Study of di-Higgs production through ZZbb detection with the ATLAS experiment

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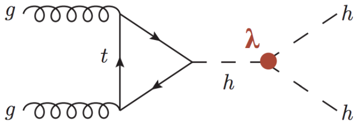
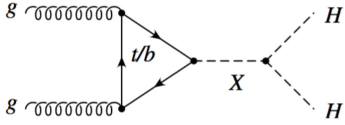
Motivation

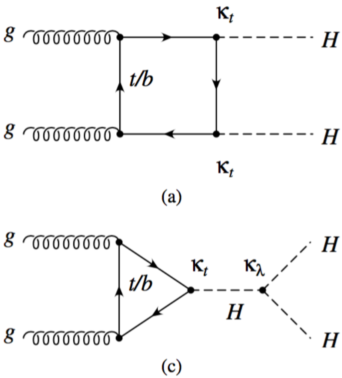
1. Search for Higgs self-coupling predicted by SM
2. Search for new particles through di-Higgs production





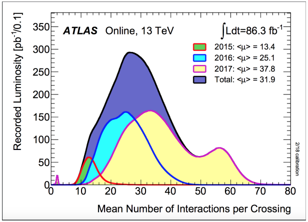
Di-Higgs Production diagrams at the LHC

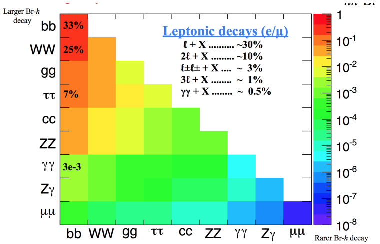
SM total cross section (up to NLO): 33 fb



Advantage and Challenge of ZZ Production Channel Search

- Comparatively low background (4l + $b\bar{b}$)
- Less dependence on high pile-up
- Statistical error dominates due to low signal
- Benefits a lot with higher integrated luminosity in the future (current aim: 3000 fb^{-1}, potential increase to 4000 fb^{-1}
- Faithful reconstruction of $b\bar{b}$ jets at high luminosity is still challenging





Current Study Objective and Methods

- Design the cuts based on kinematic distributions, and cut events where background dominates

1. Use MC samples of signal and major backgrounds at $\sqrt{s} = 13$ TeV to obtain shape of signal v.s. background
2. Cut events where background dominates
3. Study the detection sensitivity by estimate signal and background ratio

MC Sample and important parameters

- NLO SM di-Higgs production (Yukawa + self-coupling)
- Higgs and SM ZZbb background sample

	LO Signal	NLO Signal	SM ZZbb bg	ggF Higgs bg	VBS Higgs bg	ZH Higgs bg	WH Higgs bg	ttH Higgs bg
luminosity (fb^-1)	3000	3000	3000	3000	3000	3000	3000	3000
cross section (fb)	14.4023	33	66.70175	48580	3782	883.9	1373	507.1
branching ratio	0.0000722	0.0000722	1	0.00015987	0.000275	0.000275	0.000275	0.000275
NTotal	300000	3262.016	5200000	8753560	765967	150000	150000	137637.2

Table: Signal parameter source: the generator. Background parameter source: CERN Yellow Report.

Major Background

- Single Higgs (4l+bb from ttH production, significantly overlap with di-Higgs signal)
- SM production of ZZbb (VBS, triboson, loop-induced...)

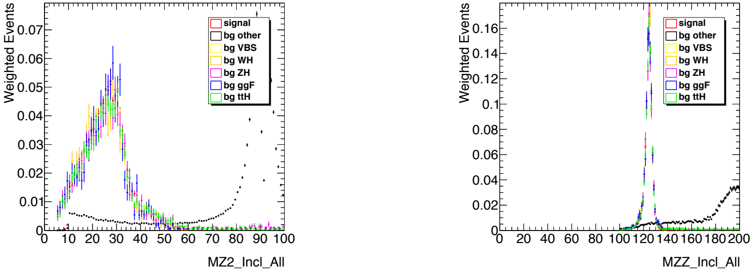
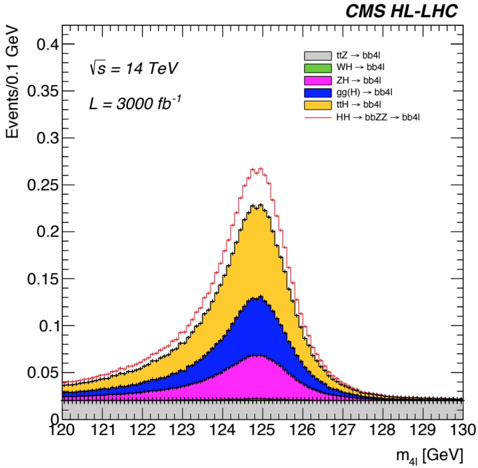


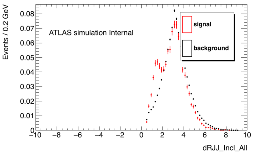
Figure: shape comparison between signal v. different sources of background

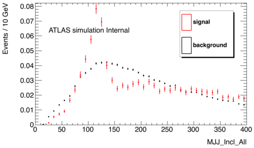
Higgs background analysis: Comparison with CMS

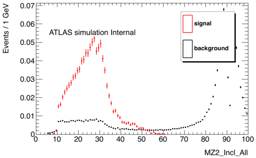


Signal v.s. background shape with preliminary cuts

	All Channels
Lepton	Two or more same flavour leptons
Jets	Two or more jets with valid Pt (Pt >-999e3)
M_{Z1}	$66\text{GeV} < M_{Z1} < 116\text{GeV}$
M_{Z2}	$5\text{GeV} < M_{Z2}$
lepton min $\delta\eta$	$\lvert\delta\eta\rvert < 2$
Lepton Quad Selection	minimize $M_{Z1} - 91\text{GeV} + M_{ZZ} - 125\text{GeV}$







Selection Design

	All Channels
Lepton	Two or more same flavour leptons
Jets	Two or more jets with valid Pt (Pt >-999e3)
M_{Z1}	66GeV $< M_{Z1} <$ 116GeV
M_{Z2}	5GeV $< M_{Z2} <$ 50GeV
M_{jj}	75GeV $< M_{jj} <$ 140GeV
Jet Pt Veto	No lead jet with $Pt <$ 60GeV
Z boson Pt Veto	No Z1 boson with $Pt <$ 80GeV or $Pt >$ 280GeV
ZZ Higgs Pt Veto	no Higgs from jets with $Pt <$ 100GeV
JJ Higgs Pt Veto	no Higgs from Z bosons with $Pt <$ 100GeV
δRjj	$\|\delta Rjj\| < 2$
minimum lepton $\delta\eta$	$\|\delta\eta ll\| < 2$

Next Steps

- further improve the cut-based analysis
- use MVA to improve the detection sensitivity if time allow

The End