

# Weekly report

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## *Outline*

1. **WWyy & comb** (BSM, hh pair)

**Xiaohu Sun**  
**16-03-2015**  
**IHEP**

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

# **HH pair searches**

**with  $WW\gamma\gamma$  final states**

**--- unblinded results cont. ---**

**CDS entry**

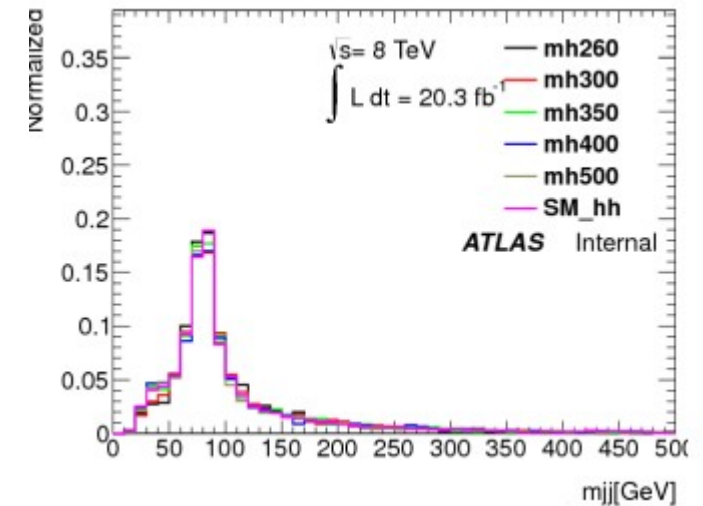
**<https://cds.cern.ch/record/1967498>**

**Unblinding talk (20<sup>th</sup> FEB)**

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

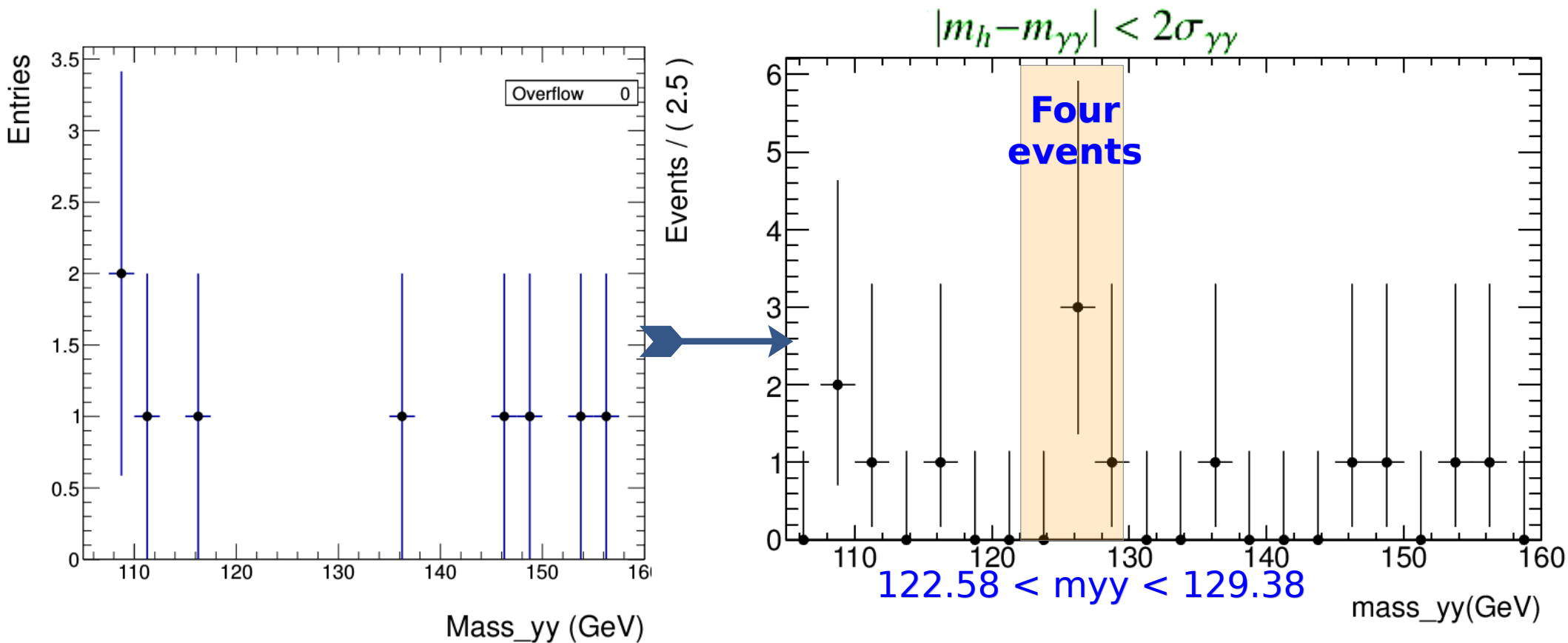
# Event details

- Four events found in signal region are
  - Run 203779 Event 34925996
  - Run 205071 Event 53075031
  - Run 206409 Event 21404695
  - Run 215414 Event 177177613
- Event kinematics in table



	203779/34925996	205071/53075031	206409/21404695	215414/177177613
Leading $\gamma$ $p_T/\eta/\phi$	98.5633/-0.852812/-1.69113	67.4636/1.64648/1.21016	93.7528/1.62641/-1.74615	67.9589/2.12717/-0.52795
Subleading $\gamma$ $p_T/\eta/\phi$	34.9792/0.0311352/1.72492	33.0454/-0.107483/-2.80046	32.9373/-0.293423/-2.2777	34.4934/0.0372347/-1.26547
$m_{\gamma\gamma}$	128.088	127.06	127.234	125.582
Leading jet $p_T/\eta/\phi$	45.1088/2.50567/0.937492	71.9527/1.98968/-0.644554	27.4681/0.002.86039/2.22521	256.965/0.647262/2.43716
Subleading jet $p_T/\eta/\phi$	25.6507/1.02382/-1.87857	33.917/-1.60218/2.50418	25.217/-2.40485/2.019	88.1251/-0.917844/-1.25418
$m_{jj}$	88.498	305.972	81.4373	390.198
Lepton $p_T/\eta/\phi$	10.6429/1.25487/1.6025	26.4419/0.277112/-0.80789	17.1516/2.43317/0.732764	33.5298/0.902979/-1.09434
$E_T^{miss}$	72.8039	35.2994	48.2987	79.7535
$E_T^{miss}$ significance	2.7585	2.37516	1.08125	5.10453
$m_T(l\nu)$	58.9137	8.145	45.3455	53.019
$m_T(l\nu jj)$	257.24.1	146.545	265.114	462.958
$m(l\nu\gamma\gamma jj)$	632.455	538.601	654.406	820.708
number of jets	2	2	4	2
number of muons	1	0	1	1
number of electrons	0	1	0	0

# Unblinded $m(\gamma\gamma)$ distribution



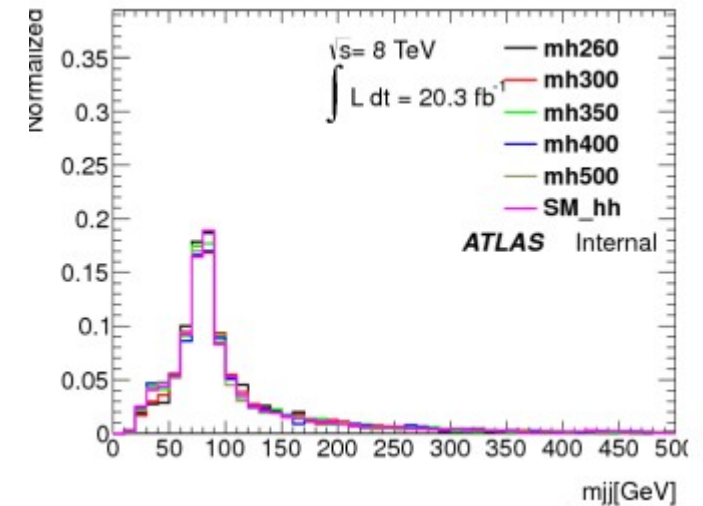
**Four events** are seen in signal region

~

we estimated:  
SM Higgs bkg = 0.243  
cont. bkg = 1.4  
in total **1.643**

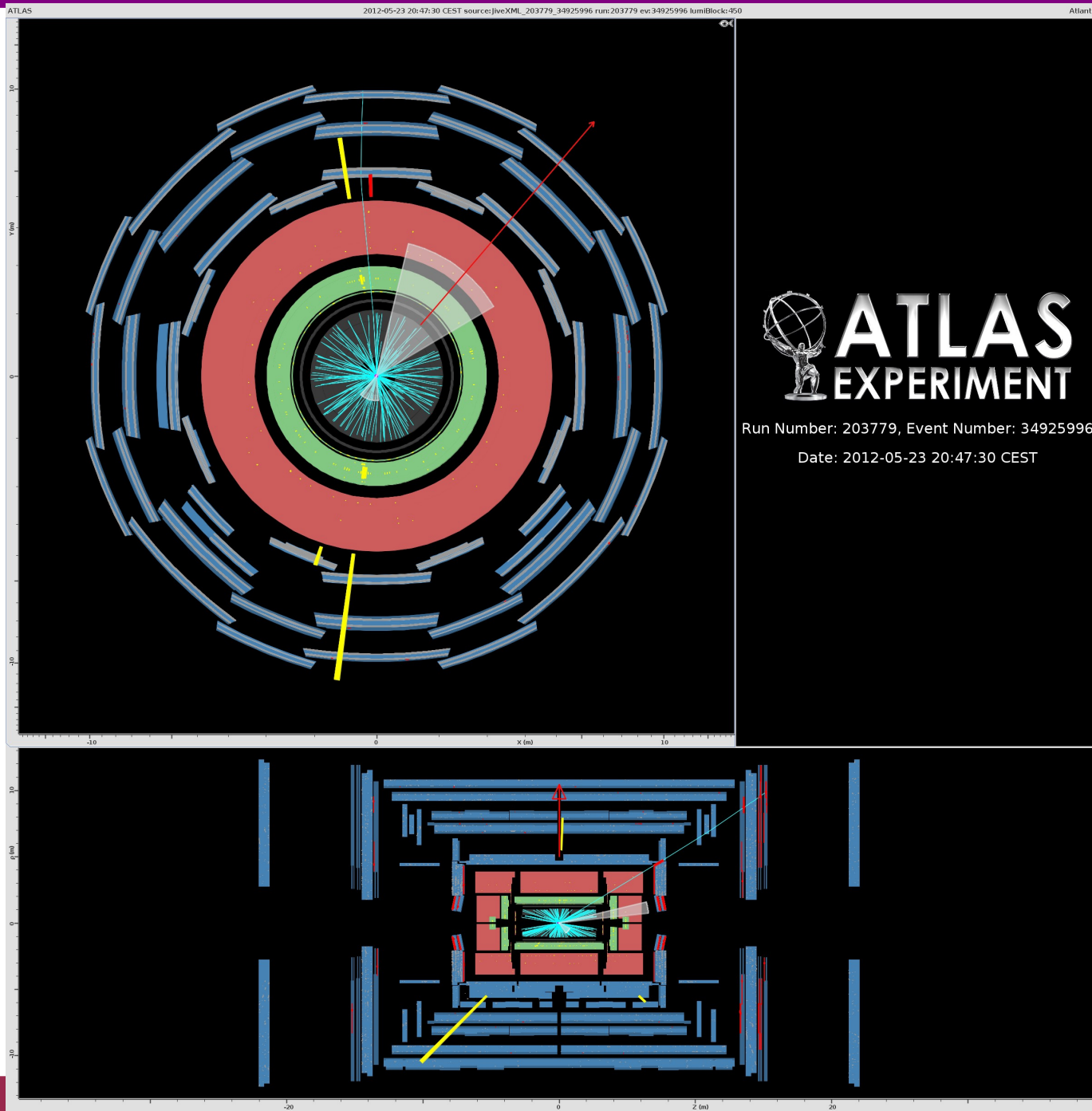
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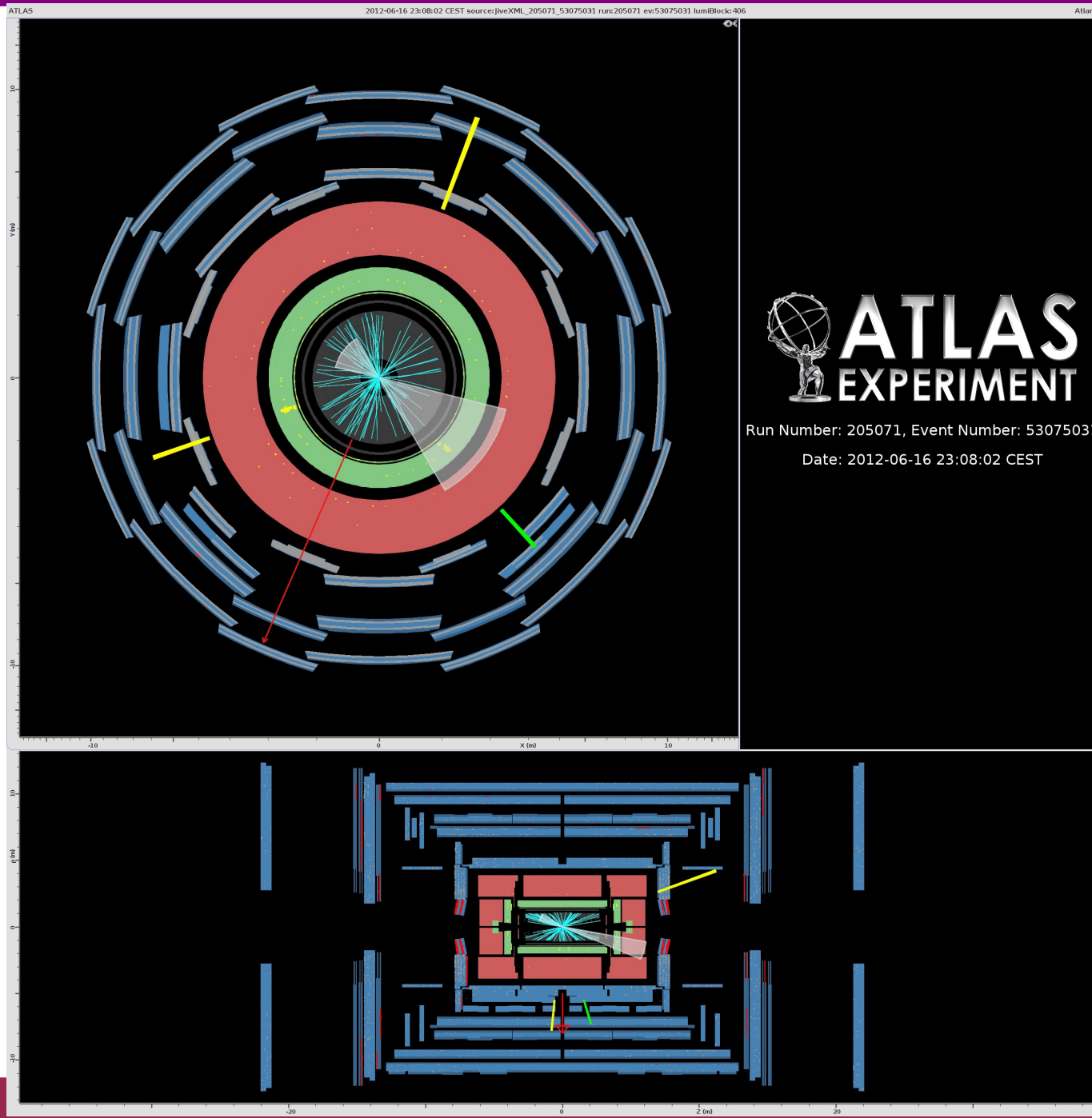


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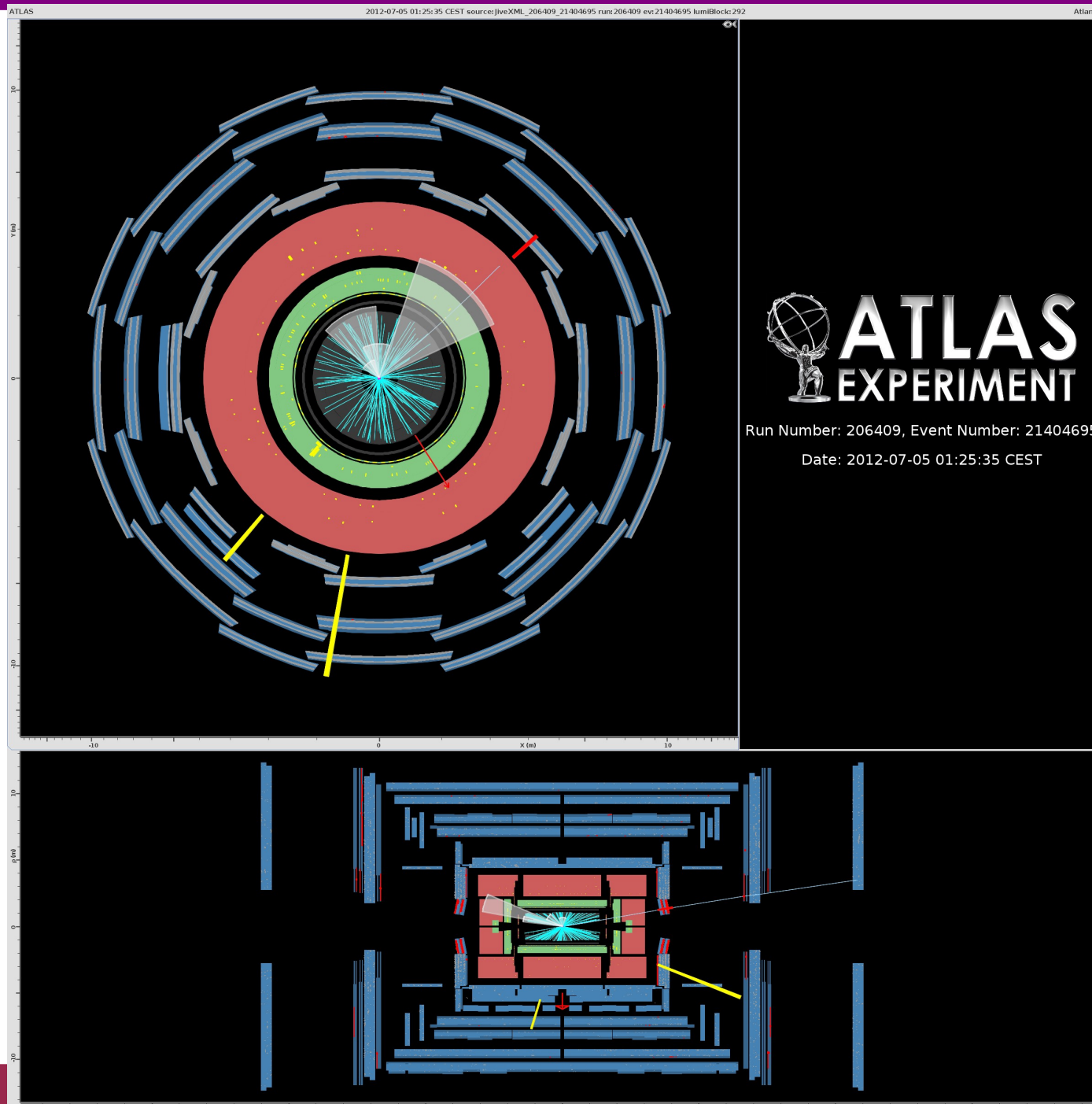
# Event display [Run 203779 Event 34925996]



# Event display [Run 205071 Event 53075031]

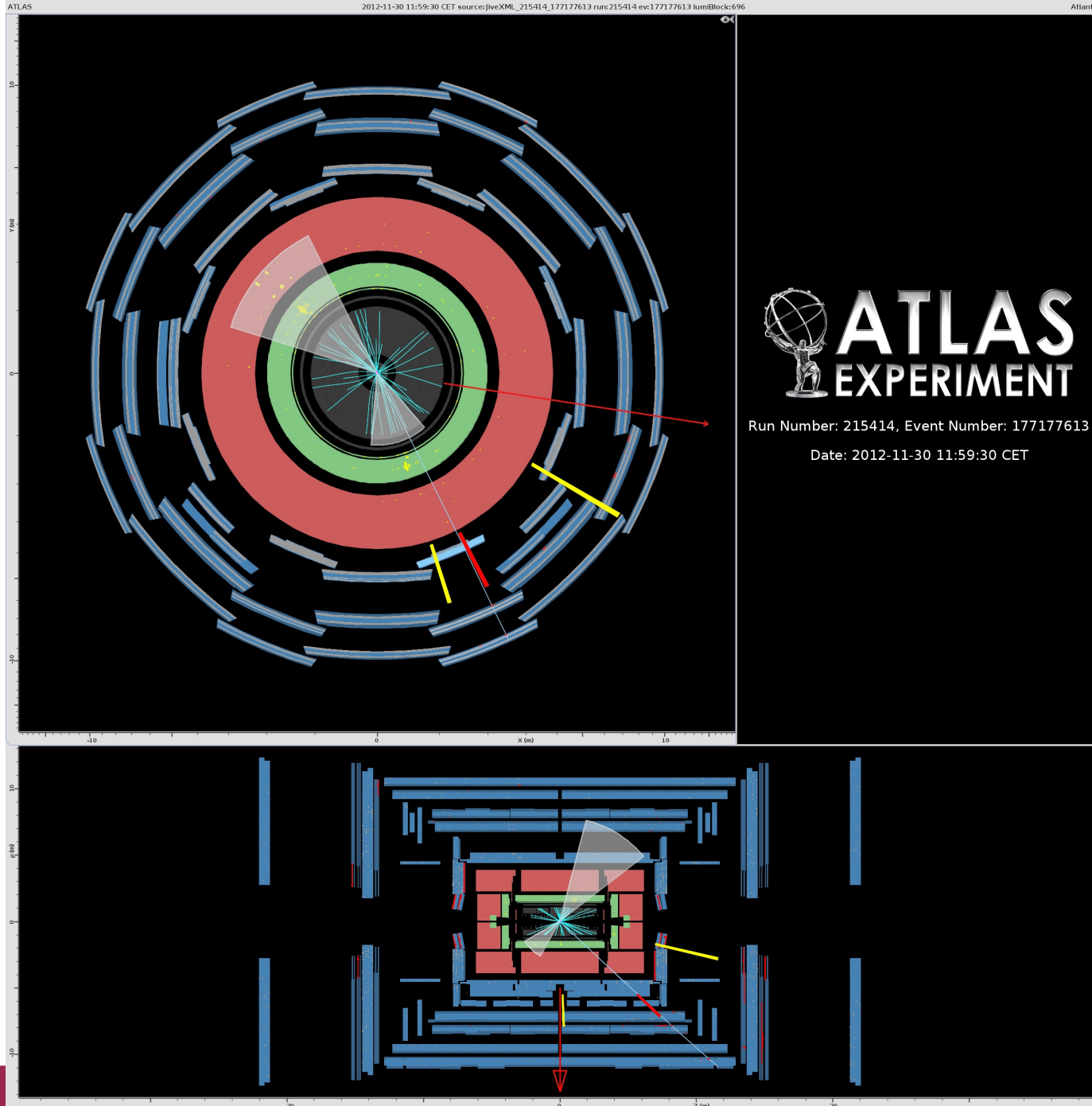


# Event display [Run 206409 Event 21404695]





# Event display [Run 215414 Event 177177613]





# Nuisance pulls

- JER nuisance parameter is slightly over-constrained in nonres in the last talk, in fact, a wrong plots was imported in the slide
- now this is the correct one

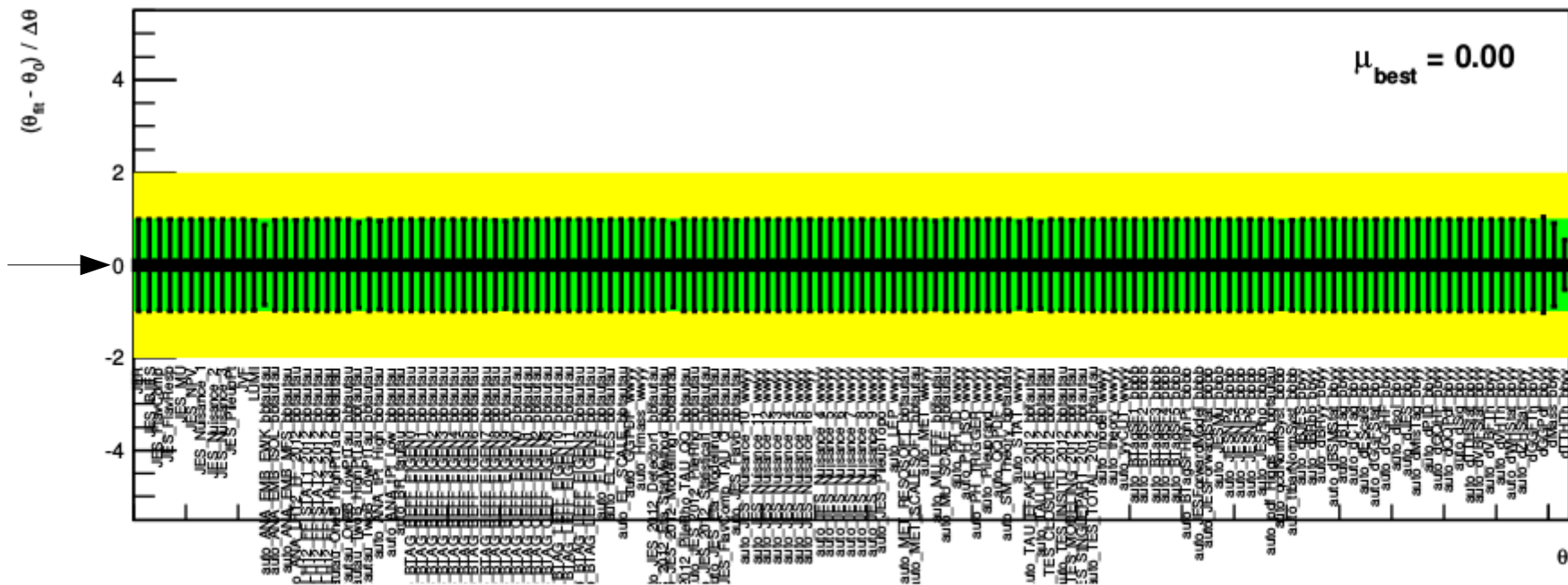
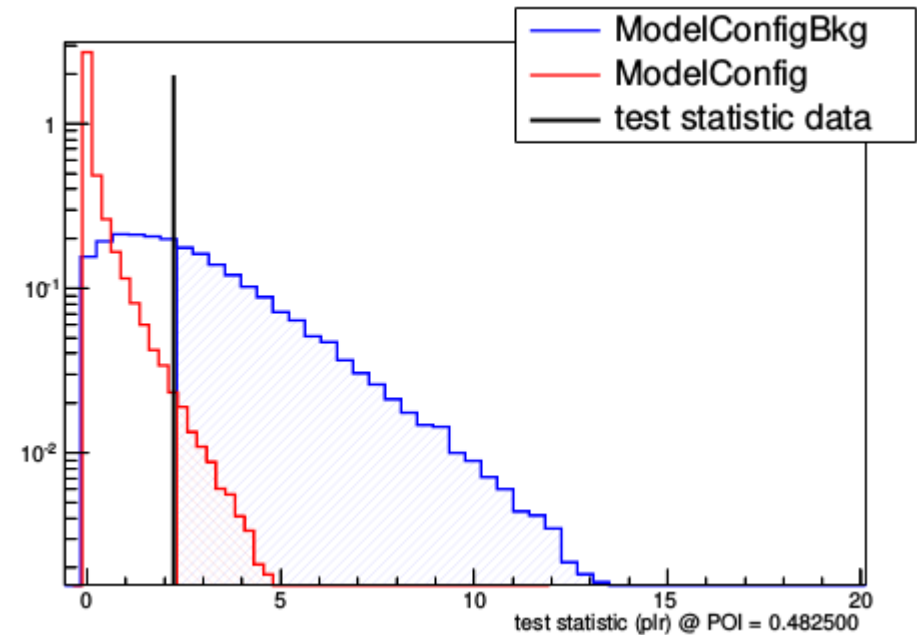
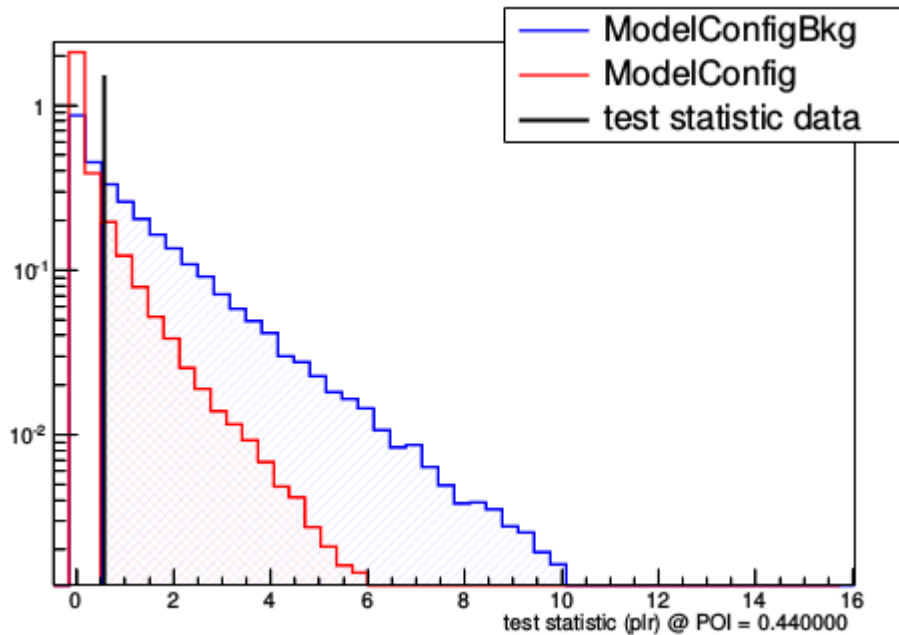
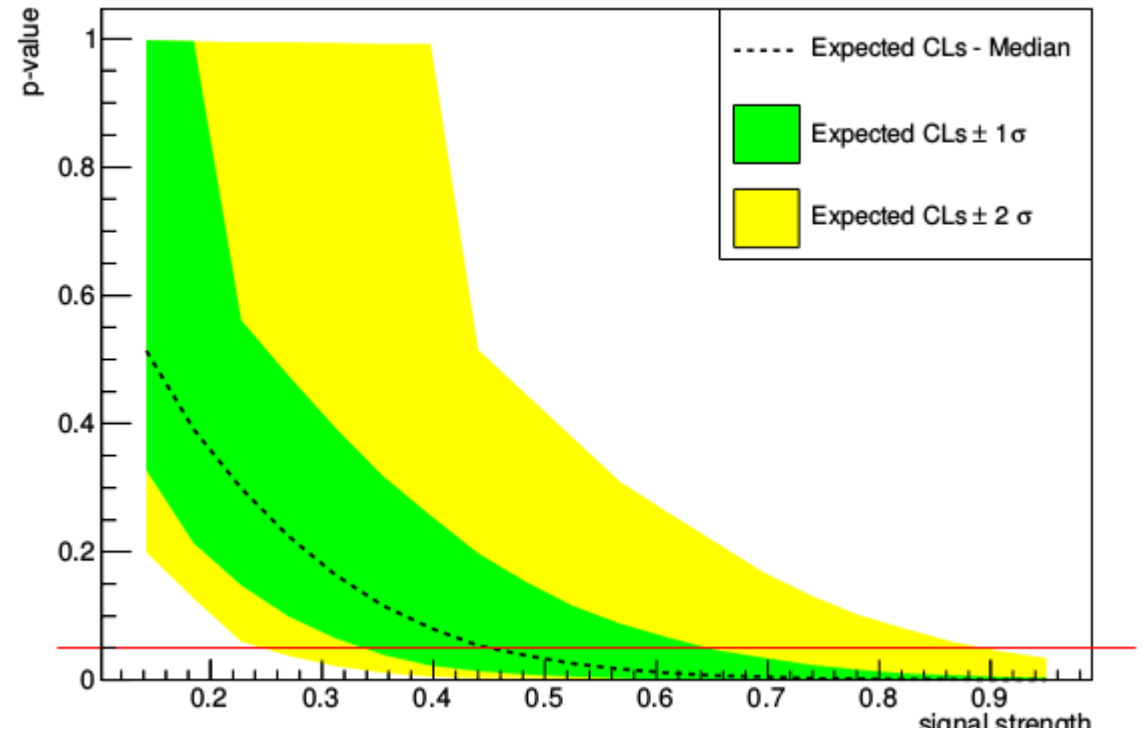


Figure 20: Nuisance parameter pull checks for non-resonance from combining  $b\bar{b}\gamma\gamma$ ,  $b\bar{b}\tau\tau$ ,  $WW\gamma\gamma$  and  $b\bar{b}b\bar{b}$

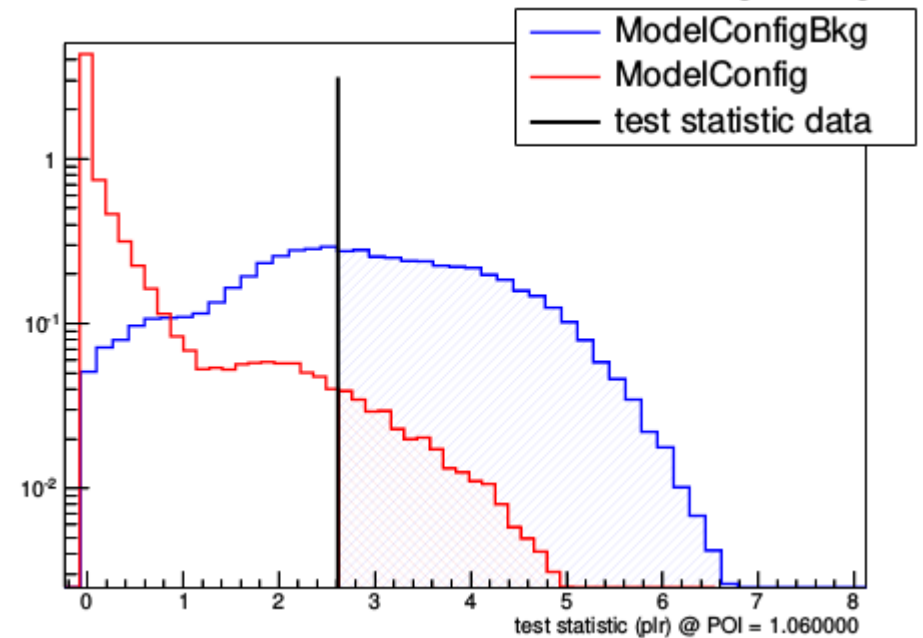
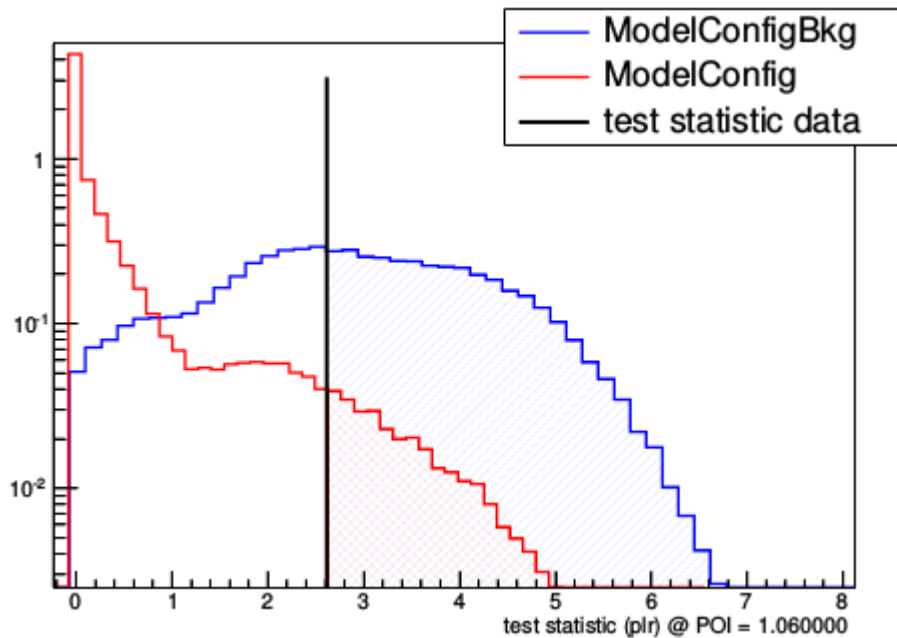
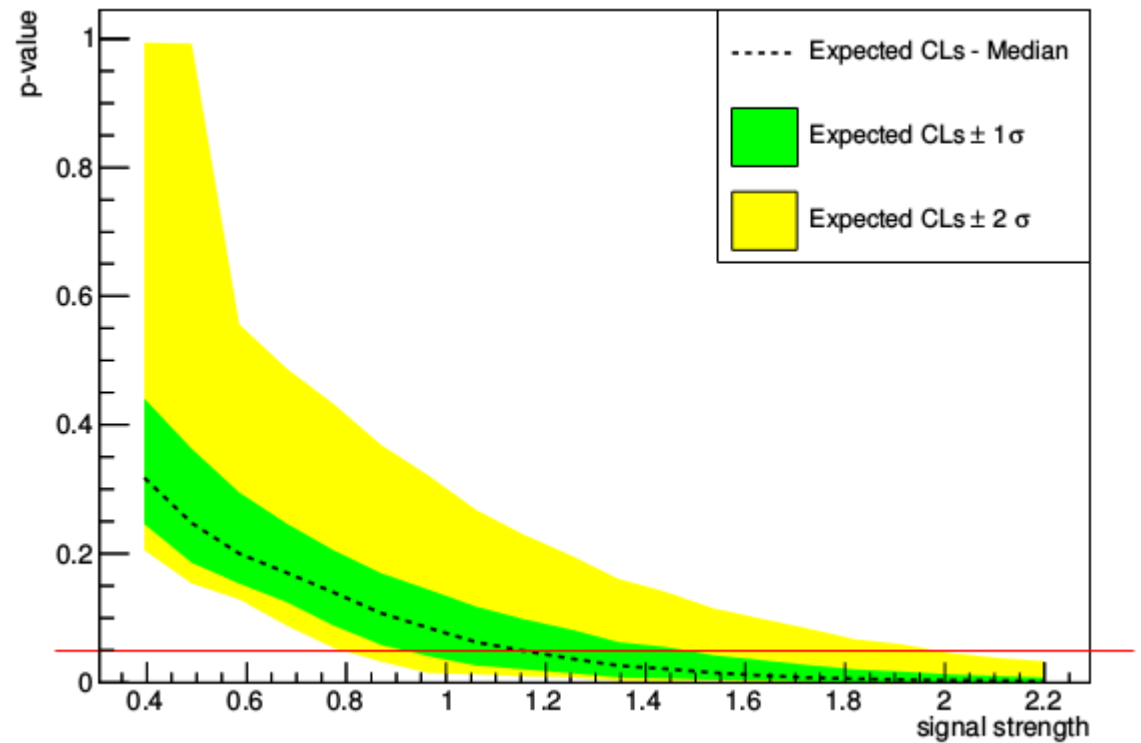
# TS nonres, toys

- 100K toys
- 20-step scan
- with Adye's script
- StandardHypoTestInv



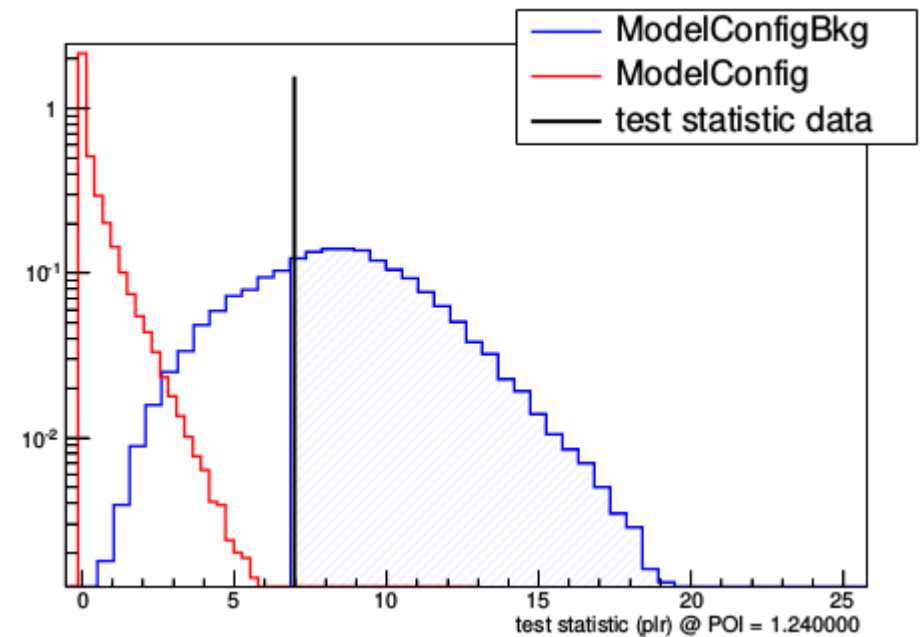
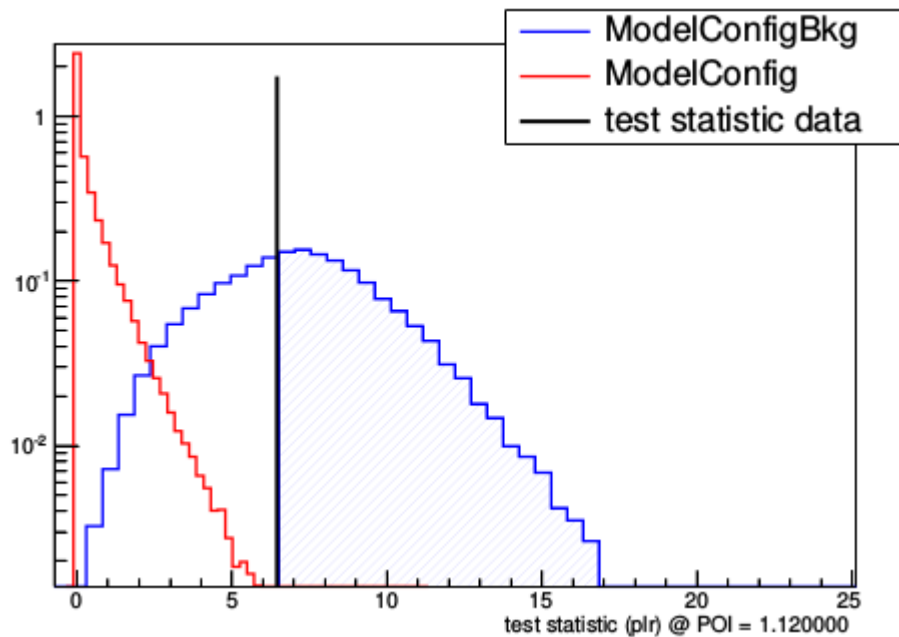
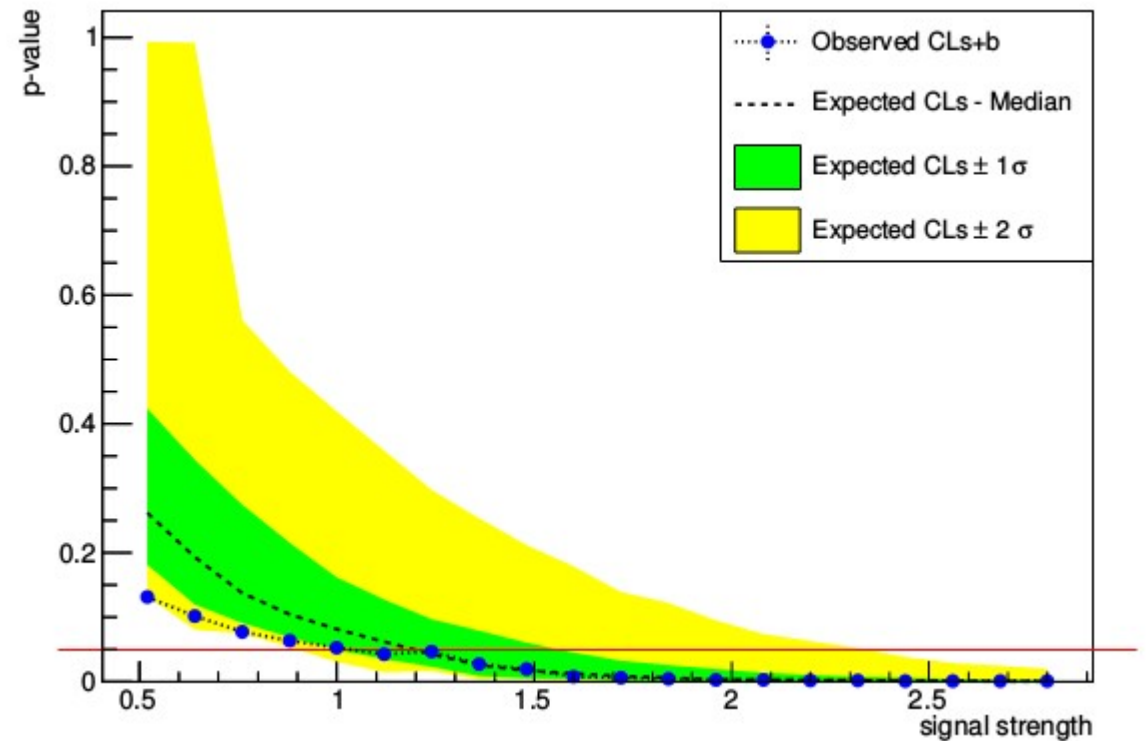
# TS 260GeV, toys

- 100K toys



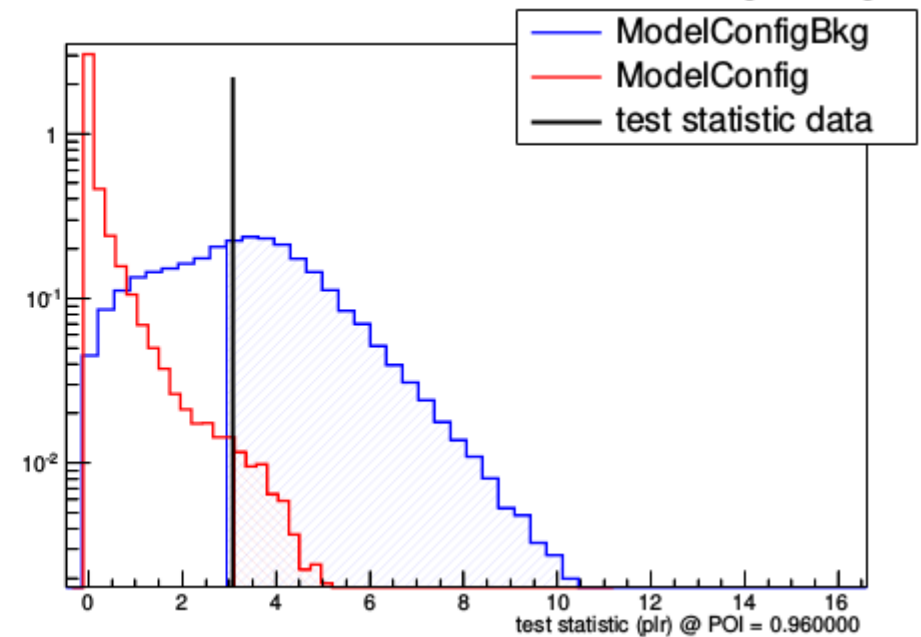
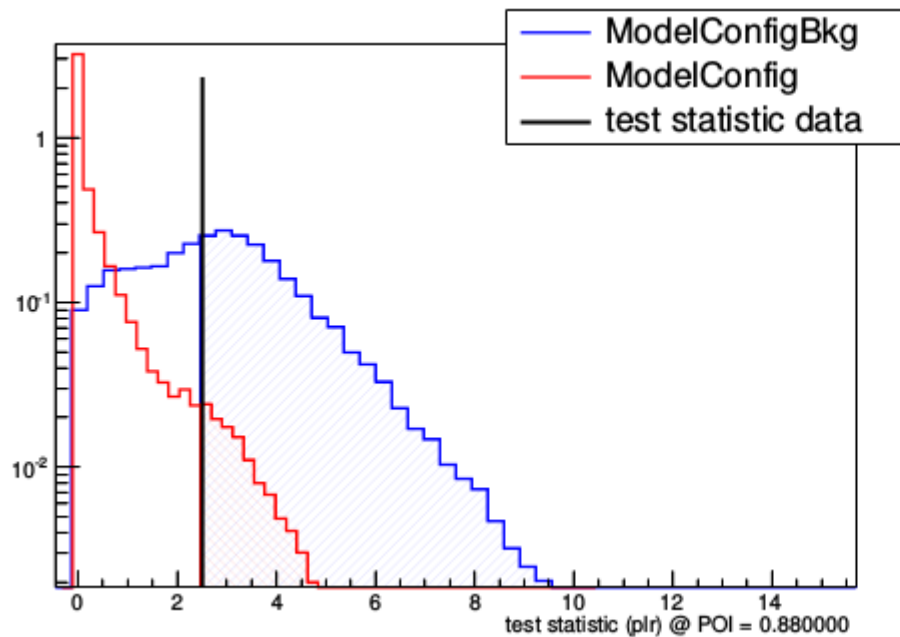
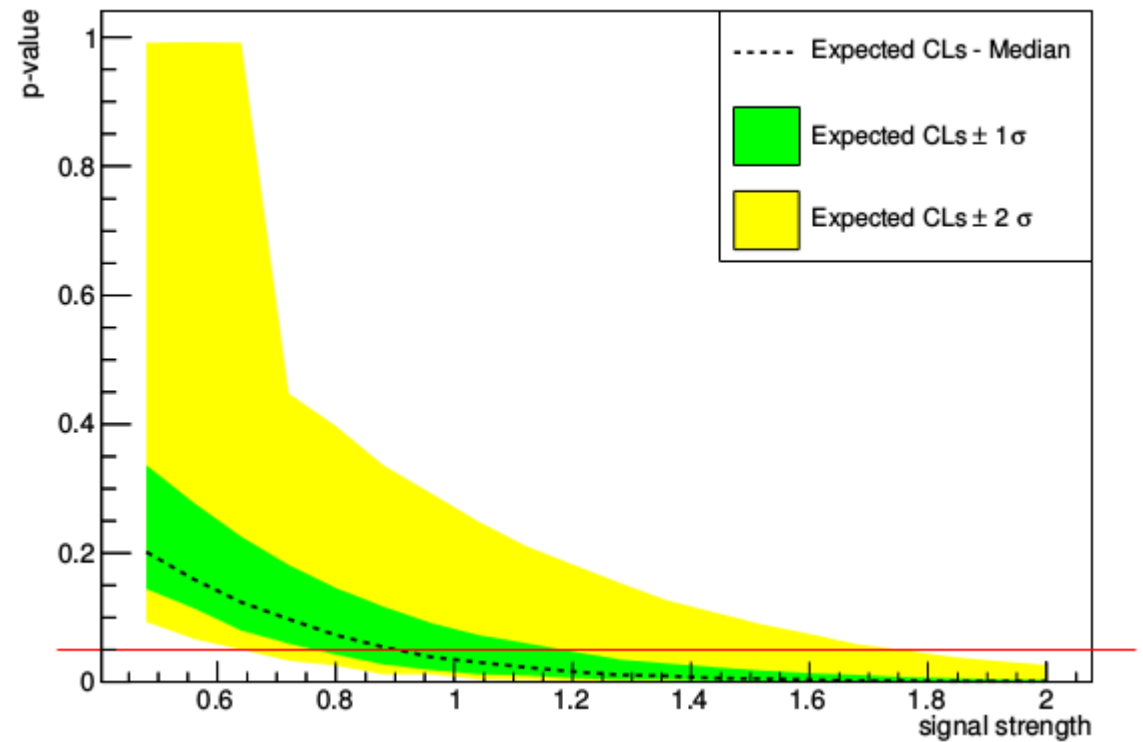
# TS 300GeV, toys

- 100K toys



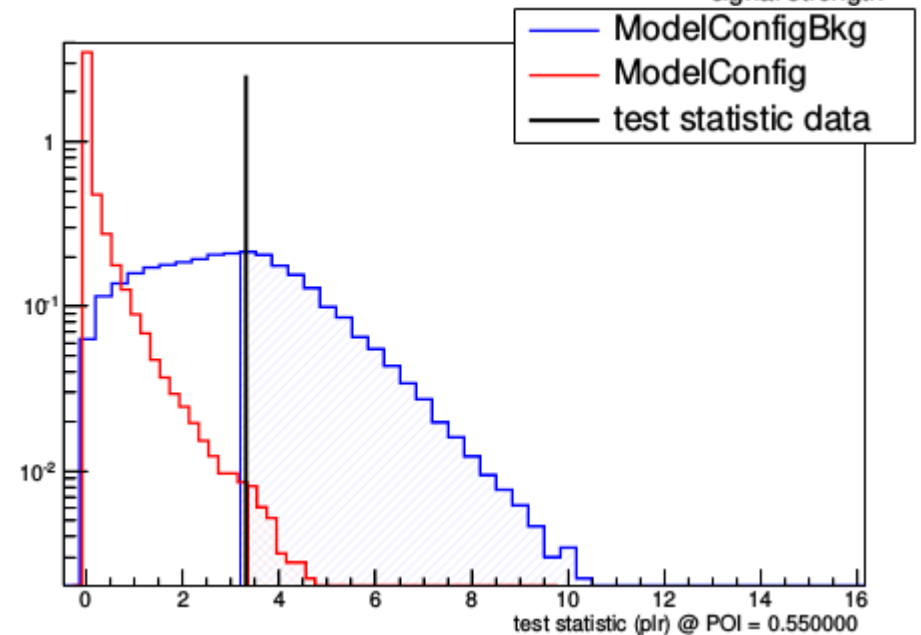
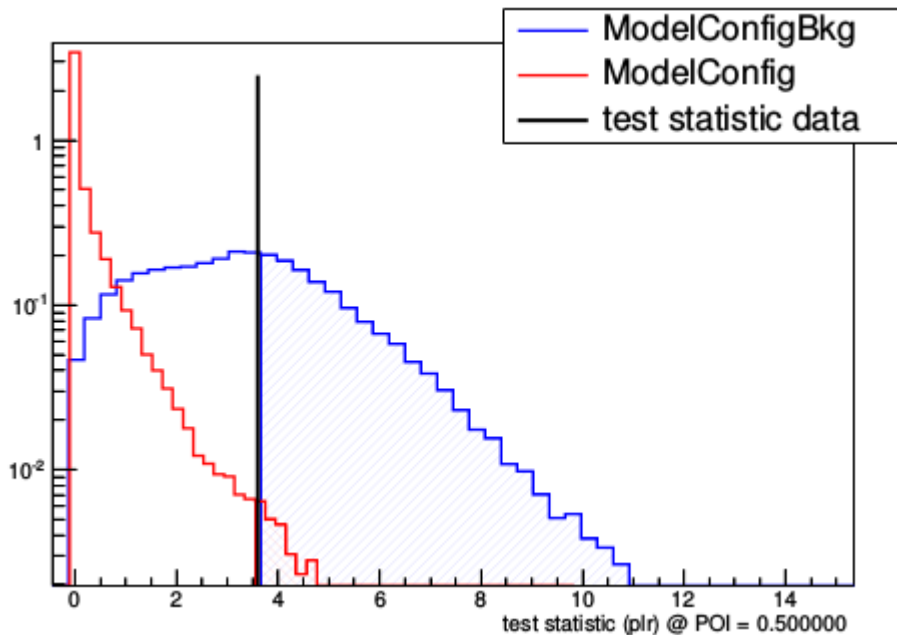
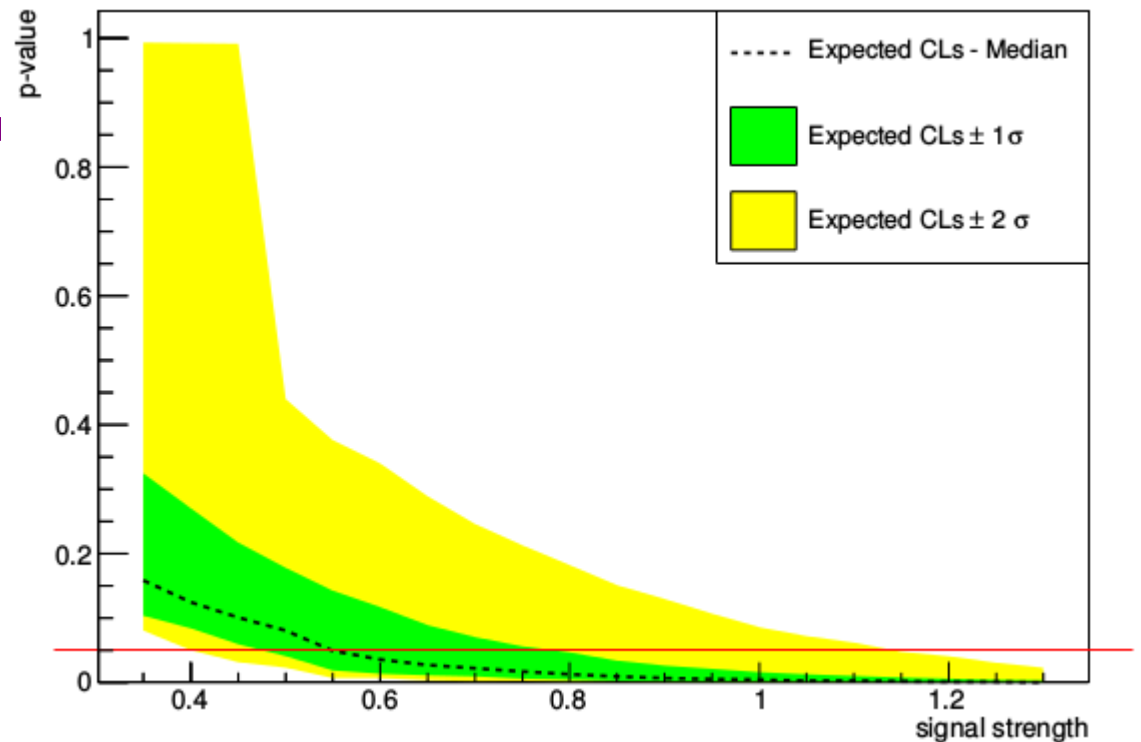
# TS 350GeV, toys

- 100K toys



# TS 400GeV, toys

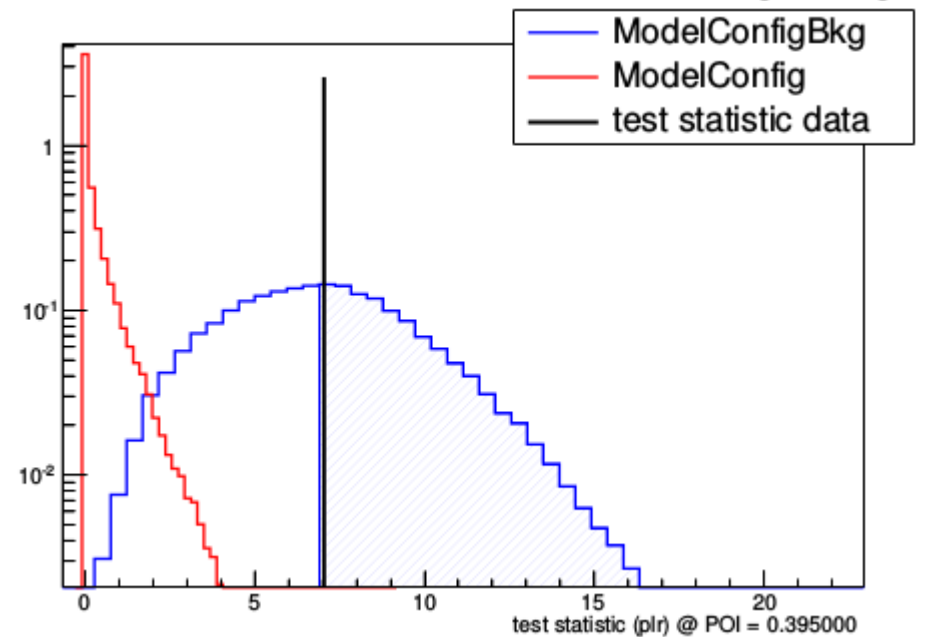
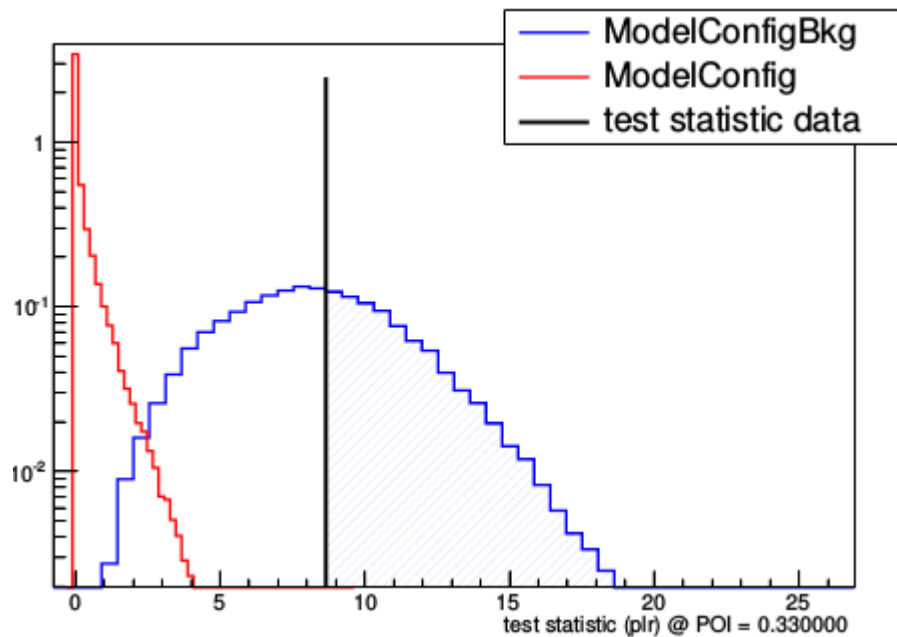
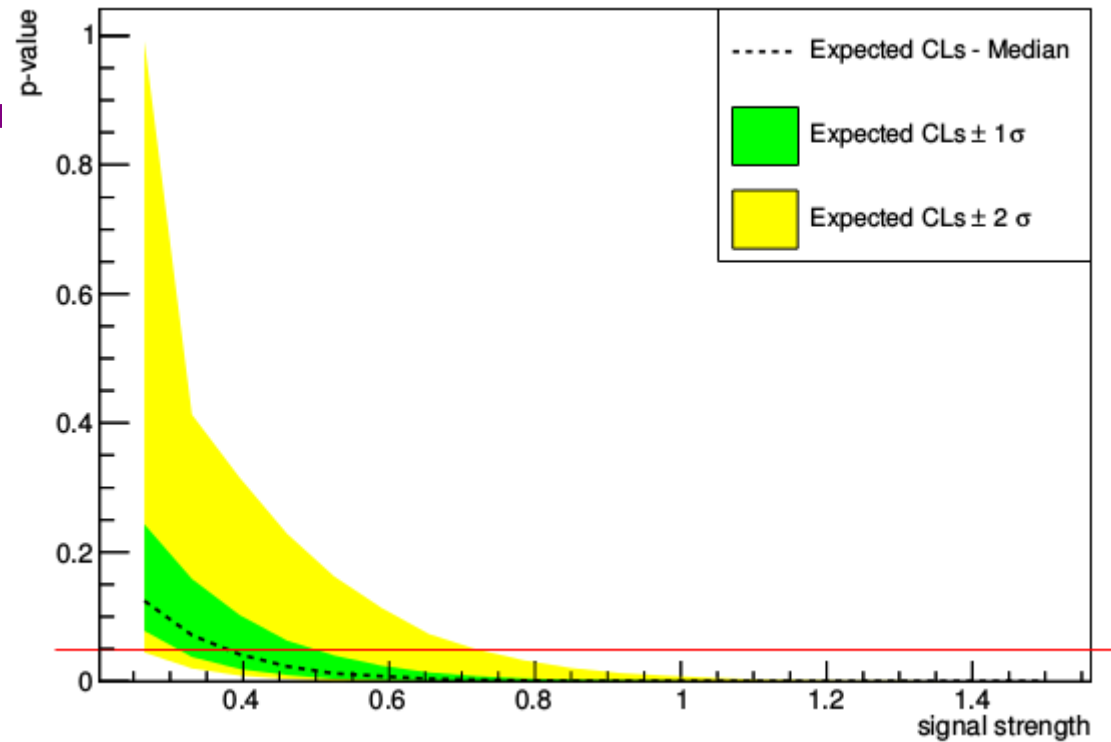
- 100K toys





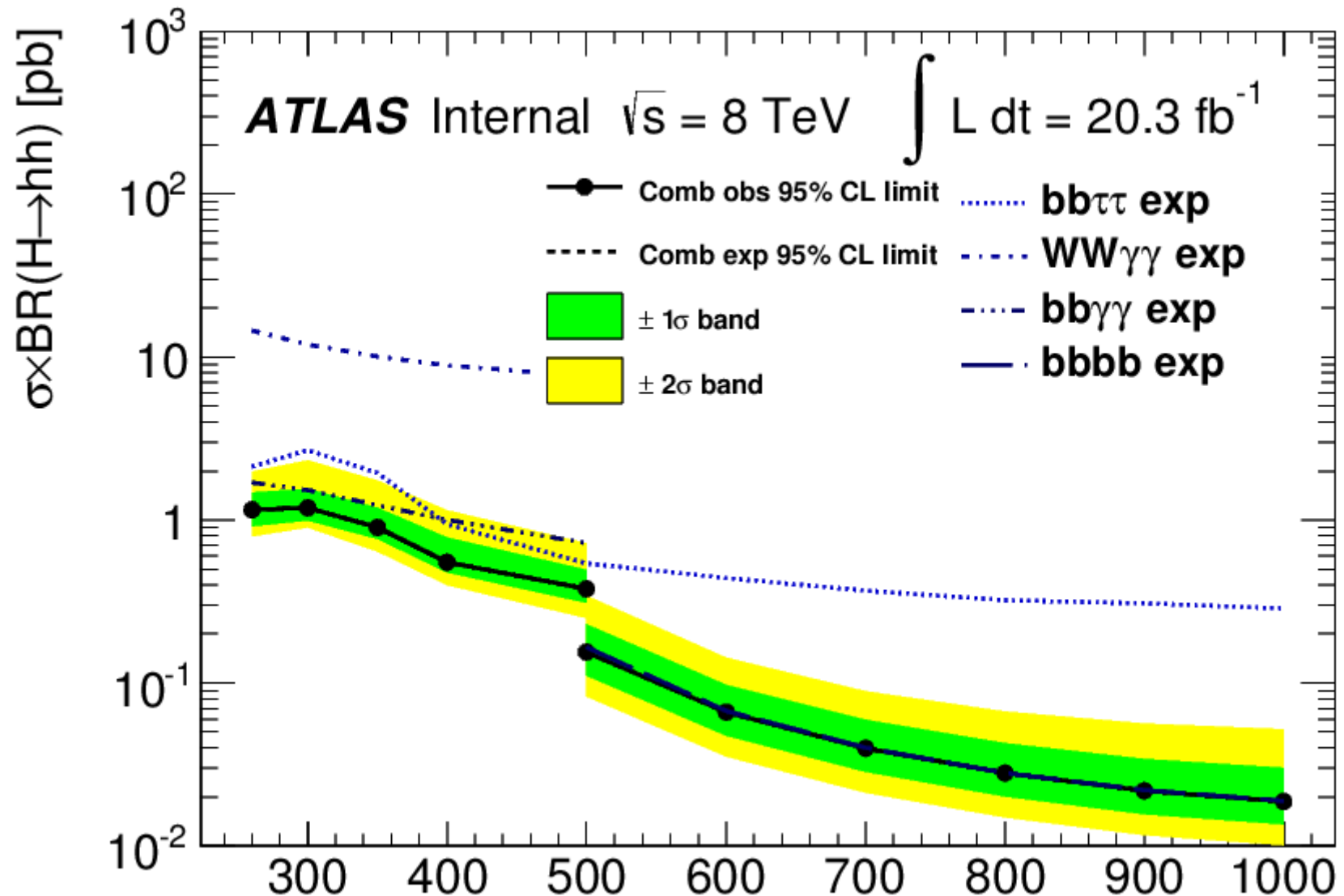
# TS 500GeV, toys

- 100K toys



# Expected limits [res]

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



# Expected limits

- [260,500] from toys

	Non-res	260 GeV	300 GeV	350 GeV	400 GeV	500 GeV
Median	0.451414	1.15206	1.19153	0.904661	0.549248	0.376823
Observed						
+2 $\sigma$	0.893215	1.98177	2.33414	1.751	1.14202	0.71873
+1 $\sigma$	0.646237	1.47962	1.56113	1.18374	0.781912	0.496316
-1 $\sigma$	0.337407	0.916101	0.9937	0.764271	0.475798	0.309803
-2 $\sigma$	0.246725	0.792097	0.90011	0.643104	0.40036	0.251077

- [500,1000] from asymptotics

	500 GeV	600 GeV	700 GeV	800 GeV	900 GeV	1000 GeV
Median	0.154233	0.06605	0.0397258	0.0279324	0.0218036	0.0187884
Observed						
+2 $\sigma$	0.342637	0.143287	0.0891335	0.0668152	0.0562005	0.0518261
+1 $\sigma$	0.228371	0.0970694	0.0592748	0.0425508	0.0341293	0.0300873
-1 $\sigma$	0.111133	0.0475927	0.0286247	0.0201269	0.0157107	0.0135381
-2 $\sigma$	0.0827806	0.0354507	0.0213219	0.0149921	0.0117026	0.0100842

# Summary

- Event display is done
- pull checks are OK now after bbtatau updates
  - no over-constrained JER any more for both nonres and res
- toys for nonres, res 260-500 are done
  - ts distributions are checked, no more problem on +2 sigma bands now
- INT note updated with all unblinded contents
  - limits, pvlues, the 4 event kinematics/displays
- **To-dos:**
  - expected bbtatau unblinded workspaces
  - bbtatau will probably also use toys (Li Qi's check)
  - prepare Nanjing talk, it (**15 mins**) will cover
    - BSM AZh (detailed) and hh analyses (brief, Huijun talk more)
    - SM Higgs?

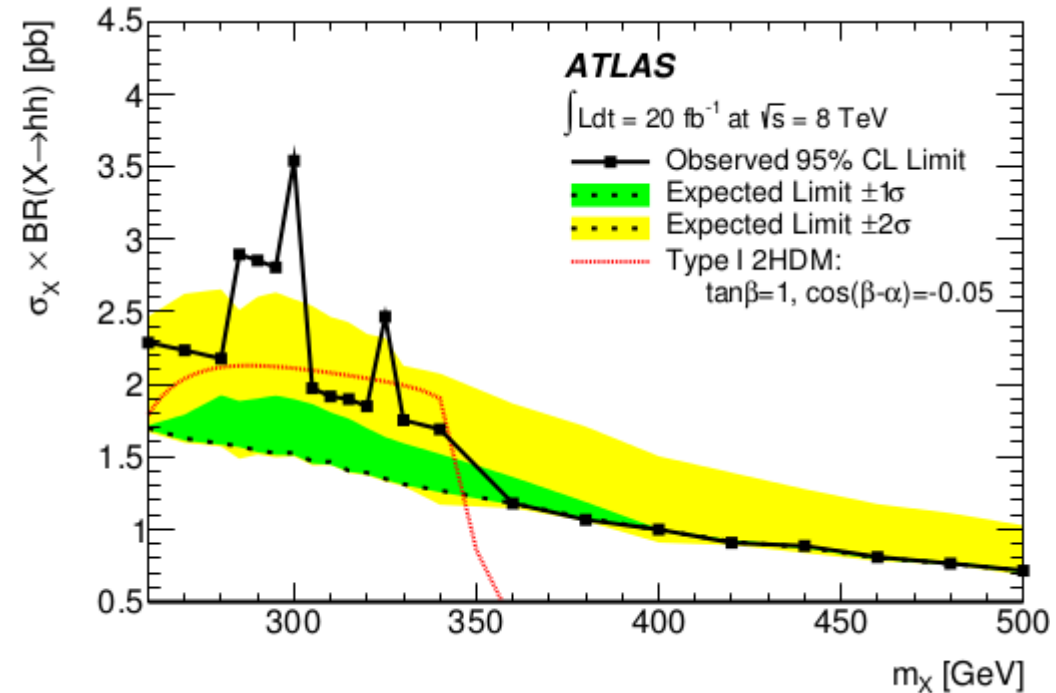
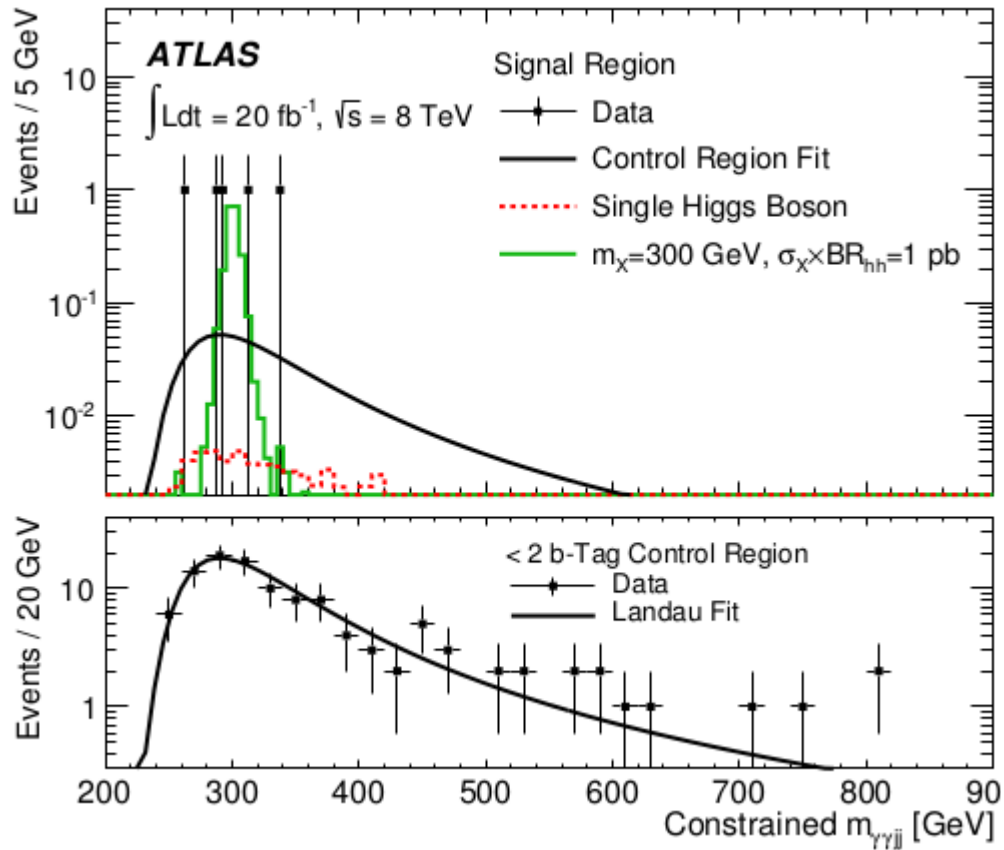
backup

# Limits before/after unblinding

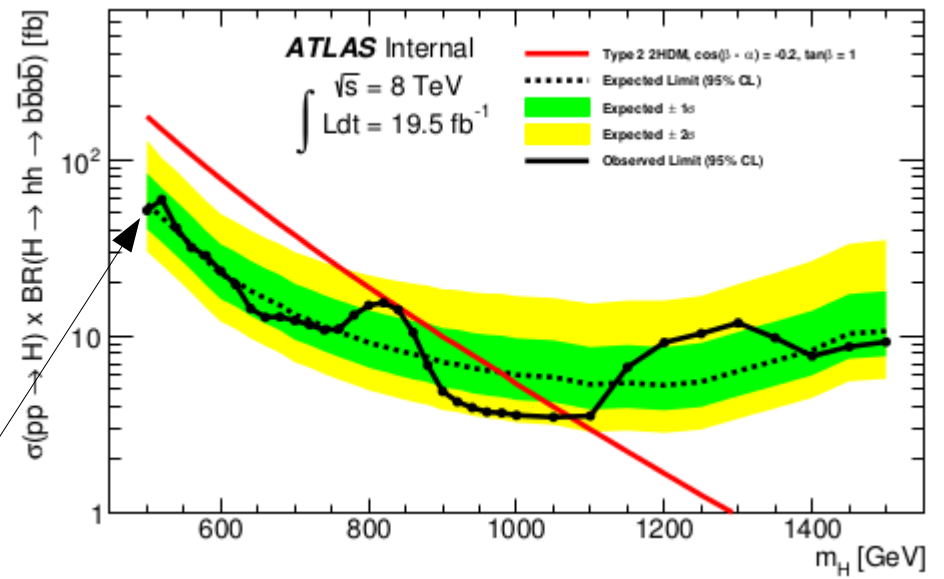
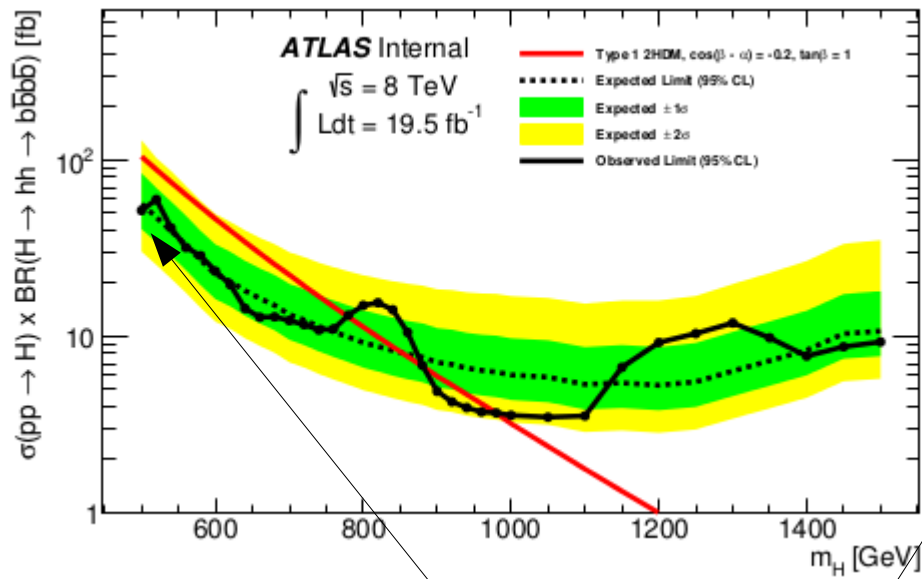
<b>before</b>	Non-res	260 GeV	300 GeV	350 GeV	400 GeV	500 GeV
Median	6.53016	10.8557	8.92967	7.50631	6.61605	5.6362
Observed						
+2 $\sigma$	13.0728	21.7998	17.8776	15.137	13.301	11.3682
+1 $\sigma$	9.23444	15.3726	12.6355	10.658	9.39486	8.09175
-1 $\sigma$	5.07175	8.33472	6.86803	5.81079	5.12704	4.39592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

<b>after</b>	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 $\sigma$	16.297	27.419	22.3968	18.9088	16.6705	14.1974
+1 $\sigma$	11.9078	19.7609	16.1852	13.631	12.0975	10.3829
-1 $\sigma$	7.10667	11.6522	9.42139	7.92885	7.15727	6.14156
-2 $\sigma$	6.70651	10.9031	8.95802	7.57311	6.80045	5.94627

# bbyy m(yy)



# bbbb

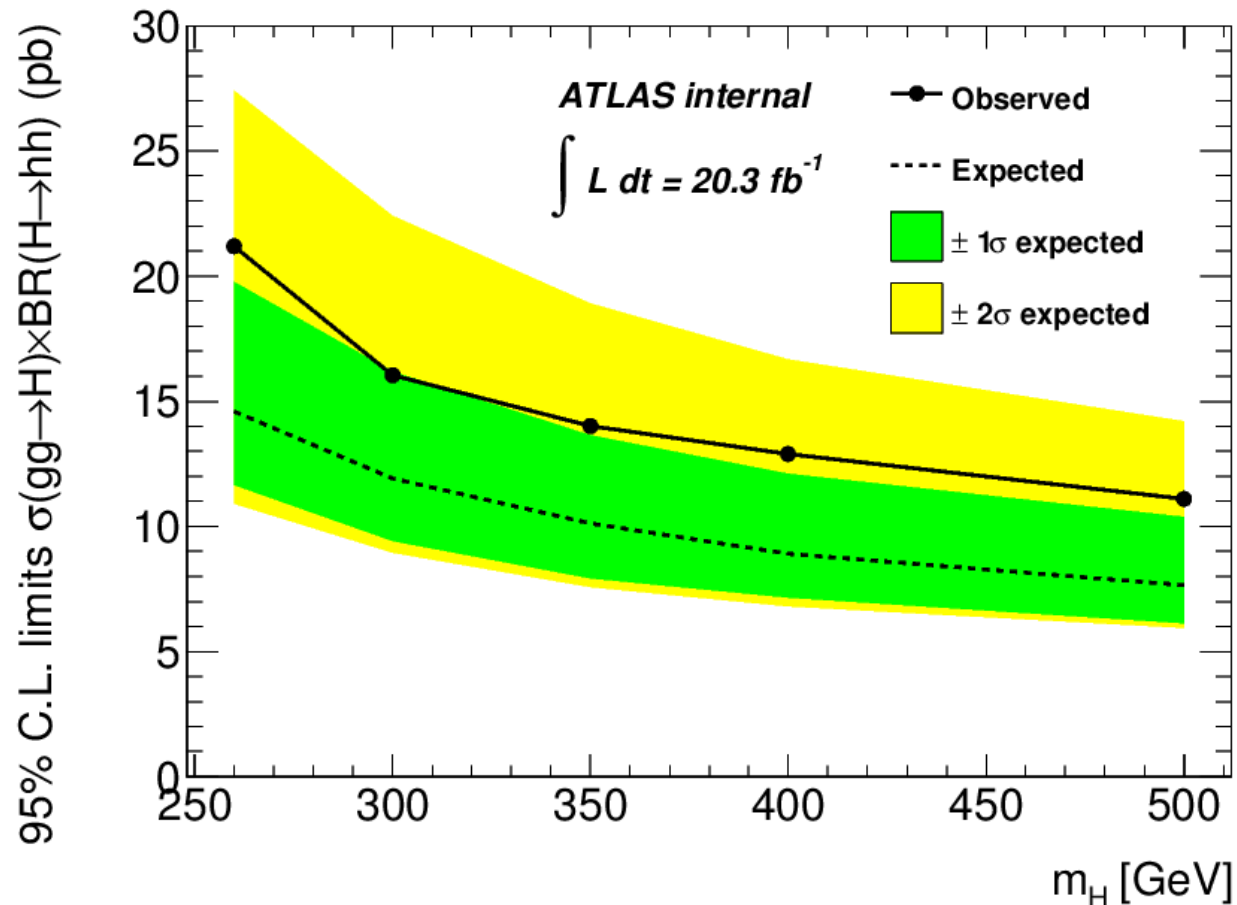


no sensitivity is seen @ 500 GeV



# Upper limits

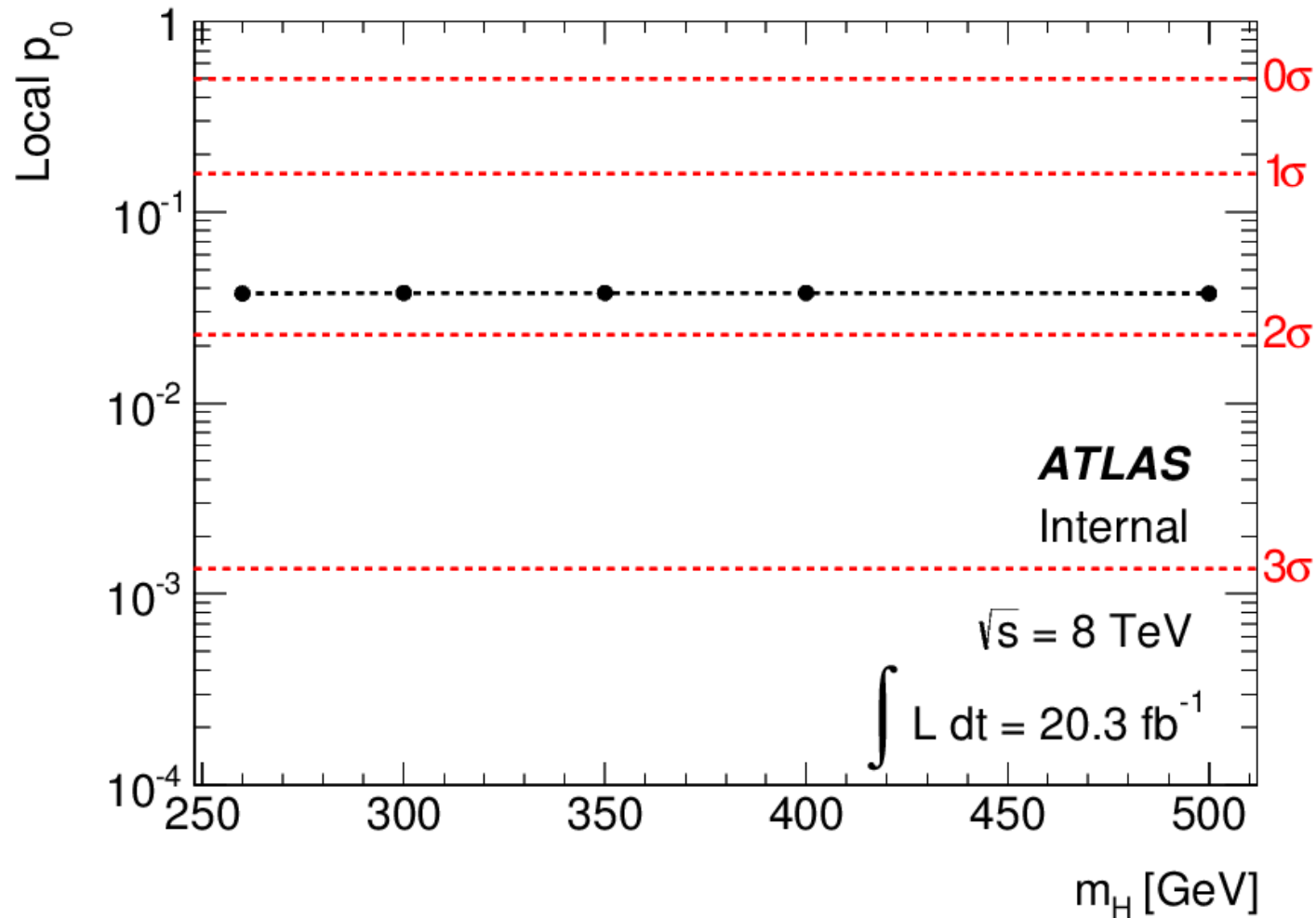
- get limits with **toys**
- expected limits are shifting a bit higher than before unblinding



the obs limits of **non-res** is 12.6259 pb  
expected median: 8.81794 pb  
--6.70651 -7.10667 +11.9078 ++16.297

# 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 <b>wwy</b> significance	OBS <b>bby</b> significance	OBS <b>wwy+bby</b> significance
260	1.7804	1.66482	2.43751
300	1.77825	2.96288	<b>3.45555</b>
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	<b>3.0461</b>

← additionally  
with bbbb  
-0.00311567  
but affect  
nothing