Collaboration on $t\bar{t}H \longrightarrow t\bar{t}WW$

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Outline

1. Introduction
2. Recent studies
3. Conlution

Physics

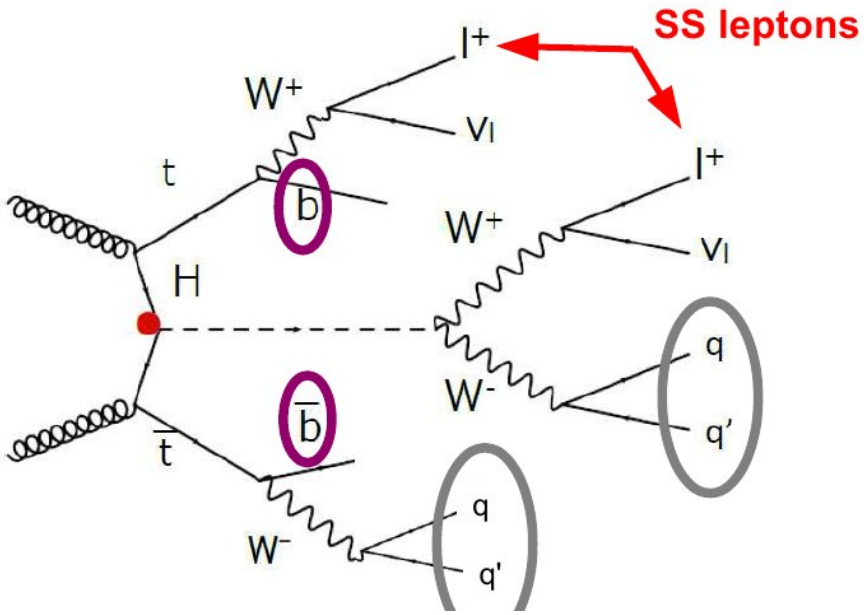
Interesting physics lies in the process :

$t\bar{t}H \rightarrow t\bar{t}WW \rightarrow 2(3,4)leps + b\bar{b} + 4(2,0)jets$

$\mathcal{L}_{t\bar{t}H} = Y_t\bar{t}[\not{H} + \frac{\epsilon}{Y_t}]tH$

1. A direct and 1'st measurement of the Yukawa coupling Y_t
   Which is not predicted by theory in SM
2. A search for a (possible) heavier Higgs
   (Relatively) enhanced in 14TeV for its gluon origin.
3. An explosure on possible CP violation ϵ in Higgs and top.
   Need high luminosity.

Experiments



1. Two SameSign or three leptons
   suppress QCD, W, Z, WW, and top backgrounds
2. One or two jet tagged as b quark
   suppress WZ, ZZ and any events without b quark
3. Two or more light jets
   suppress $t\bar{t}$ backgrounds
4. Only $t\bar{t}W$ and $t\bar{t}Z$ contaminate
   also possible to veto these two characterized backgrounds

Status

We had a Monte Carlo study before ATLAS/LHC data

Table 8: Cut flow and expected cross sections [fb] for the $t\bar{t}H$ (2L) analysis.

Sample	Total	Basic sel.	Calo iso.	Track iso.	Cone iso.	Like-sign	Z-veto	p_T^{μ}
$t\bar{t}H$ (2L, 120 GeV)	3.9	1.05±0.01	0.80±0.01	0.65±0.01	0.52±0.01	0.52±0.01	0.51±0.01	0.45±0.01
$t\bar{t}H$ (2L, 160 GeV)	11.1	4.01±0.05	3.02±0.04	2.57±0.04	2.09±0.03	2.09±0.03	2.04±0.03	1.87±0.03
$t\bar{t}H$ (2L, 200 GeV)	4.7	1.83±0.02	1.43±0.02	1.24±0.02	1.05±0.02	1.04±0.02	1.02±0.01	0.95±0.01
$t\bar{t}H$ (3L, 160 GeV)	7.2	1.83±0.03	1.57±0.02	1.40±0.02	0.88±0.02	0.28±0.01	0.26±0.01	0.24±0.01
$t\bar{t}$	833000.0	6170±80	1970±50	870±30	500±20	16±1	16±1	7.4±1.1
$t\bar{t}b\bar{b}$ (EW)	259.0	15.8±0.8	4.1±0.4	0.9±0.2	0.3±0.1	0.2±0.1	0.2±0.1	0.11±0.07
$t\bar{t}b\bar{b}$	2693.0	213±4	38±2	7.6±0.7	2.2±0.4	1.0±0.3	1.0±0.3	0.6±0.2
$gg \to t\bar{t}t\bar{t}$	2.64	0.65±0.01	0.33±0.01	0.26±0.00	0.20±0.00	0.07±0.00	0.07±0.00	0.06±0.00
$qq \to t\bar{t}t\bar{t}$	0.58	0.13±0.00	0.07±0.00	0.05±0.00	0.04±0.00	0.01±0.00	0.01±0.00	0.01±0.00
$t\bar{t}W$+0j	73.3	1.40±0.05	0.55±0.03	0.36±0.02	0.23±0.02	0.12±0.01	0.12±0.01	0.11±0.01
$t\bar{t}W$+1j	60.6	2.51±0.06	1.11±0.04	0.79±0.03	0.58±0.03	0.28±0.02	0.28±0.02	0.25±0.02
$t\bar{t}W$+2j	92.3	10.3±0.2	5.9±0.1	4.9±0.1	3.9±0.1	1.89±0.07	1.85±0.07	1.68±0.06
$t\bar{t}Z$	1440.0	33.6±0.4	26.8±0.4	23.7±0.4	17.9±0.3	2.1±0.1	1.6±0.1	1.49±0.09
Total background								11.0±1.1

CERN-OPEN-2008-020, p1364

1. Normalized to 30/fb data at 14TeV
   Please refer to the signal yield at 120GeV of Higgs mass
2. $t\bar{t}$ and $t\bar{t}W$ dominate the backgrounds
   Also similar table for 3L channels
3. Please do not take too serious on the final number
   ATLAS performance was found to be better than MC study.
4. Good example of FCPPL collabration
   J.B, M.Monnier
   H. Zhang, L.Shan, F.Lv, S.Jin

Status

There is also analysis undergoing in ATLAS on 8TeV data.

1. Both 2L and 3L final states are studied.
2. Backgrounds estimated mainly with MC
   But data driven approach is also undergoing especially for 2LSS.
3. Active participants.
   LPC Clermont
   Univ. Bogogna and Univ. Roma I
   Univ. Texas at Austin and Univ. pensylvania
   Many others

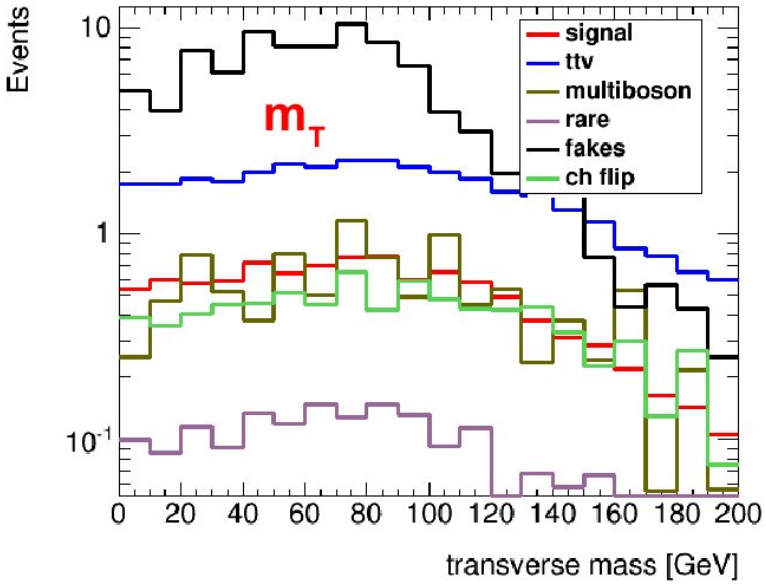
Very good progresses with promissing results ...
CMS published an upper limit, 9.1(6.7) in 2L(3L) channel on the Xsection over SM.

Recent studies

1. Aimed at Run2, 14TeV data from ATLAS
   tentatively about 20/fb as a test.
2. Understand the main backgrounds from 8TeV data
   also the main sources of systematics.
   A few examples in the following slides.
3. Optimize the analysis
   developing and training related tools/packages.

2L channel preliminary

With quite similar cuts flow in HGS8 we repeated (Julien & Otilia from CPPM):



ATLAS (we), SS exclusive

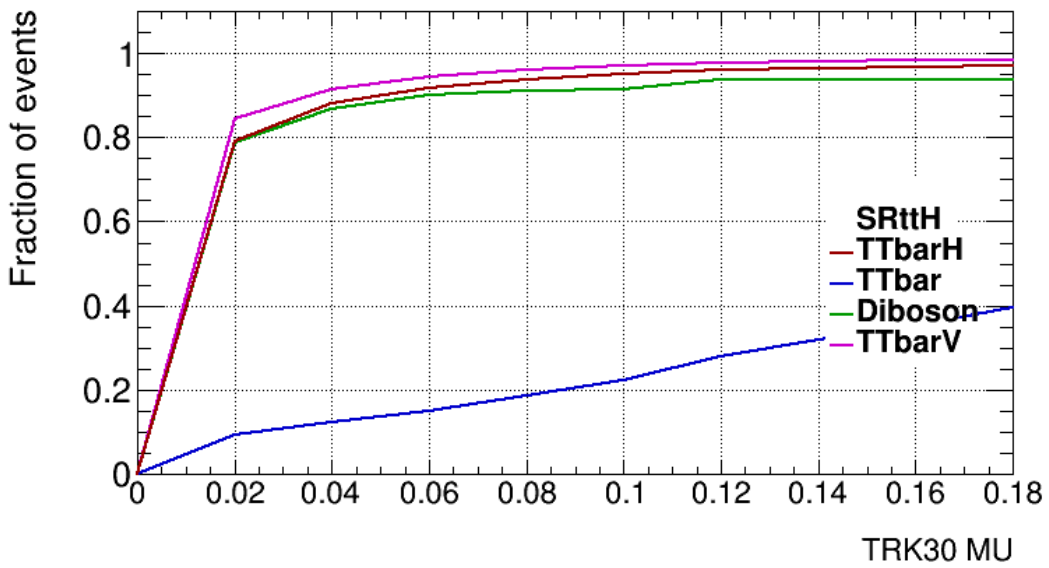
SR	Npp	Npp ee	Npp eμ	Npp $\mu\mu$
ttH	3.38	0.65	1.68	1.03
prompt SS	14.79	3.43	7.03	4.33
fake leptons	7.80	2.73	3.45	1.61
charge flip	2.24	1.06	1.18	-
total bkg	24.83	7.22	11.66	5.94
real signif	4.80	0.21	0.41	0.39

σ = 0.60

It seems we are on a correct road ...

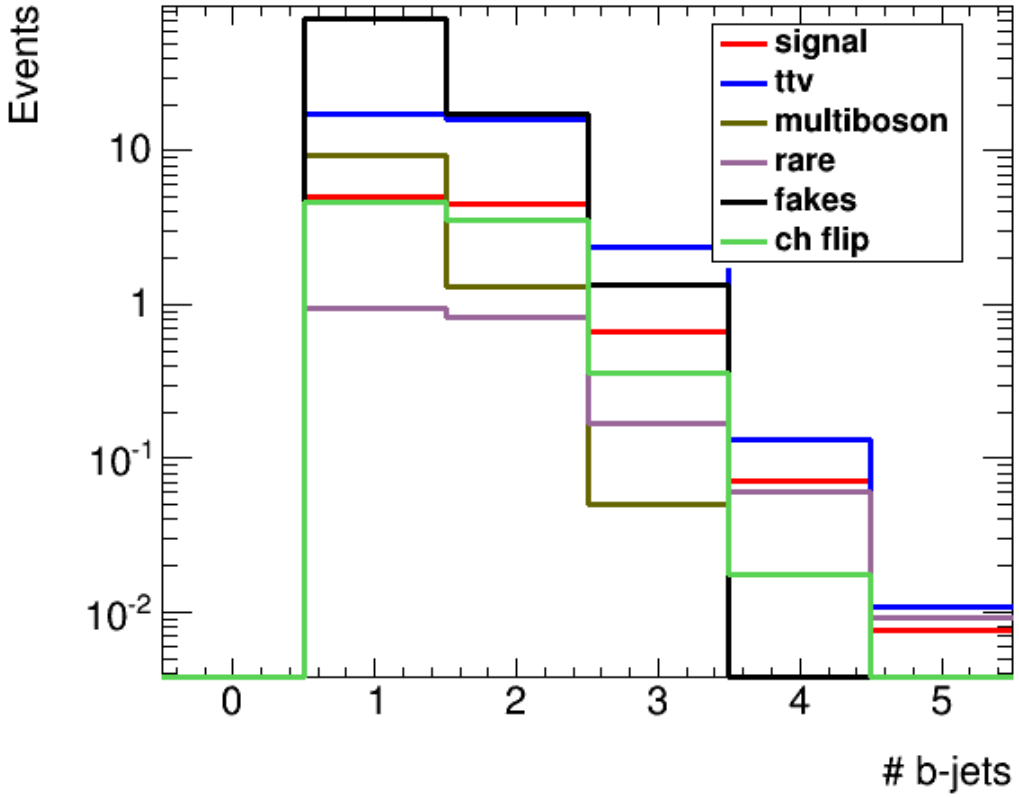
2L channel optimizations

An optimization on the track isolation for muon is investigated.



Tighten cut 0.1 (from 0.12) seem to reduce fakes (J&O).

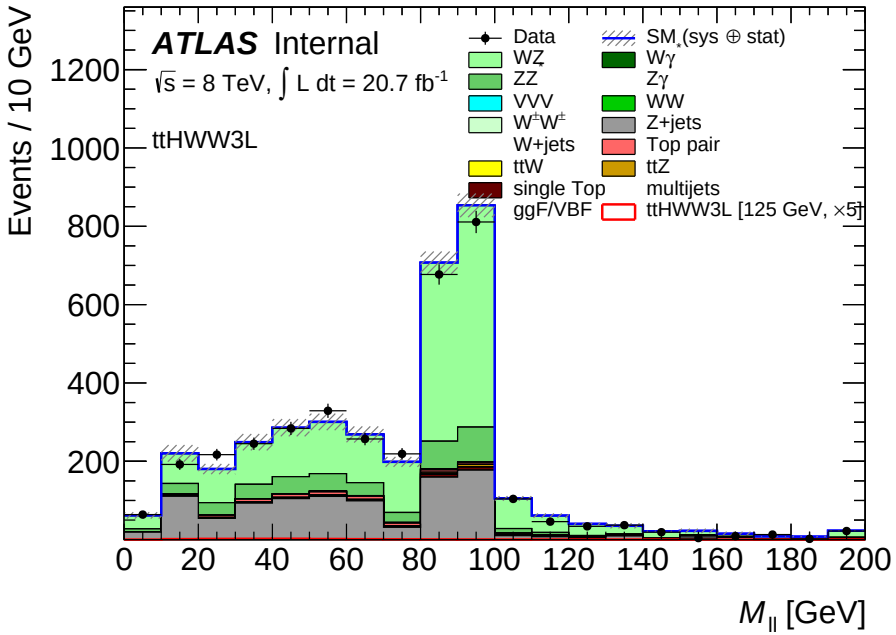
2L channel optimizations

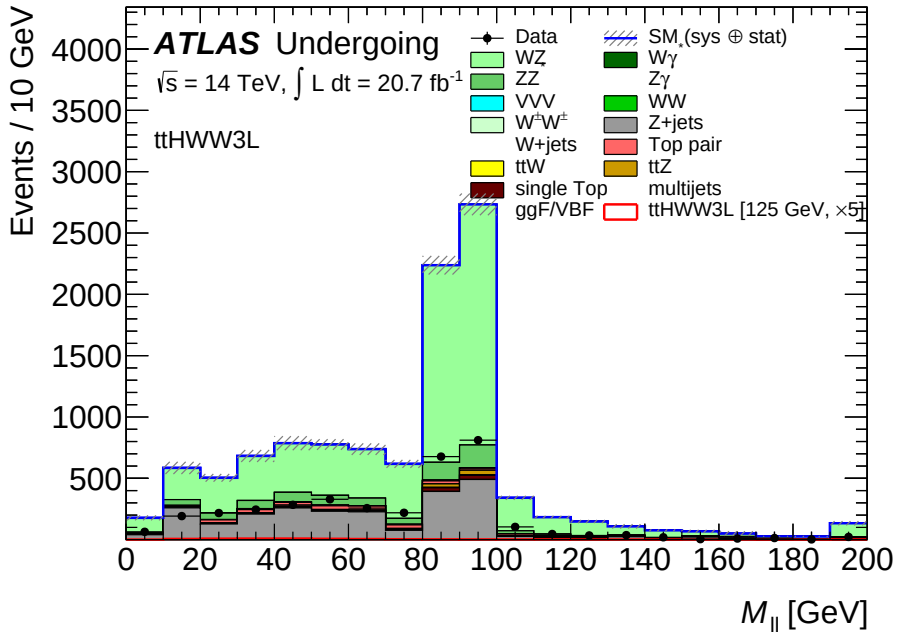


It may help to depart the signal region exclusively to $1b$, $\geq 2b$, optimization is in progress.

Recent studies : 3L channel preliminary

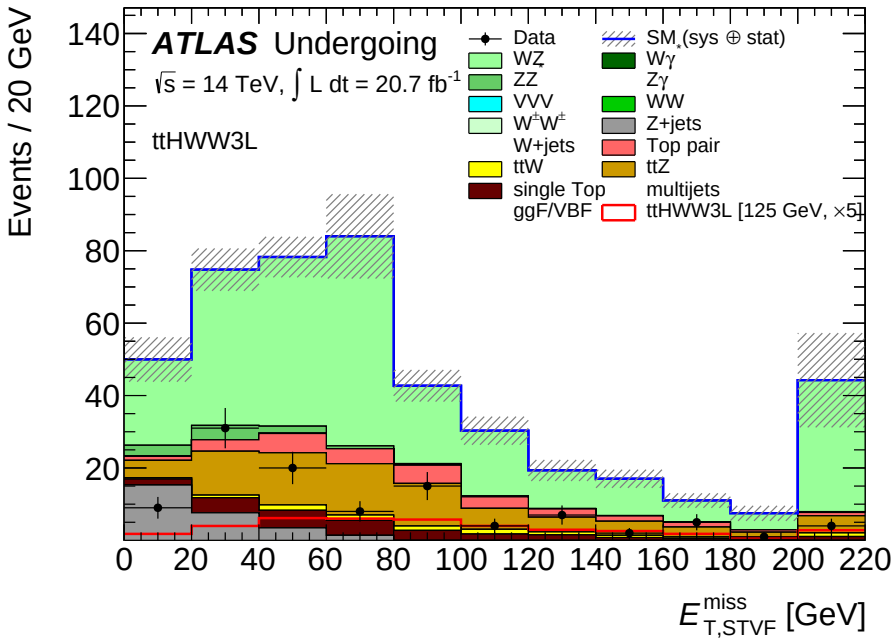
A quick feasibility via PDF reweighting(All MC).

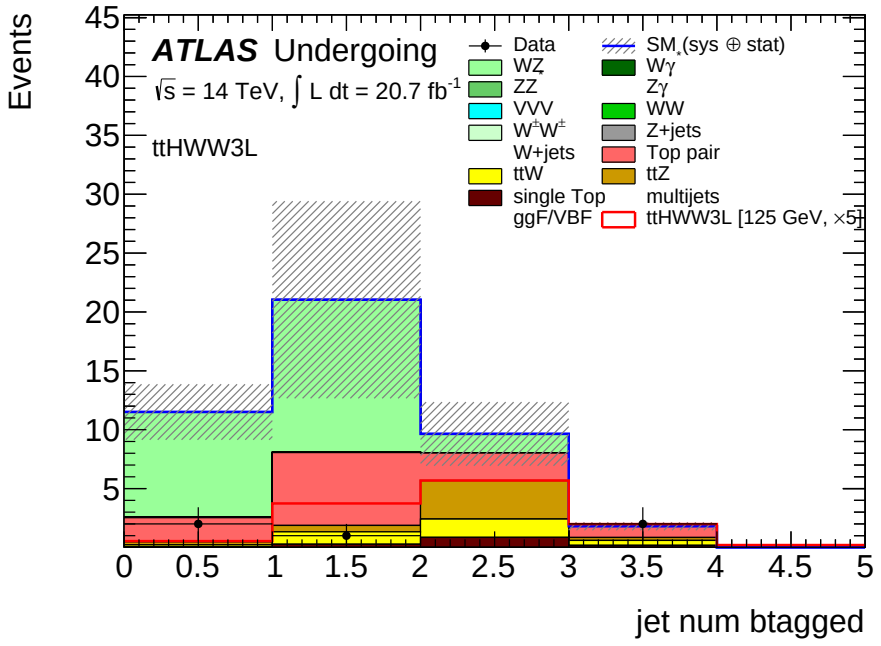




As the 1'st step WZ is reconstructed after 3L preselection.
Our codes/tools seem working well as validated on 8TeV (left).
Please ignore the *data* in the right plot and hereafter.

3L channel preliminary





After ≥ 4 jets the $t\bar{t}X$ family show up (left),
Z-veto and MET cuts basically reveal signal(right).

3L channel base

Backgrounds control in progress.

1. Normalize $t\bar{t}W$ and $t\bar{t}Z$ from data
   Challenge for thier small Xsection
2. Estimate the reducible backgrounds with data driven method.
   FakeFactors estimation against $t\bar{t}$ (and $Z + jets$)
   There need works to extend MatrixMethoe to 3L final states.

1. A good channel worth to explore in a collaboration
2. Let's work hard and efficient for it.
3. Suggestions are always welcome.

Many thanks !