Lepto-SUSY

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with
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arXiv:0903.5305 [hep-ph]

Overview

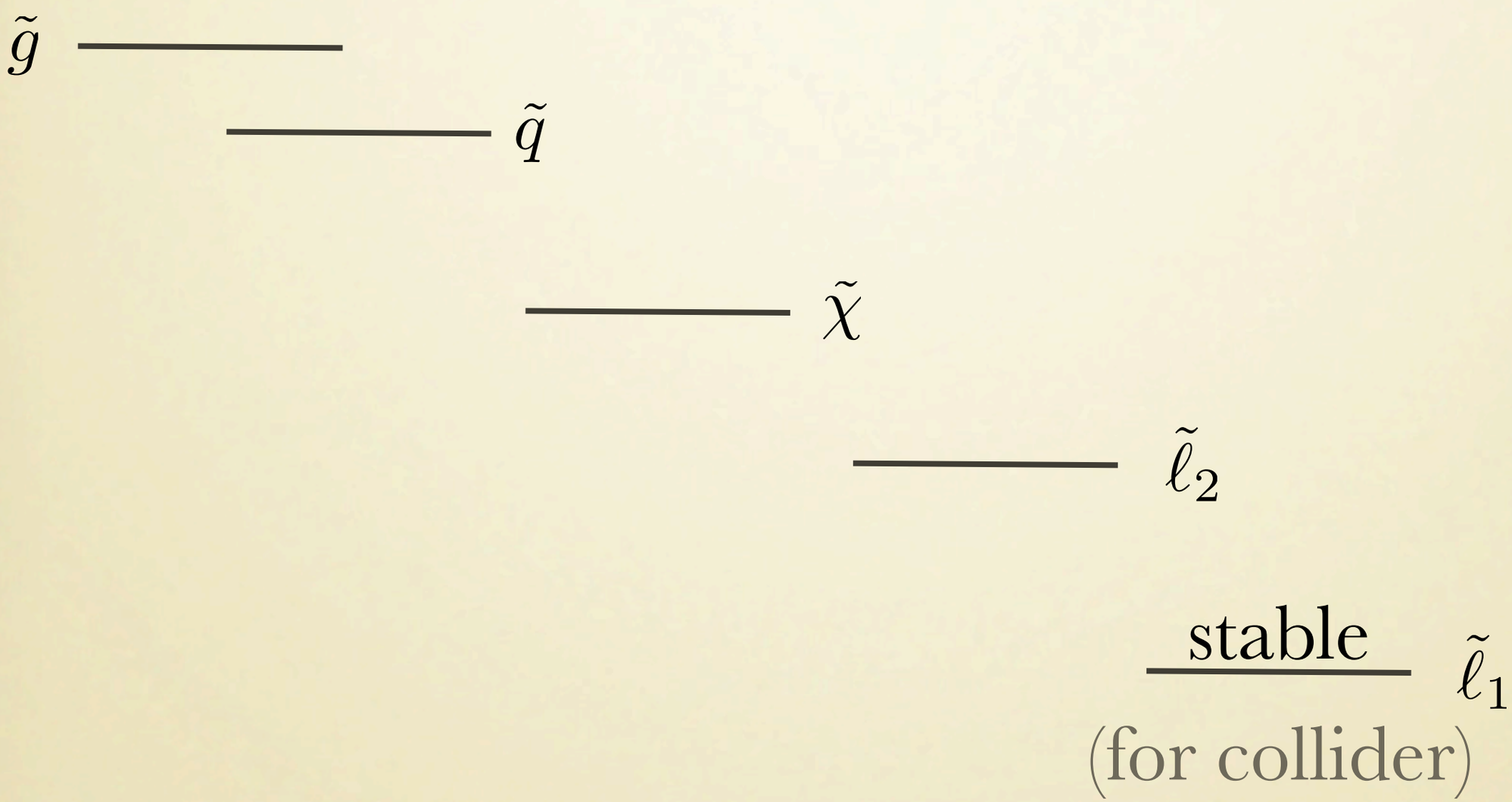
Part 1 - Lepto-SUSY basics

Part 2 - Long-lived sleptons

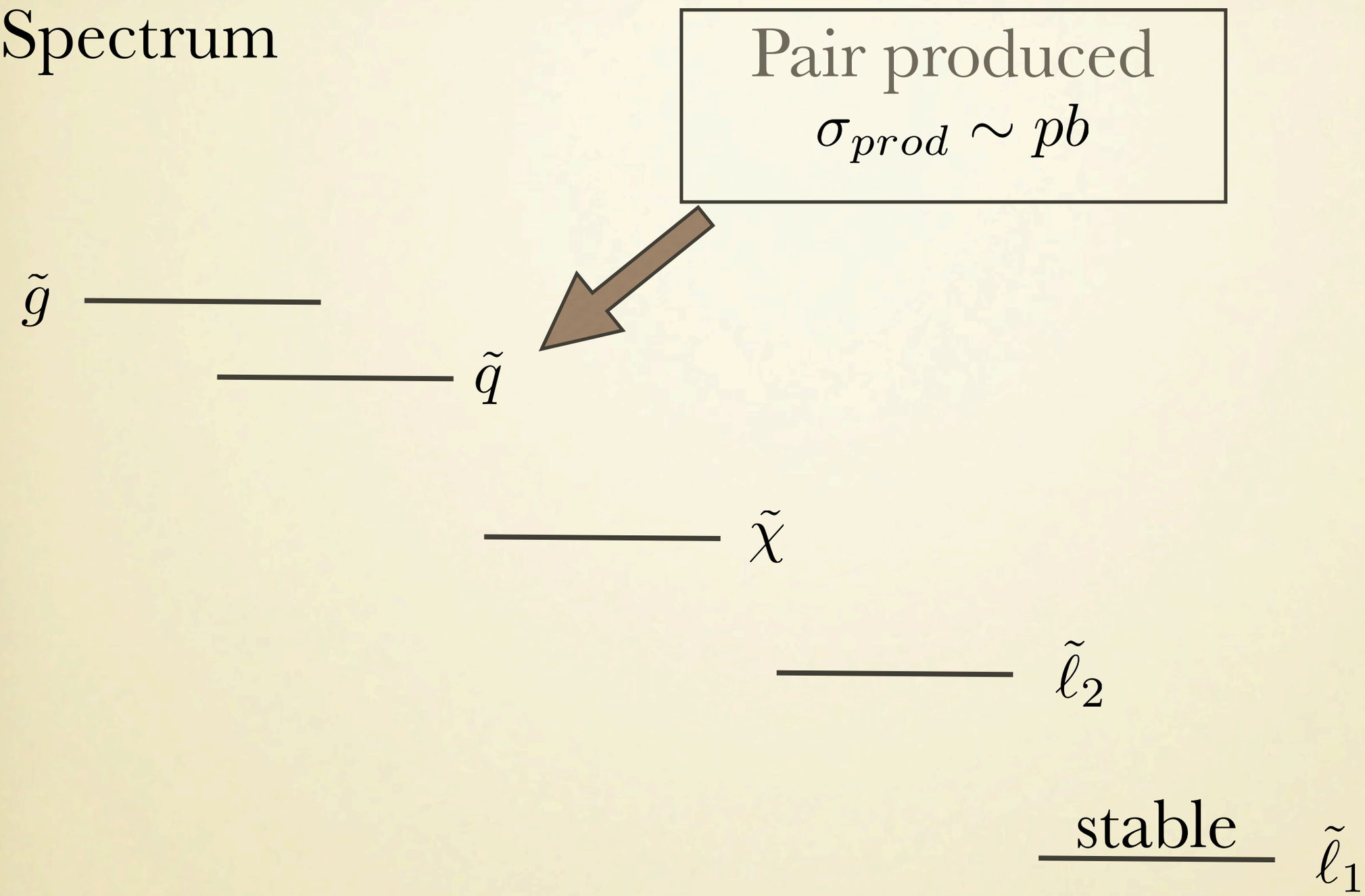
Part 3 - Higgs decays

What if?

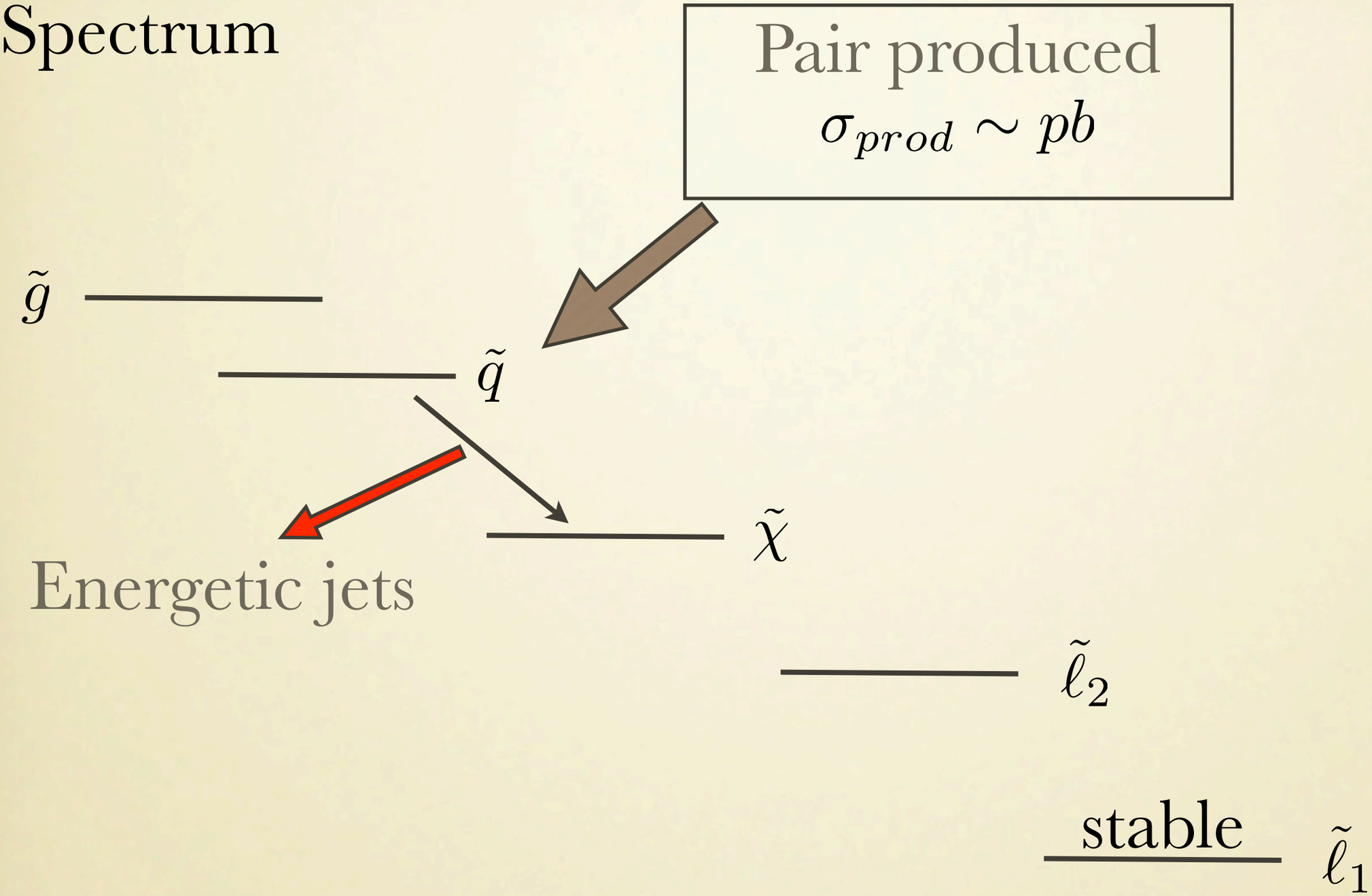
Spectrum


$\tilde{g}$
$\tilde{q}$
$\tilde{\chi}$
$\tilde{\ell}_2$
stable
$\tilde{\ell}_1$
(for collider)

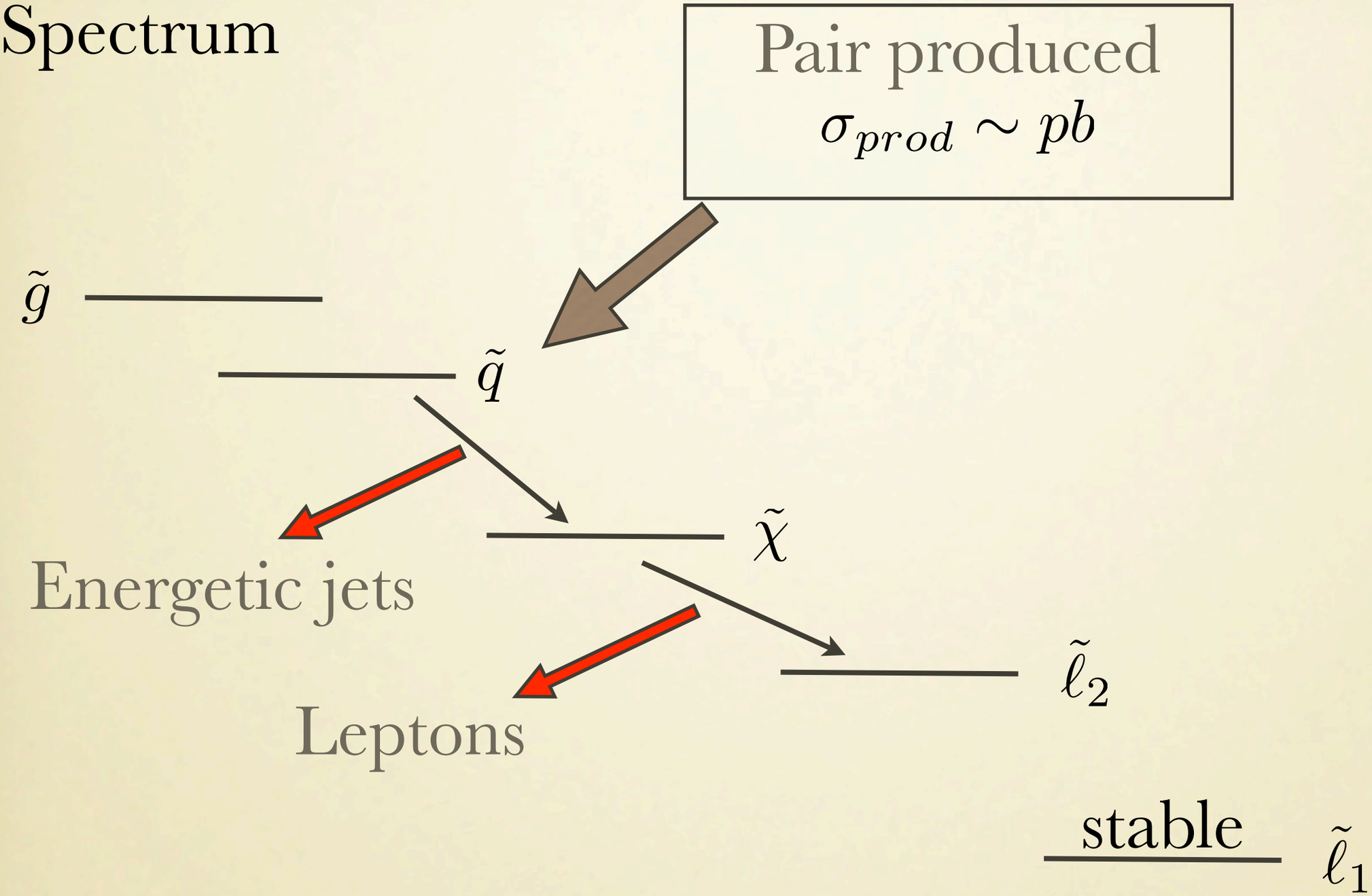
Spectrum


Pair produced
$\sigma_{prod} \sim pb$
$\tilde{g}$
$\tilde{q}$
$\tilde{\chi}$
$\tilde{\ell}_2$
stable
$\tilde{\ell}_1$

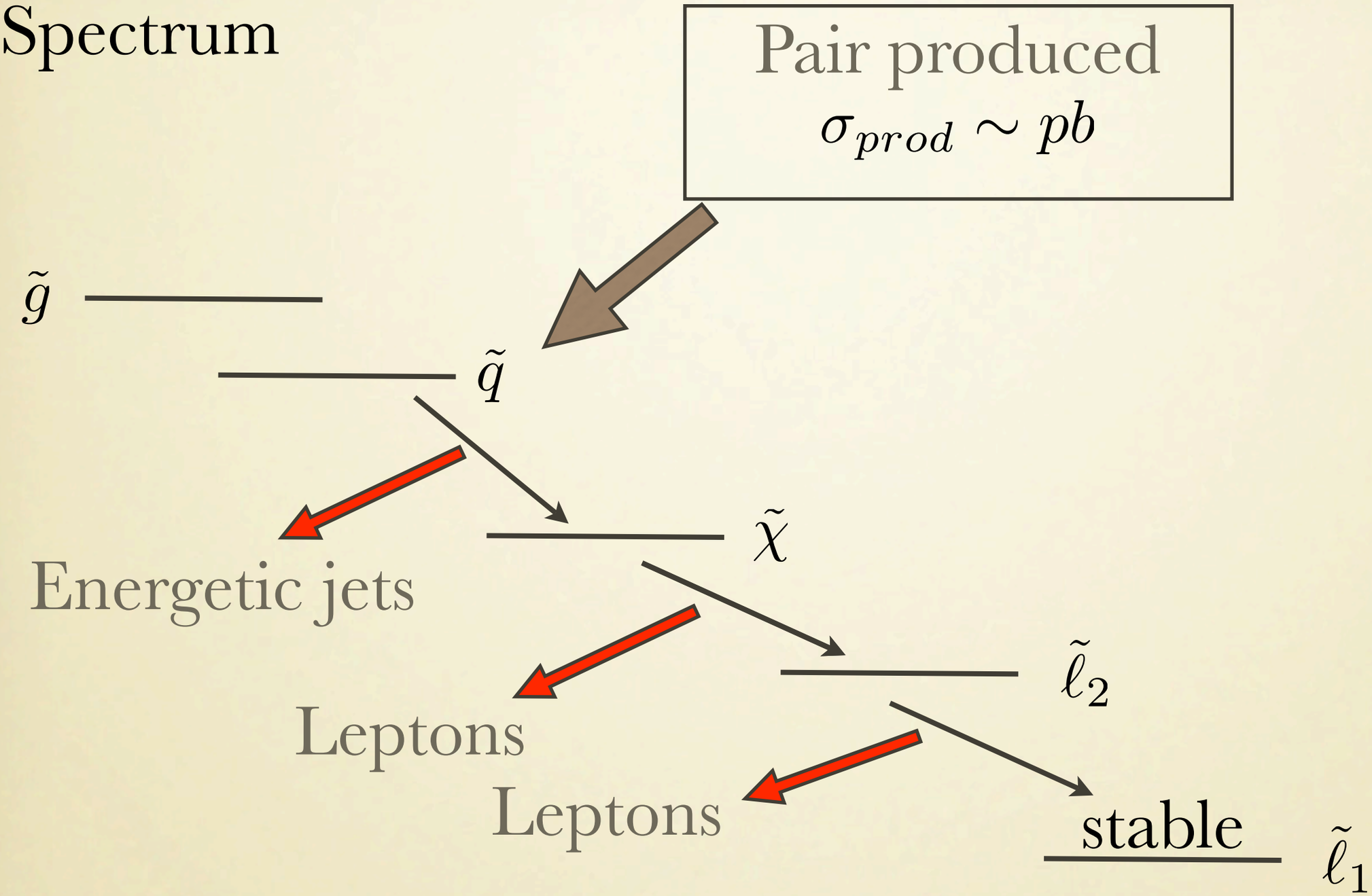
Spectrum


Pair produced
$\sigma_{prod} \sim pb$
$\tilde{g}$
$\tilde{q}$
$\tilde{\chi}$
Energetic jets
$\tilde{\ell}_2$
stable
$\tilde{\ell}_1$

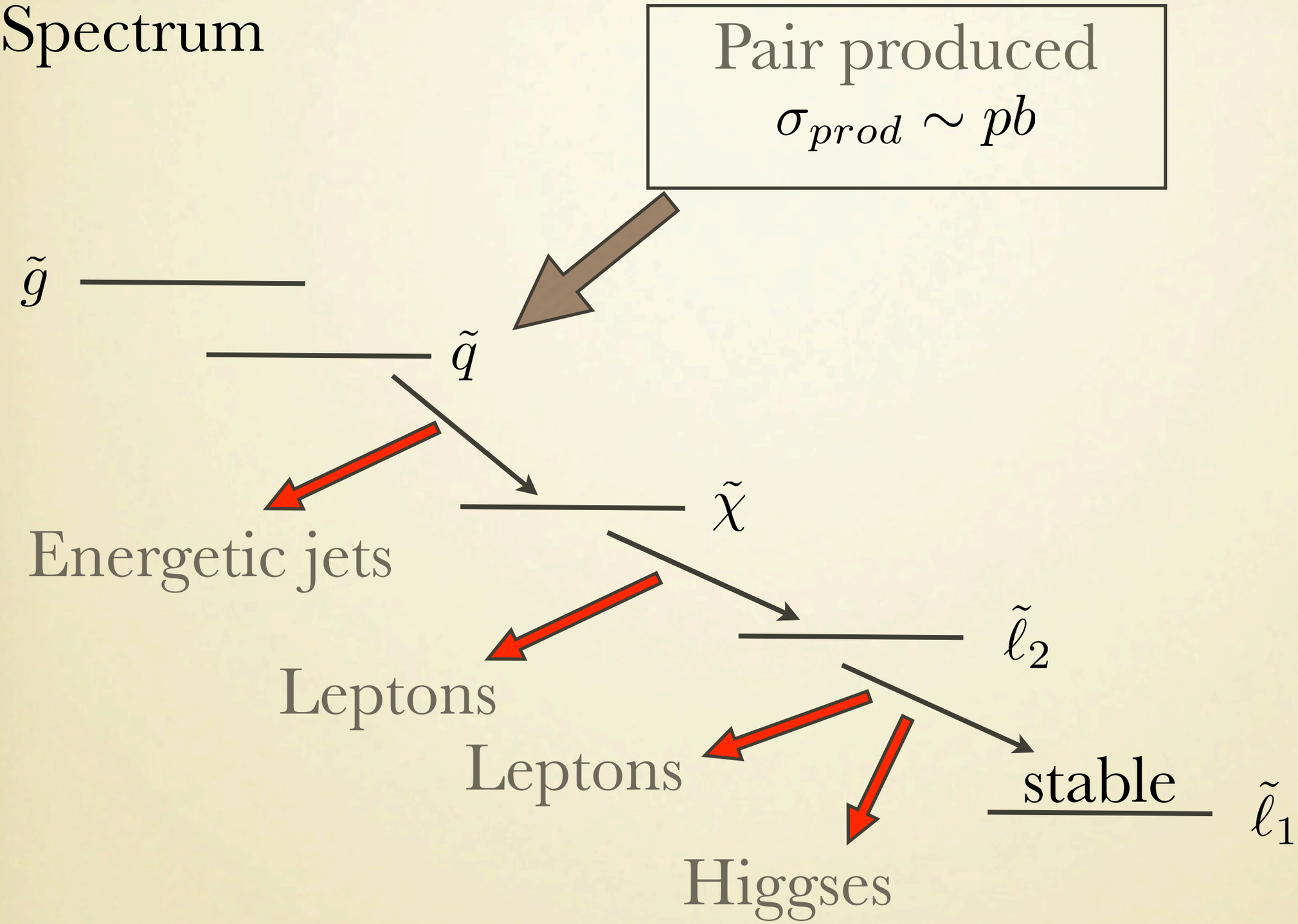
Spectrum


Pair produced
$\sigma_{prod} \sim pb$
$\tilde{g}$
$\tilde{q}$
$\tilde{\chi}$
Energetic jets
$\tilde{\ell}_2$
Leptons
stable
$\tilde{\ell}_1$

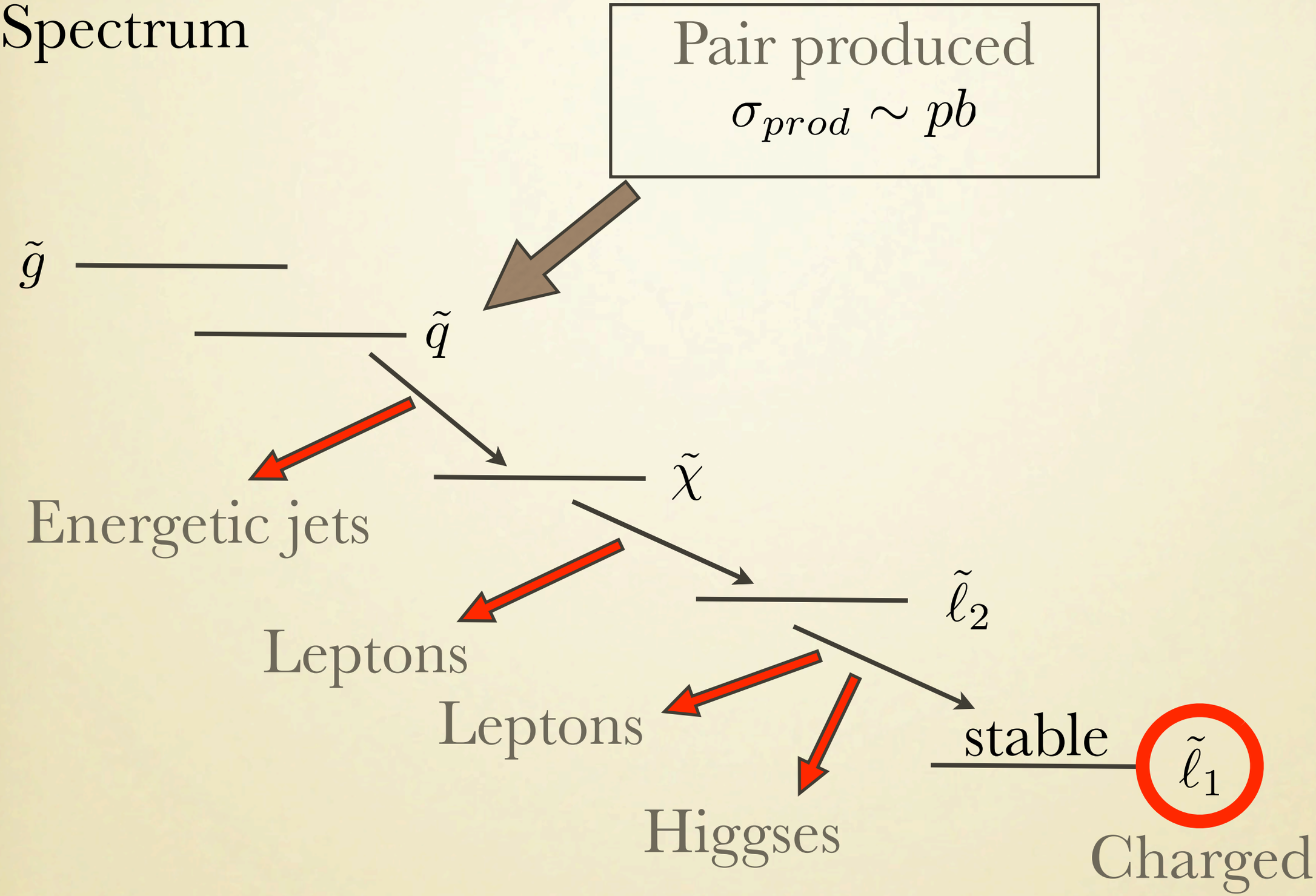
Spectrum


Pair produced
$\sigma_{prod} \sim pb$
$\tilde{g}$
$\tilde{q}$
$\tilde{\chi}$
Energetic jets
$\tilde{\ell}_2$
Leptons
Leptons
stable
$\tilde{\ell}_1$

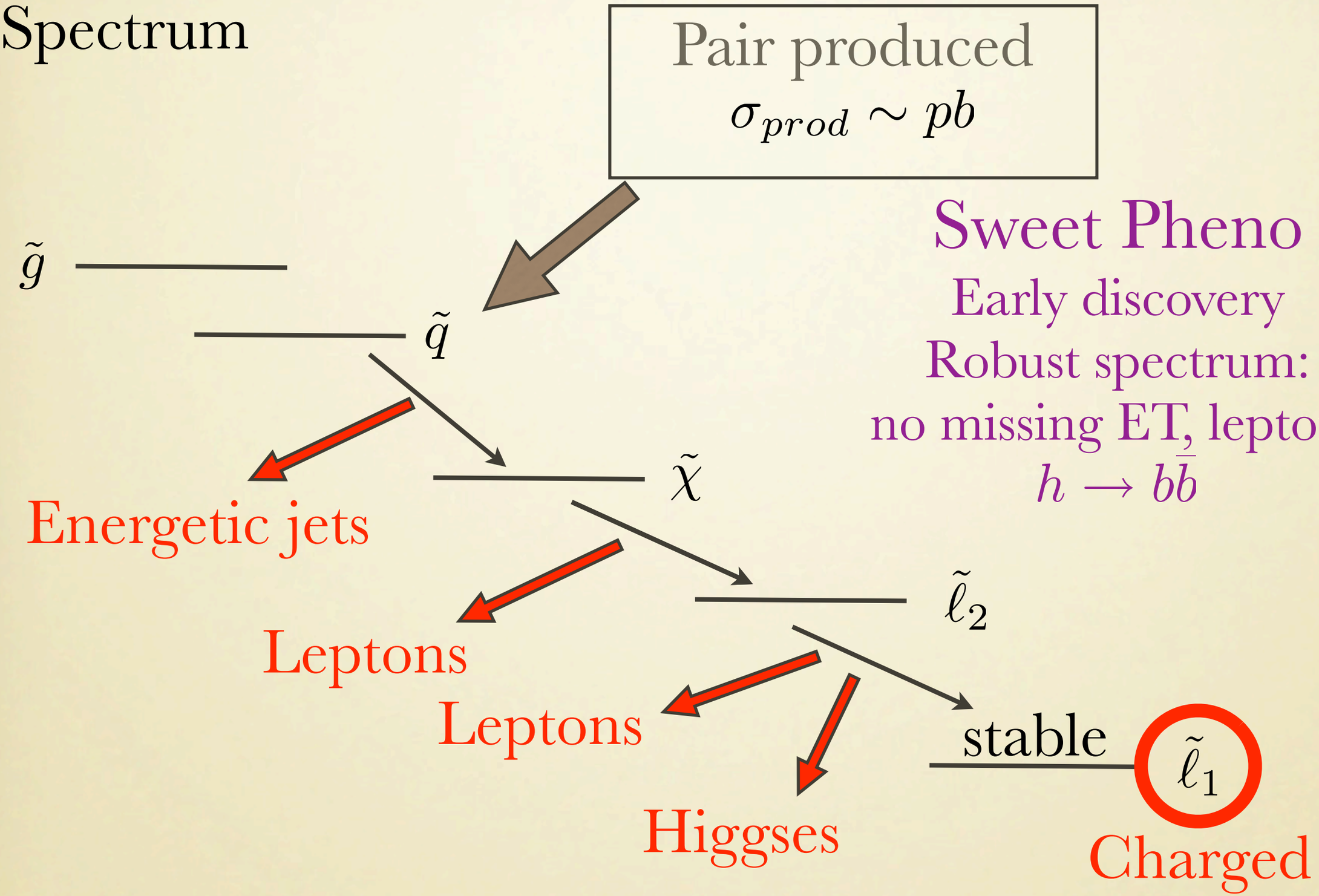
Spectrum


Pair produced
$\sigma_{prod} \sim pb$
$\tilde{g}$
$\tilde{q}$
$\tilde{\chi}$
Energetic jets
$\tilde{\ell}_2$
Leptons
Leptons
stable
$\tilde{\ell}_1$
Higgses

Spectrum


Pair produced
$\sigma_{prod} \sim pb$
$\tilde{g}$
$\tilde{q}$
$\tilde{\chi}$
Energetic jets
$\tilde{\ell}_2$
Leptons
Leptons
stable
$\tilde{\ell}_1$
Higgses
Charged

Spectrum



Sweet Pheno

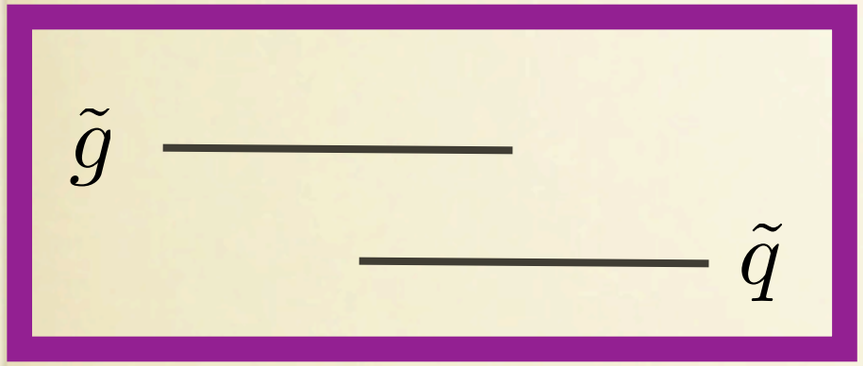
Early discovery

Robust spectrum:

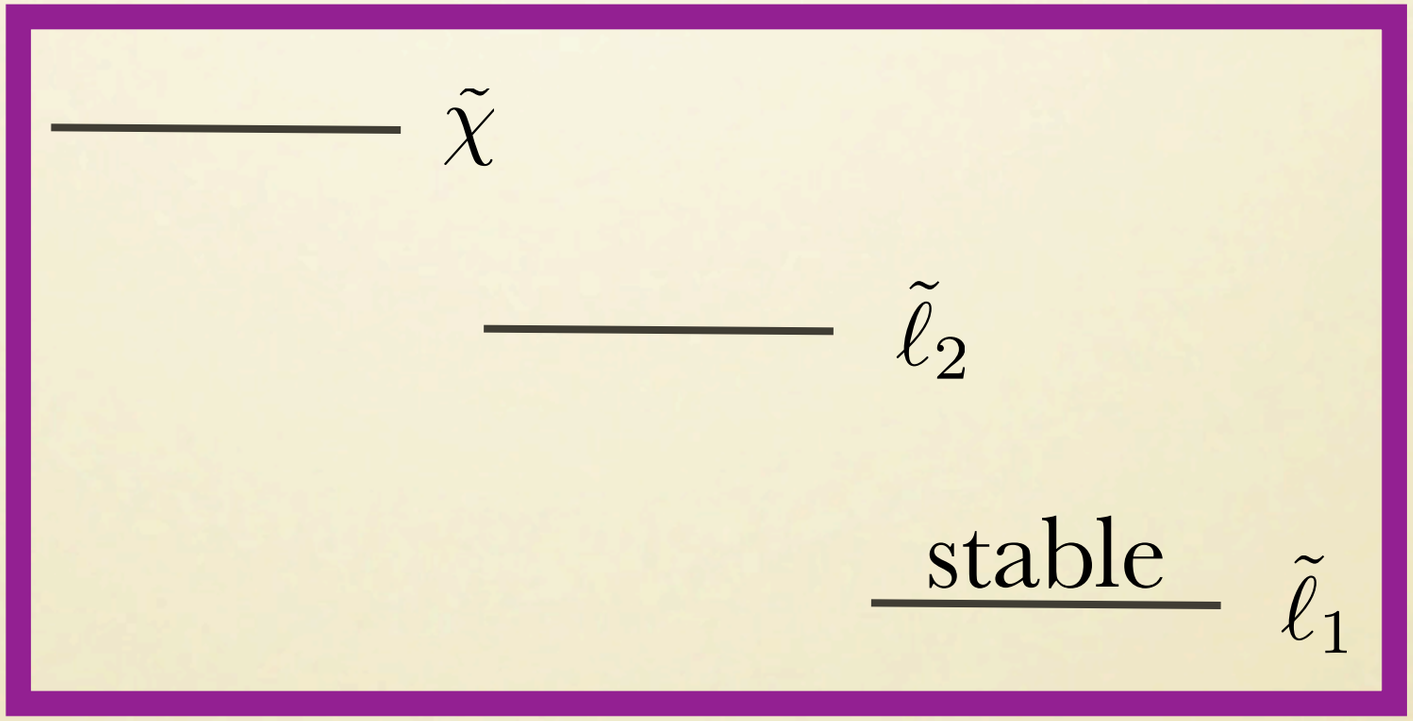
no missing ET, leptons

$h \to b\bar{b}$

How come?

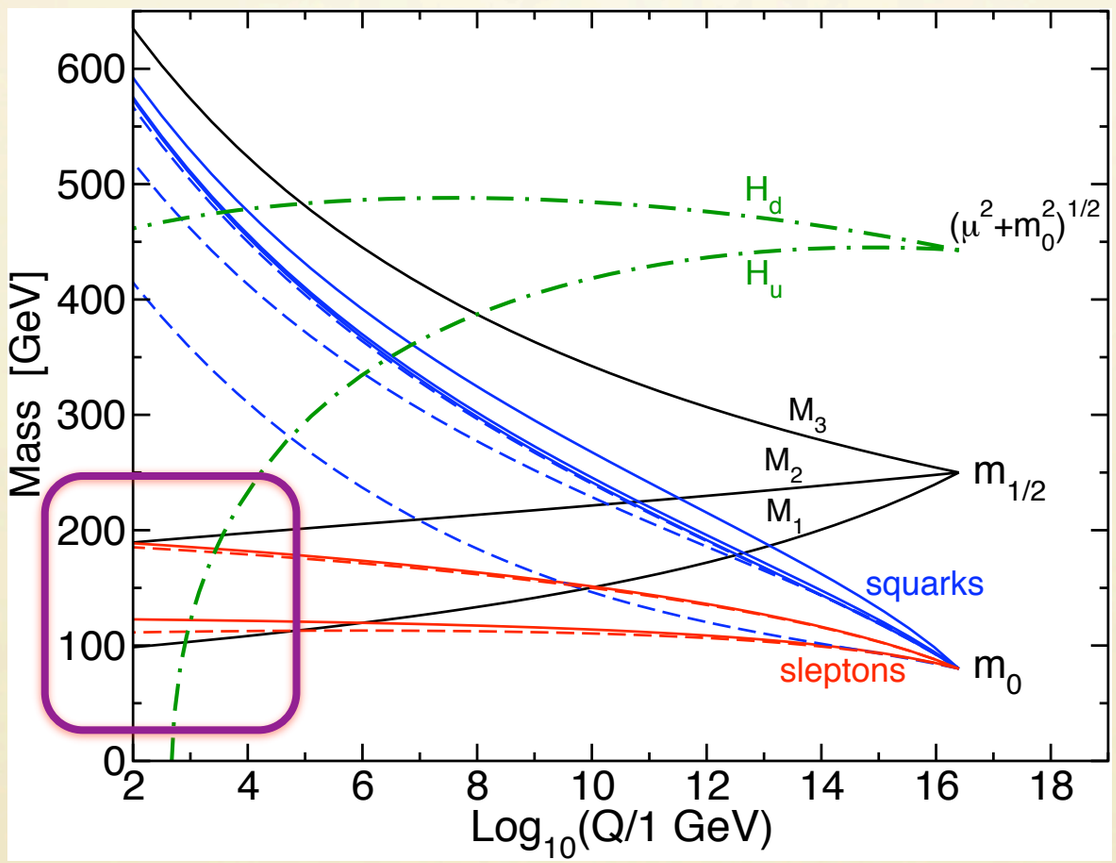


Gauginos heavier scalars



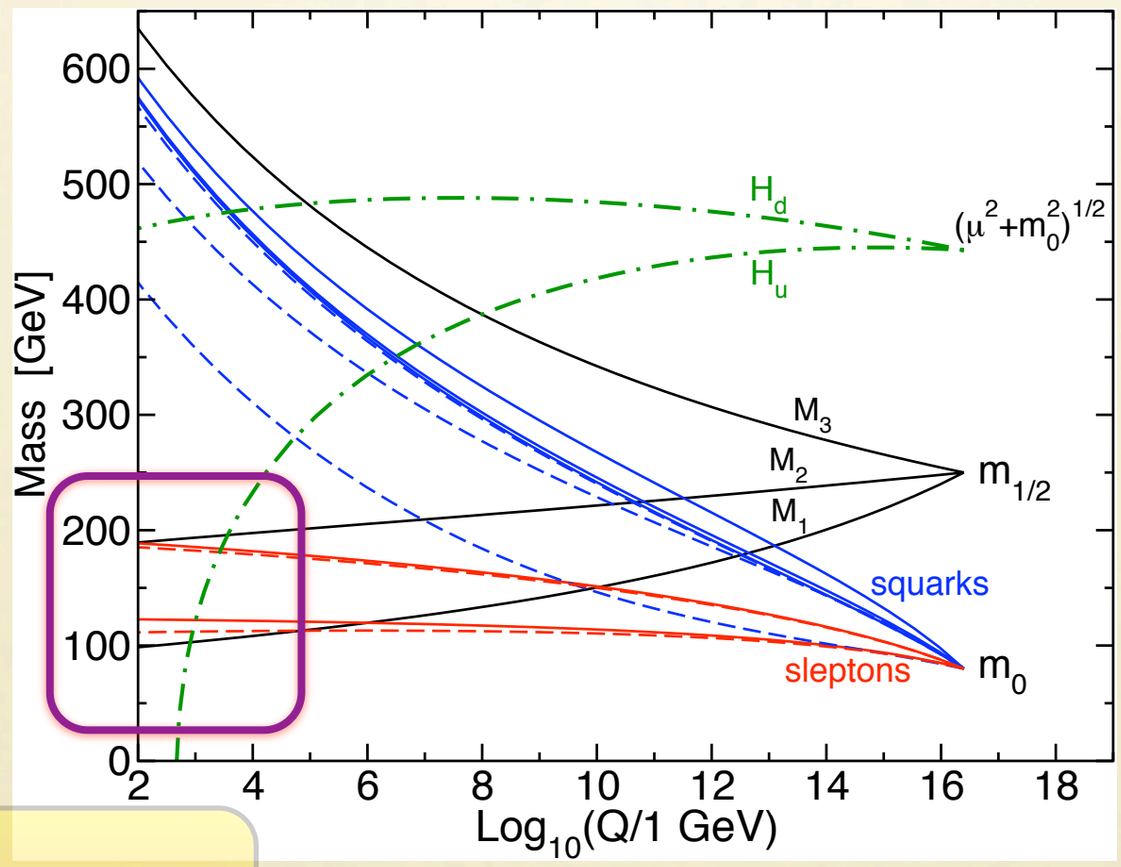
Close but no cigar

Not in mSUGRA, AMSB or GMSB benchmark points



From Martin, *A SUSY PRIMER*

Not in mSUGRA, AMSB or GMSB benchmark points



Long running

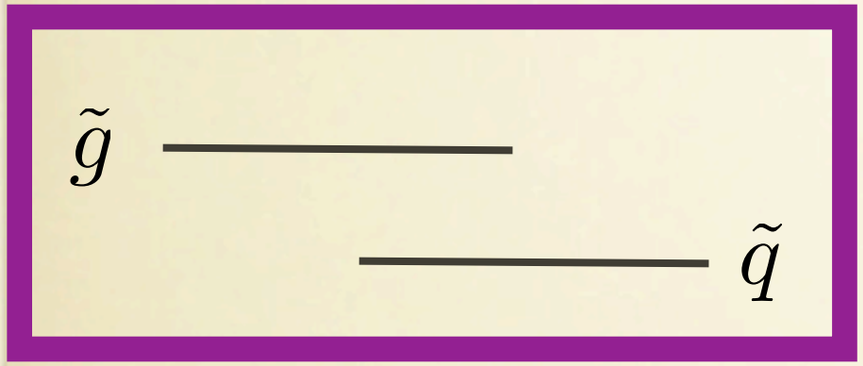
Neglect threshold effects

From Martin, *A SUSY PRIMER*

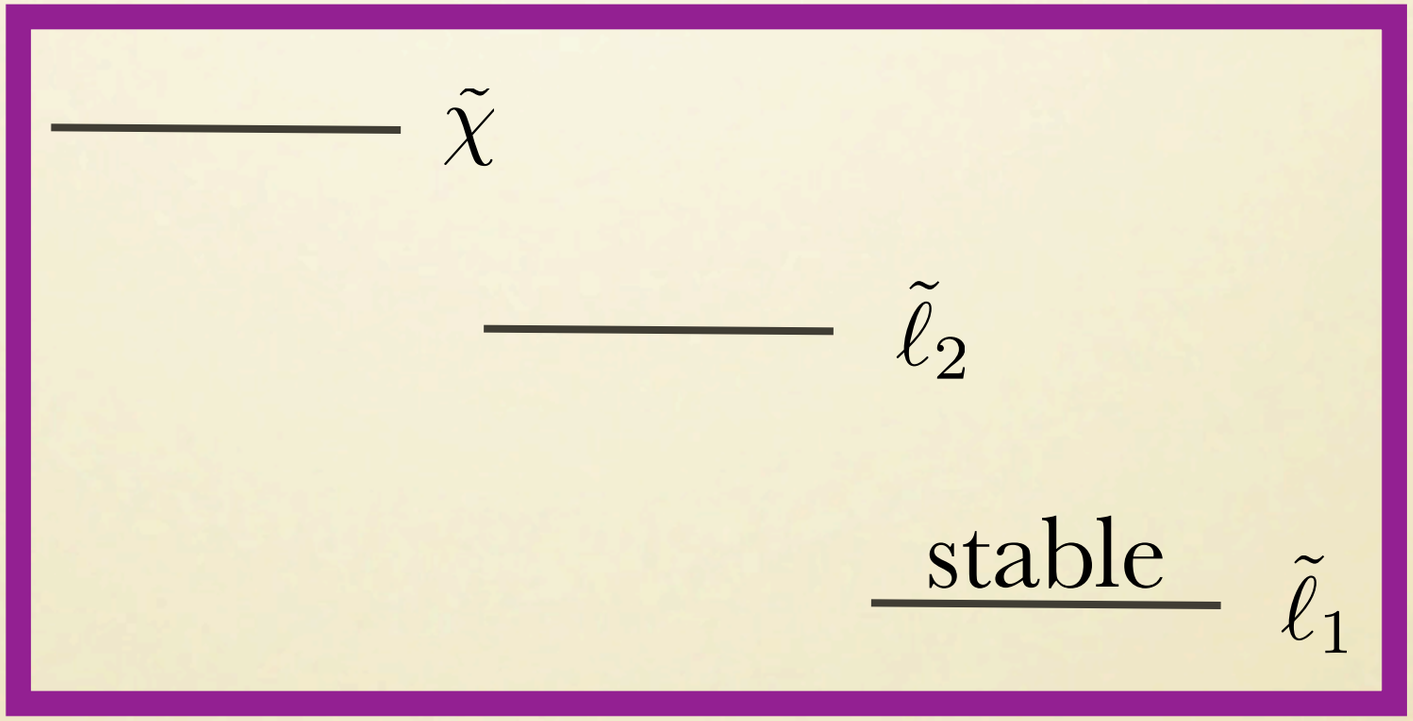
BUT this is not generic of SUSY

in low-scale gaugino mediation

GMSB with large Nmess, AMSB ...



Gauginos heavier scalars



Phenomenology

- Benchmarks
- Analysis Details
- TeVatron bounds
- Why sleptons are muons

Two benchmark scenarios

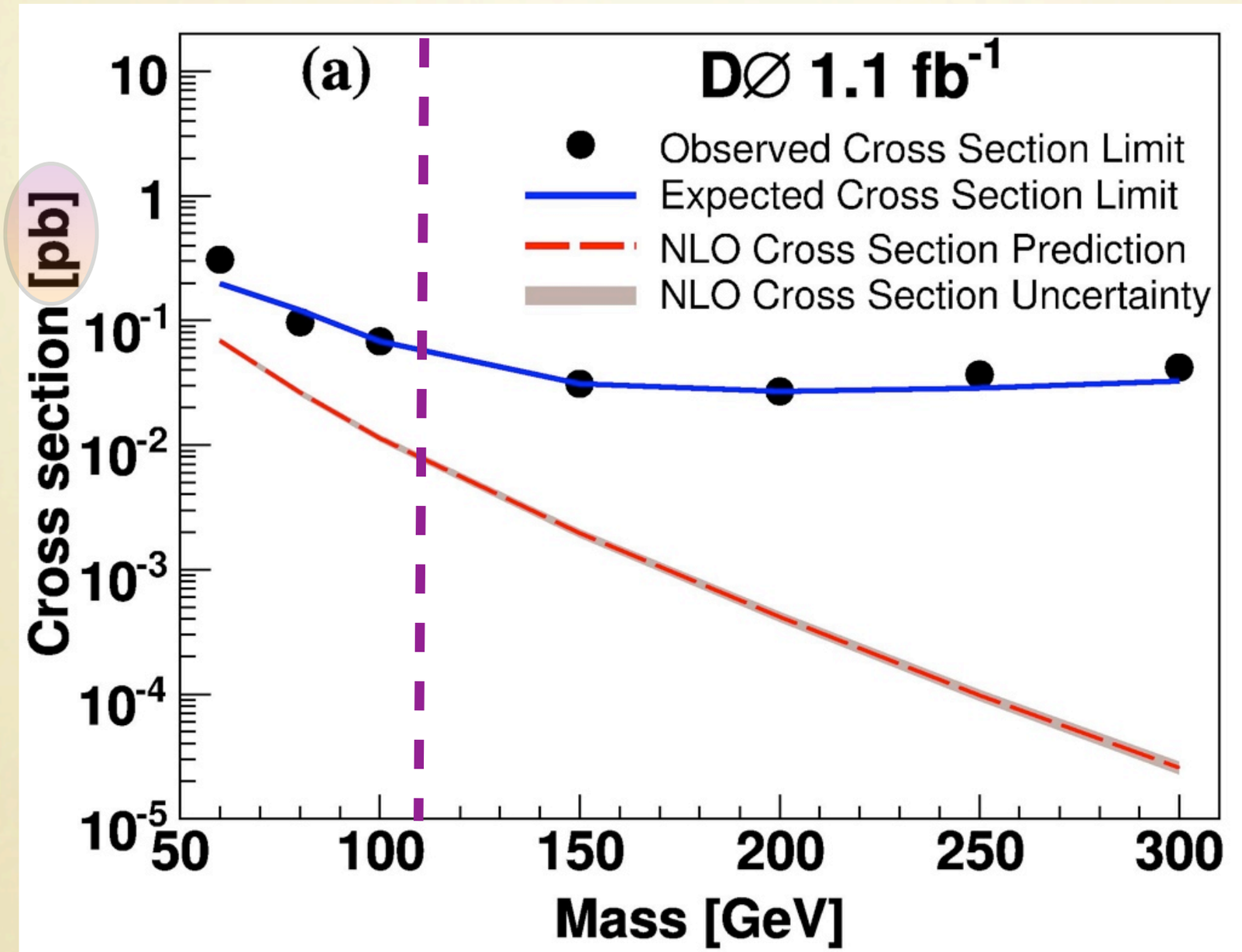
Higgs 115 GeV
sleptons 110 GeV

LS1: squark masses 1 TeV
LS2: squark masses 520-700 GeV

Production cross sections (fb)

Benchmark	LHC(14)	LHC(10)	TeVatron
LS1	2170	680	0.09
LS2	13700	5040	0.00

TeVatron limits: only apply to slepton pair production (8 fb)



"Search for Charged Massive Stable Particles with the DØ Detector" (2008)

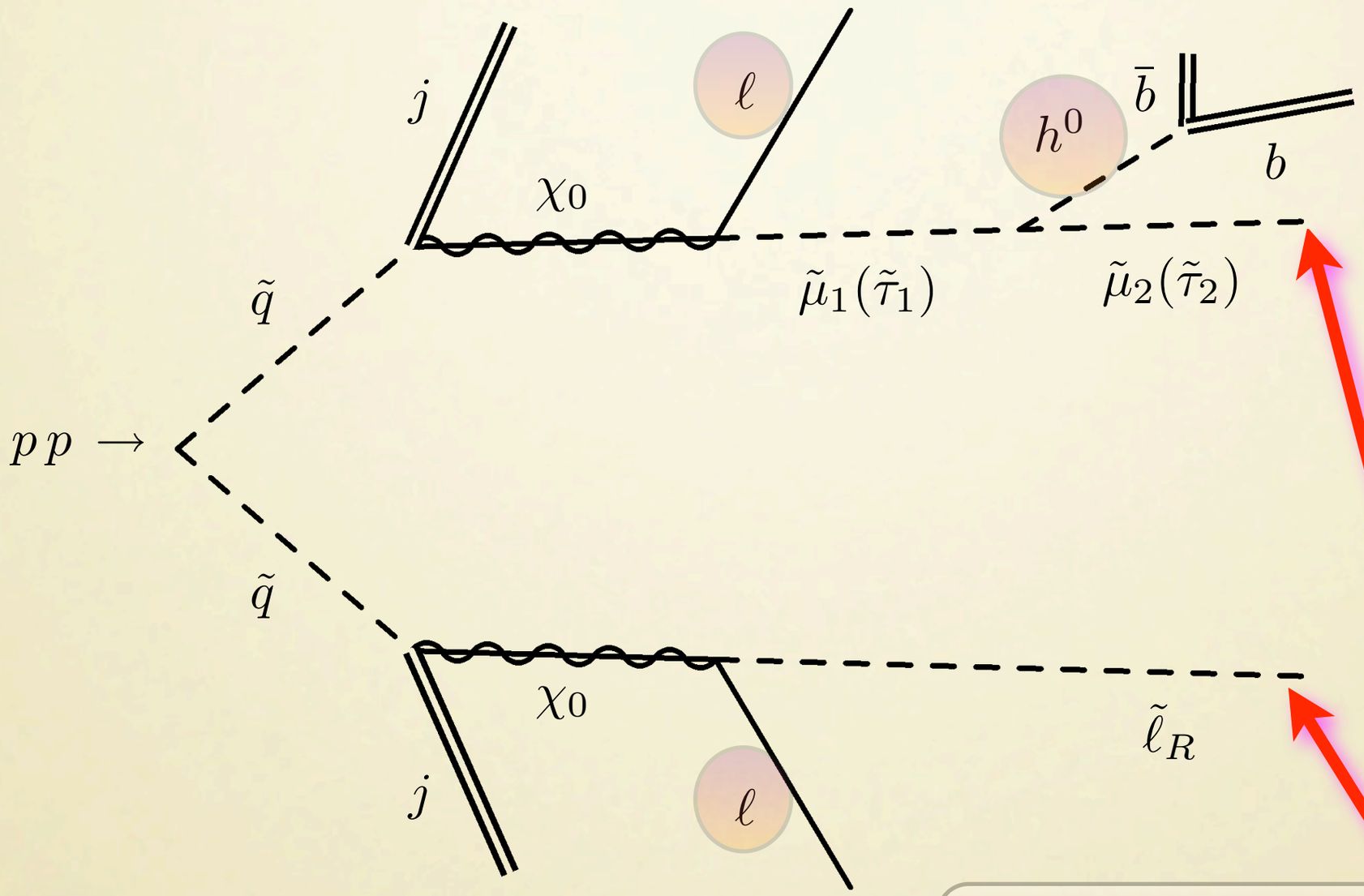
All the plots in this talk
Simulation parton level MadGraph
shower/had PYTHIA 6.4

Leptons in the $|\eta| < 2.5$ region, $p_T > 10$ GeV
and parton level isolation cuts $\Delta R_{\ell\ell}, \Delta R_{\ell j} < 0.4$

Jets in the $|\eta| < 2.5$ region, $p_T > 15$ GeV
and post-PYTHIA isolation cuts $\Delta R_{\ell j} > 0.4$

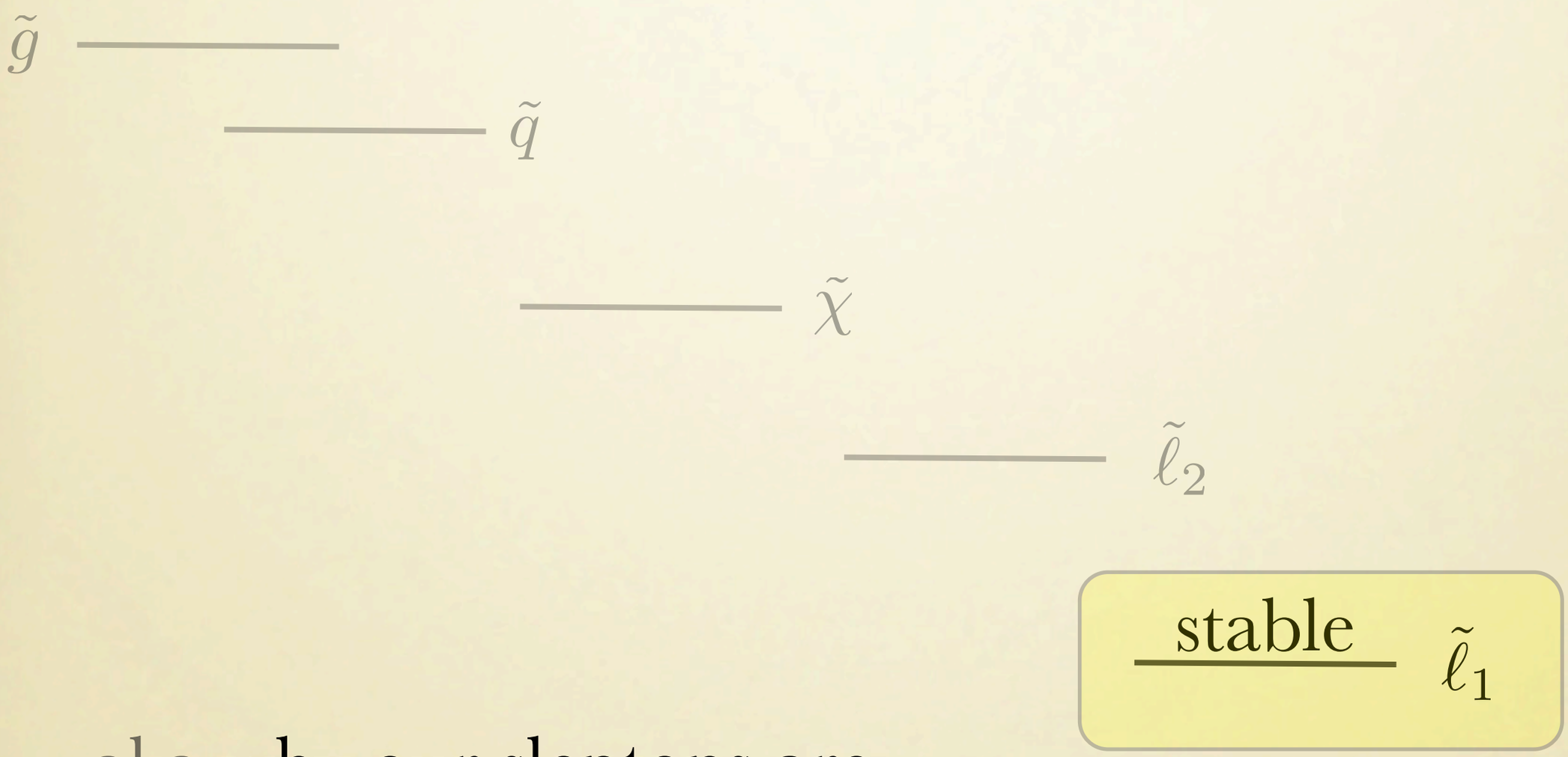
In our final analysis program used smearing and efficiencies copy/paste ATLFAST's subroutines
ElectronSmearer.cxx
JetSmearer.cxx
but not MuonSmearer.cxx, too hard for us (approx. treated muons as electrons...)

In this talk, we care about Higgses



These guys are “muons”

Heavy Charged Particles at LHC



aka why our sleptons are muons

When are the sleptons collider stable?

In gauge mediation gravitino DM

gravitino-slepton have Planck suppressed couplings

long-lived natural

In lepto-SUSY

$$m_{\tilde{\tau}} < m_{\tilde{e},\tilde{\mu}}$$

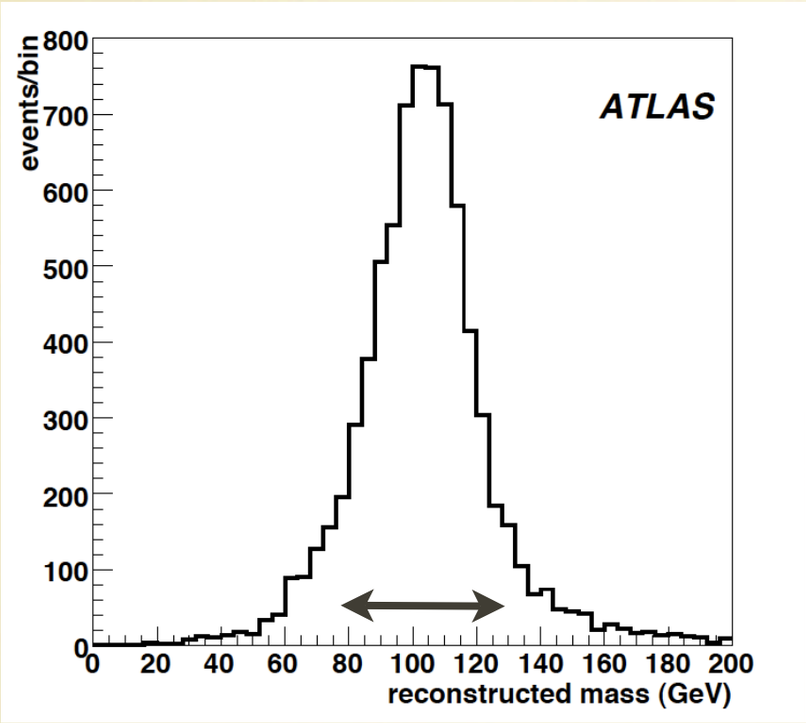
$\tilde{\ell}_R \to \ell_R \tau_R \tilde{\tau}_R$ but no kink and leptons too soft

Co-slepton scenario as in G2b in old ATLAS-TDR

Note- This is not G2b! ordering spectrum different, fewer leptons

Long-lived slepton hits like a muon with a lower β

- Time of flight → **Muon chambers**
- Specific ionization → **Tracker and/or e.m. calorimeter**



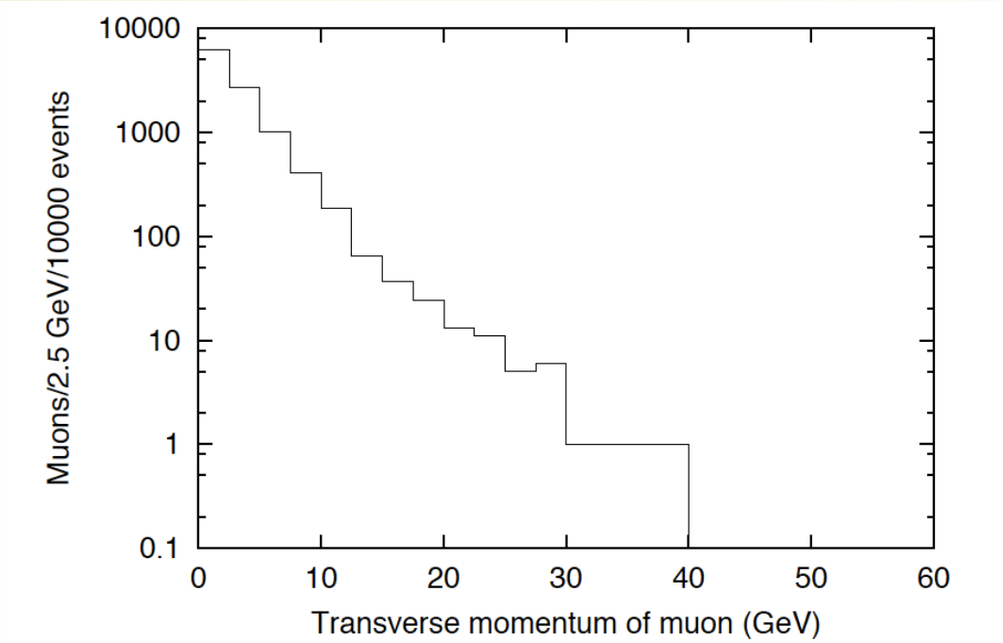
From ATLAS-TDR 2008

Mass reconstruction and charge ID

Main problems:

1. BGs --instrumental (?) and SM
2. slow: BC time
3. fast: beta error

BGs: b-decay muons

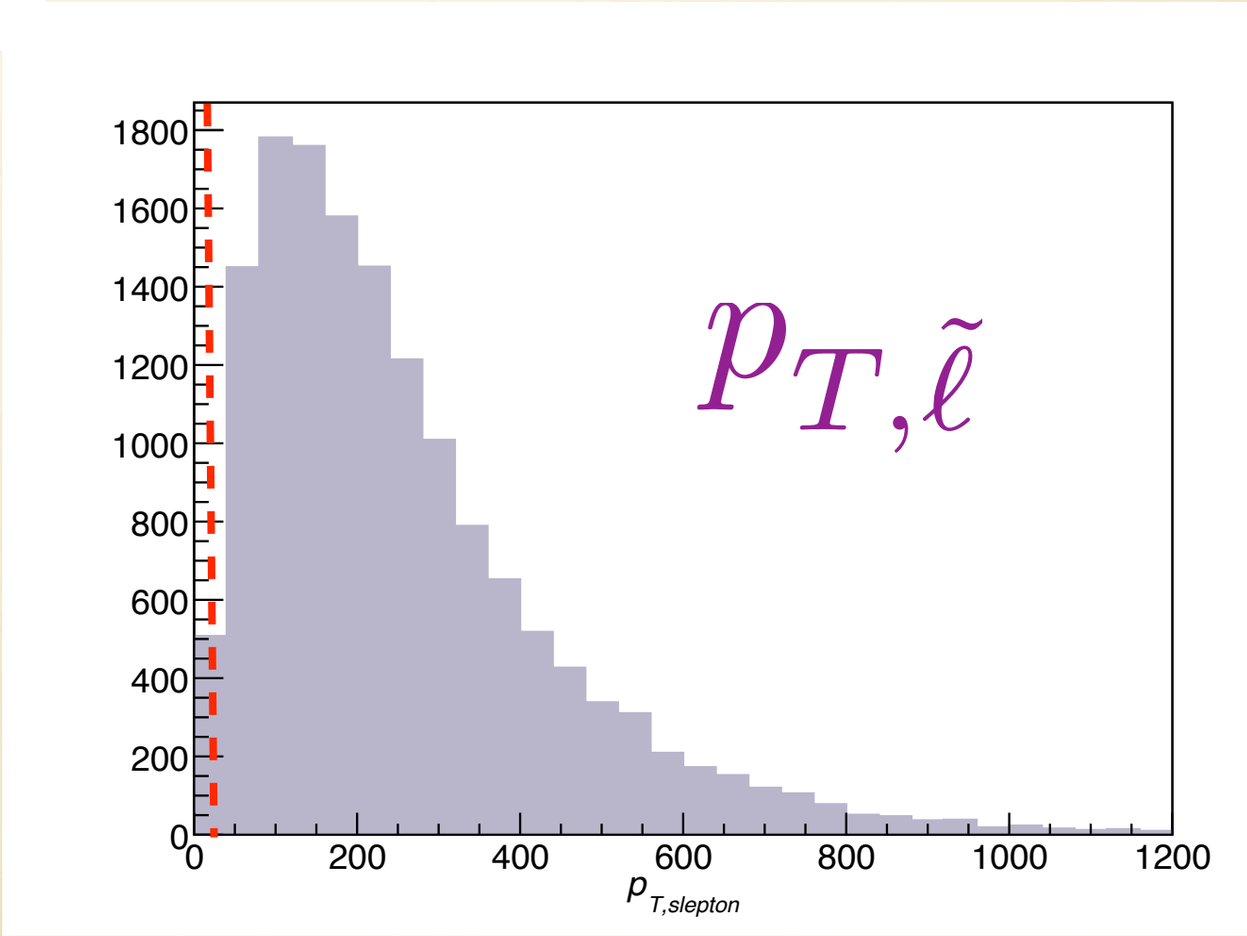


Allanach et al. hep-ph/0108097

$$p_T > 50 \text{ GeV}$$

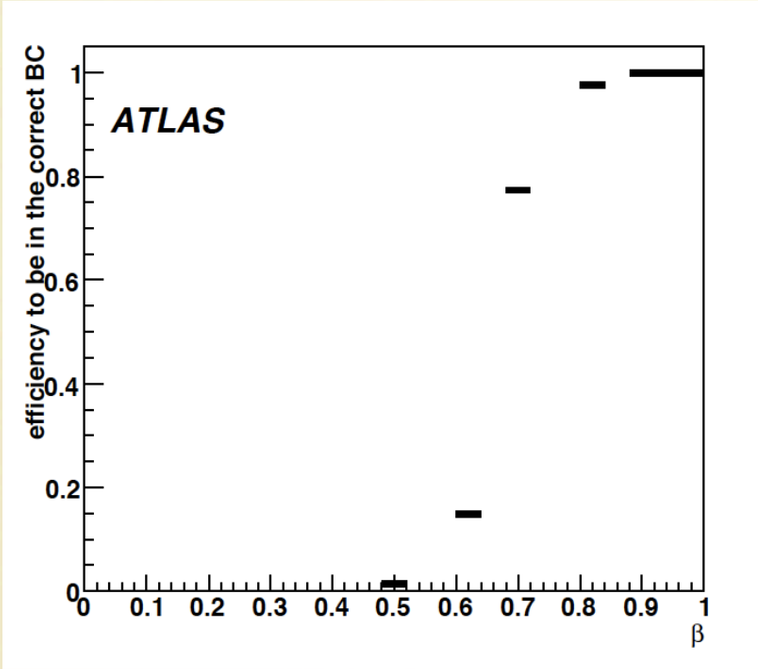
LS1

No problem,
all high-pT



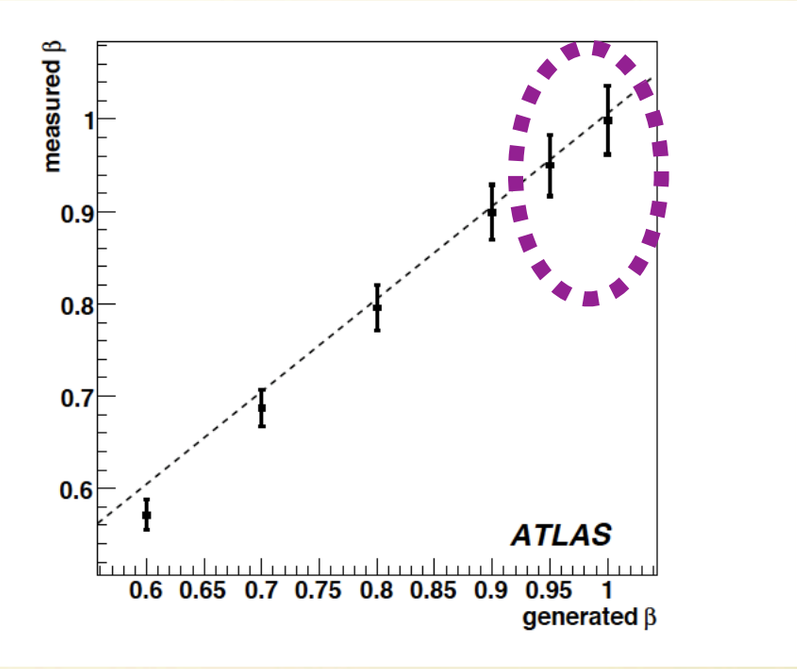
Missing it

TOO SLOW

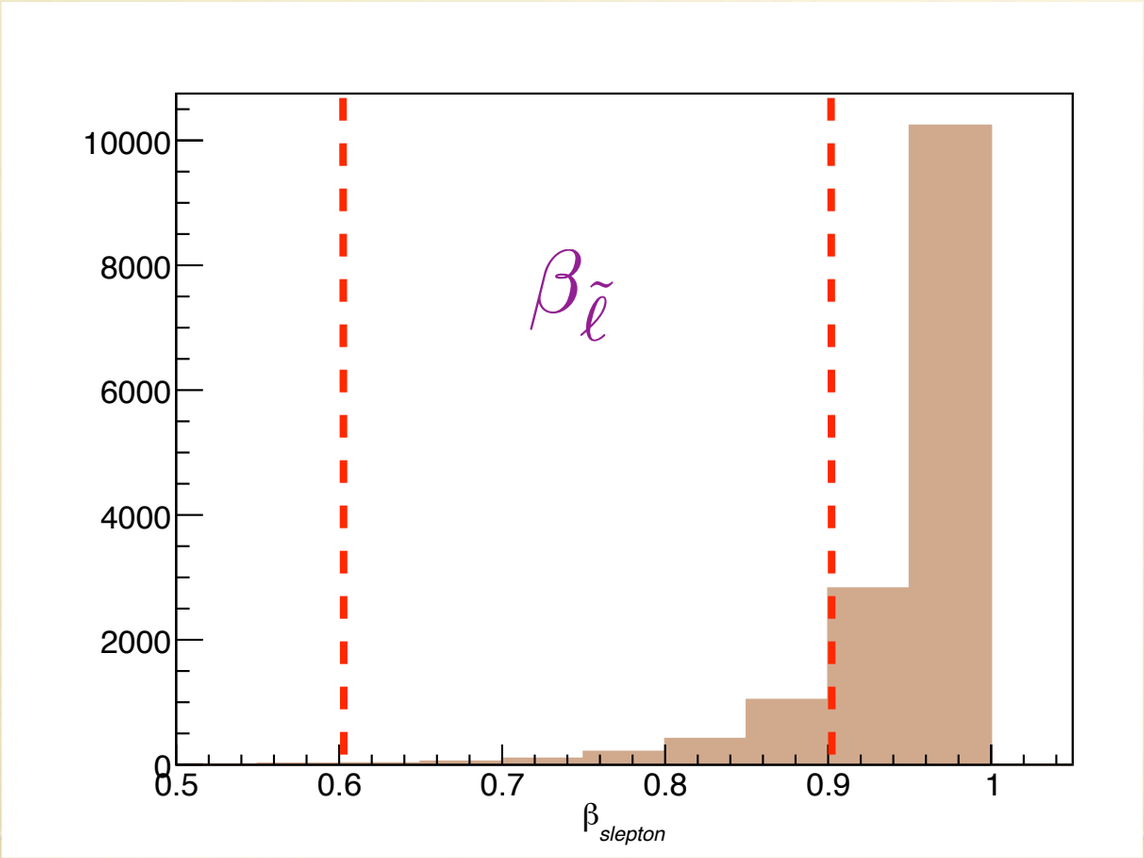


MisIDing it

TOO FAST



From ATLAS-TDR 2008



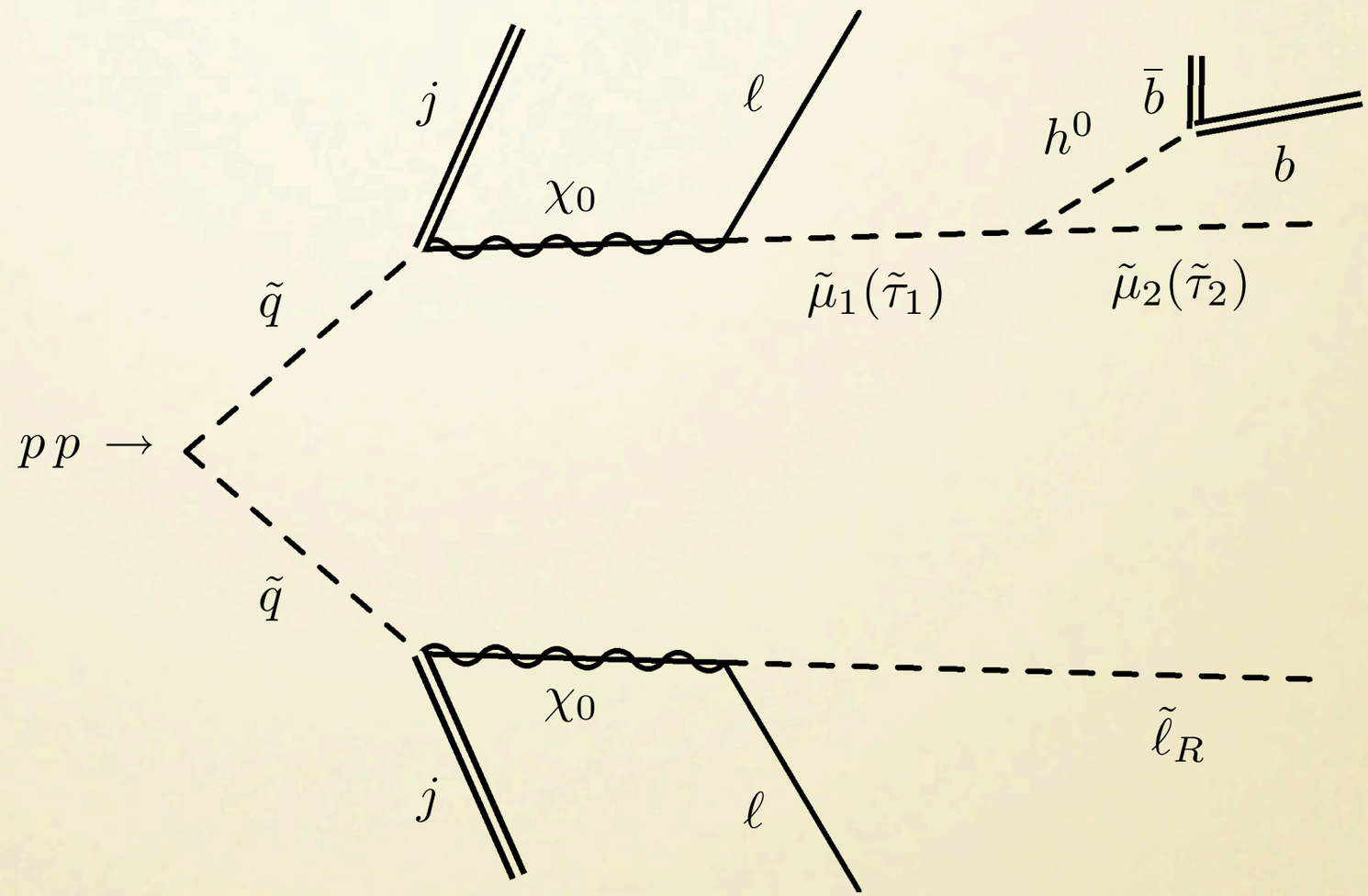
SIGNAL

Is mostly too fast

sleptons misID as muons

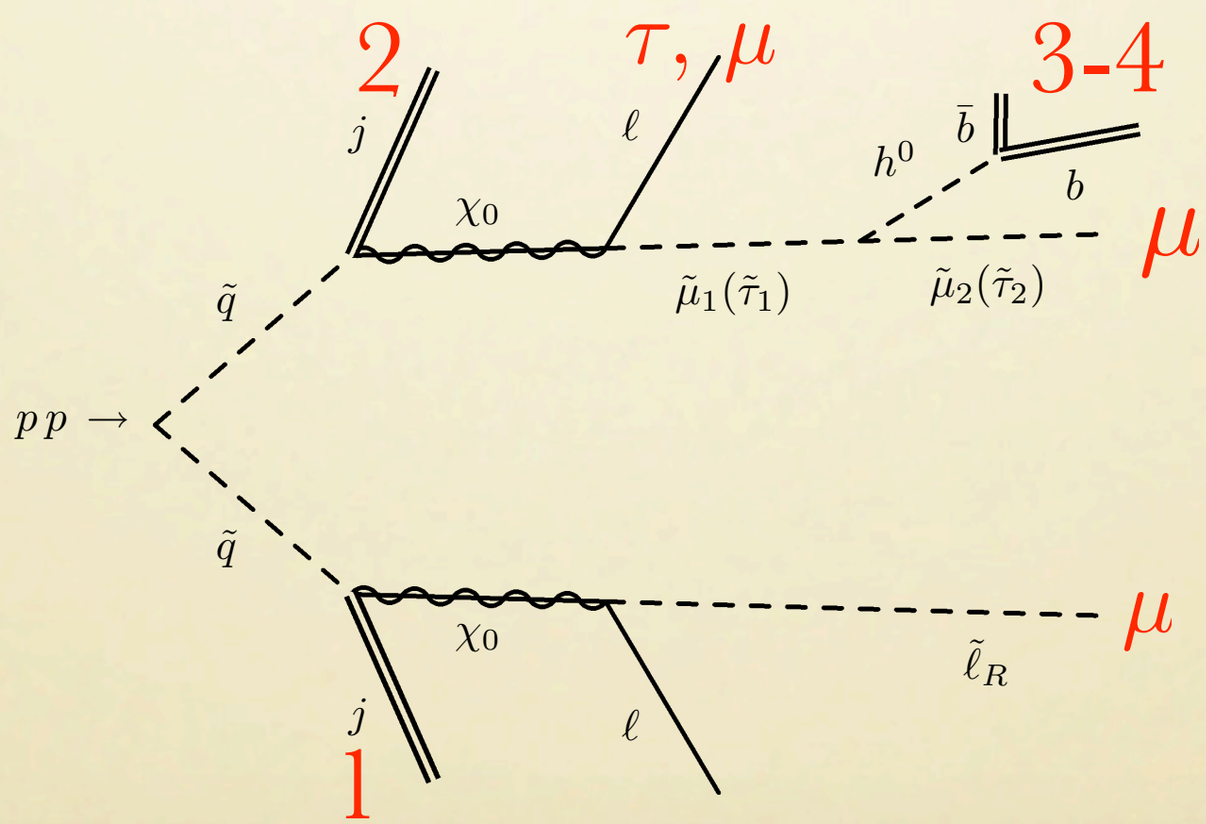
Higgs search $(3,4)\,\ell + 4\,j$

-Analysis
-Results LS1
-Results LS2
-Missing ET cut
-Backgrounds



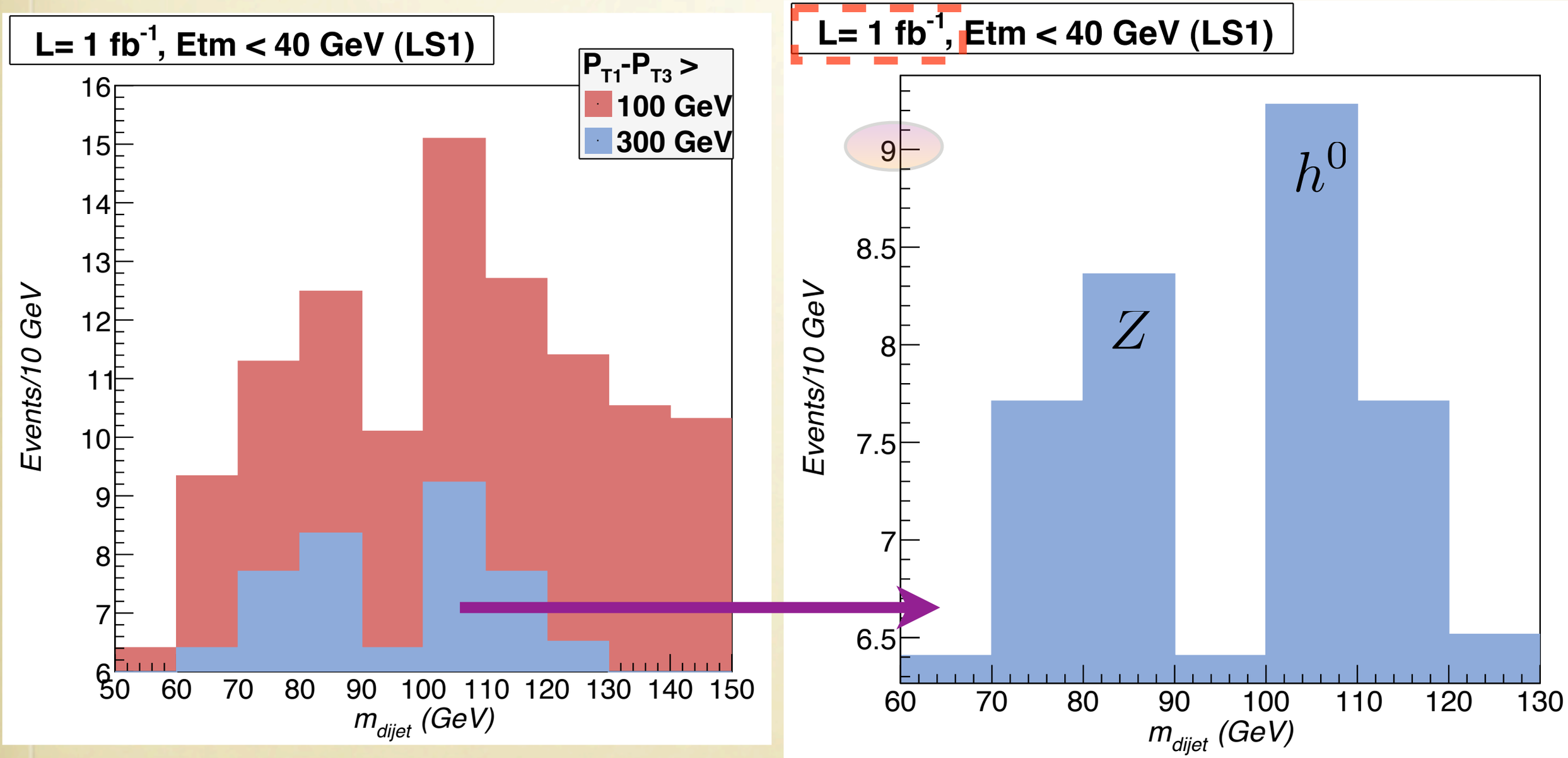
Analysis

Ask for 3 or 4 leptons
and 4 jets or more
Order jets in pT and ask 4th pT >25 GeV
Assume 1st and 2nd jets are from squarks
Form invariant mass 3rd and 4th jet



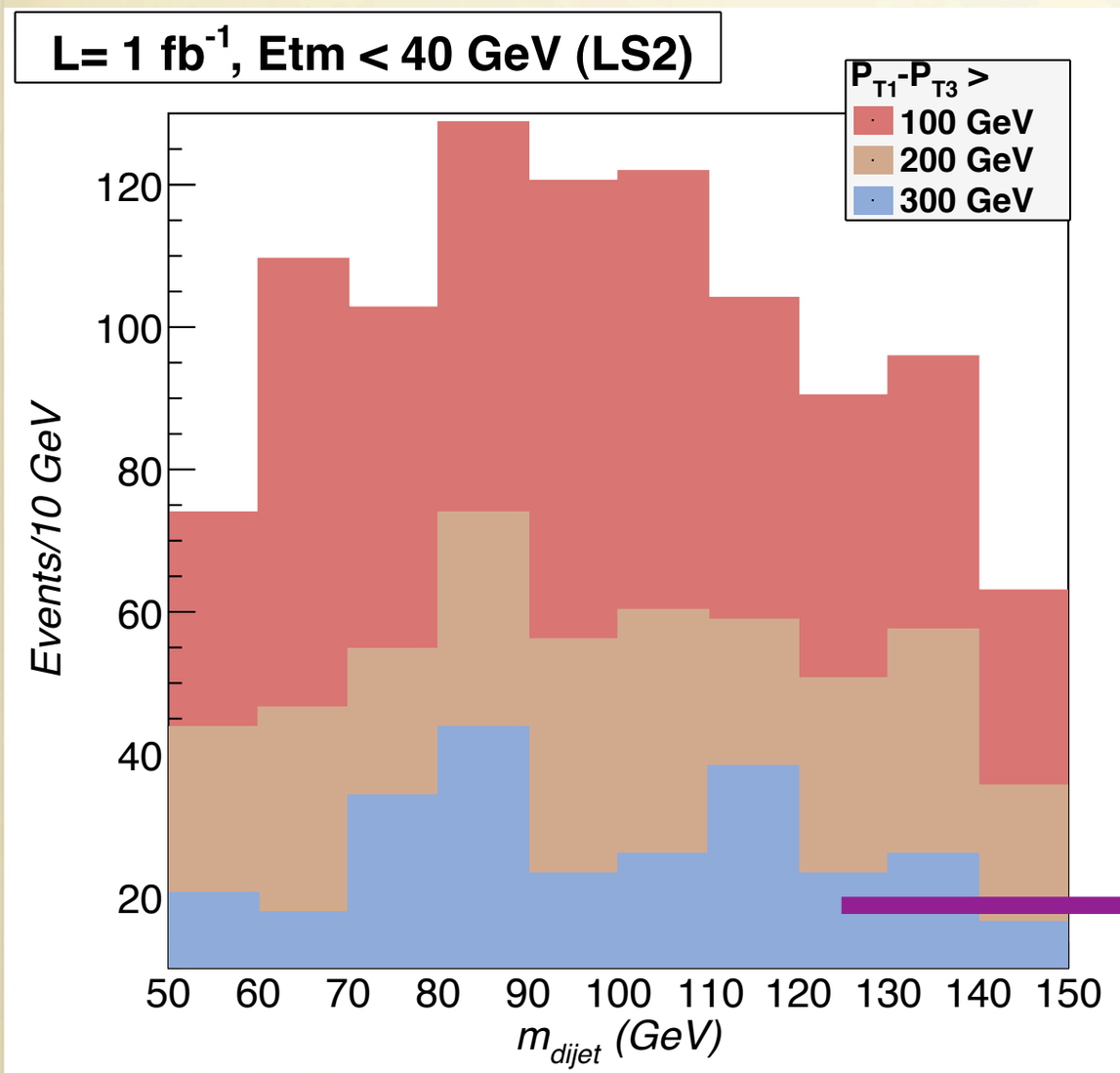
LS1 dijet invariant mass

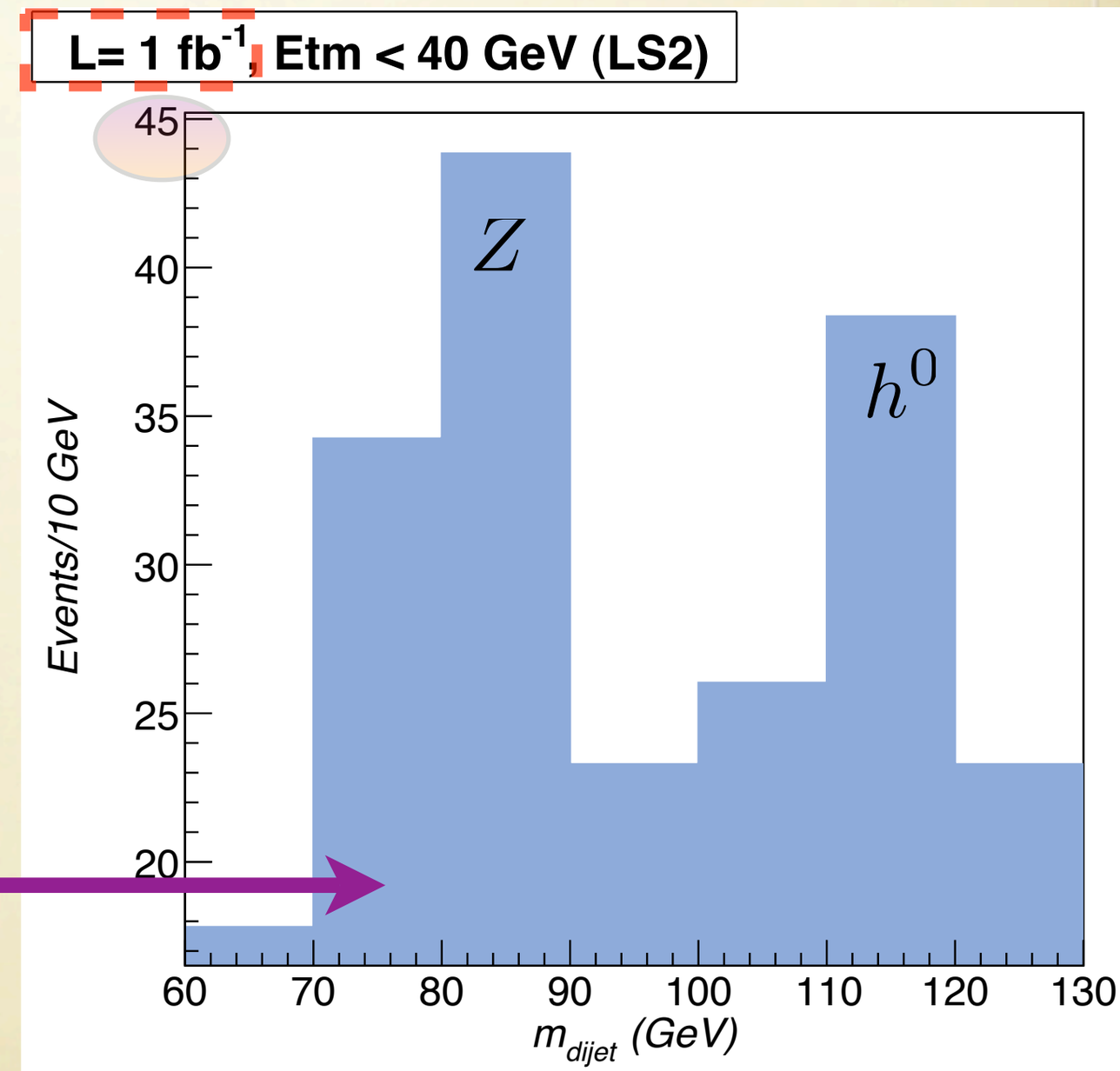
(14 to 10 is a factor 1/3)

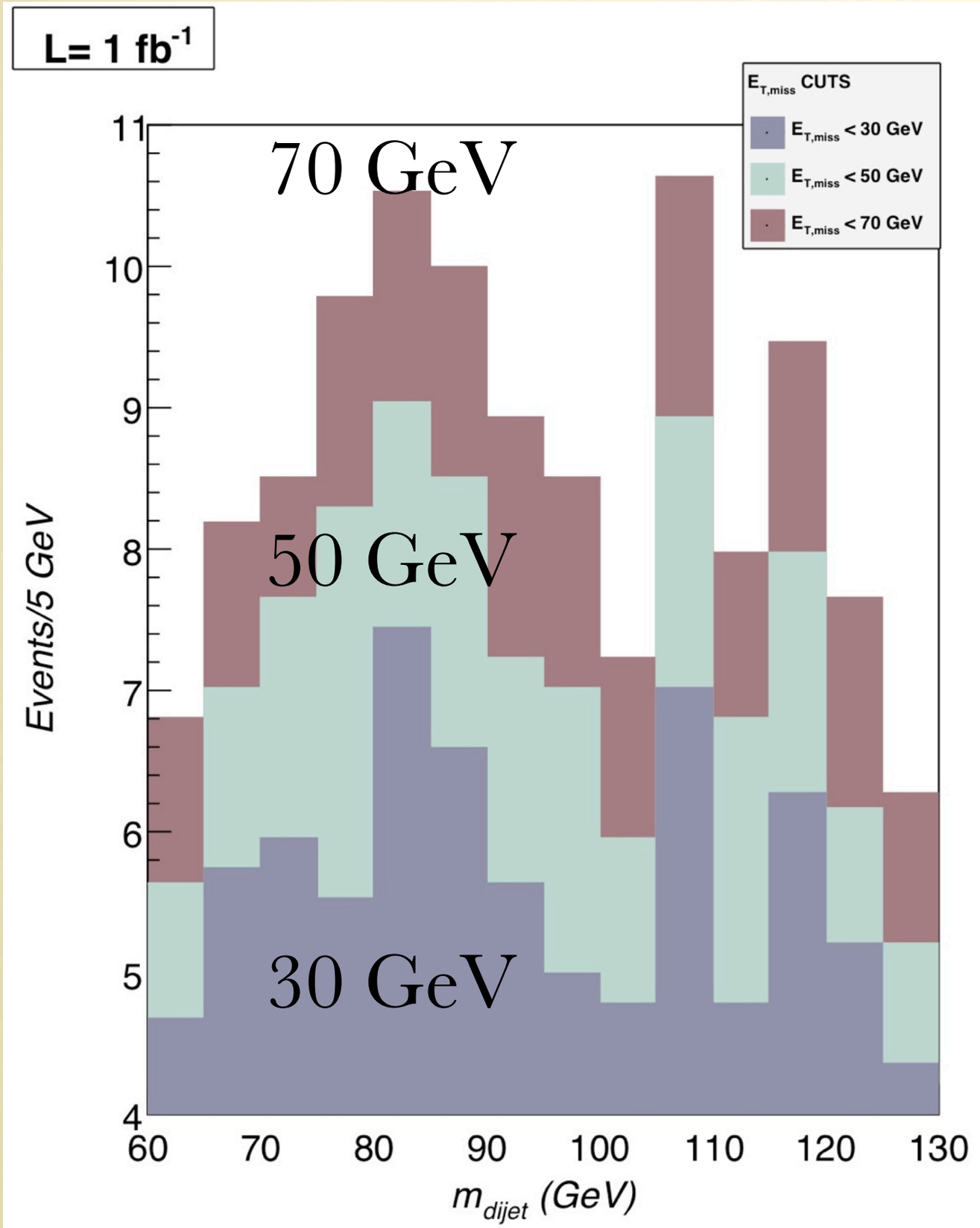


LS2 dijet invariant mass

(14 to 10 is a factor 1/3)







Varying
missing ET cuts

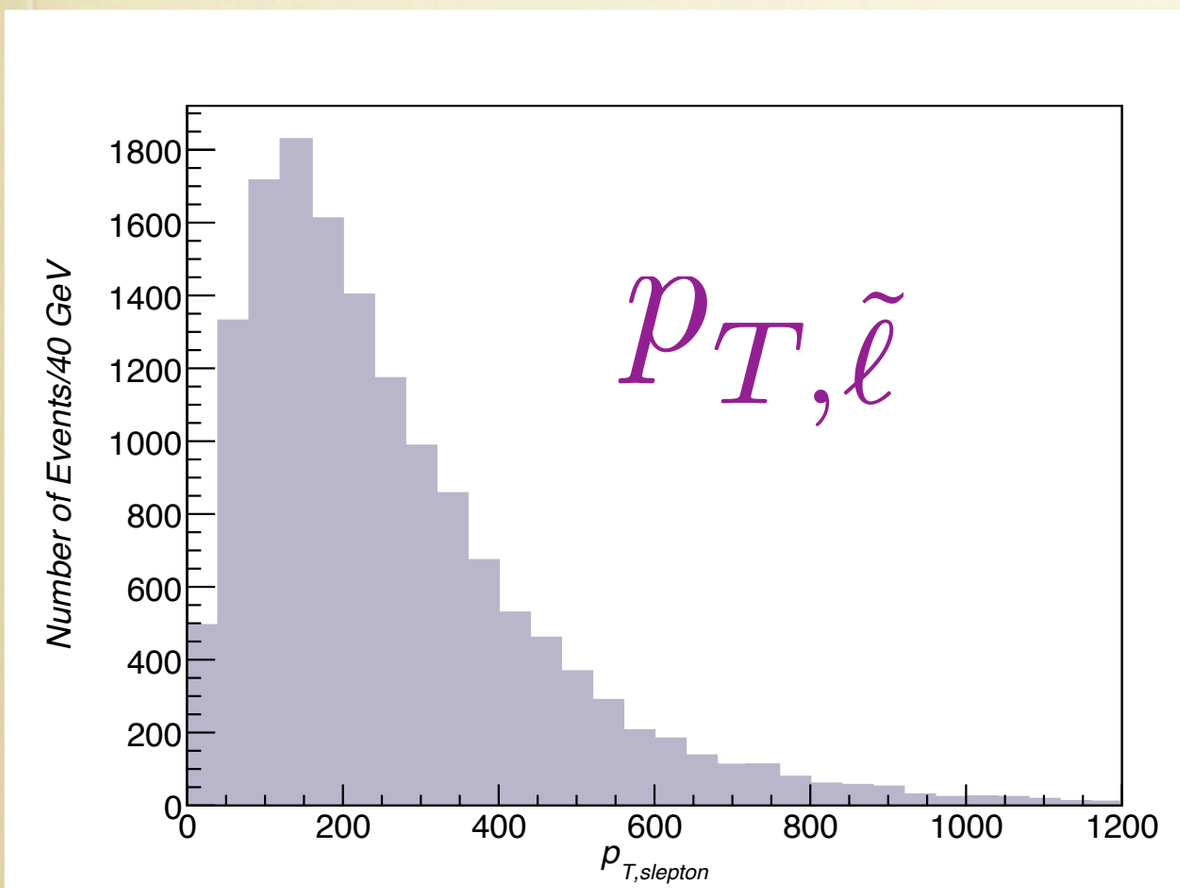
combinatorial BG

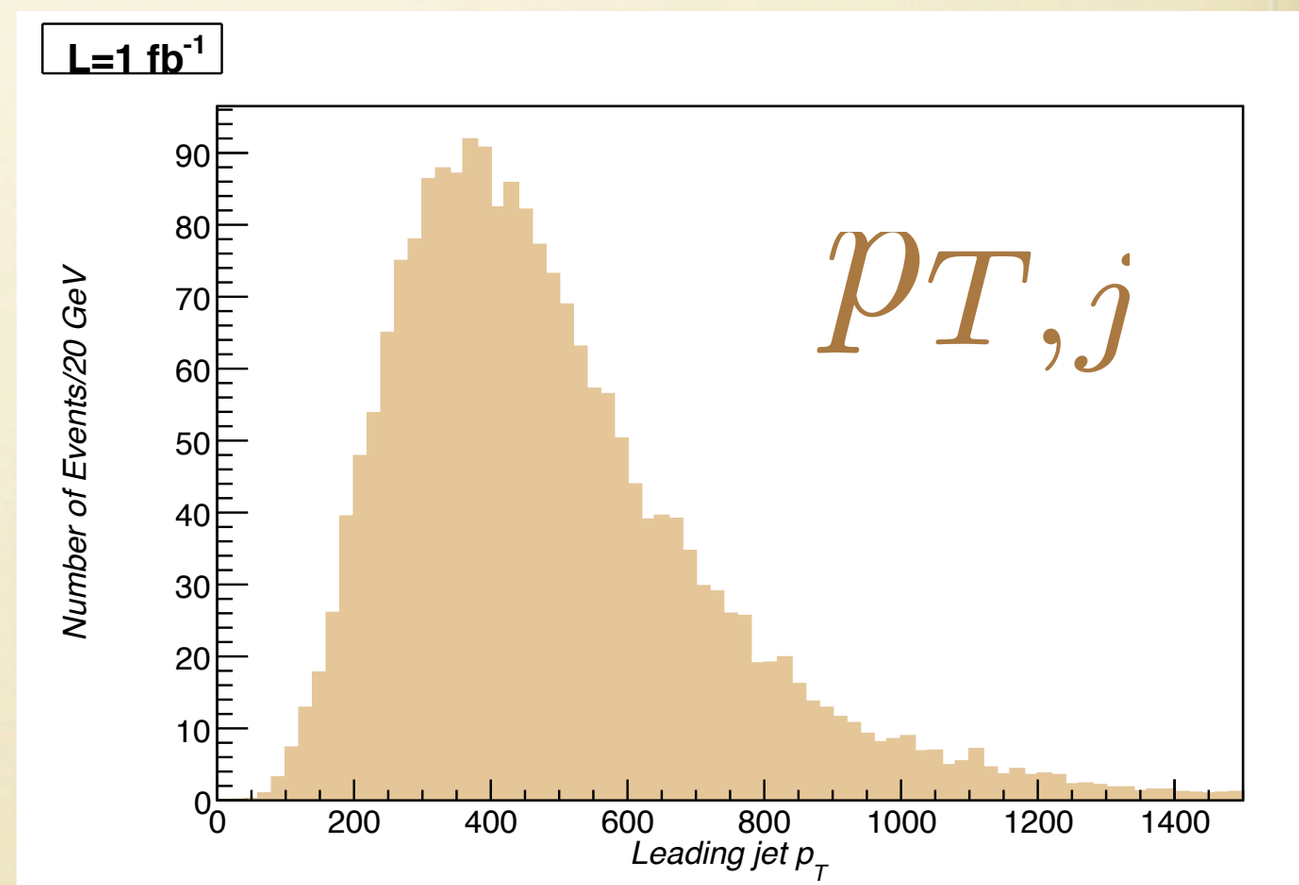
So far, all plots no SM backgrounds

Q. What are the BGs for

$$4\ell + 4j \quad 3\ell + 4j$$

when everybody is pretty hard?





Handles to reject BG:

isolation, hardness, sleptons as muons

We didn't use:

missing ET, slepton ID

Efficiencies for fakes

jet faking electron 10^{-4}

jet faking muon? we used 10^{-4}

(goss overestimate!)

b decay producing isolated lepton $5\,10^{-3}$

Generated SM BGs with ALPGEN and MG

$t\bar{t} + \text{jets}$

$W + \text{jets}$

QCD jets

$W\,Z + \text{jets}$

$Z\,Z + jets$

$Z + jets$

$b\,\bar{b}\,Z/\gamma$

None above fb after applying:

$$
\begin{aligned}
n_\ell &\geq 3 \\
n_j &\geq 4 \\
p_{T,j_1} &> 200 \text{ GeV} \\
p_{T,j_4} &> 25 \text{ GeV} \\
n_\mu &\geq 2 \\
p_{T,\ell} &> 50 \text{ GeV (leading)} \\
\Delta R_{\ell\,\ell,\,\ell\,j,\,j\,j} &> 0.4
\end{aligned}
$$

Conclusions

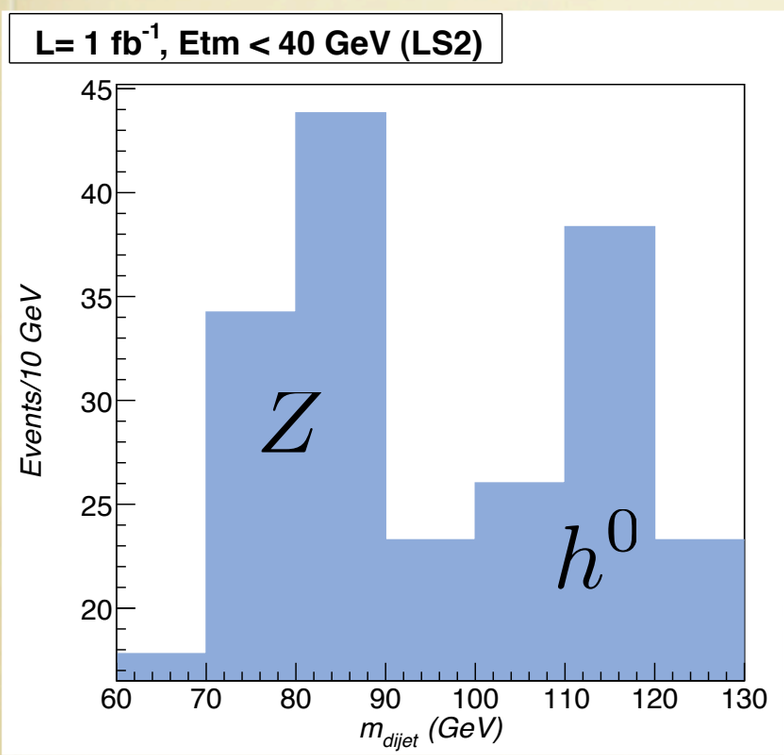
Spectrum ordering important cascade decays

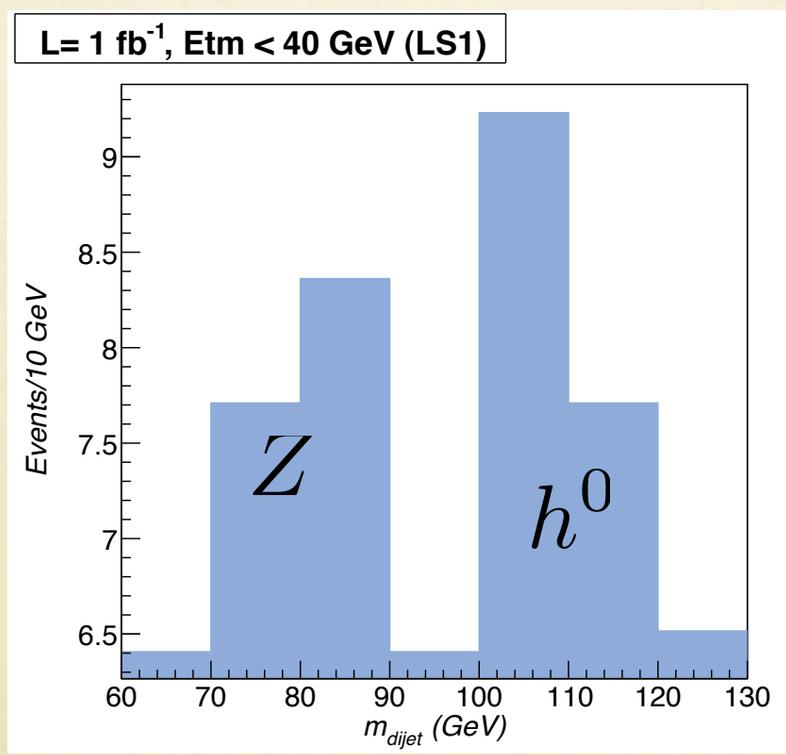
mSUGRA-like isn't generic

MSSM multi-leptonic signals possible

An opportunity window for Higgs to bbar below 1 fb-1

In general, study the bbar channel in association with clean handles





If those are there, and you search for them, you'll see them!

Thank you!