Searches For Higgs Boson Pair Production In Final States With Two Bottom Quarks And Two Tau Leptons At The LHC

Jornadas cientificas
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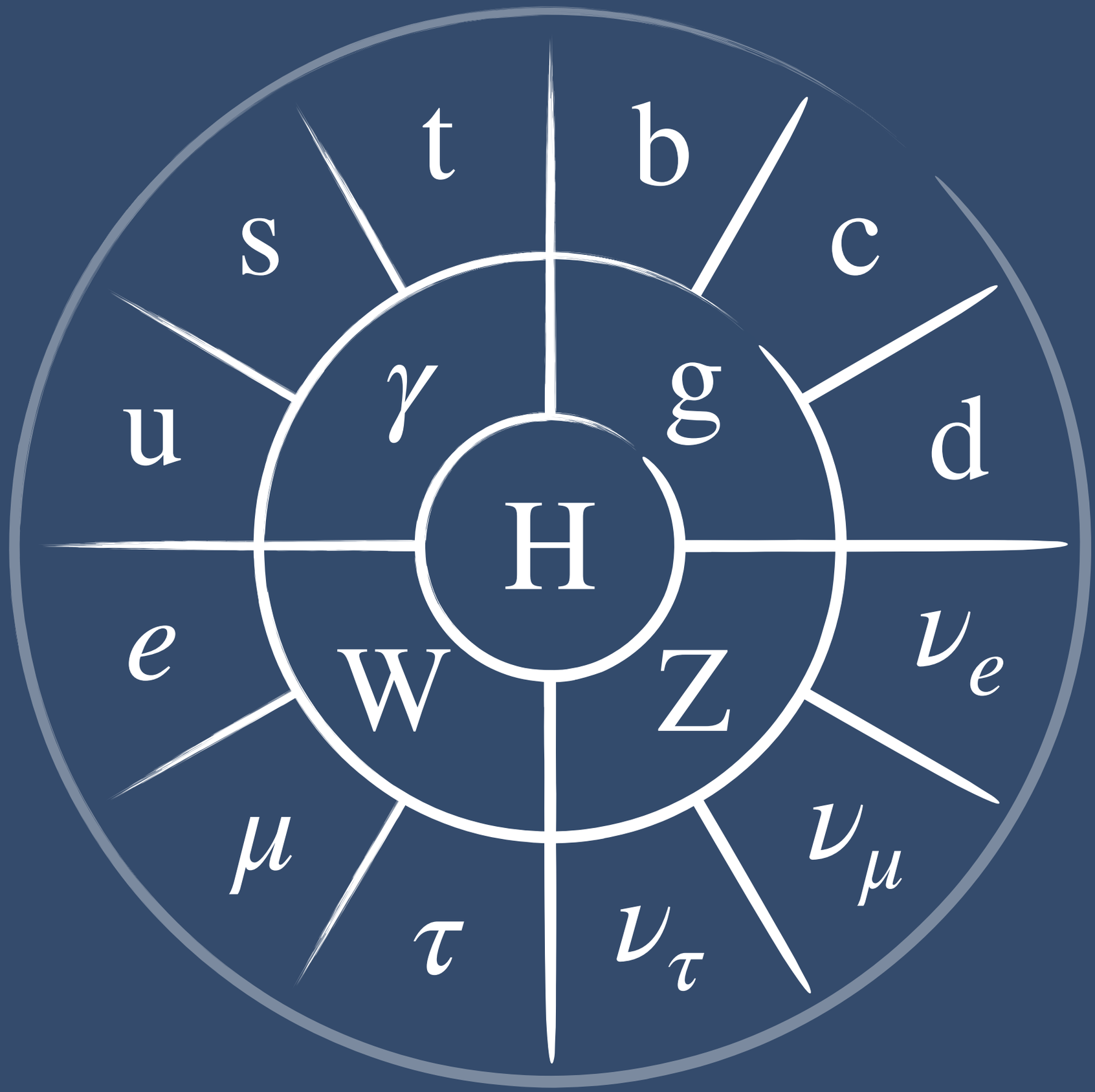
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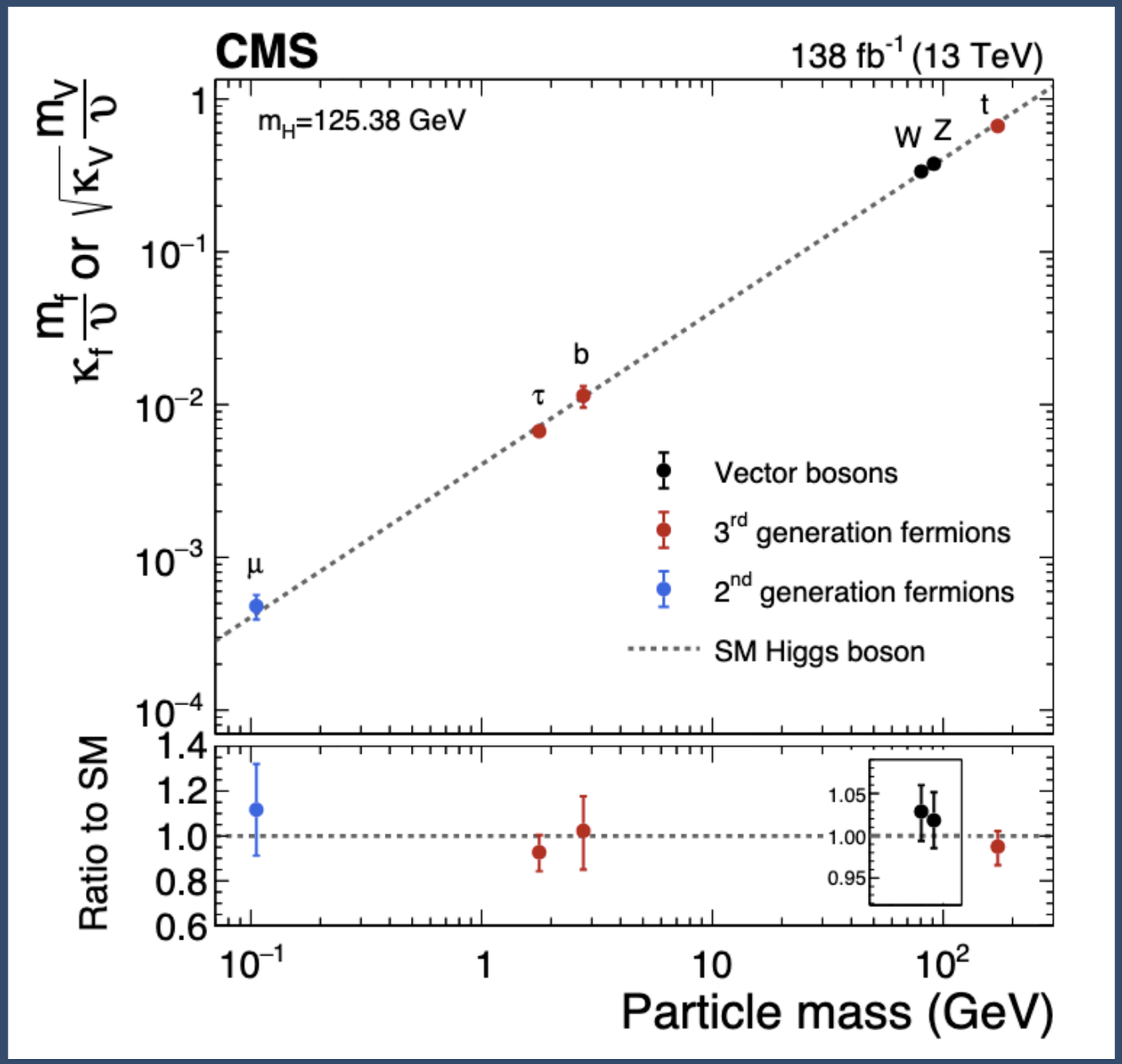
The Science Case



- Higgs couplings to W & Z Bosons as well as μ and 3rd Gen. Fermions have been measured
- Still to be measured:
  - H couplings to most 2nd and 1st Gen. Fermions
  - H self-coupling

CMS. "A portrait of the Higgs boson by the CMS experiment ten years after the discovery." *arXiv preprint arXiv:2207.00043* (2020).

The Theory

The Higgs potential before symmetry breaking can be written in terms of the physical H field:

$$V(H) = \frac{m_H^2}{2} H^2 + \lambda_3 v H^3 + \frac{\lambda_4}{4} H^4$$

With the trilinear self coupling as a parameter:

$$\lambda_3 = \lambda_4 = \lambda_{HHH} = \frac{m_H^2}{2v^2}$$

The Motivation

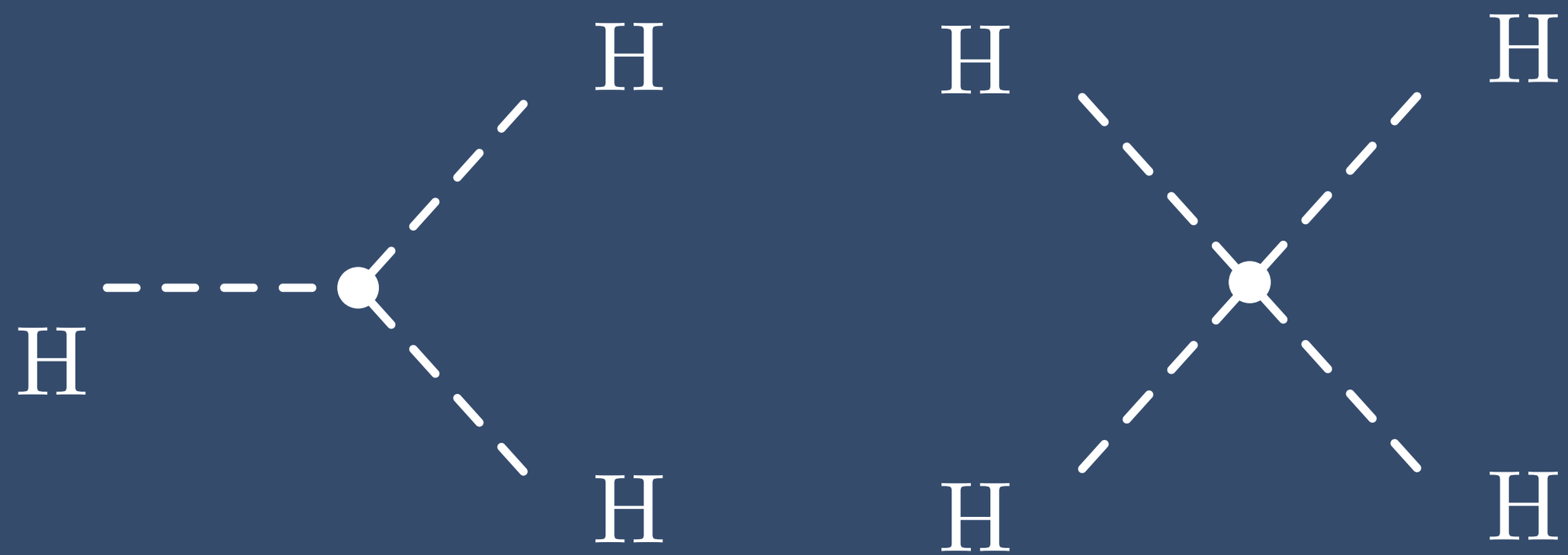
Measuring λ_{HHH} therefore provides an independent test of the SM and allows to probe $V(\Phi)$

Therefore we introduce:

$$\kappa_\lambda = \frac{\lambda_{HHH}}{\lambda_{HHH}^{\mathrm{SM}}}$$

The Higgs self couplings

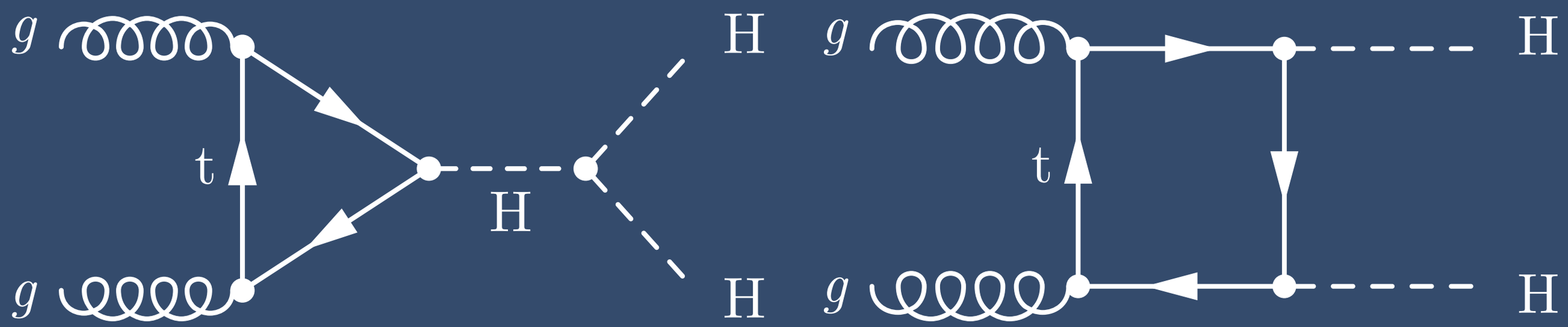
The SM predicts the following couplings:



$$\lambda_{HHH} = \frac{m_H^2}{2v^2}$$

Observable processes

The dominant processes for gluon gluon fusion:

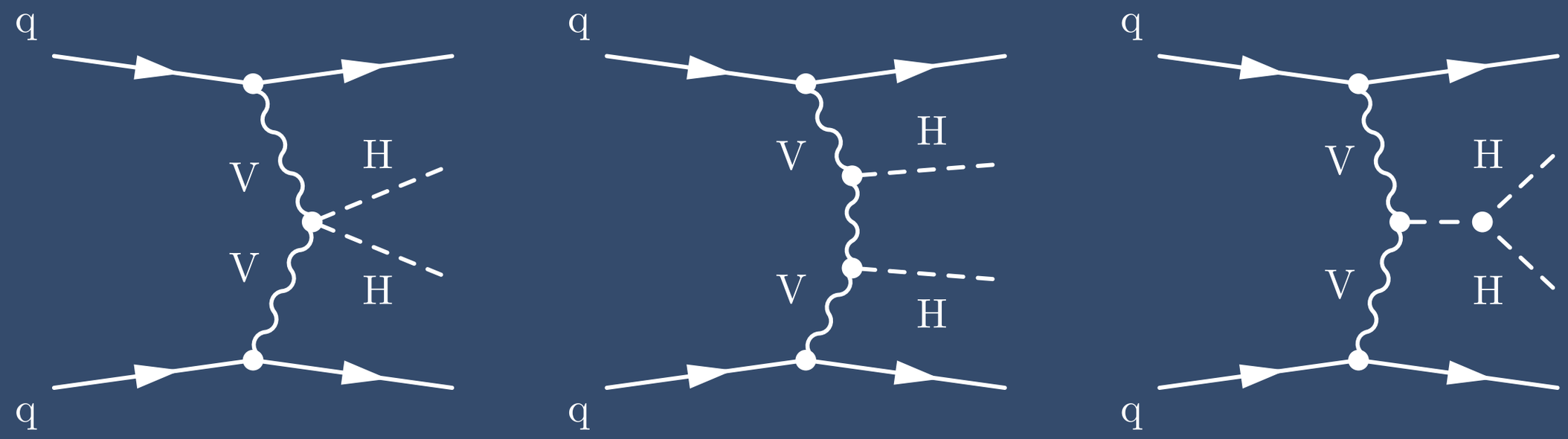


Suppress each other, hence lowering the total cross section of:

$$\sigma^{\mathrm{HH}}_{\mathrm{ggF}} = 31.05^{+2.2\%}_{-5.0\%}\ \mathrm{fb}$$

Observable processes

The dominant processes for vector boson fusion:

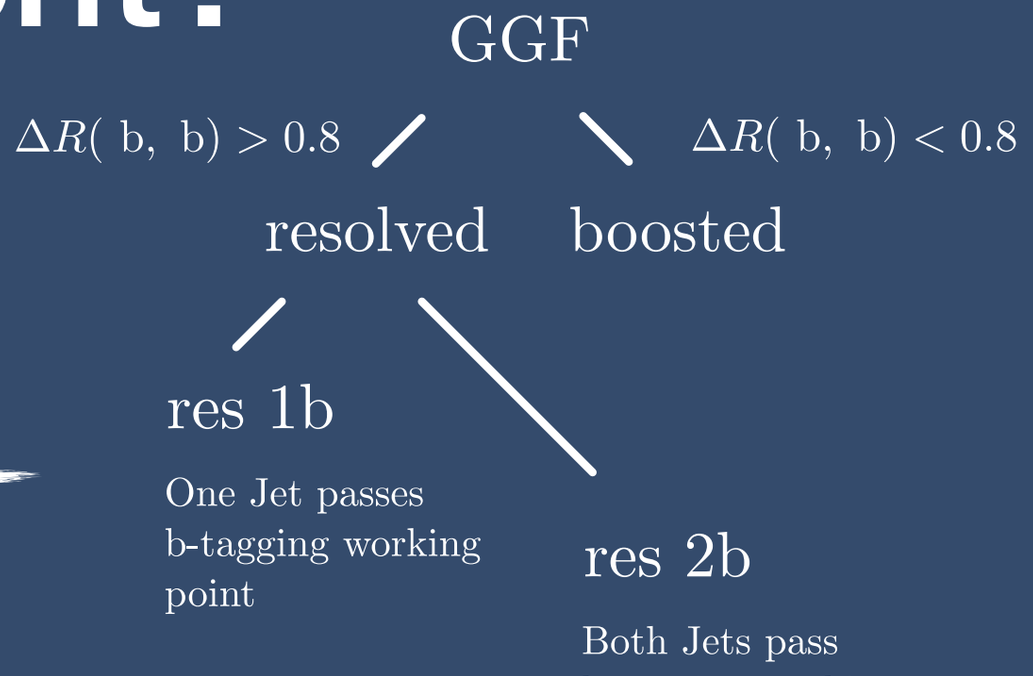


two forward jets well separated in pseudorapidity
+ large invariant mass

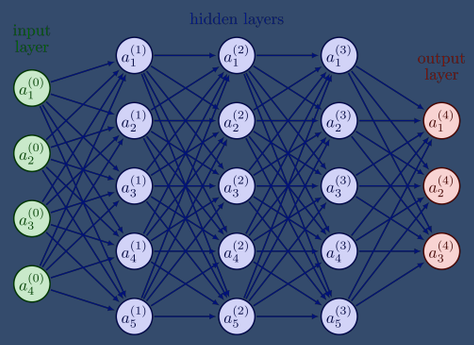
$$\sigma^{\mathrm{HH}}_{VBF} = 1.726^{+0.03\%}_{-0.04\%}\ \mathrm{fb}$$

What is my Job as a PHD student?

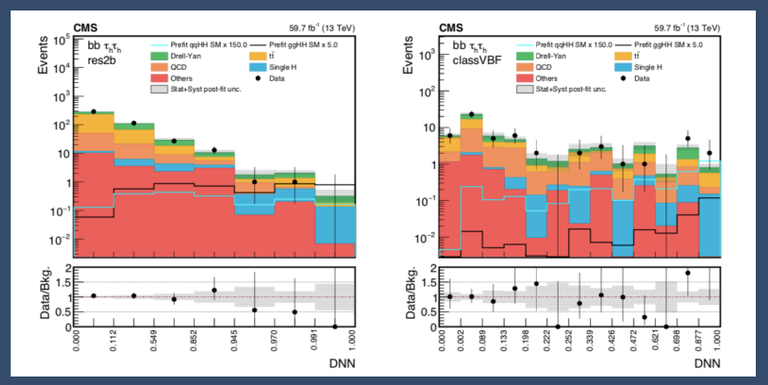
- Categorise Events by their reconstructed objects



- Build a Classification Algorithm for each event category (Signal / Background)

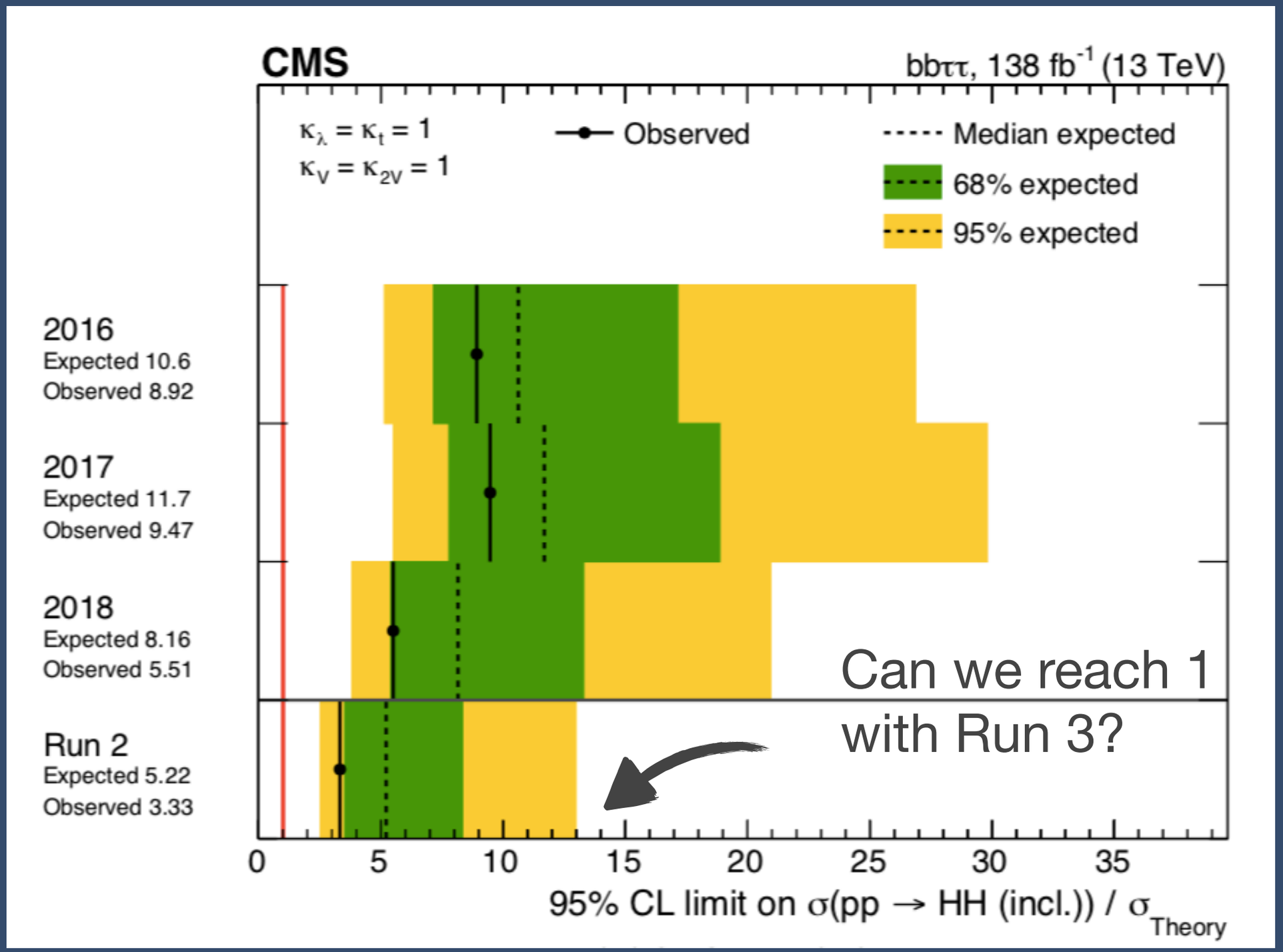


- Generate an upper limit on the observed $\sigma_{\mathrm{HH}}, \kappa_{\lambda}$



CMS collaboration. "Search for nonresonant Higgs boson pair production in final state with two bottom quarks and two tau leptons in proton-proton collisions at $\sqrt{s} = 13$ TeV." *arXiv preprint arXiv: 2206.09401* (2022).

The Prospect



CMS collaboration. "Search for nonresonant Higgs boson pair production in final state with two bottom quarks and two tau leptons in proton-proton collisions at$\sqrt{s} = 13$ TeV." *arXiv preprint arXiv:2206.09401* (2022).

Thank you for your attention