Light Charged Higgs Bosons in Two-Higgs Doublet Models

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Unanswered Questions

Higgs mass?

Neutrino oscillations?

?

Dark Matter?

And others…

New models often predict additional Higgs bosons

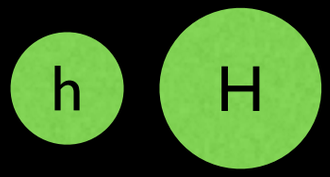
New models often predict additional Higgs bosons

Two Higgs Doublet Models

MSSM NMSSM

Higgs bosons in Two-Higgs Doublet Model

CP-even scalars



CP-odd pseudoscalar

Charged Higgs Boson

Higgs bosons in Two-Higgs Doublet Model

CP-even scalars

h H

CP-odd pseudoscalar

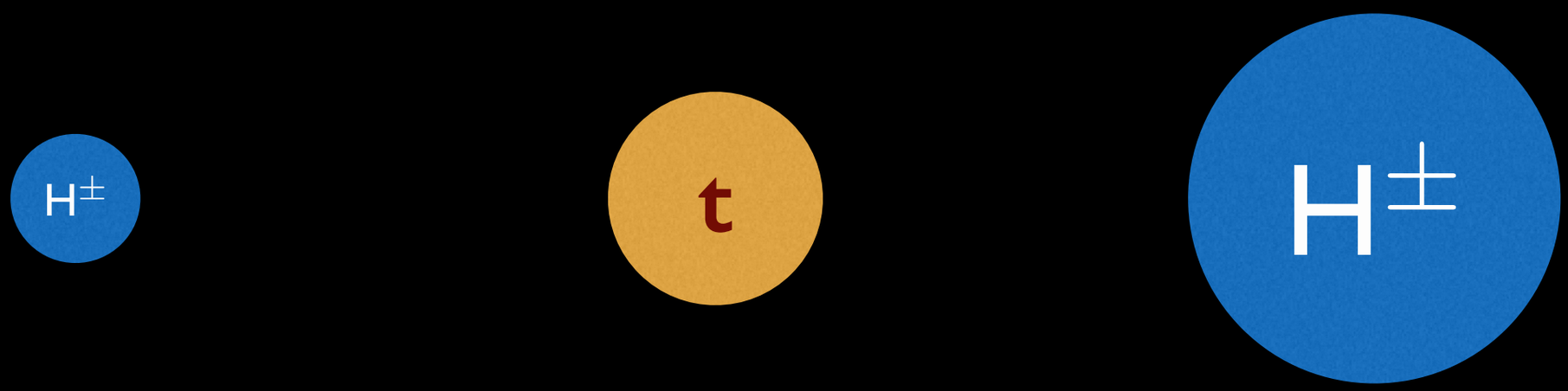
A^0

Charged Higgs Boson

$H^{\pm}$

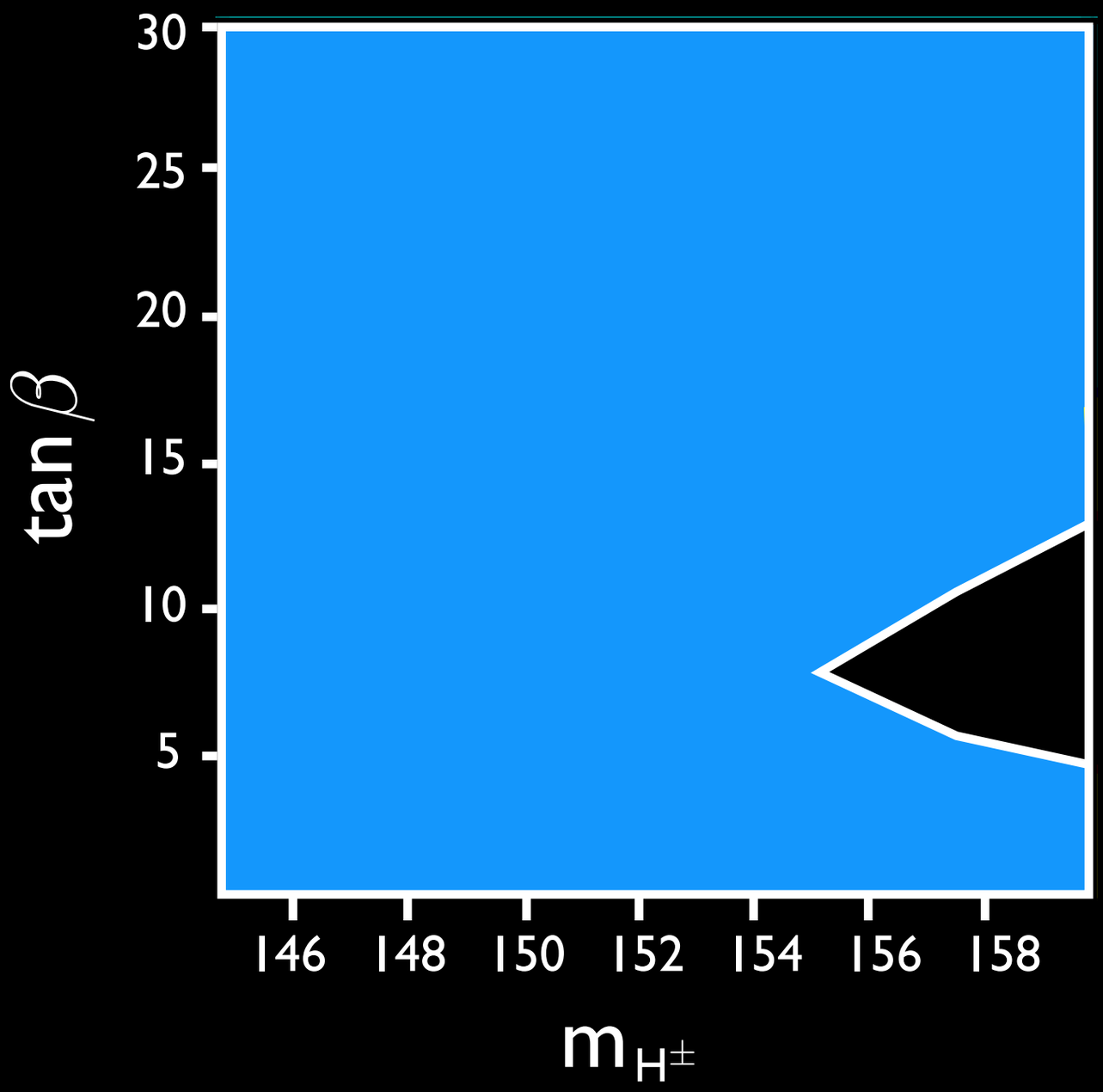
Focus of this talk

Charged Higgs Challenges



Light (< 174 GeV)		Heavy (> 174 GeV)
✓	Soft final state particles	
	Off-shell production - rare	✓
✓	Cleaner leptonic decays suppressed	✓

Current Limits on Light Charged Higgs

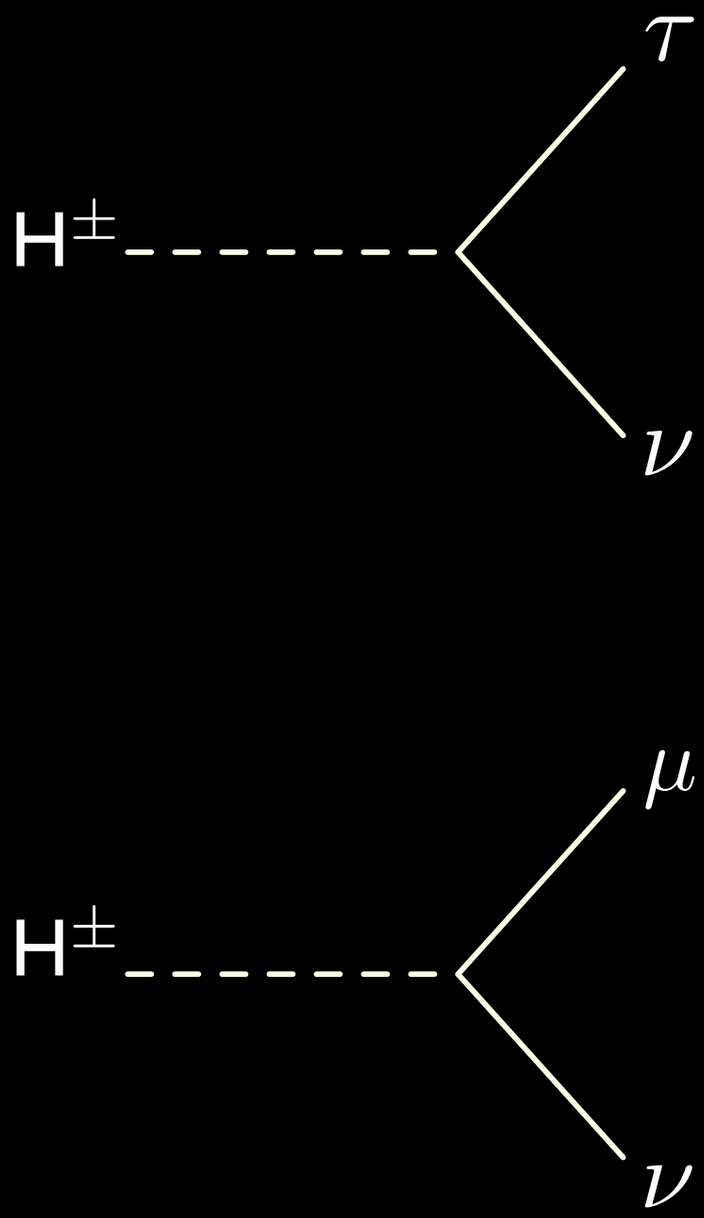


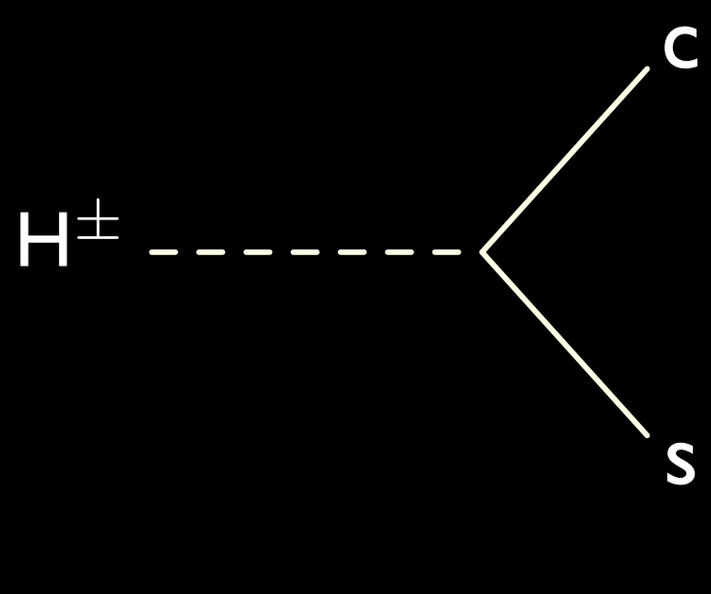
Excluded, assuming

$BR(H^{\pm} \to \tau\nu) = 100\%$

Source:
CMS Analysis, September 2014

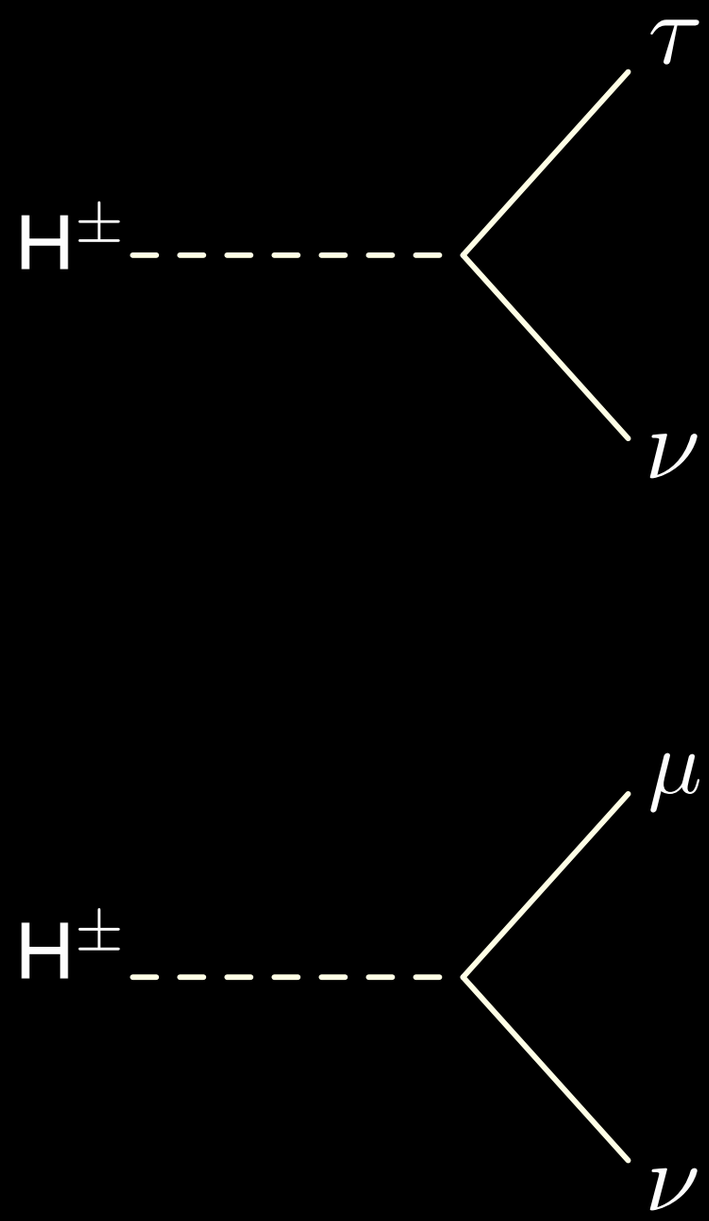
Primary decay modes of the Light Charged Higgs

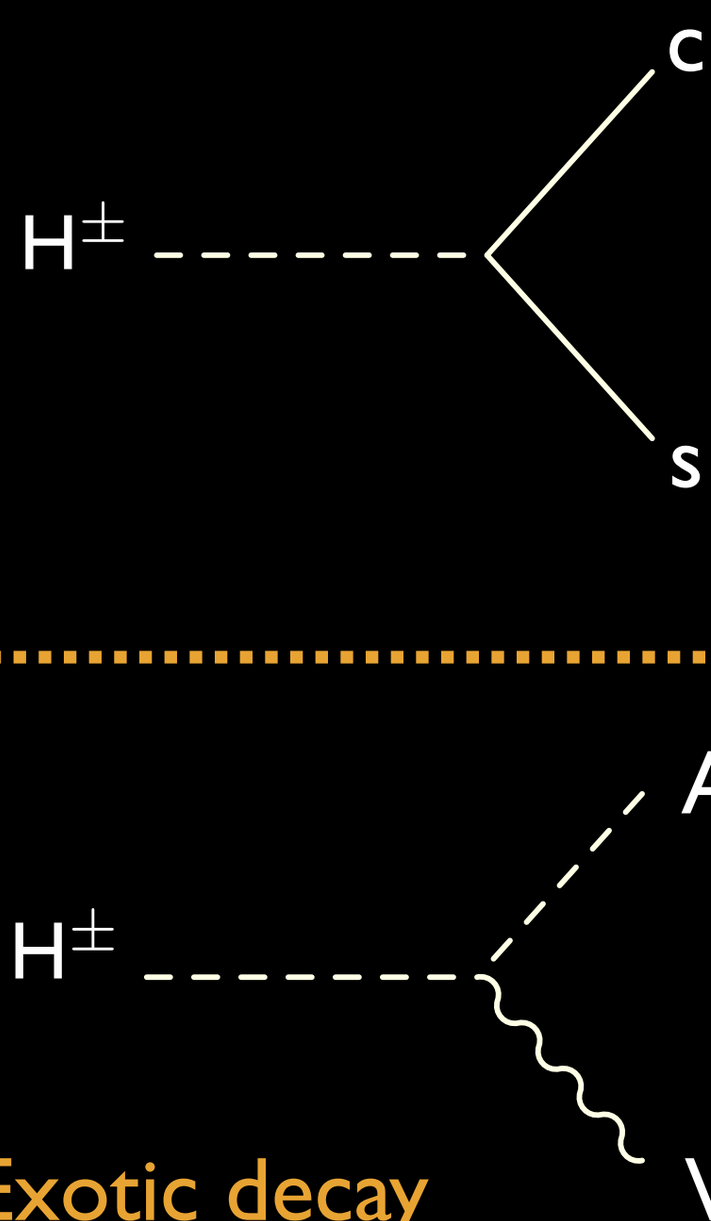




Decays to Standard Model particles

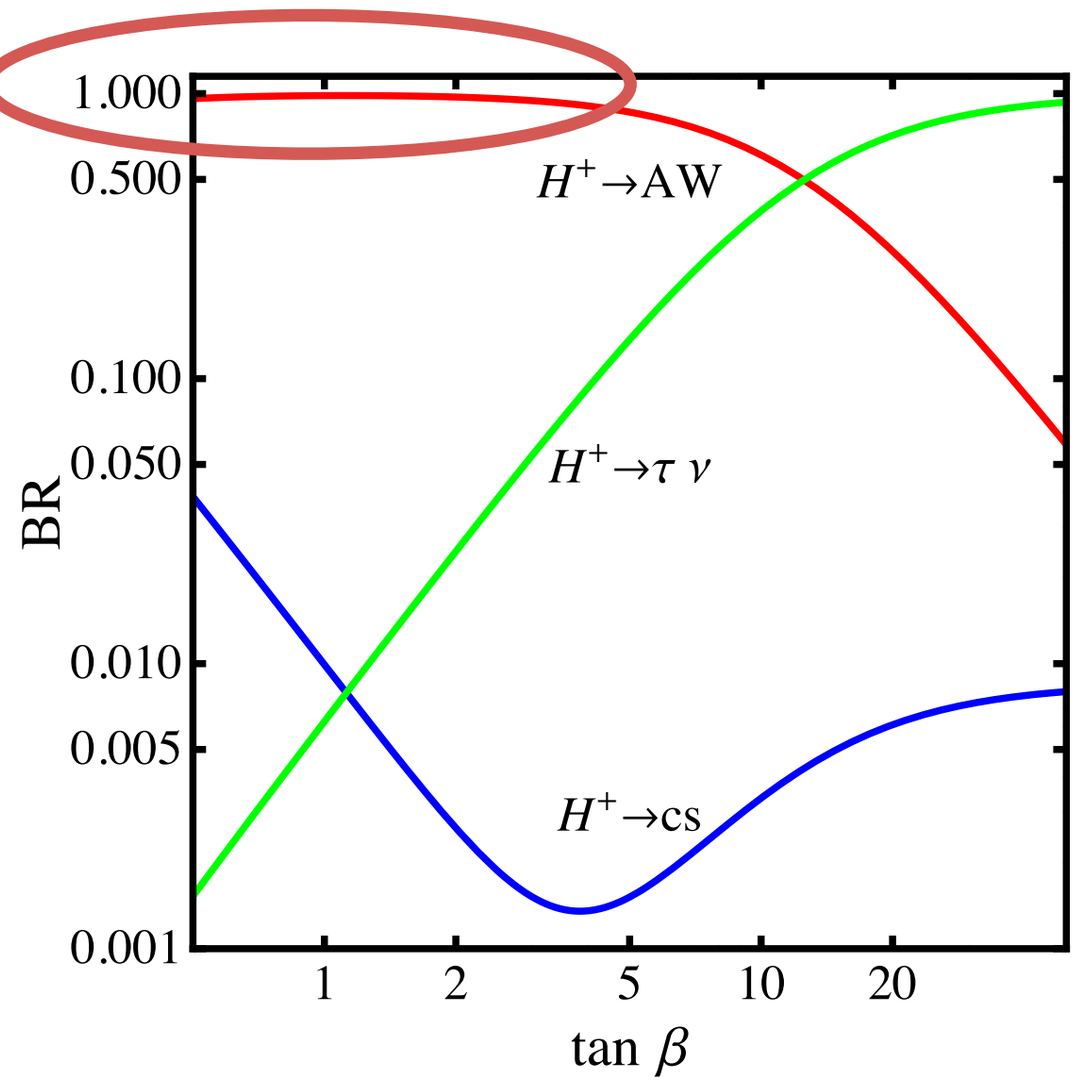
Primary decay modes of the Light Charged Higgs



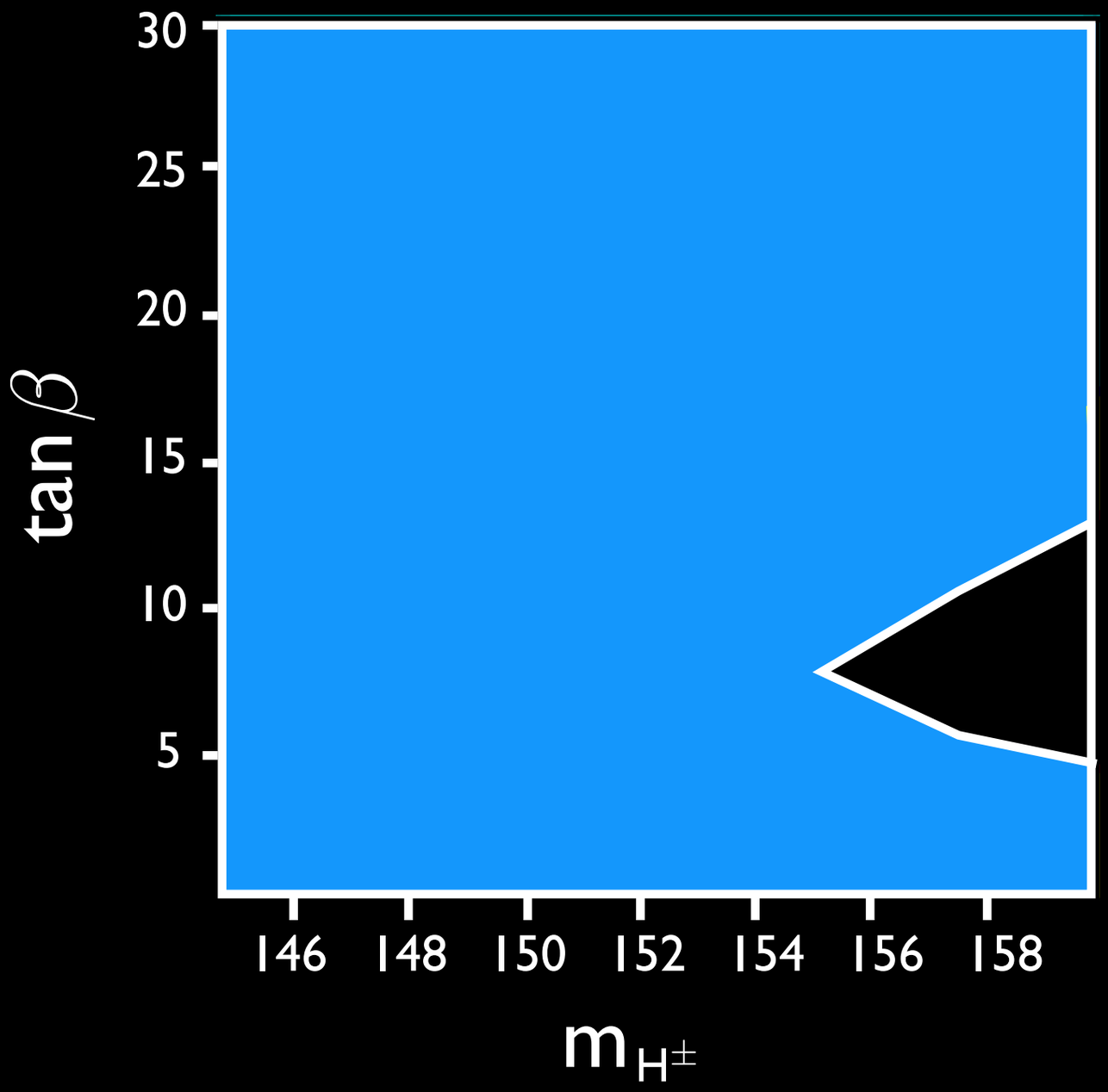


Branching Ratios

Exotic decay dominates for low tan β



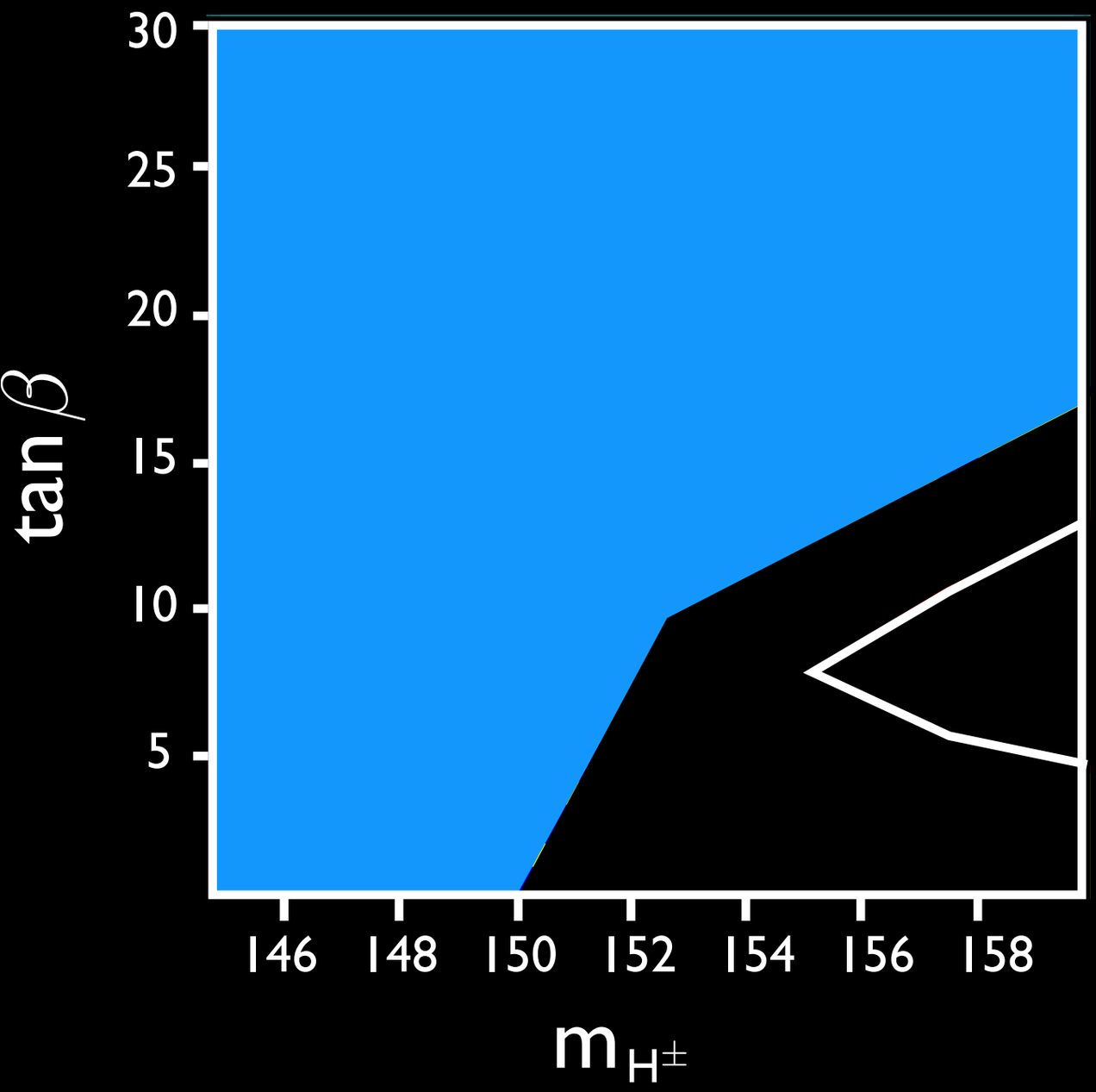
Current Limits



Excluded, assuming

$BR(H^{\pm} \to \tau\nu) = 100\%$

Relaxed Limits

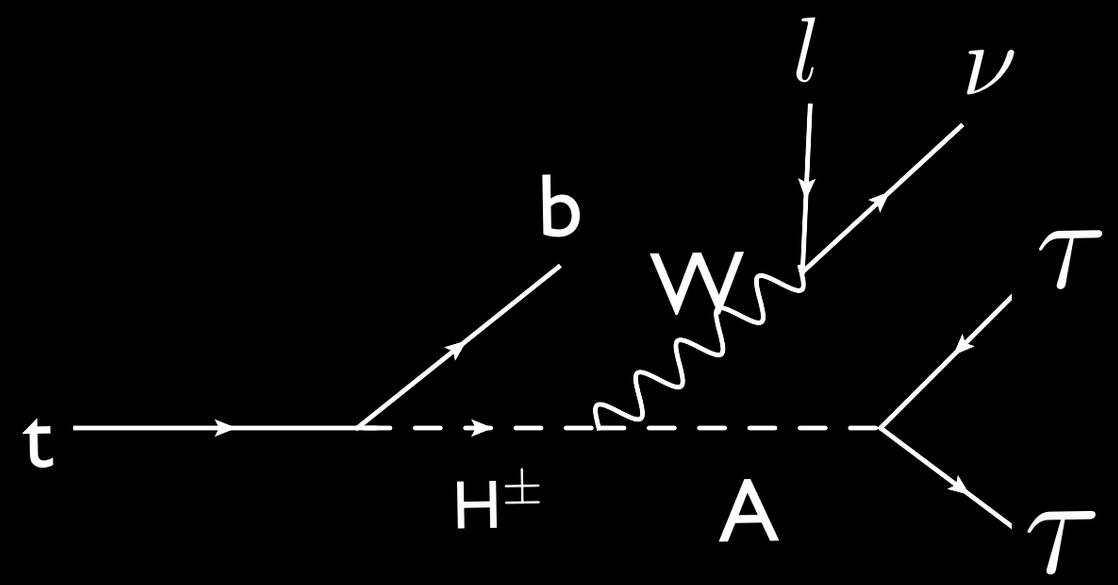


Excluded, if

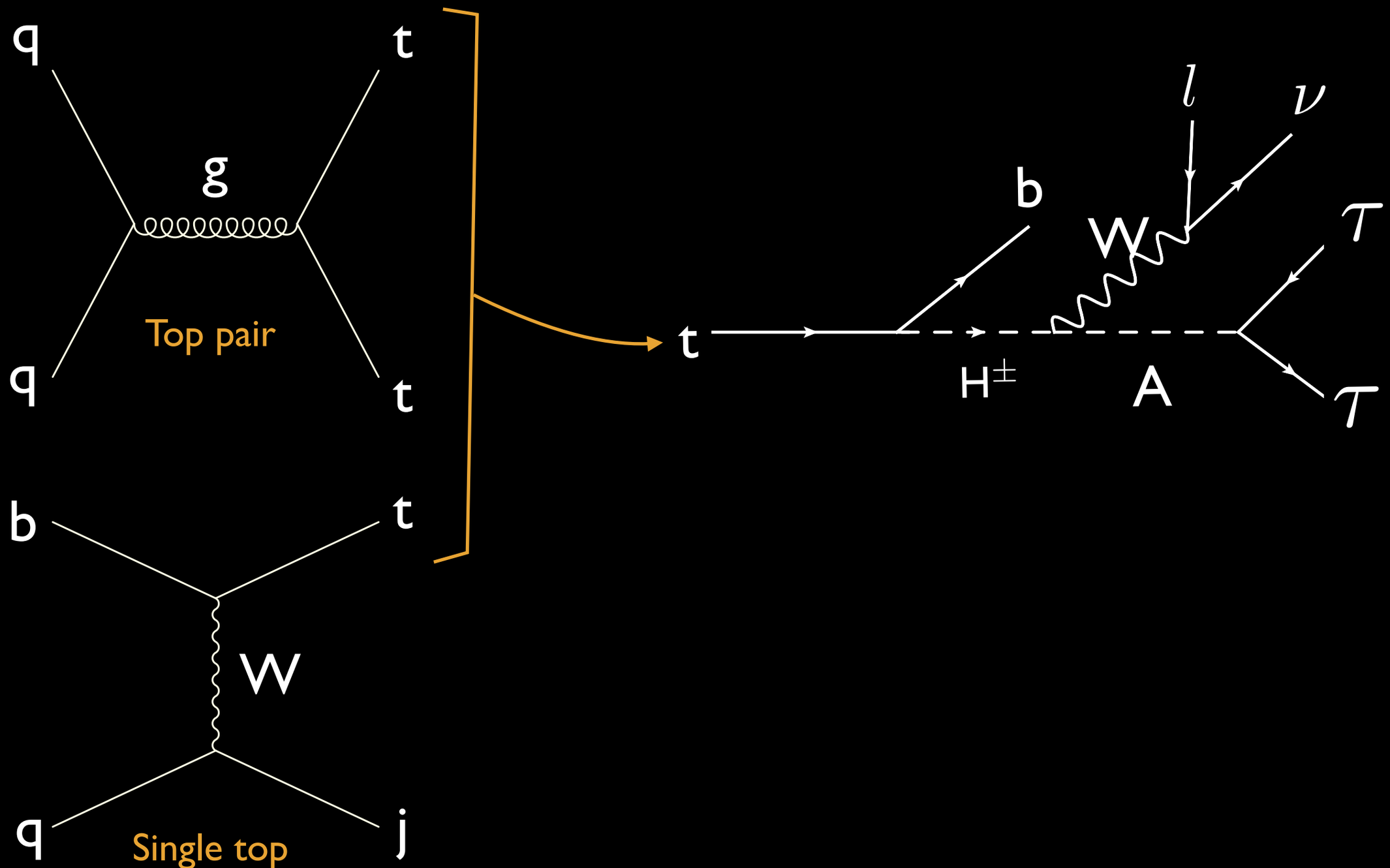
$H^{\pm} \rightarrow AW$ is possible

(Assuming existence of A with mass 70 GeV)

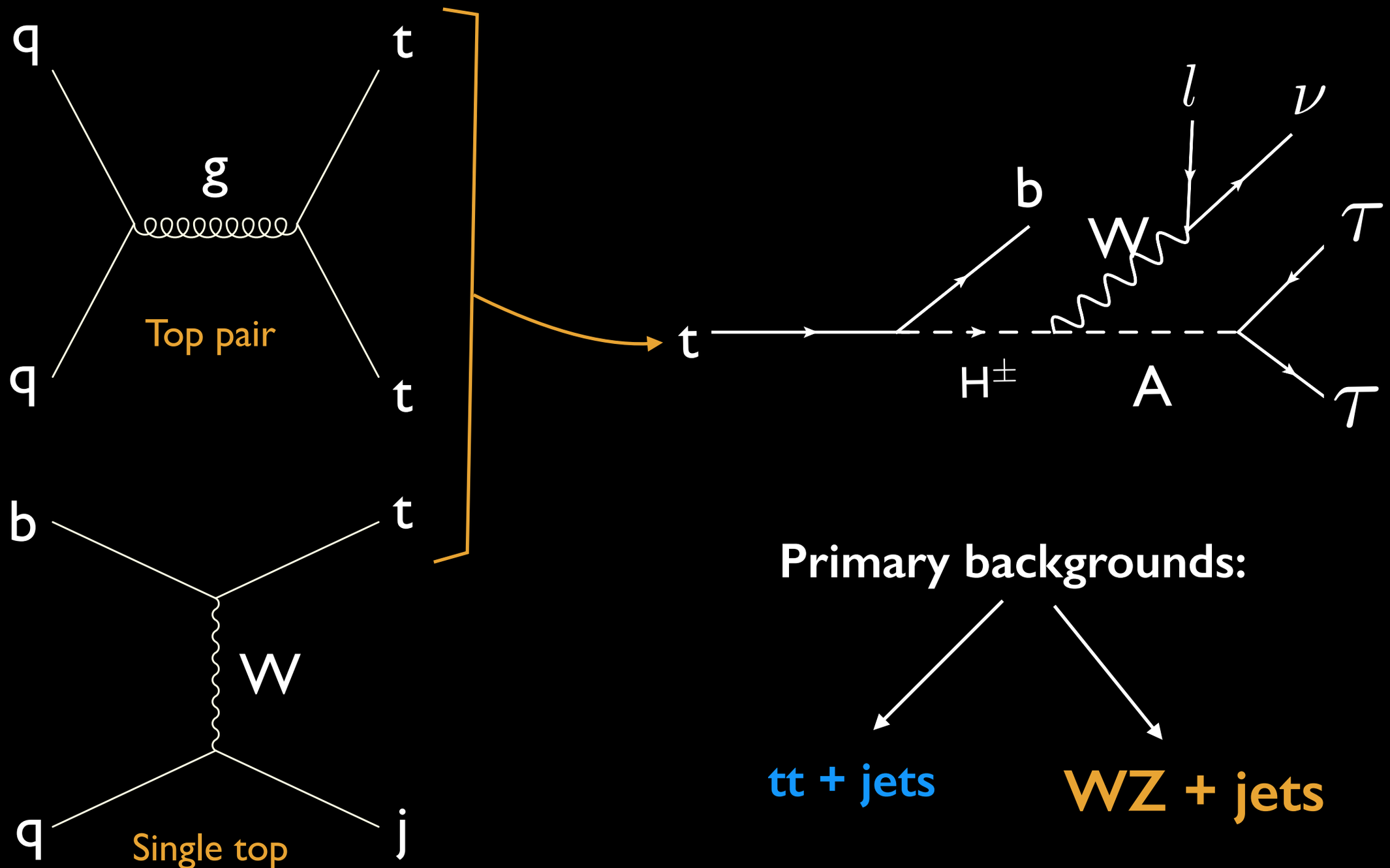
Our search channel



Our search channel



Our search channel

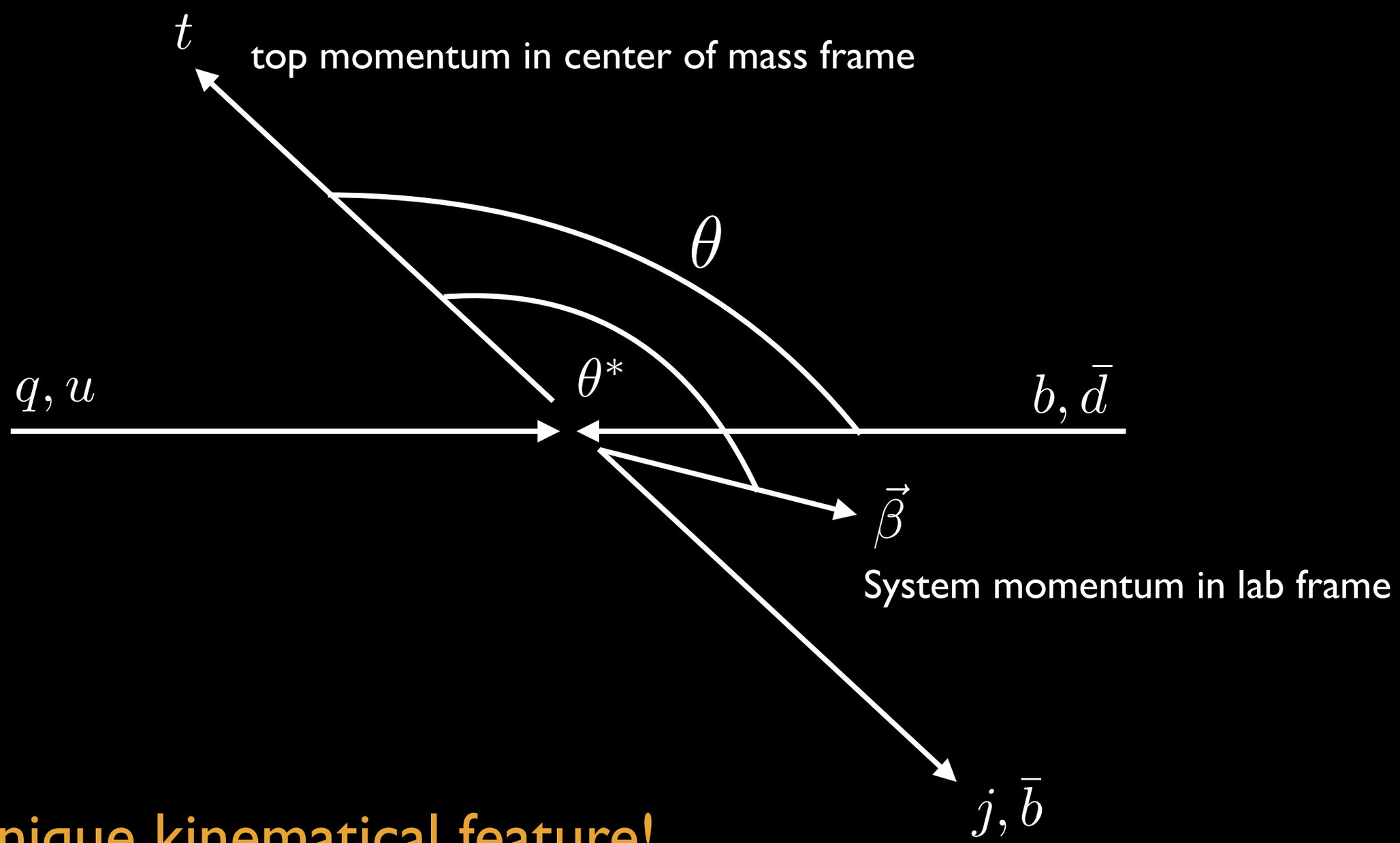


Primary backgrounds:

tt + jets

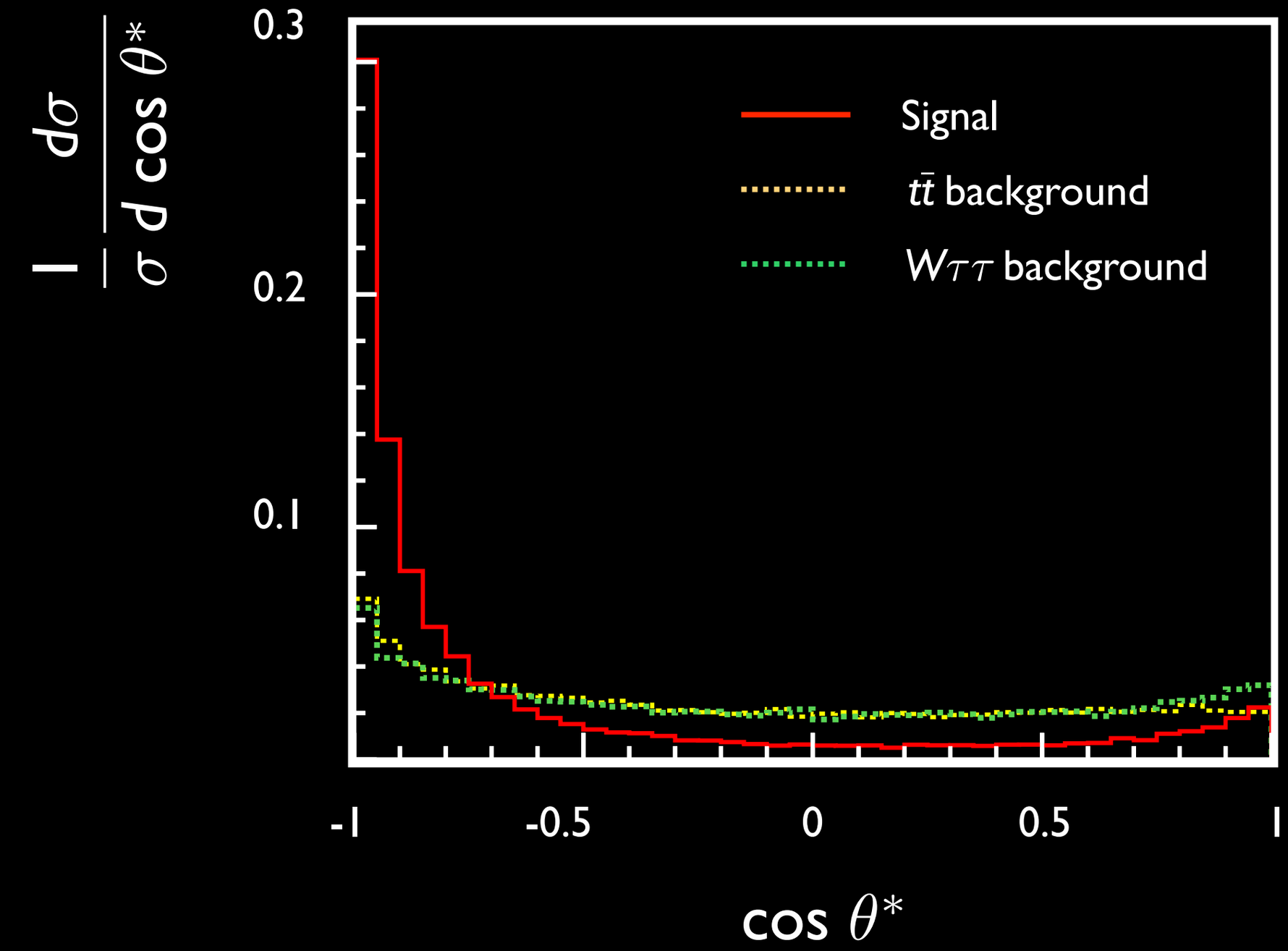
WZ + jets

Angular Correlations in Single Top Production

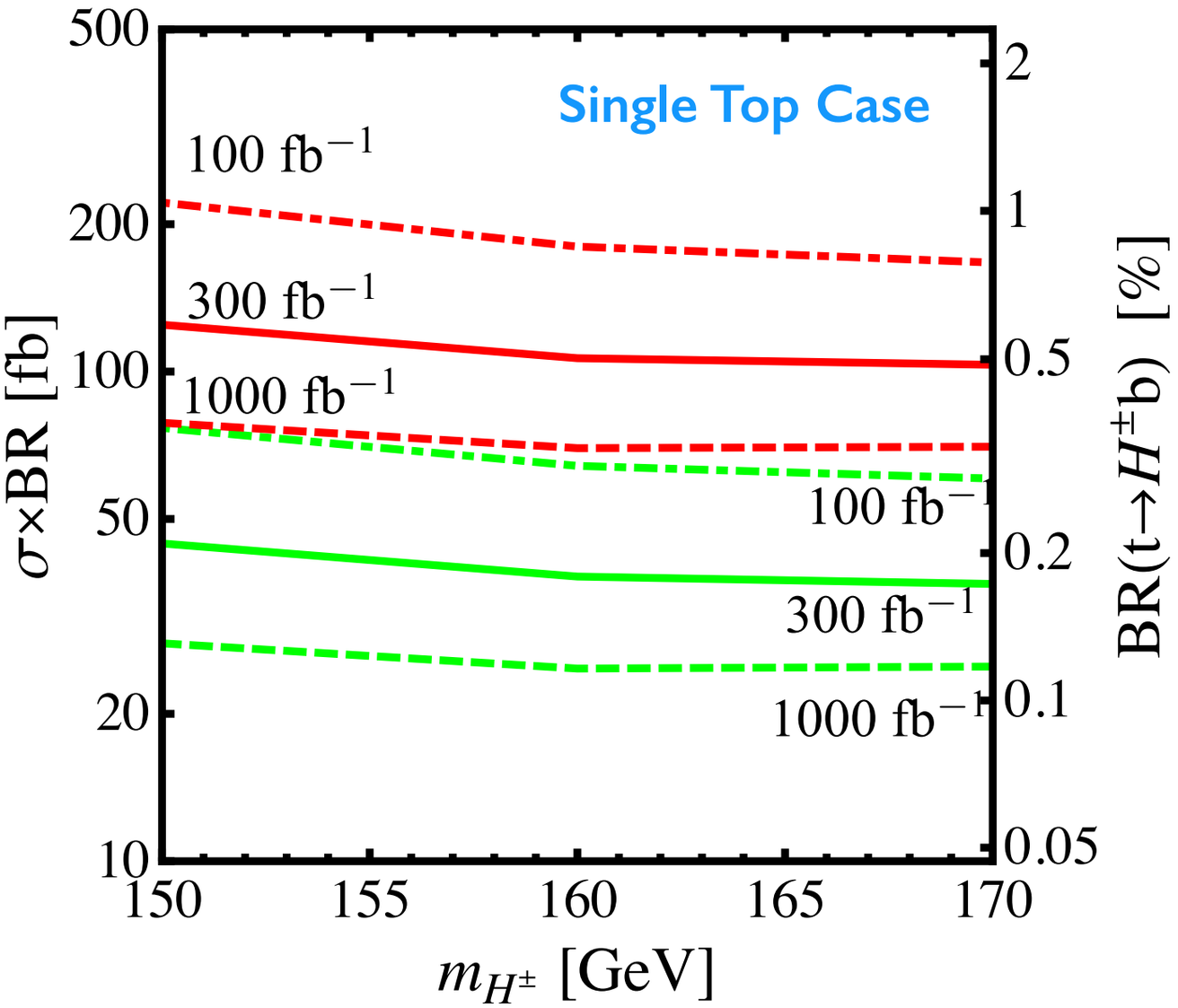


A unique kinematical feature!

Angular distribution - Signal vs. Background



Model-independent Limits



Red: Discovery

Green: Exclusion

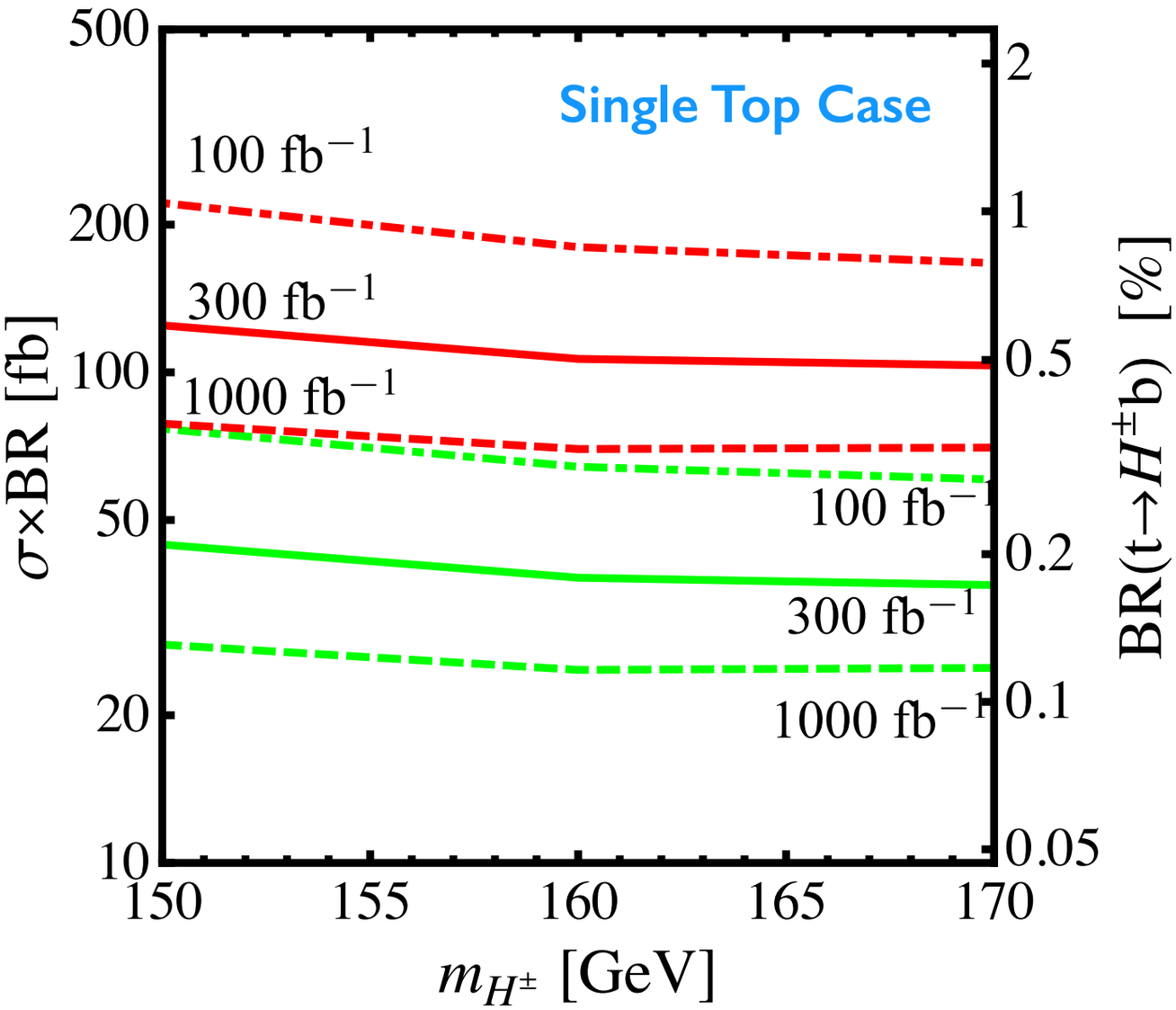
@ 14 TeV LHC

More data

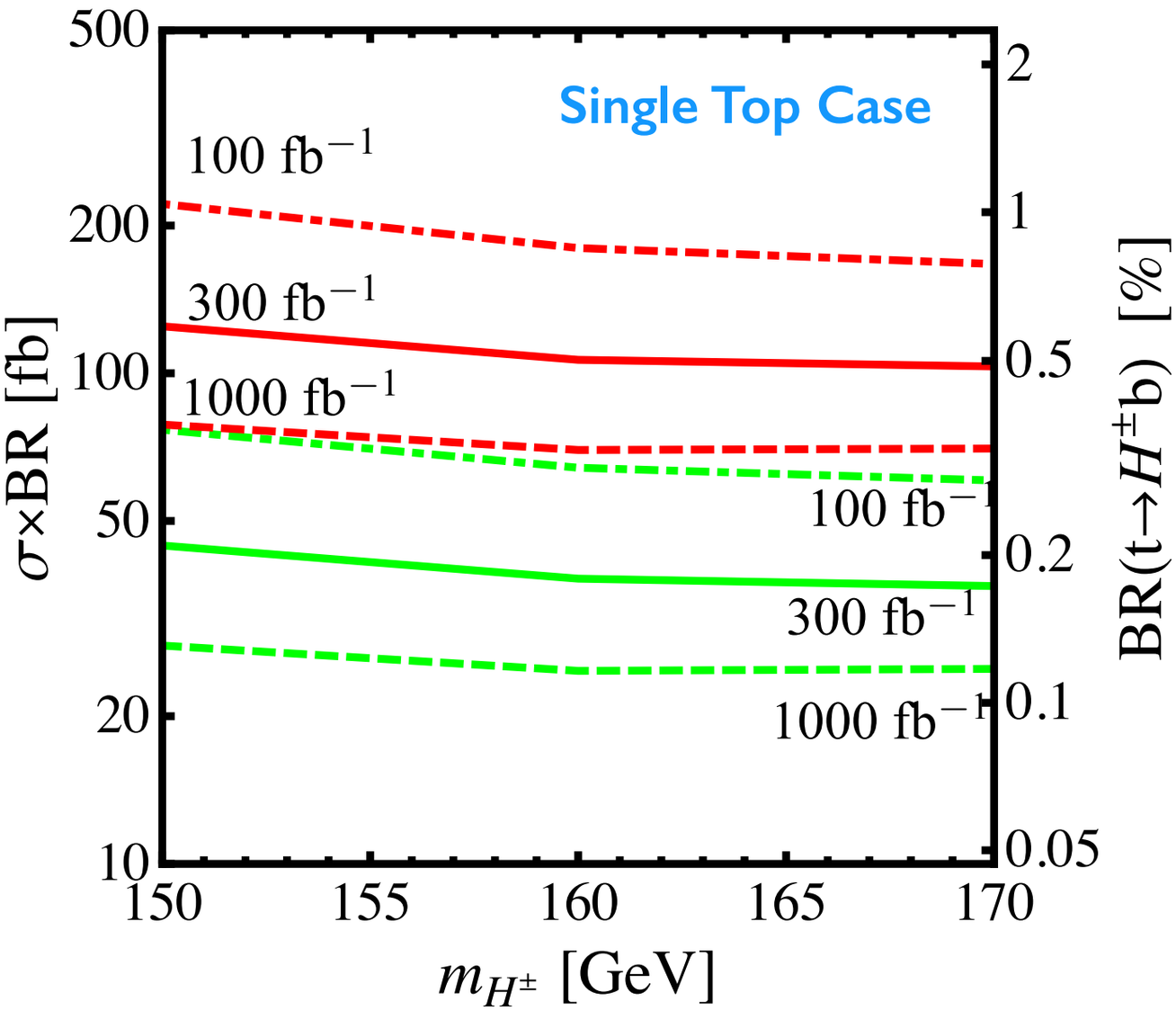
↓

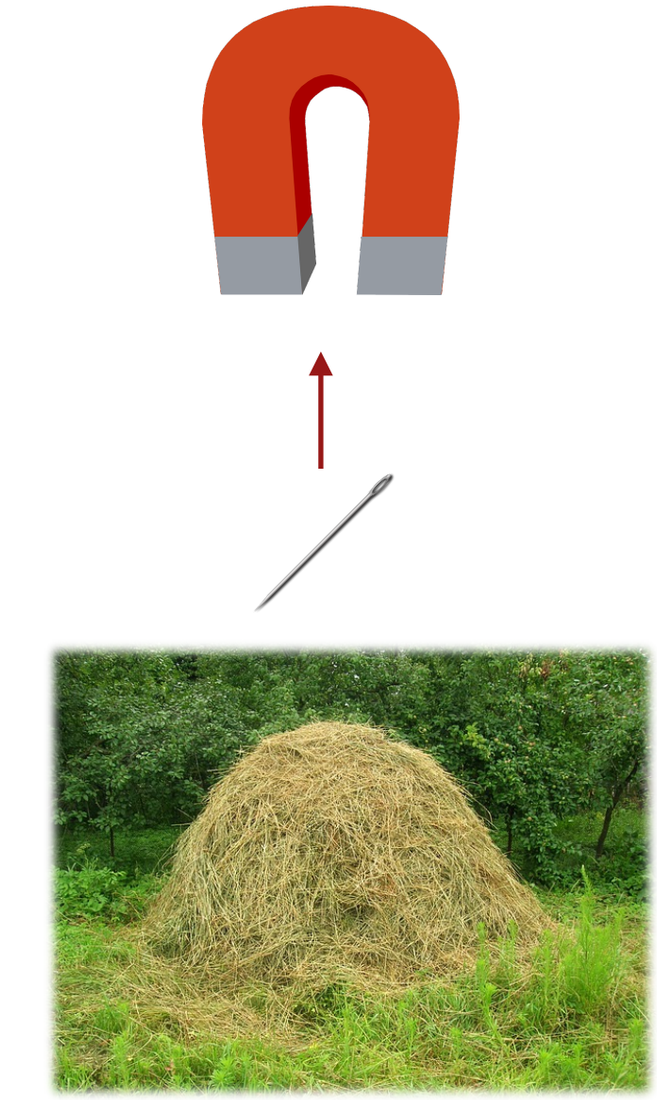
Stronger bounds!

Model-independent Limits

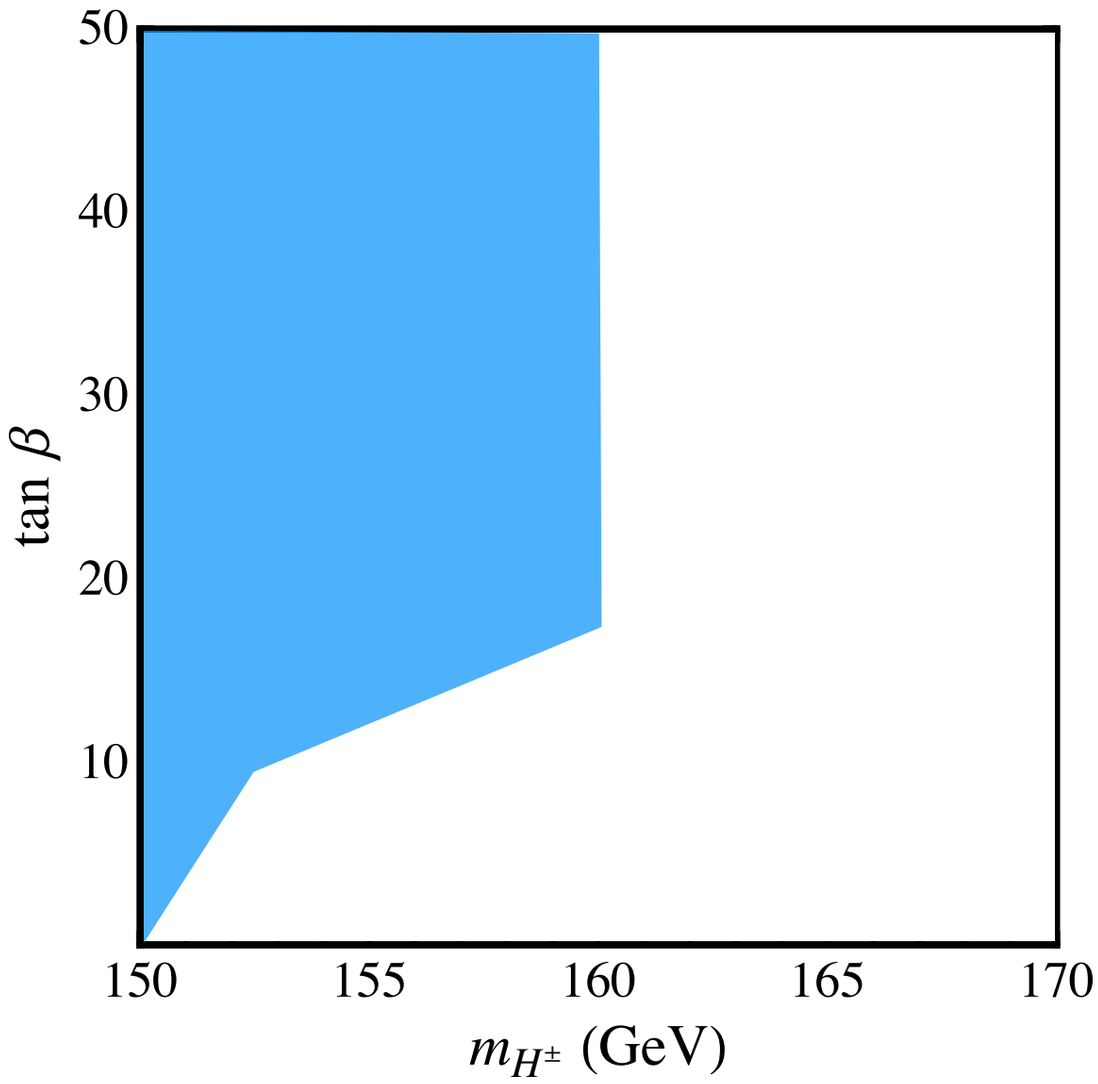


Model-independent Limits



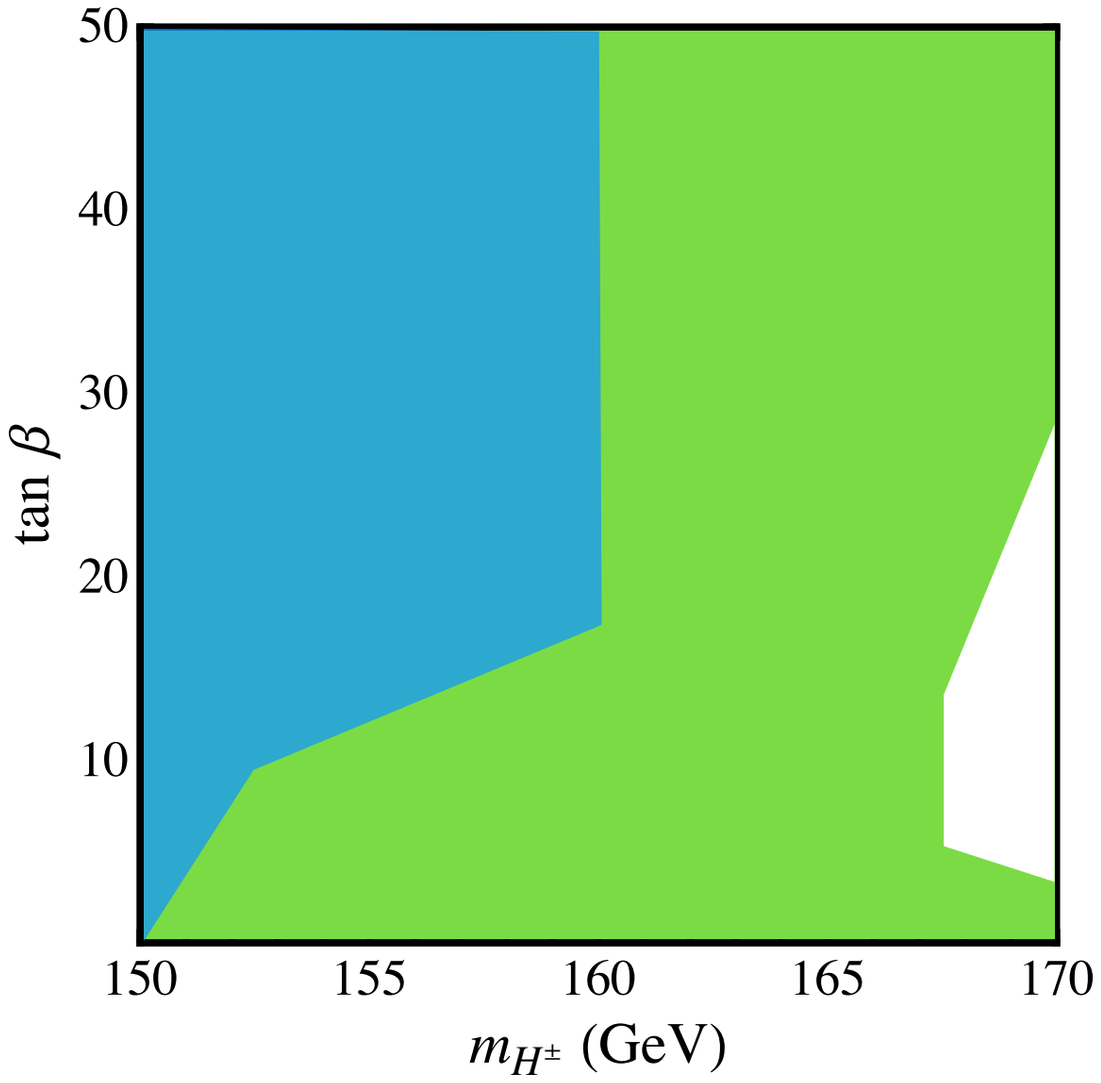


2HDM Implications



Excluded by CMS @ 20 fb-1

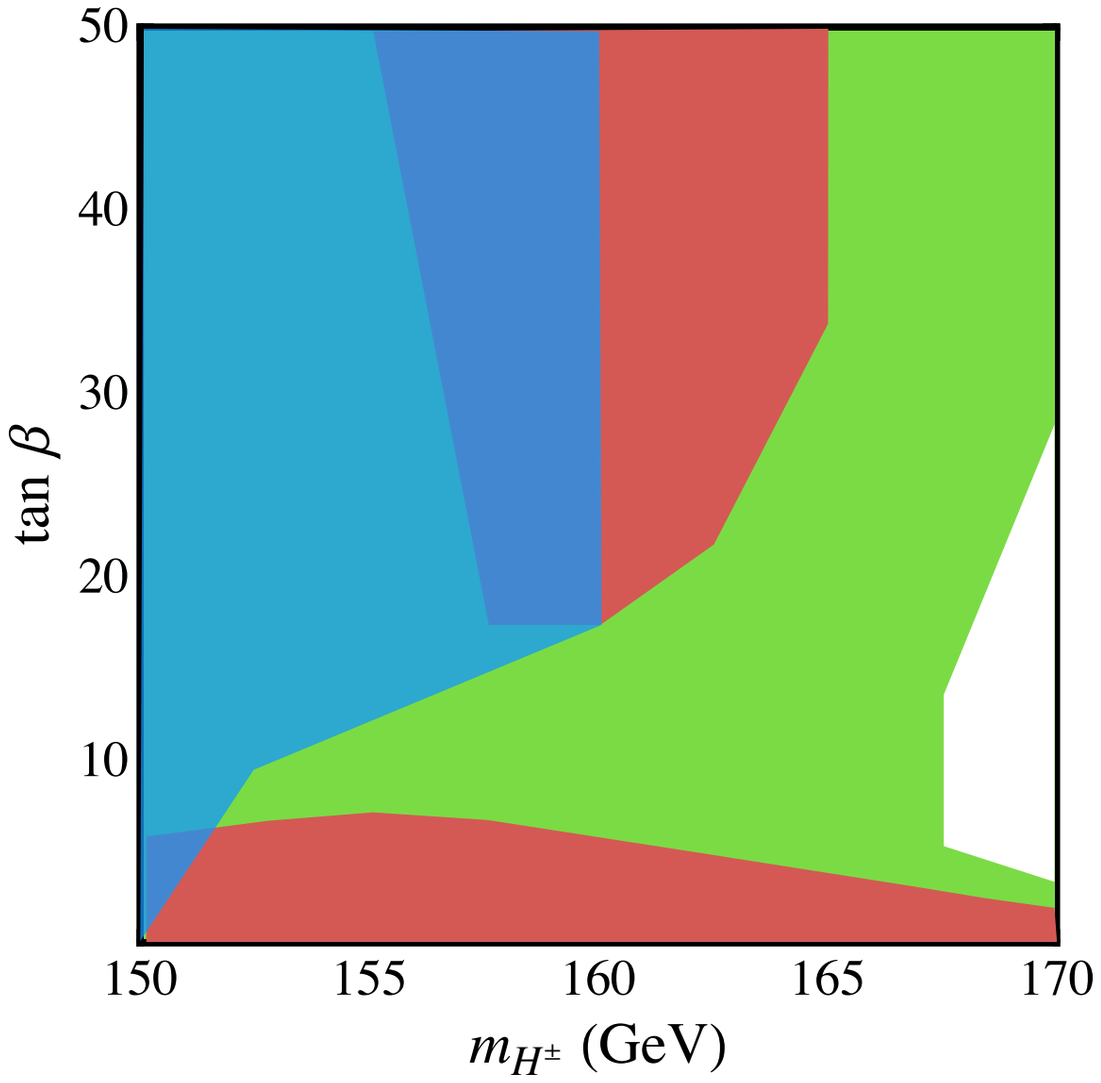
2HDM Implications



Excluded by CMS @ 20 fb-1

Can be excluded using our search strategy at 300 fb-1

2HDM Implications



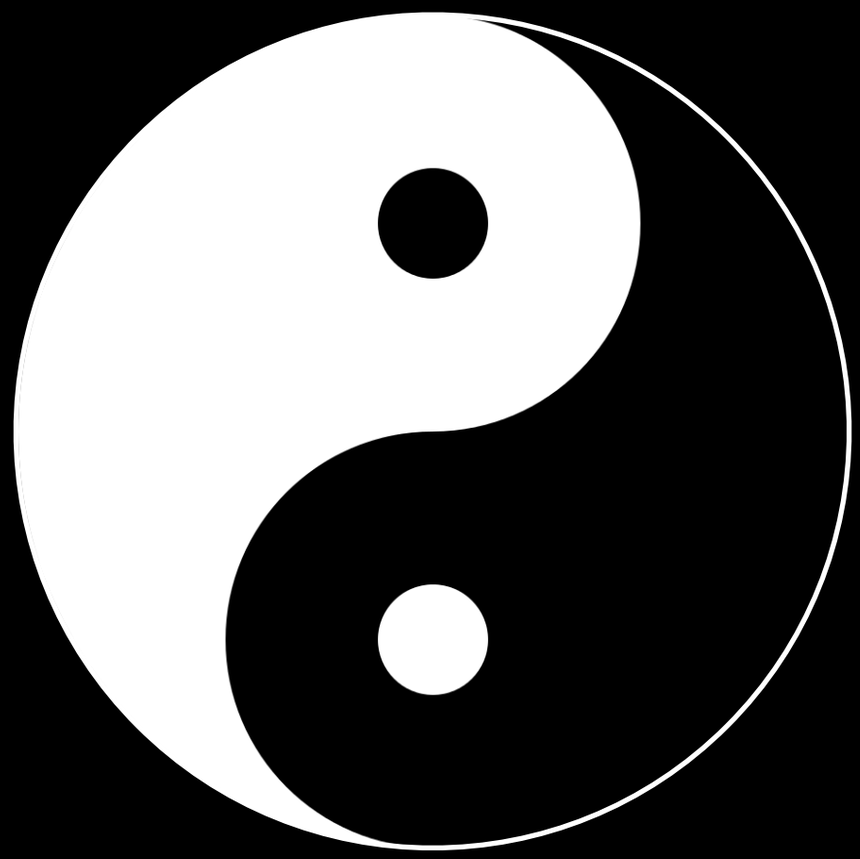
Excluded by CMS @ 20 fb-1

Can be excluded using our search strategy at 300 fb-1

Can be discovered using our search strategy @ 300 fb-1

Conclusion

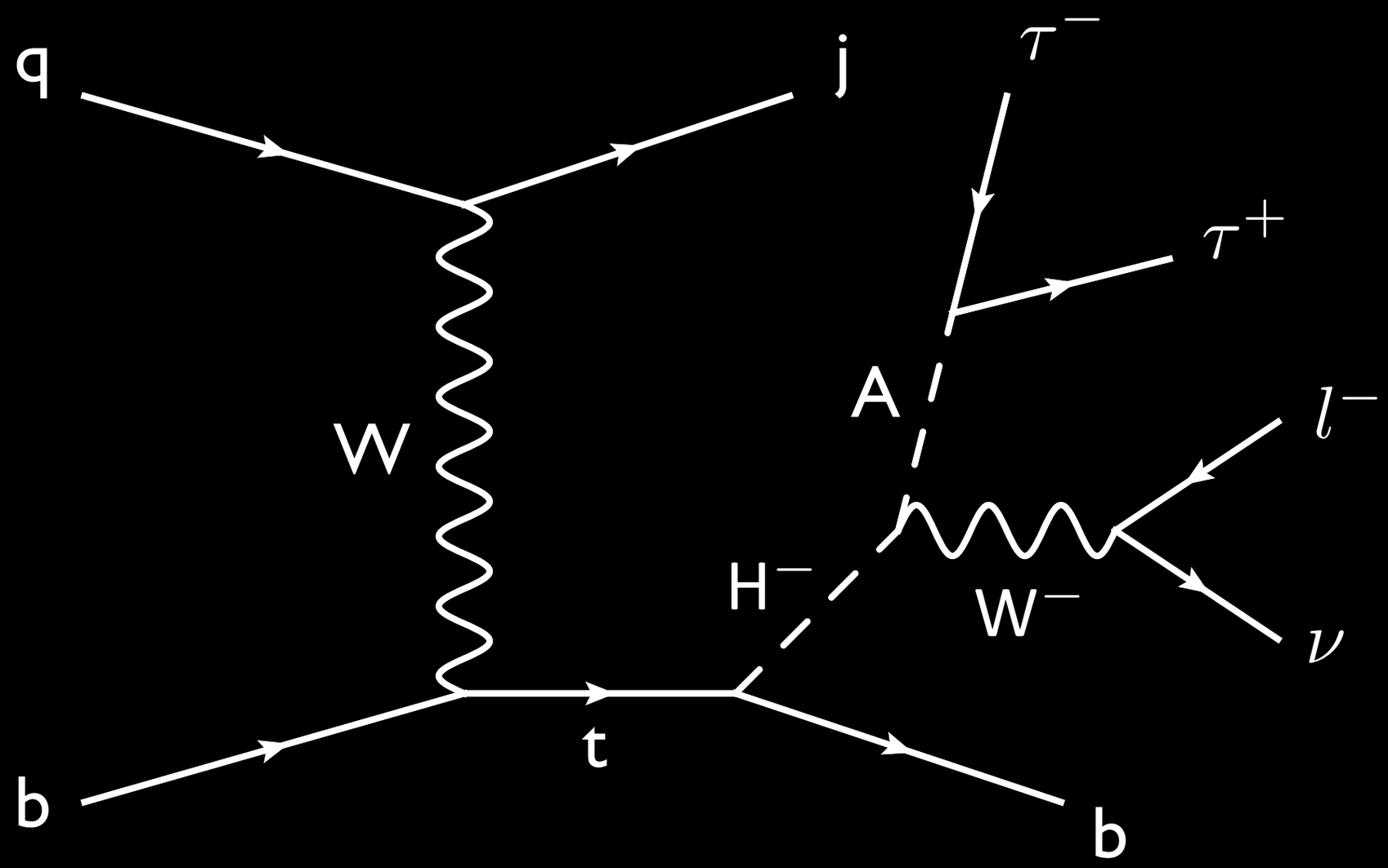
Conventional decay channels



Exotic decay channels

Backup Slides

Same-sign Dilepton Signature



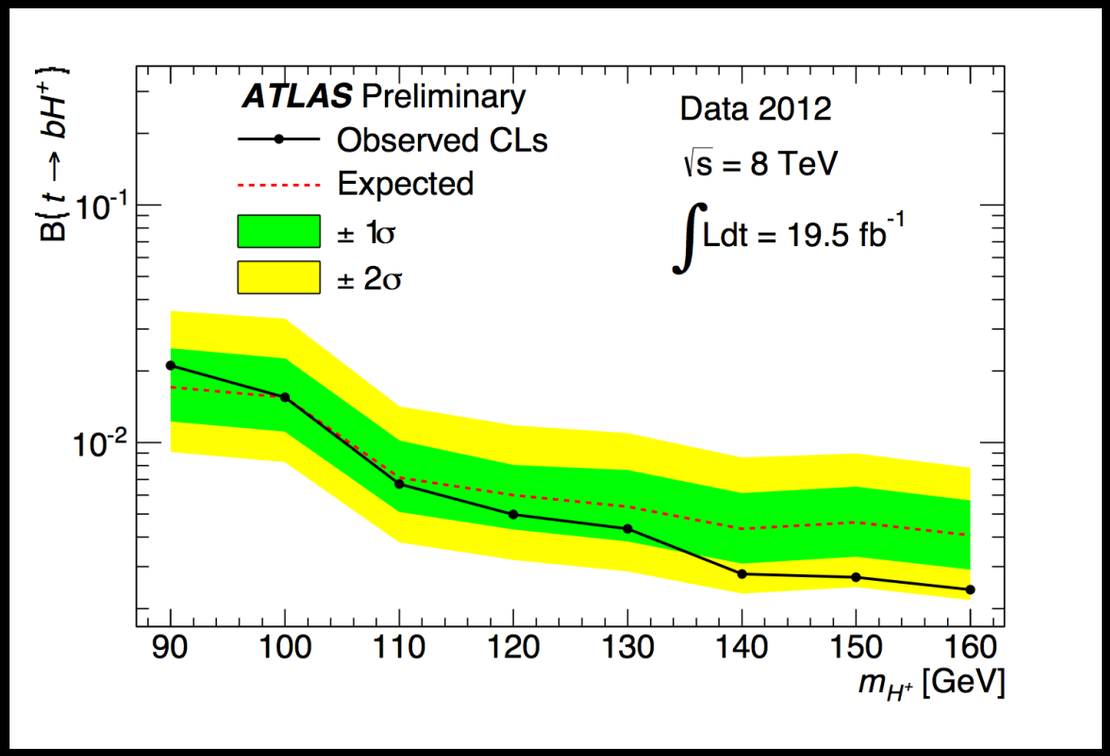
Particle Spectrum

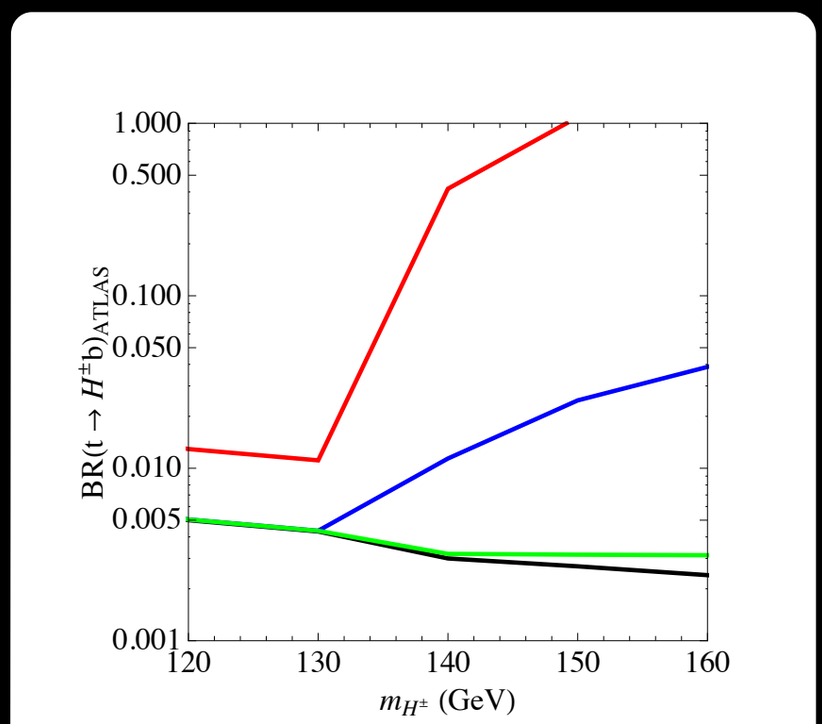
$$\langle \Phi_1 \rangle = \begin{pmatrix} 0 \\ \frac{v_1}{\sqrt{2}} \end{pmatrix} \langle \Phi_2 \rangle = \begin{pmatrix} 0 \\ \frac{v_2}{\sqrt{2}} \end{pmatrix} \longrightarrow \Phi_i = \begin{pmatrix} \mathrm{Re}(\phi_i^+) + i\mathrm{Im}(\phi_i^+) \\ (v_i + \rho_i + i\eta_i)/\sqrt{2} \end{pmatrix}$$

Eight degrees of freedom

Two CP-even scalars	One CP-odd pseudoscalar	Two charged Higgs bosons	Three would-be Goldstone bosons
h H	A^0	H^+ H^-	G^0 G^+ G^-

Assuming $B(H^+ \to \tau\nu) = 1$





$B(t \to bH^+)$ for $m_{H^+} = 150$ GeV is 0.27%
(Upper limit)

Not applicable here since the charged Higgs can decay to AW as well!