Estimation of WW Background in the $H \to WW^*$ Analysis with the Atlas Detector

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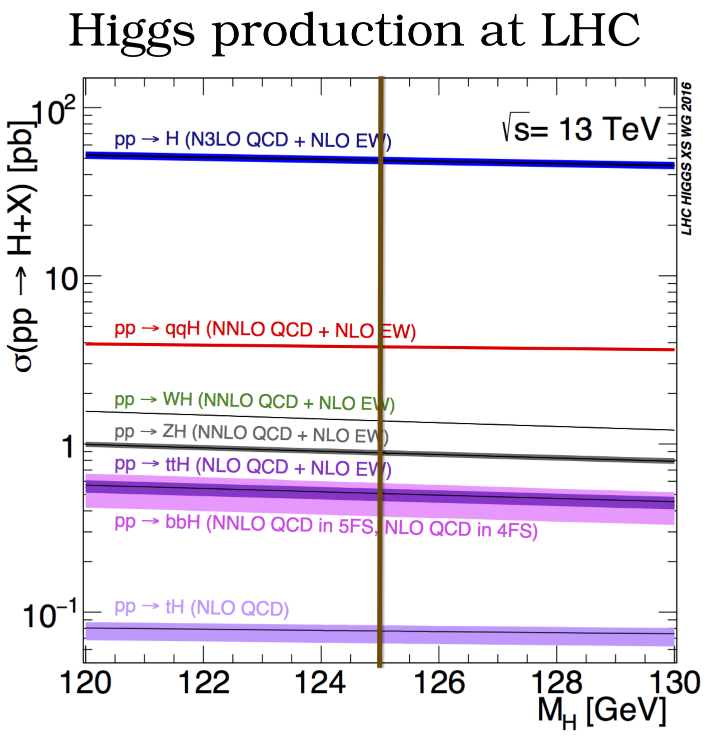
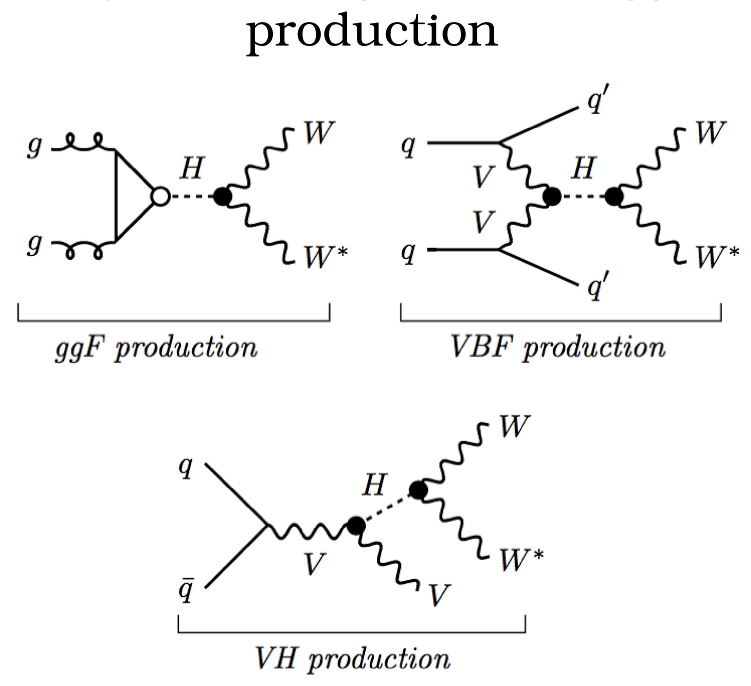
Introduction

- We focus on analysis [1] of $H \to WW^{(*)} \to l\nu l\nu$ with 36.5 fb^{-1} data samples collected with $\sqrt{s} = 13$ TeV in Run-2.
- Why $H \to WW^{(*)} \to l\nu l\nu$ channels?
  - The $H \to WW^{(*)}$ decay has second largest branching fraction, 22%.
  - Sensitive final state signature for experiment.
- Main backgrounds: WW, Top quarks, $Z \to \tau\tau$ and other backgrounds.
- Difficulties in Run-2: WW increases by 2 times but $t\bar{t}$ increases by 3.5 times from 8 TeV to 13 TeV.
- Use m_T fit the results for ggF and use BDT fit the results for VBF.

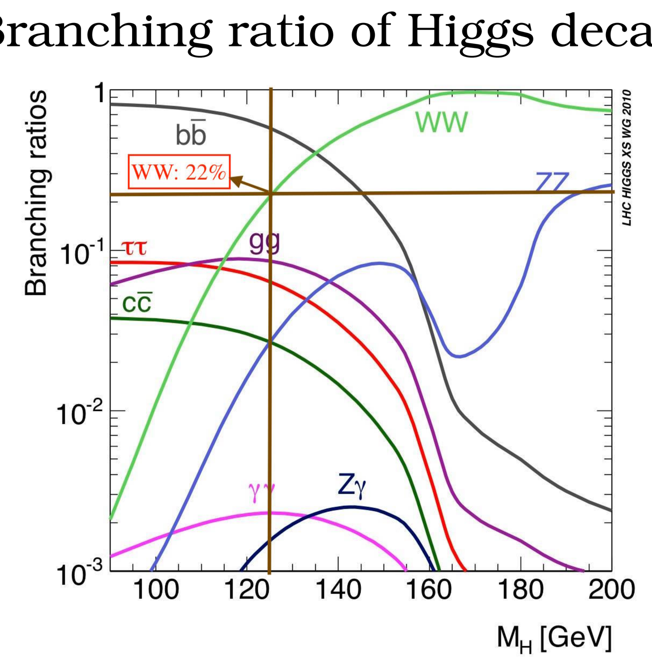
Higgs production at LHC



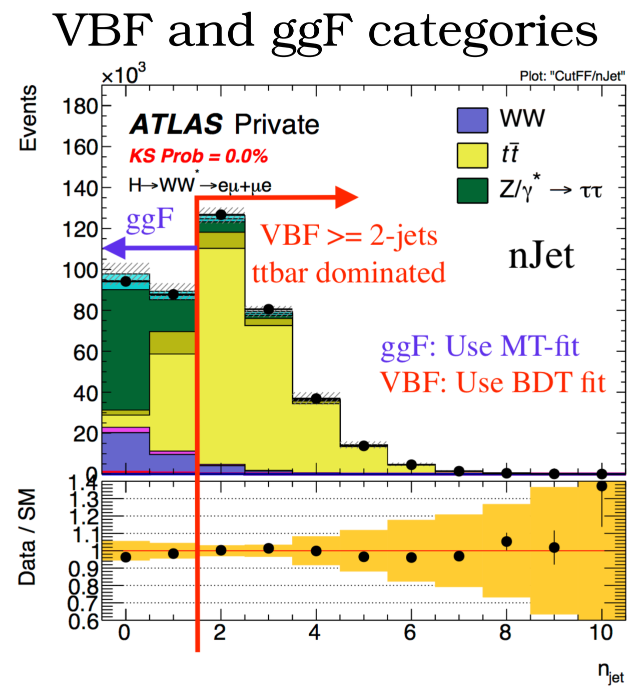
Feynman diagrams of Higgs production



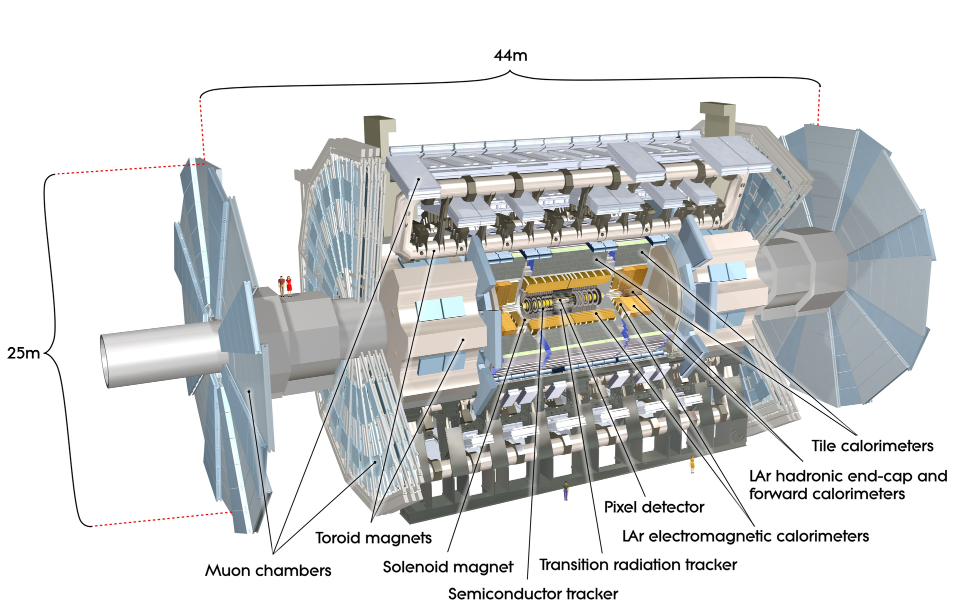
Branching ratio of Higgs decay

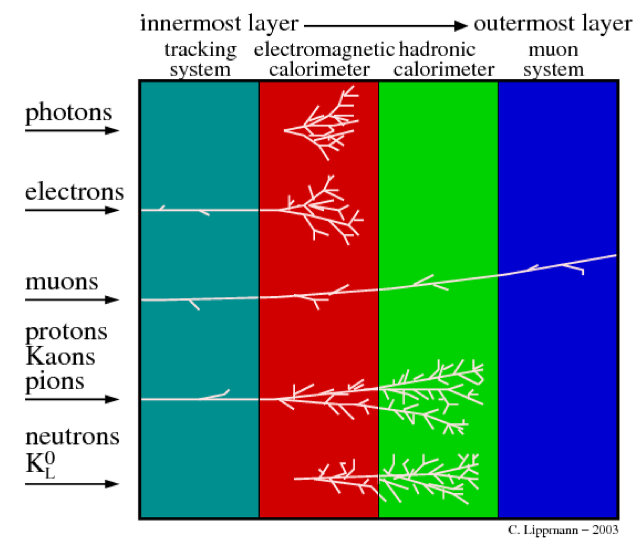


VBF and ggF categories



A Toroidal LHC ApparatuS and Particle Identification





The m_T and m_{T2} variable

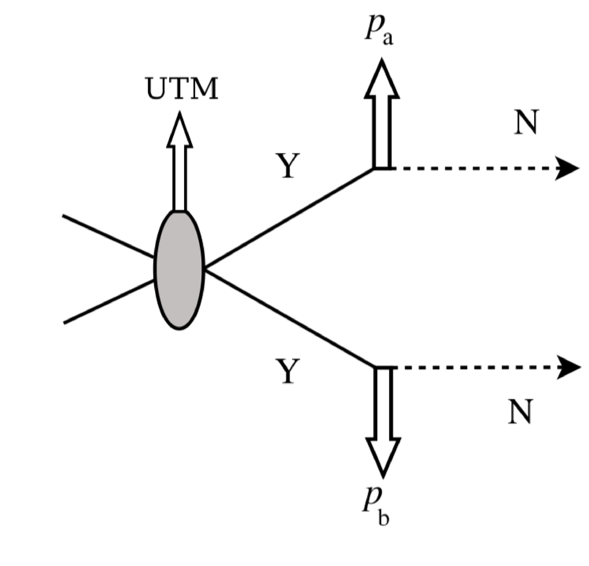
The idea of stransverse mass [2], m_{T2}, is originated from transverse mass, m_T. In this study, the invisible particles are assumed as neutrinos. The m_T and m_{T2} are defined as

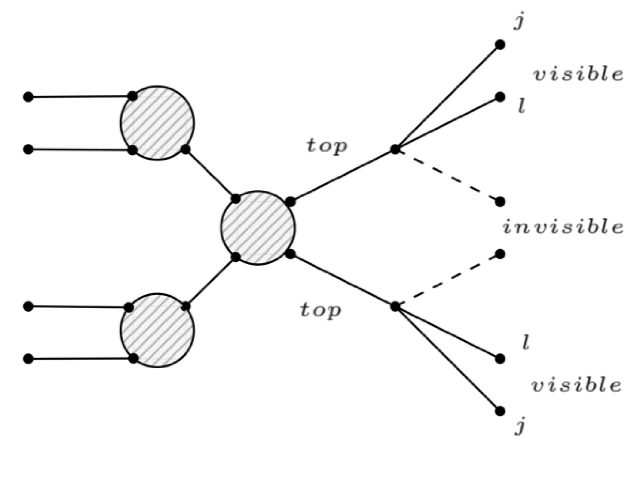
$$m_T = \sqrt{(E_T^{ll} + P_T^{\nu\nu})^2 - |P_T^{ll} + P_T^{\nu\nu}|^2} \tag{1}$$

$$m_{T2}(\mu_N) \equiv min_{\vec{p}_T^{\,a} + \vec{p}_T^{\,b} = \vec{p}_T^{\,miss}} \{max[m_T(p_T^a, p_T^1; \mu_N), m_T(p_T^b, p_T^2; \mu_N)]\} \tag{2}$$

The m_T and m_{T2} can give us an approximation to particle mass which decays into visible and invisible particles.

We use only leading jet for m_{T2} evaluation, to mimic the jet flavor compositions of $t\bar{t}$ in the b-vetoed signal region.





Acknowledgement

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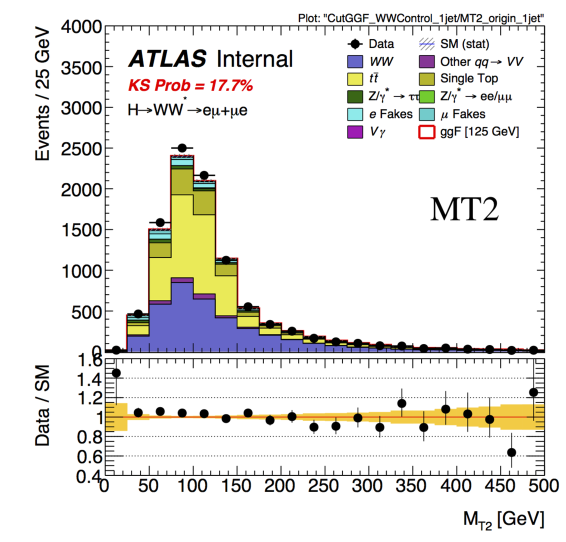
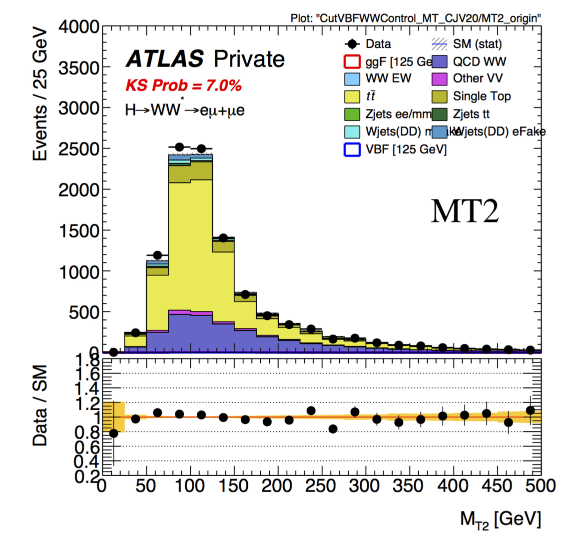
Methods

In the $H \to WW^{(*)} \to l\nu l\nu$ analysis, the estimation of WW background is important because WW background is irreducible. We can define normalization factor β and extrapolation factor α to estimate WW background in signal region.

$$B_{SR}^{est} = B_{SR} \cdot \underbrace{N_{CR}/B_{CR}}_{Normalization\,\beta} = N_{CR} \cdot \underbrace{B_{SR}/B_{CR}}_{Extrapolation\,\alpha} \tag{3}$$

WW purity can be increased with high m_{T2} phase space, $m_{T2} > 160$ GeV. The m_{T2} is used to construct WW CR/VR for both ggF and VBF.

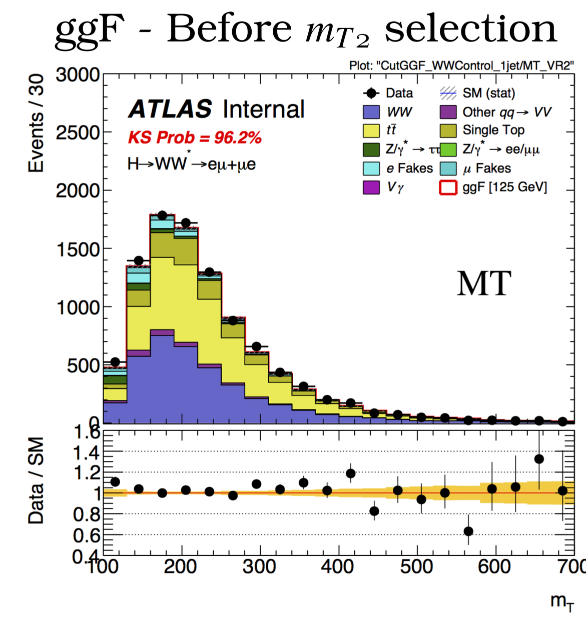




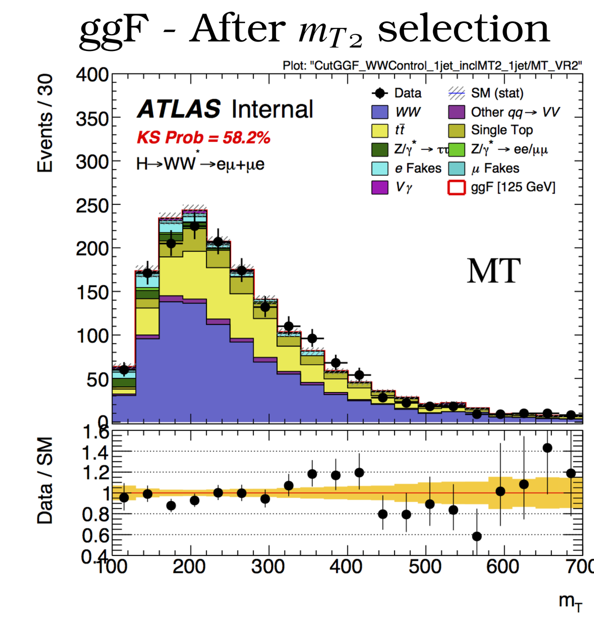
Results and Conclusion

- ggF: original WW CR → new WW CR
  - WW purity: 39% → 54%
  - Ratio of WW to Top: 0.79 → 1.62
  - m_{T2} cut efficiencies of Top: 12%
  - Normalization factor: 1.06 → 0.95
  - Extrapolation factor: 0.29 → 1.16
- VBF: new WW VR
  - WW purity: 40%
  - Ratio of WW to Top: 0.79
  - m_{T2} cut efficiencies of Top: 18%
  - Normalization factor: 0.90
  - Extrapolation factor: 0.07

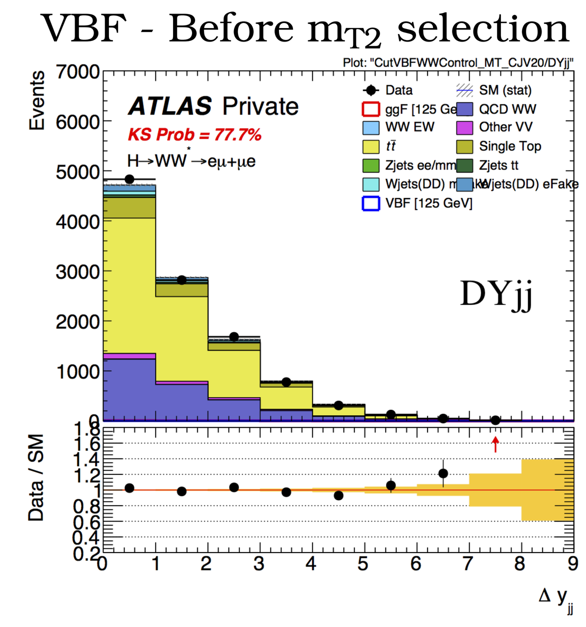
ggF - Before m_{T2} selection



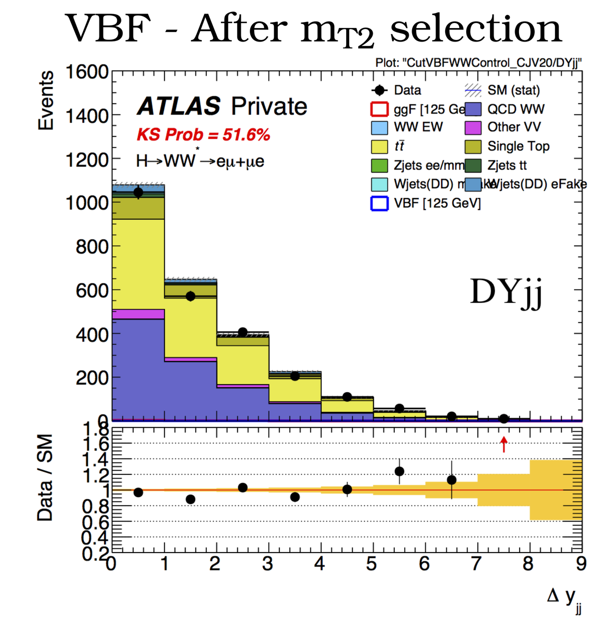
ggF - After m_{T2} selection



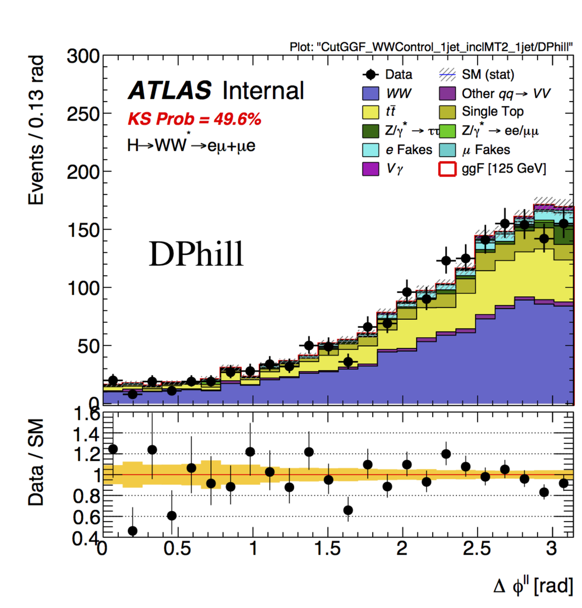
VBF - Before m_{T2} selection

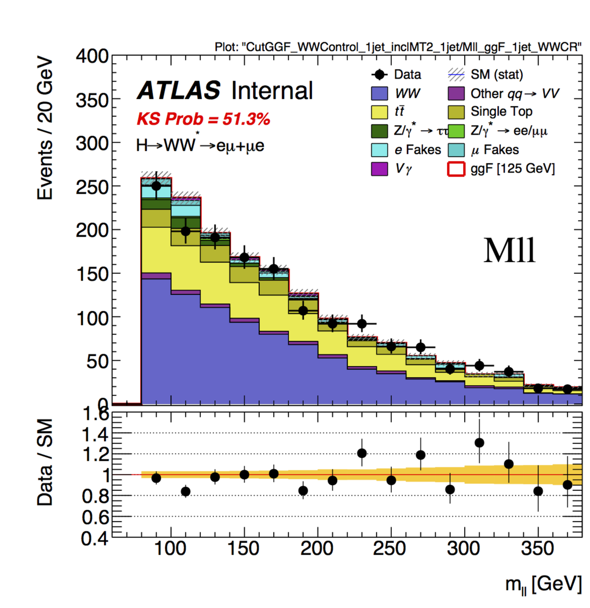


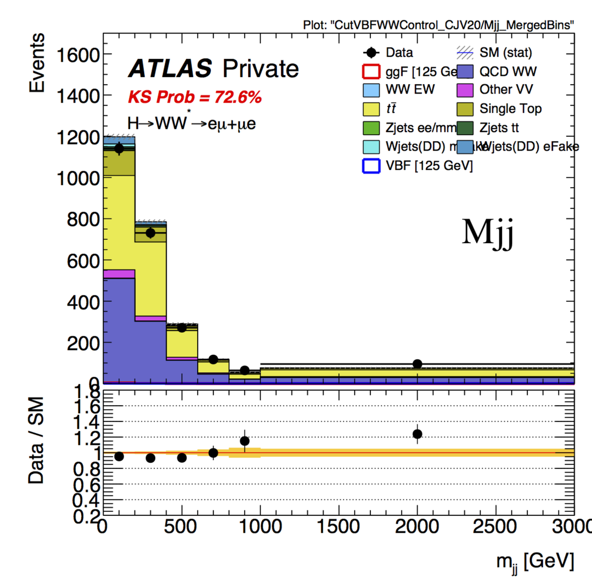
VBF - After m_{T2} selection

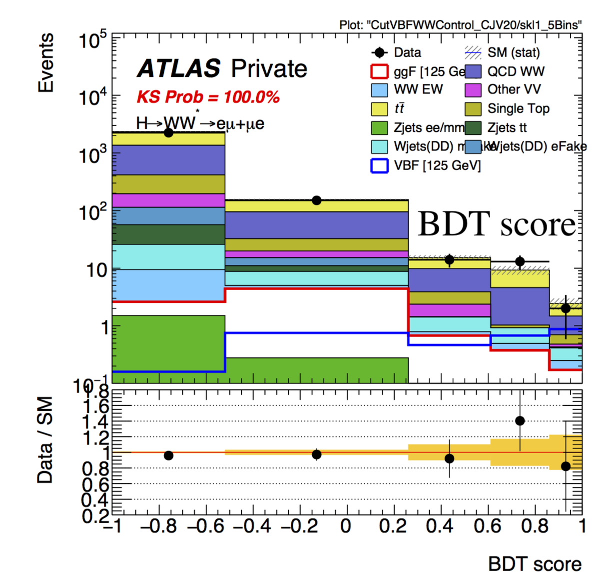


Data/MC performances in new WW CR/VR:









In both two new WW CR/VR, we have good match of data and MC. We also check the theoretical uncertainty of new WW CR/VR including generator comparison and QCD scale variation. With these studies, we can have a deeper understanding of the WW background in the SR which is important in HWW decay channel.

References

[1] The ATLAS Collaboration.
Observation and measurement of higgs boson decays to ww* with the atlas detector.
Phys. Rev., D92(1):012006, 2015.

[2] Hsin-Chia Cheng and Zhenyu Han.
Minimal kinematic constraints and m_{T2}.
Journal of High Energy Physics, 2008(2):063, 2008.

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