artwork by F. Simon

ECFA focus topic: HSelf (Higgs Self-Coupings)

Sven Heinemeyer, IFT (CSIC, Madrid)

zoom, 05/2024

Focus team:
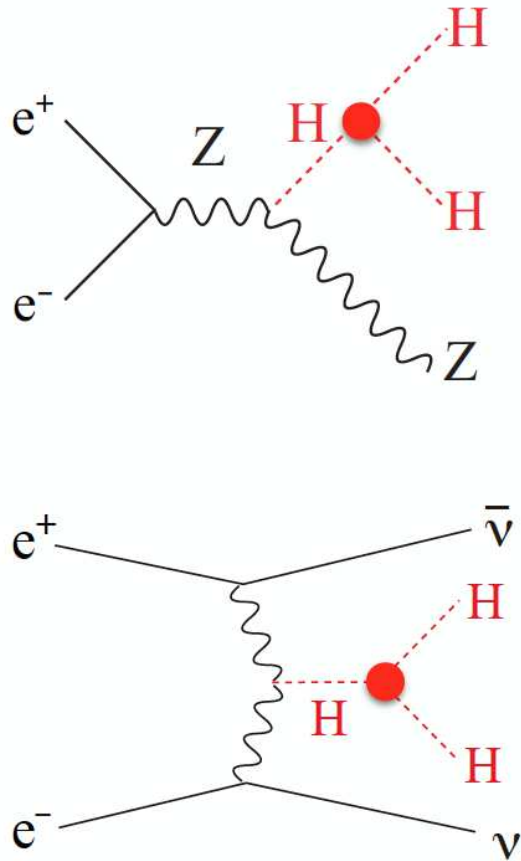
Junping Tian (leader)

Gauthier Durieux, Jose Goncalo, S.H., Michael Peskin,
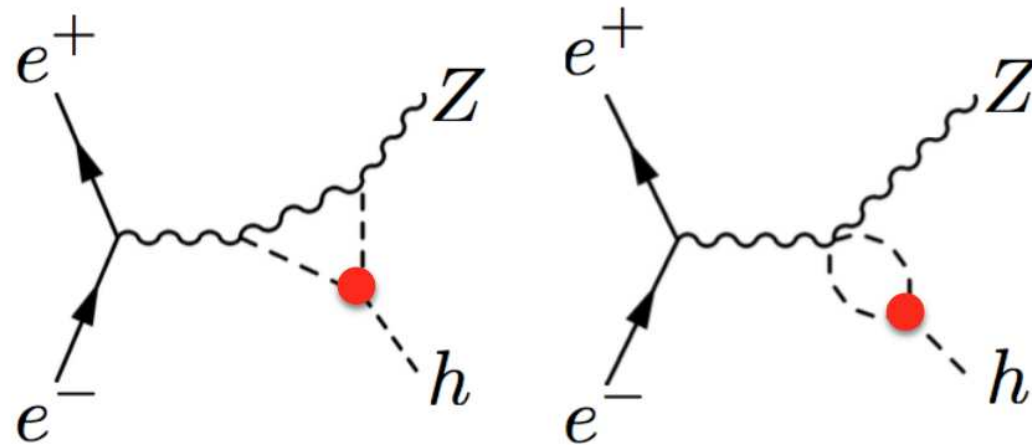
Philipp Roloff, Roberto Salerno

$\sqrt{s} \gtrsim 500$ GeV $\sqrt{s} \gtrsim 240$-250 GeV

$\sigma_{HH} \sim O(0.1)$ fb $\delta\sigma_{ZH} \sim O(1\%)$

SM triple Higgs coupling: comparison of all colliders:
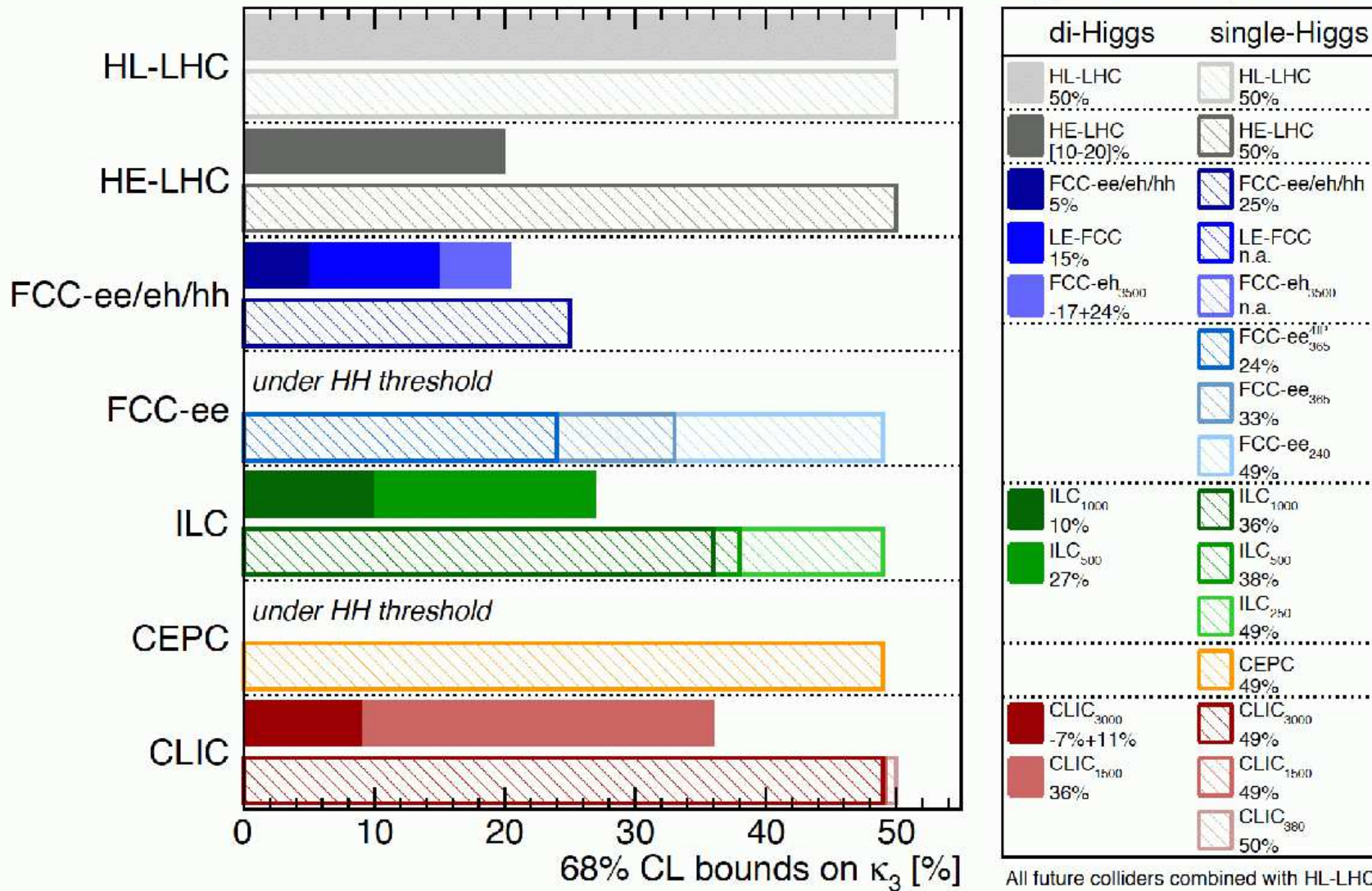
⇒ Many remaining open questions!

$$\kappa_\lambda := \lambda_{hhh}/\lambda_{hhh}^{SM}$$

Open question I:

Analysis focuses on $\kappa_\lambda \equiv 1$ (SM case)

Requirement of FOEWPT may yield $\kappa_\lambda \sim 2$

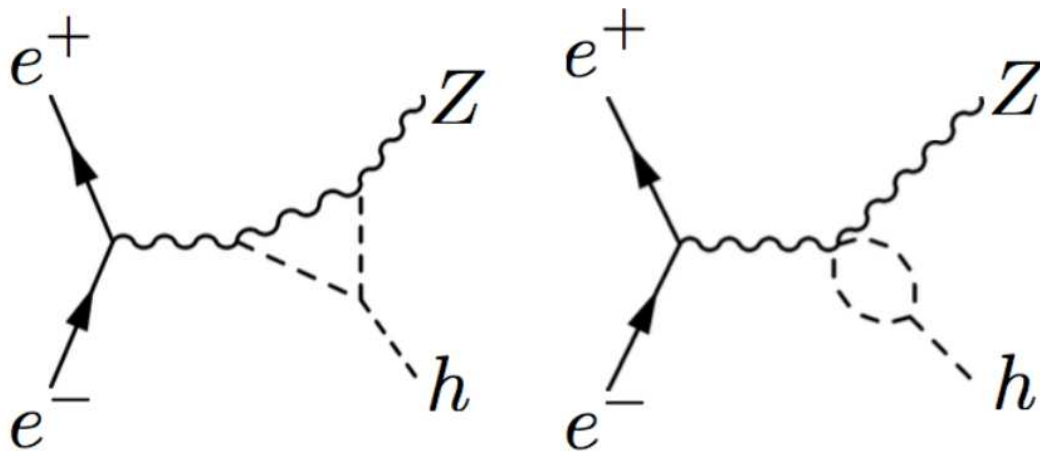**Q:** how do the experimental precisions change for $\kappa_\lambda \neq 1$?

Open question II/III:

Analysis assumes that only one Higgs boson exists (SM case)

Requirement of FOEWPT easily results in additional Higgs bosons

Q: Impact of additional Higgs boson on κ_λ determination?

Q: Determination of BSM THCs?

[McCullough, '13]

$$\delta_\sigma^{240} = 100\,(2\delta_Z + 0.014\delta_h)\,\%$$

- if only δh is deviated —> δh ~ 28%   [ILC as example]

- if both δz and δh deviated —> δh ~ 90%

- δσ could receive contributions from many other sources

Q: Can degeneracies be lifted by new observables (→ ZHang)?

Q: Impact of inclusion of other loop effects (top)?

<u>More open quesions for single Higgs:</u>

Q: can we clarify the importance of each input measurement for the κ_λ determination in the global fit?

Q: updates from experimental analyses about single-Higgs observables?

Q: single-Higgs contribution at $\sqrt{s} \gtrsim 500$ GeV should be combined with double-Higgs determination of κ_λ

<u>More open quesions for double Higgs:</u>

Q: would energy slightly above 500 GeV help in the analysis? (more boosted jets etc.?)

Q: can we do simulations with distributions for large κ_λ?

Q: can we do simulations with distributions incl. BSM THCs?

Q: improvement by machine learning, e.g. for b-tagging?

What can be done within the accelerated time-line??

What can be done within the accelerated time-line??

– community input for the ESPPU to be submitted by 03/25

– a first version of our report should be completed by (mid) December
  comments etc. can be included, but updates for the results will be difficult

– effective deadline: third ECFA Higgs factories workshop
  in Paris (10/24)
  ⇒ new results should be presented there
  ⇒ drafts of the written summaries should be available

Studies can (of course) continue afterwards and can be
published indepedently.

Time table for today:

16:10 → 16:40 **Higgs self-coupling: Impact of top-quark couplings in the SMEFT approach**

   Speaker: Mr Gauthier Durieux (CP3 - UCLouvain)

16:40 → 17:10 **Higgs self-coupling: Precise predictions in arbitrary models**

   Speaker: Johannes Braathen (DESY)

17:10 → 17:40 **Higgs self-couplings: Recent progress on experimental analysis of double Higgs processes at linear colliders**

   Speaker: Bryan Bliewert (Deutsches Elektronen-Synchrotron (DE))

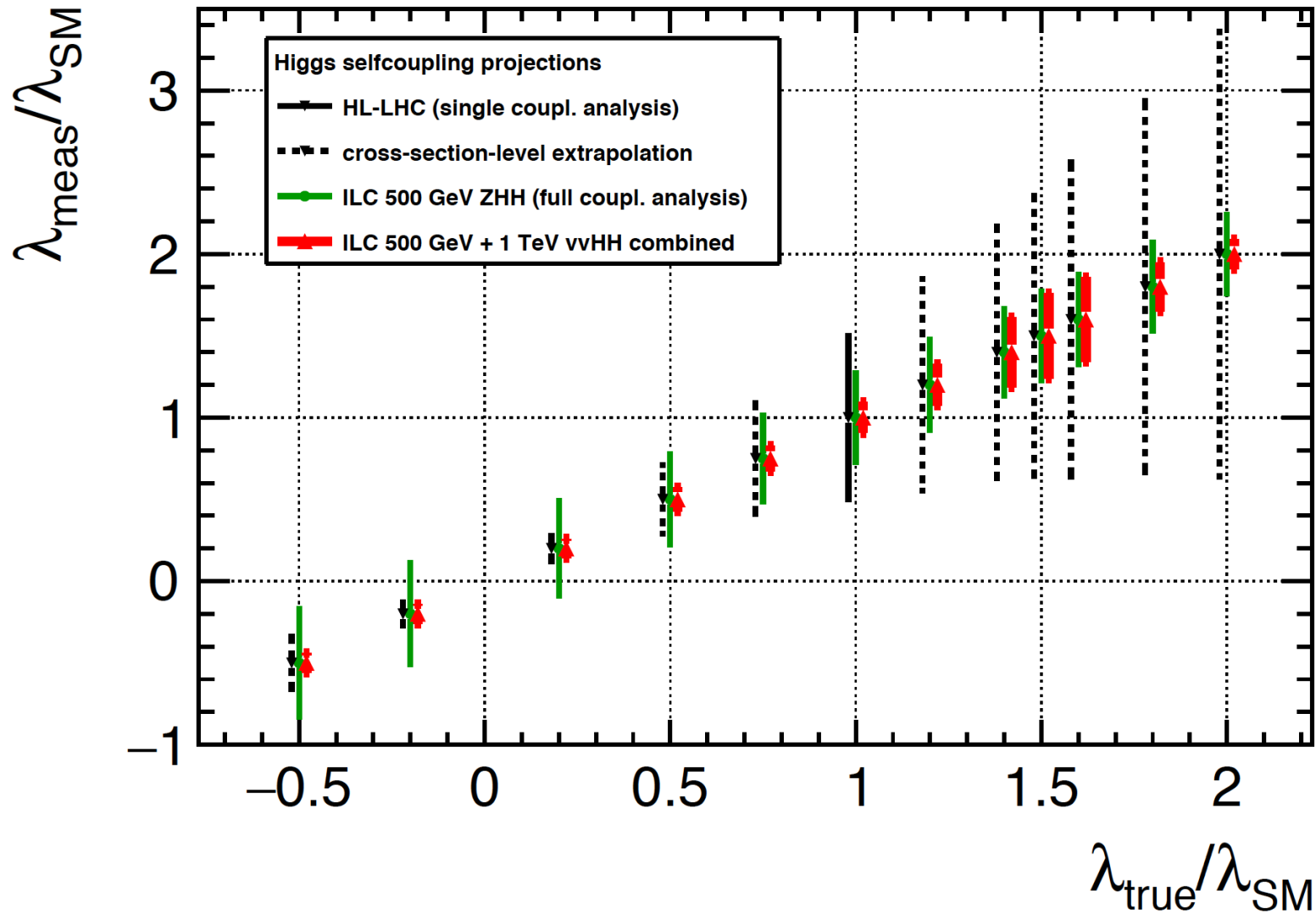**17:40** → 18:00 **Free Discussion**

⇒ several open questions will be addressed! :-)

Further Questions?

Measurement of κ_λ selfcoupling at HL-LHC/ILC:

[J. List et al. − PRELIMINARY]

⇒ over most of the parameter space ILC is clearly superior to HL-LHC

Two types of BSM effects at the LHC:

$\Rightarrow$ analyses so far focus on "SM THC": $\kappa_\lambda := \lambda_{hhh}/\lambda_{hhh}^{\text{SM}} \equiv 1$
BSM case 1: $\kappa_\lambda \neq 1$
BSM case 2: THC that involves BSM Higgses: $\lambda_{hhH}, \ldots$

Example of m_{hh} distortions: [S.H., M. Mühlleitner, K. Radchenko, G. Weiglein '24]