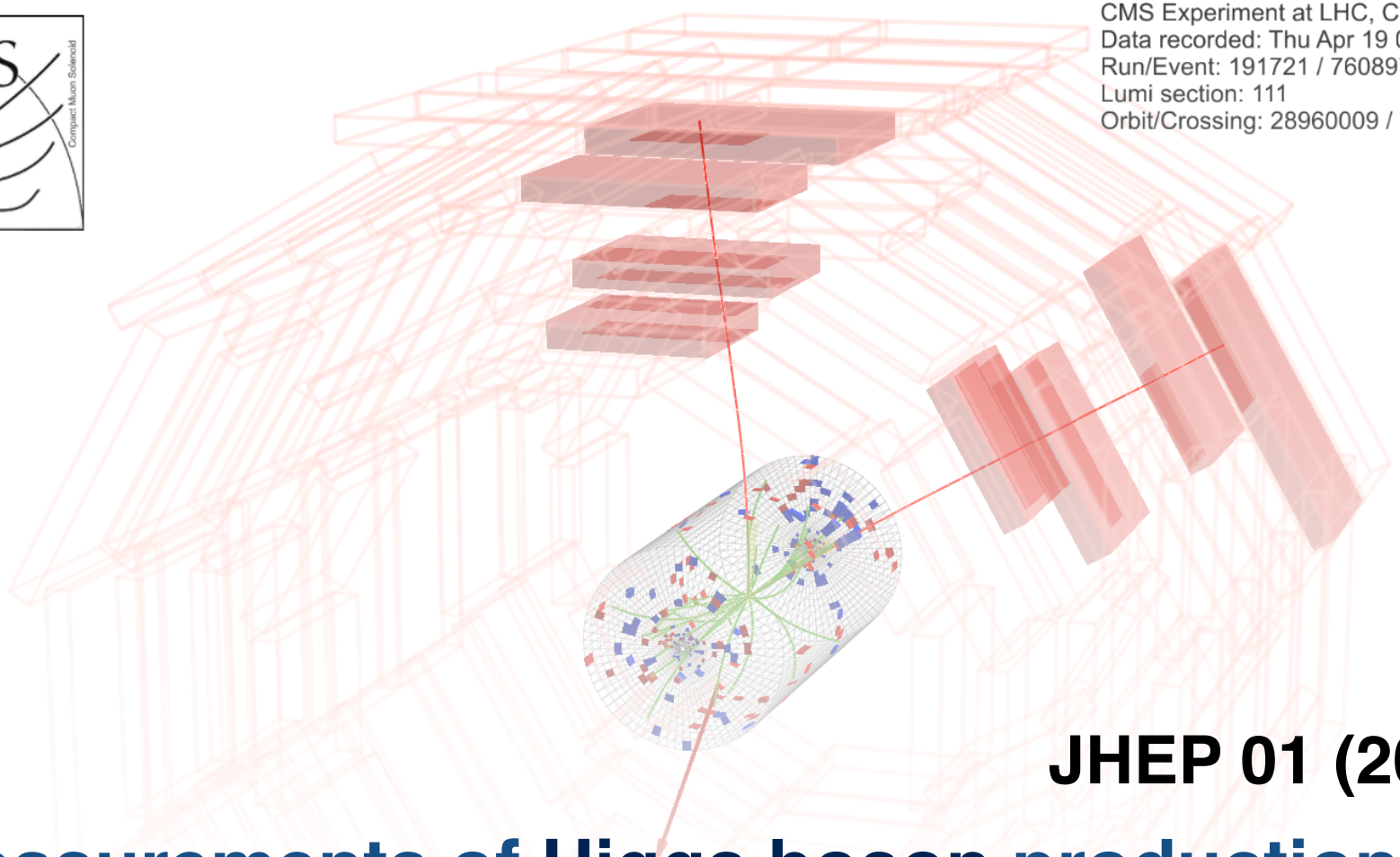


JHEP 01 (2014) 096

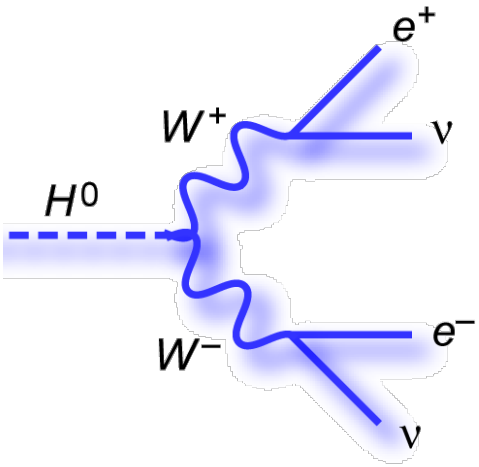
Measurements of Higgs boson production and properties in the WW decay channel with both W's decaying into electrons or muons plus neutrino using the CMS detector

P. Govoni, on behalf of the CMS Collaboration
Milano-Bicocca University and INFN

the fully leptonic H → WW →lνlν final state

- H → vector bosons: **early discovery** channels
- **VVH couplings** originate from EWSB: provide the longitudinal W_L and Z_L components to the vector bosons
- access the **Higgs boson spin** from the vector bosons decay angles
- H → WW **largest branching** ratio among them

- 2 oppositely **charged isolated leptons** (electrons and muons) with minimum p_T of 20,10 GeV
- moderate **MET**: at least 20 GeV
- **jets** counted with p_T > 30 GeV, veto on the presence of b-jets

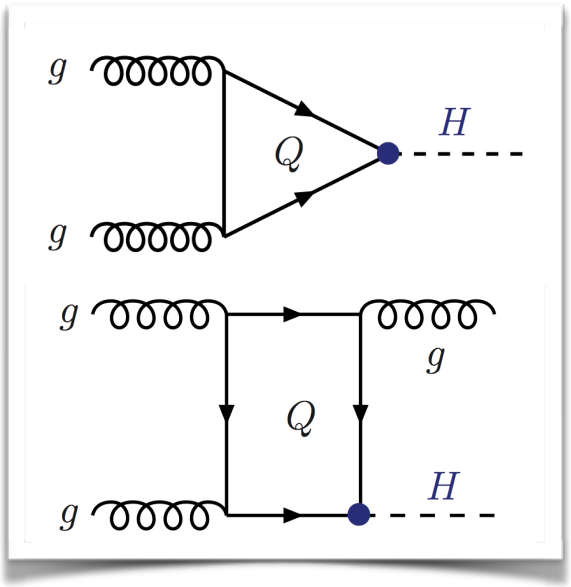


- **main backgrounds** are non-resonant WW, tt pairs production and Drell-Yan (with same-flavour leptons)
  - instrumental bkg: sub-leading, but with large uncertainty
- divide the final state study into **same-flavour and different-flavour categories**

the Higgs boson production

gluon fusion

- main production channel
- separated into 0 and 1 jet bins

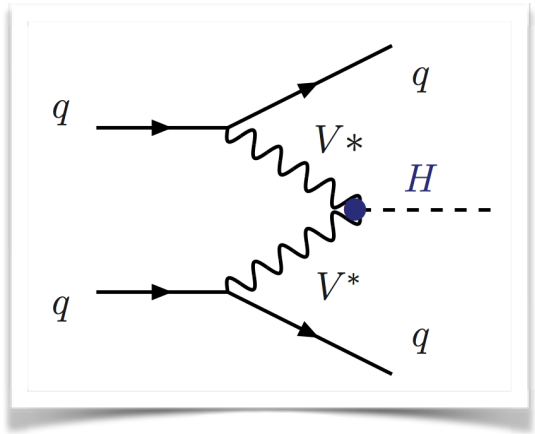


250 evt

expected signal events after all selections

vector boson fusion (VBF)

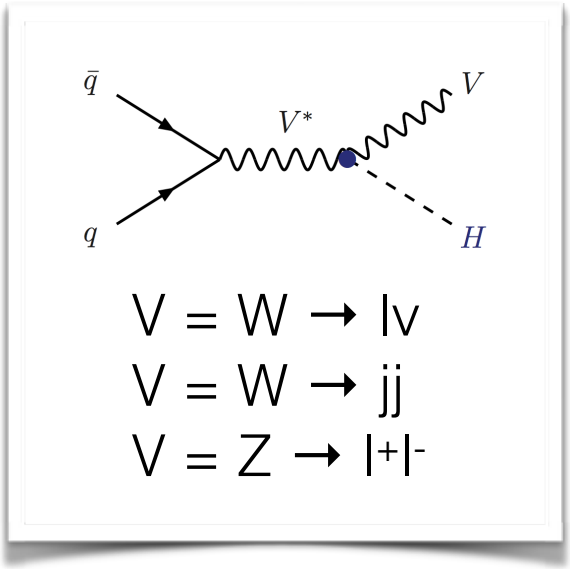
- first sub-leading production channel
- VVH coupling in production and decay



10 evt

H-strahlung (VH)

- lower cross-section
- search for the additional vector boson

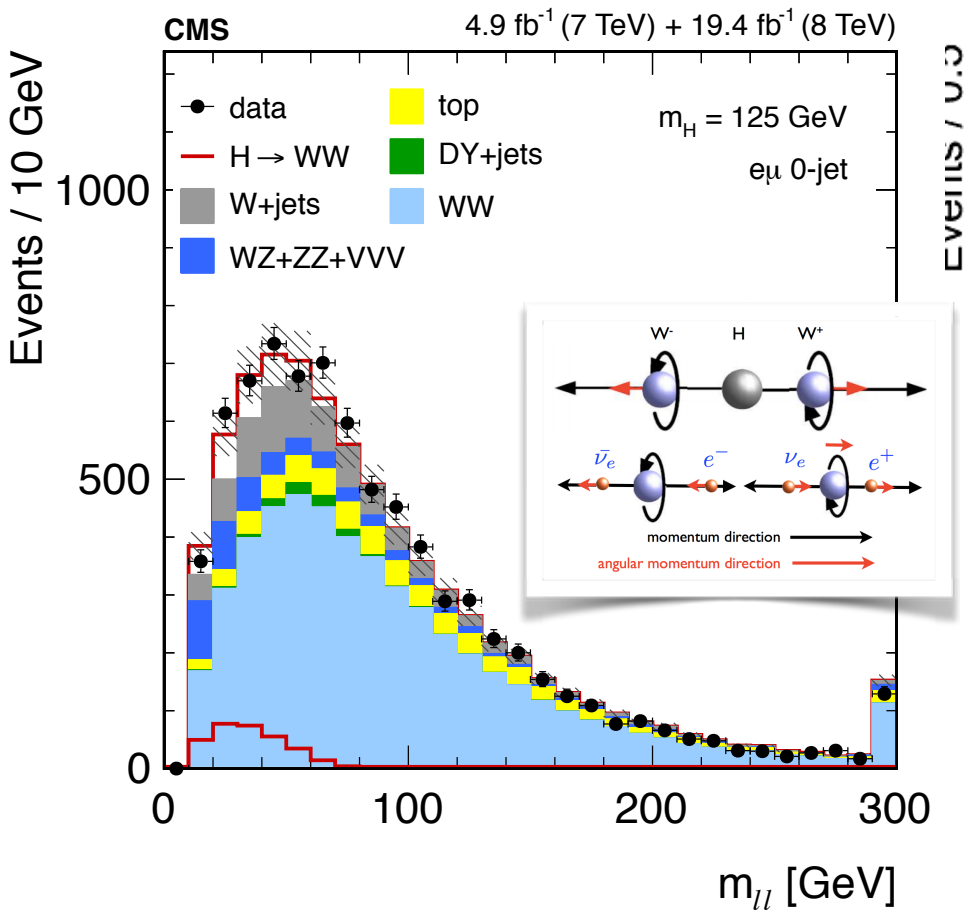


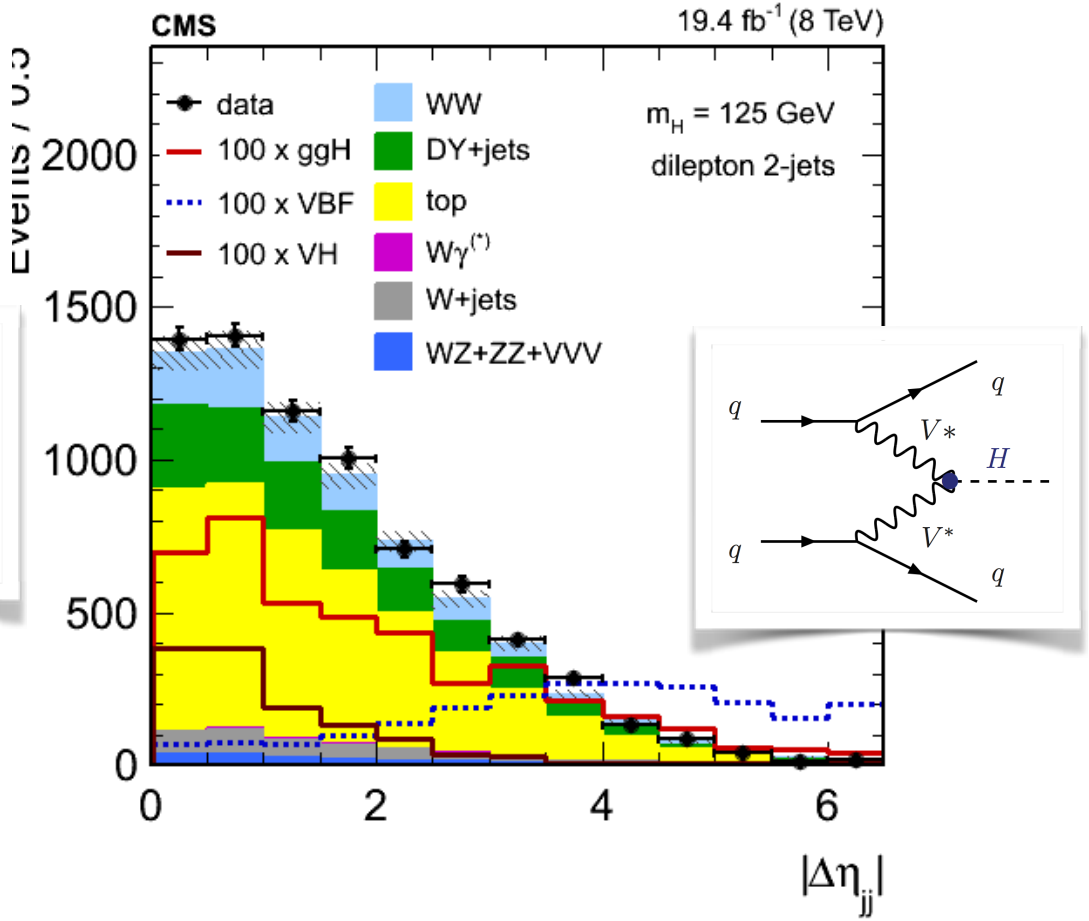
14 evt

yesterday's L. Bianchini's talk covered the ttH production

the main selection variables

- **key variables**: transverse mass m_T, di-lepton mass m_{ll} and $\Delta\phi_{ll}$
- additional handles from the **exclusive production modes**
  - **VBF**: two additional jets with large $\Delta\eta$ and invariant mass
  - **VH**: the presence of an additional vector boson

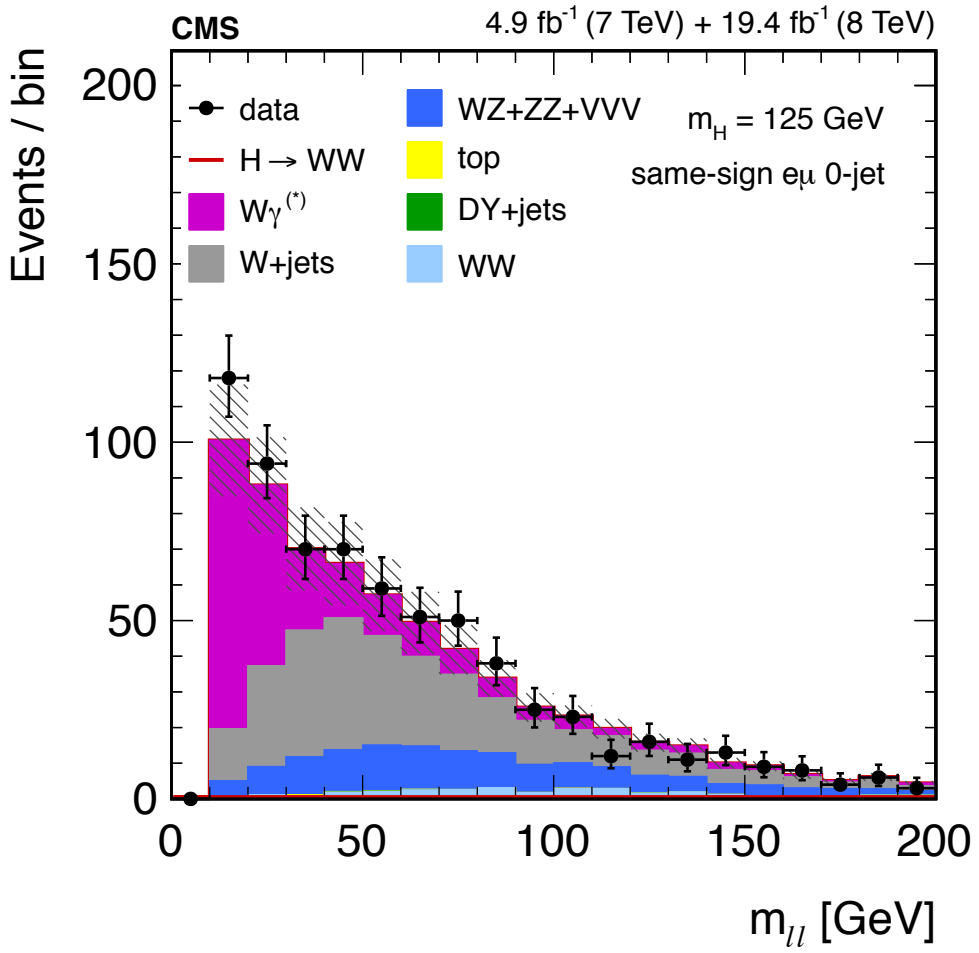


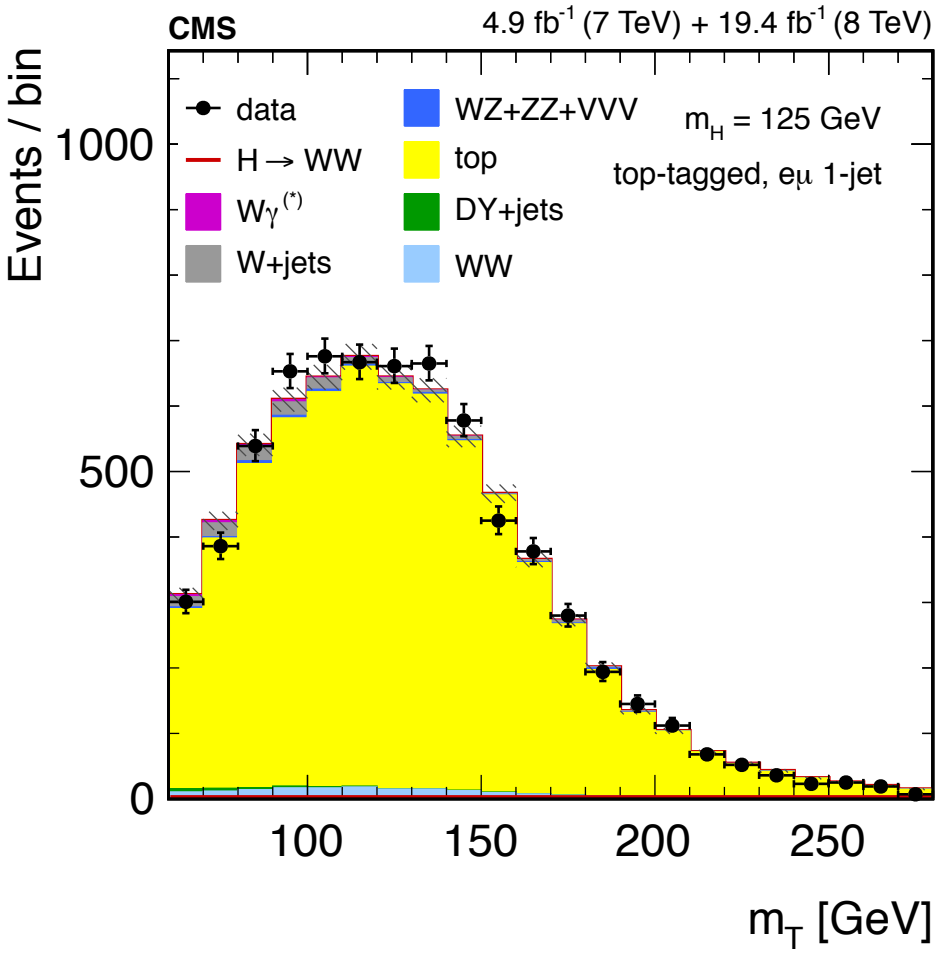


$$m_T^2 = 2p_T^{\ell\ell} E_T^{miss} \left(1 - \cos\Delta\phi(\ell\ell, \vec{E}_T^{miss})\right)$$

background control

- no H peak: **low resolution** on m_H, **data-driven background control** needed
- normalisation and shape modelling are cross-checked in **control regions**



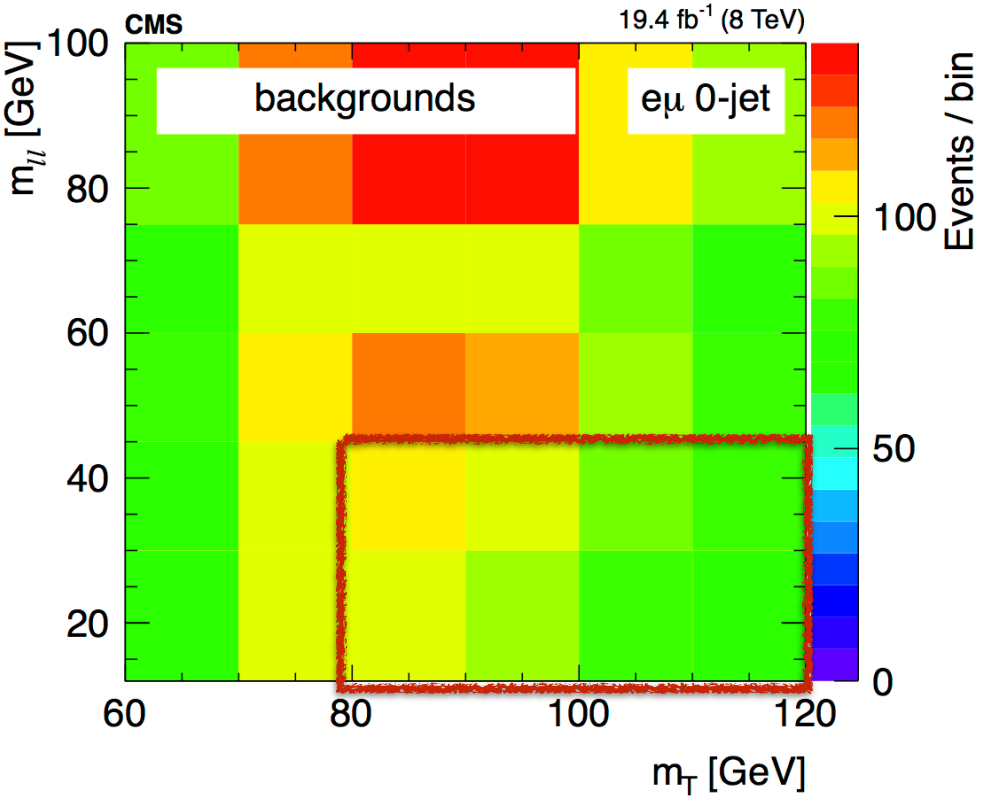


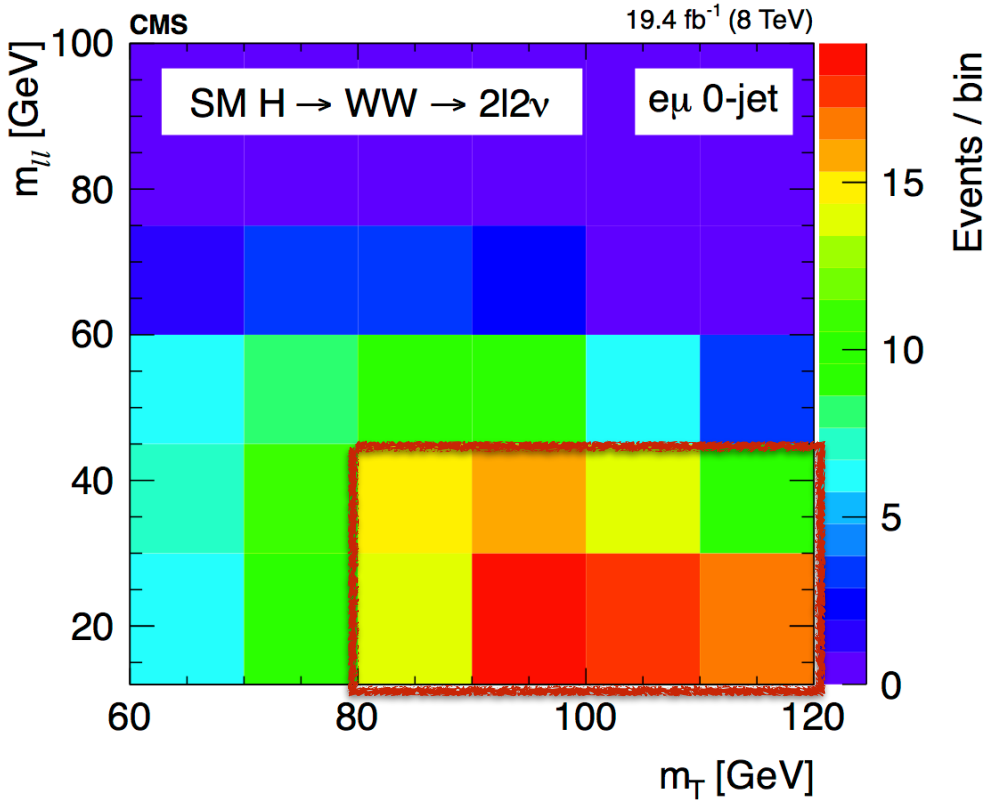
same-charge leptons pairs in the 0-jet bin

top-enriched events in the 1-jet bin

the analysis strategy in 0 and 1 jet bins

- **eμ: 2D template fit** to extract signal and background: **(m_T, m_{ll}) plane**
- **ee/μμ: cut-based** limit on the most sensitive variables

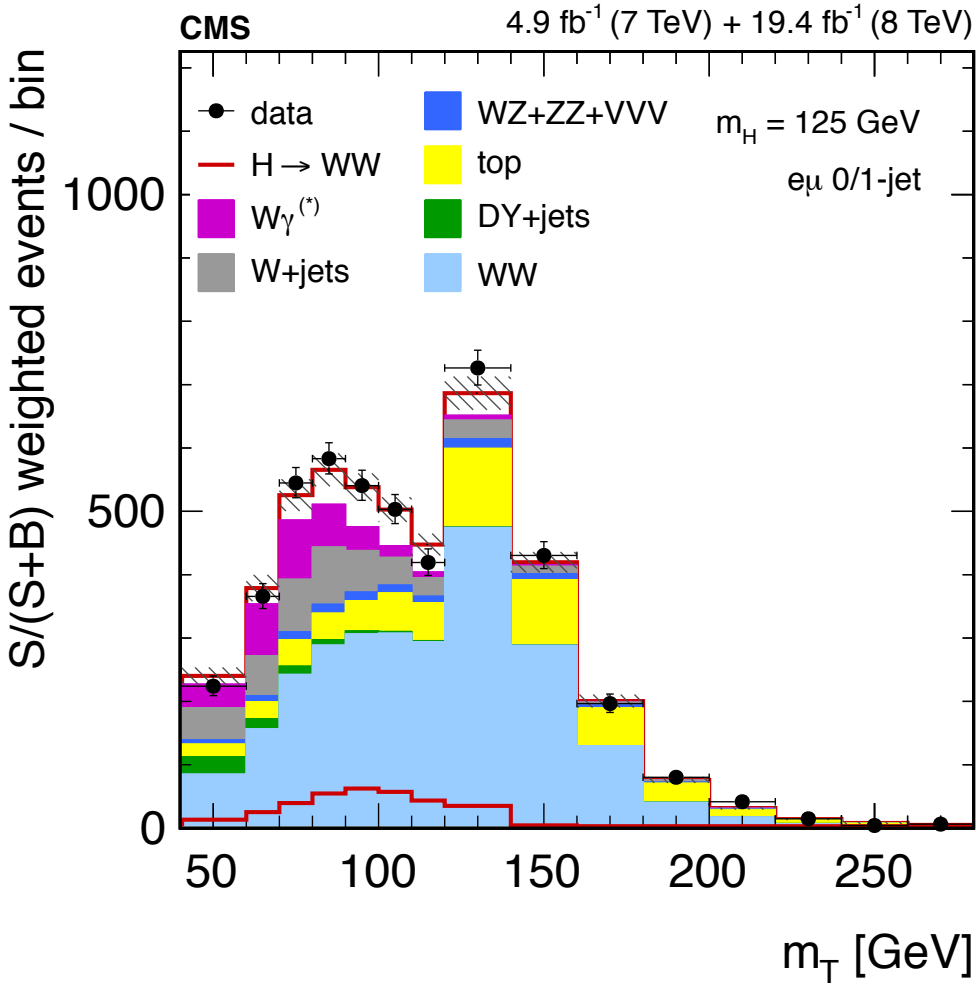


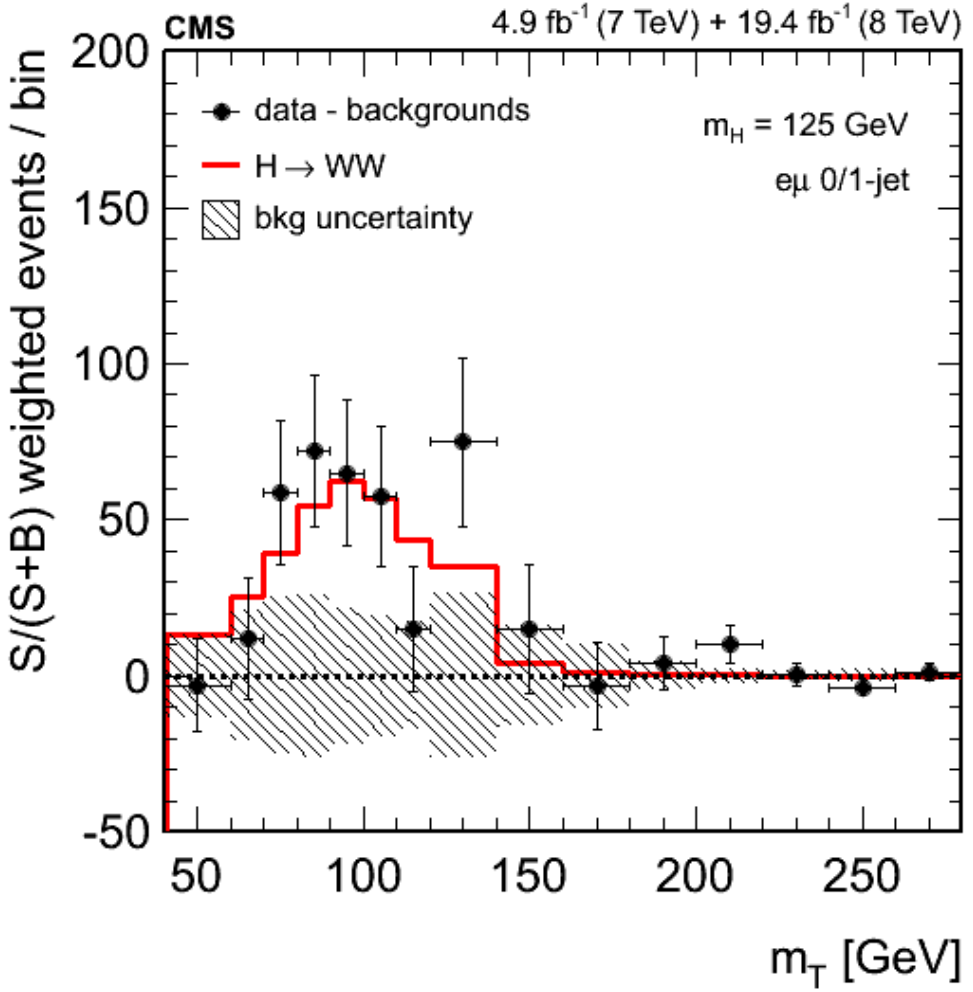


pre-fit distributions for signal and background models
(the red box is the cut-based phase space)

the result of the fit

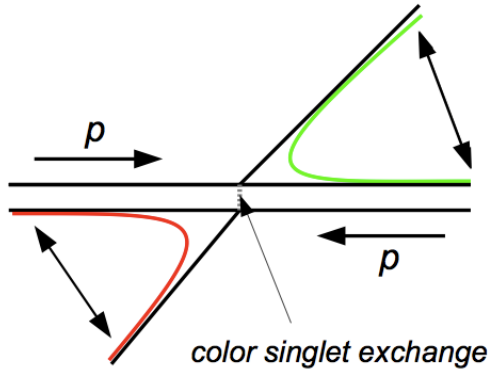
- **post-fit distributions**, overlapped to data
- S/(S+B) reweighting along m_{ll} (the other variable in the 2D plane)

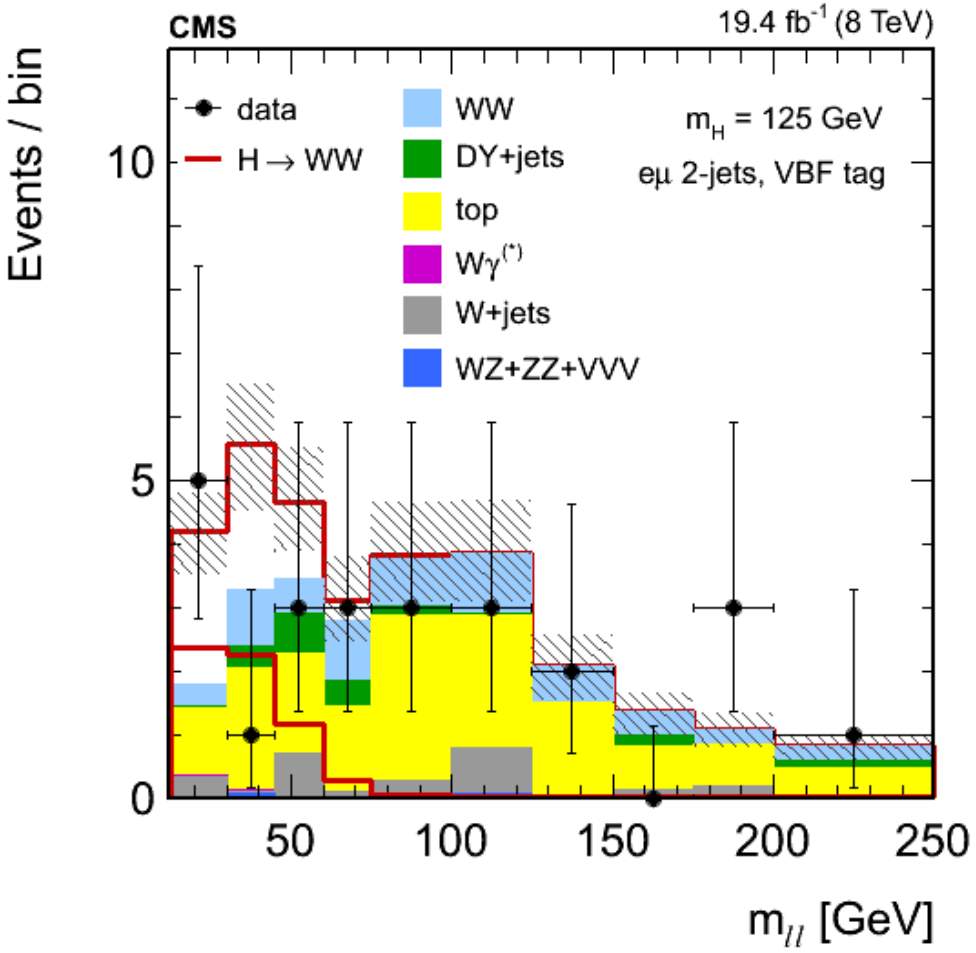


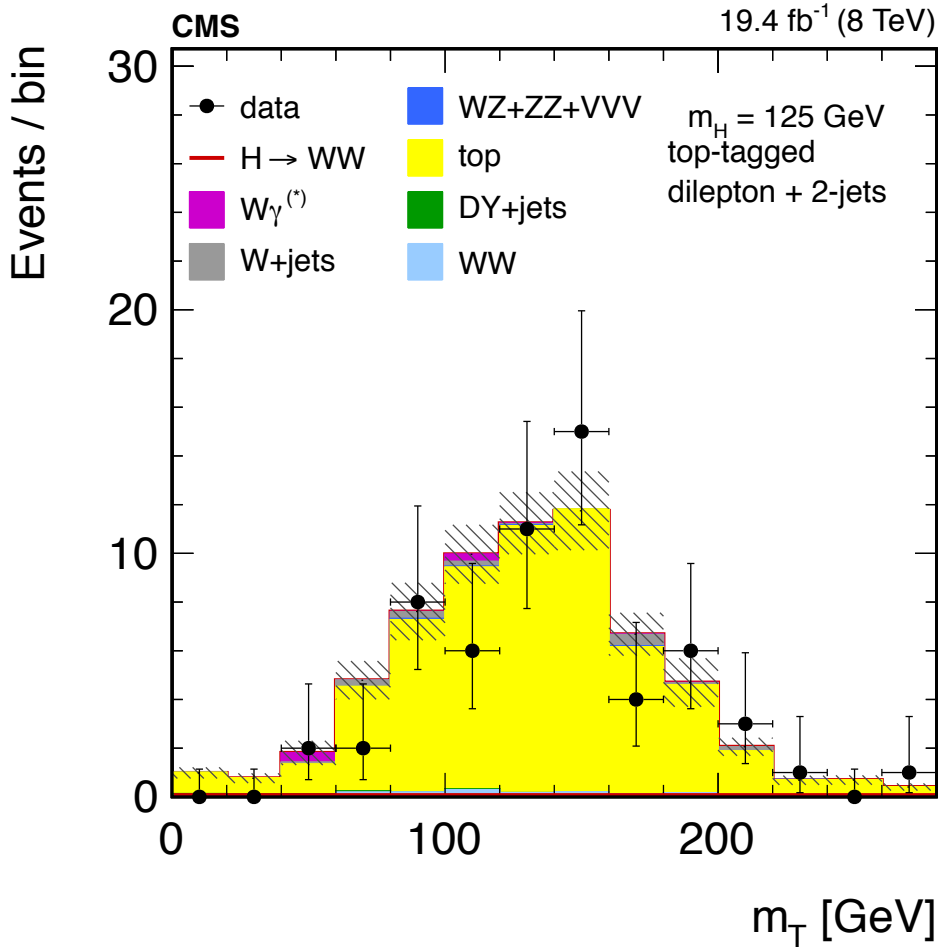


exclusive analysis: vector boson fusion

- **second production channel** (10% of the total)
- additional selection handles: **S/B ~ 1:1**
  - $\Delta\eta_{jj} > 3.5$ and $m_{jj} > 500$ GeV,
  - central activity veto, final state leptons between the tag jets

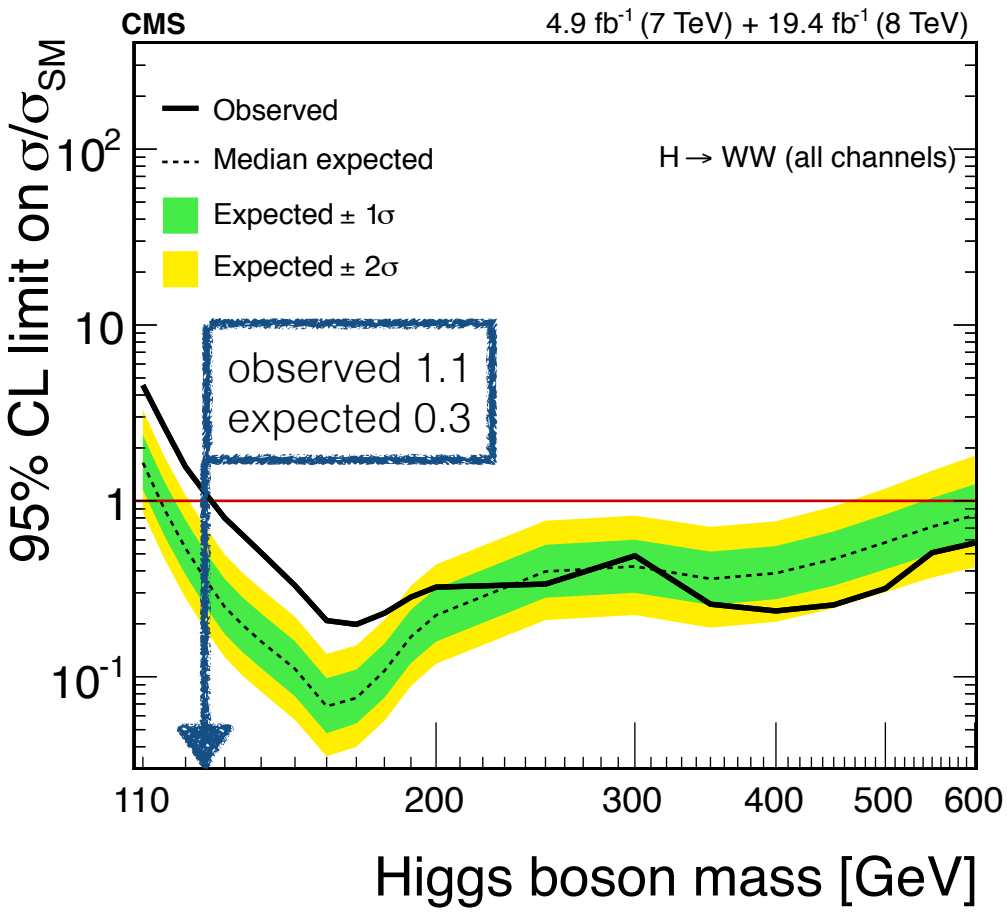




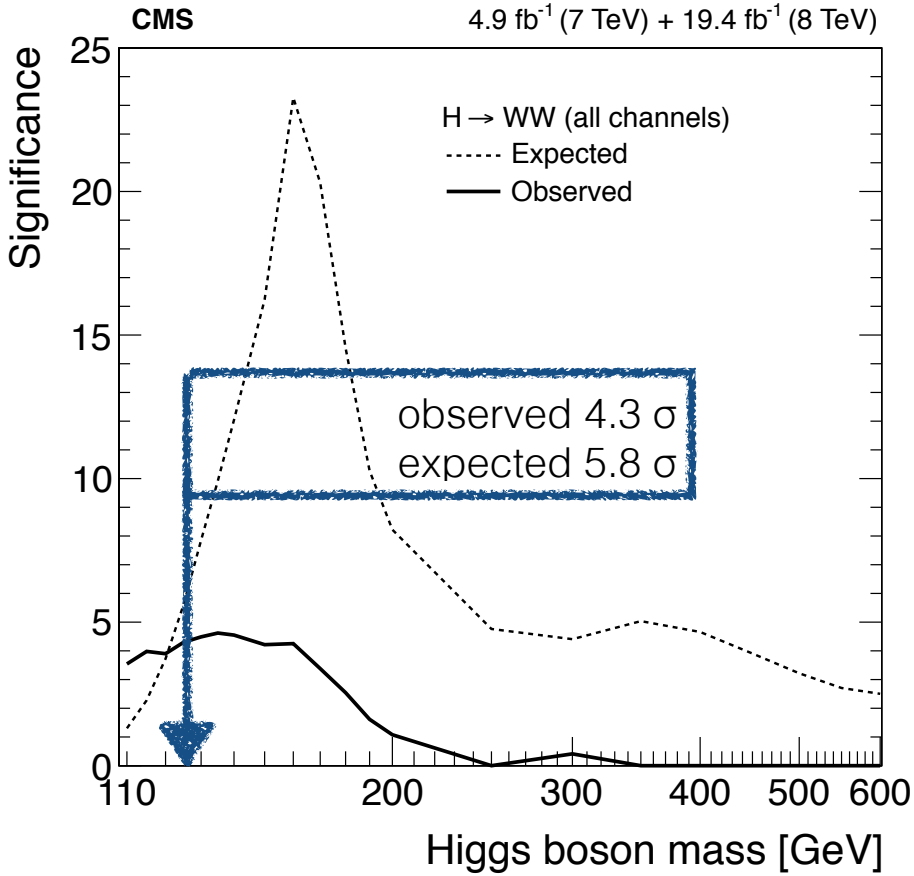


from here onwards: m_H = 125.6 GeV

the exclusion limit



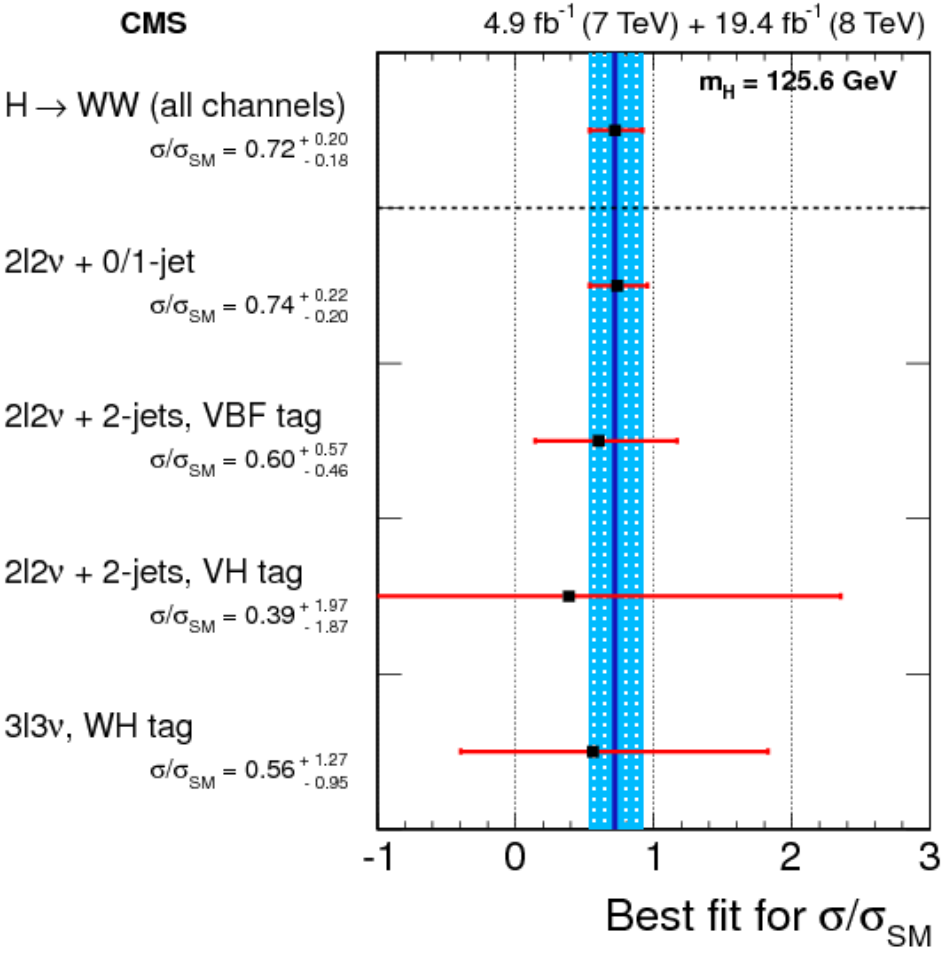
the significance



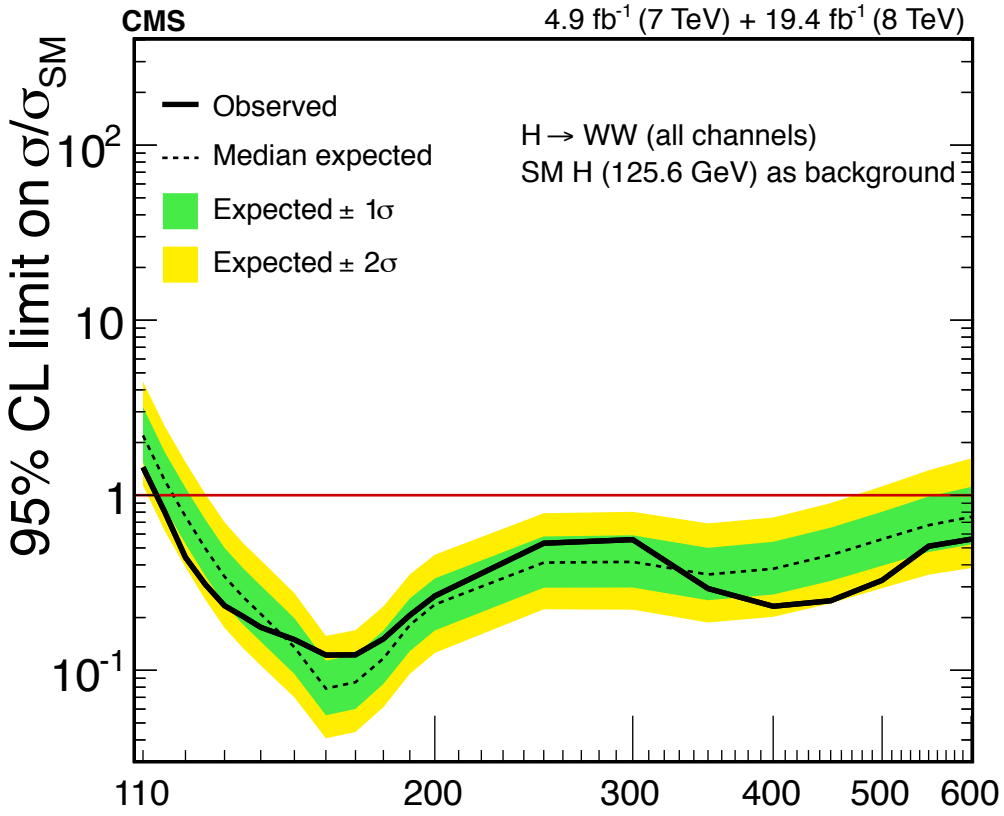
$$\sigma/\sigma_{\rm SM} = 0.72\,^{+0.20}_{-0.18} = 0.72\,^{+0.12}_{-0.12}(\text{stat.})\,^{+0.12}_{-0.10}\,(\text{th. syst})^{+0.10}_{-0.10}(\text{exp. syst})$$

additional tests

results are consistent
among different categories



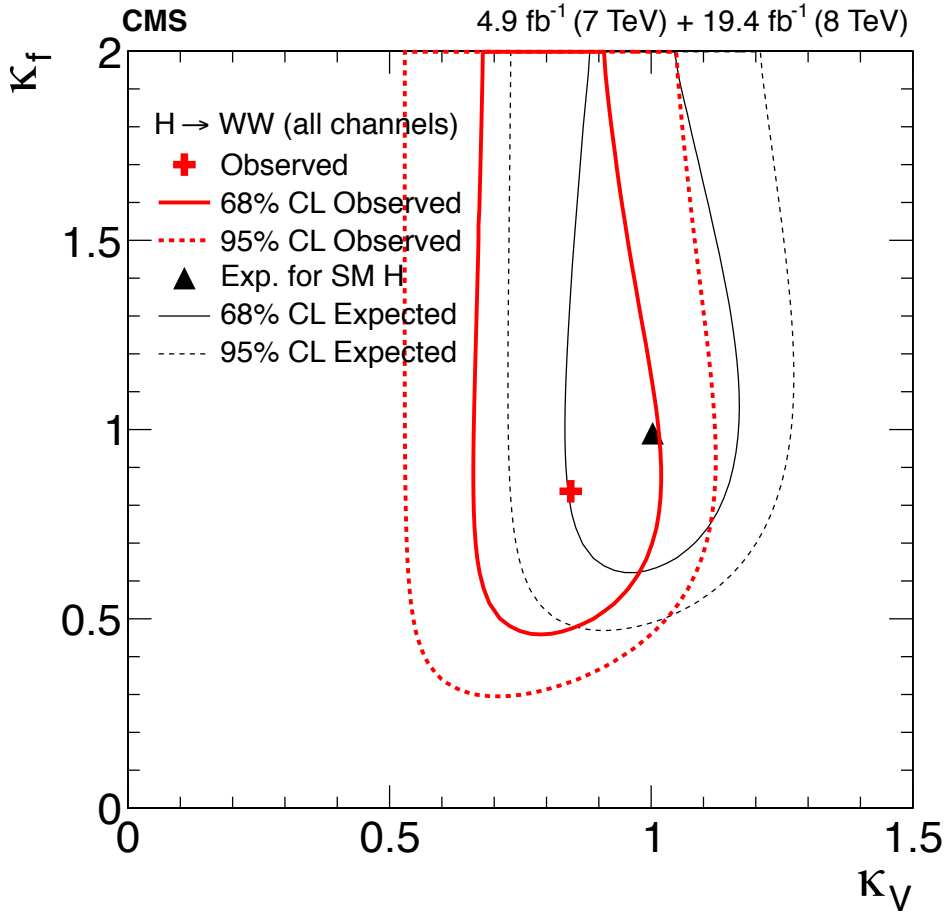
the limit with **125 GeV SM Higgs as bkg**: no signs of additional resonances



Higgs boson couplings

vary the Higgs couplings wrt the SM with multiplicative modifiers k

$$\sigma \times \mathrm{BR}(\mathrm{X} \to \mathrm{H} \to \mathrm{WW}) = \kappa_i^2 \, \frac{\kappa_\mathrm{V}^2}{\kappa_\mathrm{H}^2} \, \sigma_\mathrm{SM} \times \mathrm{BR}_\mathrm{SM}(\mathrm{X} \to \mathrm{H} \to \mathrm{WW})$$



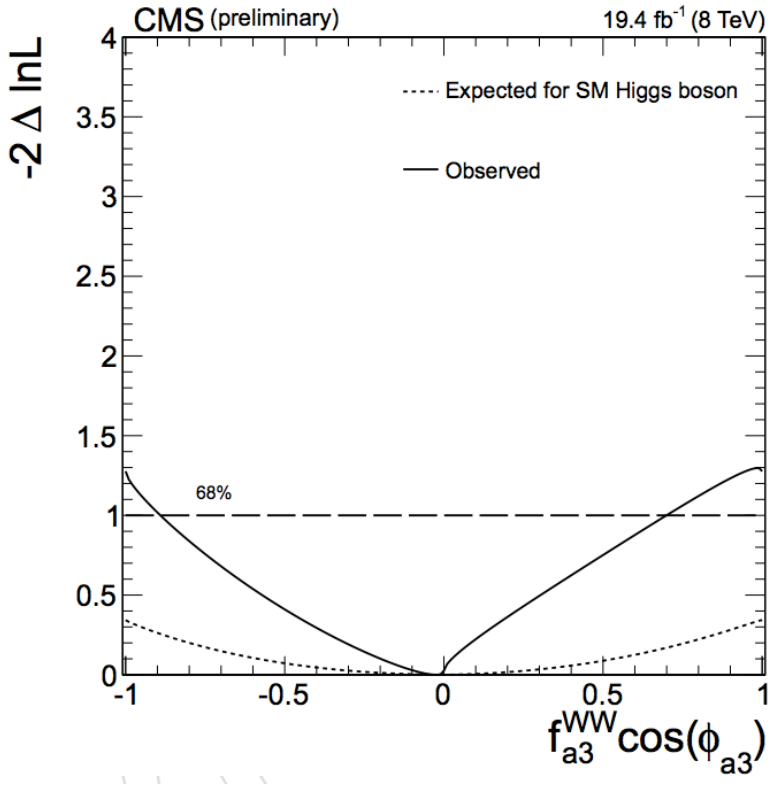
full integration in the SM fit in M. Chen talk

tensor structure measurements

- extract all the possible information on the Higgs spin and parity, starting from the **eμ 2D template fit** analysis baseline

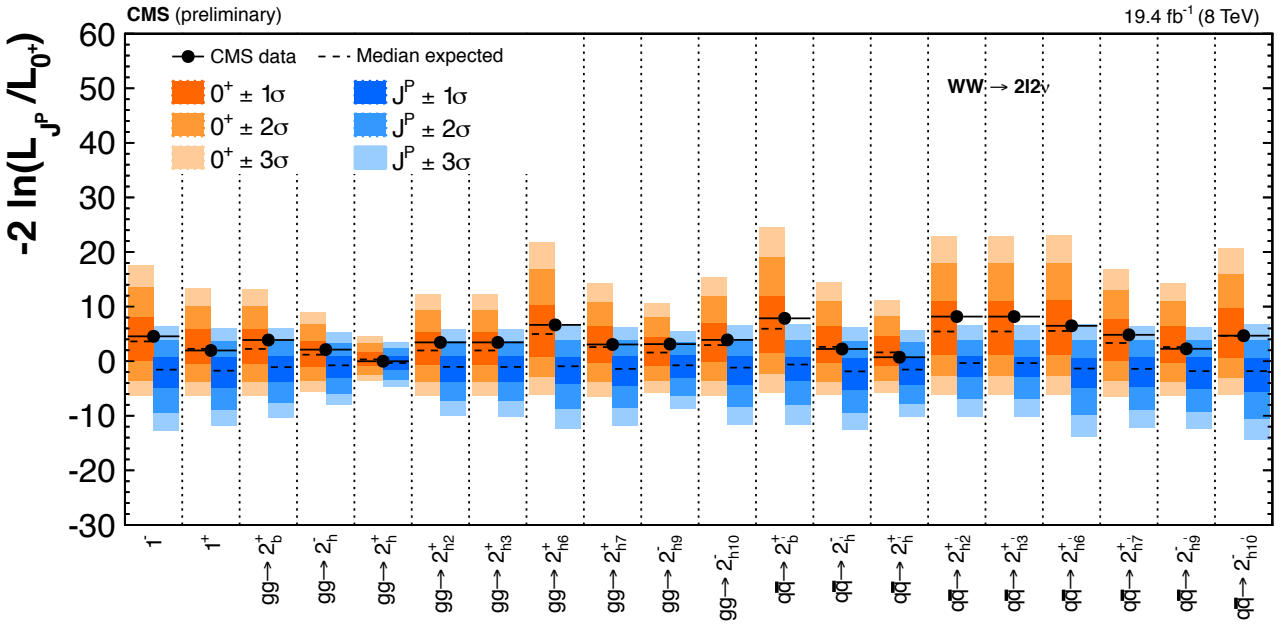
spin 0

- put **limits on the XS fractions of non-SM components** in the decay amplitude



spin 1, 2

- different pure spin hypotheses are compared to the SM case



see E. Di Marco presentation

conclusions

- **H → WW →lvlv** is one of the channels with the largest yield at the Higgs boson mass peak
  - small uncertainty on the signal strength
  - access to exclusive production channels
- with the full **7 and 8 TeV dataset** a signal with an observed significance of 4.3 σ has been observed:

$$\sigma/\sigma_{\mathrm{SM}} = 0.72\ ^{+0.20}_{-0.18} \quad \text{(at } m_H = 125.6 \text{ GeV)}$$

4.3 σ observed (5.8 σ expected)

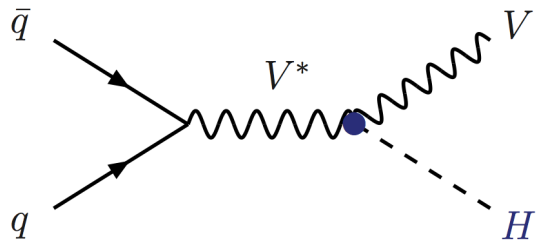
- observed significance of **1.3 σ in VBF** (expected: 2.1 σ)
- a wide investigation of the **H tensor structure** does not show any deviations from the SM

high mass analysis in tomorrow's O. Gonzalez Lopez talk

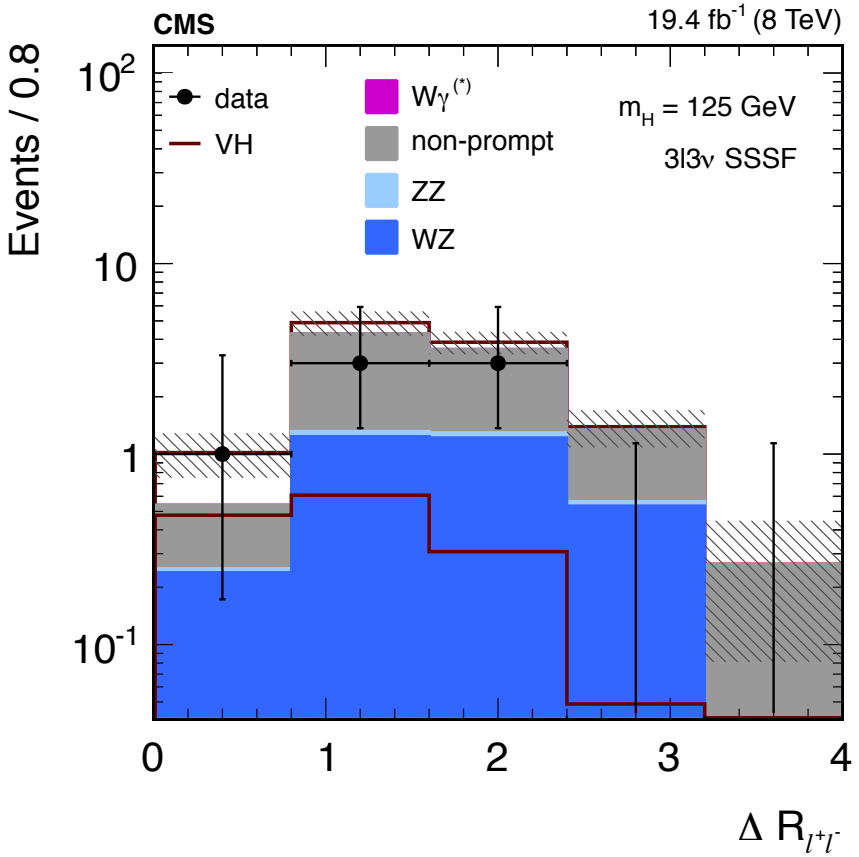
backup slides

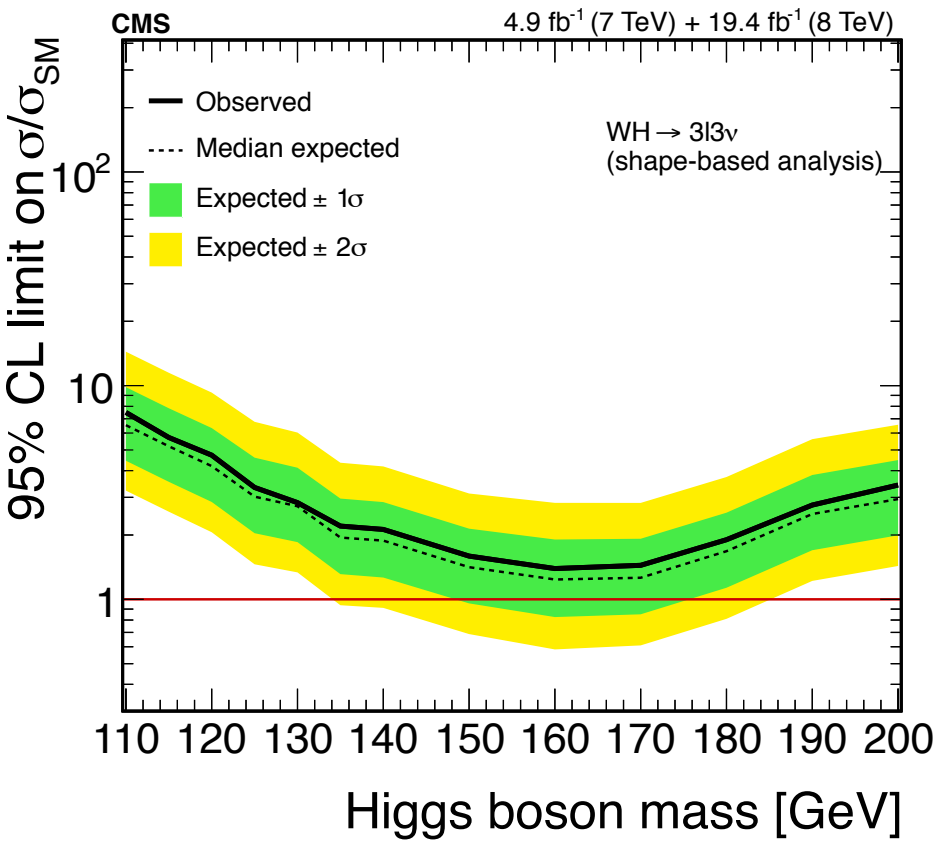
exclusive analysis: VH

- a few events expected (over all the final states)
- additional handles from the presence of the final state vector boson
- **worse S/B ratio than vbf**
- **several final states** for the vector boson addressed

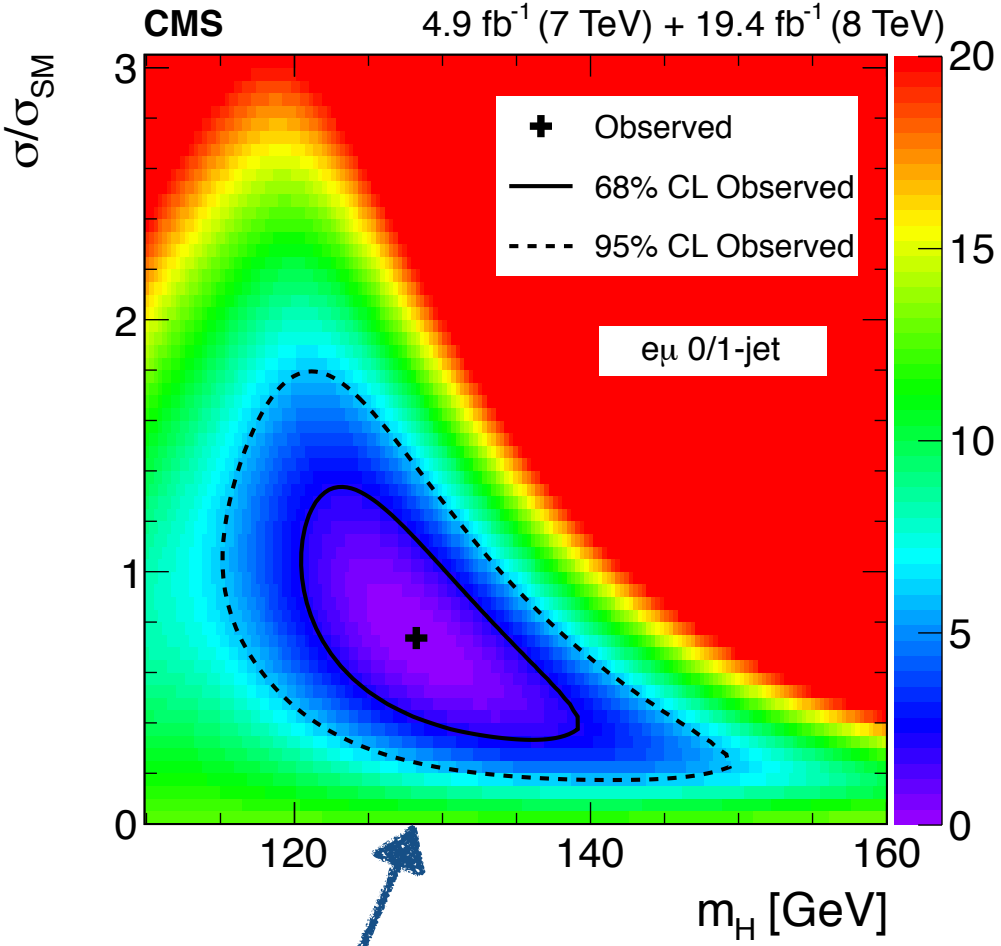


VH, V → lν, H → lνlν

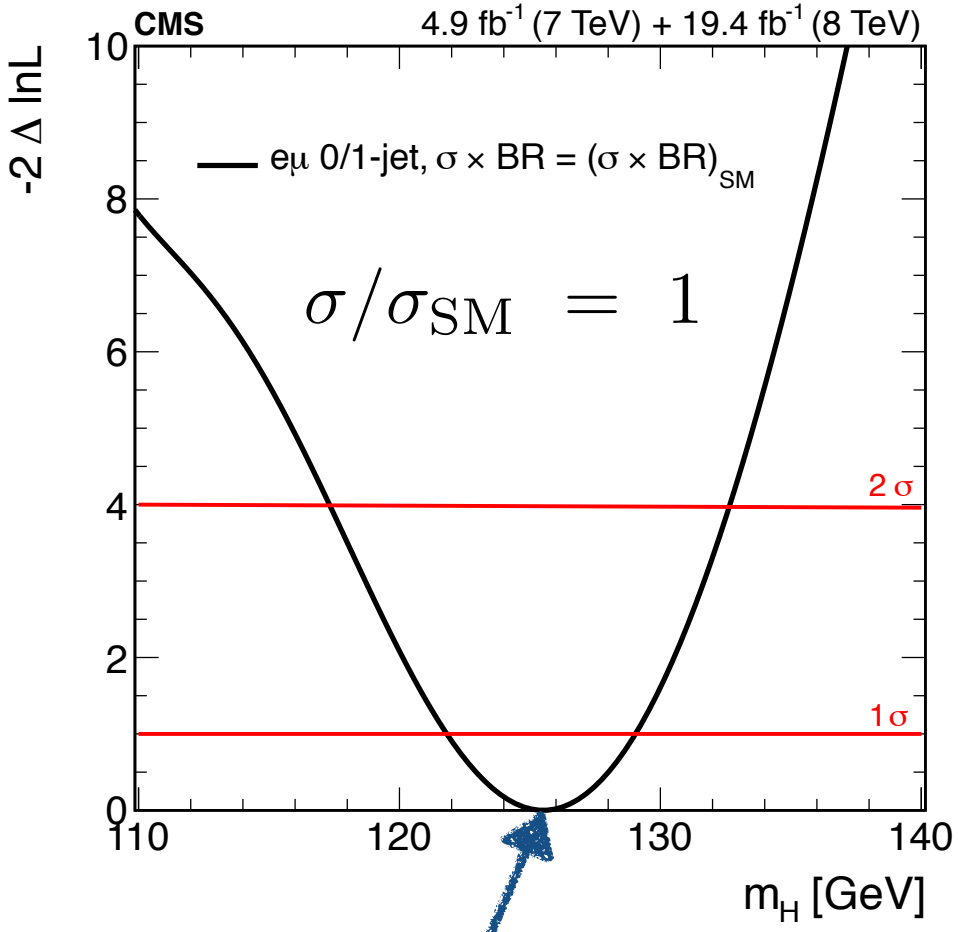




Higgs boson mass



$$m_{\mathrm{H}} = 128.2\ ^{+6.6}_{-5.3}\ \mathrm{GeV}$$



$$m_{\mathrm{H}} = 125.5\ ^{+3.6}_{-3.8}\ \mathrm{GeV}$$

the razor variable

$$m_{\mathrm{R}} = \sqrt{\frac{1}{2}\left[m_{\ell\ell}^2 - \vec{E}_{\mathrm{T}}^{\mathrm{miss}} \cdot \vec{p}_{\mathrm{T}}^{\ell\ell} + \sqrt{(m_{\ell\ell}^2 + (p_{\mathrm{T}}^{\ell\ell})^2)(m_{\ell\ell}^2 + (E_T^{\mathrm{miss}})^2)}\right]}$$