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Interplay of Direct and Indirect Searches at e^+e^- Higgs Factories

Sven Heinemeyer, IFT (CSIC, Madrid)

Hamburg, 10/2022

1. Introduction
2. Direct detection of “heavy” BSM Higgs bosons
3. Indirect detection of “heavy” BSM Higgs bosons
4. Direct detection of “light” BSM Higgs bosons
5. Conclusions

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2. Direct detection of “heavy” BSM Higgs bosons $\oplus$ interplay
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4. Direct detection of “light” BSM Higgs bosons $\oplus$ interplay
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1. Introduction

We have discoved an SM-like Higgs!

The SM cannot be the ultimate theory!

Conclusion: The discovered Higgs cannot be “the SM Higgs”!

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$\Rightarrow$ any hints from LHC results (as guideline/toy example)?

Q’: Which model?

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Q: Does the BSM physics have any (relevant) impact on the Higgs?

⇒ any hints from LHC results (as guideline/toy example)?

Q': Which model?

A1: check changed properties of the h_{125}

A2: check for additional Higgs bosons

check for additional Higgs bosons above and below 125 GeV

⇒ interplay?!

Toy example:

Two Higgs Doublet Model (2HDM):

Fields:

$$\Phi_1 = \begin{pmatrix} \phi_1^+ \\ \frac{1}{\sqrt{2}}(v_1 + \rho_1 + i\eta_1) \end{pmatrix}, \quad \Phi_2 = \begin{pmatrix} \phi_2^+ \\ \frac{1}{\sqrt{2}}(v_2 + \rho_2 + i\eta_2) \end{pmatrix}$$

Potential:

$$\begin{aligned} V \;=\; & m_{11}^2|\Phi_1|^2 + m_{22}^2|\Phi_2|^2 - m_{12}^2(\Phi_1^\dagger\Phi_2 + h.c.) + \frac{\lambda_1}{2}(\Phi_1^\dagger\Phi_1)^2 + \frac{\lambda_2}{2}(\Phi_2^\dagger\Phi_2)^2 \\ & + \lambda_3(\Phi_1^\dagger\Phi_1)(\Phi_2^\dagger\Phi_2) + \lambda_4(\Phi_1^\dagger\Phi_2)(\Phi_2^\dagger\Phi_1) + \frac{\lambda_5}{2}[(\Phi_1^\dagger\Phi_2)^2 + h.c.] \end{aligned}$$

Physical states: h, H, ($\mathcal{CP}$-even), A ($\mathcal{CP}$-odd), $H^\pm$ (charged)

"Physical" input parameters:

$$c_{\beta-\alpha}\,, \quad \tan\beta\,, \quad v\,, \quad M_h, \quad M_H\,, \quad M_A\,, \quad M_{H^\pm}\,, \quad m_{12}^2$$

Alignment limit: $c_{\beta-\alpha} \to 0$ (for $M_h \sim 125$ GeV)

Assumption (for now): $h \sim h_{125}$

Z_2 symmetry to avoid FCNC:

$$\Phi_1 \to \Phi_1 \, , \; \Phi_2 \to -\Phi_2$$

Extension of the Z_2 symmetry to fermions determines four types:

	u-type	d-type	leptons	
type I	Φ_2	Φ_2	Φ_2	
type II	Φ_2	Φ_1	Φ_1	→ MSSM type
type III (lepton-specific)	Φ_2	Φ_2	Φ_1	
type IV (flipped)	Φ_2	Φ_1	Φ_2	

Sum rule (with h SM-like): $\sin(\beta-\alpha) \approx 1$, $\cos(\beta-\alpha) \approx 0$

Unitarity/perturbativity and EWPO (so far): $\Rightarrow M_A \sim M_H \sim M_{H^\pm}$

Second toy example:

Next-Two Higgs Doublet Model (N2HDM): → (nearly) NMSSM type

Fields:

$$\Phi_1 = \begin{pmatrix} \phi_1^+ \\ \frac{1}{\sqrt{2}}(v_1 + \rho_1 + i\eta_1) \end{pmatrix} , \Phi_2 = \begin{pmatrix} \phi_2^+ \\ \frac{1}{\sqrt{2}}(v_2 + \rho_2 + i\eta_2) \end{pmatrix} , \Phi_S = v_S + \rho_S$$

Potential:

$$\begin{aligned} V \;=\; & m_{11}^2|\Phi_1|^2 + m_{22}^2|\Phi_2|^2 - m_{12}^2(\Phi_1^\dagger\Phi_2 + h.c.) + \frac{\lambda_1}{2}(\Phi_1^\dagger\Phi_1)^2 + \frac{\lambda_2}{2}(\Phi_2^\dagger\Phi_2)^2 \\ & + \lambda_3(\Phi_1^\dagger\Phi_1)(\Phi_2^\dagger\Phi_2) + \lambda_4(\Phi_1^\dagger\Phi_2)(\Phi_2^\dagger\Phi_1) + \frac{\lambda_5}{2}[(\Phi_1^\dagger\Phi_2)^2 + h.c.] \\ & + \frac{1}{2}m_S^2\Phi_S^2 + \frac{\lambda_6}{8}\Phi_S^4 + \frac{\lambda_7}{2}(\Phi_1^\dagger\Phi_1)\Phi_S^2 + \frac{\lambda_8}{2}(\Phi_2^\dagger\Phi_2)\Phi_S^2 \end{aligned}$$

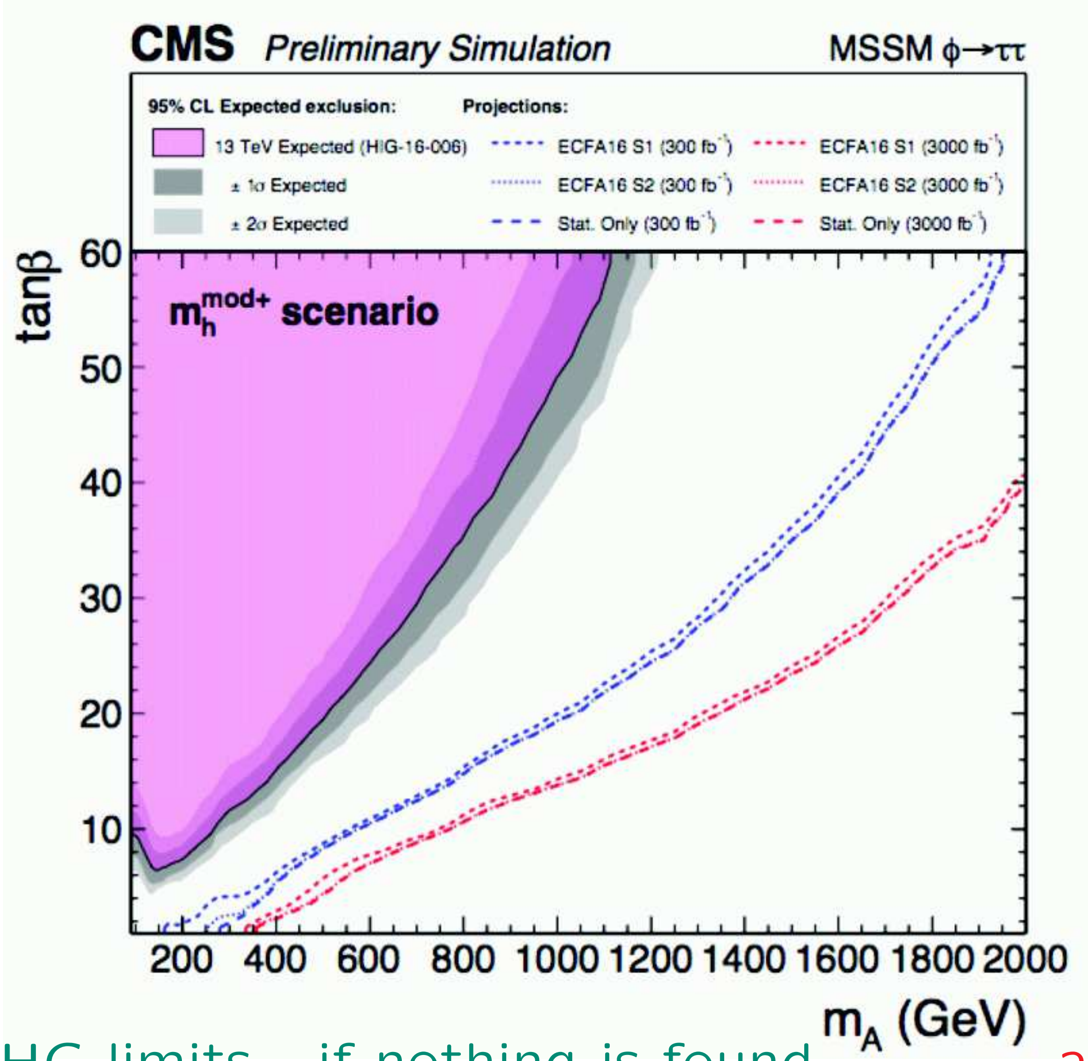
Z_2 symmetry: $\Phi_1 \to \Phi_1$, $\Phi_2 \to -\Phi_2$, $\Phi_S \to \Phi_S$

Z_2' symmetry: $\Phi_1 \to \Phi_1$, $\Phi_2 \to \Phi_2$, $\Phi_S \to -\Phi_S$ (broken by $v_S \Rightarrow$ no DM)

Physical states: h_1, h_2, h_3 ($\mathcal{CP}$-even), A ($\mathcal{CP}$-odd), $H^\pm$ (charged)

2. Direct Detection of “heavy” BSM Higgs bosons

Reach in the MSSM (type II 2HDM Higgs sector):

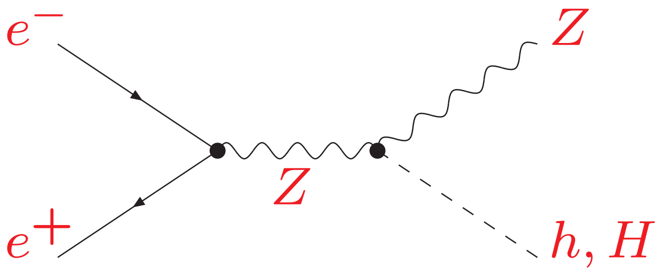


⇒ strong (HL-)LHC limits - if nothing is found analyzed in detail

⇒ but if there is something in the kinematical e^+e^- reach, it can be

Search for neutral Higgs bosons in the 2HDM at e^+e^- colliders:

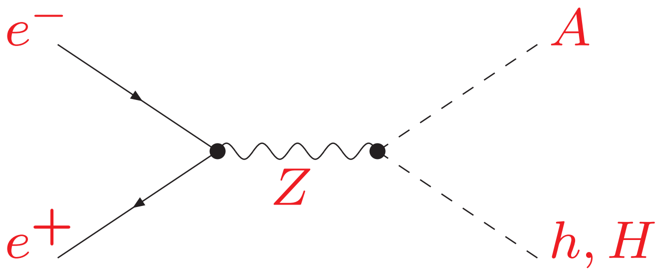
$e^+e^- \to Zh, ZH$



$$\sigma_{hZ} \approx \sin^2(\beta - \alpha)\sigma^{\mathrm{SM}}_{hZ}$$

$$\sigma_{HZ} \approx \cos^2(\beta - \alpha)\sigma^{\mathrm{SM}}_{hZ}$$

$e^+e^- \to Ah, AH$



$$\sigma_{hA} \propto \cos^2(\beta - \alpha)\sigma^{\mathrm{SM}}_{hZ}$$

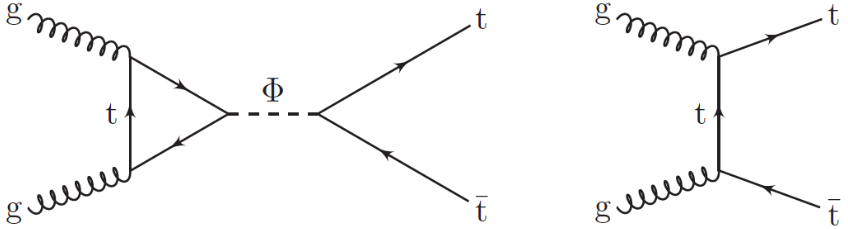
$$\sigma_{HA} \propto \sin^2(\beta - \alpha)\sigma^{\mathrm{SM}}_{hZ}$$

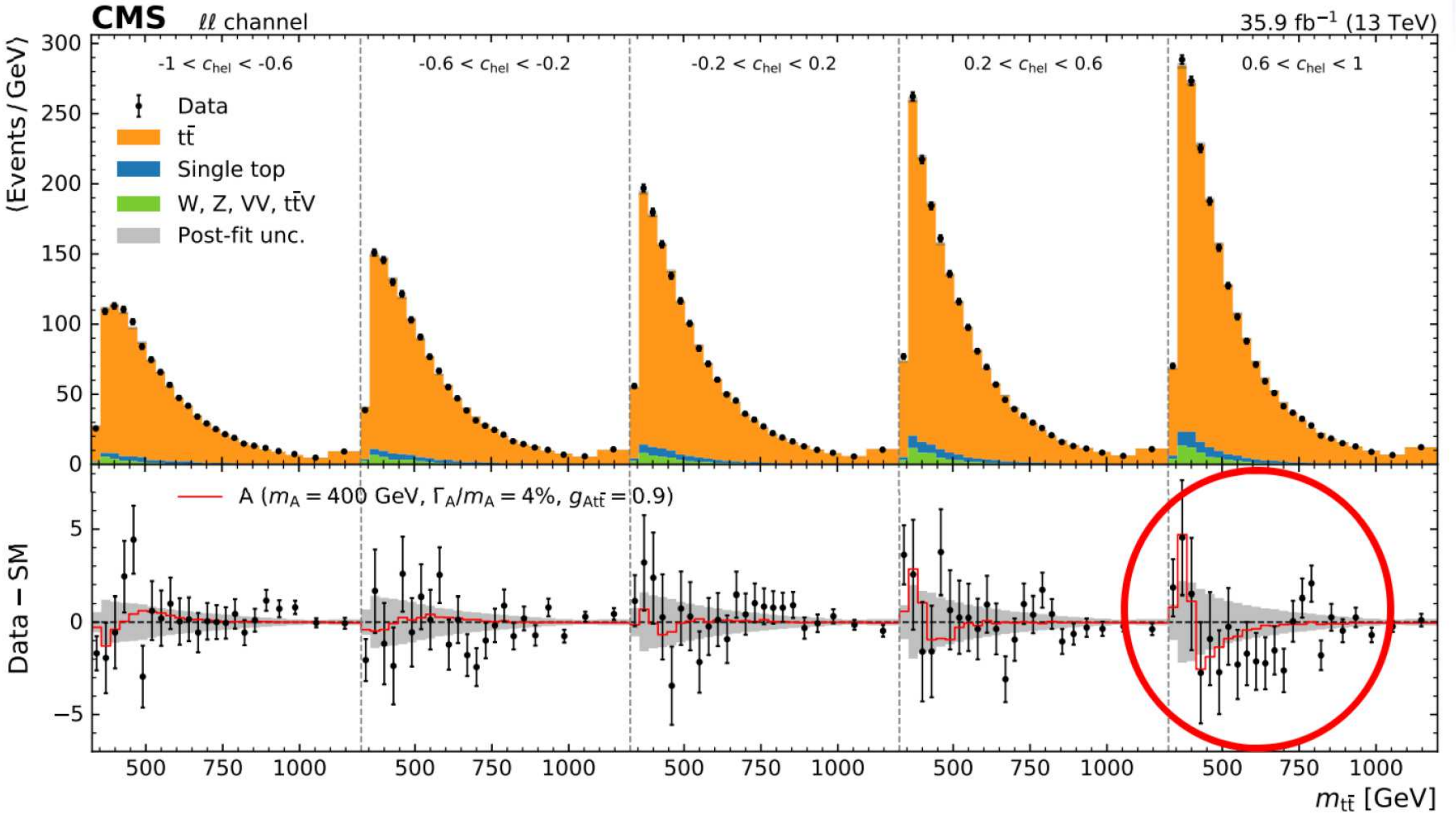
⇒ only pair production of heavy Higgs bosons! reach: $M_A \lesssim \sqrt{s}/2$

⇒ maximum ILC reach: ∼ 500 GeV, CLIC ∼ 1500 GeV

Possible hint for heavy Higgses at the LHC:

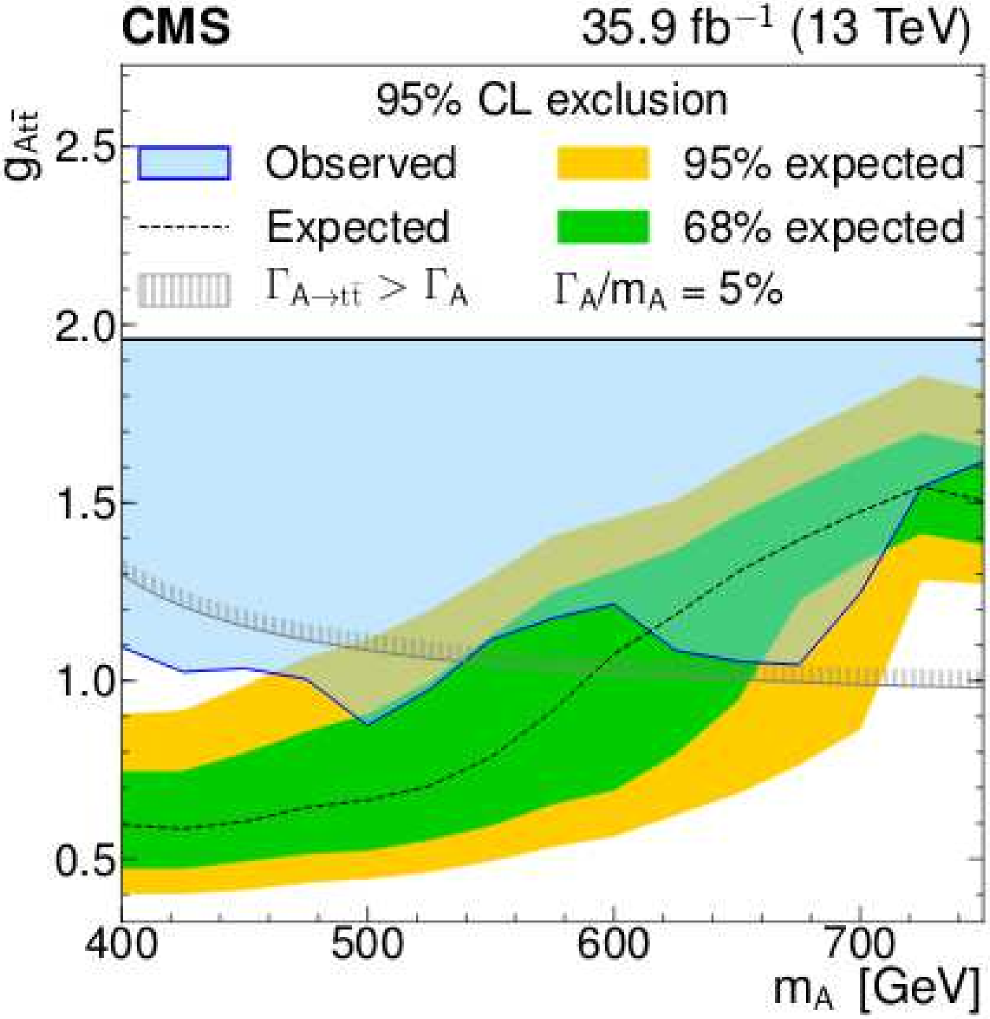
CMS Higgs-boson search in $pp \to \phi \to t\bar{t}$ at $m_\phi \sim 400$ GeV





[CMS: 1908.01115]

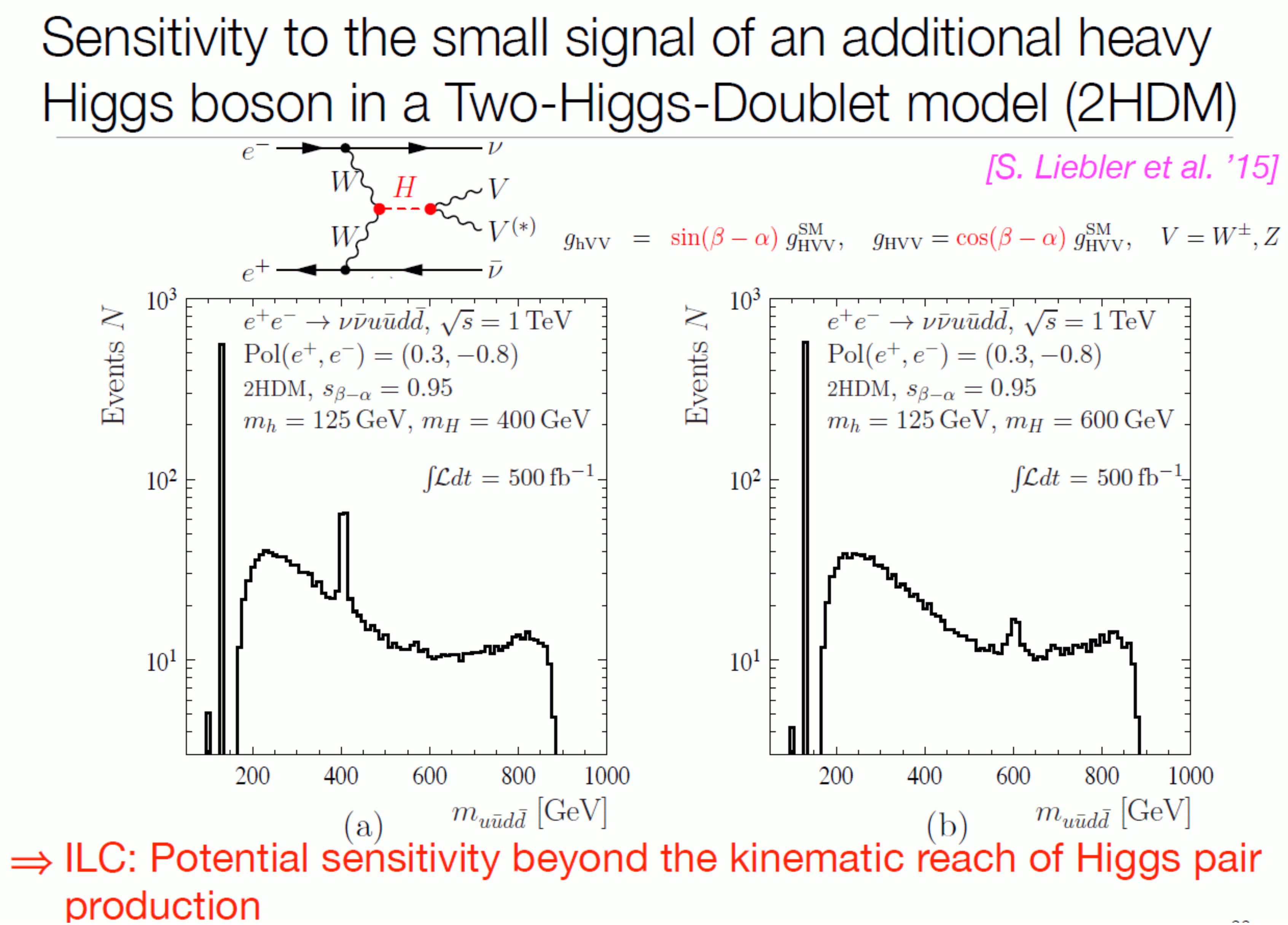
χ^2 distribution from the excess: local: $3.5\,\sigma$, global: $\lesssim 2\,\sigma$



⇒ can be explained in the N2HDM/NMSSM for $\tan\beta \sim 1.5$ ⇒ in ILC reach

[*T. Biekötter, A. Grohsjean, S.H., C. Schwanenberger, G. Weiglein '21*]

Single heavy Higgs production beyond kinematic reach:



Sensitivity to the small signal of an additional heavy Higgs boson in a Two-Higgs-Doublet model (2HDM)

[S. Liebler et al. '15]

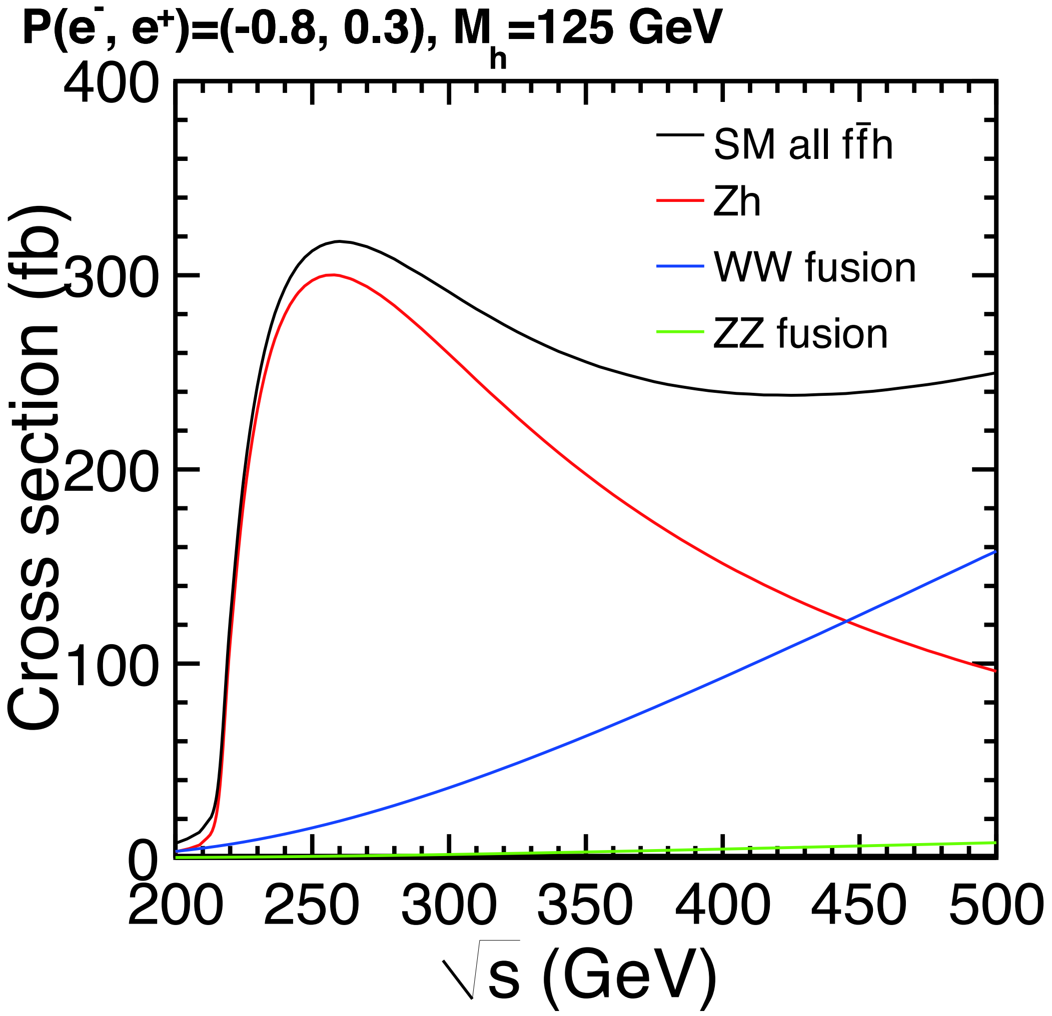
$$g_{\mathrm{hVV}} = \sin(\beta-\alpha)\, g^{\mathrm{SM}}_{\mathrm{HVV}}, \quad g_{\mathrm{HVV}} = \cos(\beta-\alpha)\, g^{\mathrm{SM}}_{\mathrm{HVV}}, \quad V = W^{\pm}, Z$$

⇒ ILC: Potential sensitivity beyond the kinematic reach of Higgs pair production

[*Taken from G. Weiglein '18*]

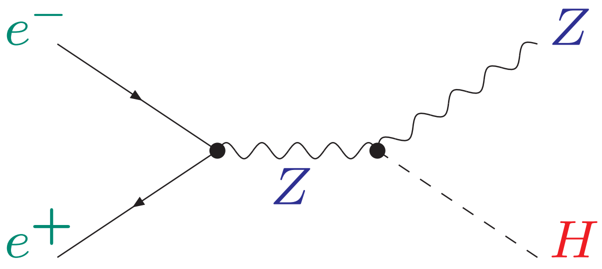
3. Indirect Detection of “heavy” BSM Higgs bosons

⇒ via h_{125} coupling measurements



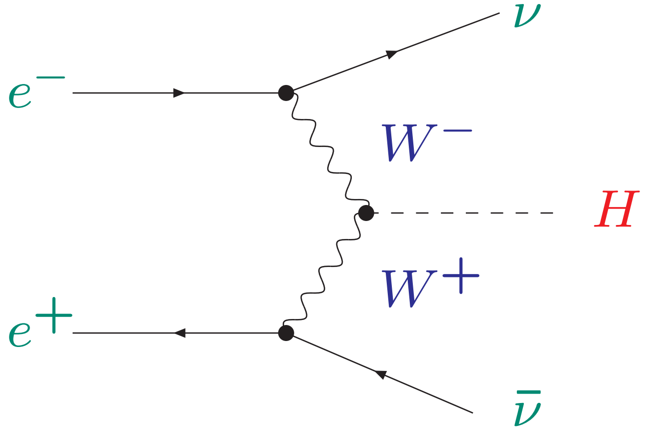
Higgs-strahlung:

$e^+e^- \to Z^* \to ZH$



weak boson fusion (WBF):

$e + e- \to \nu\bar{\nu}H$



$\sqrt{s} \sim$ 250 GeV, Higgs-strahlung dominated

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:

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

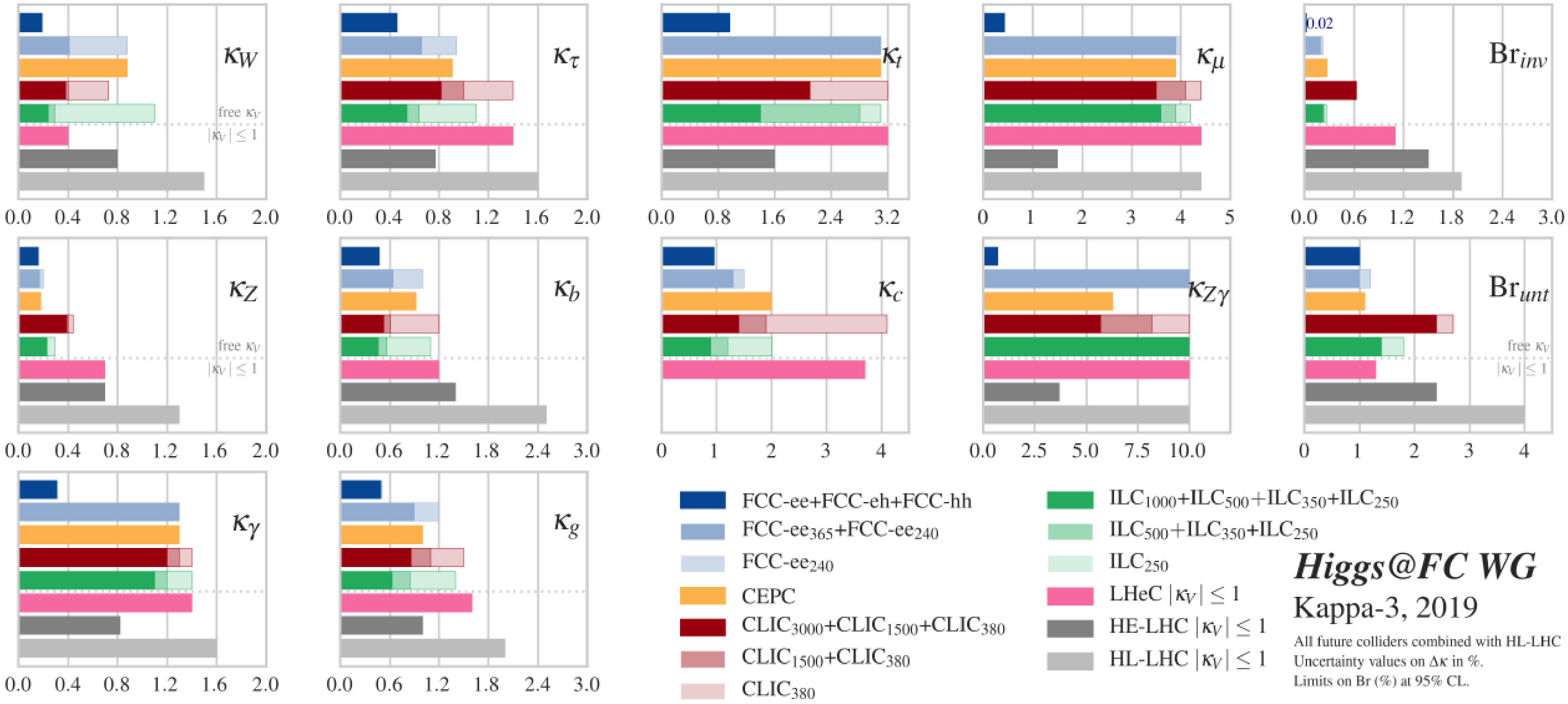
$$\kappa_F \approx 1 - (3-9)\% \left(\frac{1\ \text{TeV}}{f}\right)^2$$

⇒ couplings to bosons in the per mille range

⇒ couplings to fermions in the per cent range

⇒ at which collider can this be reached?

Future expectations for κ (kappa-3 framework)



⇒ ILC shows strong improvement over HL-LHC in many cases

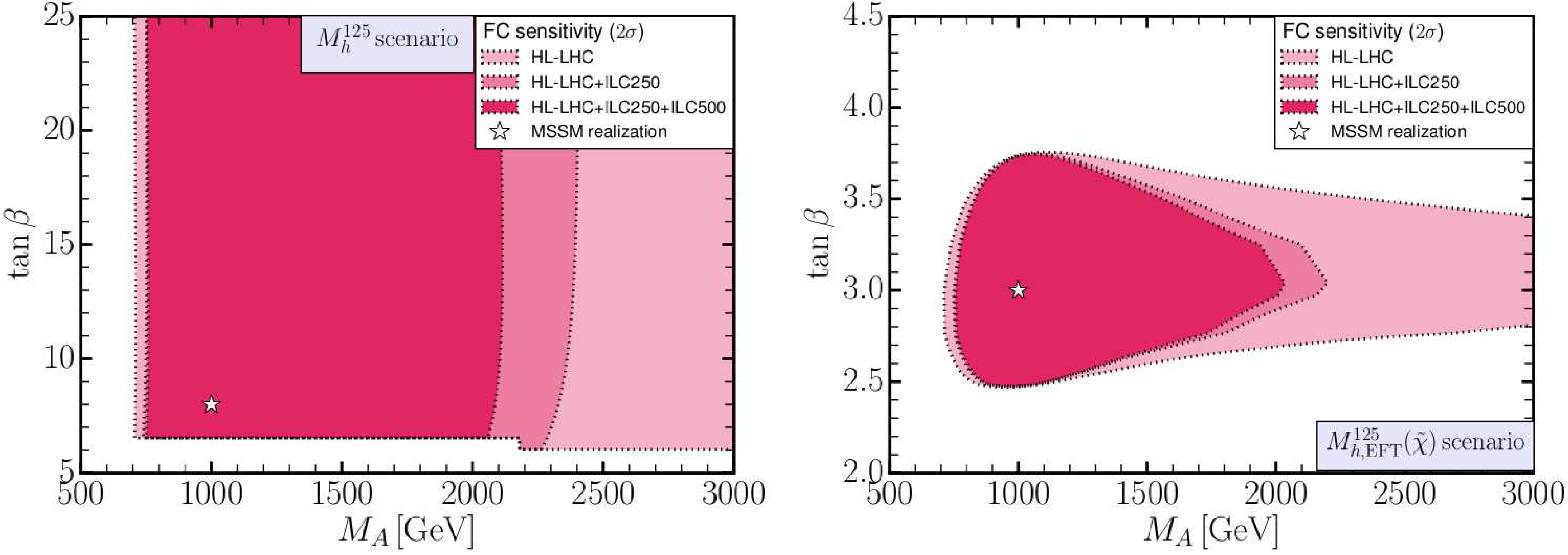
⇒ . . . and without theory assumptions

⇒ and this improvement could be decisive!

Relevance of ILC measurements:

[H. Bahl et al., '20]

- Assume a realization of an MSSM point: $M_A = 1$ TeV, $\tan\beta = 7/3$
- What limits can be set from rate/coupling measurements?



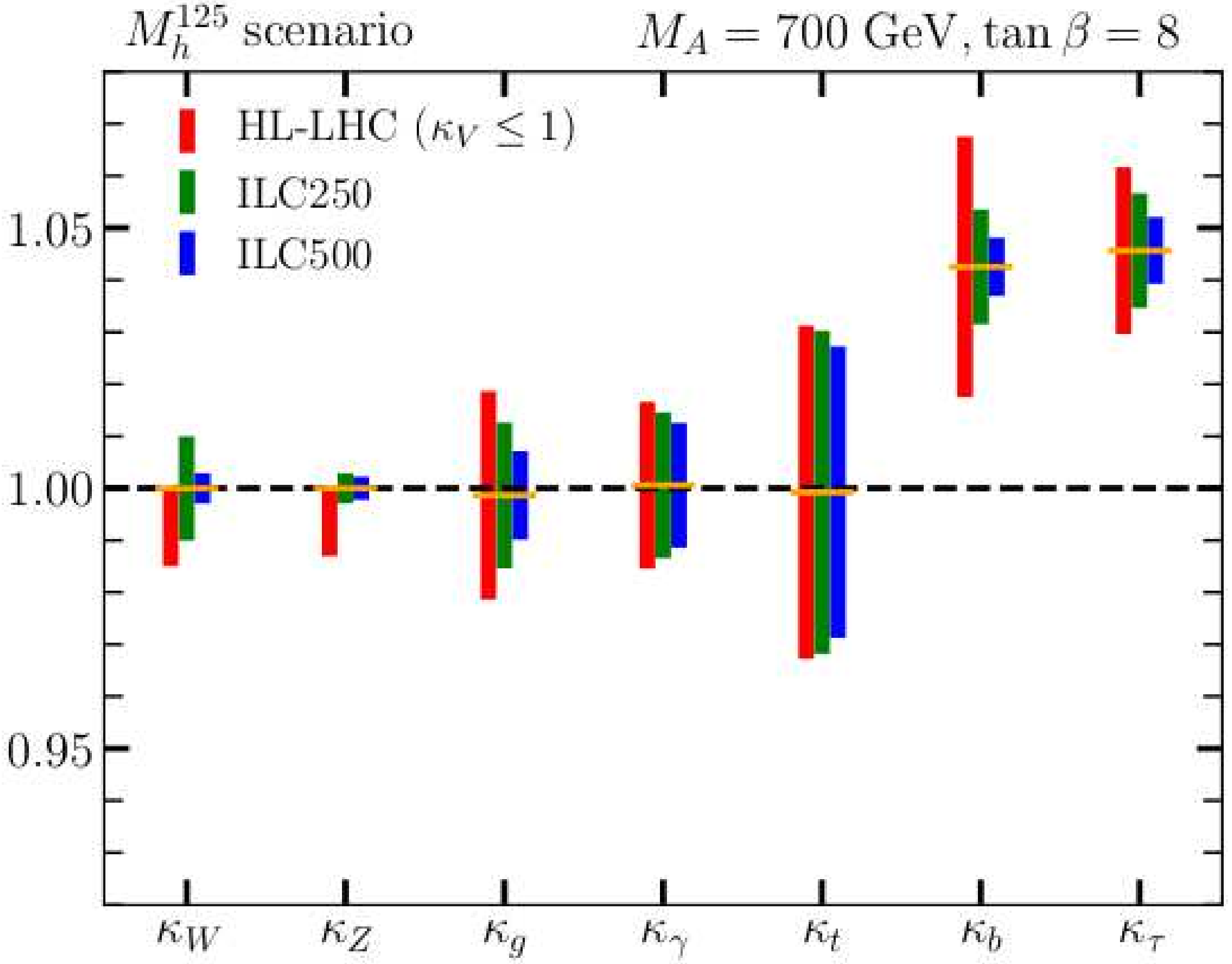
⇒ only ILC measurements give upper limit on M_A

⇒ limits on $\tan\beta$ only for small(er) $\tan\beta$

⇒ clear example of interplay!

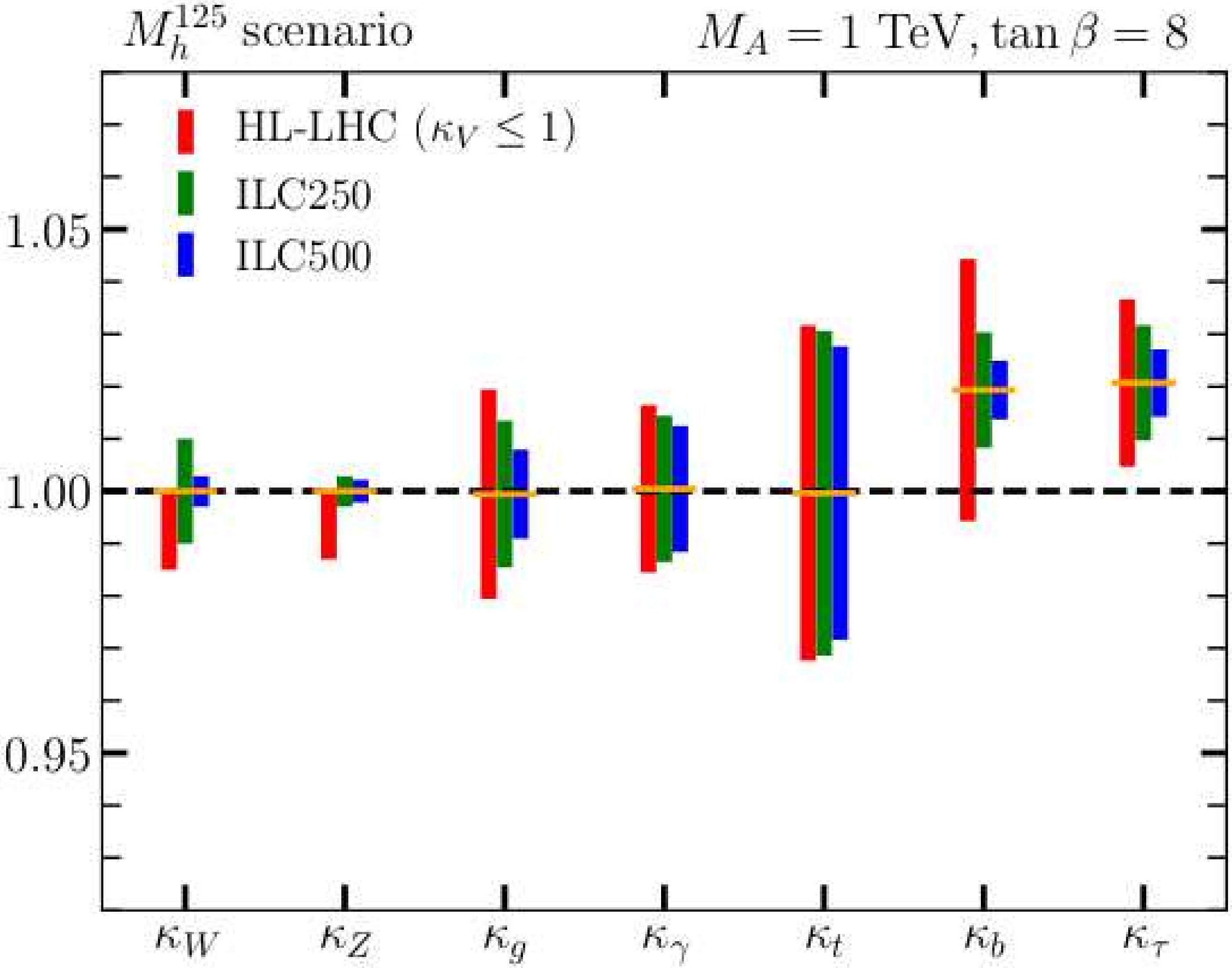
MSSM Wäscheleine I: e^+e^- precision vs. M_h^{125} ($M_A = 700$ GeV, $\tan\beta = 8$)

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



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

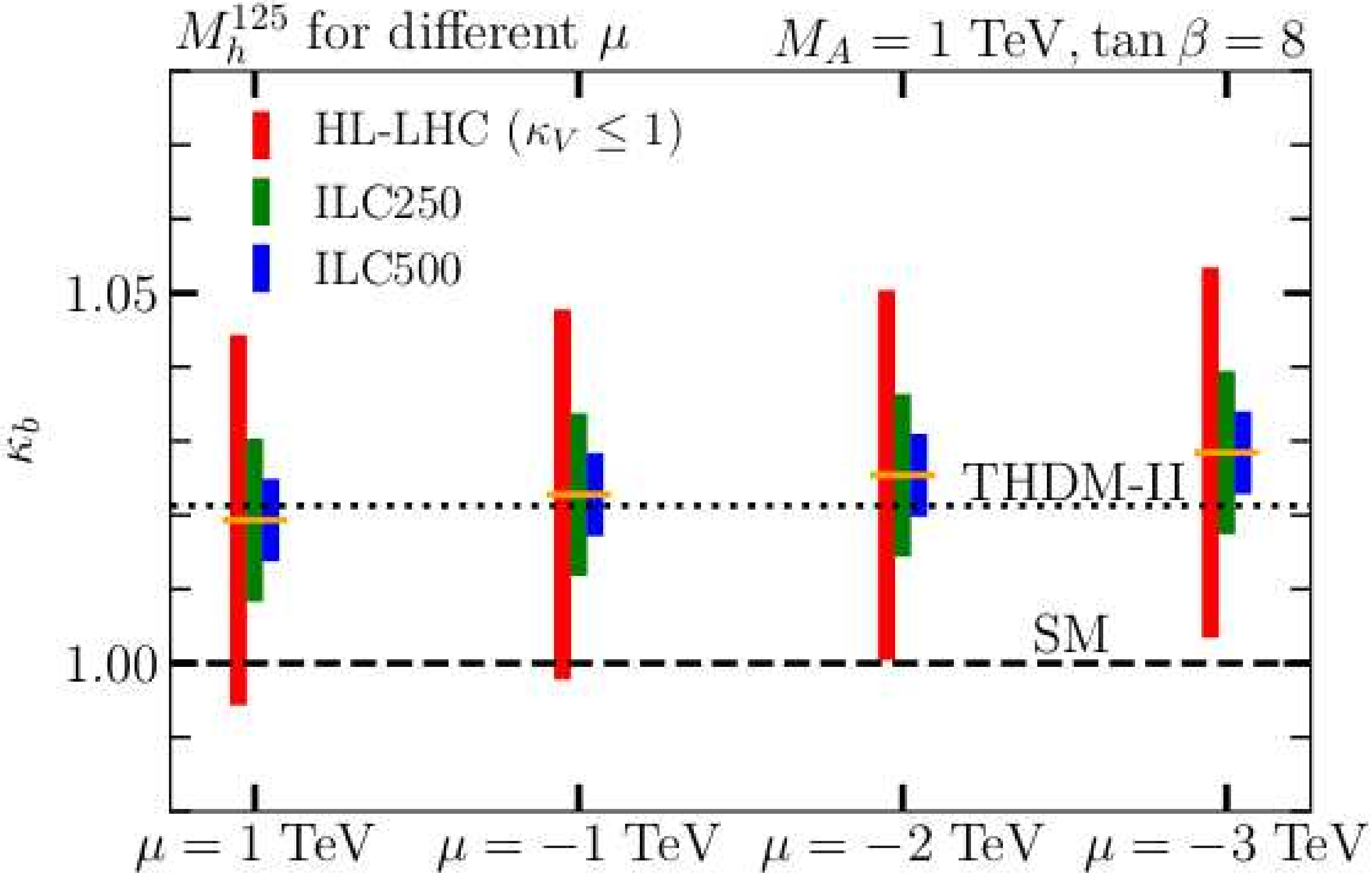
[*H. Bahl et al. '20*]



⇒ 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*]



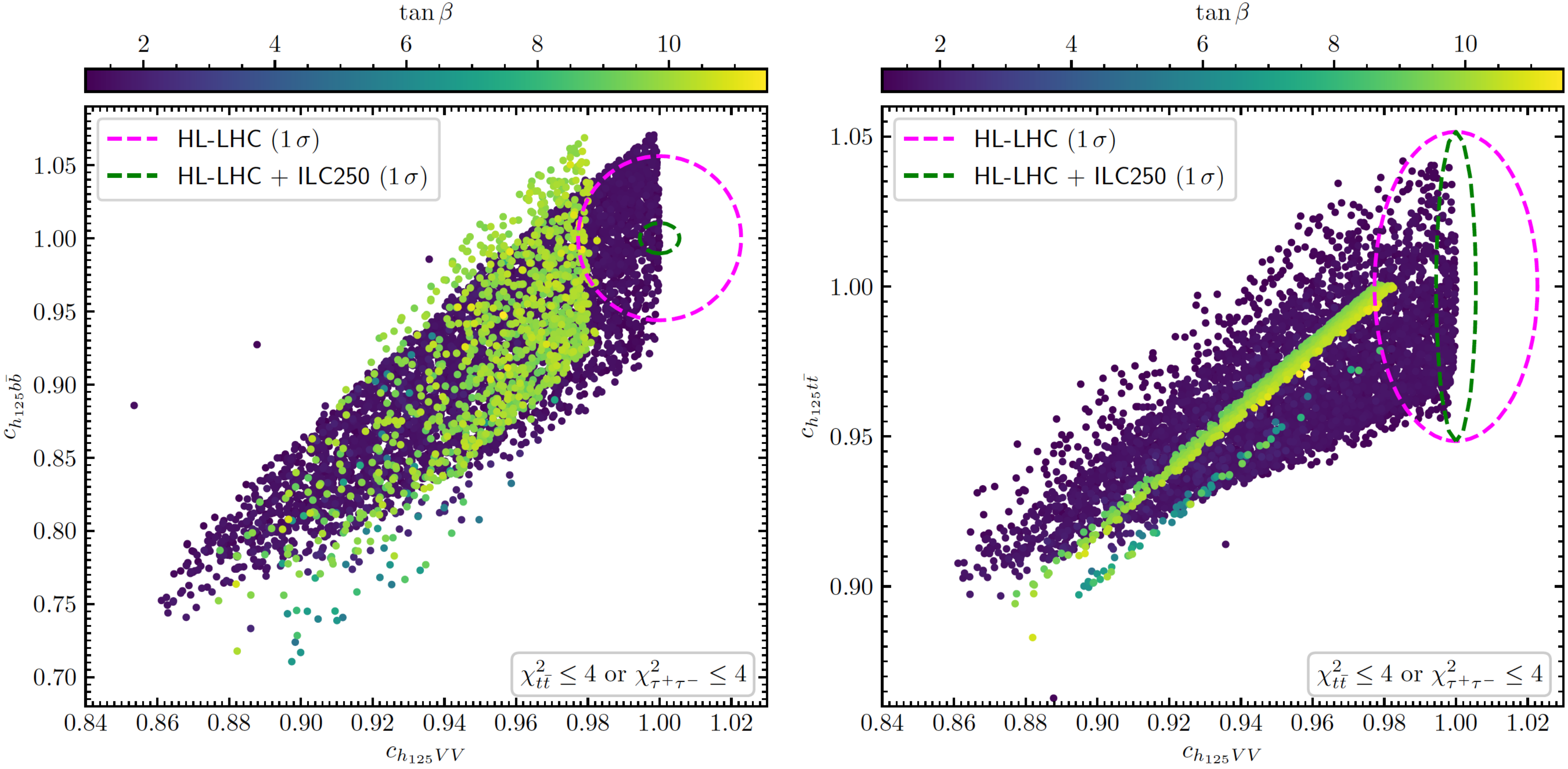
⇒ MSSM vs. 2HDM: very challenging!

⇒ direct searches needed to discriminate ⇒ interplay!

What about the "real hints" at ~ 400 GeV? → N2HDM:

What about the "real hints" at ~ 400 GeV? → N2HDM: [*T. Biekötter, A. Grohsjea*

S.H., C. Schwanenberger, G. Weiglein '21]



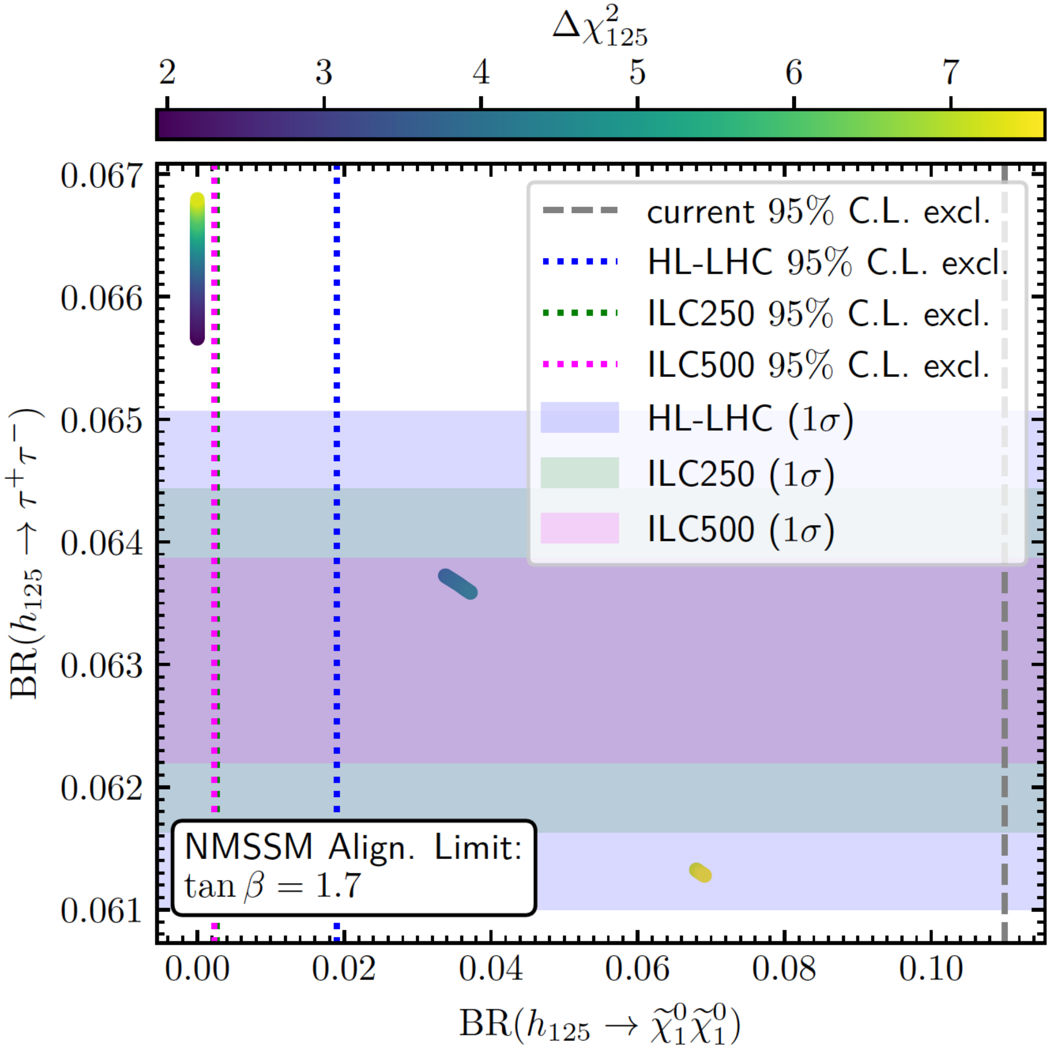
low $\tan\beta$ ($t\bar{t}$): SM limit reached, but many points show large deviation

⇒ indirect test of model predictions ⇒ interplay!

What about the "real hints" at $\sim$ 400 GeV? → NMSSM:

What about the "real hints" at ~ 400 GeV? → NMSSM:

[*T. Biekötter, A. Grohsjean, S.H., C. Schwanenberger, G. Weiglein '21*]

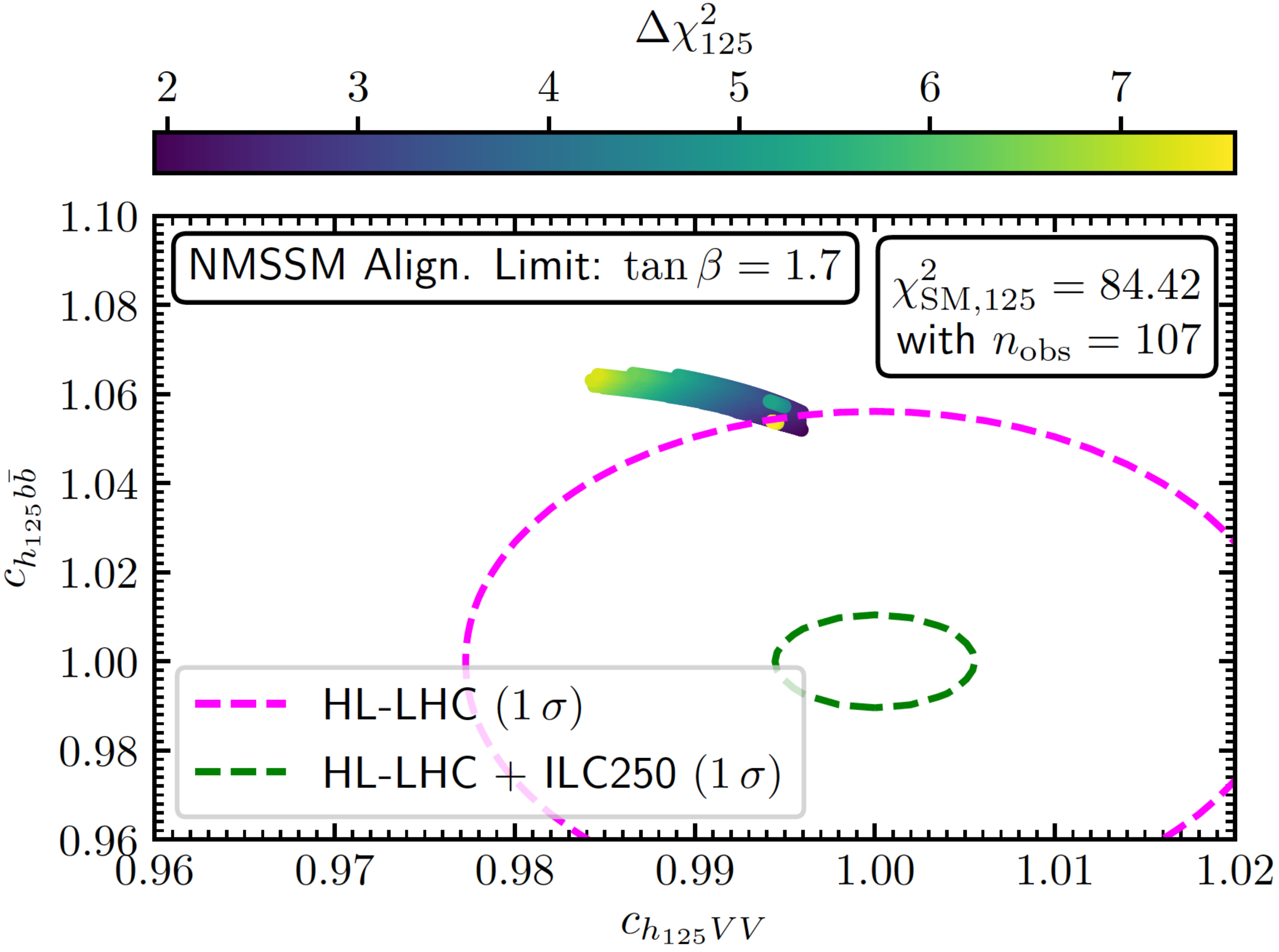


⇒ HL-LHC can test $h_{125} \to \tilde{\chi}^0_1\tilde{\chi}^0_1$ (small part of allowed parameter space)

⇒ ILC can test all points via $h_{125} \to \tau^+\tau^-$ (and via $h_{125} \to \tilde{\chi}^0_1\tilde{\chi}^0_1$)

What about the "real hints" at ~ 400 GeV? → NMSSM:

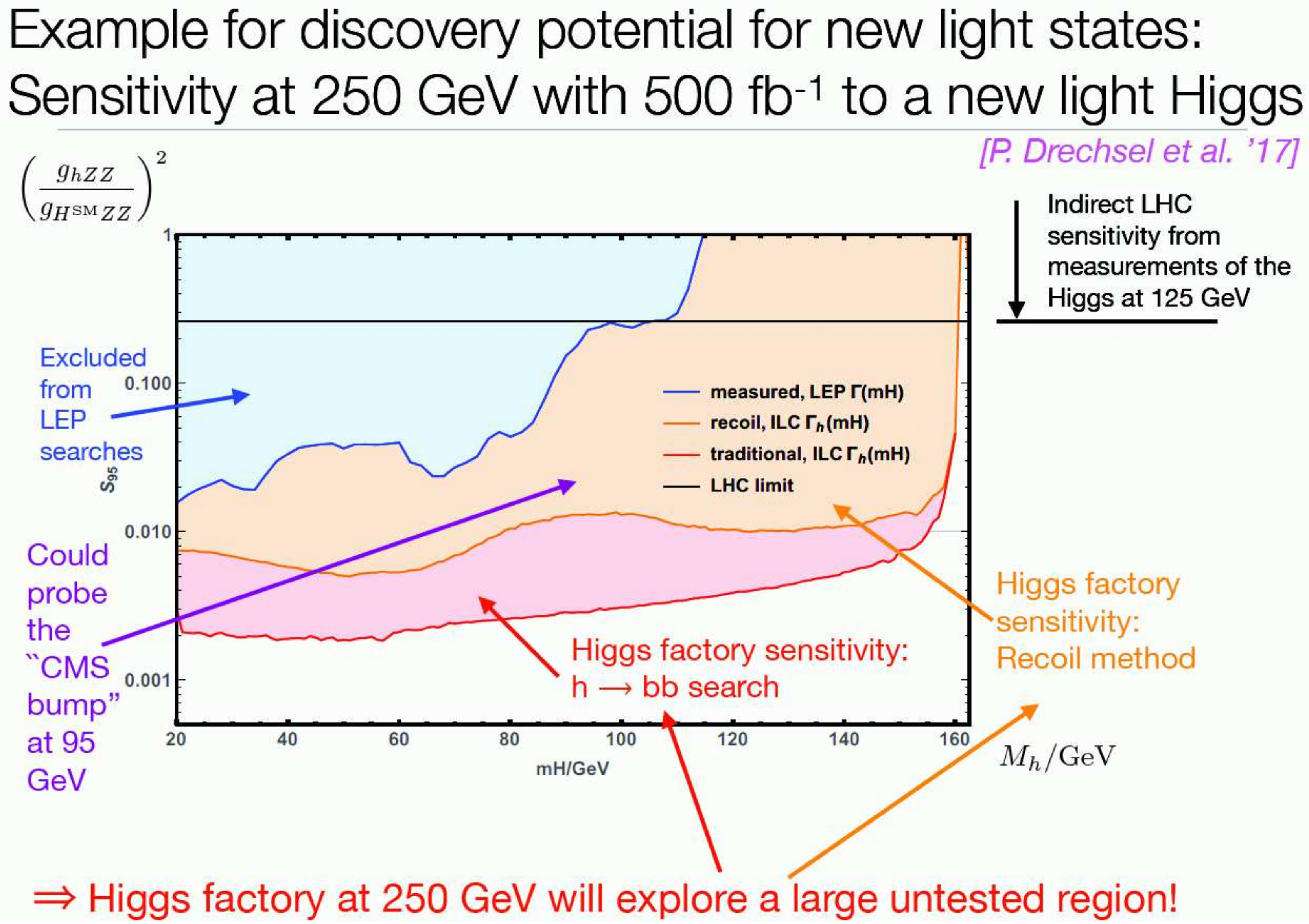
[T. Biekötter, A. Grohsjean, S.H., C. Schwanenberger, G. Weiglein '21]



⇒ HL-LHC cannot resolve the h_{125} coupling deviations

⇒ ILC can easily test this scenario via $c_{h_{125}VV}$ and $c_{h_{125}bb}$

4. Direct detection of “light” BSM Higgs bosons



Example for discovery potential for new light states: Sensitivity at 250 GeV with 500 fb^{-1} to a new light Higgs

[P. Drechsel et al. ’17]

Indirect LHC sensitivity from measurements of the Higgs at 125 GeV

Excluded from LEP searches

Could probe the “CMS bump” at 95 GeV

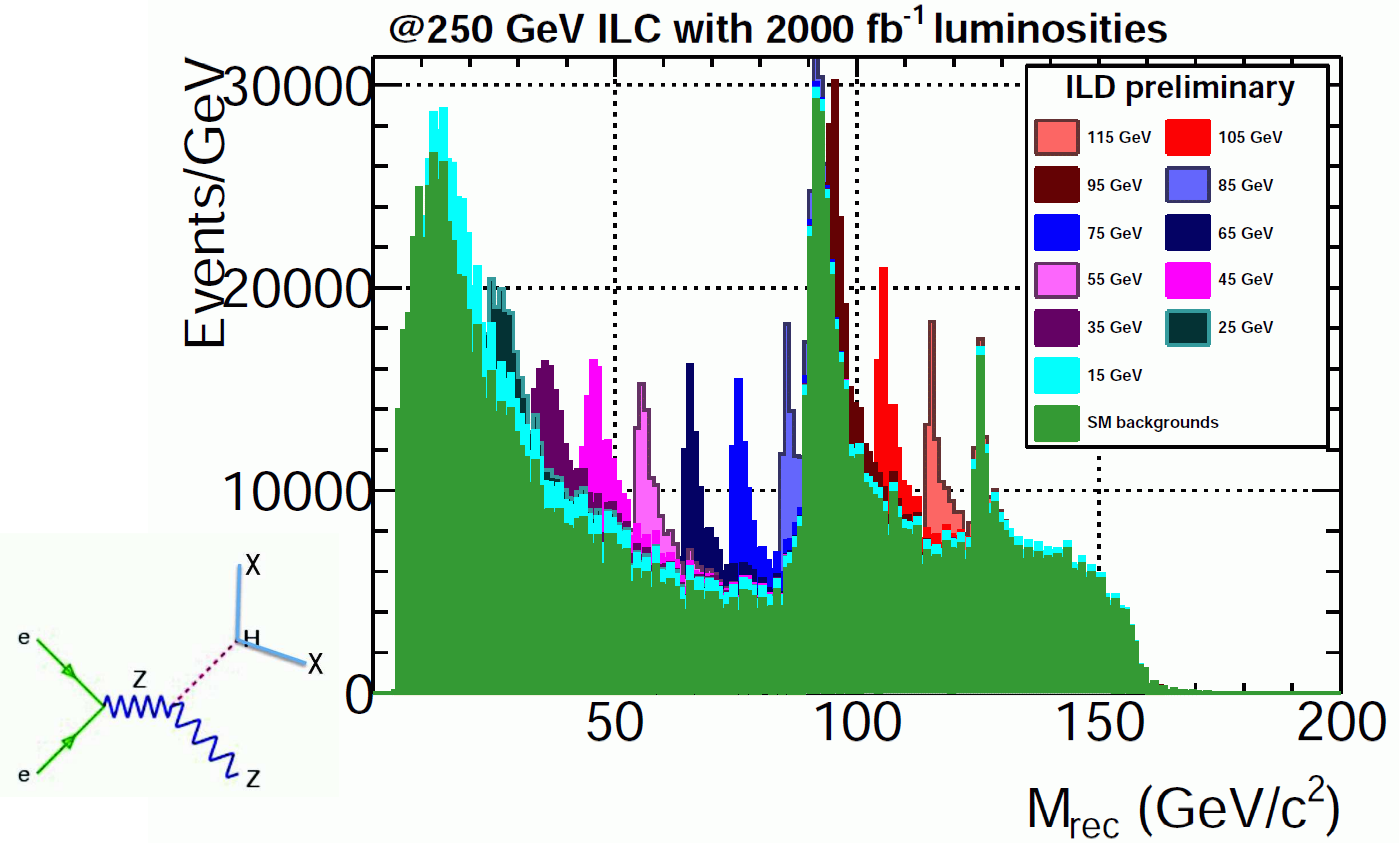
Higgs factory sensitivity: h → bb search

Higgs factory sensitivity: Recoil method

⇒ Higgs factory at 250 GeV will explore a large untested region!

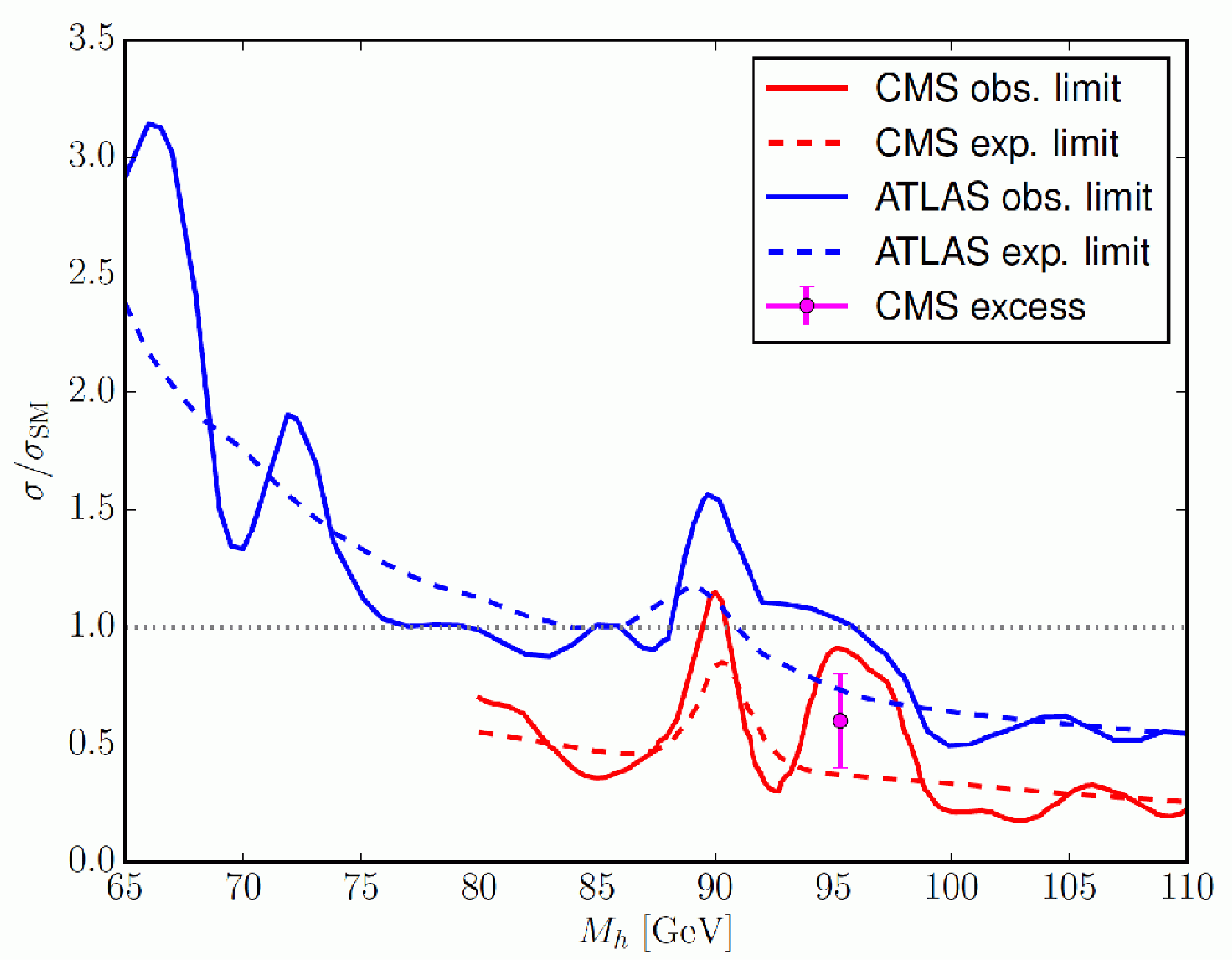
[*Taken from G. Weiglein ’18*]

Search for invisibly decaying light Higgses via recoil method: [*Y. Wang et al. '18*]



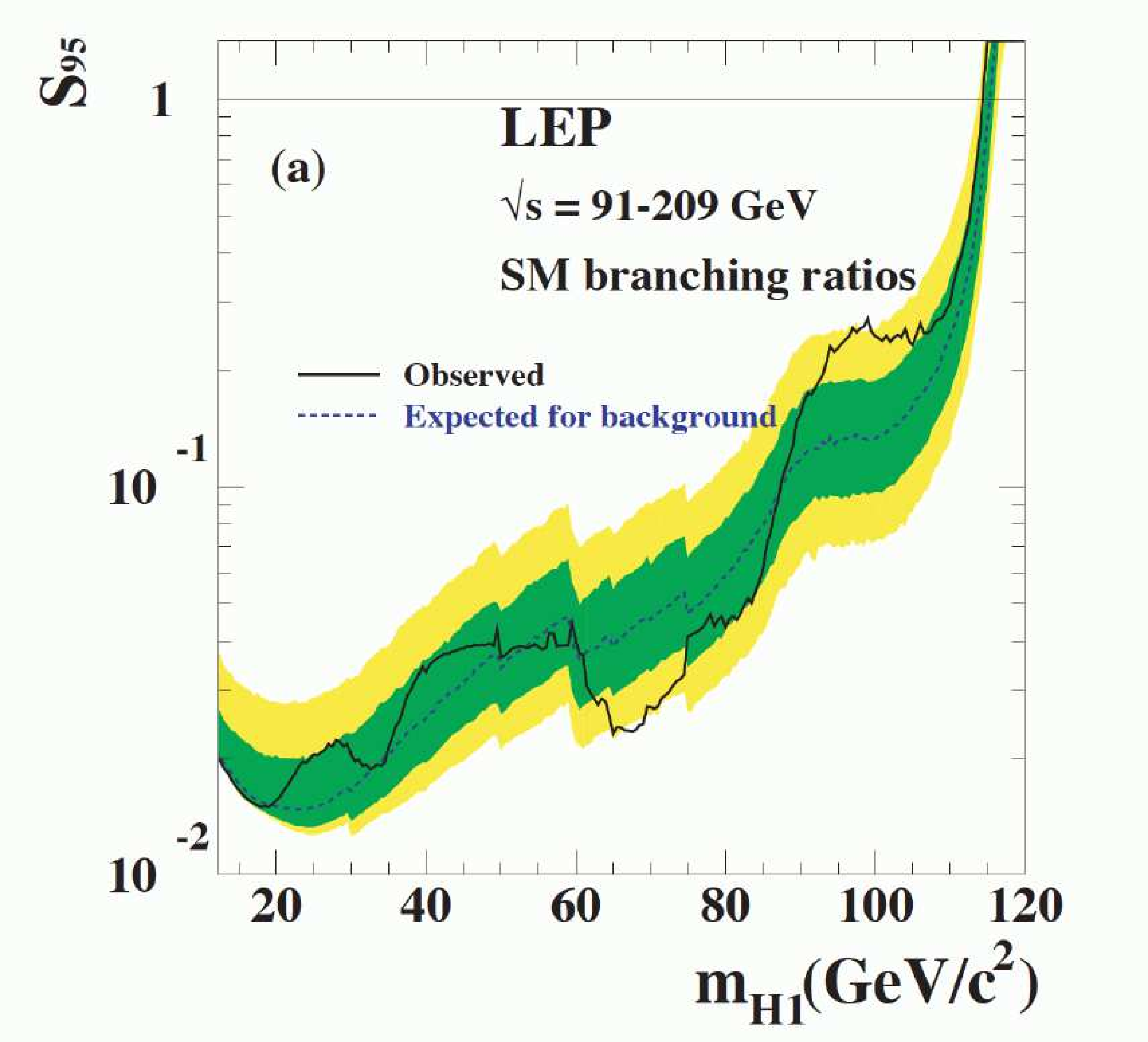
Case study: Search for $pp \to \phi \to \gamma\gamma$: excess at $m_\phi \sim 95$ GeV

[*CMS '17, ATLAS '18, S.H., T. Stefaniak '18*] $\mu_{\rm CMS} = 0.6 \pm 0.2$



⇒ if there is something, it would look exactly like this!

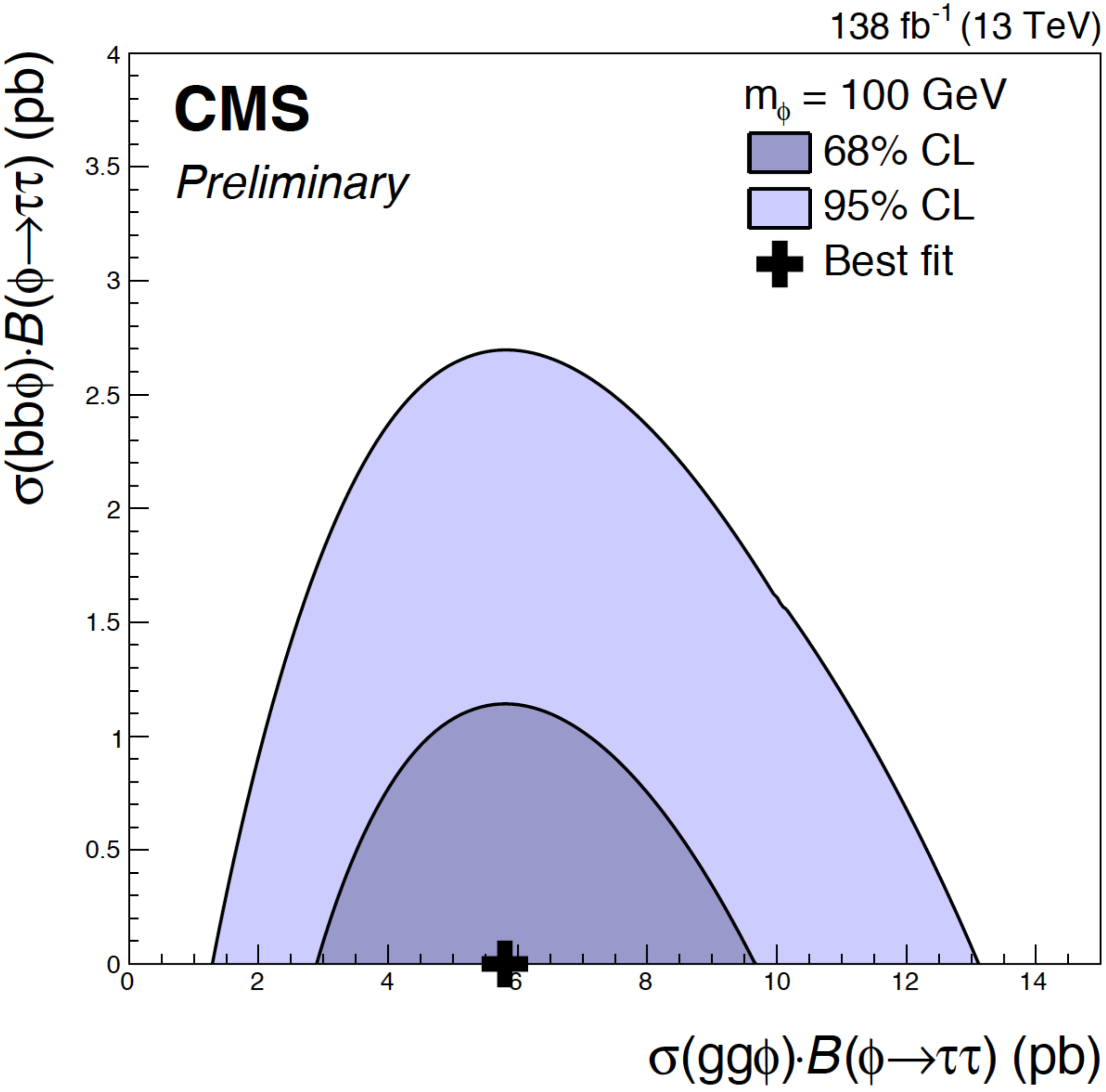
Remember the LEP excess?



$$\mu_{\text{LEP}}(98\text{ GeV}) = \left[\sigma(e^+e^- \to Zh_1) \times \text{BR}(h_1 \to b\bar{b})\right]_{\text{exp/SM}} = 0.117 \pm 0.057$$

The new $\tau^+\tau^-$ excess

[*CMS '22*]



$\Rightarrow$ clear excess of $\sim 3\,\sigma$ at $\sim$ 100 GeV

Now we have three excesses at ~ 95 GeV

$$\mu_{bb}^{\text{exp}} = 0.117 \pm 0.057, \quad {\mu_{\gamma\gamma}}^{\text{exp}} = 0.6 \pm 0.2, \quad {\mu_{\tau\tau}}^{\text{exp}} = 1.2 \pm 0.5$$

corresponding to

$$\mu_{bb}^{\text{exp}} \sim 2\,\sigma, \quad \mu_{\gamma\gamma}^{\text{exp}} \sim 3\,\sigma, \quad \mu_{\tau\tau}^{\text{exp}} \sim 2.4\,\sigma$$

Three (effectively) independent channels
⇒ no LEE (as theorist I am allowed to add naively)

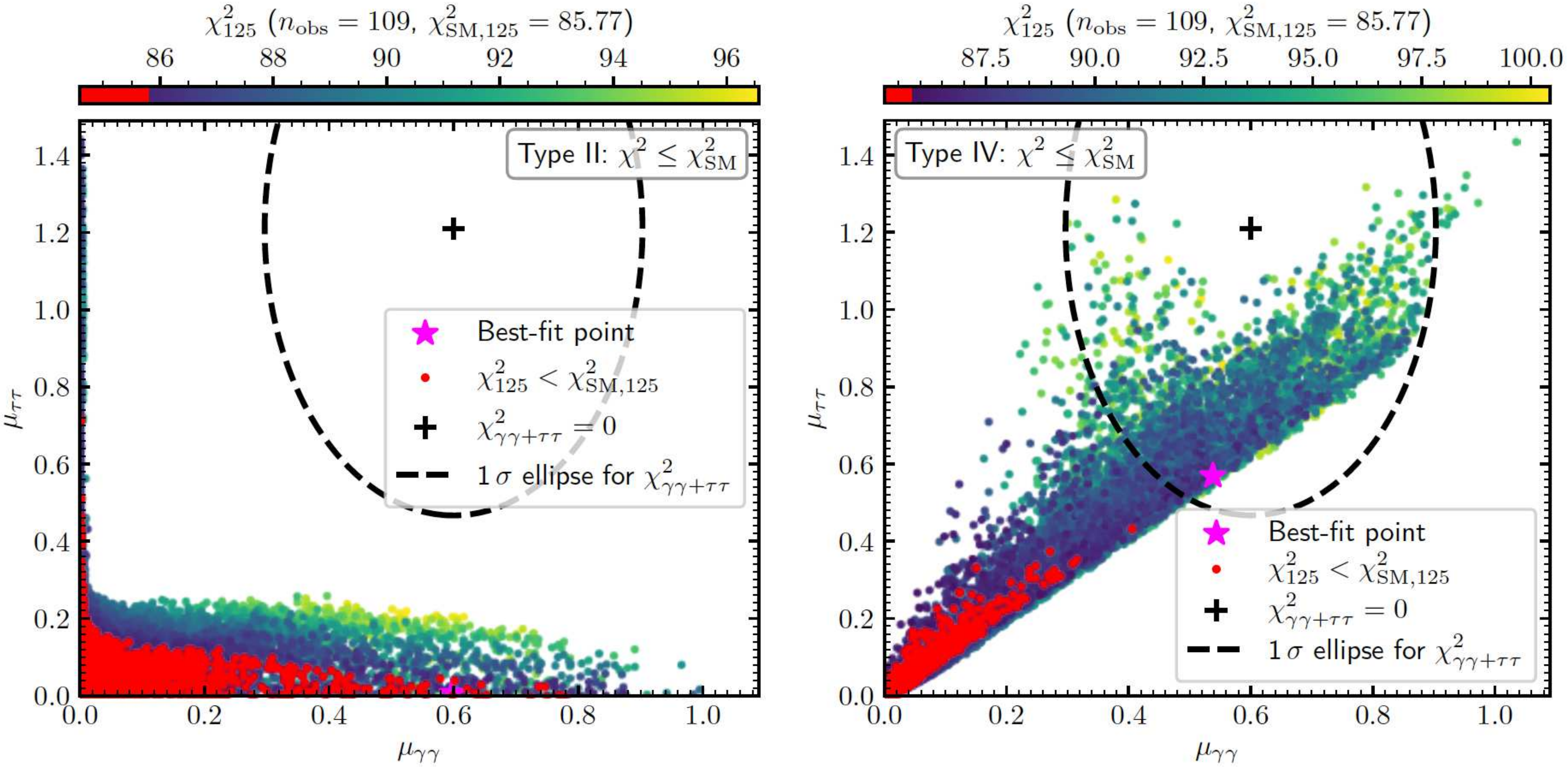
$$\boxed{\Rightarrow \sim 4.3\,\sigma}$$

$$\chi^2_{95} = \frac{(\mu_{bb}^{\text{theo}} - 0.117)^2}{(0.057)^2} + \frac{(\mu_{\gamma\gamma}^{\text{theo}} - 0.6)^2}{(0.2)^2} + \frac{(\mu_{\tau\tau}^{\text{theo}} - 1.2)^2}{(0.5)^2}$$

Can we fit all excesses together?

N2HDM type II vs. type IV

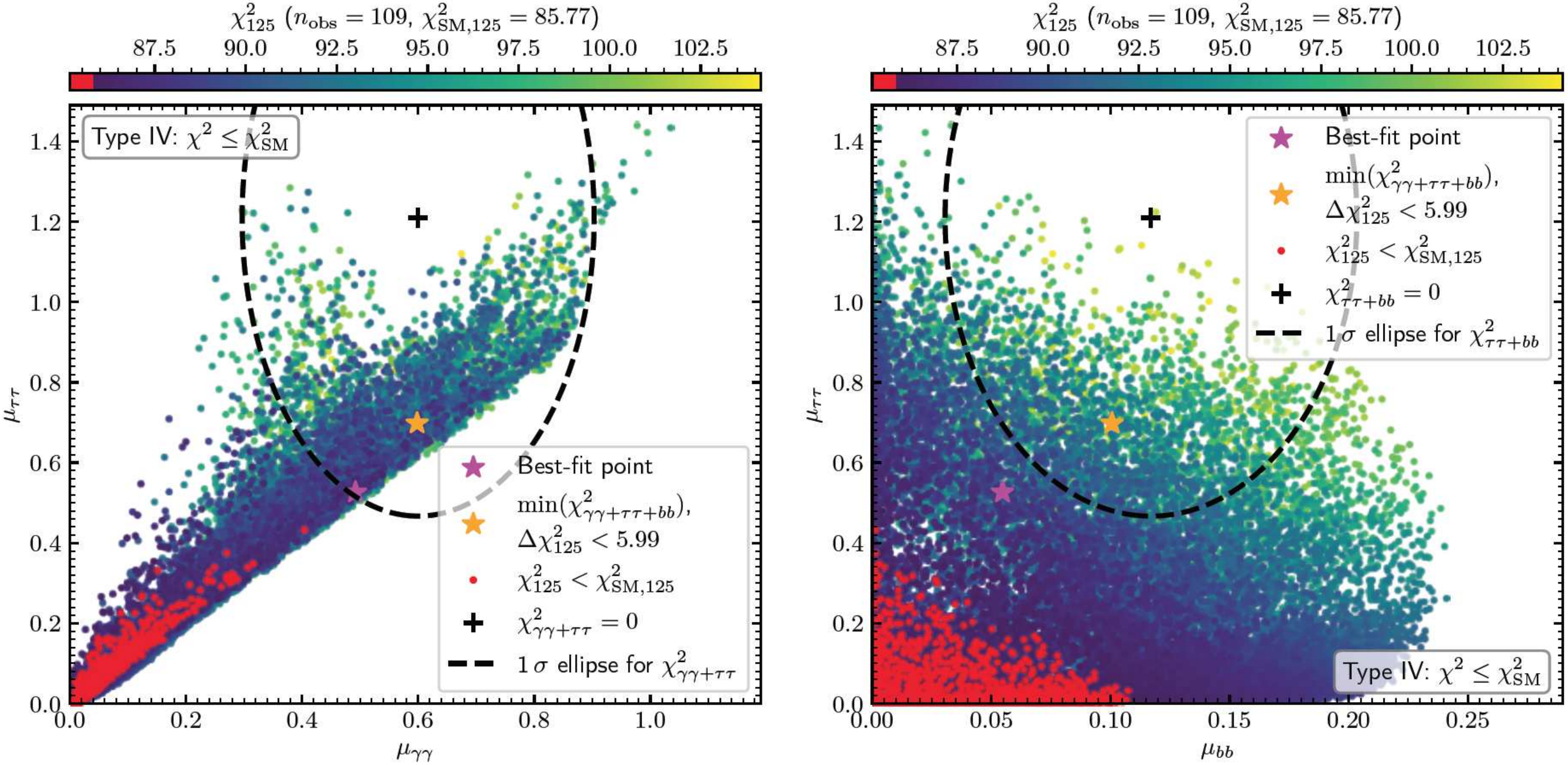
[*T. Biekötter, S.H., G. Weiglein '22*]



Color coding: χ^2_{125} from HiggsSignals

$\Rightarrow$ only type IV can fit the $\gamma\gamma$ and $\tau\tau$ excesses

N2HDM type IV: fitting all three excesses: [*T. Biekötter, S.H., G. Weiglein '22*]

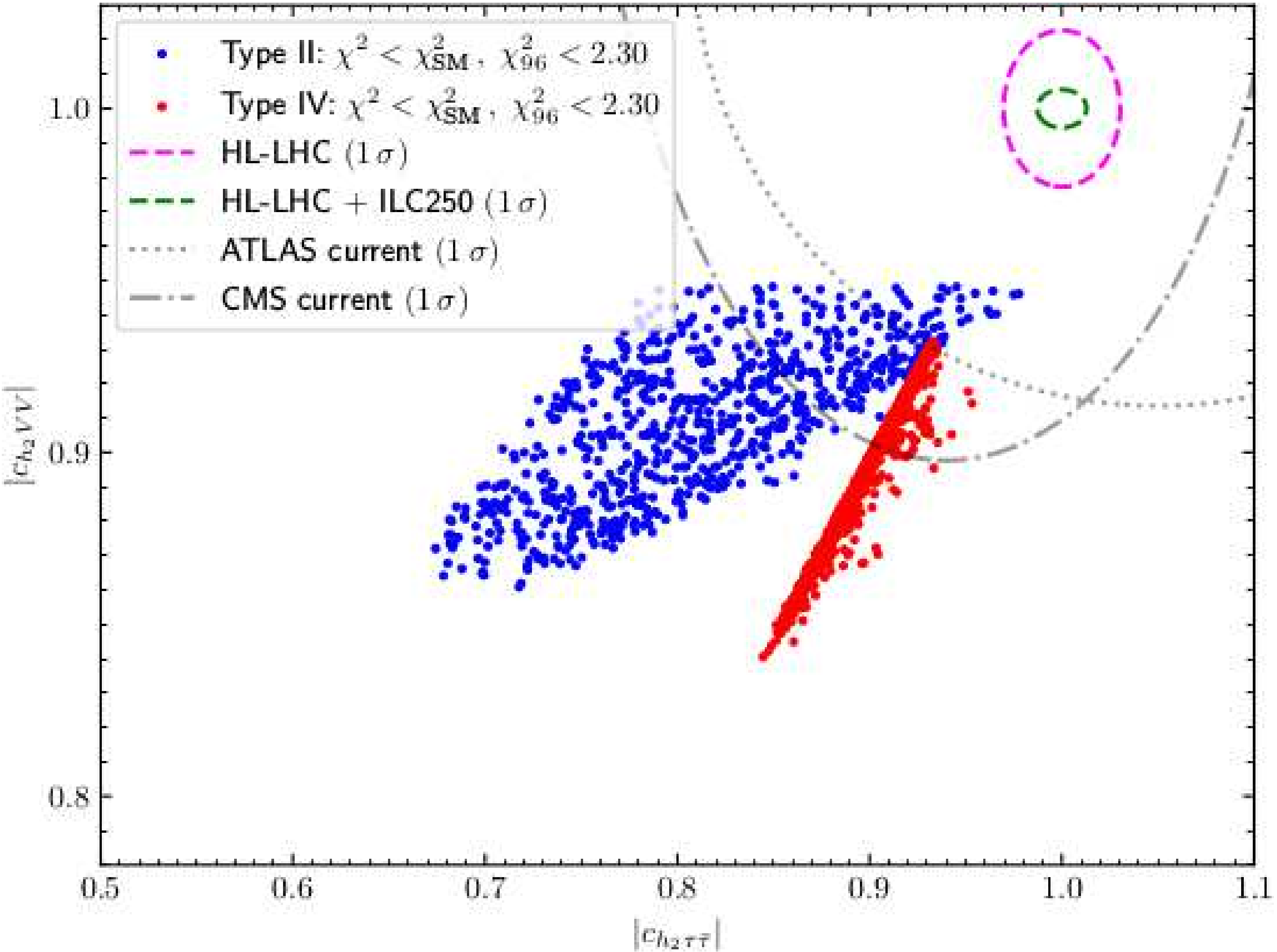


Color coding: χ^2_{125} from HiggsSignals

⇒ type IV can fit the $\gamma\gamma$, $\tau\tau$ and bb excesses

HL-LHC/ILC h_{125} coupling measurements

[T. Biekötter, S.H., G. Weiglein – PRELIMINARY]

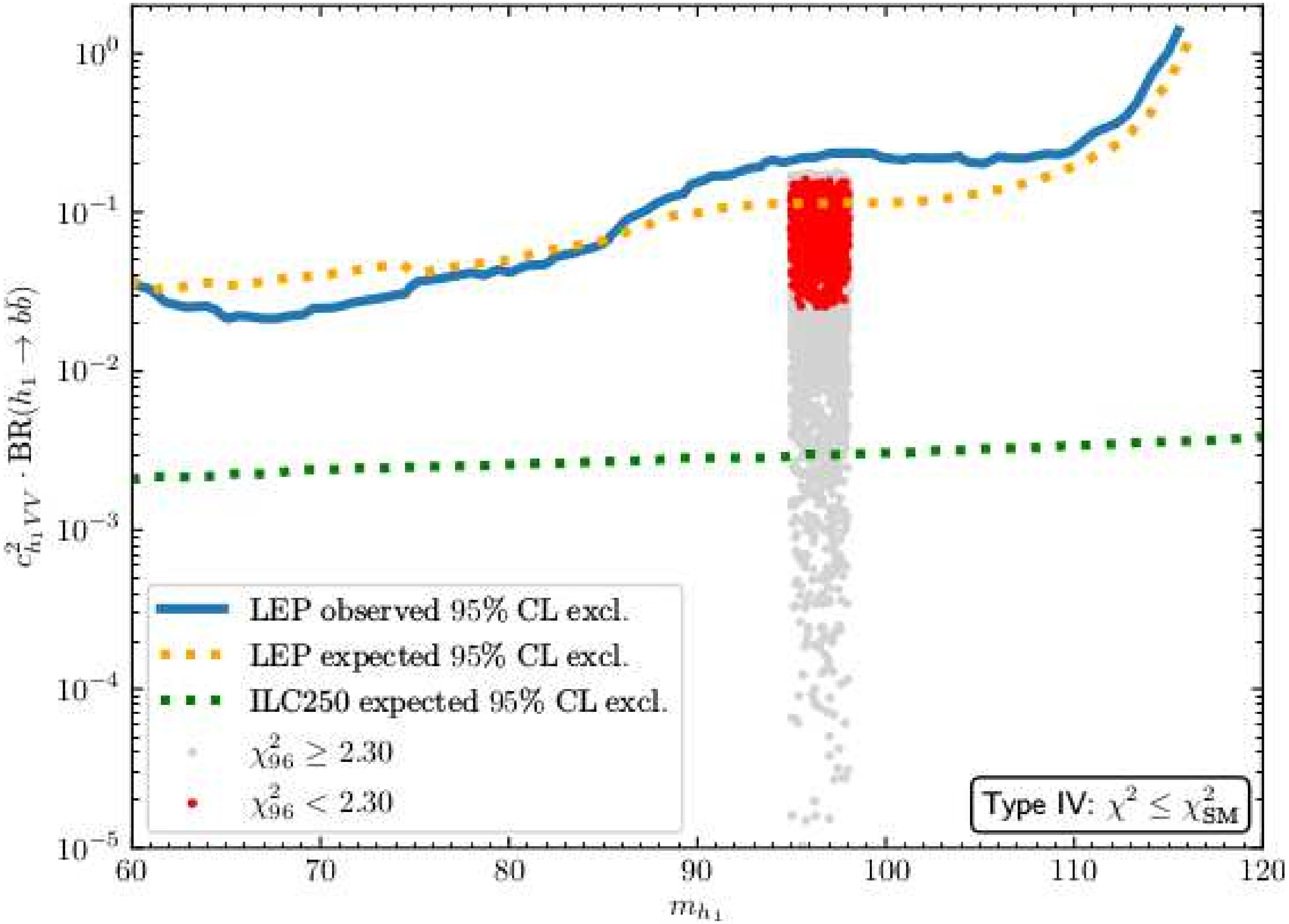


⇒ type II and IV show strong deviations from SM

⇒ indirect test of the model possible ⇒ interplay!

ILC production of the light scalar in the N2HDM type II/IV:

[*T. Biekötter, S.H., G. Weiglein – PRELIMINARY*]

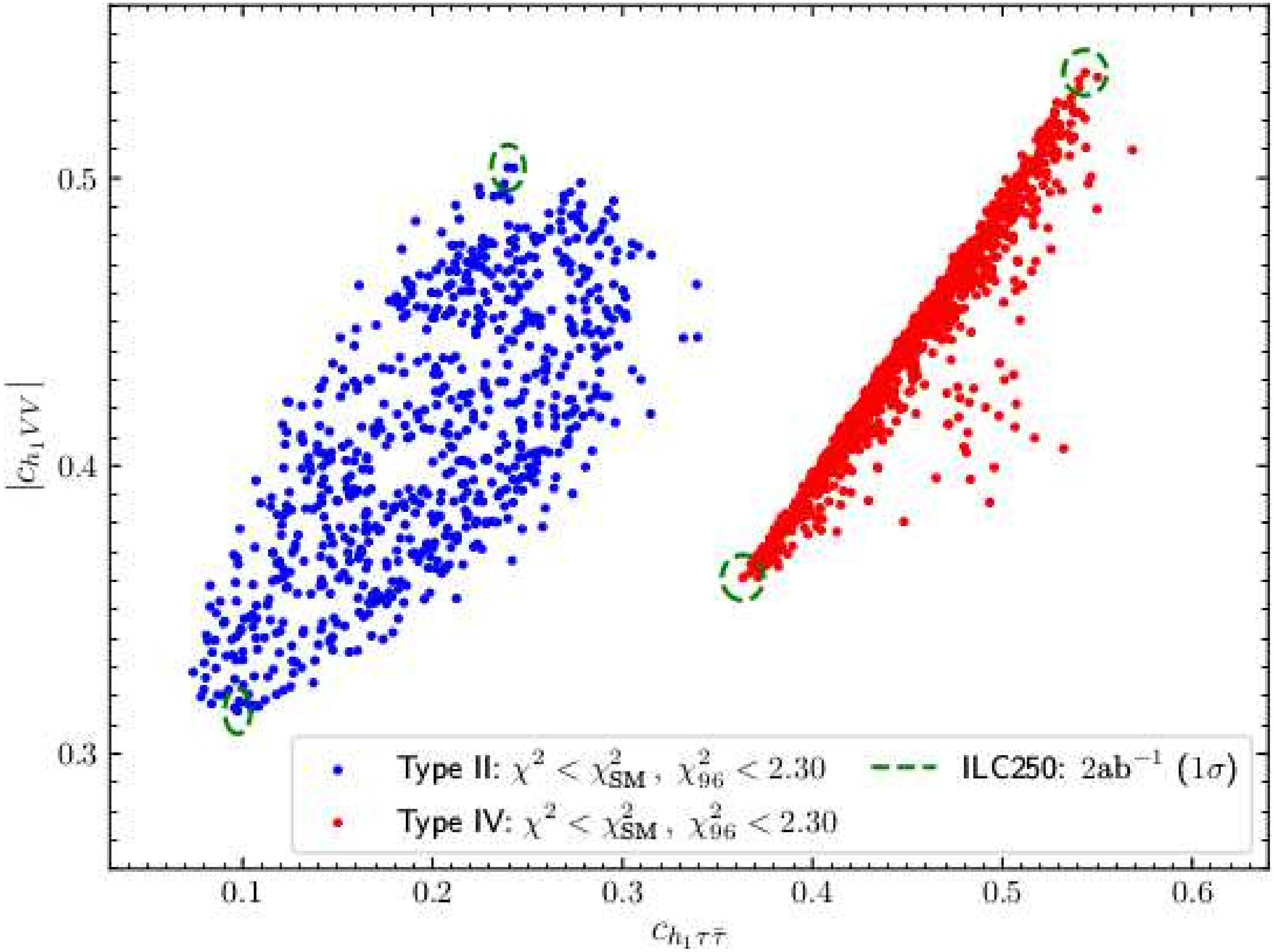


$\Rightarrow$ new state easily in the reach of the ILC $\Rightarrow$ coupling measurements

ILC ϕ_{95} coupling measurements at the ILC

[*T. Biekötter, S.H., G. Weiglein – PRELIMINARY*]

green circles: ϕ_{95} coupling precision at the ILC250



⇒ direct and indirect measurement "at once" ⇒ interplay!

5. Conclusinos

- The discovered Higgs boson cannot be the SM Higgs boson
  - search for additional Higgs bosons above and below 125 GeV $\Downarrow$
  - check changed properties of h_{125} ⇒ indirect direct

- Search for heavy Higgs bosons
  - reach of e^+e^- colliders “naturally” limited: $M_A/2 \lesssim \sqrt{s}$
  - if in reach: precision analysis possible ⇒ interplay!

- Coupling measurement of h_{125}:
  - e^+e^- precision can be decisive
  - upper limits on new Higgs mass scales possible ⇒ interplay!
  - model distinction difficult, direct searches needed ⇒ interplay!

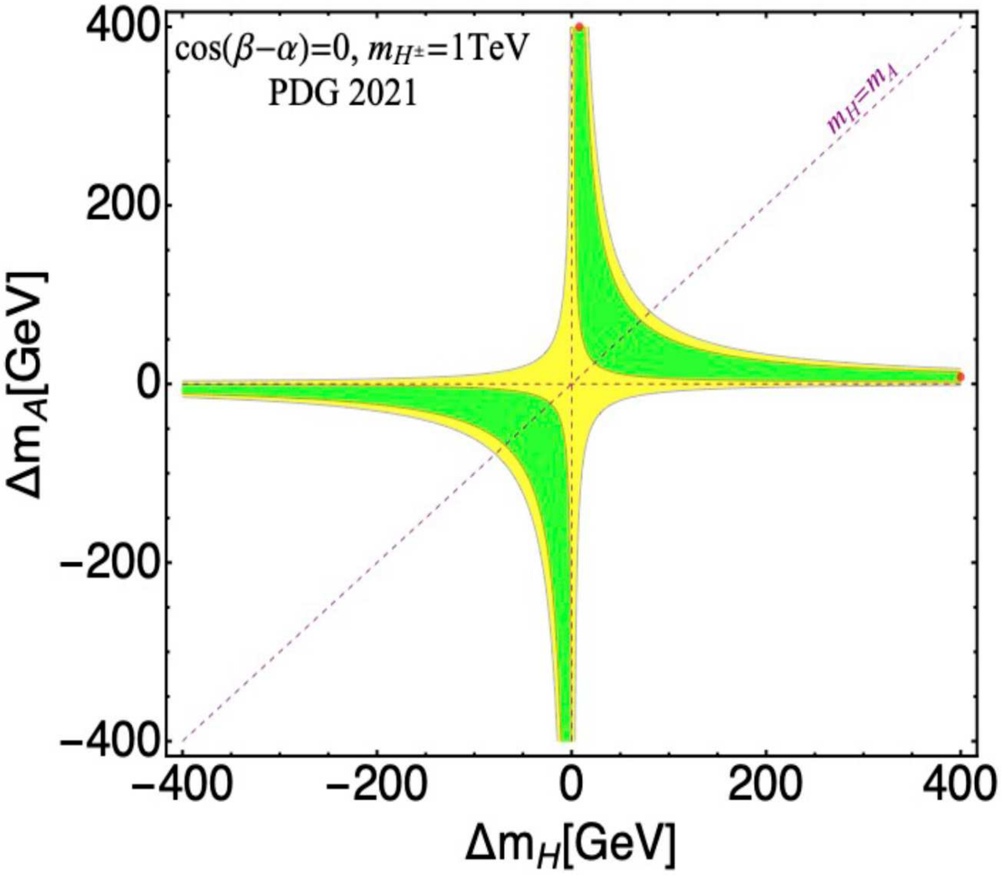
- Search for light Higgs bosons
  - reach of e^+e^- colliders very strong
  - precision measurements of new Higgs bosons possible
  - model distinction possible
  - direct and indirect measurements “at once” ⇒ interplay!


Further Questions?

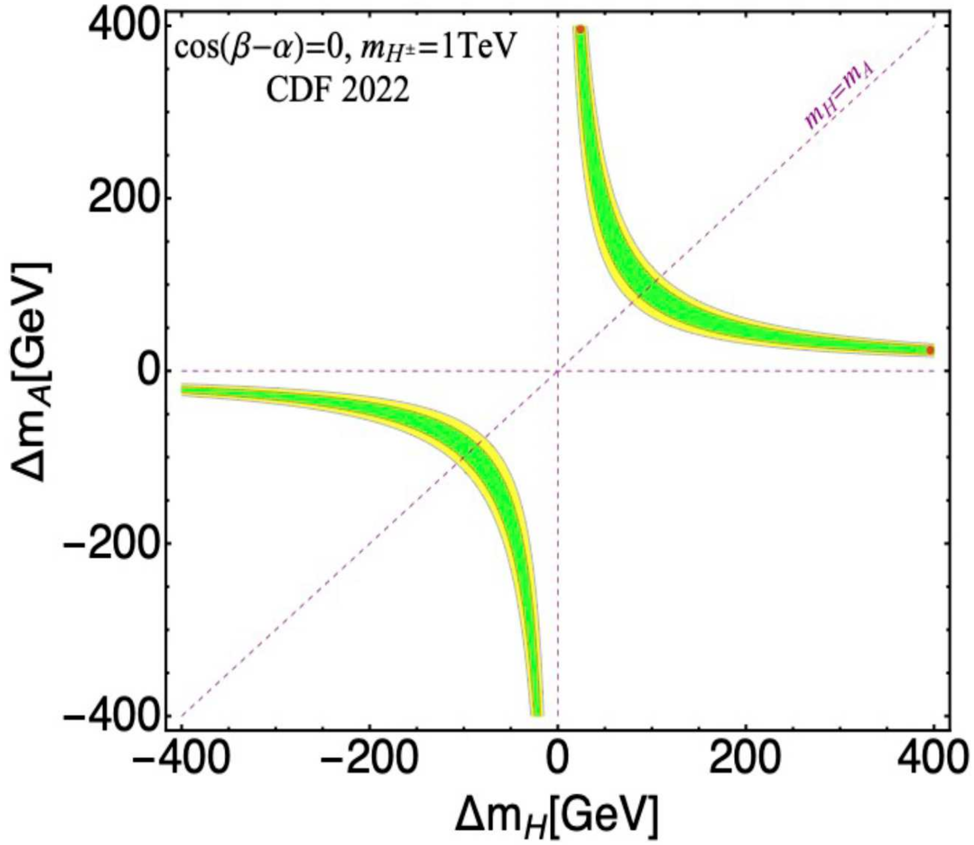
Example: $m_{H^\pm} = 1000$ GeV, $\cos(\beta-\alpha) = 0$

[C. Lu, L. Wu, Y. Wu, B. Zhu '22]

PDG 2021



M_W^{CDF}



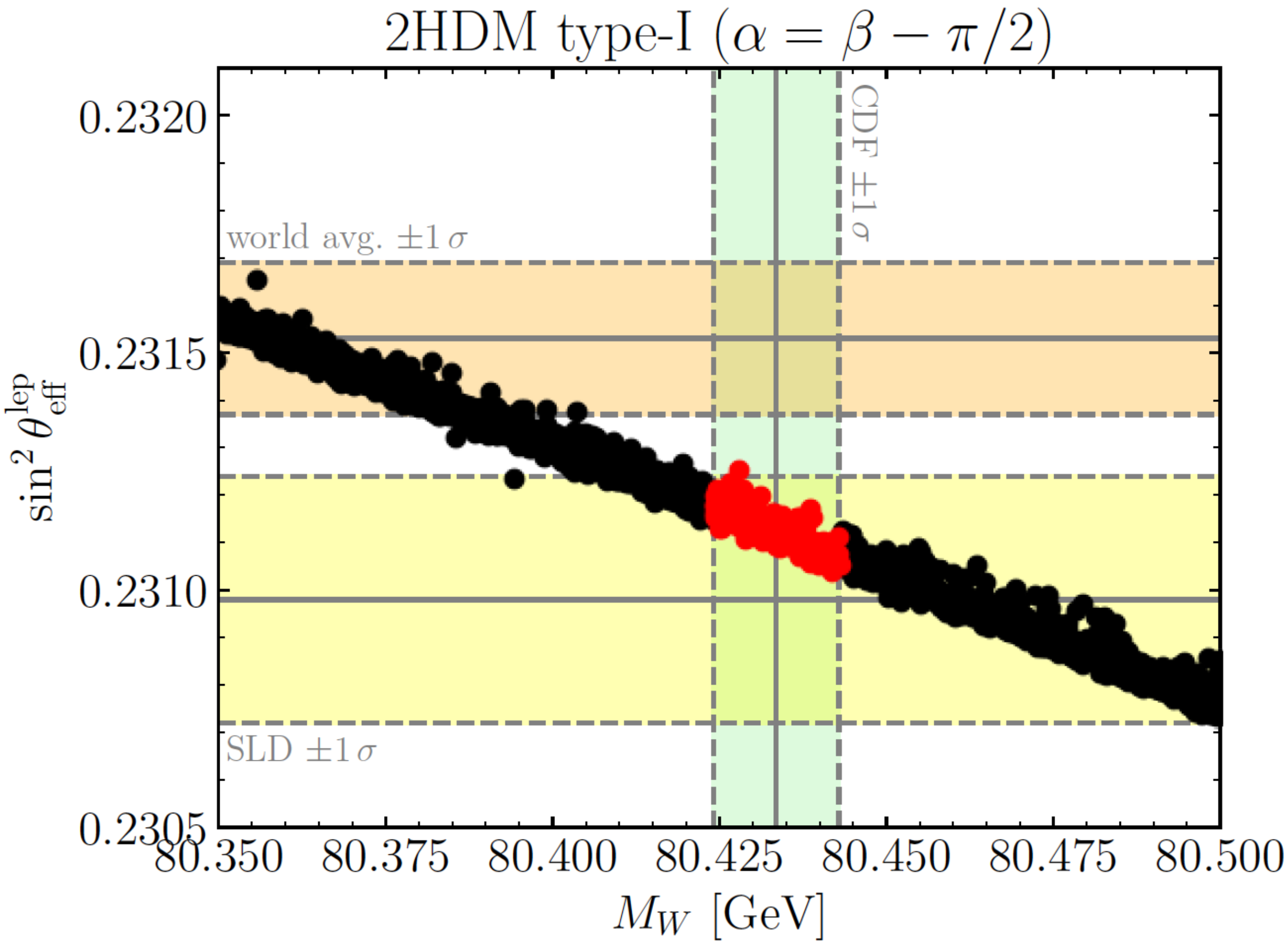
⇒ nearly no overlap of the $2\,\sigma$ regions

⇒ new CDF value requires relatively large BSM Higgs mass splitting

⇒ but no upper limit on heavy Higgs-boson mass scale

M_W^{CDF} vs. $\sin^2\theta_{\text{eff}}$ in the 2HDM

[H. Bahl, J. Braathen, G. Weiglein '22]



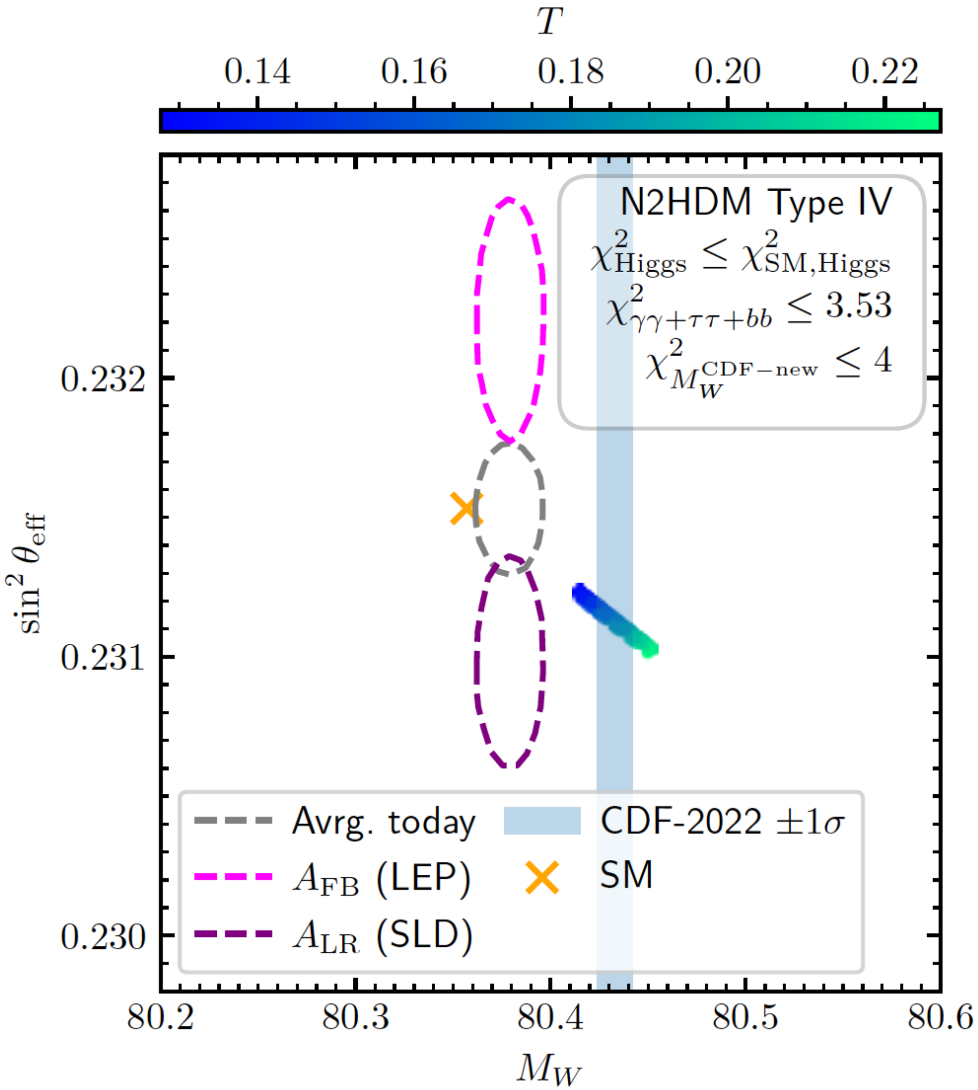
Remember: $\Delta\rho$ goes up $\Rightarrow$ M_W goes up, $\sin^2\theta_{\text{eff}}$ goes down

$\Rightarrow$ agreement only with SLD value of $\sin^2\theta_{\text{eff}}$

M_W^{CDF} vs. $\sin^2\theta_{\text{eff}}$ in the N2HDM

[*T. Biekötter, S.H., G. Weiglein '22*]

⇒ N2HDM favored by 3 independent excesses in Higgs searches at ∼ 95 GeV



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Possible hint for heavy Higgses in the N2HDM:

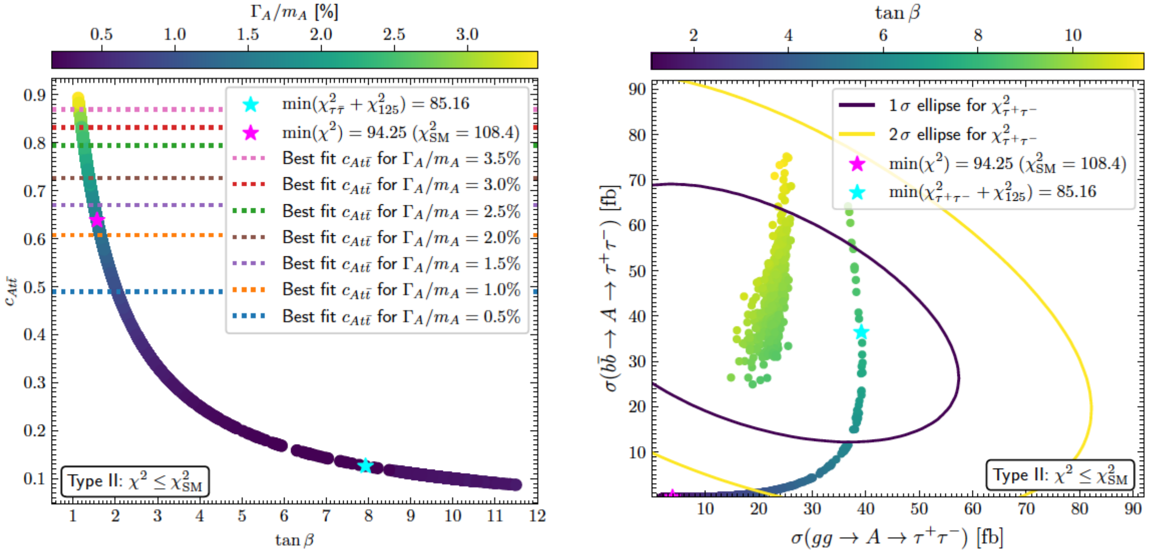
[*taken from T. Biekötter '21*]

A 400 GeV pseudoscalar in the type II N2HDM

$$\chi^2 = \chi^2_{125} + \chi^2_{t\bar{t}} + \chi^2_{\tau^+\tau^-}$$, we demand: $\chi^2 \le \chi^2_{\mathrm{SM}}$

$$20\ \mathrm{GeV} \le m_{h_{a,c}} \le 1000\ \mathrm{GeV}\ ,\quad m_{h_b} = 125.09\ \mathrm{GeV}\ ,\quad m_A = 400\ \mathrm{GeV}\ ,$$

$$550\ \mathrm{GeV} \le m_{H^\pm} \le 1000\ \mathrm{GeV}\ ,\quad 10\ \mathrm{GeV} \le v_s \le 1500\ \mathrm{GeV}\ ,\quad 0.5 \le \tan\beta \le 12.5$$



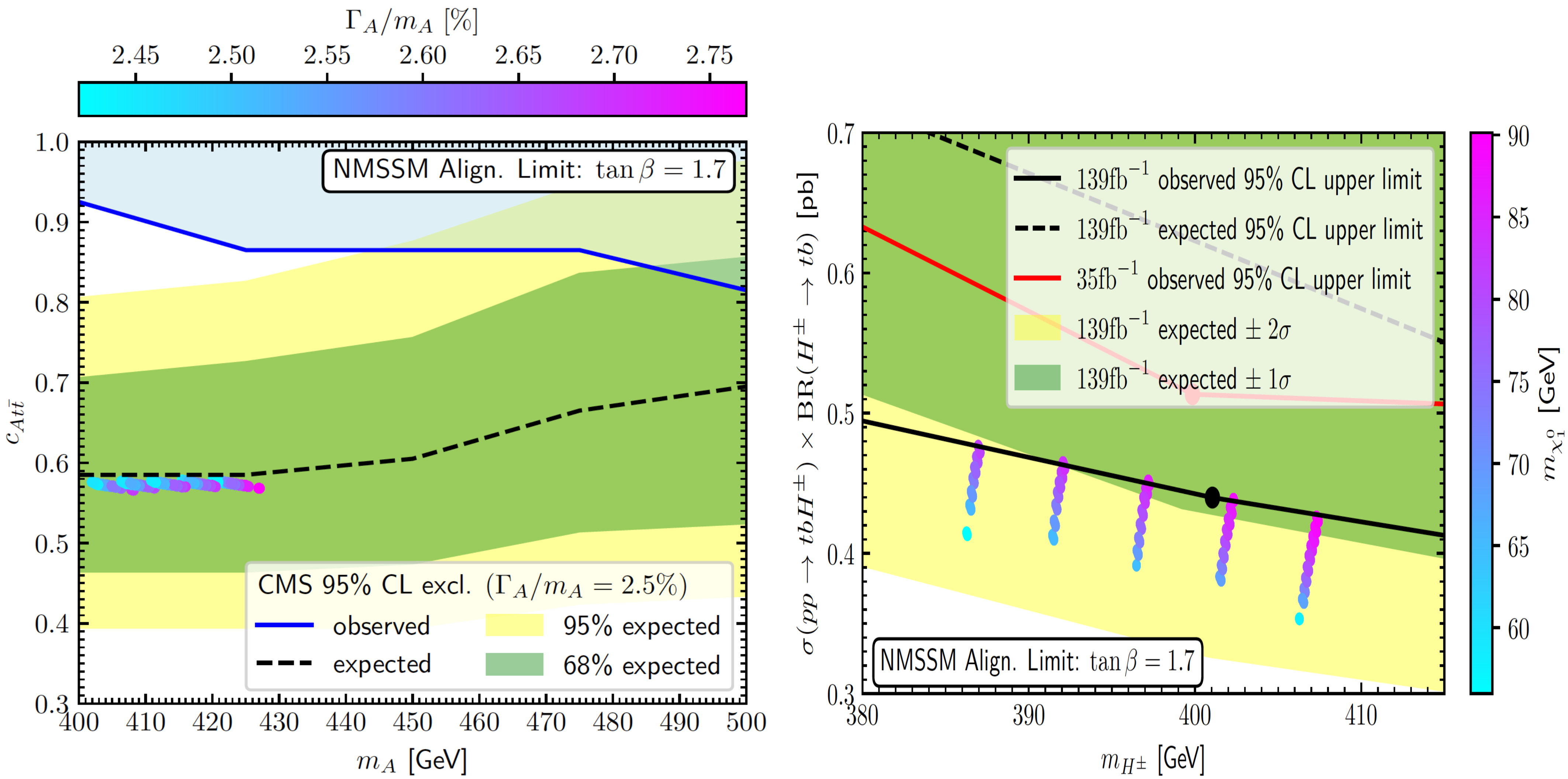
(Also the "$A \to Zh$" excess can be realized)
→ Later

Both the $t\bar{t}$ and the $\tau^+\tau^-$ excesses can be realized, but not simultaneously

$\tan\beta \lesssim 2.5$ for $t\bar{t}$ excess
$\tan\beta \gtrsim 5.5$ for $\tau^+\tau^-$ excess

[*T. Biekötter, A. Grohsjean, S.H., C. Schwanenberger, G. Weiglein '21*]

Possible hint for heavy Higgses in the NMSSM (with $\tan\beta = 1.7$):

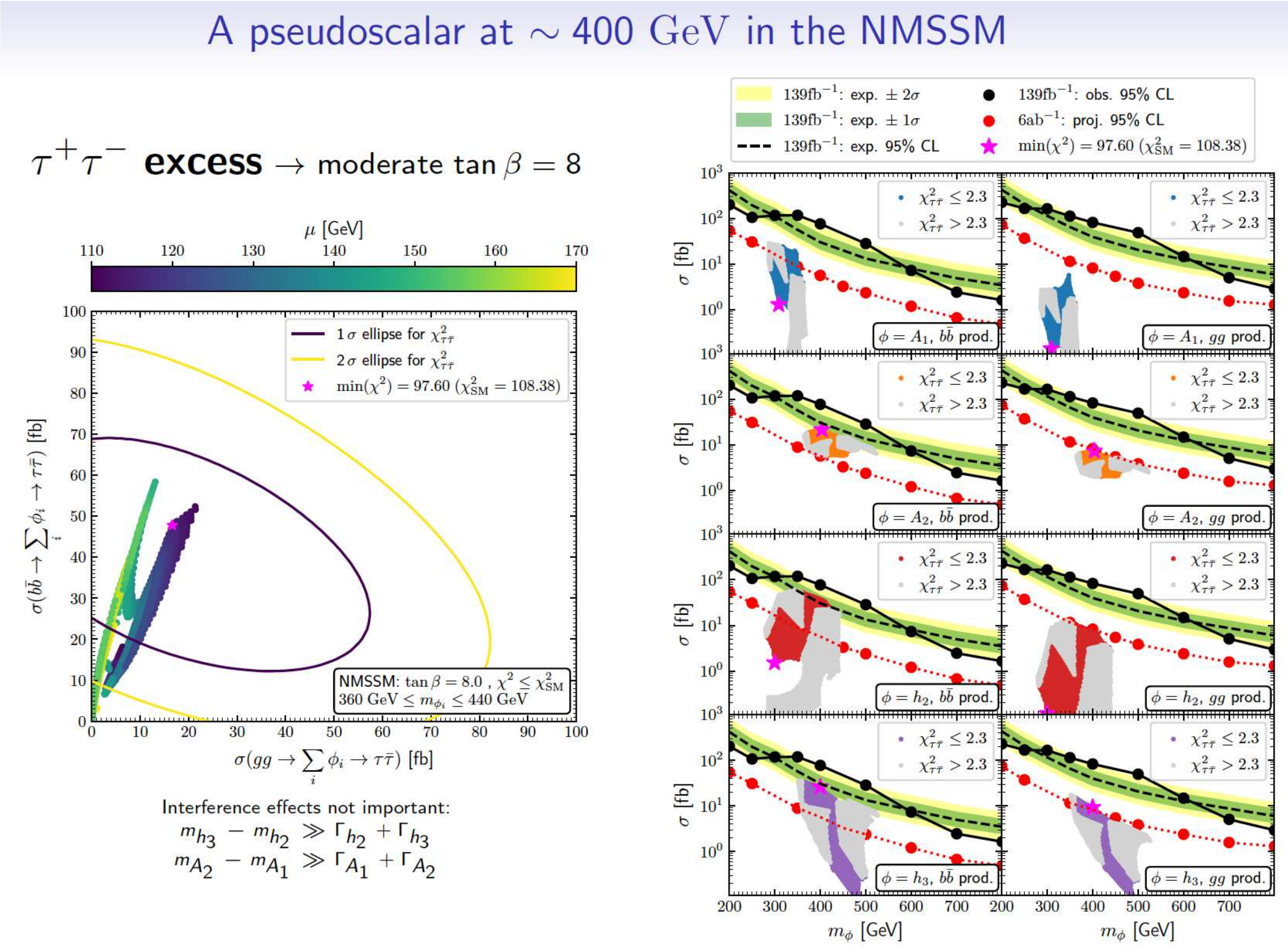


$\Rightarrow t\bar{t}$ excess can be explained in the NMSSM (with $\tan\beta \sim 1.7$)

[*T. Biekötter, A. Grohsjean, S.H., C. Schwanenberger, G. Weiglein '21*]

Possible hint for heavy Higgses in the NMSSM (with $\tan\beta = 8$):

[*taken from T. Biekötter '21*]



A pseudoscalar at ~ 400 GeV in the NMSSM

$\tau^+\tau^-$ **excess** → moderate $\tan\beta = 8$

Interference effects not important:

$$m_{h_3} - m_{h_2} \gg \Gamma_{h_2} + \Gamma_{h_3}$$
$$m_{A_2} - m_{A_1} \gg \Gamma_{A_1} + \Gamma_{A_2}$$

[*T. Biekötter, A. Grohsjean, S.H., C. Schwanenberger, G. Weiglein '21*]

SUSY realizations

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- NMSSM
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- ...

Q: Can the models fit the excesses despite the additional SUSY constraints on the Higgs sector **???**

What about the NMSSM?

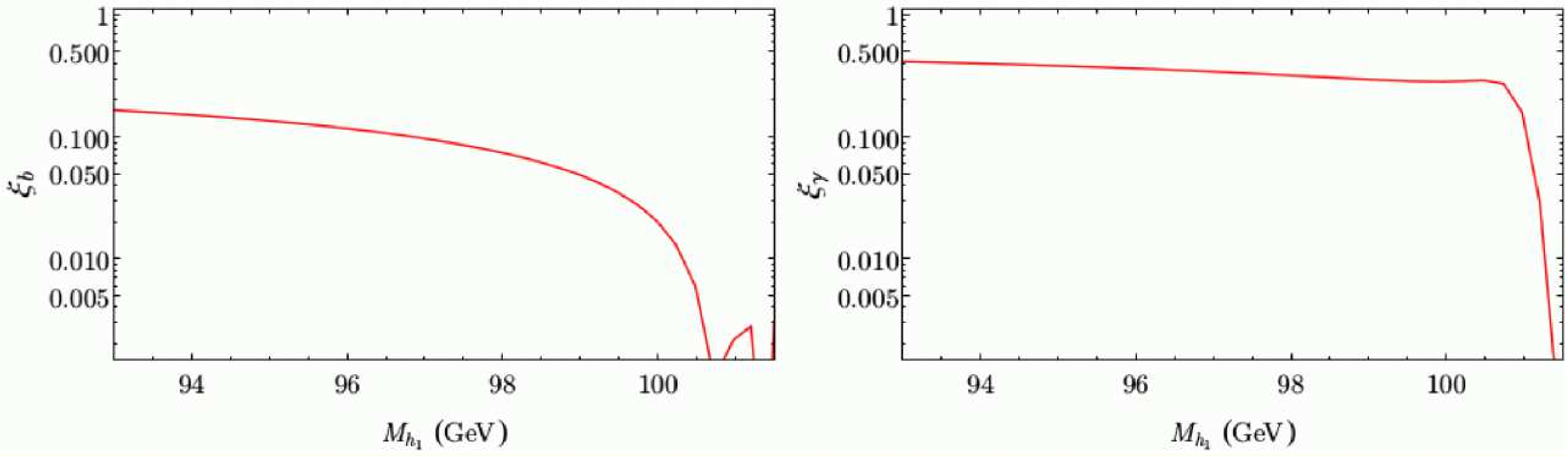
[*F. Domingo, S.H., S. Passehr, G. Weiglein '18*]

Parameters:

$\lambda = 0.6,\ \kappa = 0.035,\ \tan\beta = 2,\ \mu_{\text{eff}} = (397 + 15x)$ GeV, $M_{H^\pm} = 1$ TeV, $A_\kappa = -325$ GeV, $M_{\text{SUSY}} = 1$ TeV, $A_t = A_b = 0$

$$\xi_b \equiv \frac{\Gamma[h_1 \to ZZ] \cdot \text{BR}[h_1 \to b\bar{b}]}{\Gamma[H_{\text{SM}}(M_{h_1}) \to ZZ] \cdot \text{BR}[H_{\text{SM}}(M_{h_1}) \to b\bar{b}]} \sim \frac{\sigma[e^+e^- \to Z(h_1 \to b\bar{b})]}{\sigma[e^+e^- \to Z(H_{\text{SM}}(M_{h_1}) \to b\bar{b})]}$$

$$\xi_\gamma \equiv \frac{\Gamma[h_1 \to gg] \cdot \text{BR}[h_1 \to \gamma\gamma]}{\Gamma[H_{\text{SM}}(M_{h_1}) \to gg] \cdot \text{BR}[H_{\text{SM}}(M_{h_1}) \to \gamma\gamma]} \sim \frac{\sigma[gg \to h_1 \to \gamma\gamma]}{\sigma[gg \to H_{\text{SM}}(M_{h_1}) \to \gamma\gamma]}\ .$$



⇒ both excesses can be fitted simultaneously (at $1 - 1.5\,\sigma$)!

What about the $\mu\nu$SSM?

$\mu\nu$SSM: [*D. Lopez-Fogliani, C. Muñoz '06*]

$\mu\nu$SSM: NMSSM + well motivated RPV (in simple terms)
$\Rightarrow$ EW scale seesaw to reproduce the neutrino data

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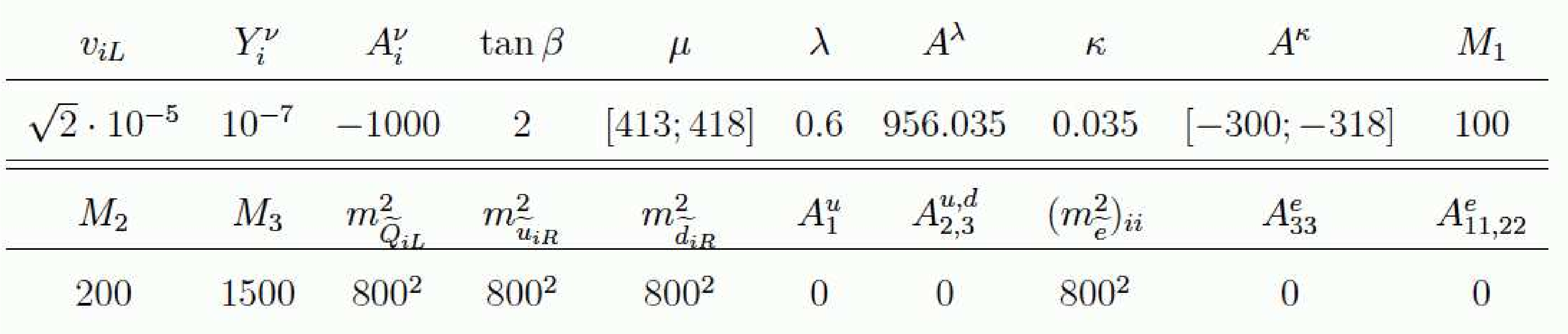
Can the $\mu\nu$SSM explain the two excesses?

[*T. Biekötter, S.H., C. Muñoz '17*]



v_{iL}	Y_i^ν	A_i^ν	$\tan\beta$	μ	λ	A^λ	κ	A^κ	M_1
$\sqrt{2}\cdot 10^{-5}$	10^{-7}	-1000	2	$[413; 418]$	0.6	956.035	0.035	$[-300; -318]$	100

M_2	M_3	$m^2_{\tilde{Q}_{iL}}$	$m^2_{\tilde{u}_{iR}}$	$m^2_{\tilde{d}_{iR}}$	A_1^u	$A_{2,3}^{u,d}$	$(m^2_{\tilde{e}})_{ii}$	A_{33}^e	$A_{11,22}^e$
200	1500	800^2	800^2	800^2	0	0	800^2	0	0

Can the $\mu\nu$SSM explain the two excesses?

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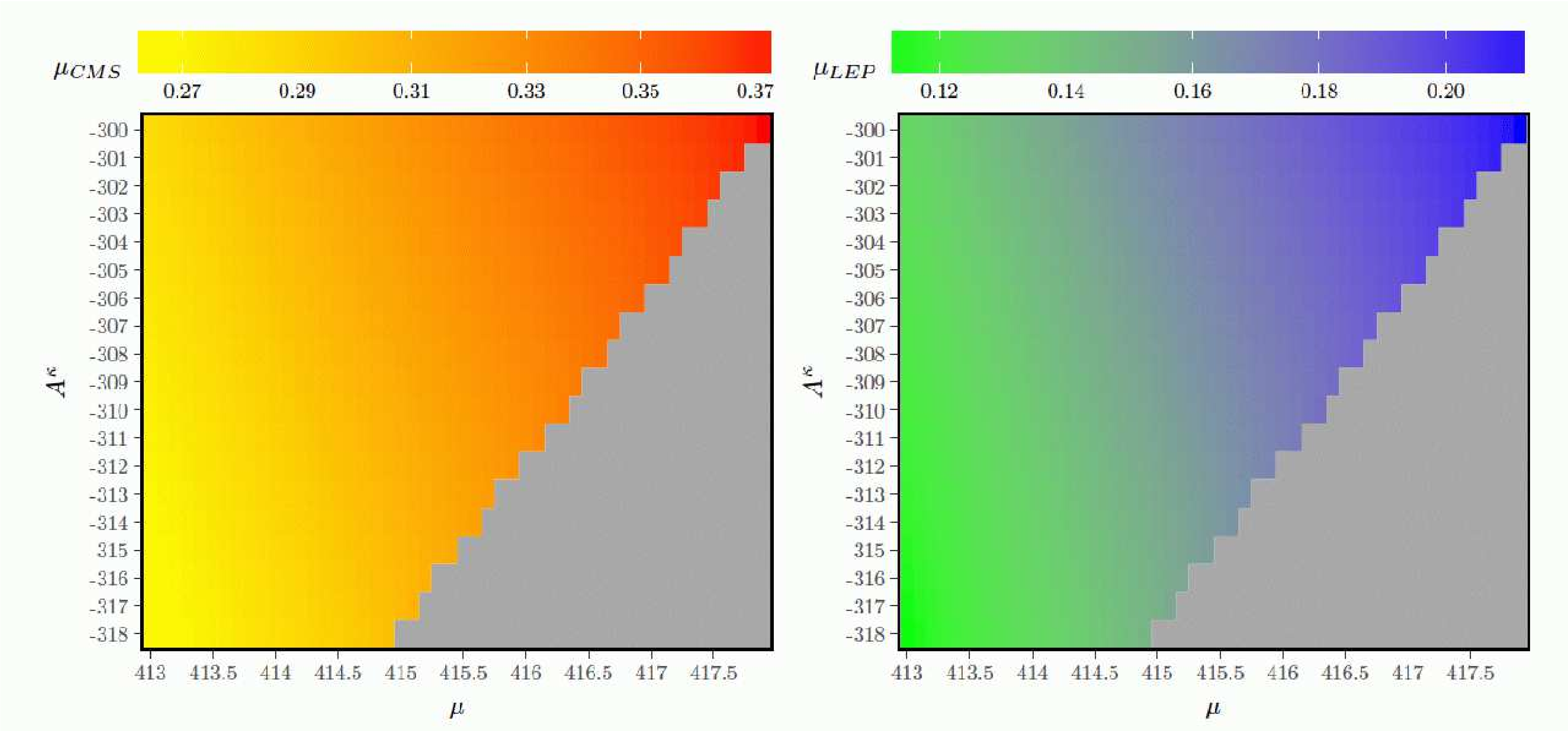
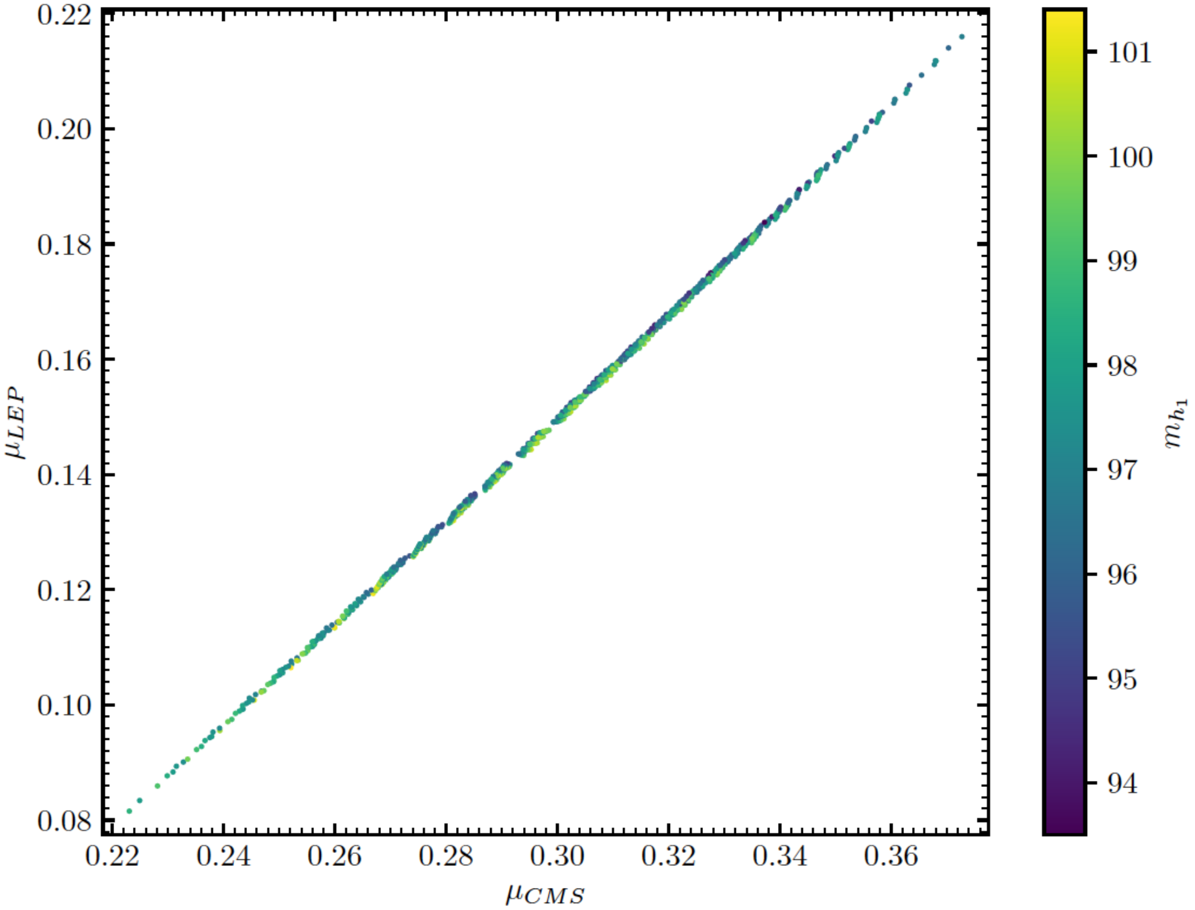


$\Rightarrow$ YES, WE CAN! :-)

at the $1 - 1.5\,\sigma$ level

Why can SUSY explain the excesses only at $1 - 1.5\,\sigma$?

[*T. Biekötter, S.H., C. Muñoz '19*]



$\Rightarrow$ SUSY enforces strong correlation!

$\Rightarrow$ note: ATLAS limits and CMS "observation"
will likely result in a lower μ_{LHC}!

The final challenge:
can the excesses at $400\ \mathrm{GeV}$ and $96\ \mathrm{GeV}$ be explained simultaneously?

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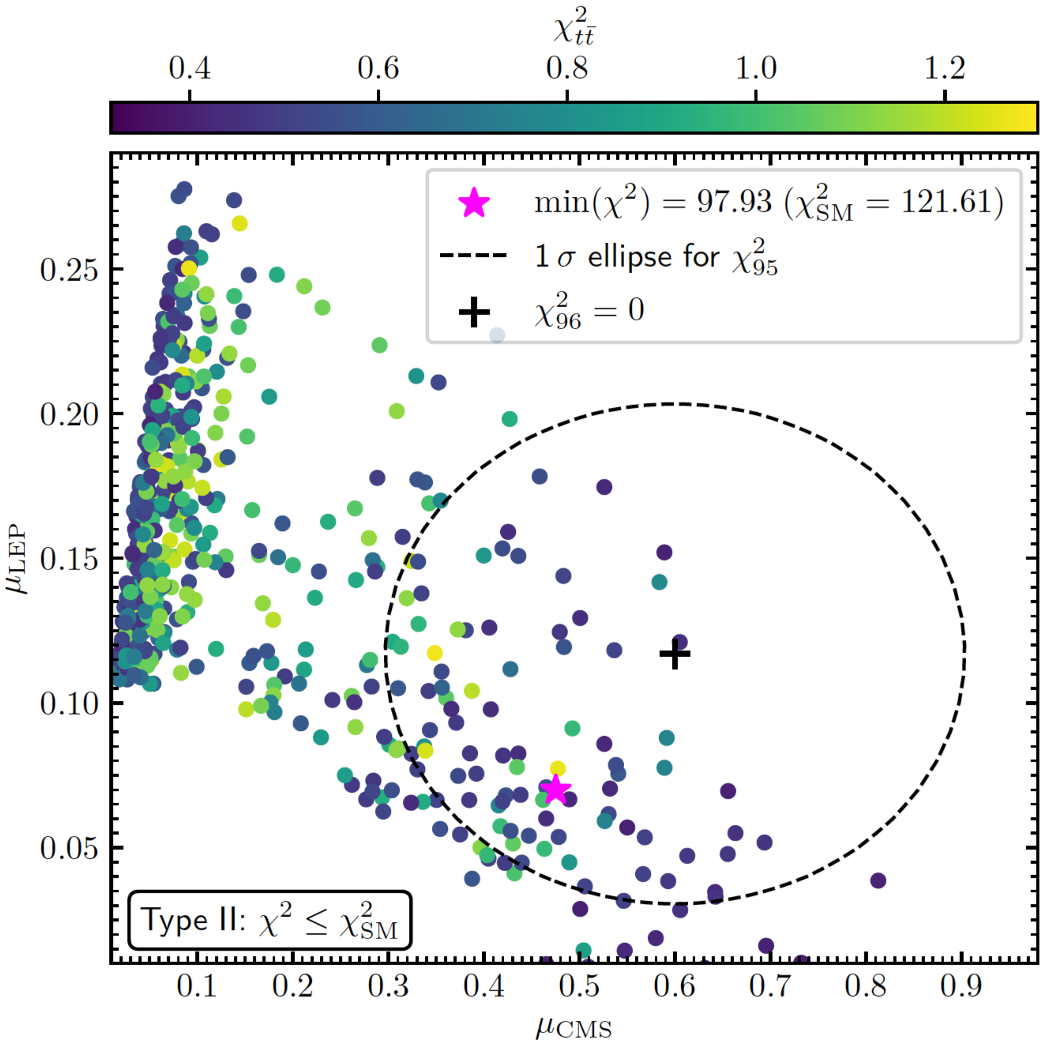
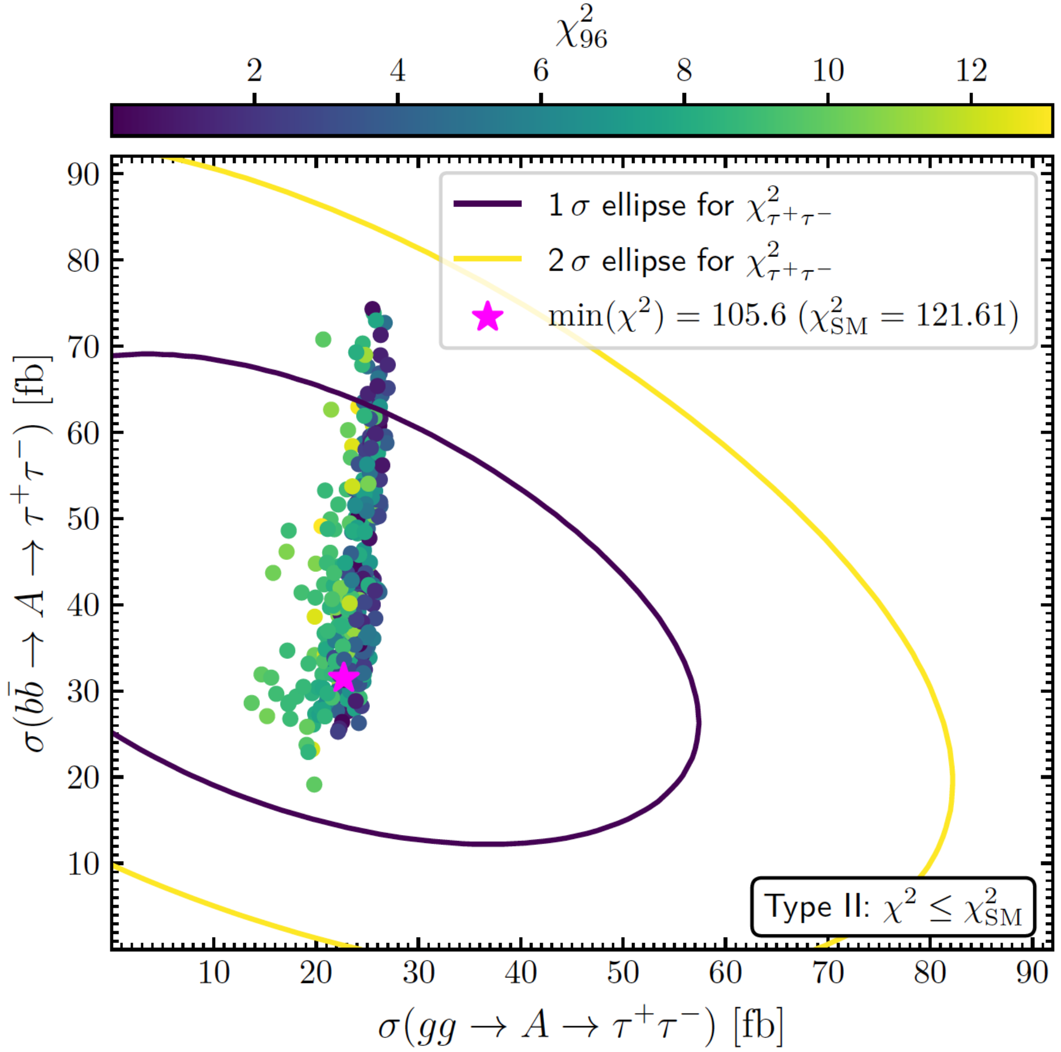
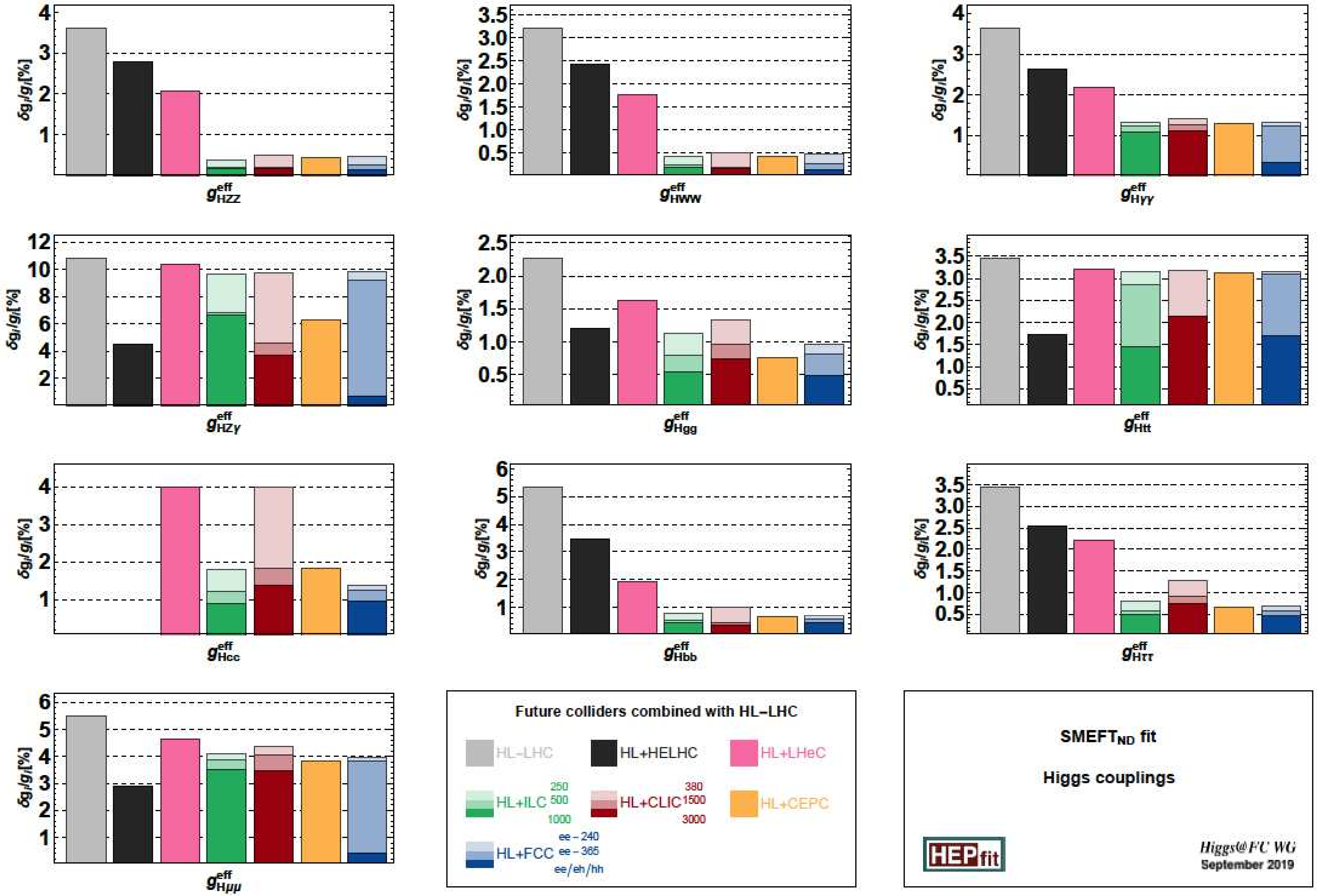
$\Rightarrow$ Yes, in the N2HDM





[*T. Biekötter, A. Grohsjean, S.H., C. Schwanenberger, G. Weiglein '21*]

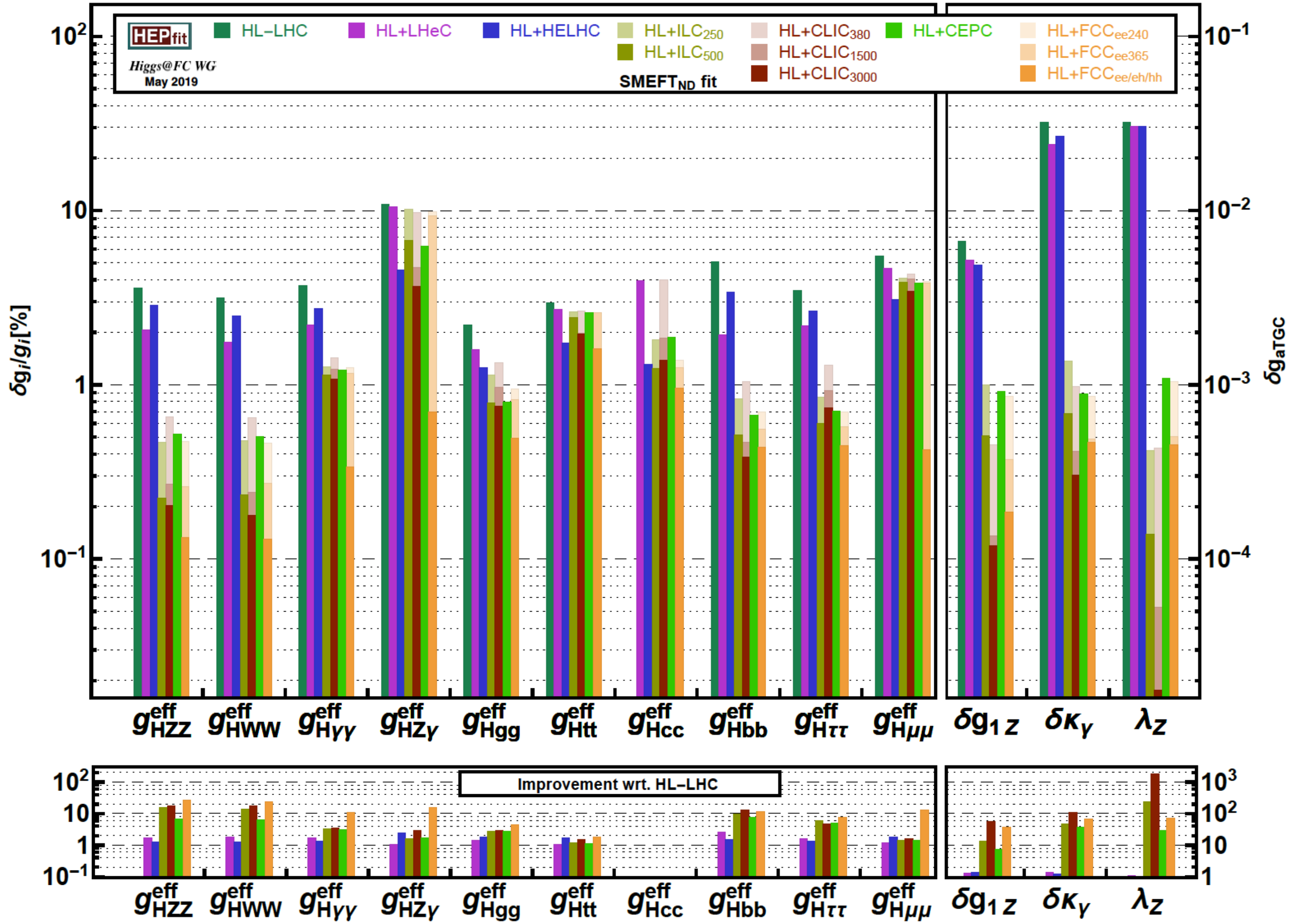
Future expections for Higgs couplings in SMEFT (I)



⇒ clear improvement with the ILC!

⇒ polarization important to disentangle BSM coupling structures

Future expections for Higgs couplings in SMEFT (II)



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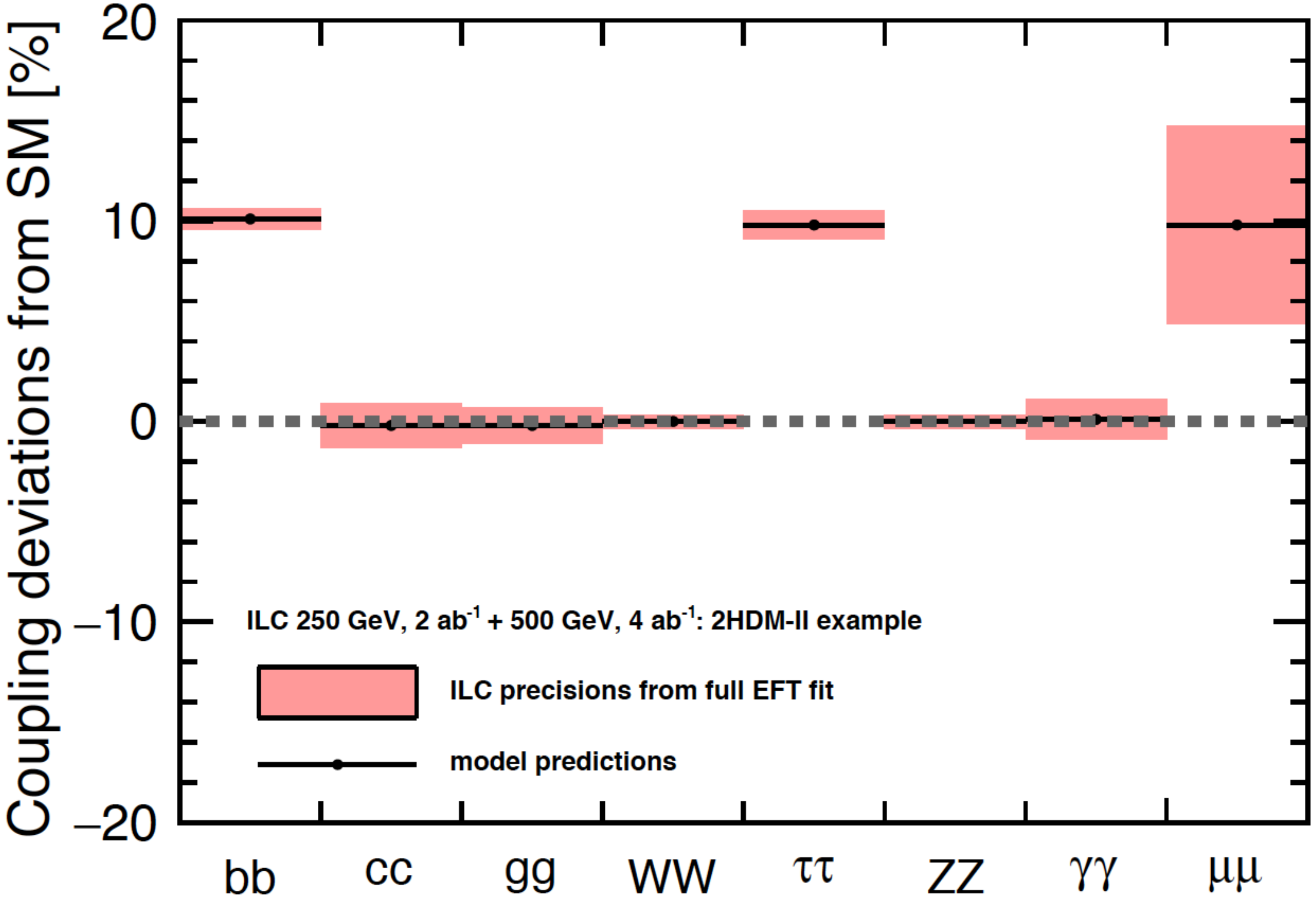
Wäscheleine I: e^+e^- precision vs. 2HDM type II prediction:

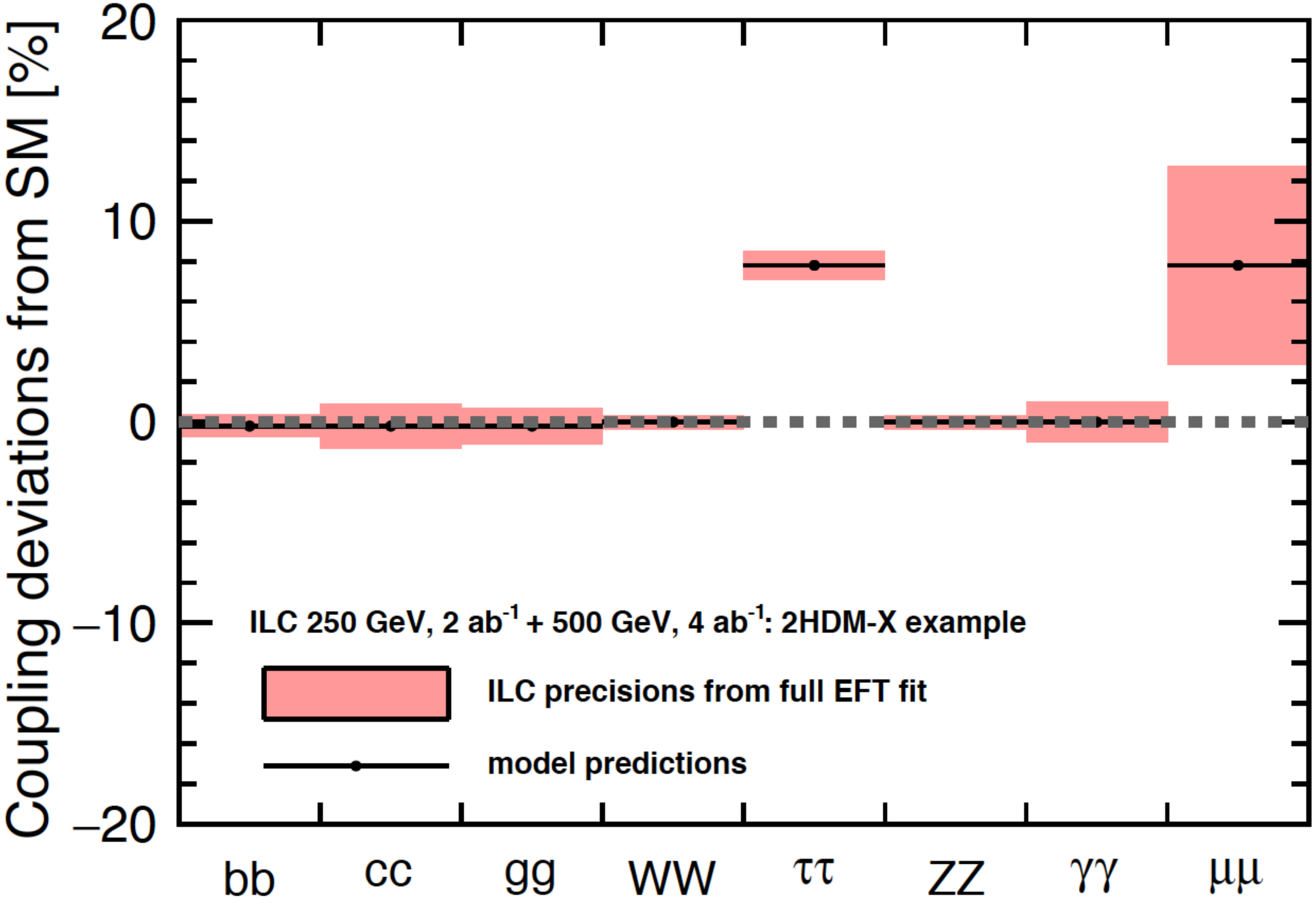
[*T. Barklow et al., '17*]



⇒ clear pattern, distinctive for 2HDM type II?!

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

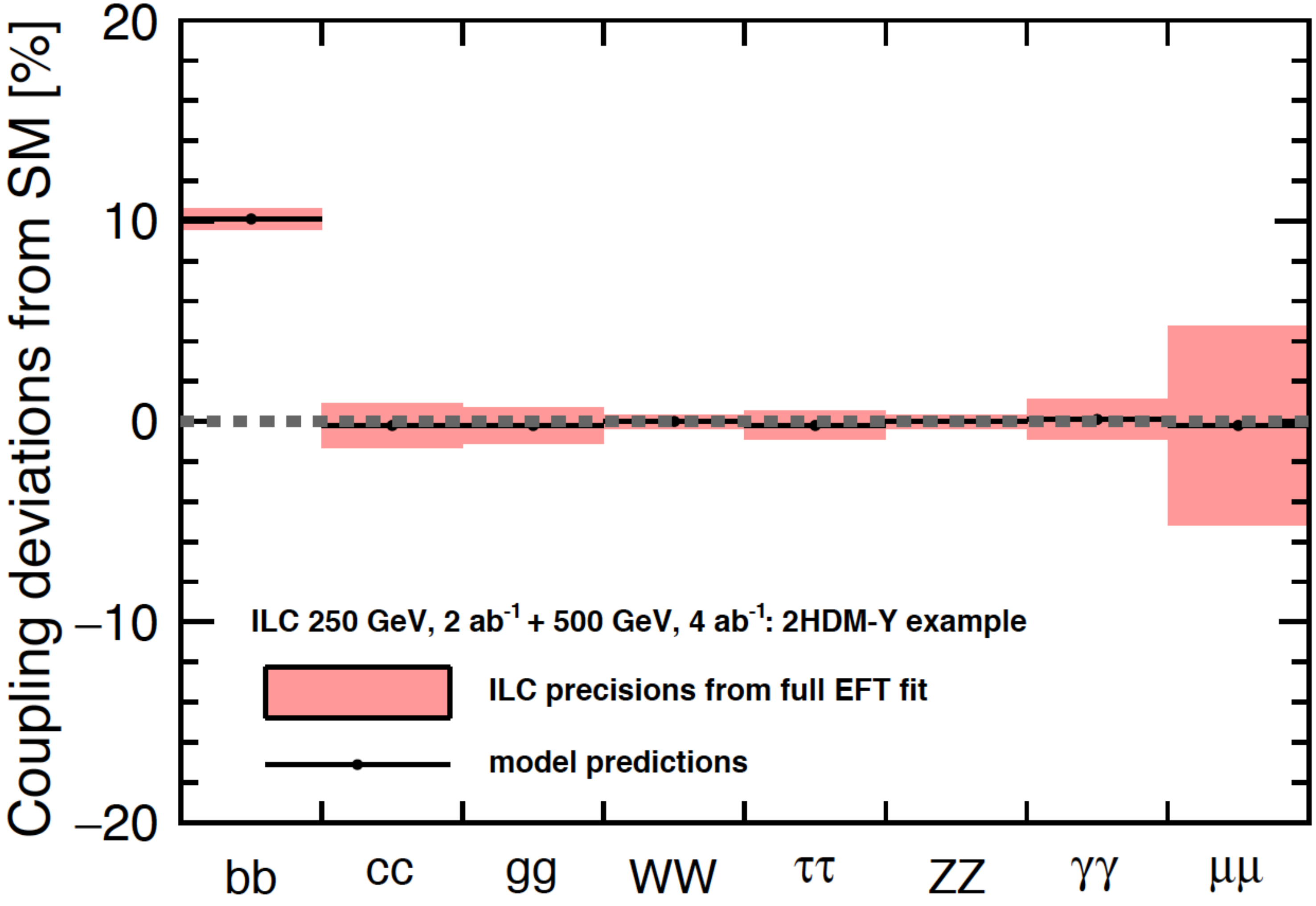
[*T. Barklow et al., '17*]



⇒ clear pattern, distinctive for 2HDM type X?!

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

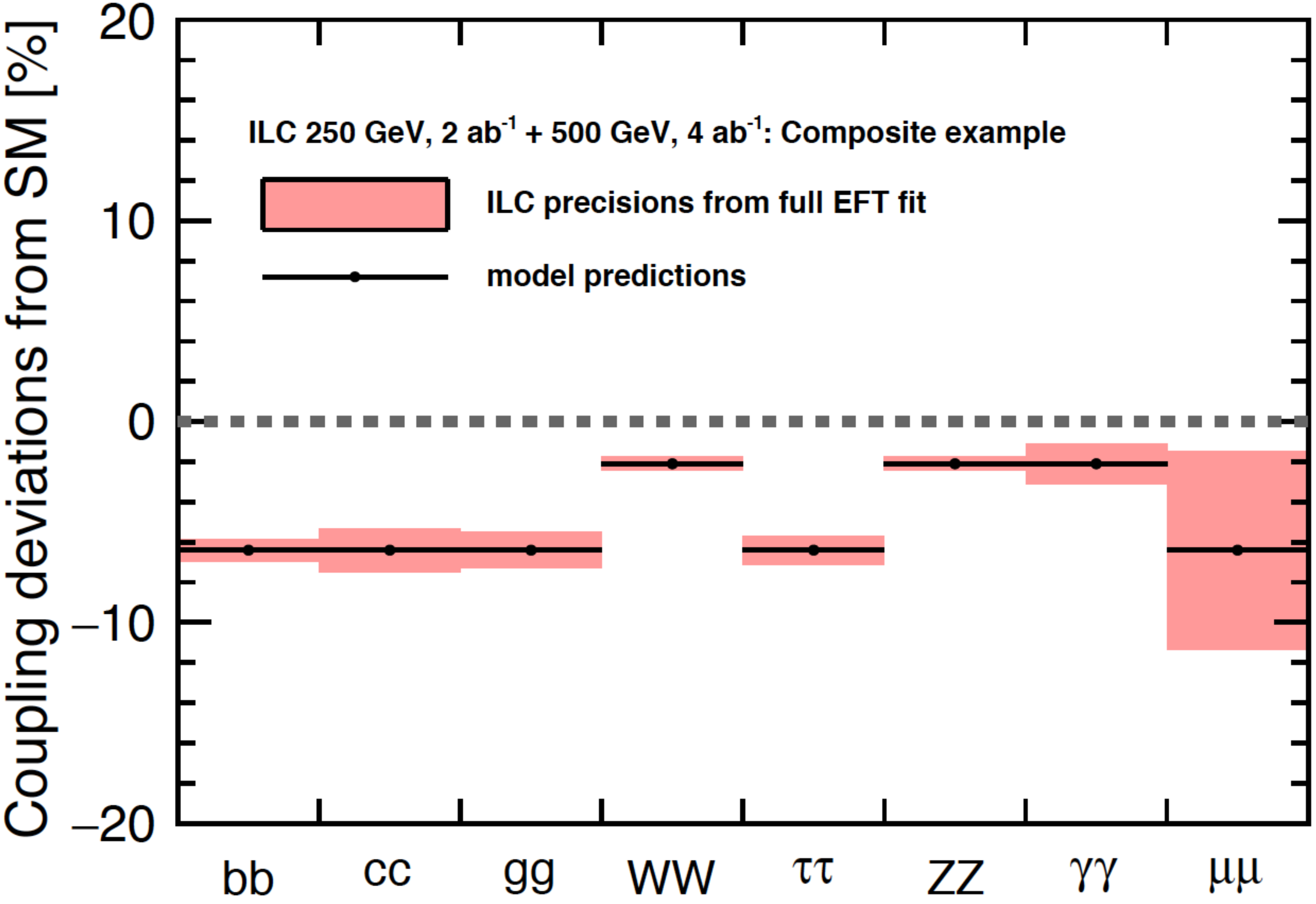
[*T. Barklow et al., '17*]



⇒ clear pattern, distinctive for 2HDM type Y?!

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

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



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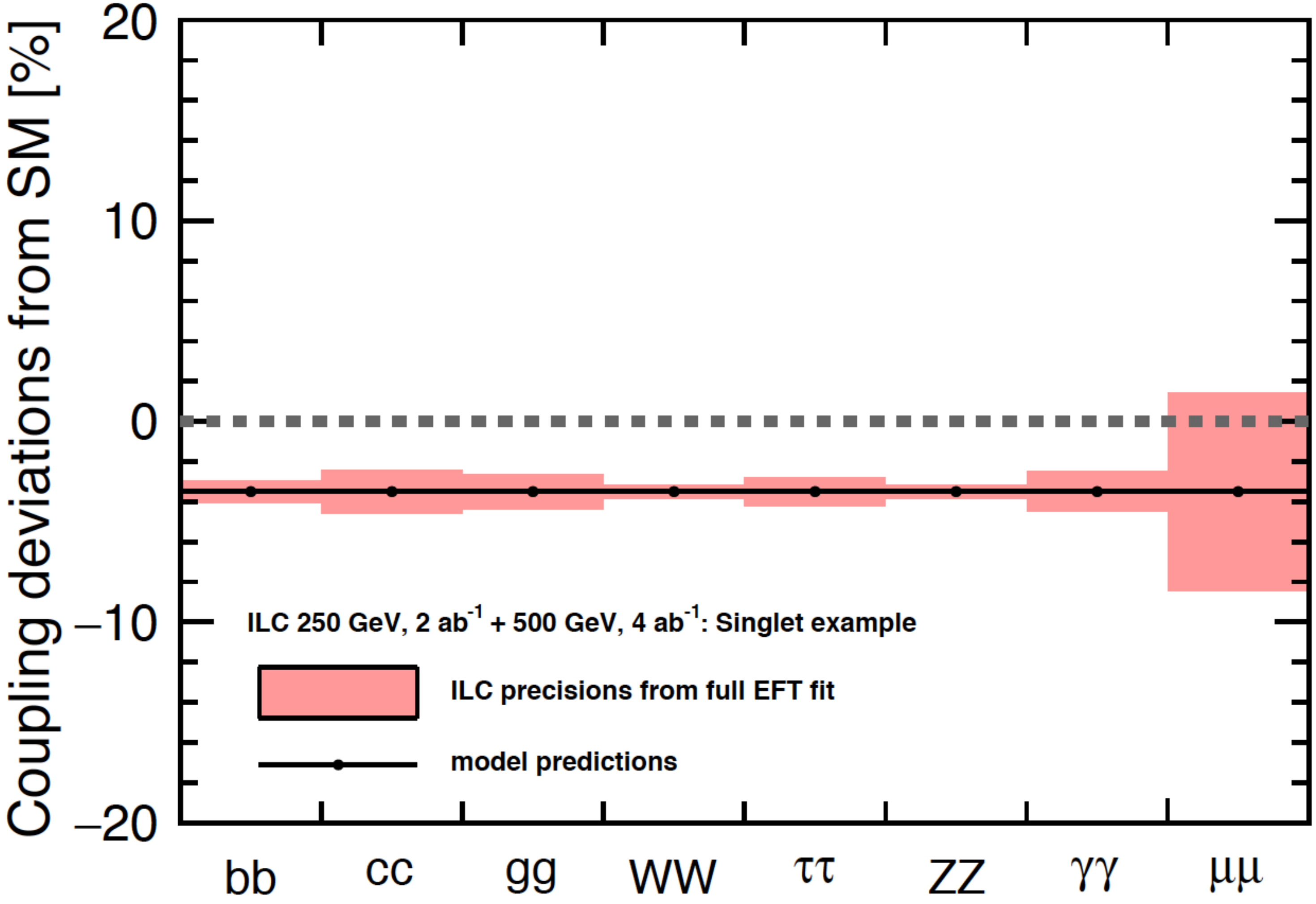
Wäscheleine V: e^+e^- precision vs. HxSM prediction:

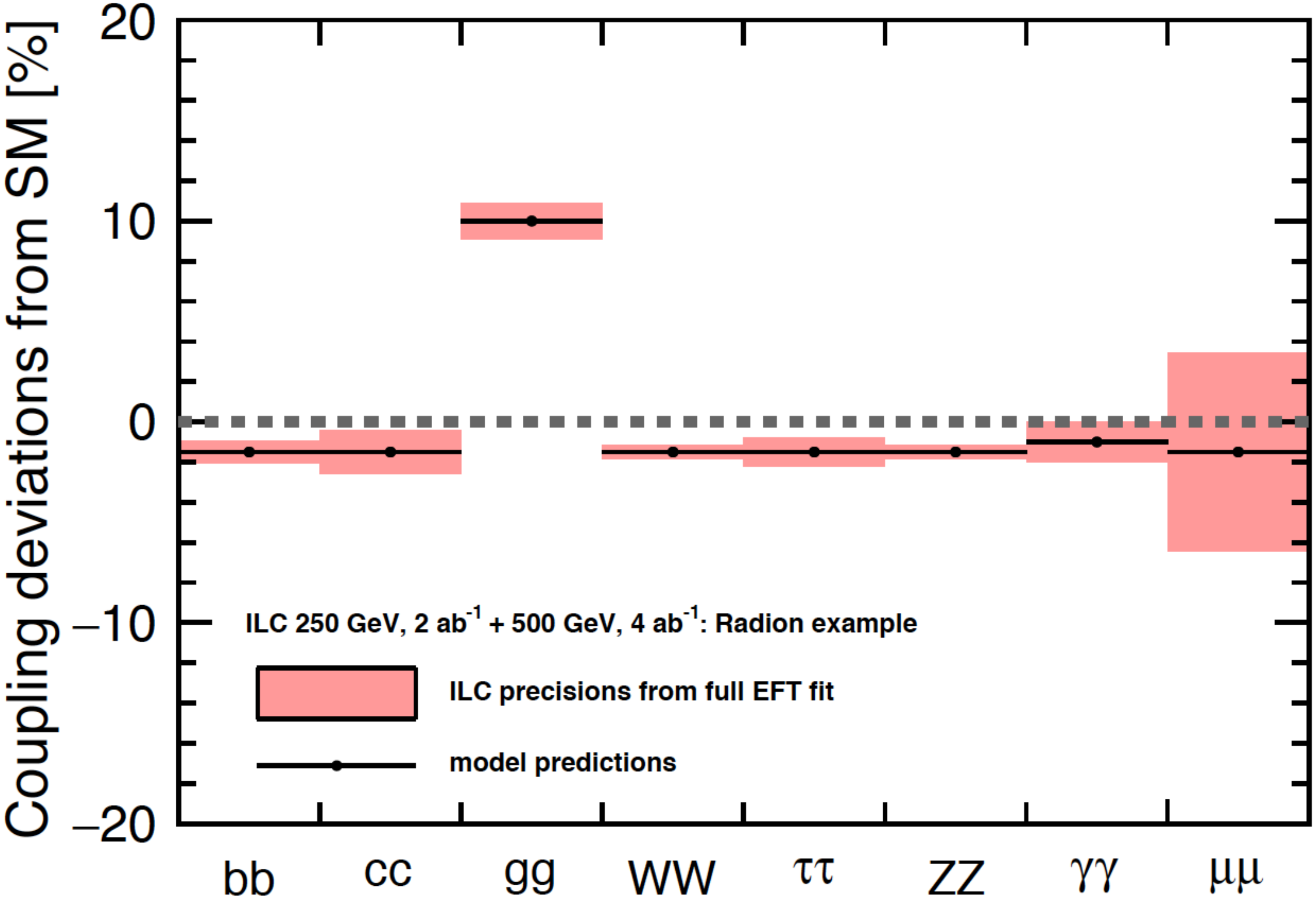
[*T. Barklow et al., '17*]



⇒ clear pattern, distinctive for HxSM?!

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

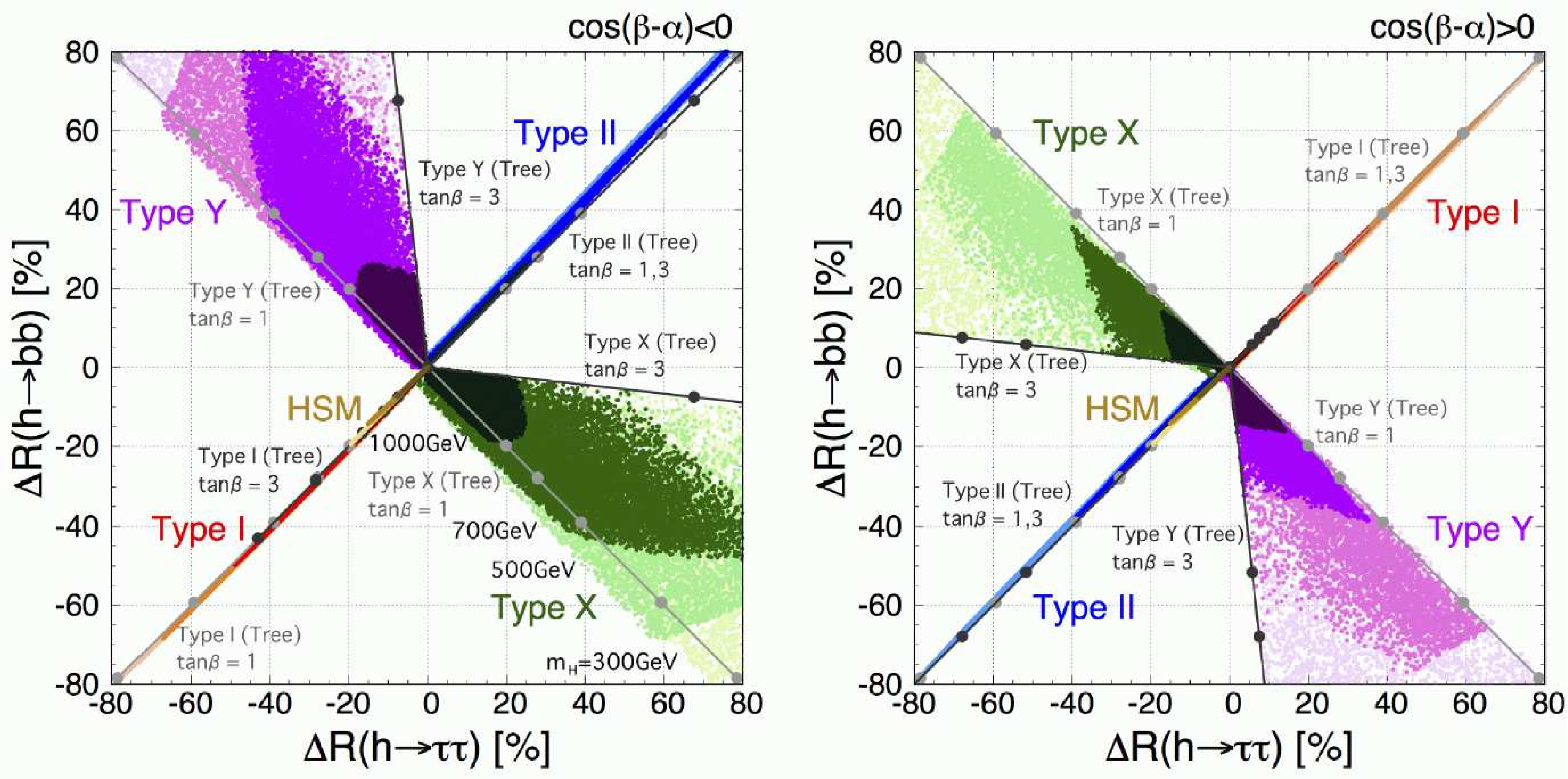
[*T. Barklow et al., '17*]



⇒ clear pattern, distinctive for Higgs Radion?!

2HDM example (I):

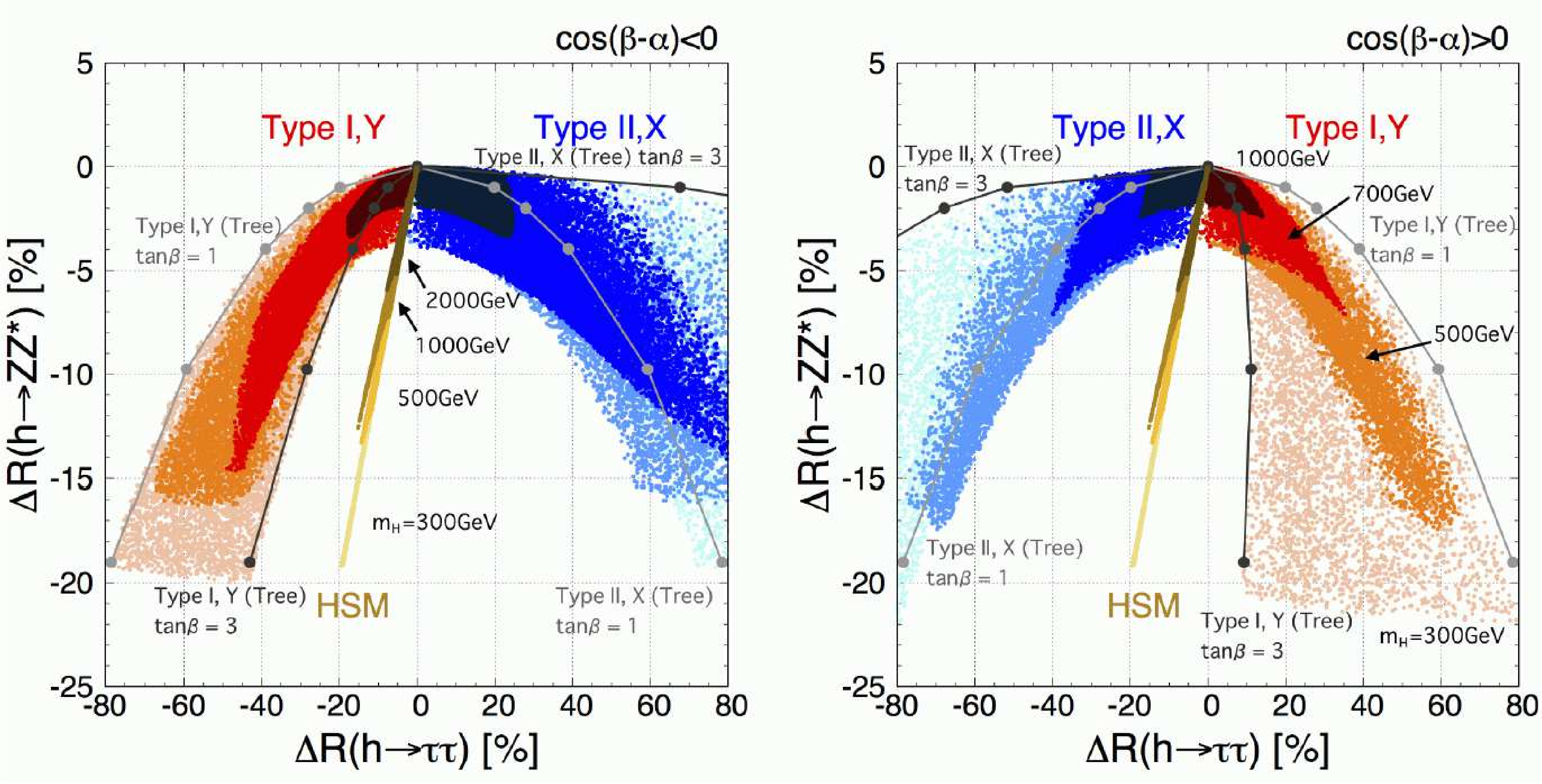
[*S. Kanemura et al. '18*]



⇒ LC precision has a great potential to discriminate the models!

2HDM example (II):

[*S. Kanemura et al. '18*]



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2HDM example (III):

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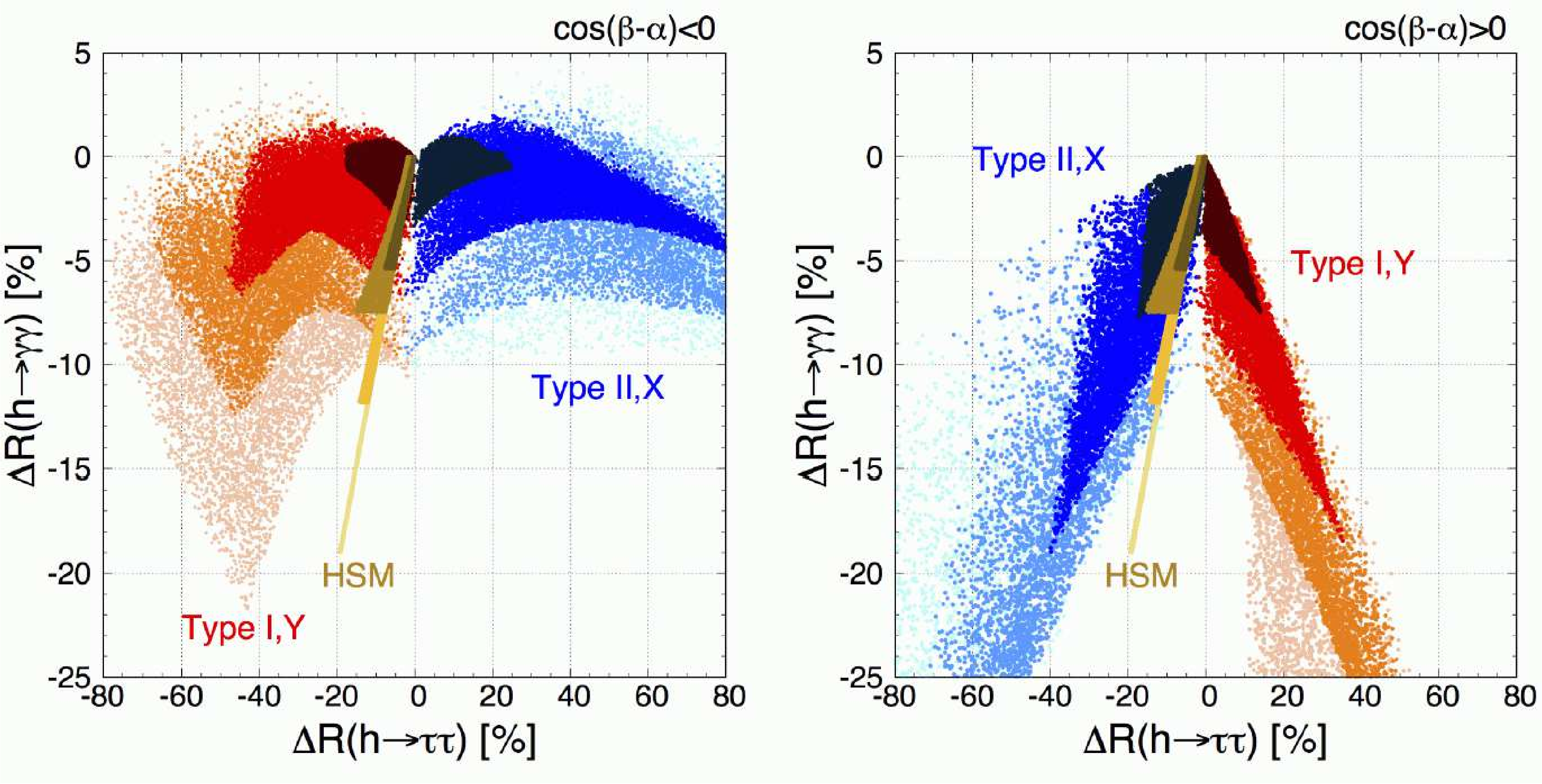

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