HH pair searches

combination with wwyy, bbyy, bbττ, bbbb

Yaquan FANG, Shan JIN, Qi LI,
Xinchou LOU, Xiaohu SUN, Huijun ZHANG
and people from bbττ, bbbb, bbyy

--- --- --- --- ---

24-04-2015

IHEP

CDS entry
[wwyy]https://cds.cern.ch/record/1967498
[bbττ]https://cds.cern.ch/record/1967500
[combination]https://cds.cern.ch/record/1984111/

Higgs approval:
https://indico.cern.ch/event/387805/

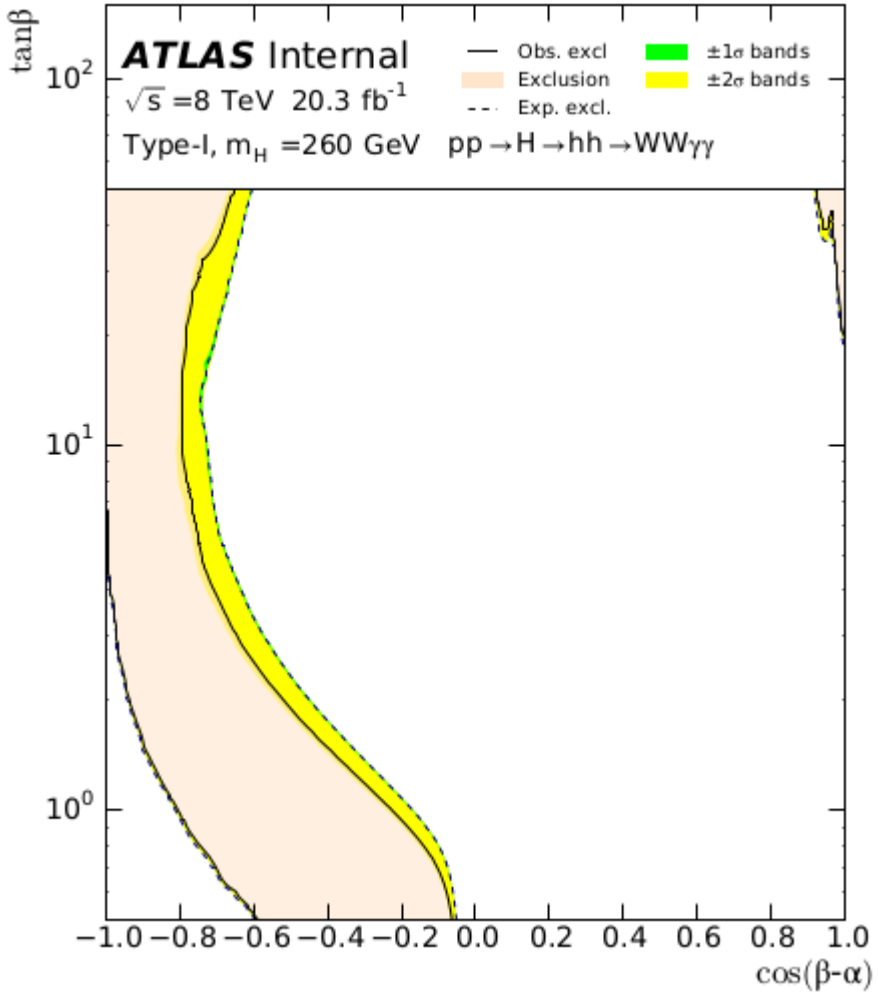
interpolated mass points

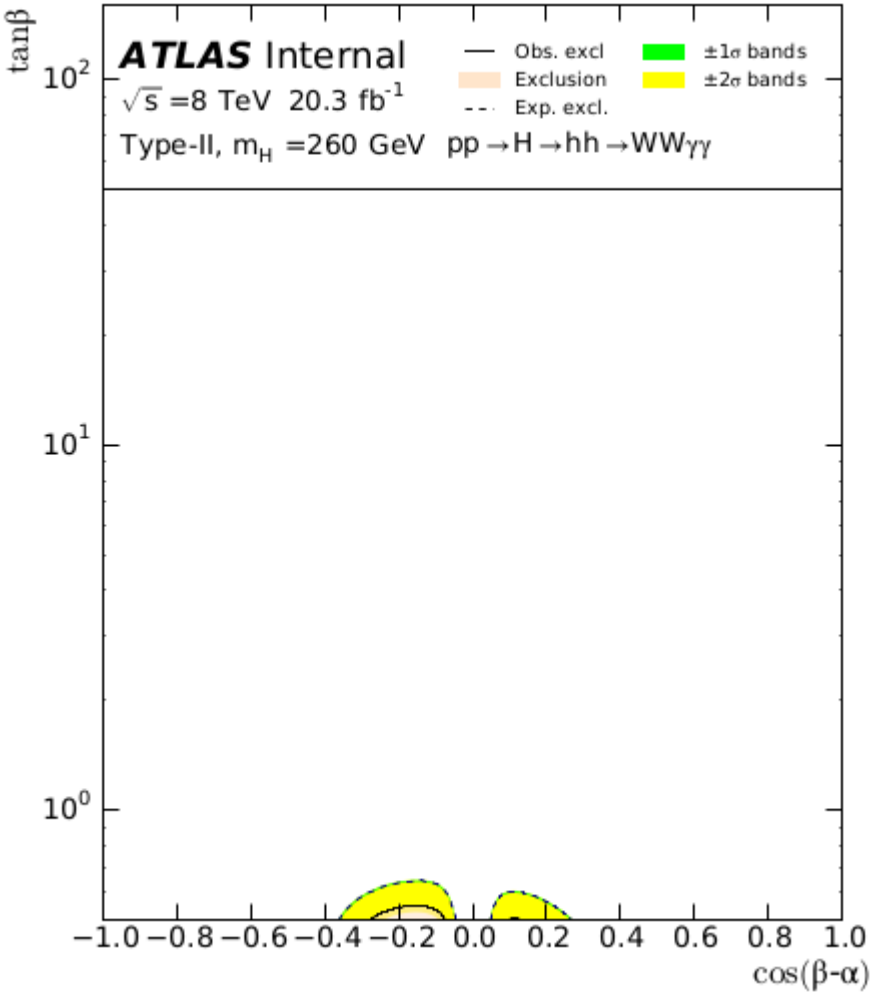
- have a first version of interpolated mass points in low mass from Keita. As he said, there will be probably updates them after his validating them
- the jobs are **running** on grid in order to get the limits for those new mass points
- our new PhD student, Qi LI, will join the efforts on this

2HDM

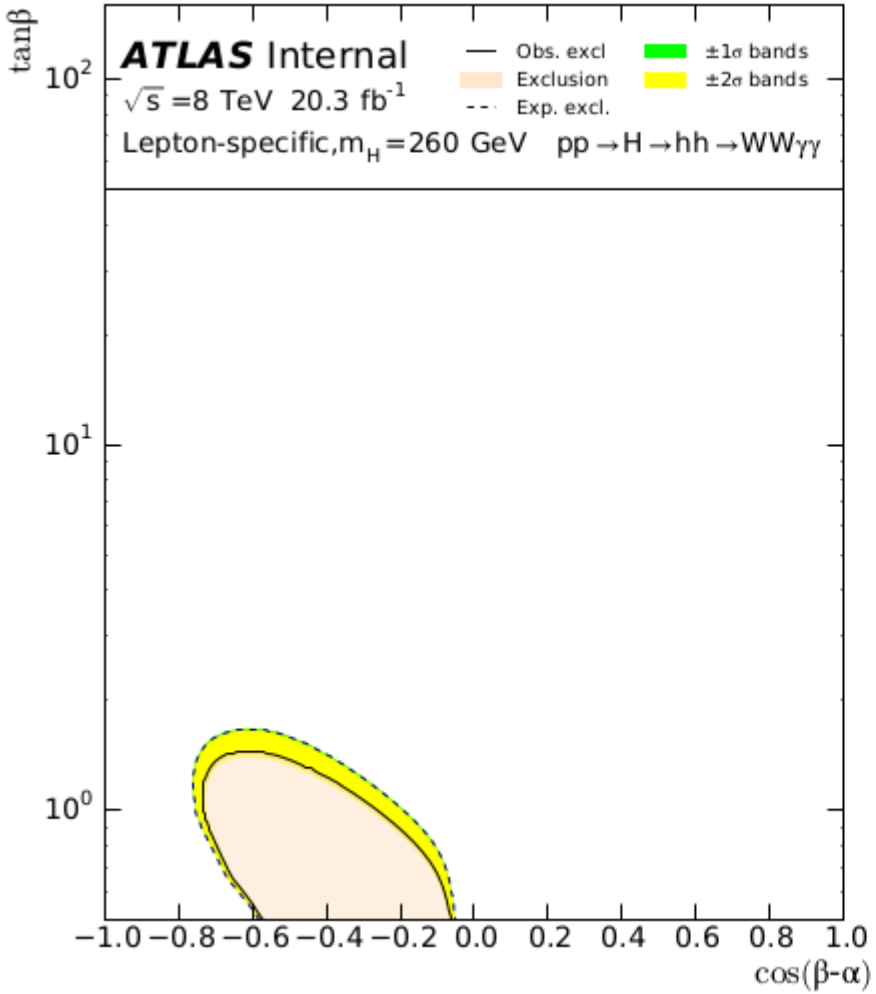
- with the help from David and hits py-script, we can produce exclusion plots more efficiently without any ROOT-Tgraph contour-closing problems
- as we agreed we will not combine the limits again as a function of BR and width across the 2HDM phase space, due to the difficulty of parametrization for the limit setting under the current time scale
- in the following, I will show the individual channel limit -> exclusions

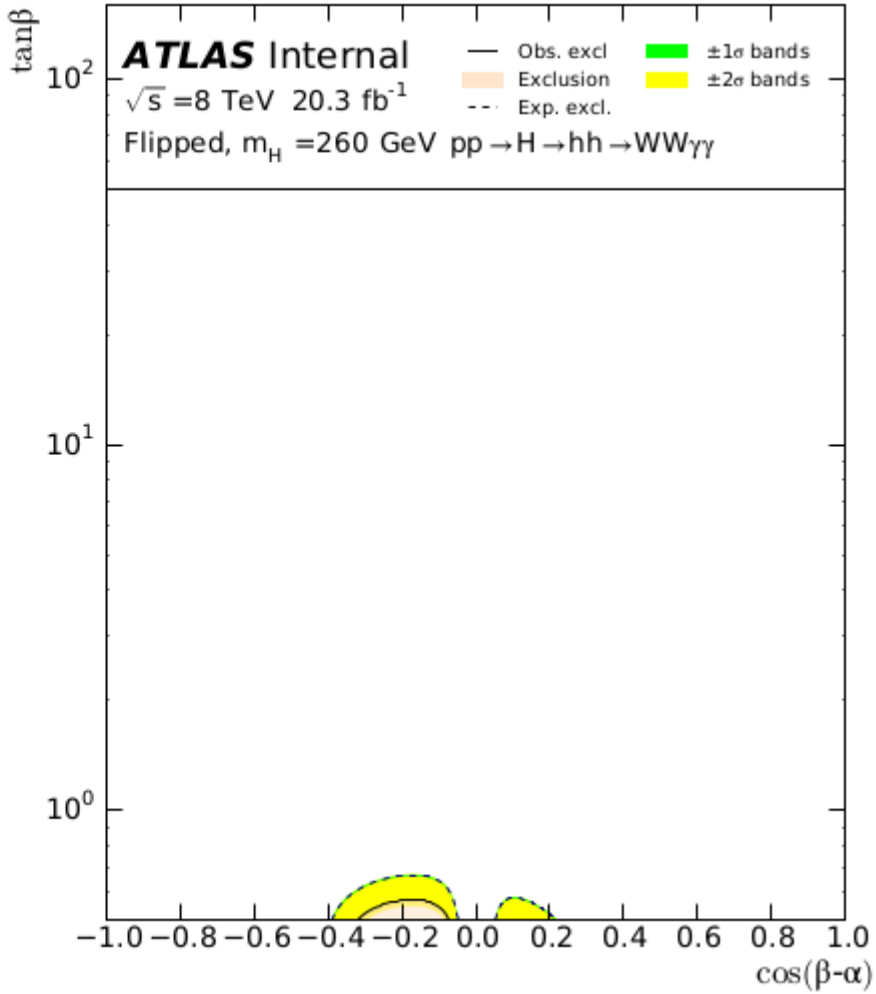
2HDM wwyy 260



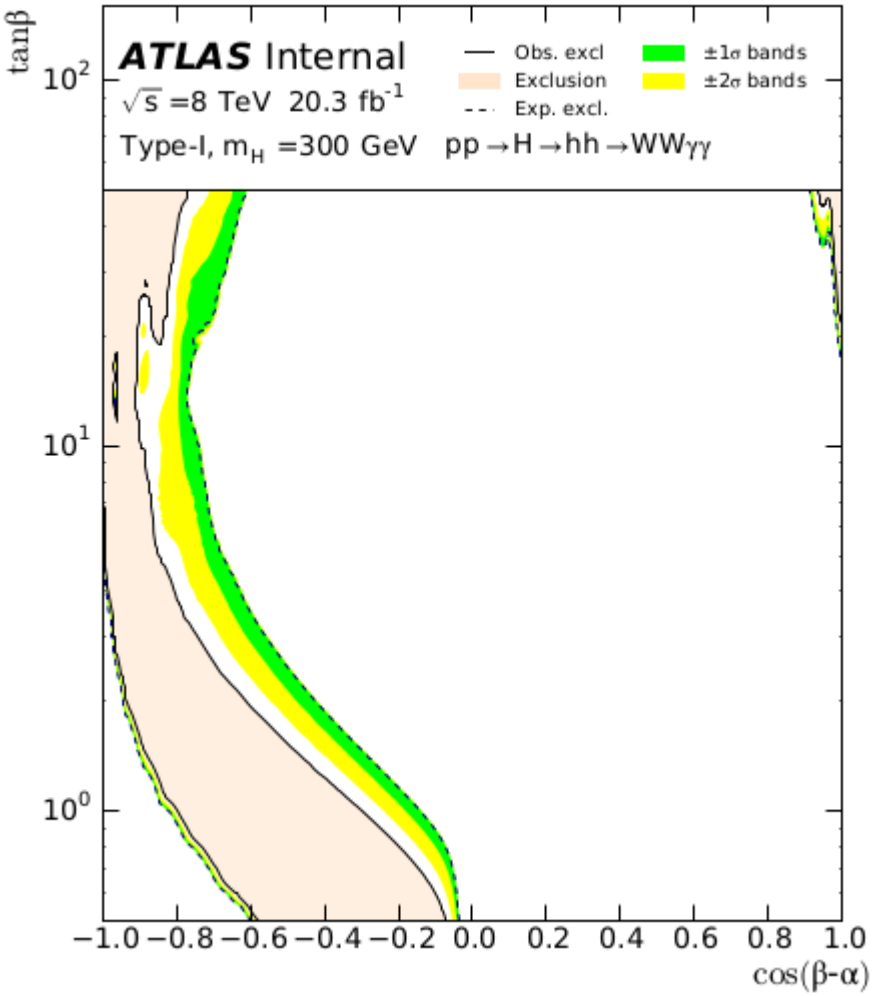


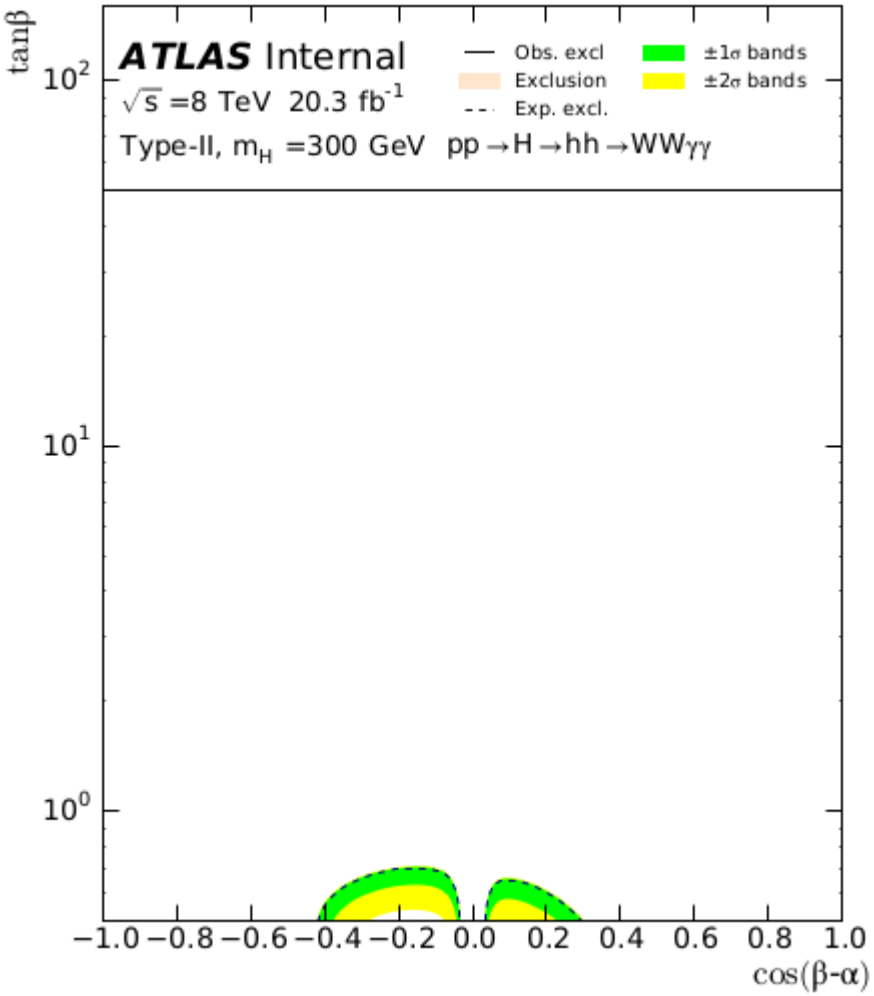
2HDM wwyy 260



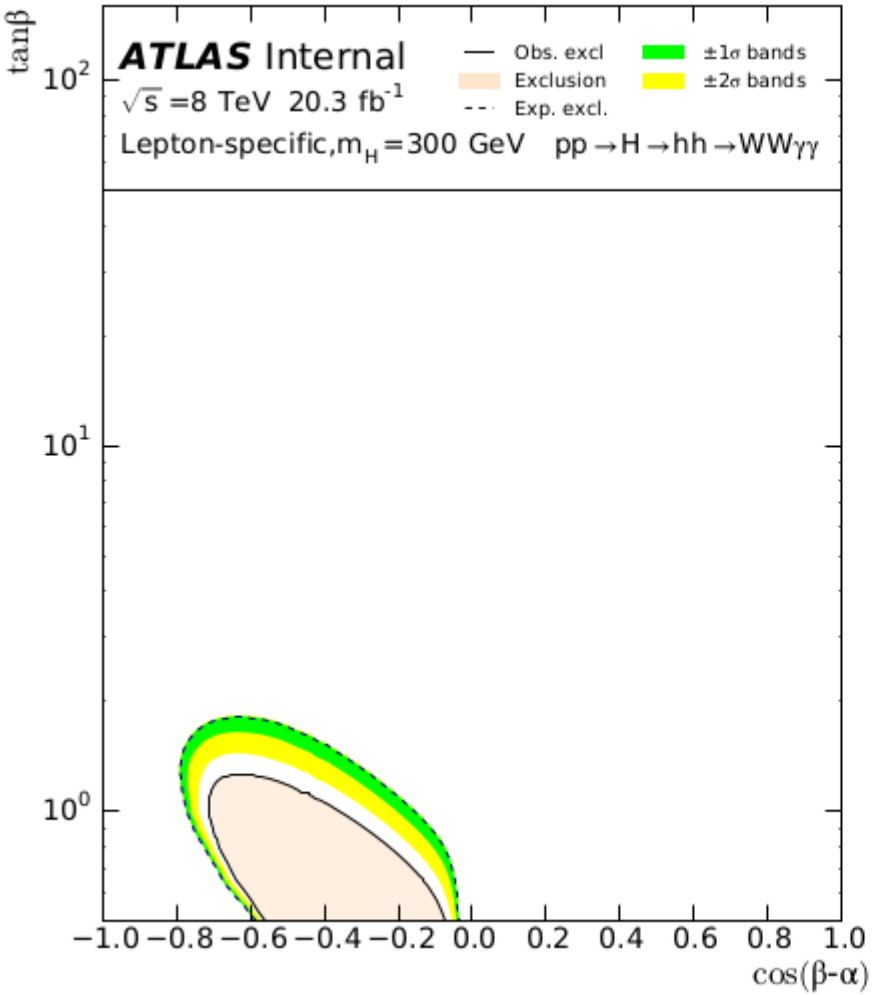


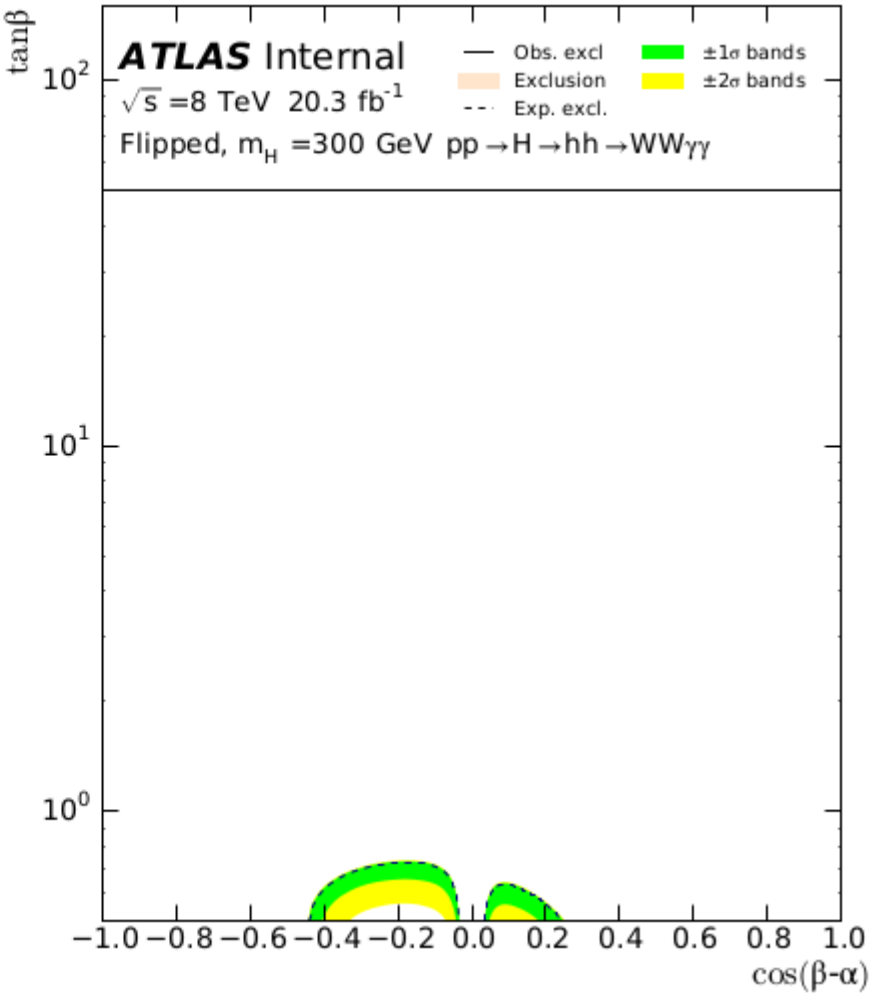
2HDM wwyy 300



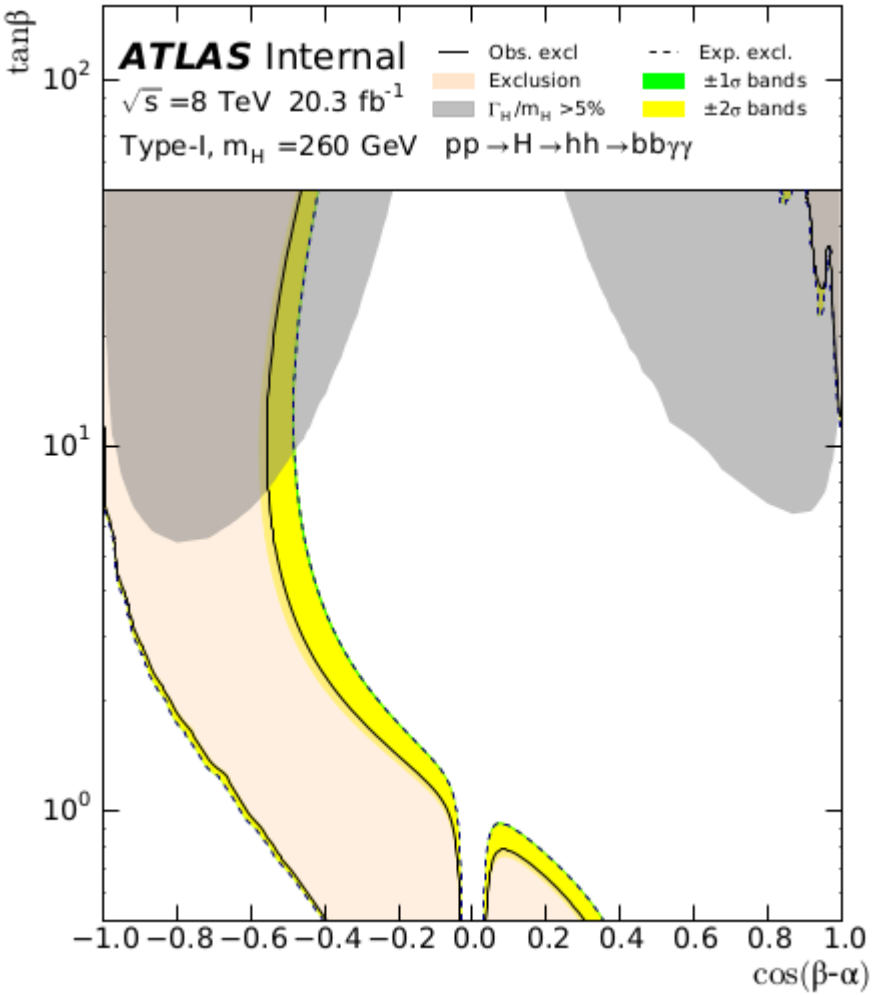


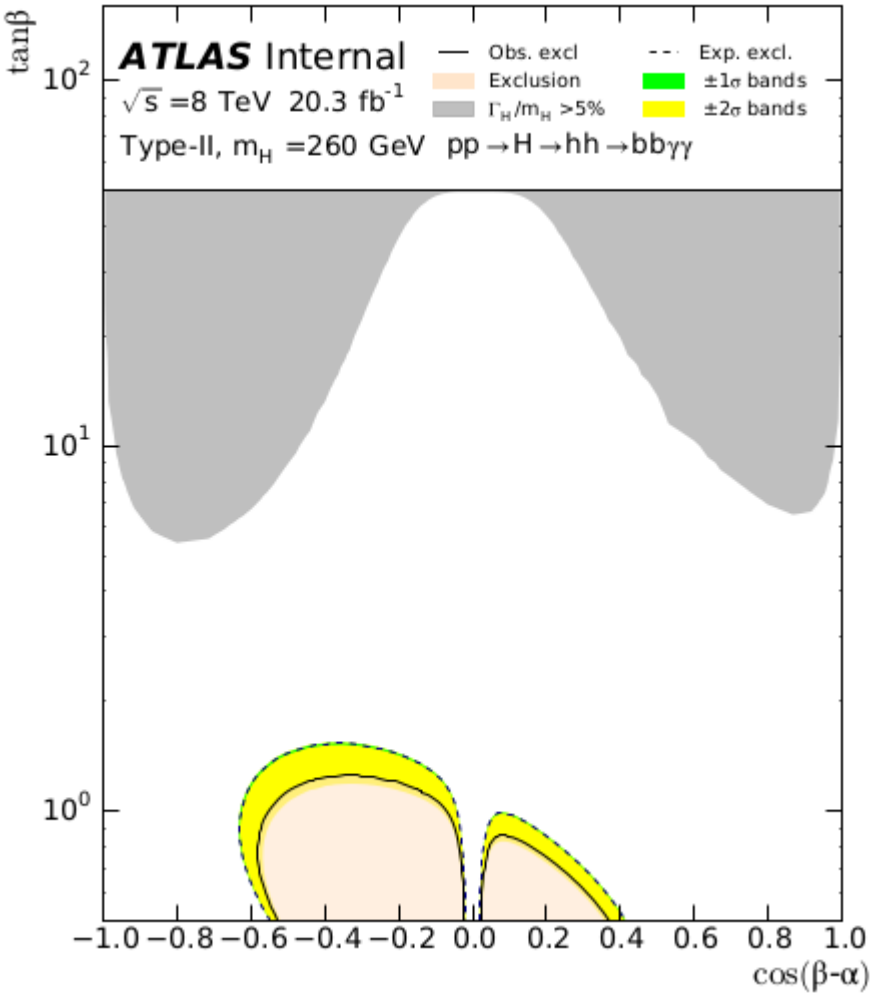
2HDM wwyy 300



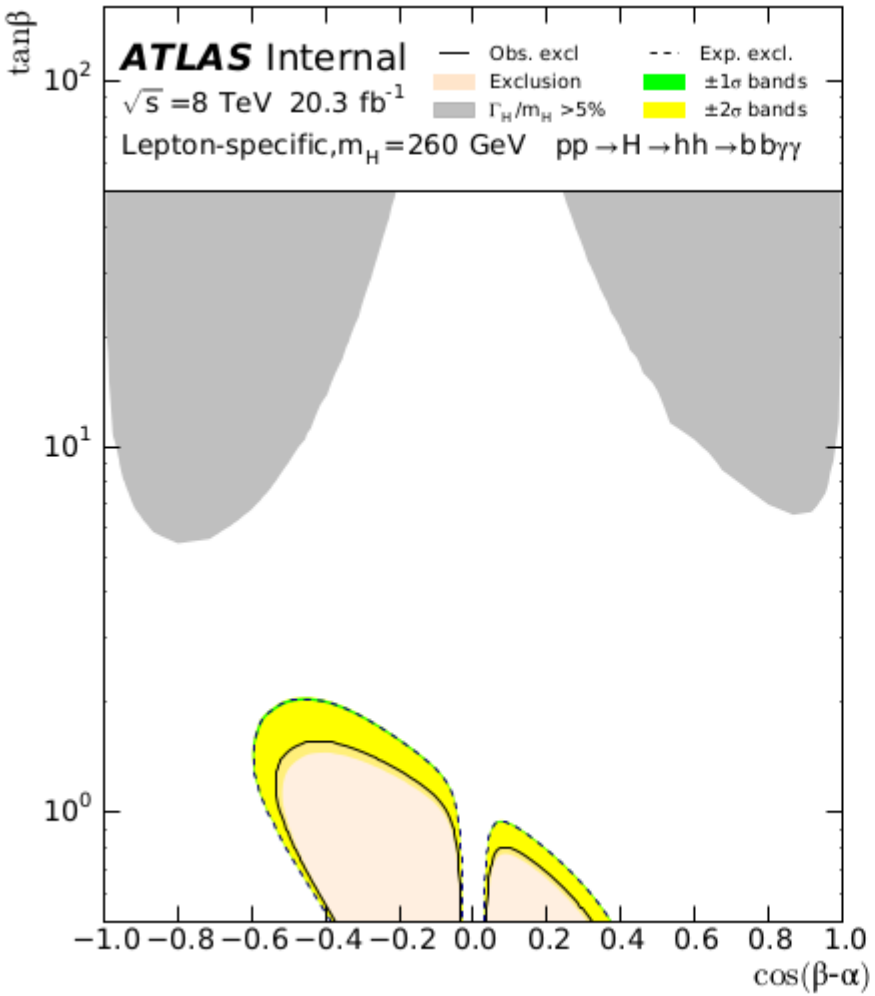


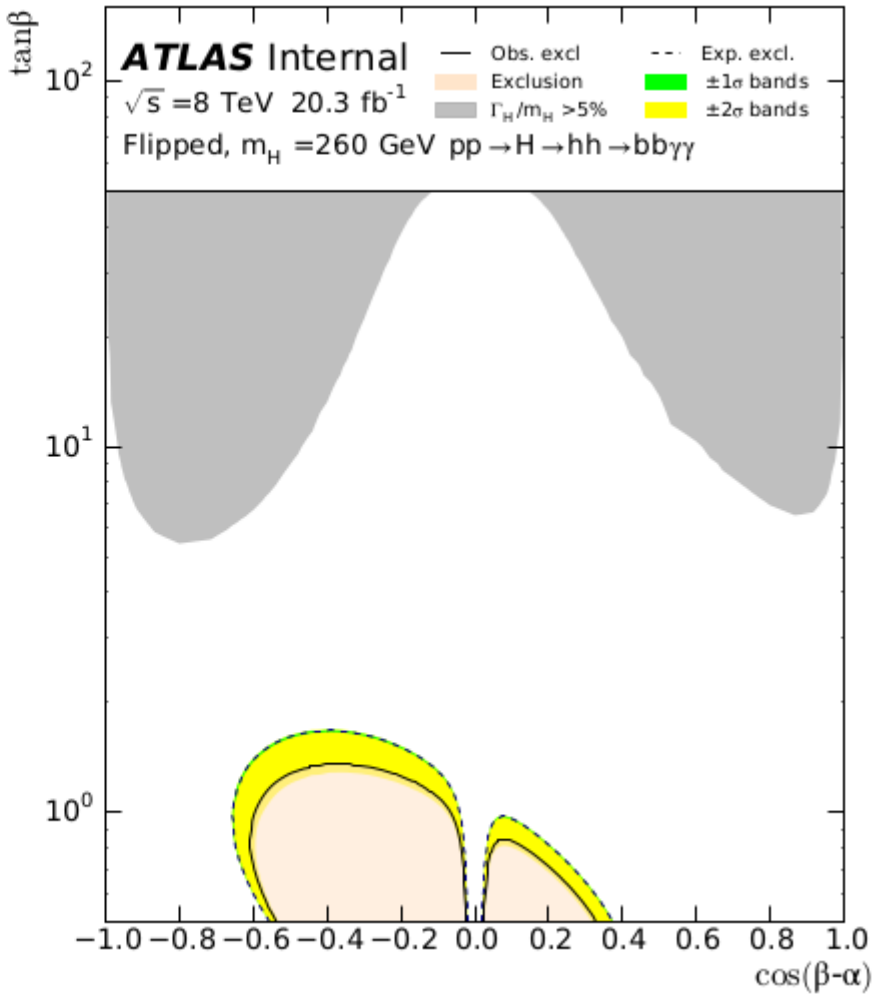
2HDM bbyy 260



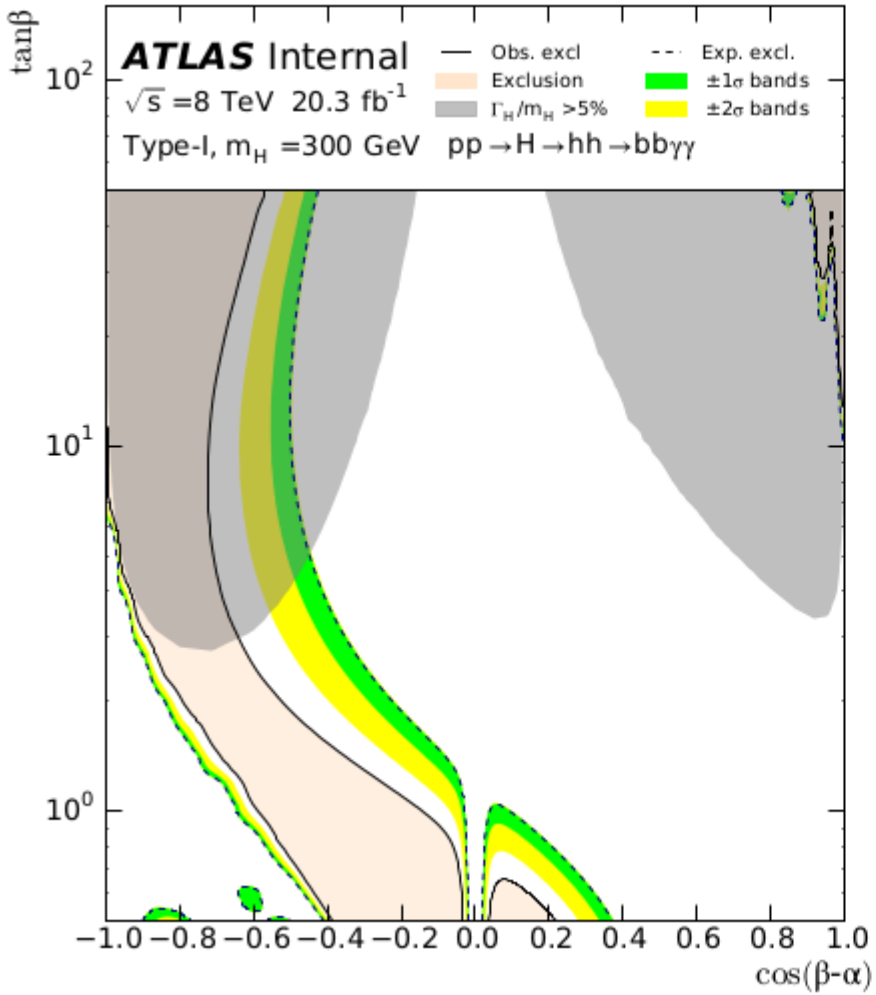


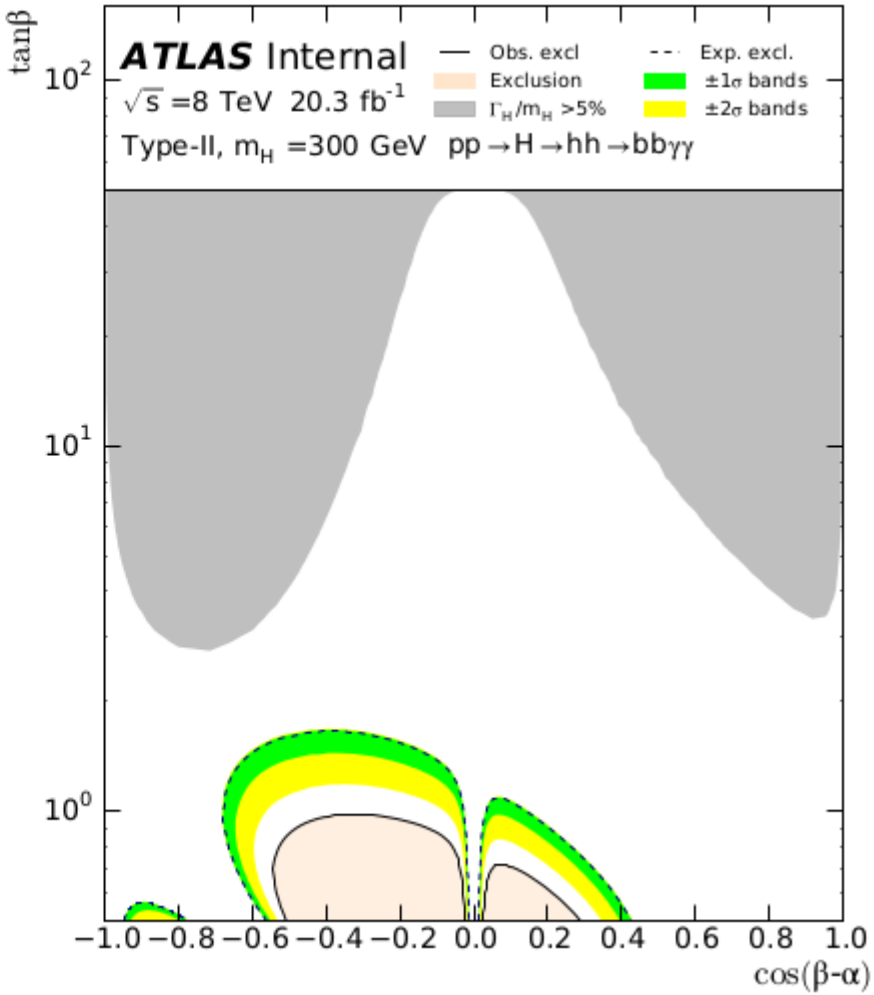
2HDM bbyy 260



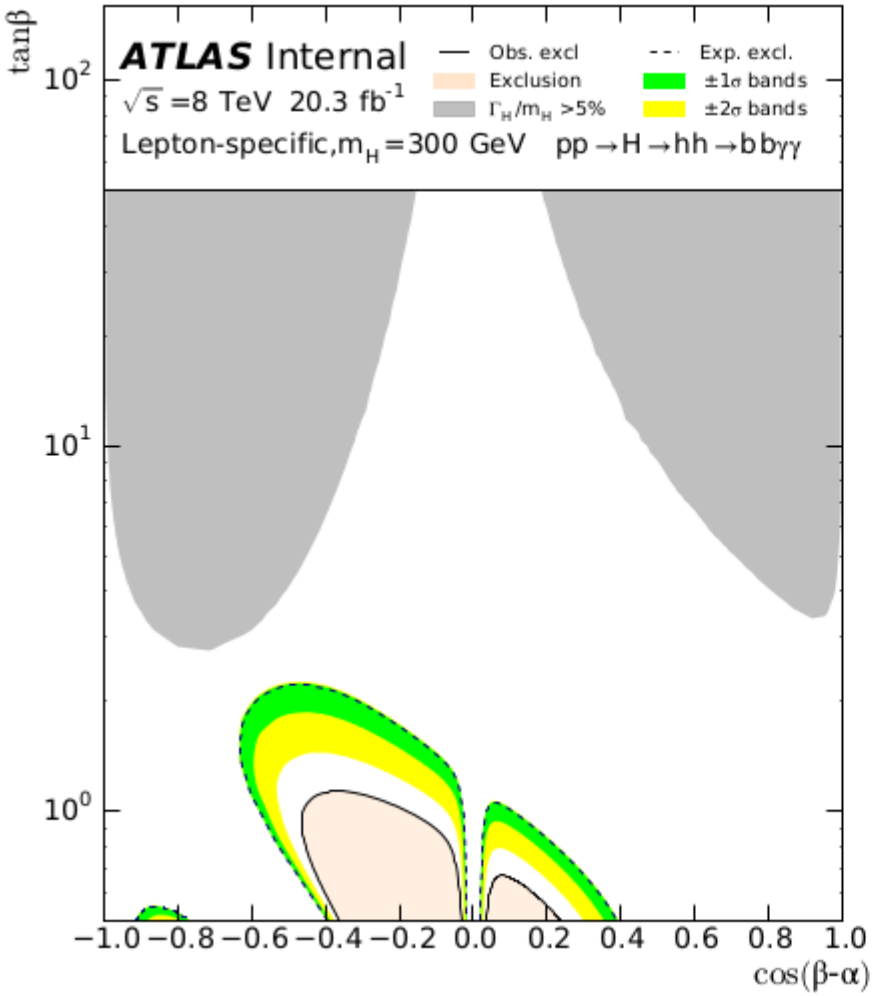


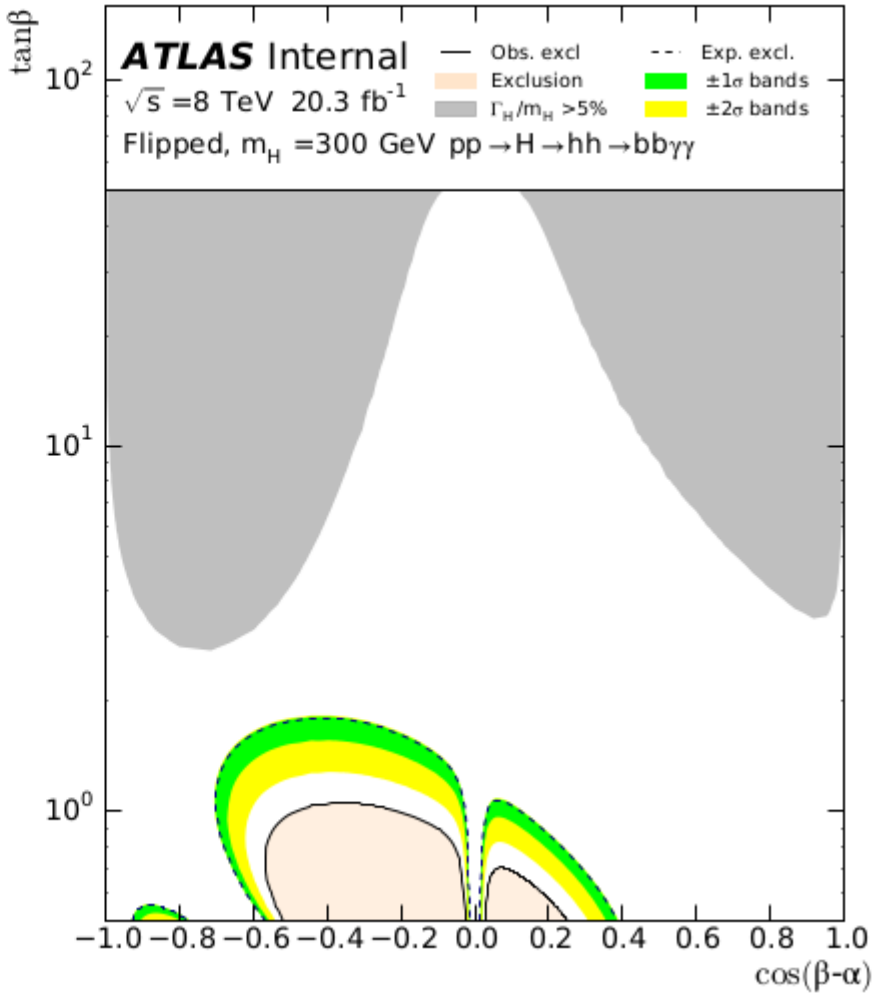
2HDM bbyy 300



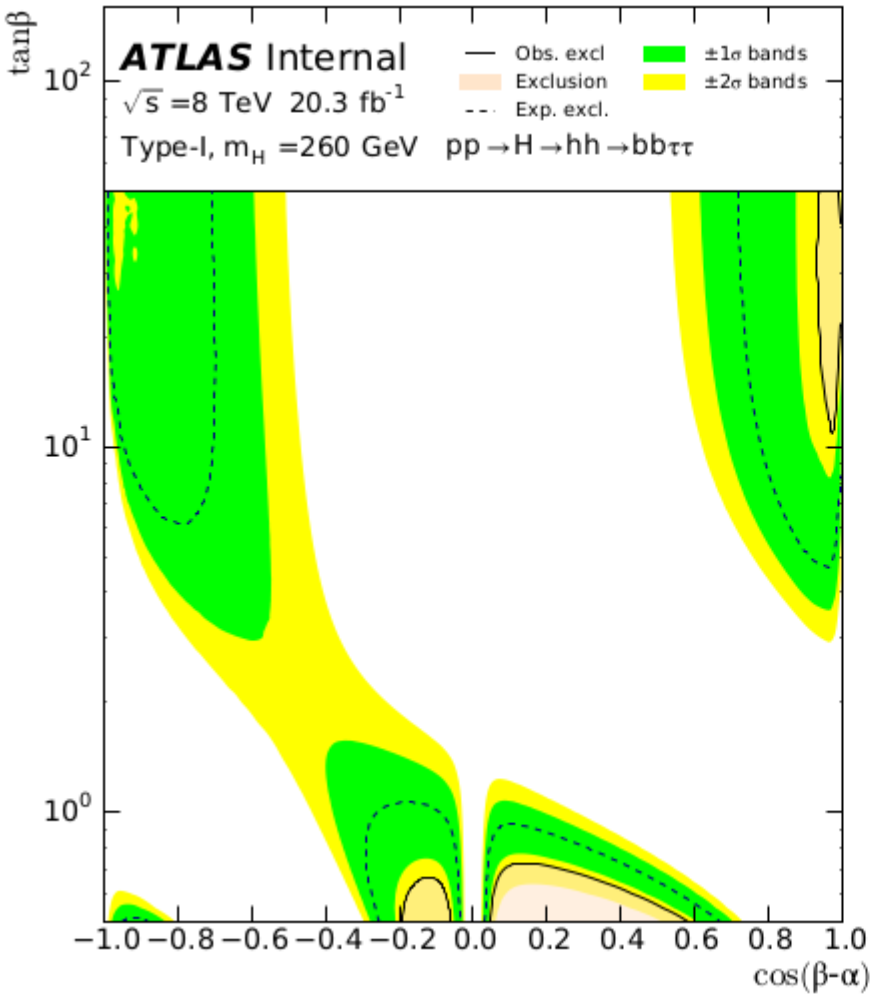


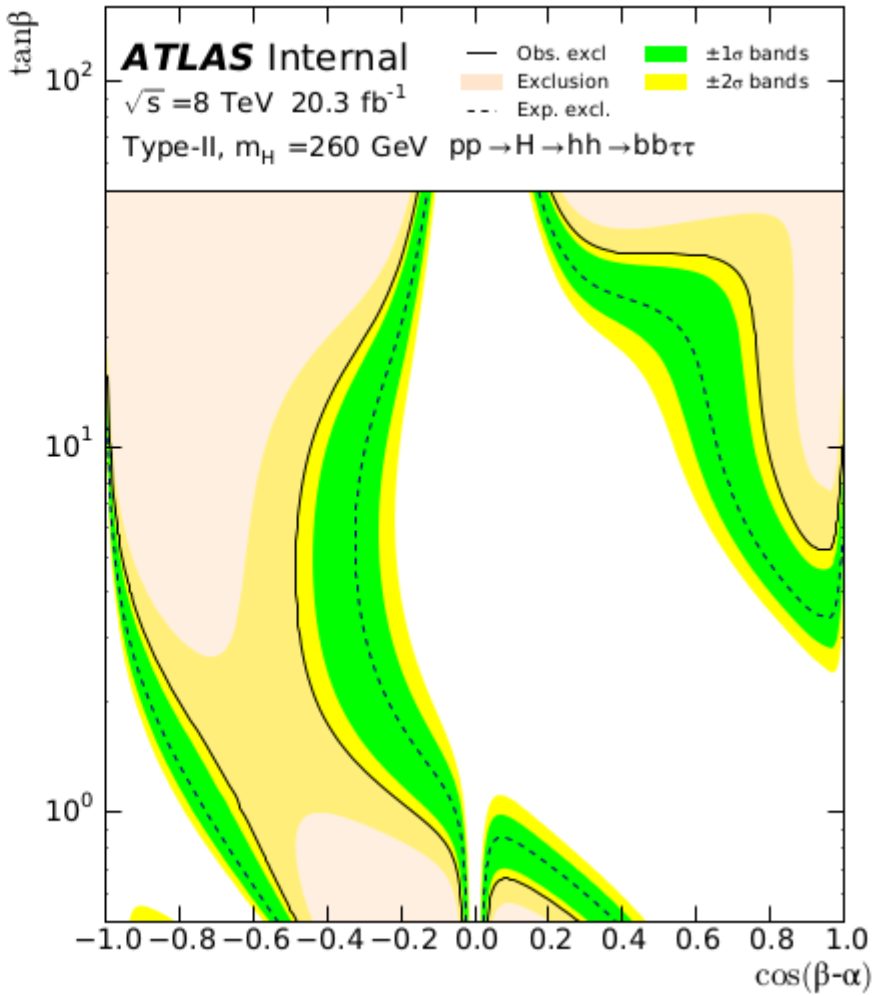
2HDM bbyy 300



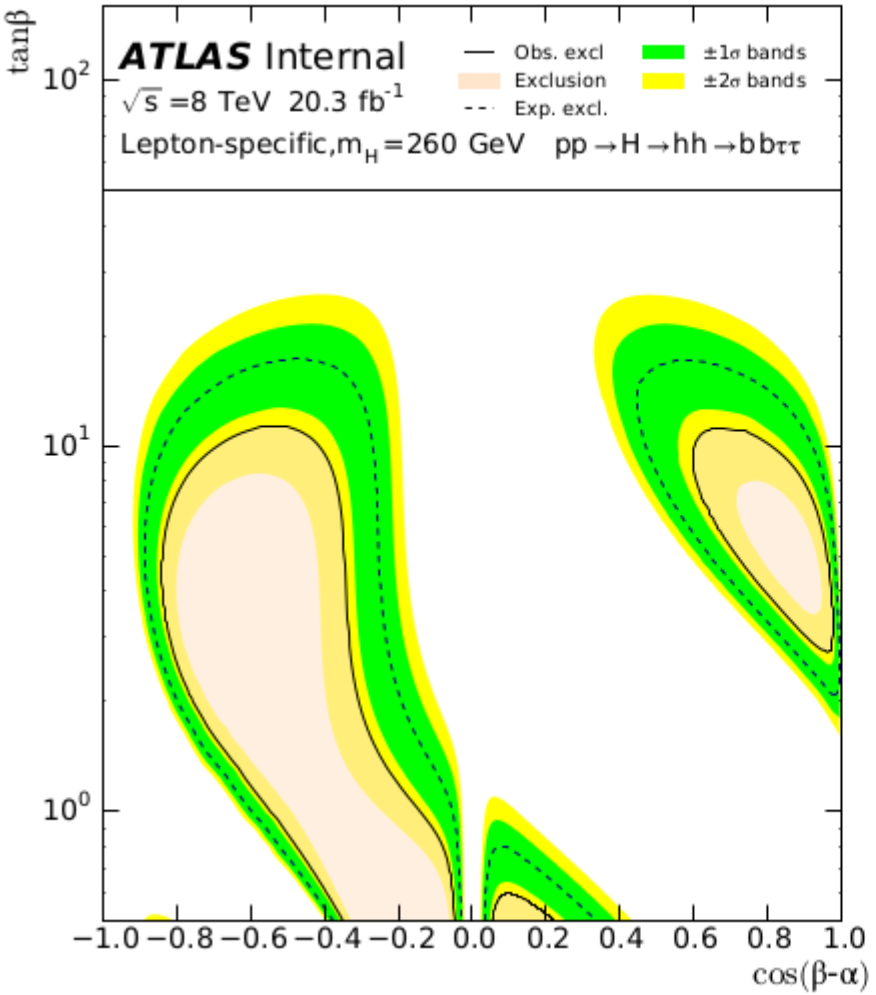


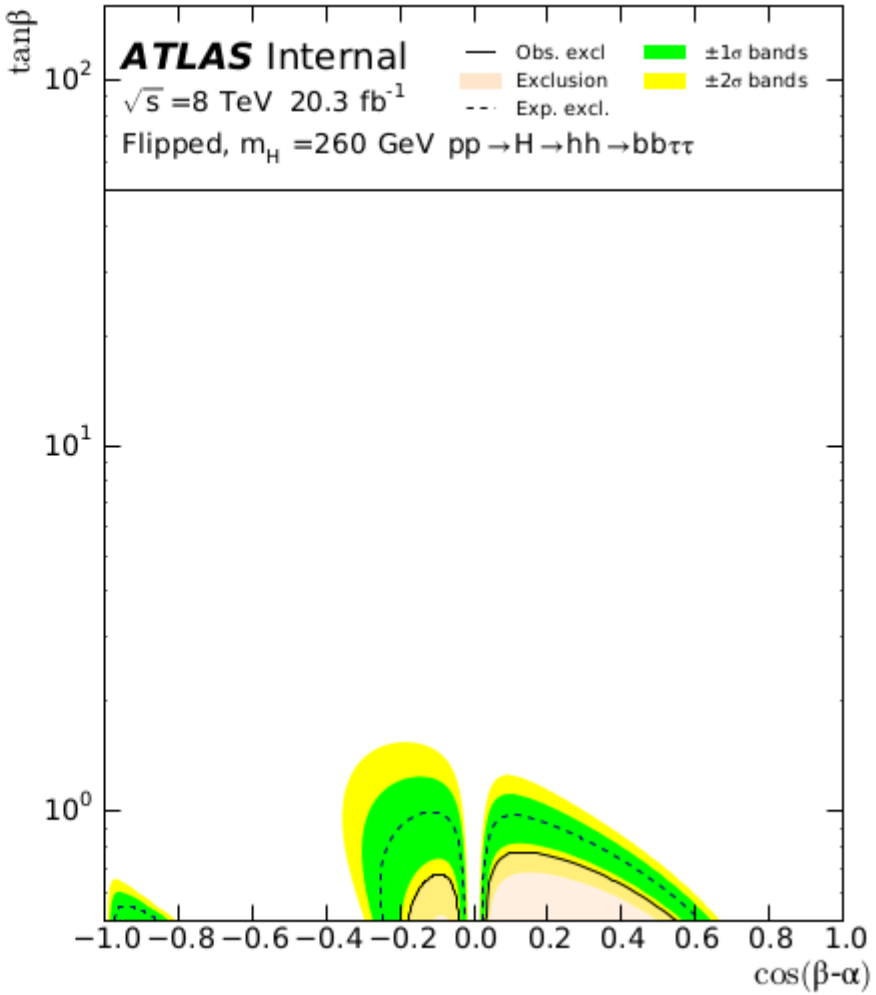
2HDM bbtautau 260



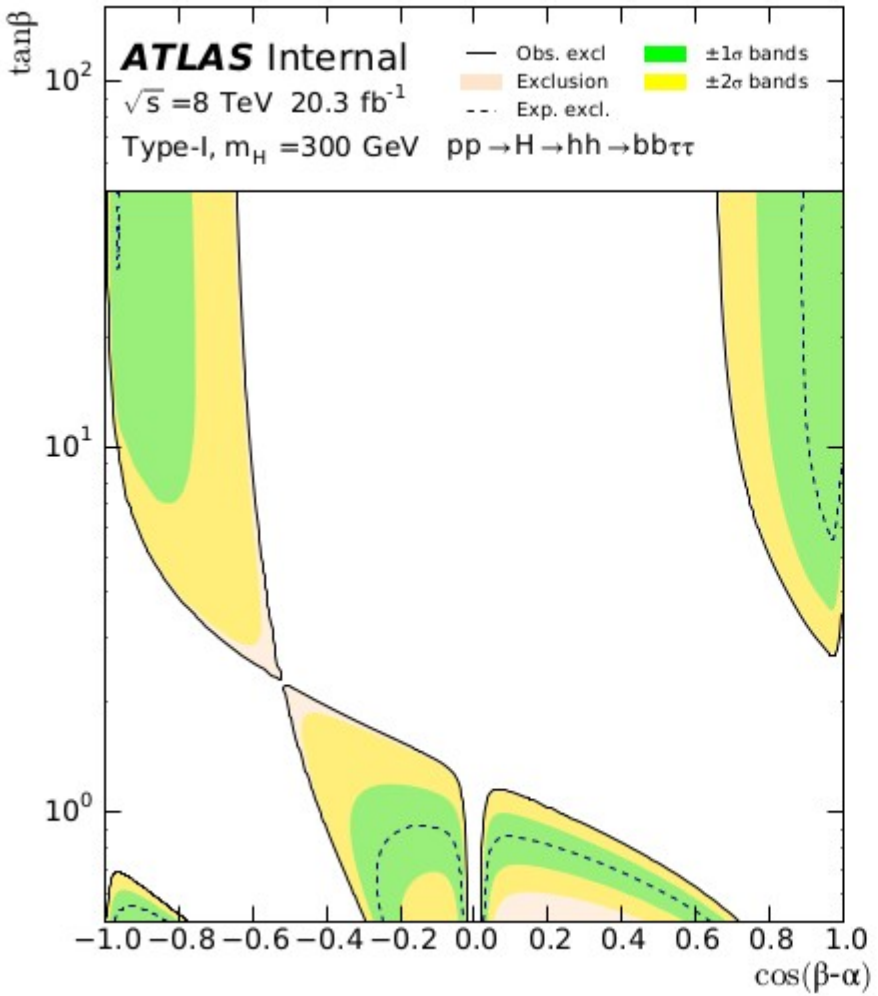


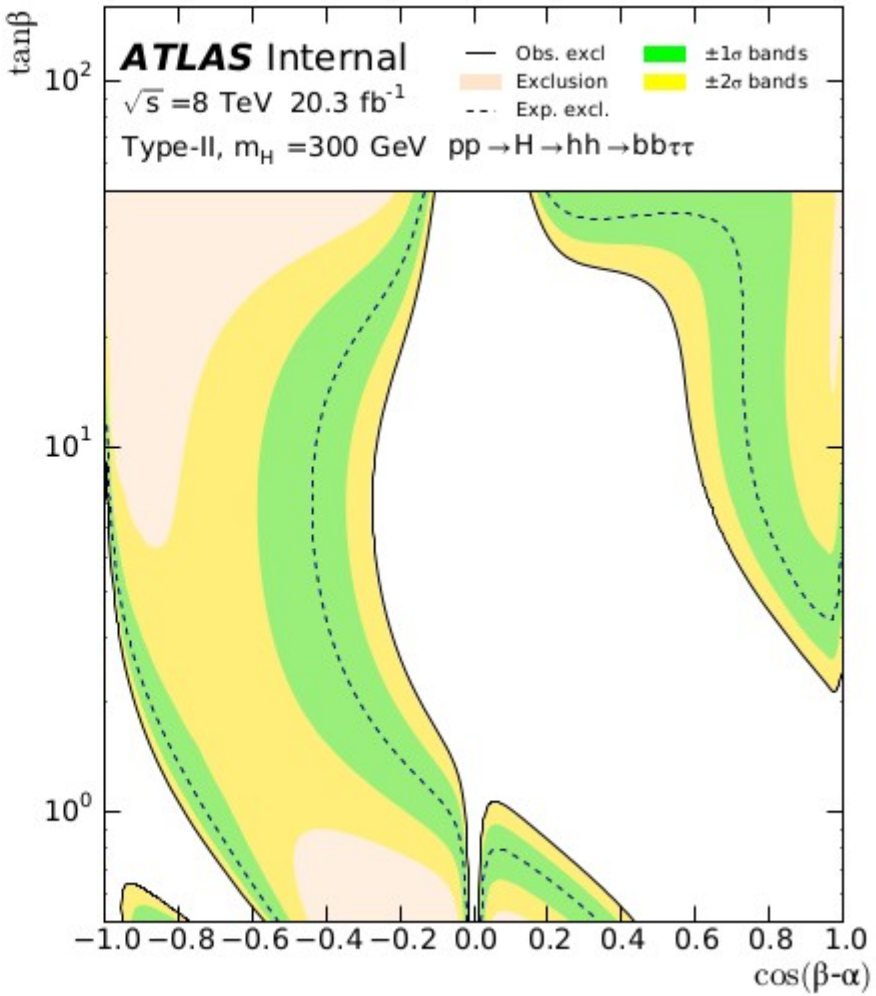
2HDM bbtautau 260



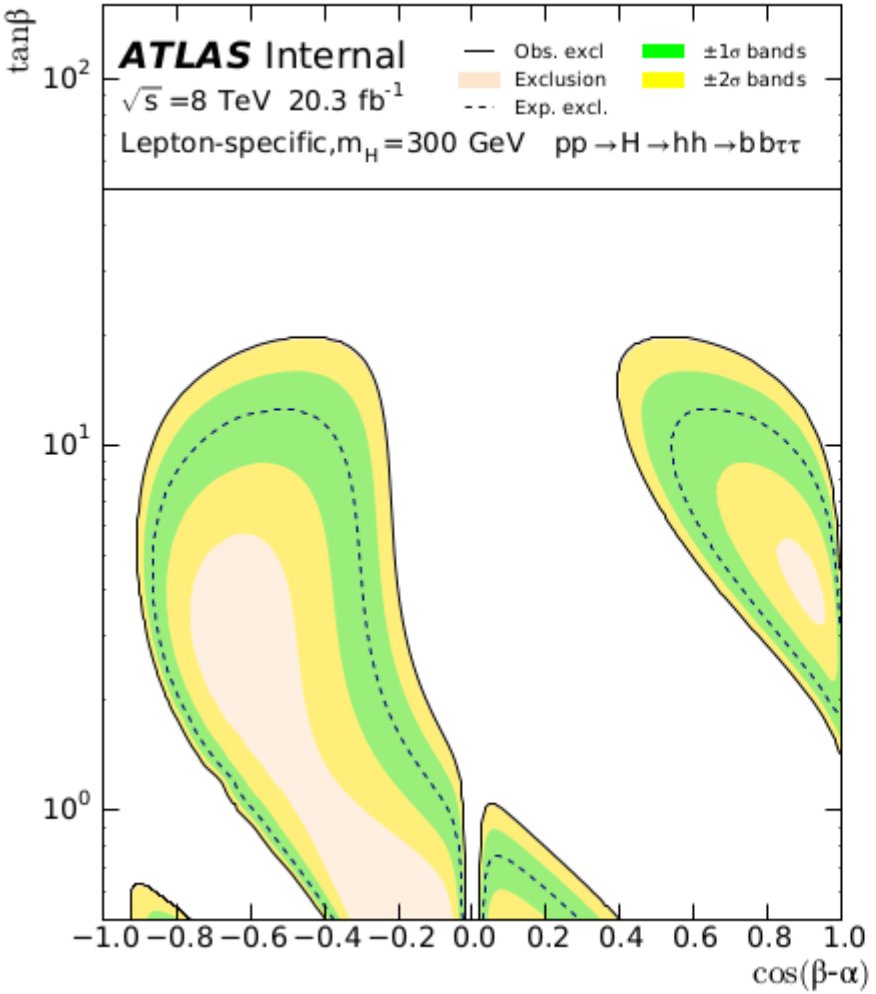


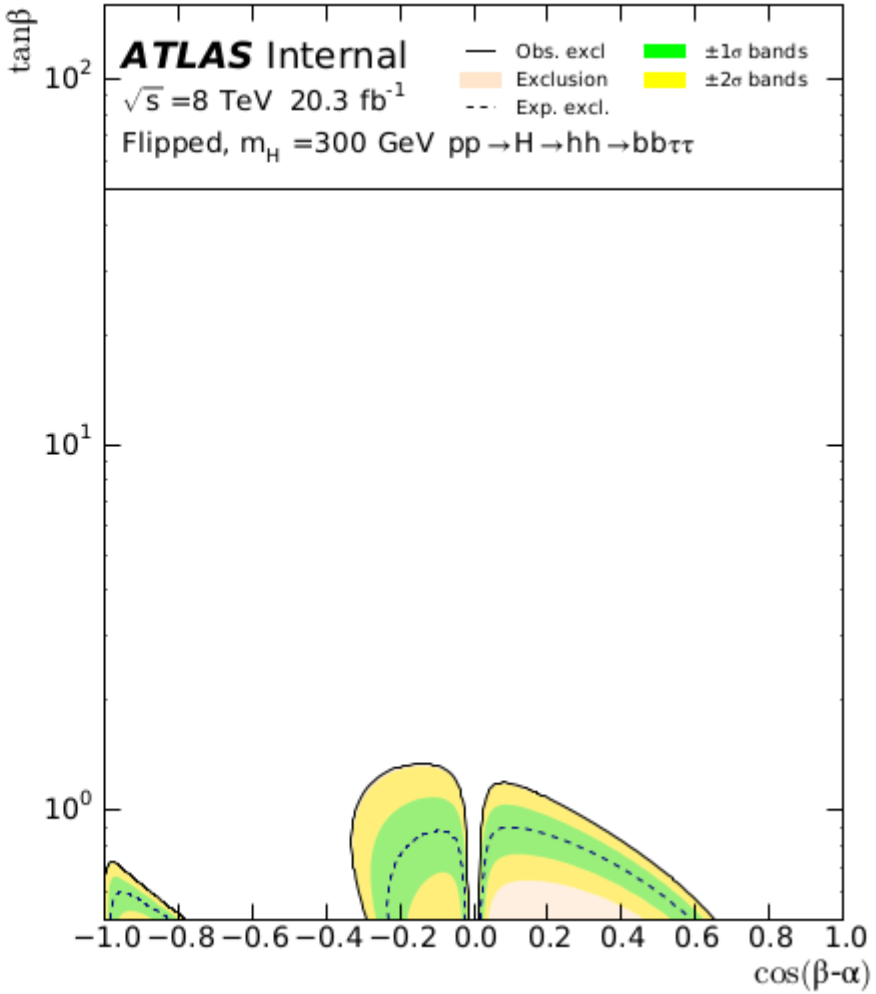
2HDM bbtautau 300





2HDM bbtautau 300

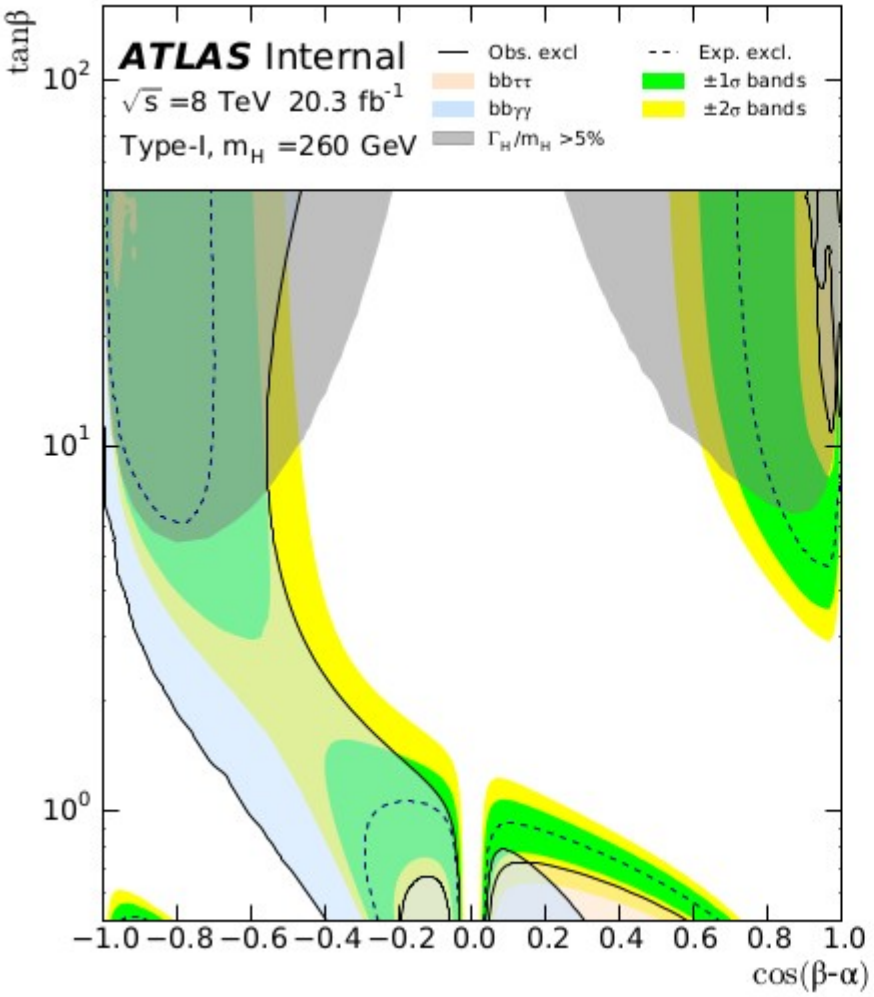


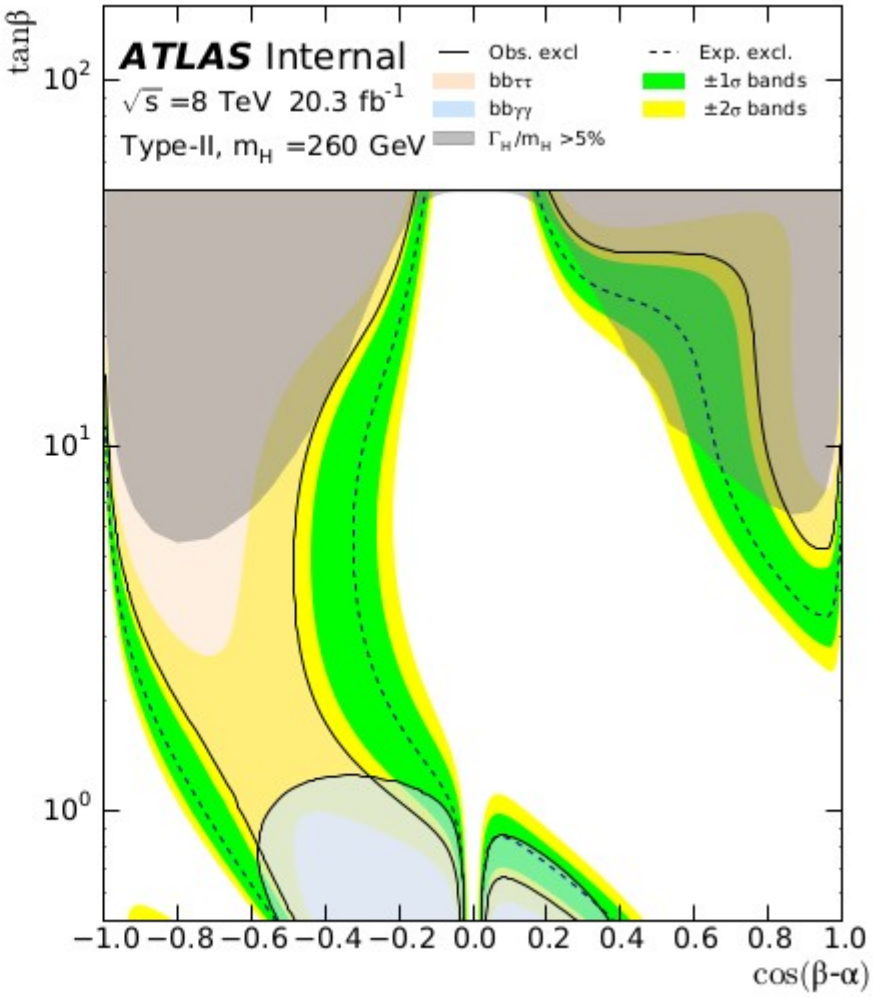


overlay plots

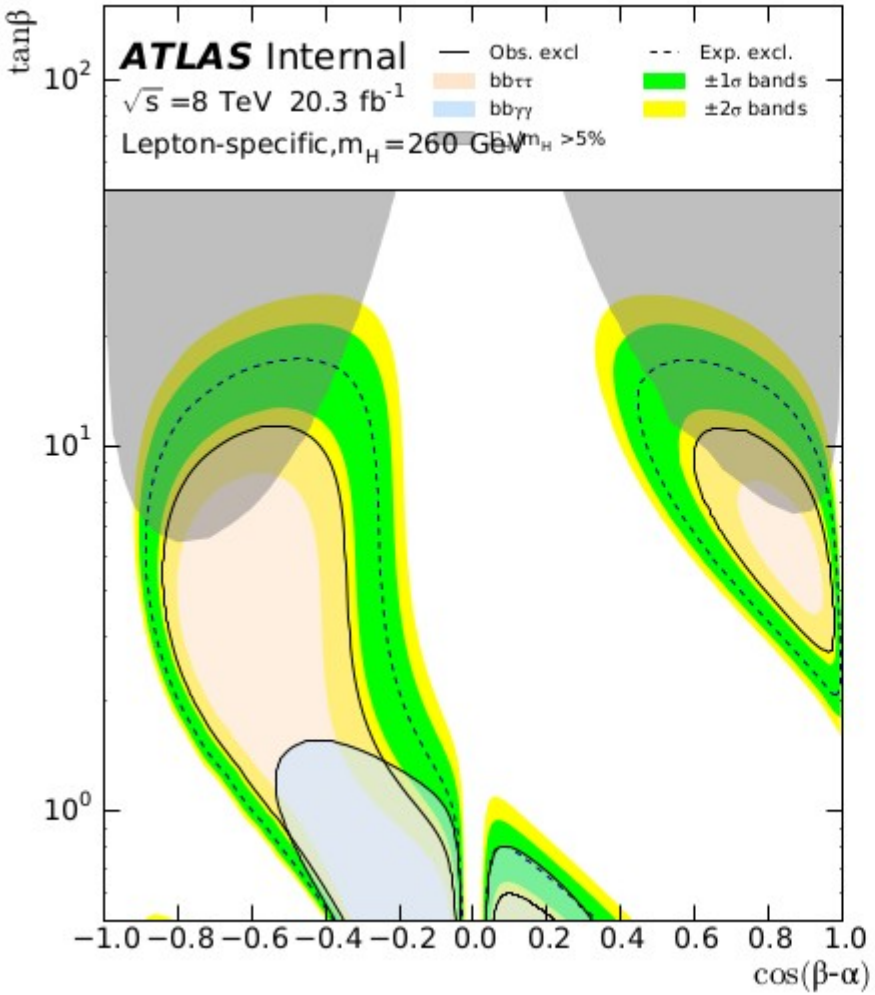
- due to small contributions from wwyy, we will continue to make plots with only bbtautau and bbyy
- a set of plots of overlaying on the bbττ exclusions the excluded regions from bbγγ as well as a mask according to width/mass ratio will be shown

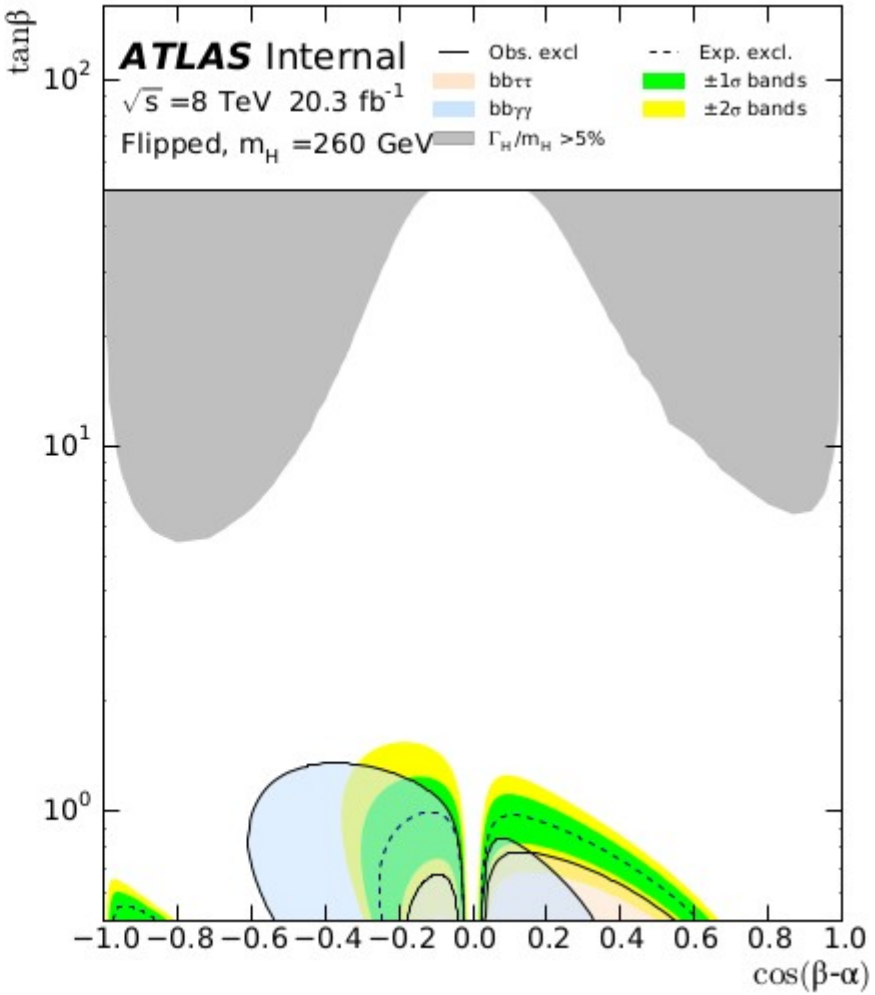
2HDM bbtautau + bbyy 260



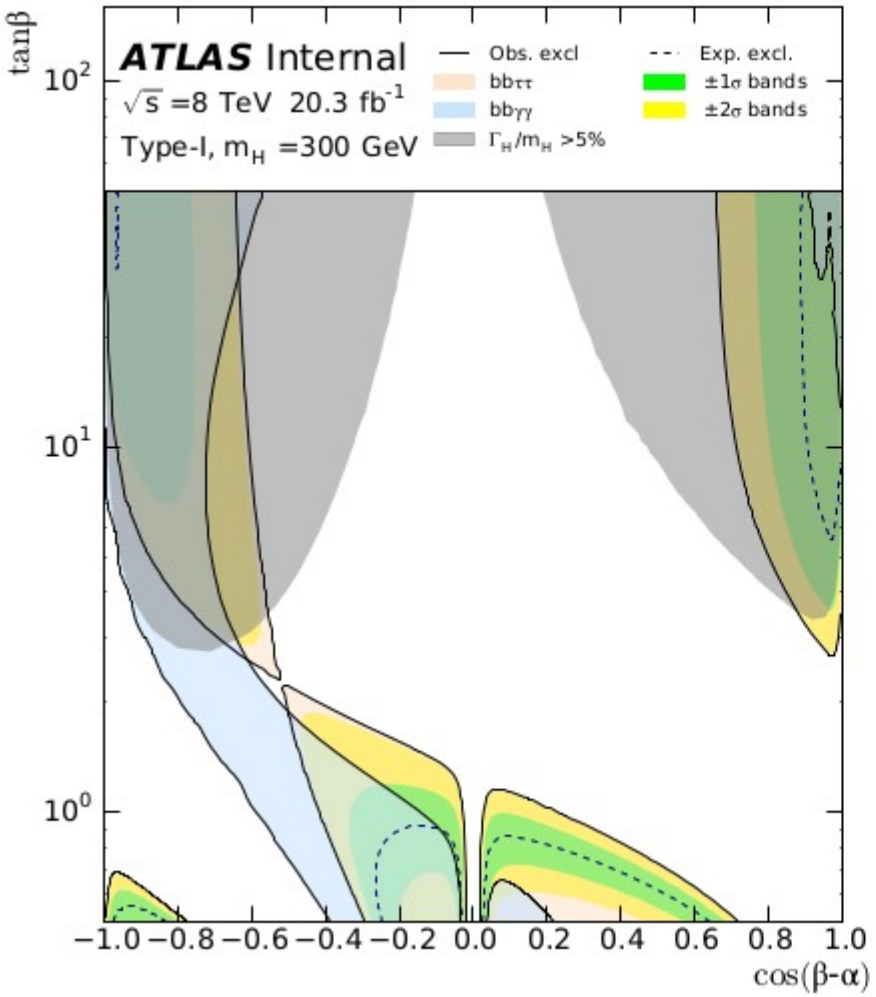


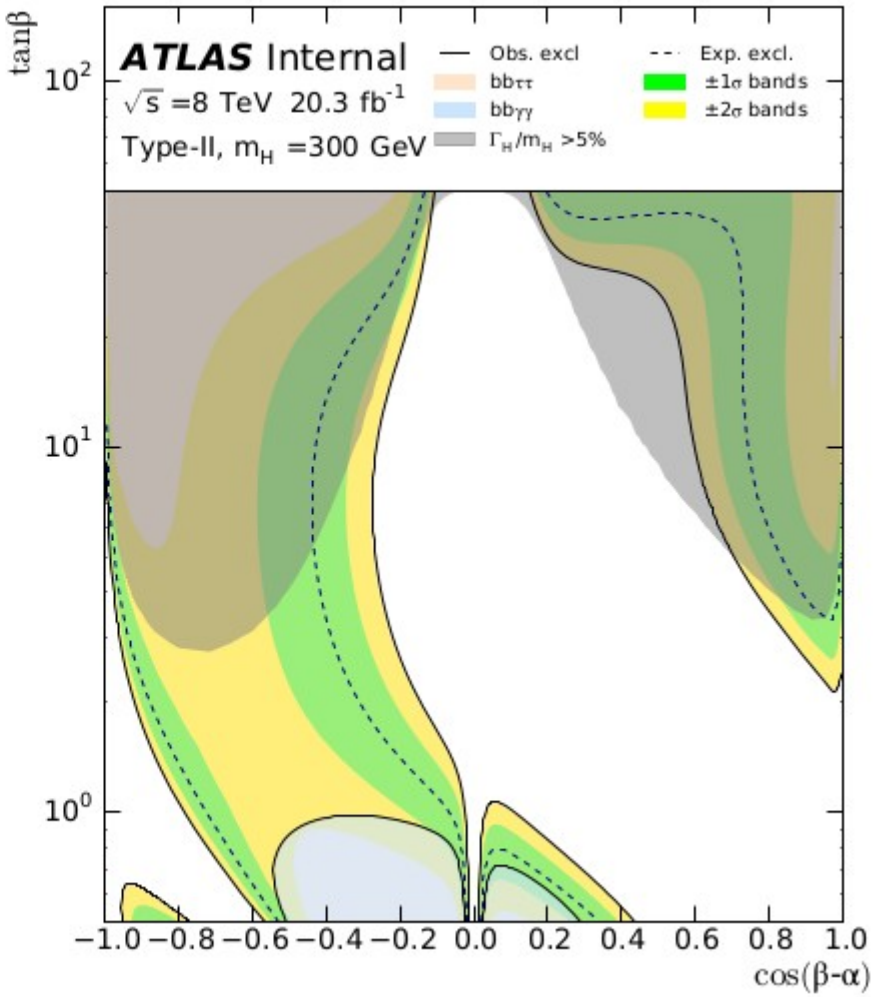
2HDM bbtautau + bbyy 260



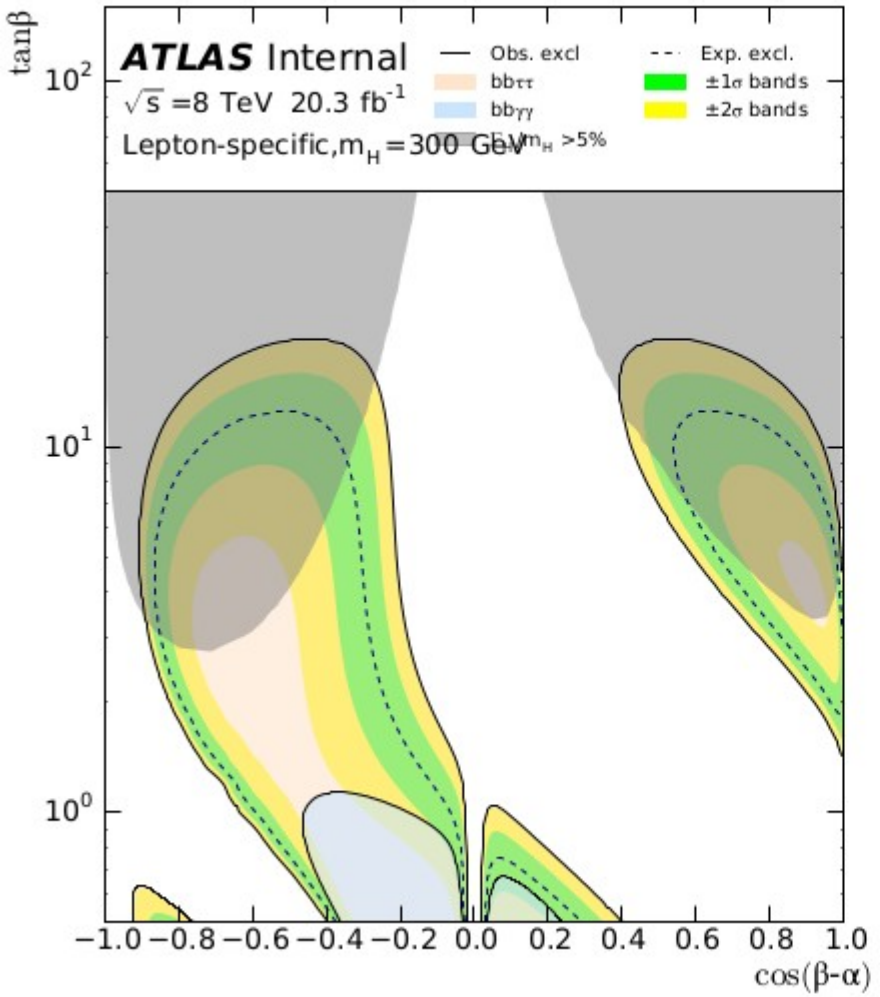


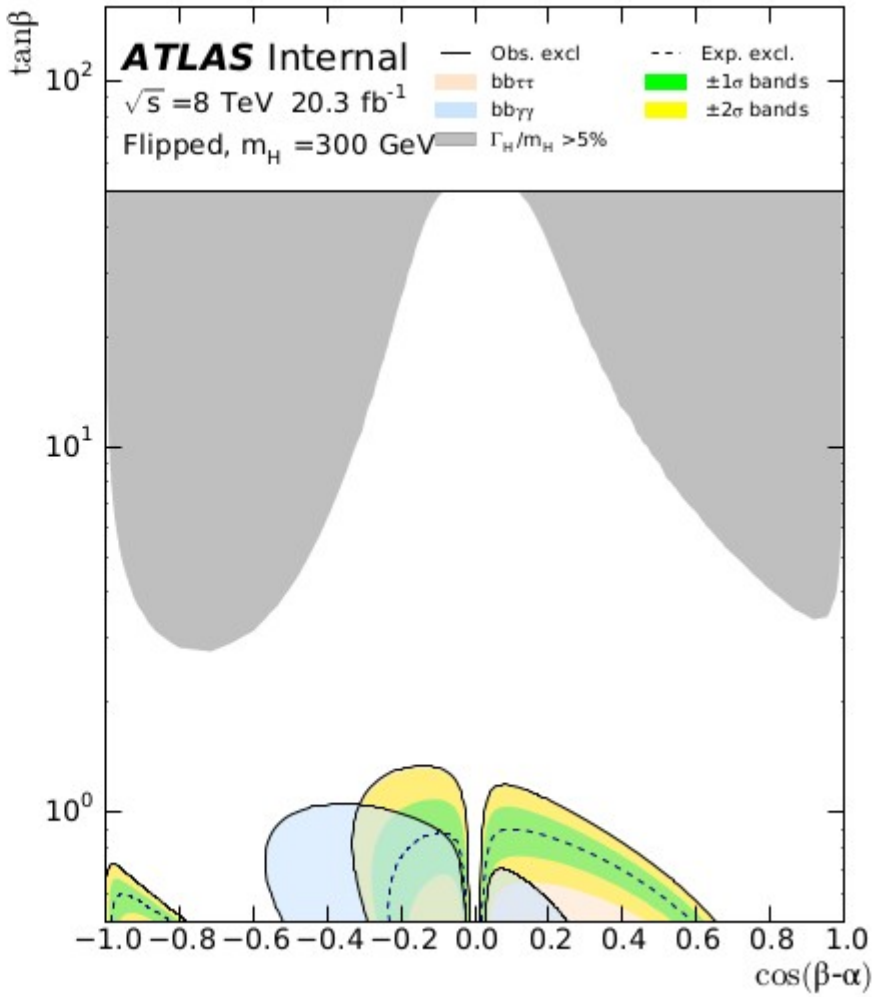
2HDM bbtautau + bbyy 300





2HDM bbtautau + bbyy 300

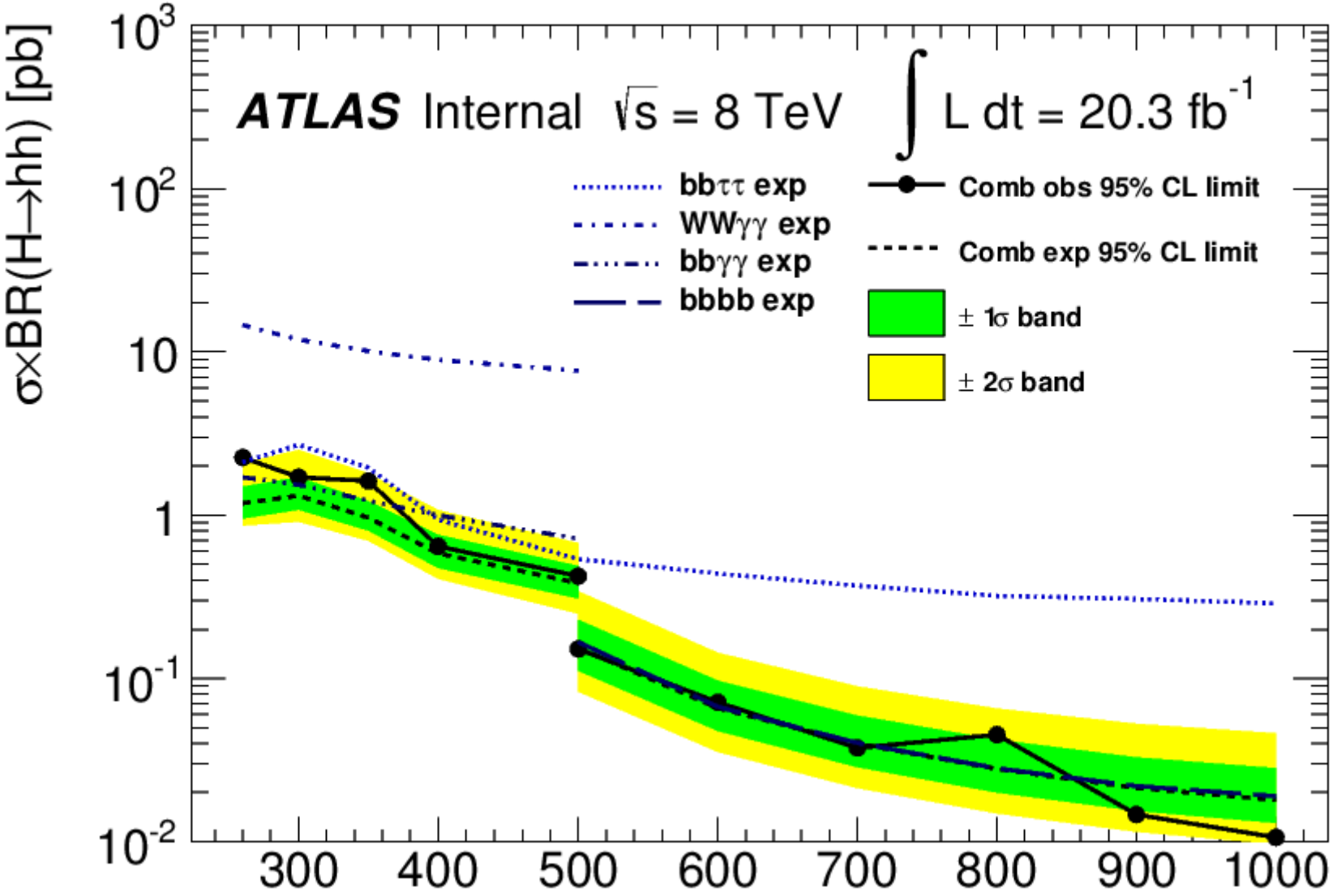




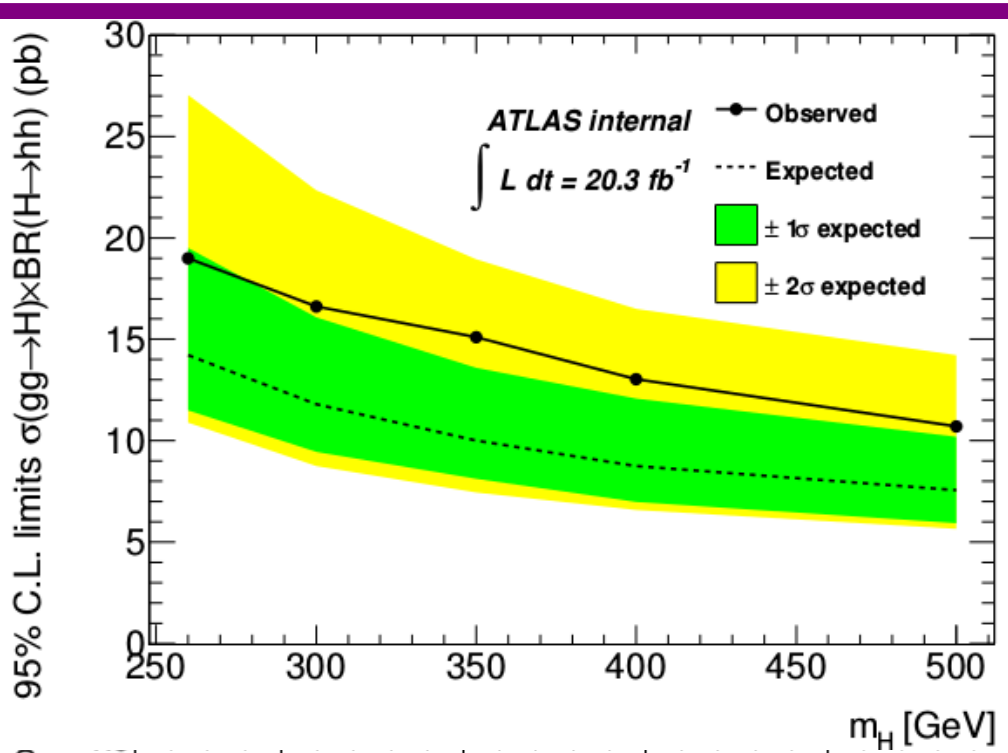
backup

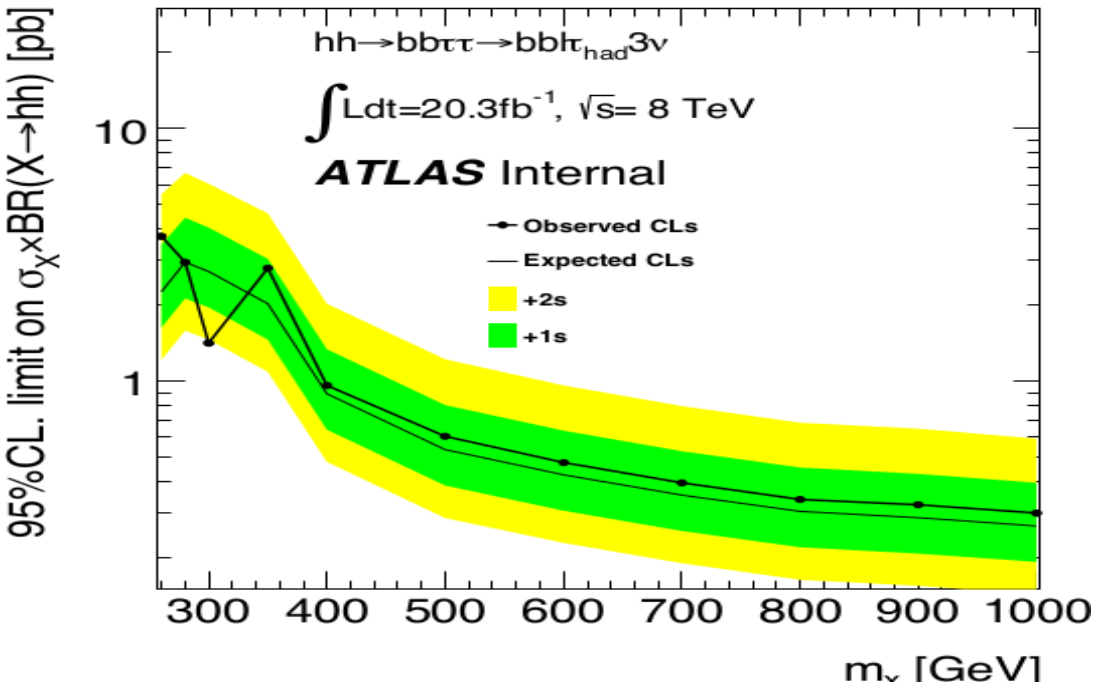
comb observed limits [res]

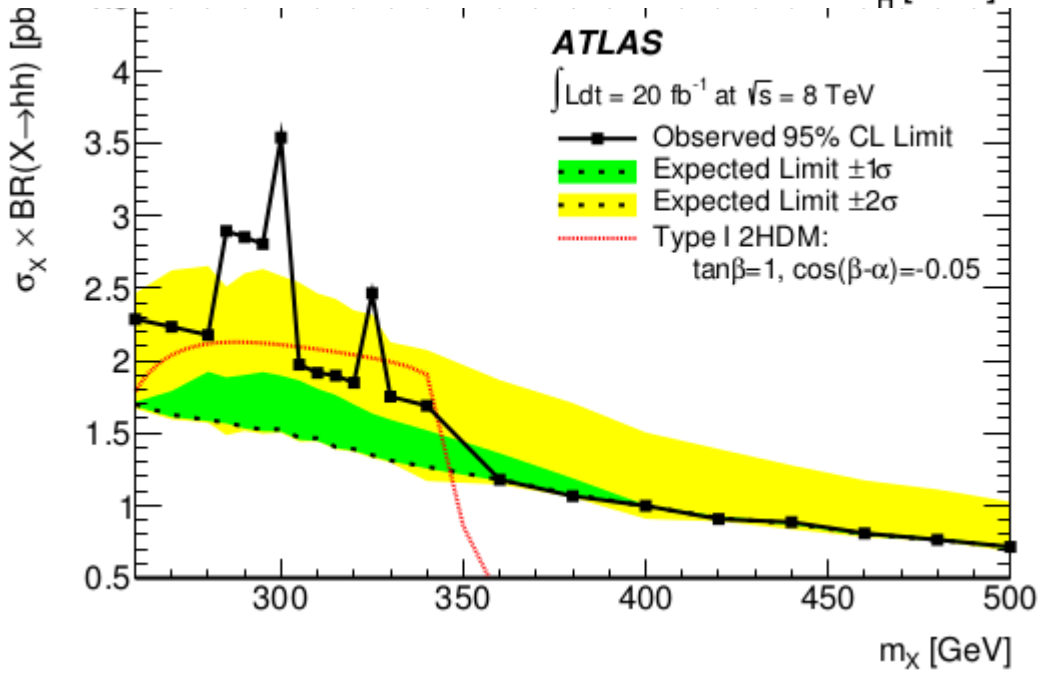
- [260,500] from toys; [500,1000] from asymptotics
- more points **interpolated** in high mass region

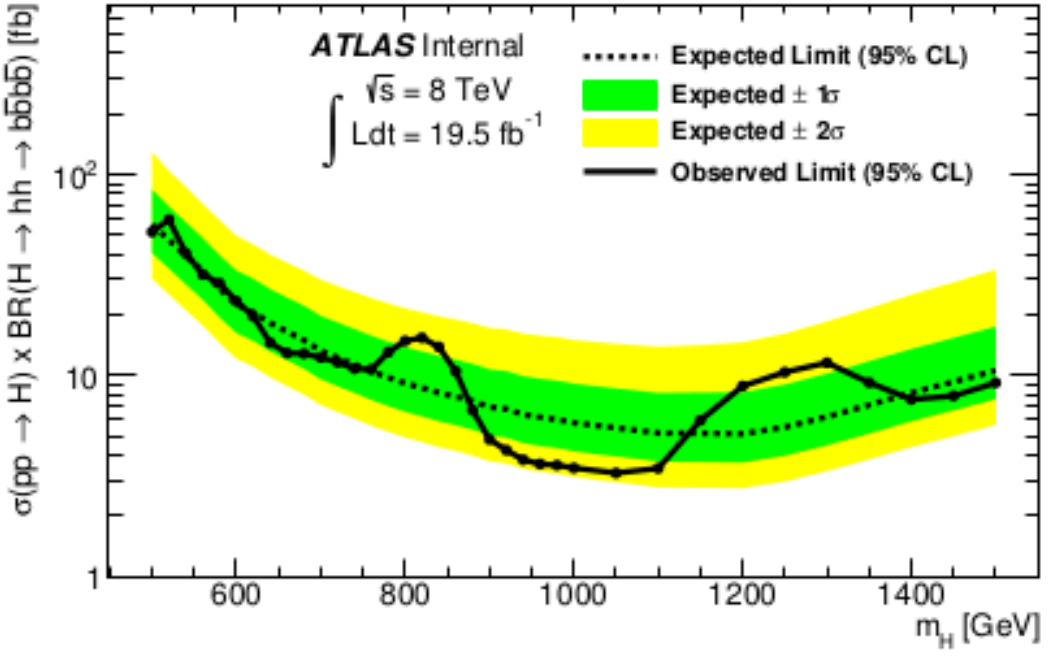


sub-channel limits [res]









comb observed limits [nonres]

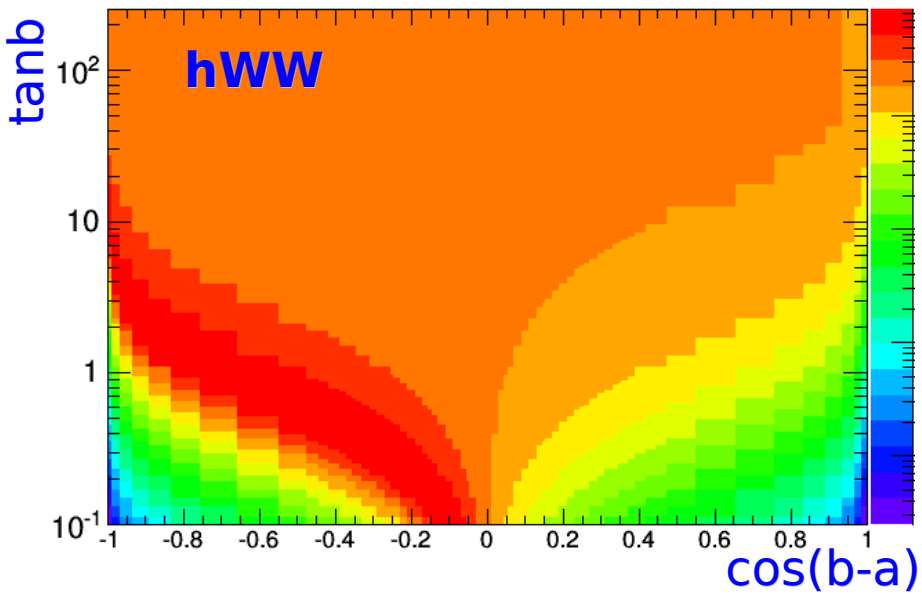
	OBS	EXP	+2sig	+1sig	-1sig	-2sig
bbbb	0.59388	0.59457	1.22329	0.85430	0.42842	0.31912
bbyy	2.20000	1.00546	2.39049	1.52719	0.72449	0.53966
wwyy	12.6259	8.81794	16.297	11.9078	7.10667	6.70651
bbττ	1.29582	1.53934	3.32687	2.26839	1.10918	0.82620
combine	0.69188	0.47370	0.93053	0.66888	0.34834	0.27022

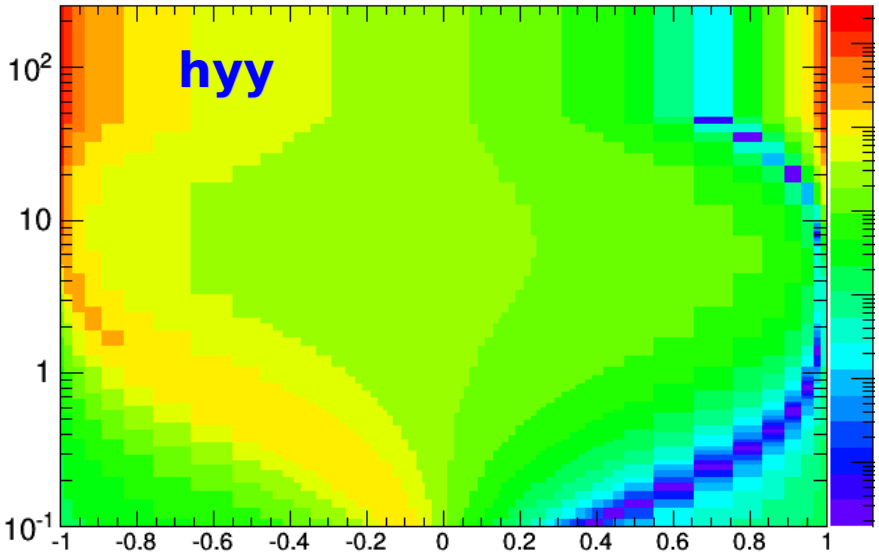
Hhh interpretation

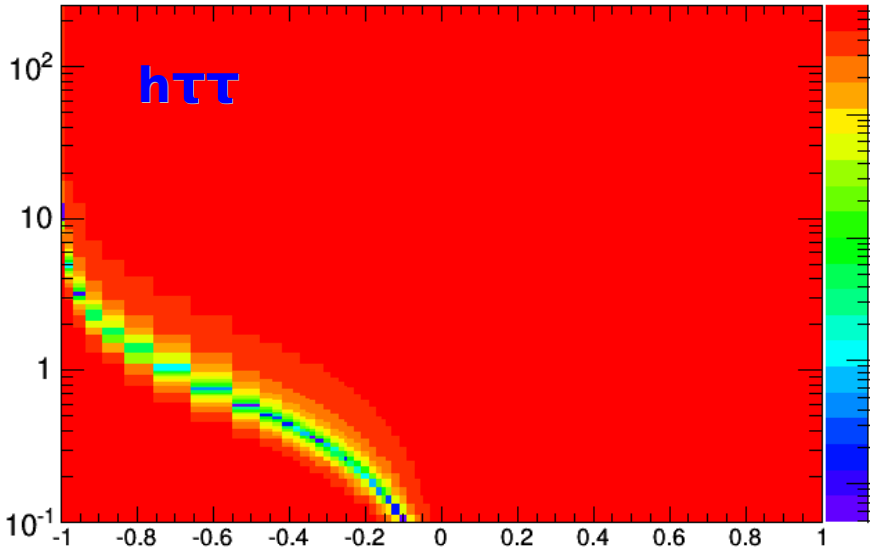
- 4 channels are included
  - res-low-mass: bbyy,bbττ,wwyy ~ for example 300GeV
  - res-high-mass: bbbb,bbττ
- open discussion

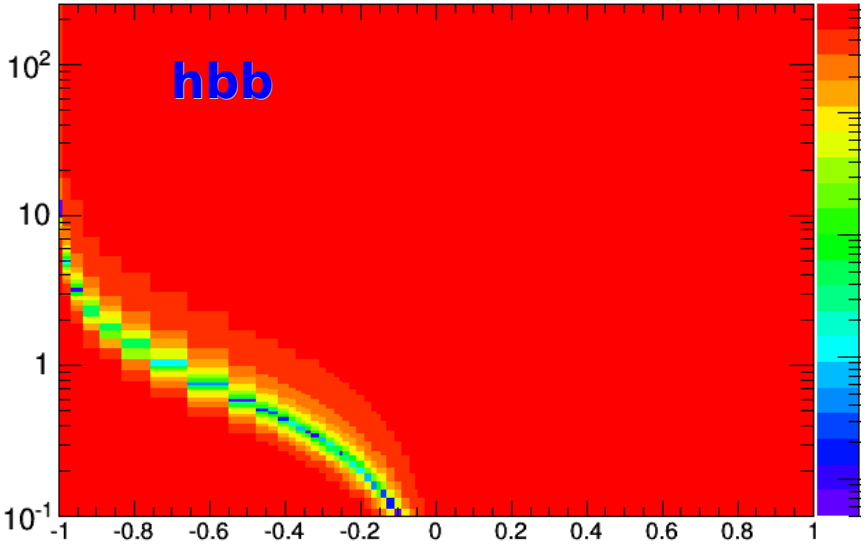
	Type I	Type II	Type III	Type IV
ξ_h^V	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$
ξ_h^u	$\frac{\cos\alpha}{\sin\beta}$	$\frac{\cos\alpha}{\sin\beta}$	$\frac{\cos\alpha}{\sin\beta}$	$\frac{\cos\alpha}{\sin\beta}$
ξ_h^d	$\frac{\cos\alpha}{\sin\beta}$	$-\frac{\sin\alpha}{\cos\beta}$	$\frac{\cos\alpha}{\sin\beta}$	$-\frac{\sin\alpha}{\cos\beta}$
ξ_h^l	$\frac{\cos\alpha}{\sin\beta}$	$-\frac{\sin\alpha}{\cos\beta}$	$-\frac{\sin\alpha}{\cos\beta}$	$\frac{\cos\alpha}{\cos\beta}$

2HDM type I @ mH = 300 GeV

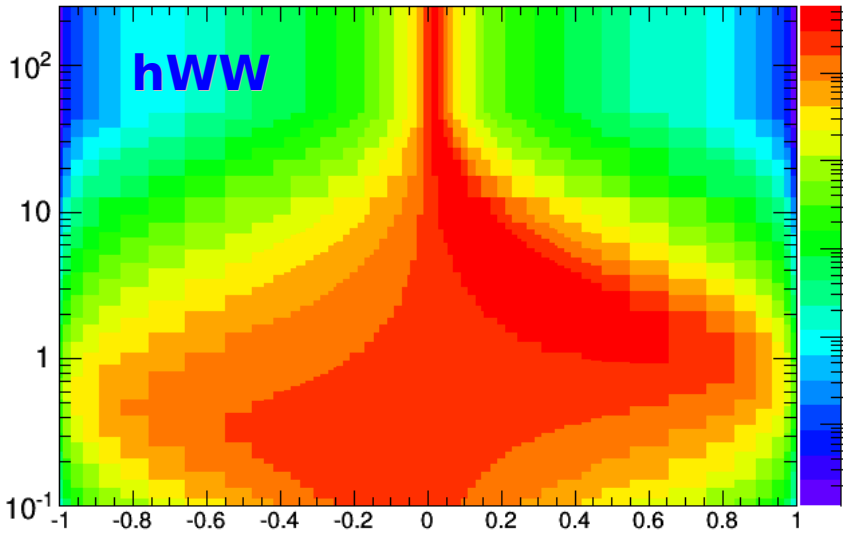


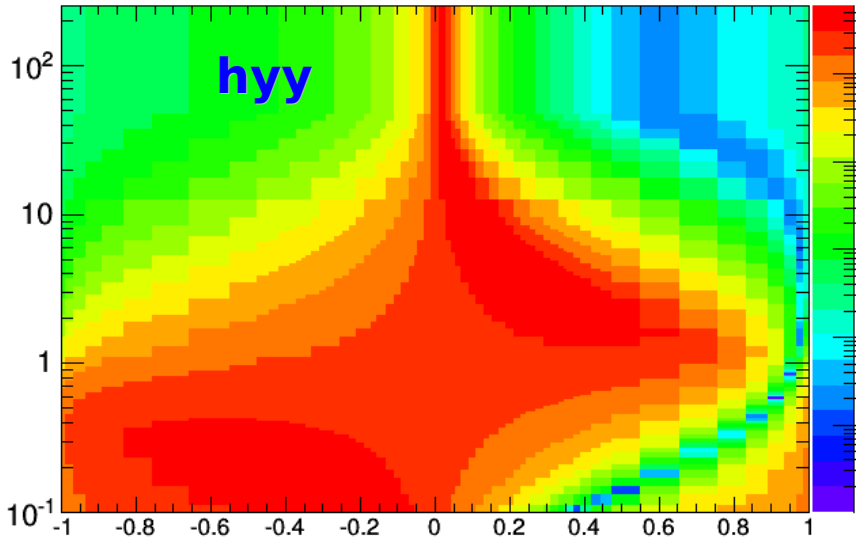


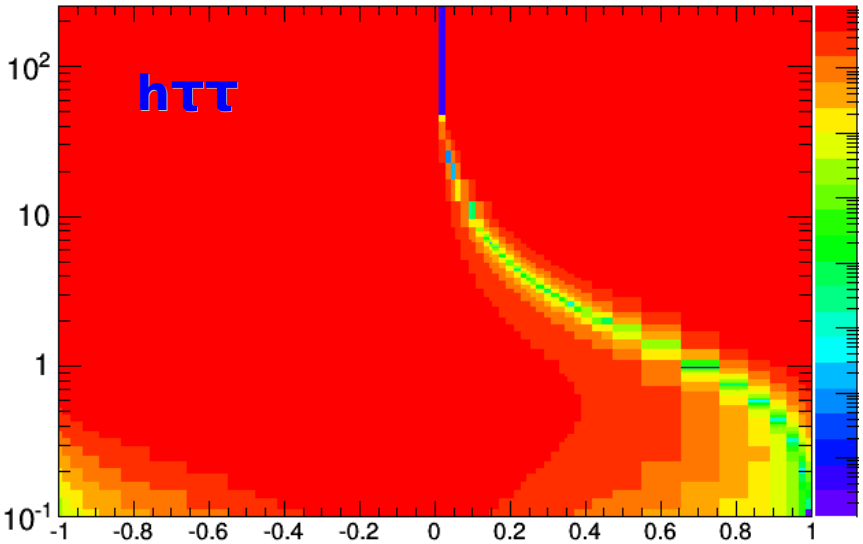


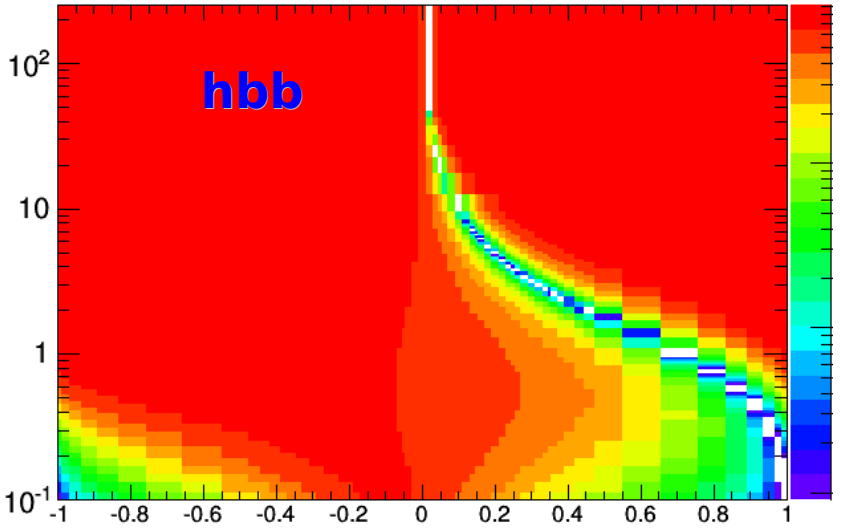


2HDM type II @ mH = 300 GeV

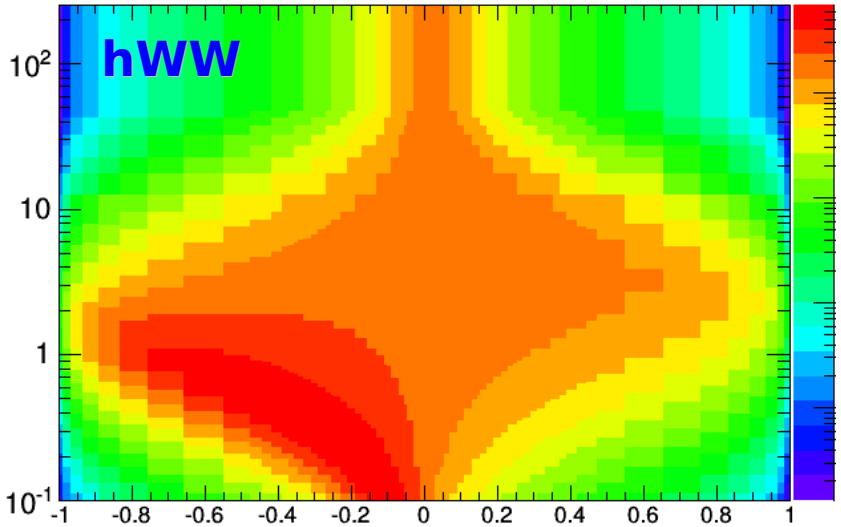


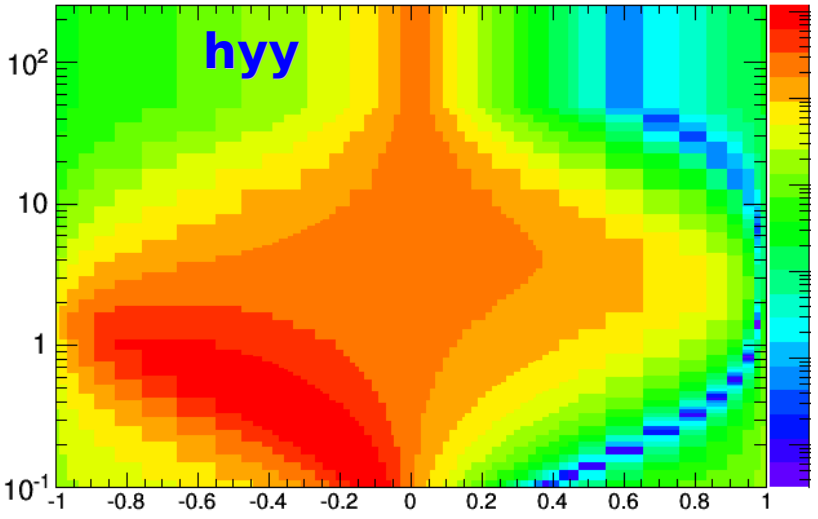


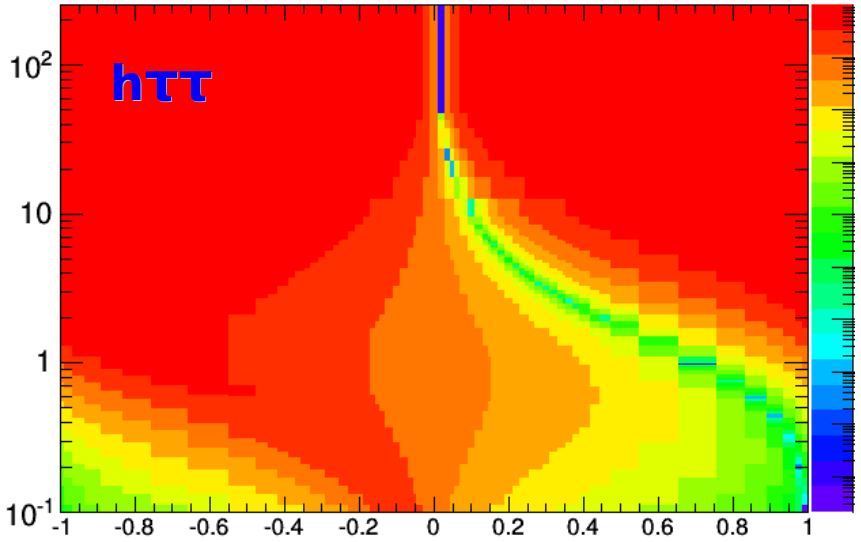


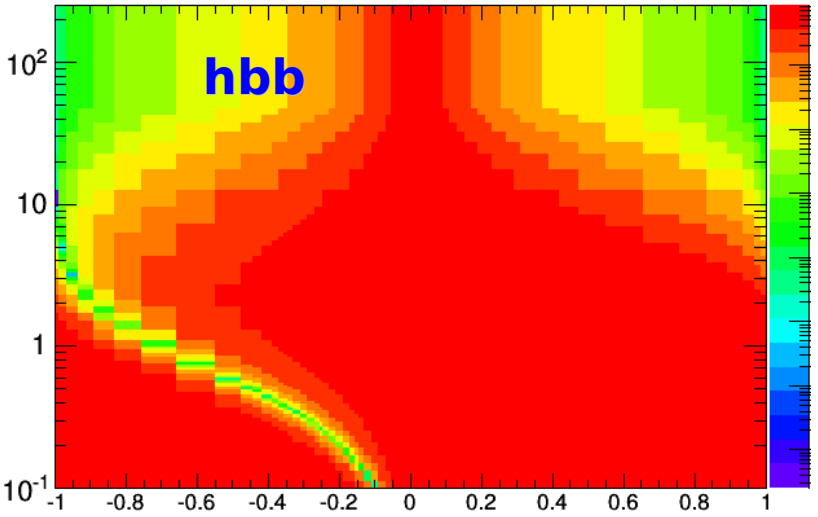


2HDM type III @ mH = 300 GeV

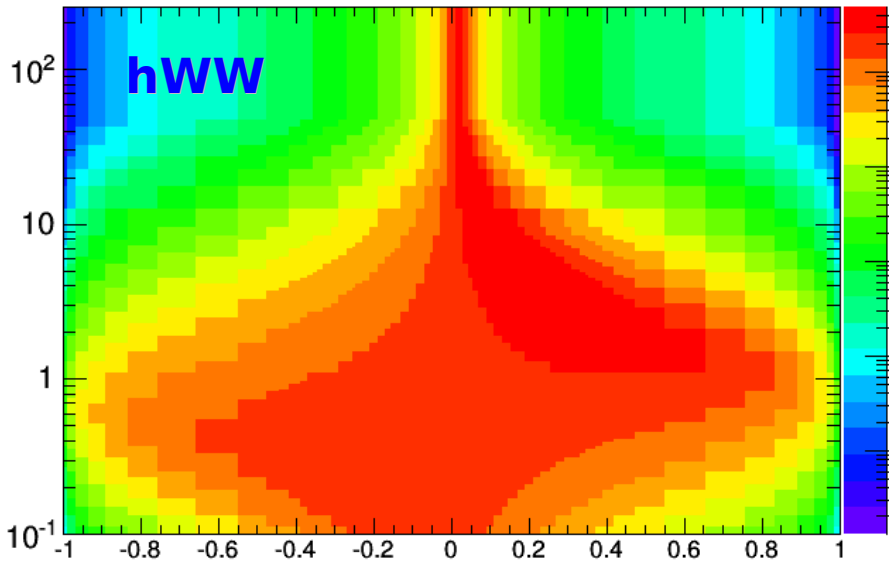


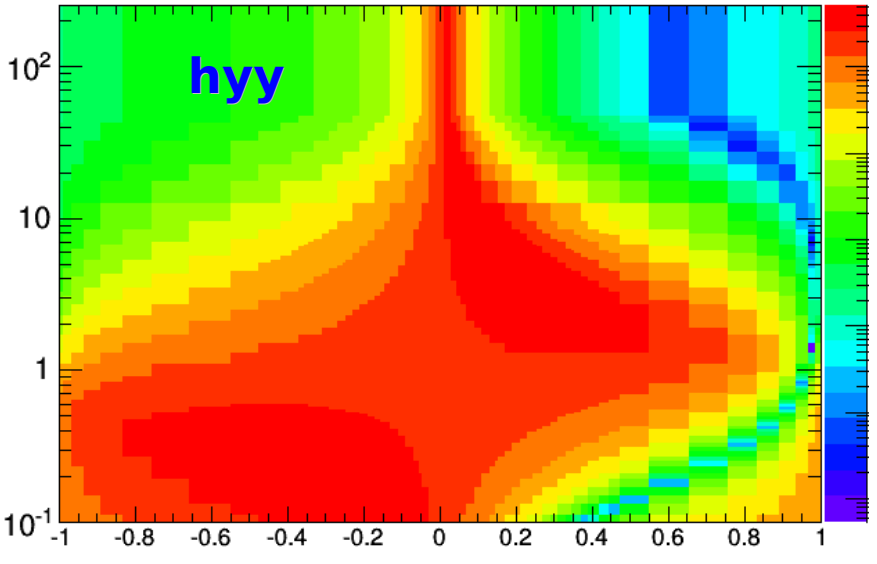


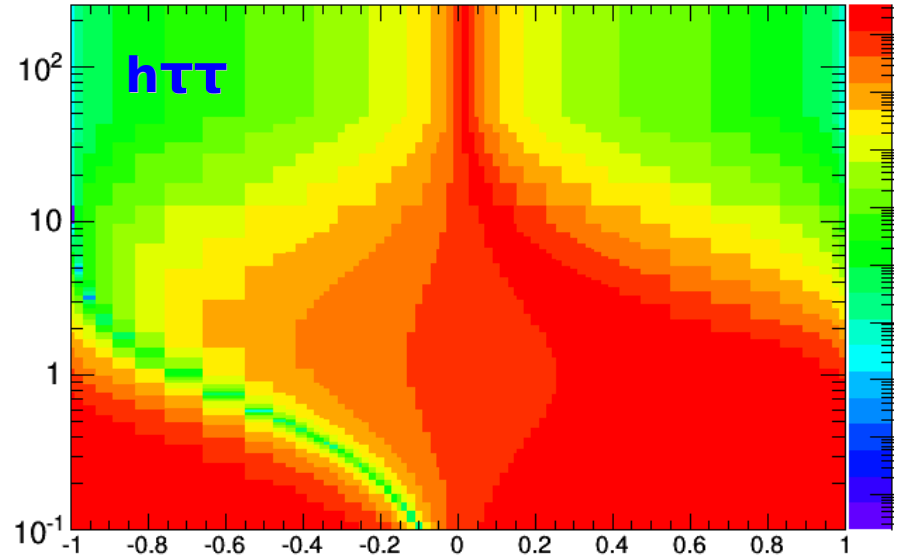


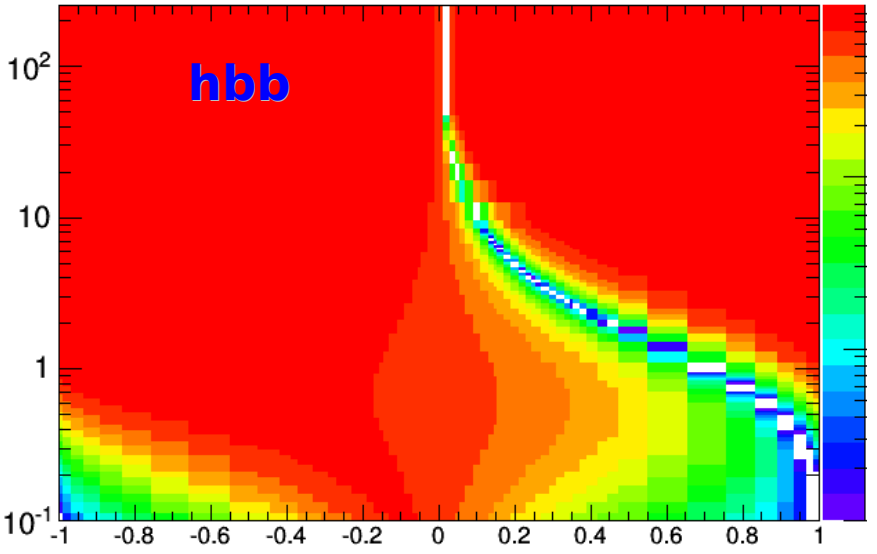


2HDM type IV @ mH = 300 GeV

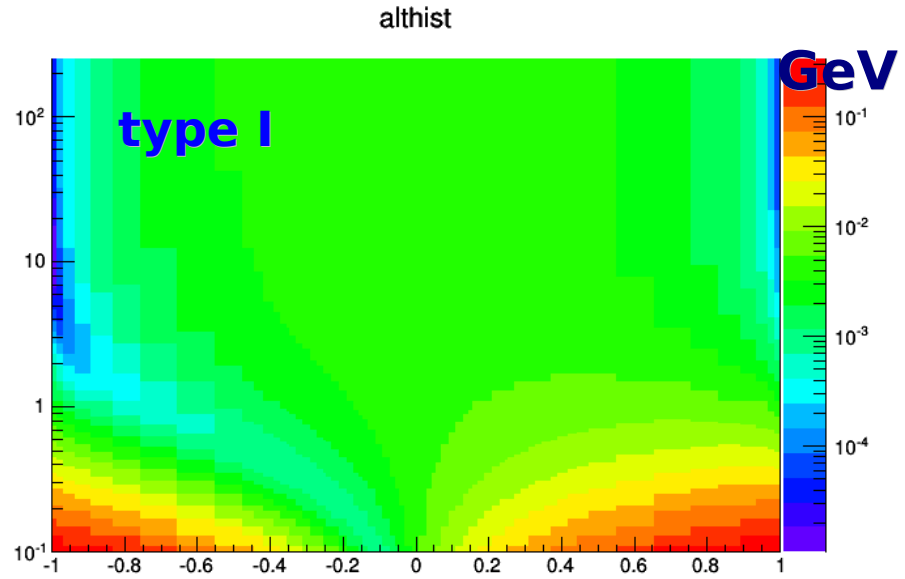


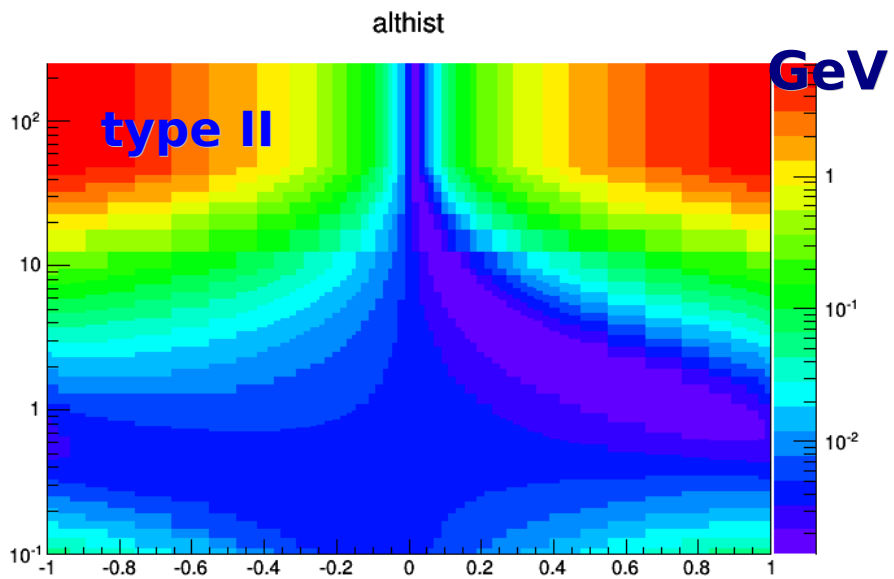


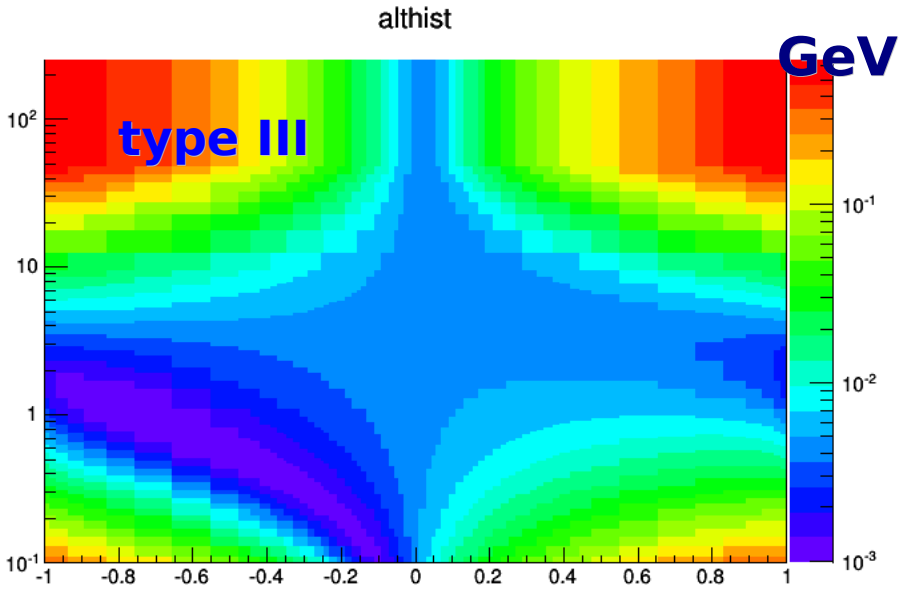


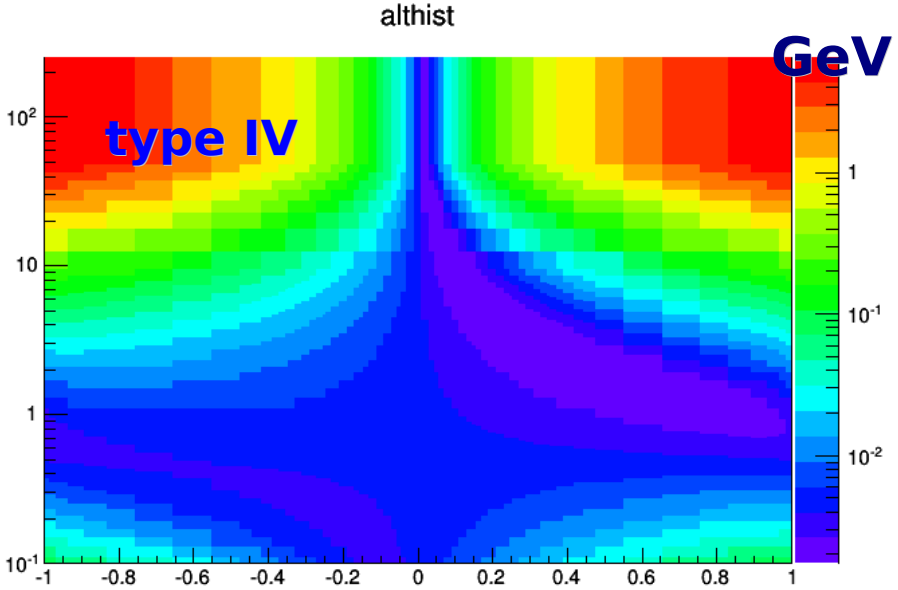


2HDM witdh_**h** @ mH = 300 GeV

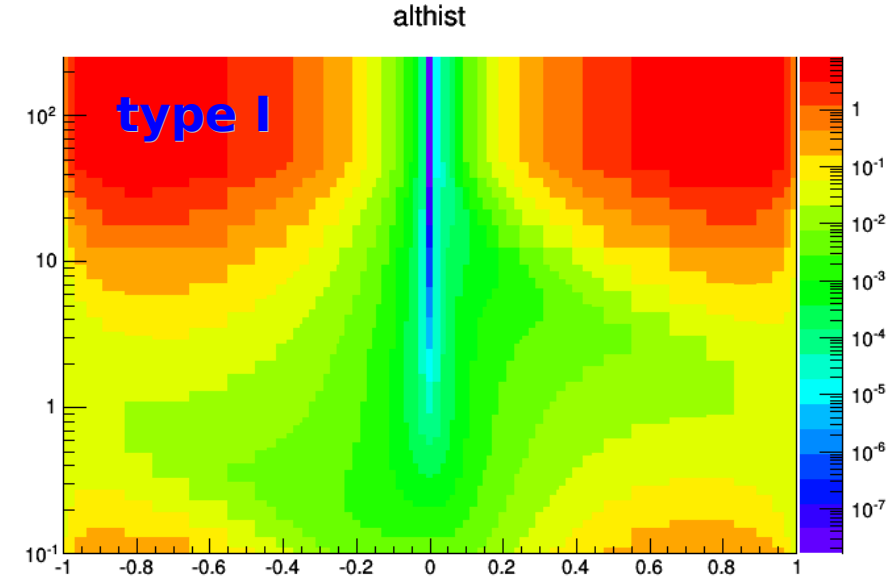


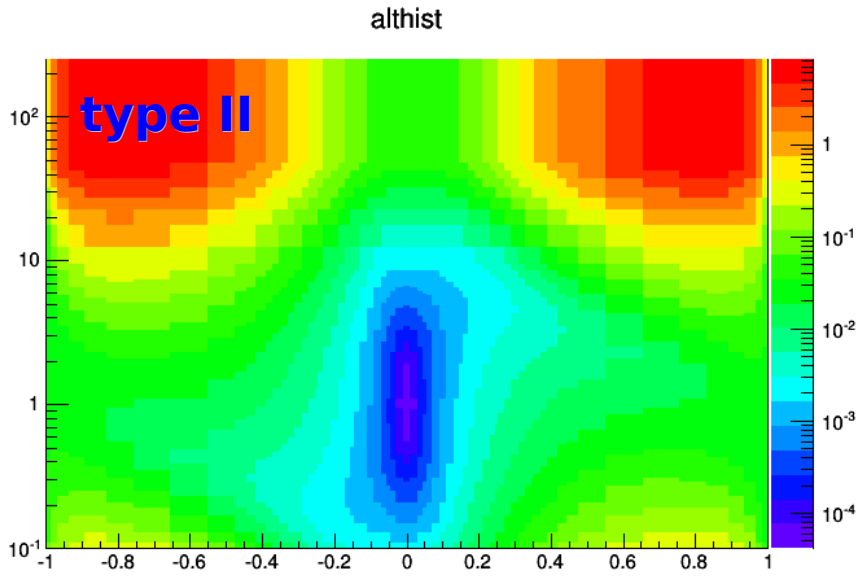


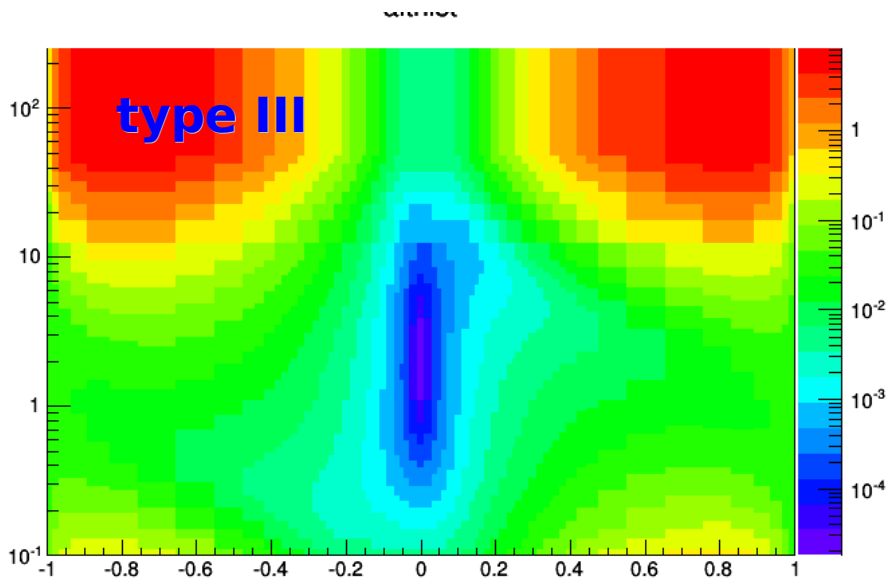


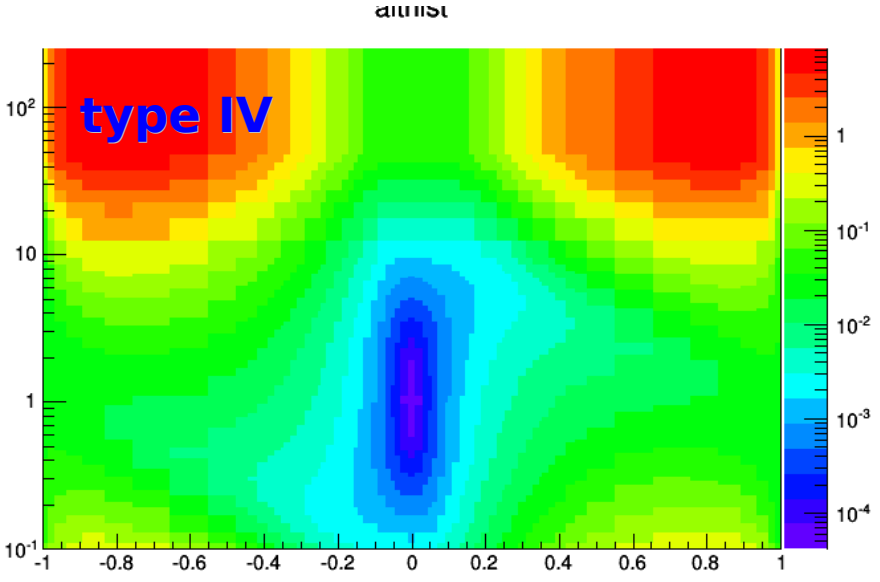


2HDM **witdh_H / mH** @ 300 GeV

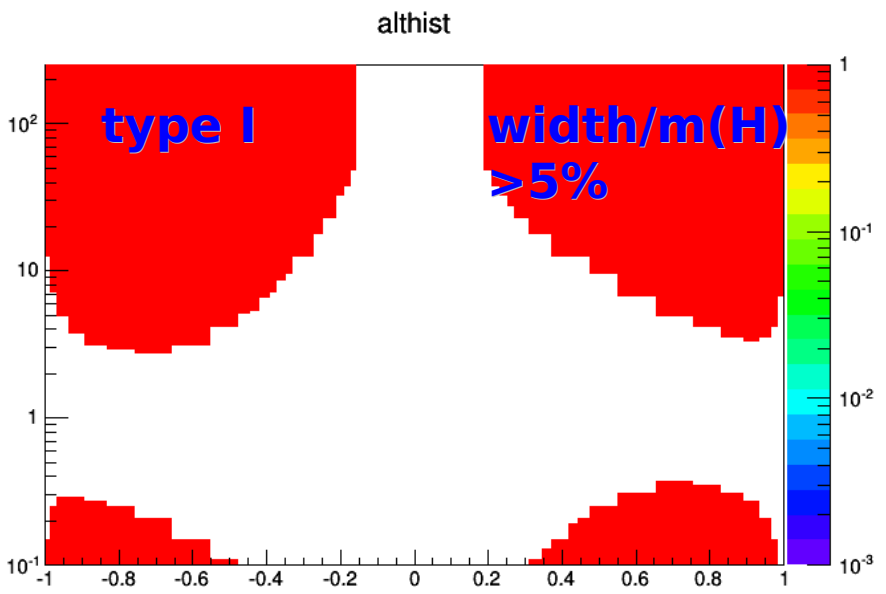


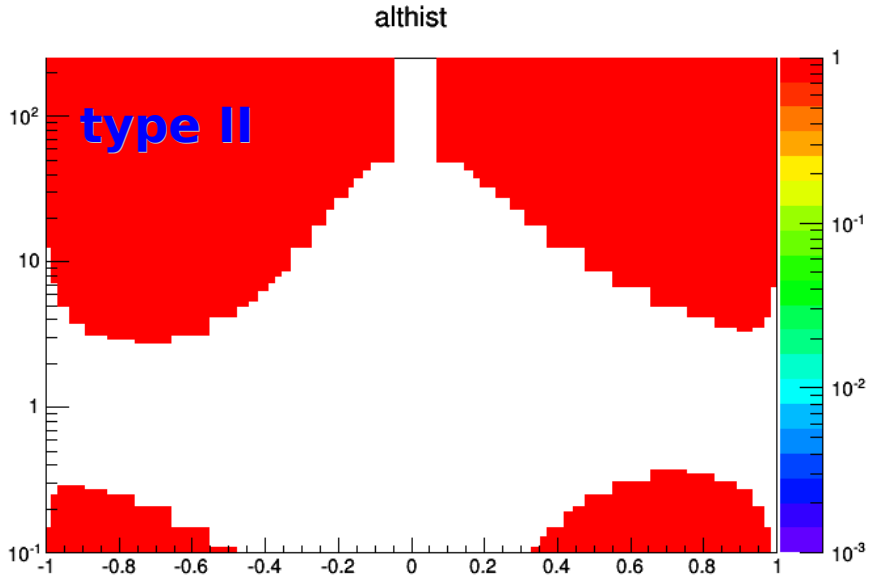


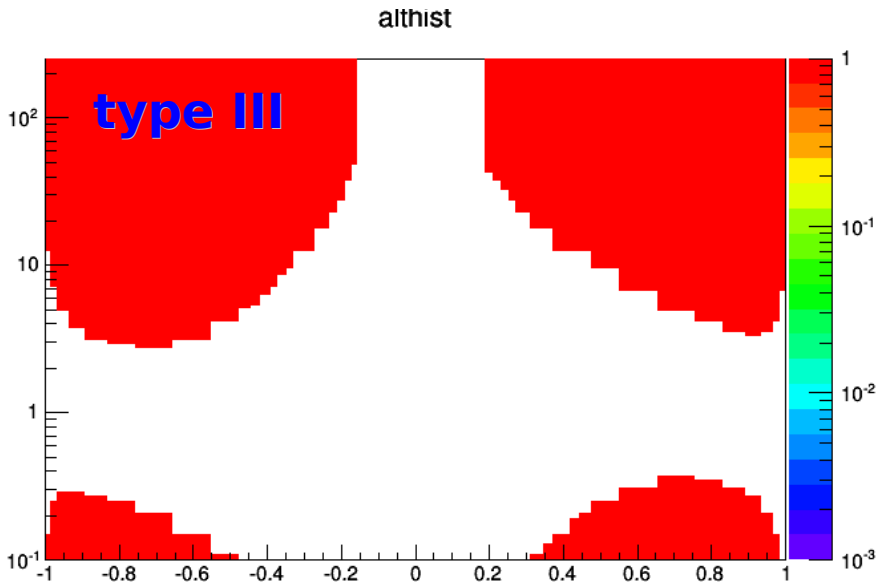


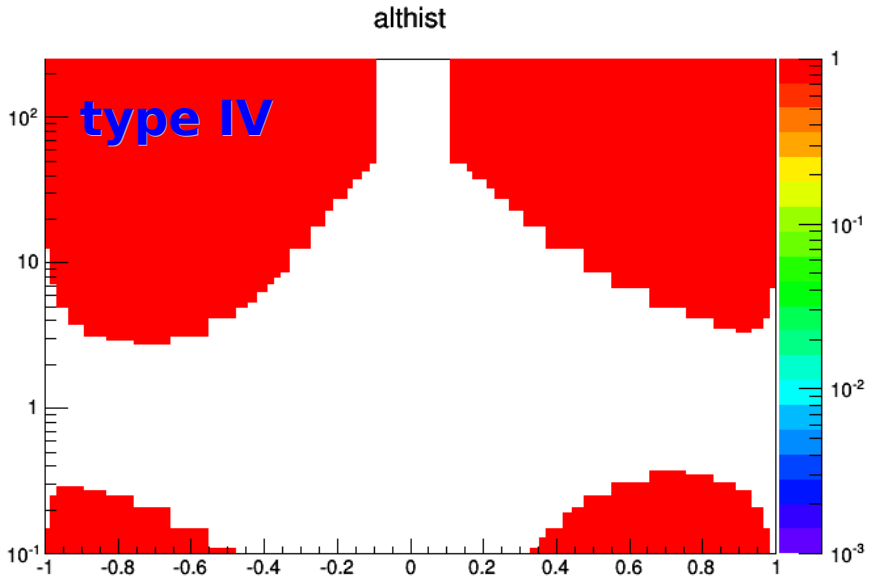


2HDM witdh_**H** / mH @ mH = 300 GeV



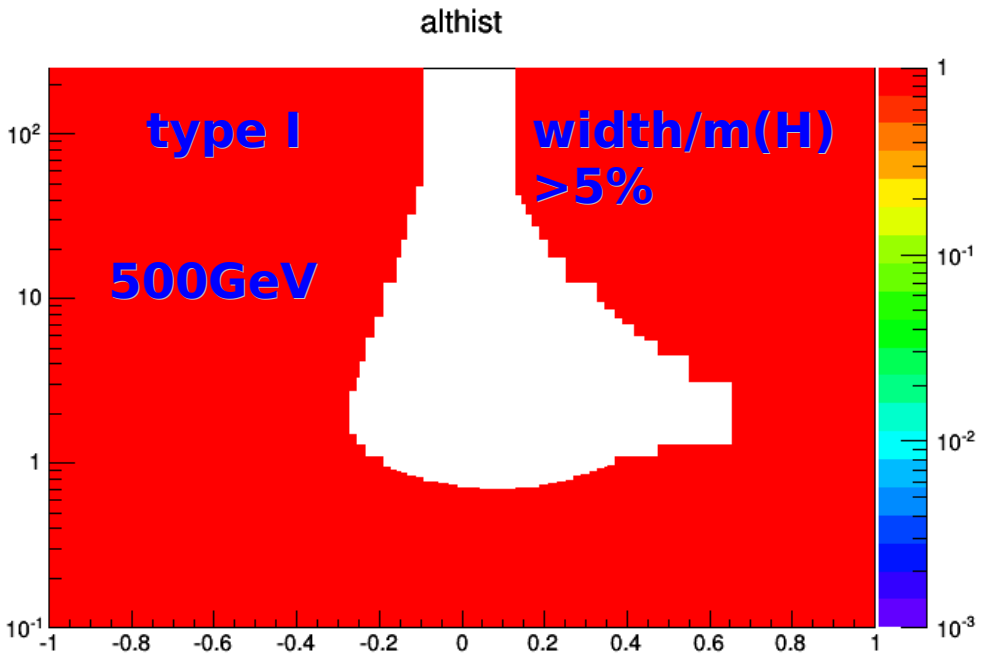


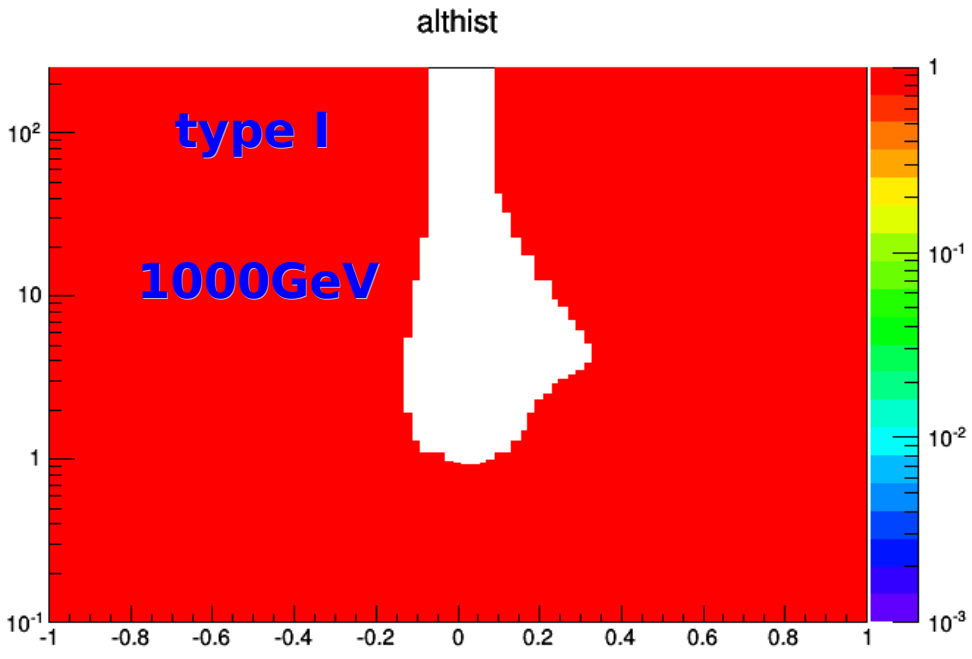




in general, width effect should be considered more than AZh case

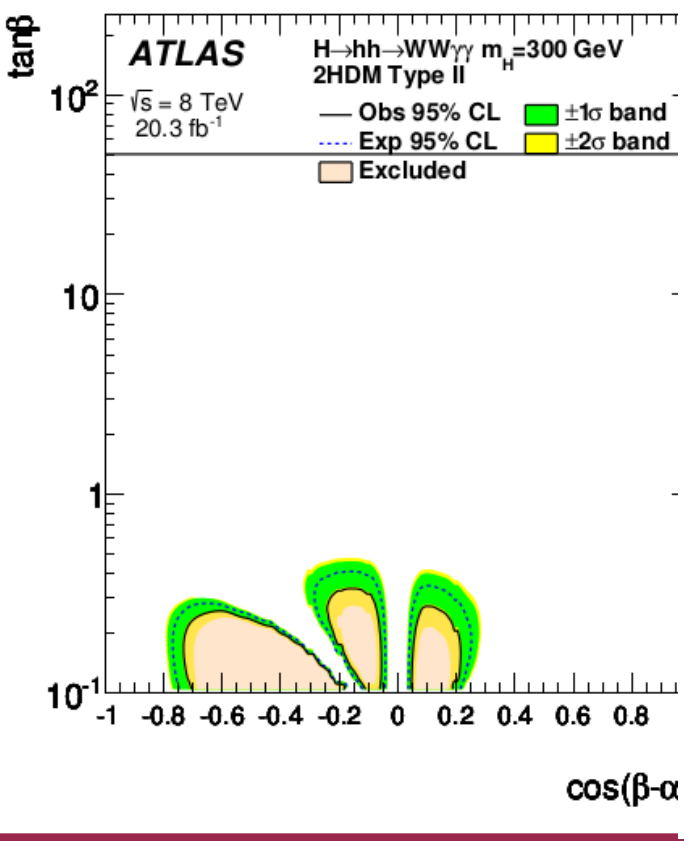
2HDM witdh_**H** / mH @ higher mH

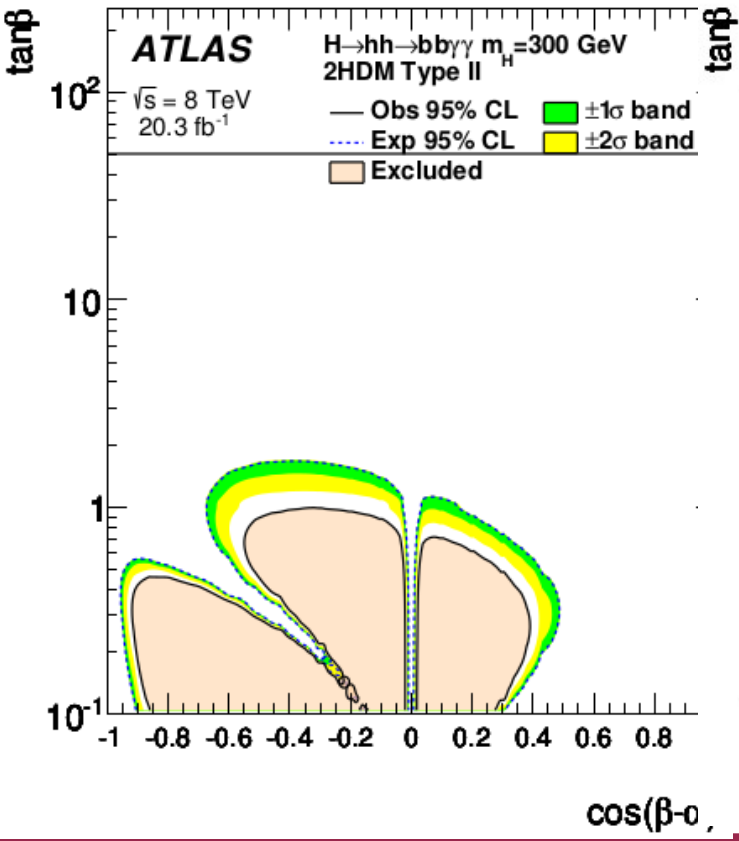


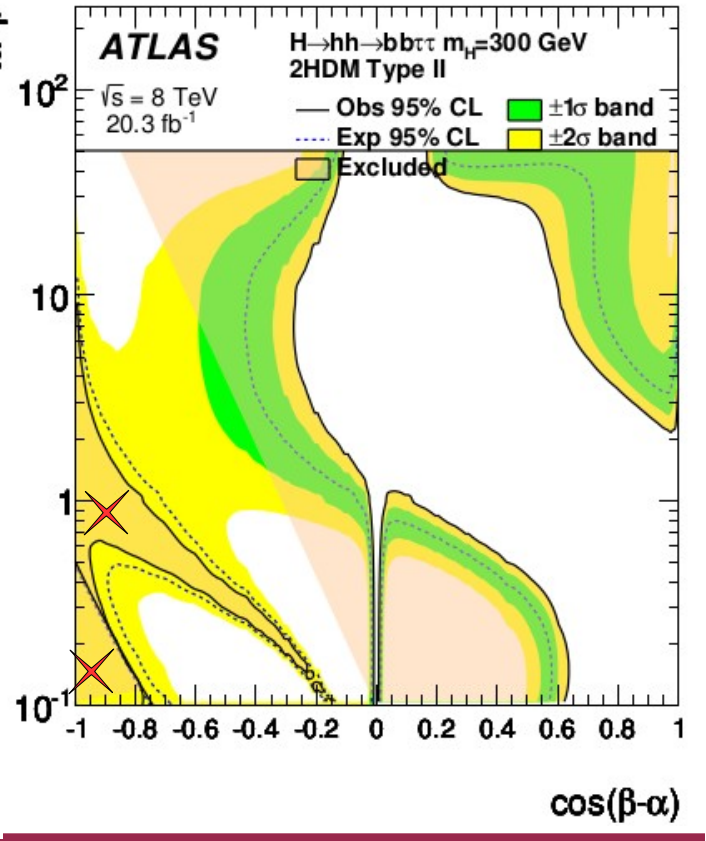


Looking at subchannel 2HDM exclusion

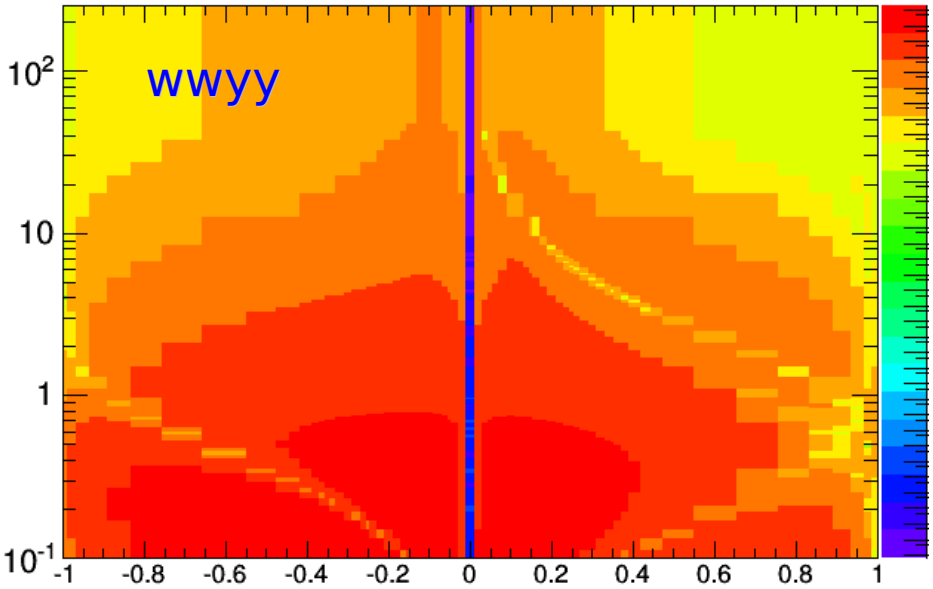
- Too many coupling, not easy to do parameterization for comb limits, Carl proposed to exclude with the most powerful limit at each point == overlay limits from all ch
- make 2HDM type II exclusion @ 300GeV wwyy / bbyy / bbtautau
- tanb should be larger than 0.5 (theo stability, we did it in Azh)
  - but wwyy does not exclude anything if you start from tb=0.5

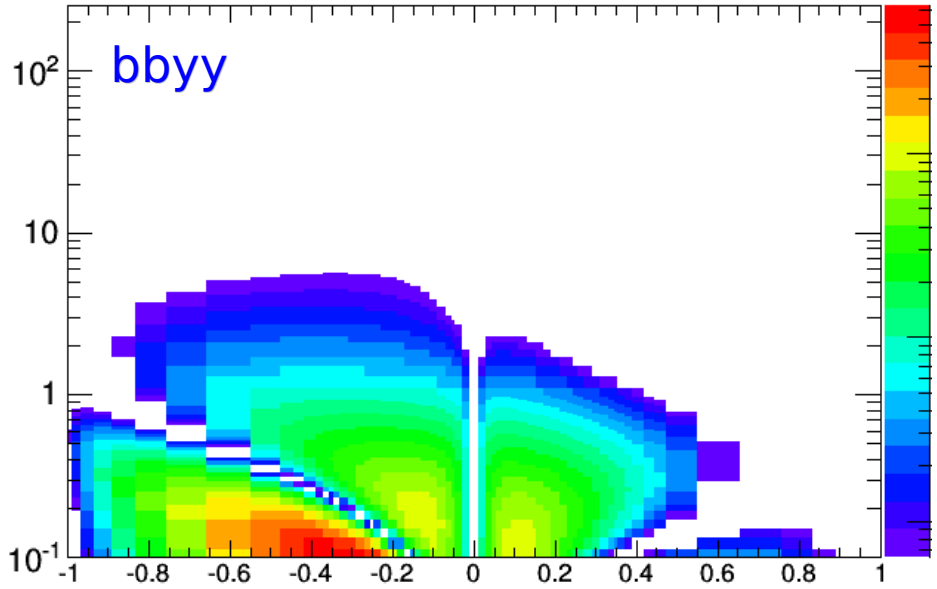


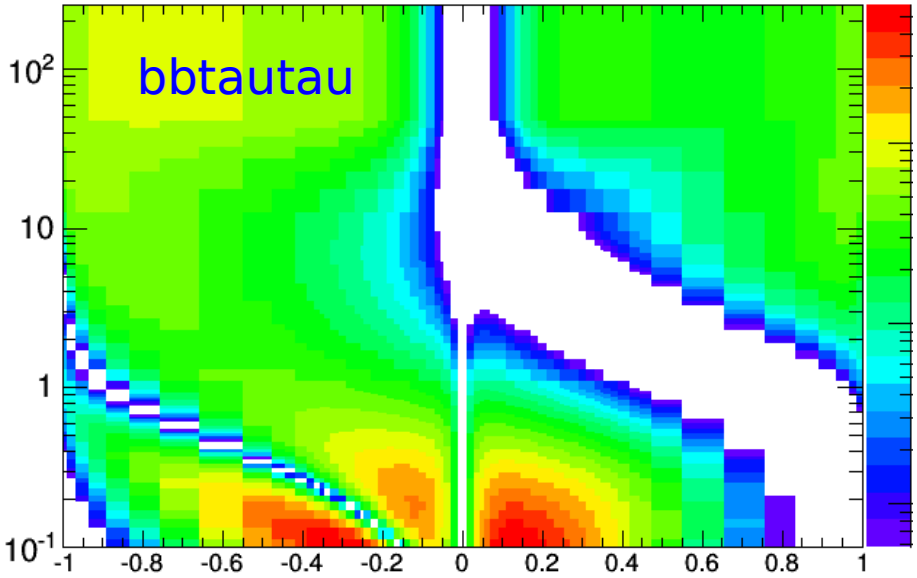




Check subchannel 2HDM xsbr contours

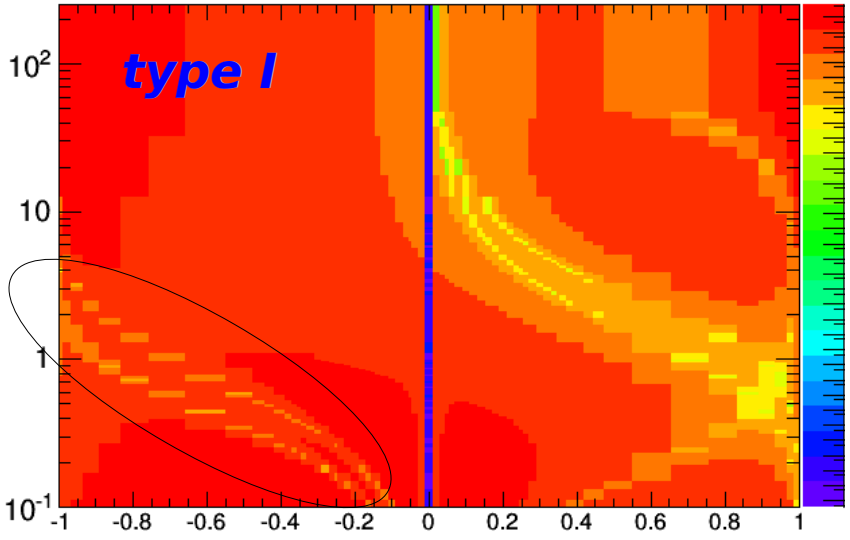


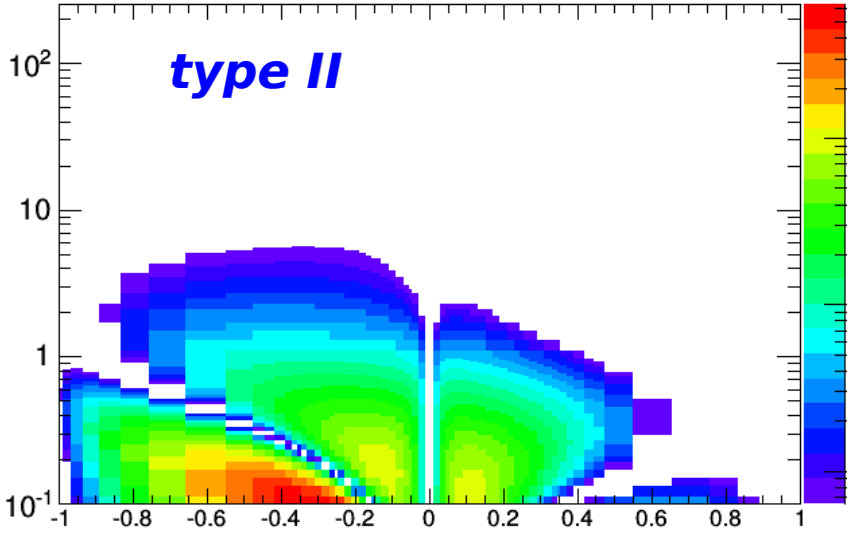


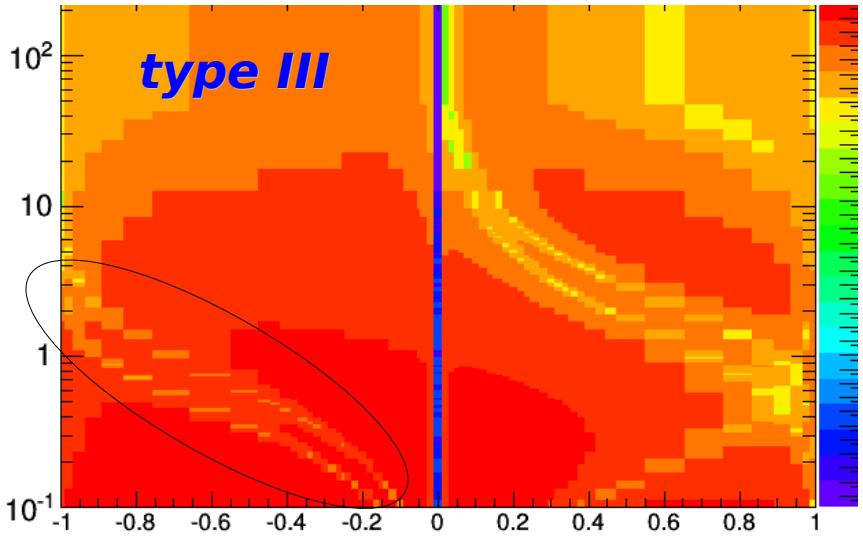


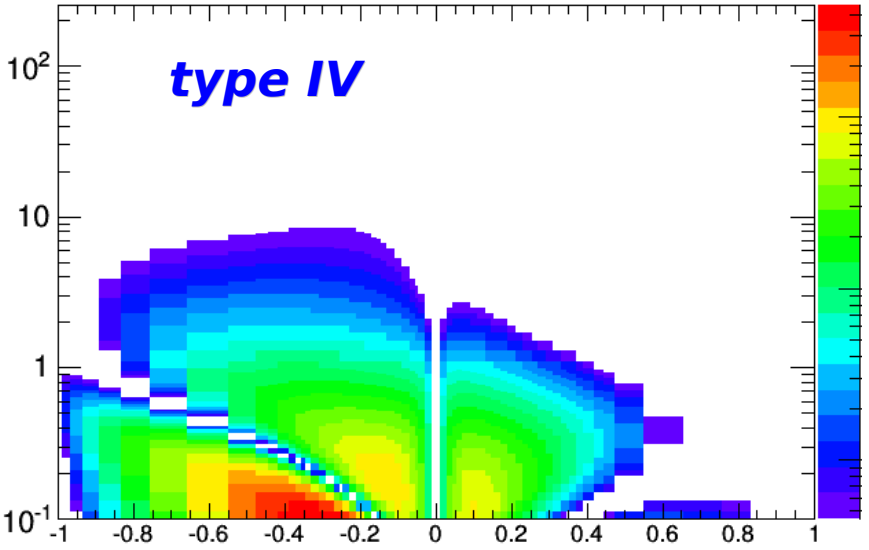
2HDM

- ***XS * BR contours in bbyy***





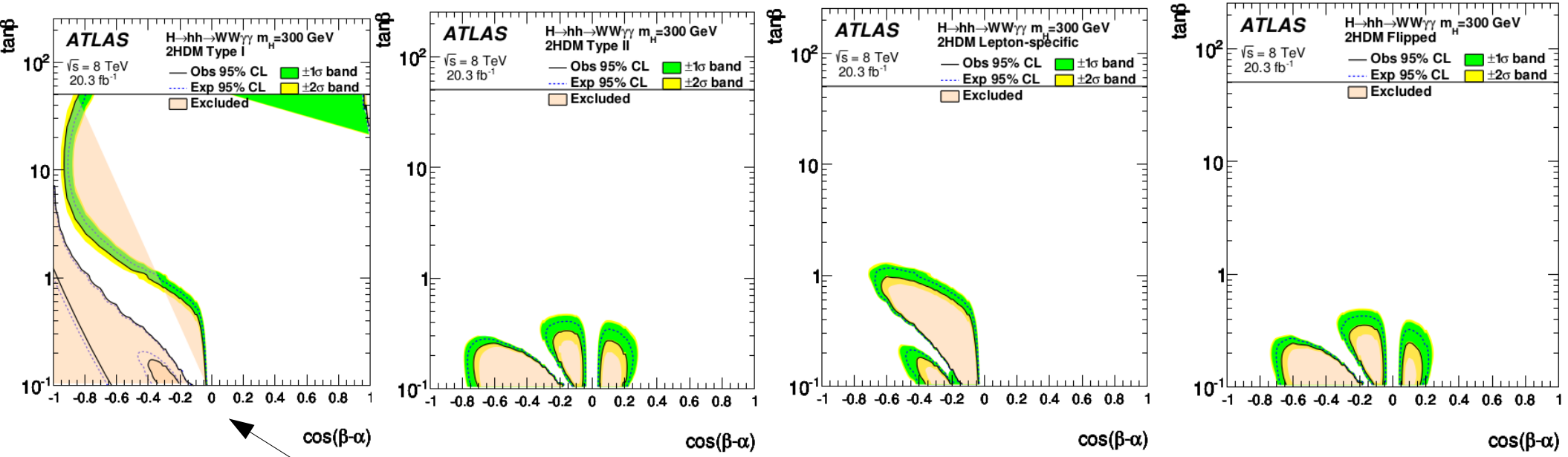


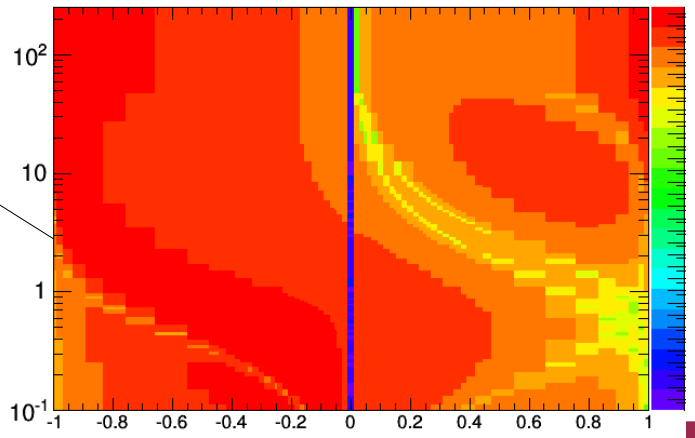


double valley structure will be difficult to deal with interpolation in plotting ...

2HDM

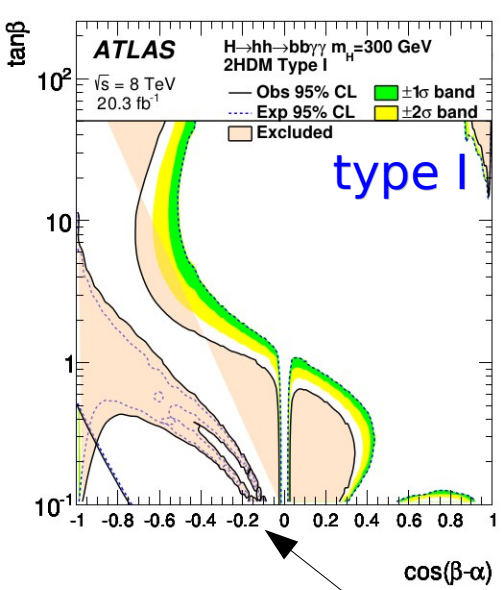
- wwyy does not contribute a lot considering the limit setting in combination and the exclusion areas
- can simply ignore wwyy channel in 2HDM interpretation

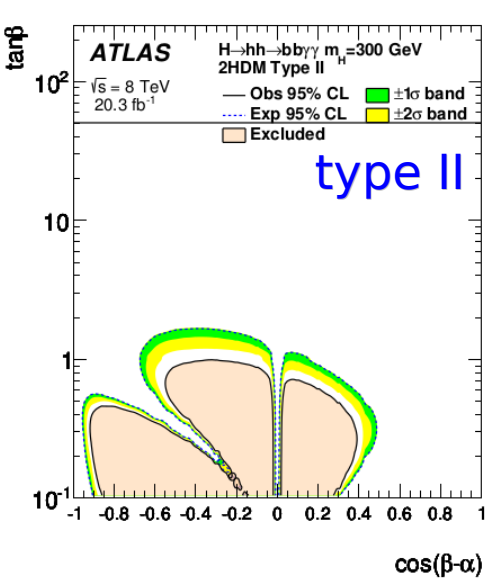


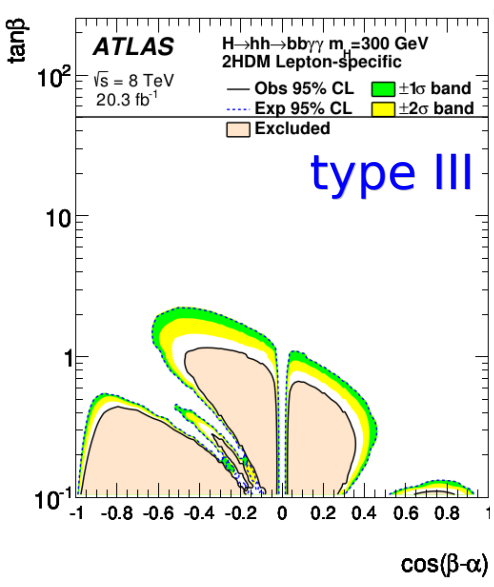


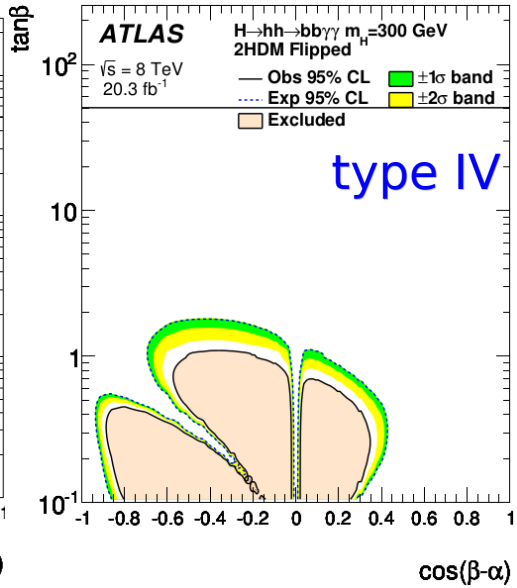
2HDM

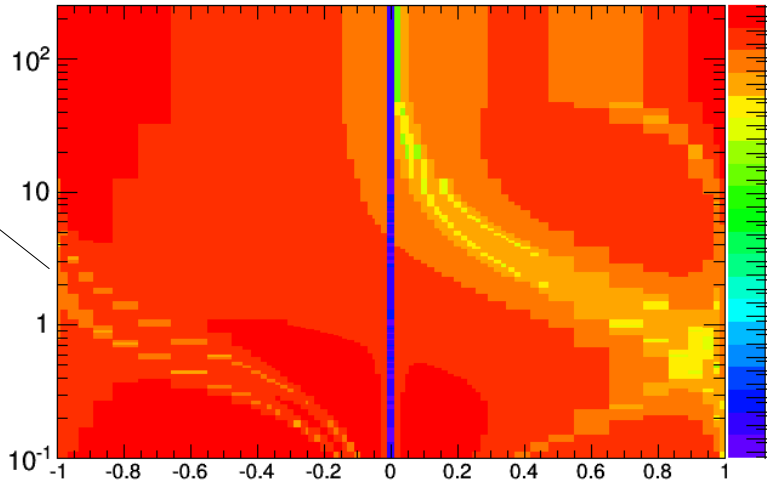
- bbyy


ATLAS
√s = 8 TeV
20.3 fb-1
H→hh→bbγγ mH=300 GeV
2HDM Type I
Obs 95% CL
Exp 95% CL
±1σ band
±2σ band
Excluded
type I
tanβ
cos(β-α)


ATLAS
√s = 8 TeV
20.3 fb-1
H→hh→bbγγ mH=300 GeV
2HDM Type II
Obs 95% CL
Exp 95% CL
±1σ band
±2σ band
Excluded
type II
tanβ
cos(β-α)

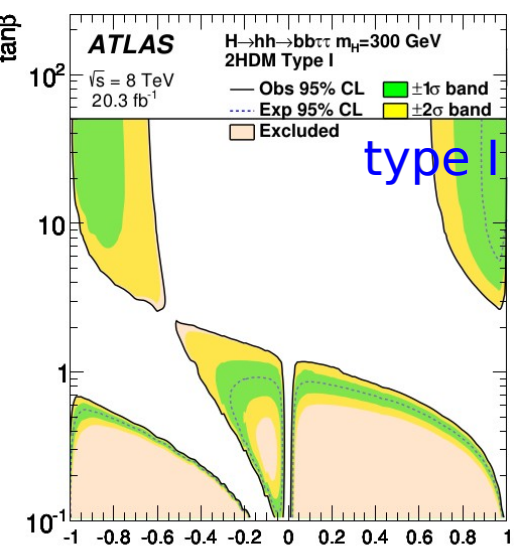

ATLAS
√s = 8 TeV
20.3 fb-1
H→hh→bbγγ mH=300 GeV
2HDM Lepton-specific
Obs 95% CL
Exp 95% CL
±1σ band
±2σ band
Excluded
type III
tanβ
cos(β-α)

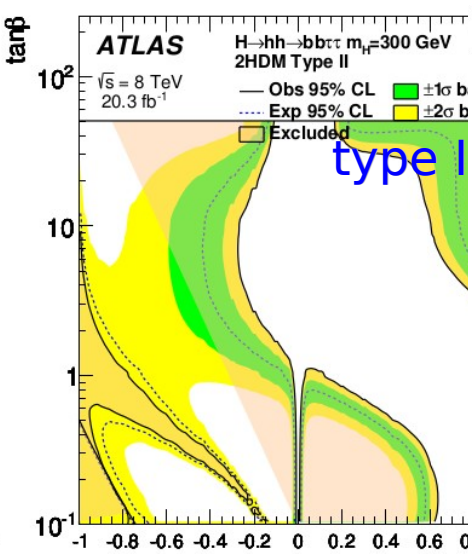

ATLAS
√s = 8 TeV
20.3 fb-1
H→hh→bbγγ mH=300 GeV
2HDM Flipped
Obs 95% CL
Exp 95% CL
±1σ band
±2σ band
Excluded
type IV
tanβ
cos(β-α)

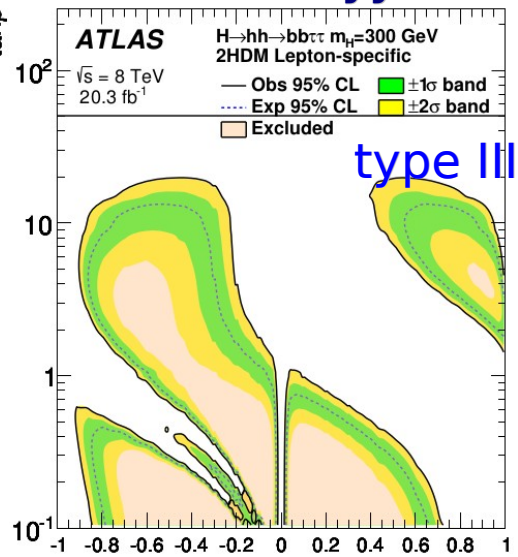

tanβ
cos(β-α)

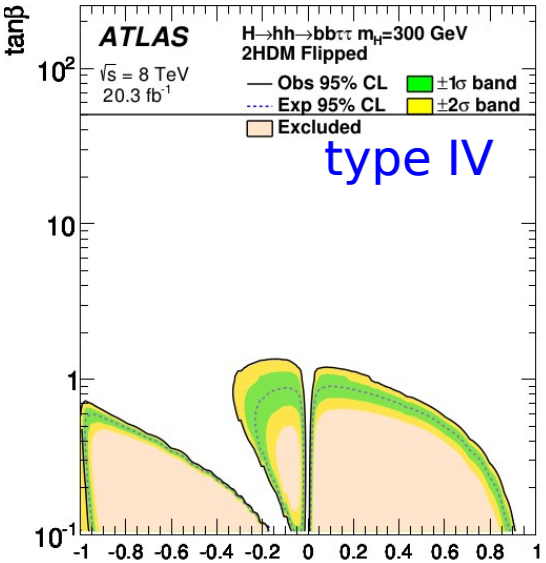
2HDM

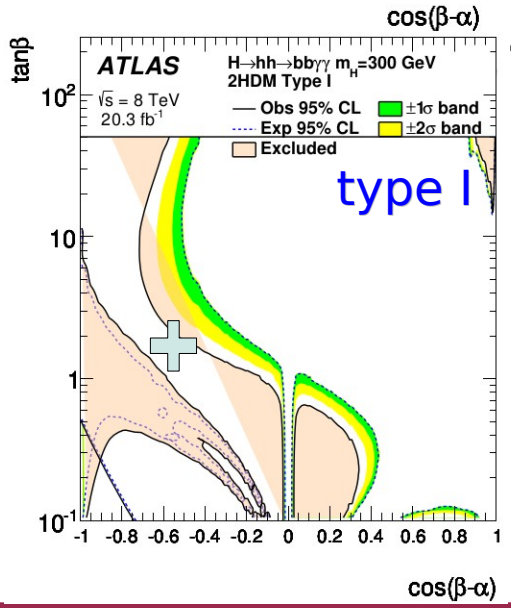
- bbtautau contributes a lot
- **bbtautau covers most of the exclusions from bbyy**

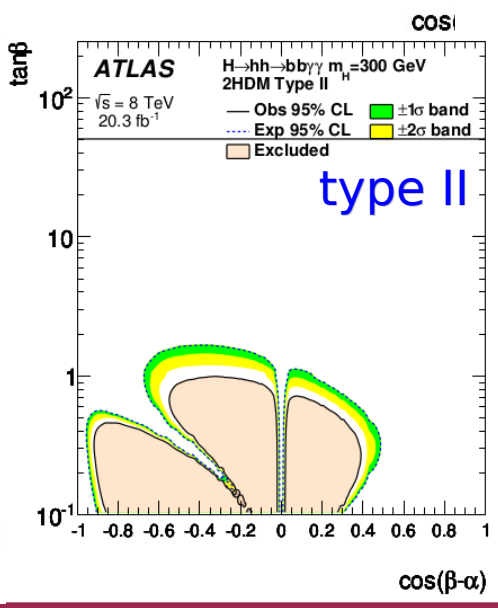


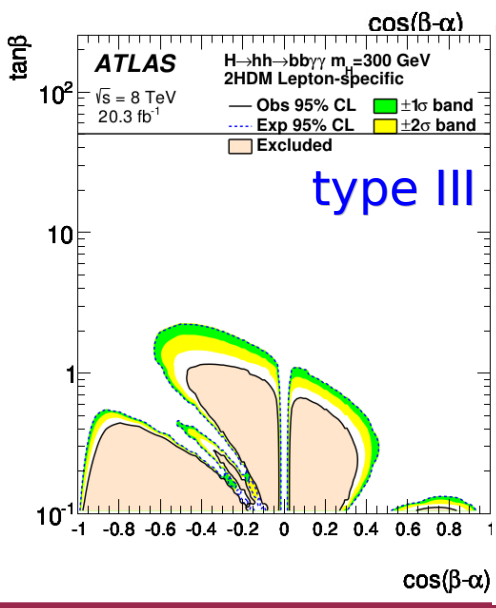


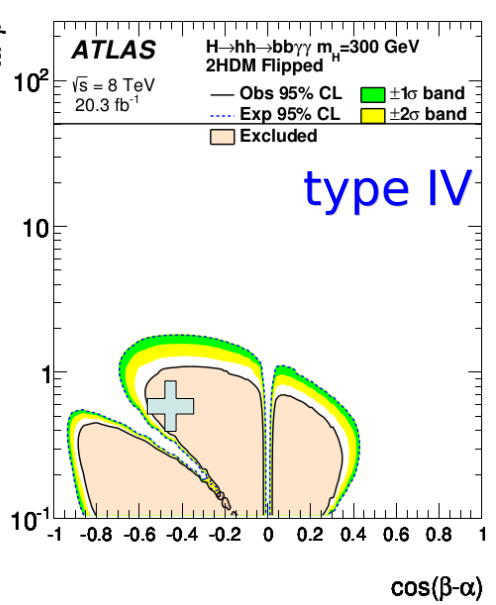






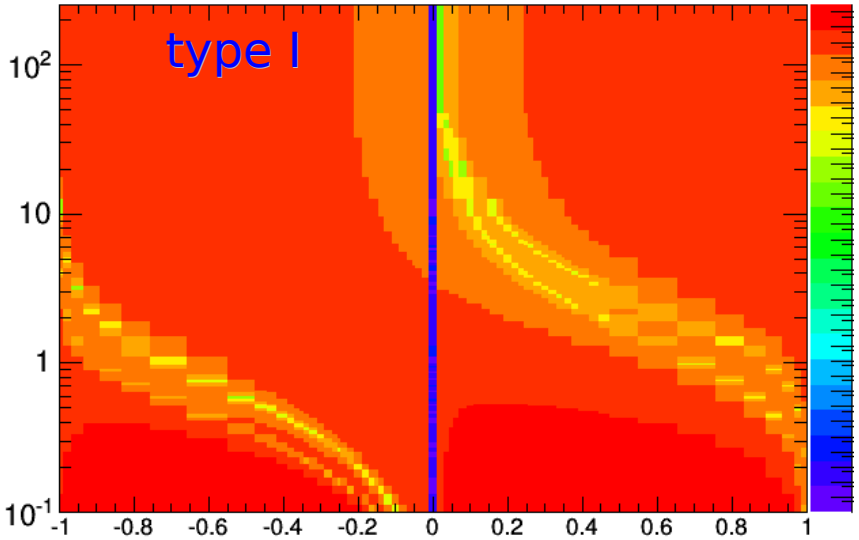


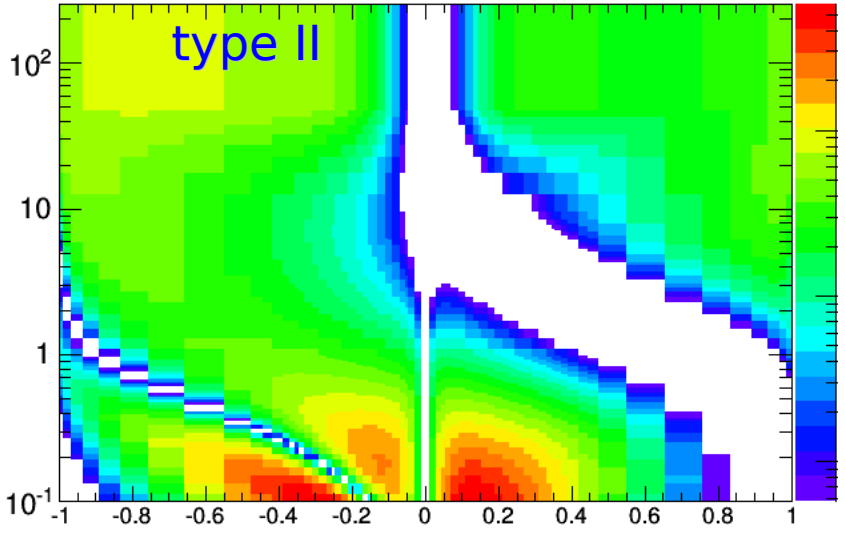


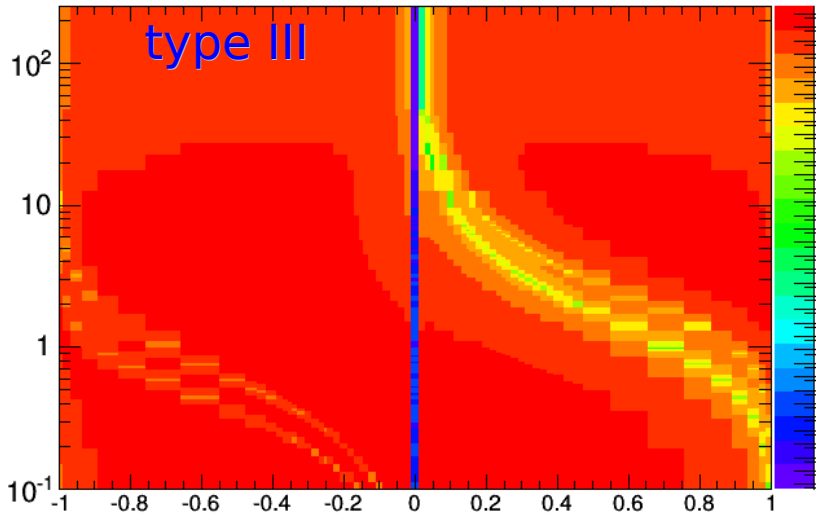


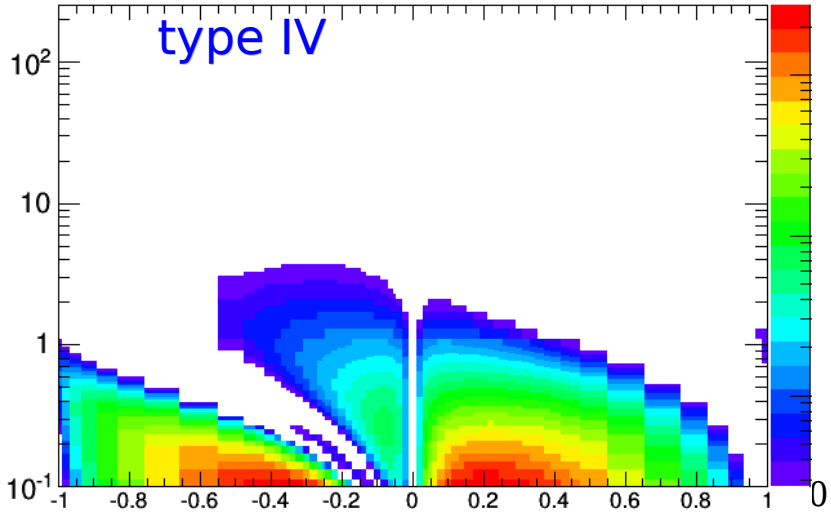
2HDM

- bbtautau XS*BR contour check to make sure the exclusion plots are correctly produced in previous page









Combined limits [nonres]

- 9.55fb is predicted in SM hh production [arXiv:1309.6594] @NNLO
-
- obs limit is **72** times the SM hh
- obs mu = xs_measured / xs_SM = **30**