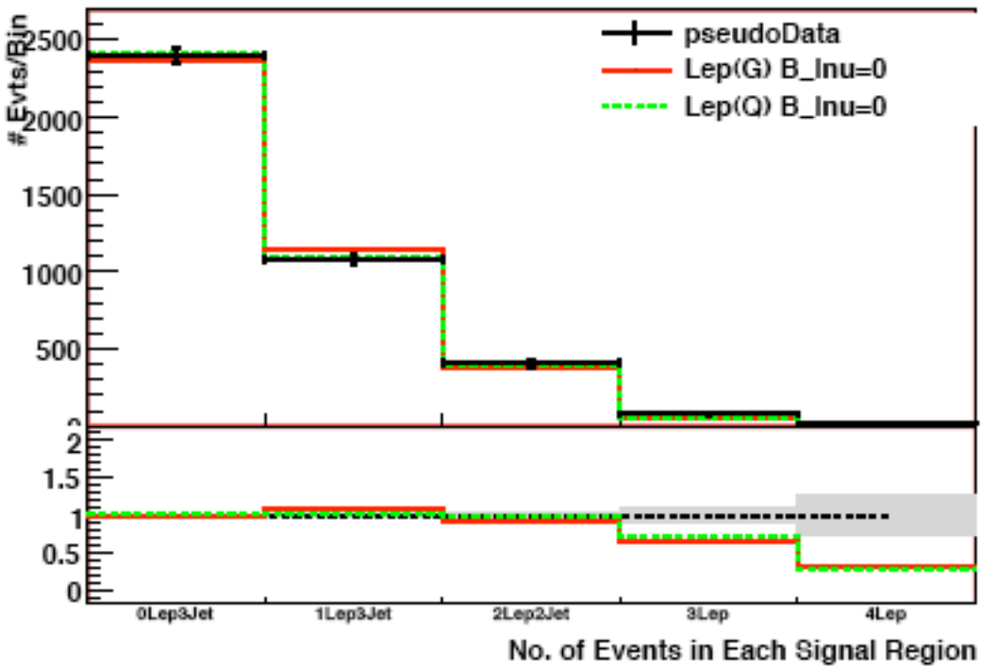
big syst. effect on masses, xsec

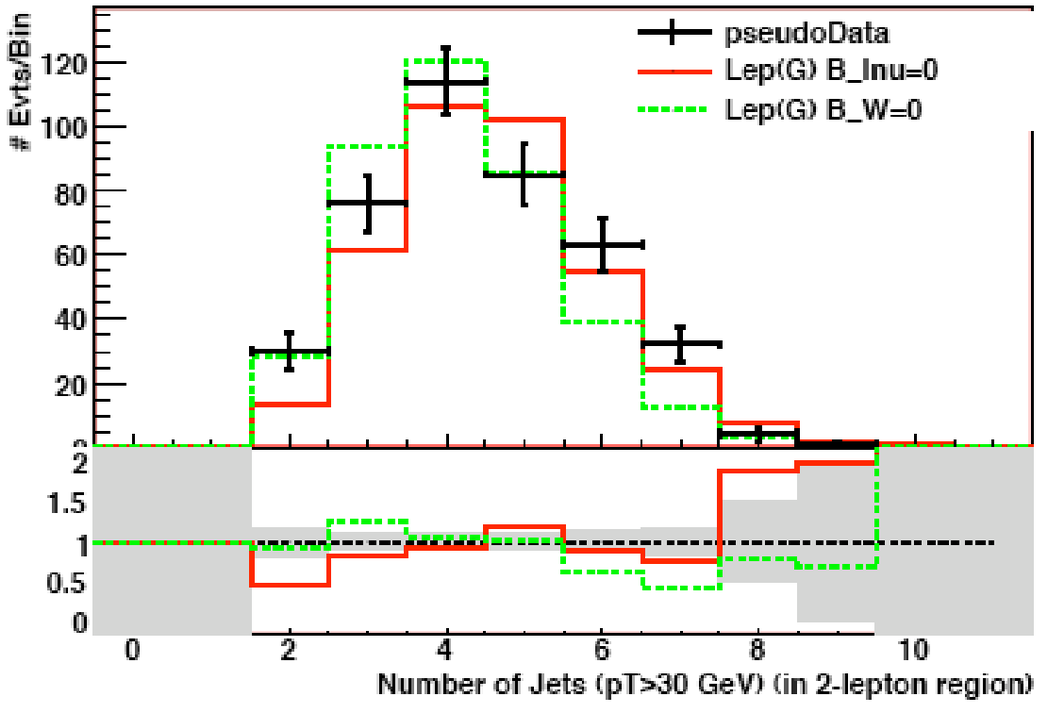
some branching ratios more stable than others

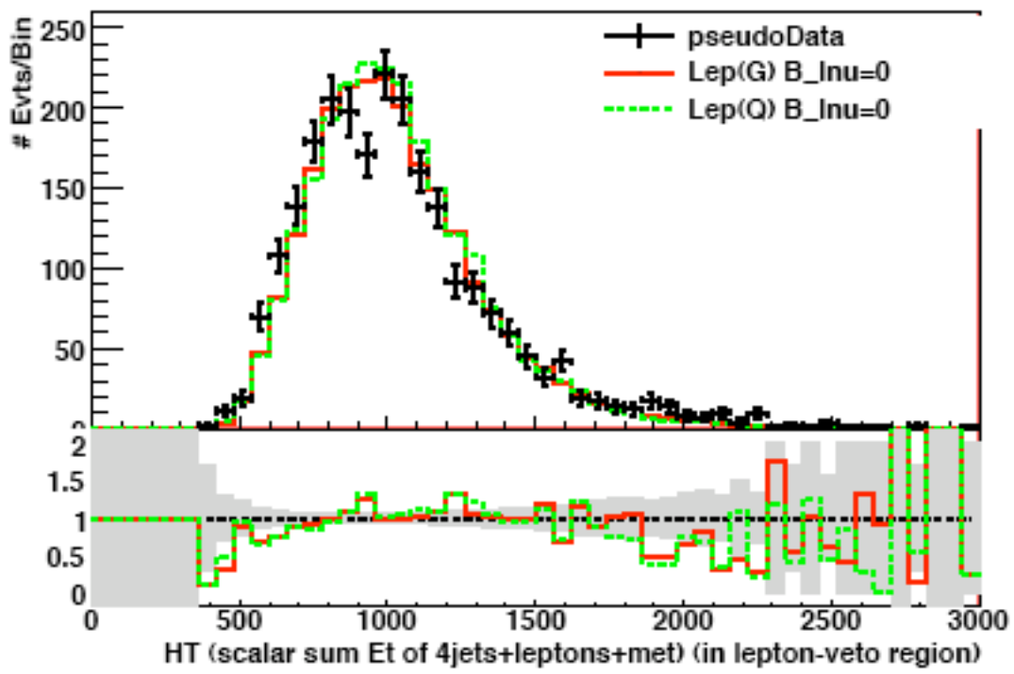
Theorist on the outside **can** estimate these from 1,2-lepton data...
but given large systematics, we're likely to make mistakes combining channels reliably

What the best fits look like

Counts, jet kinematics reproduced well!



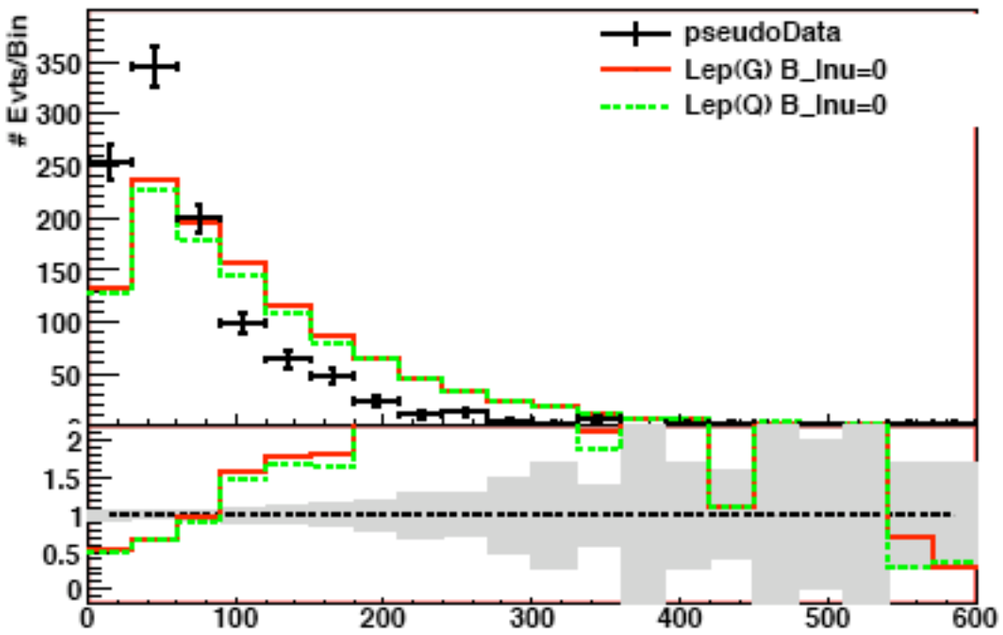




(also jet p_T plots, MET...)

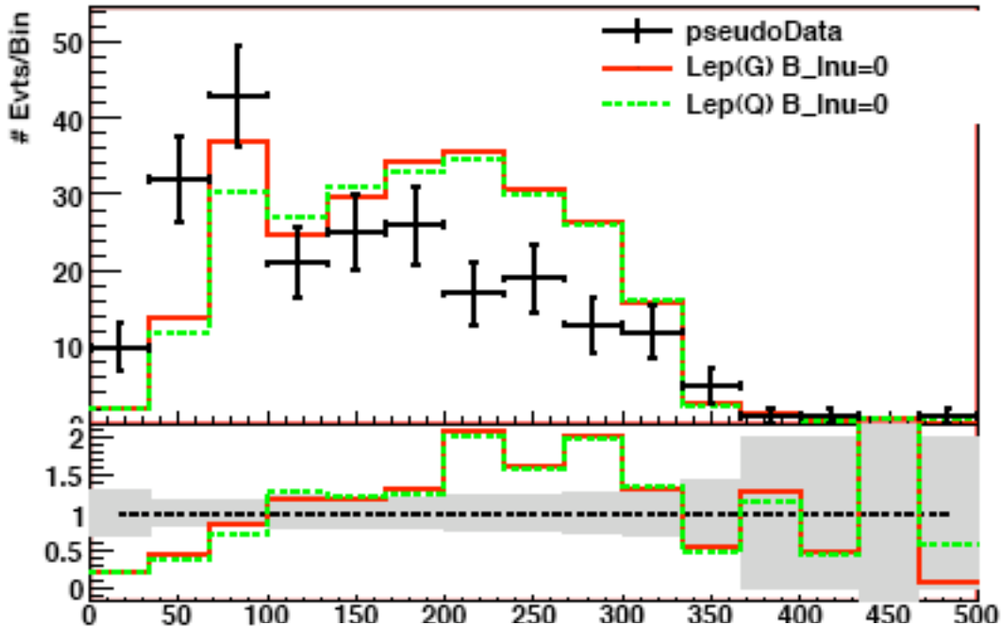
What the best fits look like

(1-lepton plots)



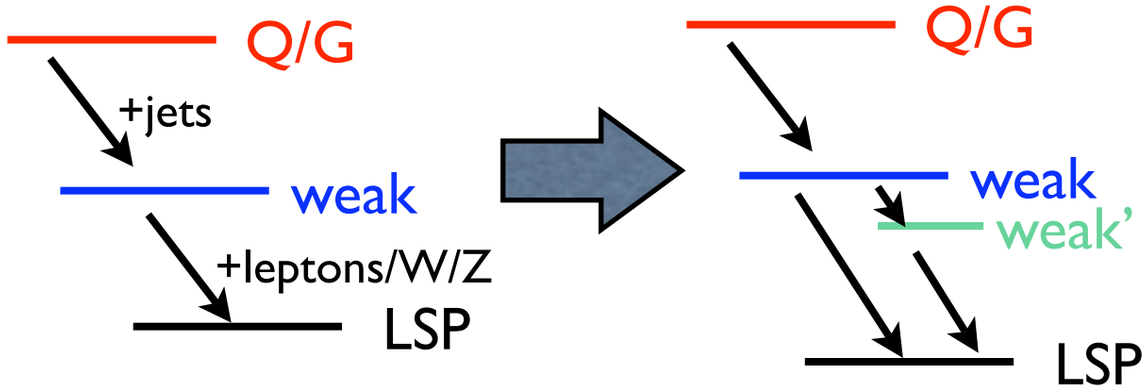
Lepton p_T

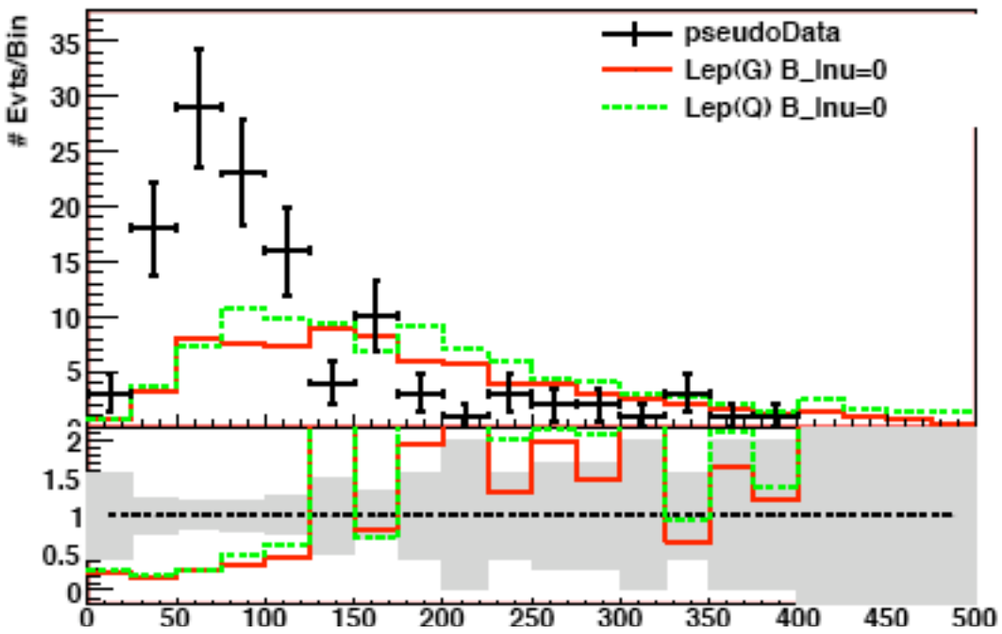
(2-lepton plots)



OSSF (e^+e^-) invariant mass

Cannot reproduce the data with these models (or with tops). Robustly demonstrating this is hard, but provides STRONG EVIDENCE for more complex source of soft, flavor-uncorrelated leptons.





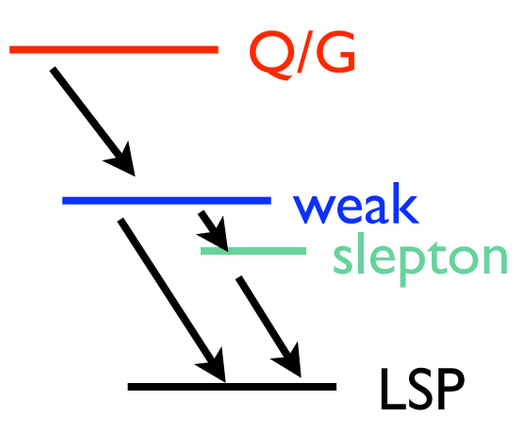
Opposite-flavor (eμ) invariant mass

(Lone theorist with PGS can NEVER draw this conclusion with confidence)

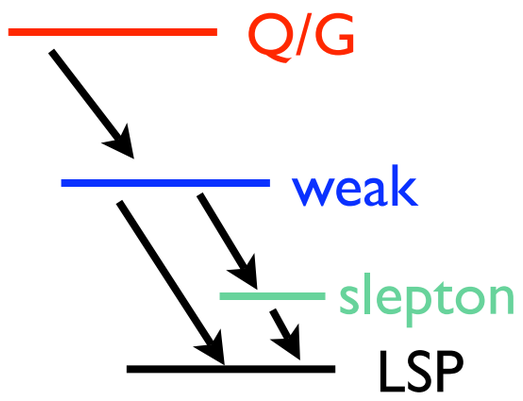
Interim Conclusions and Questions

- Data consistent with squark and/or gluino production
- Need two-stage cascades to explain data
- Large rate of single-lepton cascade (+ precise numbers)

- I play around in PGS to try to reproduce the 2-lepton counts...on-shell slepton and **charginos**.



or



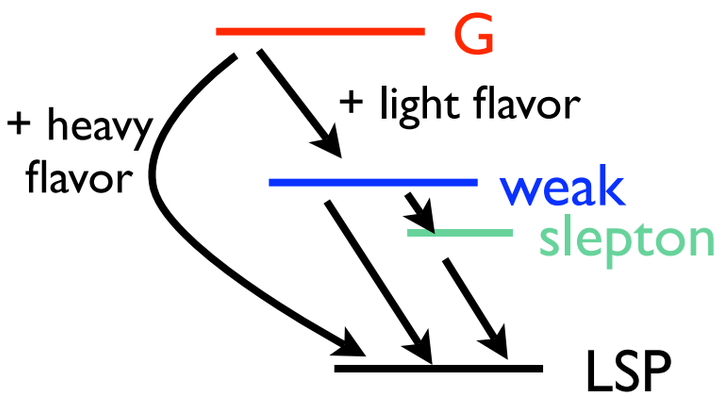
?

See if this can be confirmed from kinematics – dilepton invariant mass should have an EDGE
(this is sub-dominant source of 2-lepton events, edge didn't jump out but this motivates looking harder)

I can find SUSY models with both hierarchies, see if **any** of them are consistent with larger set of distributions in data...

More conclusions from b-jet studies

- Gluon-partner production models work better, but need ~60% branching fraction to heavy flavor. **Not** flavor-universal! (there may also be Q production)
- Lepton-rich events have *fewer* b-jets (opposite of top) – and this is not just a selection bias



(G decay could have intermediate on-shell Q's)

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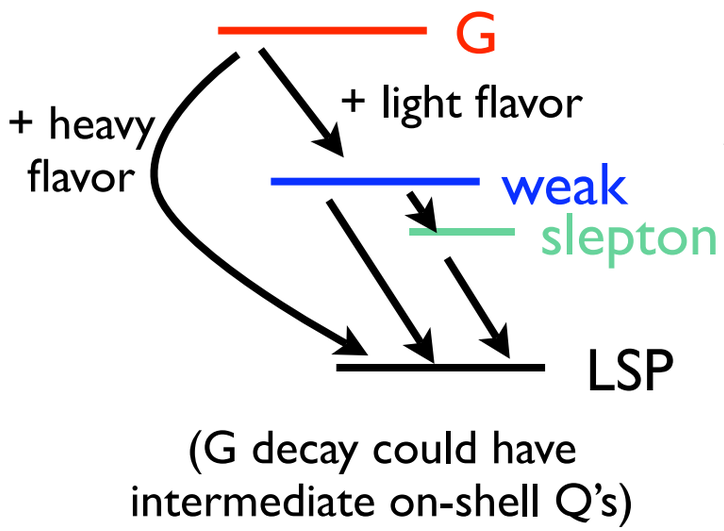
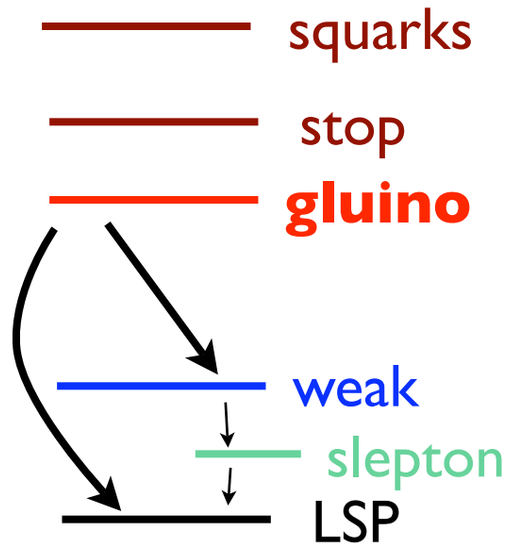
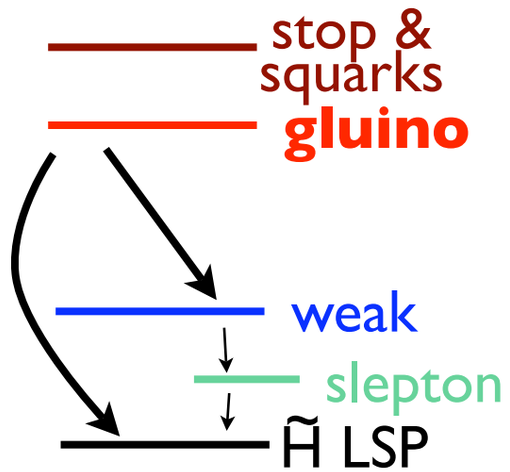


(G decay could have intermediate on-shell Q's)

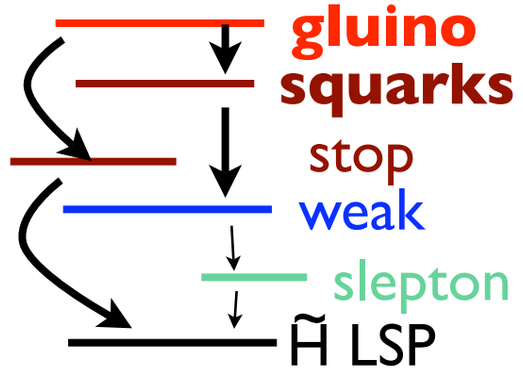
three SUSY ideas (we found reasonable models for two)



top dominates because stop is lighter



top dominates because it has biggest coupling



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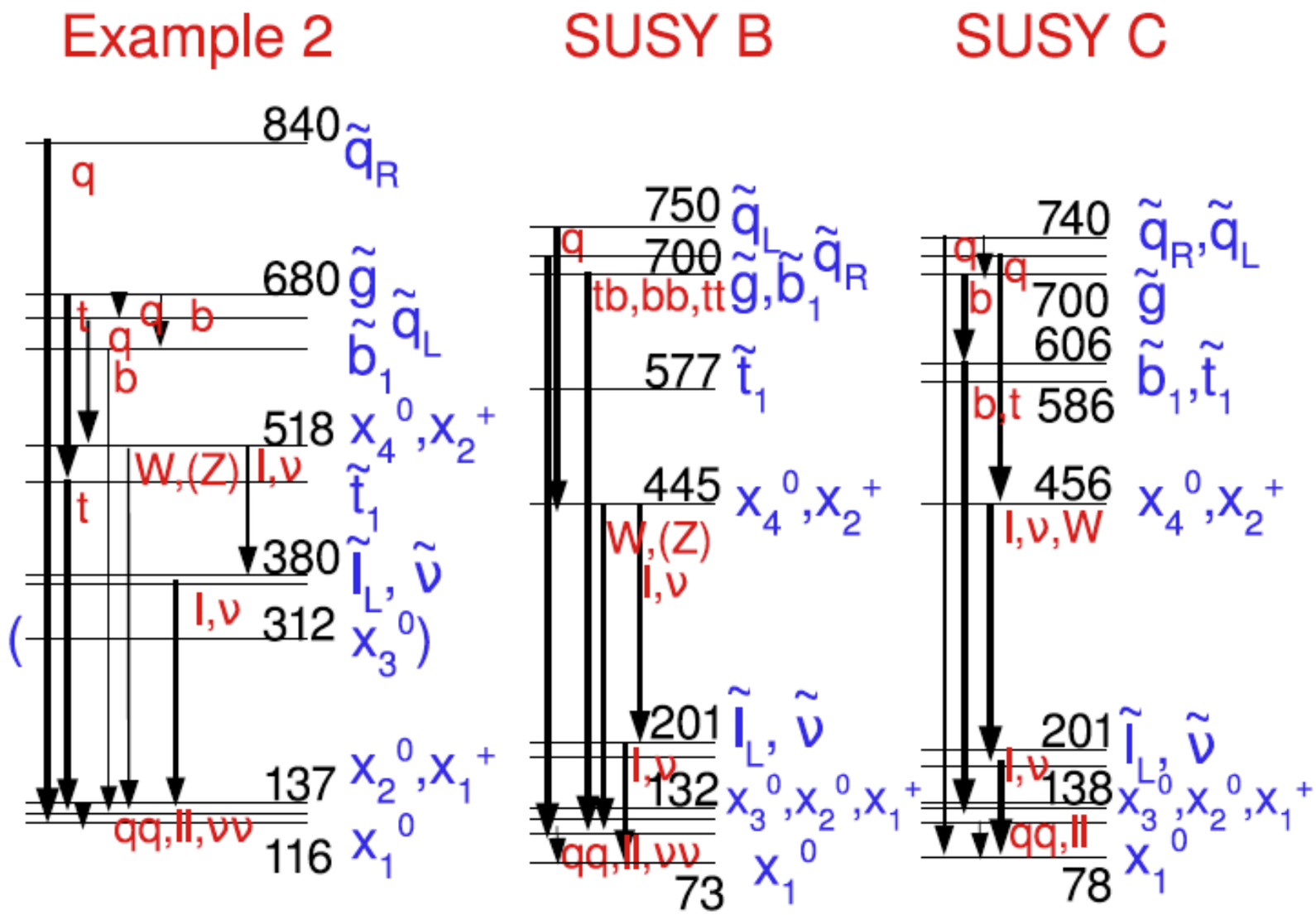
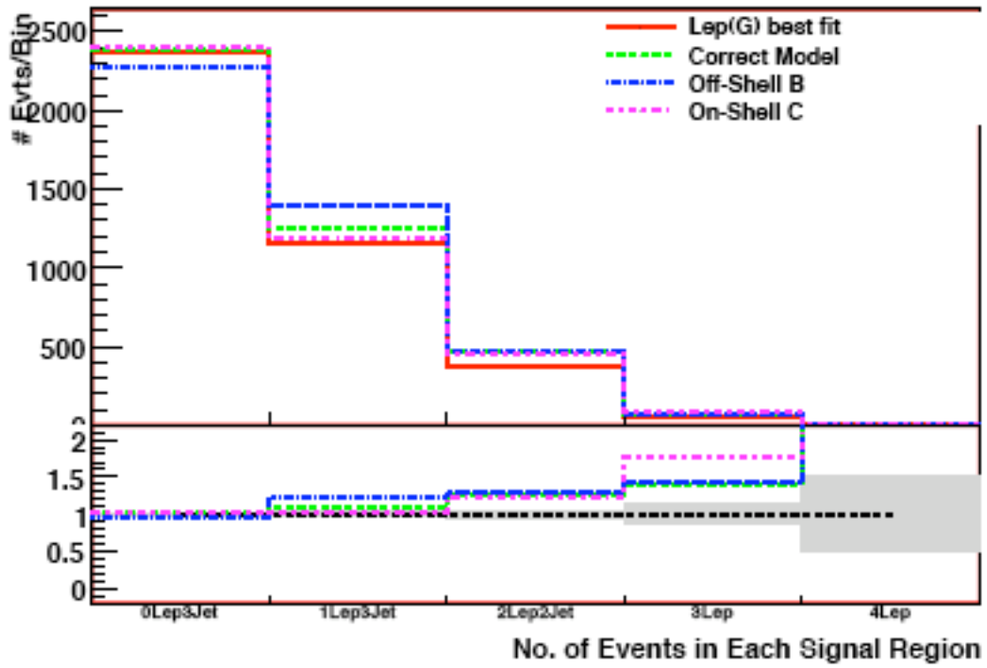
Three very different SUSY models:

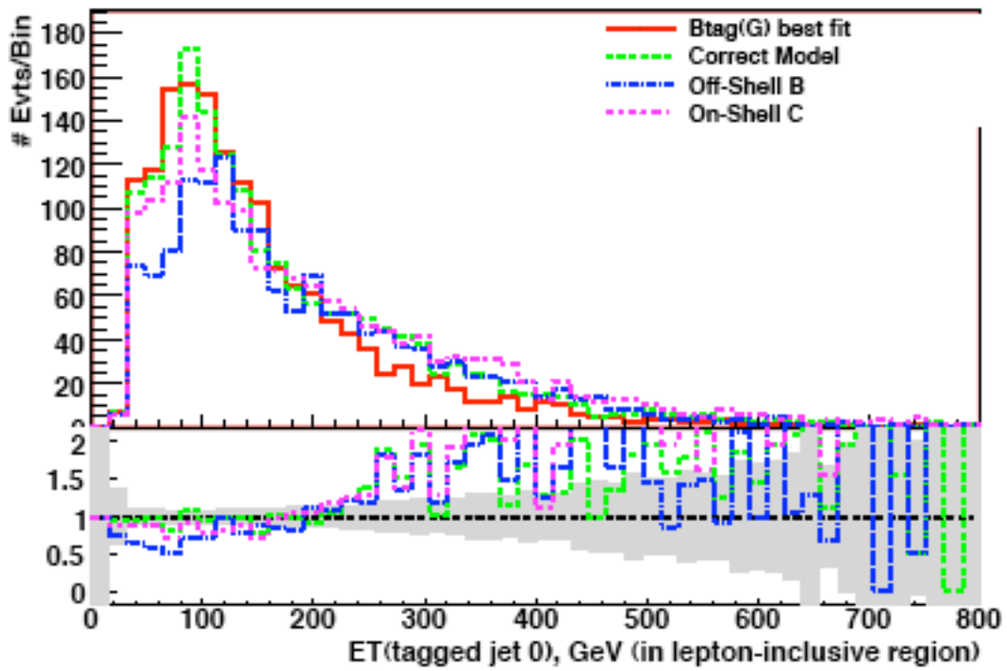


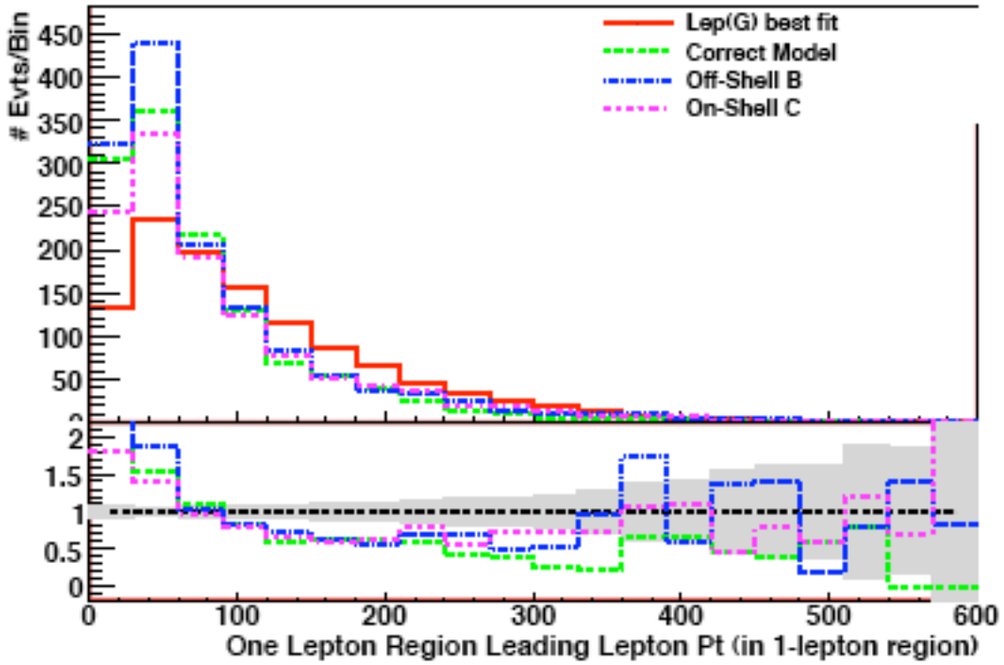
Different combinations of on/off-shell decays,
Bino much heavier/slightly lighter than Higgsino

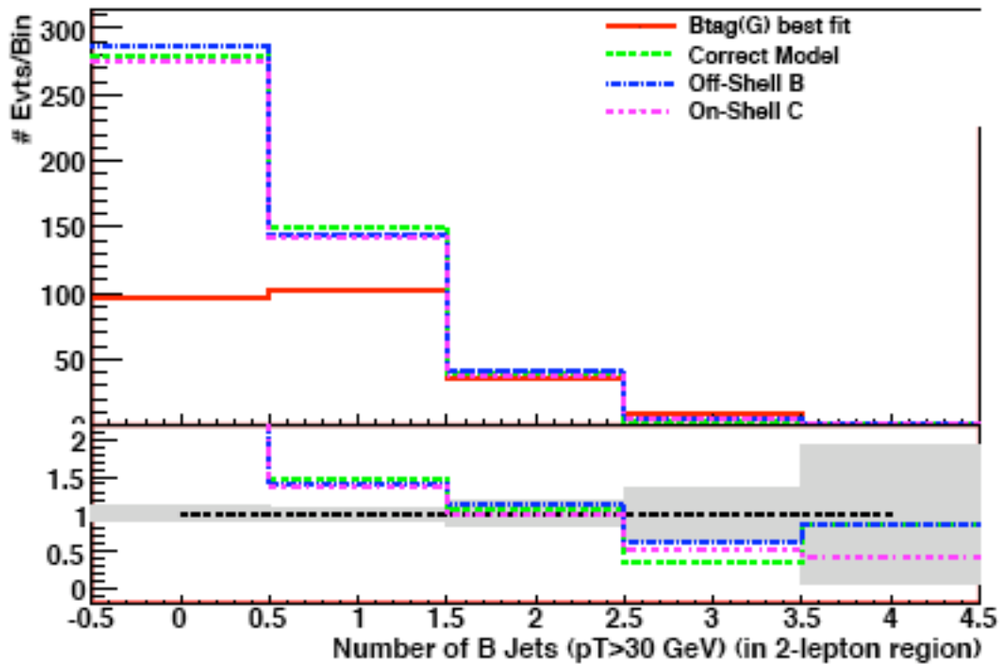
Might find one by parameter scan, another by good fortune/persistent theorist. But clear ***description of data*** helps to bring them all to light.

Finding multiple models not a weakness of our structure, but ***real ambiguity*** with "basic" distributions and low stats.









Fortunately, once we have reduced the problem to "Point A vs. Point B," many more sophisticated measurement techniques apply (cf most of today's talks)

- Pre-existing parameter space designed for jets+X+MET analyses (Simplified Models) allows thorough, **unbiased** exploration

- **Build evidence for particles** needed to explain structure of distributions

- Theorists can help find reasonable models, but we can't do it on our own with distributions