
WILL EXPLAIN
HIGGS-BOSON
PARTICLE
FOR
FOOD
HM

The Higgs Inverse Problem

in Concrete BSM Models

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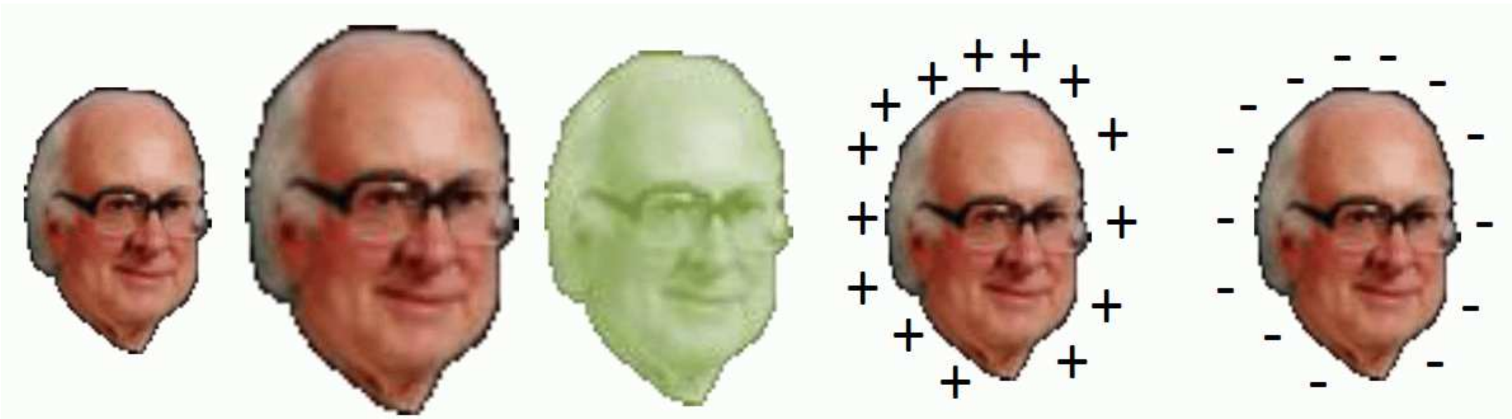
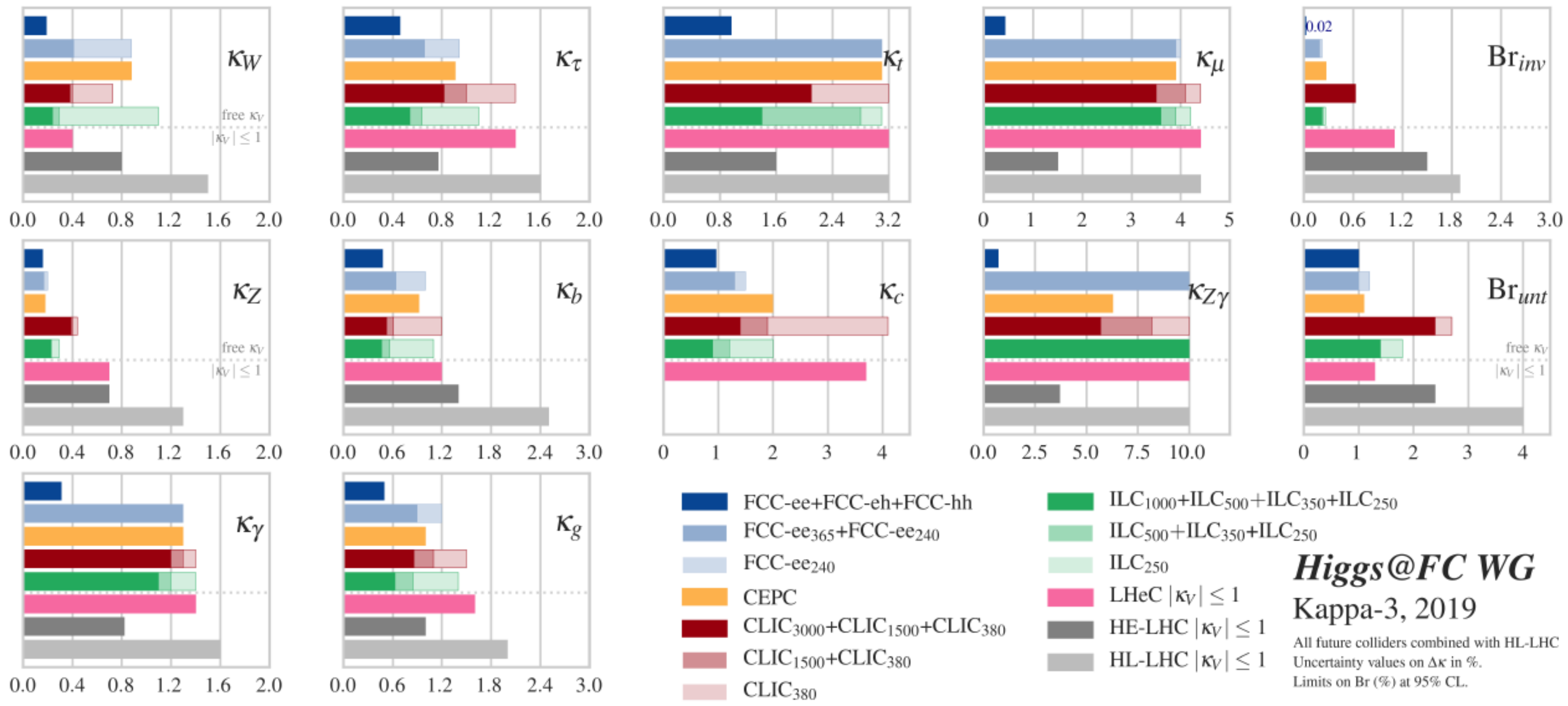
virtual, 10/2020



Future expectations for κ (kappa-3 framework)



$\Rightarrow$ high future accuracy (very roughly similar results)

$\Rightarrow$ FCC-hh/-he/-ee appears better

$\Rightarrow$ FCC-hh uses different theory assumptions, uncertainties $\lesssim 1\%$

$\Rightarrow$ also remember different time scales!

Possible deviations in BSM Higgs sectors:

Required precision for Higgs couplings?

MSSM example:

$$\kappa_V \approx 1 - 0.5\% \left(\frac{400\ \text{GeV}}{M_A}\right)^4$$

$$\kappa_t = \kappa_c \approx 1 - \mathcal{O}\,(10\%) \left(\frac{400\ \text{GeV}}{M_A}\right)^2 \cot^2\beta$$

$$\kappa_b = \kappa_\tau \approx 1 + \mathcal{O}\,(10\%) \left(\frac{400\ \text{GeV}}{M_A}\right)^2$$

Composite Higgs example:

$$\kappa_V \approx 1 - 3\% \left(\frac{1\ \text{TeV}}{f}\right)^2$$

$$\kappa_F \approx 1 - (3-9)\% \left(\frac{1\ \text{TeV}}{f}\right)^2$$

$\Rightarrow$ couplings to bosons in the per mille range
$\Rightarrow$ couplings to fermions in the per cent range

$\Rightarrow$ theory/experimental match?

Let us assume that we do see a deviation

What do we learn from that?
How do we learn something from that?

⇒ We have to compare the observed deviation with predicted deviations

⇒ Preferrably with the predicted deviations in a concrete models
(A comparison with an EFT result subsequently requires the mapping to concrete models anyway . . .)

⇒ Needed: sufficiently precise predictions in BSM model
close to ready: MSSM, NMSSM
(I am not aware of uncertainty estimates in other models)

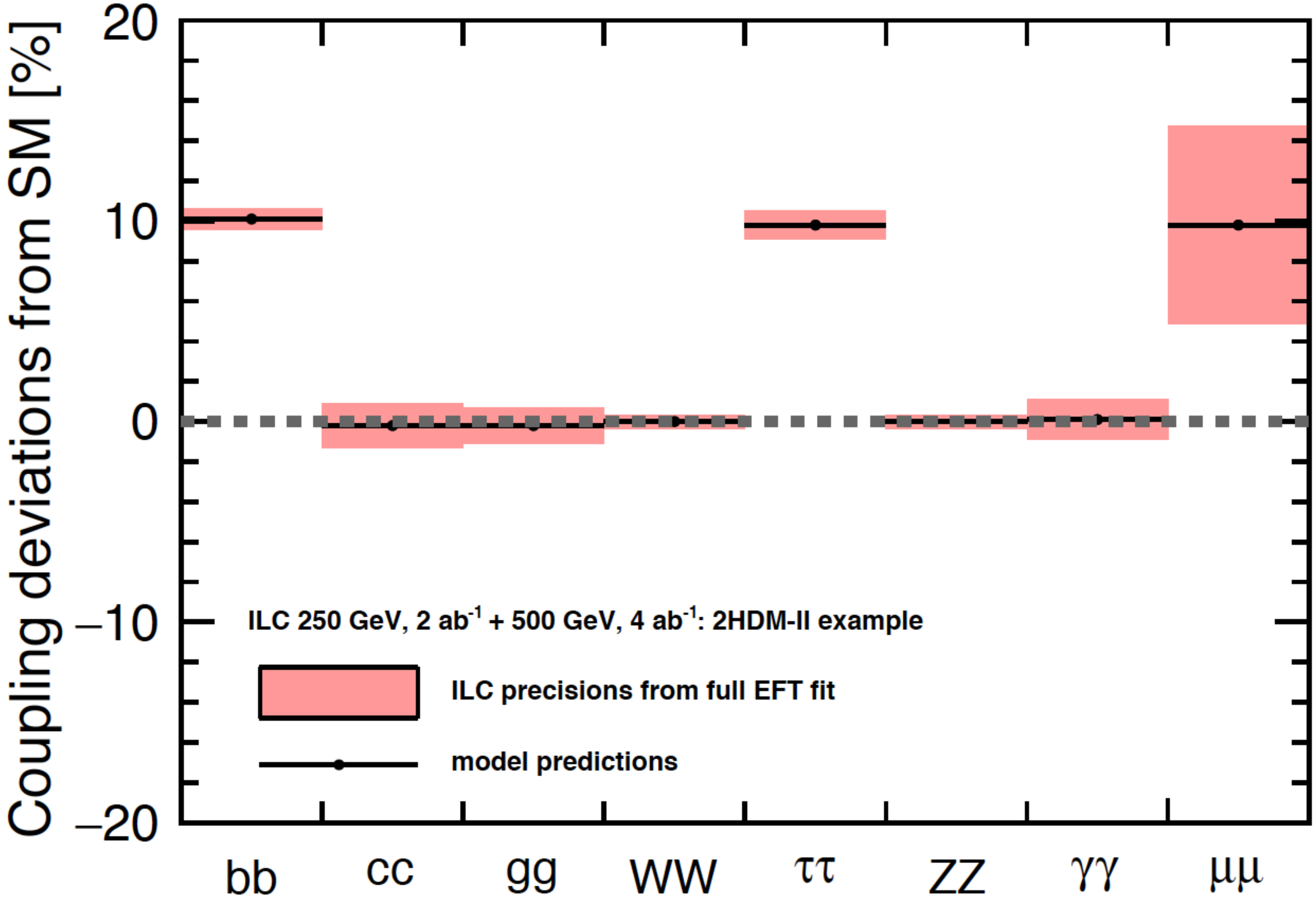
⇒ in the following:

model prediction (w/o TH unc.) ⇔ e^+e^- precision

⇒ "Wäscheleinen-Plots" (concrete: ILC500 – FCC-ee similar!)

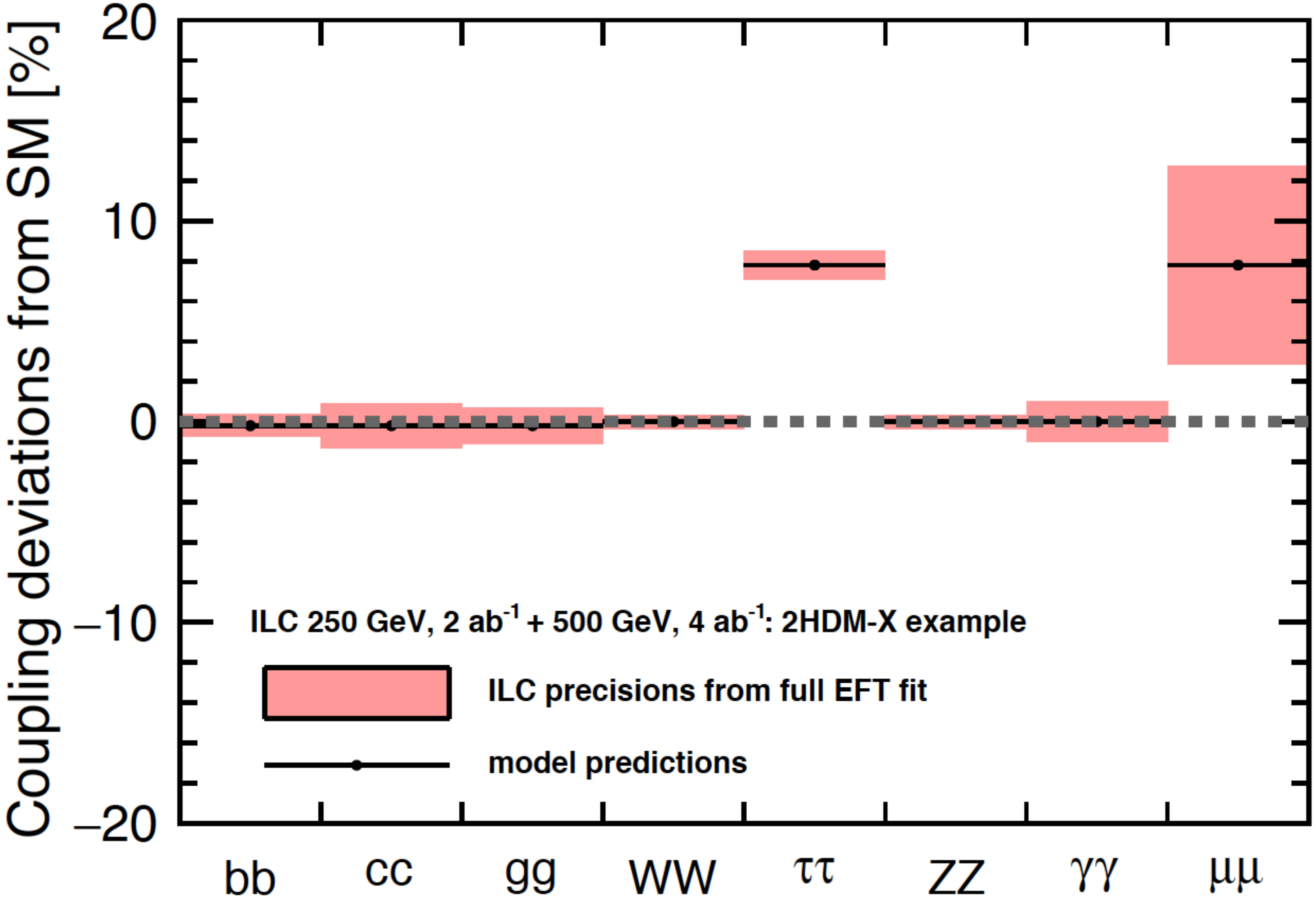
Wäscheleine I: e^+e^- precision vs. 2HDM type II prediction:

[T. Barklow et al., '17]



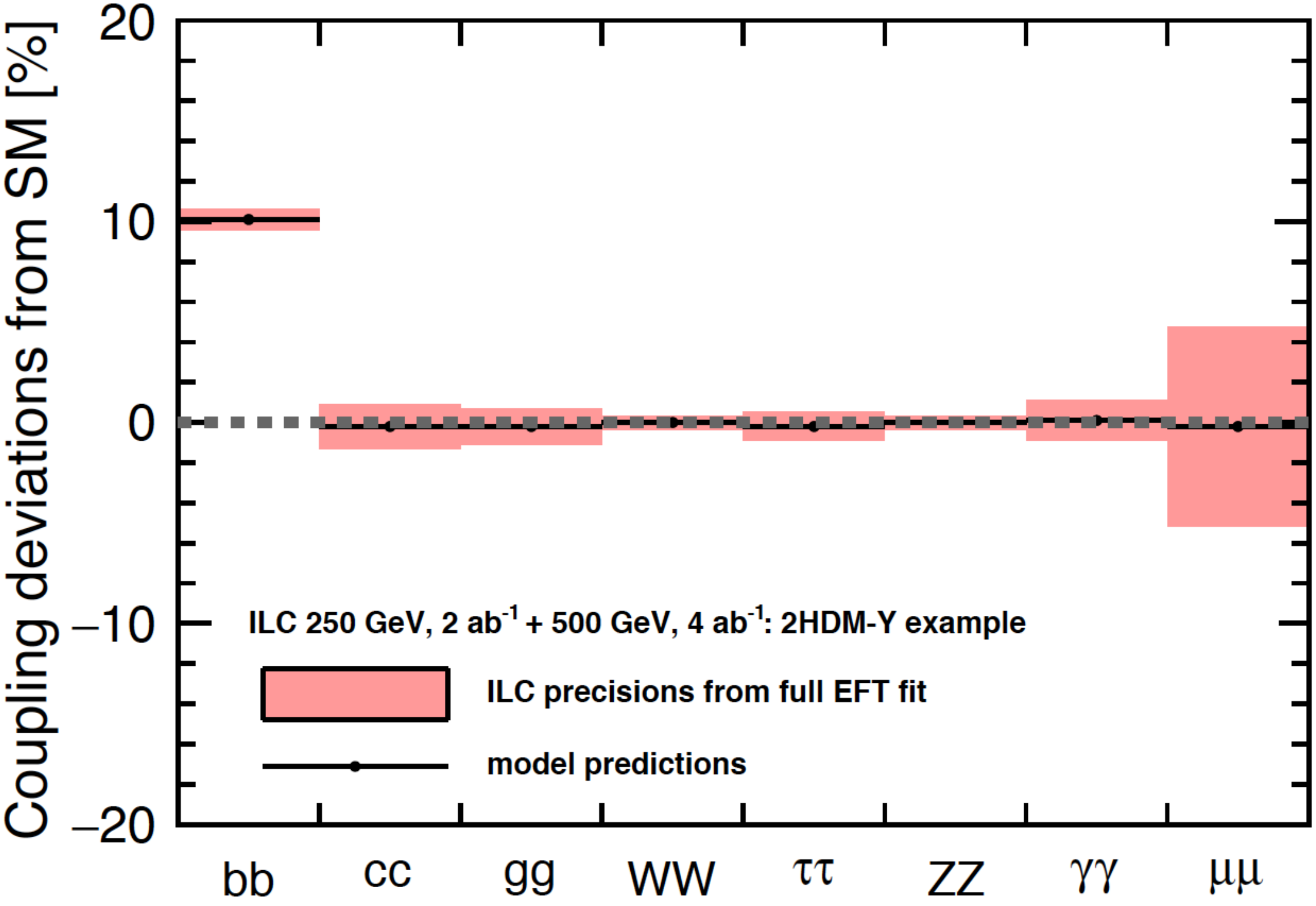
Wäscheleine II: e^+e^- precision vs. 2HDM type III prediction:

[*T. Barklow et al., '17*]



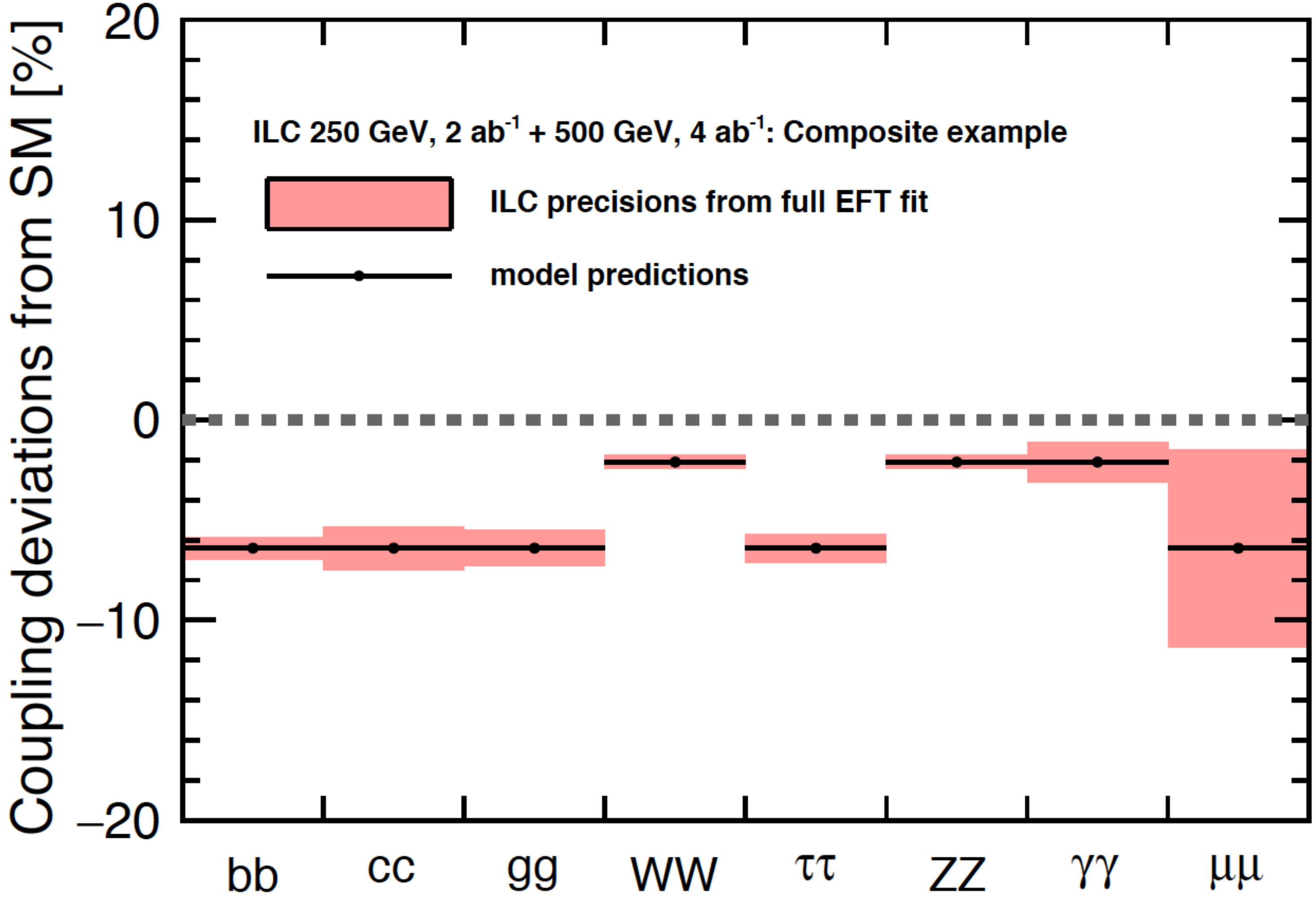
Wäscheleine III: e^+e^- precision vs. 2HDM type IV prediction:

[*T. Barklow et al., '17*]



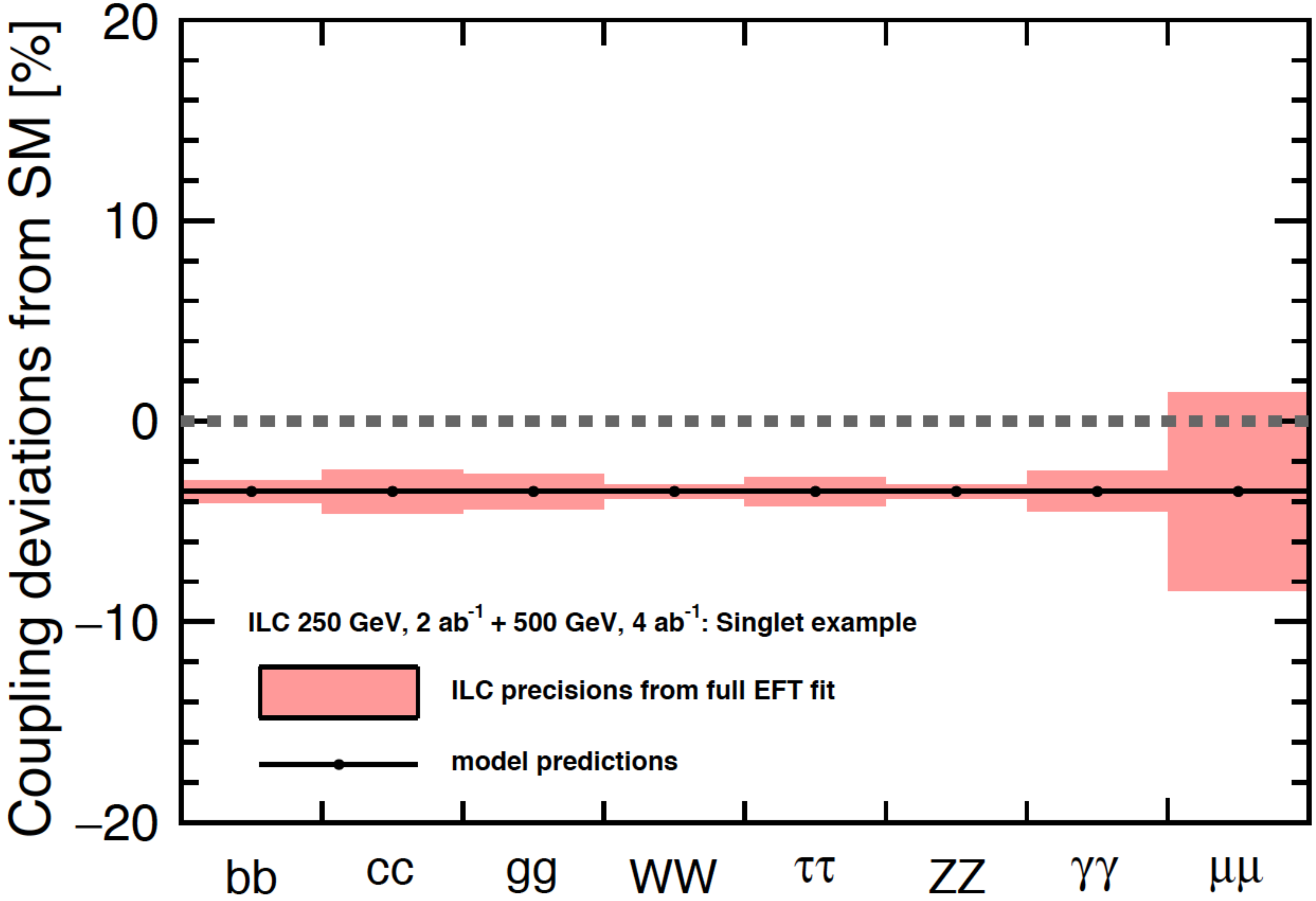
Wäscheleine IV: e^+e^- precision vs. Composite Higgs prediction:

[*T. Barklow et al., '17*]



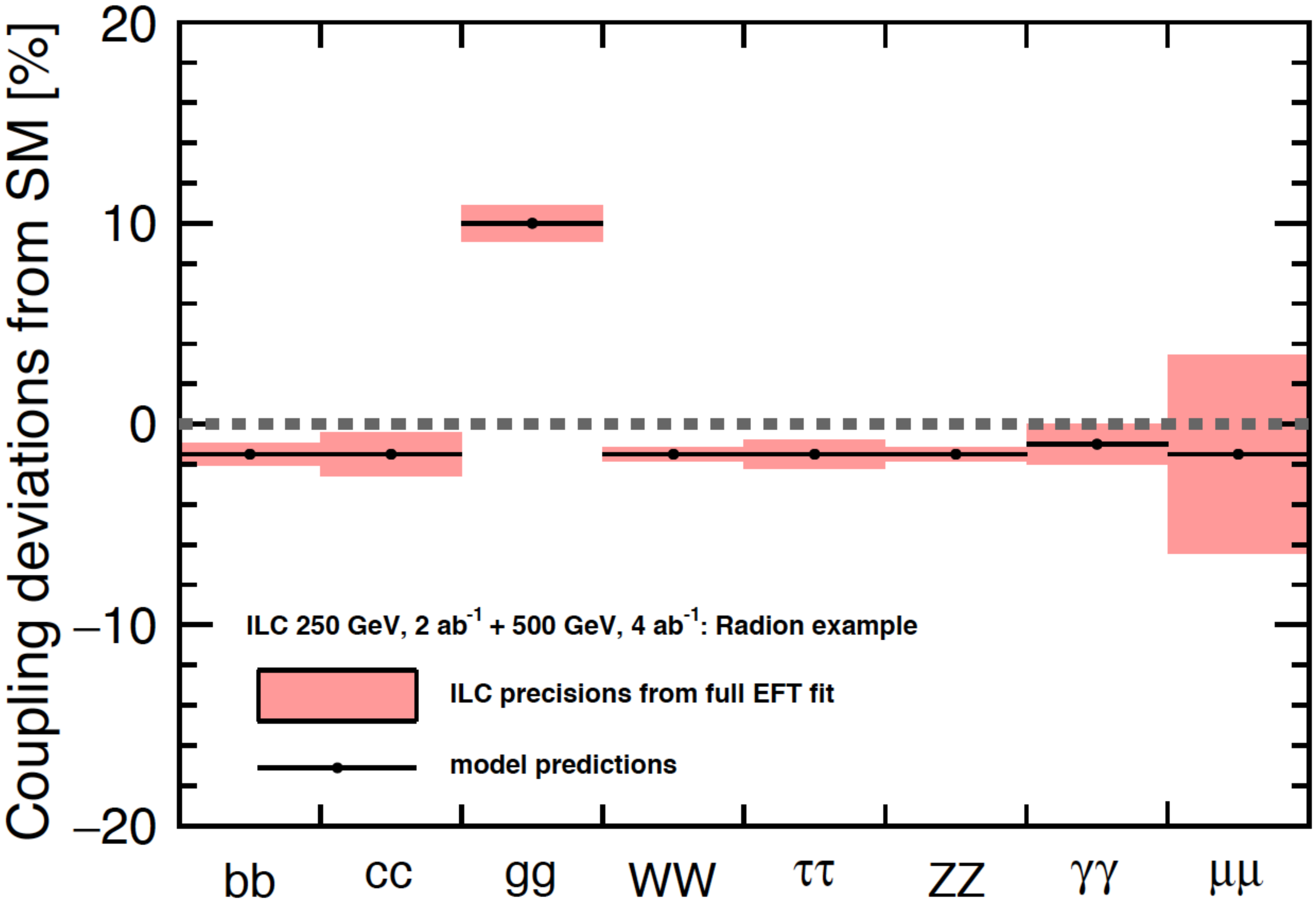
Wäscheleine V: e^+e^- precision vs. HxSM prediction:

[*T. Barklow et al., '17*]



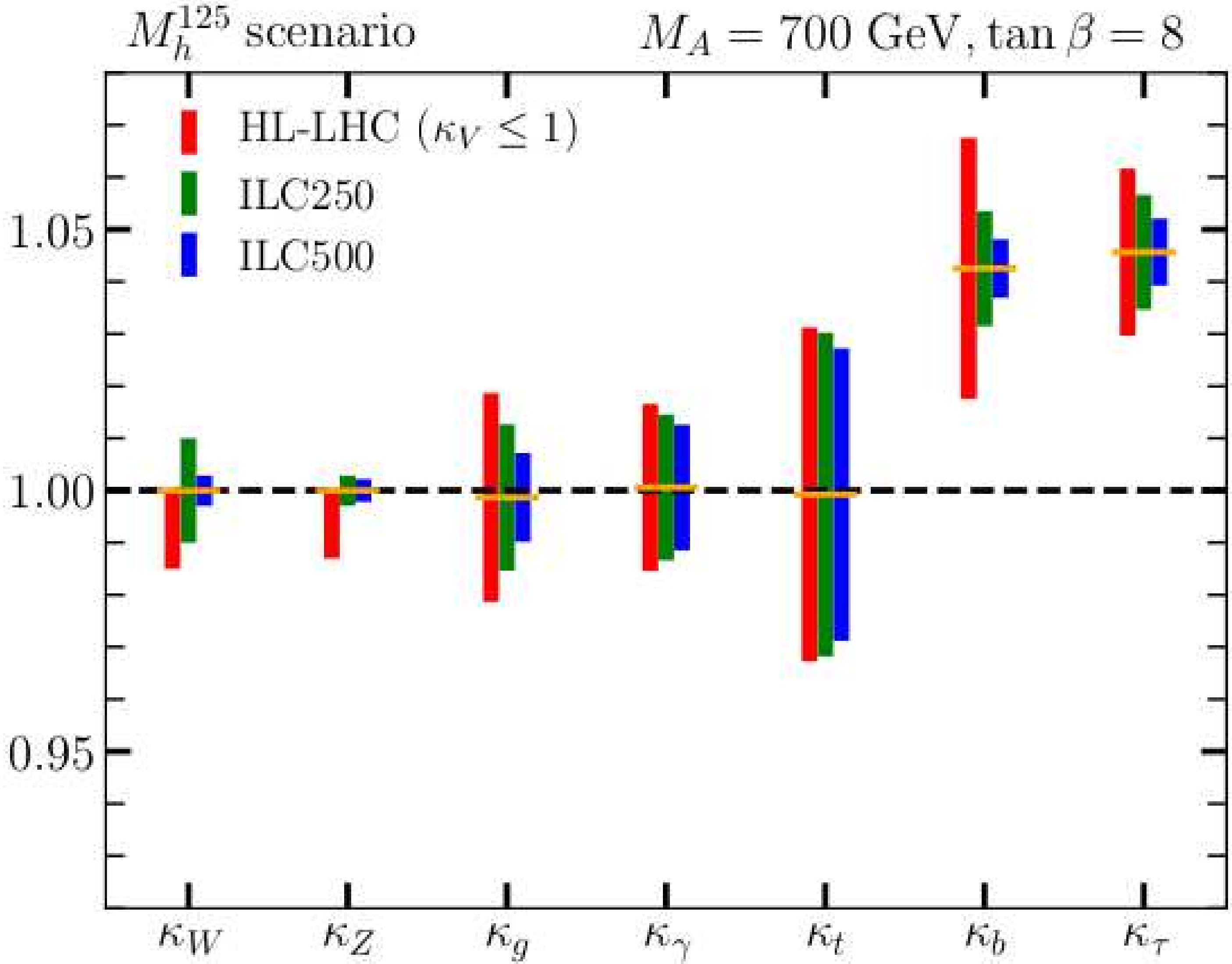
Wäscheleine VI: e^+e^- precision vs. Higgs-Radion prediction:

[*T. Barklow et al., '17*]



MSSM Wäscheleine I: e^+e^- precision vs. M_h^{125} ($M_A = 700$ GeV, $\tan\beta = 8$)

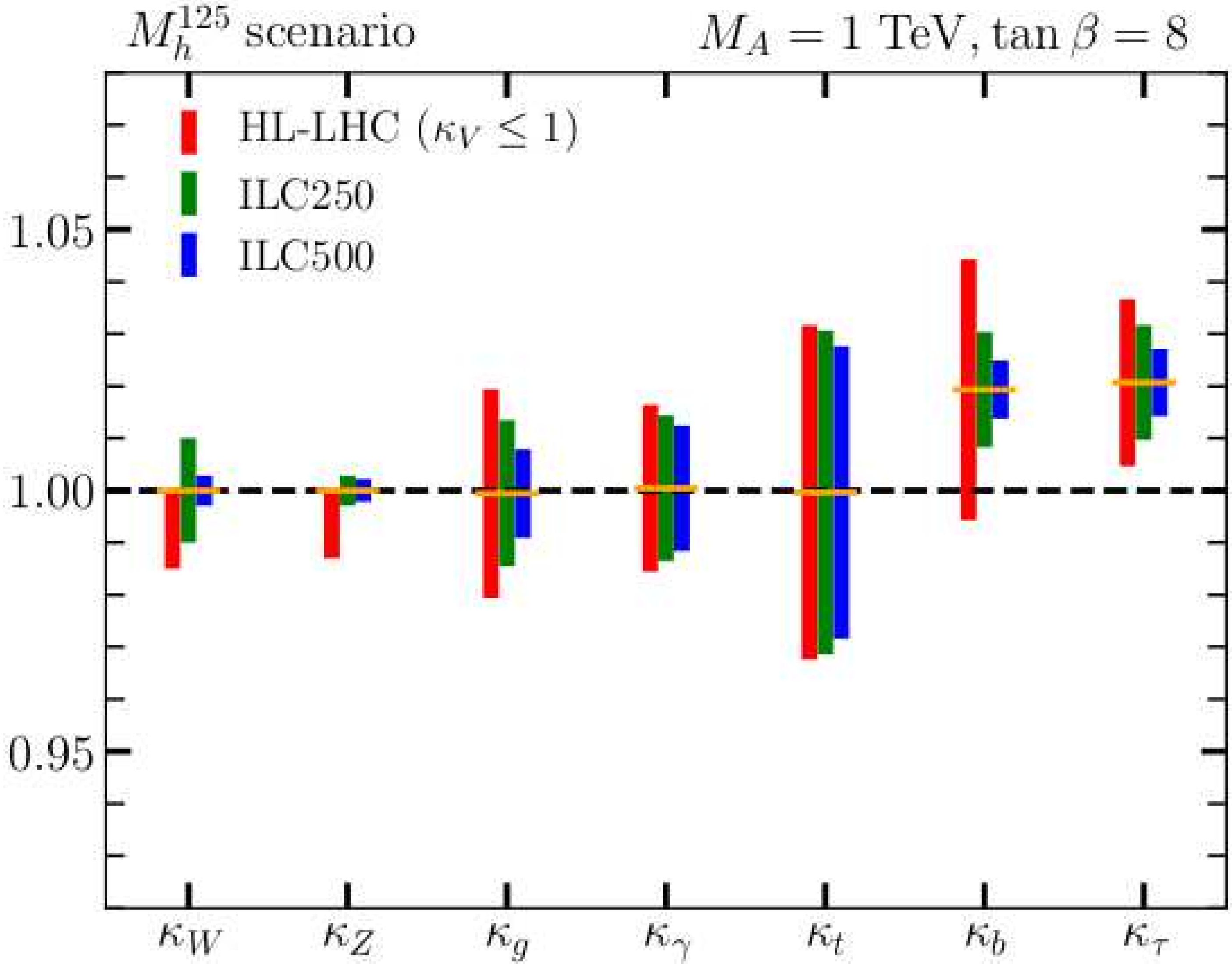
[*H. Bahl et al. '20*]



$\Rightarrow$ Type II deviations! Distinction from 2HDM possible?

MSSM Wäscheleine II: e^+e^- precision vs. M_h^{125} ($M_A = 1000$ GeV, $\tan\beta = 8$)

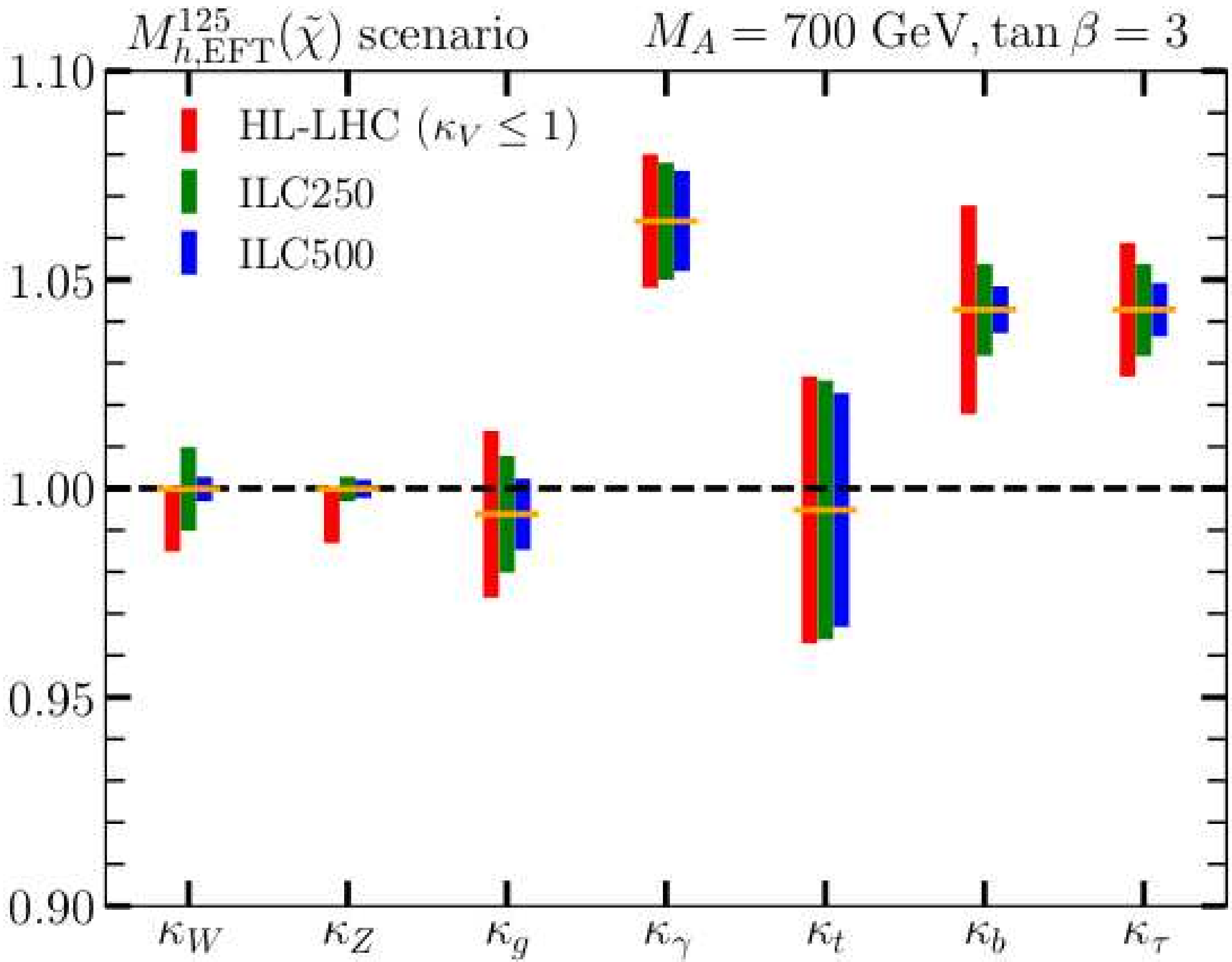
[*H. Bahl et al. '20*]



$\Rightarrow$ only e^+e^- measurements allows to set upper limit on M_A

MSSM Wäscheleine III: e^+e^- vs. $M_h^{125,\text{EFT}}(\tilde{\chi})$ ($M_A = 700$ GeV, $\tan\beta = 3$)

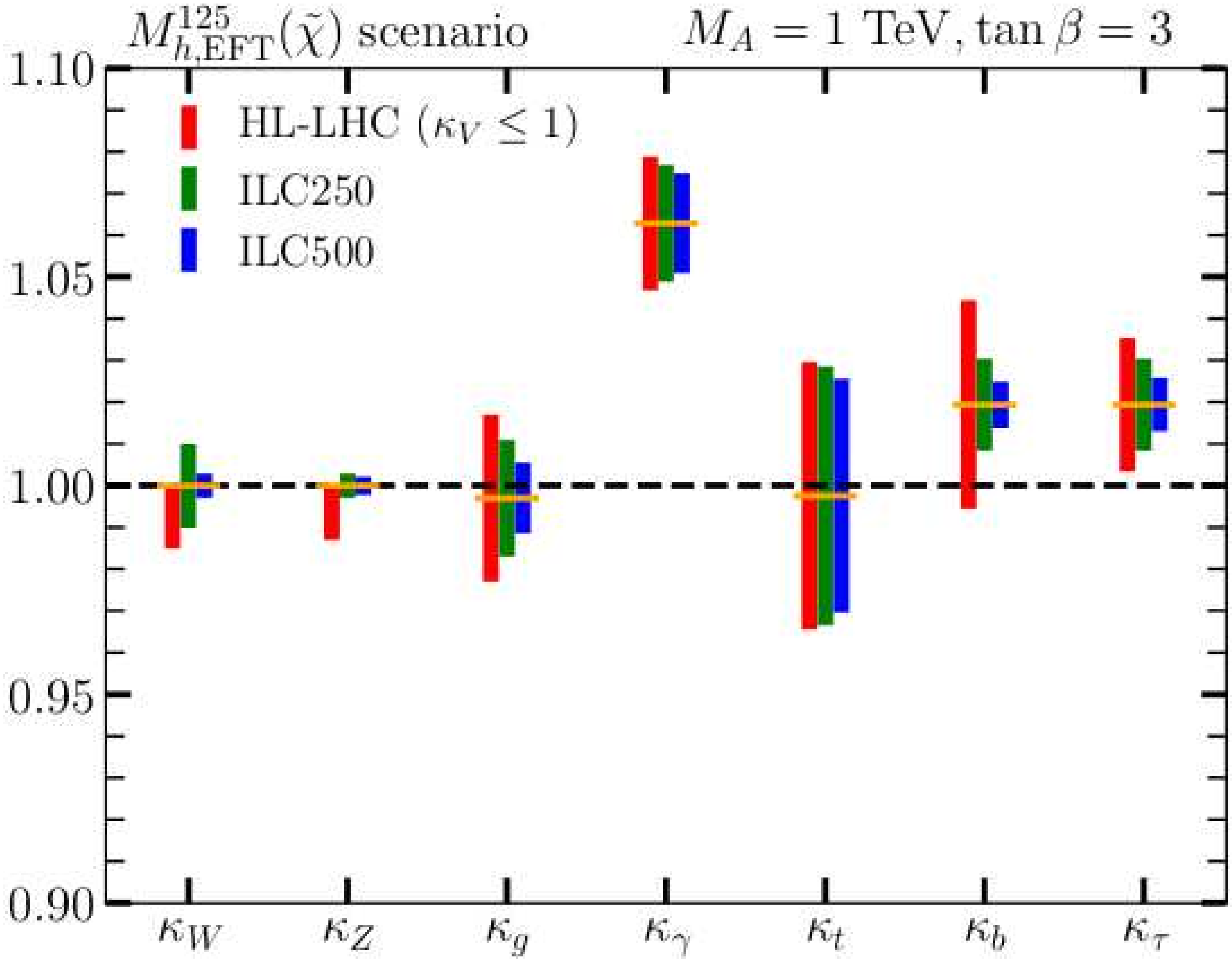
[*H. Bahl et al. '20*]



$\Rightarrow$ clear effect of light SUSY paticles

MSSM Wäscheleine IV: e^+e^- vs. $M_h^{125,\text{EFT}}(\tilde{\chi})$ ($M_A = 1000$ GeV, $\tan\beta = 3$)

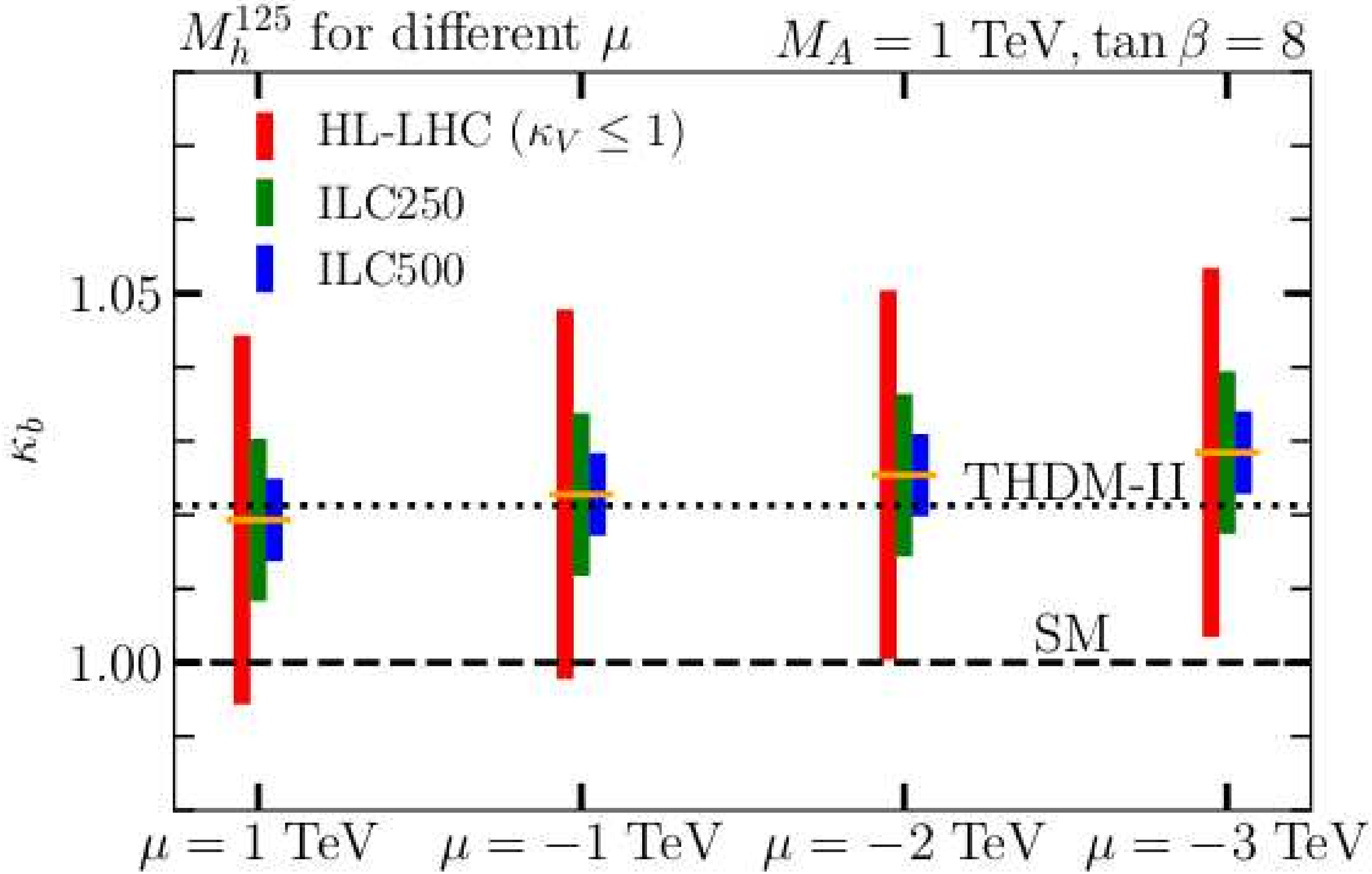
[*H. Bahl et al. '20*]



$\Rightarrow$ only e^+e^- measurements allows to set upper limit on M_A

MSSM Wäscheleine V: e^+e^- vs. M_h^{125} ($M_A = 1000$ GeV, $\tan\beta = 8$)

[*H. Bahl et al. '20*]



⇒ MSSM vs. 2HDM: very challenging!

Questions

- Models with (mainly) changed Higgs sector:
  XSM, 2HDM (type I, II, III, IV), N2HDM, 2HDMS, Composite Higgs, Radion, GM model. . .
  Q: clear, unambigous pattern?
  Q: stable under higher-order corrections?
  Q: how to distinguish "degeneracies"?
  Q: what can be learned about underlying model?

- Models with additional (light) particles:
  MSSM, NMSSM, $\mu\nu$SSM, . . . ,
  additional vector-like quarks, leptons, . . .
  Q: effects of additional particles?
  Q: distinguish between pure Higgs sector change? (MSSM vs. 2HDM II)
  Q: parameter determination?

- Important for Snowmass:
  Q: when is "decoupling" reached?
  Q: which collider will be needed?


Further Questions?