BSM THEORY OVERVIEW

Patrick Meade
YITP - Stony Brook University

BSM THEORY OVERVIEW
OR
IMPLICATIONS OF THE LHC DATA FOR EXTENSIONS OF THE STANDARD MODEL

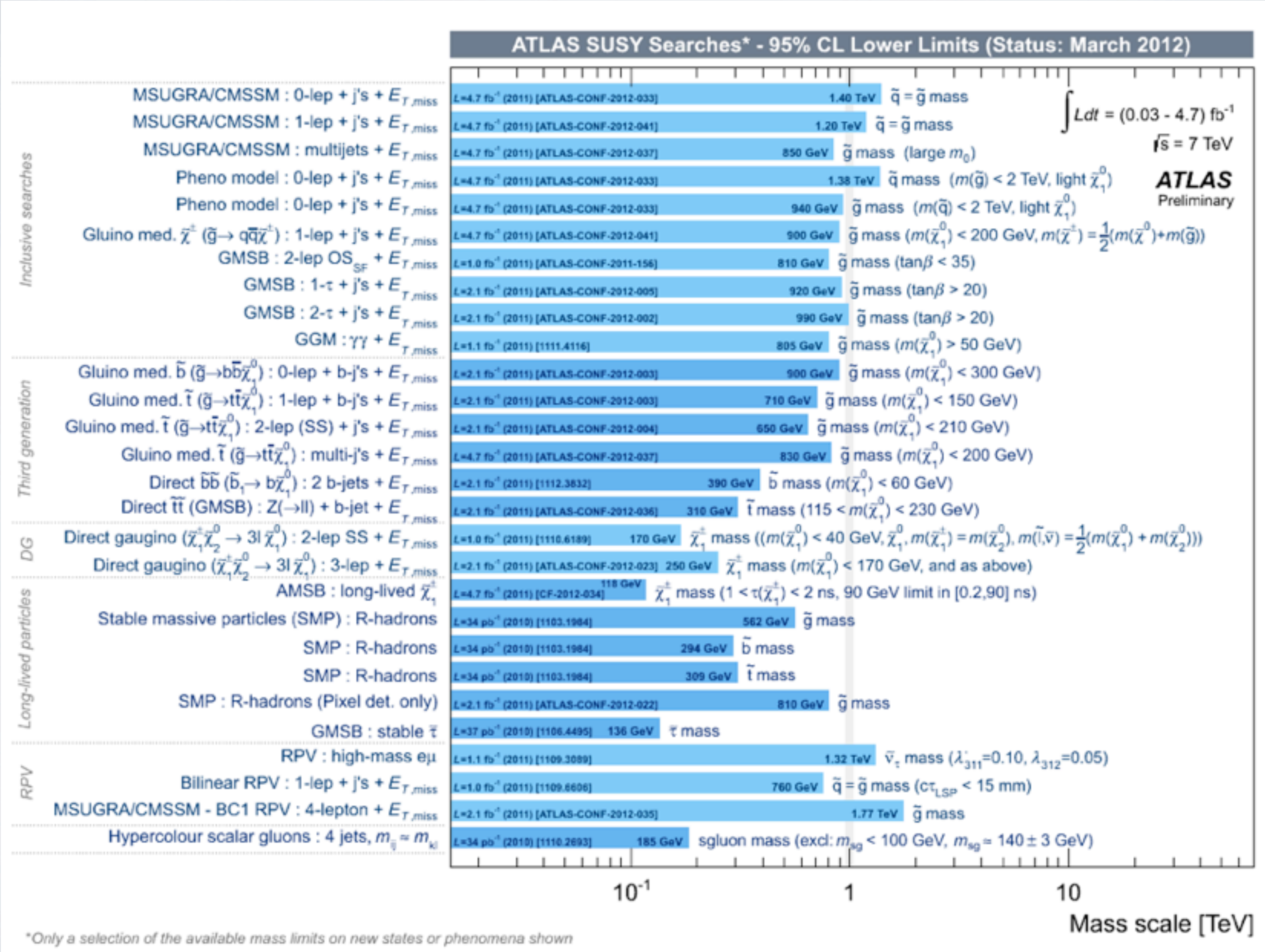
Patrick Meade
YITP - Stony Brook University

H. Murayama

OVERVIEW

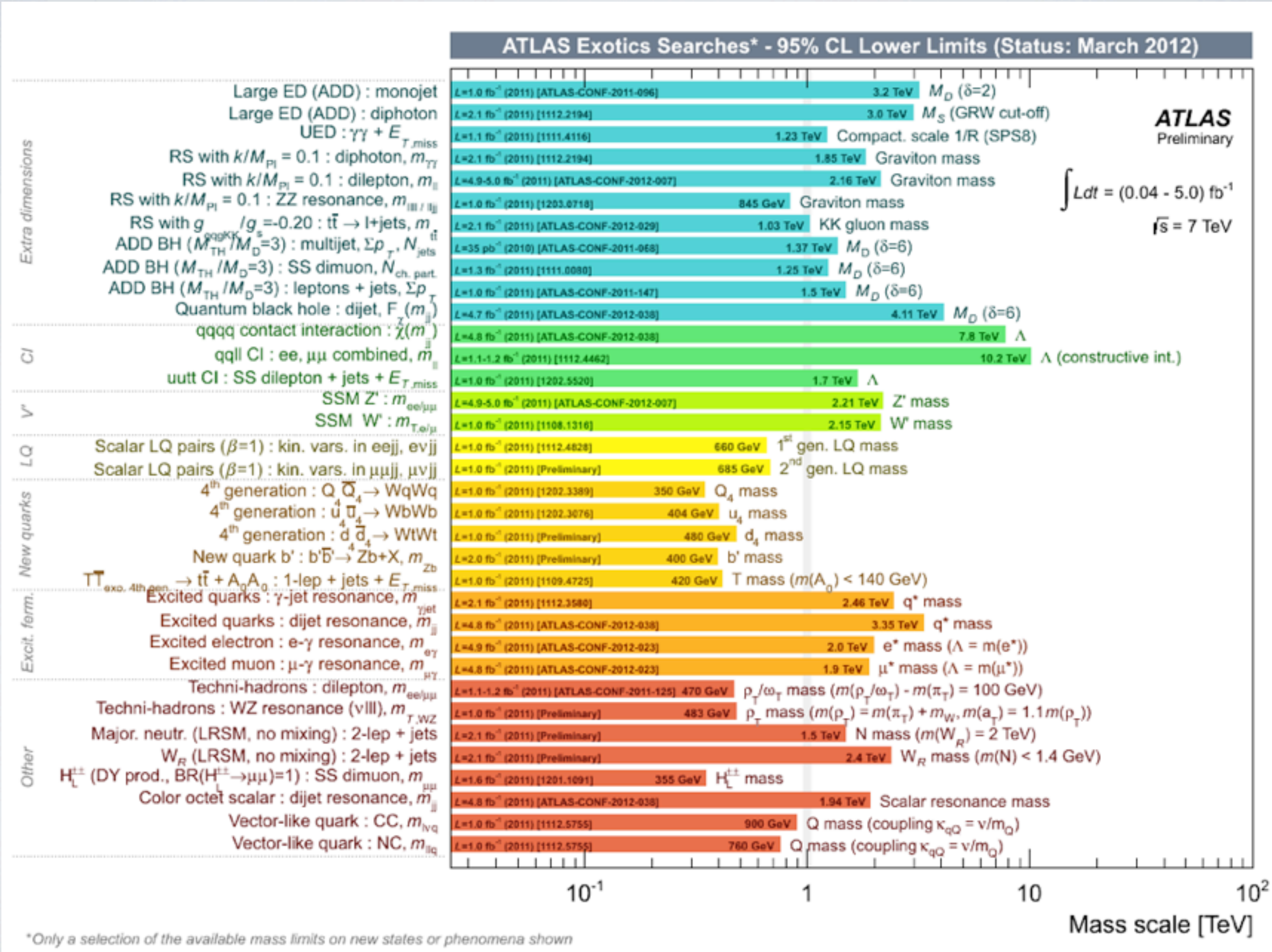
Lots of models out there...

OVERVIEW



No evidence for SUSY

OVERVIEW



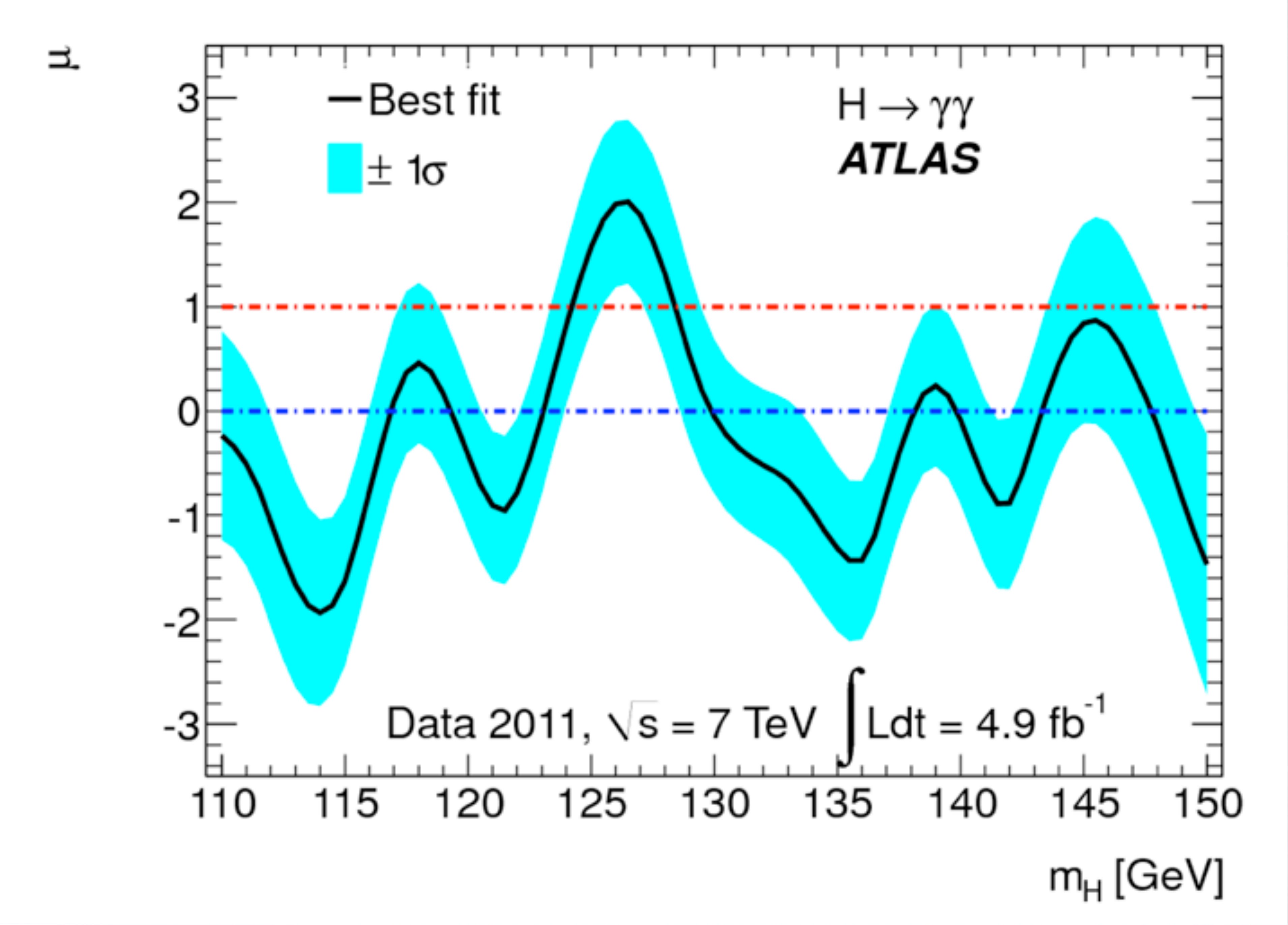
No evidence for anything else...

THE END

OR IS IT?

NOT ALL MODELS CREATED EQUALLY

AND WE FOUND SOMETHING*!



WHY HAVEN'T WE FOUND ANYTHING ELSE AND WHERE TO LOOK?

- What are we looking for so far?
  - Physics of EWSB
  - EW naturalness
  - Dark Matter
  - Odd balls

PHYSICS OF EWSB

Weakly coupled

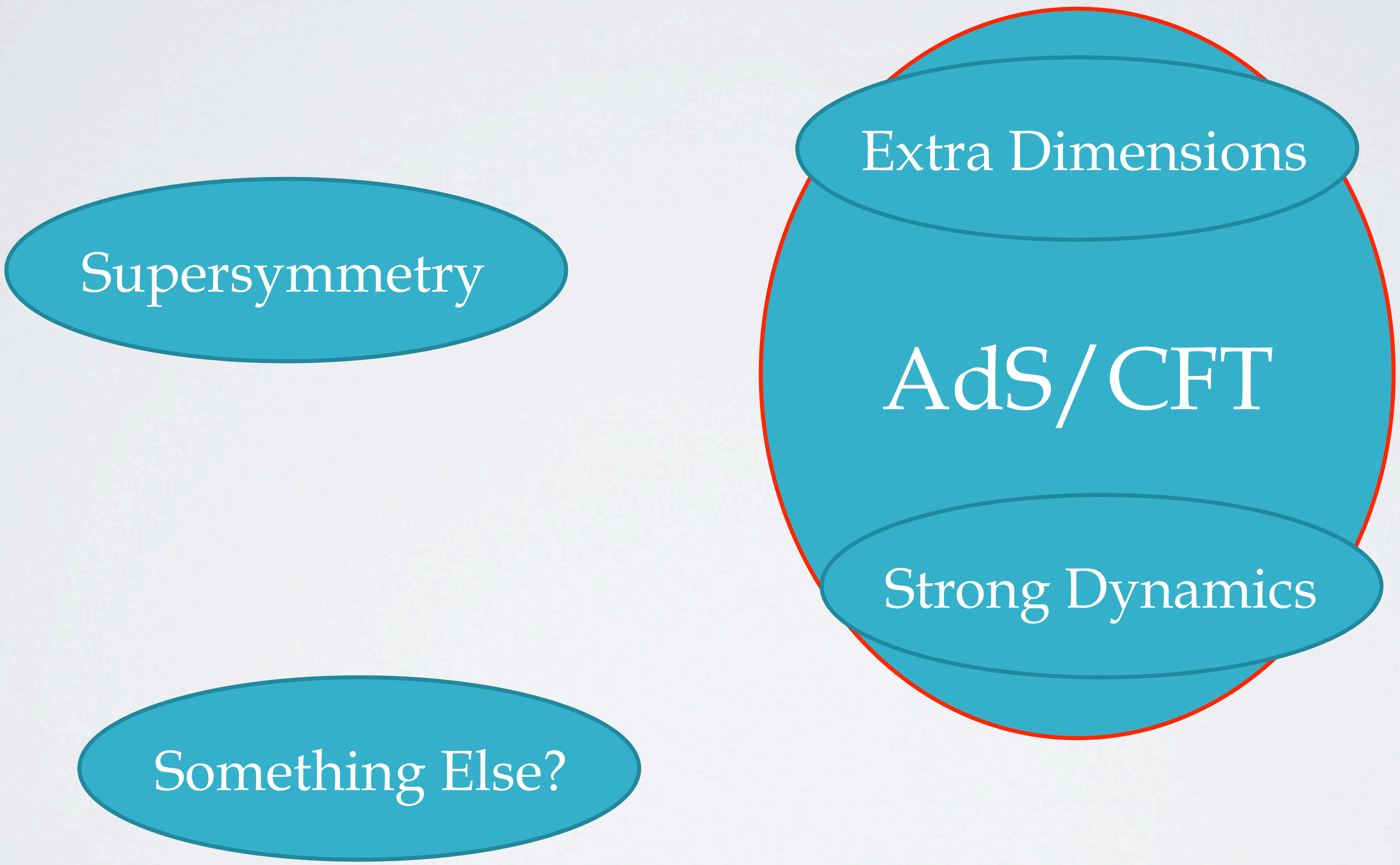
Strongly coupled

PHYSICS OF EWSB

Weakly coupled

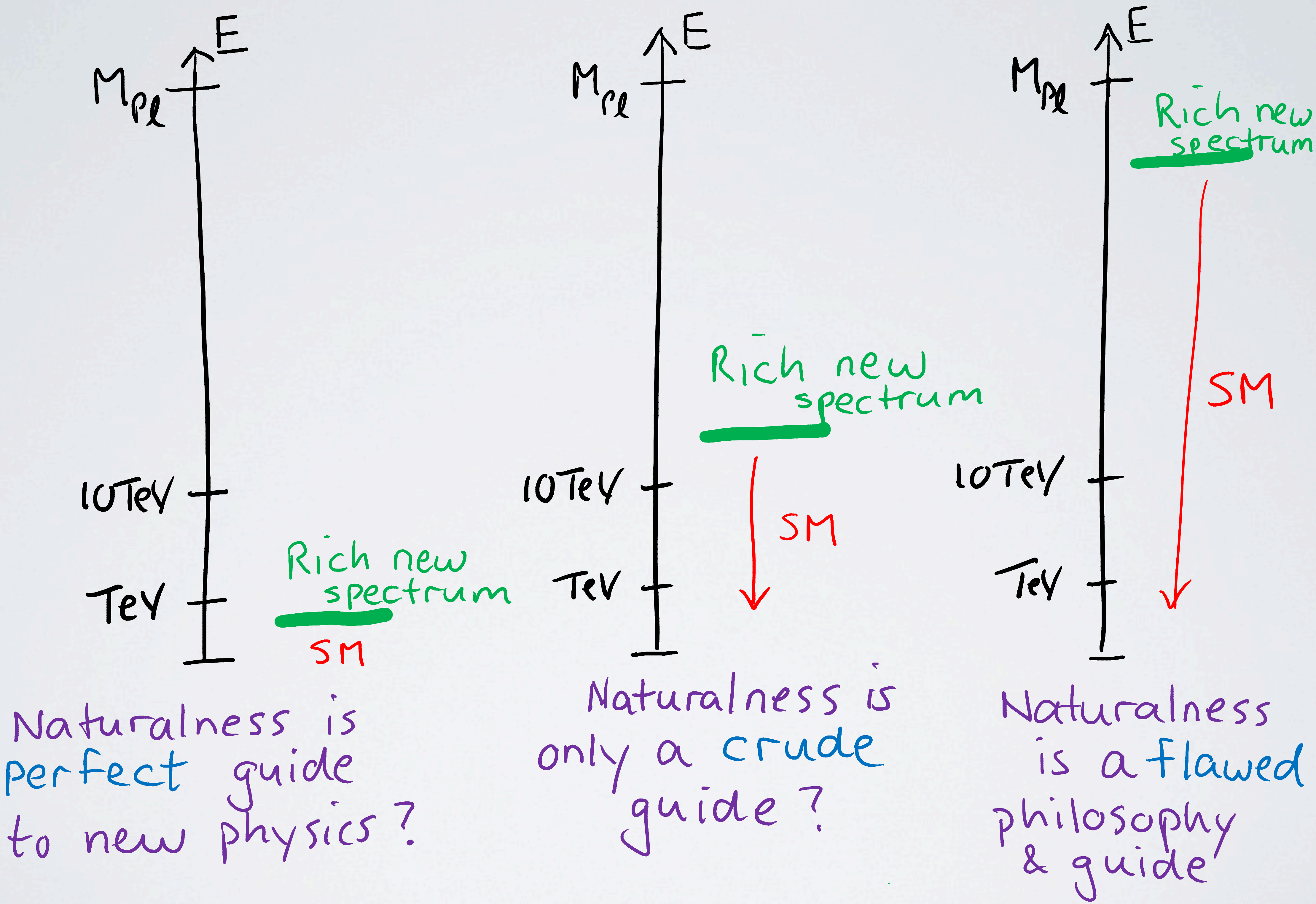
Strongly coupled

EW NATURALNESS AFTER DECADES OF RESEARCH...



R. Sundrum

EW NATURALNESS ON TRIAL



How do we put it on trial???

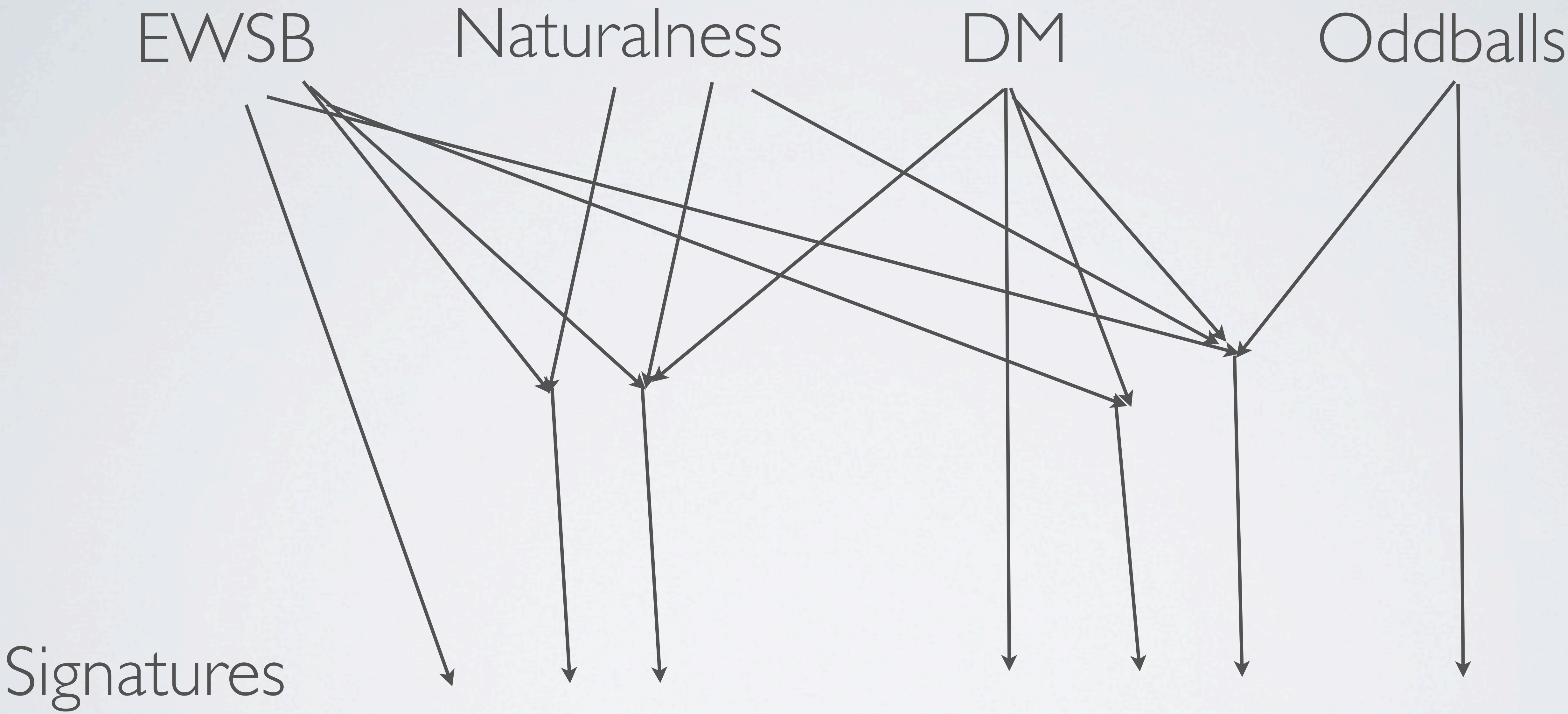
DARK MATTER/WIMP MIRACLE

$$\Omega_X \propto \frac{1}{\langle \sigma v \rangle} \sim \frac{m_X^2}{g_X^4}$$

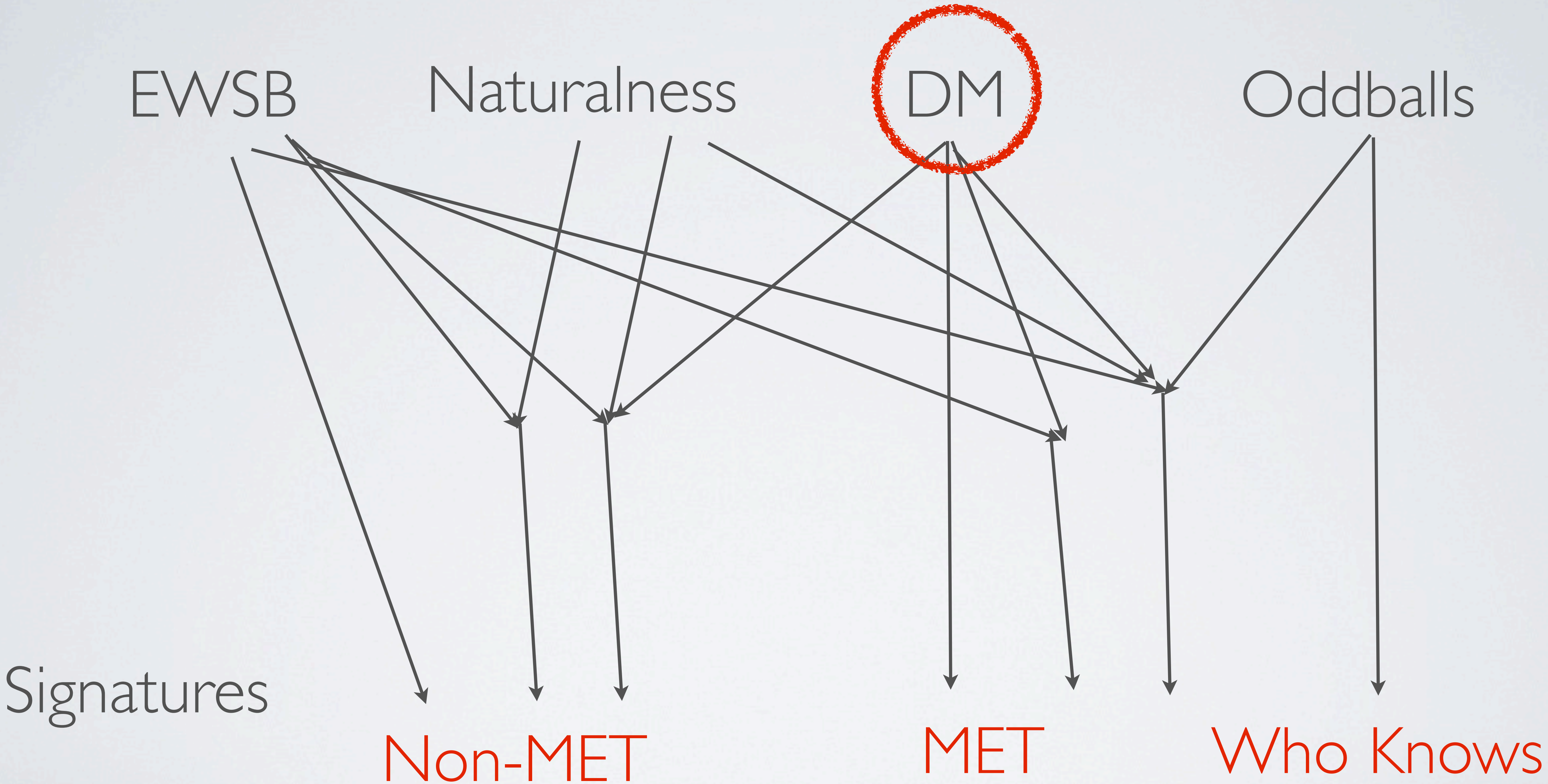
If we have weak scale couplings and masses this works out right

Just one number, maybe we put too much stock in it as far as the LHC goes

WHERE ARE WE AT?



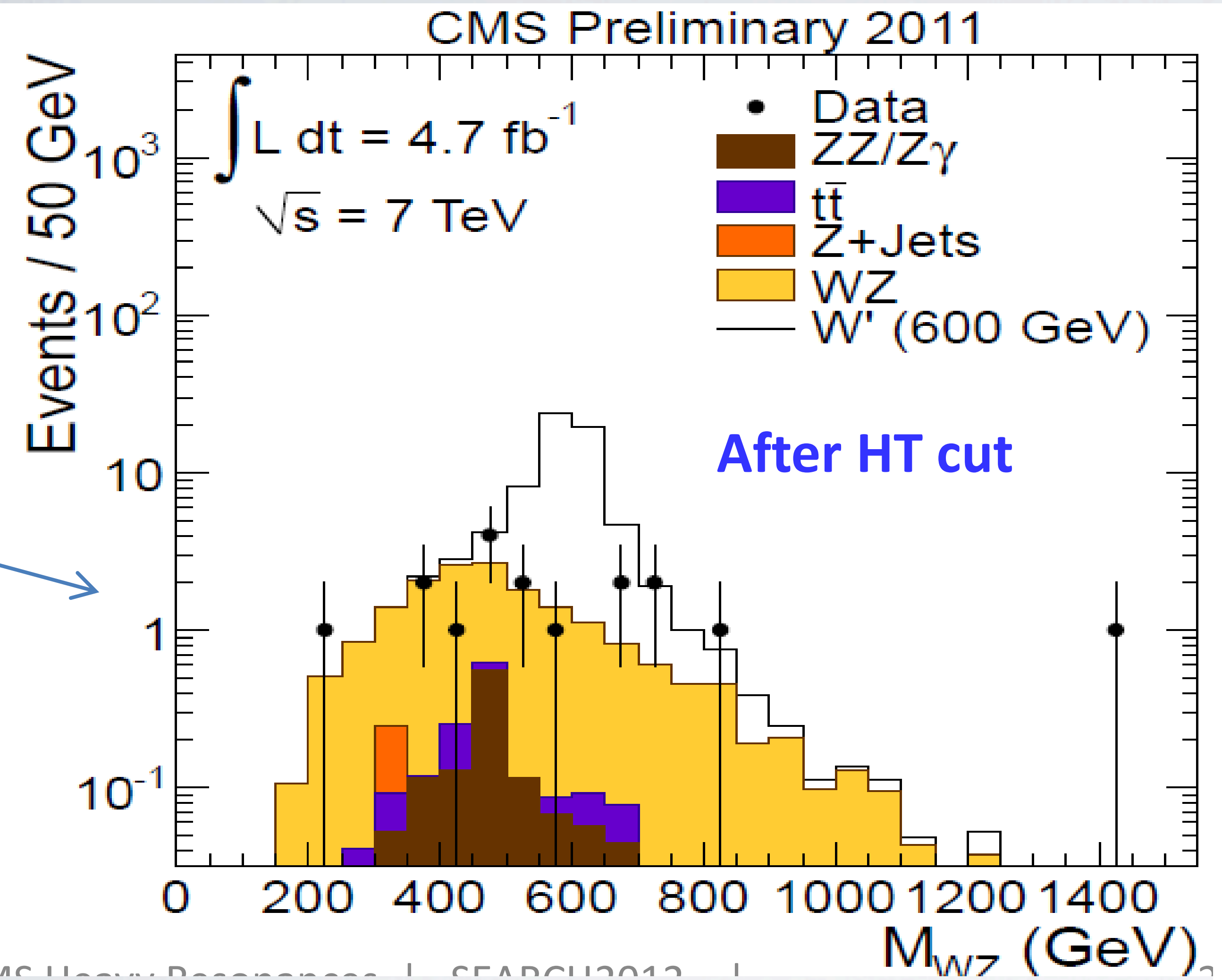
WHERE ARE WE AT?

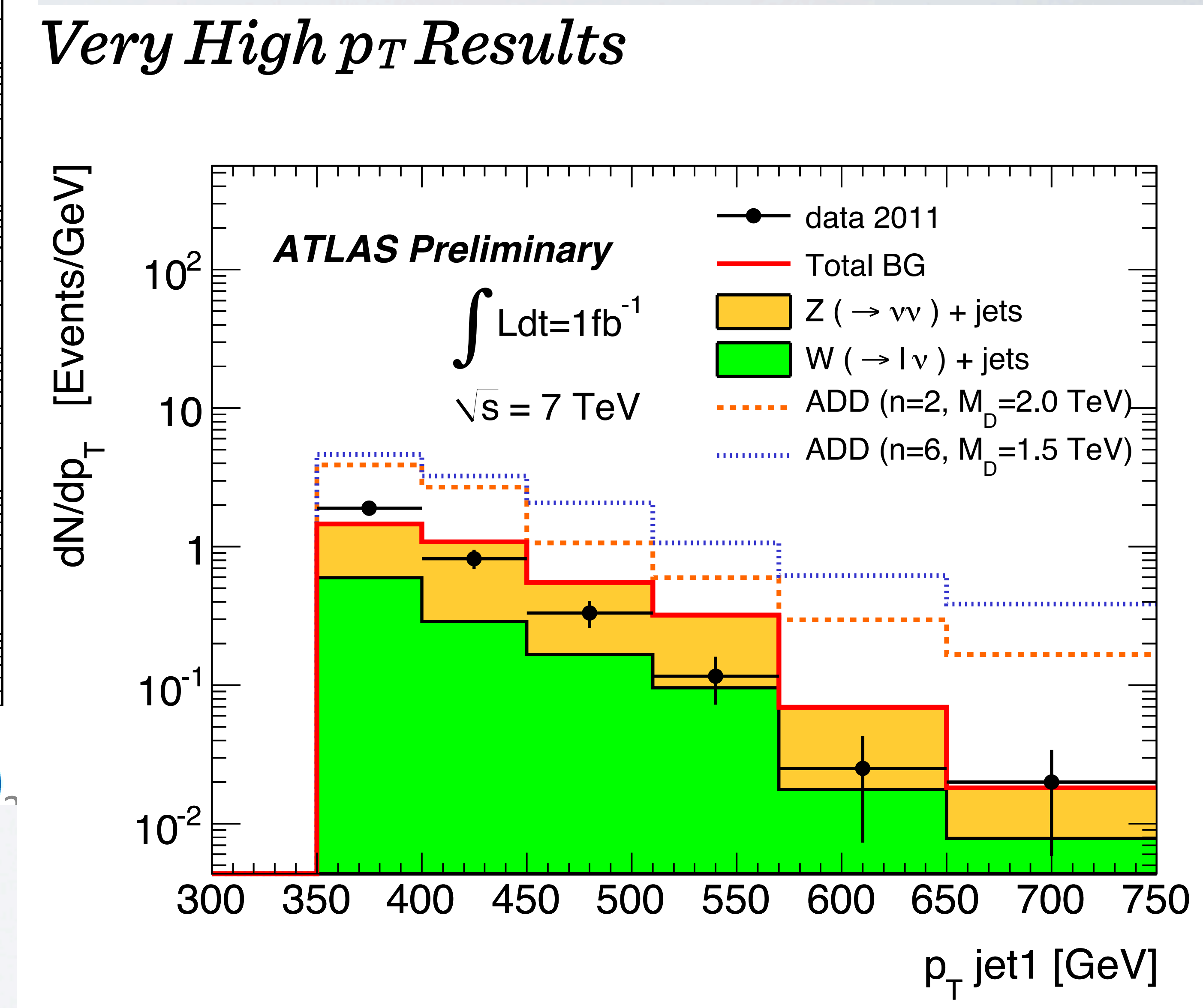


WHAT'S EXCLUDED?

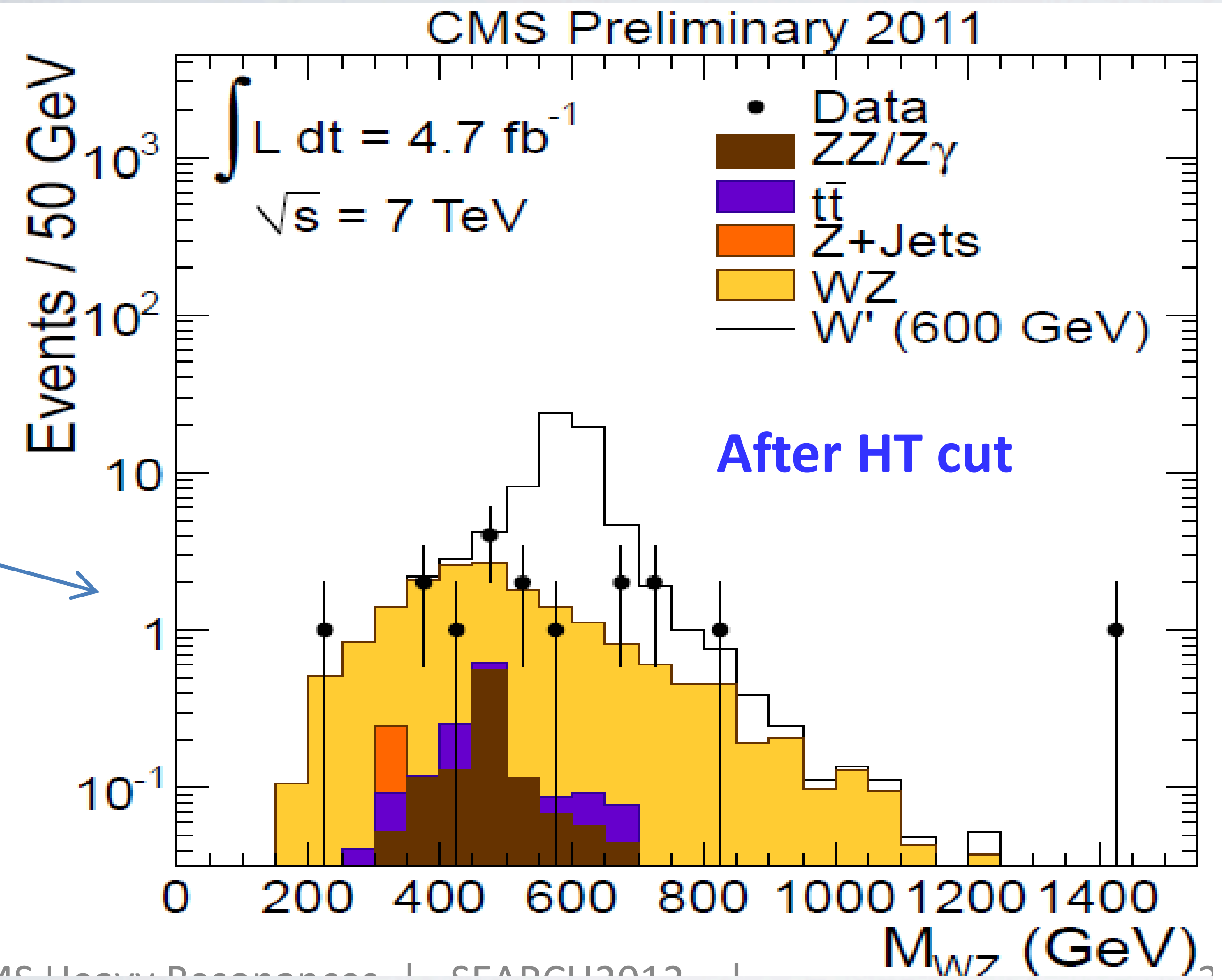
- ATLAS and CMS have done well at the following things so far:
  - Basic two body final states and close to these...
  - Really blatant oddballs
  - Anything + MET

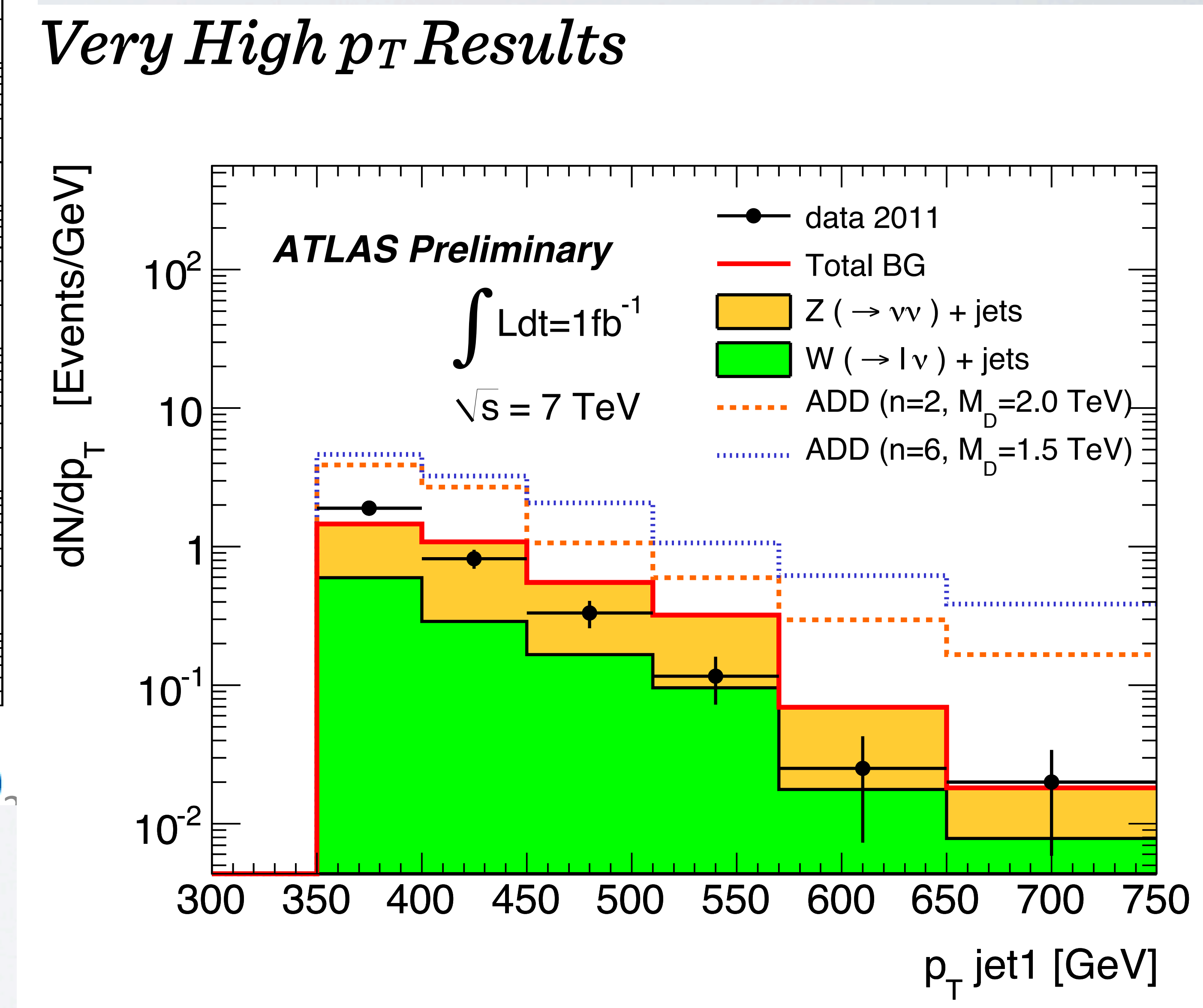
BUMPS AND BIG SIGNAL SEARCHES





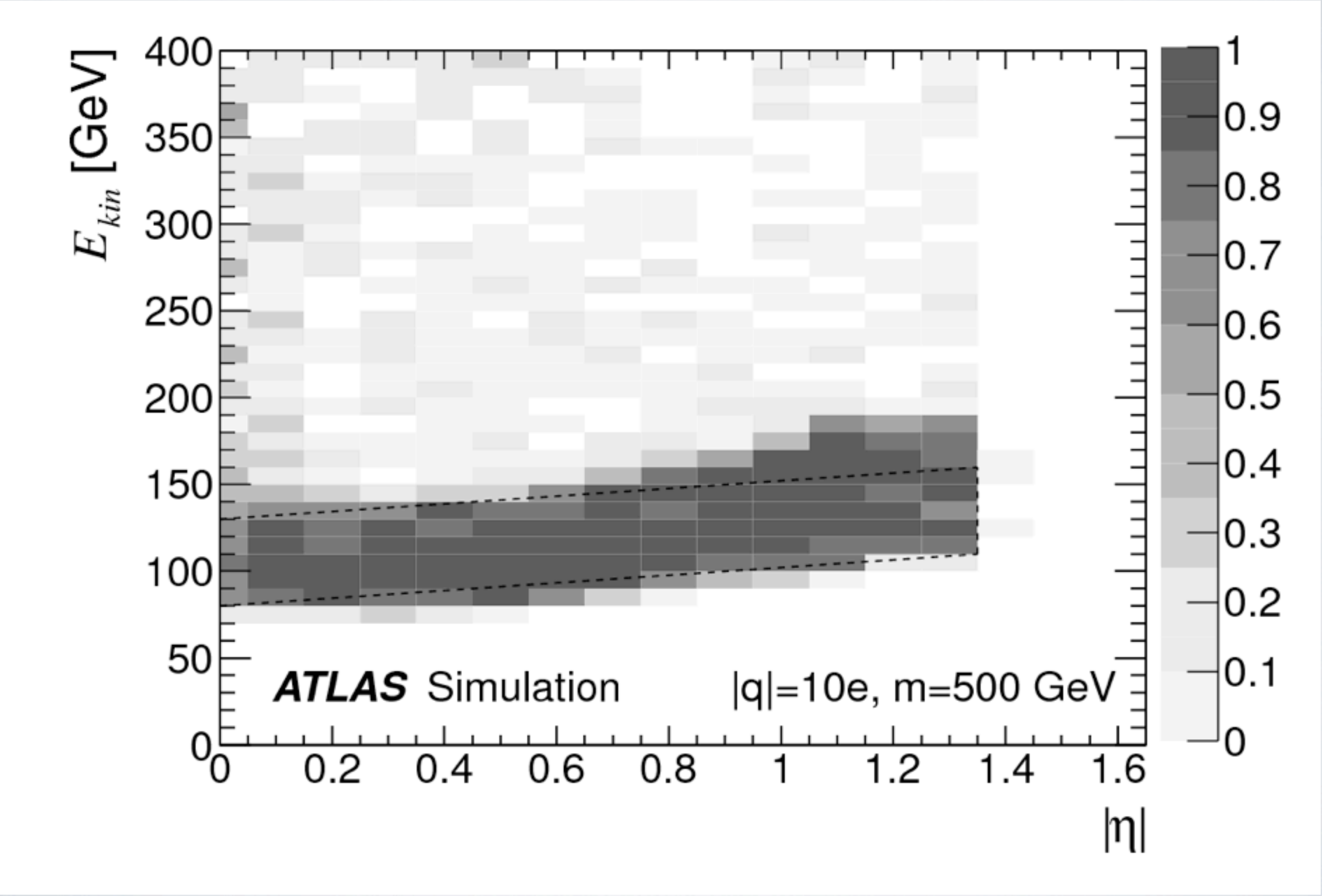
BUMPS AND BIG SIGNAL SEARCHES





Nothing here... move along our p-value is big

OBVIOUS ODDBALLS

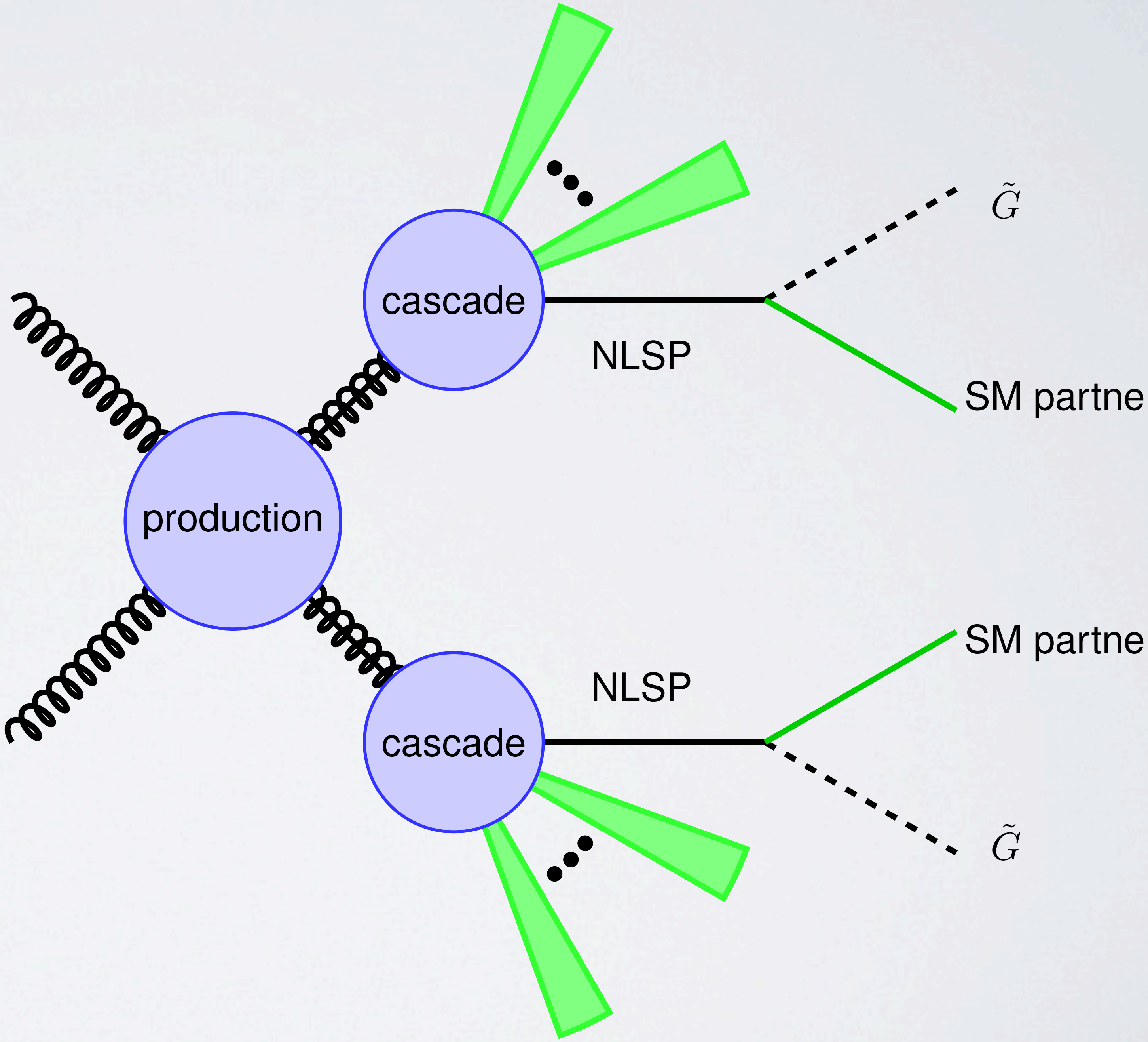


SUSY OVERVIEW

- Experiments have looked for SUSY in a variety of different flavors and channels:
  - Jets + MET
  - b jets +MET
  - 1lep+jets +MET
  - OS dileptons +MET
  - SS dileptons + MET
  - diphoton+MET
  - multileptons
  - R-hadrons
  - AMSB

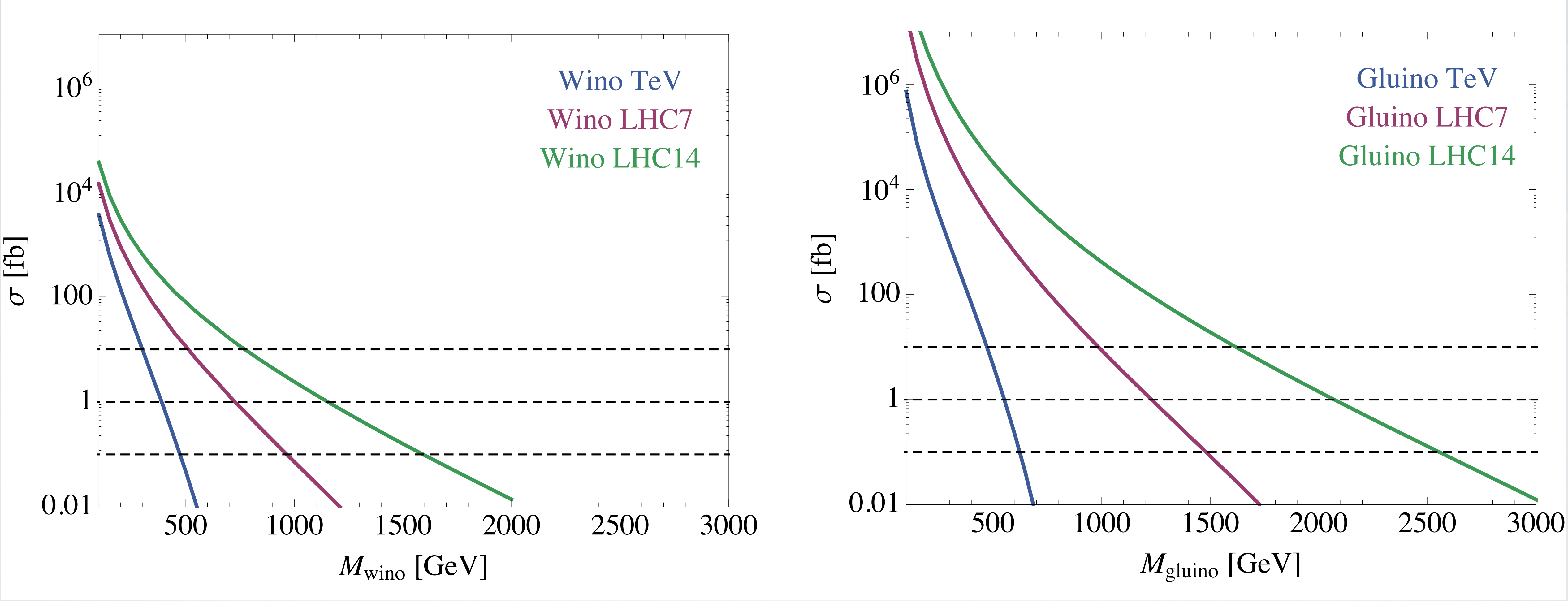
SUSY OVERVIEW

For the most part exclusion is based on MET + (n)m (b)-jets +k leptons



SUSY OVERVIEW

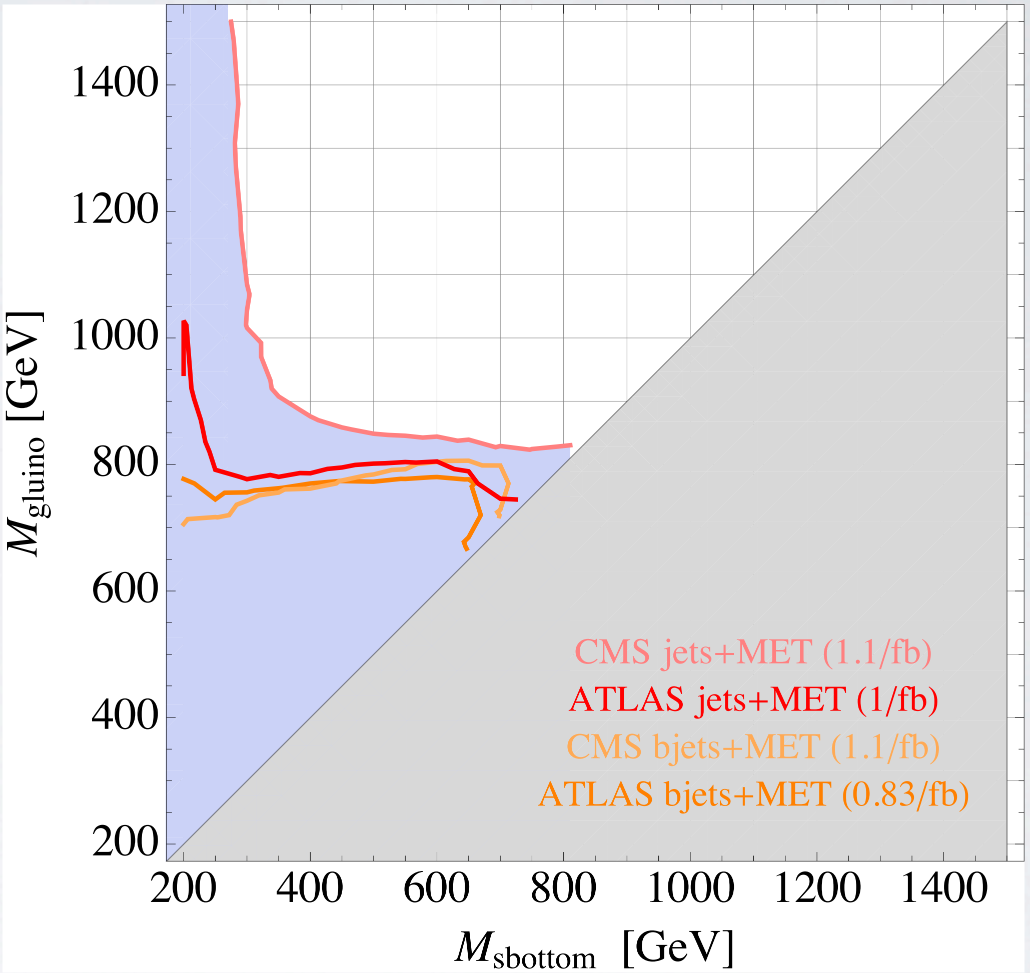
- Where do we expect exclusions?



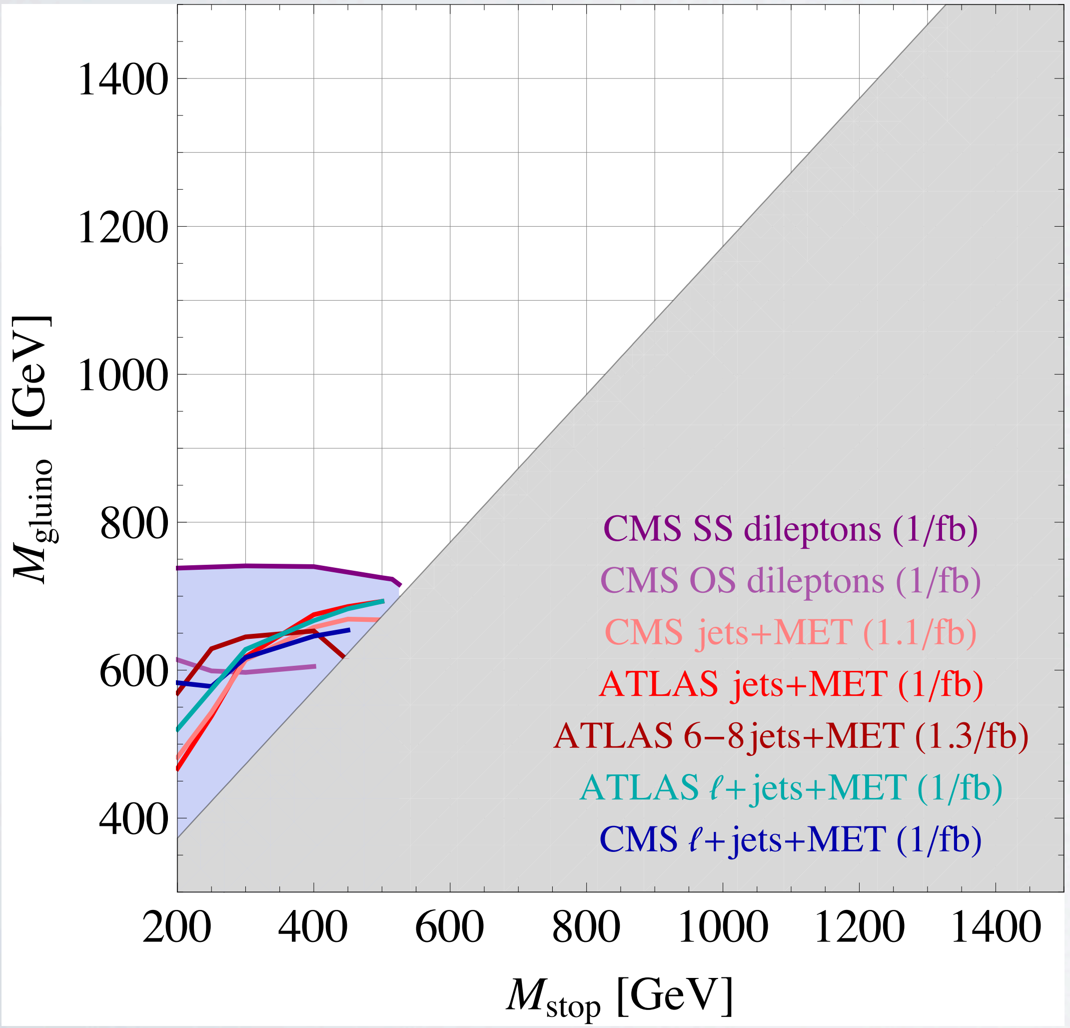
SUSY OVERVIEW

- Not all searches as powerful as they could be (at least at 1/fb)

particle	mass	relevant decays
$\tilde{g}$	M_{gluino}	$\tilde{g} \to b\tilde{b}_1$
$\tilde{b}_1$	M_{sbottom}	$\tilde{b}_1 \to b\tilde{G}$

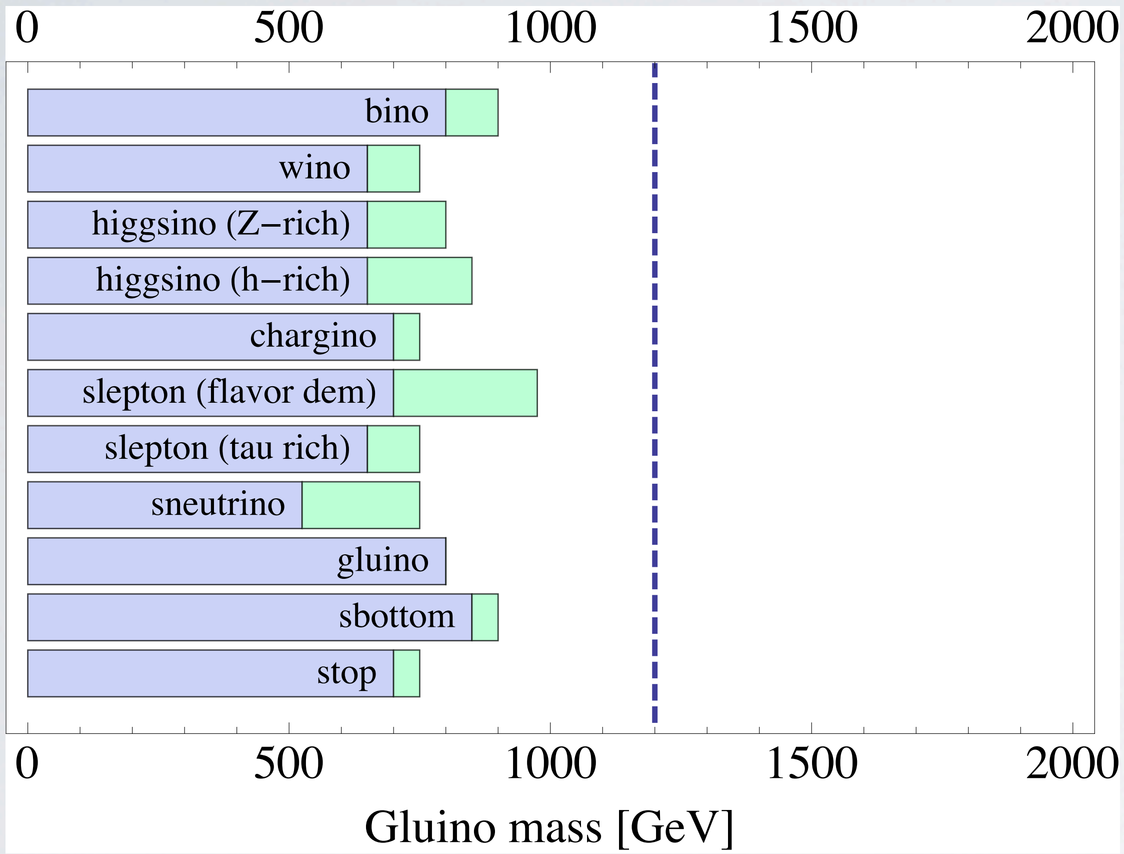


Kats, PM, Reece, Shih

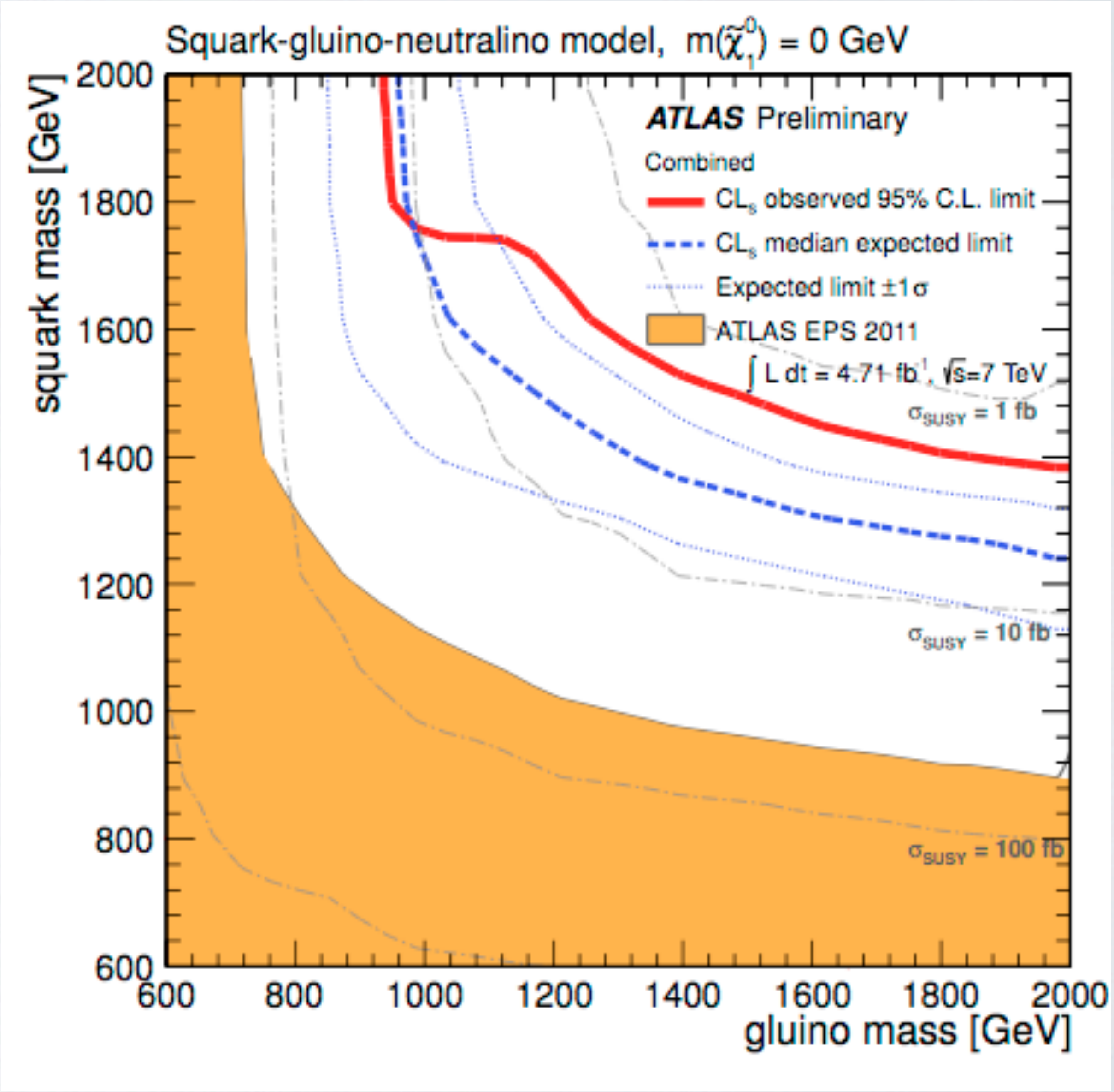


particle	mass	relevant decays
$\tilde{g}$	M_{gluino}	$\tilde{g} \to t\tilde{t}_1$
$\tilde{t}_1$	M_{stop}	$\tilde{t}_1 \to t\tilde{G}$

REGARDLESS OF SUBTLE DETAILS



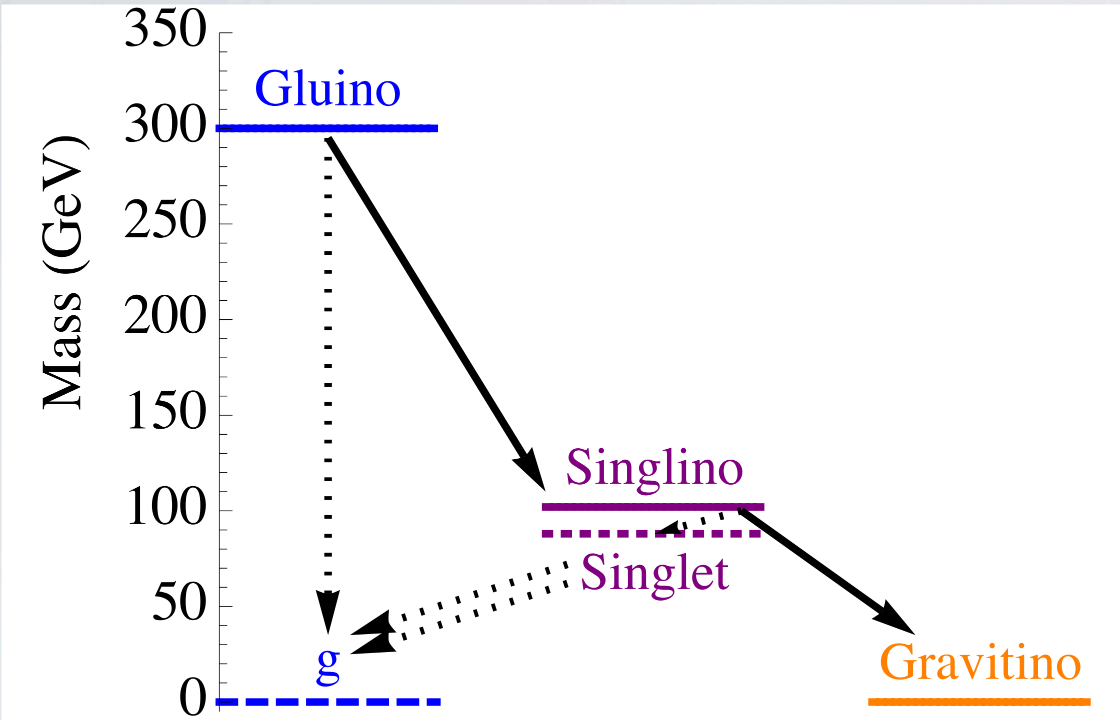
Exclusions keep pushing forwards

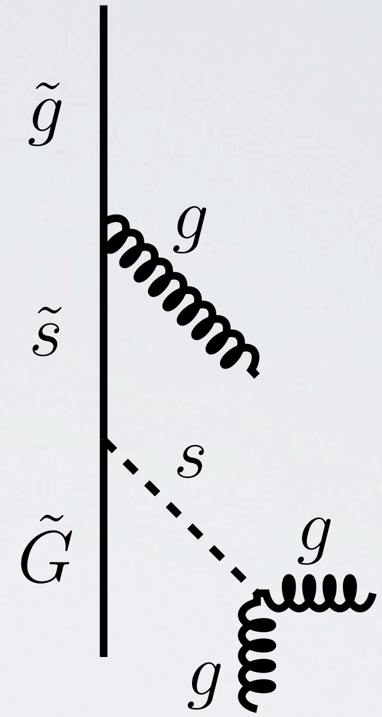


WHAT'S NOT EXCLUDED YET...

- Final states without much MET
- primarily 3rd Generation final states produced from direct production of 3rd generation partners
- Long lived final states
- Odd balls
- All of these ideas may be correlated!

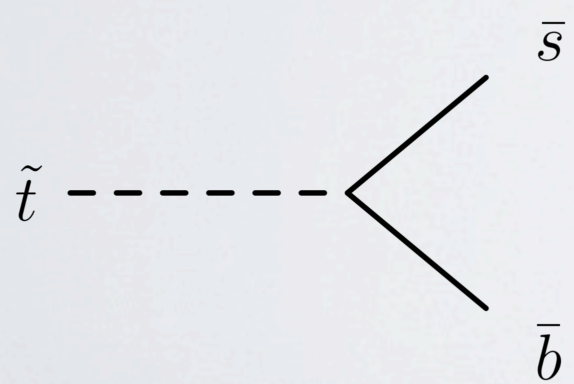
LOW MET

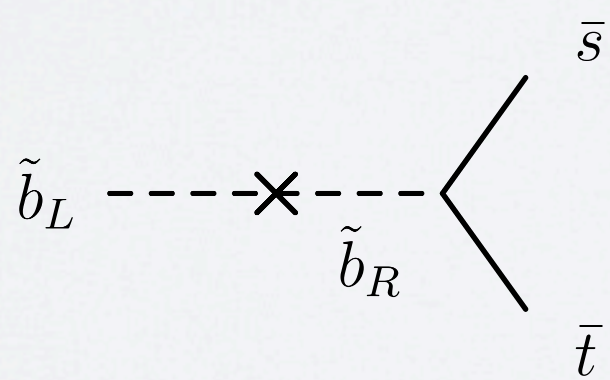




Stealth SUSY

Fan, Reece, Ruderman



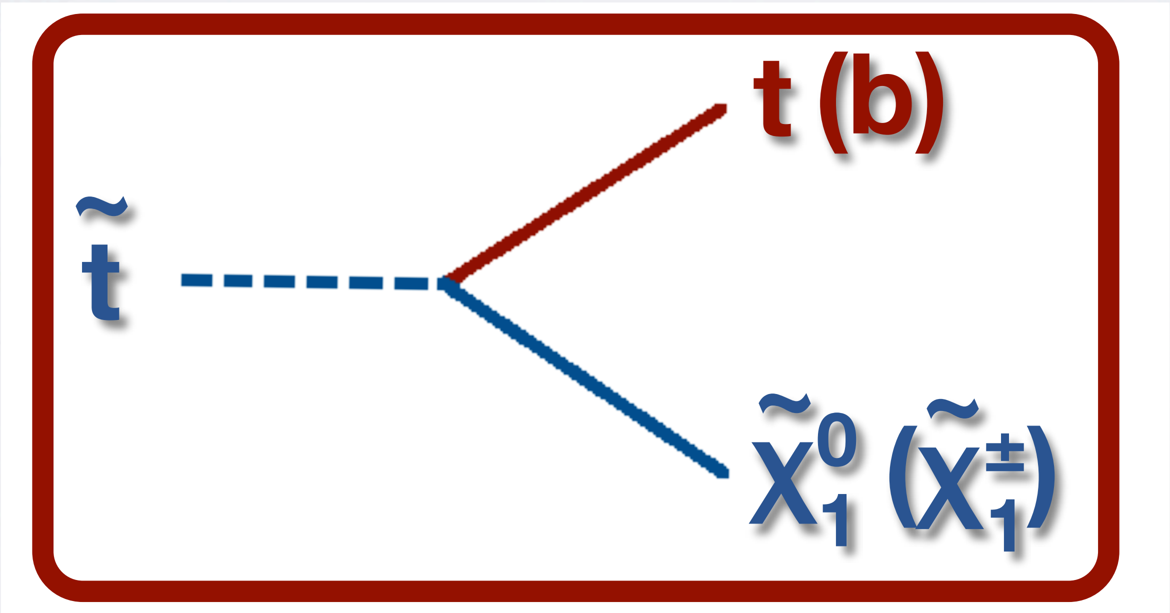


MFV RPV

Csaki, Grossman, Heidenreich

HAVEN'T DIRECTLY SEARCHED STATES FOR NATURALNESS

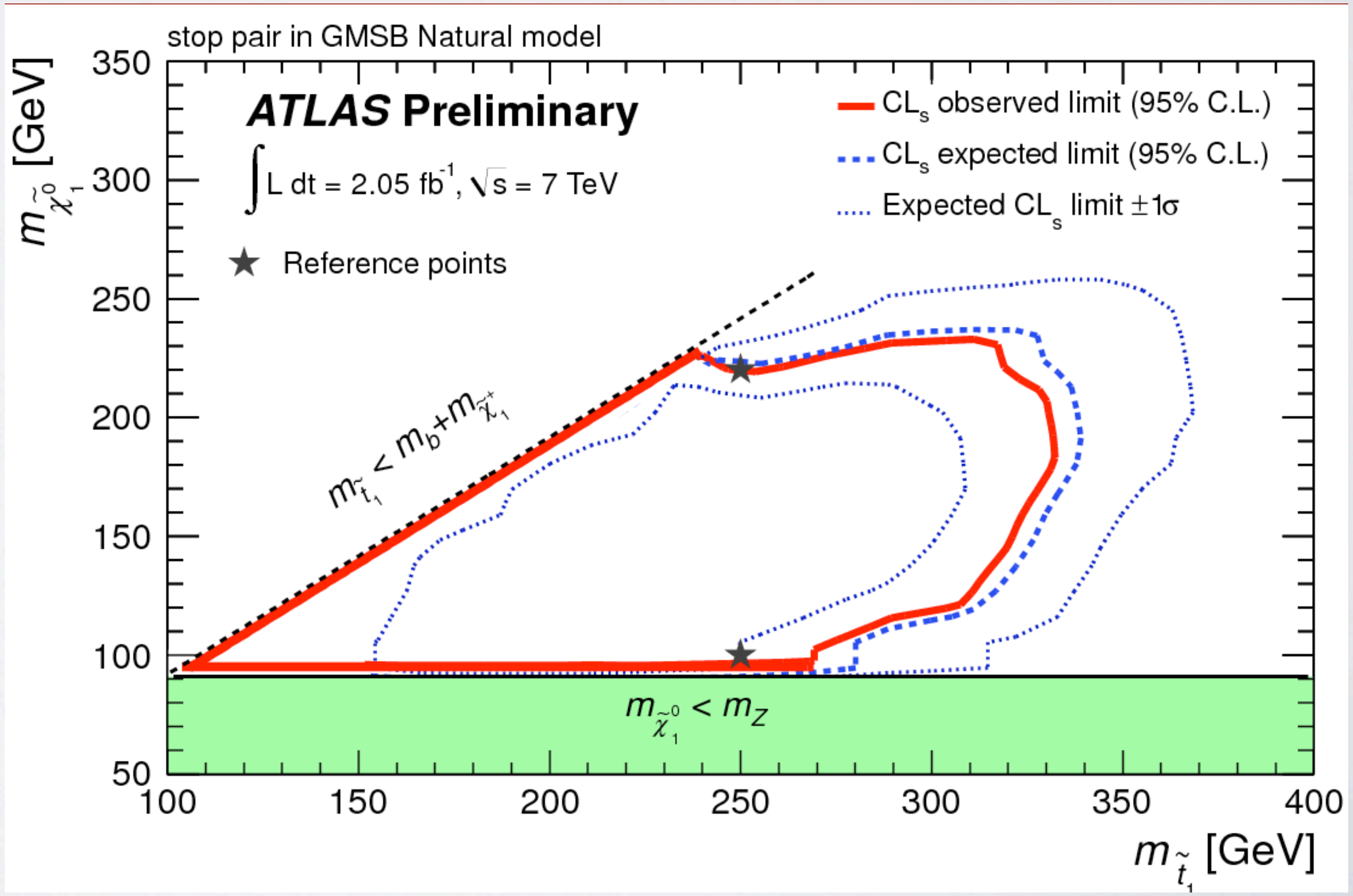
- We care about the third generation, top partners in particular for naturalness - don't HAVE to have other things around...



We've been waiting on this search for a long time...

ATLAS TO THE RESCUE!

Search for Scalar Top Quark Pair Production in Natural Gauge Mediated Supersymmetry Models with the ATLAS Detector in *pp* Collisions at $\sqrt{s} = 7$ TeV



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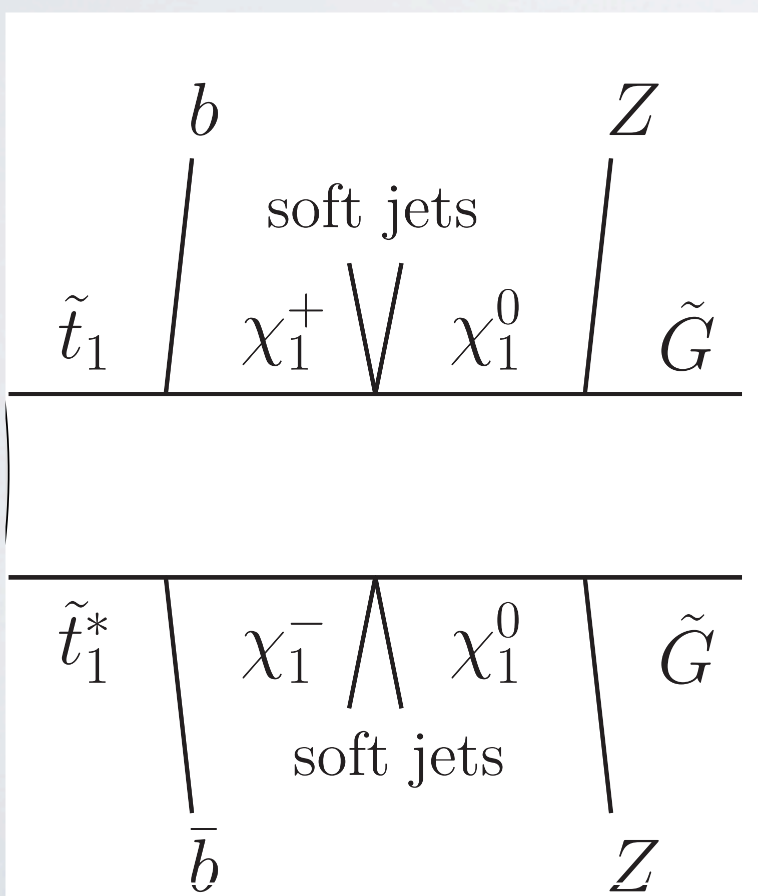
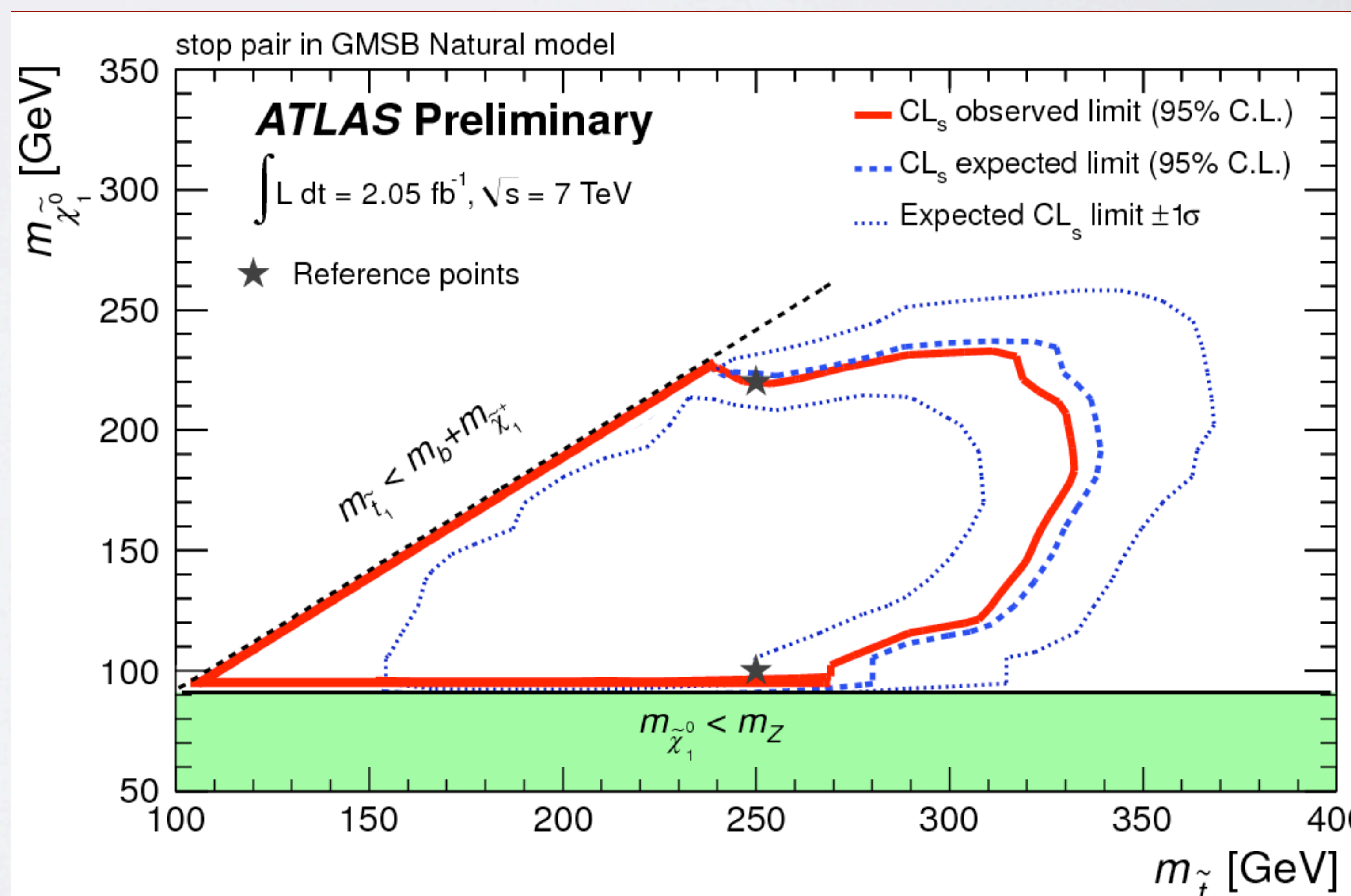
Search for Scalar Top Quark Pair Production in Natural Gauge Mediated Supersymmetry Models with the ATLAS Detector in *pp* Collisions at $\sqrt{s} = 7$ TeV

WT#$%@*? $m_{\tilde{q}_3} = m_{\tilde{u}_3} = -A_t/2; \quad \tan\beta = 10$





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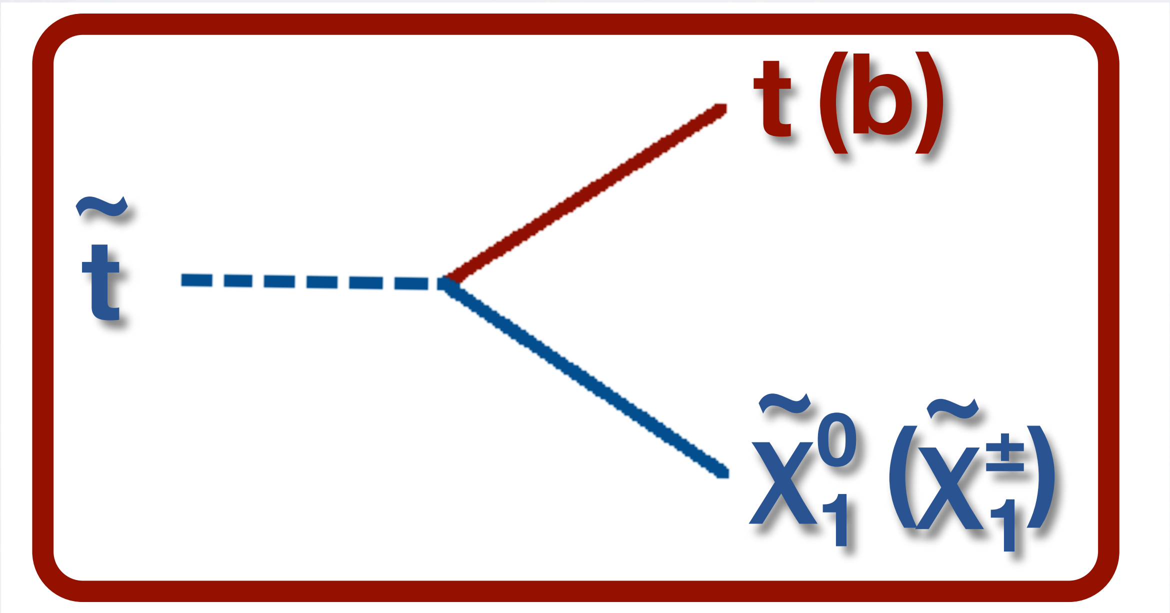


Not quite there, but we are getting there SOON!

MODEL BUILDING 3RD

- To avoid constraints we'd like to separate off first two generations from the third
  - Compositeness - Csaki, Randall, Terning
  - Flavor Mediation - Craig, Mcullough, Thaler
  - Other 3rd generation fun - Craig et al. and others in the past

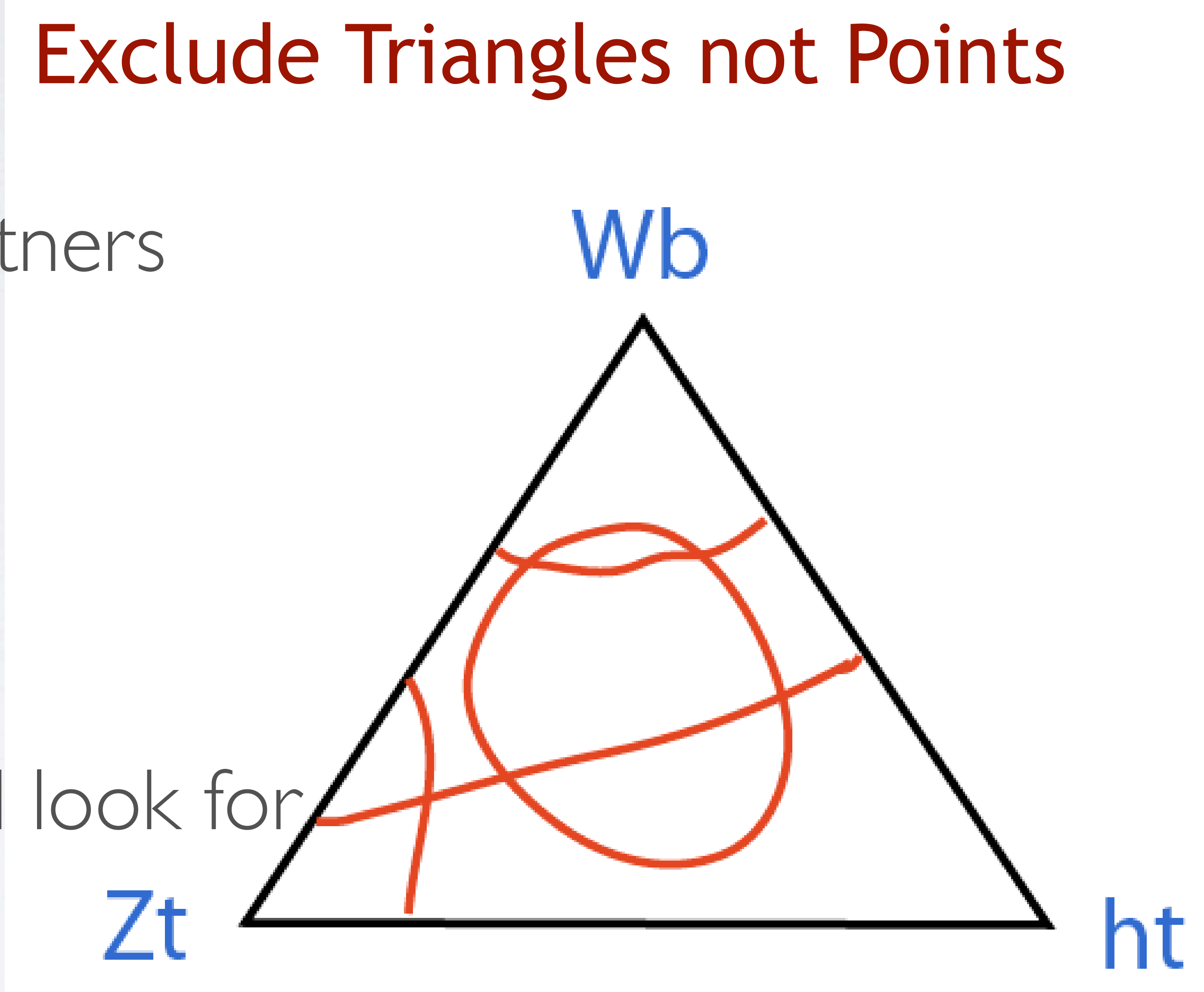
All avoid naturalness for stops, but do we really care? Depends on Higgs sector

3RD WITHOUT MET

- Only talked about "SUSY" partners
- Little Higgs, XDs, etc.
- Good Models?

3RD WITHOUT MET

- Only talked about "SUSY" partners
- Little Higgs, XDs, etc.
- Good Models? no... BUT
- Can still profess ignorance and look for motivated states



Peskin

IMPLICATIONS FROM HIGGS

- Why do we care about 3rd generation? HIGGS
- We now have something concrete to say if we have found the thing!

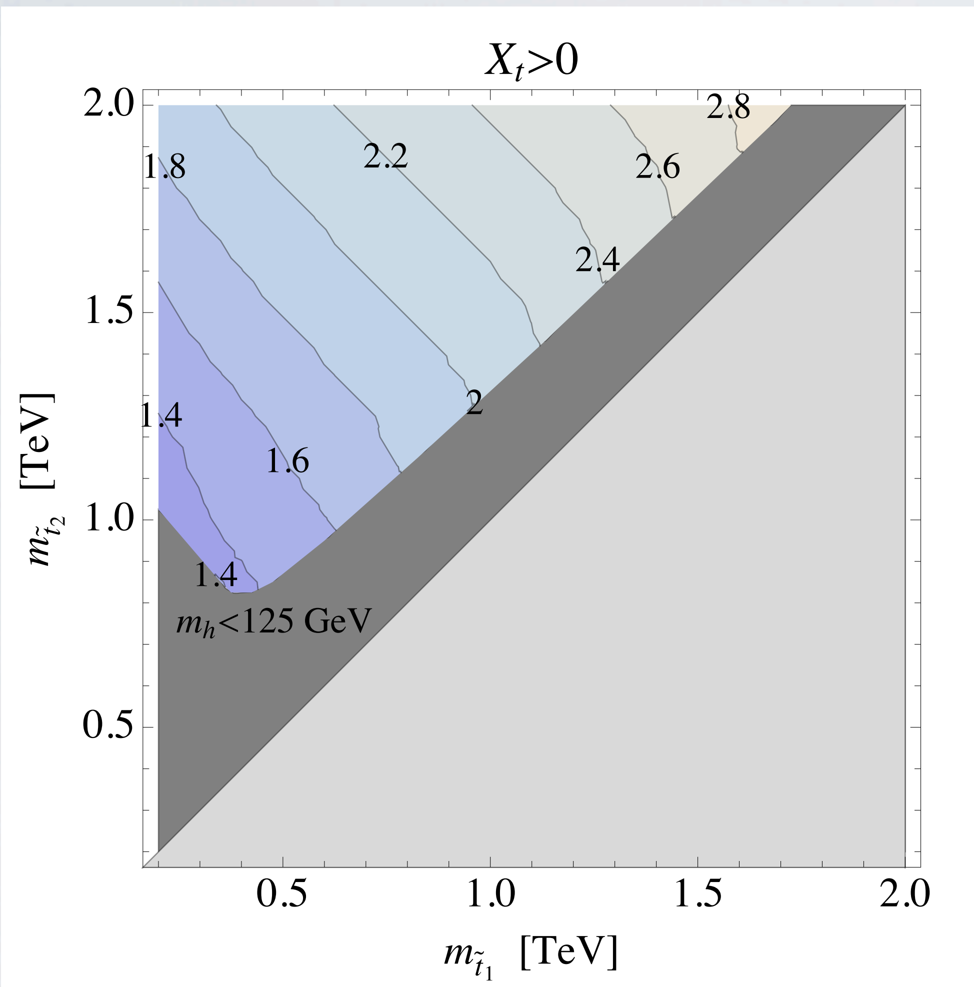
Higgs at 125 Gev, what does it mean?

Another nail in the coffin for strong coupling?

Not too great for SUSY either, right?

SUSY AND 125 GEV HIGGS

No Mixing



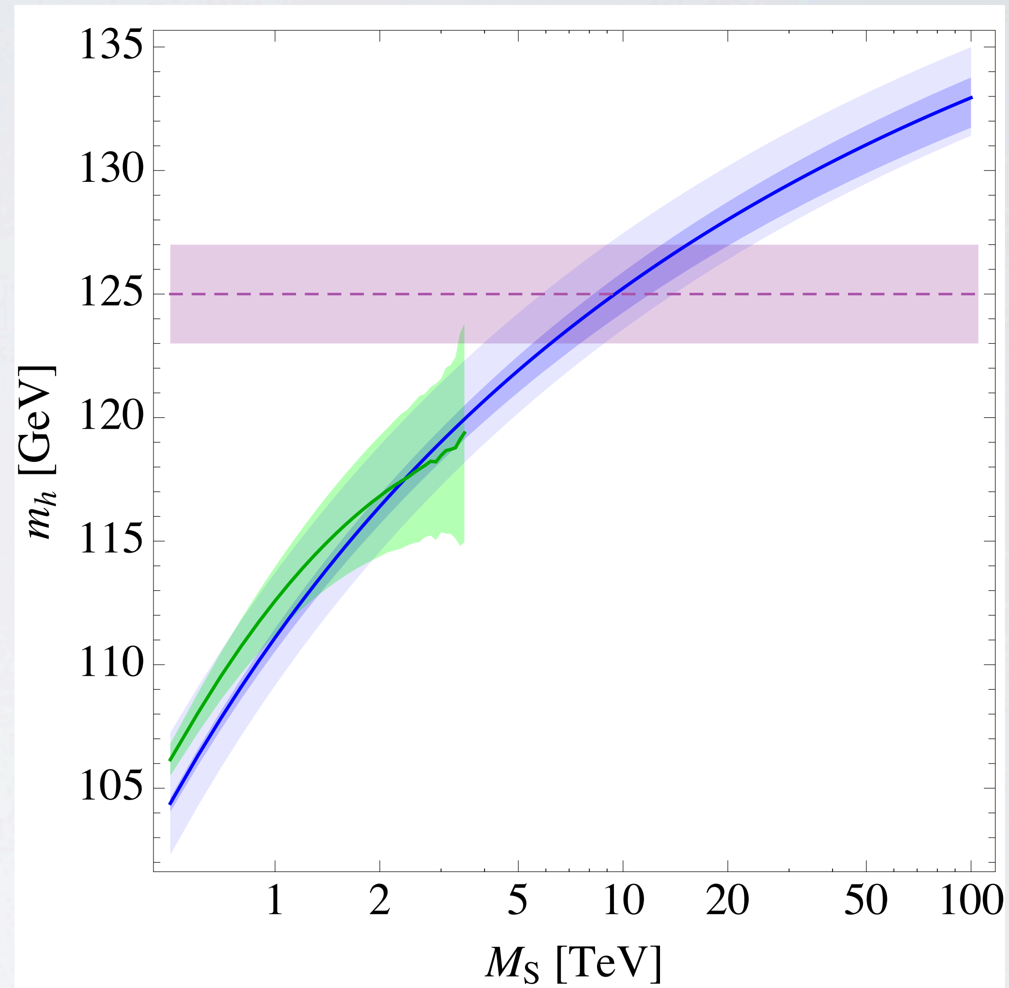


FIG. 6. Higgs mass as a function of M_S, with $X_t = 0$. The green band is the output of FeynHiggs together with its associated uncertainty. The blue line represents 1-loop renormalization group evolution in the Standard Model matched to the MSSM at M_S. The blue bands give estimates of errors from varying the top mass between 172 and 174 GeV (darker band) and the renormalization scale between $m_t/2$ and $2m_t$ (lighter band).

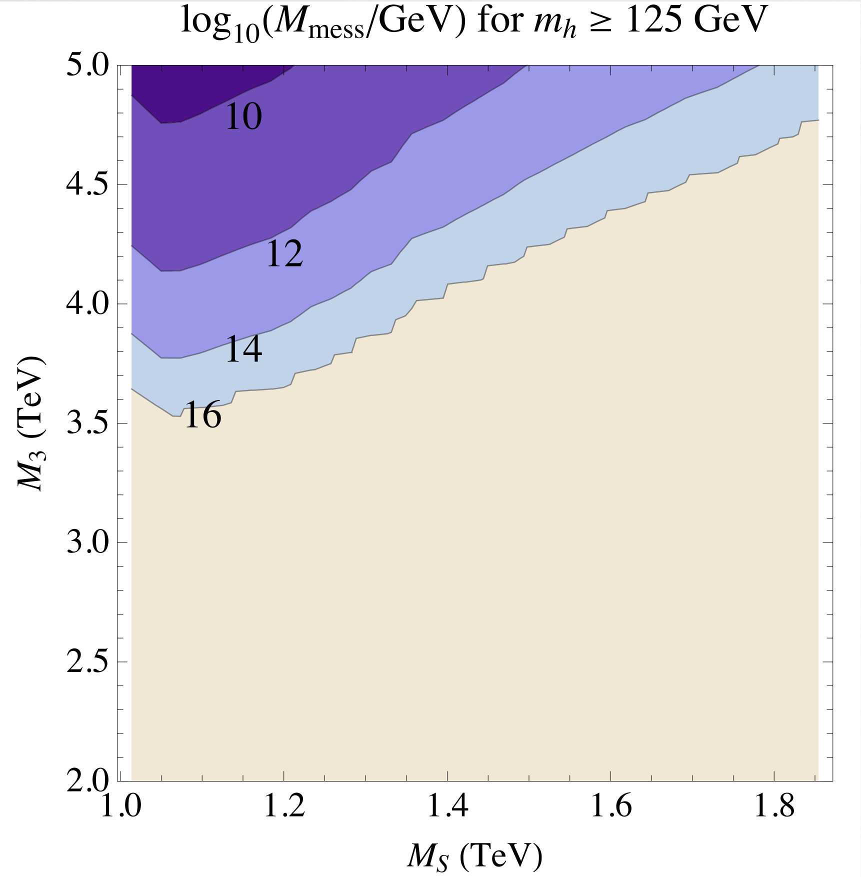
Maximal Mixing

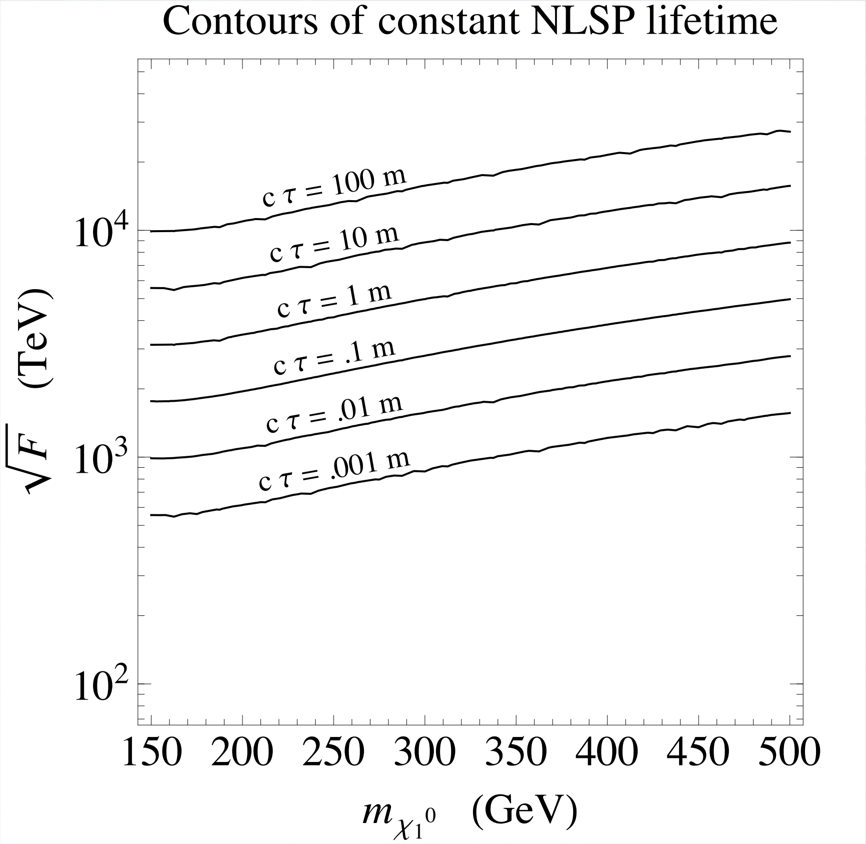
SUSY AND 125 GEV HIGGS

- Three options:
  - Maximal Mixing and "light" stops
    - No good high scale models and low scale models have to be at "high" scales
  - SUSY really heavy and tuned - Split SUSY
  - SUSY effects Higgs properties (do we care about 3rd gen as much?)

SUSY AND 125 GEV HIGGS

- "Low" scale models = Long lifetimes





Draper, PM,Reece, Shih

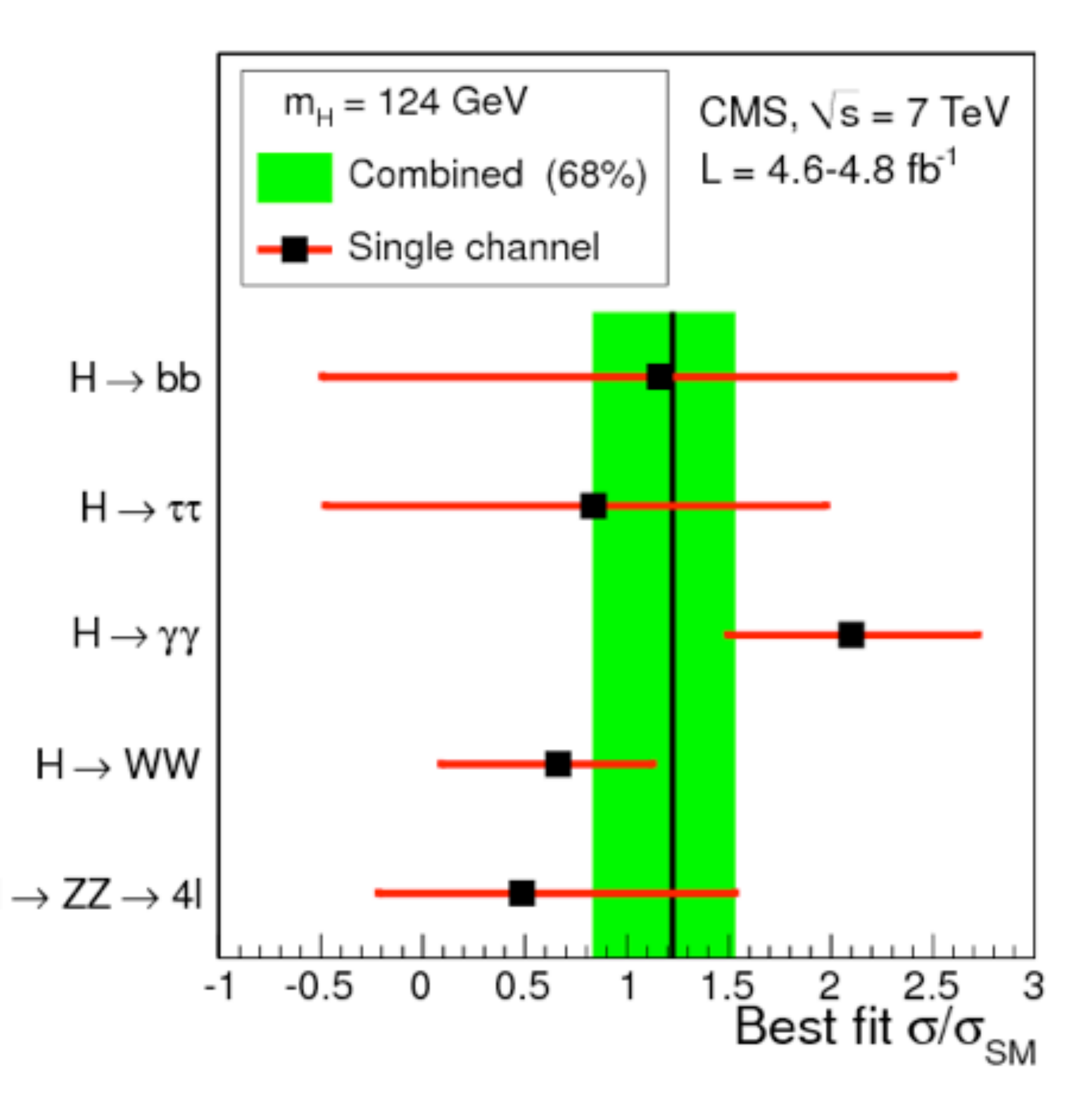
- Tuned models = Long lifetimes as well! quasi-stable R-hadrons

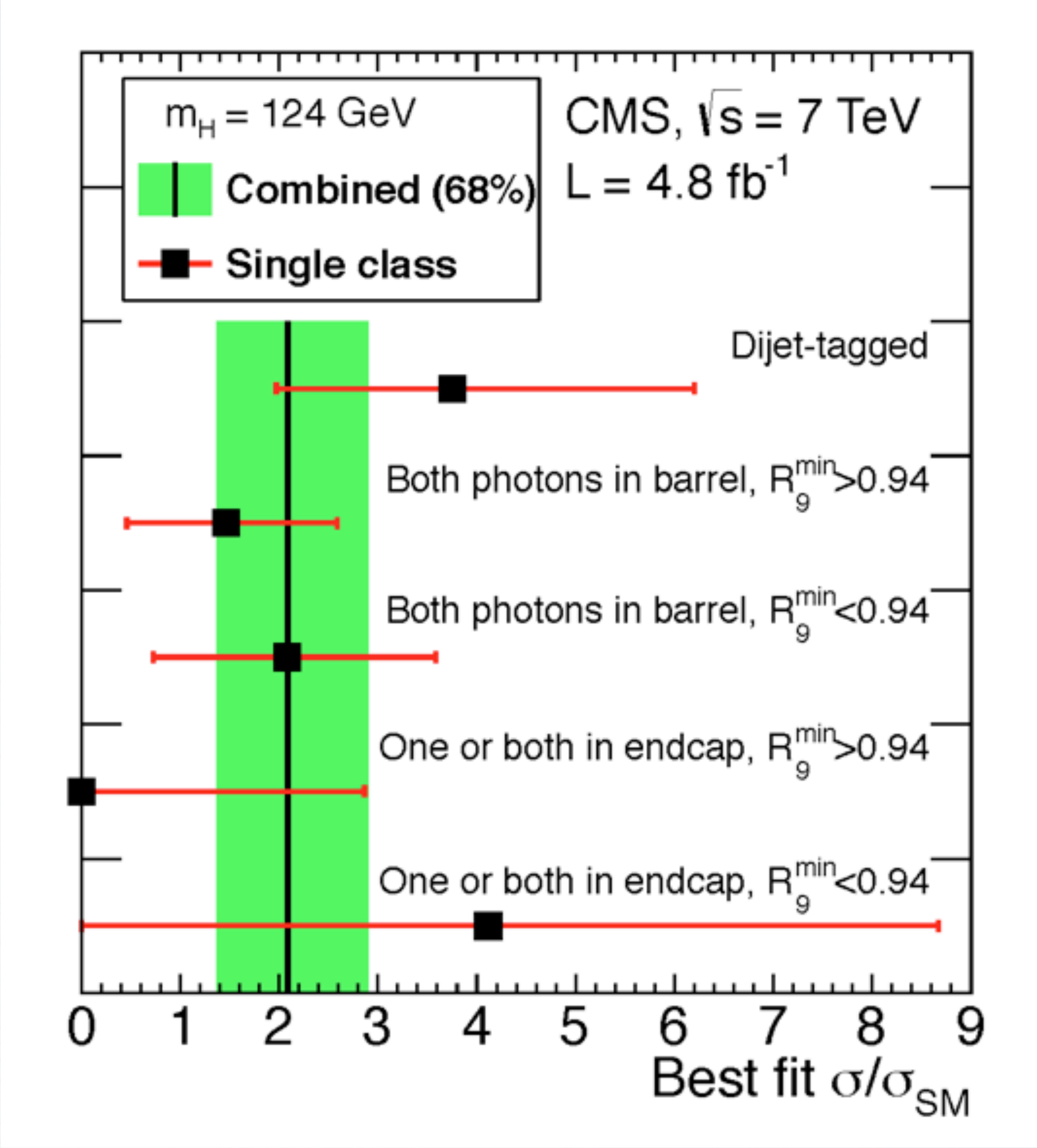
How much do we care about stops?

LONG LIFETIMES

- These exist as a whole branch of BSM models without Higgs motivation
- Handful of searches already, but typically tied to obscure models!
- Can give us deep insights!

HIGGS CORRELATIONS





HIGGS CORRELATIONS

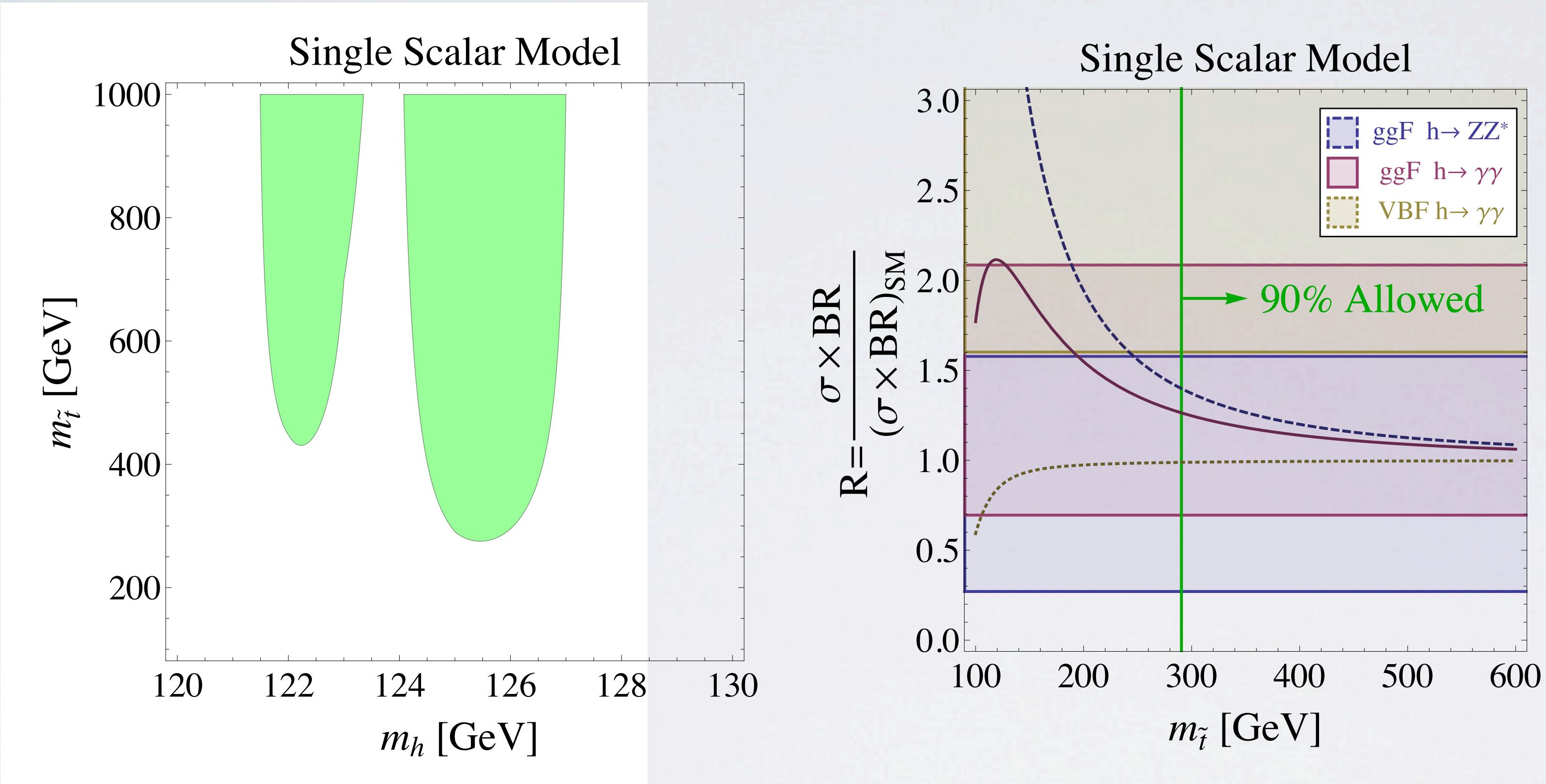
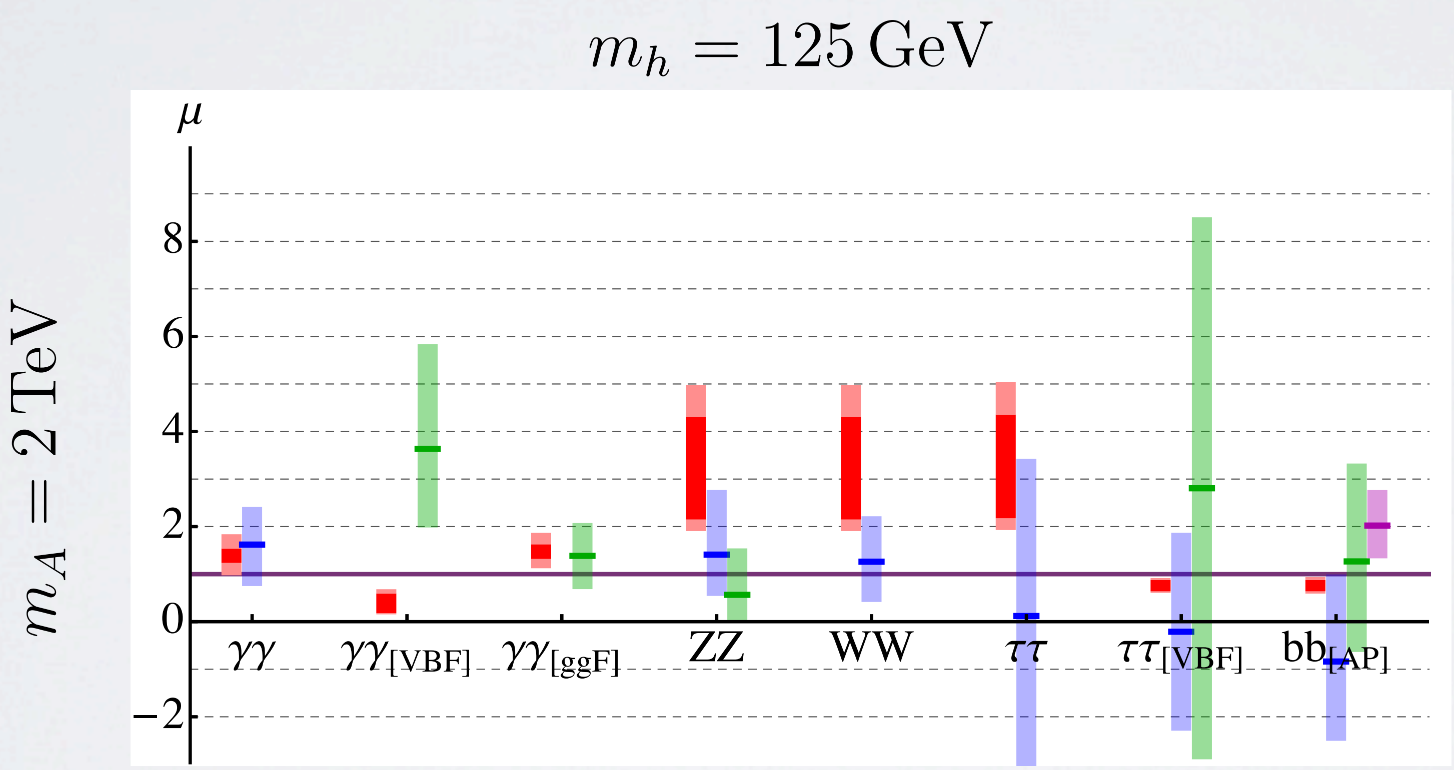


Figure 3: **Left:** Favored region, 90% CL, in the $m_{\tilde{t}} - m_h$ plane, derived from the combination of the three search channels, for the one-scalar model described in Sec. 4.1. **Right:** Constraints for $m_h = 125$ GeV. The three bands show the 1σ allowed regions from Higgs produced via gluon fusion decaying to two photons (ggF $h \to \gamma\gamma$, pink), Higgs produced via gluon fusion decaying through two Z-bosons (ggF $h \to ZZ^*$, blue), and Higgs produced via vector boson fusion decaying to two photons (VBF $h \to \gamma\gamma$, beige). The three curves show the theoretical predictions as a function of $m_{\tilde{t}}$: ggF $h \to \gamma\gamma$ (solid-pink), ggF $h \to ZZ$ (dashed-blue), and VBF $h \to \gamma\gamma$ (dotted-beige). The region to the right of the green line at $m_{\tilde{t}} = 300$ GeV shows the 90% CL experimental (combined) bound.

Carmi,
Falkowski,
Kuflik,
Volansky
+
many others

HIGGS CORRELATIONS

- By combining exclusive channels **AT THIS EARLY JUNCTURE**, we can already make important statements about BSM physics

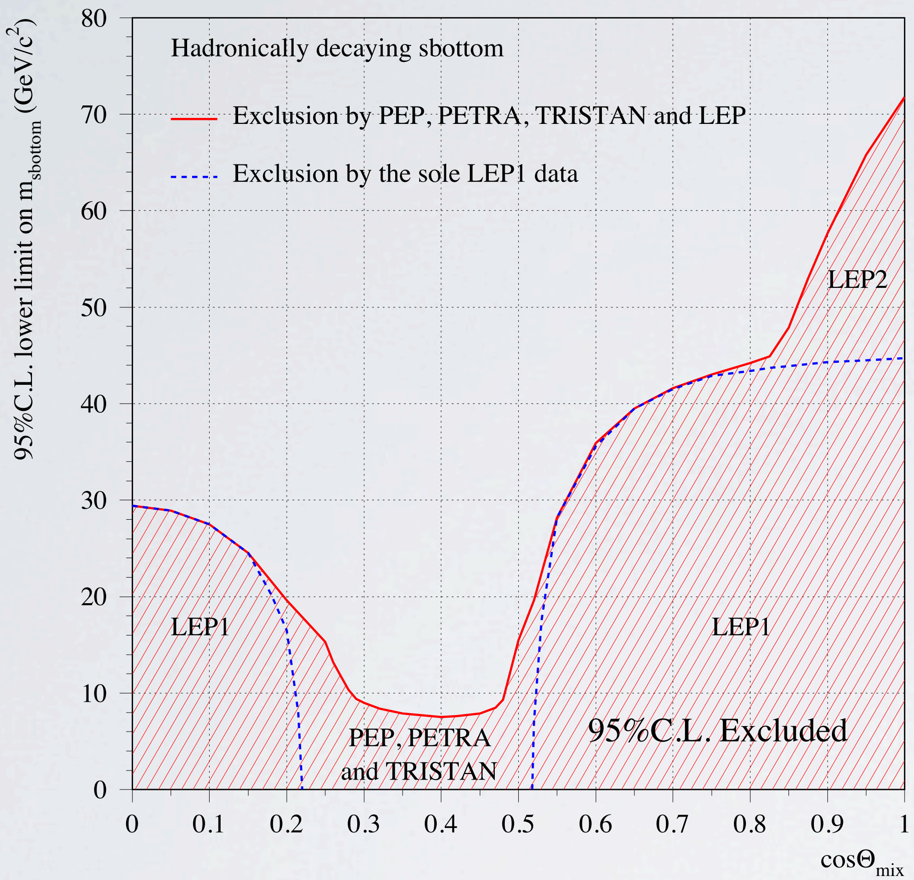


Curtin, Jaiswal, PM

Electroweak Baryogenesis in the MSSM is done!

OTHER ODDBALLS?

Janot 04



New Odd Tracks (NOTs)

eg:

$$X + \bar{X} \sim (3,1)_0 + (\bar{3},1)_0$$

$$Y + \bar{Y} \sim (1,1)_{1/9} + (1,1)_{-1/9}$$

$$\frac{1}{\Lambda^2} X \bar{d}_R Y^3$$

Microbarn cross sections without detection!

BSM THEORY STATUS

BSM THEORY STATUS

- No sign of it

BSM THEORY STATUS

- No sign of it
- Lots of holes
  - Low MET
  - No MET?
  - 3rd gen
  - Long Lifetimes
  - Odd balls

Role of BSM theory now:

Model for explanations

Models for experimentalists

Obvious MC implications:
SM needs to be better
BSM has to be ready for weird things but with accuracy