ATLAS Di-Higgs Search in ZZbb Channel

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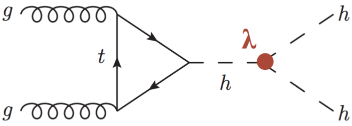
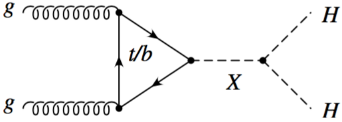
Motivation

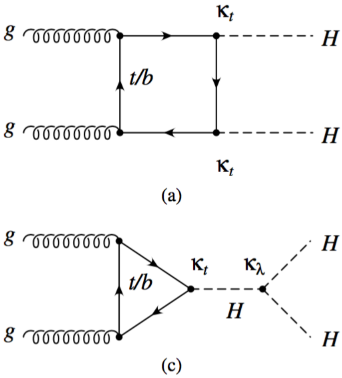
1. Search for Higgs self-coupling predicted by SM
2. Search for new particles through Higgs (BSM)

- $V(\phi) = -\mu^2\phi^*\phi + \frac{\lambda}{2}(\phi^*\phi)^2$
- $\phi_0 = \mu/\sqrt{\lambda}$
- $\phi = \phi_0 + \frac{1}{2}(\phi_1 + i\phi_2)$
- $V(\phi) = V_0 + \frac{1}{2}(2\mu^2)\phi_1^2 + \frac{\mu^2}{\phi_0}\phi_1^3 + \ldots$

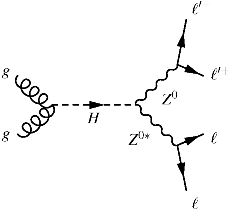


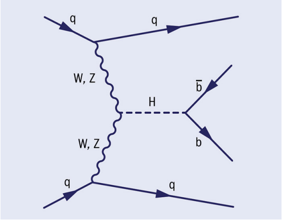


Signal of Di-Higgs Production



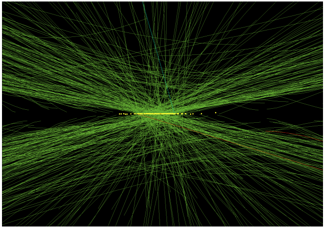
End Product

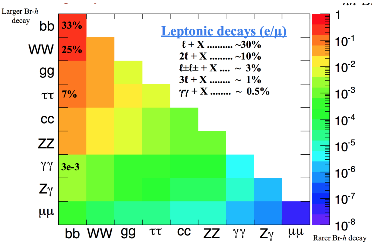




Advantage and Challenge of ZZ Production Channel Search

- Comparatively low background (4l + $b\bar{b}$)
- Less dependence on high pile-up
- Statistical error dominates due to low signal
- **Can be improved with high luminosity!**
- Faithful reconstruction of $b\bar{b}$ jets at high luminosity is still challenging





Current MC Sample

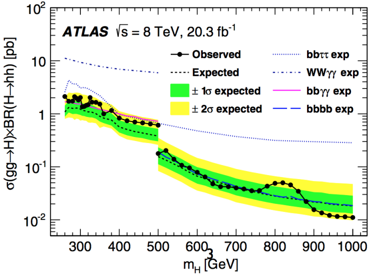
- SM Higgs self-coupling
- SM Yukawa di-Higgs production
- BSM models with M_X from 260 to 5000 GeV

Current Observation

non-resonant limits:

Analysis	$\gamma\gamma bb$	$\gamma\gamma WW^*$	$bb\tau\tau$	$bbbb$	Combined
			Upper limit on the cross section [pb]		
Expected	1.0	6.7	1.3	0.62	0.47
Observed	2.2	11	1.6	0.62	0.69
			Upper limit on the cross section relative to the SM prediction		
Expected	100	680	130	63	48
Observed	220	1150	160	63	70

resonant limits:



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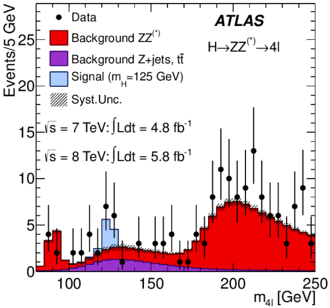
Major Background

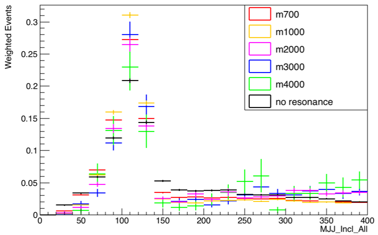
- SM production of ZZbb (VBS, triboson, loop-induced...)
- Four leptons from the backgrounds are mostly from on-shell Z boson (important for mass cut)

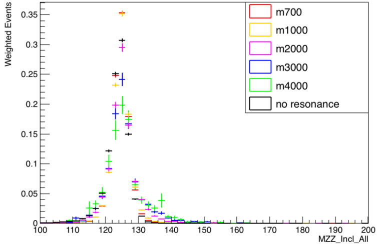


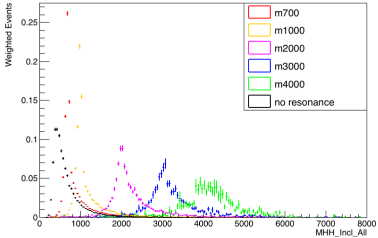
Selection Design

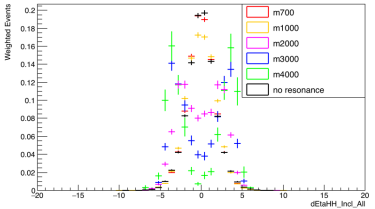
1. Mass cut (Higgs, Z, Z*)
   - 116.e3 $>$ massZ1 $>$ 66.e3
   - 116.e3 $>$ massZ2 $>$ 5.e3
2. Kinematic cuts (Pt, Eta)
   - Pt1 $>$ 20.e3, Pt2 $>$ 20.e3, Pt3 $>$ 10.e3
   - abs(Eta) $<$ 2.7
3. individual lepton selection
   - type: $ee\mu\mu$, $eeee$, $\mu\mu\mu\mu$
   - isolation: min delta R for $l_1, l_2 > 0.1$, min delta R for $l_3, l_4 > 0.2$
4. lepton quad selection
   - min(abs(massZ1-Zmass) $+$ abs(massZ2-Z*mass))

Kinematic Analysis









Next Step

- Optimize selection design to increase sensitivity (signal to background ratio)
- Study multi-variable technique (BDT) to increase sensitivity
- Extend the analysis to ee/$\mu\mu + \nu\nu$

Citation

1. John, Alison. "Di-Higgs Production at the LHC: Current Status and Future Prospects." University of Chicago.
2. Collaboration, The ATLAS. Observation of a New Particle in the Search for the Standard Model Higgs Boson with the ATLAS Detector at the LHC. [Astro-Ph/0005112] A Determination of the Hubble Constant from Cepheid Distances and a Model of the Local Peculiar Velocity Field, 31 Aug. 2012, arxiv.org/abs/1207.7214.
3. Harold, Fox; LHCP. "Latest Results on Di-Higgs Production at ATLAS." Lancaster University.

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