H → CC SEARCH AND Z → CC OBSERVATION @LHC

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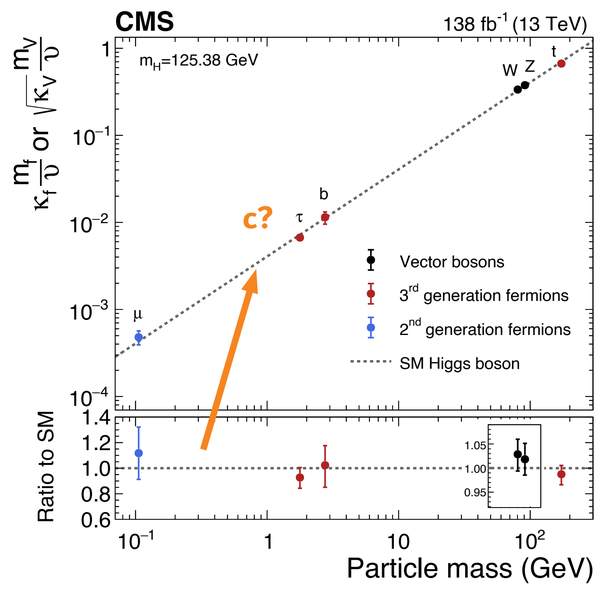
Inclusive Search for a Boosted Higgs Boson and Observation of the Z Boson Decaying to Charm Quarks with the CMS Experiment [1]

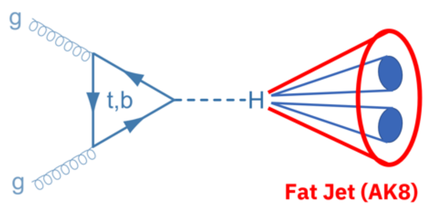
Motivation

- Higgs to charm decays are the largest unobserved part of Higgs BR
- Key component of establishing coupling to 2nd generation of fermions [2]
- Target phase space completely **orthogonal to past searches** (VH → cc) [3,4]
- Boosted regime, single AK8 jet, gluon fusion production mode



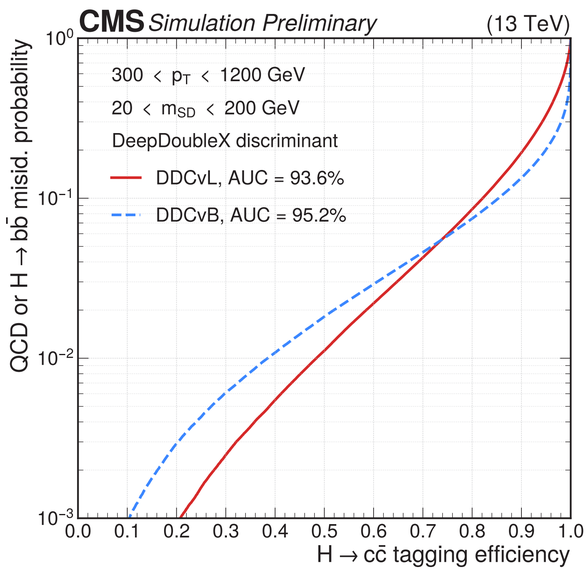
Analysis Strategy

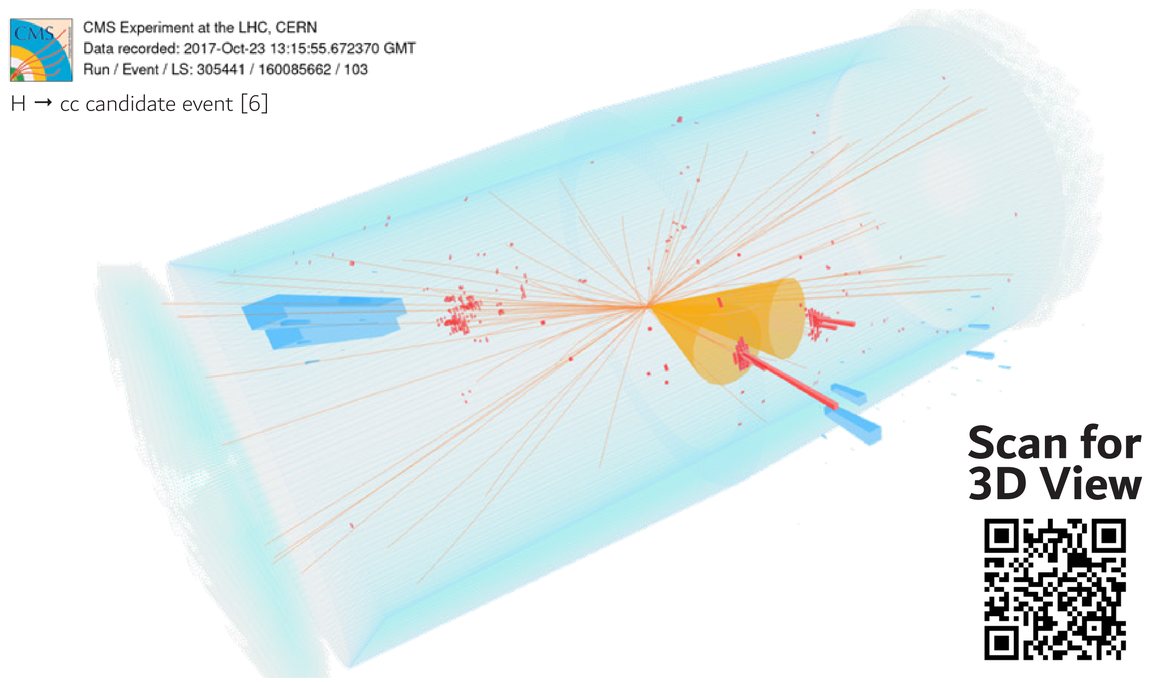
- Primarily targeting **ggH** production mode (**50% of signal yield** after selection), but VBF (30%) as well as ZH (10%) and WH (10%) events also contribute
- No additional particles in the final state unlike in associated production searches to enable background separation
- **High transverse momentum** (p_T) regime, where **decay products** are **collimated**
- Higgs candidates reconstructed as **AK8 jets** and selected using **substructure** and **heavy flavour identification** methods



Data and Selection

- Use a mix of AK8 jet triggers that is 90% efficient at p_T > 450 GeV and becomes fully efficient by 500 GeV. Full **Run2 dataset with 138 fb^{-1}** integrated luminosity
- Event level lepton veto
- **Substructure** selection for two-pronged jets with the **N_2** substructure variable, decorrelated from the jet mass with the **DDT** procedure,
- **DeepDoubleX** [5] tagger for flavour identification
  - Low-level information for particle flow candidates and secondary vertex properties, as well as high level expert variables
  - Model comprises of convolutional, recurrent and dense layers
  - Independently trained classifiers for **charm vs. light** (CvL) and **charm vs. bottom** (CvB) as well as bottom vs. light (BvL) tagging
- Loose CvB and tight CvL cut with overall light efficiency of 0.5%, bottom efficiency of 12.4% and charm (signal) efficiency of 20%

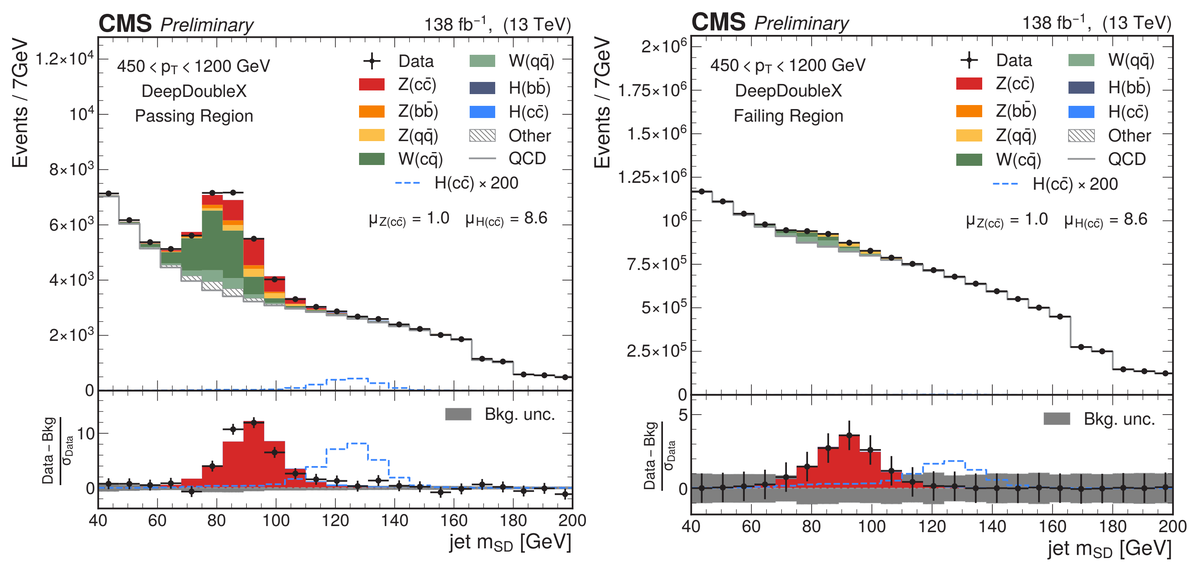




H → cc candidate event [6]

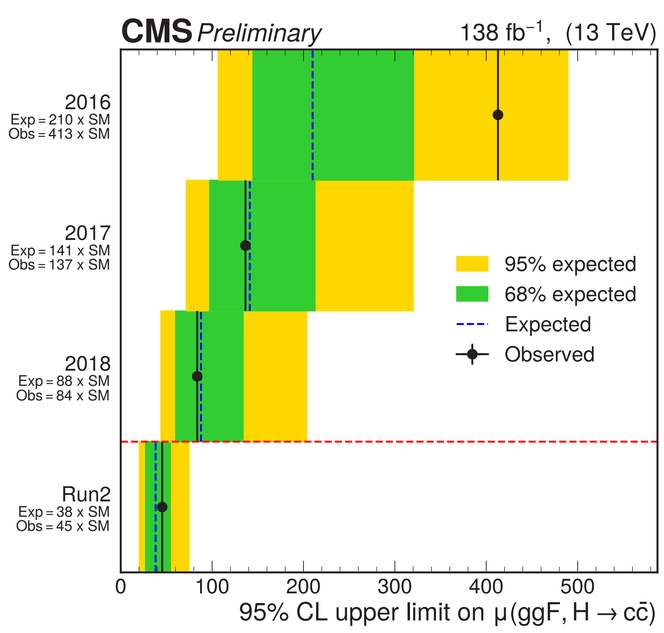
Fit

- Take the **highest scoring CvL** jet as the **Higgs candidate**
- Bin signal region (SR) phase space in **23 bins of jet soft-drop mass** from 40 to 200 GeV and **6 bins of jet p_T** between 450 and 1200 GeV
- Define control region (CR) by inverting the CvL selection to obtain a **data-driven** QCD background prediction. Remaining backgrounds taken from MC.
- Perform a simultaneous maximum likelihood SR + CR fit, constraining the QCD background shape from the CR in-situ, while measuring the signal strength



Results

- **Z → cc** process observed with **significance >> 5σ** for the first time in Z+jets production mode at the LHC with μ_Z = 1.06±0.14/0.12(exp.)0.07(th.)0.06(stat.)
- An **observed (expected) upper limit** is set on the inclusive Higgs boson cross section time the branching ratio of **H → cc** process at **45 (38)** times the standard model expectation at 95% confidence level



[1] CMS-PAS-HIG-21-012
[2] Nature 607 (2022) 60-68
[3] Phys. Rev. Lett. 120 (May, 2018)
[4] JHEP 03 (2020) 131
[5] CMS-DP-2018-046, 2018
[6] CMS-PHO-EVENTS-2022-020

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