

Title: Leptons Galore!

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Abstract: TBA

# Leptons Galore!

Veronica Sanz (YorkU)

Assamagan (BNL), Rolli (Tufts), Tarem, Tenenbaum (Technion)  
ATLAS full simulation

De Simone (MIT), Skiba (Yale), Fan (Yale&IAS)  
arXiv:0903.5305 [hep-ph] Phys. Rev. D80 (2009)

Martin (Yale&FNAL)  
arXiv:0907.3931 [hep-ph]. Accepted JHEP

# Overview

Part 1 - **Your Wishlist**

Part 2 - **Two scenarios of EWSB**

Part 3 - **High leptonic multiplicity**

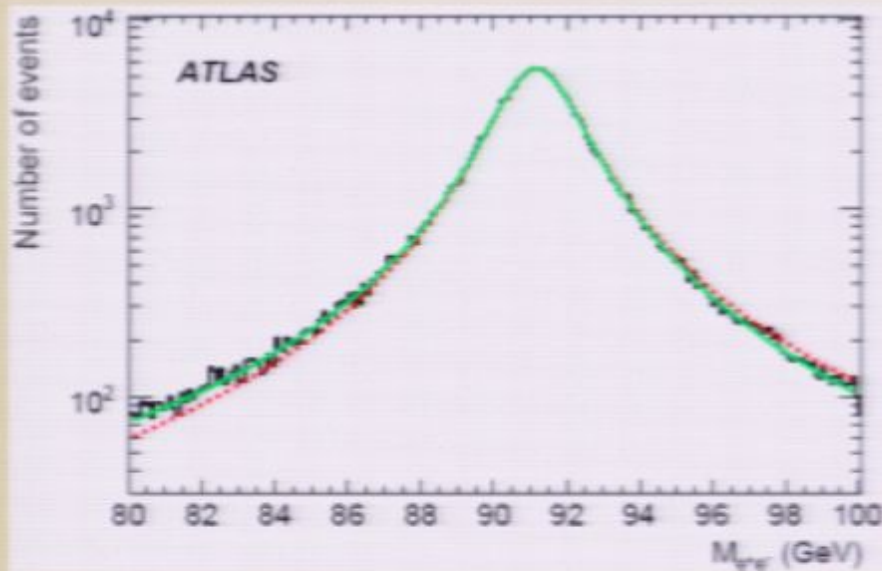
Part 4 - **What ATLAS is doing**

# Part 1 - Your Wishlist

Experimentalists are going to be  
very busy...

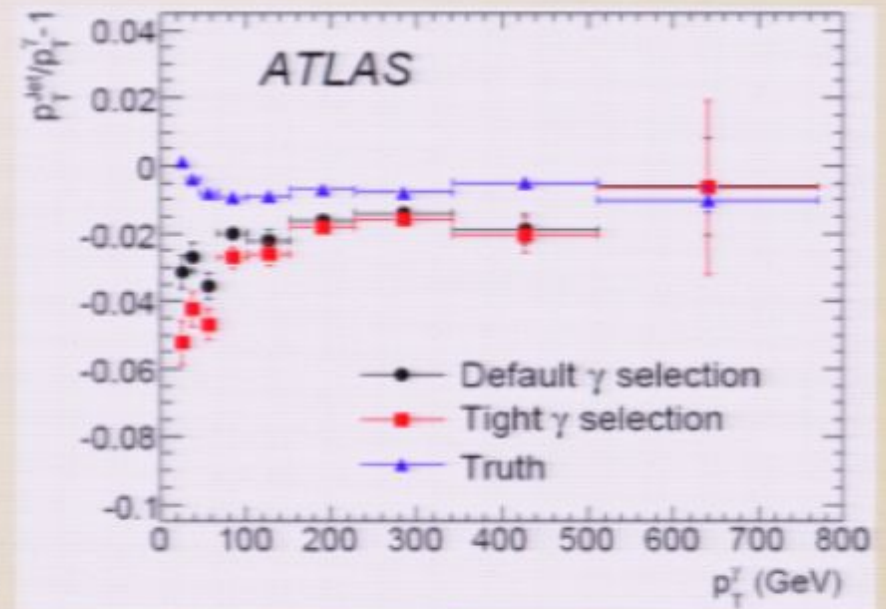
# Calibrating detector w/ standard candles

$$Z \rightarrow e^+e^-$$



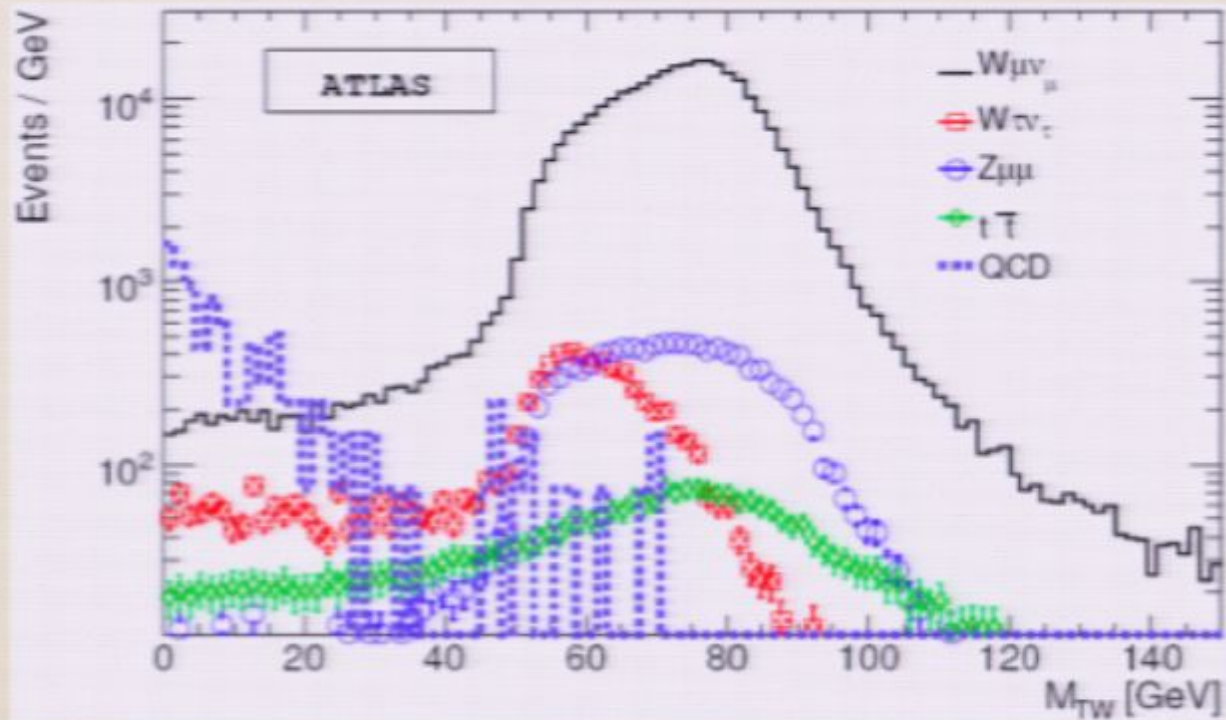
electrons

$$Z/\gamma + \text{jets}$$



jets

# Measuring EW cross sections



W mass, top mass...

But would you hope for  
New Physics ?

But would you hope for  
New Physics ?

Where?



But would you hope for  
**New Physics ?**


Where?

di-jets

jets+missing energy

# But would you hope for New Physics ?

Where?

di-jets  huge background

jets + missing energy

Disclaimer:  
my personal take  
on this

# But would you hope for New Physics ?

## Where?

huge background


di-jets



hard missing ET

calibration

jets + missing energy



Disclaimer:  
my personal take  
on this

But would you hope for  
New Physics ?

Where?

pb production cross section  
Leptons, many of them!  
No missing energy

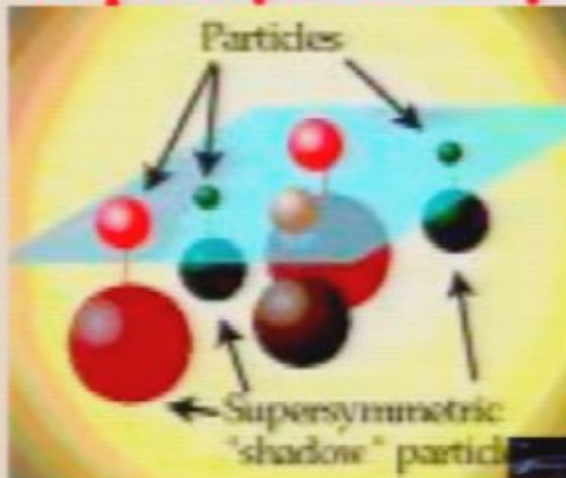
My wishlist

# Two (Three) scenarios of EWSB

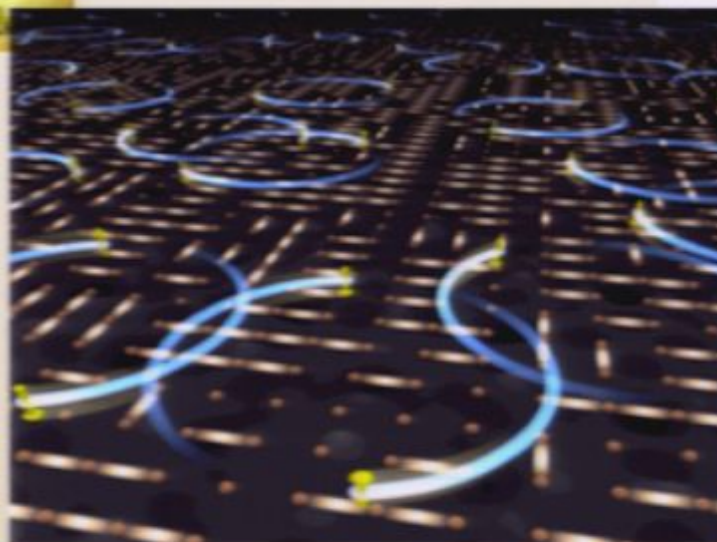
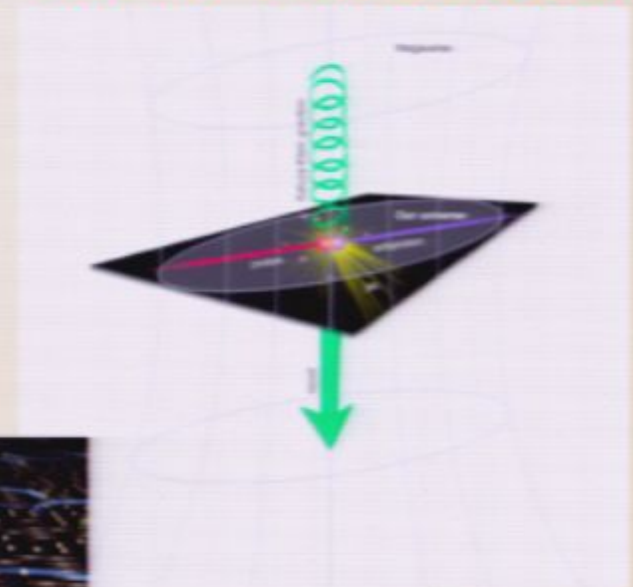
Many **New Physics** models  
Hierarchy between Planck scale  
and Electroweak scale

# Two (Three) scenarios of EWSB

## Supersymmetry



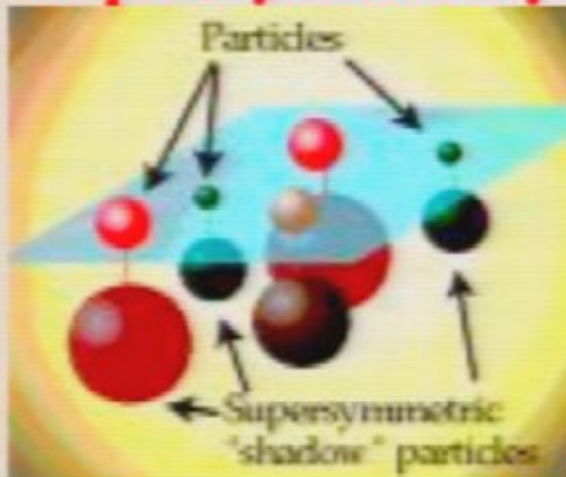
## Extra-Dimensions



## Technicolor

# Two (Three) scenarios of EWSB

## Supersymmetry



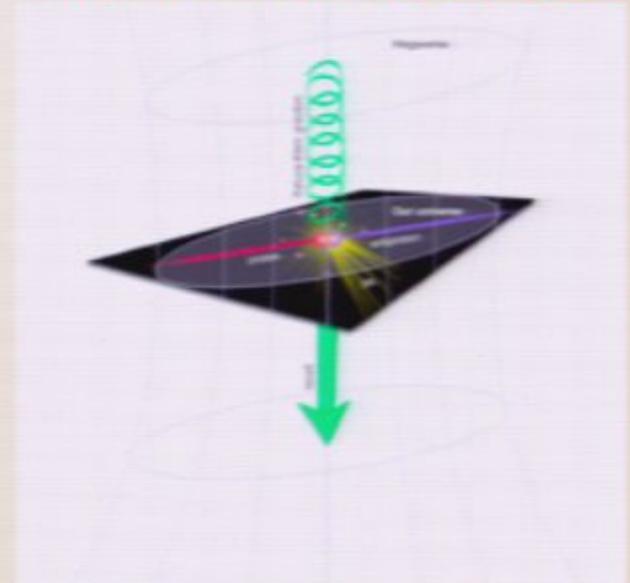
Solution 1 - It's a **symmetry**  
(which needs to be broken)



# Two (Three) scenarios of EWSB

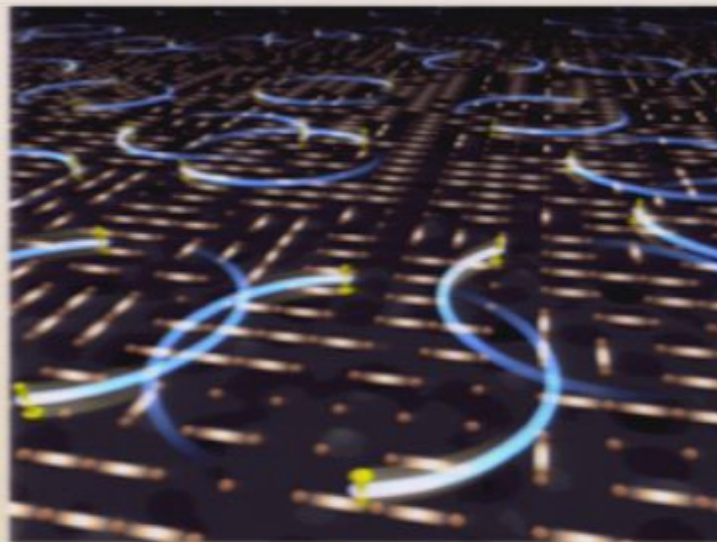
Solution 2 - It's just a  
**perspective** issue  
(what you thought large, is  
actually small)

## Extra-Dimensions



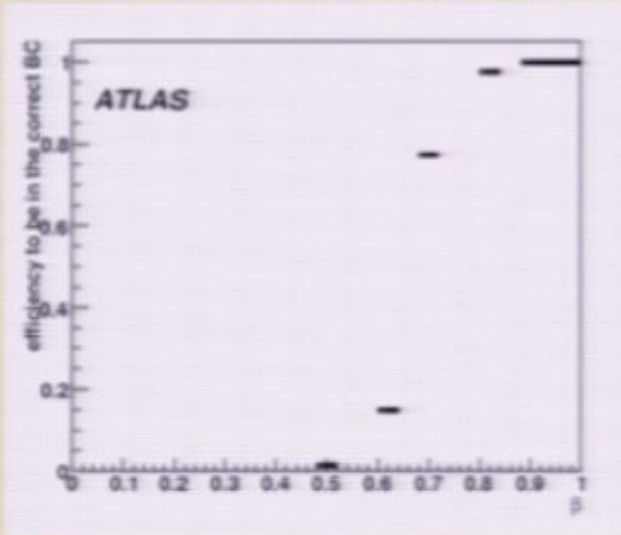
# Two (Three) scenarios of EWSB

Solution 3 - It's deja-vu  
(and therefore scary)

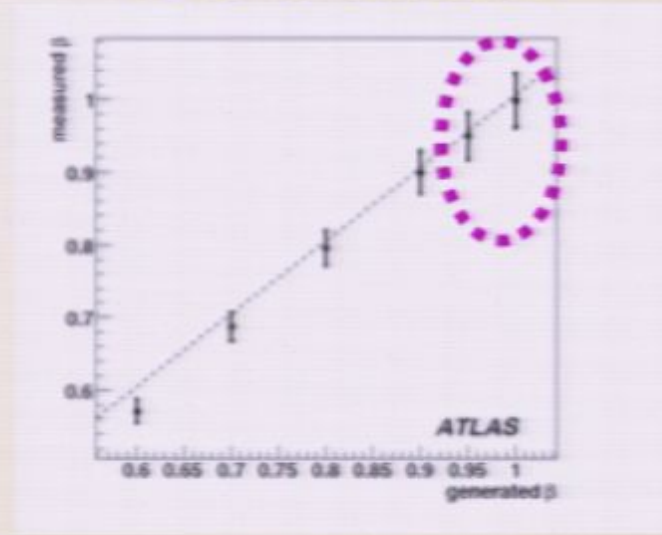


**Technicolor**

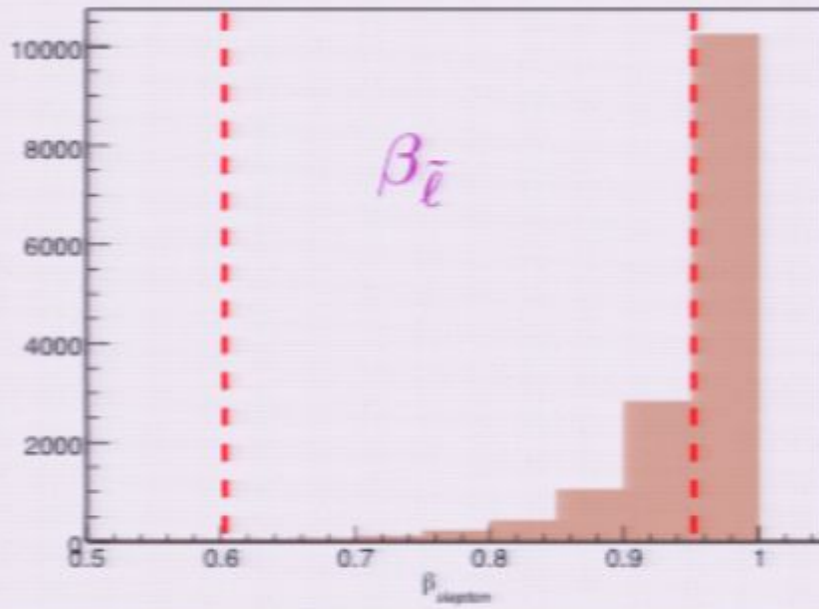
# Missing it TOO SLOW



# MisIDing it TOO FAST



From ATLAS-TDR 2008

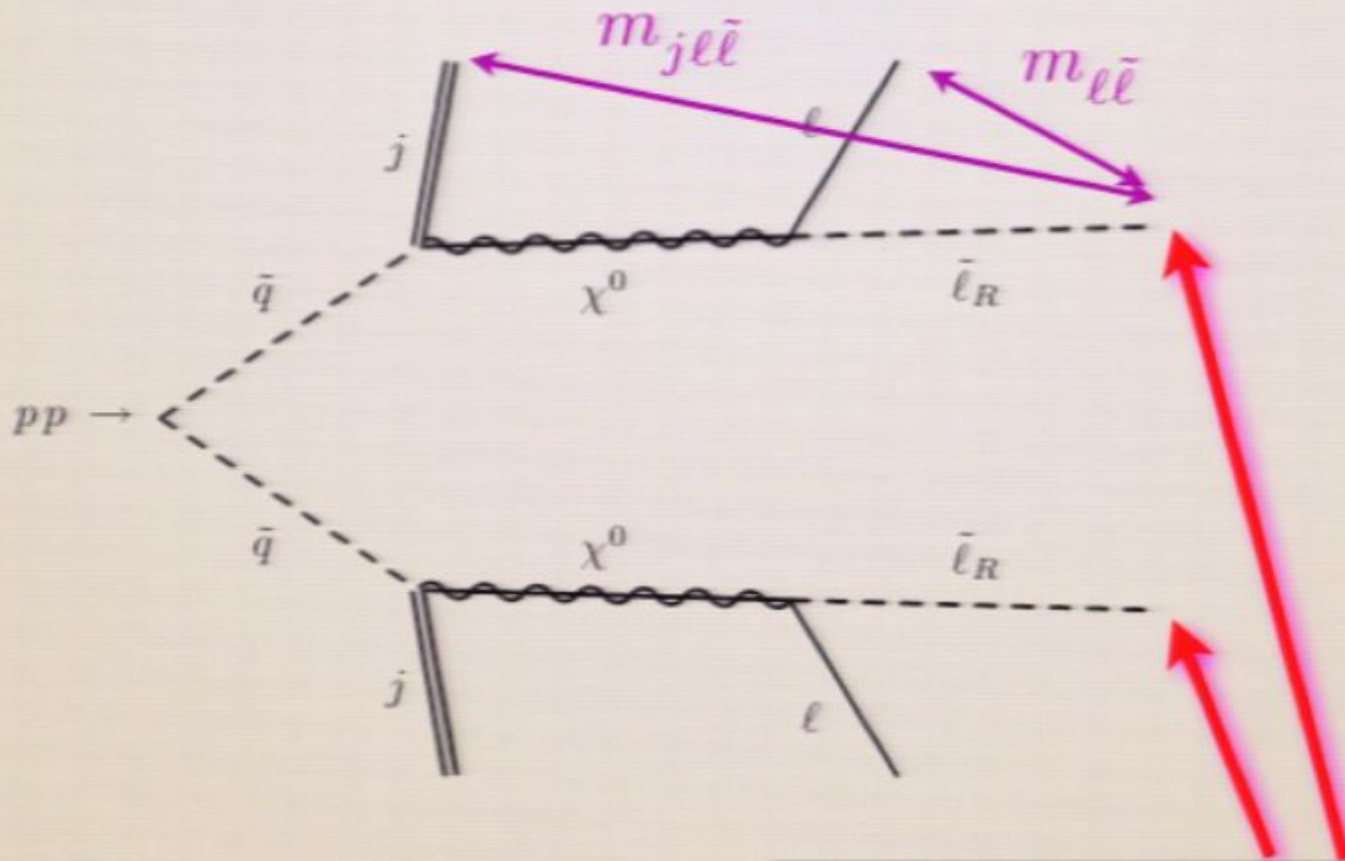


# SIGNAL

Many of them are fast  
sleptons misID as muons

# An example

$$2\ell + 2\tilde{\ell} + 2j = 4\ell + 2j$$



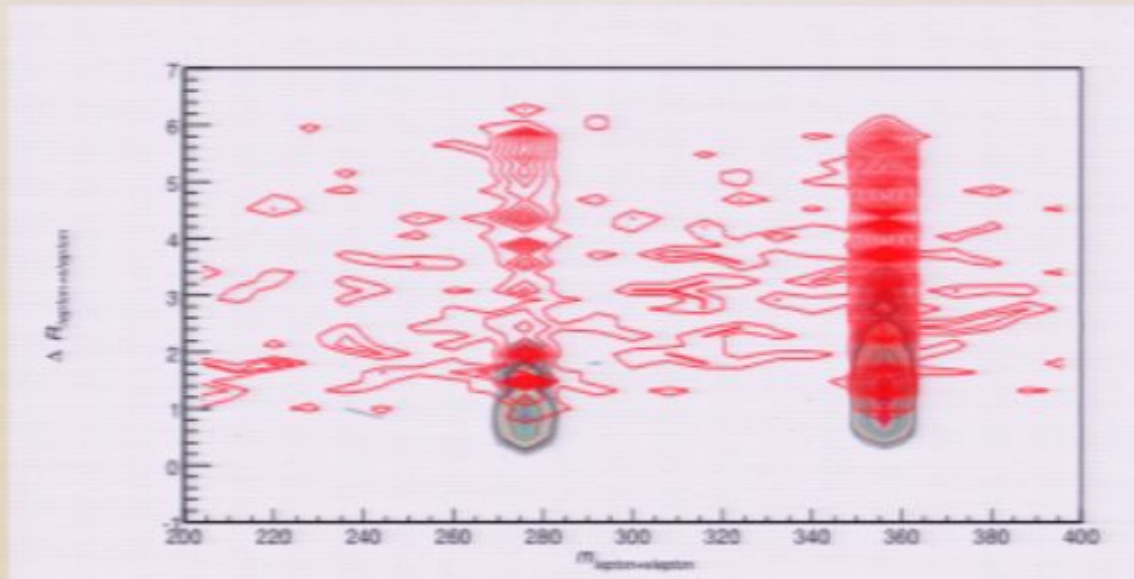
Now these guys are *muons*!

No missing energy cut required  
Number of lepton selection

Strategy to reduce combinatorics

Take 4 leptons and look for OSL with smaller delta R

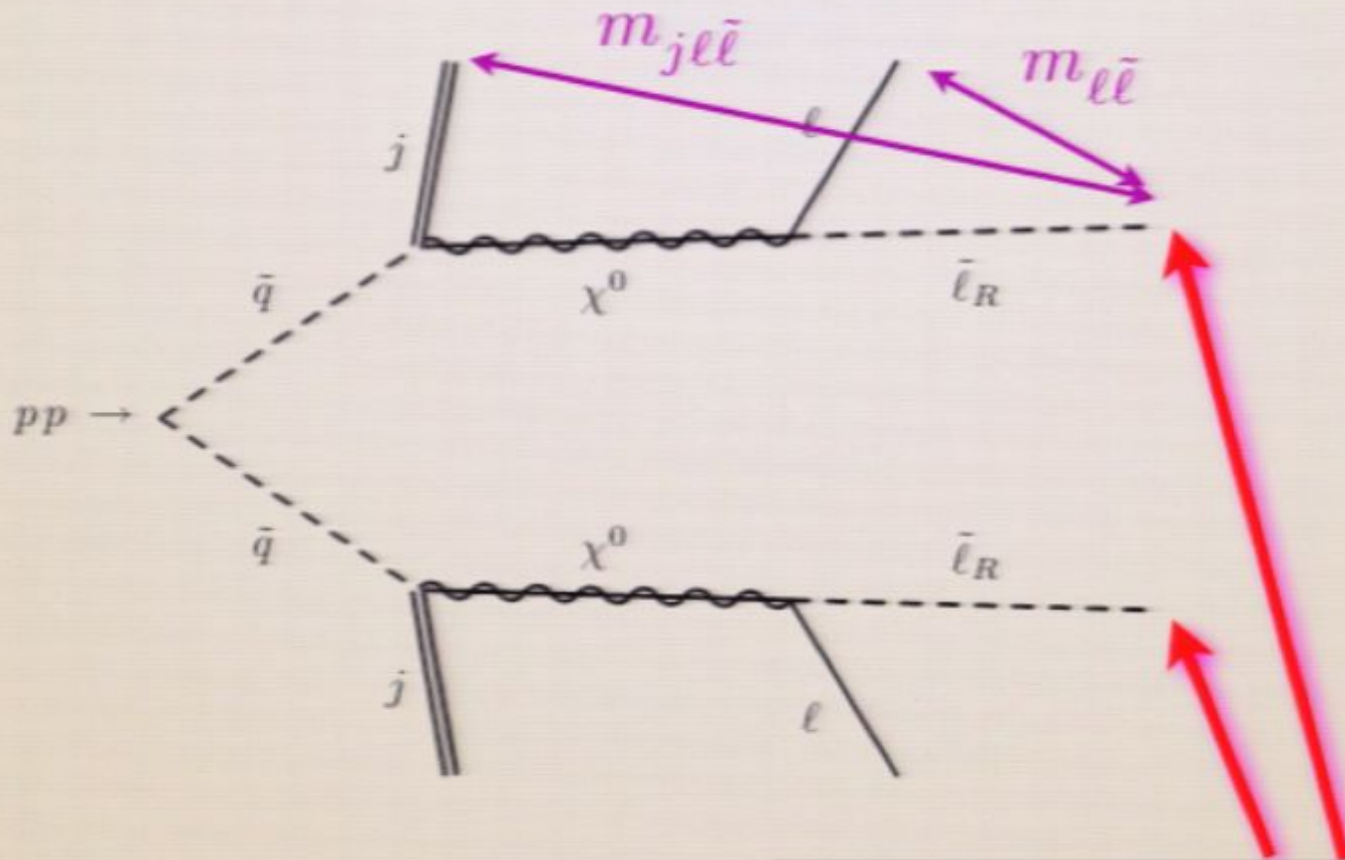
$\Delta R_{\ell\bar{\ell}}$



$m_{\ell\bar{\ell}}$

# An example

$$2\ell + 2\tilde{\ell} + 2j = 4\ell + 2j$$



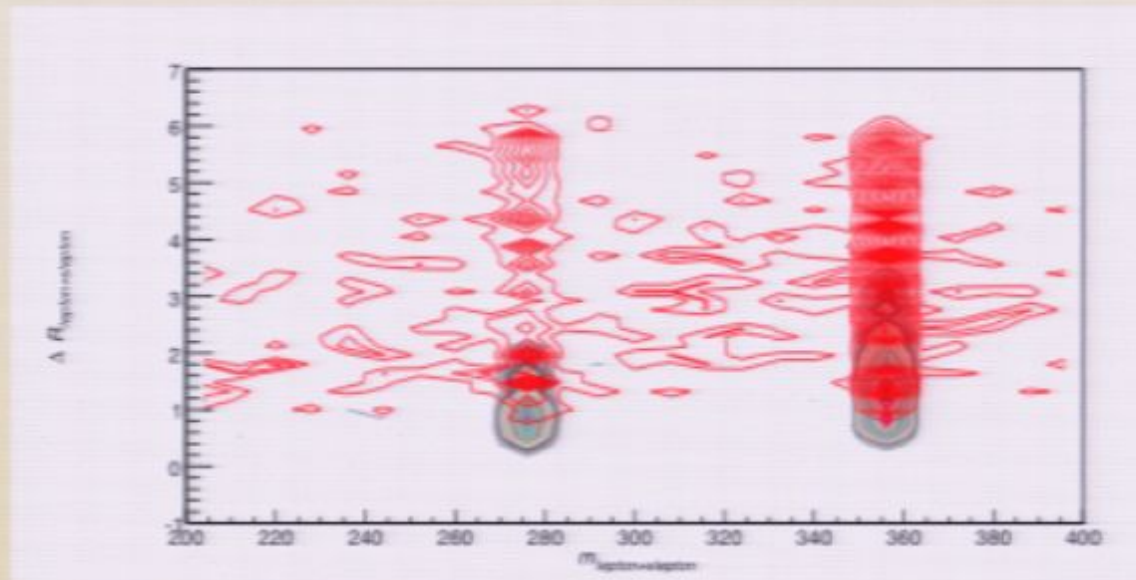
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$\Delta R_{\ell\bar{\ell}}$

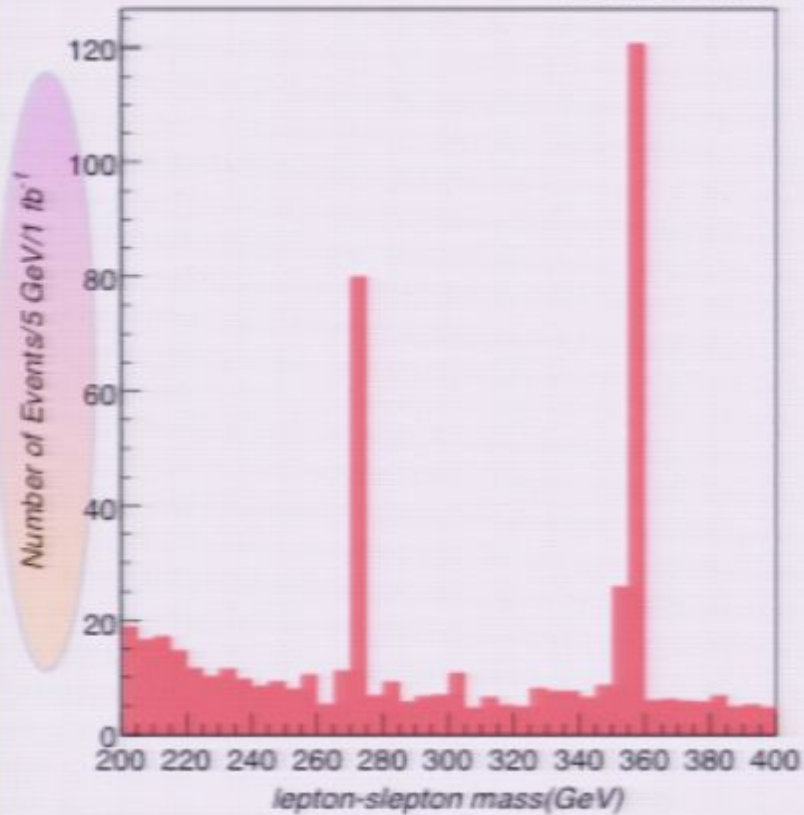


$m_{\ell\bar{\ell}}$

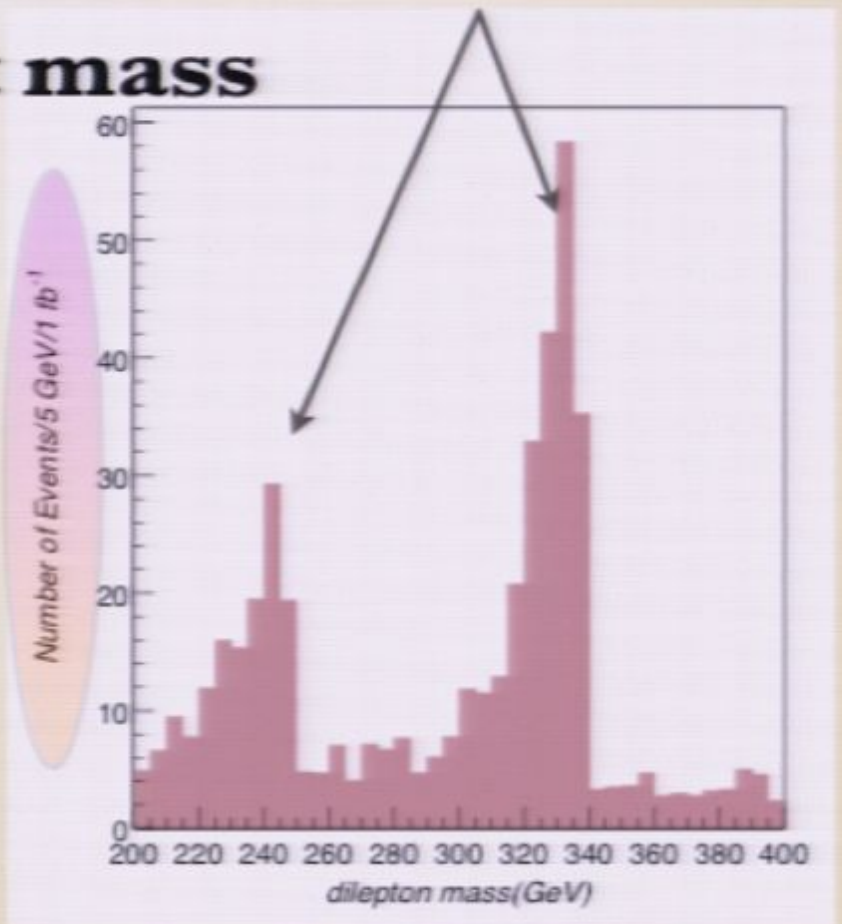
So what?

Missing mass  
similar to  
transverse mass

### Invariant mass



slepton ID



slepton misID

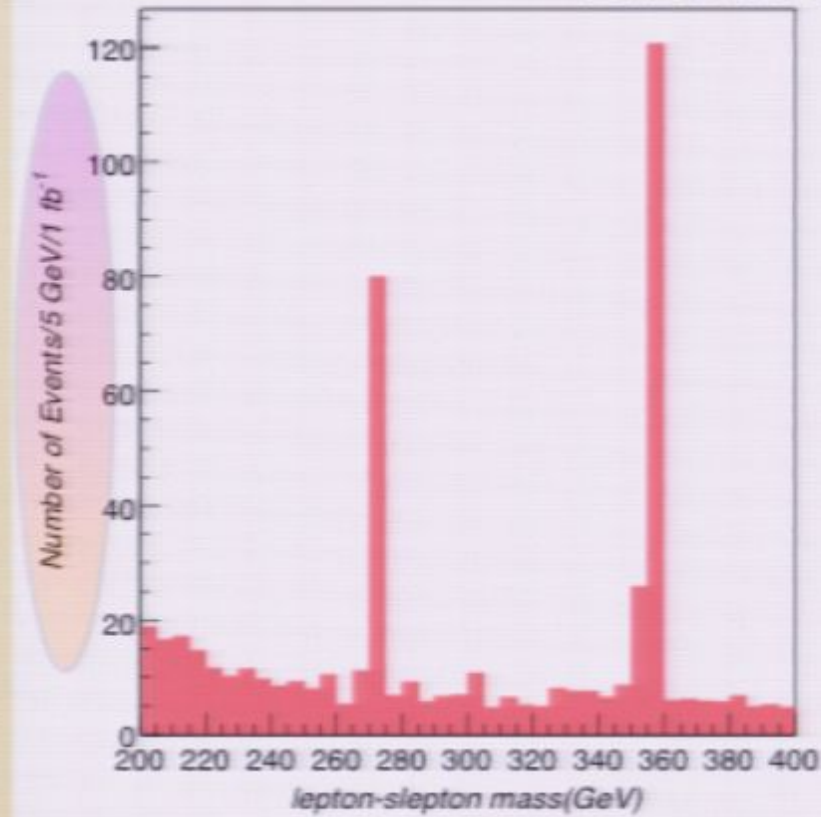


4 lepton channel  
Extra-Dimensions  
and Technicolor

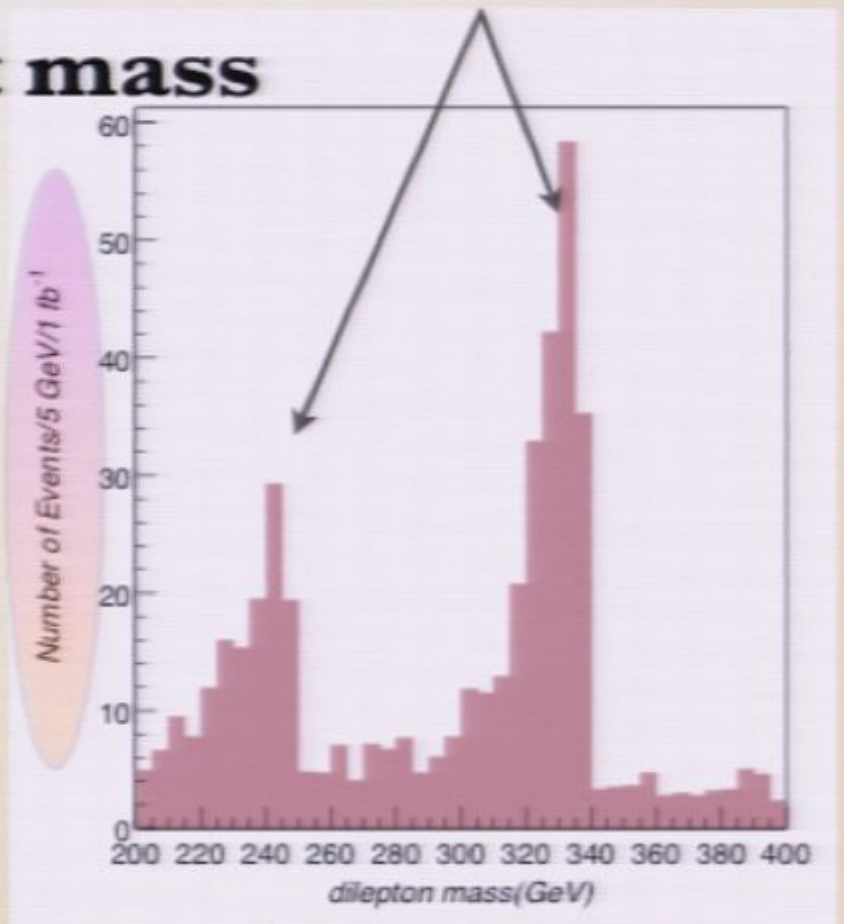
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All the plots for Higgless  
Simulation parton level MadGraph  
shower/had PYTHIA 6.4  
detector effects Pretty Good Simulator

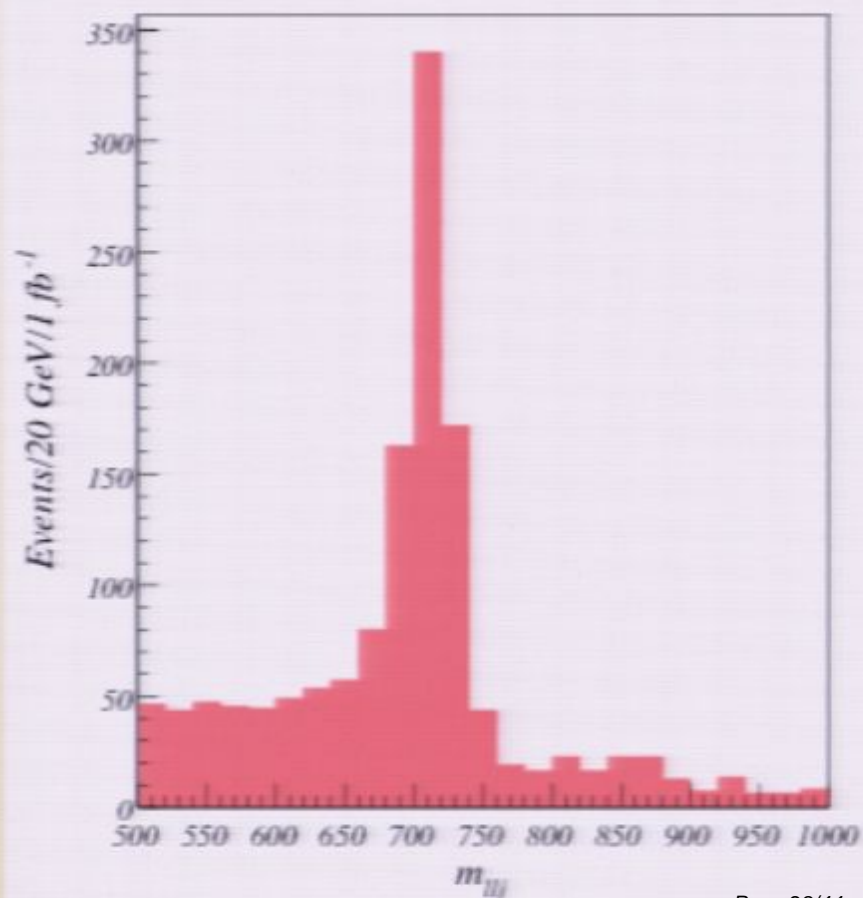
No missing energy cut  
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Number of lepton  
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for OSL with smaller  
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KK quark mass  
reconstruction



# Stepping back

All the plots for Higgless  
Simulation parton level MadGraph  
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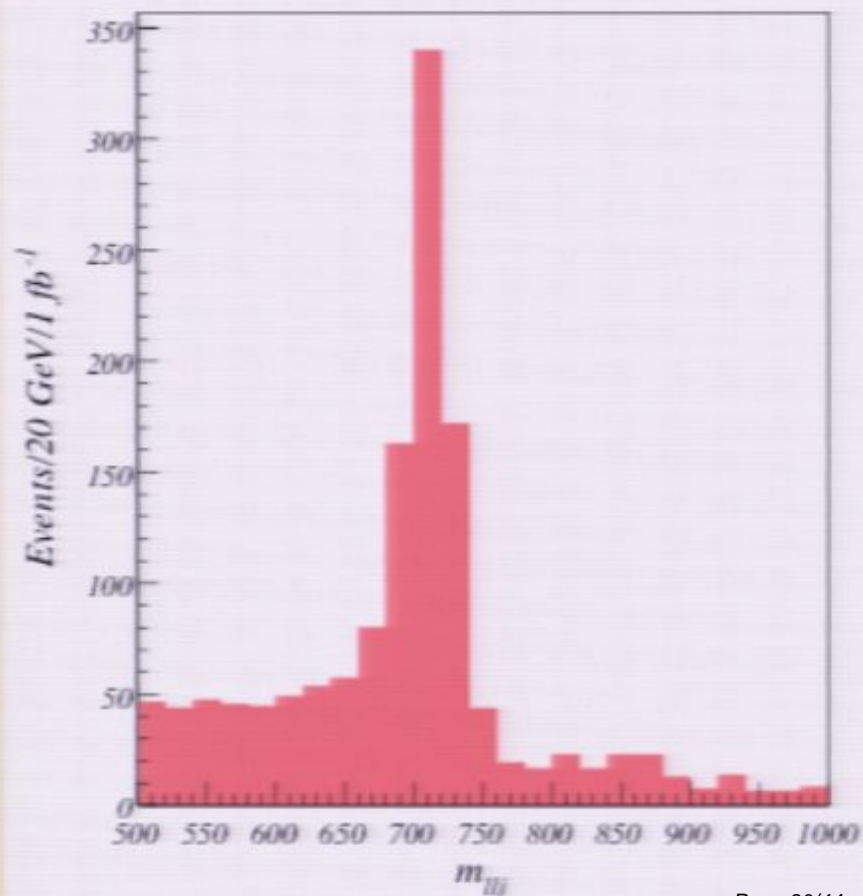
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# Stepping back

Don't need to buy into a model

If there is a new heavy quark at  
about 1 TeV

and it can decay to Z bosons

pb production cross section

4 leptons + 2 jets signal

no missing ET

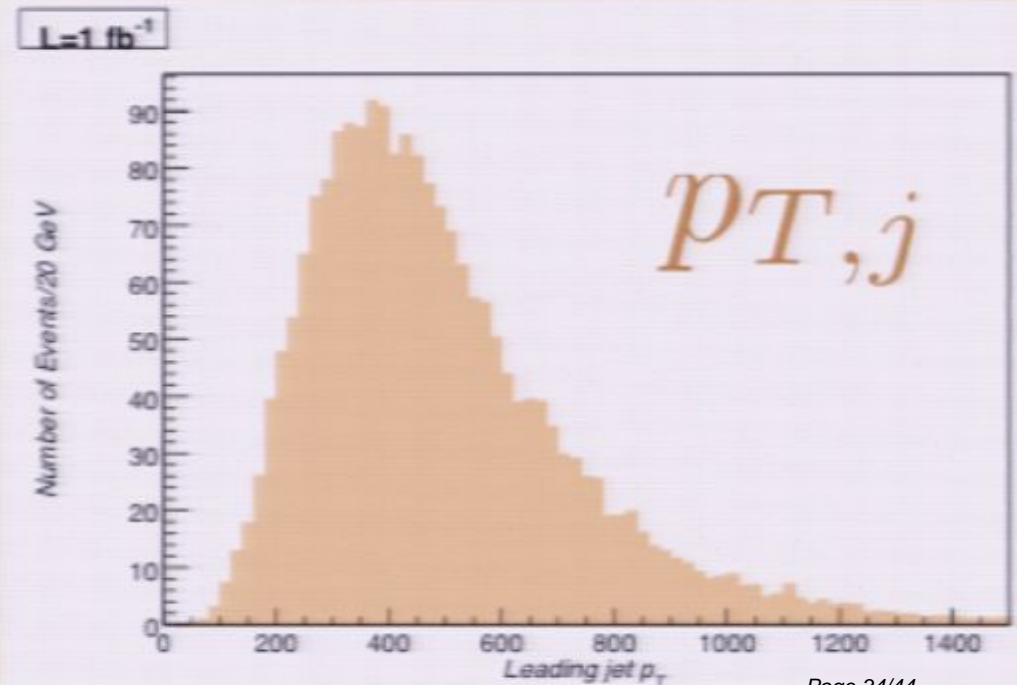
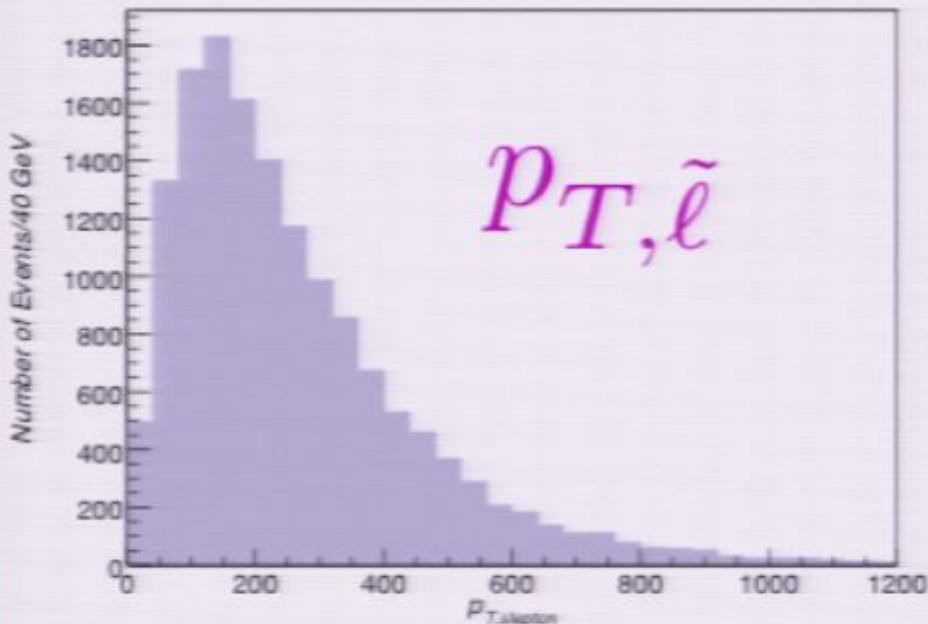


# Interlude: SM backgrounds

So far, all plots no SM backgrounds

Q. What are the BGs for  $4\ell + 2j$

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  $10^{-4}$   
(gross overestimate!)

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

## Generated SM BGs with **ALPGEN** and **MG**

None above fb after applying:

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

$W + \text{jets}$

QCD jets

$W Z + \text{jets}$

$Z Z + \text{jets}$

$Z + \text{jets}$

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

$$n_\ell = 4$$

$$n_j \geq 2$$

$$p_{T,j} \geq 100 \text{ GeV}$$

$$p_{T,\ell} \geq 50 \text{ GeV, (leading)}$$

$$\Delta R \geq 0.4 \text{ all objects}$$

# What ATLAS is doing

## Common lore

Light Higgs,  $b\bar{b}$  too hard, di-photon

AND

TeVatron bounds+ SUSY Higgs

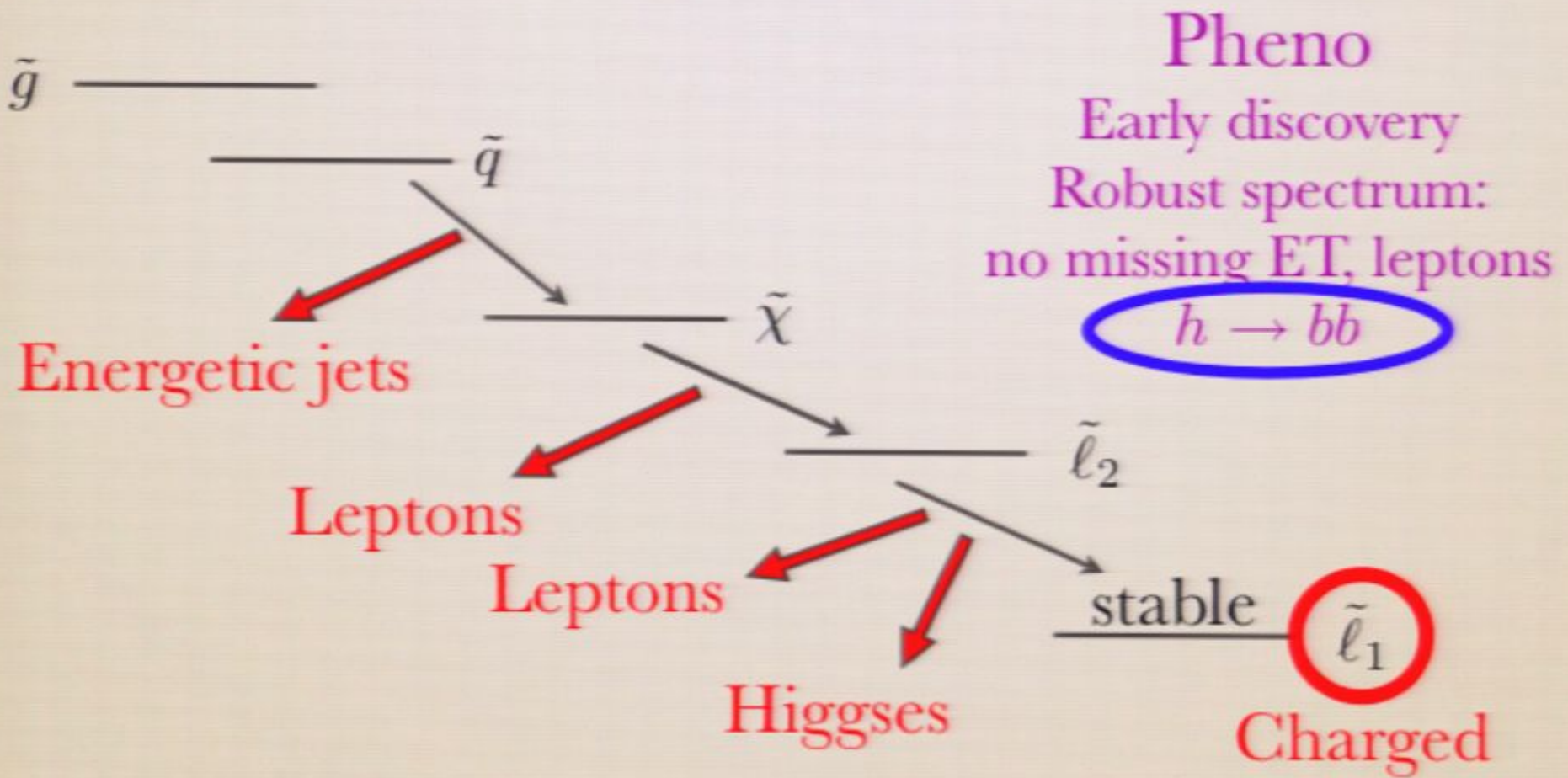
say Higgs is that light

BUT

if  $h$  to  $b\bar{b}$  with 4 leptons, BGs are no longer an  
issue

In general, worth looking at Higgs with more  
handles

no missing energy cut?  
no b-tagging?  
Wait for full simulation



with Assamagan (BNL), Rolli (Tufts), Tarem, Tenenbaum (Technion)

ATLAS-Higgs full-simulation of Lepto-SUSY

Validation and approval **done**  
final submission is today

Once the MC sample is generated  
we will study

1. High leptonic multiplicity
2. Higgs to  $b\bar{b}$
3. long-lived sleptons
4. signature based analysis

$$4\ell + X$$

Useful for all  
those models



# Conclusions

Early signatures are all around the place  
We need to look for them

Spectrum ordering important cascade decays  
(mSUGRA-like isn't generic)

Don't give up hope on early Higgs physics

Here, two examples in completely different setups  
discovery reach below  $1 \text{ fb}^{-1}$

## Pheno

Early discovery

Robust spectrum:

no missing ET, leptons

with Assamagan (BNL), Rolli (Tufts), Tarem, Tenenbaum (Technion)

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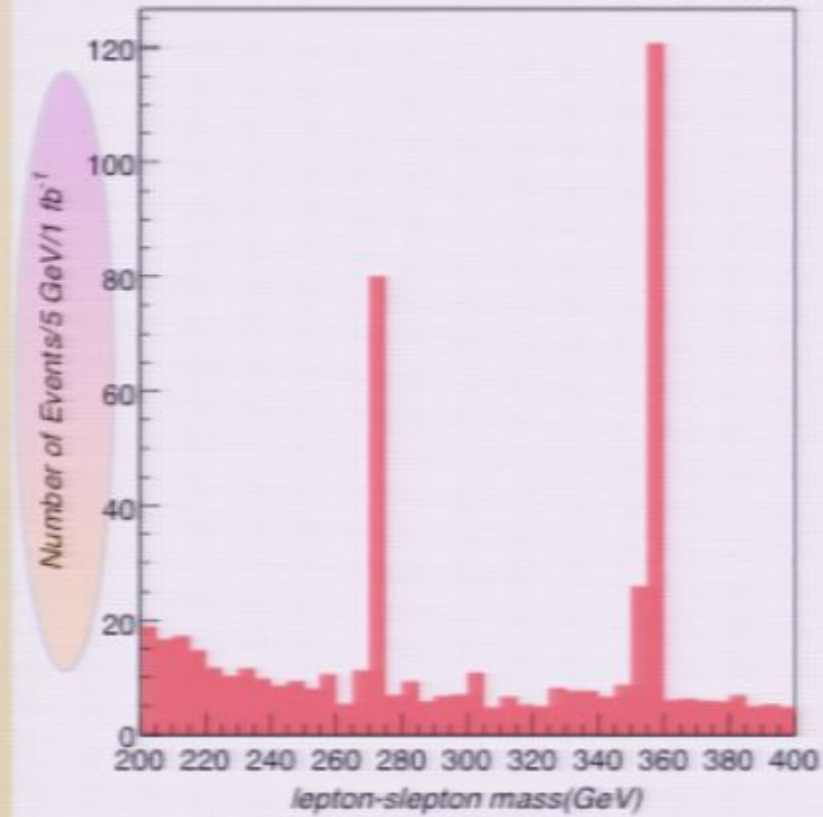
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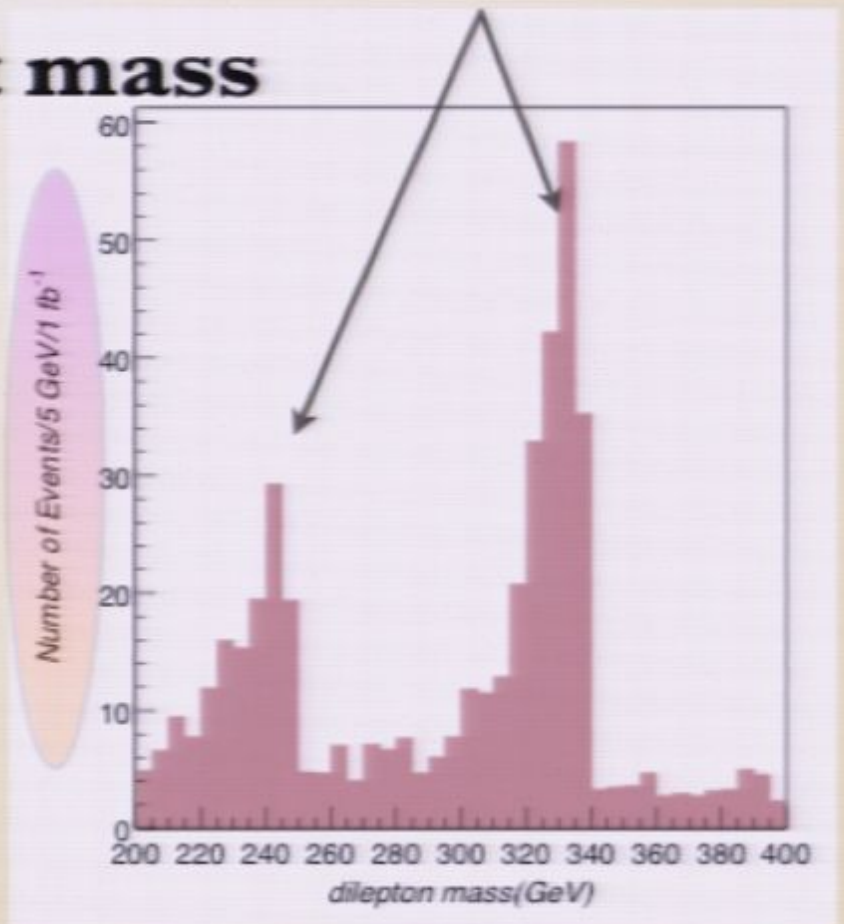
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