EXPLORING THE EW FRONTIER

Patrick Meade
Yang Institute for Theoretical Physics
Stony Brook University

Based on:

D. Curtin, P. Jaiswal, PM 1206.6888
D. Curtin, P. Jaiswal, PM, P. Tien 1304.7011
+work in progress

OR HOW I LEARNED TO STOP WORRYING AND LOVE SM MEASUREMENTS

Patrick Meade
Yang Institute for Theoretical Physics
Stony Brook University

Based on:

D. Curtin, P. Jaiswal, PM 1206.6888
D. Curtin, P. Jaiswal, PM, P. Tien 1304.7011
+work in progress

OR HOW I LEARNED TO STOP WORRYING AND LOVE SM MEASUREMENTS

GREAT WORKSHOP

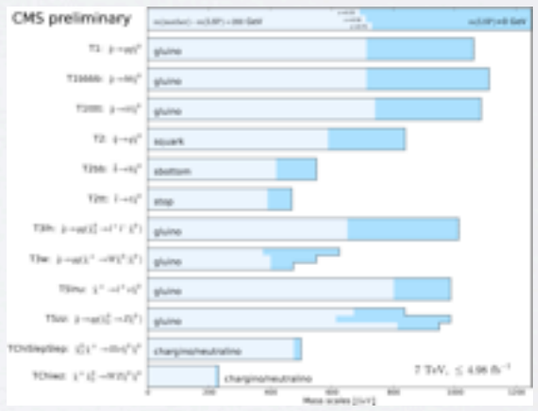
What have we learned thus far?

GREAT WORKSHOP

What we've heard

Blackhat agrees well with LHC data

is at ~125 GeV



haven't seen anything...

SUSY at 100 TeV?

WHAT THEORISTS WERE SAYING PRE LHC

SUSY is right around the corner

We'll see DM

We'll see KK states

We'll explain the baryon asymmetry

POST 7 AND 8 TEV RUNS

Maybe SUSY is at 100 TeV

Maybe it's just the Higgs

Maybe DM is an axion

Have we reached the end of particle physics?

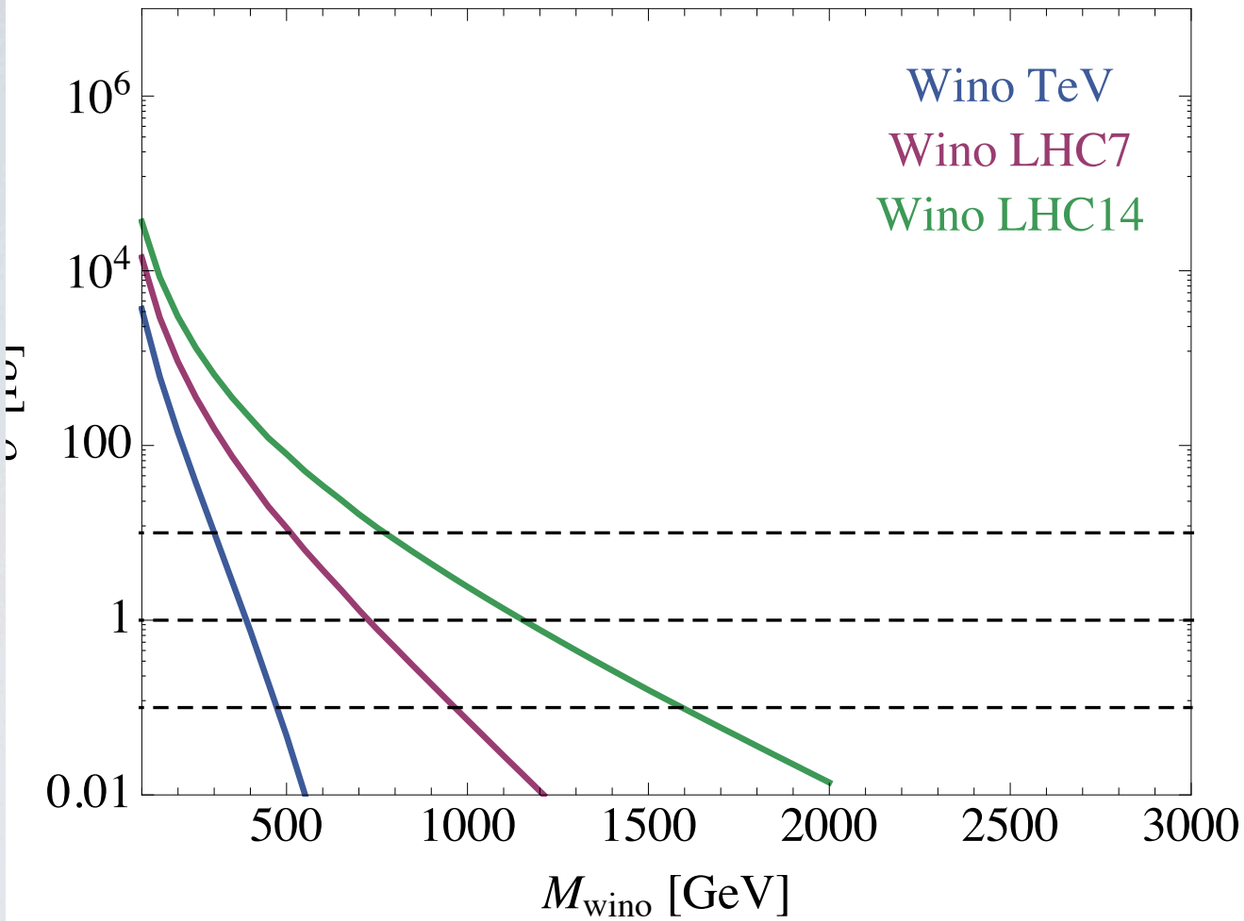
WHIPLASH OF PREDICTIONS...

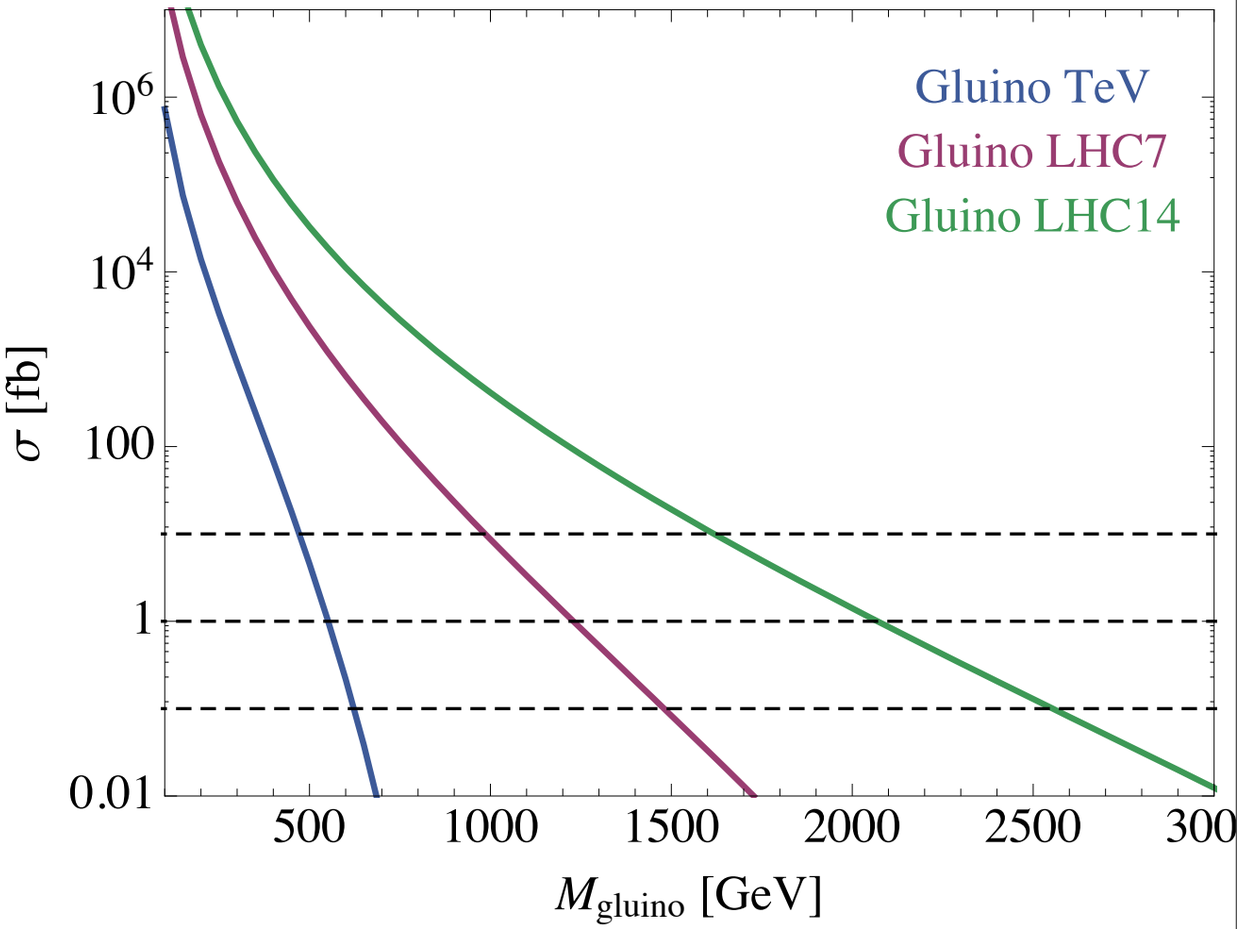
WHIPLASH OF PREDICTIONS...

or even some resurrected ones...

WHERE HAS THE LHC REALLY TAKEN US WITHOUT THE EXTRA BRAVADO?

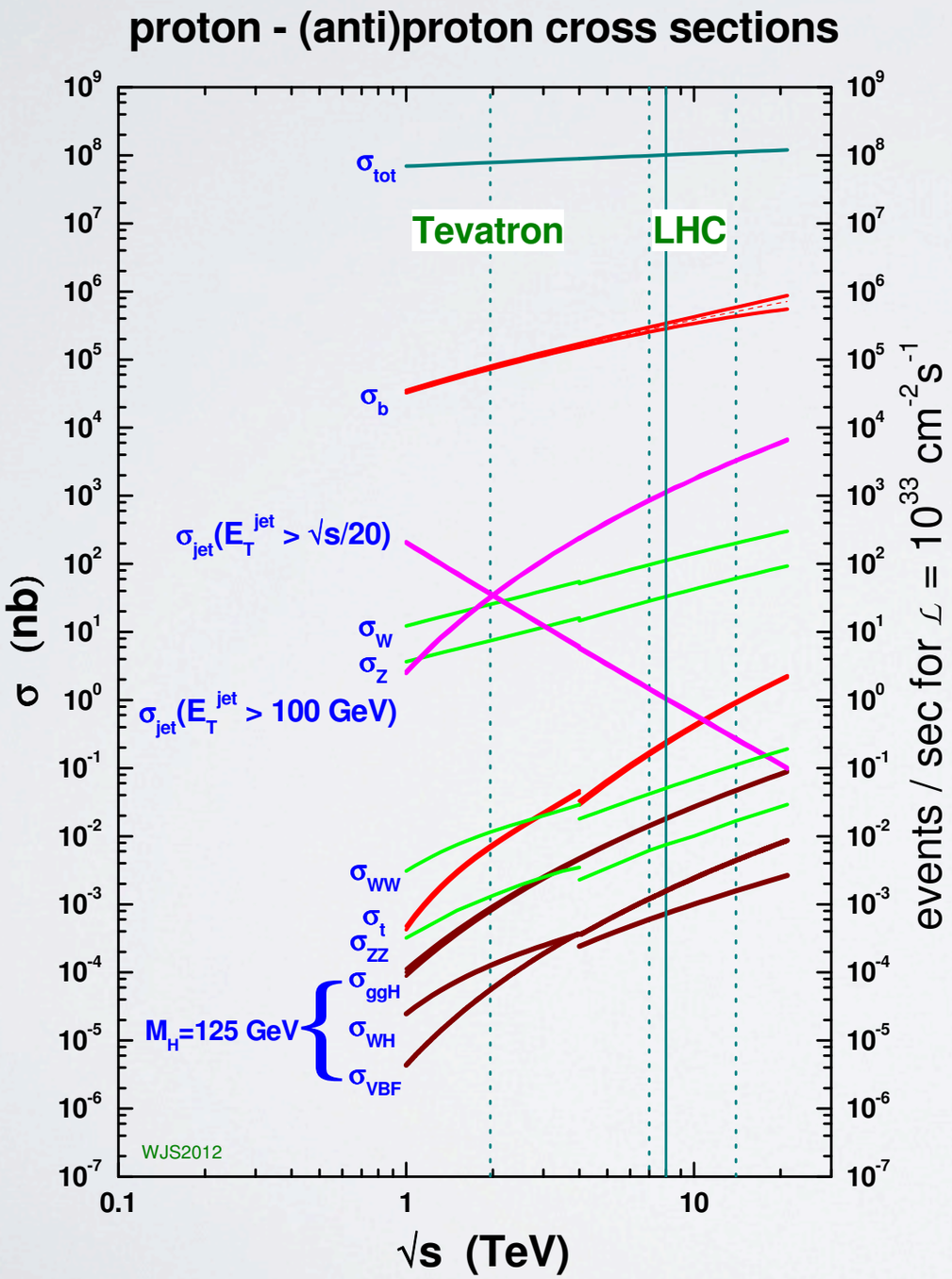
WHERE HAS THE LHC REALLY TAKEN US WITHOUT THE EXTRA BRAVADO?





Maximize Signal

WHERE HAS THE LHC REALLY TAKEN US WITHOUT THE EXTRA BRAVADO?

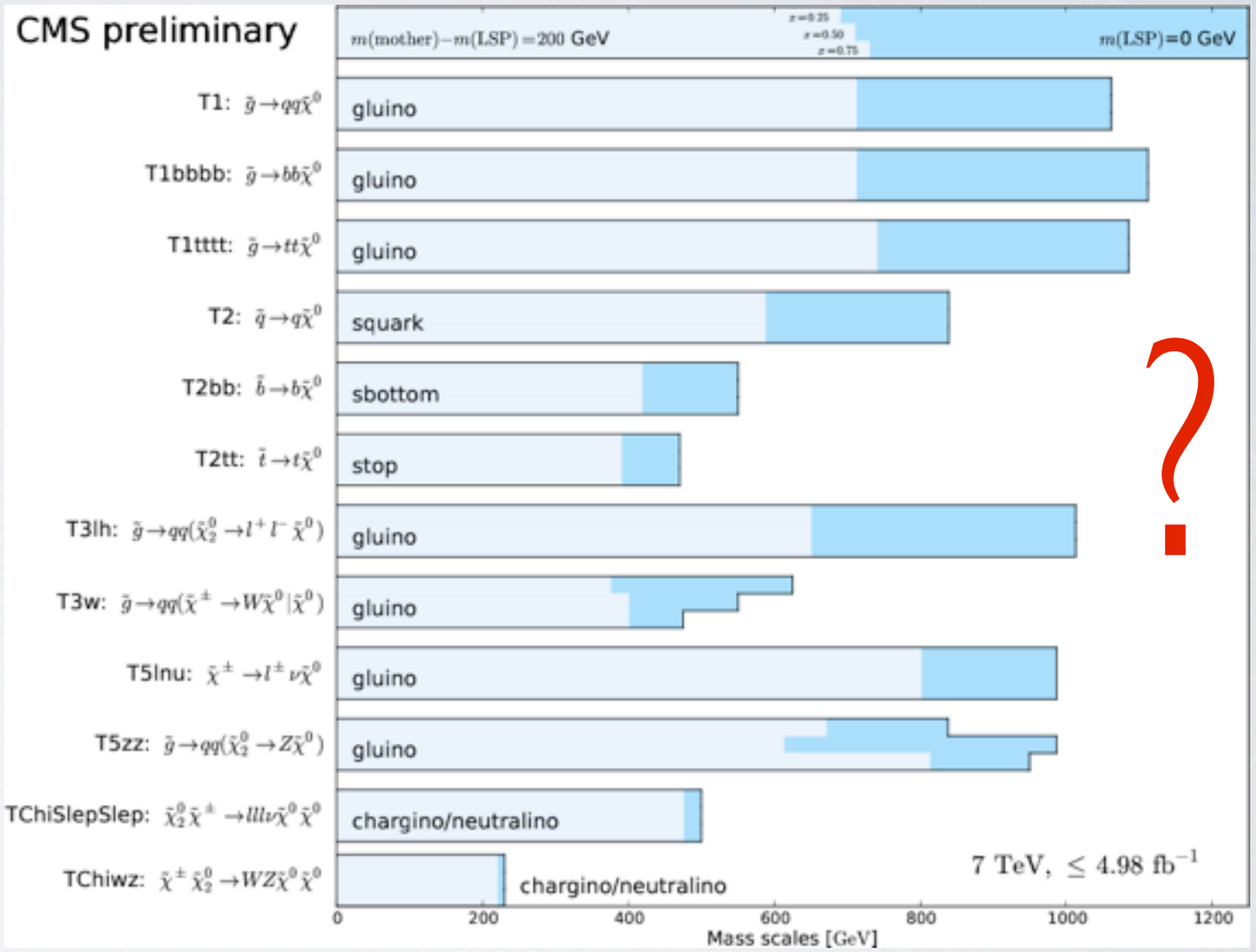


Minimize Background

WHERE HAS THE LHC REALLY TAKEN US WITHOUT THE EXTRA BRAVADO?

Does

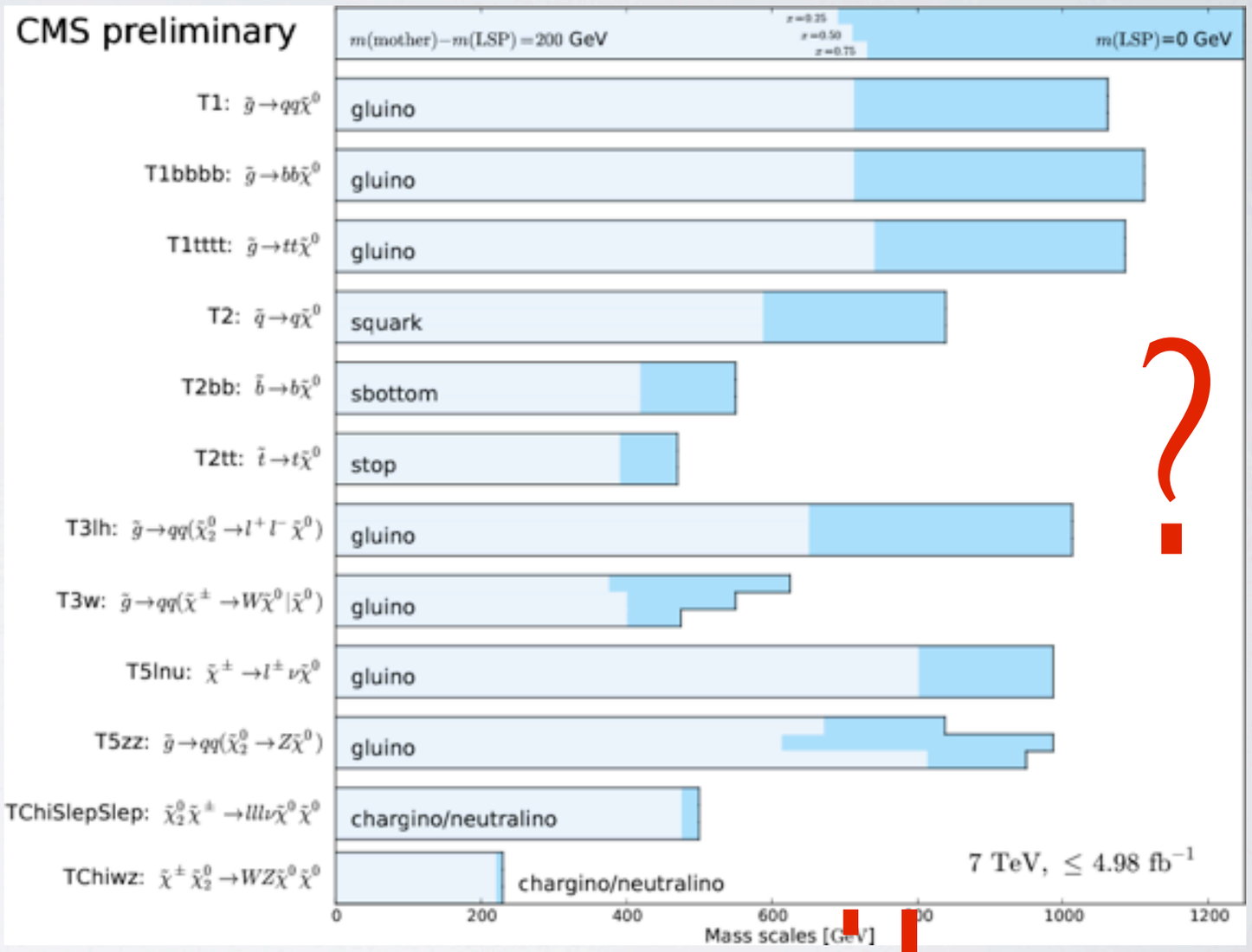
Maximize signal + Minimize Background =



WHERE HAS THE LHC REALLY TAKEN US WITHOUT THE EXTRA BRAVADO?

Does

Maximize signal + Minimize Background =



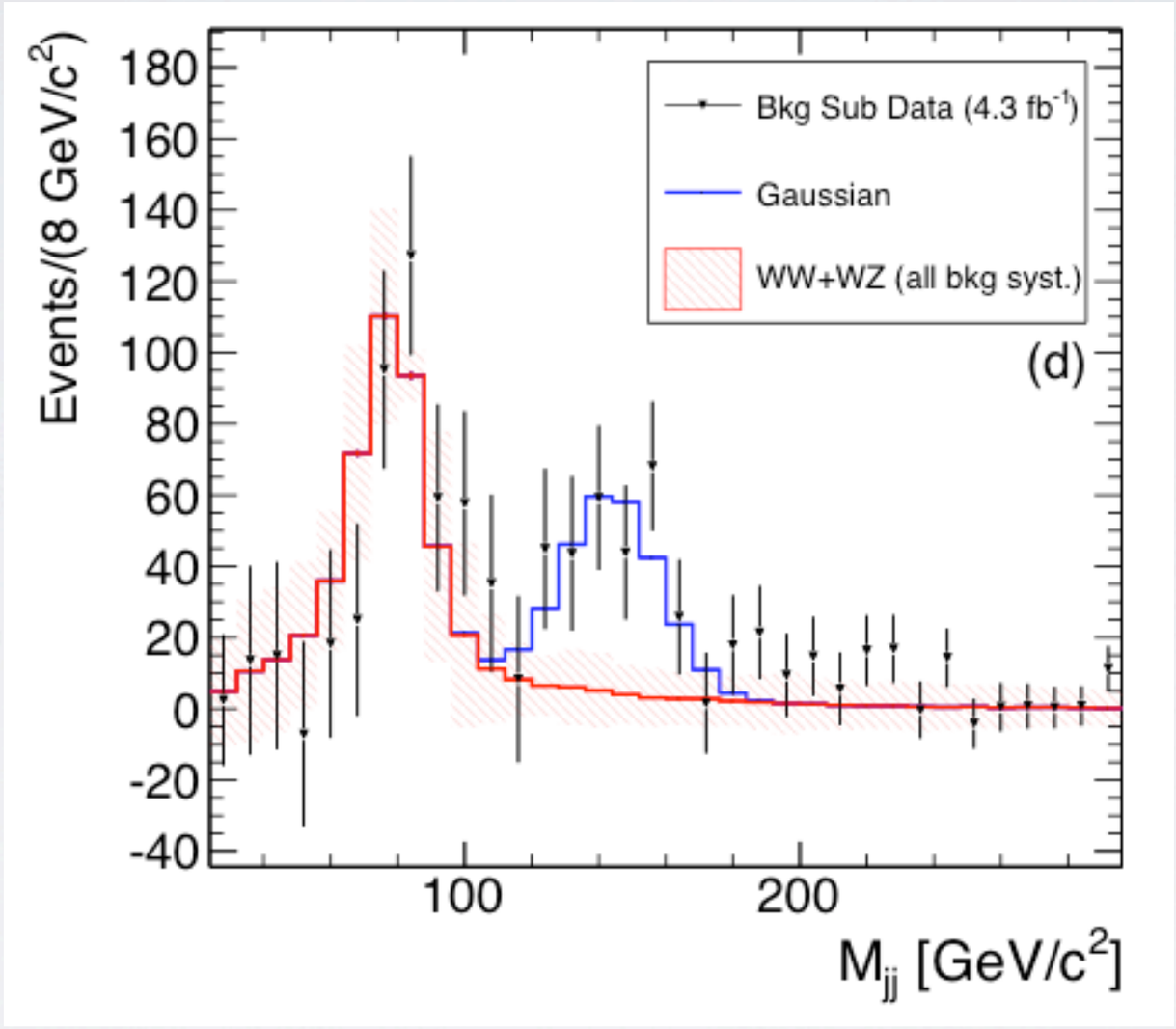
?

not necessarily

A PURPOSE DRIVEN LIFE... AT LEAST FOR COLLIDERS...

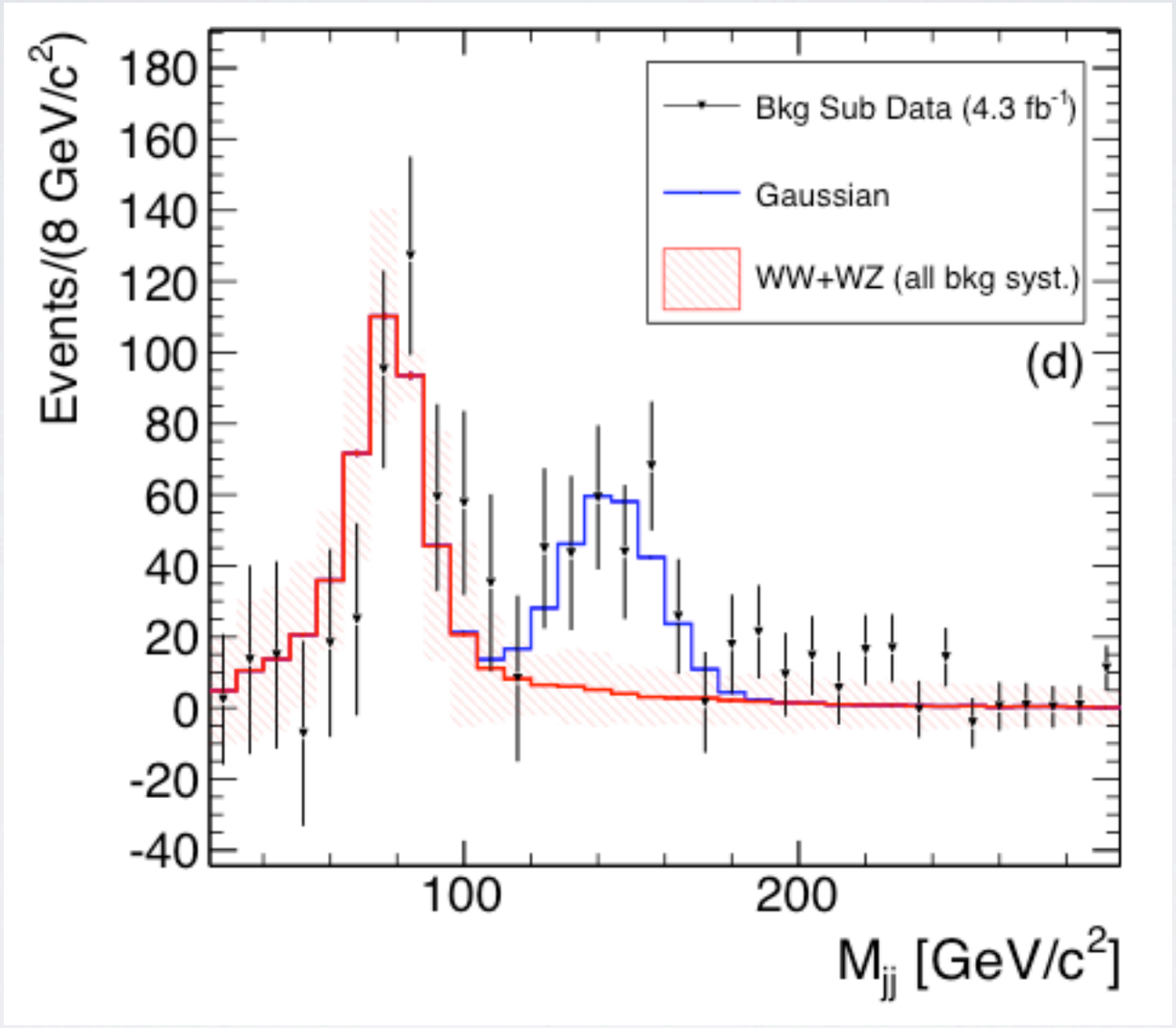
We must gain as much information from a given experiment since there may be "anomalies" later we have to contend with

A PURPOSE DRIVEN LIFE... AT LEAST FOR COLLIDERS...



We must gain as much information from a given experiment since there may be "anomalies" later we have to contend with

A PURPOSE DRIVEN LIFE... AT LEAST FOR COLLIDERS...



Had to go back to UA2! to test dijet hypotheses *not* the Tevatron or LHC!?

HOW FAR CAN THE LHC GO?

Want:

$\sigma_s \times \epsilon \times A$ ***Big***

$\sigma_b \times \epsilon \times A$ ***Small***

To discover/constrain new physics

Unfortunately these don't ***both***
occur when both scales are the **EW** scale

BOUNDS ON SUSY (MET) PRE LHC

BOUNDS ON SUSY (MET) CURRENT LHC

1000 GeV - colored sparticles (LHC)

300 GeV (LHC) EW States

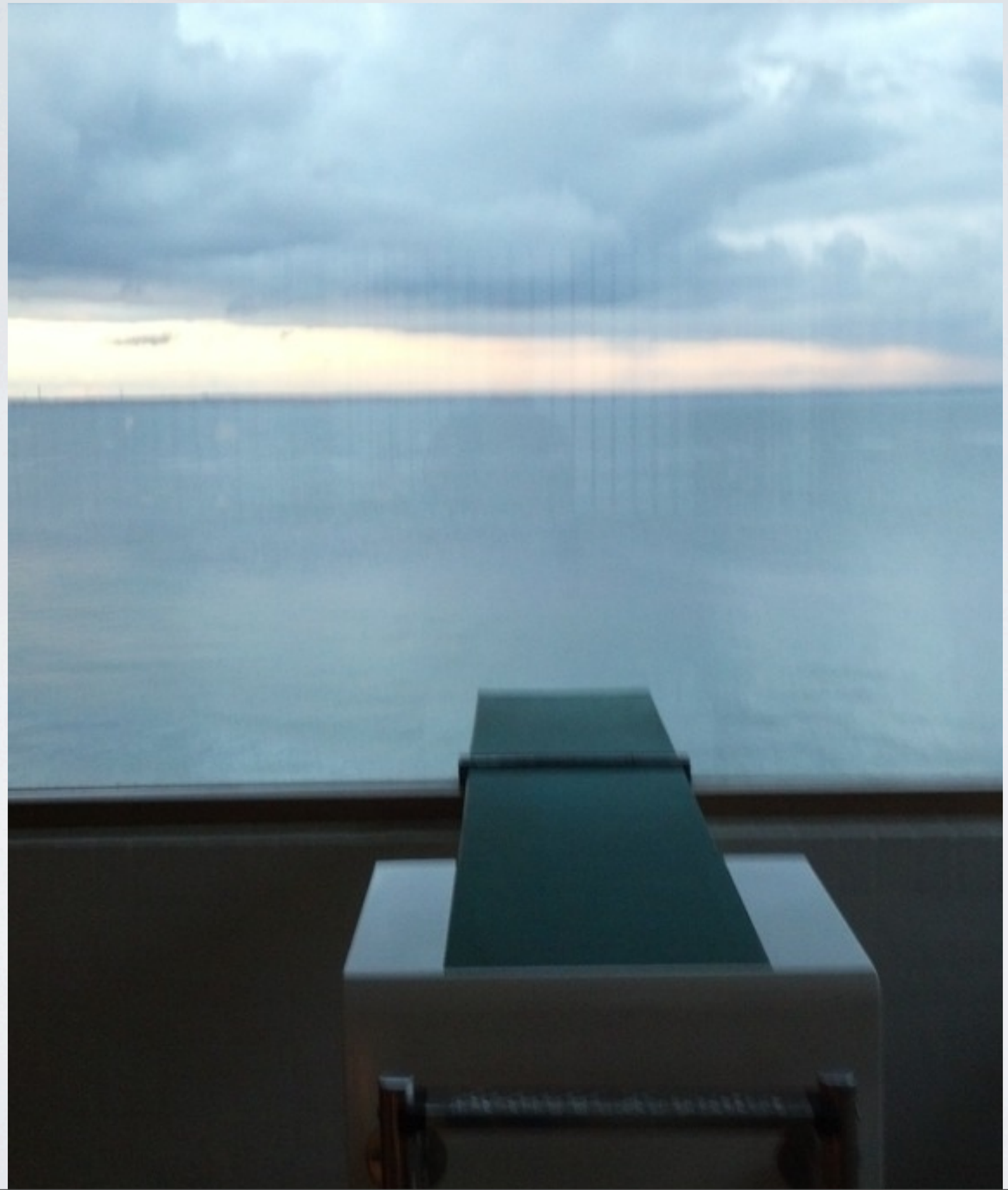
BOUNDS ON SUSY (MET) CURRENT LHC

1000 GeV - colored sparticles (LHC)

300 GeV (LHC) EW States

Here be dragons...

PLAN FOR REST OF THE TALK



PLAN FOR REST OF THE TALK

- Show that there may be new physics lurking in the EW sector
  - Give the only examples I know of at the LHC where NP fits the data significantly ***better*** than the SM itself!
    - charginos
    - stops
    - sleptons
- Demonstrate a new way to understand the EW scale using SM Standard Candles

WHERE CAN YOU EXPECT TO SEE NEW PHYSICS?

WHERE CAN YOU EXPECT TO SEE NEW PHYSICS?

WHERE CAN YOU EXPECT TO SEE NEW PHYSICS?

- Could always be just around the corner at the next energy scale

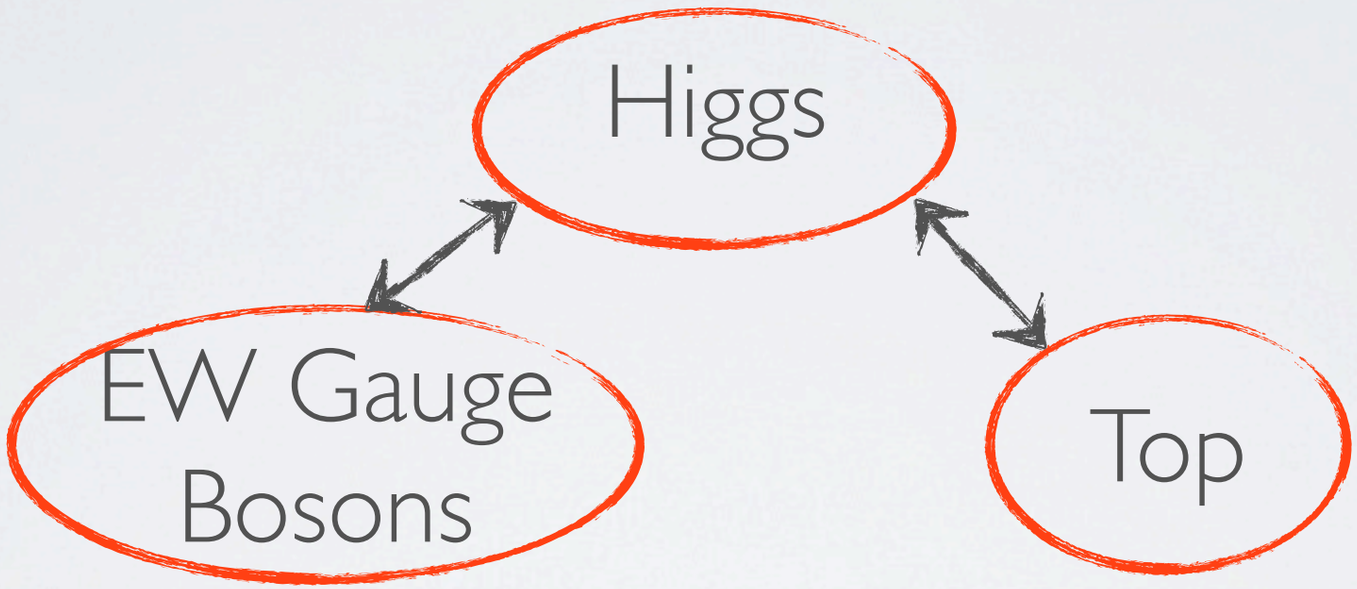
- We could already be sitting on top of it, we just have to look more carefully and become more sensitive!

  - Higgs...

  - top A_{FB} ?

  - Other things?

WHERE CAN YOU EXPECT TO SEE NEW PHYSICS?



IMPORTANCE TO LOOK FOR AT LHC

WHERE TO FIND NEW PHYSICS?

CMS Physics Results

General Information

- All CMS public results can be found in CDS , and are categorized by subject (group) in this page.
- Publications and preprints on **collision data**, ordered by time, are available at this link.
- Publications on cosmic-ray data can be found here; the paper on muon charge ratio is available here .
- The complete list of publications is here.
- Preliminary results **on collision data at 0.9, 2.36, 7, and 8 TeV** are described in Physics Analysis Summaries; Monte Carlo studies can be found here.
- Public performance plots are shown in Detector Performance Summaries.
- For any questions, please contact the CMS Physics Coordinator, Greg.Landsberg@cernSPAMNOT.ch

Physics Analyses

Physics Analysis Group	Group page	Publications	Preliminary Results	Monte Carlo studies
Forward and Small-x QCD Physics	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
B Physics and Quarkonia	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Standard Model Physics (Vector Bosons & Jets)	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Top Physics	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Higgs Physics	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Supersymmetry	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Exotica	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Beyond 2 Generations	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Heavy-Ion Physics	Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries

WHERE TO FIND NEW PHYSICS?

CMS Physics Results

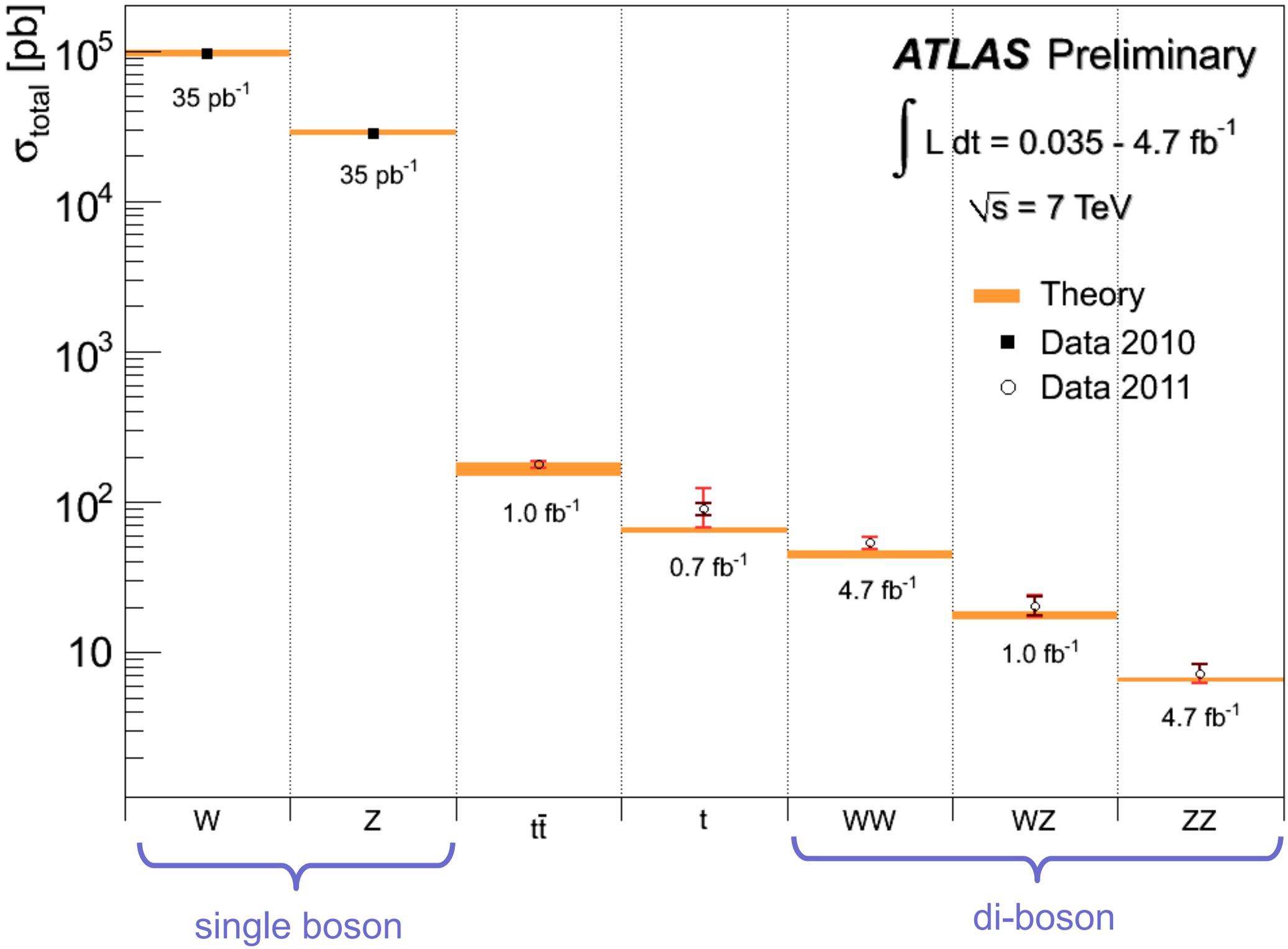
General Information

- All CMS public results can be found in CDS , and are categorized by subject (group) in this page.
- Publications and preprints on **collision data**, ordered by time, are available at this link.
- Publications on cosmic-ray data can be found here; the paper on muon charge ratio is available here .
- The complete list of publications is here.
- Preliminary results **on collision data at 0.9, 2.36, 7, and 8 TeV** are described in Physics Analysis Summaries; Monte Carlo studies can be found here.
- Public performance plots are shown in Detector Performance Summaries.
- For any questions, please contact the CMS Physics Coordinator, Greg.Landsberg@cernSPAMNOT.ch

Physics Analyses

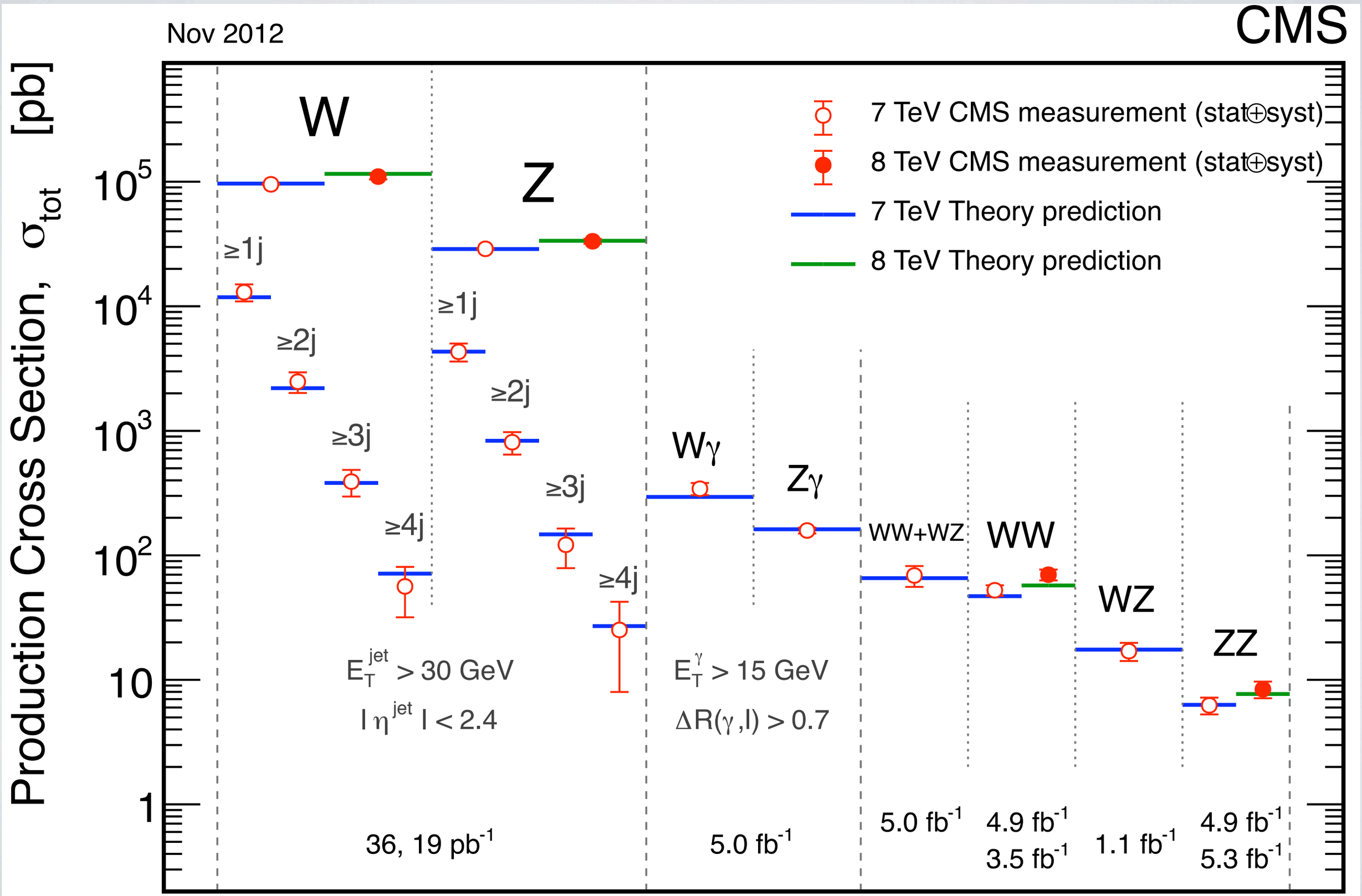
Physics Analysis Group		Group page	Publications	Preliminary Results	Monte Carlo studies
Forward and Small-x QCD Physics		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
B Physics and Quarkonia		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Standard Model Physics (Vector Bosons & Jets)		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Top Physics		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Higgs Physics		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Supersymmetry		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Exotica		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Beyond 2 Generations		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries
Heavy-Ion Physics		Plots and Results	Papers	Physics Analysis Summaries	Physics Analysis Summaries

SM CROSS SECTION PLOT

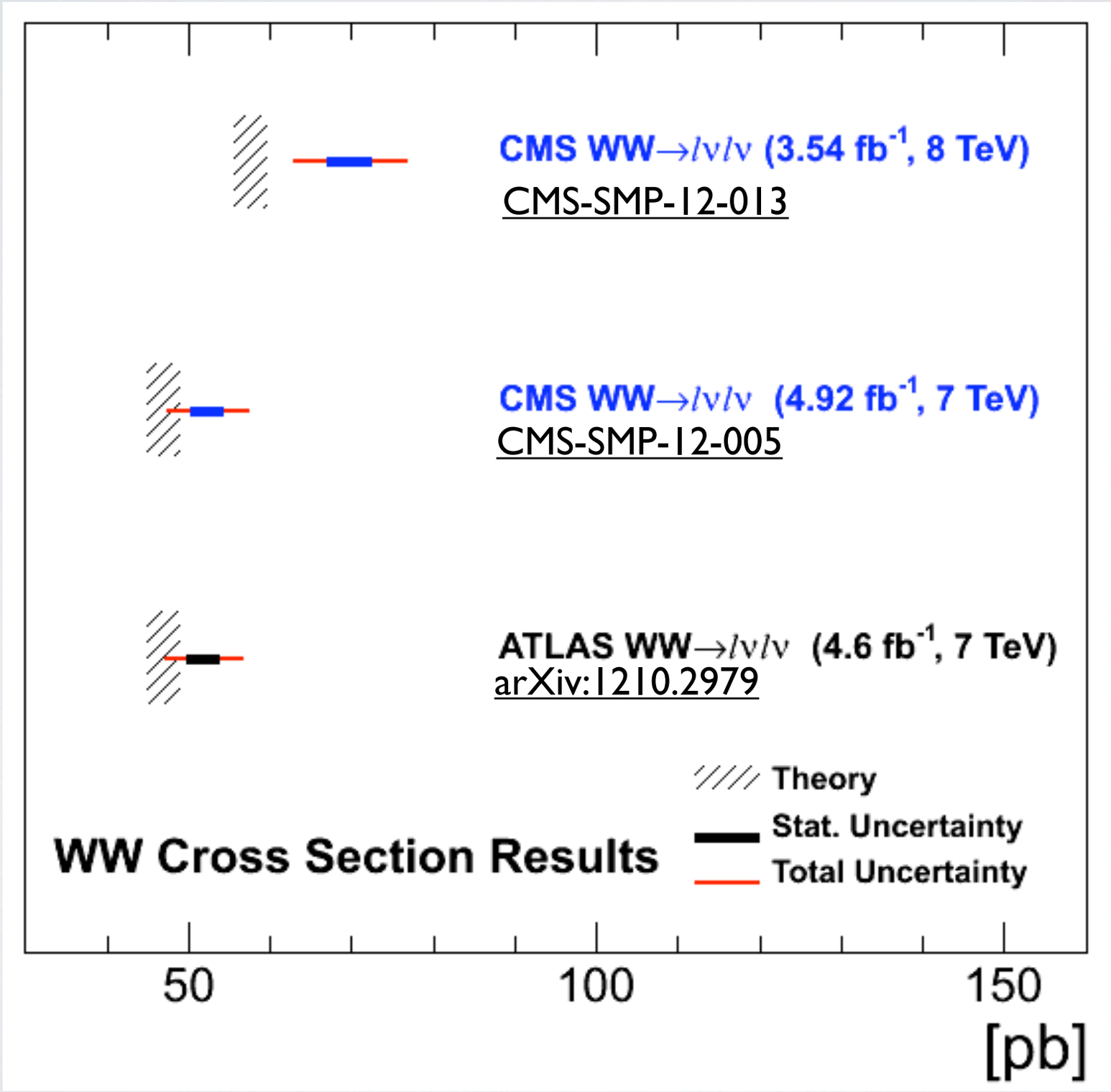


- Very similar agreement with (N)NLO predictions is observed by CMS

CMS EW HCP ZOOM IN



VISUAL "EVIDENCE"



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→WW at CMS7, ATLAS7, CMS8, ATLAS8
- What's the status?

Every reported* measurement is higher than the SM

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→WW at CMS7, ATLAS7, CMS8, ATLAS8
- What's the status?

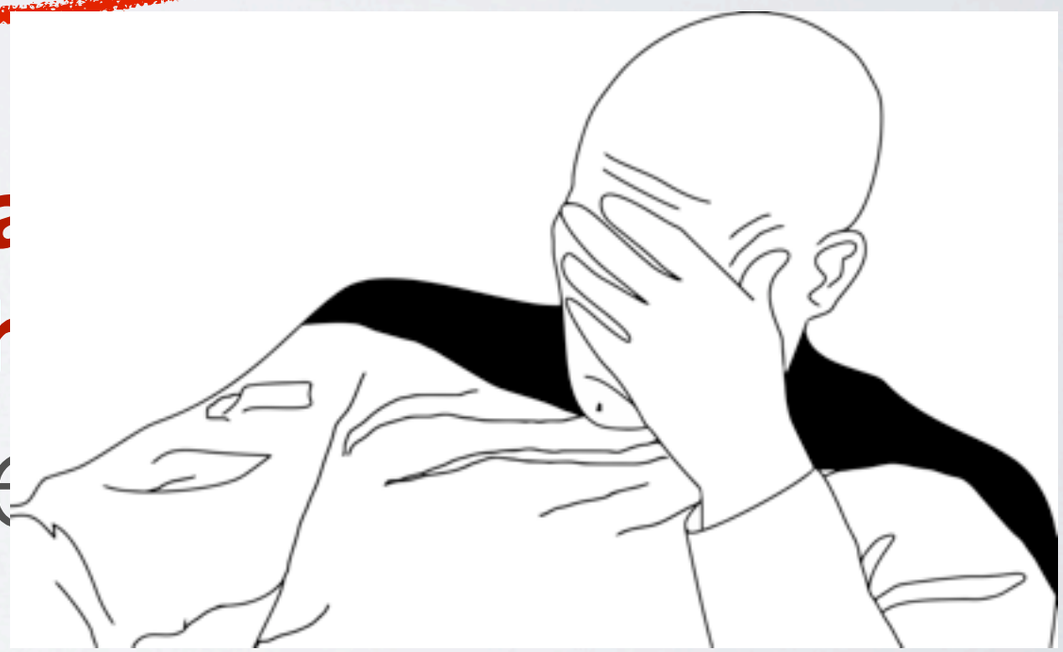
Every reported* measurement is higher than the SM

NOT Fermi line high...

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→WW at CMS7, ATLAS7, CMS8, ATLAS8
- What's the status?

Every reported* mea
higher than th
NOT Fermi line



Not astrophysics either...

WW CROSS SEC MEASUREMENTS

ATLAS 7

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

CMS 7

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

NLO theory at 7 TeV

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

ATLAS MC@NLO

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

MCFM **Campbell, Ellis, Williams**

WW CROSS SEC MEASUREMENTS

ATLAS 7

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

CMS 7

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

NLO theory at 7 TeV

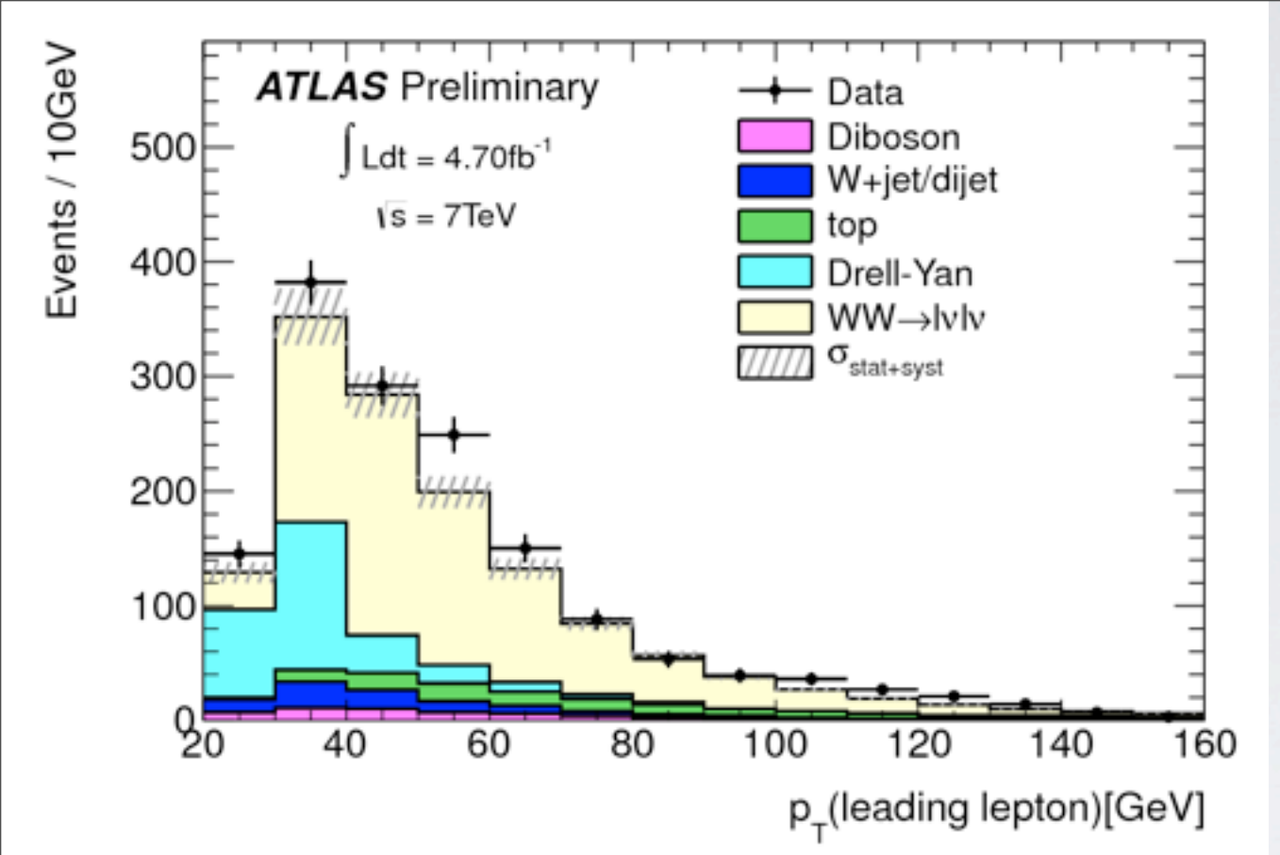
$$\sigma(pp \to W^+W^-) = 45.1 \pm 2.8\,\text{pb}$$ ATLAS MC@NLO

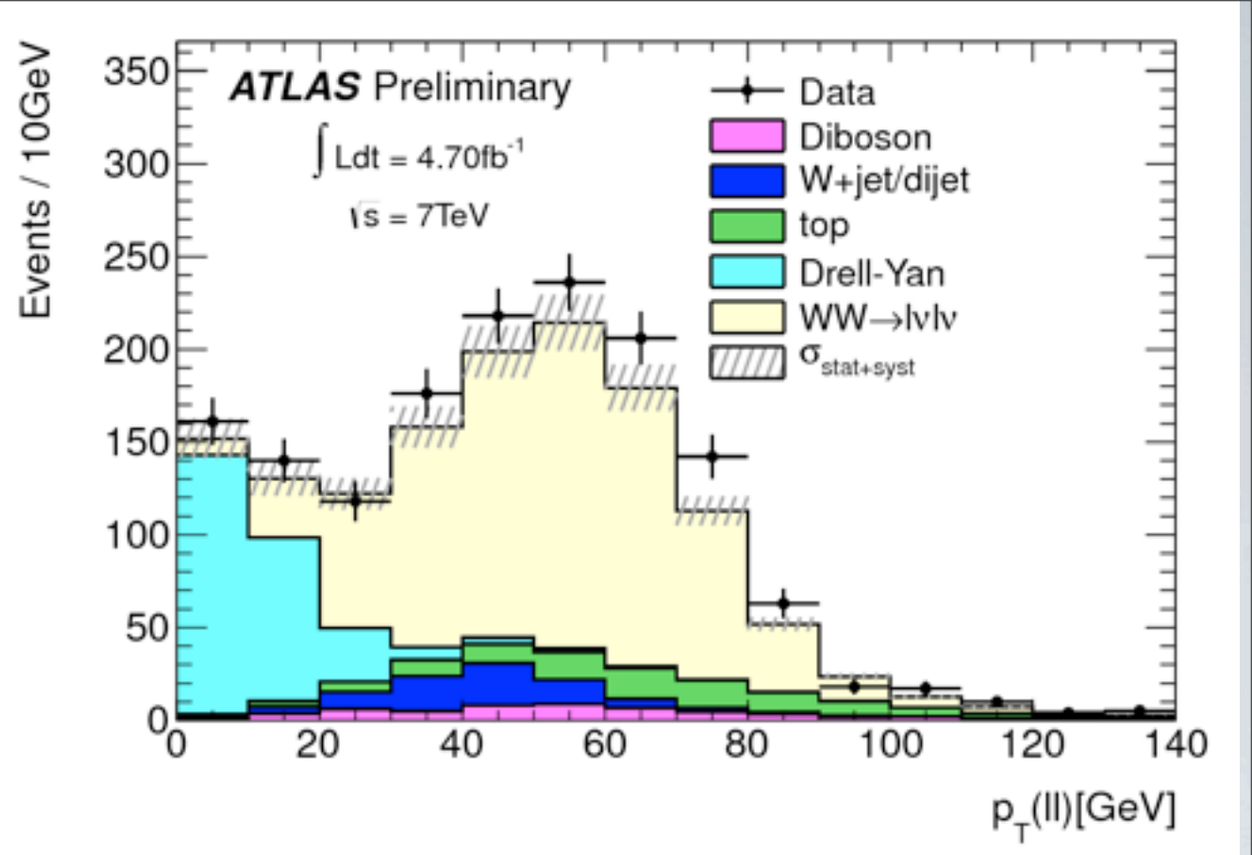
$$\sigma(pp \to W^+W^-) = 47 \pm 2\,\text{pb}$$ MCFM **Campbell, Ellis, Williams**

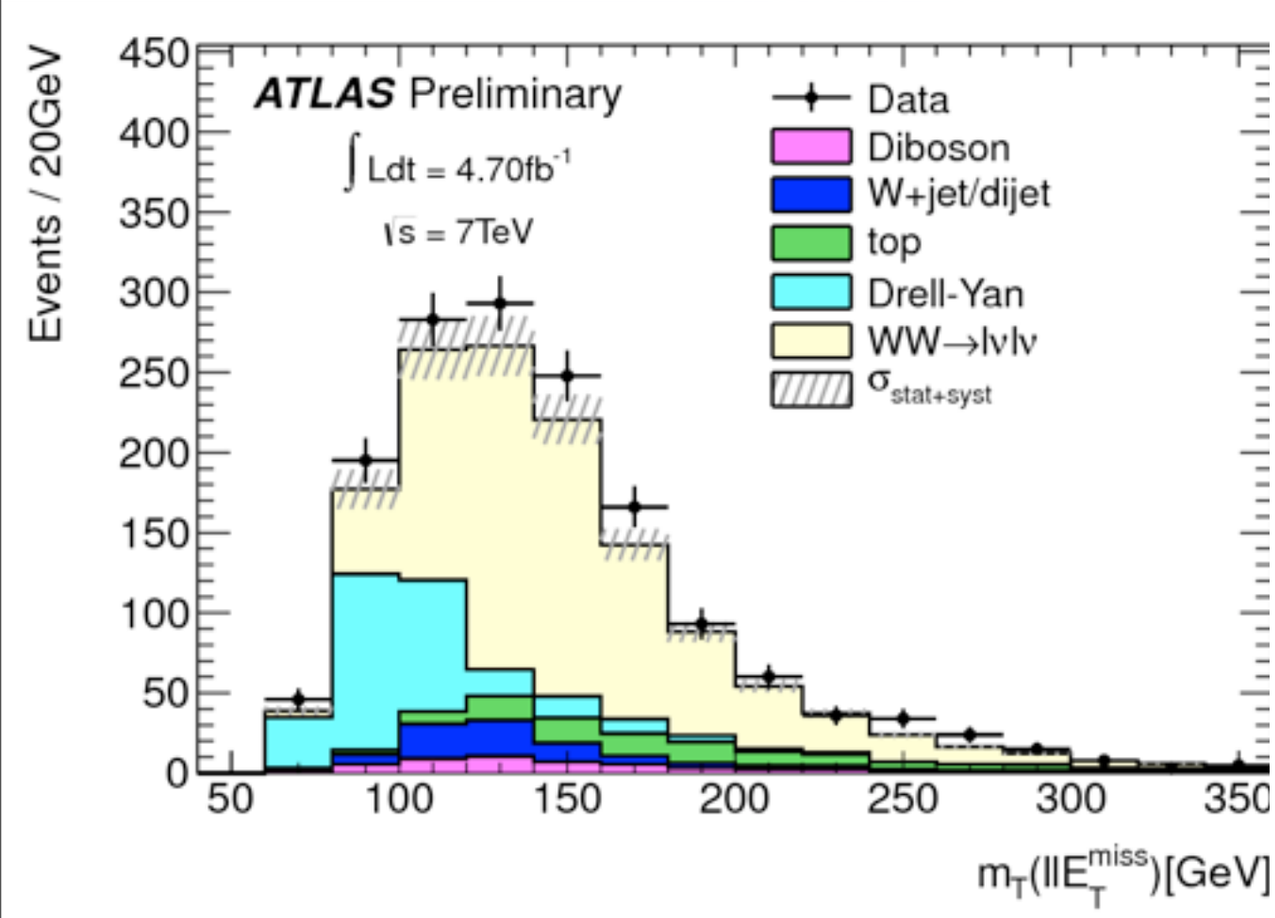
1.4σ and 1σ, this is an anomaly???

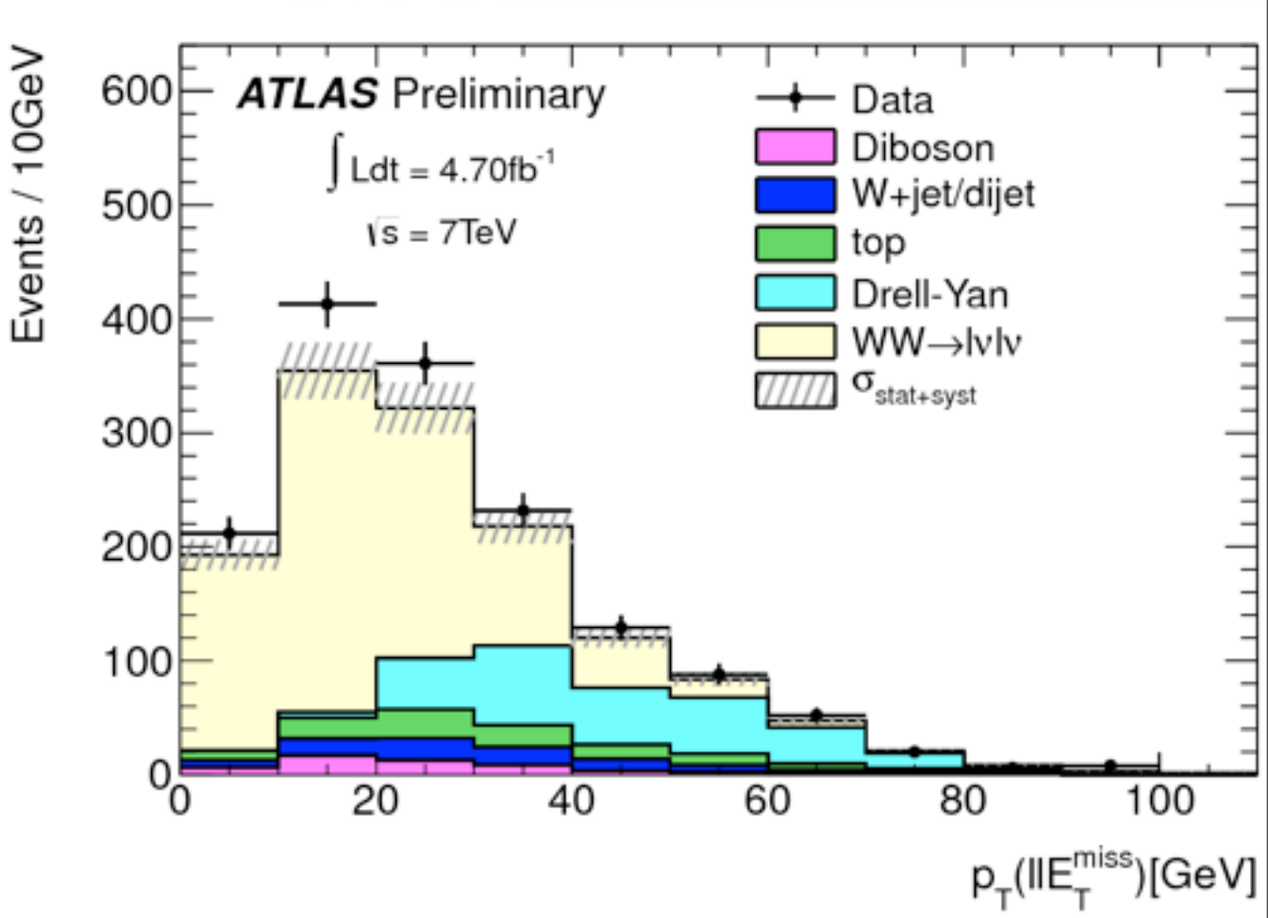
ATLAS and CMS are more consistent with each other than the SM...

NOT just a "rate" anomaly


ATLAS Preliminary
∫ Ldt = 4.70fb-1
√s = 7TeV
Data
Diboson
W+jet/dijet
top
Drell-Yan
WW→lνlν
σstat+syst
Events / 10GeV
pT(leading lepton)[GeV]


ATLAS Preliminary
∫ Ldt = 4.70fb-1
√s = 7TeV
Data
Diboson
W+jet/dijet
top
Drell-Yan
WW→lνlν
σstat+syst
Events / 10GeV
pT(ll)[GeV]


ATLAS Preliminary
∫ Ldt = 4.70fb-1
√s = 7TeV
Data
Diboson
W+jet/dijet
top
Drell-Yan
WW→lνlν
σstat+syst
Events / 20GeV
mT(llEmissT)[GeV]


ATLAS Preliminary
∫ Ldt = 4.70fb-1
√s = 7TeV
Data
Diboson
W+jet/dijet
top
Drell-Yan
WW→lνlν
σstat+syst
Events / 10GeV
pT(llEmissT)[GeV]

CMS 8 TEV 3.5/FB

WW→2ℓ2ν at 8 TeV: systematics & results

σ = 69.9 ± 2.8 (stat) ± 5.6 (sys) ± 3.1 (lum) pb

NLO prediction (MCFM): 57.25 ($^{+2.35}_{-1.60}$) pb

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

It grows at 8 TeV even faster!

$$\left.\frac{\sigma(8)}{\sigma(7)}\right|_{\rm th} = 1.21 \qquad \left.\frac{\sigma(8)}{\sigma(7)}\right|_{\rm exp} = 1.33$$

CMS 8 TEV 3.5/FB

WW→2ℓ2ν at 8 TeV: systematics & results

σ = 69.9 ± 2.8 (stat) ± 5.6 (sys) ± 3.1 (lum) pb

NLO prediction (MCFM): 57.25 ($^{+2.35}_{-1.60}$) pb

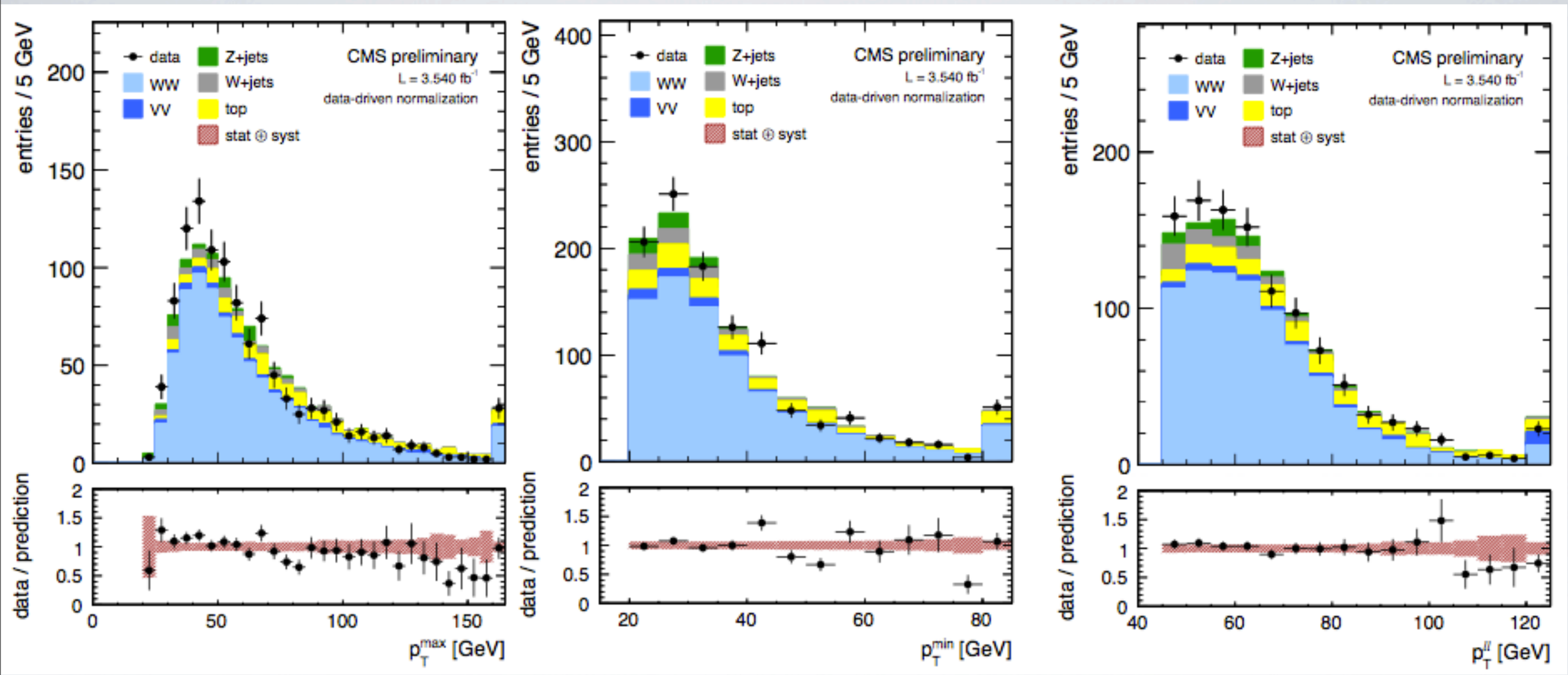
- **Already 4% statistical precision**
- **About 1.8σ higher than the NLO prediction**

It grows at 8 TeV even faster!

$$\left.\frac{\sigma(8)}{\sigma(7)}\right|_{\rm th} = 1.21 \qquad \left.\frac{\sigma(8)}{\sigma(7)}\right|_{\rm exp} = 1.33$$

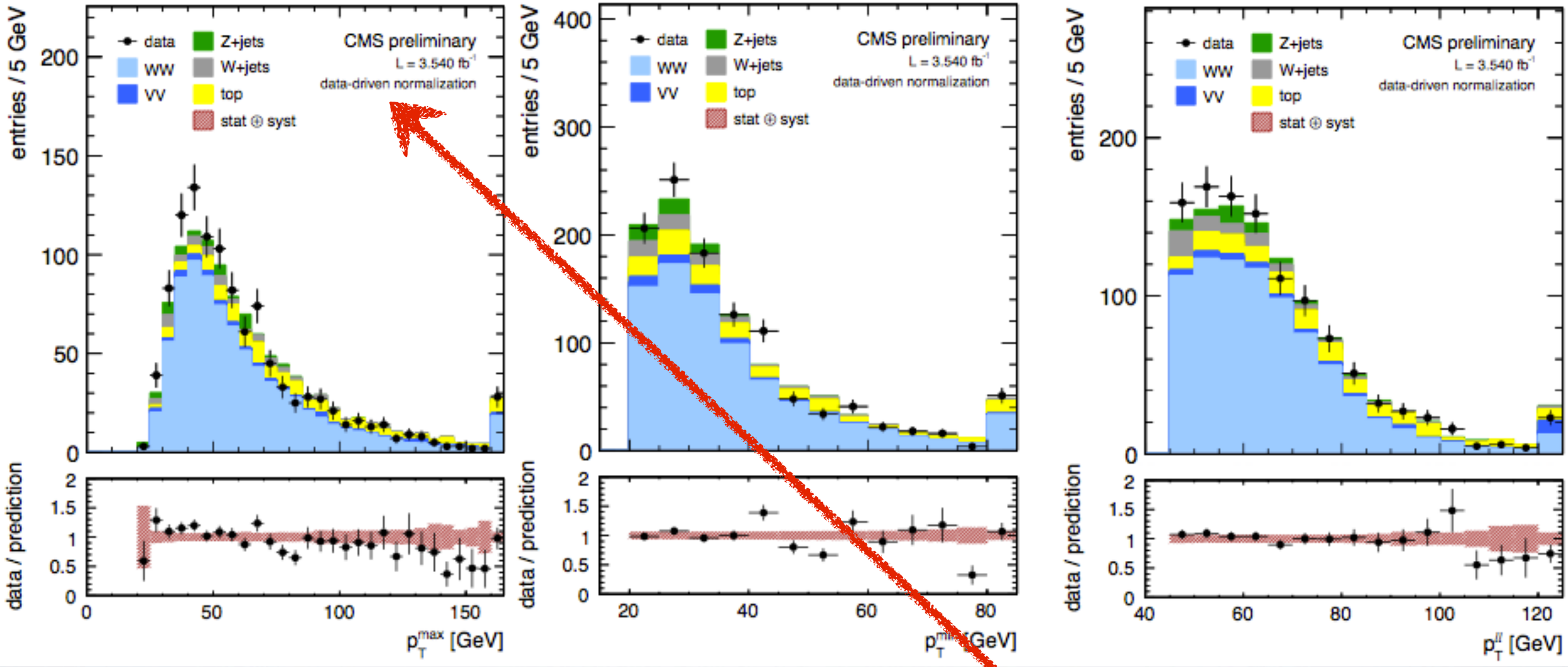
$> 3\sigma$ when combined

CMS8

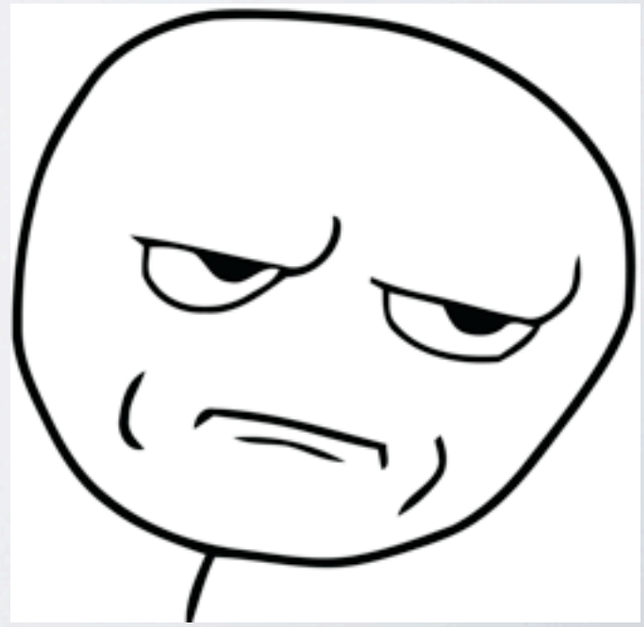


Looks pretty good...

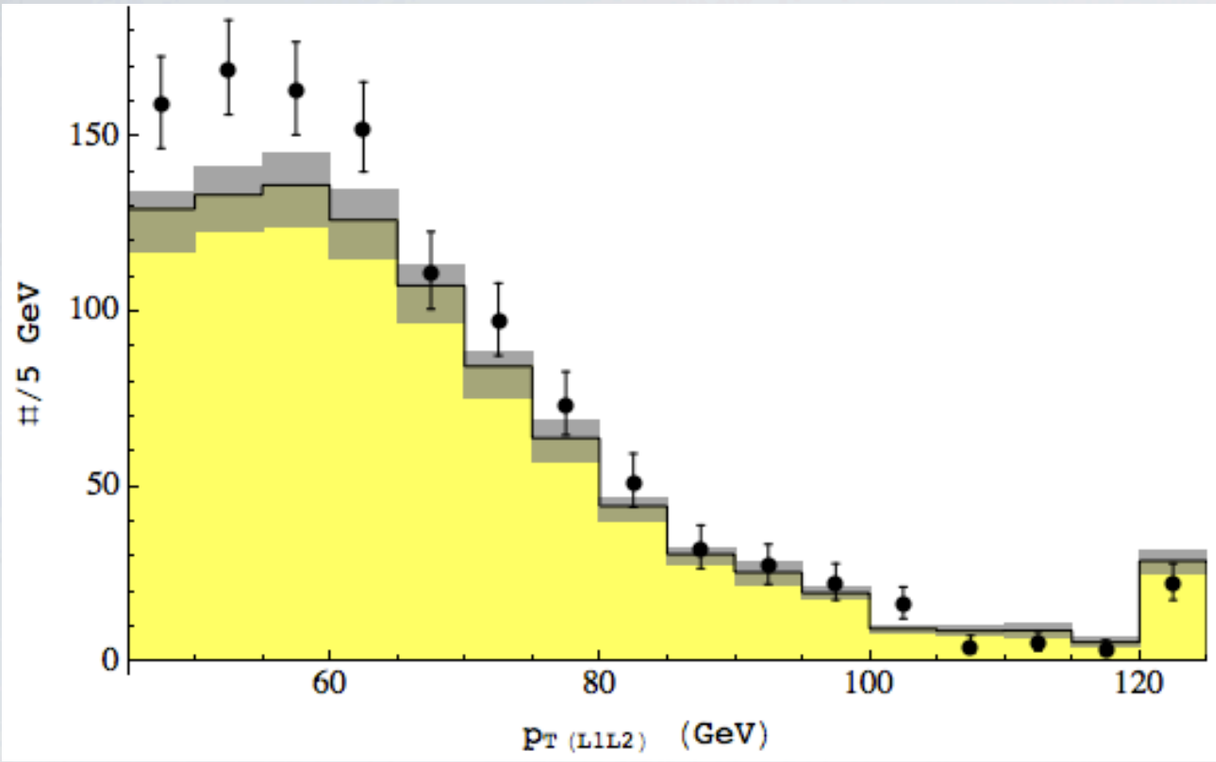
CMS8

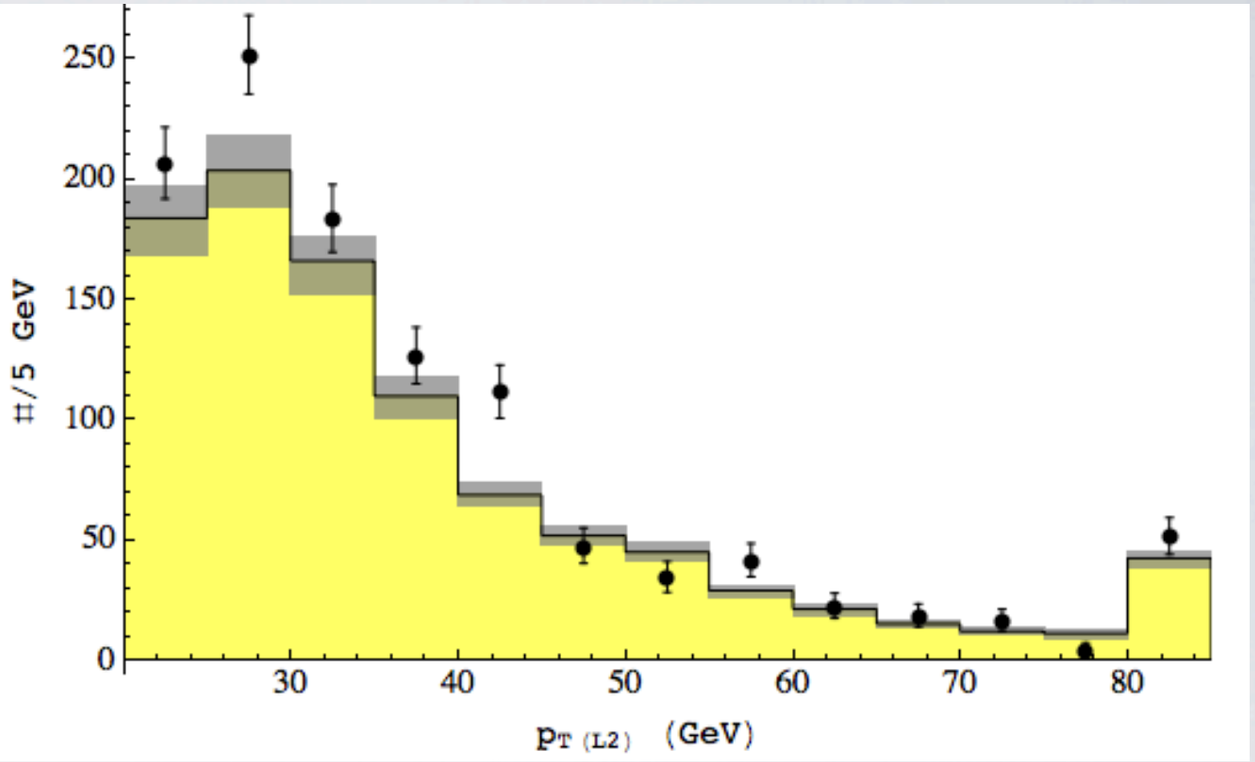


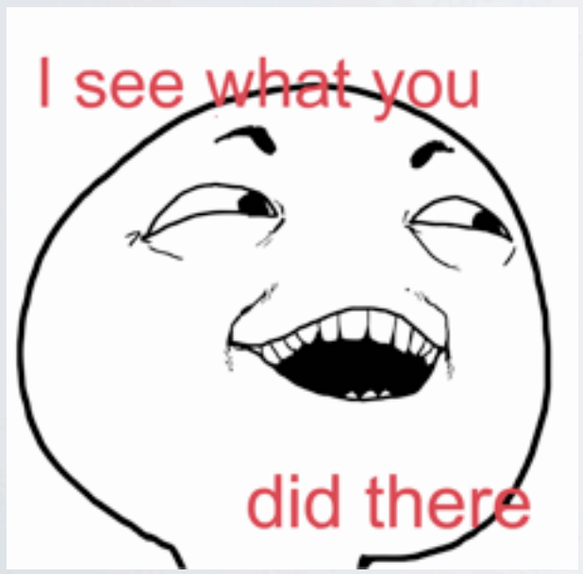
Looks pretty good...

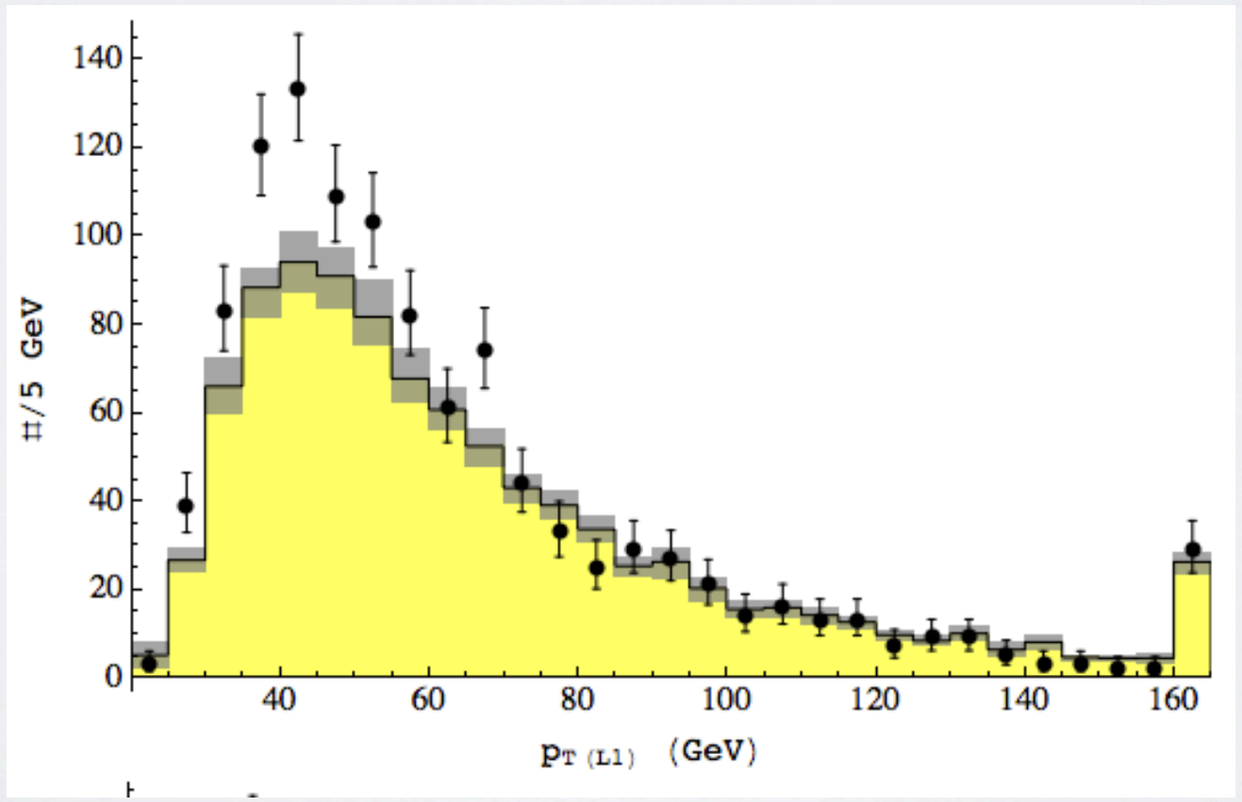


NO EXTRA NORMALIZATION...





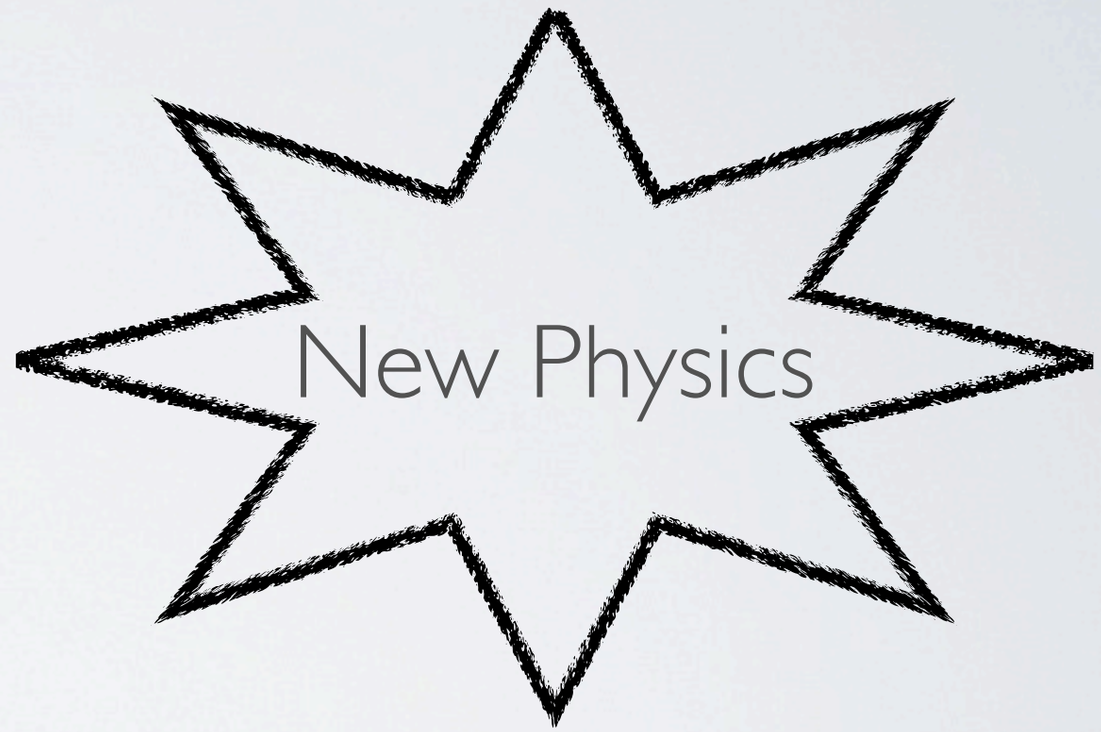




Upward fluctuations in all measurements ***or*** a trend?

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

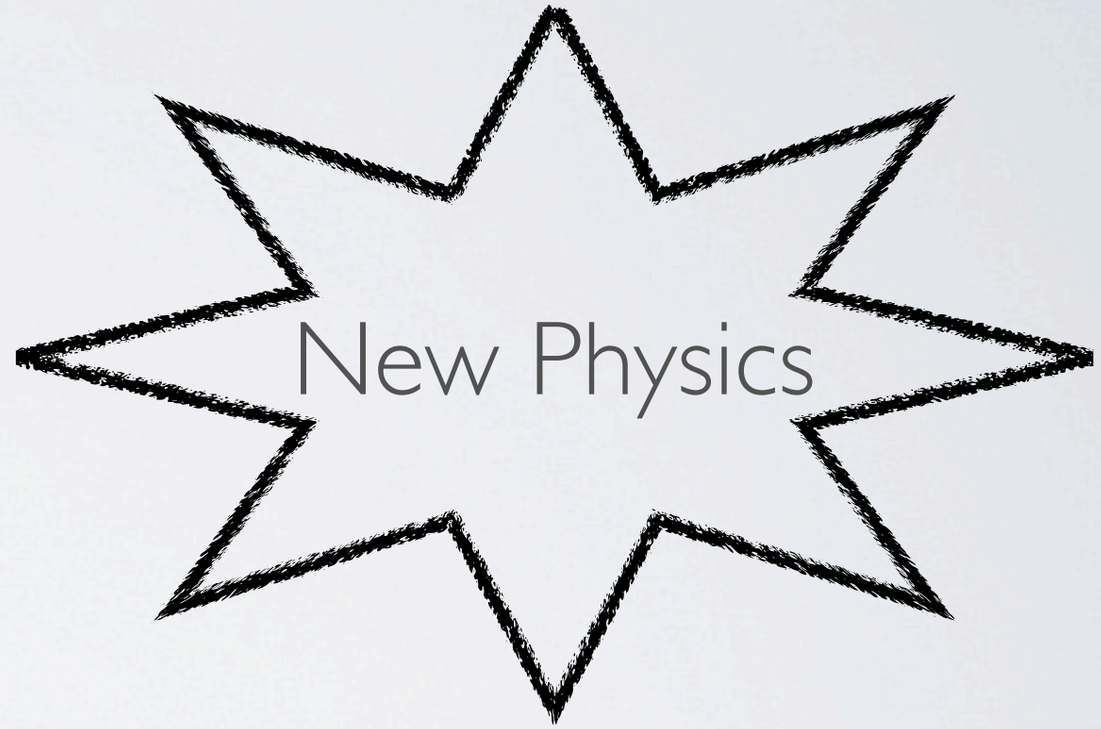
SM calculation
wrong



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

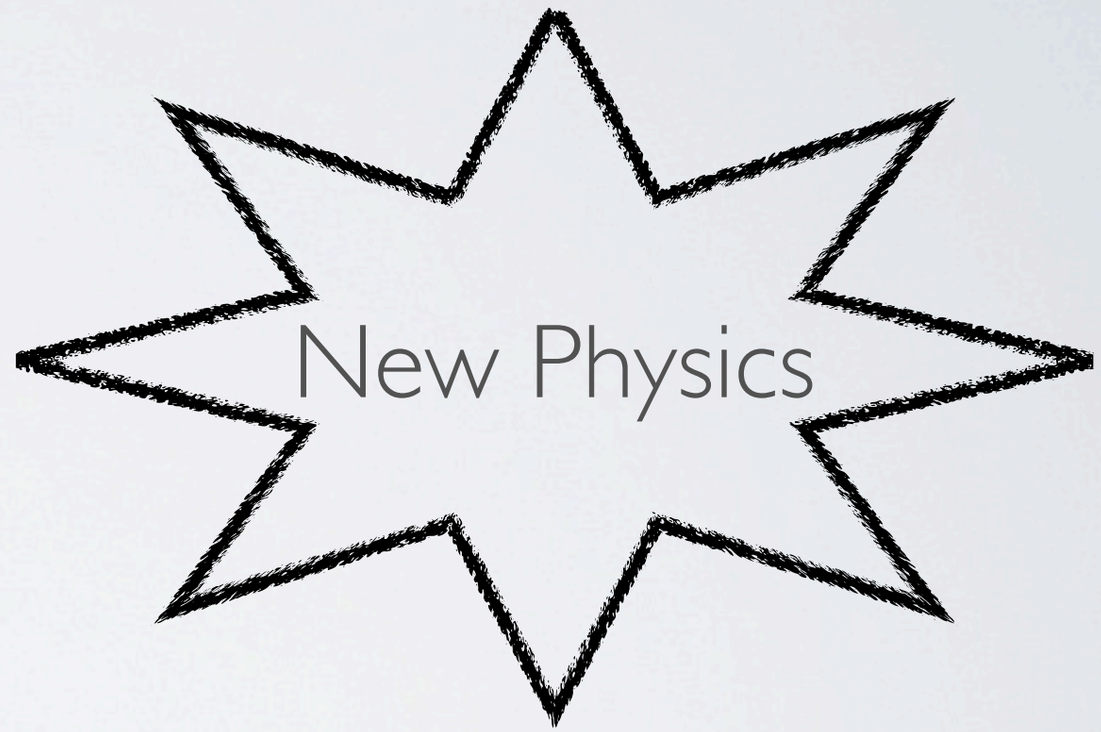


Will come back to the less traveled one
and that of course may make all the difference...

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



**** spoiler alert: Not really...***

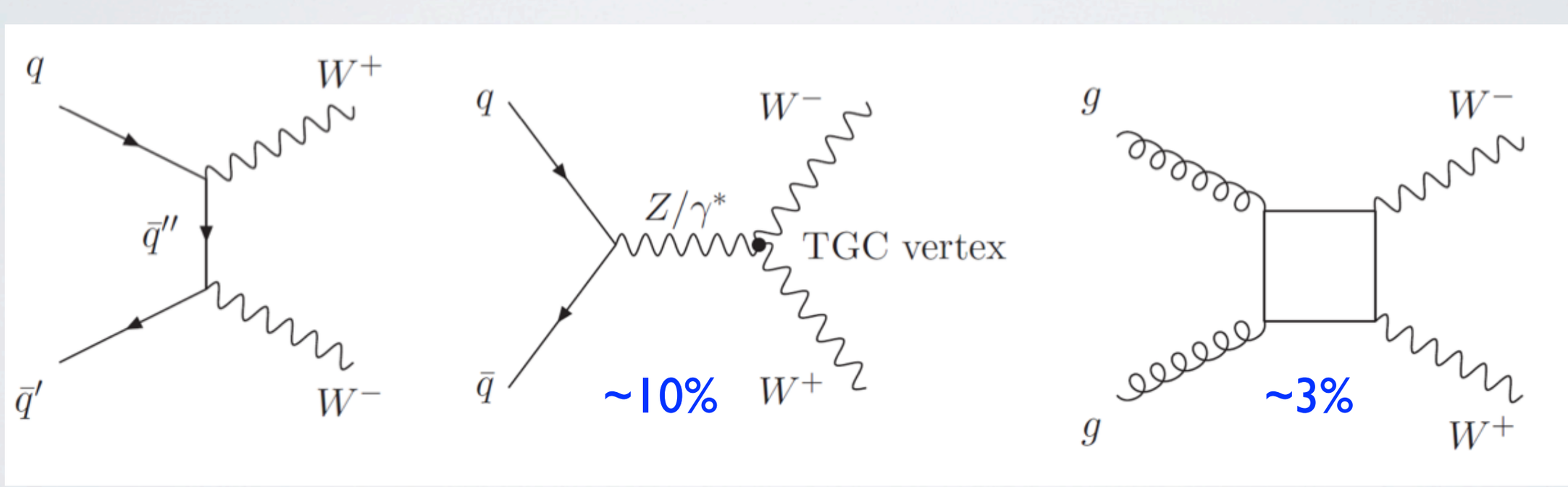
Will come back to the less traveled one
and that of course may make all the difference...

INGREDIENTS FOR BSM EXPLANATION

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

Total cross section

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



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

INGREDIENTS FOR BSM EXPLANATION

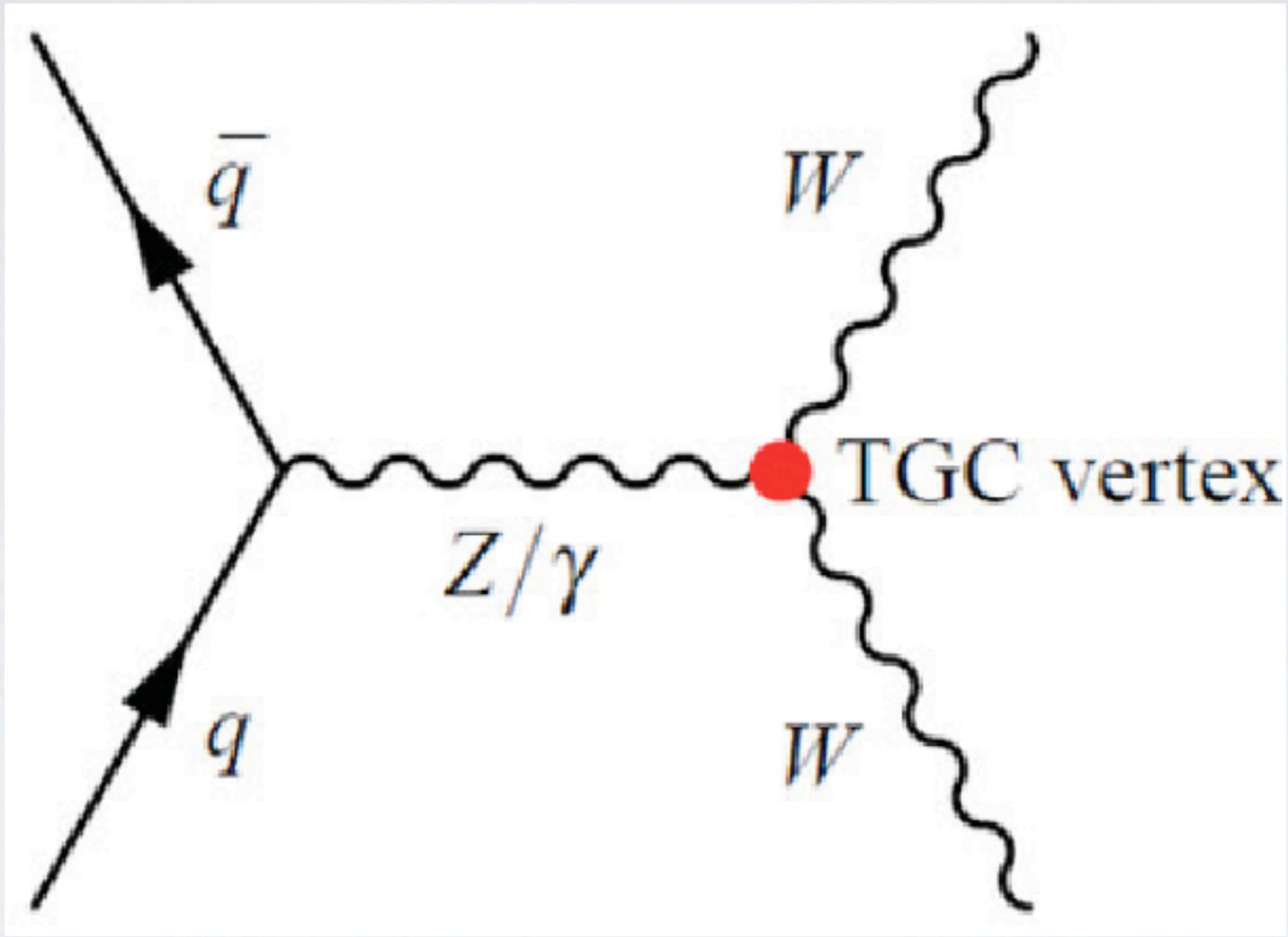
- ATLAS and CMS both measure OS dileptons + MET **with** a jet VETO

- Final state needs to be OS leptons+MET with *nothing* else essentially

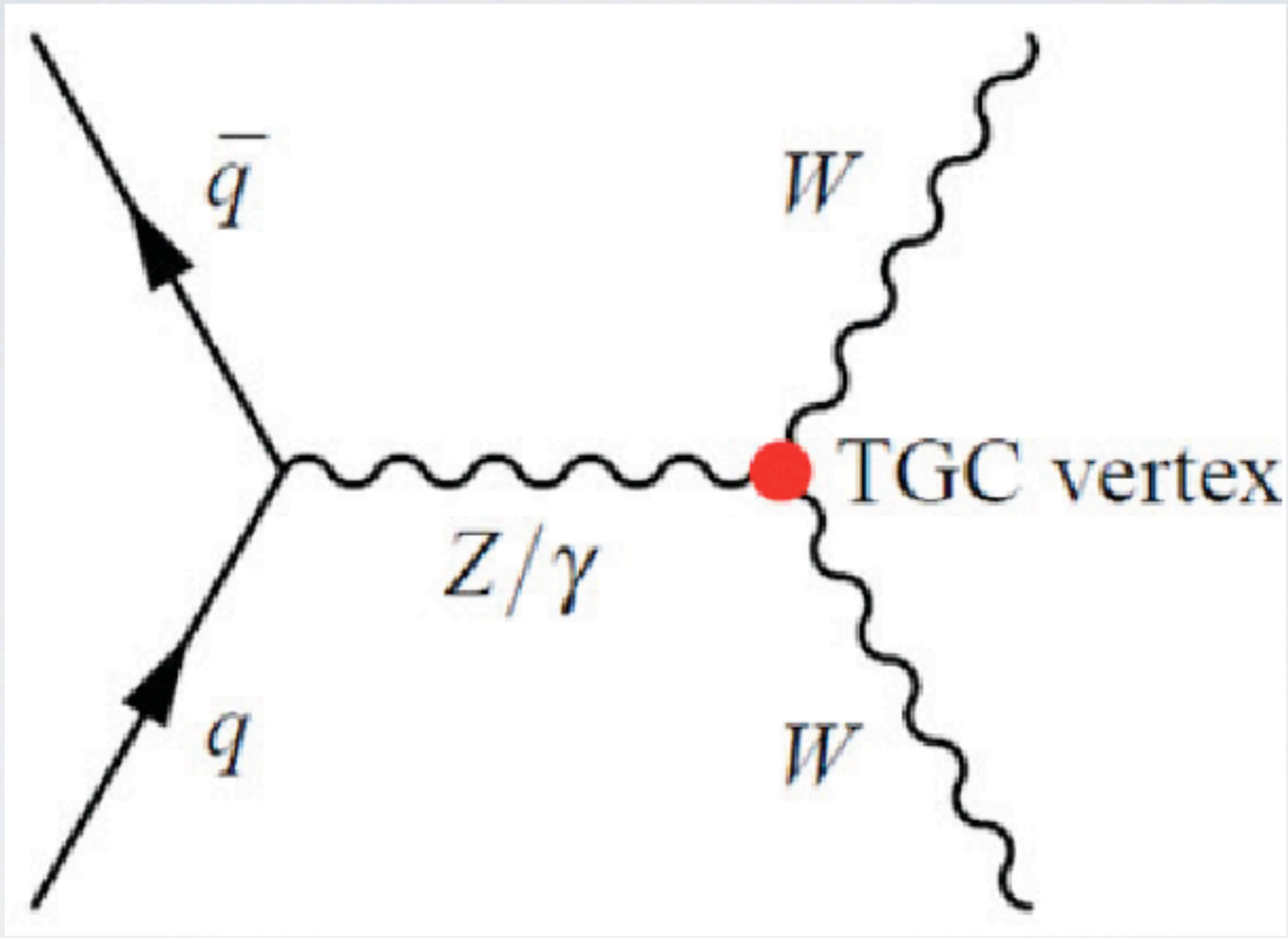
- Does ***NOT*** imply there have to be ***REAL W's***

  - Doesn't hurt either if there are!

EXPERIMENTALIST'S FAVORITE DIBOSON TOOL...



AN EXPLANATION?



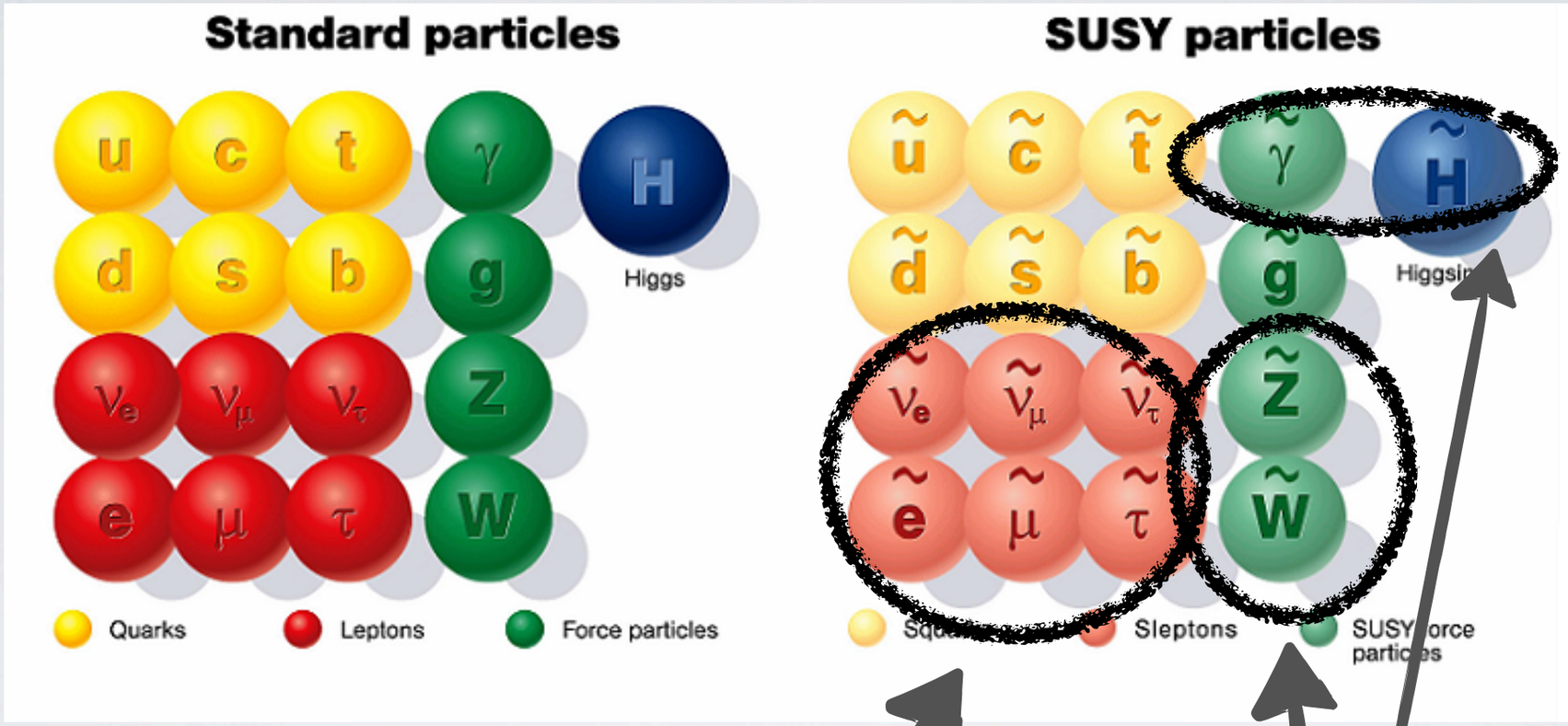
NO! Need to affect the bulk not tails of distributions!

NEW PHYSICS EXPLANATION

- Measurement is 2 leptons + MET so we need this... (jet veto)
- Kinematics ***similar*** to WW of SM
- Need a cross section of a few pb to make a difference

What does all this and more? EW GAUGINOS!!

SUSY??

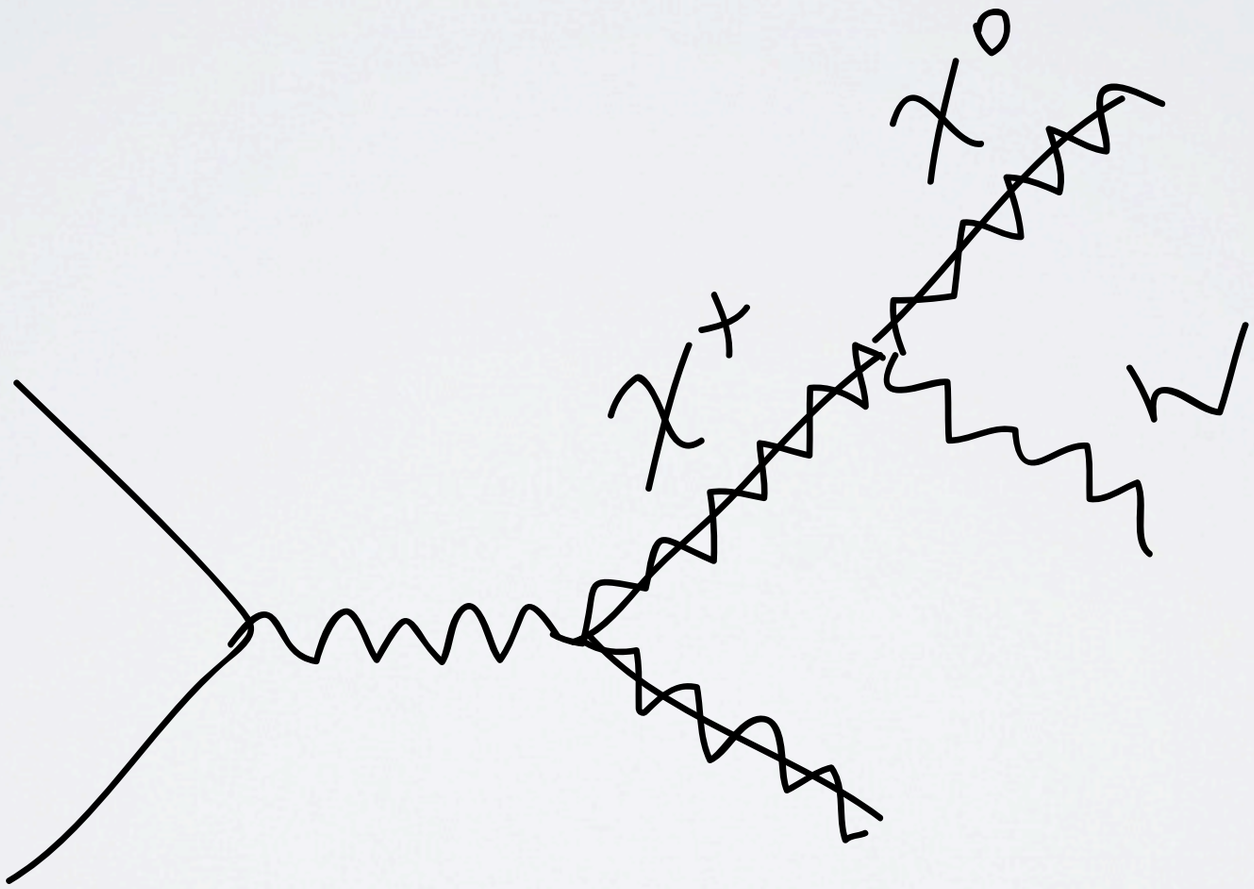


Focus here later

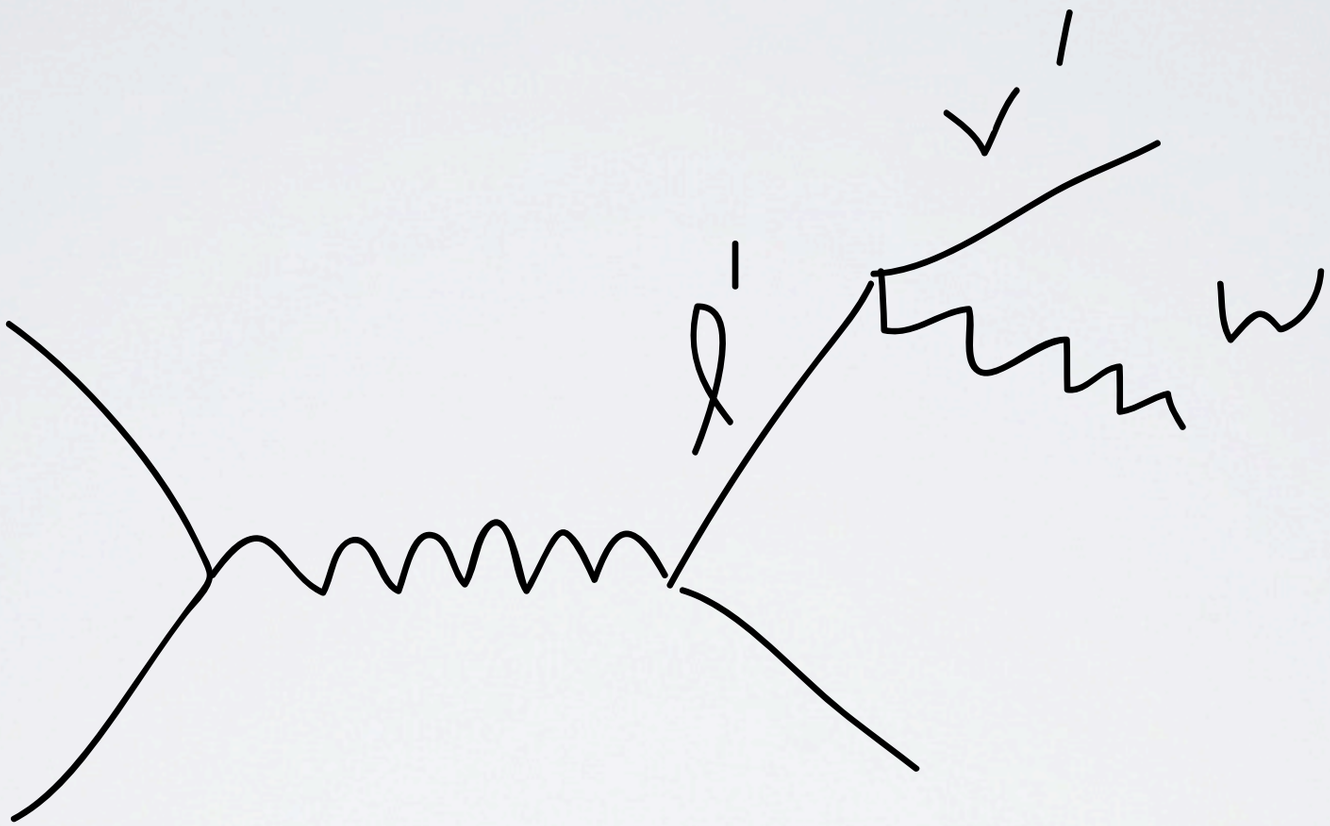
Focus here

Not talking about SUSY in general, e.g. Higgs mass see talks by Yanagida and Shih

EXAMPLE TOPOLOGIES FOR WW+MET



DON'T LIKE SUSY??



"Heavy Lepton"

GRAVITY MEDIATED SPECTRUM

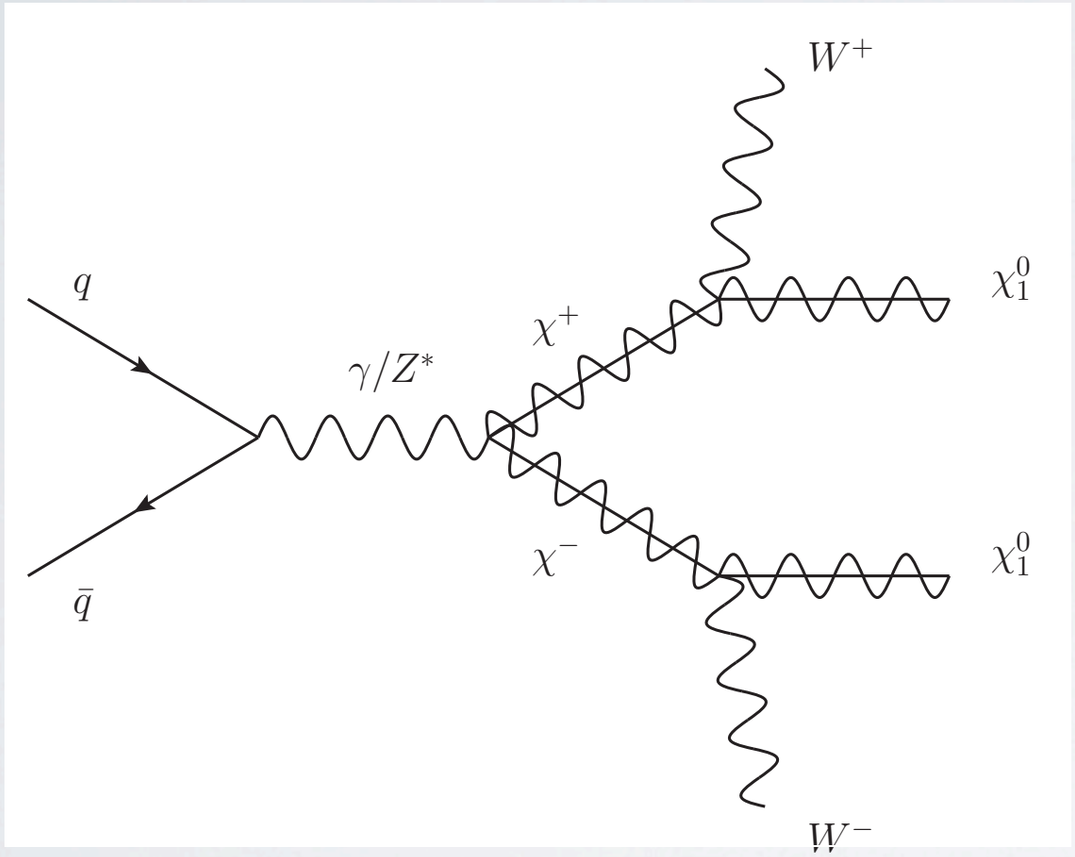
——— $\chi_1^\pm, \chi_2^0$ O(100 GeV)

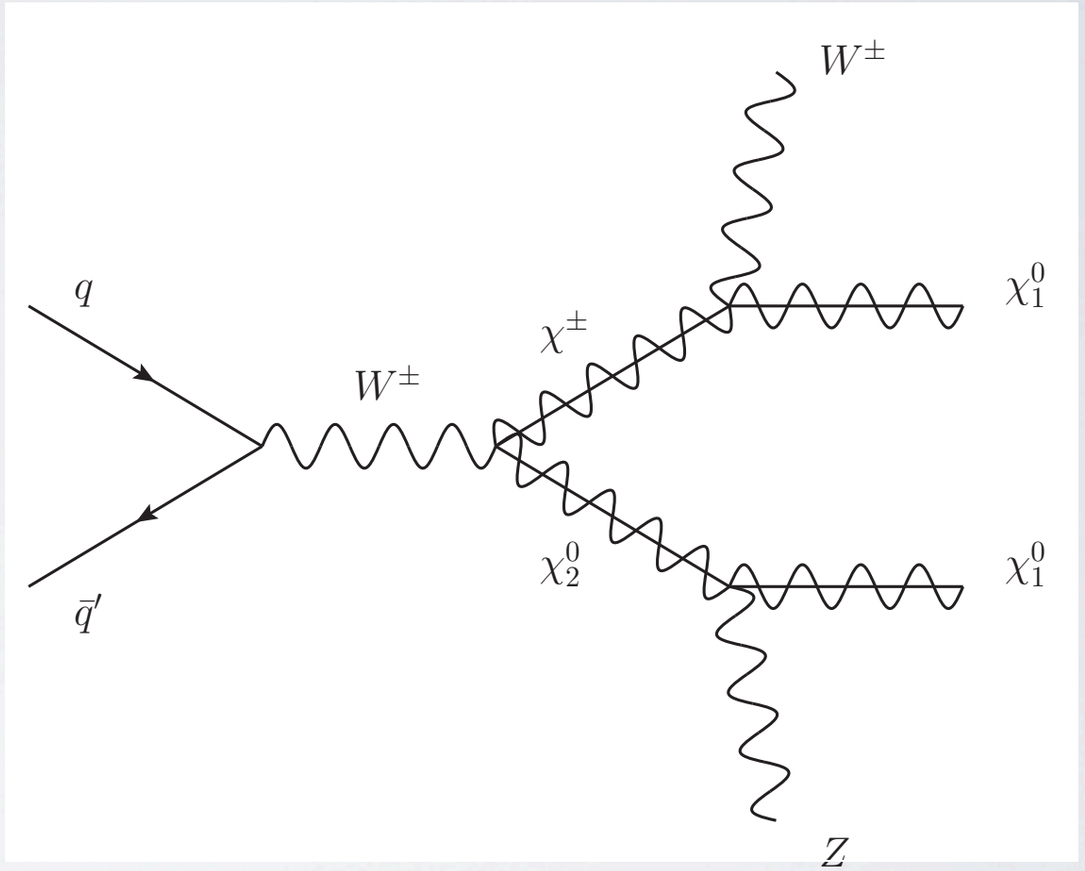
Could be at LEP limit!

Amusingly the right point
to affect the cross section significantly...

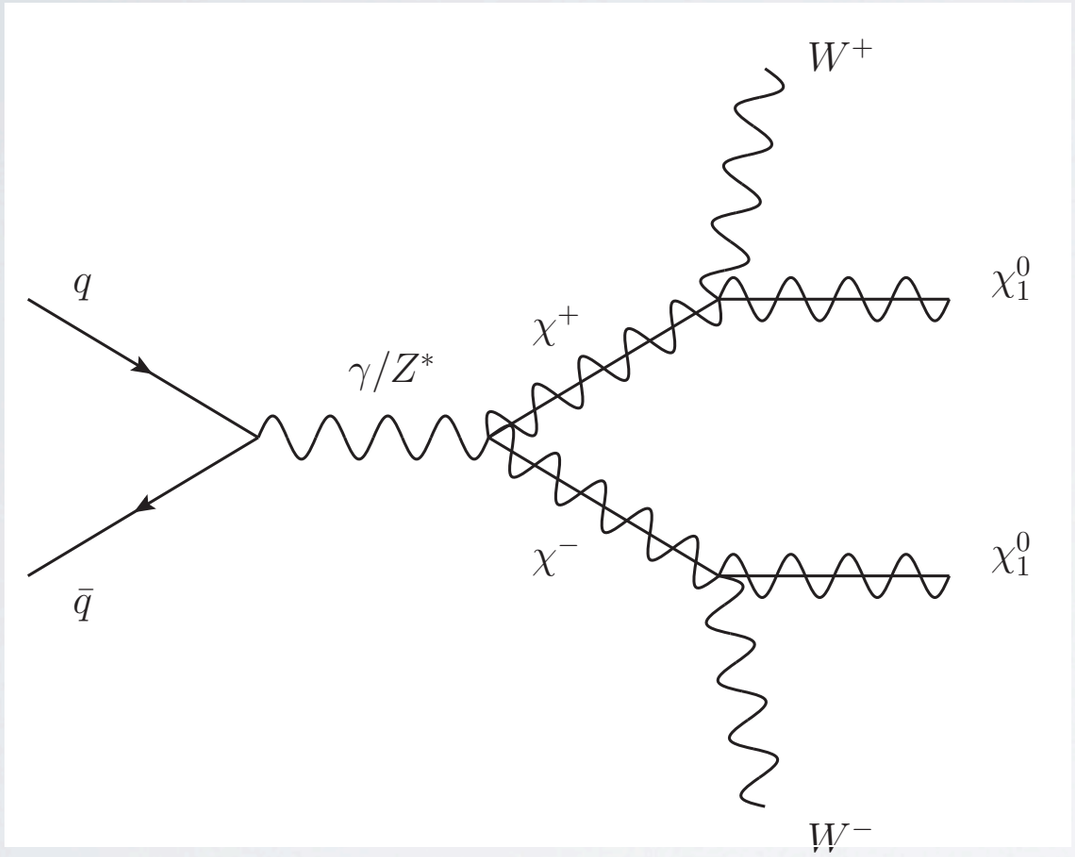
——— χ_1^0 O(GeV)

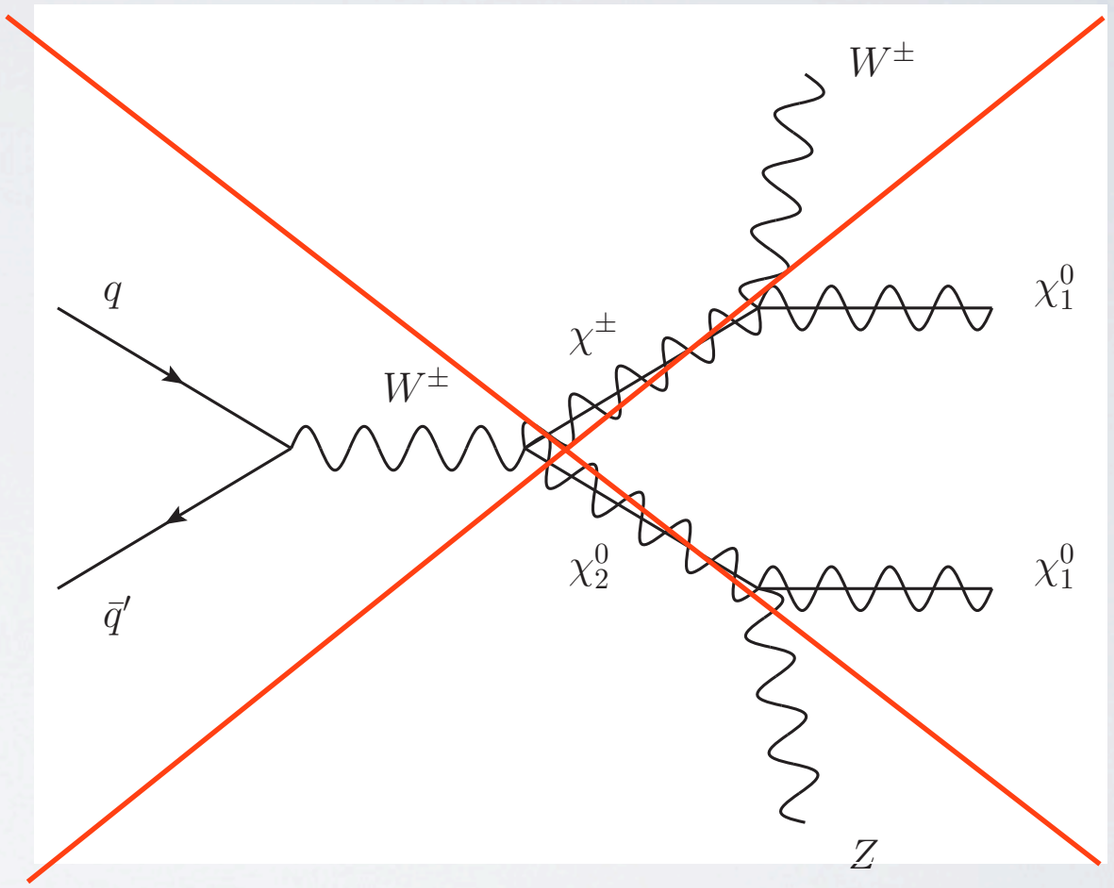
EXAMPLE TOPOLOGIES





EXAMPLE TOPOLOGIES

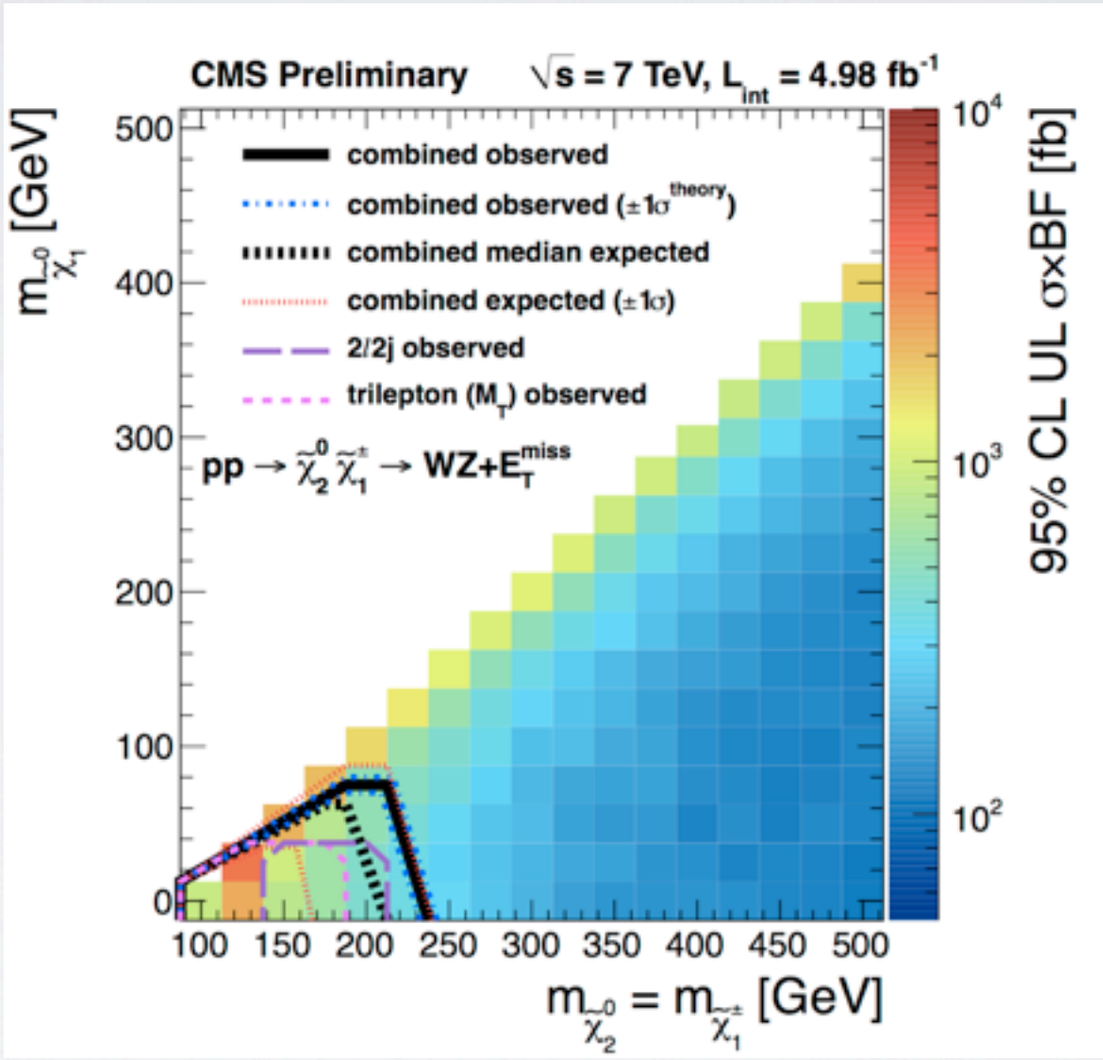




Gone after yesterdays lecture

EW GAUGINO BOUNDS

WZ final state ruled out well above LEP

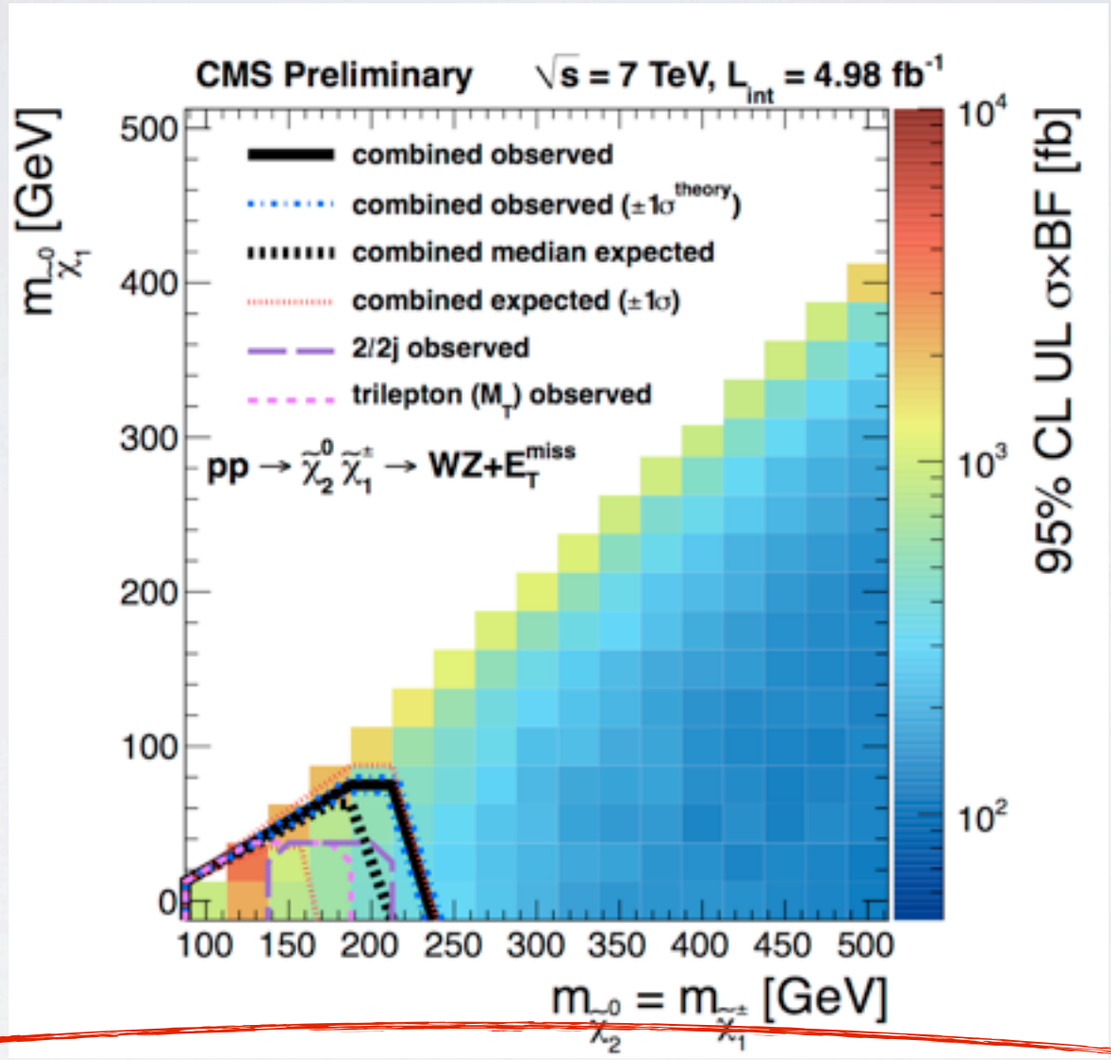


Wh state also ruled out by ATLAS 7 TeV Wh search

~ 160 GeV Higgsinos

EW GAUGINO BOUNDS

WZ final state ruled out well above LEP



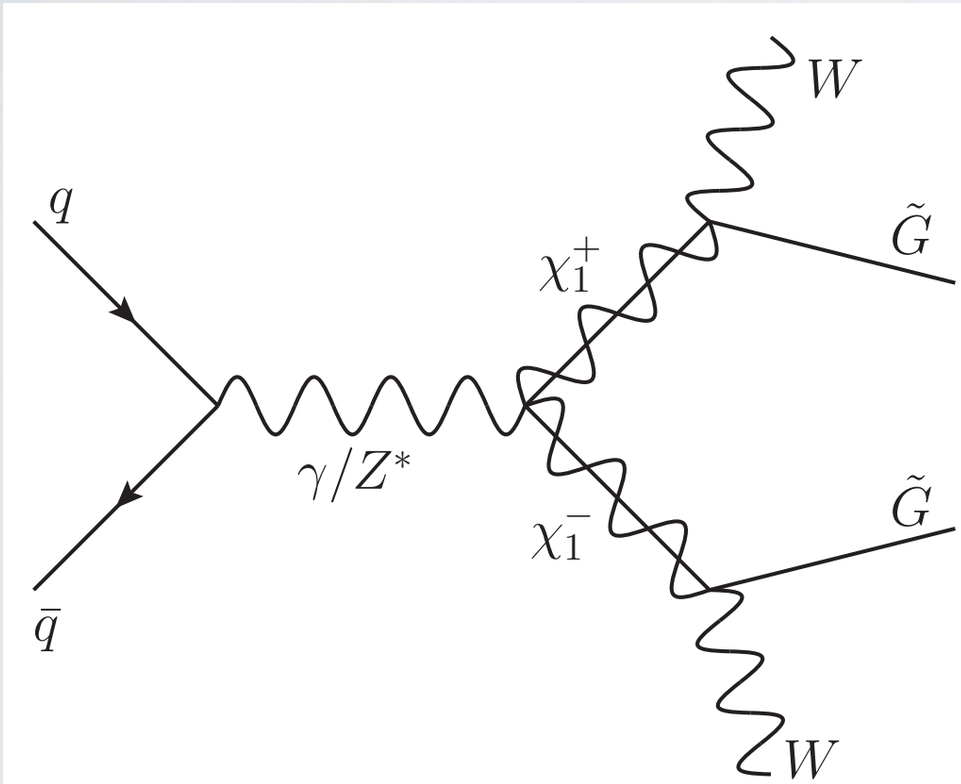
Wh state also ruled out by ATLAS 7 TeV Wh search

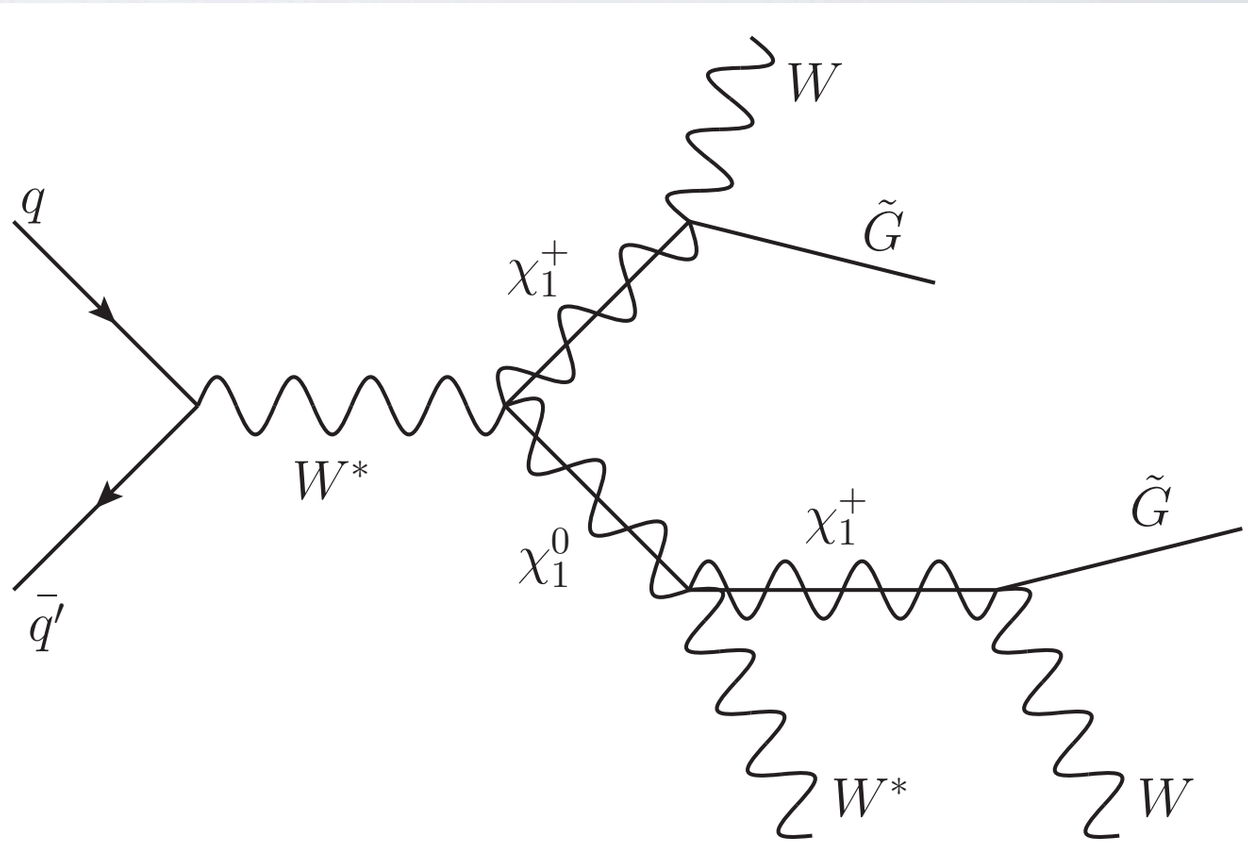
~ 160 GeV Higgsinos **1206.6888**

(ours not ATLAS)

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

- Chargino NLSP in Gauge Mediated SUSY breaking
  - low tan beta, large Wino-Higgsino mixing

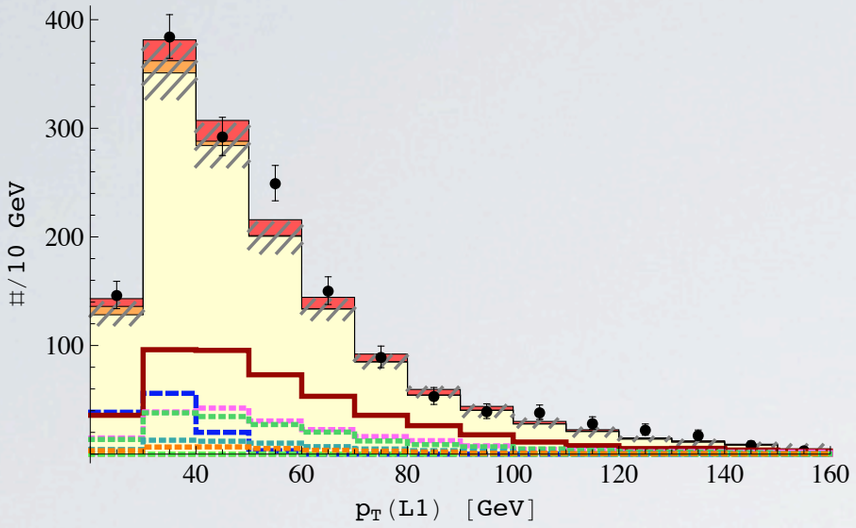


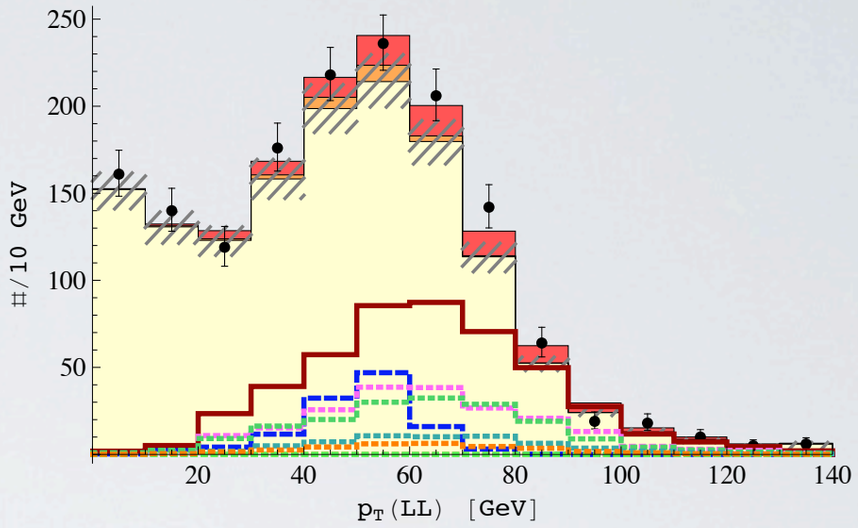


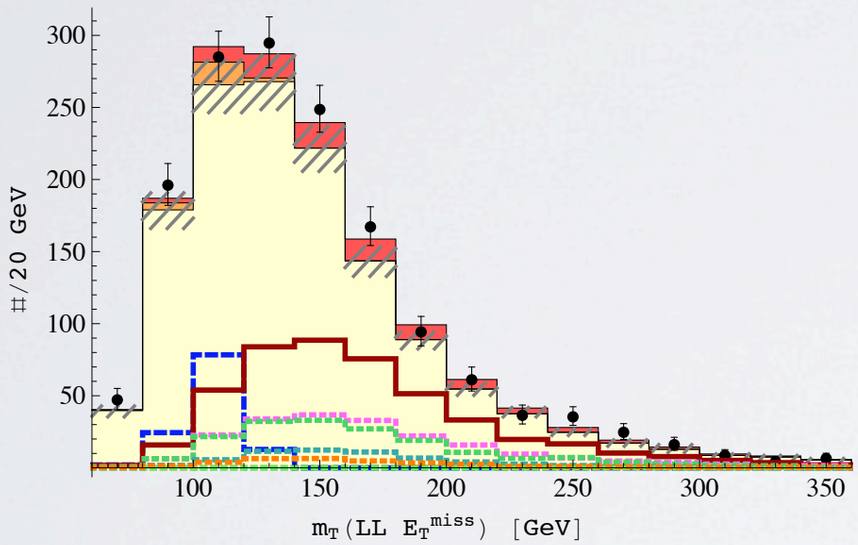
$$m_{\chi_1^\pm} \approx 110\,\mathrm{GeV} \qquad m_{\chi_2^0} \approx 130\,\mathrm{GeV} \qquad \sigma_{NLO} \sim 4.3\,\mathrm{pb}$$

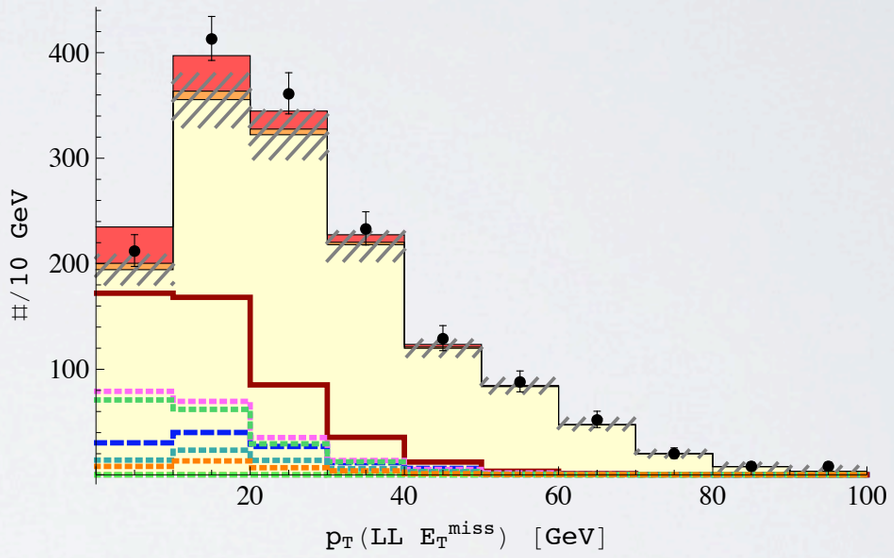
$$m_{\chi_1^0} \approx 113\,\mathrm{GeV}$$

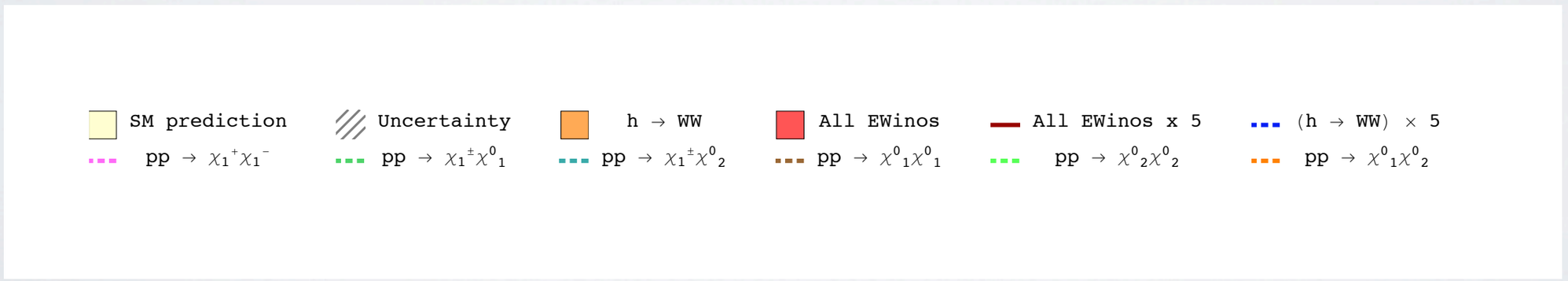
ATLAS 7





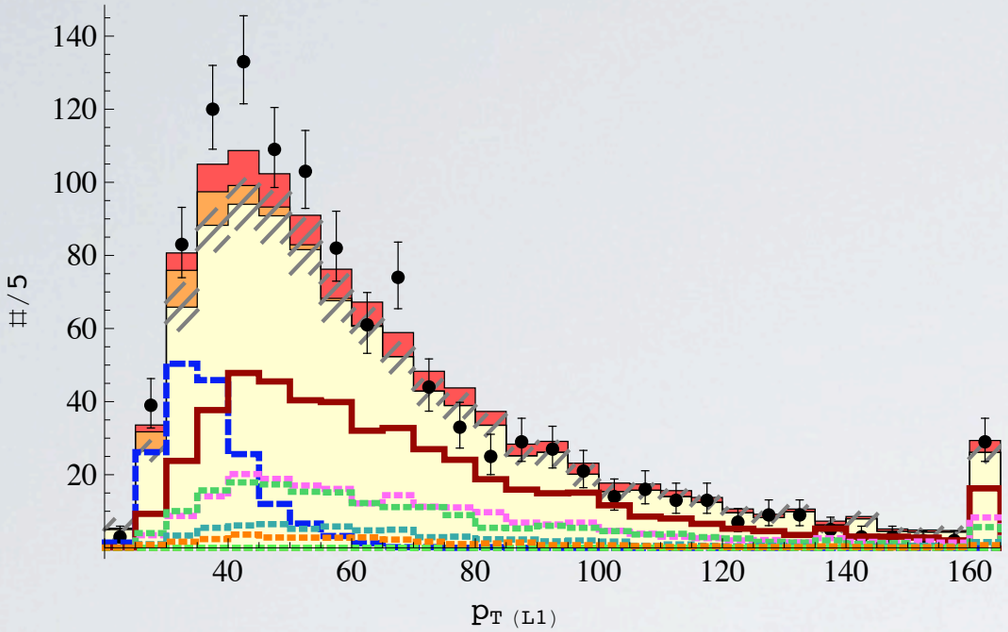


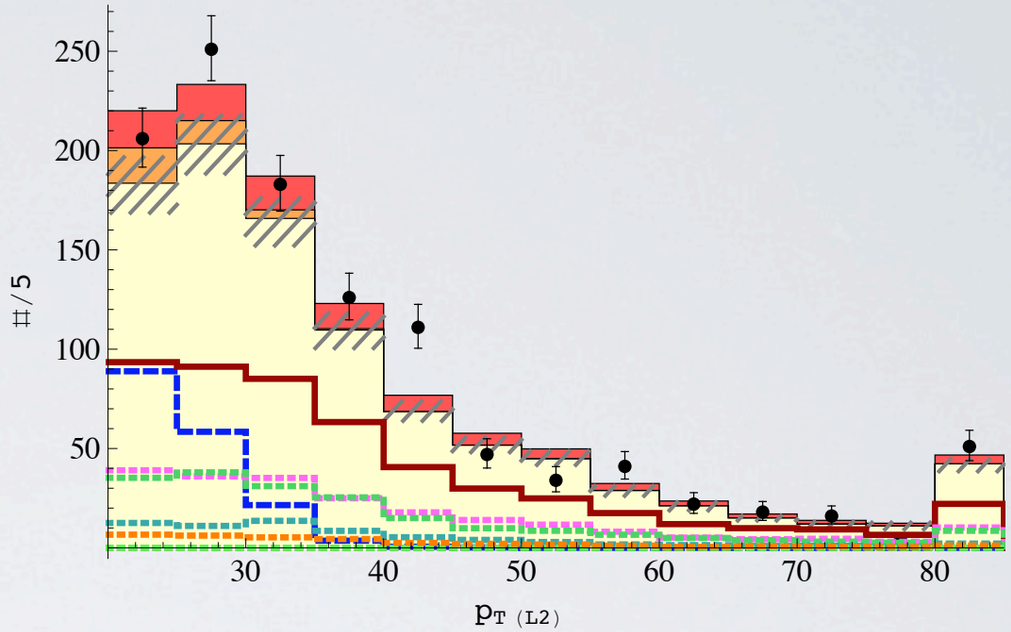


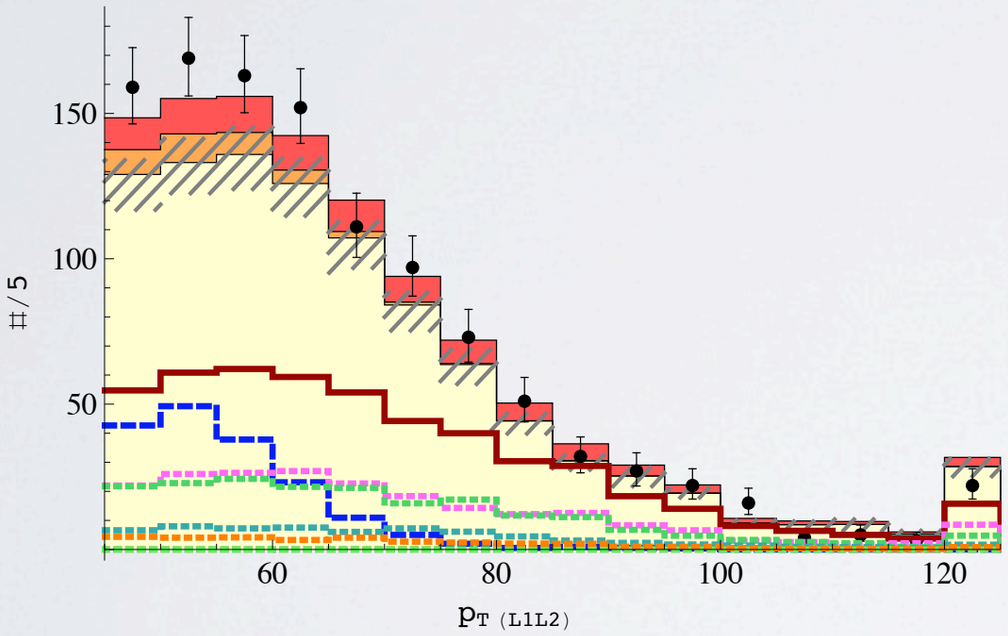


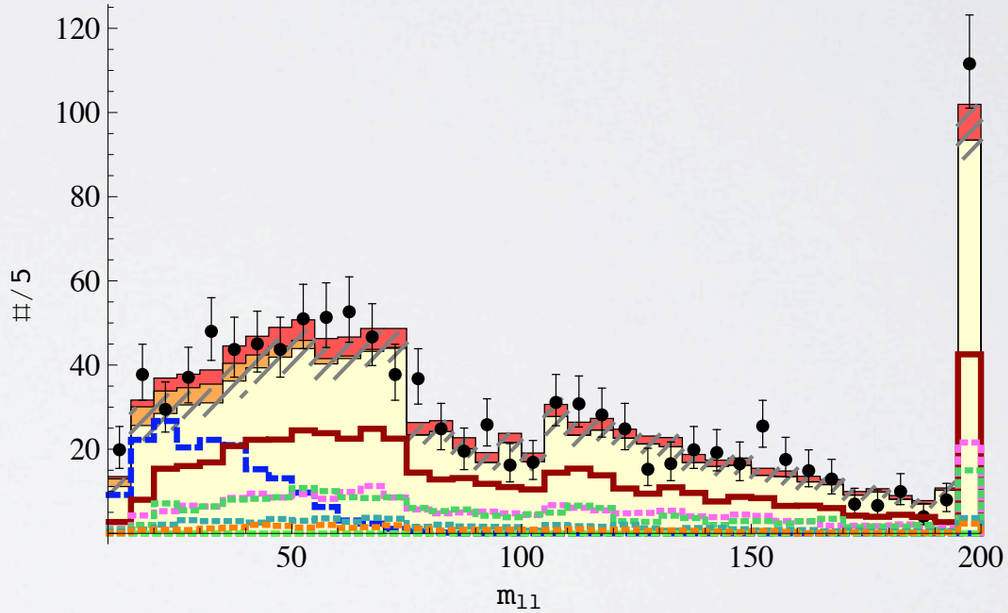
χ^2 cut in **half** compared to SM

CMS 8









SM p-value .001

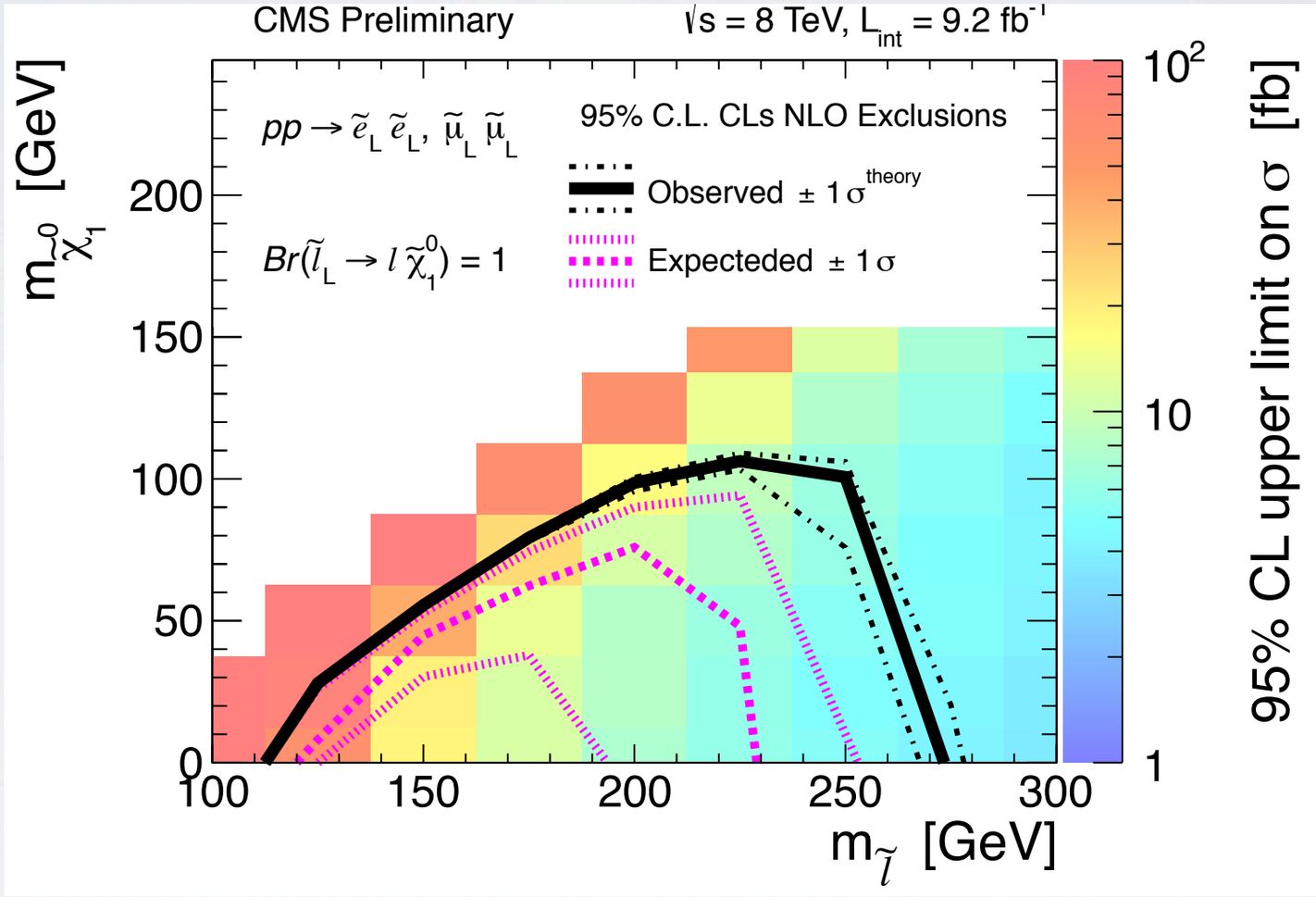
SM+charginos .3

SM+h .1

SM+h+charginos .75

CONSTRAINTS ON THIS SCENARIO

- SS dileptons
- OS dileptons



HCP says watch out for SS dileptons*

ATLAS LOOKED FOR THIS IN PARTICULAR...

Information | Discussion (0) | Files | Plots | Linkbacks

ATLAS Note

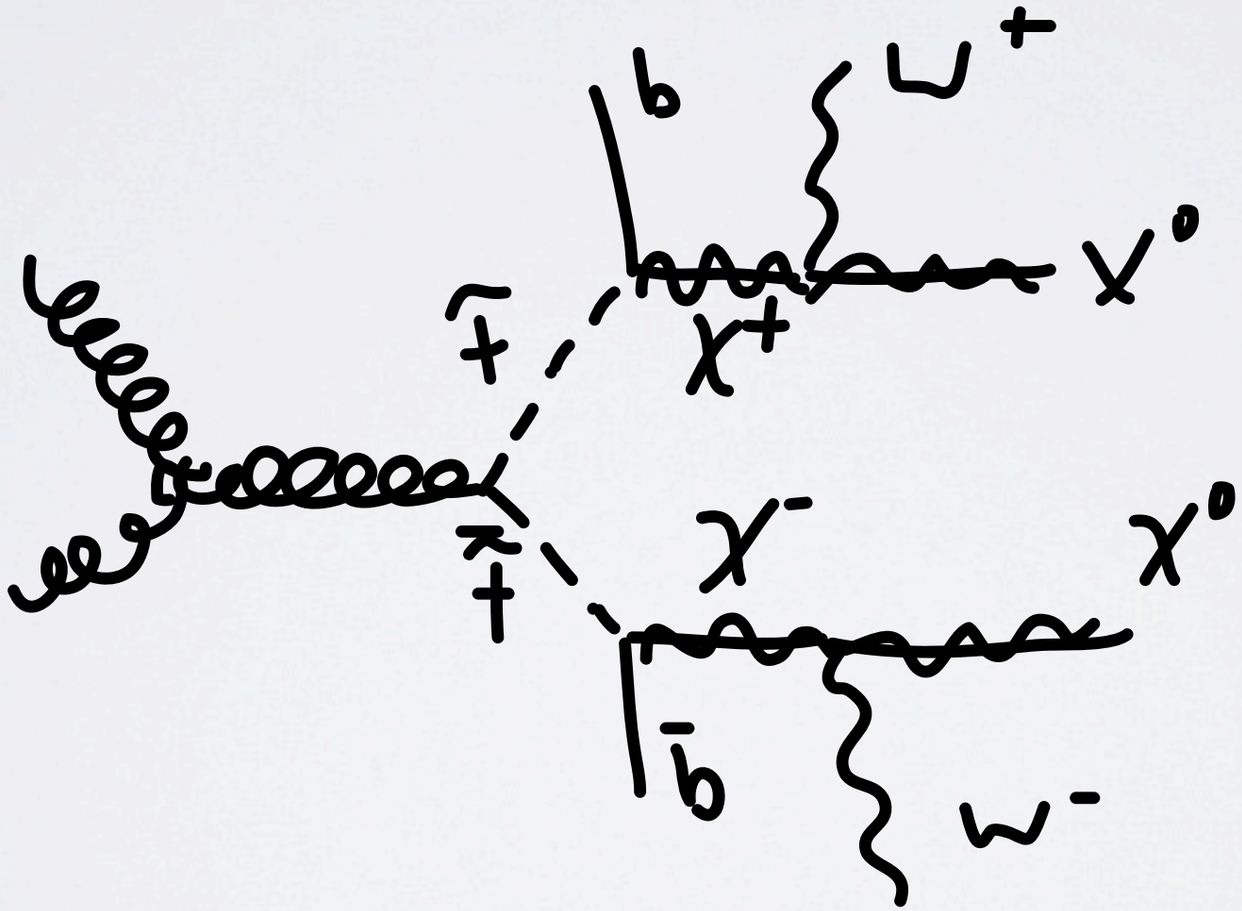
Report number	ATLAS-CONF-2013-049
Title	**Search for direct-slepton and direct-chargino production in final states with two opposite-sign leptons, missing transverse momentum and no jets in 20/fb of pp collisions at sqrt(s) = 8 TeV with the ATLAS detector**
Corporate Author(s)	The ATLAS collaboration
Imprint	16 May 2013. - mult. p.
Subject category	Detectors and Experimental Techniques
Accelerator/Facility, Experiment	CERN LHC ; ATLAS
Free keywords	SUSY ; EW ; dilepton with missing transverse energy
Abstract	Searches for the electroweak production of pairs of sleptons or charginos decaying into final states with two leptons, missing transverse momentum and no reconstructed jets are performed using 20.3 fb-1 of proton-proton collision data at sqrt(s) = 8 TeV recorded with the ATLAS experiment at the Large Hadron Collider. No significant excesses are observed with respect to the prediction from Standard Model processes. Limits are set on the masses of the slepton and of the lightest chargino for different lightest-neutralino mass hypotheses. In scenarios where sleptons decay directly into the lightest neutralino and a charged lepton, common values for left and right-handed slepton masses between 90 GeV and 320 GeV are excluded at 95% confidence level for a massless neutralino. In the scenario of chargino pair production, with wino-like charginos decaying into the lightest neutralino via an intermediate slepton, chargino masses between 130 GeV and 450 GeV are excluded at 95% confidence level for a 20 GeV neutralino. In the scenario of chargino pair production followed by the C1 -> WN1 decay, the excluded cross-section is above the model cross-section by a factor 1.9-2.8 in the C1 mass range of 100-190 GeV and then degrades gradually to 4.7 when reaching a C1 mass of 250 GeV.

OTHER EFFECTS FROM CHARGINOS

- Will not affect $h \to W^+W^-$ **sensitivity** (most models that do this are dead at 9-10 sigma)
    - Shows up in **control** regions
- Amusingly increases $h \to \gamma\gamma$ about 15%
- Same sign dileptons by end of 8 TeV should confirm/rule out
- Other transverse variables that can separate NP/SM WW/QCD

CHARGINOS FROM STRONG PRODUCTION?

$$\tilde{t}_1 \to \tilde{\chi}_1^{\pm}\, b \to \tilde{\chi}_1^0\, W^{(*)}\, b \to \tilde{\chi}_1^0\, \ell\, \nu\, b$$

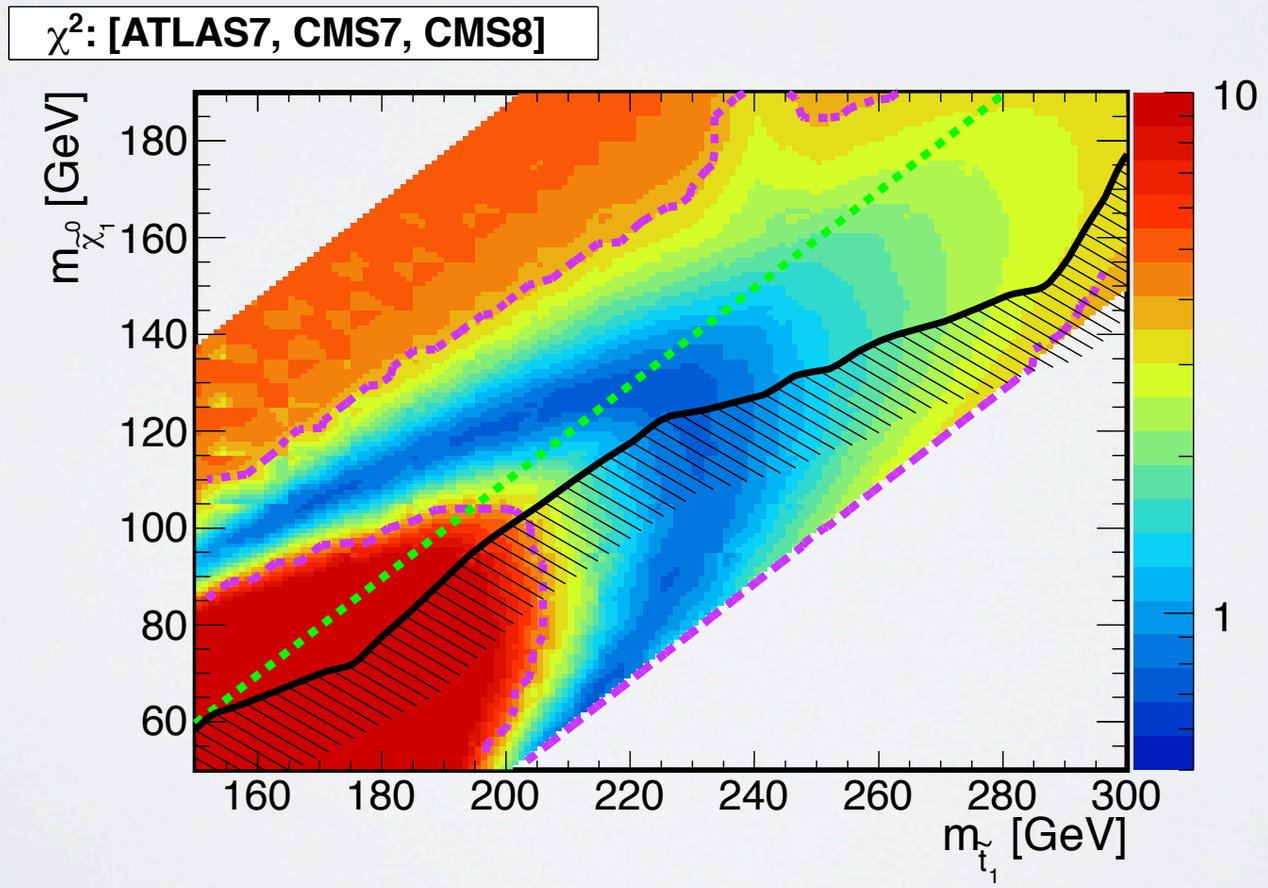


CHARGINOS FROM STRONG PRODUCTION?

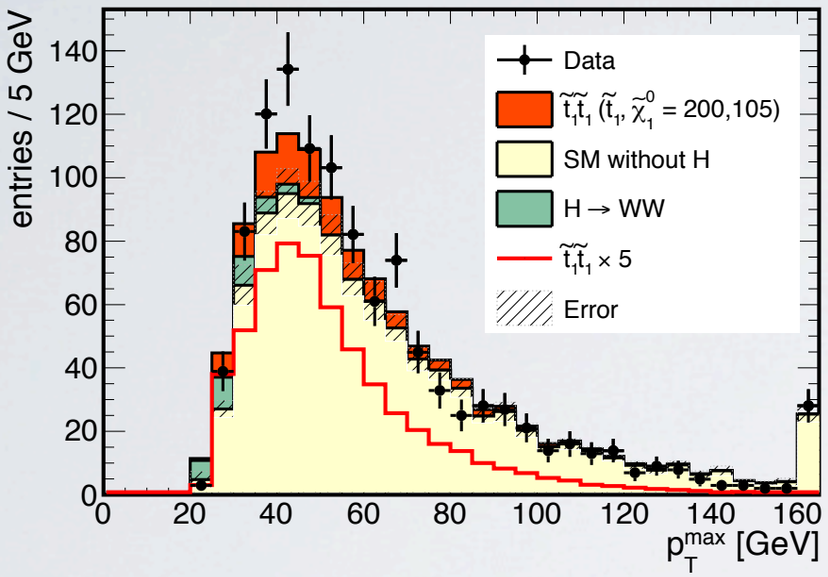
$$\tilde{t}_1 \to \tilde{\chi}_1^{\pm}\, b \to \tilde{\chi}_1^0\, W^{(*)}\, b \to \tilde{\chi}_1^0\, \ell\, \nu\, b$$

Squeeze the b's and you get WW production

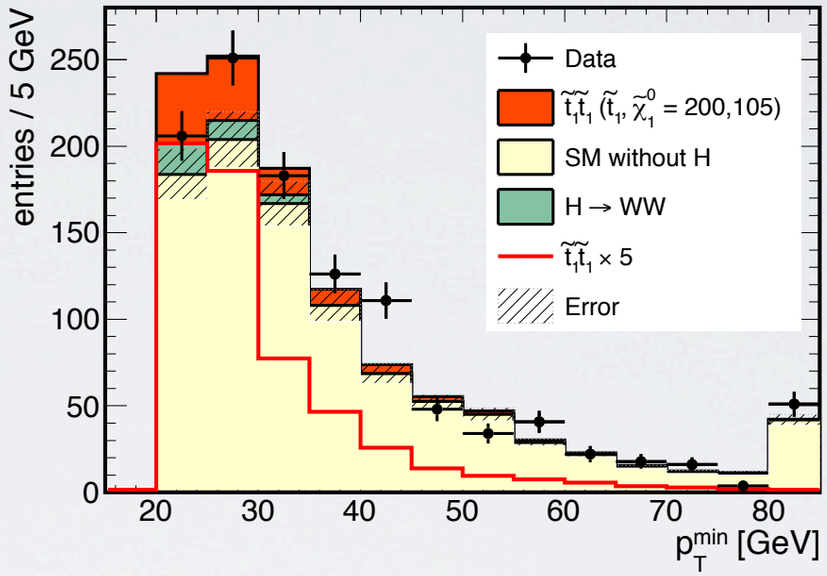
Rolbiecki and Sakurai 1303.5696



CHARGINOS FROM STRONG PRODUCTION?

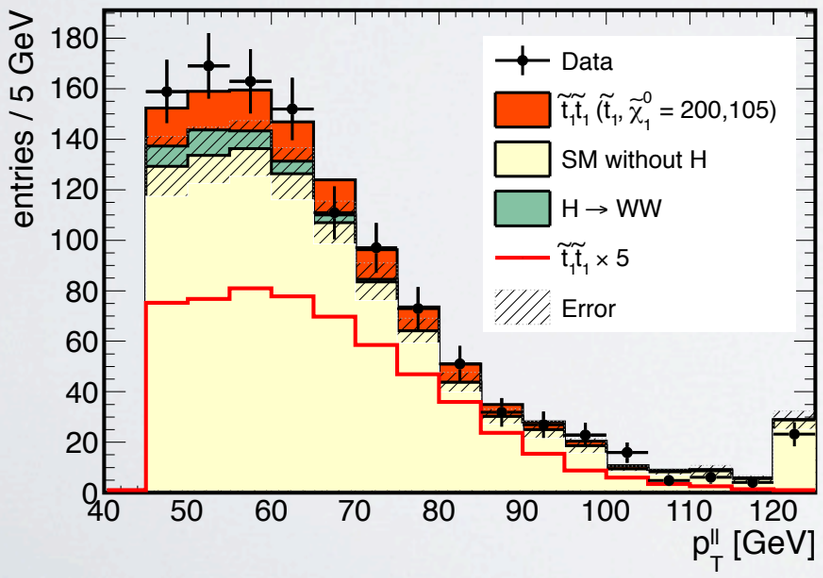


(a)

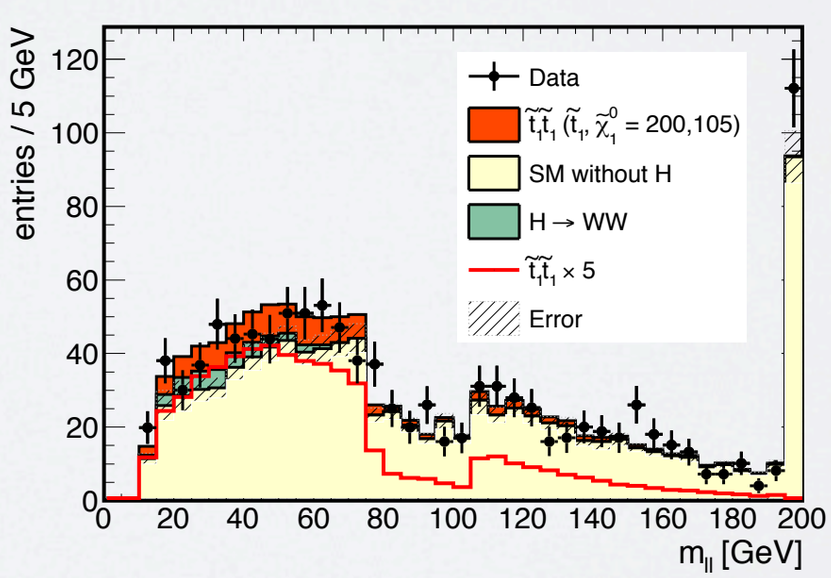


(b)

Rolbiecki and Sakurai 1303.5696

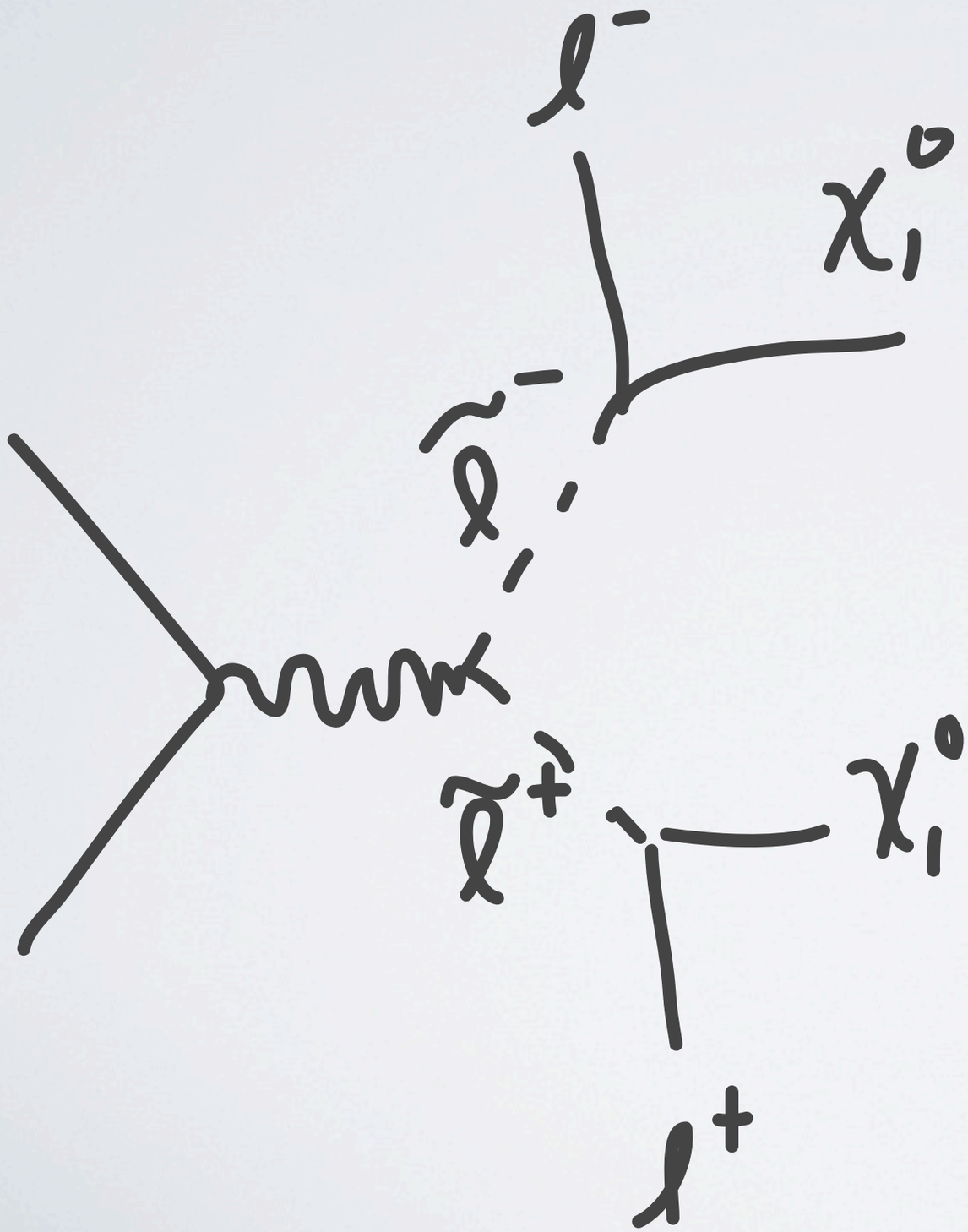


(c)

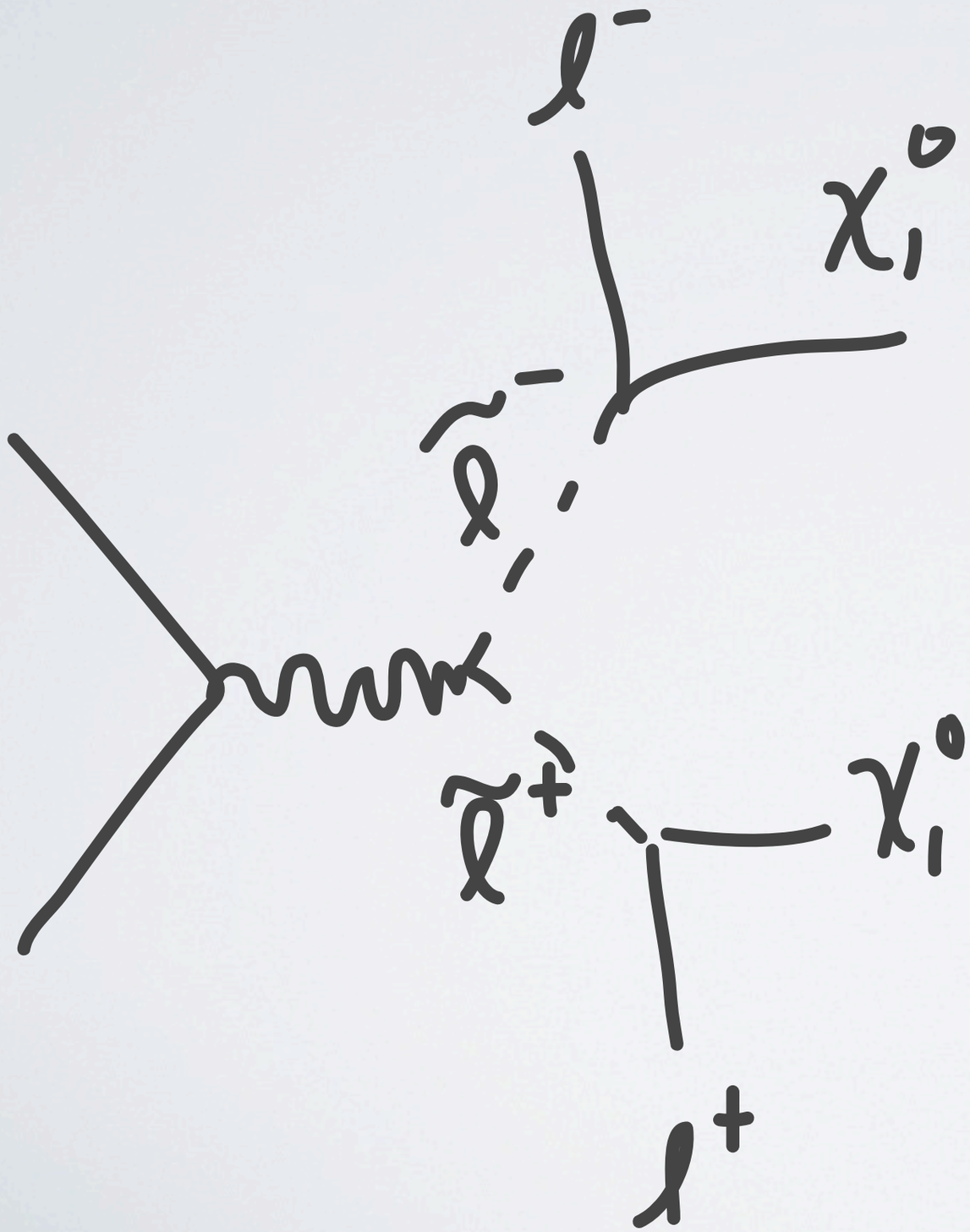


(d)

NO ONE SAID THERE HAD TO BE REAL W BOSONS!



NO ONE SAID THERE HAD TO BE REAL W BOSONS!



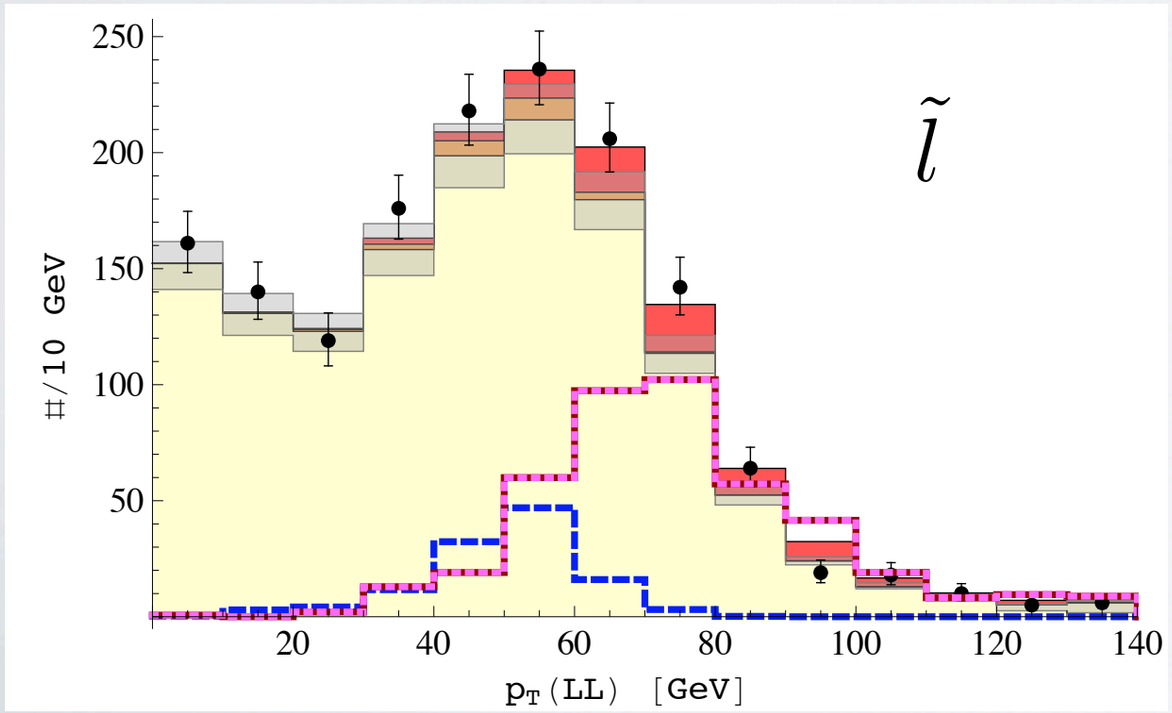
Smaller cross section

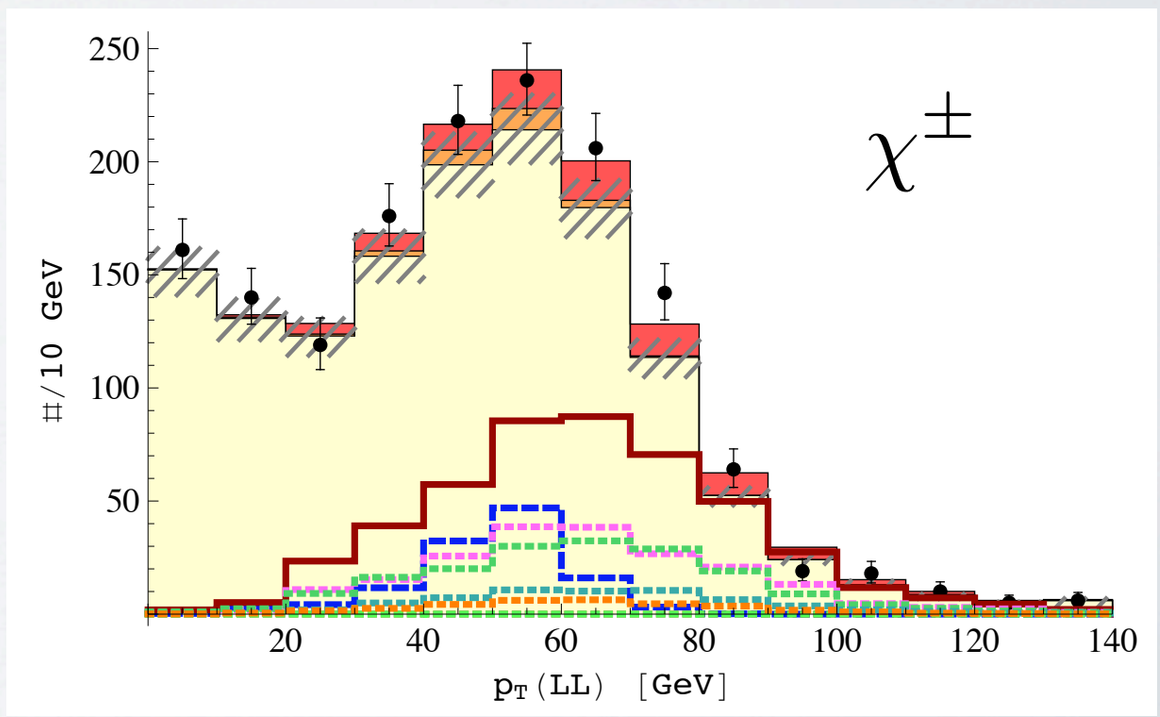
Harder MET (naively) since 2 body MET

TURNS OUT IT FITS JUST AS WELL...

$\sim 110\,\mathrm{GeV}$ ═══ $\tilde{e}, \tilde{\mu}, \tilde{\tau}_{L,R}$

$\sim 60\,\mathrm{GeV}$ ——— χ_1^0



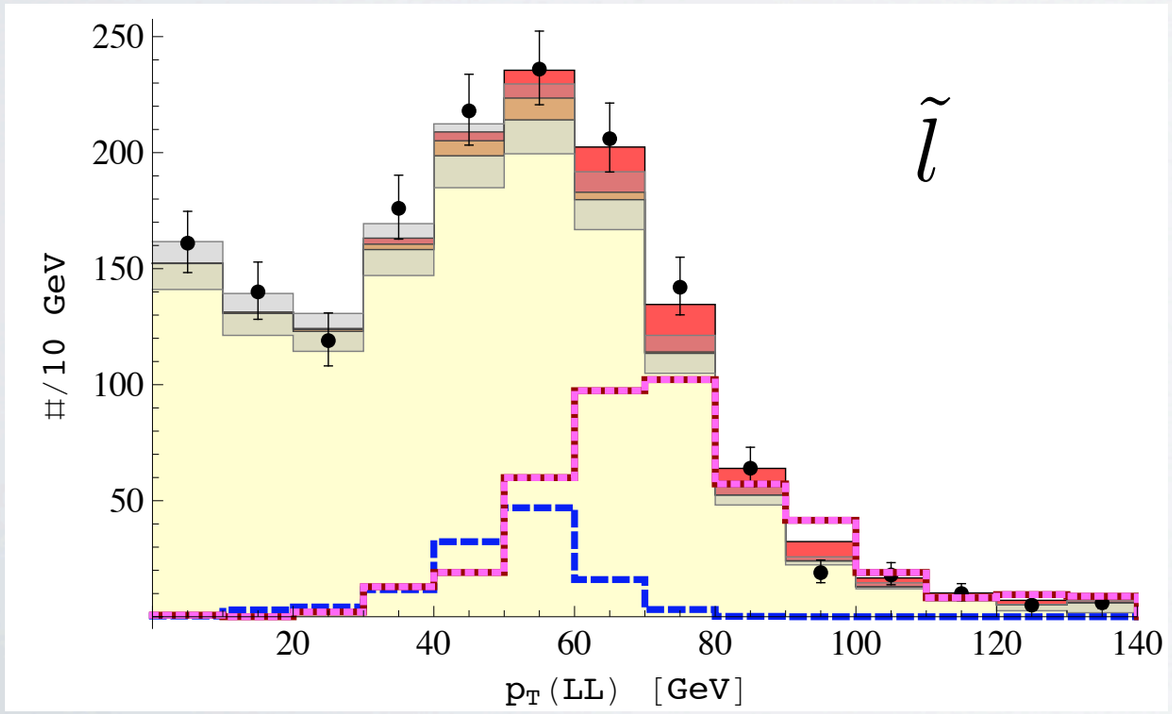


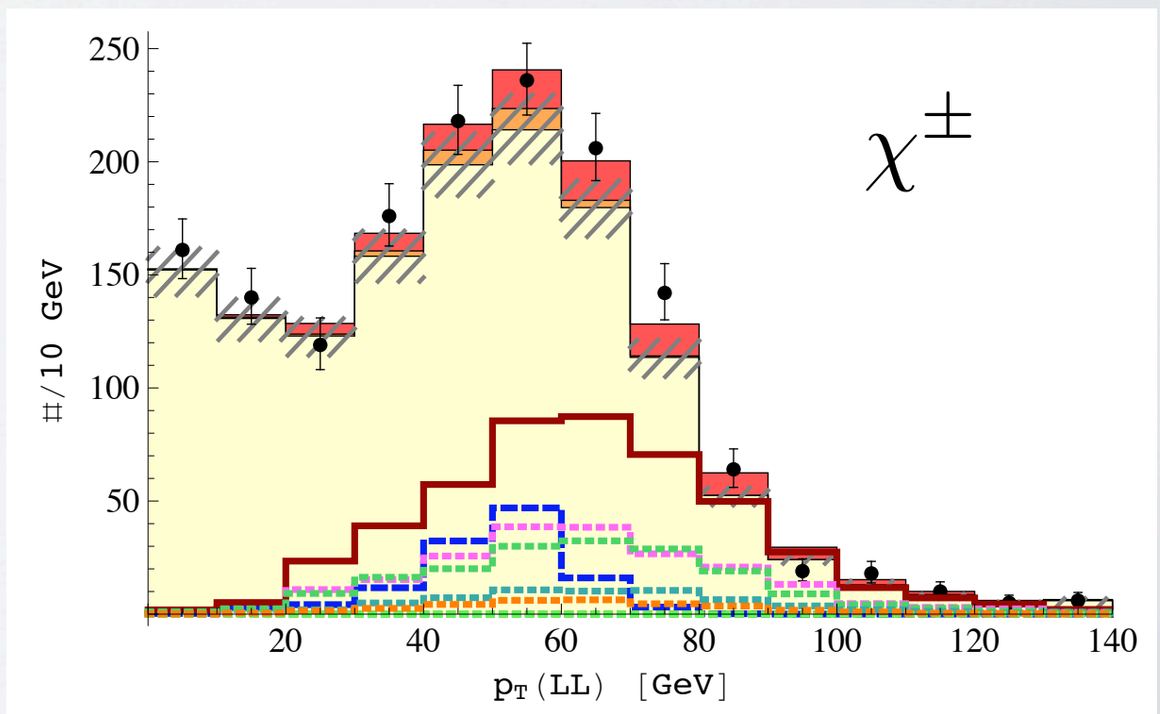
TURNS OUT IT FITS JUST AS WELL...

$\sim 110\,\mathrm{GeV}$ $\tilde{e}, \tilde{\mu}, \tilde{\tau}_{L,R}$

Can also do this just with LH sleptons

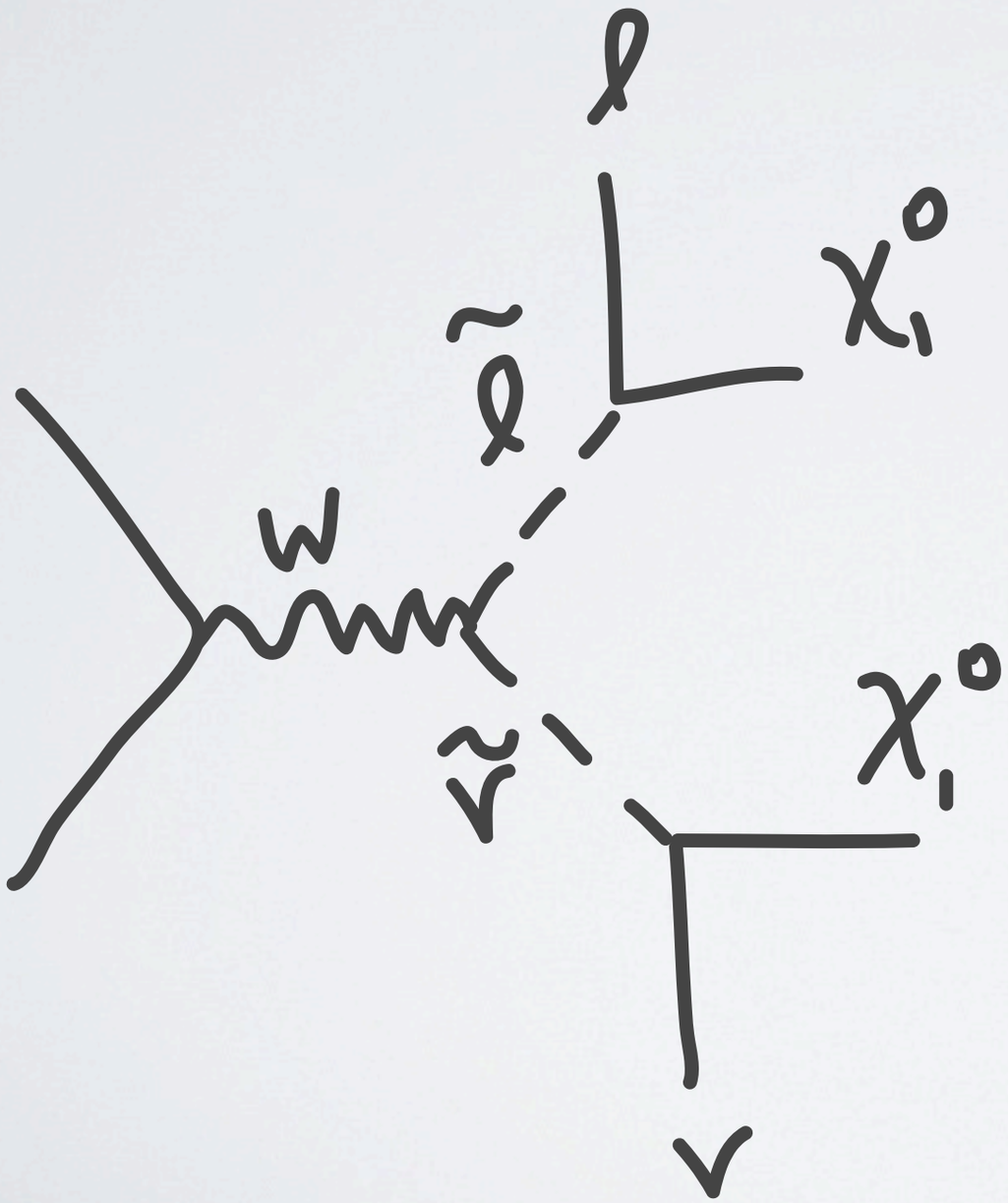
$\sim 60\,\mathrm{GeV}$ χ_1^0





ARE THERE DANGEROUS SLEPTON PROCESSES?

ARE THERE DANGEROUS SLEPTON PROCESSES?



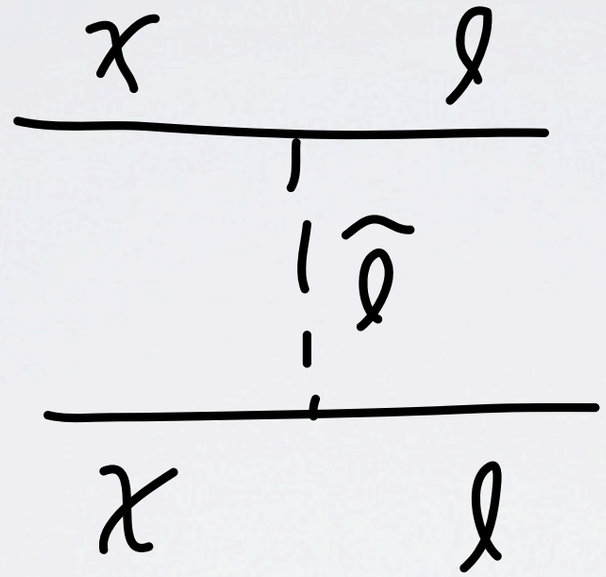
NO!

trileptons and
SS dileptons are gone!

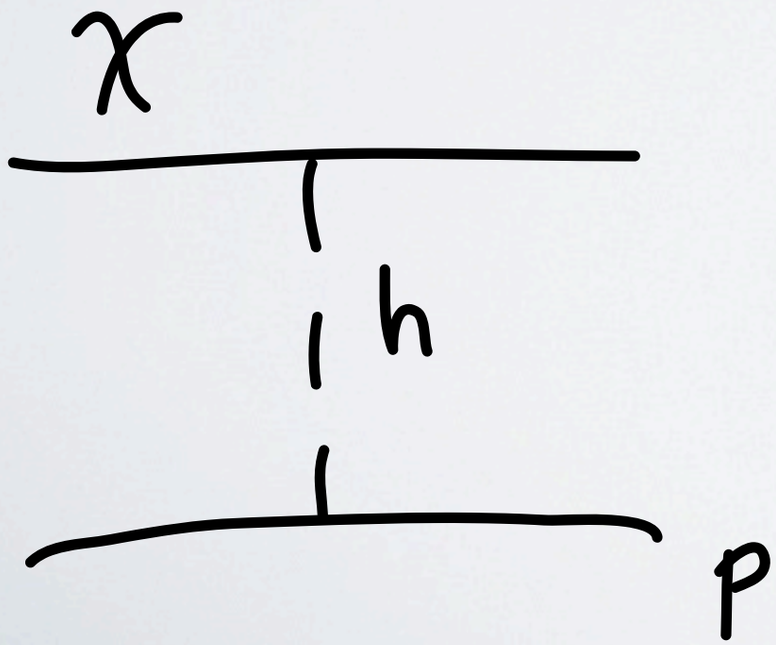
Have to look into shape variables and flavor correlations more carefully

WHAT ELSE ARE SLEPTONS GOOD FOR?

BINO DM!



Can get right relic density

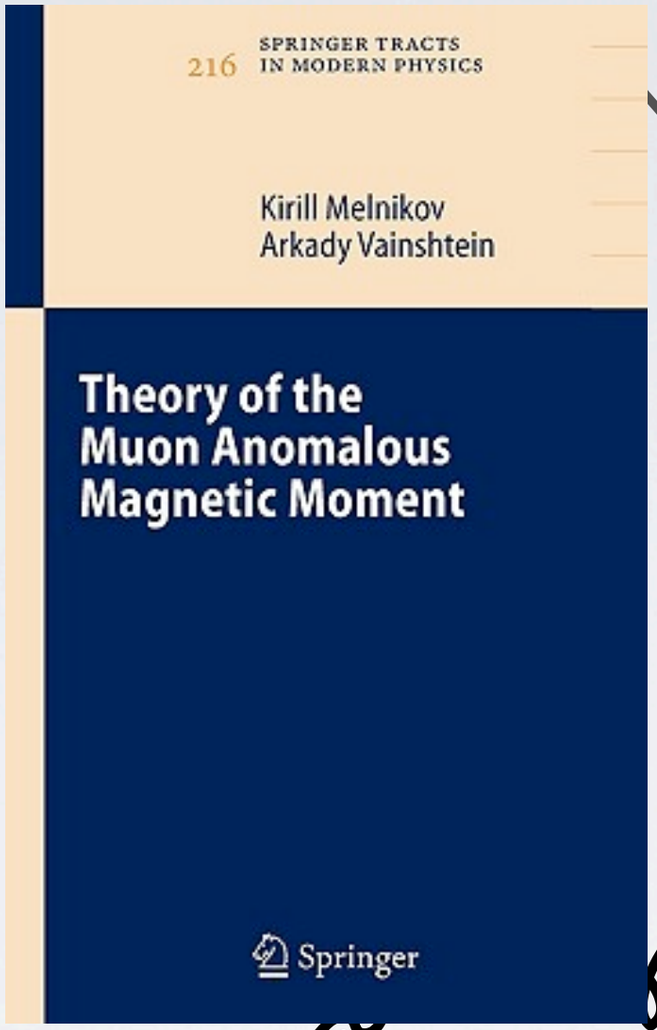


Direct Detection sails right through and is interesting for future exp!

OTHER BENEFITS OF LIGHT

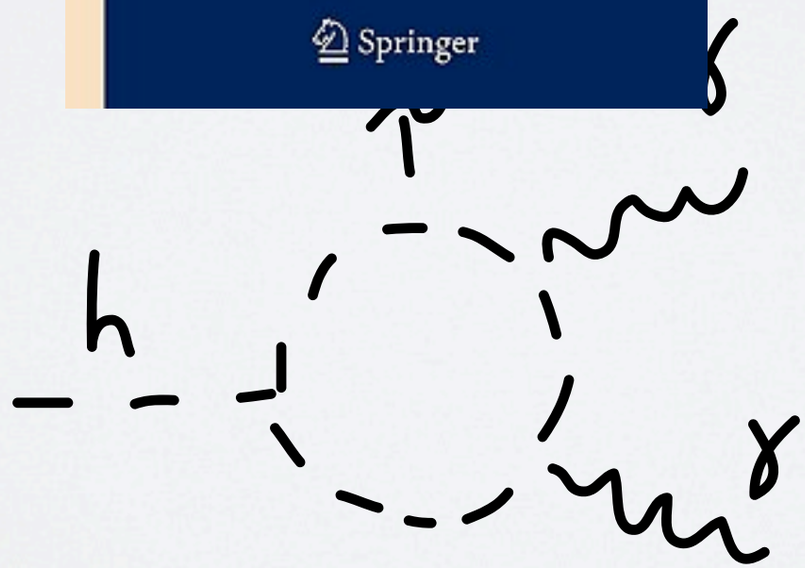
NS?

$(g-2)_\mu$



$$\delta a_\mu = a_\mu^{\rm exp} - a_\mu^{\rm SM} = (2.8 \pm 0.8) \times 10^{-9}$$

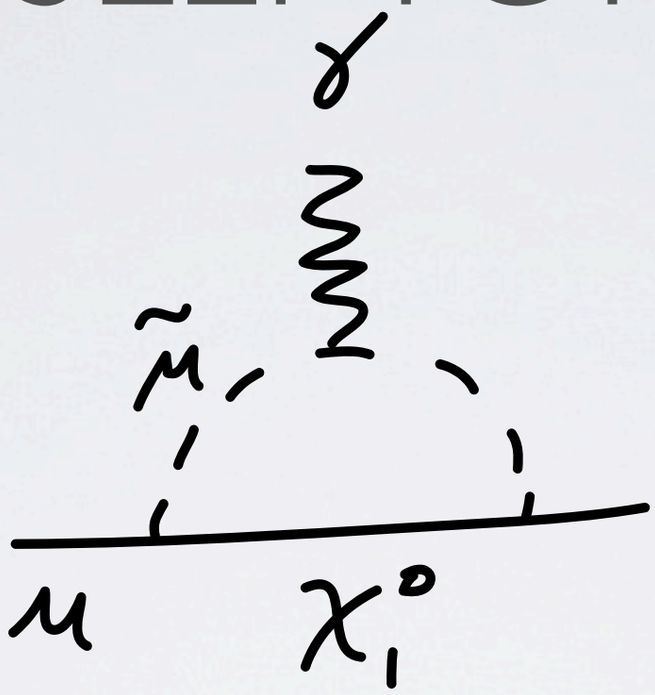
$h \to \gamma\gamma$



?

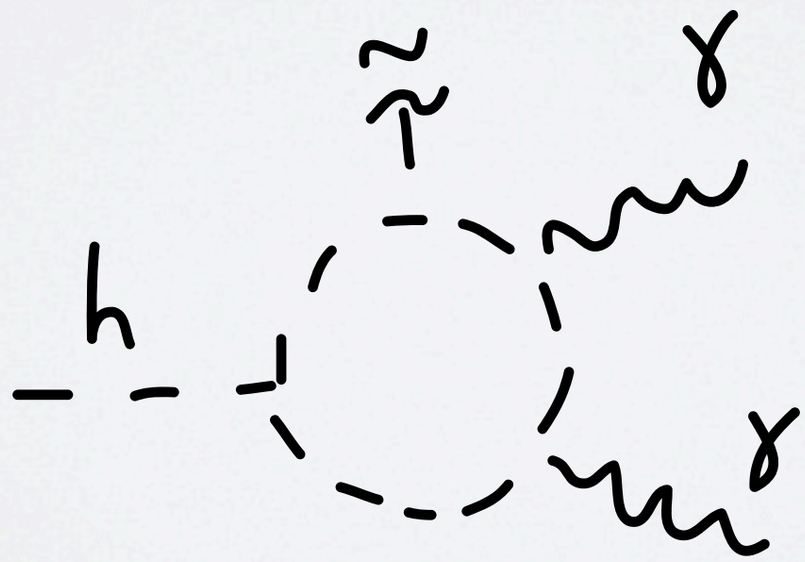
OTHER BENEFITS OF LIGHT SLEPTONS?

$(g-2)_\mu$



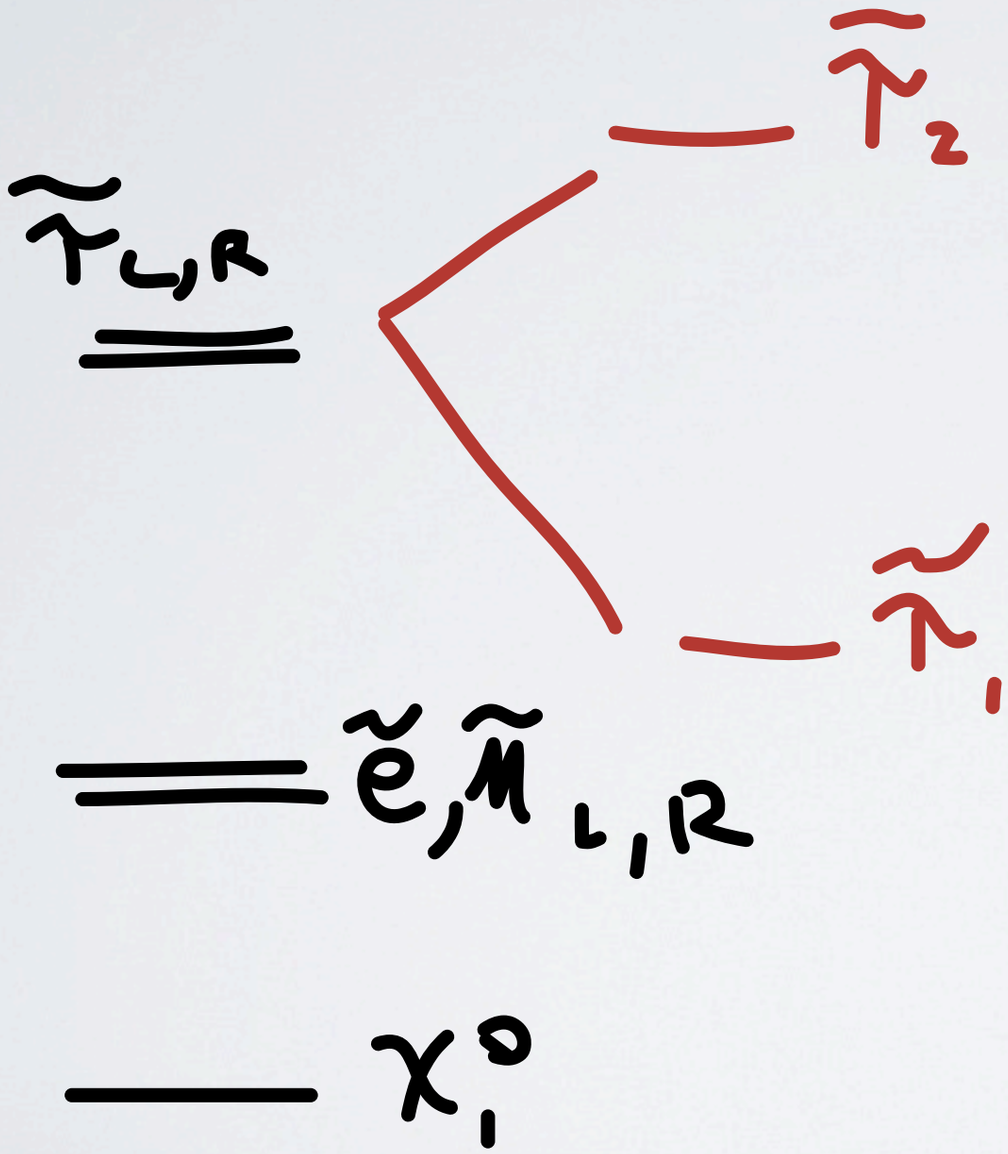
$$\delta a_\mu = a_\mu^{\rm exp} - a_\mu^{\rm SM} = (2.8 \pm 0.8) \times 10^{-9}$$

$h \to \gamma\gamma$



?

NEED SLEPTON MIXING FOR STAUS TO MAKE THE RIGHT CONTRIBUTION



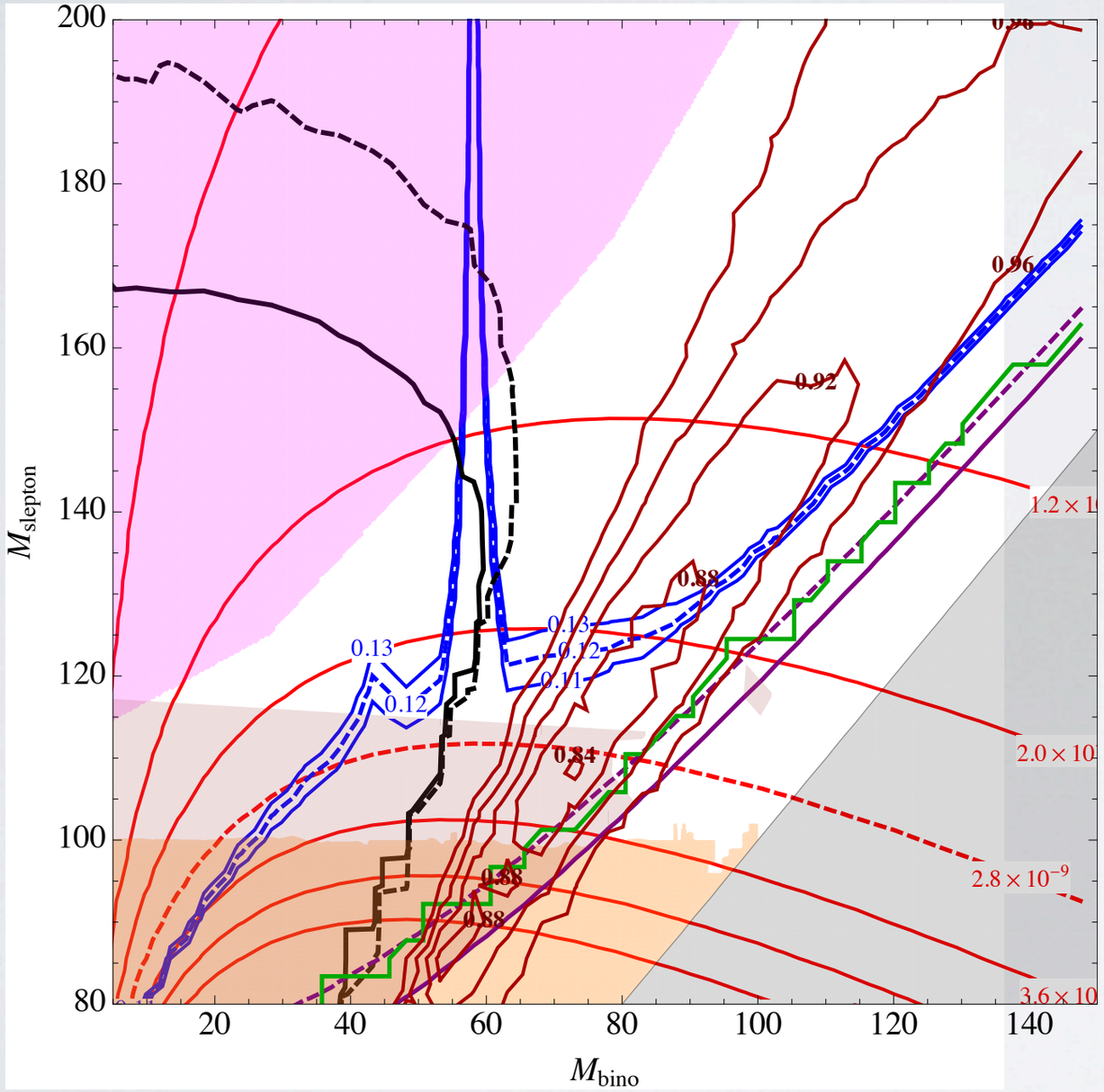
Worries:

LFV (ok)

generating spectra...

3 ANOMALIES AUTOMATICALLY ISN'T BAD...

3 ANOMALIES AUTOMATICALLY ISN'T BAD...



(b) $\tan\beta = 4, \mu = 600\,\text{GeV}$

This model ALSO changes the interpretation of the Higgs!!

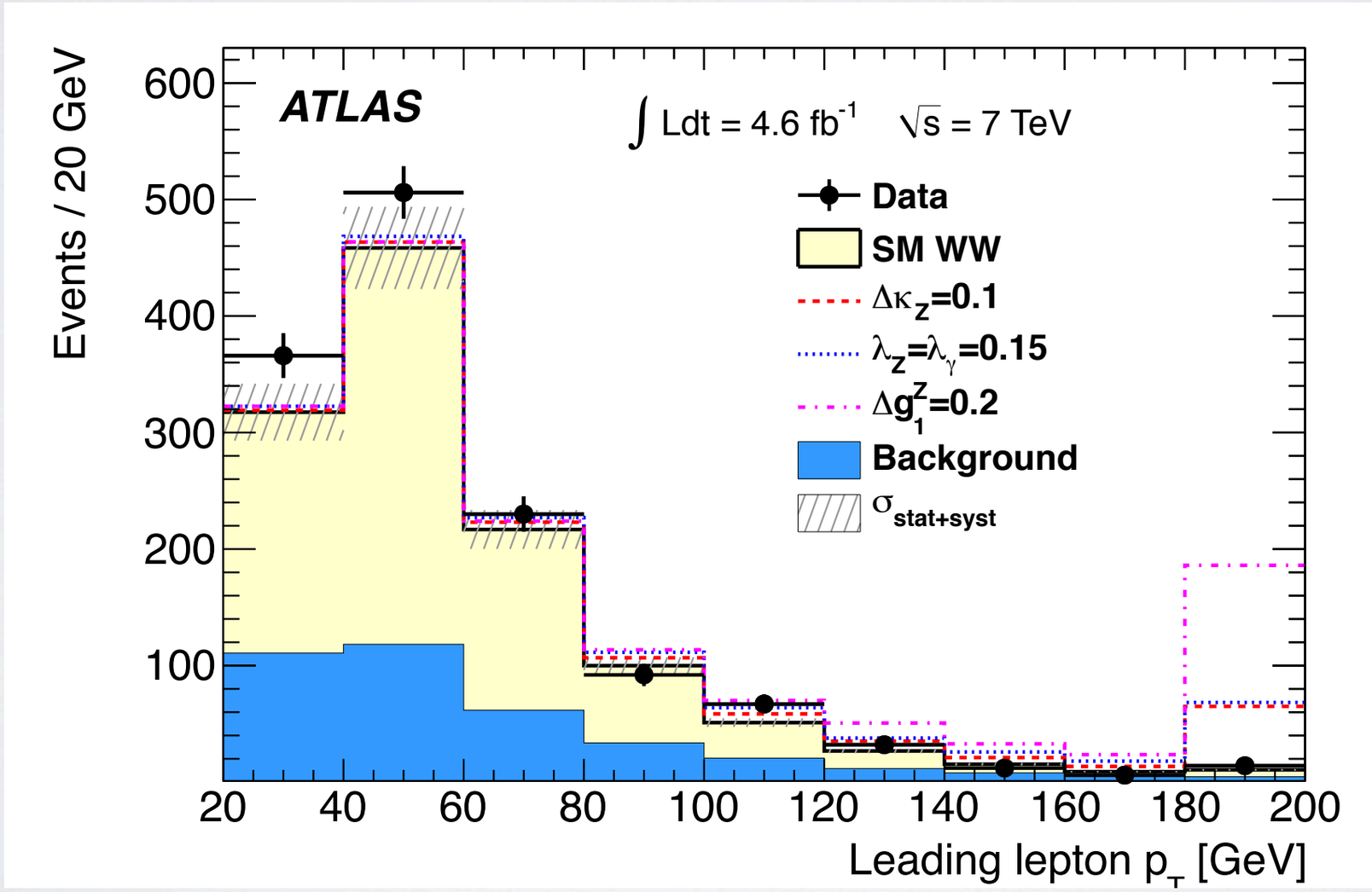
SM/EXPERIMENTAL POSSIBILITIES???

- Backgrounds Wrong - Negligible effect?
- WW cross section wrong (k-factors 1.6ish need a 20% NNLO effect)
  - higgs interferes destructively
  - EW NLO reduces as well
- Systematics

WHY DOES $\sigma(pp \to ZZ)$ AGREE?

DO YOU ONLY CARE ABOUT SM MEASUREMENTS FOR ANOMALIES???

DO YOU ONLY CARE ABOUT SM MEASUREMENTS FOR ANOMALIES???



Bounds on TGC

CAN ALSO **BOUND** NEW EW PHYSICS WITH SM MEASUREMENTS

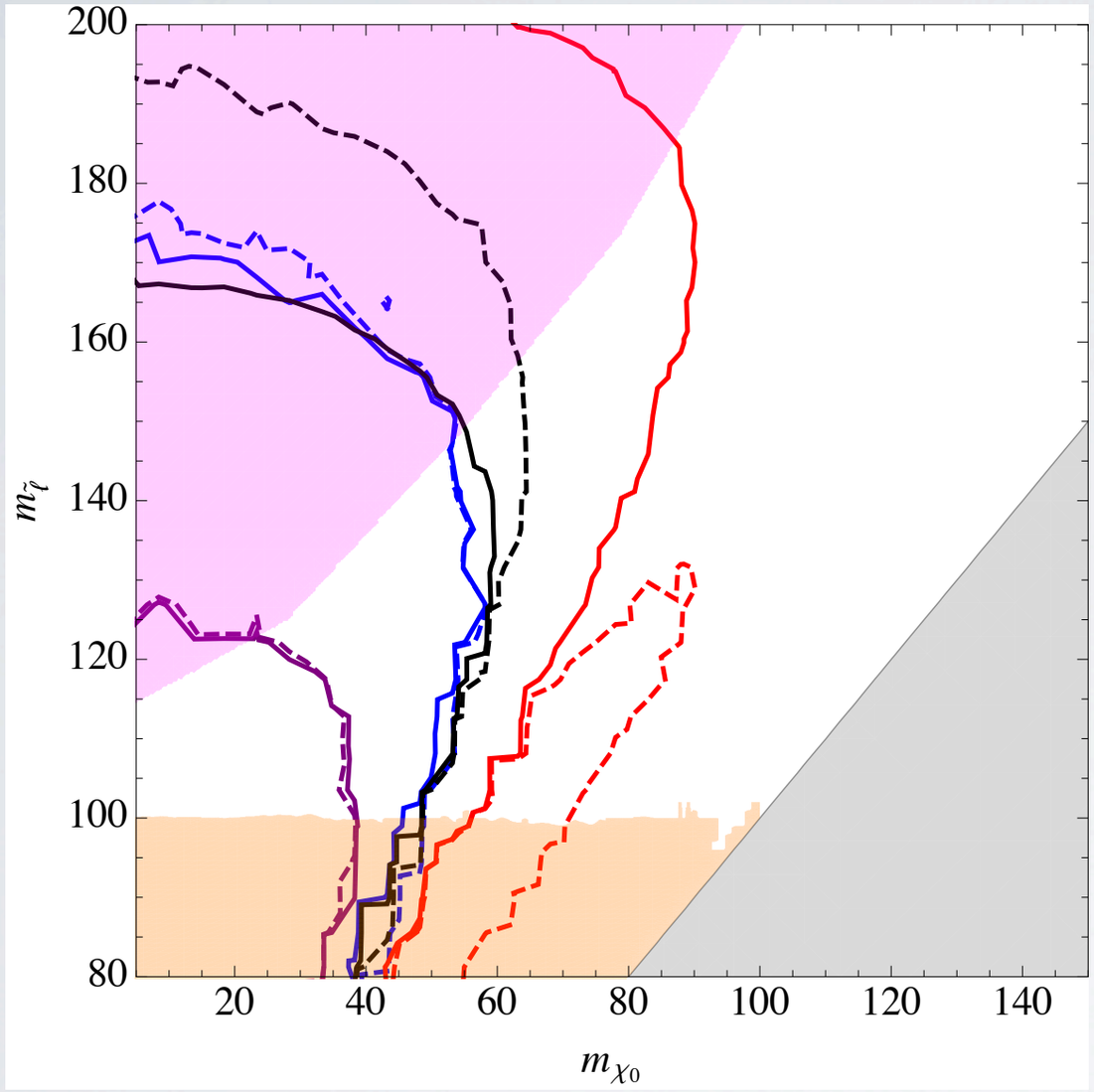
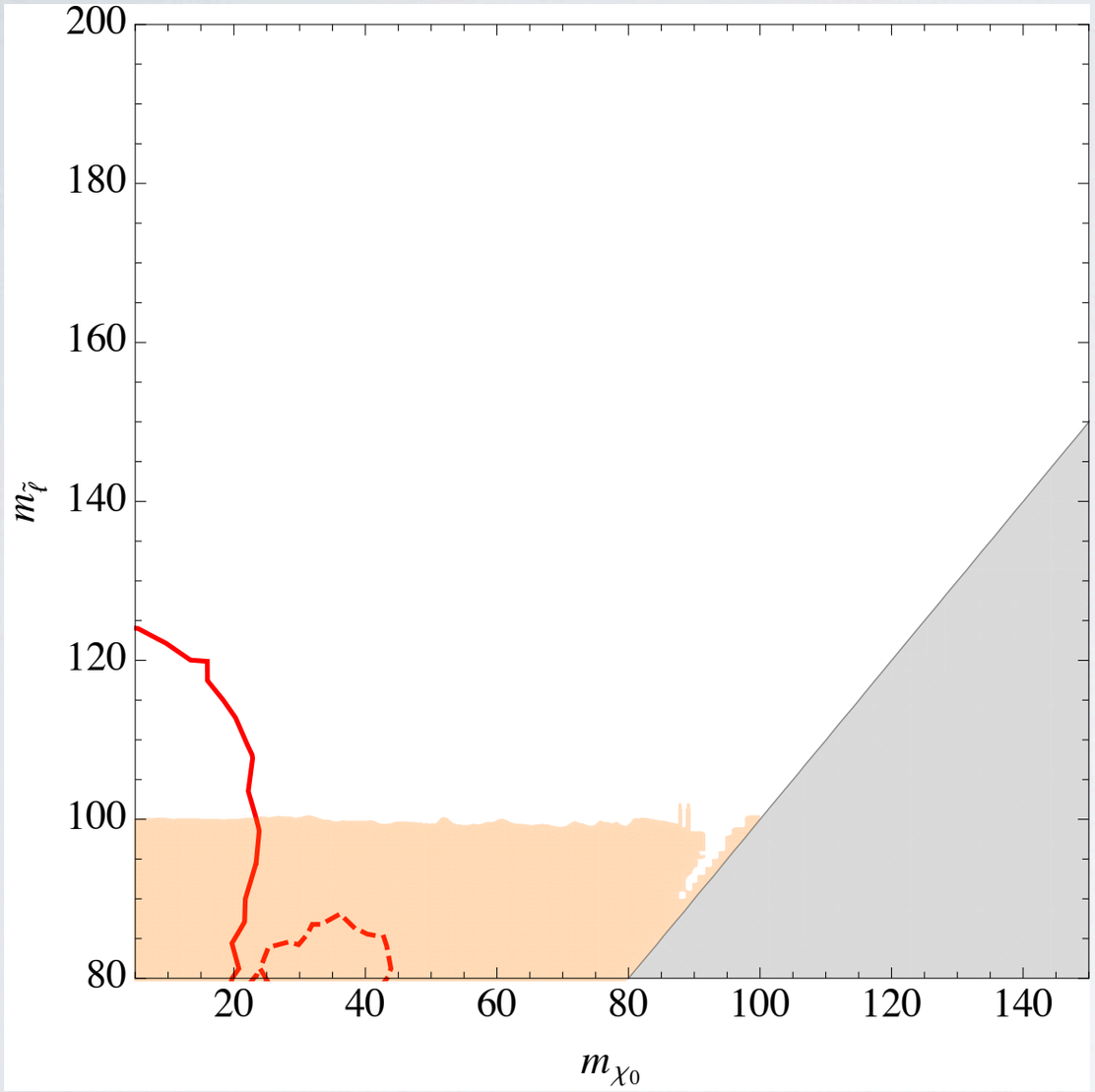


Figure 1: 95% Exclusions in the neutralino-slepton mass plane for degenerate $\tilde{e}, \tilde{\mu}$ decaying to $e/\mu + \tilde{\chi}_1^0$. Magenta regions are excluded by the CMS 9fb^{-1} LHC8 slepton search [2] (see text footnote). Orange regions are excluded by LEP [5]. The regions below the Purple (ATLAS LHC7 [9], Blue (CMS LHC7 [10]), Red (CMS LHC8 [11]) and Black (combined) lines are new exclusions we obtained from the respective W^+W^- measurements. Solid (dashed) lines represent limits obtained by (not) renormalizing the SM expectation in all kinematic distributions to match the SM + BSM normalization to data. The CMS8 W^+W^- measurement was so high that only the region *inside* the red dashed line is not 'excluded' when normalization is taken into account.

LH + RH $\tilde{e}/\tilde{\mu} \rightarrow \quad + \tilde{}^0_1$

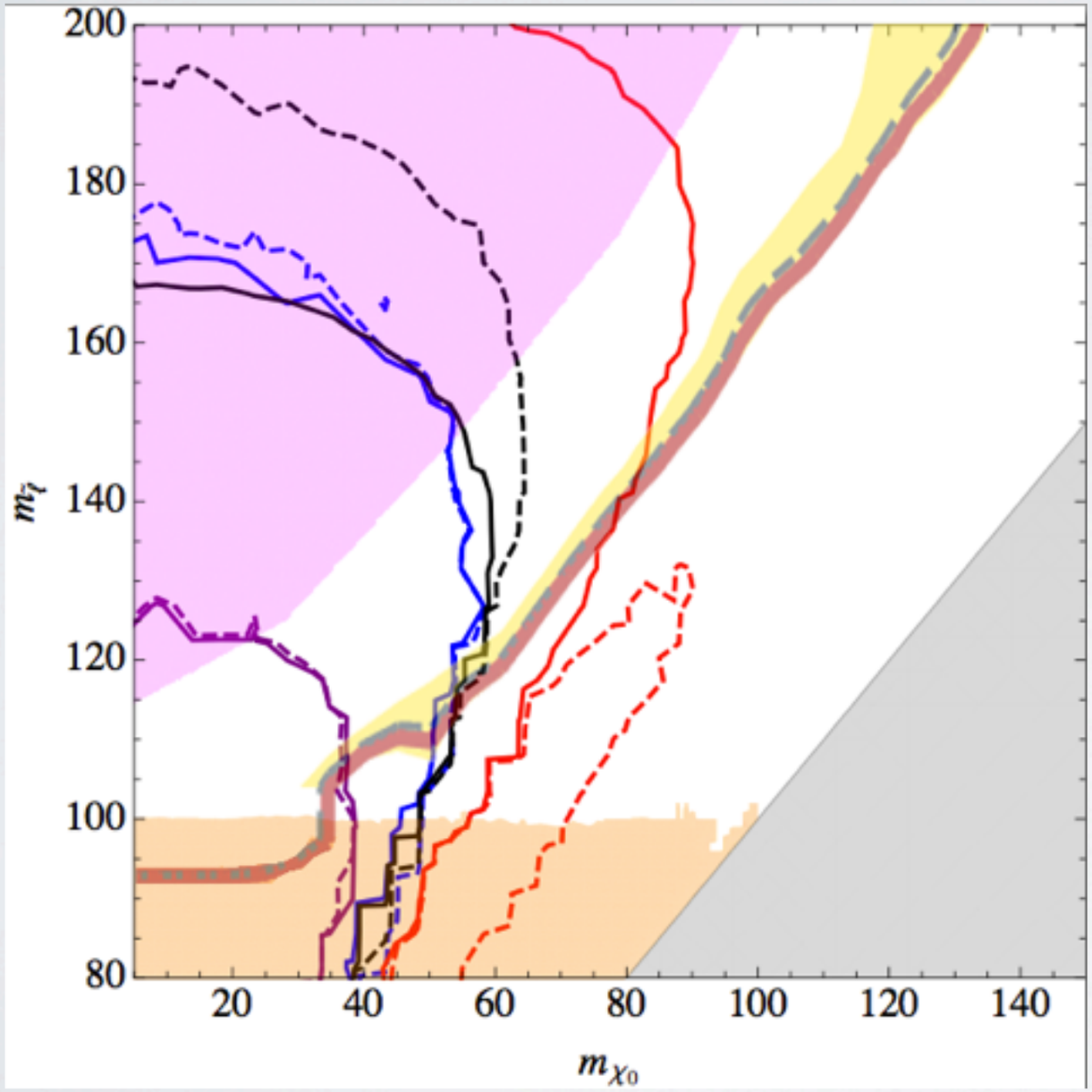
CAN ALSO **BOUND** NEW EW PHYSICS WITH SM MEASUREMENTS



RH $\tilde{e}/\tilde{\mu} \to \ell + \tilde{\chi}_1^0$

Figure 1: 95% Exclusions in the neutralino-slepton mass plane for degenerate $\tilde{e}, \tilde{\mu}$ decaying to $e/\mu + \tilde{\chi}_1^0$. Magenta regions are excluded by the CMS 9fb^{-1} LHC8 slepton search [2] (see text footnote). Orange regions are excluded by LEP [5]. The regions below the Purple (ATLAS LHC7 [9], Blue (CMS LHC7 [10]), Red (CMS LHC8 [11]) and Black (combined) lines are new exclusions we obtained from the respective W^+W^- measurements. Solid (dashed) lines represent limits obtained by (not) renormalizing the SM expectation in all kinematic distributions to match the SM + BSM normalization to data. The CMS8 W^+W^- measurement was so high that only the region *inside* the red dashed line is not 'excluded' when normalization is taken into account.

NEW ATLAS DIRECT SLEPTON SEARCH



LH+RH sleptons

Full dataset from ATLAS versus 3.5/fb CMS WW

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
    - **Chargino explanation (real W's) - Can test soon**
    - **Stops to charginos? - "natural" susy right there??**
    - **Slepton explanation (not W's!)- Can explain more phenomena and it's harder to distinguish except for flavors...**
- 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...
- Can use SM standard candles to bound new physics