Welcome Back!

Agenda Items

Upcoming Meeting Topic Proposals:
Higgs + X
Higgs BSM complementarity with other frontiers
Composite Higgs?
Suggestions?

Summary Plot Discussion

References:

Snowmass Energy Frontier Report 2013:
https://arxiv.org/pdf/1401.6081.pdf

Snowmass Higgs Working Group Report 2013:
https://arxiv.org/pdf/1310.8361.pdf

ESG Briefing Book:
https://arxiv.org/abs/1910.11775

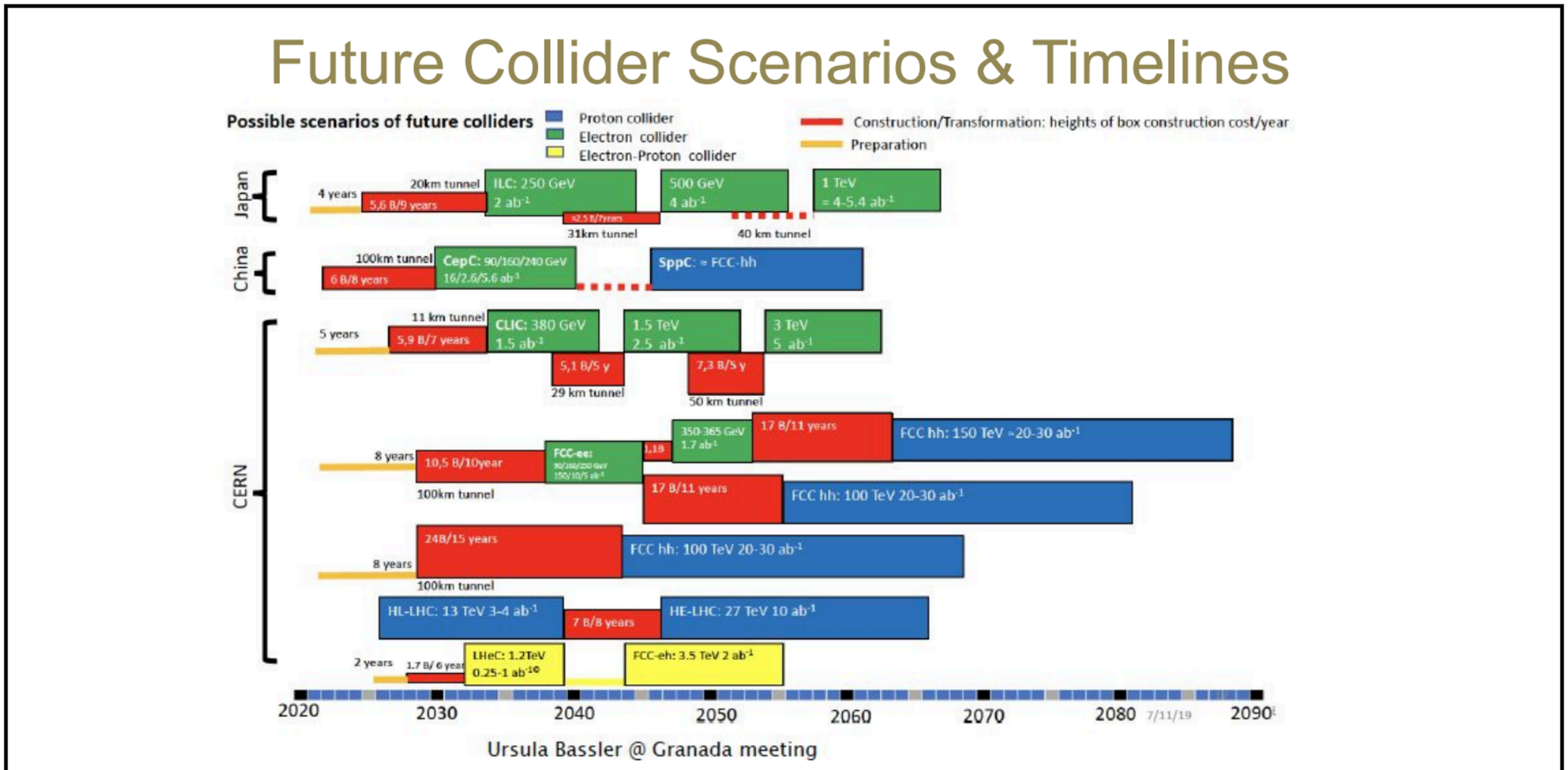
Timeline

1/21-6/21	6/30/21	7/12/21	8/30/21	9/24/21	3/15/22	5/31/22	6/30/22	7/22	9/30/22	10/31/22
Activity Slowdown	Restart of Activities	DPF Meeting + Snowmass Townhall	Now, EF restart Workshop	Snowmass day	Deadline Contributed Paper Submission	Prelim. TG Reports	Prelim. Frontier Reports	Community Summer Study (UW-Seattle)	Final Reports	Snowmass Book & ArXiv docs

- **Sept. 24, 2021: Snowmass Day,** https://indico.fnal.gov/event/50538/
  - Plenary session 12:00-2:00pm (eastern time) with short talks from all frontiers
  - EF parallel session 2:30pm-5:00pm (eastern time) with highlights by topical group
  - Early Career (EC) will be chosen as speakers: they will provide their own perspective and highlight EC studies
- **Winter 2021-2022: few one-day virtual EF workshops by topic (SM, Higgs, BSM, Colliders,…)**
  - Check progress towards March deadline for contributed papers
  - Discuss overlap with other frontiers
- **Spring 2022: EF workshop to review contributed papers**
  - Focus on main themes and messages by contributed papers, towards May deadline for TG reports.
  - Converge on summary plots and other contributions involving multiple TGs or multiple frontiers
- **March-July 2022: circulations of preliminary TG and EF reports, then public readings**

Summary Plot Discussions

Presentation by EF Conveners: link



Ursula Bassler @ Granada meeting

- Will add **EIC** and **Muon Collider** to this chart.
- Will consider **new proposals** that have come up during Snowmass 2021.
  - e.g. initiatives for gamma-gamma and plasma colliders etc.

Summary Plot Discussions

Presentation by EF Conveners: link

Snowmass 2021: EF Benchmark Scenarios

Snowmass 2021 Energy Frontier Collider Study Scenarios

Collider	Type	$\sqrt{s}$	P [%] e^-/e^+	L_{int} ab^{-1}
HL-LHC	pp	14 TeV		6
ILC	ee	250 GeV	$\pm 80/\pm 30$	2
		350 GeV	$\pm 80/\pm 30$	0.2
		500 GeV	$\pm 80/\pm 30$	4
		1 TeV	$\pm 80/\pm 20$	8
CLIC	ee	380 GeV	$\pm 80/0$	1
		1.5 TeV	$\pm 80/0$	2.5
		3.0 TeV	$\pm 80/0$	5
CEPC	ee	M_Z		16
		$2M_W$		2.6
		240 GeV		5.6
FCC-ee	ee	M_Z		150
		$2M_W$		10
		240 GeV		5
		2 M_{top}		1.5

Snowmass 2021 Energy Frontier Collider Study Scenarios

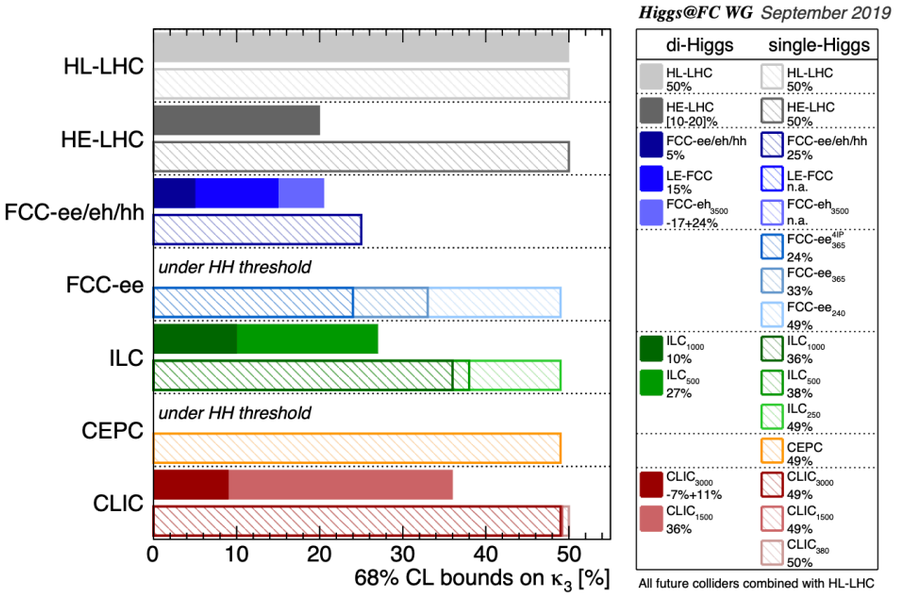
Collider	Type	$\sqrt{s}$	P [%] e^-/e^+	L_{int} ab^{-1}
FCC-hh	pp	100 TeV		30
LHeC	ep	1.3 TeV		1
FCC-eh	ep	3.5 TeV		2
muon-collider (higgs)	$\mu\mu$	125 GeV		0.02
High energy muon-collider	$\mu\mu$	3 TeV		1
		10 TeV		10
		14 TeV		20
		30 TeV		90

Note for muon-collider: It is important to note that the plan is not to run subsequently at the various c.o.m etc. These are reference points to explore and assess the physics potential and technology. The luminosity can be varied to determine how best to exploit the physics potential.

Other options to explore:

- Muon collider at a very high energy (>30 TeV?)[Need to consolidate grc list of c.o.m. energies]
- FCC pp >200 TeV? and ~75 TeV documenting sensitivity loss
- Very high energy e+e- collider
- Other emerging ideas: γ-γ collider, C^3 e^+e^- collider [C3=Cool Copper Collider]

Higgs Self Coupling Parameter κ_3 ESG



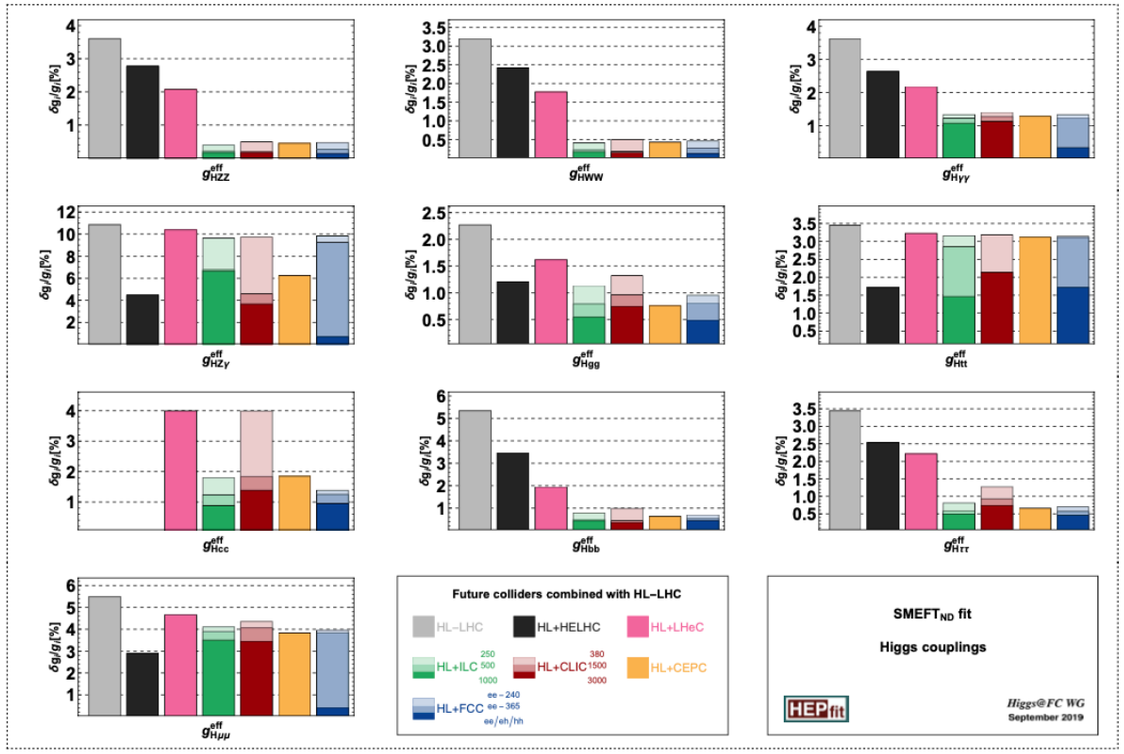
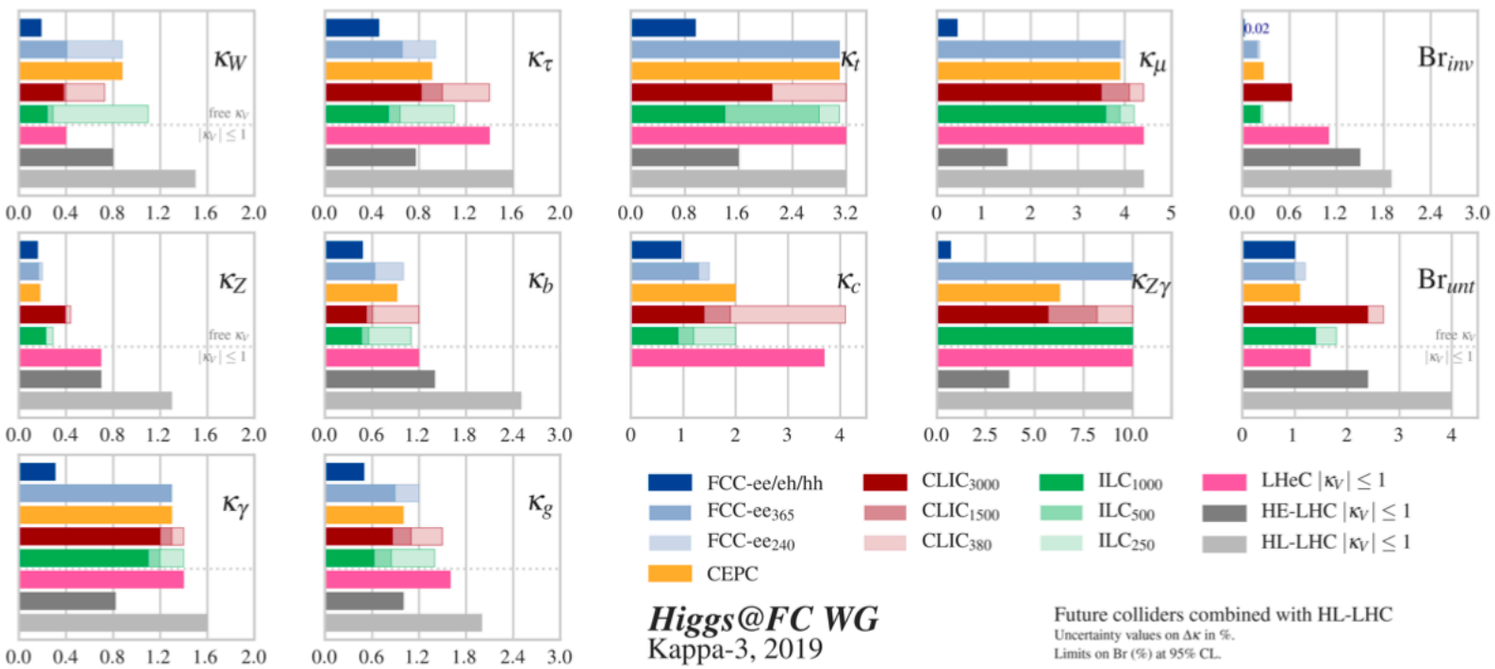


Fig. 3.9: 68% probability reach on Higgs couplings at the different future colliders from the Global fit SMEFT_{ND}. For details, see Ref. [39].

Higgs Couplings κ-framework ESG



Singlets and Doublets at Future Colliders

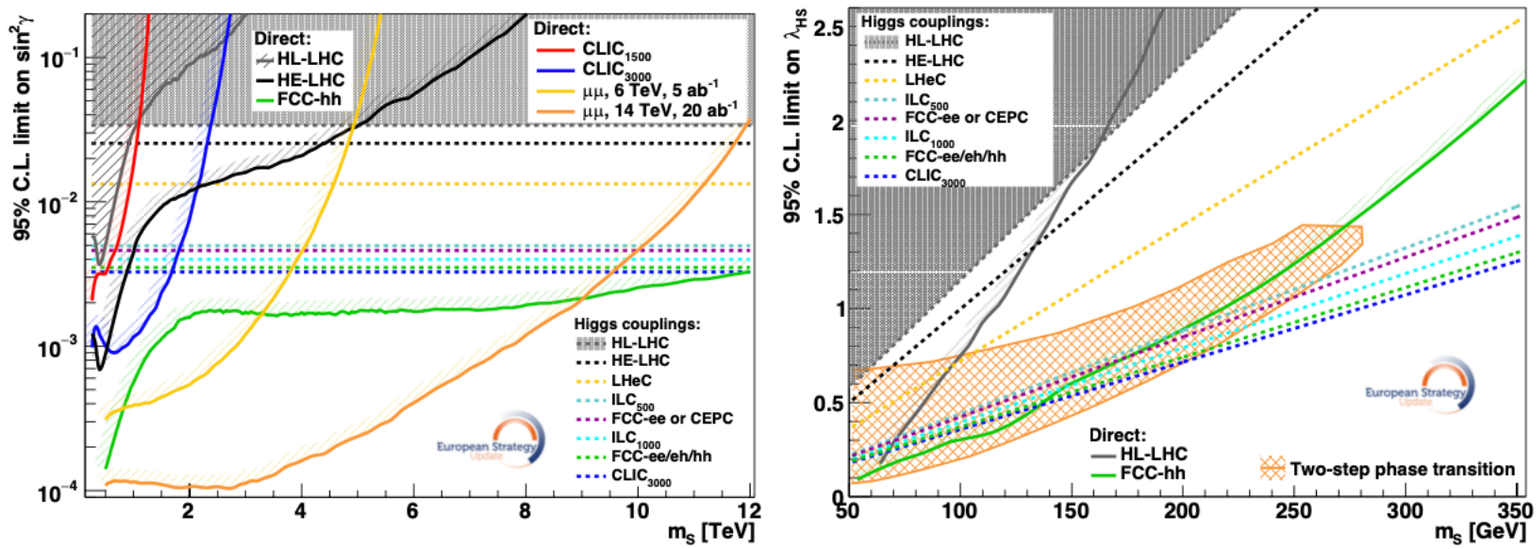


Fig. 8.11: Direct and indirect sensitivity at 95% CL to a heavy scalar singlet mixing with the SM Higgs boson (left) and in the no-mixing limit (right). The hatched region shows the parameters compatible with a strong first-order EW phase transition.

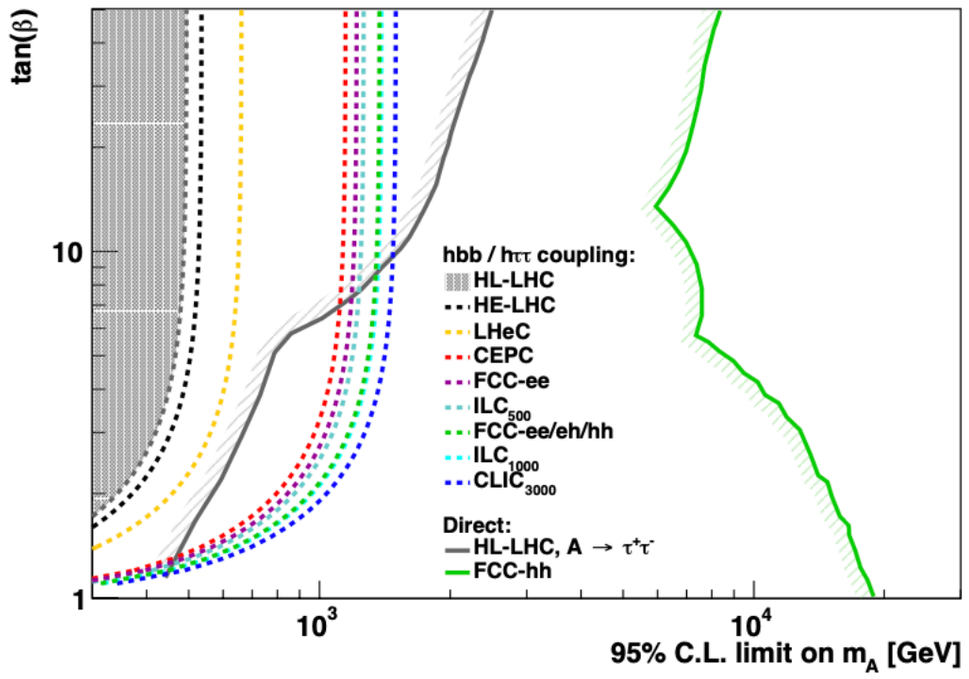
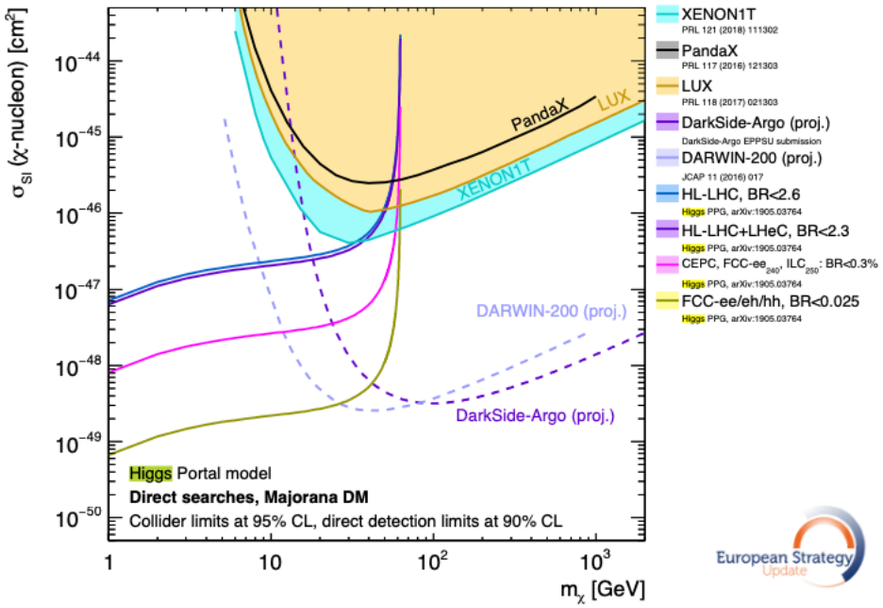


Fig. 8.12: Direct and indirect sensitivity at 95% CL to heavy neutral scalars in minimal SUSY.

Higgs Portal: Dark Matter Searches



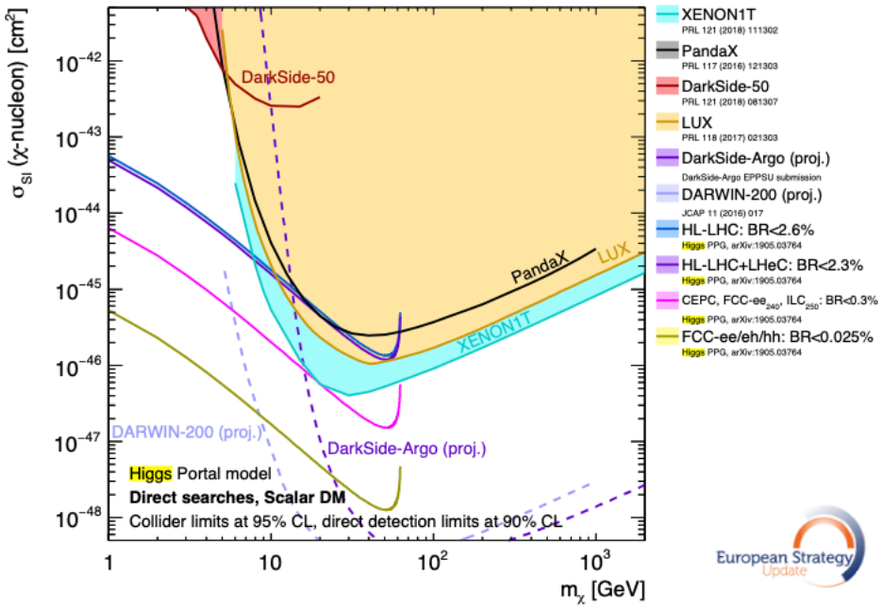


Fig. 9.3: Comparison of projected limits from future colliders (direct searches for invisible decays of the Higgs boson) with constraints from current and future direct detection experiments on the spin-independent WIMP–nucleon scattering cross section for a simplified model with the Higgs boson decaying to invisible (DM) particles, either Majorana (top) or scalar (bottom). Collider limits are shown at 95% CL and direct detection limits at 90% CL. Collider searches and DD experiments exclude the areas above the curves.

Global Fits and Composite Higgs

$$\varepsilon \equiv \frac{m_H^2}{(\Delta m_H)^2},$$

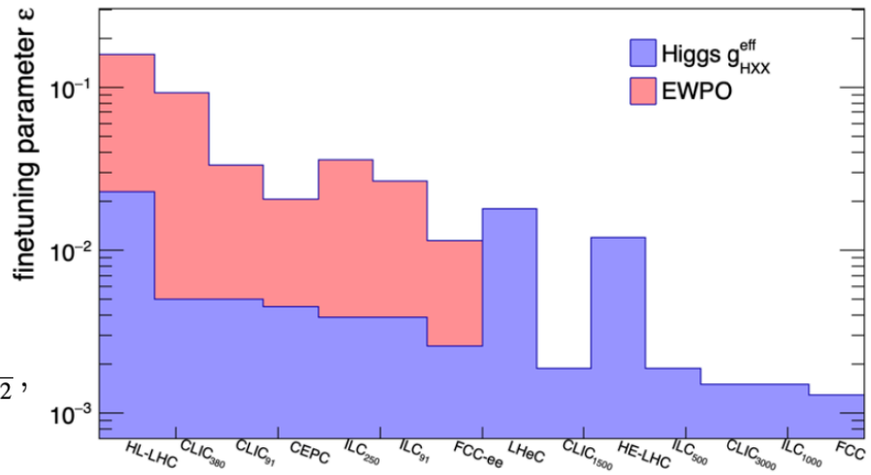


Fig. 3.11: Fine-tuning sensitivity as defined in Sect. 3.1 based on the Higgs coupling and EWPO precision projections. In each case the highest precision Higgs measurement is shown based on the EFT analysis: for HL-LHC, HE-LHC and LHeC this is the ggH coupling, and for all others it is the VVH coupling. For the EWPO the value of S is chosen, multiplied by three to be a measure of ε, and only the low-energy stages of the lepton colliders are shown. The colliders are roughly ordered by the time it takes to take the data after a project start time t_0. For projects with multiple stages, t_0 is defined as start of data taking for the first stage.

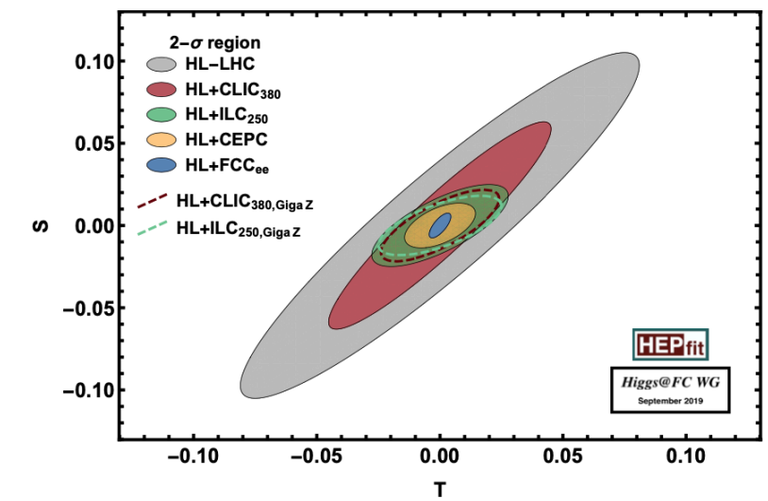


Fig. 3.7: Expected uncertainty contour for the S and T parameters for various colliders in their first energy stage. For ILC and CLIC the projections are shown with and without dedicated running at the Z-pole. All other oblique parameters are set to zero.