

Beyond the Standard Model

Recap from prev. European Strategy



CSIC



VNIVERSITAT
DE VALÈNCIA

Veronica Sanz
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BSM chapter - basic structure

- ❖ Sensitivity as exclusions, not discovery (agnostic)
- ❖ Choice of benchmarks as broad as possible
- ❖ From traditional and very specific (Supersymmetry) to as model independent as possible (EFT)
- ❖ From strong coupling (Composite Higgs), weak scale till extremely weakly coupled (feebly interacting)
- ❖ Array of signatures: from resonant searches (e.g. Z'), compositeness till LLPs
- ❖ Explore also motivations: naturalness, Dark Matter, flavour physics and baryogenesis
- ❖ Give a fair chance to all types of collider proposals (lepton vs hadron, energy vs precision), choice biased towards this effort
- ❖ Explore synergies with other experiments if possible (axions, dark sectors, GWs, direct vs indirect)

Compare experiments based on answering to fundamental questions

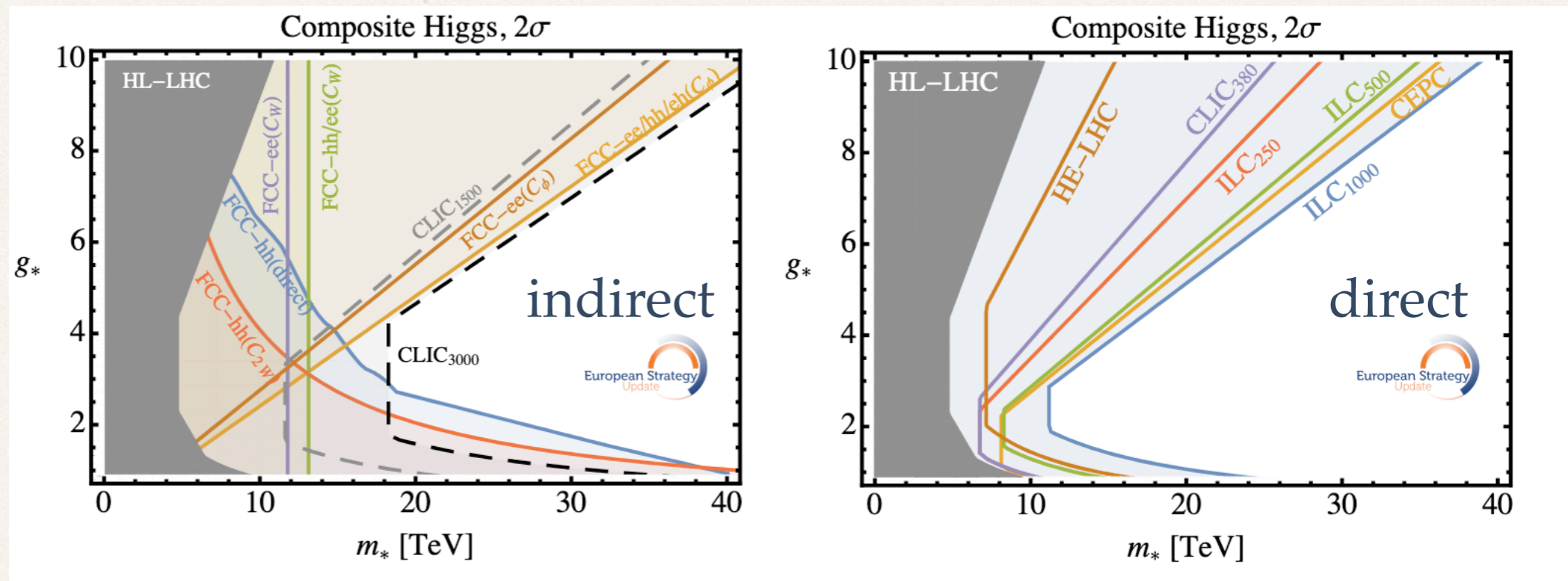
- ❖ Is the Higgs boson fundamental or composite?
- ❖ Are there new states or interactions?
- ❖ Dark Matter, thermal relics?
- ❖ New dark sectors?

Is the Higgs fundamental or composite?

A fundamental scalar is a big deal in QFT
naturalness / hierarchy problem linked to it

If Higgs is composite (a bound state) ->
a new strong sector with a typical scale and coupling to us

coupling of this
sector to SM
($\sim g_{\text{rho}} g_{\text{pi}}$ in
QCD)



scale of compositeness ($\sim \Lambda_{\text{QCD}}$)

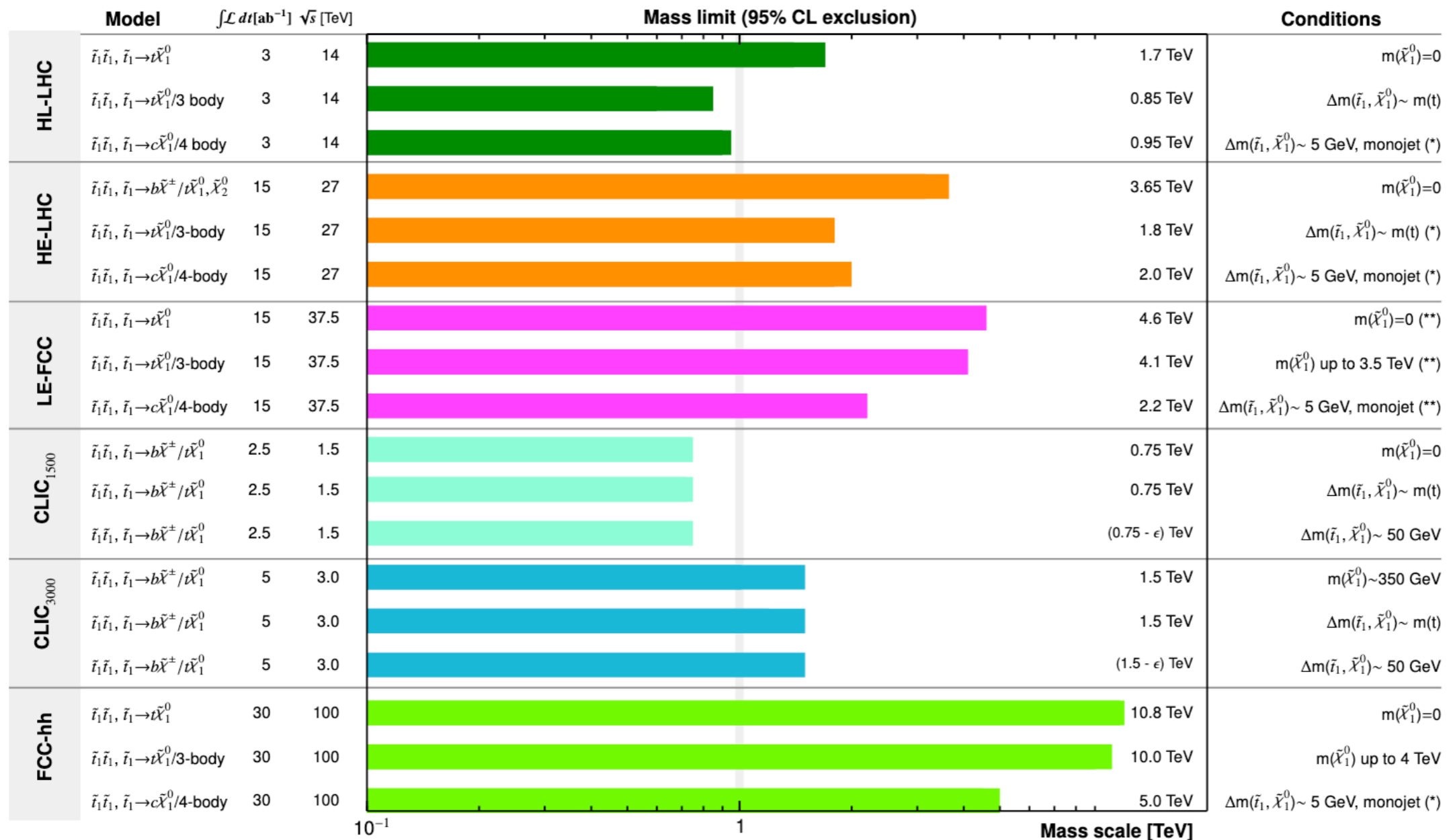
In this framework, good **interplay** direct search for composite resonances (*right*) or compositeness (EFT) through W,Z,h couplings (*left*)

Are there new states or interactions?

new states can be searched for directly at high energies

All Colliders: Top squark projections (R-parity conserving SUSY, prompt searches)

STOP SEARCH=
NATURAL SUSY



(*) indicates projection of existing experimental searches

(**) extrapolated from FCC-hh prospects

ϵ indicates a possible non-evaluated loss in sensitivity

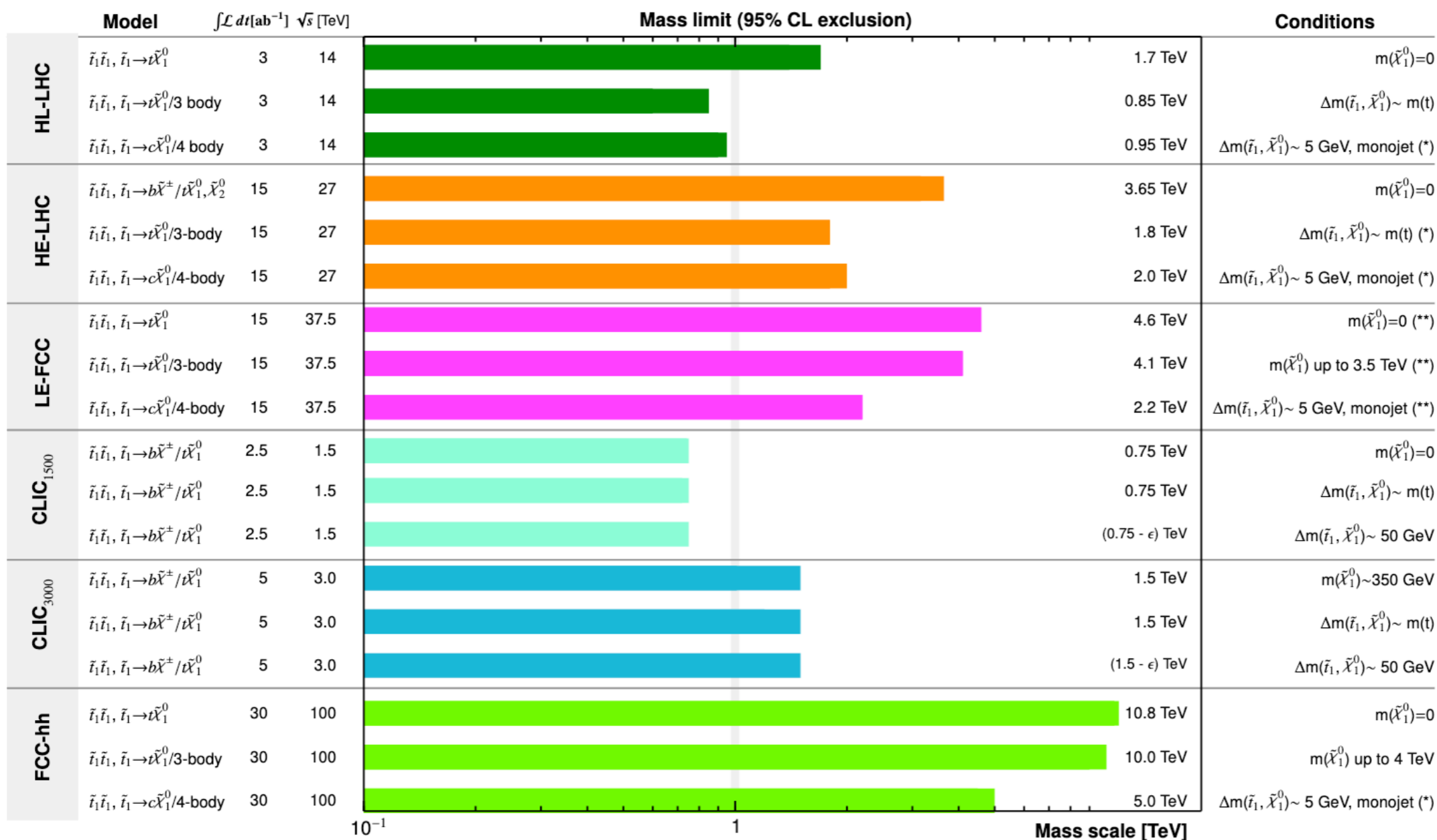
ILC 500: discovery in all scenarios up to kinematic limit $\sqrt{s}/2$

Are there new states or interactions?

new states can be searched for directly at high energies

All Colliders: Top squark projections

(R-parity conserving SUSY, prompt searches)



vanilla
compressed

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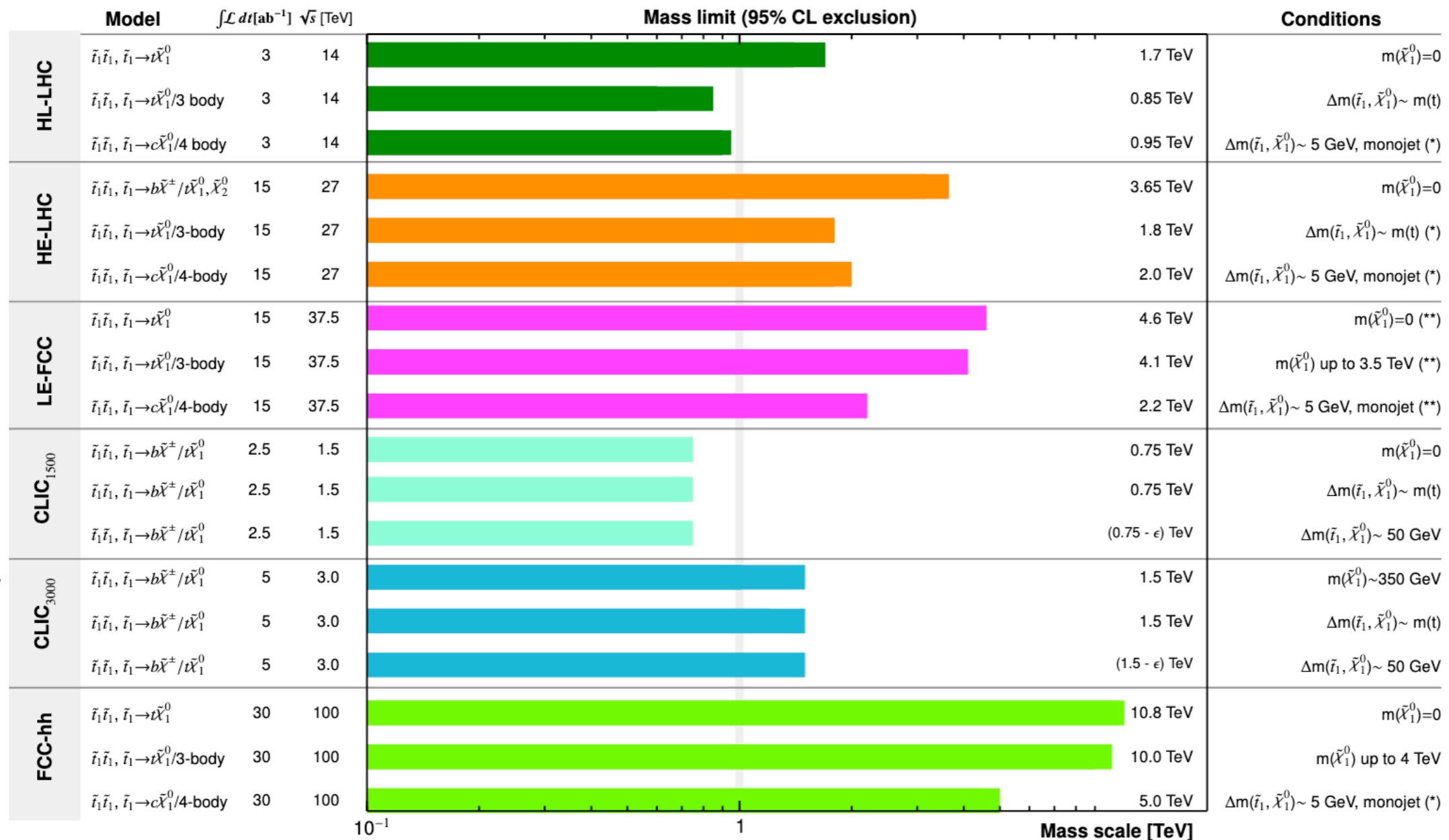
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Are there new states or interactions?

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All Colliders: Top squark projections

(R-parity conserving SUSY, prompt searches)



more stable
under
kinematics

(*) indicates projection of existing experimental searches

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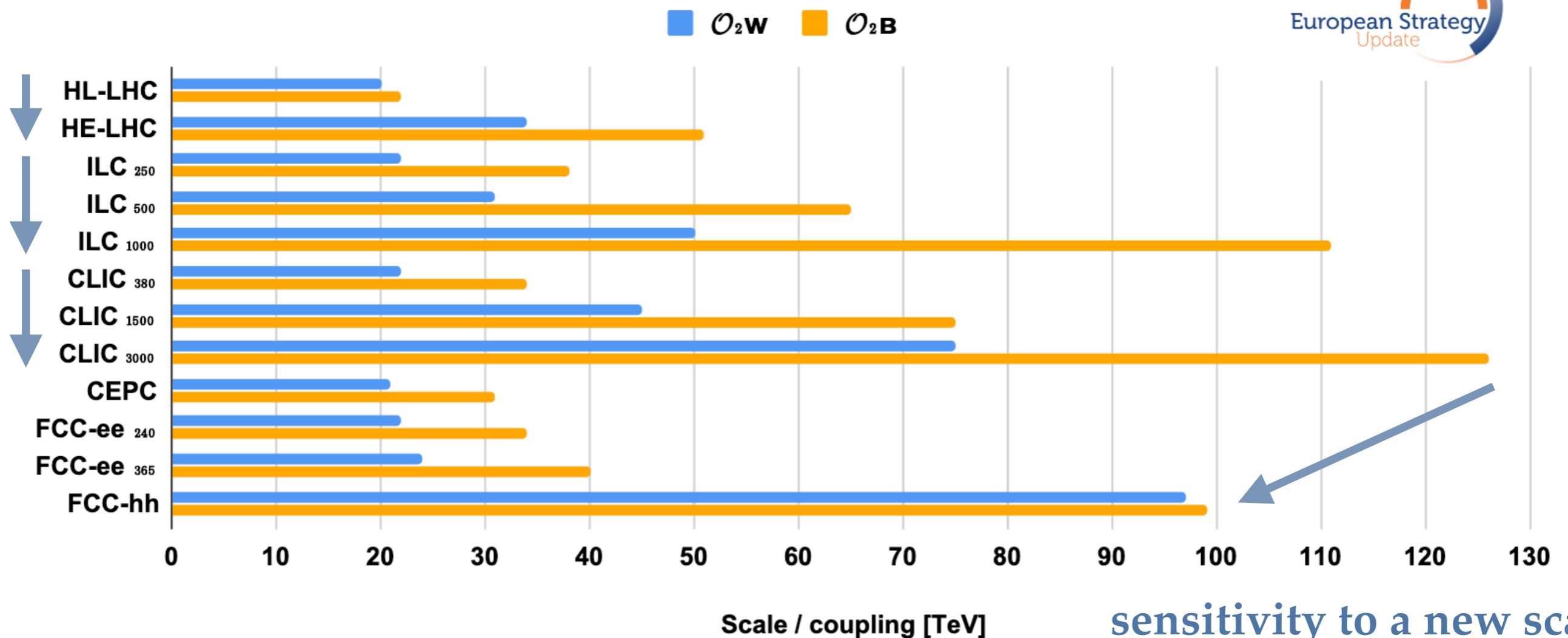
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ILC 500: discovery in all scenarios up to kinematic limit $\sqrt{s}/2$

Are there new states or interactions?

new states / interactions can be searched for indirectly both with
+ precision and with + energy
eg EFT effects more lumi and more E (E-growth)

95% CL scale limits on 4-fermion contact interactions

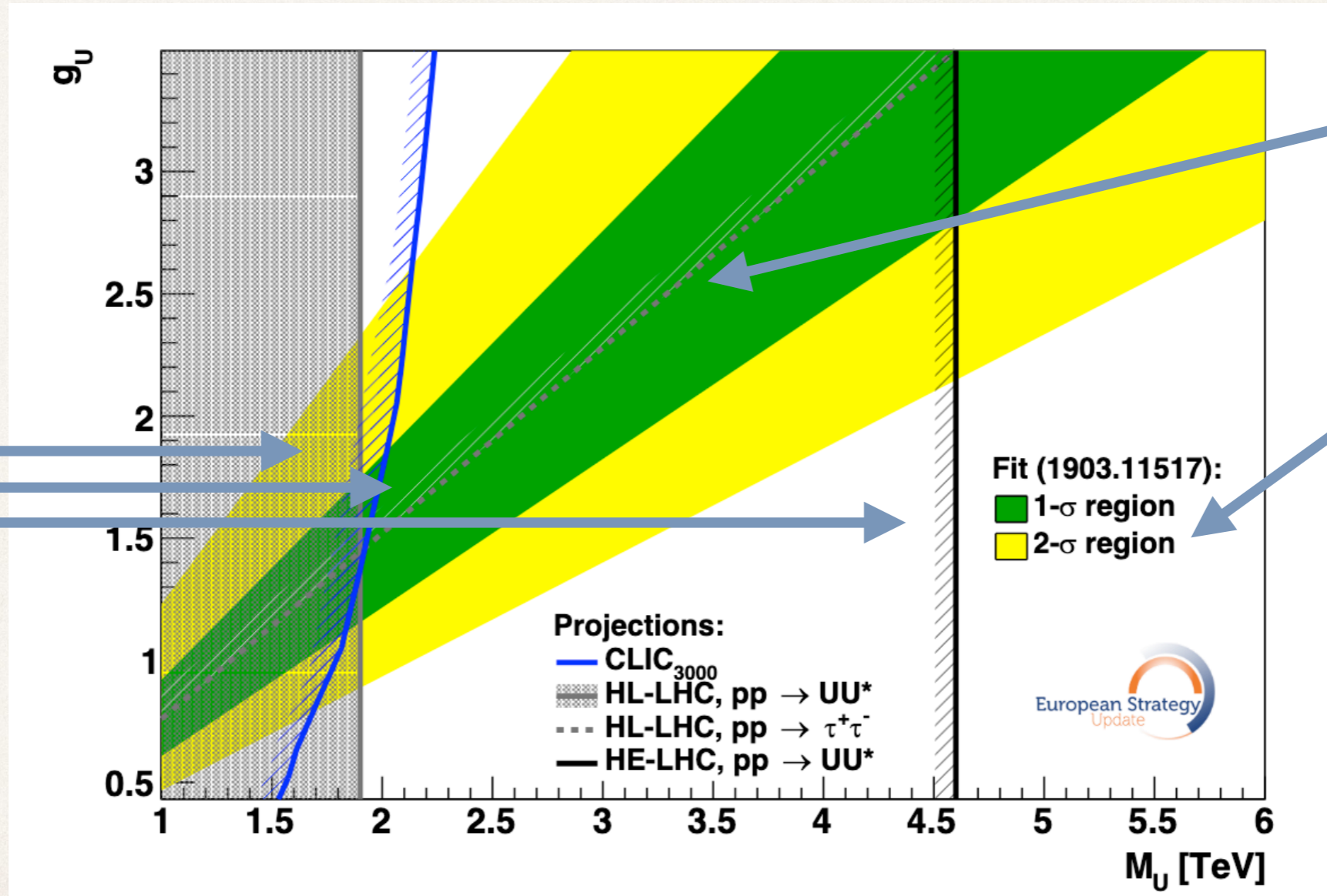


Are there new states or interactions?

new states can be searched for directly and indirectly through rare processes (flavour)

Leptoquark coupling

Direct production



Indirect
tau+tau-

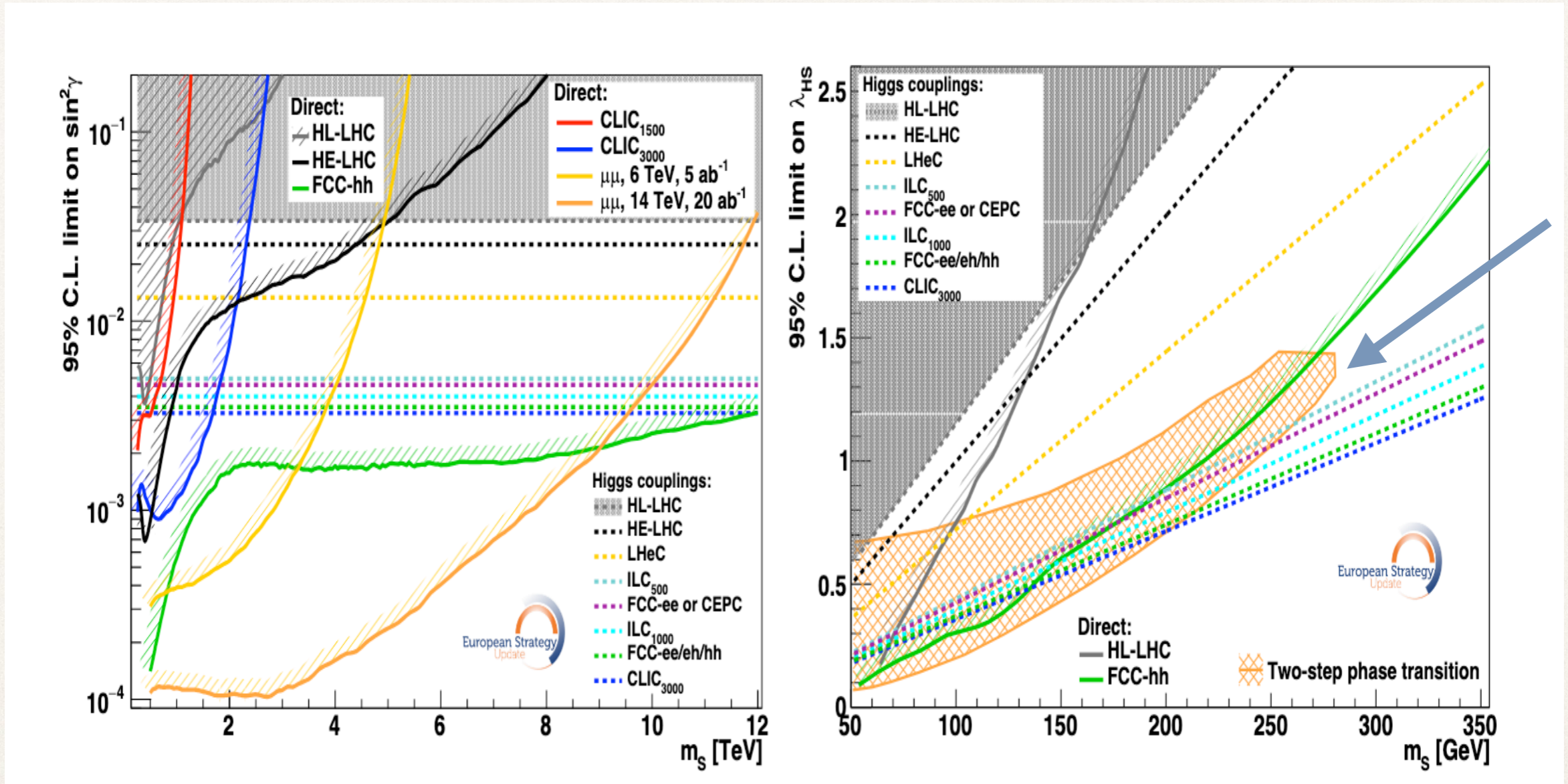
Flavour
global fit

Leptoquark
mass

Are there new states or interactions?

If this new sector talks to the Higgs, implications for EWSB
 simple benchmark singlet with mixing (*left*) or with portal
 coupling (*right*)

mixing/coupling with Higgs



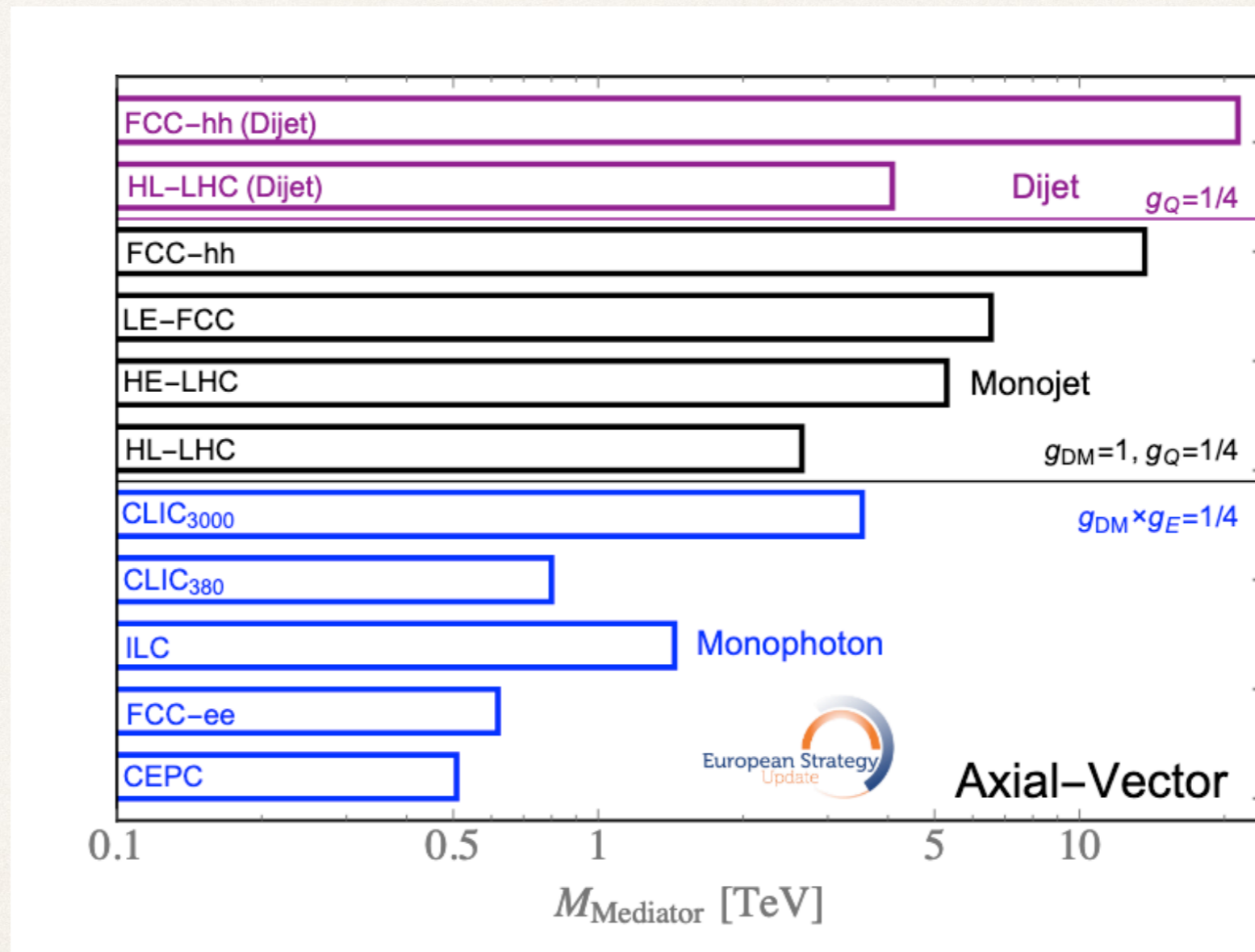
direct *vs* Higgs precision measurements
 link to PT and GWs

singlet mass

Dark Matter, thermal relics?

Can colliders rule out WIMPs?

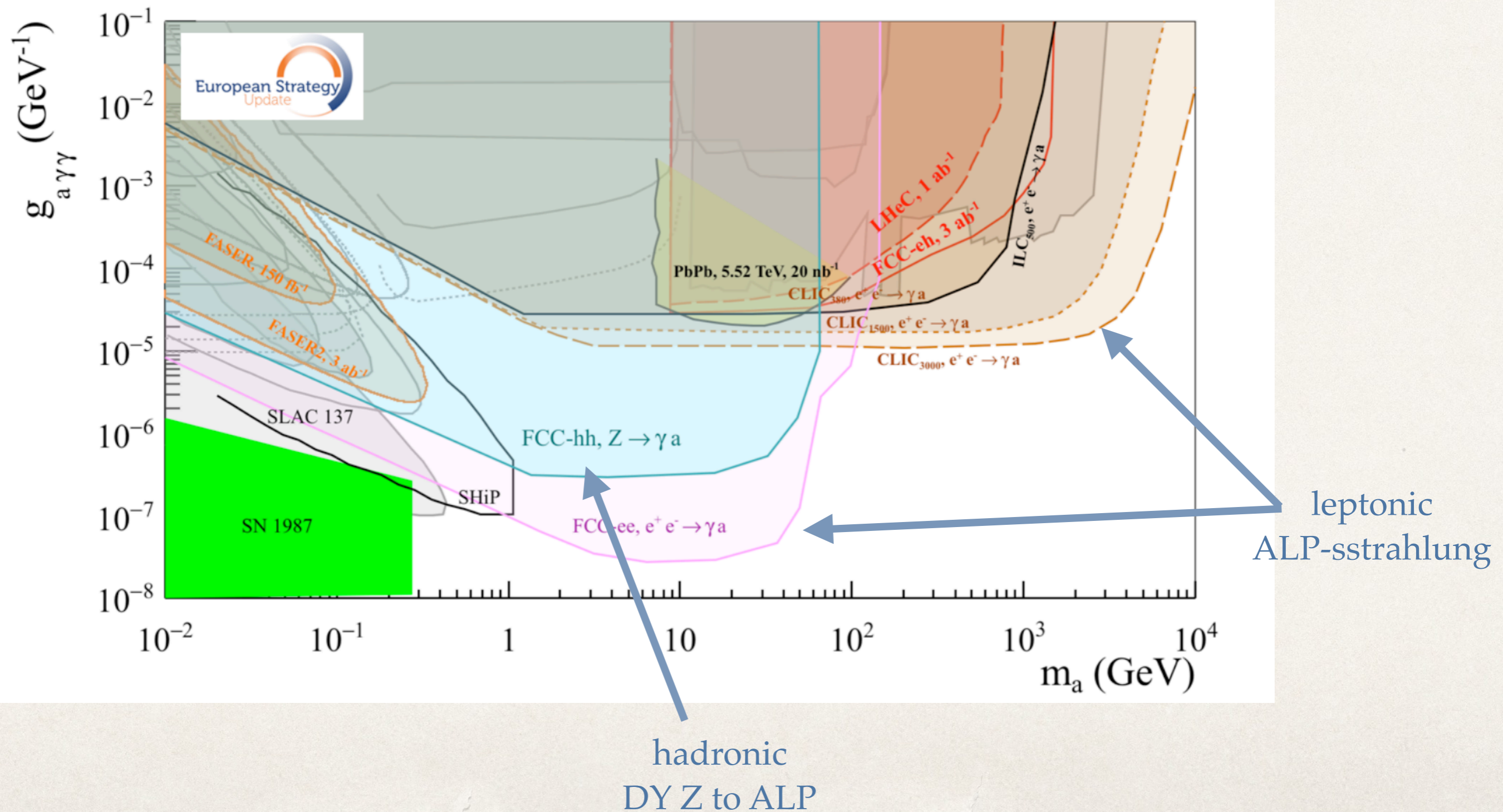
Example light DM with heavy mediator



function of coupling to leptons or quarks
EFT: combination of lumi and E-dep

Feebly interacting particles?

Reach for Dark Sectors? eg ALPs
colliders have a larger kinematic reach



Discussion

This study was done in 2018, and the pressure to pick an option was not there (really). Many things could be updated, eg.

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This study was done in 2018, and the pressure to pick an option was not there (really). Many things could be updated, eg.

- ❖ Are all the options still on the table? are there new options? Muon colliders?
- ❖ Higgs compositeness: ends up being a direct search for new EW partners, or indirect included in the SMEFT
- ❖ Direct are typical traditional searches, so apart from redoing with ML not a lot to improve
- ❖ SMEFT global fit should be redone with better account for systematics plus the proper E-dependence
- ❖ Scenarios linked to flavour: update global fit and account for Belle II etc
- ❖ Link to PTs and GWs should be redone, very rough and new GW experiments
- ❖ DM and mono-X: add mono-W/Z/t/H and update systematics, add ML
- ❖ ALPs: add off-shell production, will extend the kin reach