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FCC Physics Prospects

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Why don't we see as yet the new physics we expected to be present around the TeV scale ?

- **Is the mass scale beyond the LHC reach ?**

- **Is the mass scale within LHC's reach, but final states are elusive to the direct search ?**

These two scenarios are a priori equally likely, but they impact in different ways the future of HEP, and thus the assessment of the physics potential of possible future facilities

Readiness to address both scenarios is the best hedge for the field:

- *precision* ⇒ *higher statistics, better detectors and experimental conditions*
- *sensitivity (to elusive signatures)* ⇒ *ditto*
- ***extended energy/mass reach* ⇒ *higher energy***

The physics potential (the "case") of a future facility for HEP should be weighed against criteria such as:

(1) the **guaranteed deliverables:**
- knowledge that will be acquired independently of possible discoveries (*the value of "measurements"*)

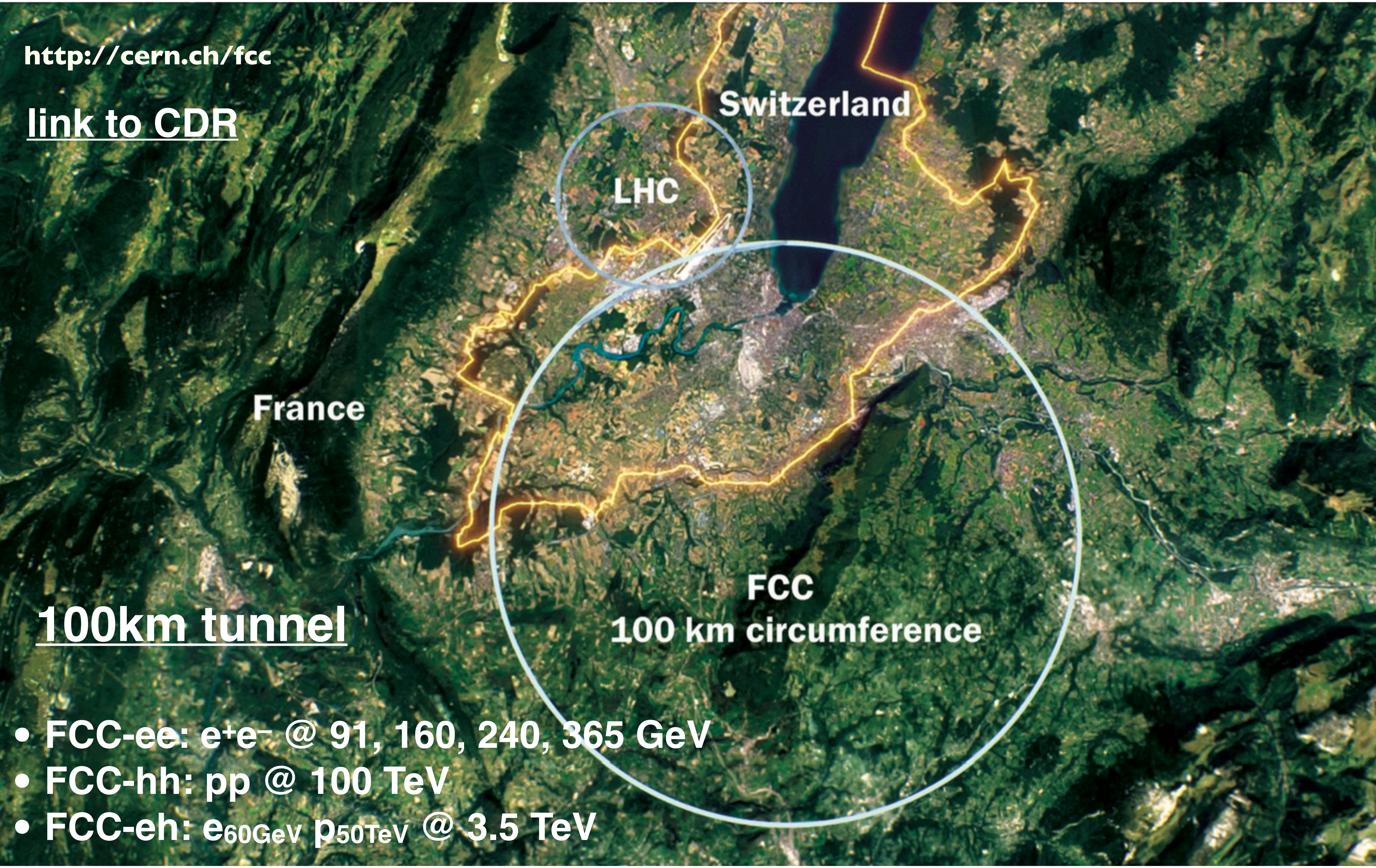
(2) the **exploration potential:**
- target broad and well justified BSM scenarios .... *but guarantee sensitivity to more exotic options*
- exploit both direct (large Q^2) and indirect (precision) probes

(3) the potential to provide conclusive **yes/no answers** to relevant, broad questions.

Future Circular Collider

http://cern.ch/fcc

link to CDR



100km tunnel

- FCC-ee: e^+e^- @ 91, 160, 240, 365 GeV
- FCC-hh: pp @ 100 TeV
- FCC-eh: e_{60GeV} p_{50TeV} @ 3.5 TeV

What a future circular collider can offer

- Guaranteed deliverables:
  - study of Higgs and top quark properties, and exploration of EWSB phenomena, with the best possible **precision and sensitivity**
- Exploration potential:
  - exploit both direct (large Q^2) and indirect (precision) probes
  - **enhanced mass reach** for direct exploration at 100 TeV
    - *E.g. match the mass scales for new physics that could be exposed via indirect precision measurements in the EW and Higgs sector*
- Provide firm Yes/No answers to questions like:
  - is there a TeV-scale solution to the hierarchy problem?
  - is DM a thermal WIMP?
  - could the cosmological EW phase transition have been 1st order?
  - could baryogenesis have taken place during the EW phase transition?
  - could neutrino masses have their origin at the TeV scale?
  - …

Event rates: examples

FCC-ee	H	Z	W	t	τ(←Z)	b(←Z)	c(←Z)
	10^6	$5\ 10^{12}$	10^8	10^6	$3\ 10^{11}$	$1.5\ 10^{12}$	10^{12}

FCC-hh	H	b	t	W(←t)	τ(←W←t)
	$2.5\ 10^{10}$	10^{17}	10^{12}	10^{12}	10^{11}

FCC-eh	H	t
	$2.5\ 10^6$	$2\ 10^7$

(1) guaranteed deliverables: Higgs properties

Coupling deviations for various BSM models, likely to remain unconstrained by direct searches at HL-LHC

https://arxiv.org/pdf/1708.08912.pdf

	Model	$b\bar{b}$	$c\bar{c}$	gg	WW	$\tau\tau$	ZZ	$\gamma\gamma$	$\mu\mu$
1	MSSM [40]	+4.8	-0.8	- 0.8	-0.2	+0.4	-0.5	+0.1	+0.3
2	Type II 2HD [42]	+10.1	-0.2	-0.2	0.0	+9.8	0.0	+0.1	+9.8
3	Type X 2HD [42]	-0.2	-0.2	-0.2	0.0	+7.8	0.0	0.0	+7.8
4	Type Y 2HD [42]	+10.1	-0.2	-0.2	0.0	-0.2	0.0	0.1	-0.2
5	Composite Higgs [44]	-6.4	-6.4	-6.4	-2.1	-6.4	-2.1	-2.1	-6.4
6	Little Higgs w. T-parity [45]	0.0	0.0	-6.1	-2.5	0.0	-2.5	-1.5	0.0
7	Little Higgs w. T-parity [46]	-7.8	-4.6	-3.5	-1.5	-7.8	-1.5	-1.0	-7.8
8	Higgs-Radion [47]	-1.5	- 1.5	+10.	-1.5	-1.5	-1.5	-1.0	-1.5
9	Higgs Singlet [48]	-3.5	-3.5	-3.5	-3.5	-3.5	-3.5	-3.5	-3.5

5 – 10 %

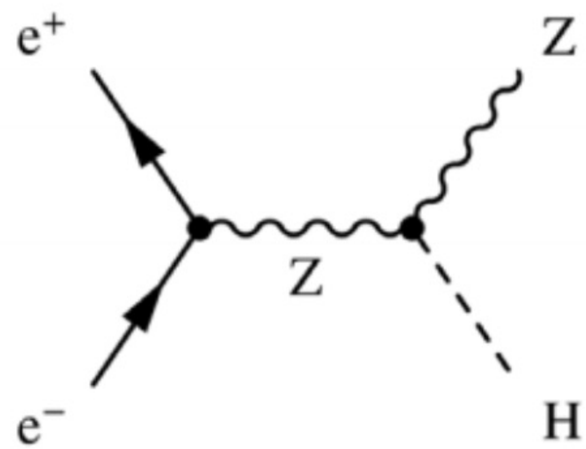
> 10%

NB: when the b coupling is modified, BR deviations are smaller than the square of the coupling deviation. Eg in model 5, the BR to b, c, tau, mu are practically SM-like

(sub)-% precision must be the goal to ensure 3-5σ evidence of deviations, and to cross-correlate coupling deviations across different channels

The absolutely unique power of $e^+e^- \rightarrow ZH$ (circular or linear):

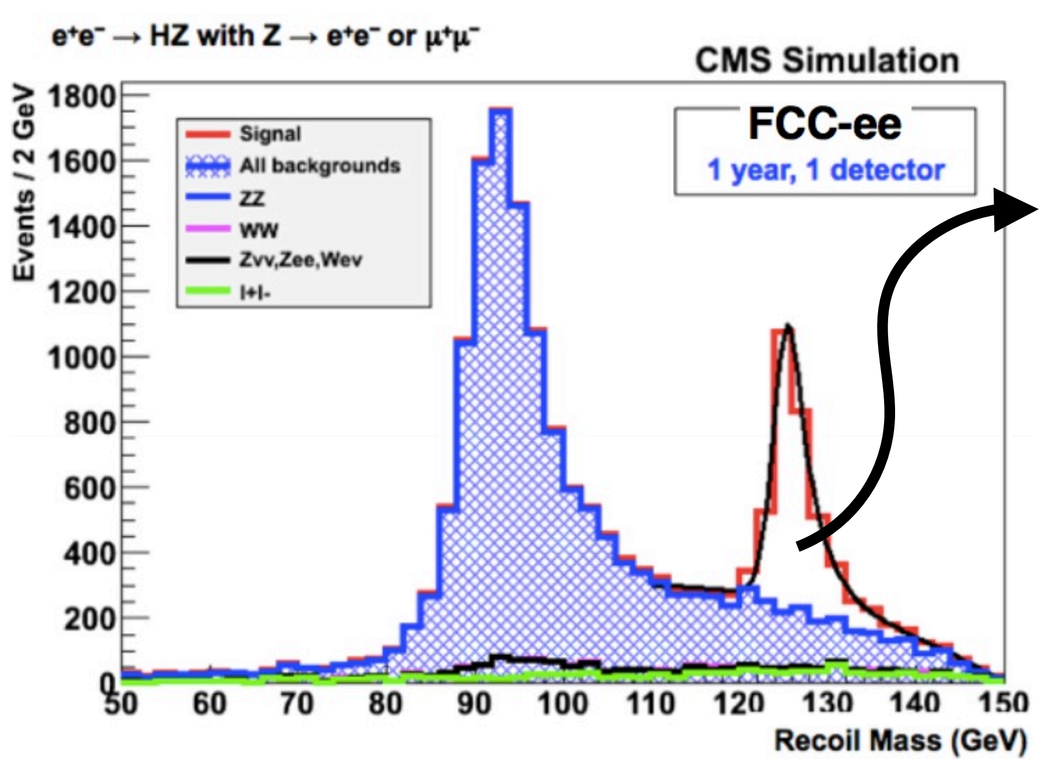
- the model independent absolute measurement of **HZZ** coupling, which allows the subsequent:
  - sub-% measurement of couplings to W, Z, b, τ
  - % measurement of couplings to gluon and charm



$p(H) = p(e^-e^+) - p(Z)$

$\Rightarrow [\, p(e^-e^+) - p(Z)\,]^2$ peaks at $m^2(H)$

reconstruct Higgs events independently of the Higgs decay mode!



$m_{recoil} = \sqrt{[\, p(e^-e^+) - p(Z)\,]^2}$

$N(ZH) \propto \sigma(ZH) \propto g_{HZZ}^2$

$N(ZH[\rightarrow ZZ]) \propto$

$\sigma(ZH) \times BR(H\rightarrow ZZ) \propto$

$g_{HZZ}^2 \times g_{HZZ}^2 / \Gamma(H)$

=> absolute measurement of width and couplings

The absolutely unique power of pp $\rightarrow$H+X:

- the extraordinary statistics that, complemented by the per-mille e^+e^- measurement of eg BR(H$\rightarrow$ZZ*), allows
  - the sub-% measurement of rarer decay modes
  - the ~5% measurement of the Higgs trilinear selfcoupling

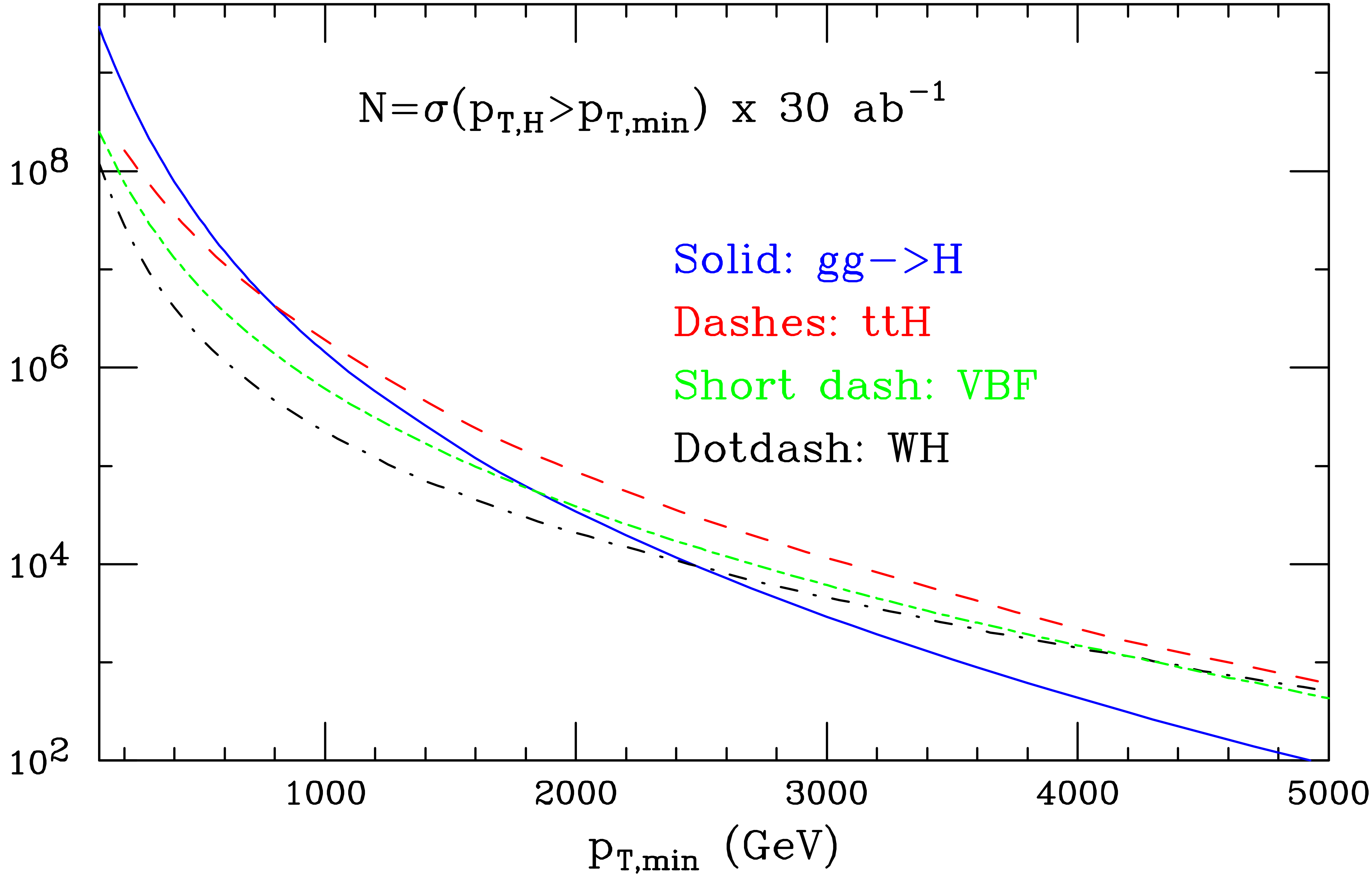
- the huge dynamic range (eg pt(H) up to several TeV), which allows to
  - probe d>4 EFT operators up to scales of several TeV
  - search for multi-TeV resonances decaying to H, or extensions of the Higgs sector

	gg$\rightarrow$H	VBF	WH	ZH	ttH	HH
N_{100}	24×10^9	2.1×10^9	4.6×10^8	3.3×10^8	9.6×10^8	3.6×10^7
N_{100}/N_{14}	180	170	100	110	530	390

$N_{100} = \sigma_{100\,\mathrm{TeV}} \times 30\ \mathrm{ab}^{-1}$

$N_{14} = \sigma_{14\,\mathrm{TeV}} \times 3\ \mathrm{ab}^{-1}$

H at large p_T



- Hierarchy of production channels changes at large $p_T(H)$:
  - $\sigma(ttH) > \sigma(gg\to H)$ above 800 GeV
  - $\sigma(VBF) > \sigma(gg\to H)$ above 1800 GeV

Three kinematic regimes

- Inclusive production, $p_T > 0$:
  - largest overall rates
  - most challenging experimentally:
    - triggers, backgrounds, pile-up ⇒ low efficiency, large systematics

  ➡ det simulations challenging, likely unreliable ⇒ regime not studied so far

- $p_T \gtrsim 100$ GeV :
  - stat uncertainty ~few × 10^{-3} for $H \to 4l, \gamma\gamma$, …
  - improved S/B, realistic trigger thresholds, reduced pile-up effects ?

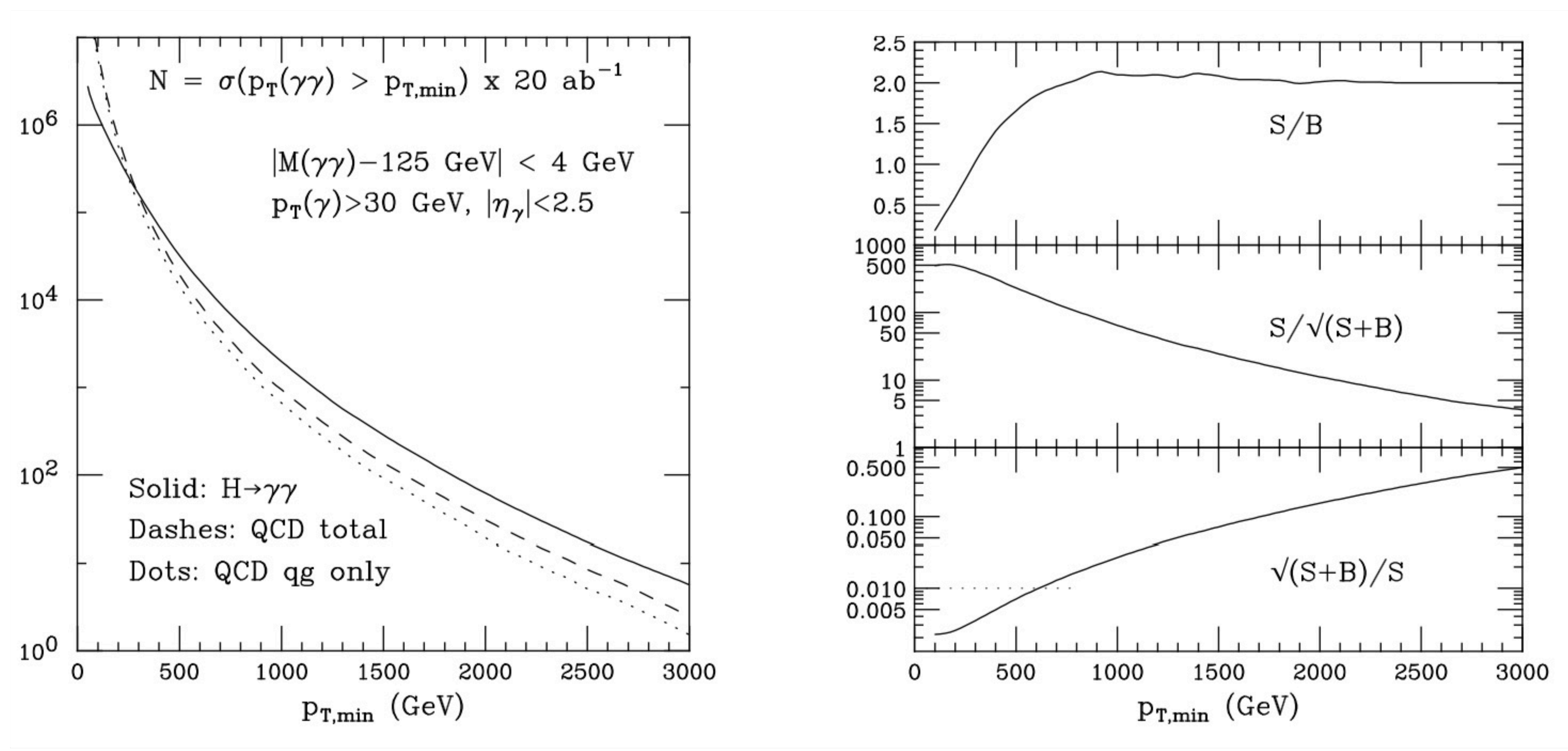
  ➡ current det sim and HL-LHC extrapolations more robust

  ➡ focus of FCC CDR Higgs studies so far

  ➡ sweet-spot for precision measurements at the sub-% level

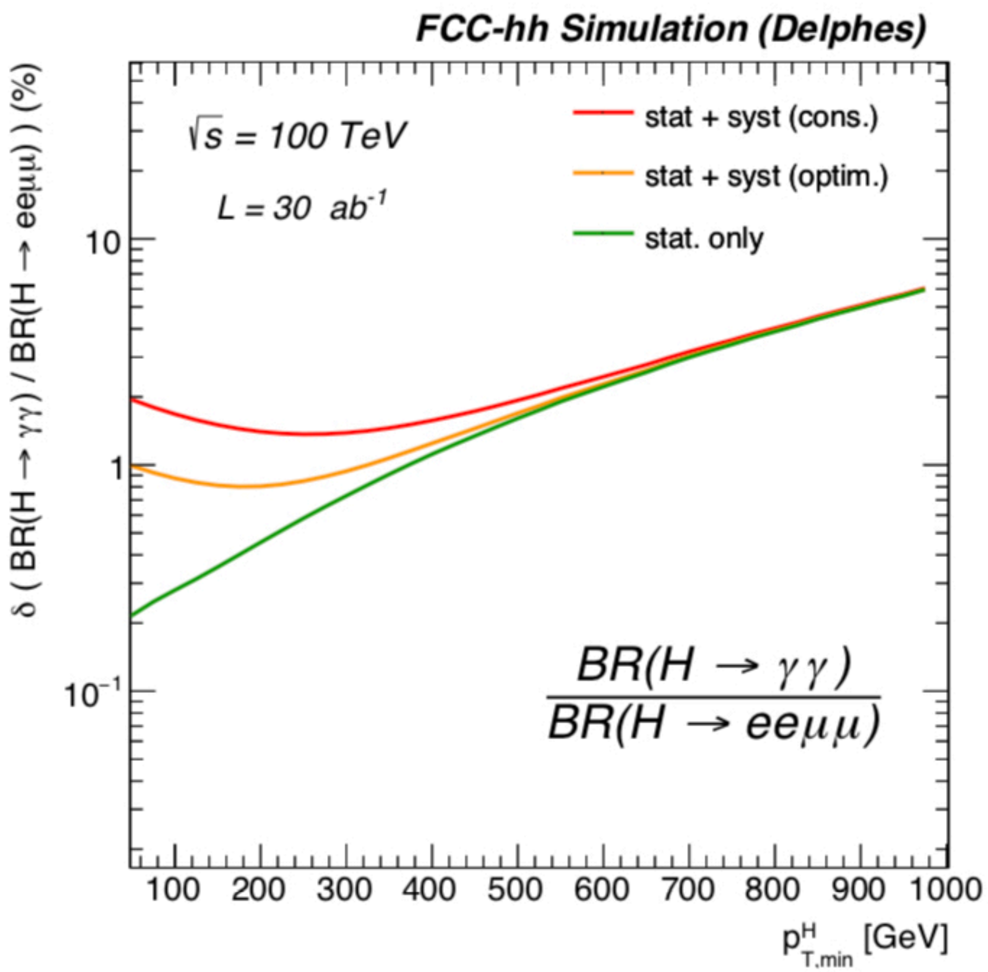
- $p_T \gtrsim$ TeV :
  - stat uncertainty O(10%) up to 1.5 TeV (3 TeV) for $H \to 4l, \gamma\gamma$ ($H \to bb$)
  - new opportunities for reduction of syst uncertainties (TH and EXP)
  - different hierarchy of production processes
  - indirect sensitivity to BSM effects at large Q^2 , complementary to that emerging from precision studies (*eg decay BRs*) at $Q \sim m_H$

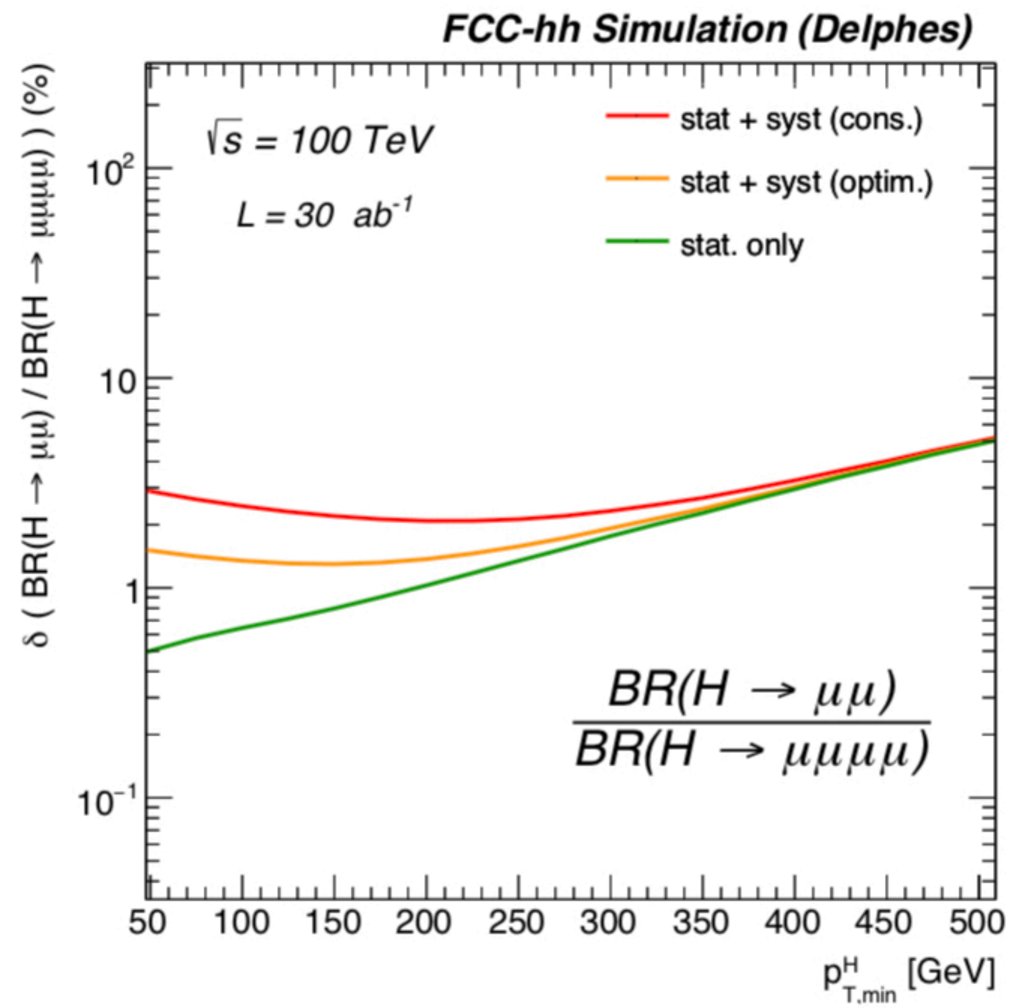
gg→H→γγ at large p_T

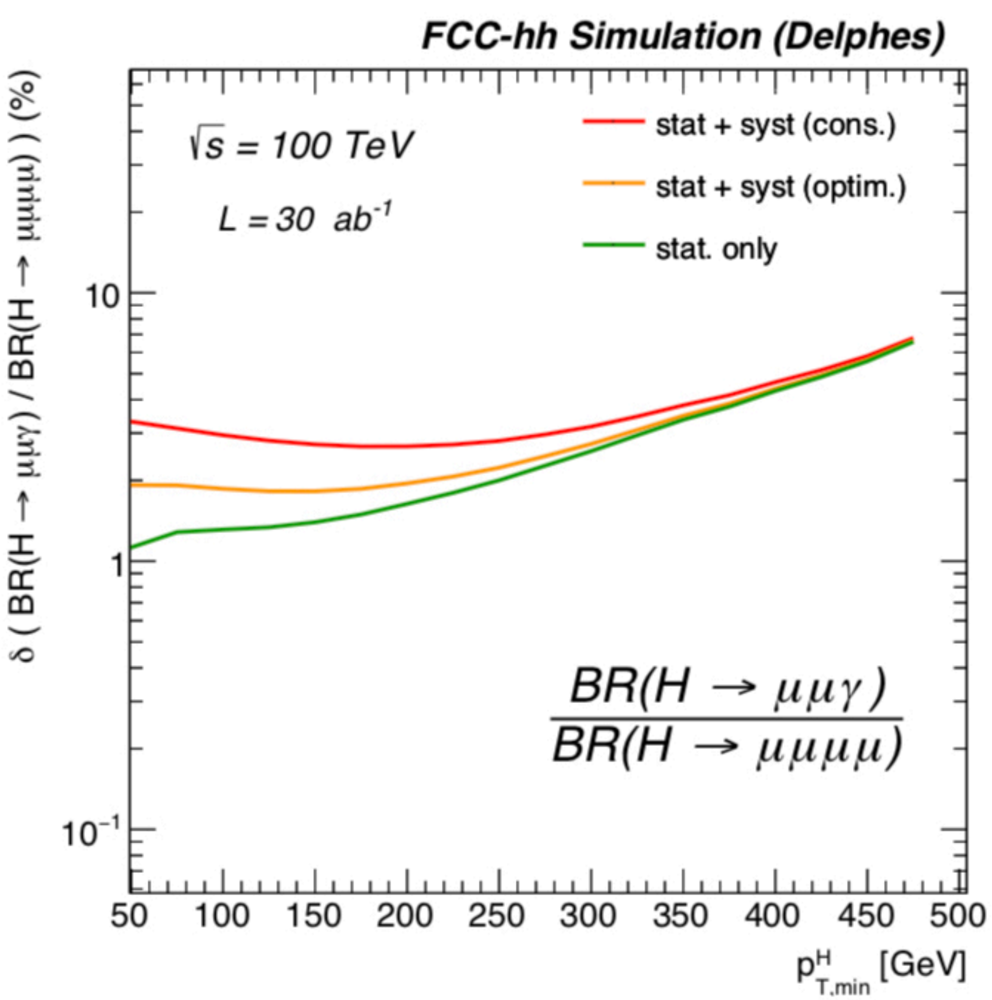


- At LHC, S/B in the H→γγ channel is O(few %)
- At FCC, for p_T(H)>300 GeV, S/B~1
- Potentially accurate probe of the H pt spectrum up to large pt

$p_{T,min}$ (GeV)	δ_{stat}
100	**0.2%**
400	**0.5%**
600	**1%**
1600	10%







Normalize to BR(4l) from ee => sub-% precision for absolute couplings

Future work: explore in more depth data-based techniques, to validate and then reduce the systematics in these ratio measurements, possibly moving to lower pt's and higher stat

Higgs couplings after FCC-ee / hh

	HL-LHC	FCC-ee	FCC-hh
$\delta\Gamma_H / \Gamma_H$ (%)	SM	**1.3**	tbd
$\delta g_{HZZ} / g_{HZZ}$ (%)	1.5	**0.17**	tbd
$\delta g_{HWW} / g_{HWW}$ (%)	1.7	**0.43**	tbd
$\delta g_{Hbb} / g_{Hbb}$ (%)	3.7	**0.61**	tbd
$\delta g_{Hcc} / g_{Hcc}$ (%)	~70	**1.21**	tbd
$\delta g_{Hgg} / g_{Hgg}$ (%)	2.5 (gg->H)	**1.01**	tbd
$\delta g_{H\tau\tau} / g_{H\tau\tau}$ (%)	1.9	**0.74**	tbd
$\delta g_{H\mu\mu} / g_{H\mu\mu}$ (%)	4.3	9.0	**0.65 (*)**
$\delta g_{H\gamma\gamma} / g_{H\gamma\gamma}$ (%)	1.8	3.9	**0.4 (*)**
$\delta g_{Htt} / g_{Htt}$ (%)	3.4	~10 (indirect)	**0.95 (**)**
$\delta g_{HZ\gamma} / g_{HZ\gamma}$ (%)	9.8	–	**0.9 (*)**
$\delta g_{HHH} / g_{HHH}$ (%)	50	~44 (indirect)	**3.5**
BR_{exo} (95%CL)	$BR_{inv} < 2.5\%$	**< 1%**	**$BR_{inv} < 0.025\%$**

NB

$BR(H\rightarrow Z\gamma,\gamma\gamma) \sim O(10^{-3}) \Rightarrow$ **$O(10^7)$ evts for Δ_{stat}~%**

$BR(H\rightarrow \mu\mu) \sim O(10^{-4}) \Rightarrow$ **$O(10^8)$ evts for Δ_{stat}~%**

pp collider is essential to beat the % target, since no proposed ee collider can produce more than $O(10^6)$ H's

* From BR ratios wrt $B(H\rightarrow ZZ^*)$ @ FCC-ee

** From $pp\rightarrow ttH$ / $pp\rightarrow ttZ$, using $B(H\rightarrow bb)$ and ttZ EW coupling @ FCC-ee

The Higgs self-coupling at FCC-hh

https://arxiv.org/abs/2004.03505

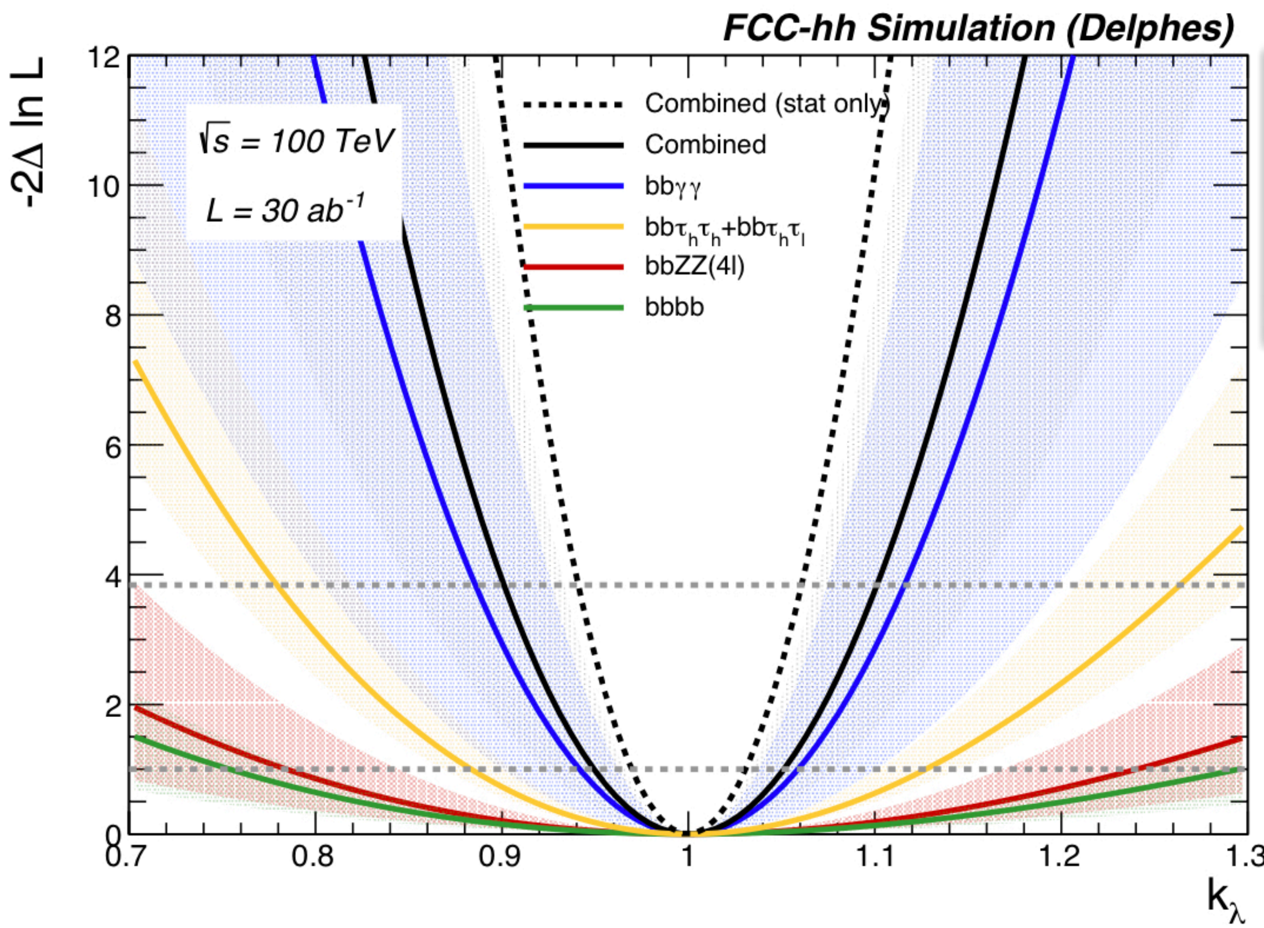


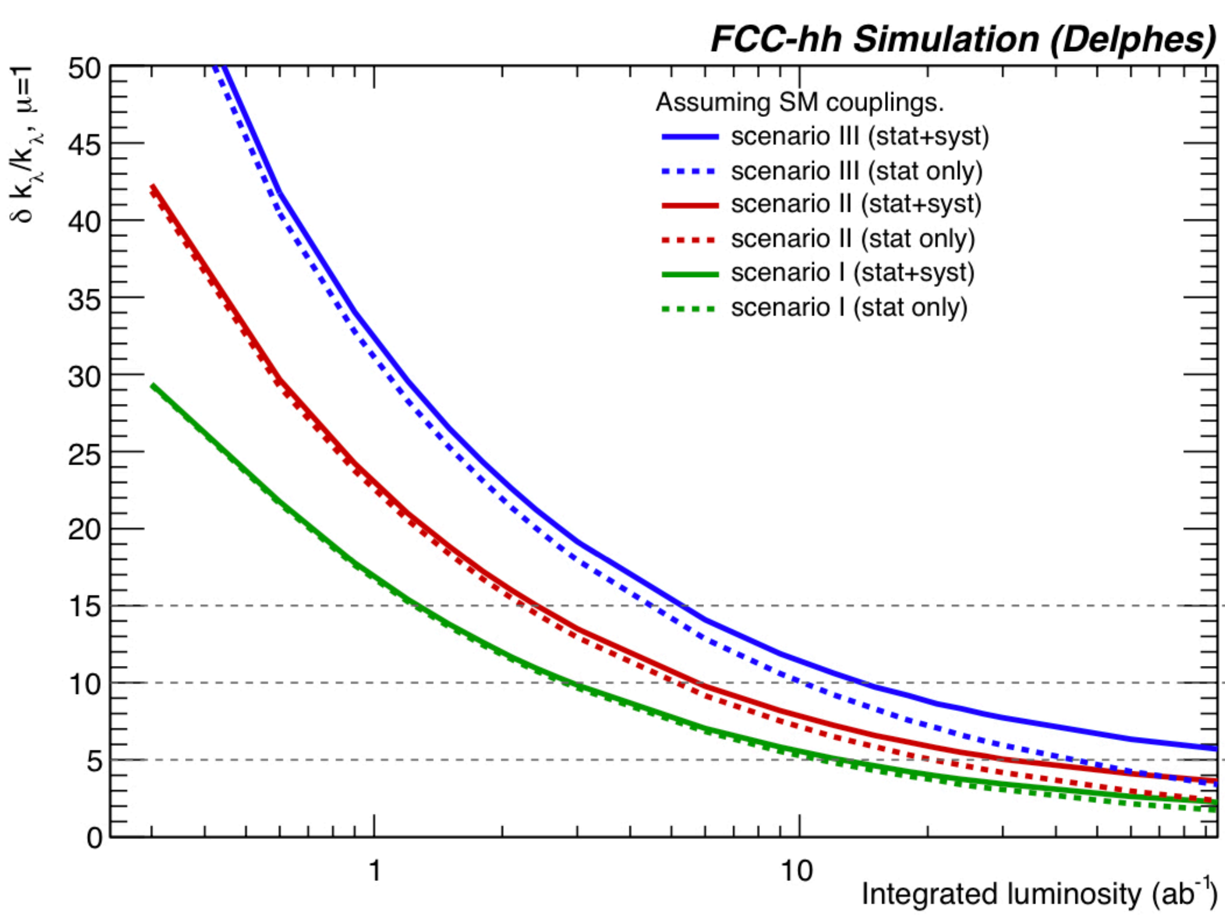
Figure 13. Expected negative log-Likelihood scan as a function of the trilinear self-coupling modifier $\kappa_\lambda = \lambda_3/\lambda_3^{SM}$ in all channels, and their combination. The solid line corresponds to the scenario II for systematic uncertainties. The band boundaries represent respectively scenario I and III. The dashed line represents the sensitivity obtained including statistical uncertainties only, under the assumptions of scenario I.

Syst scenarios

@68% CL		scenario I	scenario II	scenario III
δ_μ	stat only	2.2	2.8	3.7
	stat + syst	2.4	3.5	5.1
δ_{κ_λ}	stat only	3.0	4.1	5.6
	stat + syst	3.4	5.1	7.8

Table 7. Combined expected precision at 68% CL on the di-Higgs production cross- and Higgs self coupling using all channels at the FCC-hh with $\mathcal{L}_{int} = 30\ \text{ab}^{-1}$. The symmetrized value $\delta = (\delta^+ + \delta^-)/2$ is given in %.

I. Target det performance: LHC Run 2 conditions
II. Intermediate performance
III. Conservative: extrapolated HL-LHC performance, with today's algo's (eg no timing, etc)



Expected precision on the Higgs self-coupling as a function of the integrated luminosity.

3-5 ab^{-1} are sufficient to get below the 10% level

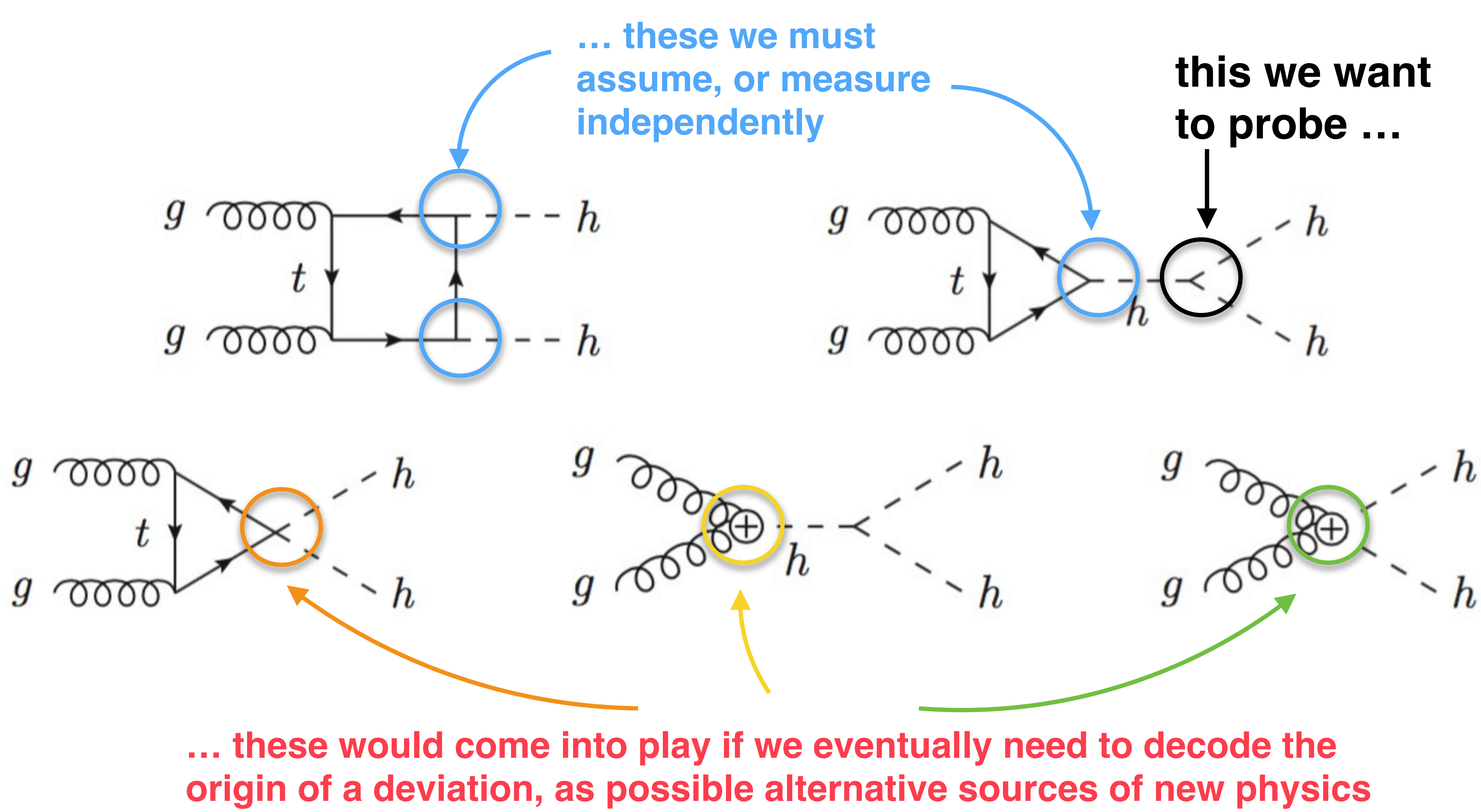
=> within the reach of the first 5yrs of FCC-hh running, in the <u>"low" luminosity / low pileup</u> phase

<u>=> the 10% precision threshold can be reached within the timescale of a similar measurement by CLIC @ 3 TeV</u>

Extracting Higgs self-coupling from HH at FCC:

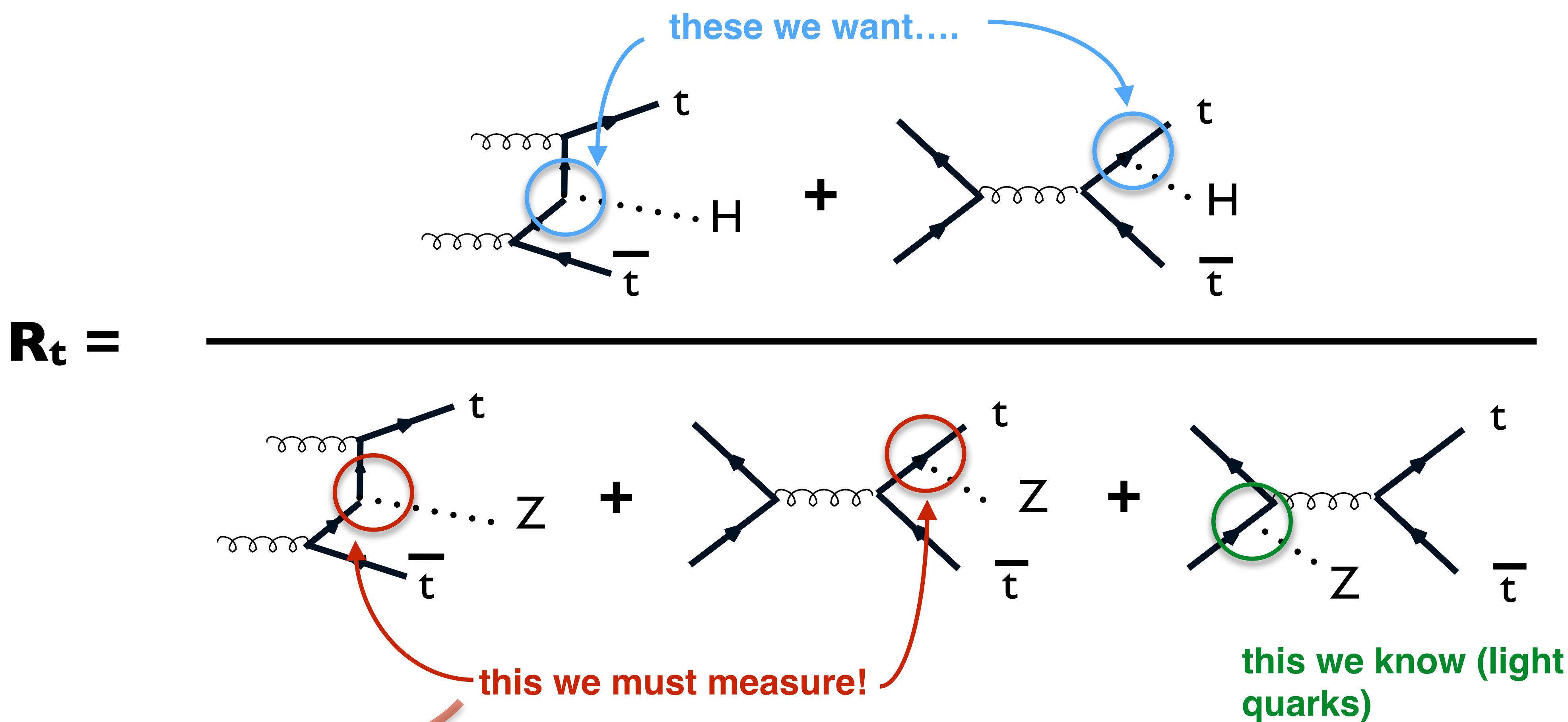
the power of ee/hh synergy & complementarity

At FCC-hh we can precisely measure HH rate … but, to interpret this as H selfcoupling:

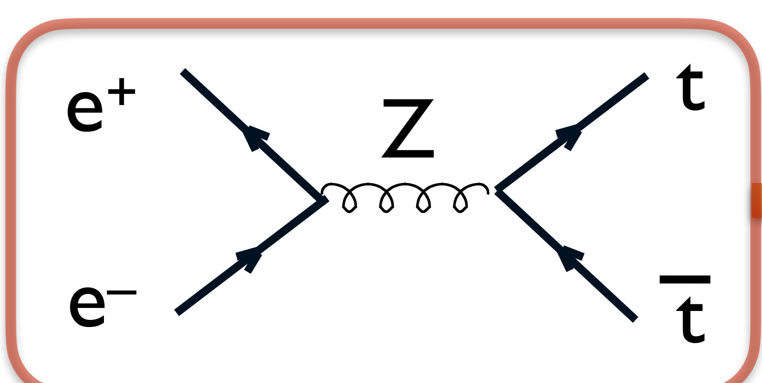


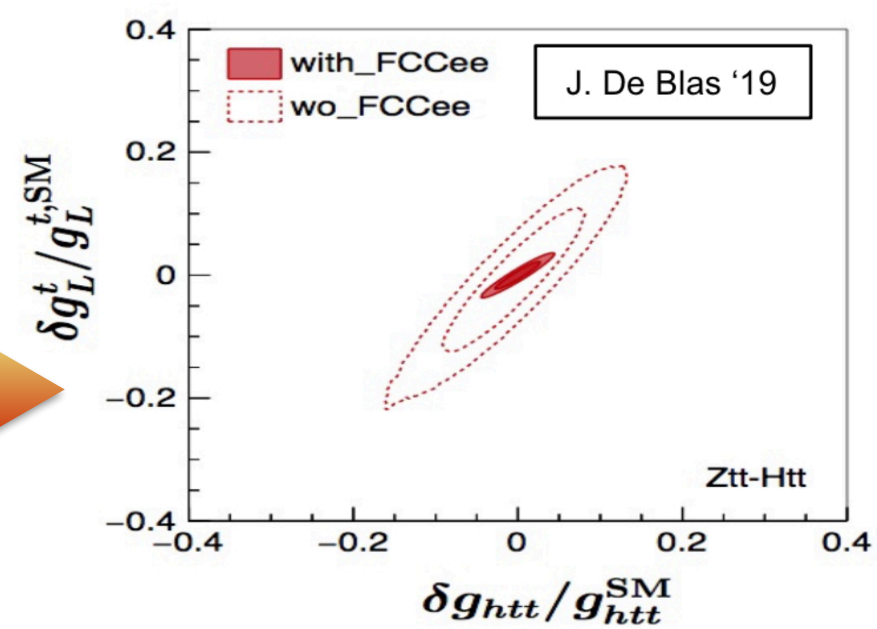
Direct measurement of ttH coupling: from $R_t = \sigma(ttH)/\sigma(ttZ)$

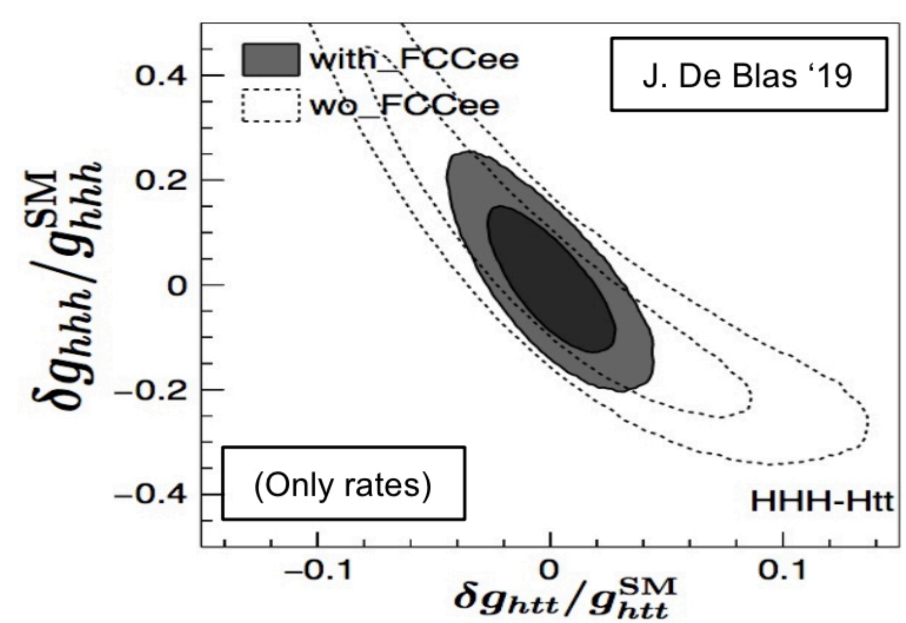
FCC-hh can measure R_t with $\Delta R_t/R_t < 2\%$ .... but:



FCC-ee







Unique at FCC-ee: $e^+e^- \to H$

D.D'Enterria et al, arXiv:2107.02686

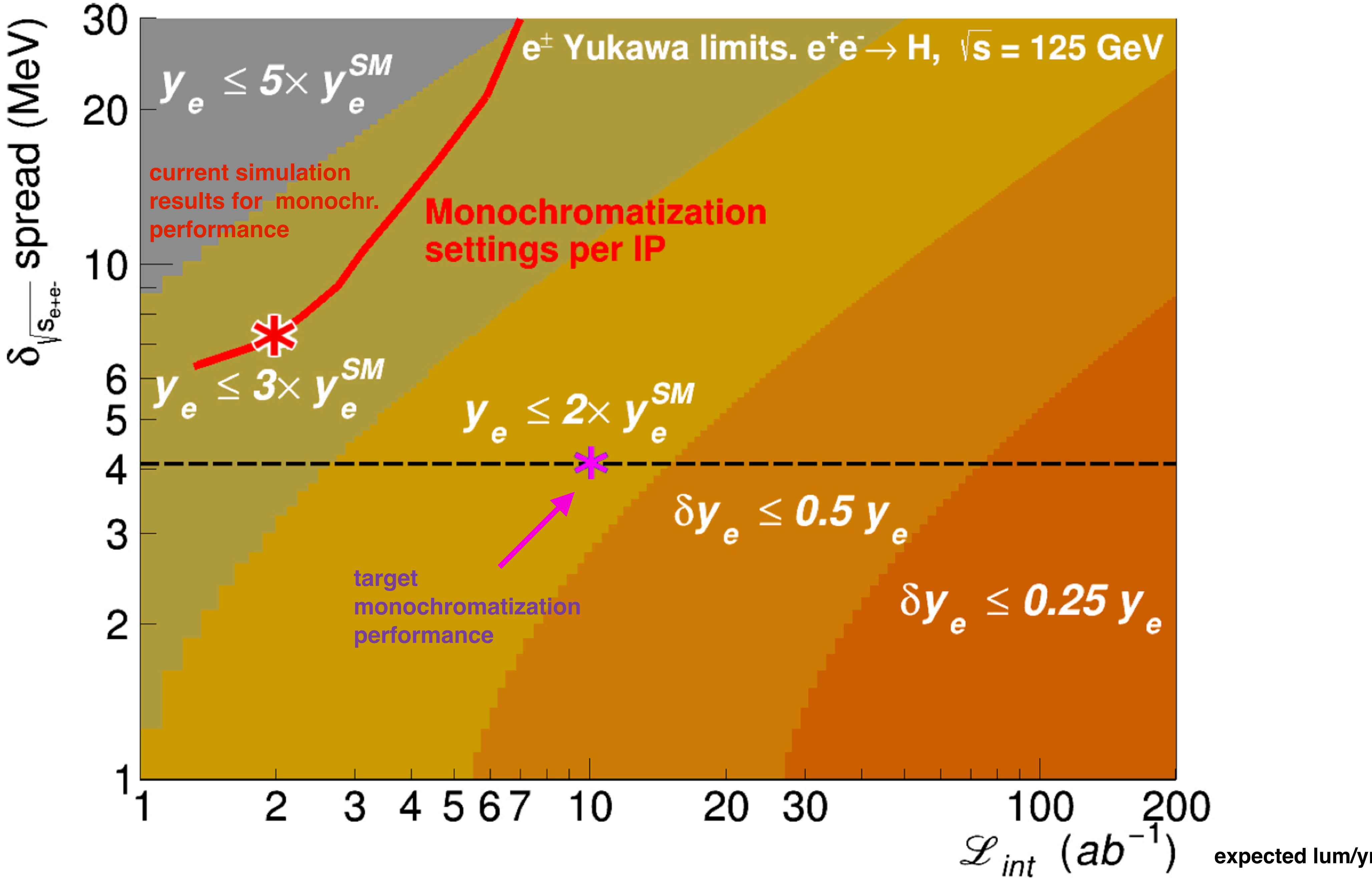


Table 6. Individual significances (in std. deviations σ) expected per decay channel for s-channel Higgs boson production in e^+e^- collisions at FCC-ee for $\mathcal{L}_{\rm int} = 10\,{\rm ab}^{-1}$ and $\delta_{\sqrt{s}} = 4.1$ MeV. The last column quotes the combined significance.

$H \to gg$	$H \to WW^* \to \ell\nu\ 2j;\ 2\ell\ 2\nu;\ 4j$	$H \to ZZ^* \to 2j\ 2\nu;\ 2\ell\ 2j;\ 2\ell\ 2\nu$	$H \to b\bar{b}$	$H \to \tau_{had}\tau_{had};\ c\bar{c};\ \gamma\gamma$	Combined
1.1σ	$(0.53 \otimes 0.34 \otimes 0.13)\sigma$	$(0.32 \otimes 0.18 \otimes 0.05)\sigma$	0.13σ	$< 0.02\sigma$	1.3σ

(1) guaranteed deliverables: EW&flavour observables

The absolutely unique power of **circular** e^+e^-:

$e^+e^- \to Z$	$e^+e^- \to WW$	$\tau(\leftarrow Z)$	$b(\leftarrow Z)$	$c(\leftarrow Z)$	$e^+e^- \to tt$
$5\ 10^{12}$	10^8	$3\ 10^{11}$	$1.5\ 10^{12}$	10^{12}	10^6

=> $O(10^5)$ larger statistics than LEP at the Z peak and WW threshold

Flavour statistics from Z decays:

Particle production (10^9)	B^0	B^-	B^0_s	Λ_b	$c\bar{c}$	$\tau^-\tau^+$
Belle II	27.5	27.5	n/a	n/a	65	45
FCC-*ee*	400	400	100	100	800	220

Additional bonus wrt B factory: (i) Lorentz boost (ii) B hadrons not accessible at the Y(4S,5S) thresholds

EW parameters @ FCC-ee

Improvement wrt current total uncertainties:

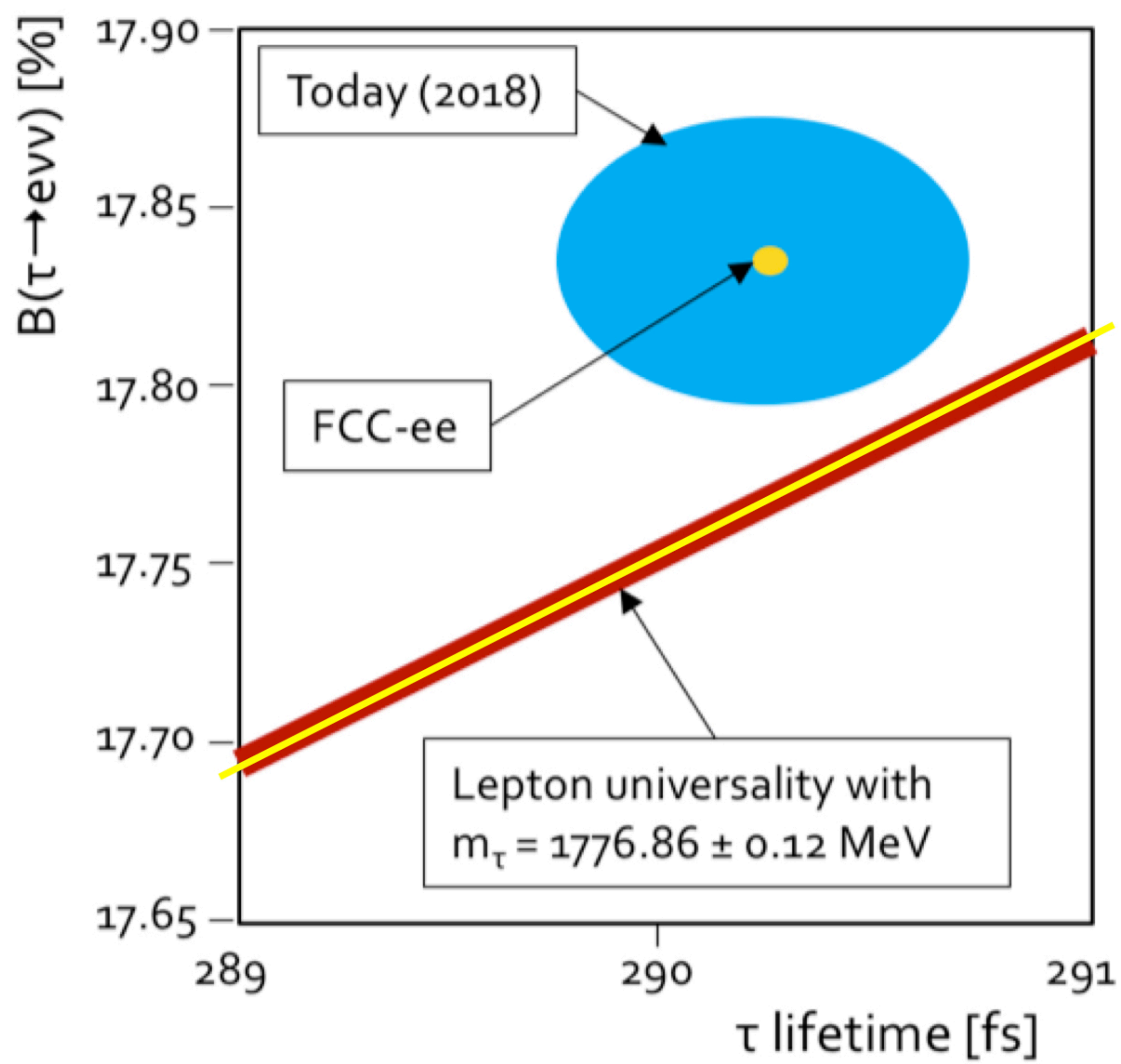
- stat precision ~ 10-1000 smaller
- with exptl syst ~ > 10-50 smaller

Currently limited by TH systematics
=>
ee goals set during the ongoing Workshop

Observable	present value ± error	FCC-ee stat.	FCC-ee syst.
m_Z (keV)	91186700±2200	5	100
Γ_Z (keV)	2495200±2300	8	100
R_l^Z ($\times 10^3$)	20767±25	0.06	0.2-1.0
α_s (m_Z) ($\times 10^4$)	1196±30	0.1	0.4-1.6
R_b ($\times 10^6$)	216290±660	0.3	<60
σ^0_{had} ($\times 10^3$) (nb)	41541±37	0.1	4
N_ν ($\times 10^3$)	2991±7	0.005	1
$\sin^2\theta_W^{\mathrm{eff}}$ ($\times 10^6$)	231480±160	3	2-5
$1/\alpha_{\mathrm{QED}}(m_Z)$ ($\times 10^3$)	128952±14	4	Small
$A_{FB}^{b,0}$ ($\times 10^4$)	992±16	0.02	1-3
$A_{FB}^{\mathrm{pol},\tau}$ ($\times 10^4$)	1498±49	0.15	<2
m_W (MeV)	80350±15	0.6	0.3
Γ_W (MeV)	2085±42	1.5	0.3
α_s (m_W) ($\times 10^4$)	1170±420	3	Small
N_ν($\times 10^3$)	2920±50	0.8	Small
m_{top} (MeV)	172740±500	20	Small
Γ_{top} (MeV)	1410±190	40	Small
$\lambda_{\mathrm{top}}/\lambda_{\mathrm{top}}^{\mathrm{SM}}$	1.2±0.3	0.08	Small
ttZ couplings	±30%	0.5 – 1.5%	Small

crucial for ttH and HHH couplings at FCC-hh

Flavour probes: eg lepton universality in tau decays



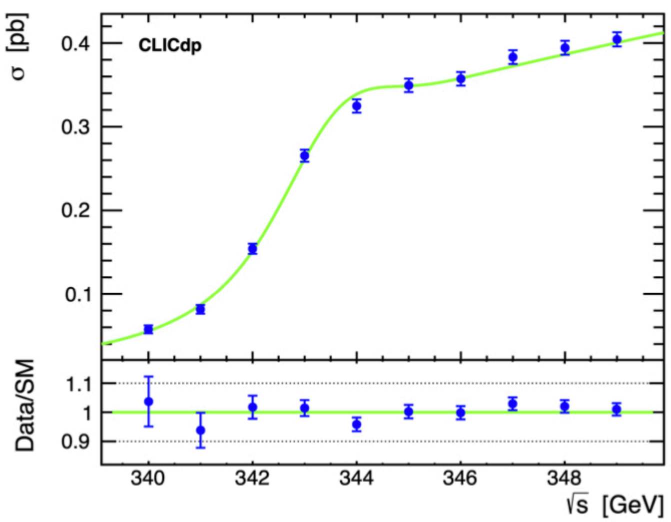
Lorentz boost crucial!

Observable	Measurement	Current precision	FCC-ee stat.	Possible syst.	Challenge
m_τ [MeV]	Threshold / inv. mass endpoint	1776.86 ± 0.12	0.004	0.04–0.1	Mass scale
τ_τ [fs]	Flight distance	290.3 ± 0.5 fs	0.001	0.04	Vertex detector alignment
$B(\tau\to e\nu\nu)$ [%]	Selection of $\tau^+\tau^-$, identification of final state	17.82 ± 0.05	0.0001	0.003	Efficiency, bkg, Particle ID
$B(\tau\to \mu\nu\nu)$ [%]		17.39 ± 0.05			

m_{top}: the advantage of circular

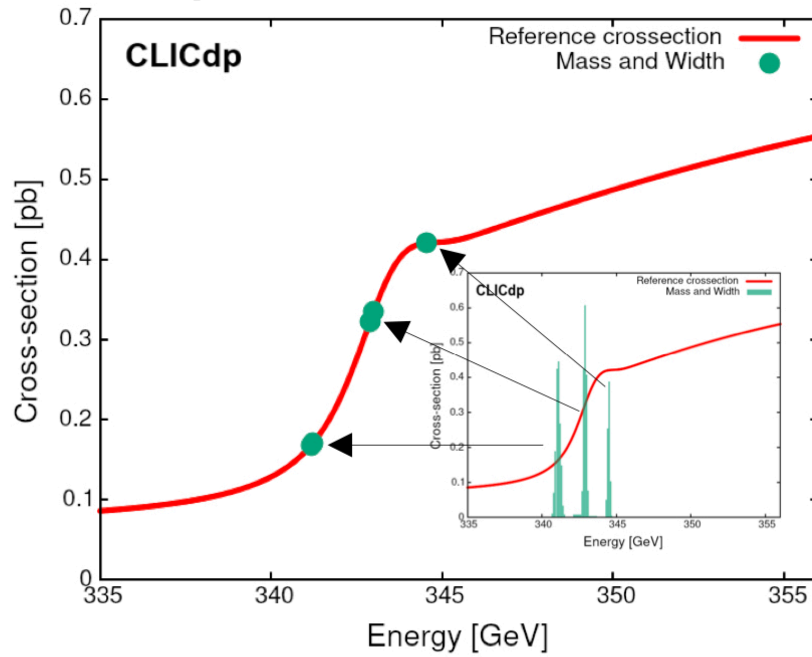
Optimisation of the threshold scan

Baseline scenario:

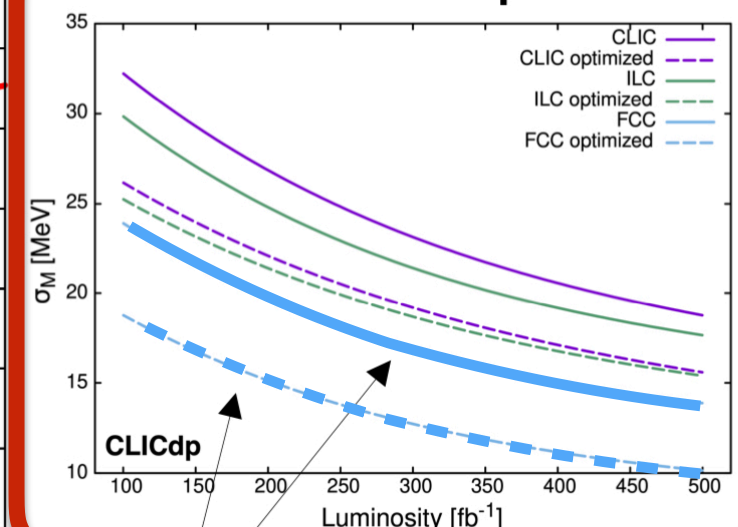


10 points of 10 fb^{-1} each

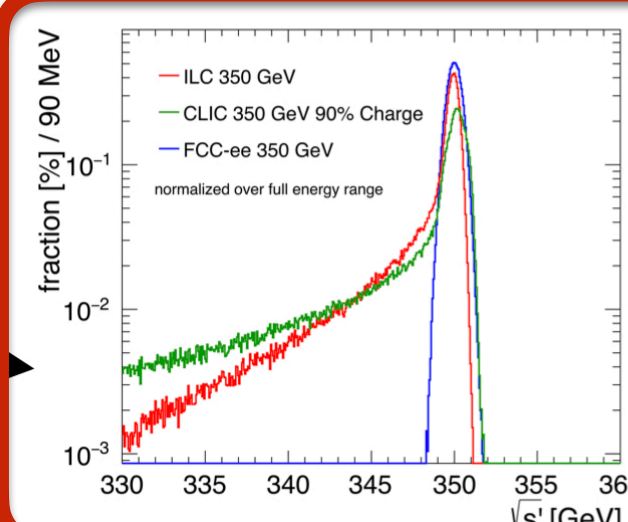
Optimised for mass & width:



Precision on top mass:



FCC-ee



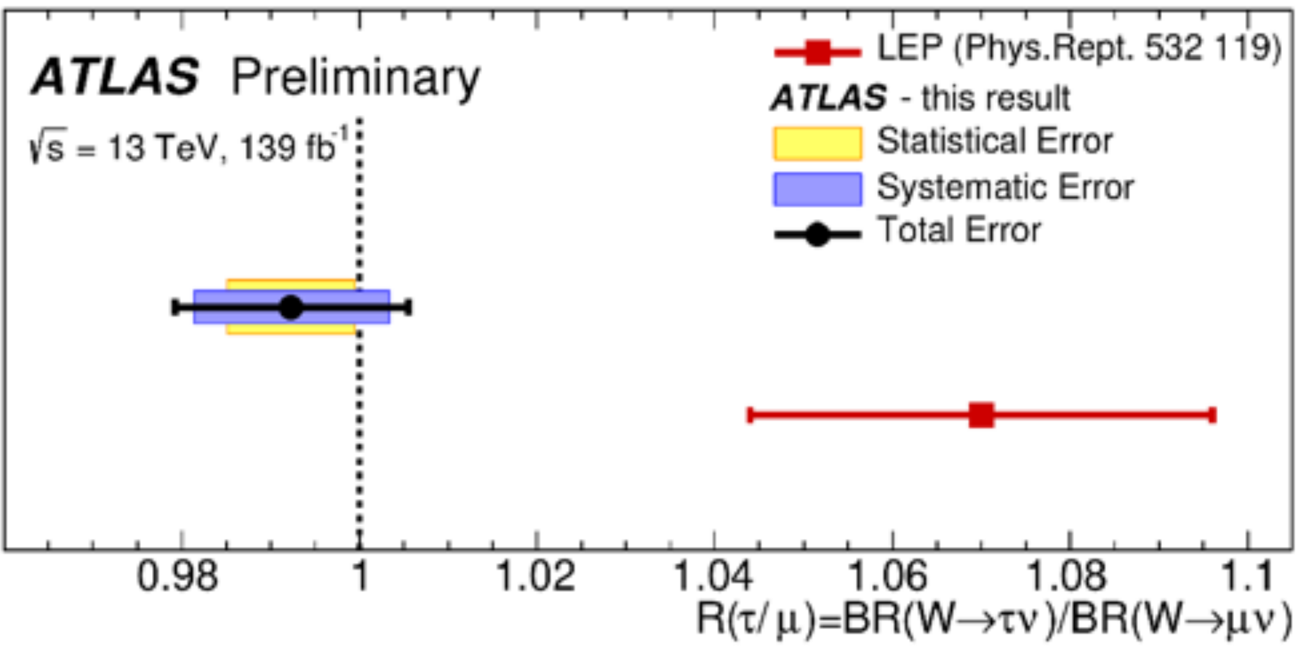
- Optimisation of quantity and centre-of-mass energy for the individual cross section measurements
→ 25% better statistical precision on top mass compared to 10 equidistant measurements

- Main difference between colliders: luminosity spectra

JHEP **07**, 070 (2021)

Precision W physics at FCC-hh: *LHC docet*

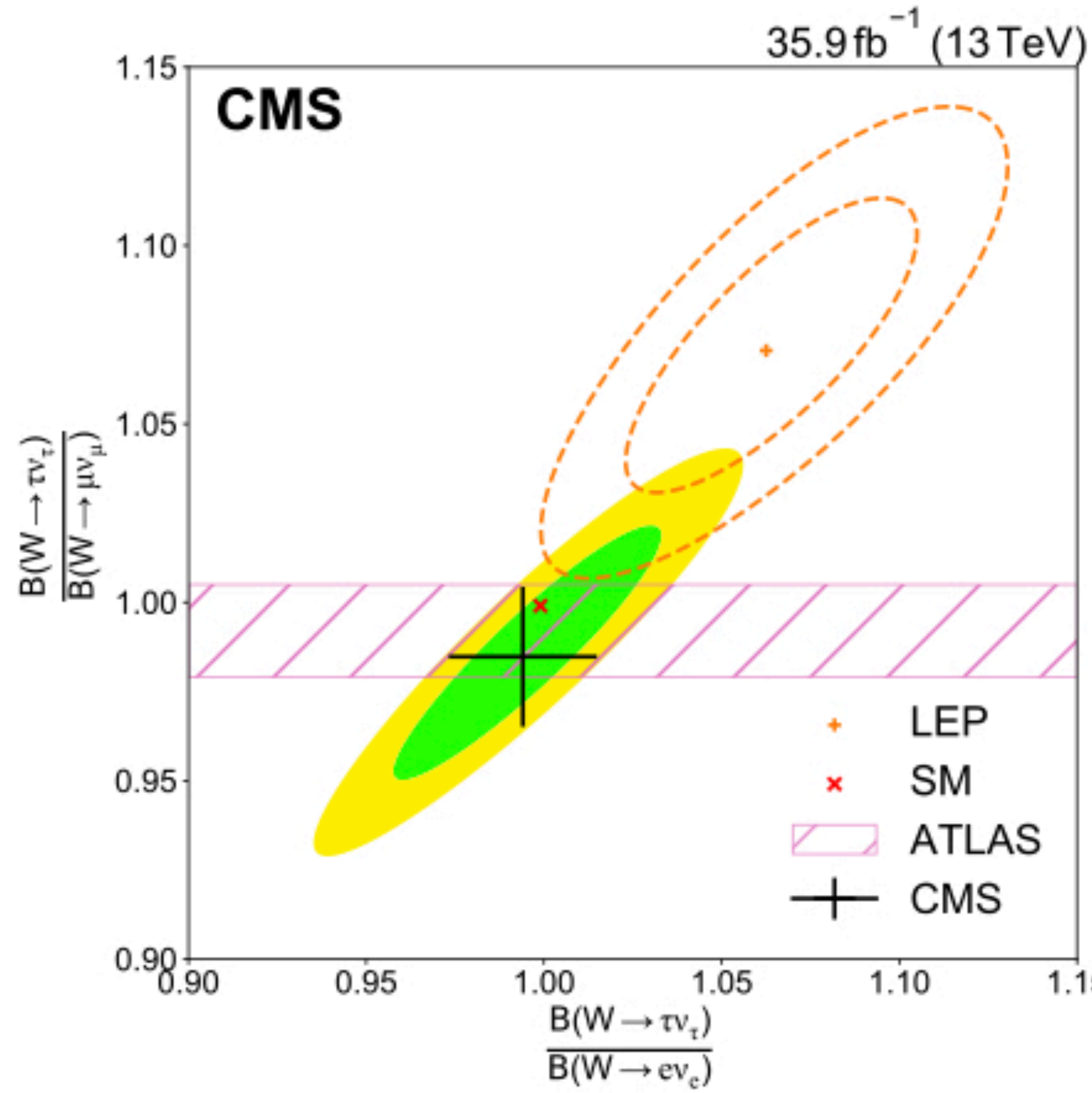
ATLAS 2020: [arXiv:2007.14040]



LEP:
***BR*(W→τν)/*BR*(W→μν) = 1.066 ± 0.025**

ATLAS:
***BR*(W→τν)/*BR*(W→μν) = 0.992 ± 0.013**

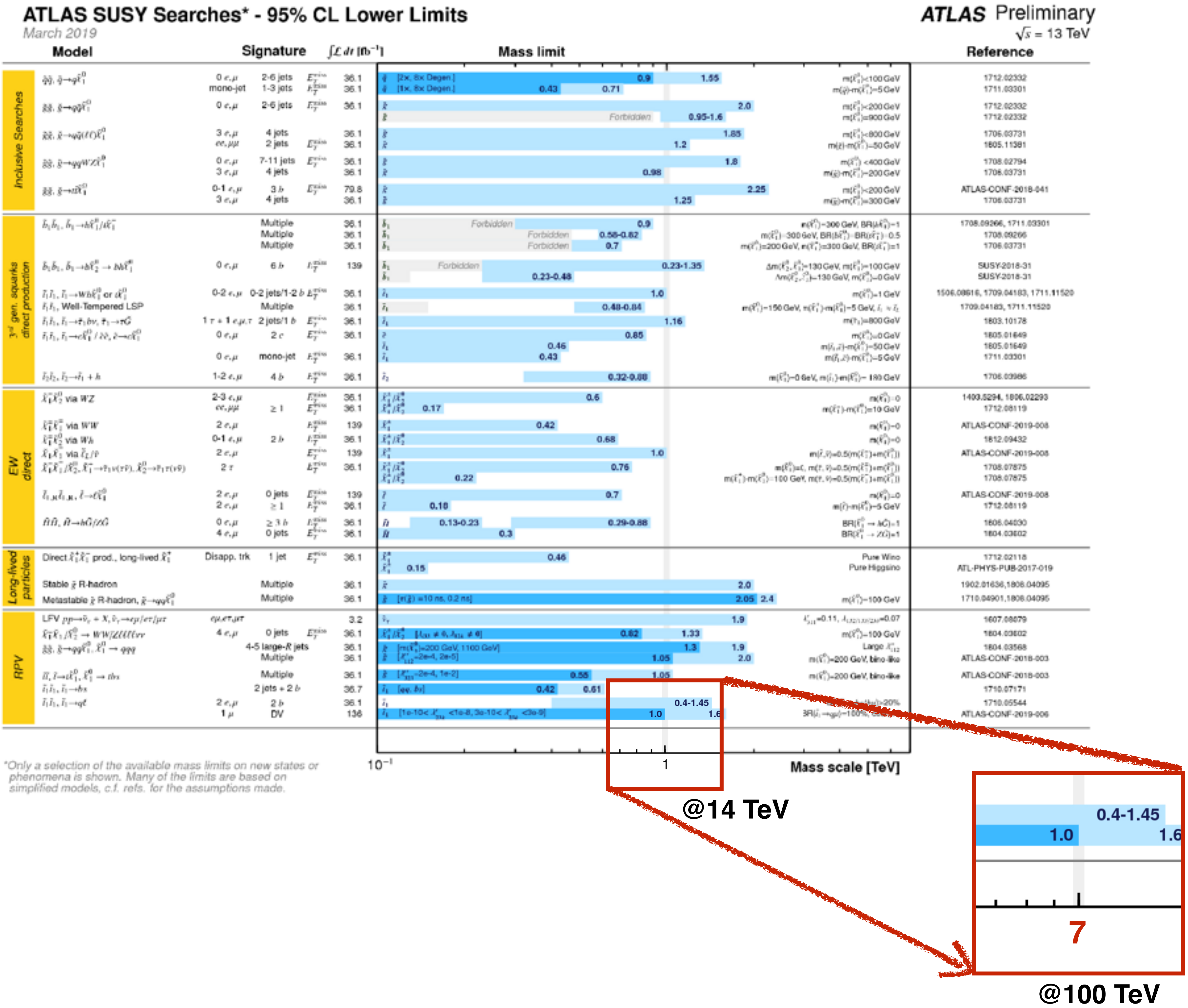
CMS 2022: [arXiv:2201.07861]



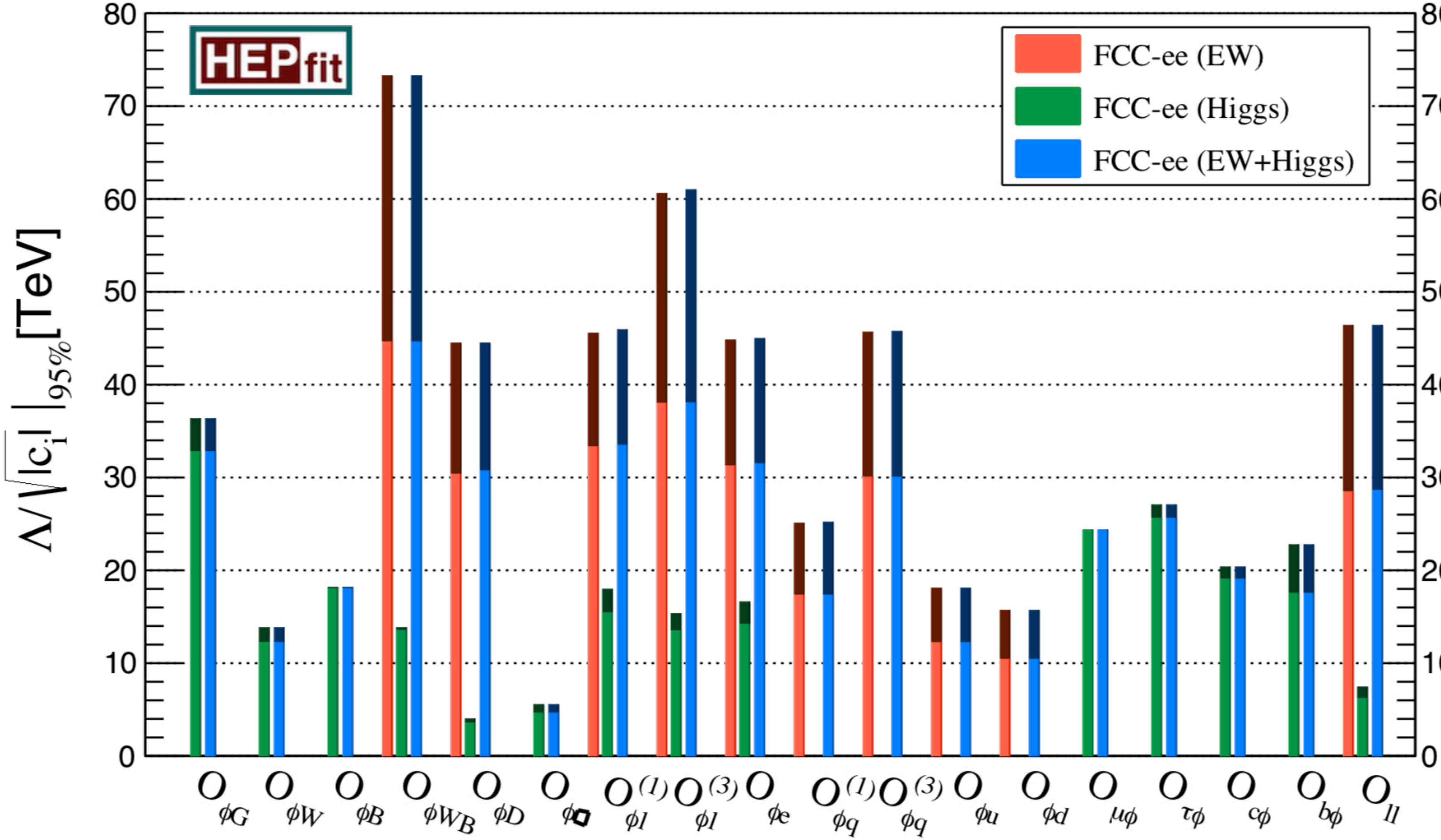
FCC-hh	t	W(←t)	τ(←W←t)
	10^{12}	10^{12}	10^{11}

~ 300 x HL-LHC statistics

(2) Direct discovery reach at high mass: the power of 100 TeV

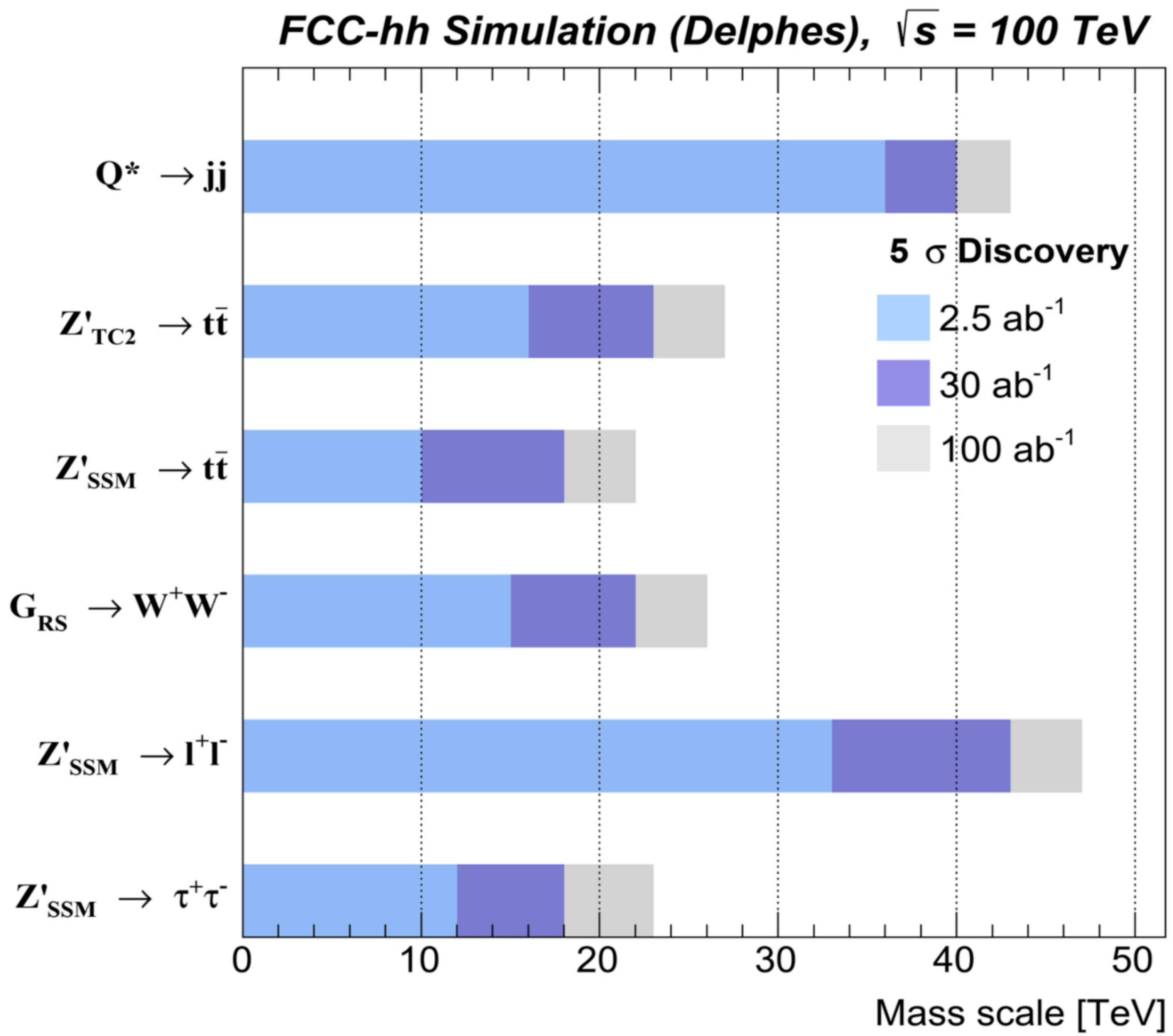

ATLAS SUSY Searches* - 95% CL Lower Limits
March 2019
ATLAS Preliminary
$\sqrt{s}$ = 13 TeV
Model
Signature
$\int \mathcal{L}\, dt$ [fb^{-1}]
Mass limit
Reference
Inclusive Searches
3rd gen. squarks direct production
EW direct
Long-lived particles
RPV
Forbidden
10^{-1}
1
Mass scale [TeV]
*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.
@14 TeV
0.4-1.45
1.0
1.6
7
@100 TeV

Global EFT fits to EW and H observables at FCC-ee



Constraints on the coefficients of various EFT op's from a global fit of (i) EW observables, (ii) Higgs couplings and (iii) EW+Higgs combined. Darker shades of each color indicate the results neglecting all SM theory uncertainties.

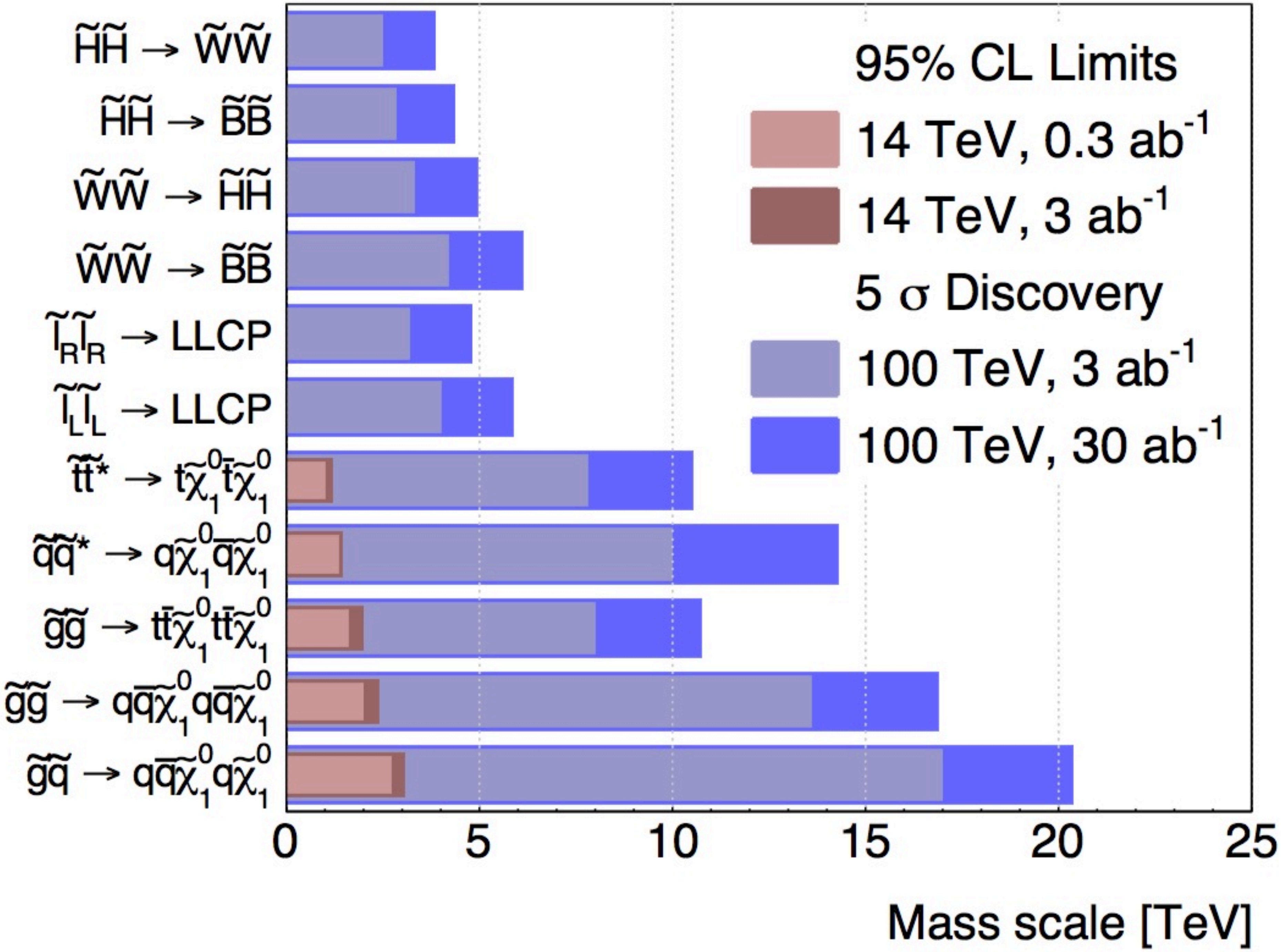
s-channel resonances



100 TeV allow to directly access the mass scales revealed indirectly by precision EW and H measurements at the future e+e– factory

Matching this discovery reach with a lepton collider would require a multi-tens TeV facility (beyond-the-beyond?).

SUSY reach at 100 TeV



15-20 TeV squarks/gluinos would require a lepton collider in the ECM range of 30-50 TeV

(3) **The potential for yes/no answers to important questions**

WIMP DM theoretical constraints

For particles held in equilibrium by pair creation and annihilation processes, (χ χ ↔ SM)

$$\Omega_{\rm DM} h^2 \sim \frac{10^9 {\rm GeV}^{-1}}{M_{\rm pl}} \frac{1}{\langle \sigma v \rangle}$$

For a particle annihilating through processes which do not involve any larger mass scales:

$$\langle \sigma v \rangle \sim g_{\rm eff}^4 / M_{\rm DM}^2$$

$$\Omega_{\rm DM} h^2 \sim 0.12 \times \left(\frac{M_{\rm DM}}{2 \ {\rm TeV}} \right)^2 \left(\frac{0.3}{g_{\rm eff}} \right)^4$$

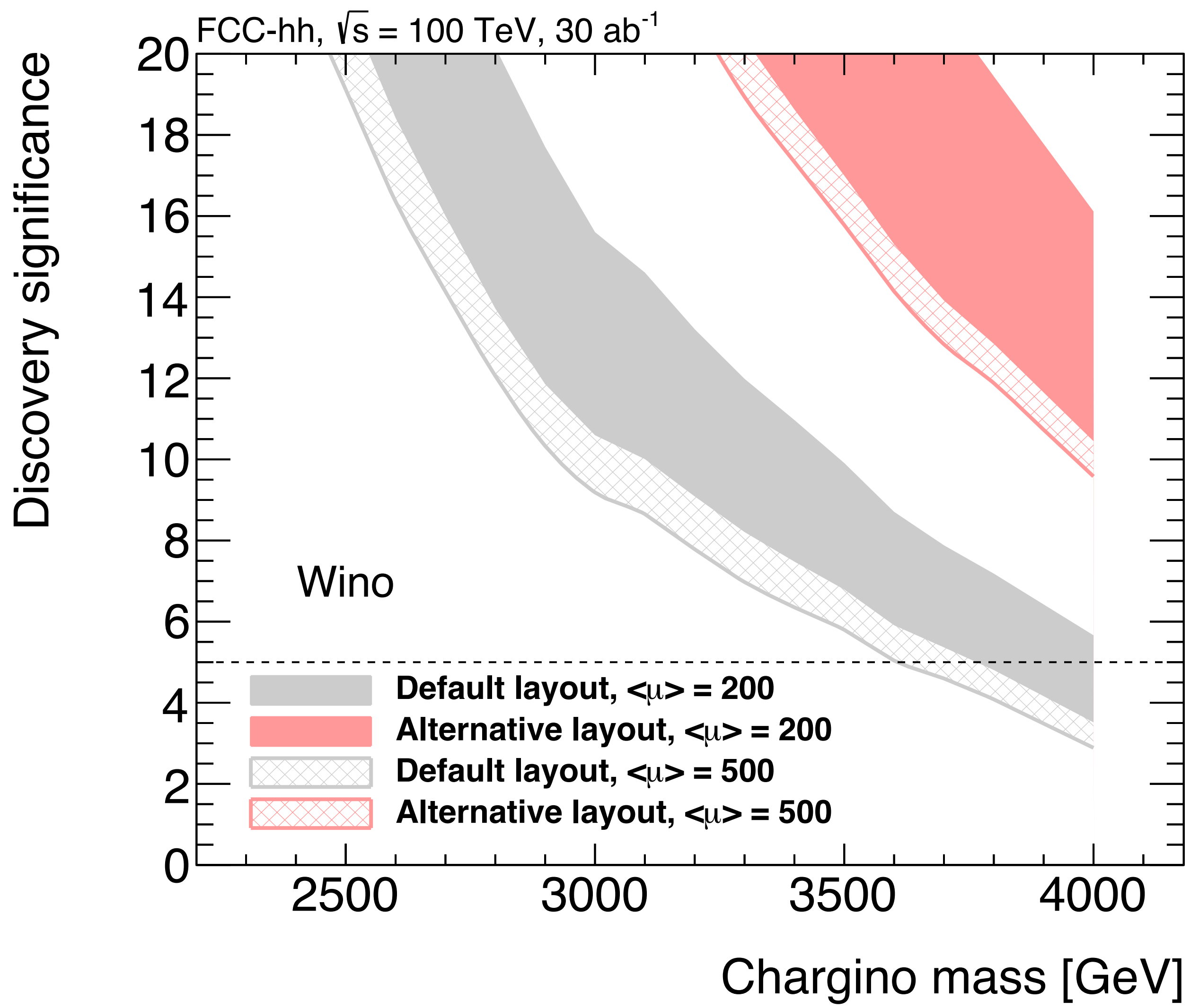
$$\Omega_{wimp}\, h^2 \lesssim 0.12$$

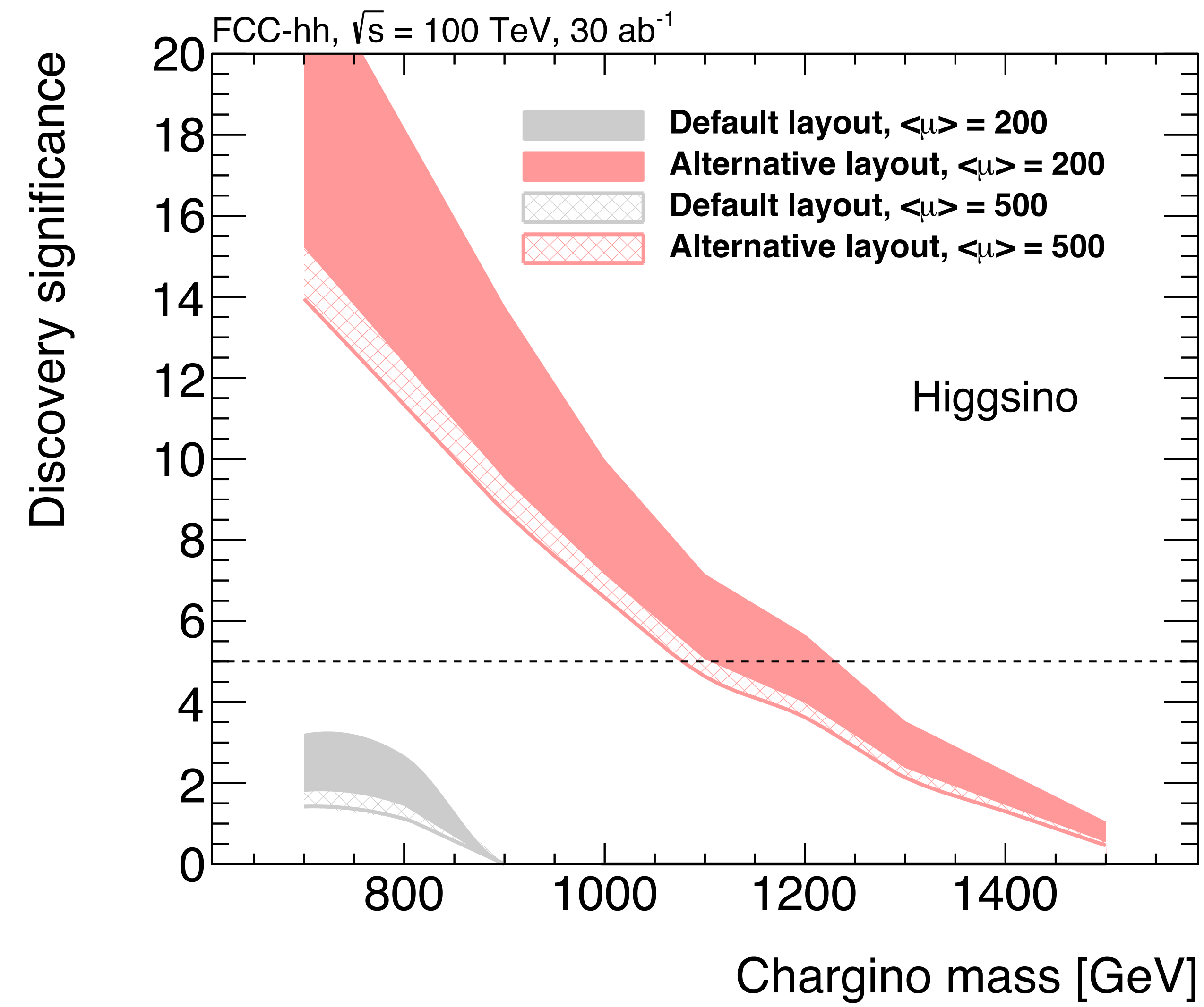
$$M_{wimp} \lesssim 2 \ {\rm TeV} \left(\frac{g}{0.3} \right)^2$$

K. Terashi, R. Sawada, M. Saito, and S. Asai, *Search for WIMPs with disappearing track signatures at the FCC-hh*, (Oct, 2018) . https://cds.cern.ch/record/2642474.

New detector performance studies

Disappearing charged track analyses
(at ~full pileup)

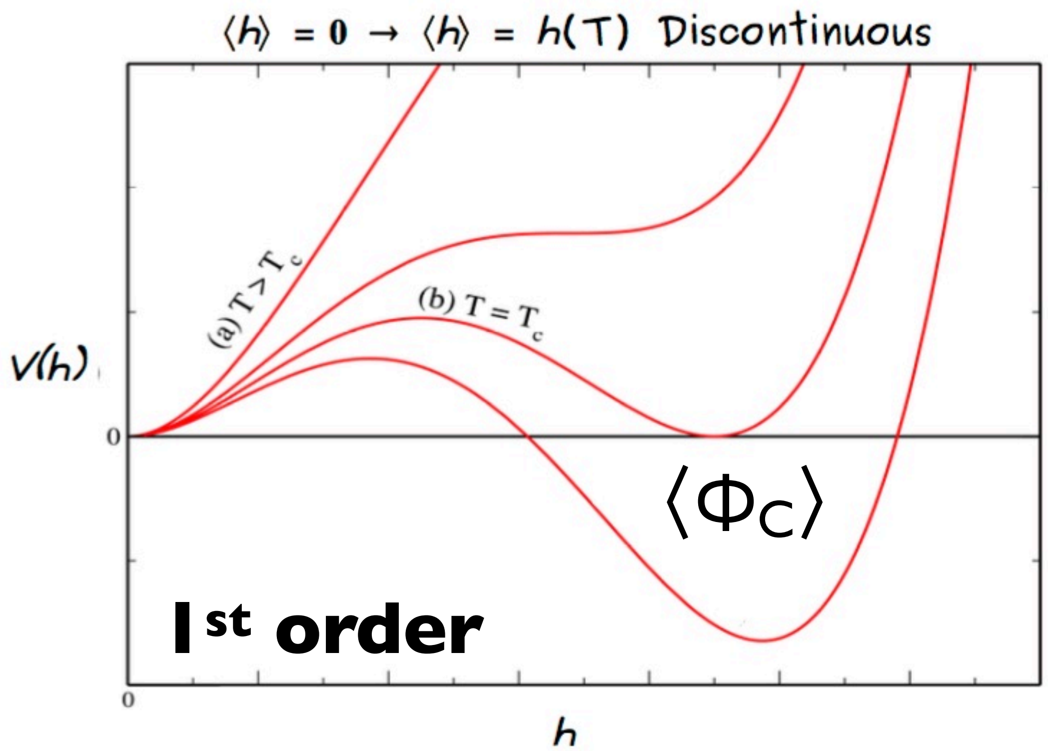


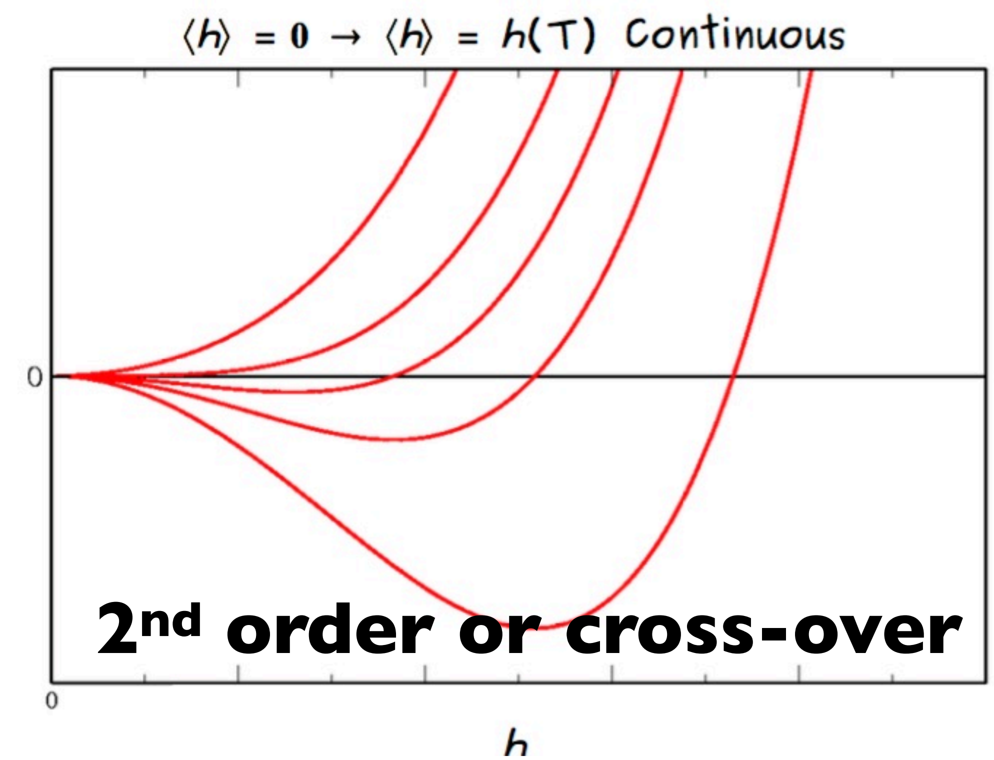


=> coverage beyond the upper limit of the thermal WIMP mass range for both higgsinos and winos !!

$$M_{wimp} \lesssim 2\ \text{TeV} \left(\frac{g}{0.3}\right)^2$$

The nature of the EW phase transition





Strong 1st order phase transition is required to induce and sustain the out of equilibrium generation of a baryon asymmetry during EW symmetry breaking

Strong 1st order phase transition $\Rightarrow \langle \Phi_C \rangle > T_C$

In the SM this requires $m_H \lesssim 80$ GeV, else transition is a smooth crossover.

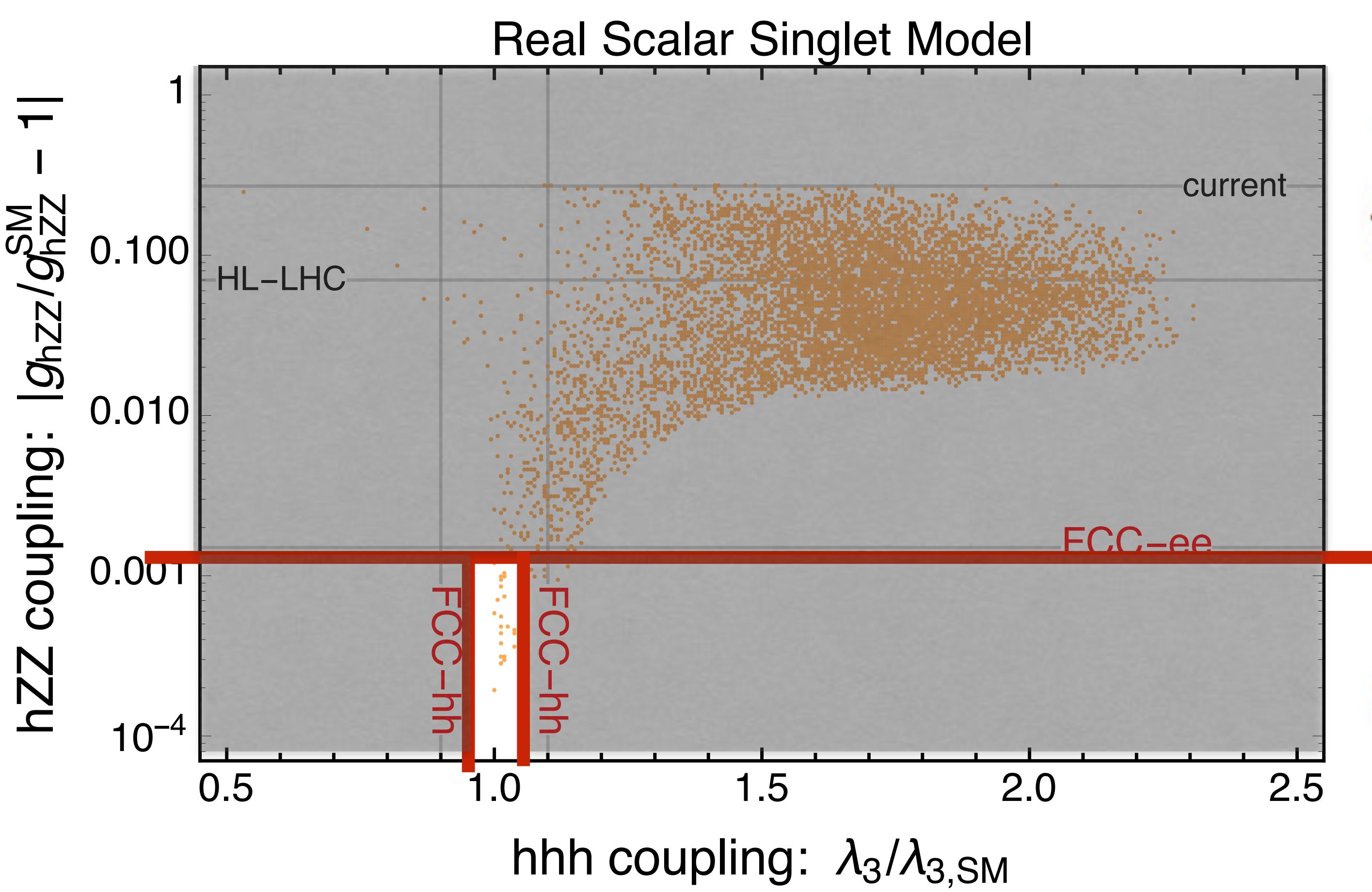
Since $m_H = 125$ GeV, **new physics**, coupling to the Higgs and effective at **scales O(TeV)**, must modify the Higgs potential to make this possible

- **Probe higher-order terms of the Higgs potential (selfcouplings)**
- **Probe the existence of other particles coupled to the Higgs**

Constraints on models with 1st order phase transition at the FCC

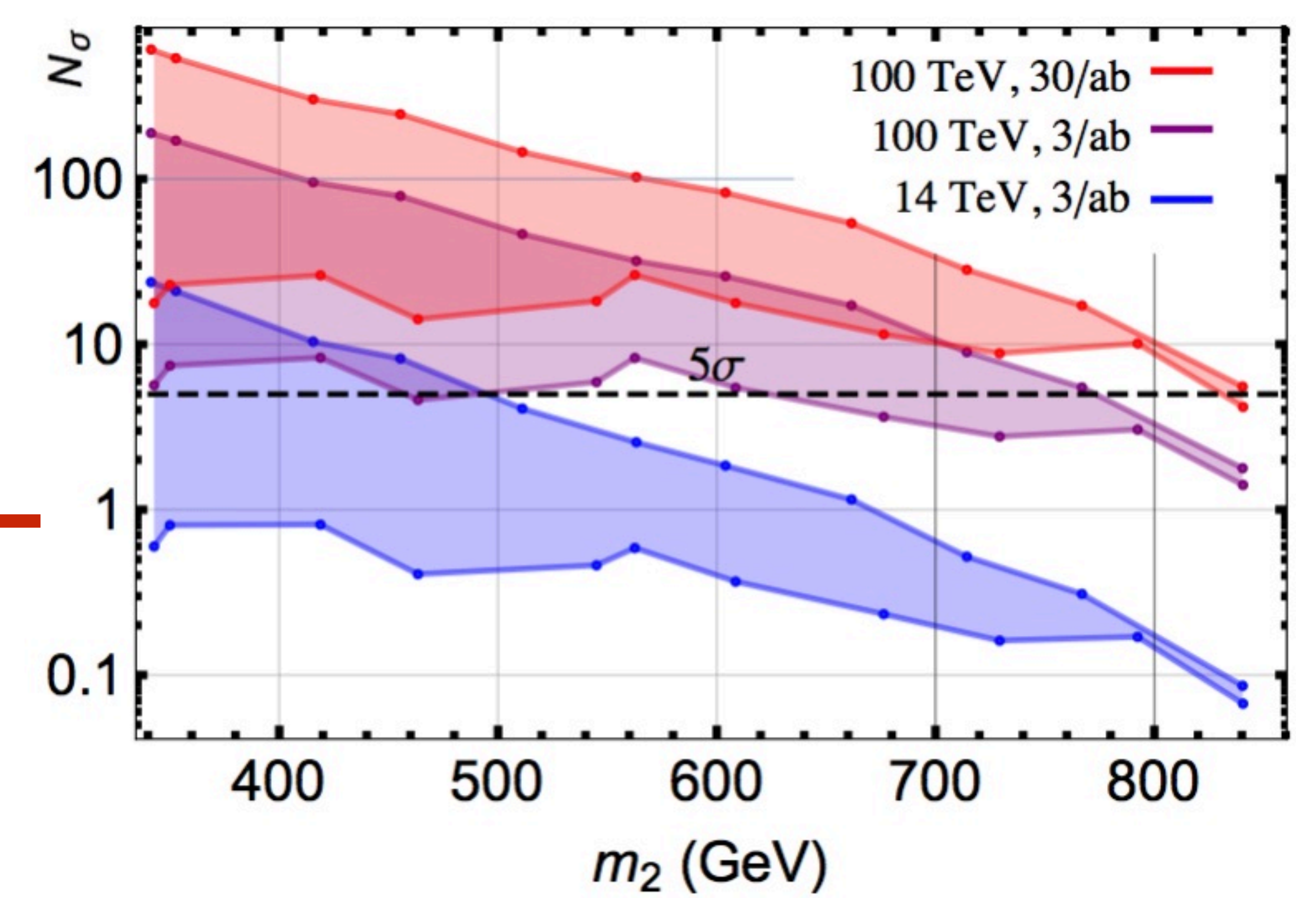
$$V(H,S) = -\mu^2\left(H^\dagger H\right) + \lambda\left(H^\dagger H\right)^2 + \frac{a_1}{2}\left(H^\dagger H\right)S + \frac{a_2}{2}\left(H^\dagger H\right)S^2 + \frac{b_2}{2}S^2 + \frac{b_3}{3}S^3 + \frac{b_4}{4}S^4.$$

Combined constraints from precision Higgs measurements at FCC-ee and FCC-hh



Parameter space scan for a singlet model extension of the Standard Model. The points indicate a first order phase transition.

Direct detection of extra Higgs states at FCC-hh

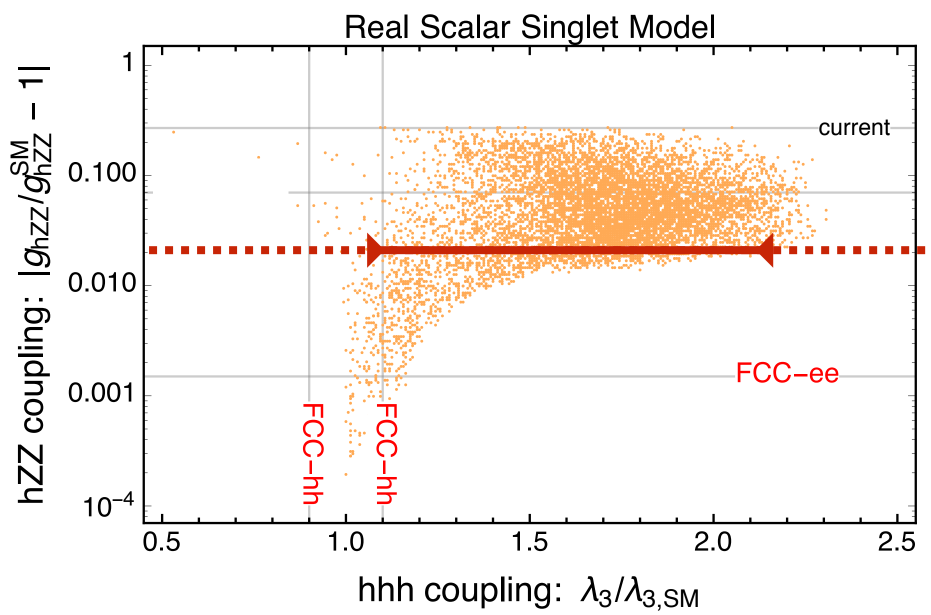


$h_2 \to h_1 h_1$ ($b\bar{b}\gamma\gamma$ + 4τ)

($h_2 \sim S$, $h_1 \sim H$)

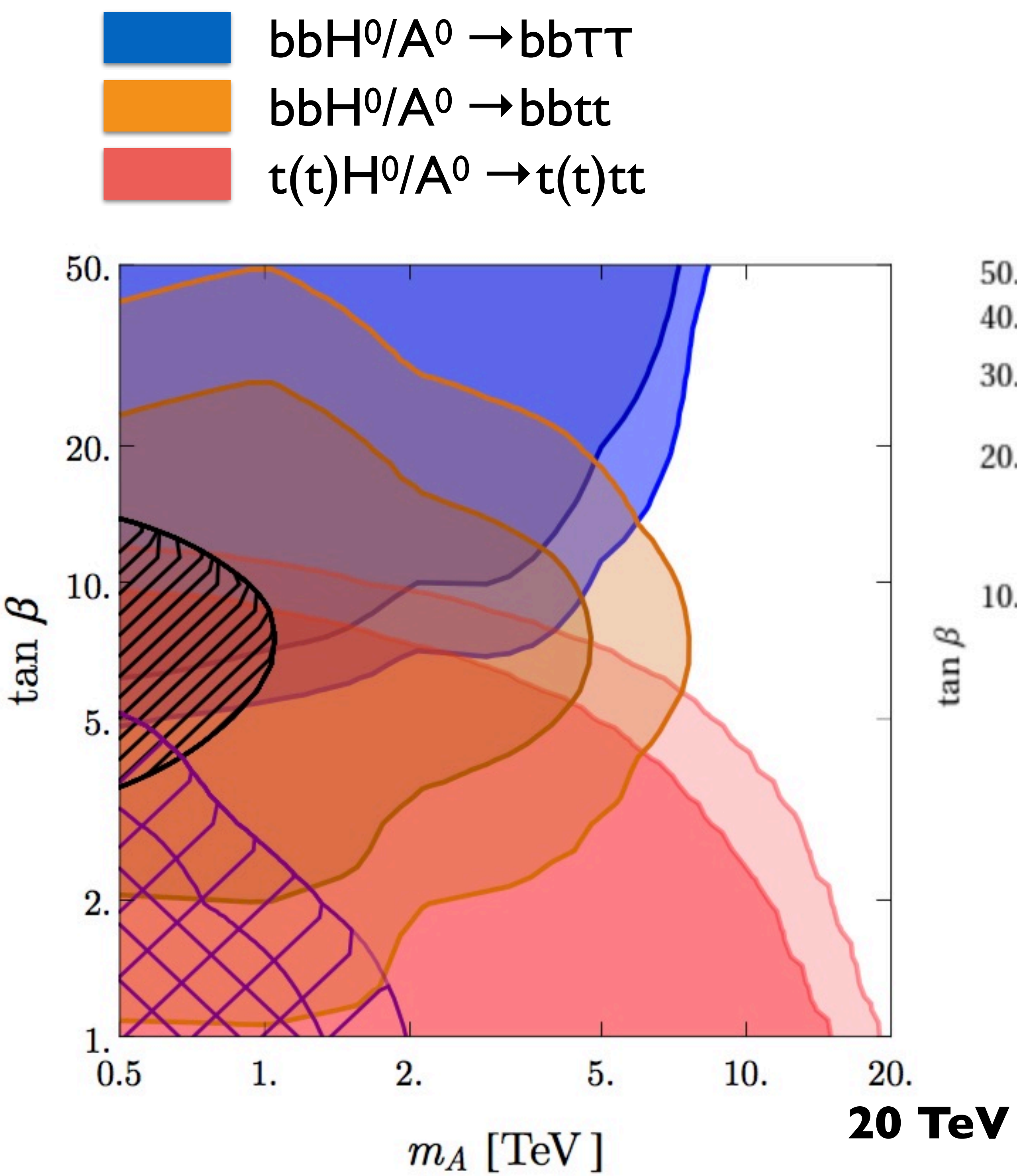
Remarks

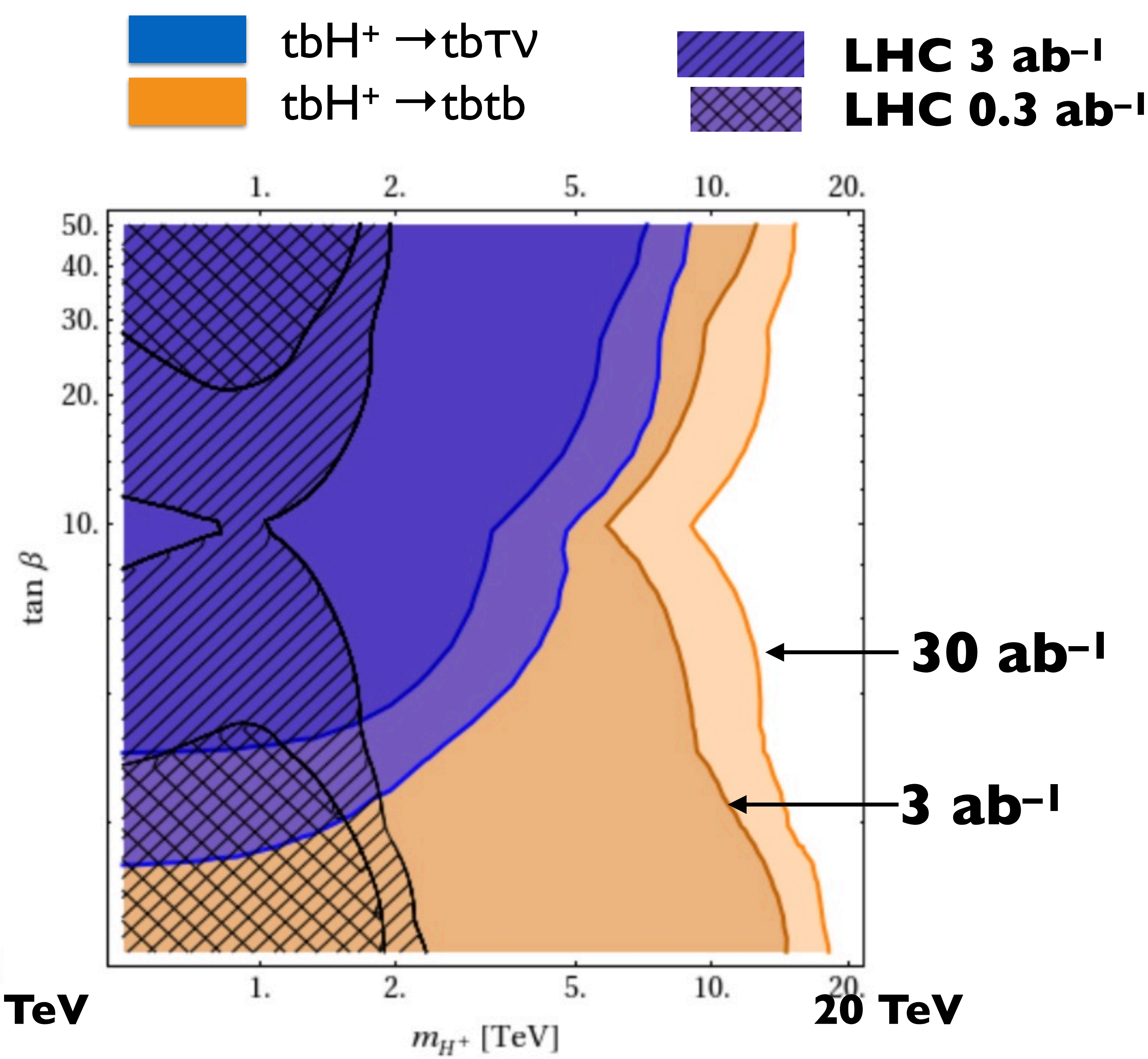
- Apparently, adding the self-coupling constraint does not add much in terms of exclusion power, wrt the HZZ coupling measurement …
- … BUT, should HZZ deviate from the SM, λ_{HHH} is necessary to break the degeneracy among all parameter sets leading to the same HZZ prediction



- The concept of *"which experiment sets a better constraint on a given parameter"* is a very limited comparison criterion, which looses value as we move from *"setting limits"* to *"diagnosing observed discrepancies"*
- Likewise, it's often said that some observable sets better limits than others: "all known model predict deviations in X larger than deviations in Y, so we better focus on X". But once X is observed to deviate, knowing the value of Y could be absolutely crucial ….
- Redundancy and complementarity of observables is of paramount importance

MSSM Higgs @ 100 TeV





N. Craig, J. Hajer, Y.-Y. Li, T. Liu, H. Zhang, arXiv:1605.08744

J. Hajer, Y.-Y. Li, T. Liu, and J. F. H. Shiu, arXiv:1504.07617

… and much more …

- Countless studies of discovery potential for multiple BSM scenarios, from SUSY to heavy neutrinos, from very low masses to very high masses, LLPs, DM, etcetcetc, with plenty of opportunities for direct discovery even at FCC-ee and FCC-eh
- Sensitivity studies to SM deviations in the properties of top quarks, flavour physics in Z decays: huge event rates offer unique opportunities, that cannot be matched elsewhere
- …
- Operations with heavy ions: new domains open up at 100 TeV in the study of high-T/high-density QCD. Broaden the targets, the deliverables, extend the base of potential users, and increase the support beyond the energy frontier community

Final remarks

- The study of the SM will not be complete until we clarify the nature of the Higgs mechanism and exhaust the exploration of phenomena at the TeV scale: many aspects are still obscure, many questions are still open.
- The exptl program possible at a future circular collider facility, combining a versatile high-luminosity e^+e^- circular collider, with a follow-up pp collider in the 100 TeV range, offers unmatchable breadth and diversity: concrete, compelling and indispensable Higgs & SM measurements enrich a unique direct & indirect discovery potential
- The next 5-6 years, before the next review of the European Strategy for Particle Physics, will be critical to reach the scientific consensus and political support required to move forward