VBF Hbb: stato e prospettive
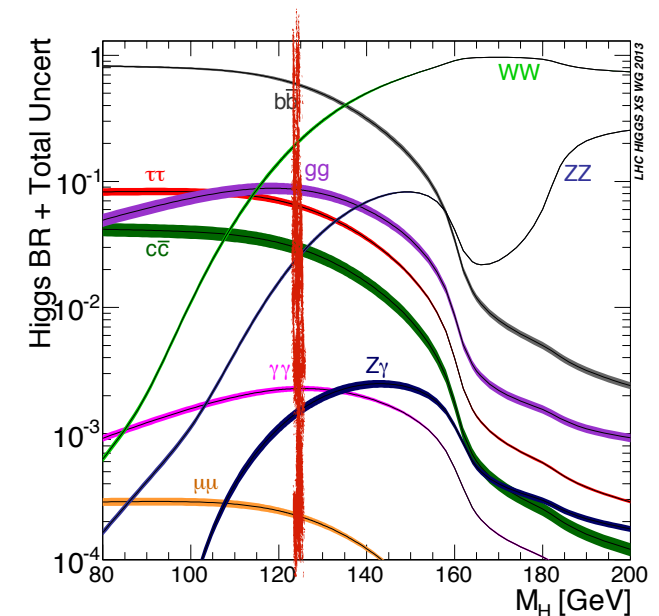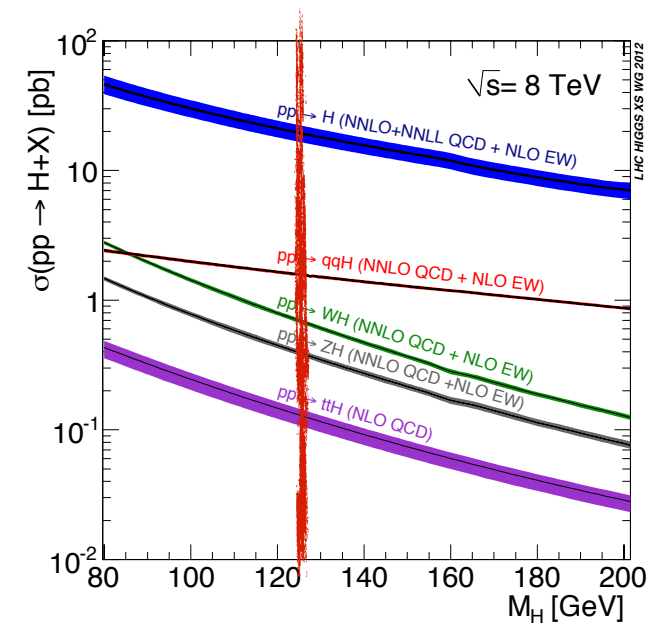
A. Coccaro, F.Parodi, C. Schiavi, C. Varni

b-tagging e analisi di stati finali con *b* quark

- Calibrazione del *b*-tagging su *c* jets
    - $D^\star$ inclusivo (Run I)
    - $W + c$ (Run II)
- Analisi con *b*-jets
    - VBF $H \to b\bar{b}$ (Run I e Run II)
    - Ricerca di nuove particelle nelo stato finale $b\bar{b}$ (Run I e Run II) (vedi Andrea)
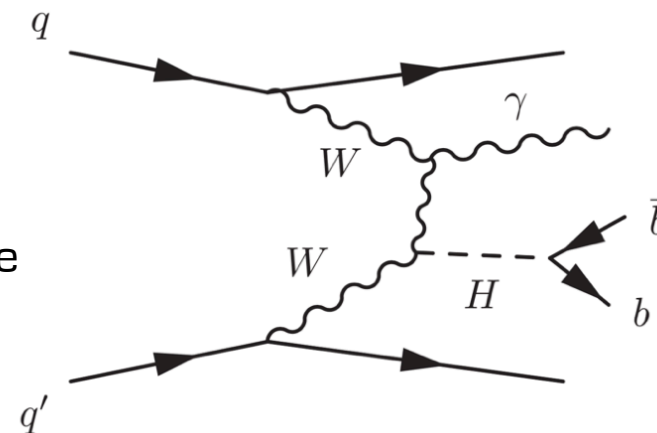
VBF H, H → bb

- Aim :
  - Investigate Yukawa coupling with bottom quarks via direct search of H → bb decay
    - Challenging search due to the many other ways of producing bottom quarks at LHC
- Targeted Decay and Production mode :
  - VBF is the second highest production mode, but it possesses a peculiar topology that can be used in triggering
  - Decay into a bottom quark pair is the main decay channel (BR: 58%)
- Latest results:
  - ATLAS collaboration : https://arxiv.org/abs/1807.08639
- Previous results :
  - Run-1 (i.e. 2012) analysis : published in 2016 [JHEP11(2016)112]

Triggering

- Analysis of 2016 data :
  - We are combining our results with the results obtained from a complementary search for an Higgs boson decaying to b-quark pairs with the addition of an impulsive photon
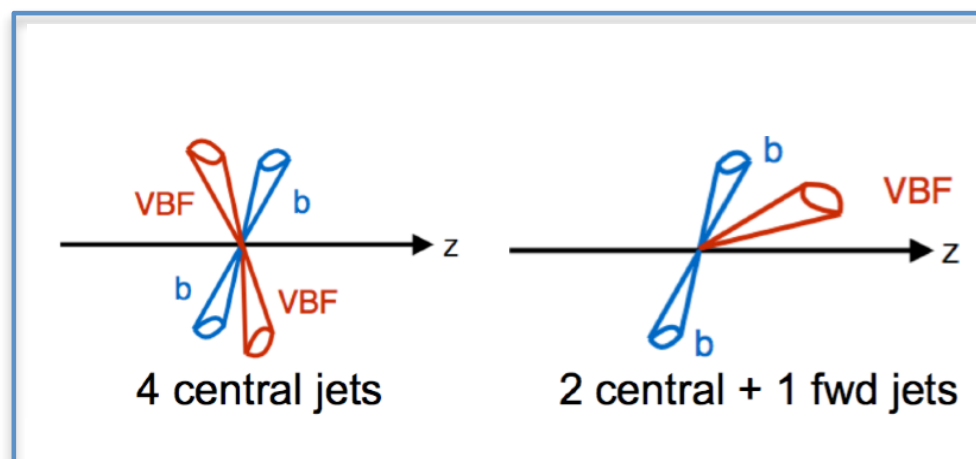   - Clean signature for efficient triggering

  - Complementary Trigger Channels :
    - **4 central** : requires at least four jets in the central region of the detector, two of which b-tagged
    - **2 central** : requires two b-tagged jets in the central region of the detector (|eta| < 2.5), and one additional jet in the forward region
    - **VBF + photon** : requires an additional impulsive photon in the central region of the detector. Further QCD background suppression by requiring impulsive photon

Inclusive channel
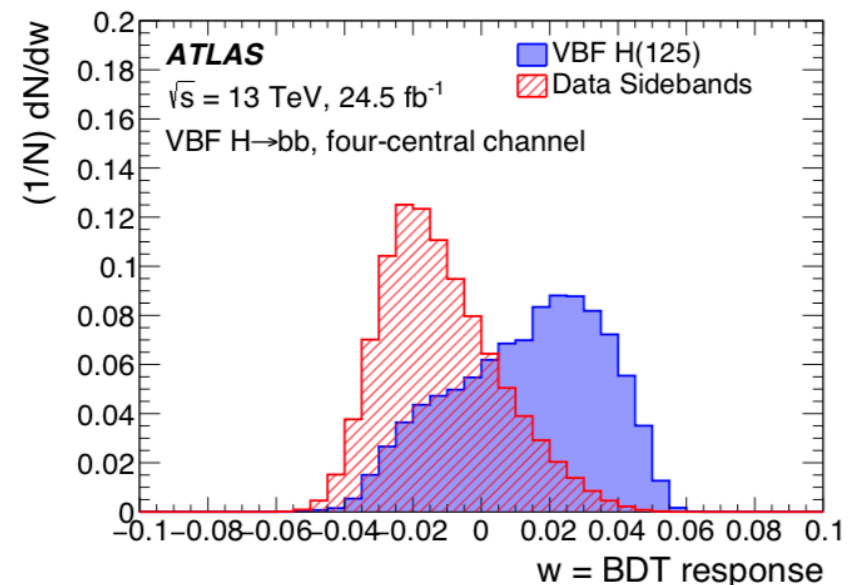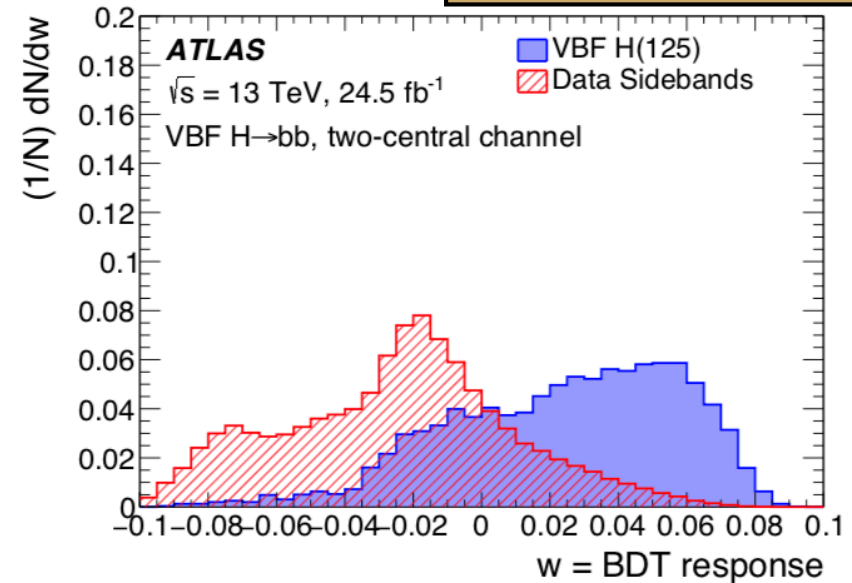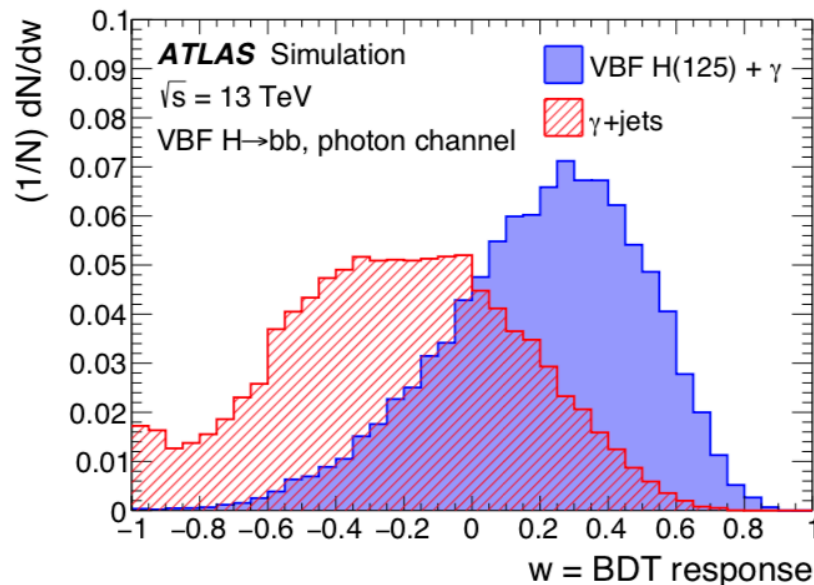
New in 2016 !

S/√B

Require online b-tagging capabilities

VBF   b

b   VBF

4 central jets

b

VBF

b

2 central + 1 fwd jets

Multivariate Analysis
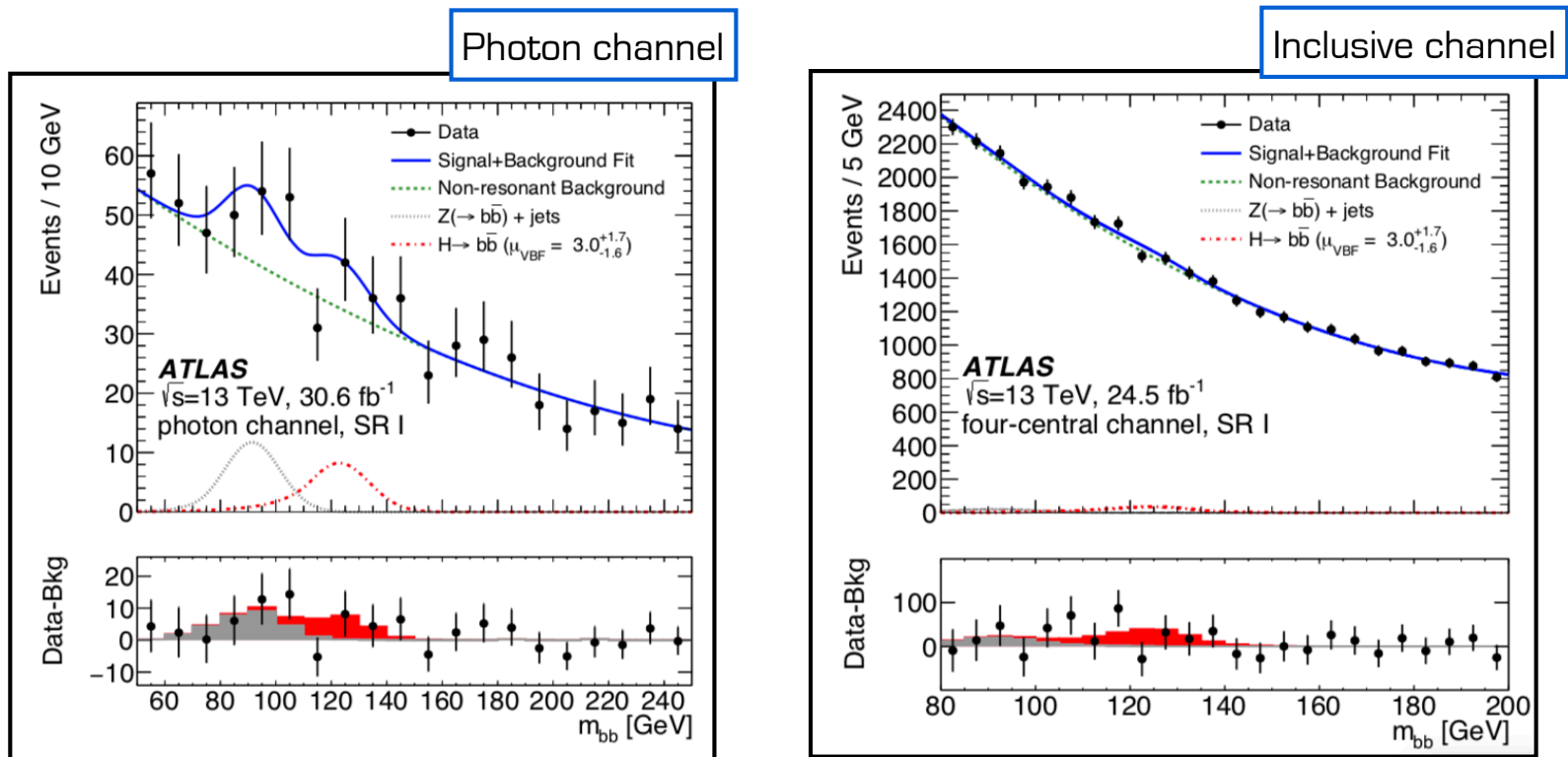
- Multivariate Tools being used for signal-background discrimination
  - Total of several input variables, according to the trigger channel
  - better sensitivity achieved w.r.t. a but-based approach
  - Events Categorised according to MVA outputs : 2, 3 and 4 regions for two-central, photon and four-central categories respectively

Fit Strategy

- <u>Signal extraction</u>
  - Simultaneous Profile likelihood fit on the different categories
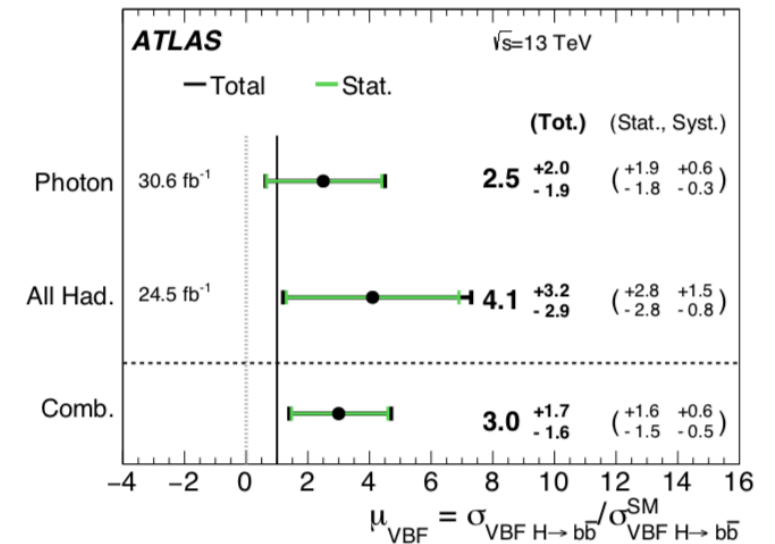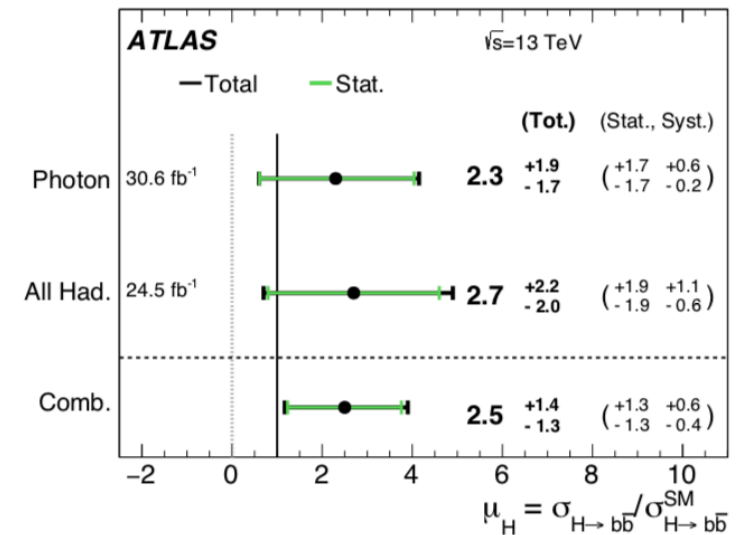

Photon channel

Inclusive channel

Results

- Combined results of the search
  - Photon channel uses 2015 and 2016 data (total of 30.6 fb⁻¹ after cleaning criteria have been applied)
  - Inclusive channels use only 2016 data (total of 24.5 fb⁻¹ after cleaning criteria have been applied)

- Inclusive Higgs Production
  - Observed (Expected) 95% CL upper limit : 4.8 $(2.5^{+1.0}_{-0.7})$
  - Signal Strength $\mu = \sigma/\sigma_{SM} = 2.5^{+1.4}_{-1.3}$

- VBF production
  - Observed (Expected) 95% CL upper limit : 5.9 $(3.0^{+1.3}_{-0.8})$
  - Signal Strength $\mu = \sigma/\sigma_{SM} = 3.0^{+1.7}_{-1.6}$

Prospettive

Analisi VBF finale RunII (con dati 2017/2018)

- Nuove segnature basate su jet a L1 (grazie a L1Topo)
- Modelling di $Z \rightarrow b\bar{b}$
    - Miglior descrizione grazie a soglie più basse su single jet grazie al nuovo schema di trigger
    - Embedding da $Z \rightarrow \mu\mu$

Metodi sviluppati (o in corso di sviluppo) interessanti anche per altre analisi

- Background fit di $M(b\bar{b})$ data-driven e conseguente stima del bias nella scelta della funzione (simile a quanto fatto in $\gamma\gamma$ ma senza ricorso a MC)
- Adversarial NN: per ottenere una variabile discrimante totalmente indipendente da $M(b\bar{b}) \rightarrow$ possibilità di usare una sola funzione $f(M(b\bar{b}))$ per descrivere il fondo in tutte le slices di variabile discriminante.
- Deep Learning: opzione aperta (non è chiaro che possa essere conciliato con lo step precedente).