



Search of $VH(H \rightarrow cc)$ in full hadronic channel

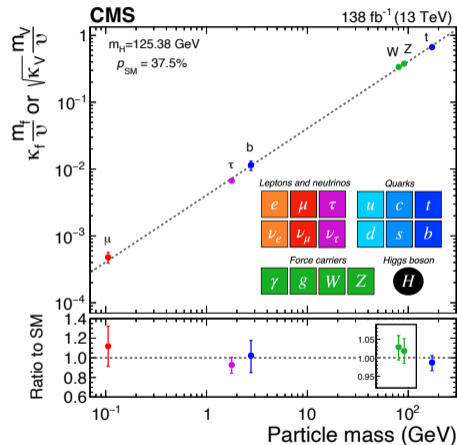
Isadora Galvão

CERN Summer Student

Supervisors: Fabio Monti and Beatriz Ribeiro Lopes (CERN)

Motivation

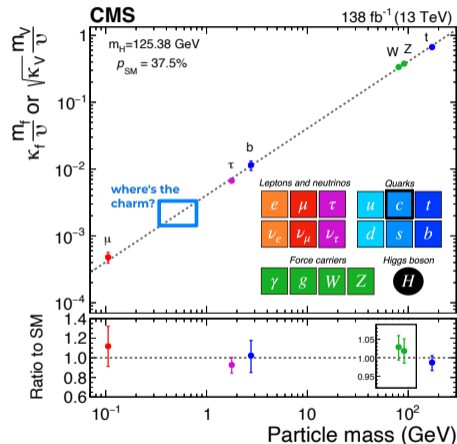
- Discover of Higgs boson in 2012
 - Interest in its properties
 - Coupling with SM particles
 - Stronger for 3rd generation
 - Probing the couplings for 2nd generation
- Validate Standard Model (SM) predictions
- Search for physics beyond the SM



<https://doi.org/10.1038/s41586-022-04892-x>

Motivation

- Discover of Higgs boson in 2012
 - Interest in its properties
 - Coupling with SM particles
 - Stronger for 3rd generation
 - Probing the couplings for 2nd generation
- Validate Standard Model (SM) predictions
- Search for physics beyond the SM

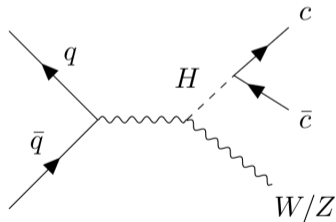


<https://doi.org/10.1038/s41586-022-04892-x>

Production process and Decay

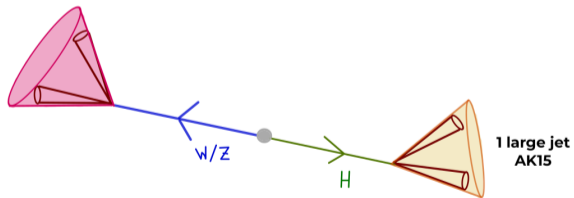
- Higgs produced in association with a vector boson (Z,W)
- Choose the decay channel
 - Leptonic: $Z \rightarrow \nu\nu$, $Z \rightarrow \ell\ell$, $W \rightarrow \ell\nu$ [$\ell = e, \mu$]
 - **Hadronic:** $V \rightarrow q\bar{q}$
 - Higher branching fraction
 - Not yet explored at CMS

	leptons	hadrons
Z	3.7294 ± 0.0108 ($\ell^+\ell^- + \mu^+\mu^-$)	69.911 ± 0.056
	20.000 ± 0.055 (invisible $\rightarrow \nu\nu$)	
W	10.86 ± 0.09 ($\ell\nu$)	67.41 ± 0.27



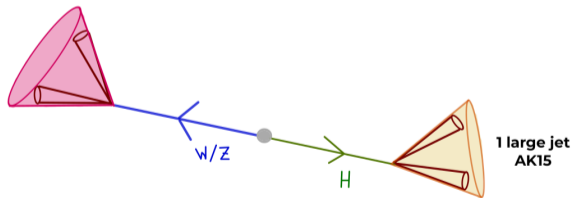
Merged-jet topology

- Two back-to-back large jets AK15 ($R=1.5$)
 - distinguish signal from background by regressed jet mass + flavor tagging



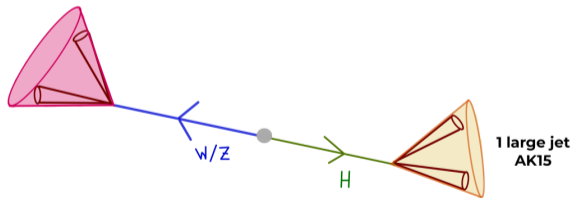
Merged-jet topology

- Two back-to-back large jets AK15 ($R=1.5$)
 - distinguish signal from background by regressed jet mass + flavor tagging



Merged-jet topology

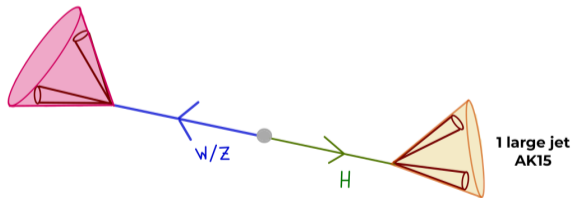
- Two back-to-back large jets AK15 ($R=1.5$)
 - distinguish signal from background by regressed jet mass + flavor tagging
- Challenge: reduce backgrounds
 - multijets process (QCD)
 - V + jets
 - single top and $t\bar{t}$ production



Merged-jet topology

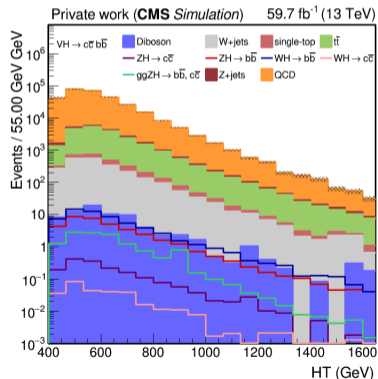
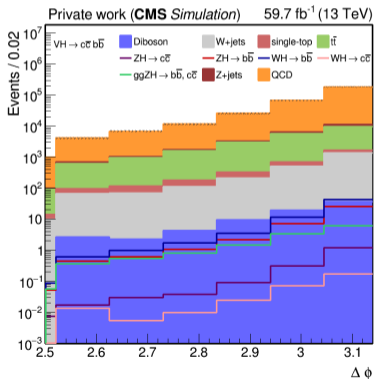
- Two back-to-back large jets AK15 ($R=1.5$)
 - distinguish signal from background by regressed jet mass + flavor tagging
- Challenge: reduce backgrounds
 - multijets process (QCD)
 - V + jets
 - single top and $t\bar{t}$ production

- Project goals:
 - Optimize analysis selections
 - Assess channel sensitivity

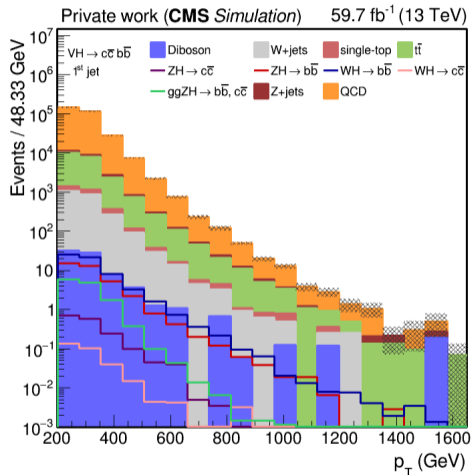


First results with MC

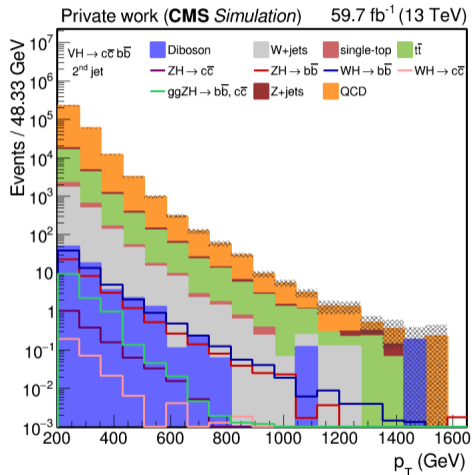
- Azimuthal angle ($\Delta\phi$) \rightarrow jets back-to-back
- HT: scalar sum of jet transverse energies
- Loose preselections on jet tagging score and event kinematics



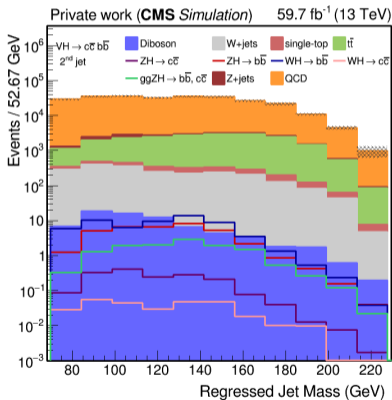
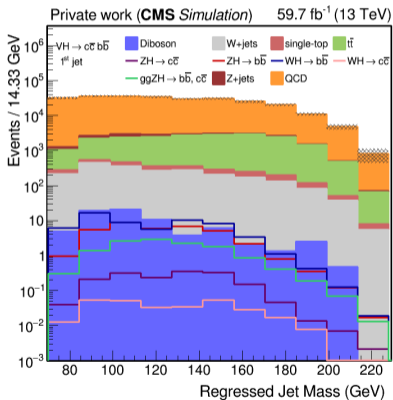
● p_T of the 1st jet



● p_T of the 2nd jet

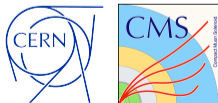


- Hard to distinguish between H and V candidate
- Working on optimization of this separation



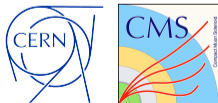
Conclusions and summary

- Higgs couplings measurements
 - one of the primary goals of the LHC physics program
 - approaching the H-to-charm coupling sensitivity
- Main challenges in VH(cc) full hadronic analysis:
 - Reduce background
 - Choose the H candidate
- Optimize the analysis selections for hadronic channel and assess channel sensitivity
- Get familiar with the data format and analysis code (*done*)
- Compare available CMS datasets in terms of trigger efficiency (*ongoing*)



Conclusions and summary

- Higgs couplings measurements
 - one of the primary goals of the LHC physics program
 - approaching the H-to-charm coupling sensitivity
- Main challenges in VH(cc) full hadronic analysis:
 - Reduce background
 - Choose the H candidate
- Optimize the analysis selections for hadronic channel and assess channel sensitivity
- Get familiar with the data format and analysis code (*done*)
- Compare available CMS datasets in terms of trigger efficiency (*ongoing*)



Thank you! Obrigada!



Backups

- Previous measurements
- Workflow
- Common selections

Previous measurements

- CMS Collaboration
 - leptonic channel, 138 fb^{-1} [[Phys. Rev. Lett. 131, 061801 \(2023\)](#)]
 - leptonic channel, 36 fb^{-1} [[JHEP 03 131 \(2020\)](#)]
 - Higgs boson properties overview [[Nature 607 \(2022\)](#)]
- ATLAS Collaboration
 - leptonic, 36 fb^{-1} [[Phys. Rev. Lett. 120, 211802 \(2018\)](#)]
 - full hadronic, $\text{VH}(\text{bb})$, 137 fb^{-1} [[Phys. Rev. Lett. 132, 131802 \(2024\)](#)]

First plots with requirements and selections

Choose H candidate

Trigger selection → best trigger path

Common Selections:

$$2.5 < \Delta\phi < 3.14$$

$$H_t > 400 \text{ GeV}$$

$$p_T(H) > 300 \text{ GeV}$$

$$p_T(V) > 300 \text{ GeV}$$

Flavor tagging:

1st AK15 jet with higher bb score

2nd AK15 jet with higher cc score

→ switch