HH pair searches status report

combination with wwyy, bbyy, bbττ, bbbb

Xiaohu SUN
on behalf of all HH analyzers

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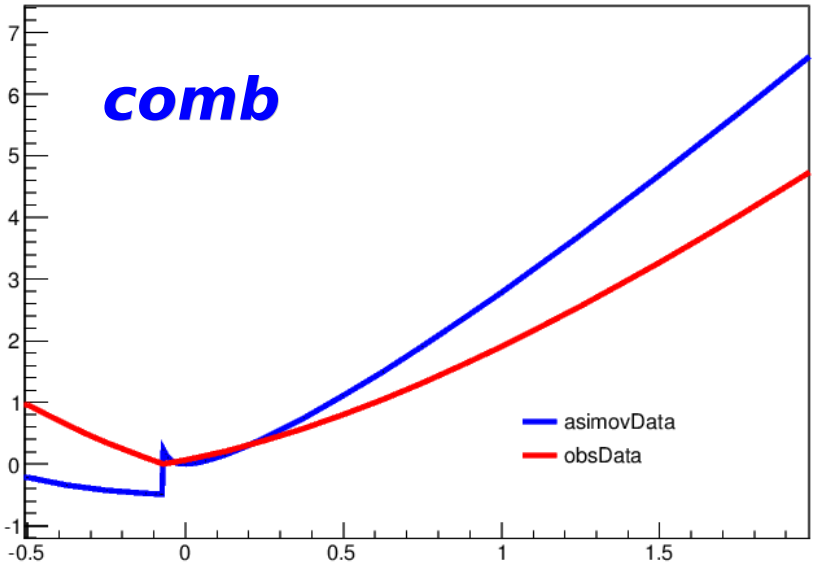
29-06-2015

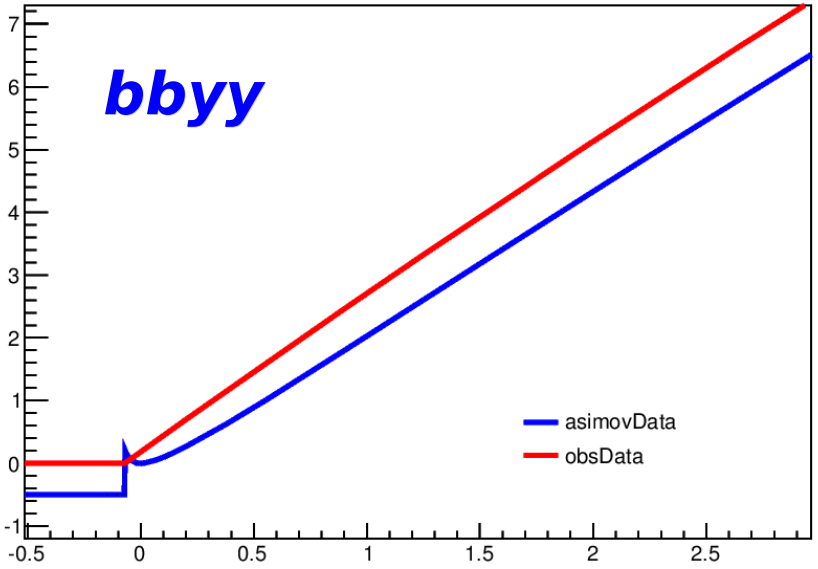
IHEP

CDS entry
[wwyy]https://cds.cern.ch/record/1967498
[bbττ]https://cds.cern.ch/record/1967500
[combination]https://cds.cern.ch/record/1984111/
[paper draft]https://cds.cern.ch/record/2008753/

Current status - limits

- In low mass: now understood p0, limits and mu_hat, but PRL curves drop below certain mu value less than 0 (from bbyy). One might need to inject data toys

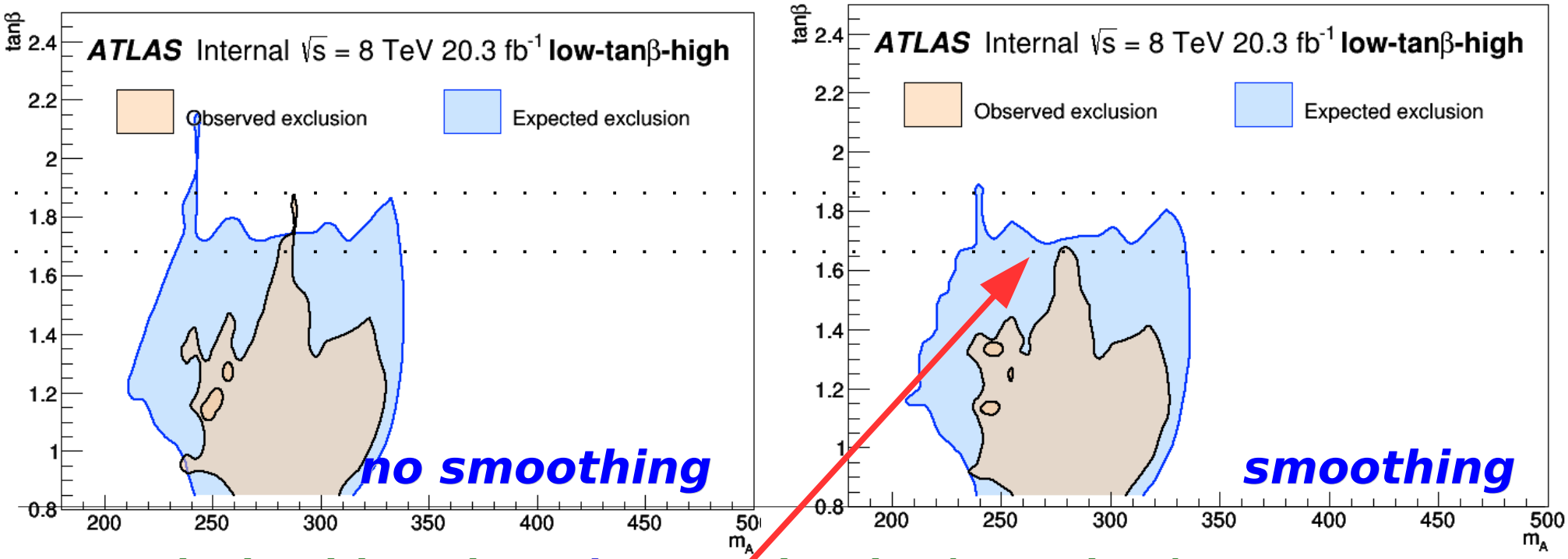




- In high mass: non-parabolic PRL due to bbbb, David is rebinning (2->1) in high mass to avoid bins with signal but no backgrouns

Current status – low-tb-high

- low-tb-high interpretation:
  - use full resolution in map file: **5 GeV vs 0.1**
  - before, we use mA 10 GeV with smooth, did not notice the fine structures in obs
  - compare no smoothing and smoothing

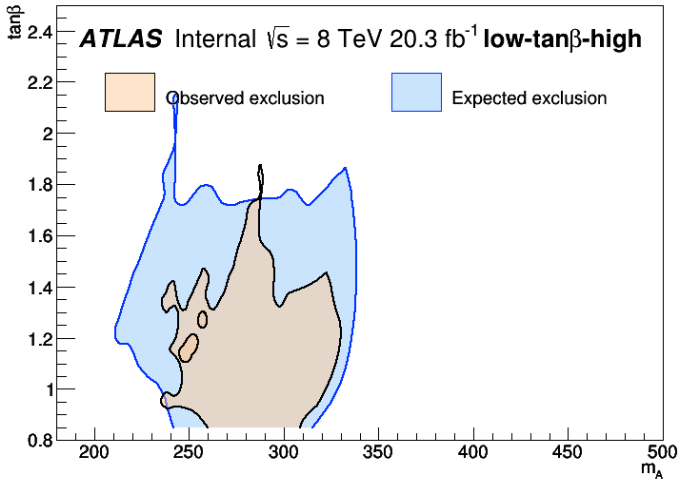


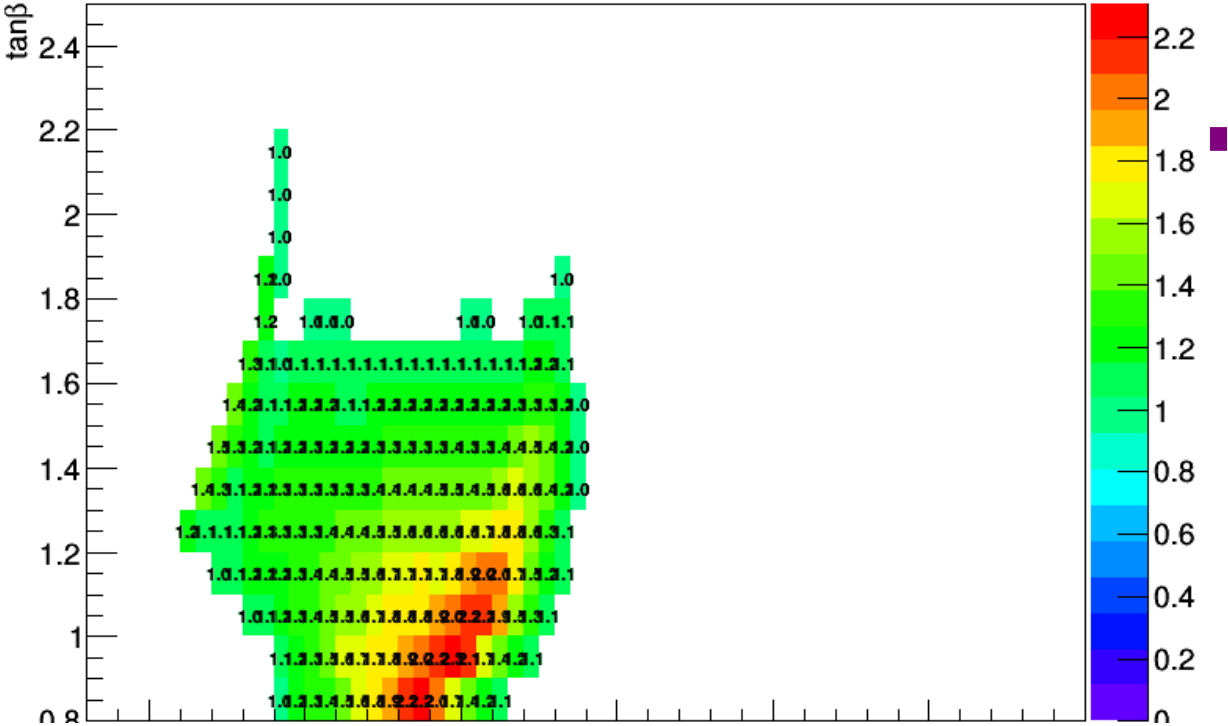
*** smooth algorithm: the Delaunay triangles (TGraph2D)**

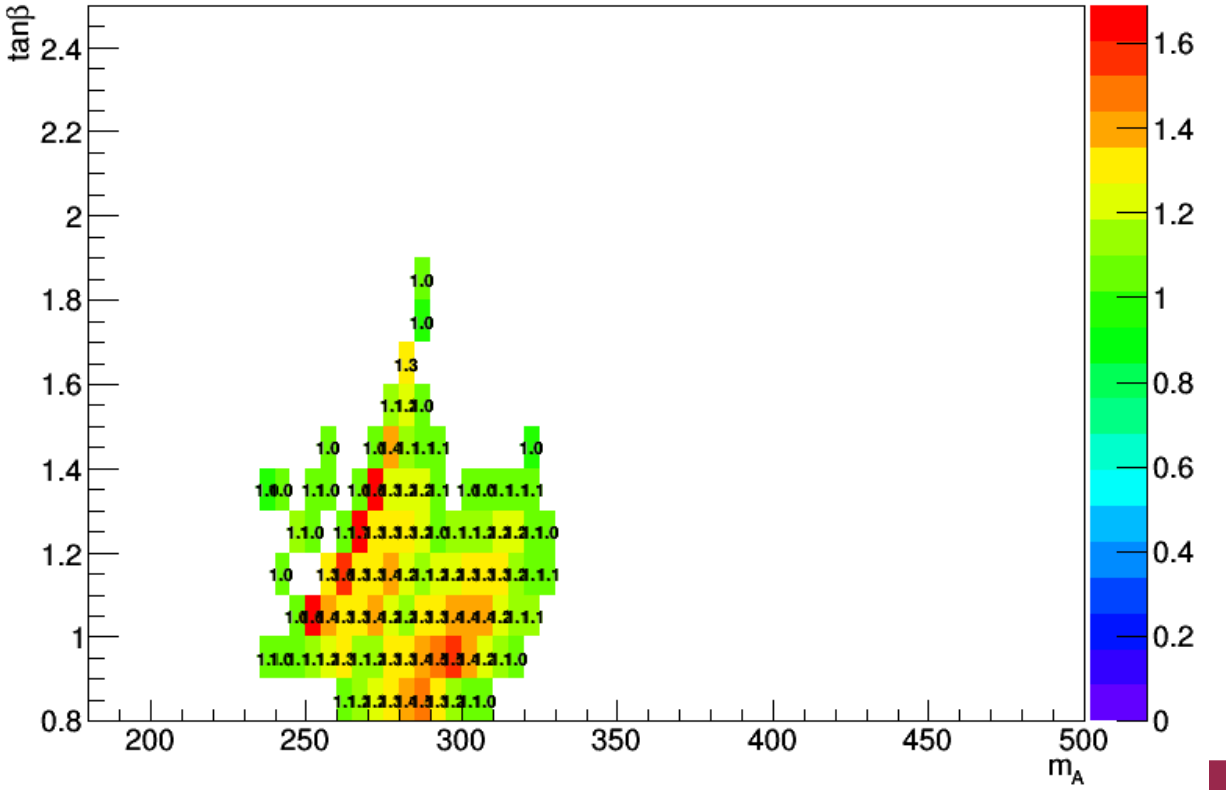
after smoothing, obs shrinks

Excl. maps

- Exclusion map before making contours
- Bins are filled with theo/limit, so once the bin content >1, this bin is excluded
- plots only show bins with theo/limit >1

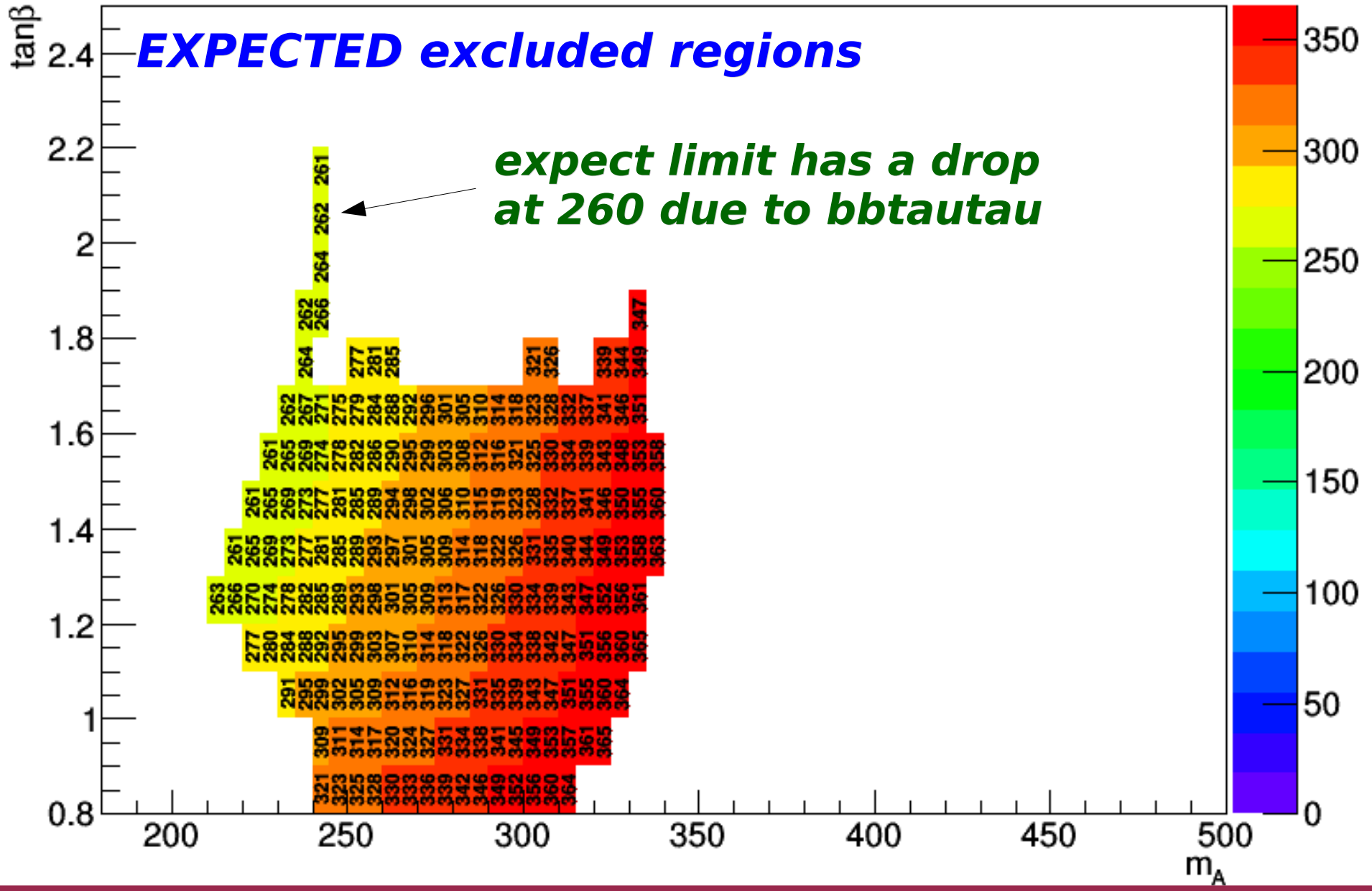






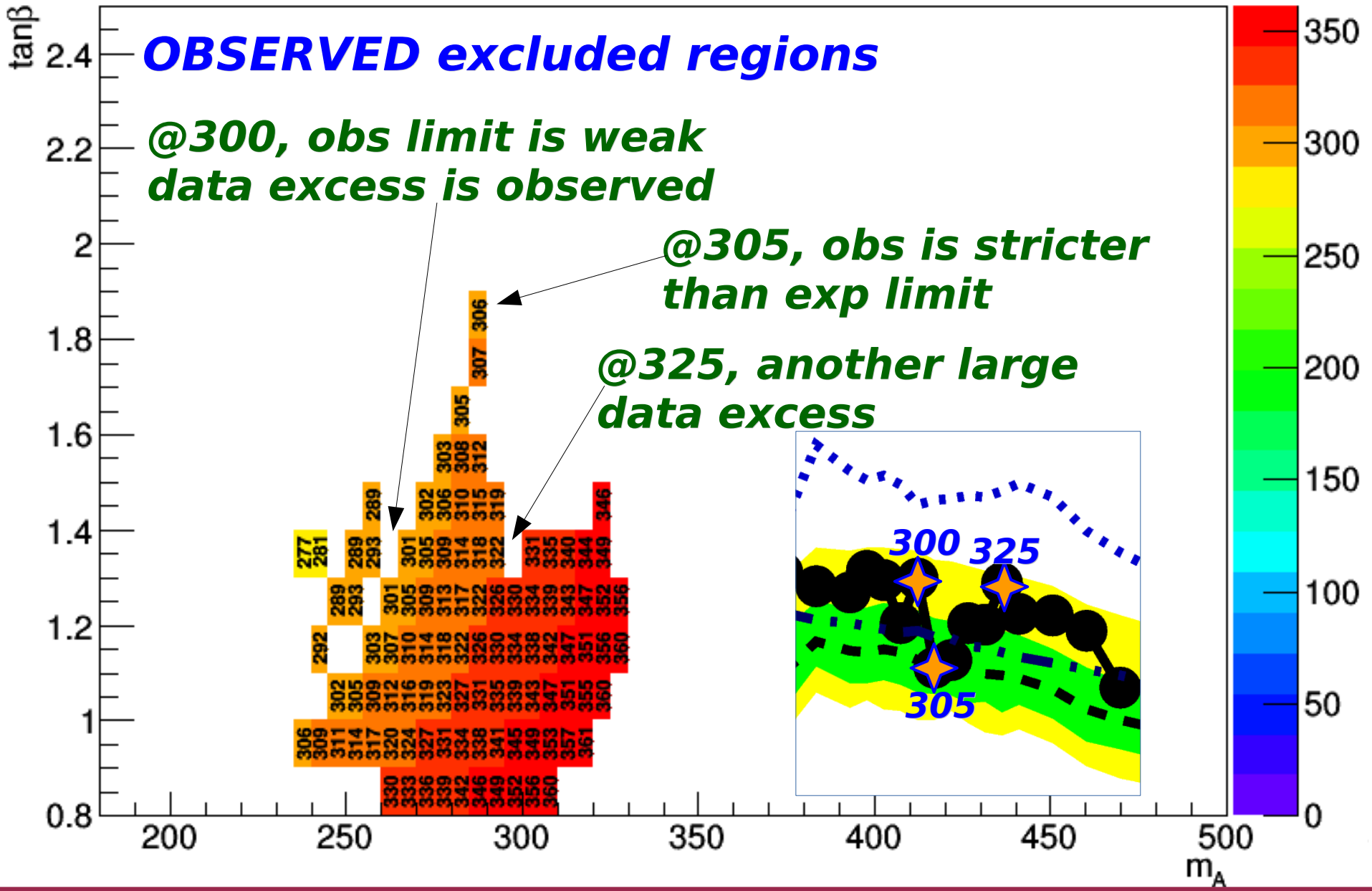
Excl. map (expected, mH)

- Map before contour making: filled with mH



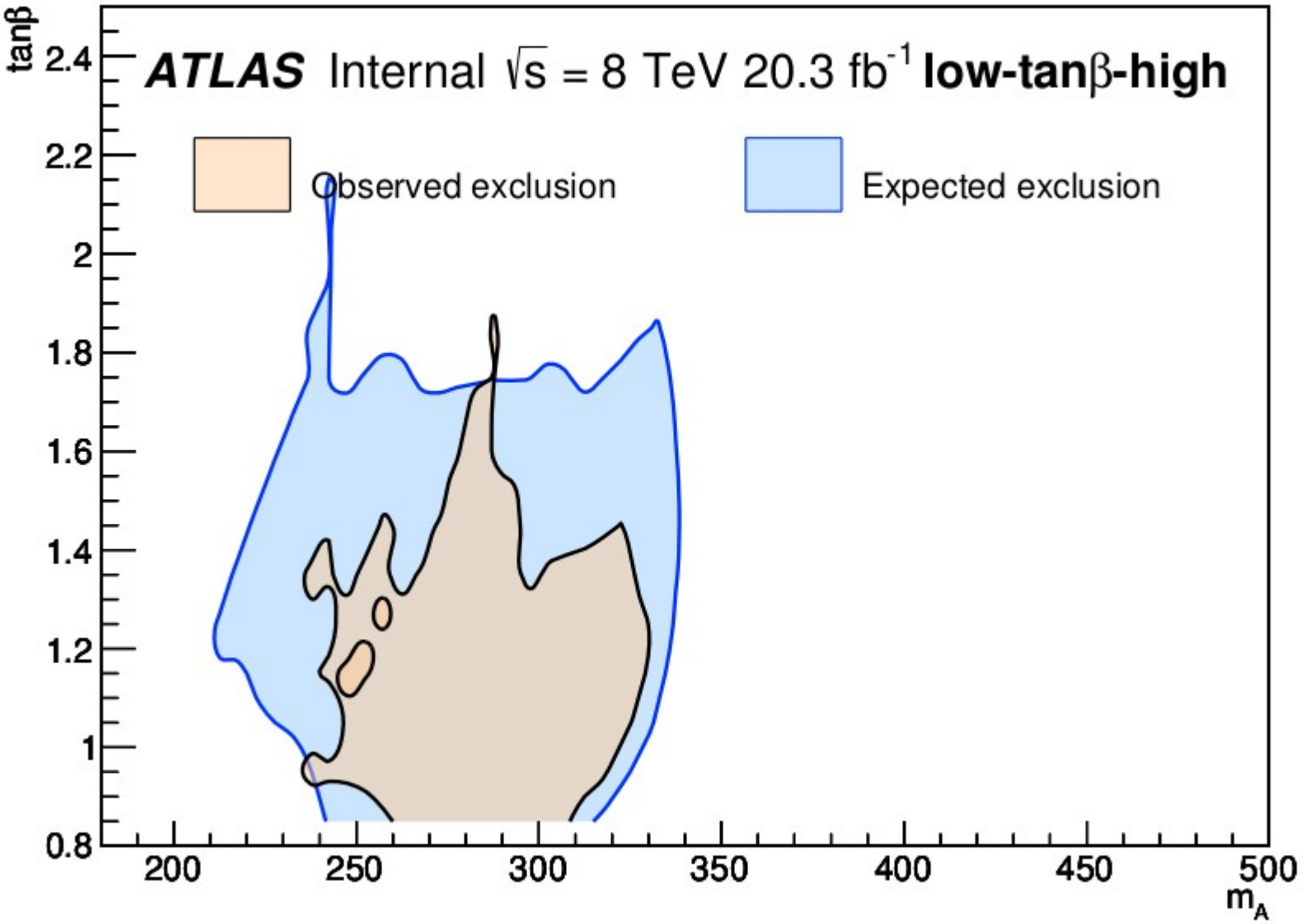
Excl. map (observed, mH)

- Map before contour making: filled with mH



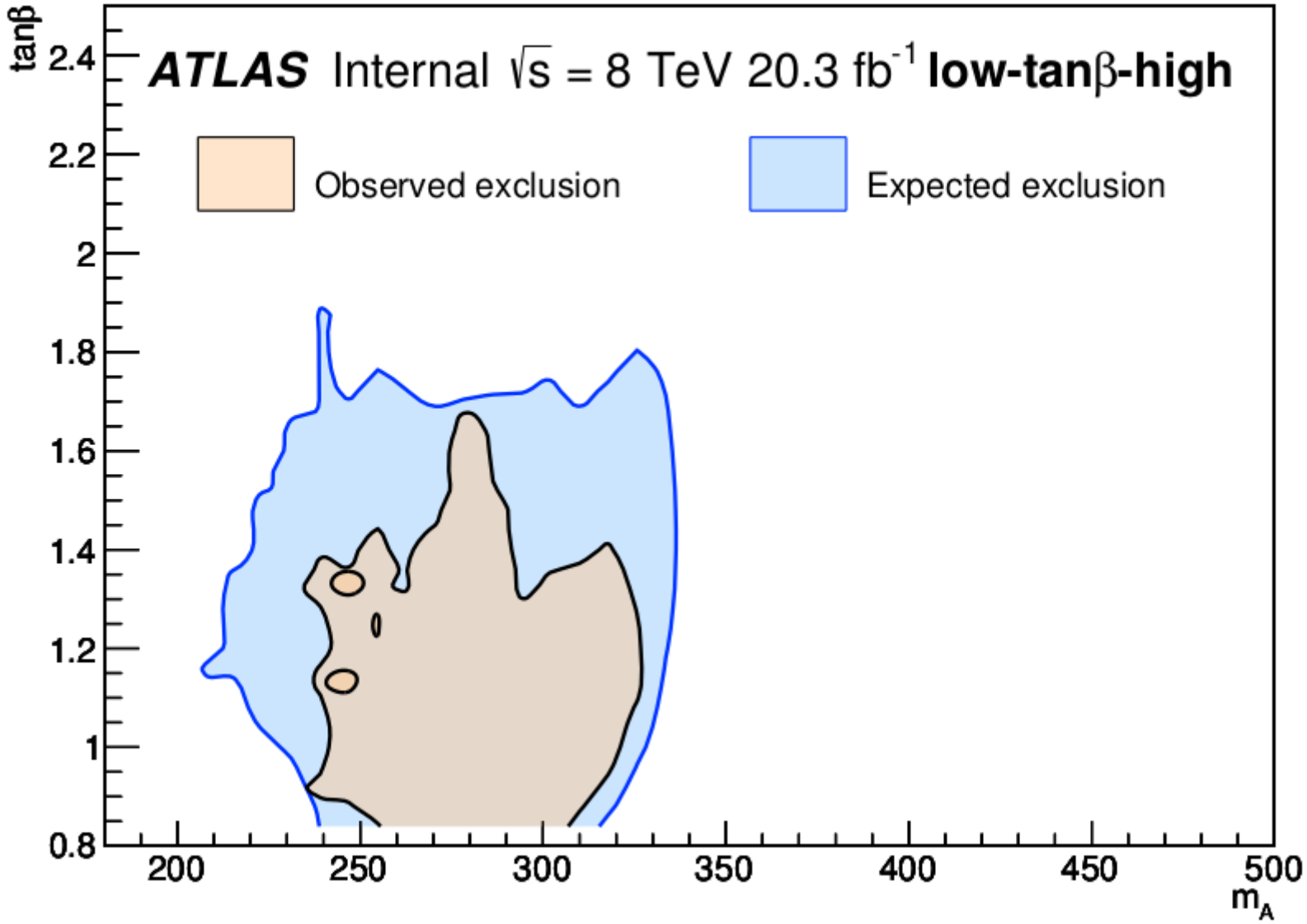
What we have now on low-tb-high 1/3

- No interpolation



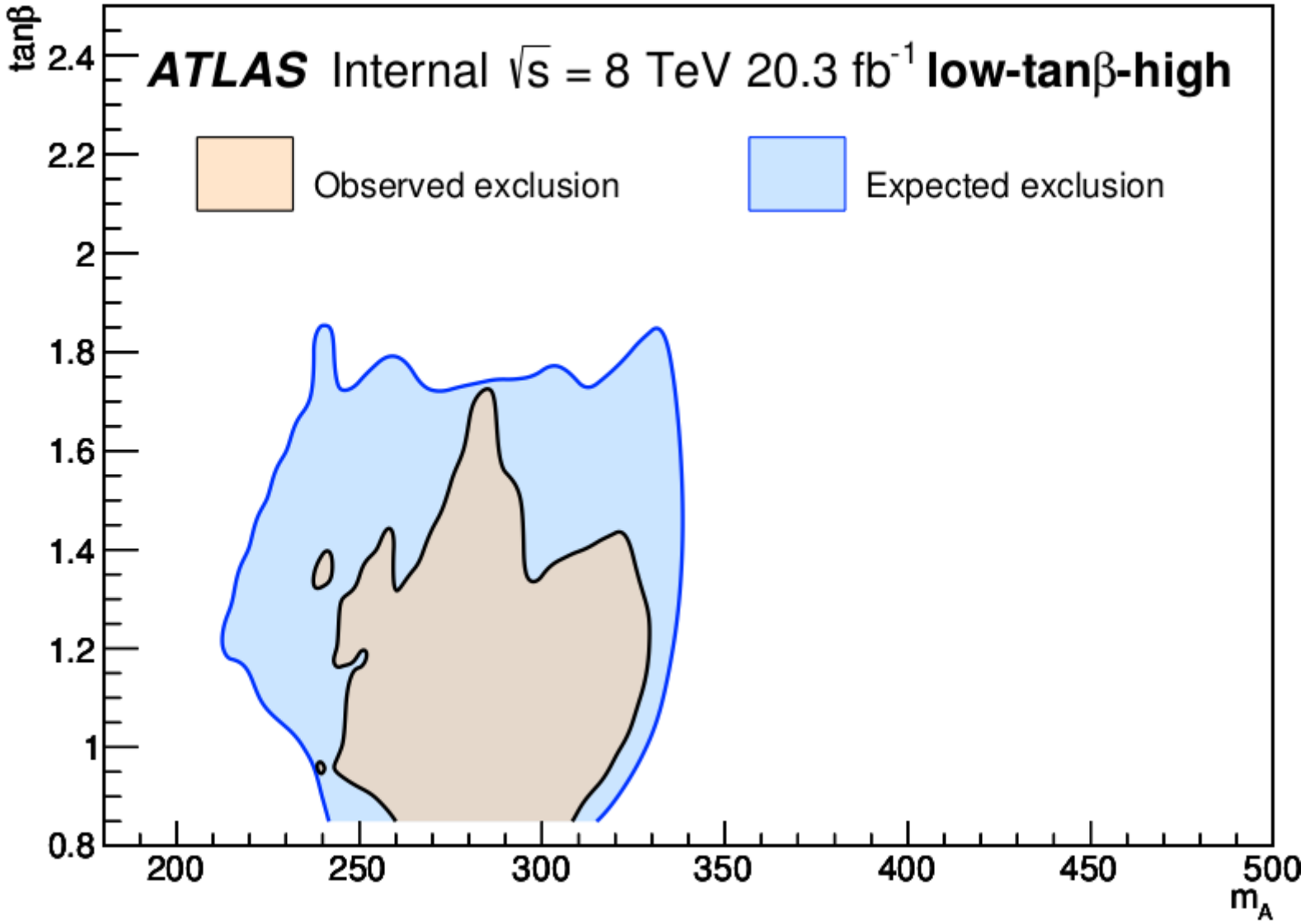
What we have now on low-tb-high 2/3

- Delauney interpolation



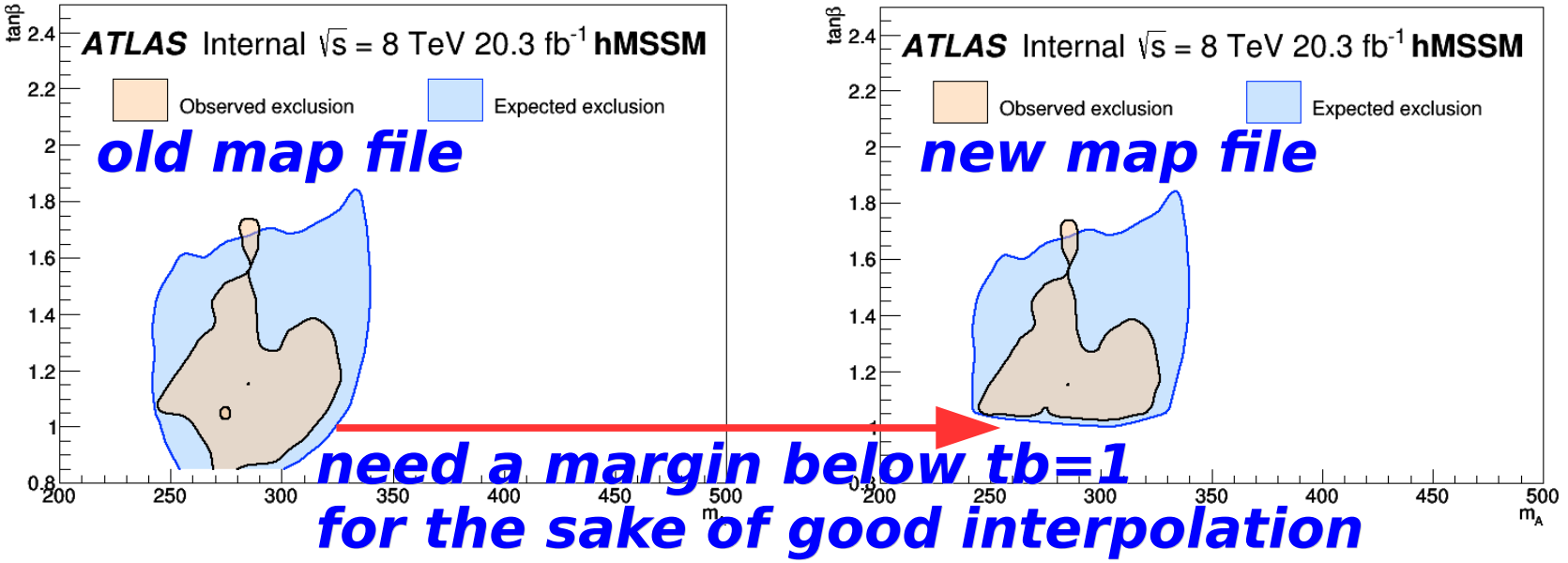
What we have now on low-tb-high 3/3

- Bilinear interpolation (#iteration=5)



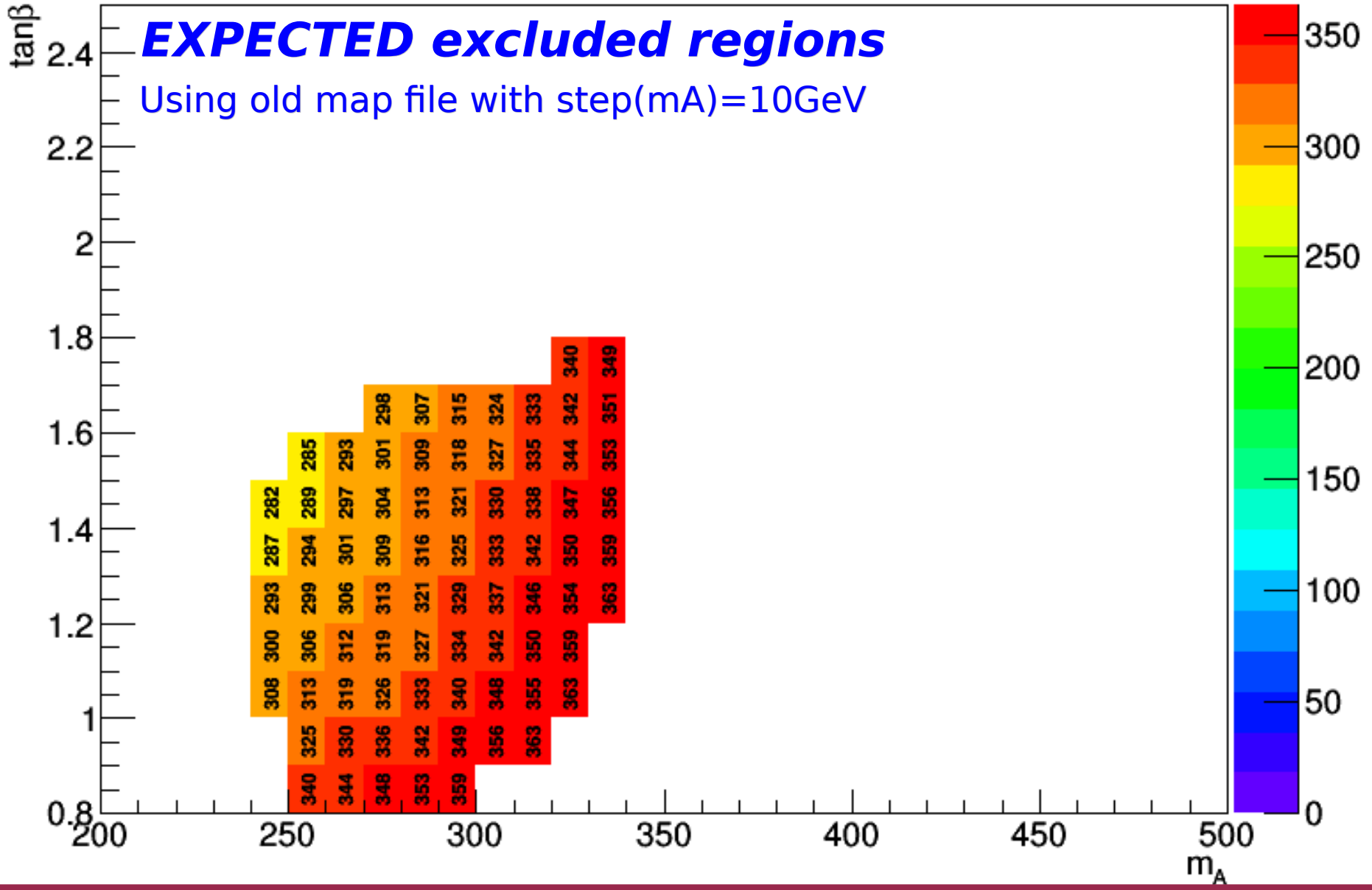
Current status - hMSSM

- hMSSM interpretation:
  - Allison and Nikos produced a new map file with ***5*** GeV on mA step (***10*** GeV previously); but the map file did not have phase points below tb=1.0 which causes interpolation issues in TGraph (closed contours are drawn @ tb~1). We asked for a margin below tb=1 (will be ready this week)



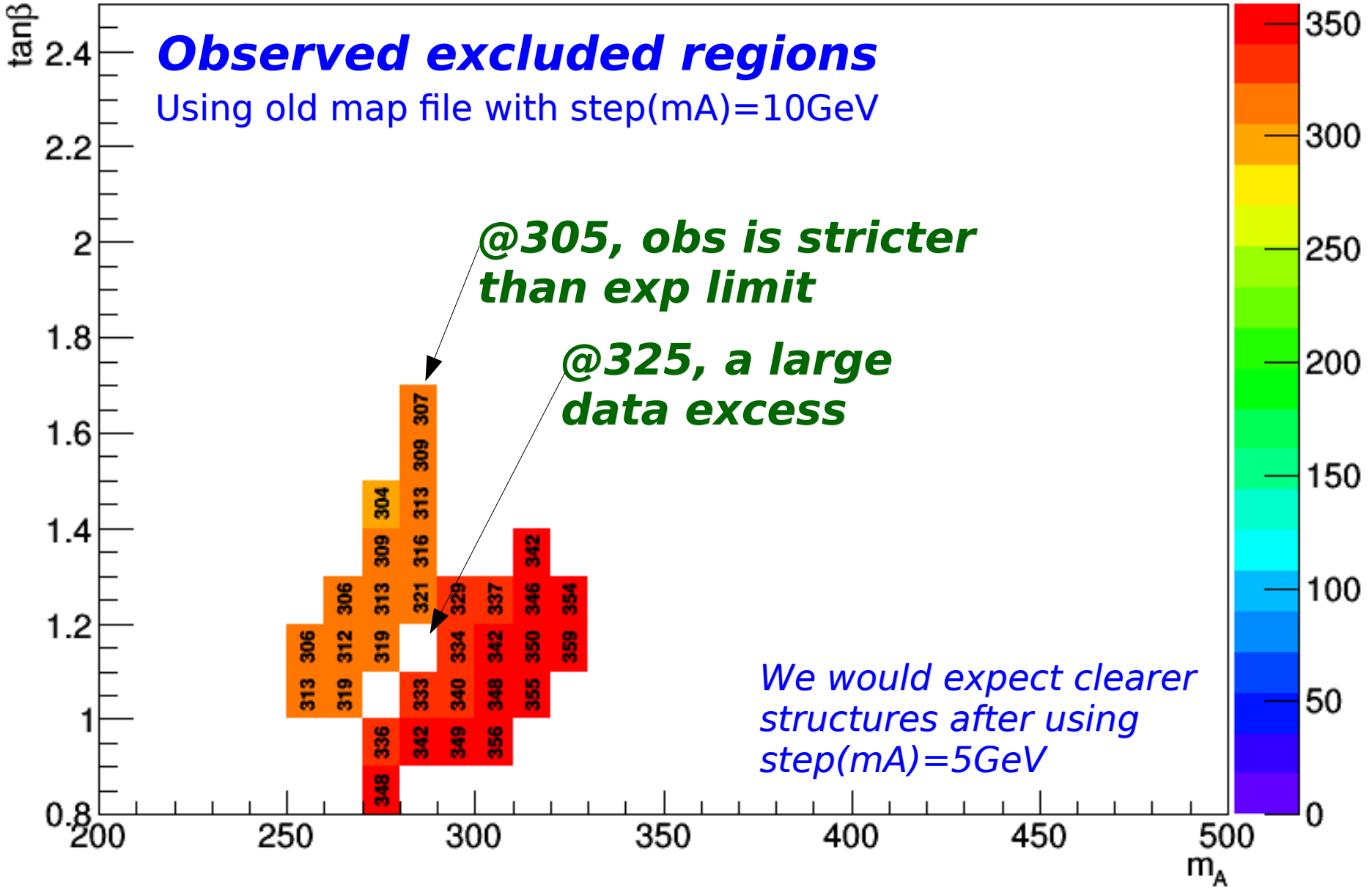
Exclu. map (expected, mH)

- Plot the exclusion maps before contour making



Exclu. map (observed, mH)

- Plot the exclusion maps before contour making



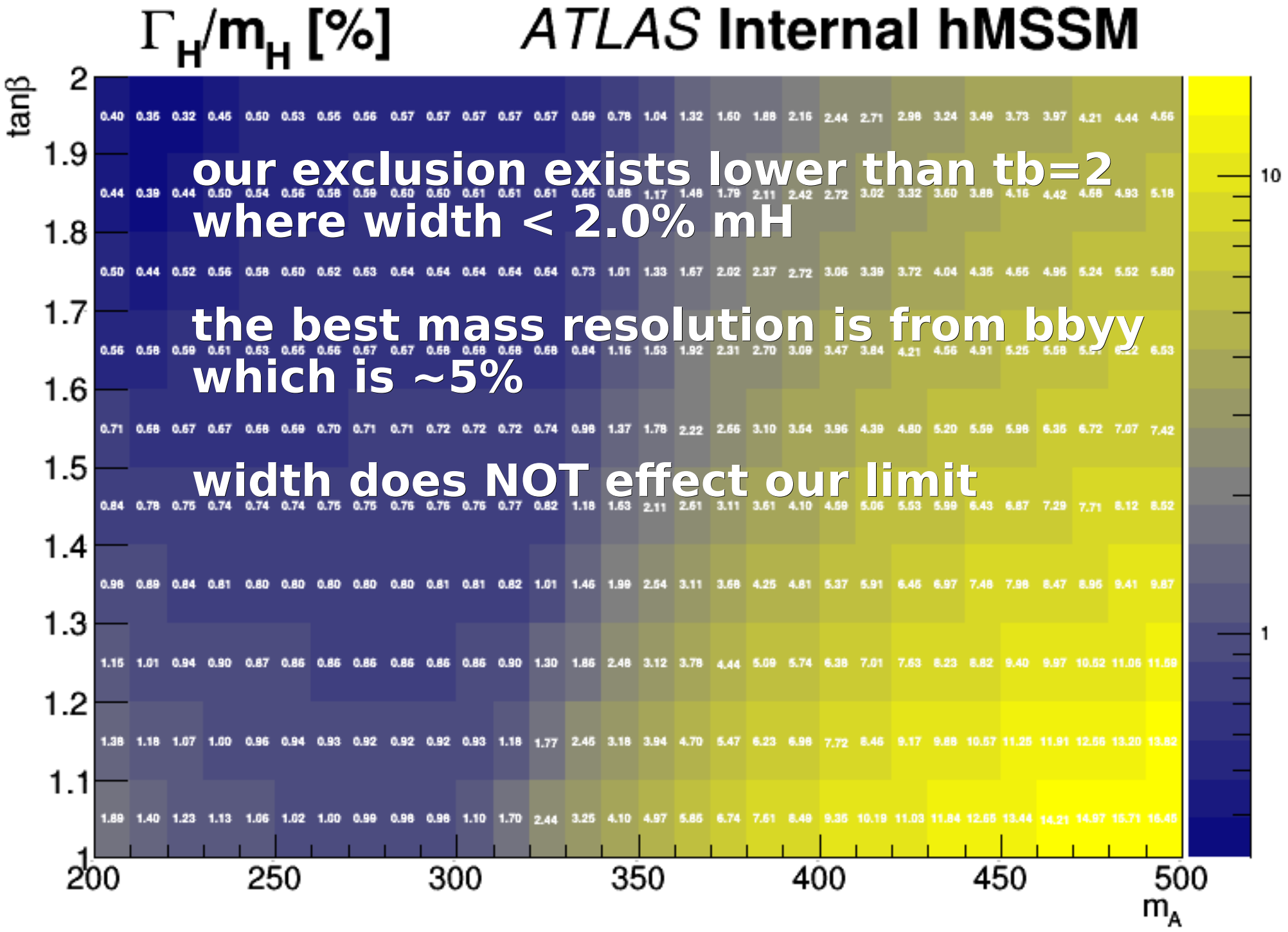
backup

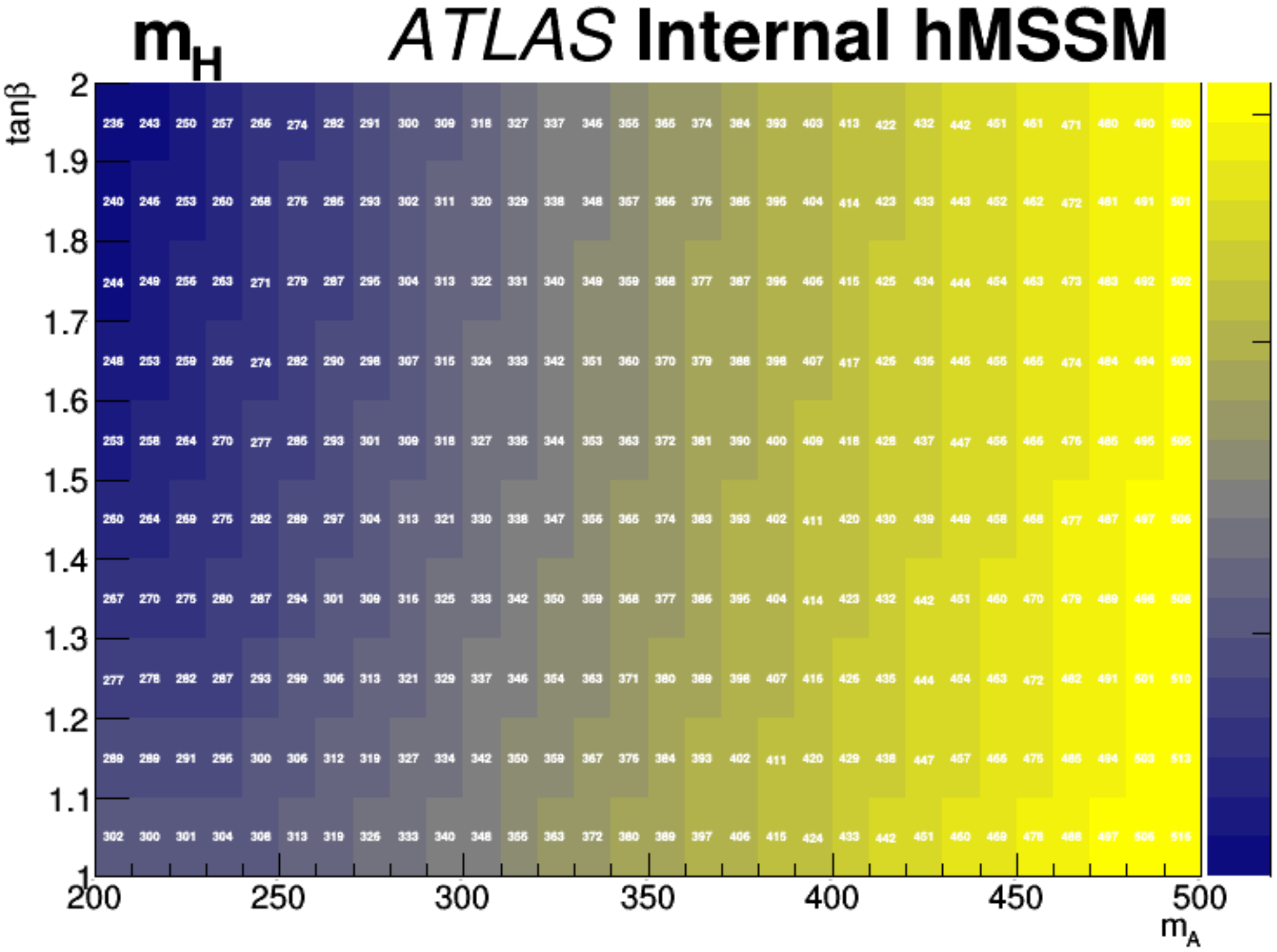
bbtautau rate uncertainty (theory)

merge Low / High pT higgs categories

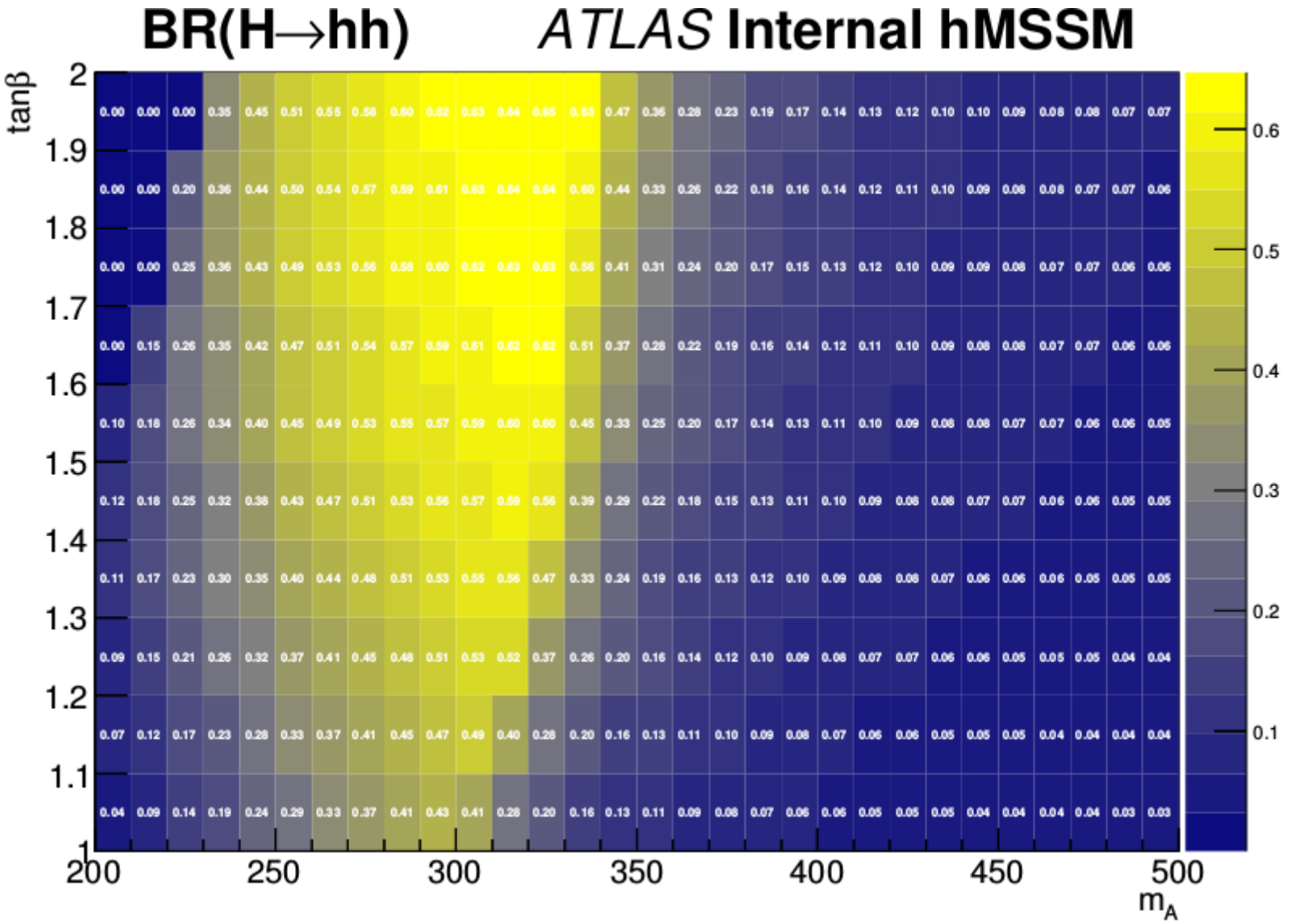
Theory uncertainty [%]

	stat	PDF	ISR, FSR	Scale
		L/H merge	L/H merge	L/H merge
260	40k	2.3	5.5	3.0
300	40k	1.5	3.8	6.2
350	40k	3.4	7.9	3.7
400	40k	0.89	2.3	2.7
500	40k	-3.1	6.0	4.5
800	40k	1.8	5.4	3.1
1000	40k	1.9	3.5	1.9
non-resonant	40k	2.5	4.2	4.2

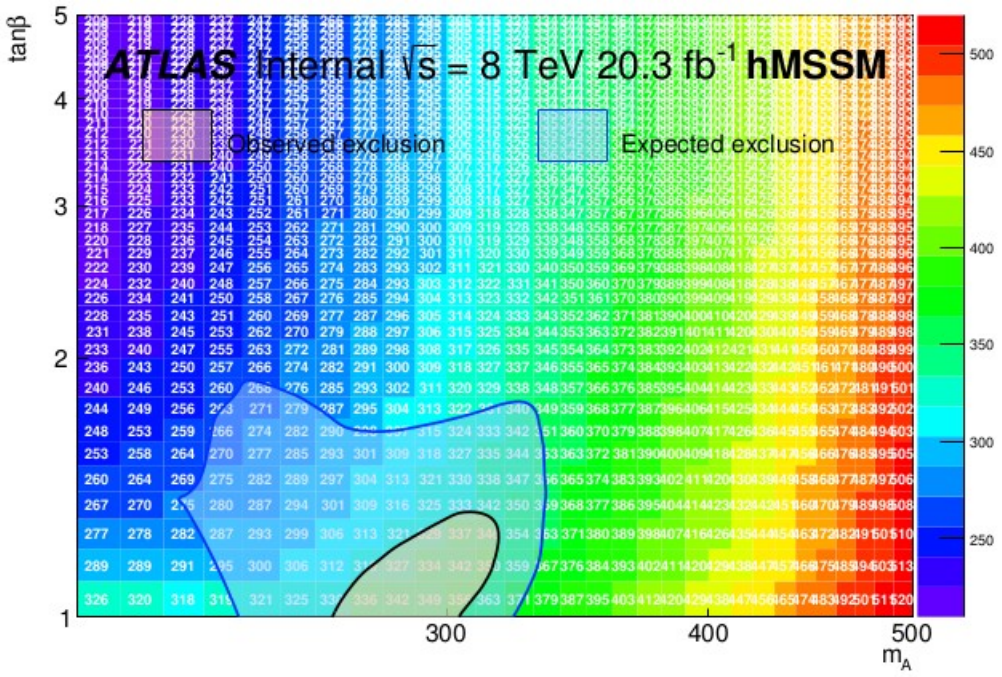

Γ_H/m_H [%]
ATLAS Internal hMSSM
tanβ
m_A
our exclusion exists lower than tb=2 where width < 2.0% mH
the best mass resolution is from bbyy which is ~5%
width does NOT effect our limit

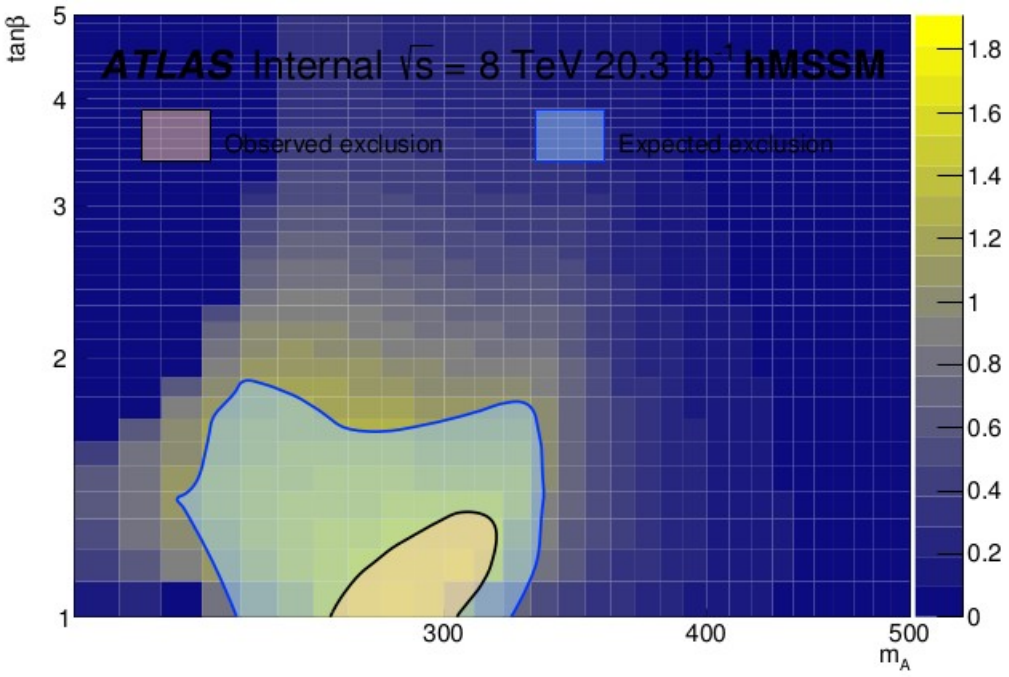

m_H
ATLAS Internal hMSSM
tanβ
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
200
250
300
350
400
450
500
m_A
236 243 250 257 266 274 282 291 300 309 318 327 337 346 355 365 374 384 393 403 413 422 432 442 451 461 471 480 490 500
240 246 253 260 268 276 285 293 302 311 320 329 338 348 357 366 376 386 396 404 414 423 433 443 452 462 472 481 491 501
244 249 256 263 271 279 287 295 304 313 322 331 340 349 359 368 377 387 396 406 415 425 434 444 454 463 473 483 492 502
248 253 259 266 274 282 290 298 307 315 324 333 342 351 360 370 379 388 398 407 417 425 436 445 455 466 474 484 494 503
253 258 264 270 277 285 293 301 309 318 327 335 344 353 363 372 381 390 400 409 418 428 437 447 456 466 476 485 495 506
260 264 269 275 282 289 297 304 313 321 330 338 347 356 365 374 383 393 402 411 420 430 439 449 458 468 477 487 497 506
267 270 275 280 287 294 301 309 316 325 333 342 350 359 368 377 386 396 404 414 423 432 442 451 460 470 479 489 498 508
277 278 282 287 293 299 306 313 321 329 337 346 354 363 371 380 389 398 407 416 426 435 444 454 463 472 482 491 501 510
289 289 291 295 300 306 312 319 327 334 342 350 359 367 376 384 393 402 411 420 429 438 447 457 466 475 485 494 503 513
302 300 301 304 308 313 319 326 333 340 348 355 363 372 380 389 397 406 415 424 433 442 451 460 469 478 488 497 506 516

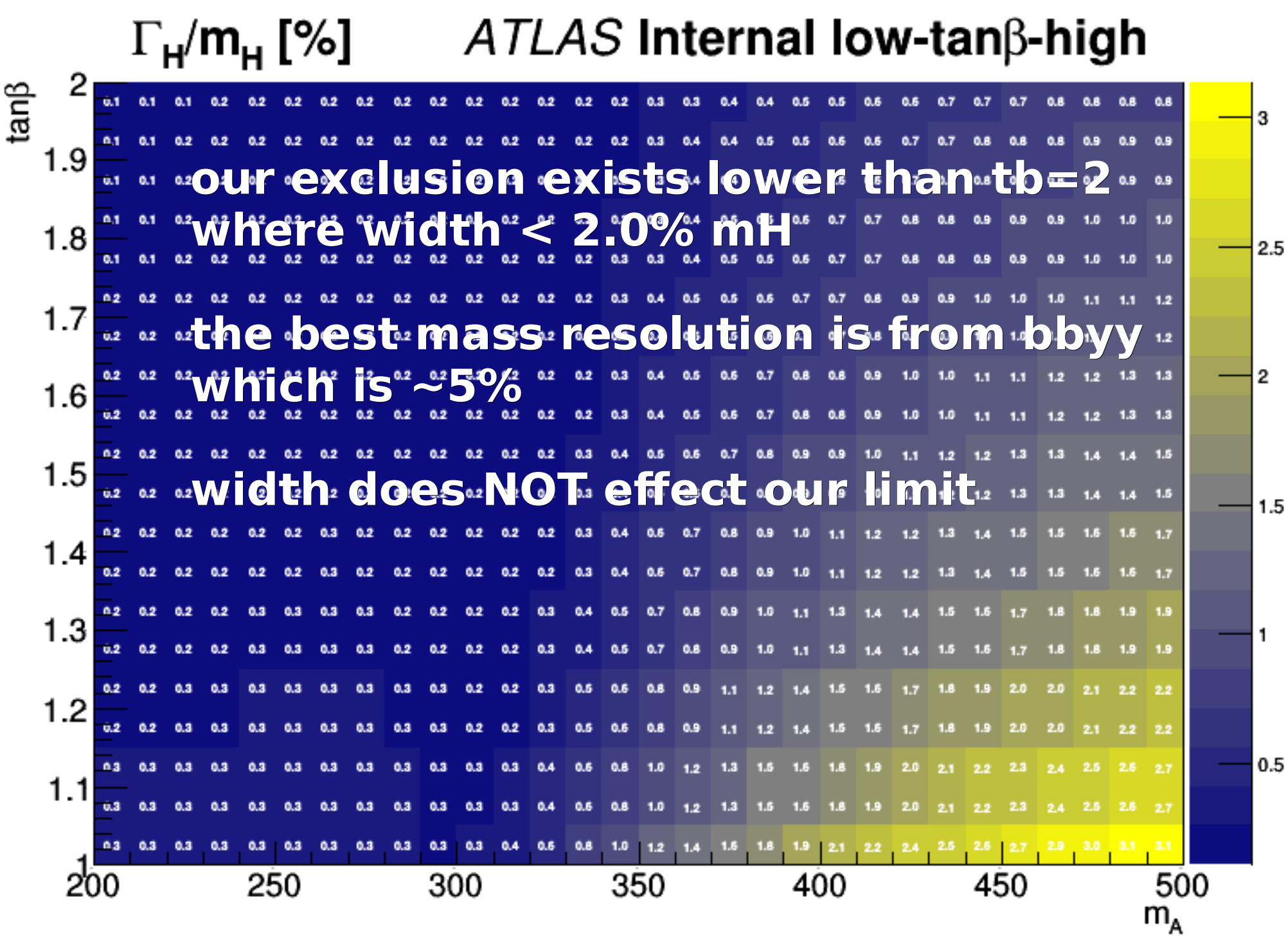
hMSSM BR(H-hh)

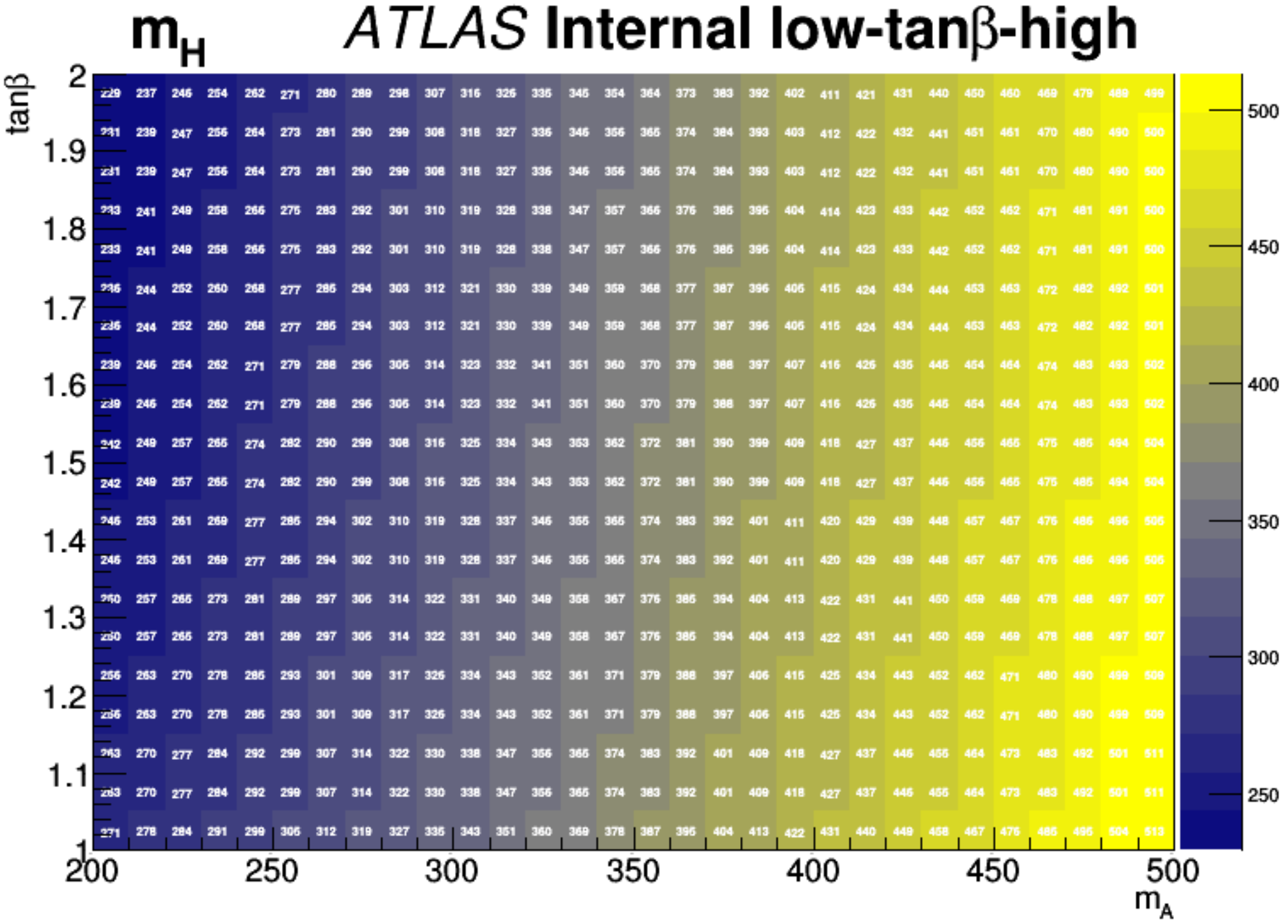

BR(H→hh)
ATLAS Internal hMSSM
tanβ
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
200
250
300
350
400
450
500
m_A
0.6
0.5
0.4
0.3
0.2
0.1

hMSSM exclusion overlaid contours

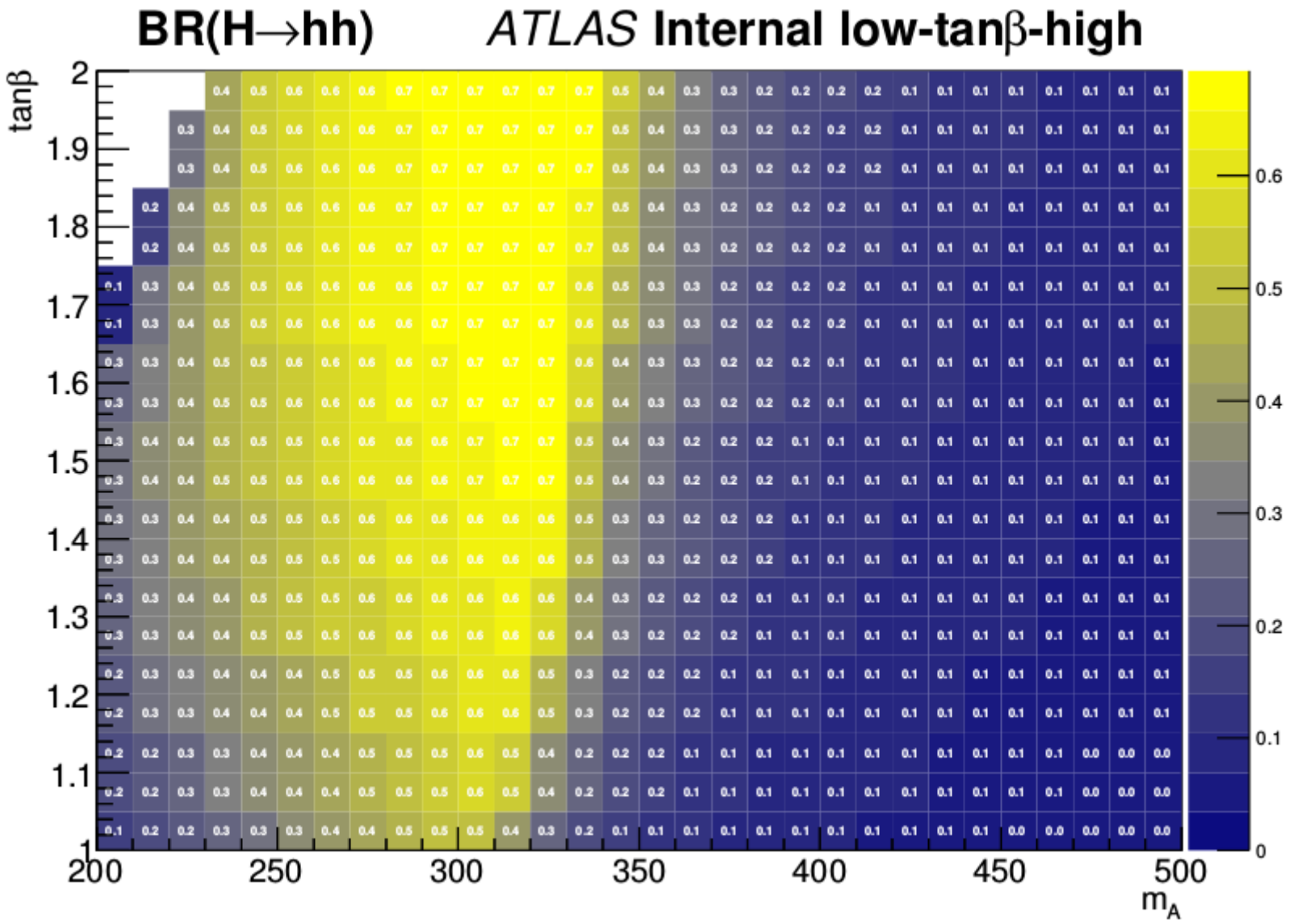




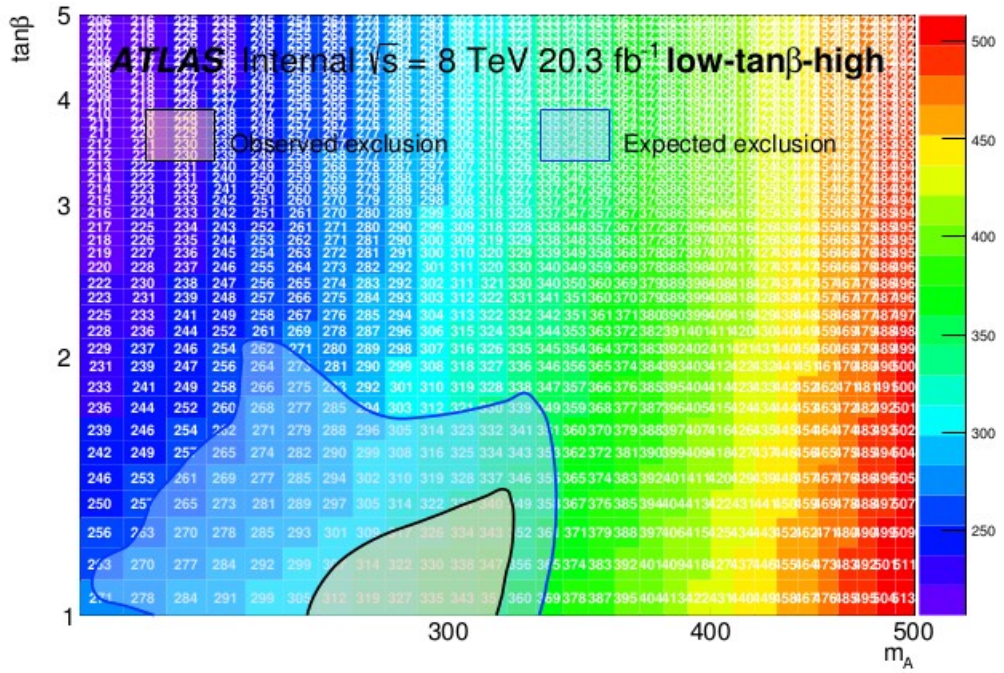

Γ_H/m_H [%]
ATLAS Internal low-tanβ-high
tanβ
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
200
250
300
350
400
450
500
m_A
3
2.5
2
1.5
1
0.5
our exclusion exists lower than tb=2
where width < 2.0% mH
the best mass resolution is from bbyy
which is ~5%
width does NOT effect our limit

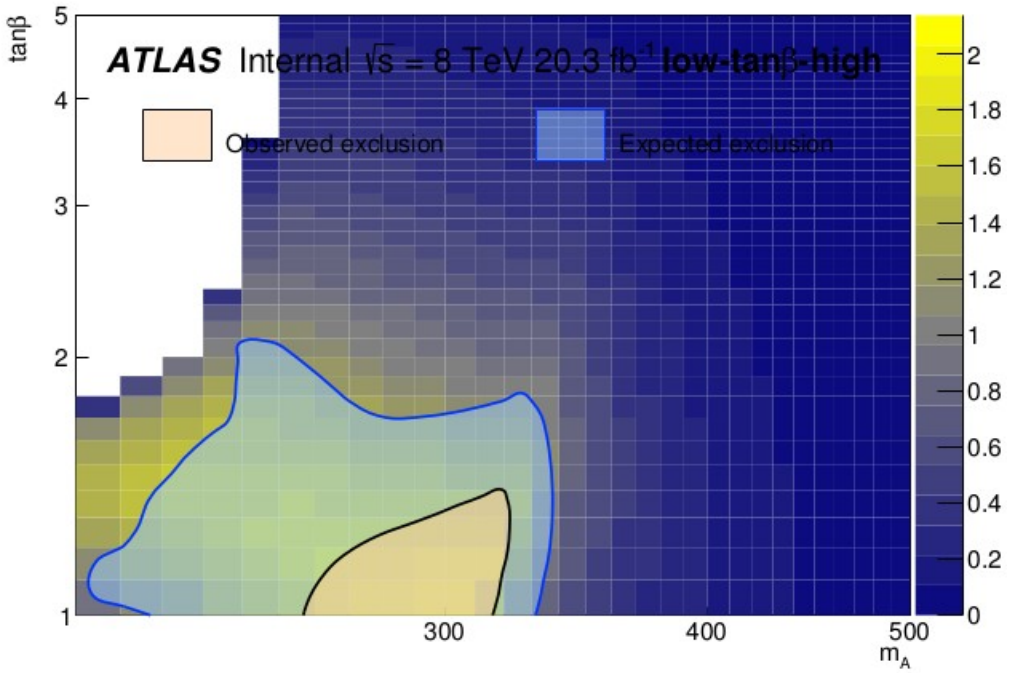

m_H
ATLAS Internal low-tanβ-high
tanβ
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
200
250
300
350
400
450
500
m_A
500
450
400
350
300
250

low-tb-high BR(H-hh)

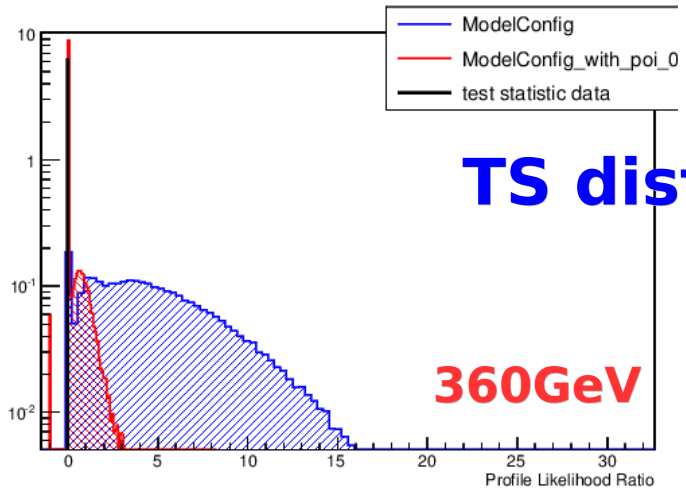


low-tb-high exclusion overlaid contours

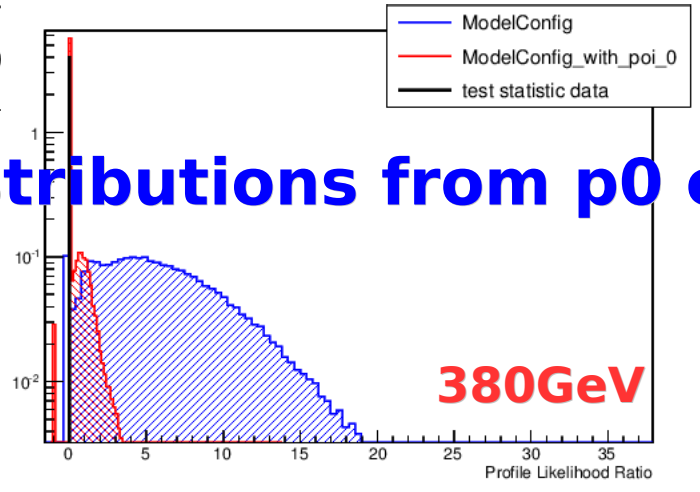


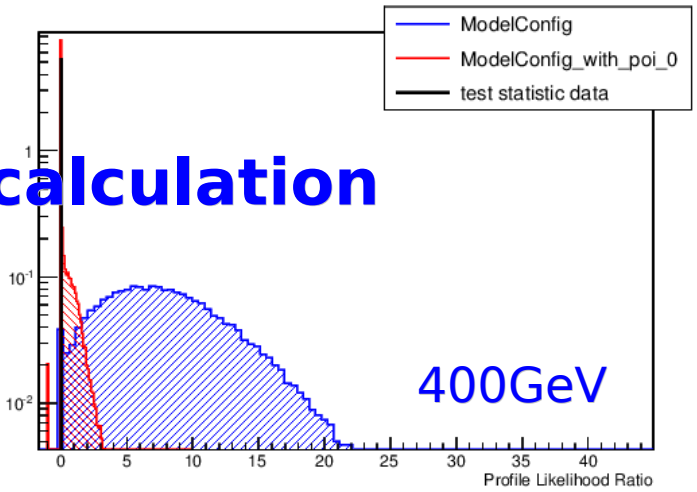


TS distributions

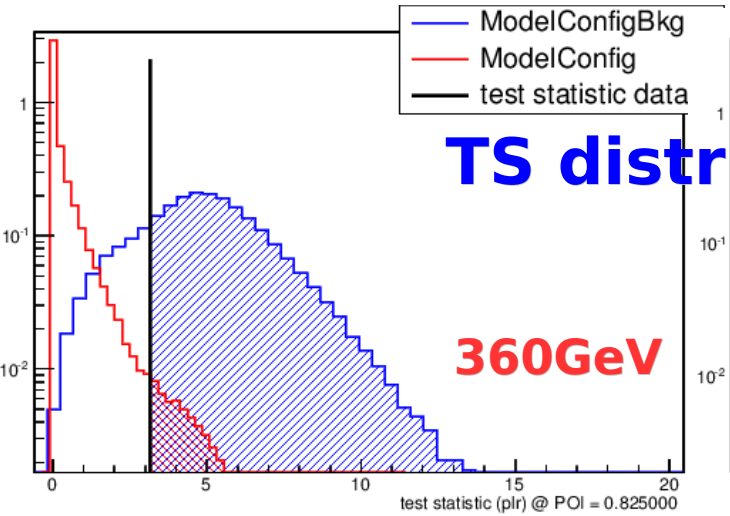


TS distributions from p0 calculation

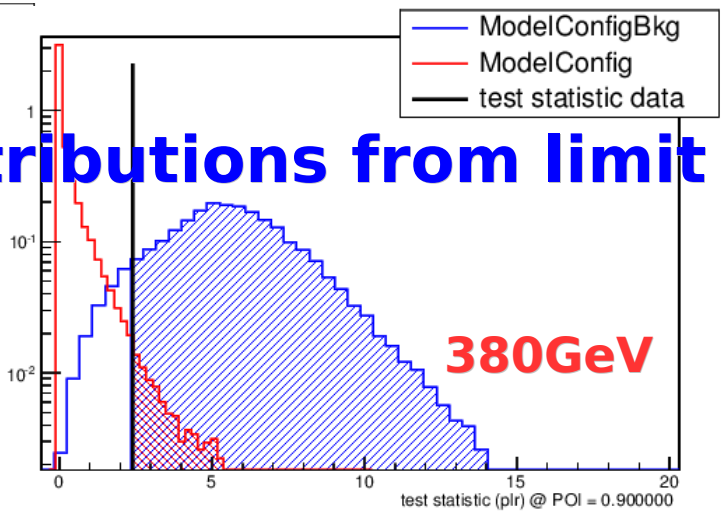


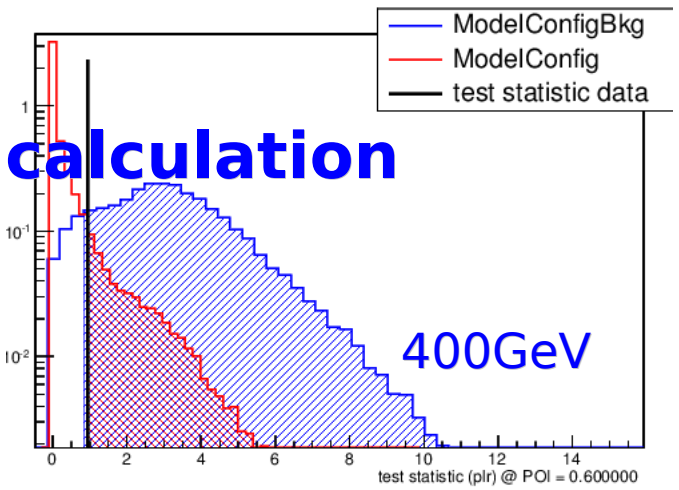


TS(data)=0 **TS(data)=0** **TS(data)=0.0524729**



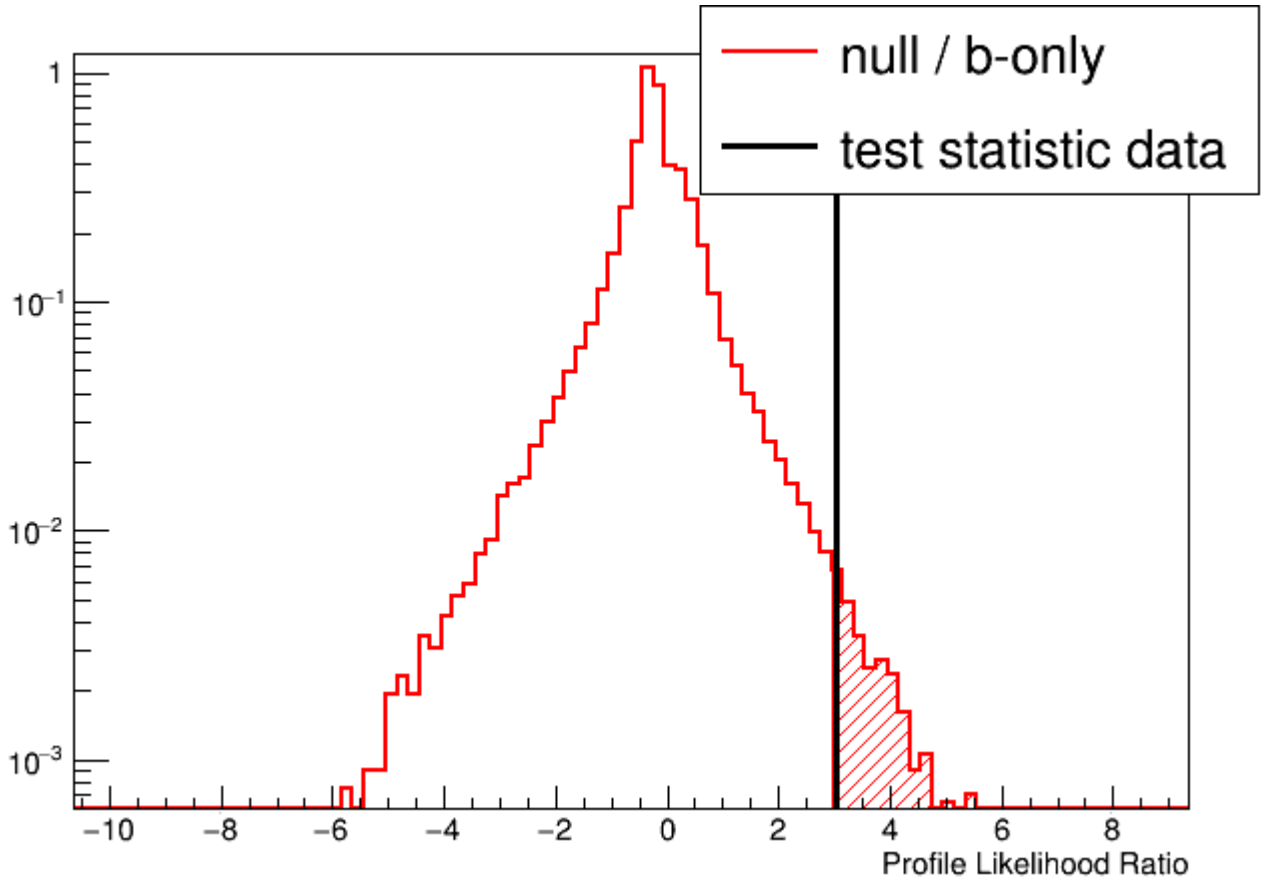
TS distributions from limit calculation





TS distribution

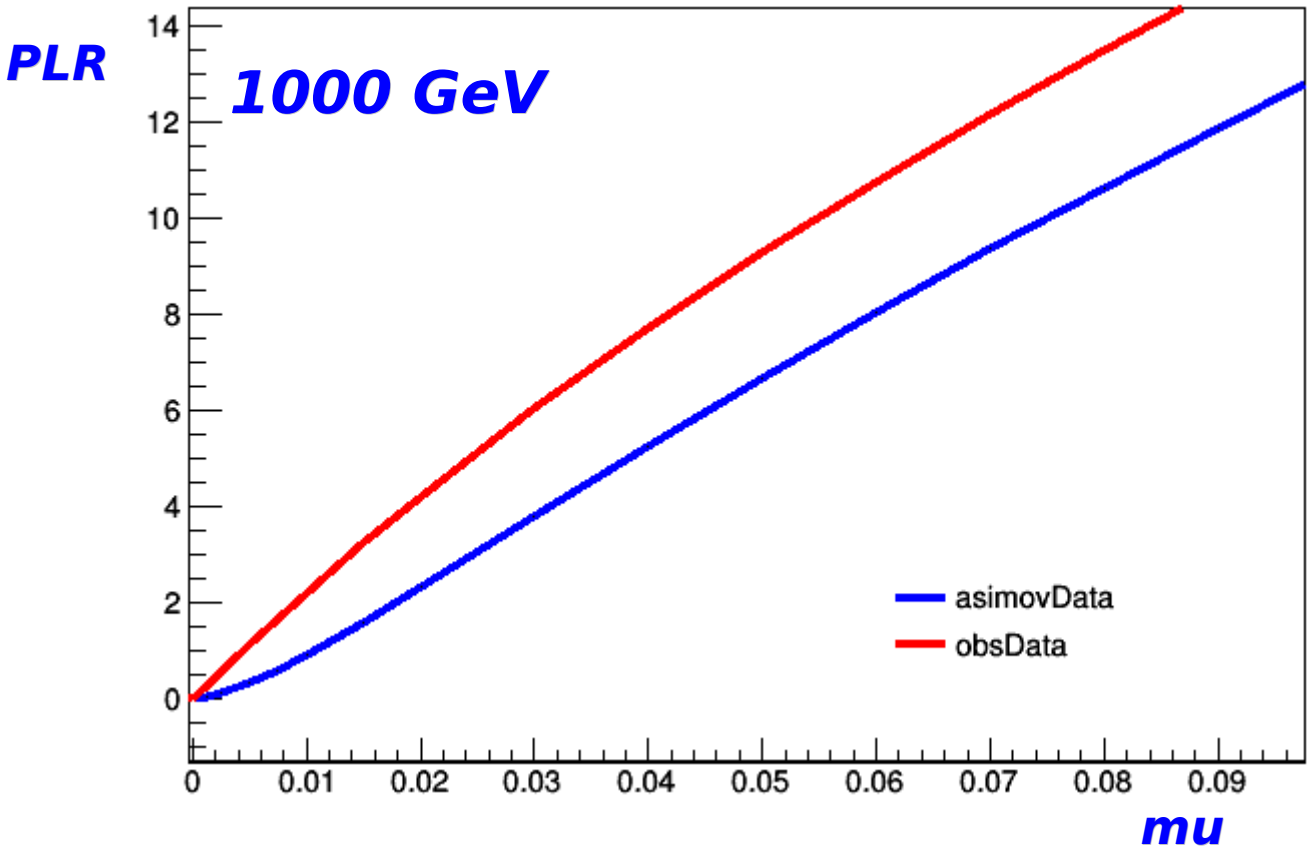
- ts distributions at 300 GeV



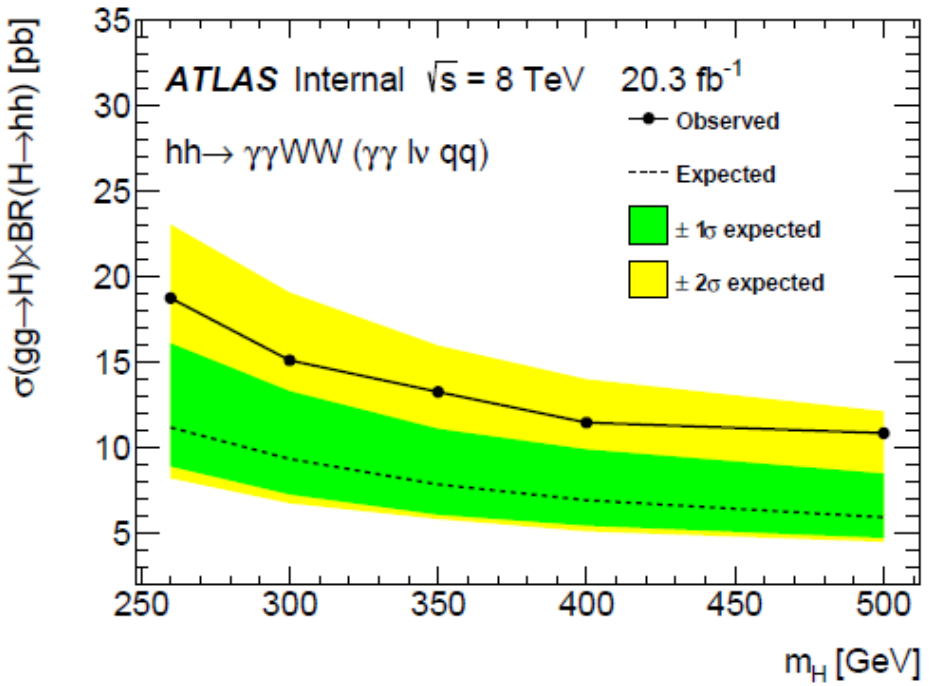
300 GeV
obs ts value: 3.03275
obs p-value: 0.0052399
obs significance: 2.55958

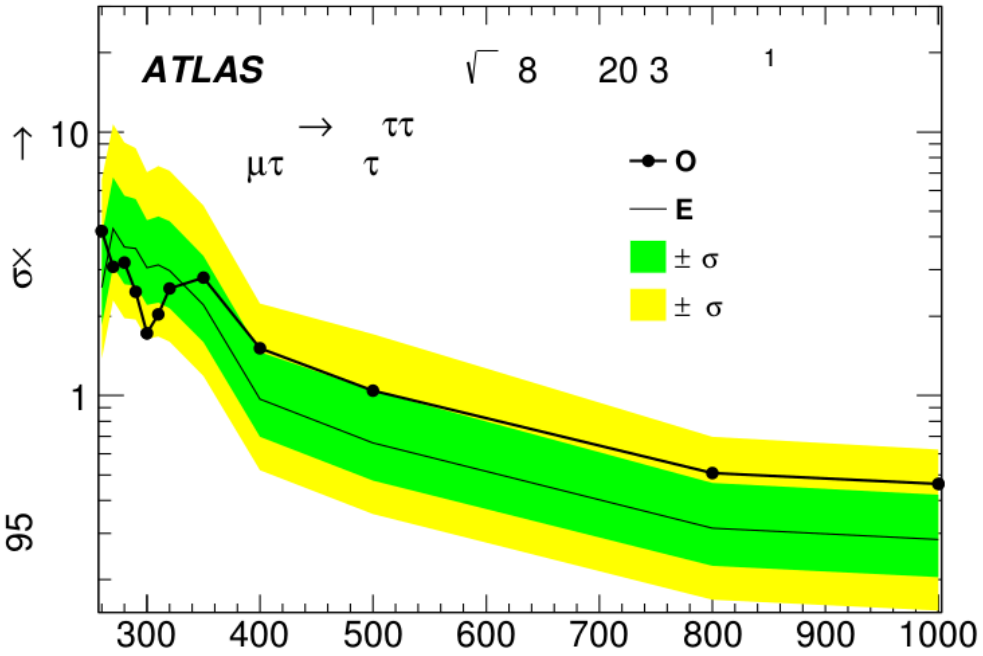
1000 PLR

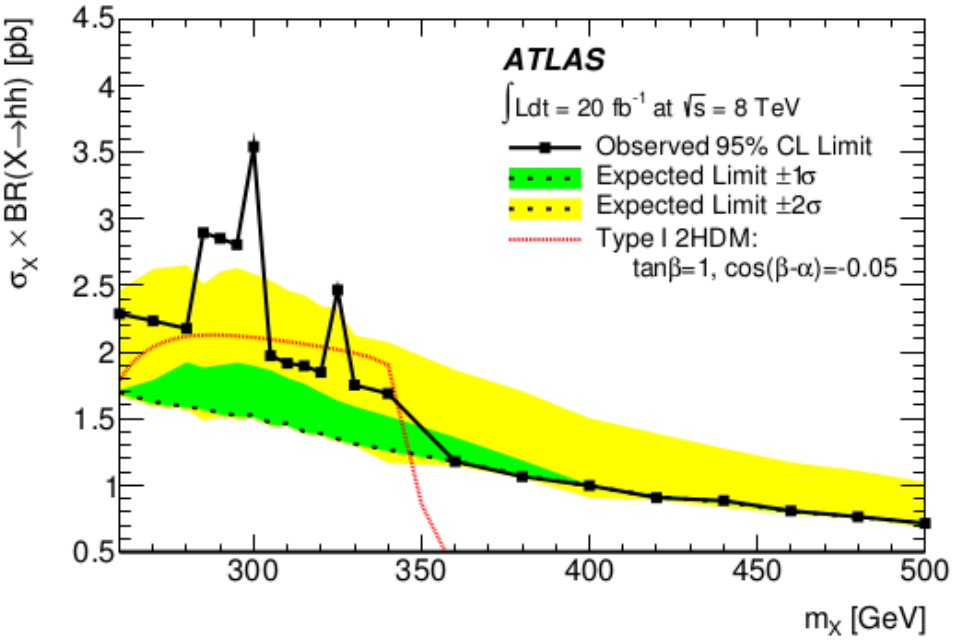
- Scan PLR for 1000 (a point with consistent p0 and limit) from mu 0 to 0.1
- mu_hat (1000) in data = -0.00463018

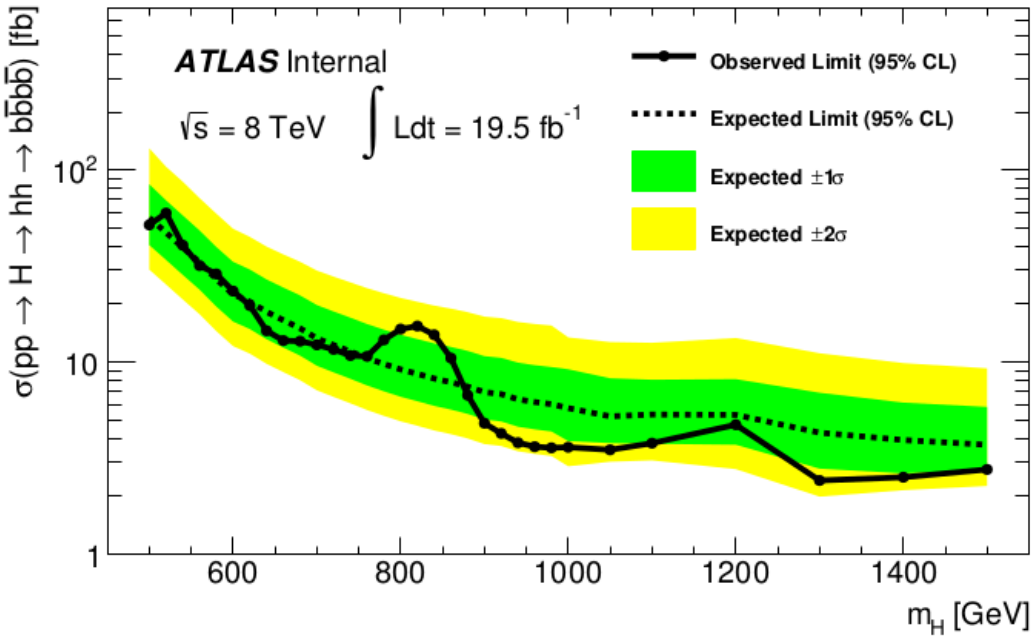


Channel limits [res]



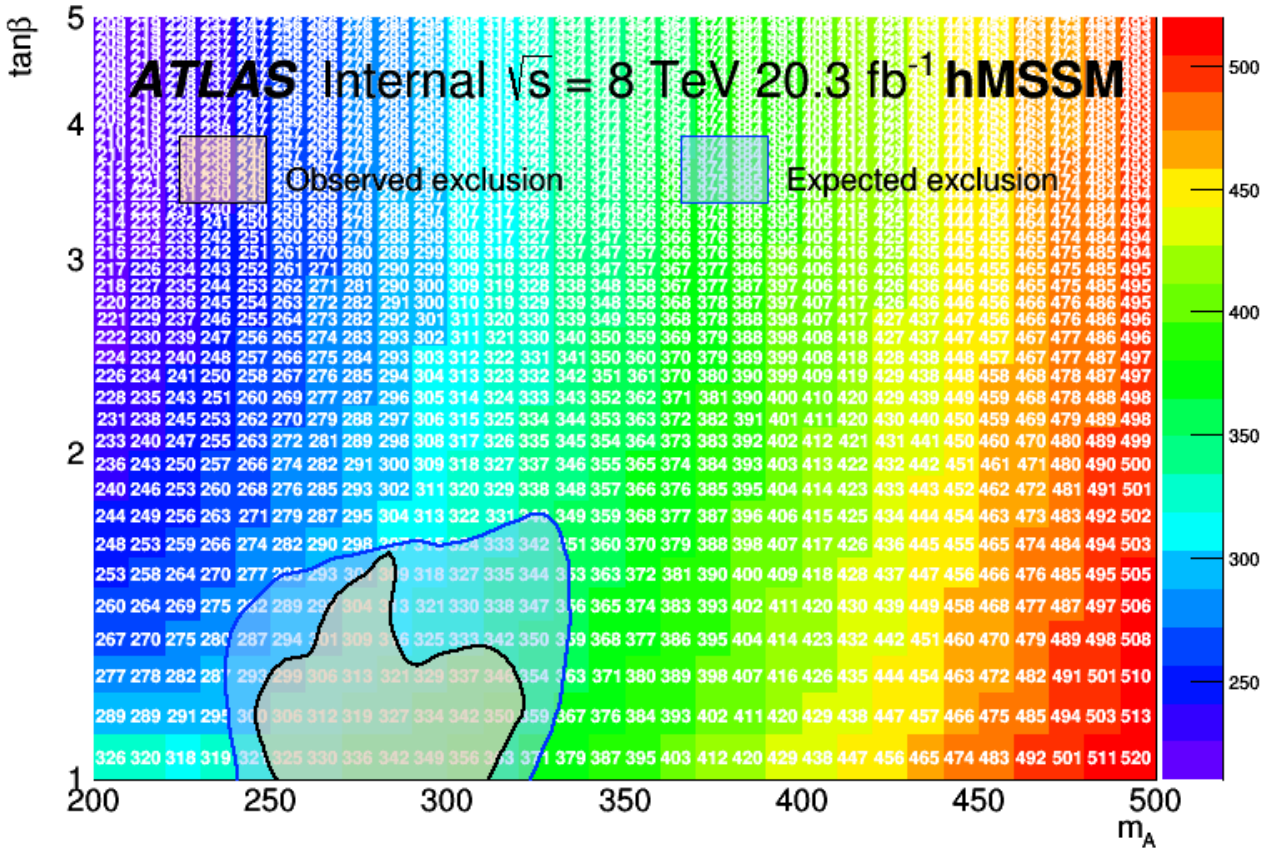






hMSSM

- EXP limits from interpolated points [270,295] are fairly high and they squeeze the exp exclusion
- while obs limits [280,295] enlarge obs exclusions due to their lower values

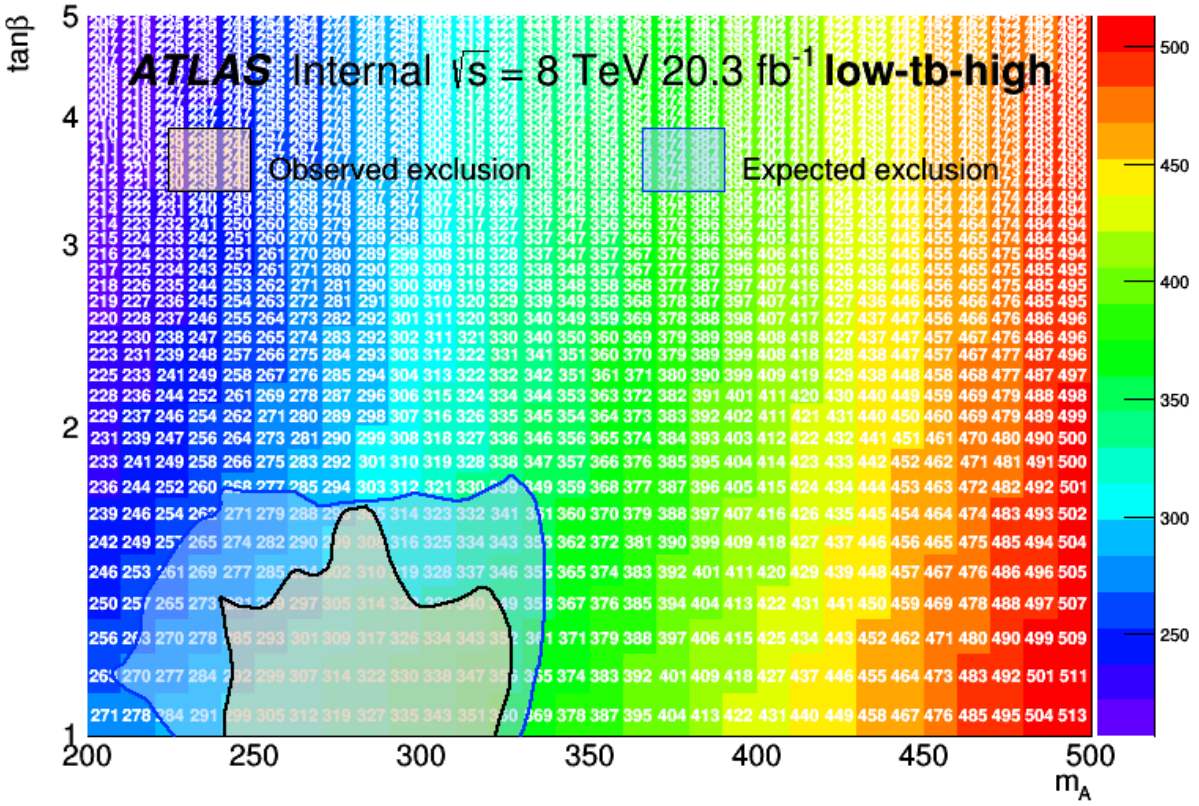


mass	obs	median
260	1.70982	1.07204
270	1.71558	**1.44778**
280	**1.68024**	**1.33733**
285	**1.86328**	**1.32284**
290	**1.79416**	**1.34562**
295	**1.75**	**1.31602**
300	1.875	1.24402
305	1.02324	1.22968
310	1.38	1.18869
315	1.38127	1.15763
320	1.42977	1.14865
325	1.83205	1.15191
330	1.54764	1.10584
340	1.51589	1.04156
350	1.38609	0.91573
360	0.988968	0.838741
380	1.12399	0.776402
400	0.757059	0.551772
420	0.6811	0.497055
440	0.649041	0.469644
460	0.624596	0.432331
480	0.593367	0.405629
500	0.583098	0.398977

original mass points

low-tb-high

- EXP limits from interpolated points [270,295] are fairly high and they squeeze the exp exclusion
- while obs limits [280,295] enlarge obs exclusions due to their lower values

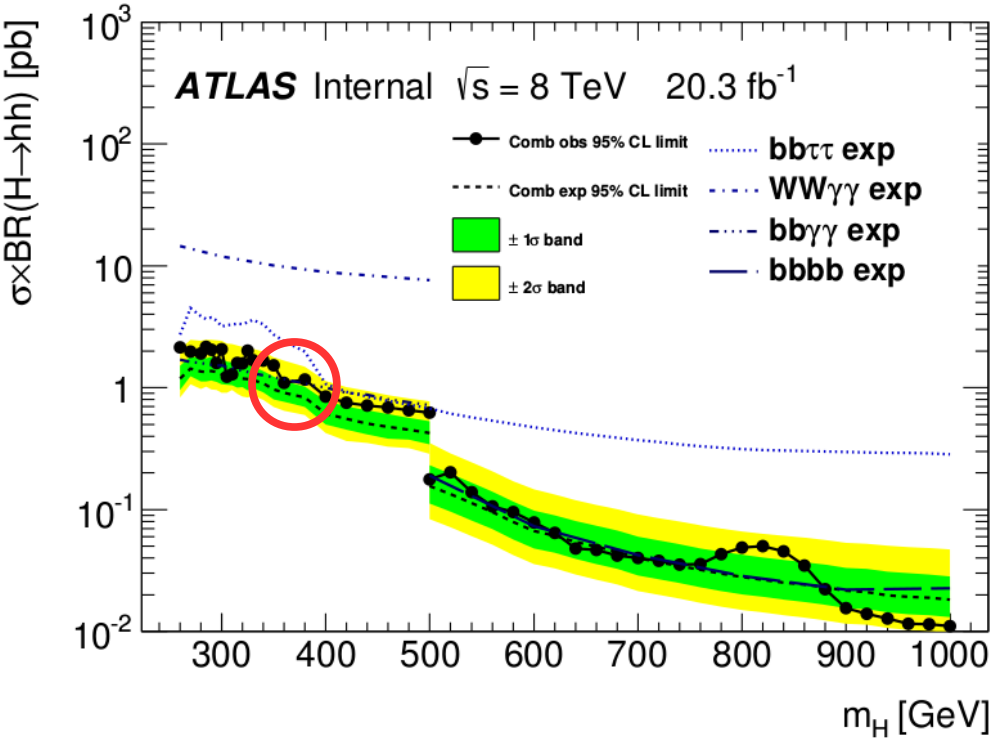


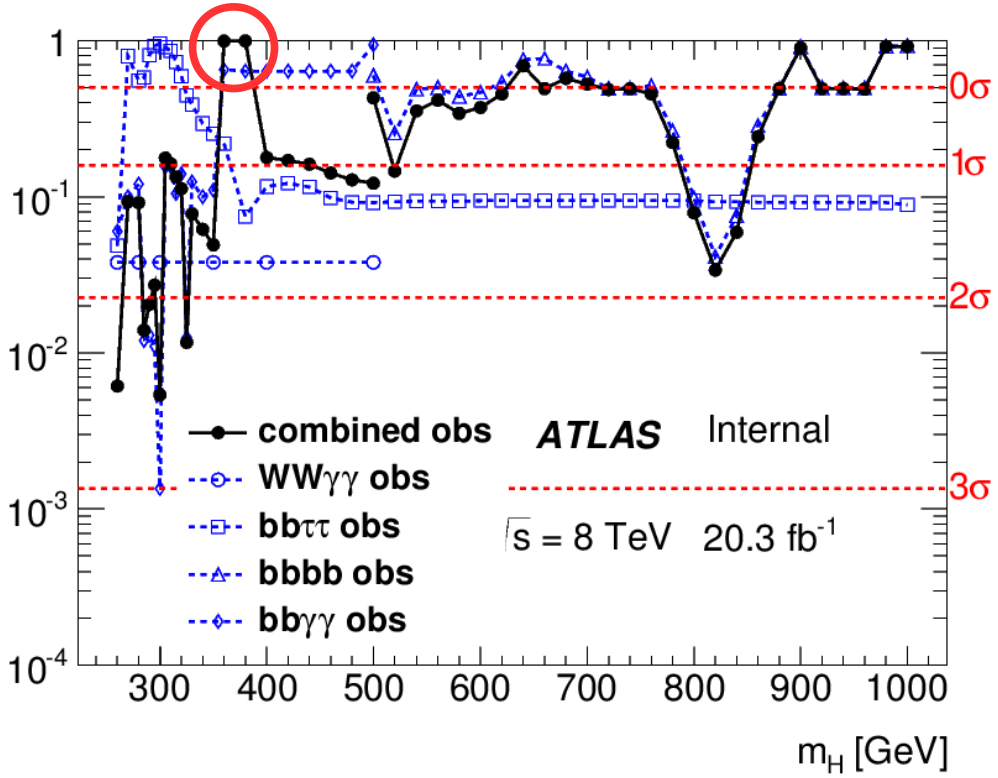
mass	obs	median
260	1.68381	1.05287
270	1.75344	**1.49313**
280	**1.64129**	**1.33096**
285	**1.86551**	**1.31533**
290	**1.52873**	**1.34658**
295	**1.75**	**1.32489**
300	1.875	1.27362
305	1.02888	1.23646
310	1.38	1.19488
315	1.41829	1.18453
320	1.38725	1.11229
325	1.783	1.10554
330	1.58405	1.14461
340	1.53546	1.04214
350	1.4123	0.925285
360	1.00468	0.86803
380	1.09831	0.758645
400	0.761744	0.549154
420	0.679285	0.500606
440	0.652151	0.463074
460	0.640985	0.443172
480	0.611022	0.419592
500	0.575566	0.387592

original mass points

The issue at 360/380

- At 360 380, limits show data excess but p0 value do not seem so





This is actually due to the definition of test statistic with which p0 values are calculated

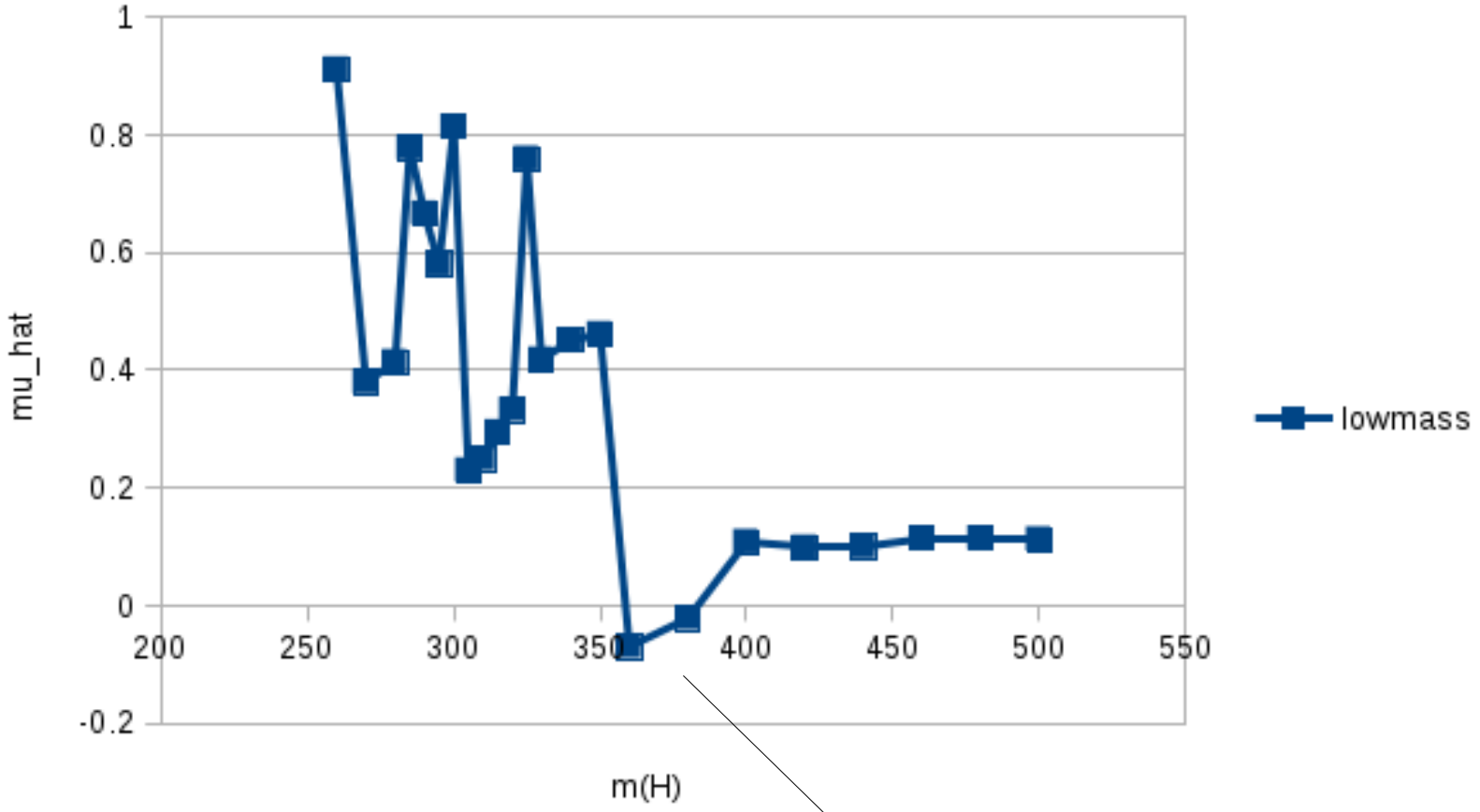
$$q_0 = \begin{cases} -2\ln\lambda(0) & \hat{\mu} \geq 0 \\ 0 & \hat{\mu} < 0 \end{cases}$$

one-sided discovery

*** http://arxiv.org/pdf/1007.1727v3.pdf

mu_hat

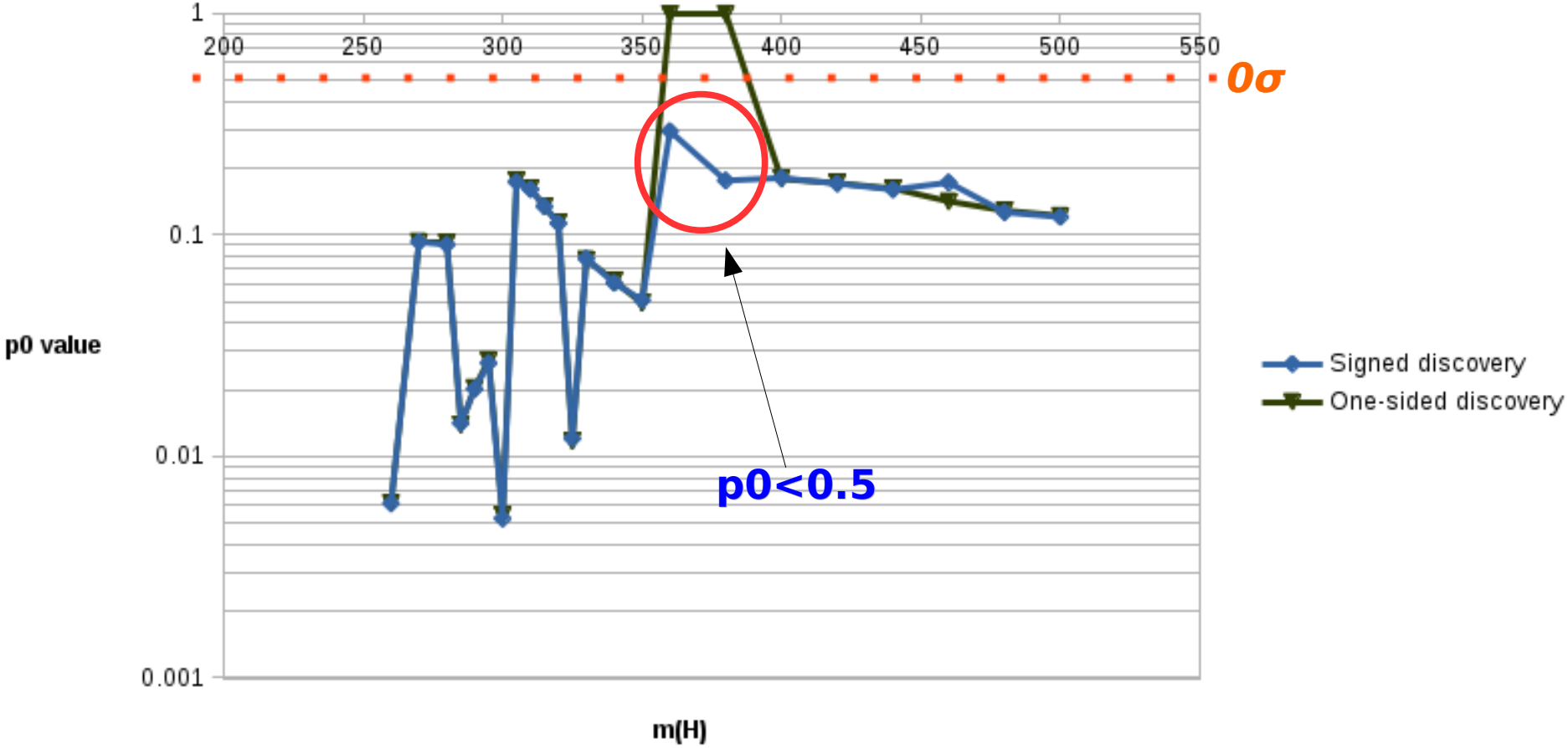
- mu_hat values are plotted as function of mH



360 & 380 have mu_hat <0

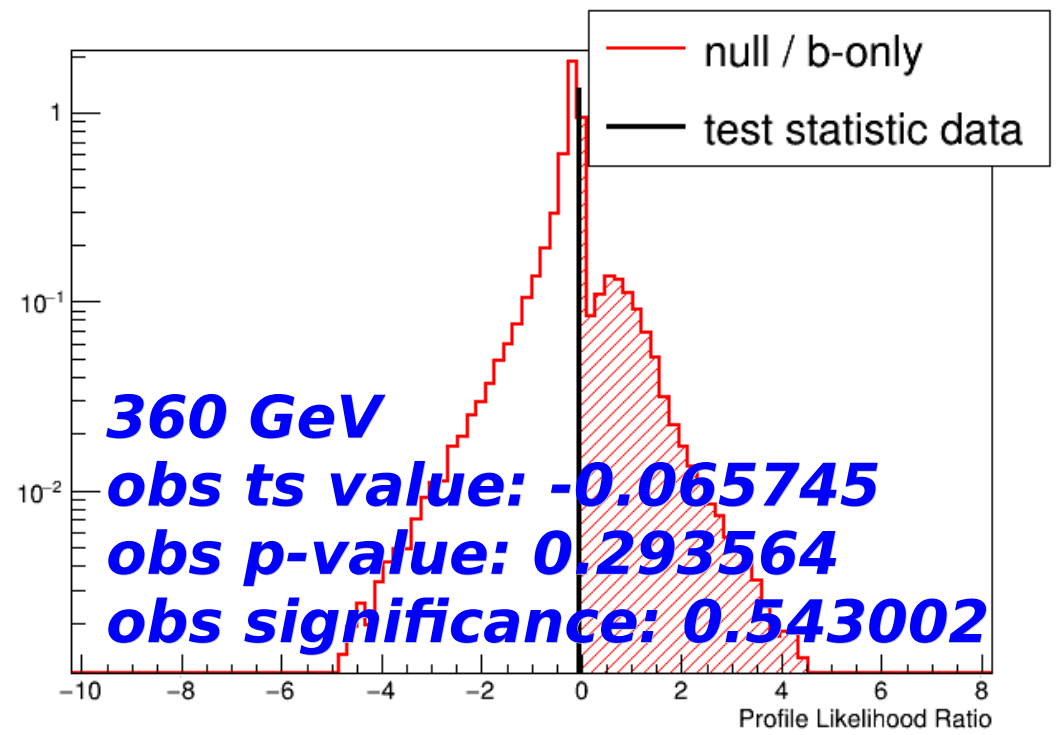
P0 values

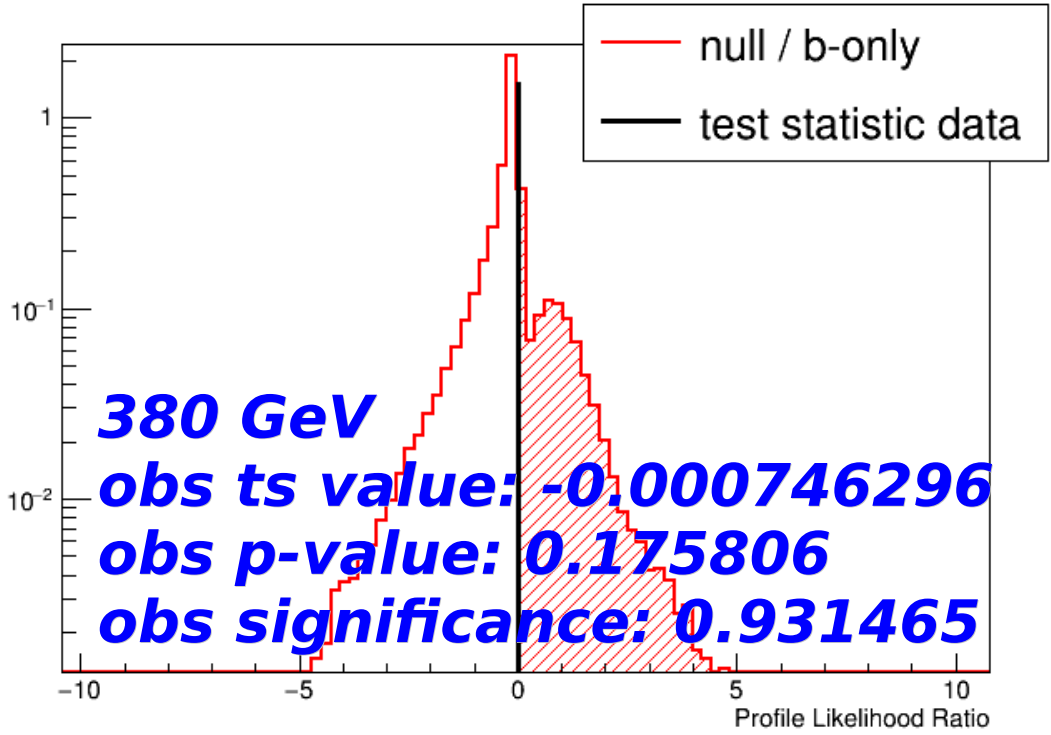
- Now, using a non-zero ts definition (“signed discovery”) when mu_hat<0, we have p0 values < 0.5 at 360 380



TS distribution

- ts distributions at 360 and 380

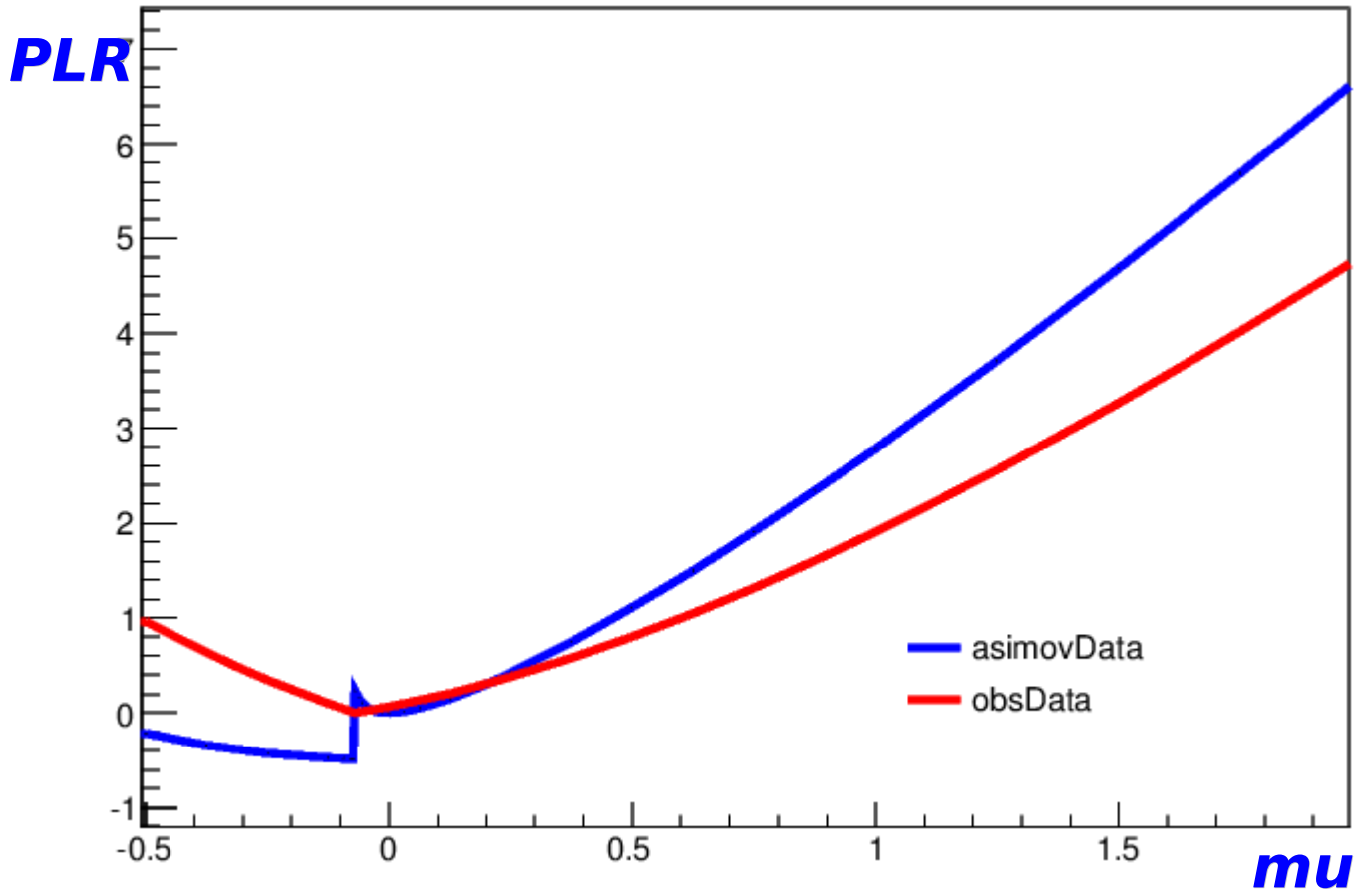




- In general, ts distributions is asymmetric; so even when ts(data) goes to negative, p0 value can still remain below 0.5

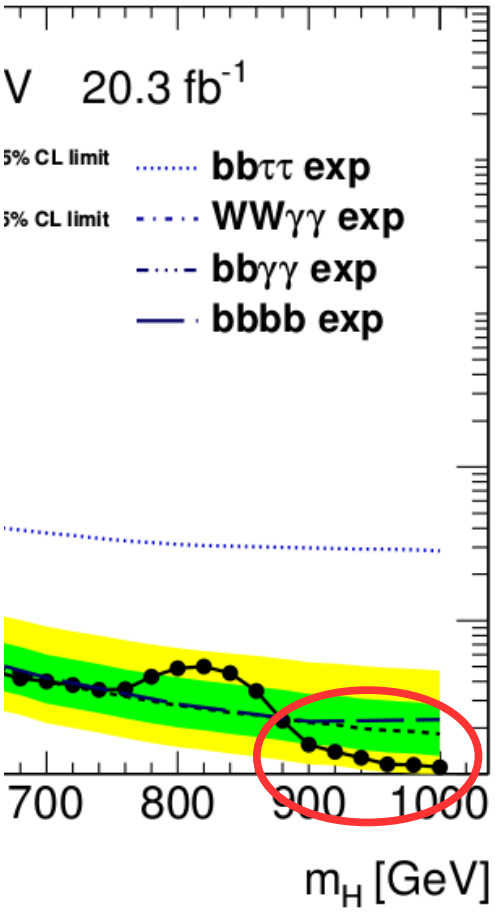
PLR curve

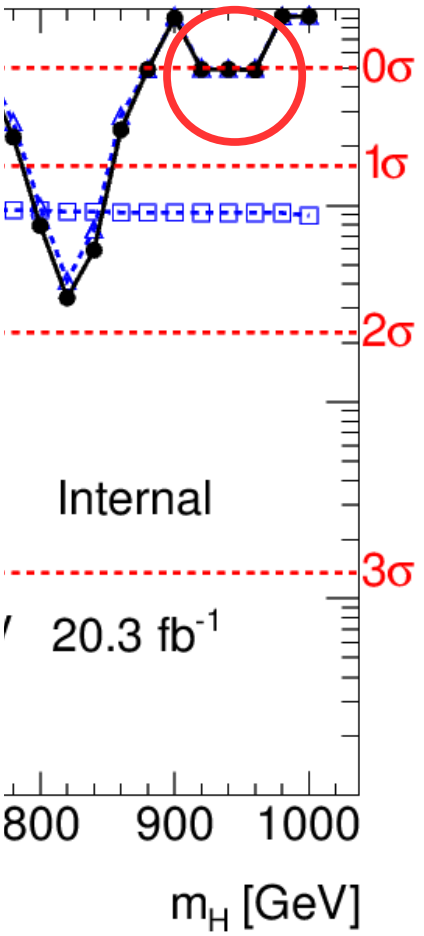
- how could mu_hat < 0 but obs limit is higher than median (data excess)?
- because PLR in data is wider than expected



The issue at 920/940/960

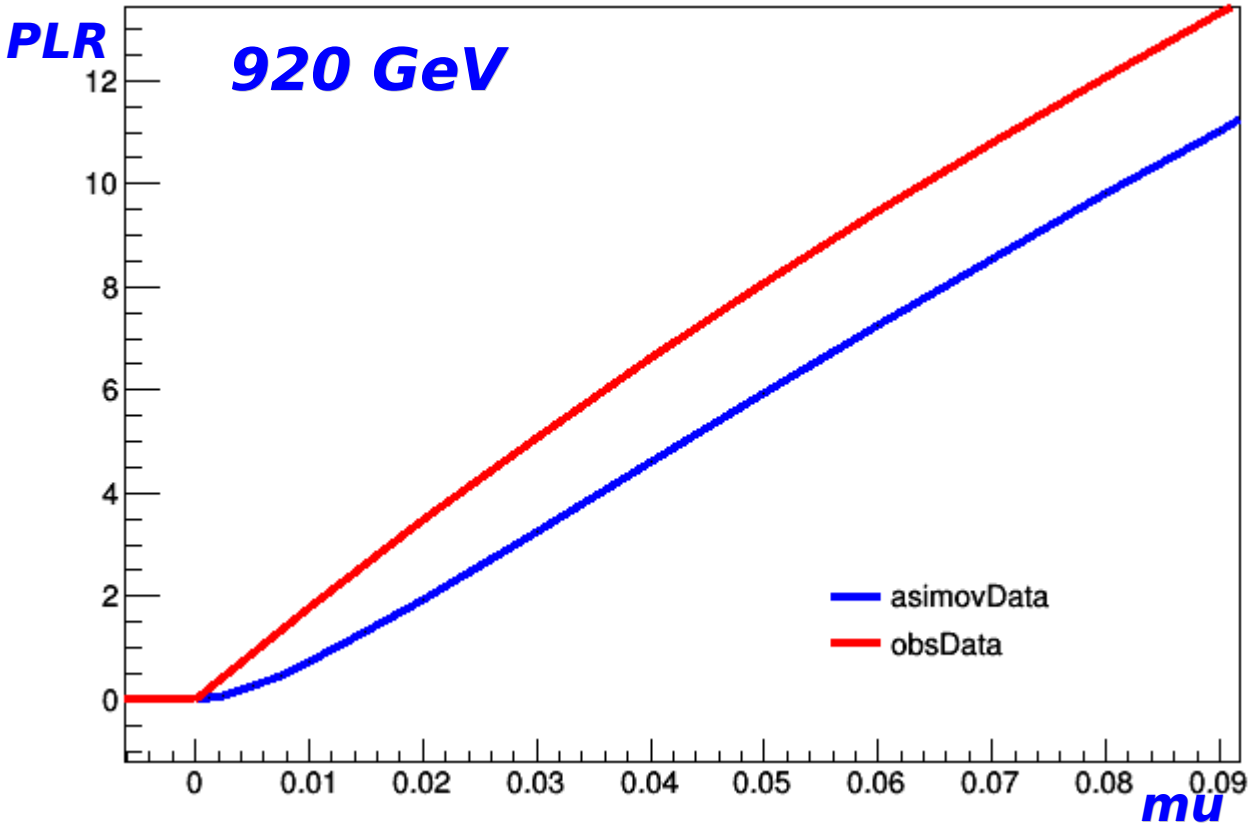
- 920 940 960 have data deficit in limit plot but p0 values seems to be 0.5 ~ 0 sigma
- by now, we have checked with David and have consistent bbbb p0 values





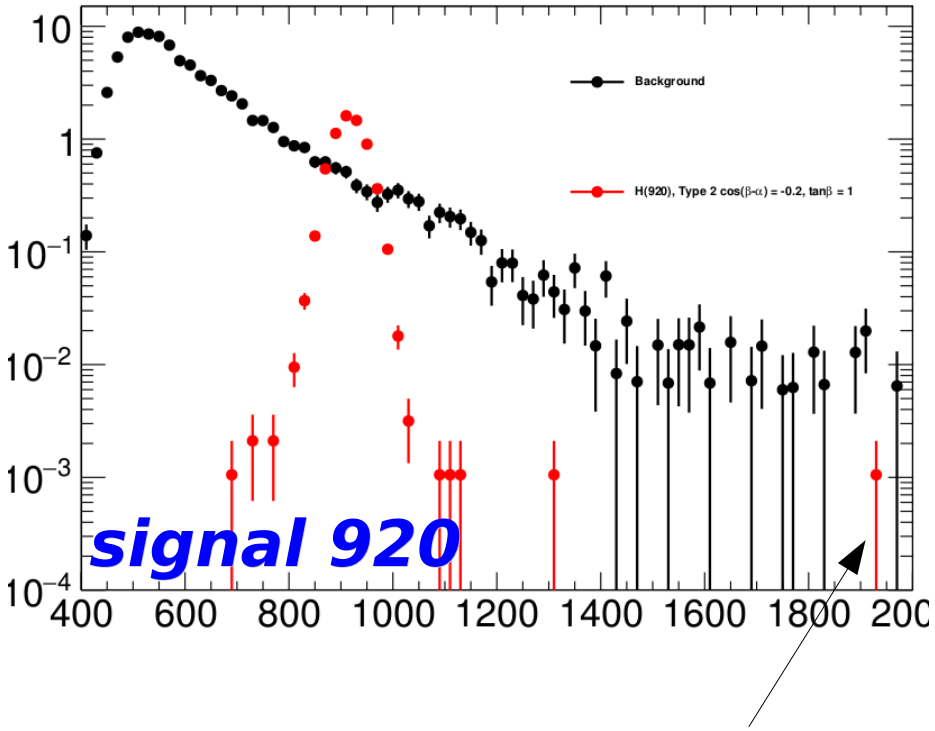
920 PLR

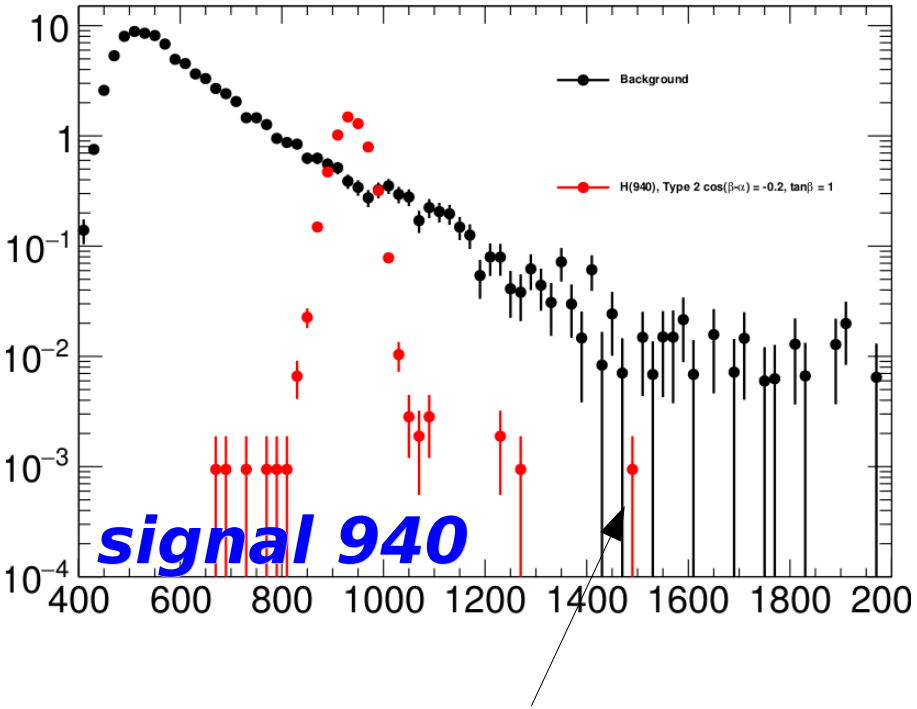
- mu_hat in obs is **positively** close to zero 7.28235e-10, giving p0 values ~0.5
- obs PLR is narrower than expected, this leads to lower limits in data
- but the non-parabolic structures seem strange, we further on check signal/bkg templates



Check bbbb sig&bkg

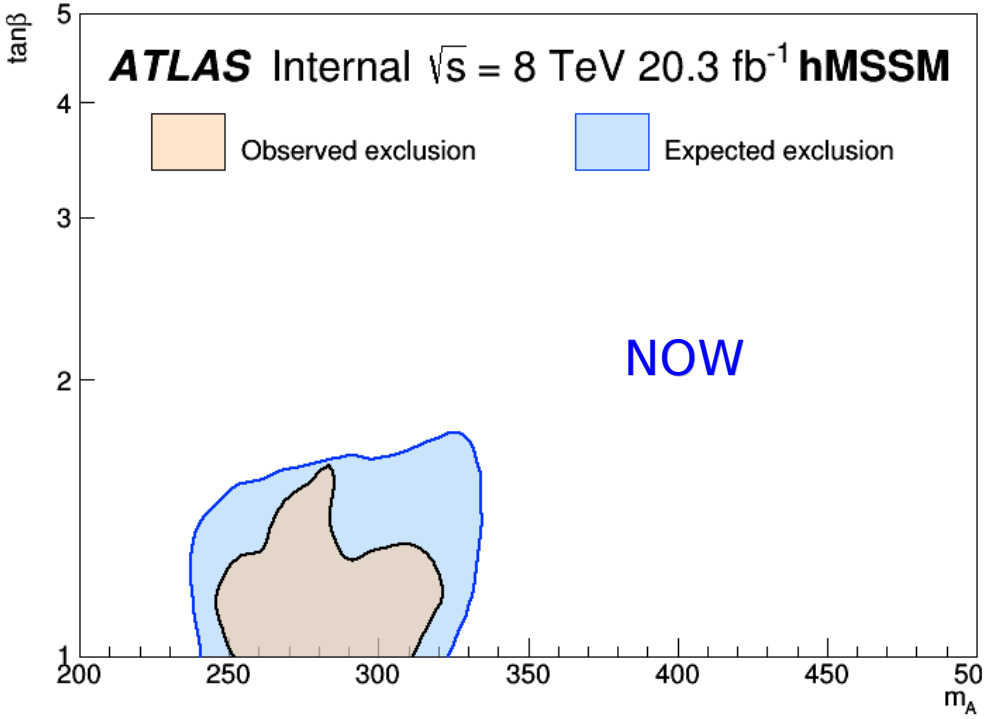
- David checked the signal and background templates used in the fit
- There are bins with only signal but no backgrounds

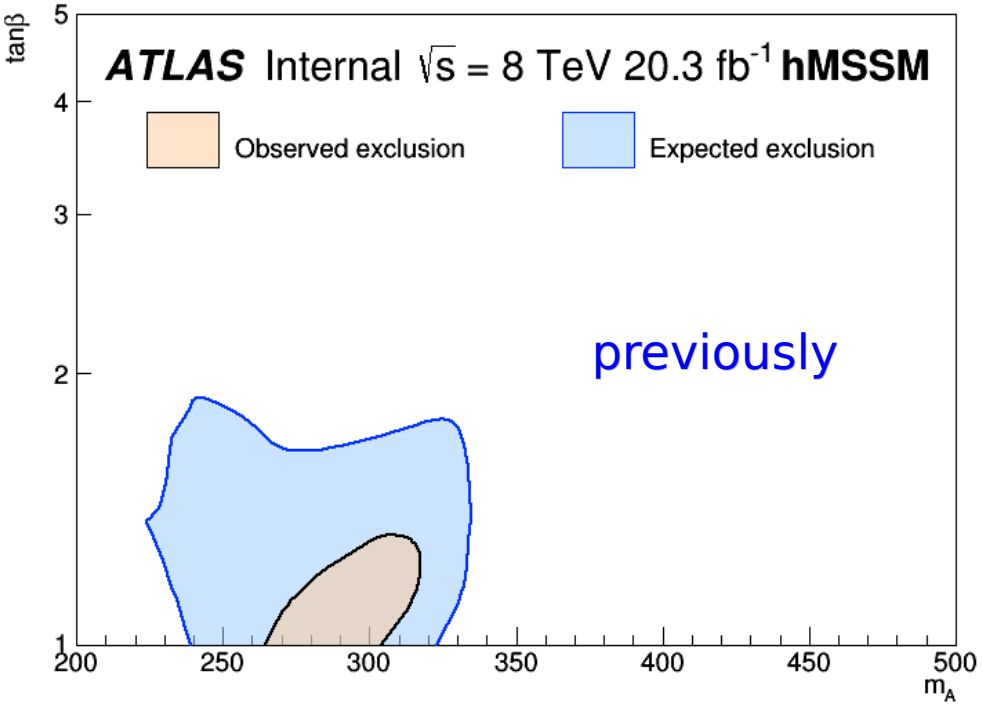




Interpretation hMSSM

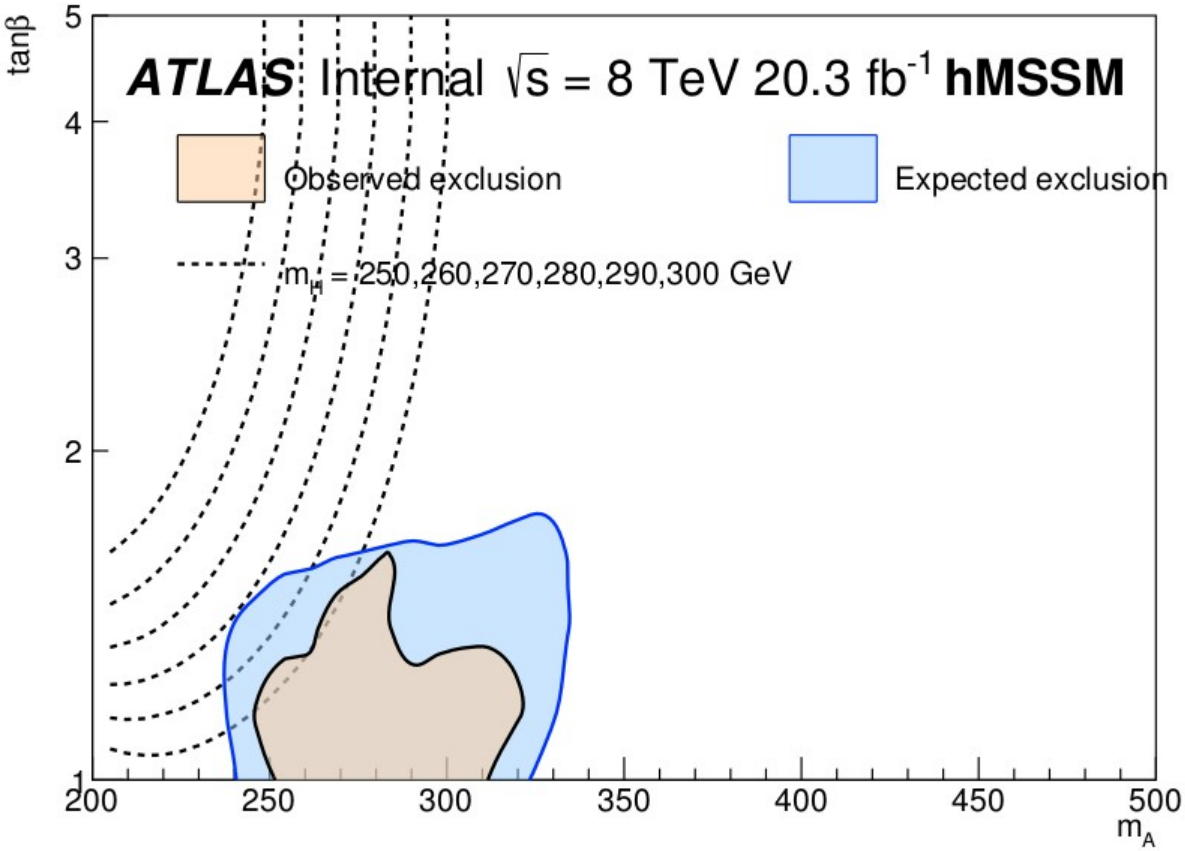
- Using **all interpolated** points to do the interpretation





hMSSM

- EXP limits from interpolated points [270,295] are fairly high and they squeeze the exp exclusion
- while obs limits [280,295] enlarge obs exclusions due to their lower values

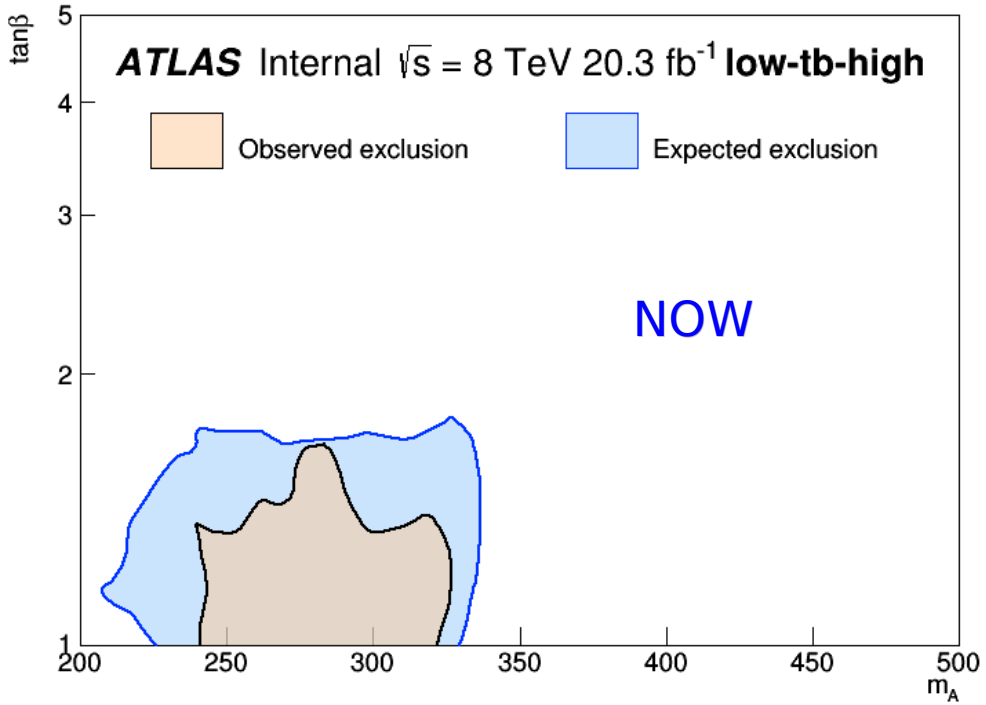


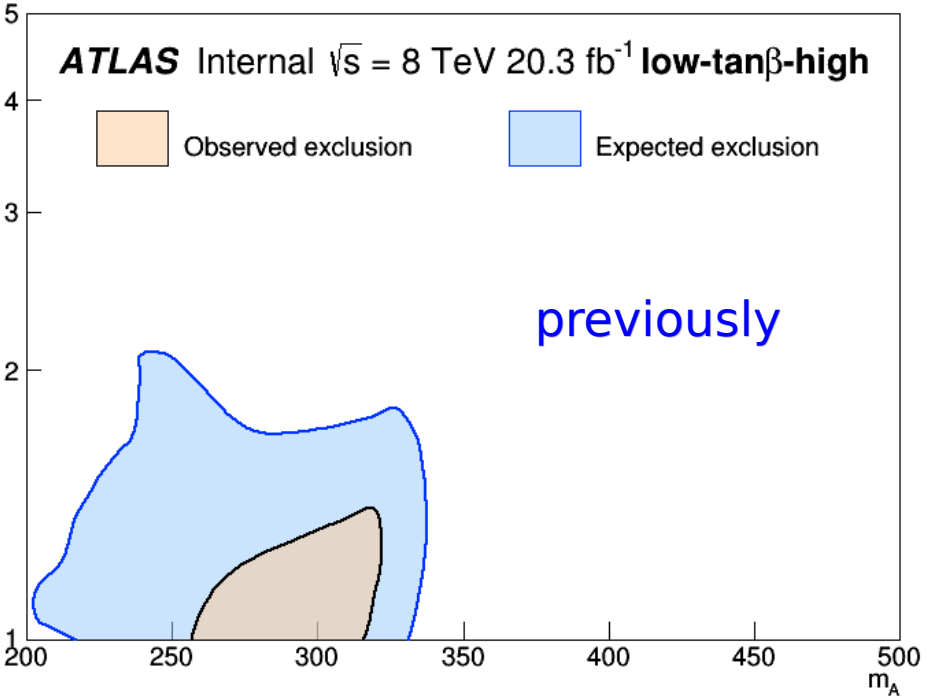
mass	obs	median
260	1.70982	1.07204
270	1.71558	**1.44778**
280	**1.68024**	**1.33733**
285	**1.86328**	**1.32284**
290	**1.79416**	**1.34562**
295	**1.75**	**1.31602**
300	1.875	1.24402
305	1.02324	1.22968
310	1.38	1.18869
315	1.38127	1.15763
320	1.42977	1.14865
325	1.83205	1.15191
330	1.54764	1.10584
340	1.51589	1.04156
350	1.38609	0.91573
360	0.988968	0.838741
380	1.12399	0.776402
400	0.757059	0.551772
420	0.6811	0.497055
440	0.649041	0.469644
460	0.624596	0.432331
480	0.593367	0.405629
500	0.583098	0.398977

original mass points

Interpretation low-tb-high

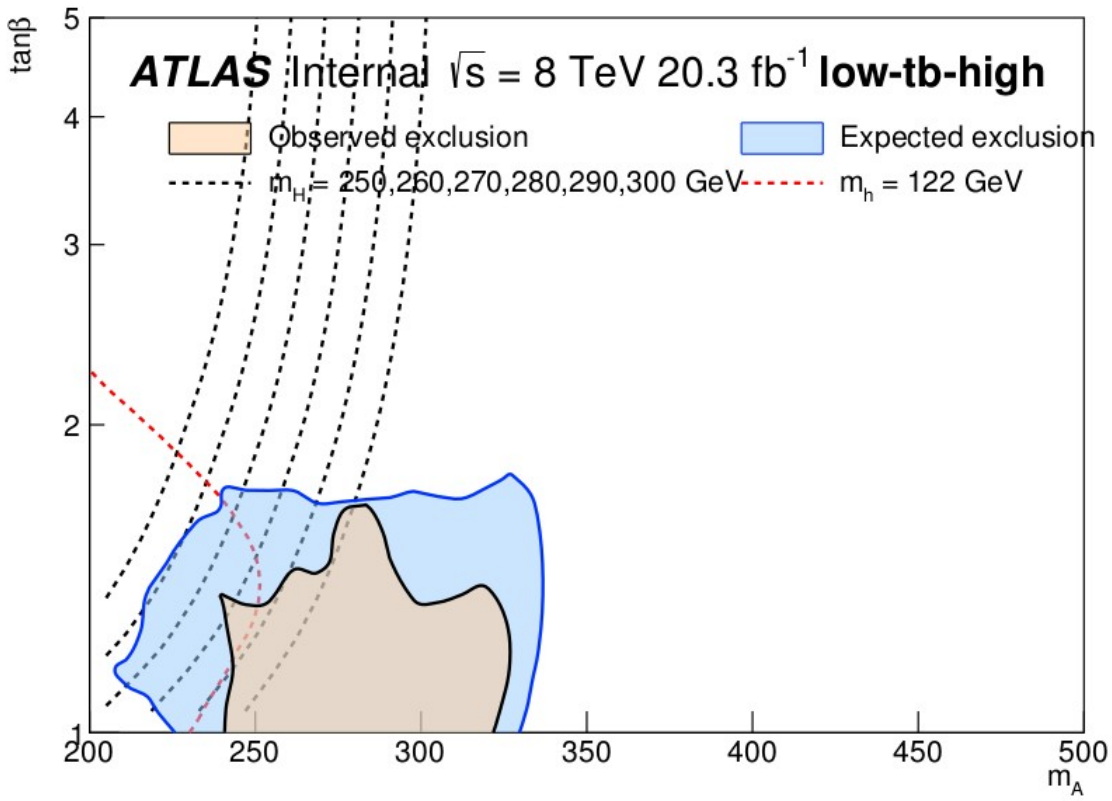
- Using **all interpolated** points to do the interpretation





low-tb-high

- EXP limits from interpolated points [270,295] are fairly high and they squeeze the exp exclusion
- while obs limits [280,295] enlarge obs exclusions due to their lower values



mass	obs	median
260	1.68381	1.05287
270	1.75344	**1.49313**
280	**1.64129**	**1.33096**
285	**1.86551**	**1.31533**
290	**1.52873**	**1.34658**
295	**1.75**	**1.32489**
300	1.875	1.27362
305	1.02888	1.23646
310	1.38	1.19488
315	1.41829	1.18453
320	1.38725	1.11229
325	1.783	1.10554
330	1.58405	1.14461
340	1.53546	1.04214
350	1.4123	0.925285
360	1.00468	0.86803
380	1.09831	0.758645
400	0.761744	0.549154
420	0.679285	0.500606
440	0.652151	0.463074
460	0.640985	0.443172
480	0.611022	0.419592
500	0.575566	0.387592

original mass points

Summary

- wwyy and bbtautau added theoretical uncertainties, small effects
- combination:
  - limits and p0 at 360/380 are explained with the checks on mu_hat and PRL
  - strange p0 values at 920/940/960 can be seen by PLR curves, but the bins with signal but no background in bbbb need to be fixed
- interpretation with all interpolated mass points shows smaller exclusions