

Phenomenology of Induced Electroweak Symmetry Breaking

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SUSY 2015

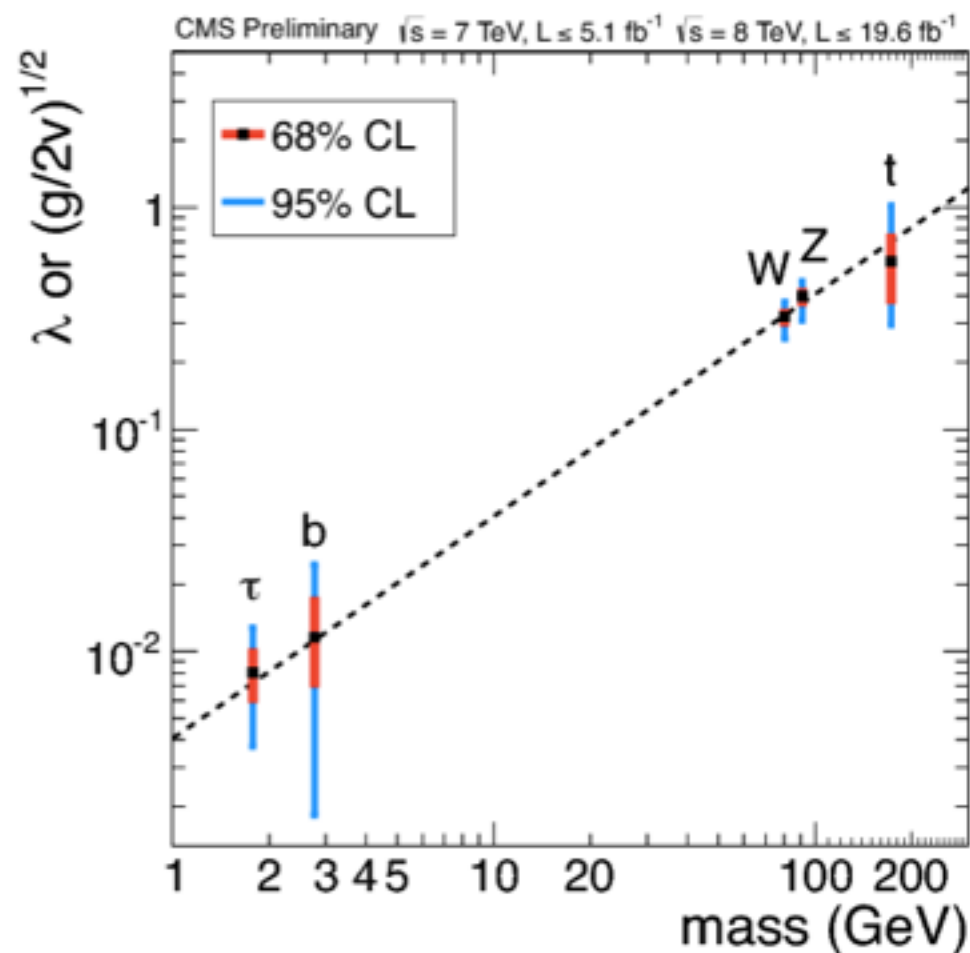
Work w /

Galloway, Luty, Salvioni, Tsai JHEP 1503

Talk Outline

- ◆ Induced Electroweak Symmetry Breaking
- ◆ Examples: MSSM + Technicolor (or extra doublets)
- ◆ Higgs Mass and Naturalness Implications
- ◆ Higgs, Pseudos, Techni-states Phenomenology

Higgs as we know it



The Higgs discovery
and ongoing
precision studies
are currently pointing
to a Standard Model
Higgs

Viabale options remain...



**Standard
EWSB**



Tilted Hat

Tilted Bowl



Induced EWSB scenarios

Use an additional source of EWSB
to tilt the potential

Could come from
another Higgs doublet
with a larger quartic
coupling
(Galloway et.al. PRD 89
or “sister Higgs”
Alves et.al.)

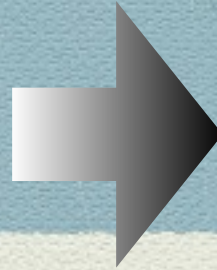
Could come from a
technicolor sector
(Azatov et.al. PRL 108)

In paper, we considered both, but for this talk,
I focus on the latter possibility

SUSY + Technicolor



+

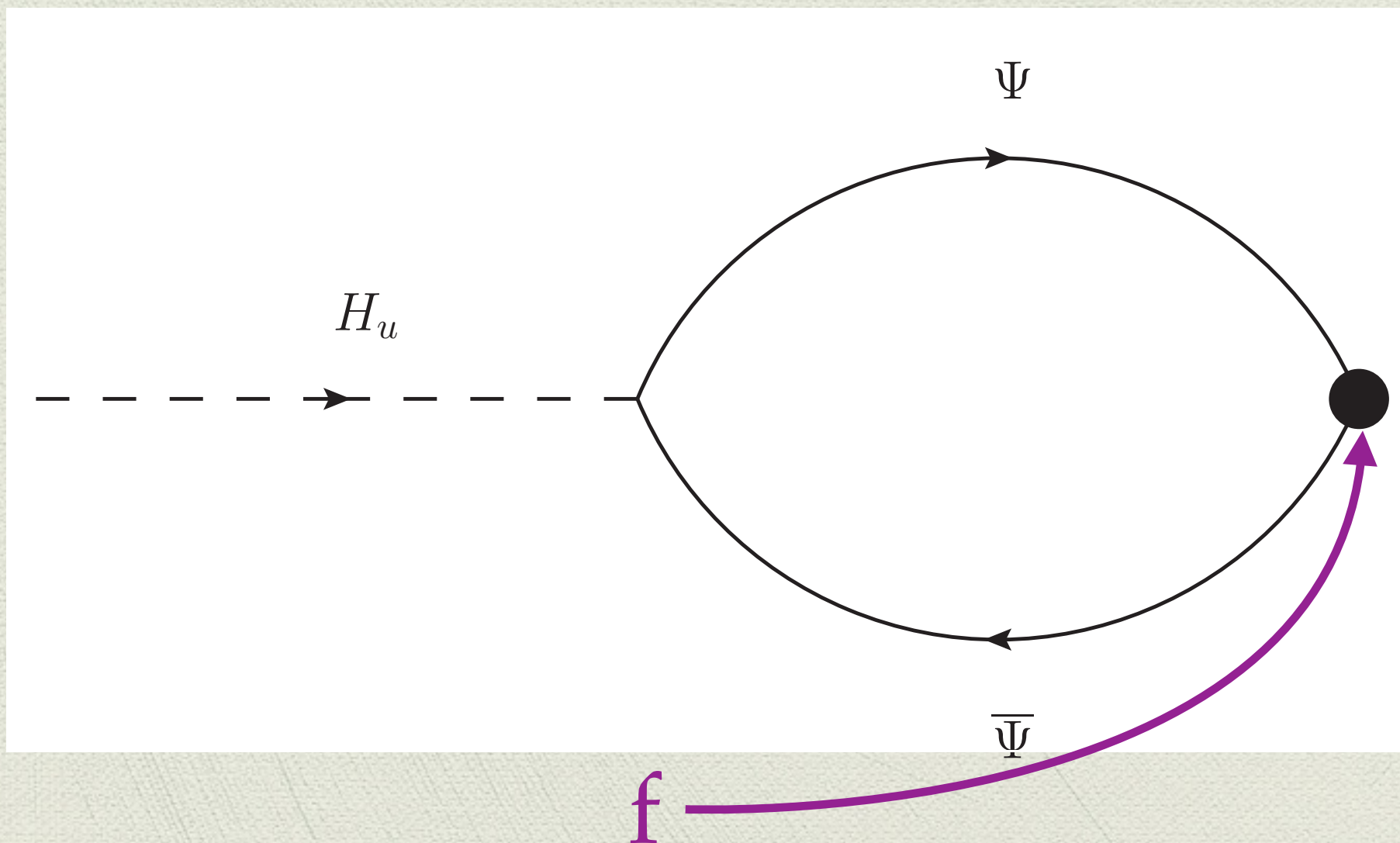


- ◆ Supersymmetry plus technicolor is an interesting combination
- ◆ If technicolor initiates EWSB at a scale $f \ll v$, can induce EWSB in elementary Higgs sector,
 $v_u, v_d \gg f$

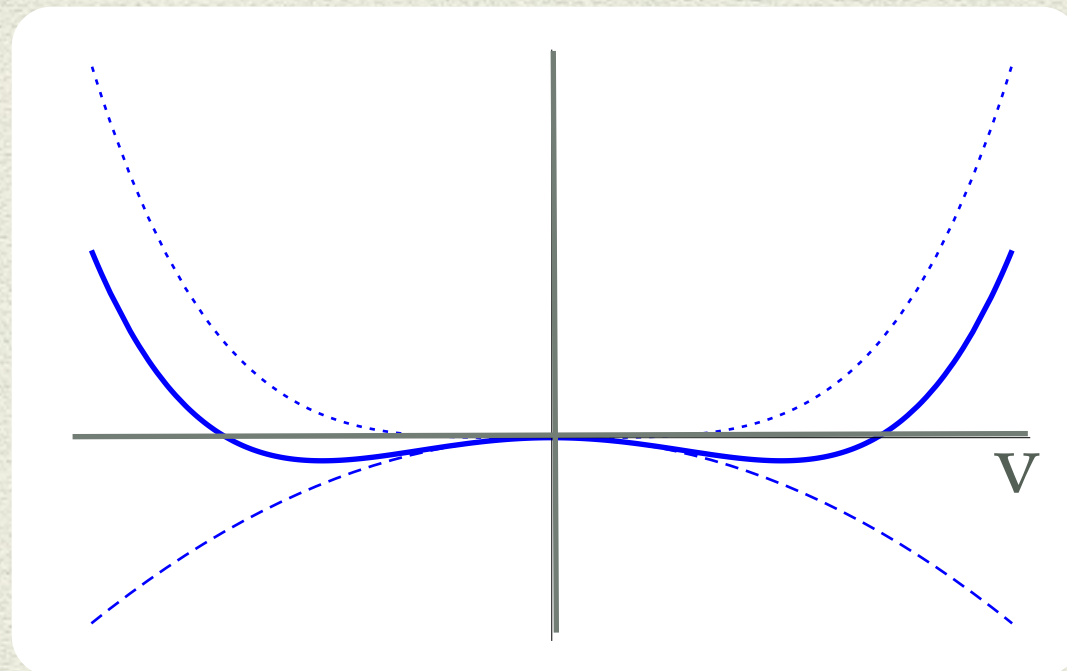
Combination considered since early 80's by
Dimopoulos, Raby
Dine, Fischler, Srednicki

Tadpole Couplings

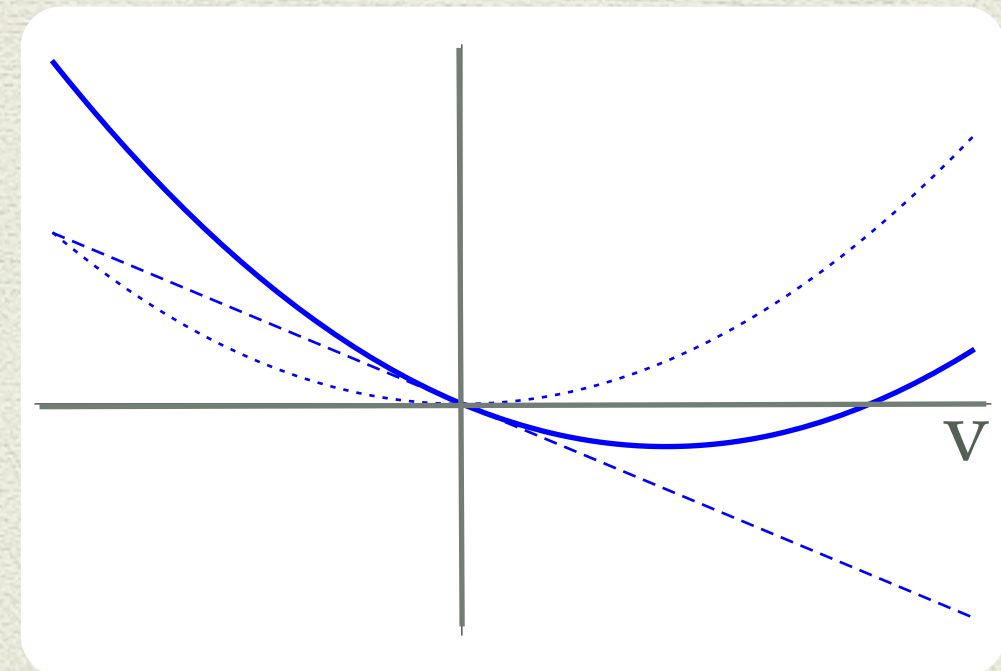
$$V \supset 4\pi f^3 \text{Tr} [\Sigma(\lambda_d H_d \lambda_u H_u)] + c.c.$$



Standard EWSB via Mexican Hat



Tilted EWSB induced by linear tadpole



Mechanism	Standard	Tadpole
Unstable/Stable Terms	Mass Term/Quartic	Linear Term/ Mass
Higgs Mass	2	M

Reasons to combine

- ◆ New source of contribution to Higgs mass
(SUSY little hierarchy problem)
- ◆ FCNCs safer than ETC
- ◆ PEWOs still require cancellations

Pseudoscalars

Due to multiple EWSB, there are would-be-Goldstones from MSSM Higgs as well as technicolor sector

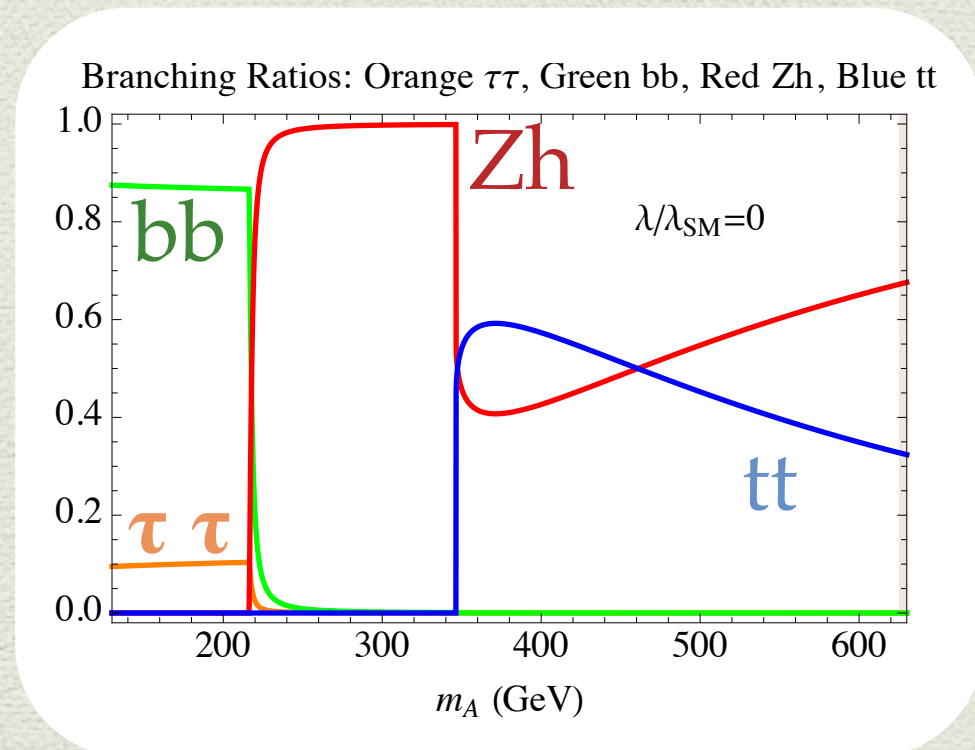
Nonzero coupling
to SM fermions
from mixing

$$A = \frac{f A_h - v A_{TC}}{\sqrt{v_h^2 + f^2}}$$

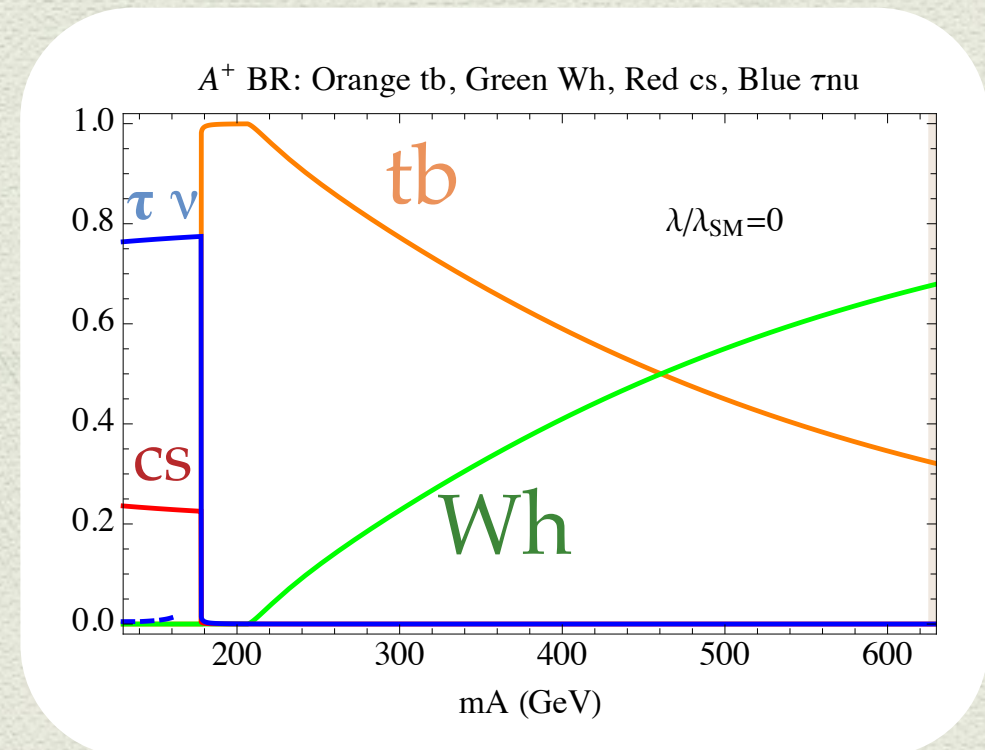
Remains nondecoupled
since coupling
raises Higgs mass

$$m_A = \frac{v}{f} \delta m_h < \frac{v}{f} 126 \text{ GeV}$$

Branching Ratios in Decoupling Limit



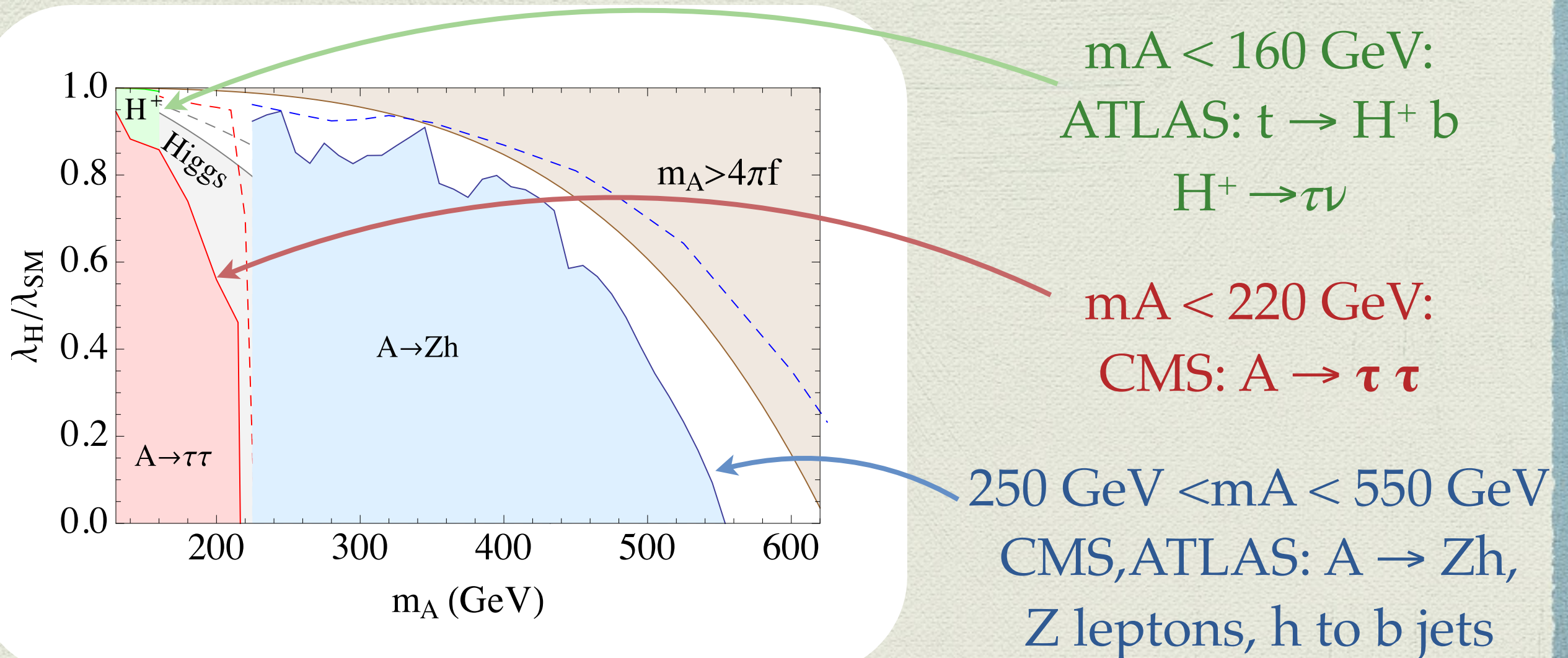
Neutral pseudoscalar BRs



Charged pseudoscalar BRs

Only weakly sensitive to elementary quartic coupling
Has a $\tan \beta = 1$ fermion structure

Pseudoscalar Constraints



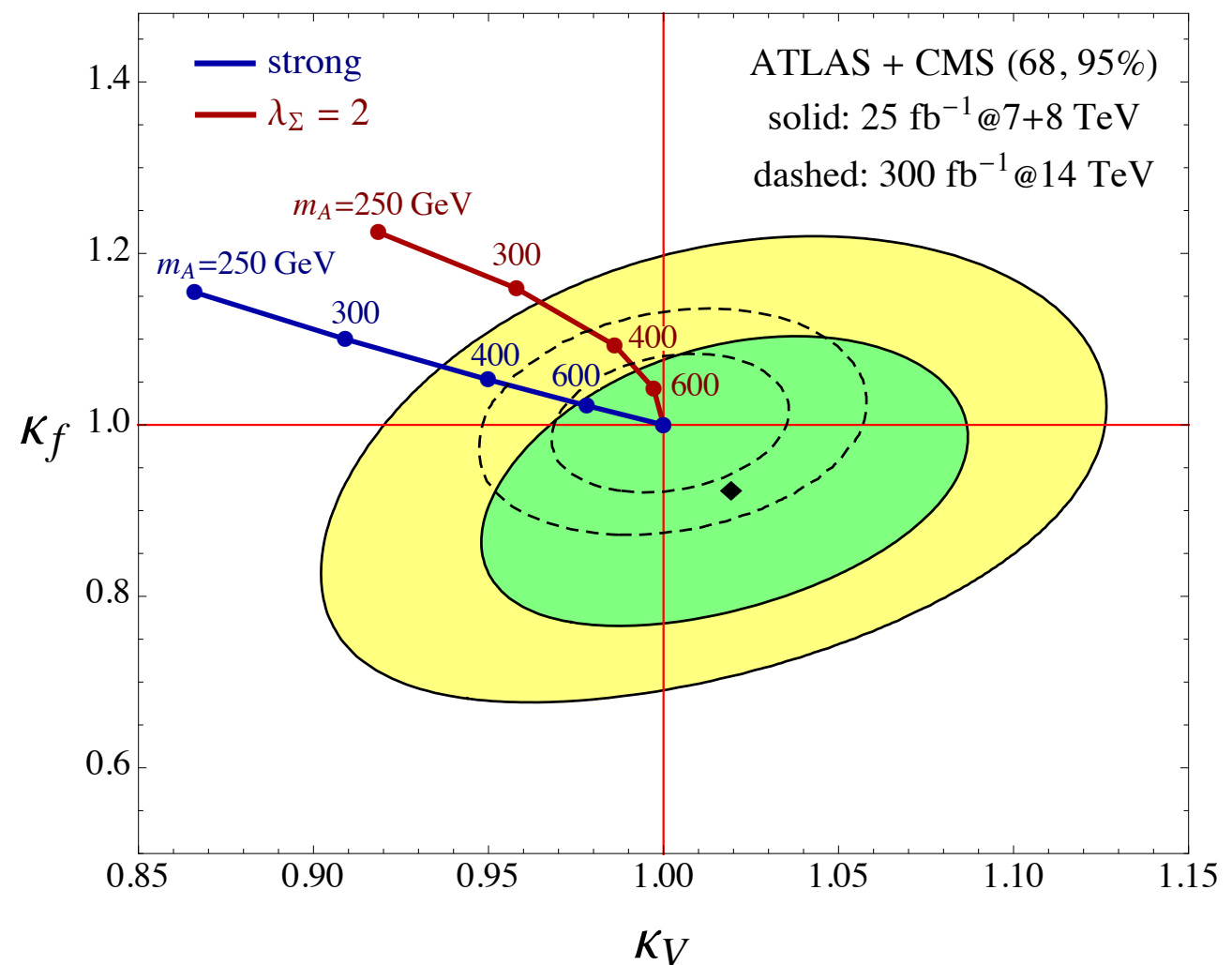
We project LHC14 w/ 300 fb^{-1} can cover the rest w/ tau and Zh search (dashed lines)

Higgs coupling constraint

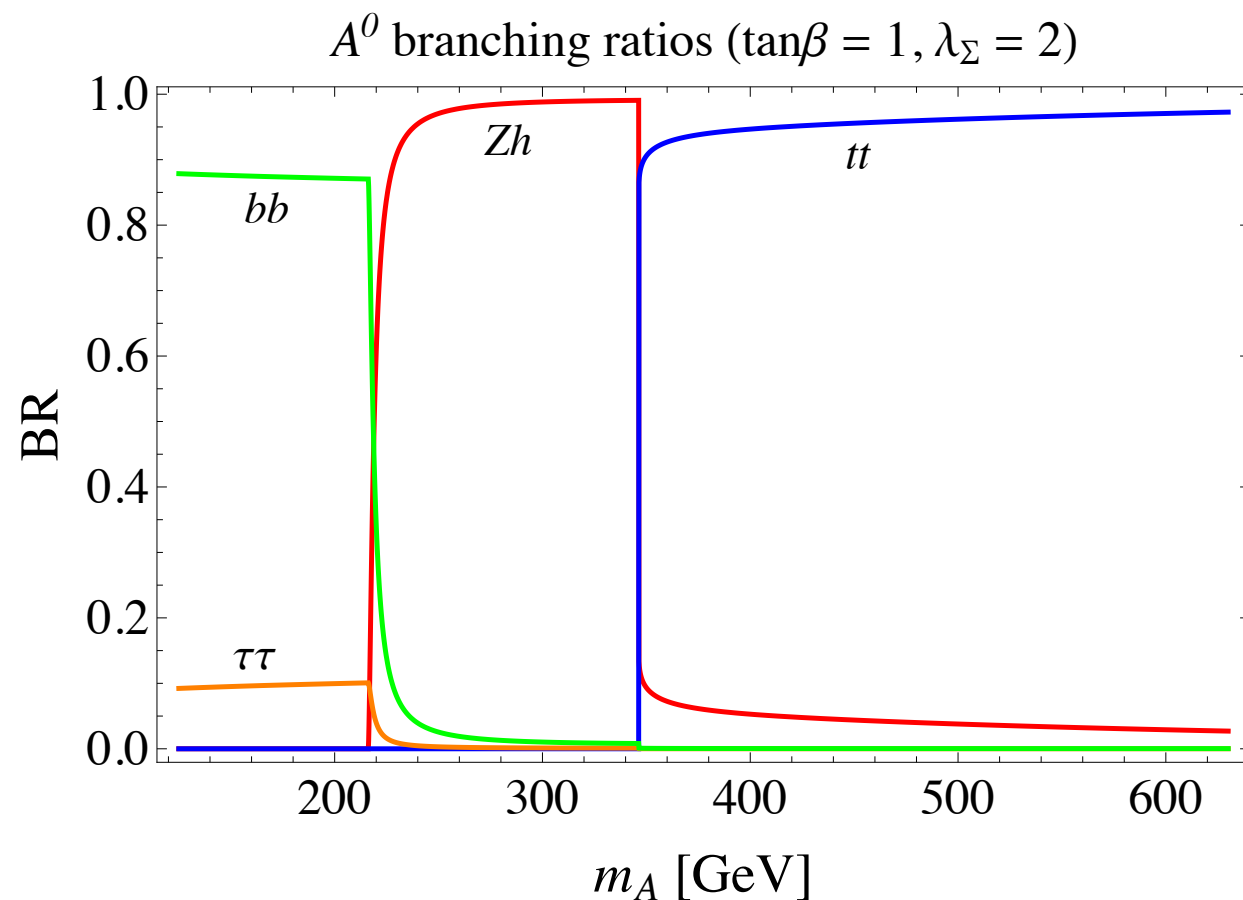
$$\kappa_V = 1/\kappa_f = \sqrt{1 - f^2/v^2}$$

Current limits are strong because they are on the wrong "side"

With Snowmass projection around SM value, limit only improves slightly



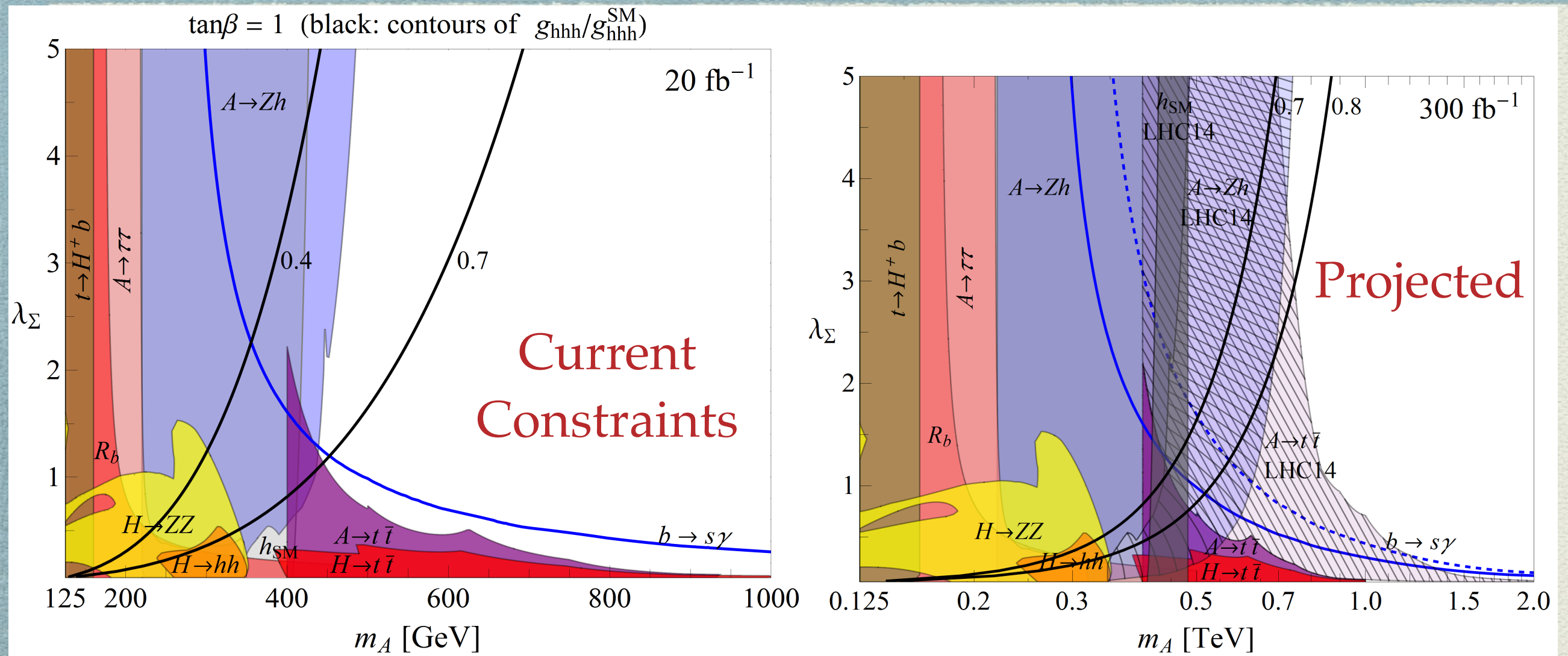
Induced EWSB w/ extra Higgs



A much larger tt BR
for Higgs case
(TC: tt was $\sim 50\%$)

Due to a cancellation in
 Zh coupling btw. both
Higgs doublets

Induced EWSB from doublet



Zh search is much weakened here, so
Run 2 top resonance search crucial at low m_A
to cover this parameter space

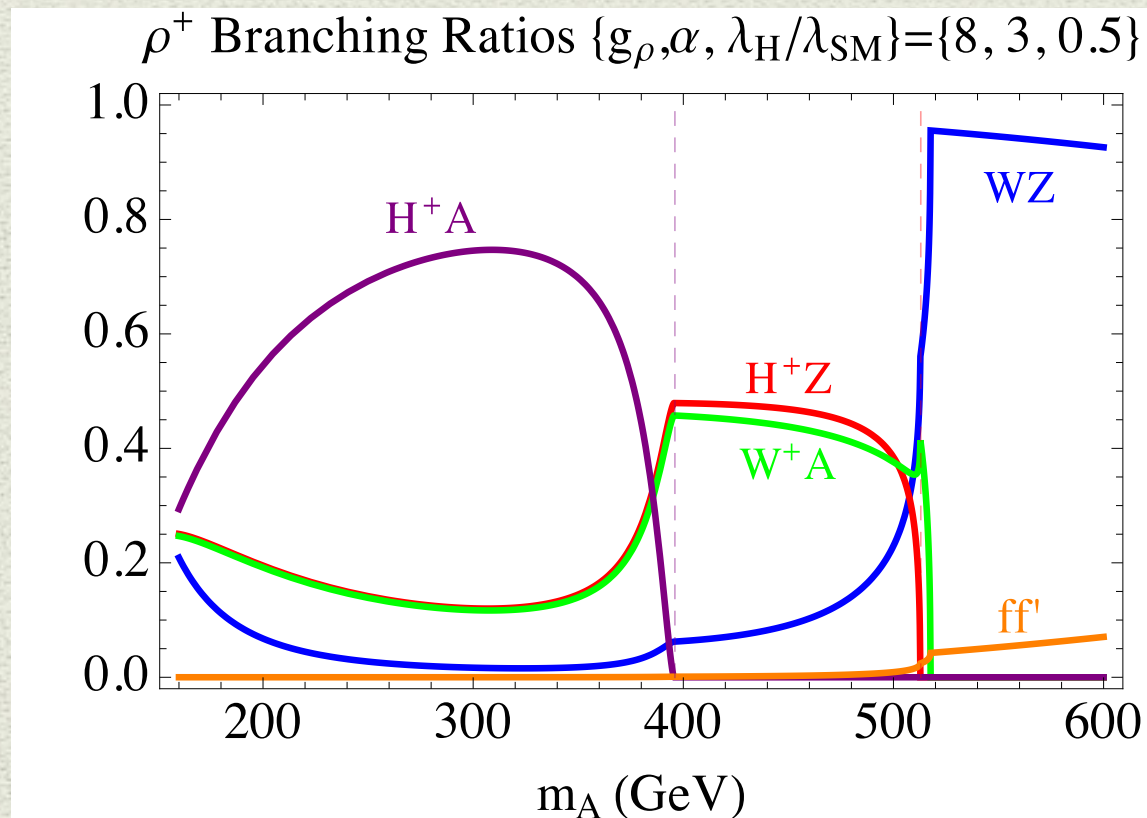
Some Model Dependent Pheno

Technirhos

Many possible decay channels due to low mass states

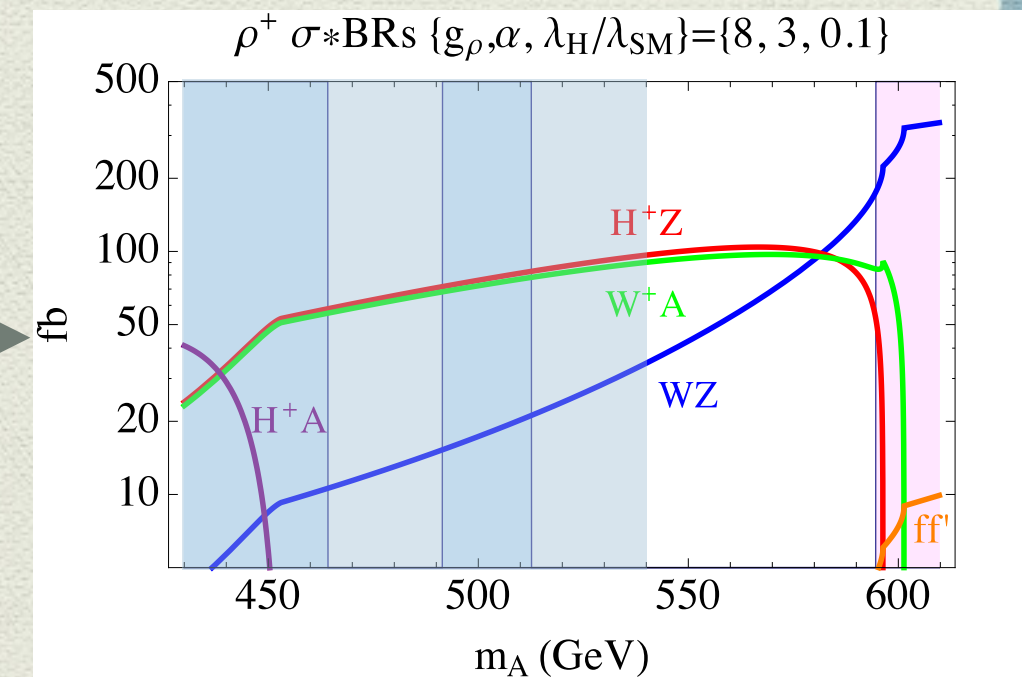
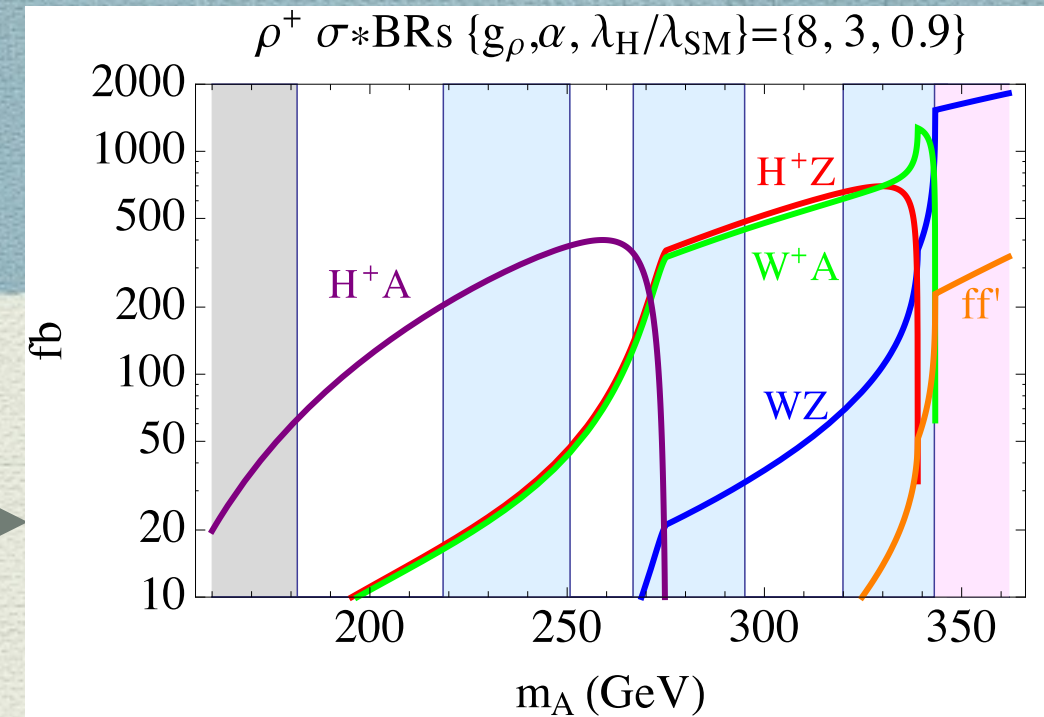
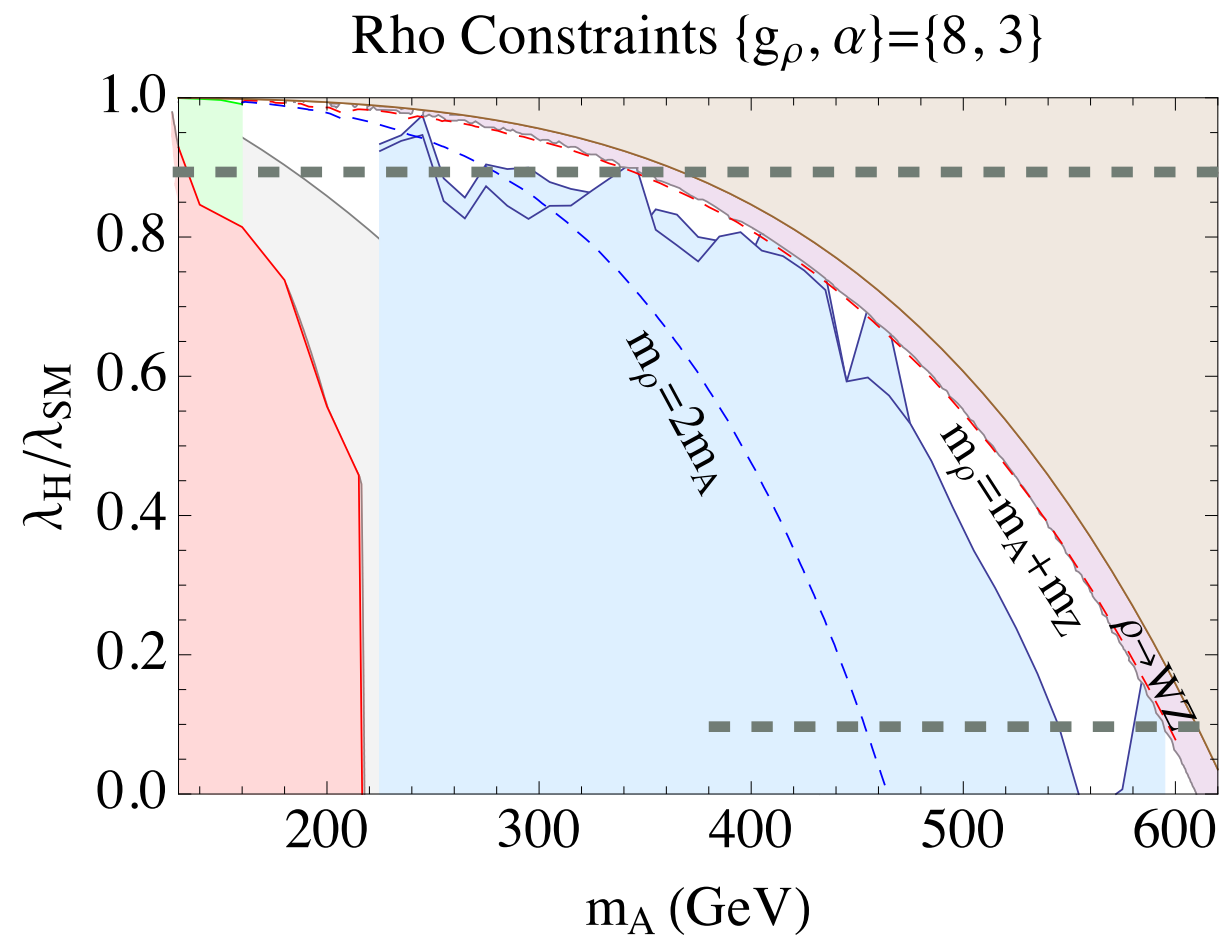
$$pp \rightarrow \rho^+ \rightarrow W^+ Z, H^+ A^0, H^+ Z, W^+ A^0$$

Once kinematically open, technirhos decay into pseudos



Naturally leads to
longer cascades, not
directly
being searched for

14 TeV Pheno



Traditional WZ search is strong until rho can decay into pseudos

For low mass A: $\rho^+ \rightarrow H^+ A^0 \rightarrow (t\bar{b}, W^+ h)(Zh, b\bar{b})$

Dibosons

Heavy vectors common in the technicolor or non-decoupling D-term models but prefer to go into pseudoscalars, not W,Z

TC model difficulties - Light ρ and A
 $m_\rho < 4\pi f < 2 \text{ TeV}$; TeV A requires
slightly larger cutoff $2.6 \times (4\pi f)$

Non-decoupling D-term - much more promising
since heavy pseudos are not linked to strong
coupling, ρ mass decoupled from f

Conclusion

- ◆ Modifications of EWSB still allowed
- ◆ Higgs potential can be changed w/ induced EWSB (e.g. Higgs trilinear suppressed)
- ◆ Examples: SUSY + technicolor or extra Higgs doublets
- ◆ SUSY+TC probed by ρ and $A \rightarrow Zh, \tau\tau$; SUSY + doublets probed by $A \rightarrow tt$ (and dibosons possible)

Thanks!!!!