Study of the H→ZZ→llqq decay mode with the ATLAS detector

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MANAGING AUTHORITY

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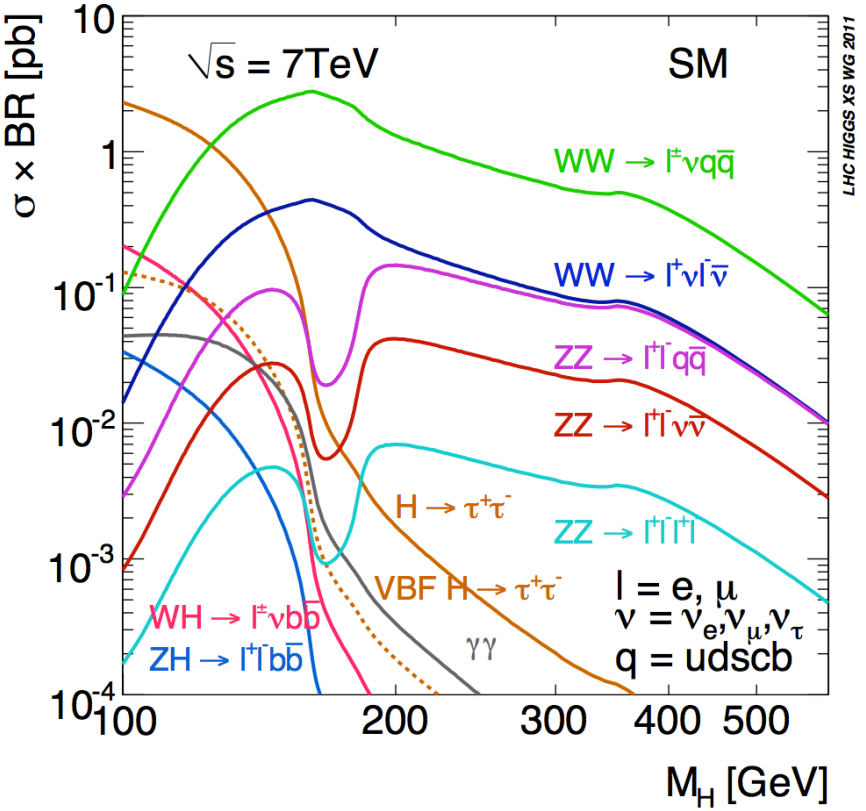
Introduction

$H \rightarrow ZZ \rightarrow llqq$

..decay mode has been studied in a wide mass range (120 GeV – 1 TeV)

Fully reconstructable final state and a high production rate (compared to other channels)



Very competitive above 200 GeV

…but suffers from large background contributions (Z+jets, QCD) in the lower mass ranges

Challenging in the lower mass regions (<200 GeV)

Introduction

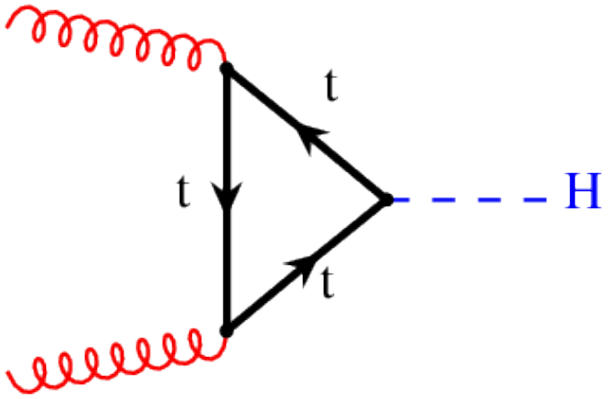
What we are looking for:

- Complete the search for the SM Higgs up to m_H~1TeV.
- BSM scenarios predict the existence of additional resonances, with couplings similar to the SM Higgs.

Analysis Categories

ggF (binned analysis)

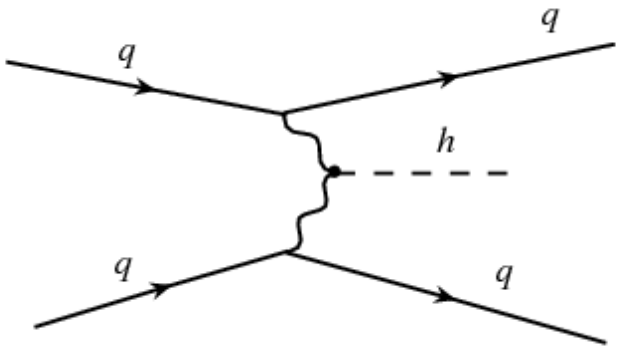
- < 2 b-tagged jets
- == 2 b-tagged jets
- >= 3 b-tagged is vetoed



VBF (inclusive analysis)

distinctive signature

2 extra jets, close to the beam-line, with high invariant mass



Introduction

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Contributing background processes

- Z+jets (mc modelled, data driven normalization)
- Top BG (mc modelled, data driven normalization)
- Diboson (ZZ,WZ,WZ mc modelled)
- W+jets (mc modelled)
- Multijet (data driven)

Event Selection ggF

- Search for an on-mass-shell $Z \rightarrow l^- l^+$
- Search for an on-mass-shell $Z \rightarrow qq$

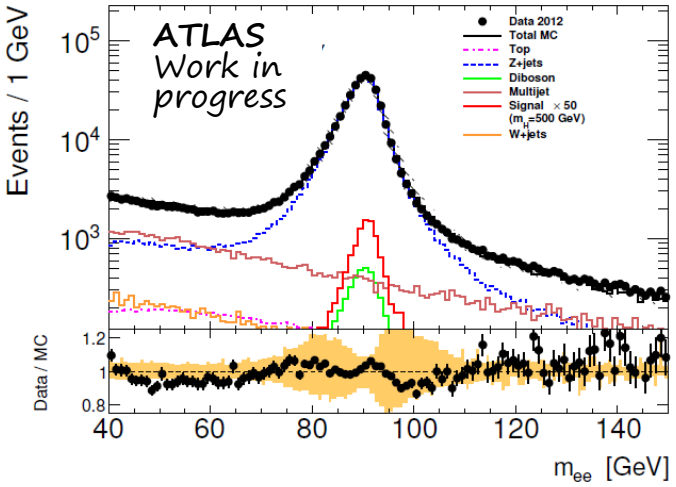
$Z \rightarrow ll$ candidate:

- $\mu\mu$ / ee pair, (op. sign for muons only)
- p_{Tl}>7GeV, $|\eta|$<2.5, track isolation,
- 3rd lepton veto,
- p_T > 25GeV for the leading lepton

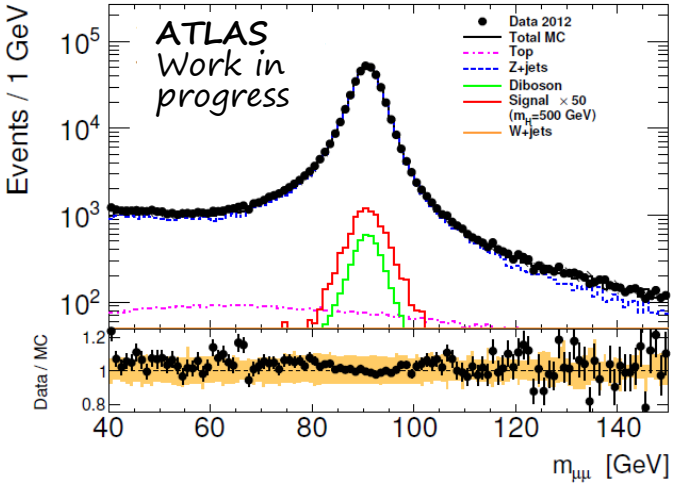
Z - mass window: 83 – 99 GeV

E_{Tmiss} < 60GeV

Dilepton mass at the 2leptons + 2jets level. Electrons (top) and muons (bottom)



(a)

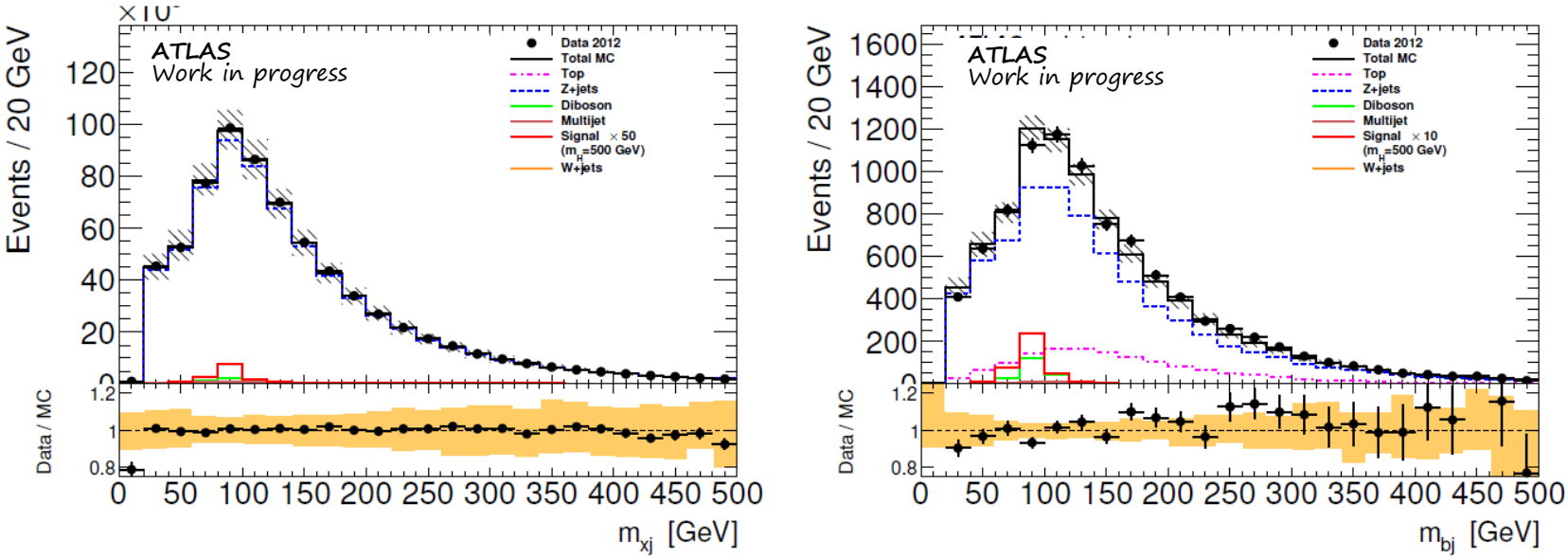


Event Selection ggF

$Z \rightarrow jj$ candidate:

- 2 antikt4topo jets, $p_T > 20$ [GeV], $|\eta| < 2.5$
- leading jet $p_T > 45$ [GeV]

Z - mass window: $70 < m_{jj} < 105$ [GeV]



Dijet mass distribution for the un-tagged category (left) and 2b-tagged (right)

Event Selection
Control Regions

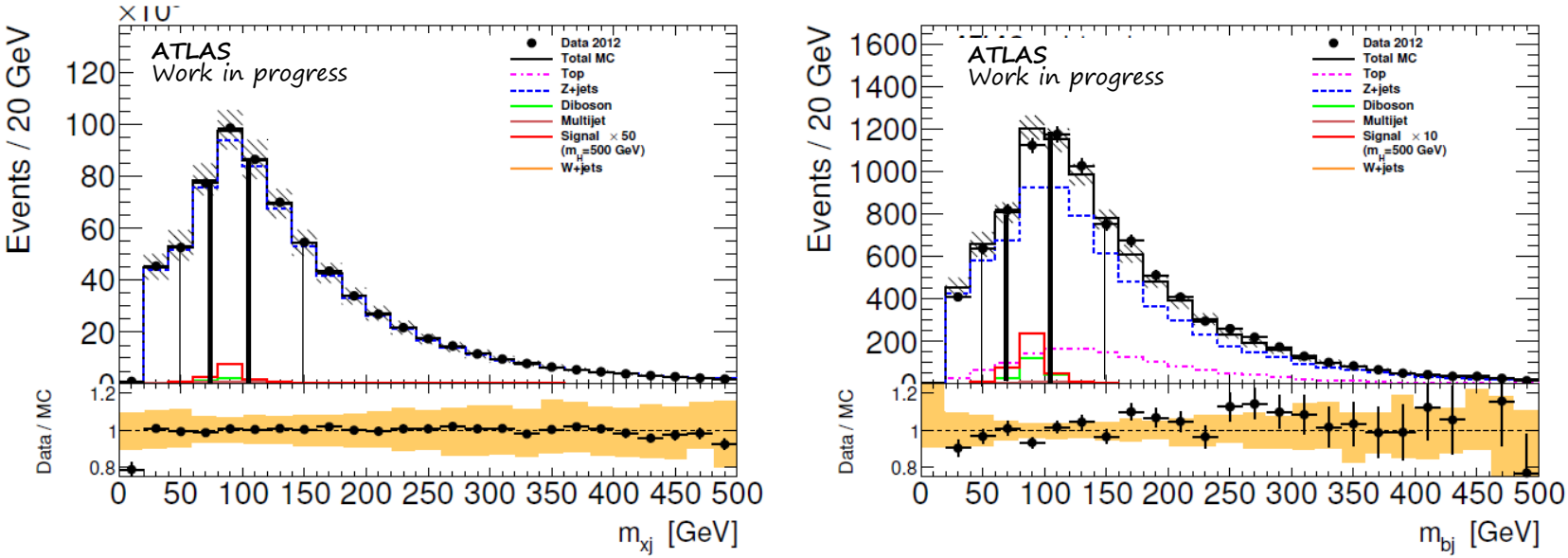
Controlling the Z+jets background:

Control region defined from the sidebands of the m_{jj} peak:

- $50 < m_{jj} < 70$ GeV && $105 < m_{jj} < 150$ GeV

Expecting:

- that the distribution of the m_{lljj} - discriminant in the CR is the same as in the Z mass-window.
- No (or miniscule) signal.

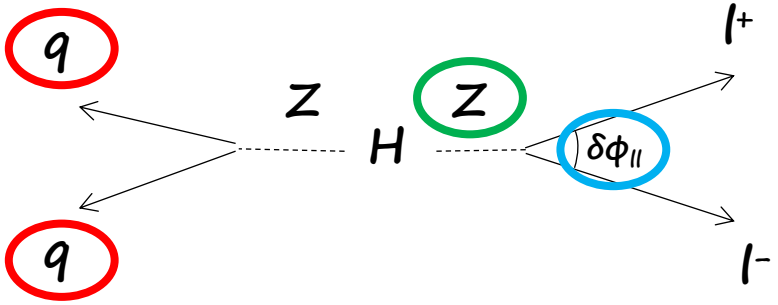


Dijet mass distribution for the un-tagged category (left) and 2b-tagged (right)

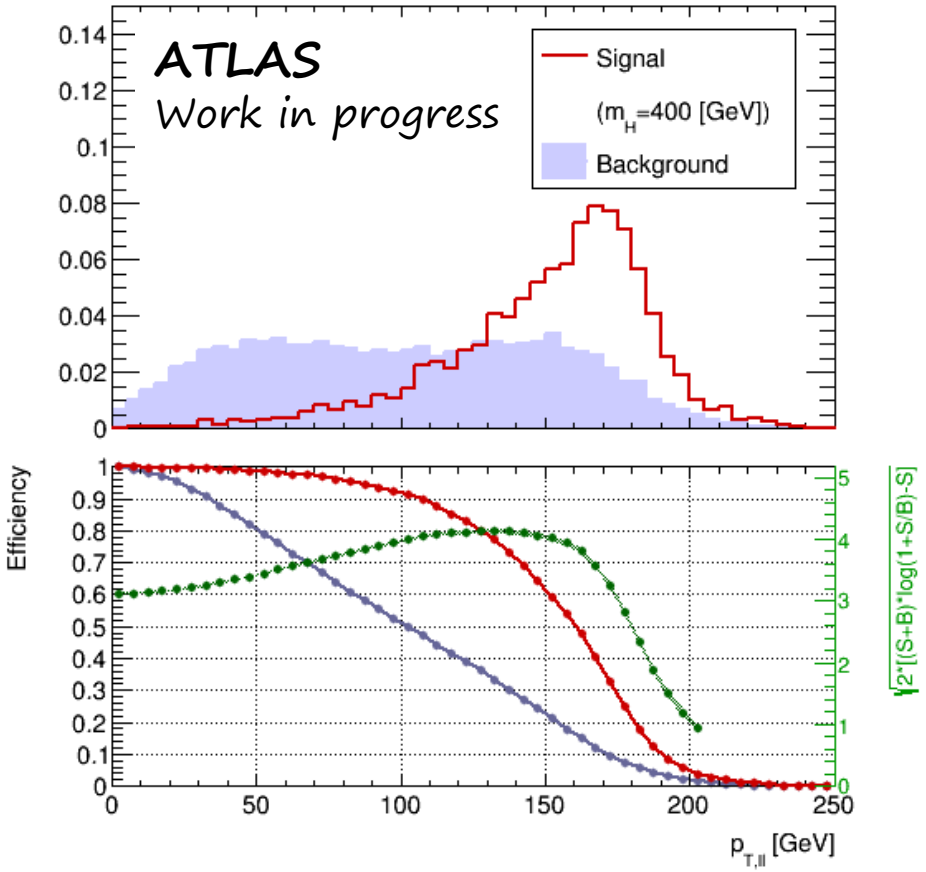
Event Selection Optimization

Optimization criteria..
in order to take advantage of the high Higgs mass:

- $p_{T,ll} > -77.5389 + 0.467368 * m_H$
- $\delta\varphi_{ll} < 1 + 3.21812e08 / m_H^{3.50049}$
- $p_{T,jets} > 0.1 * m_H$



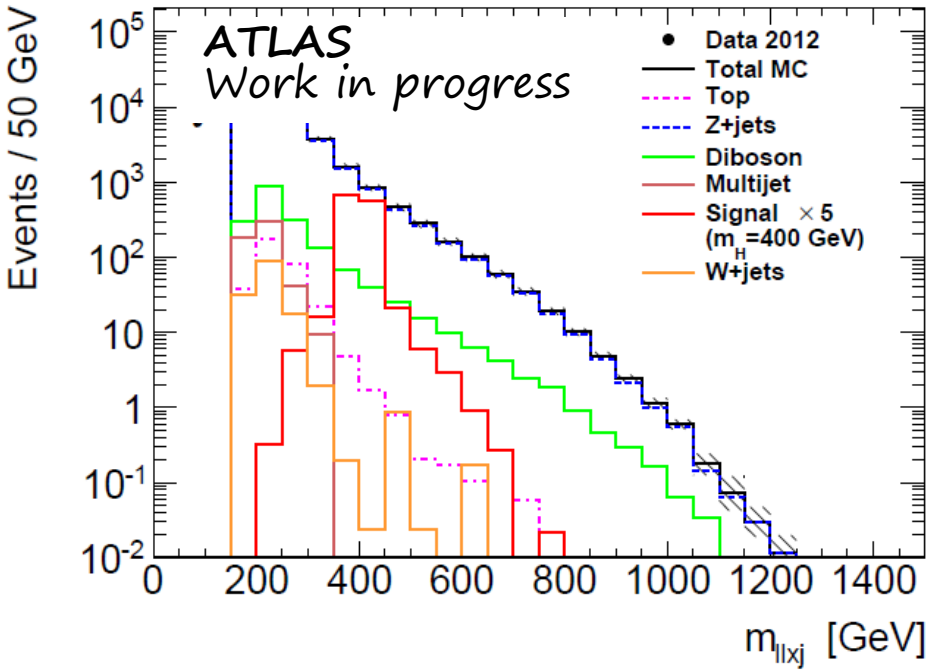
Signal / background comparison for the optimization for the cut on $p_{T,ll}$

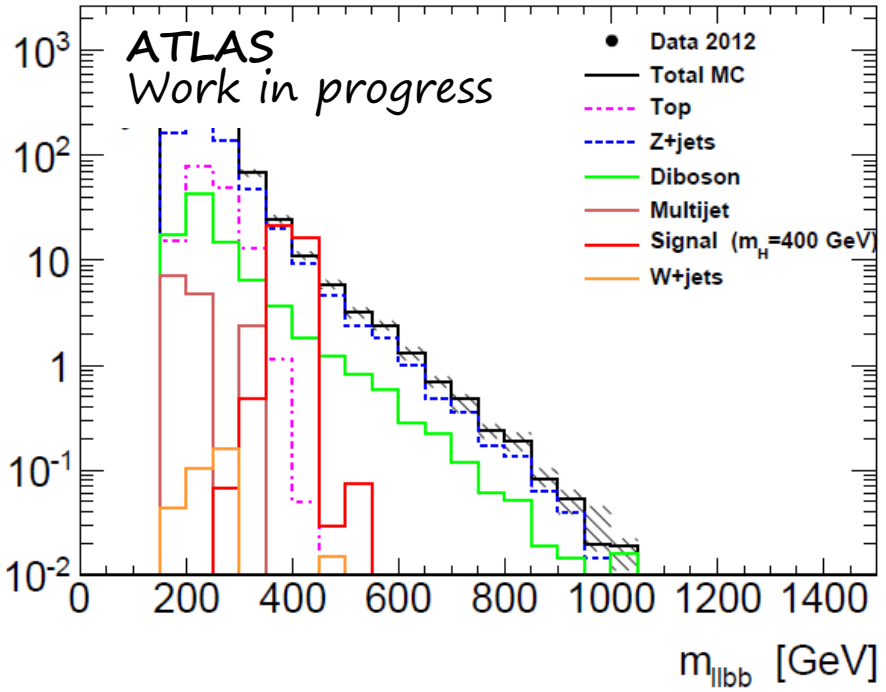


**VBF-signal and mc background compared in a region around the Higgs peak and shown with unit normalization.*

llqq: Results

Reconstructed 4-object mass distributions in the ggF category





Signal Region: Signal / backround expectation.
Showing (m_H: 400,600 GeV)

Event Selection VBF

identify the VBF tag-jets before picking the Z-jet candidates. Selection by highest invariant mass.

jets considered (antikT4):

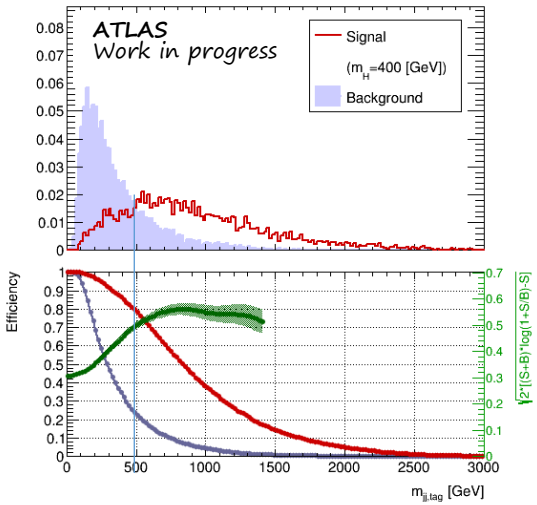
- $|\eta| < 4.5$
- $\eta_1 * \eta_2 < 0$
- not b-tagged

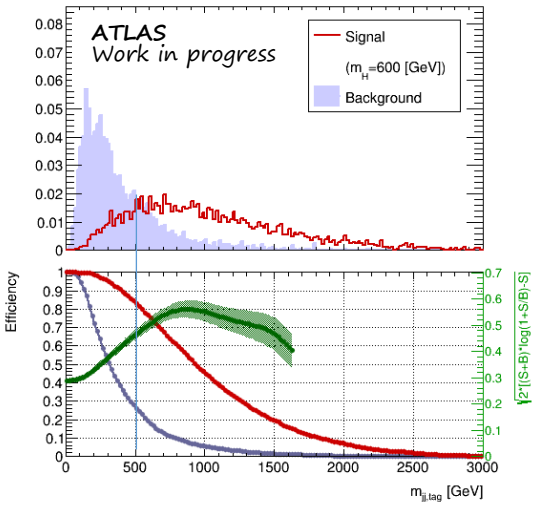
preliminary cut:

- $m_{jj,tag} > 500$ [GeV]
- $|\delta\eta_{jj,tag}| > 4$

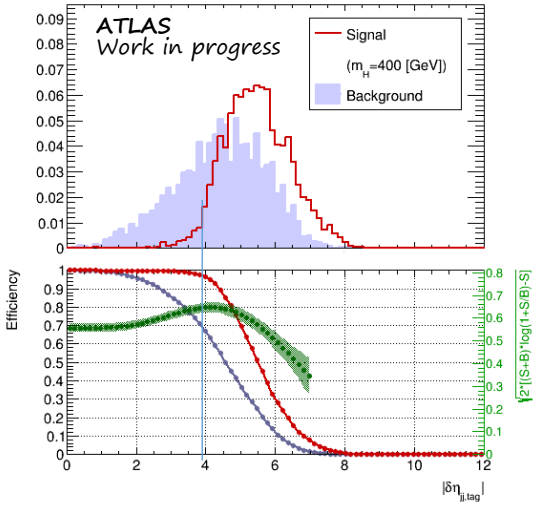
Apply the same selection as in the ggF case for the ZZ candidates

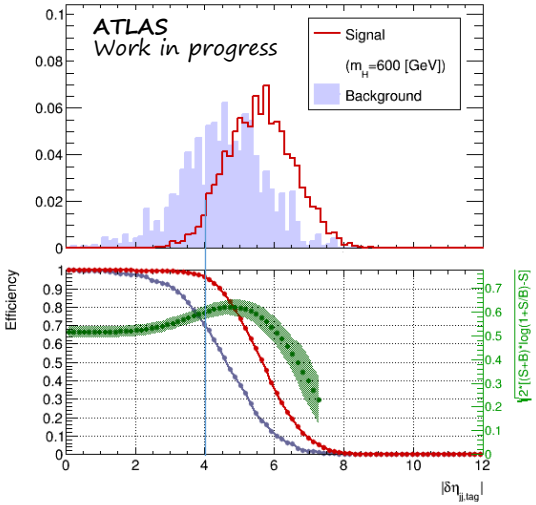
Comparison plots* $m_{jj,tag}$





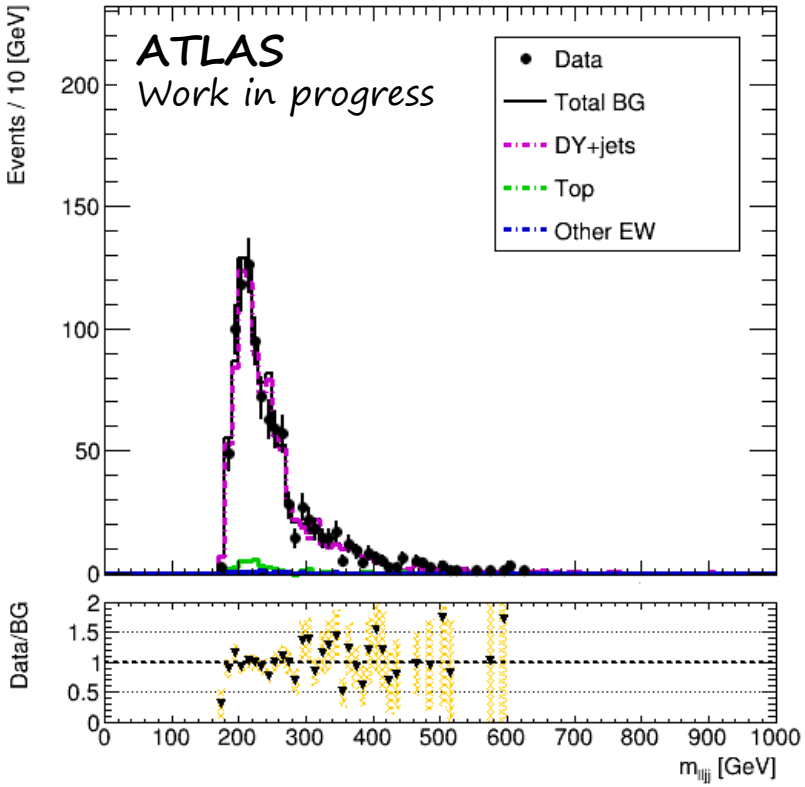
Comparison plots* $\delta\eta_{jj,tag}$



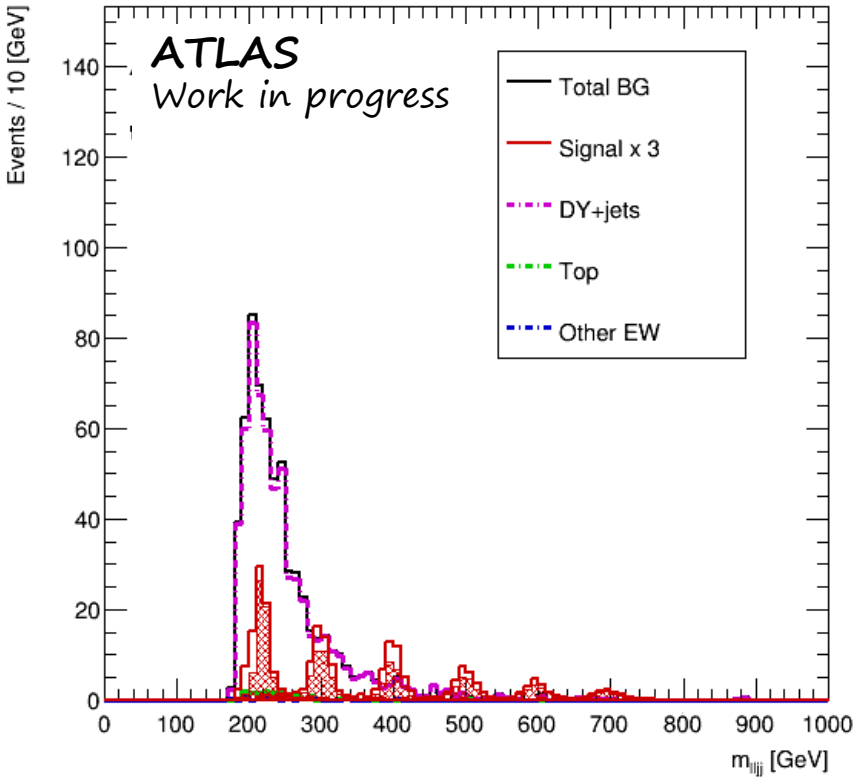


Event Selection
VBF

Reconstructed 4-object mass distributions in the VBF channel



Using mjj sidebands to control Z+jets
$50 < m_{jj} < 70$ [GeV] && $105 < m_{jj} < 150$ [GeV]



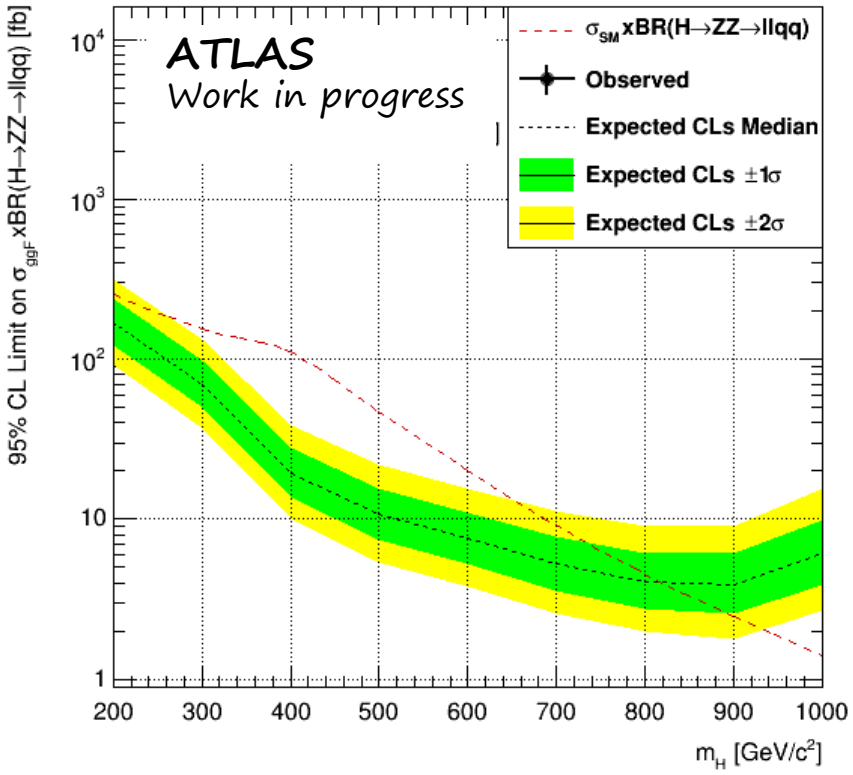
Signal Region: Signal / backround expectation.
Showing (m_H: 200,300,400,500,600,700GeV)

llqq: Expected results

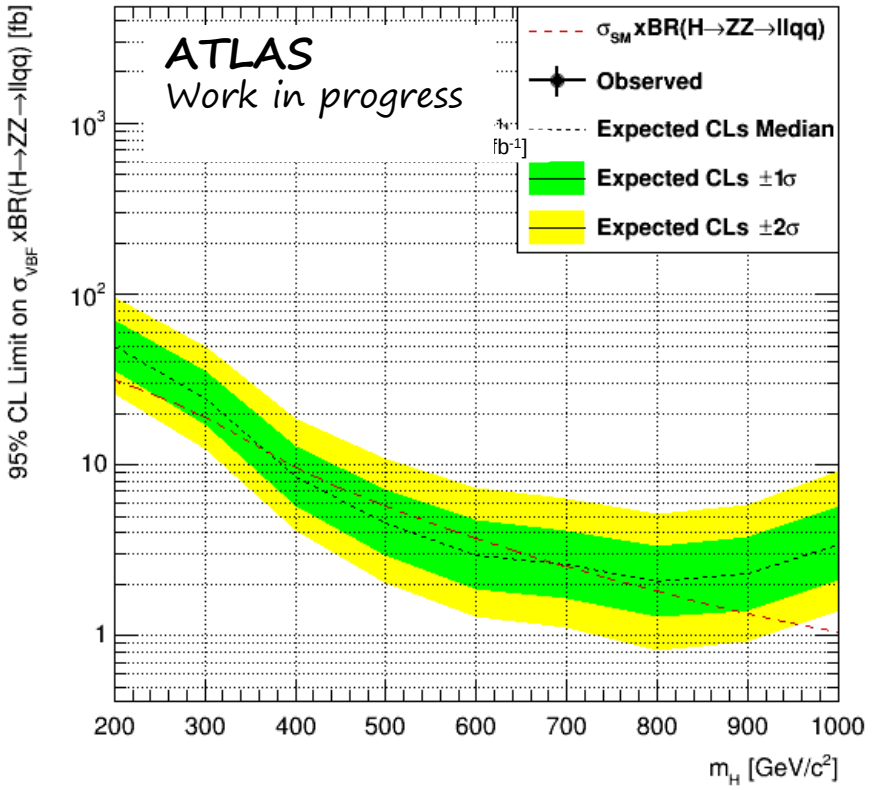
Expected 95% CLs limits on σ x BR

Using mockup data (i.e. the nominal background)

ggF (VBF profiled)



VBF (ggF profiled)



Summary

- llqq analysis is very sensitive in the high mass range

- Strategy in Run 2, will be based on the Run analyses, with certain tuning to exploit the higher amount of expected signal events

- If there's a new particle in that range, it will not escape detection during Run2!!

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