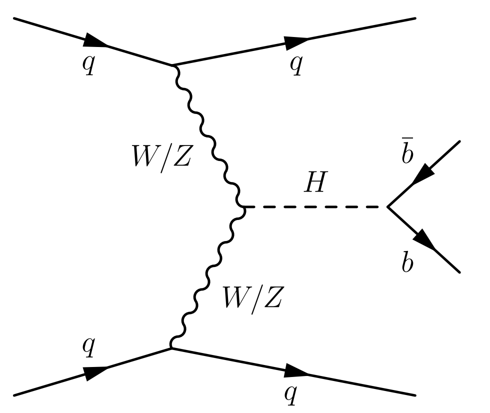
SEARCH FOR THE VECTOR BOSON FUSION PRODUCED STANDARD MODEL HIGGS BOSON DECAYING TO BOTTOM-QUARKS WITH THE ATLAS DETECTOR

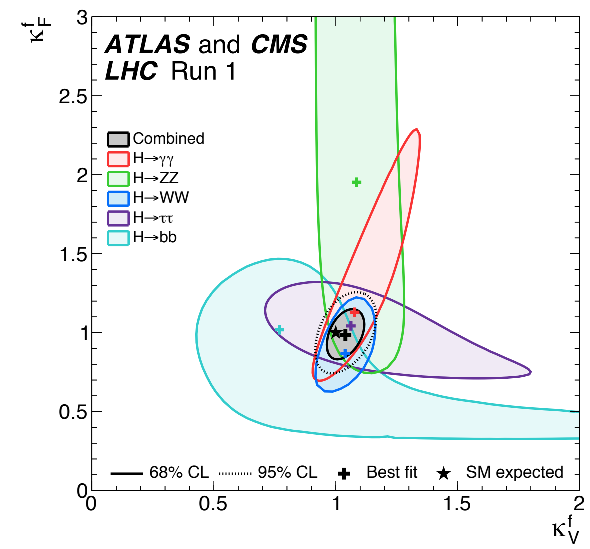
Introduction



Reasons for this search

- The measurement of the Higgs boson's coupling has been investigated mainly in the bosonic sector (clear signatures), but it's challenging for fermionic decays [1,2].
- The "Vector Boson Fusion" (VBF) mechanism has a peculiar topology, that can be exploited in order to enhance the signal to background ratio.
- Higgs boson's decay into a bottom pair has the highest Branching Ratio (~58%).

The analysis on these channels conducted on **Run-1 (2012)** data [3] has shown the main problems affecting such a search: trigger acceptance and background modelling. The analysis on **Run-2 (2016)** data has been aimed to target the weak points and sensibly enhance the sensitivity.



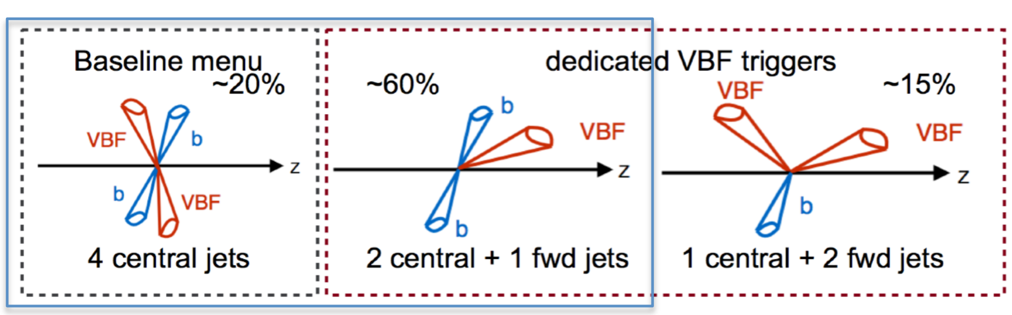
Trigger

The peculiar topology of the VBF process:

- Events with 4 jets: 2 in the central region of the detector (**b-jet**), stemming from the bottom quarks; 2 in the forward/backward region (**VBF-jet**), produced from light quarks.
- Little additional hadronic activity in the central region of the detector.
- Big pseudo-rapidity separation between the VBF-jets.

Used **topological triggers** to better identify the VBF signature

- During **Run-1 (2012) :** Topological triggers available only for a limited amount of time of the data-taking period (~20%).
- During **Run-2 (2016) :** Topological triggers available for the full data-taking period. Different trigger categories according to the position and the multiplicity of jets (used only the two most sensible regions).



Expected additional gain during **2017**, due to the introduction at Trigger level of a new component:

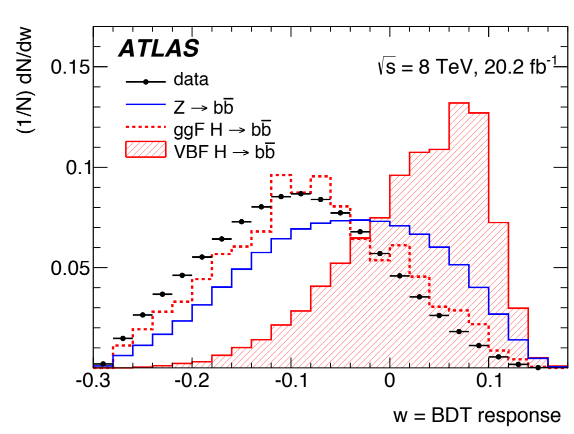
- **L1Topo** : provides topological selections based on L1 Trigger Objects.

MVA

Additional signal/background discrimination obtained by means of multivariate analysis techniques (Boosted Decision Tree)

Input variables:

- Related to the peculiar VBF topology
- Uncorrelated to the m_{bb} invariant mass spectrum

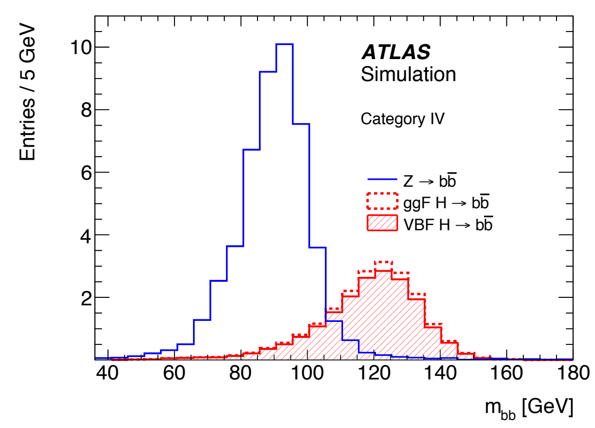


Events categorized according to the output of the multivariate discriminating variable

- **Run-1 (2012)** analysis **:** used 4 BDT categories
- **Run-2 (2016)** analysis **:** used 8 BDT categories (4 for each Trigger category)

Signal extrapolation

The signal extrapolation is performed with a simultaneous fit (profile likelihood approach) on all the BDT categories. Systematic uncertainties are included in the fit as additional nuisance parameters (introduce Gaussian constraints).



Resonant components of the fit are taken from Monte Carlo simulations :

- VBF (ggF) Higgs ➔ bb
- EWK (QCD) Z ➔ bb + jets

For the non-resonant background there are not Monte Carlo samples with enough statistics :

- The background has been parameterized with functions

Background parameterization :

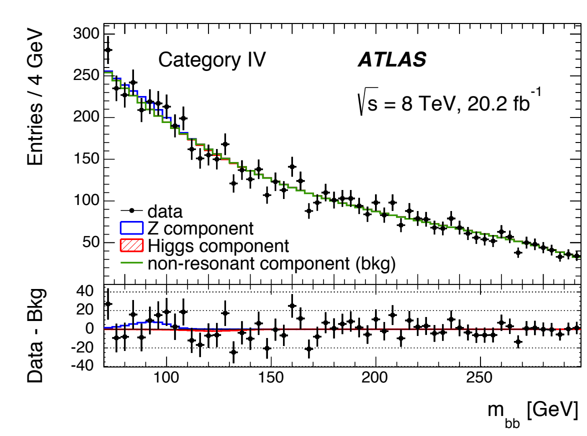
- During **Run-1 (2012) :** used a different function (Bernstein polynomial) for each BDT region.
- During **Run-2 (2016) :** used a common function (Bernstein polynomial) for all the BDT regions and linear corrections (first degree polynomial), one for each BDT region.

Results from the Run-1 (2012) analysis

The analysis of **Run-1 (2012)** data produced results in agreement with the Standard Model:

$$\mu = \sigma/\sigma_{SM} = -0.8 \pm 2.3$$

The accuracy of the measurement is limited by the systematic uncertainty (main contribution coming from the background parameterization).



Source of uncertainty		Uncertainty on μ MVA	Uncertainty on μ Cut-based
Experimental uncertainties	Detector-related	$+0.2/-0.3$	$+1.6/-1.2$
	MC statistics	±0.4	±0.1
Theoretical uncertainties	MC signal modelling	±0.1	±1.3
	Z yield	$+0.6/-0.5$	±1.4
Non-resonant background modelling	Choice of function	±1.0	±1.0
	Sideband statistics	±1.7	±3.7
Statistical uncertainties		±1.3	
Total		±2.3	$+4.6/-4.4$

Future plans

The results obtained with the analysis of **Run-1 (2012)** data show the possibility of extracting a signal from this production channel. A further request to enhance the purity of the event selection exploits the presence of a highly impulsive photon in the central region of the detector [4]. The ATLAS experiment published the first results for this new channel [5].

- We are evaluating the possibility of combining this new channel with the **Run-2 (2016)** search.

References

[1] https://arxiv.org/abs/1507.04548
[2] https://arxiv.org/abs/1606.02266
[3] https://arxiv.org/abs/1606.02181
[4] https://arxiv.org/abs/0710.2809
[5] ATLAS-CONF-2016-063

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