Search for heavy Higgs bosons *A/H* decaying to a top quark pair in *pp* collision at sqrt(s) = 8 TeV with the ATLAS detector

JC39 (11/10/2017)

Key Point I.

- Search for heavy pseudoscalar (*A*) / scalar (*H*) Higgs bosons, decaying into a ttbar

- Higgs doublet model is assumed here and searched.

  -- 2HDM was originally thought as a candidate to solve the CP violation. Simply, as the name telling us, it has two sets of doublet.

  -- it fits to many model such as, SUSY, little higgs, neutrino model, axion , , ,

  -- Besides, SM Higgs, general 2HDM has many parameters to be decided, thus, there are many models.

-- It depends on the model, but t(tbar) is naturally expected to couple strongly with those new Higgs

Key Point II.

- Data Set : 20.3 fb^{-1} of *pp* collision with √s = 8 TeV

- Channel (tag): ttbar-> (b+W->lepton) + (b+W->jets)

- data set/channel/event selections is identical as previous search

"A search for ttabr resonances using lepton-plus-jets events in proton-proton collisions at sqrt(s)=8 TeV with the ATLAS detector"

arXiv: 1505.07018 [hep-ex]

A search for heavy particles decaying to $t\bar{t}$ in the lepton-plus-jets decay channel was carried out with the ATLAS experiment at the LHC. The search uses data corresponding to an integrated luminosity of 20.3 fb^{-1} of proton–proton collisions at a centre-of-mass energy of 8 TeV. No excess of events beyond the Standard Model predictions is observed in the $t\bar{t}$ invariant mass spectra. Upper limits on the cross-section times branching ratio are set for four different signal models: a narrow (≤ 3% width) Z' boson, a broad (15.3% width) Randall–Sundrum Kaluza–Klein gluon, a Bulk Randall–Sundrum Kaluza–Klein graviton, and a narrow scalar resonance. Based on these results, the existence of a narrow leptophobic topcolour Z' in the range 0.4 TeV $< m_{Z'} <$ 1.8 TeV is excluded at 95% CL. A broad Kaluza–Klein gluon with mass between 0.4 TeV and 2.2 TeV is also excluded at 95% CL. These results probe new physics at higher mass than previous ATLAS searches for the same signature, and the results are applicable to a broader variety of heavy resonances.

Invariant mass distribution (from Simulation)

According to the paper, "S+I" is generated by modifying the simulator (MadGraph5_aMC@NLO)

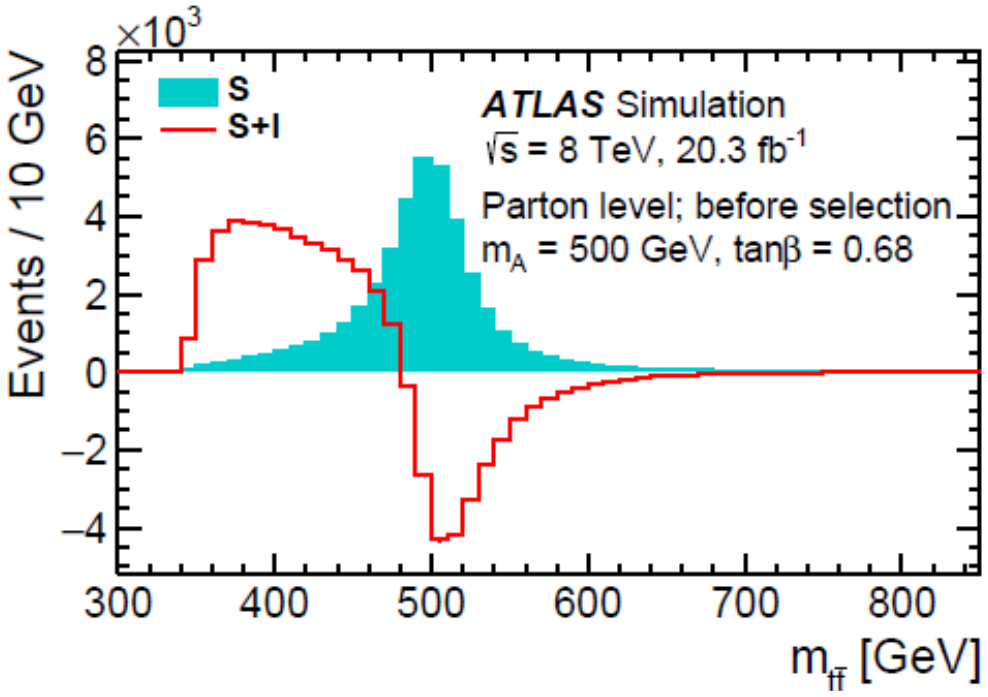


Figure 1: Distributions of the invariant mass of the $t\bar{t}$ pair from the decay of a pseudoscalar A of mass m_A = 500 GeV ($m_A \ll m_H$) at parton level before the emission of final-state radiation and before the parton shower for the pure resonance S (filled) and signal+interference contribution $S + I$ (unfilled). Events from all $t\bar{t}$ decay modes are included and no selection requirements are imposed. The distributions are normalized to an integrated luminosity of 20.3 fb^{-1}.

the modified software can have positive or negative weights. ?

Systematic uncertainties

Table 1: Average impact of the dominant uncertainties on the estimated yields

Systematic uncertainties [%]	Total bkg	S	$S + I$
Luminosity [55]	1.7	1.9	1.9
PDF	2.5	2.1	12
$t\bar{t}$ initial-/final-state radiation	3.2	–	–
$t\bar{t}$ parton shower + fragmentation	4.9	–	–
$t\bar{t}$ normalization	5.7	–	–
$t\bar{t}$ event generator	0.5	–	–
Top quark mass	0.5	2.2	13
Jet energy scale	6.4	4.9	9.3
Jet energy resolution	1.3	1.6	1.7
b-tagging: b-jet efficiency	1.5	1.3	1.1
b-tagging: c-jet efficiency	0.2	0.2	0.8
Electron efficiency	0.3	0.4	0.7
Muon efficiency	0.9	1.0	1.0
Signal MC scales	–	7.3	7.3
Reweighting	–	–	5.0
MC statistical uncertainty	0.5	2.4	11
Total uncertainty	11	10	25

dominant for the yield and shape

Background comparison

Standard Model ttbar is major component (off course) and the data seems to be roughly consistent with those expected background events.

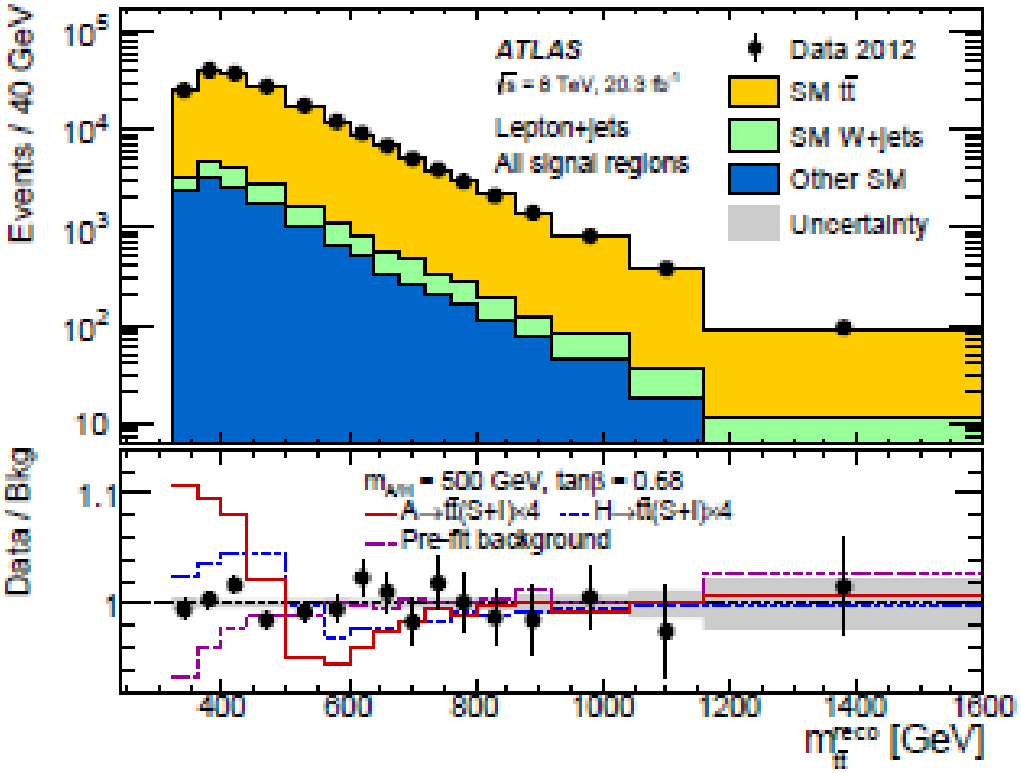
Type	e+jets	μ+jets
$t\bar{t}$	95 000 ± 11 000	93 000 ± 11 000
W+jets	6600 ± 2100	7200 ± 2300
Other bkg.	11 200 ± 1400	6100 ± 600
Total	112 800 ± 13 000	106 300 ± 12 000
Data	115 785	110 218

Expected number of background events

I was wondering if this systematic is small . . .

Table 2: Number of events observed in data and expected number of background events after the event selection, before the profile-likelihood fit to the full dataset. The uncertainty in the expected background yields is derived by summing all systematic and statistical uncertainties in quadrature. The "other bkg" component comprises single top quark, $t\bar{t}$ + W/Z, Z+jets, diboson and multijet production. Details of the estimation of these backgrounds are given in Ref. [17].

ttbar Invariant mass distribution



-- Bottom figure shows the ratio between data & background

-- the histograms of A/H are expected distribution with the assumption of their mass (500GeV) and tanβ=0.68

-- By changing these variables, they can set the limit on the parameter space

95% C.L. for the type-II 2HDM model parameters

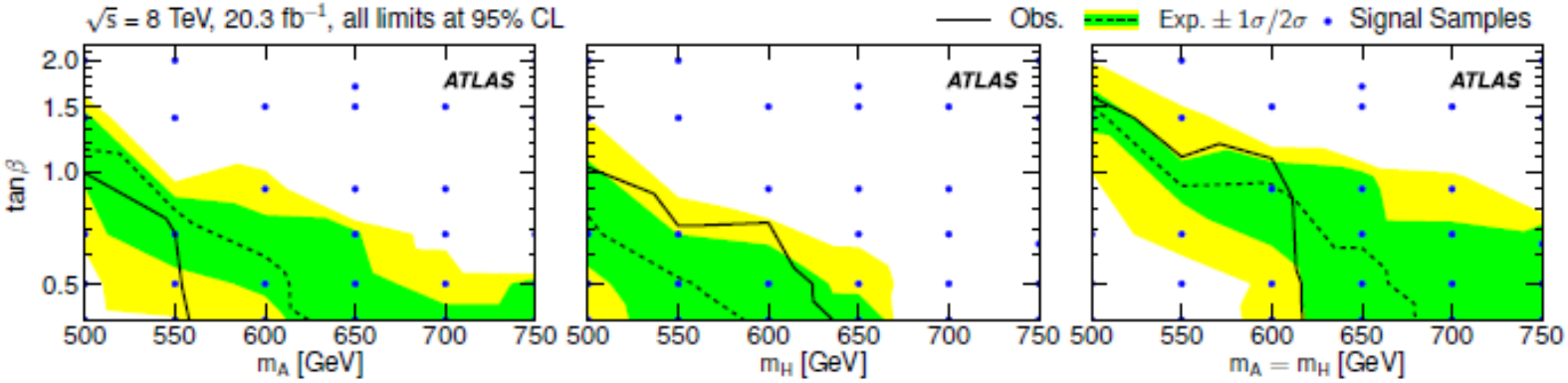


Table 3: The 95% CL observed and expected exclusion limits on $\tan\beta$ for a type-II 2HDM in the alignment limit considering only a pseudoscalar A (left), only a scalar H (middle), and the mass-degenerate scenario $m_A = m_H$ (right). A bar (–) indicates that no value of $\tan\beta \geq 0.4$ is excluded.

Mass		m_A		m_H		$m_A = m_H$	
[GeV]	$\tan\beta$:	obs.	exp.	obs.	exp.	obs.	exp.
500		< 1.00	< 1.16	< 1.00	< 0.77	< 1.55	< 1.50
550		< 0.69	< 0.79	< 0.72	< 0.52	< 1.10	< 0.92
600		–	< 0.59	< 0.73	–	< 1.09	< 0.93
650		–	–	–	–	–	< 0.62

Summary

・Search for massive pseudoscalar & scalar resonance decaying to ttbar was done with 20.3fb^{-1} pf *pp* collision at 8 TeV

・The results shows no significant deviations from SM prediction, and limits of 95% C.L. for were obtained.

・This is the first search in the final state to take into account the significant interference between the signal process and the b.g. from SM ttbar. It tightens significantly the previously published constraints on the 2HDM parameter space