HH pair searches

combination with wwyy, bbyy, bbττ, bbbb

Xiaohu SUN
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18-05-2015
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/

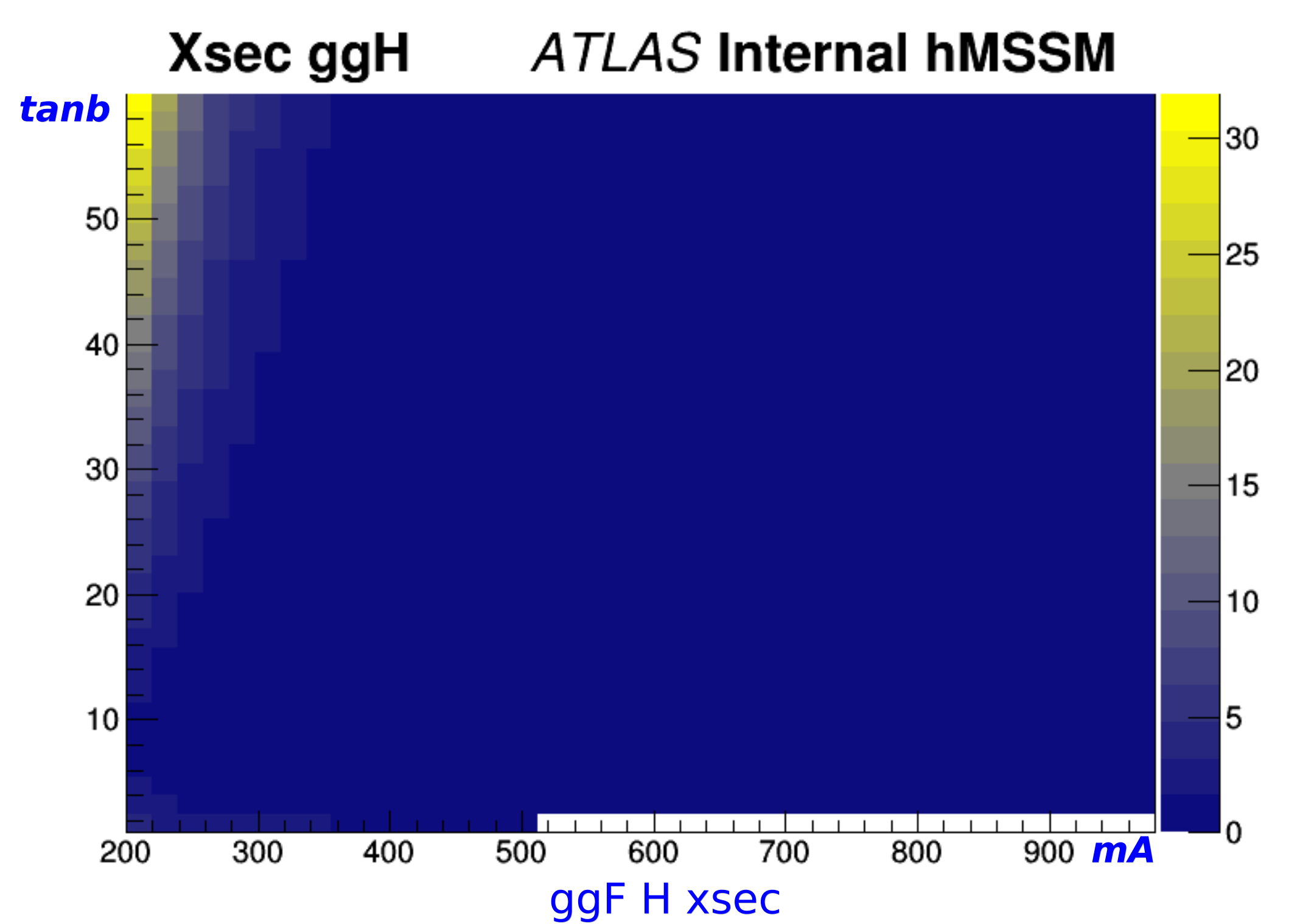
Theoretical uncertianties - HH

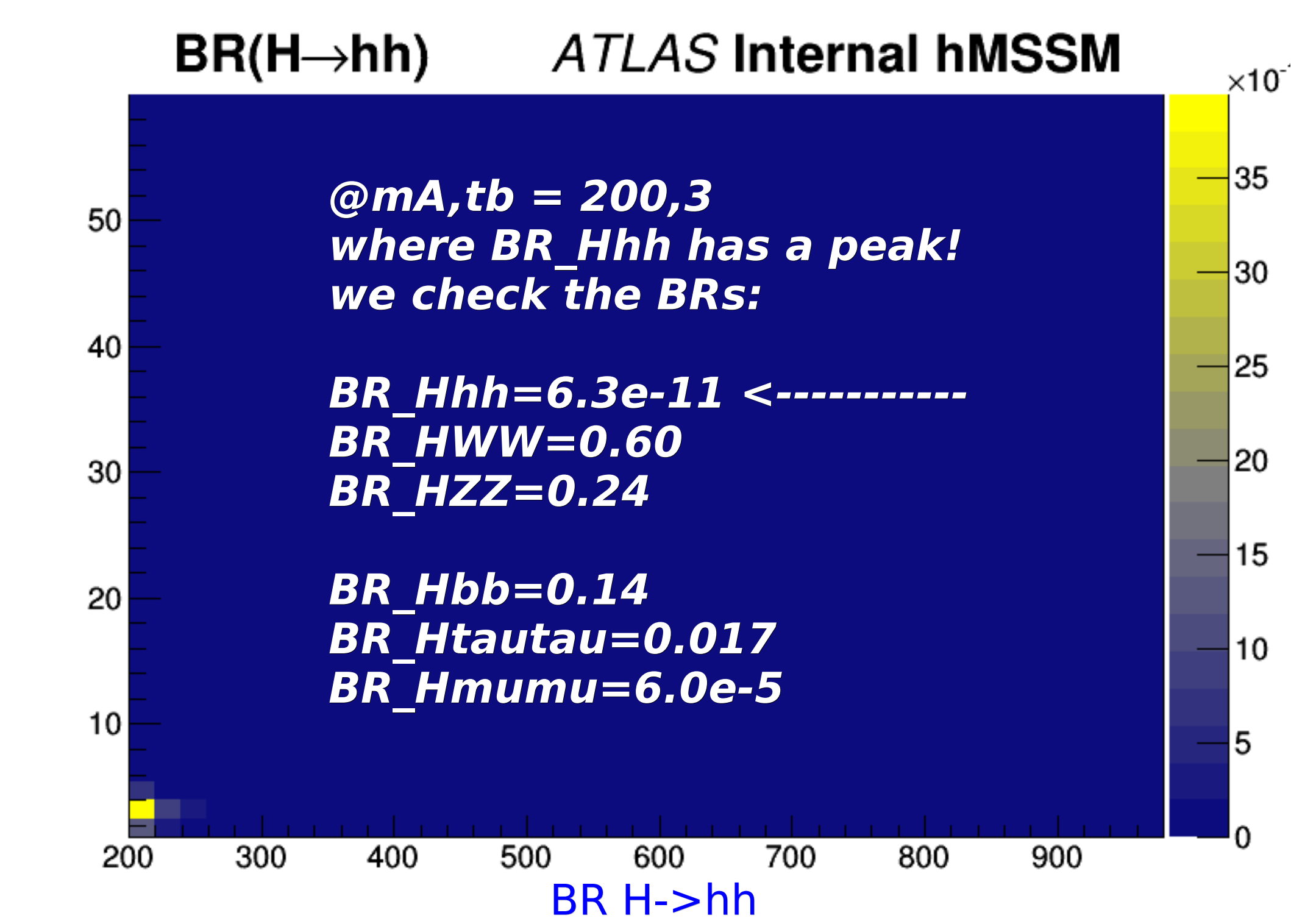
- Theoretical uncertainties estimated with variations on PDF/scale/radiation are being reproduced with a larger number of events
- Procedures are not changed since last time
- MG5 only work when an terminal is active (gridpack mode is not explored from me), so the production locally on lxplus did go slowly due to unstable connections
- Now we produced **1.2M** events -> **10** times of the the statistics of last time
- /afs/cern.ch/work/x/xiaohu/public/HH-TheoUncer/
- NNPDF is being merged manually due to a bug in old version MG5

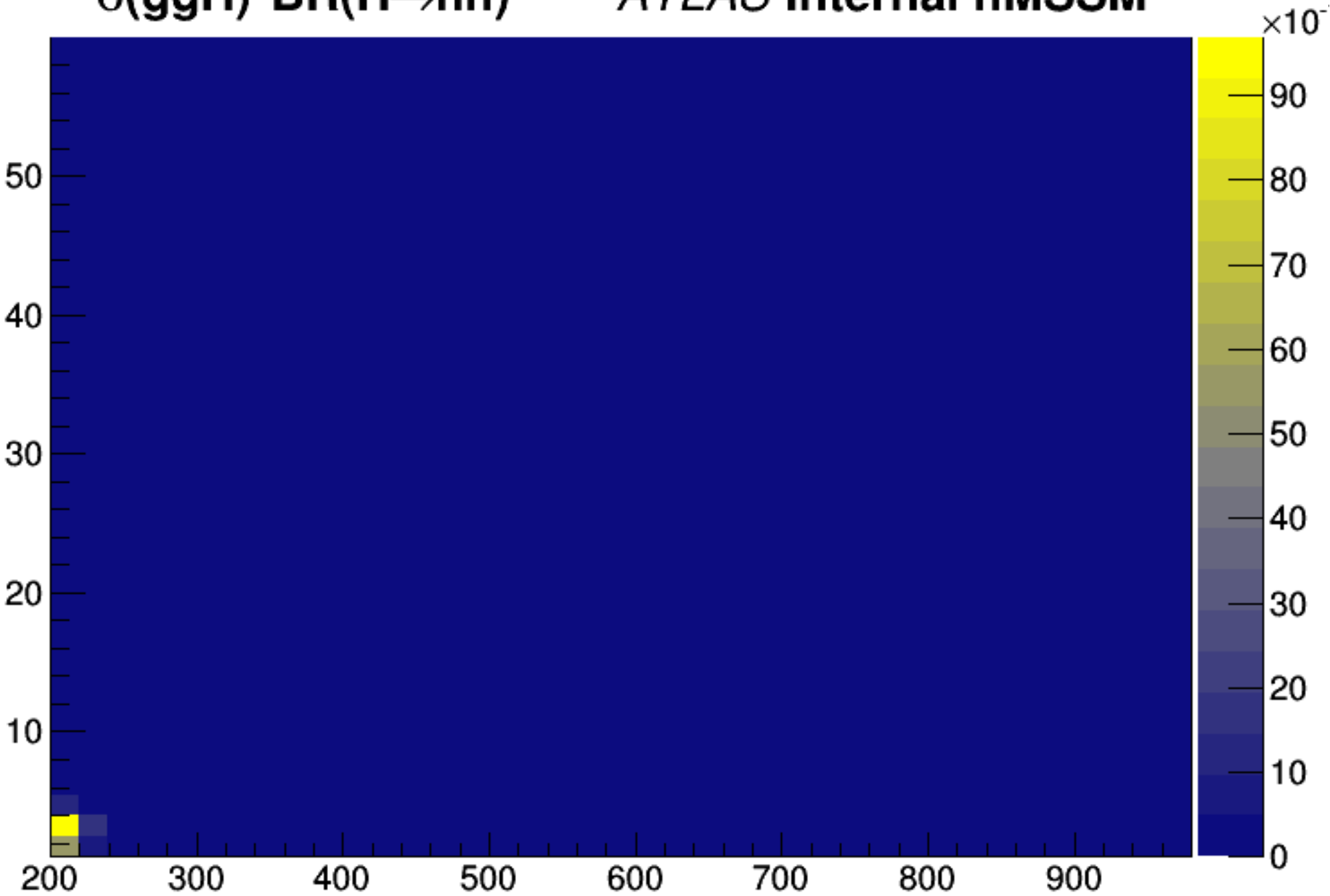
* all follows instructions from Paul T as used in AZh

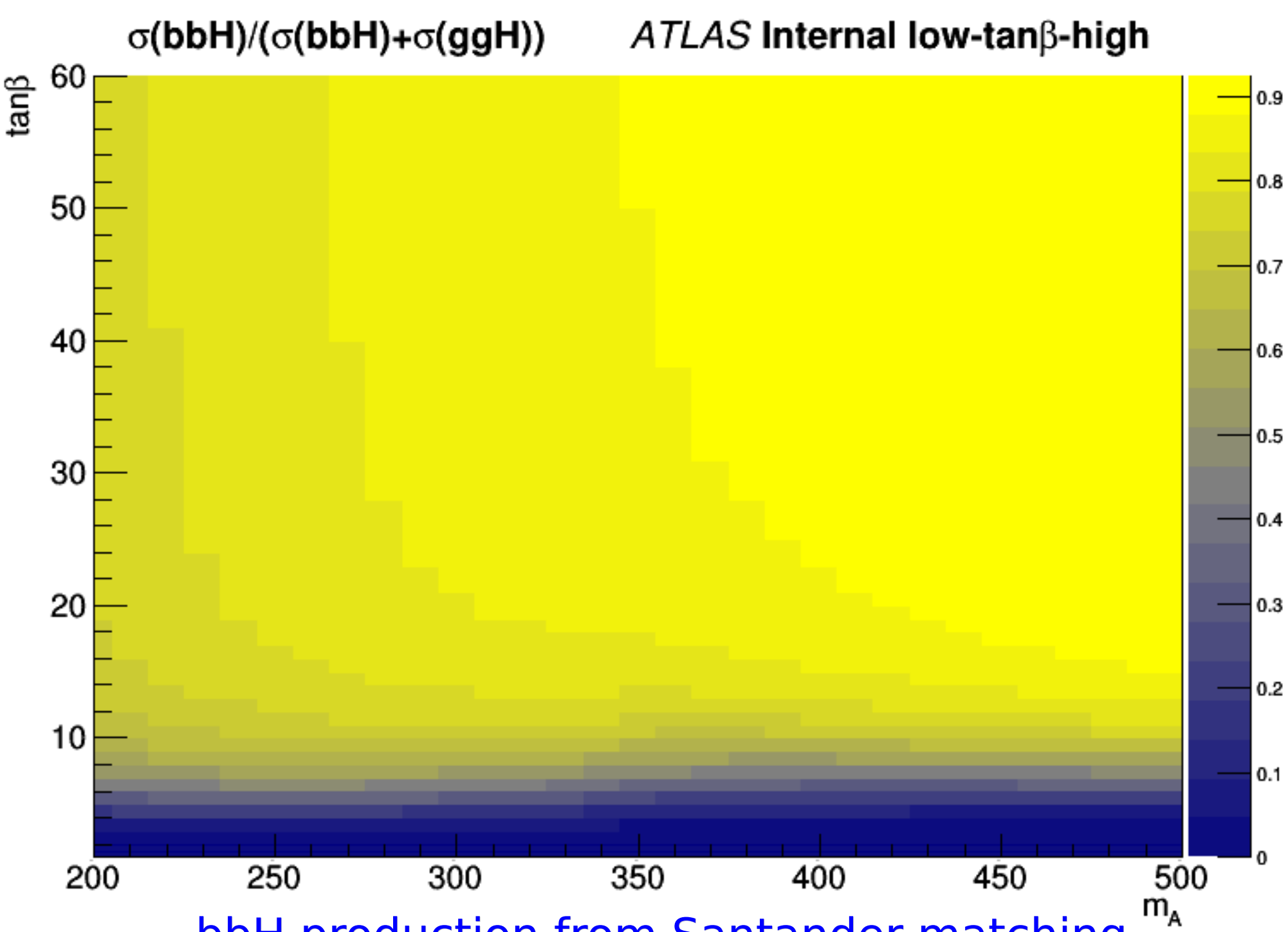
hMSSM Interpretation

- Many thanks to Nikos and Allison, we have **a new map file** for hMSSM last week
- Reported by Nikos, the only problem is that tb=0.9 has zero cross section and the grid is not enough for the low tb extrapolation
- Reported from me, strangely small BR_H_hh, because BR_H_AA is mistakenly stored instead of BR_H_hh
- This week, there might be another map file fixing the problems above; but the current one is reliable for preliminary checking on xs, width, BR etc.

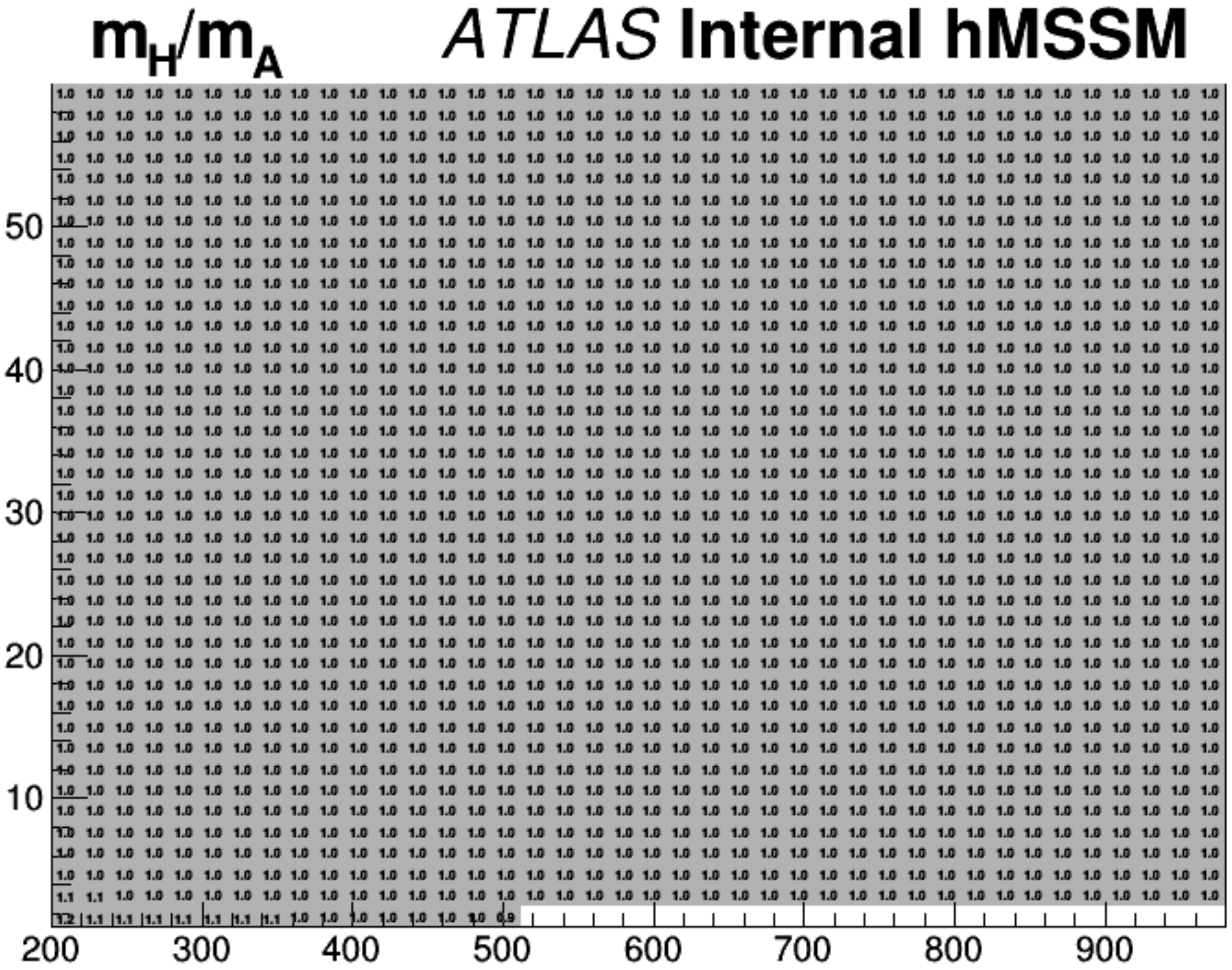

Xsec ggH
ATLAS Internal hMSSM
tanb
50
40
30
20
10
200
300
400
500
600
700
800
900
mA
30
25
20
15
10
5
0
ggF H xsec


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
50
40
30
20
10
200
300
400
500
600
700
800
900
35
30
25
20
15
10
5
0
BR H->hh

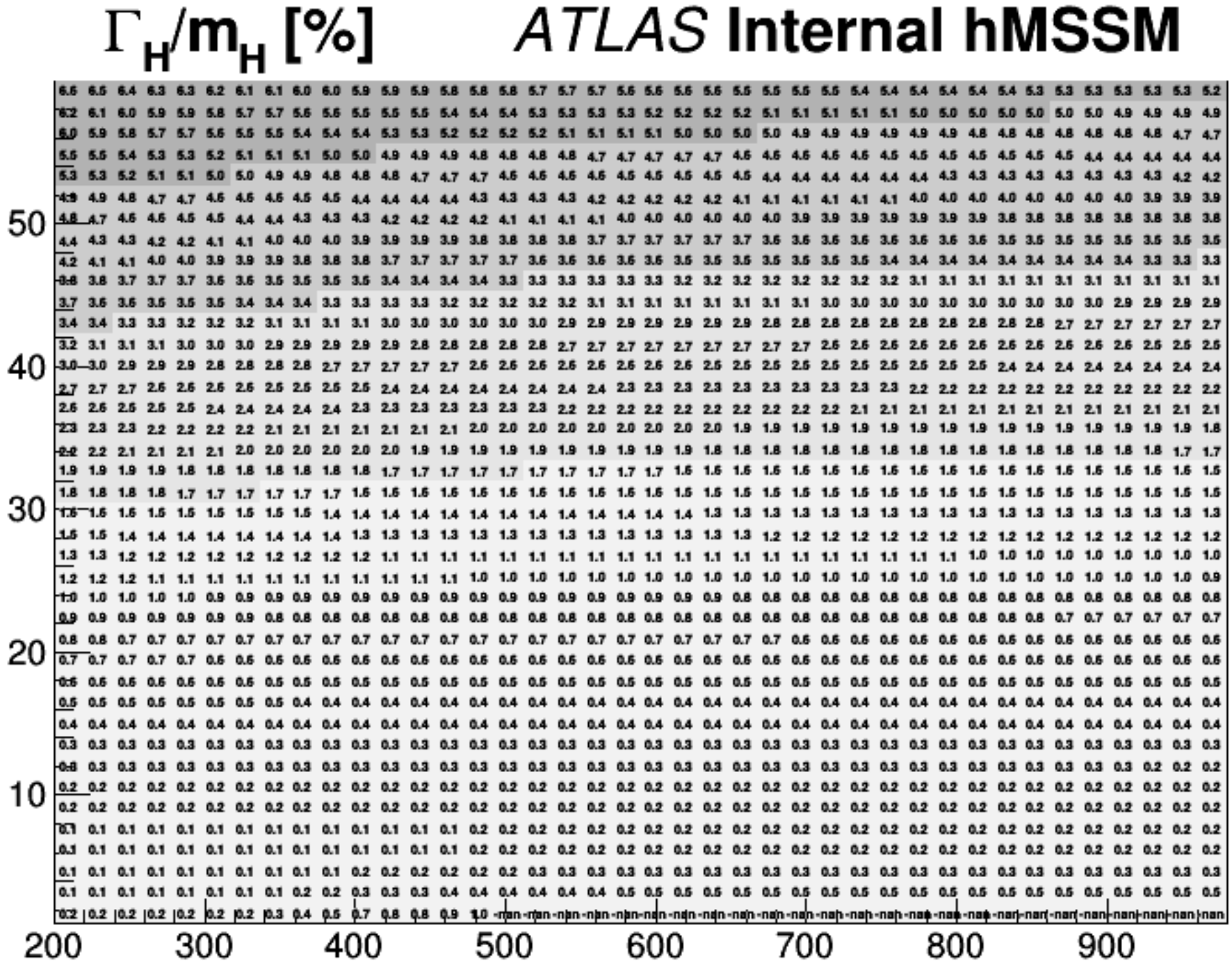

σ(ggH)*BR(H→hh)
ATLAS Internal hMSSM
×10⁻³
90
80
70
60
50
40
30
20
10
0
50
40
30
20
10
200
300
400
500
600
700
800
900
xsec_ggH * BR_Hhh



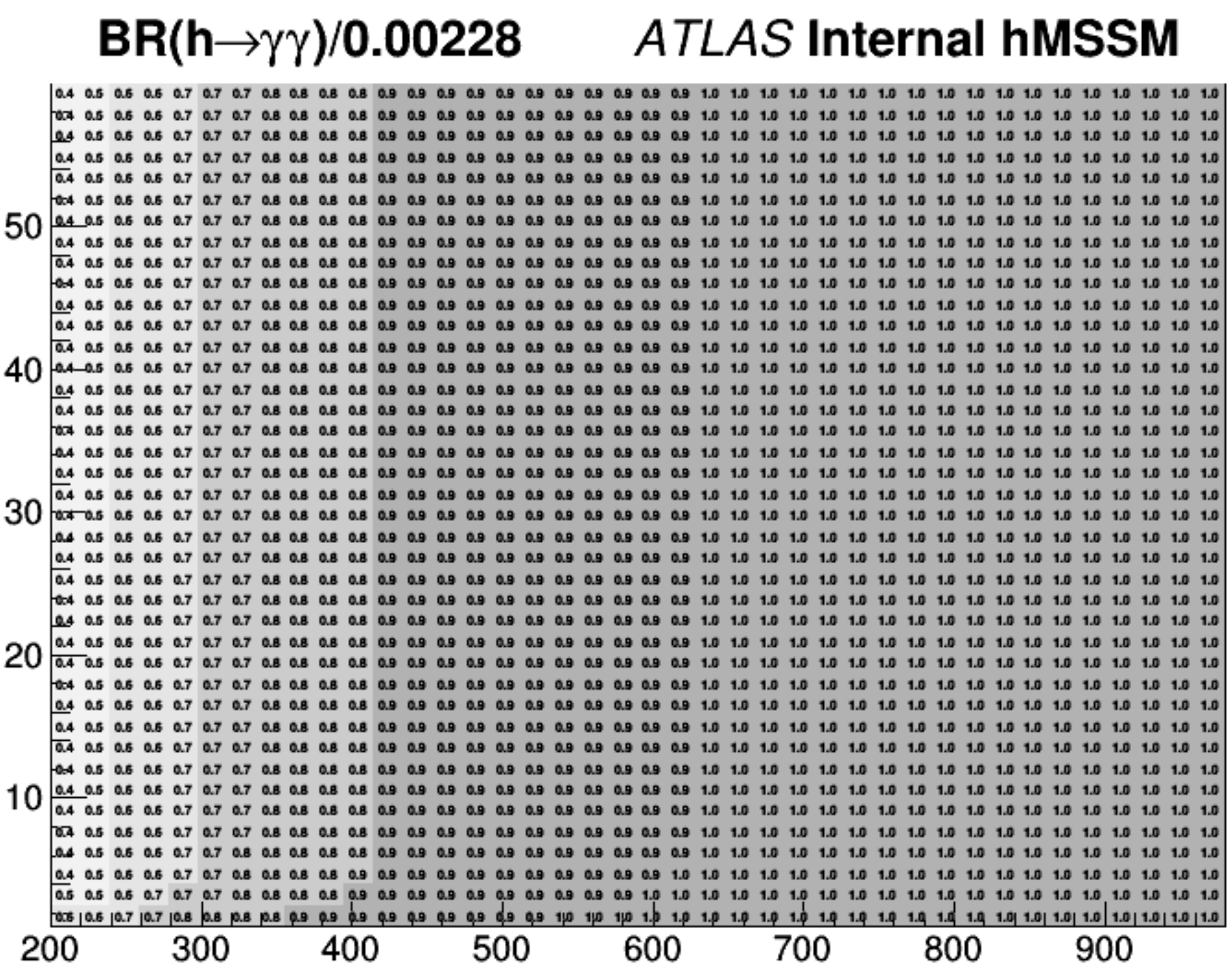
bbH production from Santander matching



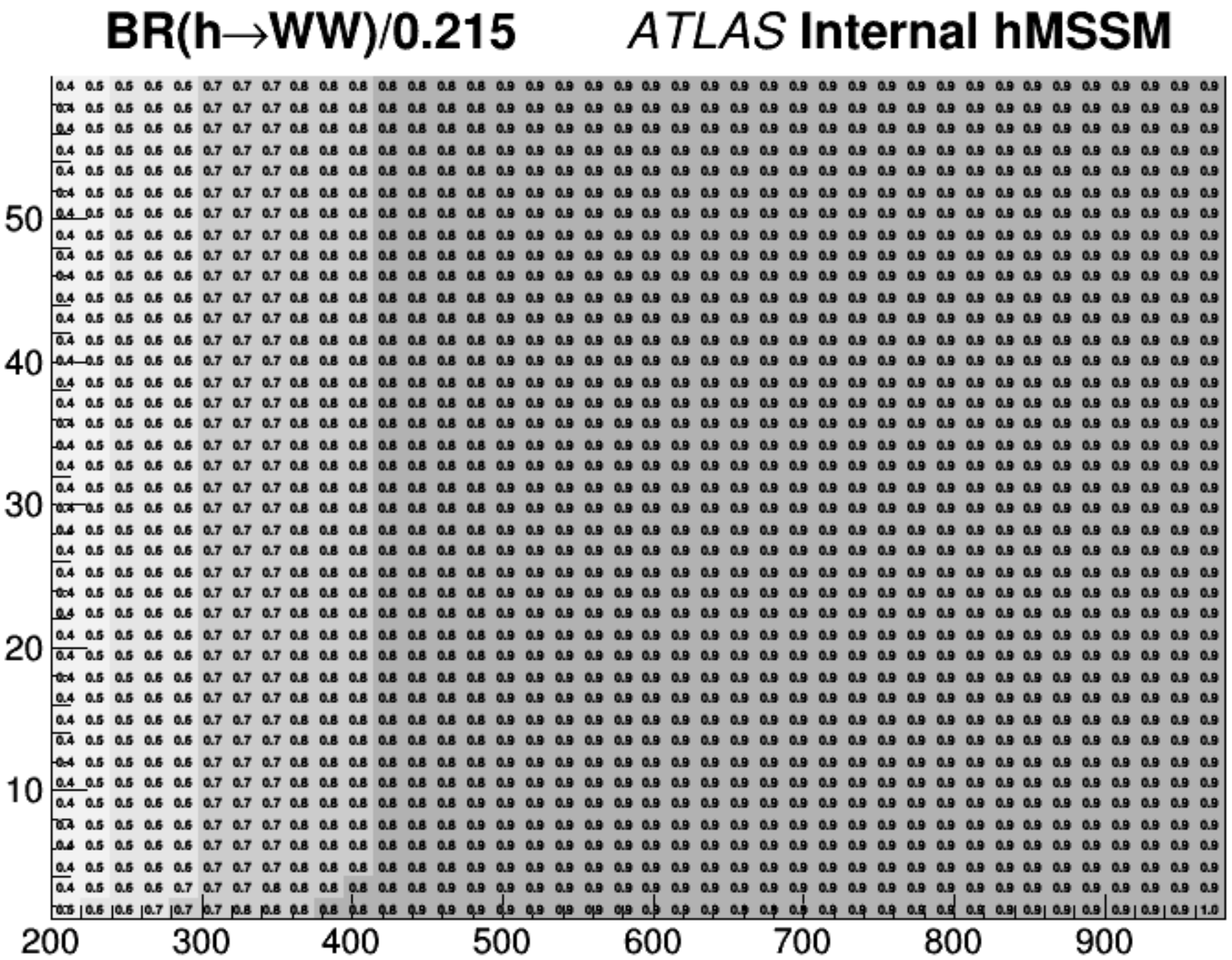
spreading around mA ~10%



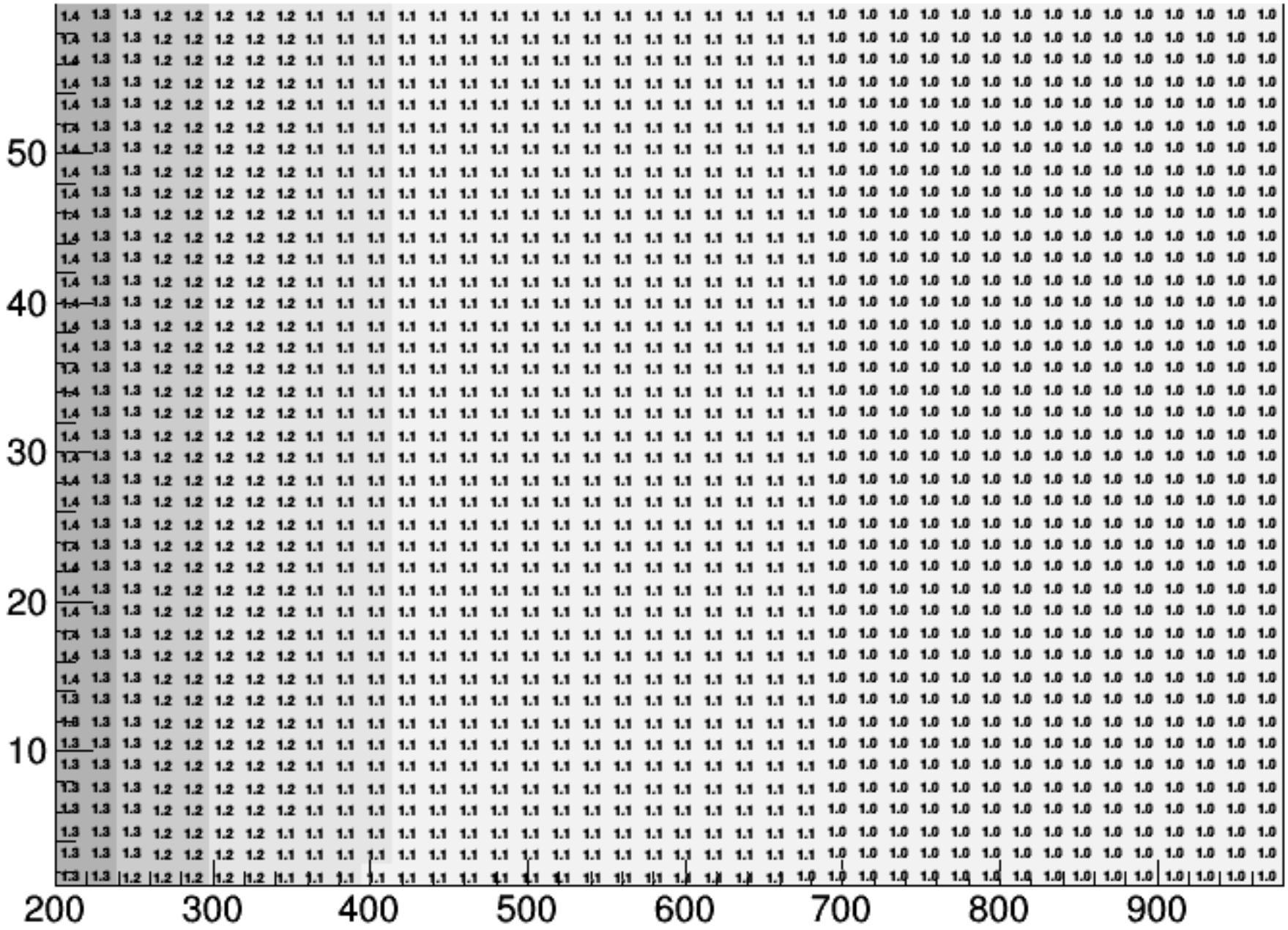
below tb=25 width<1%m(H)



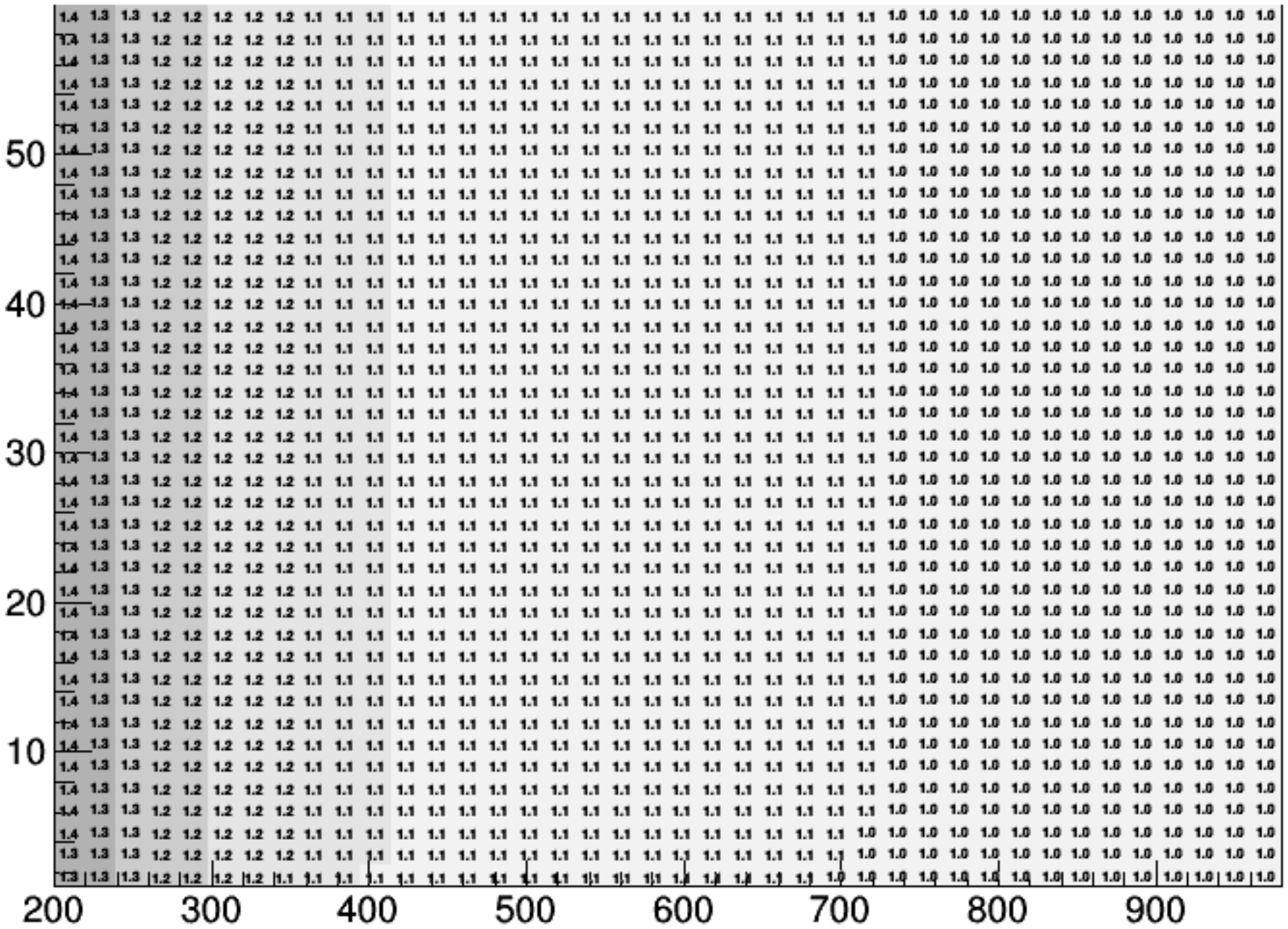
40% variations away from SM BR



50% variations away from SM BR



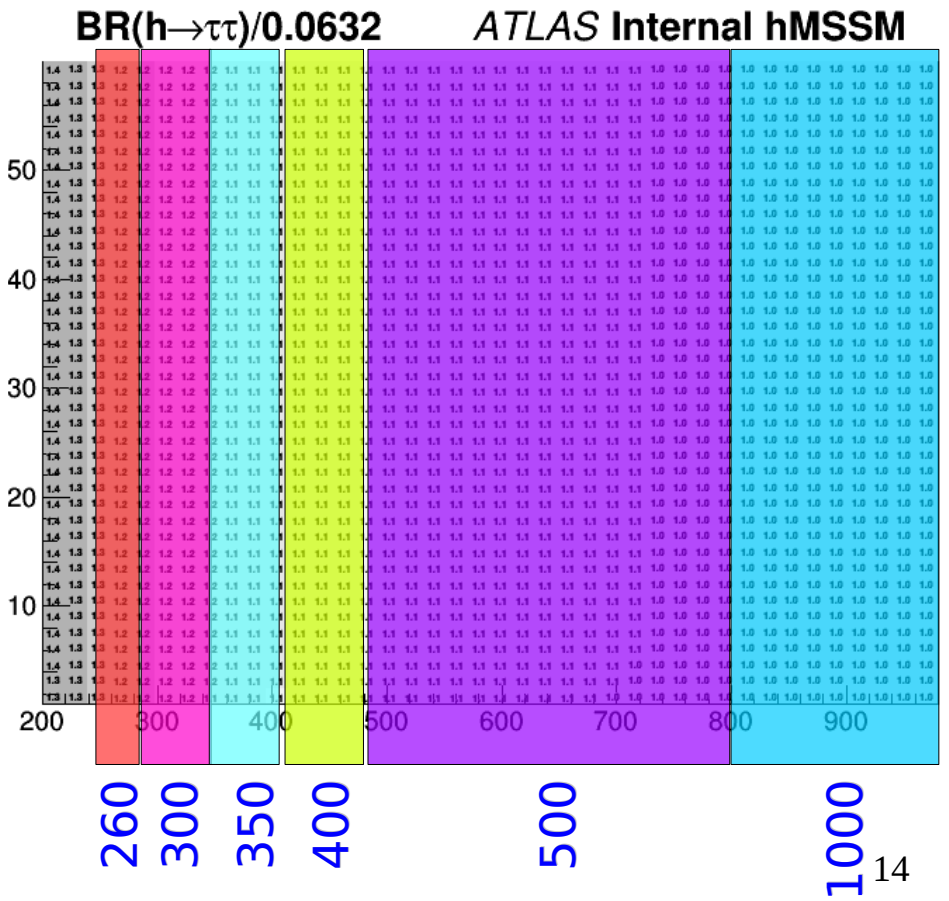
30% variations away from SM BR



30% variations away from SM BR

hMSSM - limit parametrization

- The non-SM BR of h decays should be taken into account in the combined limits
- mH is not largely deviating from mA, in most of the phase space mH~mA, we can use mA as mH approximately
- 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
  - setting BR(h->yy/ww/bb/tautau) to a group of fixed values



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

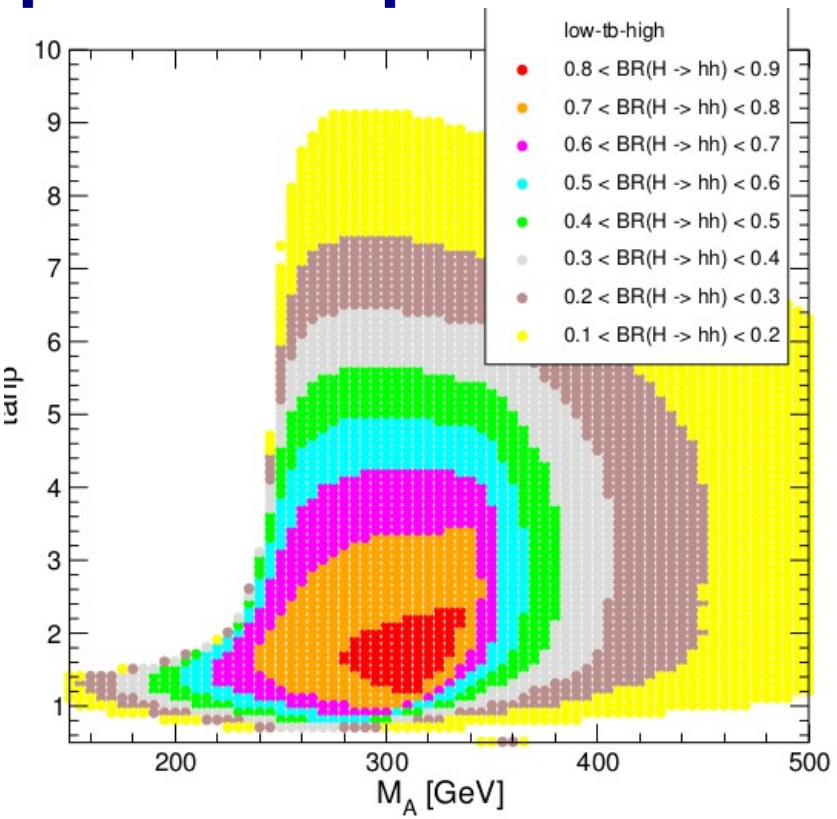
hMSSM – channel rescales

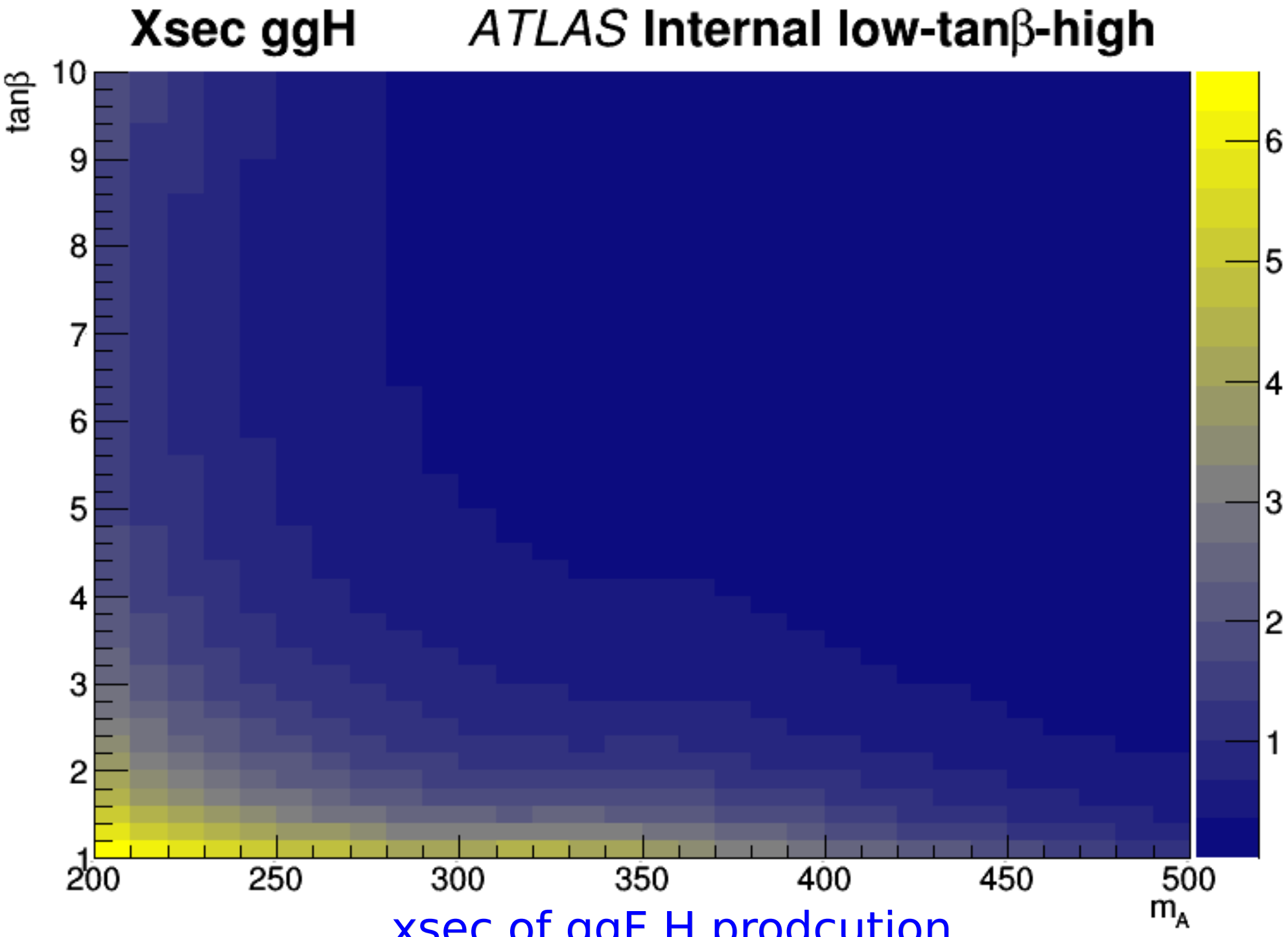
- translate BR rescales into channel rescales

	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**

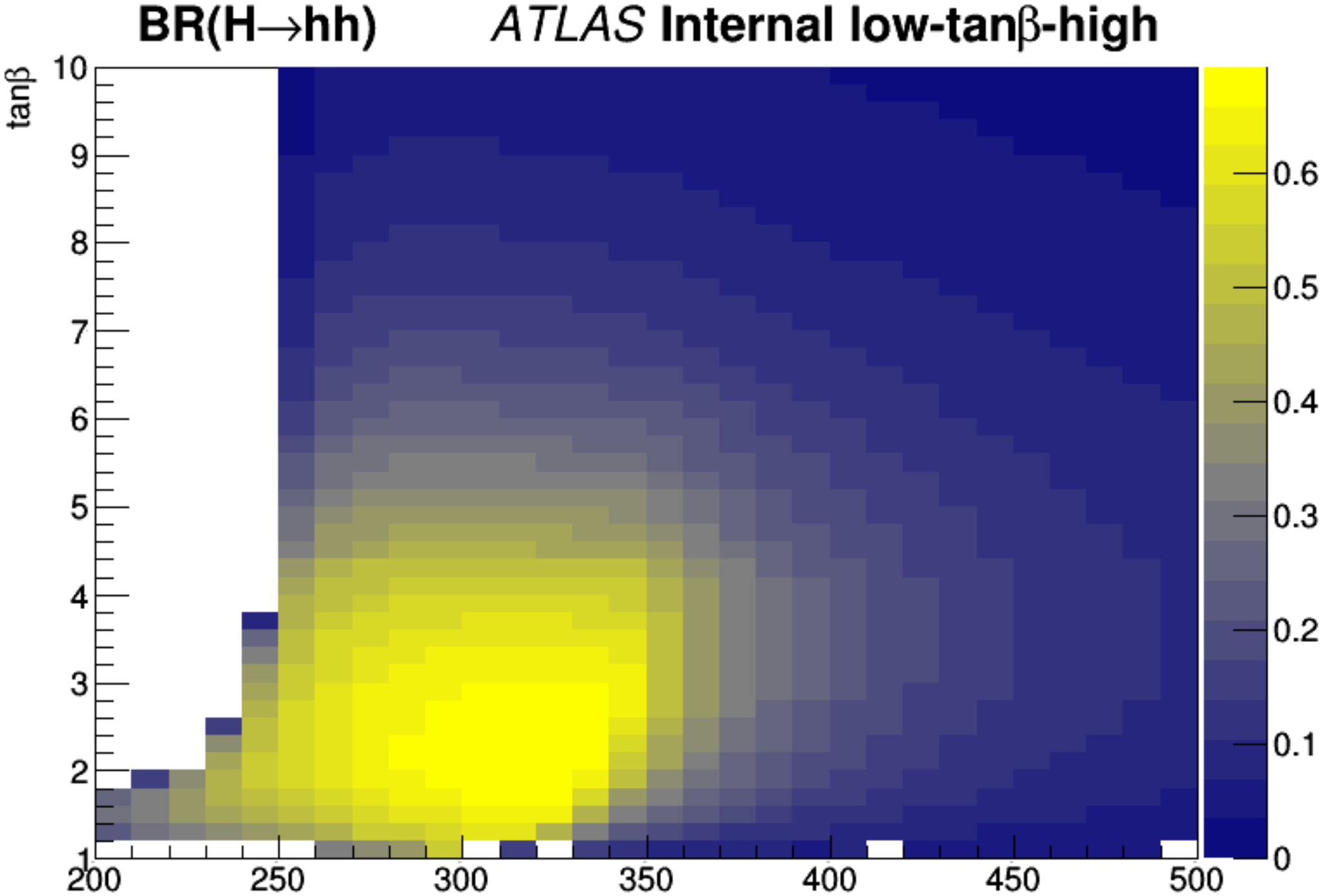
low-tb-high

- 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

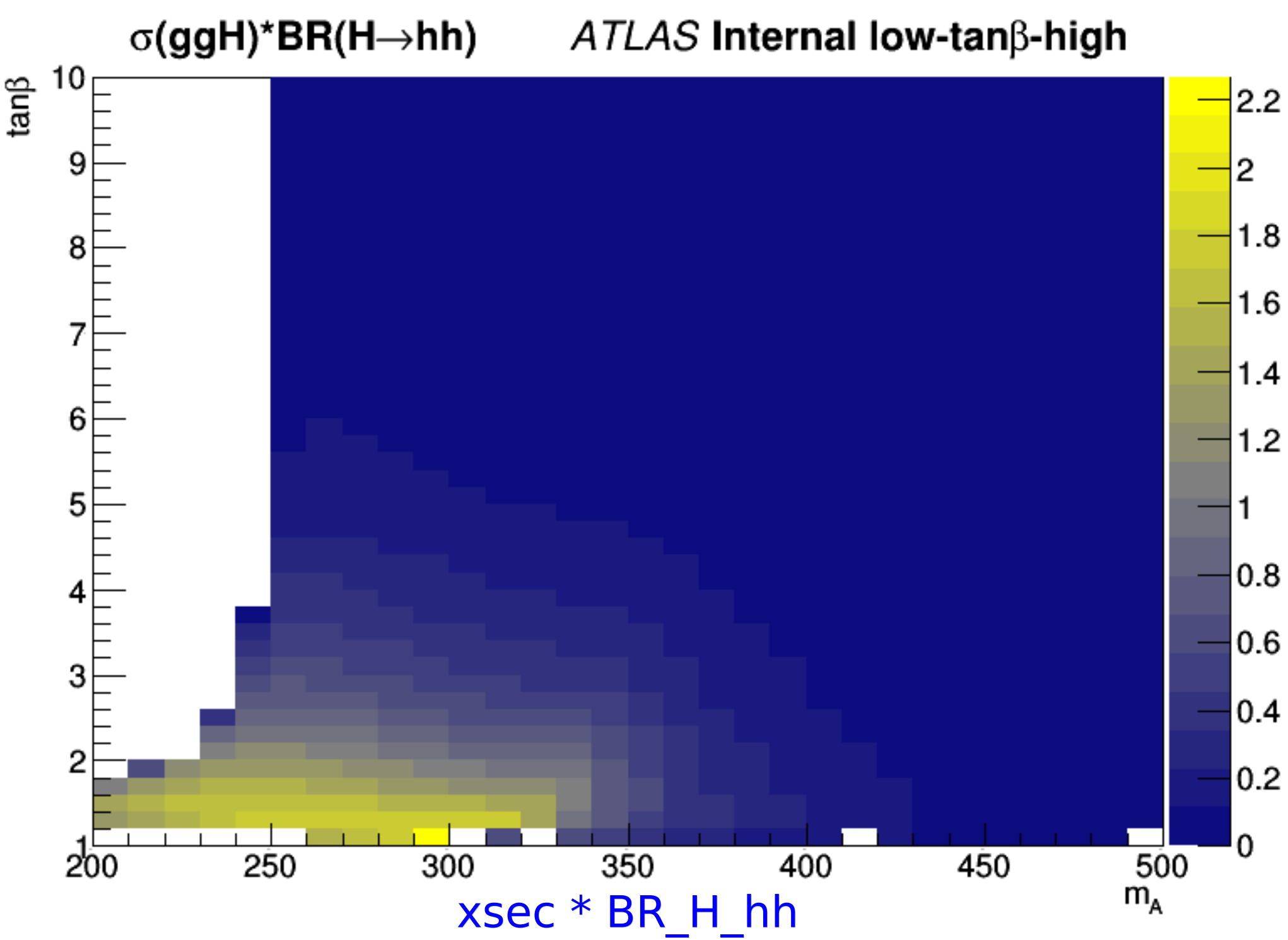




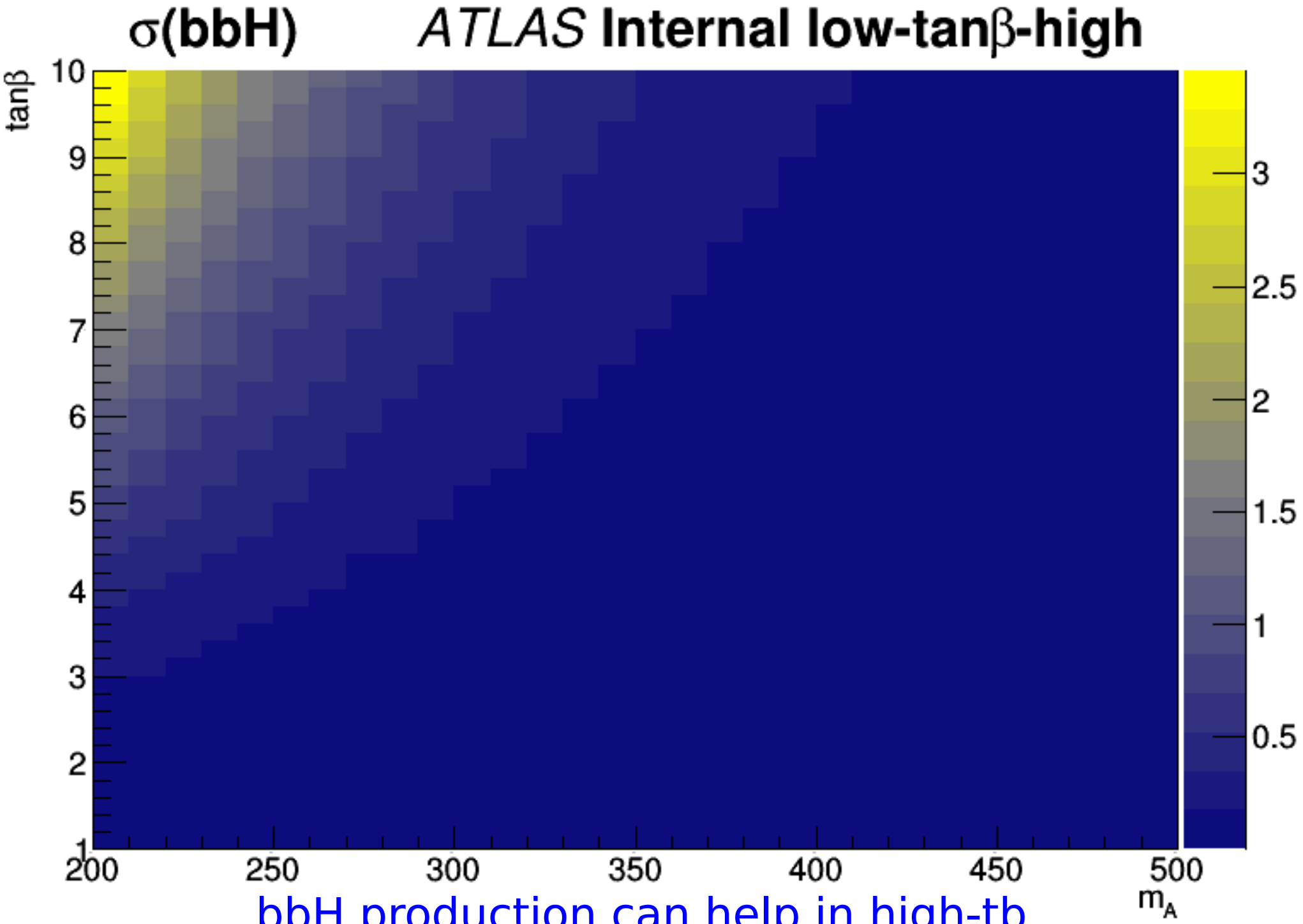
xsec of ggF H prodcution



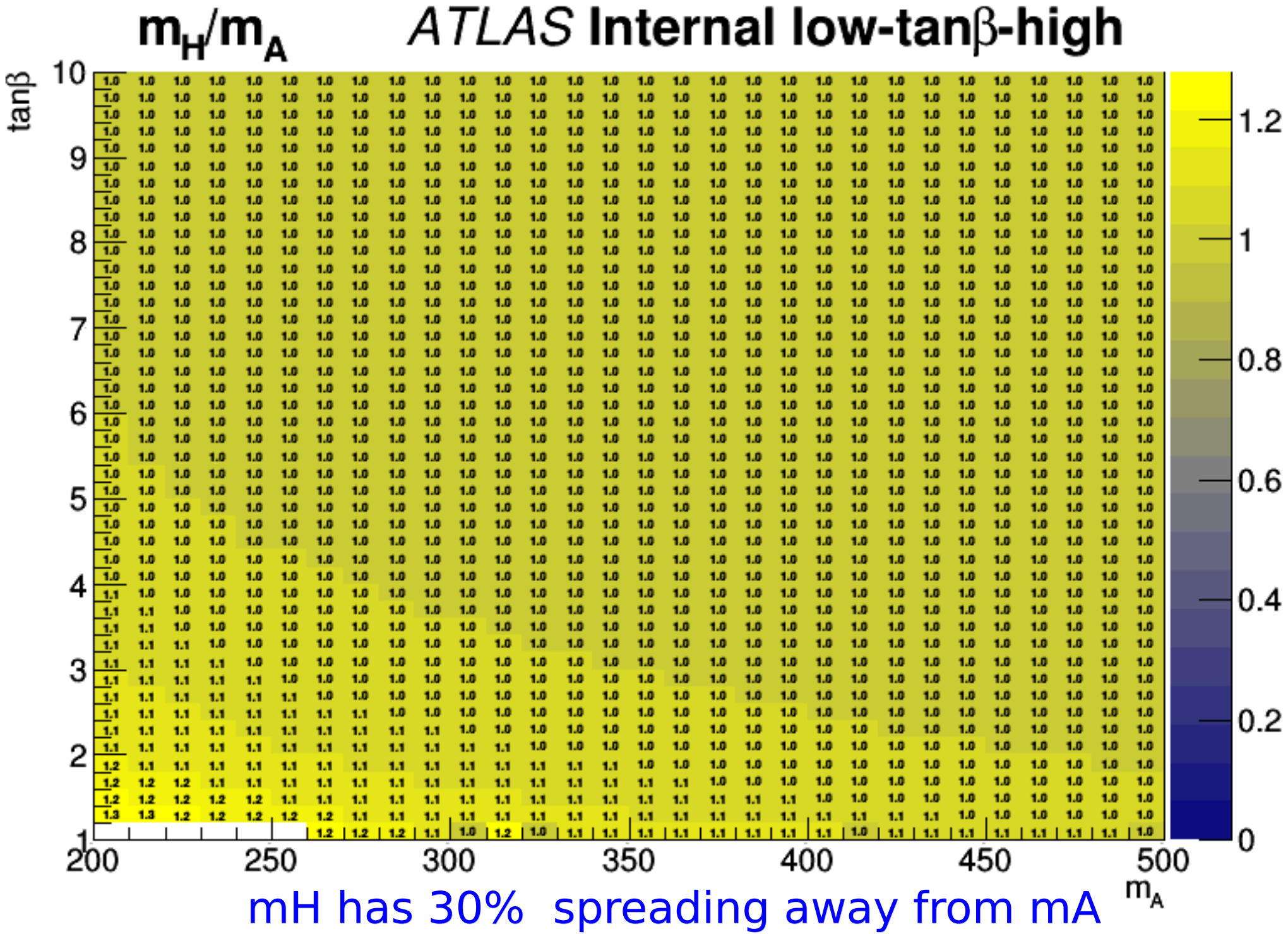
consistent with what is shown in Sven NOTE


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

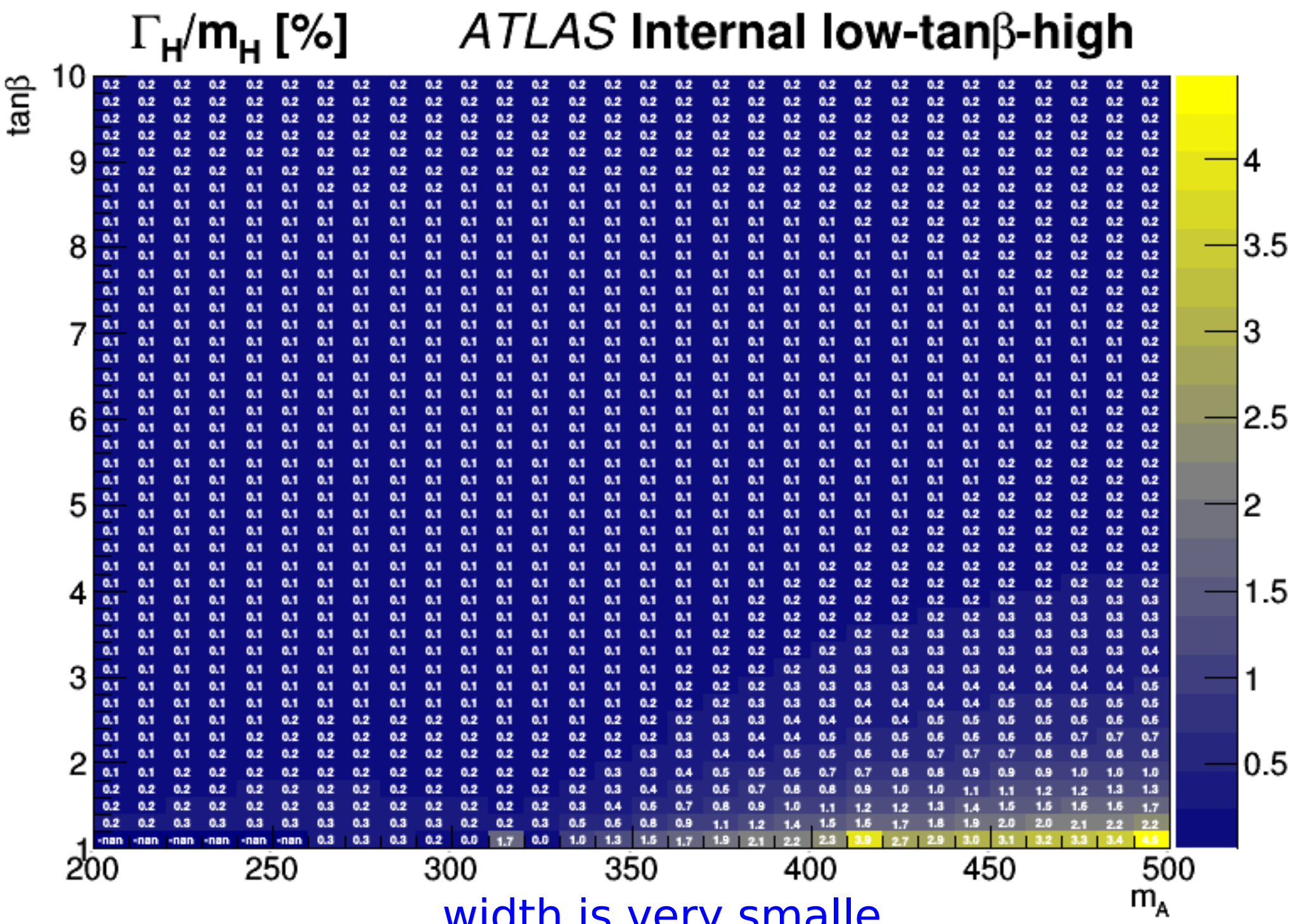
xsec * BR_H_hh



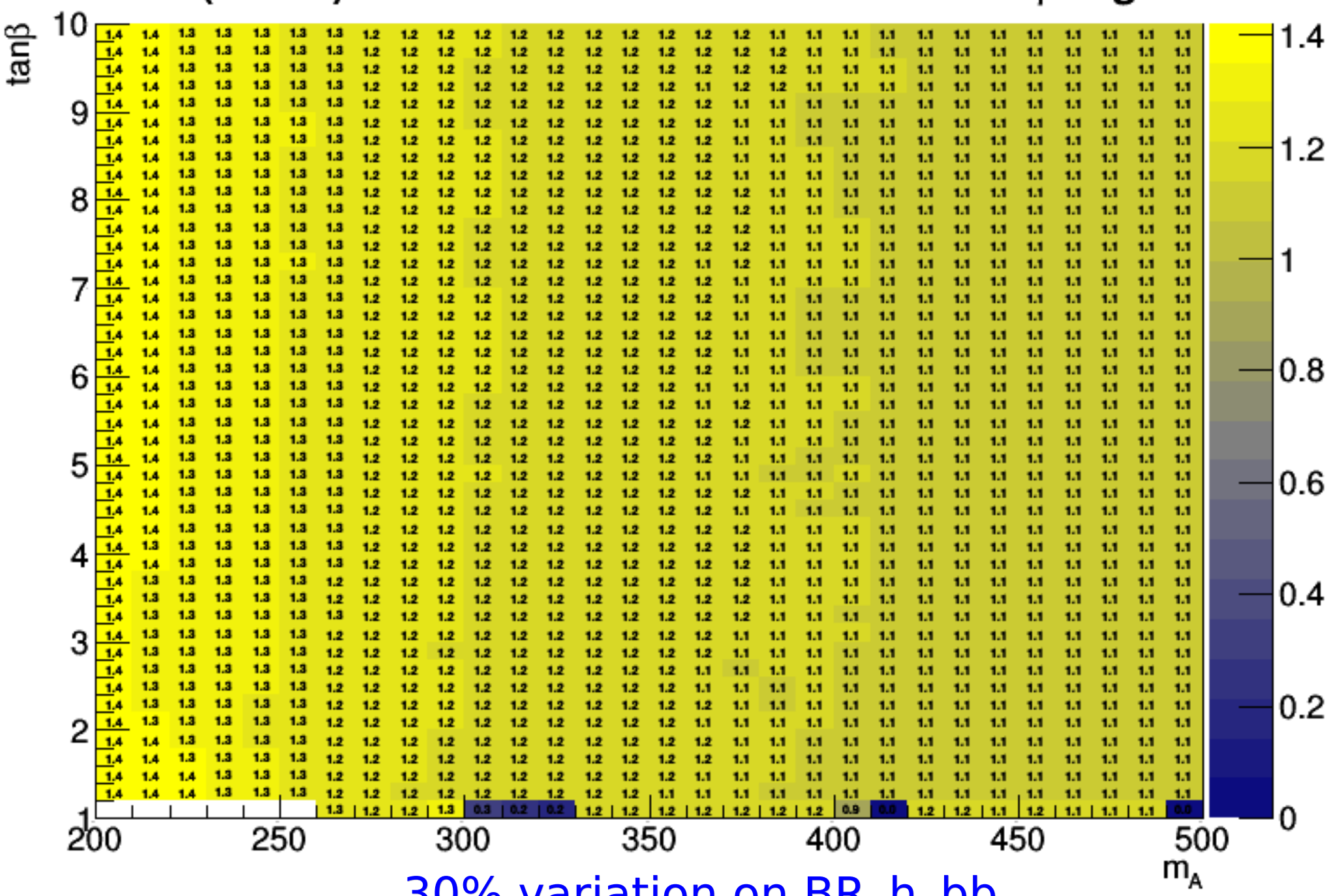
bbH production can help in high-tb



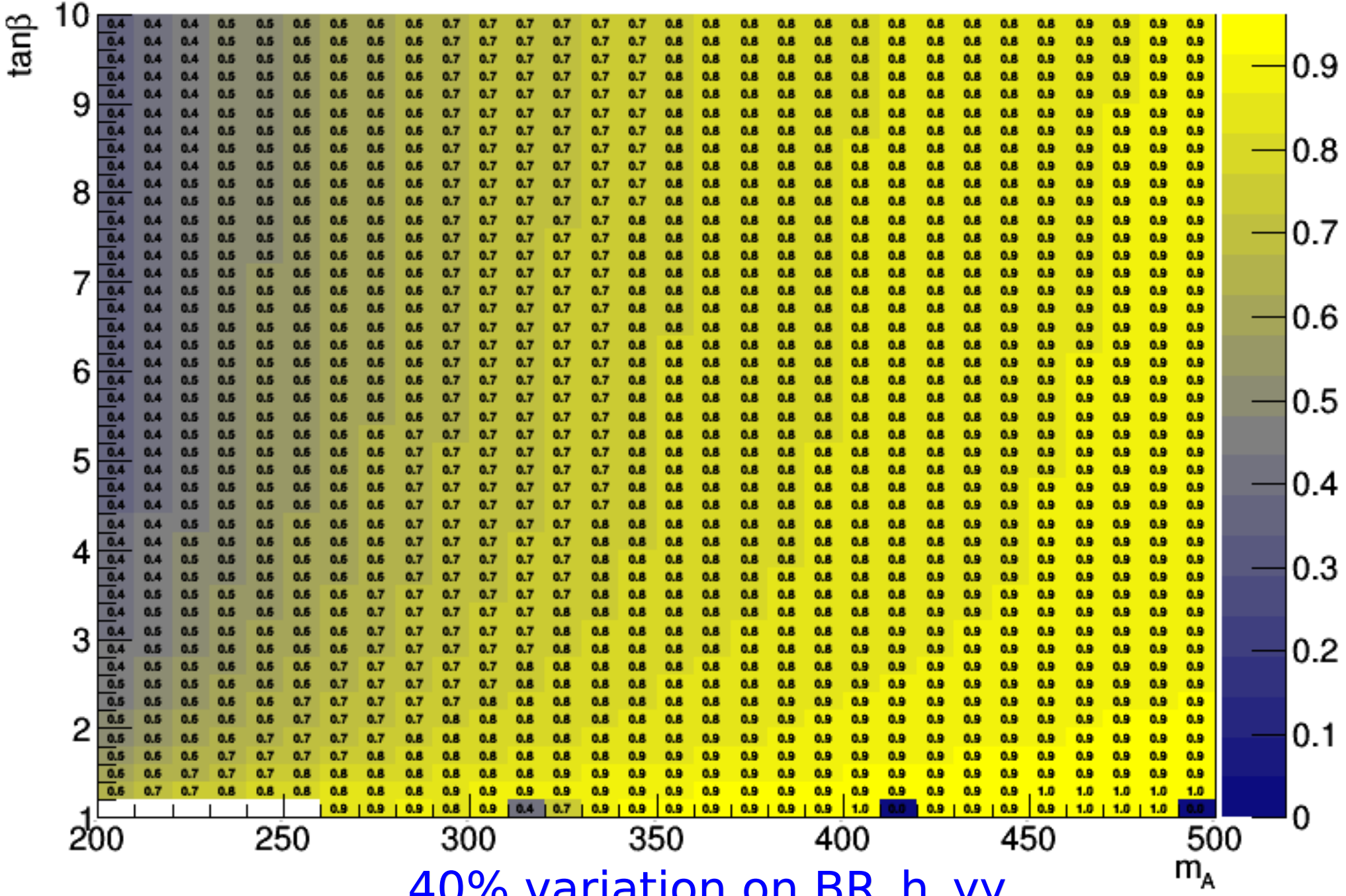
mH has 30% spreading away from mA



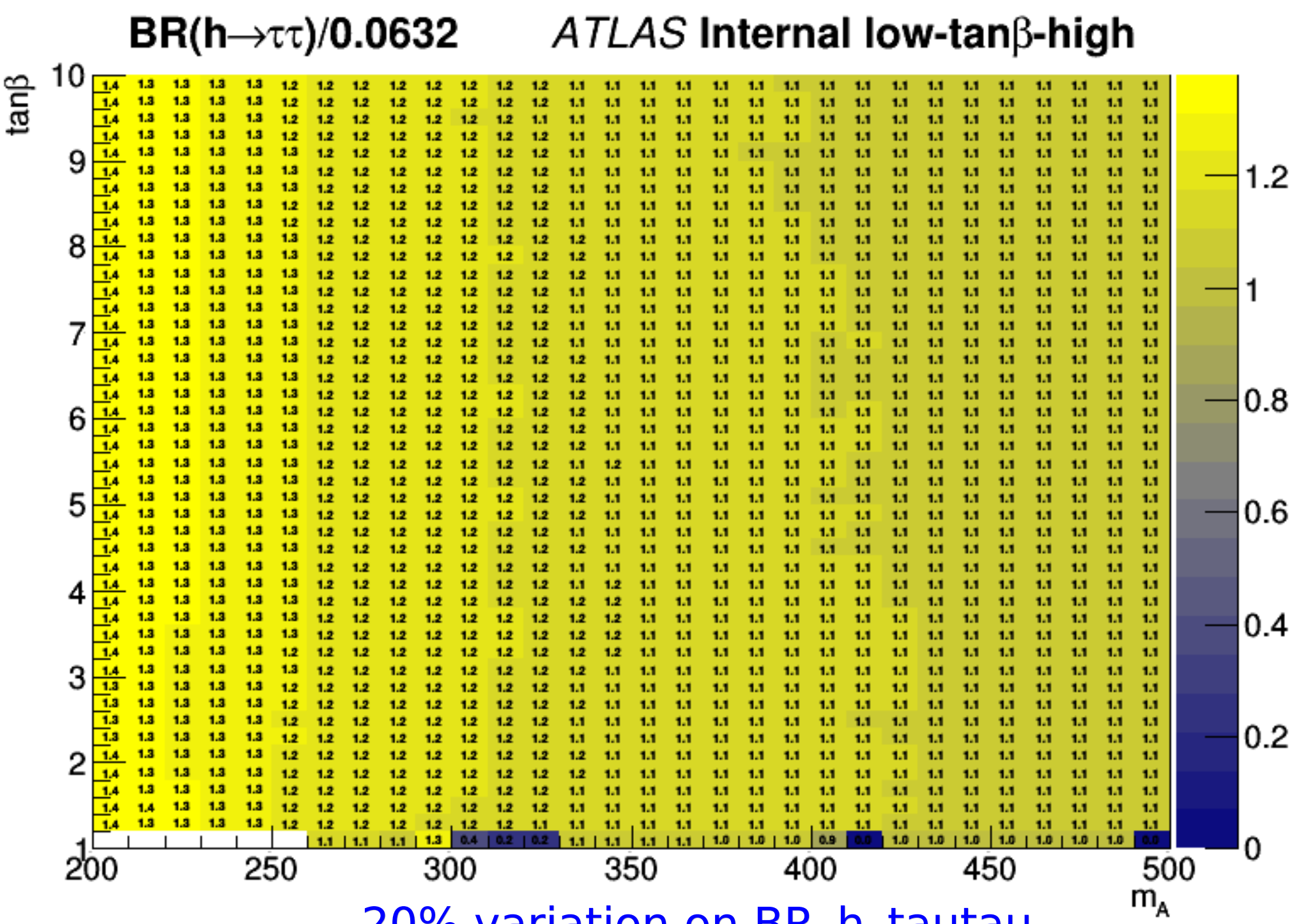
width is very smalle

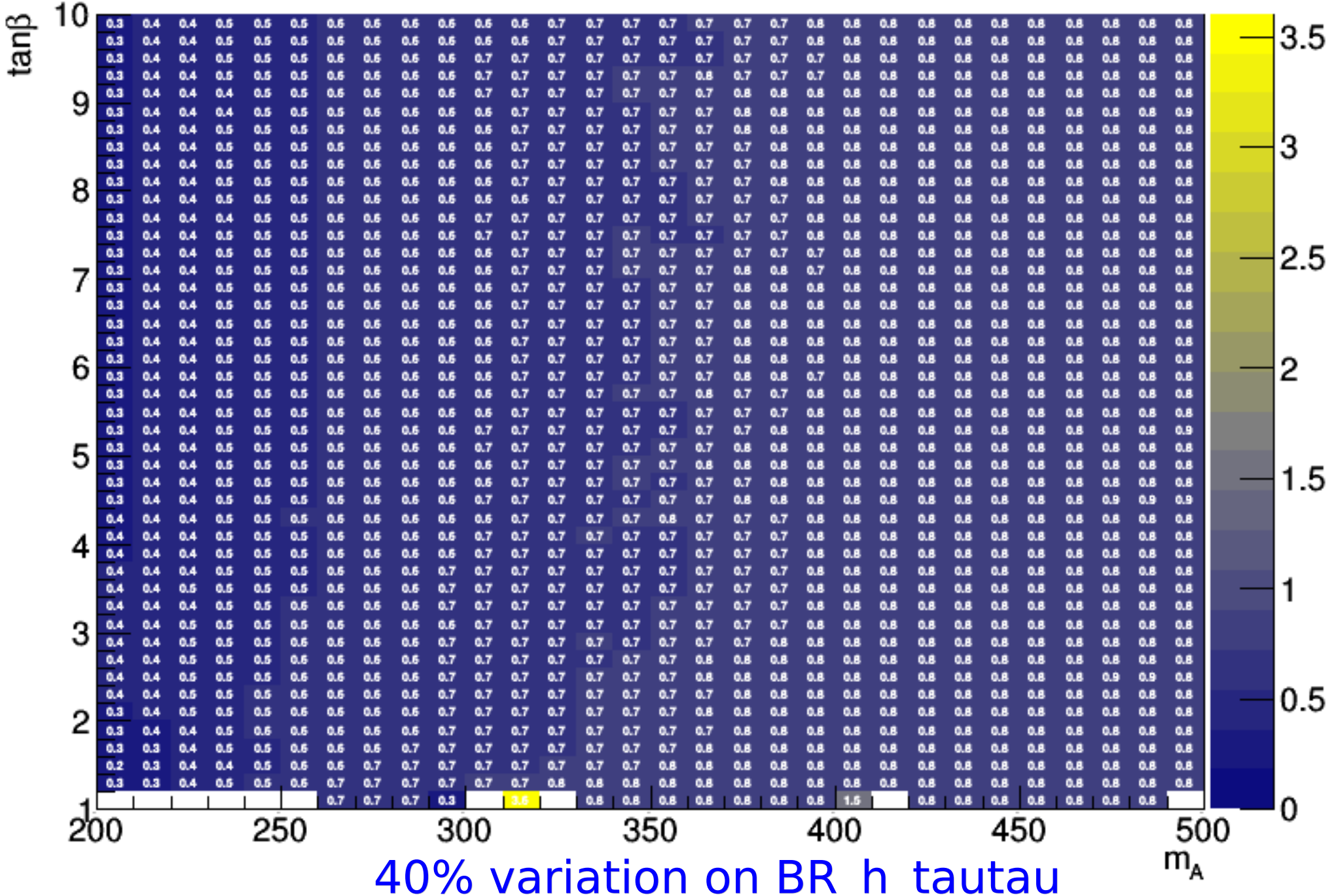


30% variation on BR_h_bb



40% variation on BR_h_yy

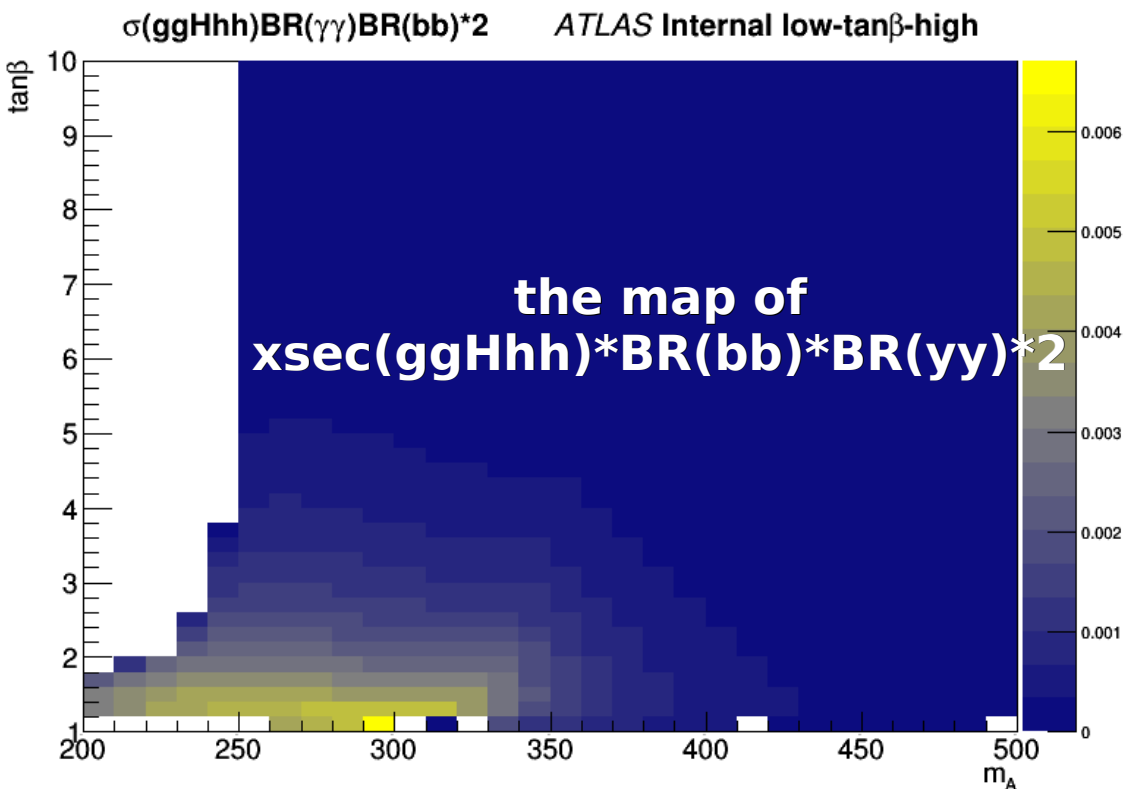

BR(h→ττ)/0.0632
ATLAS Internal low-tanβ-high
tanβ
m_A
20% variation on BR_h_tautau

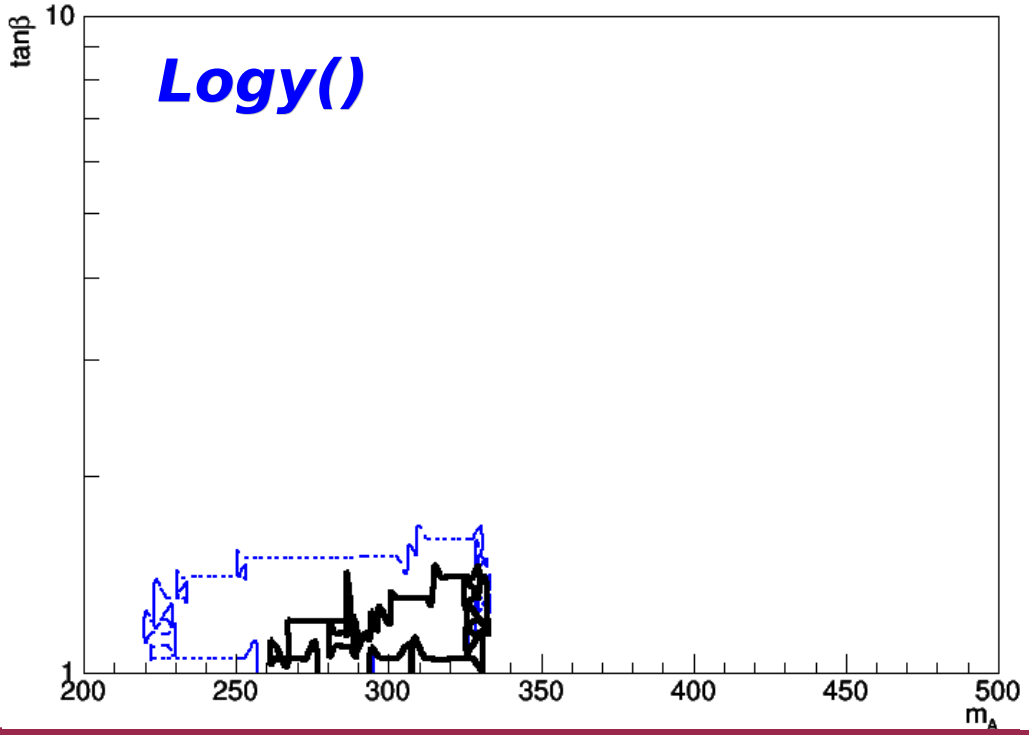


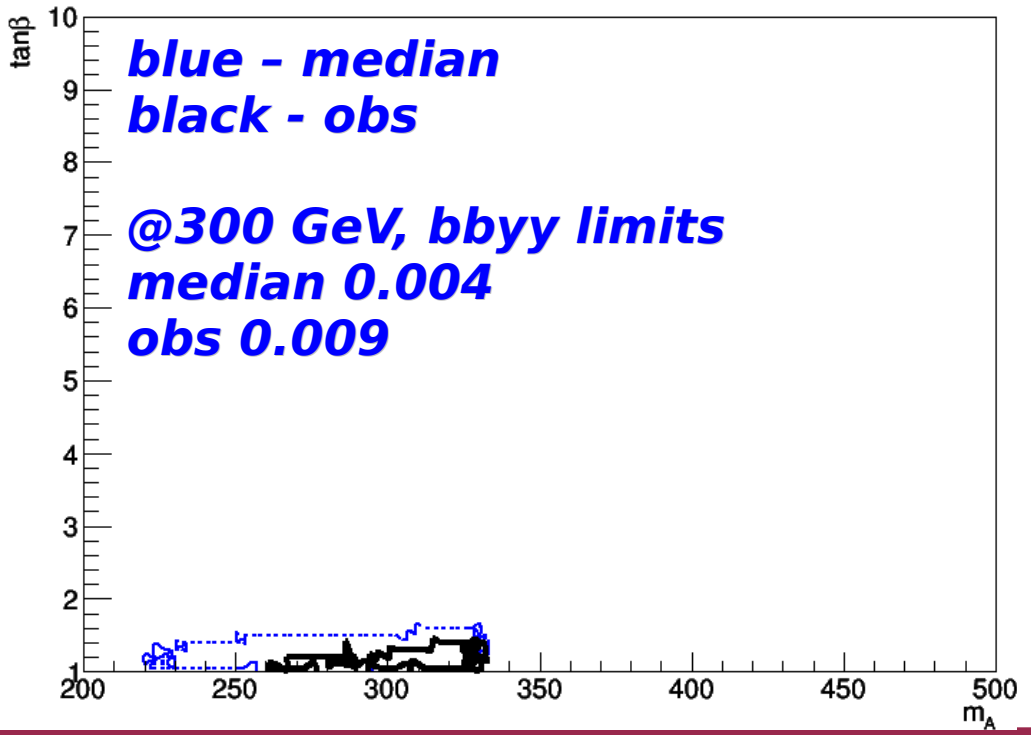
40% variation on BR_h_tautau

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

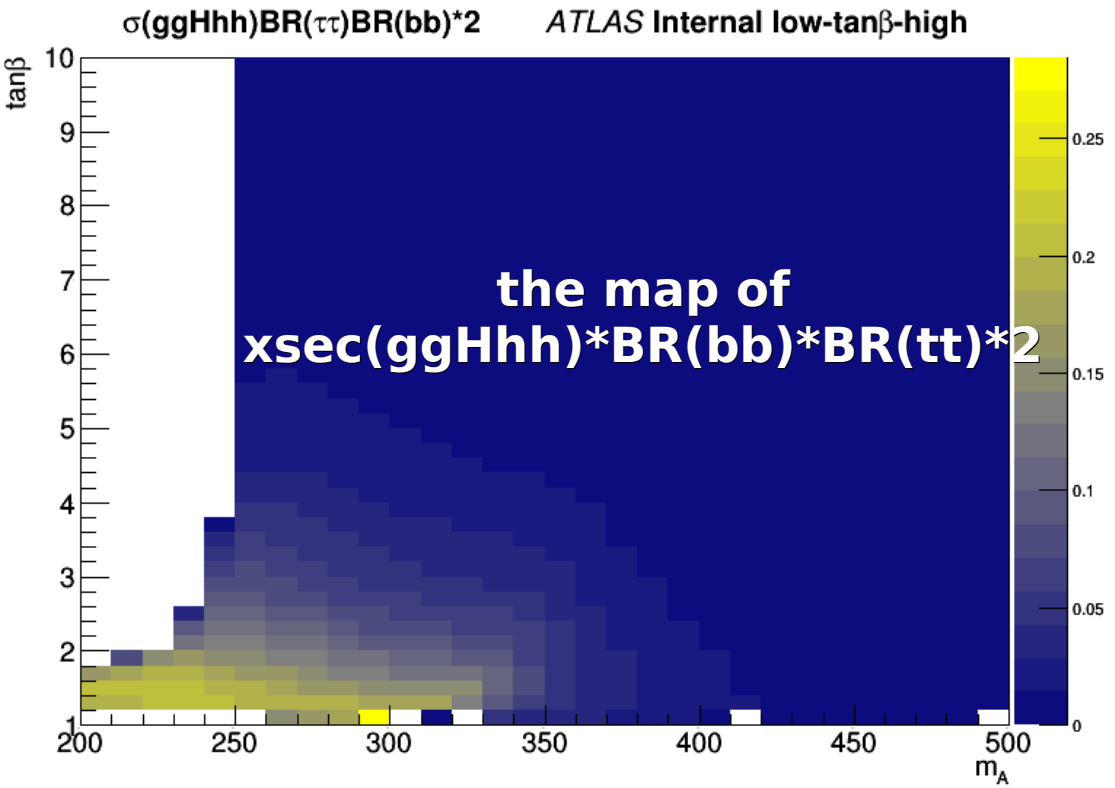


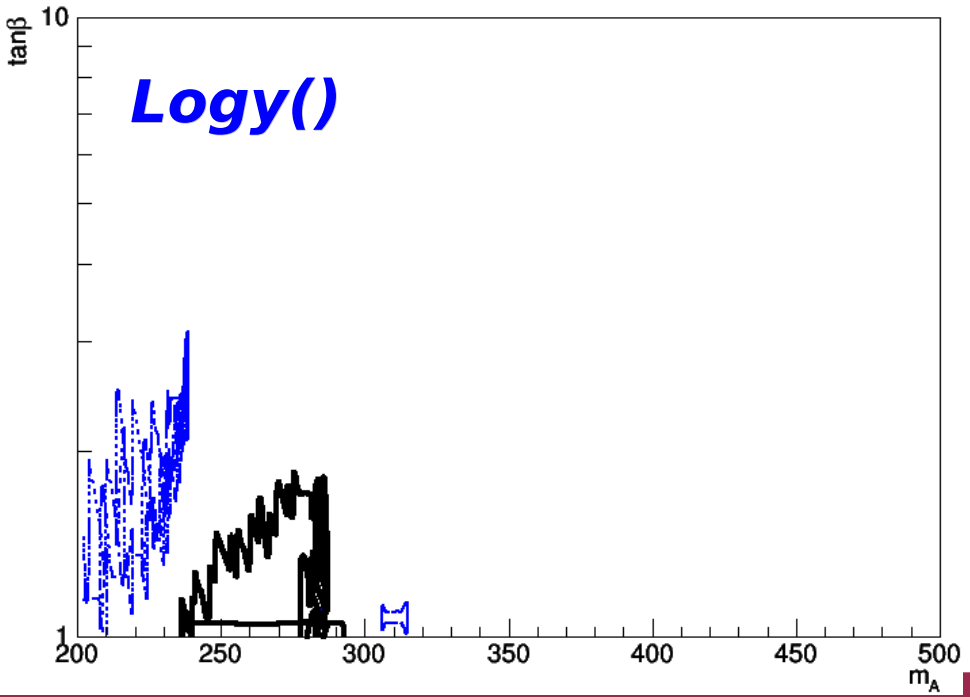


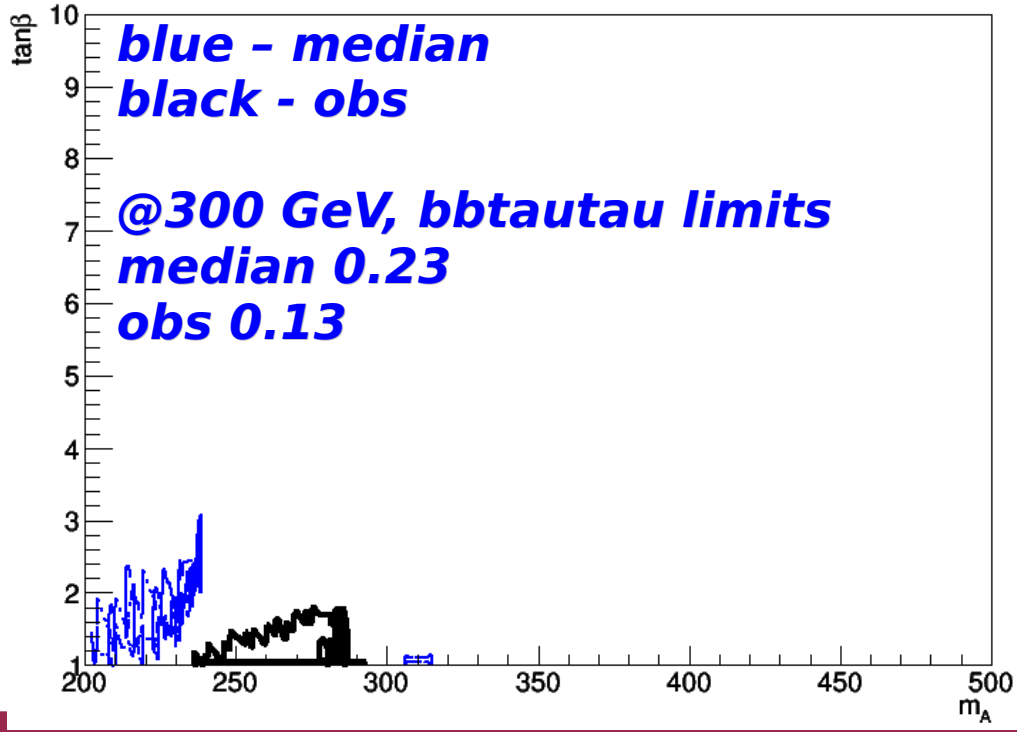


bbtt exclusions low-tb-high

- 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

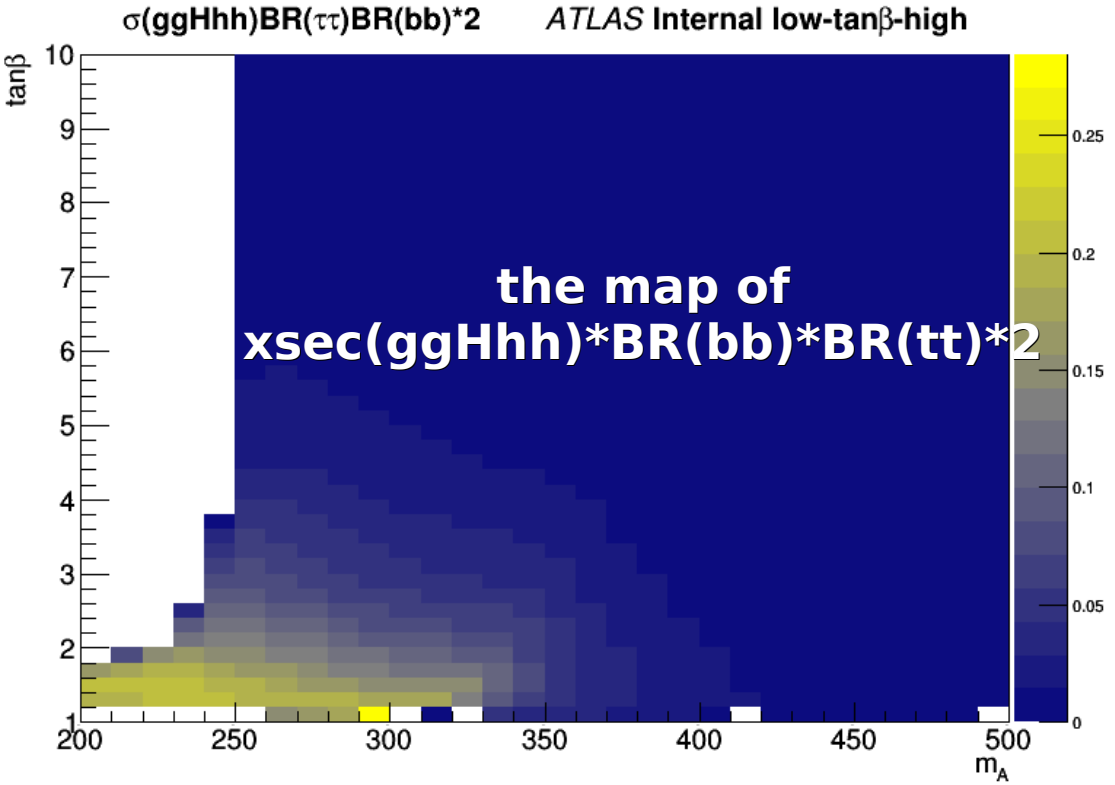


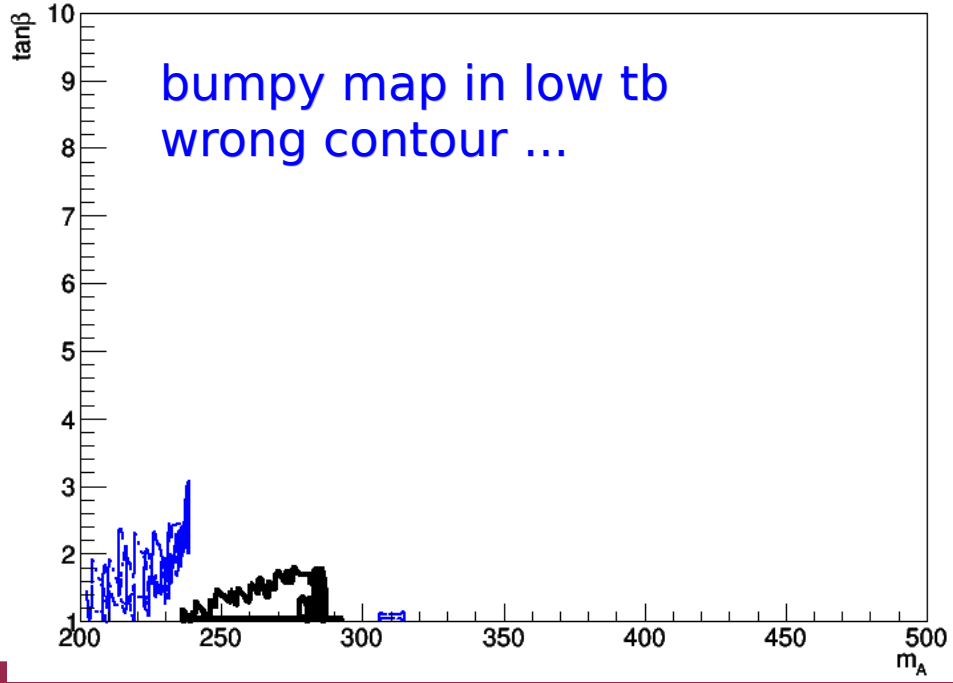


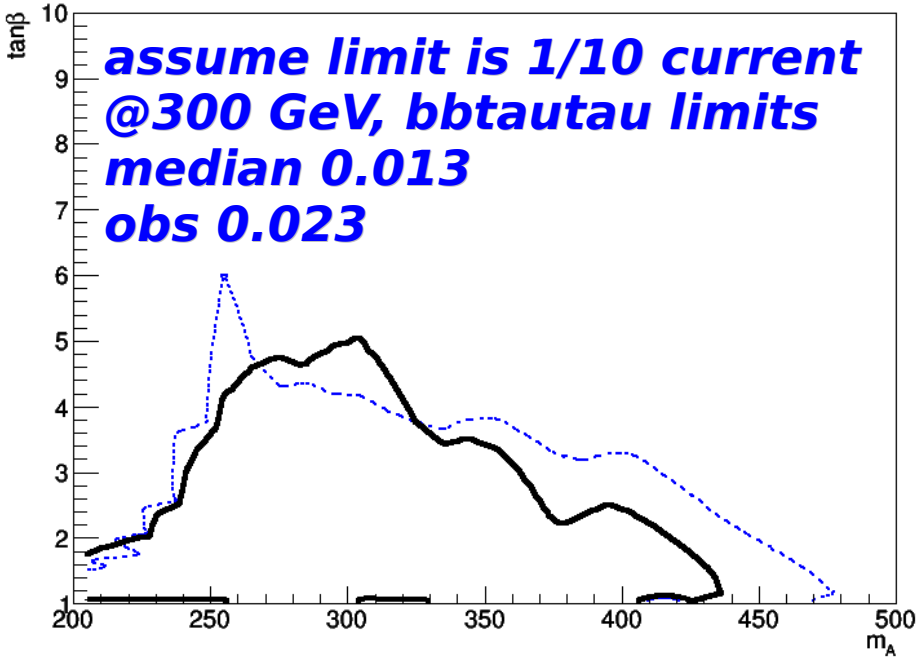


bbtt exclusions low-tb-high

- 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)







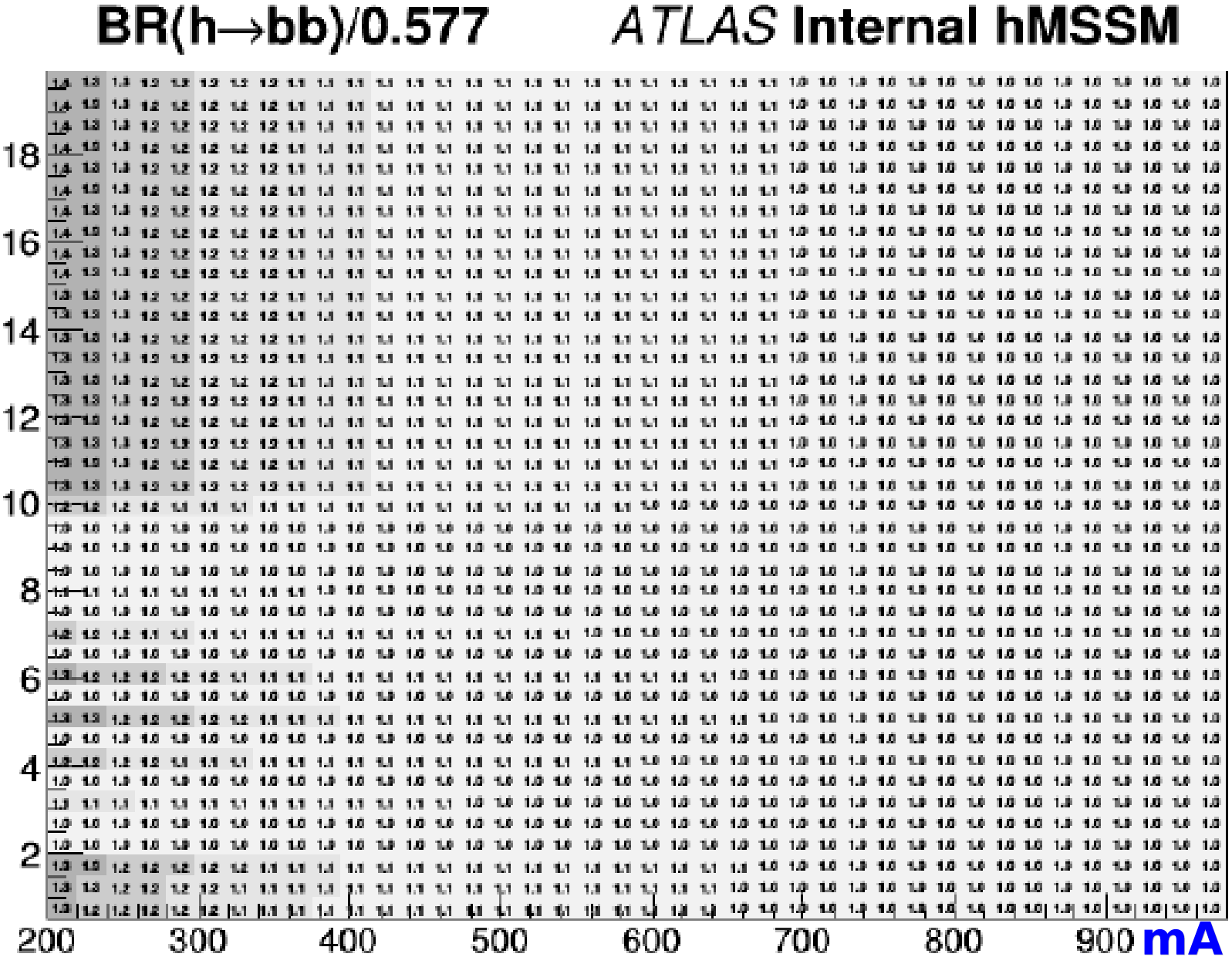
Summary

- More samples are produced, by now **1.2M** events, for signal **theoretical** uncertainty estimation
- **hMSSM**, map files has problem in **Hhh BR** (too small numbers), Nikos is looking at it; They also found the values produced do not match Djouadi's in general, being **investigated**; citation issue is discussed in email thread; We are trying to redo limits as a function of **mH,BRs** in order to take into account of non-SM Brs in combination
- for **low-tanb-high**
  - I have finished the **conversion** of plain files to ntuple/map
  - preliminary checks on **xs br**
  - preliminary checks on **exclusions** bbyy/bbtautau
  - NEED to ask Sven to see if it is possible to have a better BR calc in **tanb~1**
  - We will use the **same parameterization** on mH and BRs

backup

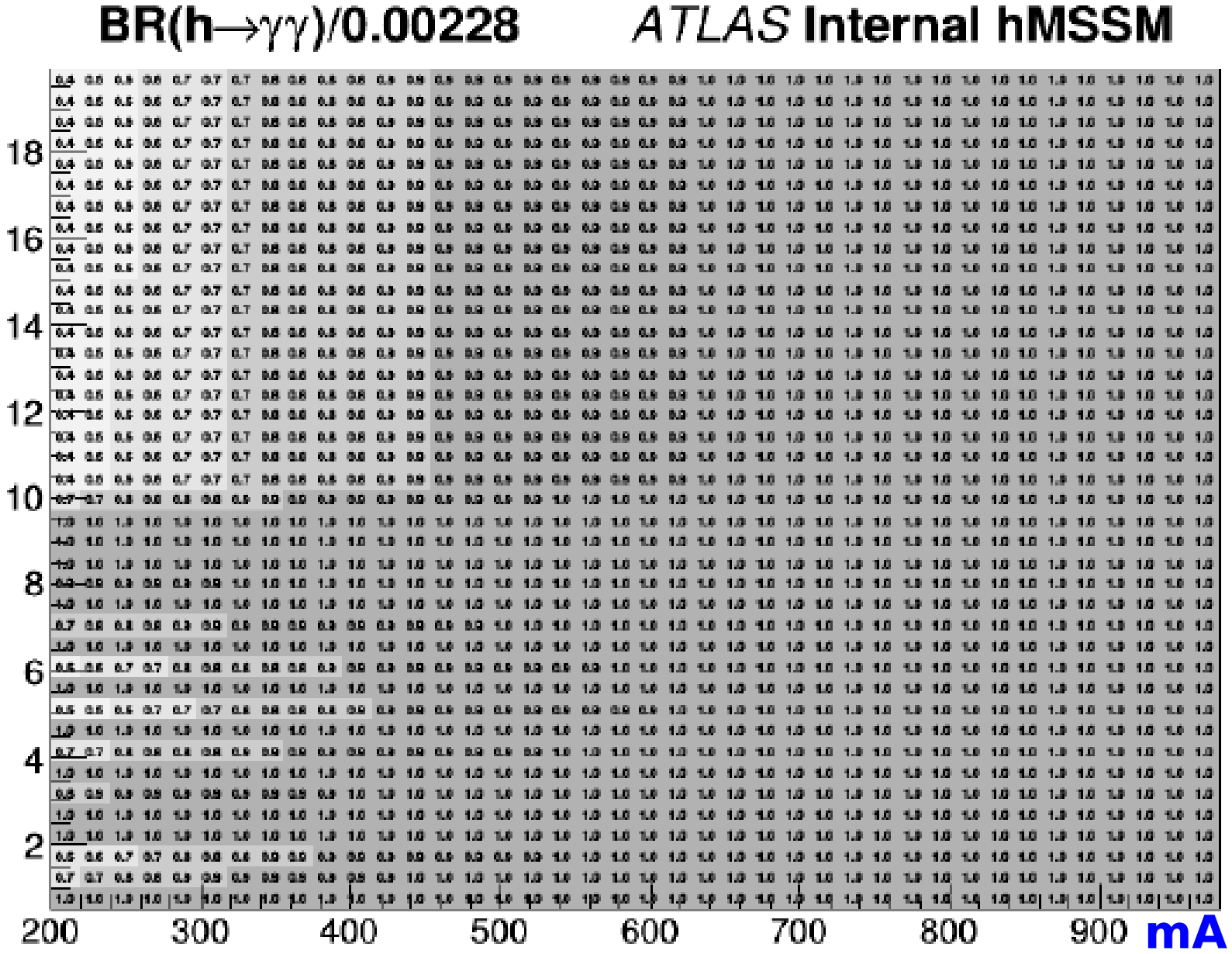
hMSSM

- BR(h-bb)/0.577 <30% variation since 260 GeV



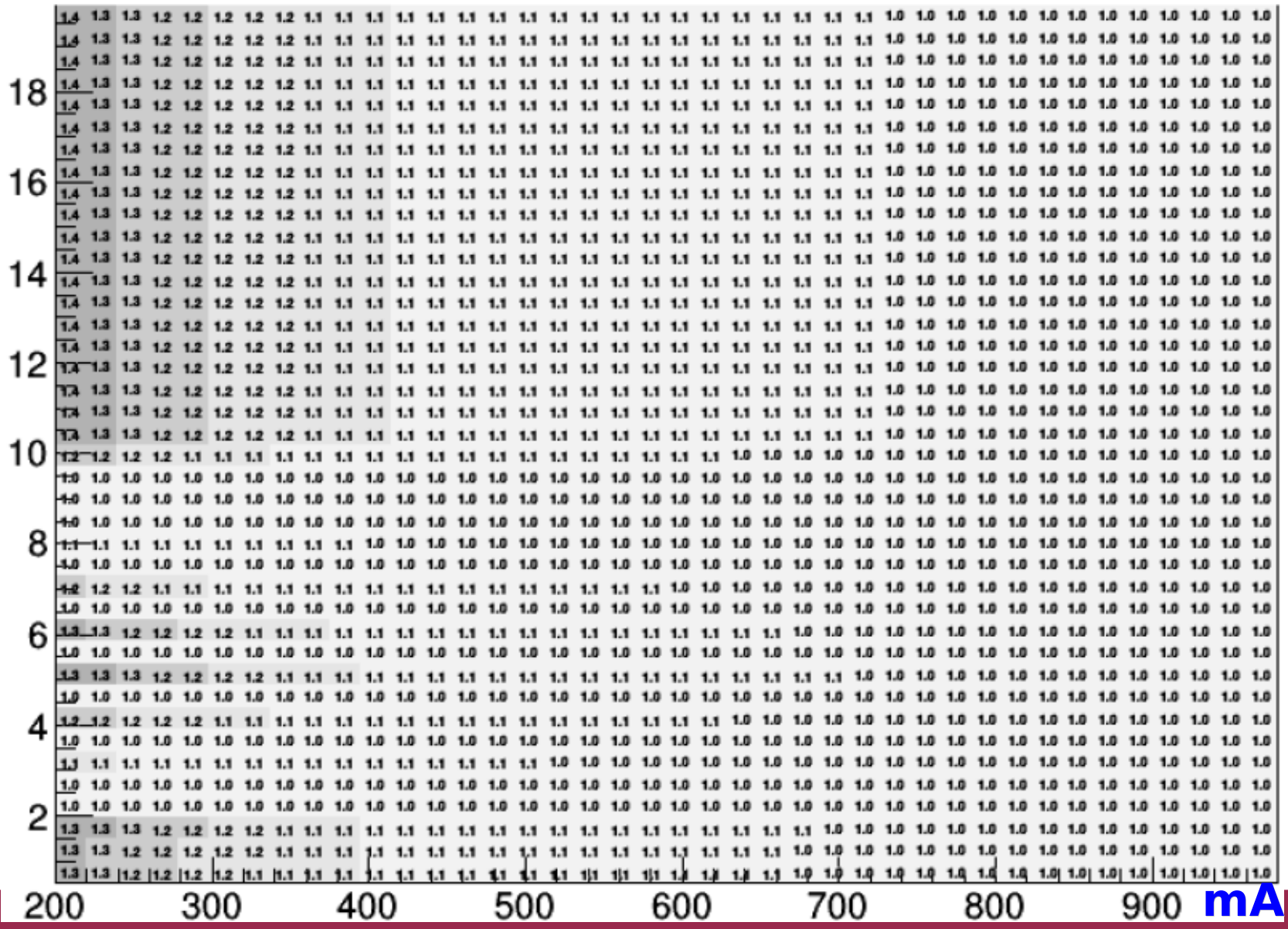
hMSSM

- BR(h-yy), variations are ~40% since 260GeV



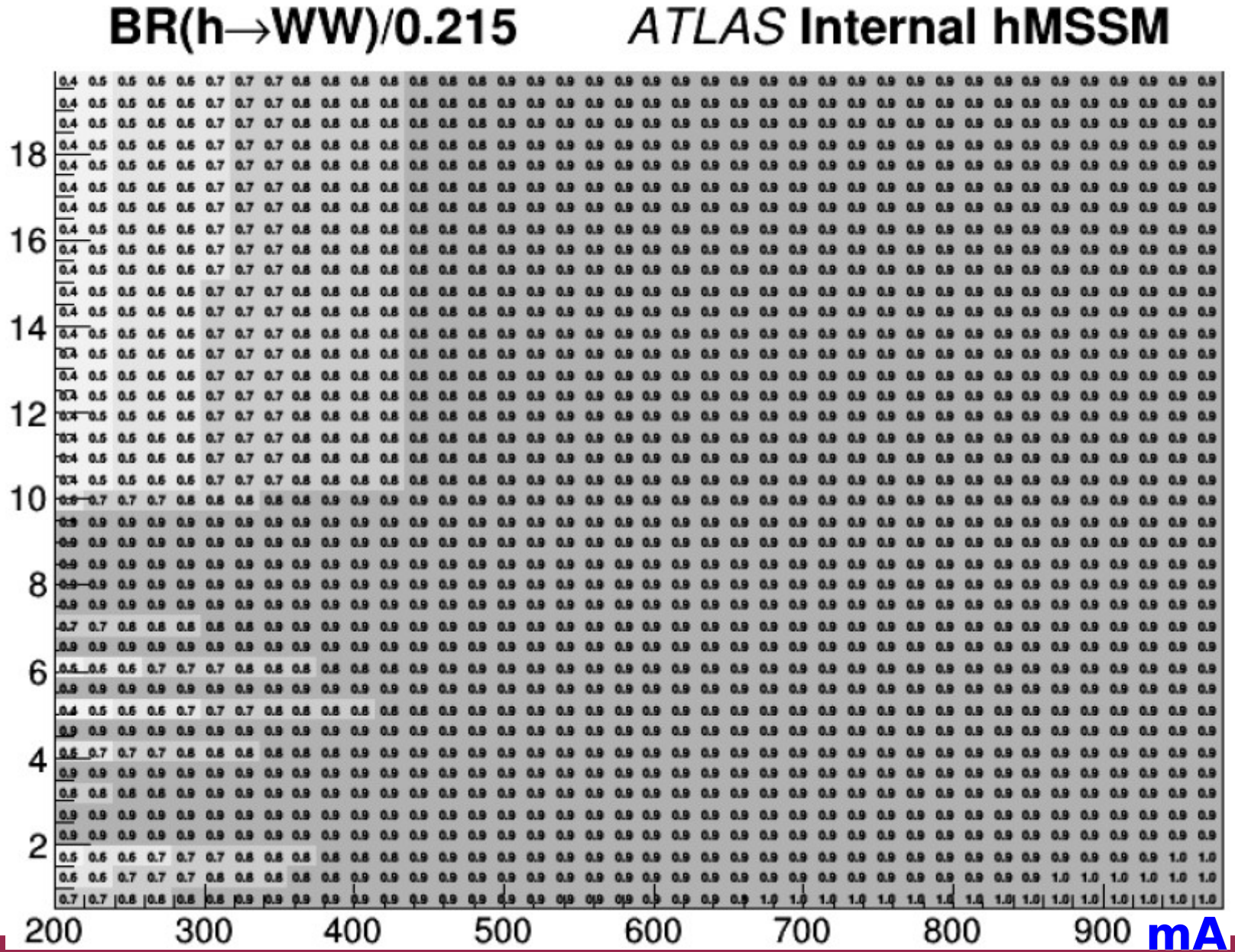
hMSSM

- BR(h-tautau) variation ~30% at most since 260 GeV



hMSSM

- BR(h-WW) variation ~50% starting from 260GeV



Theoretical uncertainties

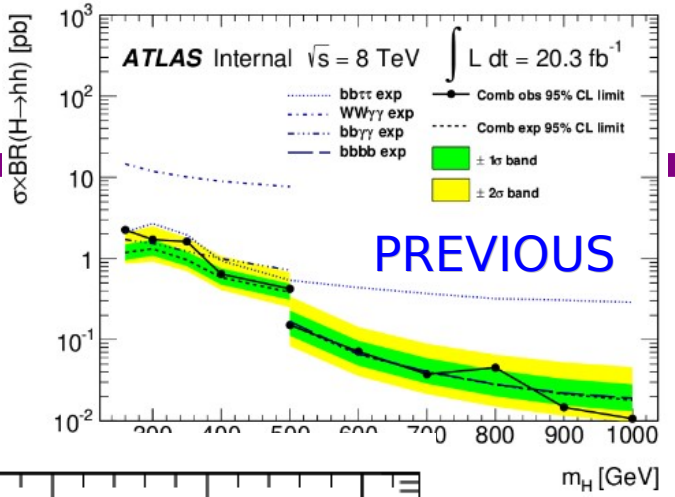
- The uncertainties do not have a specific pattern along mass
- but fluctuation seems to be large
- in agreement to use averaged value in all masses

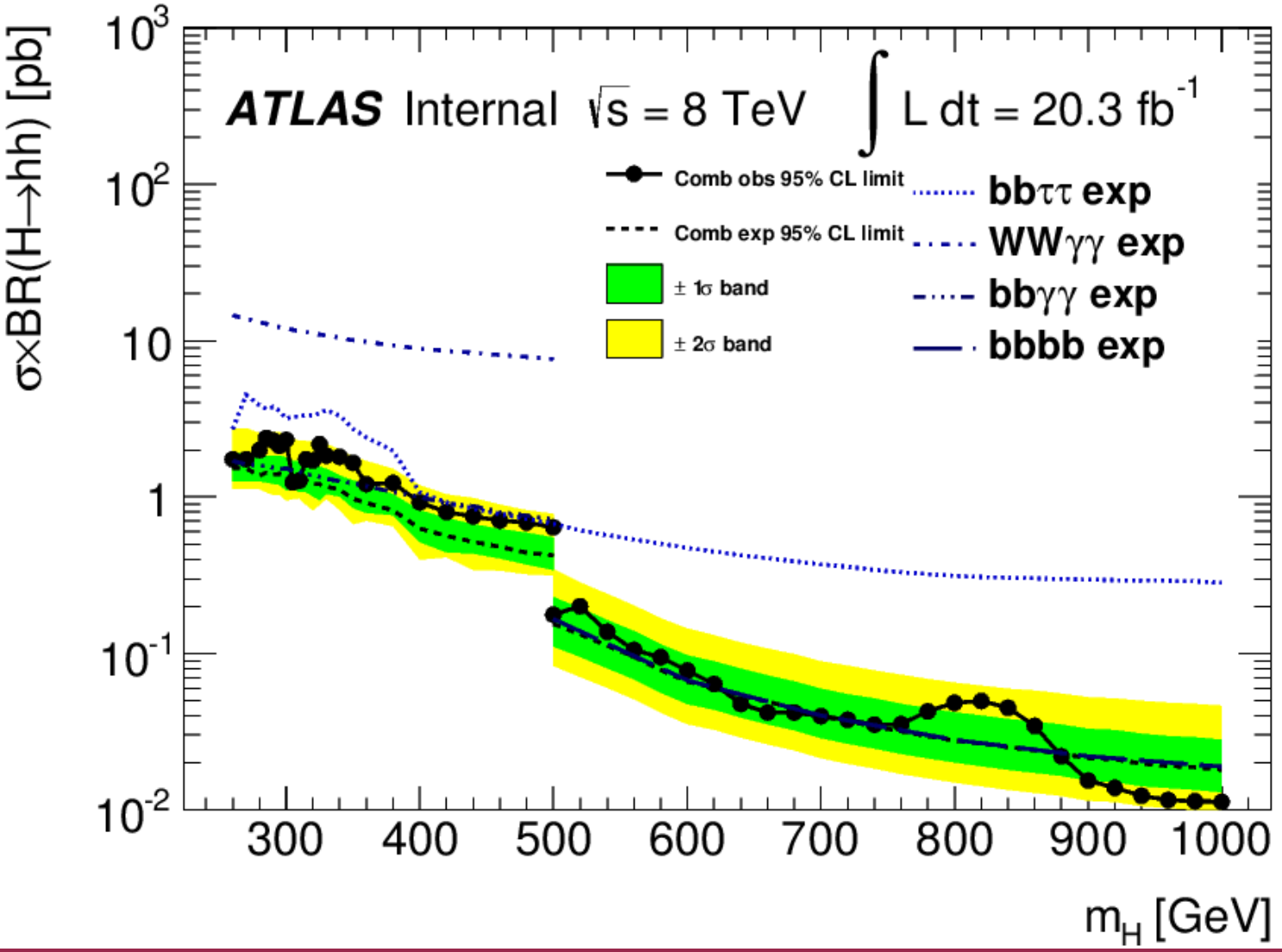
bbtautau	PDF		ISR, SFR		Scale	
	Low	High	Low	High	Low	High
Resonant(260)	1.1	18.2	14.8	54.5	15.2	54.5
Resonant(300)	4.7	8.0	9.9	14.7	10.3	32.0
Resonant(350)	21.6	12.7	36.3	21.7	22.5	30.7
Resonant(400)	20.8	2.3	41.7	14.3	47.9	20.5
Resonant(500)	4.2	2.2	25.0	7.2	33.3	12.6
Resonant(1000)	33.3	5.0	33.3	11.5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

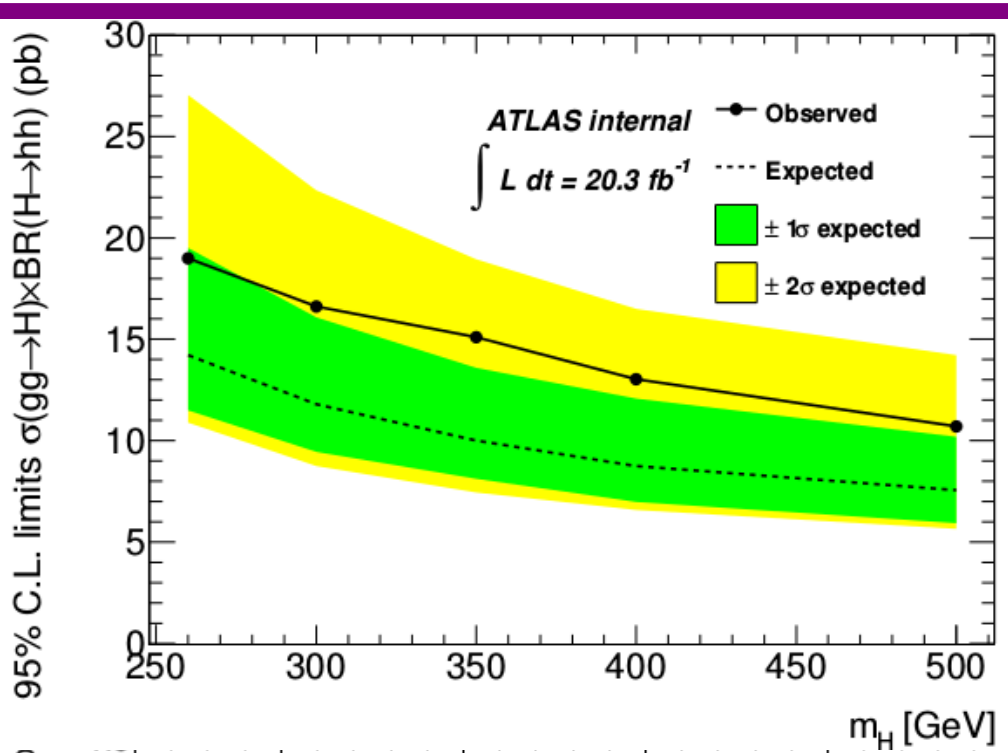
Interpolated mass points

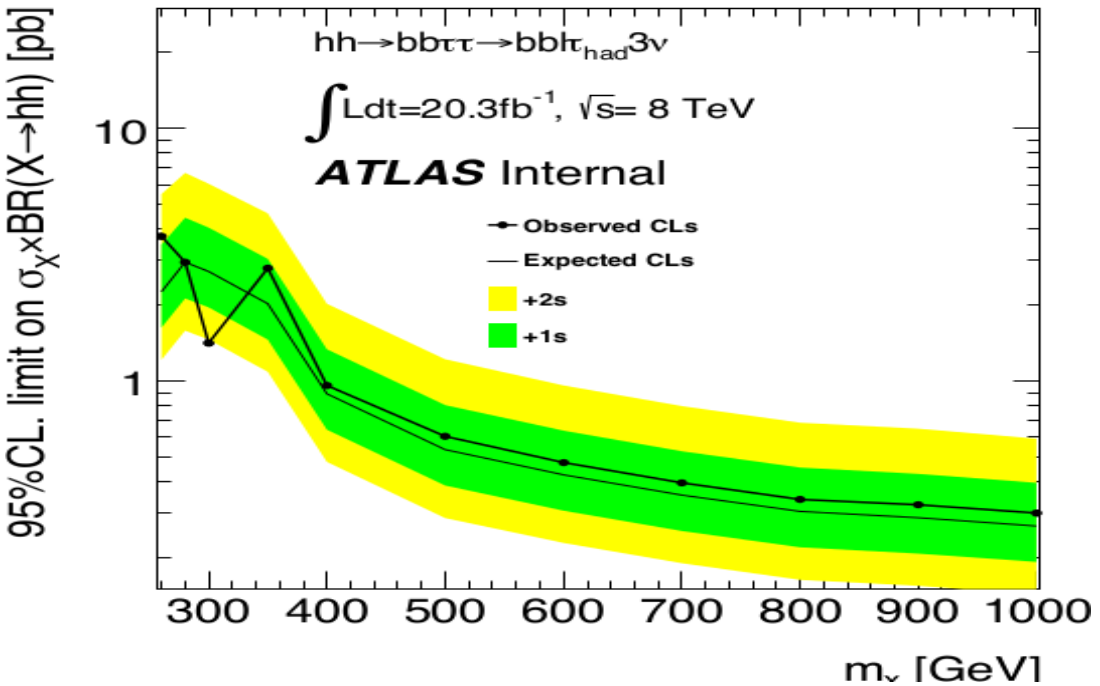
- In both low mass and high mass regions, more mass points are interpolated from available points

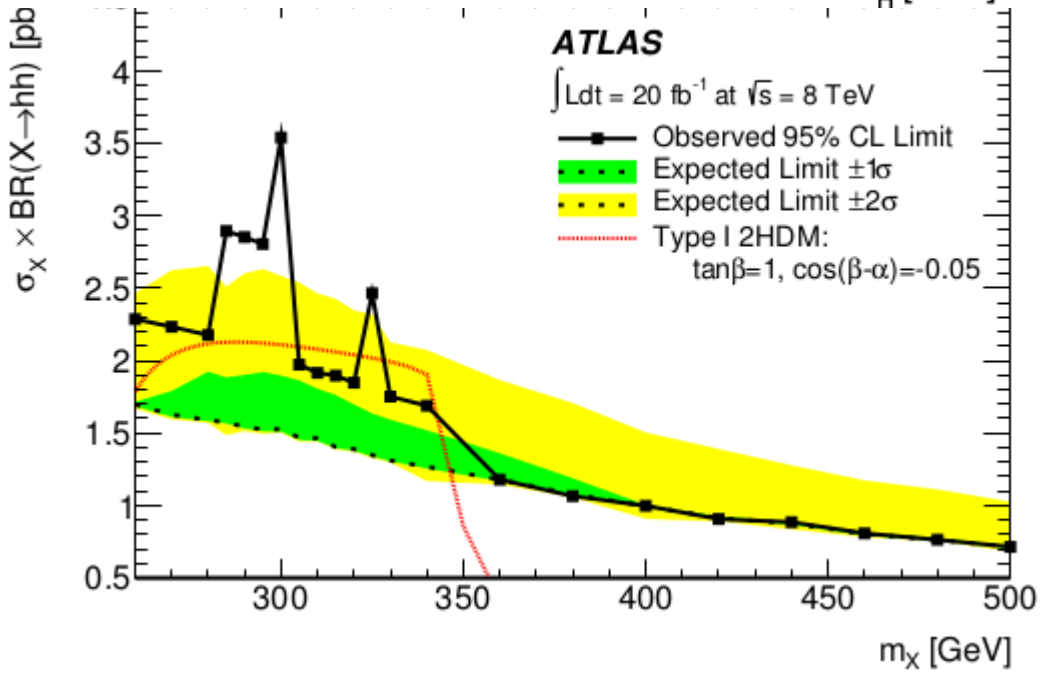


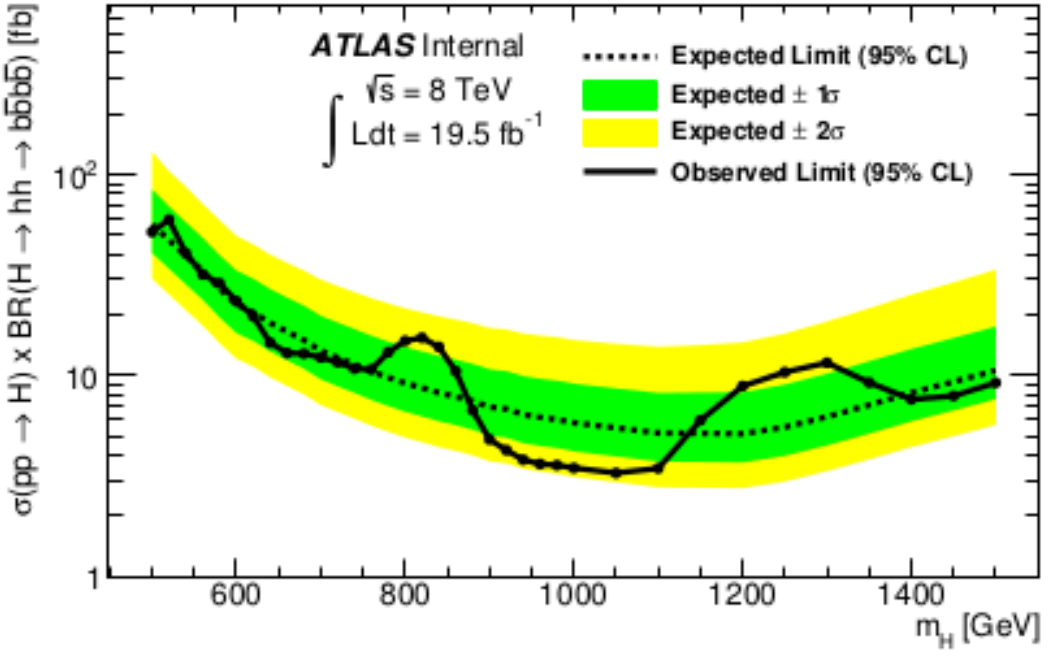


Channel limits [res]



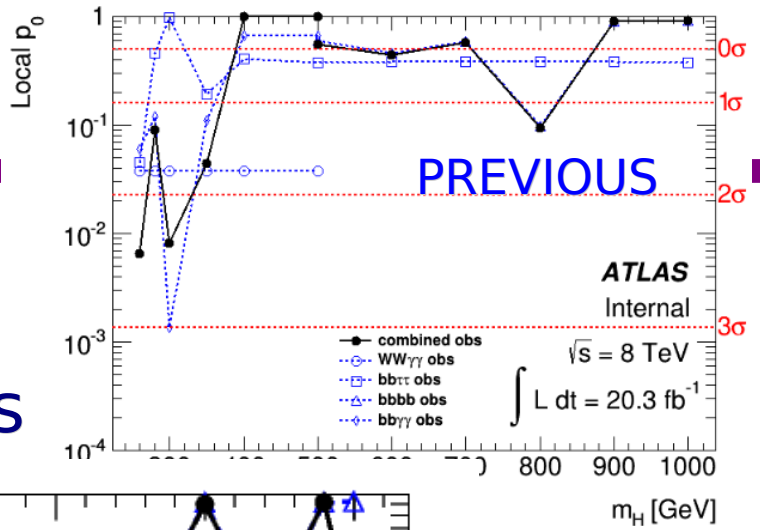


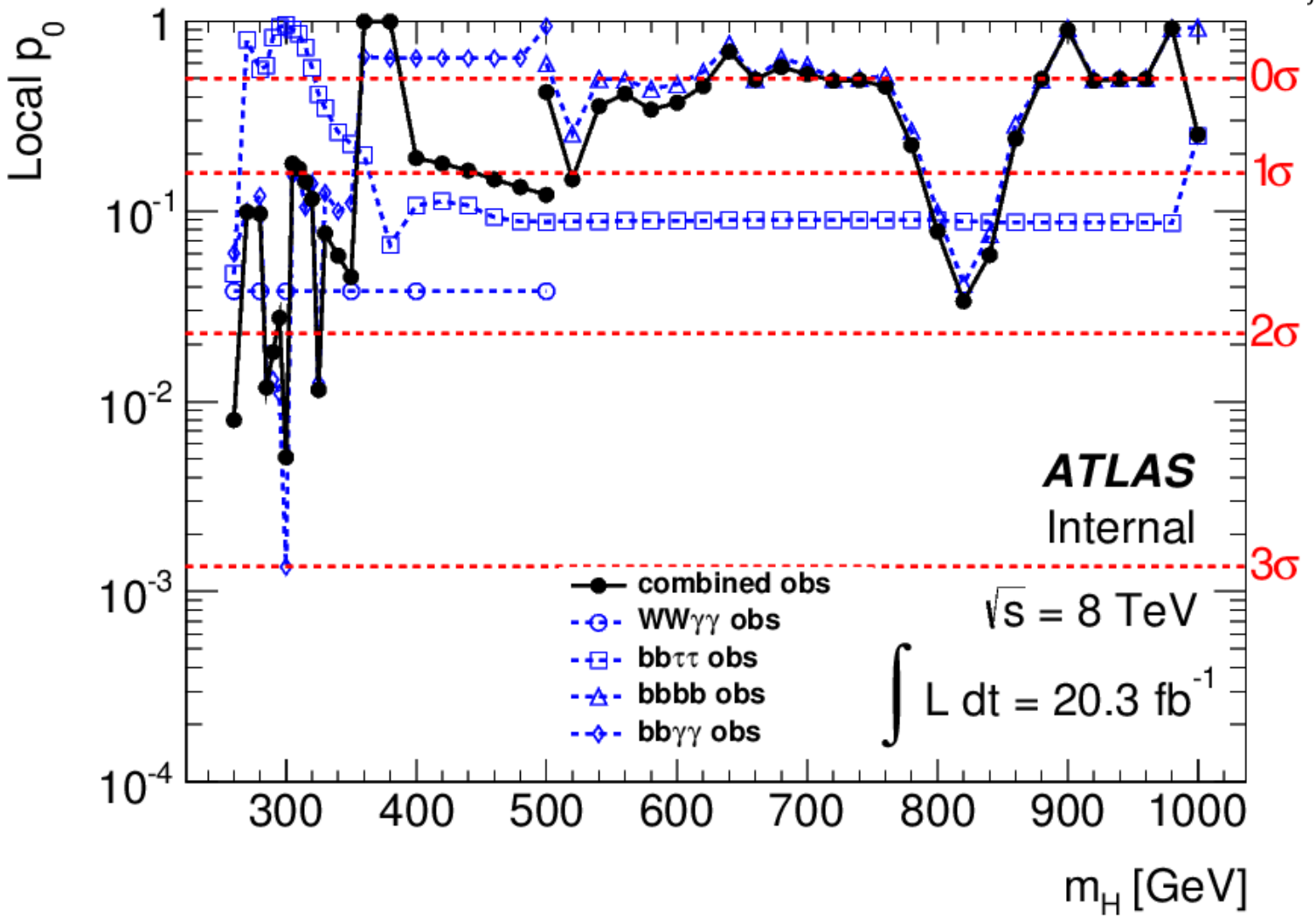




Interpolated mass points

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





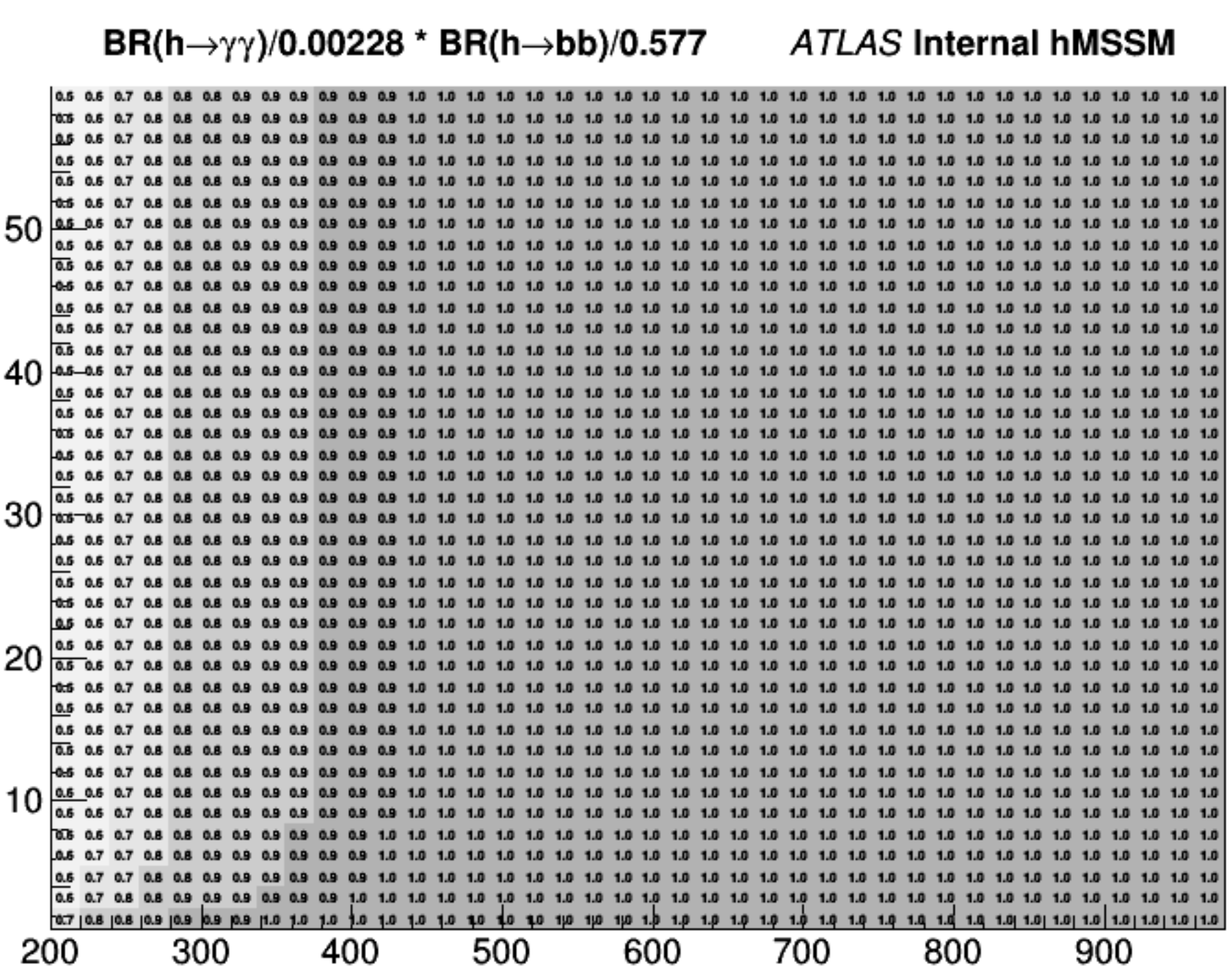
Theoretical uncertianties

- 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

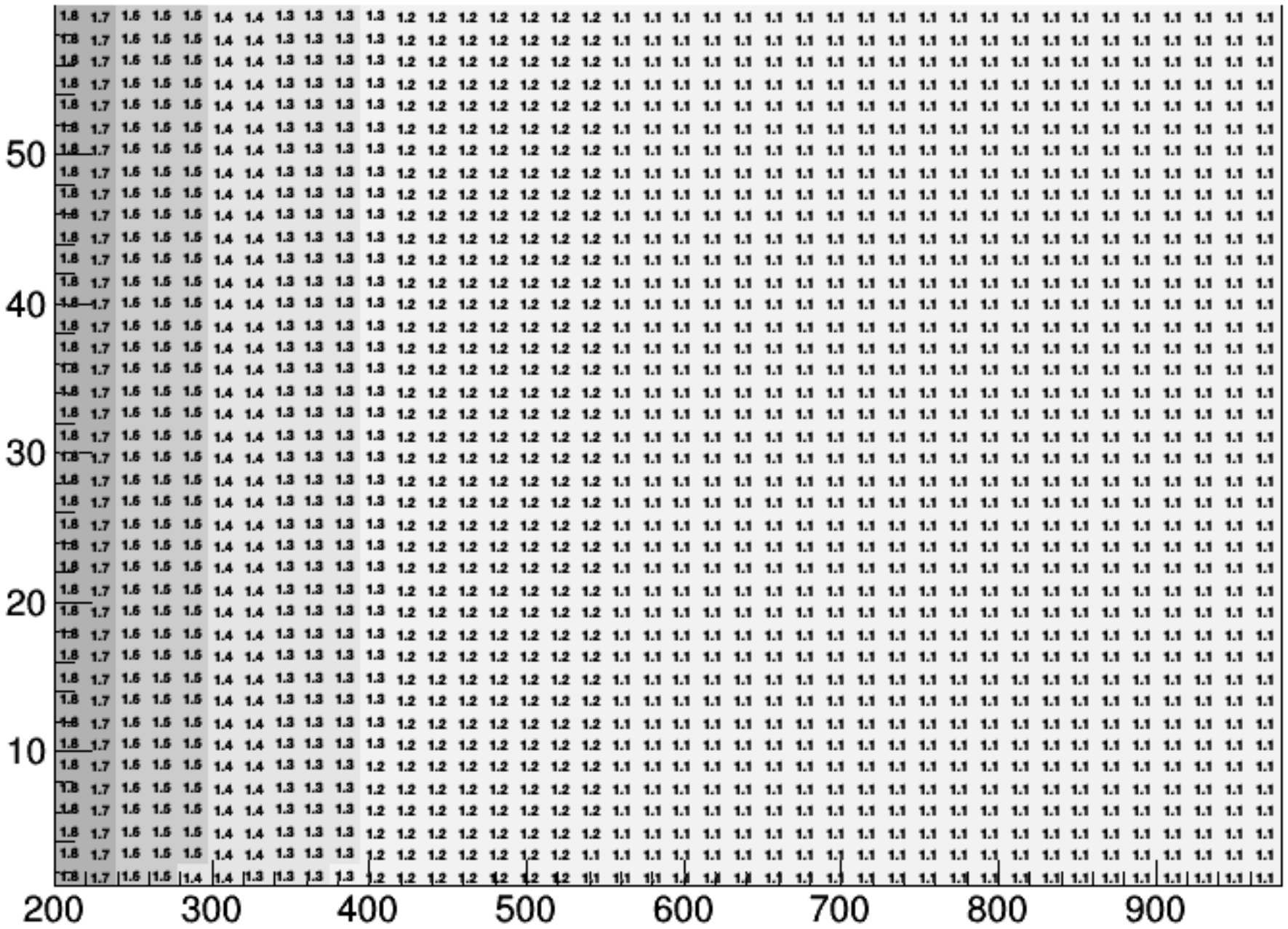
hMSSM Interpretation - **BR*BR**

- 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

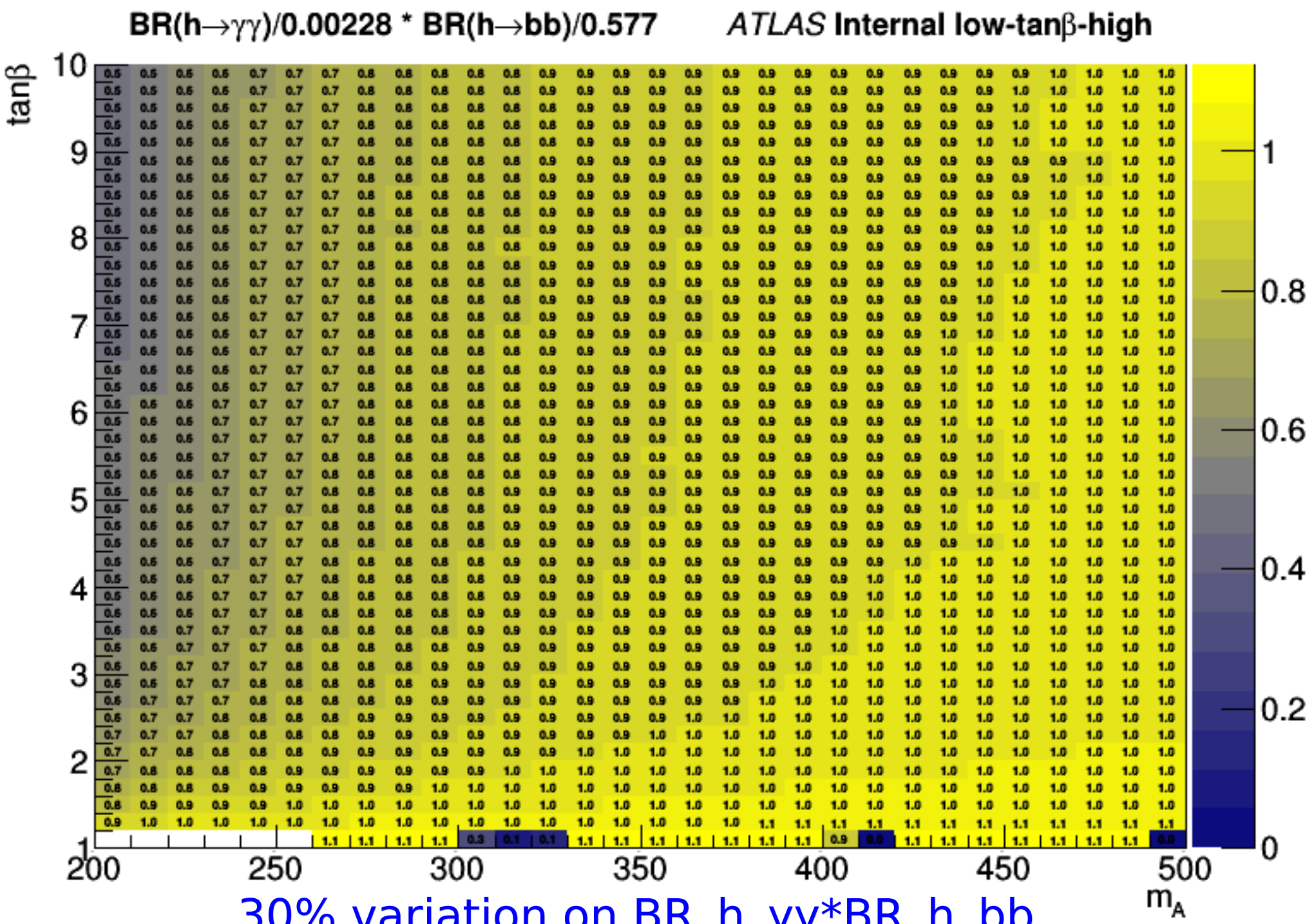


scales on hyy and hbb cancel

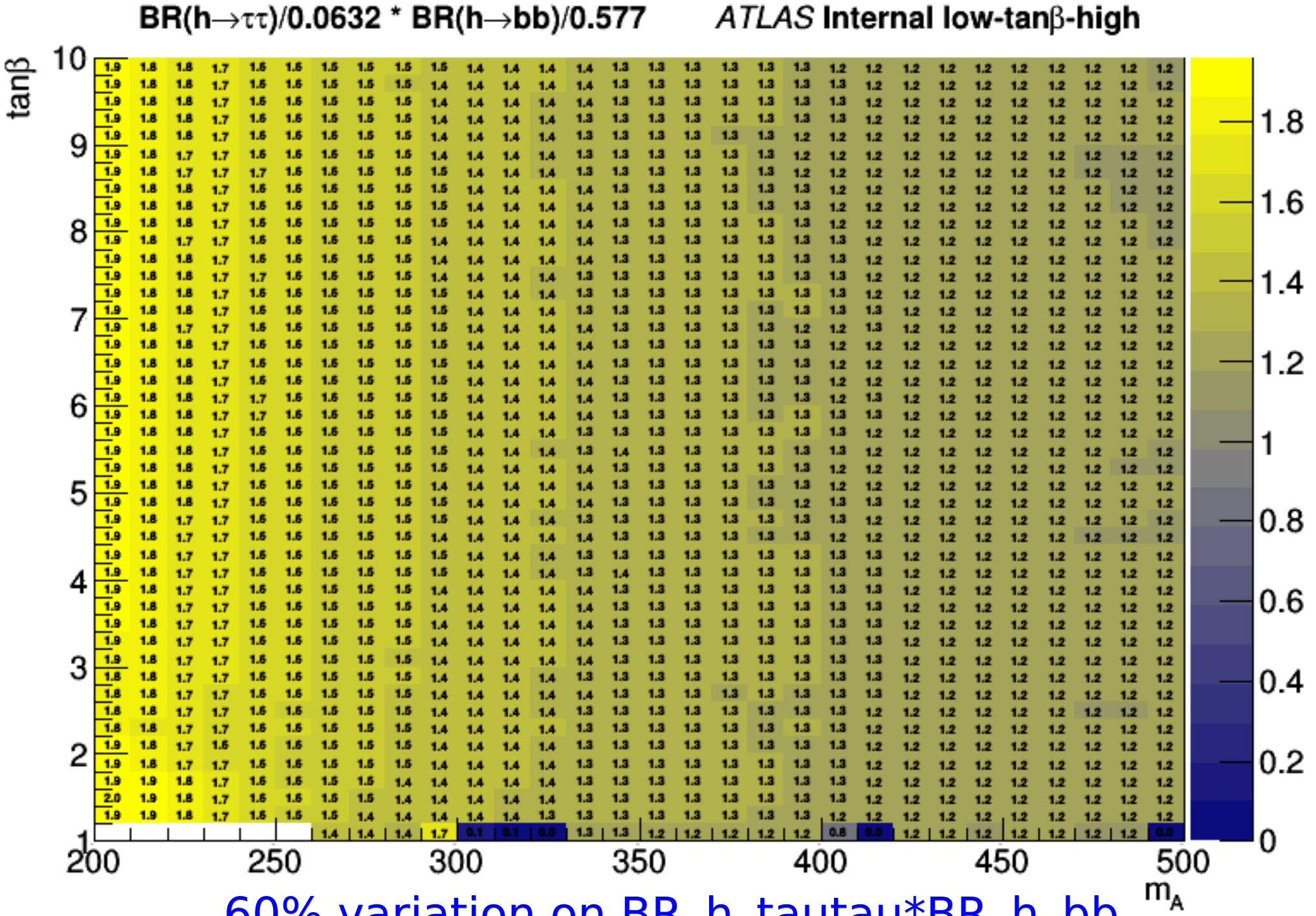
fortunately, bbyy variates < 30%



60% variation on BRtt*BRbb



30% variation on BR_h_yy*BR_h_bb



60% variation on BR_h_tautau*BR_h_bb