

# Challenges and Opportunities for Higgs Physics

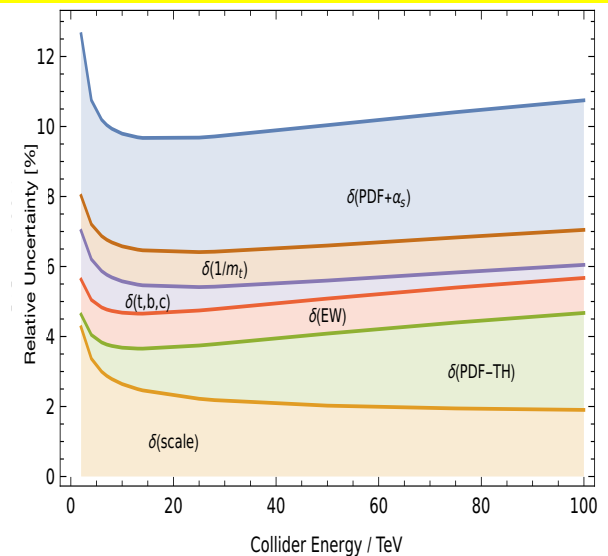
S. Dawson, BNL

Snowmass Energy Frontier Meeting

March 28-April 1, 2022

# Why is exploring the Higgs important?

- **Need simple and punchy answer. Some possibilities:** [Arxiv:2203.06164](https://arxiv.org/abs/2203.06164)
- 1) It is a fundamental part of the SM
- 2) In the SM, most everything except the Higgs mass is predicted, so we can make precise comparisons.
  - **Are existing theory calculations sufficient for the comparisons?**
    - Nice graphic showing where the uncertainties come from would be good
  - **How accurately do we need to measure?**



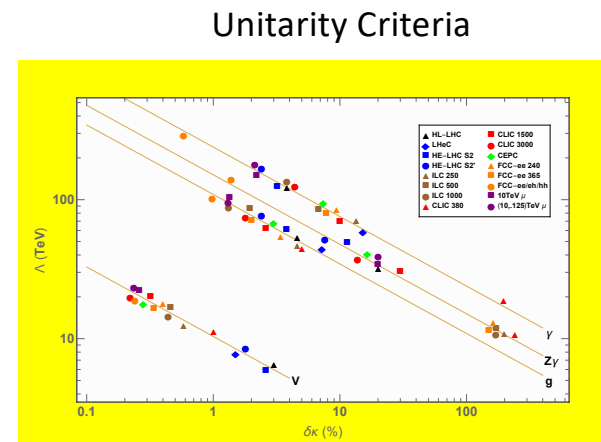
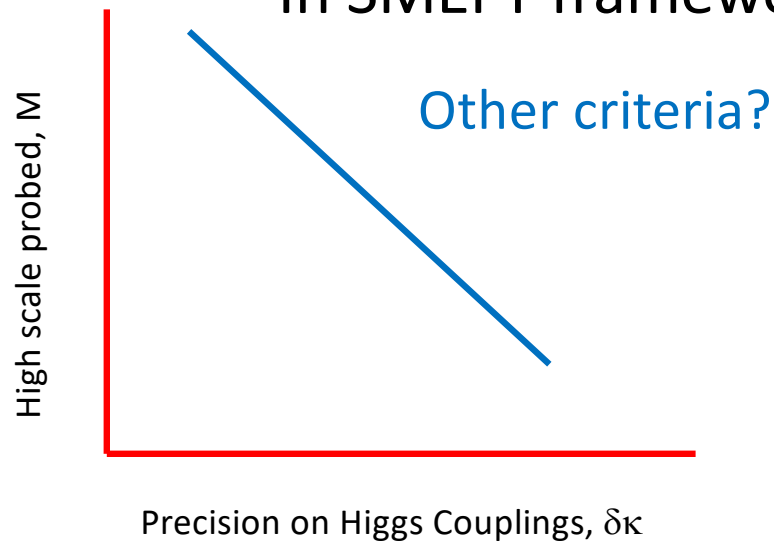
[Arxiv.2203.06730](https://arxiv.org/abs/2203.06730)

# What do we learn from precision measurements of Higgs properties?

- Precision is window to high scales.

How to make the connection? How important are specific models?

In SMEFT framework,  $\delta\kappa \sim v^2/M^2$



[Arxiv:2203.09512](https://arxiv.org/abs/2203.09512)

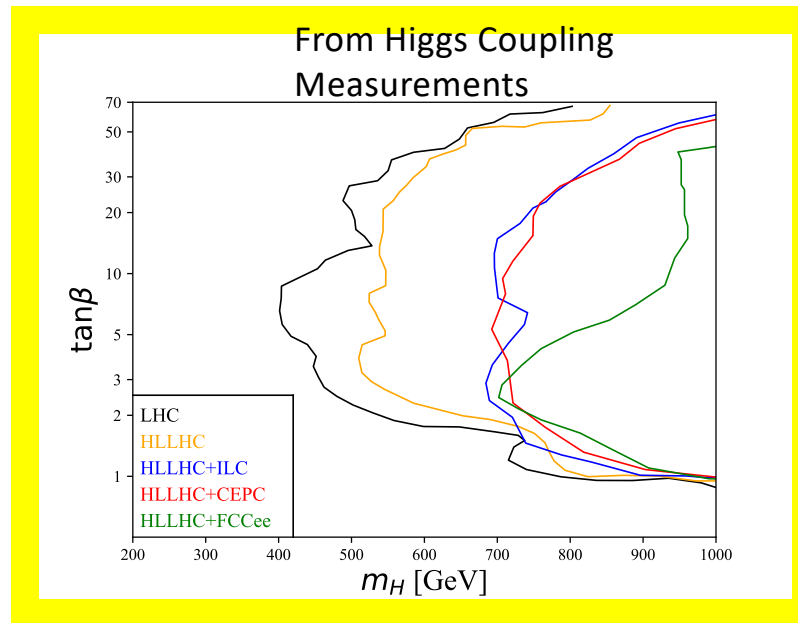
# Higgs is window to high scale physics

- Searches for new Higgs

- Can we show clearly complementarity of heavy Higgs searches and precision measurements?

Type-II 2HDM

Summary plot  
could include  
direct search limits



Need an example with  
composite Higgs or  
some strongly  
interacting scenario

[Arxiv:2203.07883](https://arxiv.org/abs/2203.07883)

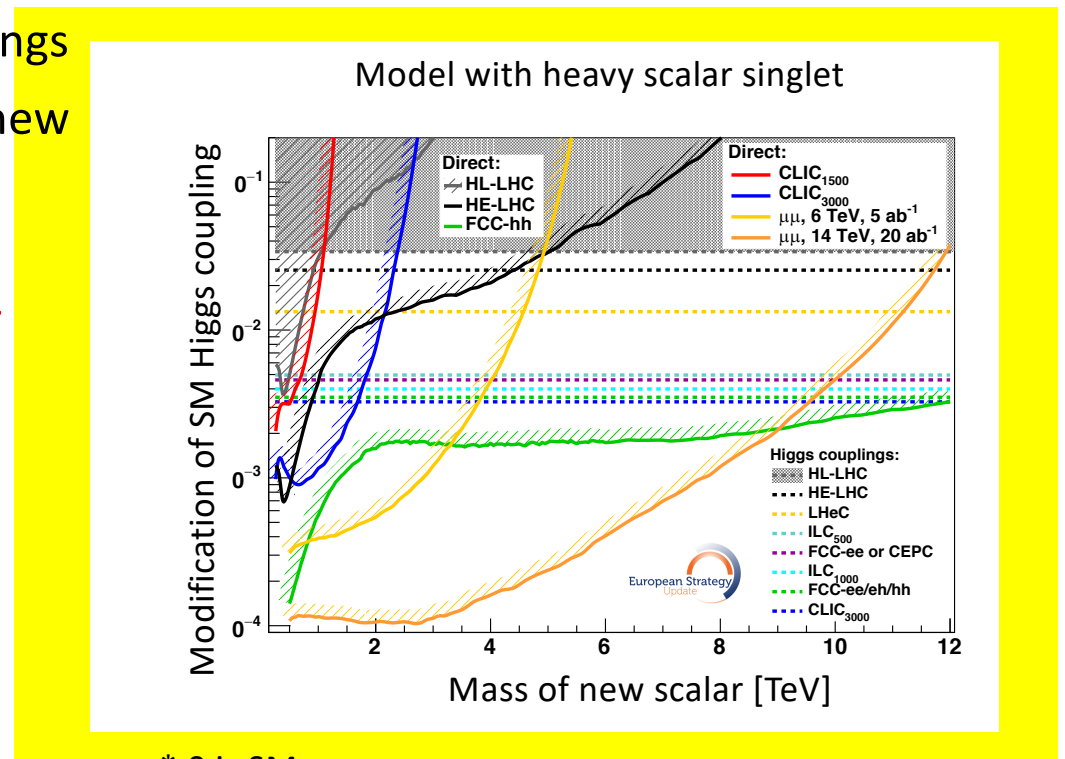
# Precision vs direct searches

- Future  $e^+e^-$  colliders give increasingly precise measurements of Higgs couplings
- Higher energy machines can look for new Higgs-like particle as a resonance

- *COMPLEMENTARITY OF APPROACHES*
- *Can we quantify this?*

Updating this figure with new projections would be interesting

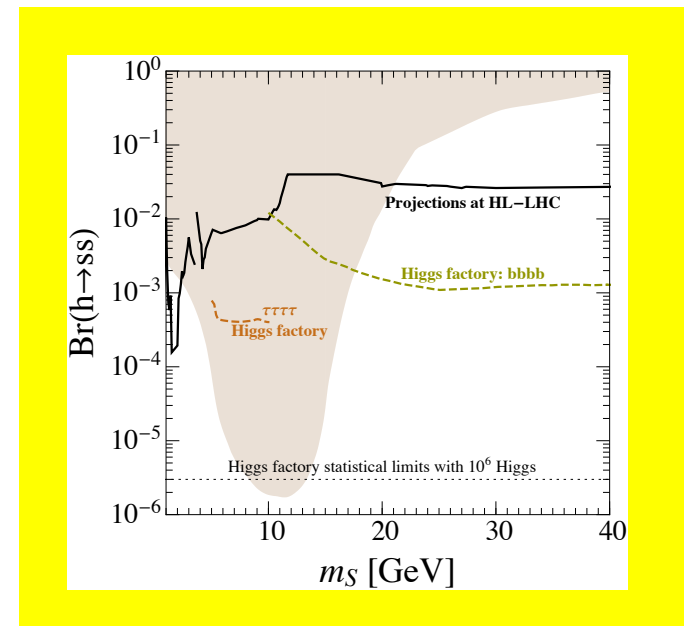
[European Strategy Report](#)



\* 0 is SM

# Higgs is window to high scale physics

- Searches for new decays and invisible decays
  - Sensitivity to different types of physics than heavy Higgs searches.
  - Can we show this nicely?
  - Exotic Higgs decays connected to EW phase transition (allowed in shaded regions)

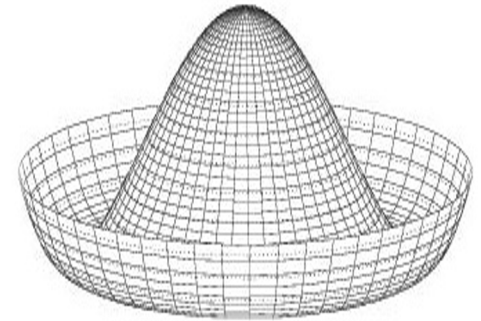


[Arxiv:2203.08206](https://arxiv.org/abs/2203.08206)

# Does EWSB work the way we think it does?

- How to best explain the importance of measuring triple Higgs coupling?
- We can quantify how well different machines can do....but we need to explain what various target measurements imply

$$\begin{aligned} V &= -\mu^2\phi^\dagger\phi + \lambda(\phi^\dagger\phi)^2 \\ &= \frac{-M_h^2}{2}h^2 + \lambda_3h^3 + \lambda_4h^4 \end{aligned}$$



How to connect precision of measurement with reach for new particles in models that predict deviations of  $\lambda_3$ ?