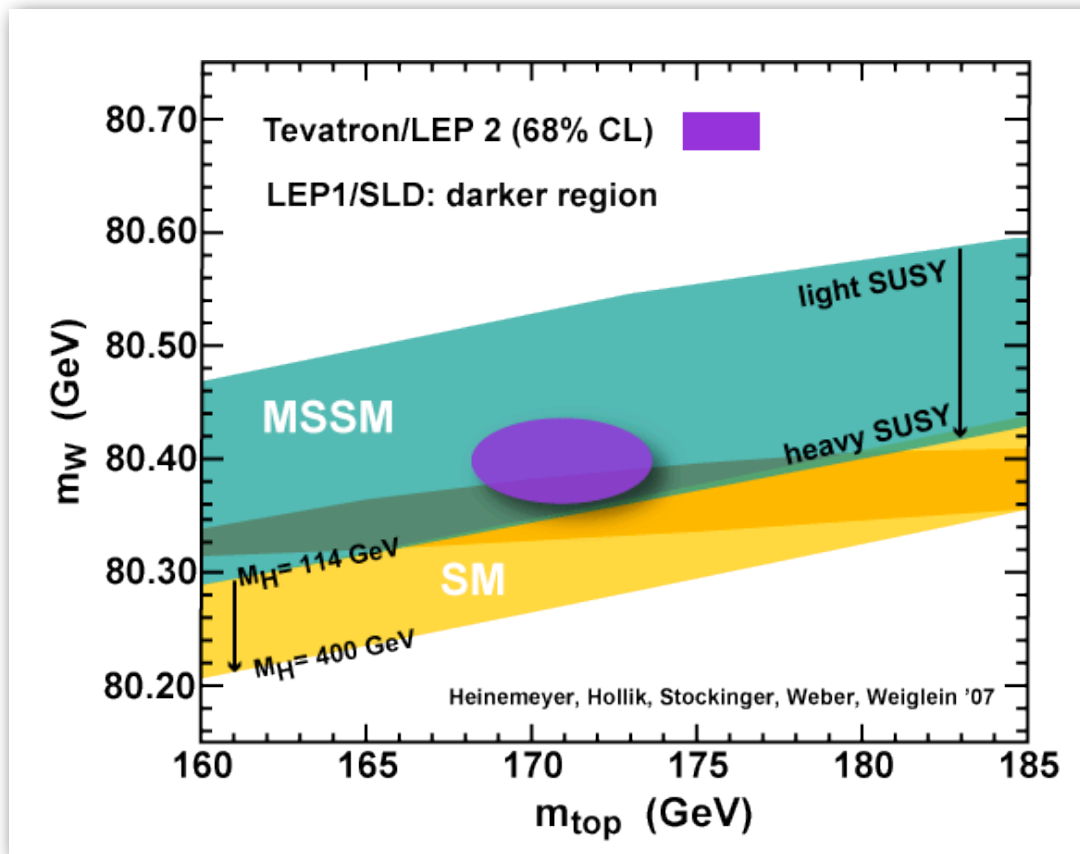


No Higgs at the LHC?

John Conway
UC Davis
LHC Early for the ILC

Latest billion dollar plot...



My view: significant chance of non-SM Higgs at LHC
...or no Higgs at all

I knew exactly where it was,
I just couldn't find it.

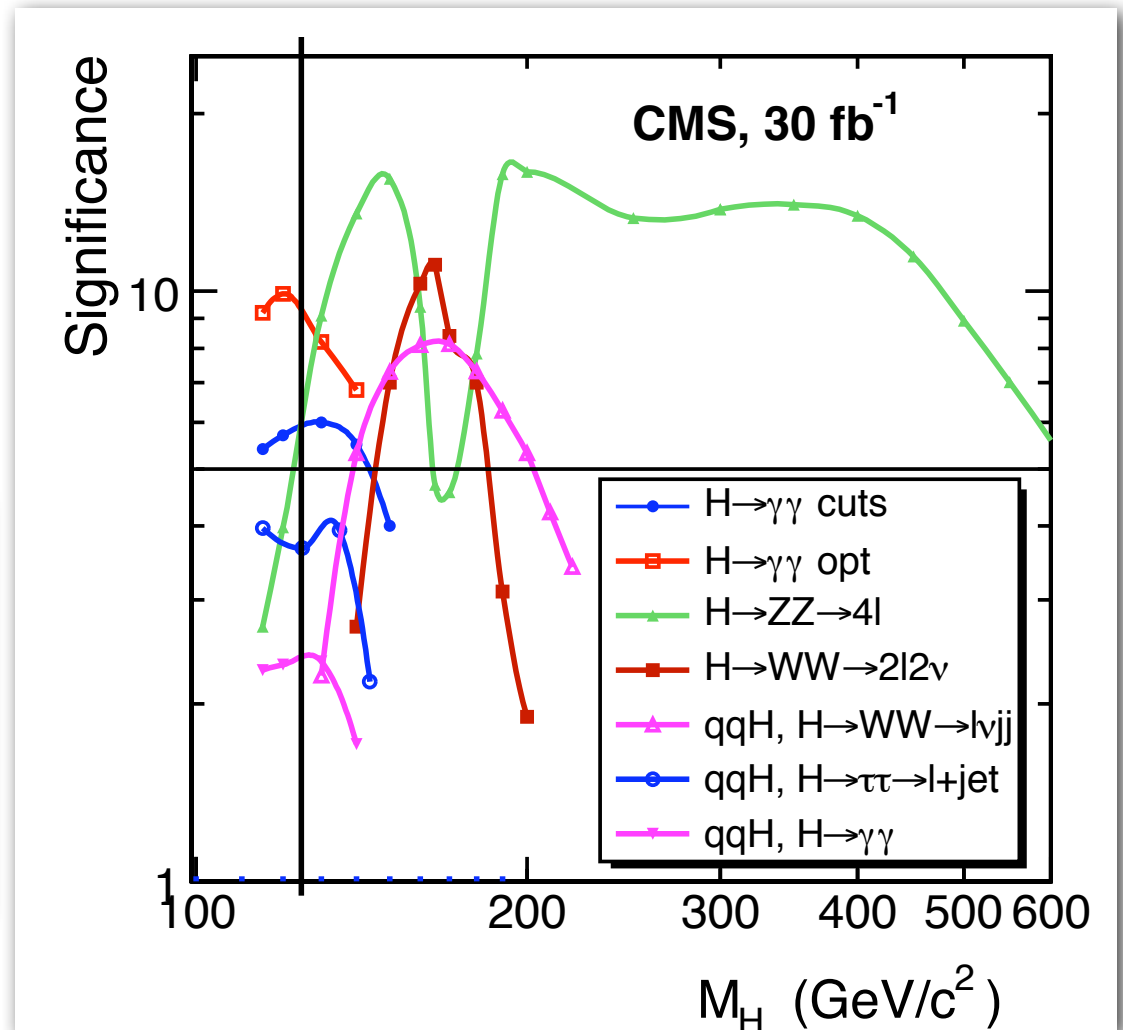
- Yogi Berra

It's 2009. What is it we are not seeing?

- main signals for SM-like Higgs at the LHC

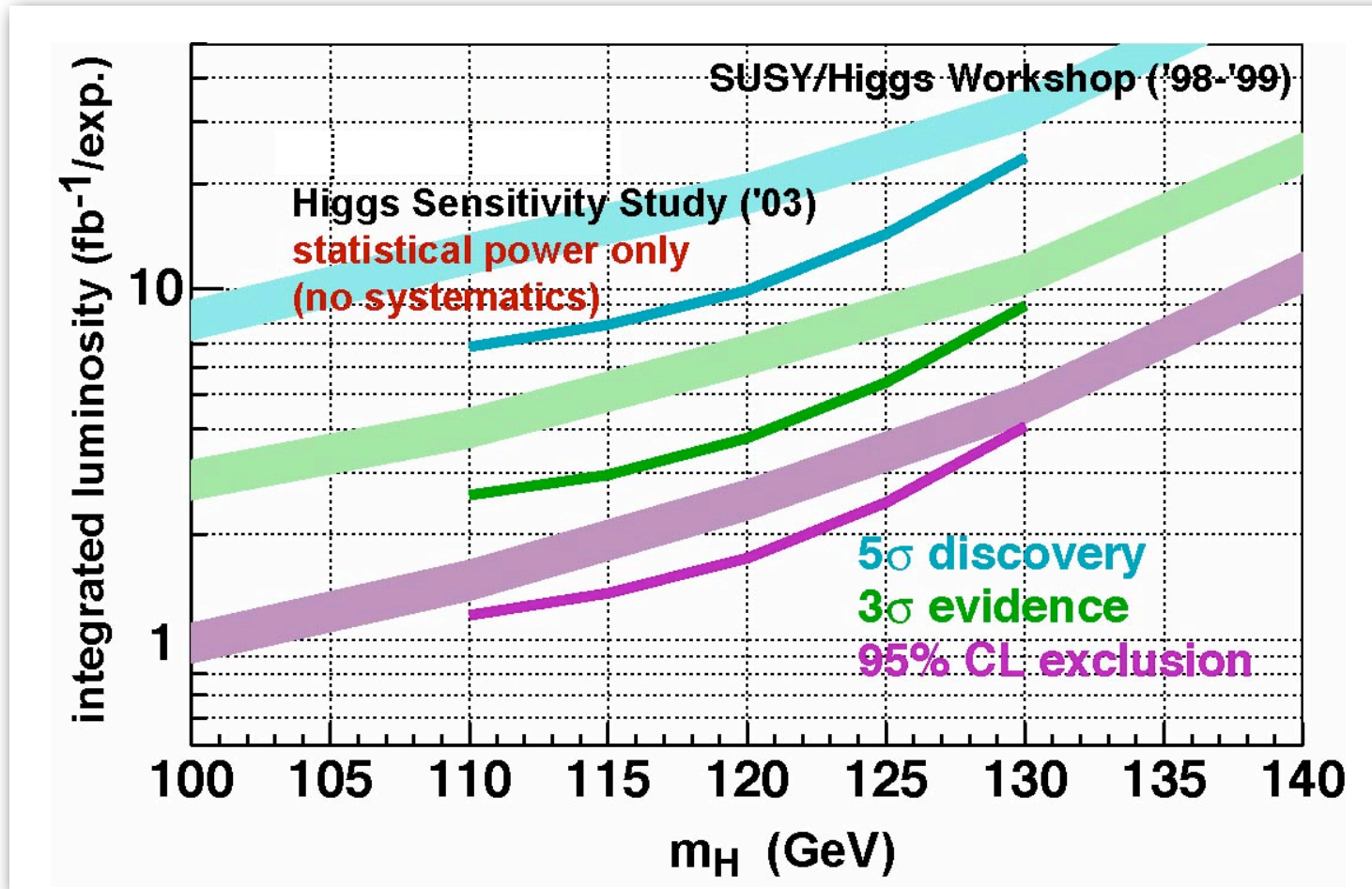
- $gg \rightarrow H \rightarrow \gamma\gamma$
- VBF: $qqH, H \rightarrow \tau\tau$
- $gg \rightarrow H \rightarrow ZZ$

If we are not seeing it at the LHC, will we already have not seen it at the Tevatron?



Tevatron reach

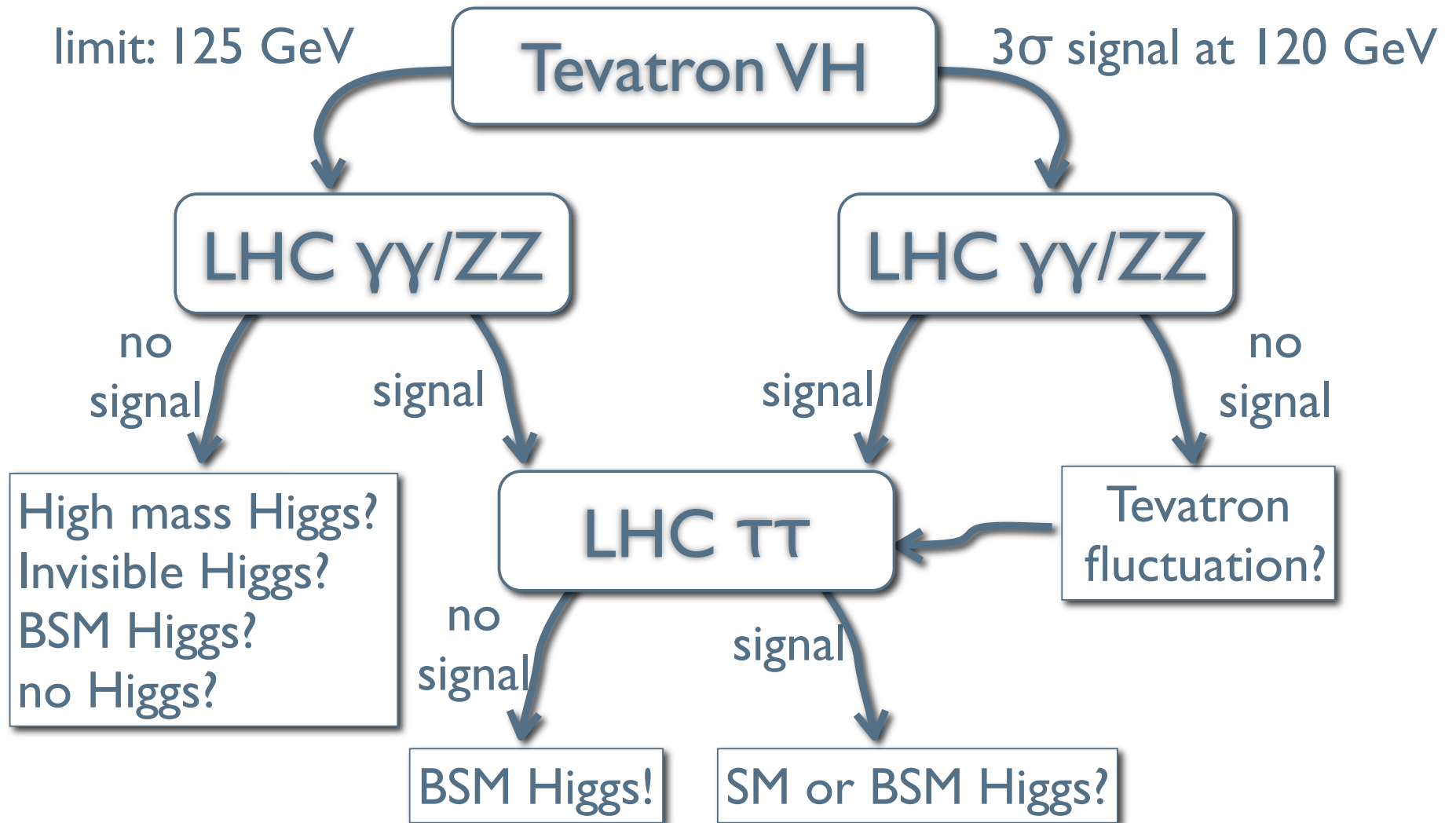
- people love to hate 'em, but still our best guess!



When you come to a fork in the
road, take it.

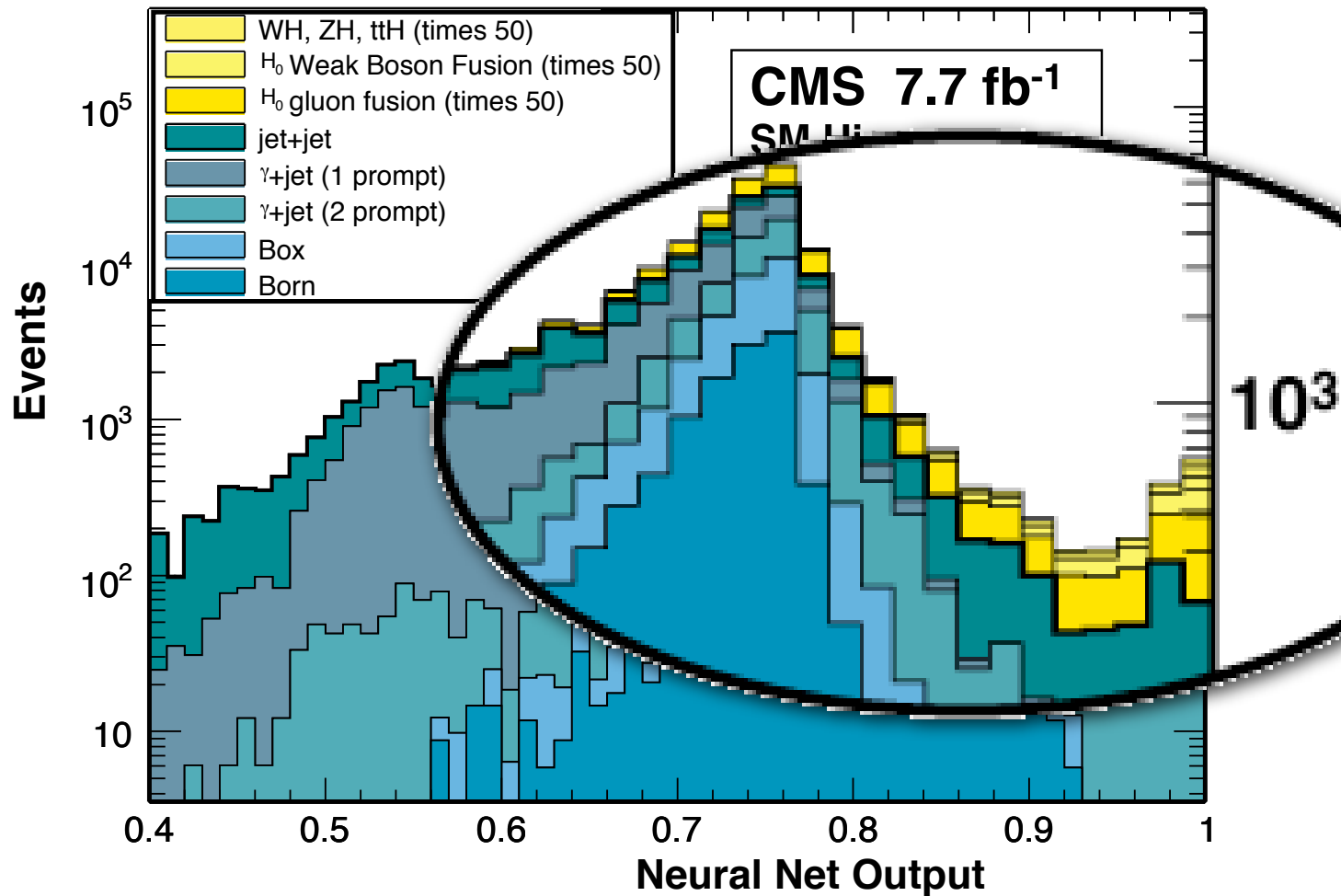
- Yogi Berra

What will the situation be two years from now?



First scenario - missing/reduced $\gamma\gamma$

- CMS has optimized NN analysis for $\gamma\gamma$ - we'll know well within 10 fb^{-1} if this is the case!



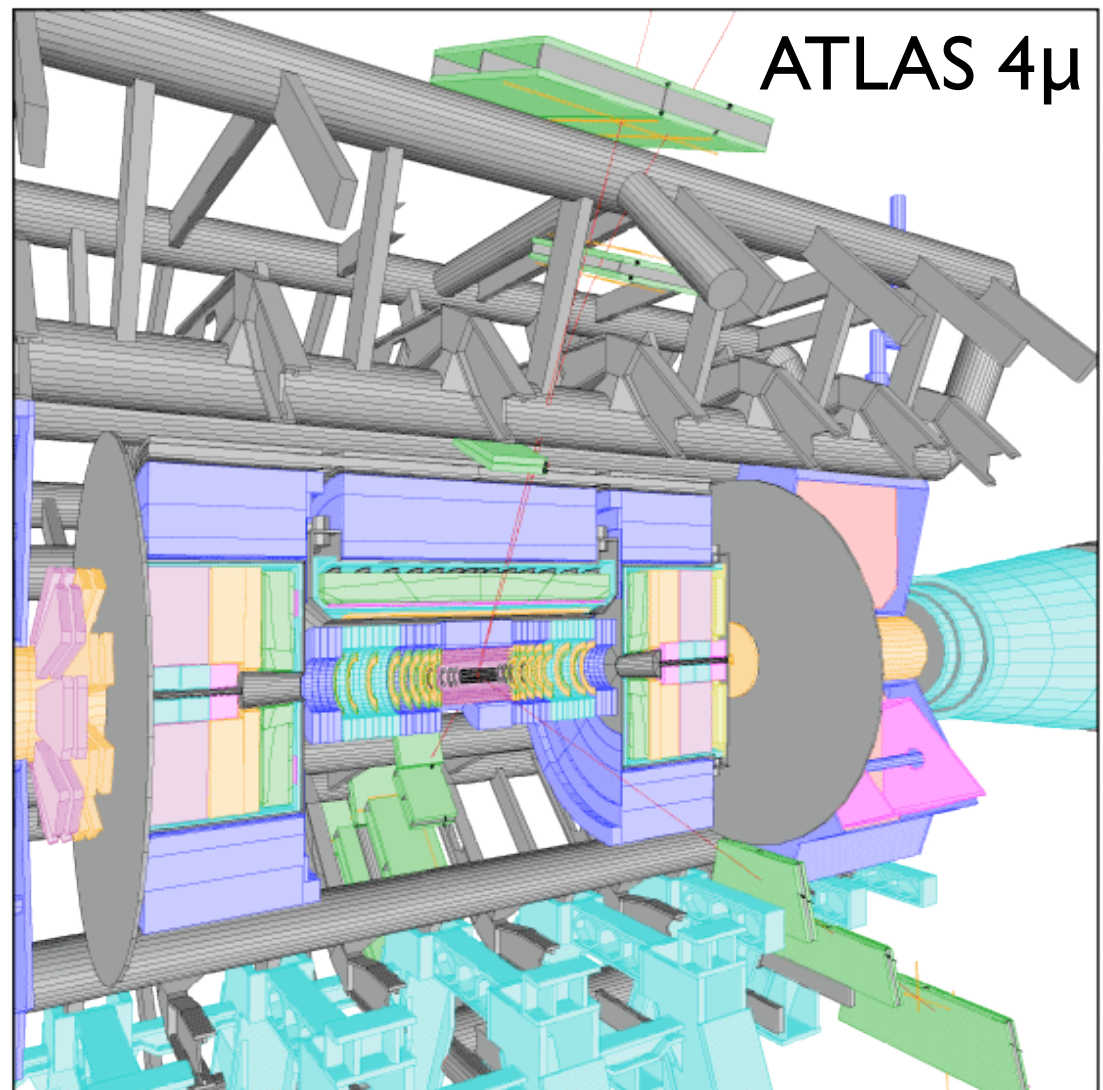
Confirmation? $h \rightarrow ZZ \rightarrow 4\ell$

eeee, eeμμ, μμμμ

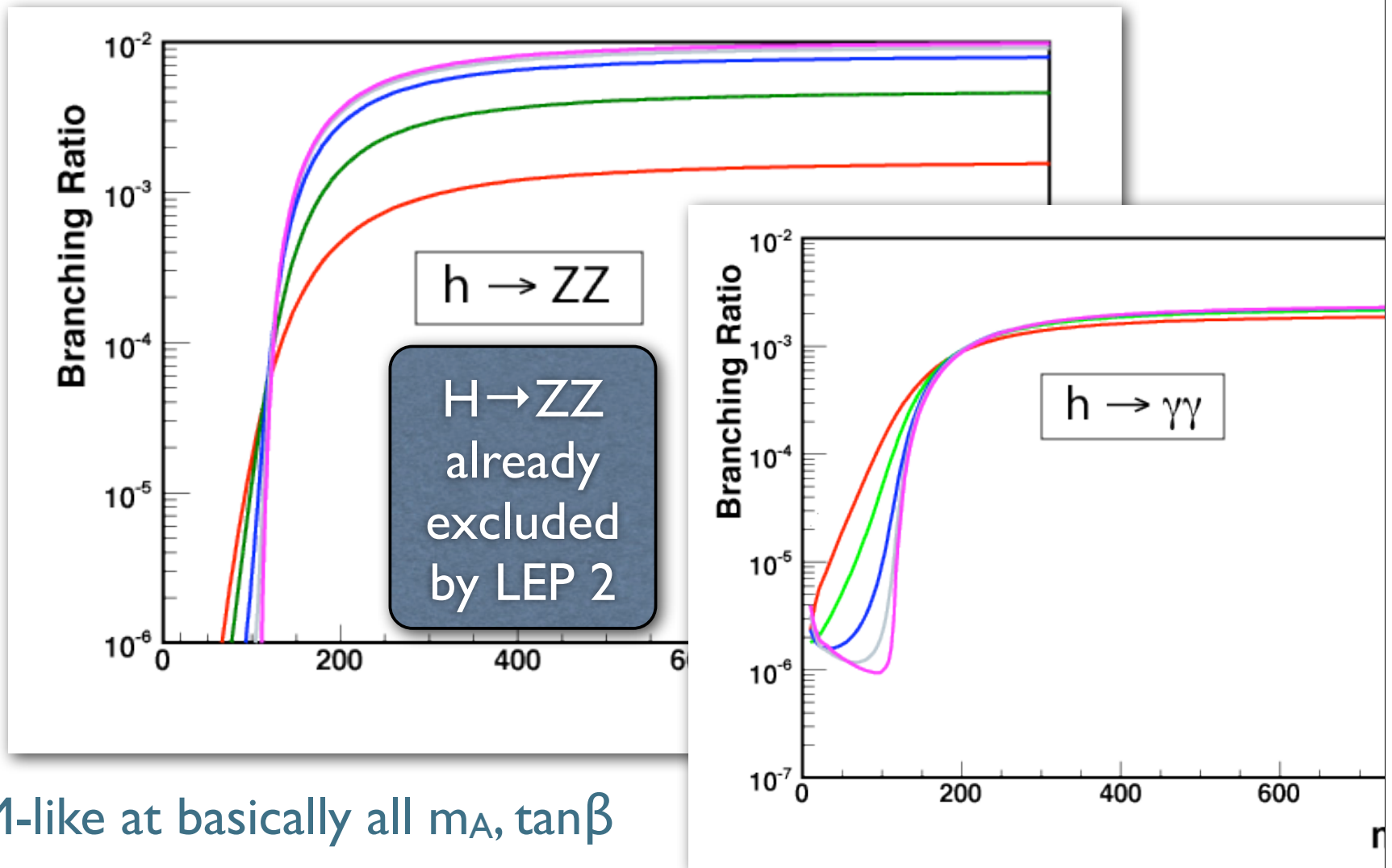
Excellent Higgs mass resolution

Relevant if h mass above ~ 125 GeV

Compare with SM rate for this process; can help with mass?

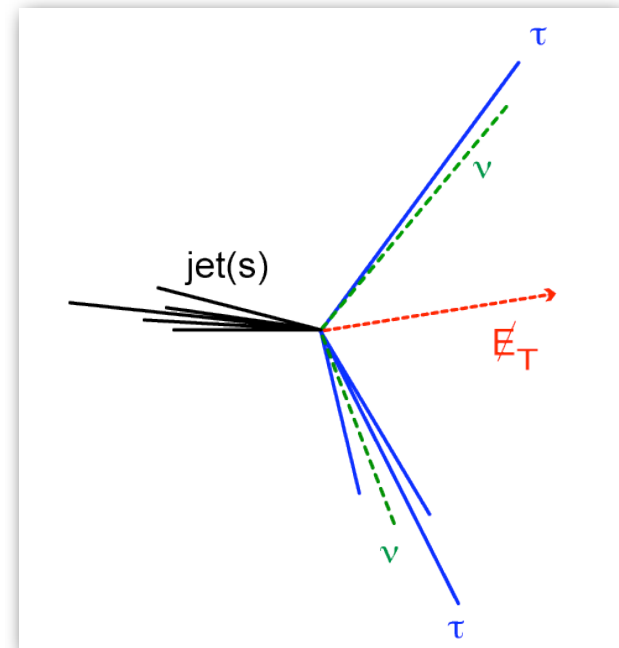
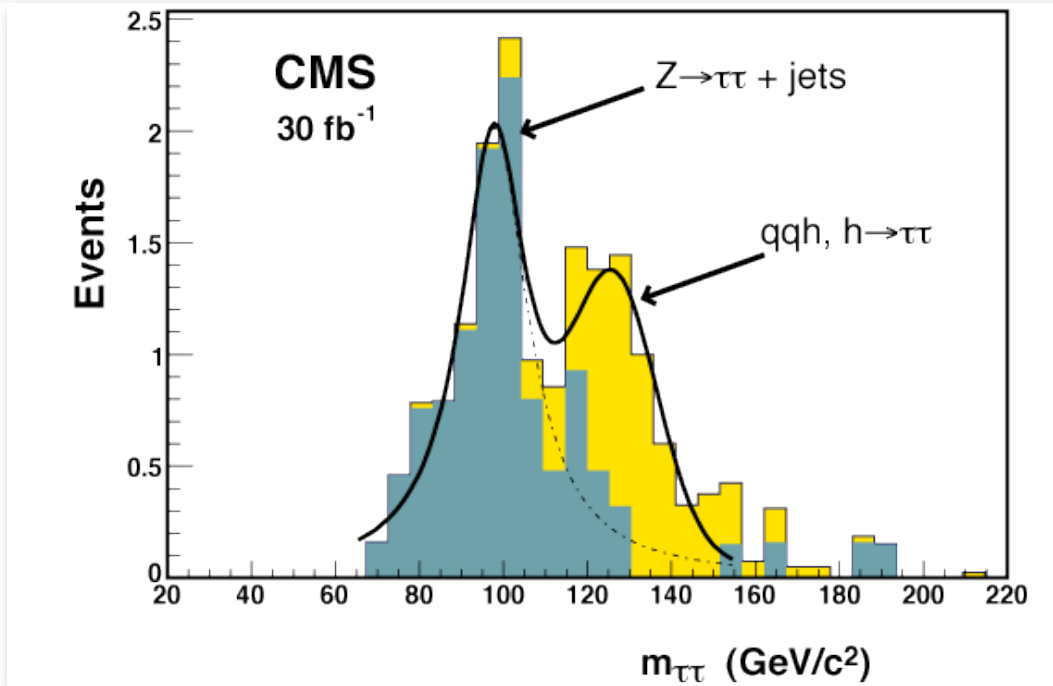


Second signal: $h \rightarrow ZZ \rightarrow 4\ell$



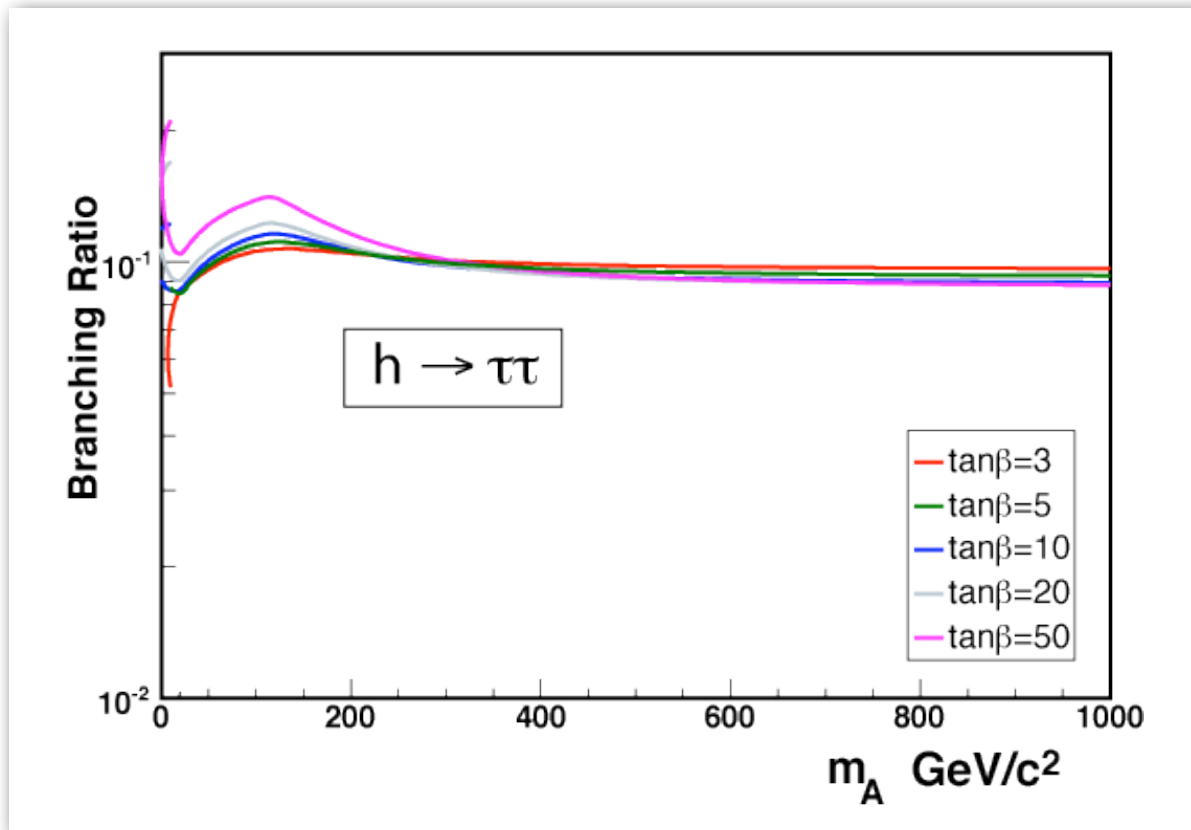
- SM-like at basically all $m_A, \tan\beta$
- BR tracks that of SM: “confirming mode”

What about $qqH, H \rightarrow \tau\tau$?



$h \rightarrow \tau\tau$ branching ratio in MSSM

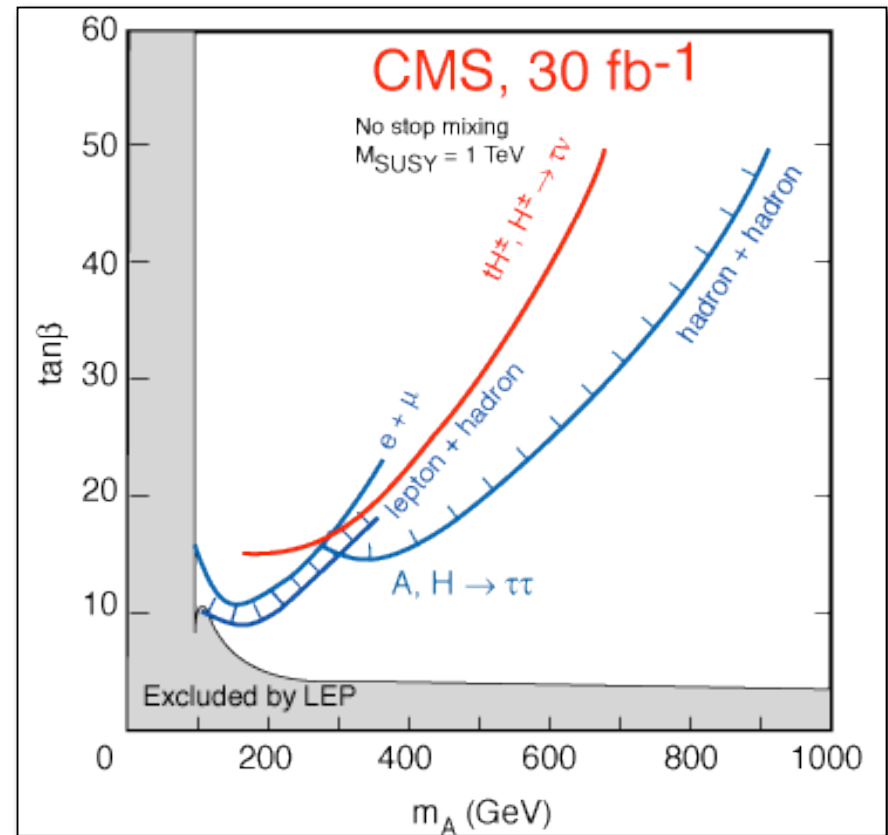
- very stable at around 10% over wide range of $m(A)$



(Are high tan beta curves right? Disagrees with FeynHiggs...)

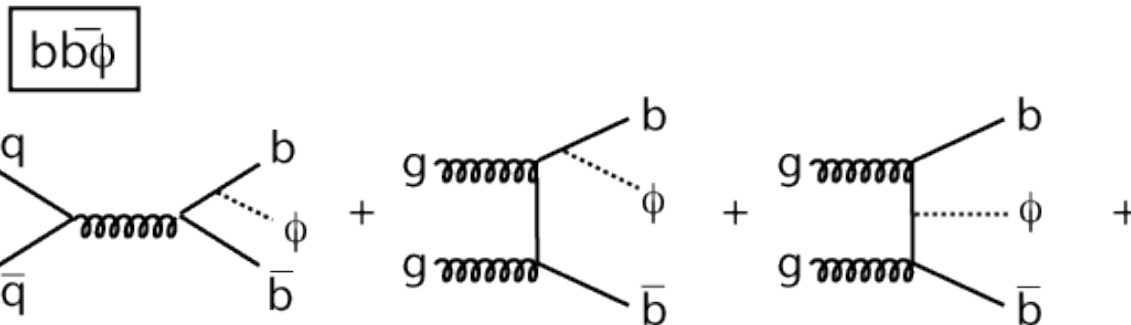
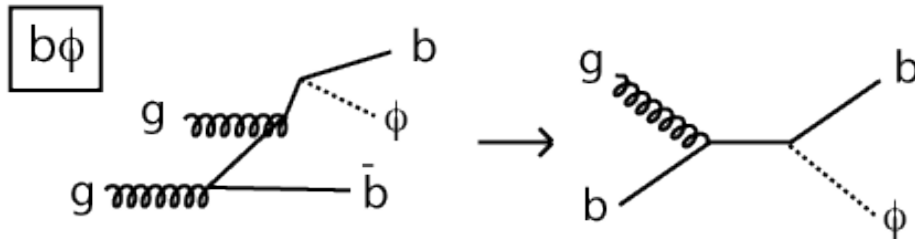
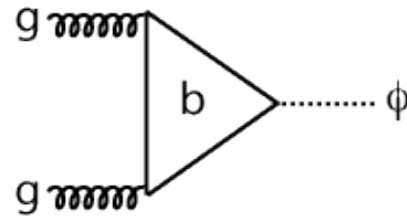
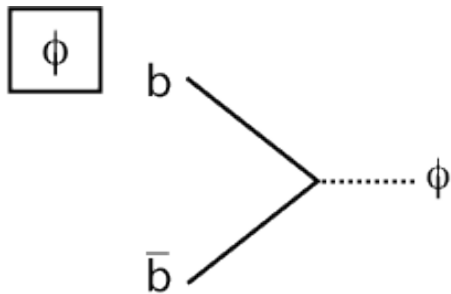
cross section for $WW \rightarrow h$ versus $m(A)$

- it's not just the branching ratio of course
- if $m(A)$ is large, then h has SM-like hVV couplings and we'll see the tau pair mode with $\sim 25\text{-}20 \text{ fb}^{-1}$
- meanwhile we need to look for enhanced production (lower $m(A)$, high $\tan\beta$) in tau pair modes



enhanced production

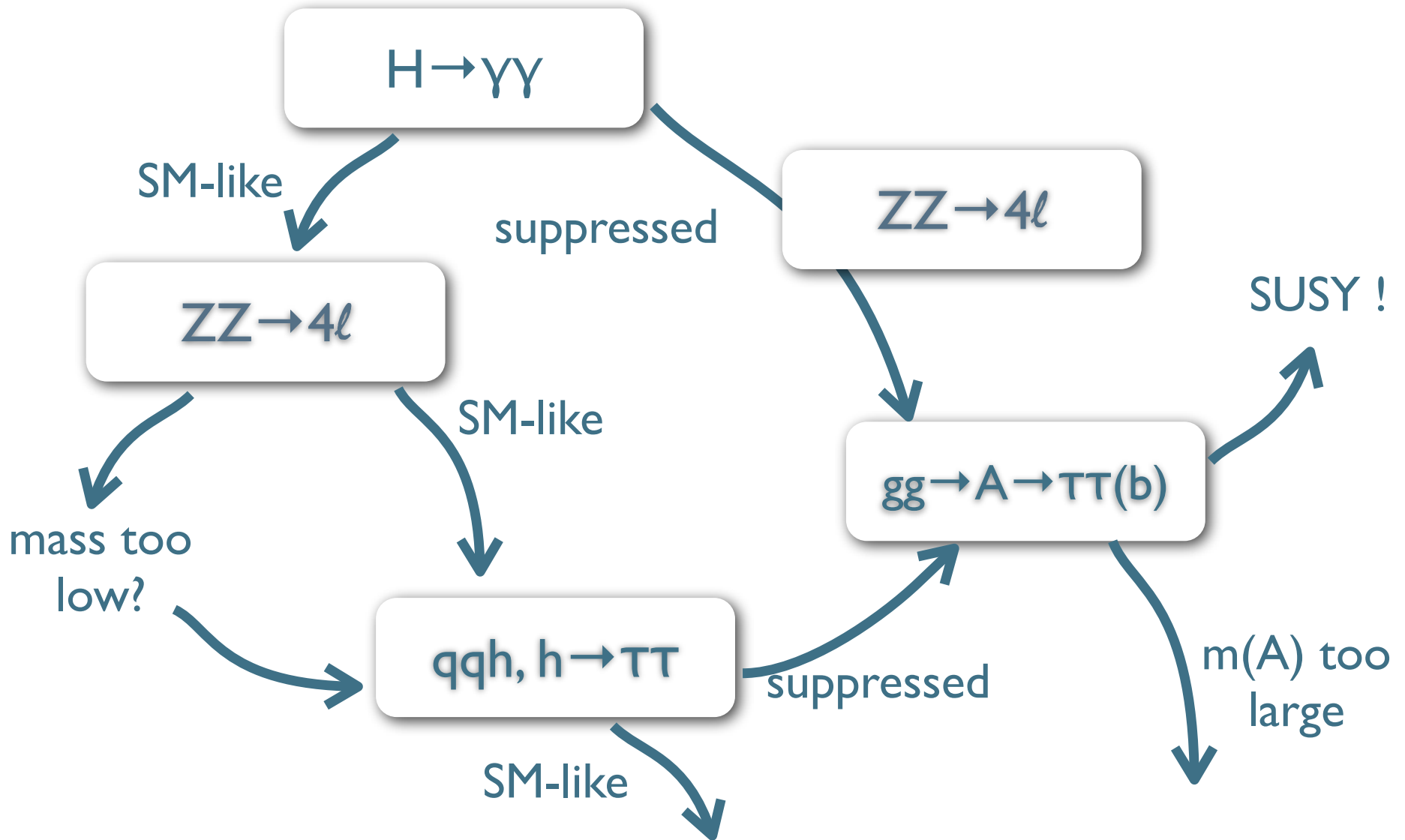
- large $\tan\beta$, not too large $m(A)$: $\tau\tau, \tau\tau b(b)$ signals



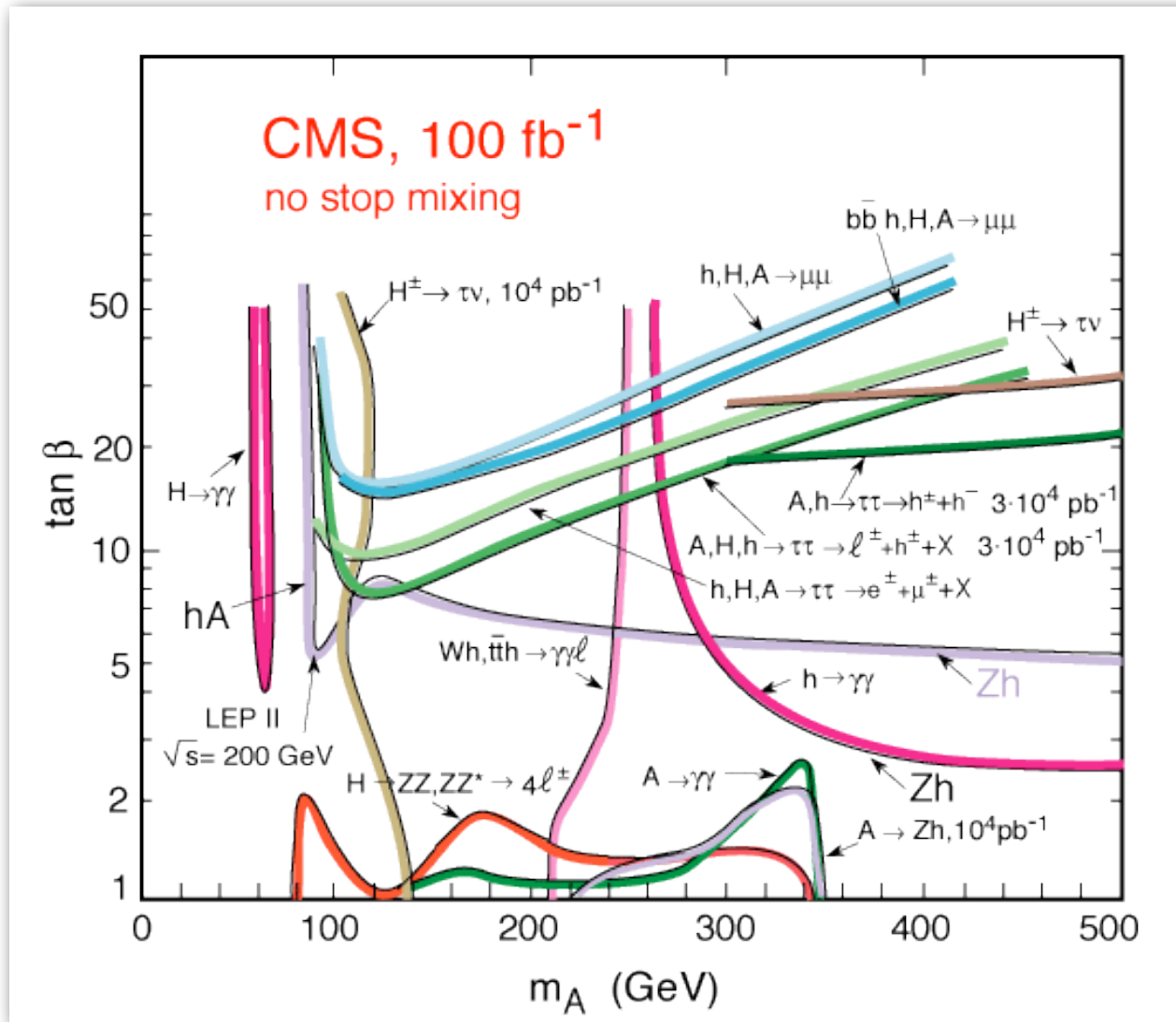
$\propto \tan^2\beta$

Tevatron could get lucky here!

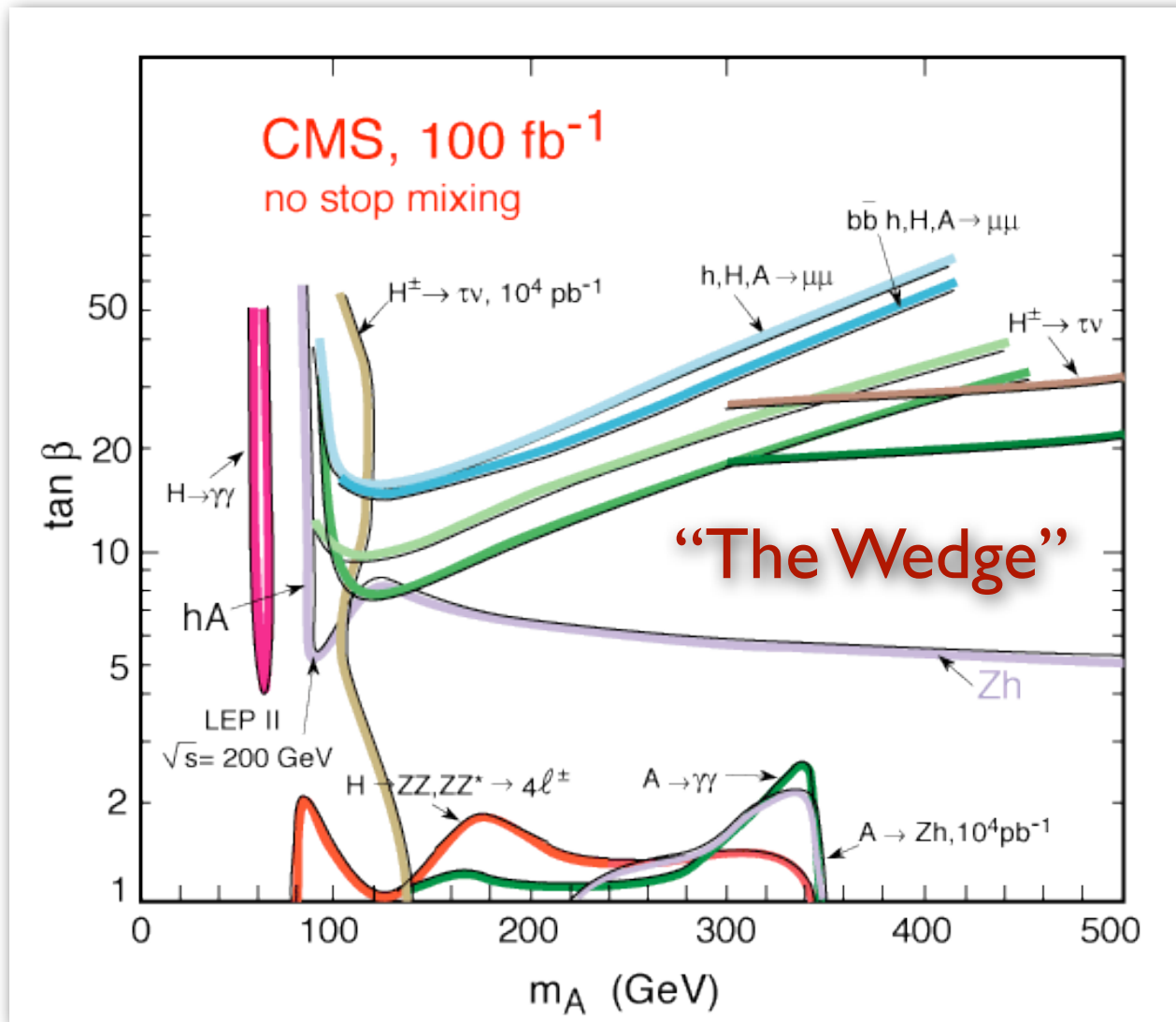
MSSM decision tree at LHC



“Tokyo subway plot” (5 σ discovery reach)



“Tokyo subway plot” (5 σ discovery reach)



Implication for Linear Collider

- absence of a $h \rightarrow \gamma\gamma$ signal means we are in an interesting world...but is it explorable with a 500 GeV machine?
- suppressed $h \rightarrow \gamma\gamma$ is very interesting and could mean that A/H are reachable with a 500 GeV machine
 - * an early LHC signal of enhanced, high $\tan\beta$ SUSY would be a powerful argument for a 500 GeV machine
- SM-like $h \rightarrow \gamma\gamma$ means we may be in a situation where only independent evidence of SUSY can help...or a TeV LC

see Tim Tait's talk for more...

Not enough experimental work
so far on non-SM, non-MSSM
Higgs searches!

CPNSH workshop report out:

CP 2HDM

MSSM with CP phases

NMSSM (MSSM+singlet)

RPV MSSM

extra gauge groups

Little Higgs models

Large extra dimensions

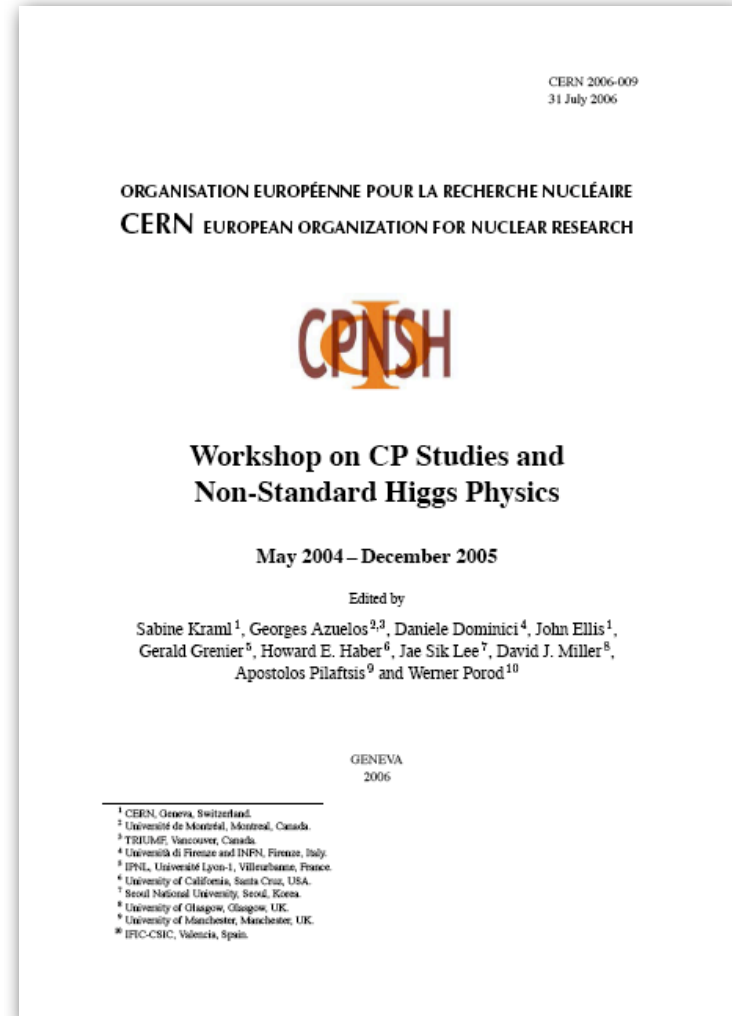
Warped extra dimensions

Higgsless Models

Strongly interacting Higgs

Technicolor

Higgs Triplets



<http://kraml.web.cern.ch/kraml/cpnsh/>

“Higgs Hunters Guide to
non-standard Higgs”

If this was easy it wouldn't be so hard.

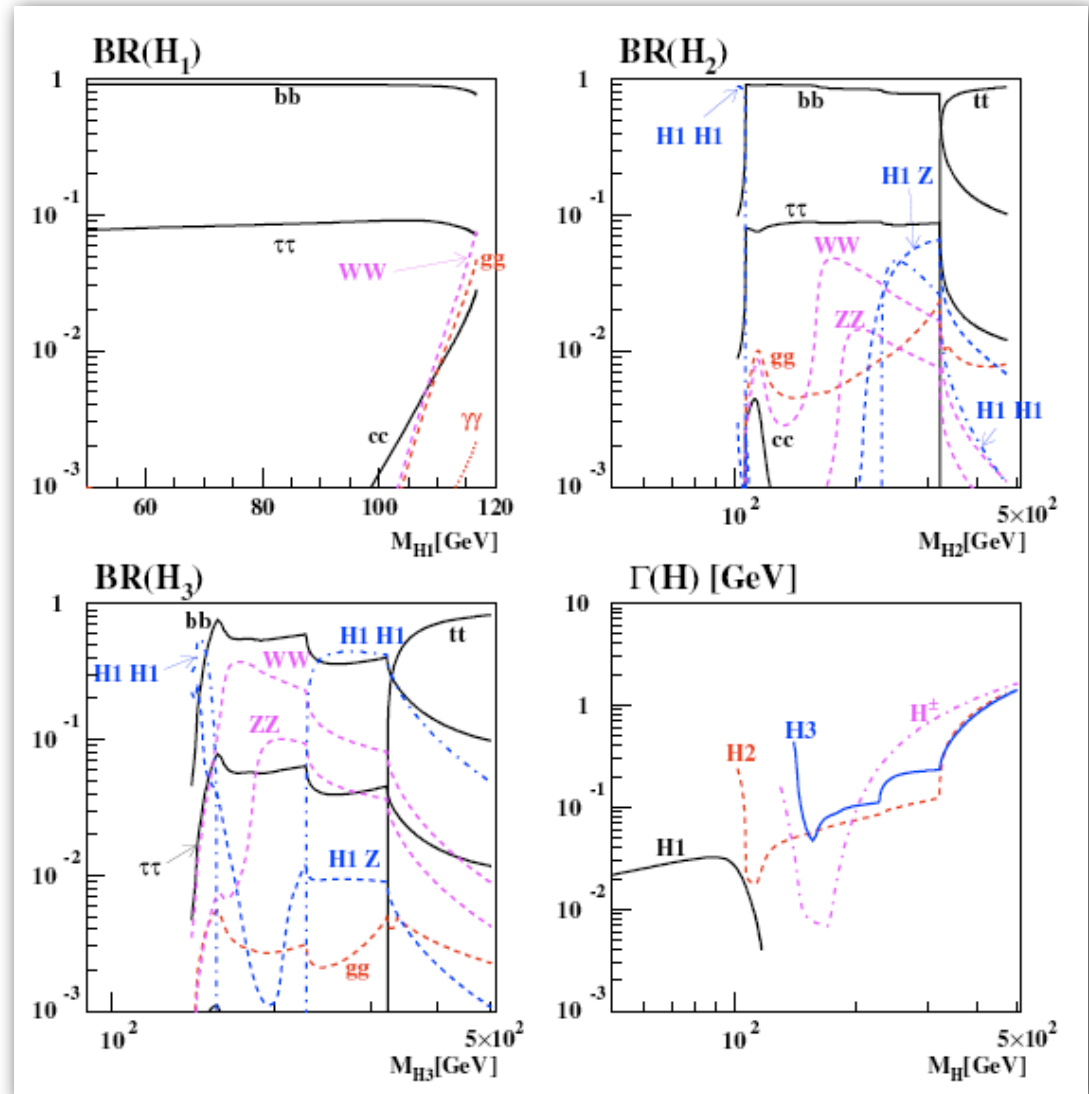
- Yogi Berra

One example: MSSM
with CP phases

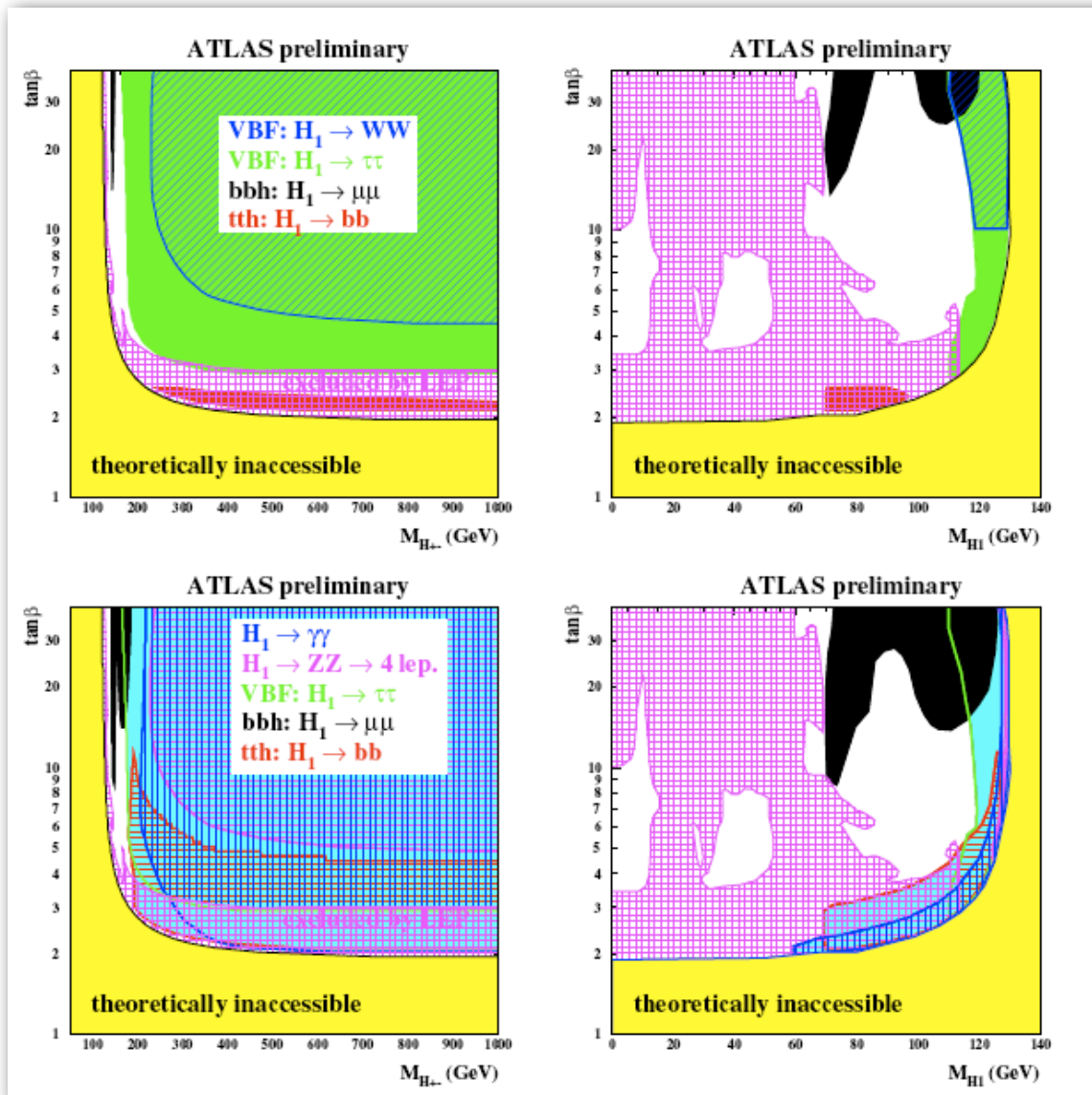
Three Higgs bosons
 H_1, H_2, H_3

Branching ratios
look somewhat
familiar!

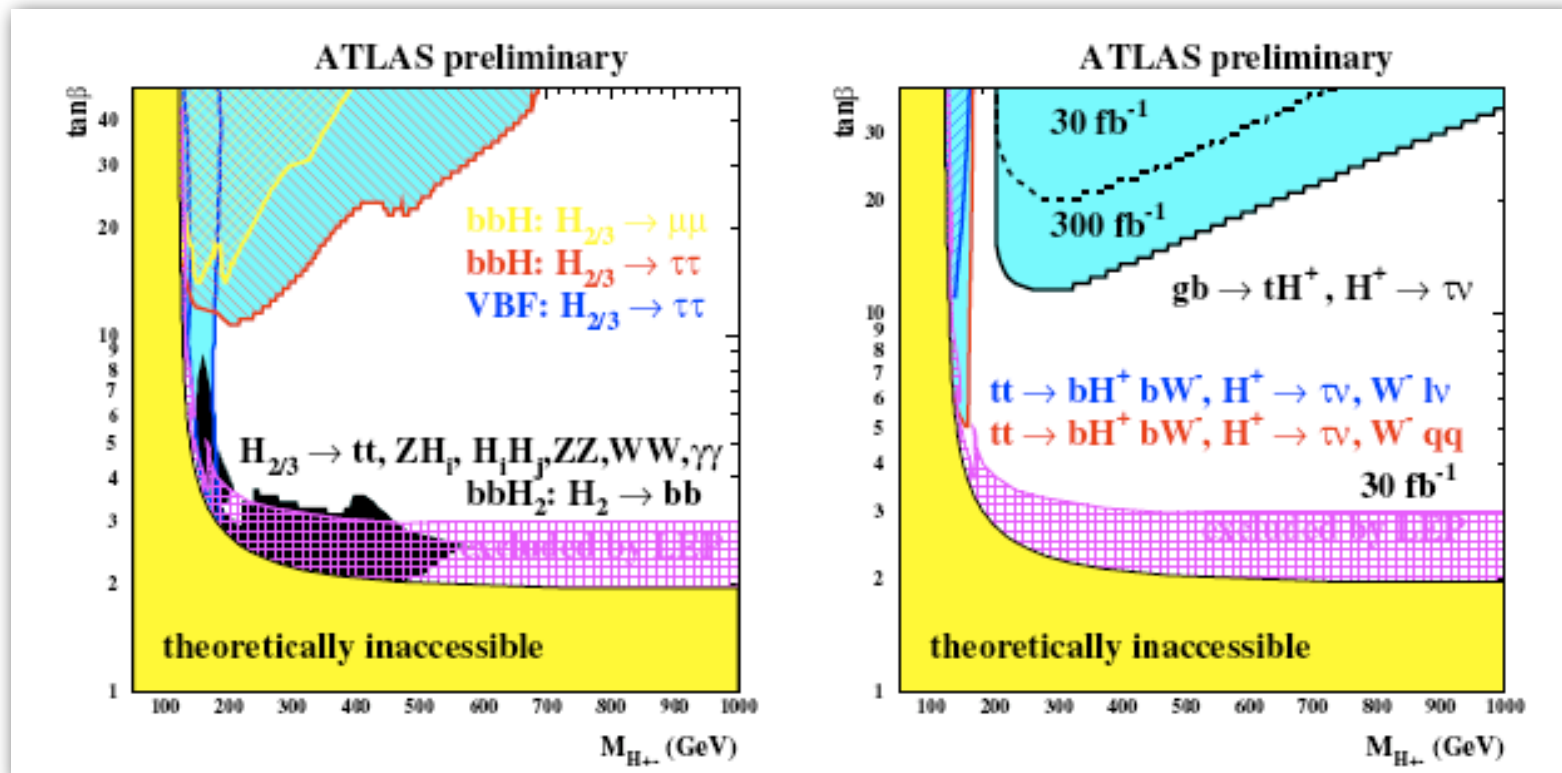
Use SM, MSSM
searches to probe
the model



ATLAS reach for H^\pm, H_1



ATLAS reach for H_2, H_3



what about really no Higgs signals?

- no gamma gamma signal
- no $Z \rightarrow 4\ell$ signal
- no tau pairs ($qqH, H \rightarrow \tau\tau, gg \rightarrow \tau\tau, gb \rightarrow \tau\tau b \dots$)
 - ▶ Little Higgs
 - ▶ Technicolor
 - ▶ UED
 - ▶ extra gauge groups
 - ▶ ...

These might give observable signals at the LHC eventually but could be difficult to justify a 500 GeV Linear Collider!

You give 100% for the first half of the game, and if that's not enough, in the second half you give what's left.

- Yogi Berra

Our parallel program

- J. Gunion - Introduction
 - G. Cacciapaglia - No-Higgs scenarios
 - T.Tait - MSSM scenarios
 - J. Reuter - Little Higgs
 - J. Gunion - Extra/exotic decay channels
- discussion

You can observe a lot just by watching.

- Yogi Berra