Measuring the Higgs Self-Coupling with Di- and Single-Higgs Processes

ICHEP 2020

Maximilian Swiatlowski,
On behalf of ATLAS

TRIUMF

Results from ATLAS-CONF-2019-049

The Higgs is the Center

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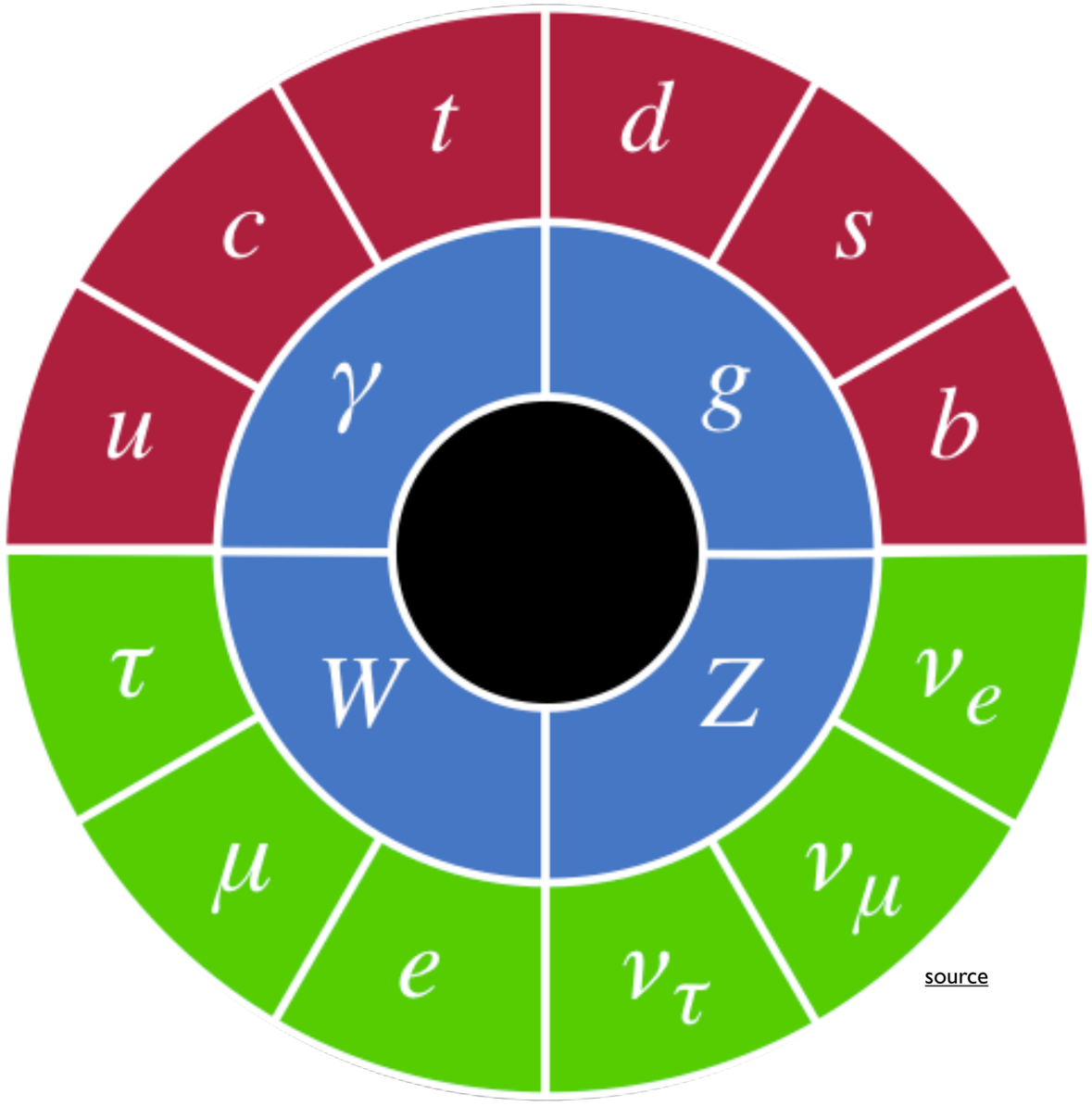

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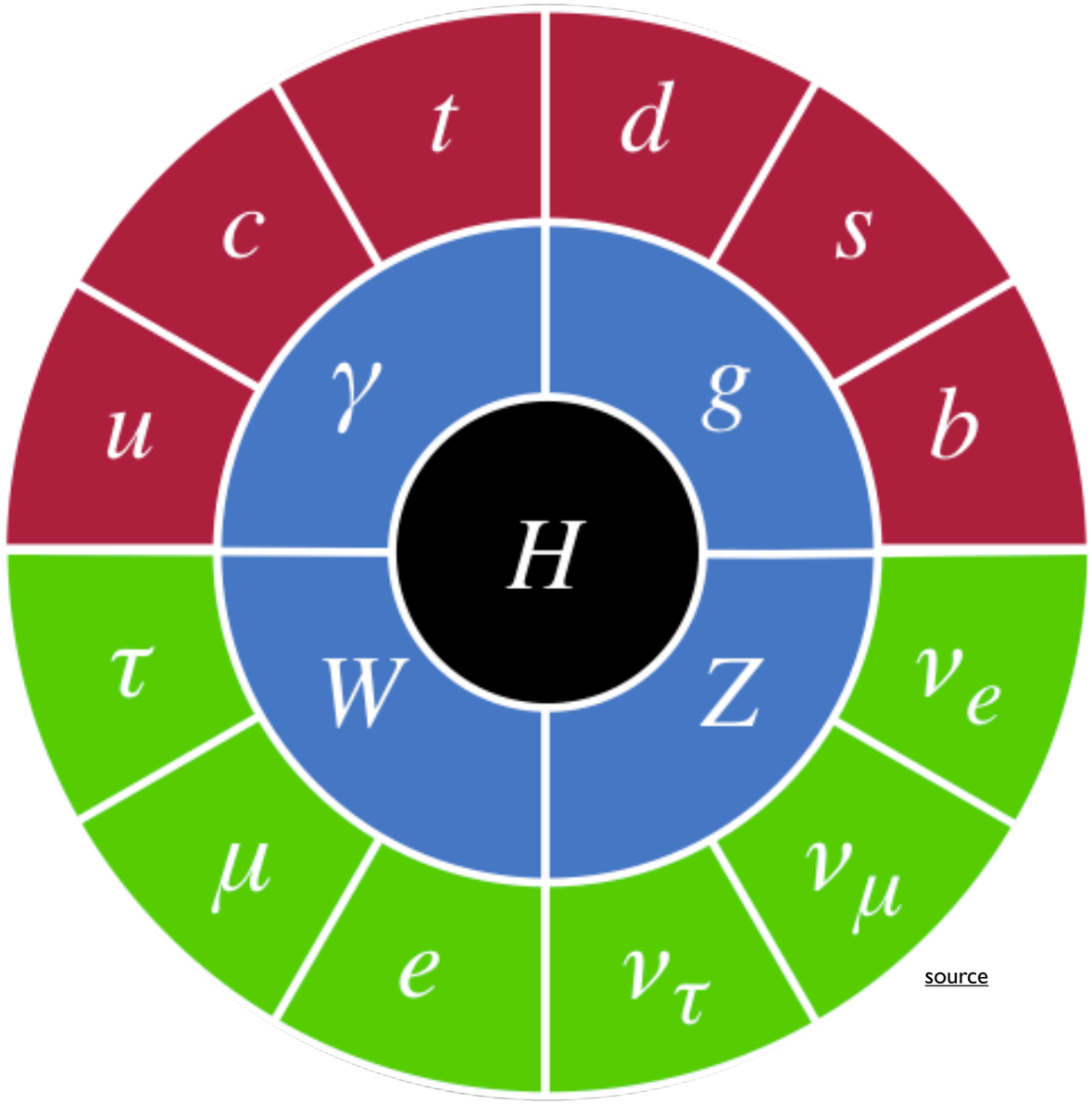

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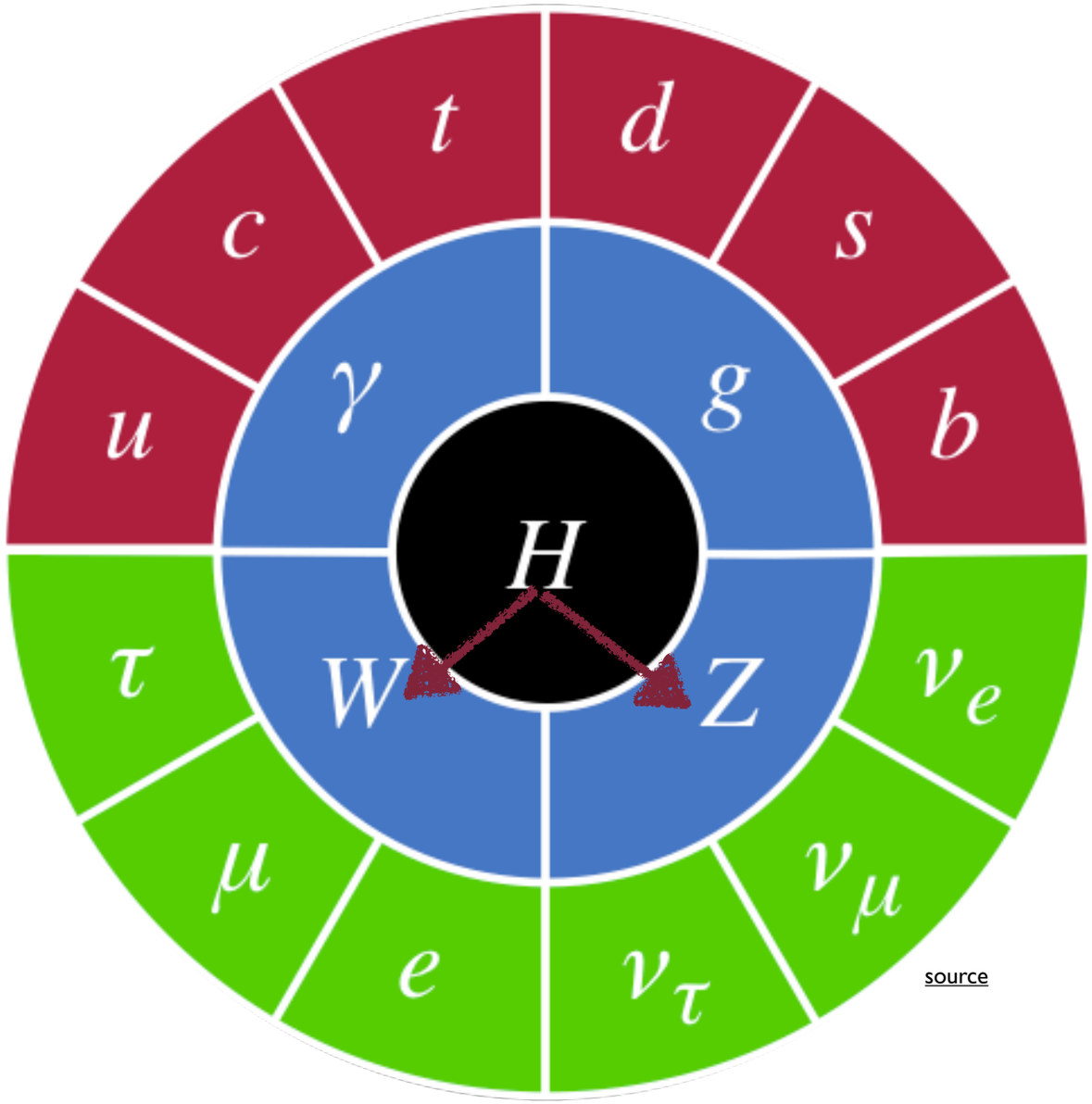

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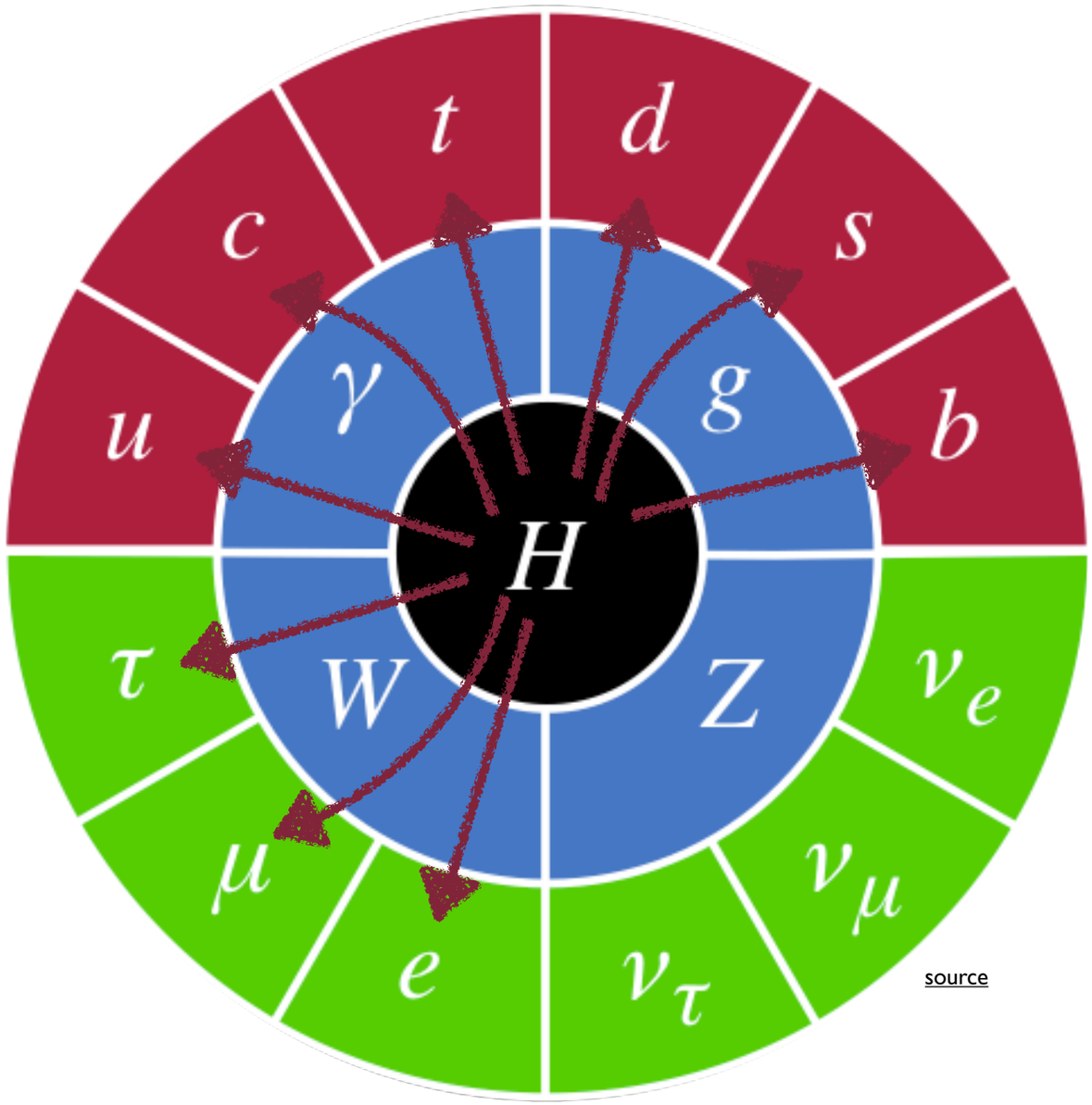

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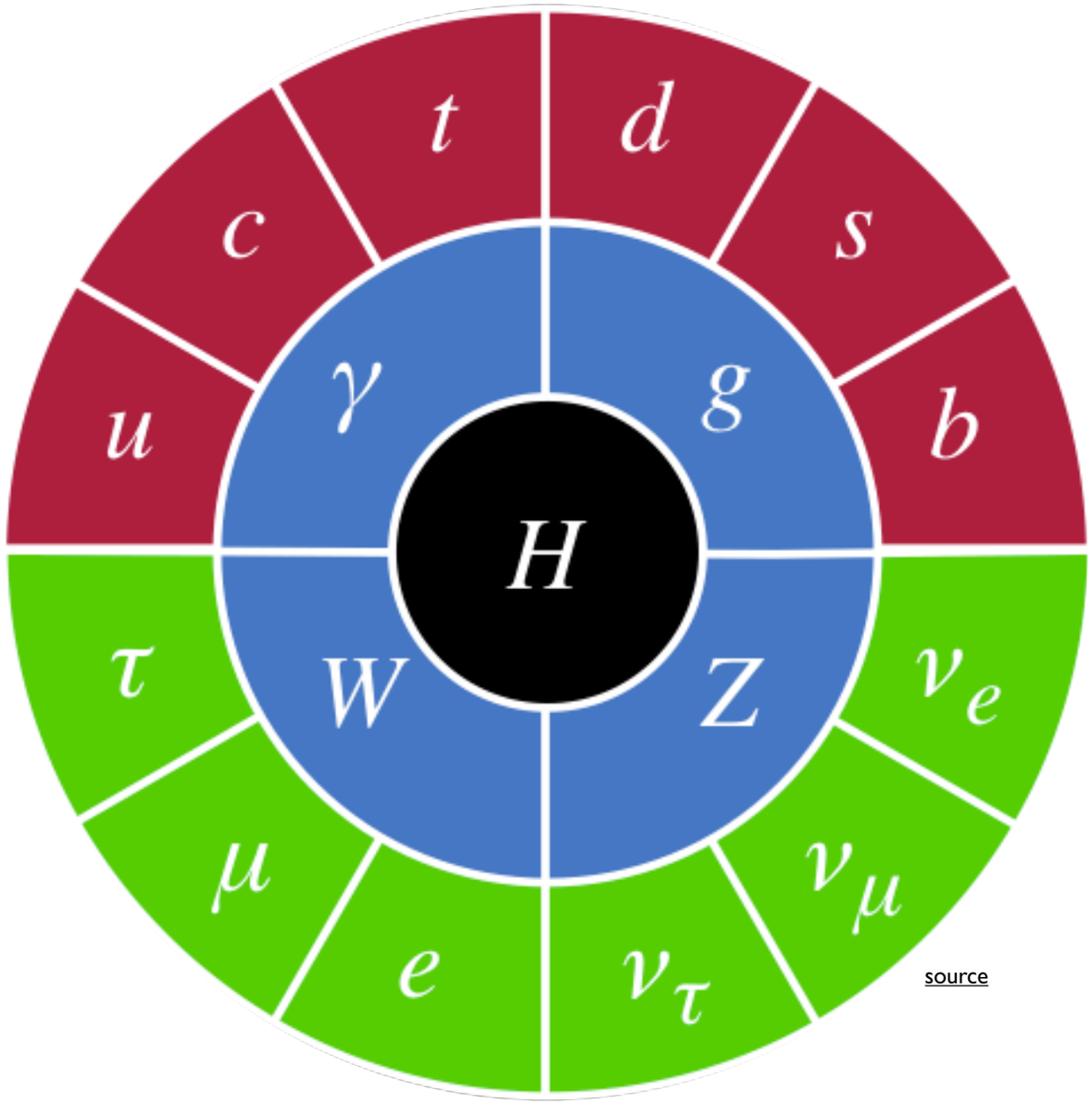

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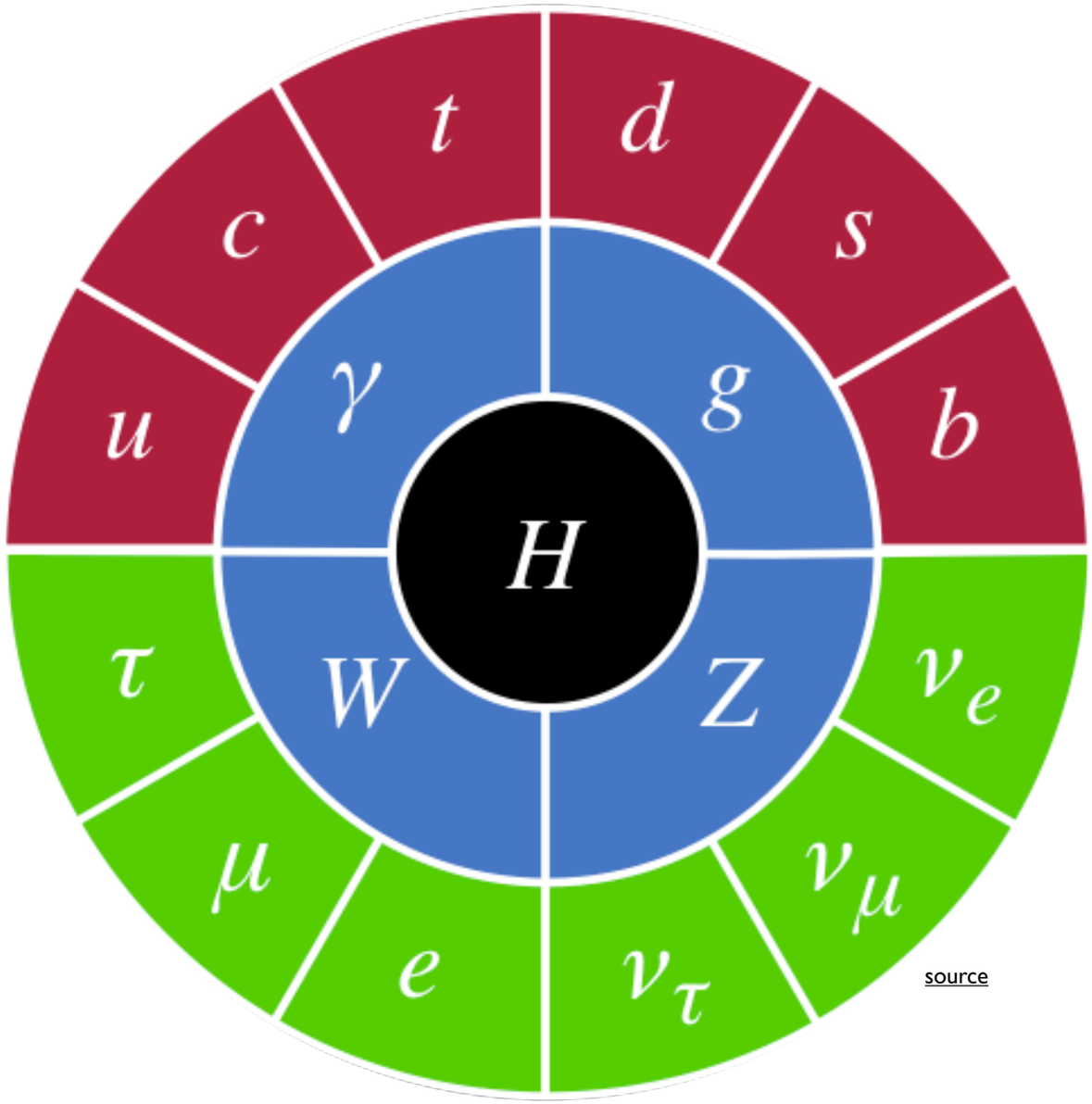

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Understanding the Higgs is key to Understanding the SM, and physics beyond

The Mystery of the Potential

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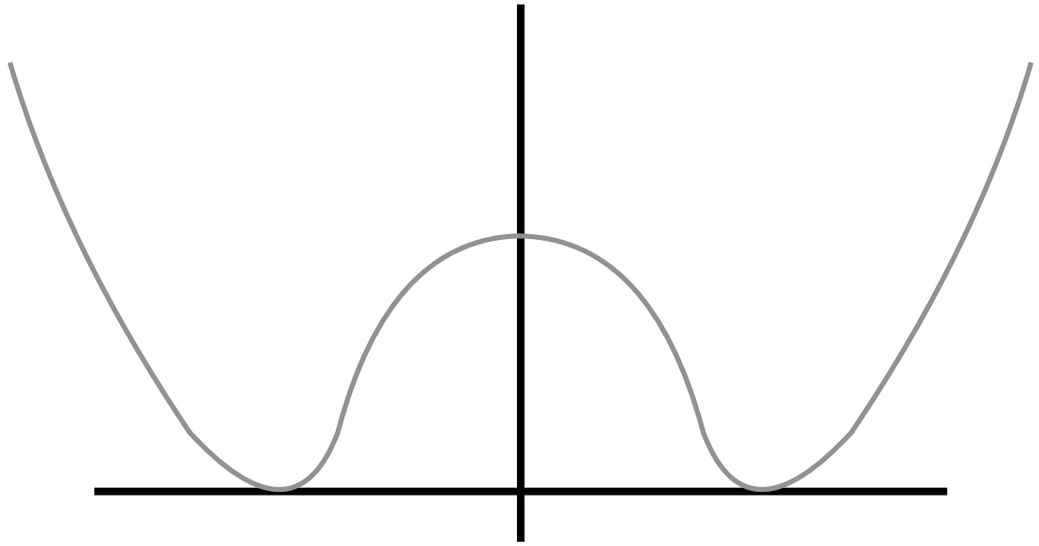

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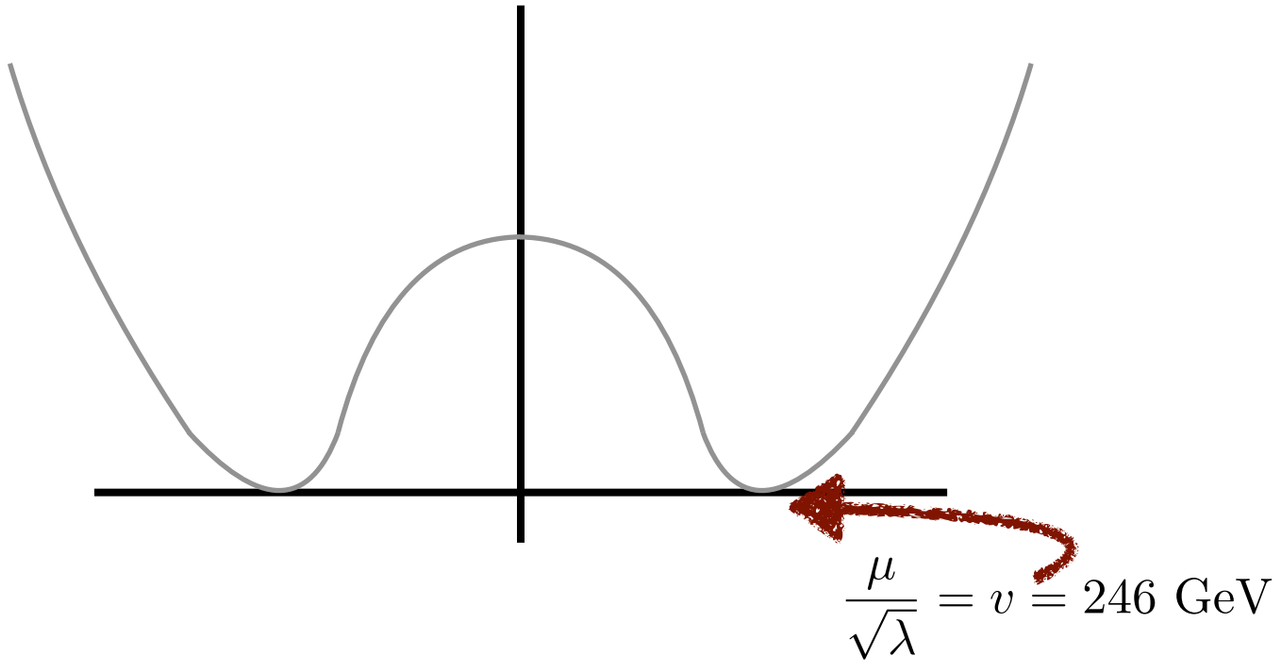

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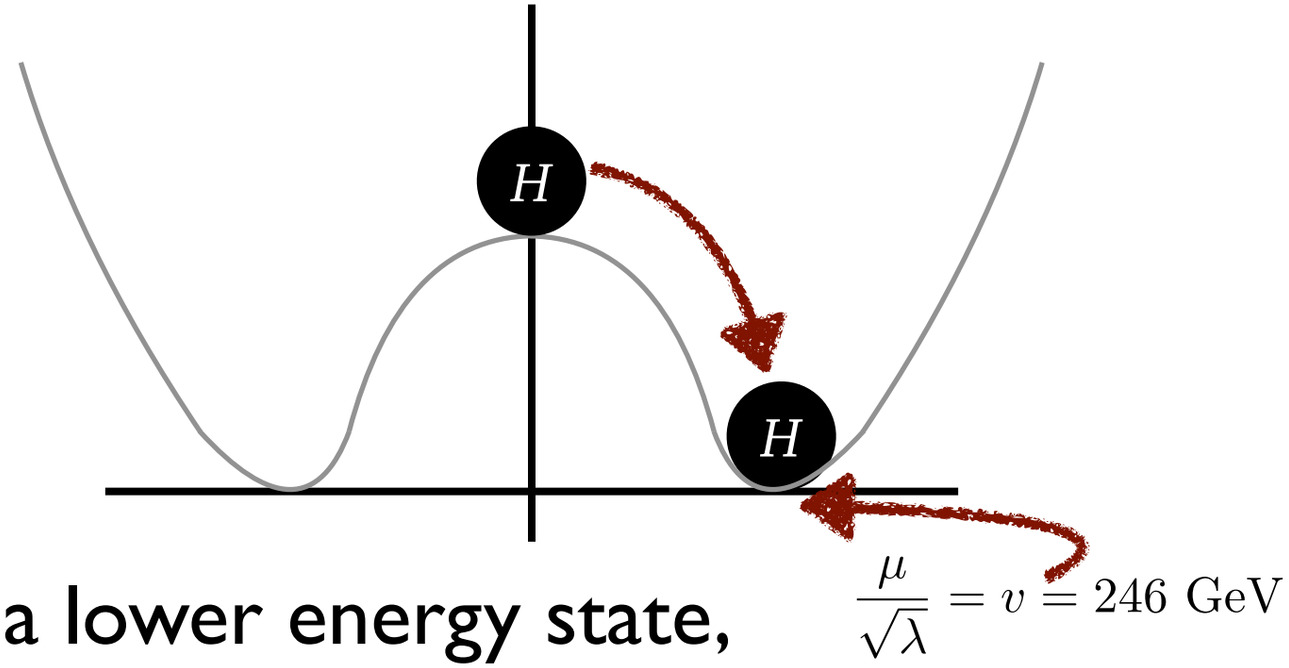

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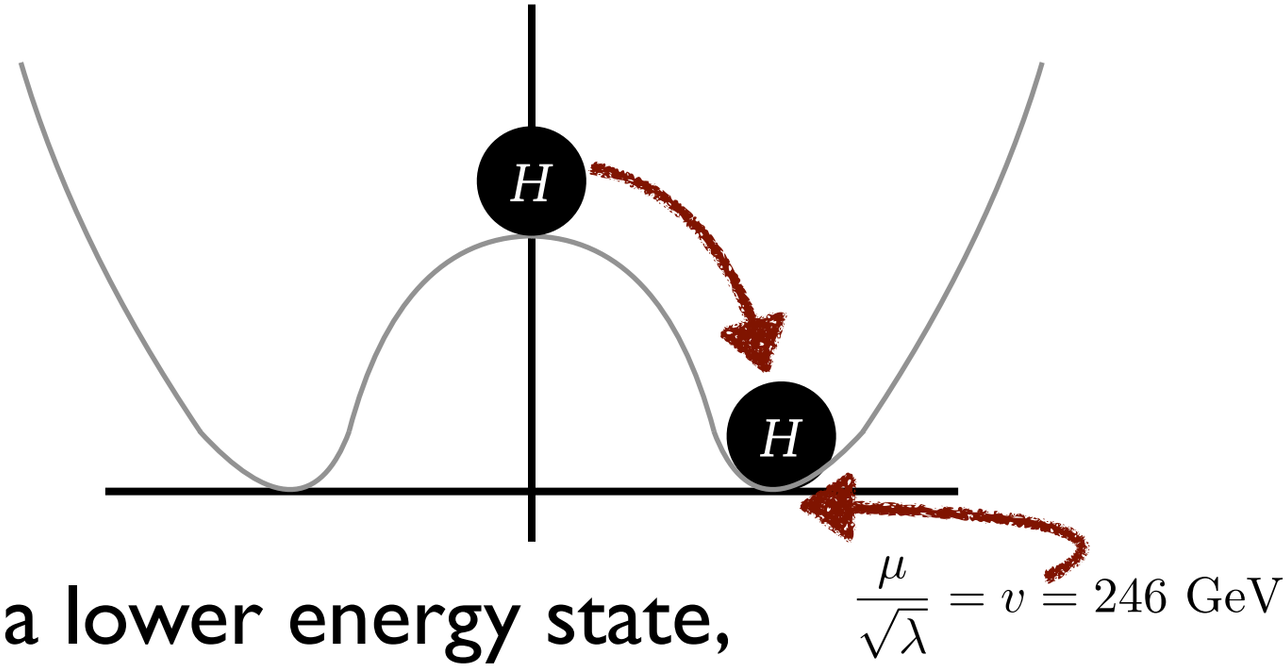

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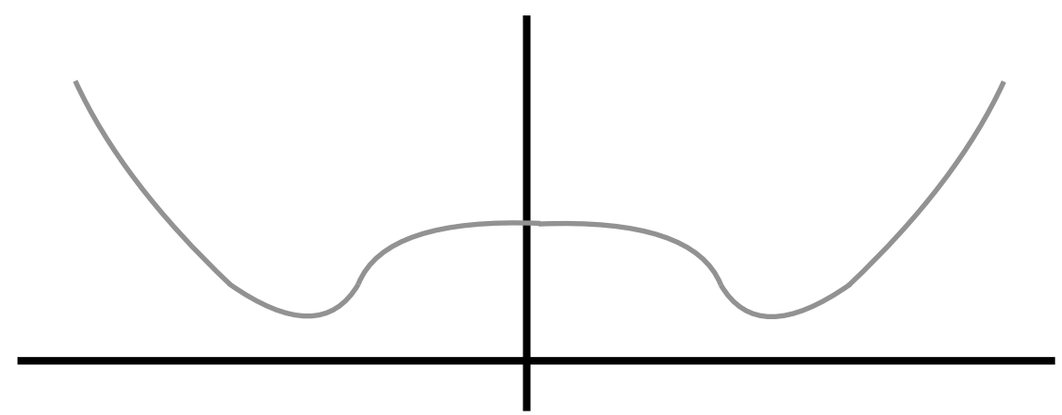

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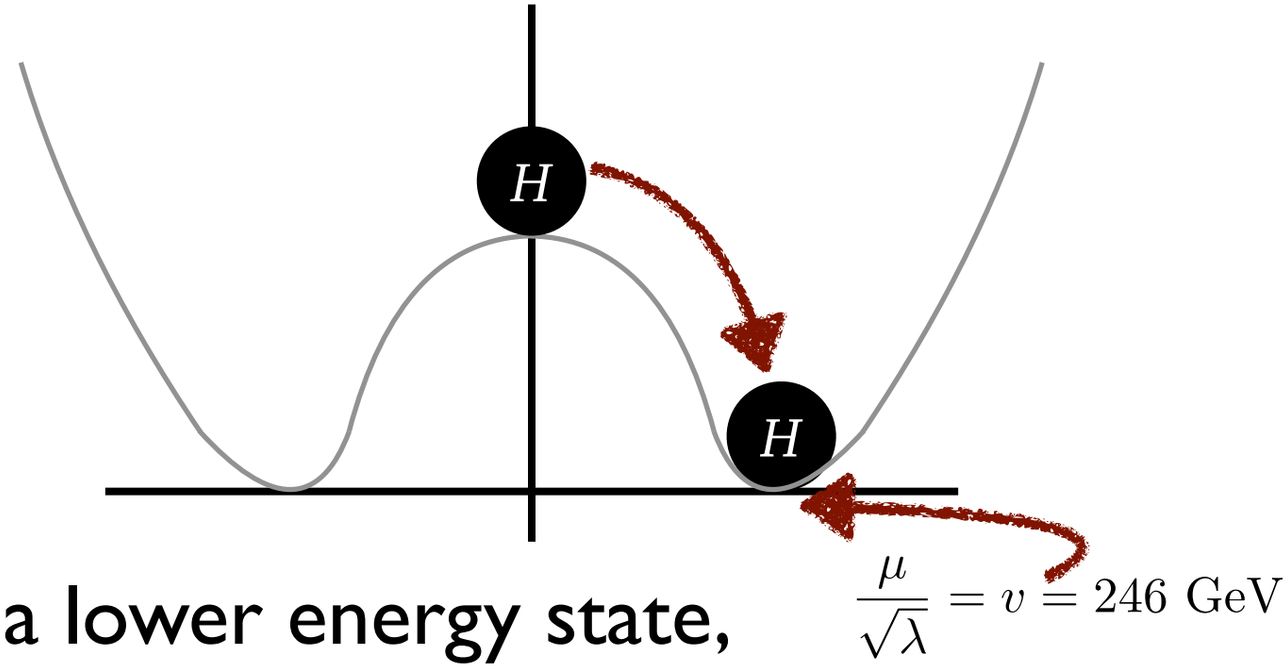

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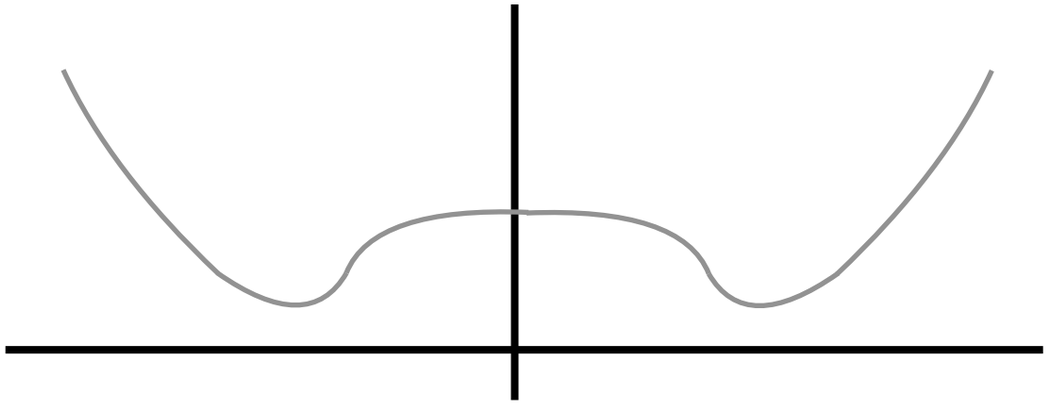

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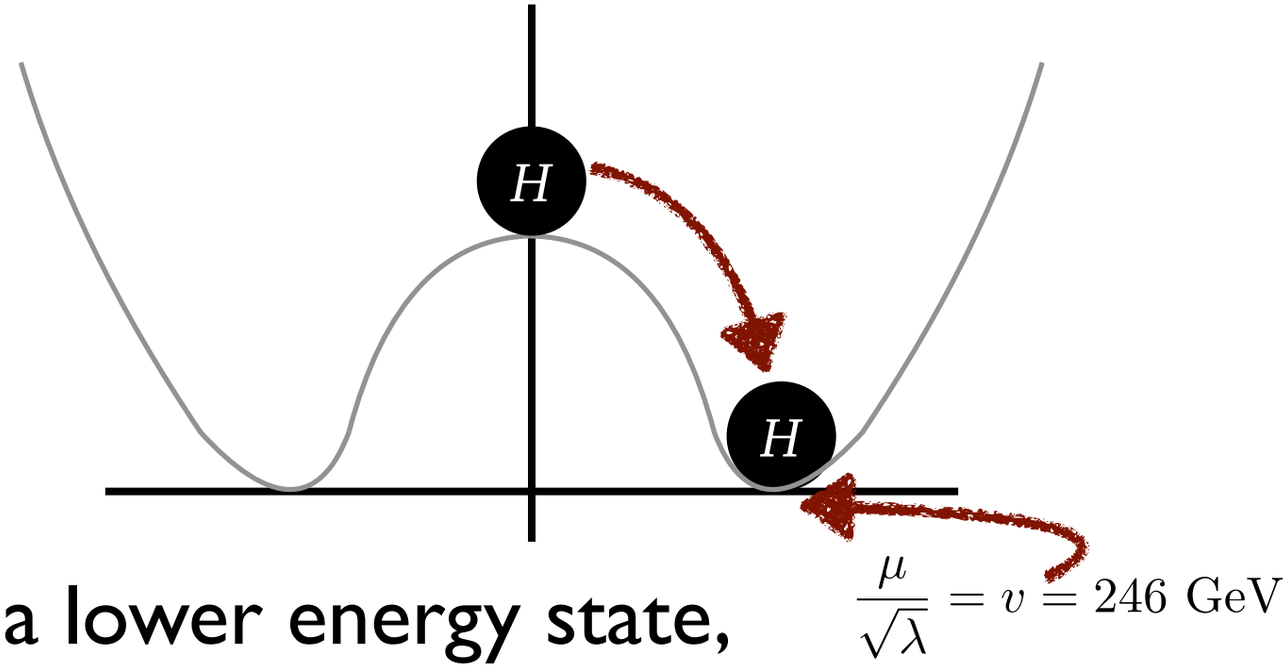

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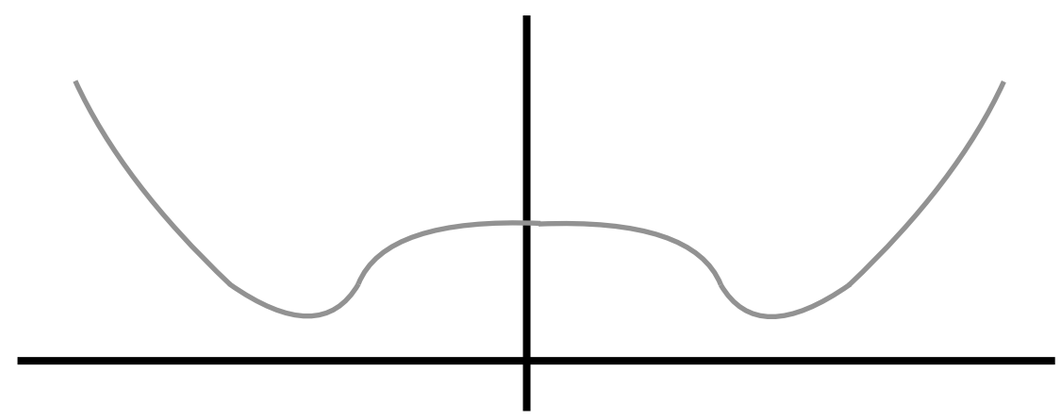

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Why does this matter?

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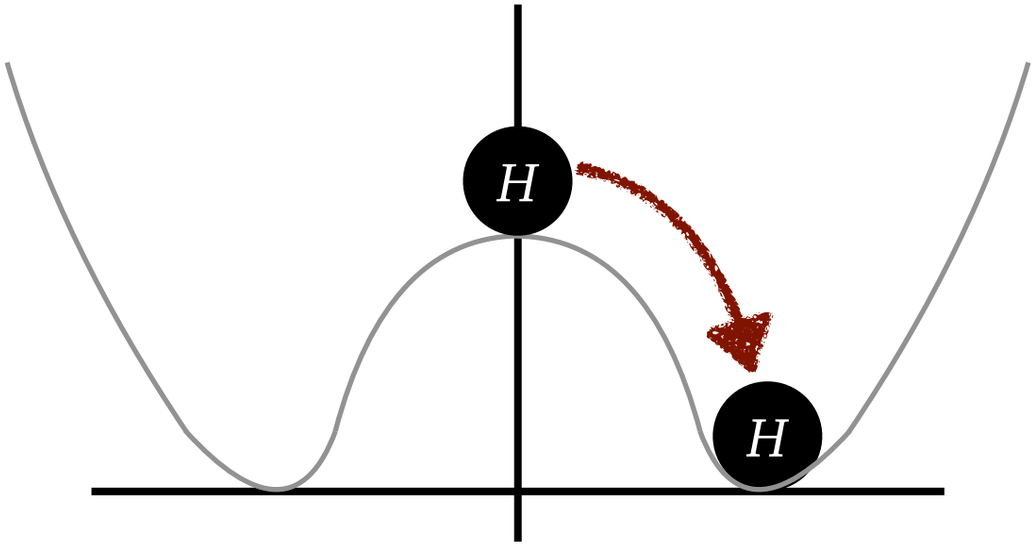

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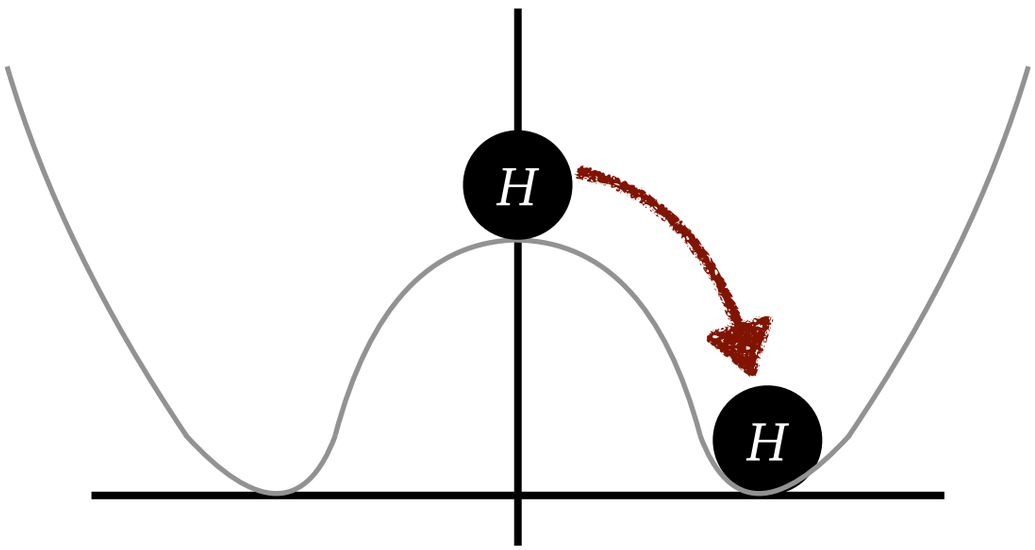

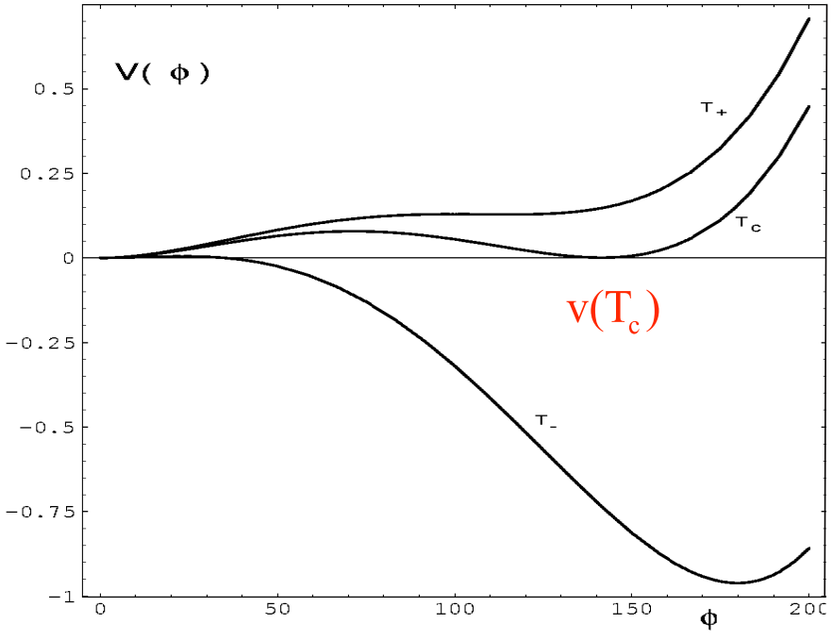

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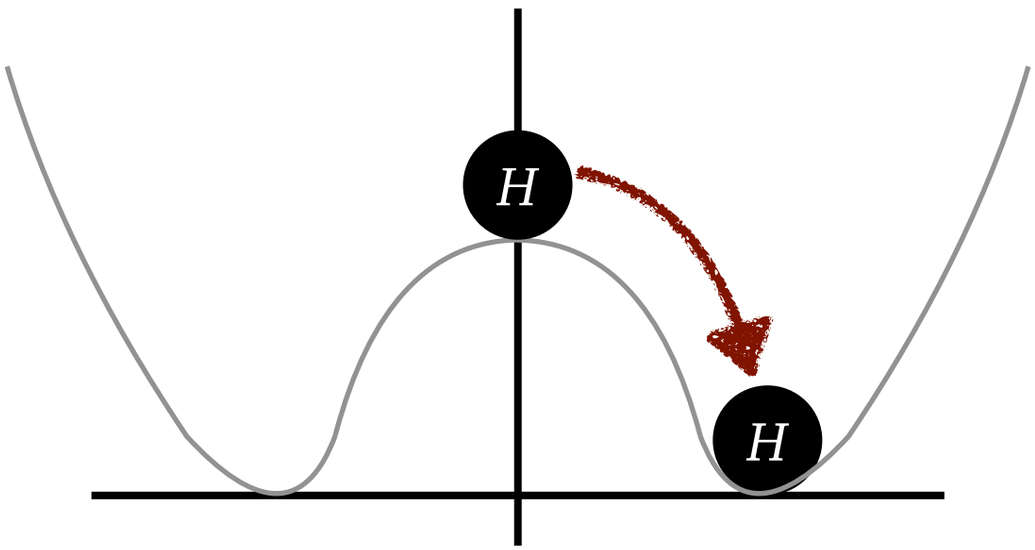

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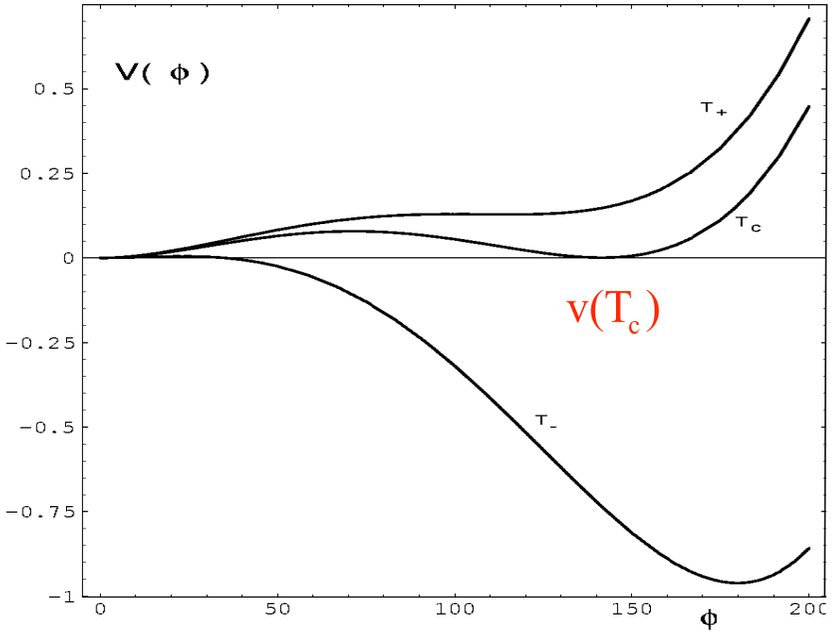
And generically: it's hard to alter only the potential, and not change any other Higgs couplings!



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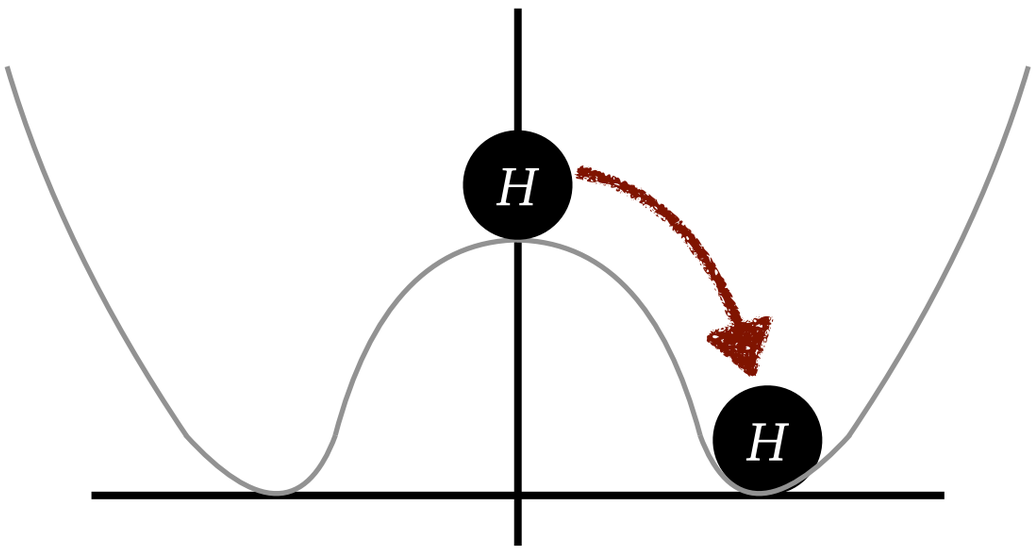

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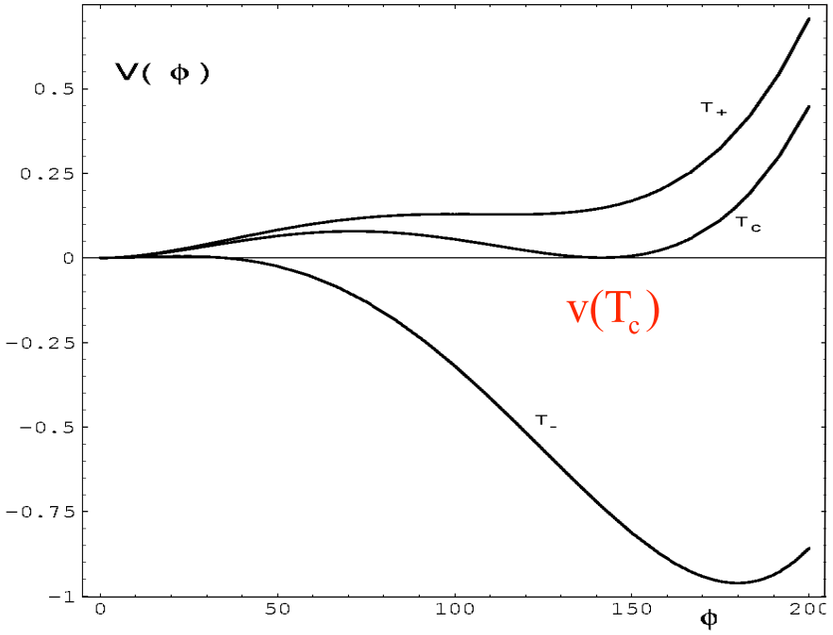

If we can measure the shape of the potential, we can find hints of fundamental, critical new physics!

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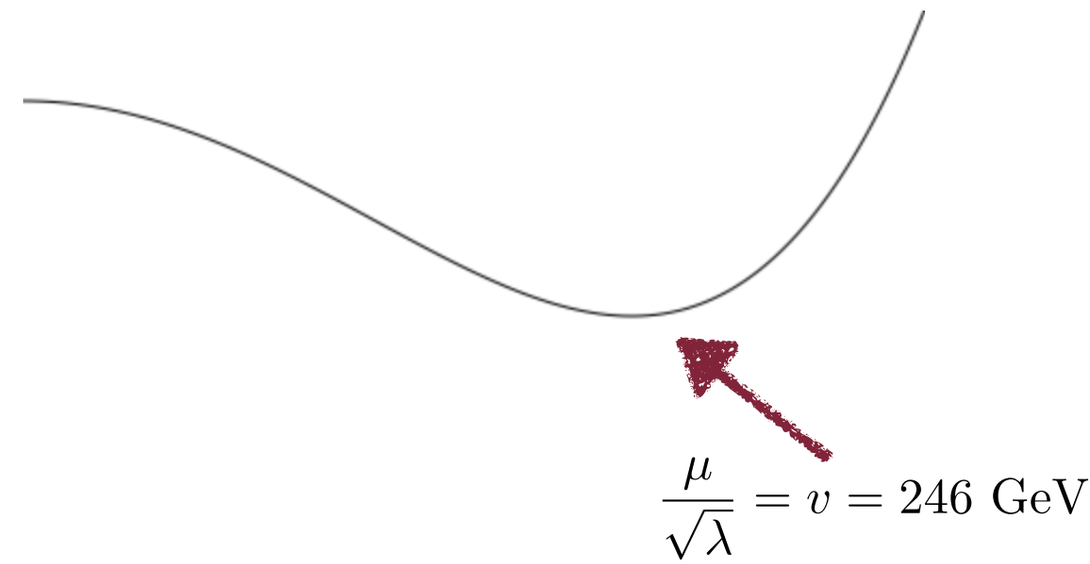

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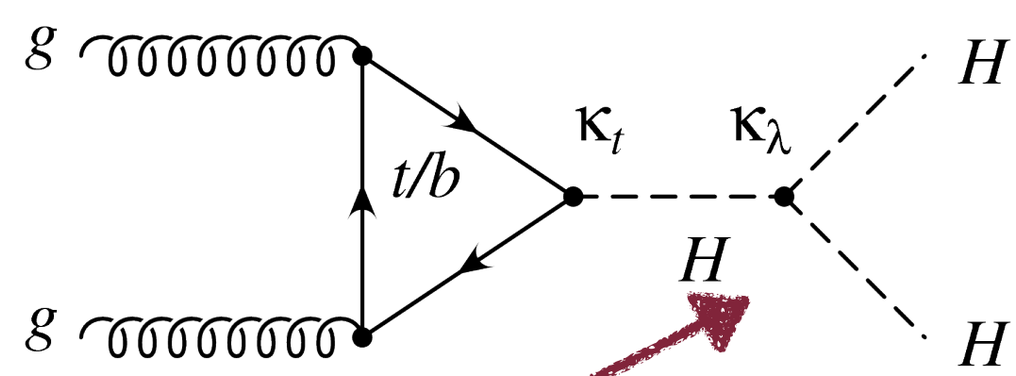

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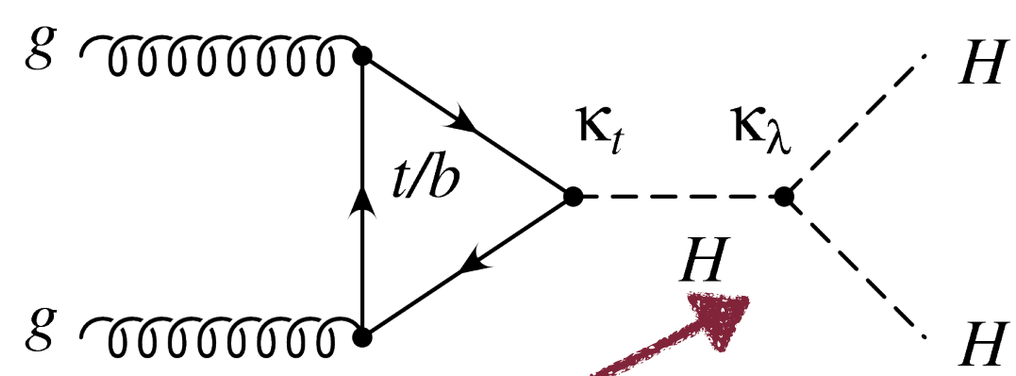

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$$\kappa_\lambda = \frac{\lambda_{HHH}}{\lambda_{HHH}^{SM}}$$

This higher-order term tells us more about the shape of the potential!

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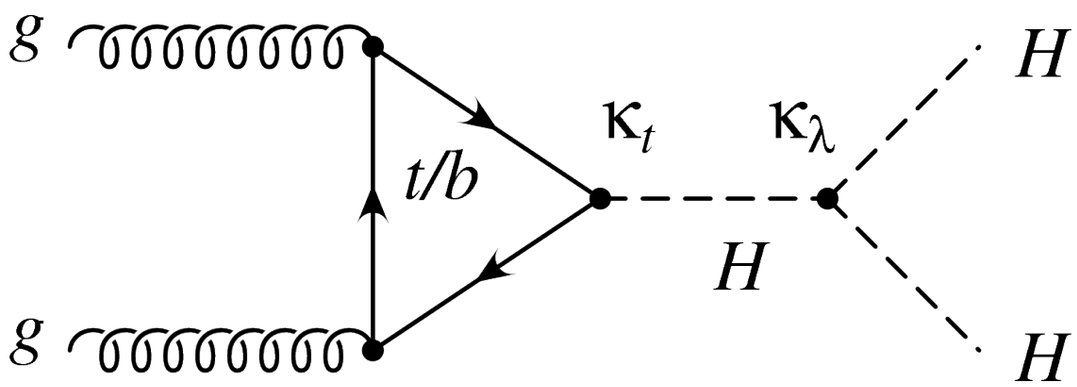

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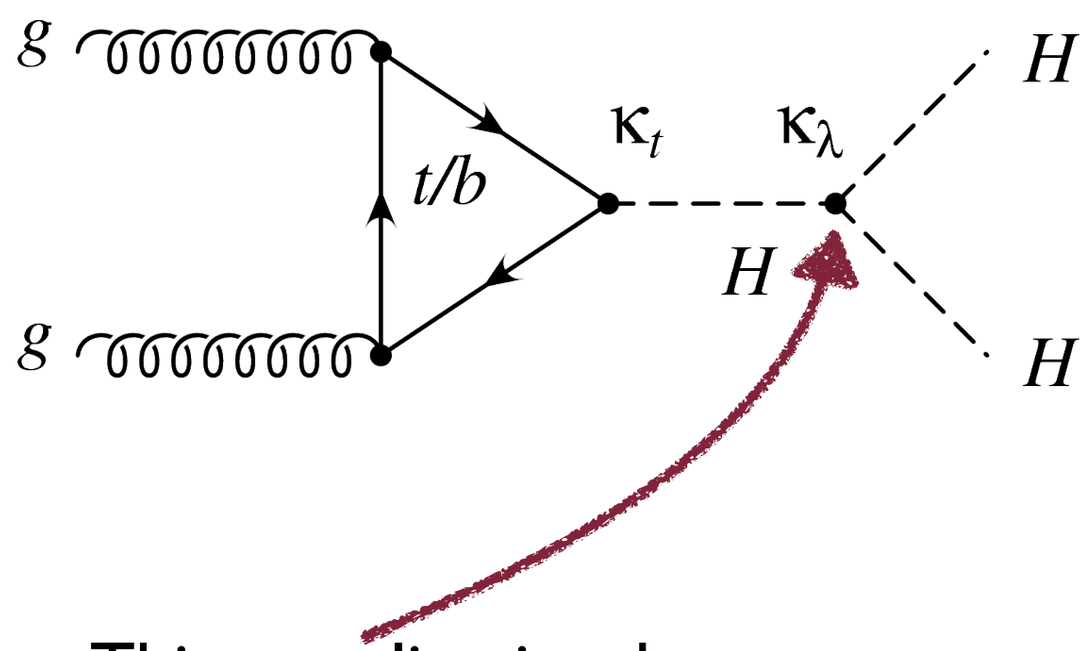

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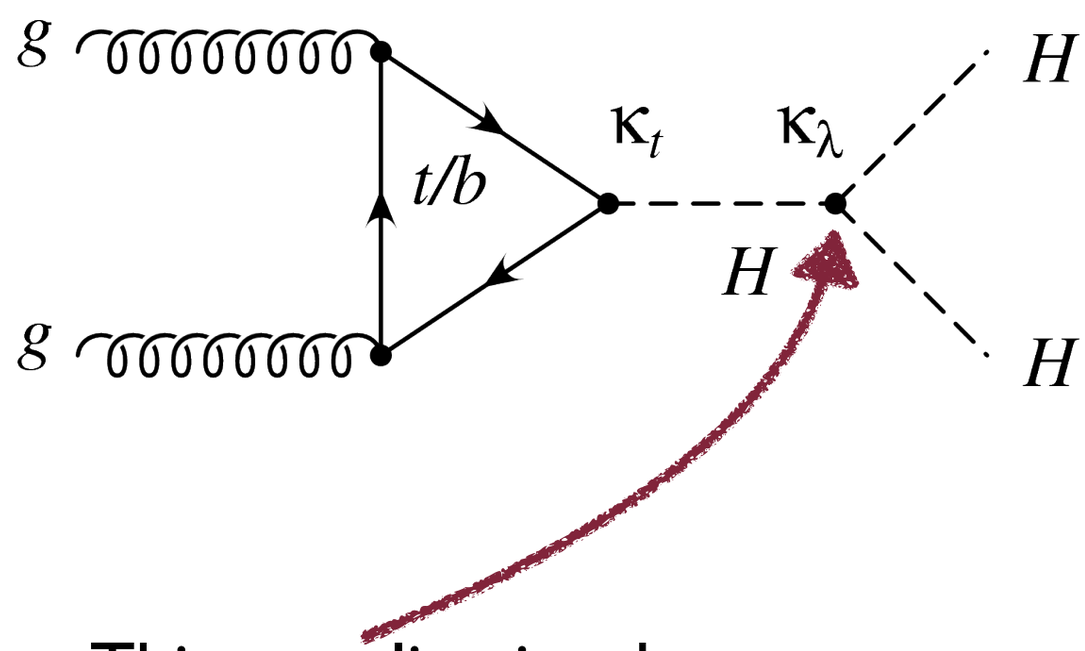

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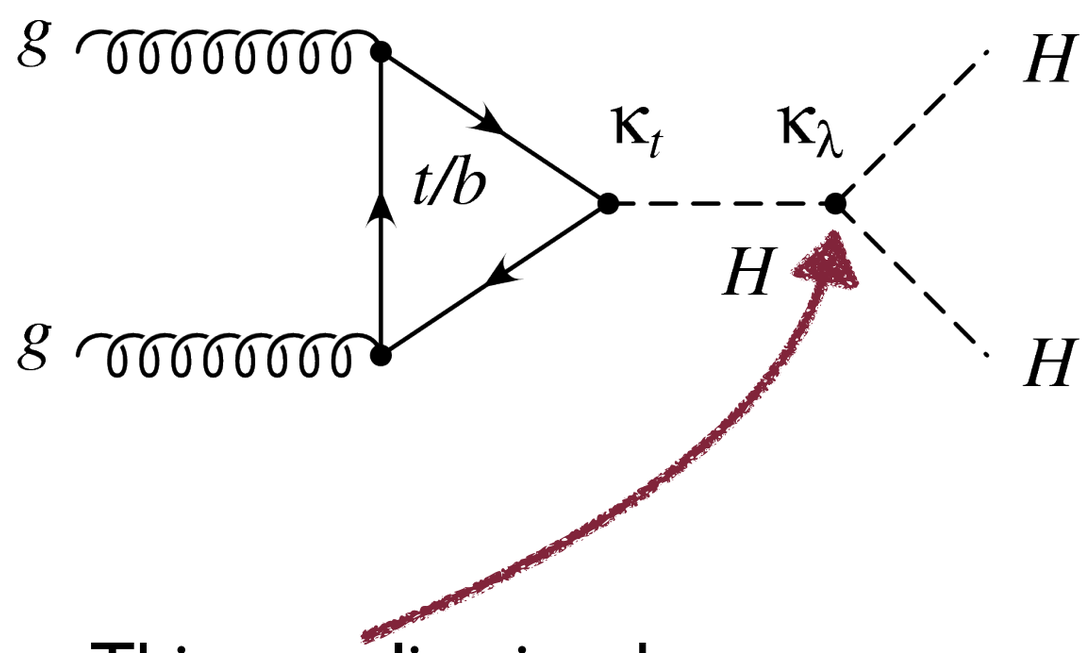

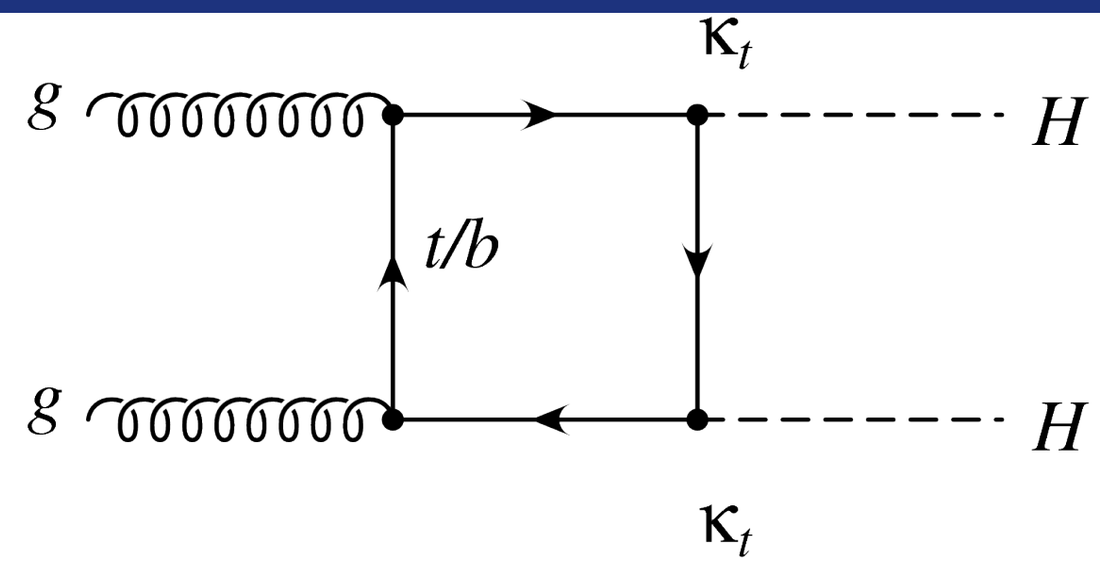

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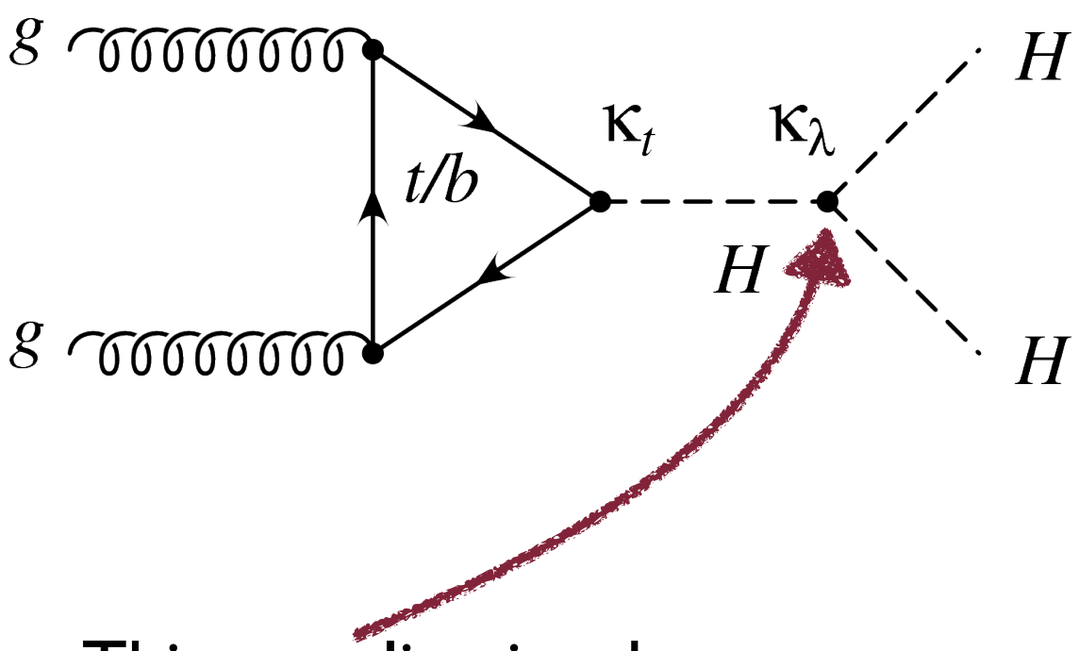

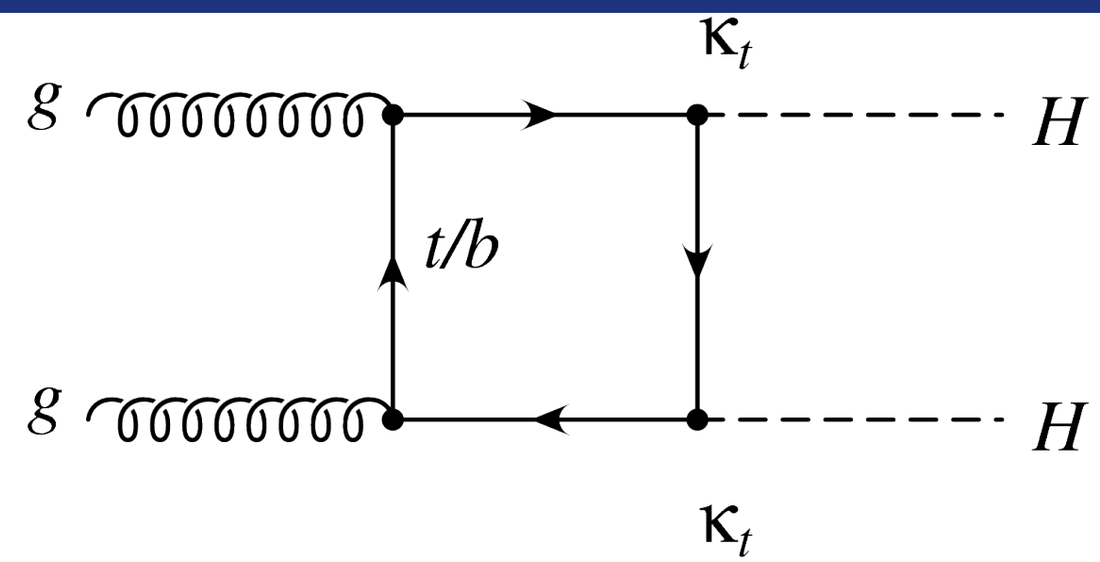

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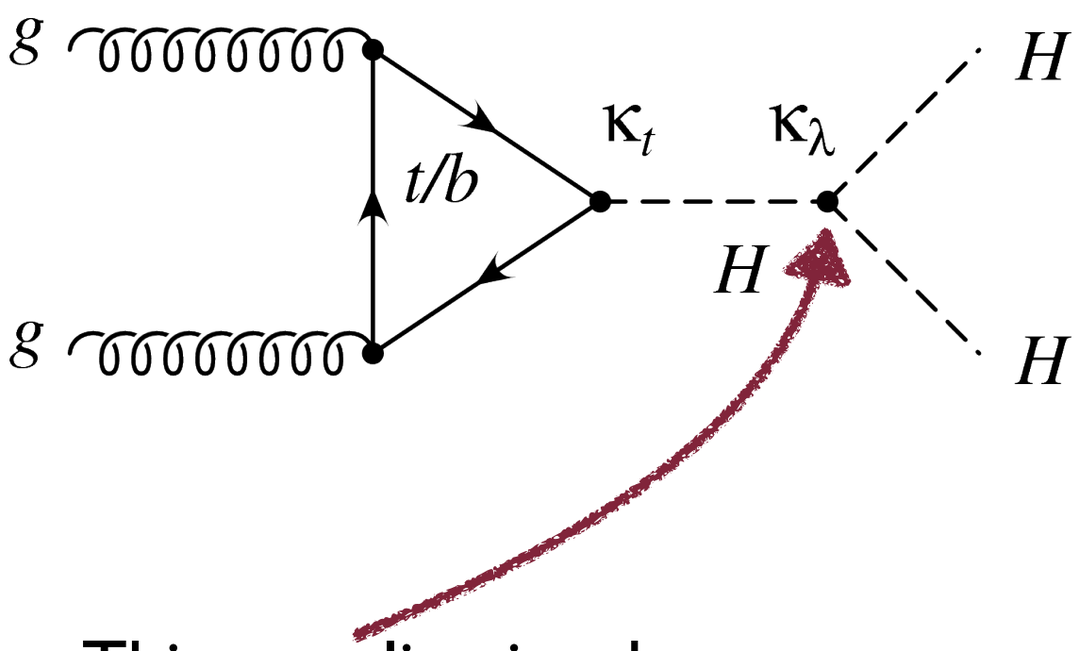

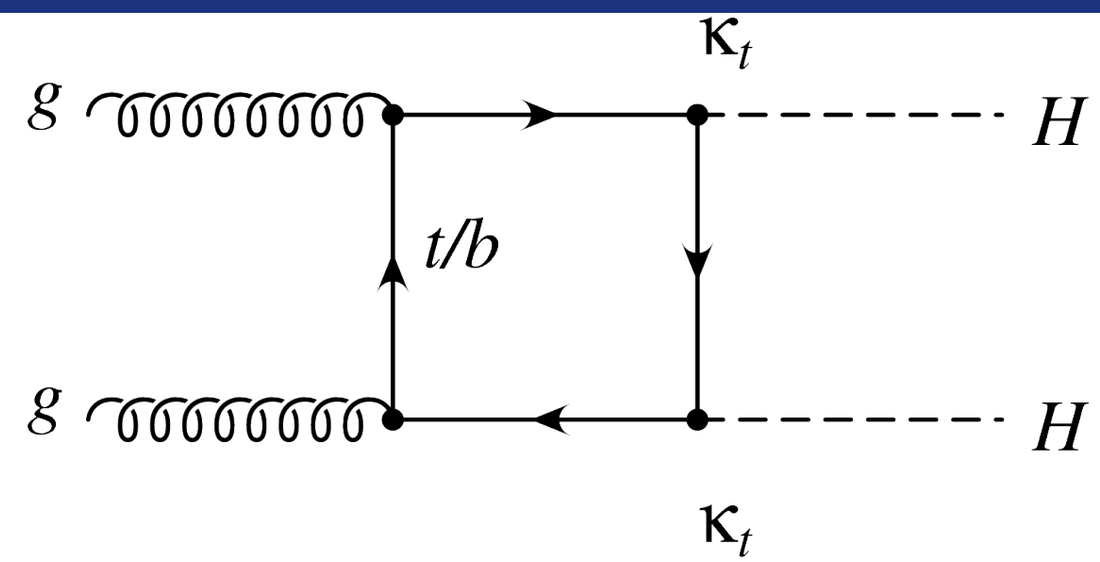

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Also important: κ_λ always appears with κ_t: sensitivity can change if κ_t allowed to float

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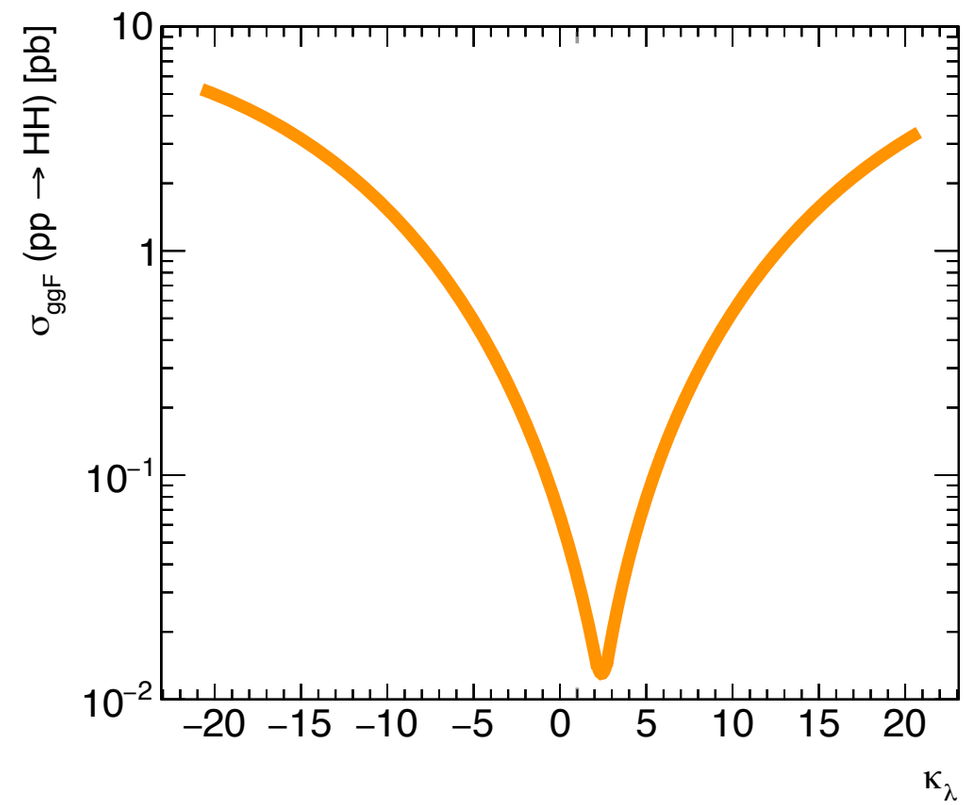
If κ_λ isn't the SM value interference diminishes: larger cross section!



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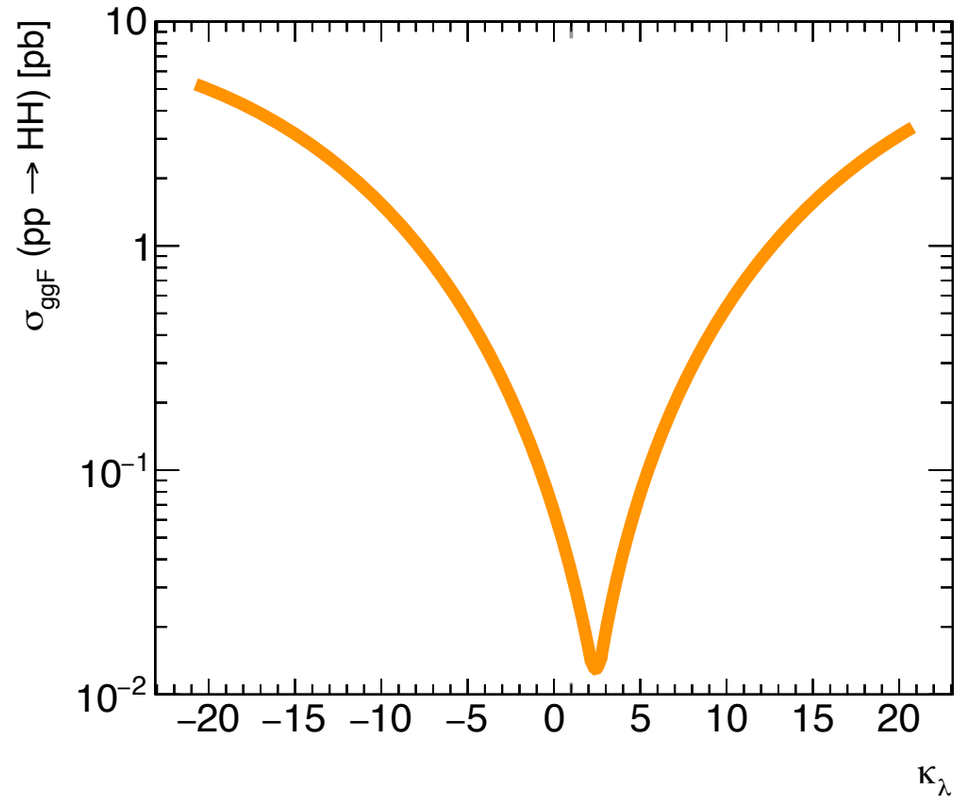

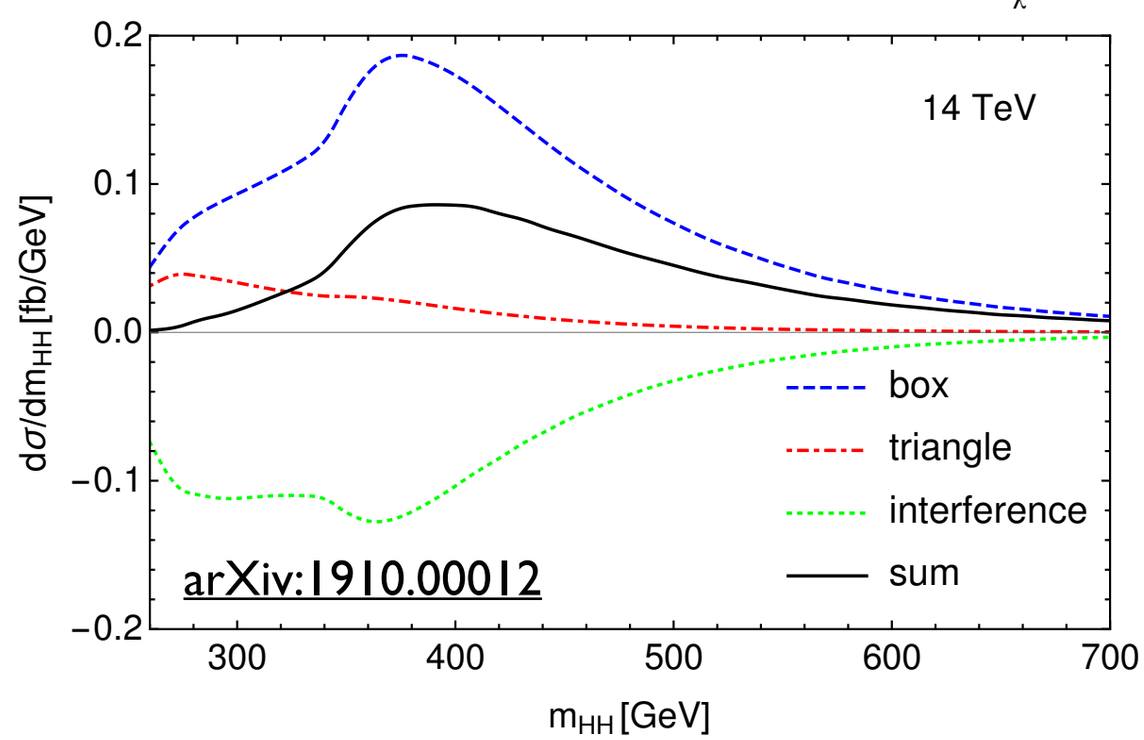

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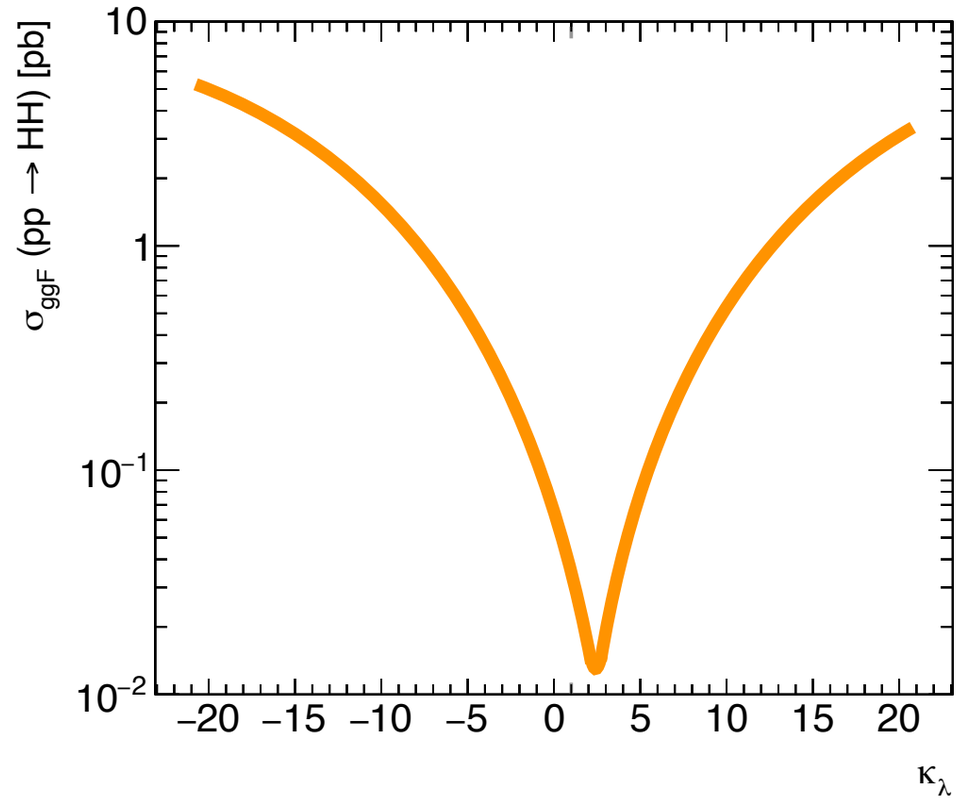
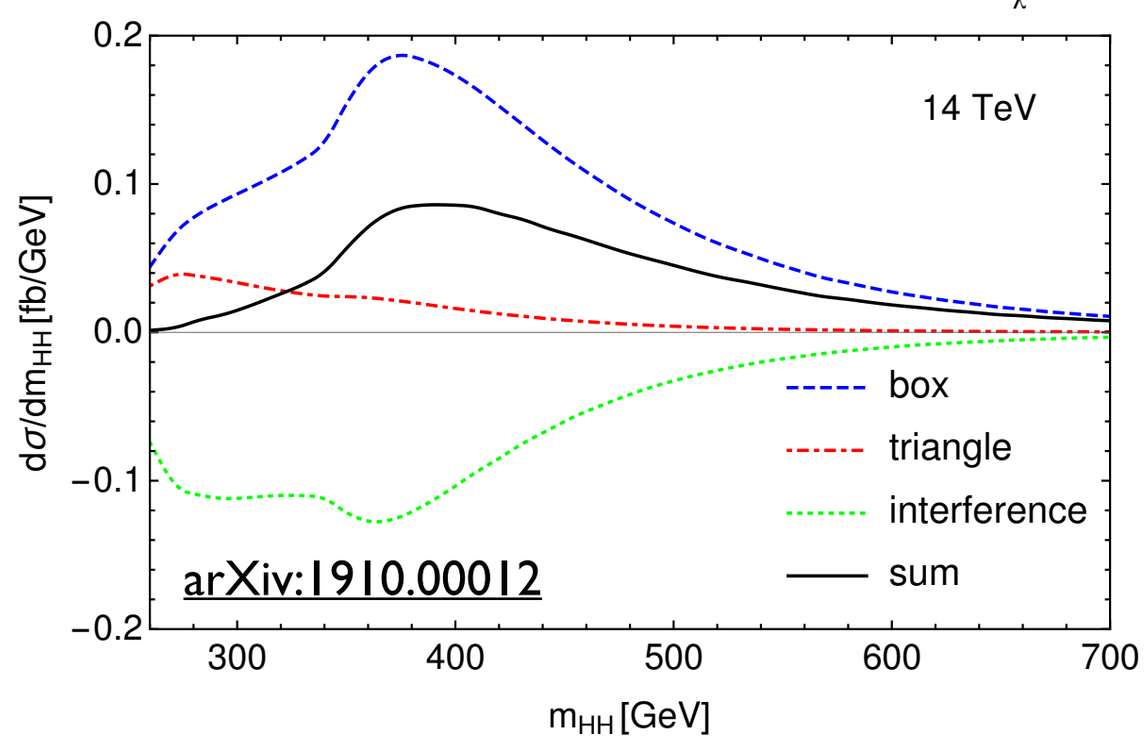
Measuring κ_λ is challenging: need both rate and shape information for best constraints





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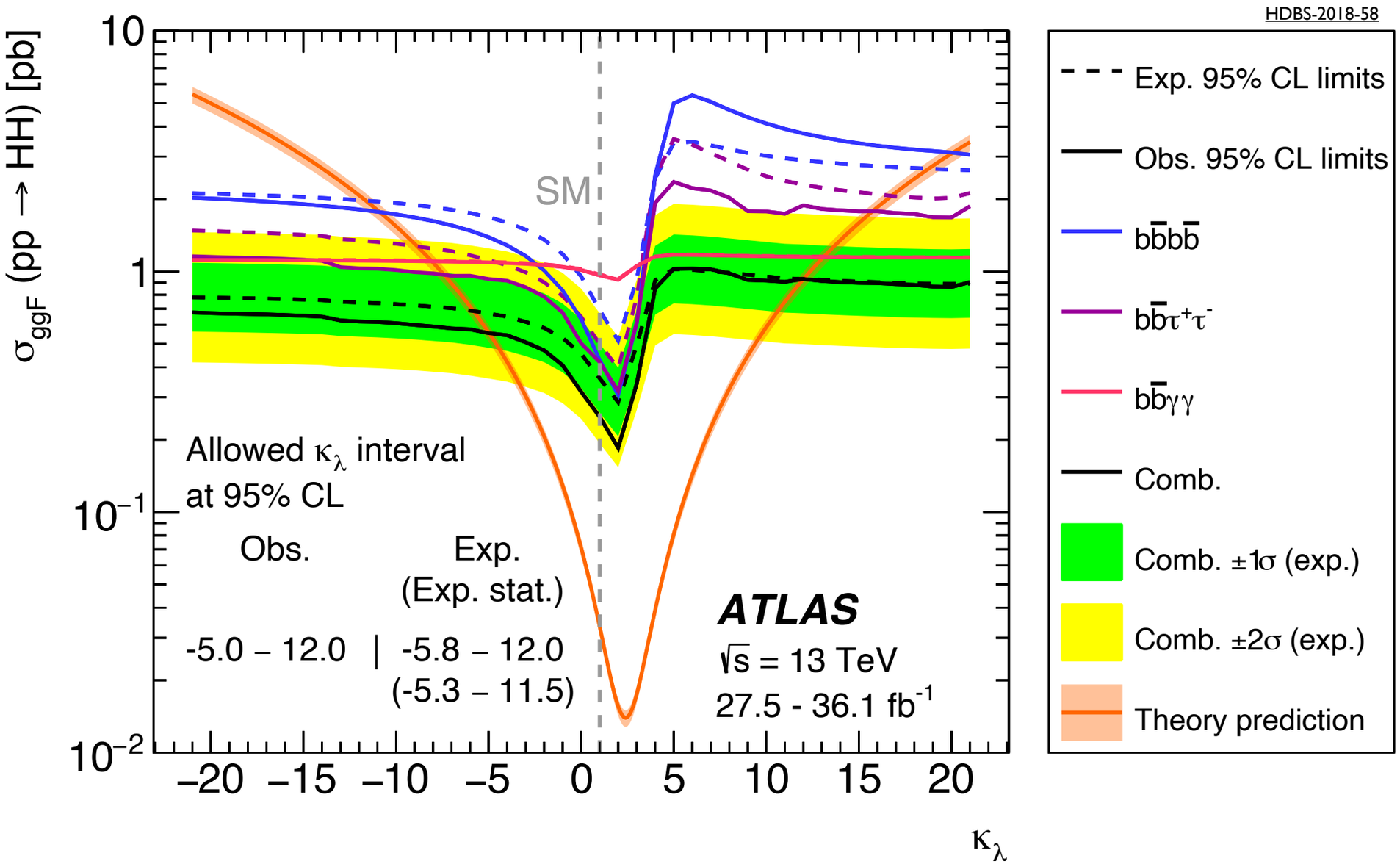

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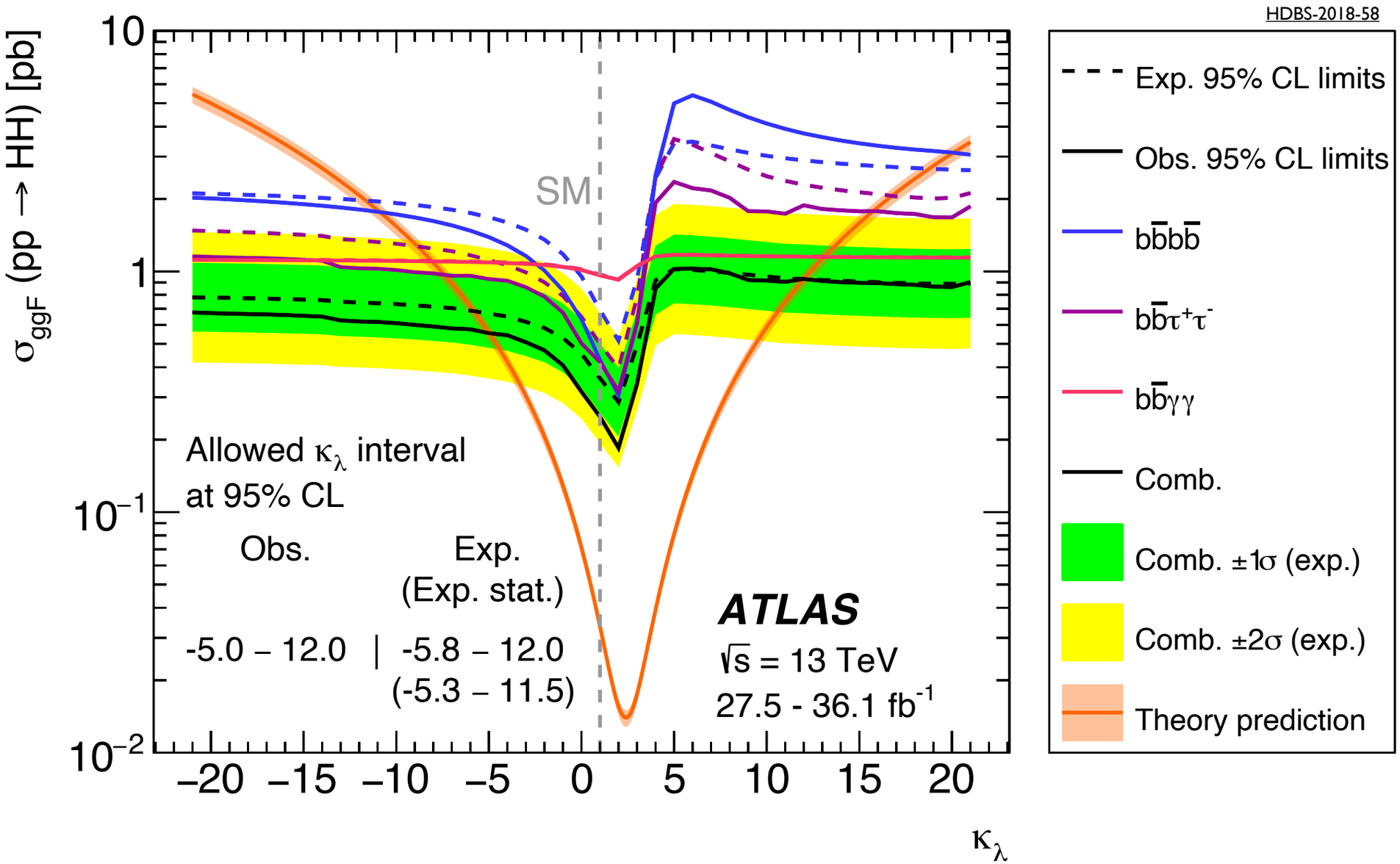

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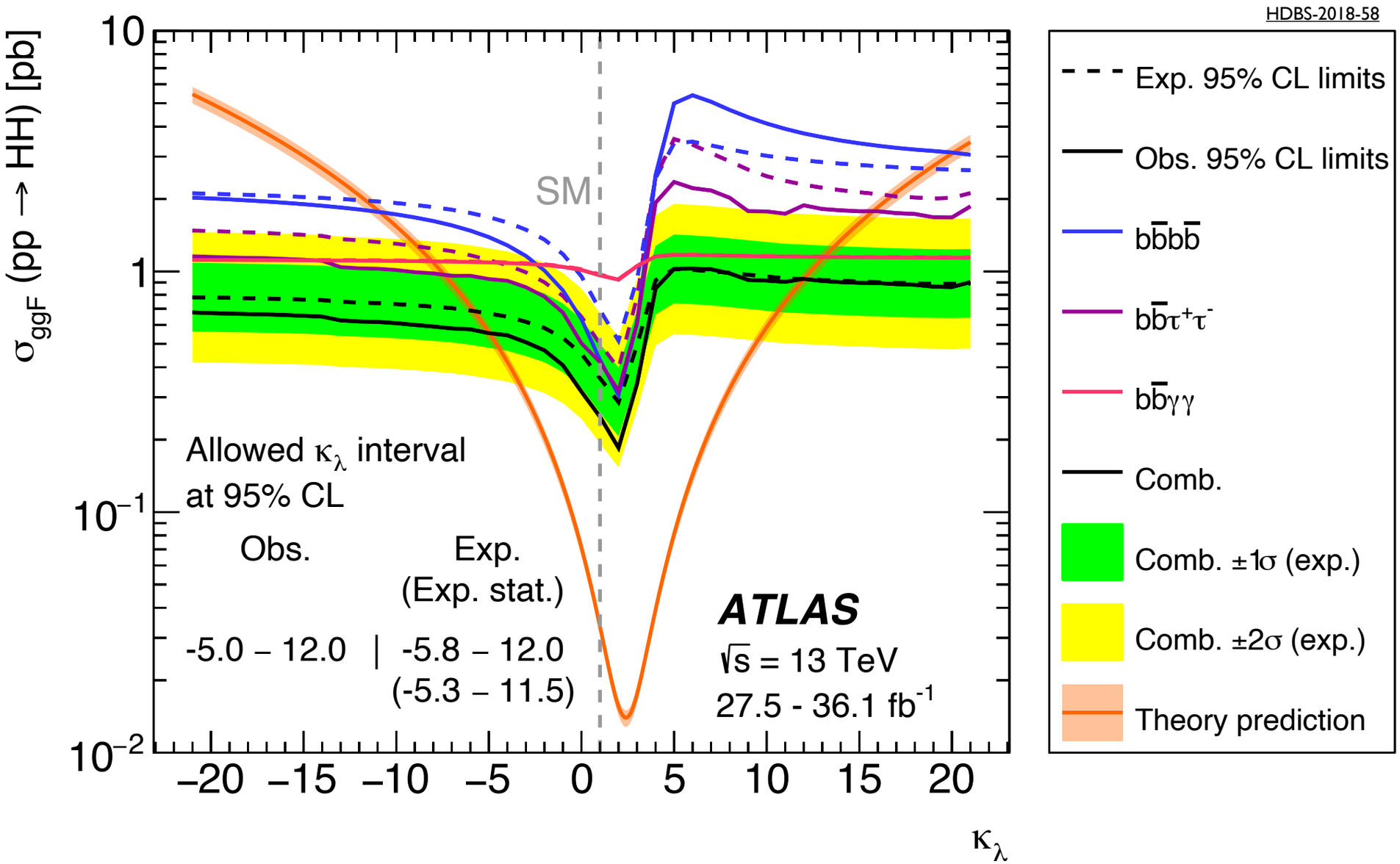

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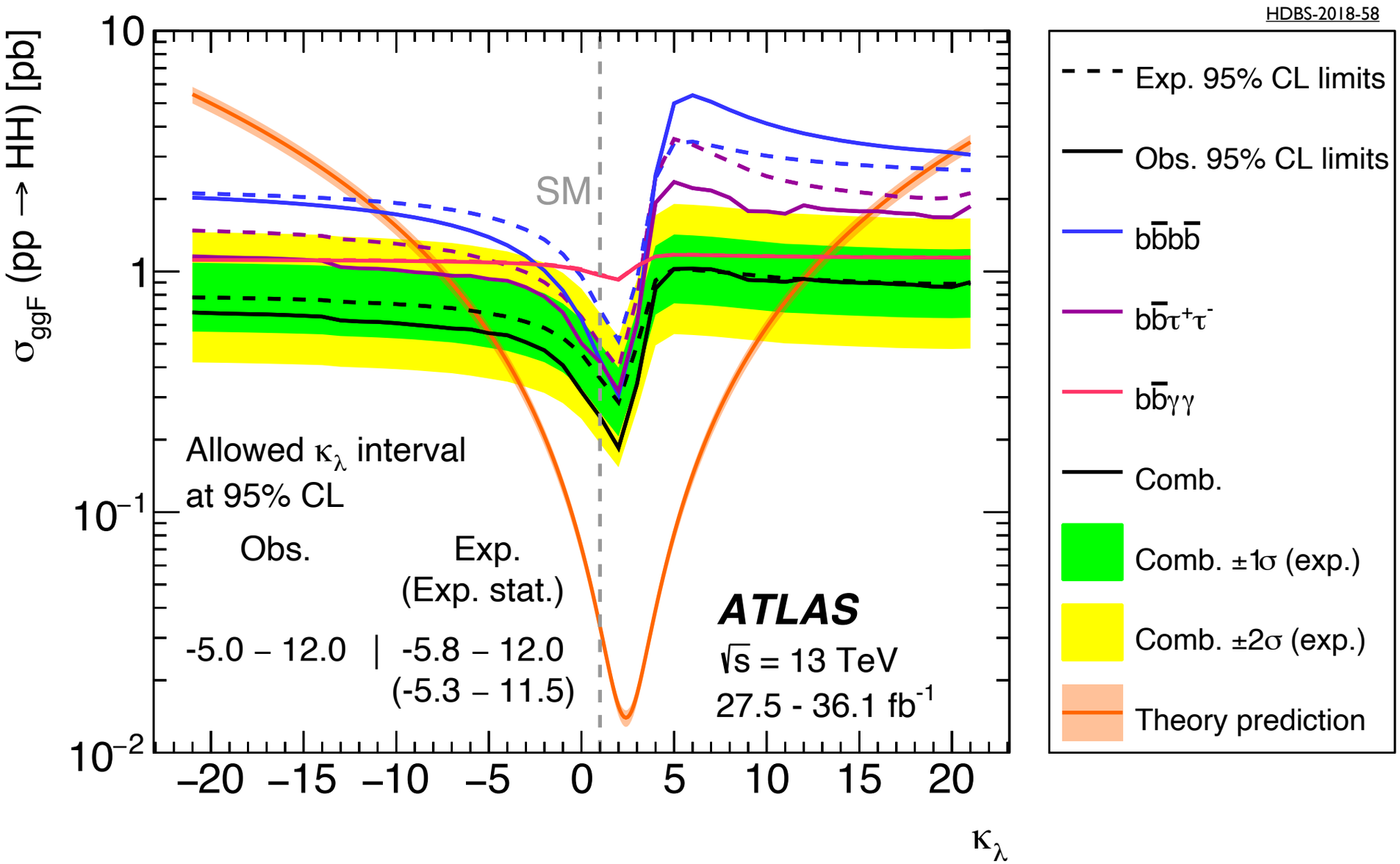

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Can we say anything else?

Measuring with Single Higgs

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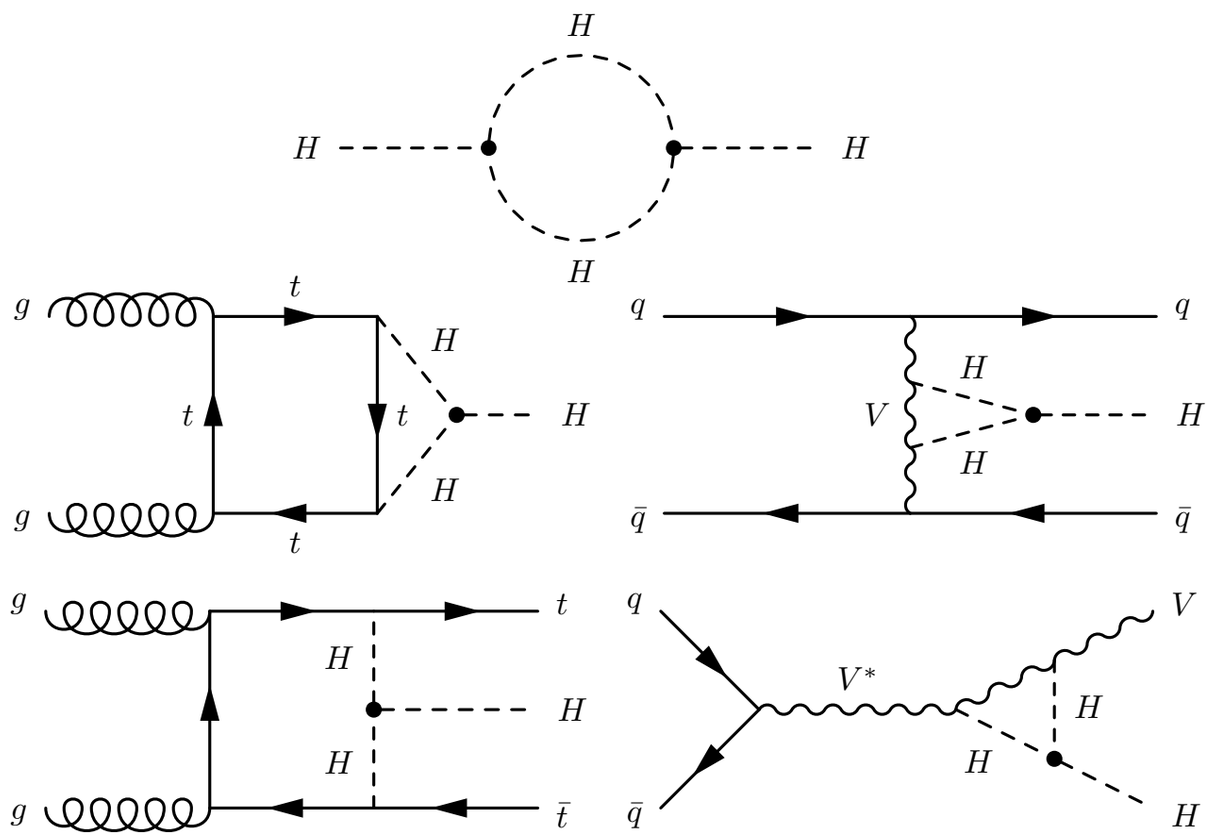

Single Higgs final states can also be sensitive to κ_λ

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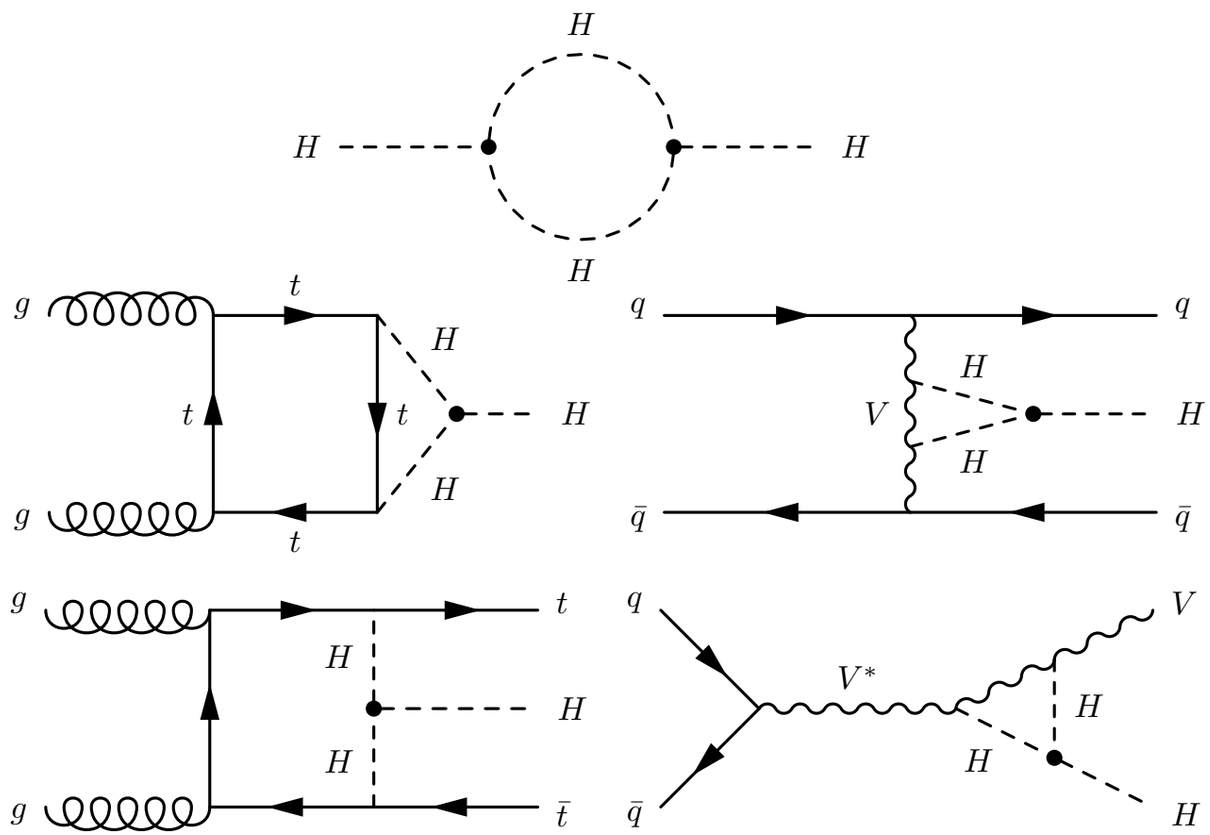

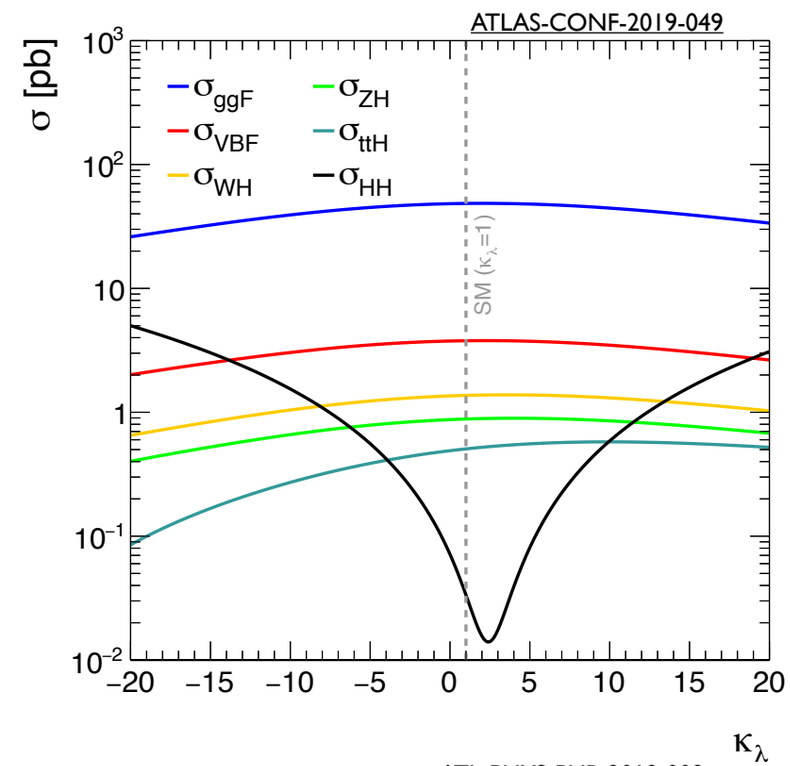

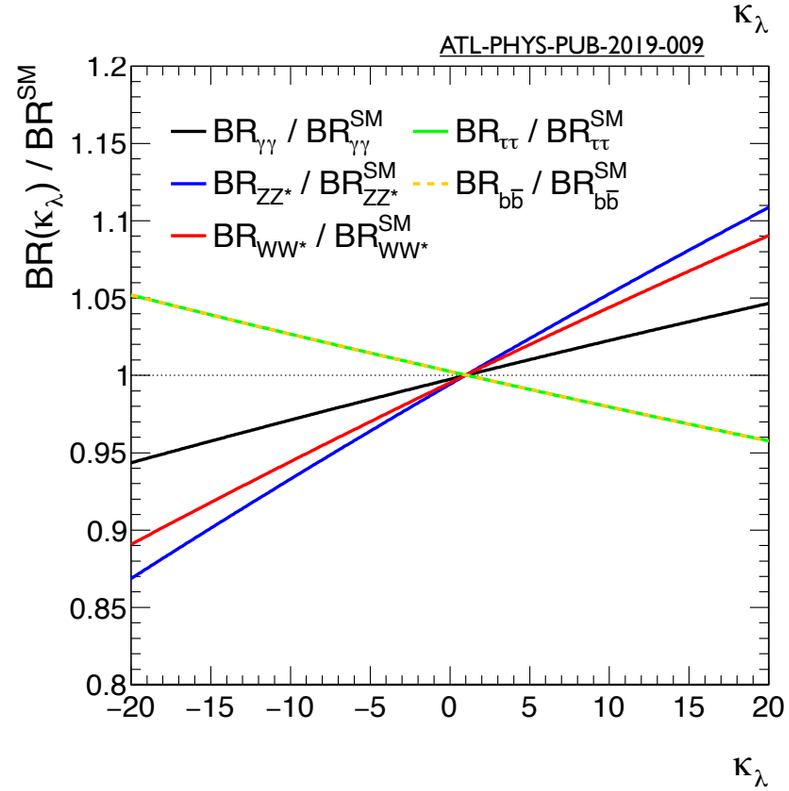

Single Higgs final states can also be sensitive to κ_λ

NLO EW corrections give Higgs cross-section, branching ratios, and kinematics dependence on κ_λ

Combining Single and Double

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Perform two types of interpretations:

1. New physics only in κ_λ
2. New physics in any κ coupling

Results: κ_λ

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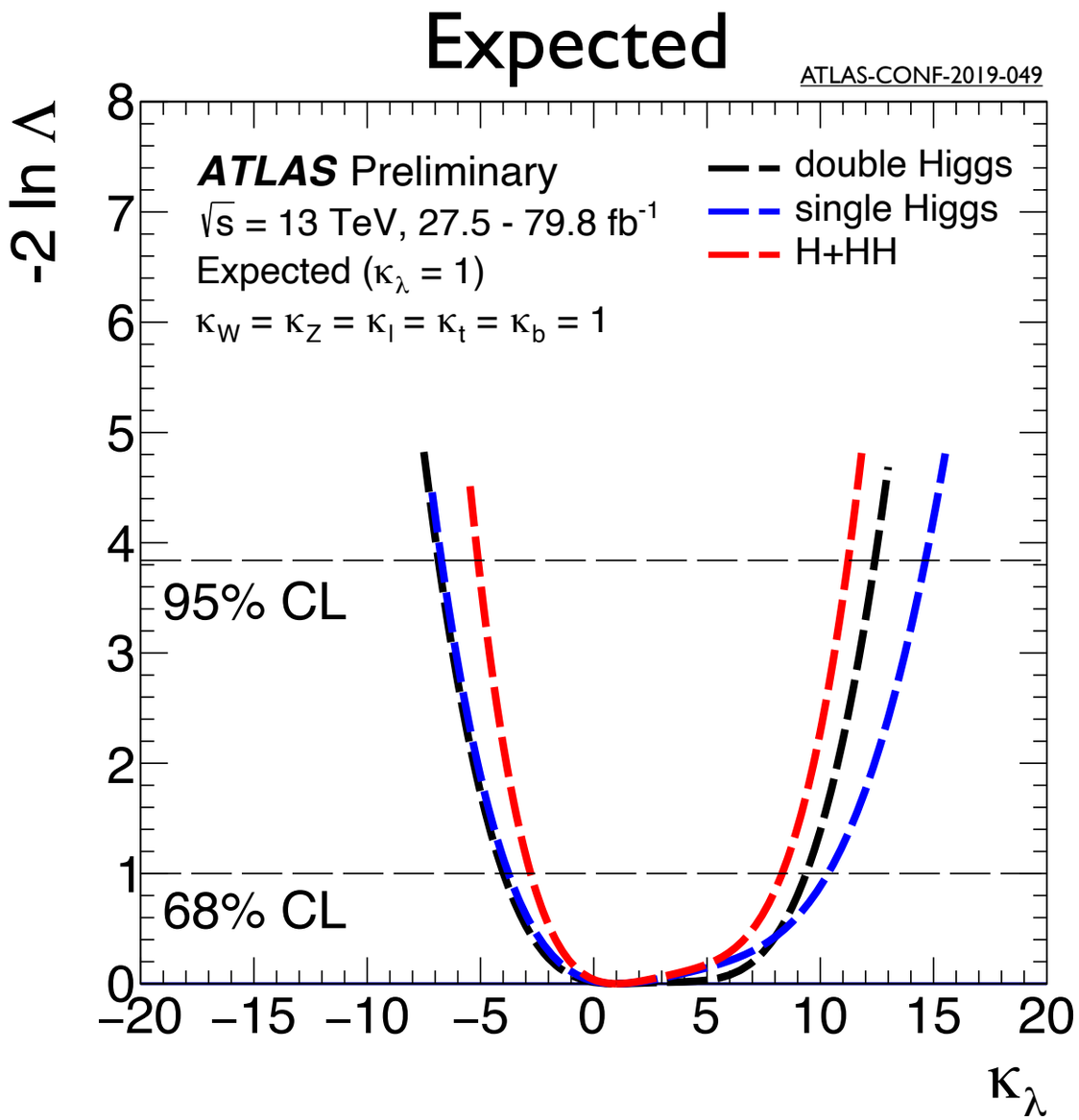

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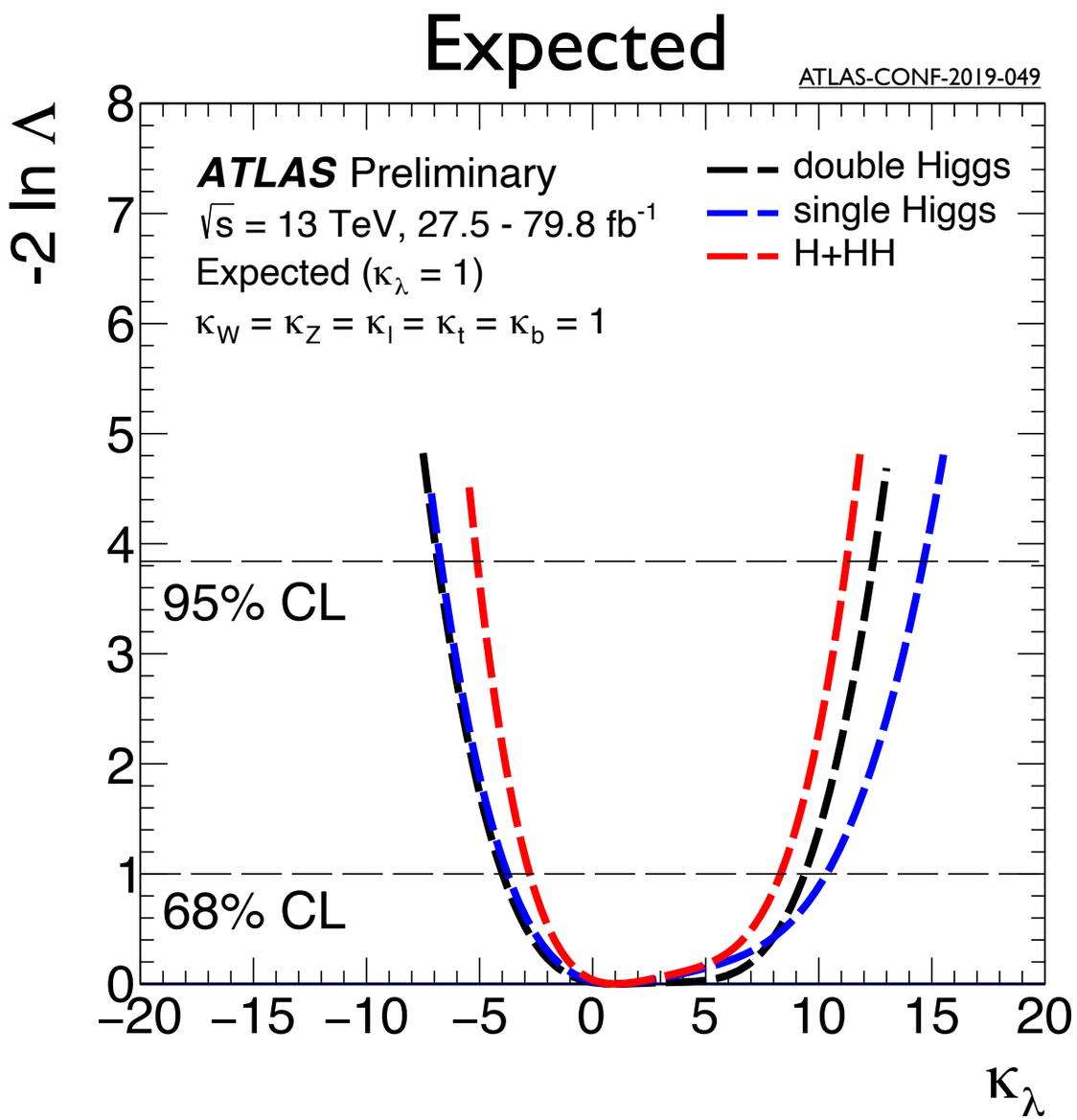

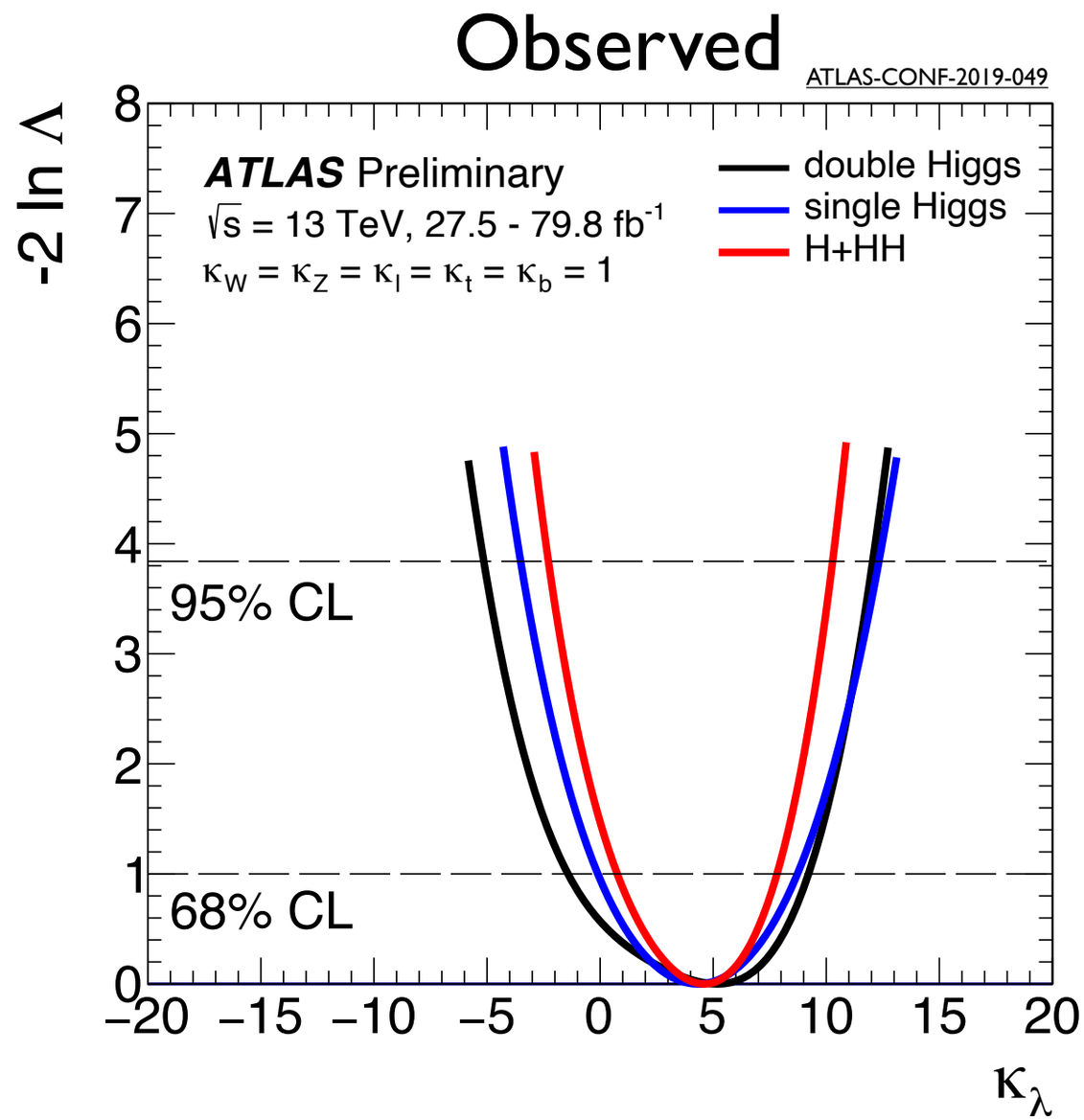

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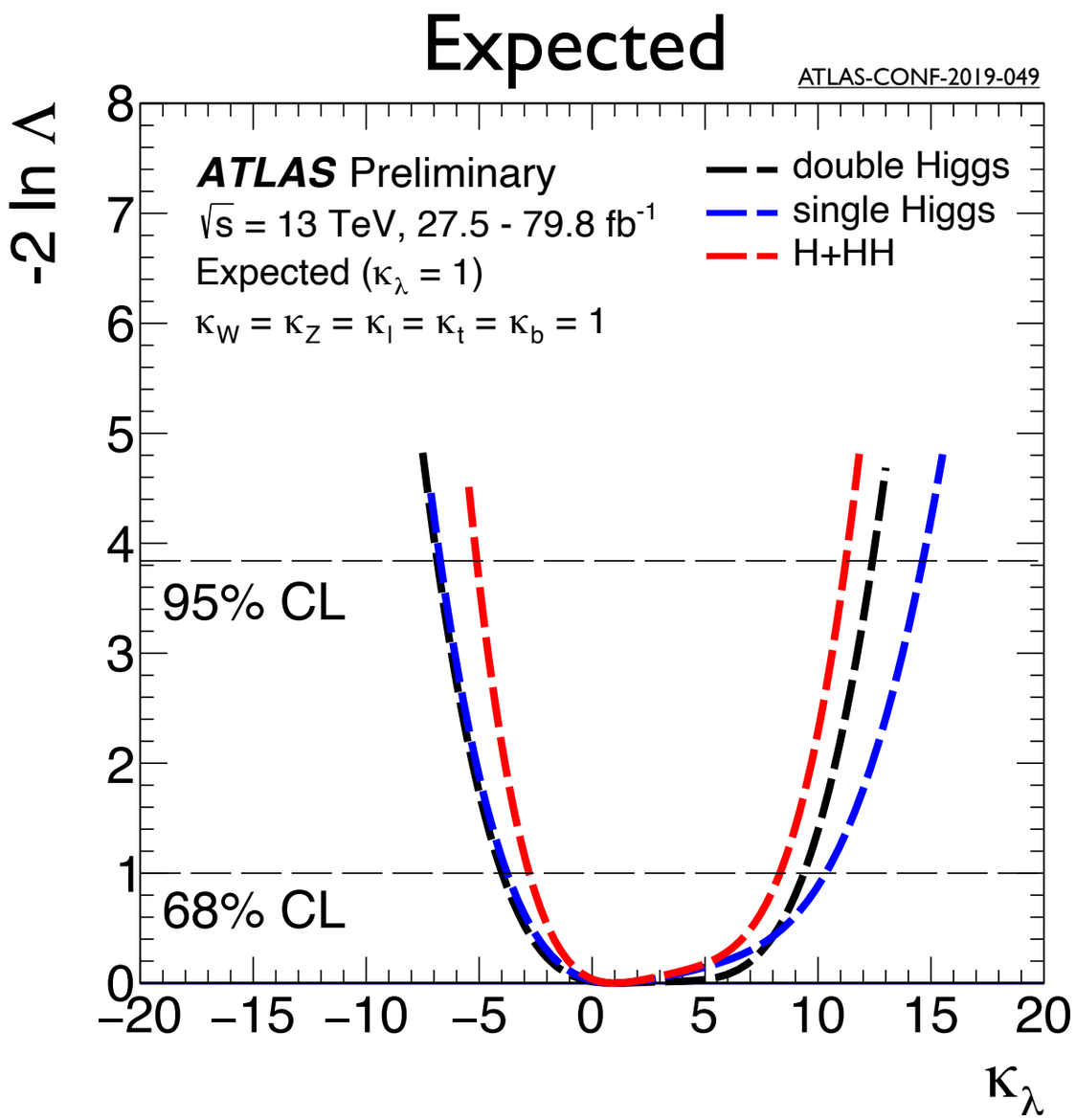

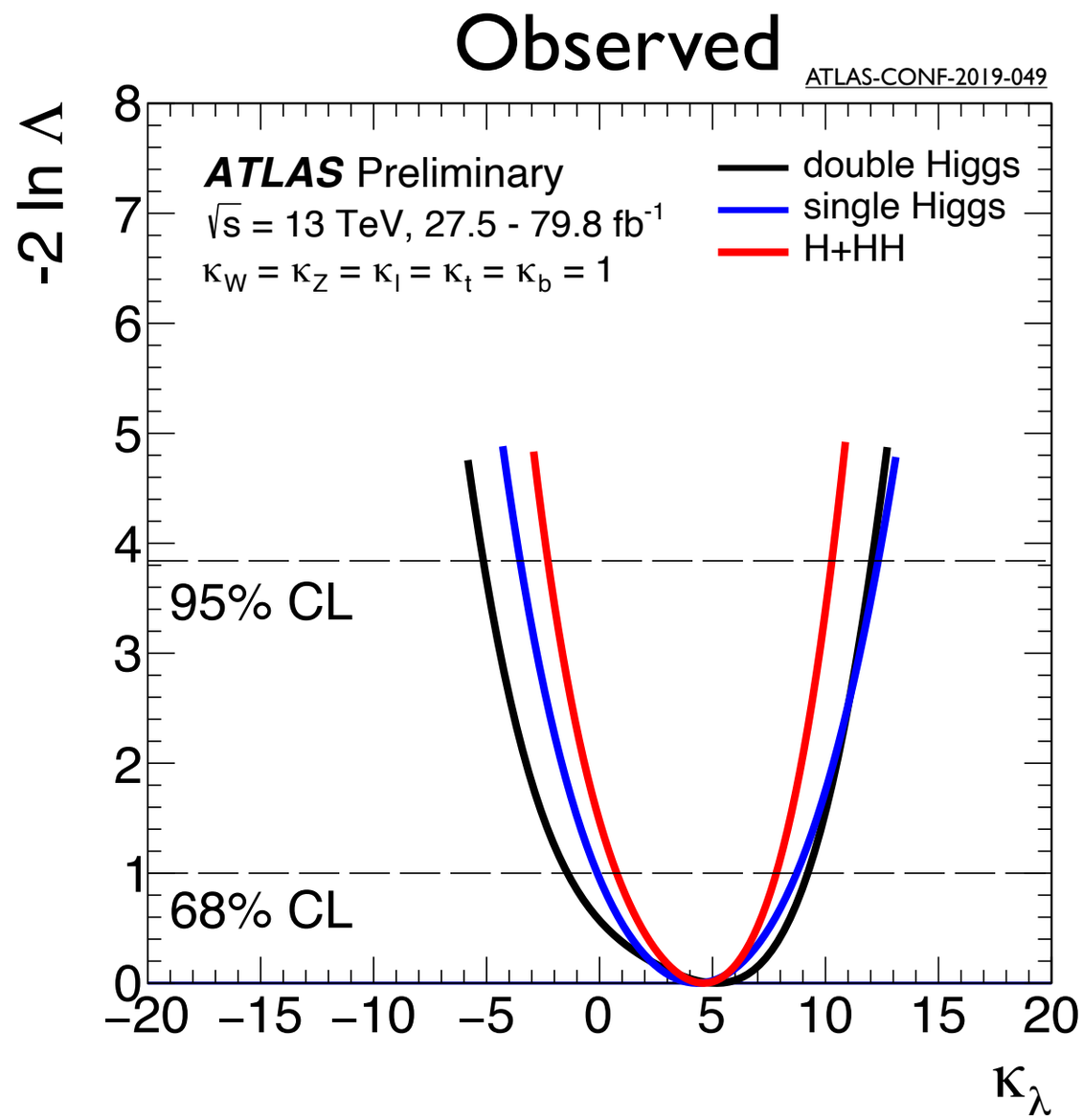

Di-Higgs and **Single-Higgs** provide similar limits on κ_λ!

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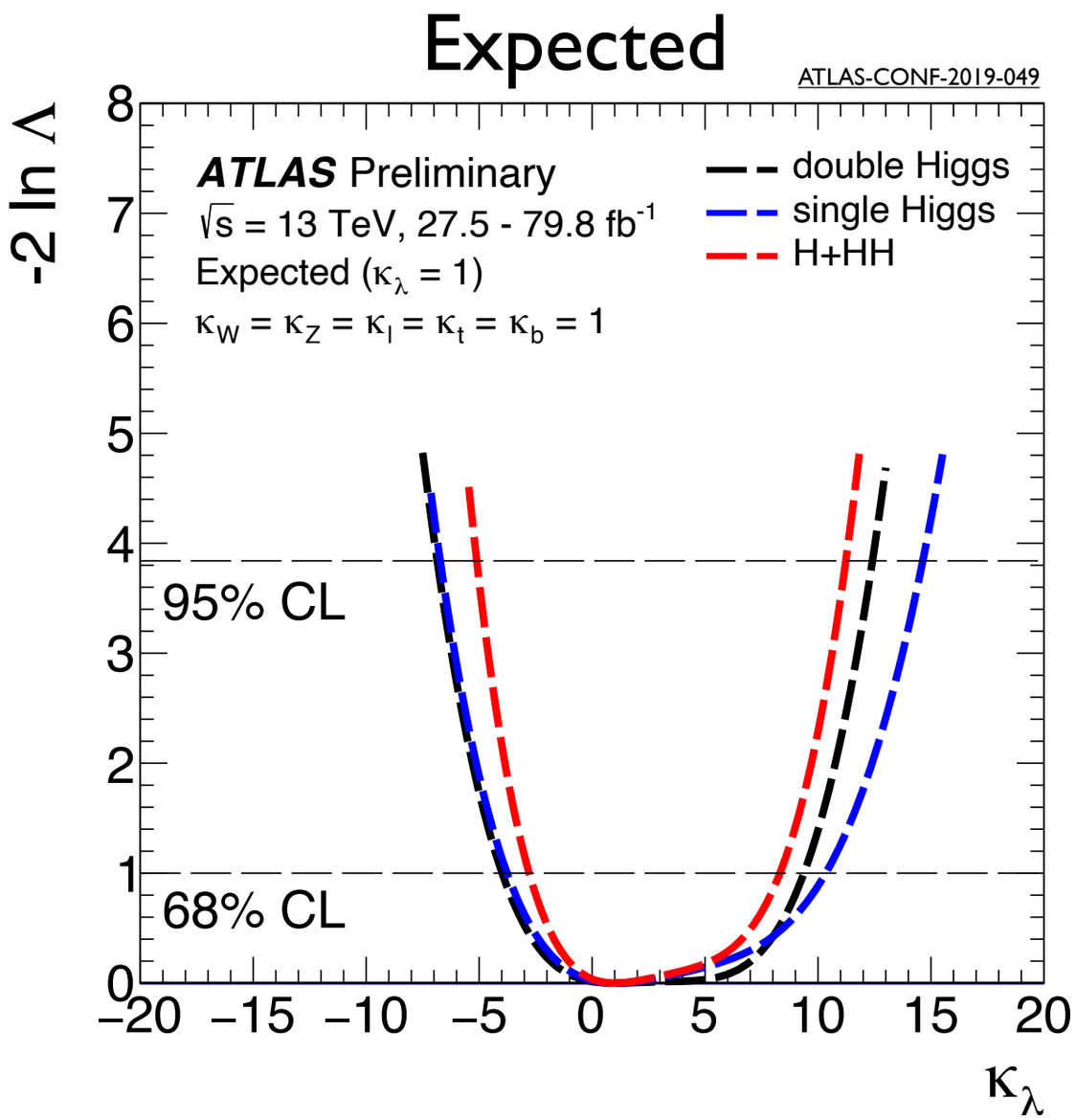

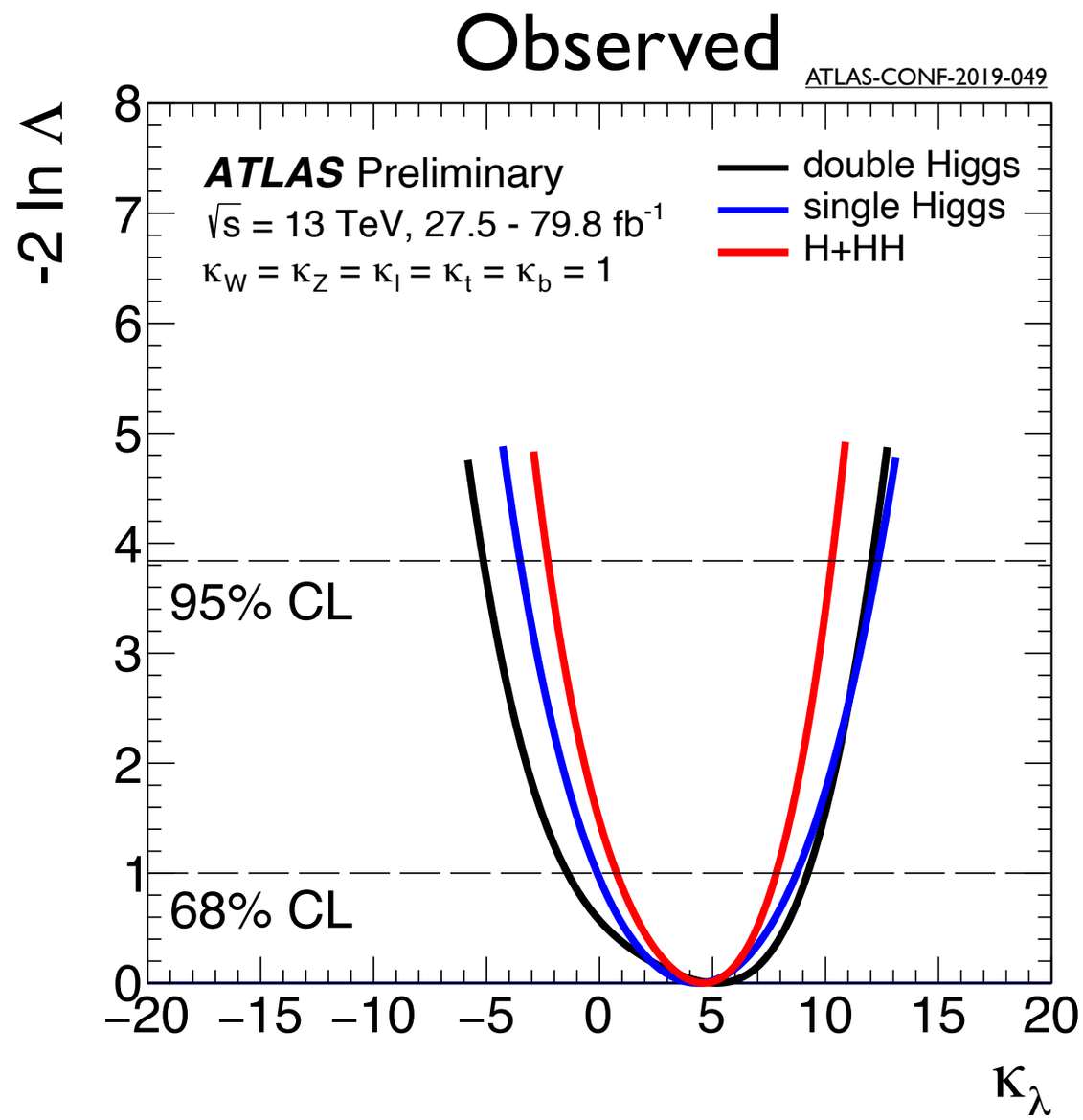

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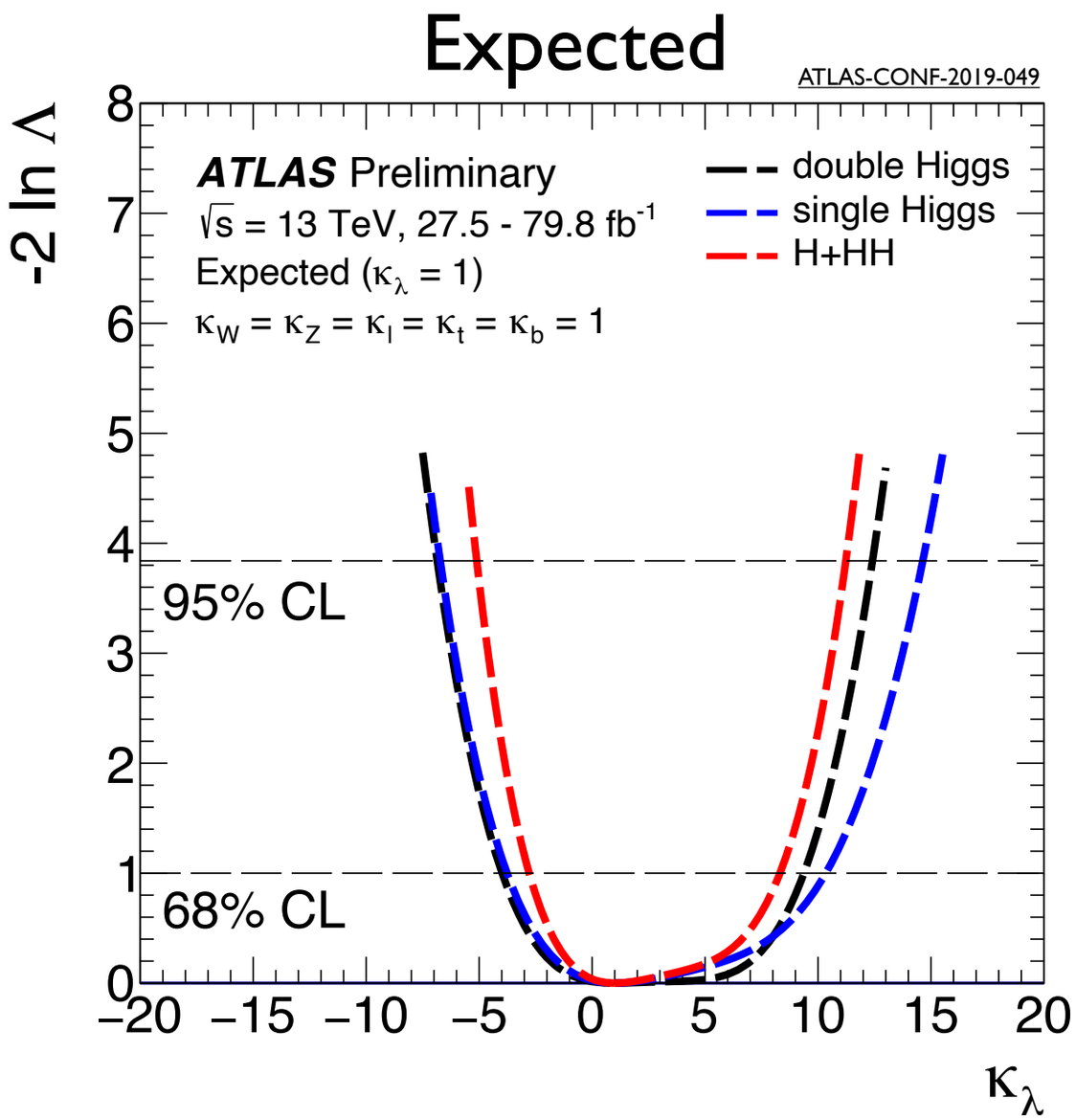

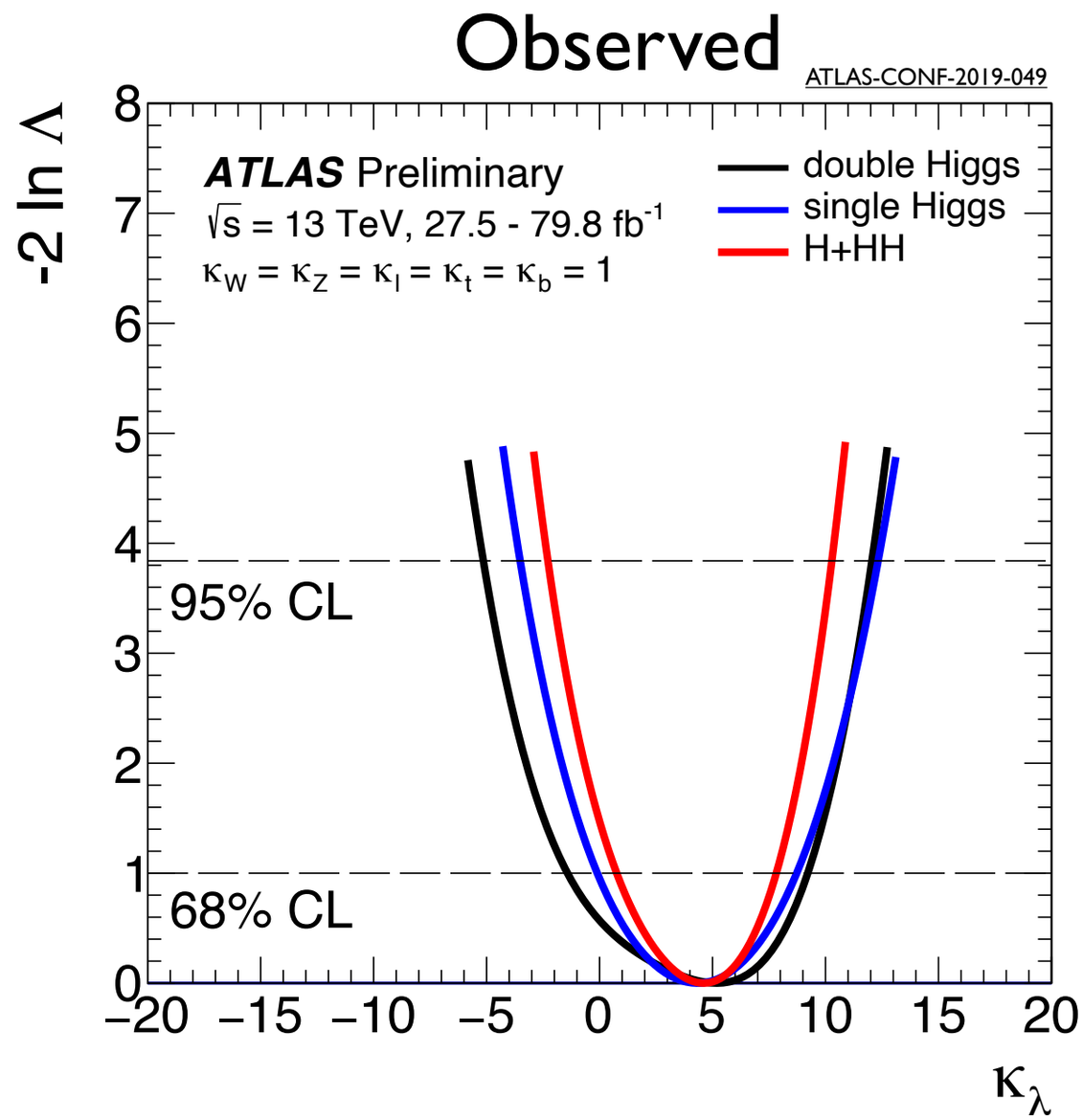

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Combination provides strongest limits

Relaxing Constraints

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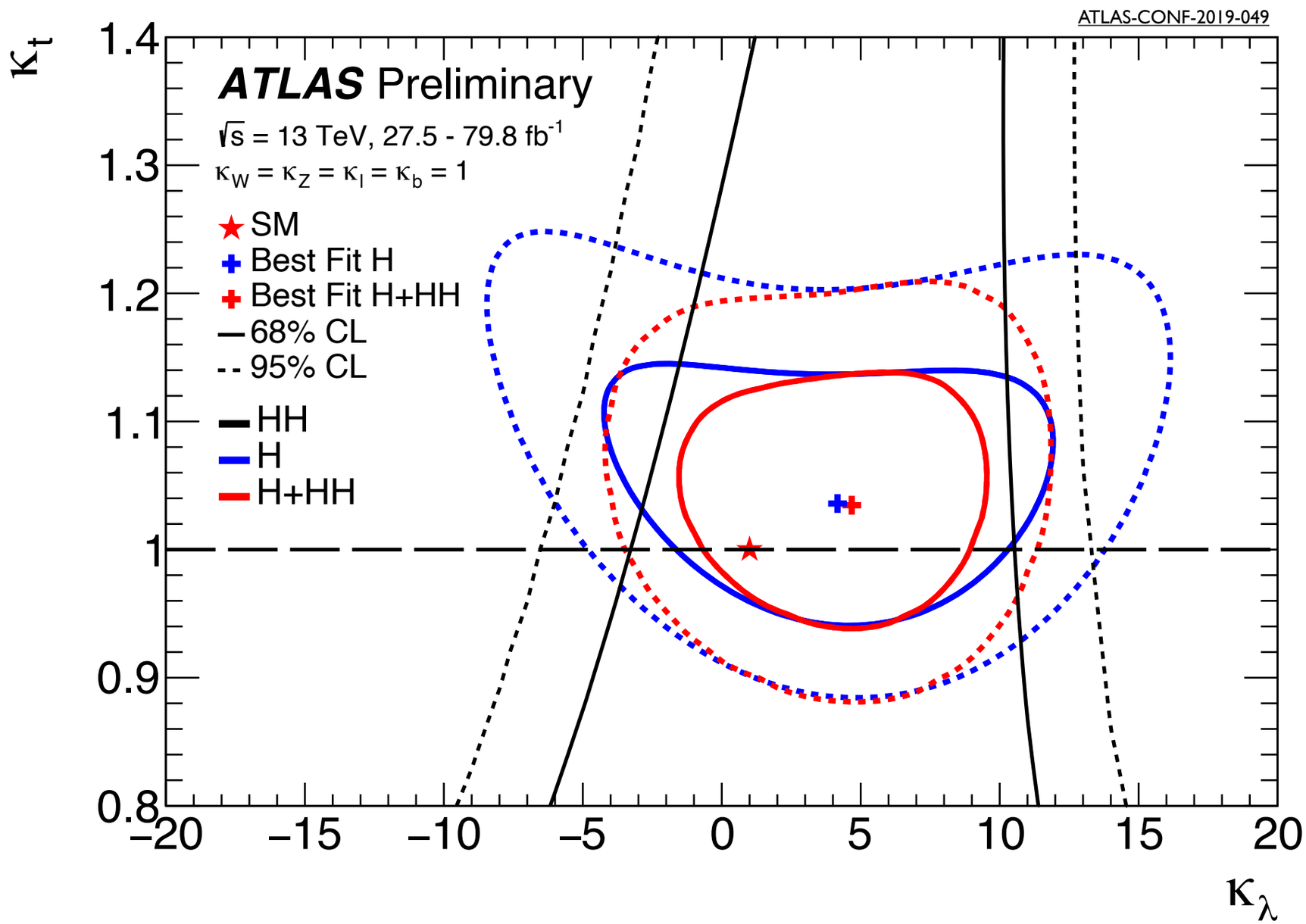

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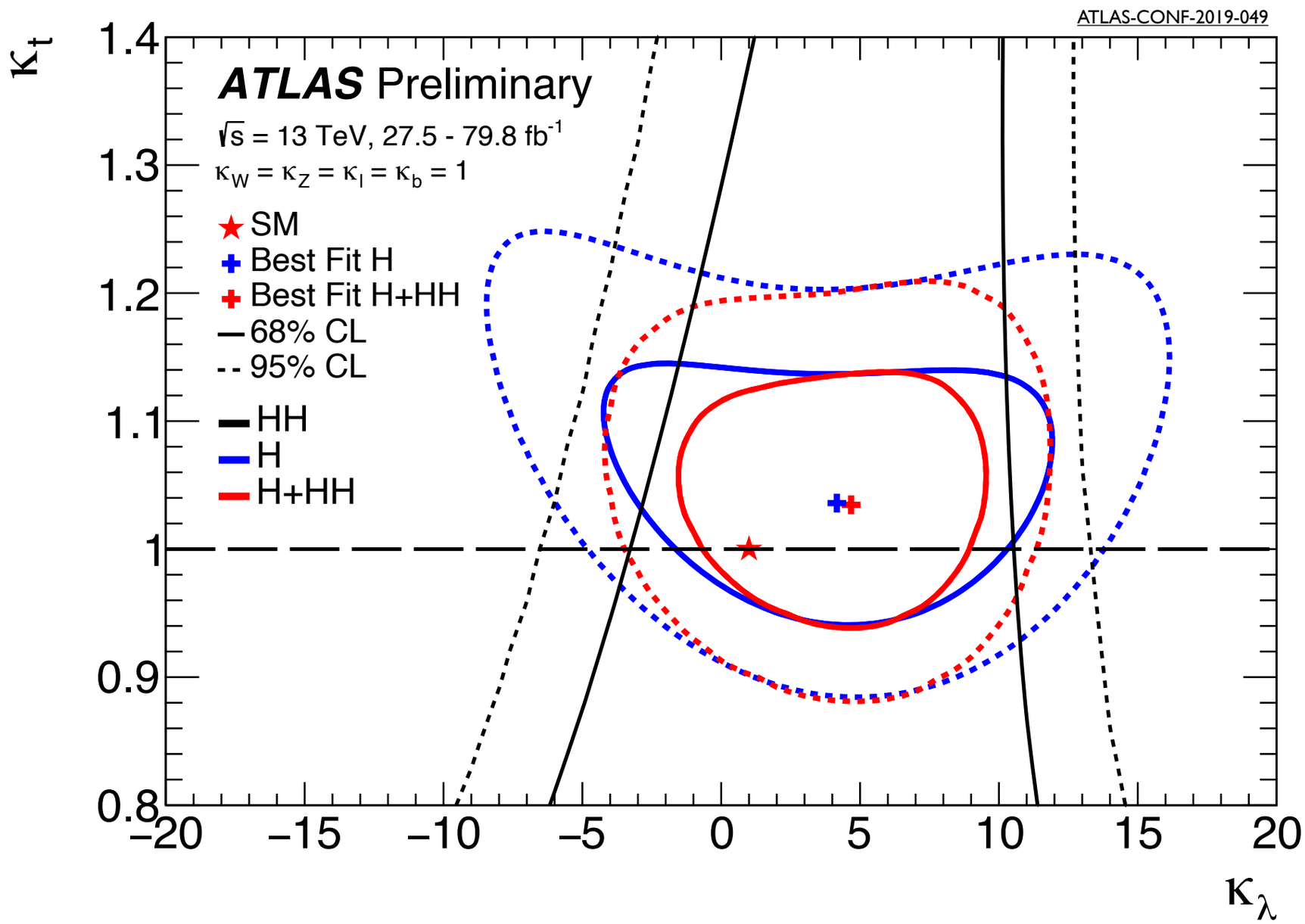

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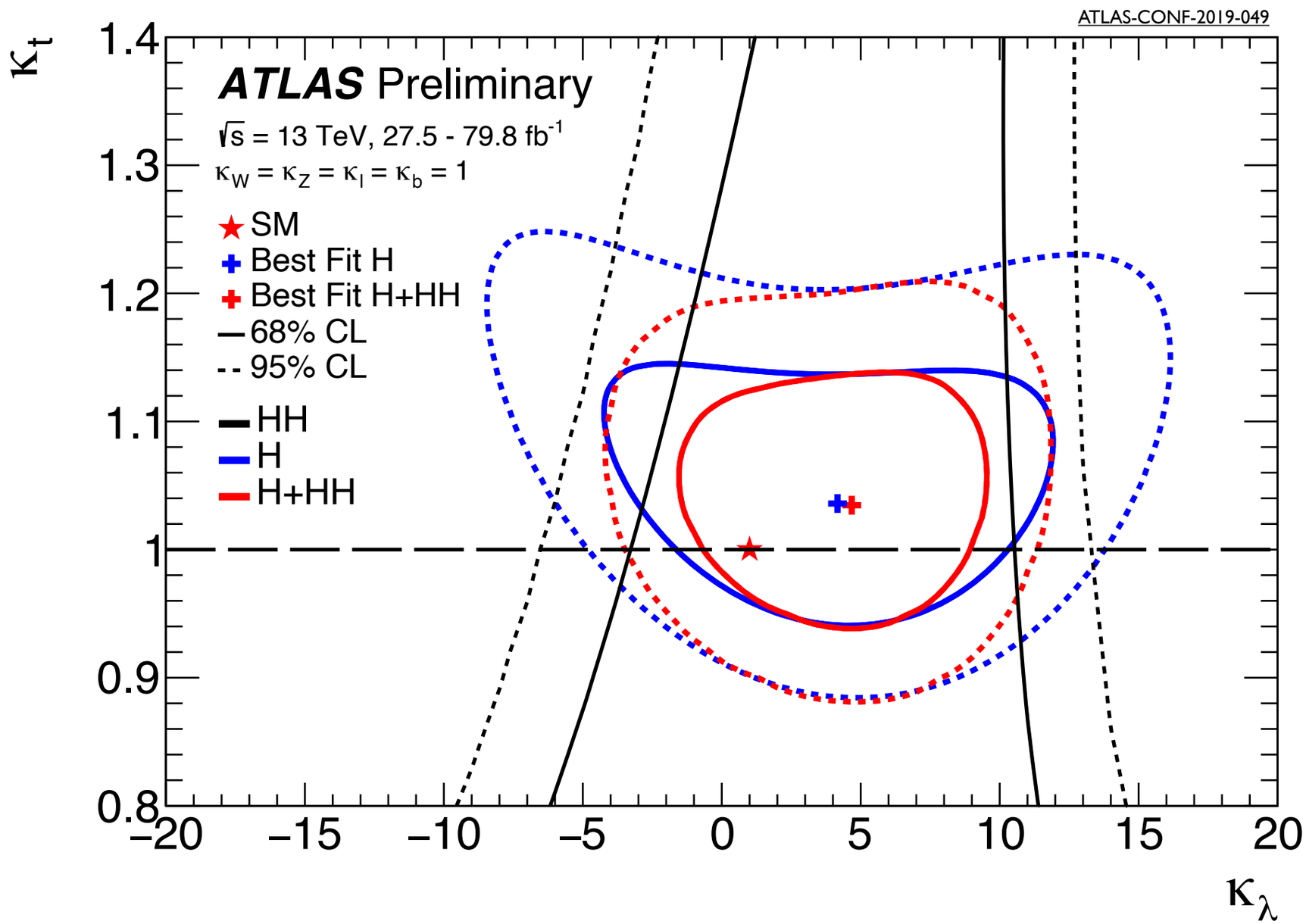

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Single Higgs allows the **Combinations** to be sensitive to variations in both parameters

Even Fewer Constraints

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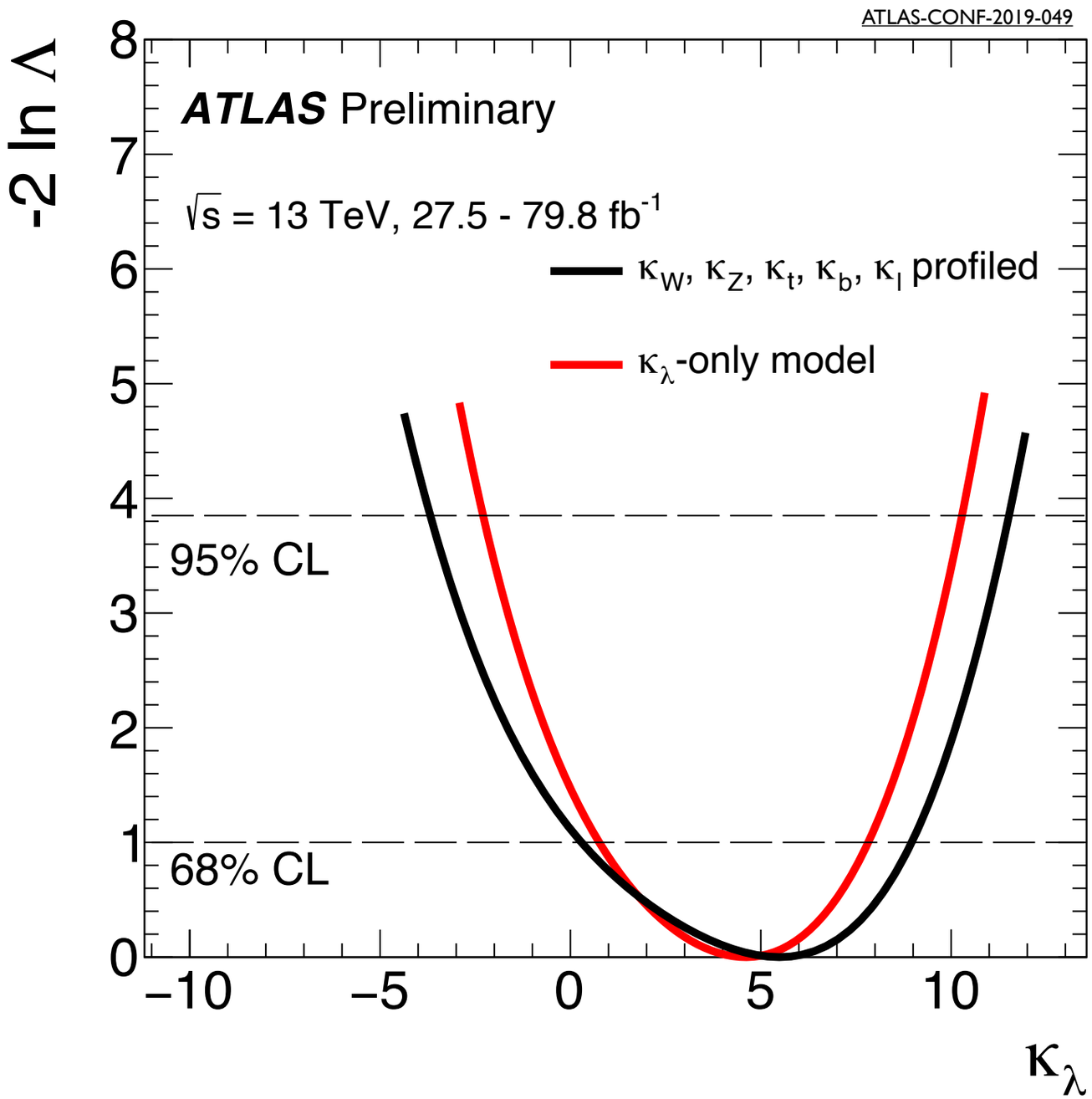

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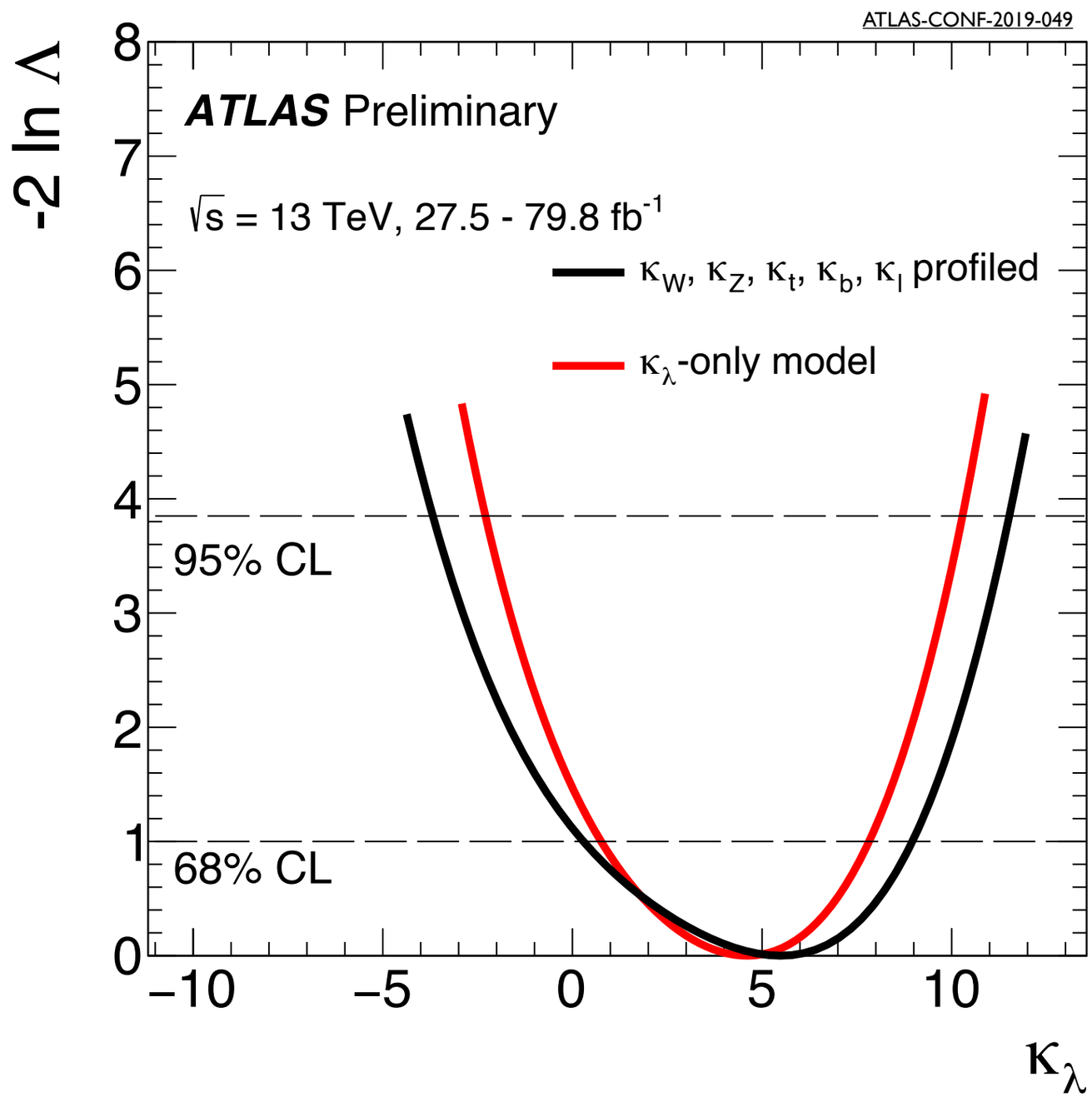

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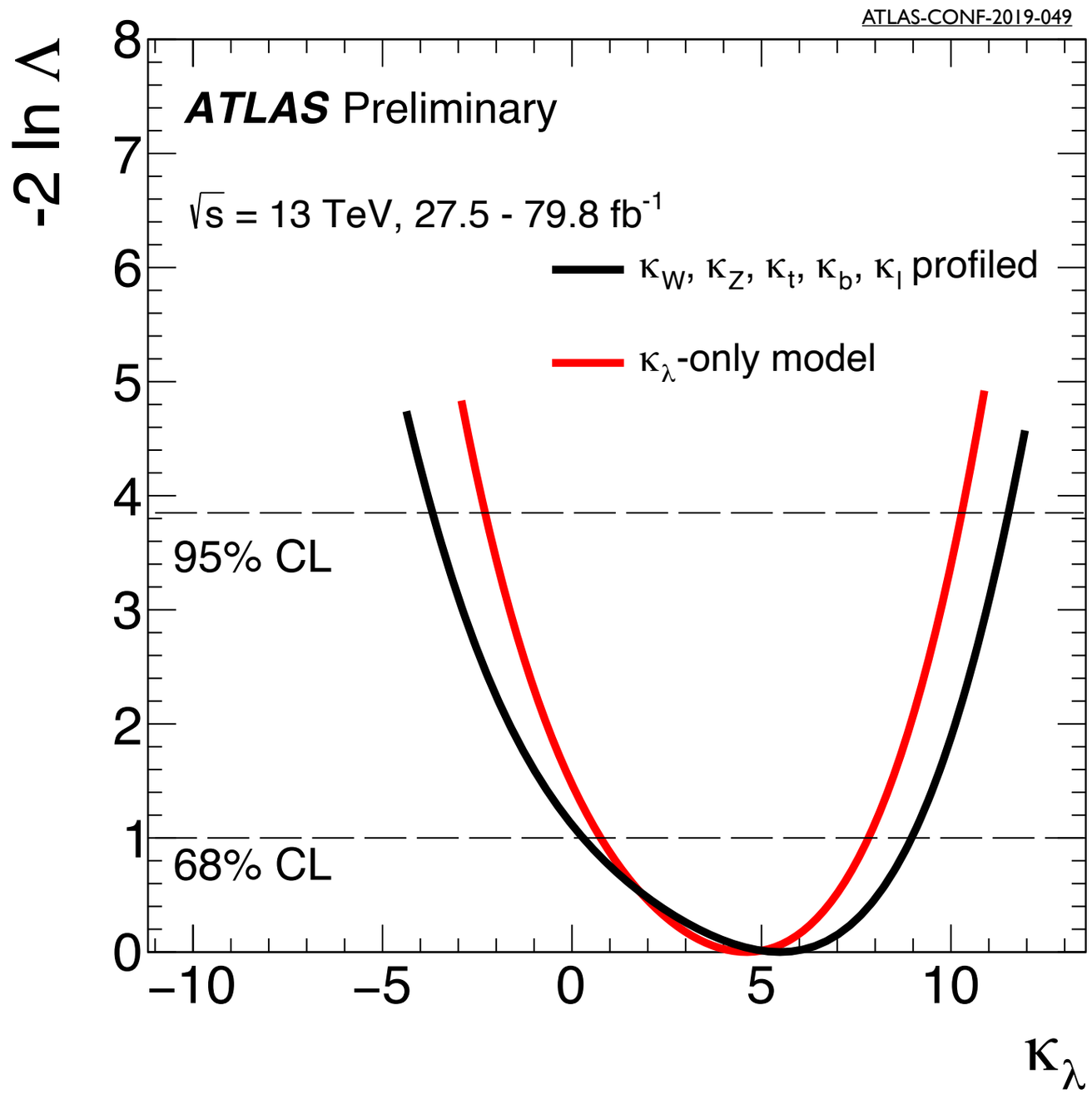

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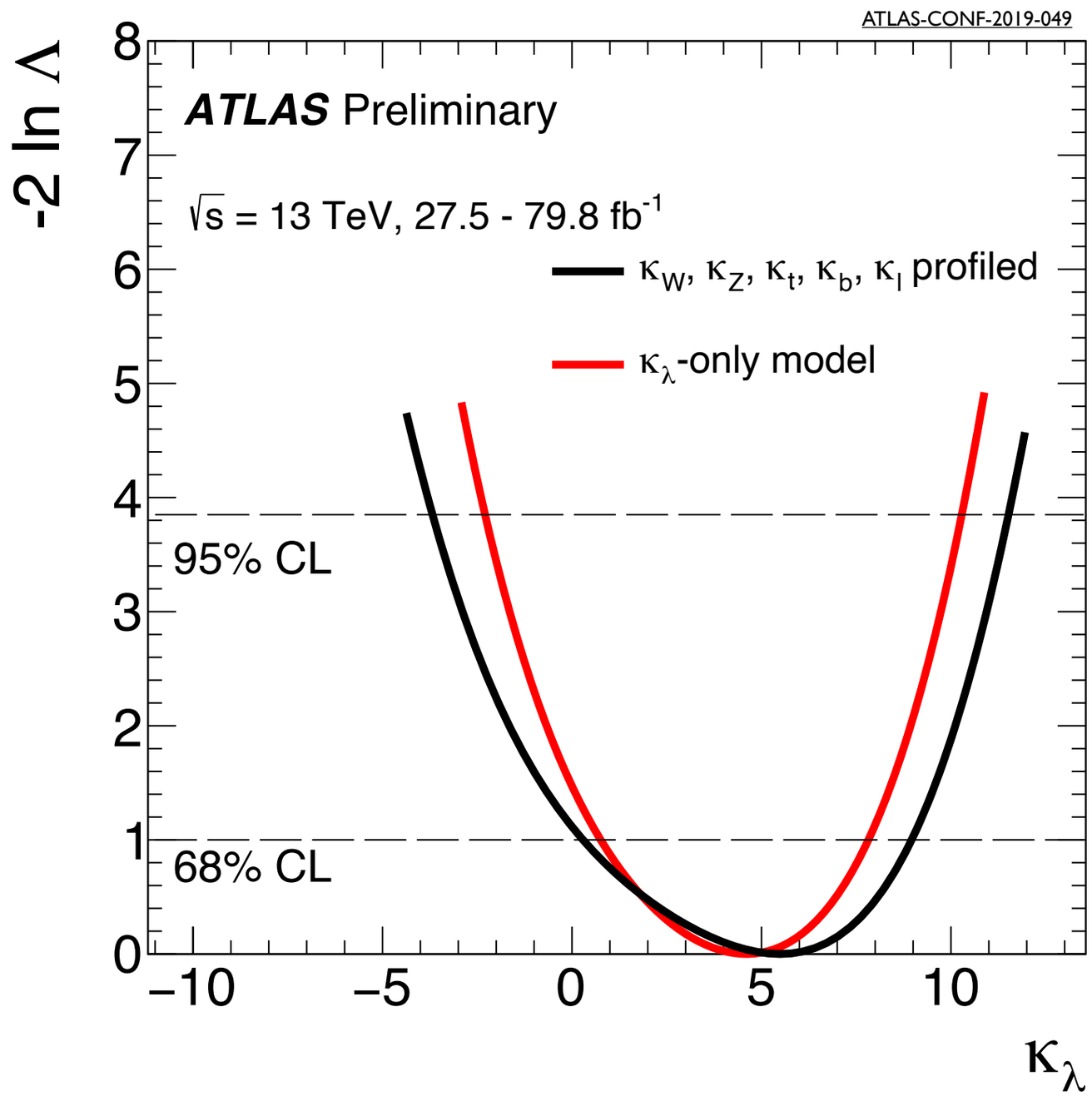

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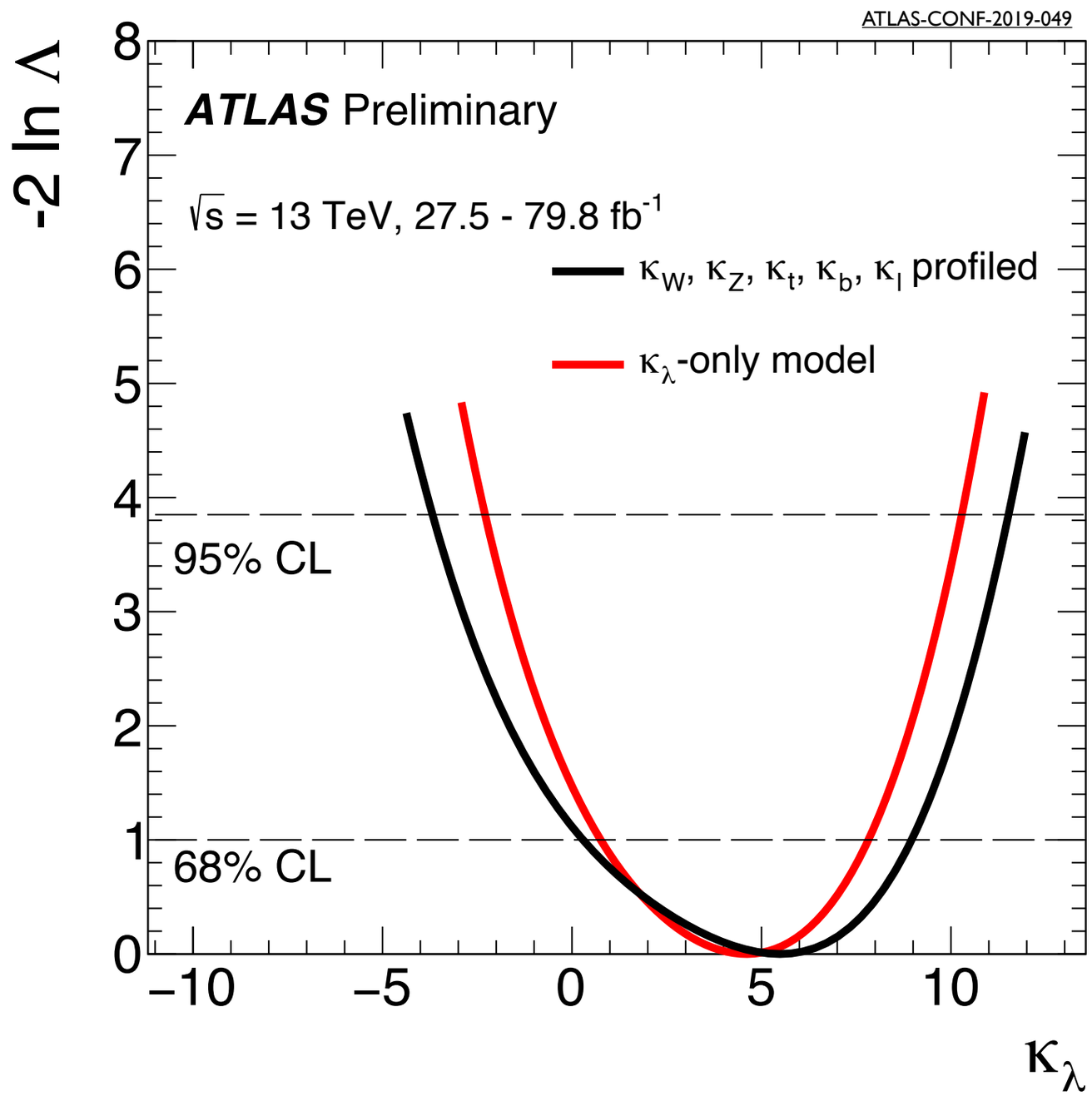

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Important to consider most general constraints: difficult without single Higgs

What Next?

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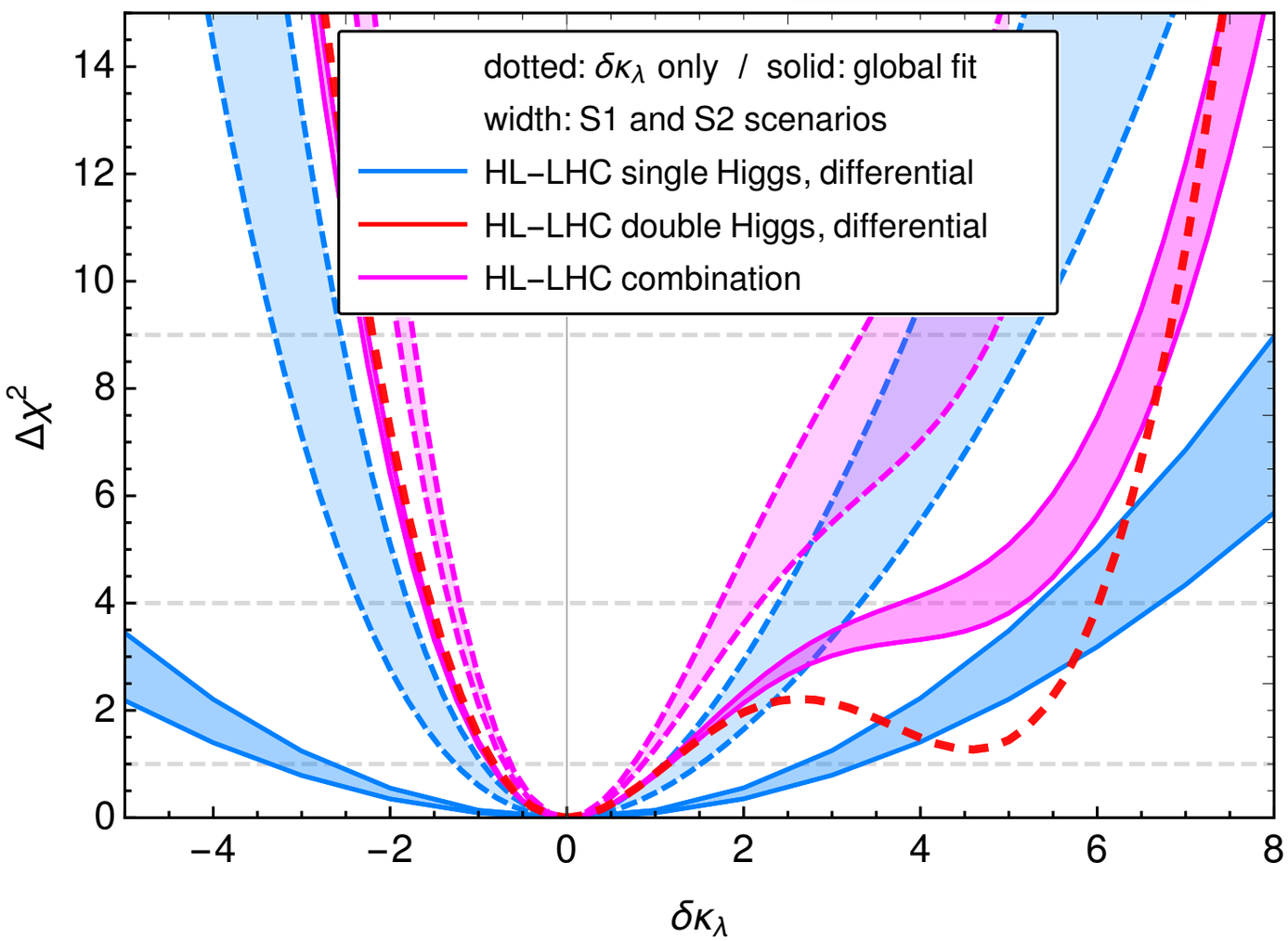
arXiv:1902.00134



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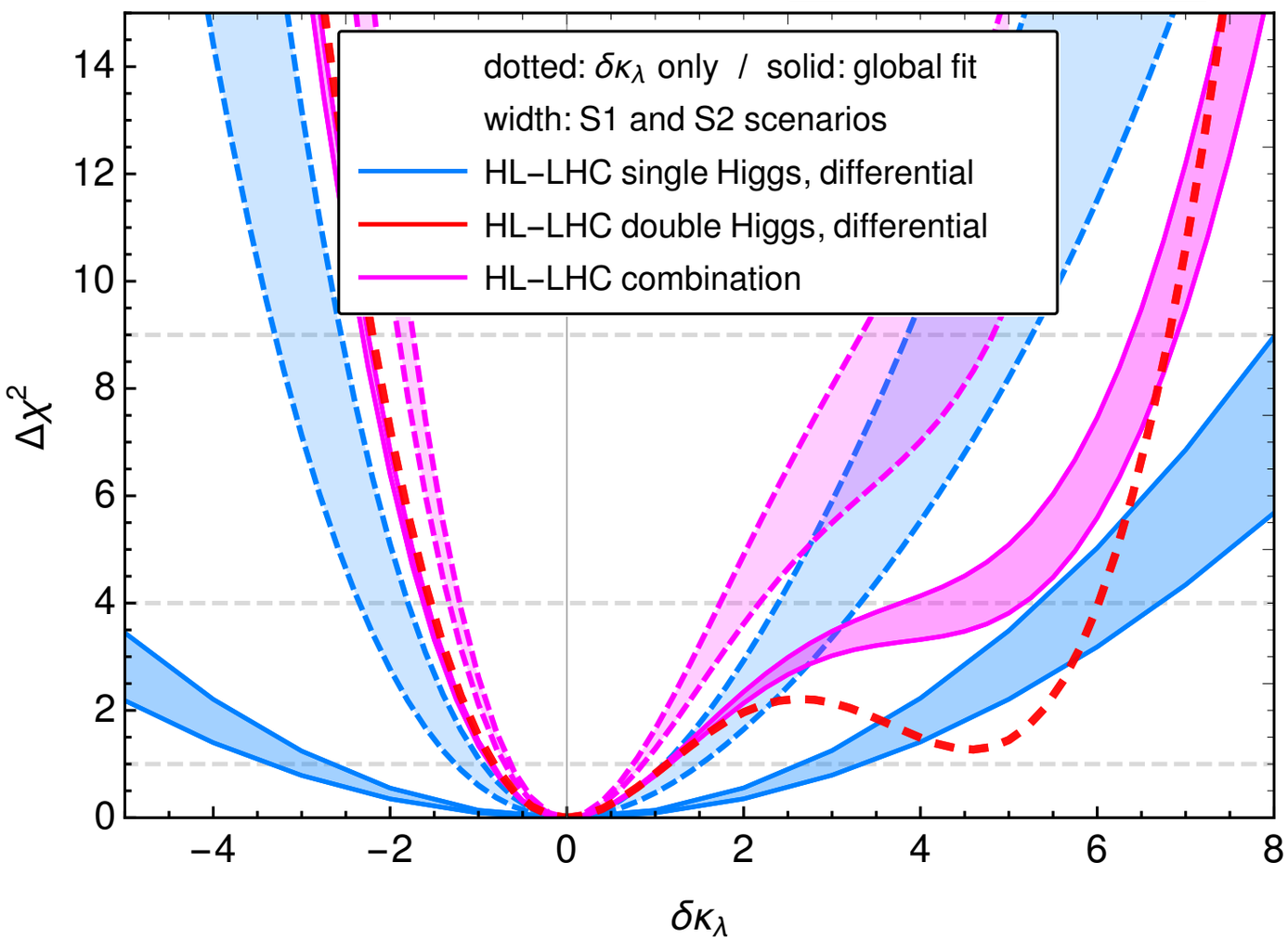

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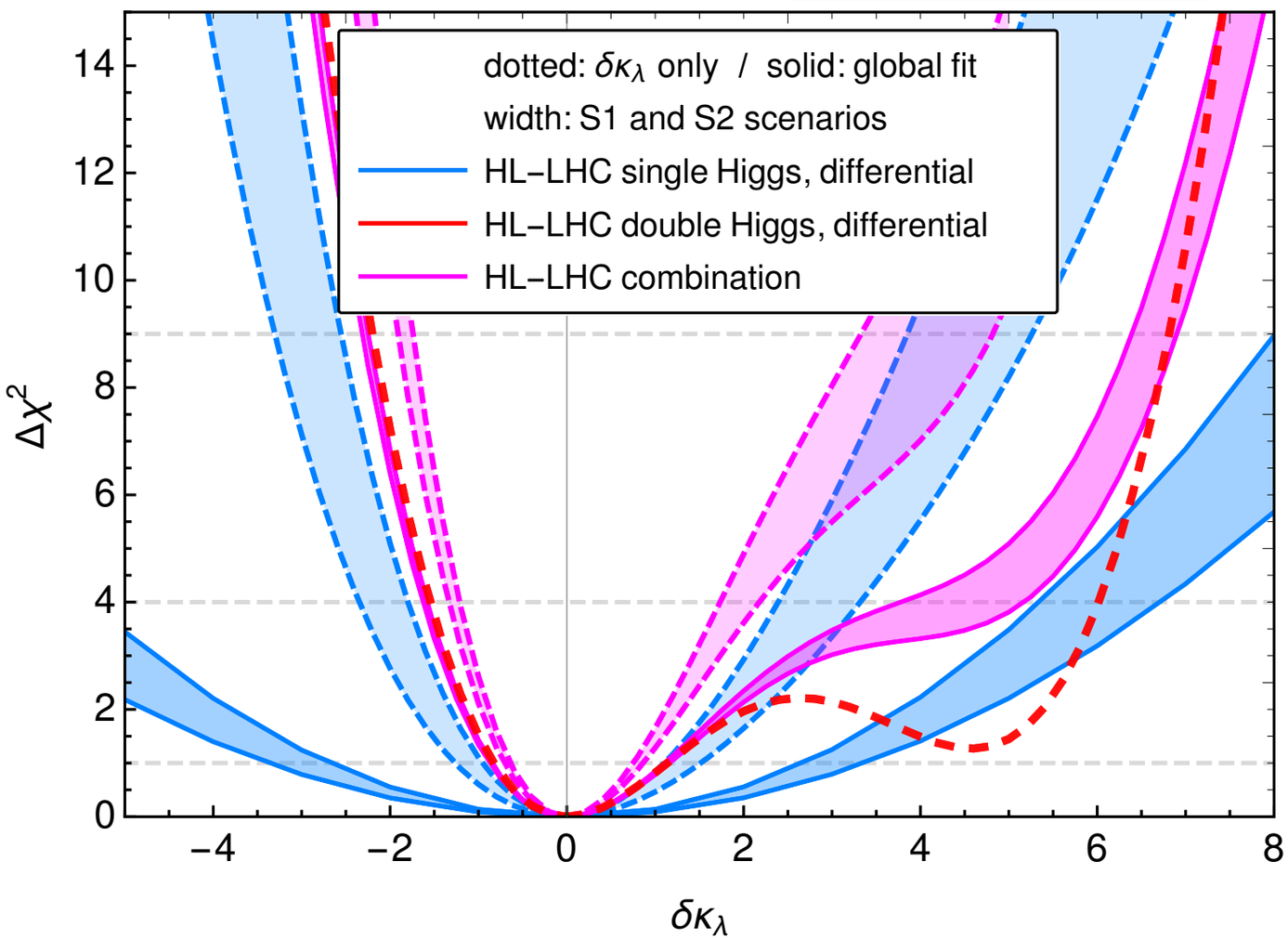

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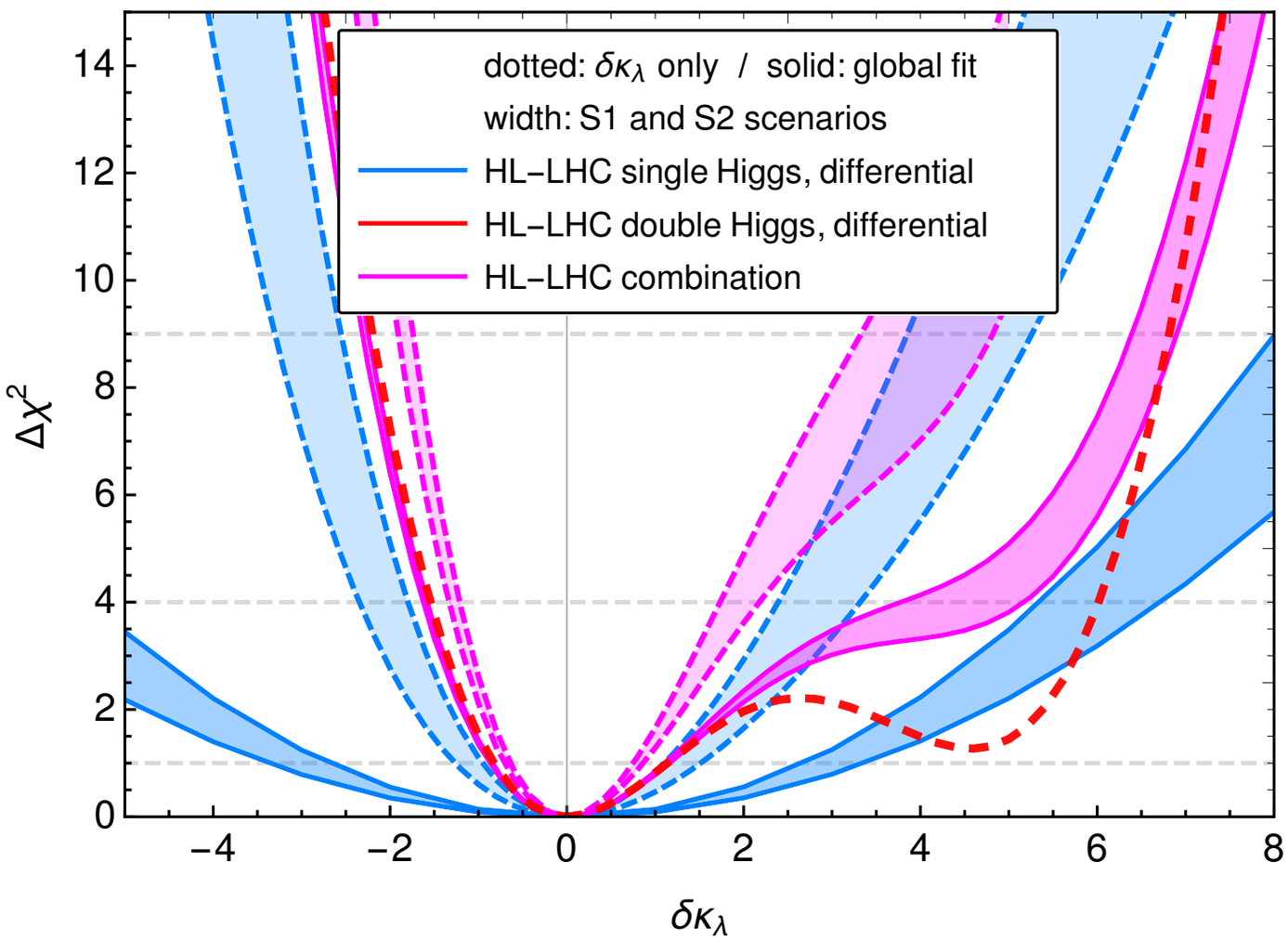

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… and will help reduce assumptions: can expand to EFT models with even fewer constraints

Conclusions

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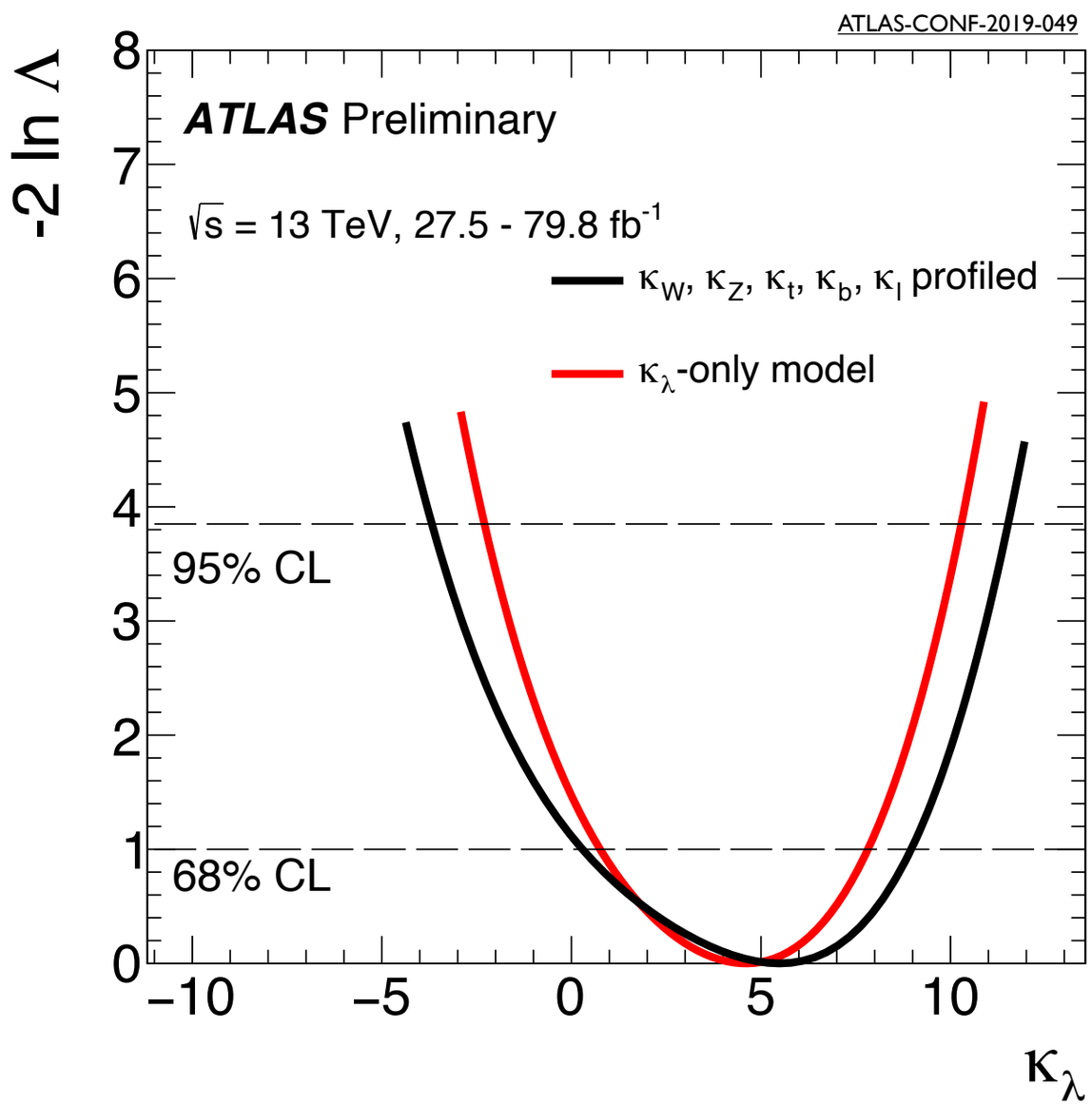

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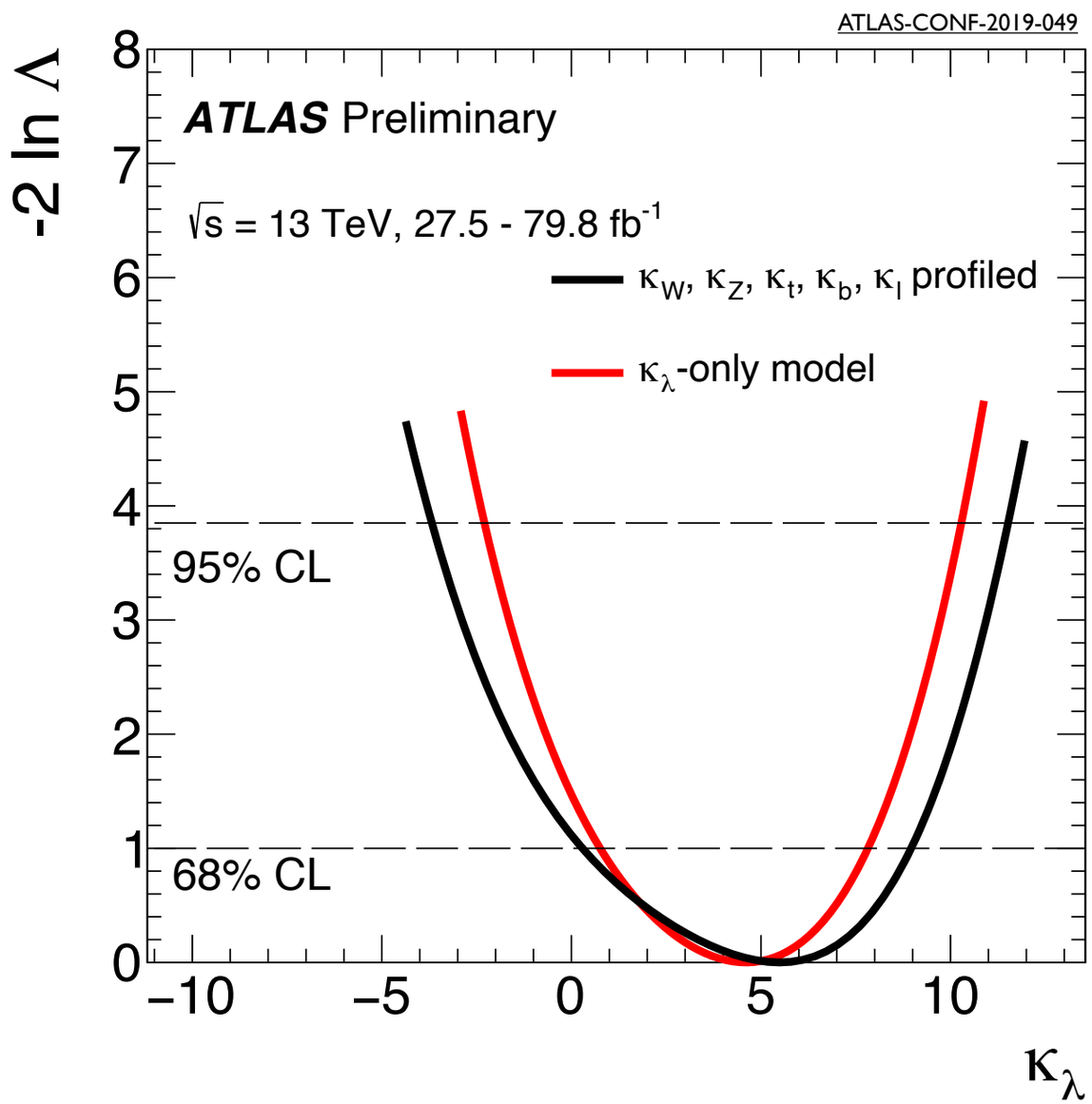

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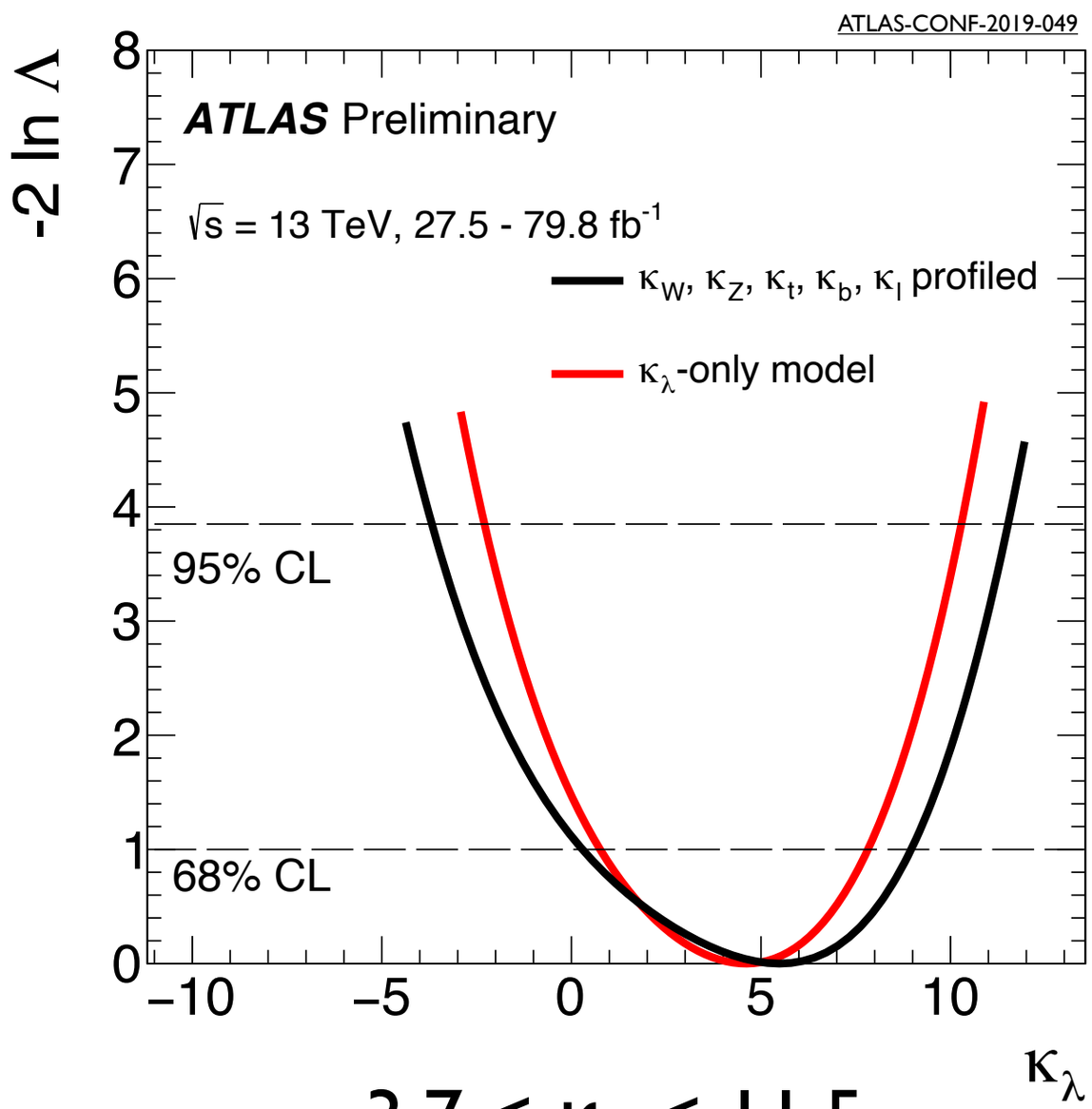


$-3.7 < \kappa_\lambda < 11.5$

$-2.3 < \kappa_\lambda < 10.3$

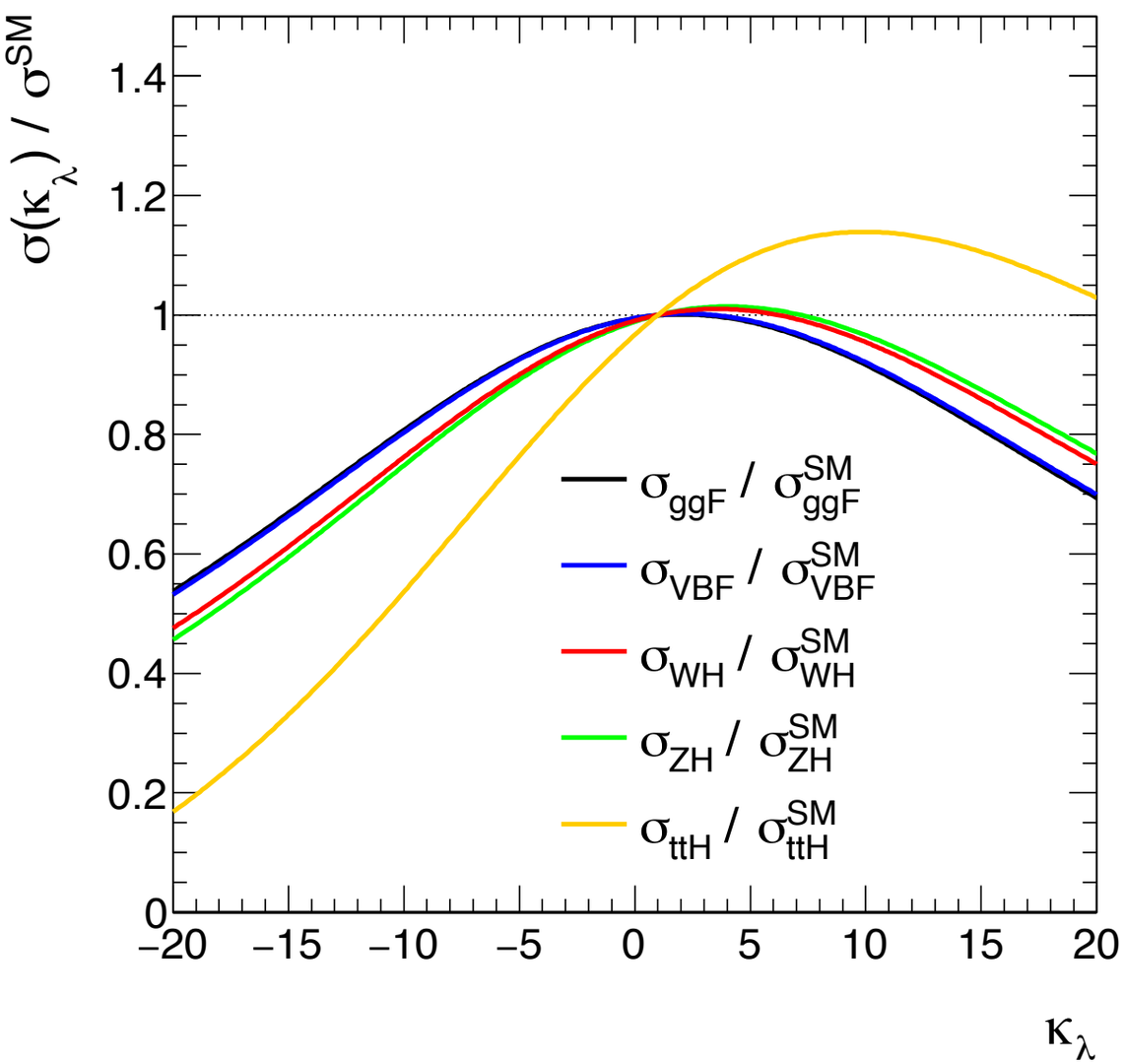
ATLAS has performed a unique, new measurement combining single and di-Higgs final states to measure the Higgs self-coupling

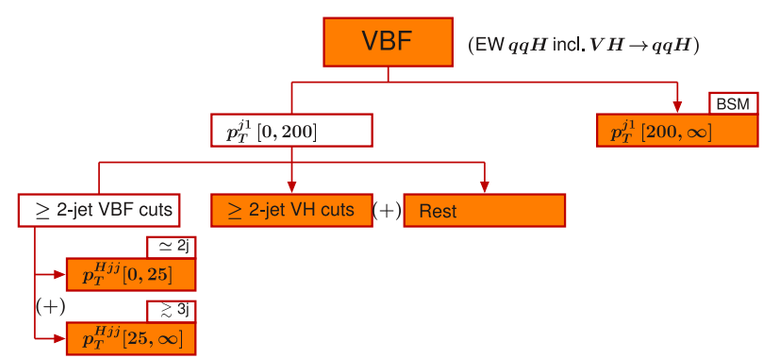
With more physics constraints, we can relax the model assumptions and test more 'realistic' deviations from the SM

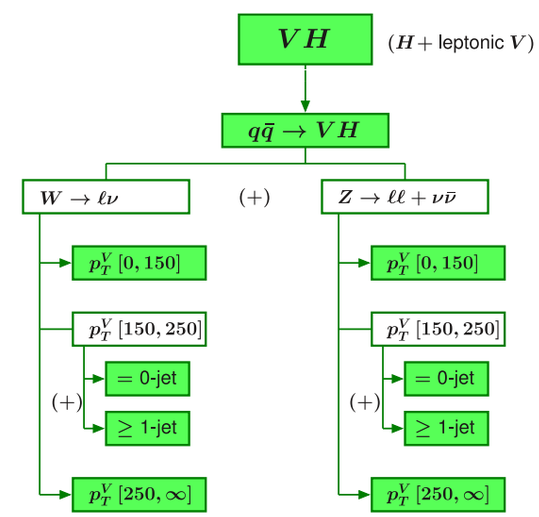
This combination provides the **most precise**, and **most general**, constraints on the Higgs self-coupling

Thank You!

More on Single Higgs

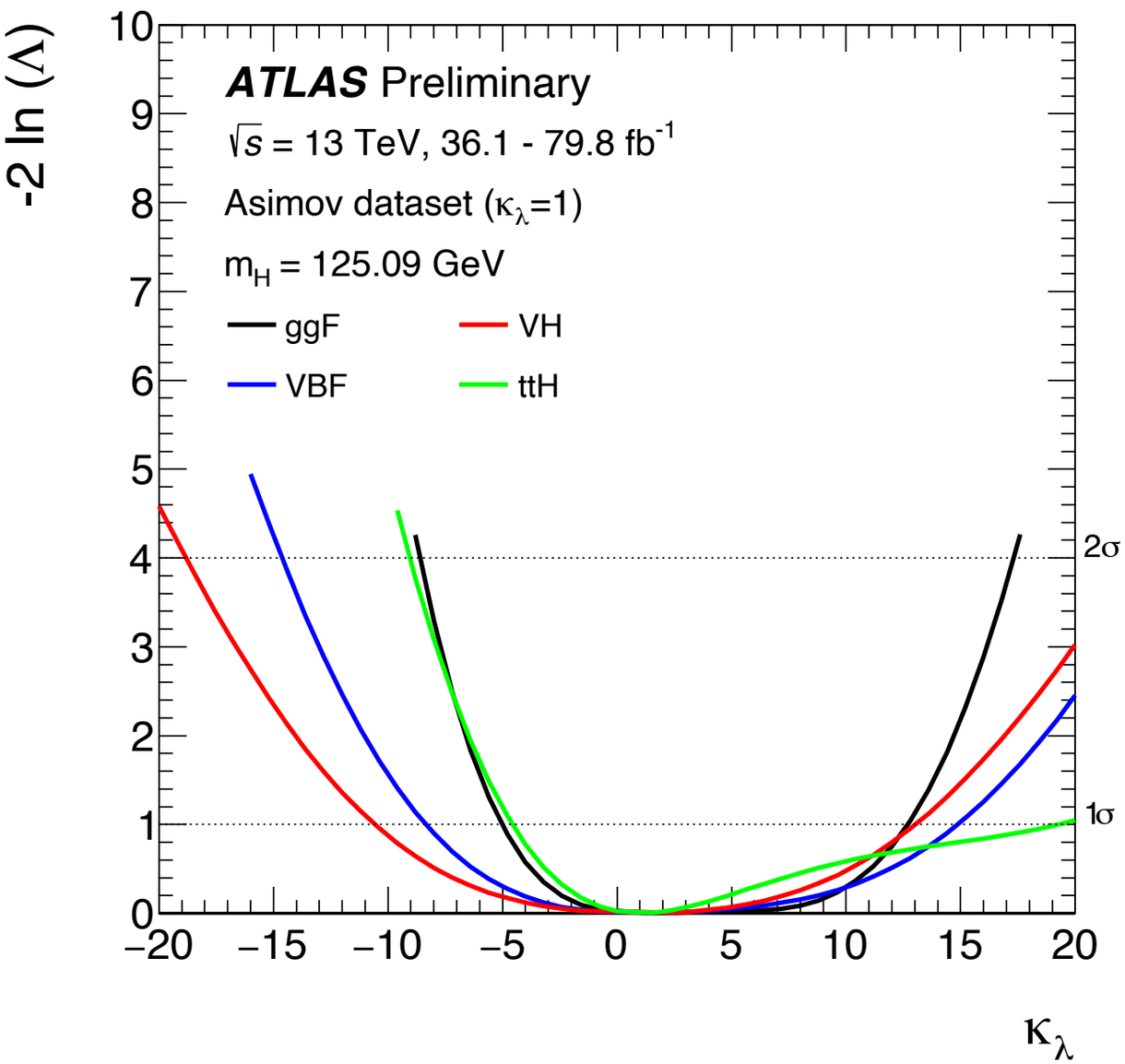


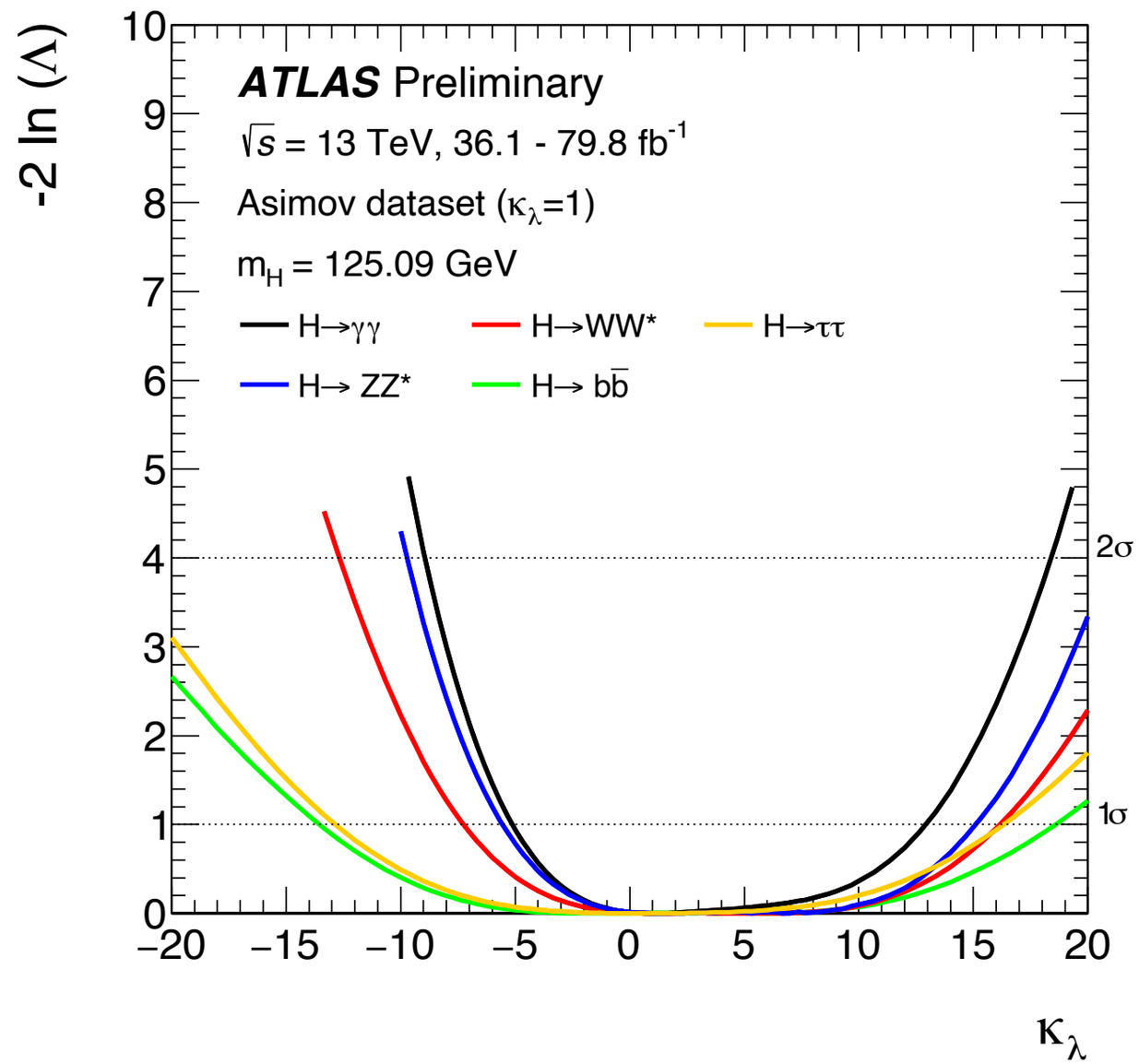




Constructed from figures in arXiv:1610.07922

More on Single Higgs





More on Combination