A search for resonant and non-resonant di-Higgs production in bbtautau channel with the ATLAS detector

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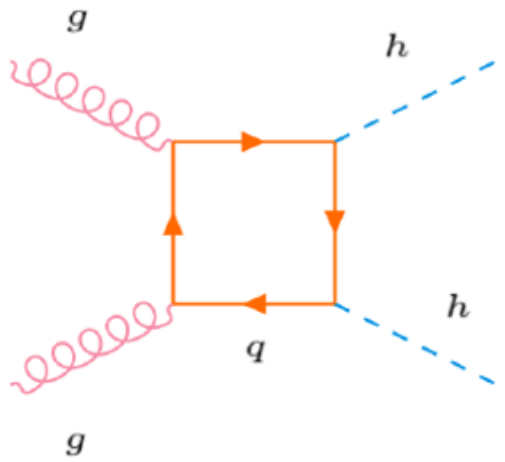
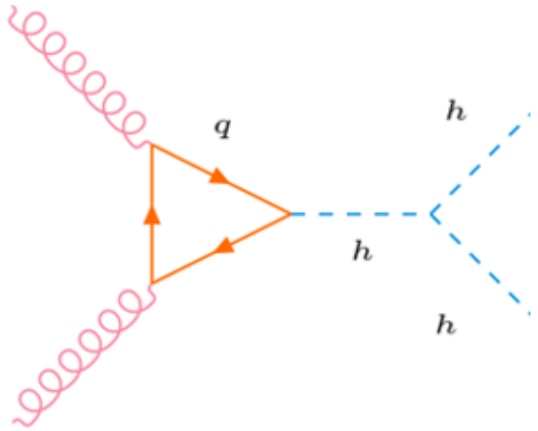
di-Higgs Overview

- Two ways of non-resonant di-Higgs production.
- The Higgs mechanism (HM) is governed by the Higgs potential.
- A direct probe to HM: Higgs trilinear coupling constant λ_{HHH}.
- Only the triangle diagram is sensitive to the λ_{HHH}!

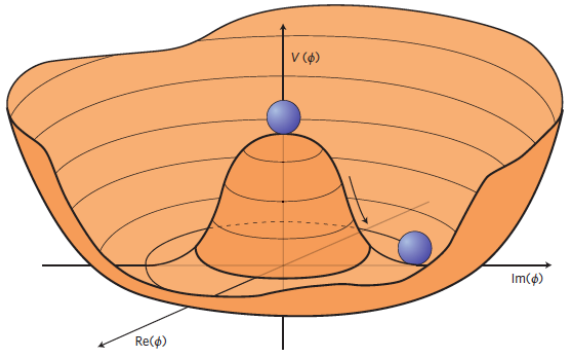
Box diagram:



Triangle diagram:



Higgs potential:

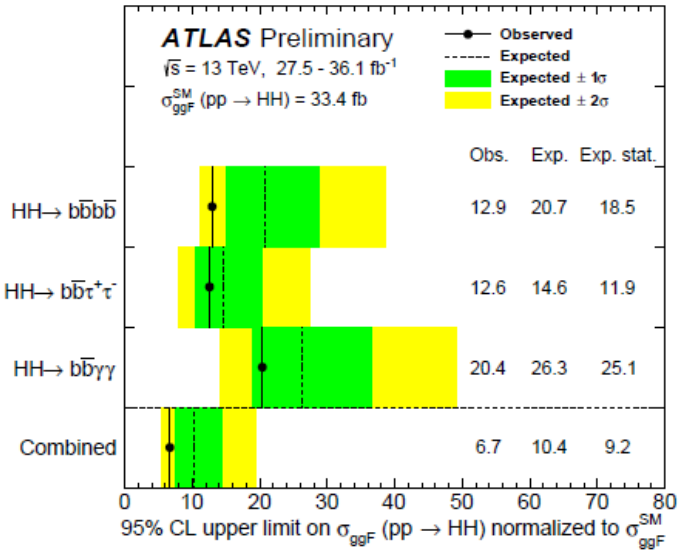


$$V(x) = \frac{\lambda}{2}\nu^3 H(x) + \lambda\nu^2 H(x)^2 + \nu H(x)^3 + \frac{\lambda}{4}H(x)^4 = m_H^2\frac{H(x)^2}{2} + \lambda_{HHH}\frac{H(x)^3}{3!} + \lambda_{HHHH}\frac{H(x)^4}{4!}$$

bbtautau overview

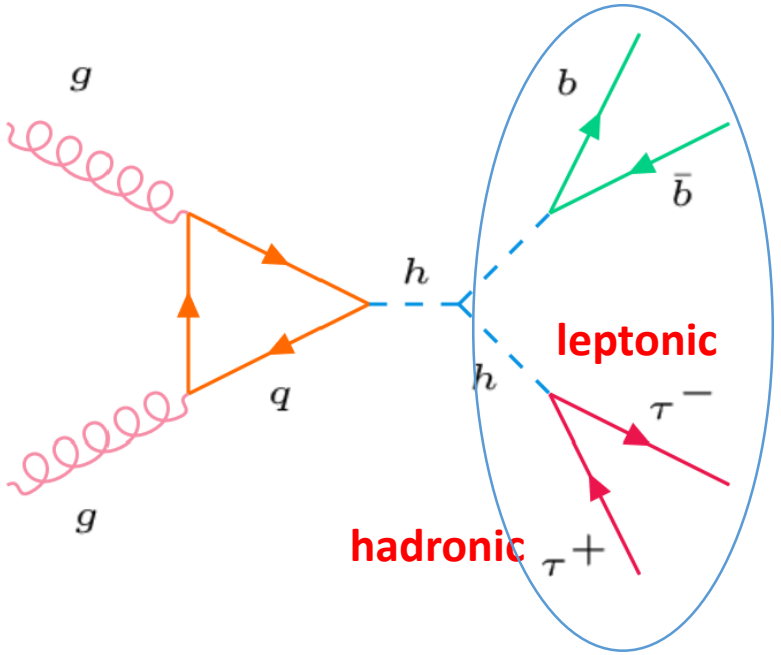
$bb\tau\tau$ features:

- Relatively small background.
- Relatively high branching ratio.



Branching ratio:

	bb	WW	ττ	ZZ	γγ
bb	33%				
WW	25%	4.6%			
ττ	7.4%	2.5%	0.39%		
ZZ	3.1%	1.2%	0.34%	0.076%	
γγ	0.26%	0.10%	0.029%	0.013%	0.0053%



$bb\tau\tau$ is currently the most sensitive decay channel!

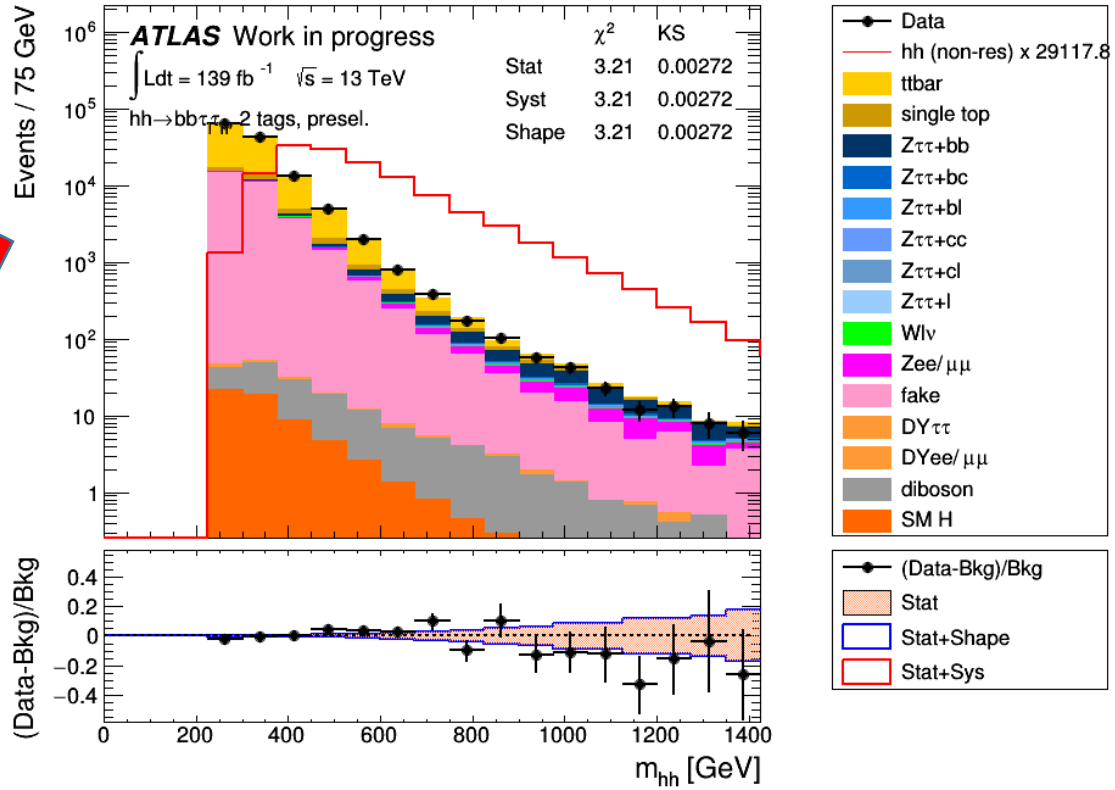
This study will focus on **LepHad** channel

$\tau^+\tau^-$ decay	Branching ratio
$b\bar{b}\tau_{had}\tau_{had}$	41%
$b\bar{b}e\tau_{had}$	23%
$b\bar{b}\mu\tau_{had}$	23%
$b\bar{b}\tau_{lep}\tau_{lep}$	12%

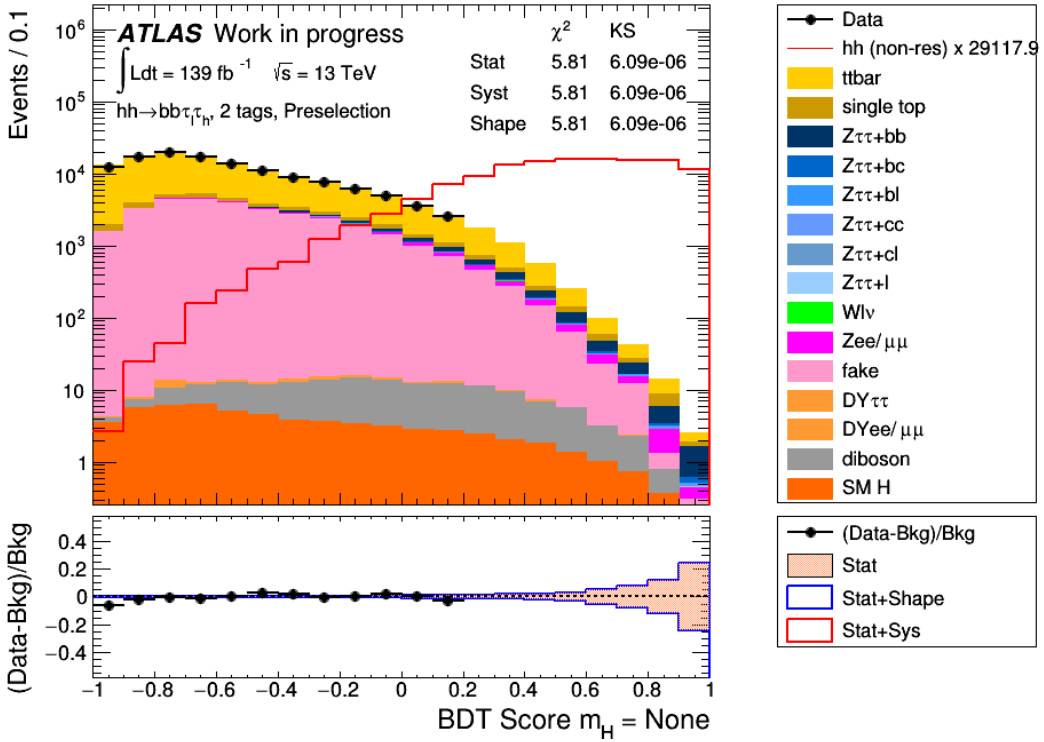
Event selection

- Events with the required final state, passing the single lepton trigger (SLT) are selected.
- Boosted decision tree (BDT) is used to further separate the signal and background.
- Inputs of BDT uses various kinematic variables.

BDT Input:



BDT Score:



- The BDT output (BDT score) is used as the discriminant.

Results

Results:

- Without further improvement to the previous analysis except higher luminosity.

- Upper limits are set on non-resonant di-Higgs production at 95% CL are calculated for full run2 data.

Non-res	Observed	-2σ	-1σ	Expected	+1σ	+2σ
Full Run2 Result						
Xs[pb]	Blinded	0.012	0.016	0.022	0.031	0.041
Xs/Xs(SM)[pb]	Blinded	4.89	6.57	9.11	12.68	17.00

- Previous analysis: 21.46

Improvement:

- Implementation of the new b-jet tagger.

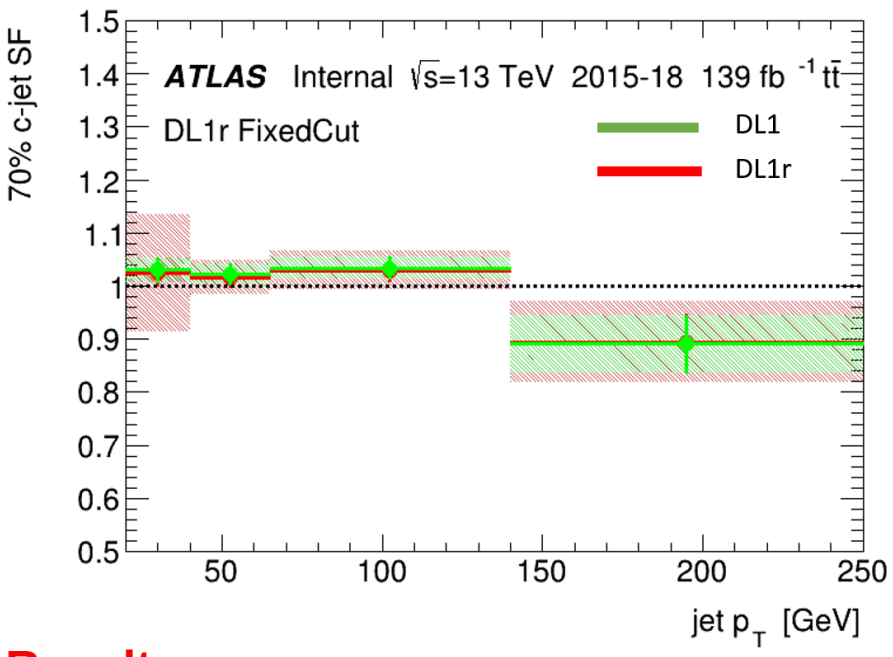
- Average gain of ~9% in limits!

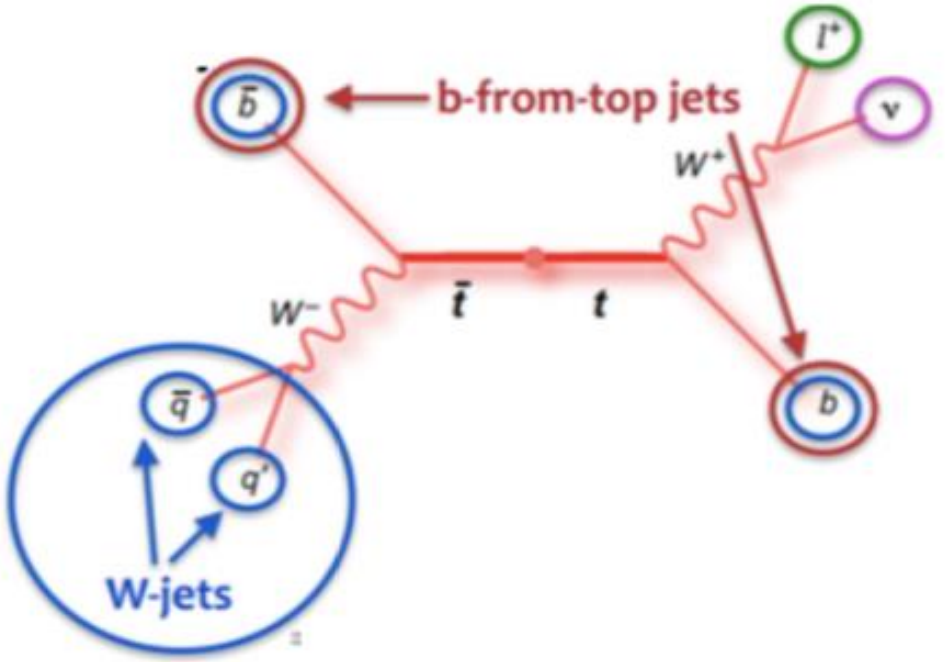
- Work going on the analysis with new recommendation.

Plans:

- A paper in summer with resonant result, another one in late 2020 with non-resonant result.

Additional remarks





Results:

- Carried out the latest Charm jet calibration with Andy and Nikos.

Improvement:

- Developing a new selection which can increase ~60% of statistics.

Qualification task:

- C-jet calibration: measuring the rate of c-jets mis-identified as b-jets with semi-leptonic $t\bar{t}$ decay.

Plans:

- Provide official light-jet mis-tag calibration for all ATLAS analysers for spring conferences and qualify as an ATLAS author by spring.