

Title: New electroweak states in plain sight

Date: Dec 04, 2012 01:00 PM

URL: <http://www.pirsa.org/12120017>

Abstract: The LHC has made remarkable progress in exploring the SM at new energies and demonstrating remarkable agreement with theoretical predictions. In this talk I will discuss one area where the SM does not fit as well as expected, and what could be hints of new physics showing up in the electroweak sector.

NEW EW STATES IN PLAIN SIGHT

Patrick Meade
Yang Institute for Theoretical Physics
Stony Brook University

Based on:

D. Curtin, P. Jaiswal, PM 1206.6888

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OR HOW I LEARNED TO STOP
WORRYING AND LOVE SM
MEASUREMENTS

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OR HOW I LEARNED TO STOP
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MEASUREMENTS

**about no
obvious BSM
physics**

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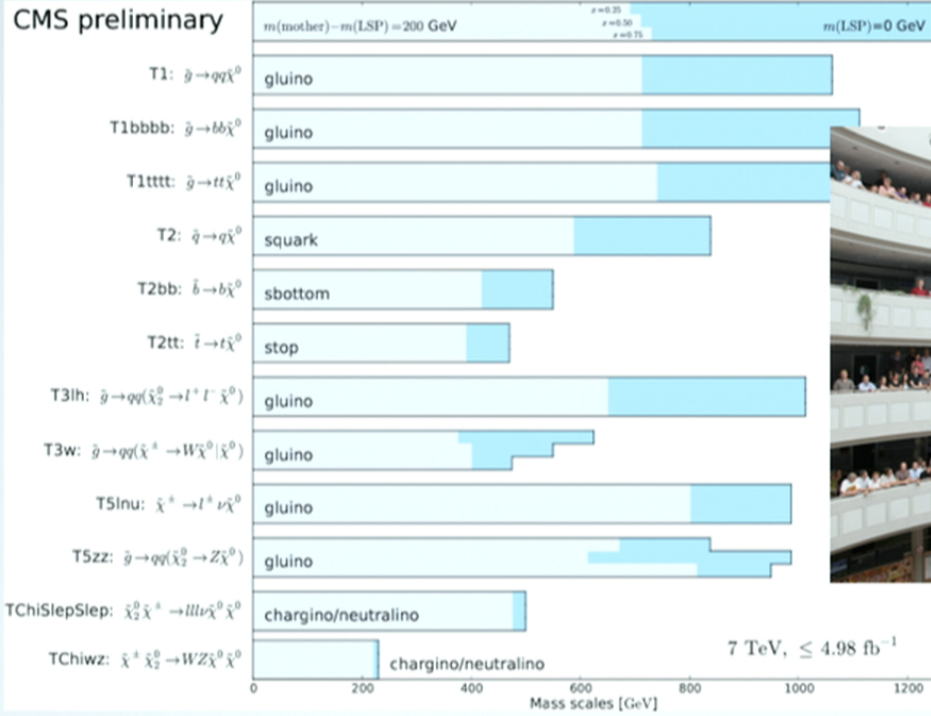
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OUTLINE: A FAIRY TALE WITH CONSEQUENCES

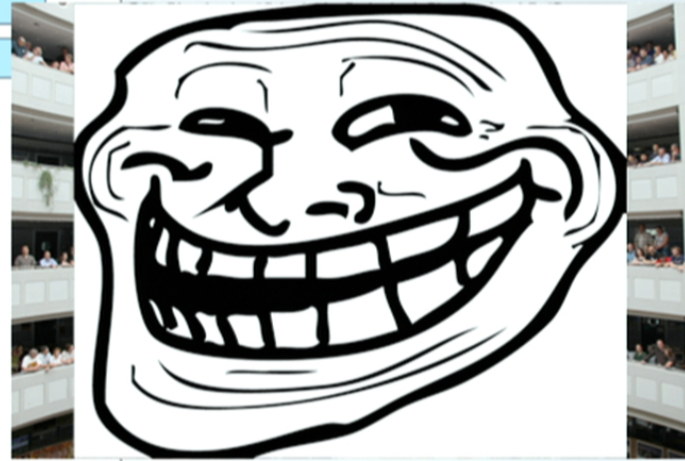
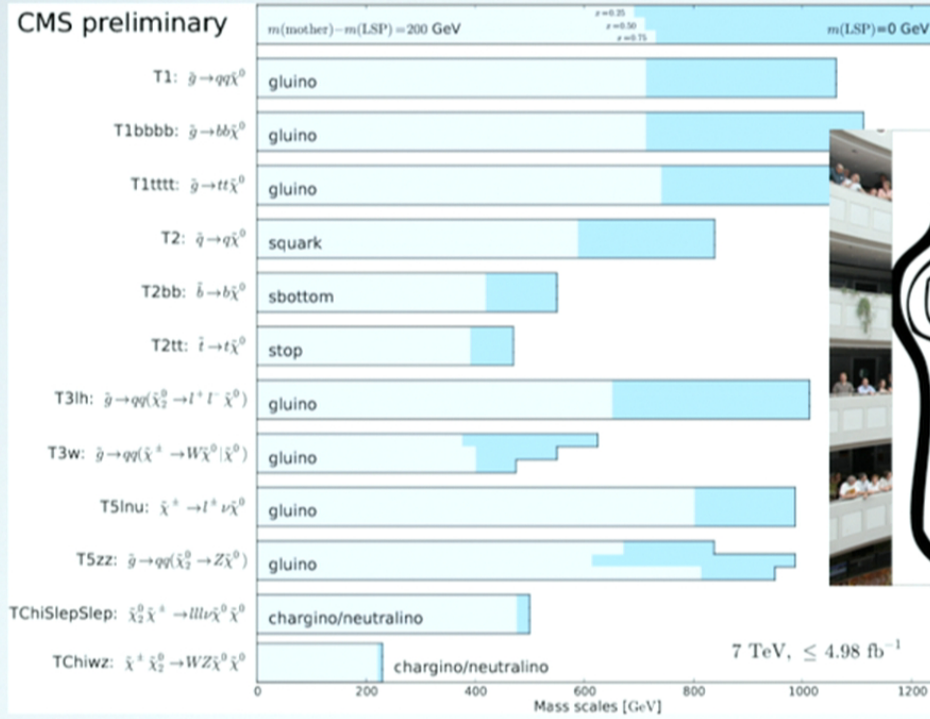
- Experimental hints of nothing or something...
- New EW states to explain
- Constraints
- Other explanations?

SUSY SUSY NOWHERE...

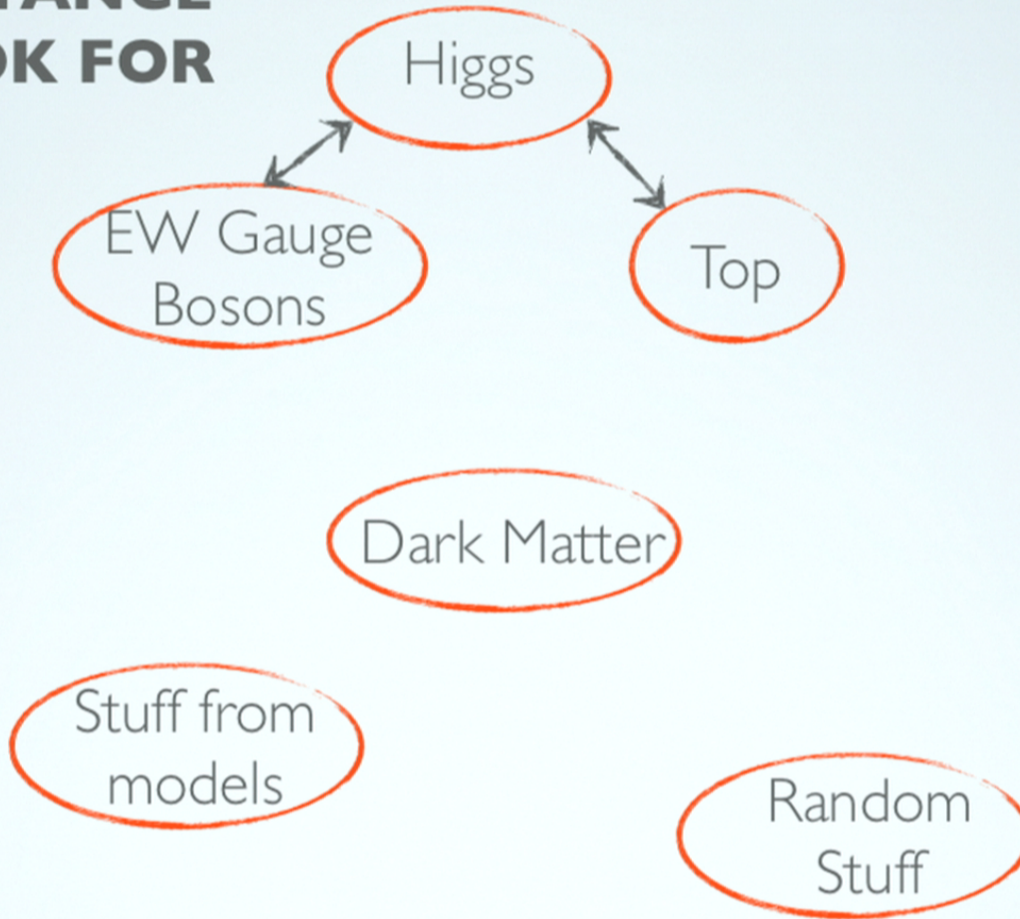


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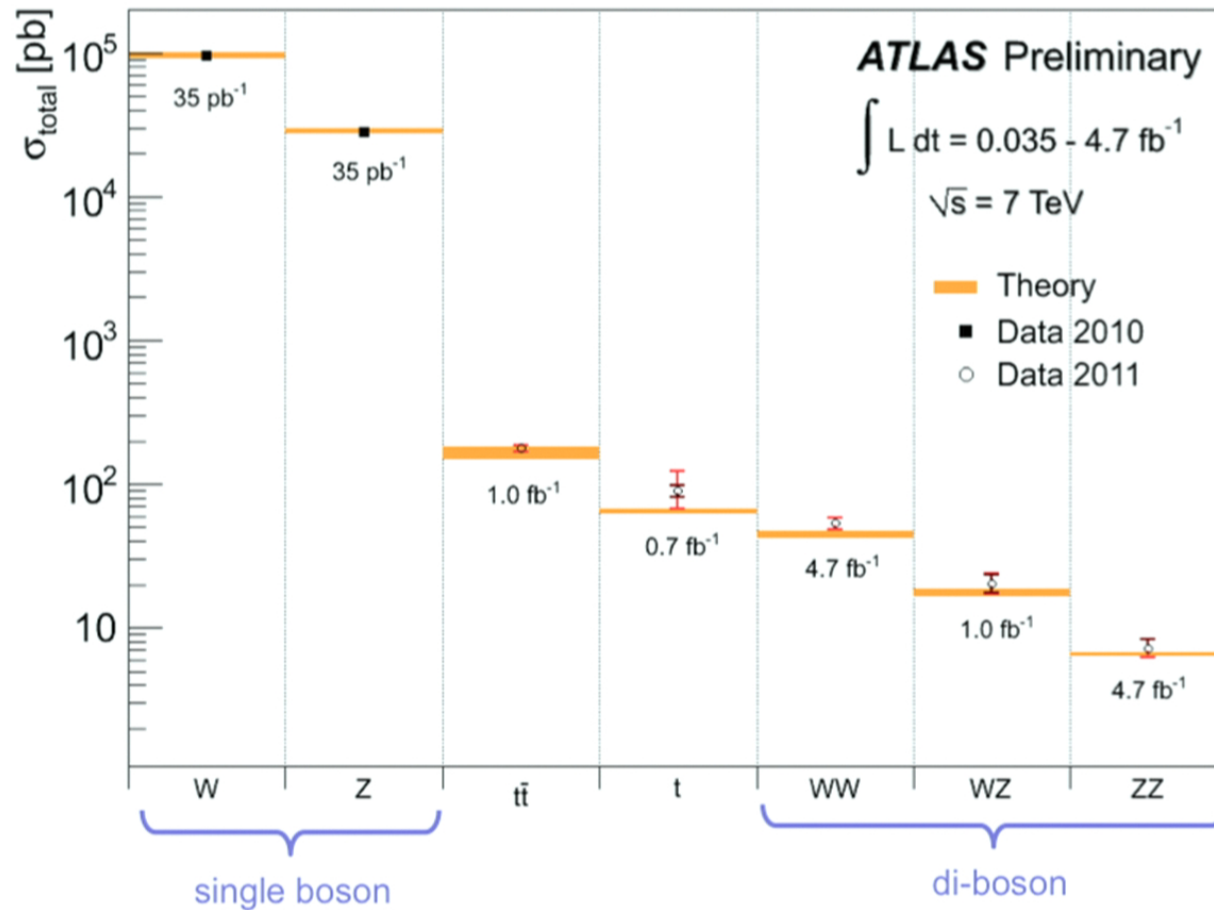
CMS preliminary



IMPORTANCE TO LOOK FOR

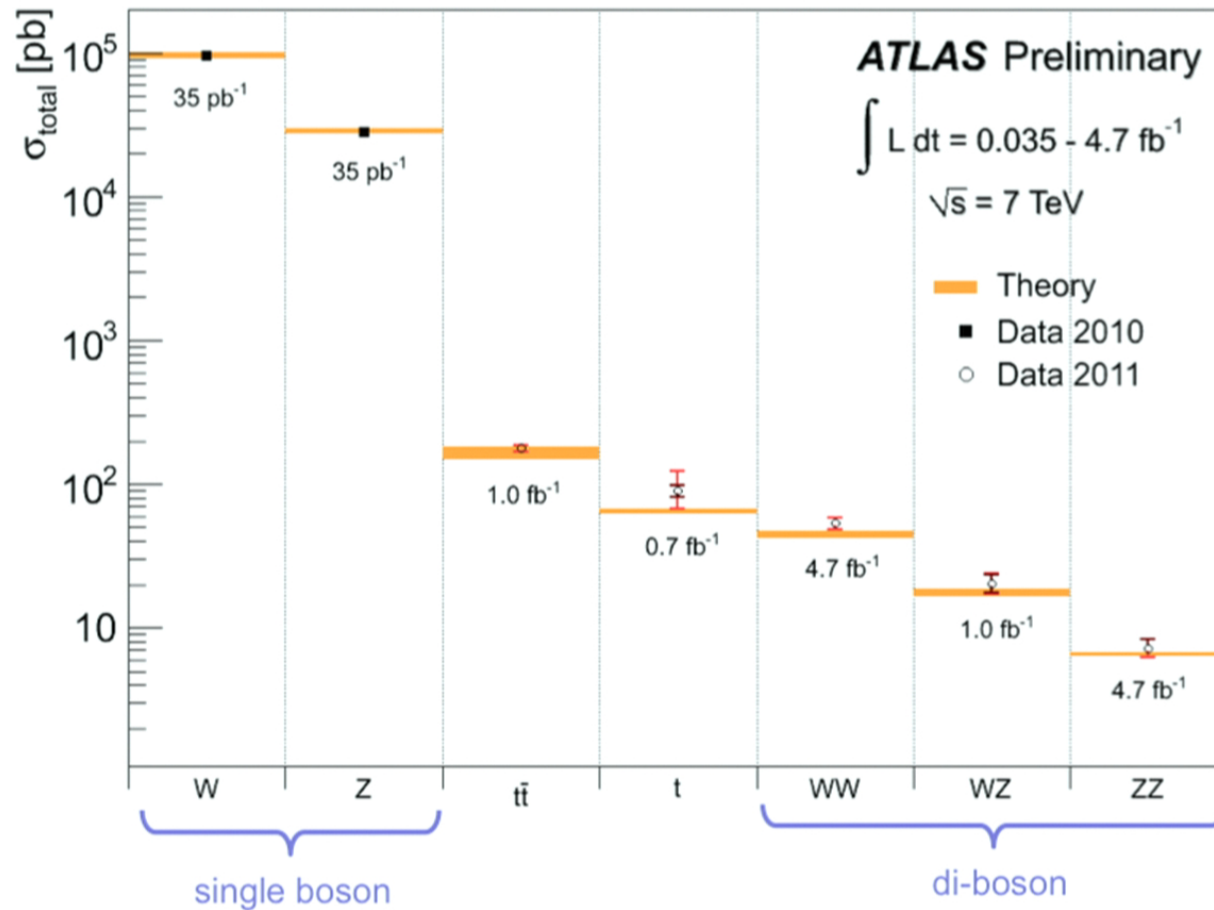


SM CROSS SECTION PLOT



• Very similar agreement with (N)NLO predictions is observed by CMS

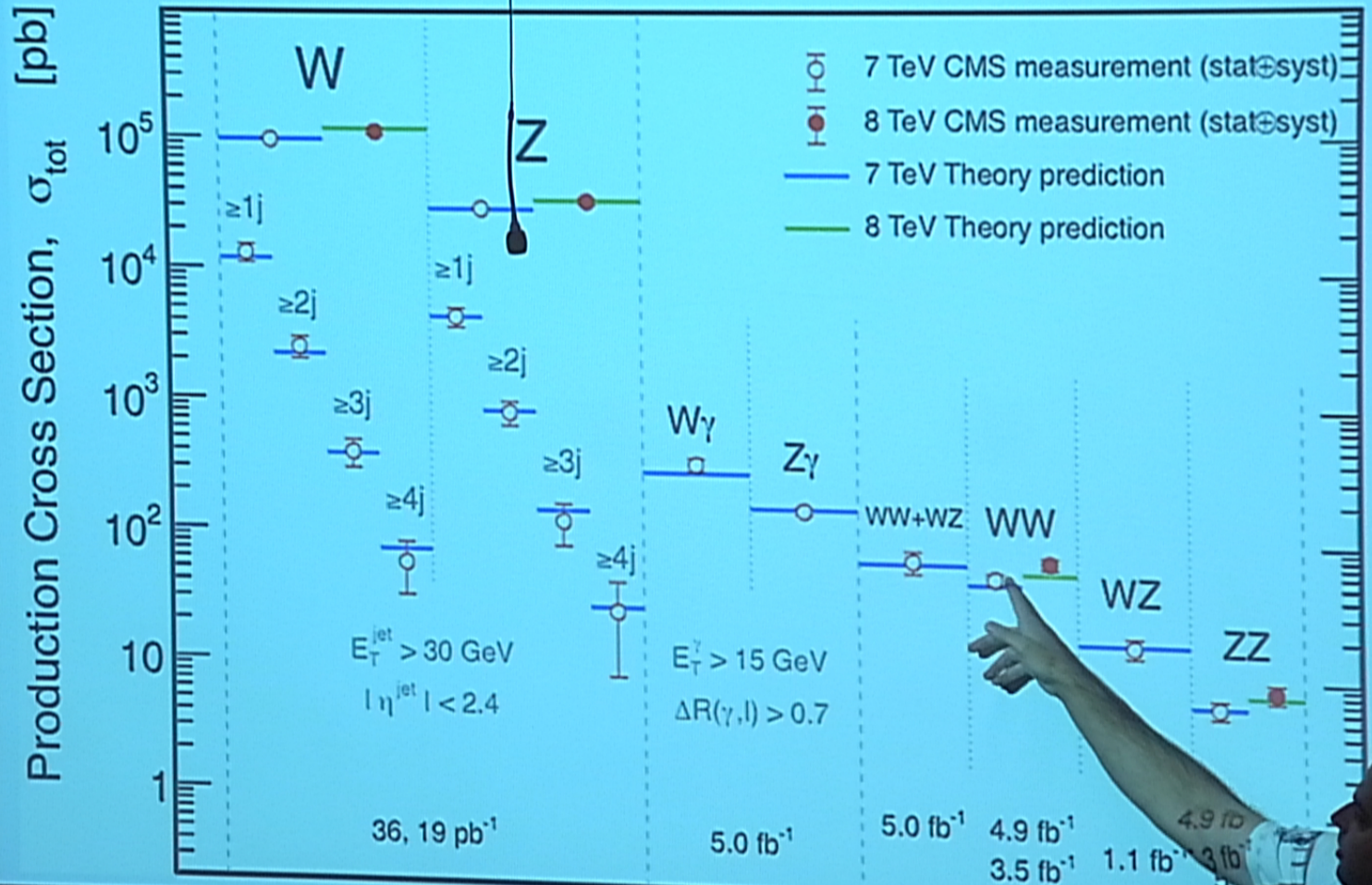
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Nov 2012

CMS



WW CROSS SECTION

- In principle the LHC makes 8 measurements highly sensitive to the WW cross section
 - SM WW at CMS7, ATLAS7, CMS8, ATLAS8
 - $h \rightarrow WW$ at CMS7, ATLAS7, CMS8, ATLAS8
- What's the status?

Every reported* measurement is higher than the SM

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WW CROSS SEC MEASUREMENTS

ATLAS 7

$$\sigma(pp \rightarrow W^+W^-) = 53.4 \pm 2.1(\text{stat}) \pm 4.5(\text{sys}) \pm 2.1(\text{lum}) \text{ pb}$$

CMS 7

$$\sigma(pp \rightarrow W^+W^-) = 52.4 \pm 2(\text{stat}) \pm 4.5(\text{sys}) \pm 1.2(\text{lum}) \text{ pb}$$

NLO theory at 7 TeV

$$\sigma(pp \rightarrow W^+W^-) = 45.1 \pm 2.8 \text{ pb}$$

$$\sigma(pp \rightarrow W^+W^-) = 47 \pm 2 \text{ pb}$$

ATLAS MC@NLO
Campbell,
MCFM Ellis,
Williams

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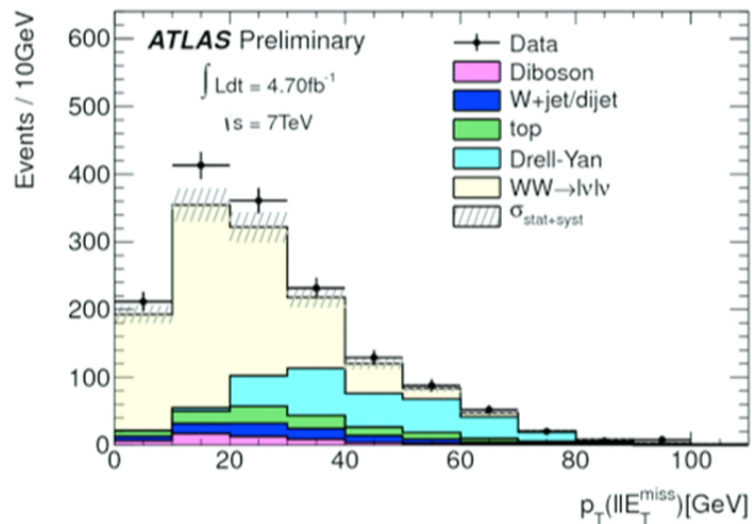
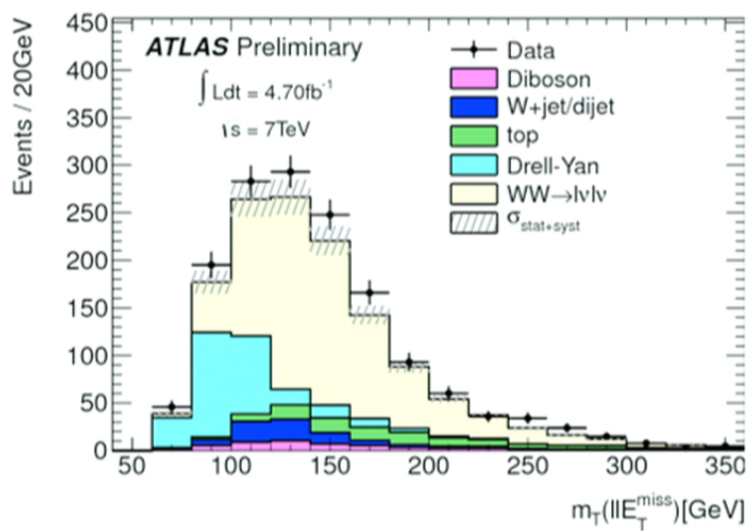
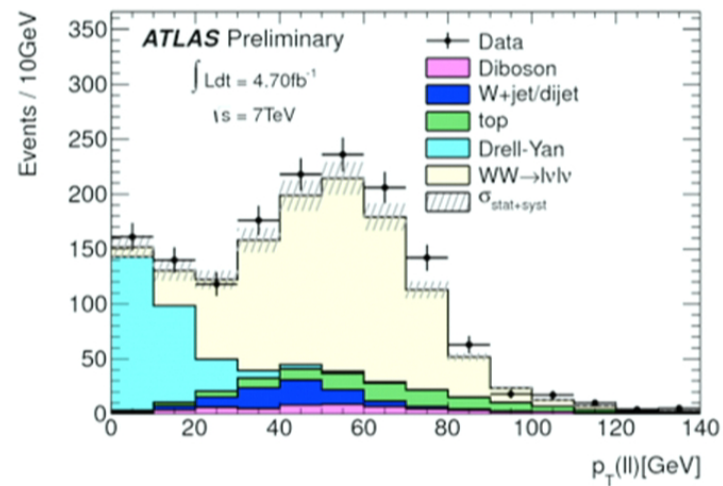
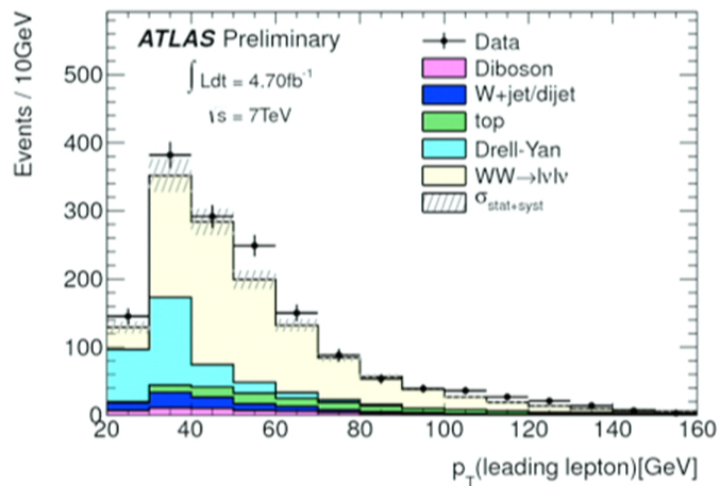
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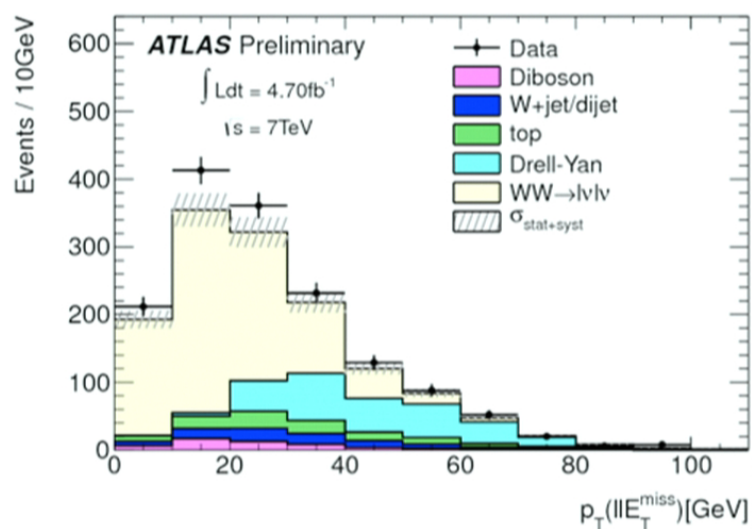
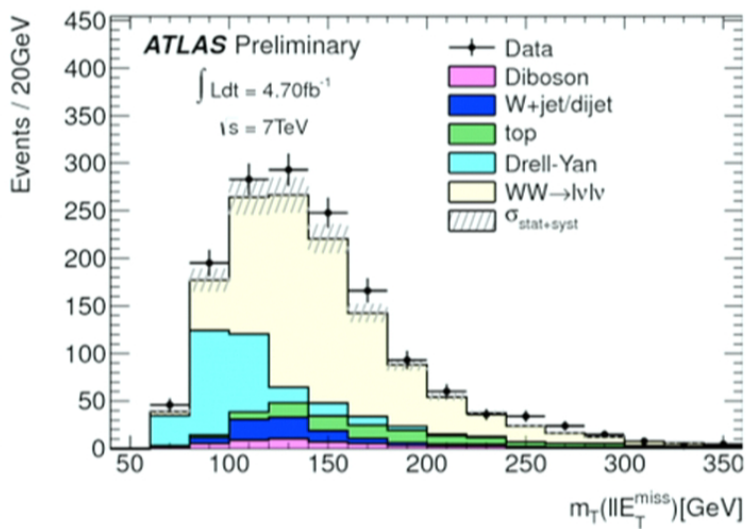
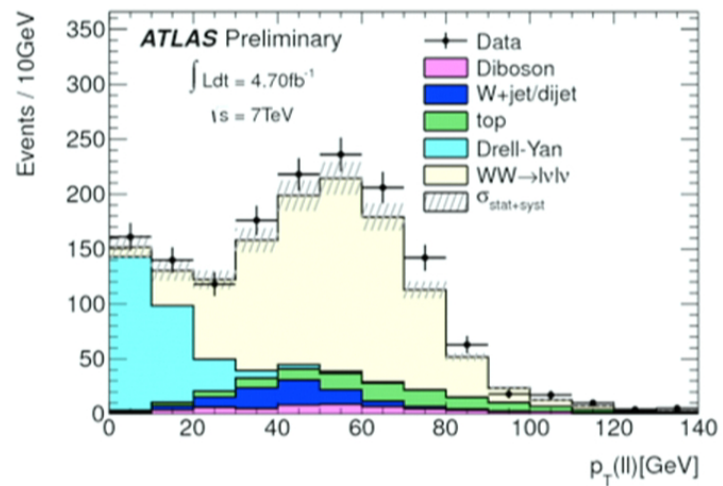
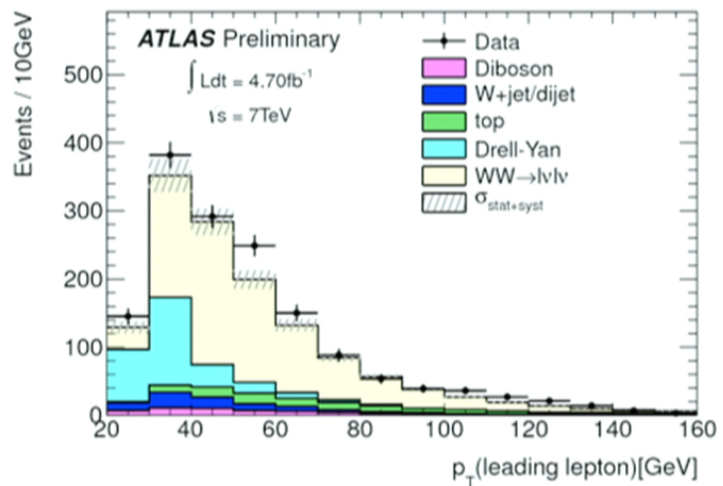
MCFM
Campbell,
Ellis,
Williams

*1.4 σ and 1 σ , this is an
anomaly???*

ATLAS and CMS are more
consistent with each other than the SM...

NOT just a “rate” anomaly





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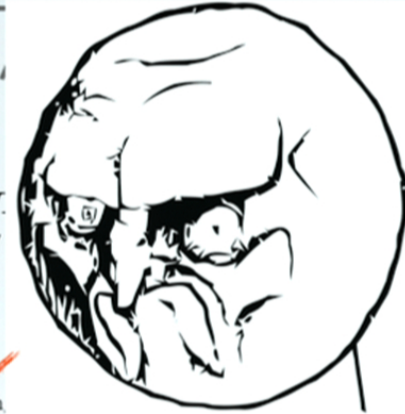
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UPDATED LHC-7

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NO.

Significance about the same as before

Additional $p_t(\ell)$ cut

CMS 8 TEV 3.5/FB

WW \rightarrow 2 ℓ 2 ν at 8 TeV: systematics & results



$$\sigma = 69.9 \pm 2.8 \text{ (stat)} \pm 5.6 \text{ (sys)} \pm 3.1 \text{ (lum)} \text{ pb}$$
$$\text{NLO prediction (MCFM): } 57.25 \left(\begin{array}{c} +2.35 \\ -1.60 \end{array} \right) \text{ pb}$$

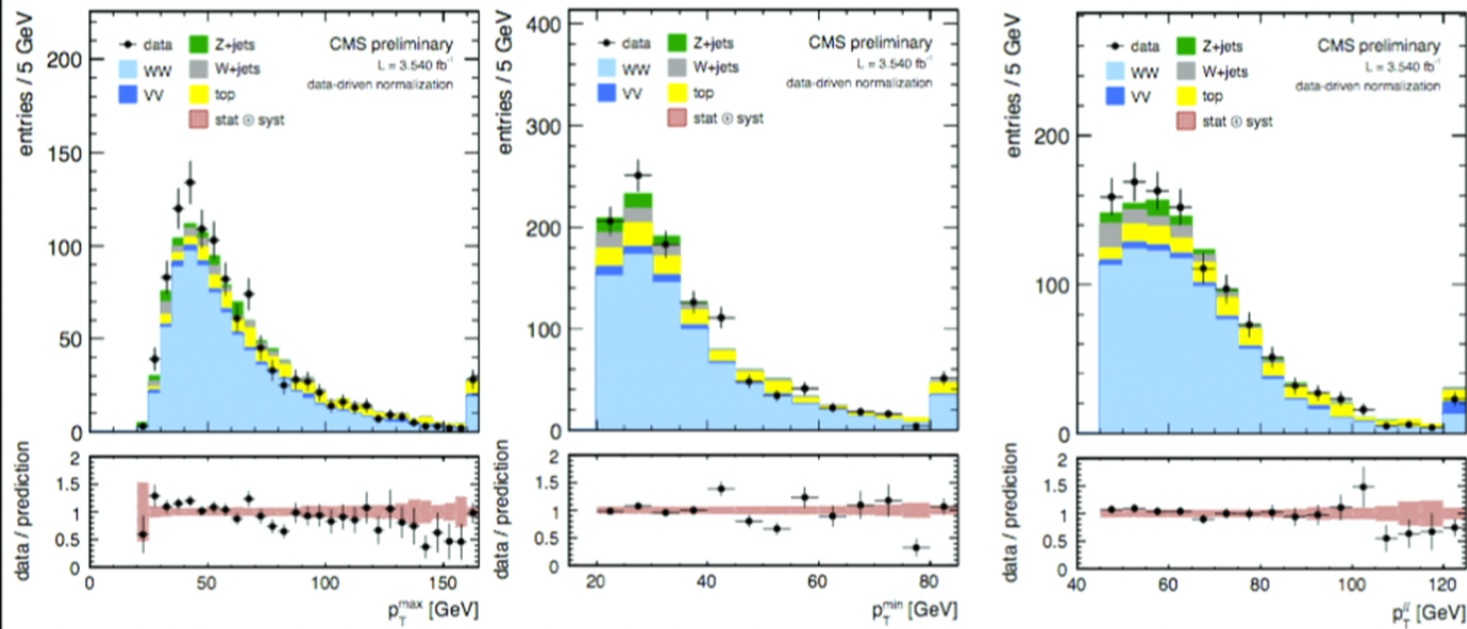
- **Already 4% statistical precision**
- **About 1.8 σ higher than the NLO prediction**

It grows at 8 TeV even faster!

$$\left. \frac{\sigma(8)}{\sigma(7)} \right|_{\text{th}} = 1.21$$

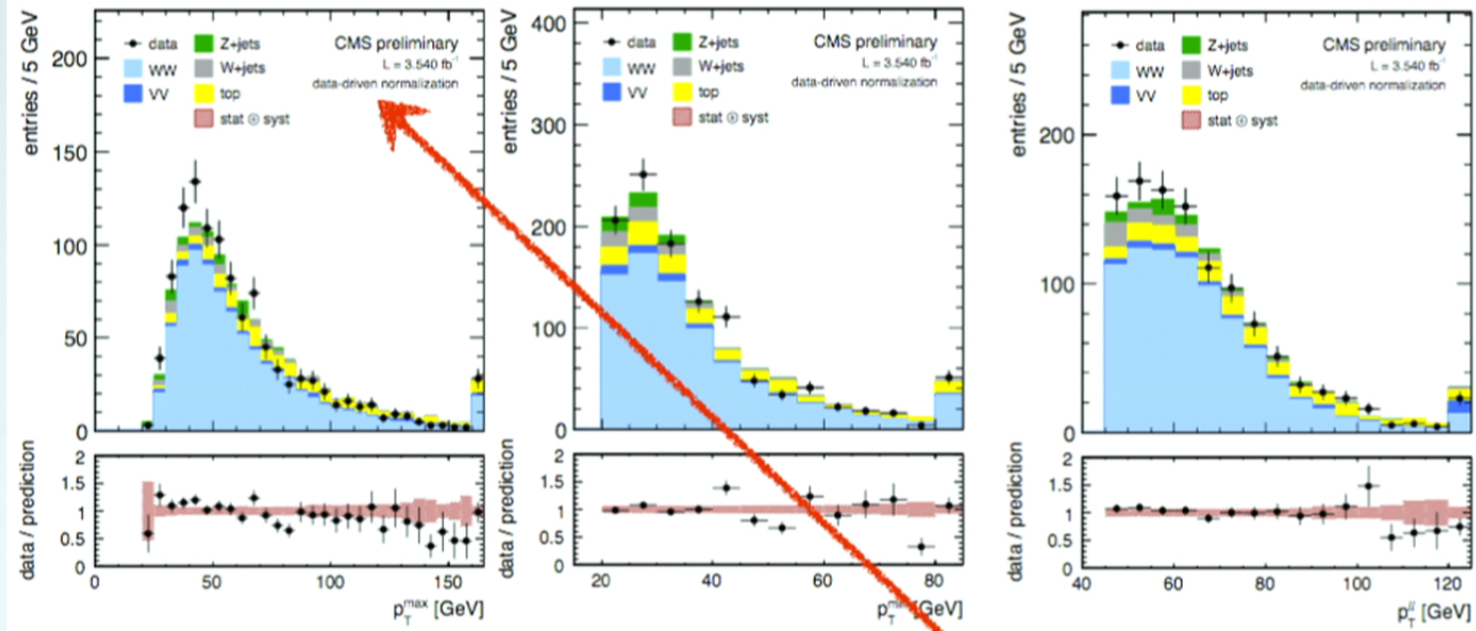
$$\left. \frac{\sigma(8)}{\sigma(7)} \right|_{\text{exp}} = 1.33$$

CMS8

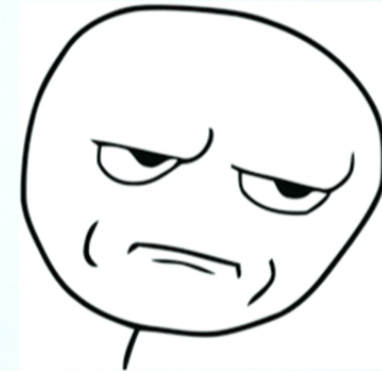


Looks pretty good...

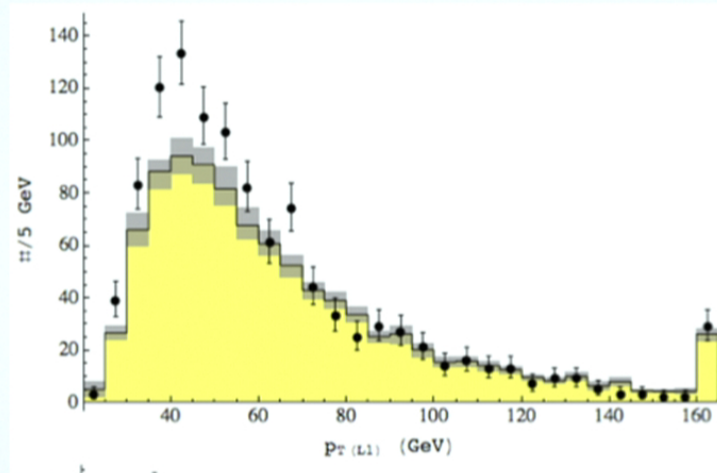
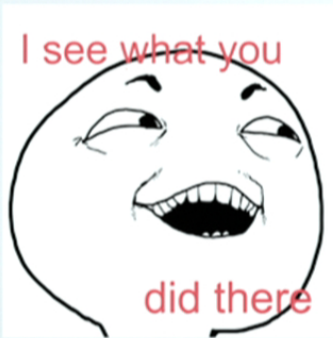
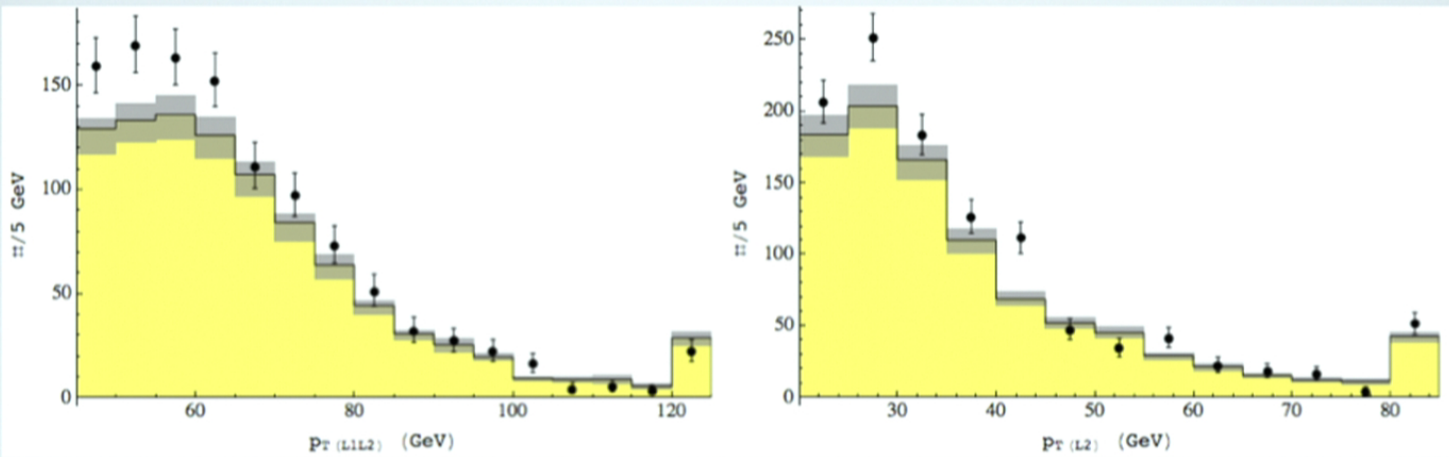
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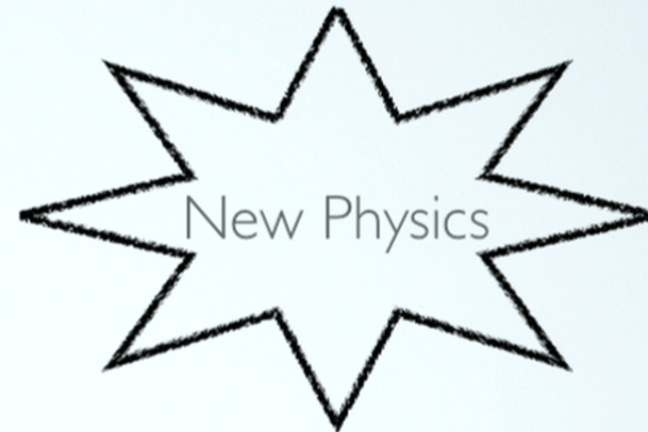
NO EXTRA NORMALIZATION...



Upward fluctuations in all measurements **or** a trend?

Two roads diverged in a yellow wood,
and sorry I could not travel both...

SM calculation
wrong

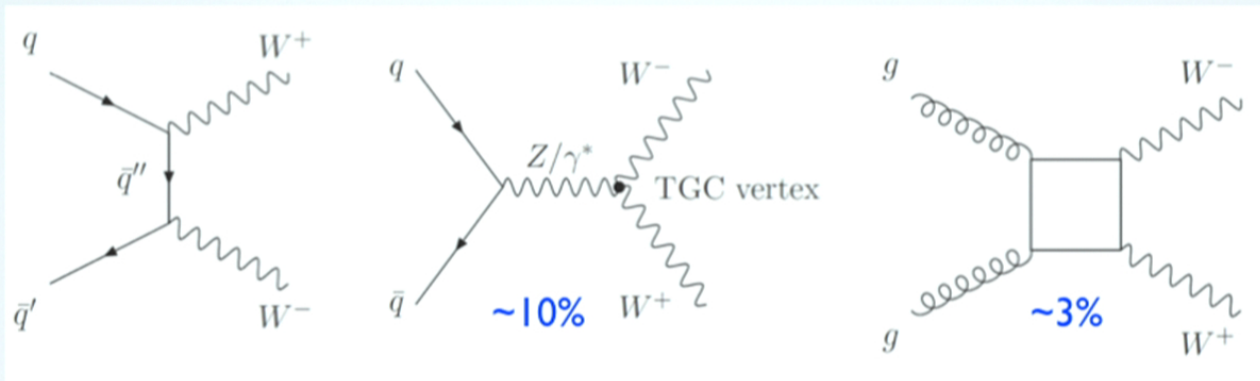


INGREDIENTS FOR BSM EXPLANATION

- Need to first understand what it MEANS to measure the WW cross section!

Total
cross section

$$\sigma_{WW} = \frac{N_{\text{data}} - N_{\text{bkg}}}{C_{WW} \times A_{WW} \times \text{BR} \times \mathcal{L}}$$



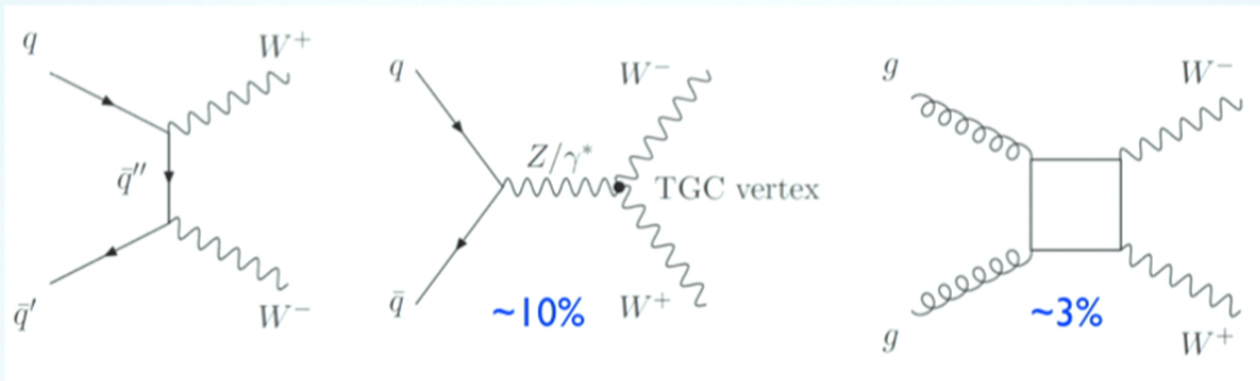
Count opposite sign dileptons + MET in a fiducial region
with a jet veto and a few other requirements

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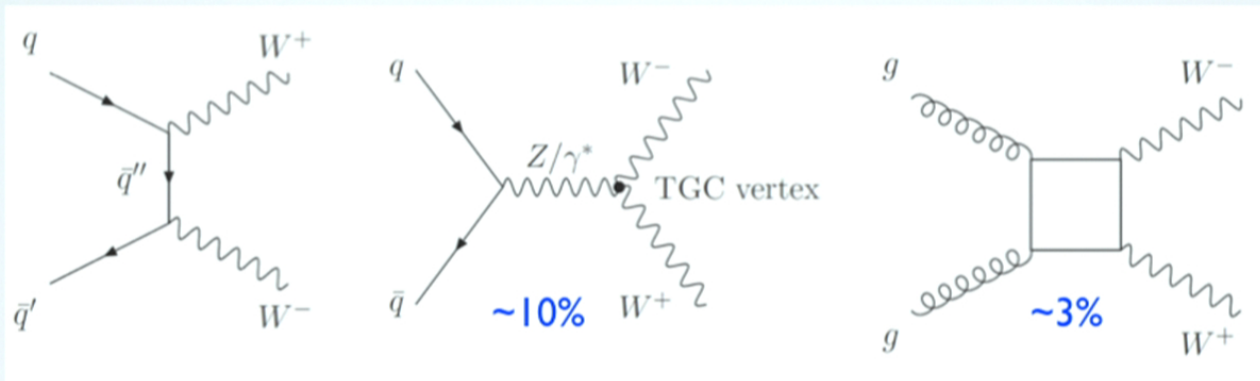
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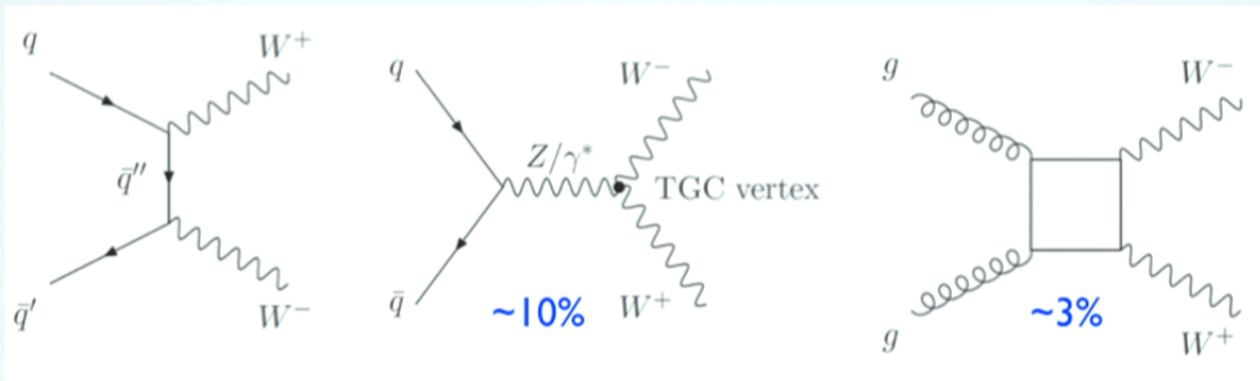
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- ATLAS and CMS both measure OS dileptons + MET **with** a jet VETO
- Final state needs to be OS leptons+MET with *nothing* else essentially
- Does **NOT** imply there have to be **REAL W's**
 - Doesn't hurt either if there are!

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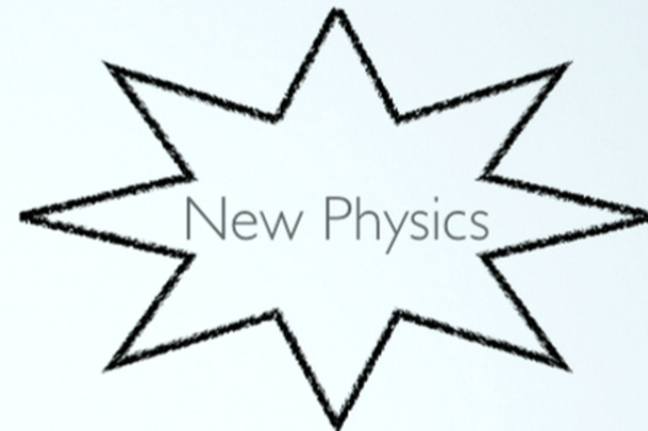
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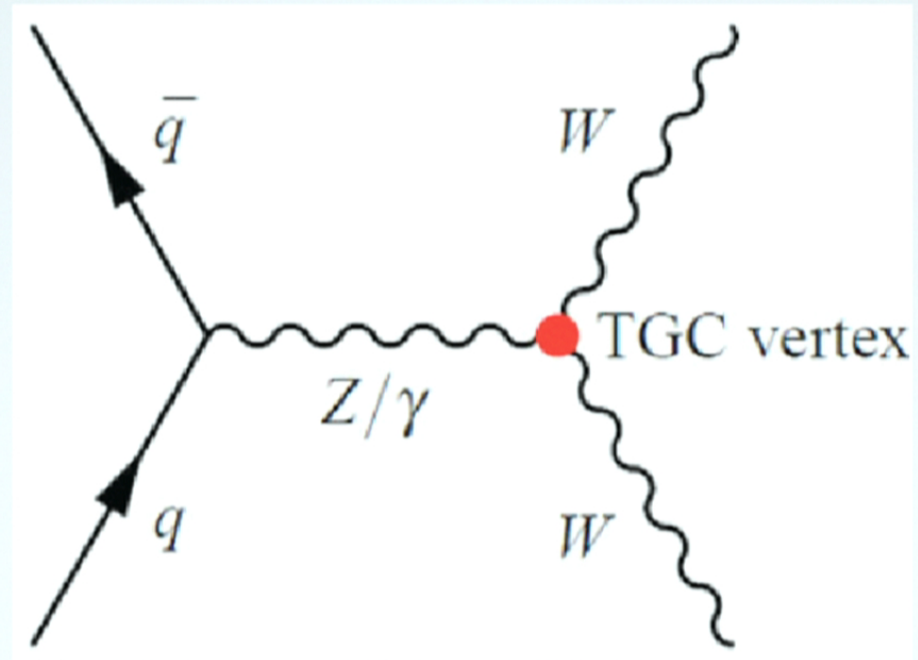
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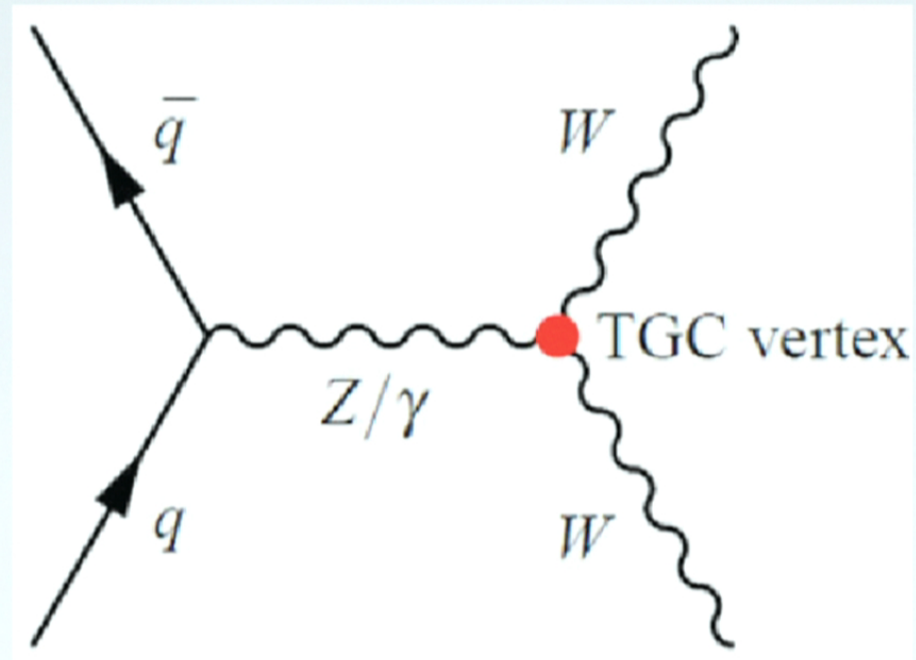


Will come back to the less traveled one
and that of course may make all the difference...

EXPERIMENTALIST'S FAVORITE DIBOSON TOOL...

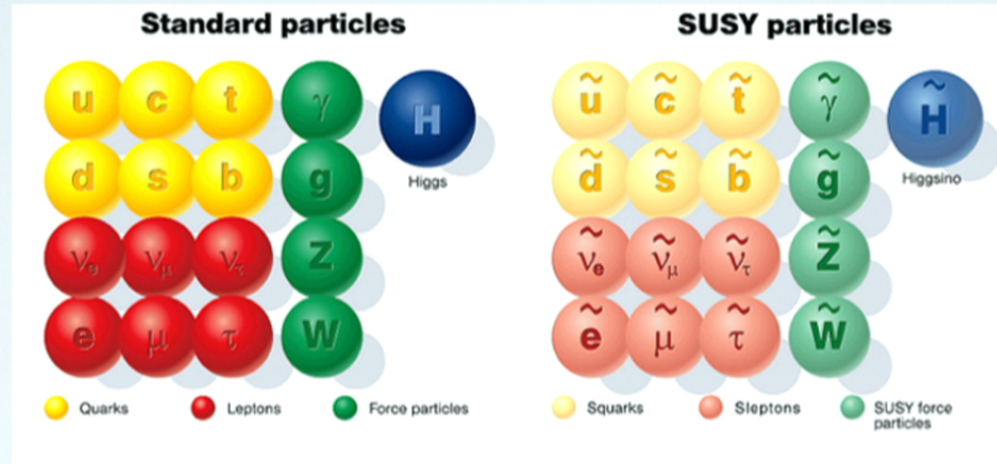


AN EXPLANATION?



NO! Need to affect the bulk not tails of distributions!

SUSY??



We've found ALMOST half of the particles...

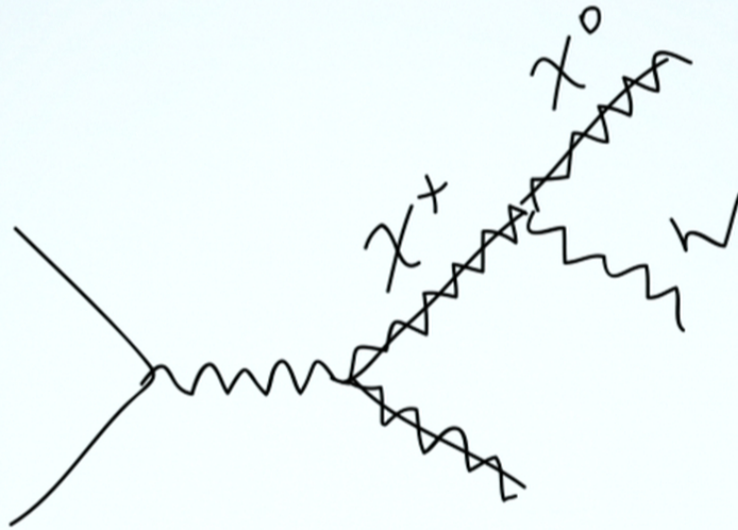
SUSY (MET) LHC

————— 1000 GeV - colored
(Tevatron) particles

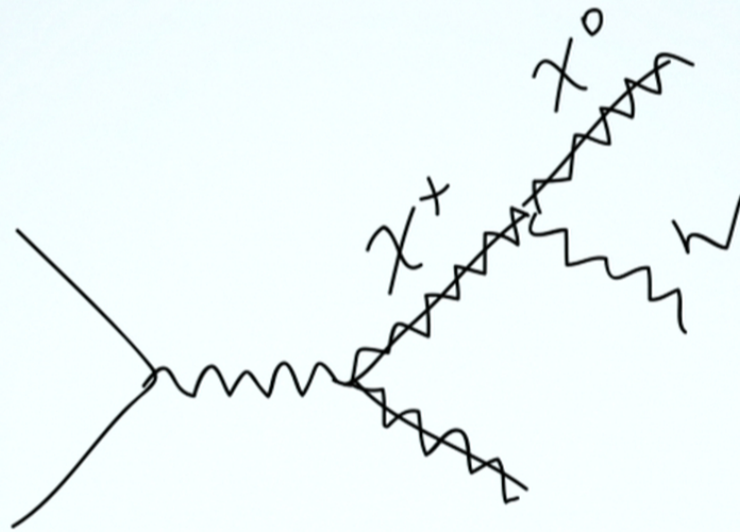
————— 100 GeV EW
(LEP) States

**Just starting to enter
into EW game**

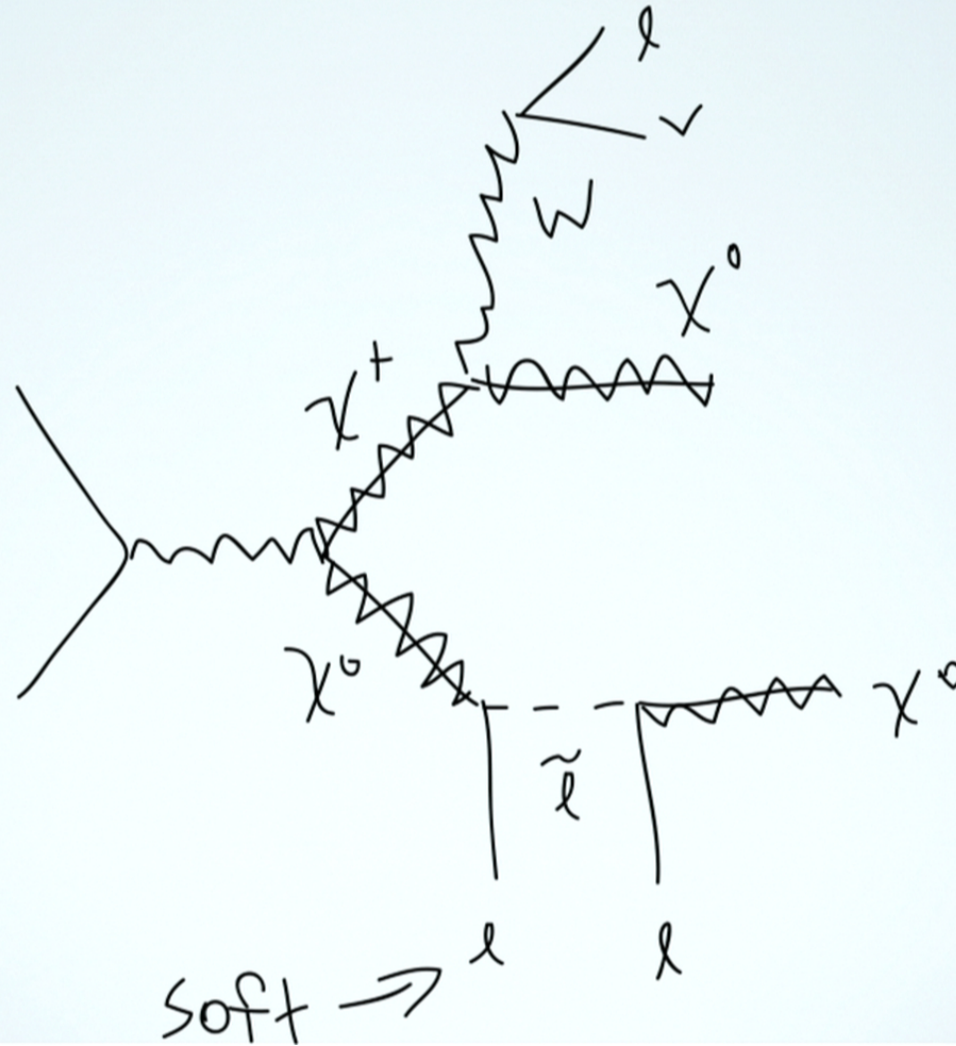
EXAMPLE TOPOLOGIES FOR WW+MET



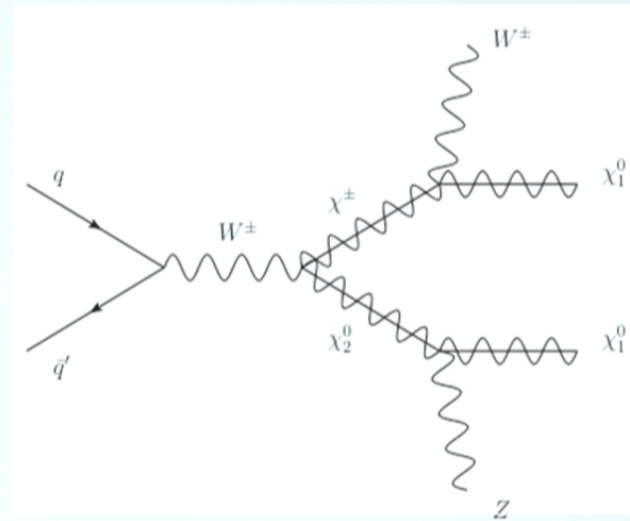
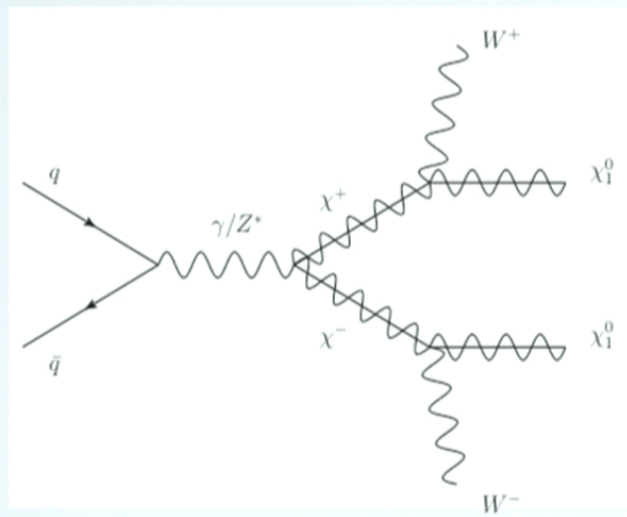
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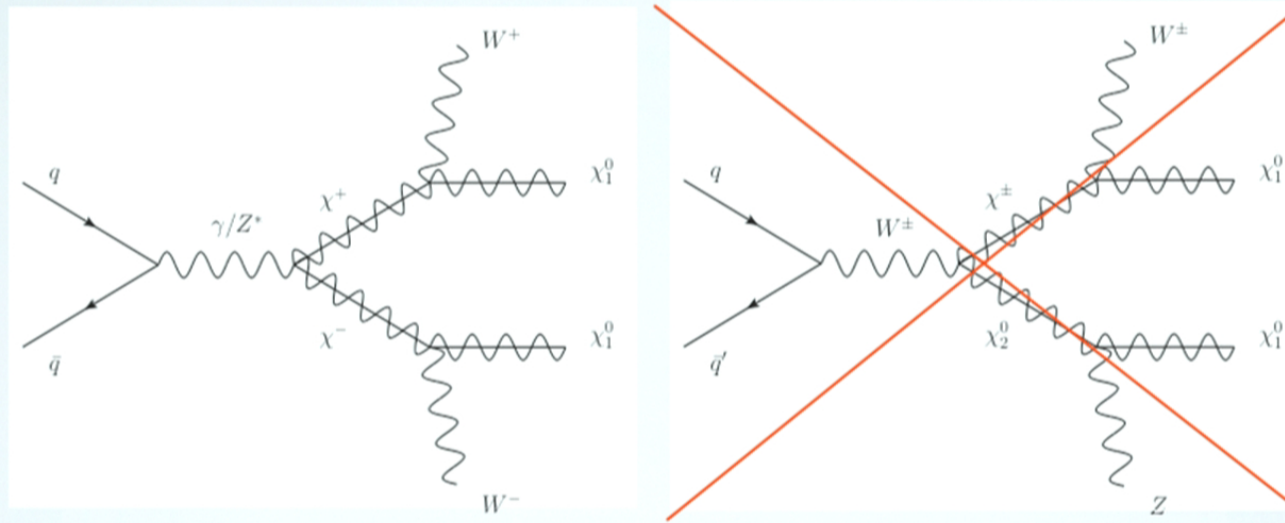
SUSY HAS OTHER OPTIONS



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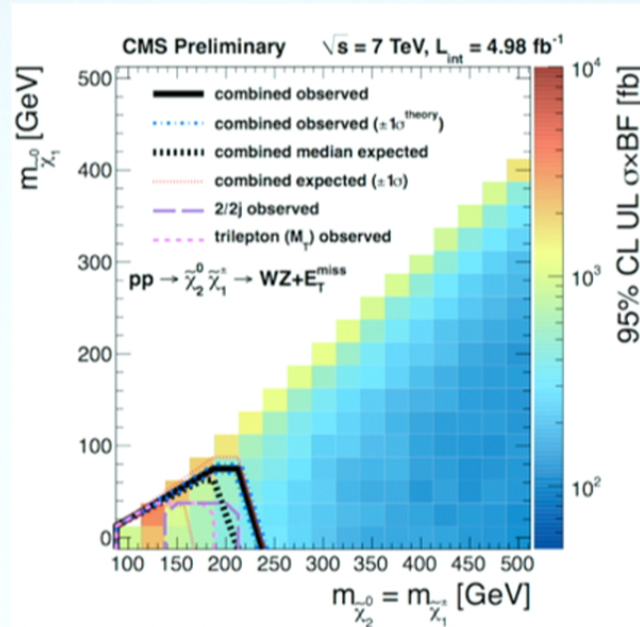
EXAMPLE TOPOLOGIES



Tied for second most
interesting result of summer

EW GAUGINO BOUNDS

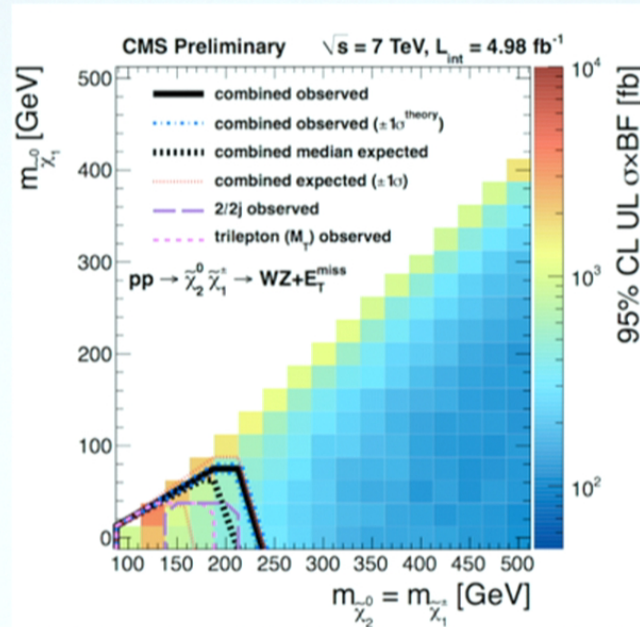
WZ final state ruled out well above LEP



Wh state also ruled out by ATLAS 7 TeV Wh search
~ 160 GeV Higgsinos

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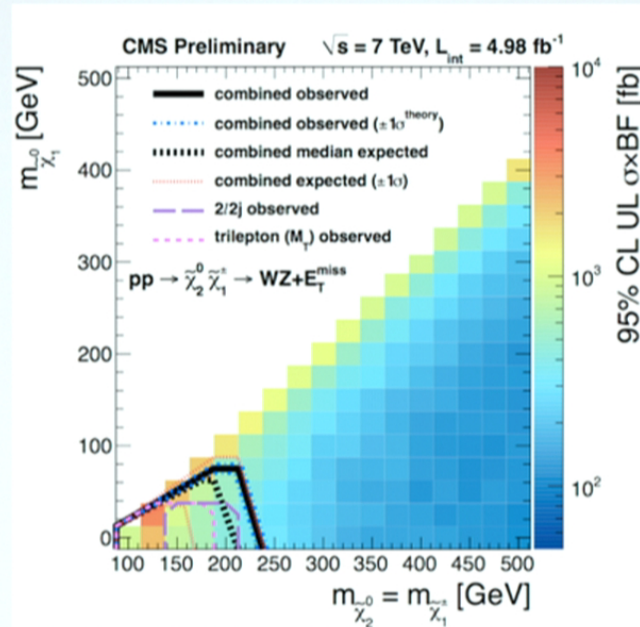
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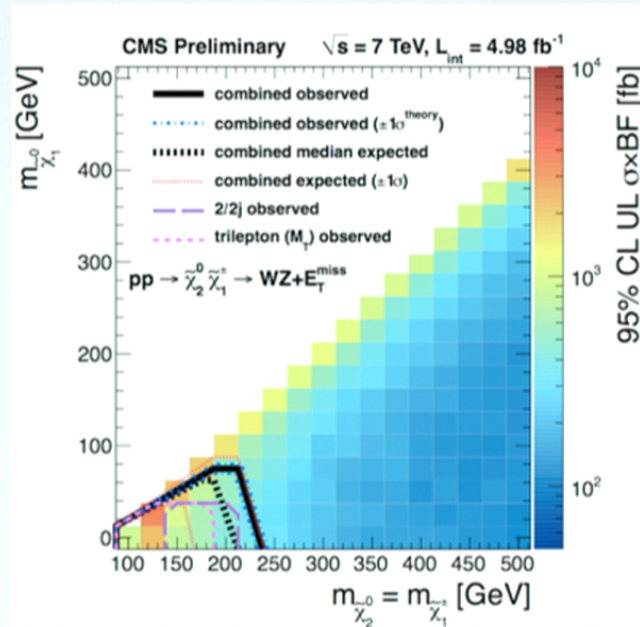
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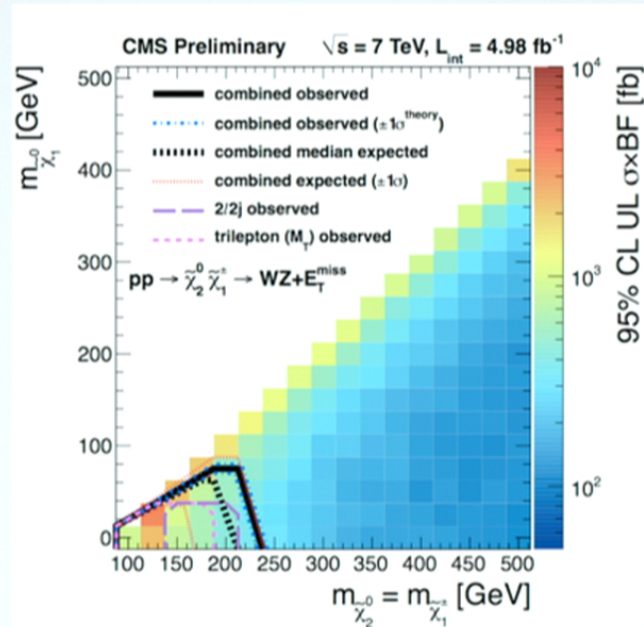
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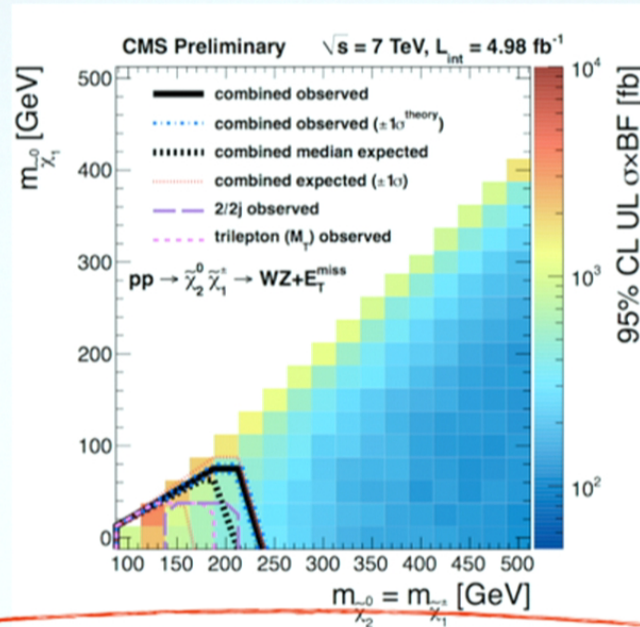
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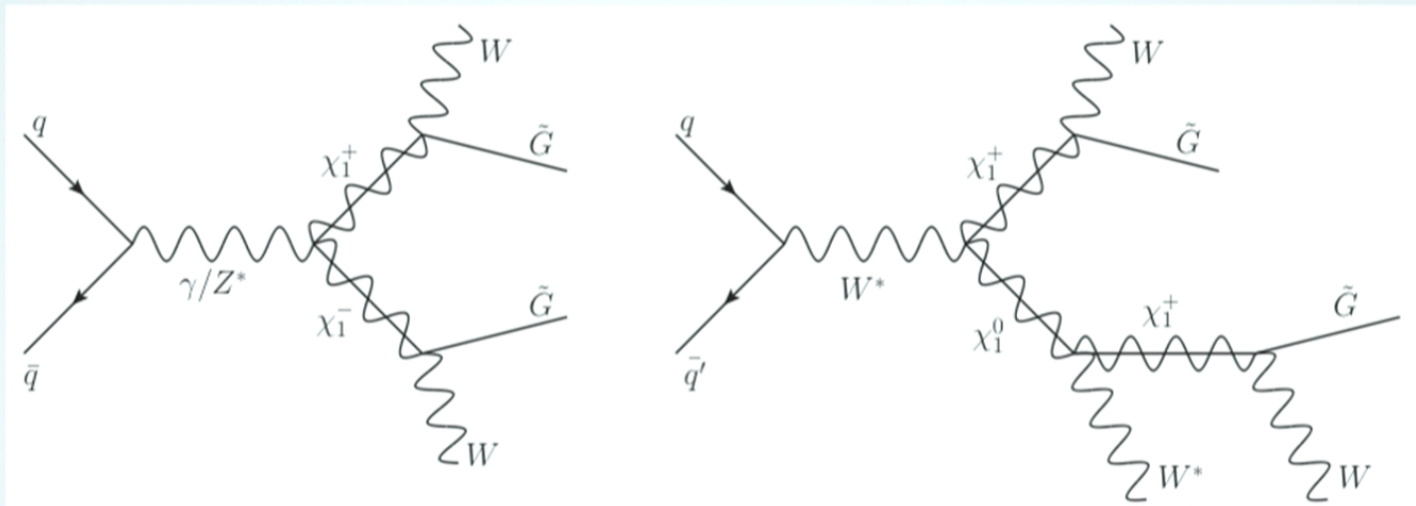
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~ 160 GeV Higgsinos **1206.6888**

(ours not ATLAS)

ARE THERE WAYS OUT? WW WITHOUT WH AND WZ??

- Chargino NLSP (also have gravity setups with sleptons)
- low tan beta, large Wino-Higgsino mixing



$$m_{\chi_1^\pm} \approx 110 \text{ GeV}$$

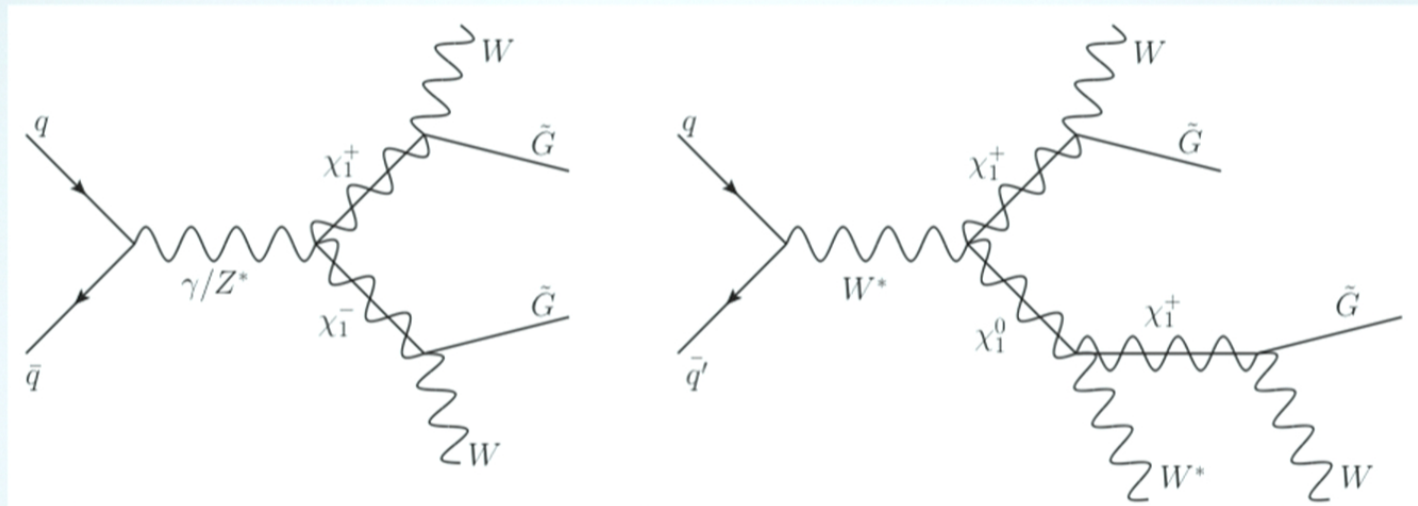
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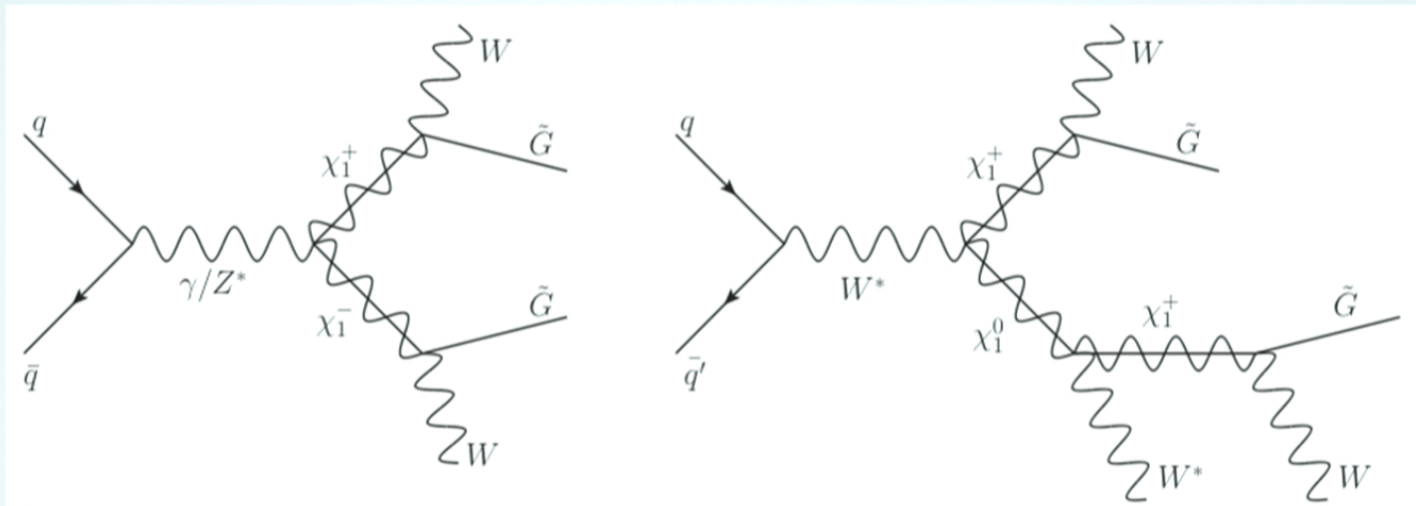
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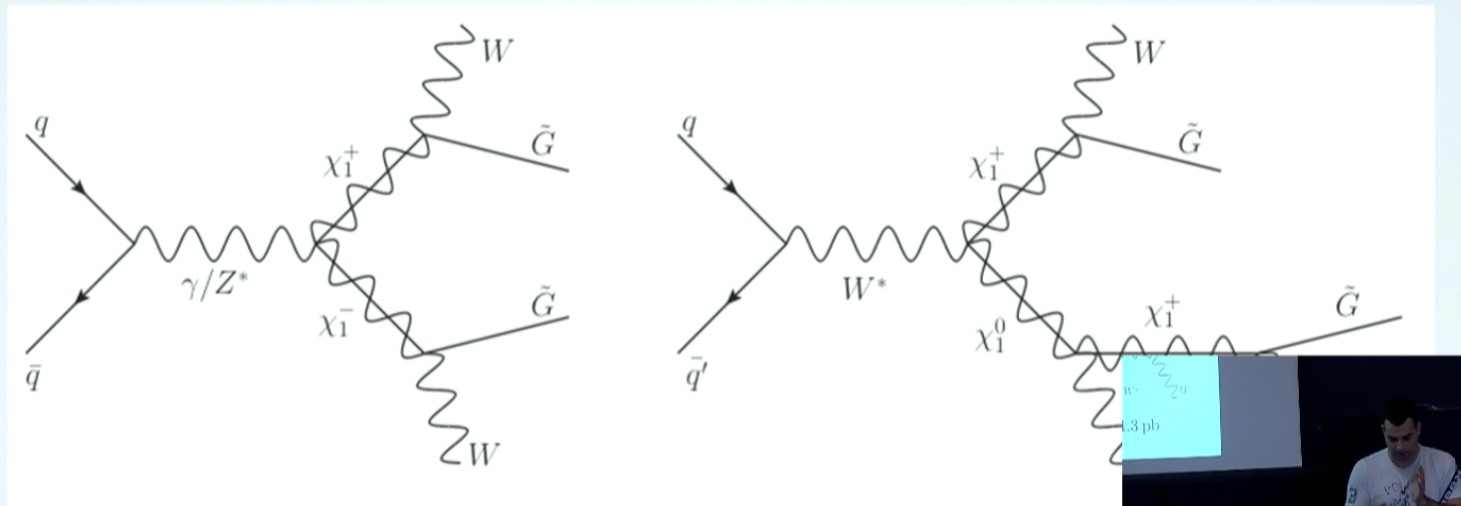
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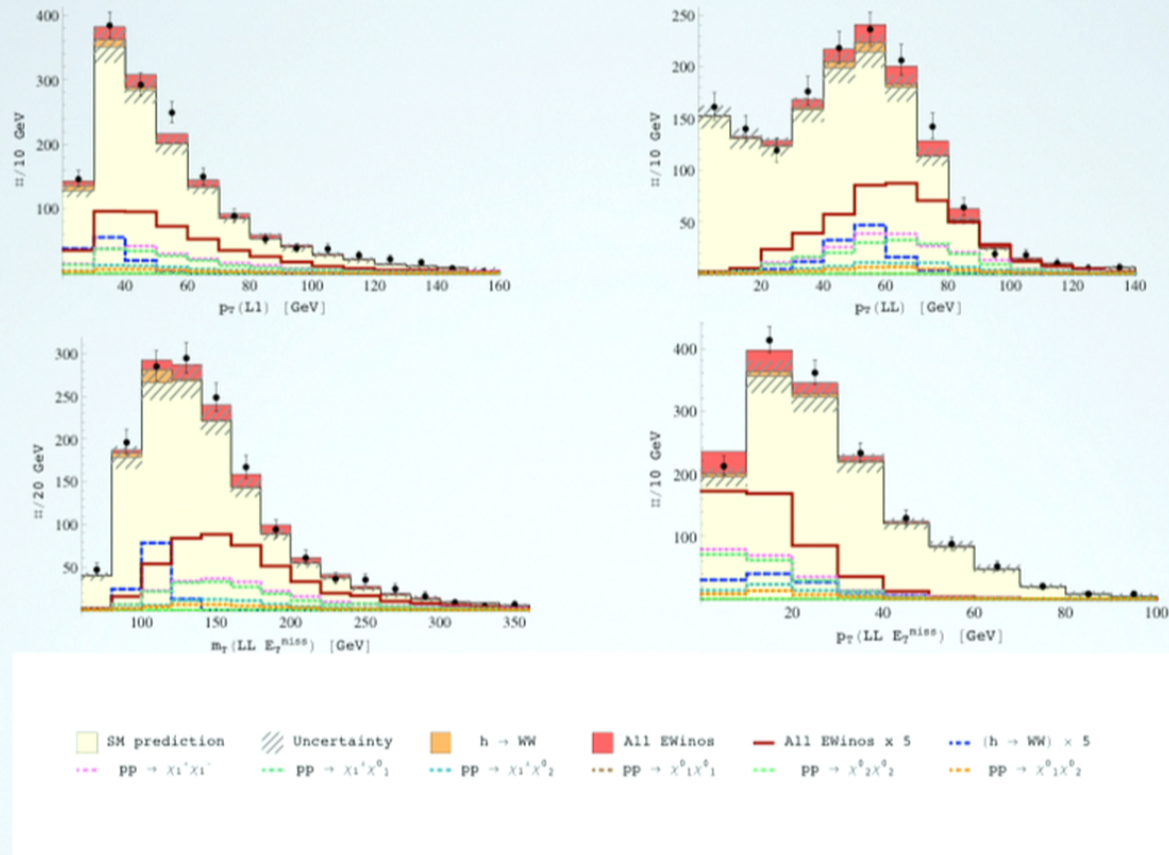
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$$m_{\chi_{10}} \approx 113 \text{ GeV}$$

$$m_{\chi_{20}} \approx 130 \text{ GeV}$$

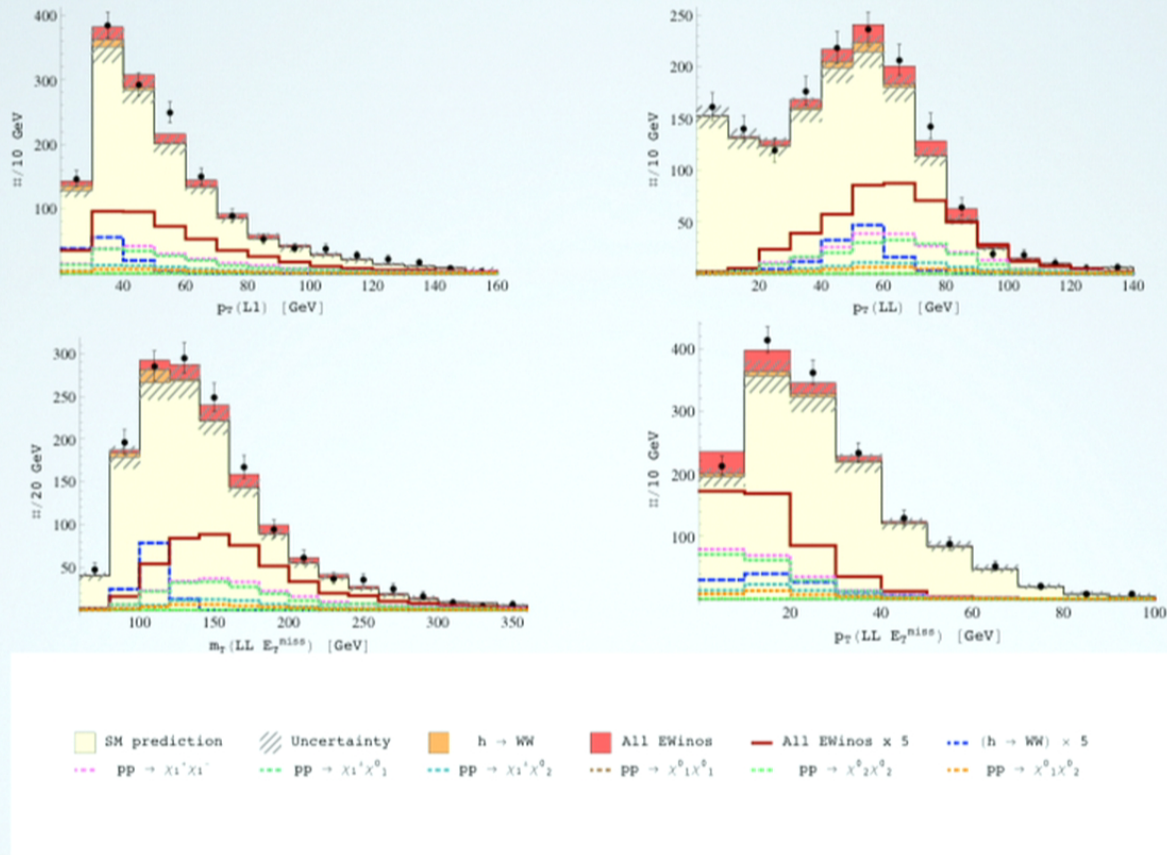
$$\sigma_{NLO} \sim$$

ATLAS 7



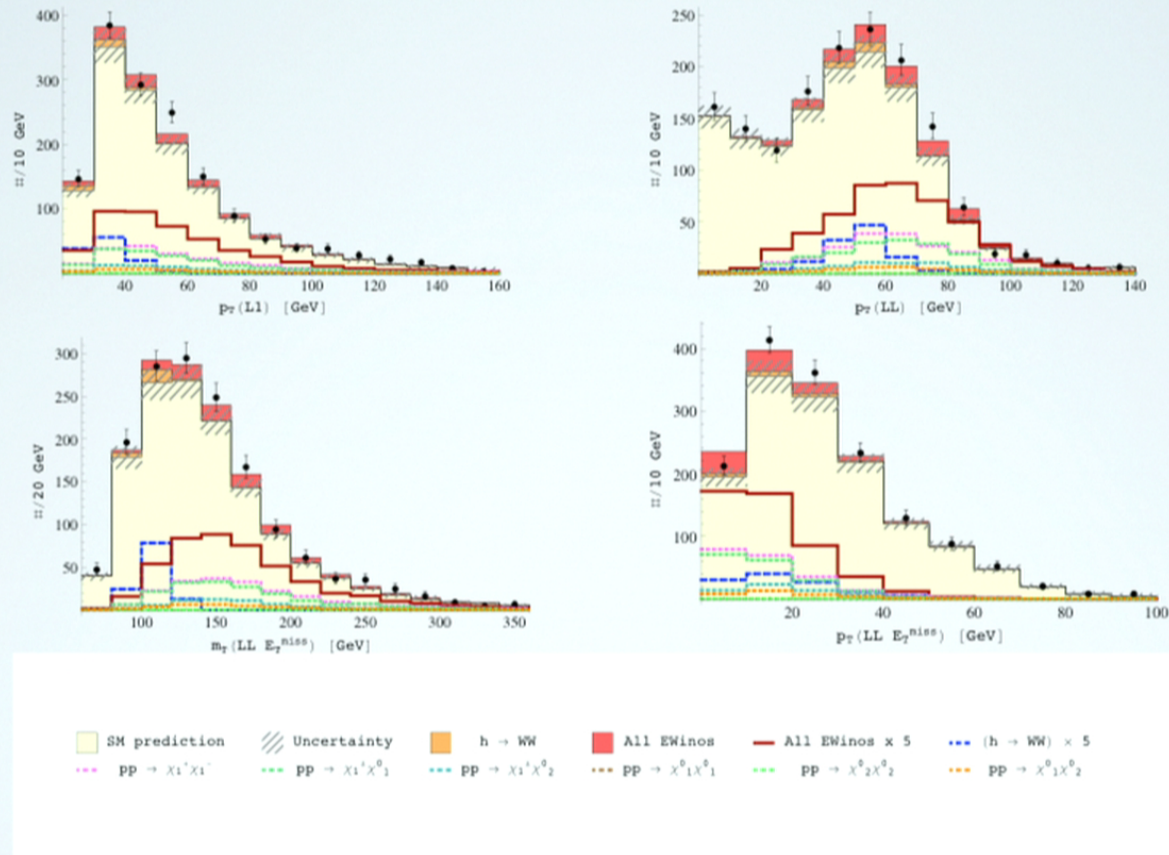
χ^2 cut in **half** compared to SM

ATLAS 7



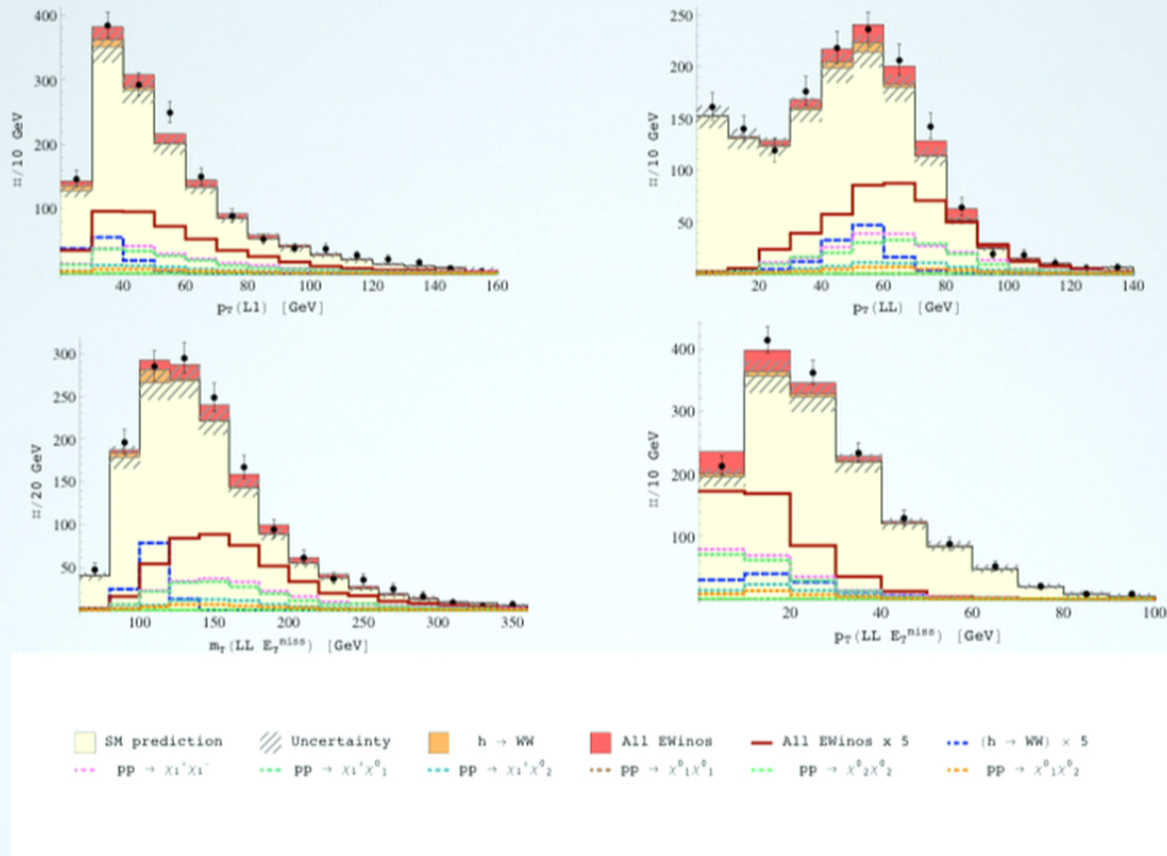
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ATLAS 7



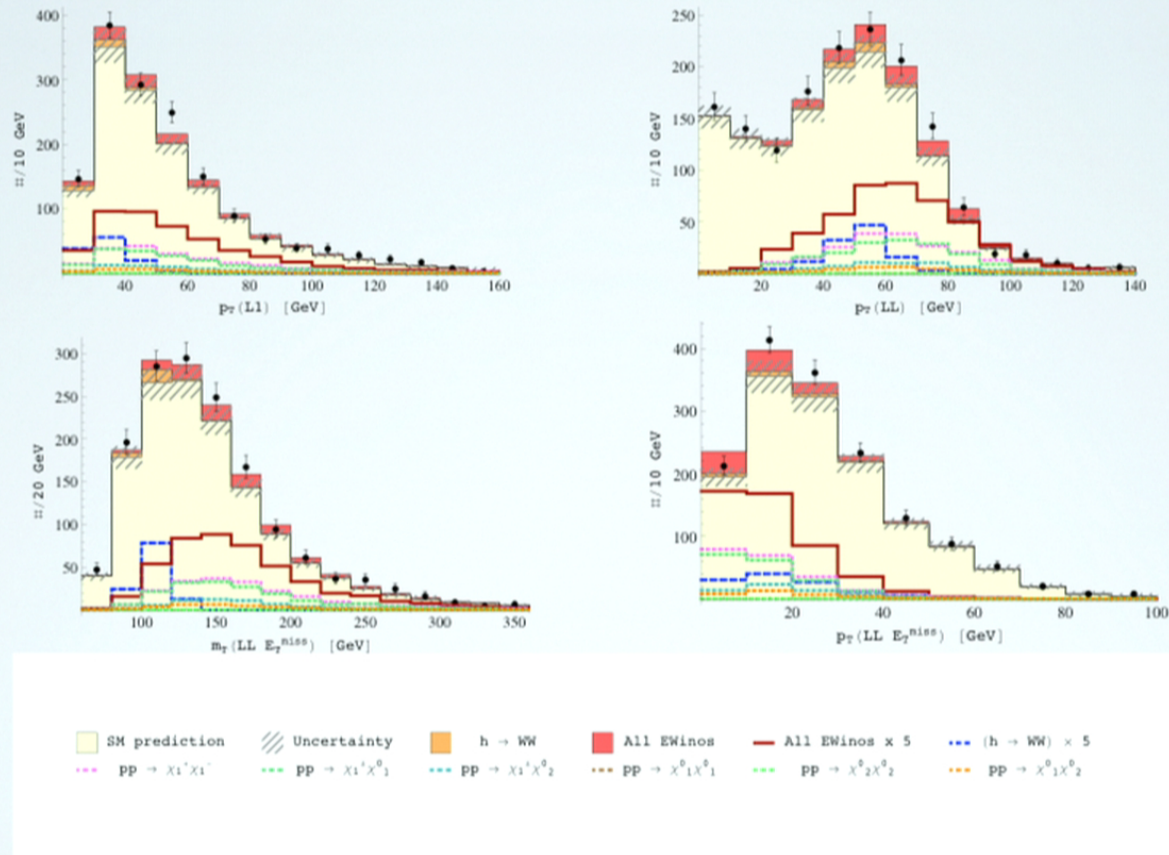
χ^2 cut in **half** compared to SM

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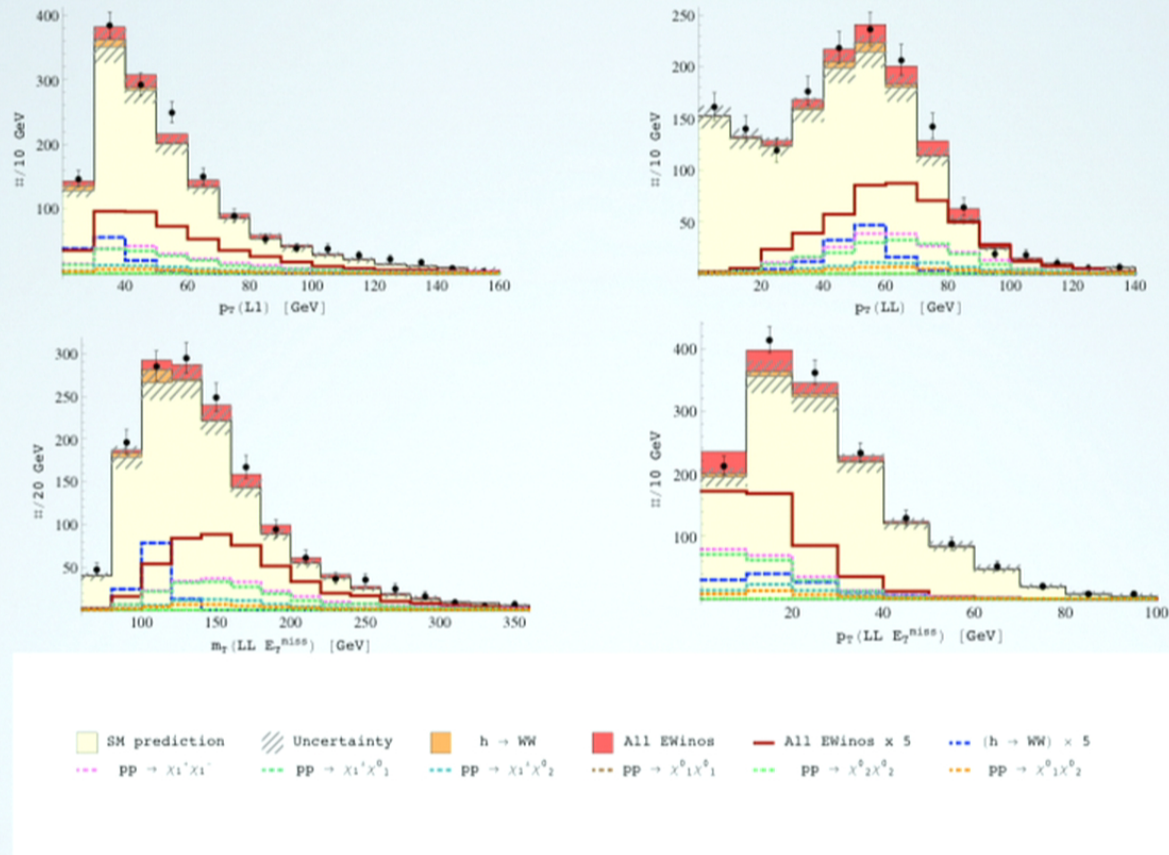
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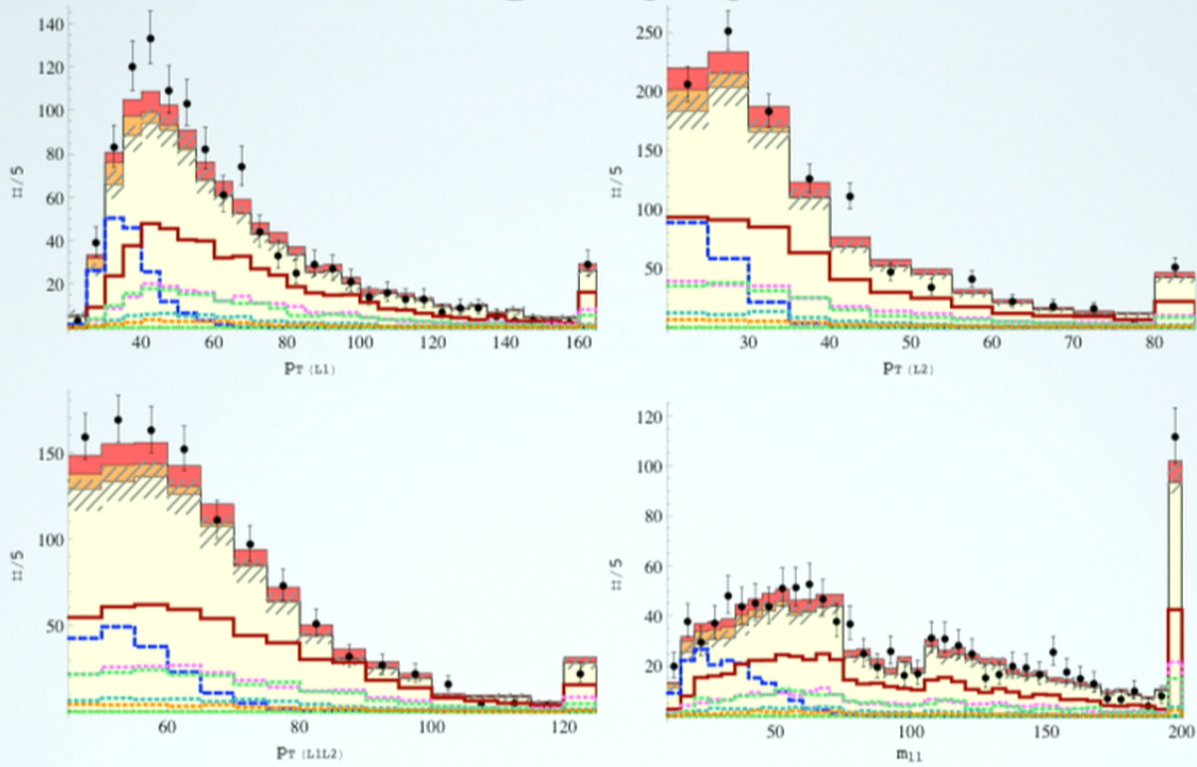
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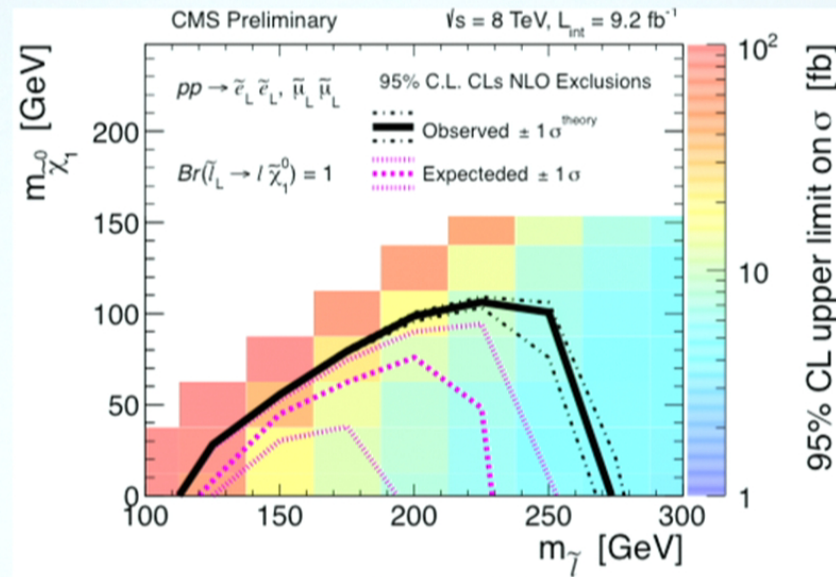
SM+charginos .3

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CONSTRAINTS ON THIS SCENARIO

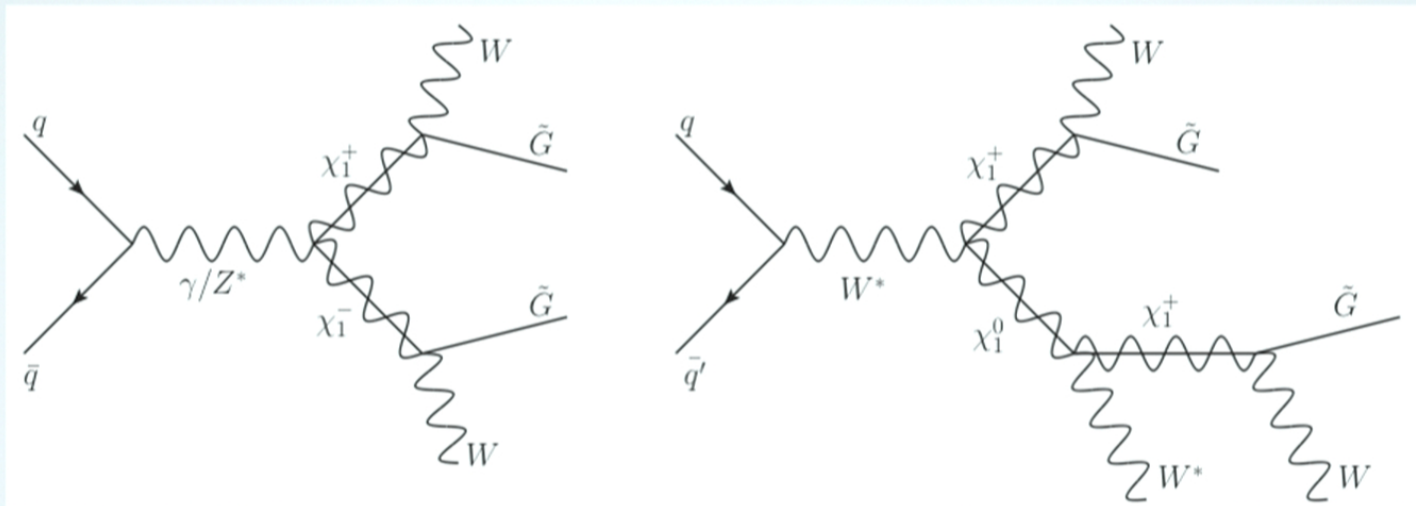
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Remarkably everything works as of ICHEP
Still looking at HCP results!

ARE THERE WAYS OUT? WW WITHOUT WH AND WZ??

- Chargino NLSP (also have gravity setups with sleptons)
- low tan beta, large Wino-Higgsino mixing



$$m_{\chi_1^\pm} \approx 110 \text{ GeV}$$

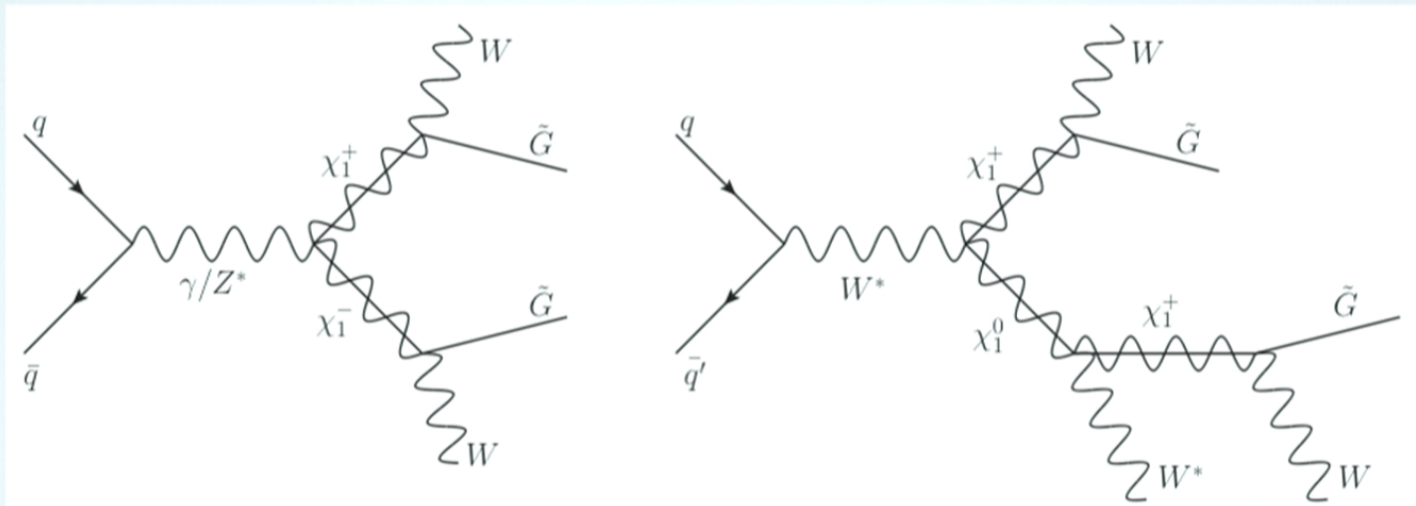
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$$\sigma_{NLO} \sim 4.3 \text{ pb}$$

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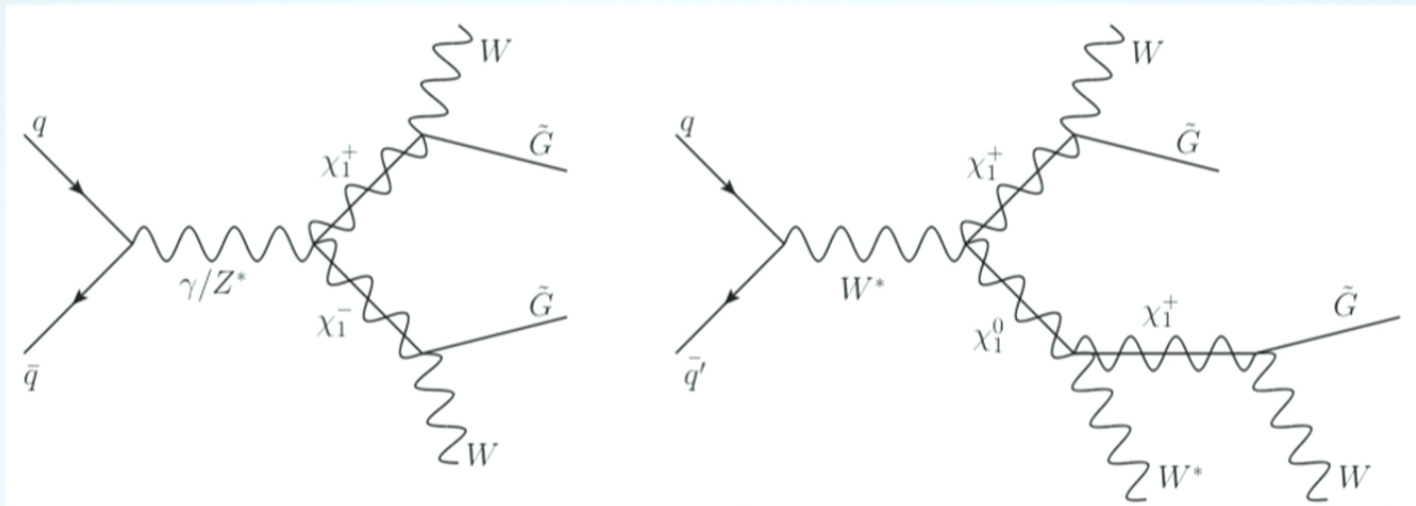
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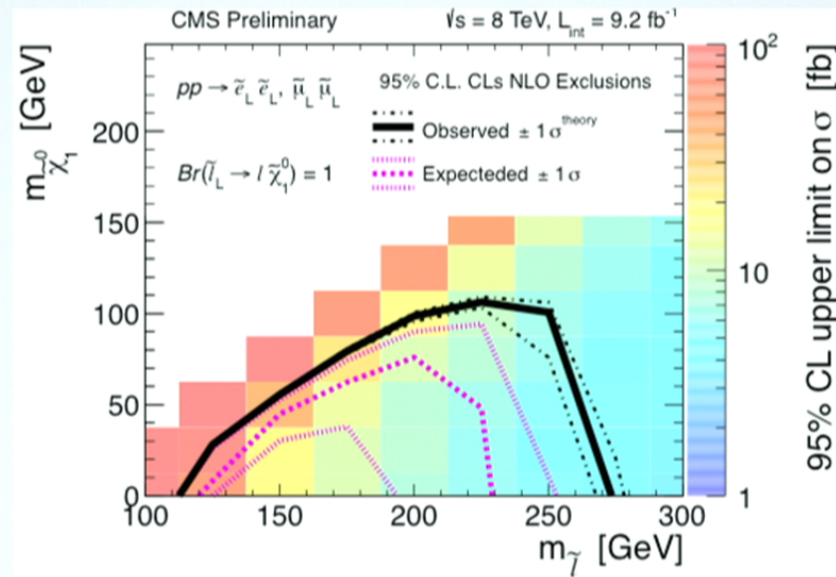
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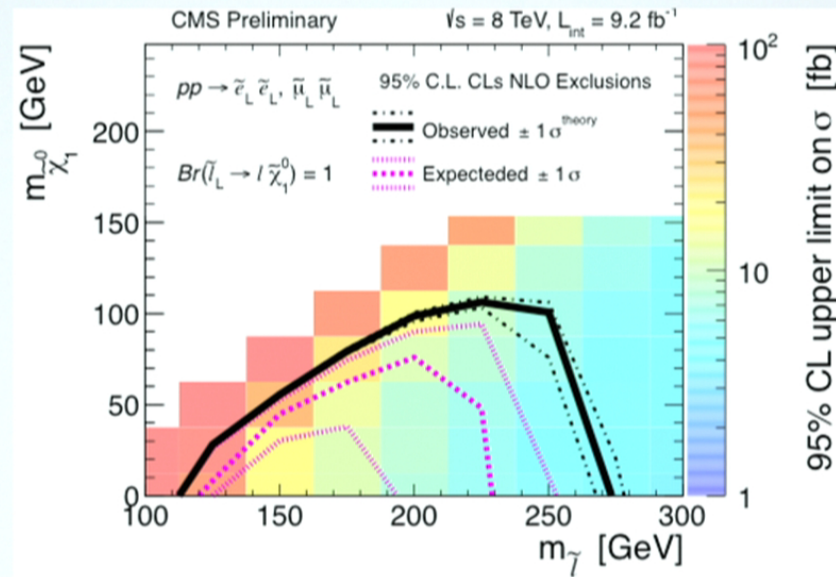
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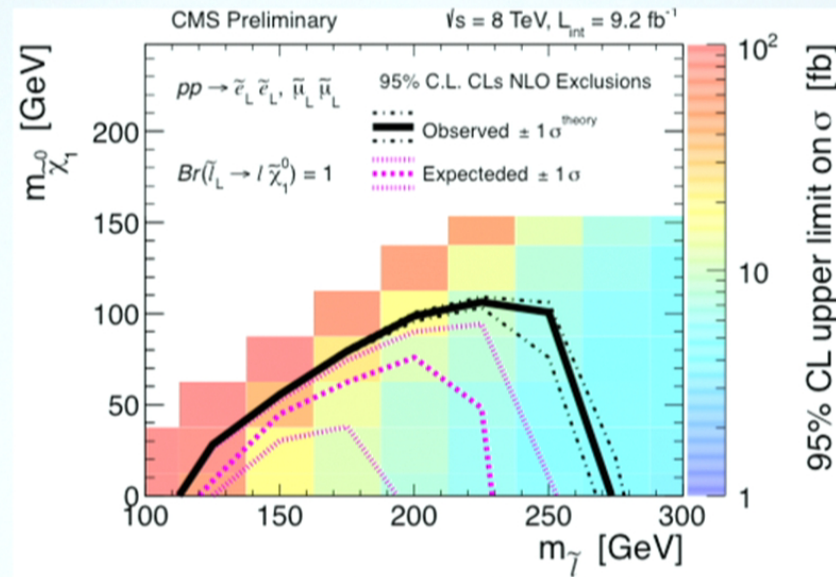
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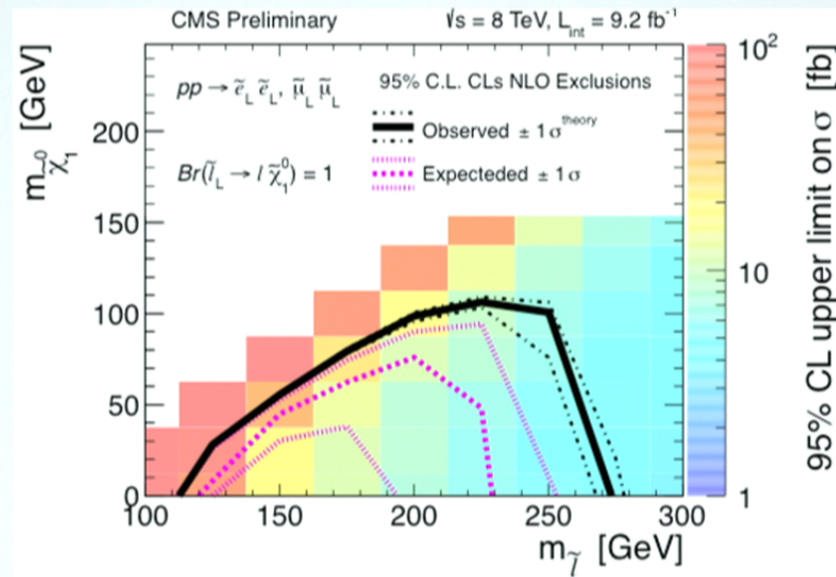
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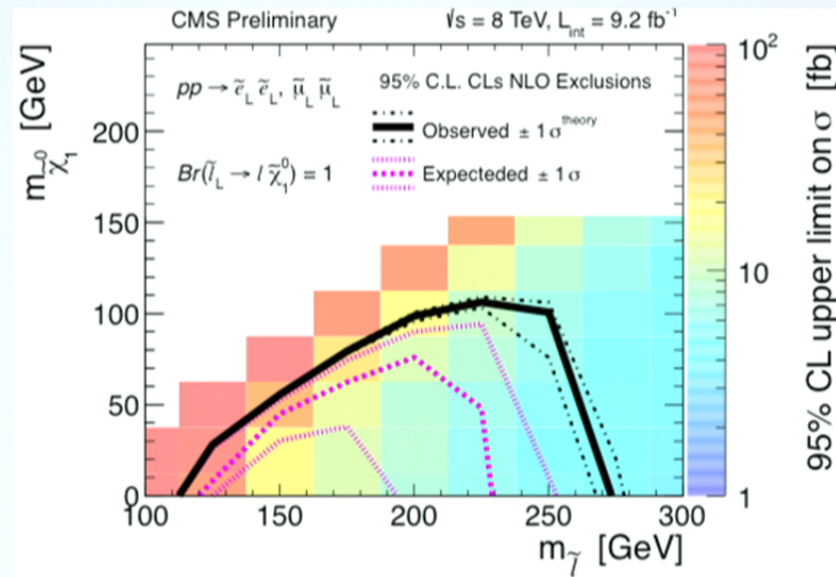
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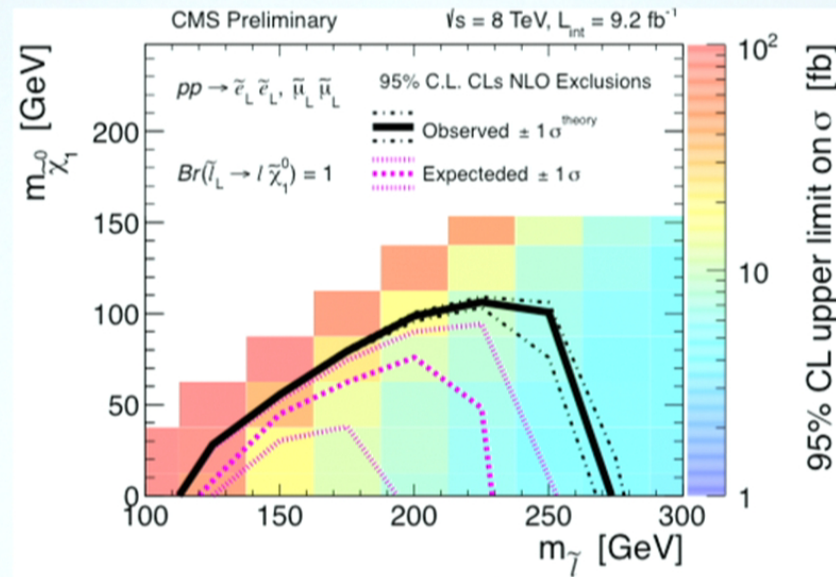
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OTHER EFFECTS FROM NP

- Will not affect $h \rightarrow W^+W^-$ **sensitivity** (most models that do this are dead at 9-10 sigma)
 - Shows up in **control** regions
- Amusingly increases $h \rightarrow \gamma\gamma$ about 15%
- Same sign dileptons by end of 8 TeV should confirm/rule out
- Other transverse variables that can separate NP/SM WW/
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- Backgrounds Wrong - Negligible effect?
- WW cross section wrong (k-factors 1.6ish need a 20% effect)
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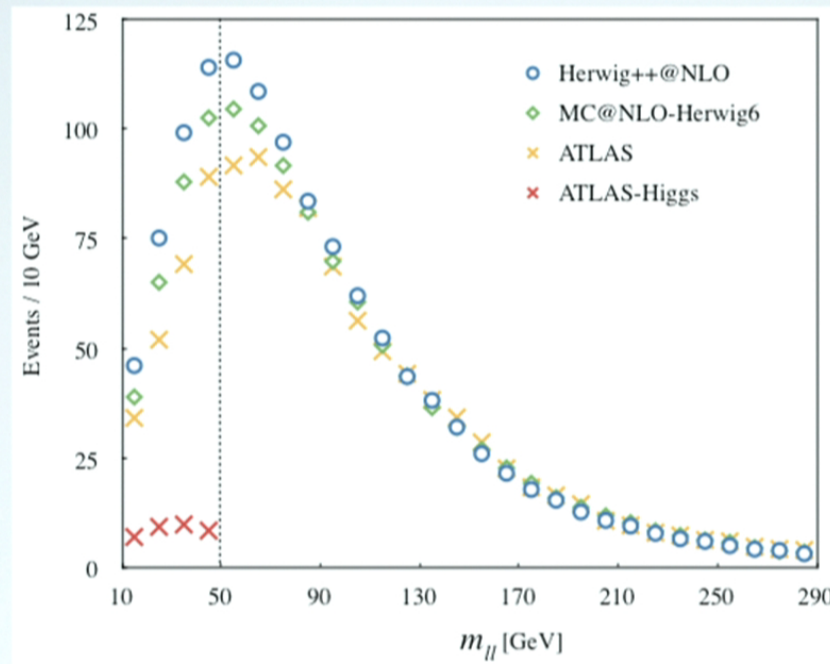
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THEORIST MC SCAN...



Holdom
1211.2729

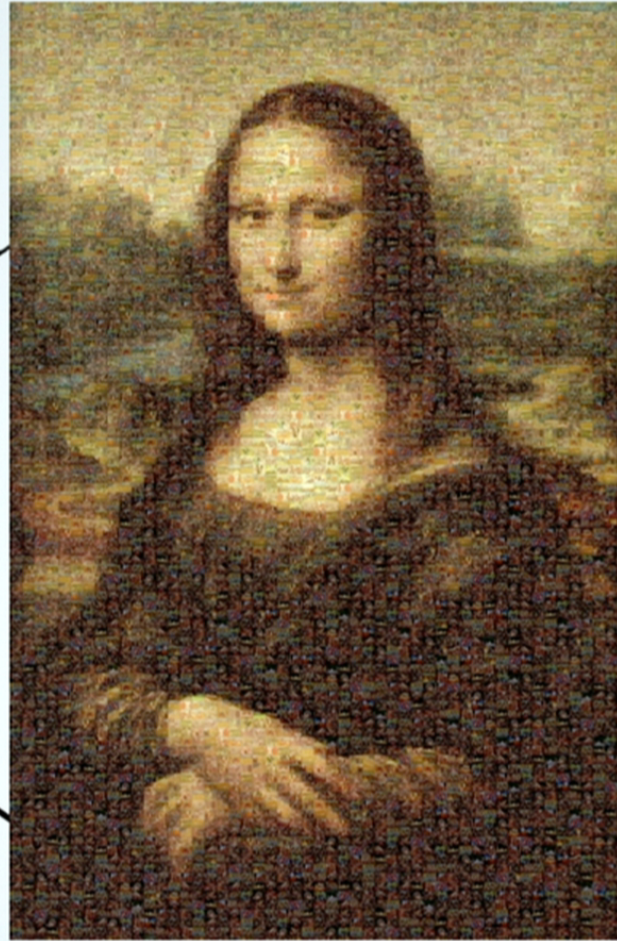
*Implications
for Higgs searches!*

Figure 2: Comparison of $m_{\ell\ell}$ distributions of the WW continuum background normalized in the $80 < m_{\ell\ell} < 290$ GeV region. Only the ATLAS values include the full detector simulation. The two event generators do not include the $gg \rightarrow WW$ contribution. Also shown is the simulated 125 GeV Higgs signal in the signal region. ATLAS results are obtained from Fig. (14b) [2].

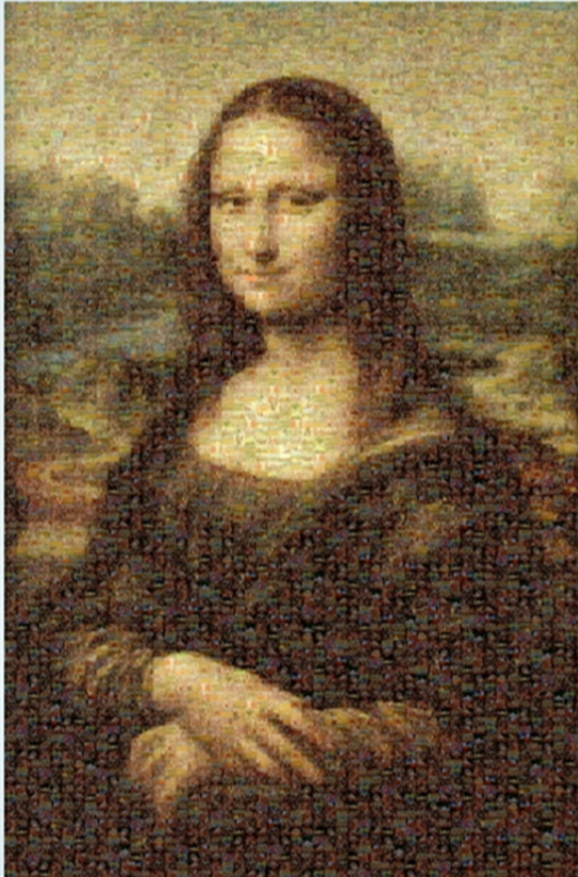
HOW MUCH DOES THIS MATTER IN THE END THOUGH?

- ATLAS and CMS got the same cross section at 7 TeV
 - CMS uses MADGRAPH for WW!!!!??
- We'd like to have some more reliable theory systematic estimate
 - NNLO
 - Resummation

HOW DO WE GO FURTHER?



MASTERPIECE FROM MASTERPIECES?



CONCLUSIONS

- WW cross section is showing a trend from a theorists point of view, to the point that I'm thinking it's not a fluctuation... you can think whatever you want
- New physics CAN explain this and fit better than the SM
- SM calculations should be improved to NNLO+N⁽ⁿ⁾LL
- As long as you exclude fluctuation this is a very interesting channel to follow since it has ramifications all over the place...

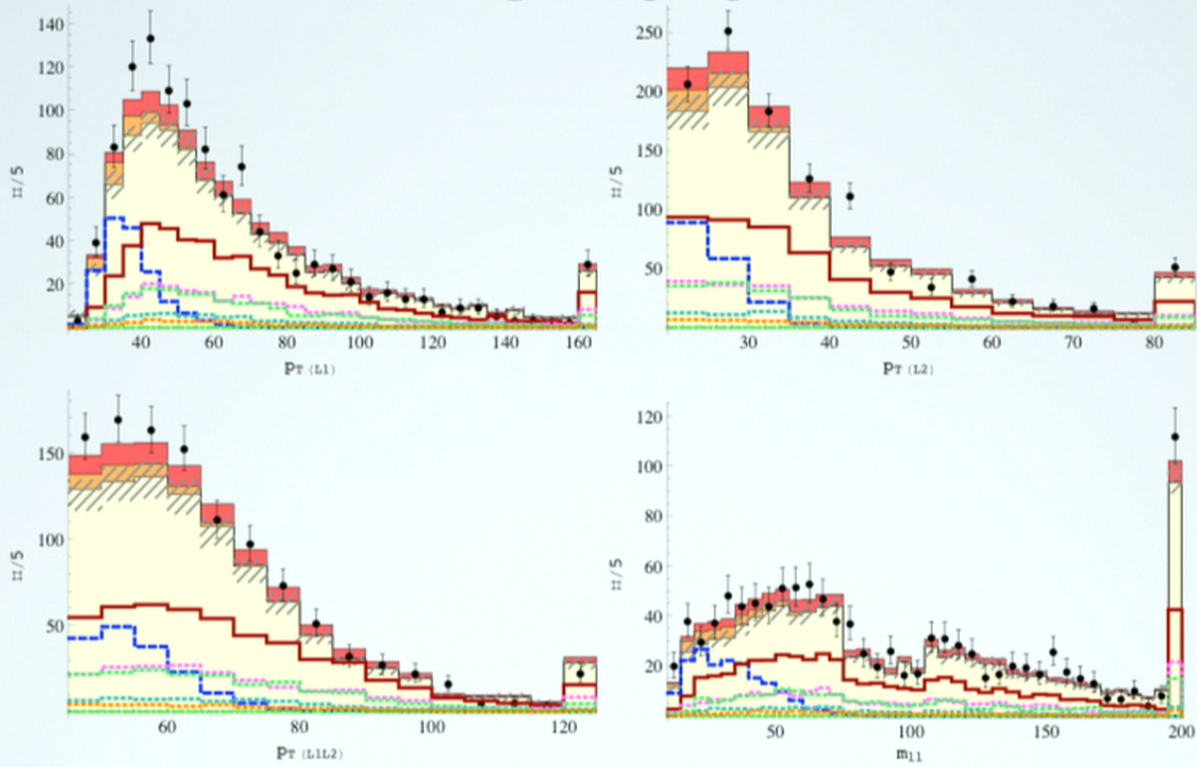
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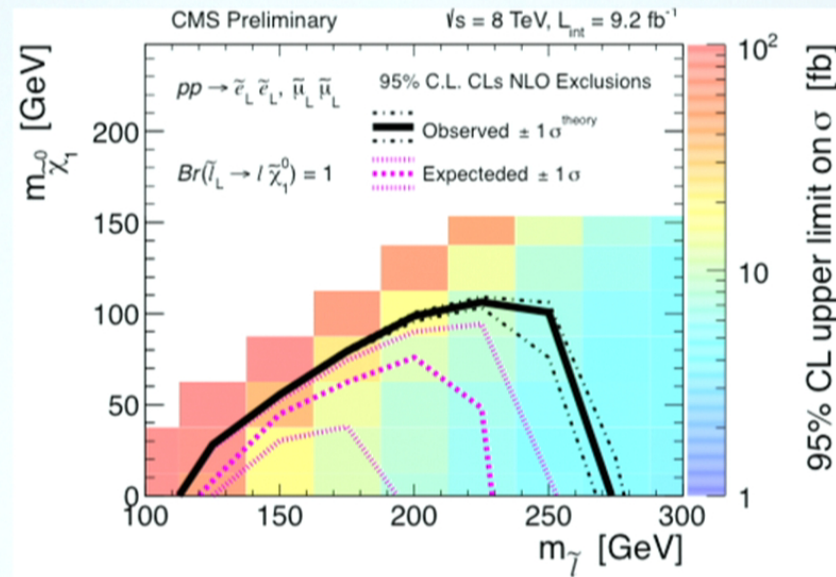
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