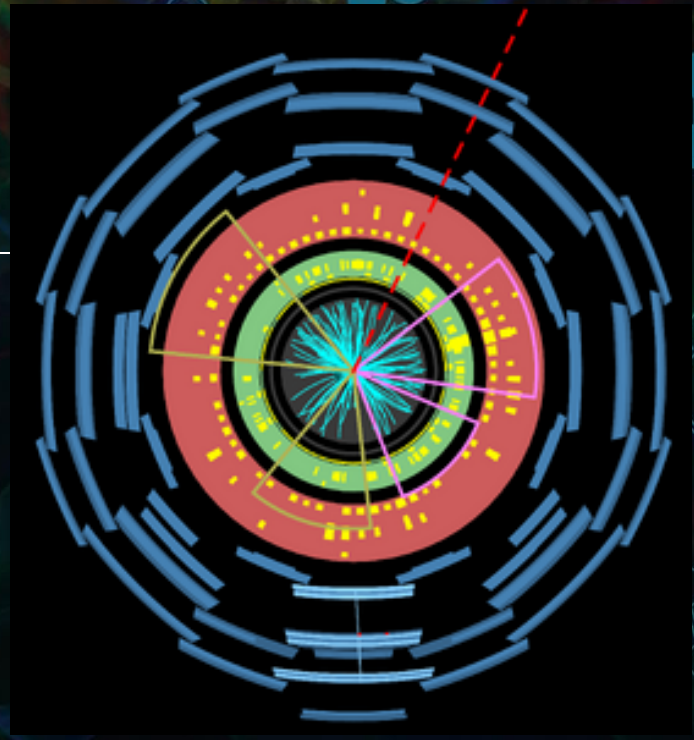
Probing Higgs-charm Yukawa Structure at the ATLAS Experiment

Prajita Bhattarai

SLAC Summer Institute, August 11, 2026

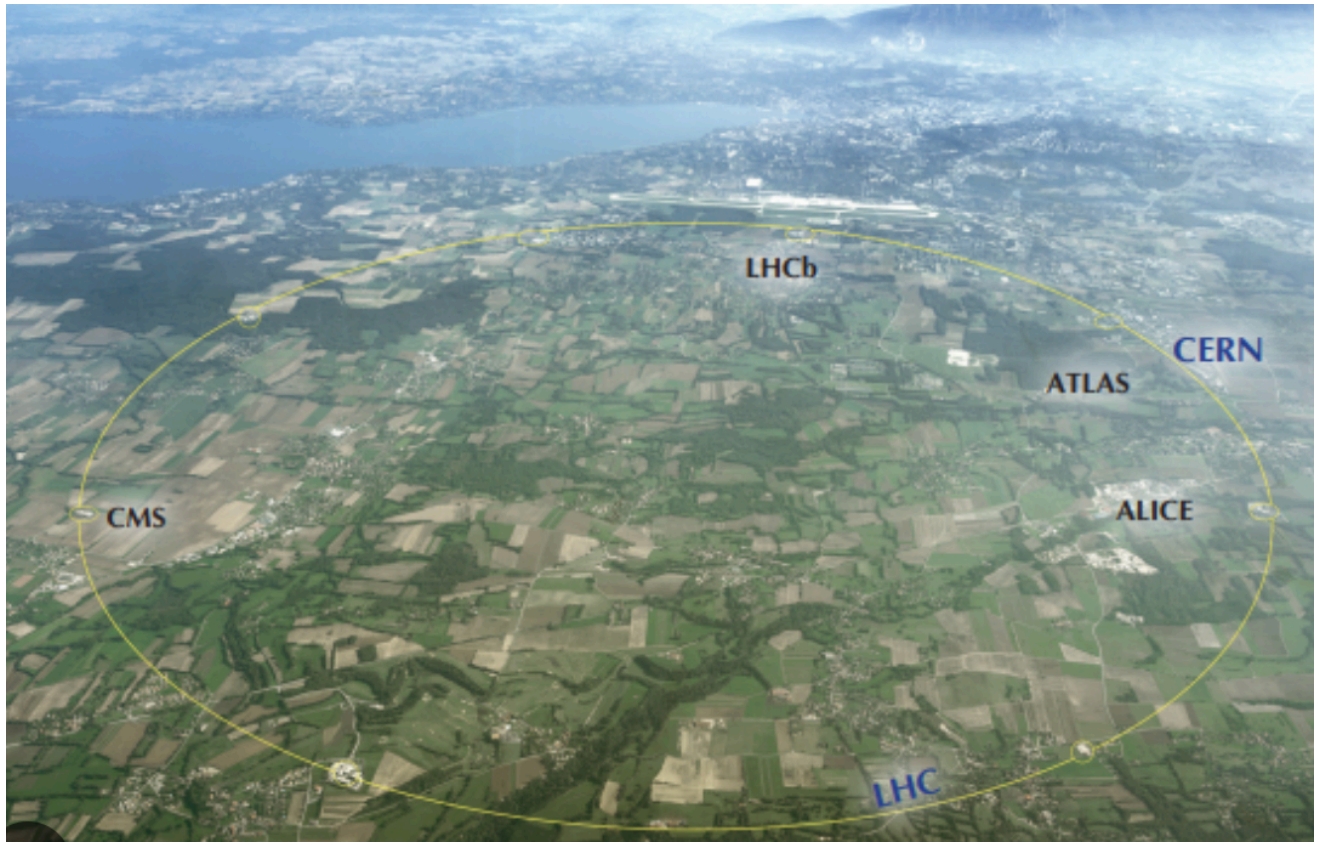


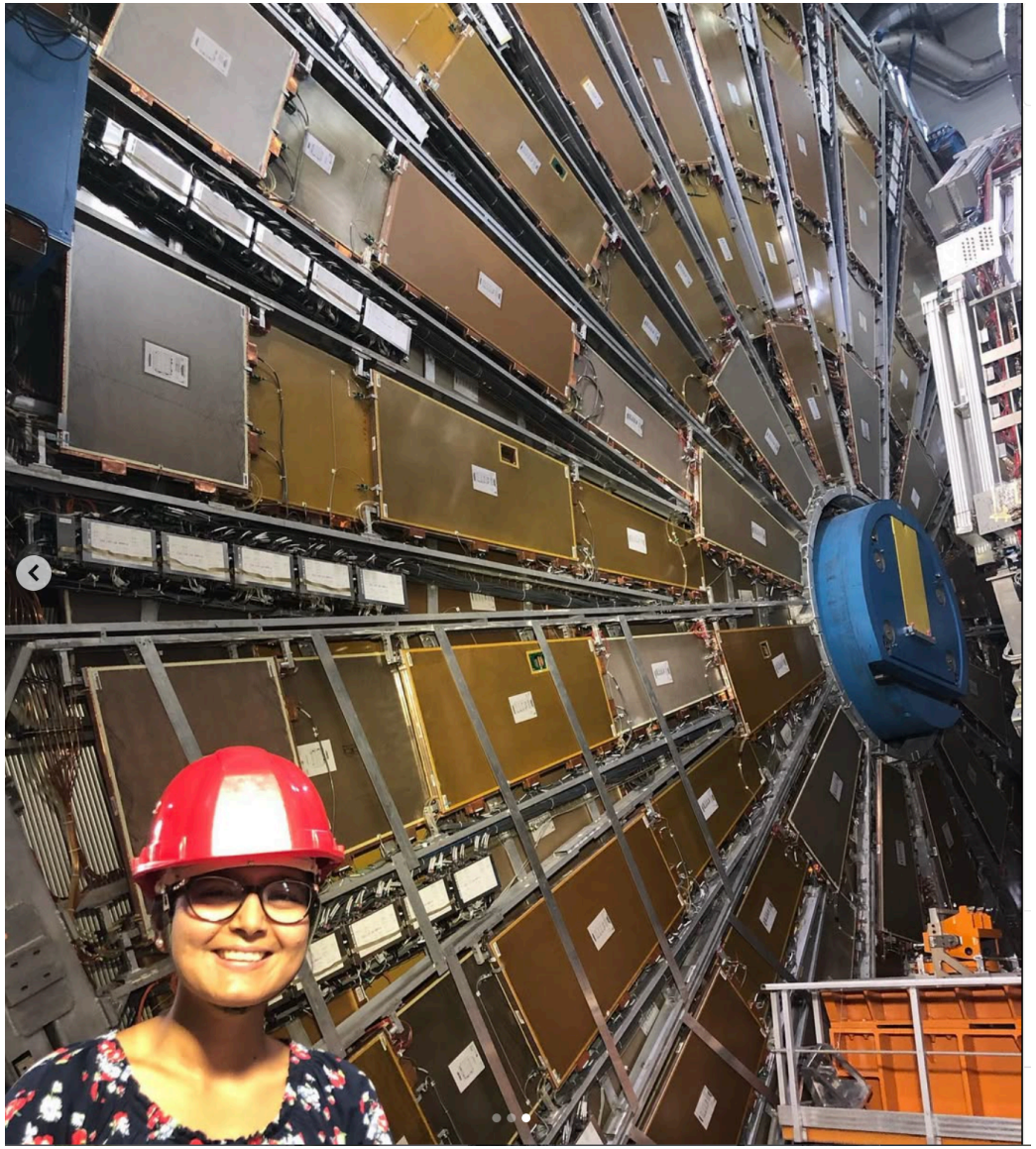
SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Introduction

- Postdoc with the SLAC ATLAS group, working on Higgs physics and building Silicon tracker for the ATLAS experiment at the LHC

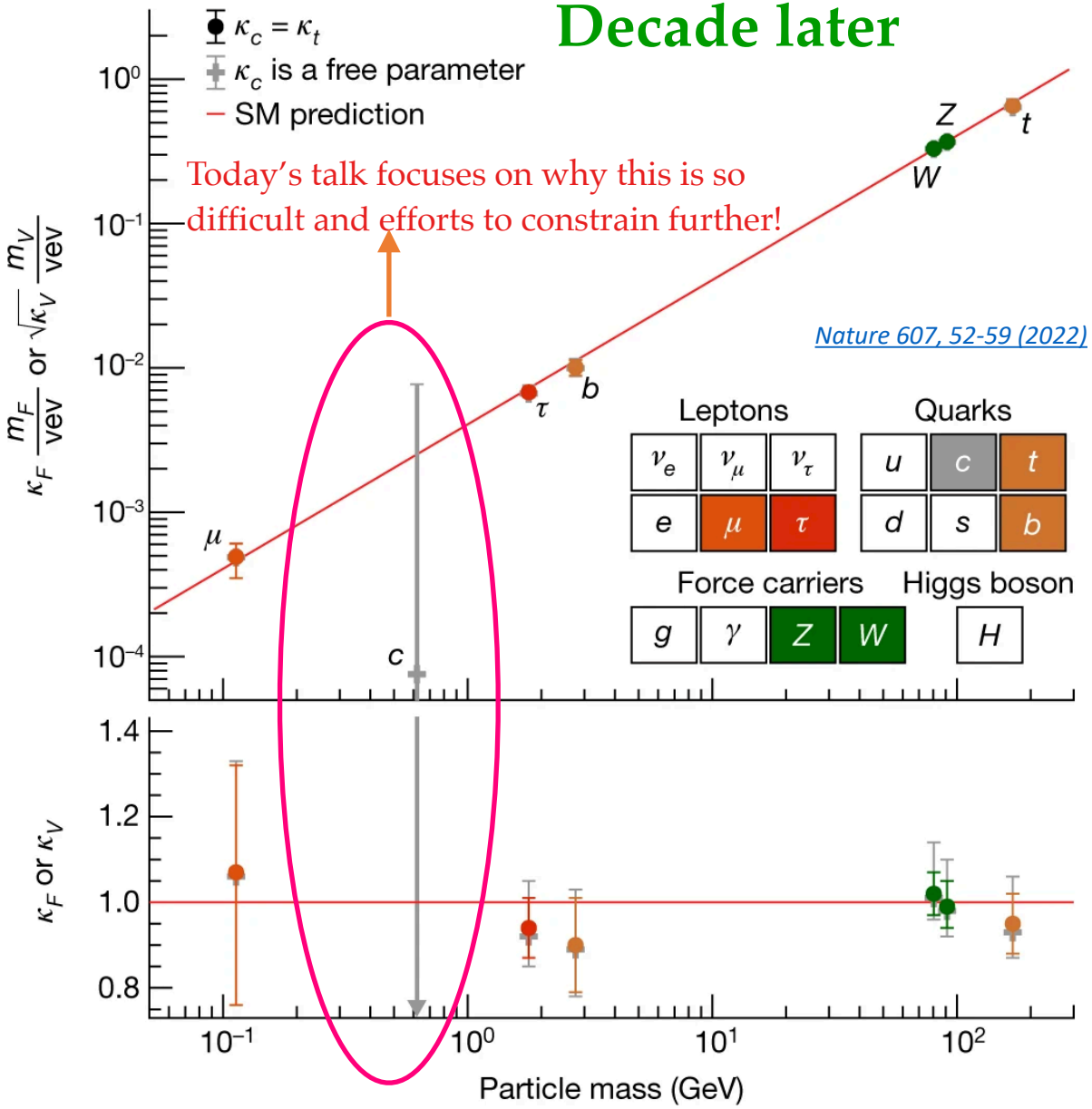




The Real Introduction

Higgs discovery!

Decade later



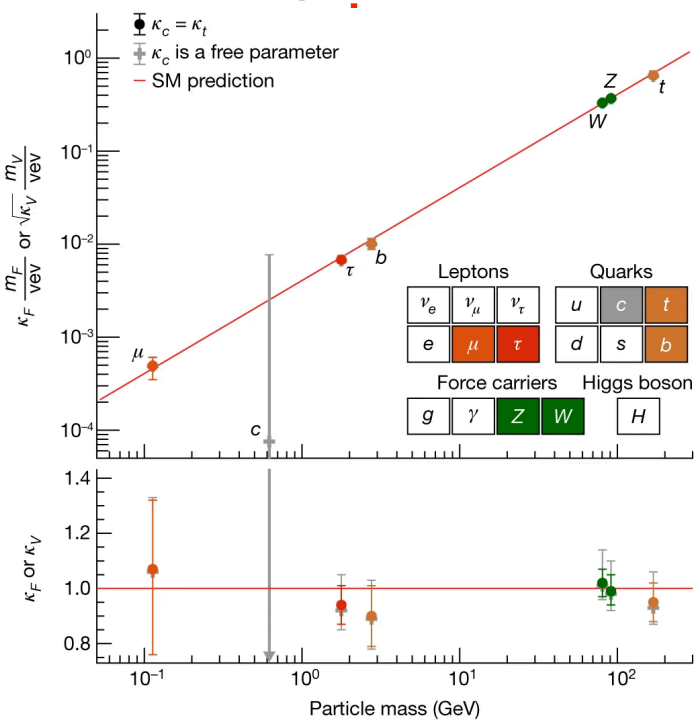
Motivation

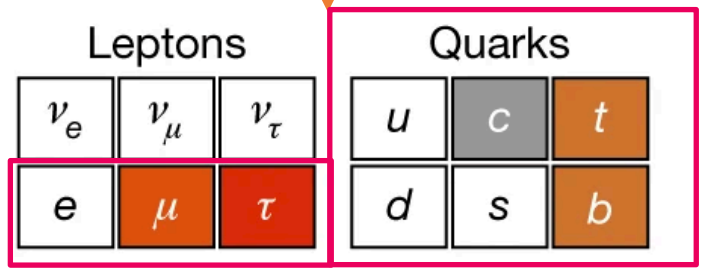
Why care about Higgs-charm coupling?

gauge boson interactions | fermion interactions | Yukawa couplings | Higgs-gauge couplings | Higgs self-couplings

$$\mathcal{L}_{SM} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + i\bar{\psi}\gamma^{\mu}D_{\mu}\psi + \bar{\psi}_i y_{ij}\psi_j\phi + h.c. + |D_{\mu}\phi|^2 - V(\phi)$$

SM fermions get mass

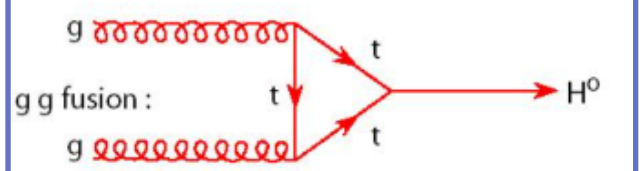


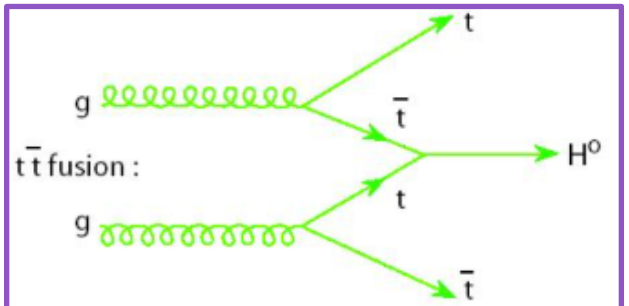


- Present experimental measurements follow the SM very well
  - Measured 3rd generation quarks & lepton very well!
  - For second generation leptons: experimental evidence of Higgs coupling to muons
  - For second generation quark sector: charm is the only accessible option
- New physics scenarios could alternate second/first generation coupling to be different from SM
  - Imperative to measure!

Higgs Production @LHC

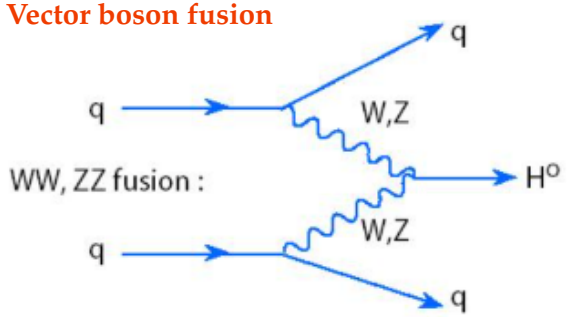
ggF: Largest production mode & background

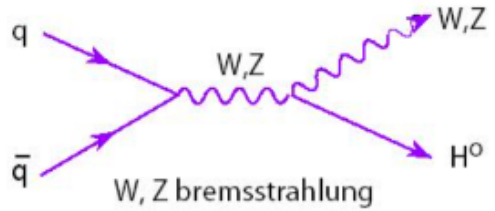




Top quark pair

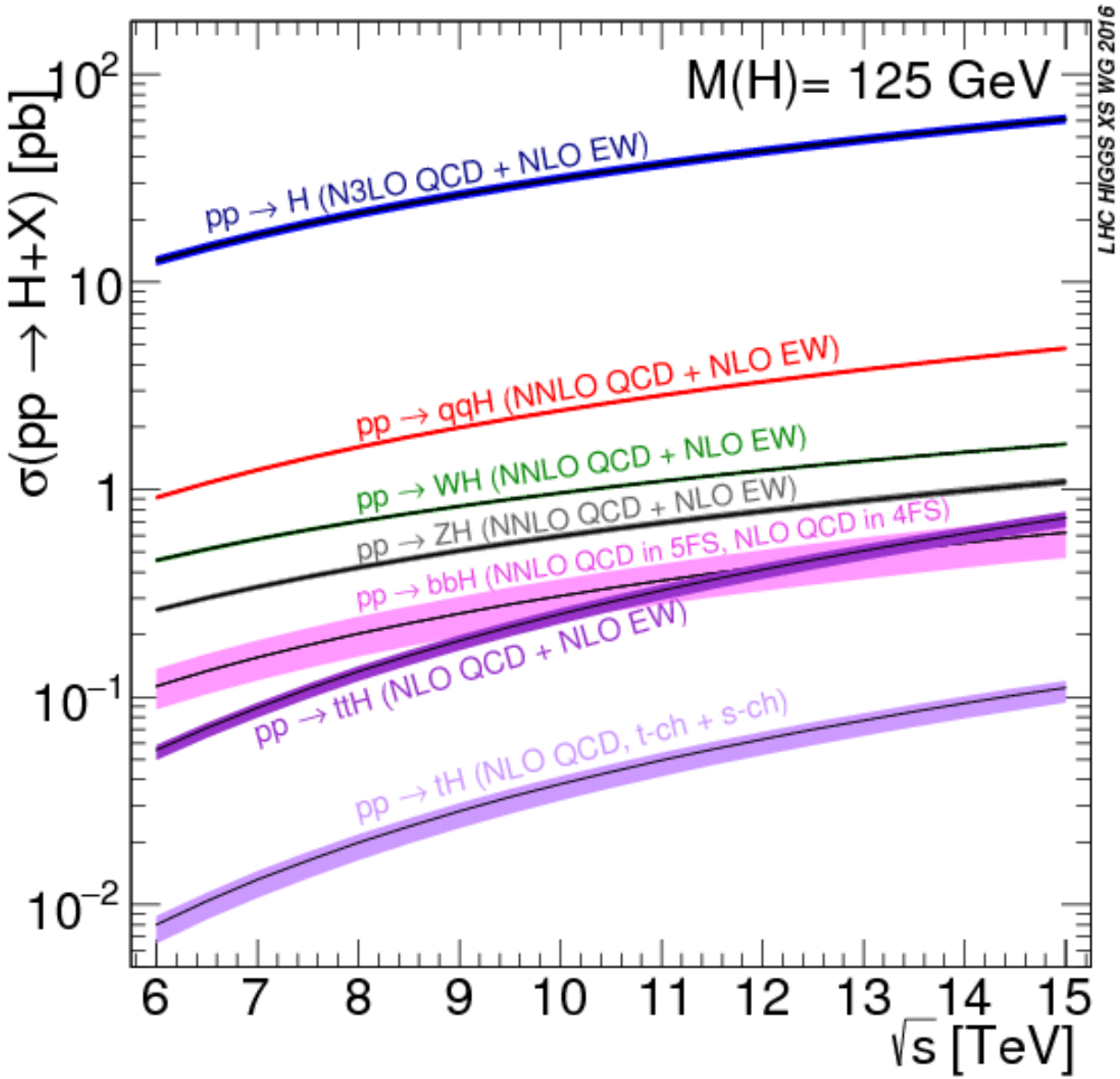
Vector boson fusion



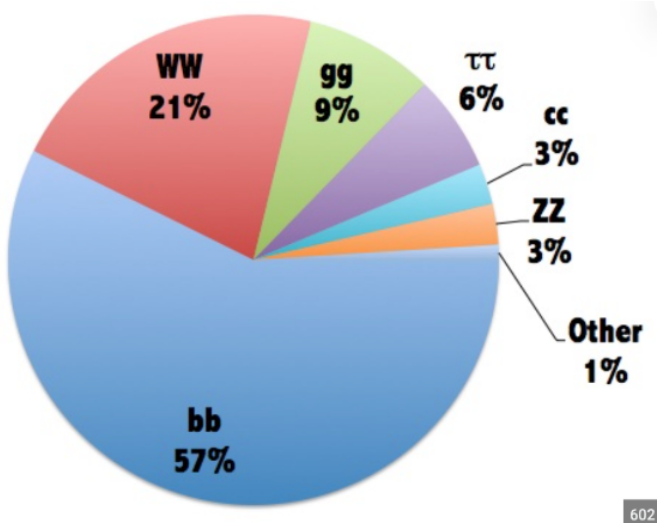


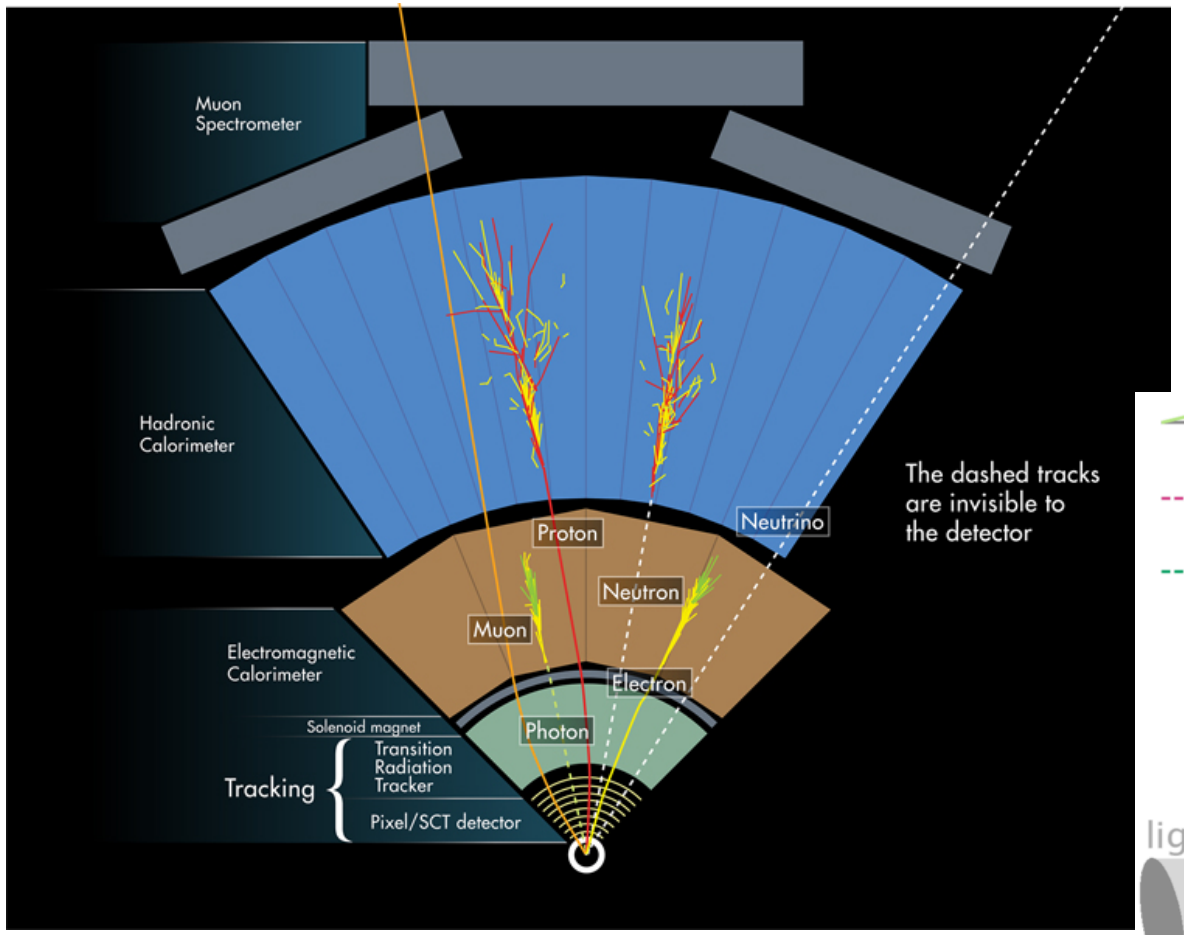
In association with W or Z, very clean!

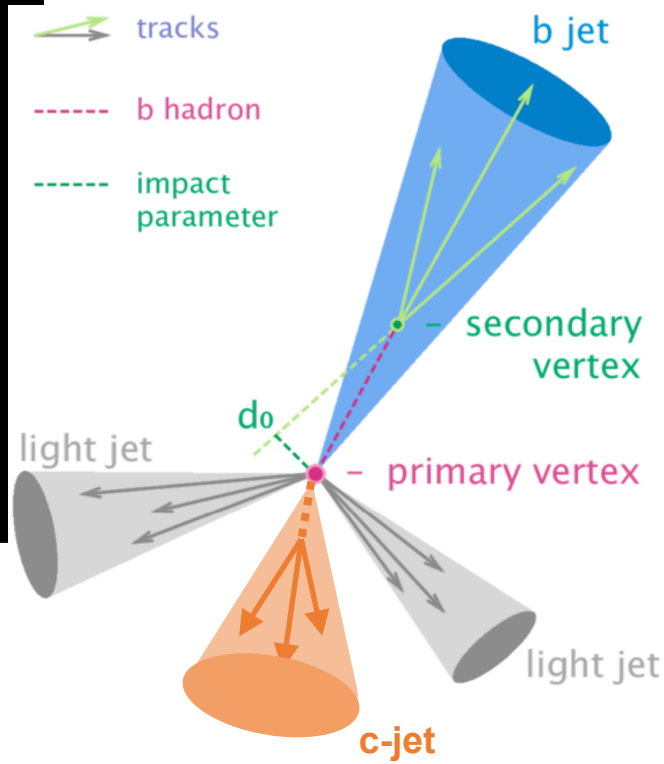
Main production probe for H—>cc



Challenges of H—> cc @LHC

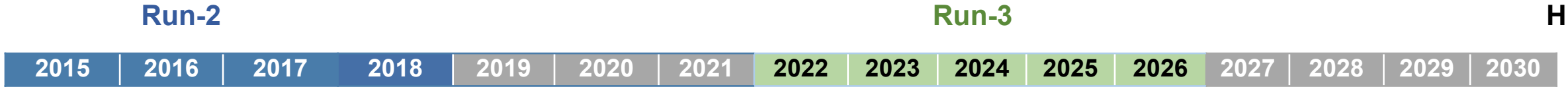




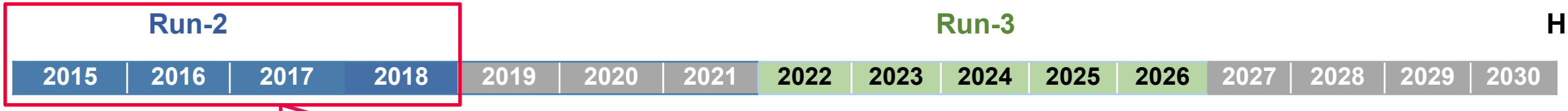


- H—>cc 20X rarer than H—>bb
- Harder to identify c-jets from b or light-quark/gluon jets
  - All hadronic objects appear as scary of particle in a cone (jets) in the detector

H—> cc at the LHC



H—> cc at the LHC



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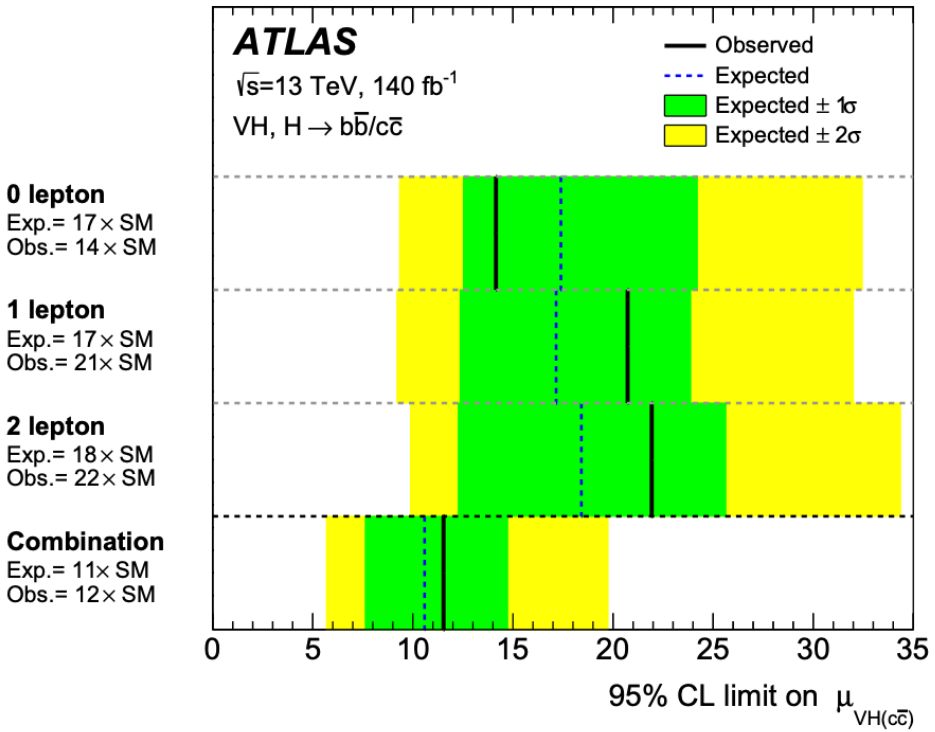
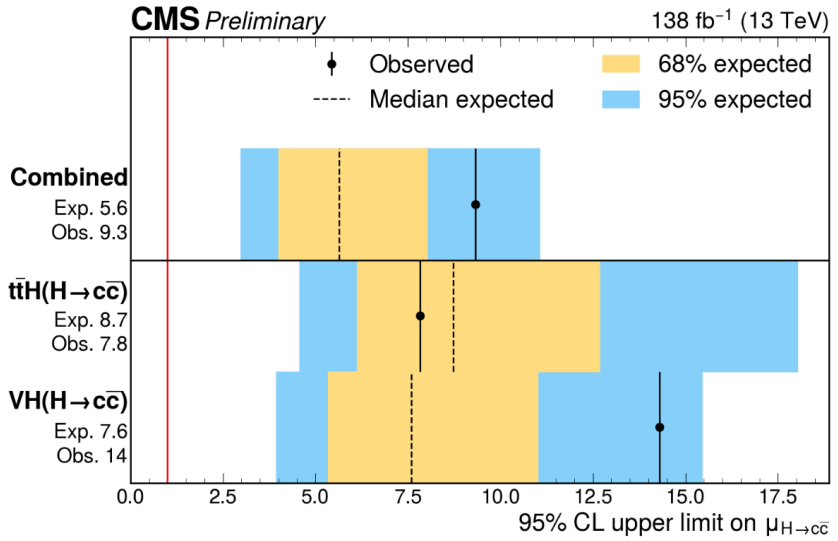
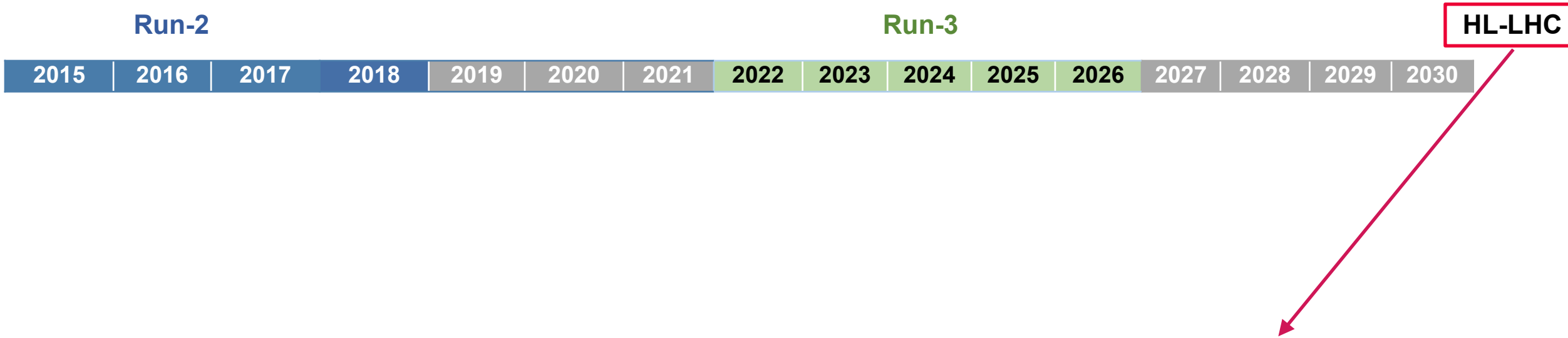


Phys. Rev. Lett. 136 (2026) 011801



- Very difficult to probe only upper limits on H—>cc
- Associated production mode (VH) most sensitive and analyzed by both ATLAS & CMS
- In addition CMS has analyzed ttH production mode!
- Most stringent 95% upper limit 9.3xSM prediction

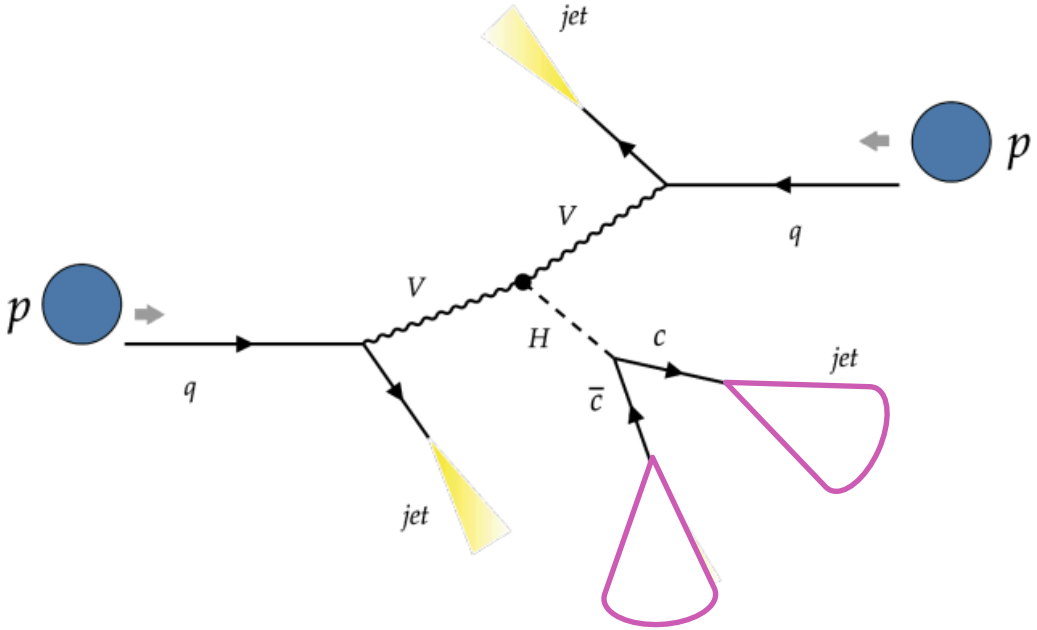
H—> cc at the LHC



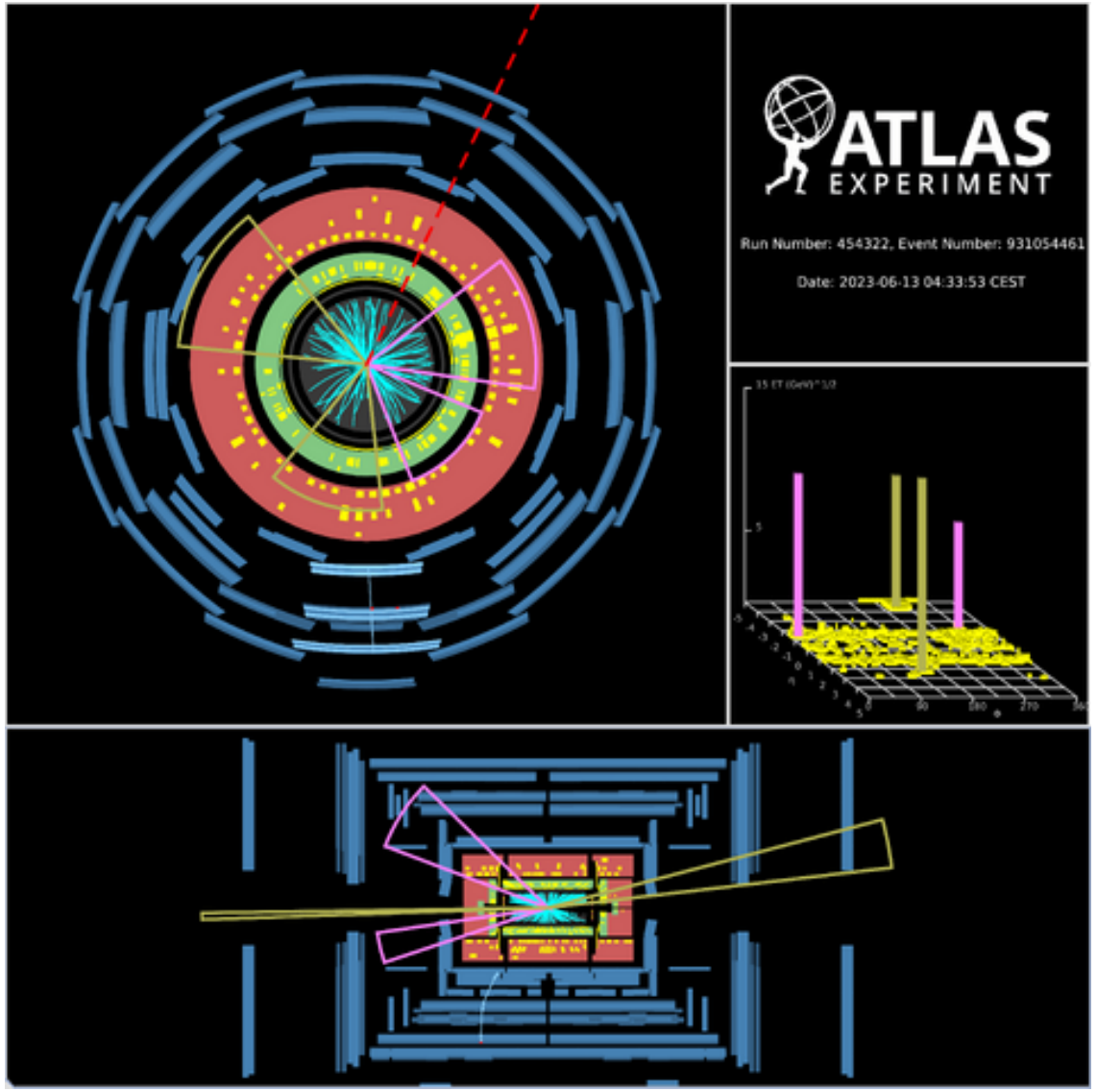
➡ Even with 10X more data from high luminosity LHC, projected upper limit on H—>cc 1.5X SM, no projected evidence no projected observations! [ATL-PHYS-PUB-2025-018]

Is this all we can do?

Adding VBF production mode

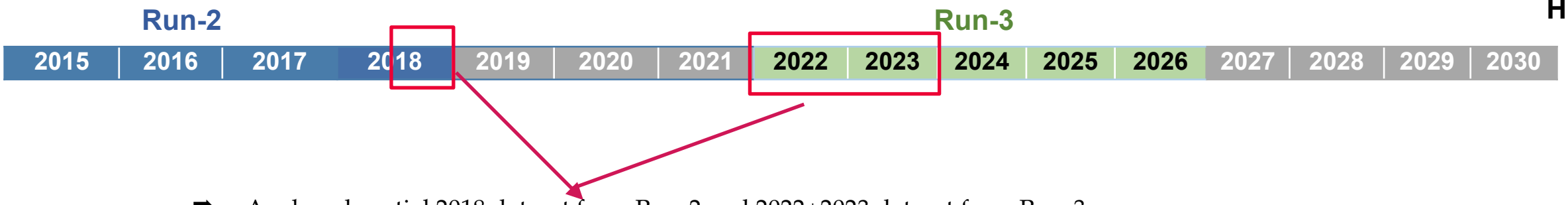


➡ First analysis of H—>cc in the VBF production mode (second largest production mode)



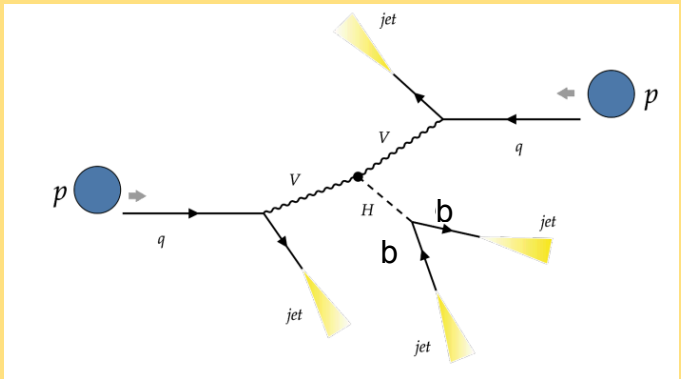
arXiv:2511.21911

VBF H—>bb/cc

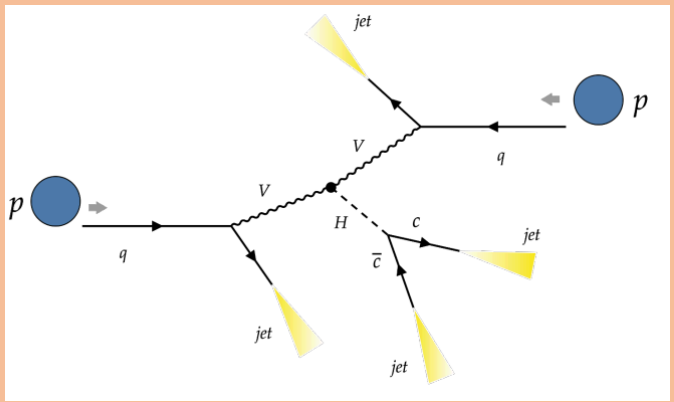


- Analyzed partial 2018 dataset from Run-2 and 2022+2023 dataset from Run-3
- Since H—>bb a large background in H—>cc search, H—>bb measured simultaneously
- Regions defined based on if both Higgs candidate jets are b- or c-tagged and data-taking year

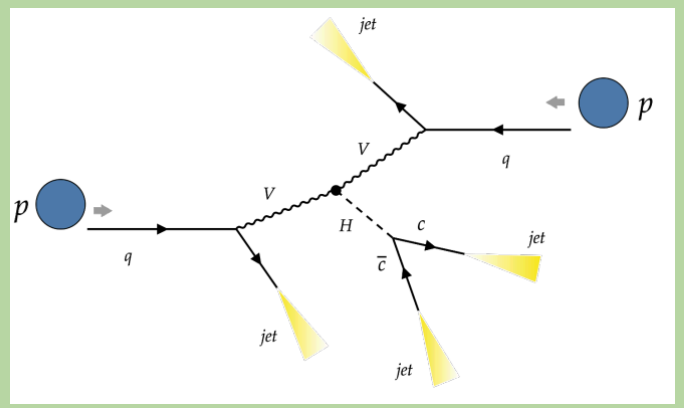
Run 3 $H \to bb$



Run 3 $H \to cc$



Run 2 $H \to cc$



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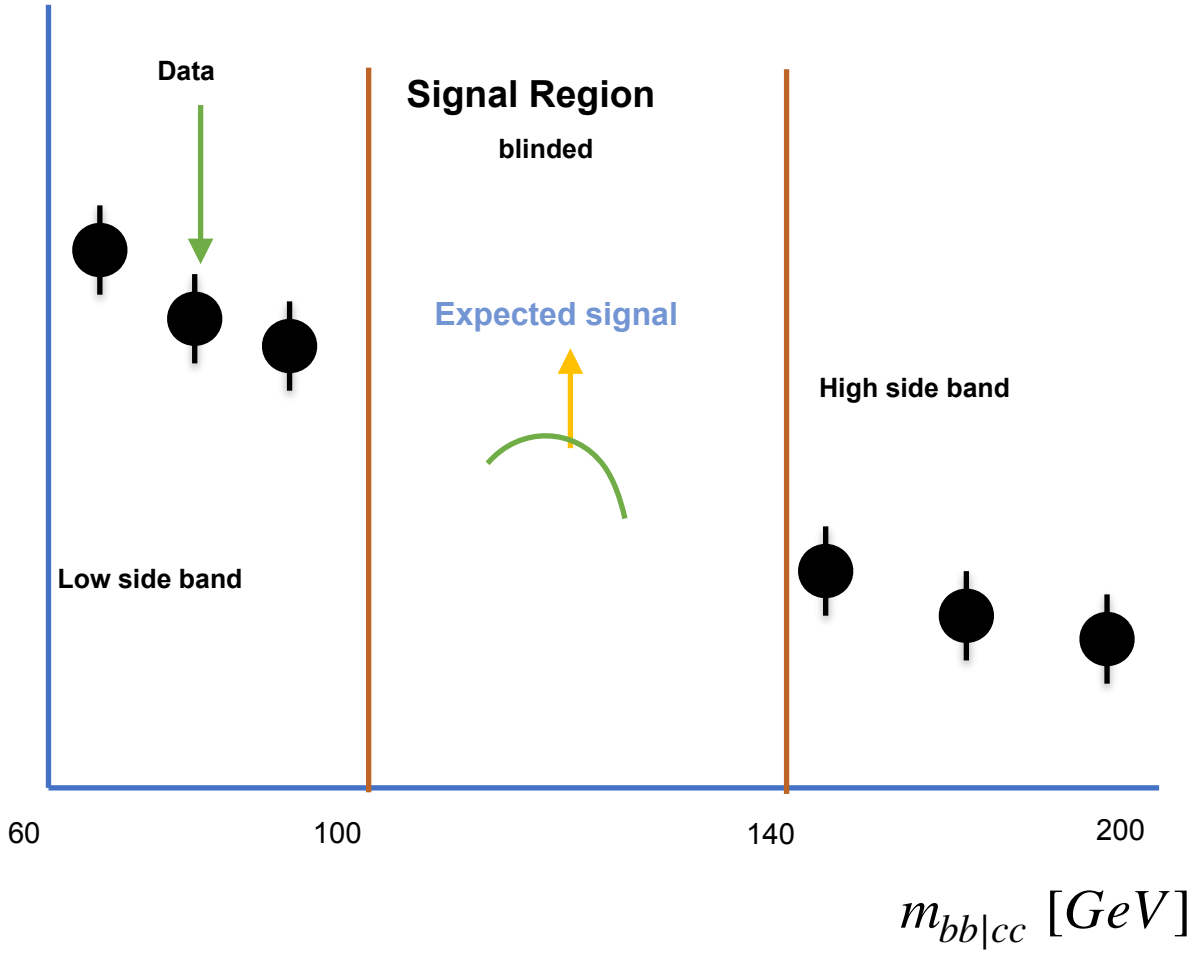
Per analysis Region

arXiv:2511.21911

➡ **Task 1**: For each channel we need to estimate non-res bkg from data

For each region



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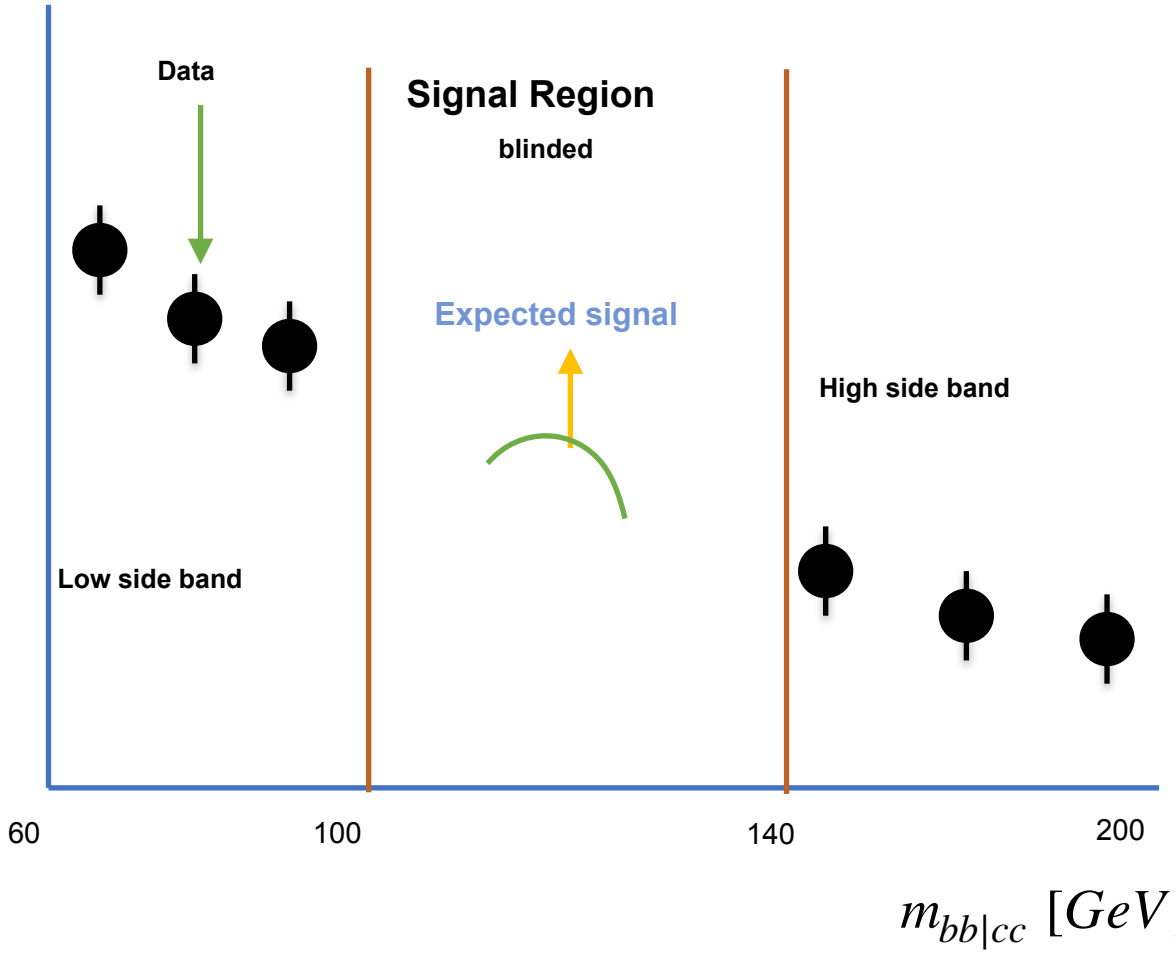
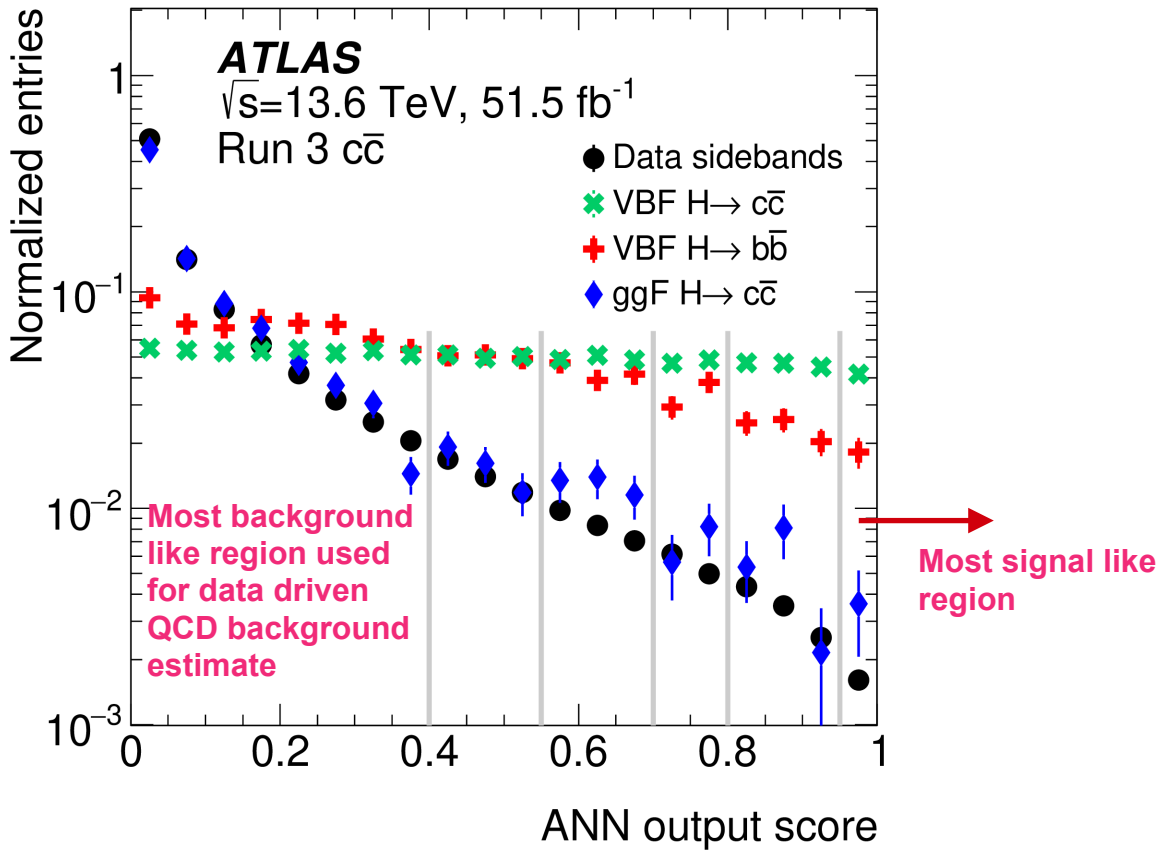


➡ **Task 2**: For each channel we need to separate signal events from background events



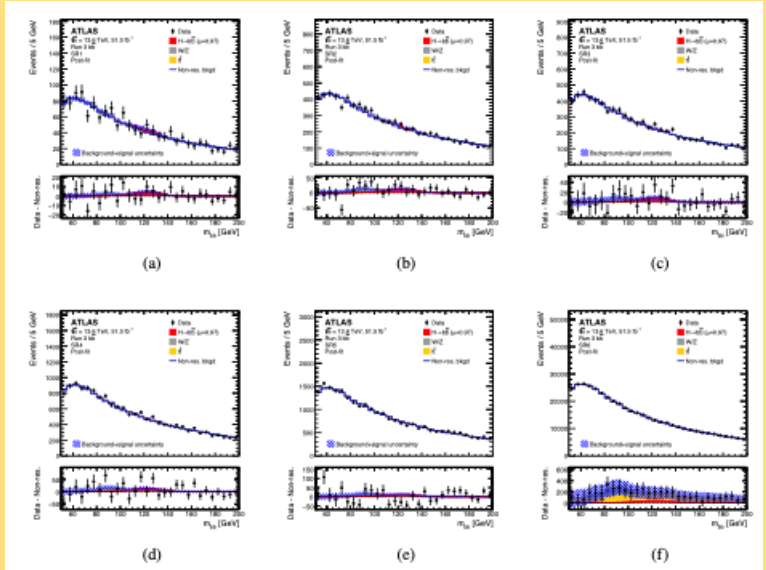
Final Analysis Fit

arXiv:2511.21911

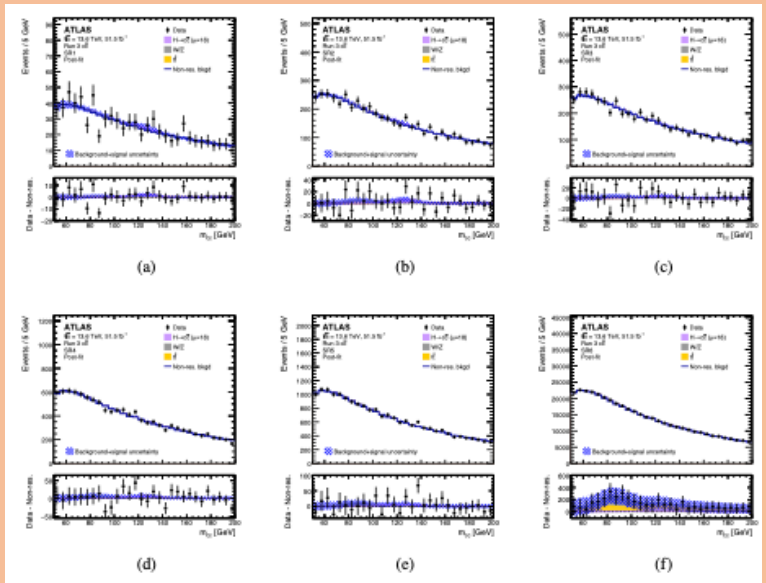
➡ Fit all 18 regions to extract the two POIs simultaneously

$$\mu_{bb} = \frac{Observed\ bb}{SM\ Pred.\ bb} \qquad \mu_{cc} = \frac{Observed\ cc}{SM\ Pred.\ cc}$$

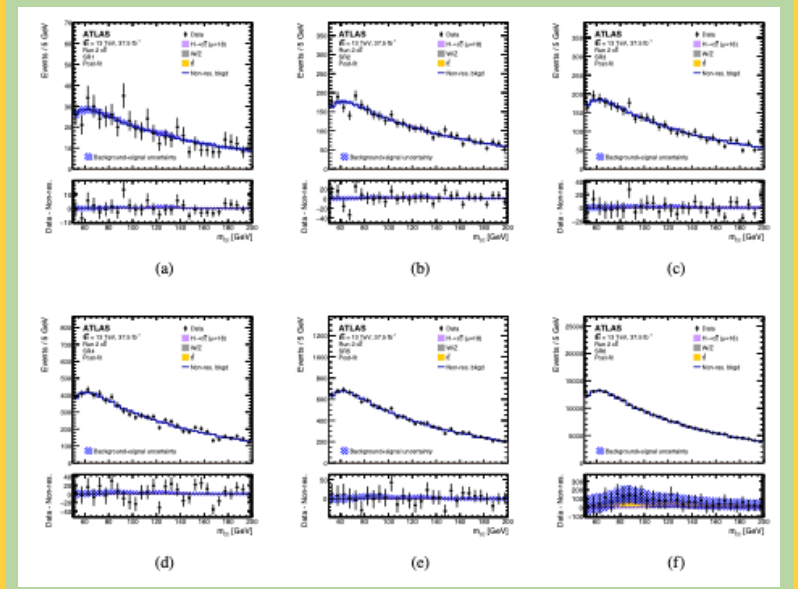
$Run\ 3\ H \to bb$



$Run\ 3\ H \to cc$

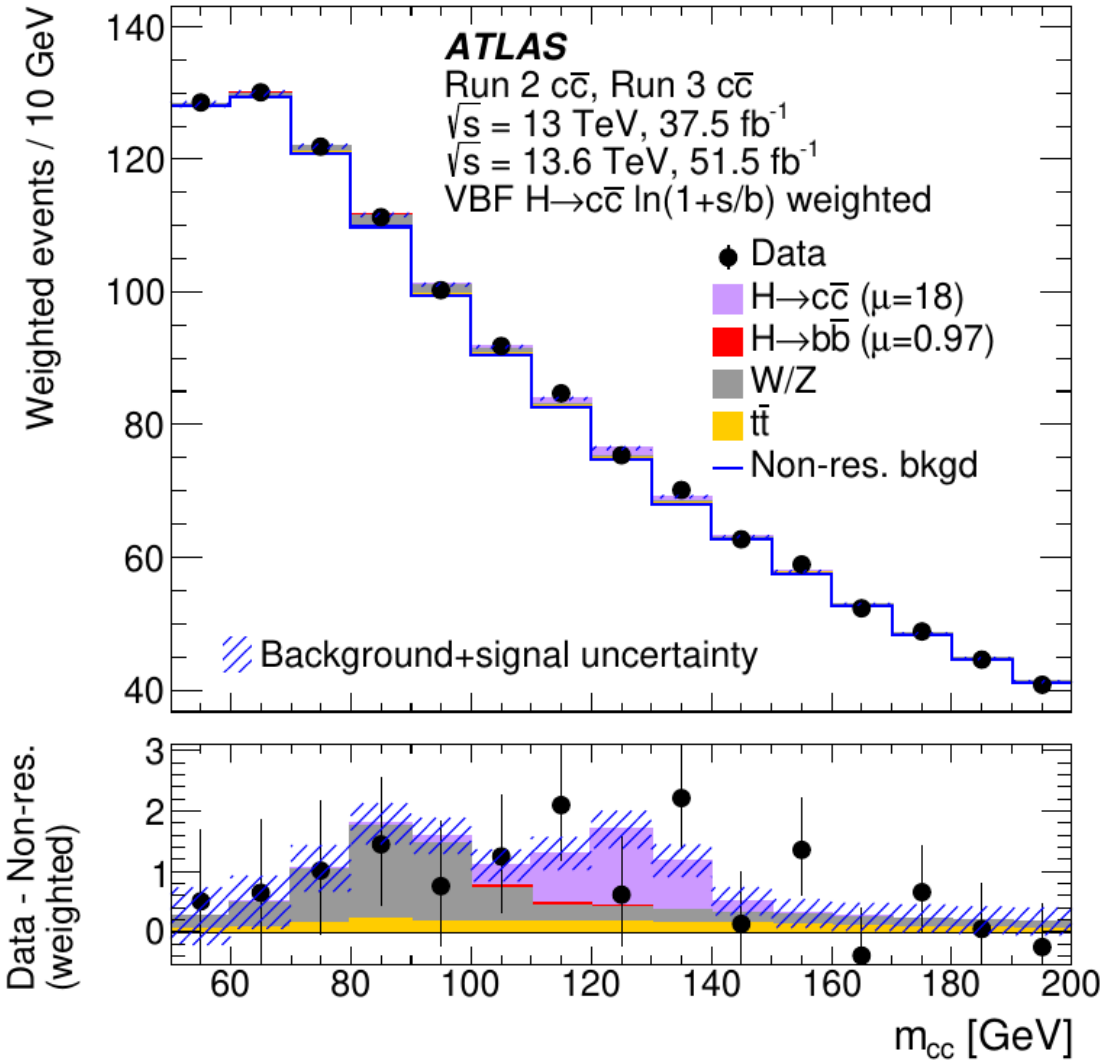


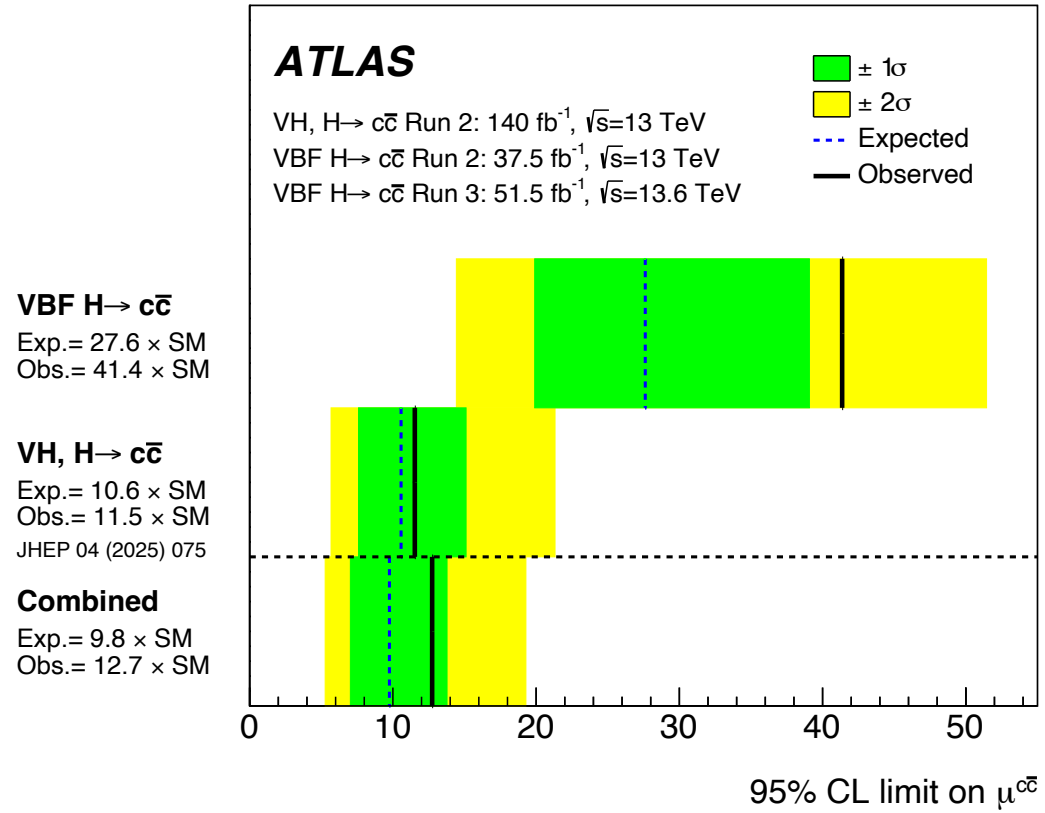
$Run\ 2\ H \to cc$



Results VBF H—>cc

arXiv:2511.21911





VBF H→ cc̄
Exp.= 27.6 × SM
Obs.= 41.4 × SM

VH, H→ cc̄
Exp.= 10.6 × SM
Obs.= 11.5 × SM
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Combined
Exp.= 9.8 × SM
Obs.= 12.7 × SM

8% expected improvement with 63% more data

Well limit for observed gets worse :(

Results VBF H—>bb

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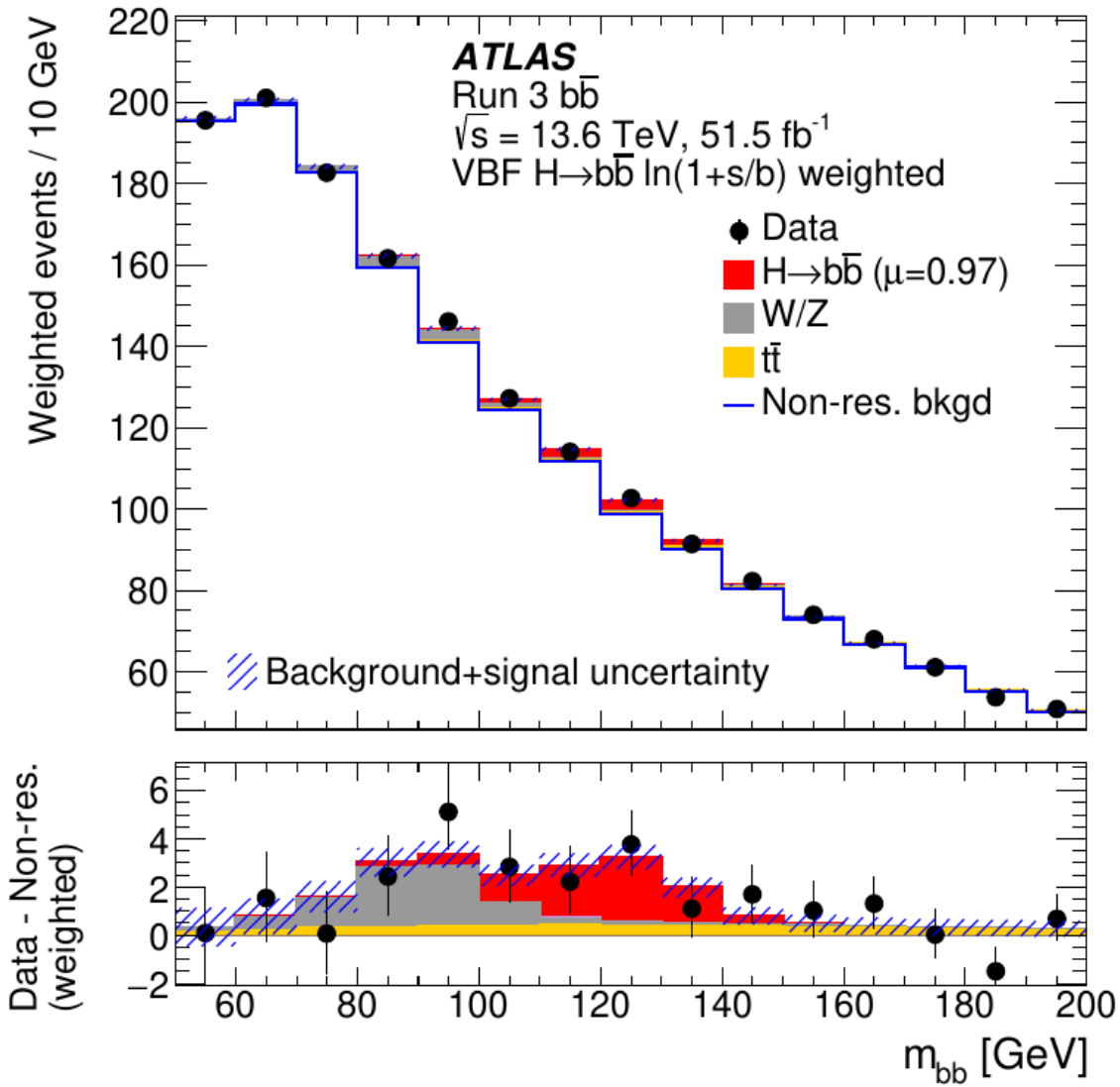

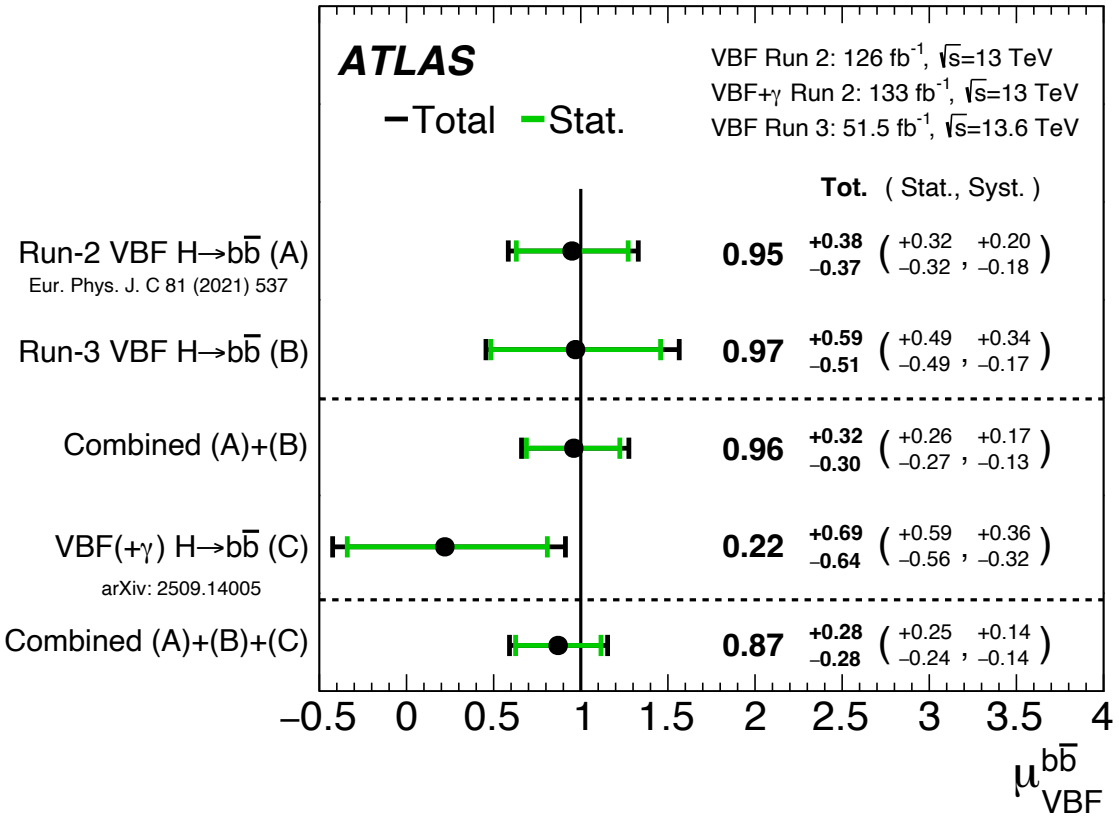

First evidence of VBF H—>bb combined with Run-2 dataset

Summary

- Probing Higgs-charm Yukawa coupling extremely challenging but provides direct access to Higgs second generation quark coupling
- Even with full LHC dataset, current projections doesn't show evidence for H—>cc using the clean VH production mode
- Adding other production modes crucial to extract most from the dataset
- Presented first analysis of the VBF H—>cc/bb at LHC, lots of room for improvements in future