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

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

17-04-2015

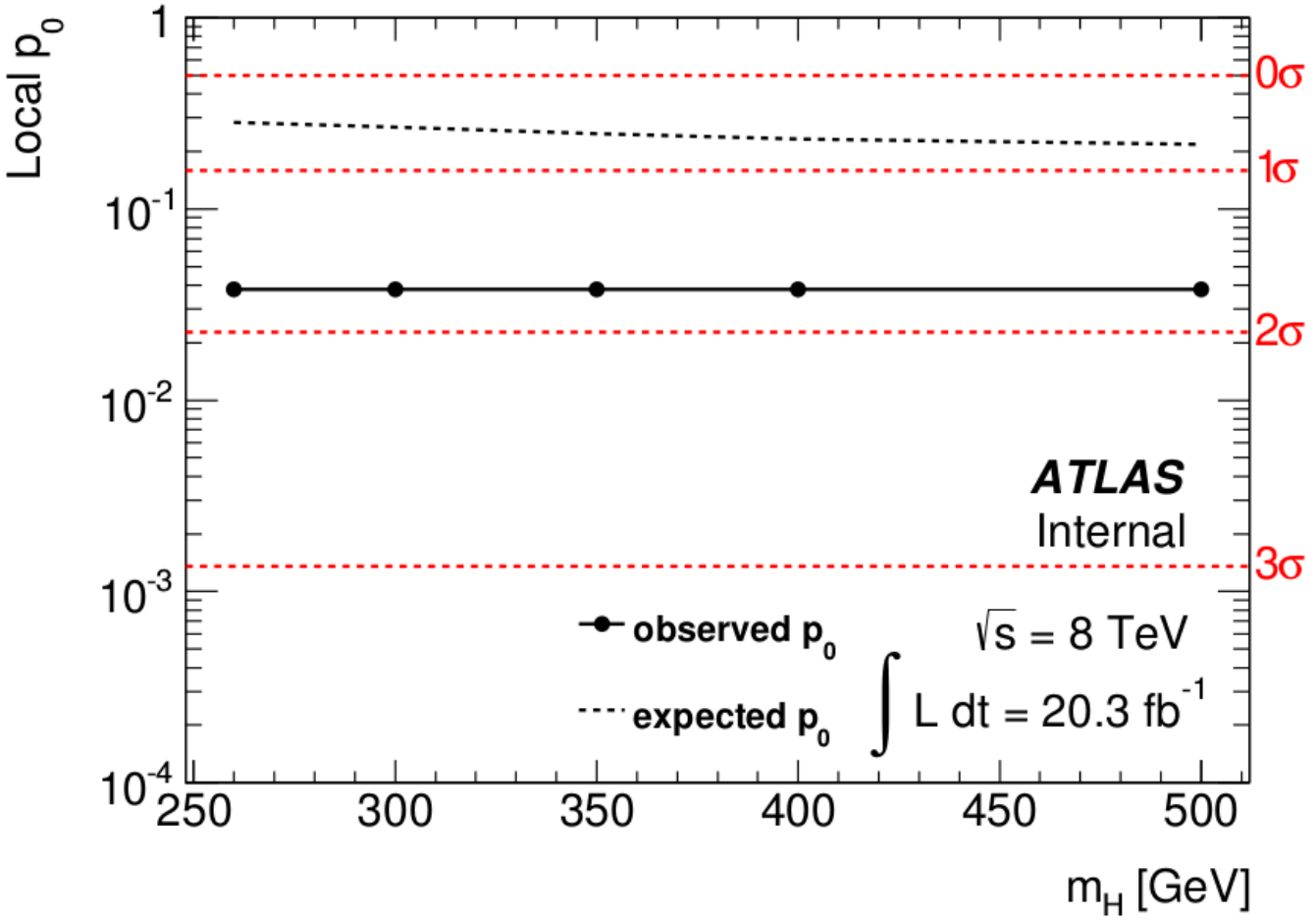
IHEP

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/

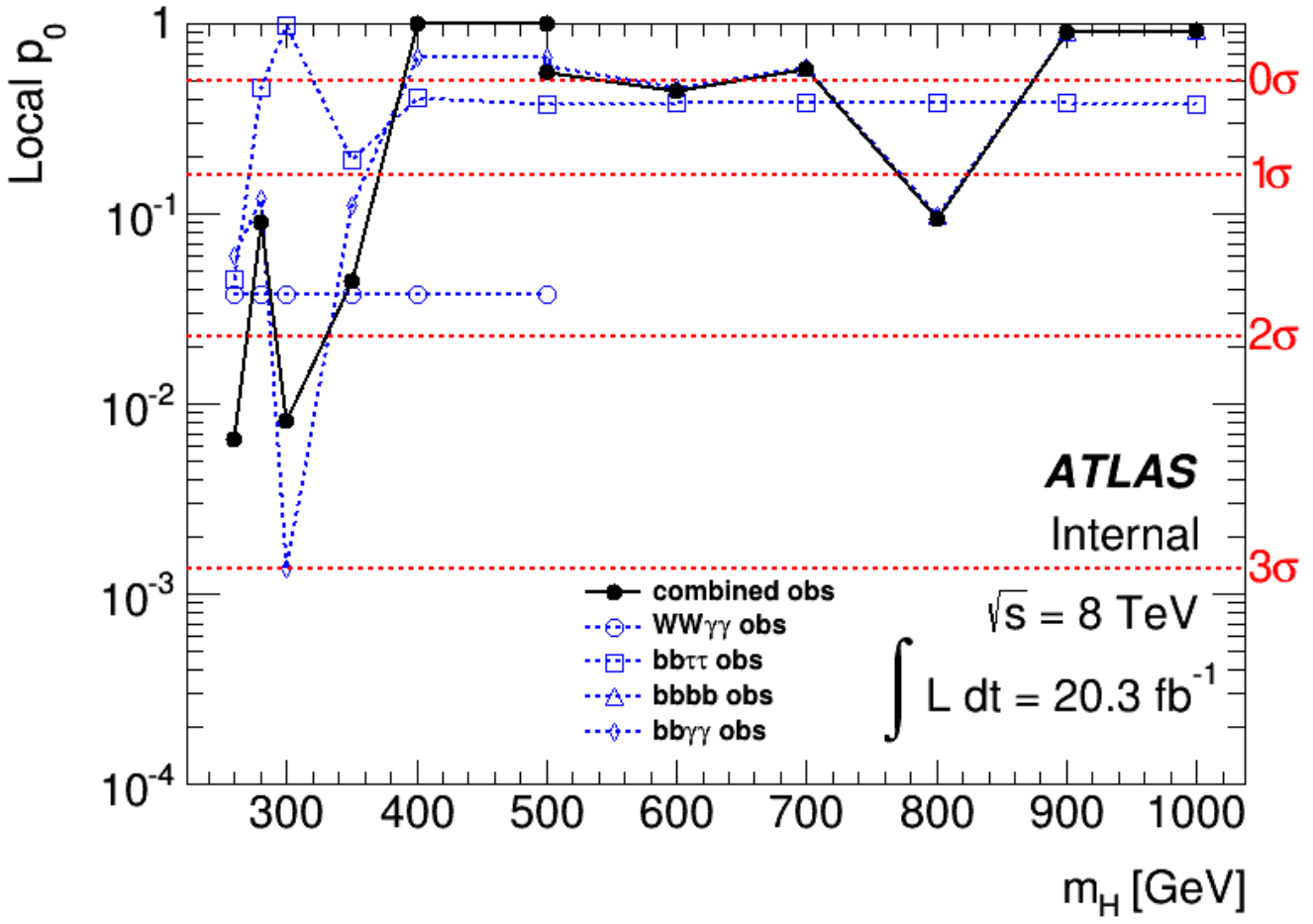
wwyy p0 updates [wwyy int note]

- inject 1pb signal for each mass before any cuts
- due to an increasing signal efficiency as a function of mass, the expected p0 decreases along the mass



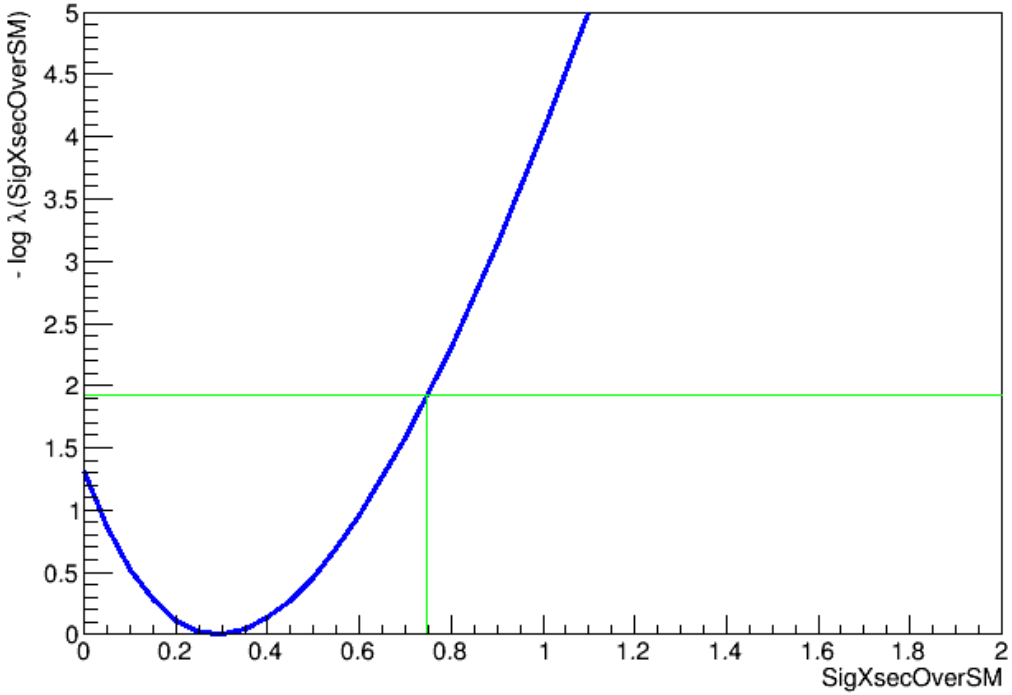
comb p0 updates [hhcomb int note]

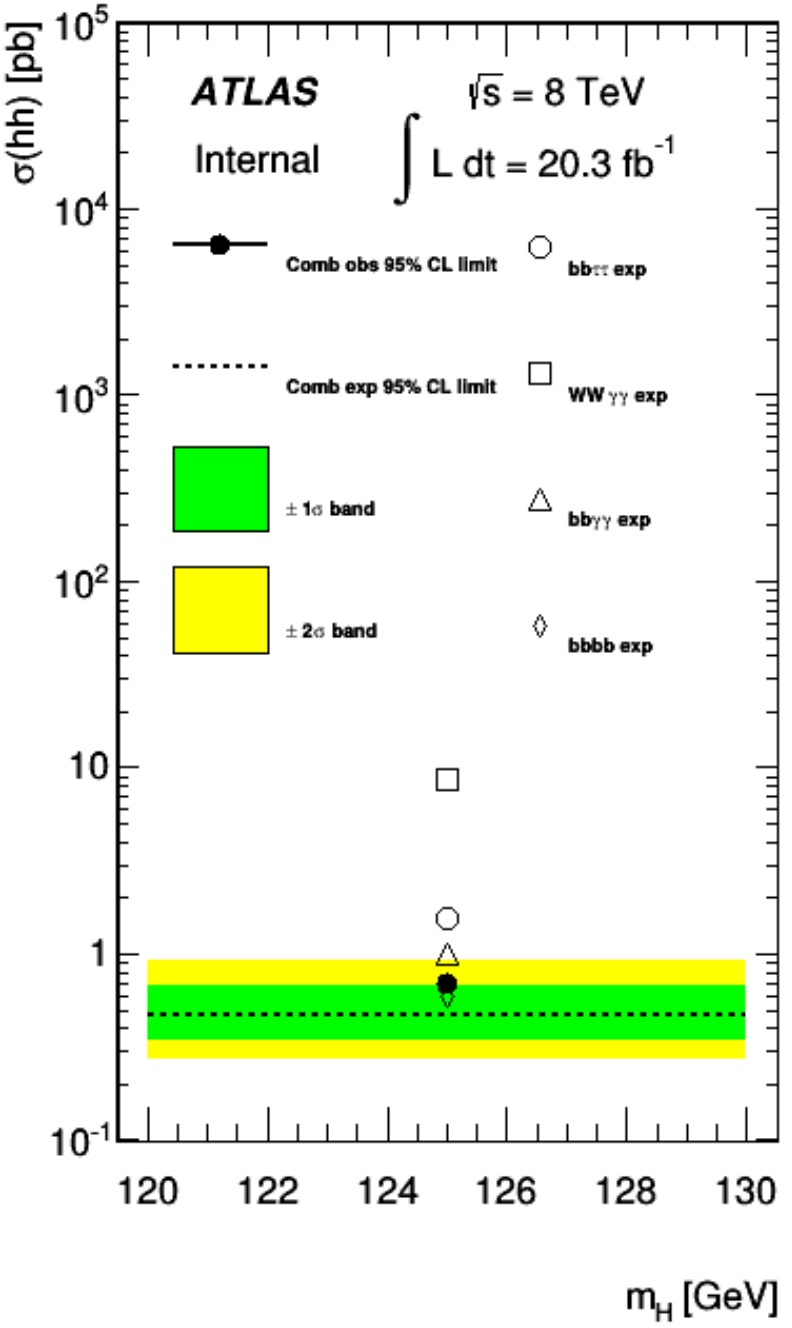
- newly added mass point of **280**GeV
  - combining bbtautau+bbyy@280 and wwyy@260
- 280 limitis also finished on grid, to-be-added



Combined limits [nonres]

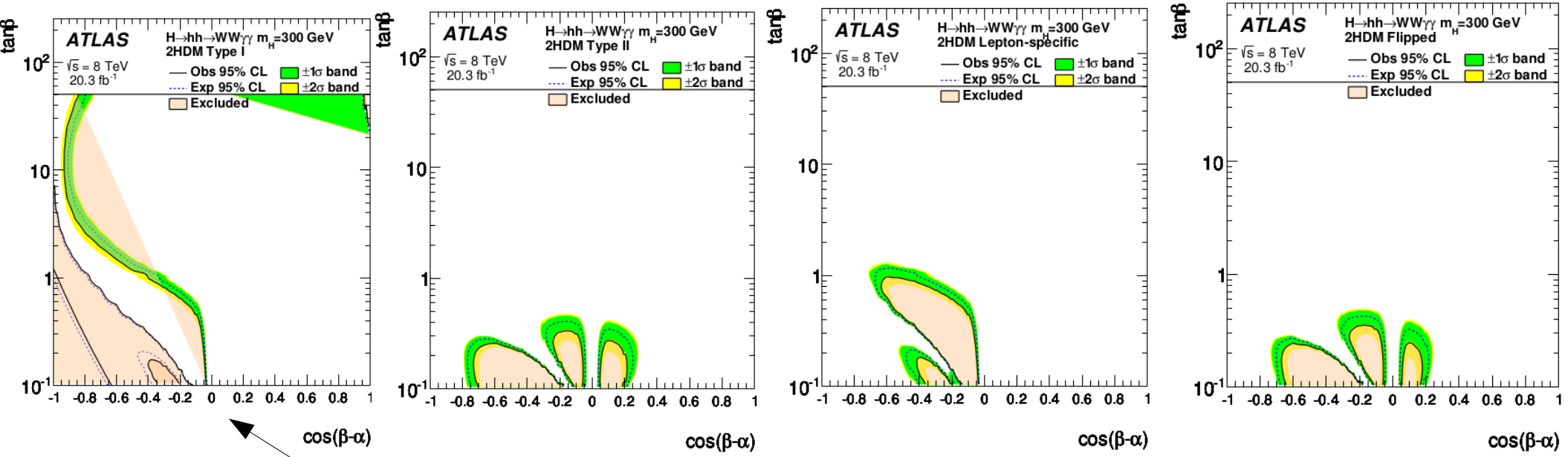
- For non-resonance (toys), the contributions are mainly from bbbb, bbγγ followed by bbττ and wwγγ
- 9.55fb is predicted in SM hh production [arXiv:1309.6594] @NNLO
- obs limit is **72** times the SM hh
- obs mu = xs_measured / xs_SM = **30**

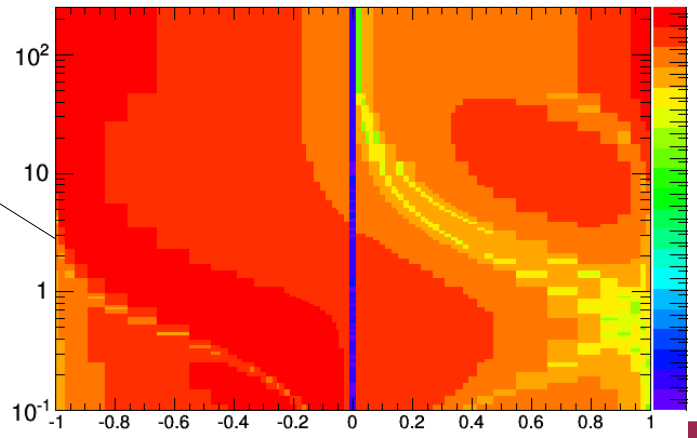




2HDM

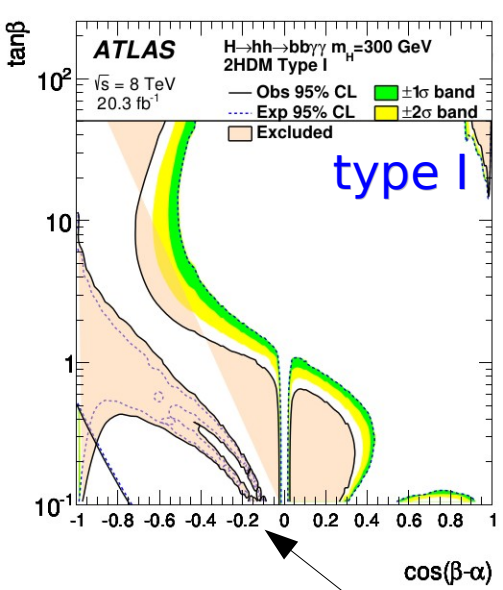
- wwyy does not contribute a lot considering the limit setting in combination and the exclusion areas
- can simply ignore wwyy channel in 2HDM interpretation

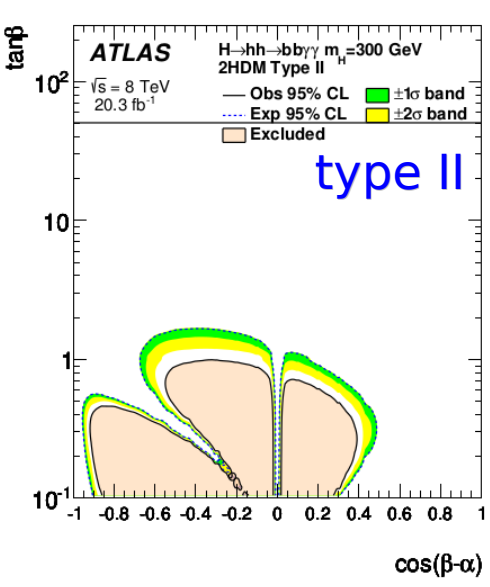


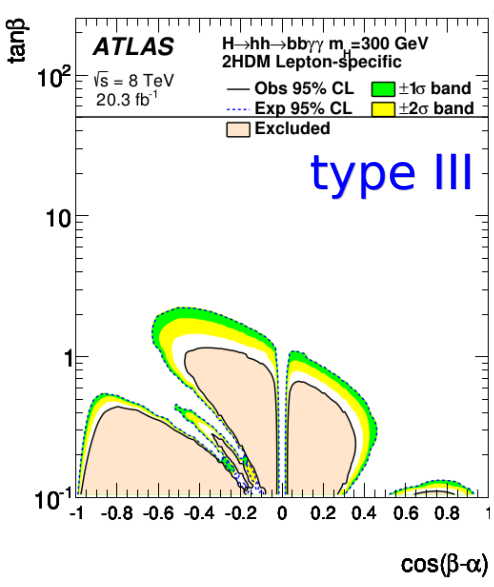


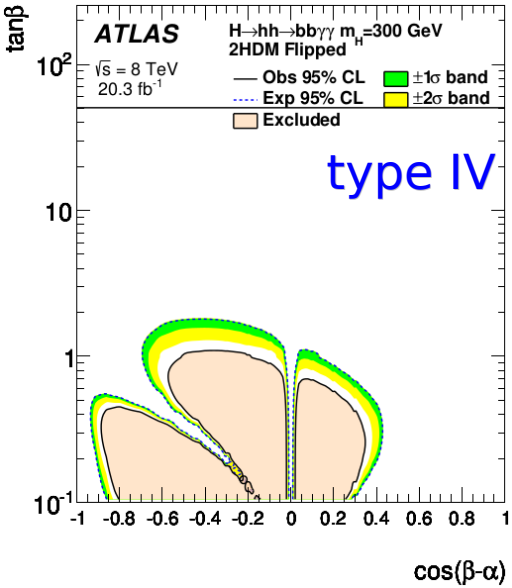
2HDM

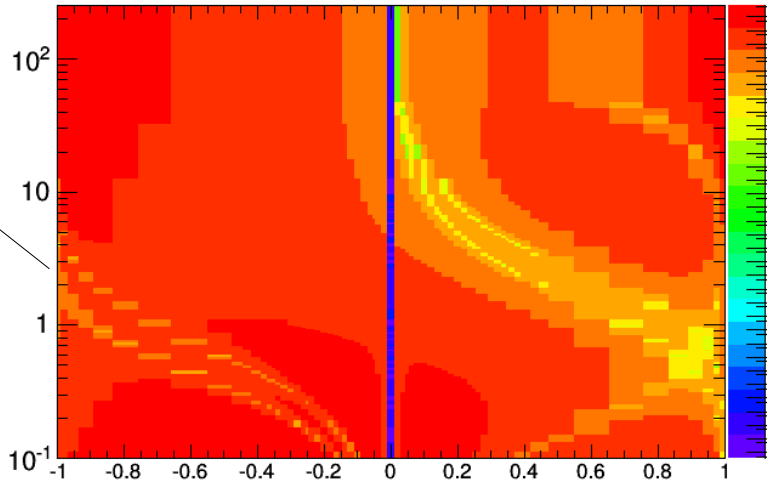
- bbyy


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


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

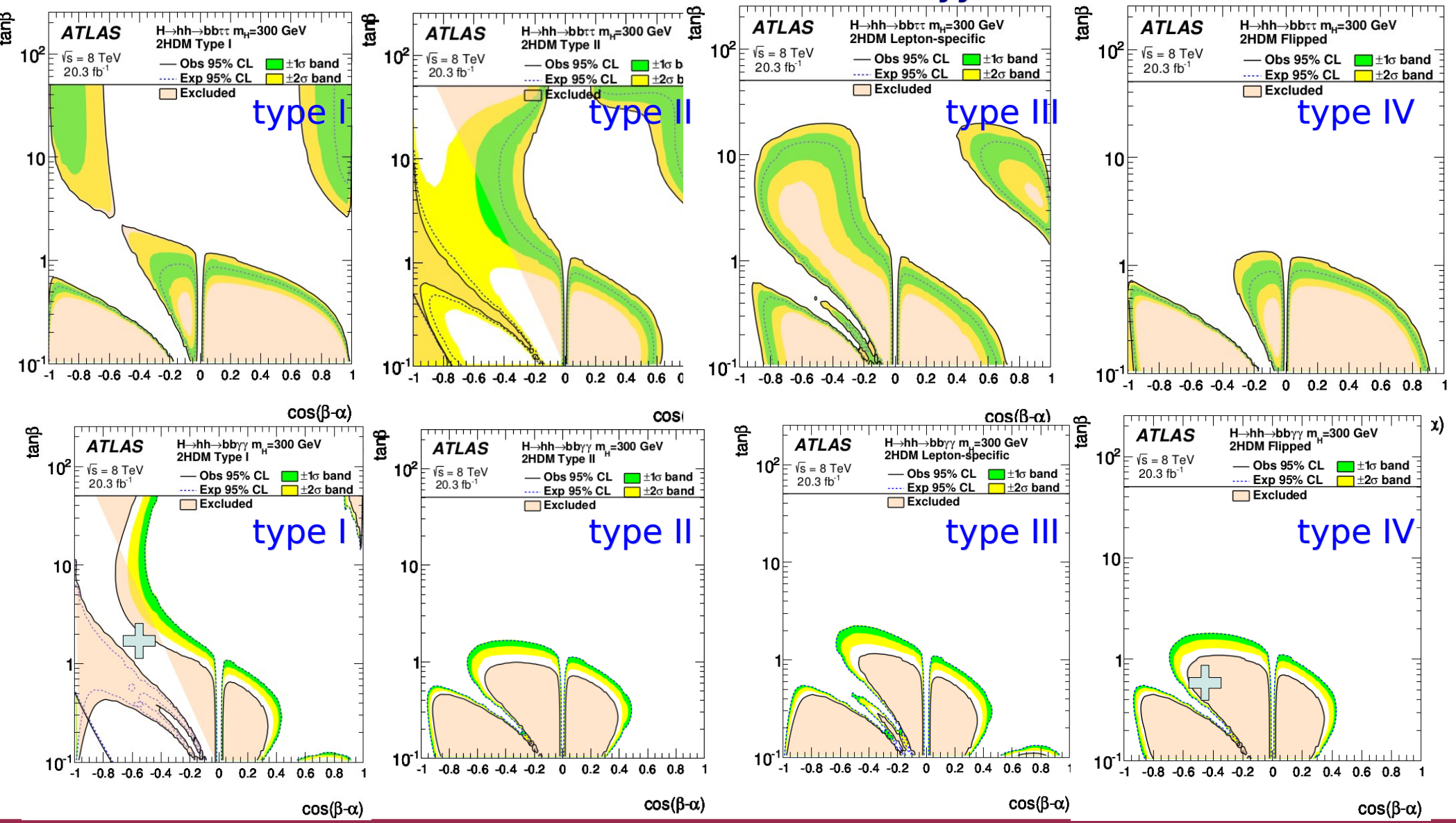

ATLAS
H→hh→bbγγ m_H=300 GeV
2HDM Lepton-specific
√s = 8 TeV
20.3 fb^-1
Obs 95% CL
Exp 95% CL
±1σ band
±2σ band
Excluded
type III
tanβ
cos(β-α)


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


tanβ
cos(β-α)

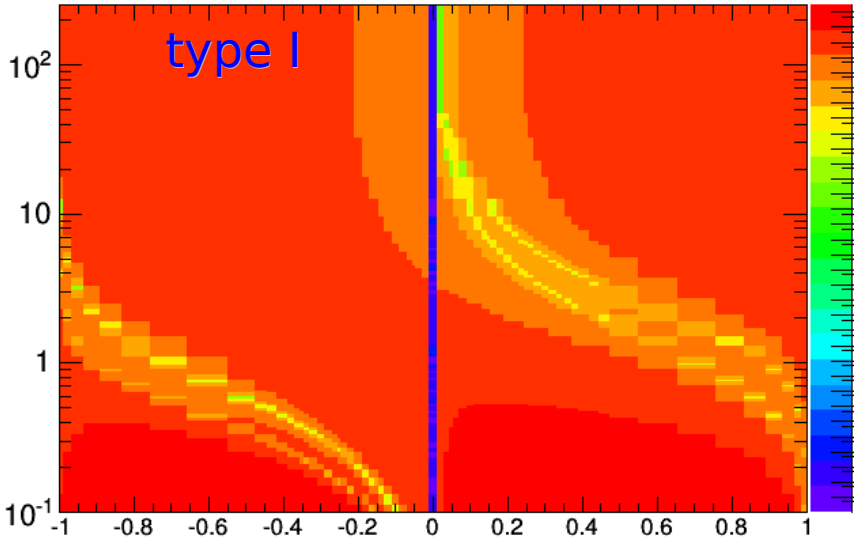
2HDM

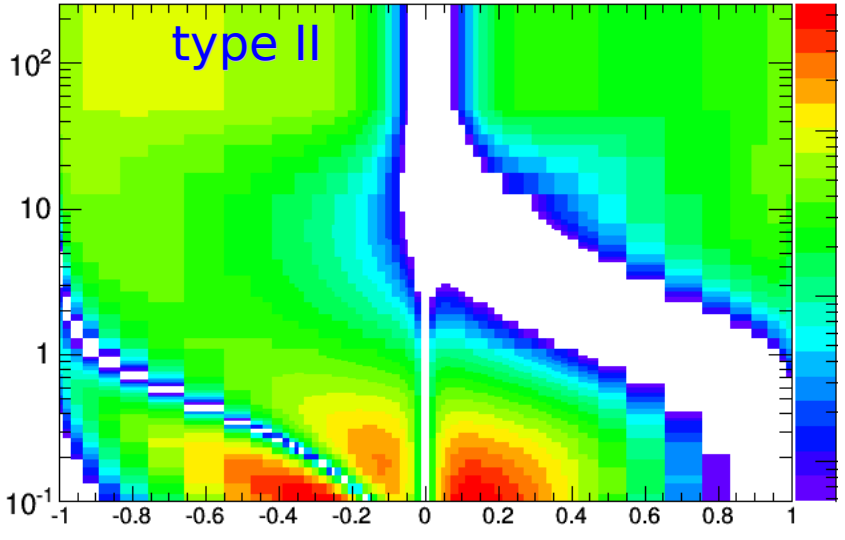
- bbtautau contributes a lot
- **bbtautau covers most of the exclusions from bbyy**

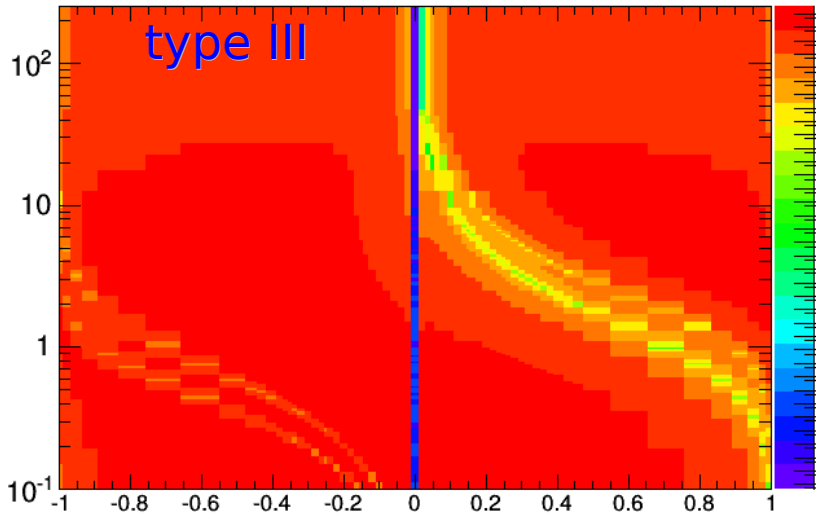


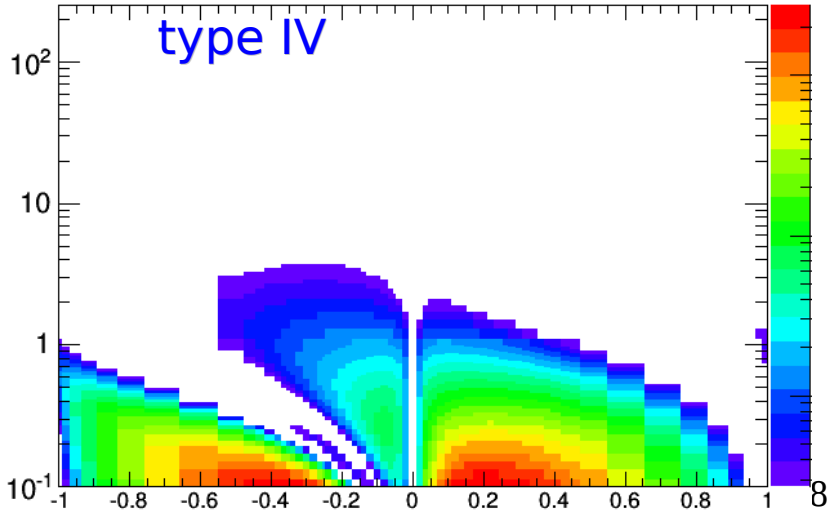
2HDM

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









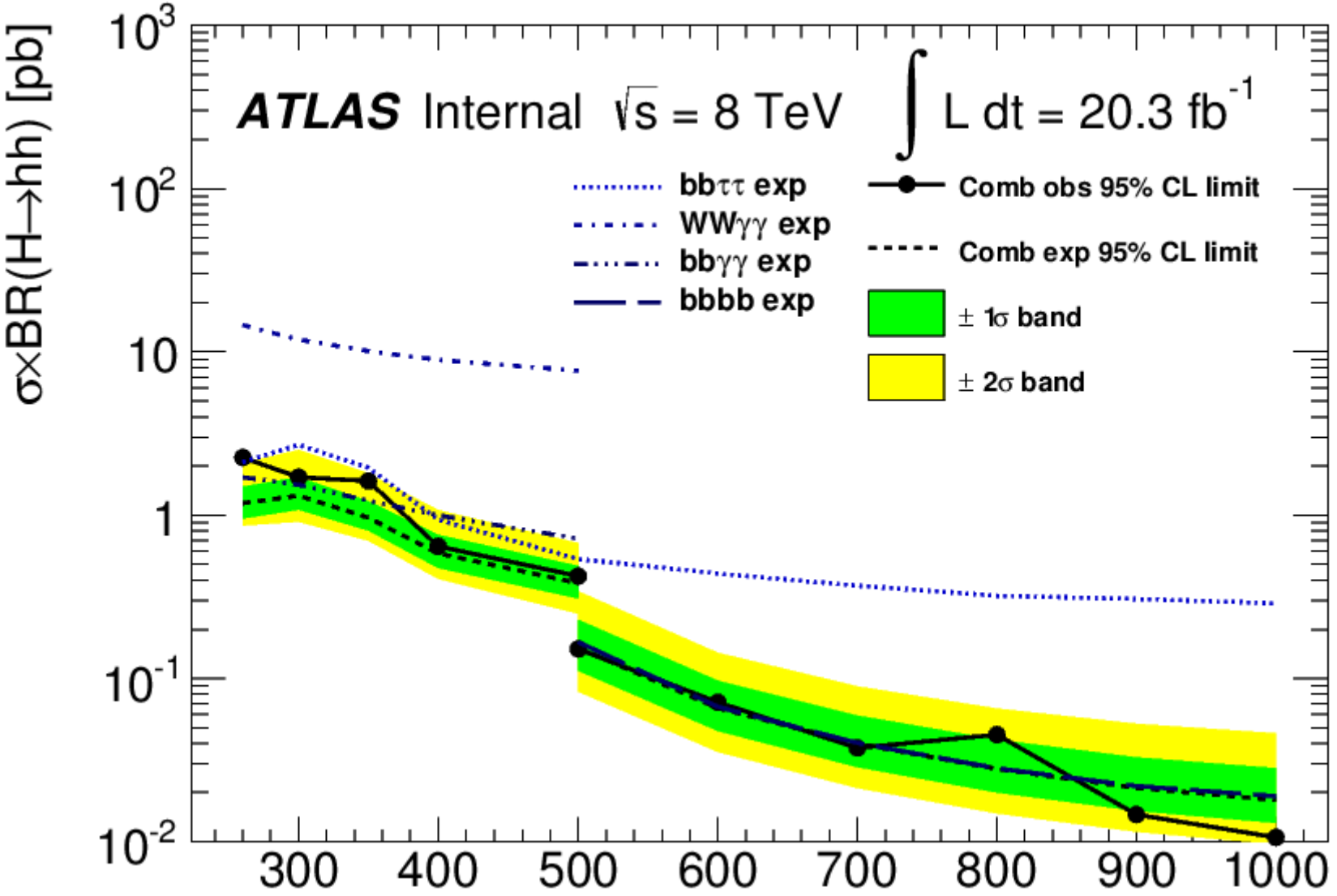
Summary

- interpolation in bbtautau
  - low mass region follow mass points of bbyy
  - high mass region, dominated by bbbb, needed?
- interpolation in wwyy can be simplified into an interpolation of signal efficiency as a function of mass, due to the same bkg estimates independent of mass
- 2HDM
  - 1. overlay exclusions from bbtt and bbyy in transparent style
  - 2. take into account of bbyy exclusions only if width<X%
- All CDS comments up to now have been answered
- a check on non-res limit with all systematics shutdown … ongoing, any idea of switching off nuisance parameters from the workspace level?

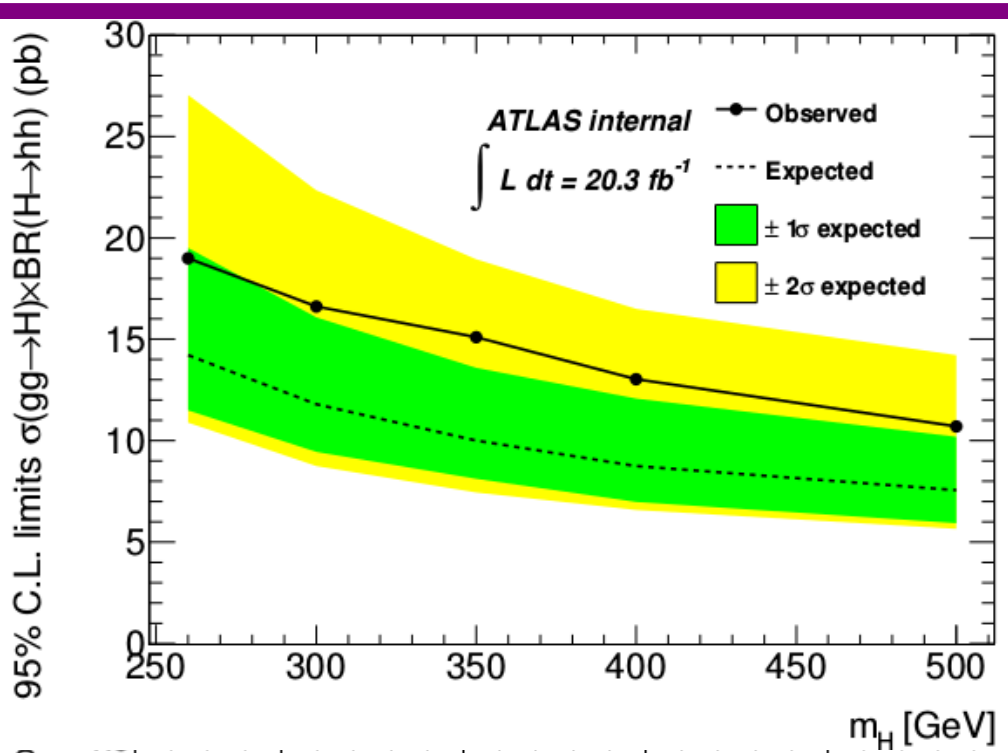
backup

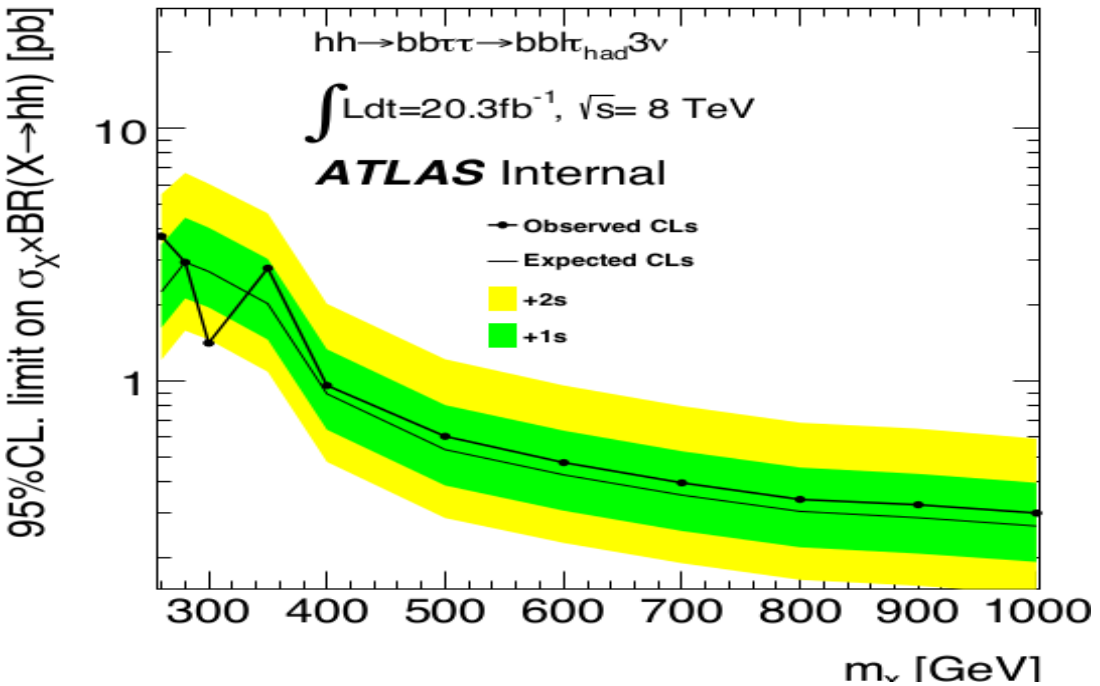
comb observed limits [res]

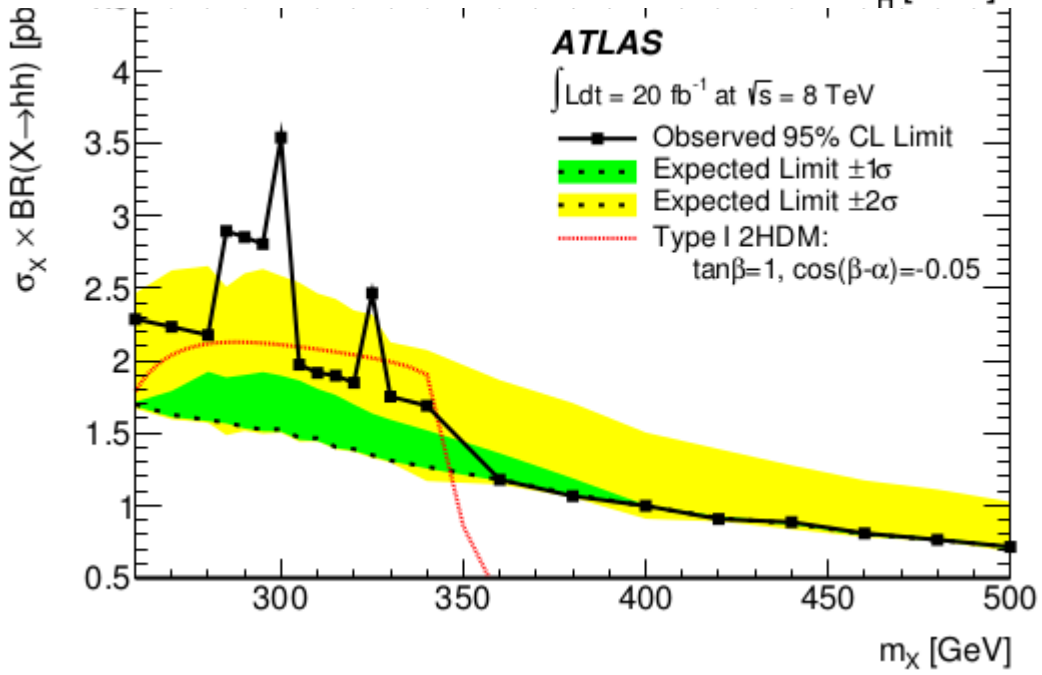
- [260,500] from toys; [500,1000] from asymptotics
- more points **interpolated** in high mass region

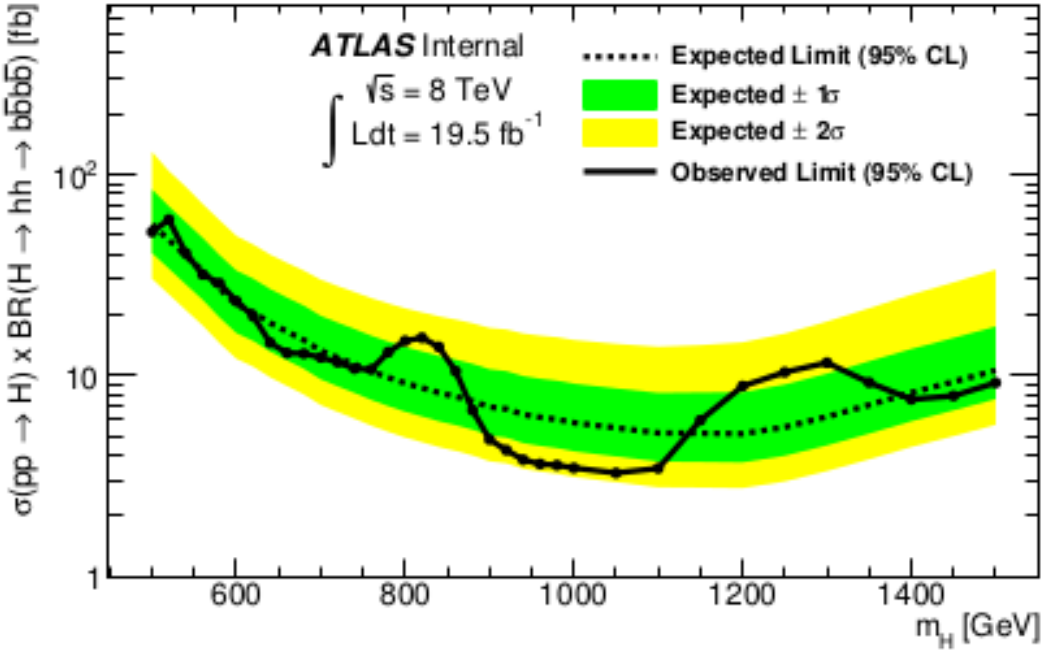


sub-channel limits [res]









comb observed limits [nonres]

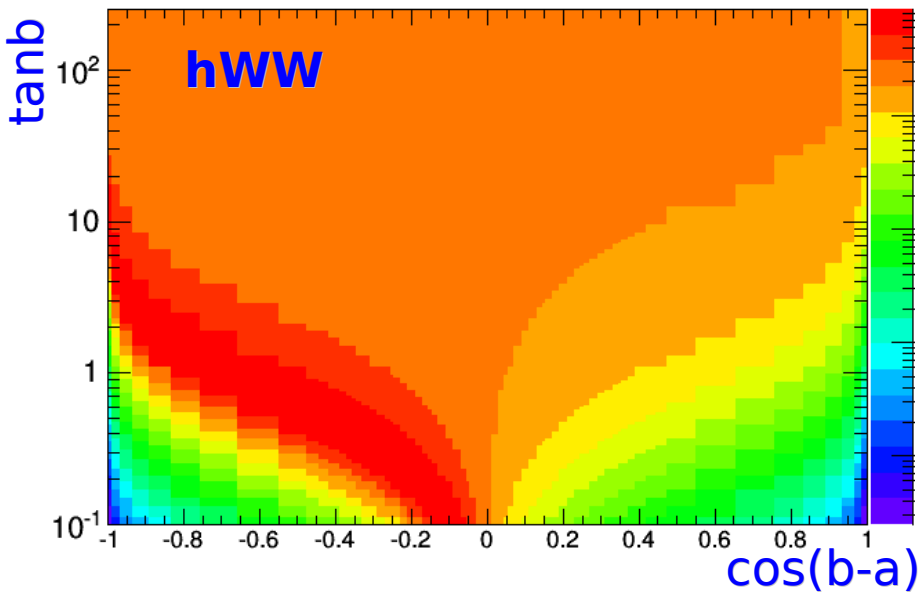
	OBS	EXP	+2sig	+1sig	-1sig	-2sig
bbbb	0.59388	0.59457	1.22329	0.85430	0.42842	0.31912
bbyy	2.20000	1.00546	2.39049	1.52719	0.72449	0.53966
wwyy	12.6259	8.81794	16.297	11.9078	7.10667	6.70651
bbττ	1.29582	1.53934	3.32687	2.26839	1.10918	0.82620
combine	0.69188	0.47370	0.93053	0.66888	0.34834	0.27022

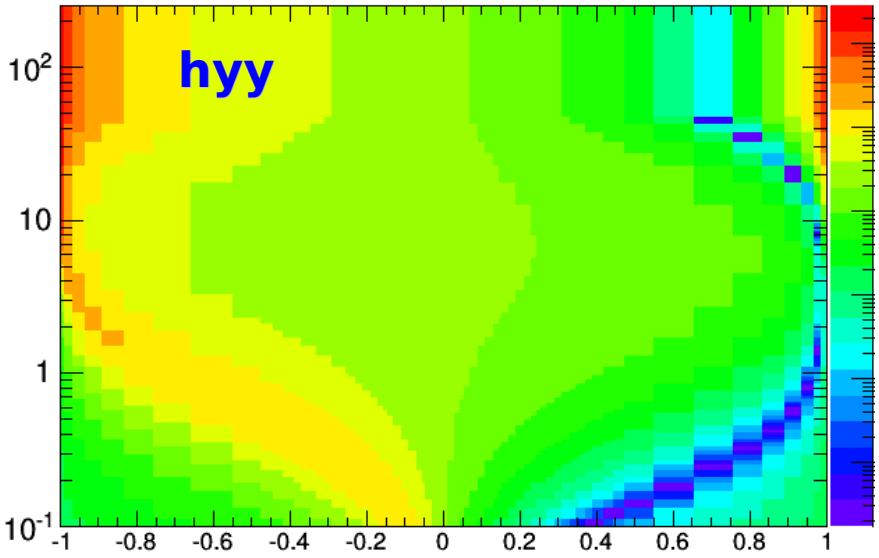
Hhh interpretation

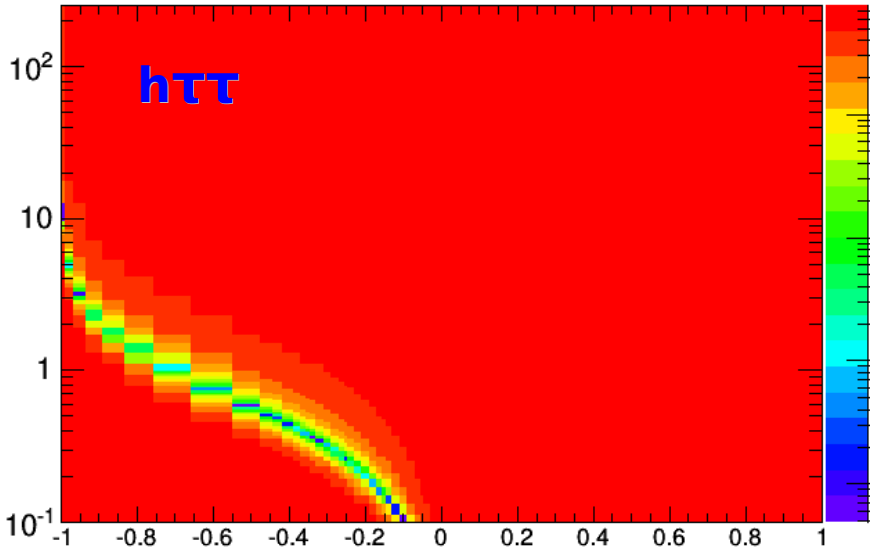
- 4 channels are included
  - res-low-mass: bbyy,bbττ,wwyy ~ for example 300GeV
  - res-high-mass: bbbb,bbττ
- open discussion

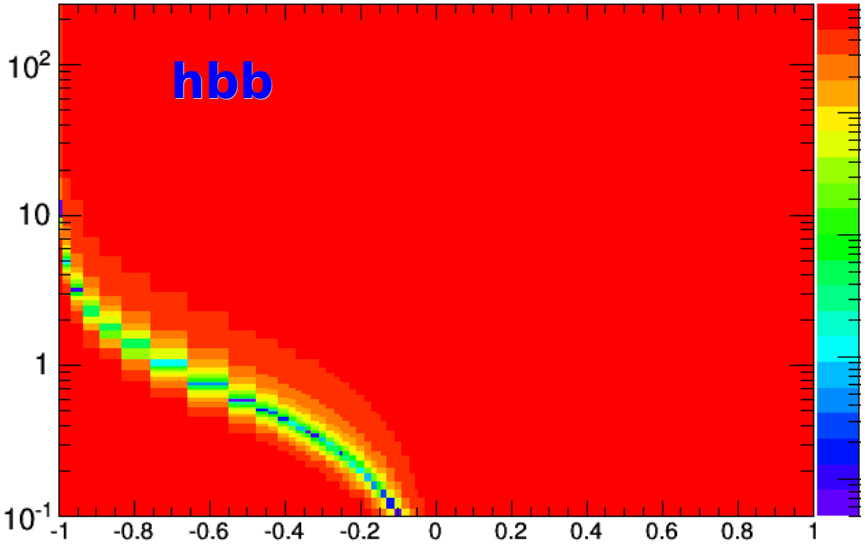
	Type I	Type II	Type III	Type IV
ξ_h^V	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$	$\sin(\beta-\alpha)$
ξ_h^u	$\frac{\cos\alpha}{\sin\beta}$	$\frac{\cos\alpha}{\sin\beta}$	$\frac{\cos\alpha}{\sin\beta}$	$\frac{\cos\alpha}{\sin\beta}$
ξ_h^d	$\frac{\cos\alpha}{\sin\beta}$	$-\frac{\sin\alpha}{\cos\beta}$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

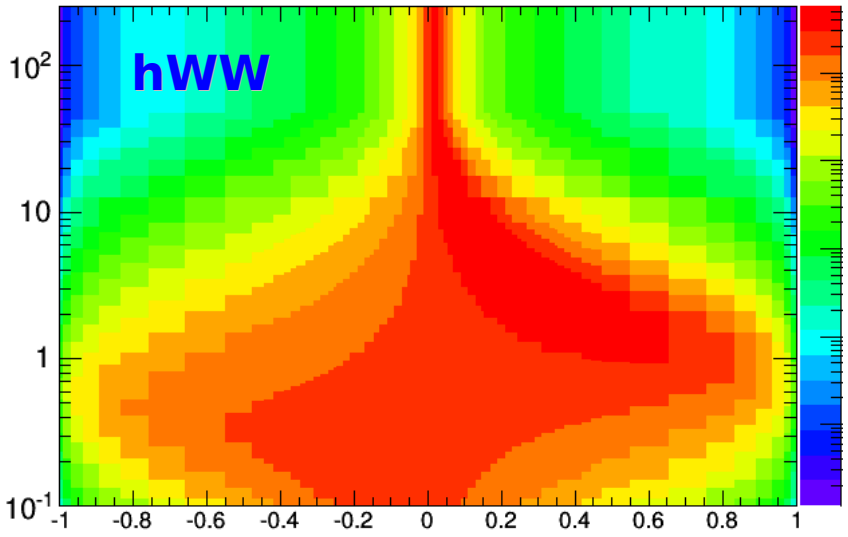


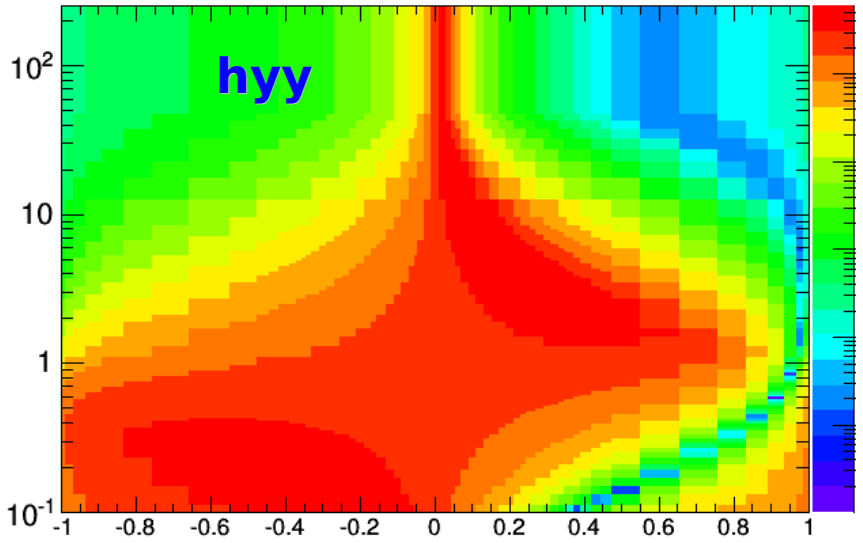


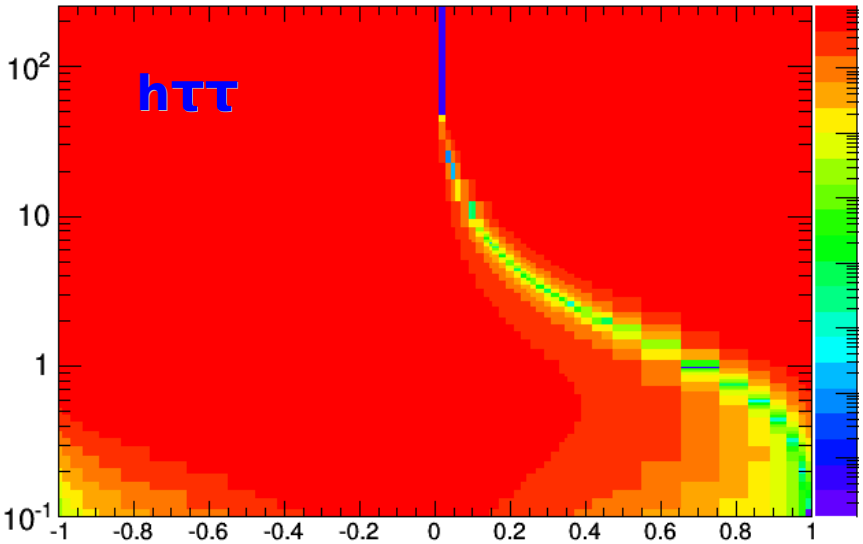


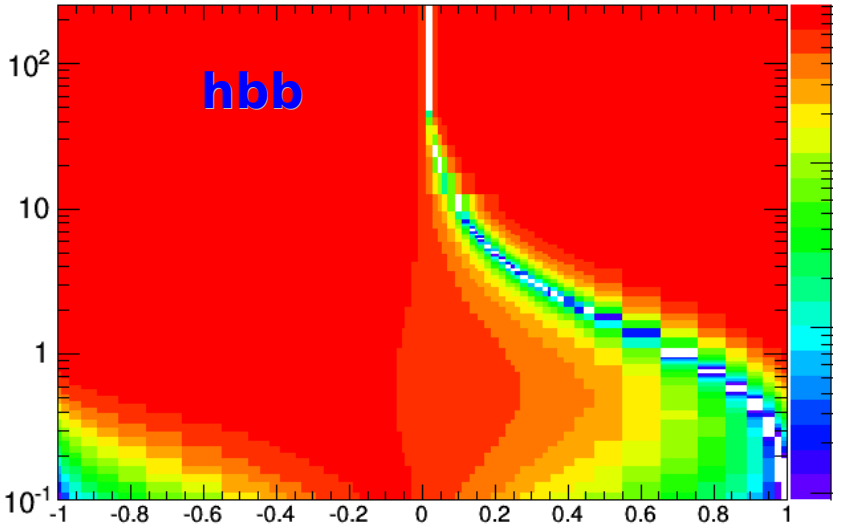


2HDM type II @ mH = 300 GeV

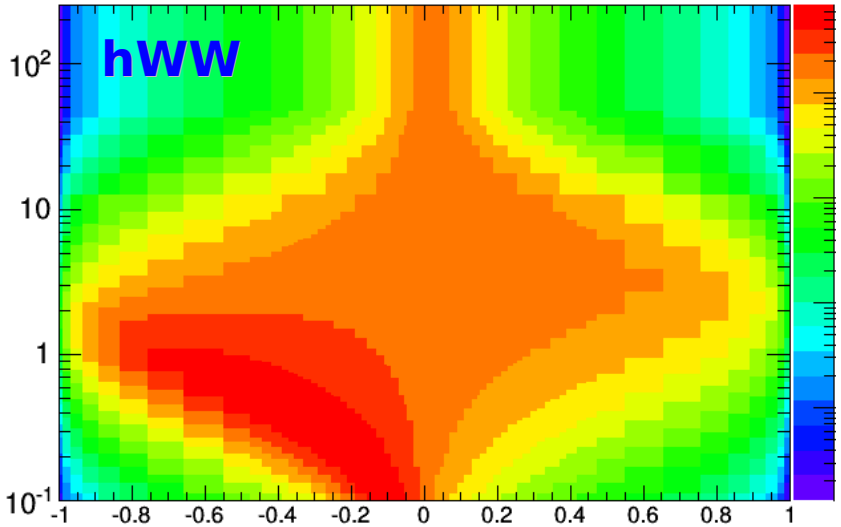


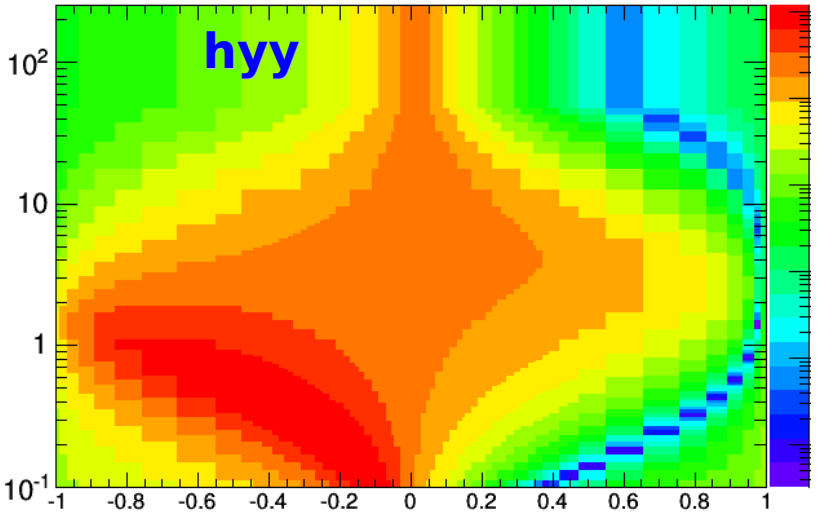


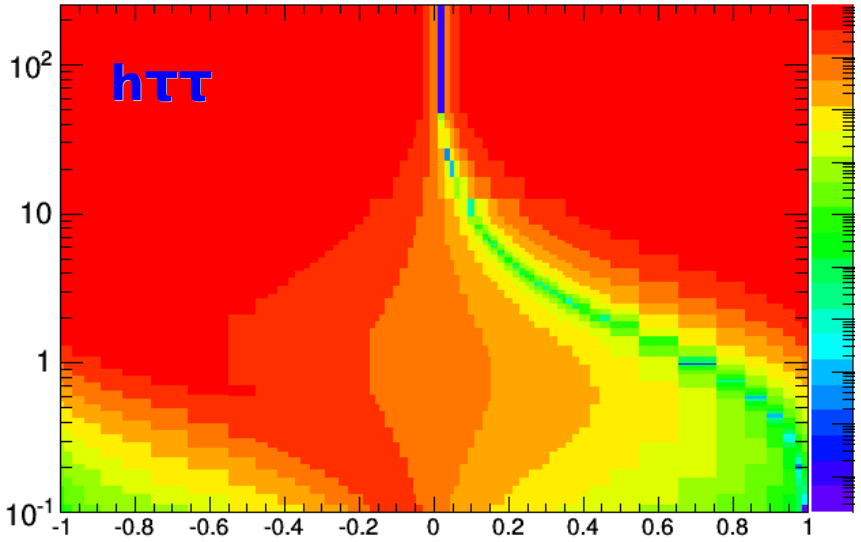


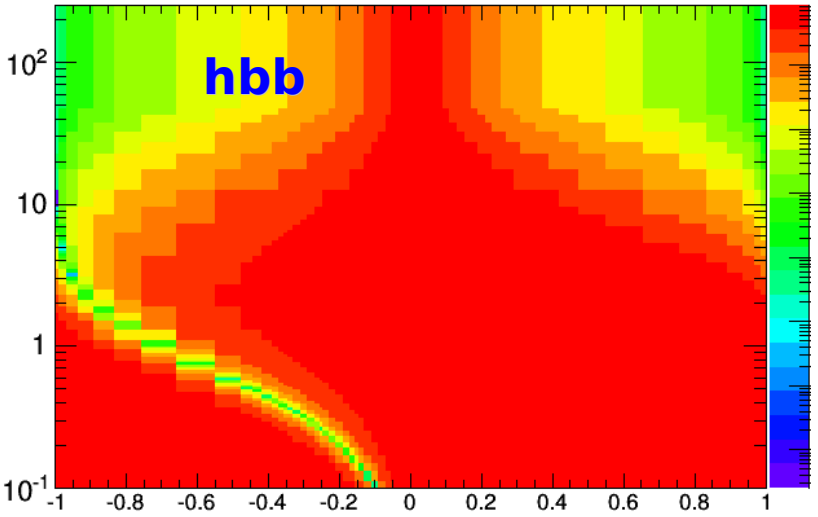


2HDM type III @ mH = 300 GeV

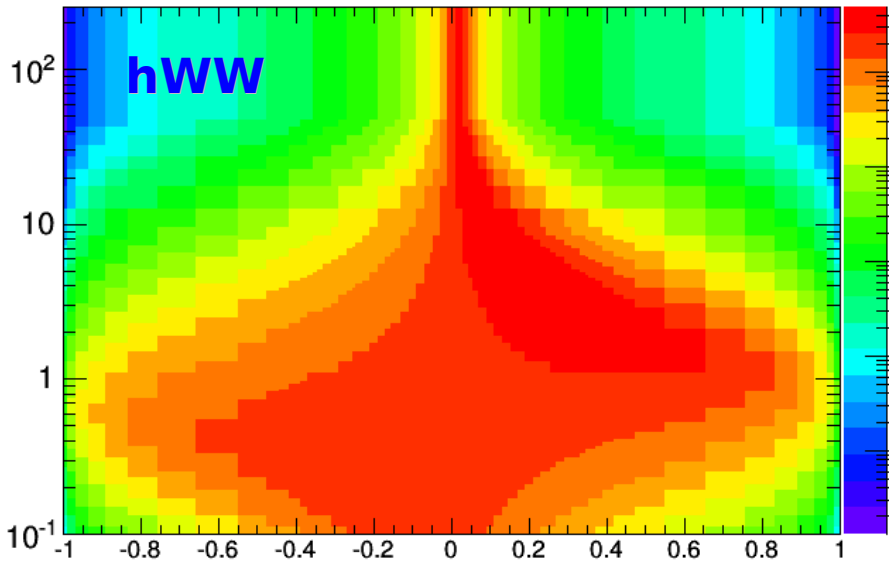


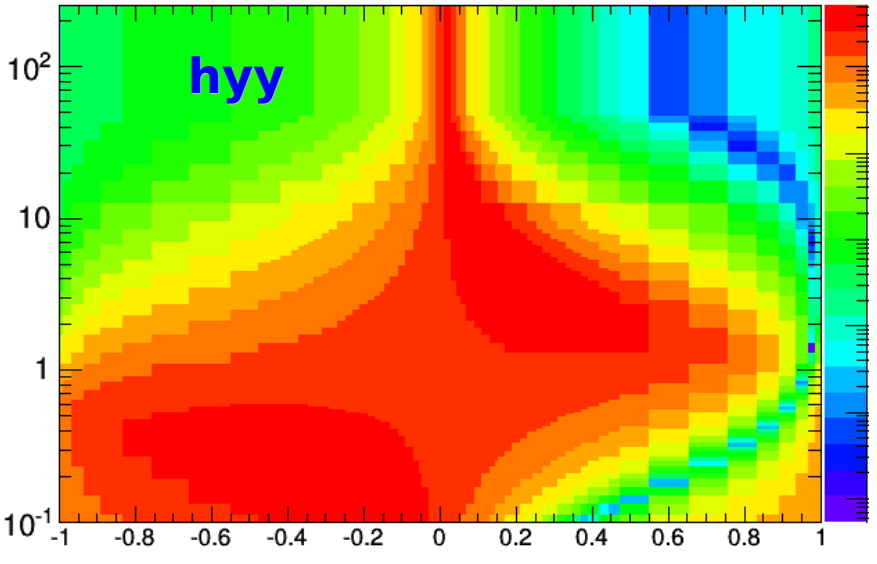


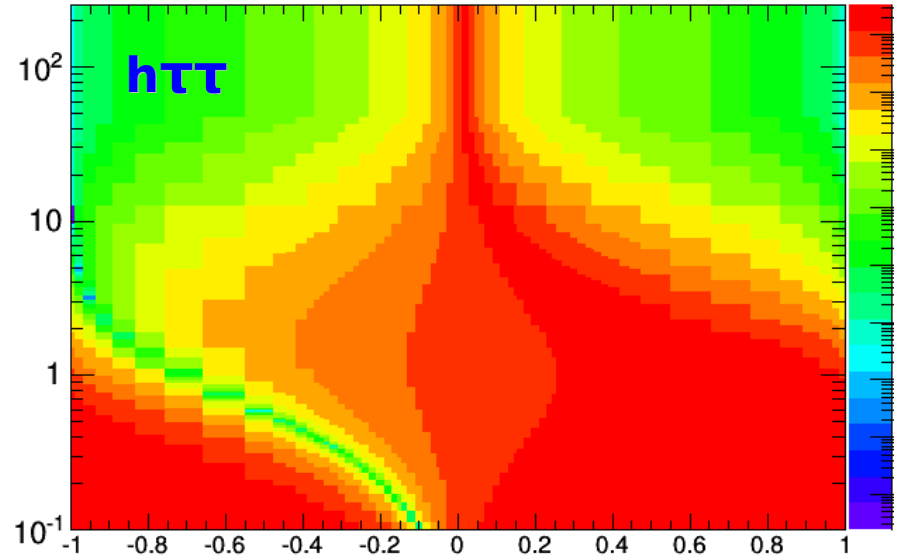


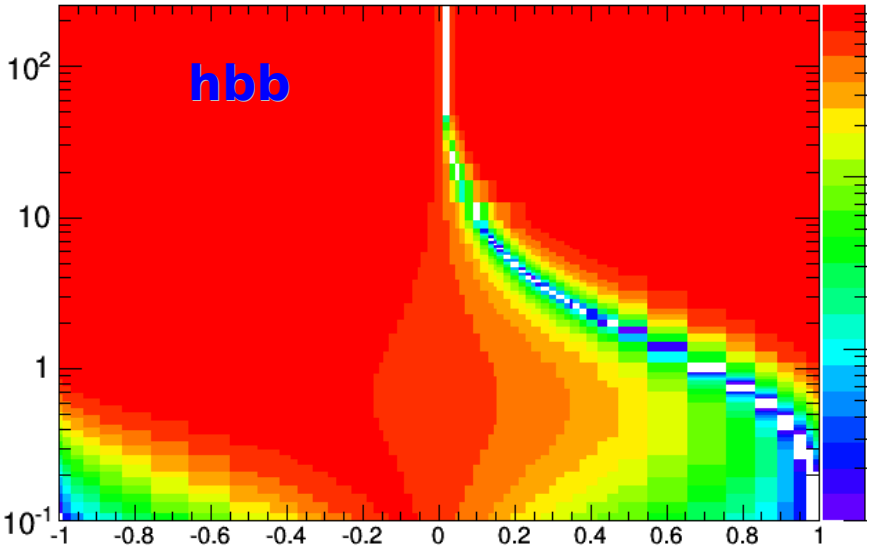


2HDM type IV @ mH = 300 GeV

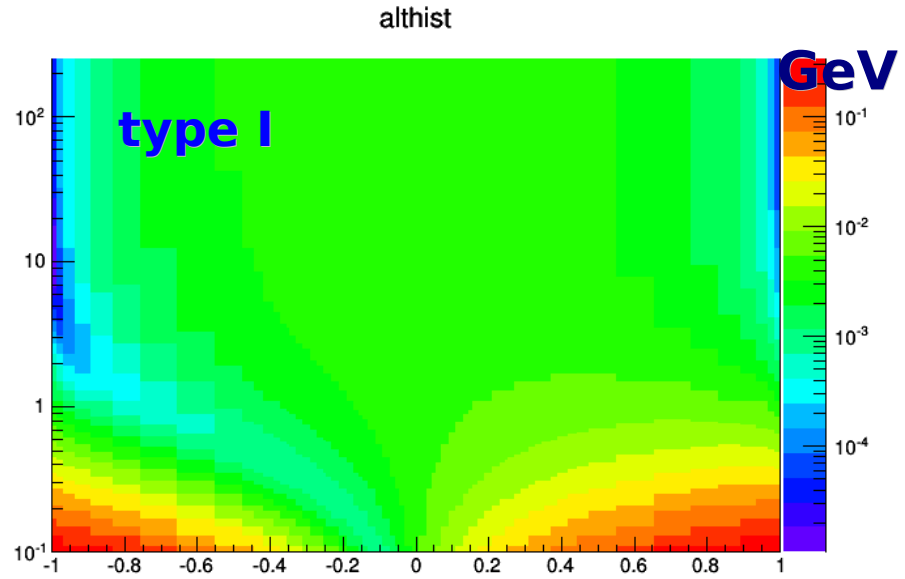


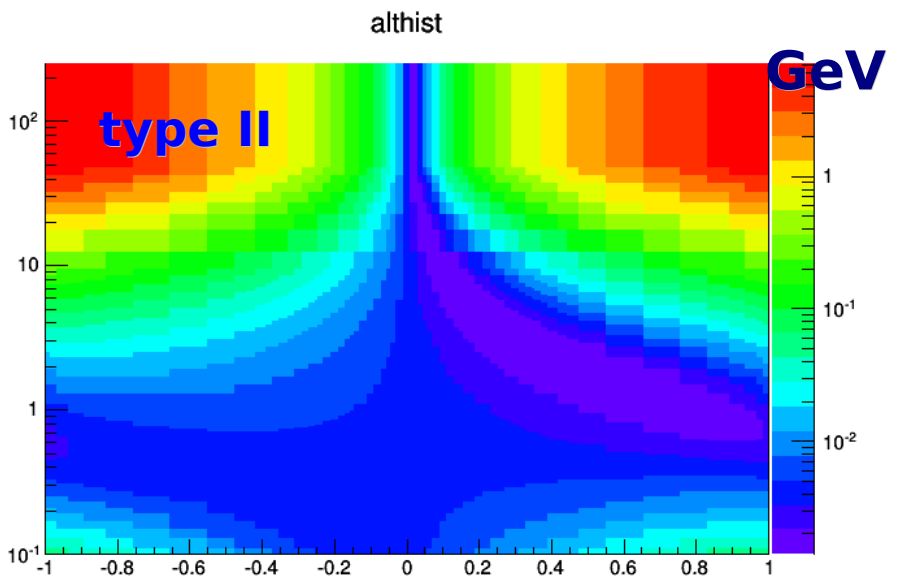


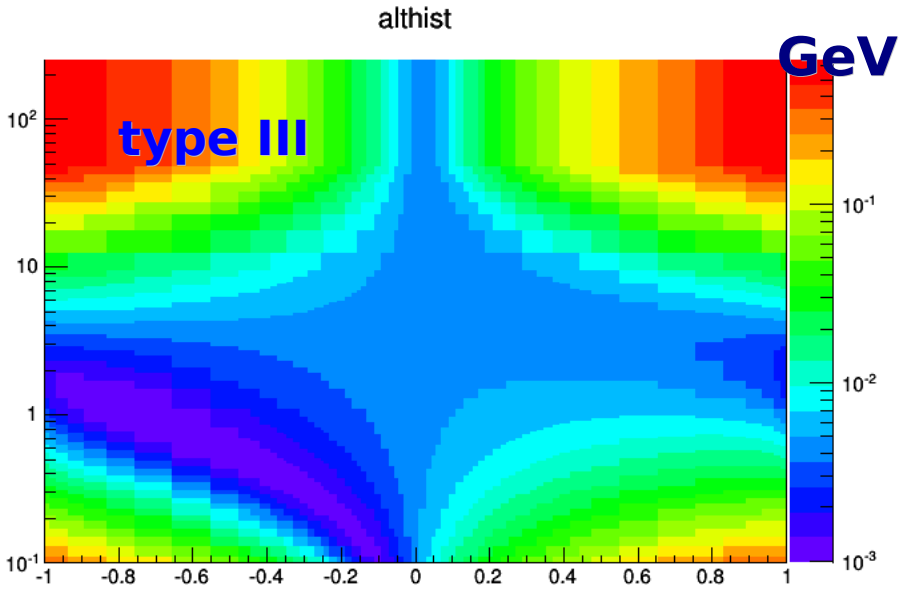


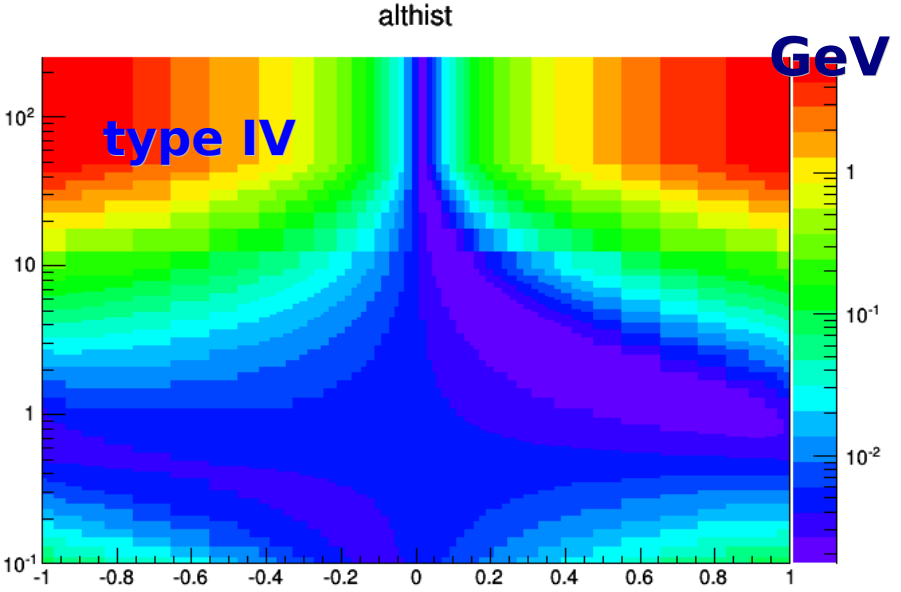


2HDM witdh_**h** @ mH = 300 GeV

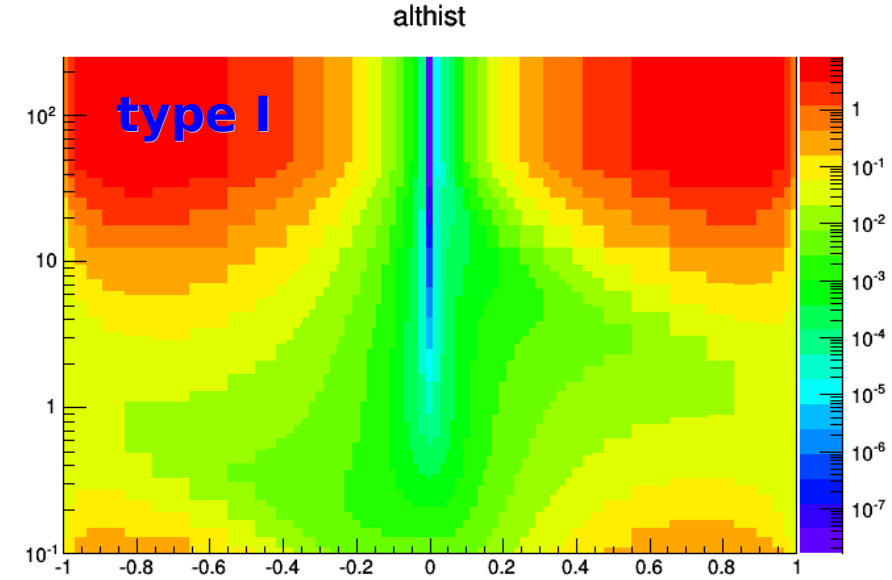


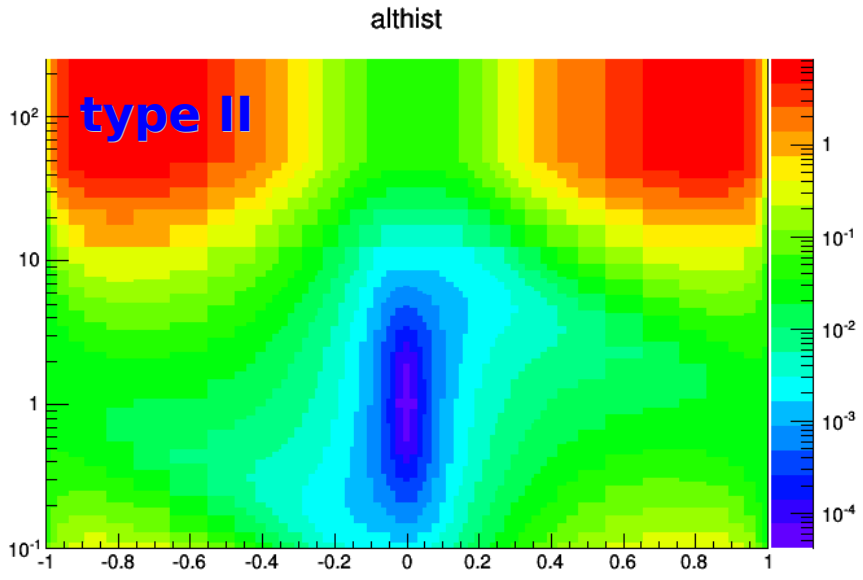


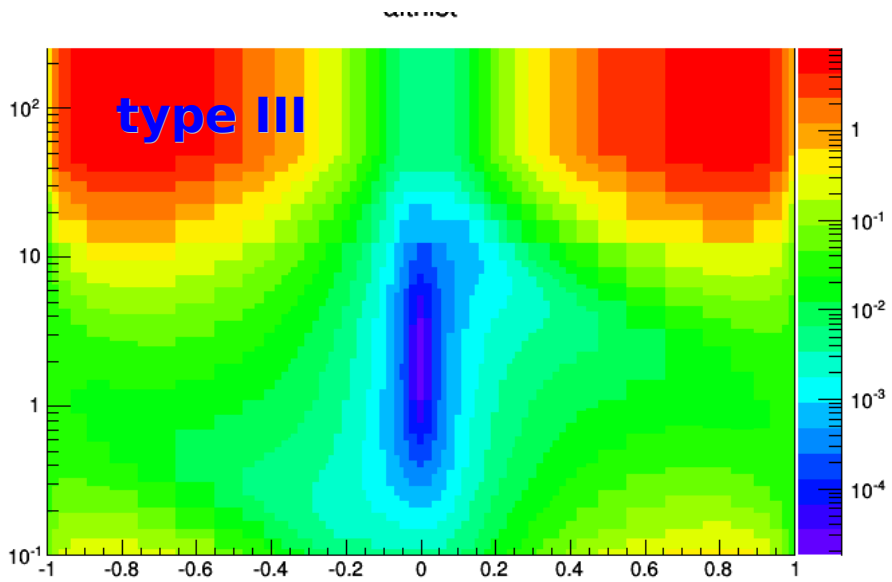


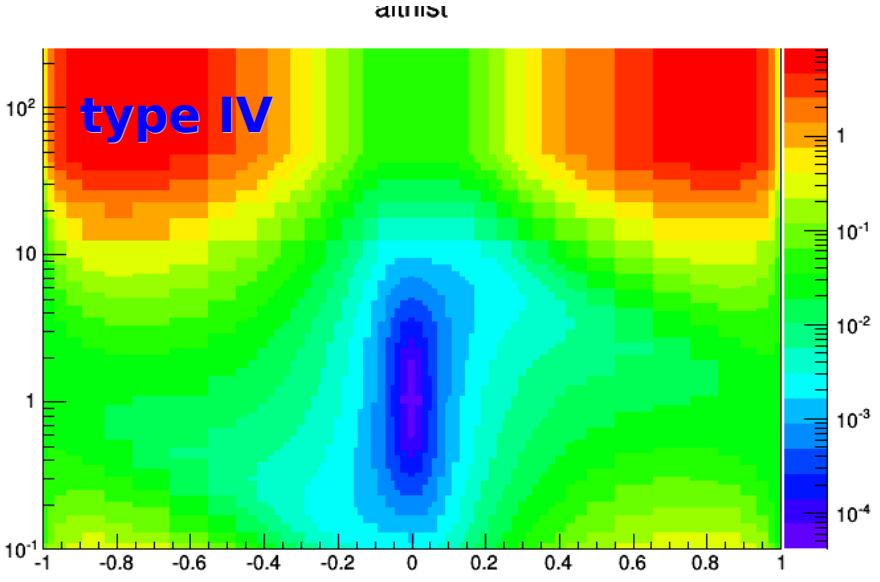


2HDM **witdh_H / mH** @ 300 GeV

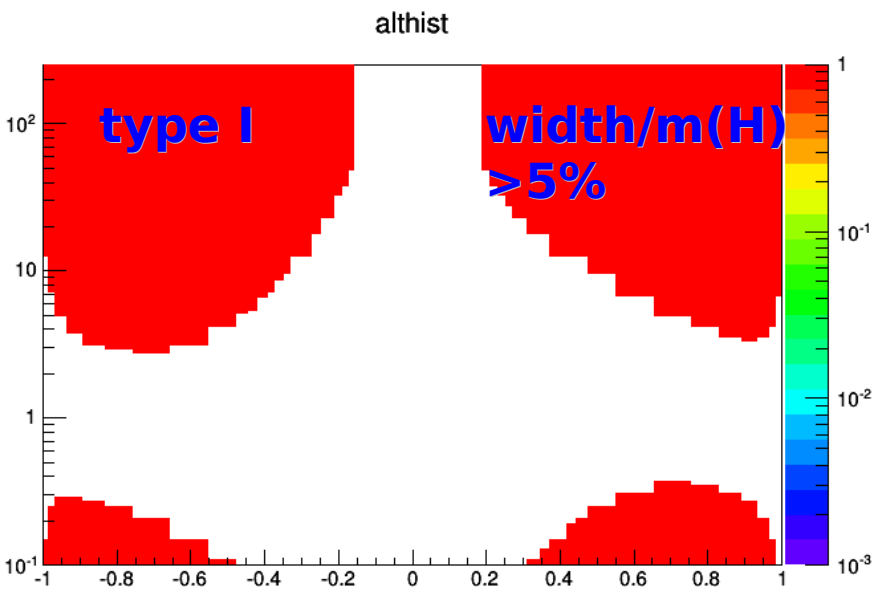


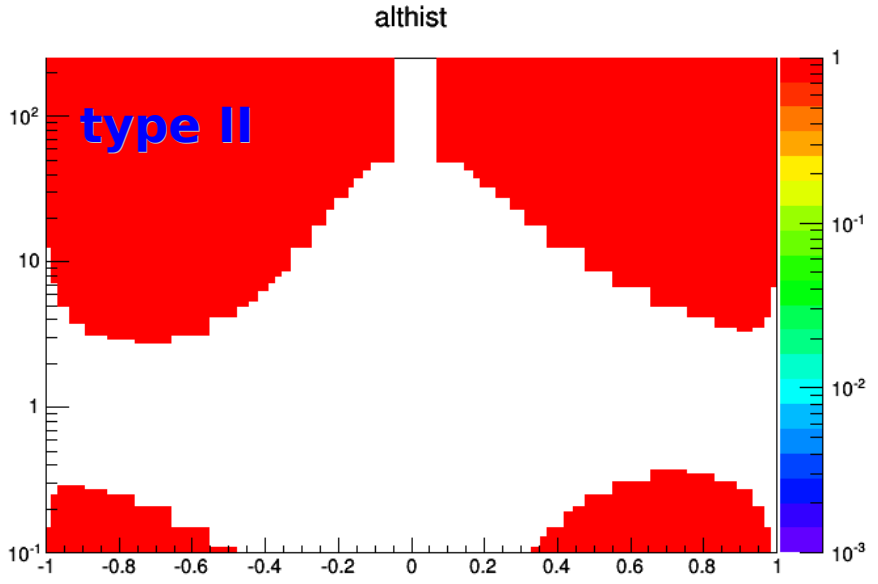


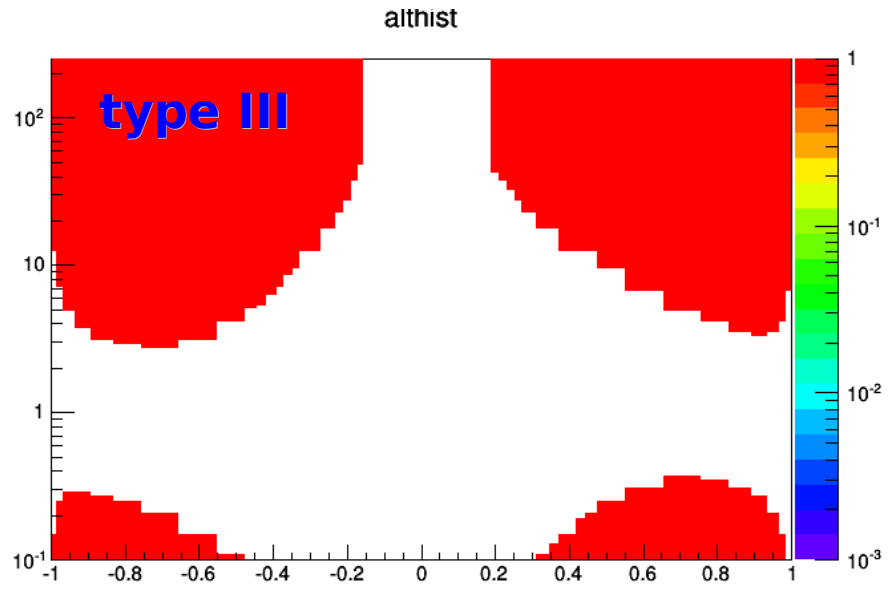


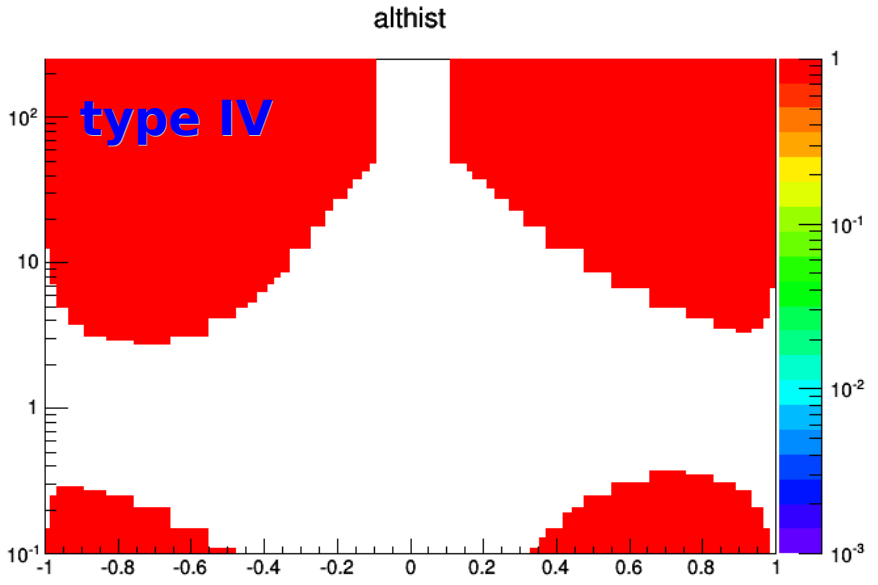


2HDM witdh_**H** / mH @ mH = 300 GeV



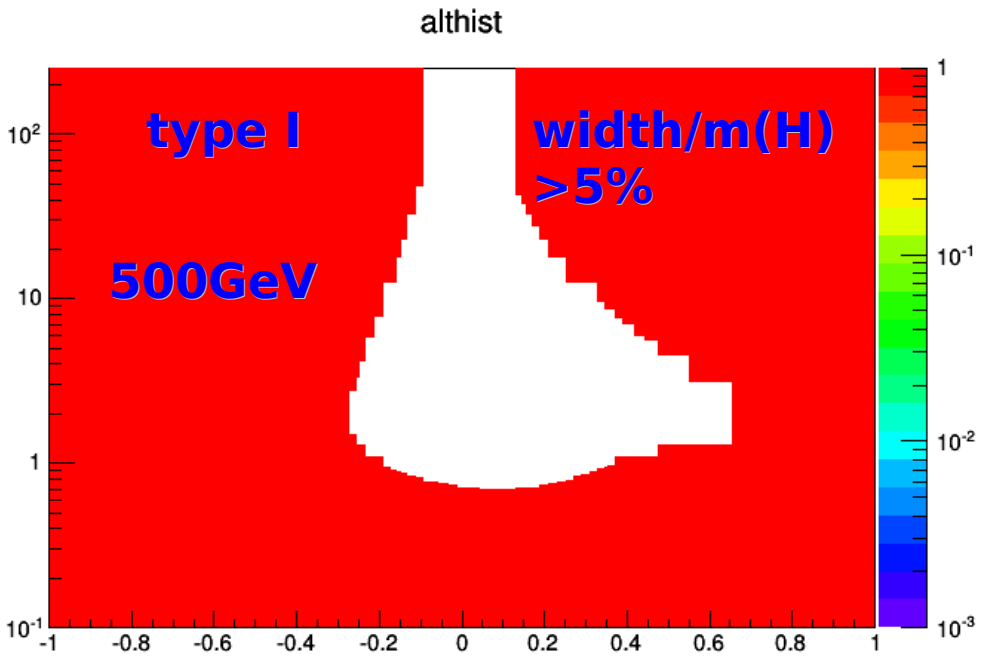


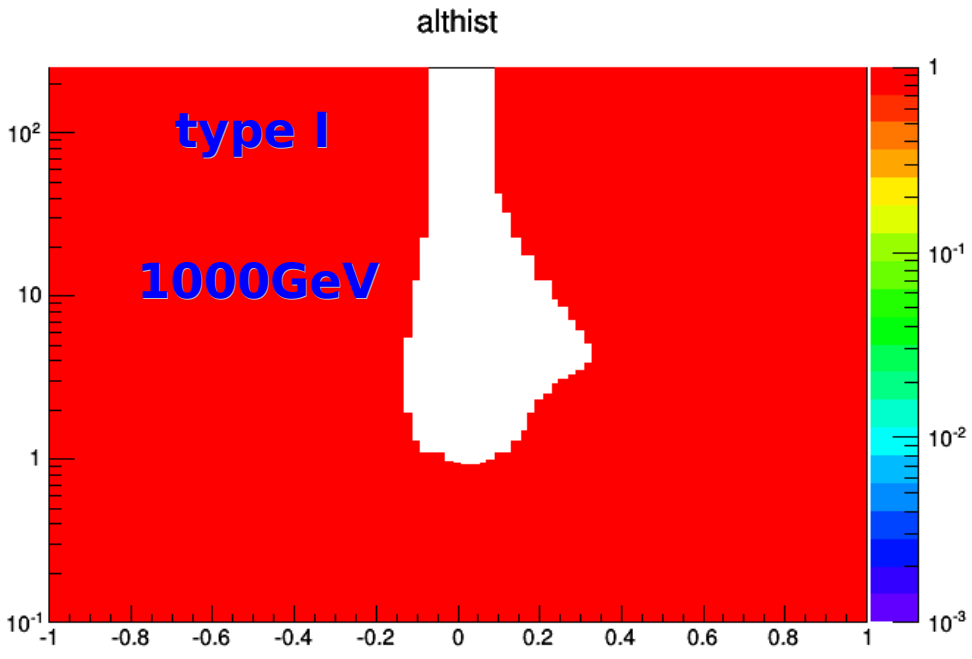




in general, width effect should be considered more than AZh case

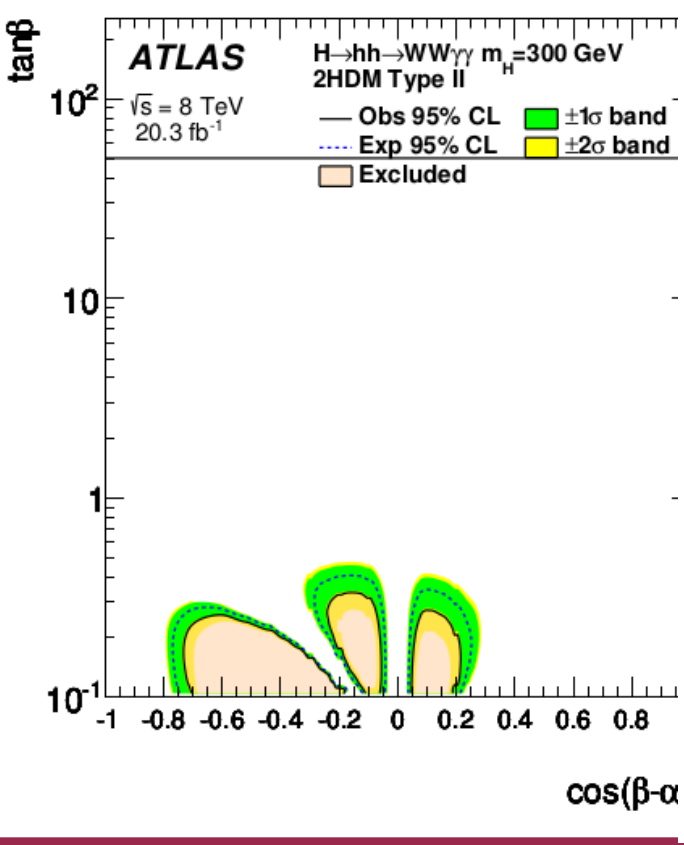
2HDM witdh_**H** / mH @ higher mH

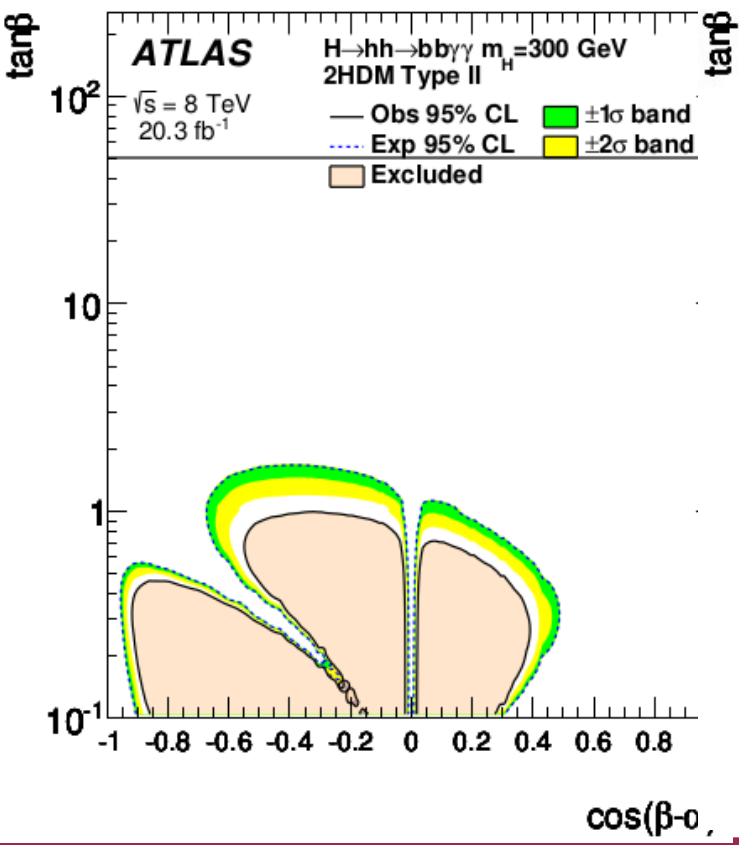


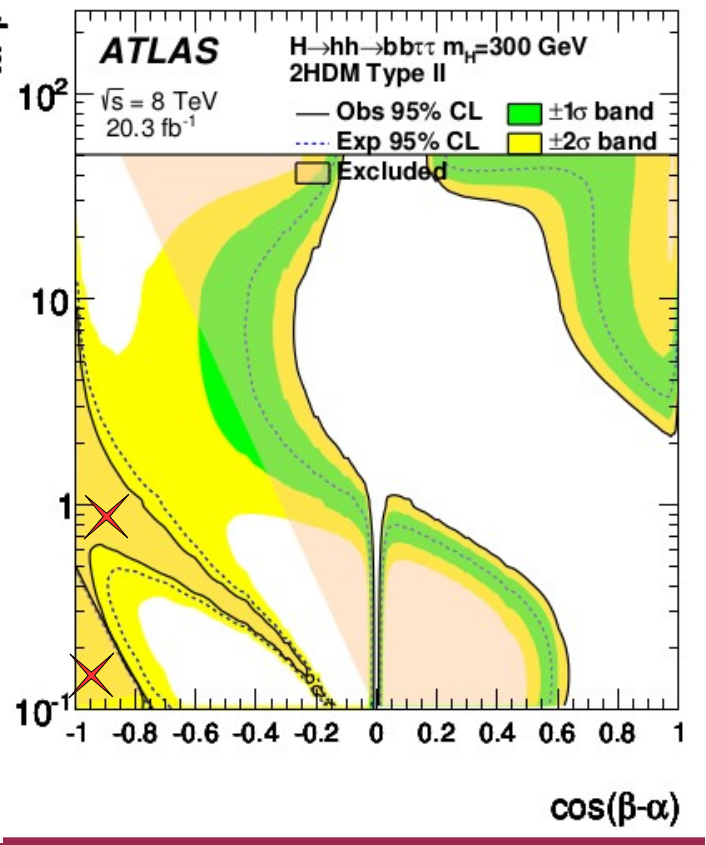


Looking at subchannel 2HDM exclusion

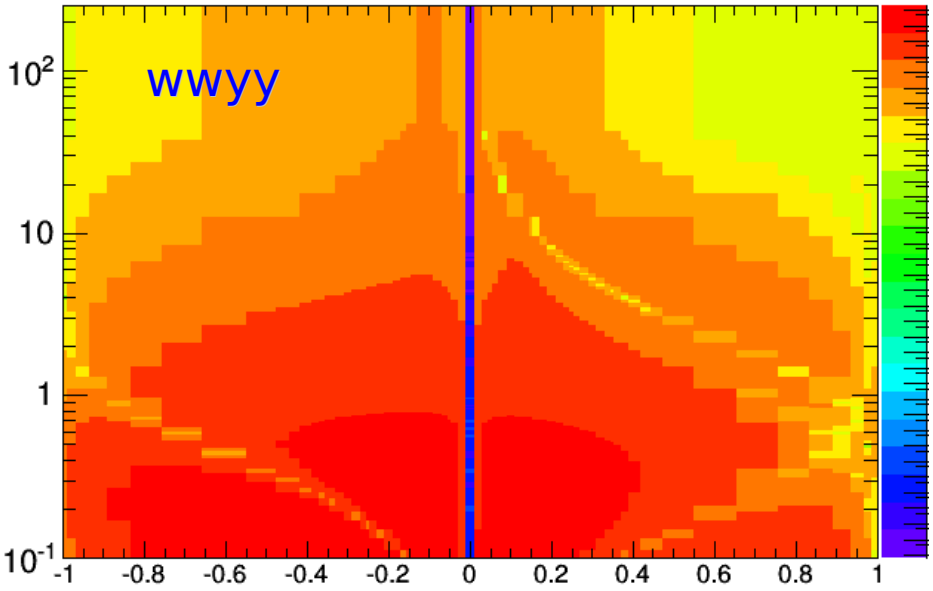
- Too many coupling, not easy to do parameterization for comb limits, Carl proposed to exclude with the most powerful limit at each point == overlay limits from all ch
- make 2HDM type II exclusion @ 300GeV wwyy / bbyy / bbtautau
- tanb should be larger than 0.5 (theo stability, we did it in Azh)
  -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

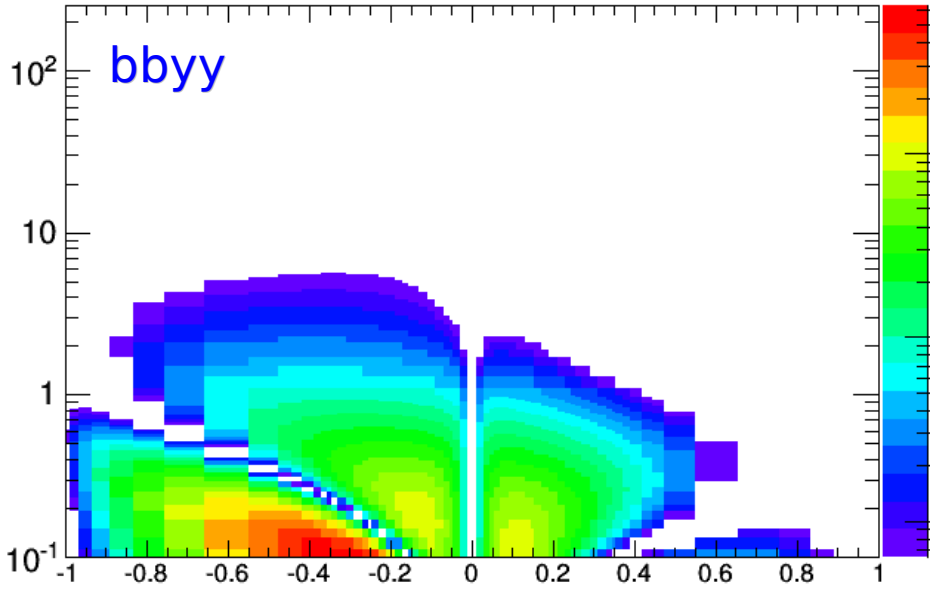


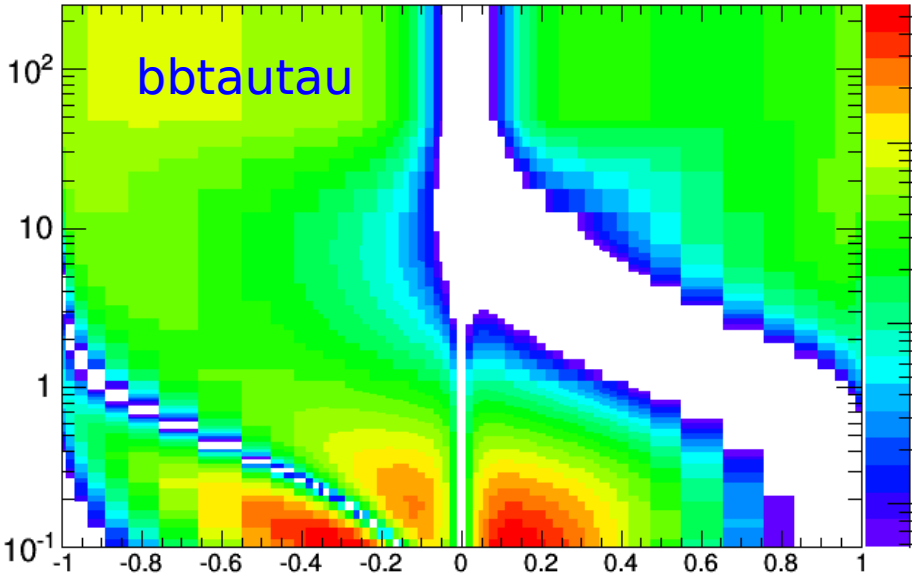




Check subchannel 2HDM xsbr contours

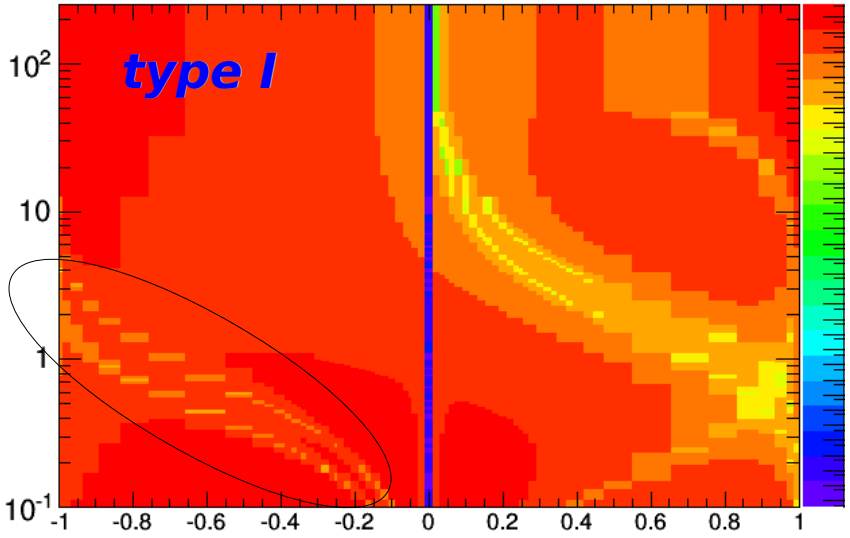


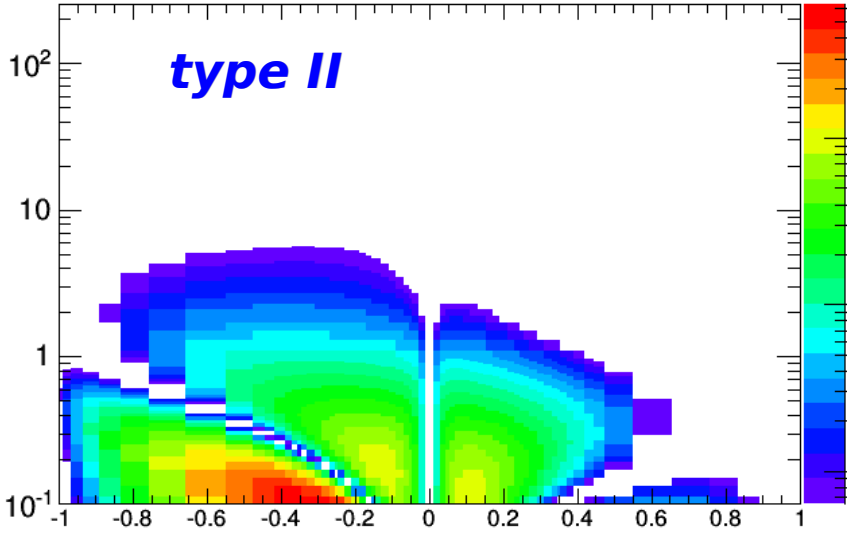


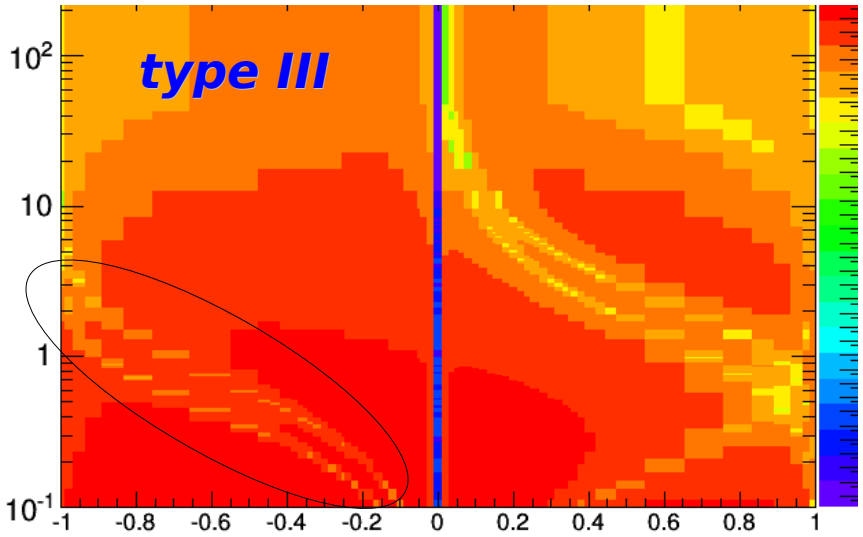


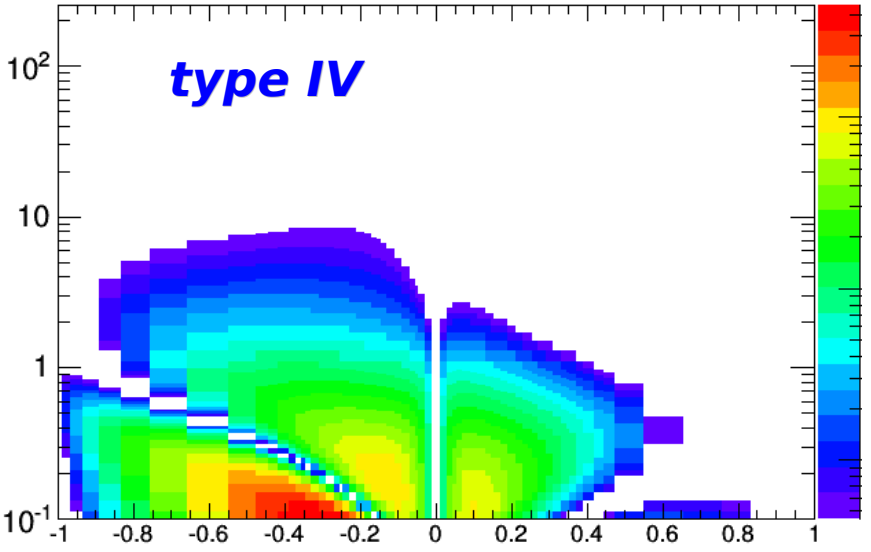
2HDM

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









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