European Strategy
for Particle Physics

Plenary / **BSM physics**

Experimental programs to address open issues in BSM physics

Rebeca Gonzalez Suarez (Uppsala University)

23-27 JUNE 2025 Lido di Venezia

How can the different proposed facilities
help address the open questions in particle physics?

- In the previous talk, a set of benchmarks was introduced:

    1. New gauge forces

    2. Compositeness

    3. Extension of the minimal real scalar sector giving 1st order EW phase transition and possibly stability

    4. Minimal dark matter (WIMP) global

    5. Flavor

    6. Symmetries as a solution of the Higgs naturalness problem; SUSY and other models (such as neutral naturalness)

    7. Portals (dark photon, dark Higgs, HNLs, axions, ALPs)

The figures

- The team is working on a set of more than 30 figures based on the inputs received

  - Not all of them will be in the book

  - We cannot show every single one of them in this talk

  - We will go through some representative ones, benchmark by benchmark

- All details were shared in our parallel sessions on Monday

  - <u>First session</u>
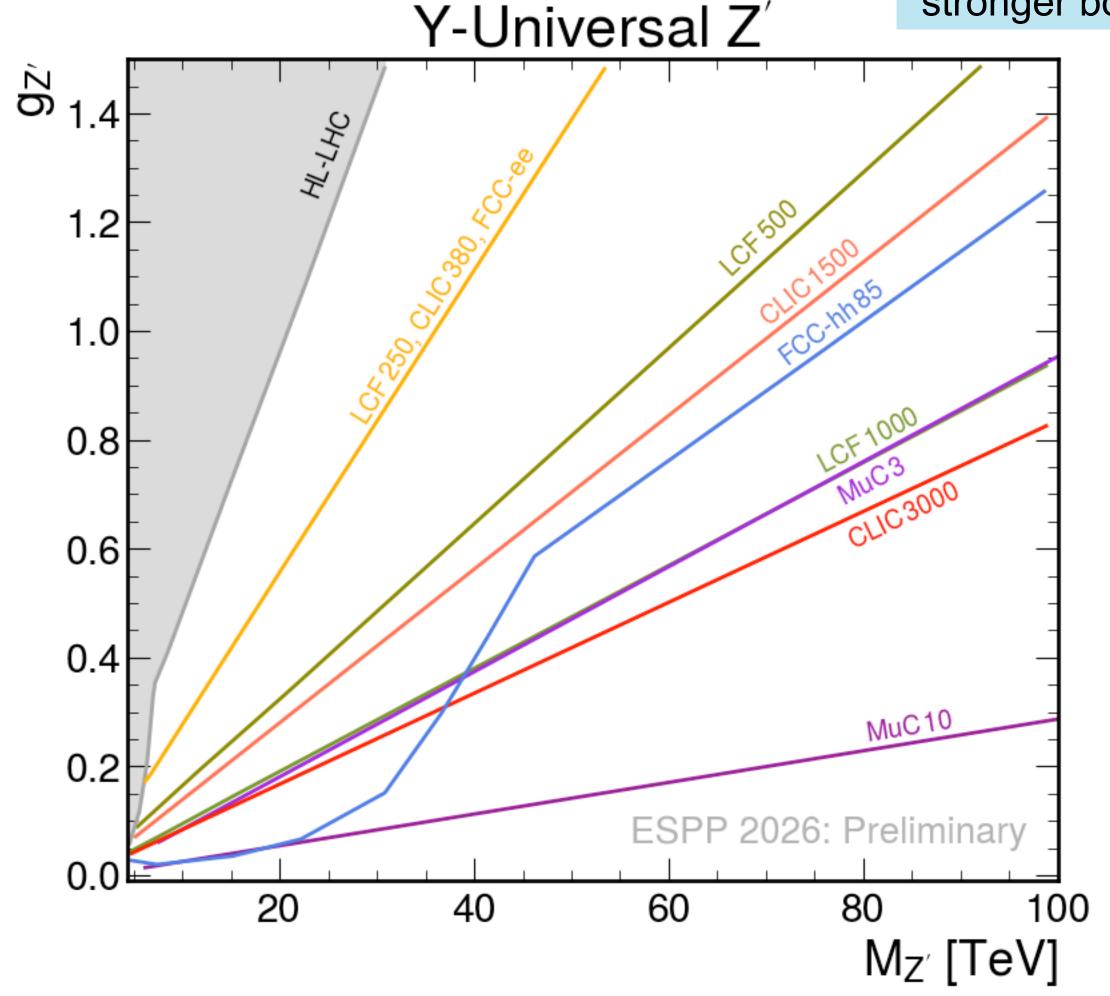
  - <u>Second session</u>

1 - New Gauge Forces

Roberto Franceschini, Aurelio Juste

Y-Universal Z'

- New neutral gauge boson Z' that couples to SM particles in proportion to their hypercharge

- Representative of gauge boson coupled to all fermions

  - g' and MZ' are the effective coupling of Z' to leptons and the mass of Z'

- **Updated figure**, additions:

  - muon collider at 3 and 10 TeV [207] and a rescaling from 100 TeV to 85 TeV for FCC-hh [227] [233] [241] [242] [247] [261]

  - Rescaling done via: http://collider-reach.web.cern.ch/

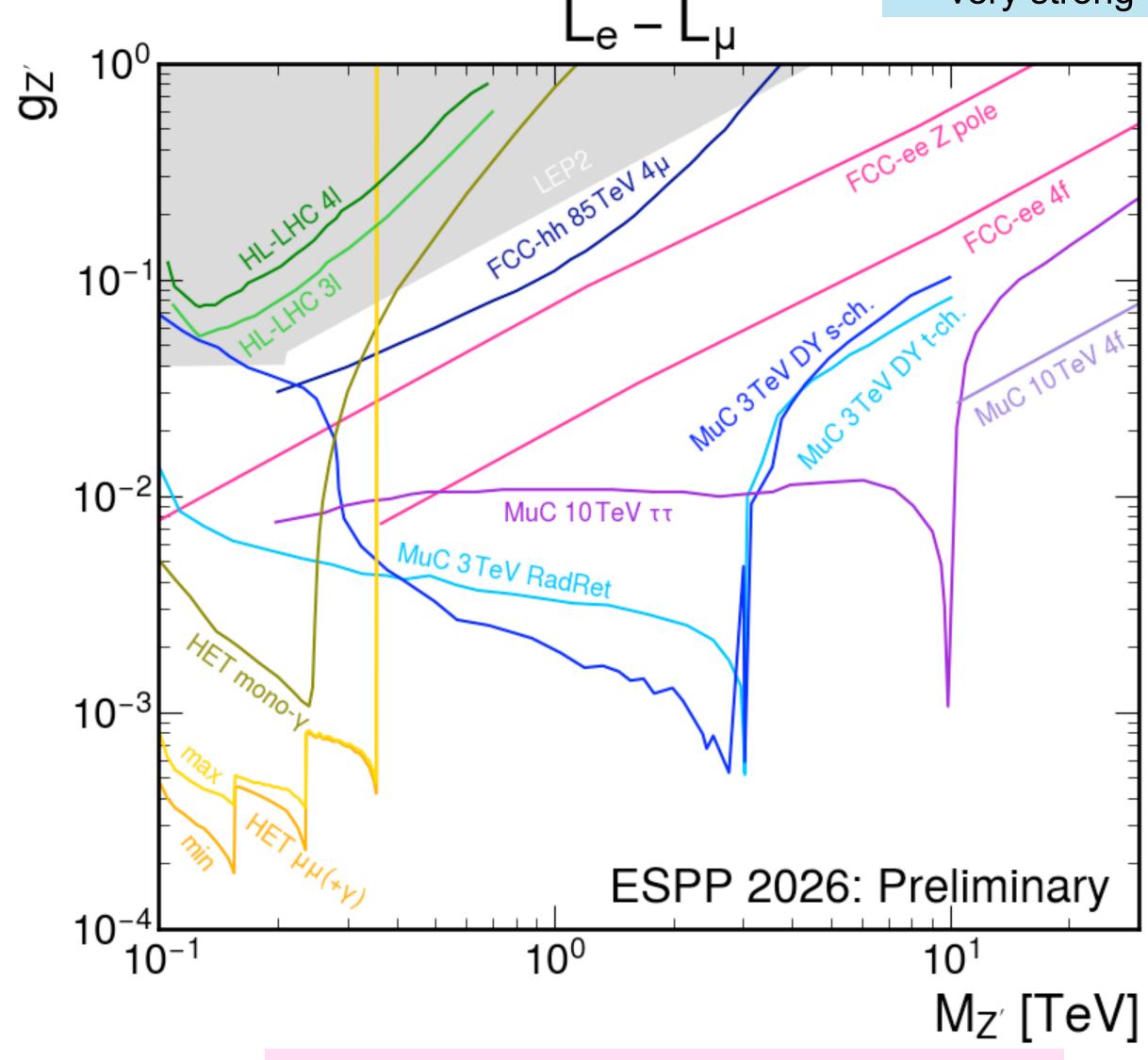 - Will be further updated once new bounds on are available from the EW fit.

Exclusion reach of different colliders on the Y-universal Z' model parameters

Direct (round) and Indirect (straight)

Le-Lμ

- Leptophilic Z′ with gauge group U(1) Lx–Ly and vector couplings to the SM leptons

  - g′ and mZ′ are the effective coupling of Z′ to leptons and the mass of Z′

- **New figure**, includes:

  - Higgs Electroweak Top factory (HET): FCC-ee (4f, μμ γ + mono γ), ILC Delphes (mono γ)

  - FCChh (result from 2205.13552 for 100 TeV rescaled to 85 TeV)

  - MuC 2308.12804, 2205.13552 (EFT , direct 3 TeV, 10 TeV(TBU))

Another scenario under consideration B3-L3
(B-L only in the third generation)

Lepton colliders very effective, very strong EFT bounds

Exclusion reach of different colliders on the Le-Lμ model parameters
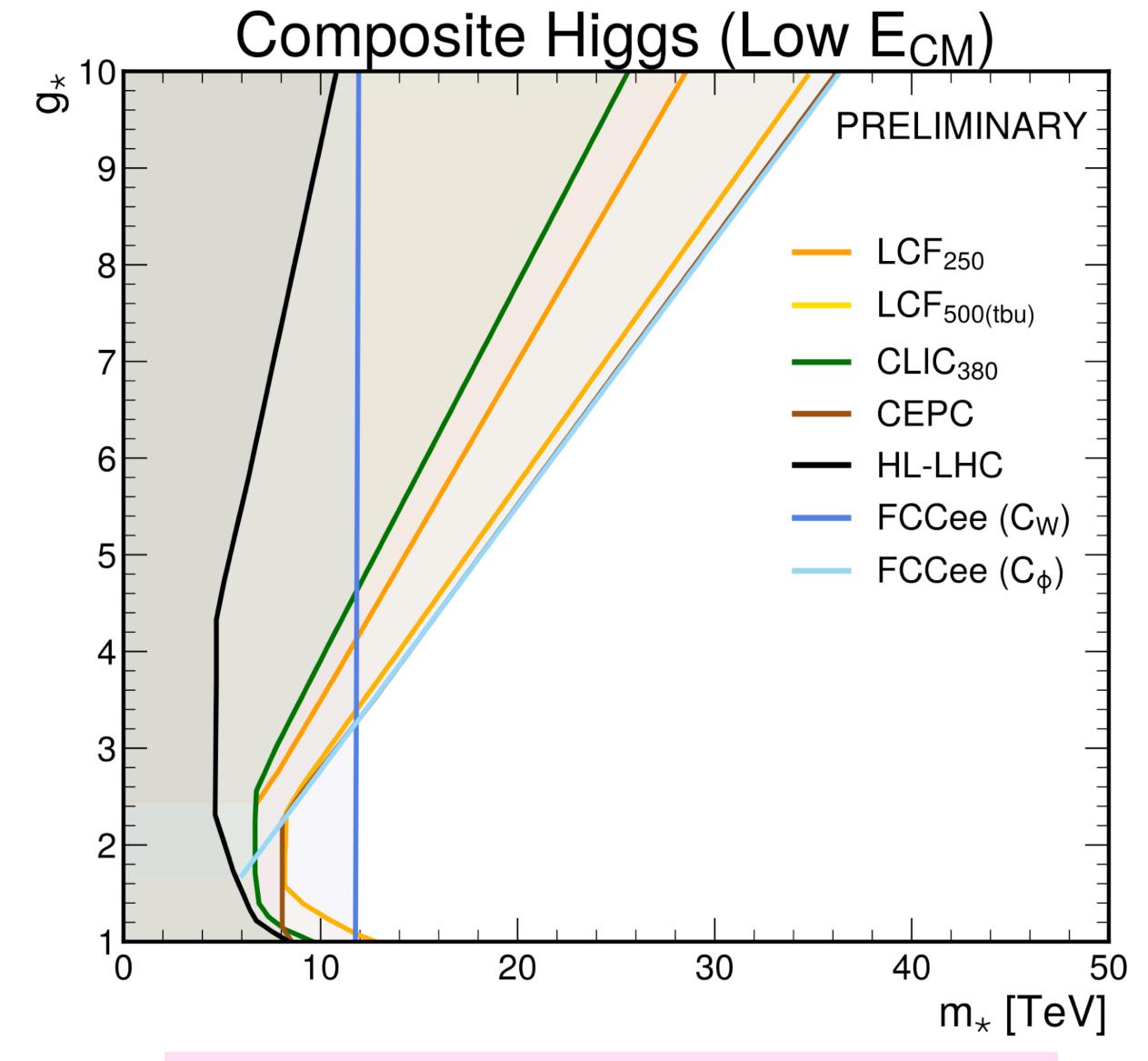
2 - Compositeness

Roberto Franceschini, Loukas Gouskos

Compositeness

- Higgs compositeness provides a possible solution to the hierarchy problem.

- m_*: compositeness scale -how high in energy we need to go to see signs of compositeness; g^*: effective coupling constant - how strong those effects will be

- Indirect limits depending on EWPO → considering adding direct search for resonances (e.g., VLQs, top partners..)

- **Updated figure**, additions:

  - added µ-Col10 TeV; LEP 3 pending, machinery in place to produce it when EFT inputs available

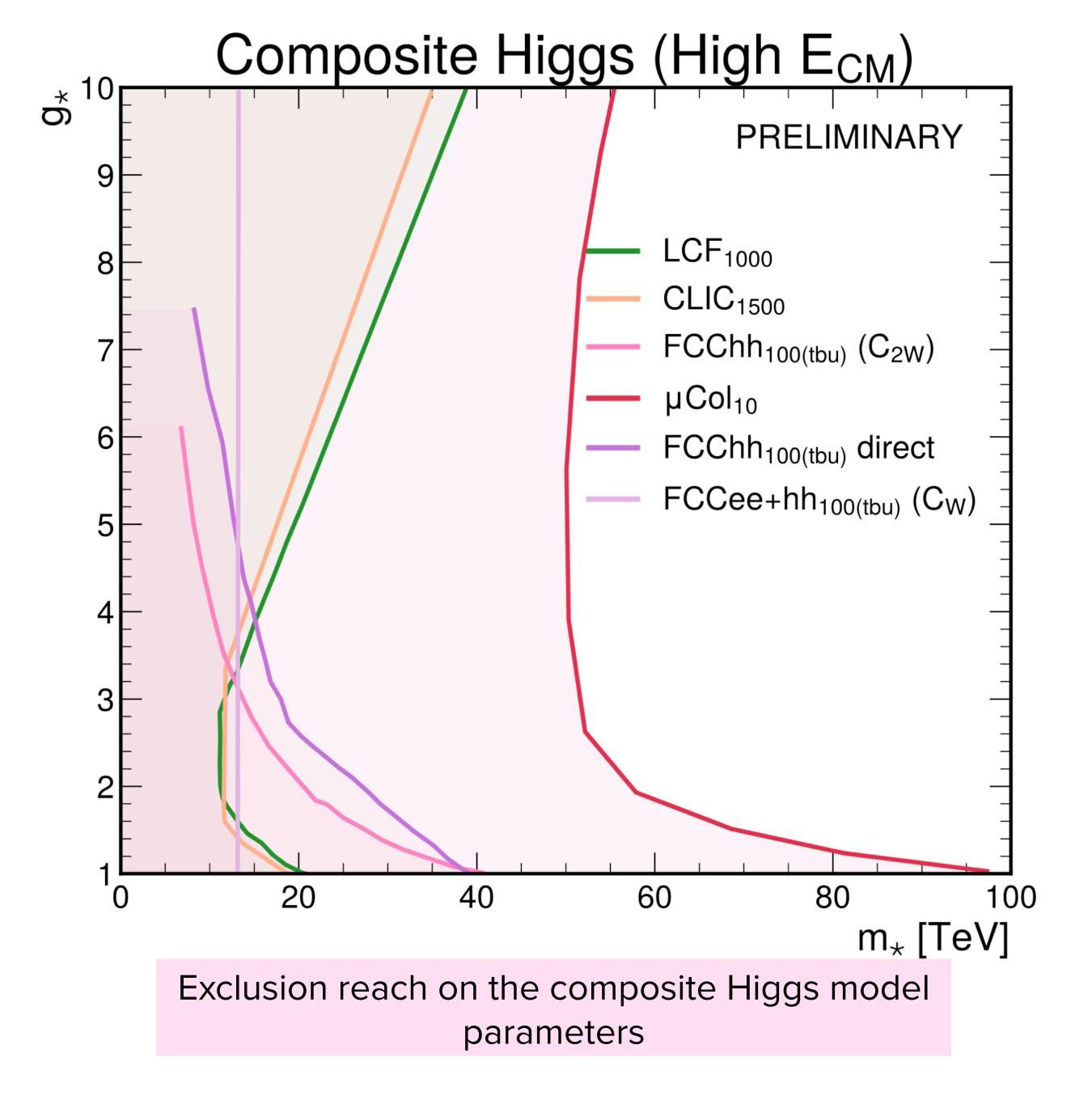Non-RG: each EFT operator is independent (à la ESPPU 2020)

Composite Higgs (Low E_{CM})

PRELIMINARY

- LCF$_{250}$
- LCF$_{500(tbu)}$
- CLIC$_{380}$
- CEPC
- HL-LHC
- FCCee (C_W)
- FCCee (C_ϕ)

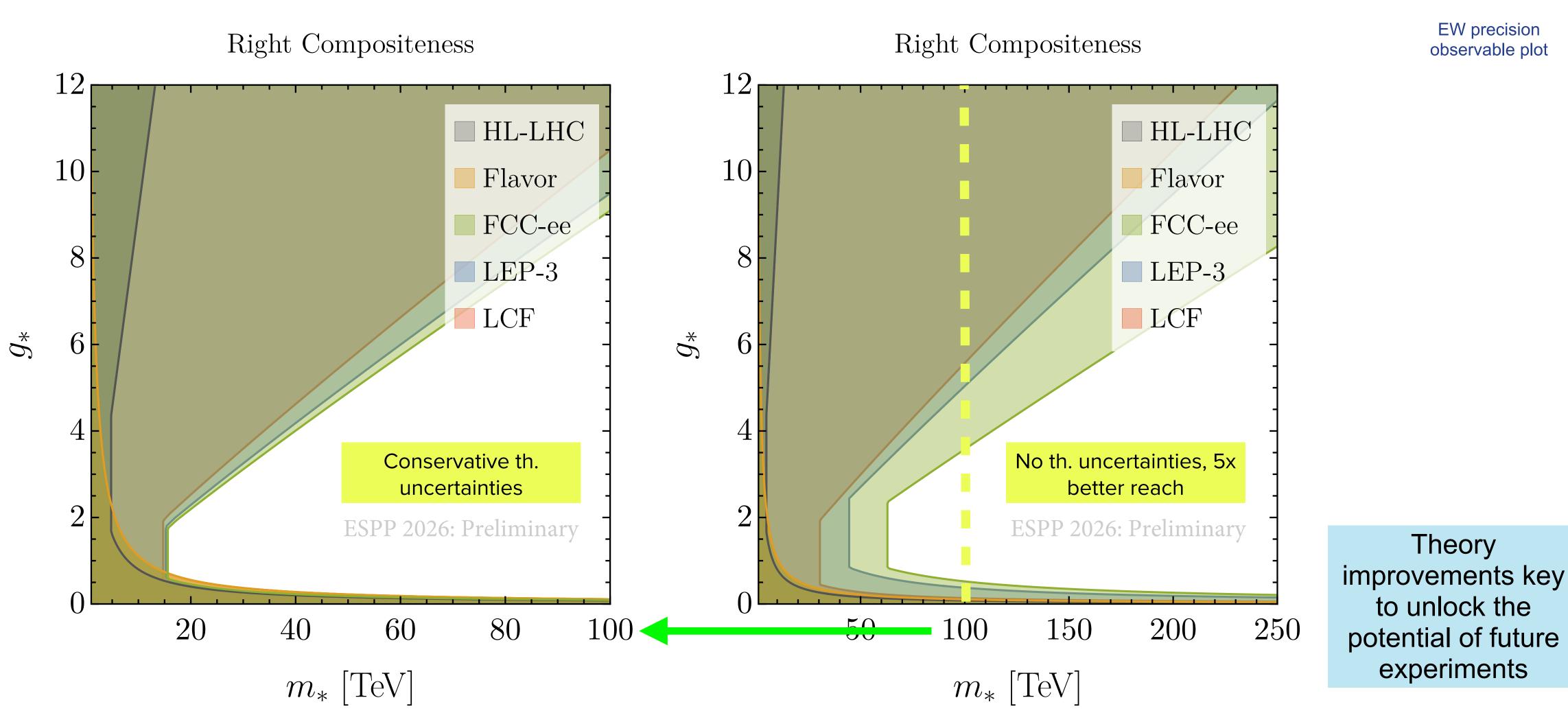Exclusion reach on the composite Higgs model parameters

Compositeness

- Higgs compositeness provides a possible solution to the hierarchy problem.

- m_*: compositeness scale -how high in energy we need to go to see signs of compositeness; g^*: effective coupling constant - how strong those effects will be

- Indirect limits depending on EWPO → considering adding direct search for resonances (e.g., VLQs, top partners..)

- **Updated figure**, additions:

  - added μ-Col10 TeV; LEP 3 pending, machinery in place to produce it when EFT inputs available

Non-RG: each EFT operator is independent (à la ESPPU 2020)

Composite Higgs (High E_{CM})

PRELIMINARY

- LCF$_{1000}$
- CLIC$_{1500}$
- FCChh$_{100(tbu)}$ (C$_{2W}$)
- μCol$_{10}$
- FCChh$_{100(tbu)}$ direct
- FCCee+hh$_{100(tbu)}$ (C$_W$)

Exclusion reach on the composite Higgs model parameters

RG-improved
Operators mix via RG evolution (new: PPG 2025), SILH framework

EW precision observable plot

Right Compositeness

Legend:
- HL-LHC
- Flavor
- FCC-ee
- LEP-3
- LCF

Conservative th. uncertainties

ESPP 2026: Preliminary

g_* (vertical axis), m_* [TeV] (horizontal axis)

Right Compositeness

No th. uncertainties, 5x better reach

ESPP 2026: Preliminary

Theory improvements key to unlock the potential of future experiments

3 - Extension of the minimal real scalar sector giving 1st order EW phase transition and possibly stability

Nathaniel Craig, Loukas Gouskos

Scalar singlet: direct and indirect sensitivity

- Scalar singlet S mixing with SM Higgs, parameterize by mass m, mixing angle

- **Updated figure**, includes:

  - HL-LHC: Projections for combination of searches (S →hh → bbtautau, bbbb, bbgammagamma) [170]

  - muC: S →hh→ 4b [207]

  - FCC-hh: S → ZZ

  - Indirect sensitivity [140],[170], [207], [203]

Direct and indirect limits on a singlet scalar mixing with the Higgs boson as a function of singlet mass m and squared mixing angle in the "custodial limit" BR(S➤hh) = BR(S➤ZZ) = BR(S➤WW)/2. Dashed gray lines indicate two characteristic scalings of the mixing angle as a function of the singlet mass corresponding to an independent singlet vacuum expectation value and an EWSB-induced singlet vacuum expectation value, respectively.

Higgs potential

- Interpretation of Higgs self-coupling measurements in terms of the shape of the Higgs potential

- Using the SMEFT-6 parameterization presented in Appendix B of the ATLAS-CMS submission

- **New plot**, includes:

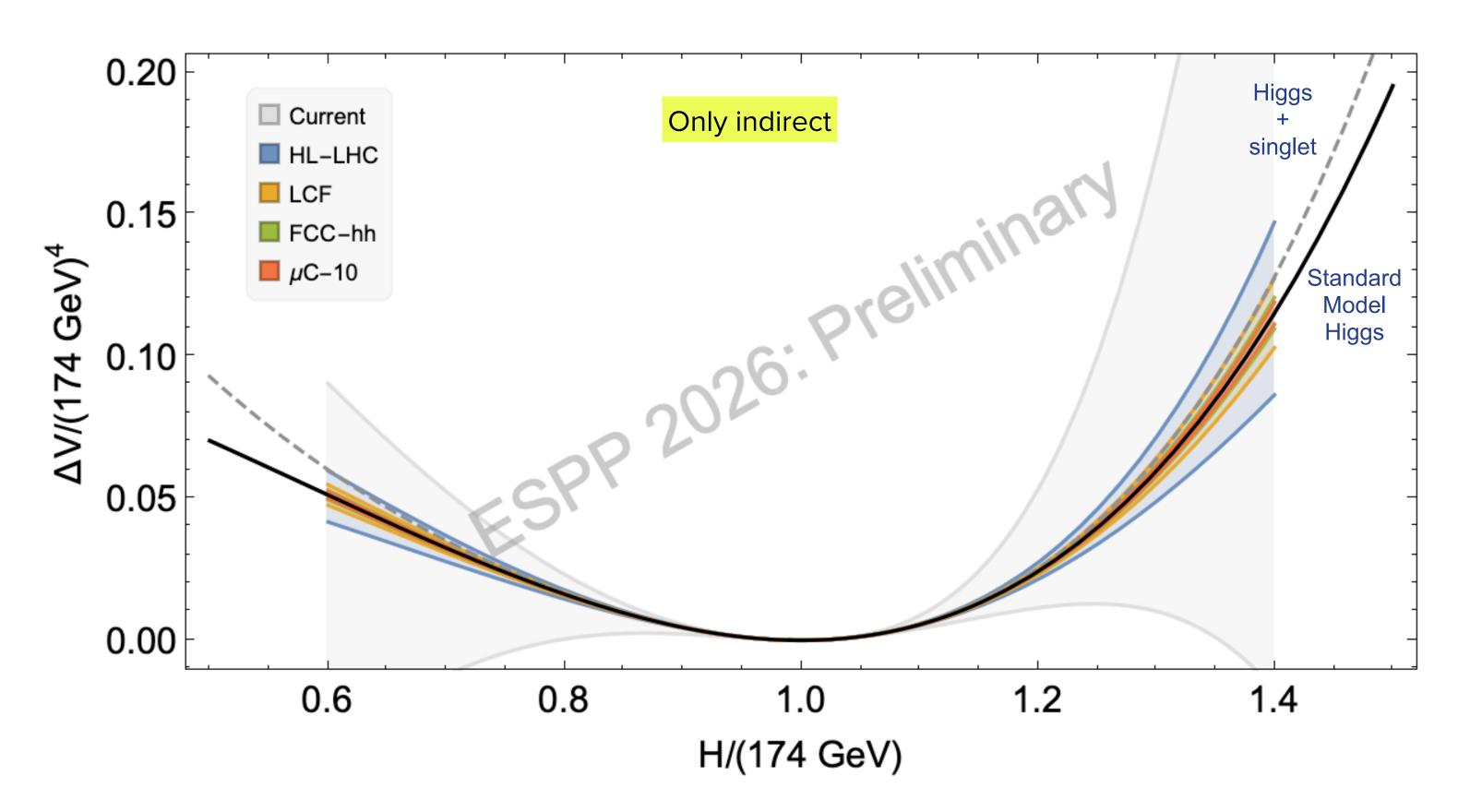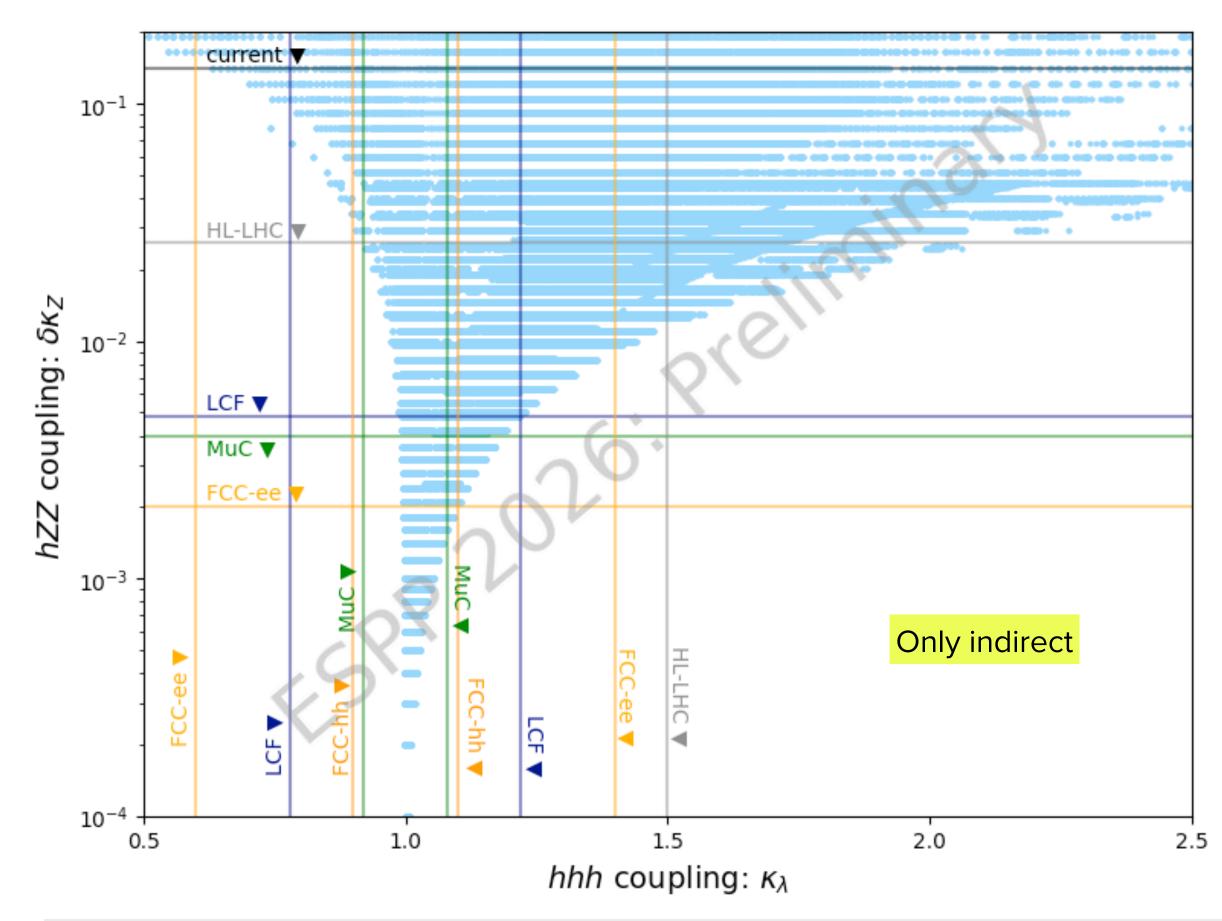 - Inputs from HL-LHC [170], LCF [140], FCC-hh [247,261], MuC-10 [ID207]

Illustration of the effective understanding of the Higgs potential provided by the 95% CL uncertainties on κ3 currently obtained by the CMS experiment at the LHC and expected at the HL-LHC, FLC, FCC-hh, and 10 TeV muC. Shaded regions denote the 95% uncertainty on κ3 , interpreted in terms of uncertainties on the shape of the Higgs potential in the SMEFT-6 parameterization, in a regime of validity where corrections to the Higgs potential shape are dominated by the trilinear coupling. The solid black line corresponds to the Standard Model Higgs prediction, while the dashed grey line is the effective potential arising from a Z2-symmetric singlet scalar with quartic coupling κ=8 and bare mass m = 4mt.
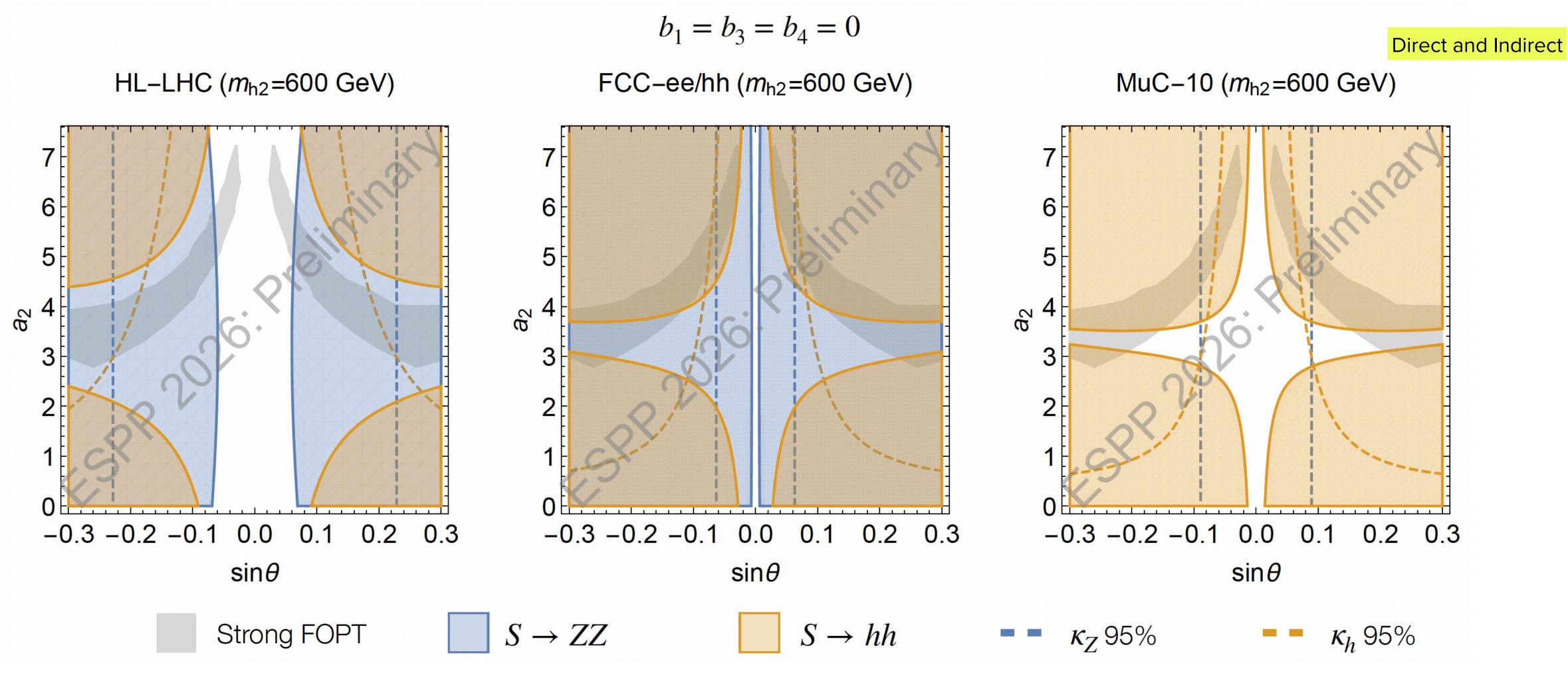
Scalar singlet: first-order phase transition

- Projections for Higgs coupling measurements on a singlet scalar mixing with the Higgs boson

- Focusing on parameter points where the scalar leads to a strong first-order electroweak phase transition

- **New plot**, includes:

  - Parameter scan of full scalar singlet model resulting in a first-order electroweak phase transition

  - Limits: HL-LHC [170], LCF [140], FCC-ee [233], FCC-hh [247,261], MuC-10 [207]

Parameter space of the singlet scalar leading to a first-order electroweak phase transition as a function of corrections to the Higgs self-coupling and Higgs coupling to Z bosons.

First-Order Electroweak Phase Transition

$$b_1 = b_3 = b_4 = 0$$

Direct and Indirect

HL–LHC (m_{h2}=600 GeV) — **FCC–ee/hh (m_{h2}=600 GeV)** — **MuC–10 (m_{h2}=600 GeV)**

Legend: Strong FOPT · $S \to ZZ$ · $S \to hh$ · κ_Z 95% · κ_h 95%
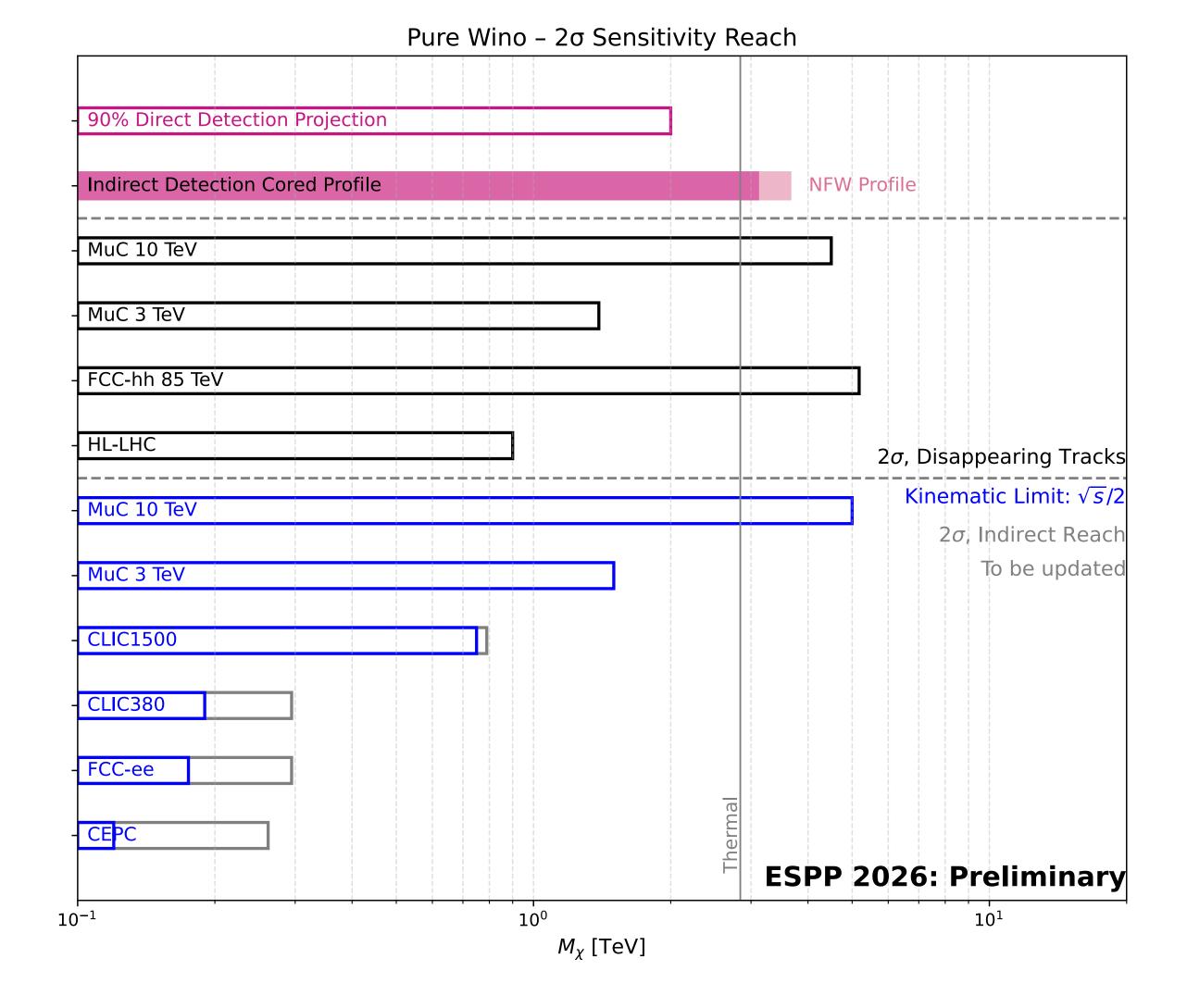
The space of theories enabling strongly first-order electroweak PT is bounded and coverable by the combination of direct searches, Higgs precision, and self-coupling

4 - Minimal dark matter (WIMP) global

Tim Cohen, Annapaola de Cosa

Wino

- Minimal dark matter model (WIMP)

- Wino: Majorana fermion triplet

- Updated plot with new:

  - Indirect detection, relic abundance lines

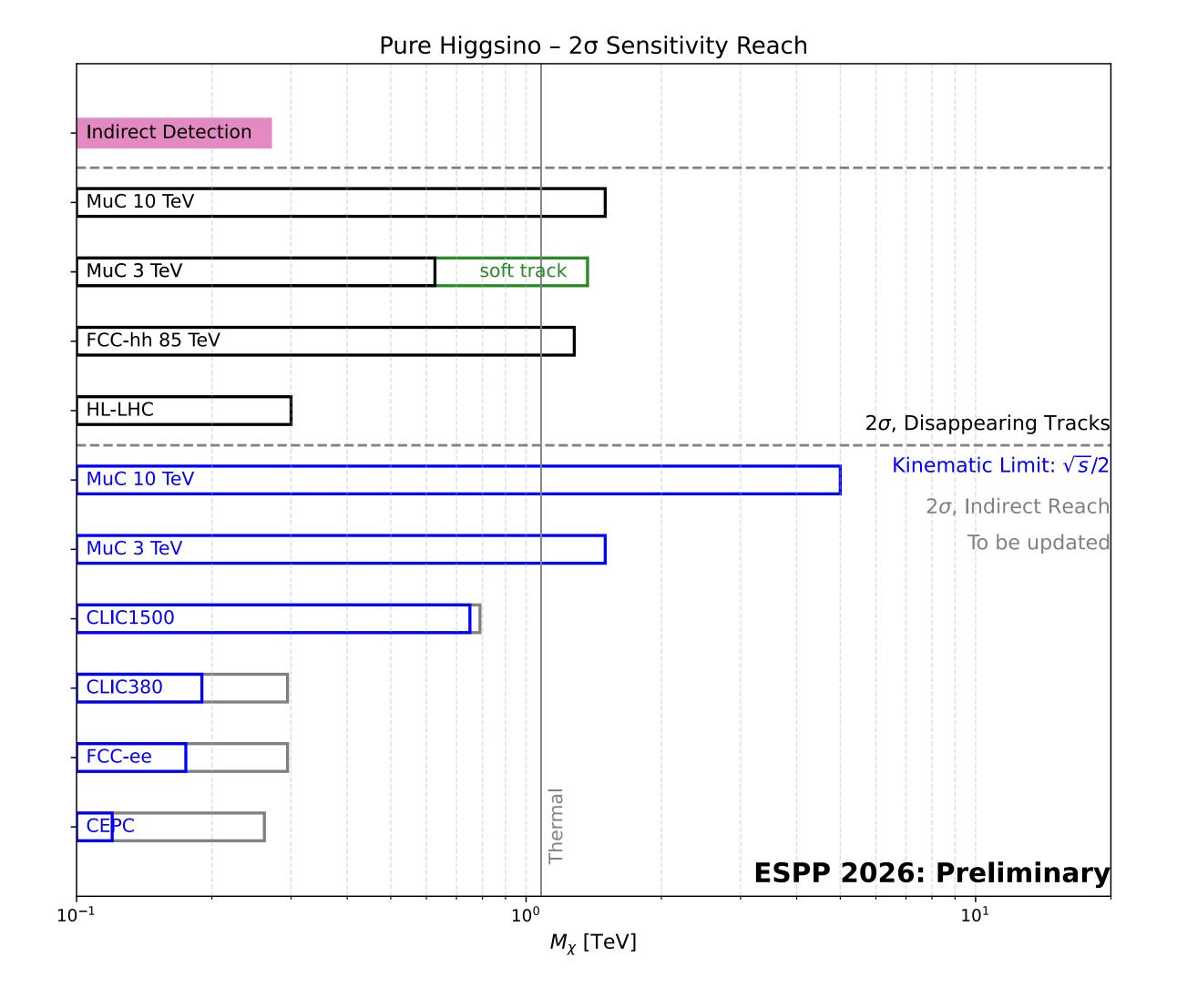 - Collider inputs: MuC, FCC-hh rescaled to 85 TeV

Pure Wino – 2σ Sensitivity Reach

- 90% Direct Detection Projection
- Indirect Detection Cored Profile · NFW Profile
- MuC 10 TeV
- MuC 3 TeV
- FCC-hh 85 TeV
- HL-LHC · 2σ, Disappearing Tracks
- MuC 10 TeV · Kinematic Limit: $\sqrt{s}/2$
- MuC 3 TeV · 2σ, Indirect Reach · To be updated
- CLIC1500
- CLIC380
- FCC-ee
- CEPC

Thermal

ESPP 2026: Preliminary

M_χ [TeV]
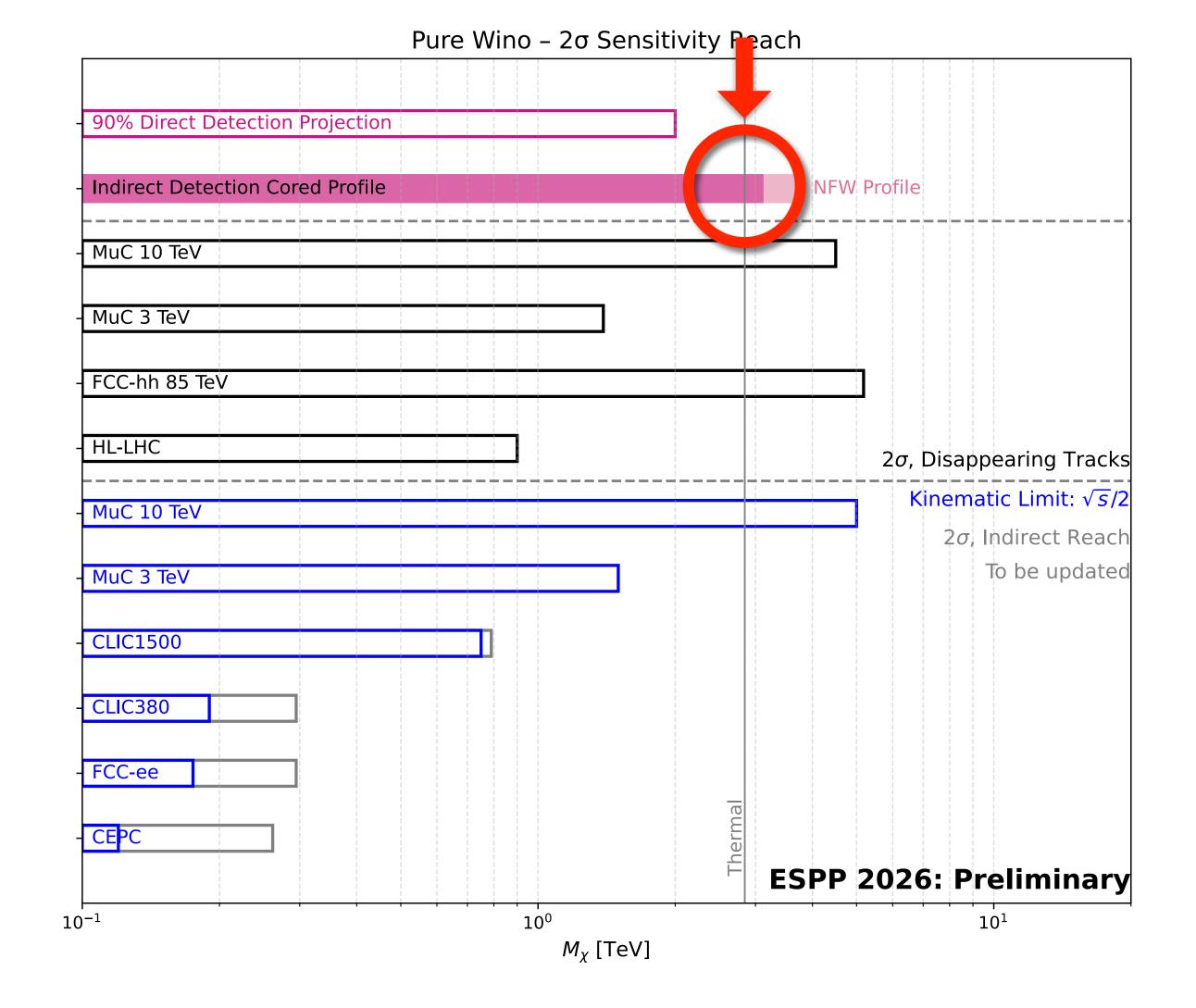
Summary of 2σ sensitivity reach to pure Winos at future colliders.
Current indirect DM detection constraints (which suffer from unknown halo-modelling uncertainties) and projections for future direct DM detection (which suffer from uncertainties on the Wino-nucleon cross section) are also indicated. The vertical line shows the mass corresponding to DM thermal relic.

Wino

- Minimal dark matter model (WIMP)

- Wino: Majorana fermion triplet

- Updated plot with new:

  - Indirect detection, relic abundance lines

  - Collider inputs: MuC, FCC-hh rescaled to 85 TeV

Pure Wino – 2σ Sensitivity Reach

90% Direct Detection Projection

Indirect Detection Cored Profile — NFW Profile

MuC 10 TeV

MuC 3 TeV

FCC-hh 85 TeV

HL-LHC

2σ, Disappearing Tracks

MuC 10 TeV

Kinematic Limit: $\sqrt{s}/2$

2σ, Indirect Reach

To be updated

MuC 3 TeV

CLIC1500

CLIC380

FCC-ee

CEPC

Thermal

ESPP 2026: Preliminary

M_χ [TeV]

Summary of 2σ sensitivity reach to pure Winos at future colliders.
Current indirect DM detection constraints (which suffer from unknown halo-modelling uncertainties) and projections for future direct DM detection (which suffer from uncertainties on the Wino-nucleon cross section) are also indicated. The vertical line shows the mass corresponding to DM thermal relic.

Higgsino

- Minimal dark matter model (WIMP)

- Higgsino: Dirac fermion doublet

- Updated plot with new:

  - Indirect detection, relic abundance lines

  - Collider inputs: MuC, FCC-hh rescaled to 85 TeV

Higher energies cover higher mass ranges for Wino/ Higgsino

Pure Higgsino – 2σ Sensitivity Reach

Indirect Detection

MuC 10 TeV

MuC 3 TeV — soft track

FCC-hh 85 TeV

HL-LHC

2σ, Disappearing Tracks

MuC 10 TeV — Kinematic Limit: $\sqrt{s}/2$

2σ, Indirect Reach

To be updated

MuC 3 TeV

CLIC1500

CLIC380

FCC-ee

CEPC

Thermal

ESPP 2026: Preliminary

M_χ [TeV]

Summary of 2σ sensitivity reach to pure Higgsinos at future colliders.
Current indirect DM detection constraints (which suffer from unknown halo-modelling uncertainties) and projections for future direct DM detection (which suffer from uncertainties on the Wino-nucleon cross section) are also indicated. The vertical line shows the mass corresponding to DM thermal relic.

5 - Flavor

Sophie Renner, Lesya Shchutska
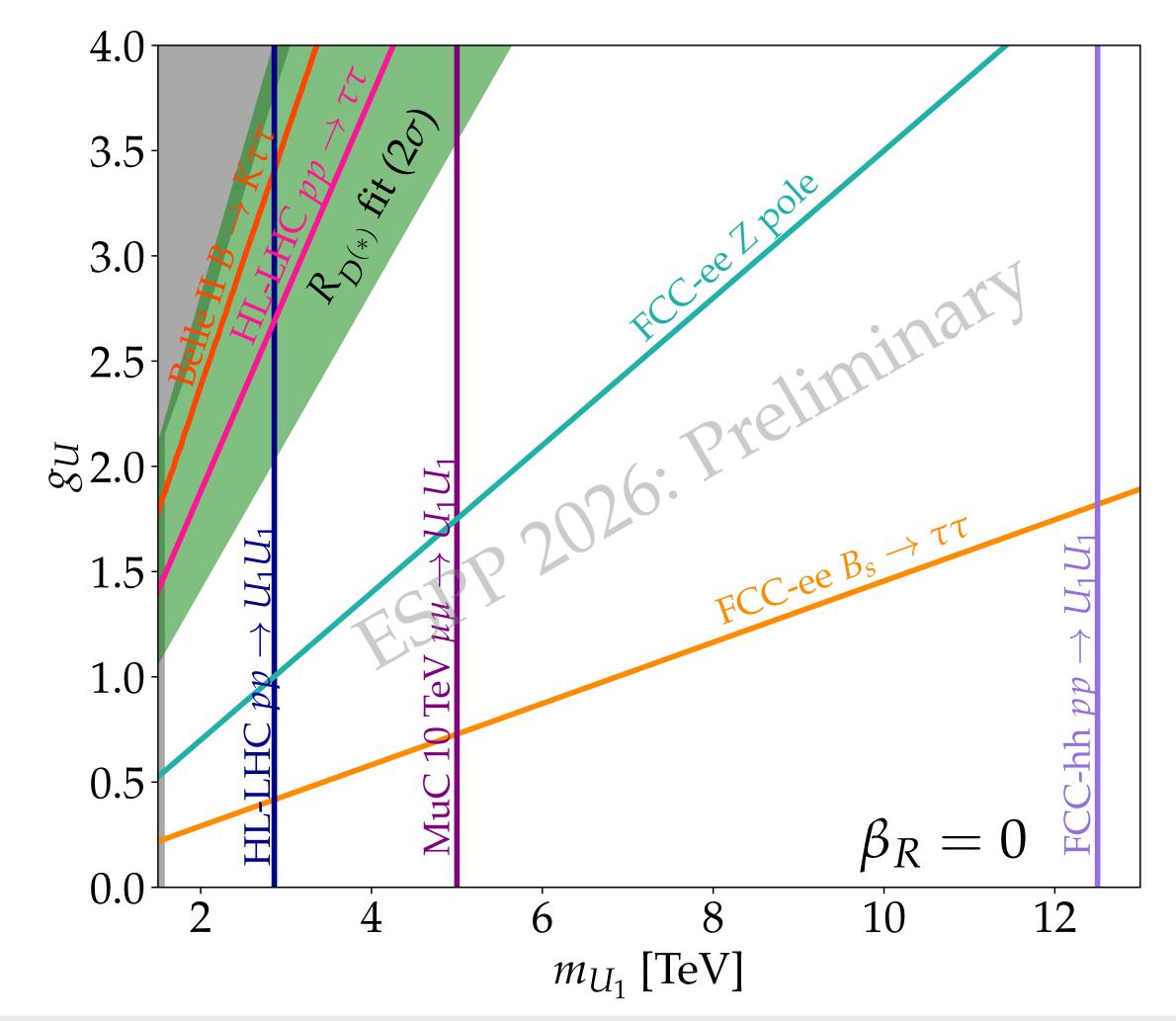
U$_1$ leptoquark (tauonic)

- Vector leptoquark with couplings to left handed 3rd generation quarks and leptons

  - motivated as a possible origin of the R$_{D(*)}$ anomalies

- **Updated plot**

  - Inputs: Projections for Key Measurements in Heavy Flavour Physics, Muon Collider, FCC

  - Collider reach used to extrapolate HL-LHC

Strong indirect projections from FCC-ee Z pole and flavor programs. Complementary direct sensitivity from hadron and muon colliders (direct FCC-hh bound at ~12 TeV)
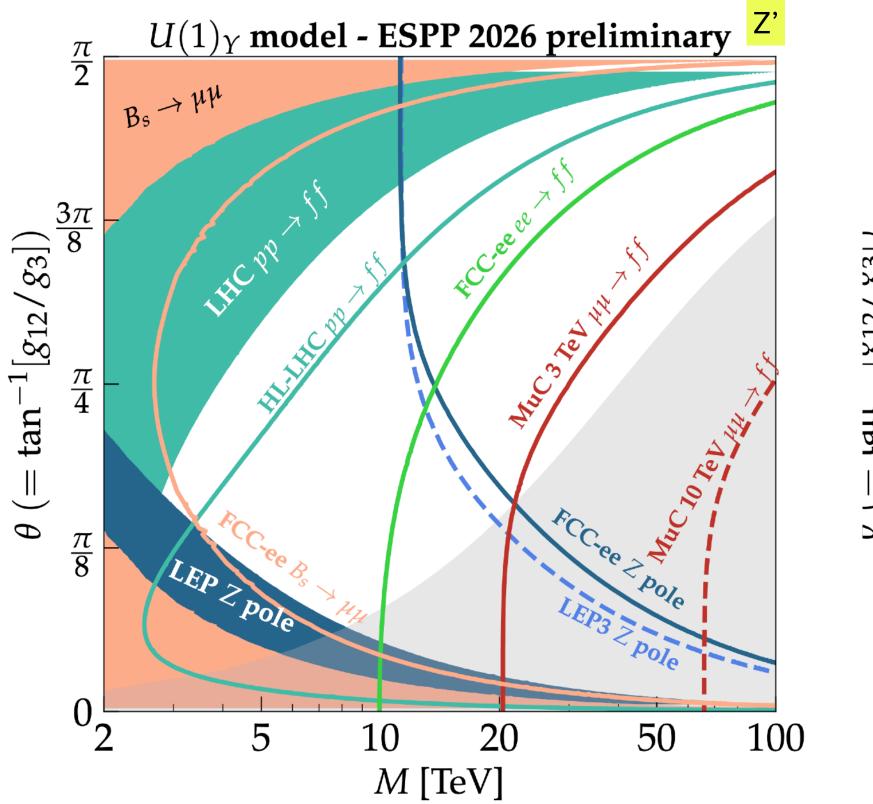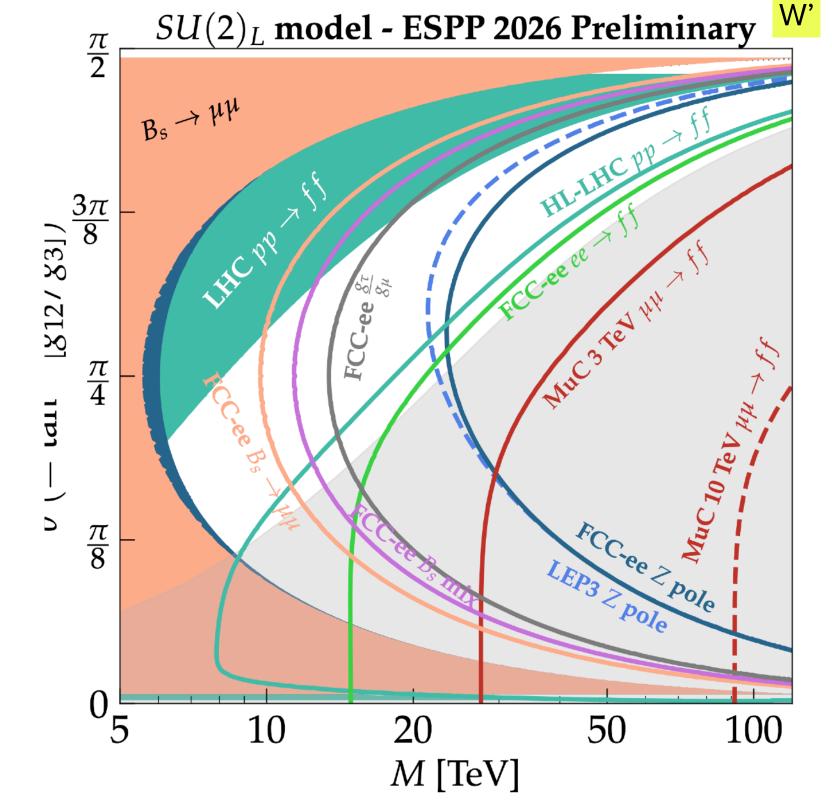
Current constraints and projected sensitivities (all at 95% CL) on the vector U$_1$ leptoquark coupling to third generation leptons and predominantly to third generation quarks. Also shown is the preferred region (at 1 σ in darker green, and at 2σ in lighter green) to explain the R$_{D(*)}$ measurements, from a global fit to b ⇥ cτν processes (citation). This assumes couplings to left handed fermions only, and a minimal U(2)Q flavour symmetry assumption for the quark sector in which the misalignment between the gauge and flavour basis gives g$_{\mu b}$ = g$_U$ and g$_{\mu s}$ = 0.1 g$_U$.

Flavour deconstructed gauge models

- New gauge bosons arising from a flavored symmetry breaking

  - Heavy Z' and W' with flavour-dependent couplings

- **New plot**, includes:

  - Inputs: Projections for Key Measurements in Heavy Flavour Physics,Muon Collider, FCC, LEP3

Large indirect effects from electroweak precision. Combination of indirect searches at FCC-ee have capacity to exclude most of the natural region.
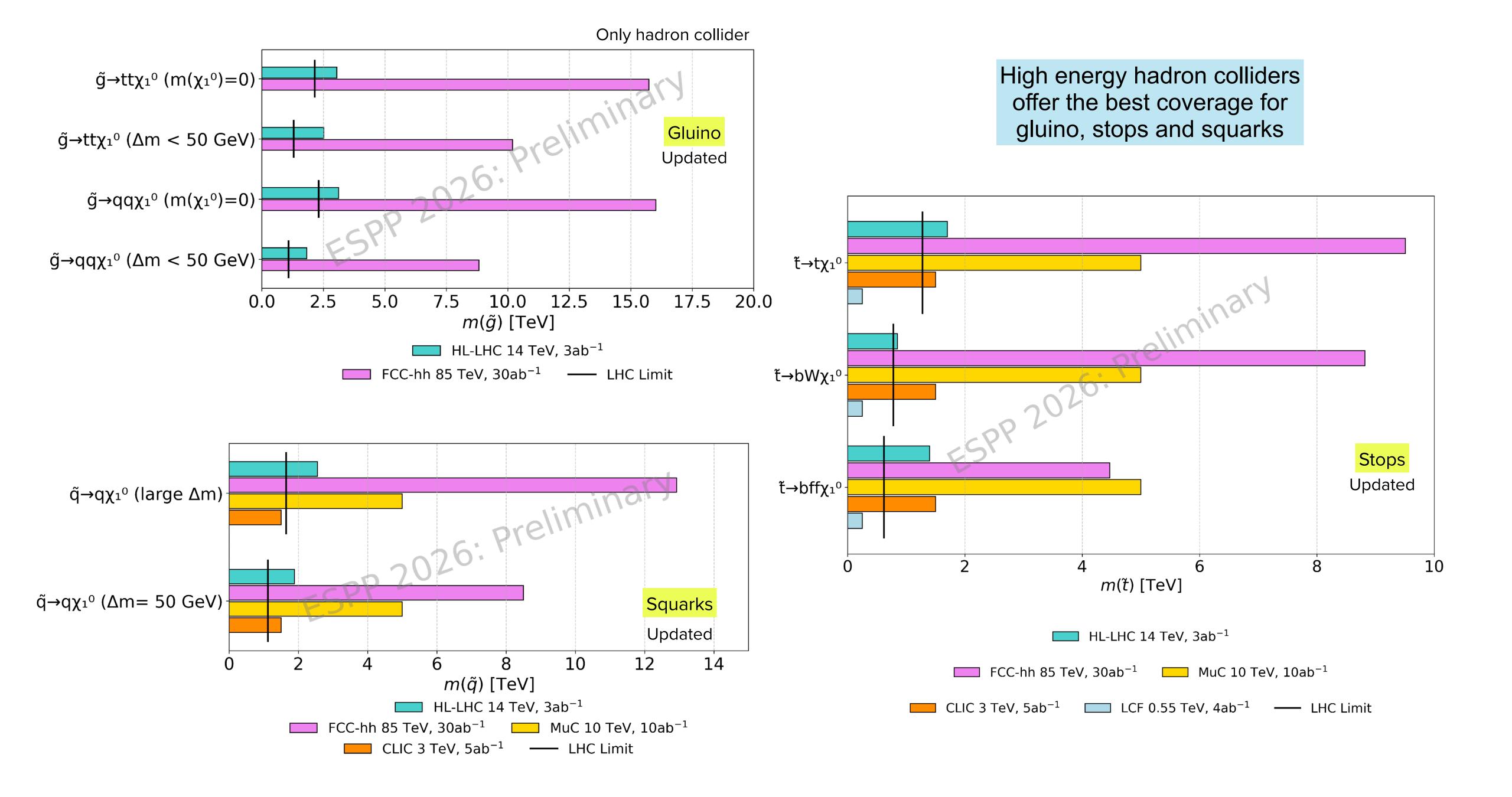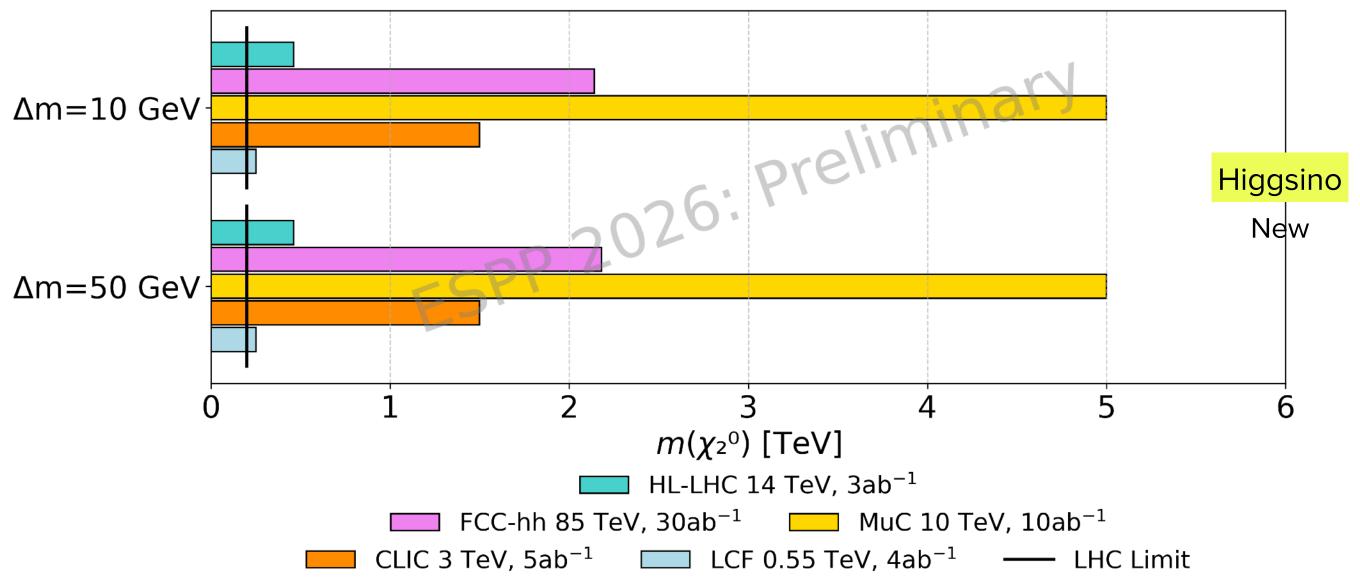
Current constraints and projected sensitivities (all at 95% CL) on the parameter space of new flavoured vector bosons arising from a deconstructed gauge model. The tangent of the angle θ measures the ratio of the coupling to light (first and second generation) fermions vs the coupling to third generation fermions. The gauge basis is assumed to be aligned with the up quark mass basis. LEFT: The parameter space of a Z ' gauge singlet boson arising from a deconstructed U(1)$_Y$ gauge symmetry. RIGHT: The parameter space of a W ' SU(2)$_L$ triplet boson arising from a deconstructed SU(2)$_L$ gauge symmetry.
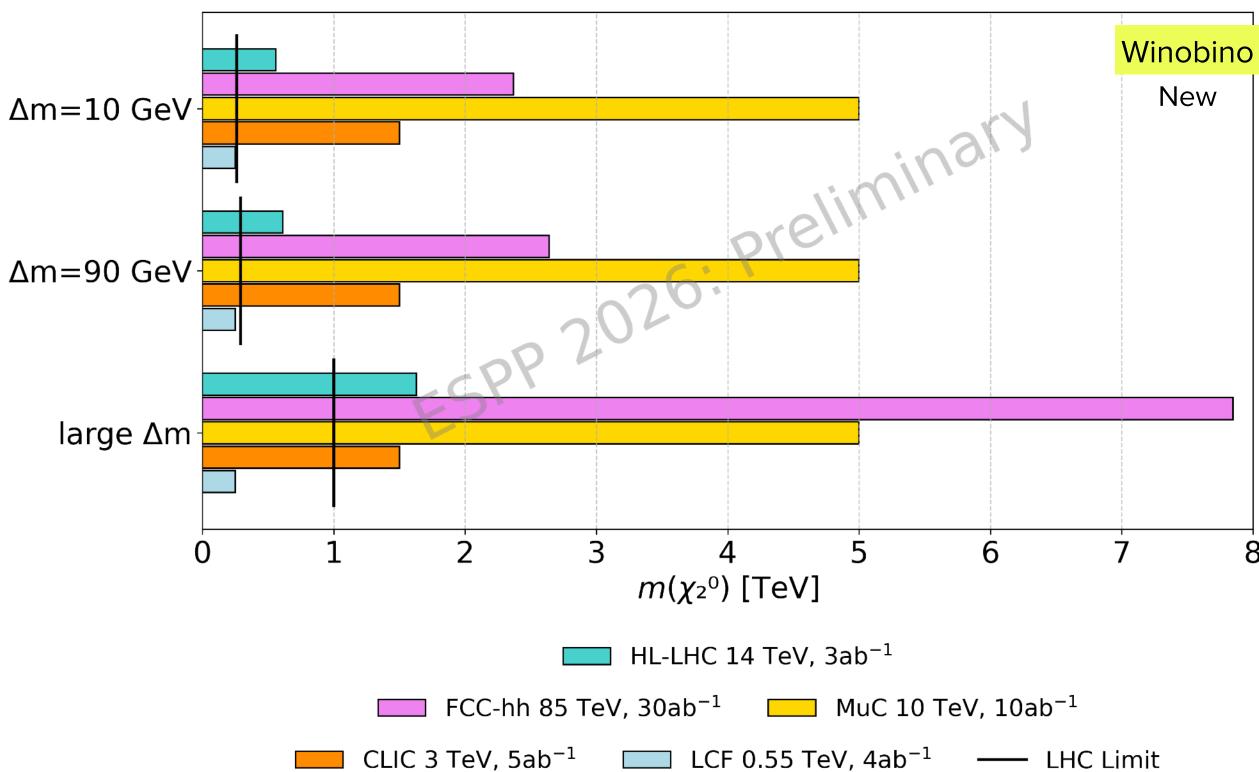
6 - Symmetries as a solution of the Higgs naturalness problem; SUSY and other models (such as neutral naturalness)

Nathaniel Craig, Tim Cohen, Aurelio Juste

Only hadron collider

Gluino
Updated

$\tilde{g} \to tt\chi_1^0$ (m(χ_1^0)=0)
$\tilde{g} \to tt\chi_1^0$ (Δm < 50 GeV)
$\tilde{g} \to qq\chi_1^0$ (m(χ_1^0)=0)
$\tilde{g} \to qq\chi_1^0$ (Δm < 50 GeV)

$m(\tilde{g})$ [TeV]

- HL-LHC 14 TeV, 3ab^{-1}
- FCC-hh 85 TeV, 30ab^{-1}
- LHC Limit

High energy hadron colliders offer the best coverage for gluino, stops and squarks

$\tilde{t} \to t\chi_1^0$
$\tilde{t} \to bW\chi_1^0$
$\tilde{t} \to bff\chi_1^0$

Stops
Updated

$m(\tilde{t})$ [TeV]

Squarks
Updated

$\tilde{q} \to q\chi_1^0$ (large Δm)
$\tilde{q} \to q\chi_1^0$ (Δm= 50 GeV)

$m(\tilde{q})$ [TeV]

- HL-LHC 14 TeV, 3ab^{-1}
- FCC-hh 85 TeV, 30ab^{-1}
- MuC 10 TeV, 10ab^{-1}
- CLIC 3 TeV, 5ab^{-1}
- LHC Limit

- HL-LHC 14 TeV, 3ab^{-1}
- FCC-hh 85 TeV, 30ab^{-1}
- MuC 10 TeV, 10ab^{-1}
- CLIC 3 TeV, 5ab^{-1}
- LCF 0.55 TeV, 4ab^{-1}
- LHC Limit

Dramatic improvement in sensitivity wrt HL-LHC. Complementarity between high-energy hadron and lepton colliders

Higgs mass constraint

- Compare direct reach in top partners to physical Higgs mass prediction (not fine-tuning).

- Measured Higgs mass provides a sharp target for supersymmetry:

  - Expected limits on the stop mass for a Higgs boson of 125 GeV

- **New plot**
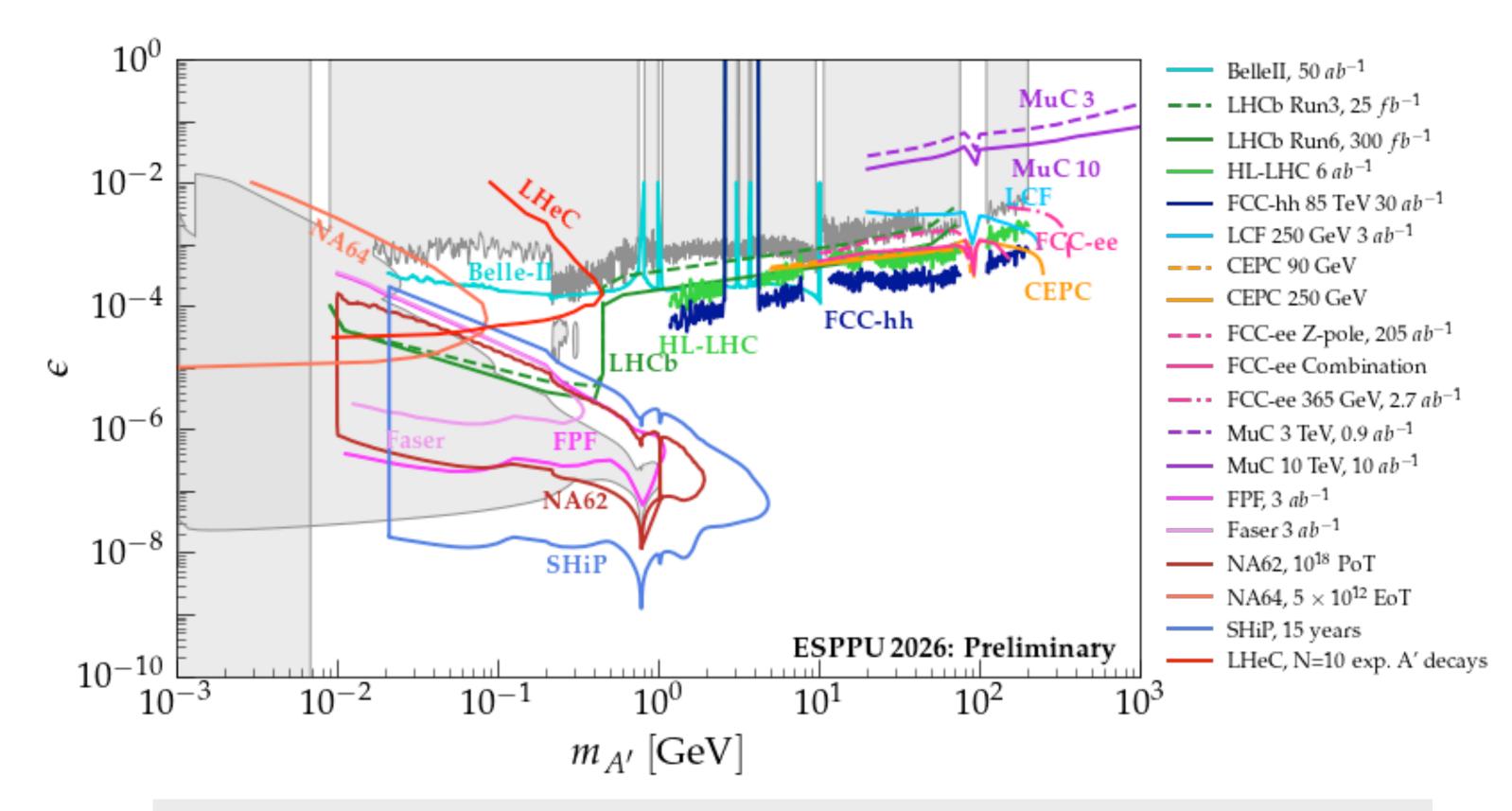
7 - Portals

Tim Cohen, Nathaniel Craig, Roberto Franceschini, Sophie
Renner, Lesya Shchutska, Annapaola de Cosa

Dark photon

- Dark Photons A' are massive vector particles from an extra dark U(1) symmetry

- Minimal Dark Photon →1 new single state, A'

  - DM assumed to be out of reach (too heavy or belonging to a different sector)

- Collider and beam dump experiments

- **Updated plot**
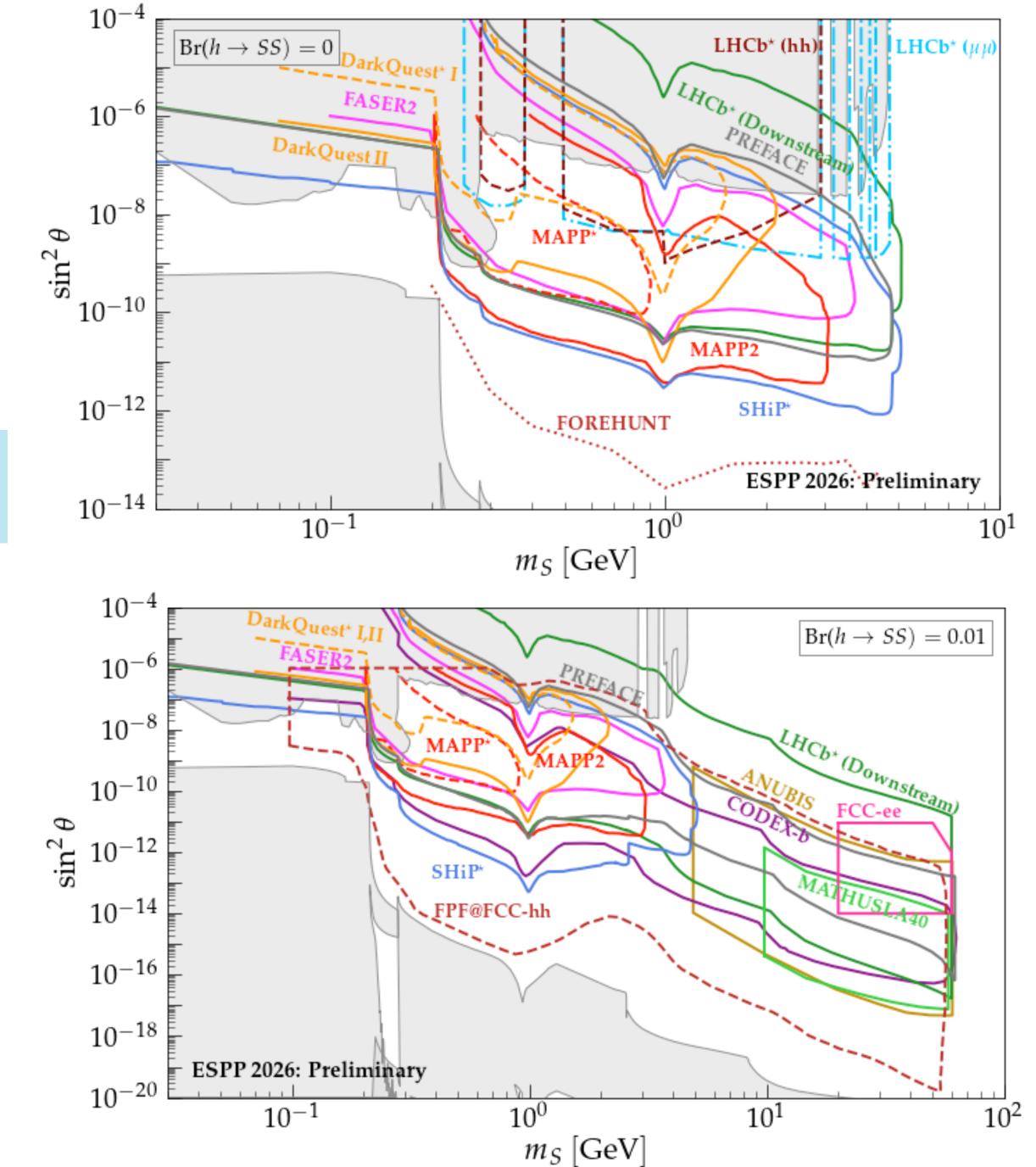
90% CL exclusion limits for Dark Photons in the plane mixing parameter ε versus Dark Photon mass. HL-LHC, CEPC, FCC-ee and FCC-hh curves correspond to 95% CL exclusion limits. LHeC curve correspond to N=10 expected A' decays and 0 background. The sensitivity of future colliders, mostly covers the large-mass, large-coupling range, and is fully complementary to the the low-mass, very low- coupling regime where beam-dump and fixed-target experiments are most sensitive. Belle II and LHCb upgrade provide additional coverage in the medium-mass, high-coupling region.

Dark scalar/Higgs

- BC4: no quartic coupling ($\lambda=0$), Br(h→SS)=0. Production through hadron decays, dark higgsstrahlung (for higher masses) and gluon fusion

- **New plot**

  Low mass: beam-dump and forward experiments, large potential for dedicated experiments at FCC-hh

- BC5: Br(h→SS)=0.0. Production via Higgs decays

- **Updated plot**

  - FCC-ee experiments are sensitive to much lower BF. The results are rescaled to 1% for comparison purposes

  - FPF-like facility at the FCC-hh can lead to significant improvement
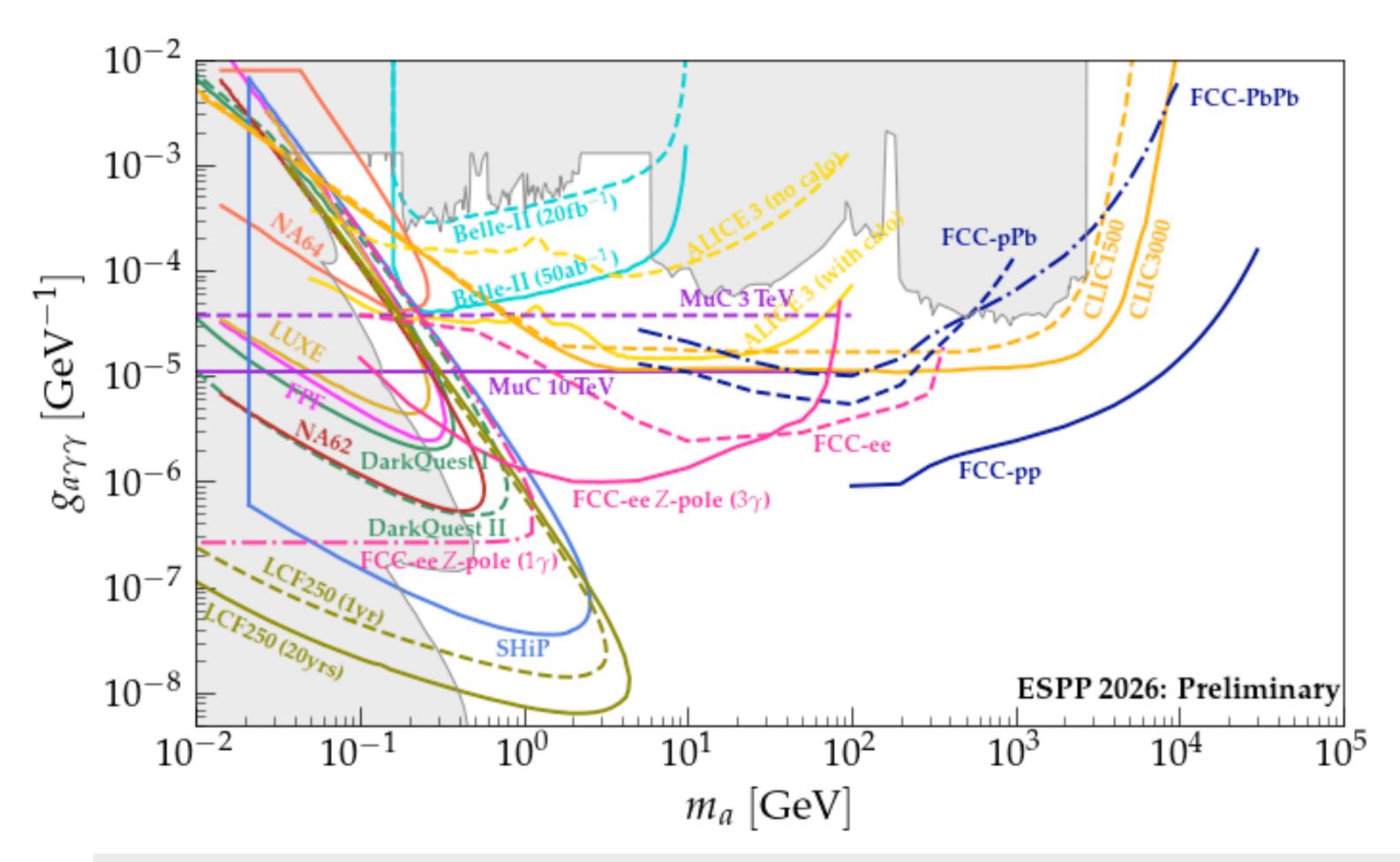
ALPs

Low couplings under 1GeV (very long-lived): beam dump experiments
Masses between 1 and 90 GeV: FCC-ee
Above 90 GeV & strong couplings: high energy (linear and hadron colliders)

- Pseudo-scalar Portal

- Rich phenomenology depending on the area of the phase space

- Limits from beam dump and collider experiments

- **Updated plot**
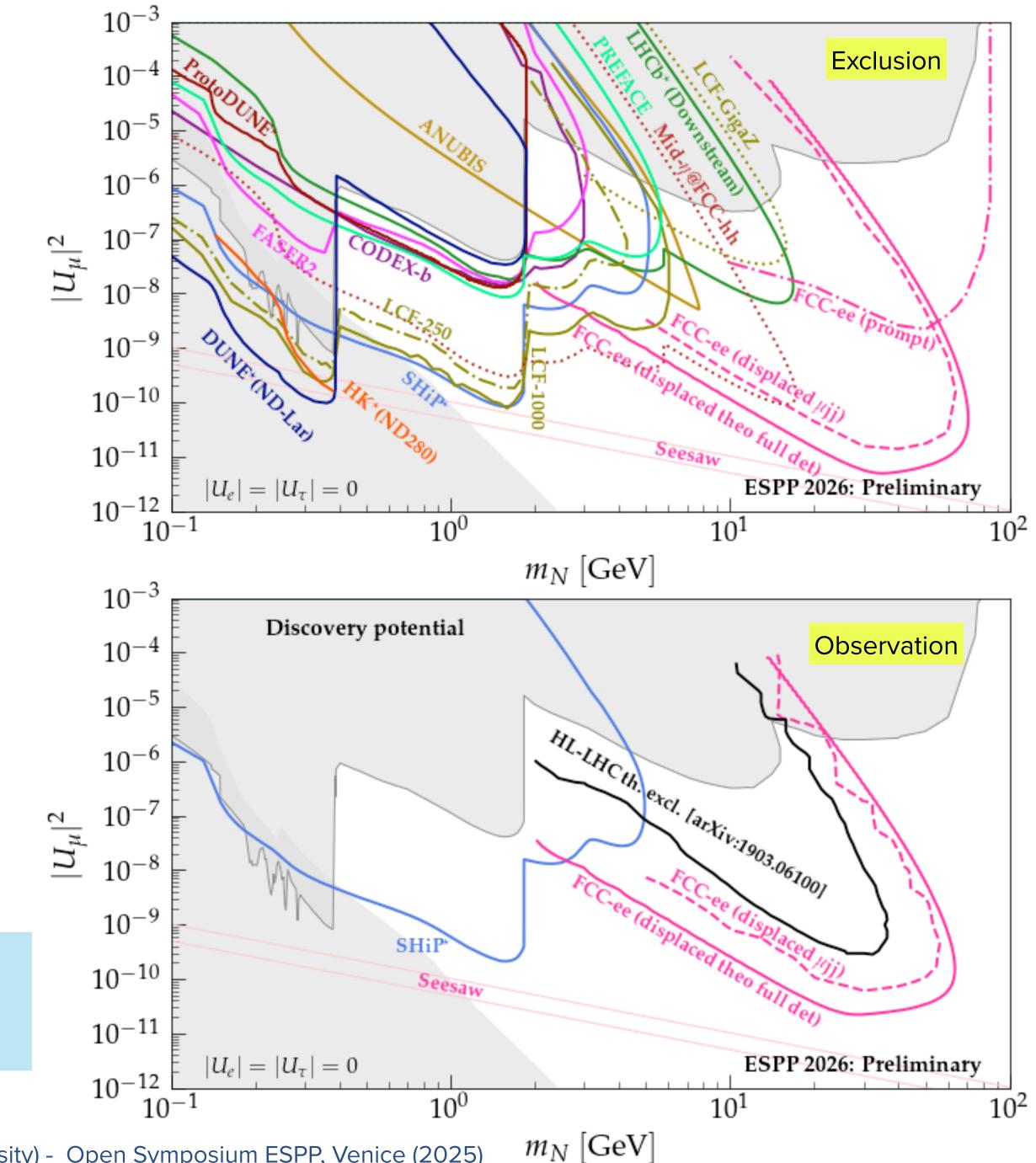
Exclusion limits on ALPs coupling to photons as a function of the ALP mass. All curves correspond to 90% CL exclusion limits, except for FCC-ee, FCC-hh and ILC(95% CL exclusion limits).

HNLs

- Simplified benchmark model: HNLs N with mixing solely to muon neutrinos (as an example).

  - Mixing is given by the mixing angle Uµ (BC7)

- Different facilities sensitive to different mass regimes (complementarity)

- **Updated/different plot**

- Significant part of the allowed parameter space under 100 GeV within the discovery reach of SHiP and FCC-ee at the Z-pole

  - More than an order of magnitude in coupling strength for a discovery post-HL-LHC

- **New plot**

Below the b mass: beam-dump experiments/off-axis, shielded detectors
Below the kaon mass (cosmologically disfavored): neutrino facilities
Below the Z mass: dominated by FCC-ee at the Z-pole
Masses above 100 GeV (strong couplings): high-energy colliders

In Summary

The BSM landscape
Towards the update of the European strategy
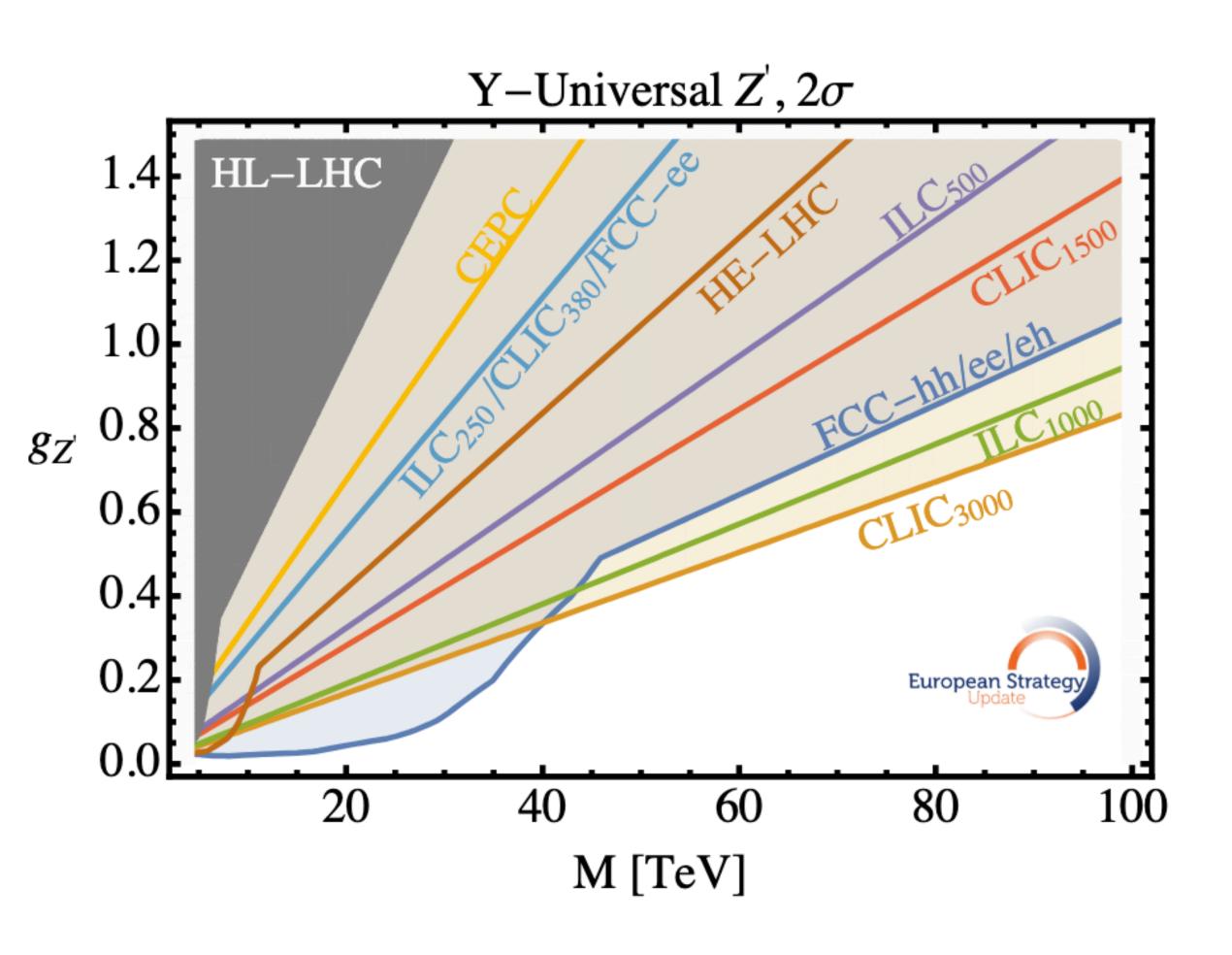
- Very rich landscape of BSM possibilities at future colliders

- Interplay between:

  - Ultimate indirect sensitivity from extremely high precision measurements in the EWK sector

  - Direct access to new physics in a wide range of masses and coupling scales

- Complementarity between working groups (Flavor, Neutrinos, DM), and also between colliders and non-collider experiments

Thank you!
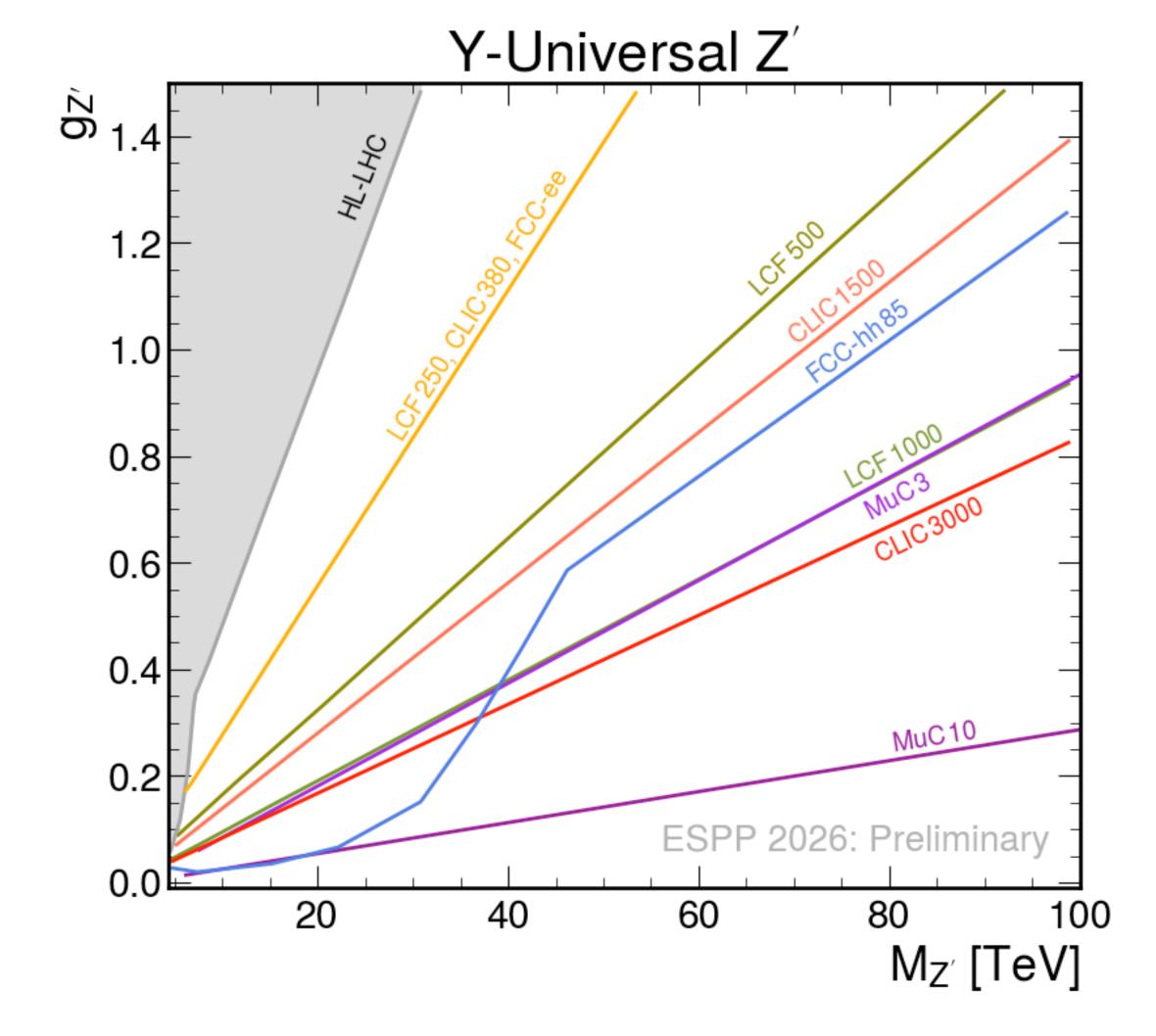
Backup
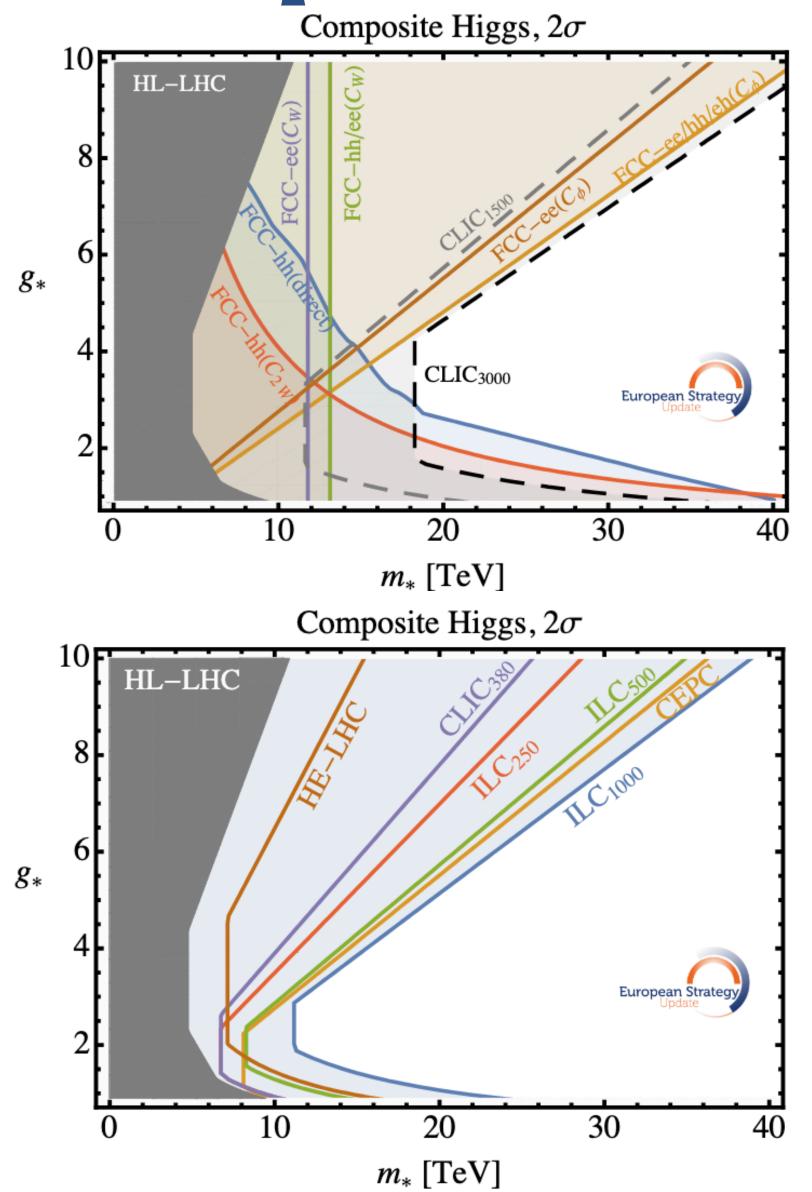
Updated plots: Before and after
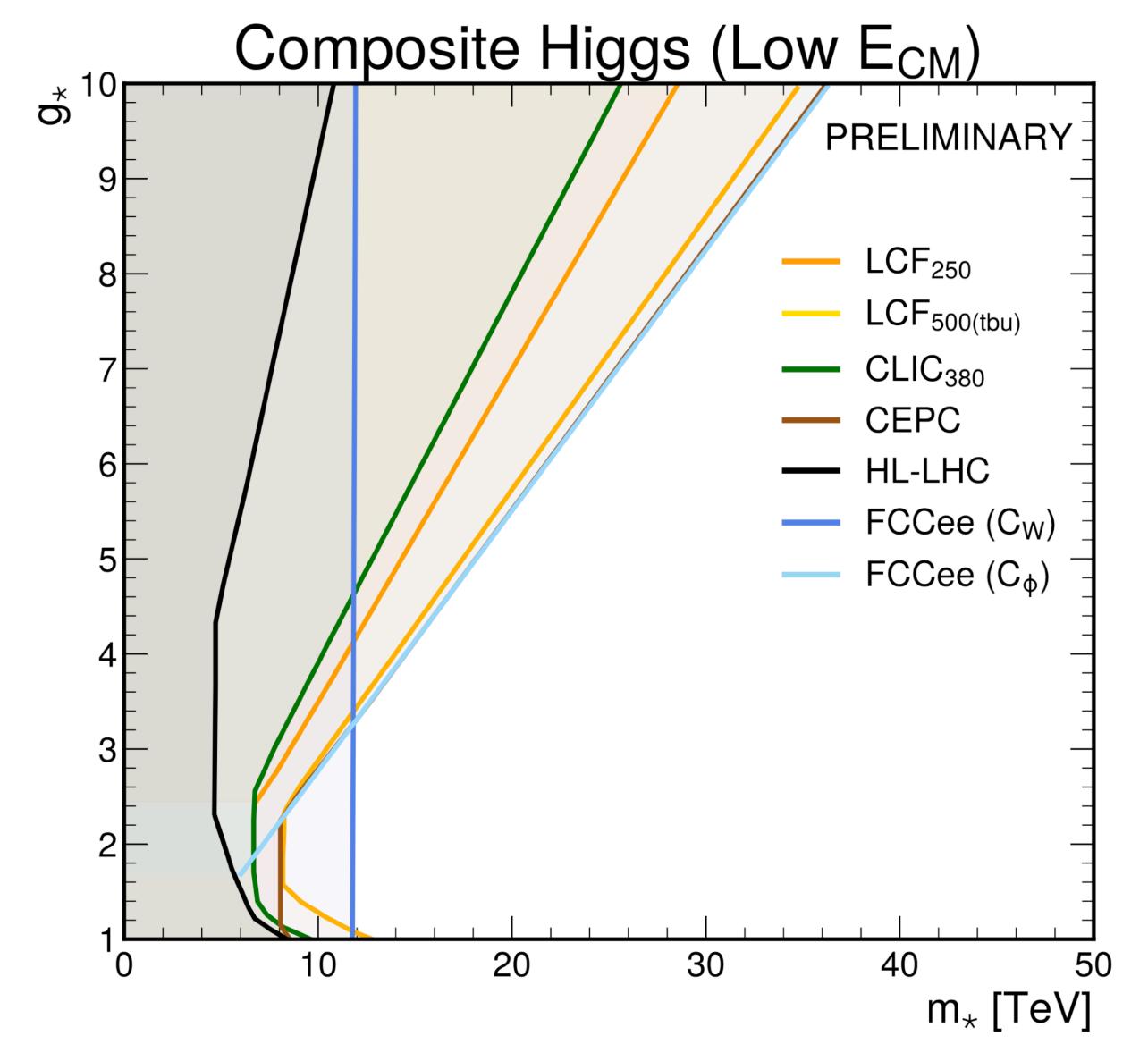
Universal hypercharge Z'

Compositeness

Composite Higgs, 2σ

Composite Higgs (Low E_{CM})

PRELIMINARY

- LCF$_{250}$
- LCF$_{500(tbu)}$
- CLIC$_{380}$
- CEPC
- HL-LHC
- FCCee (C_W)
- FCCee (C_ϕ)

Compositeness

Composite Higgs, 2σ

HL–LHC

FCC–ee(C_W)
FCC–hh/ee(C_W)
FCC–hh(direct)
FCC–hh(C_{2W})
$CLIC_{1500}$
FCC–ee(C_ϕ)
FCC–ee/hh/eh(C_ϕ)
$CLIC_{3000}$

European Strategy Update

m_* [TeV]

Composite Higgs, 2σ

HL–LHC
HE–LHC
$CLIC_{380}$
ILC_{250}
ILC_{500}
CEPC
ILC_{1000}

European Strategy Update

m_* [TeV]

Composite Higgs (High E_{CM})

PRELIMINARY

g_*

—— LCF_{1000}
—— $CLIC_{1500}$
—— $FCChh_{100(tbu)}$ (C_{2W})
—— μCol_{10}
—— $FCChh_{100(tbu)}$ direct
—— $FCCee+hh_{100(tbu)}$ (C_W)

m_* [TeV]

Scalar singlet: direct and indirect sensitivity

Wino

Pure Wino

Pure Wino – 2σ Sensitivity Reach

ESPP 2026: Preliminary

Higgsino

Pure Higgsino

Pure Higgsino – 2σ Sensitivity Reach

Additional simplified models

Additional simplified models

U$_1$ leptoquark (tauonic)

Fit (1903.11517):
- 1-σ region
- 2-σ region

Projections:
- CLIC$_{3000}$
- HL-LHC, pp → UU*
- HL-LHC, pp → τ$^+$τ$^-$
- HE-LHC, pp → UU*

$\beta_R = 0$

Gluino mass reach
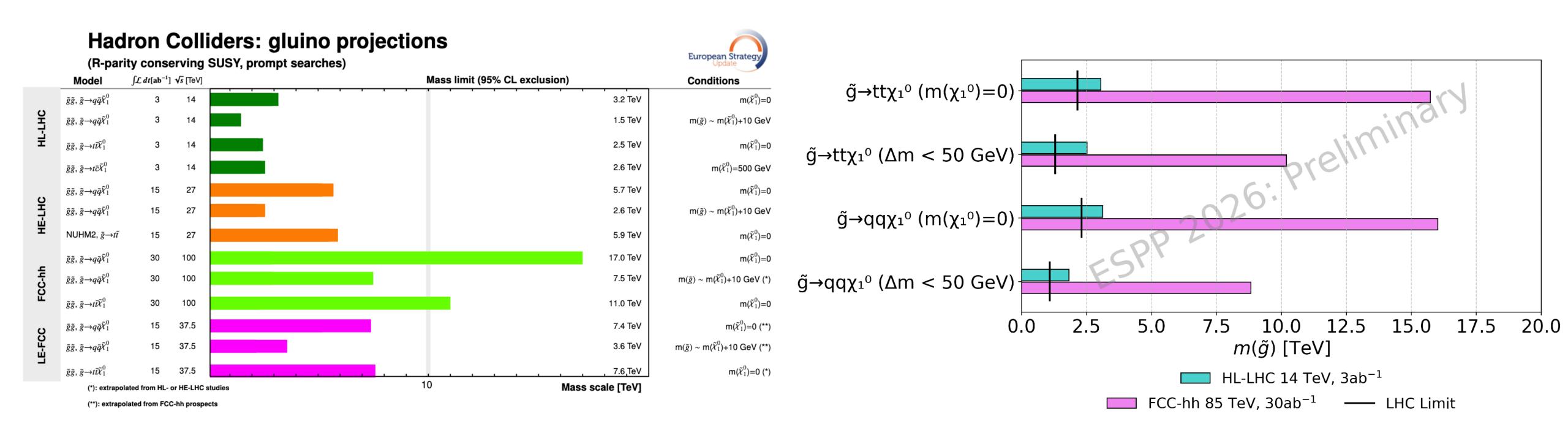
Hadron Colliders: gluino projections (R-parity conserving SUSY, prompt searches) — table of mass limits (95% CL exclusion) for HL-LHC, HE-LHC, FCC-hh, LE-FCC.

Gluino mass reach $m(\tilde{g})$ [TeV] for various decay channels: $\tilde{g}\rightarrow tt\chi_1^0$ $(m(\chi_1^0)=0)$, $\tilde{g}\rightarrow tt\chi_1^0$ $(\Delta m < 50$ GeV$)$, $\tilde{g}\rightarrow qq\chi_1^0$ $(m(\chi_1^0)=0)$, $\tilde{g}\rightarrow qq\chi_1^0$ $(\Delta m < 50$ GeV$)$. Comparison of HL-LHC 14 TeV, 3 ab^{-1}; FCC-hh 85 TeV, 30 ab^{-1}; and LHC Limit.

Squarks mass reach
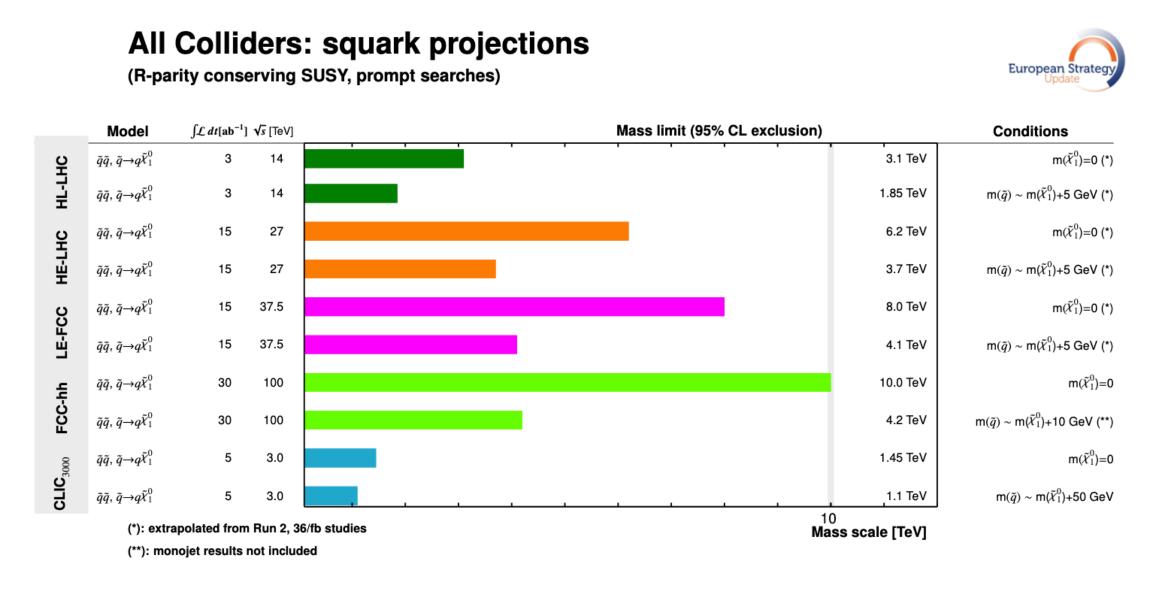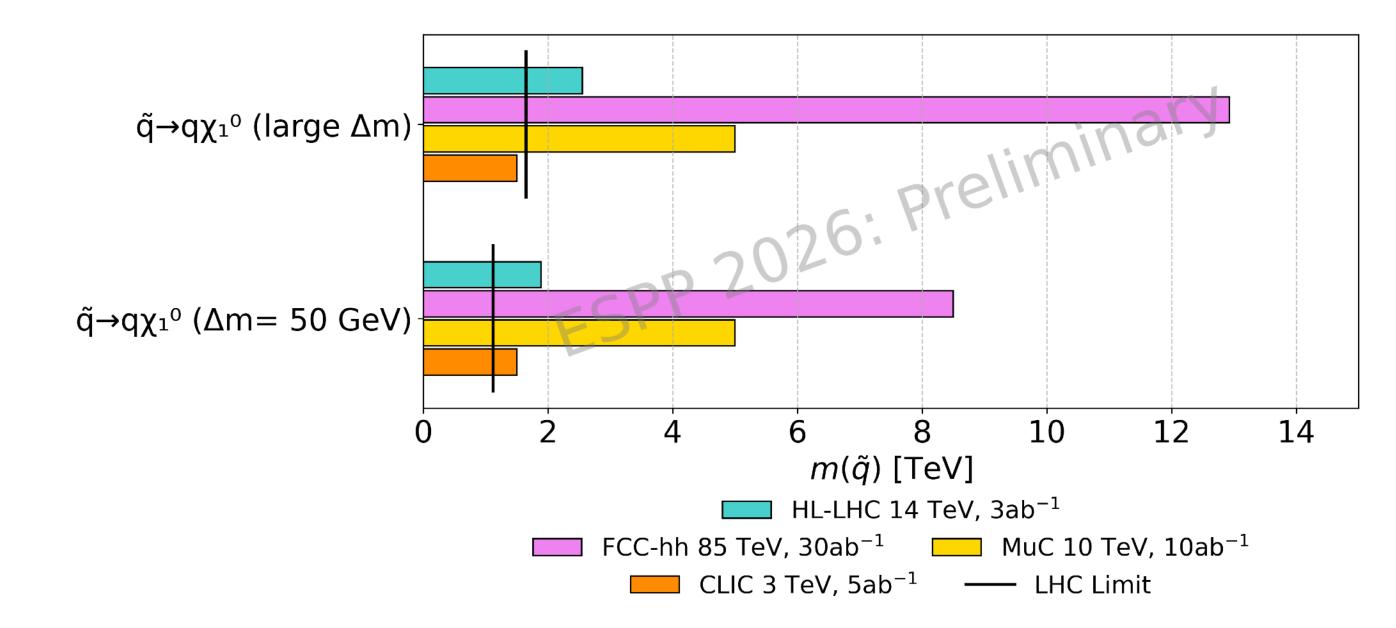
Fig. 8.7: Exclusion reach of different hadron and lepton colliders for first- and second-generation squarks.
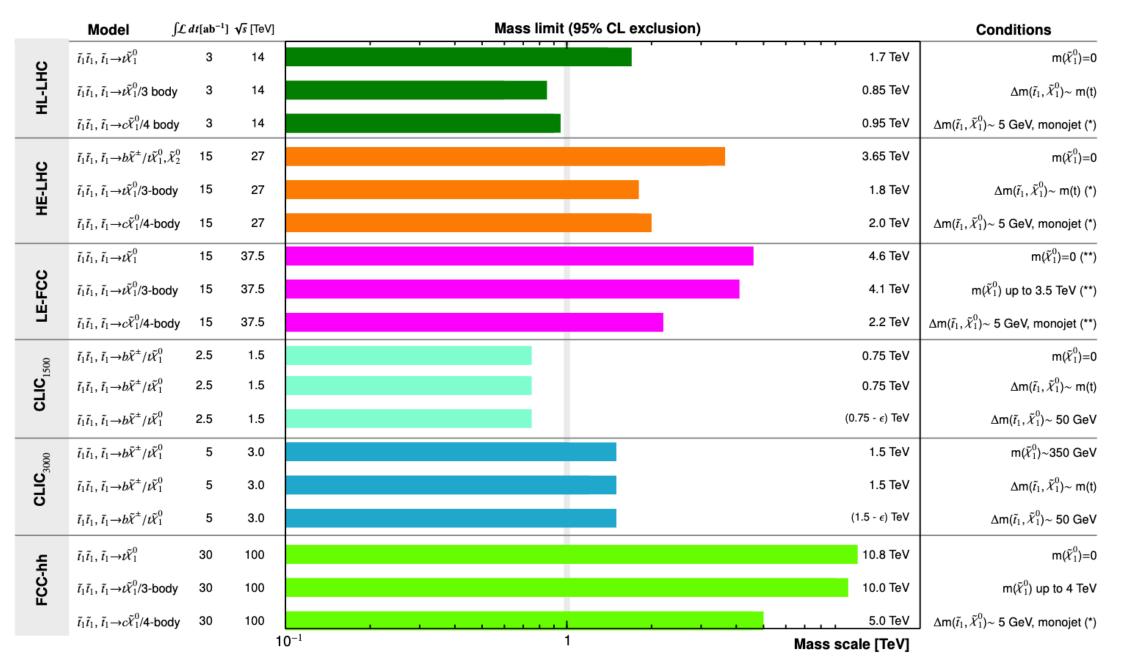
Stops mass reach

All Colliders: Top squark projections
(R-parity conserving SUSY, prompt searches)
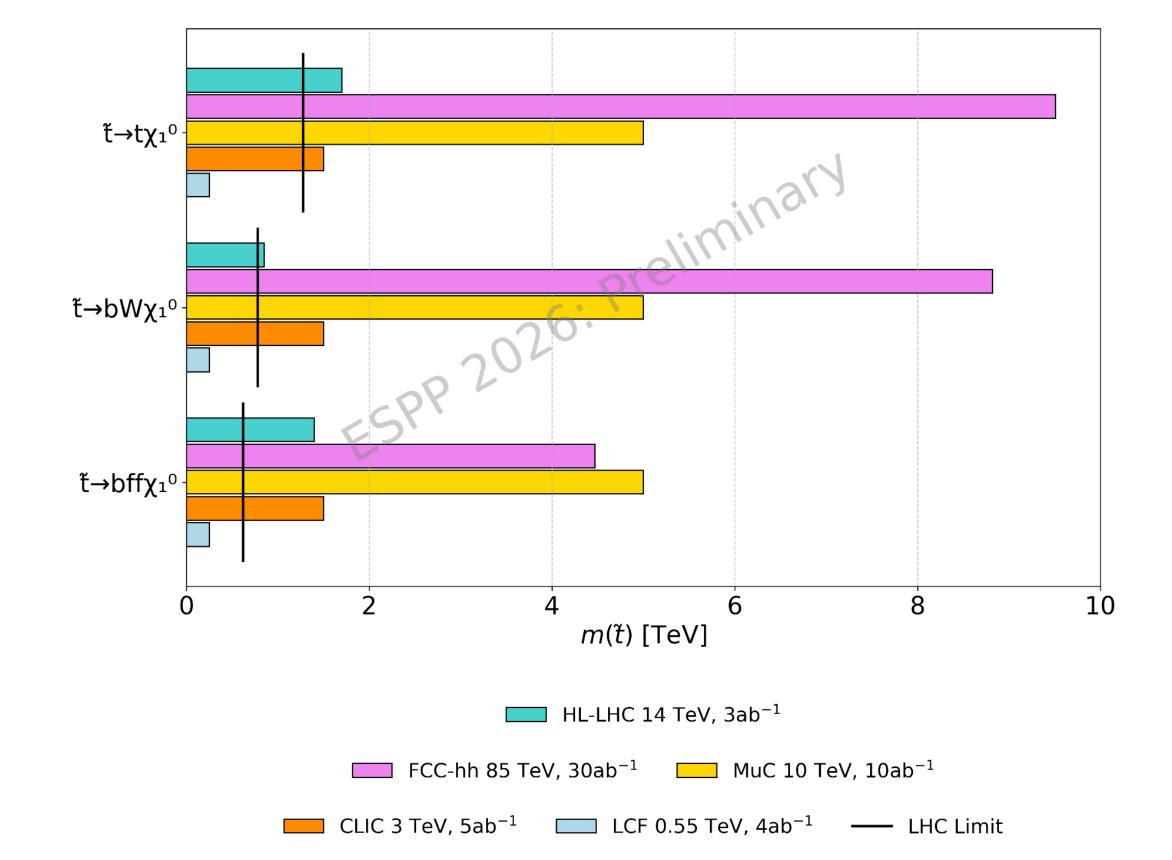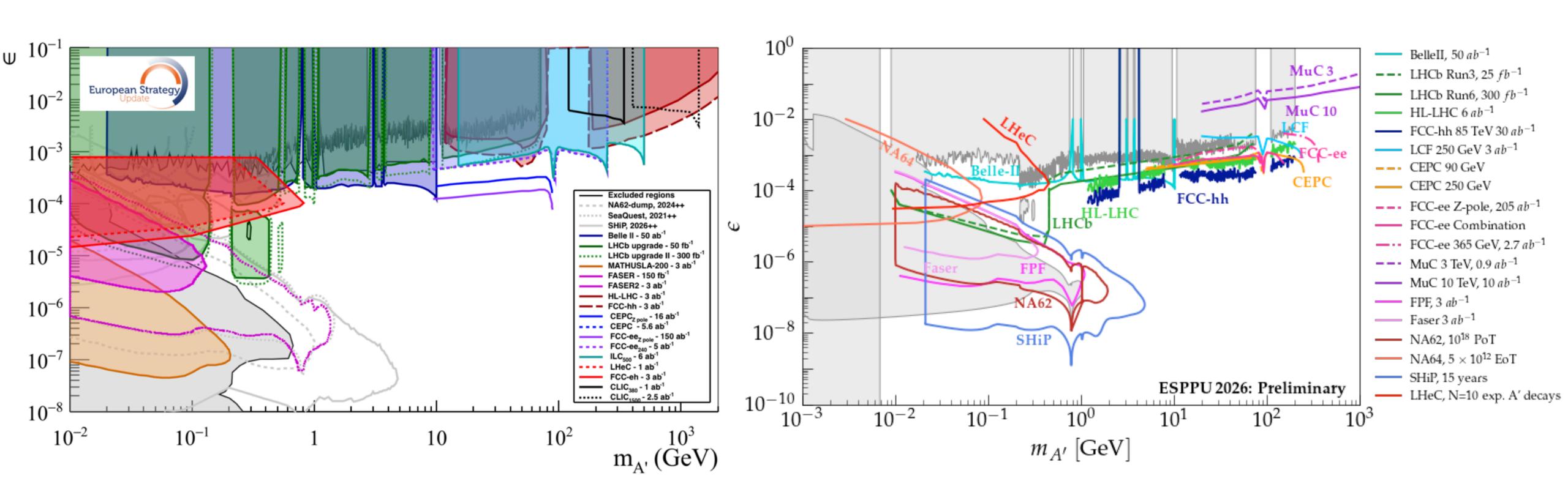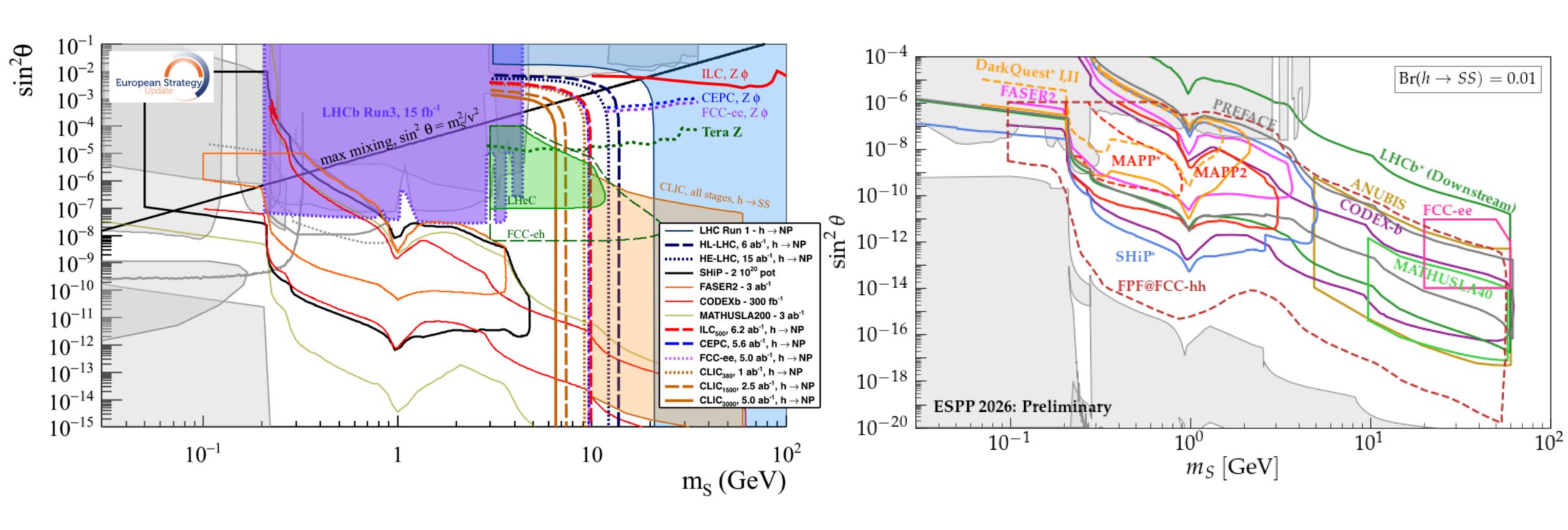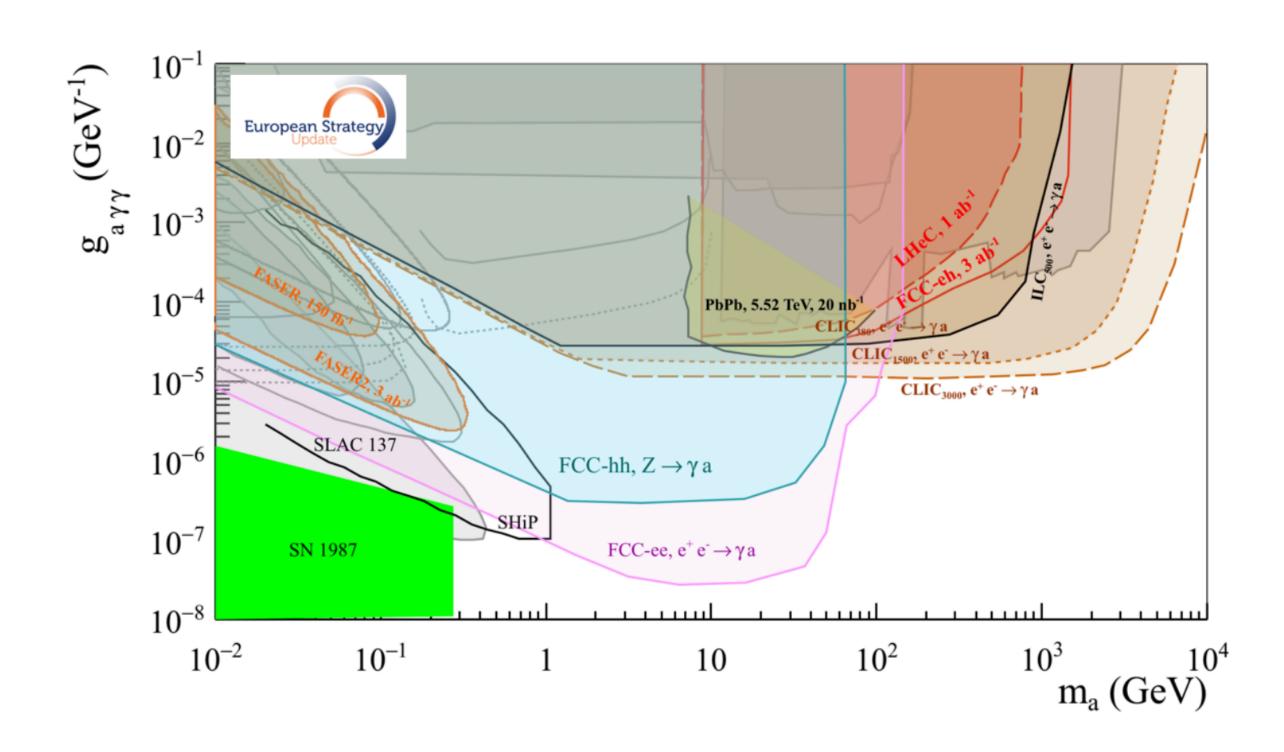
Dark photon
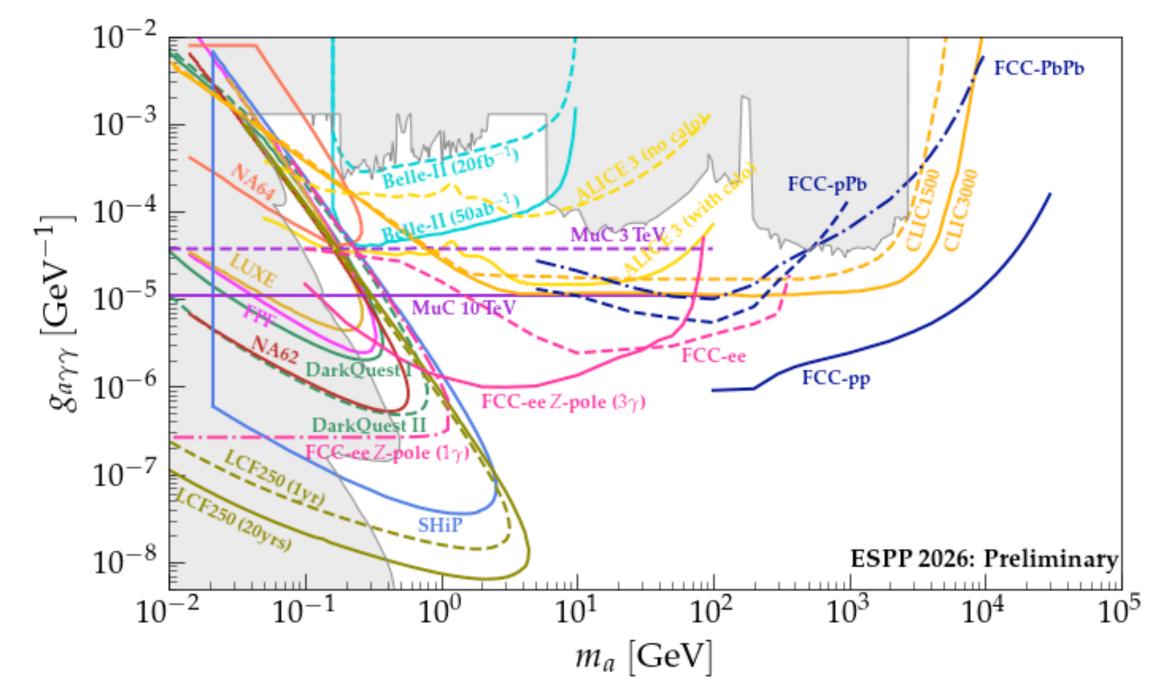
Dark scalar/Higgs
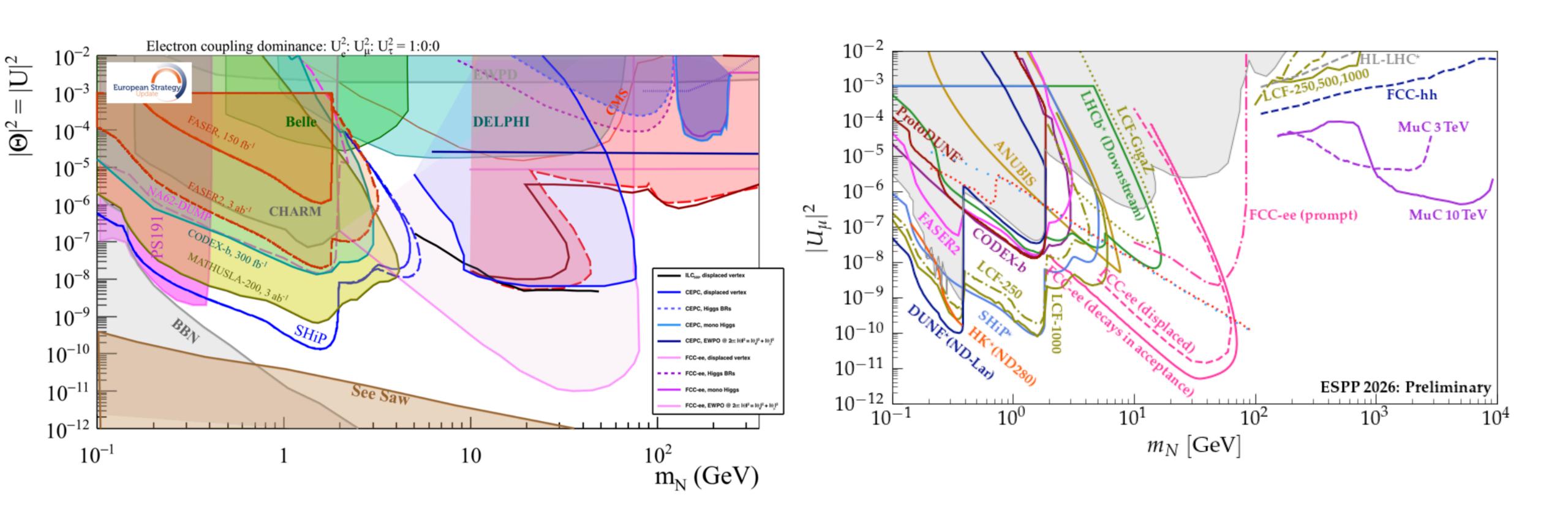
ALPs
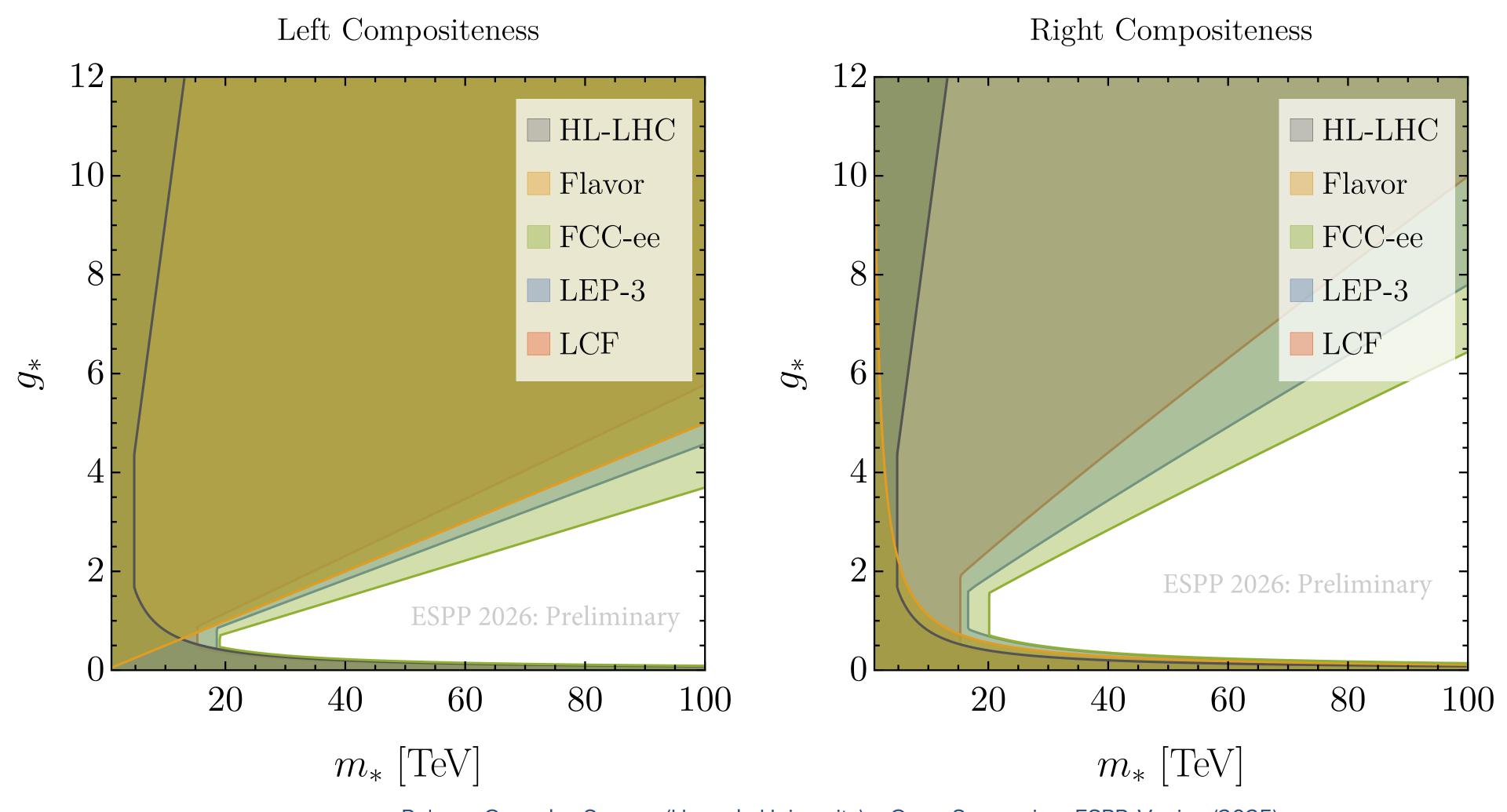
HNLs

Remaining figures

RG-improved
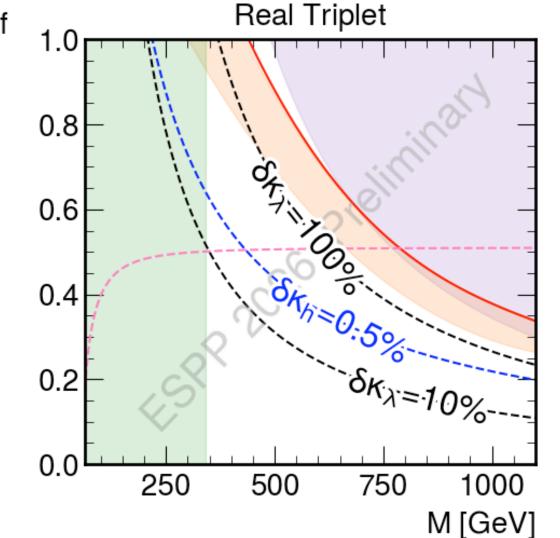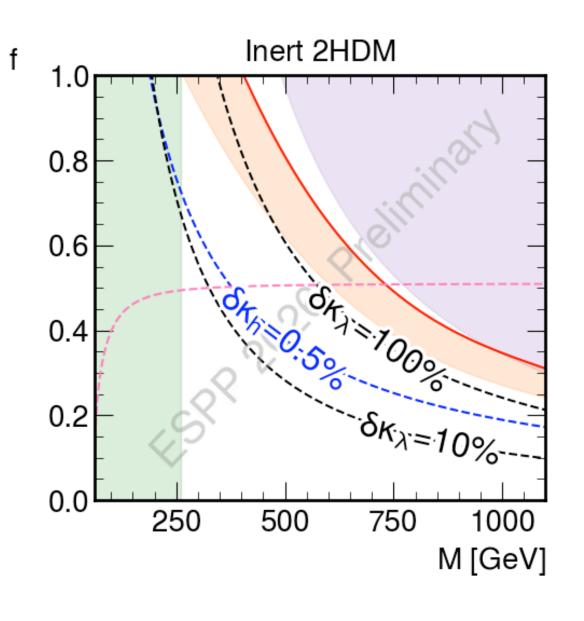## Operators mix via RG evolution (new: PPG 2025), SILH framework

Left Compositeness

Right Compositeness
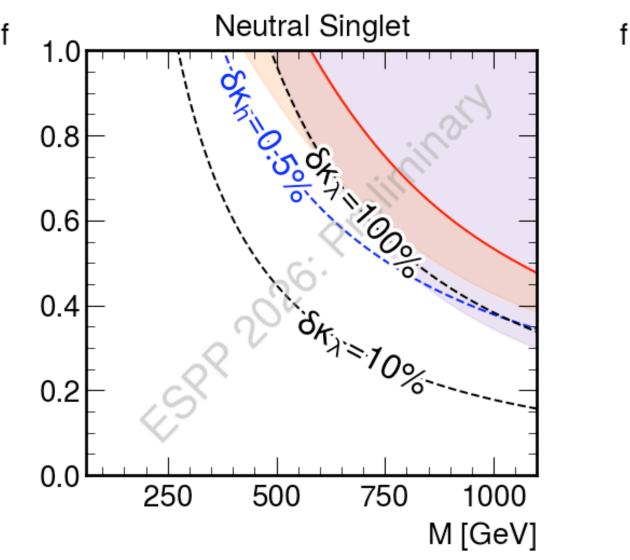
Beyond the singlet: Z_2 symmetric scalars

- Scalars with various electroweak charges, no mixing with the Higgs.

- **New plot,** projections for three types of scalars coupling to the Higgs boson through a Z_2-symmmetric coupling (pair produced).
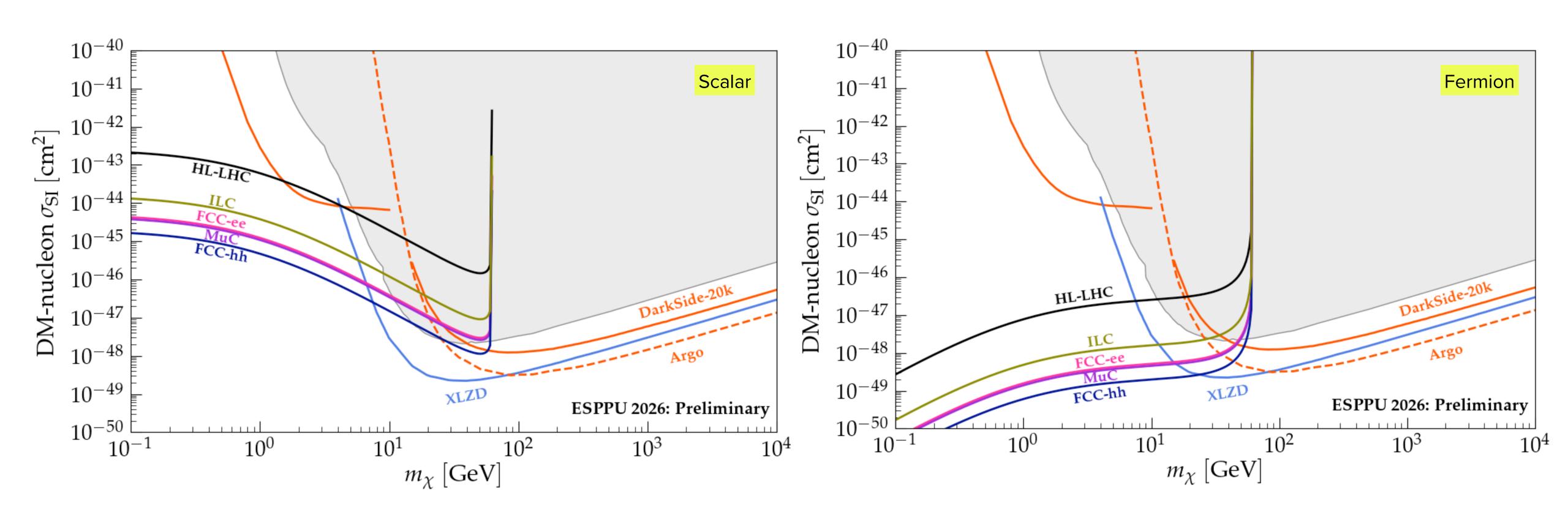
fraction of mass from the Higgs
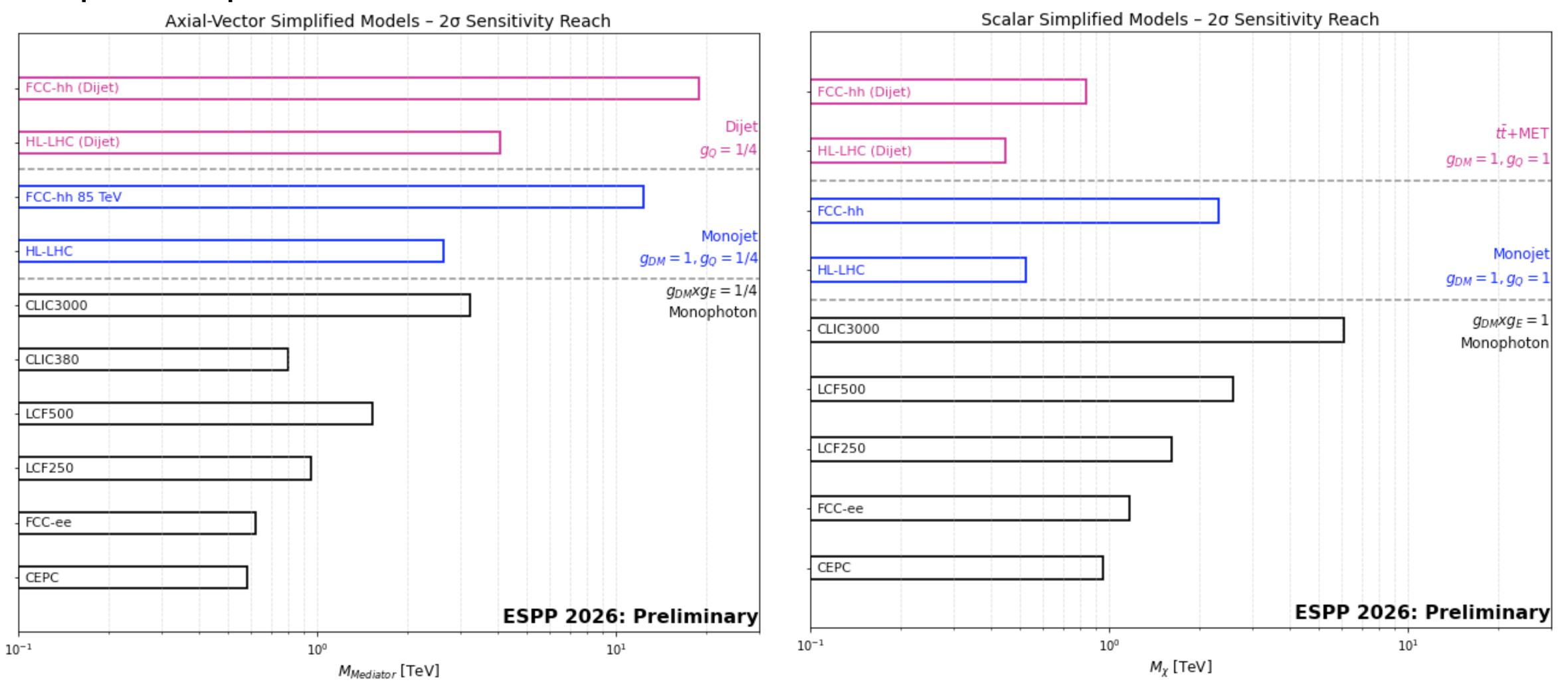
Parameter space of custodially-symmetric Z_2 -symmetric scalars with various electroweak charges (singlet, real triplet, and inert doublet) coupled to the Higgs boson as a function of the physical scalar mass and the fraction f of mass obtained from electroweak symmetry breaking. The red shaded region indicates a first-order phase transition, while and the red line indicates gravitational waves observable by LISA. The purple region indicates the breakdown of perturbative unitarity, while the green region indicates current LHC limits.
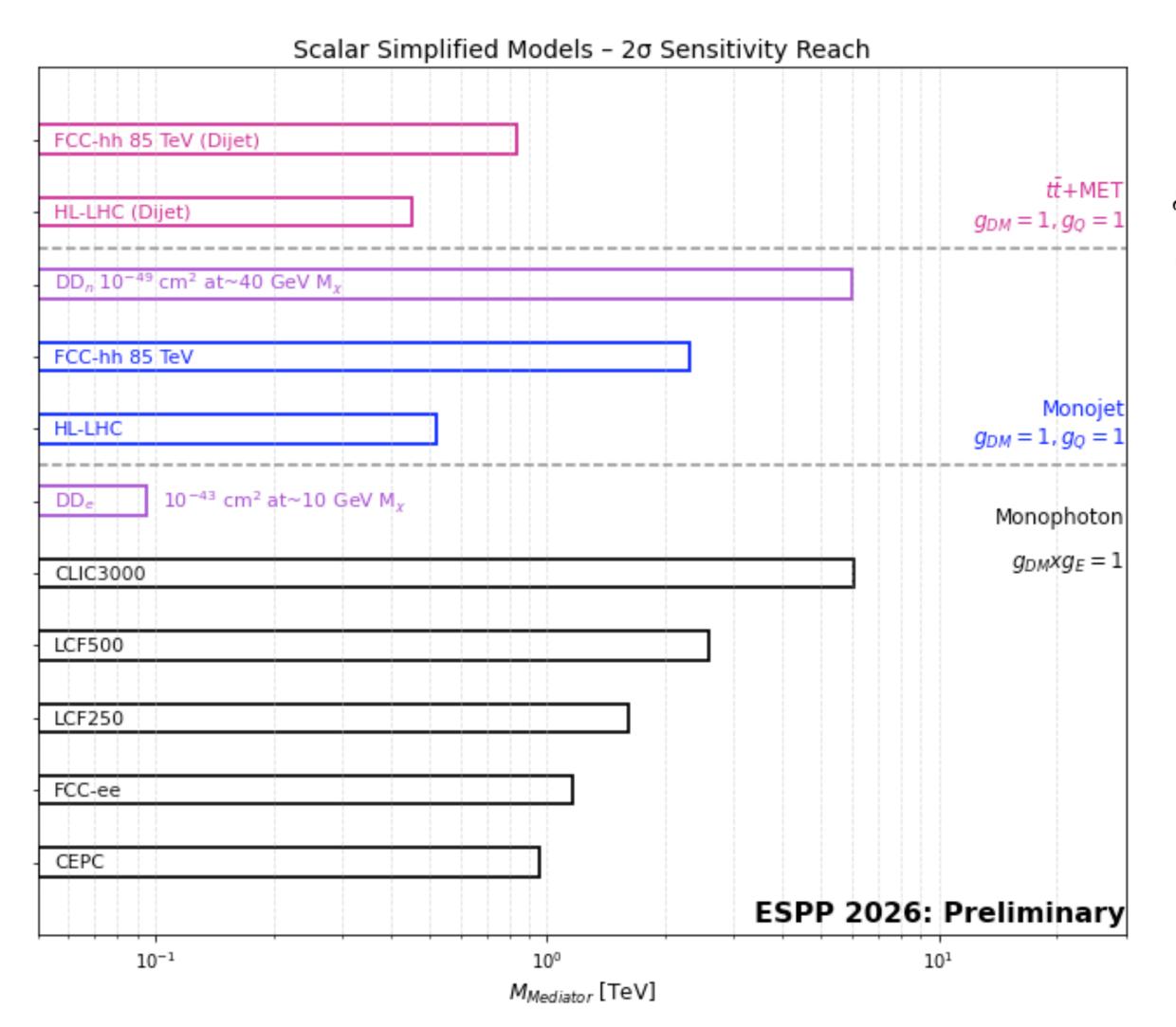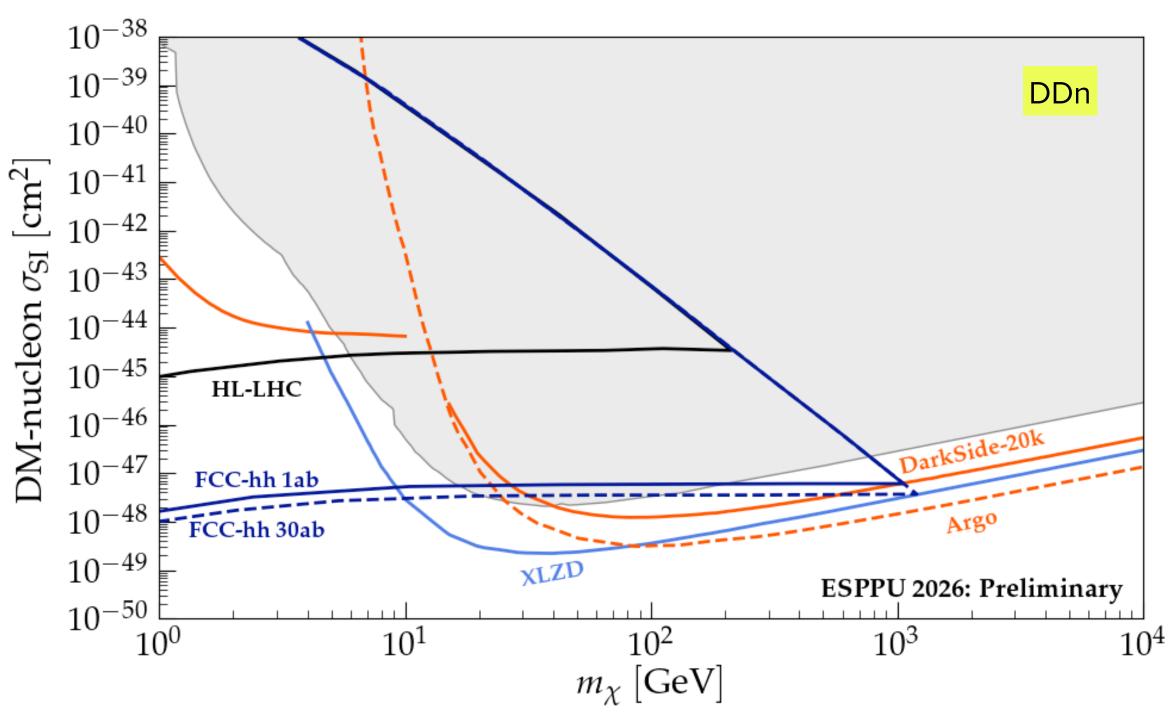
Additional simplified models (gone?)

- Updated plots

Axial-Vector Simplified Models – 2σ Sensitivity Reach

Scalar Simplified Models – 2σ Sensitivity Reach

Higgs Portal DM

Scalar portal

Scalar Simplified Models – 2σ Sensitivity Reach

ESPP 2026: Preliminary
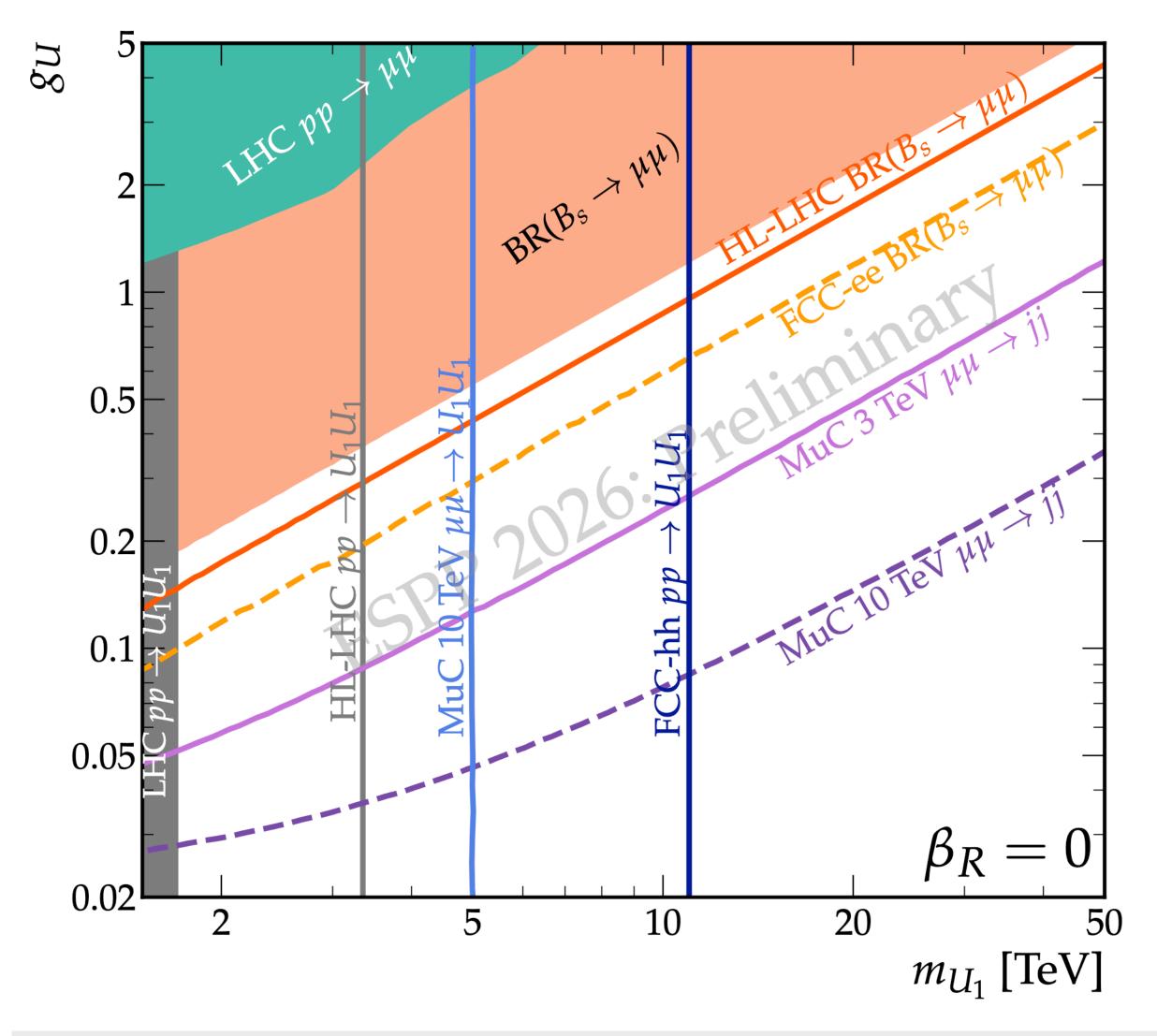

ESPPU 2026: Preliminary

U₁ leptoquark (muonic)

- Vector leptoquark with couplings to left handed 3rd generation quarks and 2nd generation leptons

- **New plot**

  - Inputs: Projections for Key Measurements in Heavy Flavour Physics, Muon Collider, FCC

  - HL-LHC projections and FCC-hh projections done using Collider Reach

  - To-do: FCC-hh extrapolation of pp → μμ

Not such a large increase in precision at FCC-ee for Bs → μμ as compared to (c.f. previous slide) Bs → ττ
Complementary direct sensitivity from hadron and muon colliders, and indirect sensitivity from Drell-Yan
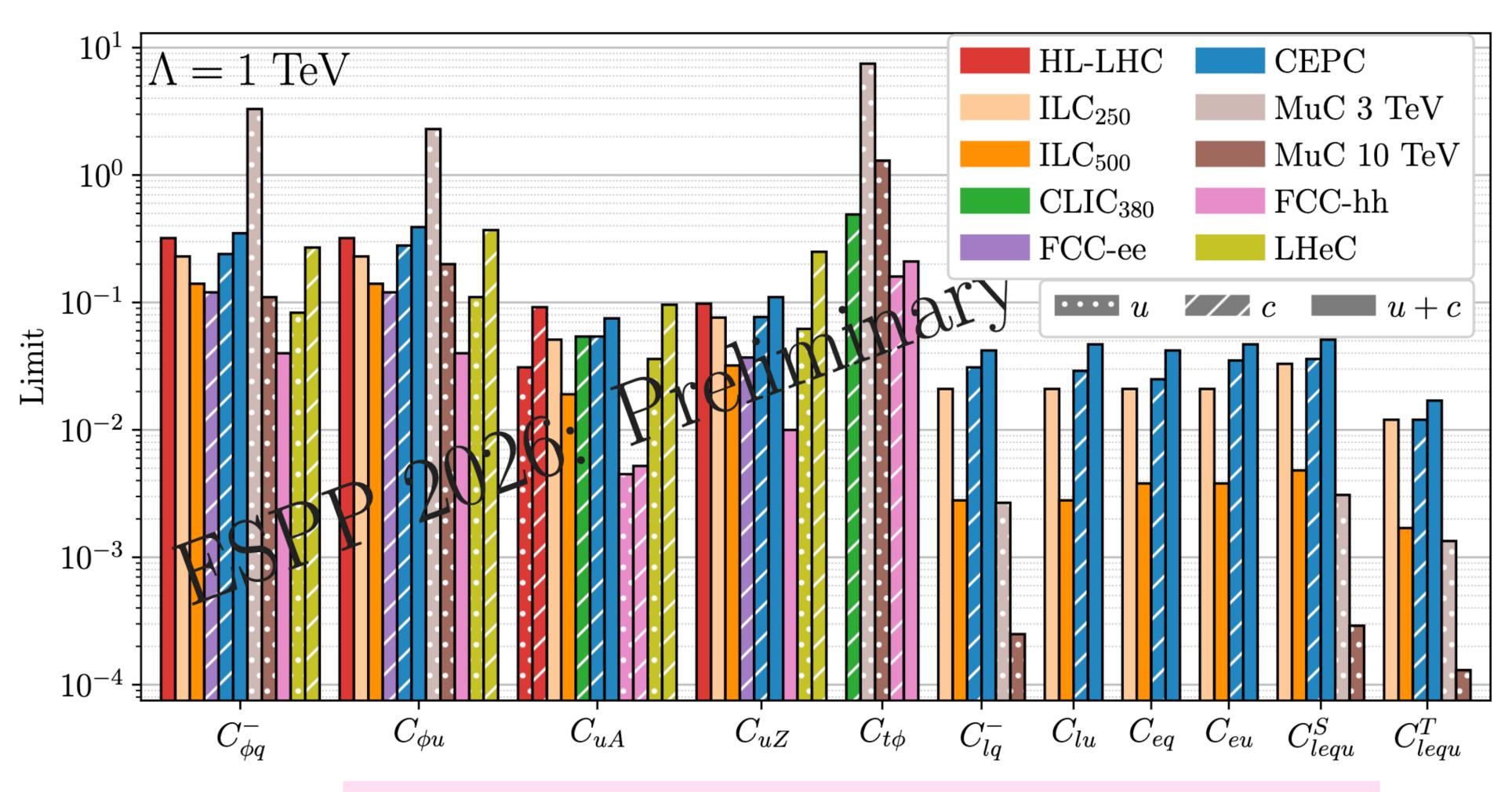

Current constraints and projected sensitivities (all at 95% CL) on the vector U_1 leptoquark coupling to second generation leptons and predominantly to third generation quarks. This assumes couplings to left handed fermions only, and a minimal $U(2)_Q$ flavour symmetry assumption for the quark sector in which the misalignment between the gauge and flavour basis gives $g_{\mu b} = g_U$ and $g_{\mu s} = 0.1\, g_U$.

TOP FCNCs

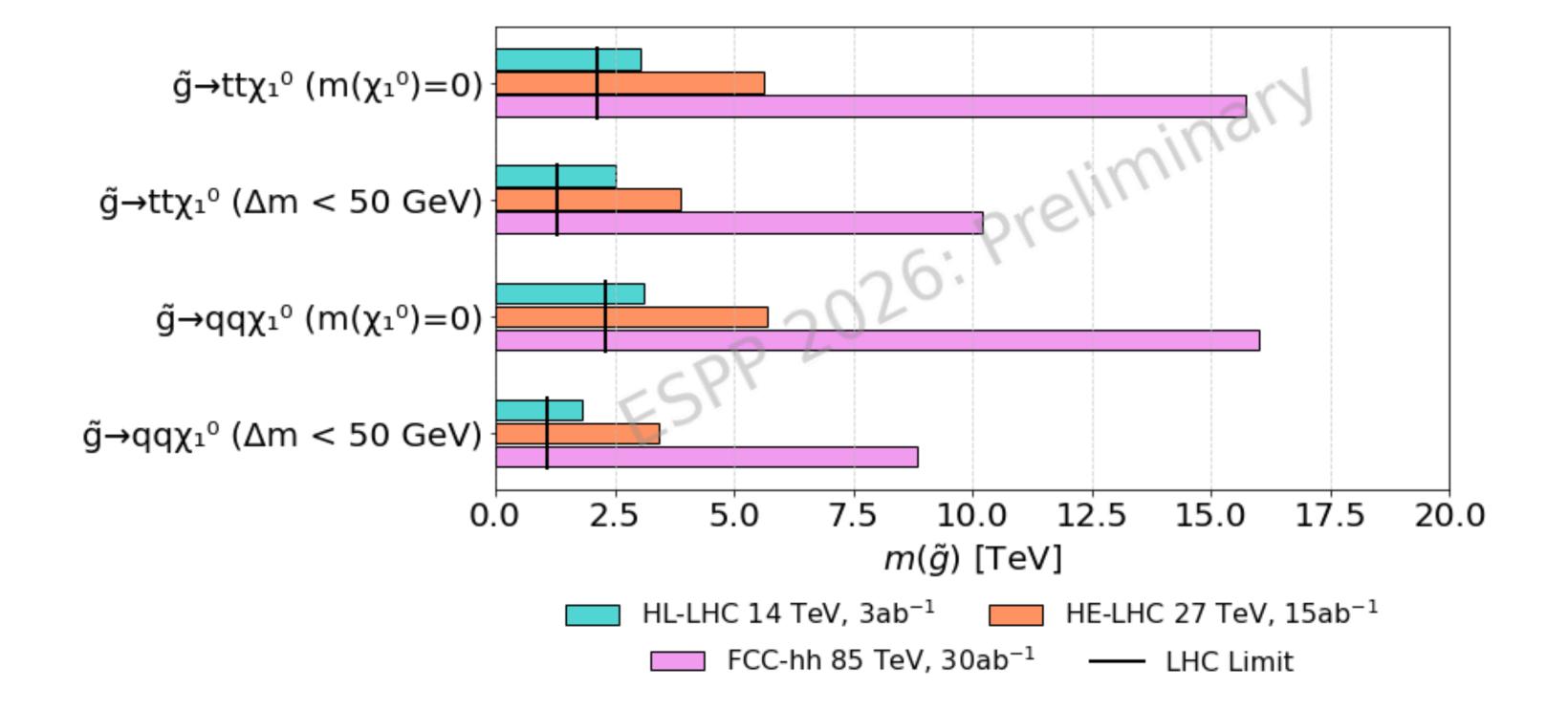- FCNCs can be parameterised in terms of Wilson coefficients

- **New plot**

  - Inputs: CLIC, ILC, CEPC, Muon Collider, FCC

Sensitivity to $t \to c$ and $t \to u$ transitions in terms of coefficients of SMEFT operators (in LHC TOP WG conventions)
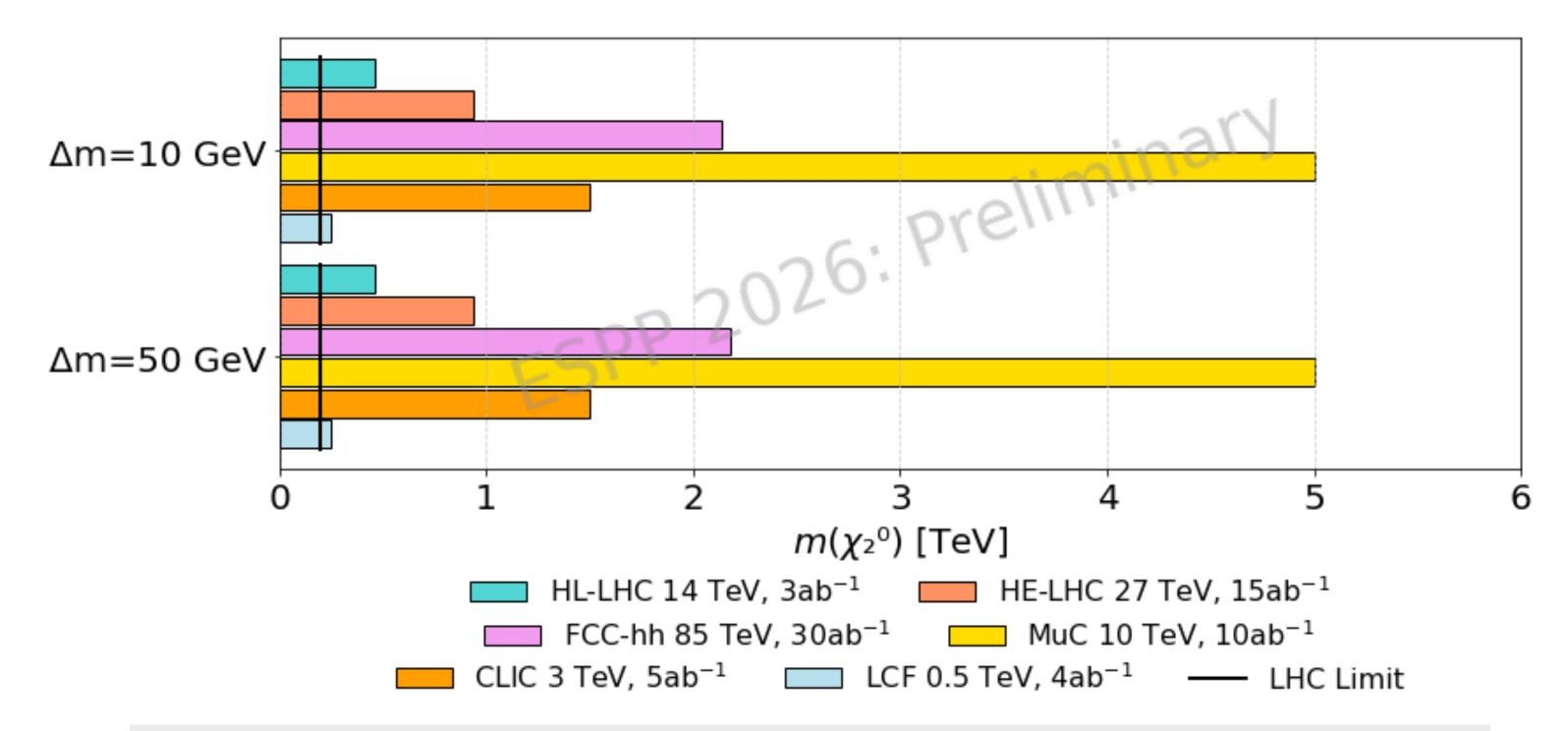
Gluino mass reach

- **Updated plot**

Projected 95% exclusion limit for gluinos as a function of gluino mass in a gluino-LSP simplified model for four decay modes. Limits for hadron colliders are obtained with luminosity scaling using the collider-reach tool. (a) Gluino decay into top quarks + LSP, corresponding to large gluino-LSP mass splitting. (b) Gluino decay into off-shell top quarks + LSP, corresponding to compressed gluino-LSP mass splitting Δm =50 GeV.

(c) Gluino decay into light-flavor quarks + LSP, corresponding to large gluino-LSP mass splitting. (d) Gluino decay into light-flavor quarks + LSP, corresponding to compressed gluino-LSP mass splitting Δm = 50GeV.
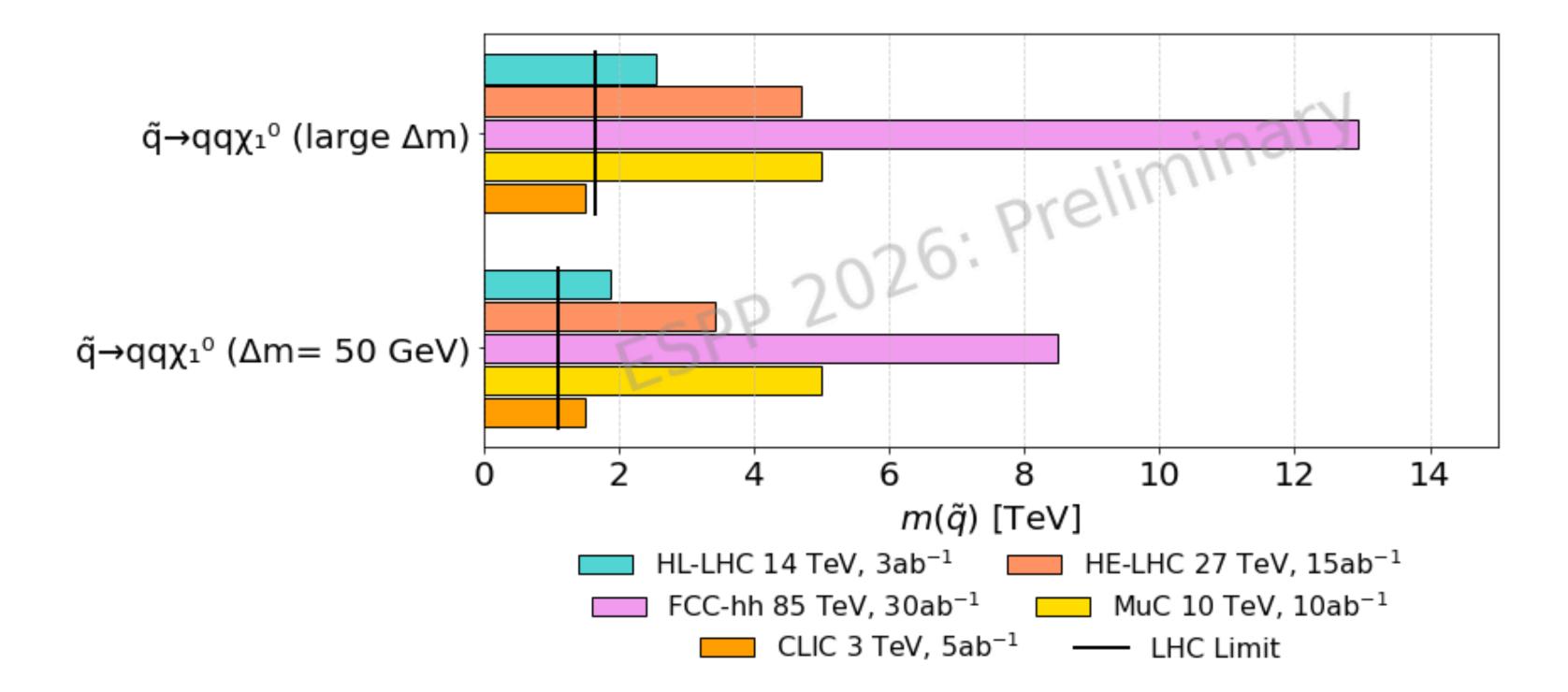
Higgsino mass reach

- **New plot**

Projected 95% exclusion limit for higgsinos as a function of higgsino mass in a higgsino simplified model for two decay modes. Limits for hadron colliders are obtained with luminosity scaling using the collider-reach tool, while limits for lepton colliders correspond to half of the center of mass energy for distinctive final states. (a) Heavier neutral and charged higgsino decay to lightest neutral higgsino, corresponding to compressed mass splitting Δm = 10 GeV.

(b)Heavier neutral and charged higgsino decay to lightest neutral higgsino, corresponding to compressed mass splitting Δm = 50 GeV

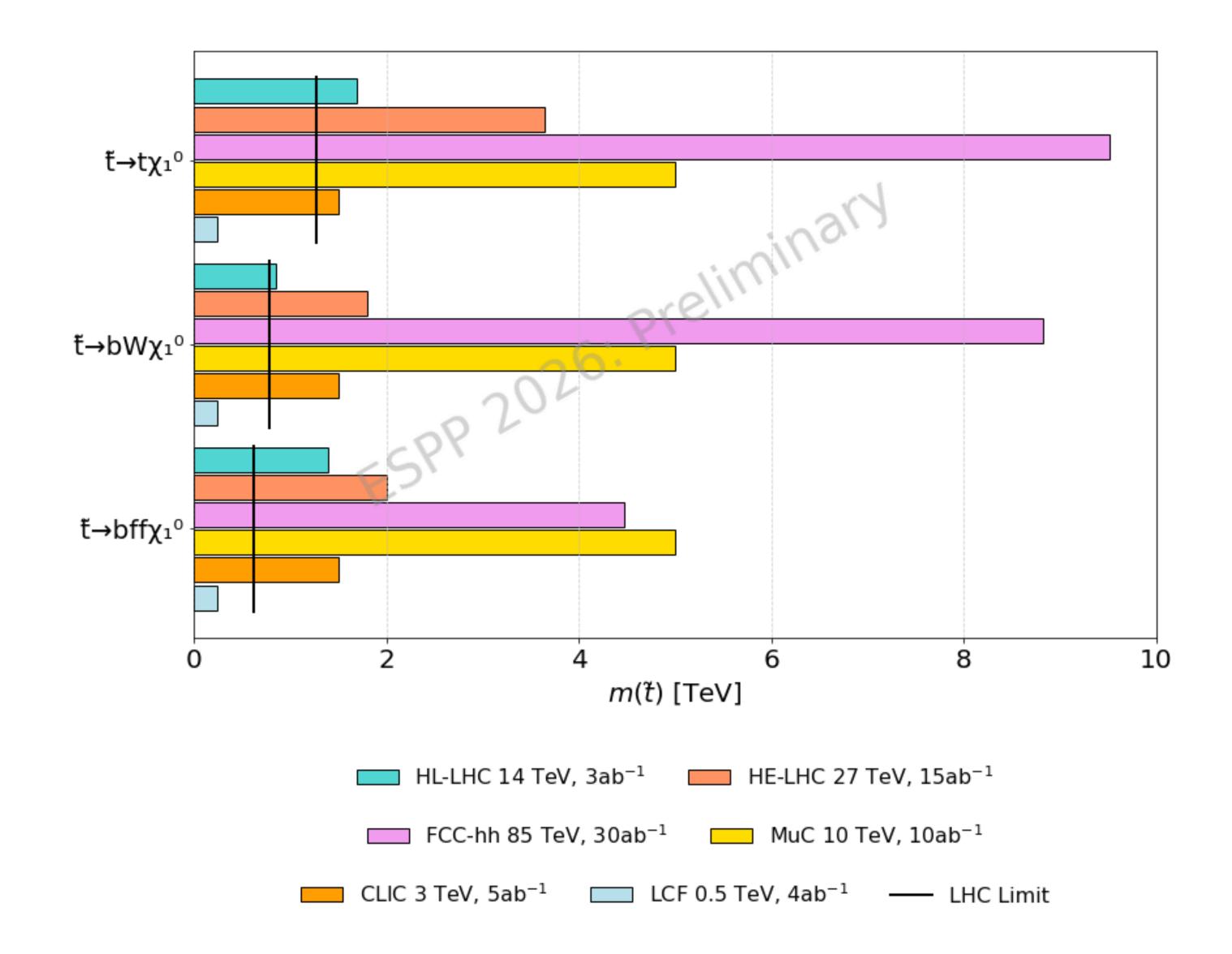# Squarks mass reach

- **Updated plot**

Projected 95% exclusion limit for light-flavor squarks as a function of squark mass in a squark-LSP simplified model for two decay modes. Limits for hadron colliders are obtained with luminosity scaling using the collider-reach tool, while limits for lepton colliders correspond to half of the center of mass energy for distinctive final states. (a) Squark decay into quarks + LSP, corresponding to large squark-LSP mass splitting. (b) Squark decay into quarks + LSP, corresponding to compressed squark-LSP mass splitting $\Delta m = 50$ GeV

Stops mass reach

- **Updated plot**

Projected 95% exclusion limit for the lightest stop squark as a function of stop mass in a stop-LSP simplified model for three decay modes. Limits for hadron colliders are obtained with luminosity scaling using the collider-reach tool, while limits for lepton colliders correspond to half of the center of mass energy for distinctive final states. (a) Stop decay into top quark + LSP, corresponding to large stop-LSP mass splitting. (b) Stop decay into bottom quark + W boson + LSP, corresponding to stop-LSP mass splitting between mW and mt . (c) Stop decay into bottom quark + off-shell W boson + LSP, corrresponding to stop-LSP mass splitting below mW.
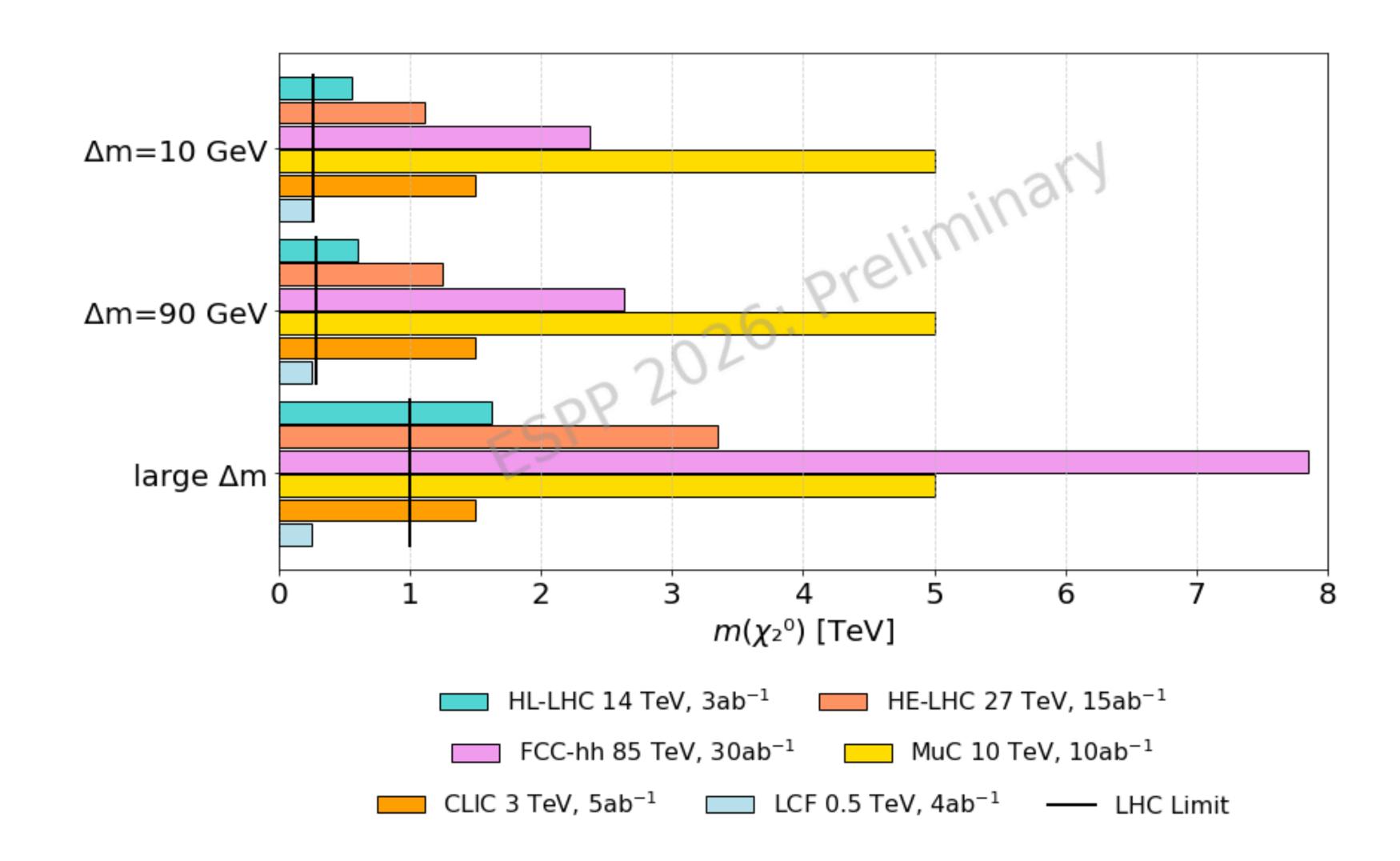
WinoBino mass reach

- **New plot**

Projected 95% exclusion limit for wino + bino as a function of wino mass in a wino-bino simplified model for three decay modes. Limits for hadron colliders are obtained with luminosity scaling using the collider-reach tool, while limits for lepton colliders correspond to half of the center of mass energy for distinctive final states. (a) Wino decay to bino + electroweak bosons, corresponding to compressed wino-bino mass splitting Δm = 10 GeV. (b) Wino dec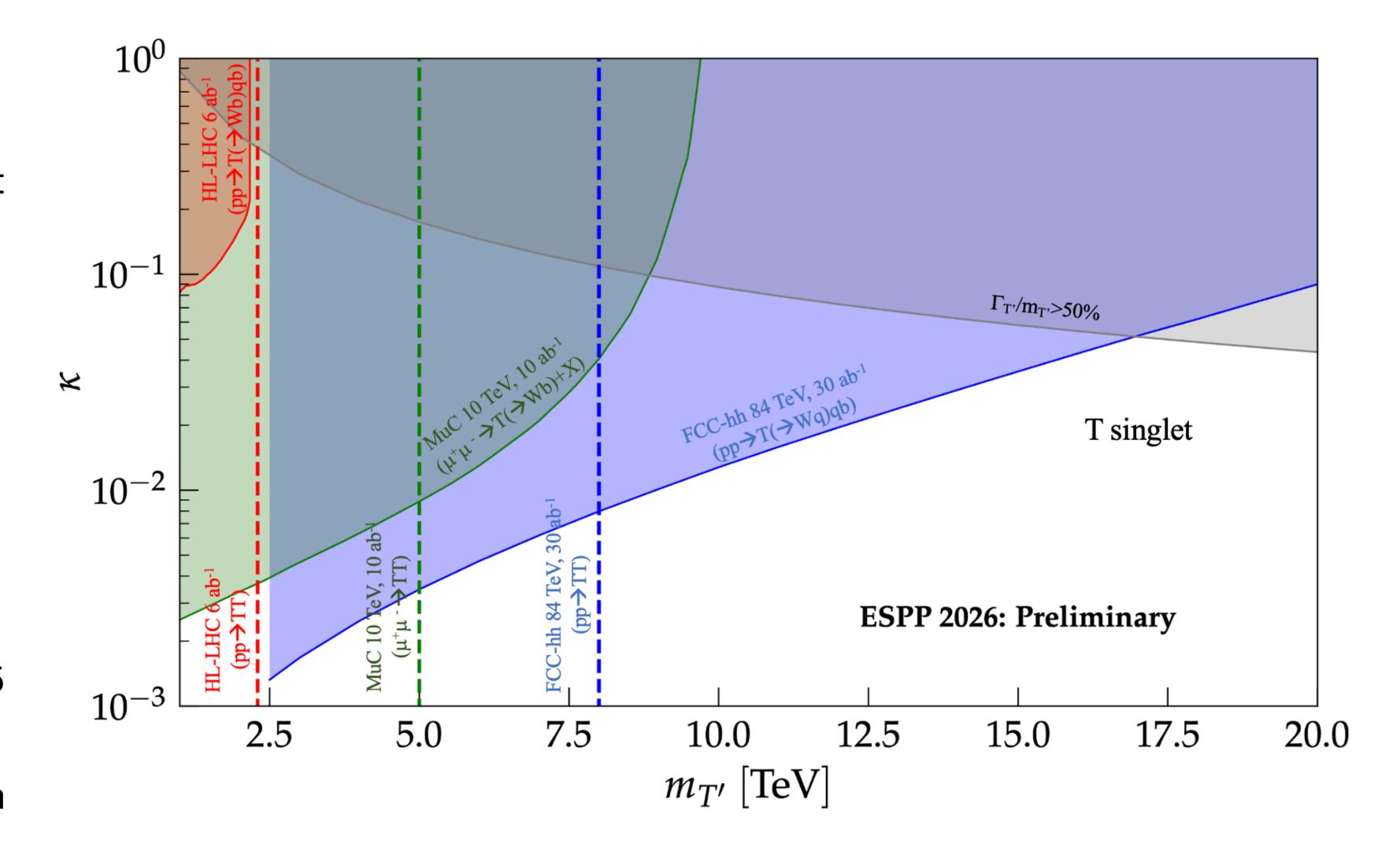ay to bino + electroweak bosons, corresponding to moderately compressed wino-bino mass splitting Δm = 50 GeV. (c) Wino decay to bino + electroweak bosons, corresponding to large wino-bino mass splitting.
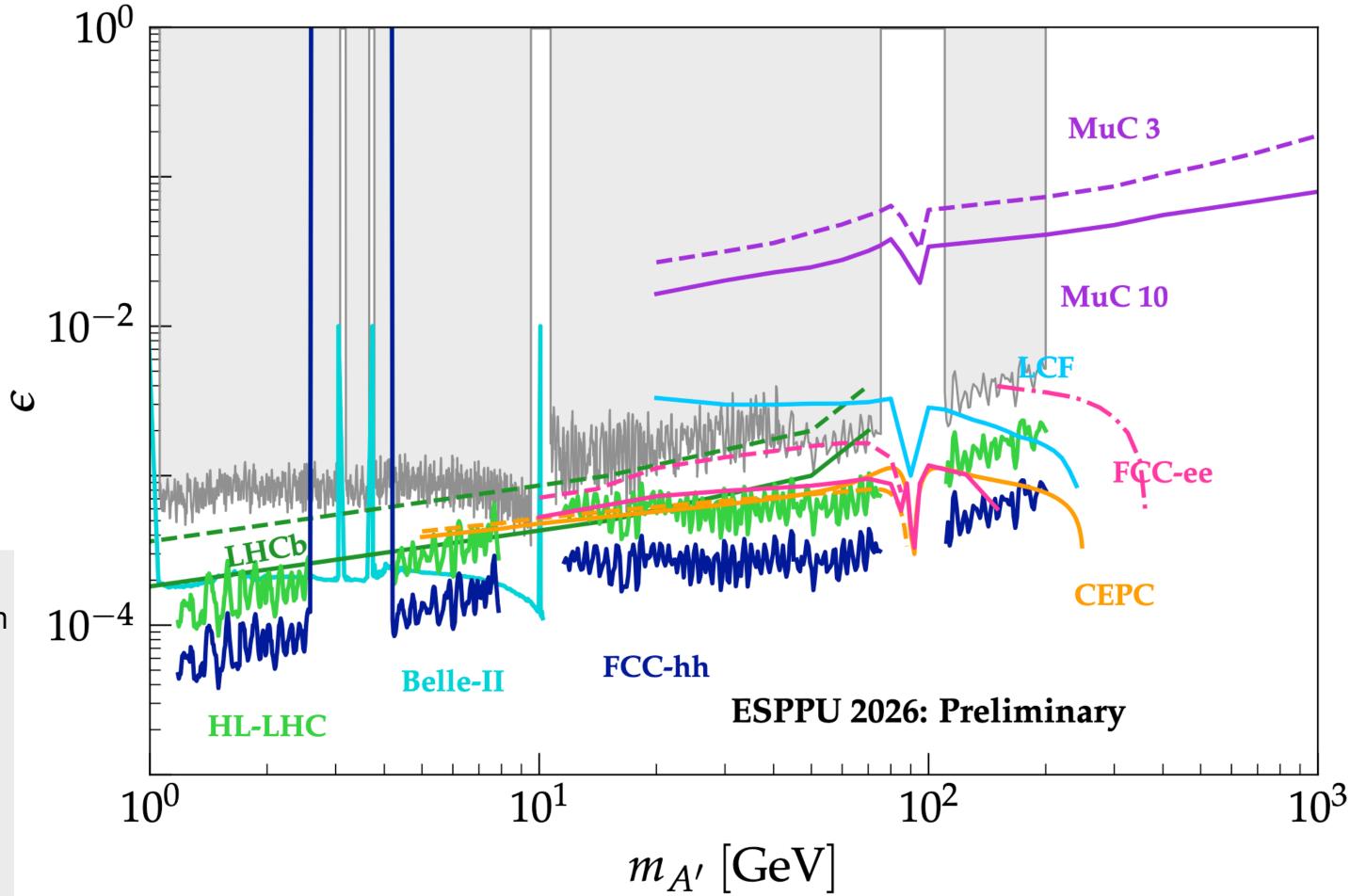
VLQ projection

- Light Higgs also favors light top partners in composite models

- **New plot**, includes

  - HL-LHC: single & pair, ATLAS extrapolation

  - MuC 10: single: [2502.20443]; pair: kinematic threshold

  - FCC-hh: single: LO MG5 + ATLAS extrapolation; pair:rescale 100 TeV FCC-hh (c.f. 10 TeV from ATLAS extrap).

  - Width: [2502.20443]

Only colliders

High dark photon mass region: 90% CL exclusion limits for Dark Photons in the plane mixing parameter ε versus Dark Photon mass. HL-LHC, CEPC, FCC-ee and FCC-hh curves correspond to 95% CL exclusion limits. The sensitivity of future colliders mostly covers the large-mass, large-coupling range. Belle II and LHCb upgrade provide additional coverage in the medium mass, high-coupling region.
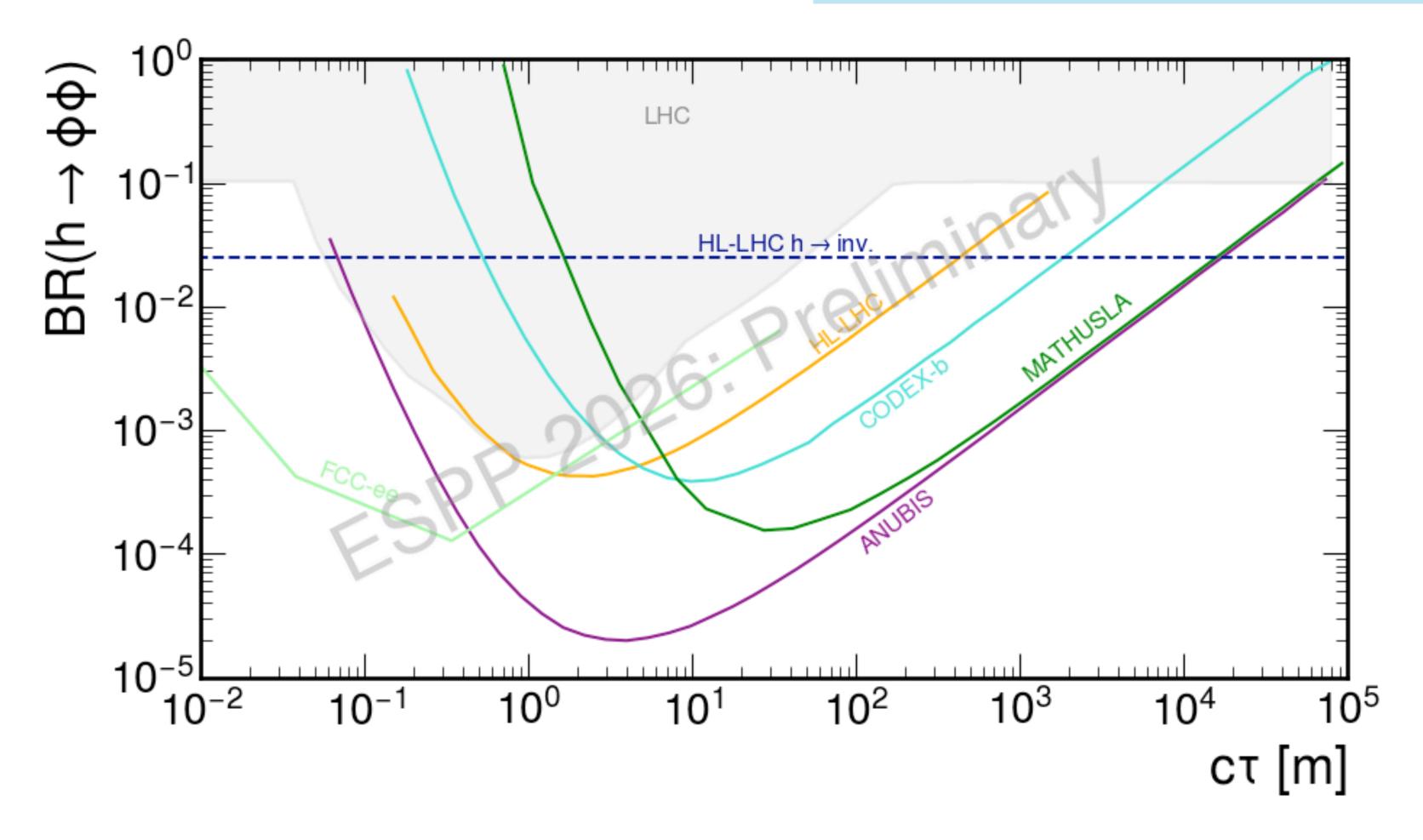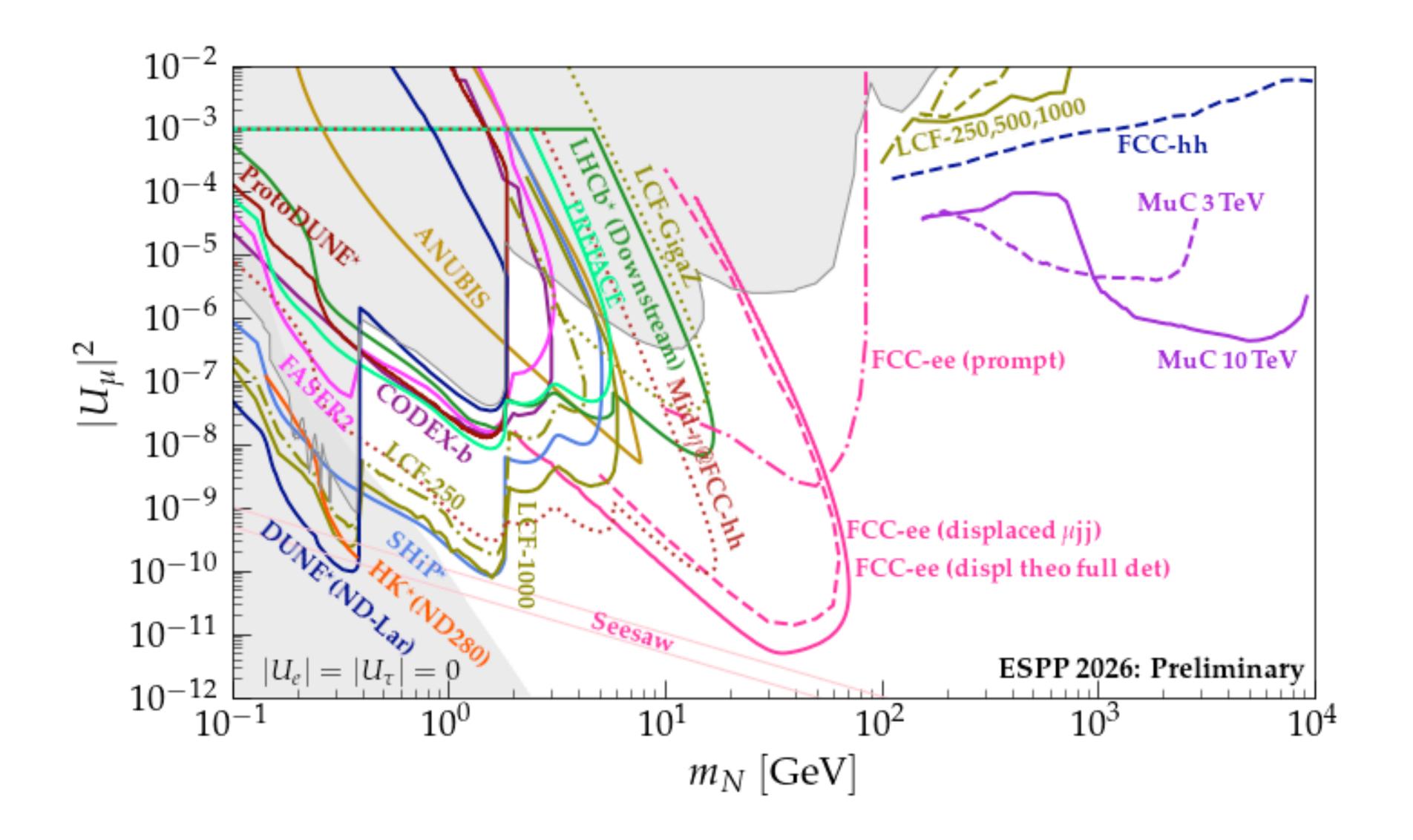
Higgs portal LLP

- Simplified model based on the Higgs-like scalar S in which S is a long-lived particle produced in Higgs decays.

- Sensitivity in the plane of $c\tau$ and BR(h→φφ), where φ is the light scalar mass eigenstate.

- **New plot**

- Limit curves for ANUBIS, CODEX-b, MATHUSLA, HL-LHC (ATLAS), and the current LHC exclusion are taken from the PBC submission (2505.00947). The limit for FCC-ee is obtained by rescaling the 20 GeV benchmarks from 2412.10141 to obtain a limit as function of branching ratio.

The end