LCH @ LHC

J.R. Espinosa

IMPLICATIONS OF LHC DATA FOR A LIGHT COMPOSITE HIGGS

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★ focus on Higgs searches

[hep-ph/1003.3251] + Aug'11 update

In collab. with Christophe Grojean (CERN) and Maggie Mühlleitner (Karlsruhe)

HIGGS OUROBOROS

SM Higgs sector is the less tested and more problematic

Affected by hierarchy problem

Calls for new physics at the TeV scale

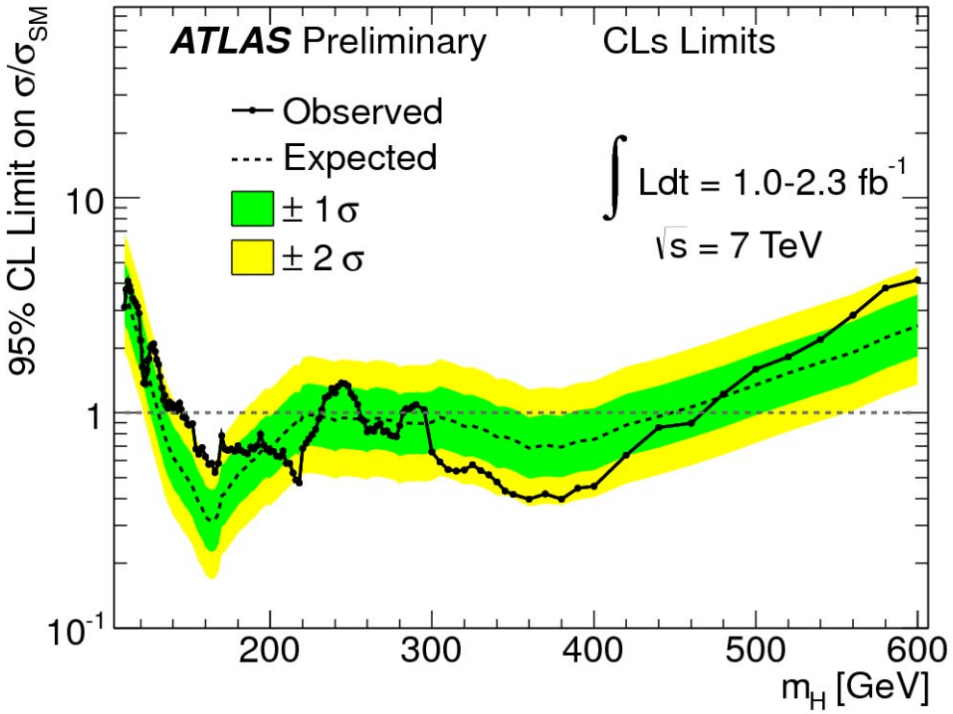
It's very likely that the Higgs will depart from its SM properties

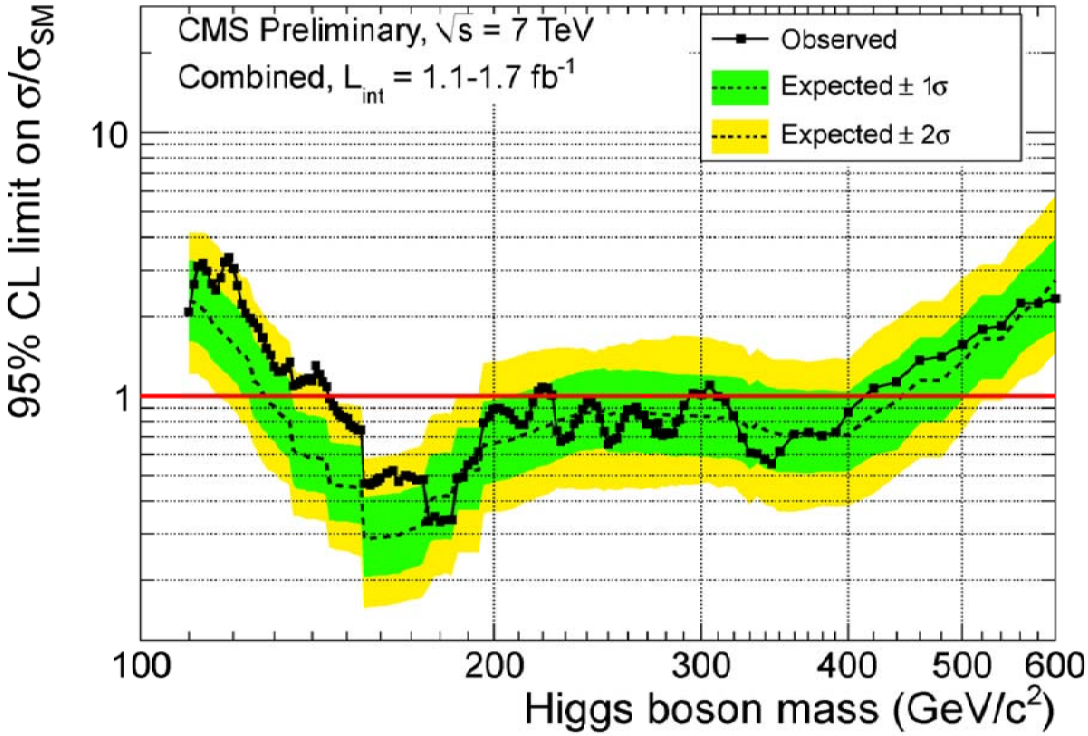
IMPORTANCE OF THE HIGGS

Not as the keystone of the SM

but as the portal to reveal the cracks in the SM

FANTASTIC PROGRESS





We look forward to:

★ Lower limits and then Excesses

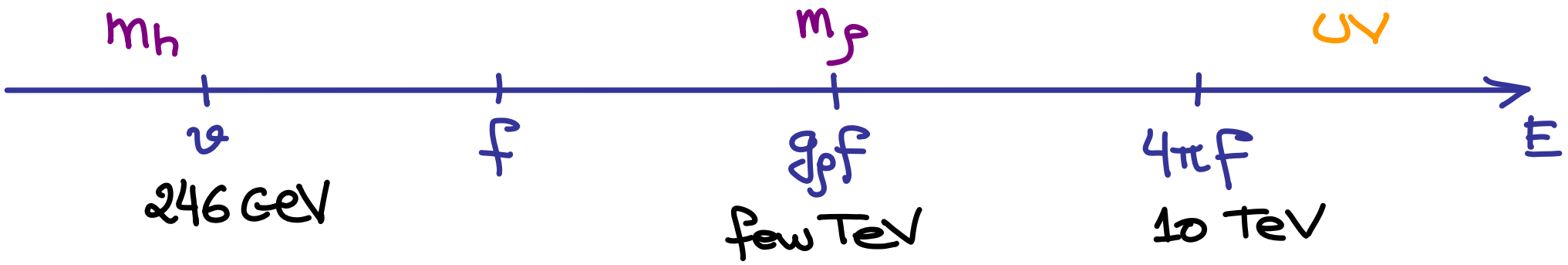
that make these kind of plots not applicable!

Two main avenues for BSM Higgs

- ★ Elementary Higgs (SUSY, ...)
- ★ Composite Higgs ← This talk

More precisely Light Composite Higgs

Bound state of fields from a strongly interacting sector the PseudoGoldstone remnant of a global symmetry brkng.



In this talk $m_h \in [80\,\text{GeV}, 200\,\text{GeV}]$

EFFECTIVE LAGRANGIAN DESCRIPTION

Giudice, Grojean, Pomarol, Rattazzi '07

$$\mathcal{L}_{SILH} = \frac{c_H}{2f^2}(\partial_\mu |H|^2)^2 + \frac{c_T}{2f^2}\left(H^\dagger \overleftrightarrow{D_\mu} H\right)^2 + \left(\frac{c_{yf}}{f^2}|H|^2 \bar{f}_L H f_R + h.c.\right)$$

$$+ \frac{i c_W g}{2m_\rho^2}\left(H^\dagger \sigma^i \overleftrightarrow{D^\mu} H\right)(D^\nu W_{\mu\nu})^i + \frac{i c_B g'}{2m_\rho^2}\left(H^\dagger \overleftrightarrow{D^\mu} H\right)(\partial^\nu B_{\mu\nu}) + \dots$$

H of Goldstone origin:

$\mathcal{L}_{SILH}$ Non generic! ➡ More predictive

Relic effects from heavy strong sector, controlled by

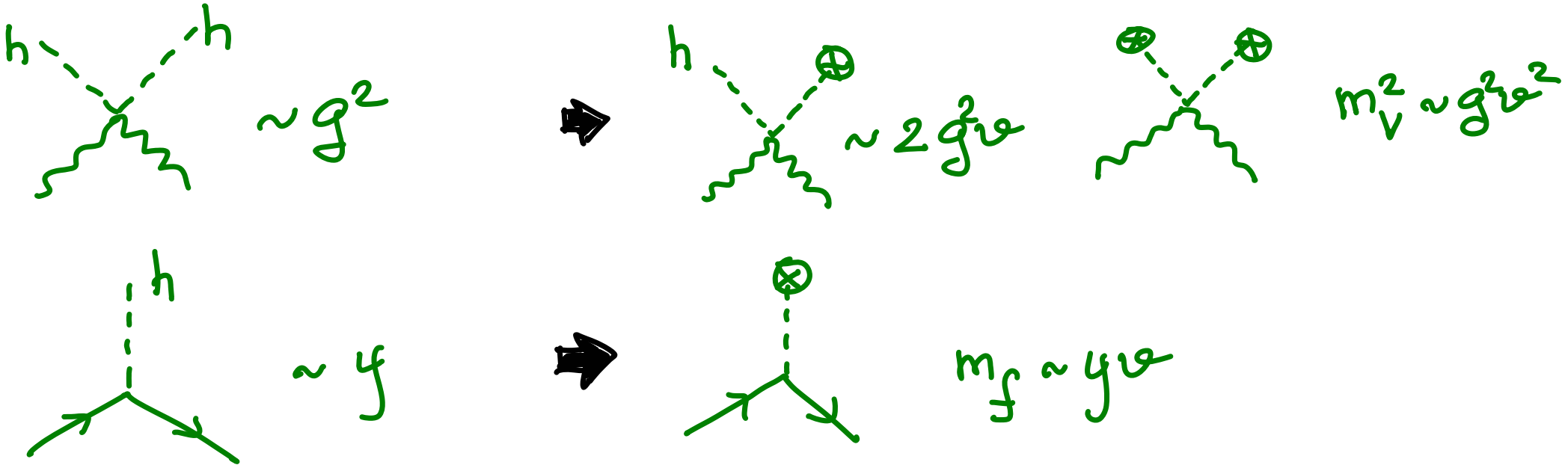
$$\xi \equiv \frac{v^2}{f^2}$$

$\xi = 0$ ➡ SM $\qquad$ $\xi = 1$ ➡ Technicolor limit

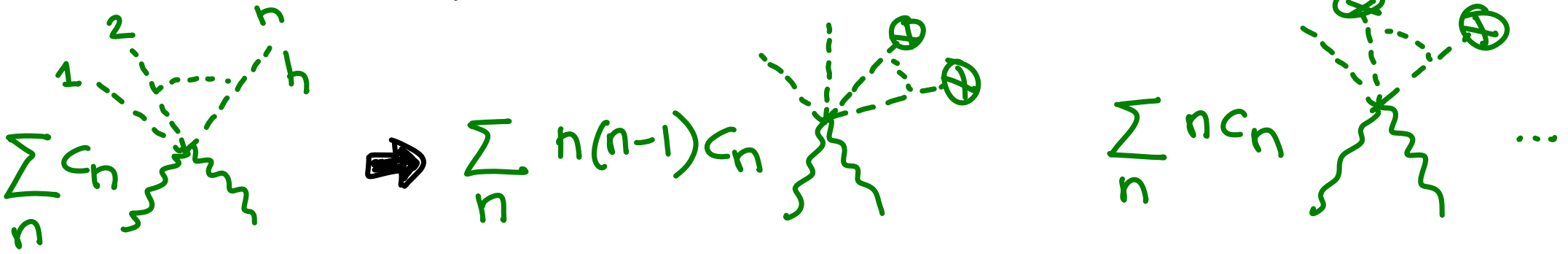
Electroweak precision tests prefer smaller ξ

ANOMALOUS HIGGS PROPERTIES

SM connection between masses and higgs couplings:



is LOST in the presence of nonrenormalizable h interactions



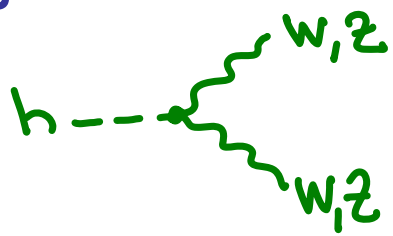
Two concrete models

Based on holographic 5D AdS models with $SO(5)/SO(4)$ coset space

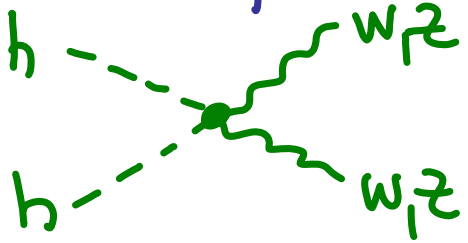
Contino, Nomura, Pomarol, Agashe, Da Rold '03 '05 '07

Minimal ⇨ just 4 Goldstones : $\{\underbrace{G^0, G^\pm}_{Z_L^0, W_L^\pm}, h\}$ ← LCH

Gauge interactions of h fixed by coset structure :

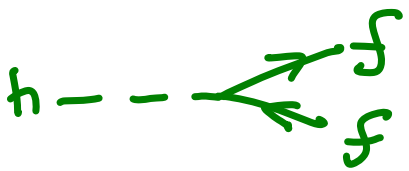


$\sqrt{1-\xi}\times(SM)$



$(1-2\xi)\times(SM)$

Interaction with fermions depend on the fermionic reps. under $SO(5)$

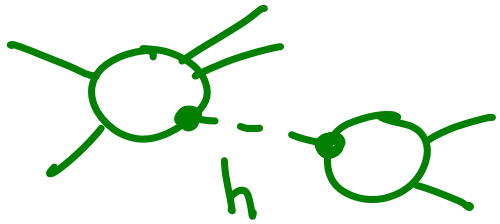


- Spinorials : $\sqrt{1-\xi}\times(SM)$ — MCHM4
- Fundamentals: $\frac{1-2\xi}{\sqrt{1-\xi}}\times(SM)$ — MCHM5

SEARCH OF LIGHT COMPOSITE HIGGS

★ Only h couplings modified w.r.t. SM
(only composite state)

Signal process
modified



but same kinematics.

★ Background processes unaffected.

➡ Can use SM analyses !

MCHM4

Universal reduction:  $\sqrt{1-\xi} \times (SM)$

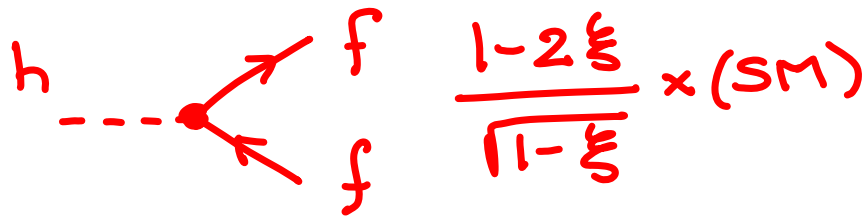
Production Xsections $\sigma_{LCH} = (1-\xi)\sigma_{SM}$

BRs unaffected

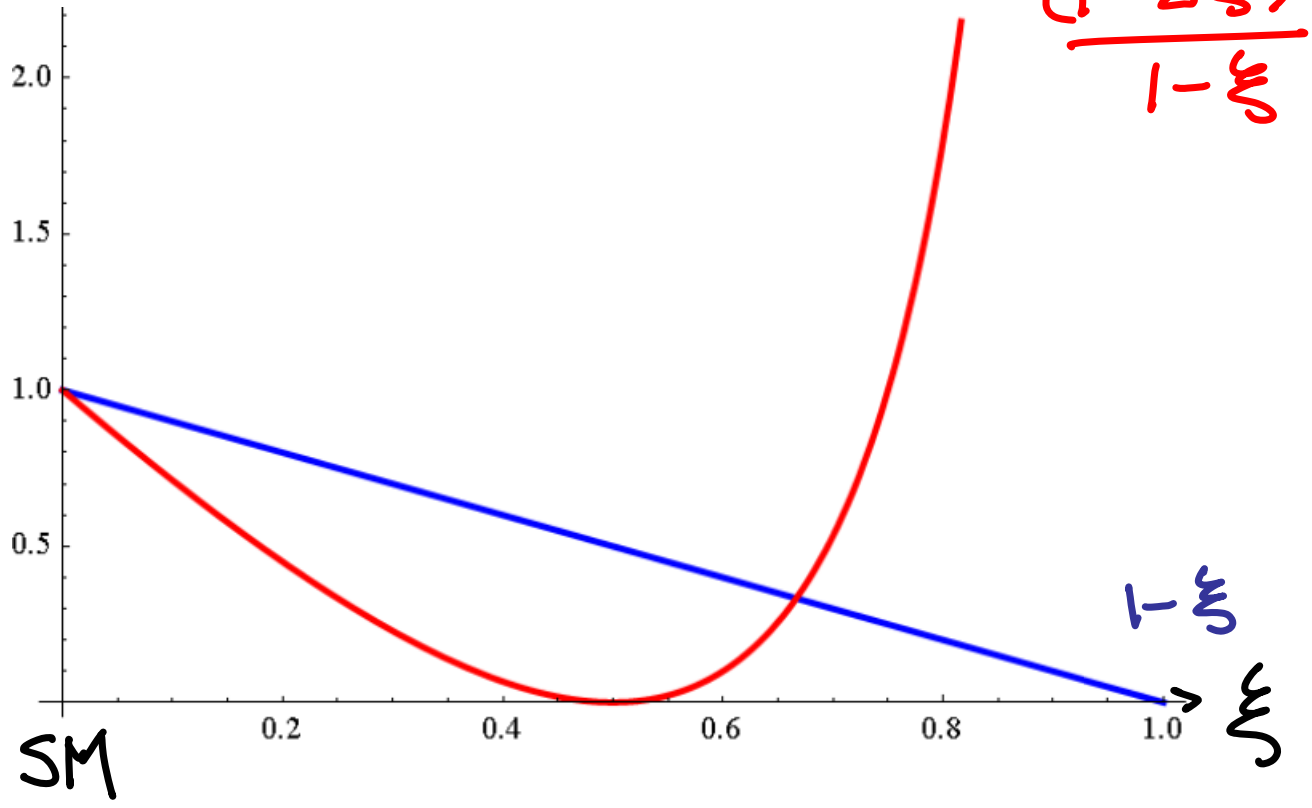
Higgs width $\Gamma_h = (1-\xi)\Gamma_{SM}$

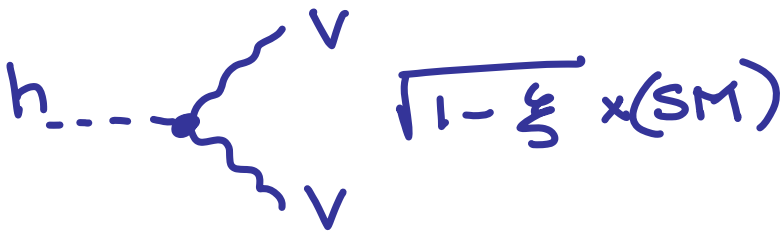
MCHM5

(Rescaling factors)^2



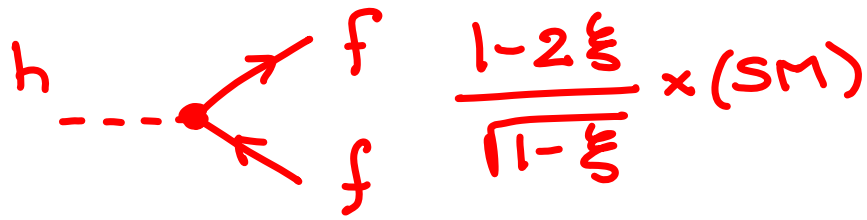
$\frac{(1-2\xi)^2}{1-\xi}$



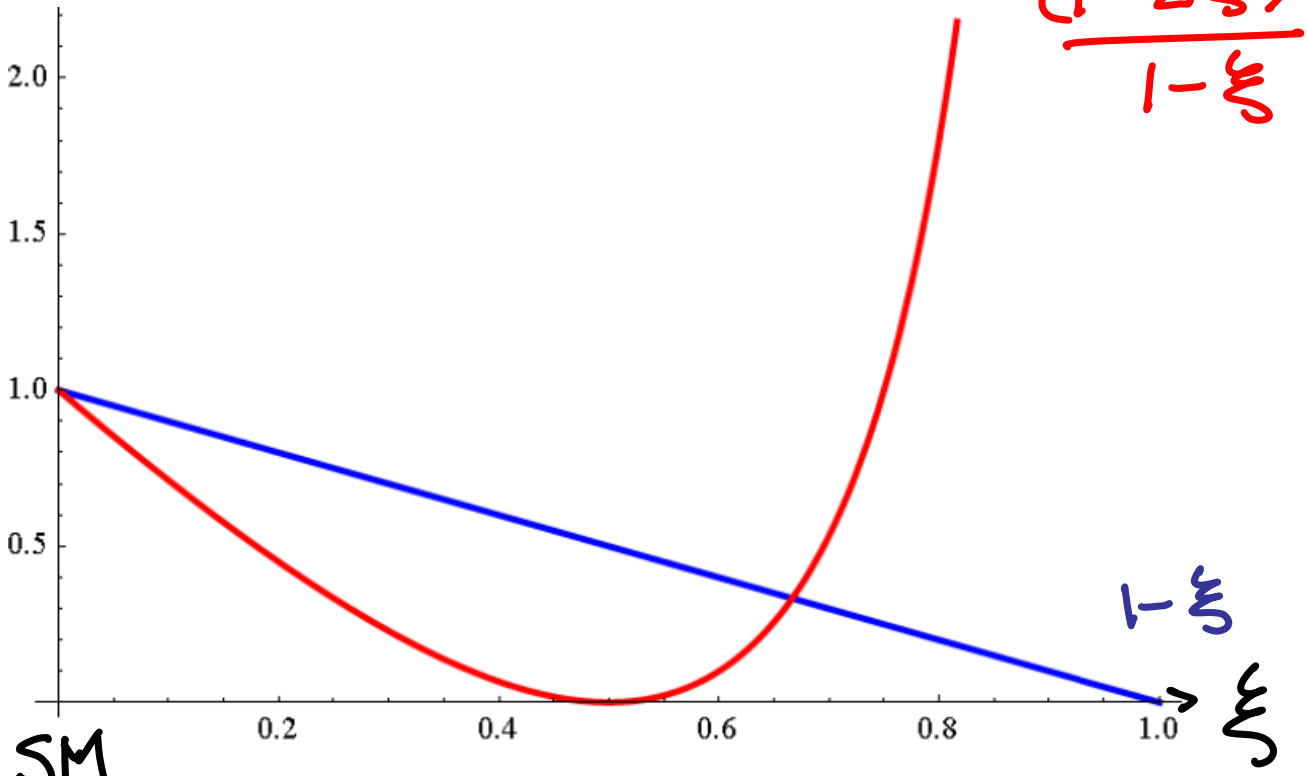


MCHM5

(Rescaling factors)^2

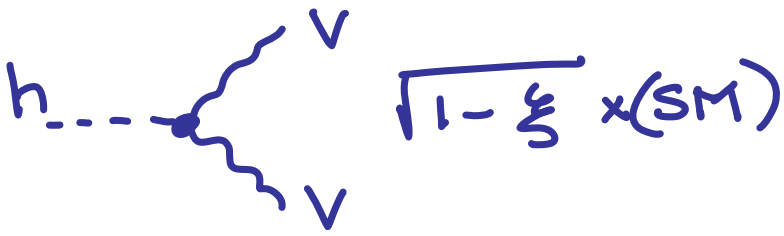


$\frac{(1-2\xi)^2}{1-\xi}$



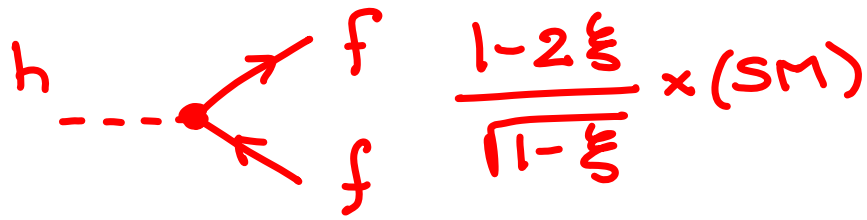
SM

Reduction for small ξ

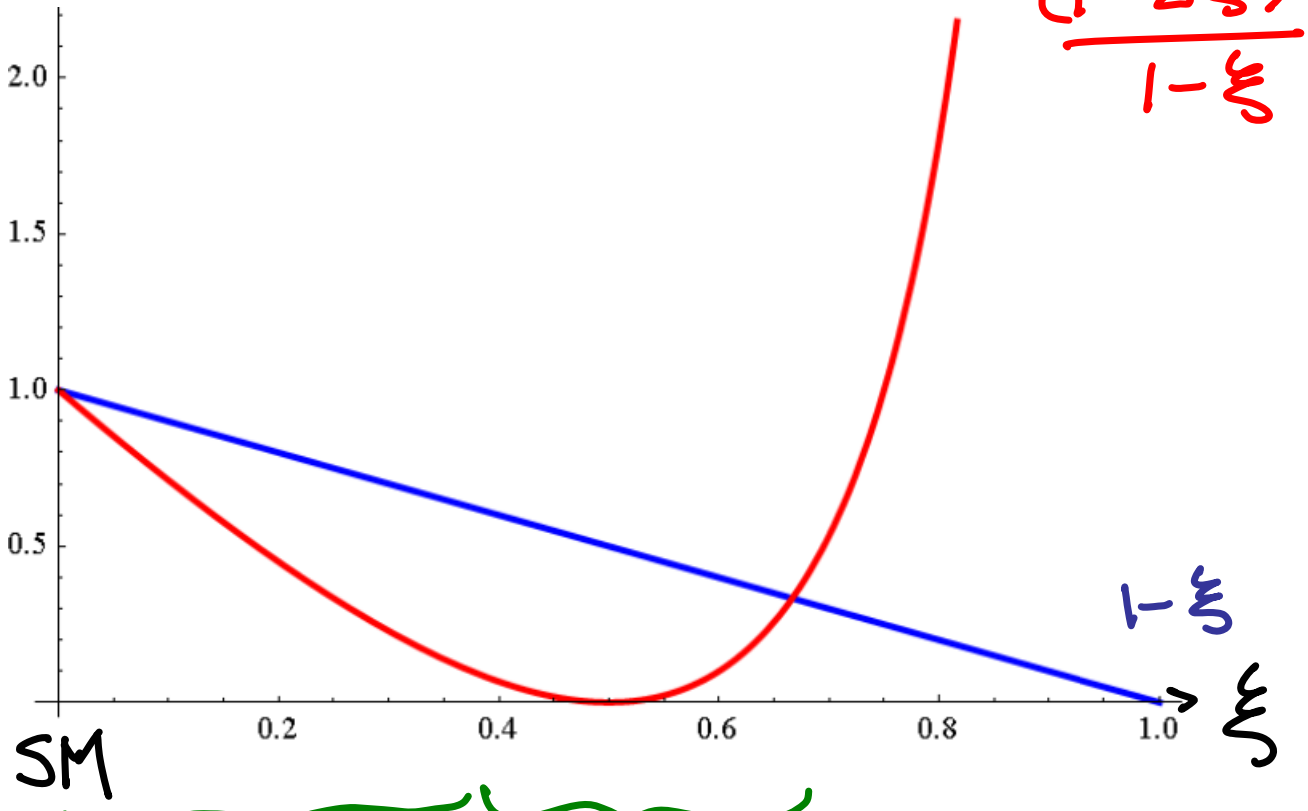


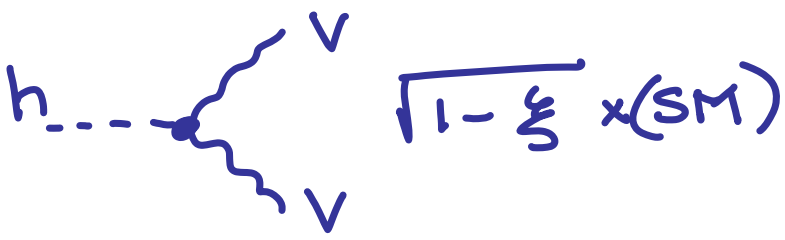
MCHM5

(Rescaling factors)^2



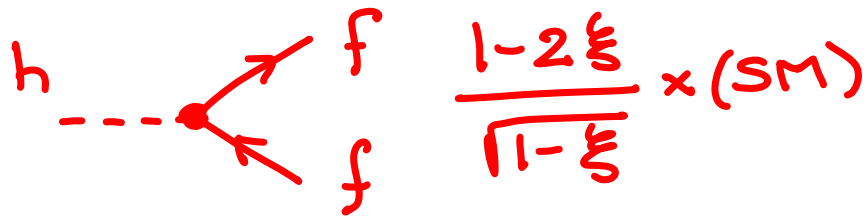
$\frac{(1-2\xi)^2}{1-\xi}$





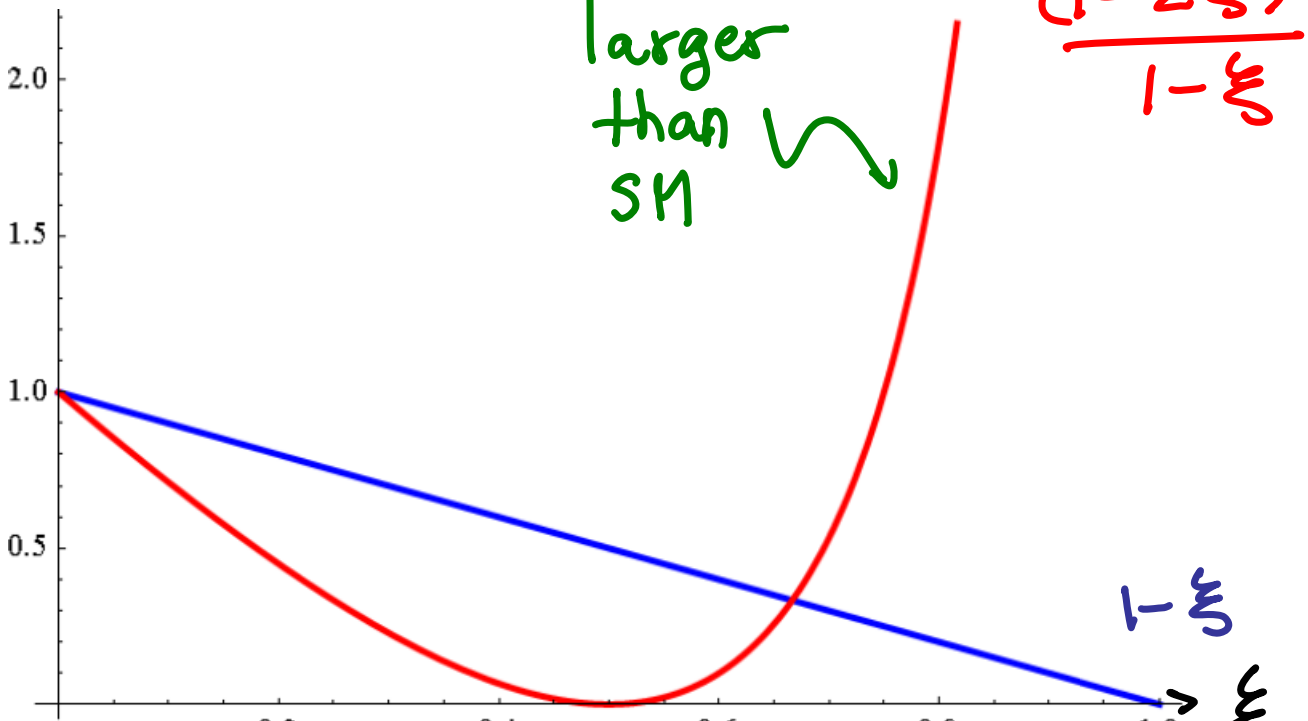
MCHM5

(Rescaling factors)^2



$\frac{(1-2\xi)^2}{1-\xi}$

larger than SM

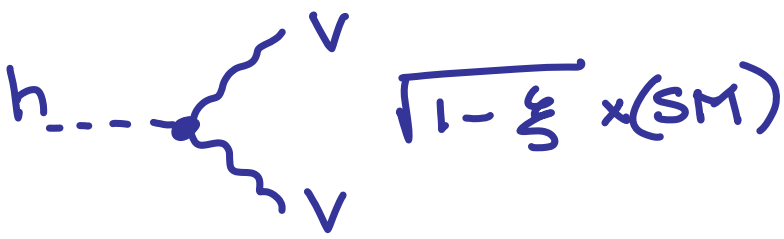


SM

Reduction for small ξ

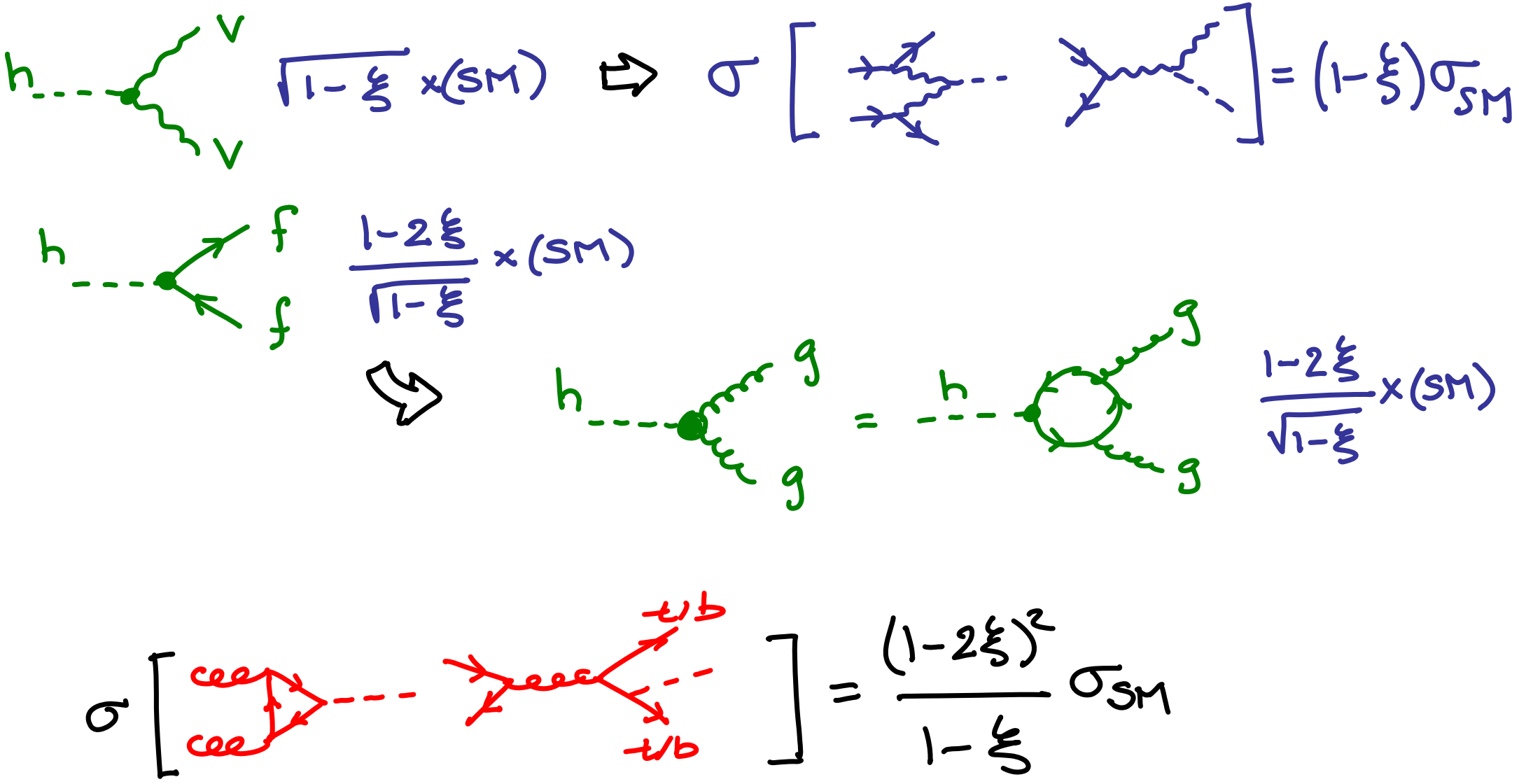
fermio-phobic

gaugeo-phobic

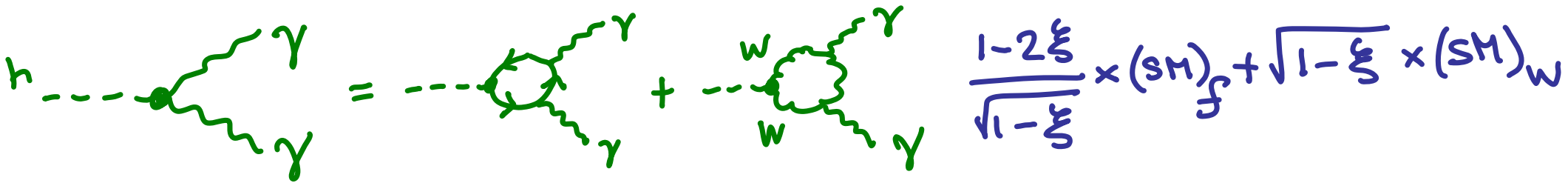


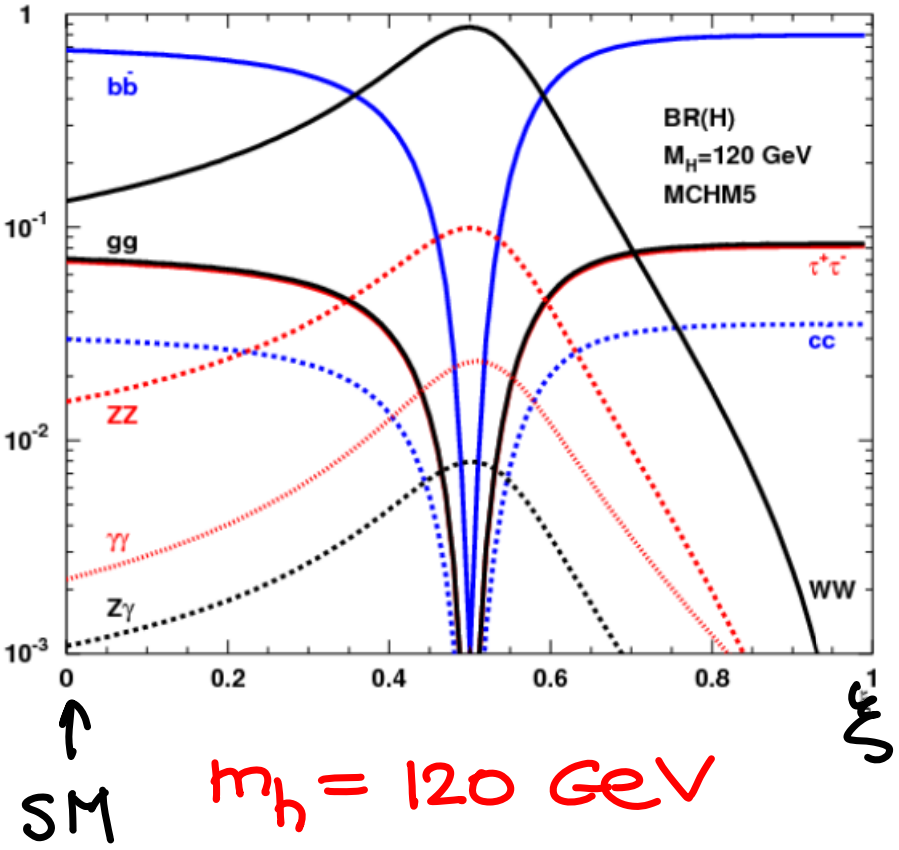
MCHM5

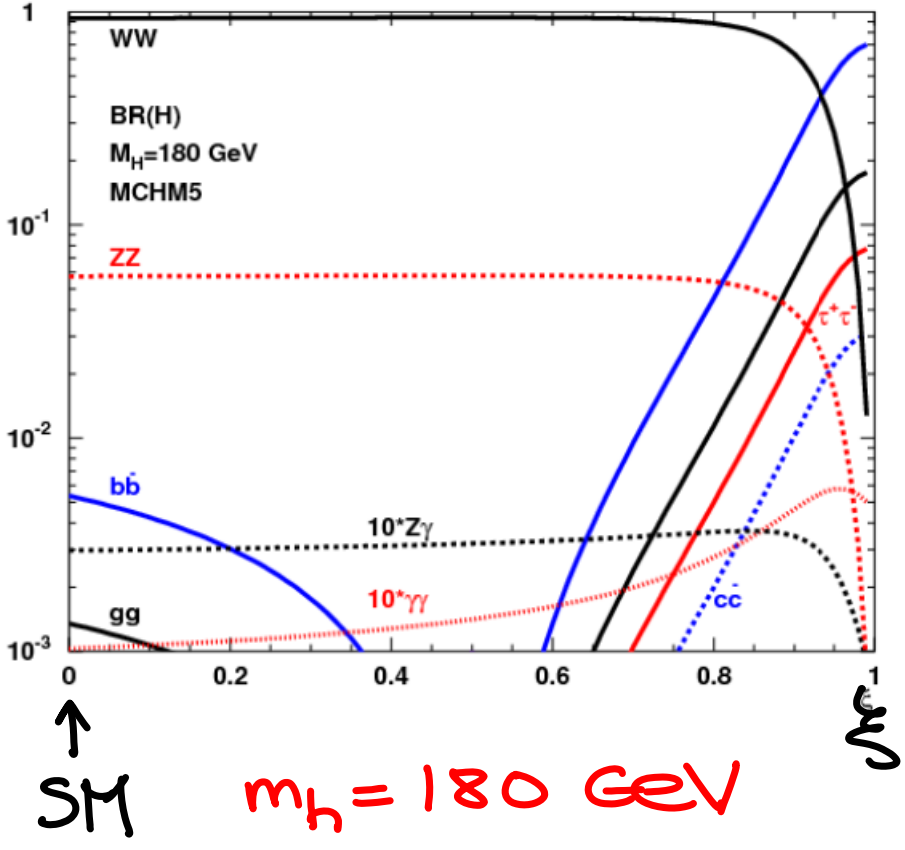
Production Xsections :



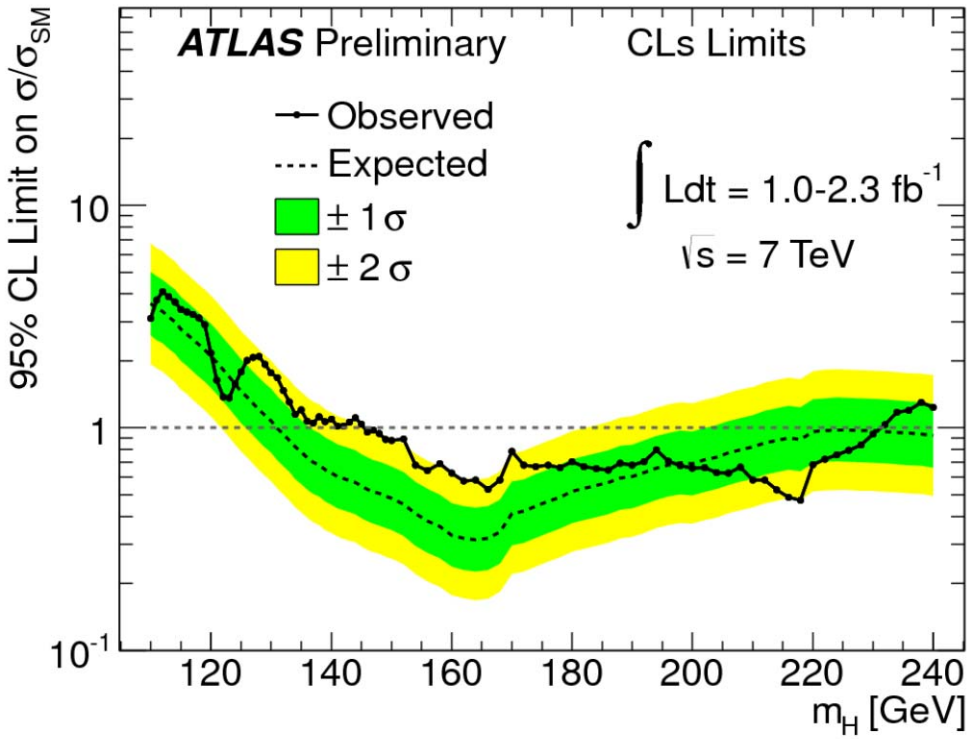
BRs (MCHM5)

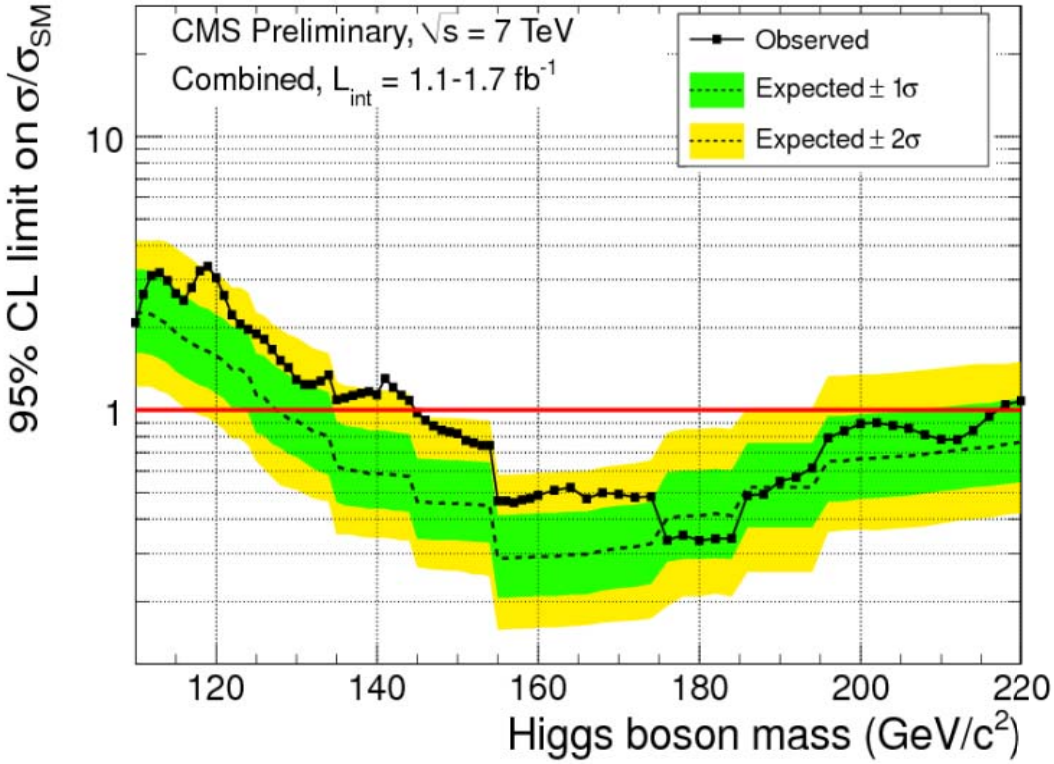

h
γ
γ
=
γ
γ
+
W
γ
W
γ
$\frac{1-2\xi}{\sqrt{1-\xi}} \times (SM)_F + \sqrt{1-\xi} \times (SM)_W$


1
10^{-1}
10^{-2}
10^{-3}
0
0.2
0.4
0.6
0.8
1
ξ
bb̄
gg
ZZ
γγ
Zγ
τ⁺τ⁻
cc
WW
BR(H)
M_H=120 GeV
MCHM5
SM
m_h = 120 GeV

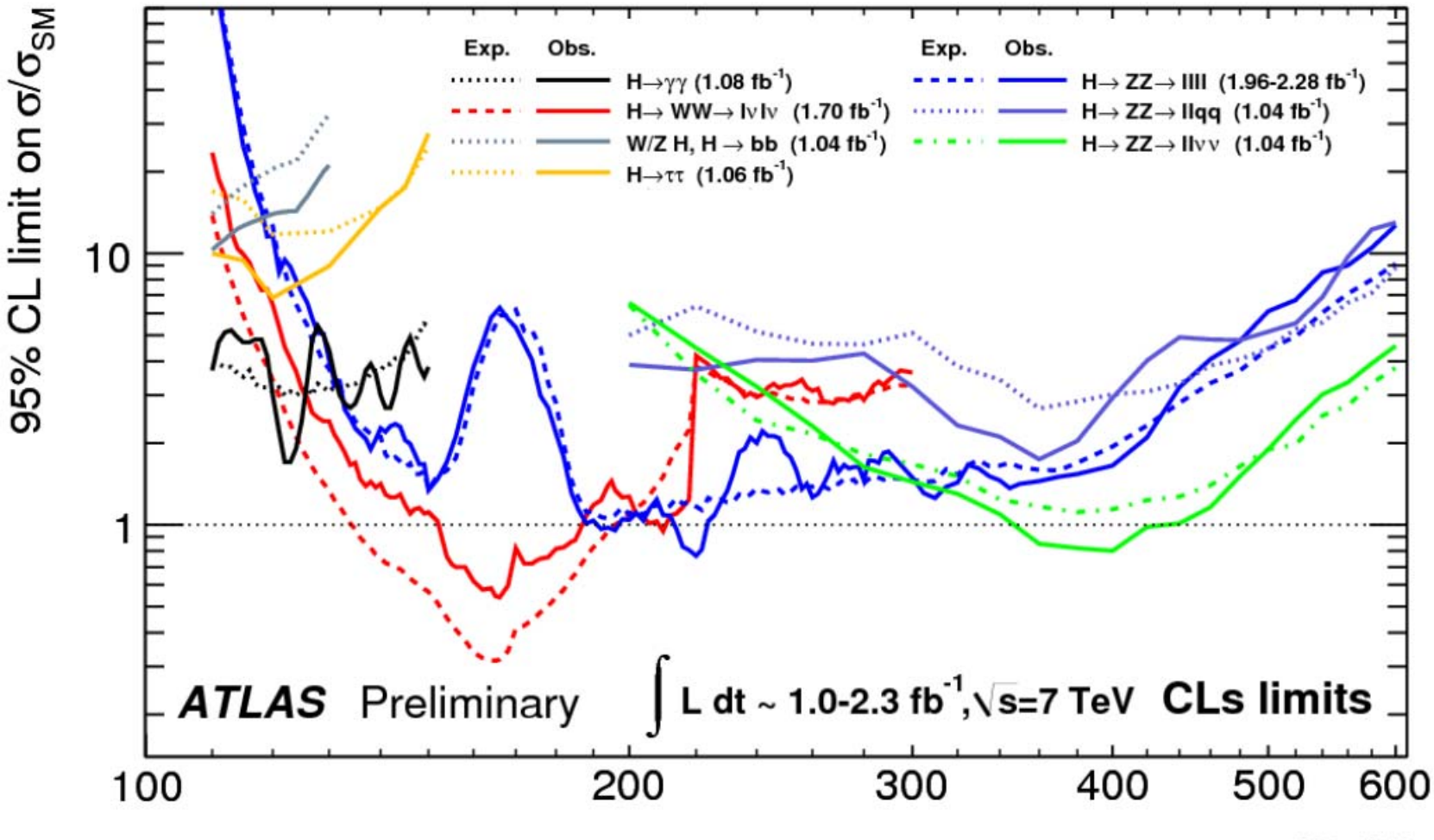

1
10^{-1}
10^{-2}
10^{-3}
0
0.2
0.4
0.6
0.8
1
ξ
WW
BR(H)
M_H=180 GeV
MCHM5
ZZ
τ⁺τ⁻
bb̄
10*Zγ
10*γγ
gg
cc̄
SM
m_h = 180 GeV

COMBINED LIMITS FOR LIGHT m_h





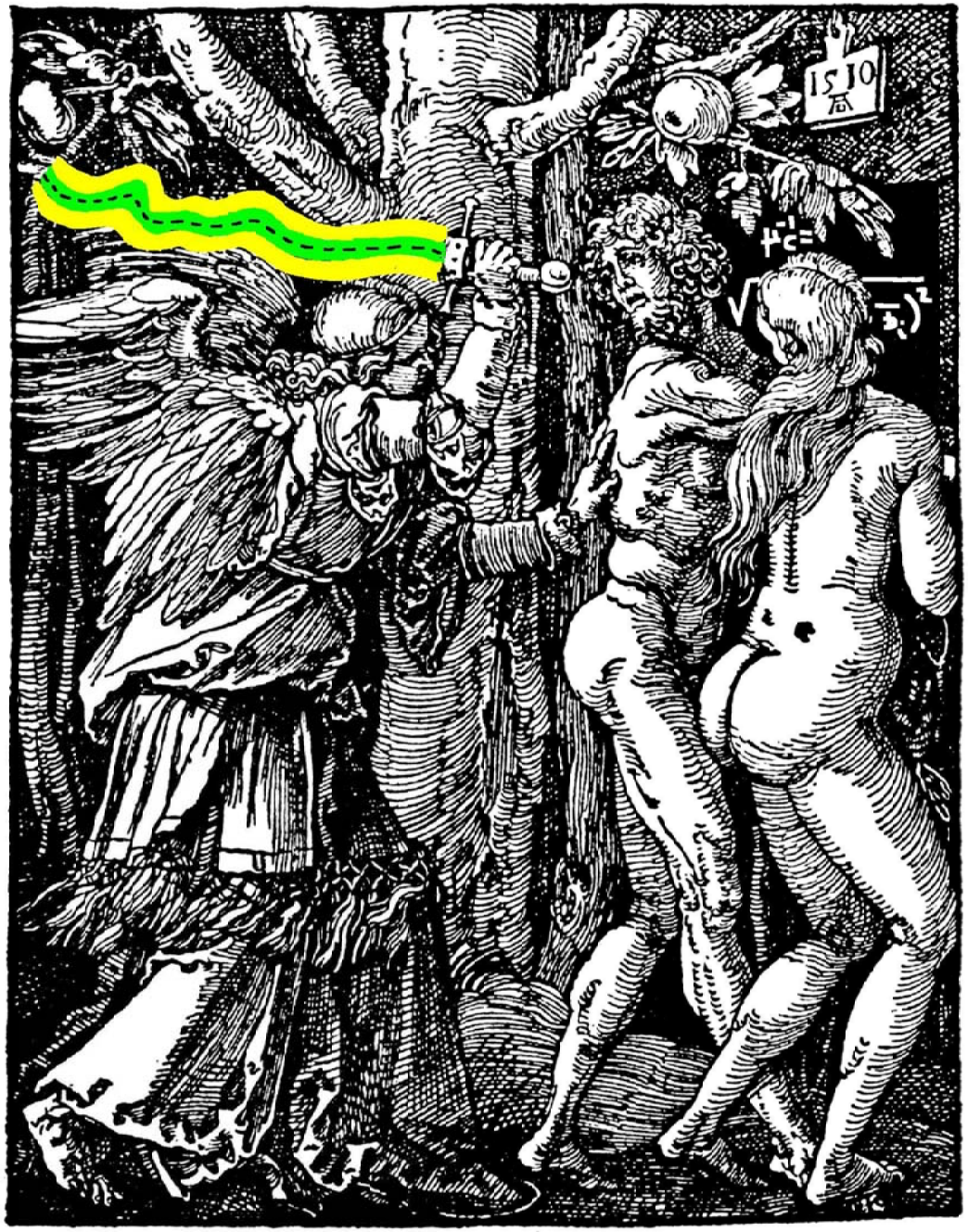
BACK TO INDIVIDUAL CHANNELS



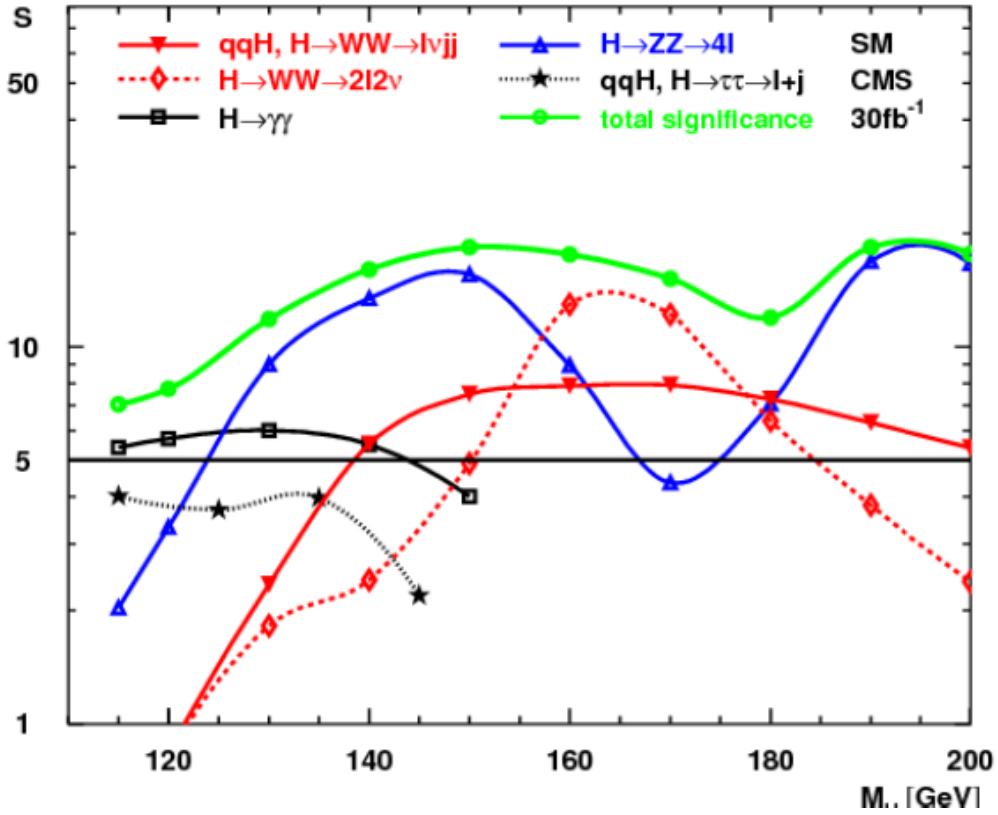
★ Re-scale individual channels separately

★ Combine them back

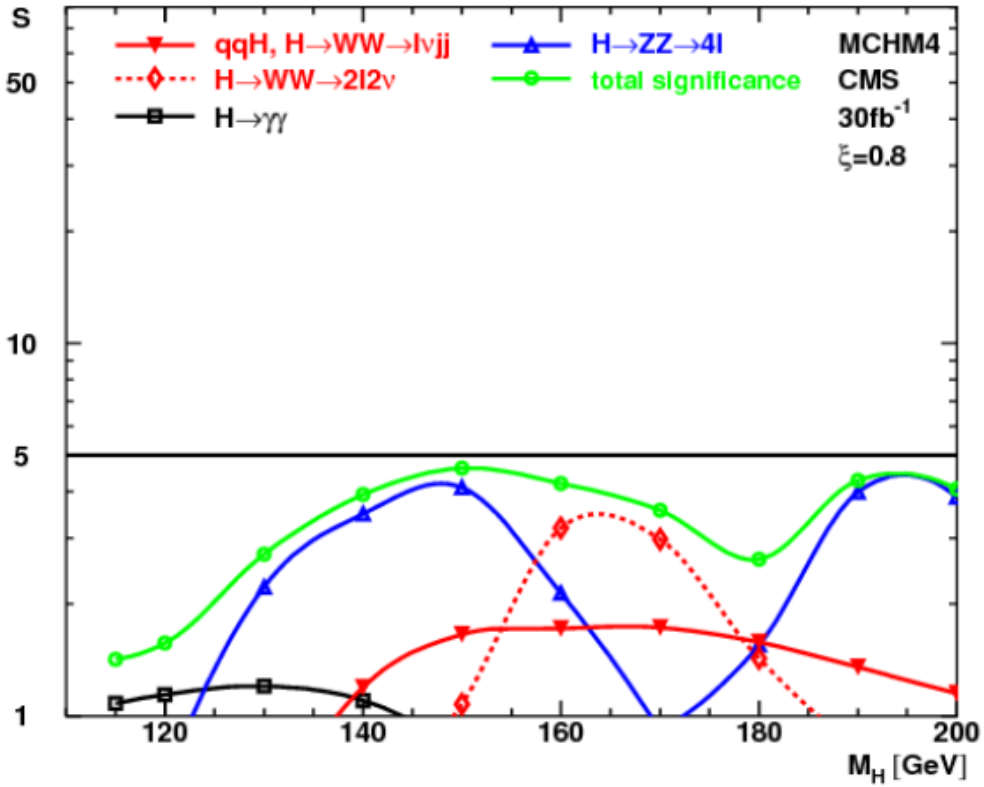
YE SHALL NOT COMBINE!*



EXPECTATIONS (30fb^{-1})



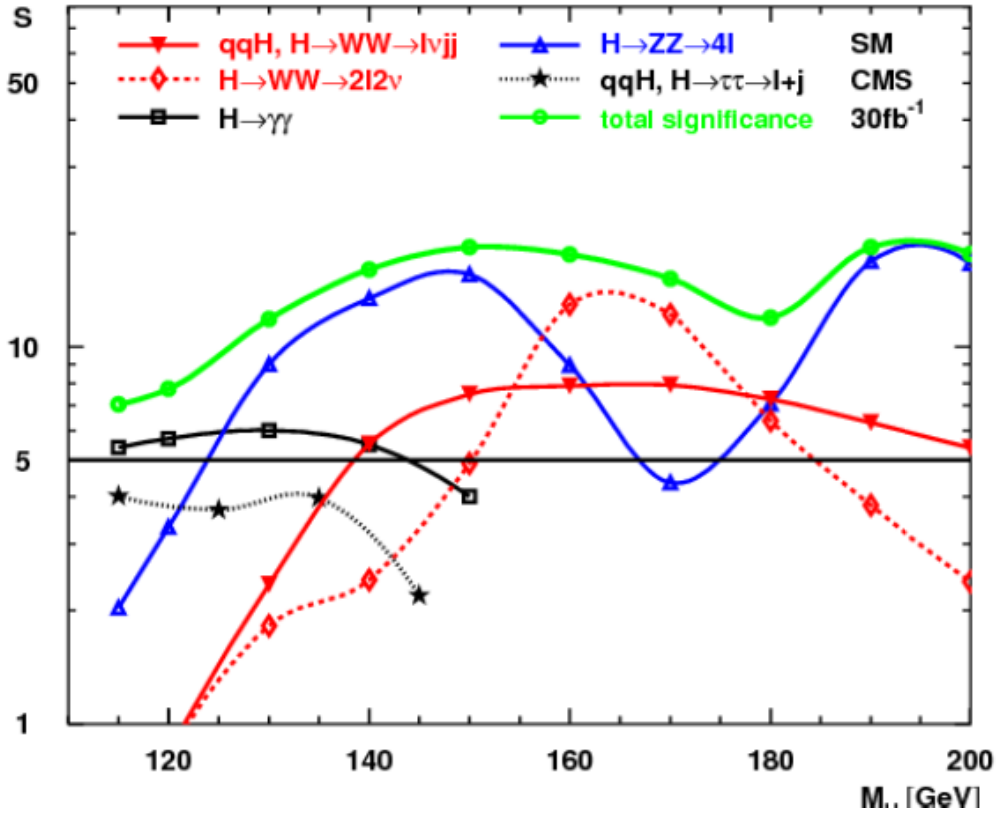
SM



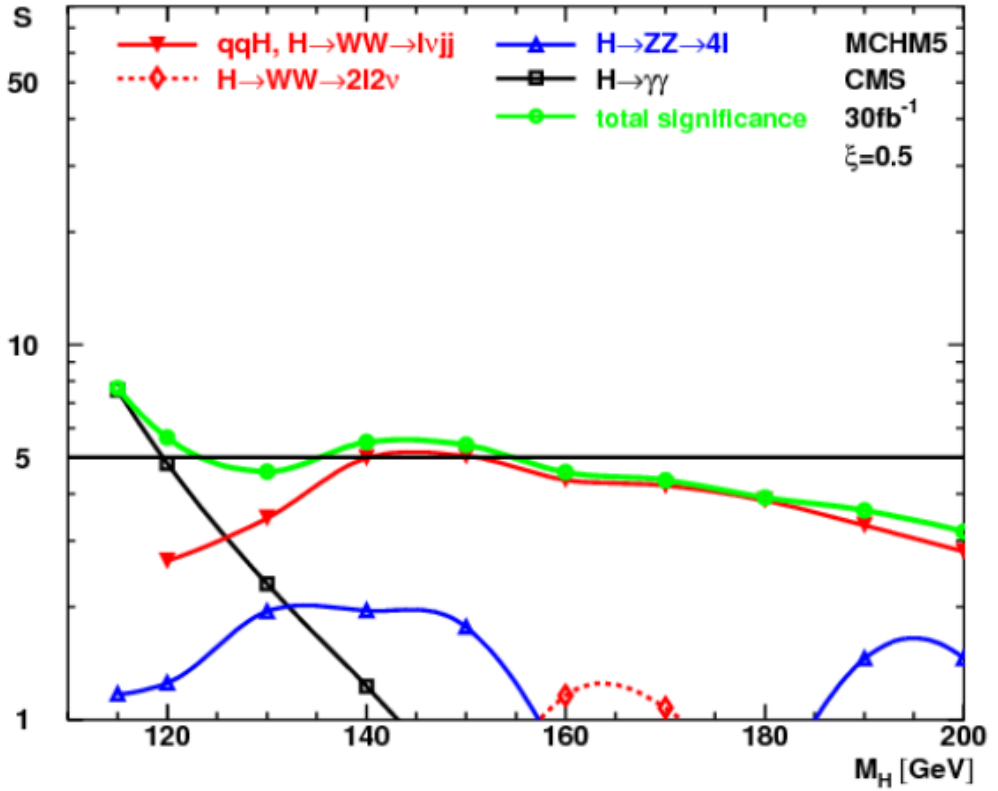
MCHM4

($\xi = 0.8$)

EXPECTATIONS (30fb^{-1})

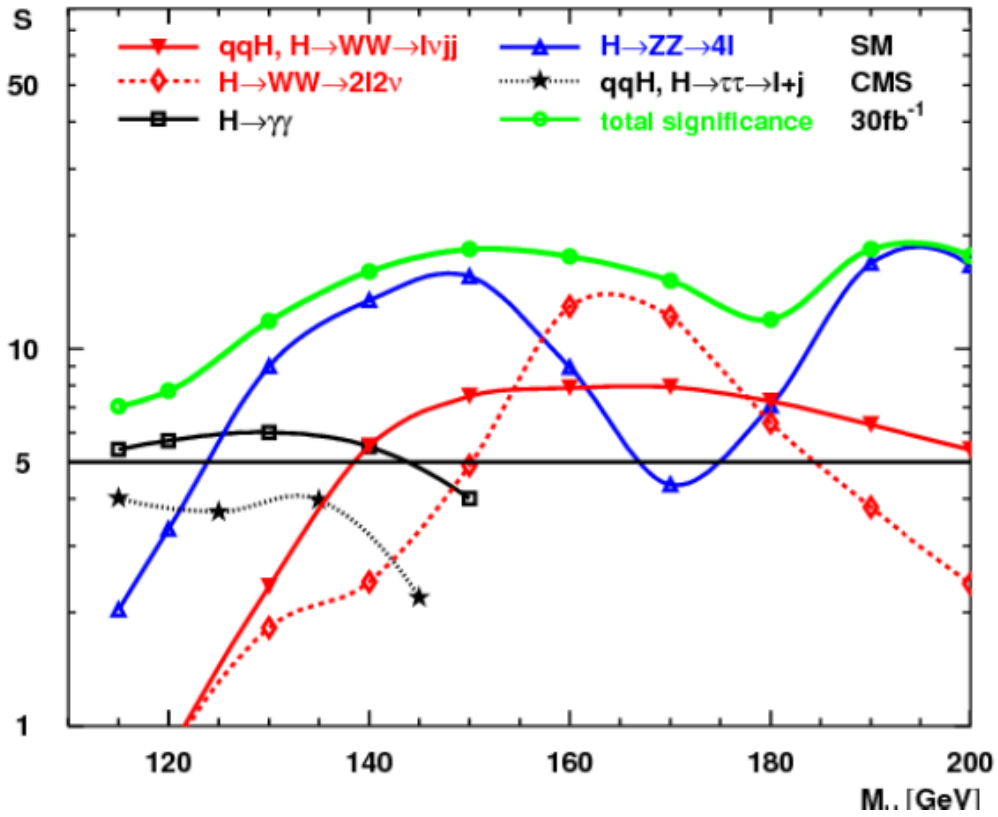


SM

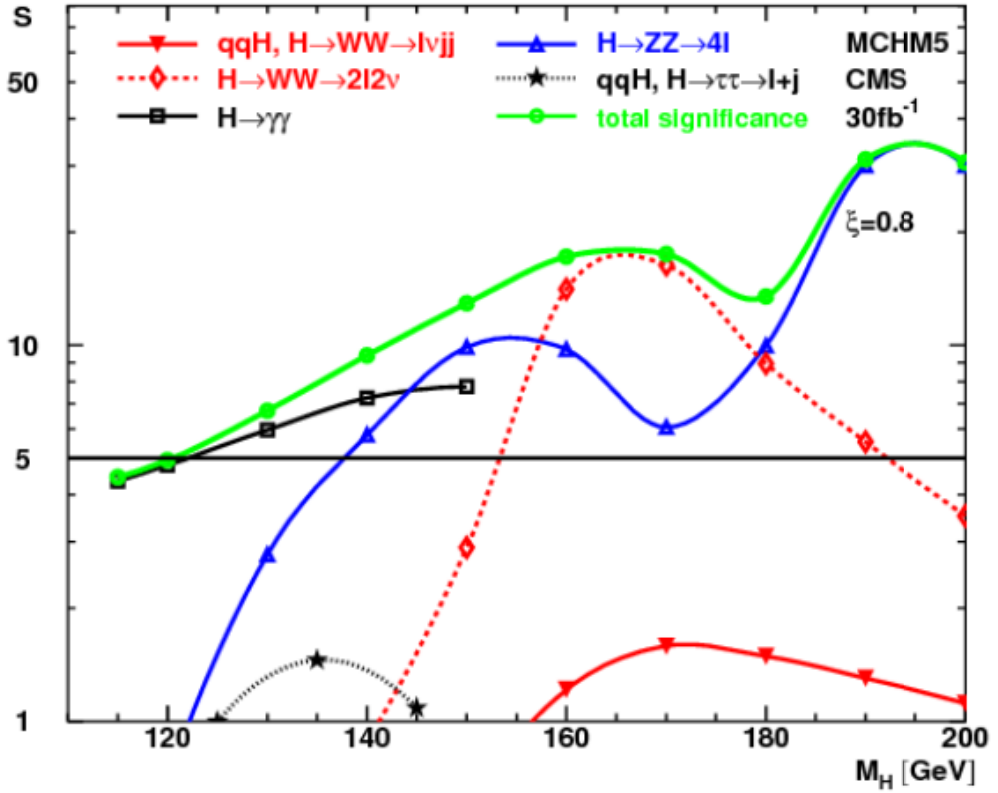


MCHM5 ($\xi = 0.5$)

EXPECTATIONS (30fb^{-1})



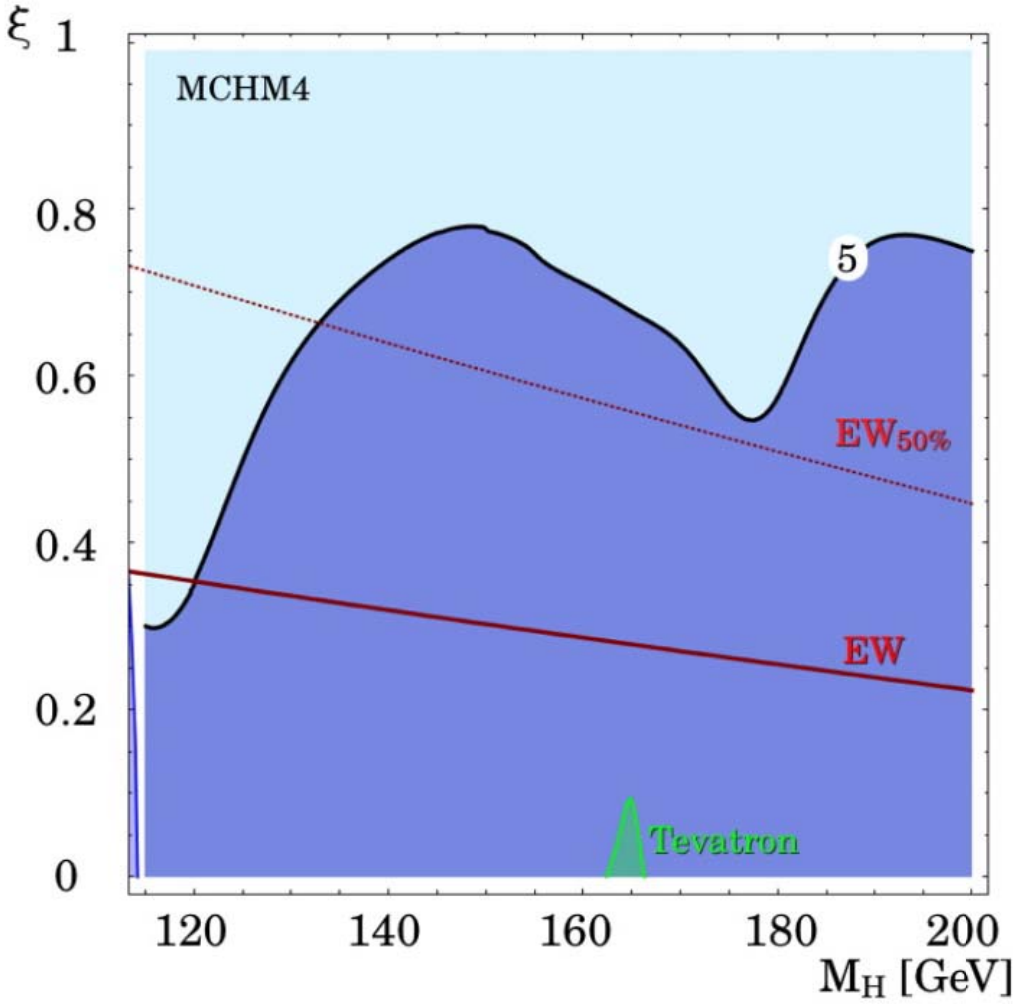
SM



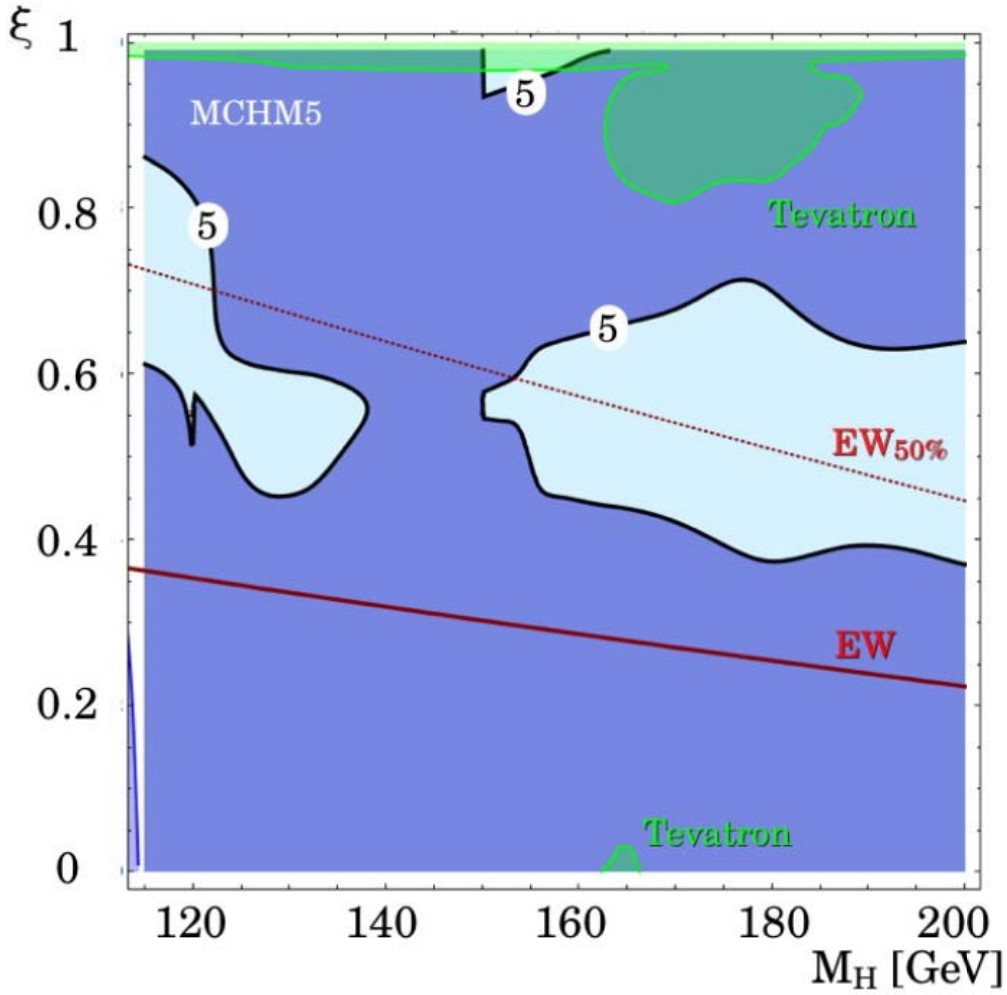
MCHM5

($\xi = 0.8$)

EXPECTATIONS (3 of 5)

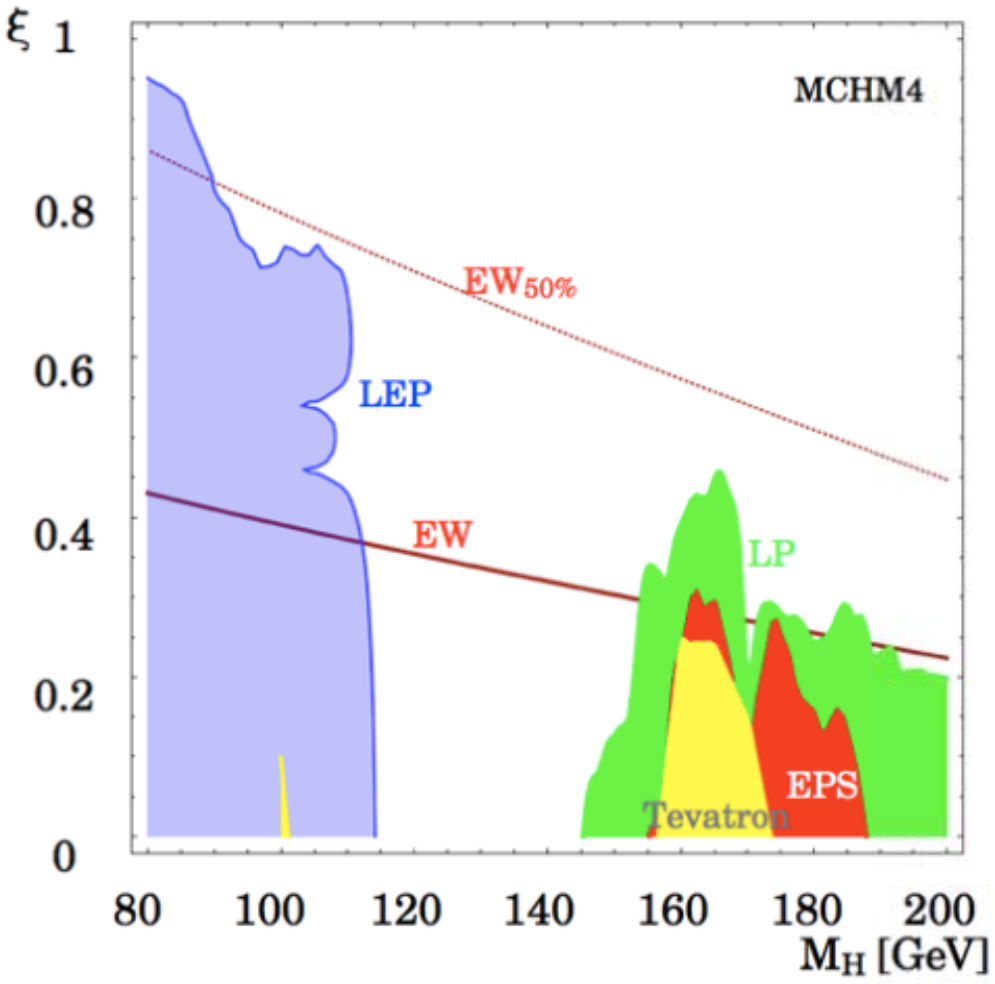


MCHM4

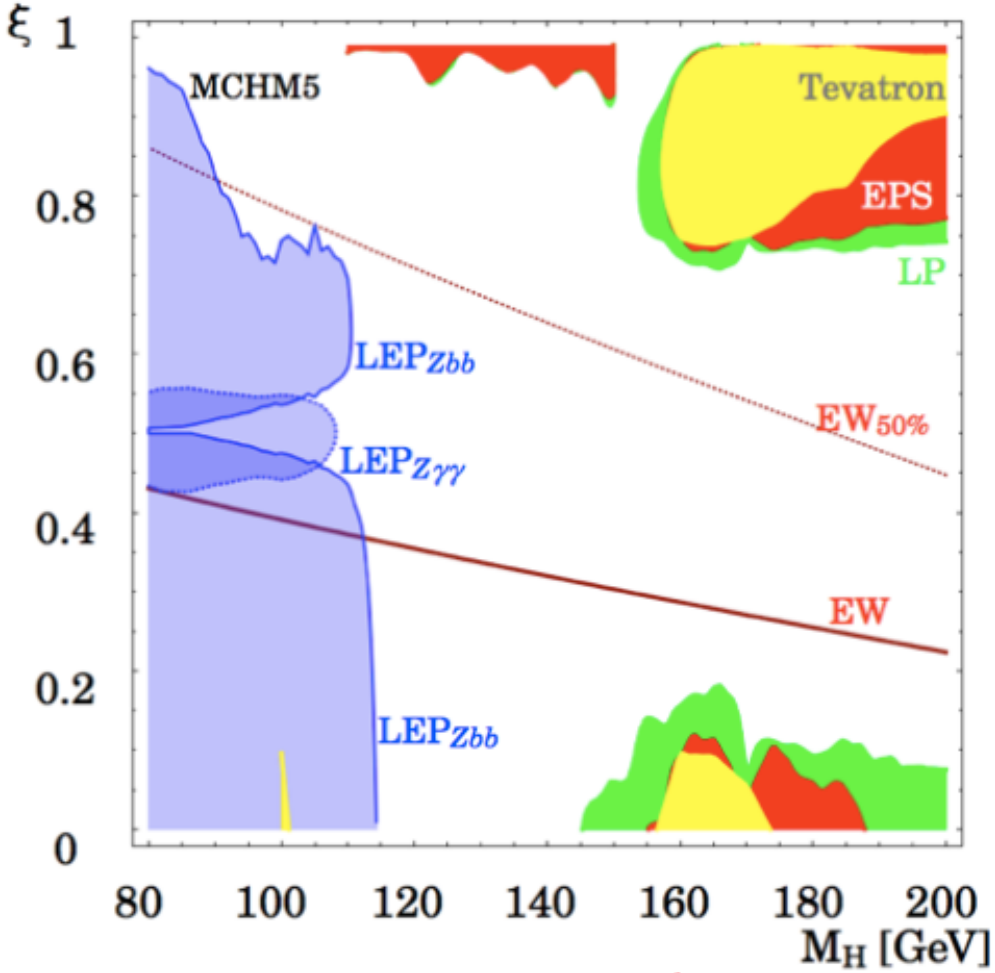


MCHM5

EXCLUSIONS



MCHM4



MCHM5

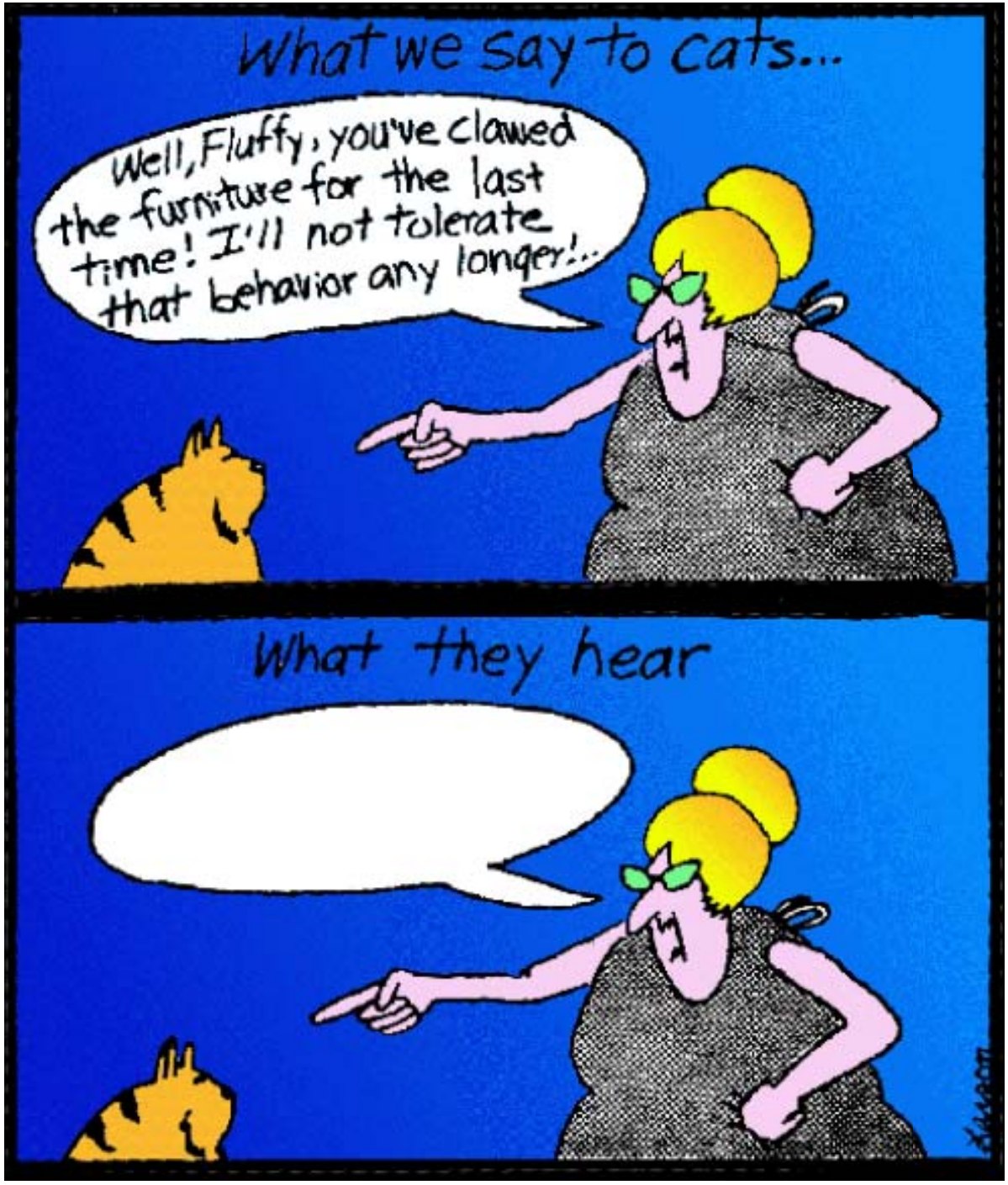
CONCLUSIONS

- Very likely Higgs is not SM-like
- Besides a SUSY Higgs we should seriously consider
  - Light Composite Higgses (EWP tests) (hierarchy problem)
- Combined TH-EXP effort to improve the analysis is worth undertaking.
- Discussed expectations and exclusion from LHC Higgs searches on 2 benchmark models

TH-EXP DIALOGUE

Gary Larson

TH-EXP DIALOG / PESSIMIST VERSION



Gary Larson

WHAT EXPERIMENTALISTS TELL THEORISTS:

Beware of correlations and uncertainties!

Don't do these combinations at home!

WHAT EXPERIMENTALISTS TELL THEORISTS:

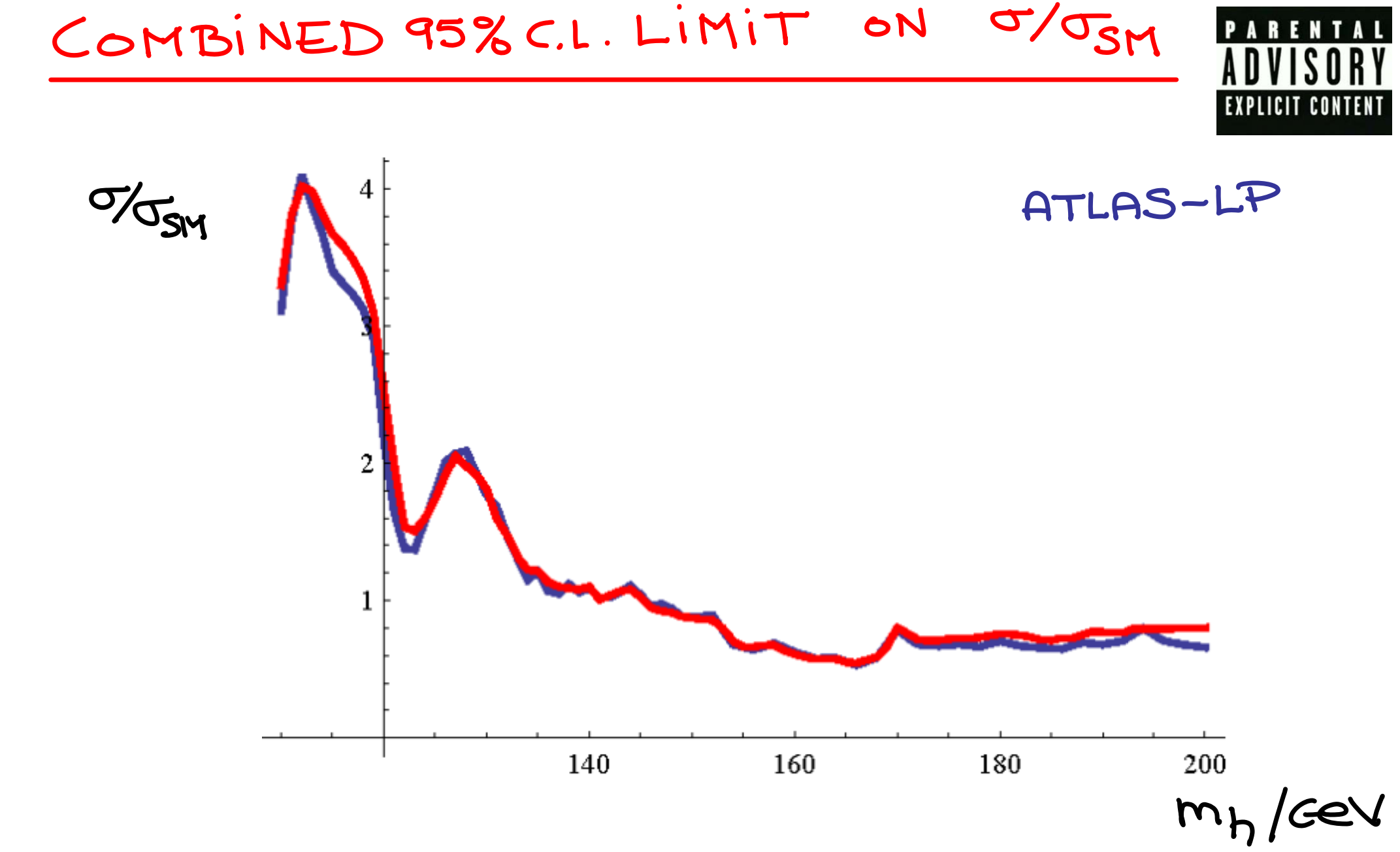
Beware of correlations and uncertainties!

Don't do these combinations at home!

WHAT THEORISTS HEAR/THINK:

Let's see how well we can do it!

COMBINED 95% C.L. LIMIT ON σ/σ_{SM}



SM Xcheck

MODEL SPACE

$$\mathcal{L}_{EWSB} = \frac{v^2}{4} Tr\left[D_\mu \Sigma^\dagger D^\mu \Sigma\right]\left(1 + 2a\frac{h}{v} + b\frac{h^2}{v^2}\right) - y_f \bar{f}_L \Sigma f_R \left(1 + c\frac{h}{v}\right)$$

Unknown parameters a, b, c.

	a	b	c
SM	1	1	1
MCHM4	$\sqrt{1-\xi}$	$1-2\xi$	$\sqrt{1-\xi}$
MCHM5	$\sqrt{1-\xi}$	$1-2\xi$	$\frac{1-2\xi}{\sqrt{1-\xi}}$
Dilaton	$\sqrt{b}$	b	$\sqrt{b}$