HH pair searches

combination with wwγγ, bbγγ, bbττ, bbbb

Xiaohu SUN

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26-05-2015

IHEP

CDS entry

[wwγγ]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/

Theoretical uncertainties

- Theoretical uncertainties estimated with variations on PDF/scale/radiation are being reproduced with a larger number of events
- Procedures are not changed since last time
- Now we produced **1.2M** events -> 10 times of the the statistics of last time, since the beginning of this week
- /afs/cern.ch/work/x/xiaohu/public/HH-TheoUncer/

* all follows instructions from Paul T as used in AZh

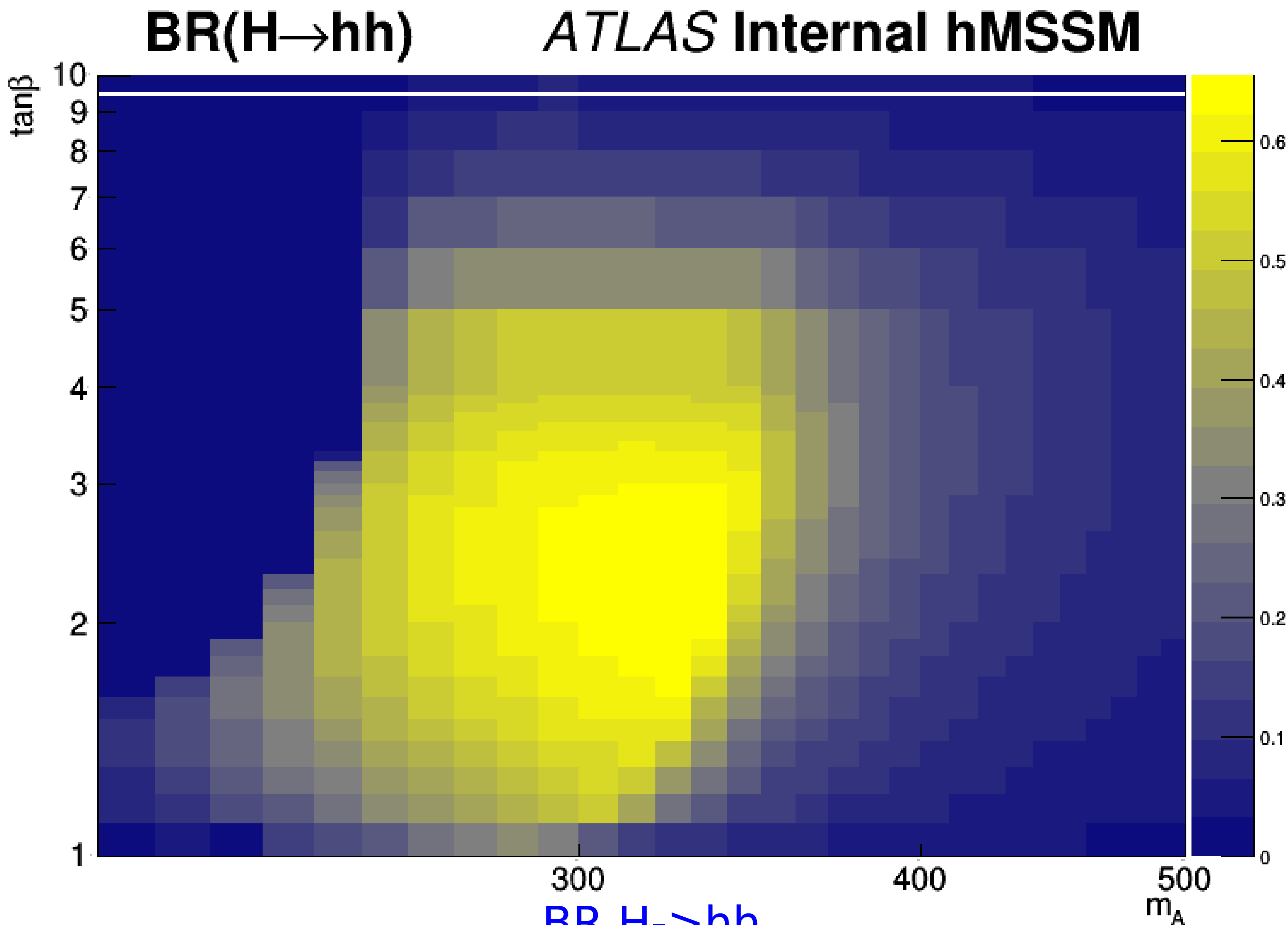
Systematic uncertainties

- produce grouped systematic uncertainties with the script pointed by Carl

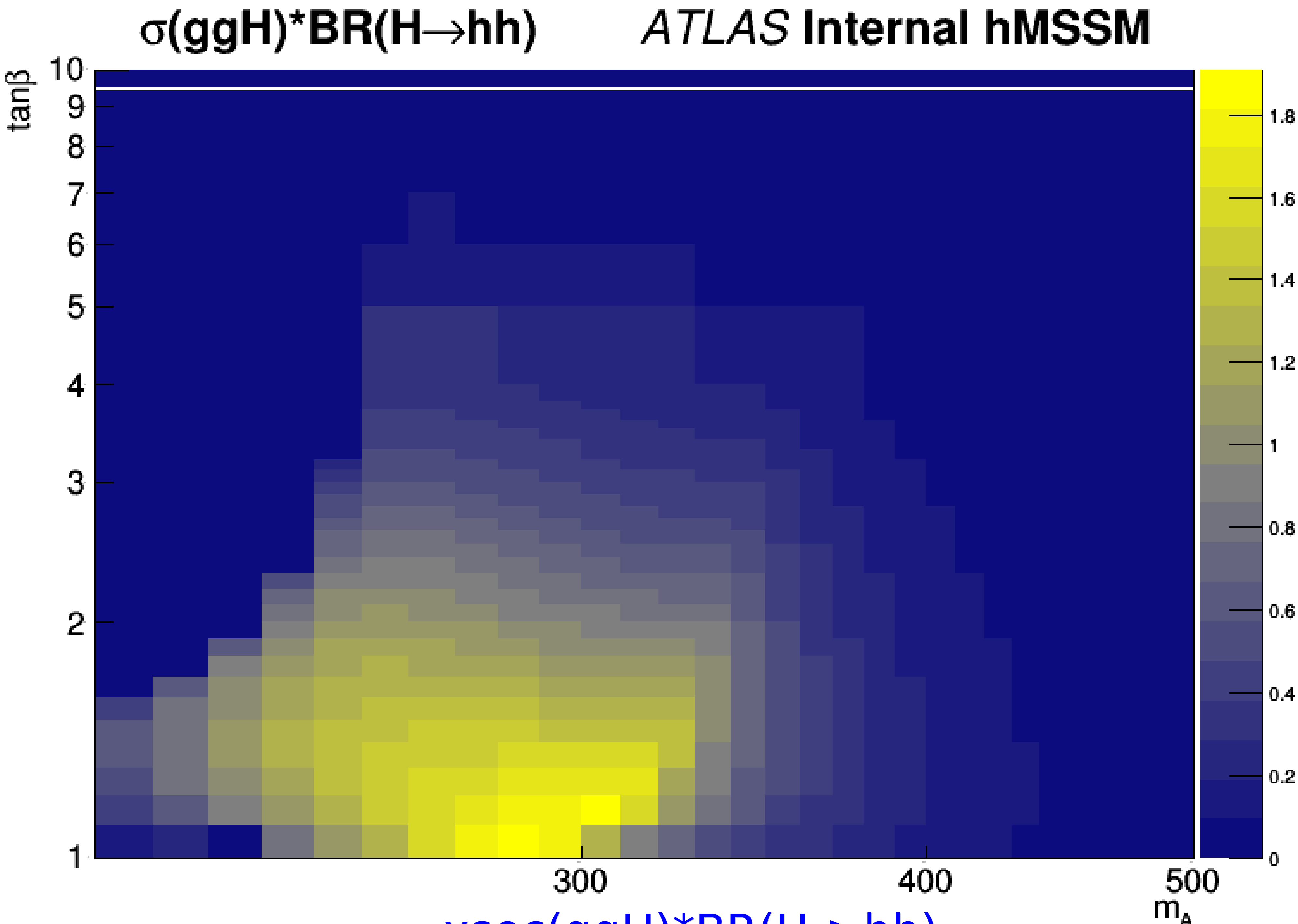
```
 Set of nuisance          Impact on error
      parameters
----------------------------------------------------------
            Total   +  0.671   -   0.454
         DataStat   +  0.603   -   0.431
         FullSyst   +  0.294   -   0.143
             Jets   +  0.130   -   0.059
    Signal theory   +  0.107   -   0.039
          Leptons   +  0.053   -   0.028
             Lumi   +  0.037   -   0.013
        Btagging   +  0.035   -   0.015
          Photons   +  0.026   -   0.008
              MET   +  0.019   -   0.009
----------------------------------------------------------
```

hMSSM Interpretation

- Many thanks to Nikos and Allison, we have **another new map file** for hMSSM this week
- the strangely small BR_H_hh is fixed


BR(H→hh)
ATLAS Internal hMSSM
tanβ
10
9
8
7
6
5
4
3
2
1
300
400
500
m_A
0.6
0.5
0.4
0.3
0.2
0.1
0

BR H->hh

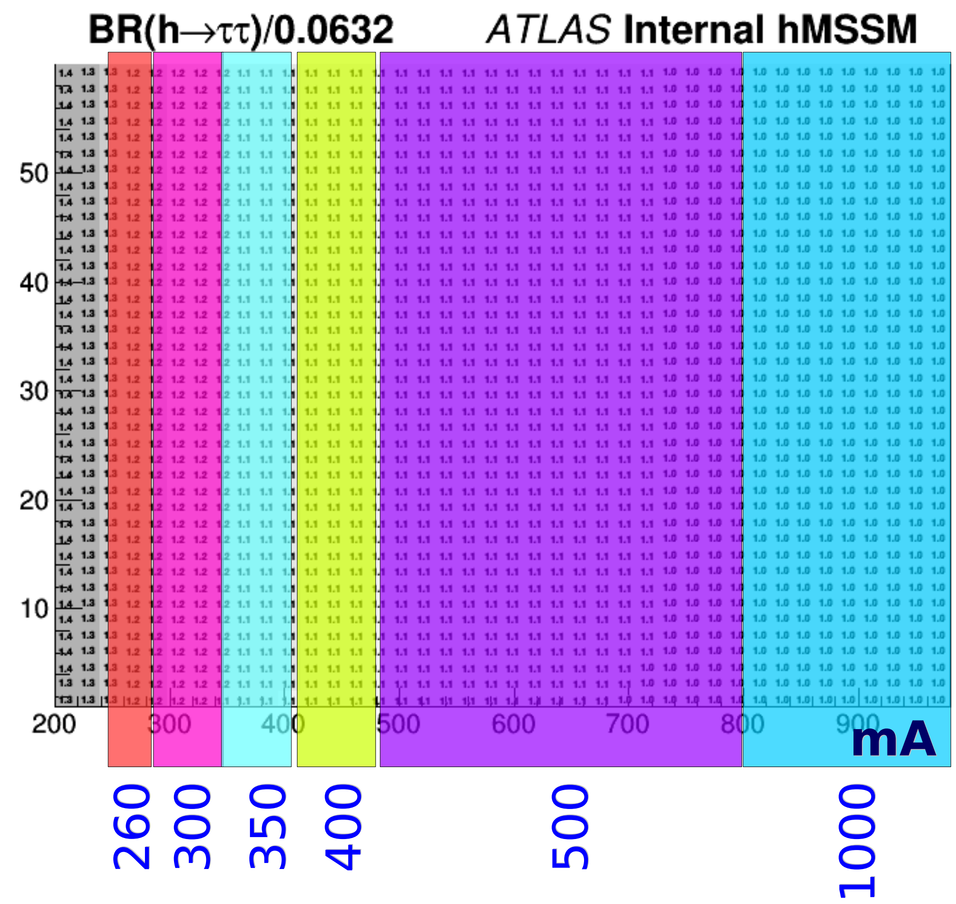


xsec(ggH)*BR(H->hh)

hMSSM - limit parametrization

- The **non-SM BR** of h decays should be taken into account in the combined limits

- ***Assume mH=mA***
- BR(h->yy/ww/bb/tautau) is a function of mH but ***NOT dependent*** on tb, we can simplify the parametrization
- Limit is parametrized as a function of
  - mH
  - BR(h-yy/ww/bb/tt)
- BRs are a group of fixed values according to mH



hMSSM – BR rescales

- Parametrization grid definition on mH,BRs

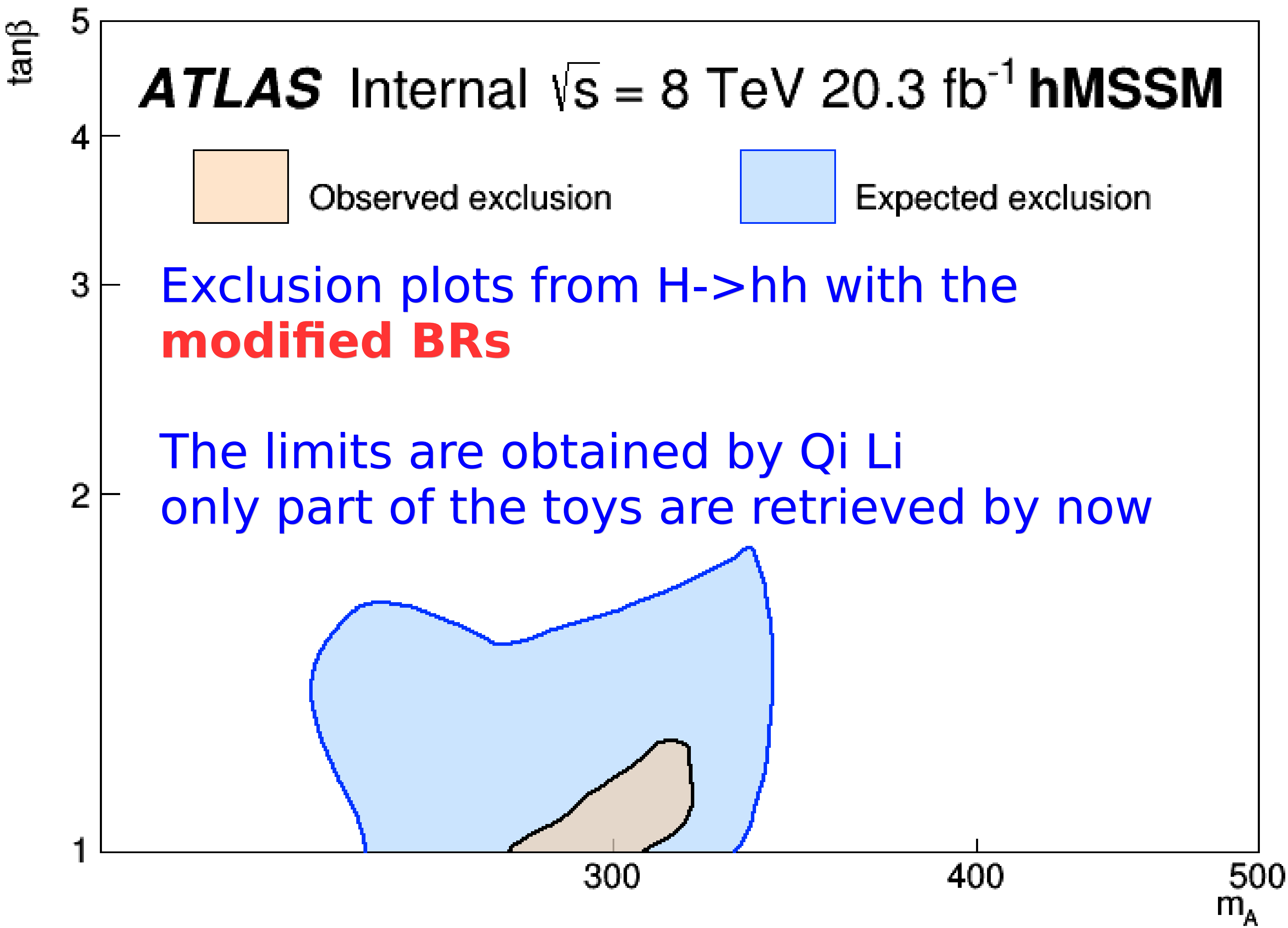
	260	300	350	400	500	800/1000
BR(yy)	0.6	0.7	0.8	0.8	0.9	1.0
BR(ww)	0.6	0.7	0.8	0.8	0.9	0.9
BR(bb)	1.2	1.2	1.2	1.1	1.1	1.0
BR(tautau)	1.2	1.2	1.2	1.1	1.1	1.0

* rounding to 0.1

hMSSM – channel rescales

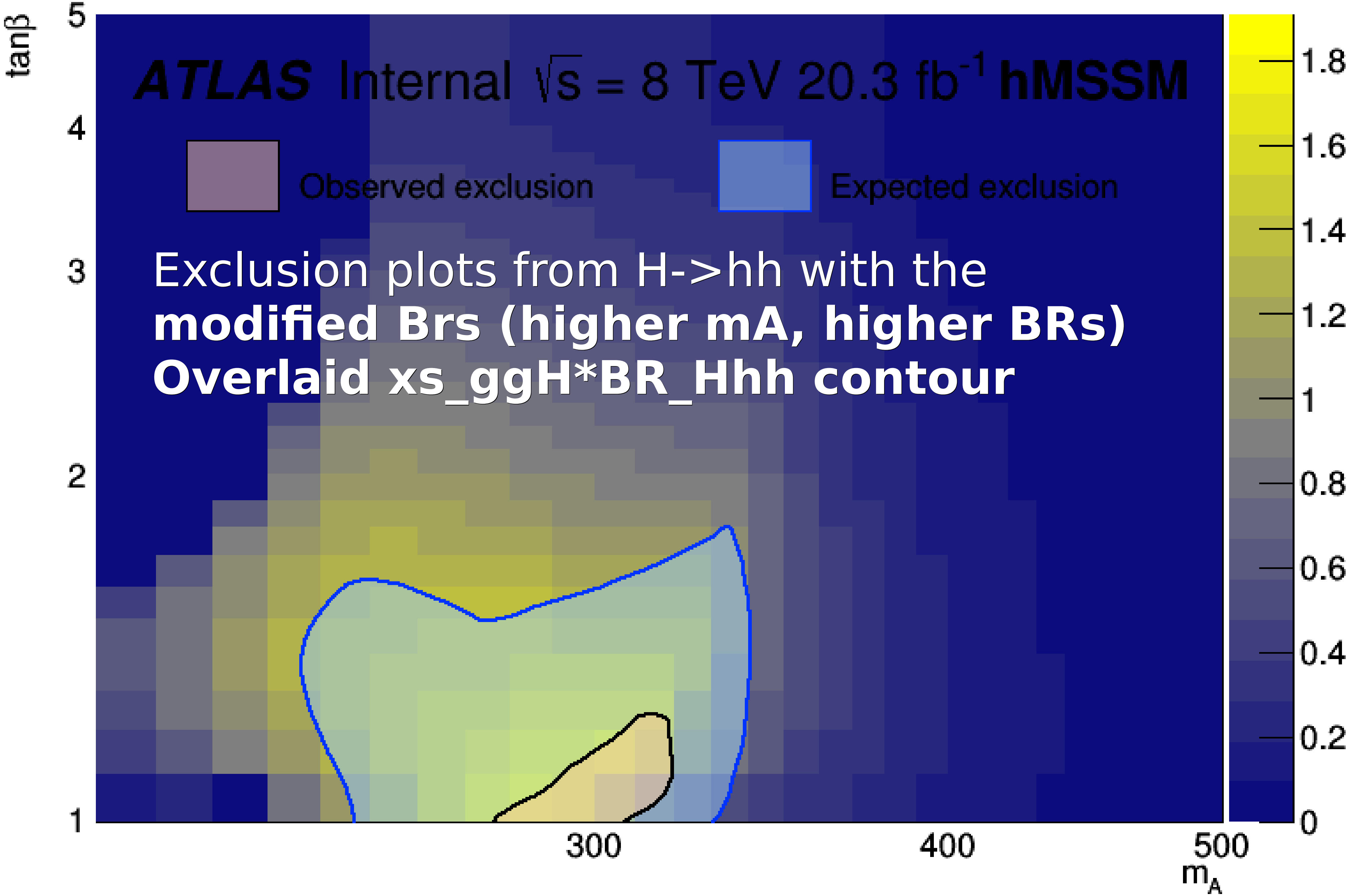
- translate BR rescales into channel rescales

	260	300	350	400	500	800/1000
bbyy	**0.72**	**0.84**	**0.96**	**0.88**	**0.99**	**-**
wwyy	**0.36**	**0.49**	**0.64**	**0.64**	**0.81**	**-**
bbtautau	**1.44**	**1.44**	**1.44**	**1.21**	**1.21**	**1.0**
bbbb	**-**	**-**	**-**	**-**	**1.21**	**1.0**



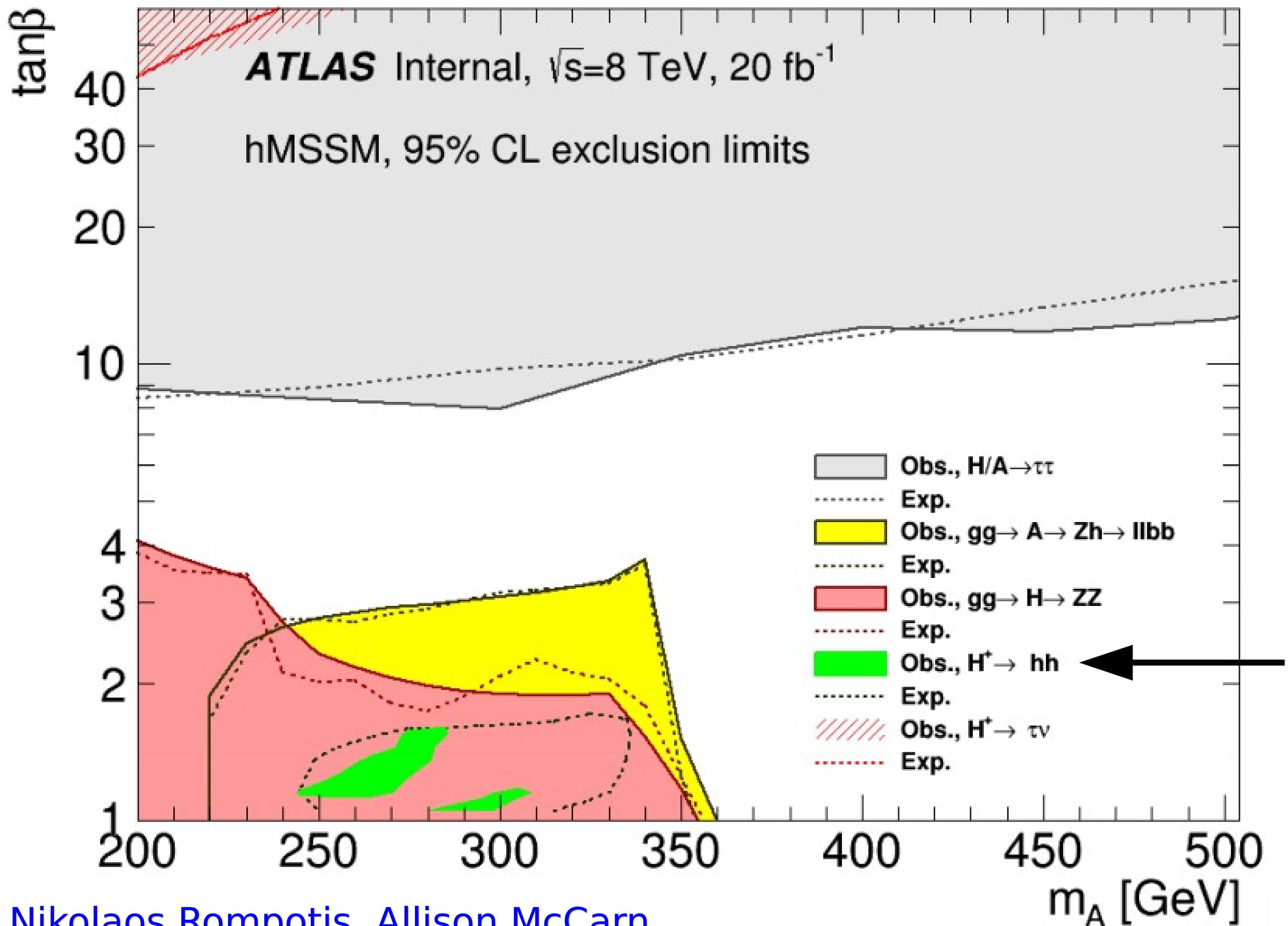
Exclusion plots from H->hh with the **modified BRs**

The limits are obtained by Qi Li
only part of the toys are retrieved by now



Exclusion plots from H->hh with the
modified Brs (higher mA, higher BRs)
Overlaid xs_ggH*BR_Hhh contour

hMSSM – compared to other channels

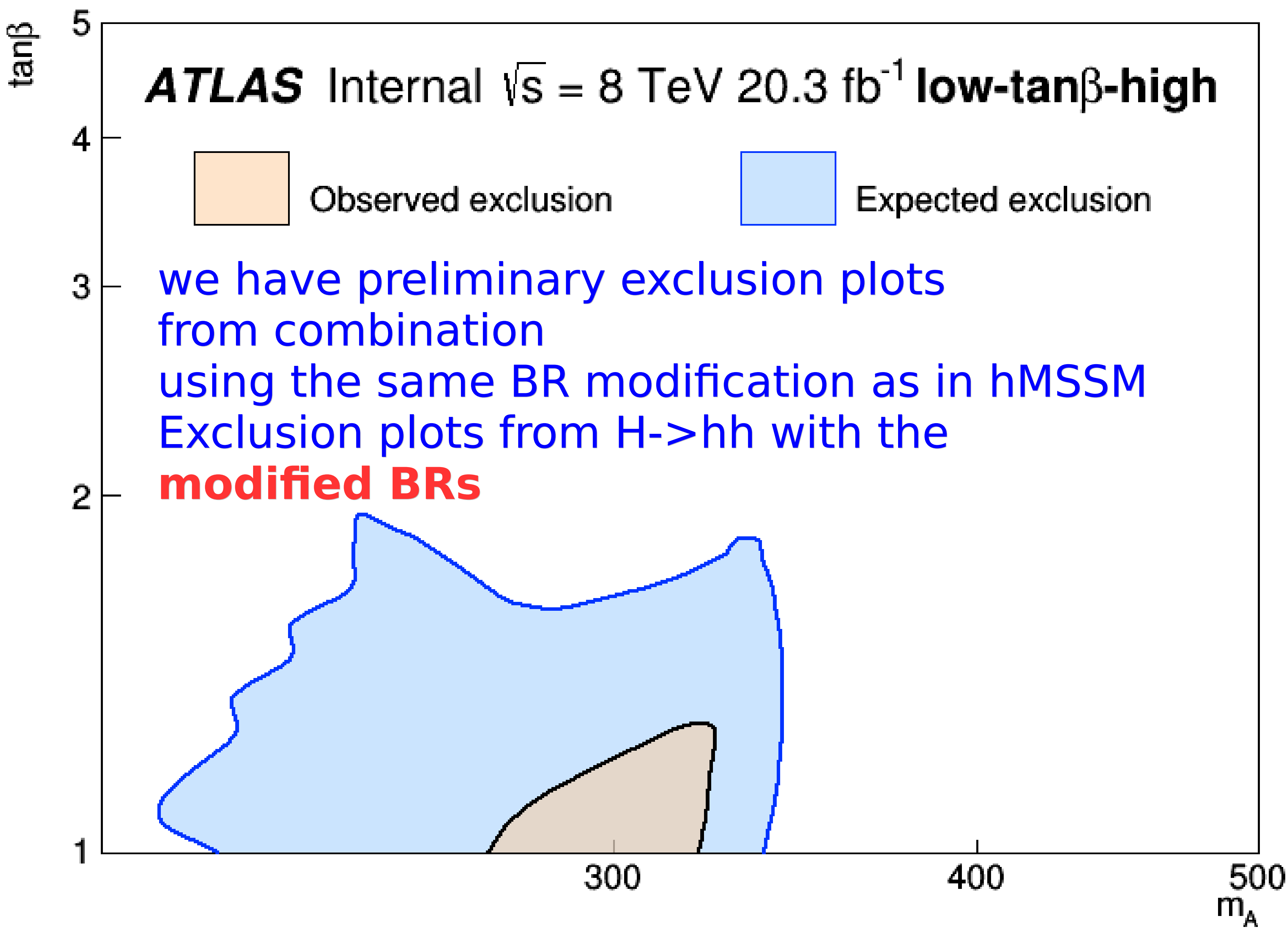


Nikolaos Rompotis, Allison McCarn

https://indico.cern.ch/event/393422/contribution/3/material/slides/0.pdf

low-tb-high

- BR map in plain files from Sven
  - tb~1, numeric instability, missing points;
  - inspired by Nikos, ask Sven to run the calculation with tb=1.01;
  - just added to the map file



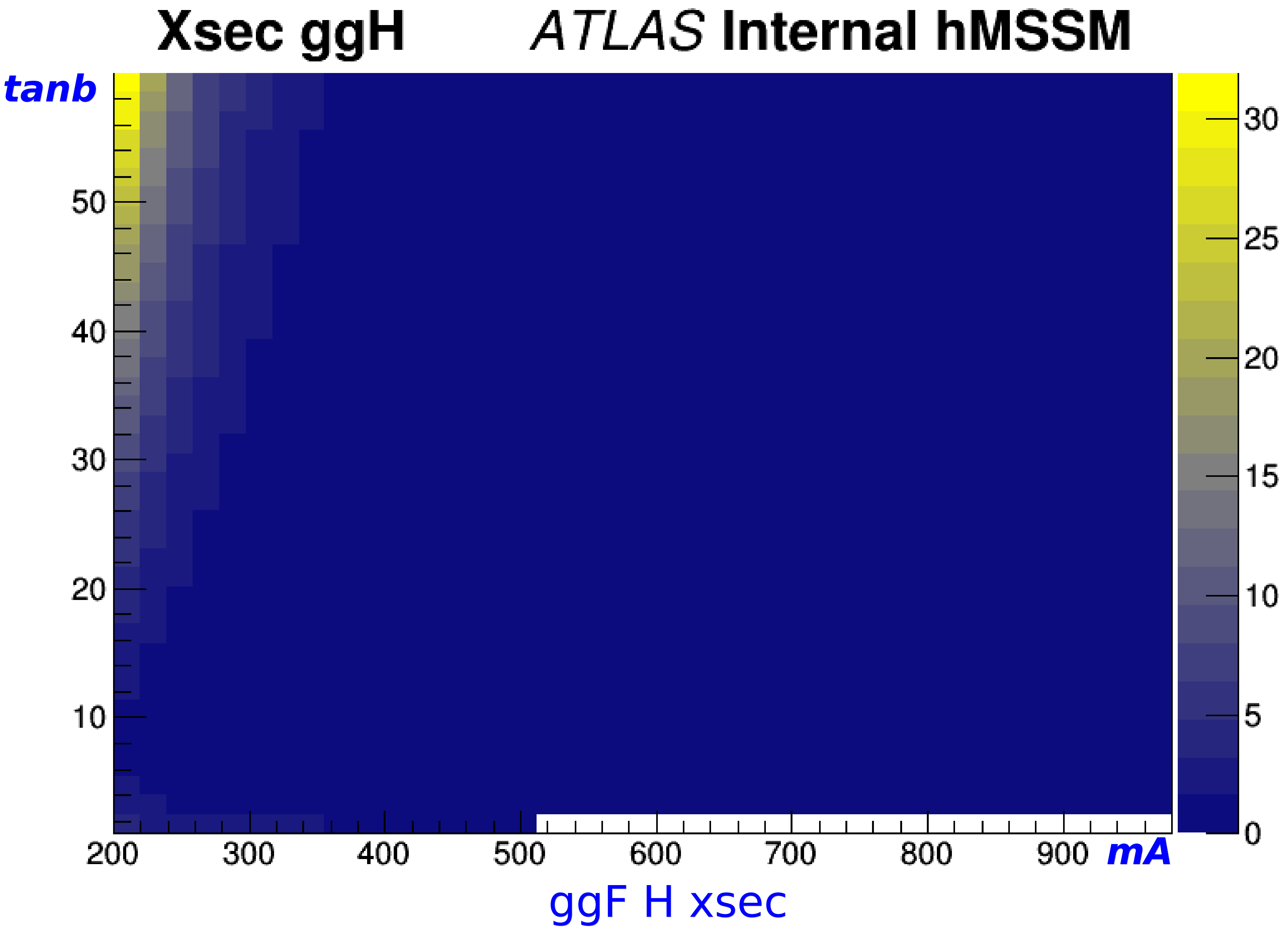
we have preliminary exclusion plots
from combination
using the same BR modification as in hMSSM
Exclusion plots from H->hh with the
modified BRs

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HXSWG3LowTanB

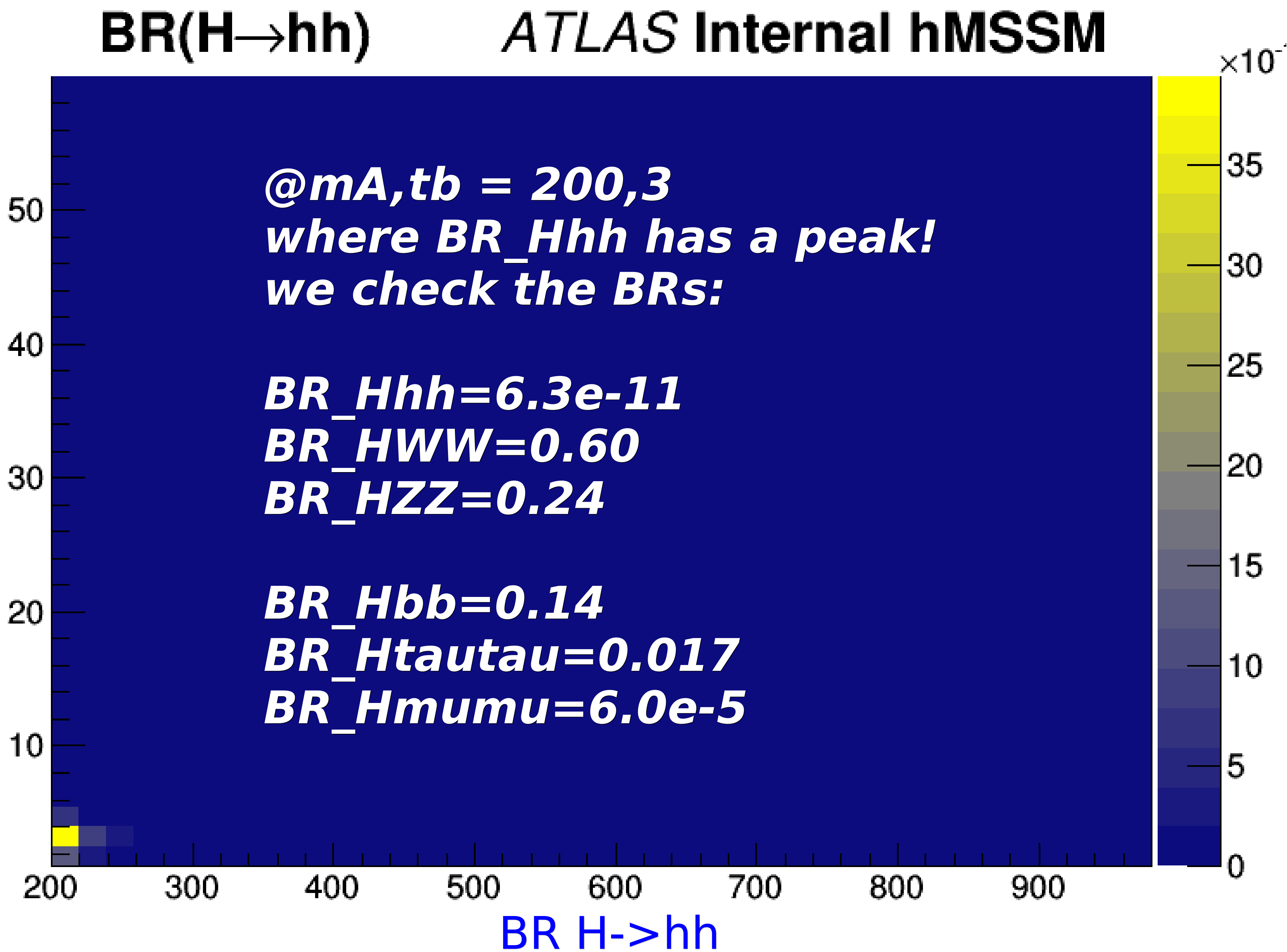
Summary

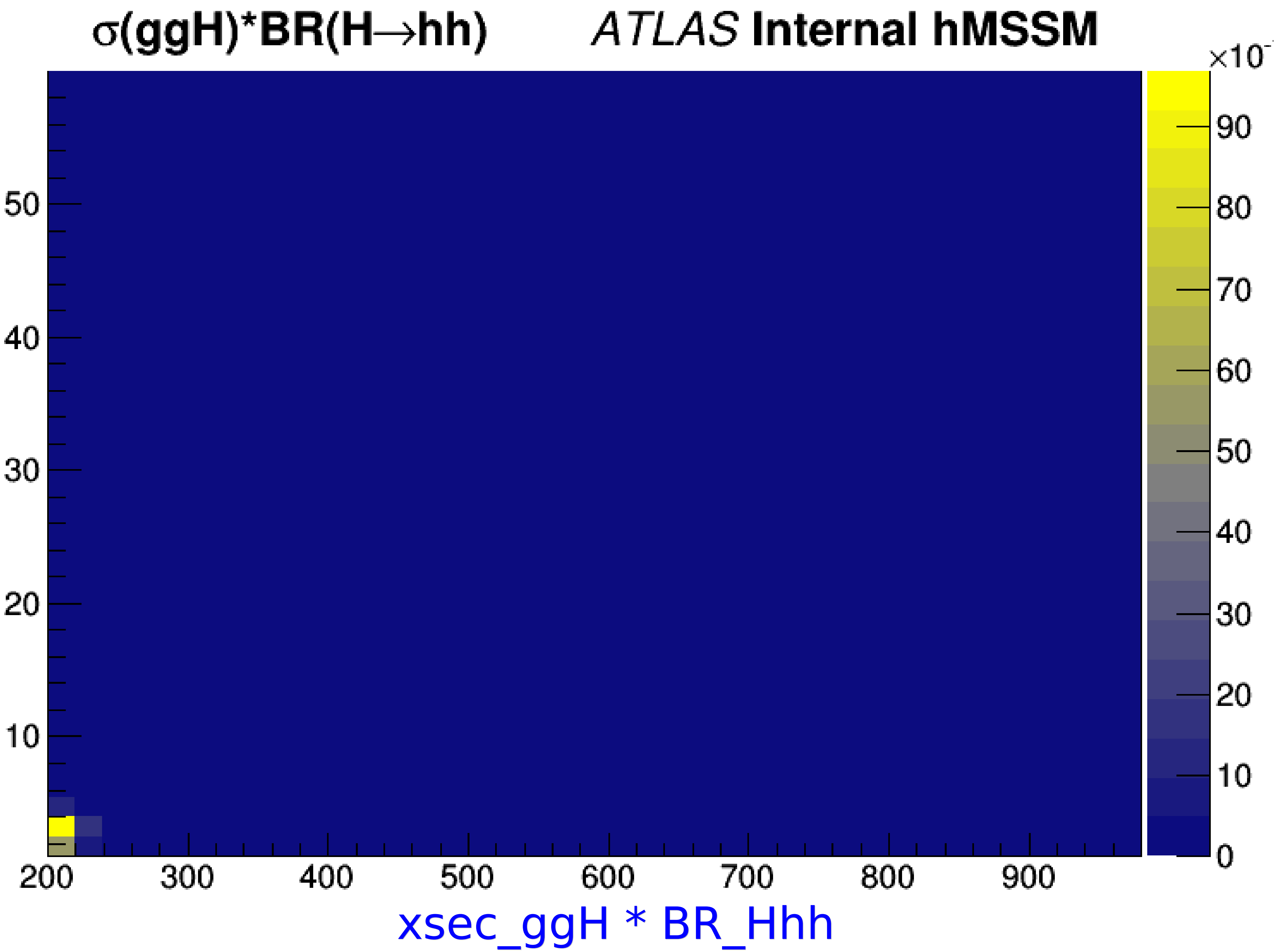
- Uncertainties are grouped and are estimated for each, we see **statistical is still larger** than systematic uncertainties; asked for more mass point, being running them
- **1.2M** events, for signal **theoretical** uncertainty estimation
- **hMSSM**, map files has problem in **Hhh BR** (too small numbers) is fixed; preliminary exclusion plots; **fixed gap issue** asked by Jianming on Friday
- **low-tanb-high,** preliminary exclusion plots, **fixed gap issue** asked by Jianming on Friday

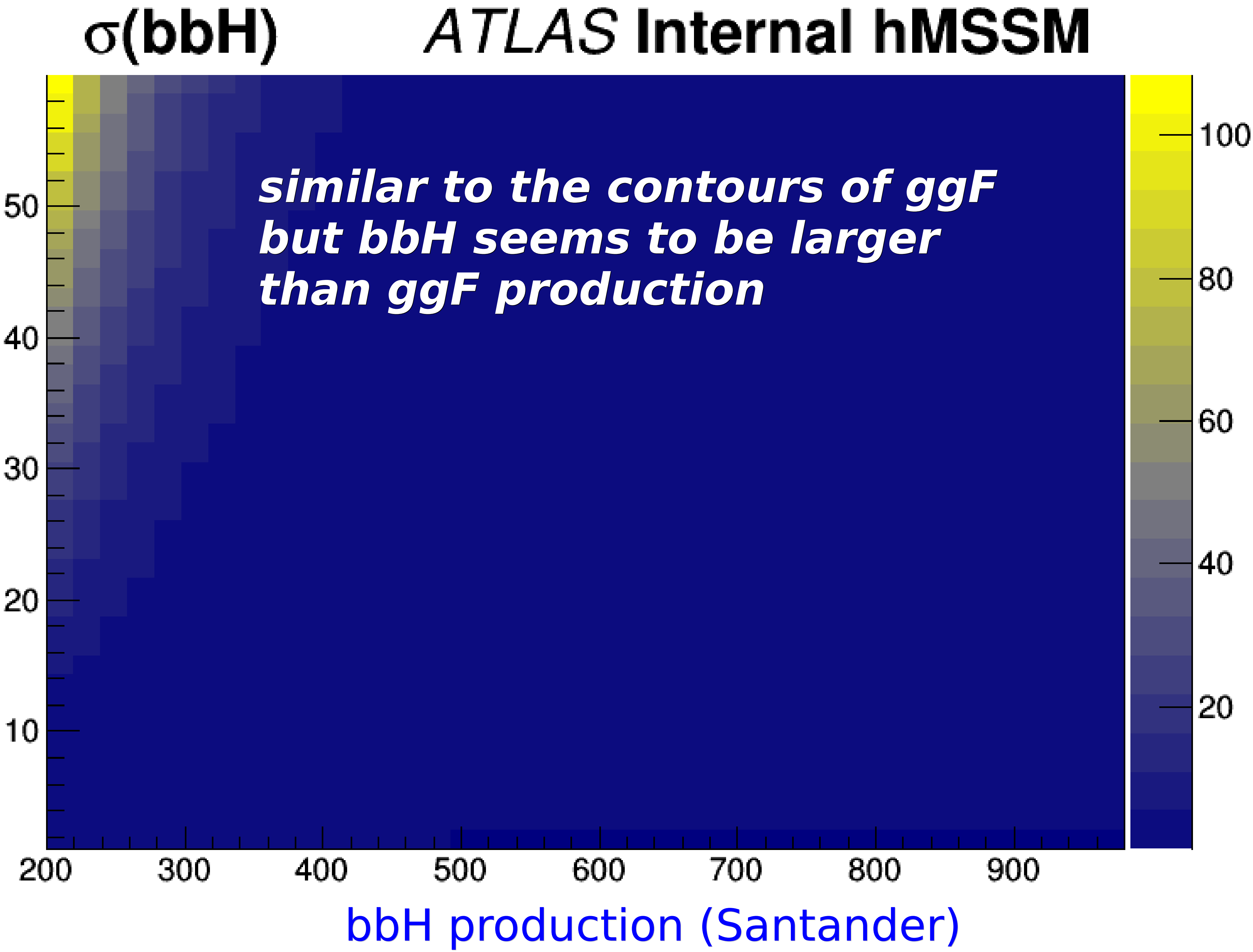
backup

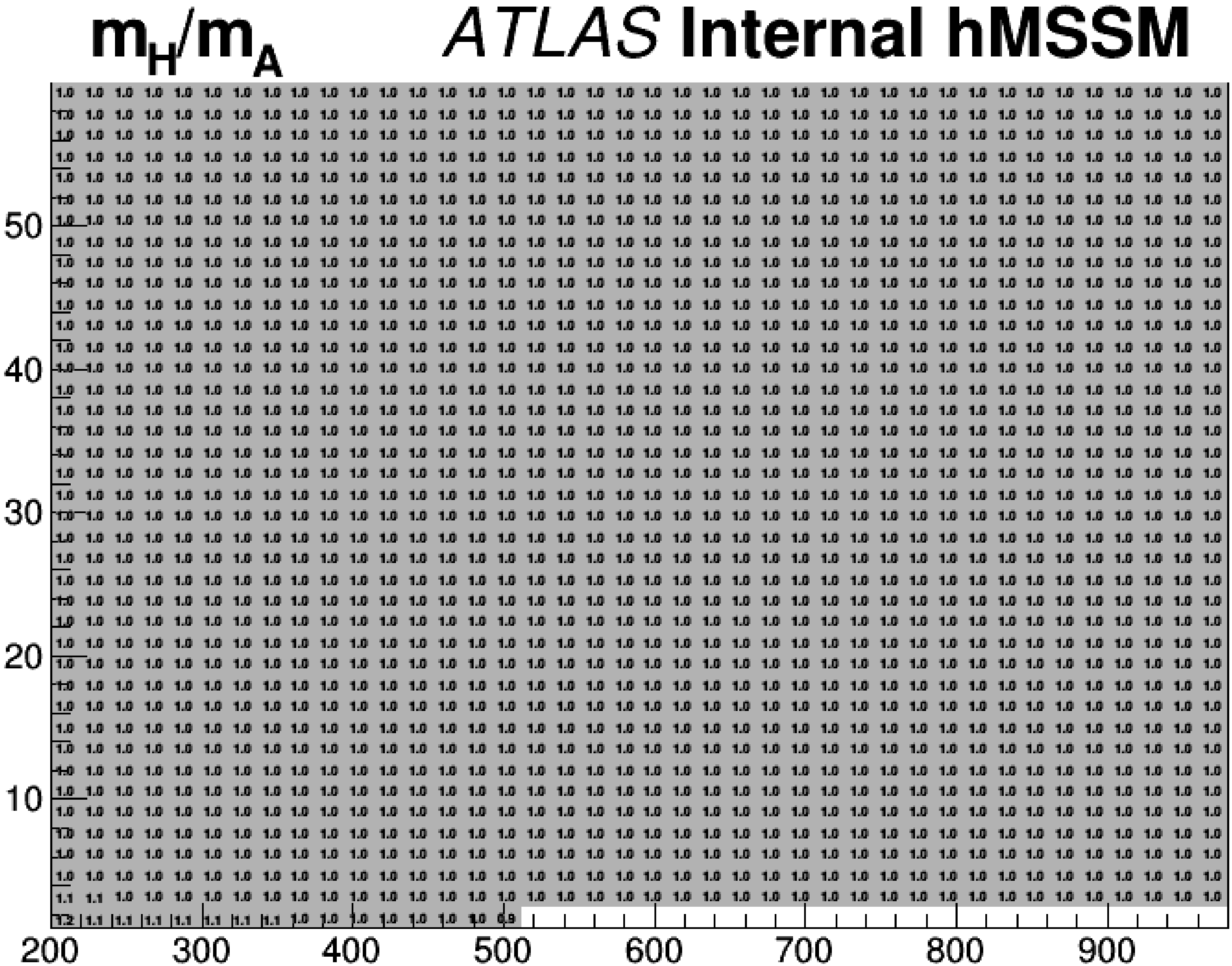


Xsec ggH
ATLAS Internal hMSSM
tanb
50
40
30
20
10
200
300
400
500
600
700
800
900
mA
30
25
20
15
10
5
0
ggF H xsec

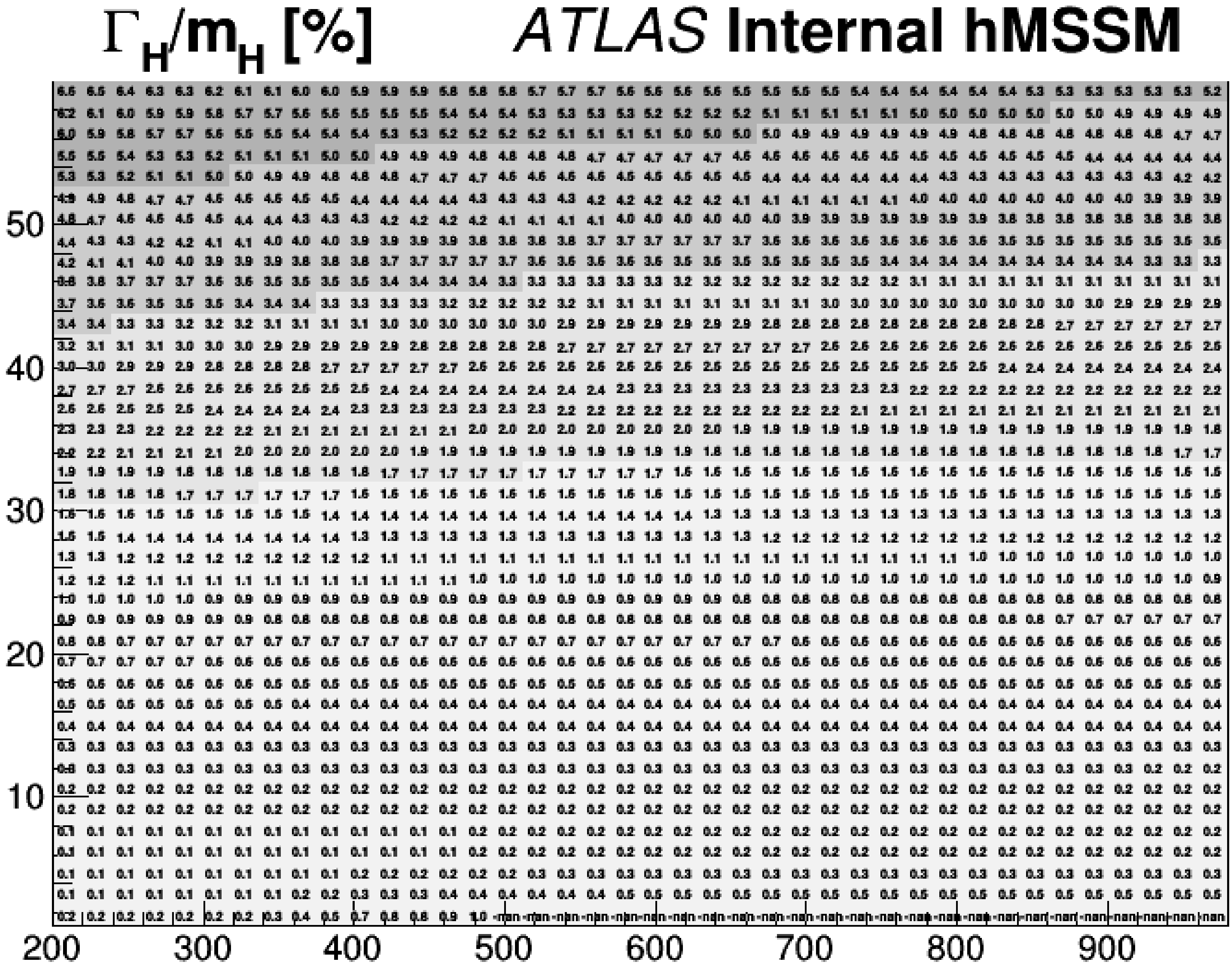

BR(H→hh) ATLAS Internal hMSSM
@mA,tb = 200,3
where BR_Hhh has a peak!
we check the BRs:
BR_Hhh=6.3e-11
BR_HWW=0.60
BR_HZZ=0.24
BR_Hbb=0.14
BR_Htautau=0.017
BR_Hmumu=6.0e-5
BR H->hh
50
40
30
20
10
200
300
400
500
600
700
800
900
35
30
25
20
15
10
5
0


σ(ggH)*BR(H→hh)
ATLAS Internal hMSSM
50
40
30
20
10
200
300
400
500
600
700
800
900
xsec_ggH * BR_Hhh
×10
90
80
70
60
50
40
30
20
10
0

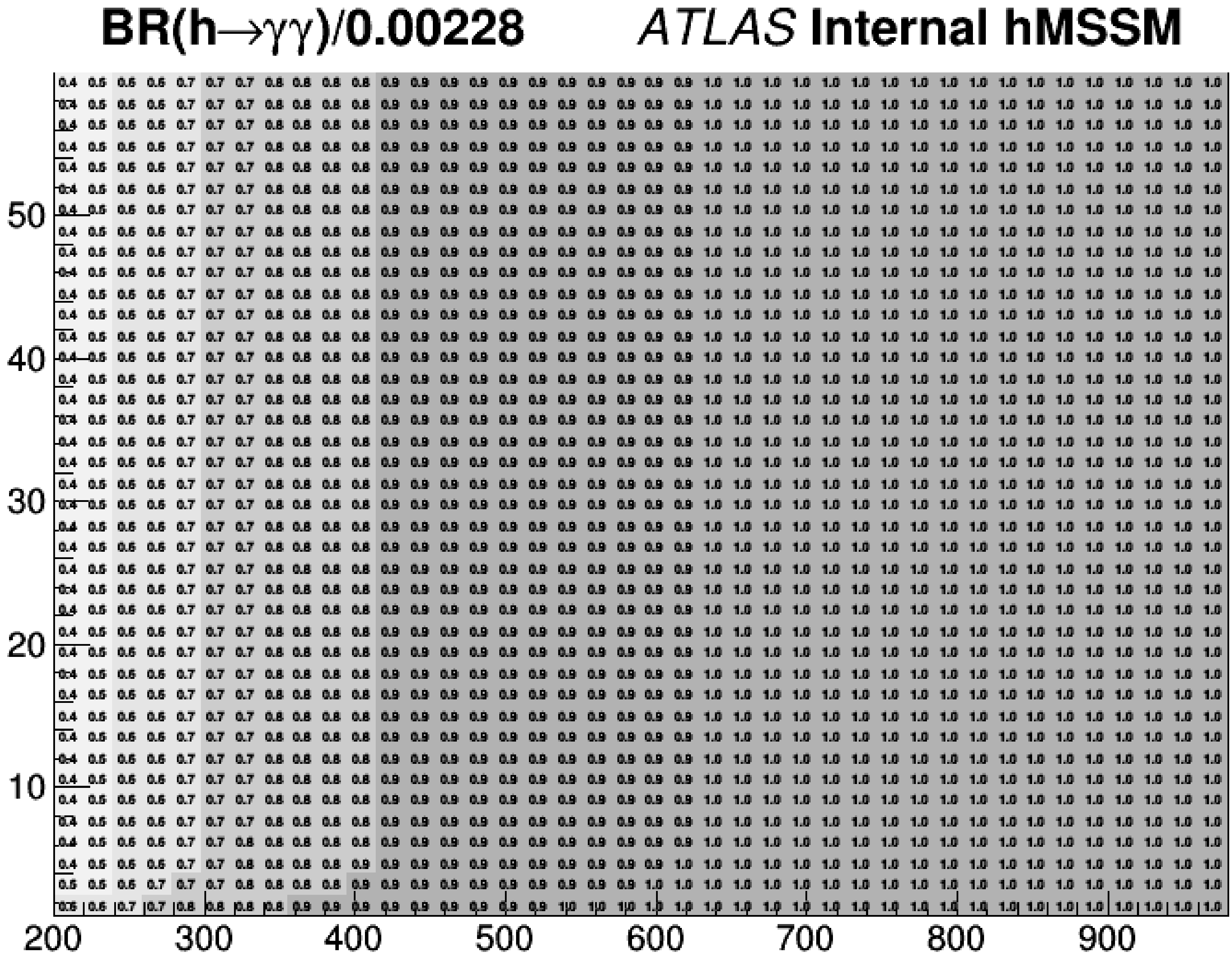

σ(bbH)
ATLAS Internal hMSSM
similar to the contours of ggF
but bbH seems to be larger
than ggF production
10
20
30
40
50
200
300
400
500
600
700
800
900
20
40
60
80
100
bbH production (Santander)



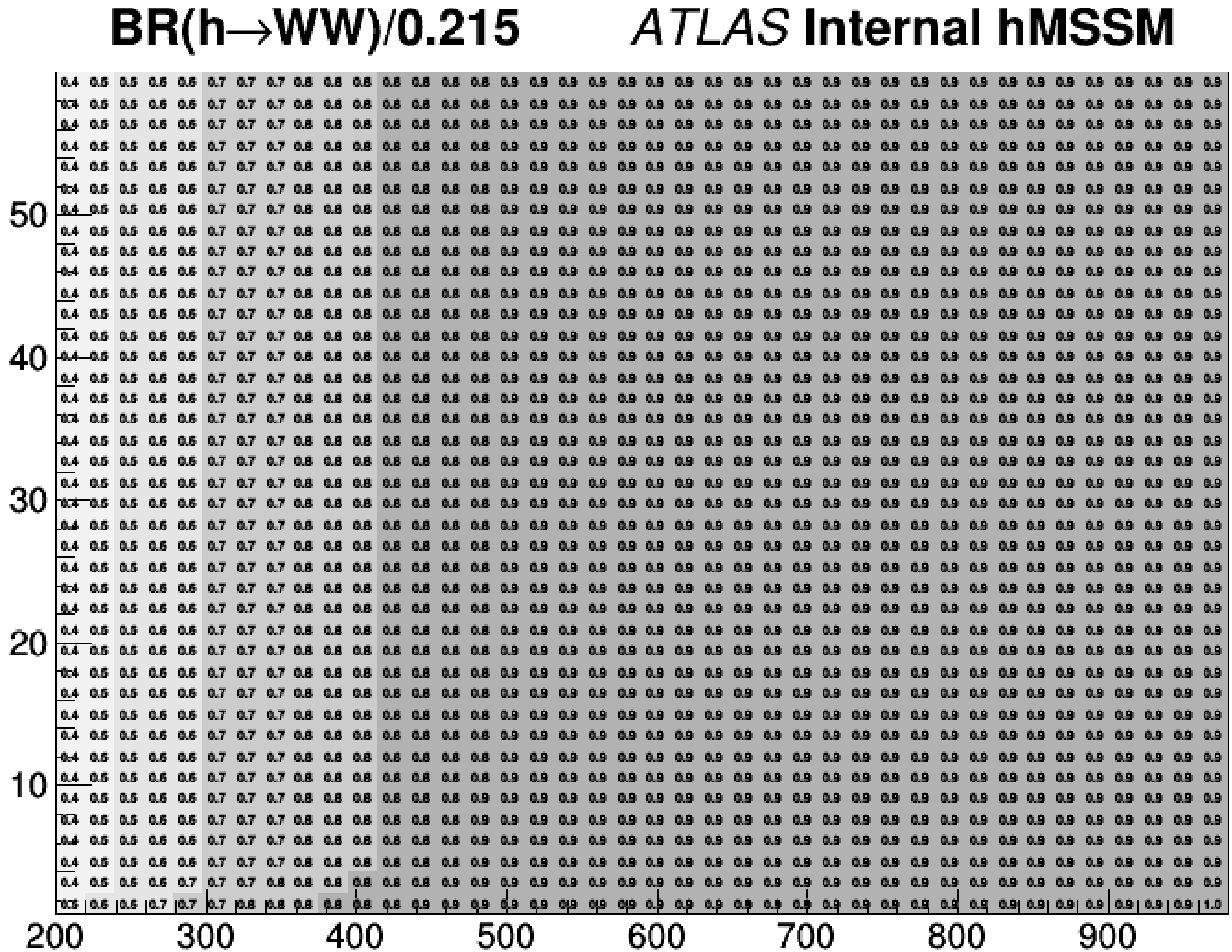
spreading around mA ~10%



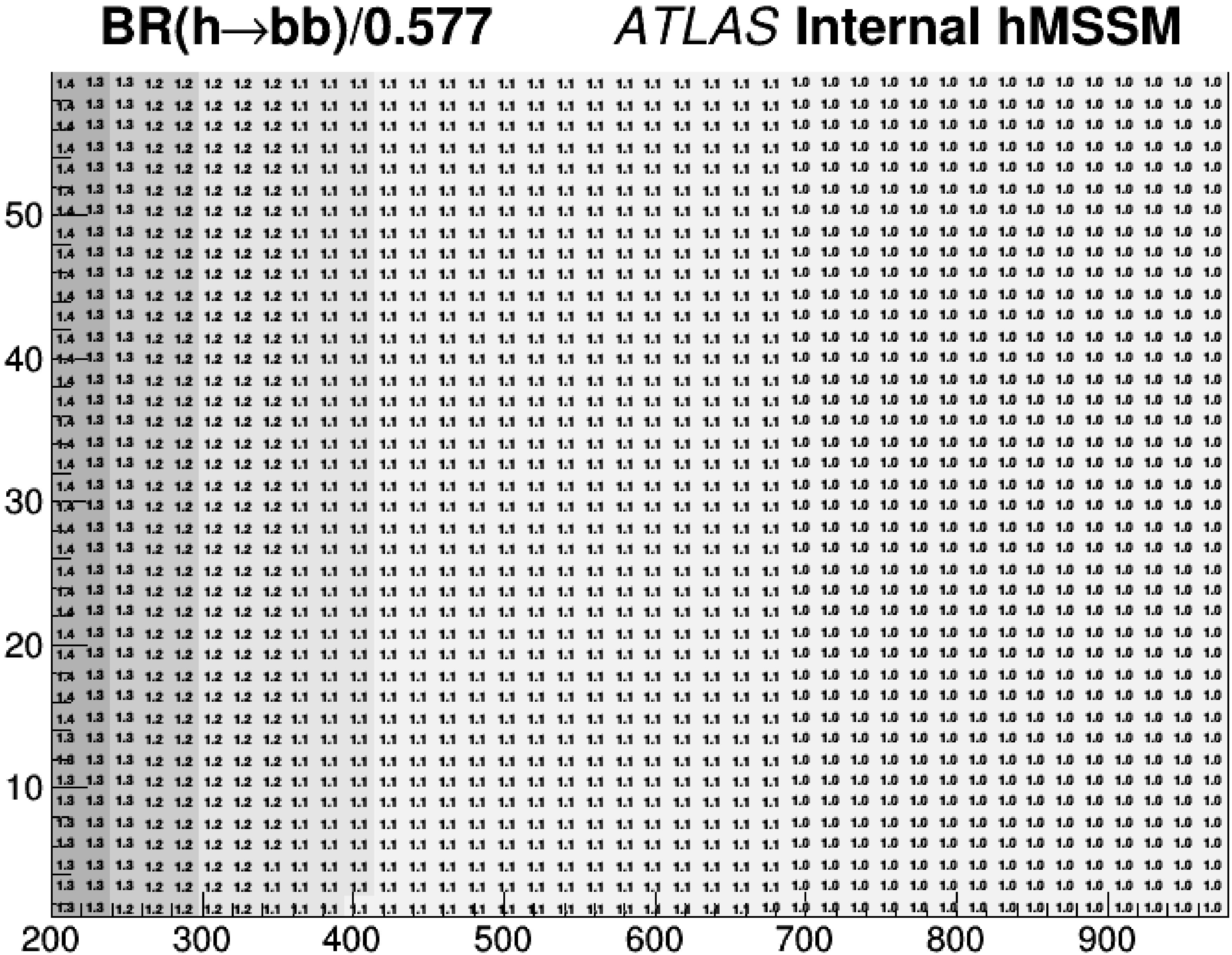
below tb=25 width<1%m(H)



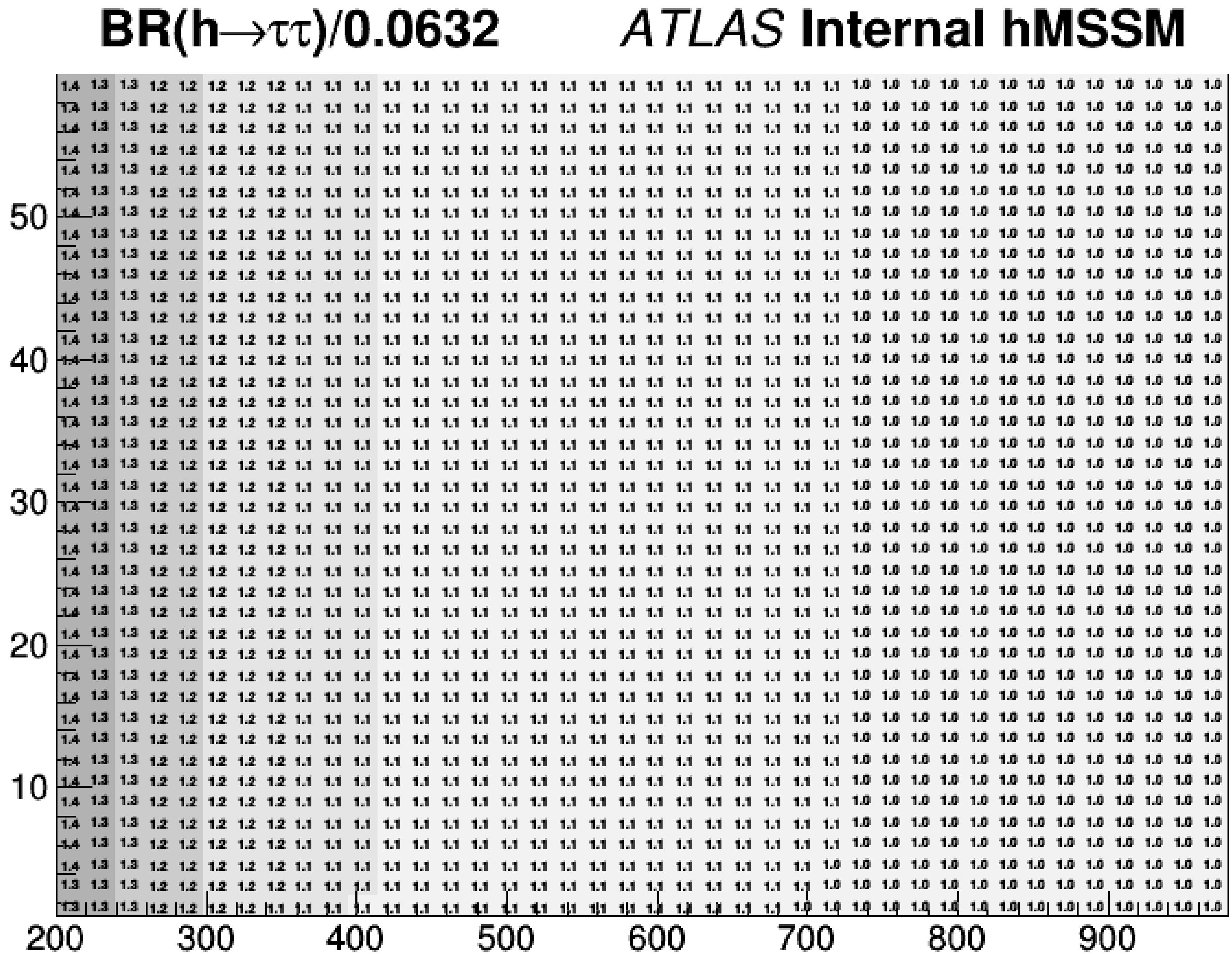
40% variations away from SM BR



50% variations away from SM BR



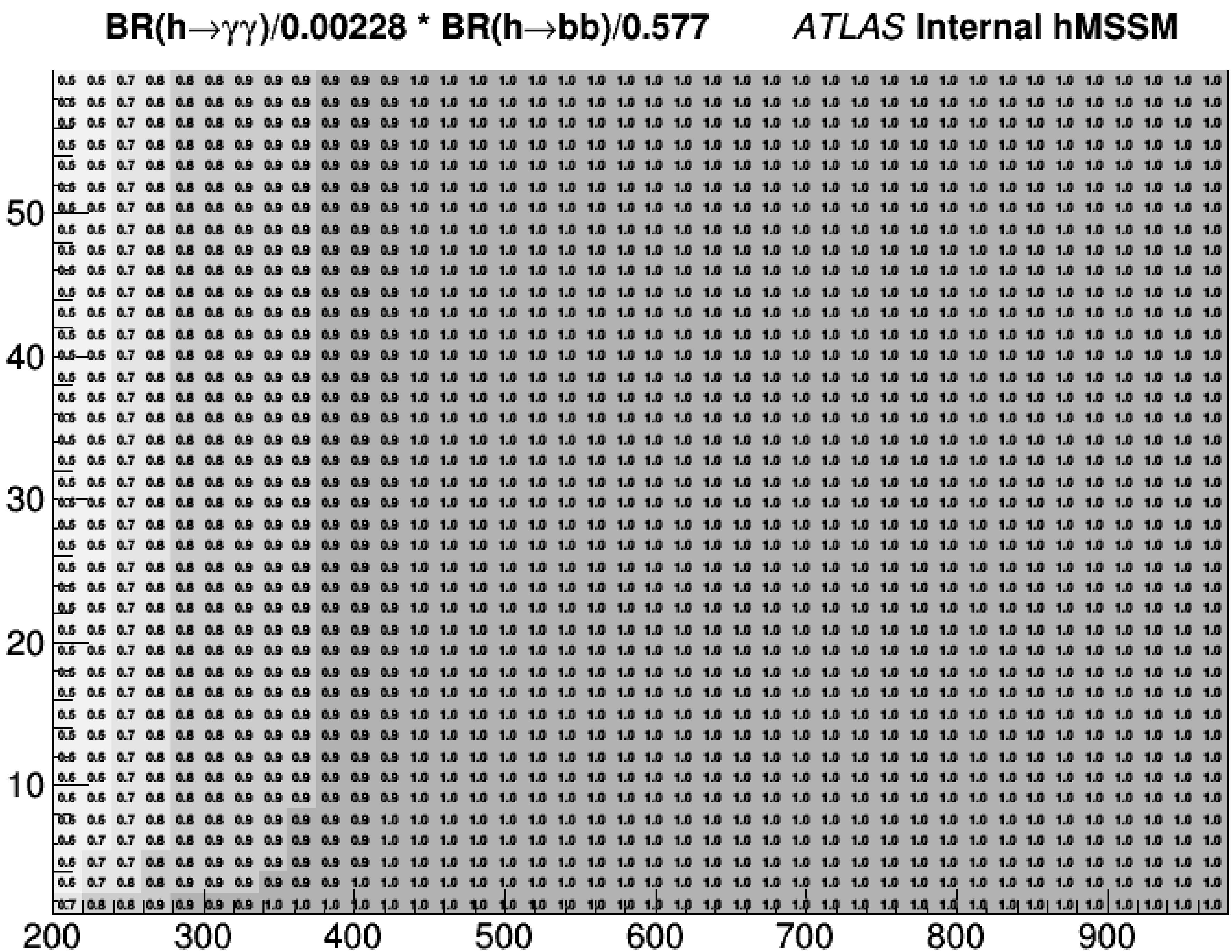
30% variations away from SM BR



30% variations away from SM BR

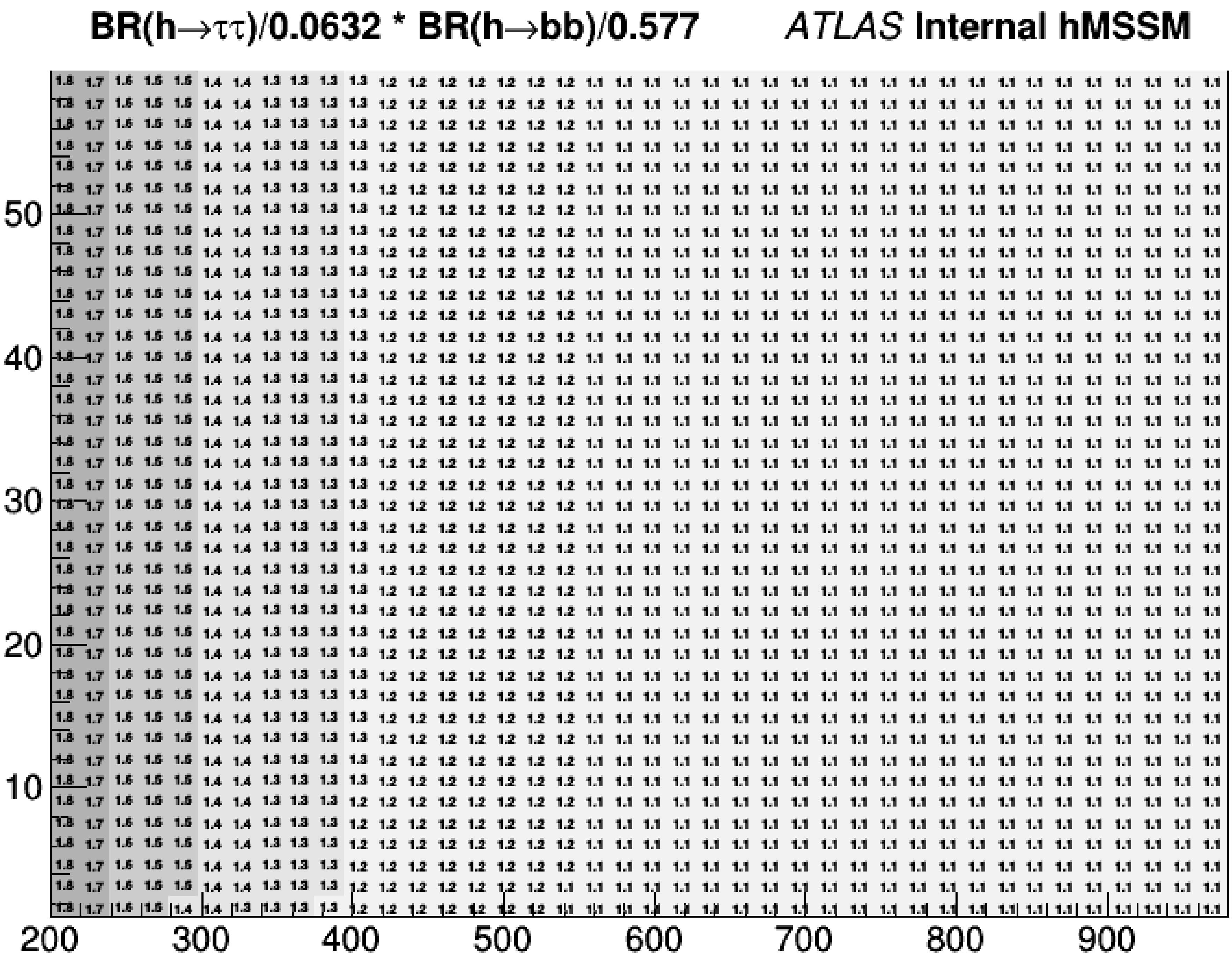
hMSSM Interpretation - **BR*BR**

- bbyy is rescaled by BR(bb)BR(yy)
- bbtautau is rescaled by BR(bb)*BR(tautau)
- wwyy is rescaled by BR(yy)BR(WW)
- bbbb is rescaled by BR(bb)^2
- these BR **products** make the rescaling in each channel **quadratically** larger/smaller
  - e.g. BR variation=30% -> limit variation=69%
- if the couplings are rescaled in the same way, the rescaling on products will be "squared", such as hbb/htautau, hww/hyy
  - affecting channels: bbtautau, bbbb, wwyy



scales on hyy and hbb cancel

fortunately, bbyy variates < 30%

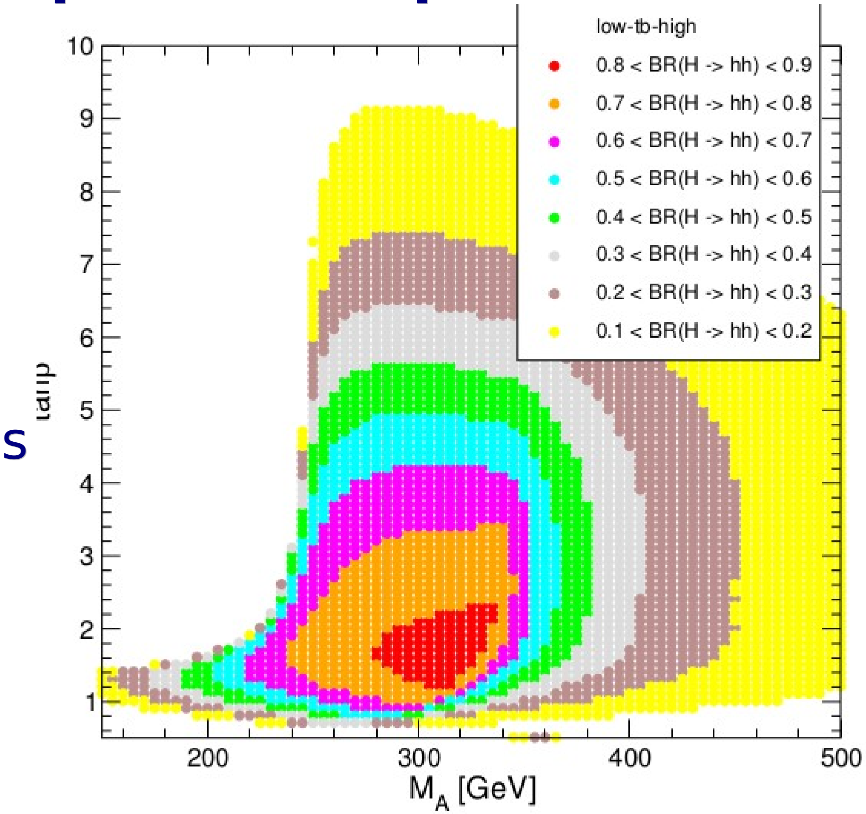


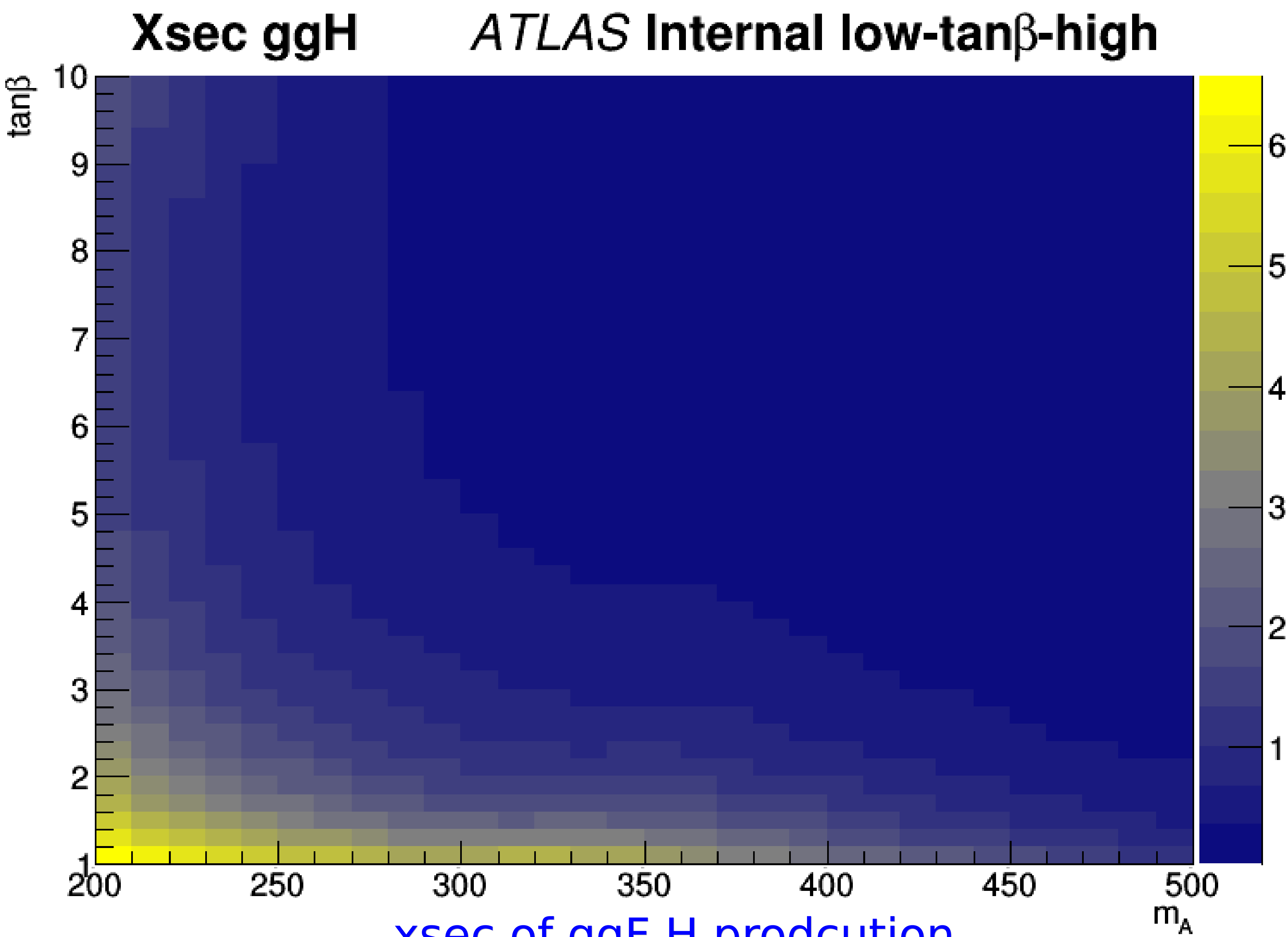
60% variation on BRtt*BRbb

low-tb-high

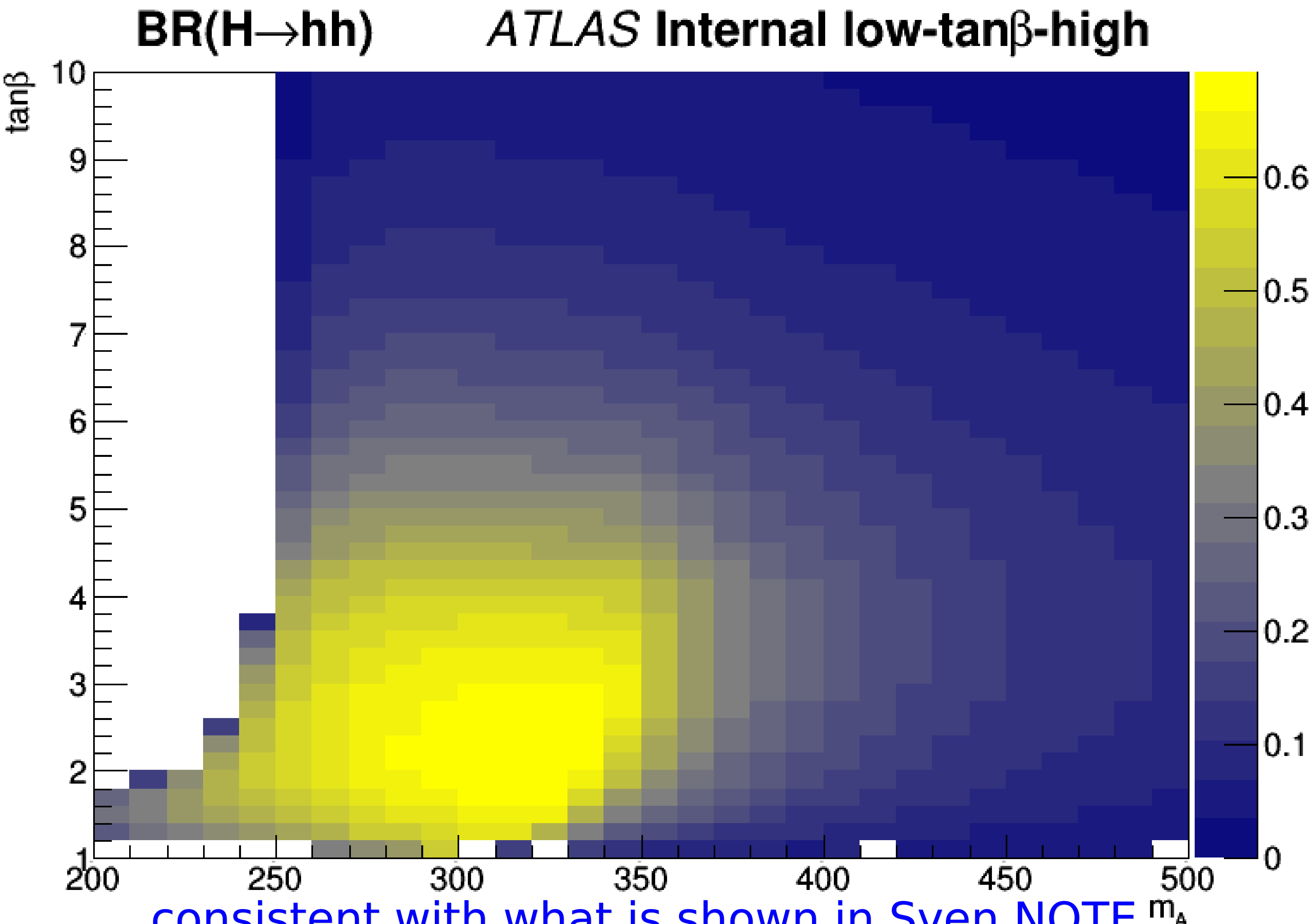
- BR map in plain files from Sven
  - some incomplete phase points in very low tanb and mA region (theoretically unstable)
  - some duplicated phase points due to technical issues
- I have stripped out all duplicated phase points and converted available points into **ntuple and map** formats

- XS map from Stefan, but the current numbers are only used for giving an idea of xs and scale uncertainties
- I have merged them into our **map** files

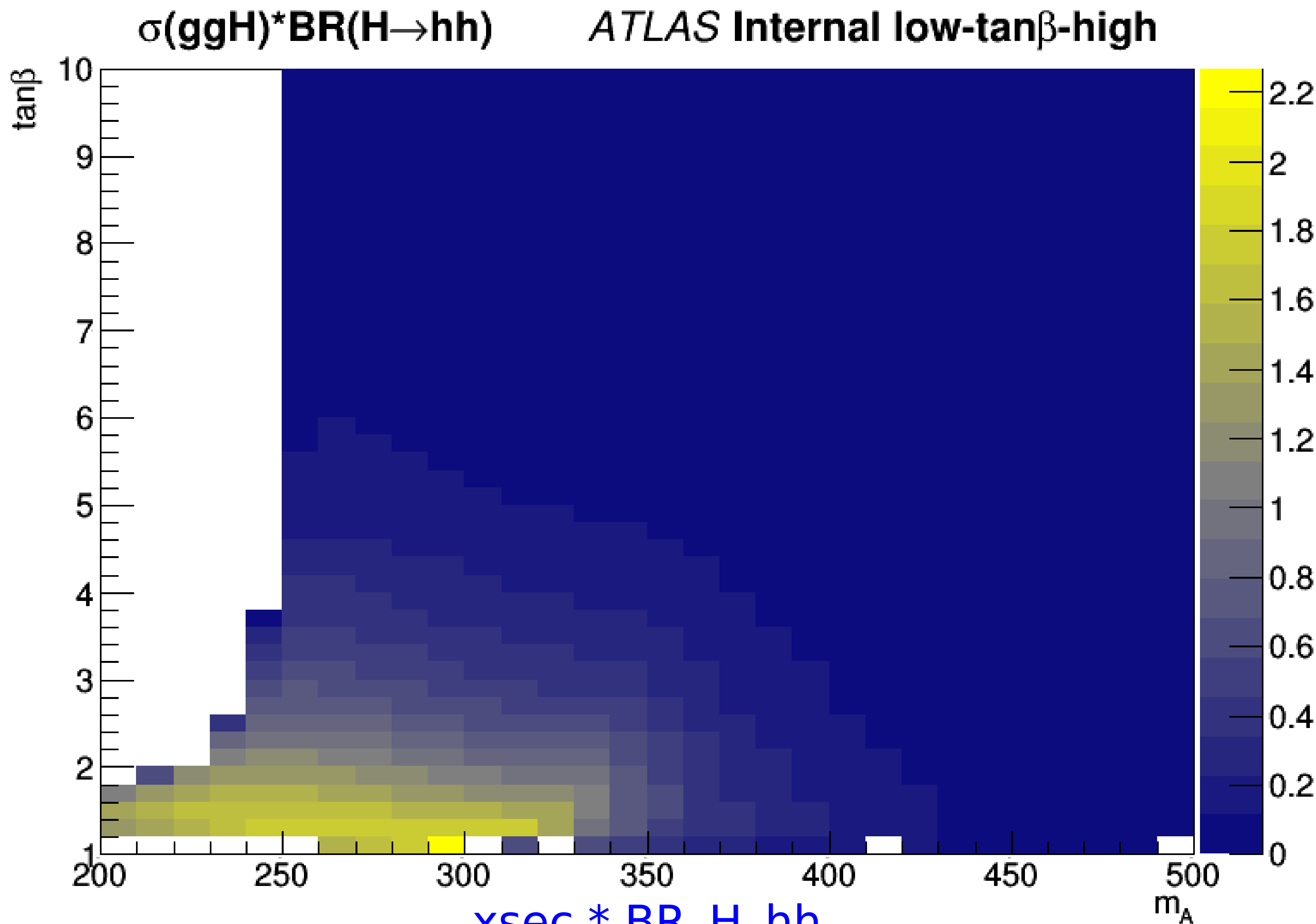




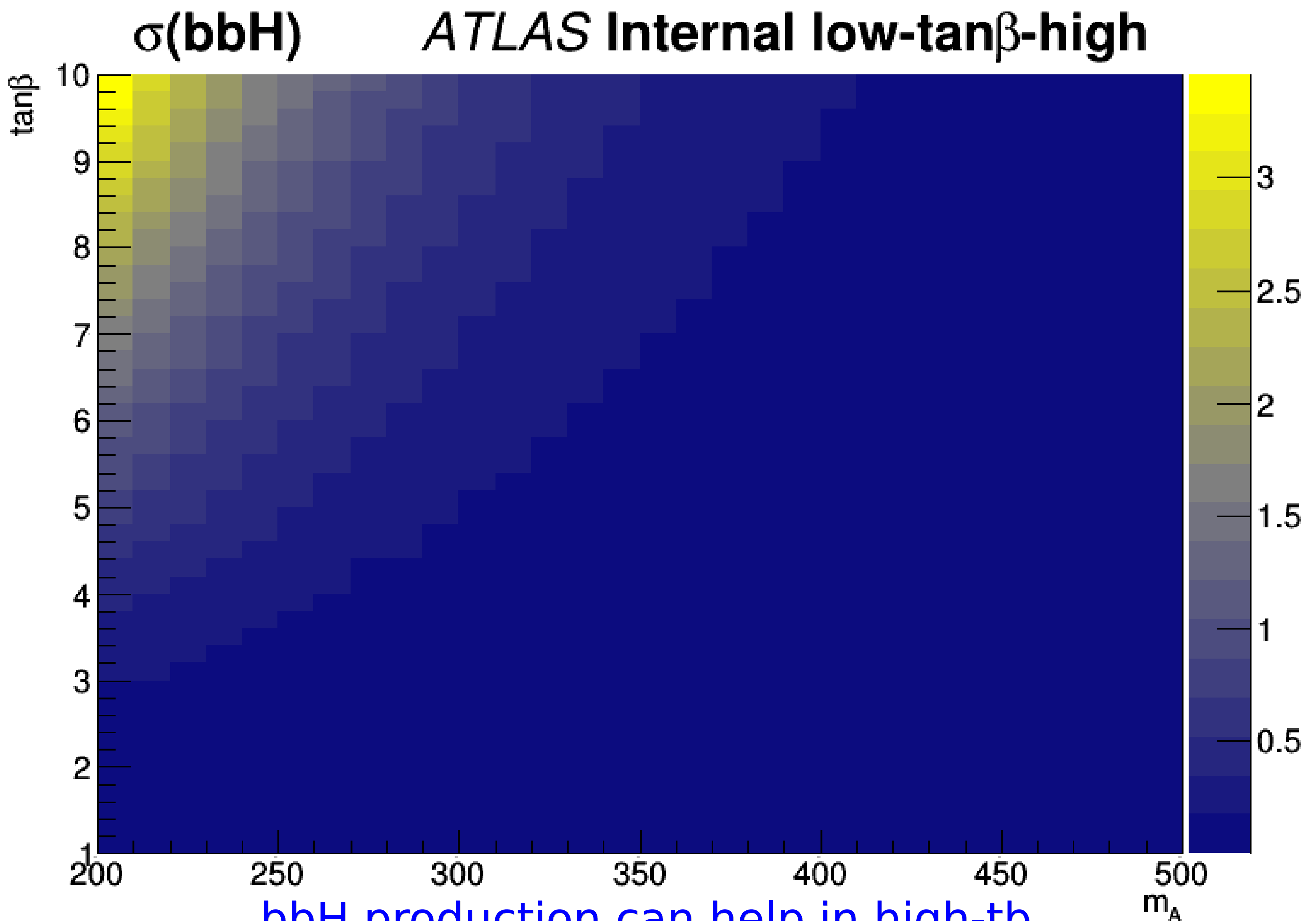
xsec of ggF H prodcution



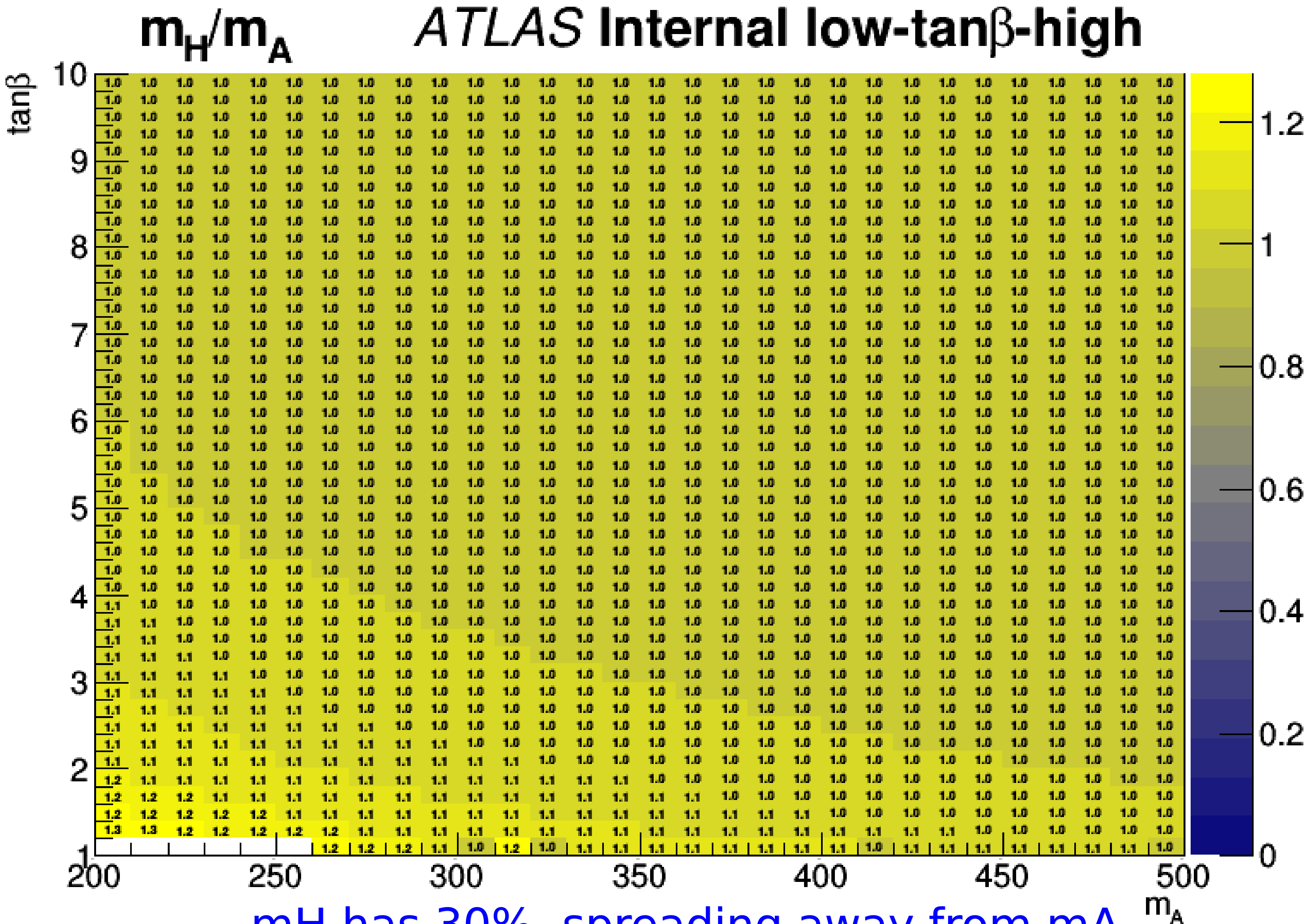
consistent with what is shown in Sven NOTE


σ(ggH)*BR(H→hh)
ATLAS Internal low-tanβ-high
tanβ
m_A
10
9
8
7
6
5
4
3
2
1
200
250
300
350
400
450
500
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

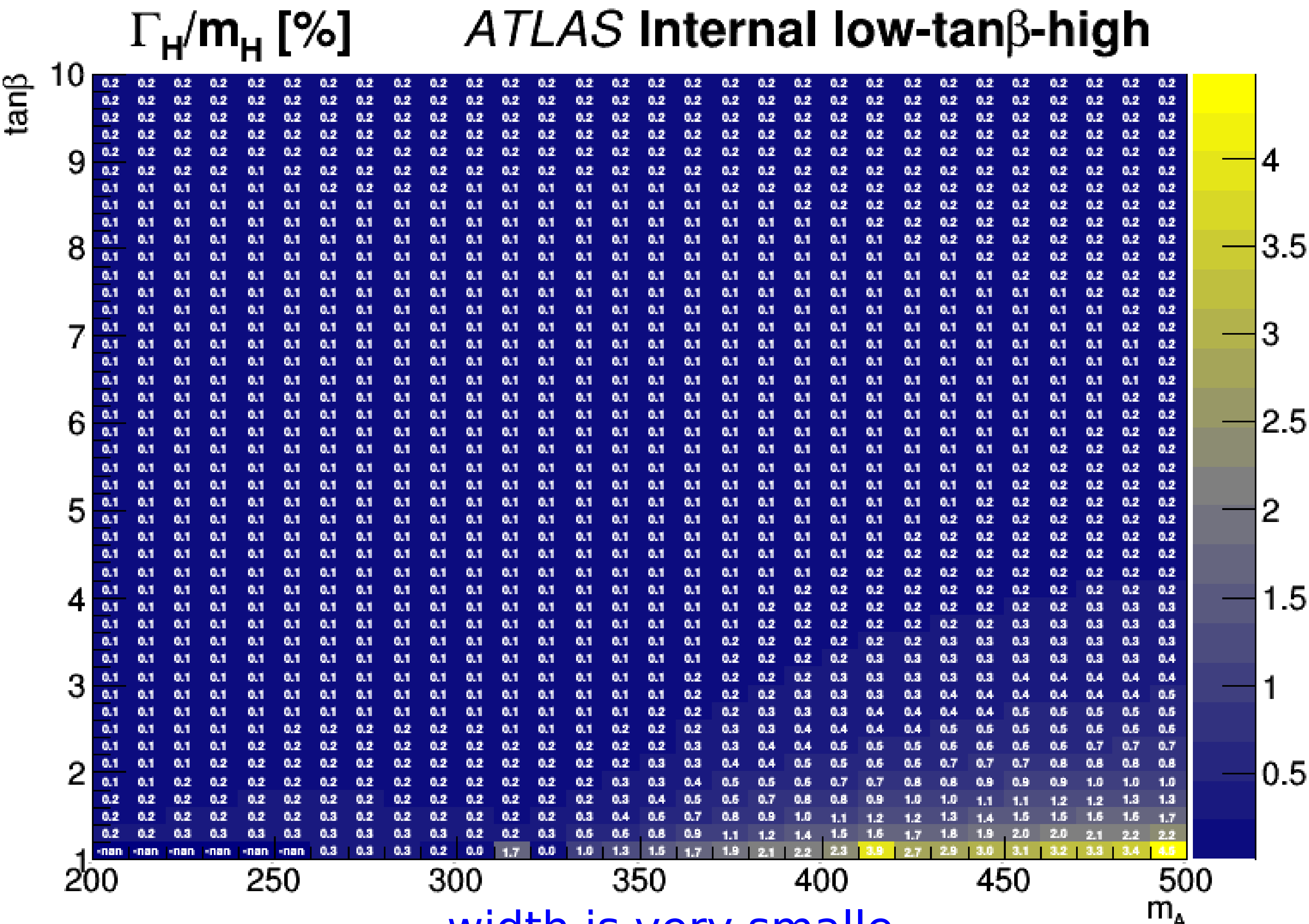
xsec * BR_H_hh



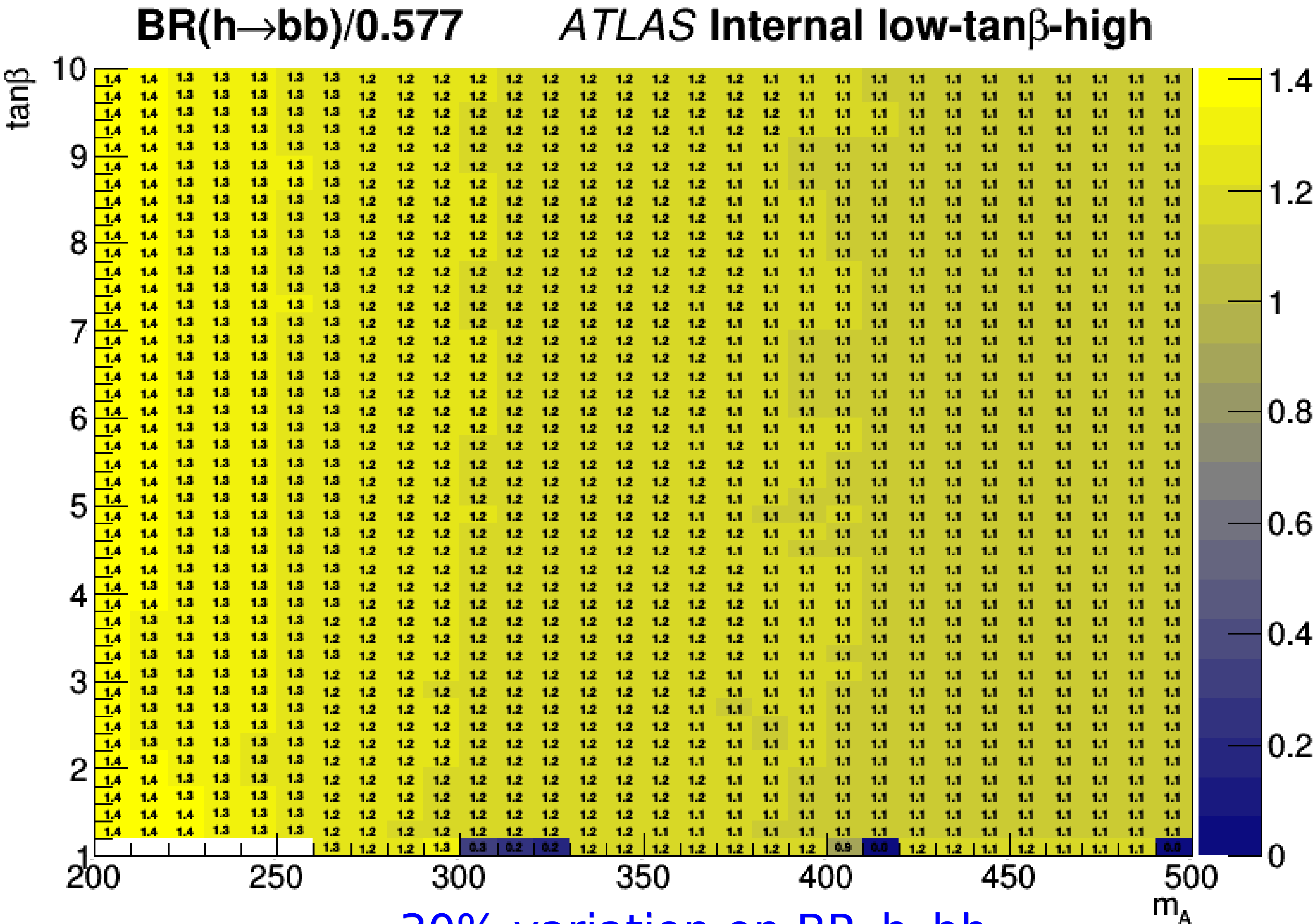
bbH production can help in high-tb



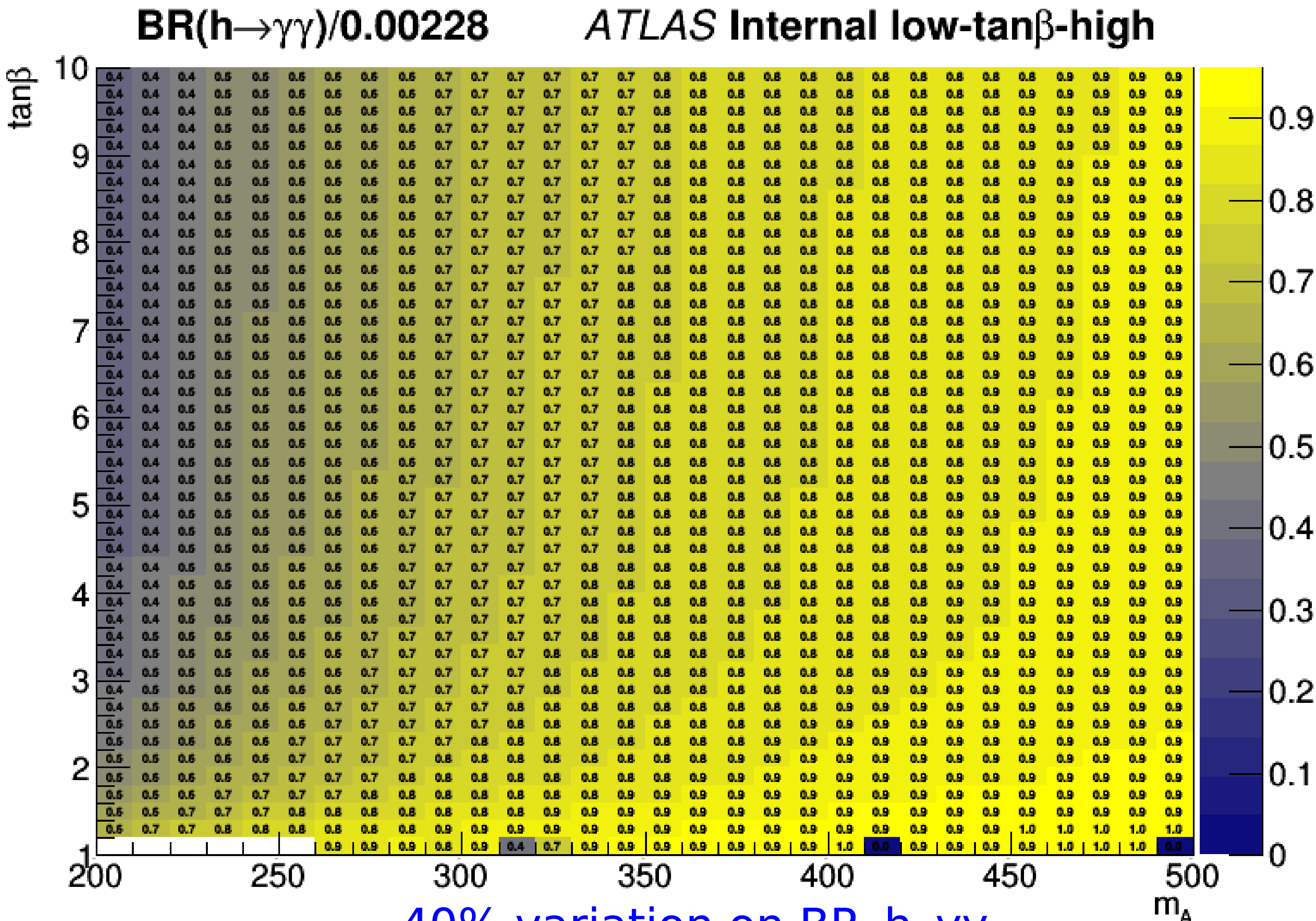
mH has 30% spreading away from mA



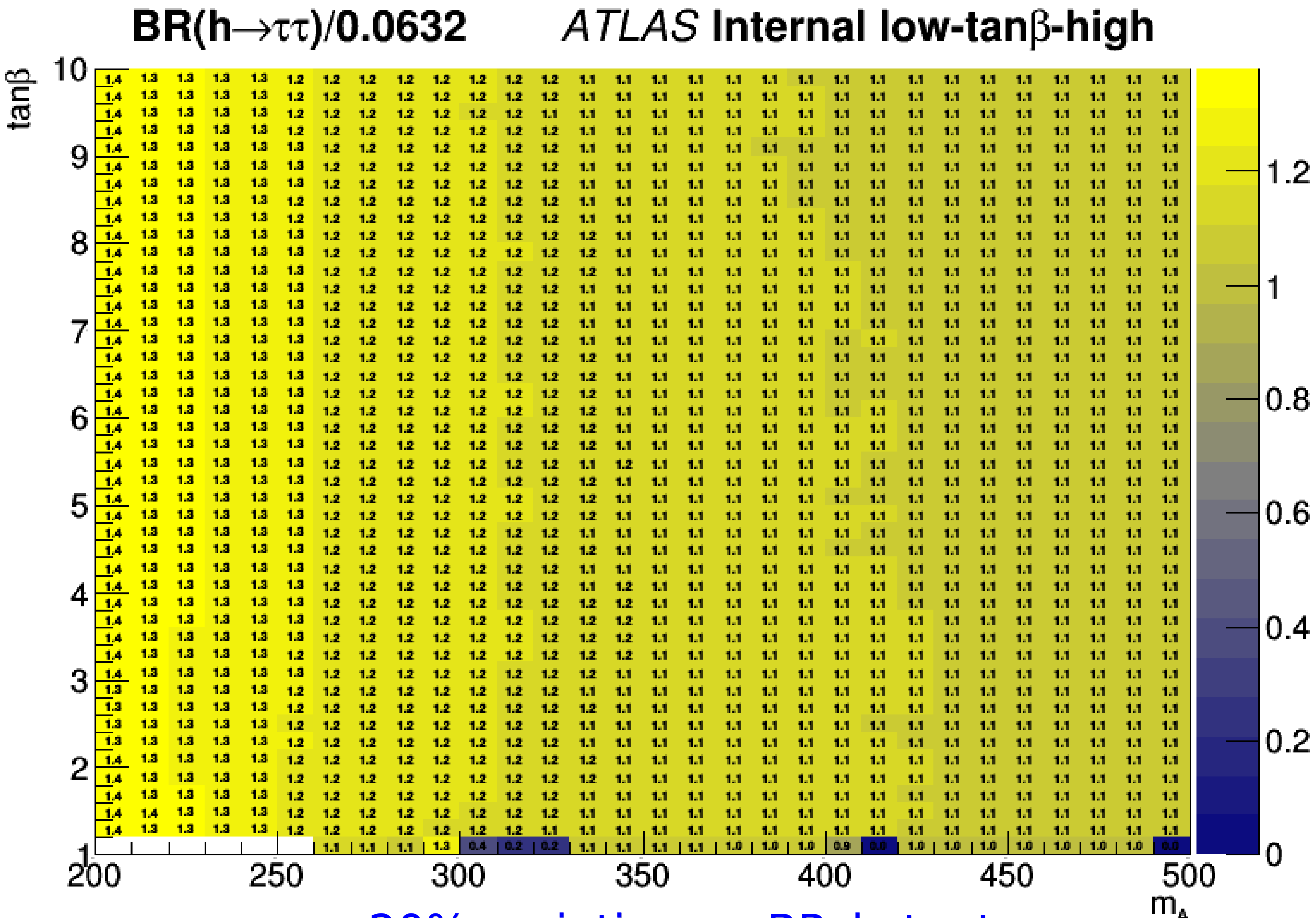
width is very smalle



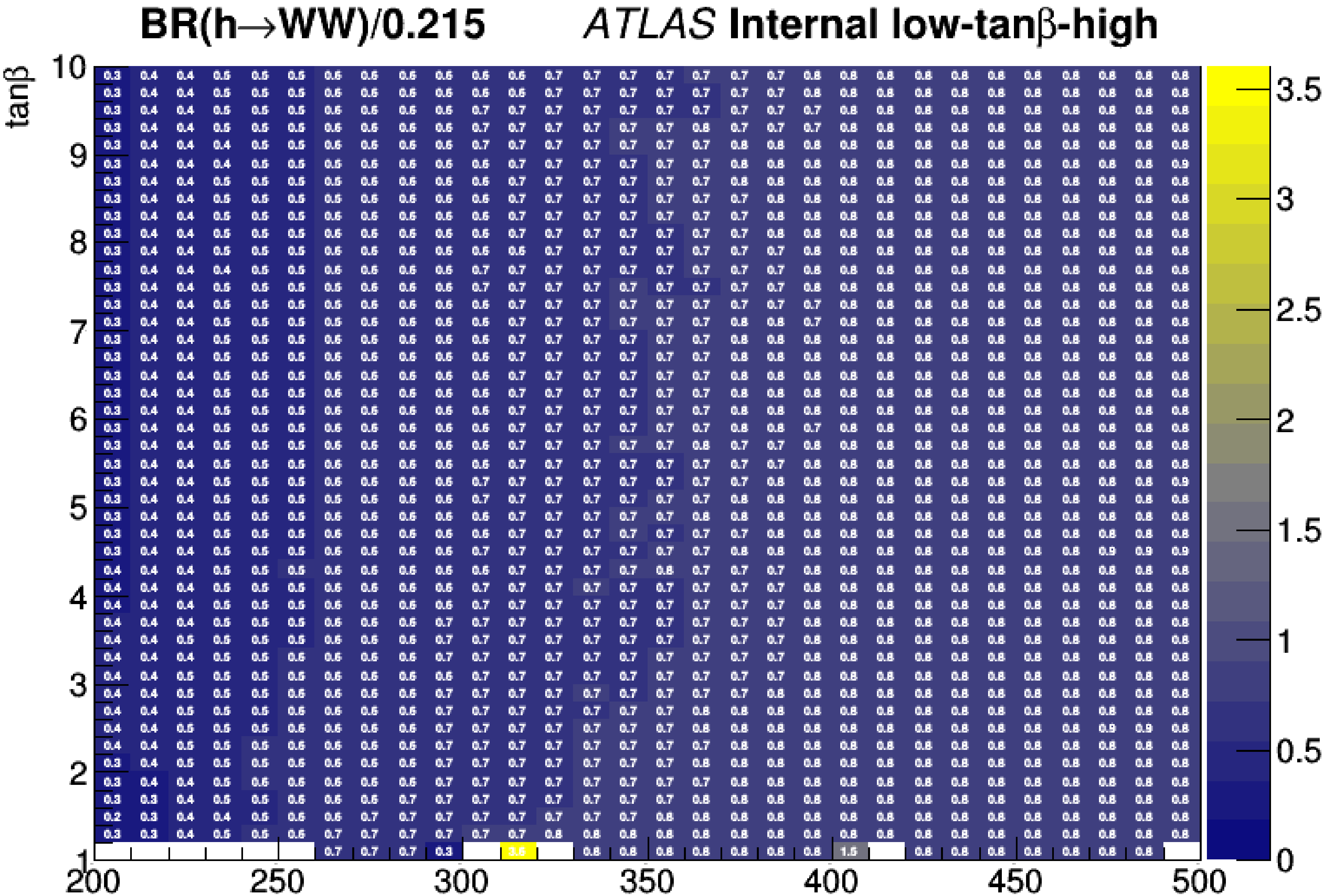
30% variation on BR_h_bb



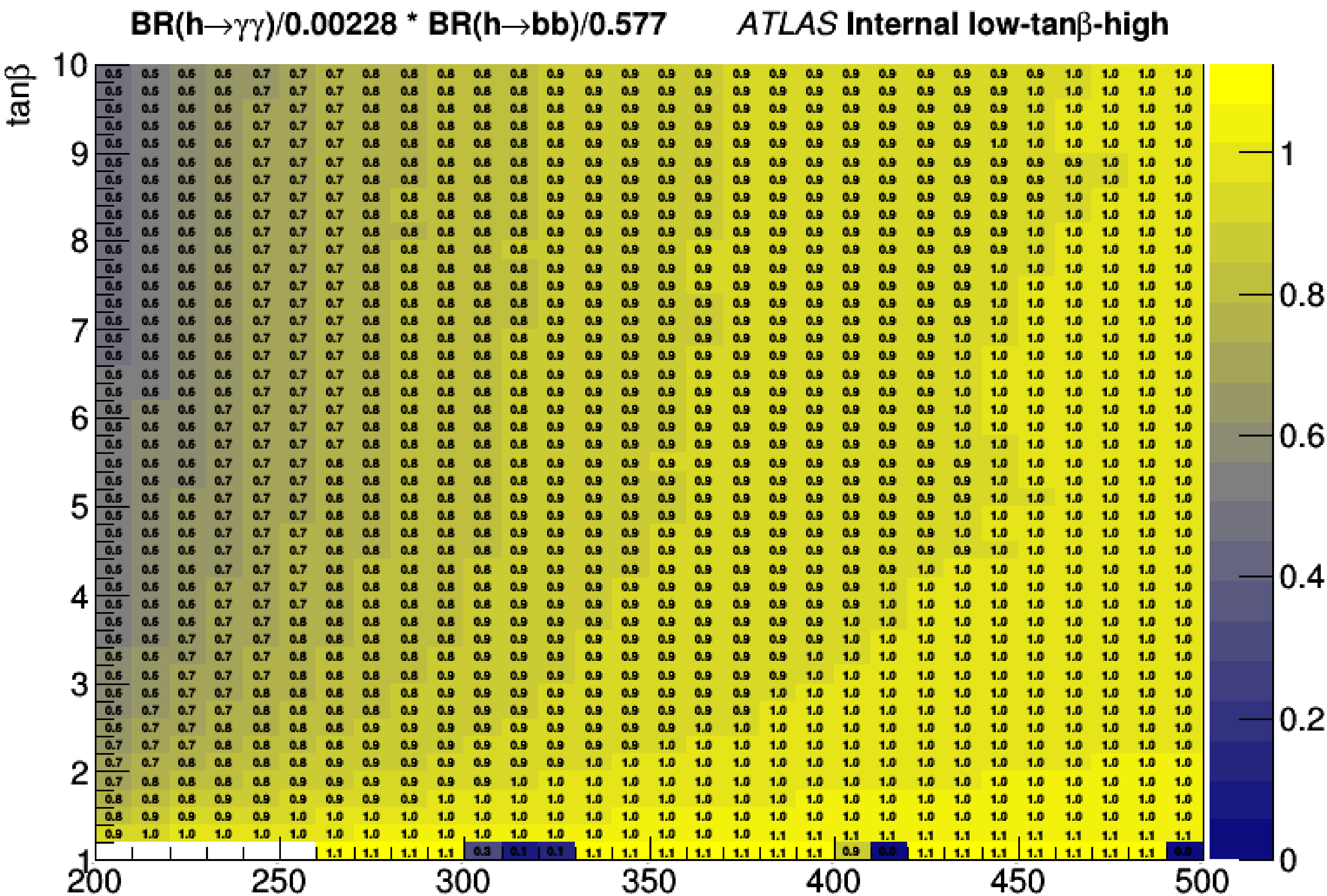
40% variation on BR_h_yy



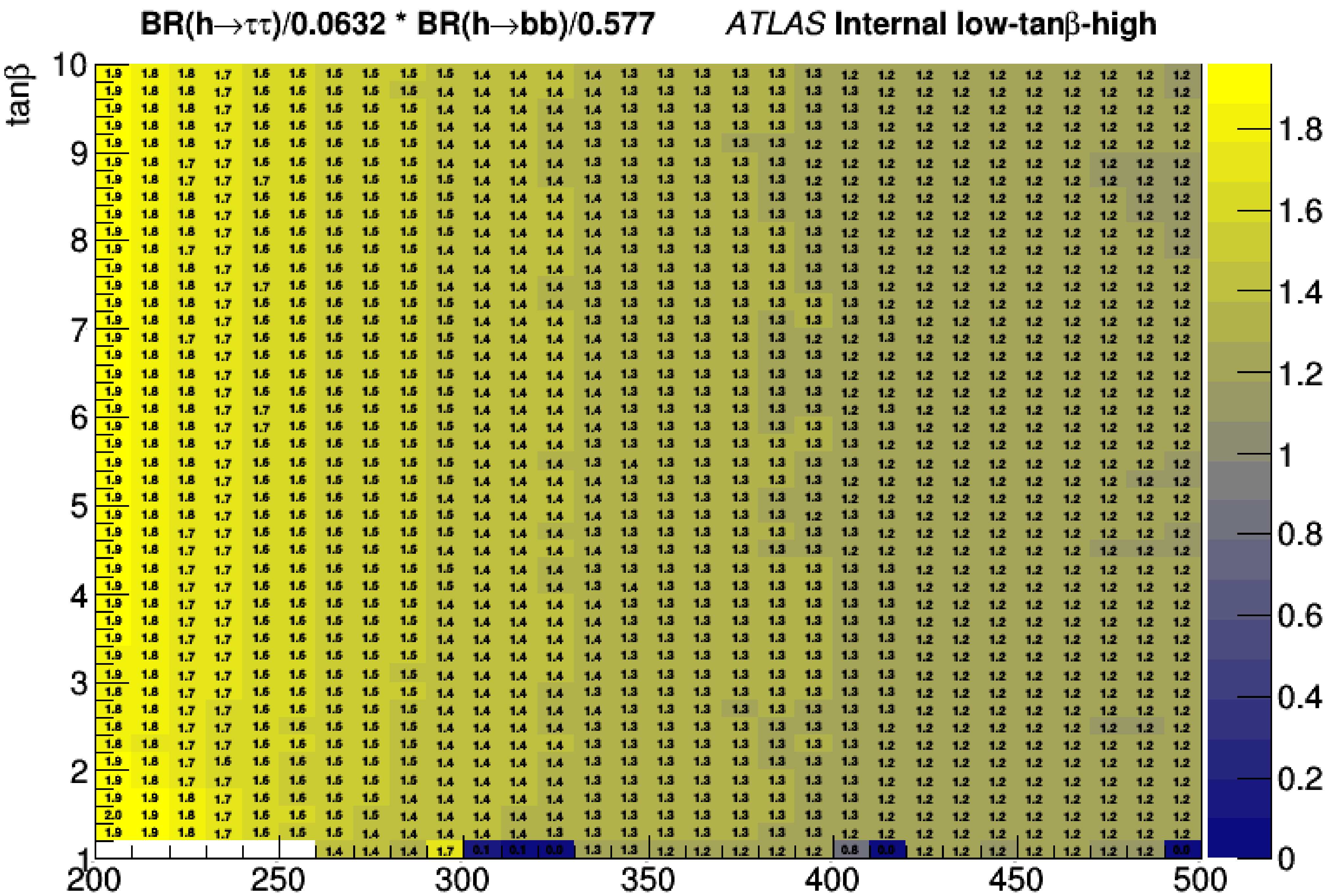
20% variation on BR_h_tautau



40% variation on BR_h_tautau



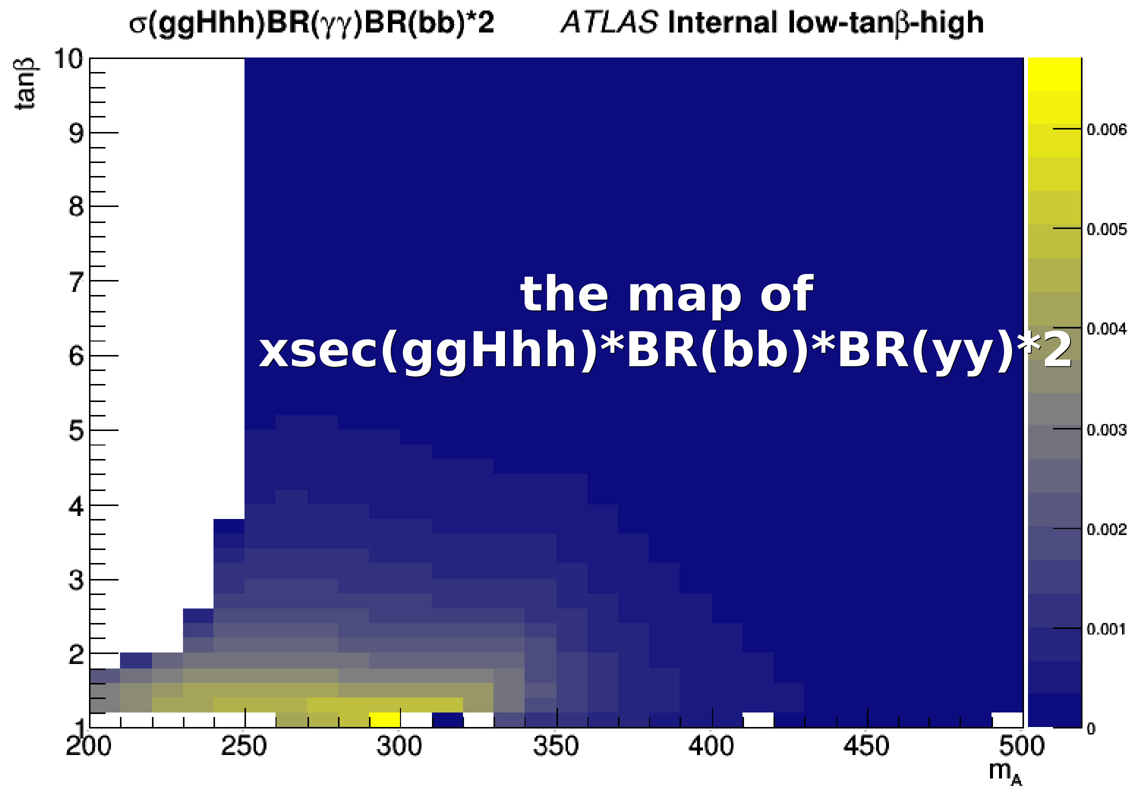
30% variation on BR_h_yy*BR_h_bb

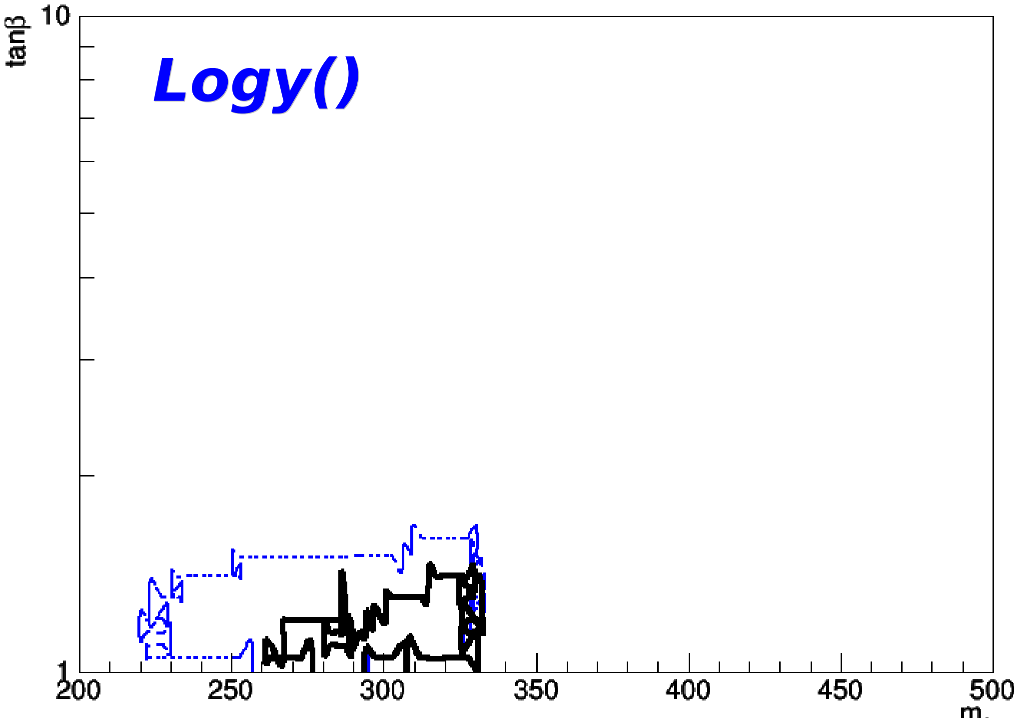


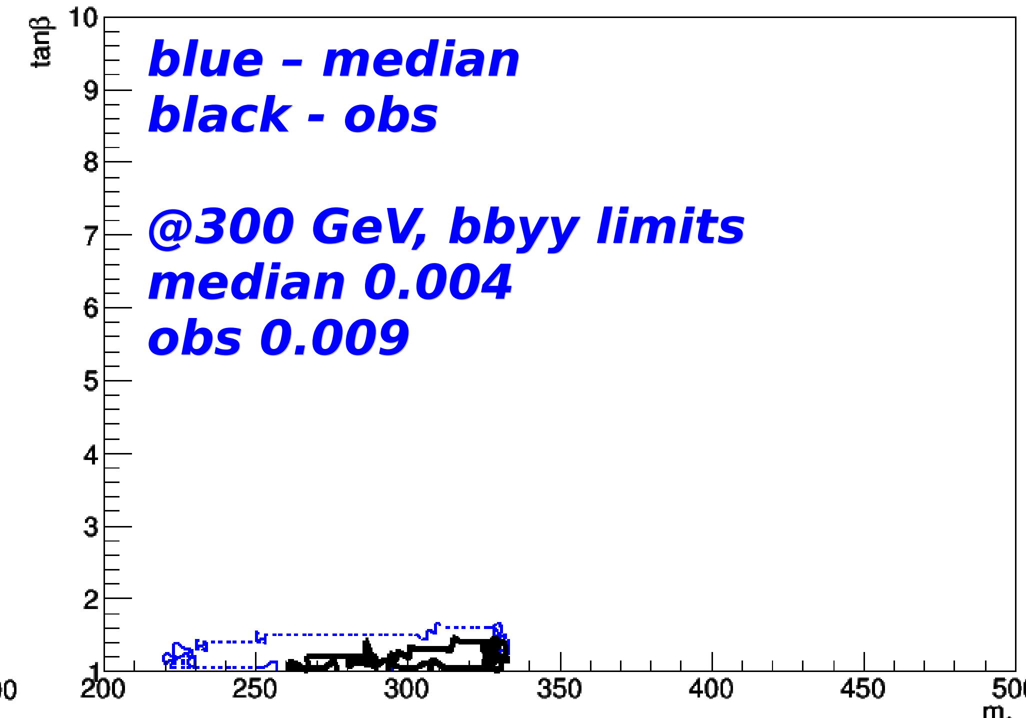
60% variation on BR_h_tautau*BR_h_bb

bbyy exclusions low-tb-high

- make a preliminary exclusion plot for bbyy on the value of xsec(ggHhh)BR(bb)BR(yy)*2
- the exclusion is seen in very low tanb region
- maybe better to use logY

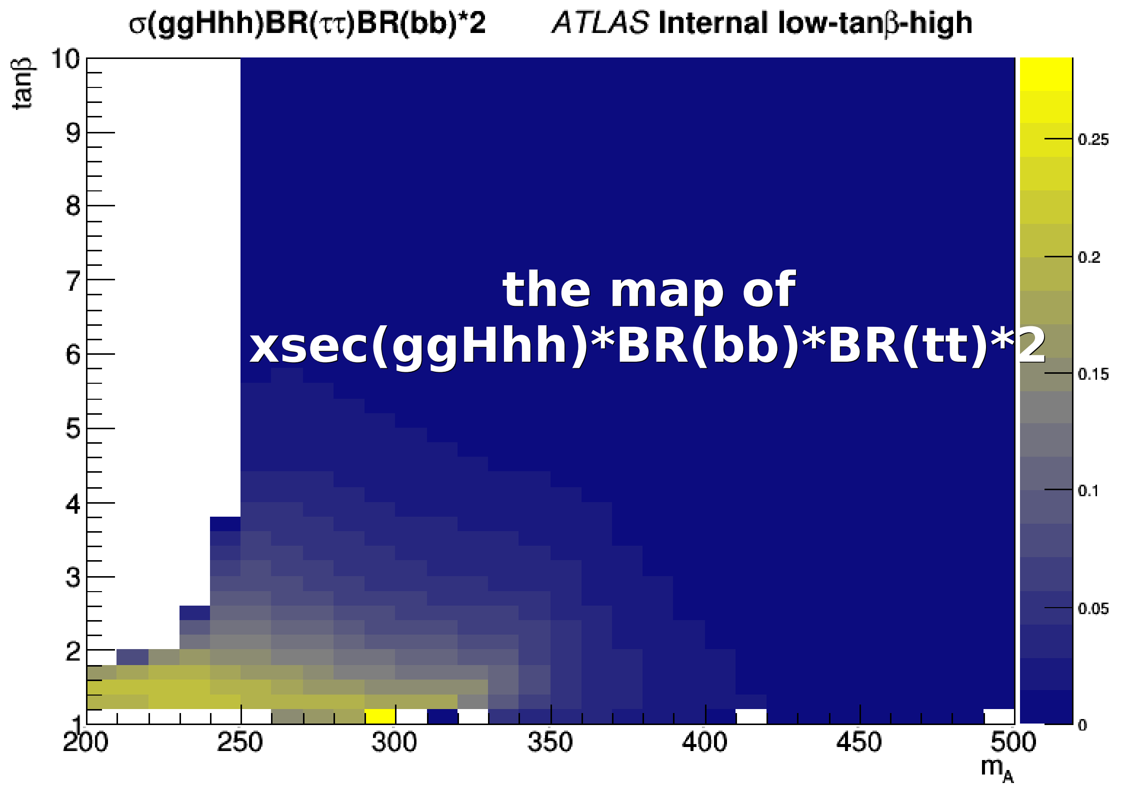


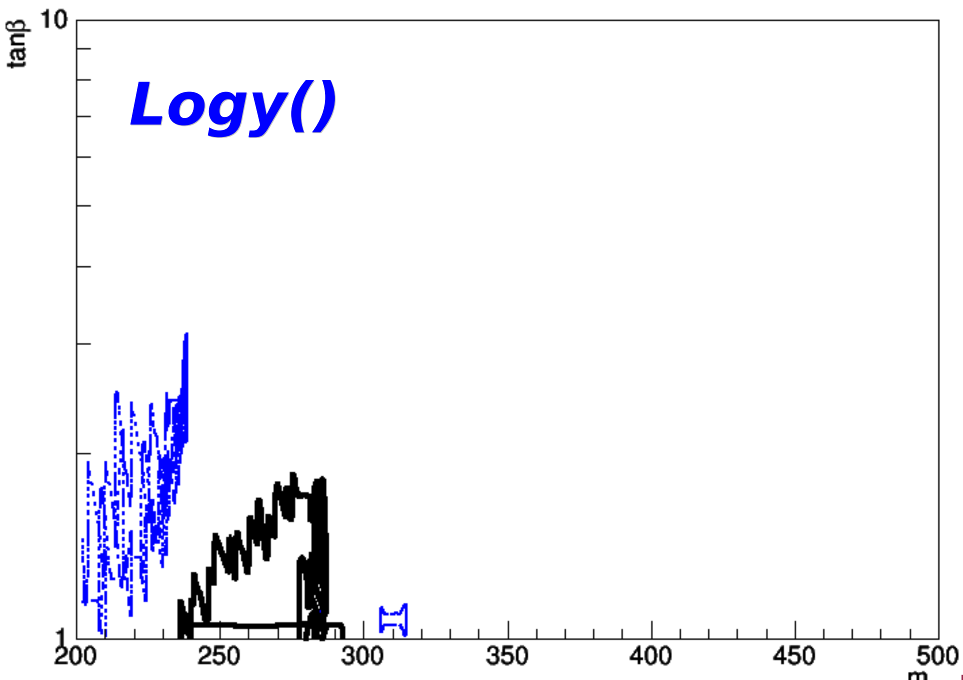


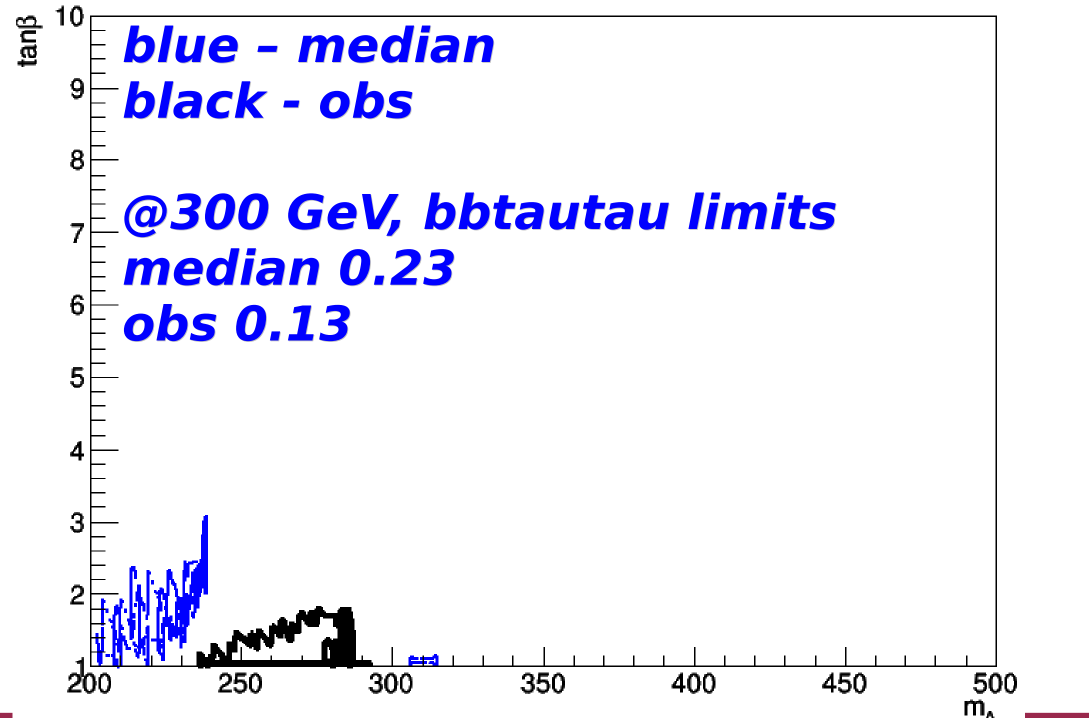


bbtt exclusions low-tb-high

- make a preliminary exclusion plot for bbtautau on the value of xsec(ggHhh)BR(bb)BR(tautau) *2
- the exclusion is seen in very low tanb region
- maybe better to have logY

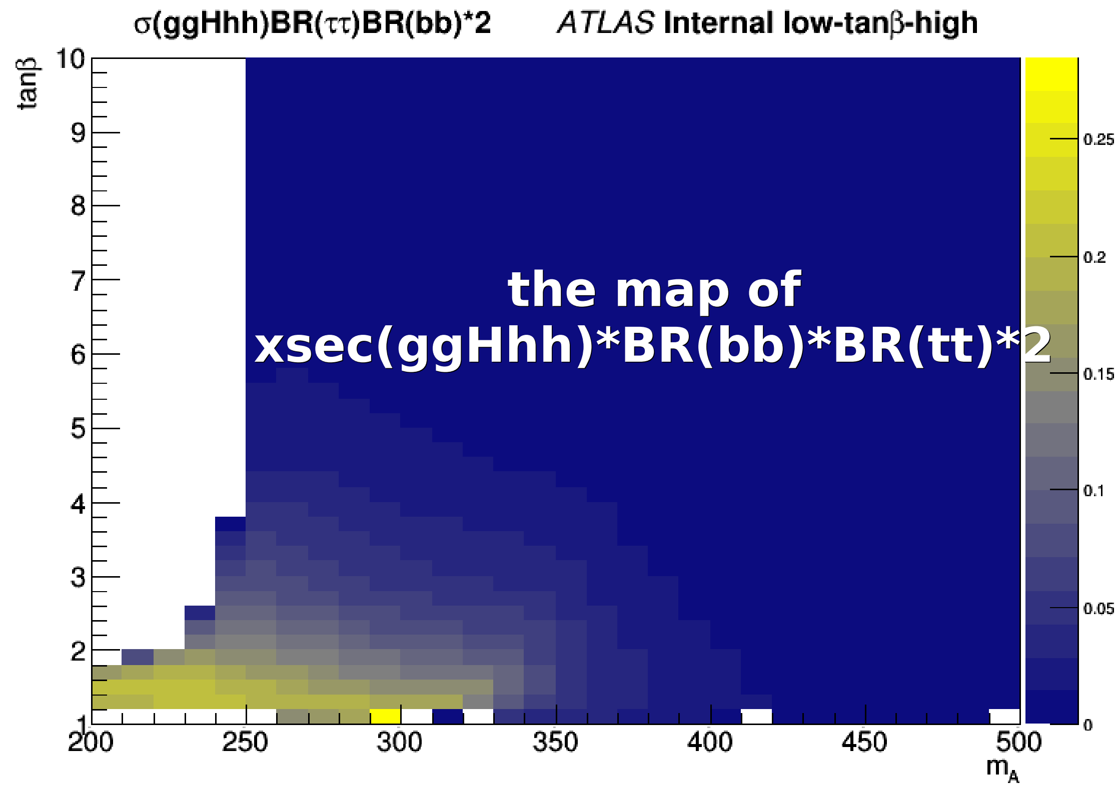


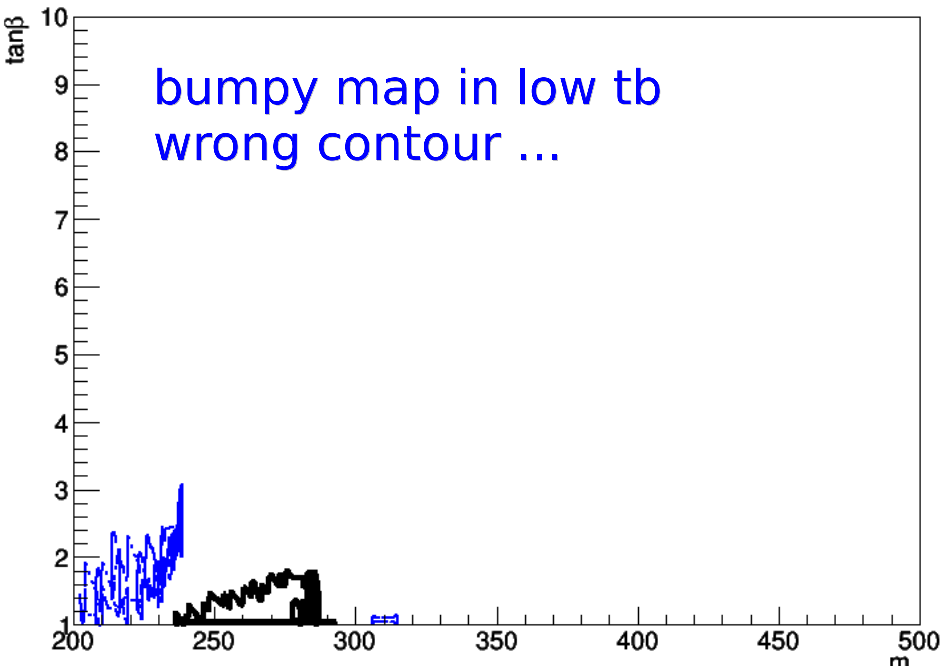


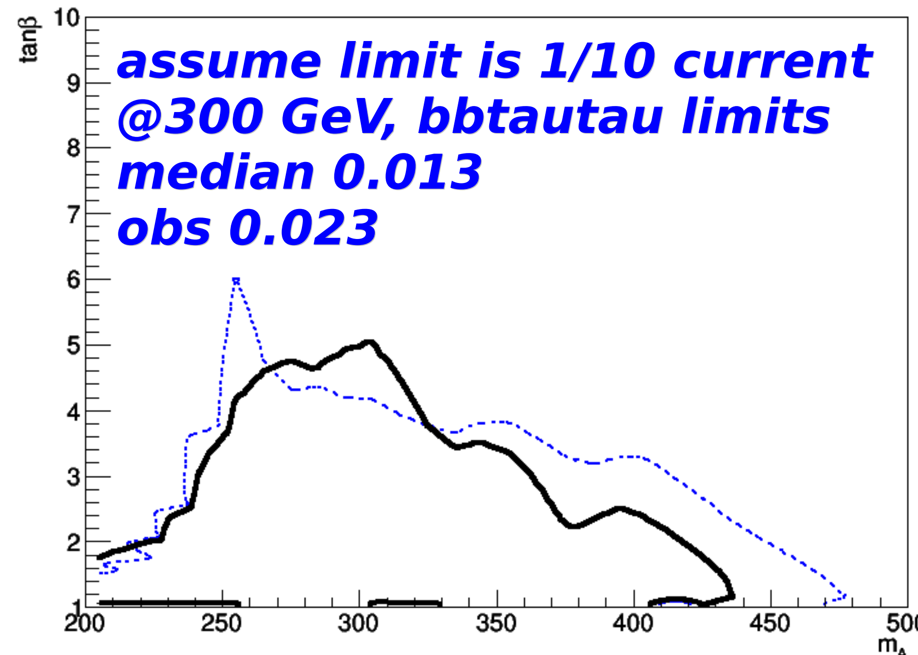


bbtt exclusions low-tb-high

- In very low tb, there are theoretically ***unstable*** phase points -> contour failures ...
- justify the exclusion script itself does not have any problem. assume limit is 10 times better, i.e. 1/10*current limit (plot on the right)







Theoretical uncertainties

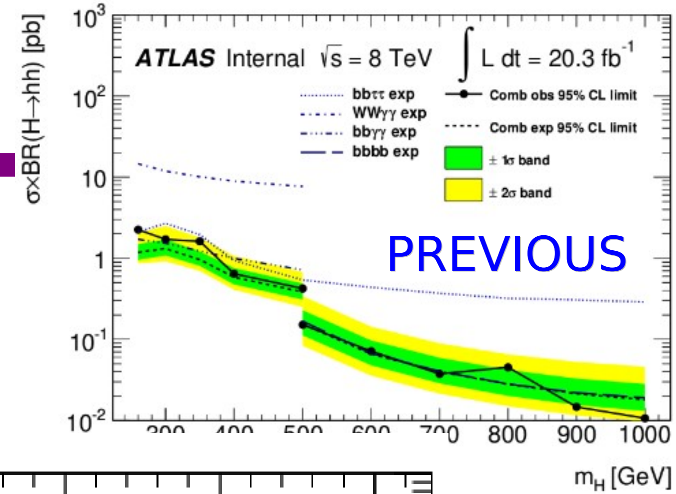
- The uncertainties do not have a specific pattern along mass
- but fluctuation seems to be large
- in agreement to use averaged value in all masses

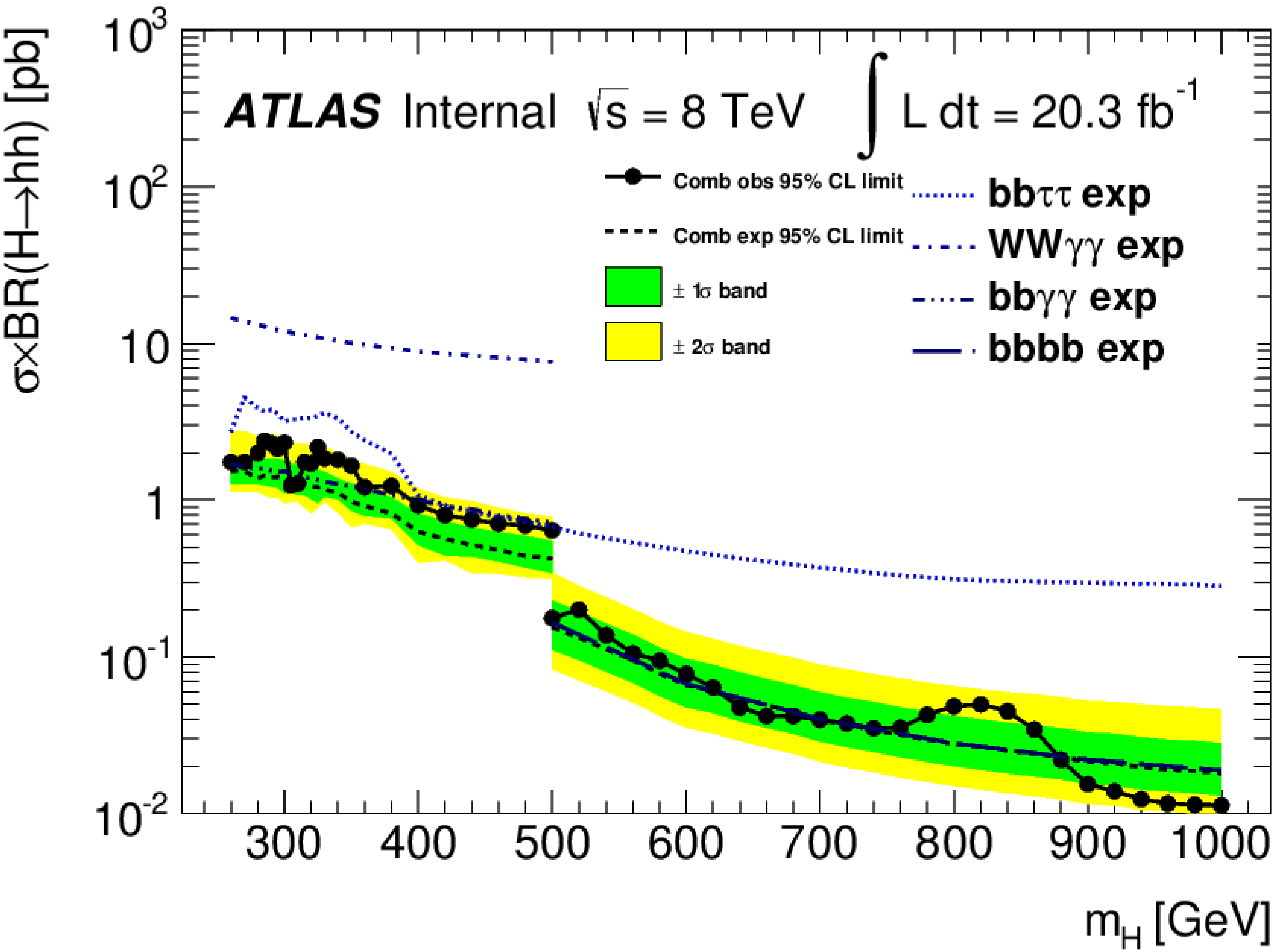
bbtautau	PDF		ISR, SFR		Scale	
	Low	High	Low	High	Low	High
Resonant(260)	1.1	18.2	14.8	54.5	15.2	54.5
Resonant(300)	4.7	8.0	9.9	14.7	10.3	32.0
Resonant(350)	21.6	12.7	36.3	21.7	22.5	30.7
Resonant(400)	20.8	2.3	41.7	14.3	47.9	20.5
Resonant(500)	4.2	2.2	25.0	7.2	33.3	12.6
Resonant(1000)	33.3	5.0	33.3	11.5	33.3	5.2
non-resonant	11.8	3.5	29.4	5.8	39.2	12.7

Mass **wwyy**	260	300	350	400	500	Sm_hh
SCALE	2.2%	2.8%	3.2%	1.6%	2.3%	2.2%
PDF	4.6%	2.7%	7.0%	6.9%	1.9%	4.0%
ISRFSR	6.7%	4.1%	2.7%	3.7%	3.2%	1.7%

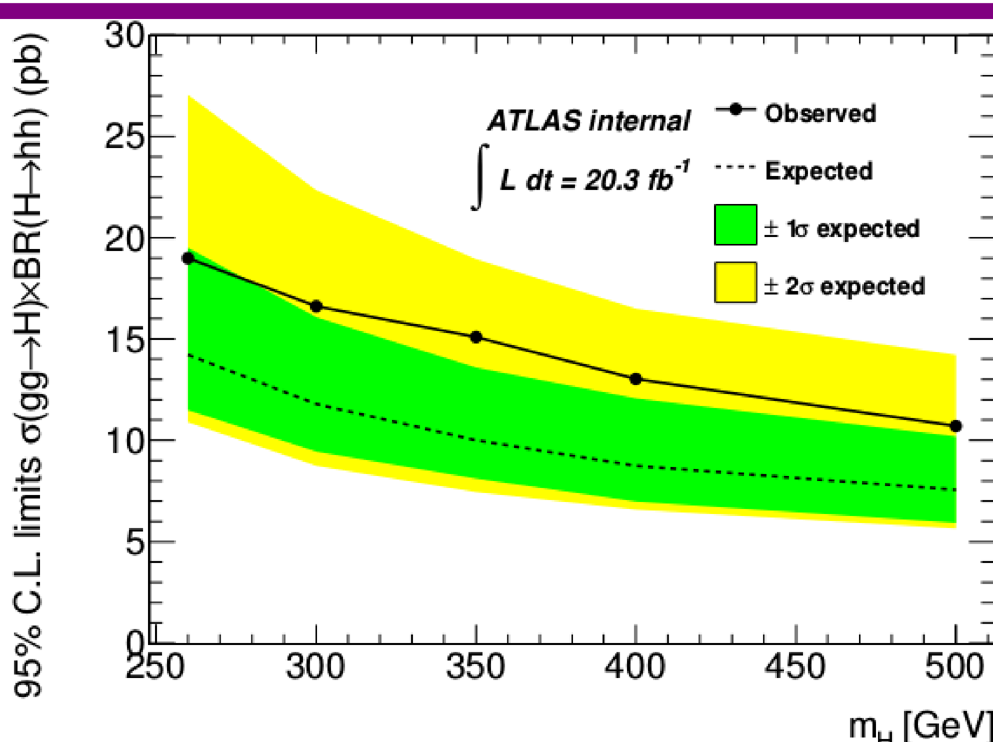
Interpolated mass points

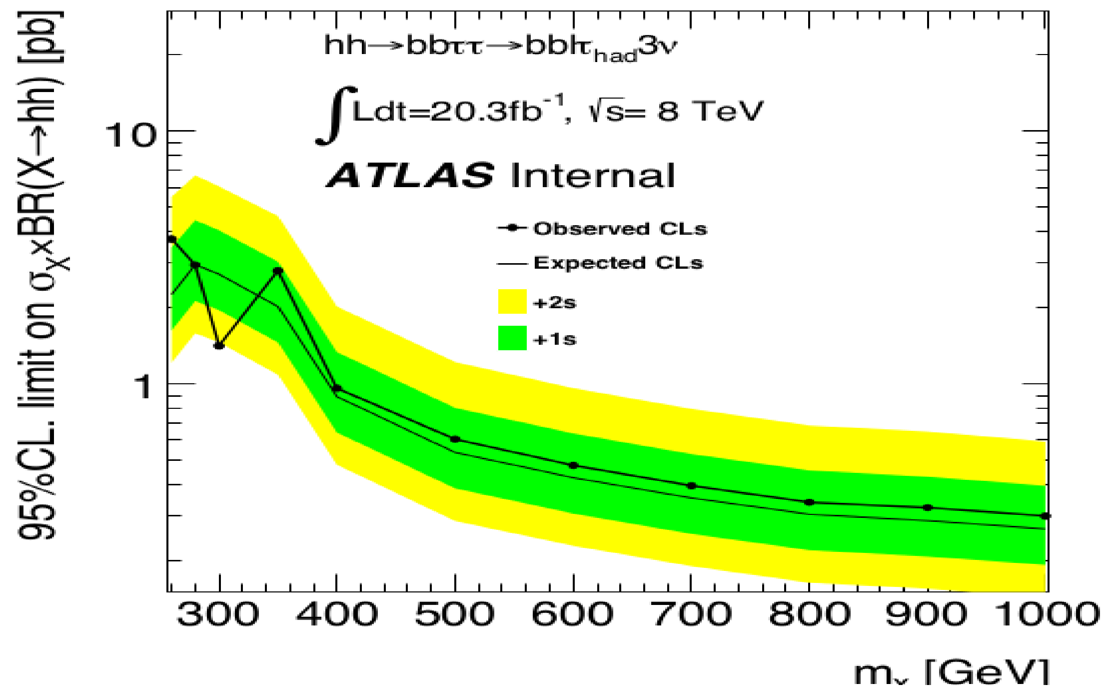
- In both low mass and high mass regions, more mass points are interpolated from available points

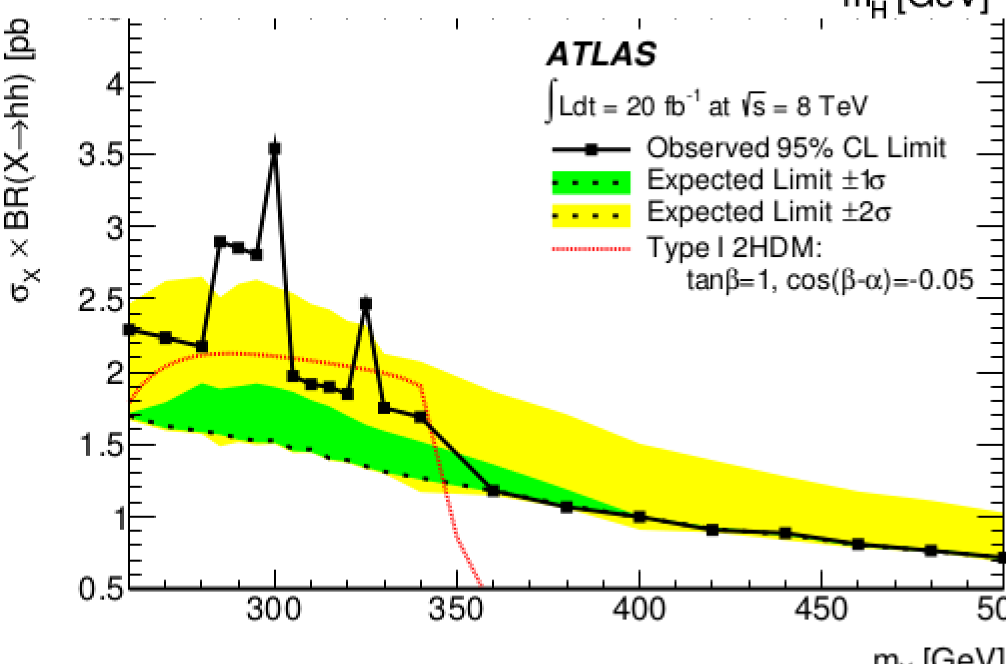


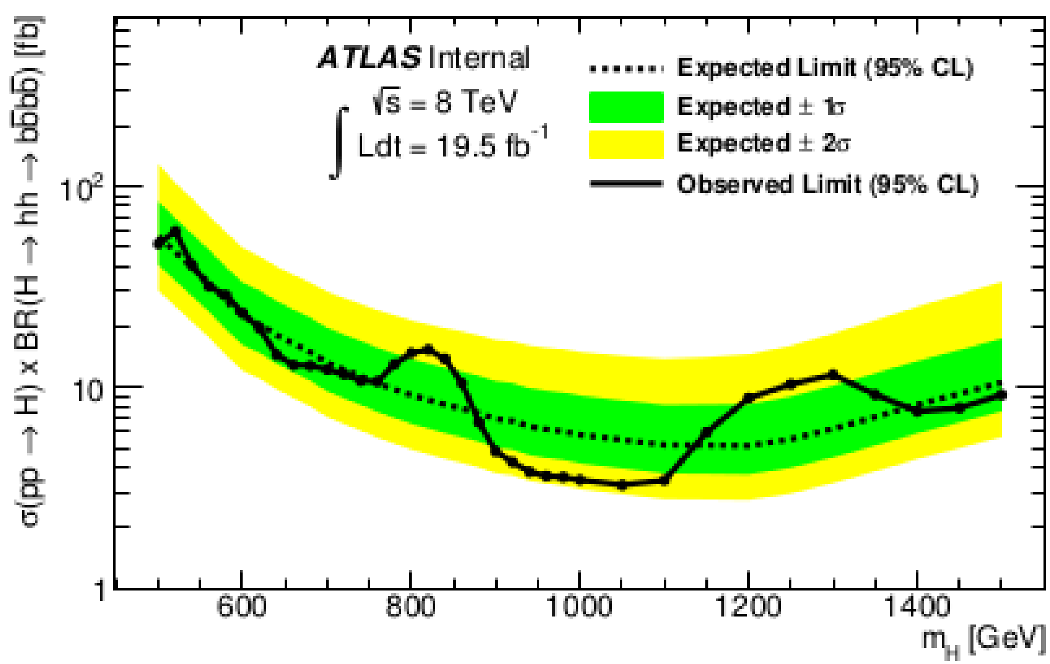


Channel limits [res]

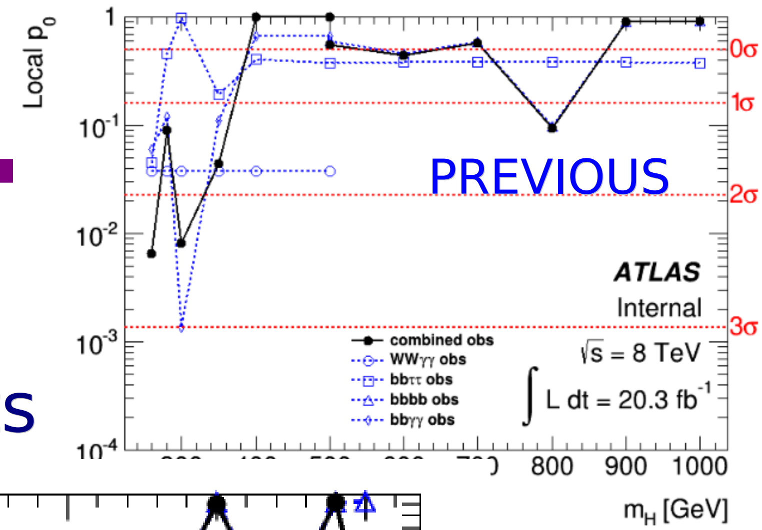




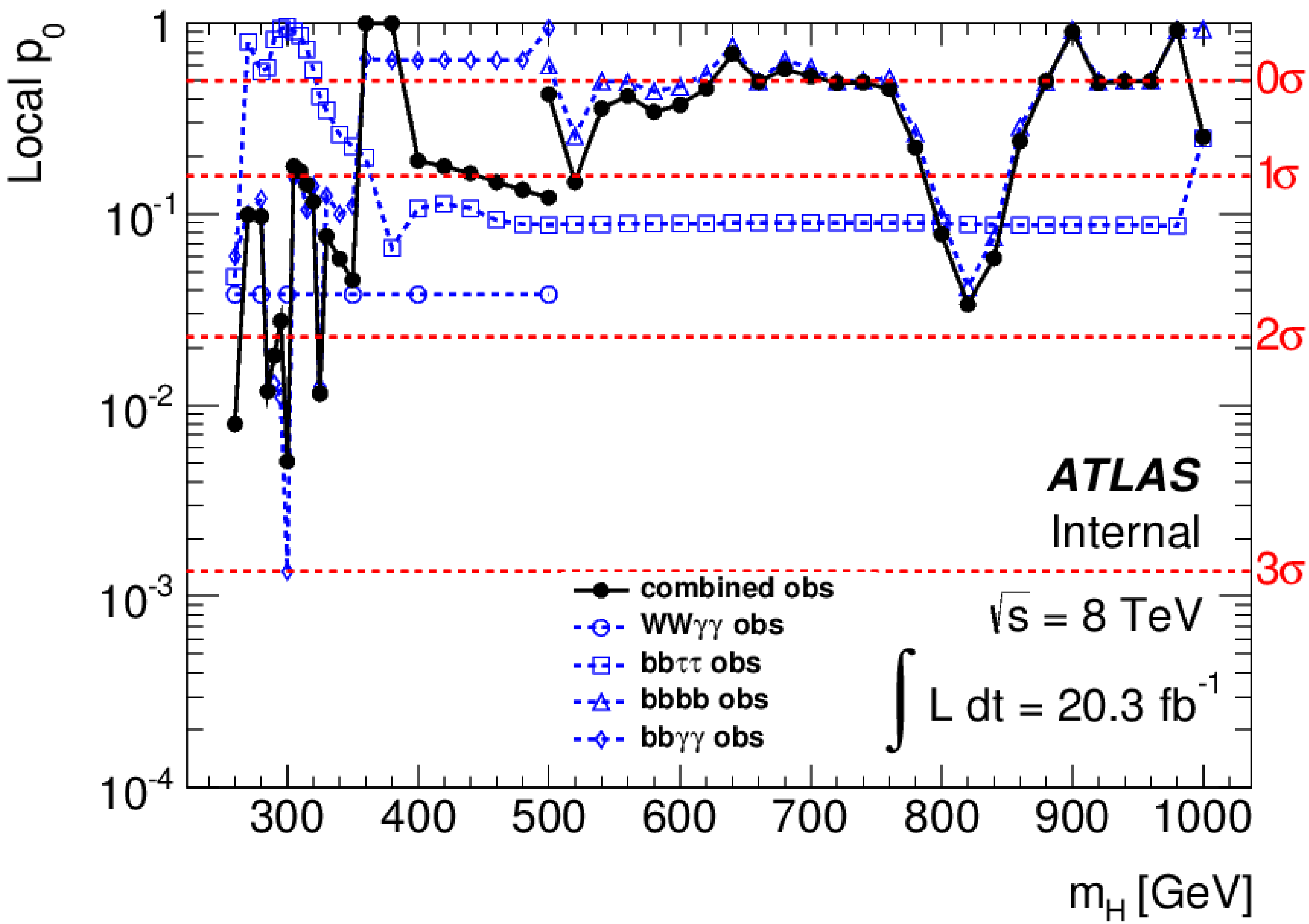




Interpolated mass points



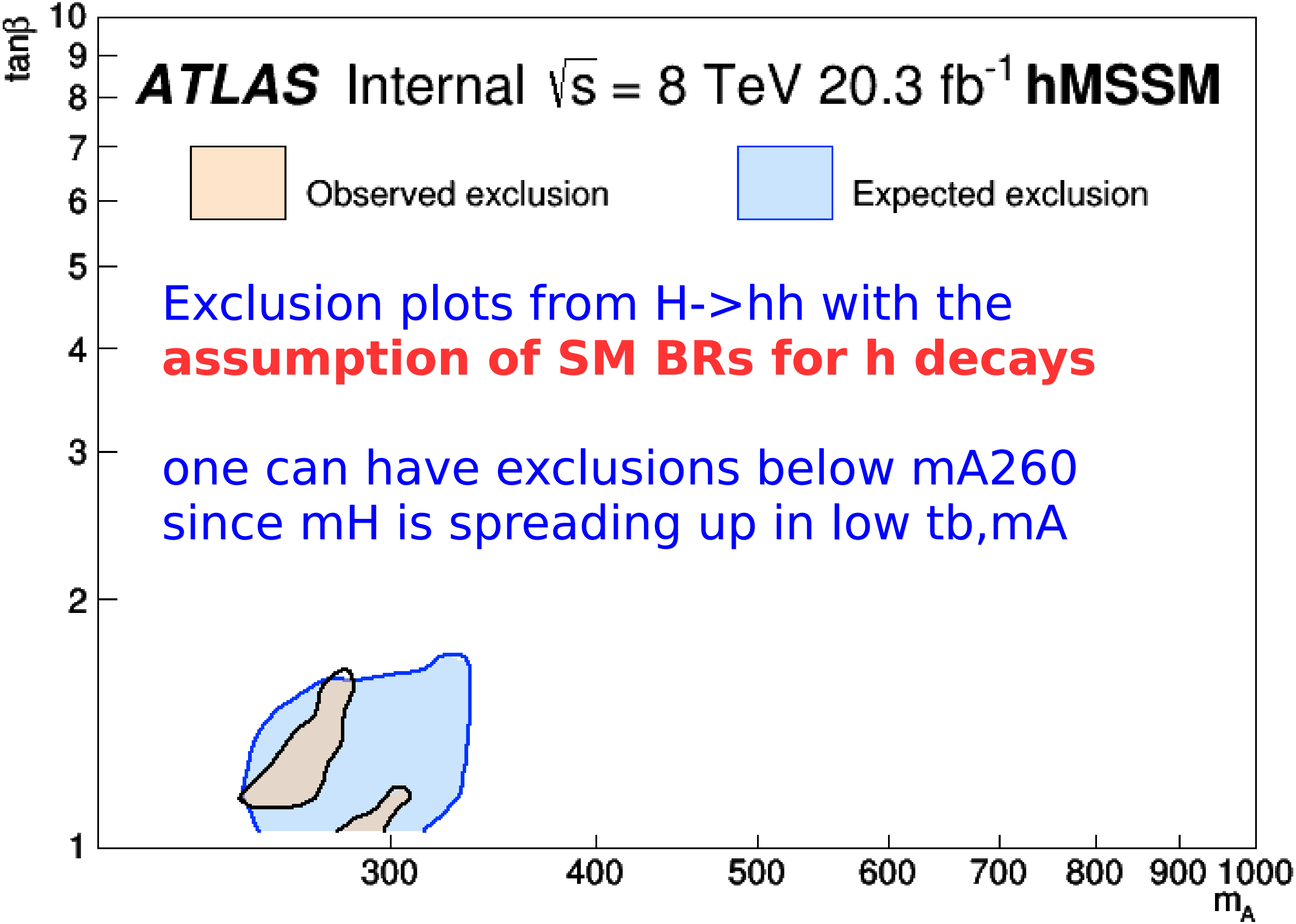
- In both low mass and high mass regions, more mass points are interpolated from available points



Theoretical uncertianties

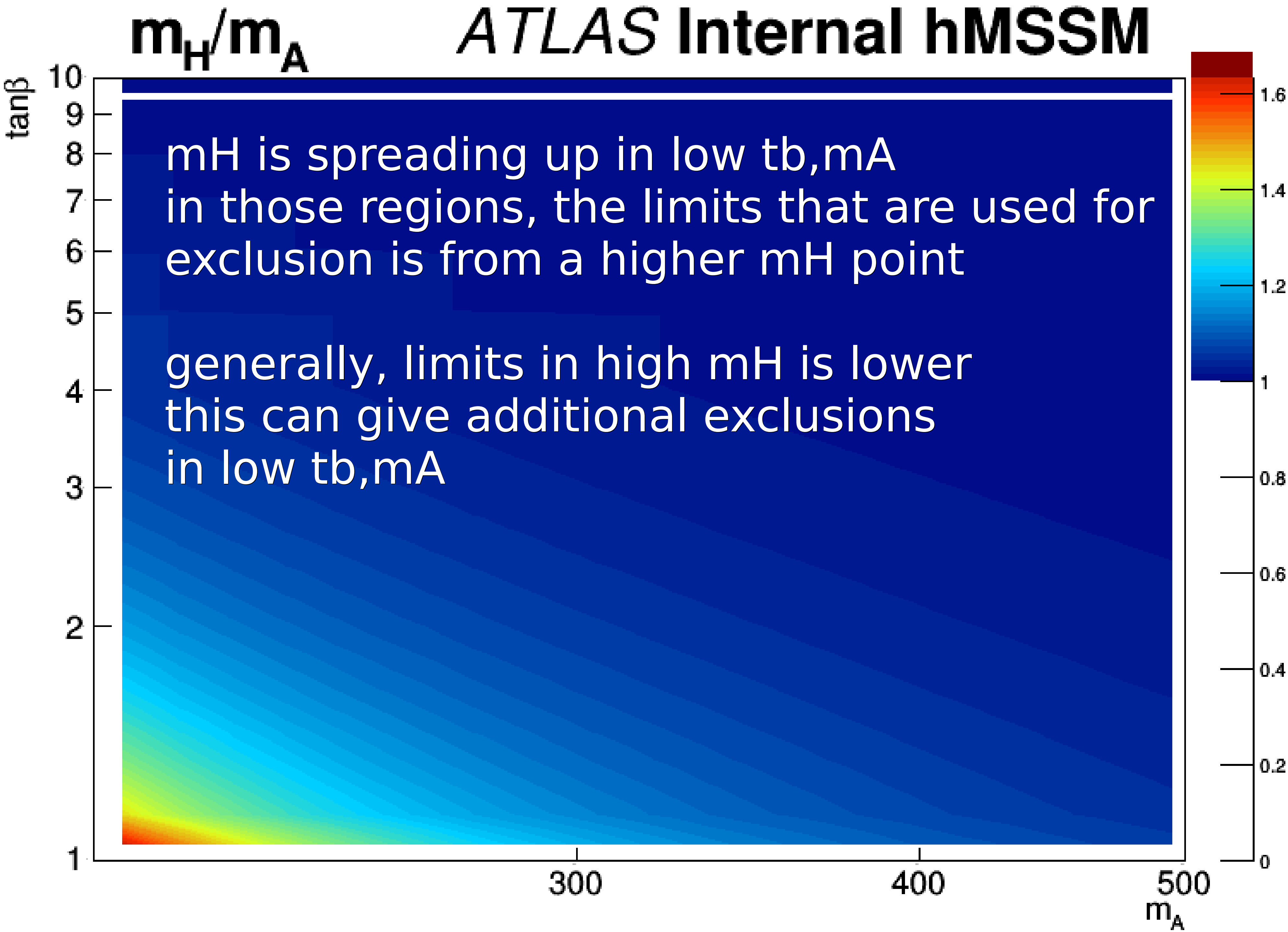
- Theoretical uncertainties are estimated with variations on PDF/scale/radiation → three nuisance parameter are created for them respectively
- For PDF uncert, compare MSTW2008lo68 and NNPDF to nominal sample cteq6l1
- For factorization/renormalization uncert, compare
  - cteq6l1_facDn_renDn
  - cteq6l1_facNo_renDn
  - cteq6l1_facUp_renNo
  - cteq6l1_facDn_renNo
  - cteq6l1_facNo_renUp
  - cteq6l1_facUp_renUp
- For ISR/FSR uncert, compare isr_up/dn and fsr_up/dn

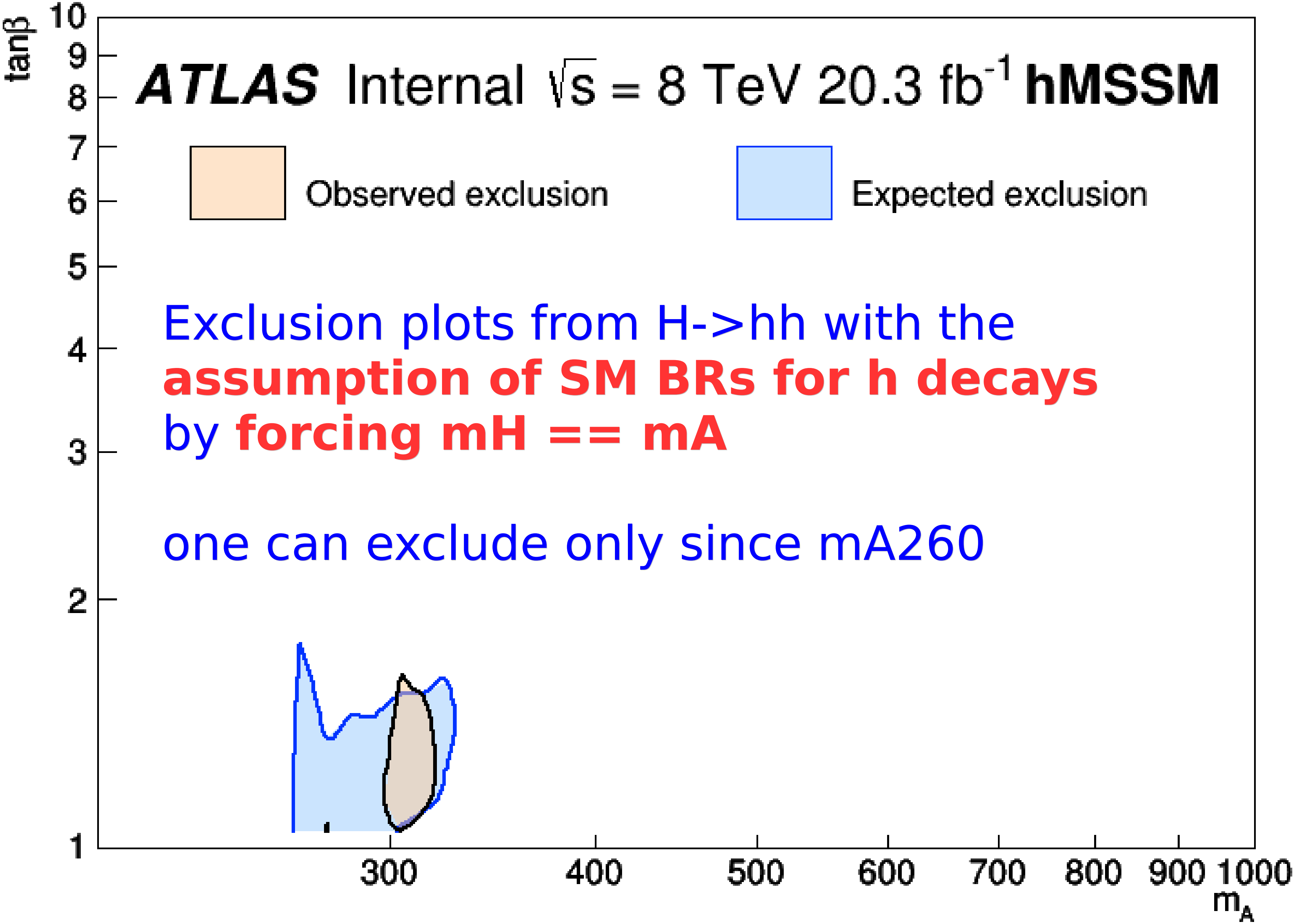
  * all follows instructions from Paul T as used in AZh



Exclusion plots from H->hh with the **assumption of SM BRs for h decays**

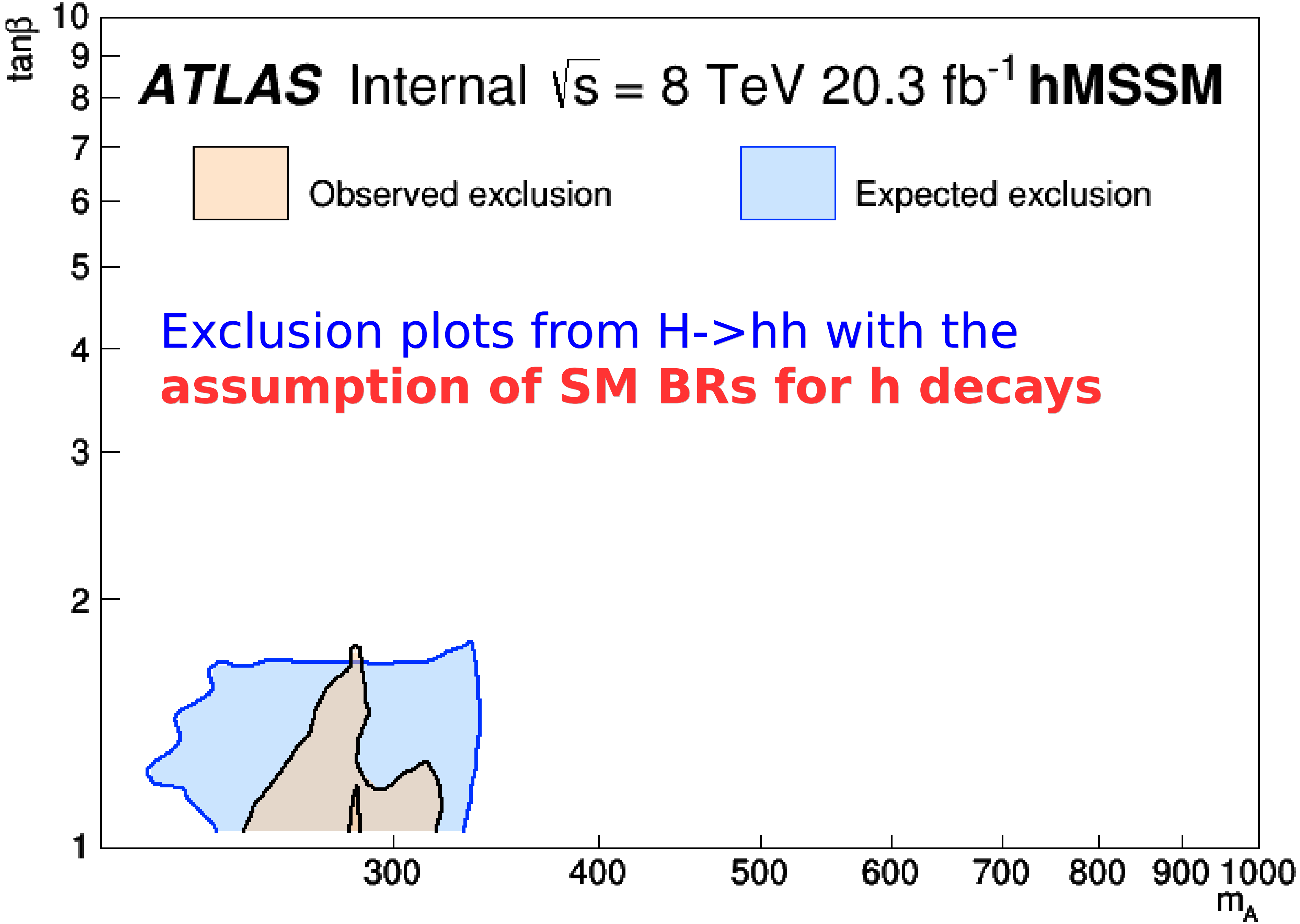
one can have exclusions below mA260
since mH is spreading up in low tb,mA


m_H/m_A
ATLAS Internal hMSSM
tanβ
m_A
mH is spreading up in low tb,mA
in those regions, the limits that are used for
exclusion is from a higher mH point
generally, limits in high mH is lower
this can give additional exclusions
in low tb,mA



Exclusion plots from H->hh with the **assumption of SM BRs for h decays** by **forcing mH == mA**

one can exclude only since mA260



https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HXSWG3LowTanB