Search for heavy Higgs boson in the WW->lvlv channel at ATLAS

Weimin Song

on behalf of the group

FCPPL 2017, Tsinghua University, Beijing

Outline

1. Introduction to the project

2. Search for heavy Higgs boson in the WW->lvlv channel

3. Proposal for 2017

Introduction to the project

Motivation

To search for new physics by studying the WW final state at ATLAS

Members

LAL SDU USTC

Zhiqing Zhang

Weimin Song

Yingchu Zhu

Lianliang Ma

Yongke Zhao

Kunlin Han

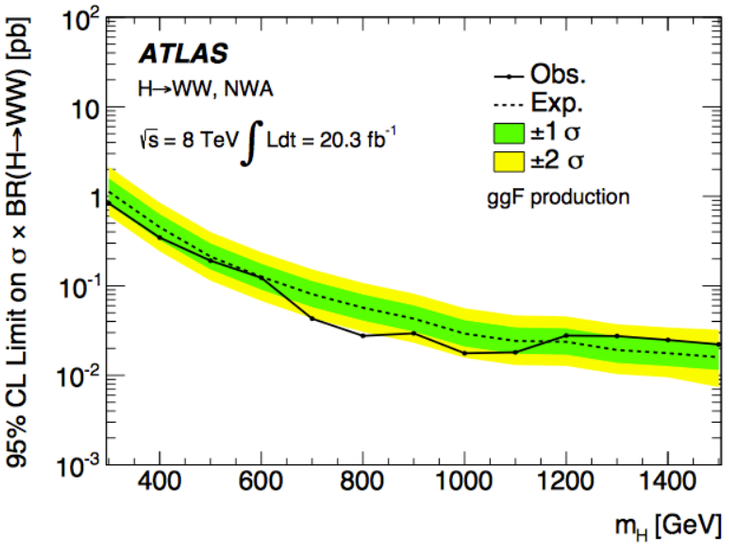
Publications

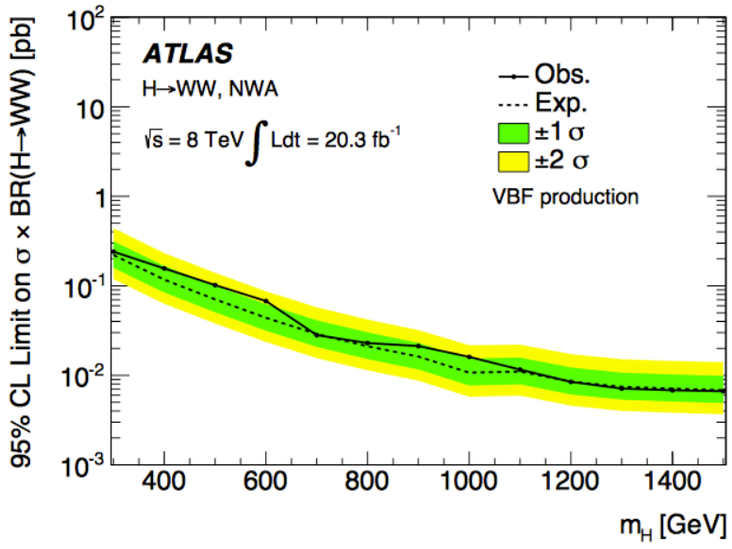
In 2016, two ATLAS publications and two CONF Notes

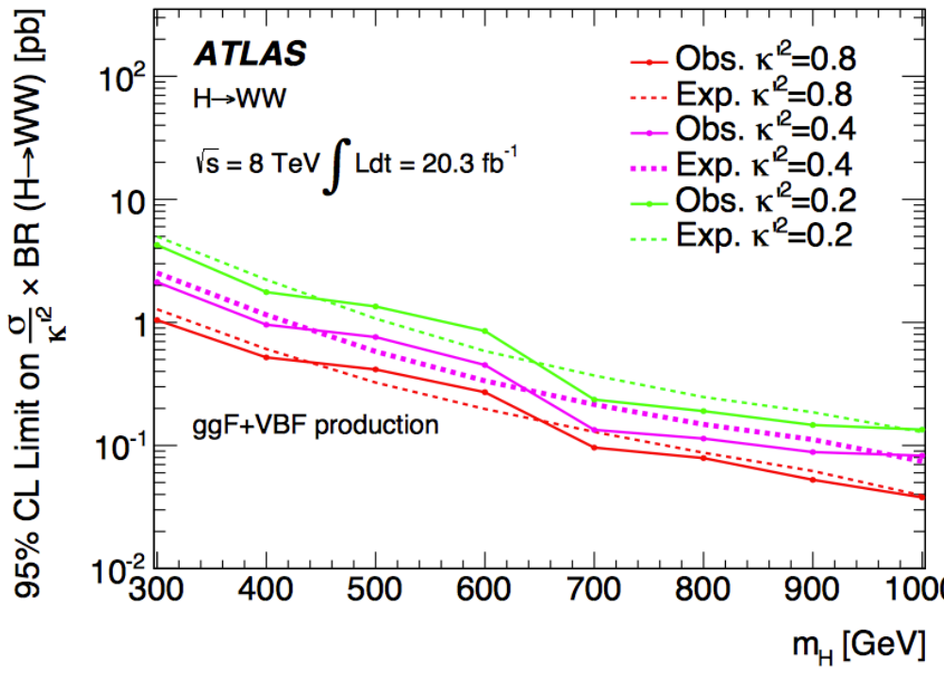
Public result(1)

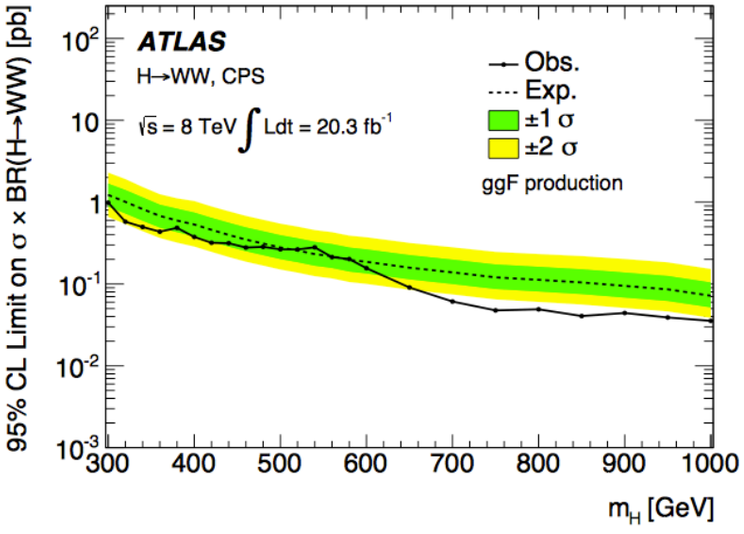
JHEP 01 (2016) 032

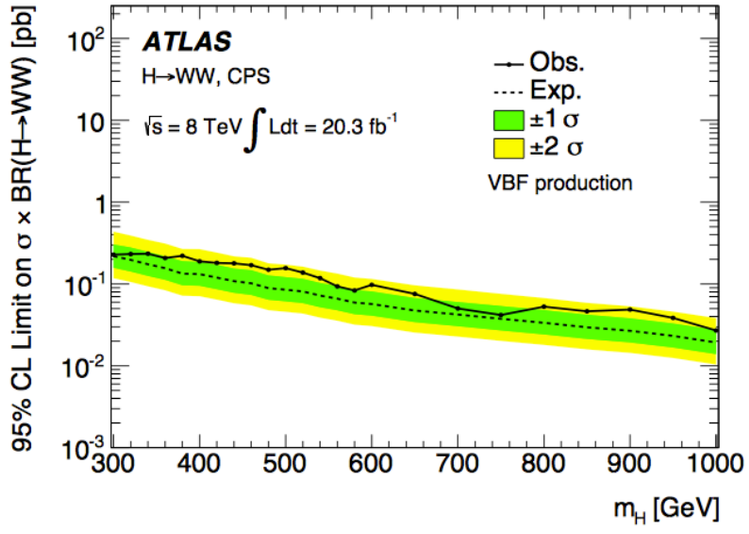
Search for a high-mass Higgs boson decaying to a W boson pair in pp collisions at √s = 8 TeV with the ATLAS detector









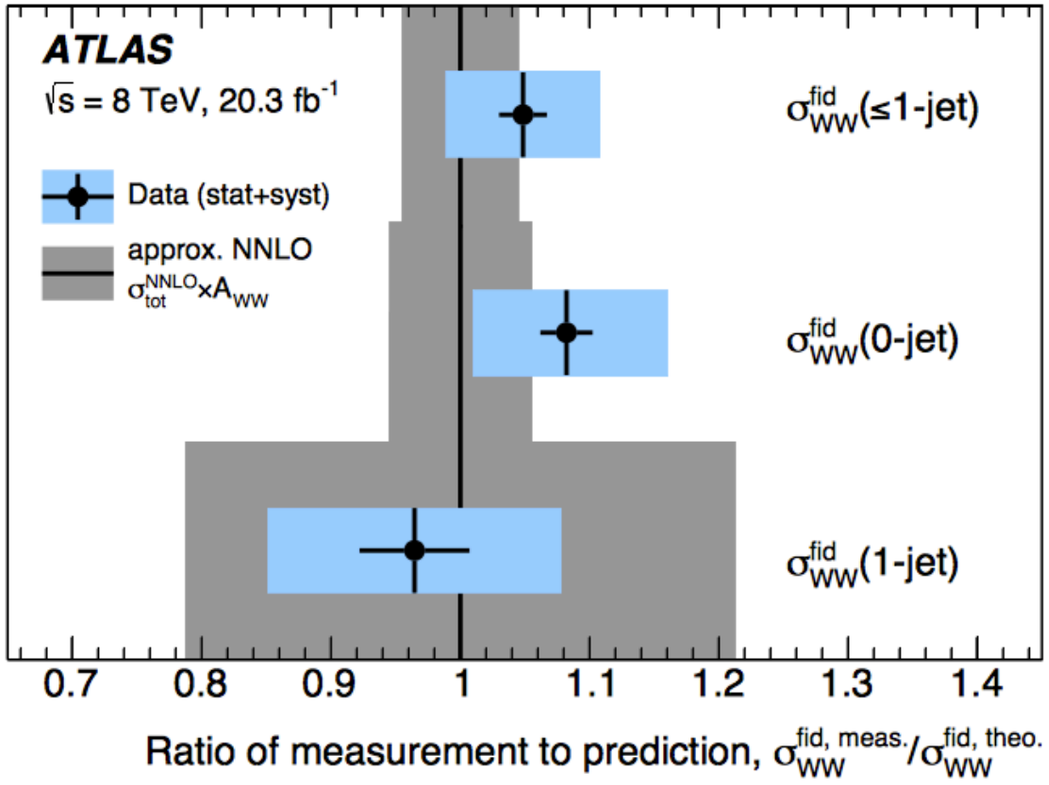


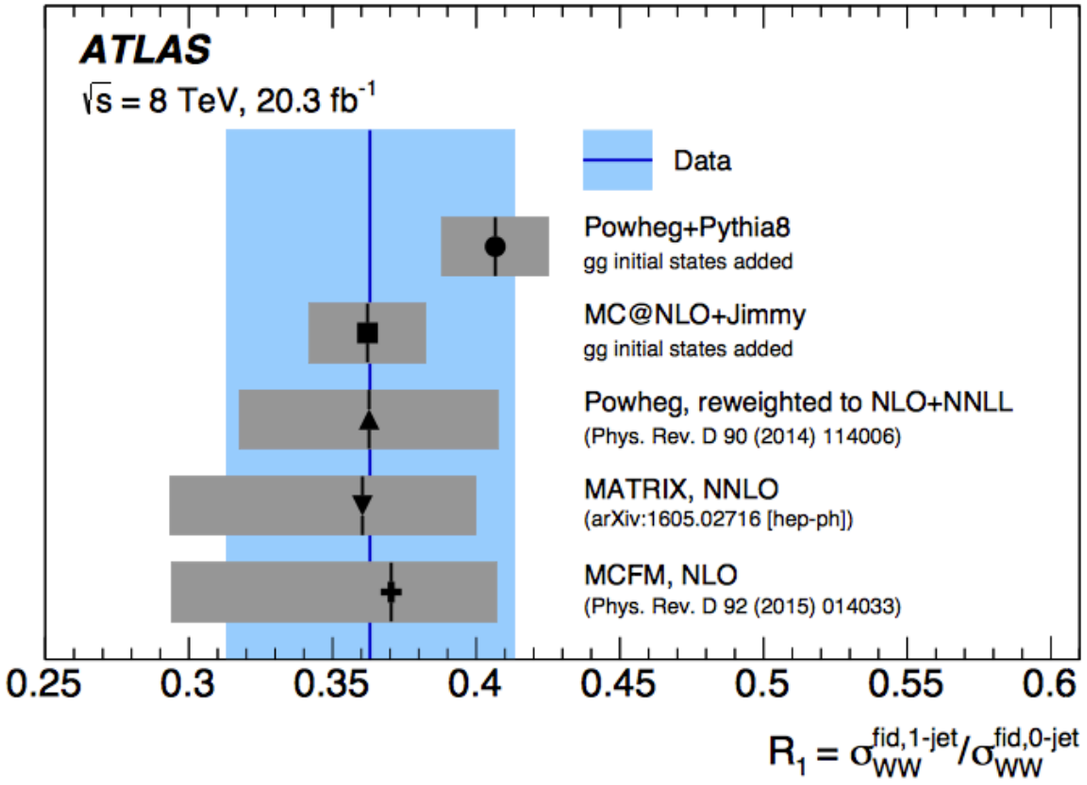
NO new Physics!

Public result(2)

Phys. Lett. B763 (2016) 114

Measurement of W+W− production in association with one jet in proton–proton collisions at √s = 8 TeV with the ATLAS detector

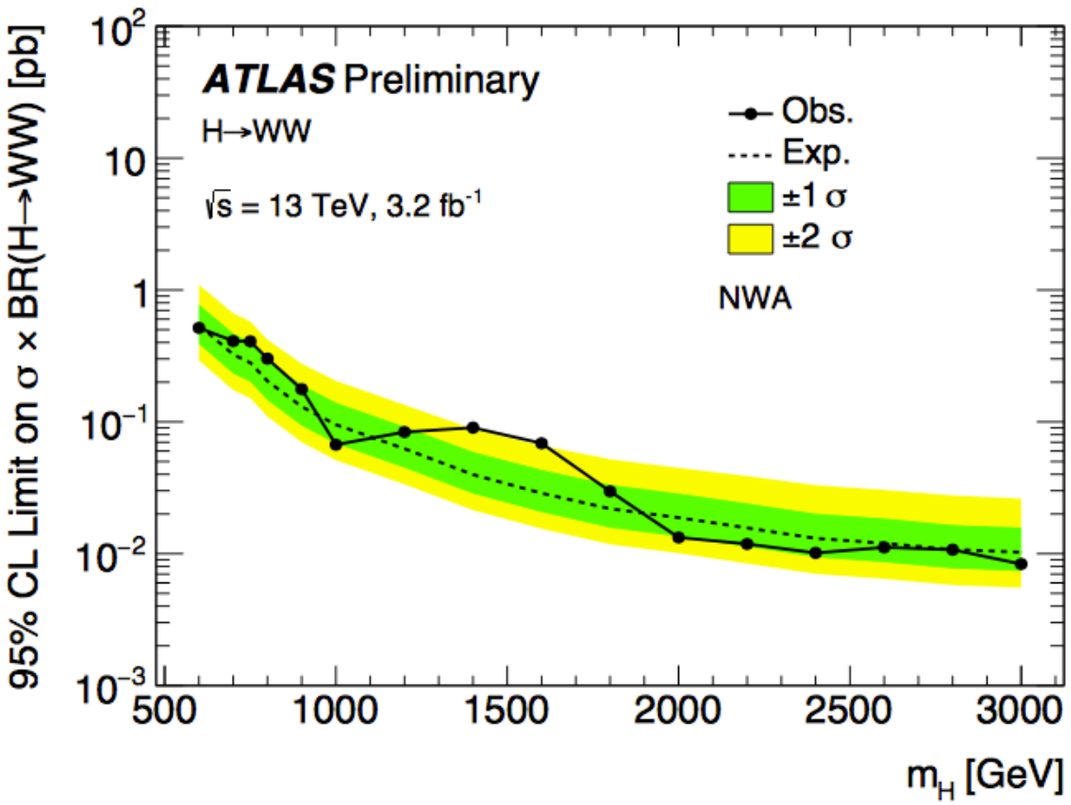


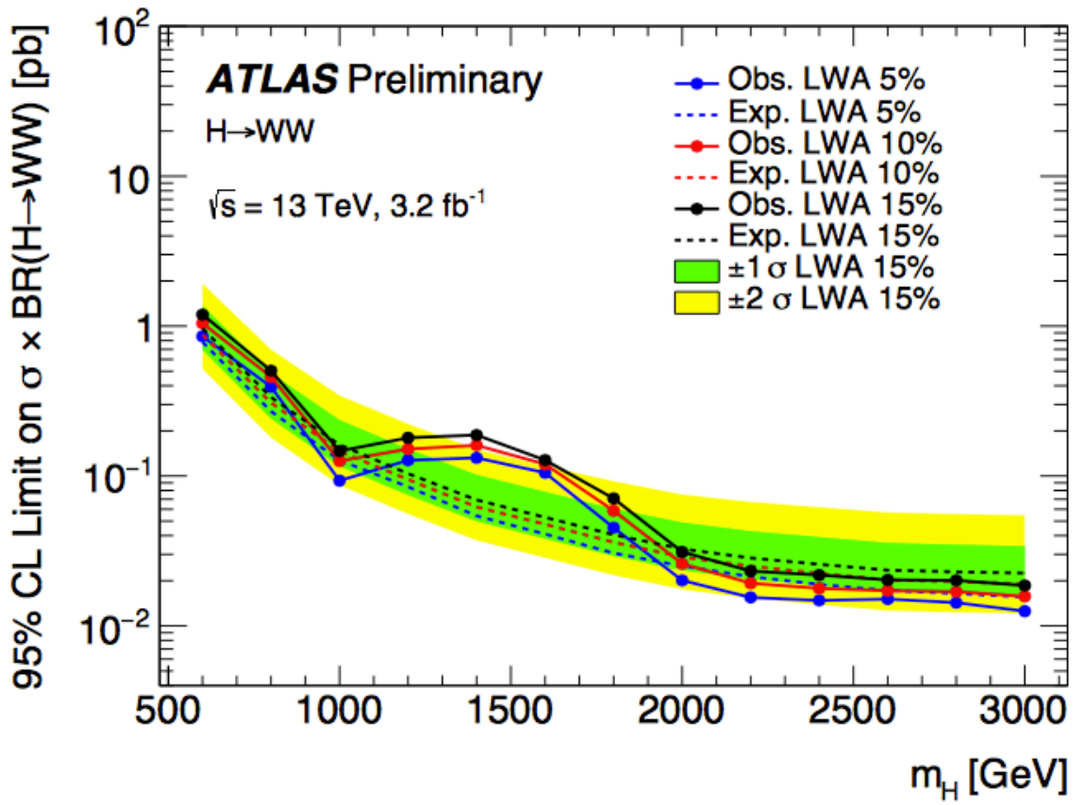


NO new Physics!

Public result(3)

Search for a high-mass Higgs boson decaying to a W boson pair in pp collisions at √s = 13 TeV with the ATLAS detector



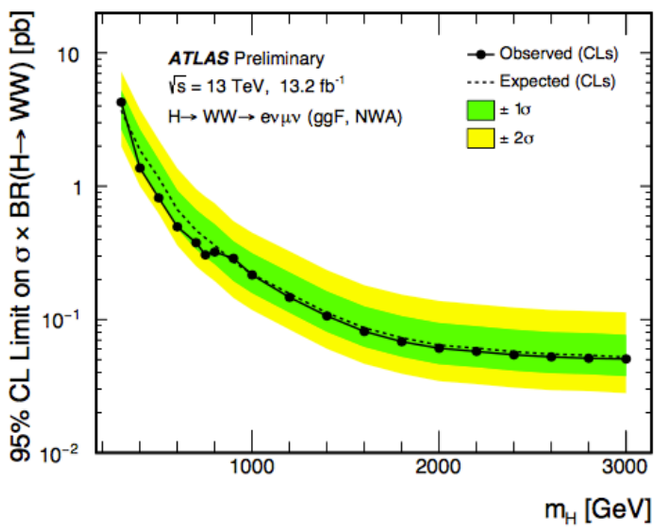


https://cds.cern.ch/record/2147445/files/

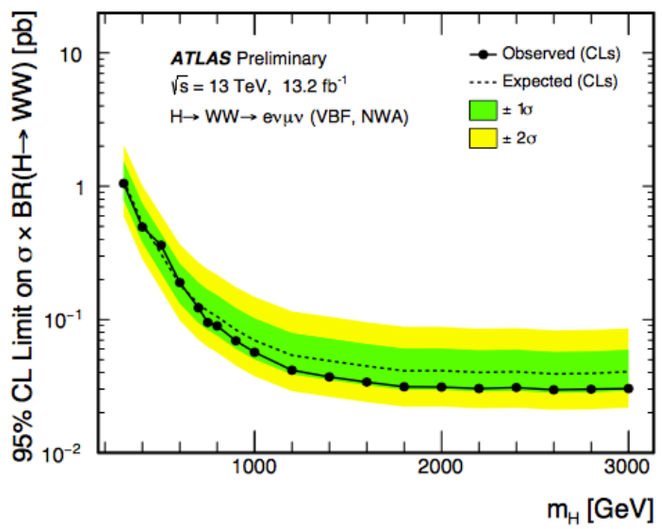
NO new Physics!

Public result(4)

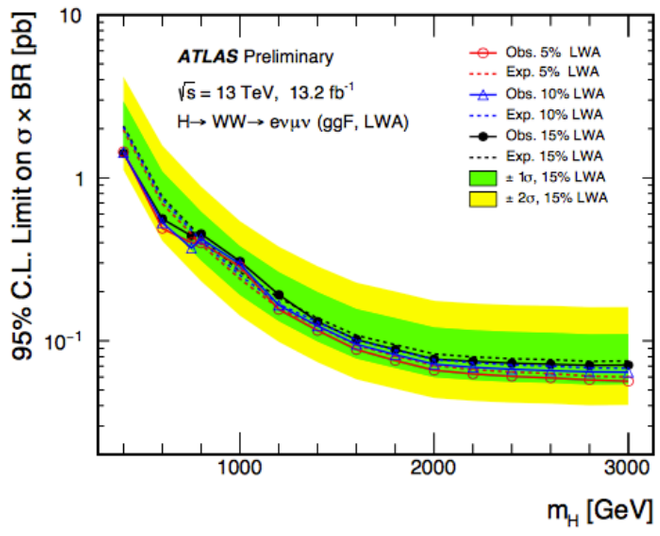
Search for a high-mass Higgs boson decaying to a W boson pair in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector



(a) NWA, ggF



(b) NWA, VBF



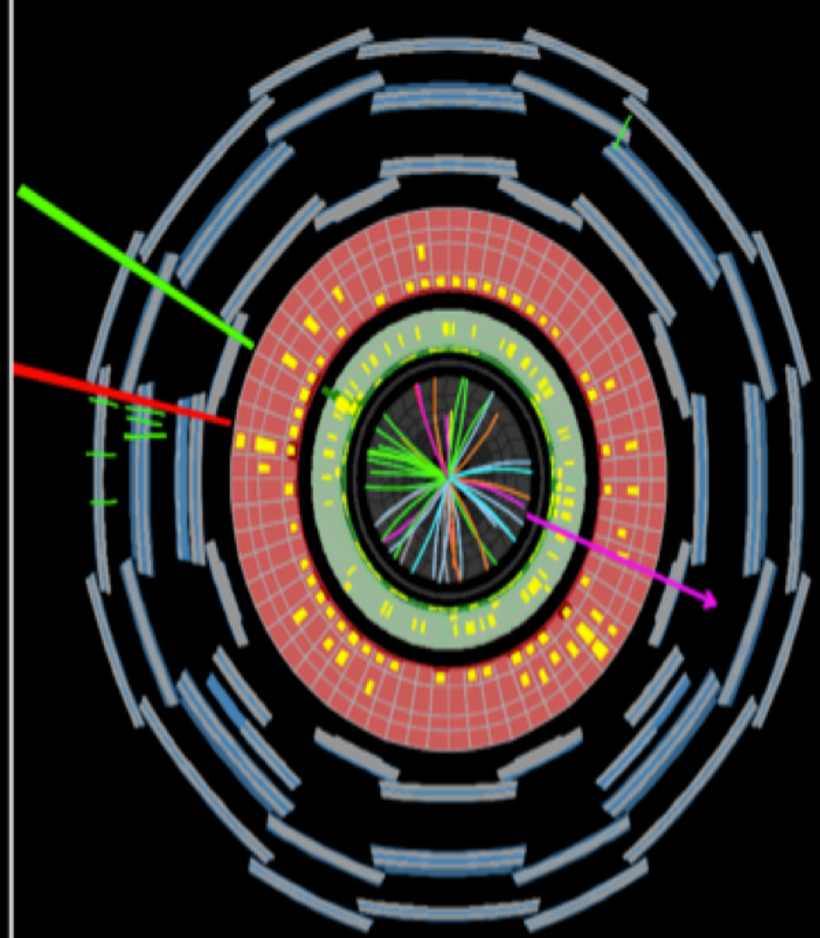
(c) LWA, ggF

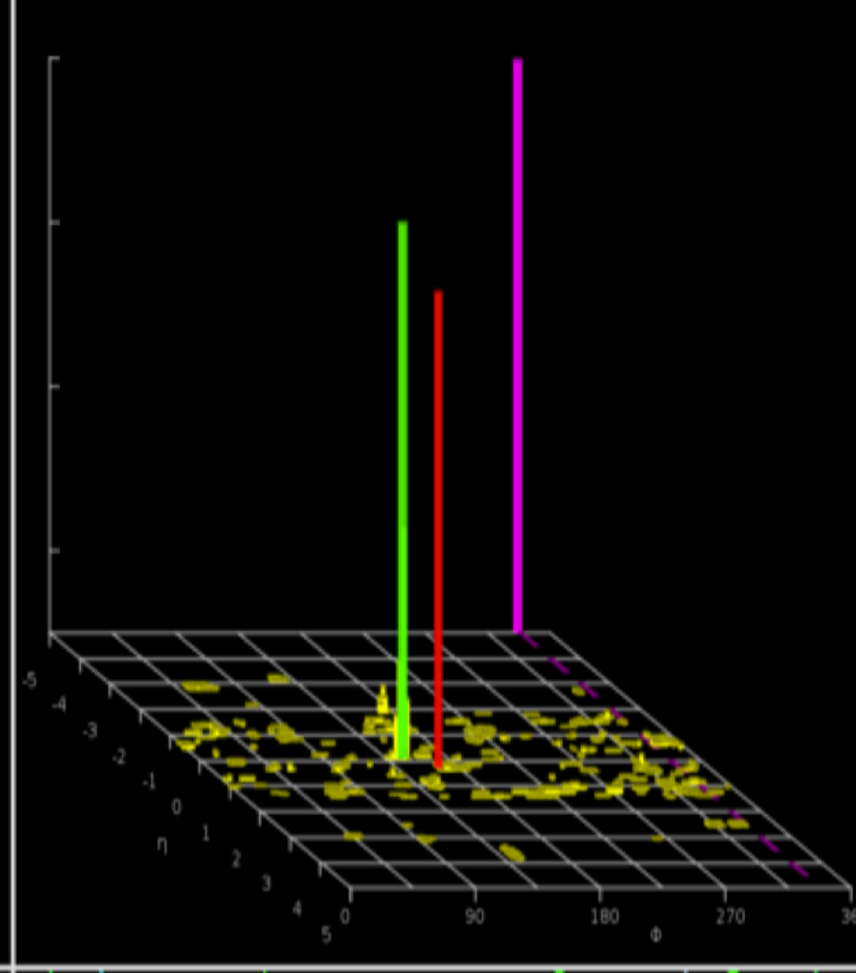
NO new Physics!

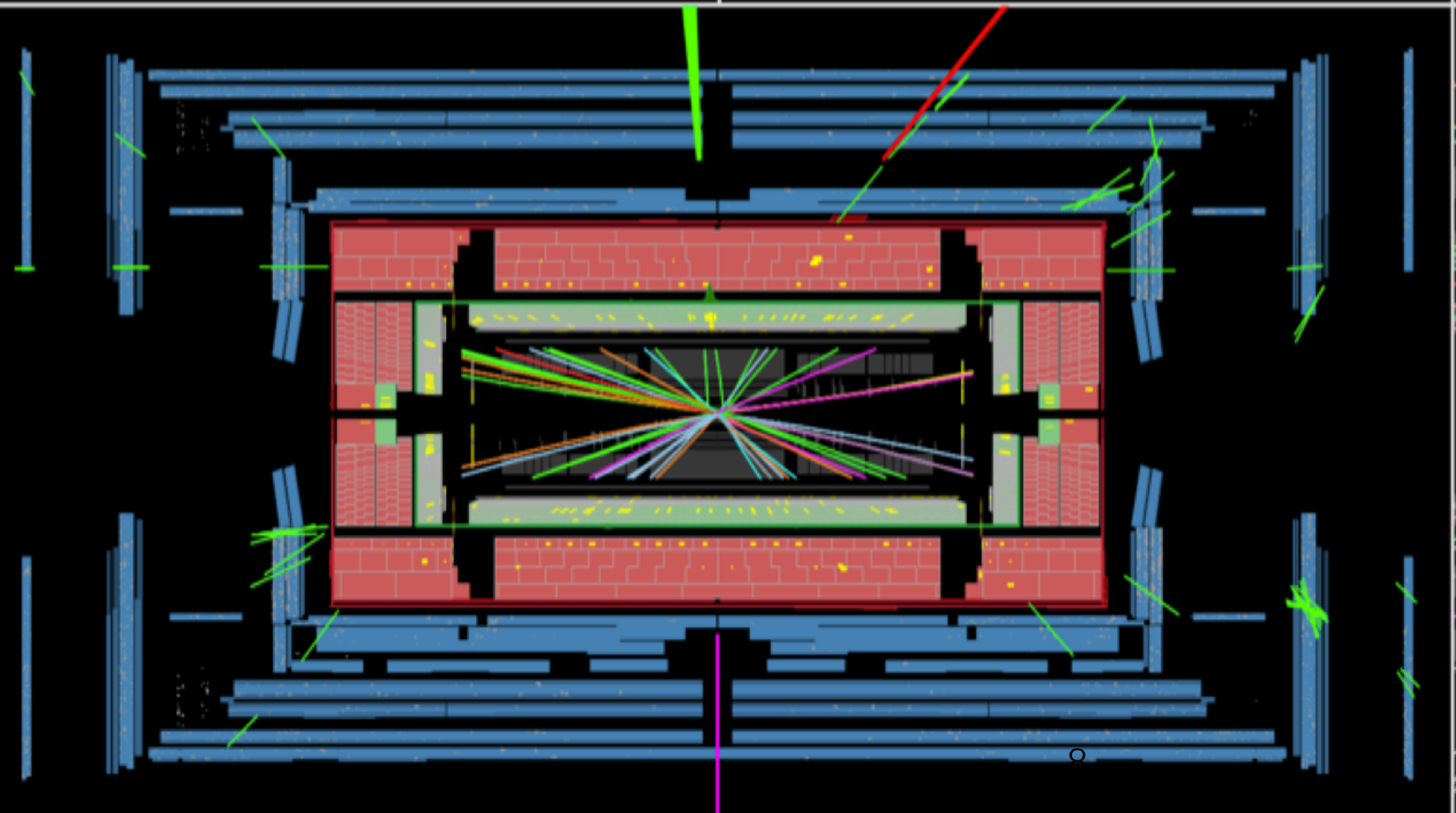
https://cds.cern.ch/record/2206243

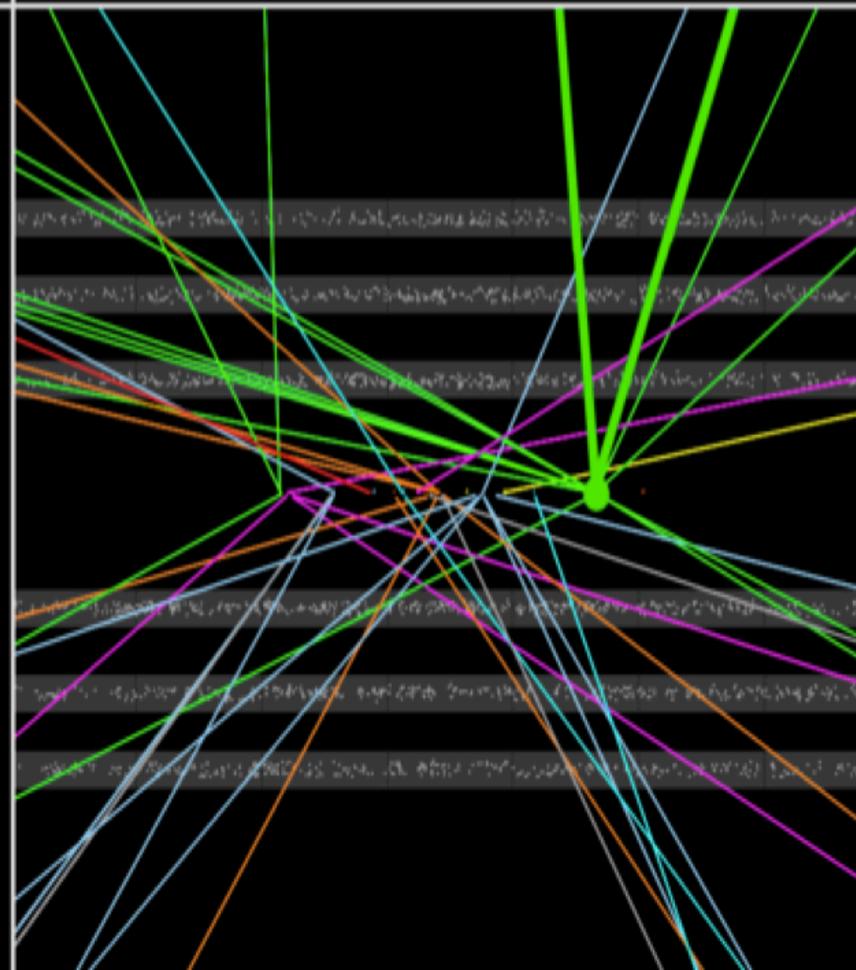
ATLAS EXPERIMENT

Search for heavy Higgs boson
in WW->lvlv channel









Philosophy

1. We human beings are not satisfied with the current framework of physics: dark matter, mass hierarchy, asymmetry between matter and anti-matter, quantum gravity, naturalness.....are still not understood. We are looking for something new by different methods according to tastes: precision measurement of the parameters of the SM, putting a detector on the space station or underground, searching new particles on colliders.....

2. Large hadron collider at CERN is running at the highest energy region we ever achieved, and without no doubt that it is a good place to search for something new.

3. Even though h(125) was discovered, we are not sure whether it is the single child or not; WW decay channel is with large branching fraction if the mass of "higgs brother" is higher; leptonic tag mode of W is clean when comparing with hadronic one.

Clearly knowing the three truth above, God said, to search for a heavy higgs in WW->lvlv final state, then we did that.

Event selection

Two leptons with difference flavour

SR_{ggF}	SR_{VBF1J}	SR_{VBF2J}
Preselection cuts: $p_T^{lead} > 25\,GeV$, $p_T^{sublead} > 15\,GeV$, 3rd lepton veto, $m_{\ell\ell} > 10\,GeV$		
$N_{b\text{-jet}} = 0$ $\lvert\Delta\eta_{\ell\ell}\rvert < 1.8$ $m_{\ell\ell} > 55\,GeV$ $p_T^{lead} > 45\,GeV$ $p_T^{sublead} > 30\,GeV$ $\max(m_T^W) > 50\,GeV$		
Inclusive in N_{jet} but excluding VBF1J and VBF2J phase space	$N_{jet} = 1$ $\lvert\eta_j\rvert > 2.4$ $\min(\lvert\Delta\eta_{j\ell}\rvert) > 1.75$	$N_{jet} \geq 2$ $m_{jj} > 500\,GeV$ $\lvert\Delta y_{jj}\rvert > 4$

Reduce Top

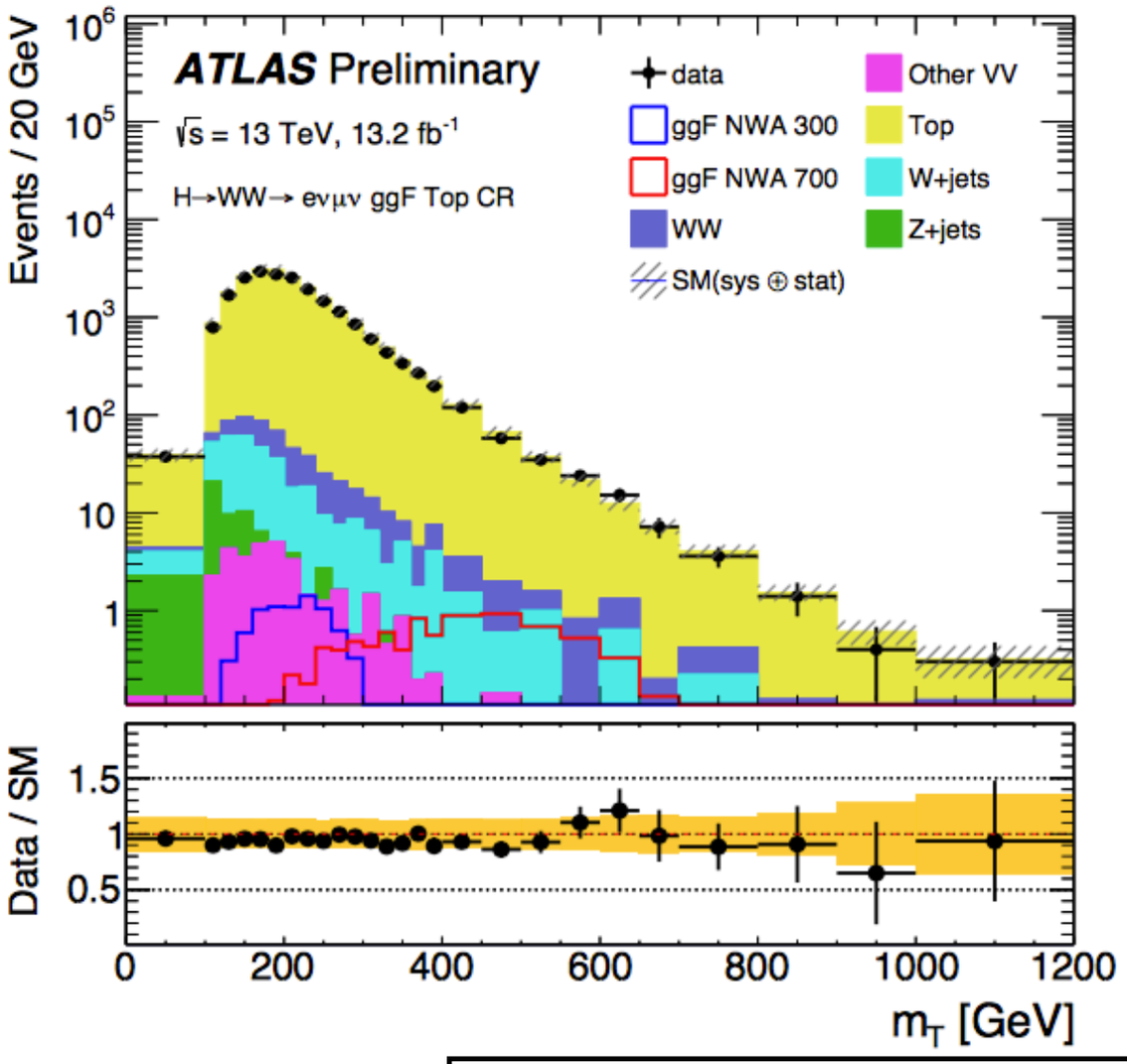
Reduce WW

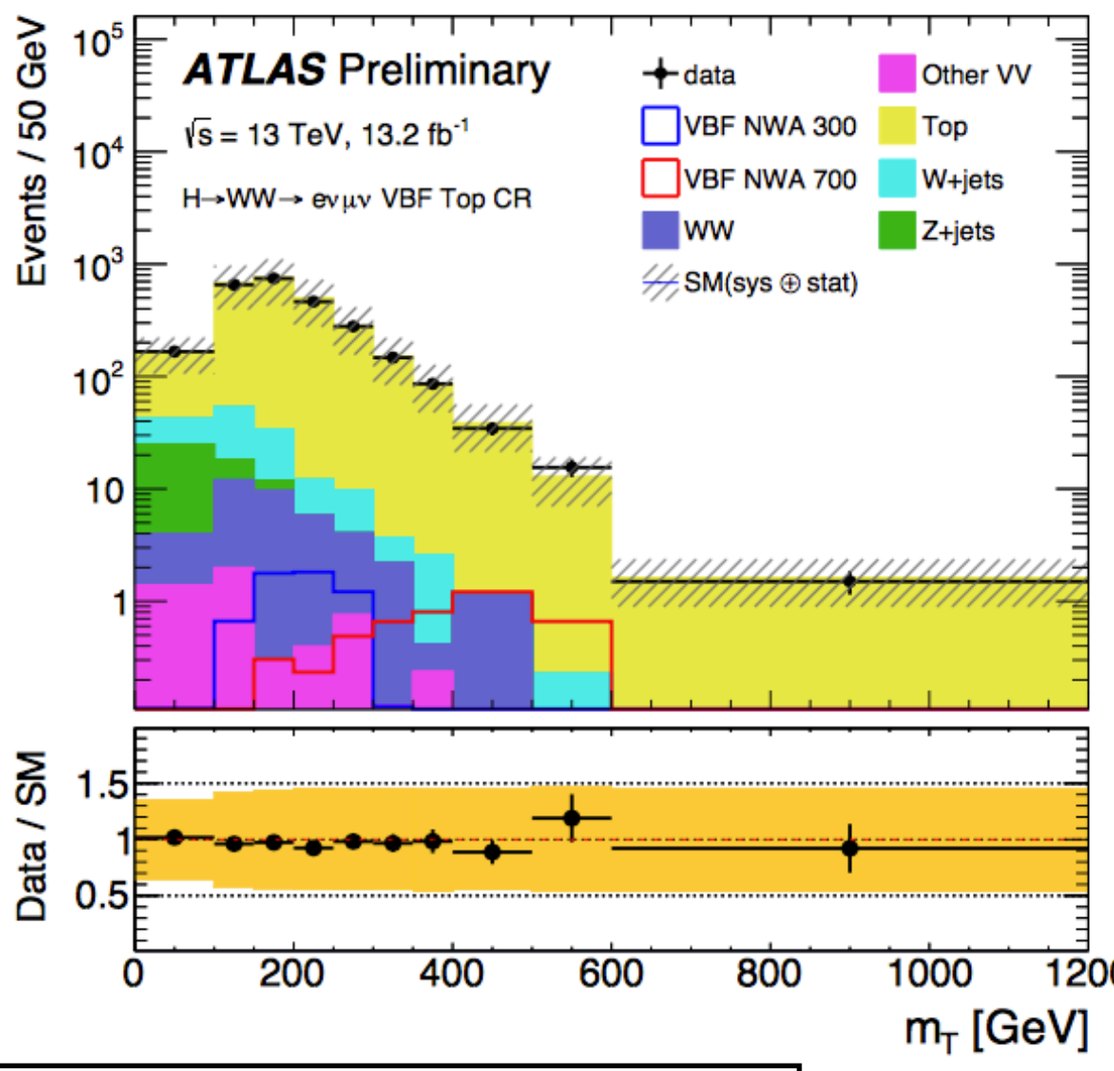
Reduce fake

Reduce Z+Jet

Top background

A top control region is defined by **reversing the b-tagging** requirement to validate the Monte Carlo modelling and the normalisation (the production cross section)

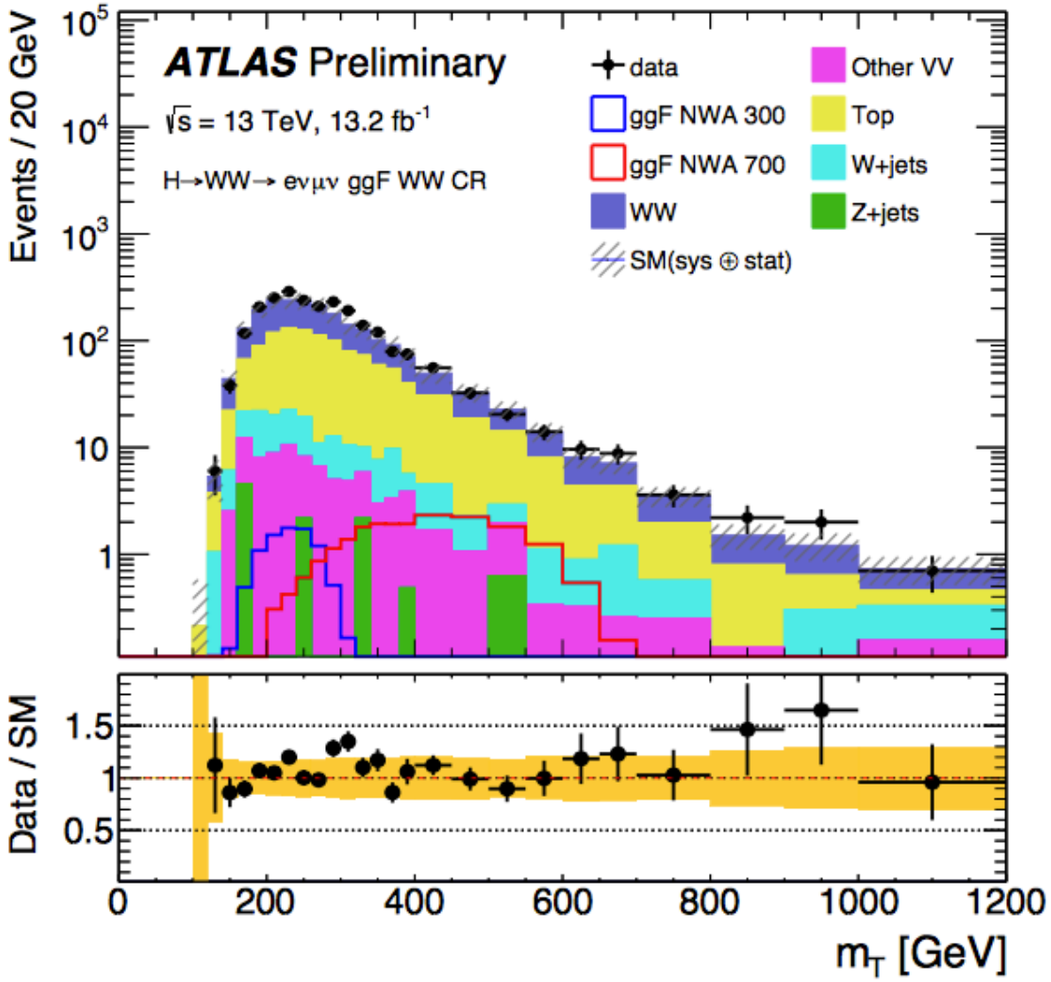


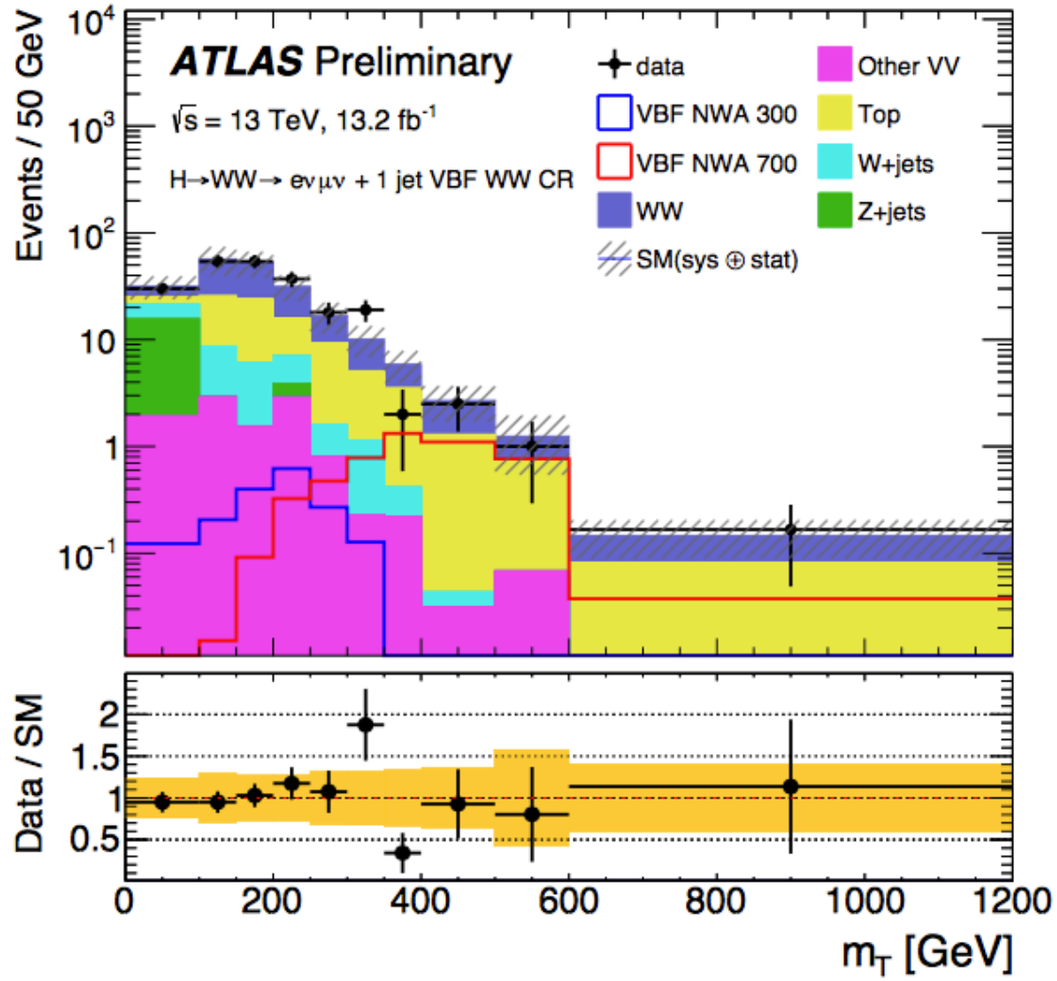


The post-fit normalisation factors (NF) from a simultaneous fit to all signal and control regions are $0.95^{+0.09}_{-0.08}$ and $0.96^{+0.13}_{-0.14}$ in the ggF (left) and the VBF (right) CRs.

WW background

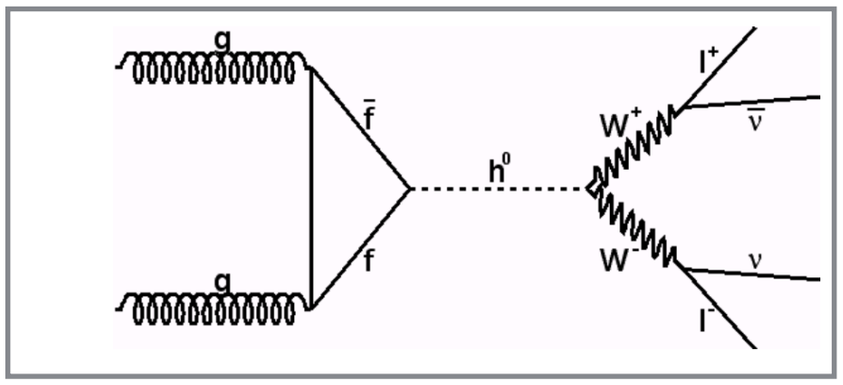
A WW control region is defined by **reversing the delta_eta_ll or mll** requirement to validate the Monte Carlo modelling and the normalisation (the production cross section)

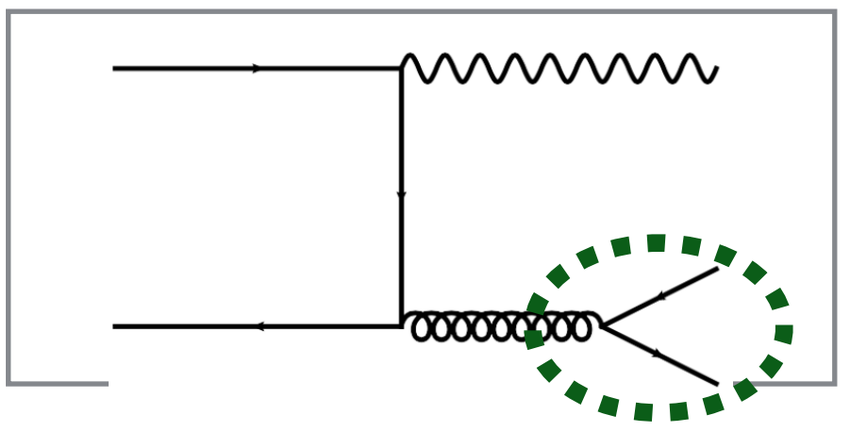


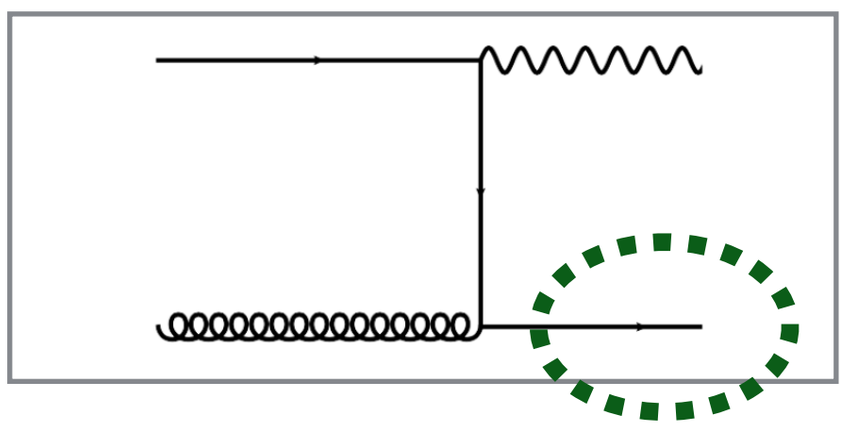


The NF is $1.3^{+0.2}_{-0.1}$ for quasi-inclusive ggF (left) control region, and $1.2^{+0.5}_{-0.3}$ for VBF 1 Jet (right) control region.

Fake background







Signal

W+Jets: if one jet fakes as a lepton, it will be with the same topology as signal

W+Jets in SR= id + id; W+Jets in CR=id+anti-id; F.F.=id/anti-id;

W+Jets in SR ⟷ W+Jets in CR ★ N_Id / N_Anti-id

Systematic uncertainty

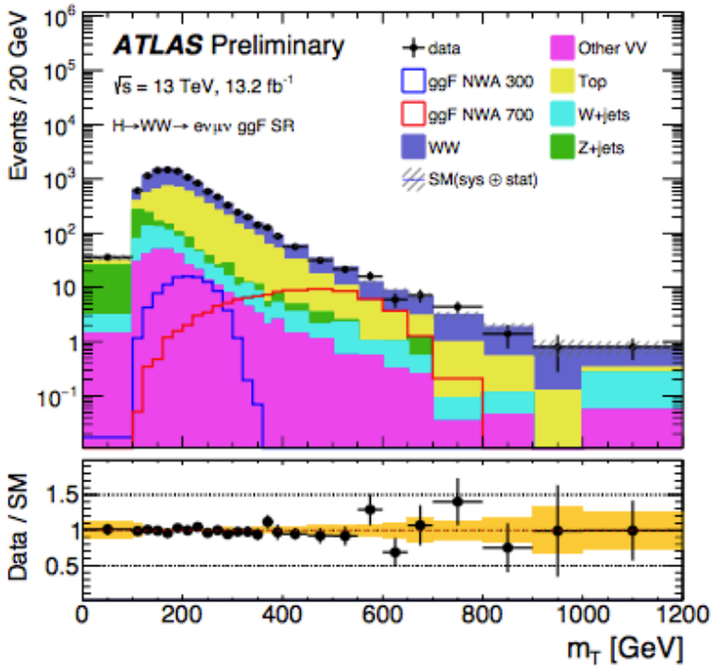
Experimental:

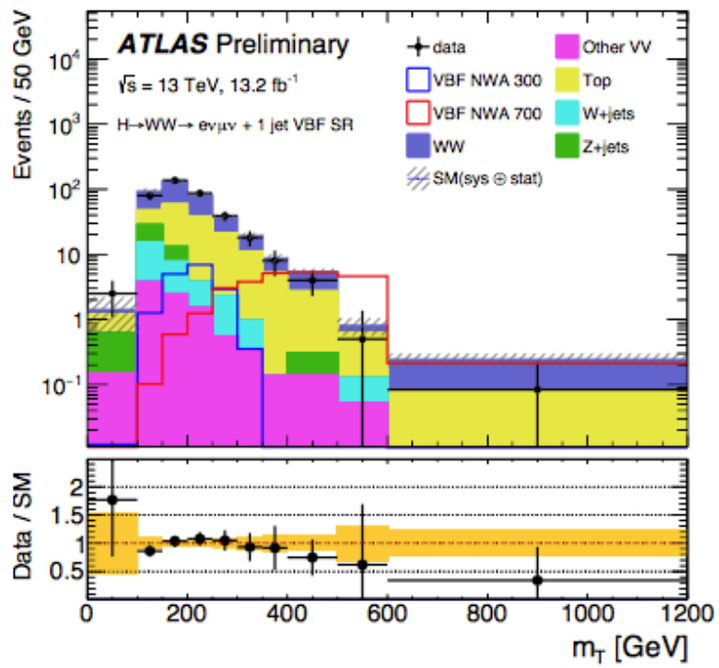
	Top-quark			WW		
Source	SR_{ggF}	SR_{VB1J}	SR_{VBF2J}	SR_{ggF}	SR_{VBF1J}	SR_{VBF2J}
Jet	4.6	9.8	12	1.3	16	23
b-tag	17	6.2	13	1.7	0.99	3.3
MET	0.09	0.03	0.37	0.22	0.18	0.46
JVT	2.1	0.73	2.2	1.0	0.45	1.8
MC Stat.	0.42	2.4	2.5	0.58	2.7	4.8

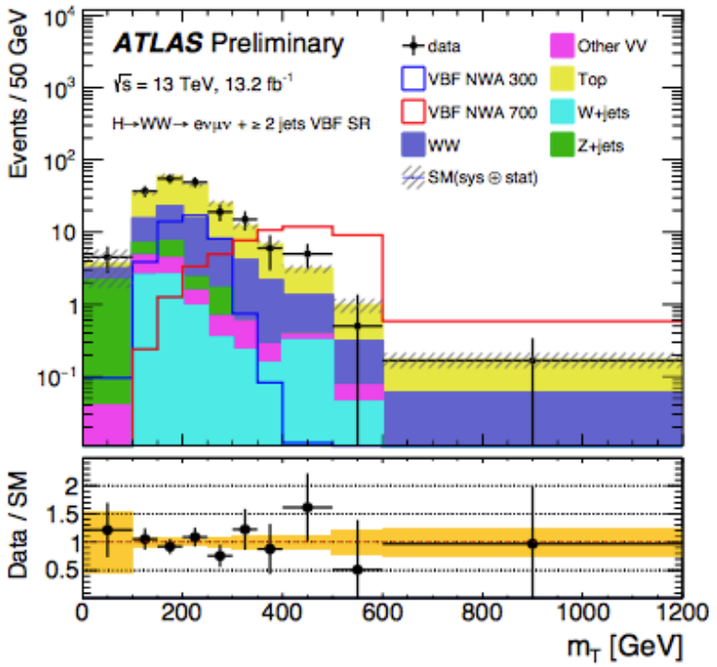
Theoretical:

PDF, high order correction on the matrix element, parton shower, and Monte Carlo mis-modelling correction……

Signal region



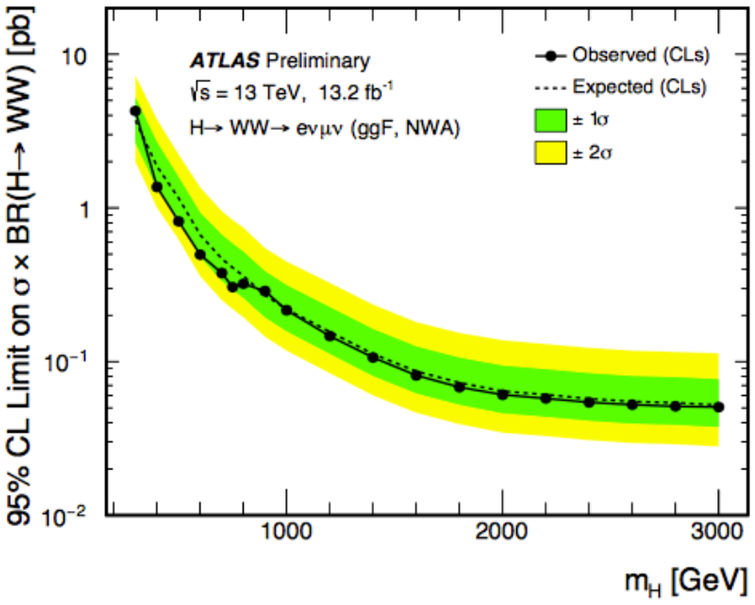




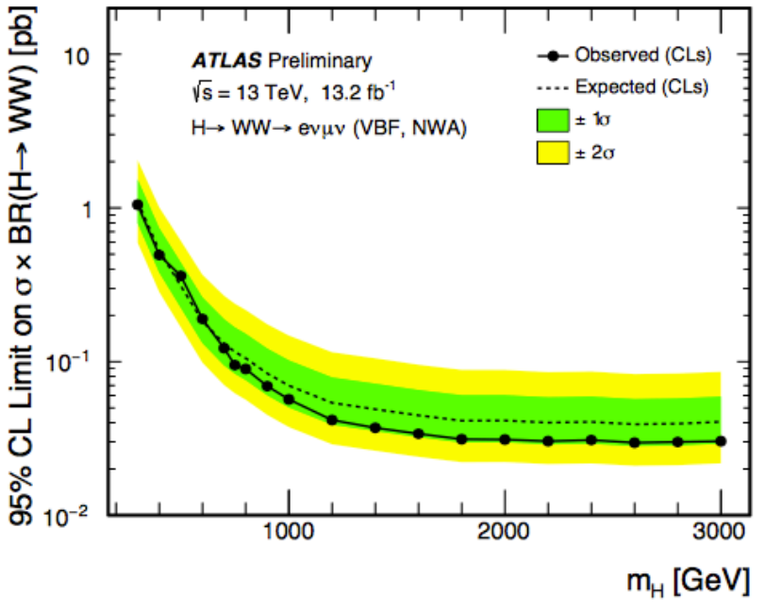
$$m_{\mathrm{T}} = \sqrt{(E_{\mathrm{T}}^{\ell\ell} + E_{\mathrm{T}}^{\mathrm{miss}})^2 - |\mathbf{p}_{\mathrm{T}}^{\ell\ell} + \boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}}|^2}$$

$$E_{\mathrm{T}}^{\ell\ell} = \sqrt{|\mathbf{p}_{\mathrm{T}}^{\ell\ell}|^2 + m_{\ell\ell}^2}\,.$$

Result interpretation

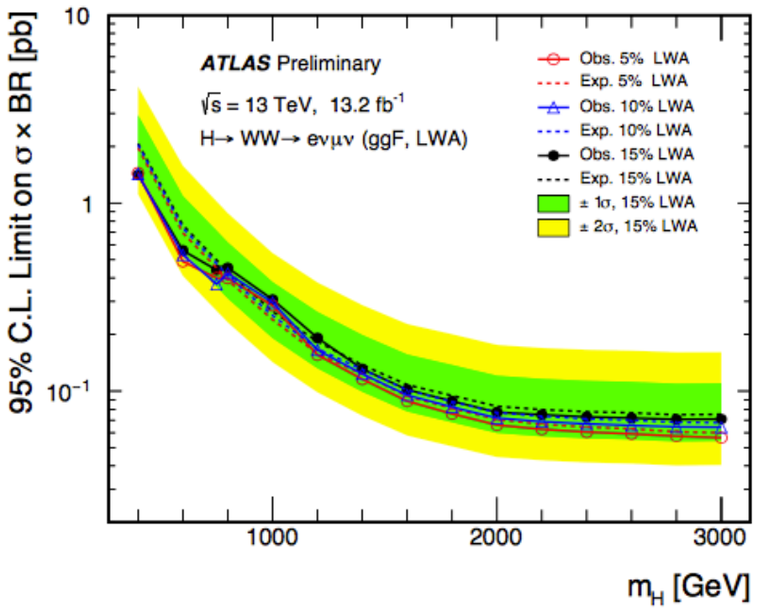


(a) NWA, ggF



(b) NWA, VBF

Nothing new is there now!



(c) LWA, ggF

New result with 3 times large data sample will come soon

Summary and proposal for 2017

1. A project about searching for a heavy higgs in WW->lvlv final state at ATLAS is carried out, and results with small data sample were released without finding it; the result with a larger data sample will come out soon.

2. In 2017, we will keep on going to search something new by a more generic final state if heavy higgs is not discovered in WW->lvlv final state: high pt Z (ll) + anything.

Thanks very much for the supporting from FCPPL.

BACK UP

The definition of CRs

WW $\mathrm{CR}_{\mathrm{ggF}}$	Top $\mathrm{CR}_{\mathrm{ggF}}$	WW $\mathrm{CR}_{\mathrm{VBF1J}}$	Top $\mathrm{CR}_{\mathrm{VBF}}$
Preselection cuts: $p_{\mathrm{T}}^{\mathrm{lead}} > 25\,\mathrm{GeV}$, $p_{\mathrm{T}}^{\mathrm{sublead}} > 15\,\mathrm{GeV}$, 3rd lepton veto, $m_{\ell\ell} > 10\,\mathrm{GeV}$			
$N_{b\text{-jet}} = 0$	$N_{b\text{-jet}} = 1$	$N_{b\text{-jet}} = 0$	$N_{b\text{-jet}} \geq 1$
$\lvert\Delta\eta_{\ell\ell}\rvert > 1.8$	$\lvert\Delta\eta_{\ell\ell}\rvert < 1.8$	($\lvert\Delta\eta_{\ell\ell}\rvert > 1.8$ or	–
$m_{\ell\ell} > 55\,\mathrm{GeV}$		$m_{\ell\ell} < 55\,\mathrm{GeV}$)	–
$p_{\mathrm{T}}^{\mathrm{lead}} > 45\,\mathrm{GeV}$		$p_{\mathrm{T}}^{\mathrm{lead}} > 25\,\mathrm{GeV}$	$p_{\mathrm{T}}^{\mathrm{lead}} > 25\,\mathrm{GeV}$
$p_{\mathrm{T}}^{\mathrm{sublead}} > 30\,\mathrm{GeV}$		$p_{\mathrm{T}}^{\mathrm{sublead}} > 25\,\mathrm{GeV}$	$p_{\mathrm{T}}^{\mathrm{sublead}} > 15\,\mathrm{GeV}$
$\max(m_{\mathrm{T}}^{W}) > 50\,\mathrm{GeV}$		–	–
Excluding VBF		VBF1J	VBF1J or VBF2J
VBF1J and VBF2J		phase space	phase space