European Strategy for Particle Physics

PLENARY / **BSM**

Status and open questions in physics beyond the standard model

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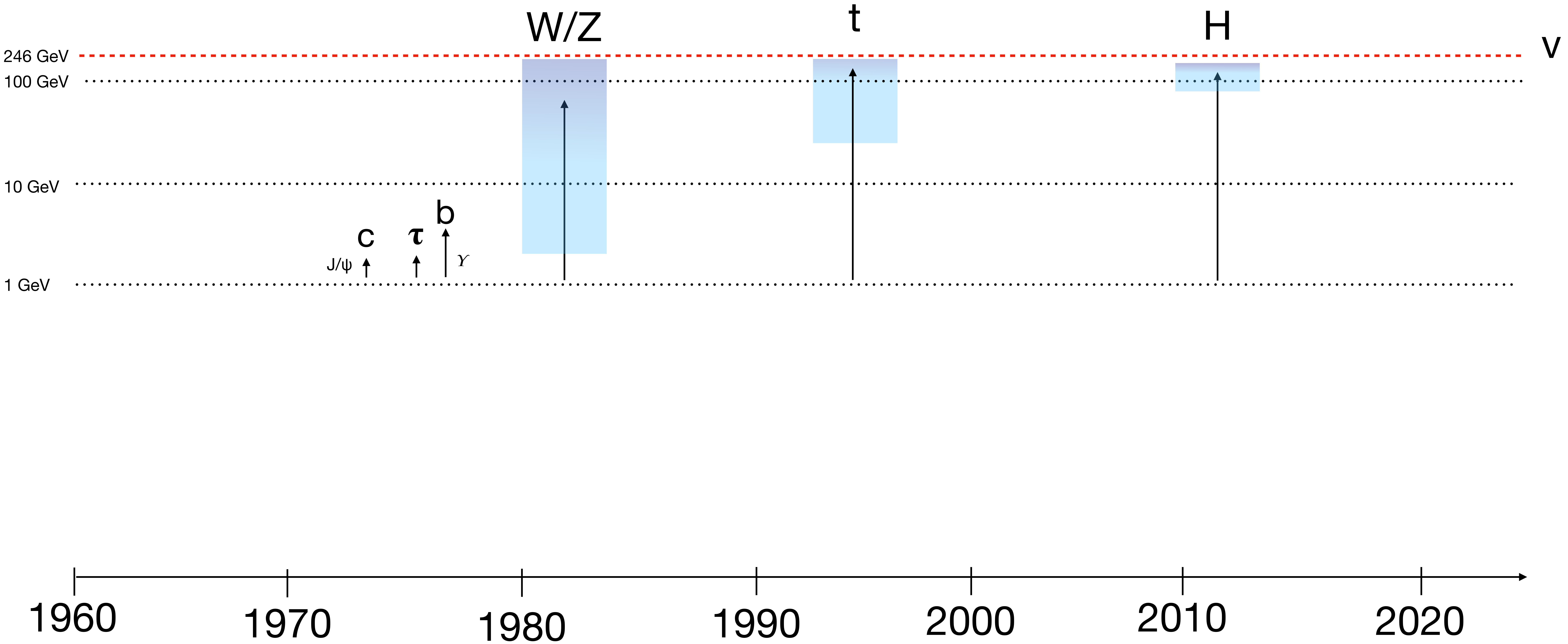
Introduction

Experimental point of view

The story of collider physics in the last 60 years is marked by the accelerators eras and punctuated by key discoveries



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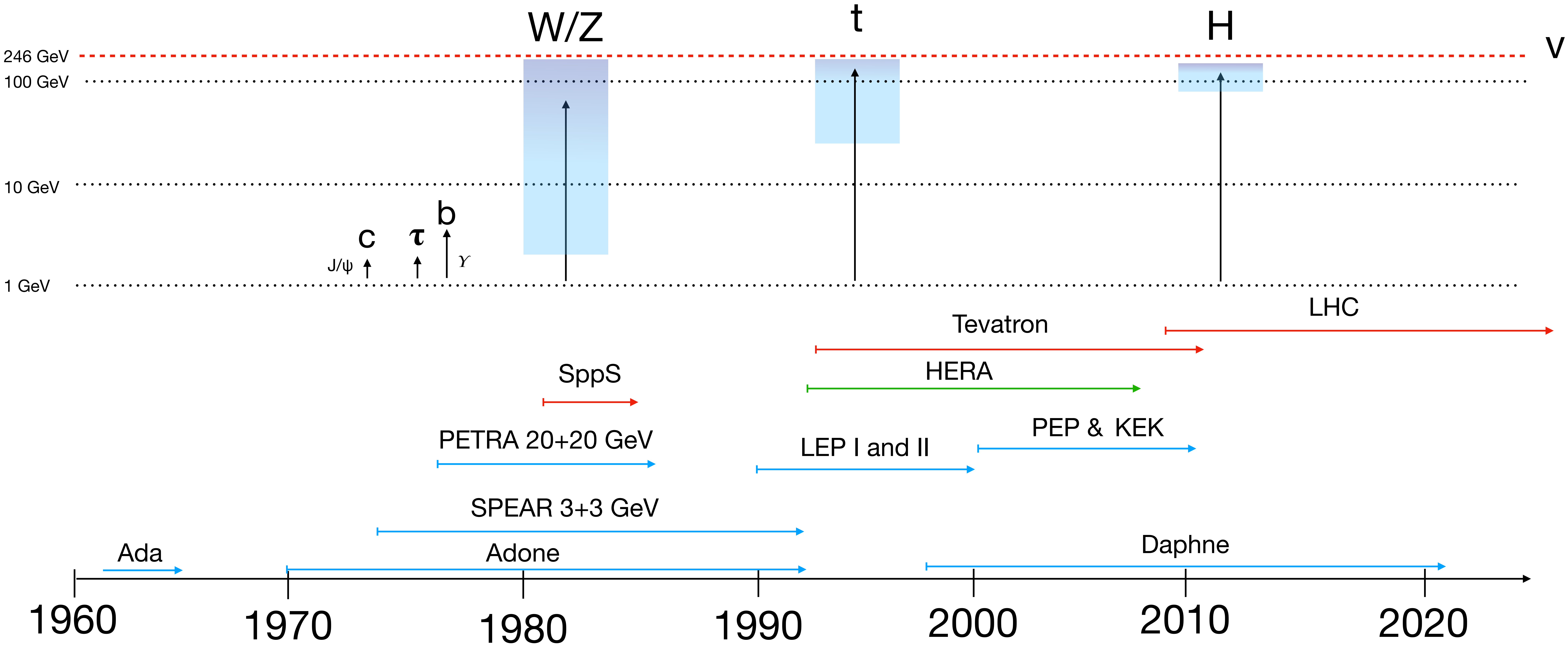
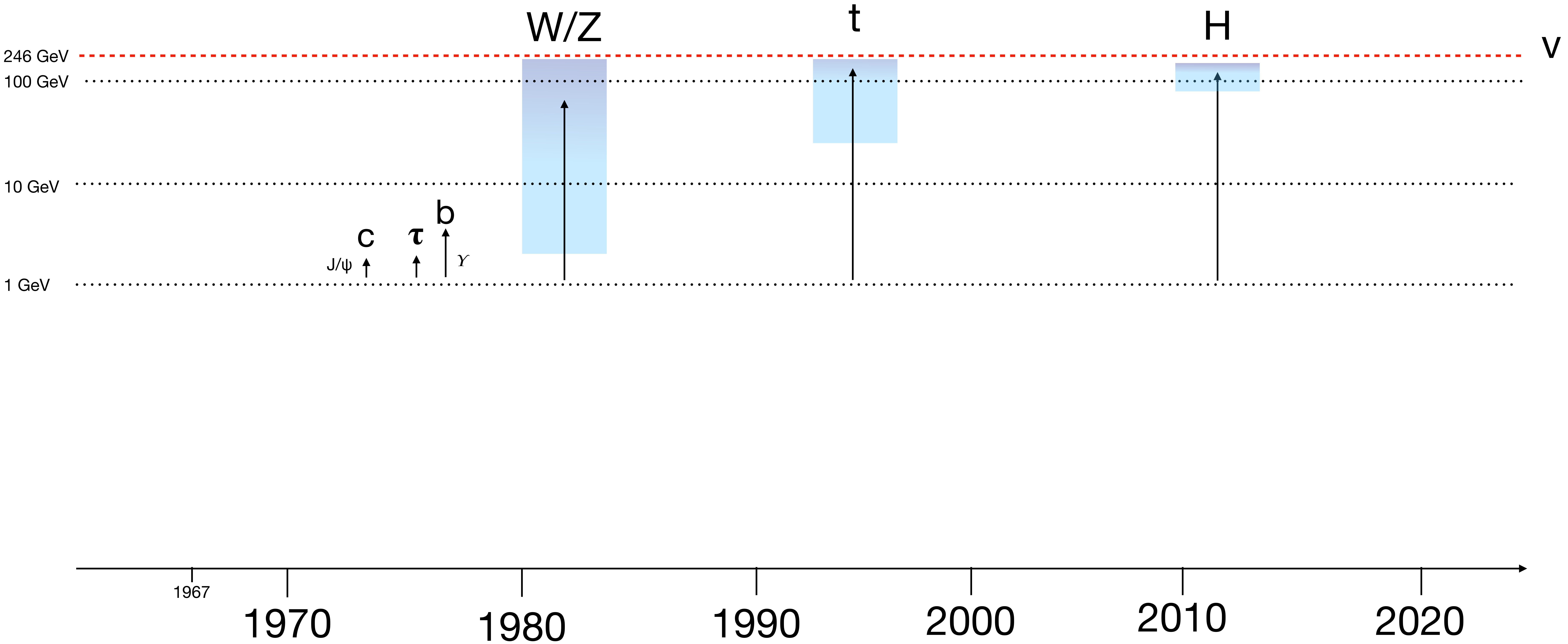


Theorist's point of view

The story of collider physics in the last 60 years is the slow yet steady turning of the Standard Model into a Standard Theory for Strong and EW interactions.



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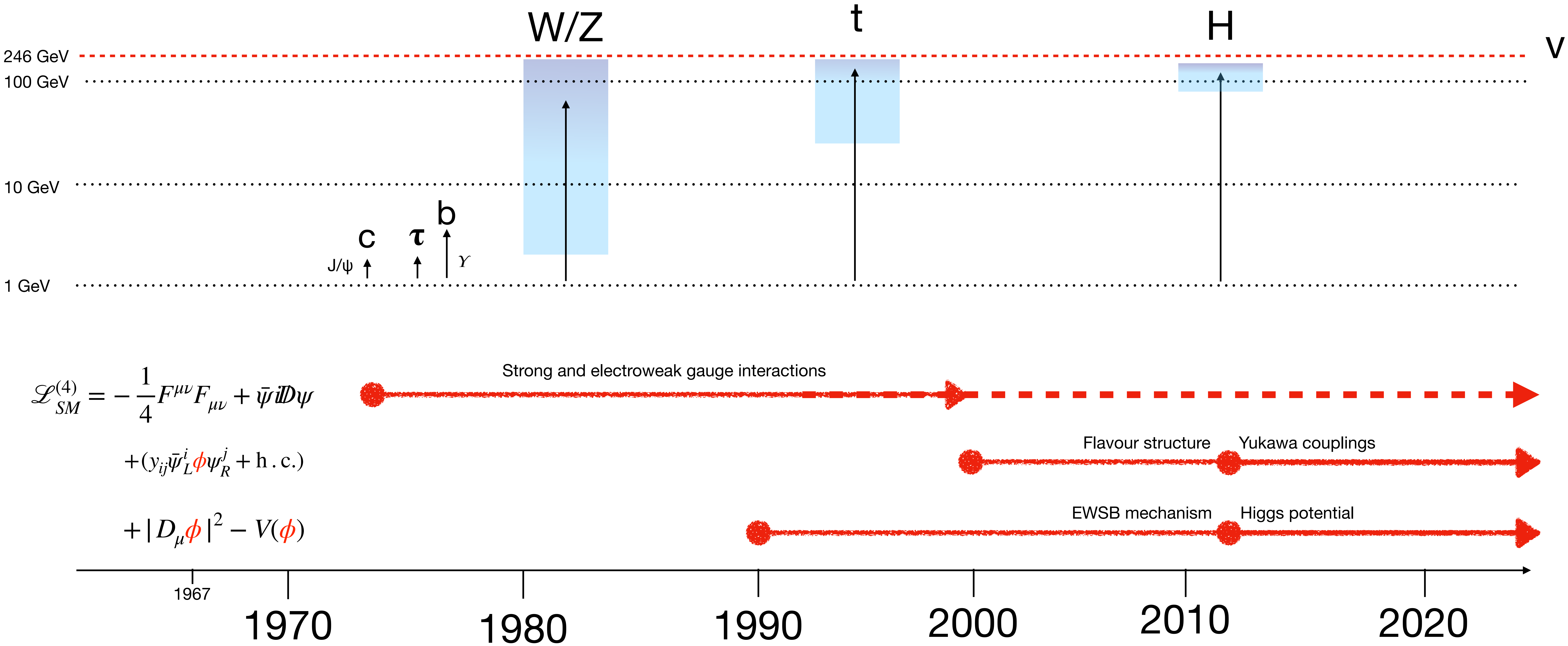
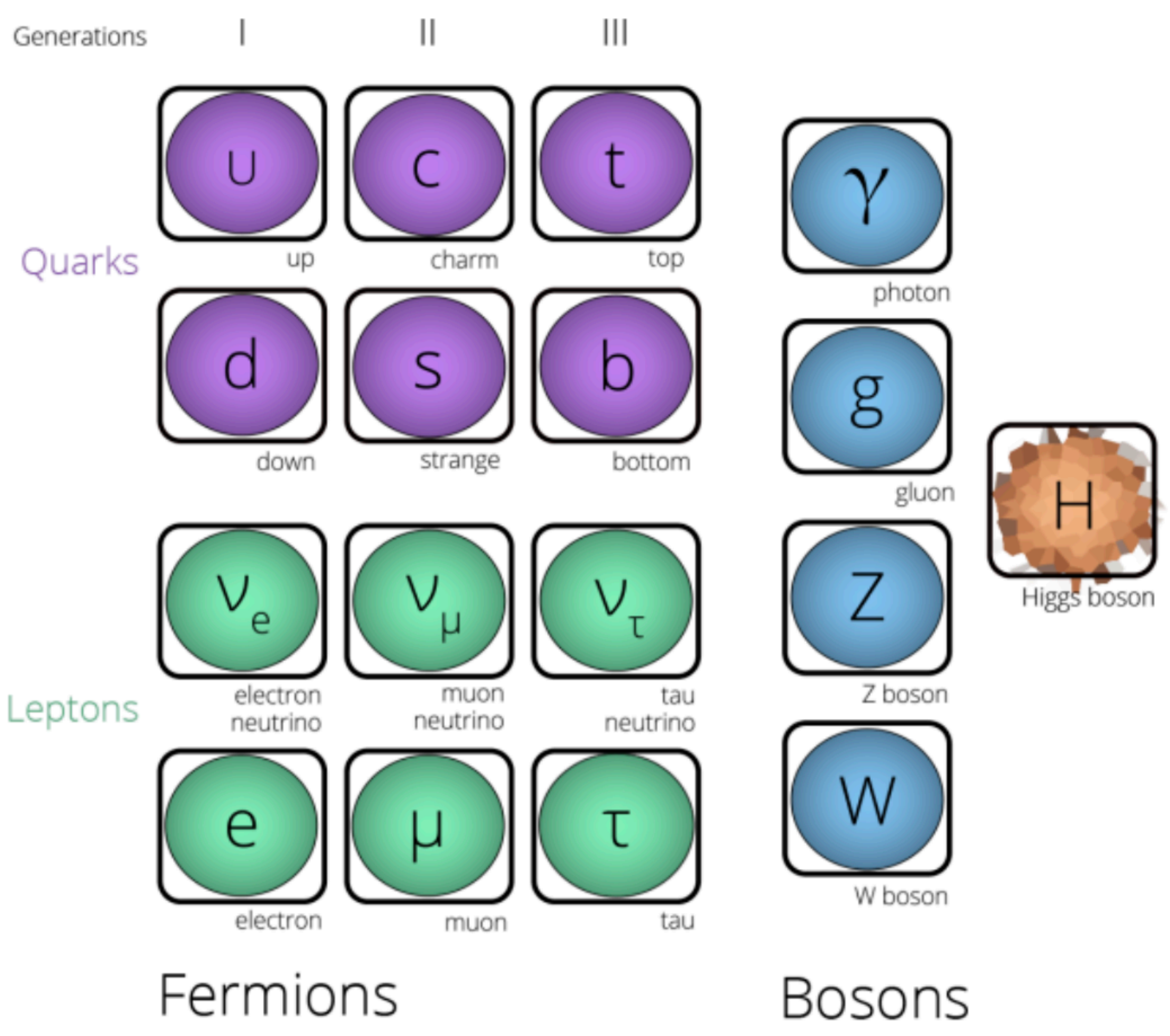


Where do we stand?

$$\mathscr{L}^{(4)}_{SM} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} + \bar{\psi} i \not{D} \psi + (y_{ij}\bar{\psi}^i_L \phi \psi^j_R + \mathrm{h.c.}) + |D_\mu \phi|^2 - V(\phi)$$

3 gauge forces

1 scalar force



Renormalizable field theory:

- $SU(3)_c$ x $SU(2)_L$ x $U(1)_Y$ gauge symmetries
- Matter is organised in chiral multiplets
- The SU(2) x U(1) symmetry is spontaneously broken to $U(1)_{EM}$
- Yukawa interactions ⇒ fermion masses, mixing and CP violation
- Matter+gauge group ⇒ Anomaly free
- Neutrino masses can be accommodated in a natural way

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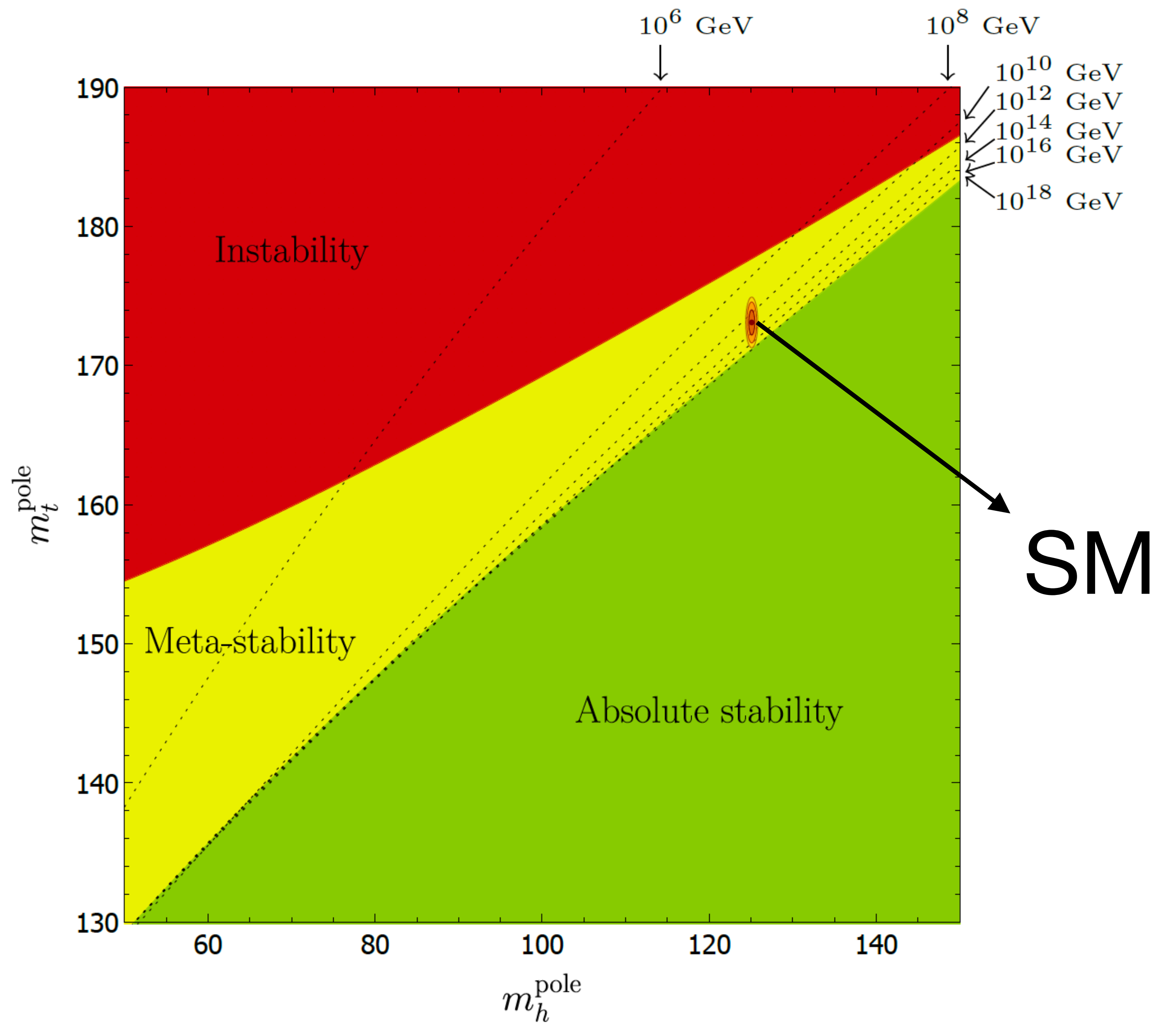
MF, CPV, Flavour — Custodial, MV — EWSB/EWBG



[Andreassen et al. 1707.08124]

Apparently accidental, but key aspects for successful phenomenology:

- Lepton and Baryon number conservation
- Custodial symmetry
- Absence of FCN interactions
- Small and hierarchical mixing among quarks
- Collective suppression of CP violation
- IR values of the parameters do not indicate any problem at high scales, including vacuum stability

These are not only difficult to explain in one go, but are also typically not respected by extensions of the SM.

Where do we stand?

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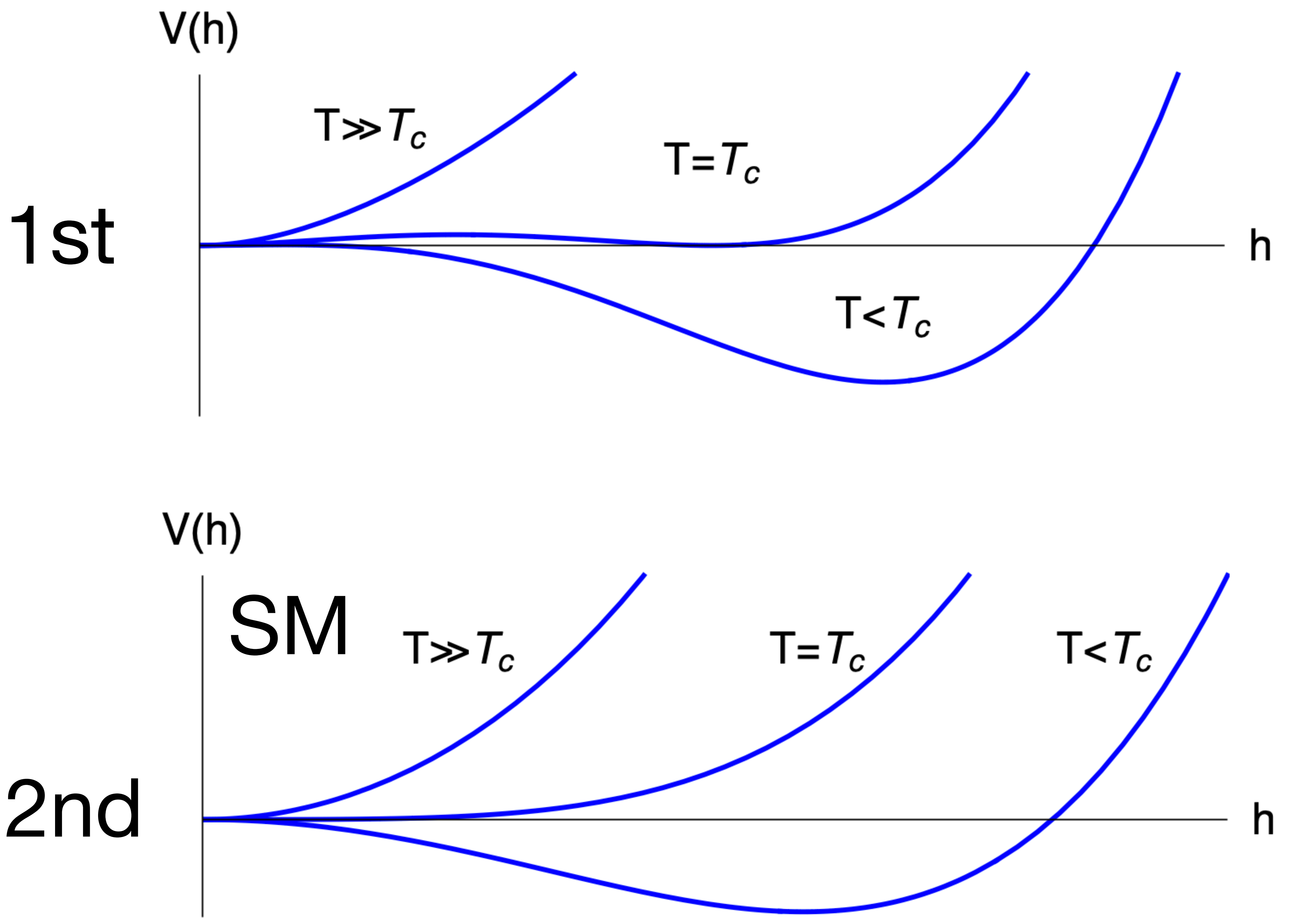
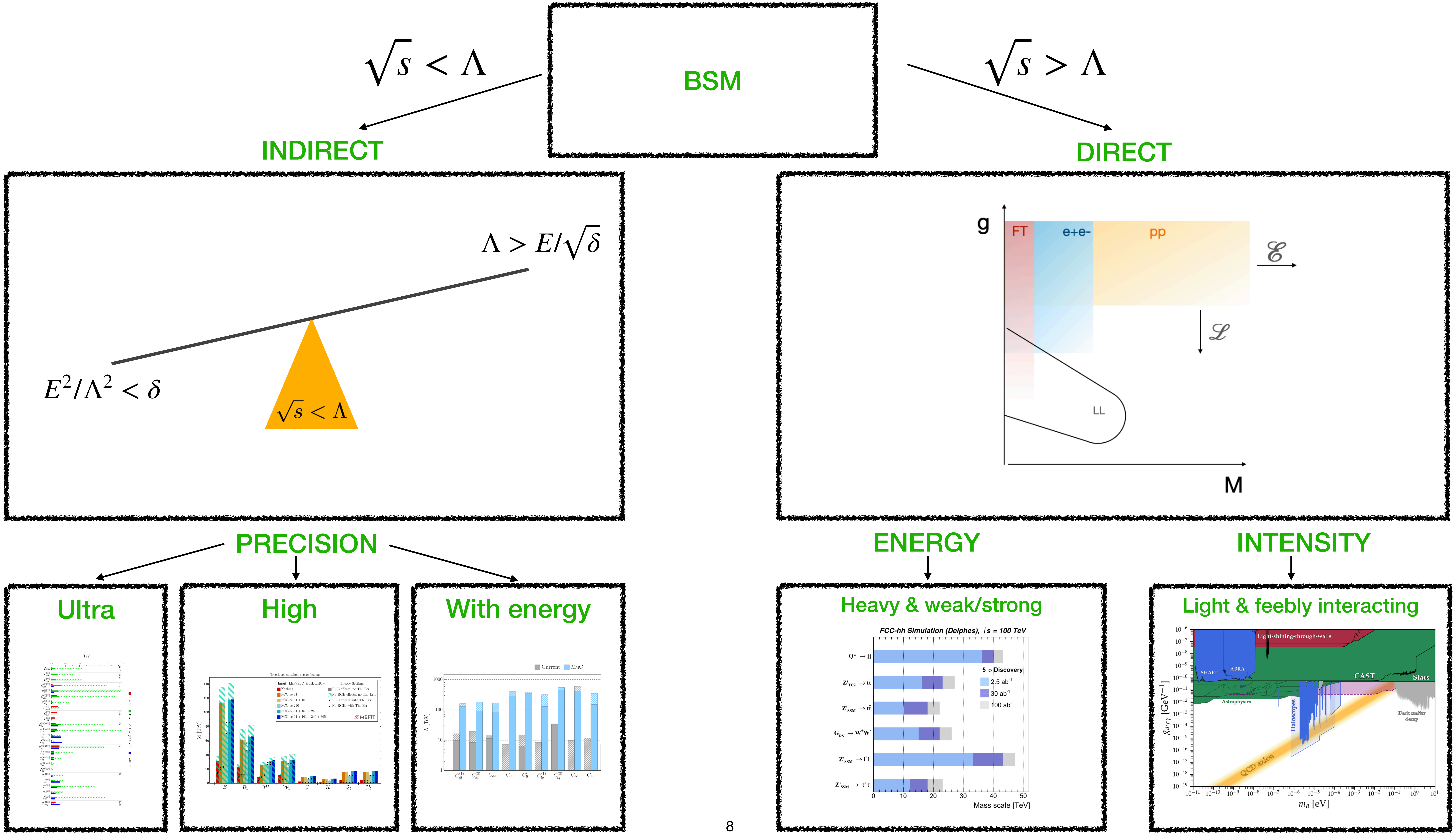


Yet many aspects of the SM are problematic vis-à-vis phenomenology:

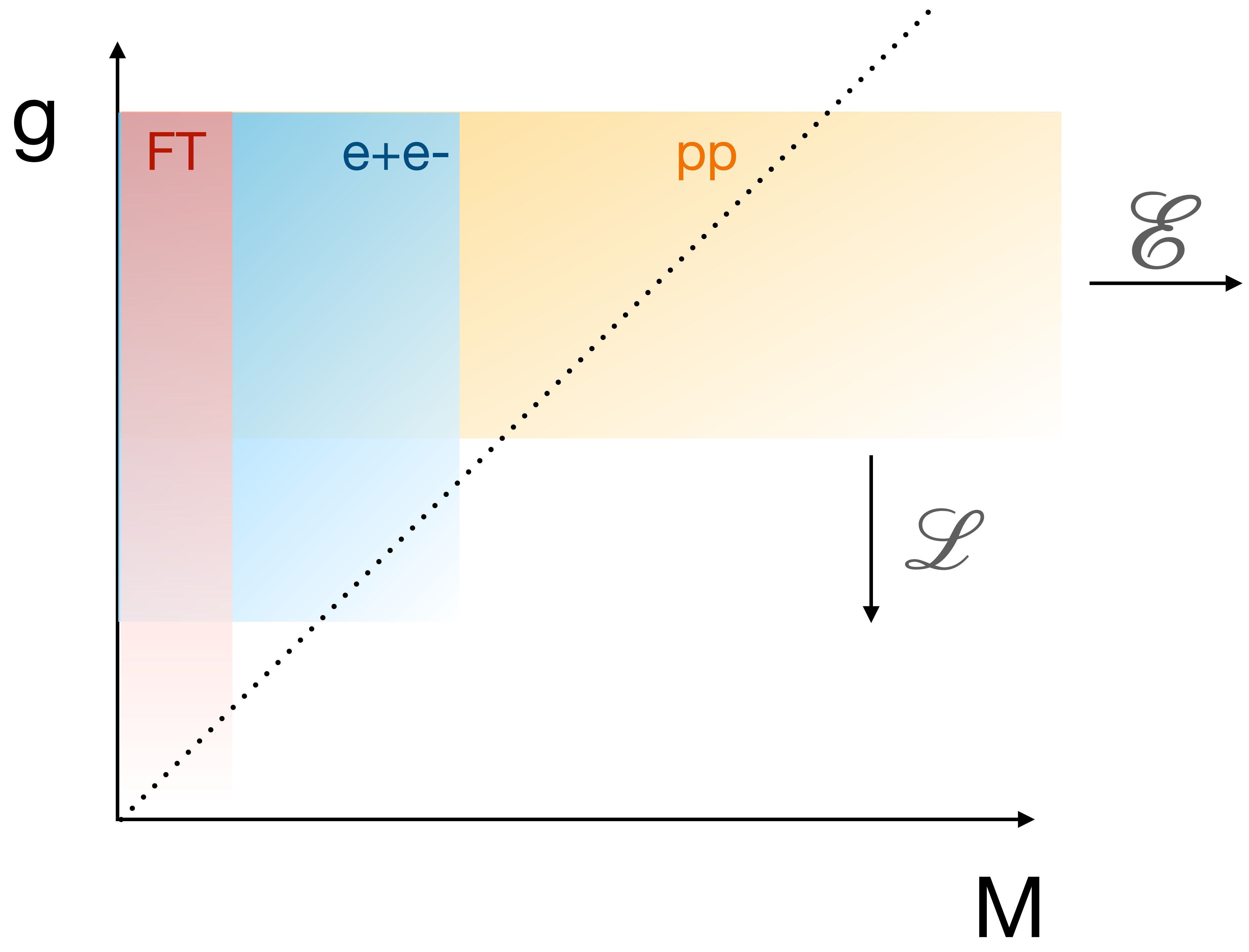
- EWBG difficult because of smallness of CPV and no strong first order transition (SFOPT)
- Nature of Dark Matter
- Unnaturally small Higgs mass and its origin
- Unnaturally small strong CP violation
- Fermion mass hierarchy and origin of CP violation

Beyond SM theories typically address one (or two) of the above problems at the time. We don't have a precise idea of where the scale of NP might reside.


BSM
$\sqrt{s} < \Lambda$
$\sqrt{s} > \Lambda$
INDIRECT
DIRECT
$\Lambda > E/\sqrt{\delta}$
$E^2/\Lambda^2 < \delta$
$\sqrt{s} < \Lambda$
g
FT
e+e-
pp
$\mathscr{E}$
$\mathscr{L}$
LL
M
PRECISION
ENERGY
INTENSITY
Ultra
High
With energy
Heavy & weak/strong
Light & feebly interacting
FCC-hh Simulation (Delphes), $\sqrt{s}$ = 100 TeV
5 σ Discovery
Mass scale [TeV]
Current
MuC
Light-shining-through-walls
CAST
Stars
Astrophysics
Haloscopes
QCD axion
Dark matter decay

Λ is low

BSM direct searches at energy frontier



$$\mathscr{L}_{BSM} \supset \mathscr{L}_{SM}$$

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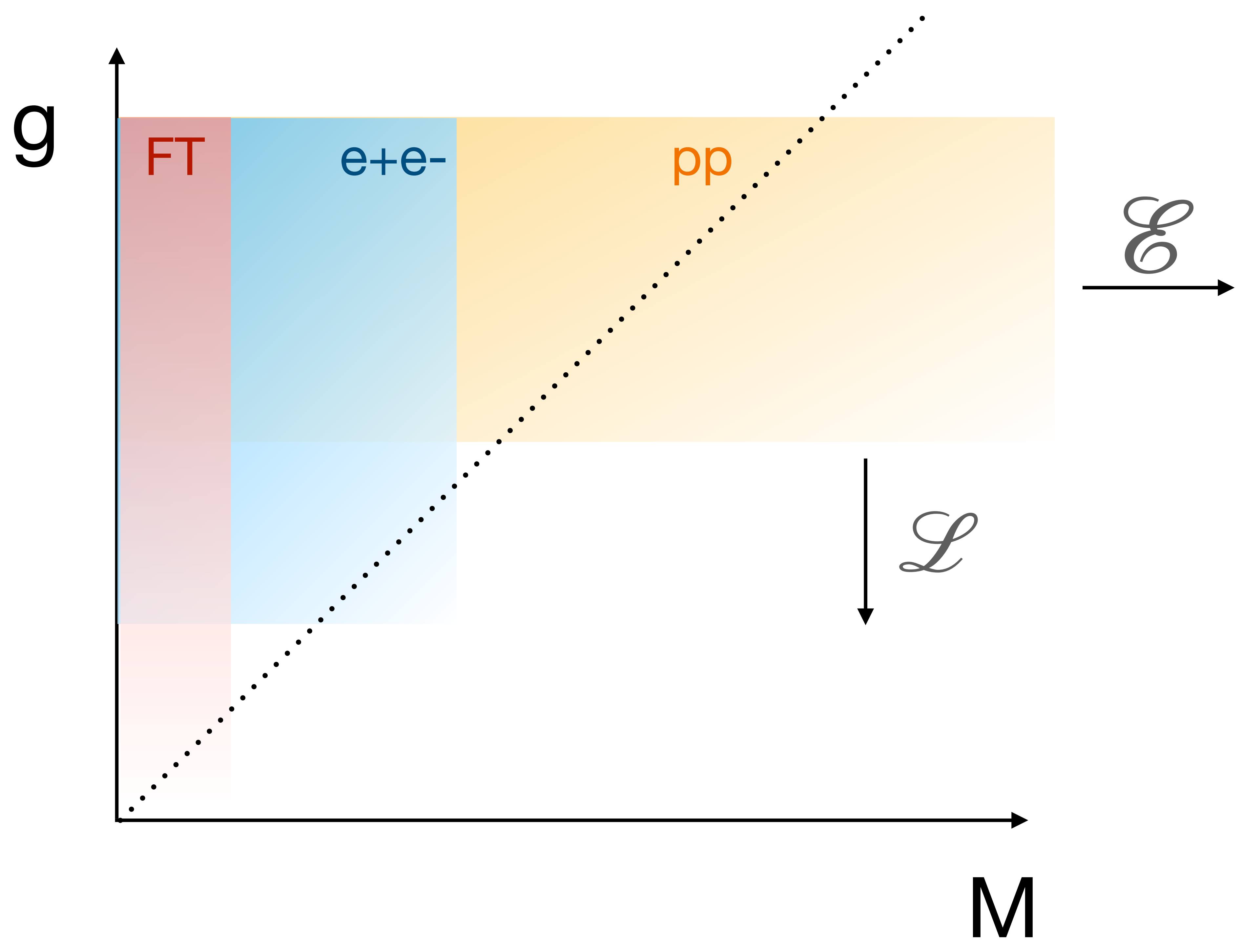

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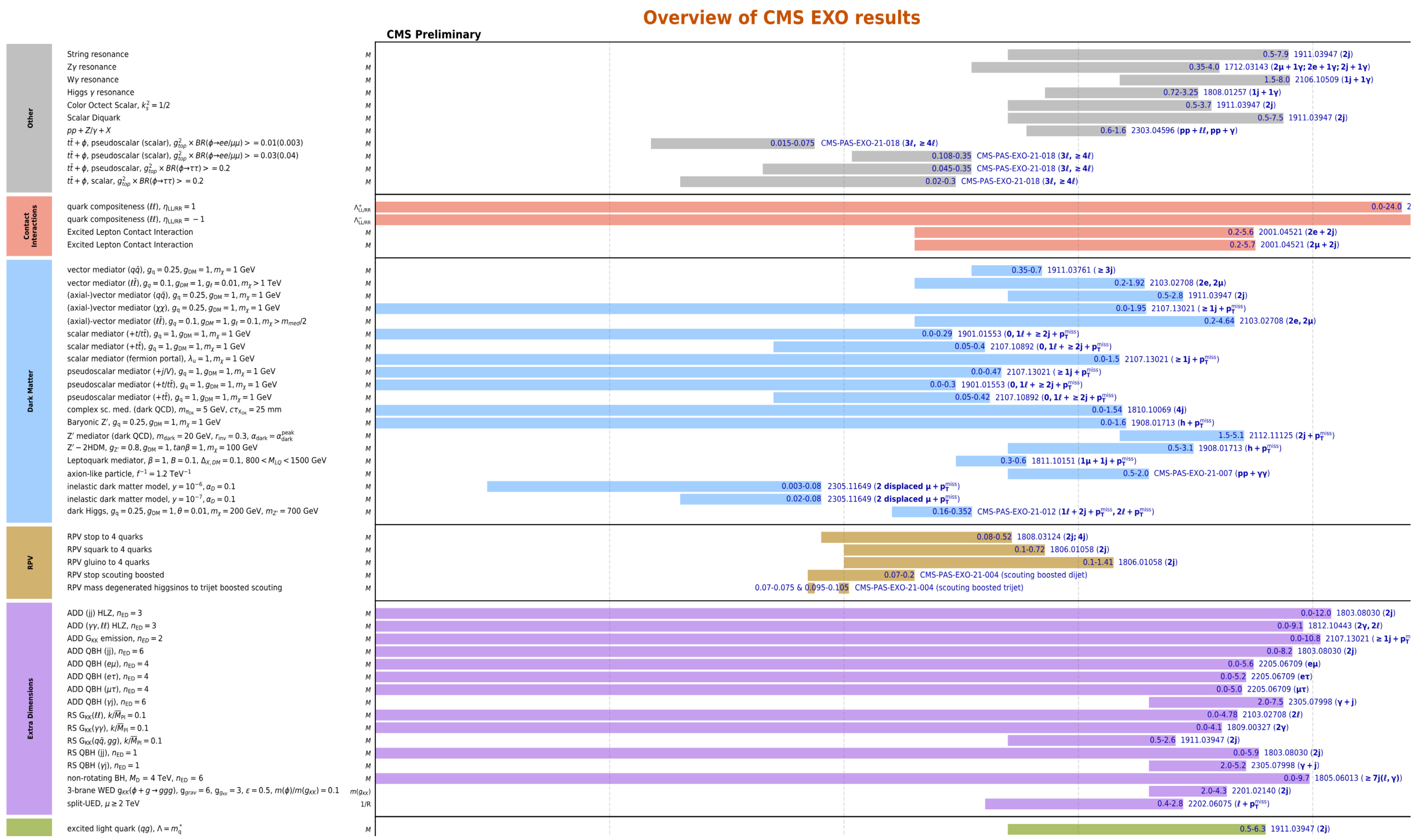

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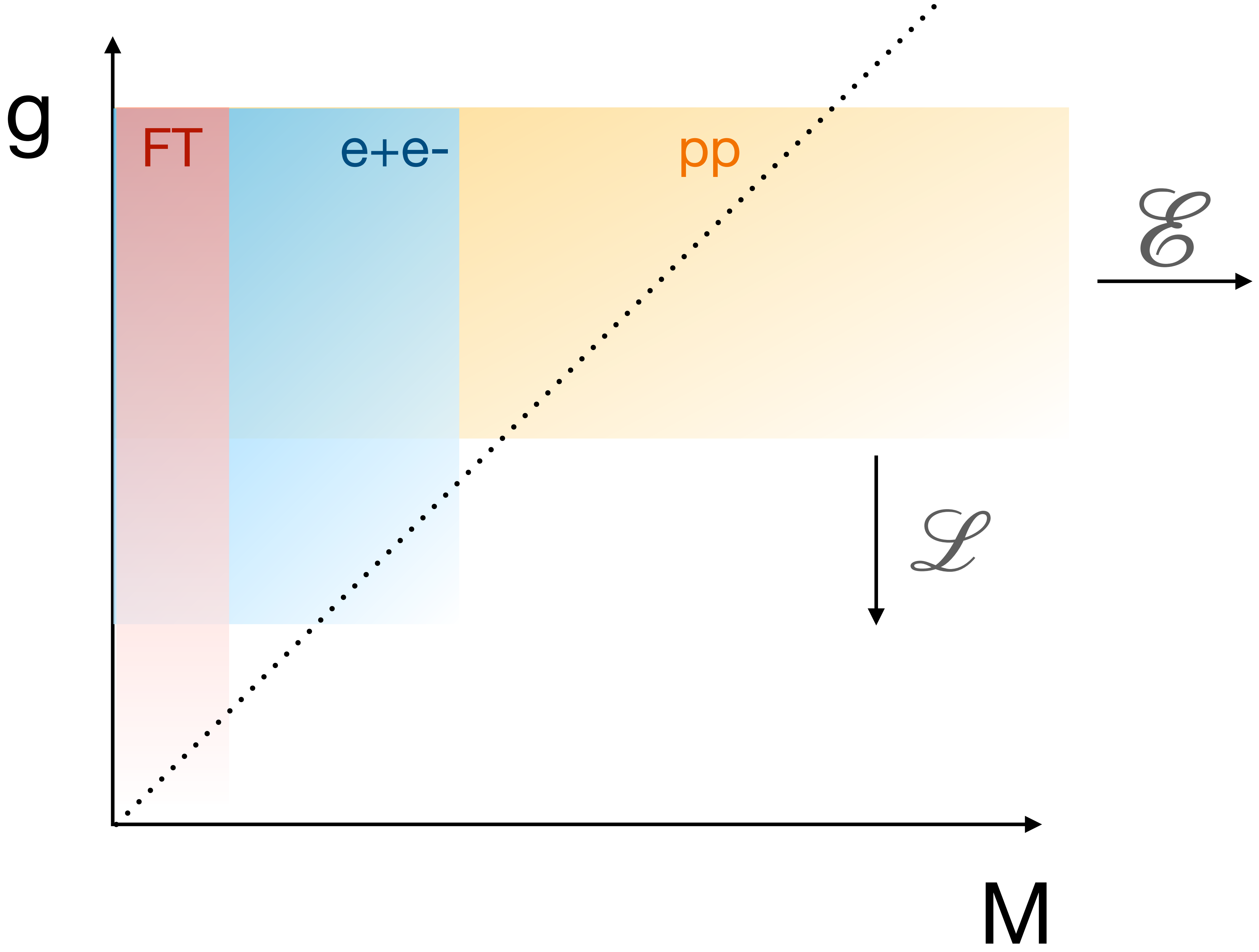
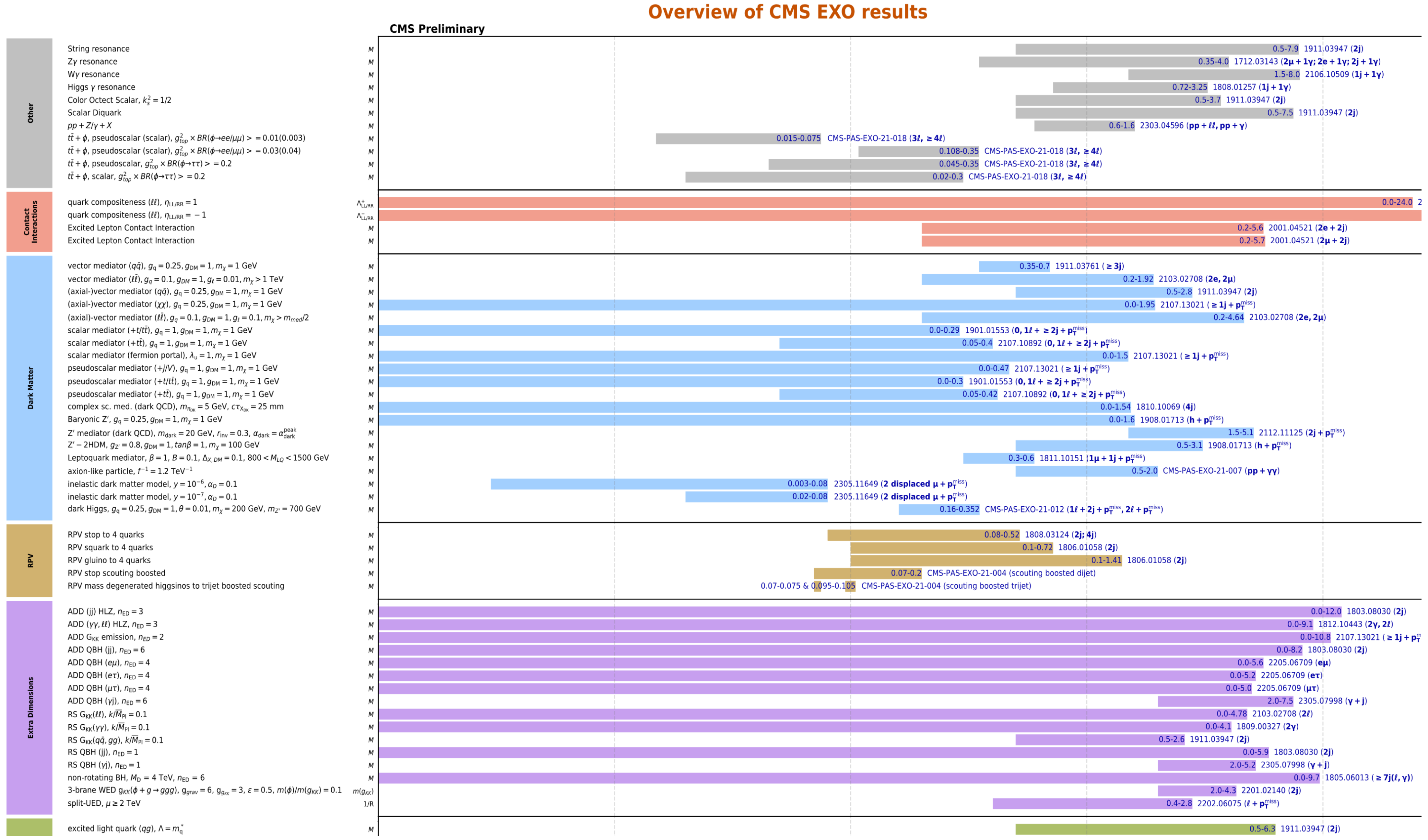


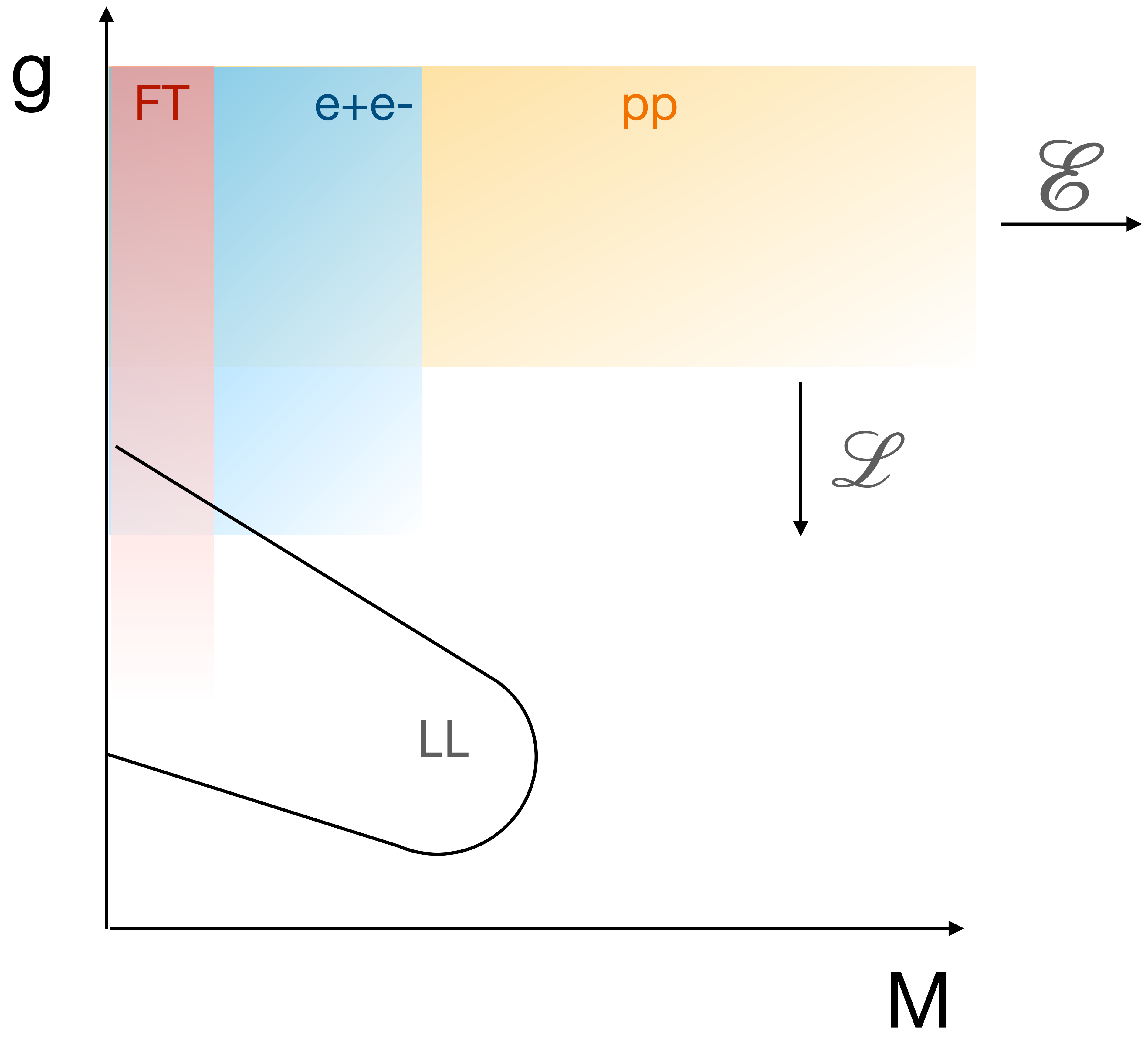


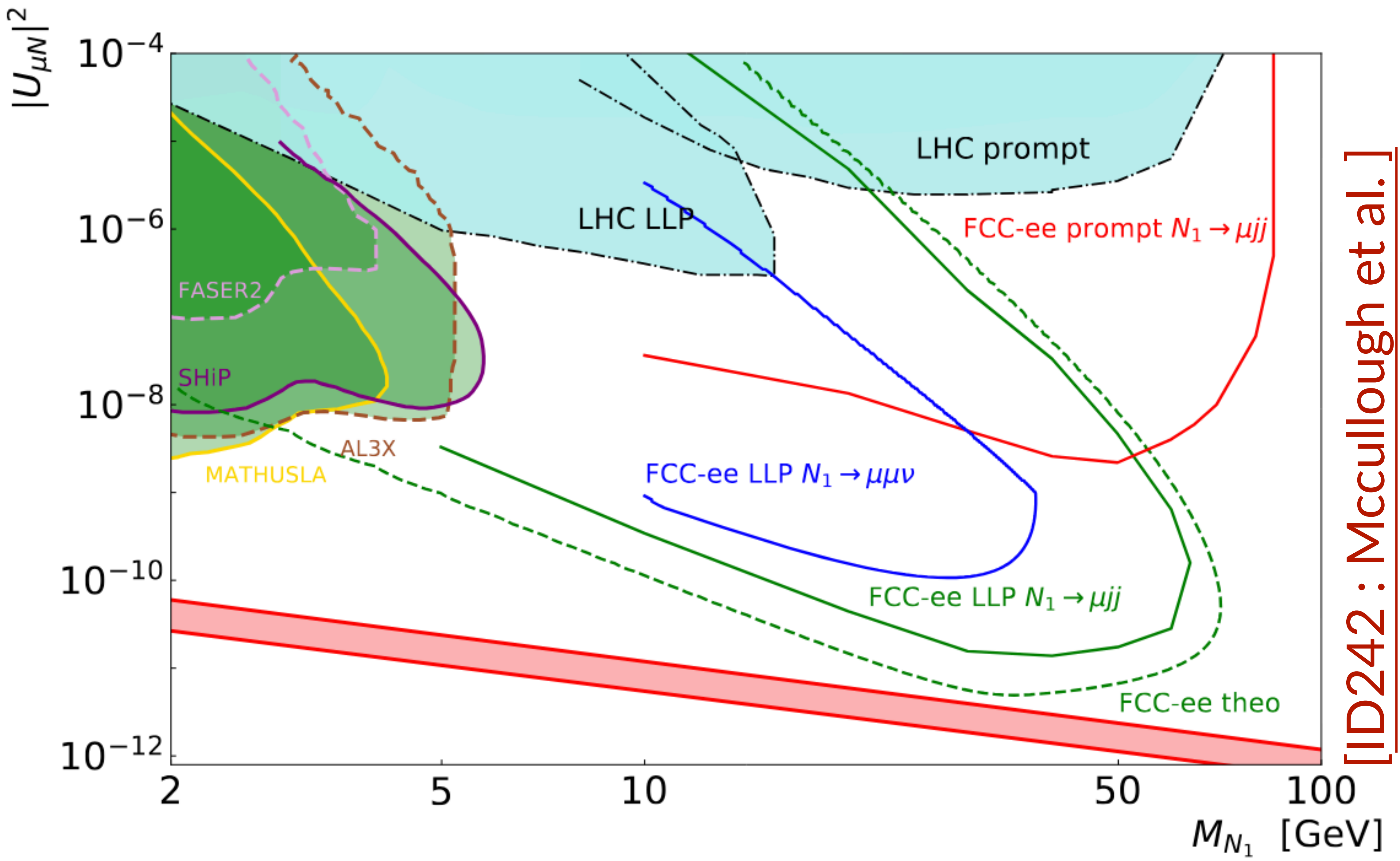
$\mathscr{L}_{BSM} \supset \mathscr{L}_{SM}$

$\#\mathscr{L}_{BSM} \geq$ #experimentalists?

Λ is low

BSM direct searches at energy and intensity frontiers





[ID242 : Mccullough et al.]

Λ is high

Effective Field Theory

When the energies probed by the experiment are lower than Λ, it is possible to encompass all possible UV theories into a universal $\mathscr{L}_{EFT}$ including all possible deformations of the SM.

Usual “SM” measurements can be interpreted in a universal way at an intermediate layer.

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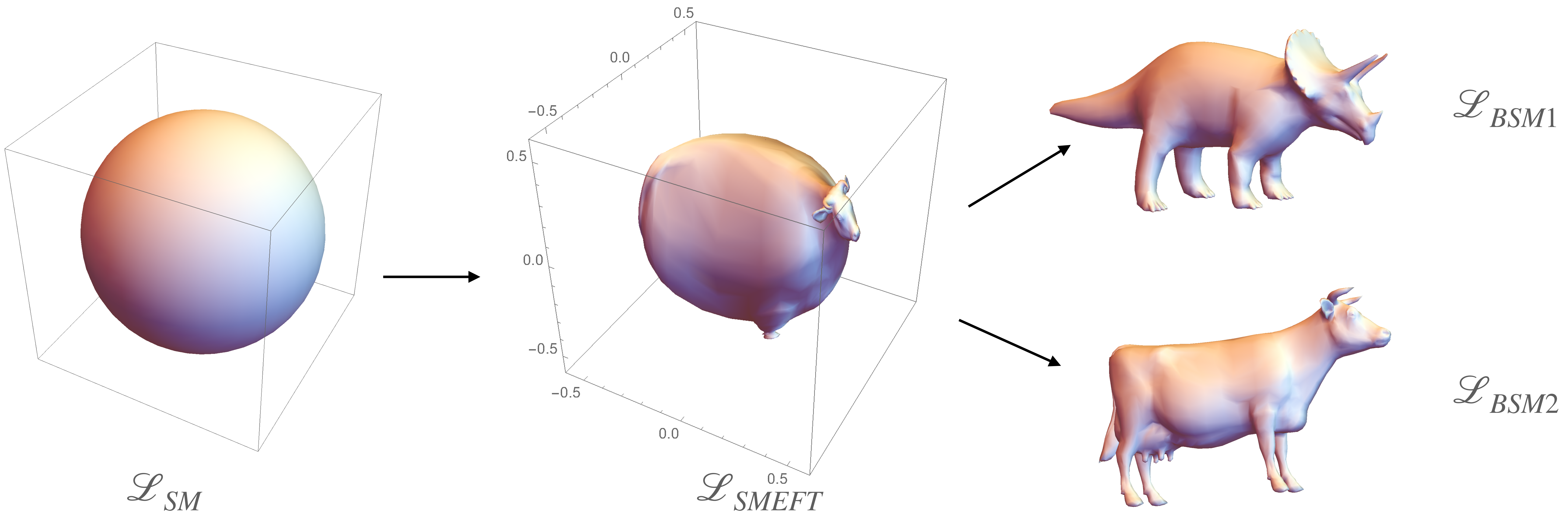

Λ_{BSM} is high
SMEFT

$$\mathscr{L}_{SMEFT} = \mathscr{L}^{(2)} + \mathscr{L}^{(4)} + \frac{1}{\Lambda}\mathscr{L}^{(5)} + \frac{1}{\Lambda^2}\mathscr{L}^{(6)} + \ldots$$

Rattazzi®

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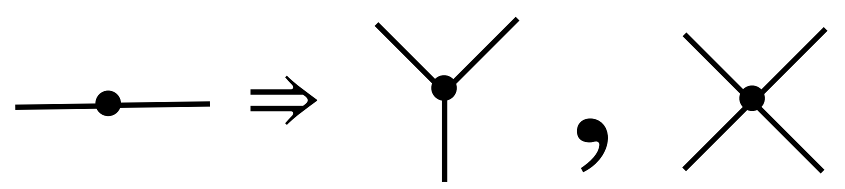
$$m_\nu = 0$$

$$U(1)_L^3 \times U(1)_B$$

GIM

$$Y_u, Y_d, Y_l \Rightarrow \cancel{\text{Flavor}}\ \&\ \cancel{CP}$$



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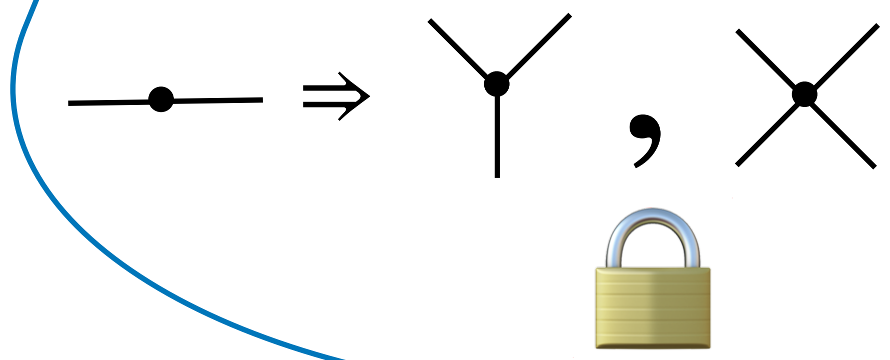


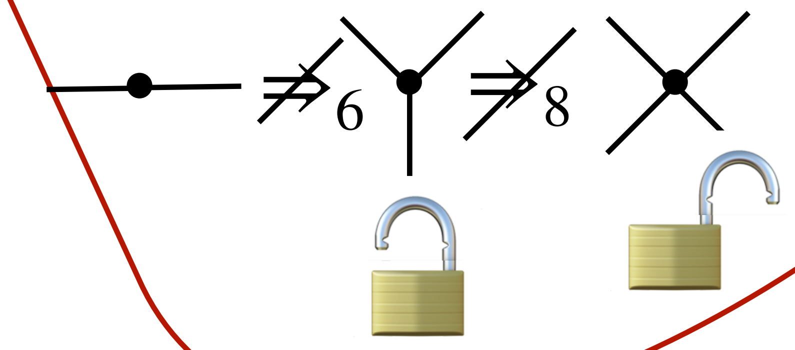
$\cancel{U(1)}_L \to m_\nu \neq 0$

~~Flavor~~ $\Rightarrow \mu \to e\gamma, \Delta m_K, \dots$

$\cancel{CP} \Rightarrow$ edm's

Dipoles $\Rightarrow (g-2)_\mu$

$U(1)_B \Rightarrow p \to \pi^0 e^+$



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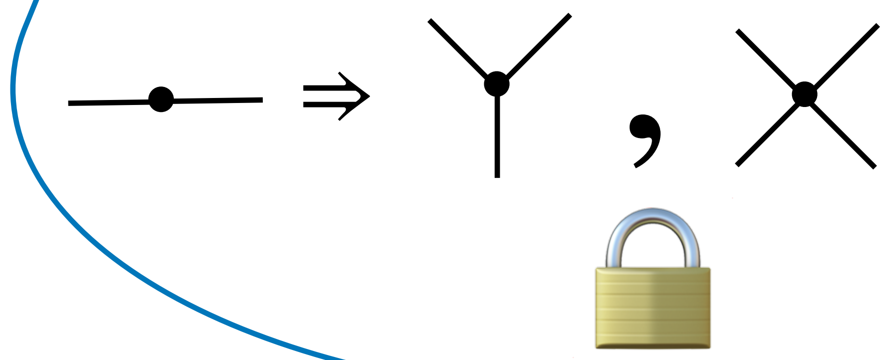

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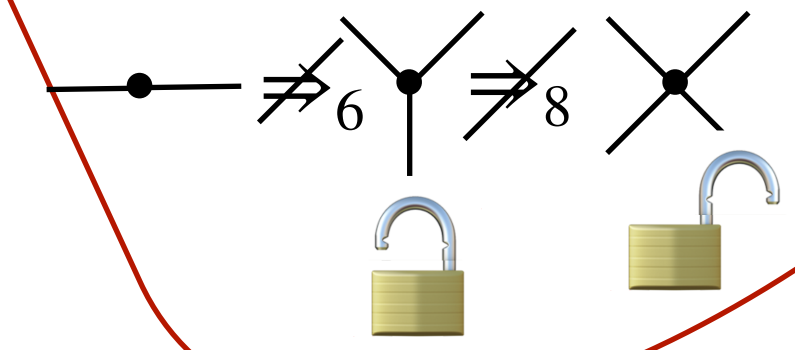

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$\Rightarrow \Lambda \simeq 10^3$ GeV

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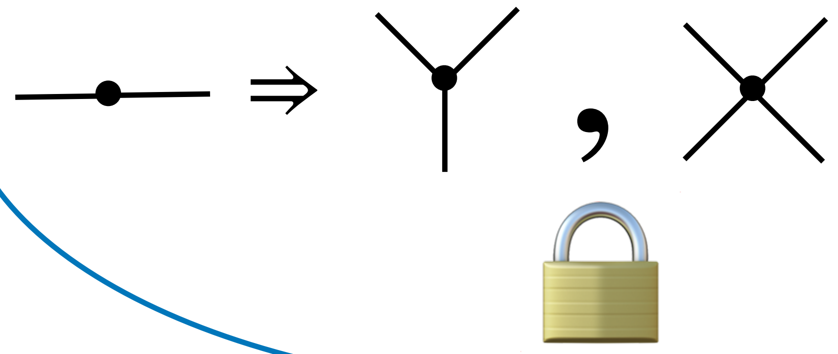

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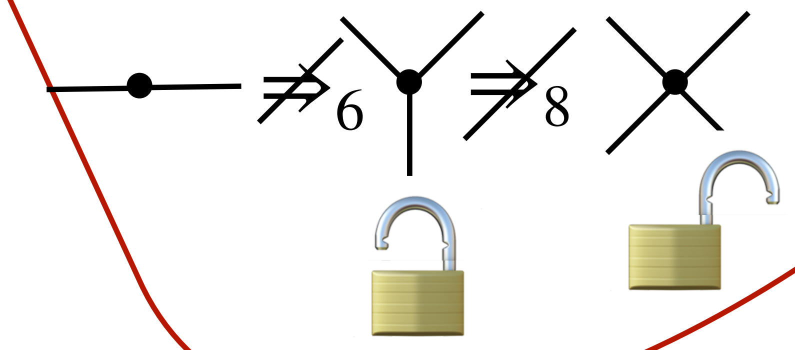

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Λ_{BSM} is high

SMEFT

Λ_{UV}

TeV

TeV Λ_{UV}

Simplicity 🙂

Naturalness ☹️

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$\not\Rightarrow_6 \quad \not\Rightarrow_8 \quad \Rightarrow \Lambda \geq 10^3$ GeV

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Λ_{BSM} is high
Precision for discovery

The master equation of an EFT approach has three key elements:

$$\Delta \mathrm{Obs}_n = \mathrm{Obs}_n^{\mathrm{EXP}} - \mathrm{Obs}_n^{\mathrm{SM}} = \frac{1}{\Lambda^2} \sum_i a_{n,i}^{(6)}(\mu)\, c_i^{(6)}(\mu) + \mathcal{O}\left(\frac{1}{\Lambda^4}\right)$$

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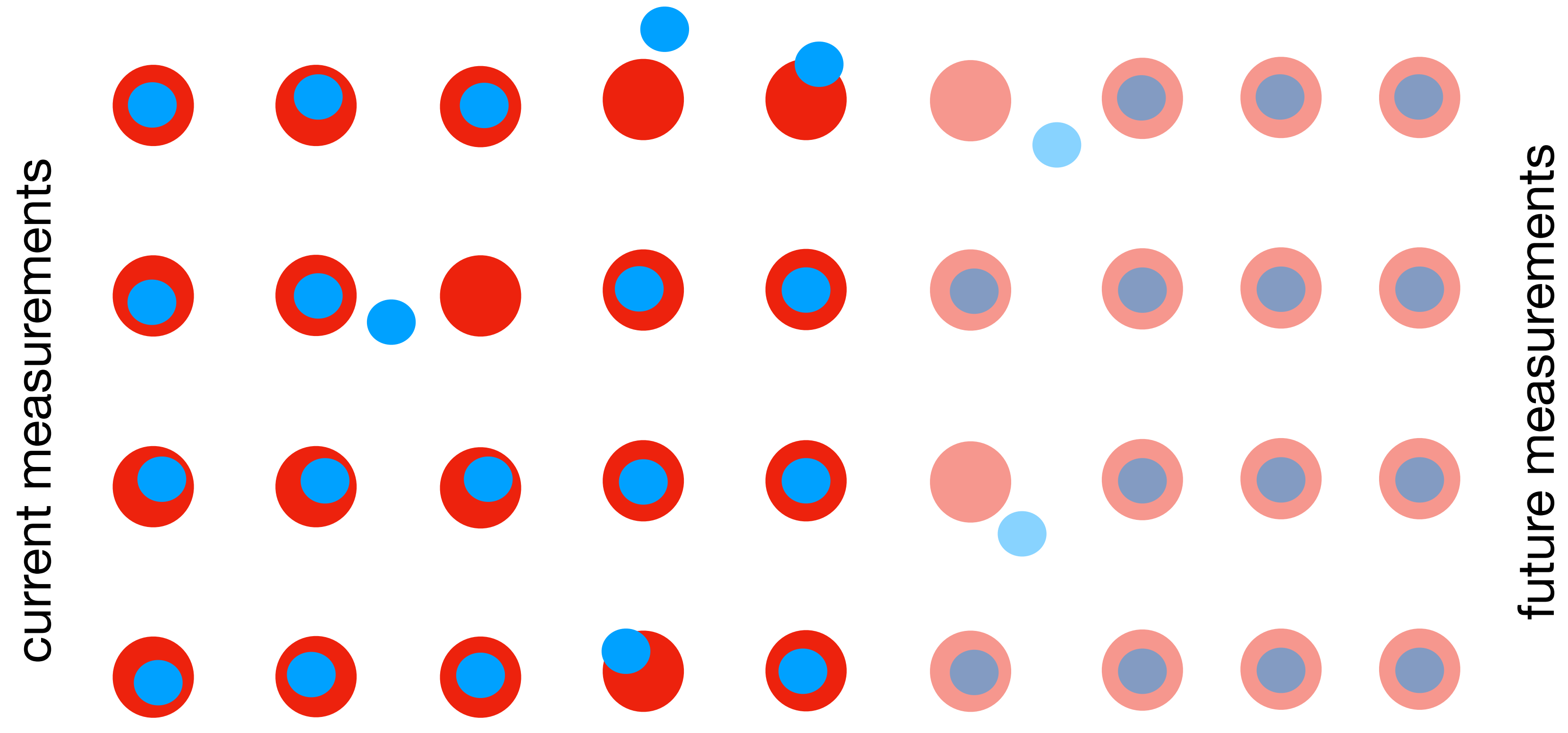

$\Rightarrow$ increased NP Sensitivity

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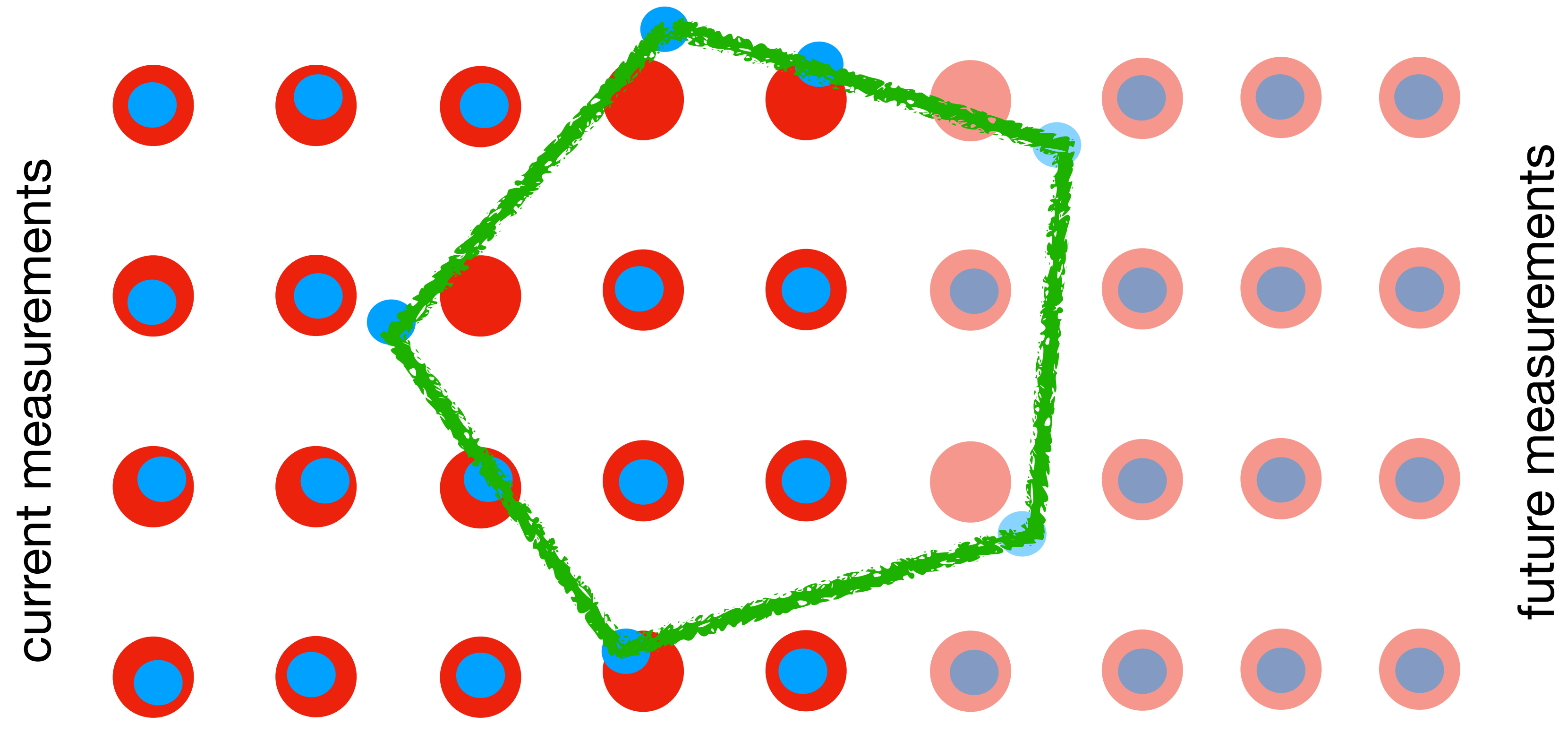

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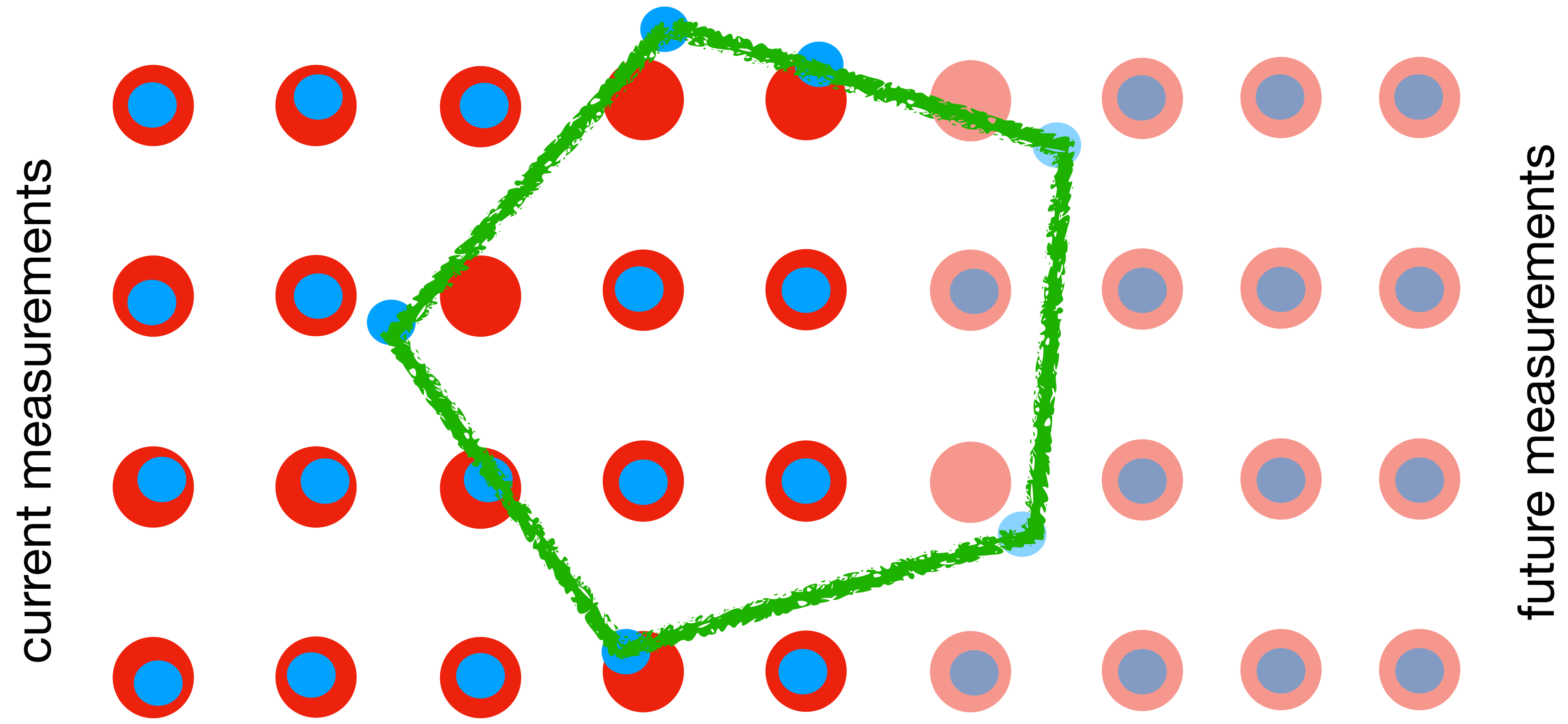
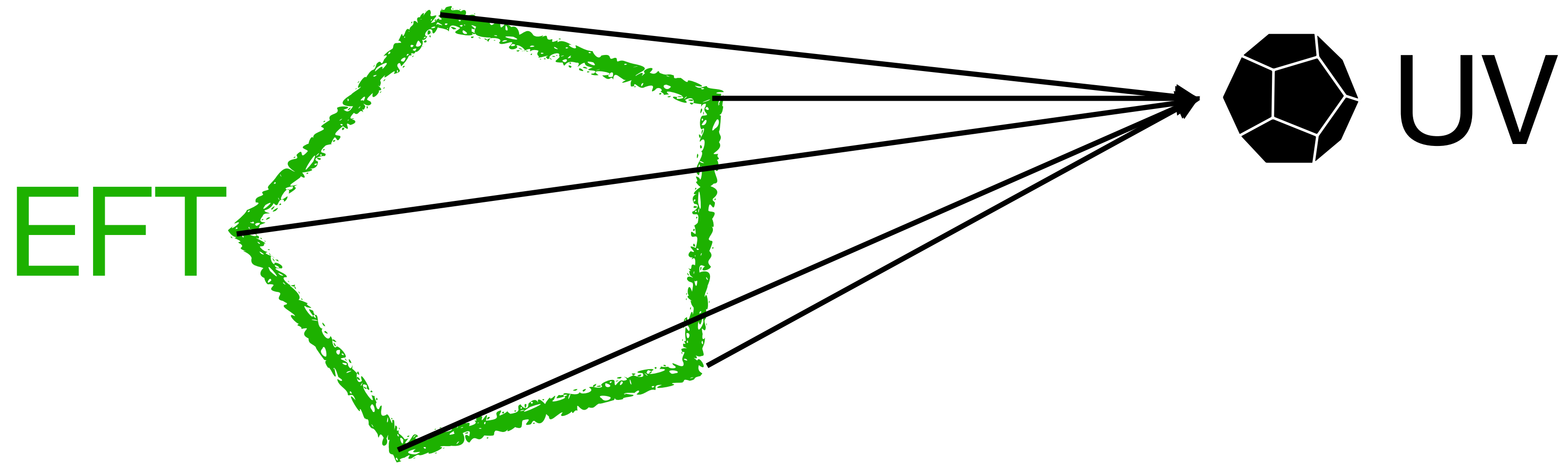


$\Rightarrow$ increased NP Sensitivity

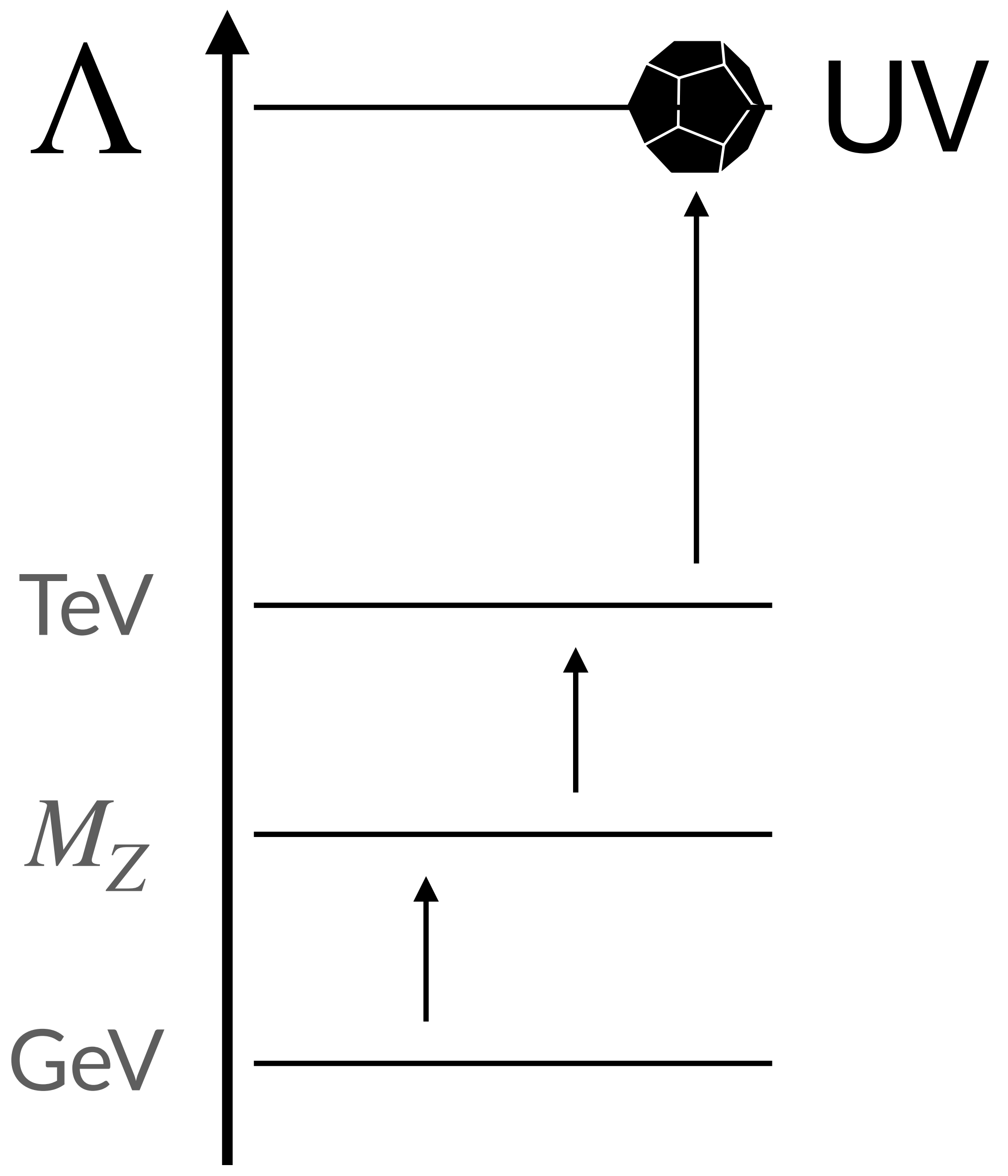
$\Rightarrow$ increased UV identification power



Λ_{BSM} is high

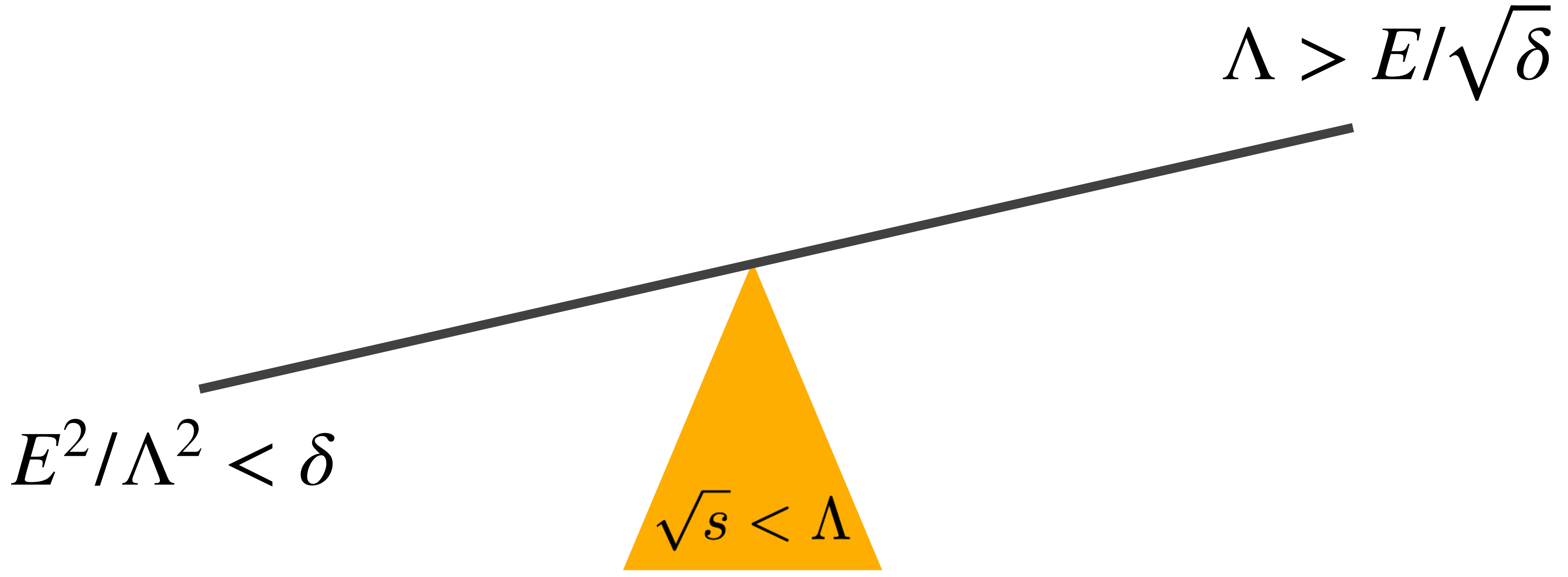
Scales and energy

Linking observables at different scales



An EFT allows to connect measurements at different scales without needing to know the UV. See later for an example in Flavour.

Energy helps precision

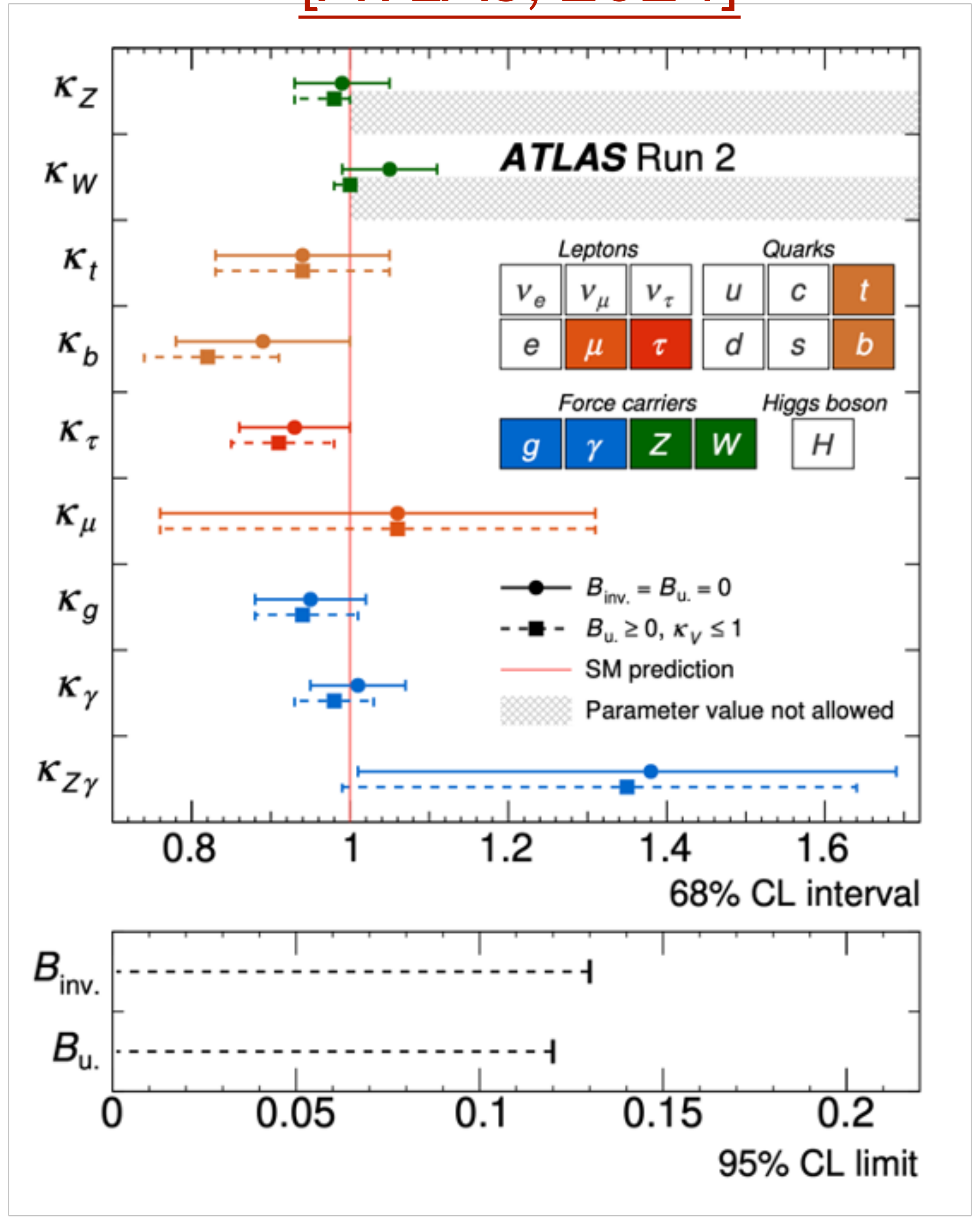


$$\text{Obs} = \text{Obs}^{\text{SM}} \cdot \left(1 + \sum_i \frac{E^2}{\Lambda^2} c_i \Delta_i\right)$$

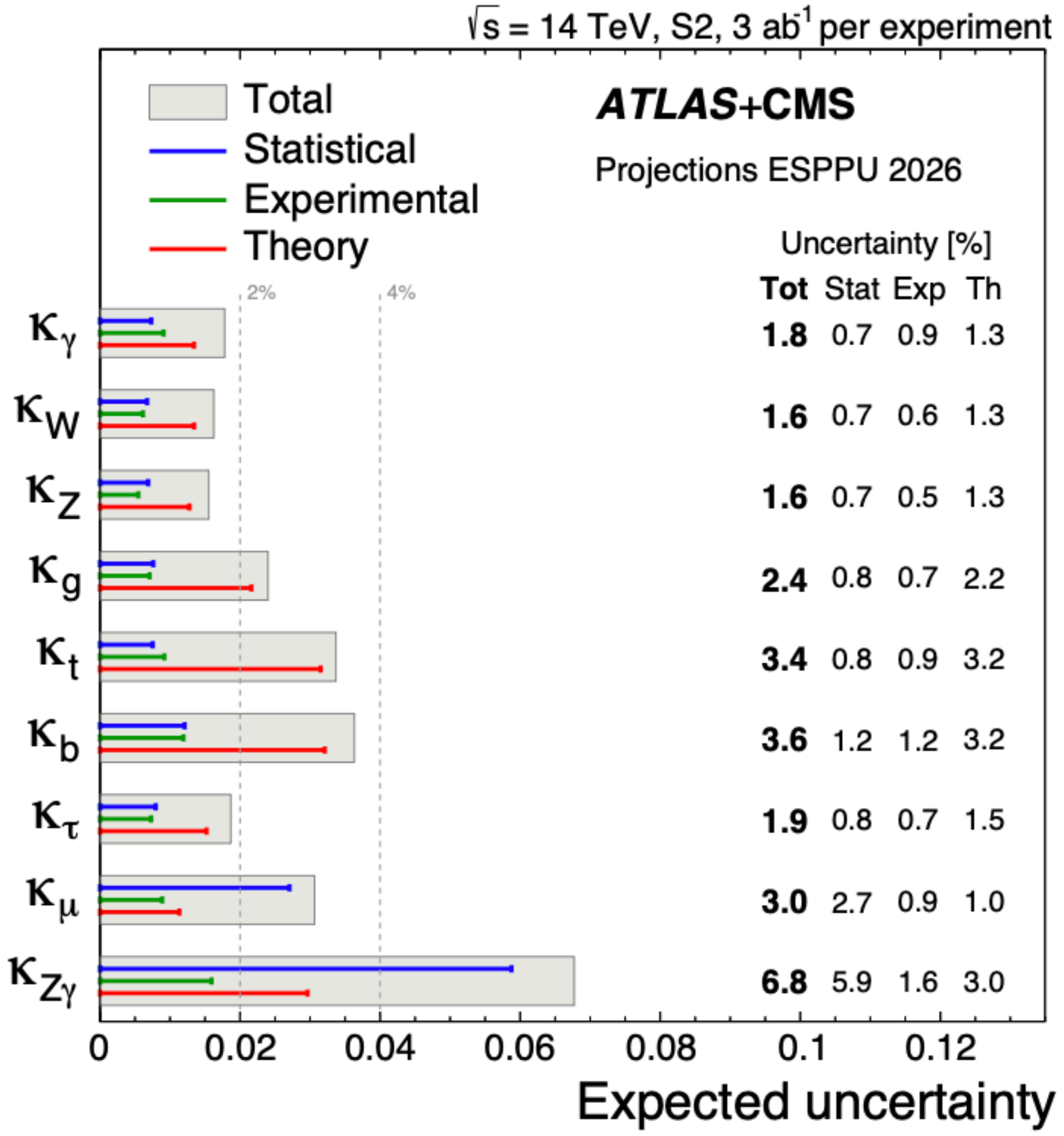
For $\Lambda = 100$ TeV, one needs $\delta = 10^{-6}$ precision for E=100 GeV, while δ=1% is enough at 10 TeV (for $c_i\Delta_i \sim 1$).

The Higgs future

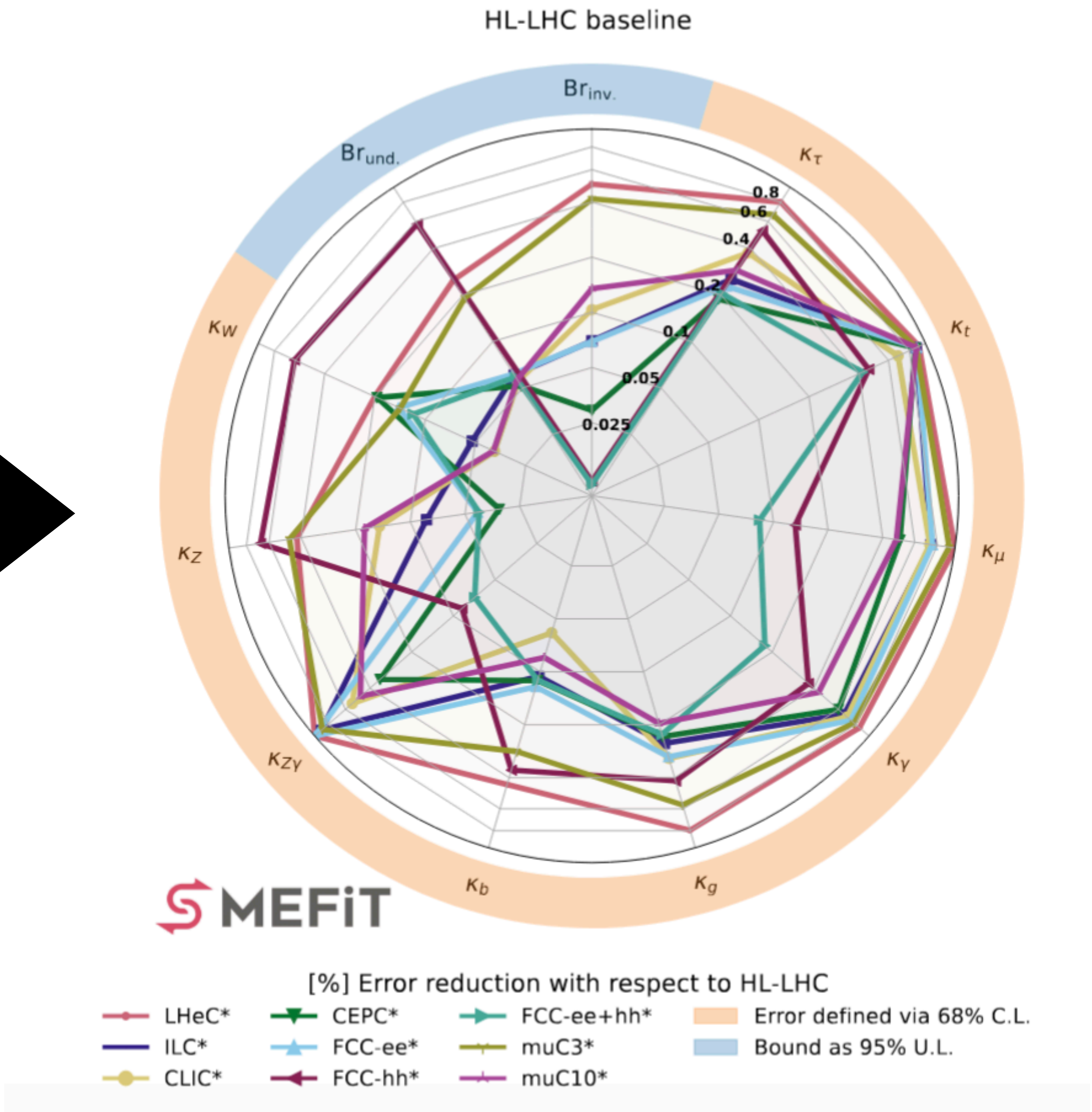
[ATLAS, 2024]



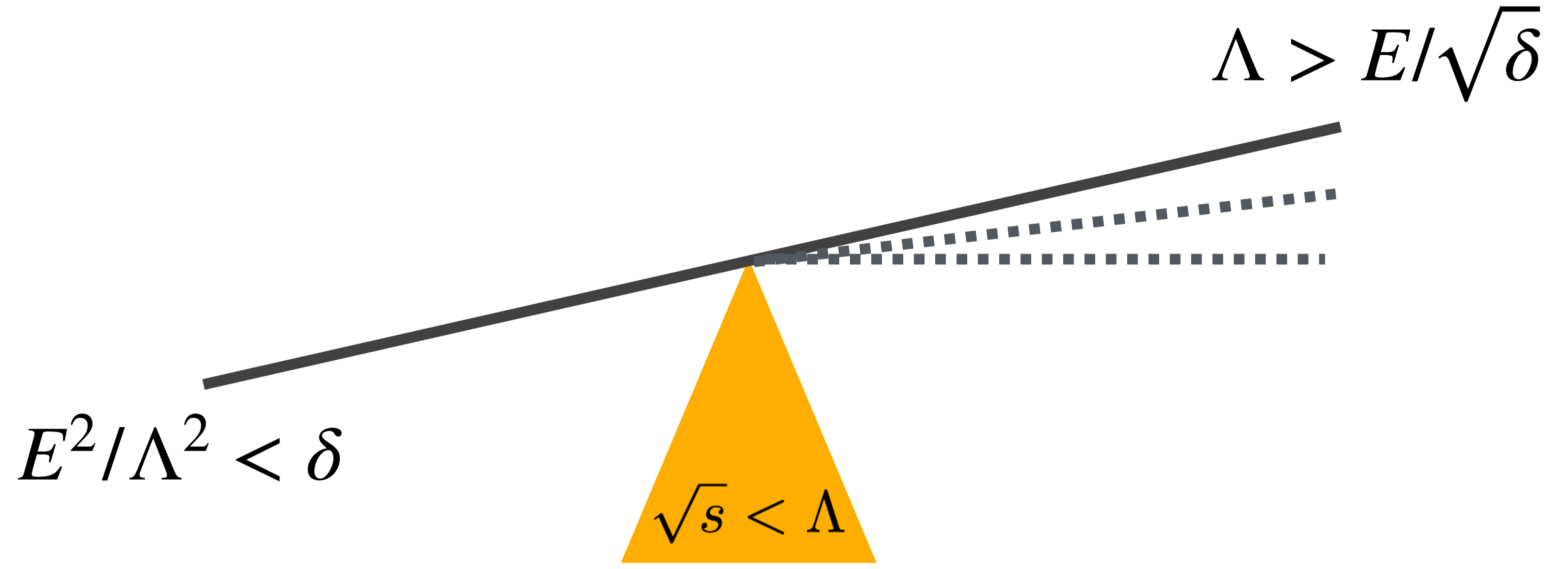
[ID170: CMS&ATLAS]



	Tot	Stat	Exp	Th
κ_γ	**1.8**	0.7	0.9	1.3
κ_W	**1.6**	0.7	0.6	1.3
κ_Z	**1.6**	0.7	0.5	1.3
κ_g	**2.4**	0.8	0.7	2.2
κ_t	**3.4**	0.8	0.9	3.2
κ_b	**3.6**	1.2	1.2	3.2
κ_τ	**1.9**	0.8	0.7	1.5
κ_μ	**3.0**	2.7	0.9	1.0
$\kappa_{Z\gamma}$	**6.8**	5.9	1.6	3.0



10-20% → 2-4% → 0.1-1 %



$\Lambda_{\rm BSM}$ is high

Naturalness

$$\mathscr{L} \quad = \quad \mathscr{L}^{(2)}$$

$$m_h^2 \simeq \Lambda^2$$

This term is responsible for the so called hierarchy problem. It's the only dimensional parameter of the SM Lagrangian, and should be order of Λ^2.

$$\delta g_H / g_H{}^{\rm SM} \sim c\,\varepsilon \qquad \varepsilon \equiv m_H^2/\Delta m_H^2$$

Consider the case of New Physics due to the presence of a top partner.

Different models can be realised, which in ABSENCE of tuning, give:

1] $\Delta m_H^2 \sim m_T^2 \sim m_H^2 \Rightarrow \epsilon \sim 1$: Usual Soft SUSY

2] $\Delta m_H^2 \sim \dfrac{3y_t^2}{4\pi^2} m_T^2 \Rightarrow \epsilon \sim 1/20$: Super Soft SUSY and CH

3] $\Delta m_H^2 \sim \dfrac{3\lambda_h}{16\pi^2} m_T^2 \Rightarrow \epsilon \sim 1/100$: Natural Naturalness

Is there room for discovery?

A simple toy example

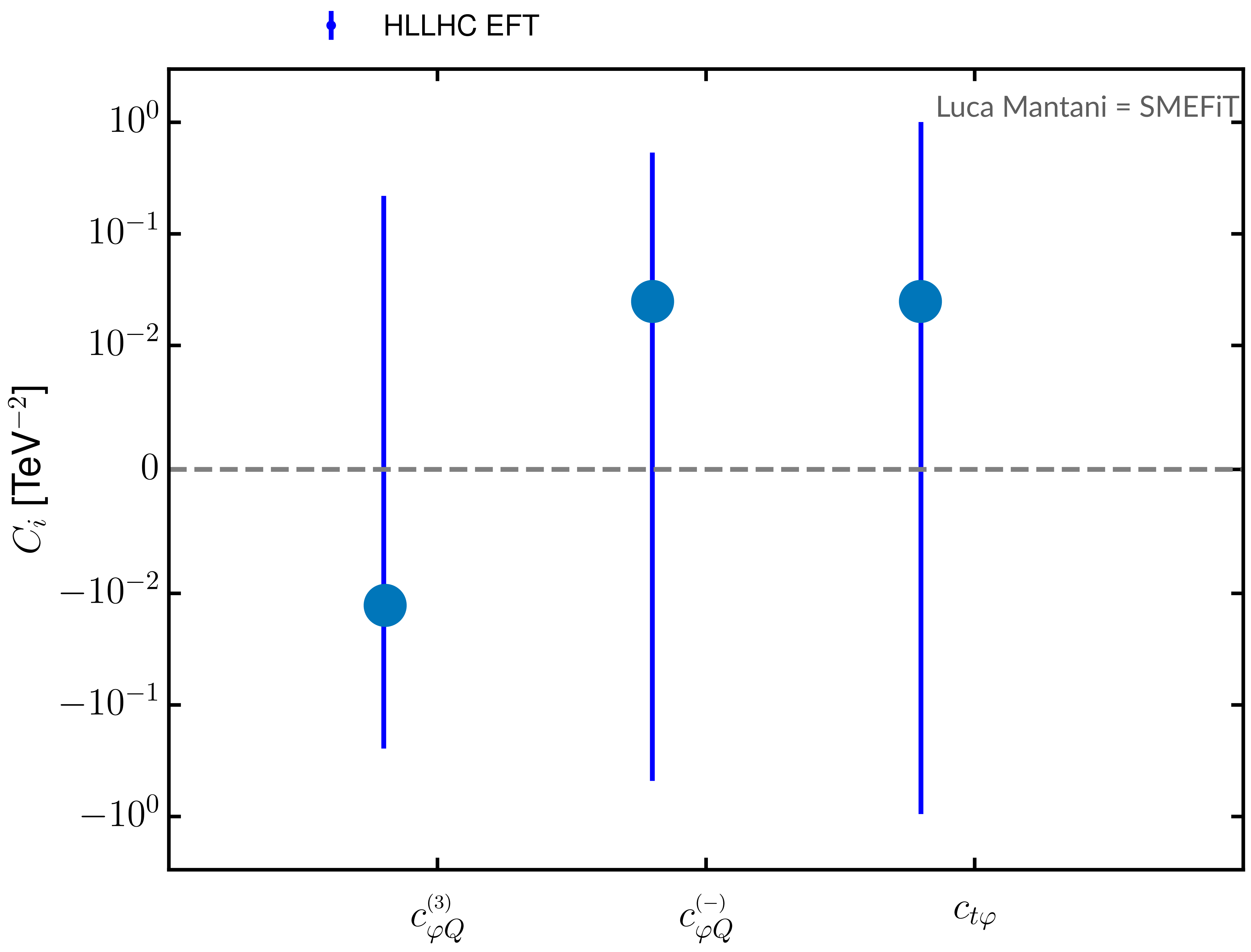
Imagine a vector-like heavy quark exists at 4 TeV. This is currently not excluded by the direct searches at the LHC and will not at the end of HL-LHC.

How would a discovery unfold?

1] Some tension + pattern at the HL-LHC

2] Clear identification of deviation at FCC-ee through EFT

3] Model matching up in the UV. Identifying the scale with the help of RGE.



Is there room for discovery?

A simple toy example

Imagine a vector-like heavy quark exists at 4 TeV. This is currently not excluded by the direct searches at the LHC and will not at the end of HL-LHC.

How would a discovery unfold?

1] Some tension + pattern at the HL-LHC

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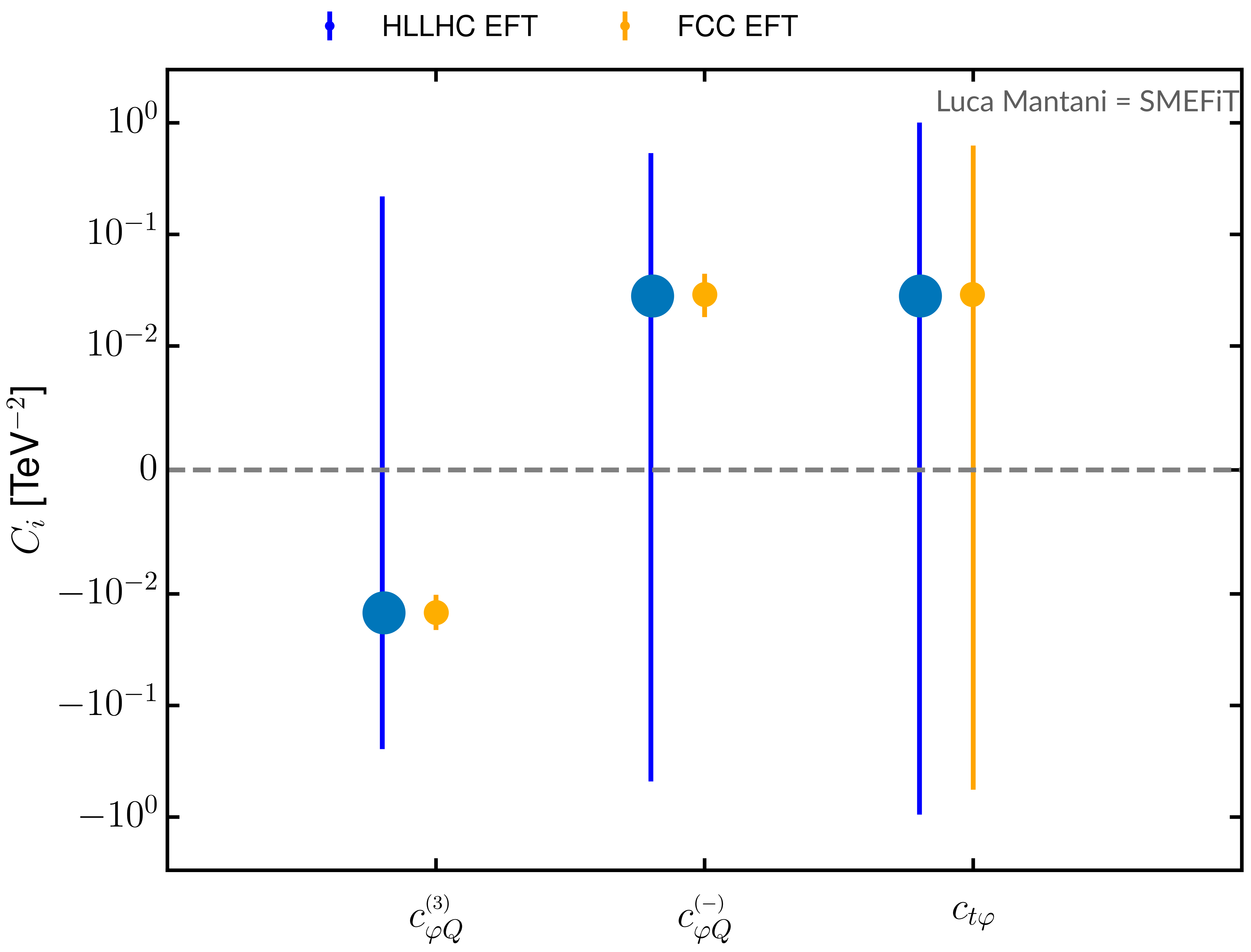

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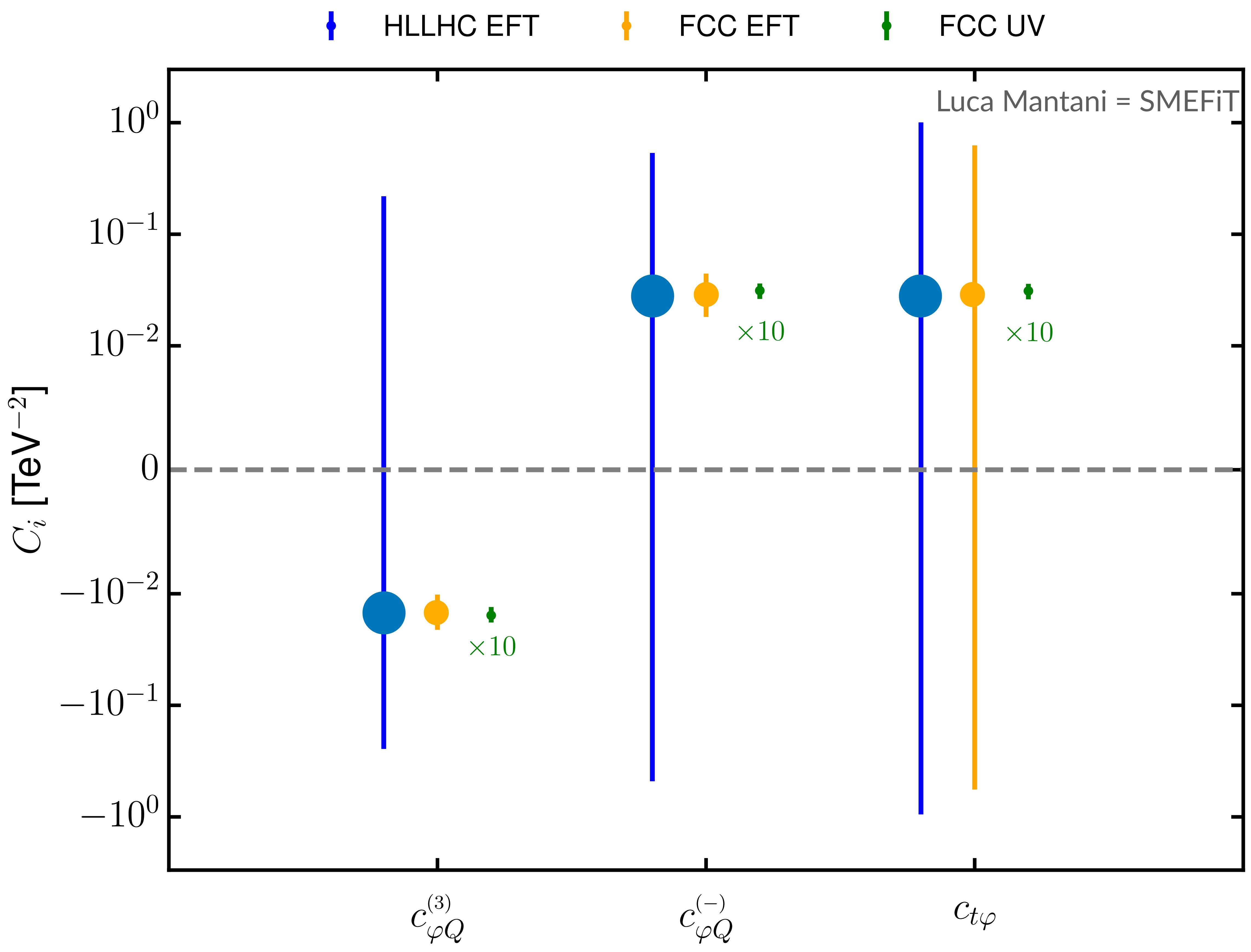

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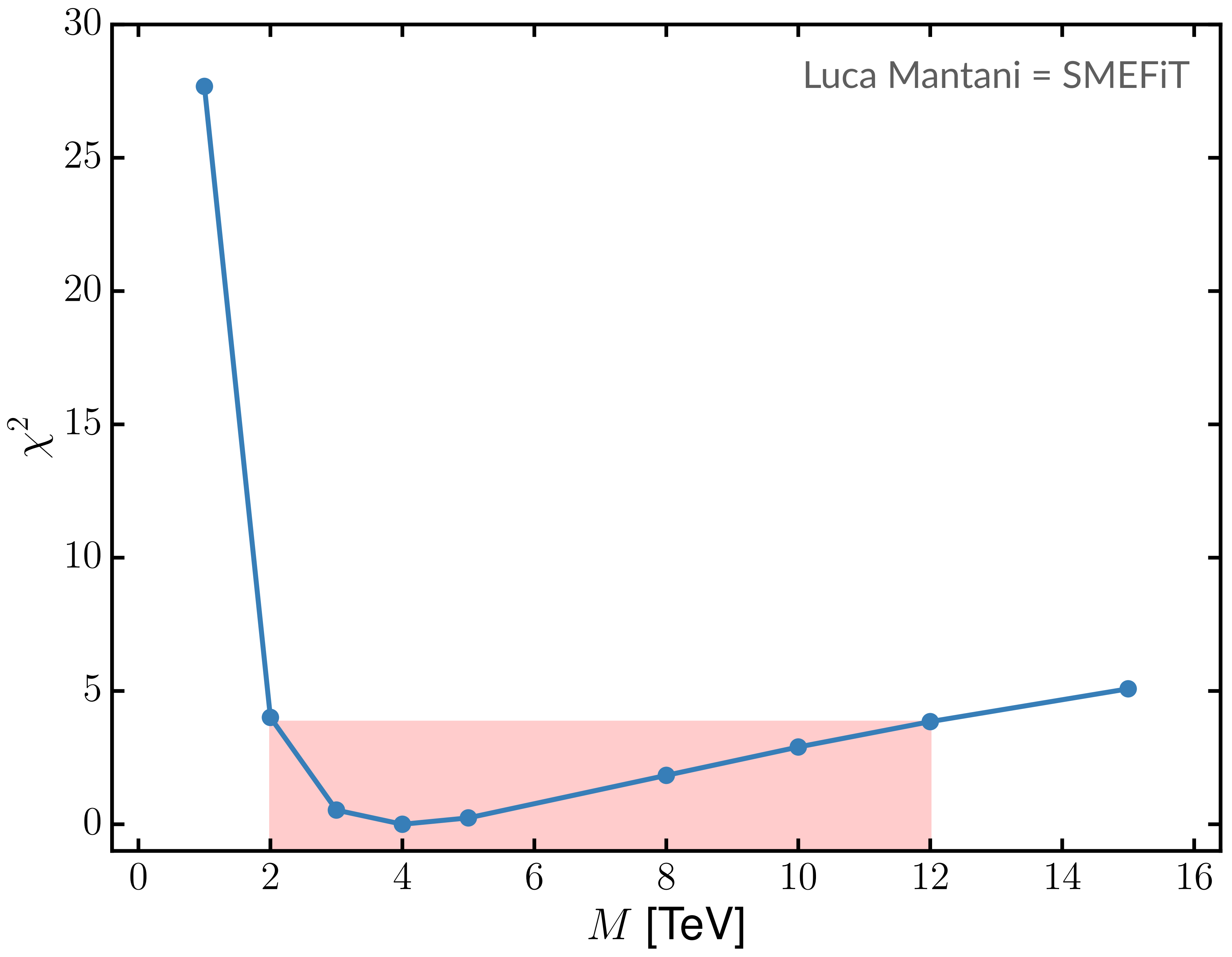
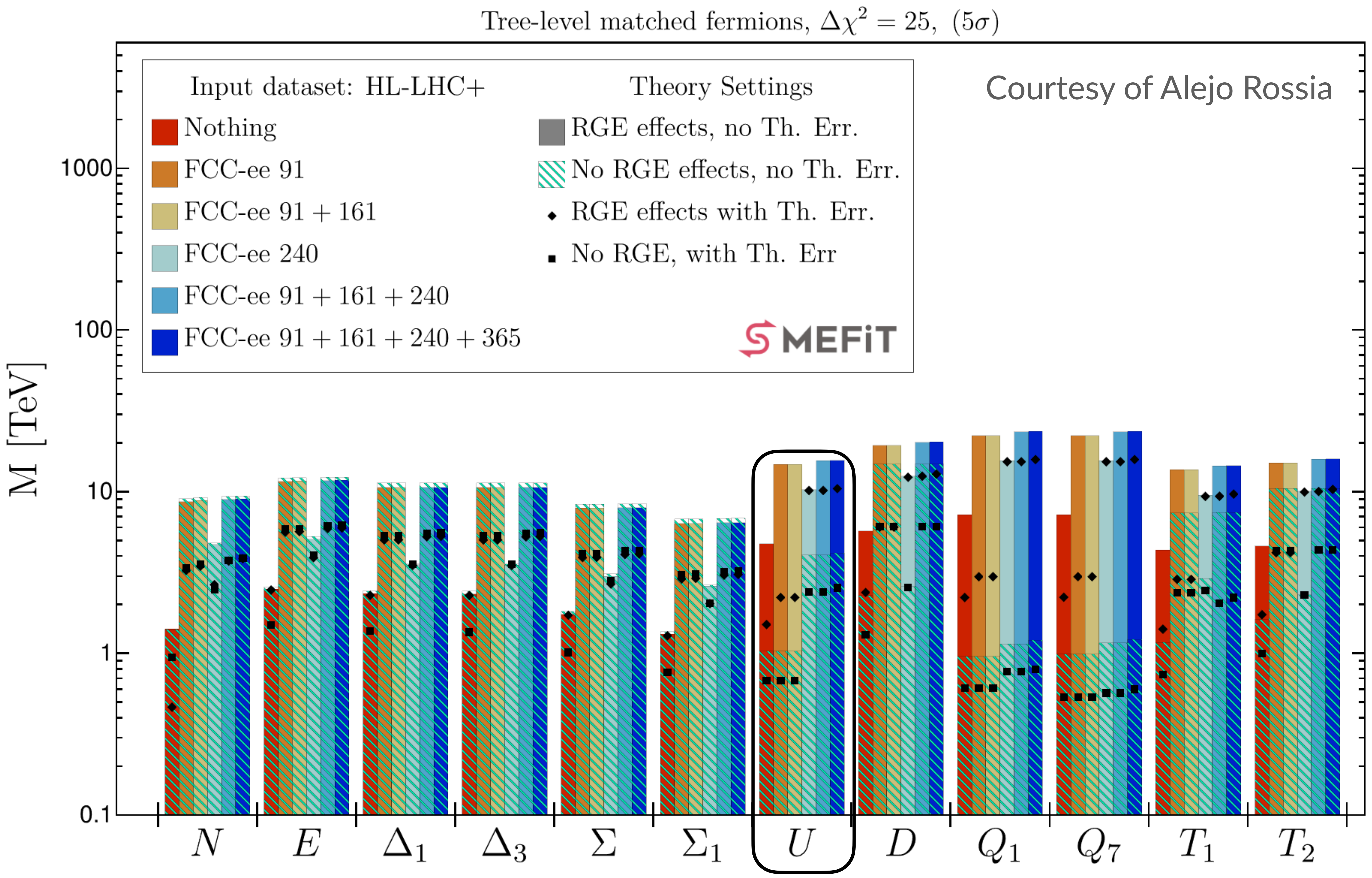
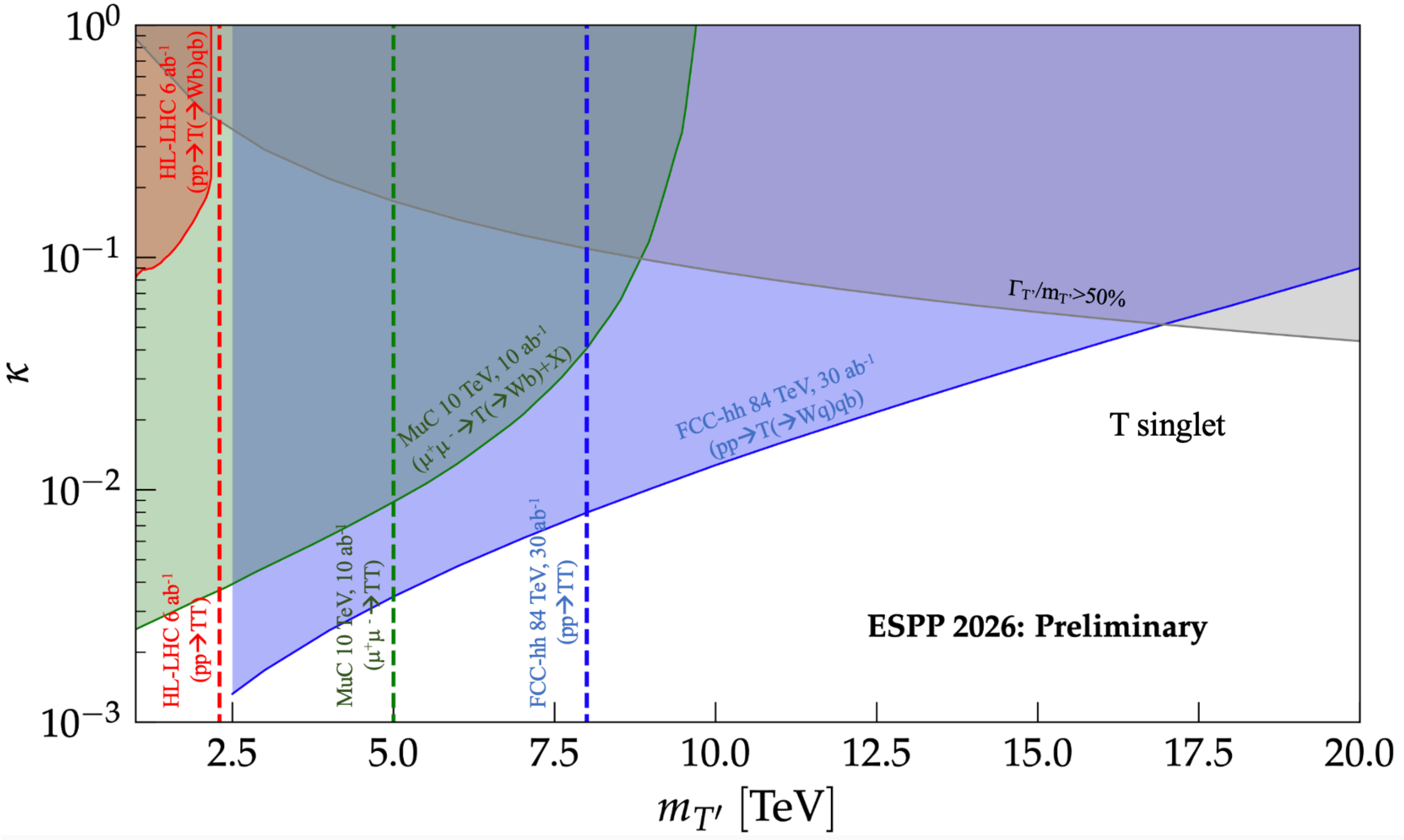


Is there room for discovery?

A simple toy example



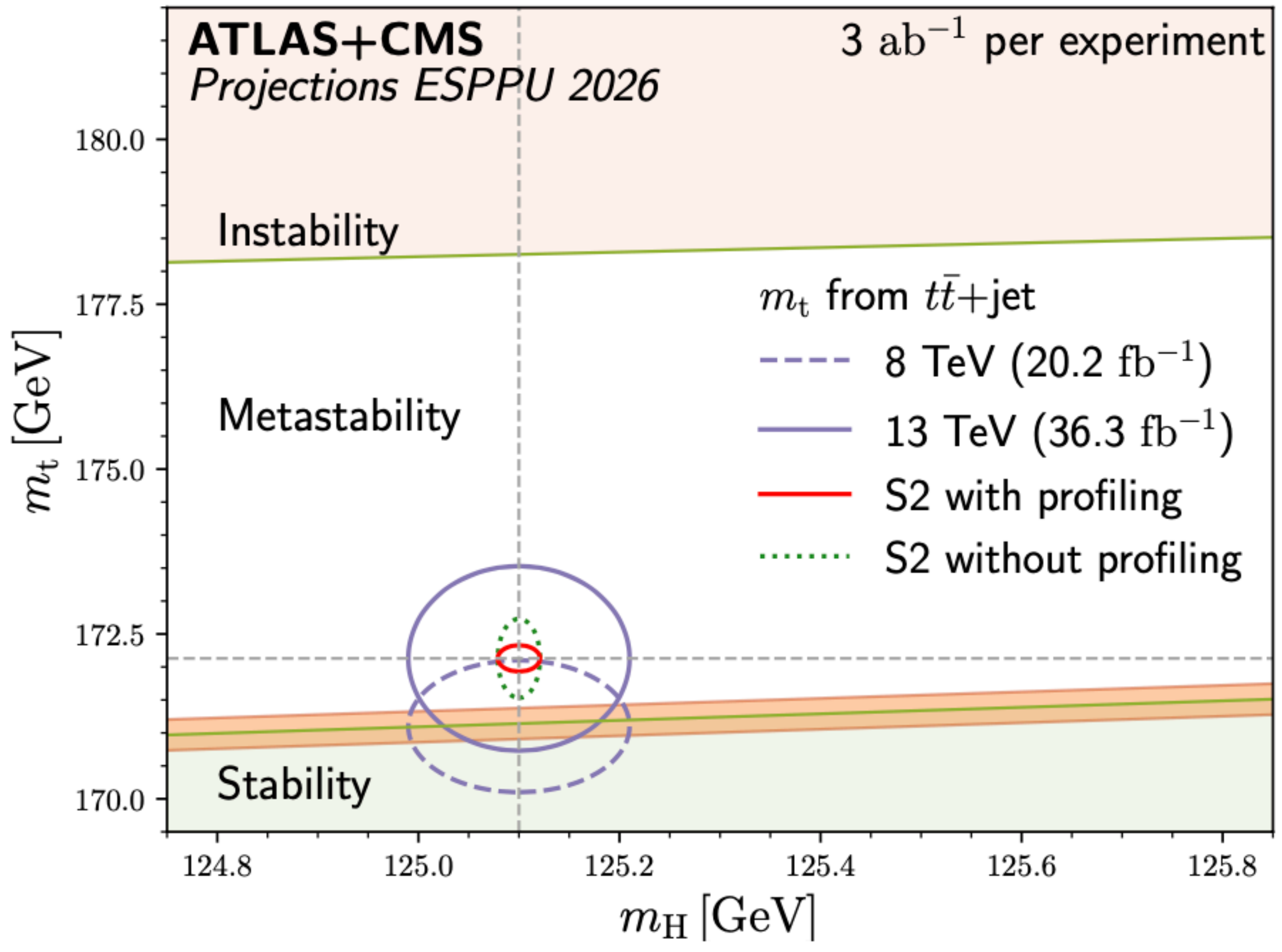


Now just illustrative. It could be interesting to study this and other cases.

Lessons from the HL-LHC

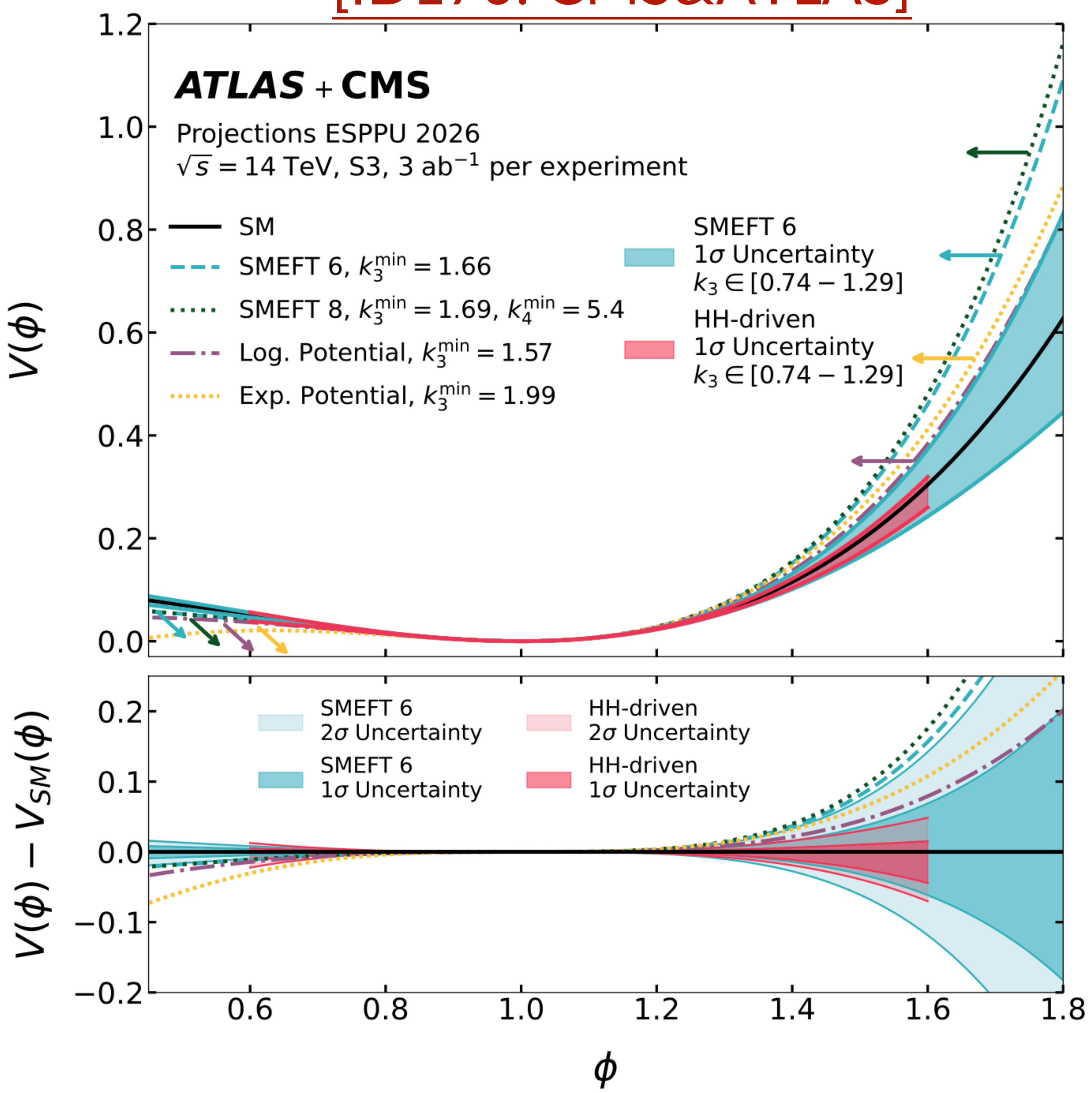
Questions with 3 inverse attobarns

[ID170: CMS&ATLAS]



Is the SM vacuum stable or metastable? ✔

[ID170: CMS&ATLAS]

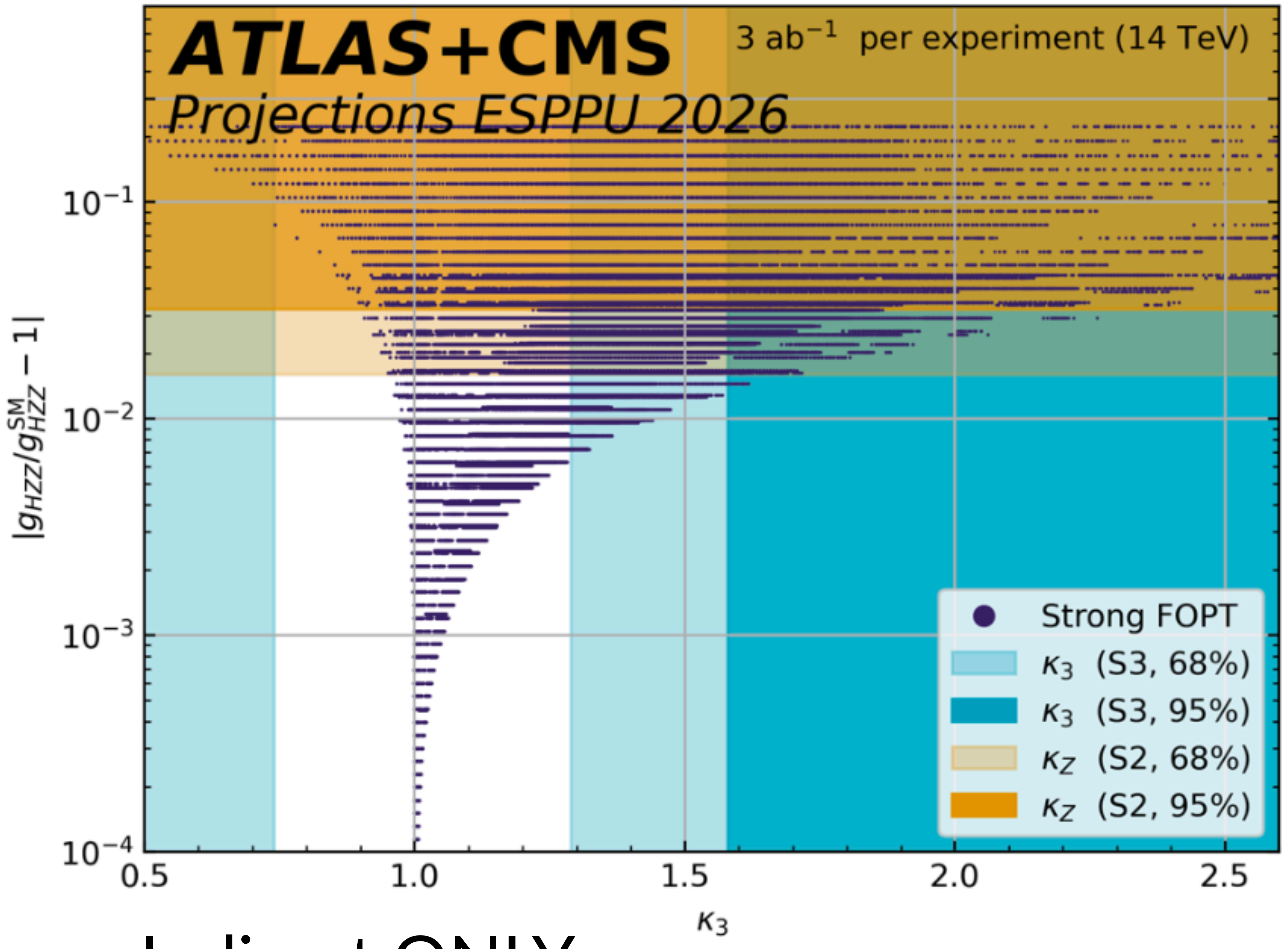


Is the Higgs potential compatible with a SFOPT? ✔

Lessons from the HL-LHC

Questions with 3 inverse attobarns

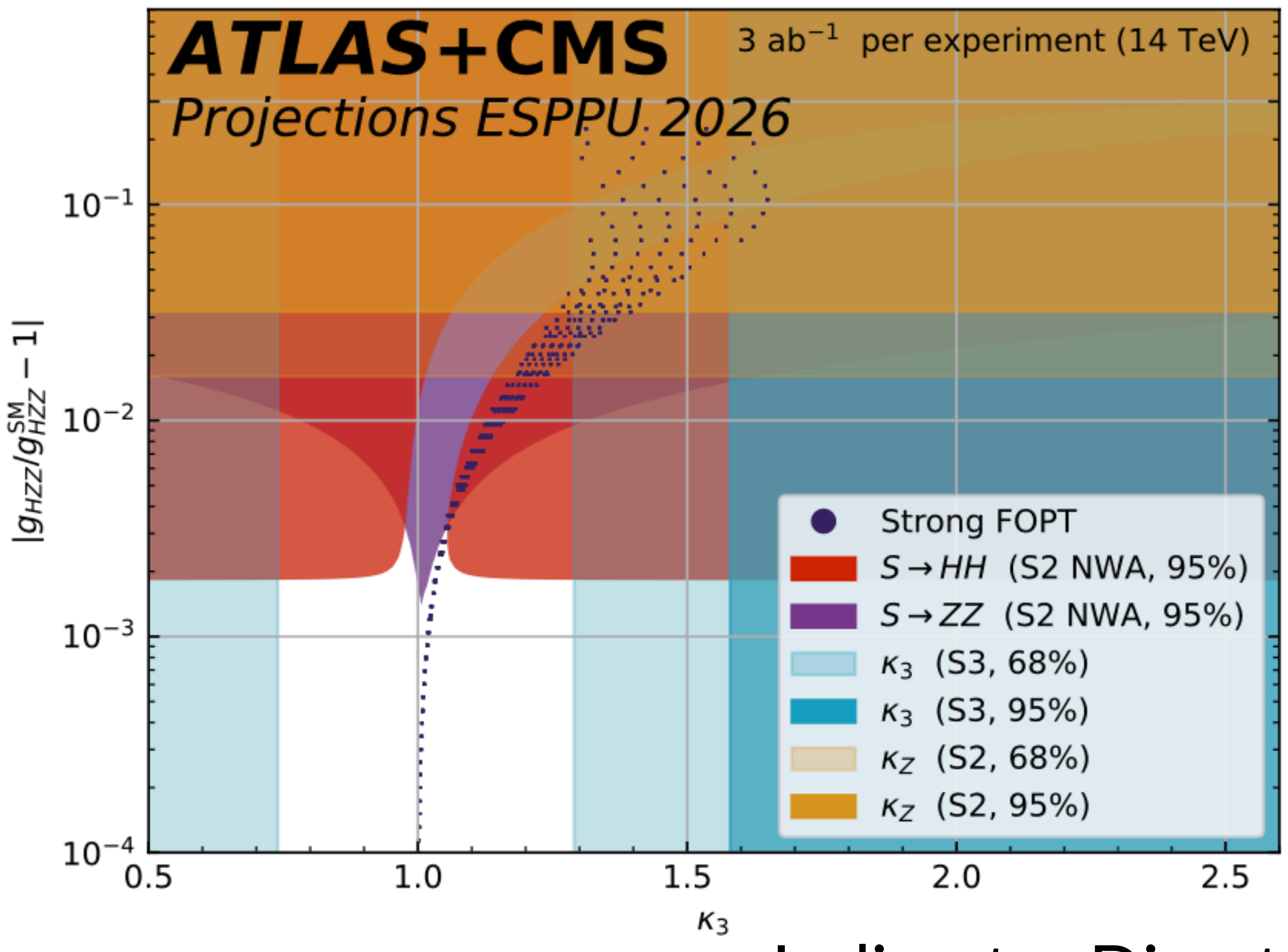
$$V(\Phi,S) = -\mu_H^2|\Phi|^2 + \lambda_H|\Phi|^4 + b_1 S - \frac{\mu_S^2}{2}S^2 + \frac{b_4}{4}S^4 + \frac{a_2}{2}|\Phi|^2S^2 + \frac{b_3}{3}S^3 + \frac{a_1}{2}|\Phi|^2 S\,.$$



[ID170: CMS&ATLAS]

Indirect ONLY

FOPT Selection - $m_S = 300$ GeV, $b_3 = 0$ GeV, $b_4 = 0.25$



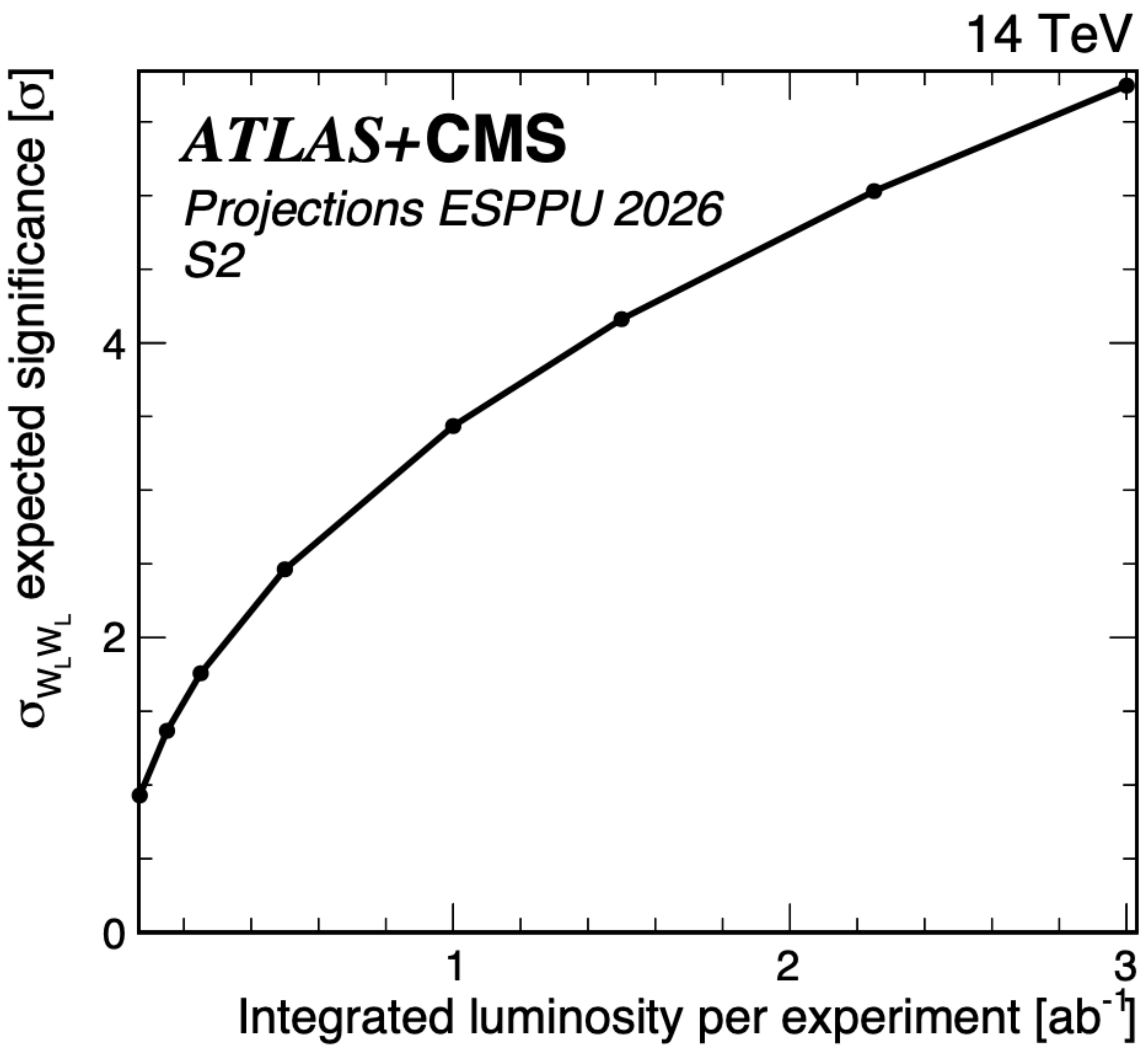
[ID170: CMS&ATLAS]

Indirect + Direct

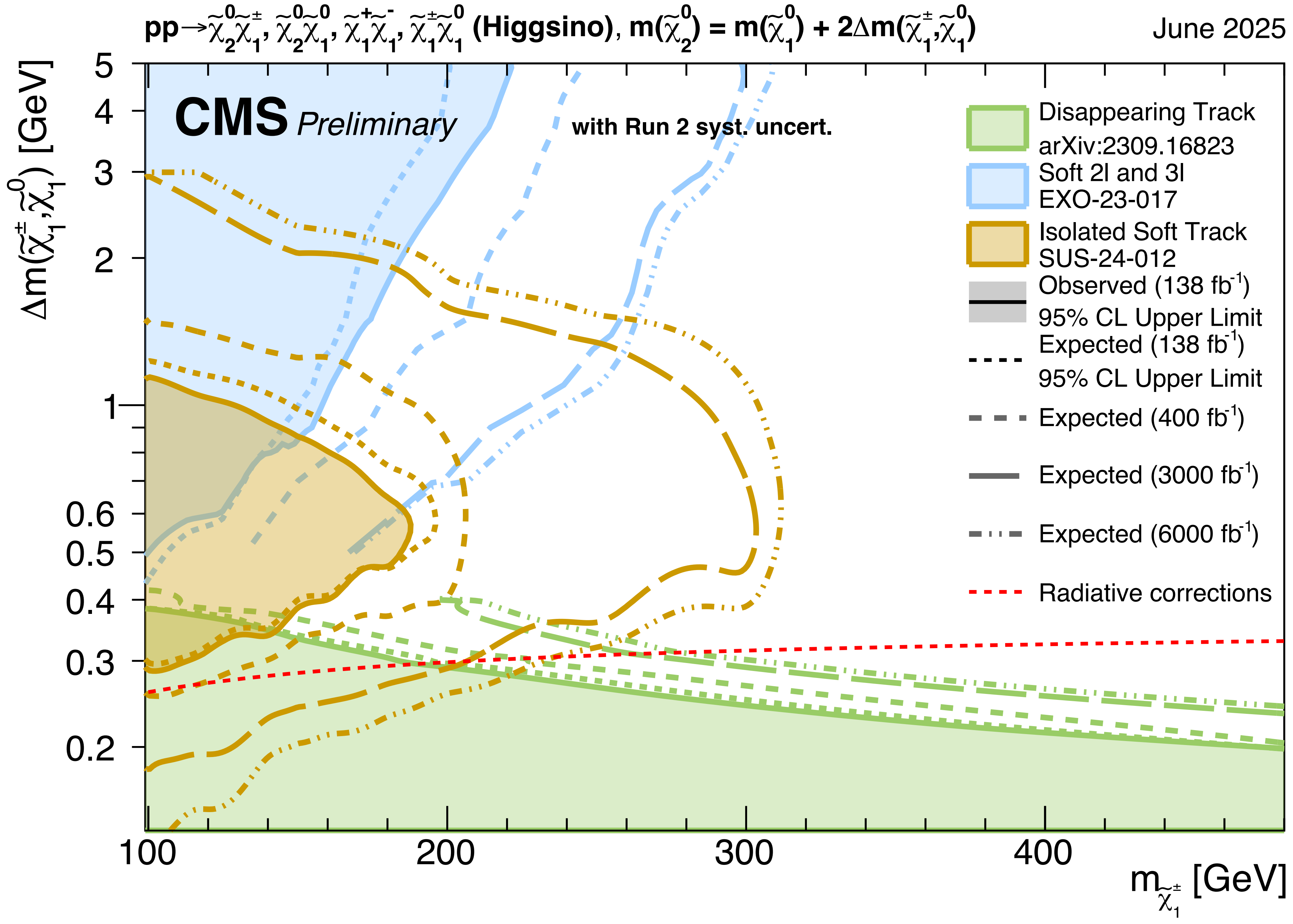
Can we exclude a strong 1st order phase transition within a model? ✓

Lessons from the HL-LHC

Questions with 3 inverse attobarns



[ID170: CMS&ATLAS]



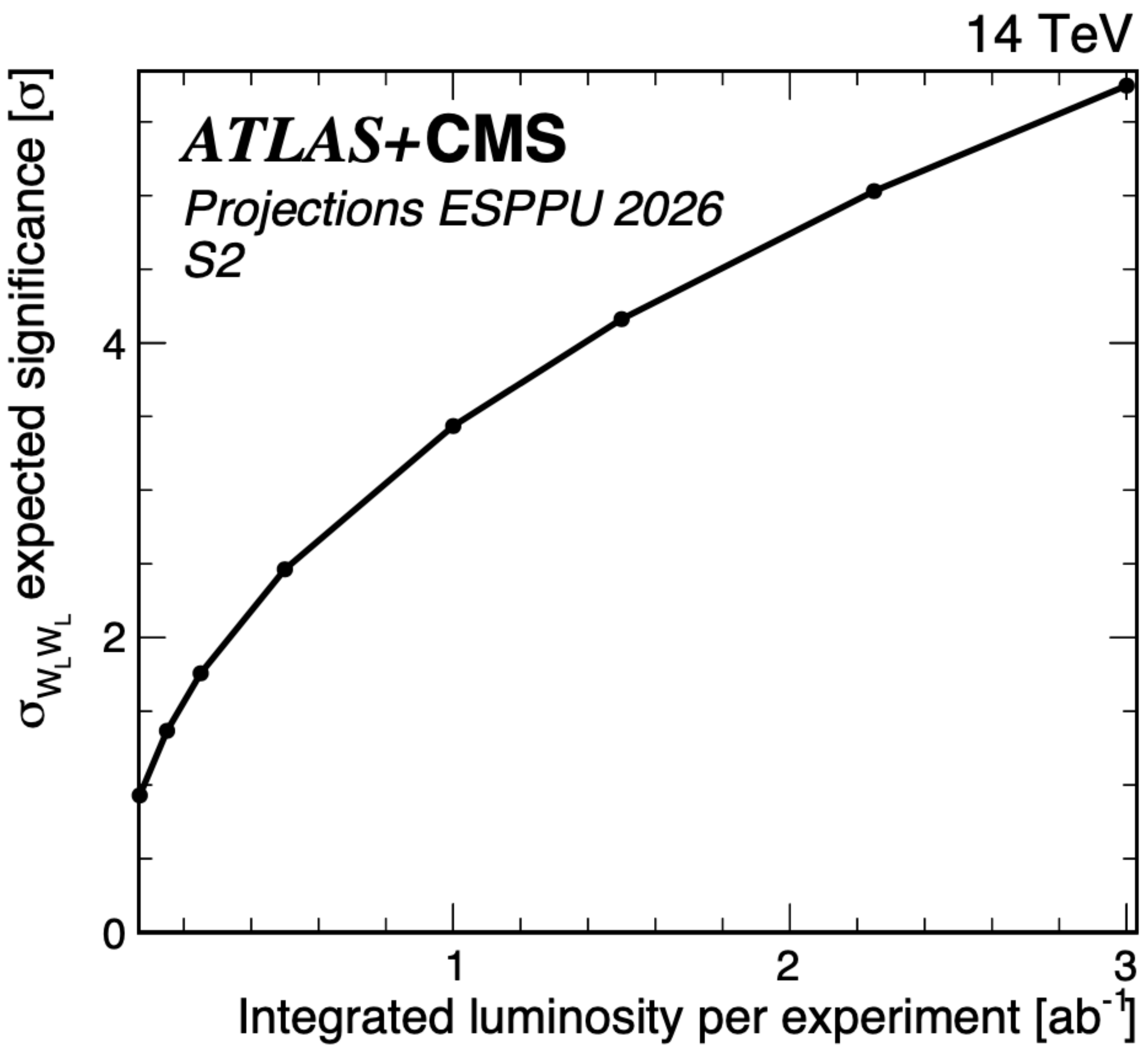
[CMS:EXO/EXO-23-017]

Can we observe EW restoration at the LHC? ✔

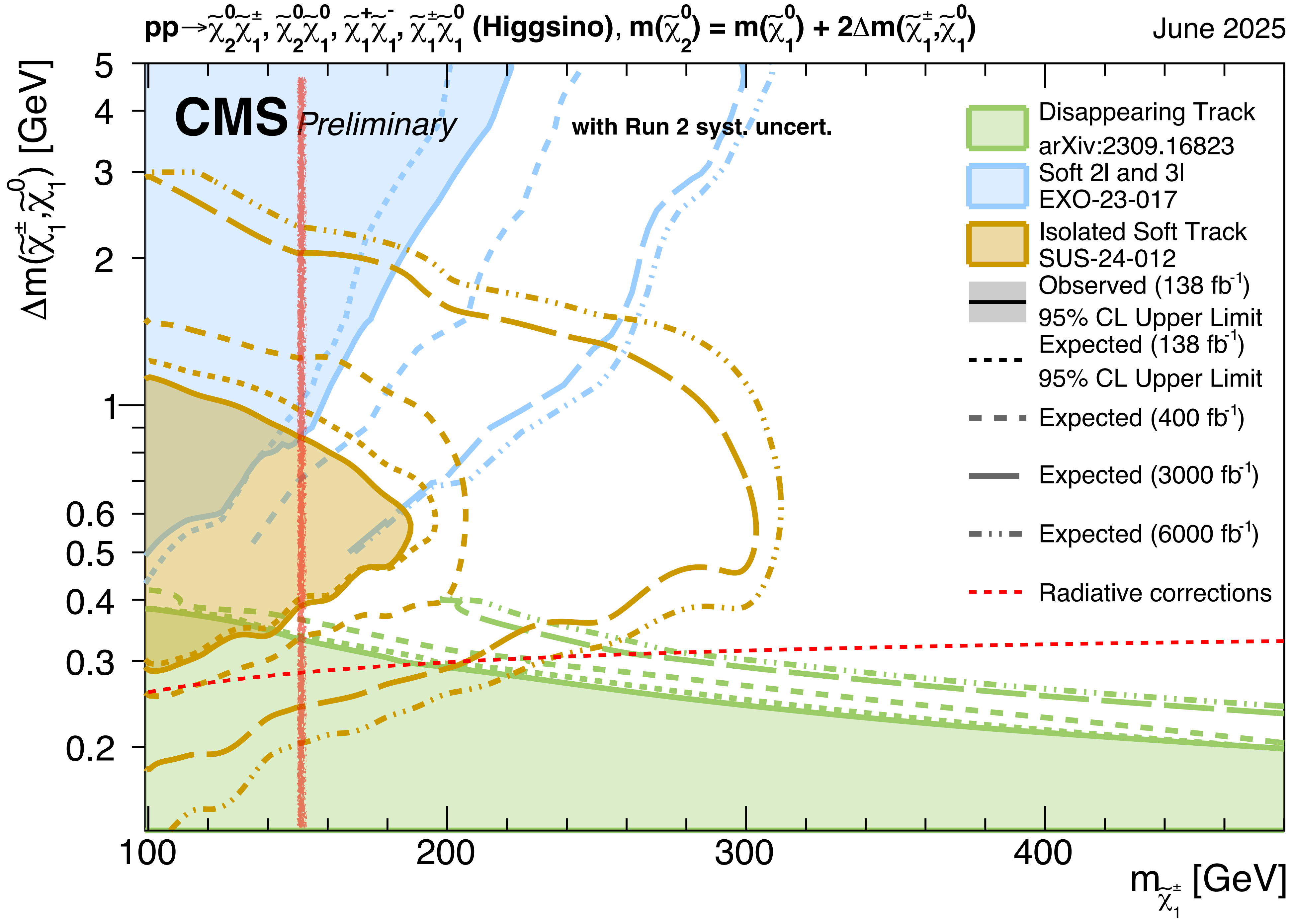
Can a relic Higgsino be excluded? X

Lessons from the HL-LHC

Questions with 3 inverse attobarns



[ID170: CMS&ATLAS]



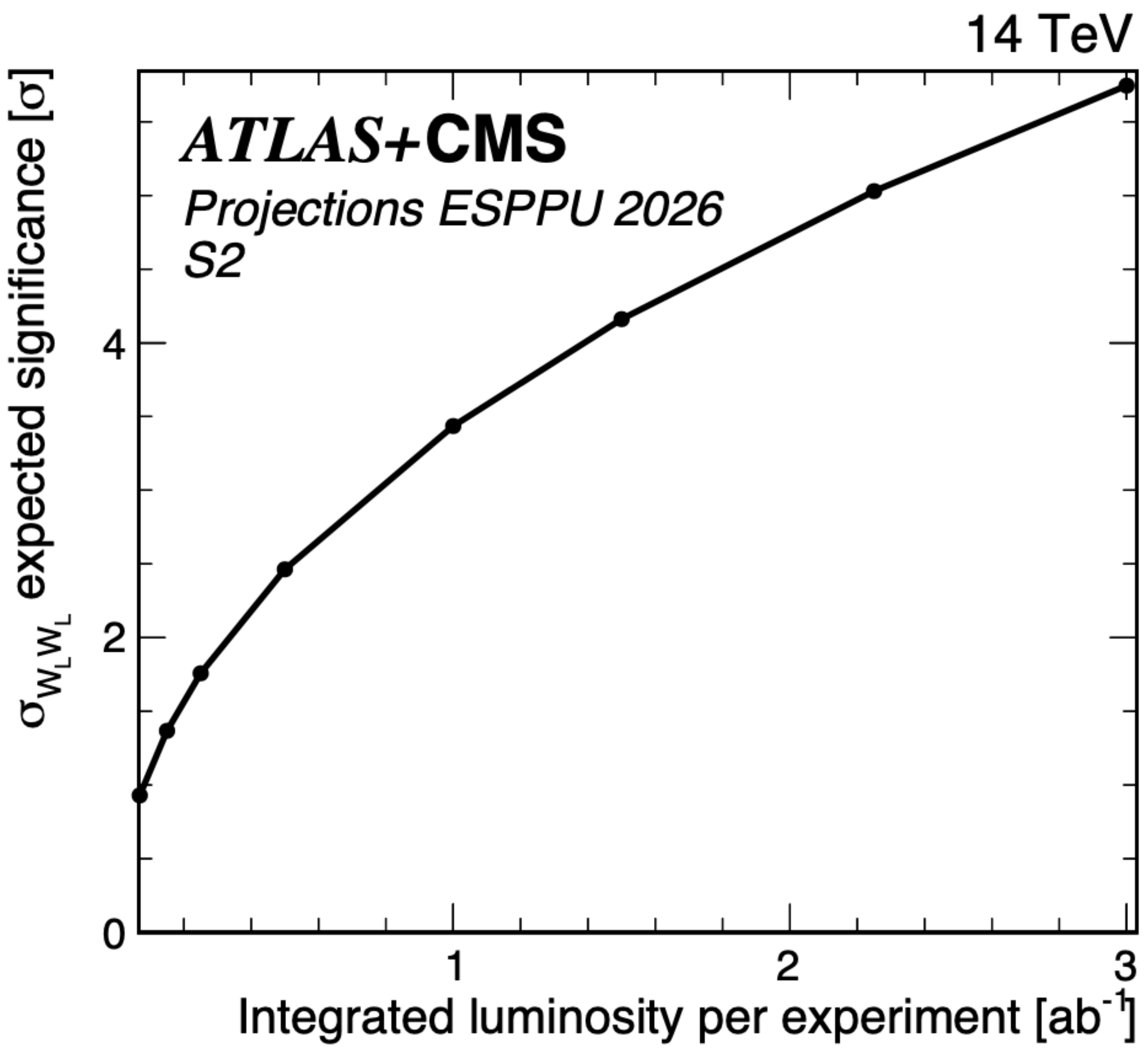
[CMS:EXO/EXO-23-017]

Can we observe EW restoration at the LHC? ✓

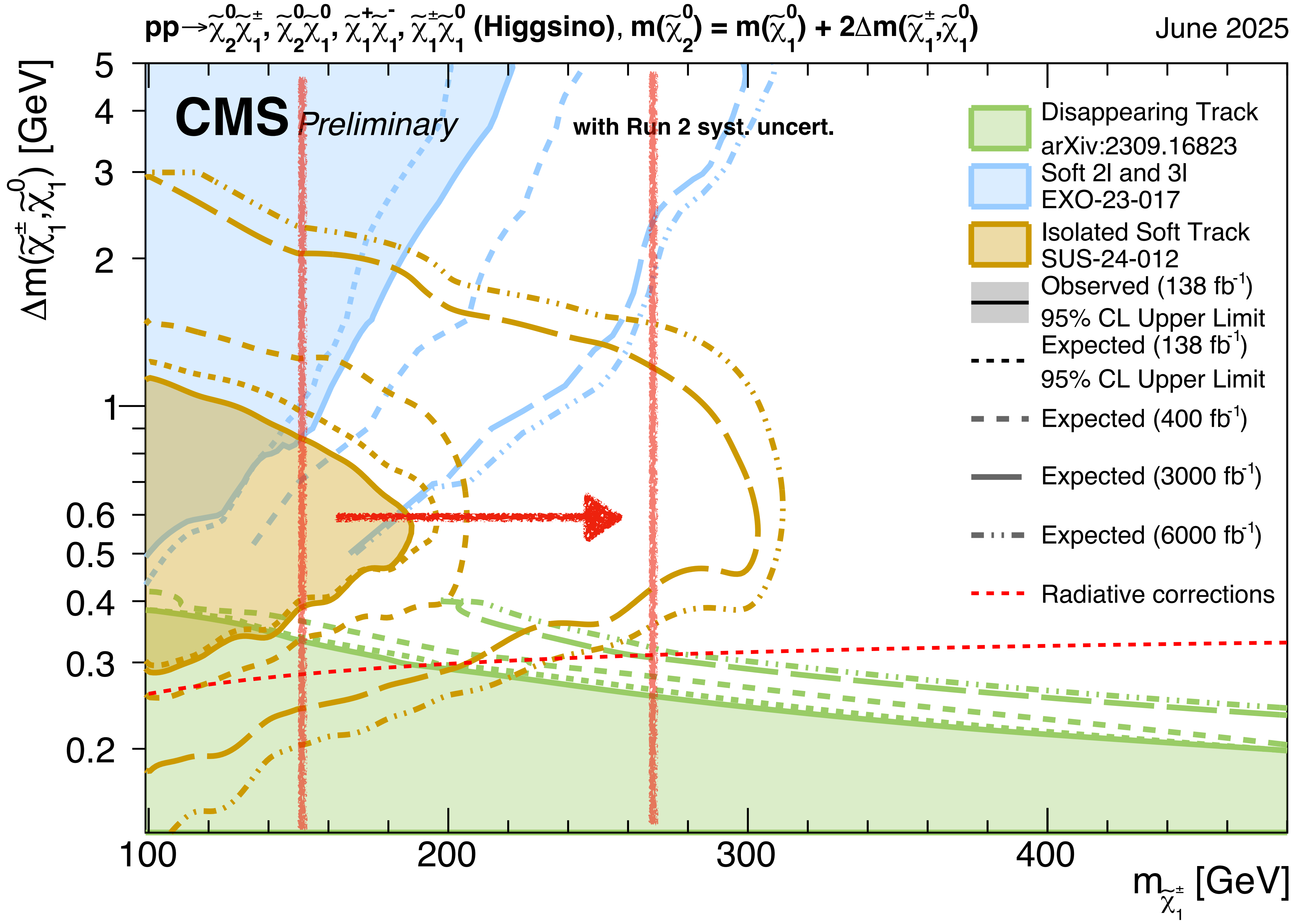
Can a relic Higgsino be excluded? X

Lessons from the HL-LHC

Questions with 3 inverse attobarns



[ID170: CMS&ATLAS]



[CMS:EXO/EXO-23-017]

Can we observe EW restoration at the LHC? ✔

Can a relic Higgsino be excluded? X

BSM WG

PPG BSM Group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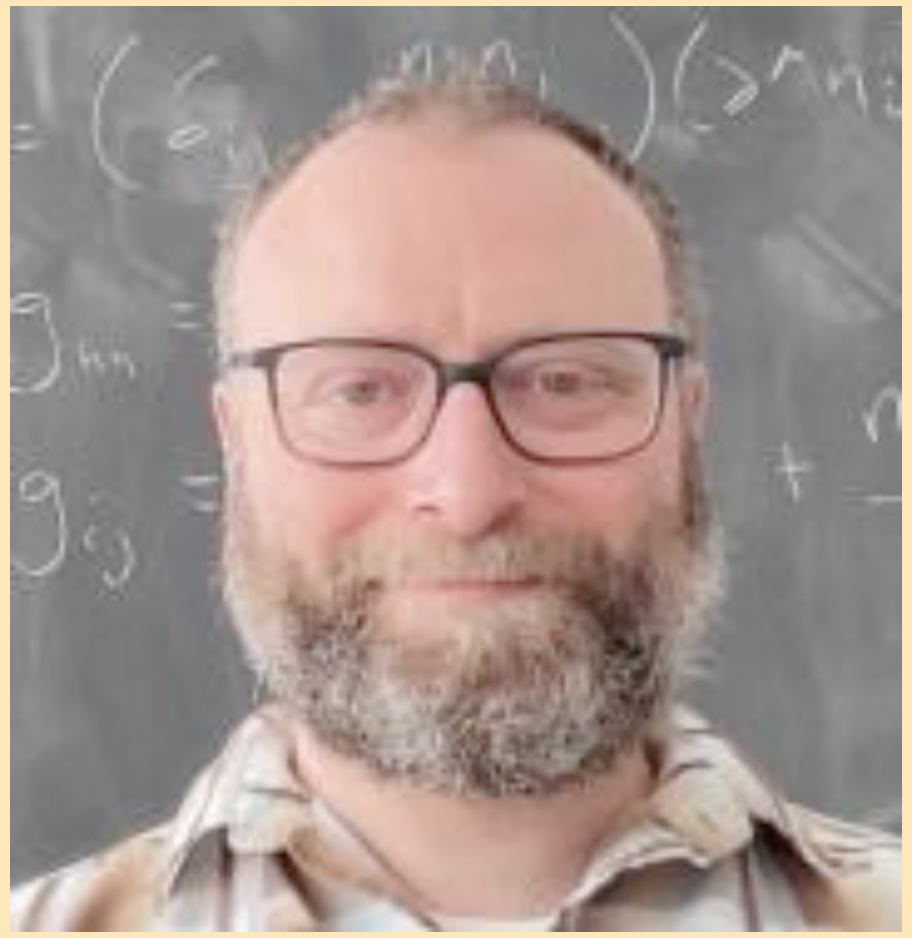


Sophie Renner (Glasgow)


Roberto Franceschini (Rome III)



Benedikt Maier (Imperial)


Rebeca Gonzalez Suarez (Uppsala)


Fabio Maltoni (UCLouvain/Bologna)

Mandate & inputs

The mandate of the BSM working group is to collect the information from the input to the strategy and explore the potential of on-going and future experiments to answer questions related to the existence of physics beyond the standard model.

Our group naturally overlaps with the activities of the WGs on Flavour, Electroweak, and Neutrino physics and cosmic messengers and DM and Dark sectors.

			Benchmark 1	Benchmark 2	Benchmark 3	Benchmark 4	Benchmark 5	Benchmark 6	Benchmarks 7-10
			Roberto & Aurelio	Roberto & Loukas	Nathaniel & Loukas	Tim & Annapaola	Sophie & Lesya	Nathaniel/Tim & Aurelio	Lesya + Annapaola + all th
#	Id	Link	New gauge forces	Compositeness	EWBG simple models	Thermal WIMP	Flavour/collider	SUSY/naturalness	The portals - Dark Photo
1	19	The Forward Physics Facility at the Large Hadron Collide							
2	21	Search for the electric dipole moment of the neutron wi							
3	23	Prospects and Opportunities with an upgraded FASER N							
4	27	Exploring the Dark Universe: A European Strategy for Ax							
5	37	Long-Baseline Atom Interferometry							
7	43	REDTOP: Rare Eta Decays TO Explore New Physics							
8	44	Proposal for a shared transverse LLP detector for FCC-ee							
9	46	Search for feebly interacting particles with the Lohengri							
10	50	Searching for Light Dark Matter and Dark Sectors with th							
12	55	Kaon Physics: A Cornerstone for Future Discoveries							
13	61	MATHUSLA: An External Long-Lived Particle Detector to							
14	71	CERN AD/ELENA Antimatter Program							
16	85	Higgs Criticality and the Metastability Bound: a target fo							
17	92	The LUXE Experiment							
19	100	Probing and Knocking with Muons							
20	109	Searching for millicharged particles with the FORMOSA							
21	113	Quantum Information meets High-Energy Physics: Input							
23	118	The DUNE Science Program							
25	130	Simplified Models Expose the Interplay of Direct an							
26	132	Input to the European Strategy for Particle Physics – KAT							
27	134	PSI European Strategy Input							
28	135	Neutrino Scattering: Connections Across Theory and Exp							
29	140	A Linear Collider Vision for the Future of Particle Ph							
30	141	The ECFA Higgs/Electroweak/Top Factory Study							
31	145	SHiP experiment at the SPS Beam Dump Facility							
34	158	Community input to the European Strategy on particle p							
35	164	Science of the LISA mission: A Summary for the Europea							
40	170	Highlights of the HL-LHC physics projections by ATLAS ar							
42	179	The HIBEAM/NNBAR program							
43	182	CONUS100: Precision neutrino physics with coherent ela							
46	188	LEP3: A High-Luminosity e+e− Higgs & Electroweak Fact							
47	190	Particle Physics at the European Spallation Source							
49	199	CODEX-b: Opening New Windows to the Long-Lived Part							
50	201	Statement of the Pierre Auger Collaboration as input for							
51	205	The Belle II Experiment at SuperKEKB							
52	207	The Muon Collider							
53	214	The Large Hadron electron Collider (LHeC) as a bridge pr							
54	215	A roadmap for astroparticle theory in Europe							
55	224	Community Support for Physics with high-luminosity pro							
56	225	The Project 8 Neutrino Mass Experiment							
57	227	Prospects for physics at FCC-hh							
60	232	The Short-Baseline Near Detector at Fermilab							
61	233	FCC Integrated Programme Stage 1: The FCC-ee							
62	234	Enhancing New Physics Searches with a Future Beam Du							
63	235	Summary Report of the Physics Beyond Colliders S							
65	239	Physics Prospects for a near-term Proton-Proton C							
66	241	The FCC integrated programme: a physics manifesto							
67	242	Prospects in BSM physics at FCC							
68	247	FCC Integrated Programme Stage 2: The FCC-hh							
69	250	Rich dark sectors							
70	251	Physics opportunities with high-brightness, high-intensit							
71	253	Input to the European Strategy for Particle Physics - 202							
74	261	FCC Integrated Programme: FCCee and FCChh							
75	267	Constraining the real scalar singlet extension of the SM							
77	273	2026 EPPSU input from the ANUBIS Collaboration							
78	274	Dark Matter Complementarity: from the Snowmass							
77	81	Discovery potential of LHCb Upgrade II							
64	68	Input from the ALICE Collaboration							

Choosing the focus

Even with the above scheme clear in mind, there could be many possibilities of summarising the BSM input:

1. By New Physics models
2. By showcasing specifically the strengths of each accelerator project
3. By focusing on specific signatures
4. By open fundamental questions
5. …

Our focus

We have chosen to focus on:

Specific questions that can be addressed through **new physics scenarios** which can be constrained or discovered at present and future experiments, also through multi-pronged approaches, putting together collider data in combination with different experiments or observations possibly at different scales.

In a few instances we have literally updated scenarios of the 2020 strategy.

(Open) Methodology

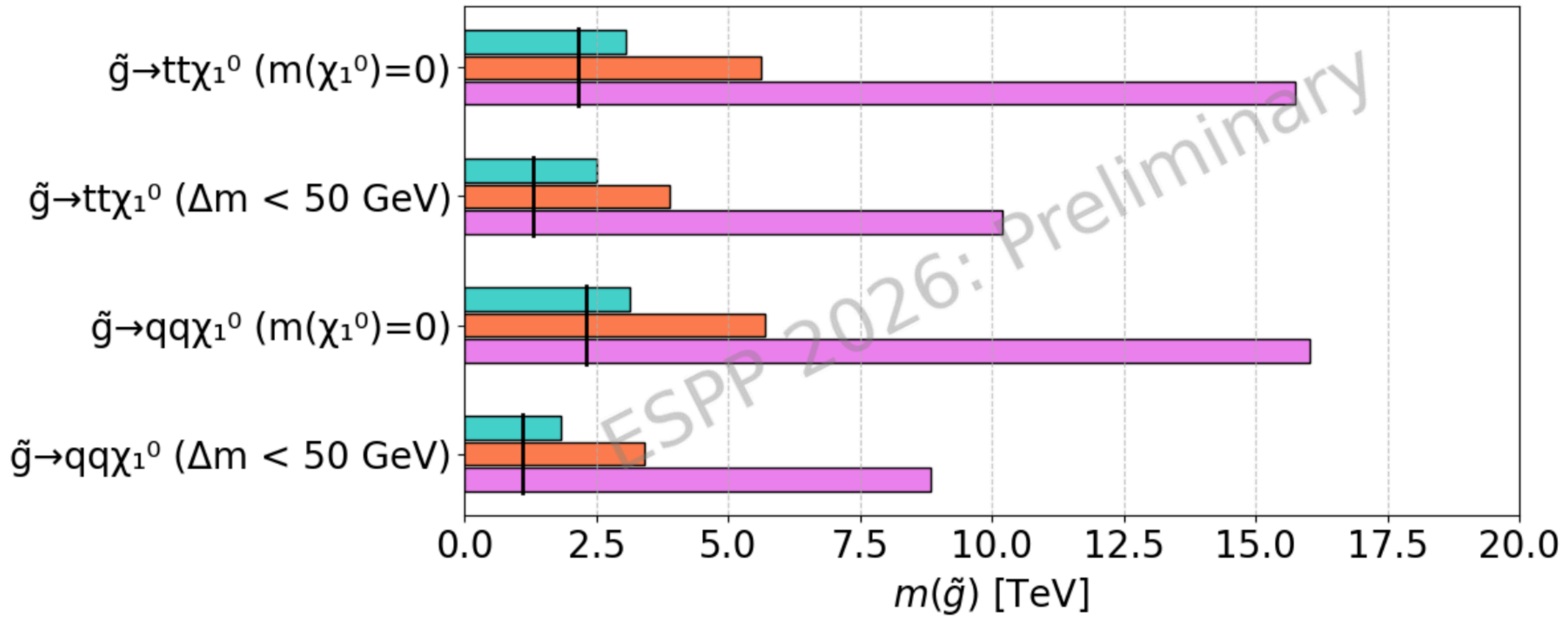
14 repositories

- HeavyDM Private · 0 · 0 · 0 · 0 · Updated 6 hours ago
- SUSY Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated 9 hours ago
- EWBG Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated 9 hours ago
- Yprime Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated yesterday
- Flavor Private · Mathematica · 0 · 0 · 0 · 0 · Updated yesterday
- DMDS-Plots Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated 2 days ago
- Quasi-elastic-DM Public · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated 2 days ago
- DarkScalar Private · 0 · 0 · 0 · 0 · Updated 2 days ago
- DarkPhoton Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated 2 days ago
- HNL Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated 2 days ago
- ALPs Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated 2 days ago
- Inelastic-DM Public · 0 · 0 · 0 · 0 · Updated 3 days ago
- WIMPs Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated last week
- templates Private · Jupyter Notebook · 0 · 0 · 0 · 0 · Updated last month

In order to compile the comparison plots we have collected the input data, the python notebook, and a description in GitHub repository to be made public.

Great collaboration with DMDS/Neutrino/EW/Flavour WGs

```
plt.xlabel(r"$m(\tilde{g})$ [TeV]", fontsize=20)
plt.yticks(y_pos, methods, fontsize=20)
plt.xticks(fontsize=20)
plt.grid(axis='x', linestyle="--", alpha=0.7)
first = plt.legend(handles=top_handles, loc='upper center', bbox_to_anchor=(0.5, -0.18), ncol=3, frameon=False,
second = plt.legend(handles=bottom_handles, loc='upper center', bbox_to_anchor=(0.5, -0.28), ncol=2, frameon=Fal
plt.gca().add_artist(first)

#Not needed for Venice
# Add the image as an inset
#img = mpimg.imread('espp_logo.png')
# Get the current axes object
ax = plt.gca()
# The arguments to inset_axes are [x, y, width, height] in fractions of the parent axes.
#ax_inset = ax.inset_axes([0.76, -0.03, 0.3, 0.3]) # Adjust position and size as needed
#ax_inset.imshow(img)
#ax_inset.axis('off') # Hide axes for the inset image

ax.set_xlim(0, 20)

# Add the diagonal text with gray color and transparency
plt.text(10, 1.5, 'ESPP 2026: Preliminary', fontsize=40, color=(0.5, 0.5, 0.5, 0.4), # Gray color with alpha for
         rotation=27, ha='center', va='center')

plt.tight_layout()
plt.savefig('SUSY_gluino.png', dpi=300, bbox_inches='tight')

plt.show()
```



Benchmarks

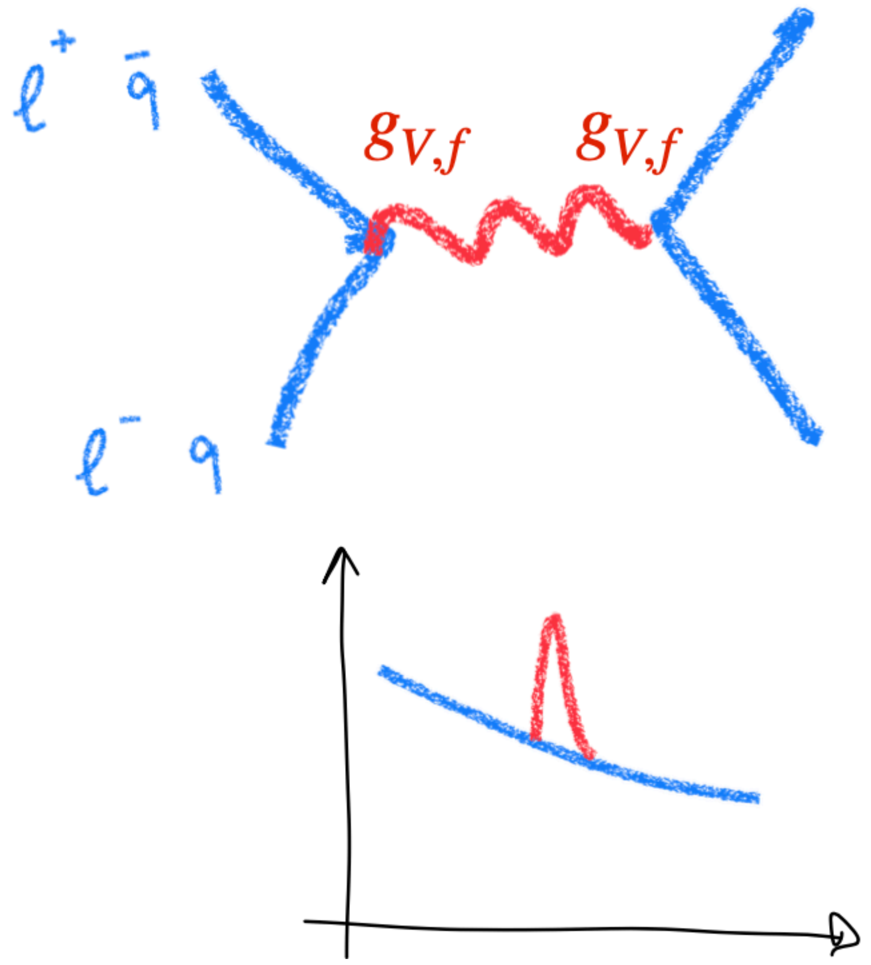
Questions and scenarios

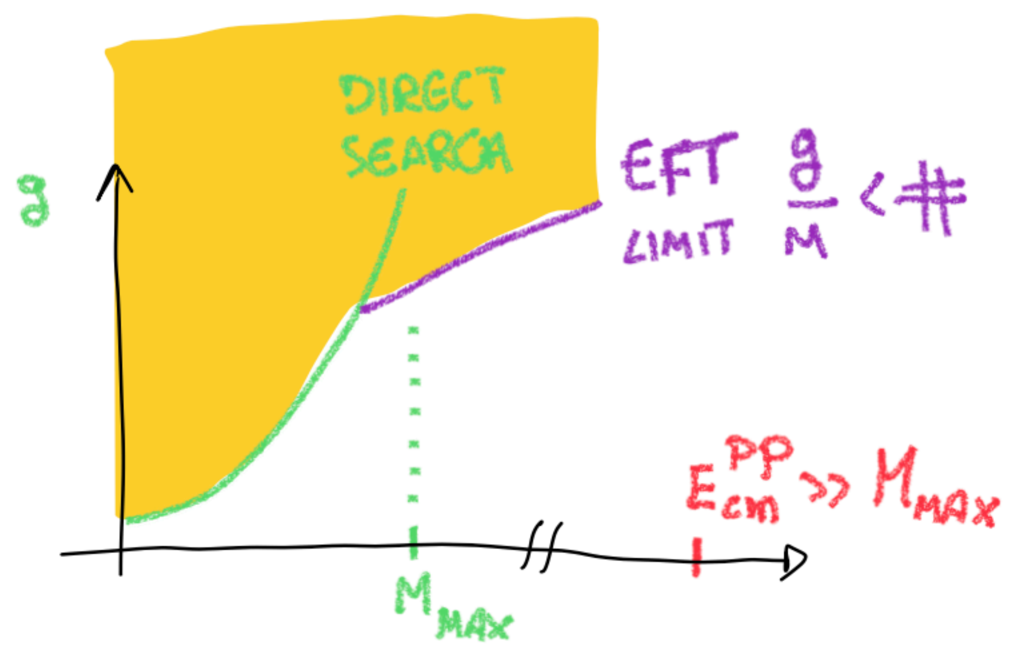
#	Question	Model	Method
1	Are there new gauge forces?	Z'	Direct and indirect
2	Are the heaviest particles of the SM elementary?	SILH	Indirect
3	Can we understand the EW phase transition?	Singlet and simplified models	Direct and indirect
4	Can we discover a WIMP?	Minimal DM	Direct and indirect
5	Are solutions to the flavour problem visible at high-Q2?	Leptoquarks, top FCNC	Direct and indirect
6	Do symmetries exist that protect the Higgs?	SUSY	Direct
7	Is the SM alone in the Universe?	Simplified model	Energy and Intensity

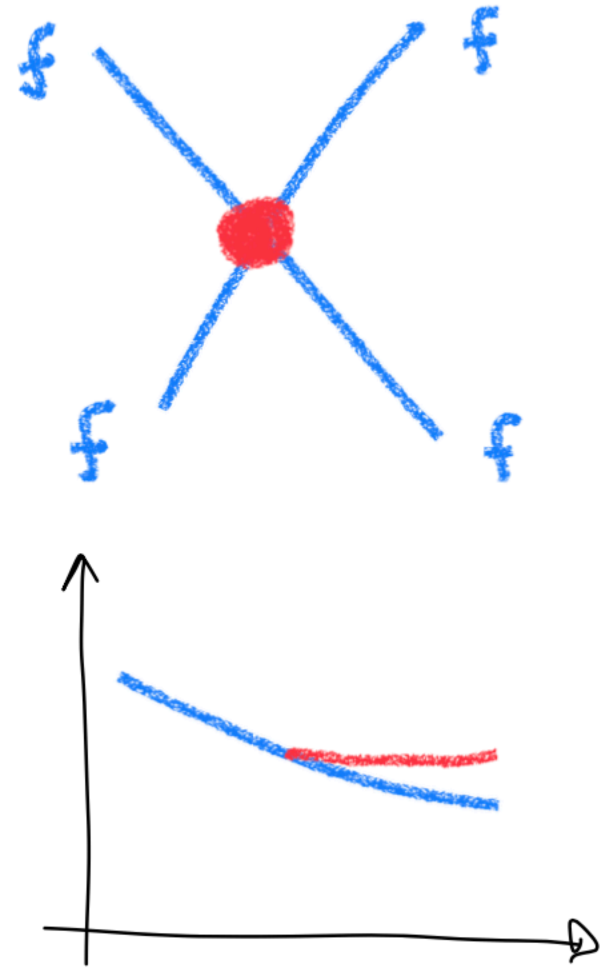
Questions and scenarios

#	Question	Model	Method
1	Are there new gauge forces?	Z’	Direct and indirect

- Important benchmark: origin of ν masses in B-L, DM portal, typically very interesting experimental signatures.
- It links to the dark photon portal signatures.
- Probe of the interplay between direct and indirect searches We received input for a limited number of scenarios often not overlapping.



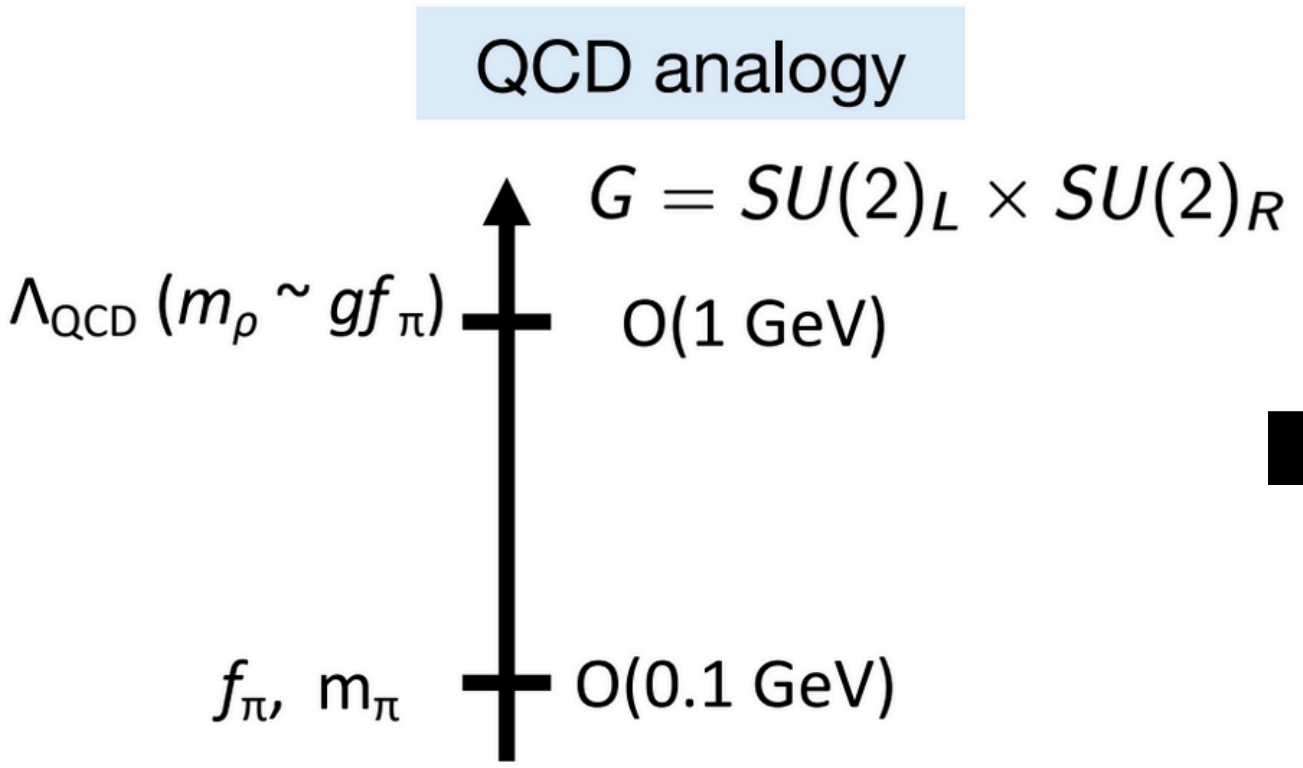


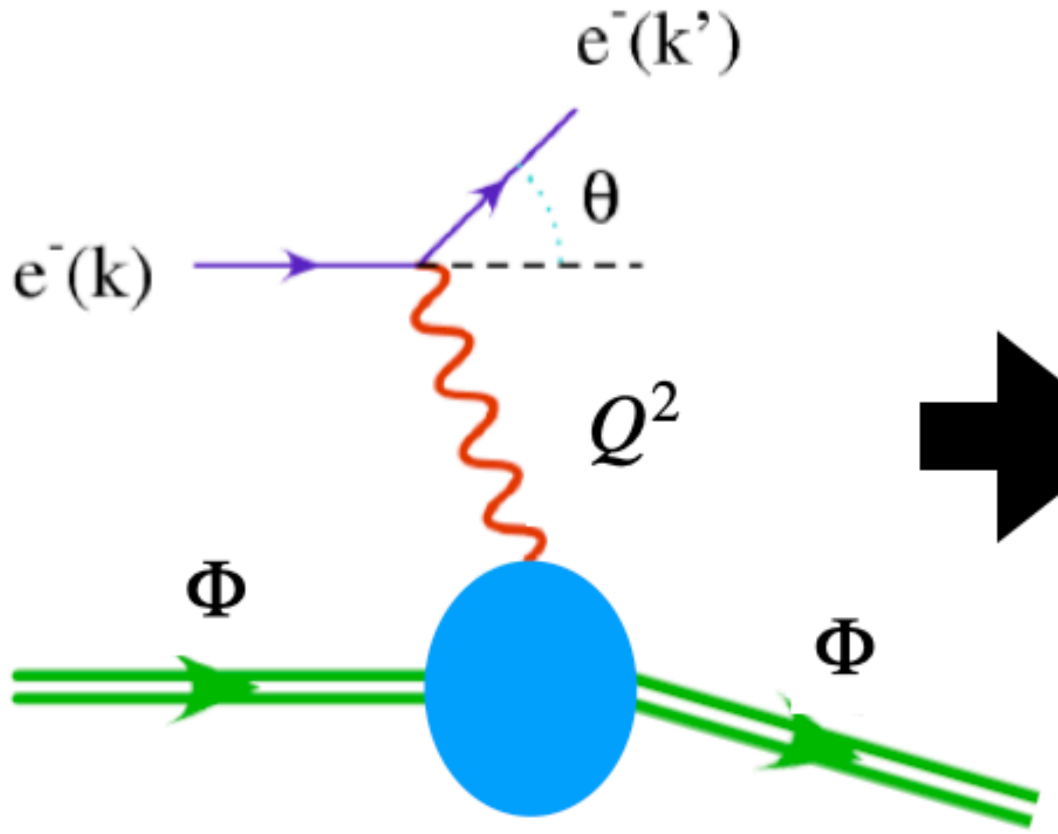


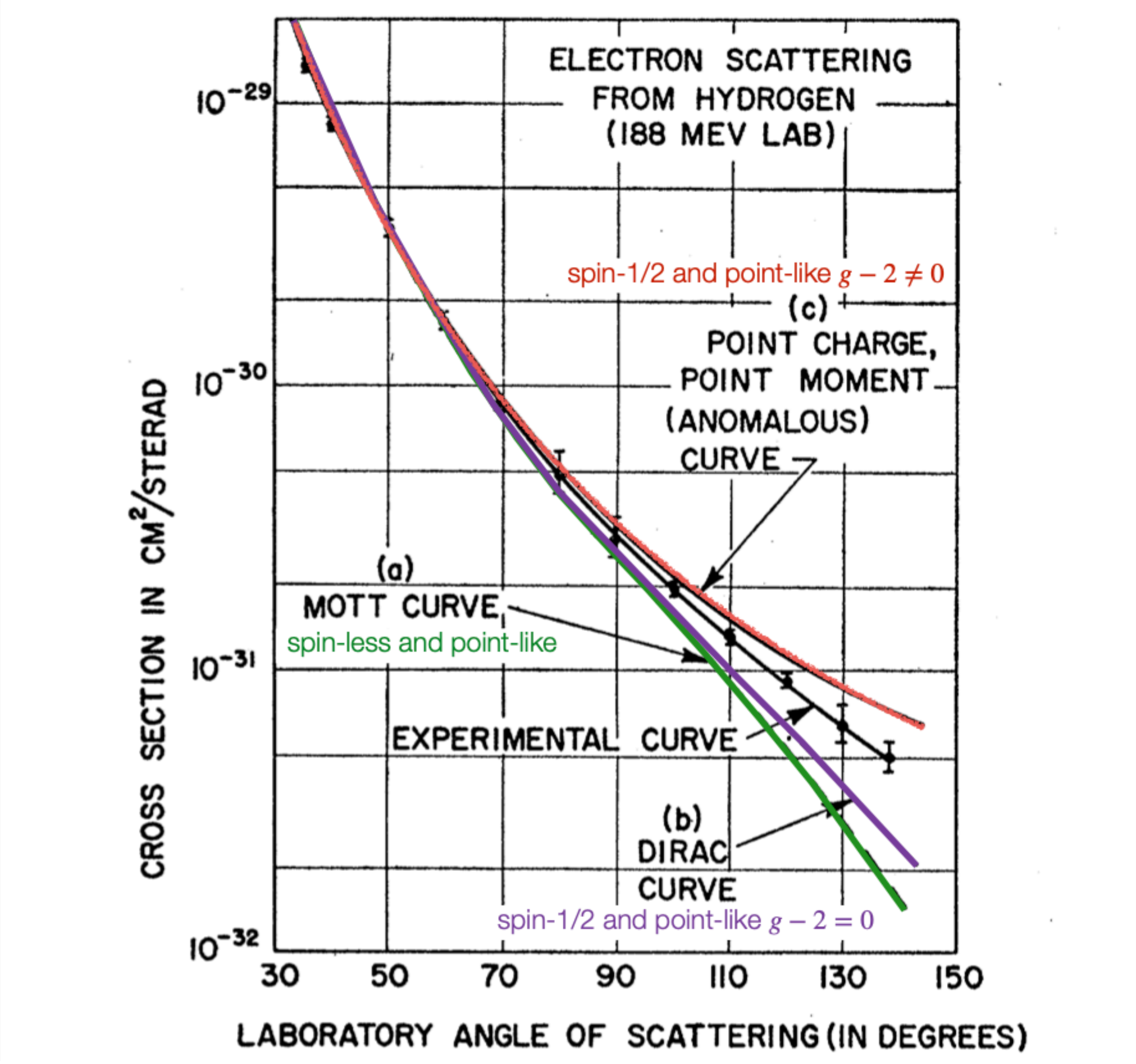
4

Questions and scenarios

#	Question	Model	Method
2	Are the heaviest particles of the SM elementary?	SILH	Indirect





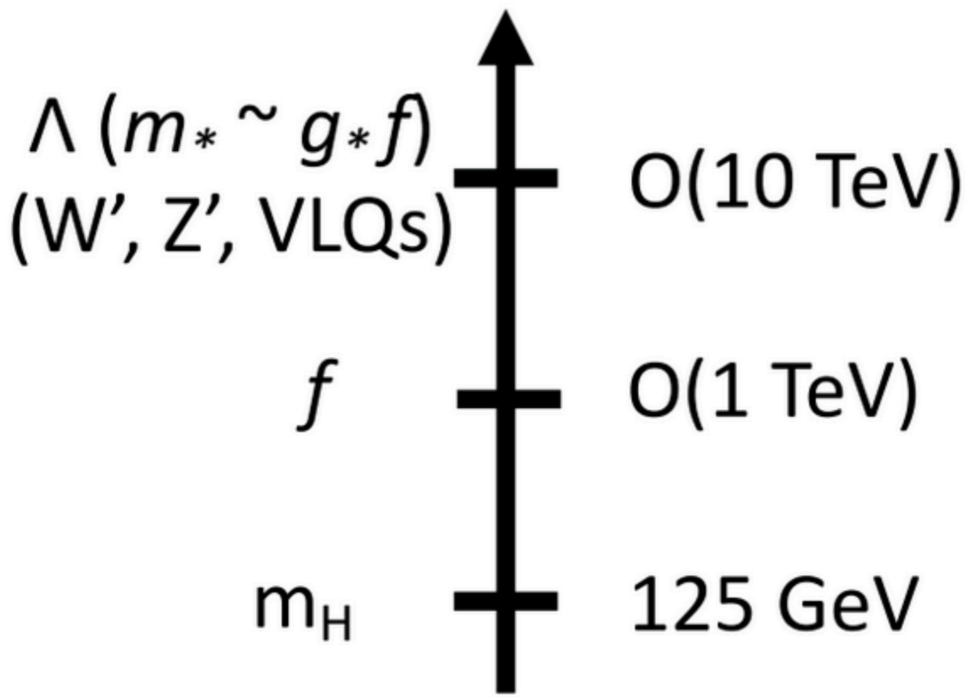


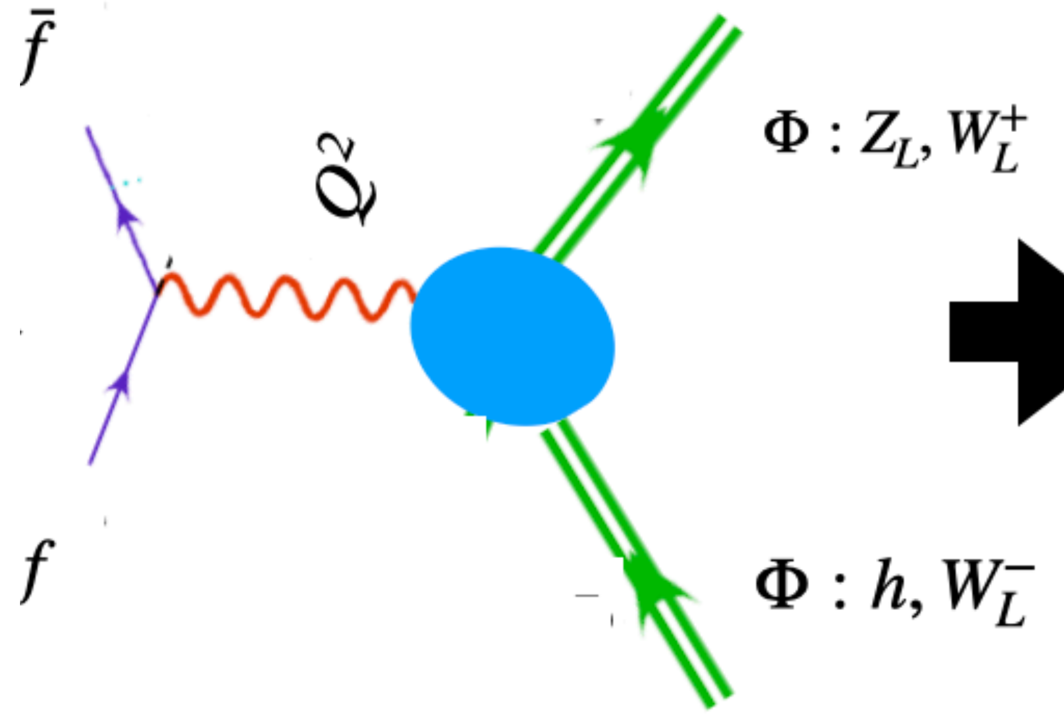
Quintessential indirect approach

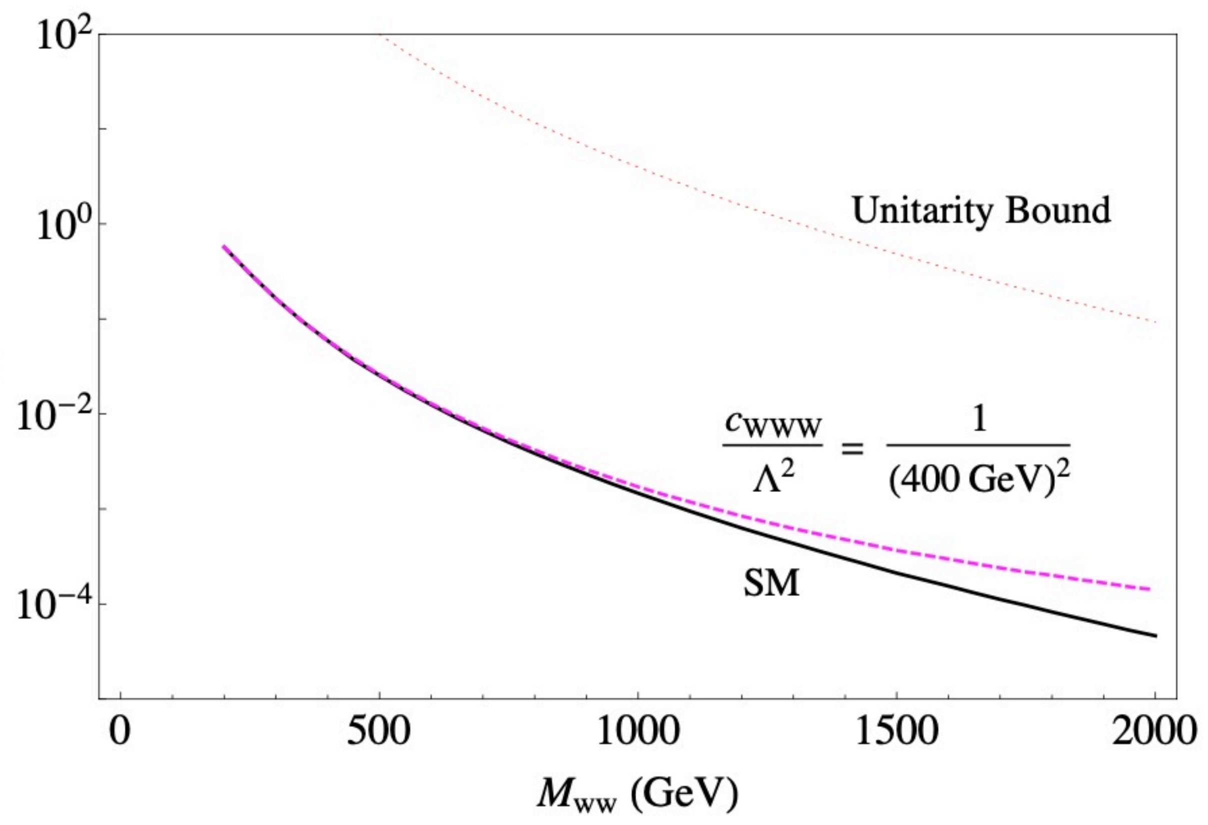
Questions and scenarios

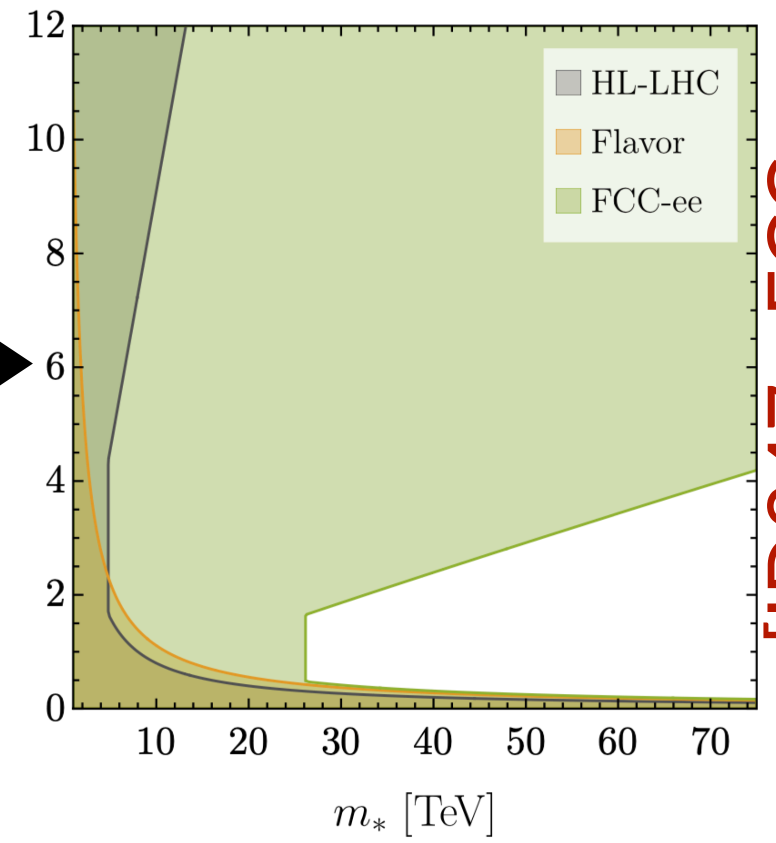
#	Question	Model	Method
2	Are the heaviest particles of the SM elementary?	SILH	Indirect

Composite Higgs









[ID247 : FCC

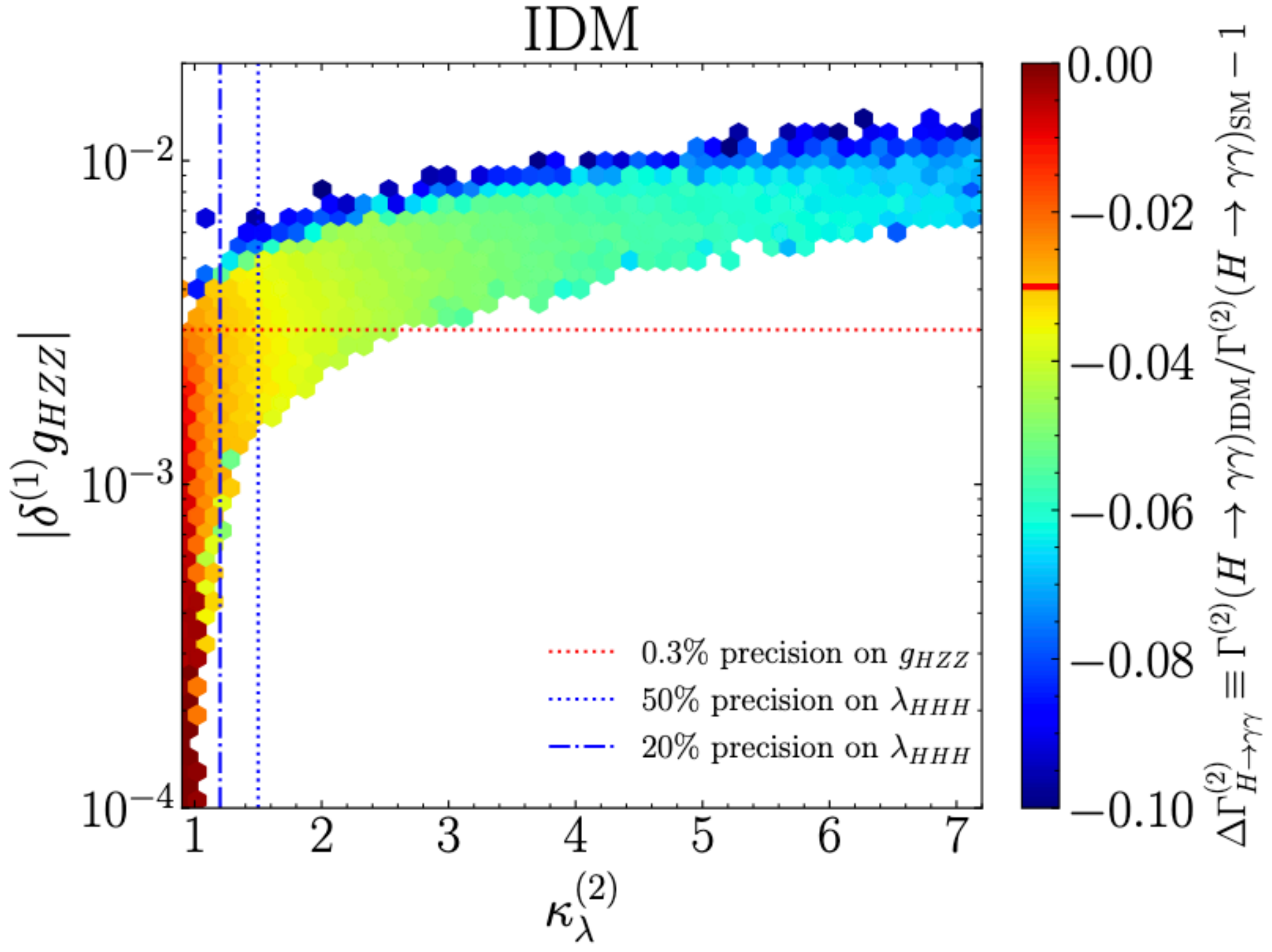
- Results given in a plane (M^*, g^*). These models predict new resonances that can be also searched directly.
- New scenarios considered, including RG running effects.

Questions and scenarios

#	Question	Model	Method
3	Can we understand the EW phase transition?	Singlet and simplified models	Direct and indirect

- The problem of EWBG in the standard model. Tied to accurate measurement of the Higgs-self coupling.
- Discussed in all collider inputs.
- New physics model realisations that can be constrained also by direct measurements.
- We choose a simple, yet sufficiently rich, scenario to perform a study of the various constraints, including the HL-LHC.

[ID140 : A LC vision]

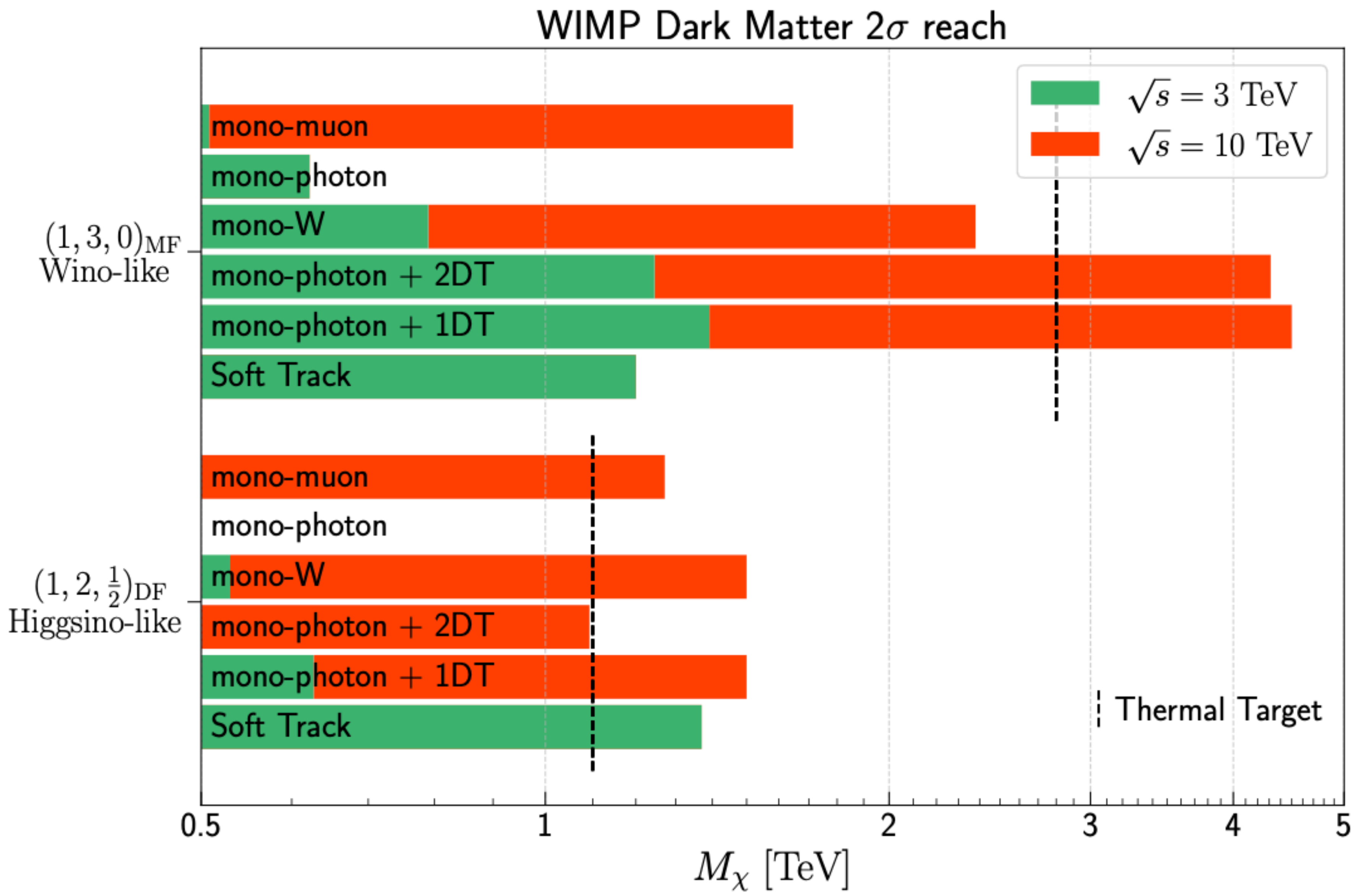


$$V(\Phi, S) = -\mu_H^2|\Phi|^2 + \lambda_H|\Phi|^4 + b_1 S - \frac{\mu_S^2}{2}S^2 + \frac{b_4}{4}S^4 + \frac{a_2}{2}|\Phi|^2S^2 + \frac{b_3}{3}S^3 + \frac{a_1}{2}|\Phi|^2 S\,.$$

Questions and scenarios

#	Question	Model	Method
4	Can we discover a WIMP?	Minimal DM	Direct and indirect

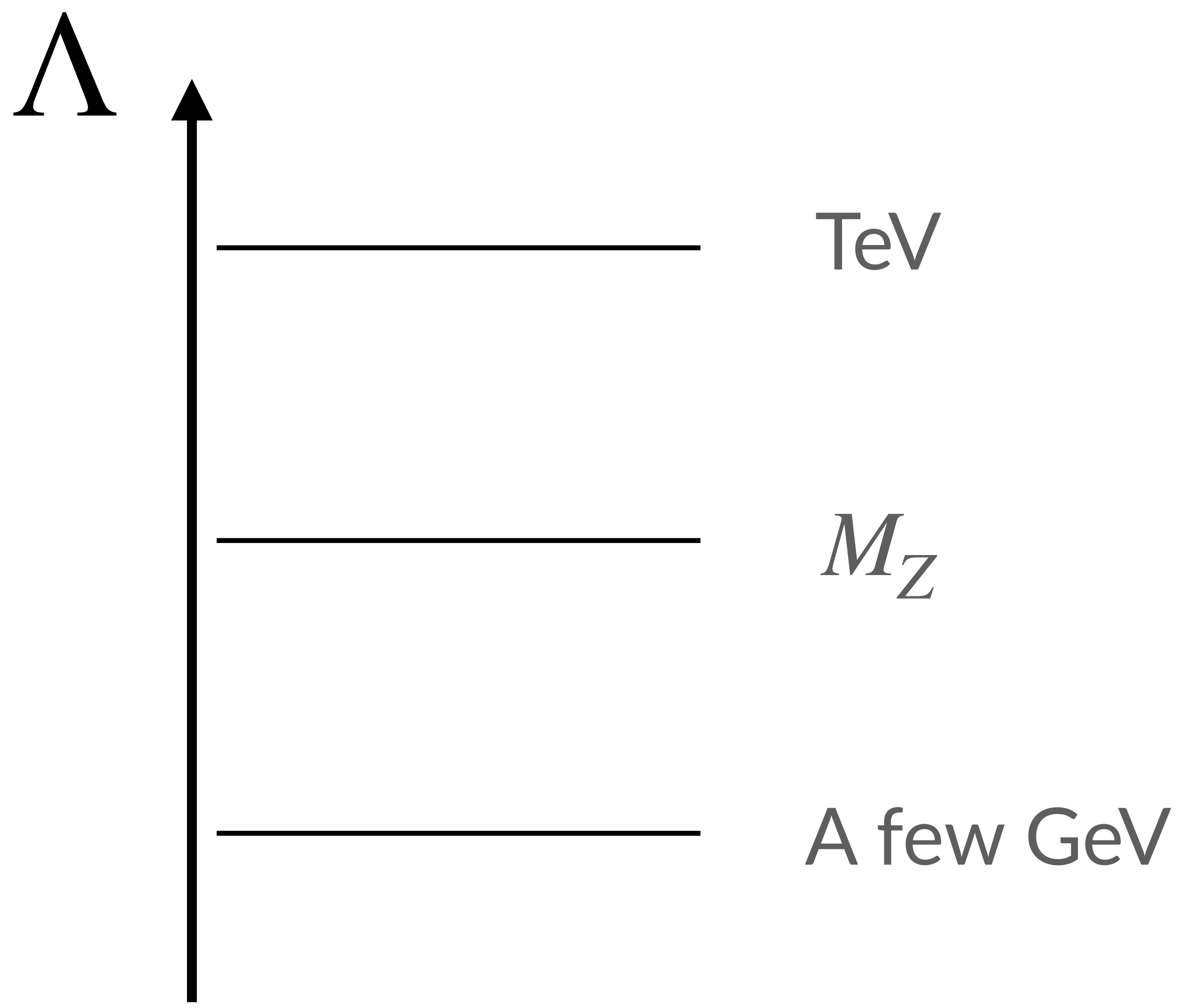
- In collaboration with the DMDS WG
- Minimal DM
- A variety of signatures at colliders



[ID207 : Meloni et al.]

Questions and scenarios

#	Question	Model	Method
5	Are solutions to flavour problem directly accessible at high Q2?	Leptoquarks, top FCNC	Direct and indirect



- In collaboration with the flavour WG
- Unique probe of the interplay between flavour, EWPO and direct searches

Questions and scenarios

#	Question	Model	Method
6	Do symmetries exist that protect the Higgs?	SUSY and CH	Direct

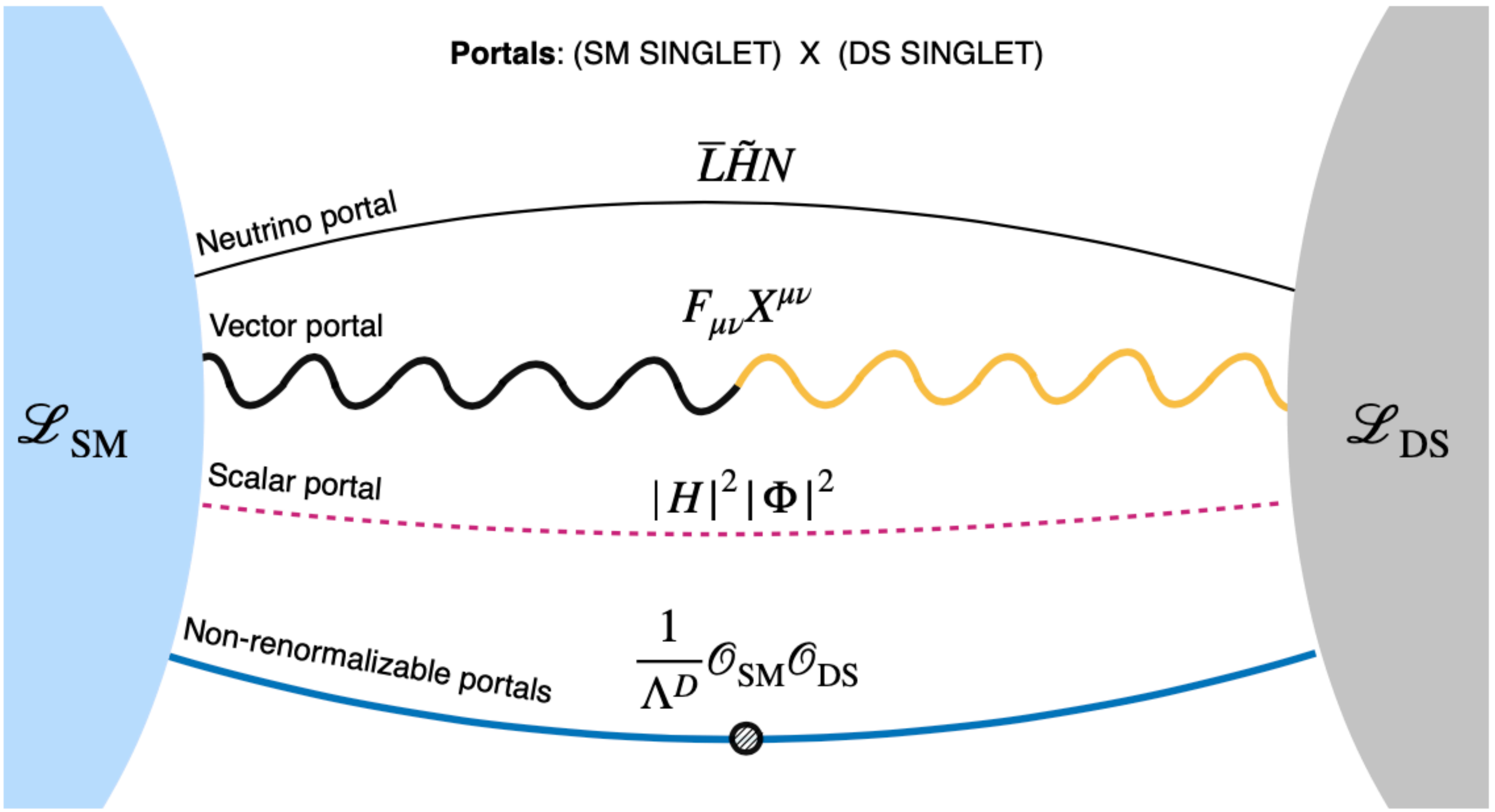
- In connection with the naturalness problem
- SUSY is still the best TH framework for UV model building exploration
- SUSY has also been used as a signal generator
- Other symmetries

	γ	ℓ	τ	j	t	W	Z	h	E_T
γ	H,A						H		χ^0_1
ℓ		RPV	RPV	RPV	RPV				$\tilde{\ell}$
τ			H,A	RPV	RPV				$\tilde{\tau}$
j				H,A	RPV				$\tilde{q}$
t					H,A				$\tilde{t}$
W						H		$H^\pm$	$\chi^\pm$
Z							H	A	$\tilde{h}$
h								H	$\tilde{h}$
E_T									h

- *disappearing tracks*
- *R-hadrons*
- *HSCPs*
- *displaced photons*
- *....*

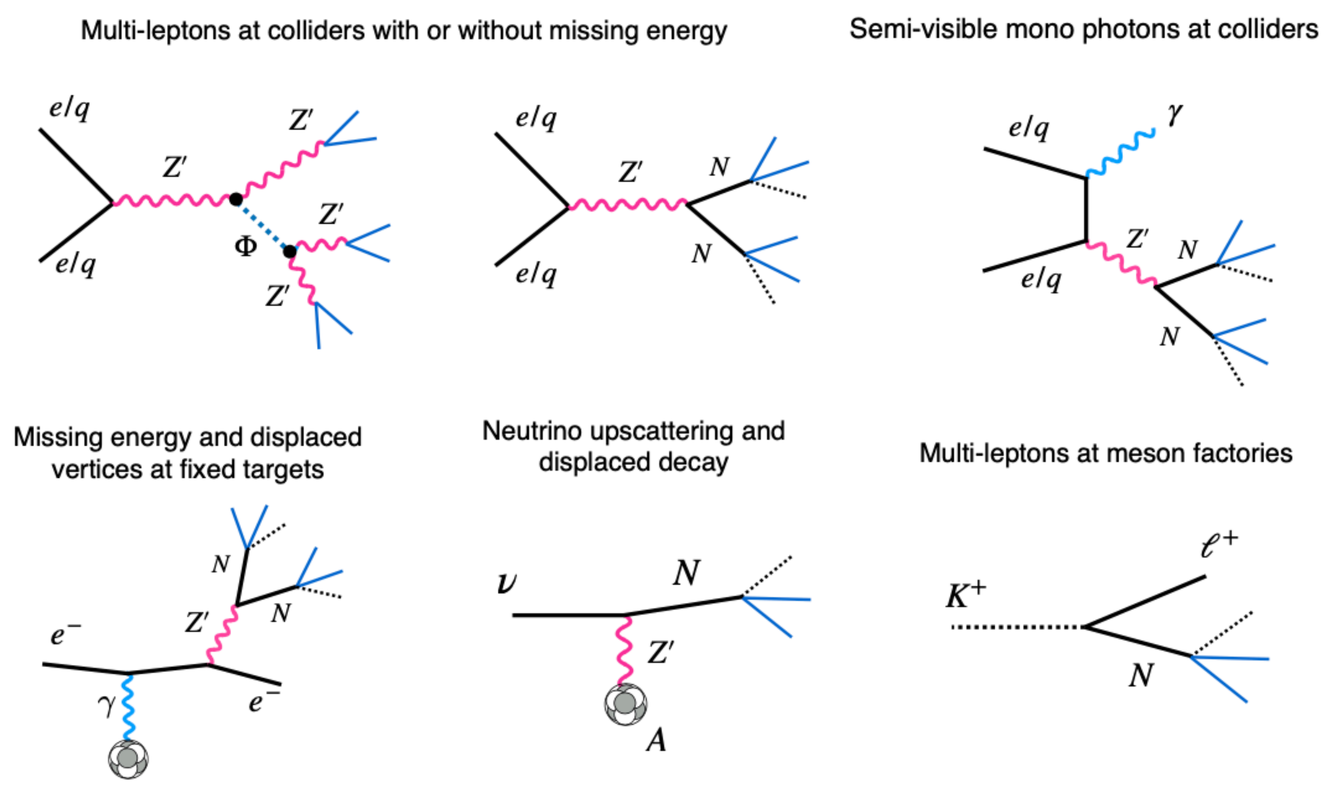
Questions and scenarios

#	Question	Model	Method
7	Is the SM alone in the Universe?	Simplified model	Energy and Intensity



[ID250 : Rich sectors]

Note that in realistic BSM extensions, more than one portal is activated and the phenomenology becomes more intricate (rich!)



The current approach is to simplify the matters and consider one portal at the time.

Questions and scenarios

#	Question	Model	Method
1	Are there new gauge forces?	Z’	Direct and indirect
2	Are the heaviest particles of the SM elementary?	SILH	Indirect
3	Can we understand the EW phase transition?	Singlet and simplified models	Direct and indirect
4	Can we discover a WIMP? $\phi\phi$	Minimal DM	Direct and indirect
5	Are solutions to the flavour problem visible at high-Q2?	Leptoquarks, top FCNC	Direct and indirect
6	Do symmetries exist that protect the Higgs?	SUSY	Direct
7	FF portal: search for dark photons	Simplified model	Energy and Intensity
8	phi.phi portal: search for dark scalars	Simplified model	Energy and Intensity
9	PQ-inspired states: reach for a ALP scalar	Simplified model	Energy and Intensity
10	L.phi portal: reach for a HNL	Simplified model	Energy and Intensity

Summary

- The search for phenomena that go beyond the SM is one of the main drivers of the field of HEP.
- We do not have a clear indication or rock-solid theoretical argument on where new physics necessary to address open fundamental issues demands lies.
- As we will see, already for a limited number of questions the number of signatures and possibilities is very rich.
- A future collider programme is needed that can fully leverage on precision and energy, covering the widest range of observables at different scales, (below, at and above the weak scale), and that can significantly sharpen our knowledge of SM phenomena.