

HH pair searches

with WW $\gamma\gamma$ final states

--- unblinded results cont. ---

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CDS entry

<https://cds.cern.ch/record/1967498>

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IHEP

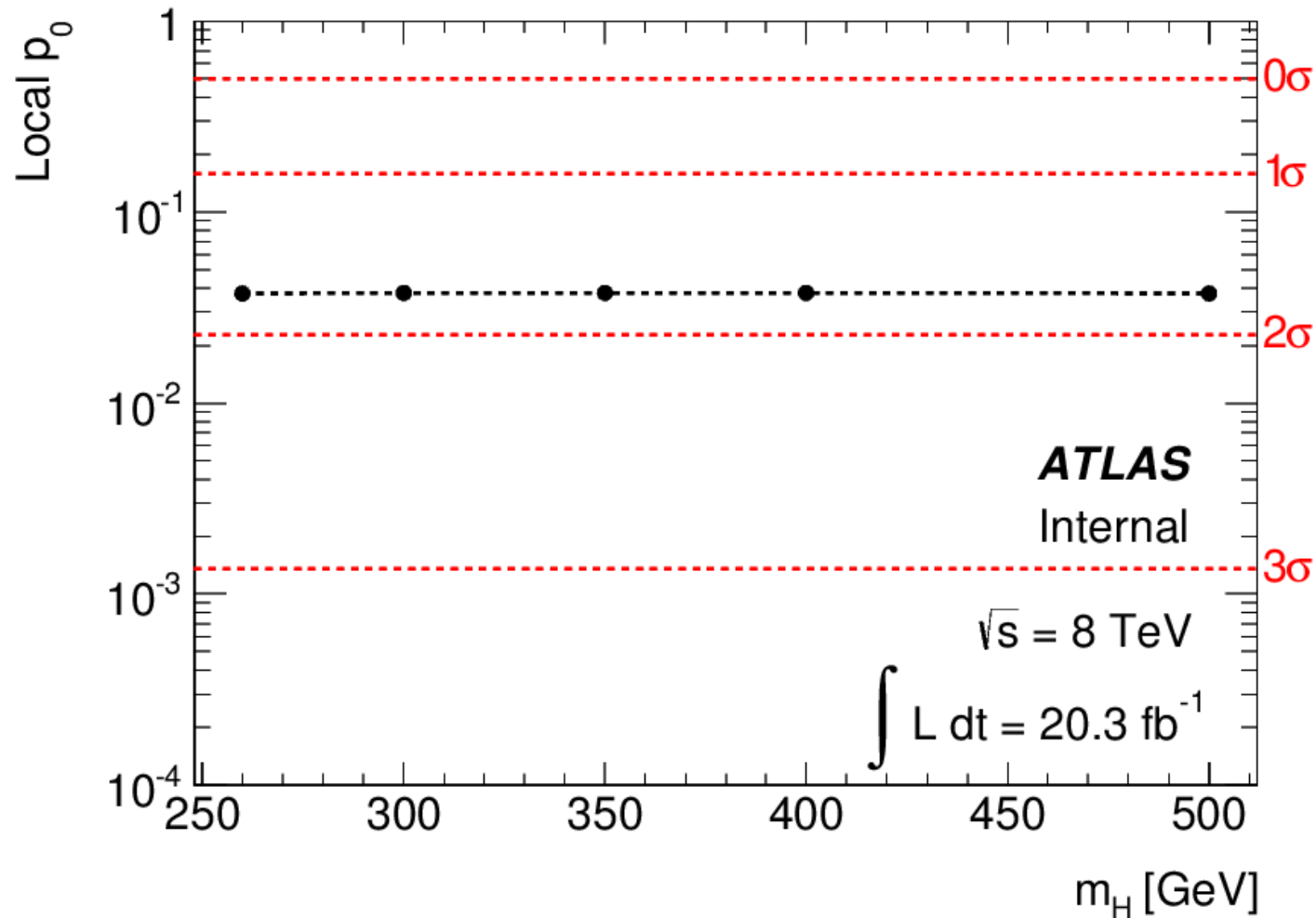
Unblinding talk

<https://indico.cern.ch/event/375385/contribution/0/material/slides/0.pdf>

Search for Higgs pair production with decays to WW and $\gamma\gamma$ in 20.3 fb $^{-1}$
proton-proton data at 8 TeV

Pvalues, significance

- updated with toys



non-res p-value 0.037602

Combined significance [toys]

Updated

- obtained wwy p-values from ~1M **toys**
- calculate bby p-values also with ~1M toys to cross-check with bby paper
- simply quadratically sum up significances to have a first look at combining wwy+bby before bbtatau unblinded

	OBS wwy significance	OBS bby significance	OBS wwy+bby significance
260	1.7804	1.66482	2.43751
300	1.77825	2.96288	3.45555
350	1.77931	1.32207	2.21671
400	1.77902	1.00548	2.0435
500	1.78042	1.29771	2.20317
SM HH	1.77922	2.47247	3.0461

← additionally
with bbbb
-0.00311567
but affect
nothing

Combined significance [asym]

Updated

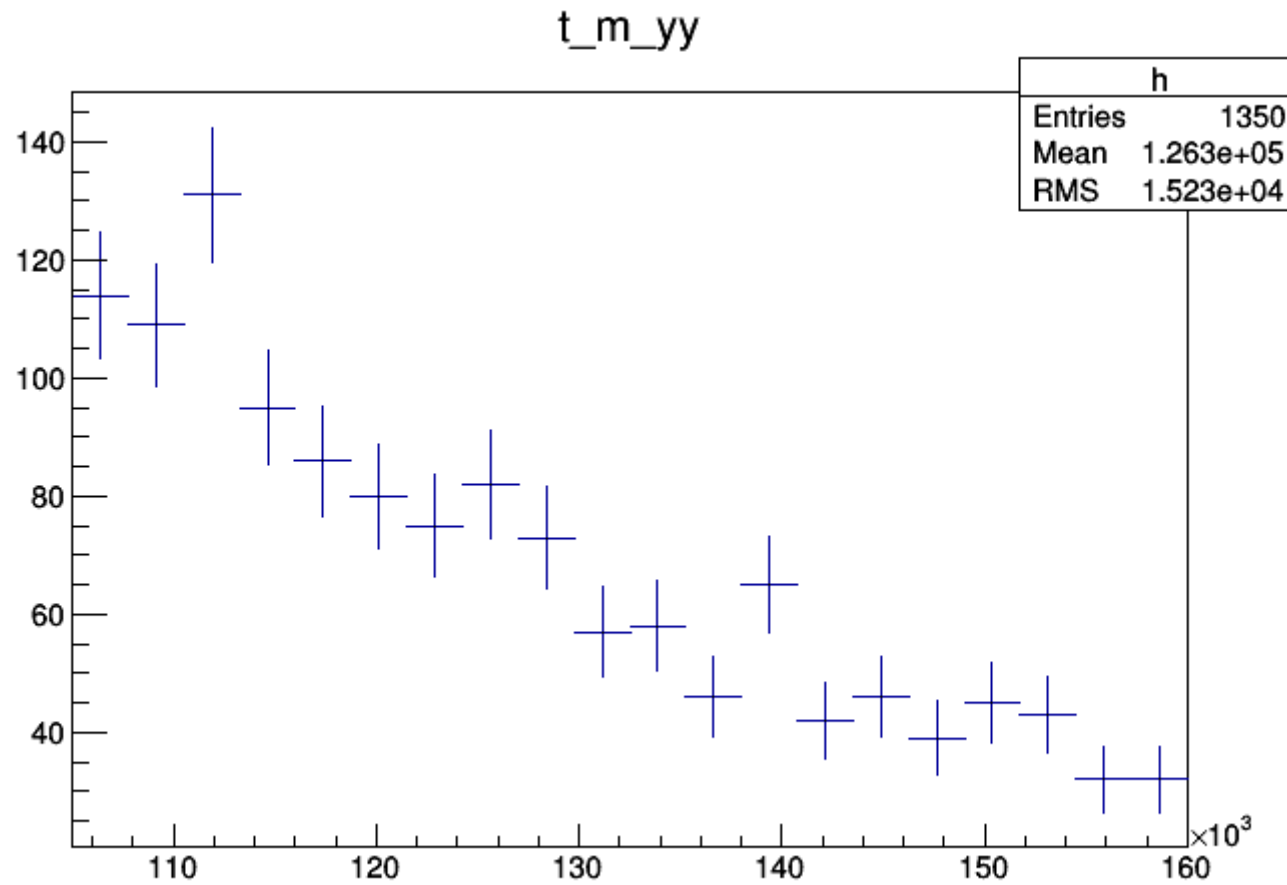
- many thanks to Aaron, we now produce reasonable significances, similar to each other among all mass points
- both** wwyy and bbyy pvalues on this page are extracted with **asymmptotics** (cross-checked with two scripts)

	OBS wwyy significance	OBS bbyy significance	OBS wwyy+bbyy significance
260	1.37533	1.59989	2.10978
300	1.37511	2.86355	3.17661
350	1.37513	1.22168	1.83943
400	1.37536	-0.510741	-
500	1.37538	-0.362726	-
SM HH	1.37536	2.43556	2.87344

← additionally
with bbbb
-0.00311567
but affect
nothing

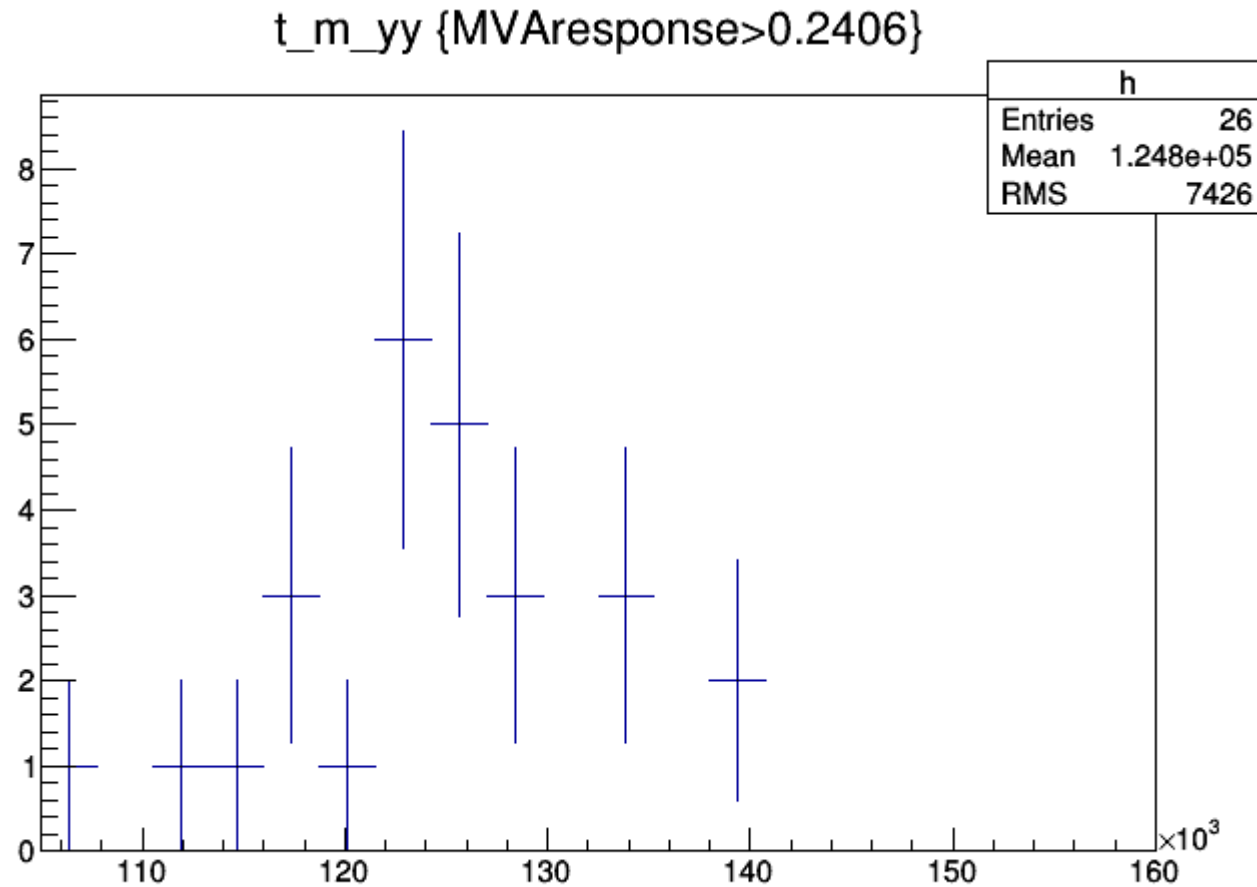
Hadhad

- my distribution after selections and before BDT final cut



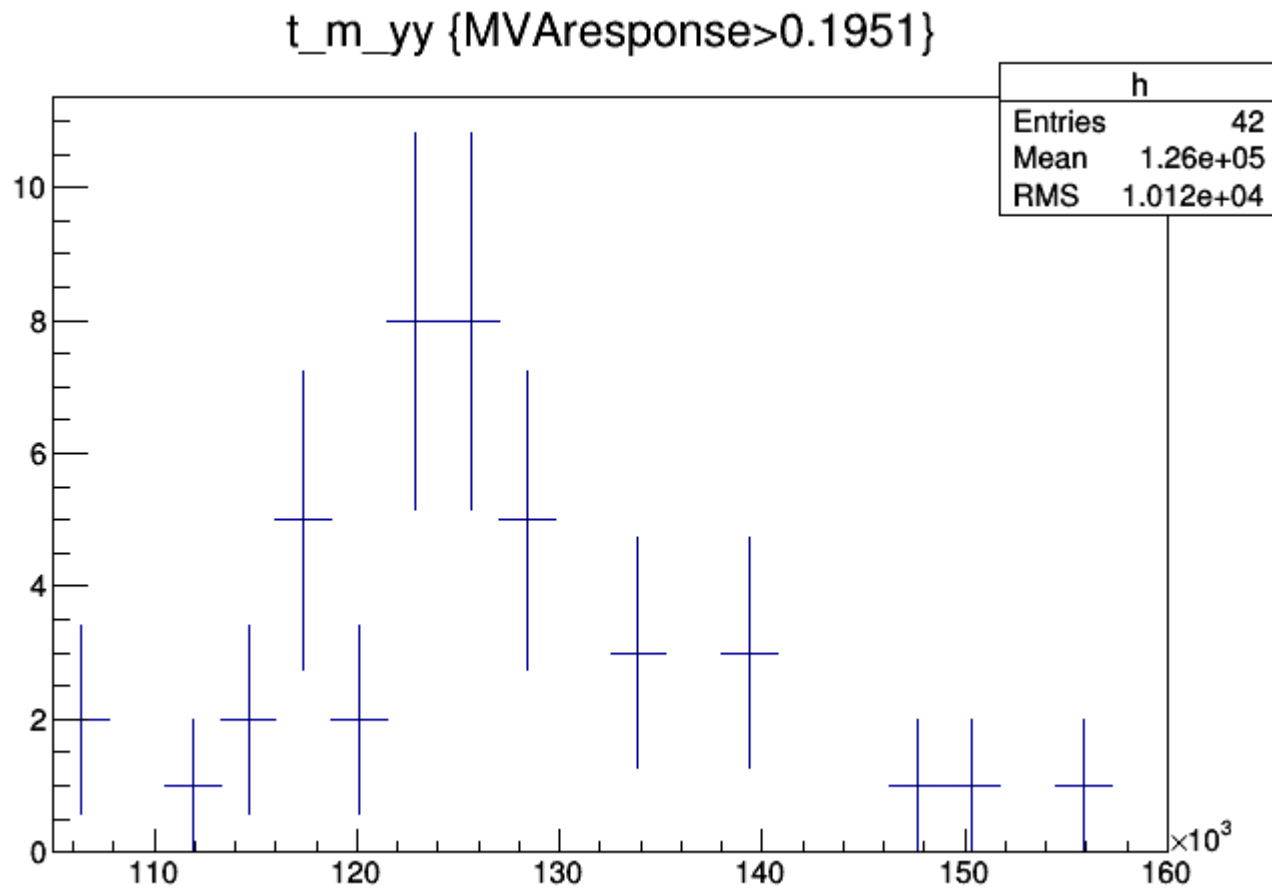
Hadhad [260]

- my distribution after selections and BDT final cut



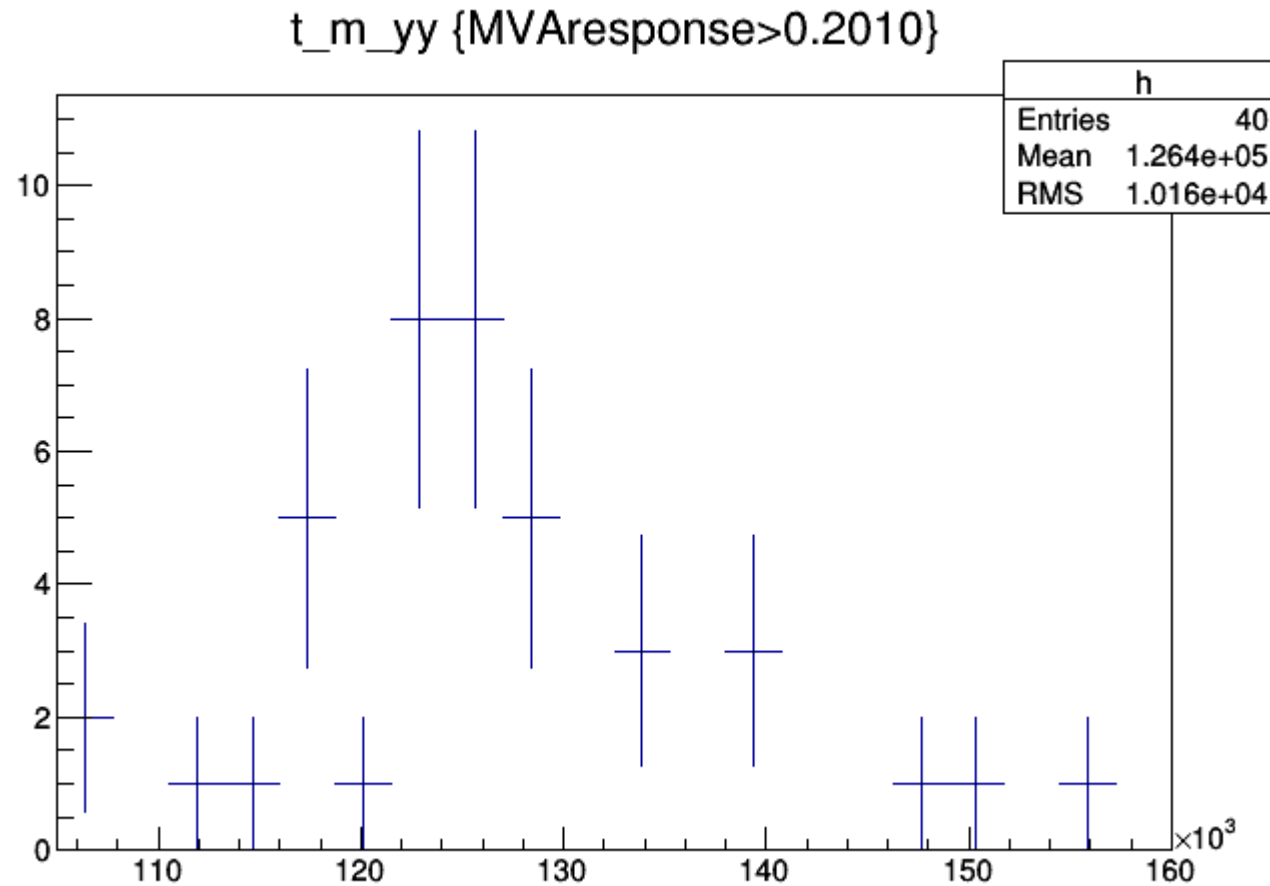
Hadhad [300]

- myy distribution after selections and BDT final cut



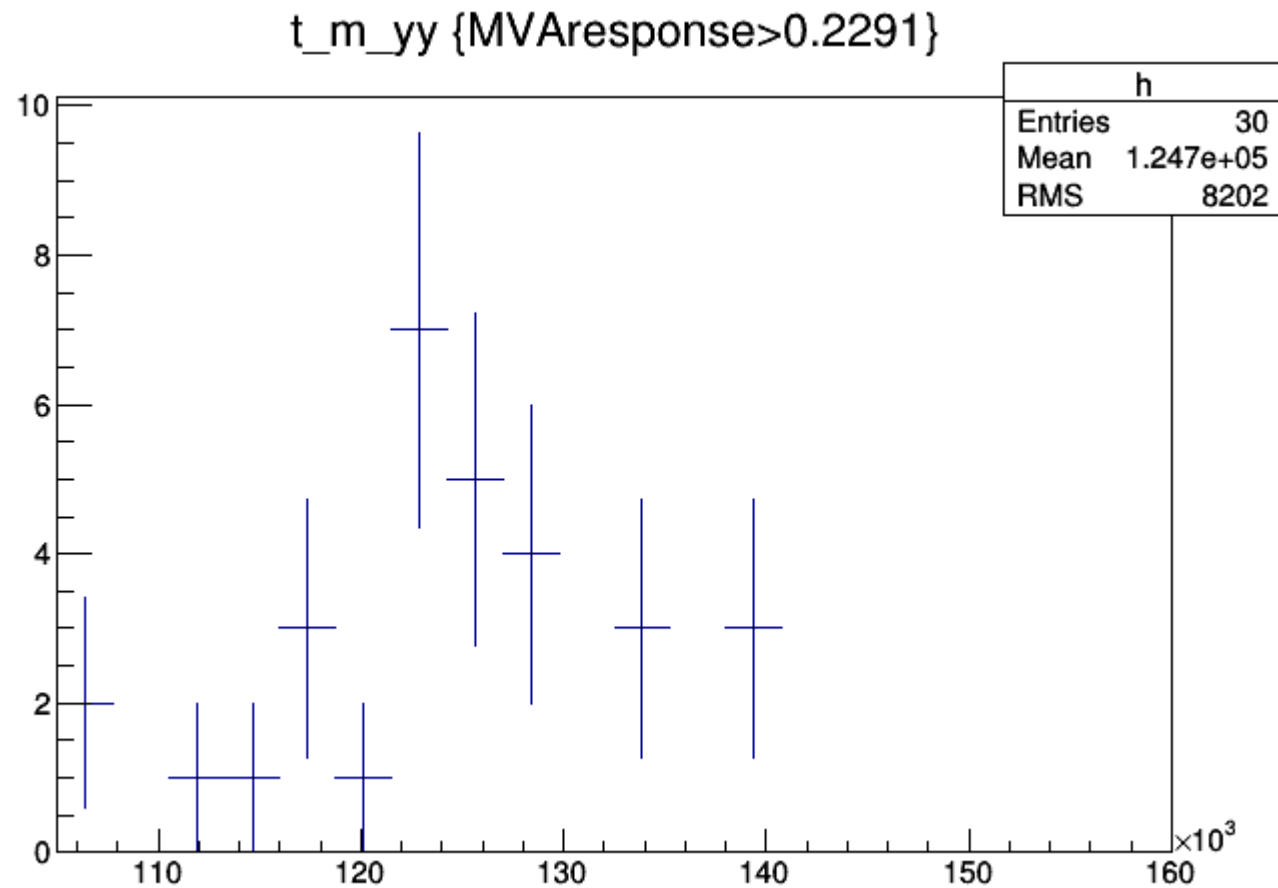
Hadhad [350]

- my distribution after selections and BDT final cut



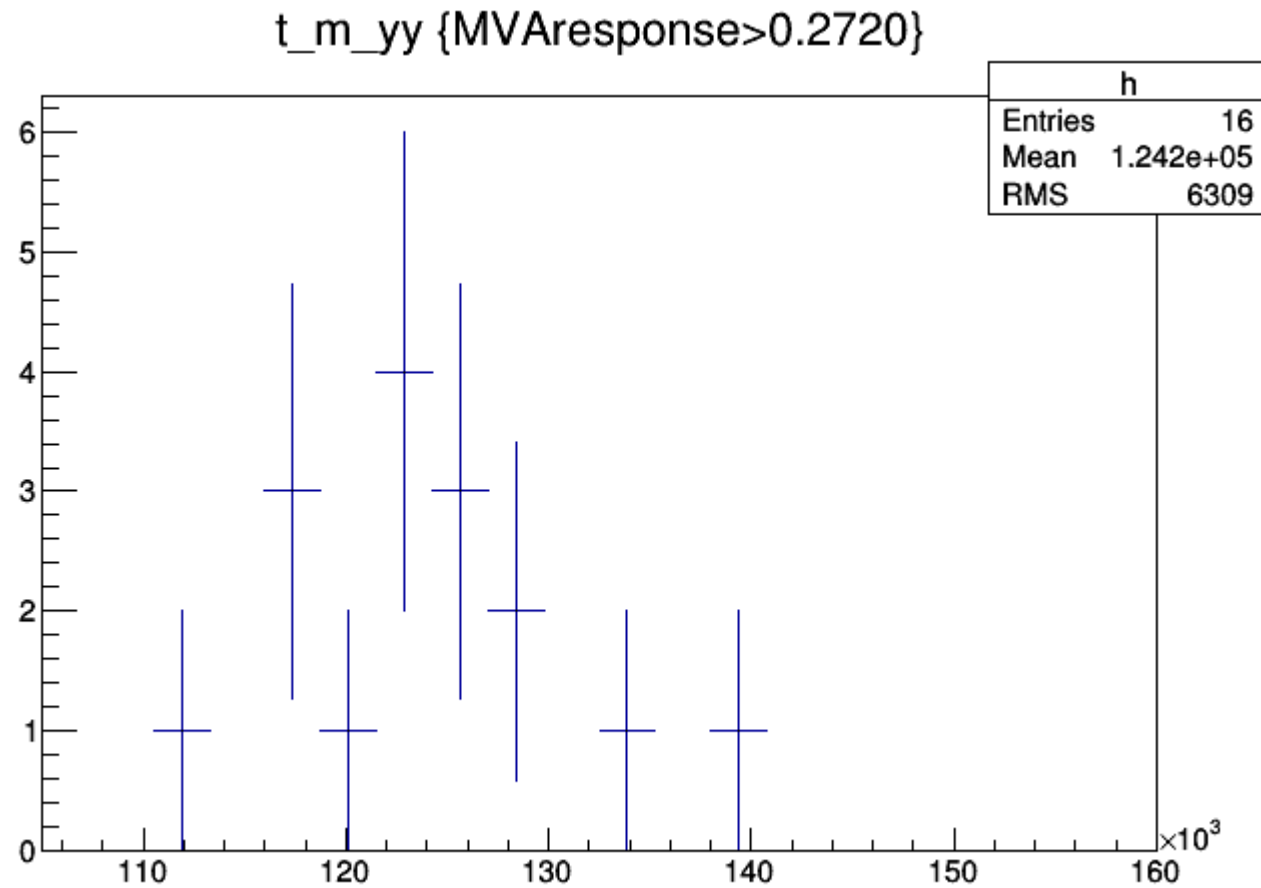
Hadhad [400]

- my distribution after selections and BDT final cut



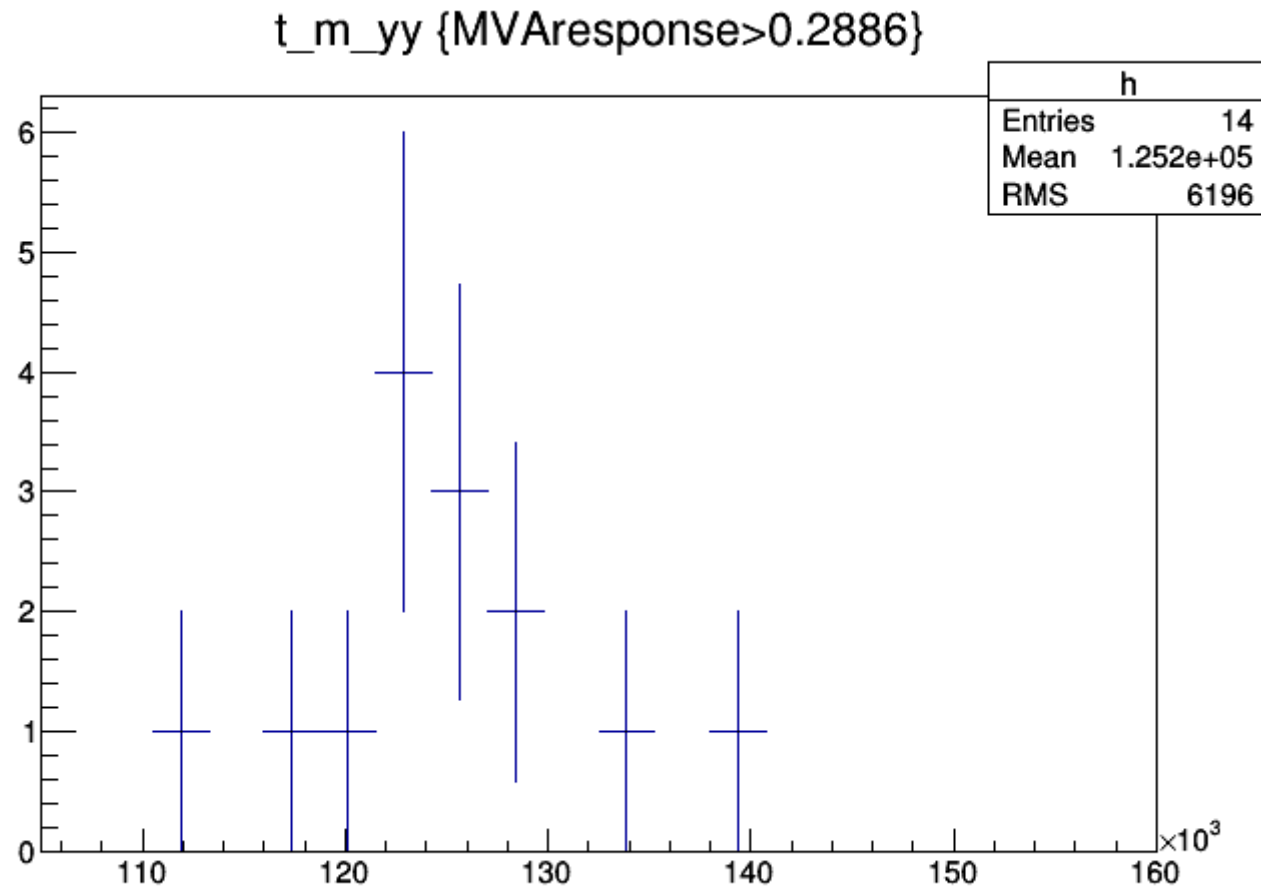
Hadhad [500]

- my distribution after selections and BDT final cut



Hadhad [nonres]

- my distribution after selections and BDT final cut



backup

P-value [$\sim 1\text{M}$ toys] - wwyy

[nores]

- Null p-value = 0.037602 +/- 0.00019119
- Significance = 1.77922 +/- 0.00233324 sigma
- Number of Alt toys: 990000
- Number of Null toys: 990000
- Test statistic evaluated on data: 0.945488
- CL_b: 0.037602 +/- 0.00019119
- CL_s+b: 0.0376091 +/- 0.000191207
- CL_s: 1.00019 +/- 0.00719167

[260GeV]

- Null p-value = 0.0375054 +/- 0.000197017
- Significance = 1.7804 +/- 0.00240942 sigma
- Number of Alt toys: 930000
- Number of Null toys: 930000
- Test statistic evaluated on data: 0.945461
- CL_b: 0.0375054 +/- 0.000197017
- CL_s+b: 0.0376344 +/- 0.000197343
- CL_s: 1.00344 +/- 0.00744784

P-value [$\sim 1\text{M}$ toys] - wwyy

[300GeV]

- Null p-value = 0.0376814 +/- 0.000193347
- Significance = 1.77825 +/- 0.00235551 sigma
- Number of Alt toys: 970000
- Number of Null toys: 970000
- Test statistic evaluated on data: 0.945488
- CL_b: 0.0376814 +/- 0.000193347
- CL_{s+b}: 0.0375959 +/- 0.000193136
- CL_s: 0.997729 +/- 0.00724426

[350GeV]

- Null p-value = 0.0375945 +/- 0.000199398
- Significance = 1.77931 +/- 0.00243381 sigma
- Number of Alt toys: 910000
- Number of Null toys: 910000
- Test statistic evaluated on data: 0.945488
- CL_b: 0.0375945 +/- 0.000199398
- CL_{s+b}: 0.0377231 +/- 0.000199725
- CL_s: 1.00342 +/- 0.00751985

P-value [$\sim 1\text{M}$ toys] - wwyy

[400GeV]

- Null p-value = 0.0376186 +/- 0.000193192
- Significance = 1.77902 +/- 0.00235683 sigma
- Number of Alt toys: 970000
- Number of Null toys: 970000
- Test statistic evaluated on data: 0.945488
- CL_b: 0.0376186 +/- 0.000193192
- CL_{s+b}: 0.0375876 +/- 0.000193116
- CL_s: 0.999178 +/- 0.00725834

[500GeV]

- Null p-value = 0.0375032 +/- 0.000197012
- Significance = 1.78042 +/- 0.00240946 sigma
- Number of Alt toys: 930000
- Number of Null toys: 930000
- Test statistic evaluated on data: 0.945488
- CL_b: 0.0375032 +/- 0.000197012
- CL_{s+b}: 0.0376484 +/- 0.000197378
- CL_s: 1.00387 +/- 0.00745043

P-value [$\sim 1\text{M}$ toys] - bbyy

[nores]

- Null p-value = $0.00670909 \pm 8.20451\text{e-}05$
- Significance = 2.47247 ± 0.00437109 sigma
- Number of Alt toys: 990000
- Number of Null toys: 990000
- Test statistic evaluated on data: 2.9659
- CL_b: $0.00670909 \pm 8.20451\text{e-}05$
- CL_{s+b}: $0.00688283 \pm 8.30933\text{e-}05$
- CL_s: 1.0259 ± 0.0176291

[260GeV]

- Null p-value = $0.0479745 \pm 0.000220427$
- Significance = 1.66482 ± 0.00220905 sigma
- Number of Alt toys: 940000
- Number of Null toys: 940000
- Test statistic evaluated on data: 1.27981
- CL_b: $0.0479745 \pm 0.000220427$
- CL_{s+b}: $0.0477989 \pm 0.000220044$
- CL_s: 0.996341 ± 0.00648032

P-value [$\sim 1\text{M}$ toys] - bbyy

[300GeV]

- Null p-value = $0.00152386 \pm 4.15815\text{e-}05$
- Significance = 2.96288 ± 0.00839954 sigma
- Number of Alt toys: 880000
- Number of Null toys: 880000
- Test statistic evaluated on data: 4.10003
- CL_b: $0.00152386 \pm 4.15815\text{e-}05$
- CL_{s+b}: $0.00150795 \pm 4.13642\text{e-}05$
- CL_s: 0.98956 ± 0.0382874

[350GeV]

- Null p-value = $0.0930727 \pm 0.000291998$
- Significance = 1.32207 ± 0.00175394 sigma
- Number of Alt toys: 990000
- Number of Null toys: 990000
- Test statistic evaluated on data: 0.746297
- CL_b: $0.0930727 \pm 0.000291998$
- CL_{s+b}: $0.0929828 \pm 0.000291871$
- CL_s: 0.999034 ± 0.00443372

P-value [$\sim 1\text{M}$ toys] - bbyy

[400GeV]

- Null p-value = 0.157334 +/- 0.000364115
- Significance = 1.00548 +/- 0.00151308 sigma
- Number of Alt toys: 1000000
- Number of Null toys: 1000000
- Test statistic evaluated on data: 0
- CL_b: 0.157334 +/- 0.000364115
- CL_{s+b}: 0.156415 +/- 0.000363248
- CL_s: 0.994159 +/- 0.00325944

[500GeV]

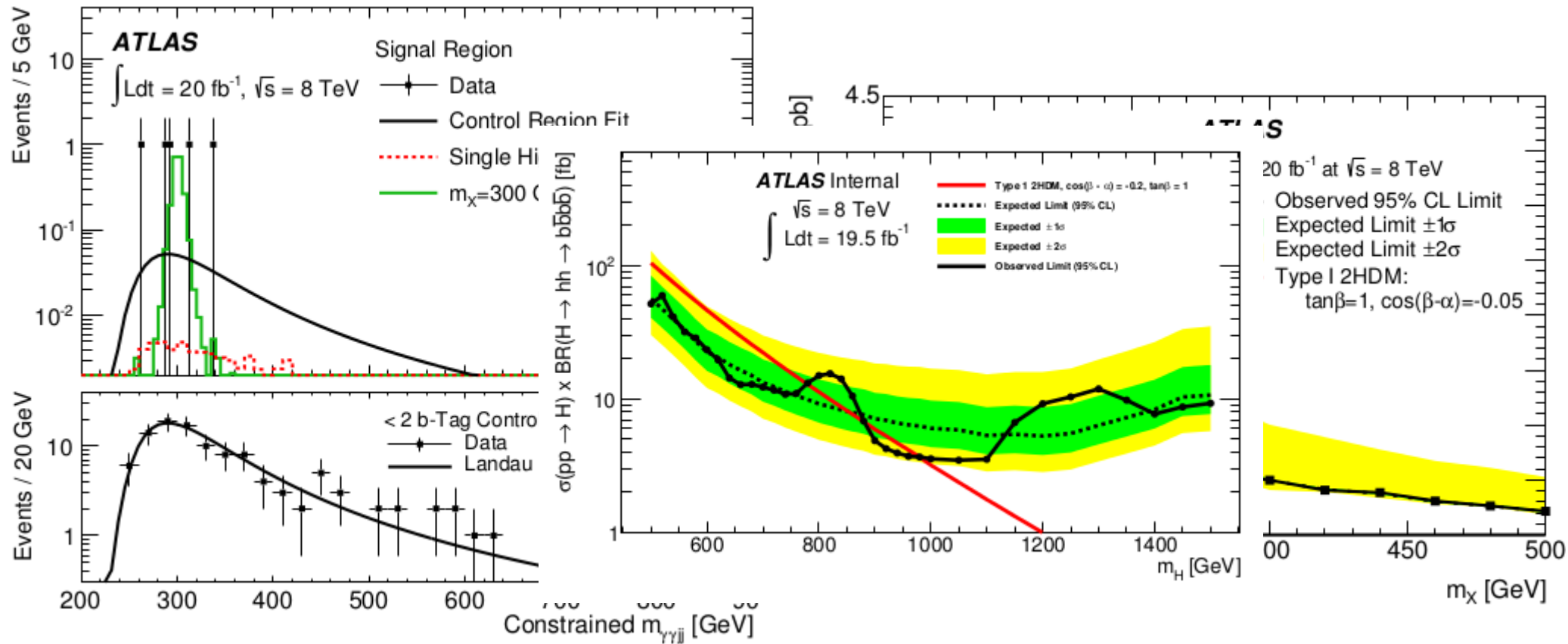
- Null p-value = 0.097193 +/- 0.00029622
- Significance = 1.29771 +/- 0.00172343 sigma
- Number of Alt toys: 1000000
- Number of Null toys: 1000000
- Test statistic evaluated on data: 0
- CL_b: 0.097193 +/- 0.00029622
- CL_{s+b}: 0.097541 +/- 0.000296693
- CL_s: 1.00358 +/- 0.00432133

Limits before/after unblinding

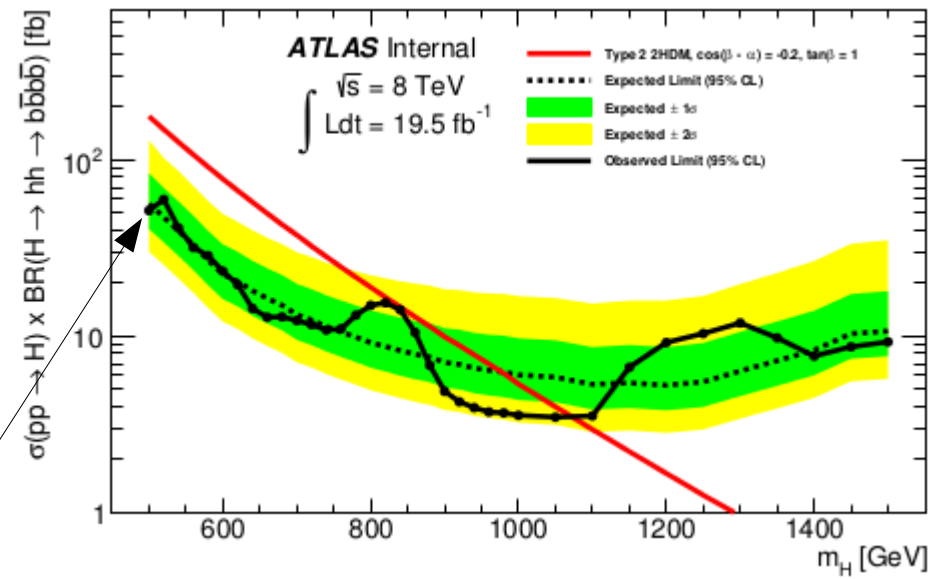
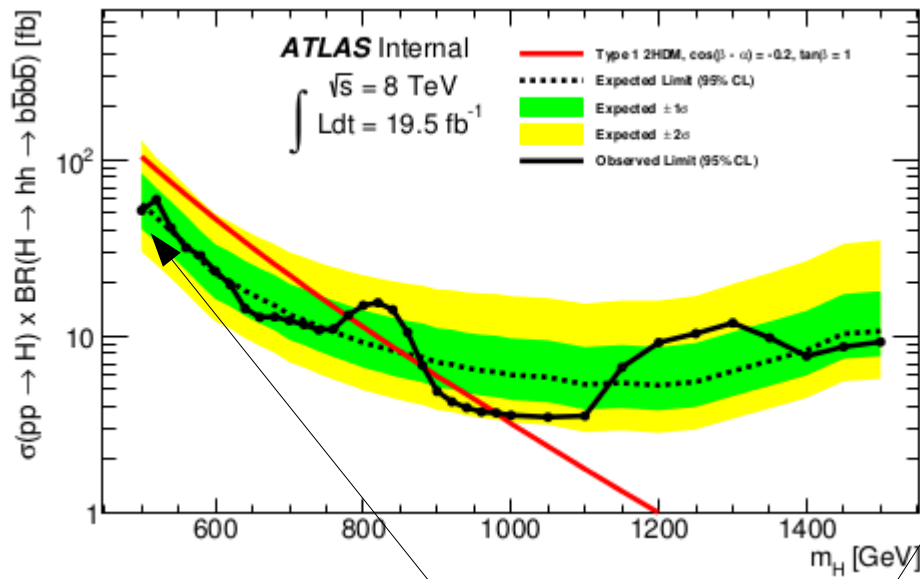
before	Non-res	260 GeV	300 GeV	350 GeV	400 GeV	500 GeV
Median	6.53016	10.8557	8.92967	7.50631	6.61605	5.6362
Observed						
+2 σ	13.0728	21.7998	17.8776	15.137	13.301	11.3682
+1 σ	9.23444	15.3726	12.6355	10.658	9.39486	8.09175
-1 σ	5.07175	8.33472	6.86803	5.81079	5.12704	4.39592
-2 σ	4.87975	7.89317	6.48935	5.53279	4.94406	4.20521

after	Non-res	260 GeV	300 GeV	350 GeV	400 GeV	500 GeV
Median	8.81794	14.5853	11.9224	10.1206	8.90901	7.65974
Observed	12.6259	21.1806	16.0369	14.0016	12.8876	11.1007
+2 σ	16.297	27.419	22.3968	18.9088	16.6705	14.1974
+1 σ	11.9078	19.7609	16.1852	13.631	12.0975	10.3829
-1 σ	7.10667	11.6522	9.42139	7.92885	7.15727	6.14156
-2 σ	6.70651	10.9031	8.95802	7.57311	6.80045	5.94627

bbyy m(yy)



bbbb



no sensitivity is seen @ 500 GeV