Outcome of ESPPU symposium at Venice

Justine Serrano – Ana Teixeira

With slides stolen from Marie-Hélène Schune, Tim Gershon, Karl kacobs,...

ESPP – 2026 update

- Update of the previous strategy defined in 2020. Process initiated by the CERN council. Driven by the **European Strategy Group** **(ESG),** chaired by Karl Jakobs.

- **Goal**: 'The Strategy should aim to develop a visionary and concrete plan that greatly advances knowledge in fundamental physics through the realisation of the next flagship project at CERN. This plan should attract and value international collaboration and allow Europe to continue to play a leading role in the field.
  Regarding a future collider project, the Strategy update should include the preferred option for the next collider at CERN and prioritised alternative options to be pursued if the preferred plan turns out not to be feasible or competitive.'

- More information about the process here: https://europeanstrategyupdate.web.cern.ch/

Timeline for the update of the European Strategy for Particle Physics

French HEP community input : https://arxiv.org/pdf/2504.08759
CEA and CNRS contribution by A. Petit and F. Jacq

Physics preparatory group

- 9 working groups
- organized parallel sessions at the symposium and plenary talks/discussion
- prepared the "Briefing Book", based on the input it gathers from the community:

https://cds.cern.ch/record/2944678

Working Group			
	Co-convener (PPG member)	Co-convener	Scientific Secretary
Electroweak physics	Monica Dunford (DE, exp)	Jorge de Blas (ES, theory)	Emanuele Bagnaschi (IT)
Strong interactions	Cristinel Diaconu (FR, exp)	Andrea Dainese (IT, exp, HI)	Chiara Signorile-Signorile (DE)
Flavour physics	Gino Isidori (CH, theory)	Marie-Hélène Schune (FR, exp)	Maria Piscopo (NL)
BSM physics	Fabio Maltoni (BE/IT, theory)	Rebeca Gonzalez Suarez (SE, exp)	Benedikt Maier (UK)
Neutrino physics and cosmic messengers	Pilar Hernandez (ES, theory)	Sara Bolognesi (FR, exp)	Ivan Esteban (ES)
Dark matter and dark sector	Jocelyn Monroe (UK, exp)	Matthew McCullough (CERN, theory)	Yohei Ema (CERN)
Accelerator science and technology	Gianluigi Arduini (CERN, acc)	Phil Burrows (UK, exp, acc)	Jacqueline Keintzel (CERN)
Detector instrumentation	Thomas Bergauer (AT, exp)	Ulrich Husemann (DE, exp)	Dorothea vom Bruch (FR)
Computing	Tommaso Boccali (IT, exp, comp)	Borut Kersevan (SL, exp, comp)	Daniel Thomas Murnane (DK)

- https://agenda.infn.it/event/44943
- > 600 participants

	Monday	Tuesday	Wednesday	Thursday	Friday
09:00	Opening Session	Large-scale accelerator projects at CERN, part I	Electroweak Physics Talks (i), (ii) Discussion	BSM Talks (i), (ii) Discussion	Overarching topics (by ESG Working groups) e.g. National input and others
	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
11:15	Parallel 1 | Parallel 2 | Parallel 3 | Parallel 4 | Parallel 5	Large-scale accelerator projects at CERN, part II	Strong Interactions Talks (i), (ii) Discussion	Dark Matter / dark sector Talks (i), (ii) Discussion	Overarching topics (cont.) (by ESG Working groups) Closeout Session Key messages from the symposium
13:00	Lunch Break	Lunch break	Lunch break	Lunch break	
14:00 15:00	Parallel 1 | Parallel 2 | Parallel 3 | Parallel 4 | Parallel 5	Status in China, Japan, US	Flavour Talks (i), (ii) Discussion	Detector Technologies status of DRDs, R&D needs, timeline, required resources	
16:00	Parallel 6 | Parallel 7 | Parallel 8 | Parallel 9	Coffee break	Coffee break	Coffee break	
	Coffee break	Accelerator Technologies Status of critical item, R&D needs timeline, required resources	Neutrinos and Cosmic Messengers Talks (i), (ii) Discussion	Computing Status of critical item, R&D needs timeline, required resources	
	Parallel 6 | Parallel 7 | Parallel 8 | Parallel 9				
19:15		Communicating the case for CERN's next flagship collider			

9:00 - 10:45 Opening Session

Parallel Sessions I - IV
11:15 - 13:00 Parallel I - IV, part I
Lunch Break: 13:00 - 14:00

14:00 - 15:30 Parallel I - IV, part II
Very short break: 15:30 - 15:40 to change rooms
15:40 - 17:00 Parallel V - IX, part I
17:00 - 17:20 Coffee break
17:20 - 19:15 Parallel V-IX, part II

16:45 - 19:15 Accelerator Tech.

For each **Physics Block**:
(i) Status, open questions
(ii) How can they be addressed by the various projects
(iii) Discussion

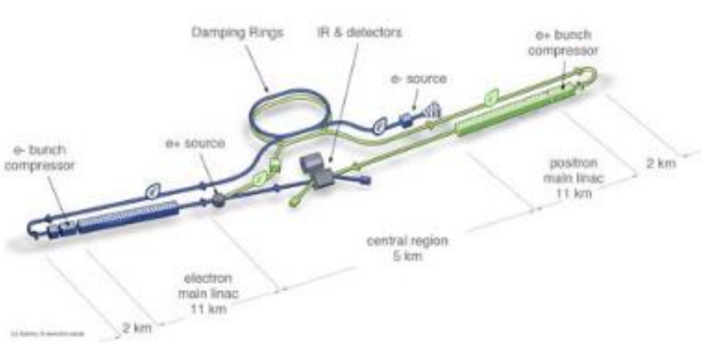
11:15 - 12:30 ESG Session II
12:30 - 13:30 Closeout session

Proposed large-scale projects at CERN, ~ 2045

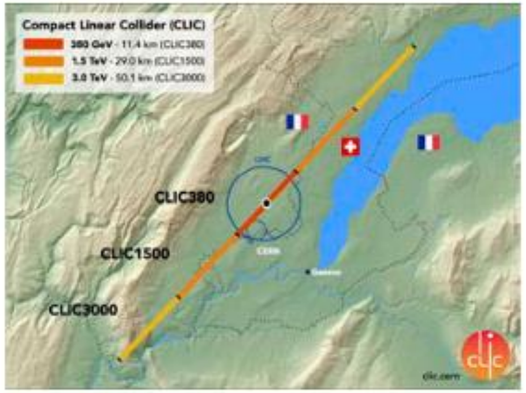
e^+e^- colliders
("Higgs factories")

FCC-ee (e^+e^-, circular, 91 – 365 GeV)

LCF (e^+e^-, linear, 91 – 240, 550 GeV)



CLIC (e^+e^-, linear, 380 GeV, 1.5 TeV)

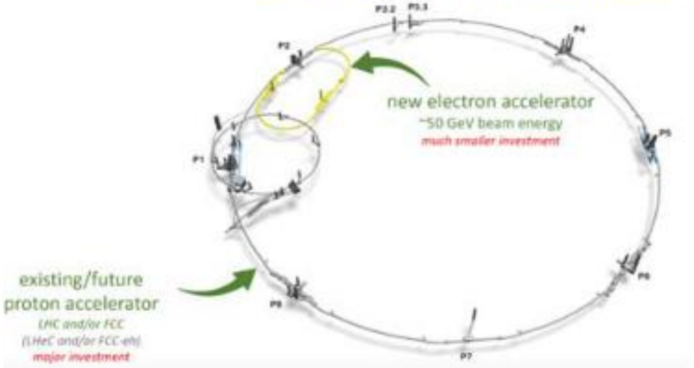


Intermediate projects

(Leave room (time, budget, resources) for further development of THE machine that can probe directly the energy frontier at the 10 TeV parton scale)

LEP3 (e^+e^-, circular, 91 – 230 GeV)

LHeC (ep, circular, electron ERL, 50 GeV e^-, > 1 TeV ep collisions)



K. Jakobs, ESPP Open Symposium, 27th June 2025

And in the long term: FCC-hh, muon collider,..

Major players for flavour physics:

Indicative timeline

WE ARE HERE

2030s

Belle-II
e^+e^- @$\Upsilon(4S)$

LHCb
(+ ATLAS & CMS)

LHCb 50 fb^{-1}
Belle-II 10 ab^{-1}

τ and D physics :
BESIII + STCF (1 ab^{-1}/y)

2040s

Belle-II
e^+e^- @$\Upsilon(4S)$

LHCb
(+ ATLAS & CMS)

LHCb-UII 300 fb^{-1}
Belle-II 50 ab^{-1}

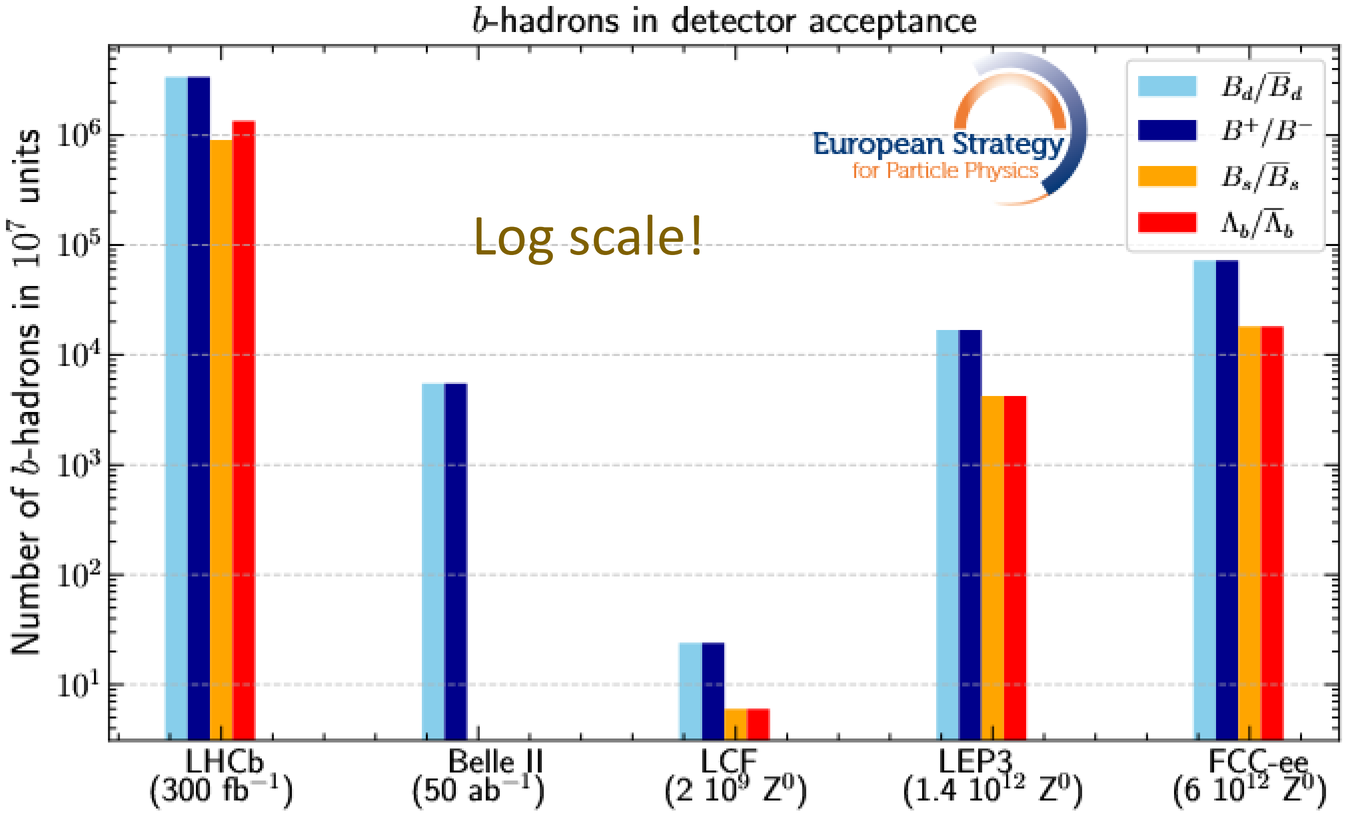
2050s

e^+e^- @ Z^0 pole
(+WW)

5 Giga : 5.10^9 Z^0 ← Linear collider
2 TeraZ : 2.10^{12} Z^0 ← LEP3
6 TeraZ : 6.10^{12} Z^0 ← FCCee

Open Symposium (Venice, June 2025) - Marie-Helene Schune - Flavour WG report 14

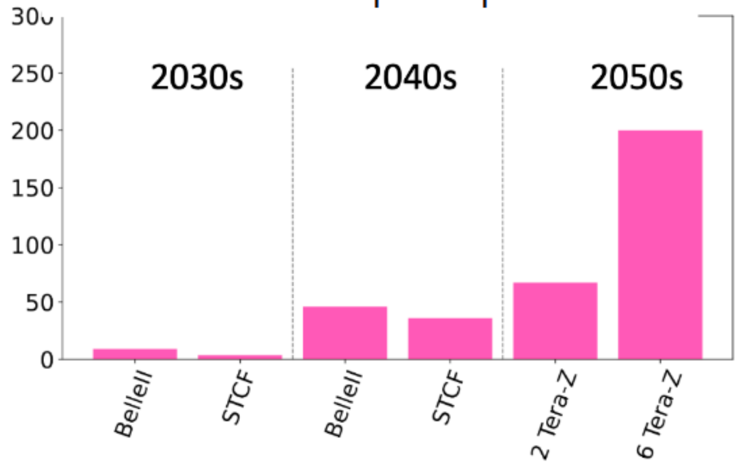
Flavour production @ Z pole



Trigger efficiency <100%

$e^+ e^-$ colliders

billions of $\tau^+ \tau^-$ pairs produced



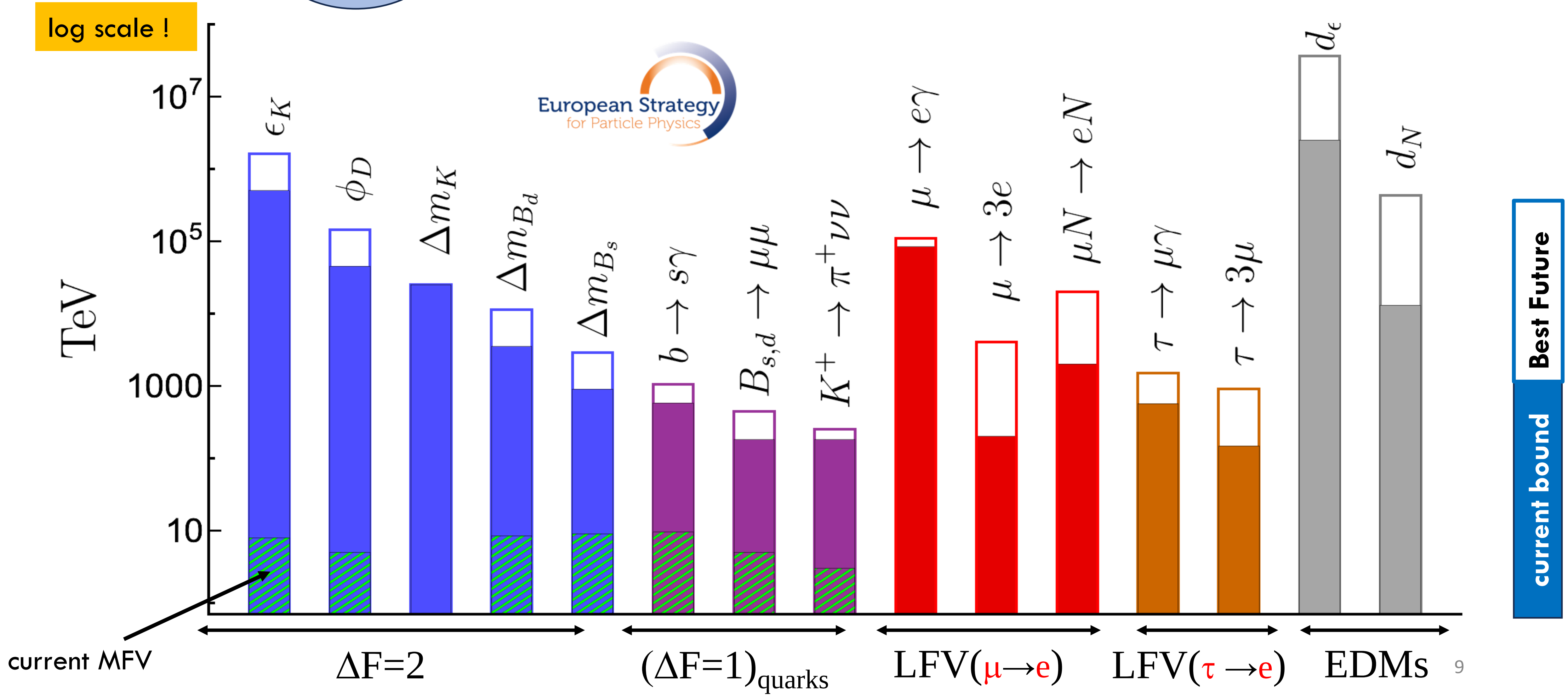
$BR(Z^0 \rightarrow \tau^+ \tau^-) = 3.4\%$

$$\mathcal{L} = \mathcal{L}_{SM} + \frac{C_i}{\Lambda^2}\mathcal{O}_i$$

NP introduces new contact interactions

2 parameters game for each contact interaction

Very constraining bounds **assuming C_i=1** (but misleading)



From Tim Gershon:

What is best experimental scenario for flavour physics?

Theory discussed later

Full exploitation of the HL-LHC

- LHCb Upgrade II (300/fb)
- Enlarged flavour physics programme at ATLAS and CMS (3/ab)
- Data taking completed by ~2041

Completion of SuperKEKB/Belle II

- 50/ab e^+e^- collisions at Υ(4S) resonance (likely to require interaction region upgrade)
- Data-taking completed by ~2042

Full FCC programme

- FCC-ee with
  - significant Z pole run
  - ability to vary $\sqrt{s}$ ↑ and ↓
  - detectors optimised considering flavour
- FCC-hh with
  - dedicated flavour physics experiment
  - sufficient R&D lead-time

Complemented by dedicated kaon, pion, muon and EDM experiments

→ Meaning nEDM, COMET, PIONEER….

Concluding key messages from K. Jakobs

see full presentation here:
https://agenda.infn.it/event/44943/contributions/267517/attachments/137766/207161/ESPP_Venice_Summary_2025.06.27.pdf

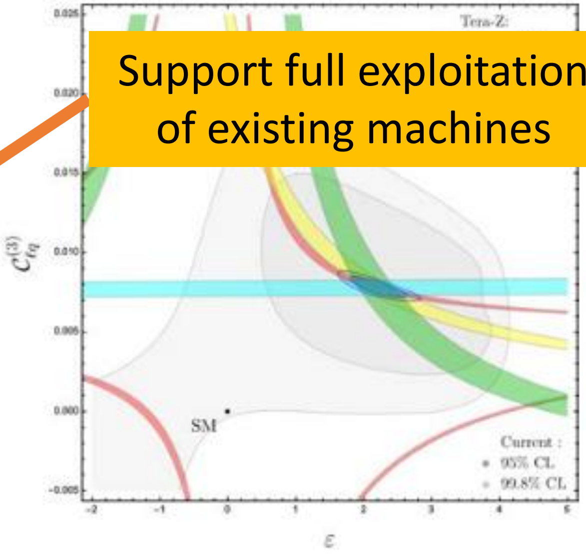
Flavour Physics

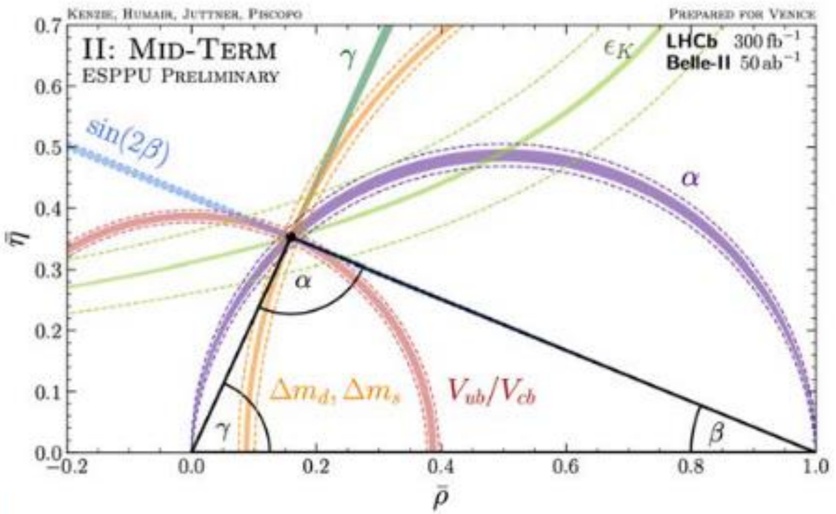
- Precision Higgs, electroweak, and flavour physics are three facets of for indirect discoveries
  → their **synergy is essential to maximise the discovery potential**

- B/D/tau physics: major improvements from full exploitation of available facilities up to 2040s (LHCb-II, ATLAS/CMS, Belle-II)
  Beyond that, **$6 \cdot 10^{12}$ Z^0 would provide a further major step forward**
  Giga-Z is not an option for flavour physics

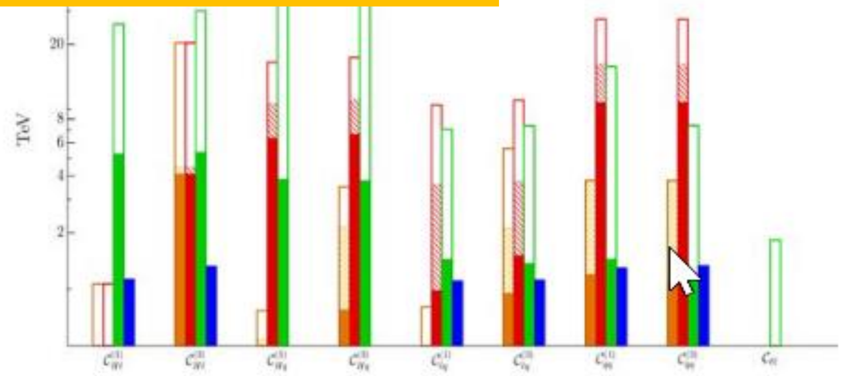
- Support needed for theory (key role of Lattice QCD)

Support full exploitation of existing machines





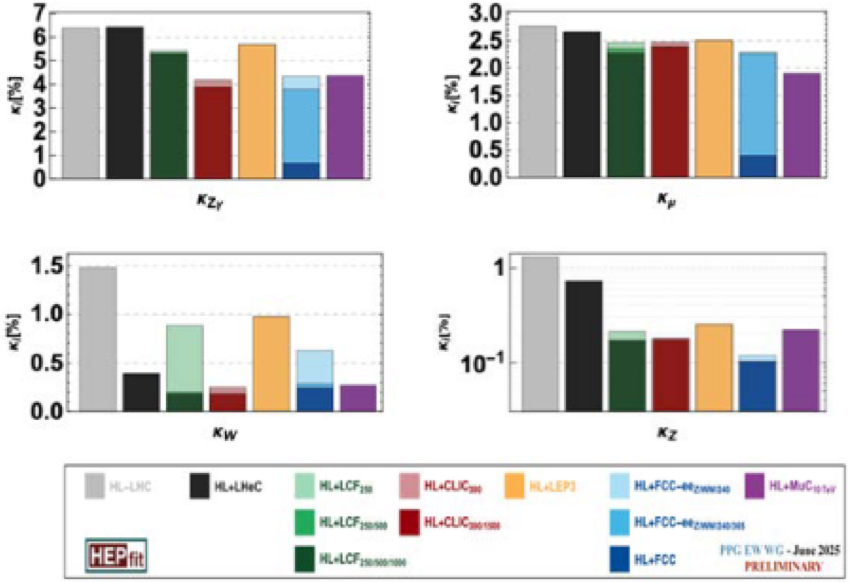
Flavour does not want a linear collider!



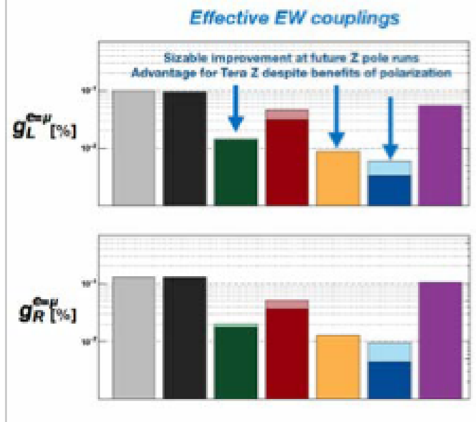
Electroweak Physics

- The **HL-LHC** will provide legacy measurements for top, ttH, λ_3 and rare decays until a top and high energy run
- **Multiple energy points in e^+e^- colliders** are important to Higgs precision (i.e. width, HWW, λ_3)
- **Tera-Z brings highest overall sensitivity to el.weak**
- Significantly improved high-precision tests of the el.weak sector are vital to guide future direct searches of new physics
- Precision and energy are strongly complementary
- A focus on both precision (→ smaller effects) and breadth (→ characterization of any eventual signal) is important in the search of the unknown.
- Fundamental advancements in theory techniques and tools needed

Higgs physics

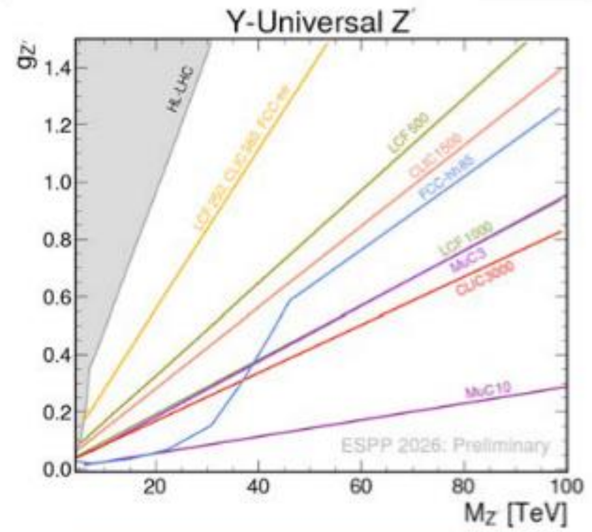


Z pole physics

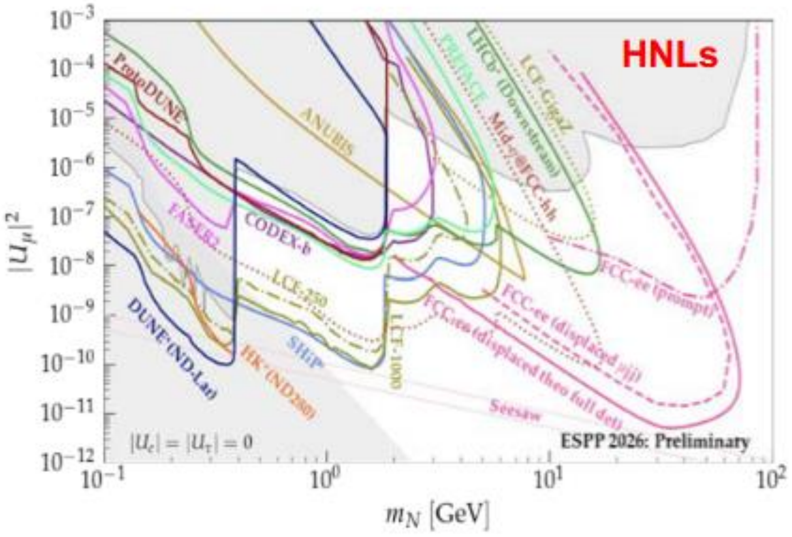


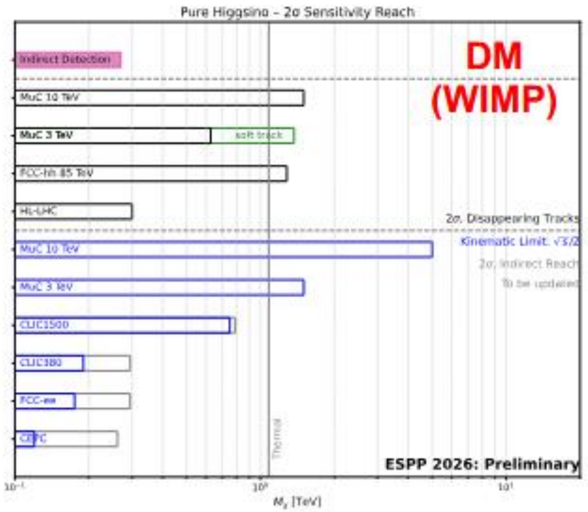
Searches for BSM Physics

- Need for a future collider programme that can fully leverage both ***precision and energy****, covering the widest range of observables at different scales* – below, at and above the weak scale –
- Sensitivity to new physics below the EW scale, typically feebly interacting particles, requires strong synergy with dedicated experiments and fixed target experiments to provide maximal coverage

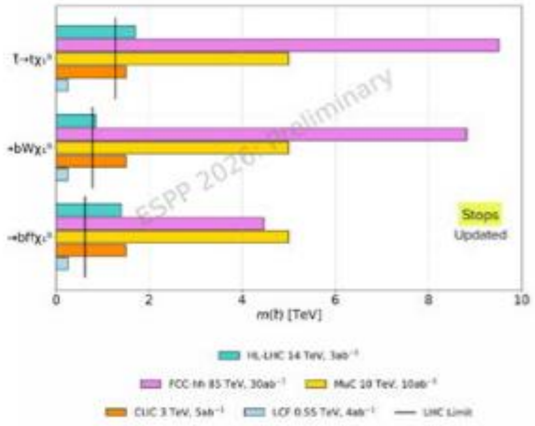


Exclusion reach of different colliders on the Y-universal Z' model parameters





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

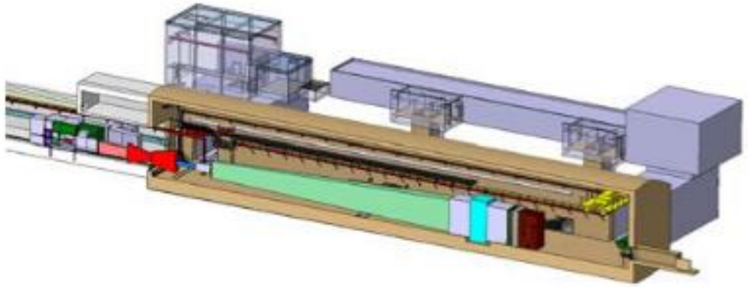


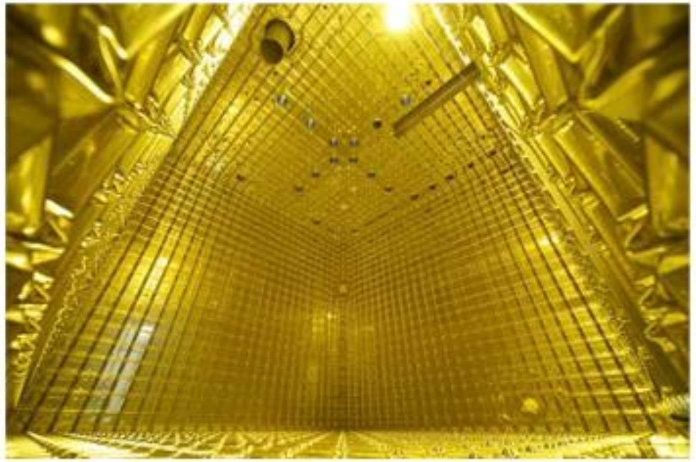
Diversity in the Physics Programme

Keeping **diversity in the particle physics** programme is essential: the next collider project should not come at the expense of a diverse scientific programme in Europe in terms of resources.

Ensuring a diverse and comprehensive physics programme is crucial for addressing fundamental physics questions, including fixed-target, neutrino, flavour, astroparticle and nuclear physics experiments

We do not know where new physics might be hiding → potential for groundbreaking discoveries





Final Words

Over the past years very significant progress has been made towards the realisation of the next flagship project at CERN

- FCC: Successful completion of the Feasibility Study; No technical showstoppers identified
- Overwhelming support for the integrated FCC-ee/hh programme by the HEP communities in the CERN Member and Associate Member states and beyond;

  The strong support is largely based on the superb physics potential and the long-term prospects (FCC-ee /hh)
- Discussions on the financial feasibility are ongoing (CERN management and Council)

Discussions on the prioritisation of alternative options are ongoing

- Linear colliders (LCF, CLIC) present as well mature options for a Higgs factory at CERN
- LEP3 and LHeC could be considered as “intermediate” collider projects
- The differences in the physics potential (→ Physics Briefing Book), review of the technical readiness and the final input from the national HEP communities (due by 14 Nov.) will be important ingredients in the final recommendations by the European Strategy Group

Keeping a strong complementary physics programme beyond colliders is essential

The areas of Neutrino Physics, Dark Matter Search experiments, astroparticle (covered by the APPEC Roadmap) and nuclear physics experiments (covered by the NuPPEC Long Run Plan) are also important to complement the future collider programme

Since then…

- **Nov 3rd: Assessment of large-scale accelerator projects at CERN - Report of ESG WG2a : https://cds.cern.ch/record/2947728**

Project	Scope	TRL	R&D	Test facilities	Performance	Site preparation	Schedule	Cost	Risk
CLIC 380 GeV, 1.5 TeV		4 - 6 / 5.2							
FCC-ee 91-365 GeV		4 - 7 / 6.0							
FCC-hh 85 TeV		4 - 7 (Nb_3Sn) / 4.3 2 - 7 (HTS) / 3.2							
FCC-hh - SA 85 TeV		4 - 7 (Nb_3Sn) / 5					Nb_3Sn		
LCF 250 - 550 GeV		5 - 7 / 5.5							
LEP3 91 - 230 GeV		3 - 6 / 4.0							
LHeC: HL-LHC + 50 GeV ERL		3 - 6 / 4.5							
MC 3.2 TeV, 7.6 TeV		3.2 TeV: 3 - 5 7.6 TeV: 2 - 5							

Table 16: Summary table schematically representing the key findings of the WG according to the assessment criteria and based on the present status of the large-scale collider project proposals as submitted to the ESPP2026. Scope=Scope level-of-definition; TDR=Technical Readiness Level score - the range of values and the cost-weighted average for the baseline scenarios are listed; the colour code is selected based on on the cost-weighted average TRL score (TRL≥ 6 - green, 4≤TRL<6 - yellow, TRL<4 - red); R&D=R&D requirements, R&D plan level-of-definition, R&D funding status; Test facilities=need of test facilities or demonstrators and (if needed) level-of-definition of their scope; Performance=Performance uncertainty; Site preparation=Site preparation status; Schedule=Schedule uncertainty; Cost=Cost uncertainty; Risk=Risk level-of-definition. The cost-weighted average TRL score could not be estimated for the MC project as there is no detailed cost breakdown by sub-system. The colour code for the various criteria is defined according to the summary assessment in the Tables A.1 to A.8.

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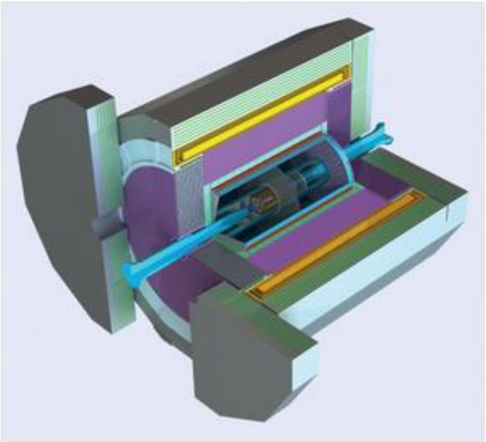
CEPC matures, but approval is on hold

26 October 2025



Mature design The CEPC Study Group has published a technical design report for its reference detector. Credit: CEPC Study Group 2025 arXiv:2510.05260

In October, the Circular Electron–Positron Collider (CEPC) study group completed its full suite of technical design reports, marking a key step for China's Higgs-factory proposal. However, CEPC will not be considered for inclusion in China's next five-year plan (2026–2030).

"Although our proposal that CEPC be included in the next five-year plan was not successful, IHEP will continue this effort, which an international collaboration has developed for the past 10 years," says study leader Wang Yifang, of the Institute of High Energy Physics (IHEP) in Beijing. "We plan to submit CEPC for consideration again in 2030, unless FCC is officially approved before then, in which case we will seek to join FCC, and give up CEPC."

named constructing or participating in a Higgs factory as a strategic priority. Following China's decision to defer CEPC, attention now turns to Europe, where the ongoing update of the European Strategy for Particle Physics will prioritise recommendations for the laboratory's flagship collider beyond the HL-LHC. Domestically, China will consider other large science projects for the 2026 to 2030 period, including a proposed Super Tau–Charm Facility to succeed the Beijing Electron–Positron Collider II.

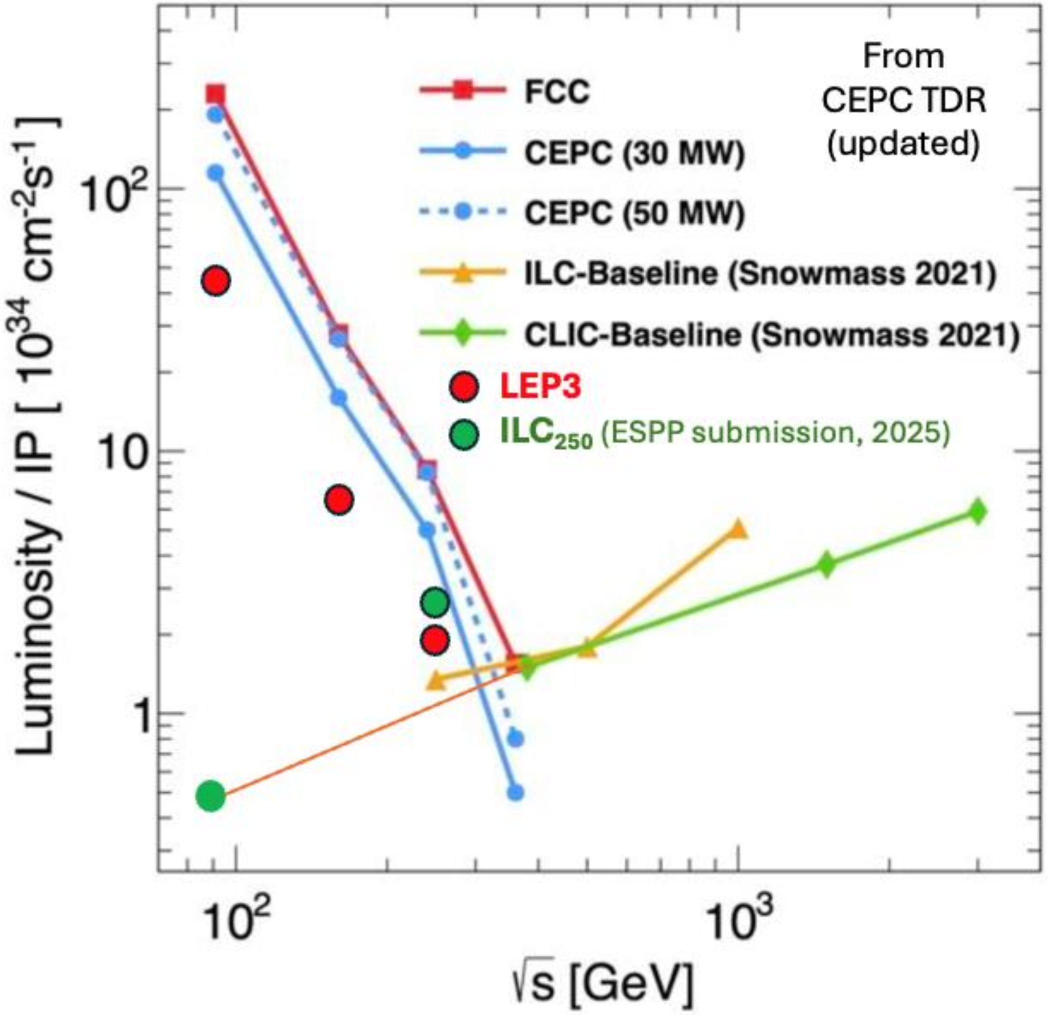
☺

Final remarks

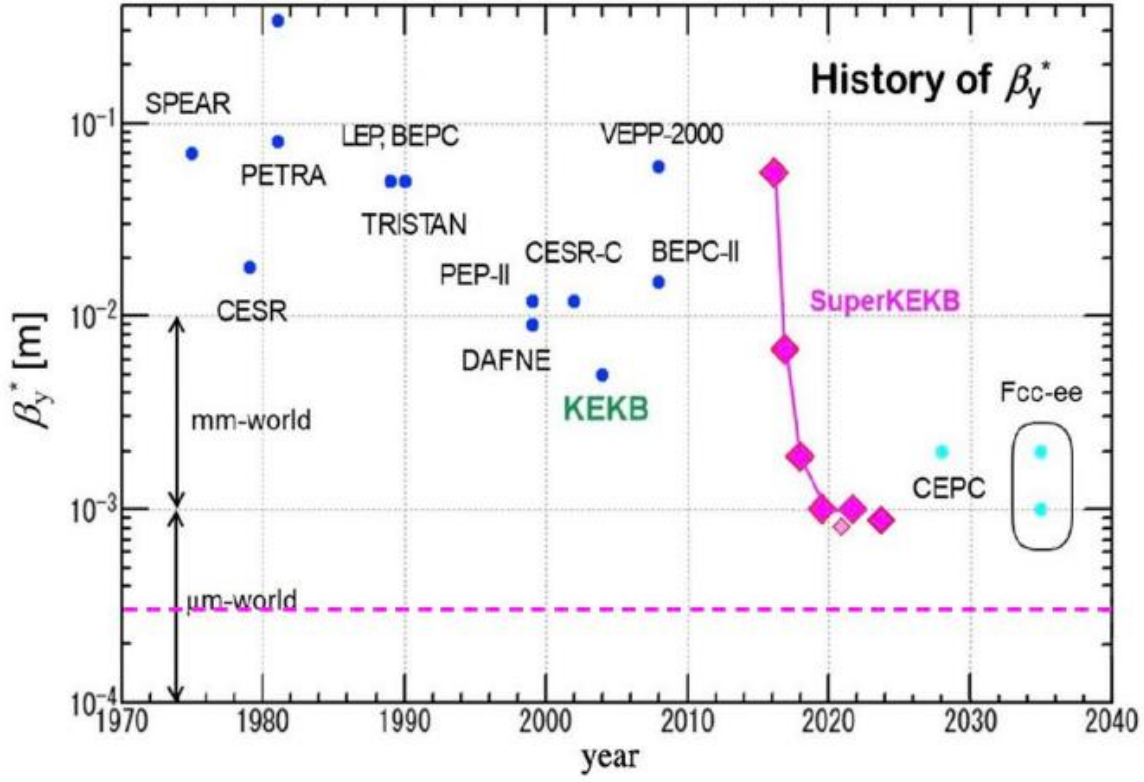
- A lot of work done by the PPG, take a look at the briefing book
- Support to Belle II and LHCb upgrade II clearly affirmed
- Flavour physics needs **statistics** (Tera Z) and **a dedicated detector**
- Flavour physics has also a **rich program of small and middle size experiments**, that needs to by pursued
- Precision of SM **theoretical predictions** should match the expected experimental precisions
- CERN project approval should come in 2028

Coming soon:

More slides…



From
CEPC TDR
(updated)
FCC
CEPC (30 MW)
CEPC (50 MW)
ILC-Baseline (Snowmass 2021)
CLIC-Baseline (Snowmass 2021)
LEP3
ILC250 (ESPP submission, 2025)
Luminosity / IP [10^34 cm^-2s^-1]
√s [GeV]



History of β_y^*
SPEAR
PETRA
LEP, BEPC
TRISTAN
VEPP-2000
CESR
PEP-II
CESR-C
BEPC-II
DAFNE
KEKB
SuperKEKB
Fcc-ee
CEPC
mm-world
μm-world
β_y^* [m]
year

IMCC

International Muon Collider Collaboration

Collaboration formed 2022, currently **hosted by CERN**

- **61 formal member institutions,** still growing
- Currently centred in Europe, strong US contribution
- R&D progamme developed with global community

Goals:

- O(10 TeV) collider
- First stage by around 2050

IAC review (last week):
"During its current IMCC review, the IAC was highly impressed by the significant progress and the marked improvement in the robustness and quality of the studies. The muon collider presents an extraordinary technical opportunity, and encouragingly, all major technical challenges are being actively tackled. In particular, launching and supporting a cooling demonstrator and test stands as soon as possible will be crucial to sustaining this strong momentum."

Now need the **support of the ESPPU** and others for this **global R&D programme**

FCC-ee main parameters and operation plan

parameter	Z	WW	H (ZH)	$t\bar{t}$	
Collision energy $\sqrt{s}$ [GeV]	88, 91, 94	157, 163	240	340-350	365
synchrotron radiation/beam [MW]	50	50	50	50	50
beam current [mA]	1294	135	26.8	6.0	5.1
number bunches / beam	11200	1852	300	70	64
total RF voltage 400 / 800 MHz [GV]	0.08 / 0	1.0 / 0	2.1 / 0	2.1 / 7.4	2.1 / 9.2
luminosity / IP [10^{34} $cm^{-2}s^{-1}$]	144	20	7.5	1.8	1.4
luminosity / year [ab^{-1}]	68	9.6	3.6	0.83	0.67
run time (including lumi ramp-up) [years]	4	2	3	1	4
total integrated luminosity [ab^{-1}]	205	19.2	10.8	0.4	2.7
total number of events	6 10^{12} Z	2.4 10^{8} WW (incl. WW at higher $\sqrt{s}$)	2.2 10^{6} ZH 65k WW → H	2 10^{6} $t\bar{t}$ + 370k ZH + 92k WW → H	

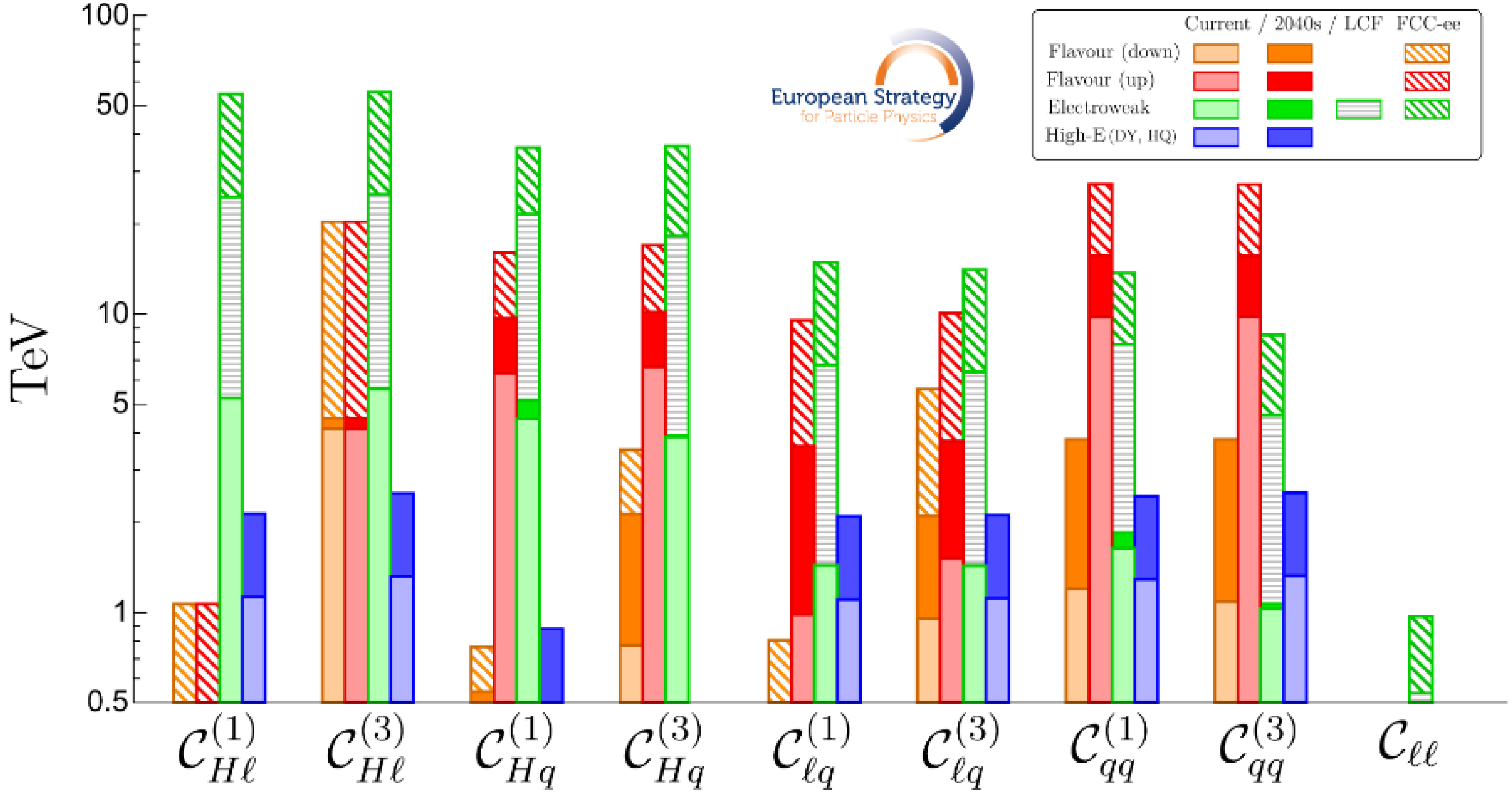
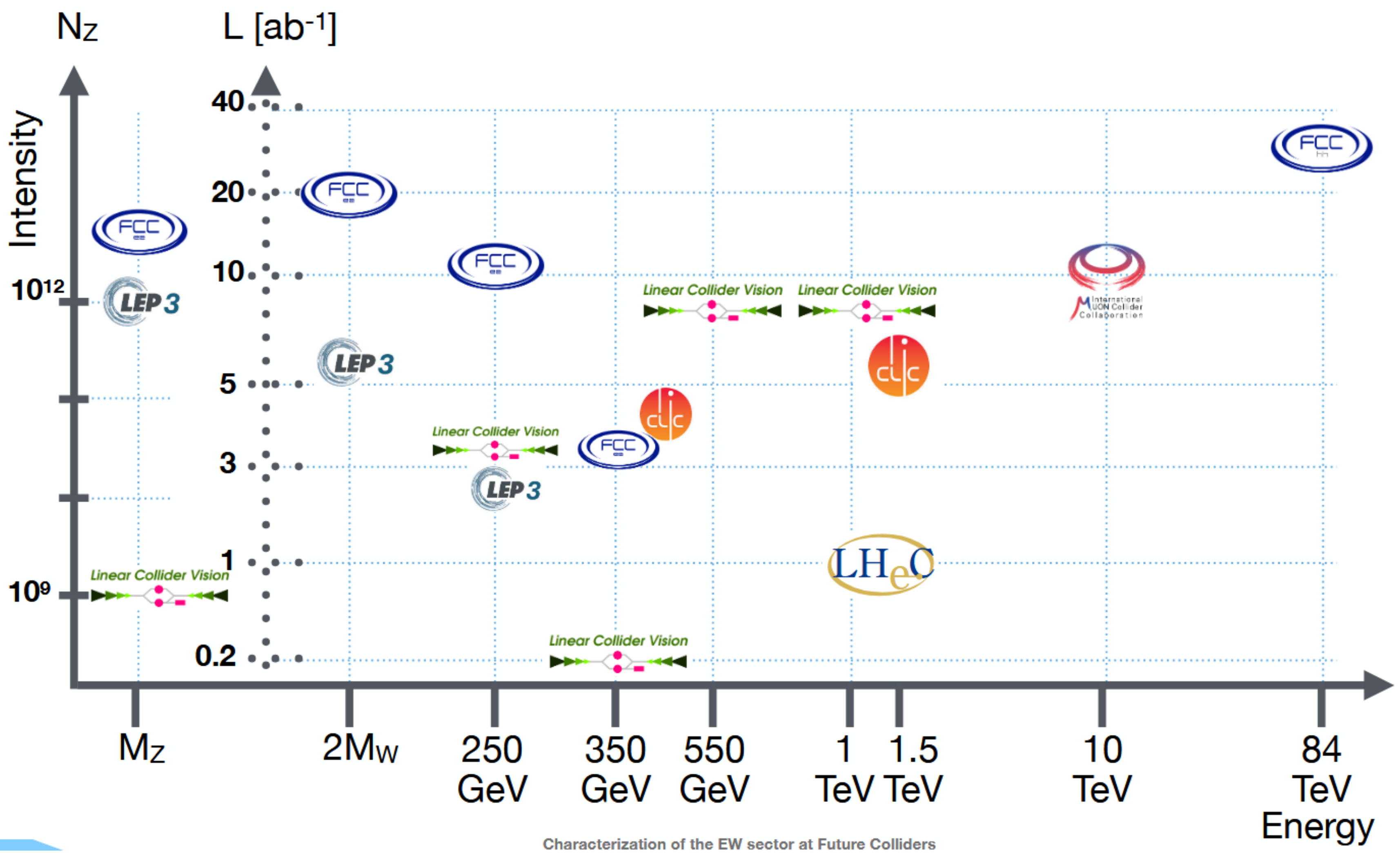


Fig. 5.16: Bounds on coefficients of selected dimension-six SMEFT operators from flavour, EW, and high-energy observables (Drell-Yan and heavy-quark production). The operator notation follows the Warsaw basis [264] with implicit flavour structure consisting only of 3$^{\text{rd}}$ generation fields (with up or down alignment in the quark case). The bounds are obtained considering one operator at a time and analysing separately the three different sets of observables. Projections for all the bounds at the end of HL-LHC and Belle-II are shown. For flavour and EW observables only, two different future scenarios (LCF and FCC-ee) are considered.

Comparing future collider capabilities

Very different design to address the search for new physics



An explicit example of flavour – EW interplay (*assuming NP signal*)