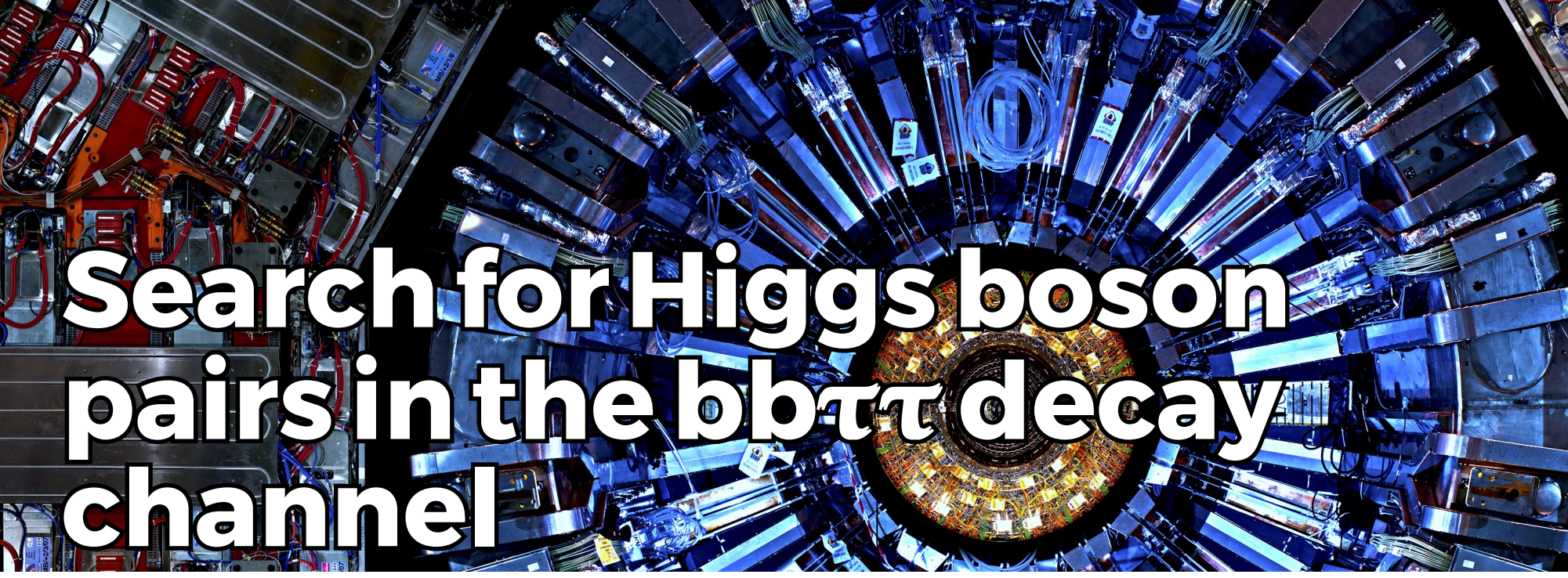

Search for Higgs boson pairs in the bbττ decay channel

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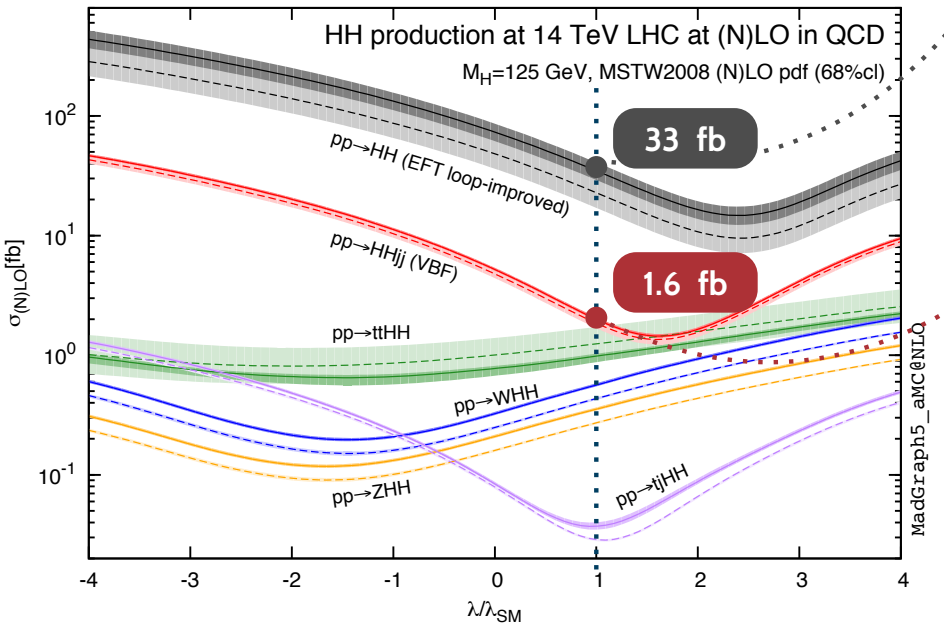
The HH production

- Unique probe of the Higgs mechanism
  - allows measurement of the Higgs self-coupling **λ**
  - it brings information on the shape of the Higgs potential

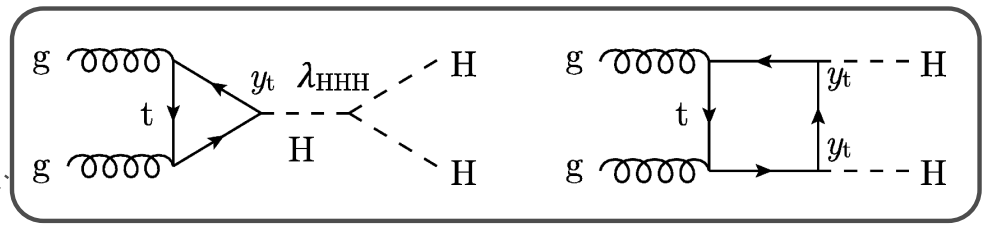
Non-resonant searches

Process predicted by the SM

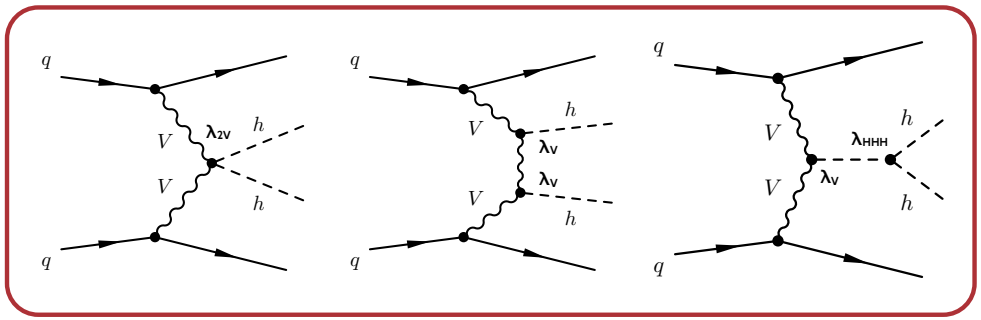
BSM effects can result in anomalous couplings (enhanced cross section)



Gluon Fusion (ggF)



Vector Boson Fusion (VBF)

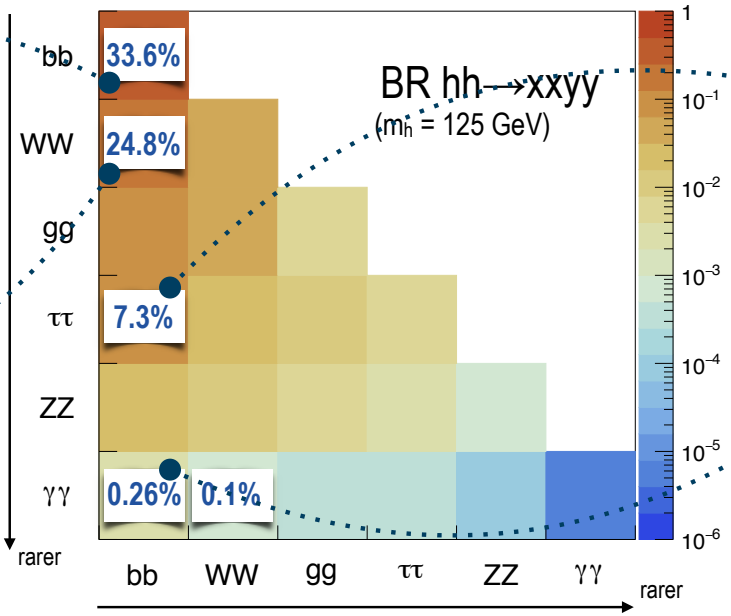


HH decay channels

Dominant production mode: gluon Fusion ($\sigma_{HH} \sim 33$ fb at 13 TeV)

bbbb
largest BR, large QCD and $t\bar{t}$ contamination

bbWW
large BR, large $t\bar{t}$ contamination



bbττ
good **compromise** between BR and purity

bbγγ
low branching ratio, high purity

- Trade-off between BR and purity
- coverage of different phase spaces
- different sensitivity in different mass ranges

All channels are complementary, a lot to gain by combining

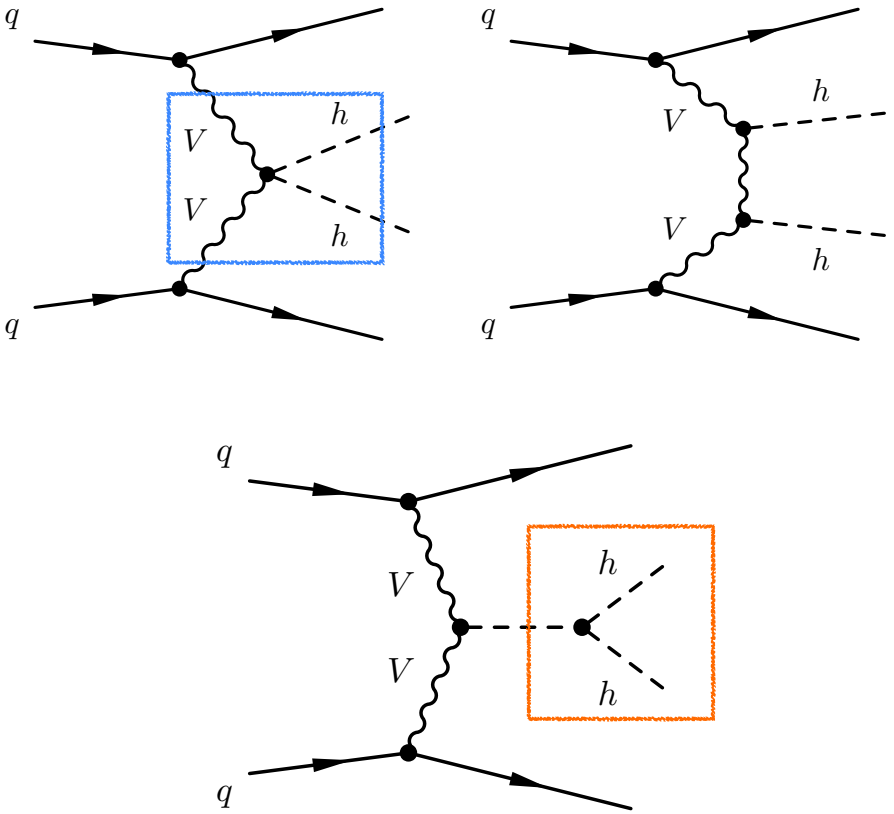
Latest CMS bbττ results, data 2016, exp upper limit: **25**$\times\sigma_{SM}$ PLB778(2018)
CMS Combination, data 2016, exp upper limit: **13**$\times\sigma_{SM}$ CMS PAS HIG-17-030

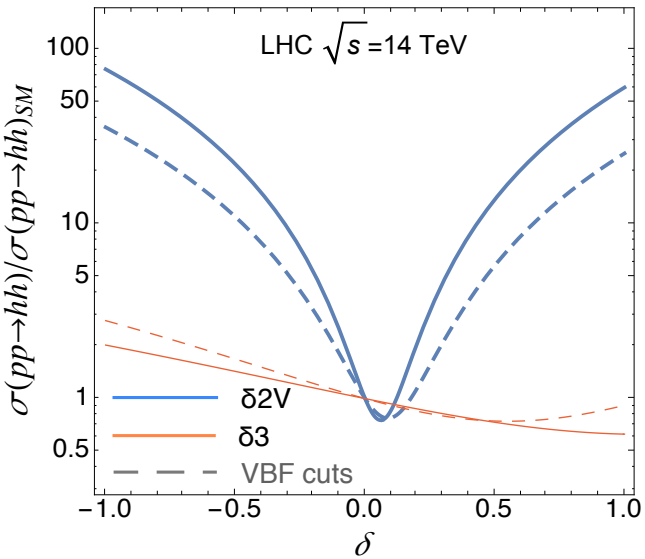
The Vector Boson Fusion production mode

arXiv:1401.7340

VBF HH production cross section is ~ 2 fb at $\sqrt{s} = 13$ TeV

- in addition to λ_3, can constrain λ_{2V} (= λ_V^2 in the SM)

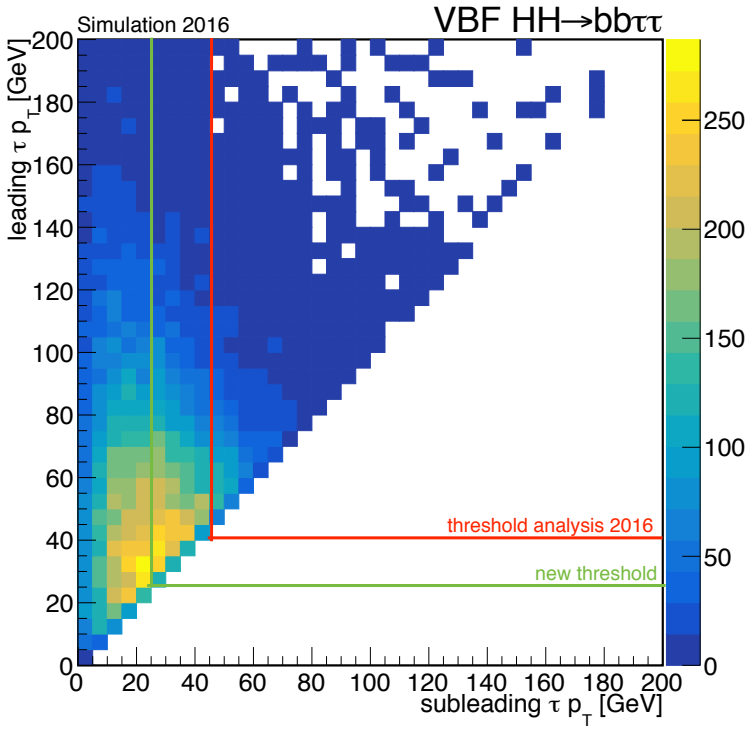




- **high sensitivity on λ_{2V}**: σ/σ_{SM} up to 50 for $|\delta_{2V}| \sim 1$
  - $\delta = \lambda/\lambda_{SM} - 1$

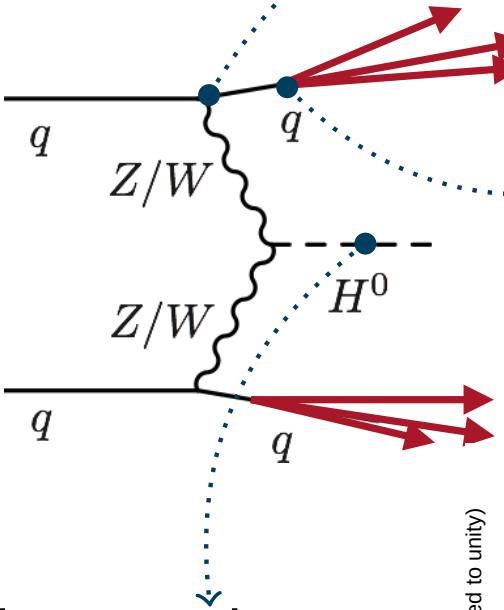
VBF: challenges and strategy

- rare process: $\sigma_{ggF} \sim 20 \times \sigma_{VBF}$
- the acceptance on the VBF signal is limited by the τ p_T threshold mostly driven by trigger requirements
- high ggF contamination



1. Exploit the VBF topology to expand the acceptance starting from the trigger level - *next slides*
2. Design a VBF event category for the inclusive HH→ bbττ analysis
   well advanced (not shown today)
3. Discriminate the VBF contribution from the ggF contamination
   preliminary (not shown today)

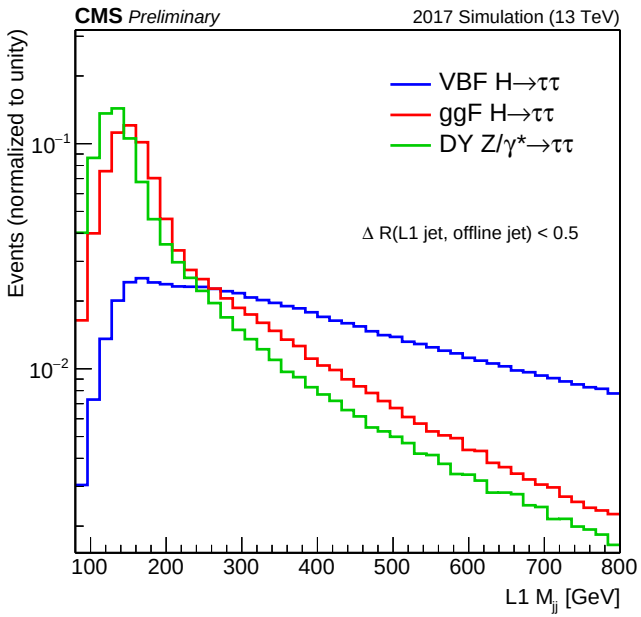
The VBF process

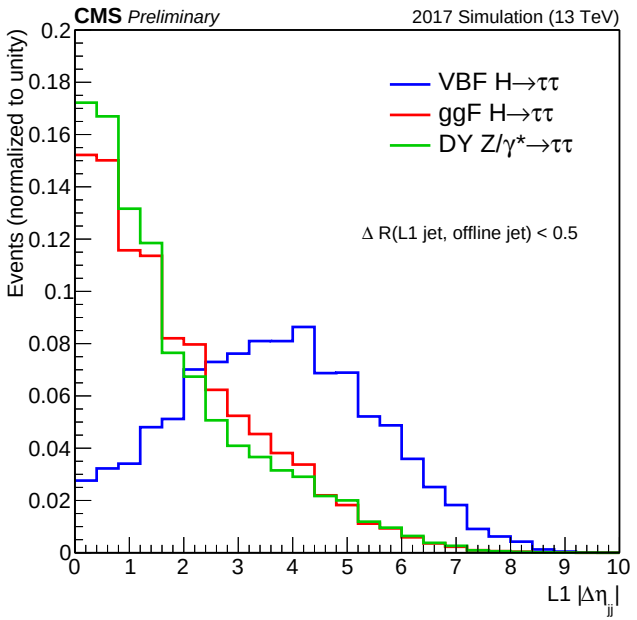


within the *p*-*p* interaction, the involved quarks can emit vector bosons, losing a small amount of their longitudinal energy

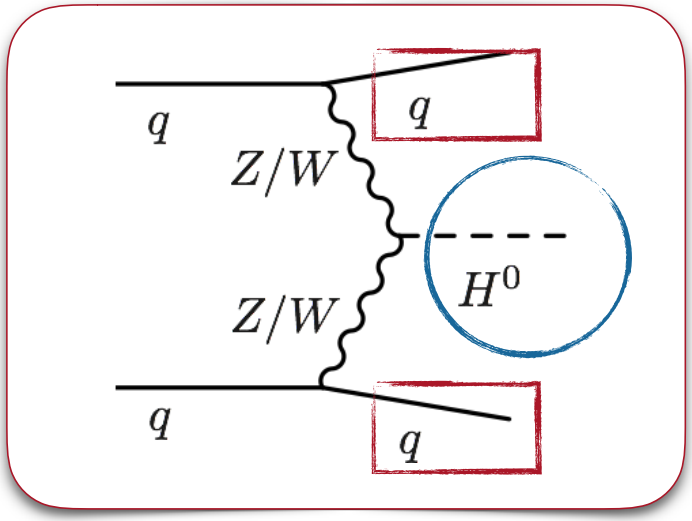
the hadronization of a quark or gluon results in **jets**: the VBF jet pair has **large invariant mass** and **large angular separation**

the Higgs boson decay products are usually in the central region of the detector



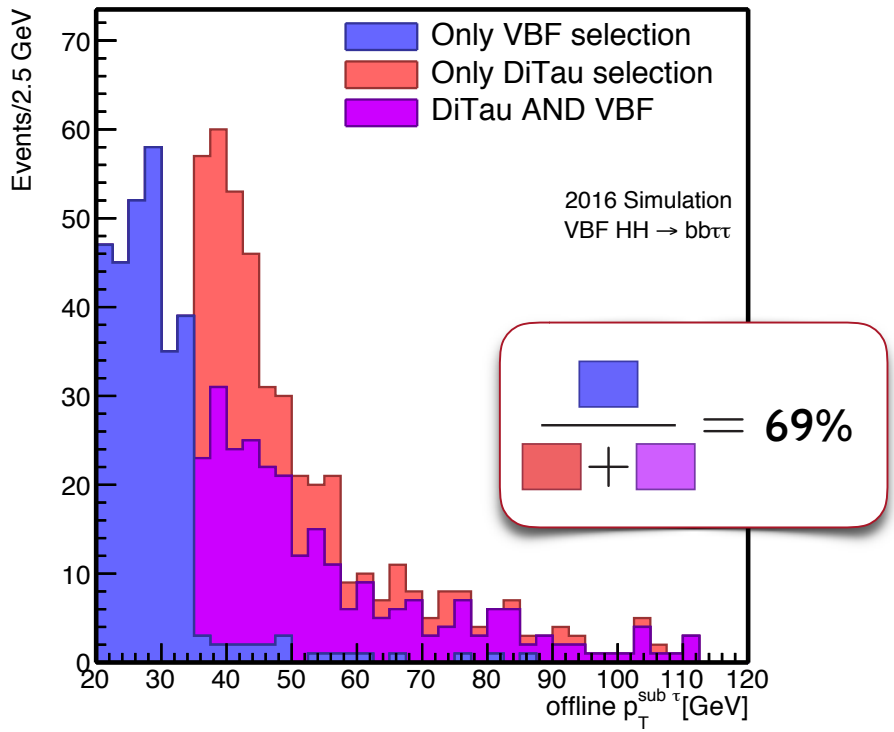


VBF L1 trigger strategy and performance



L1 trigger selection for VBF production:

- at least one jet with $E_T > X$
- at least two jets with $E_T > Y$ and $m_{jj} > Z$



The usual trigger strategies target the **decay mode**, while in this case the selection is specific for the **production mode**: using it as a complement to the classic triggers, **the phase-space is expanded** and the sensitivity to VBF is improved

The L1 VBF trigger is online since 2017 and VBF HH→ bbττ HLT paths are built on top of it.

Conclusion

- Higgs production pair searches are performed in different channels
- The Vector Boson Fusion production mode, unexplored in the bb$\tau\tau$ analyses until now, can bring additional information to test the Higgs mechanism
- A VBF HH$\rightarrow$ bb$\tau\tau$ strategy is being defined
  - Major challenge: **extremely rare process**
  - I designed a **VBF dedicated trigger algorithm**, online since 2017, to enhance the signal event yield
  - The next HH$\rightarrow$ bb$\tau\tau$ analysis (data >= 2017) will include a VBF category