

# update of Higgs coupling precision in EFT fit

details in ILC supporting document for ESU, arXiv:1903.01629  
Higgs part done together with K.Fujii, J.List, M.Peskin, et al

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## updates

- bug fix in EFT fitting program
  - systematic errors that enter the fit
  - comparison between polarized and unpolarized e+e-
  - ILC Scenario 2 for comparison with HL-LHC
- 

## general message we stressed in the long document

- the capabilities of a e+e- machine, in view of Higgs precision measurements, are best illustrated in the Standard Model Effective Field Theory (SMEFT)

see some technical introduction in recent talk JT@HPNP2019

bug fix

Barklow, Fujii, Jung, Peskin, JT, 1708.09079

Equation (83)

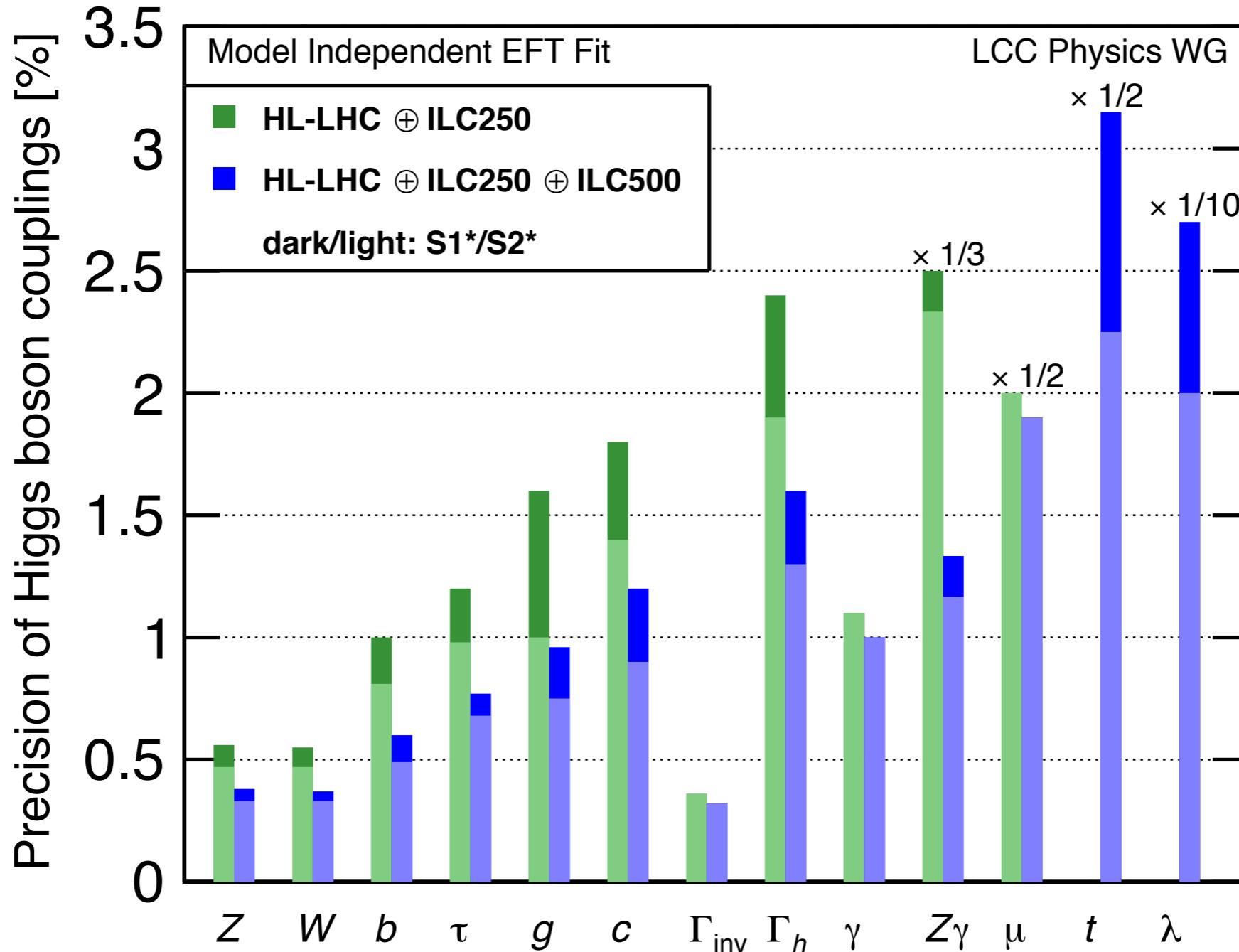
$$\delta g_R = -c_w^2 \delta g + (1 + c_w^2) \delta g' - \frac{1}{2 s_w^2} c_{HE}$$
$$-\frac{1}{2} c_w^2 (8 c_{WW}) + c_w^2 (8 c_{WB}) + \frac{1}{2} \frac{s_w^2}{c_w^2} (1 + c_w^2) (8 c_{BB})$$


“-” sign was missed in the code of fitting program

among 4 typos reported by S.Jung & J.Lee,  
this one turns out to have important effects:

ILC Higgs precisions become better,  
e.g.  $g(hZZ)$  @ ILC250, 0.67%  $\rightarrow$  0.56%

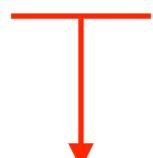
# up-to-date ILC precisions



systematic errors included in the global fit

for every  $\sigma$  and  $\sigma \times \text{BR}$  measurement

- 0.1% from theory computations
- 0.1% from luminosity
- 0.1% from beam polarizations
- $0.1\% \oplus 0.3\%/\sqrt{L/250}$  from b-tagging and analysis



newly added a limit of 0.1% systematic errors  
from experimental analysis

same systematic errors are used for  
unpolarized case, except without item 3

polarized versus unpolarized

- consistent formalism for global fit: SMEFT
- consistent estimations of input measurements: ILC full simulations
- consistent inclusion of systematic errors

# polarized versus unpolarized

coupling	2/ab-250 pol.	+4/ab-500 pol.	5/ab-250 unpol.	+ 1.5/ab-350 unpol	2/ab-350 $e^-$ pol.
$HZZ$	0.56	0.38	0.80	0.42	0.51
$HWW$	0.55	0.37	0.80	0.42	0.50
$Hbb$	1.0	0.60	0.98	0.66	1.0
$H\tau\tau$	1.2	0.77	1.0	0.75	1.3
$Hgg$	1.6	0.96	1.3	0.99	1.6
$Hcc$	1.8	1.2	1.4	1.2	2.2
$H\gamma\gamma$	1.1	1.0	1.2	1.0	1.1
$H\gamma Z$	7.5	4.0	8.5	6.8	6.6
$H\mu\mu$	4.0	3.8	3.8	3.7	4.0
$Htt$	-	6.3	-	-	-
$HHH$	-	27	-	-	-
$\Gamma_{tot}$	2.4	1.6	2.1	1.5	2.4
$\Gamma_{inv}$	0.36	0.32	0.34	0.30	0.58

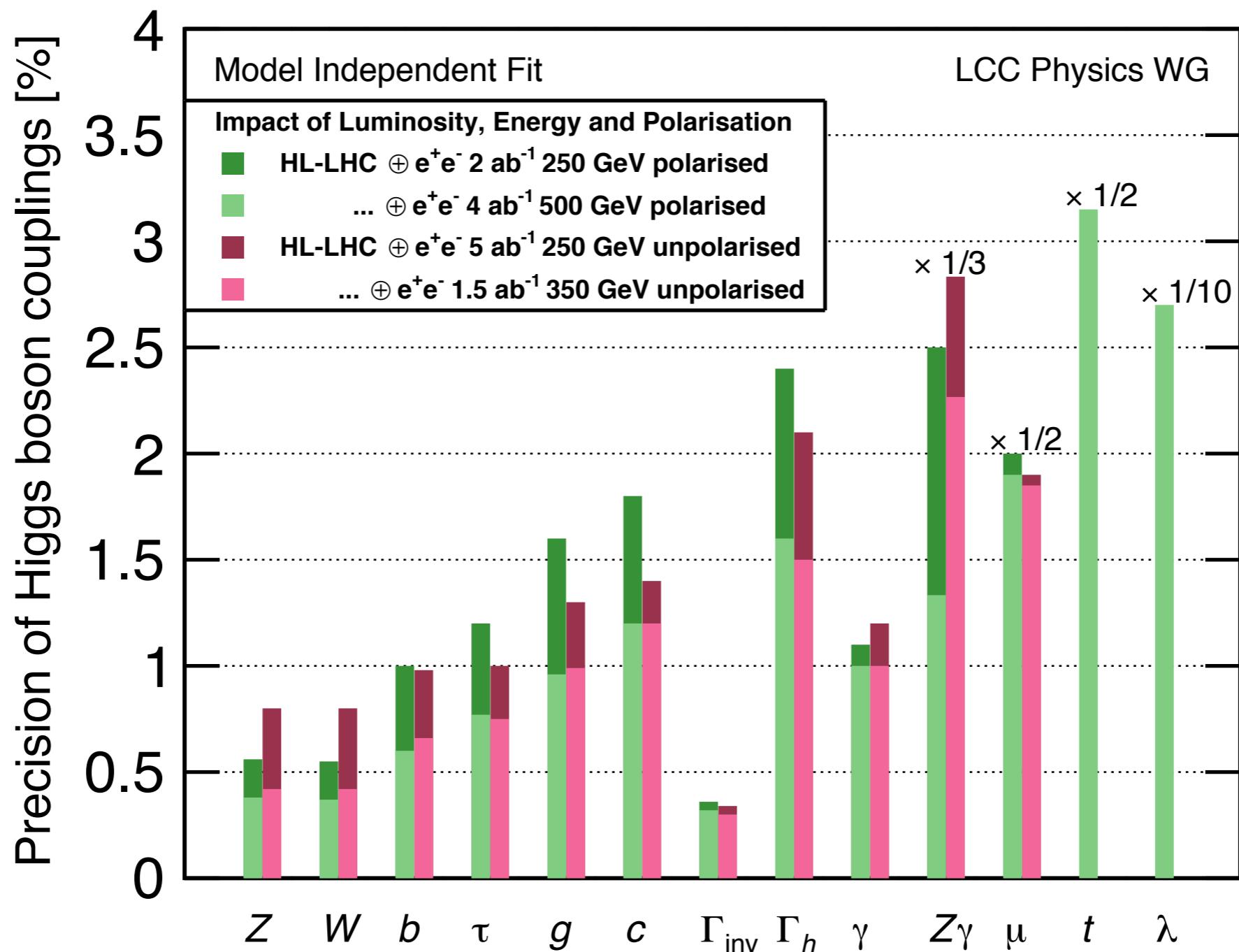
- without improved EWPOs by dedicated Z-pole / WW runs

# polarized versus unpolarized

coupling	2/ab-250 pol.	+4/ab-500 pol.	5/ab-250 unpol.	+ 1.5/ab-350 unpol
$HZZ$	0.50	0.36	0.64	0.40
$HWW$	0.50	0.36	0.65	0.41
$Hbb$	1.0	0.59	0.87	0.66
$H\tau\tau$	1.1	0.75	0.95	0.75
$Hgg$	1.6	0.96	1.2	0.98
$Hcc$	1.8	1.2	1.4	1.1
$H\gamma\gamma$	1.1	1.0	1.1	1.0
$H\gamma Z$	7.0	3.7	8.3	5.1
$H\mu\mu$	4.0	3.8	3.8	3.7
$Htt$	-	6.3	-	-
$HHH$	-	27	-	-
$\Gamma_{tot}$	2.3	1.6	1.9	1.5
$\Gamma_{inv}$	0.36	0.32	0.34	0.30

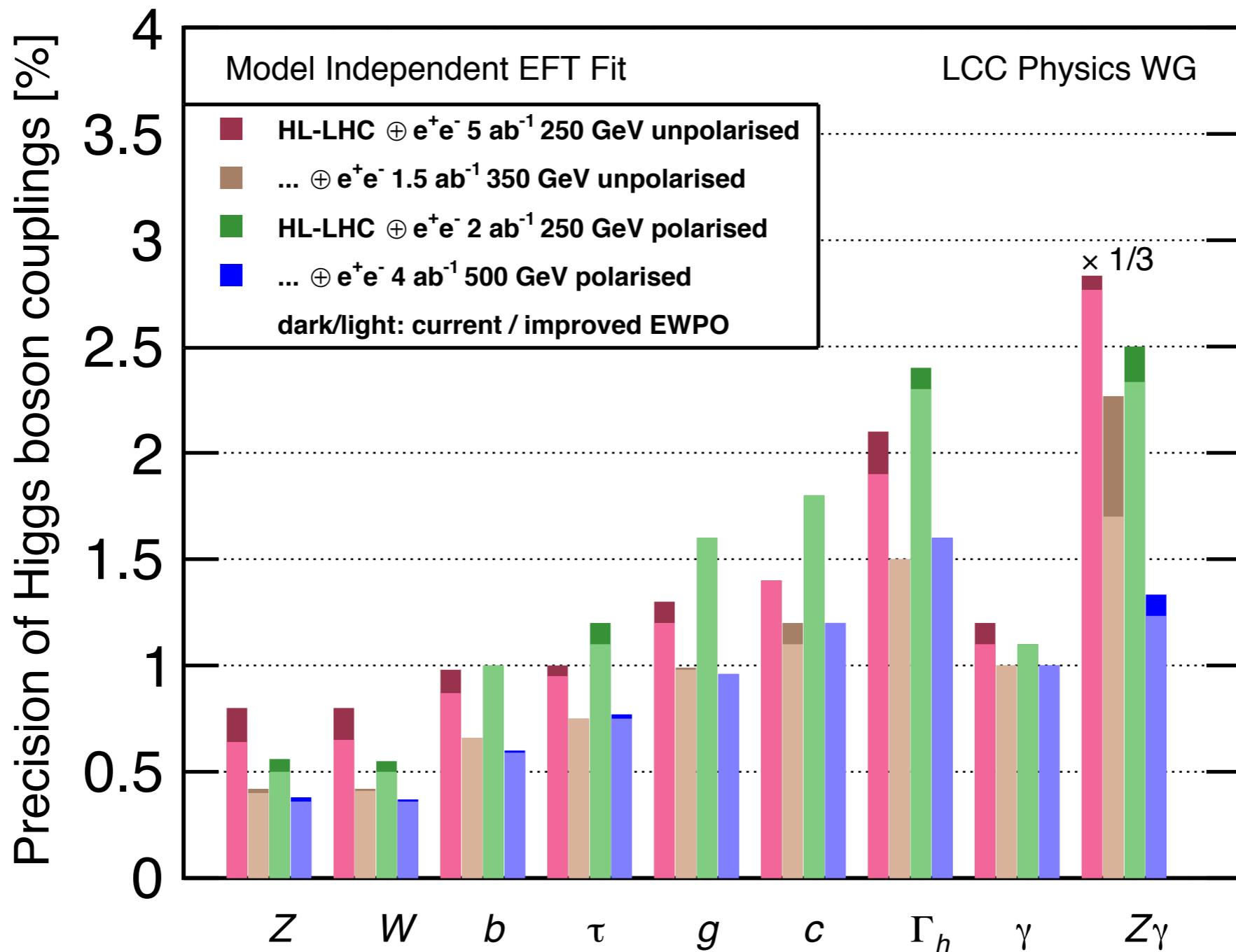
- for unpolarized case, include improved EWPOs by dedicated Z-pole / WW runs; for polarized case, only include improved A\_LR by x10 from same 250 GeV run

# polarized versus unpolarized



- without improved EWPOs by dedicated Z-pole / WW runs

polarized versus unpolarized



## polarized versus unpolarized

- similar precisions between ILC250 2 ab<sup>-1</sup> and 5 ab<sup>-1</sup> unpolarized
- improved EWPOs help 250 GeV significantly
- with additional 350 or 500 GeV run, effects of improved EWPOs become very small

## ILC versus HL-LHC

- there is no “apple-to-apple” comparison: LHC can’t determine Higgs total width, global fit is model dependent
- HL-LHC Scenario 2 bases on very optimistic systematic errors
- ILC estimations are based on current full simulation results, too conservative

## ILC versus HL-LHC

- for a bit more direct comparison, in our EFT fit we tried to add a few (2) assumptions, which have also been included in LHC kappa fit
- total width constraint: no BSM decay mode
- no anomalous hZZ/hWW couplings: SM-like Lorentz structure

(inspired by one comment from B.Grzadkowski at HPNP2019,  
the 2nd assumption actually has deep physics reason:  
justifiable in general weakly-coupled models)

## ILC versus HL-LHC

- in addition, we also define ILC Scenario 2, in which optimistic estimations of input measurements are assumed

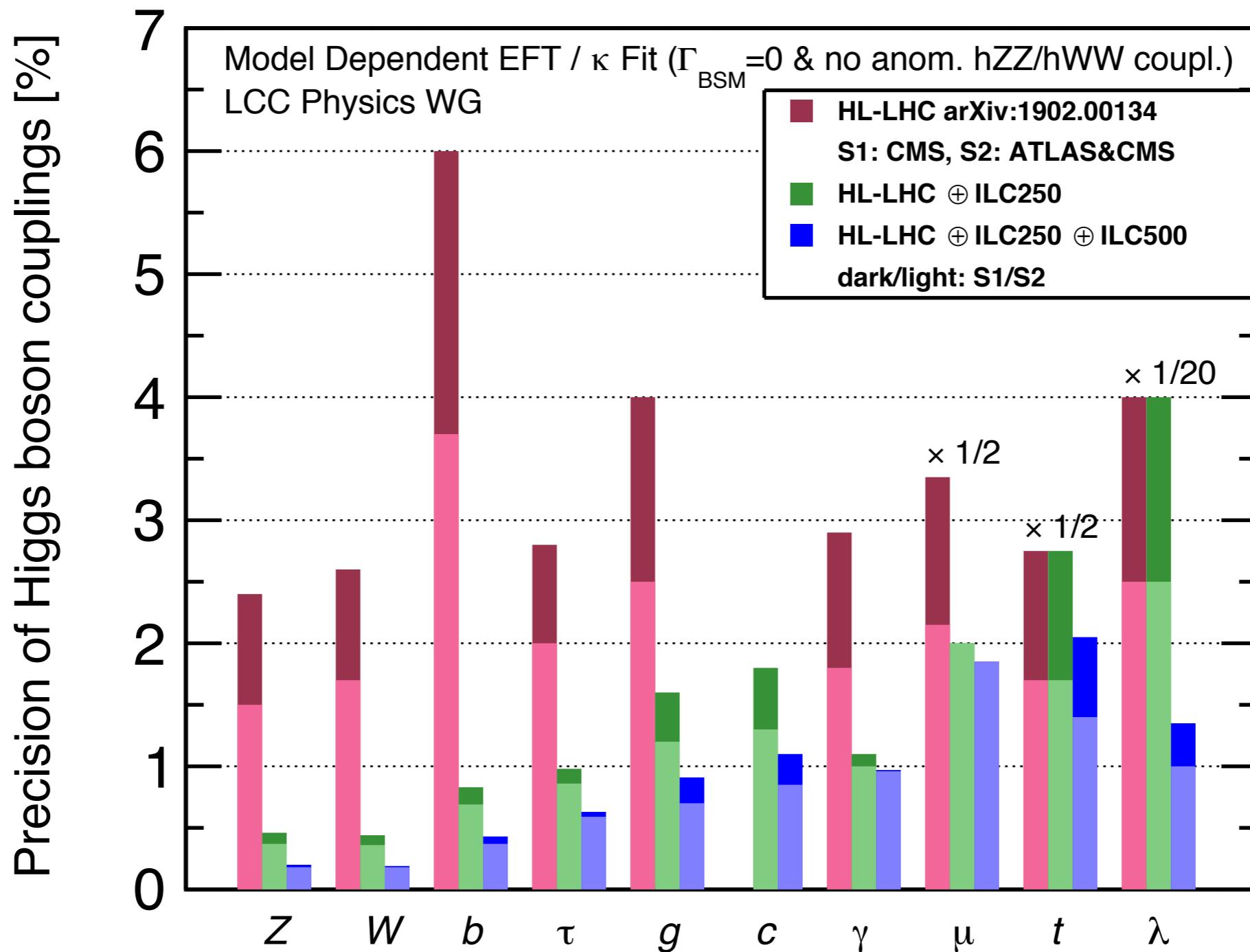
### improvement factors in ILC S2

- 10% from better jet-clustering algorithm
- 20% from better flavor-tagging algorithm
- 20% from more statistics by including more signal channels in  $h \rightarrow WW^*$
- $\times 10$  better for  $A_{LR}$  using  $e^+e^- \rightarrow \gamma Z$  at ILC250
- as a consequence, 30% improvement for Higgs self-coupling and top-Yukawa coupling

# ILC: projections for 4 scenarios



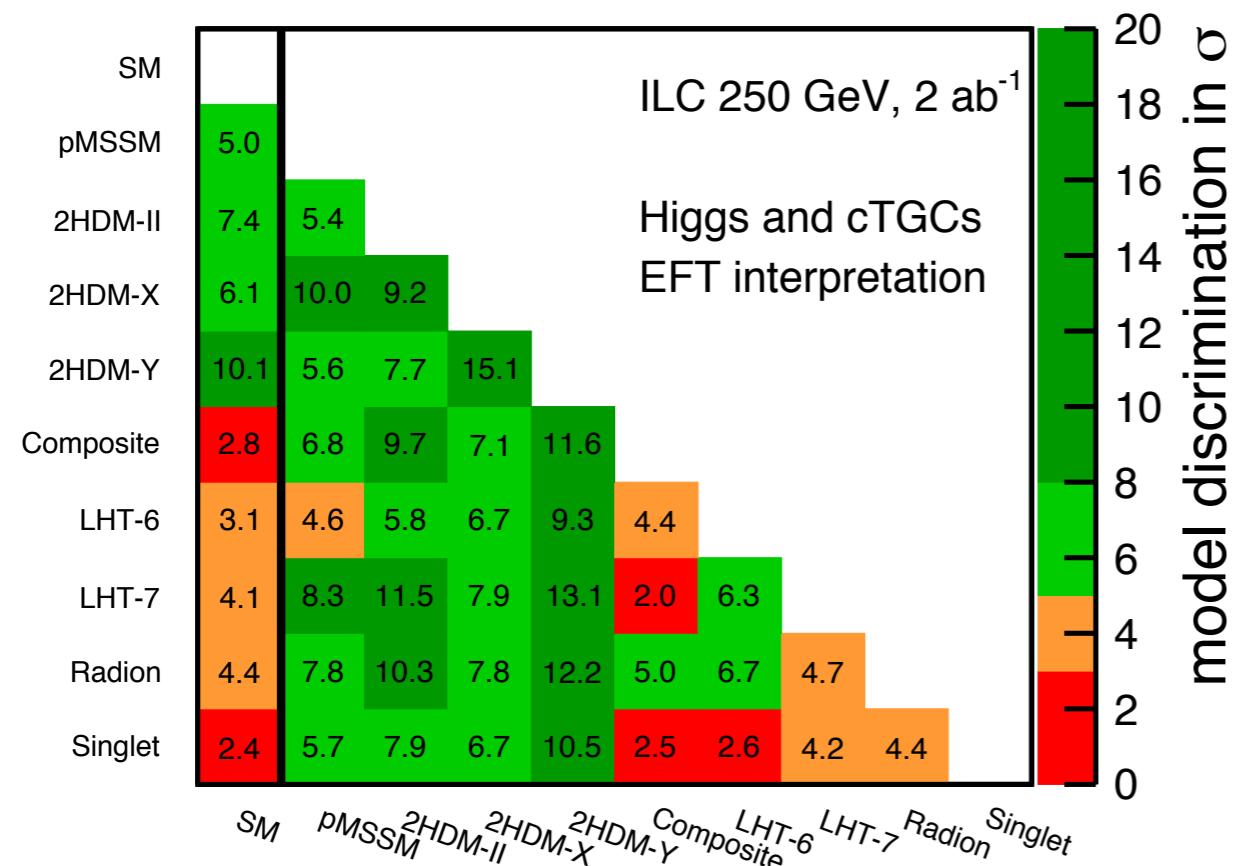
# ILC versus HL-LHC



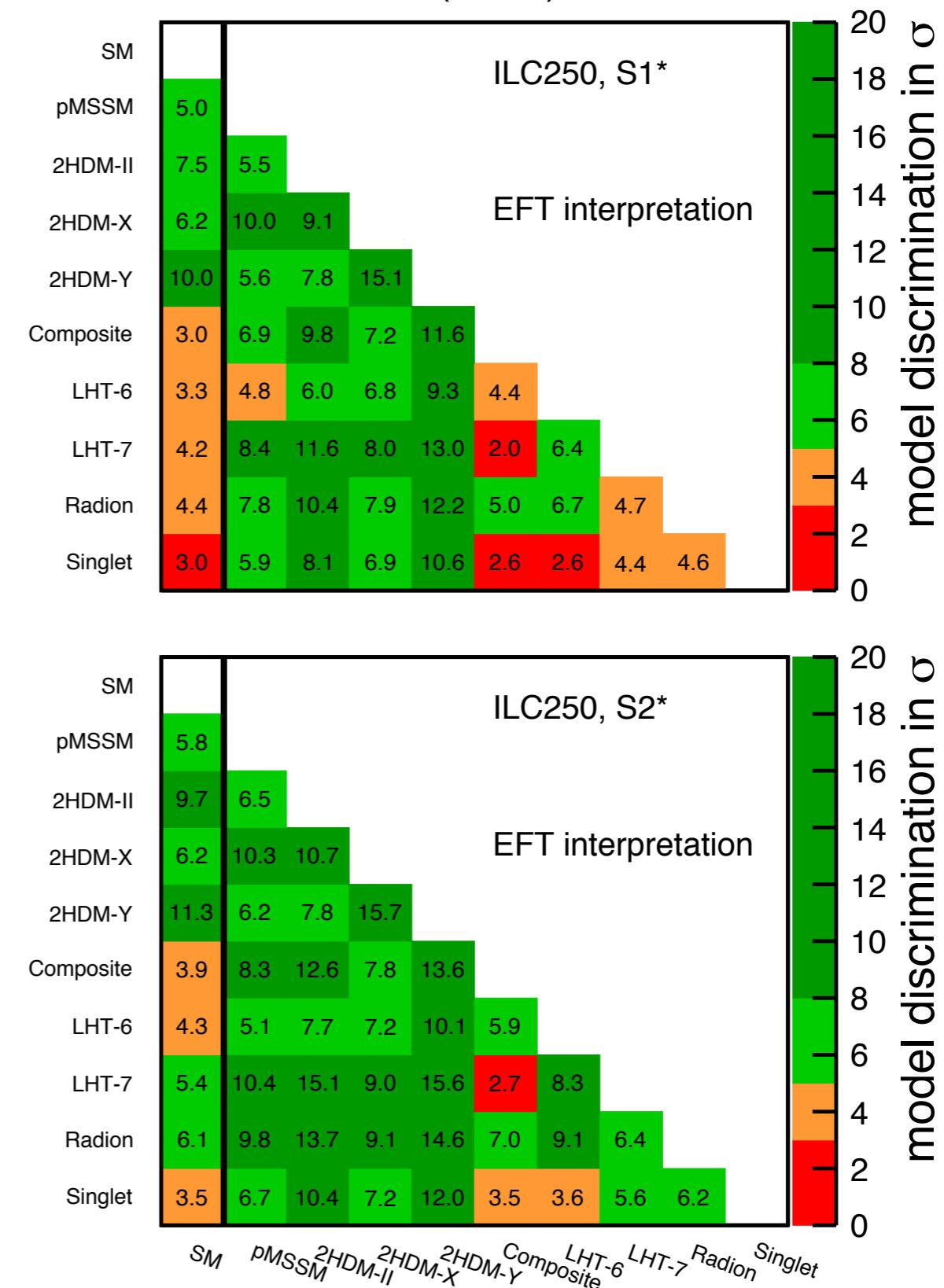
backup

# updated BSM models discrimination

(new)

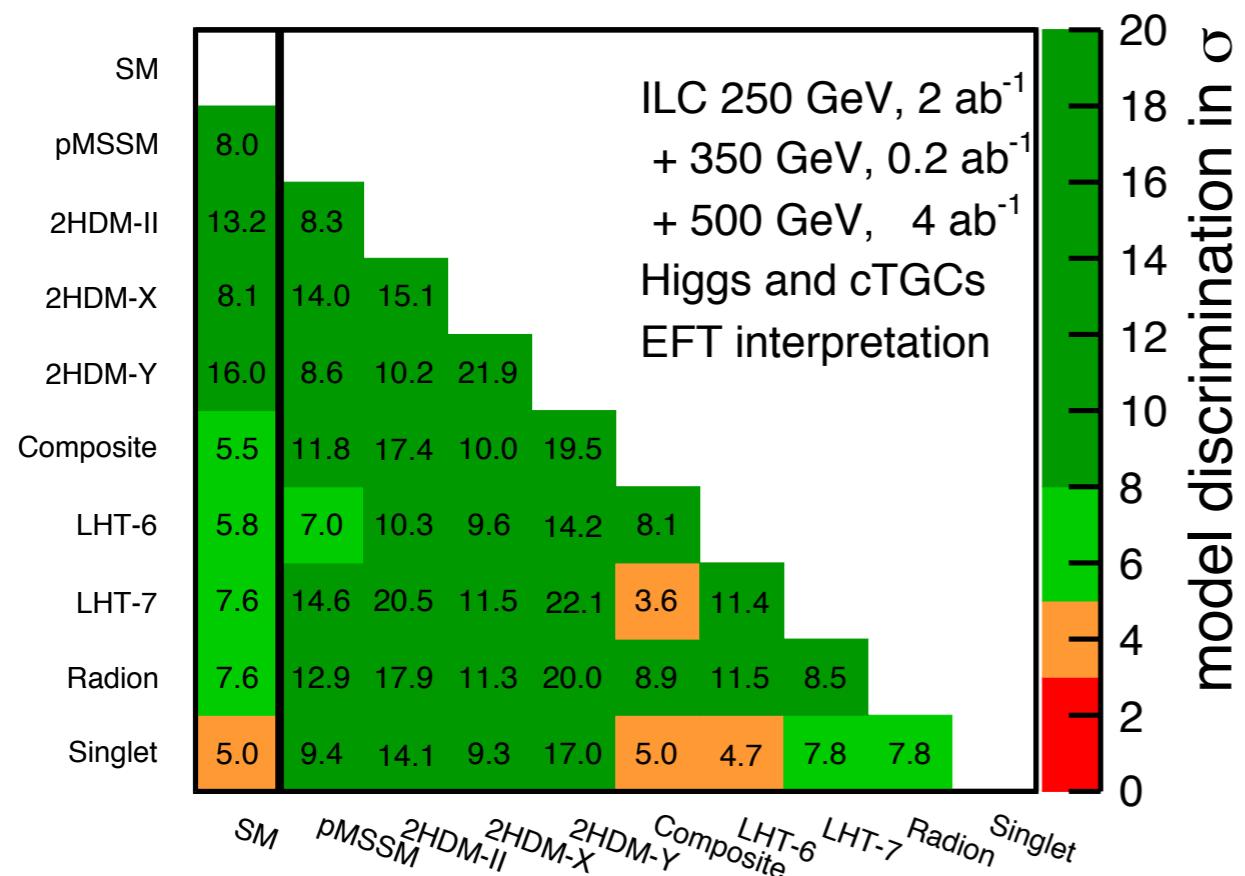


(old; 1710.07621)



# updated BSM models discrimination

(new)



(old; 1710.07621)

