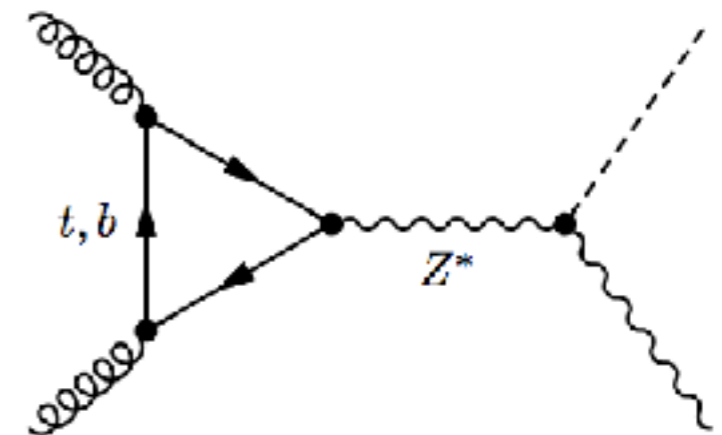
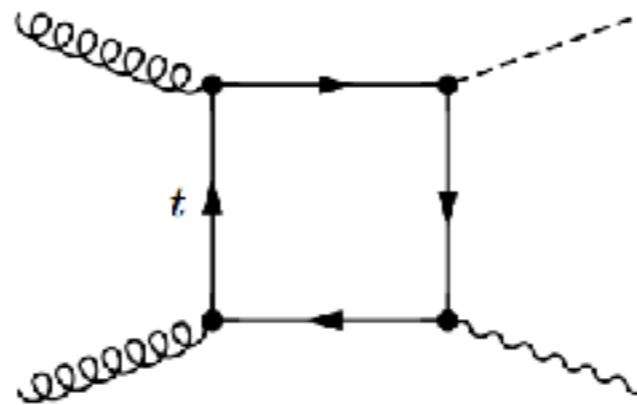
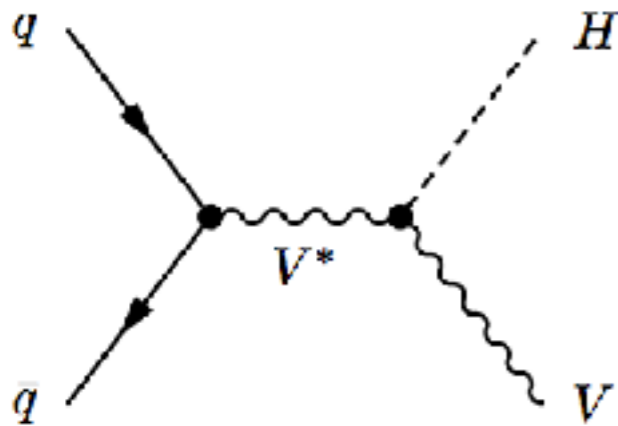


# WG1:VH Introduction

Emanuele Re, Francesco Tramontano, Luca Perrozzi, CP

Towards the 14th Workshop of the LHC Higgs Cross Section Working Group

Cern, 29 January 2018



## Next LHC HXSWG General Workshop

- ▶ <https://indico.cern.ch/event/665524/>
- ▶ 26-27 March 2018 [WG1 session on Monday 26]
- ▶ 2 VH talks foreseen: 20'(th.)+20'(exp.)

Today's meeting: organise our **contributions to the workshop**  
and the next step of the HXSWG VH **activities for the next months**

# Goal(s) of this meeting

- ▶ **collect material towards 14th LHC HXSWG General Meeting (end of March)**
- ▶ discuss background modeling activity within HXSWG:VH
- ▶ overview of recent theory developments
- ▶ any feedback from experimental collaboration

Two dedicated talks for VH: 20'(theory) + 20'(experiments)

Usual structure - cover recent developments from theory side, review experimental results (mainly from VH(bb)).

Possible dedicated discussion on **UE/PS/MPI/had uncertainty treatment** (transversal to H production modes / channels)

## **Simplified Template Cross Section:**

- ▶ jointly covered with WG2
- ▶ not a lot of development from 2017 workshop
- ▶ feedback from first implementation in experimental analyses

# Goal(s) of this meeting

- ▶ collect material towards 14th LHC HXSWG General Meeting (end of March)
- ▶ **discuss background modeling activity within HXSWG:VH**
- ▶ overview of recent theory developments
- ▶ any feedback from experimental collaboration

## "Kick-off" meeting today

We have some mandate from WG1 to discuss background modeling relevant for Higgs analyses, in specific / well motivated cases (e.g.  $tt+bb$  for  $ttH$ ).

It's possible to prepare a public note from the HXSWG, for well defined studies which don't need to wait for a full YR.

**V+heavy flavor production:** important background for  $VH(bb)$  searches

Goal of a first **simple** HXSWG  $V+hf$  study

- ▶ support experimental collaboration in choice of MC generator/setup

Possible first approach:

- ▶ define  $VH(bb)$  phase space (compromise selection between ATLAS and CMS cuts)
- ▶ suite of MC prediction comparison
- ▶ accounting for constraints in MC production for experimental collaboration (CPU cost, timescales)

# Goal(s) of this meeting

- ▶ collect material towards 14th LHC HXSWG General Meeting (end of March)
- ▶ **discuss background modeling activity within HXSWG:VH**
- ▶ overview of recent theory developments
- ▶ any feedback from experimental collaboration

## "Kick-off" meeting today

- ▶ assess interest of experiments for this type of study (feedback on which results are useful is welcome)
- ▶ gauge who's interested in contributing

Target -  
well contained study on a  
~short timescale  
(~months, not ~years)

## Goal of a first **simple** HXSWG V+hf study

- ▶ support experimental collaboration in choice of MC generator/setup

## Possible first approach:

- ▶ define VH(bb) phase space (compromise selection between ATLAS and CMS cuts)
- ▶ suite of MC prediction comparison
- ▶ accounting for constraints in MC production for experimental collaboration (CPU cost, timescales)

# Goal(s) of this meeting

- ▶ collect material towards 14th LHC HXSWG General Meeting (end of March)
- ▶ discuss background modeling activity within HXSWG:VH
- ▶ **overview of recent theory developments**
- ▶ any feedback from experimental collaboration

## From last HXSWG VH meeting:

- ▶ NNLO QCD WH(bb) predictions *[talk today]*  
(Fabrizio Caola, Gionata Luisoni, Kirill Melnikov, Raoul Röntschi)
- ▶ VH(bb) @ NNLO QCD in production and decay *[see June meeting]*
- ▶ Towards NNLOPS for VH *[see June meeting, maybe update by end of March?]*
- ▶ NLO QCD+EW VH Monte Carlo event generation *[talk today]*  
(Federico Granata, Jonas M. Lindert, Carlo Oleari, Stefano Pozzorini)
- ▶ First look at higher-orders for loop-induced ggZH production  
(unlikely to have updates for NLO calculation for March  
we could look at 0+1j merged samples in Sherpa/Madgraph)

# BACK-UP

# Previous WG1 VH meetings

- ▶ <https://indico.cern.ch/event/648099/> [June: theory overview]
- ▶ <https://indico.cern.ch/event/666958/> [October: experimental overview]



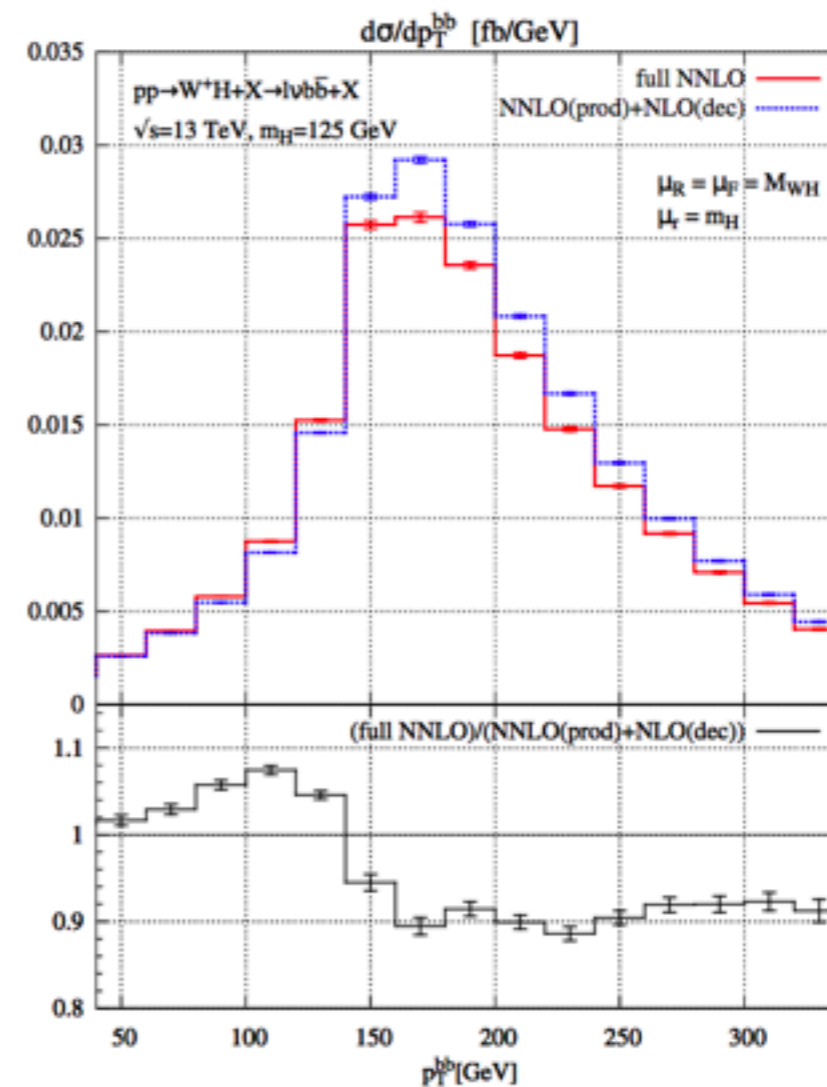
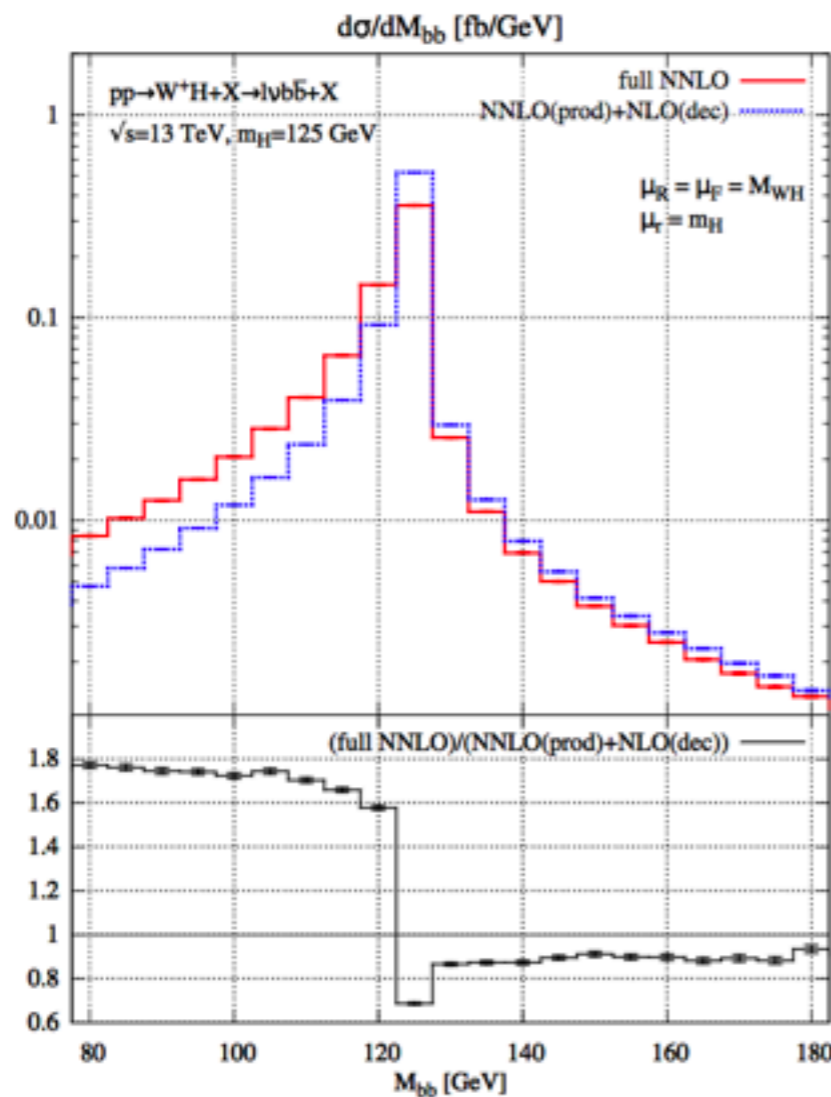
# VH(bb) @ NNLO in production and decay

Large  $m(bb)$  lineshape effect from NNLO H(bb) decay -  
 how much of it is covered when looking at showered events?

<https://arxiv.org/pdf/1705.10304.pdf>

$\sigma$ (fb)	NNLO(prod)+NLO(dec)	full NNLO
$W^+H$	$4.23 \pm 0.02$	$3.96 \pm 0.02$

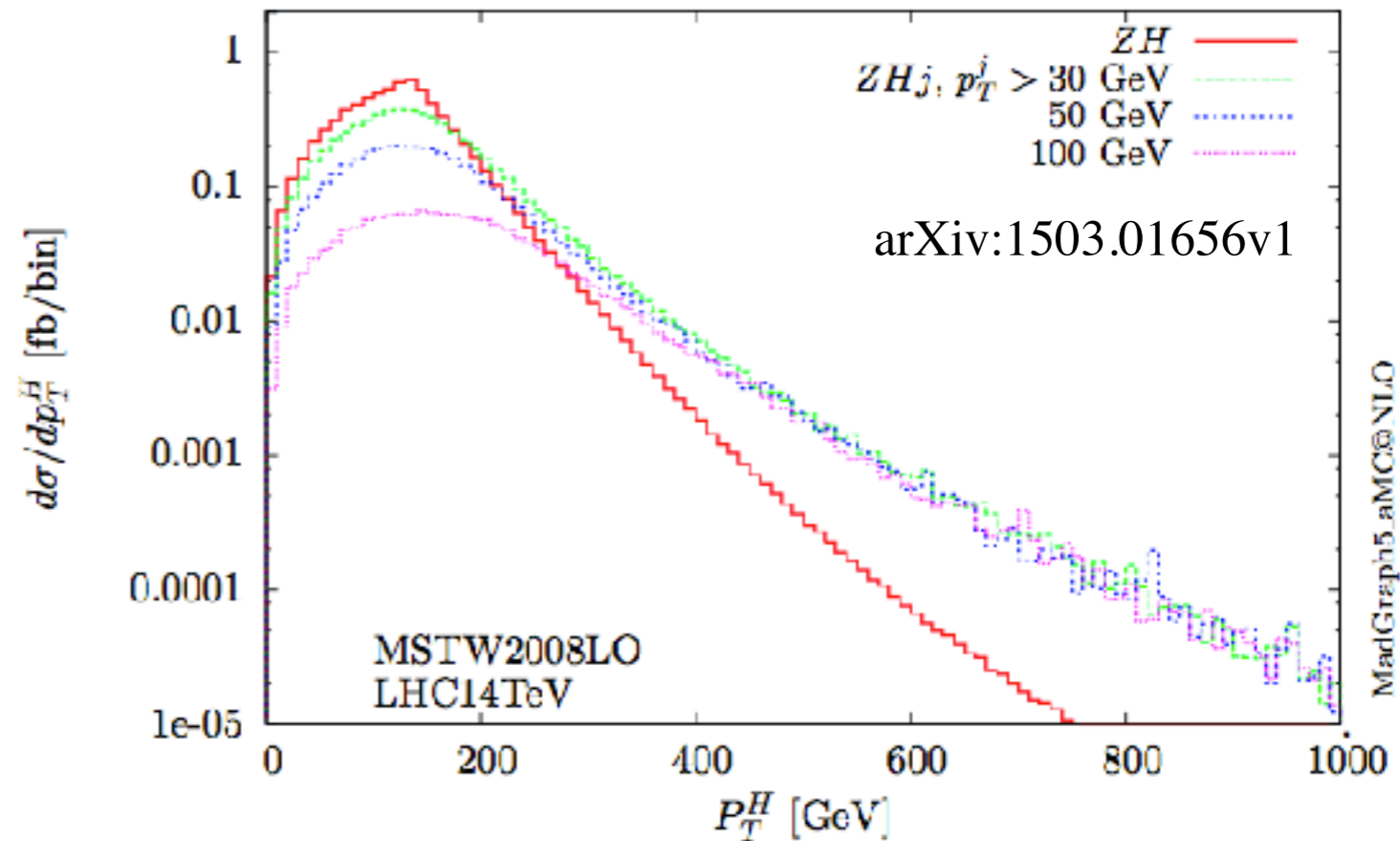
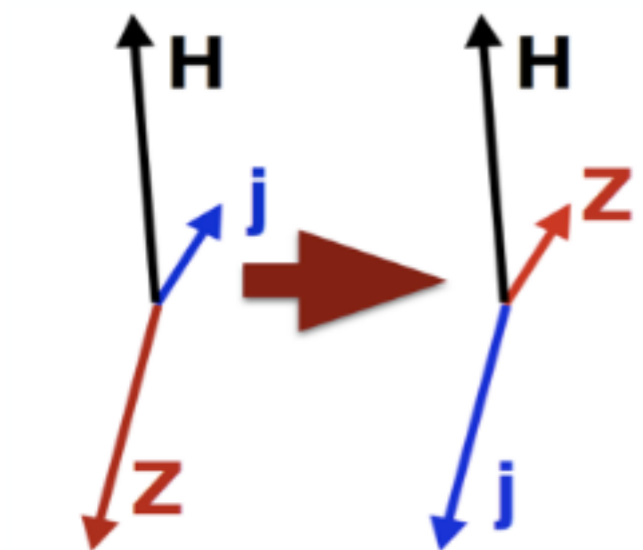
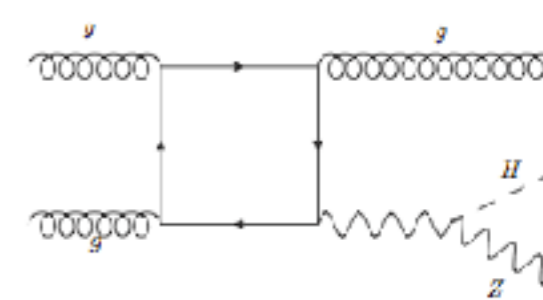
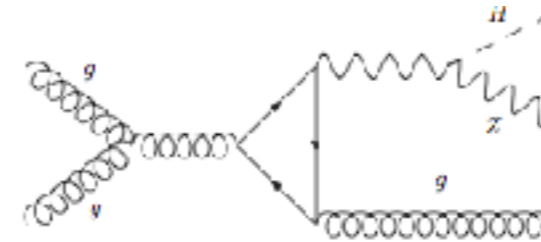
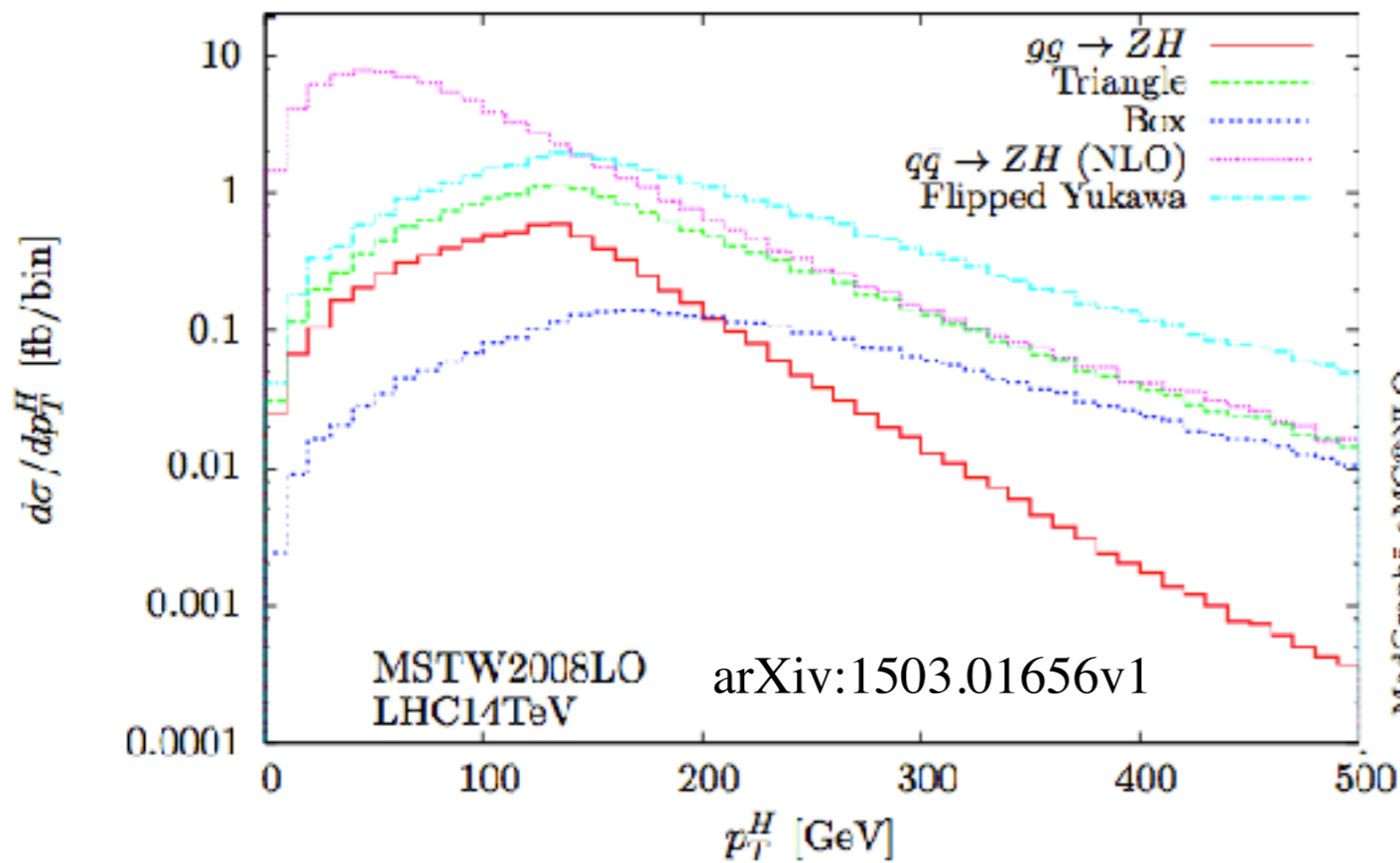
$K_{fact} \sim -6.5\%$



**LHC13 analysis:**  $p_T^l > 15$  GeV,  $|\eta_l| < 2.5$ ,  $p_T^W > 150$  GeV, 2  $b$ -jets  $p_T^b > 25$  GeV,  $|\eta_b| < 2.5$ , flavour- $k_T$   $R = 0.5$ .

Left panel:  $M_{bb}$  spectrum of the  $b$ -jets pair. Right panel:  $p_T^{bb}$  spectrum of the  $b$ -jets pair. Lower panels: spectra normalized to the NNLO+nlo results.

# ggZH (loop-induced) diagrams



# Simplified Template Cross Sections - VH

## STXS: separating measurements from interpretations

- ▶ maximize measurements sensitivity
- ▶ minimize theory dependence (models&systematics)
- ▶ combine **all decay channels**
- ▶ measure **XS instead of signal strengths**
- ▶ measure XS separately for **production modes**
- ▶ measure XS in **simplified fiducial volumes**
- ▶ allow for advanced analysis techniques (**MVAs**)

## Exclusive phase space regions (“bins”) defined to

- ▶ maximize experimental sensitivity
- ▶ minimize dependence on theory uncertainties directly folded into the measurements
- ▶ provide sensitivity to BSM scenarios

$$\sigma^{\text{meas}} = A^{\text{ggH}} \times \mu_{\text{ggH}} \times \sigma_{\text{ggH}}^{\text{SM}} + A^{\text{VBF}} \times \mu_{\text{VBF}} \times \sigma_{\text{VBF}}^{\text{SM}} \quad \begin{array}{l} A^{\text{ggH}} \\ A^{\text{VBF}} \end{array} \begin{array}{l} \text{Signal acceptance} \\ \text{theory dependent} \end{array}$$



$$\sigma^{\text{meas}} = A_a^{\text{ggH}} \times \sigma_a^{\text{ggH}}^{\text{SM}} + A_b^{\text{ggH}} \times \sigma_b^{\text{ggH}}^{\text{SM}} + A_c^{\text{VBF}} \times \sigma_c^{\text{VBF}}^{\text{SM}} \quad \text{a,b,c = “bins” of STXS}$$

$A_i^{\text{ggH}}$  Signal acceptance dependent on SM signal kinematic only within the given bin “i”

$A_i^{\text{VBF}}$  [reduce theory dependence]