

# AITANA

# Future Colliders

# activities in 2023

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VNIVERSITAT  
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**IFIC**  
INSTITUT DE FÍSICA  
CORPUSCULAR



**CSIC**  
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

- ▷ Future Colliders Landscape
- ▷ The ECFA Higgs Factory Workshop
- ▷ News on ILC & FCC
  
- ▷ Milestones, conferences, etc..
- ▷ Roles, convenerships etc
  
- ▷ Important dates 2024

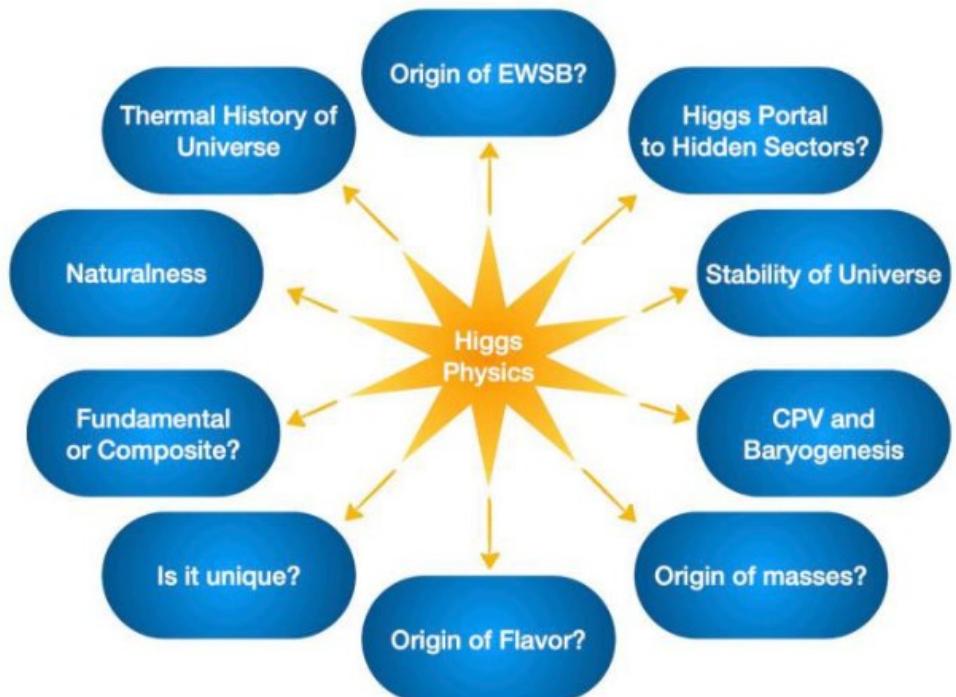


► Who are we? (Physics studies not accelerator or detector)

- J. Fuster, M. Vos, V. Mitsou (seniors)
- A. Saibel (postdoc), M. Staelens (postdoc, soon to join the FC activities), A. I., ( tenure track)
- E. Musumeci, J.P. Márquez (PhD)



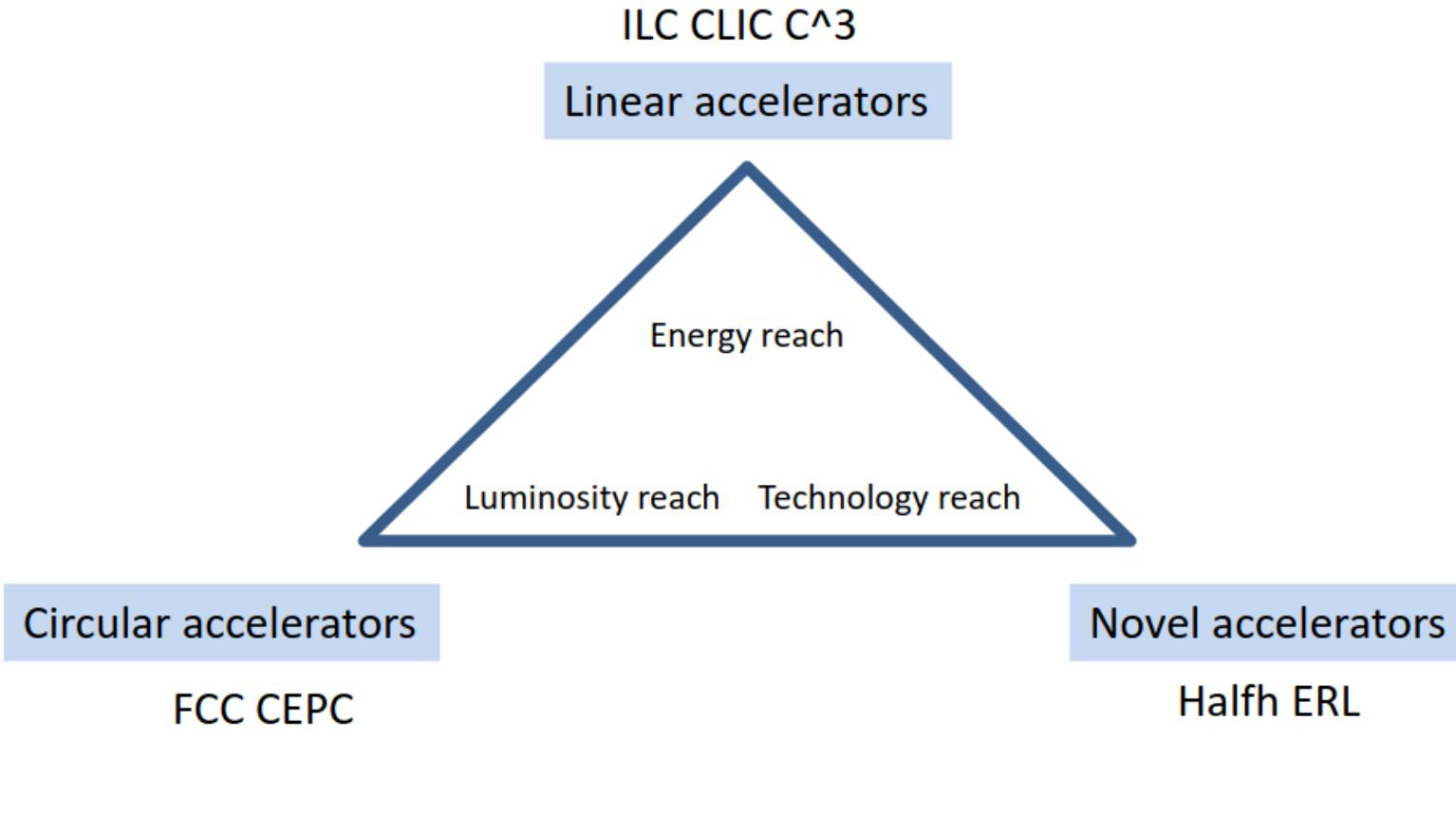
# The Future of HEP



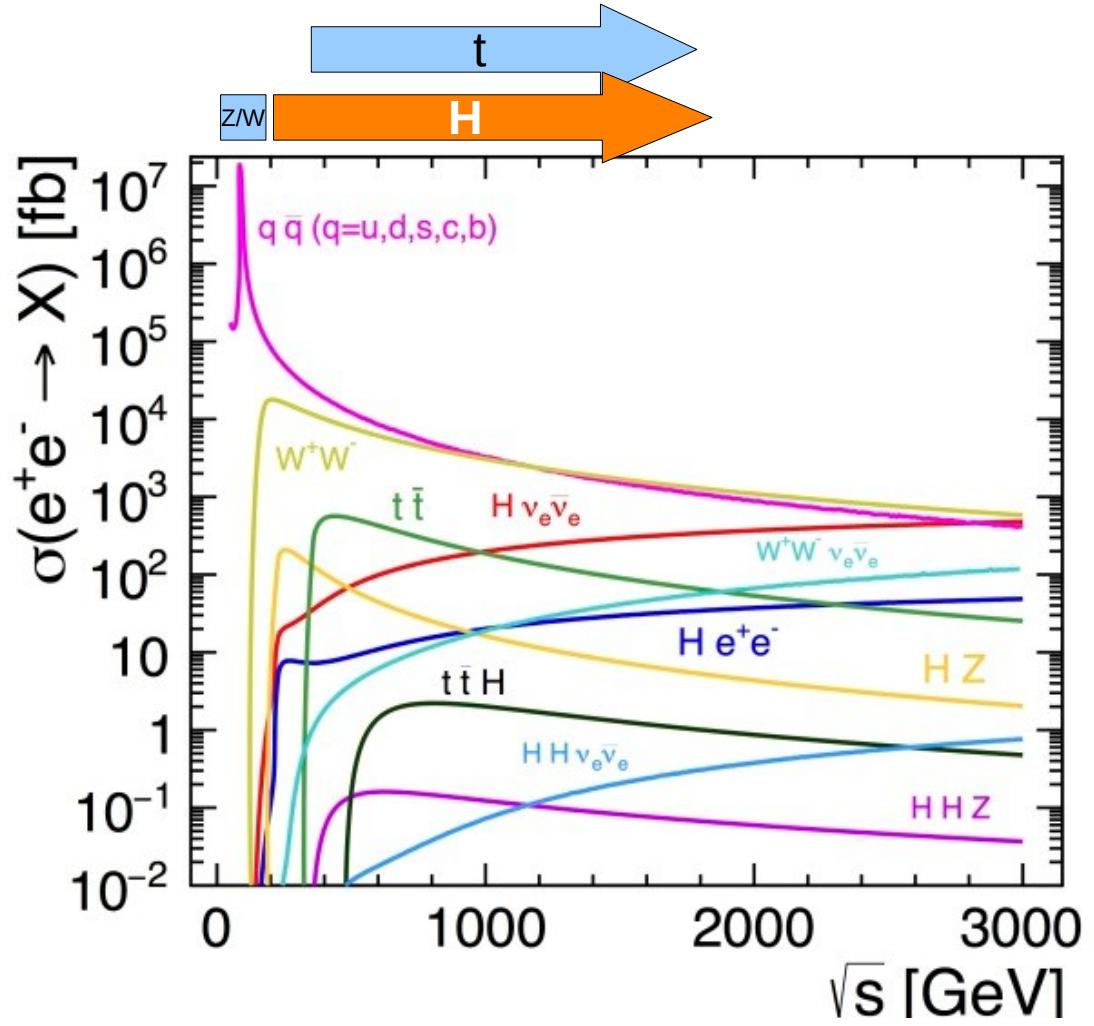
From talk by Gavin Salam  
at ICFA Seminar 2023

- Higgs physics is at the core of most of our open questions
- There are “guaranteed discoveries” in the Higgs sector

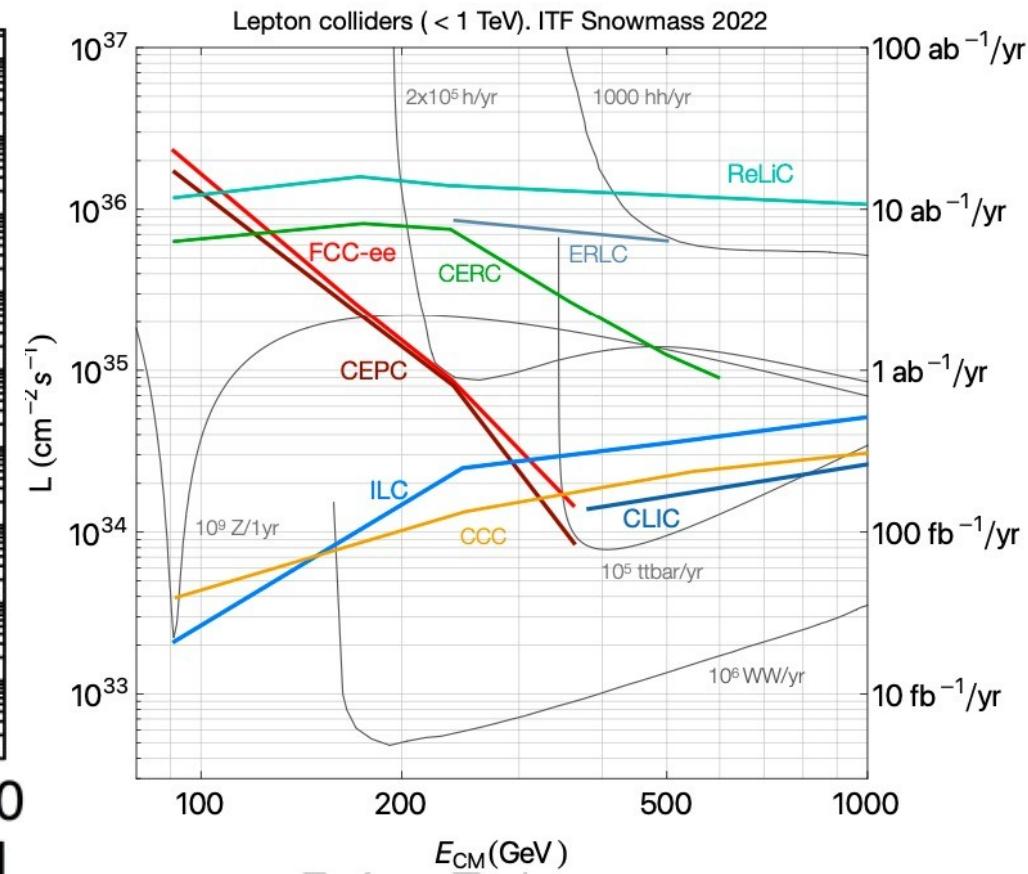
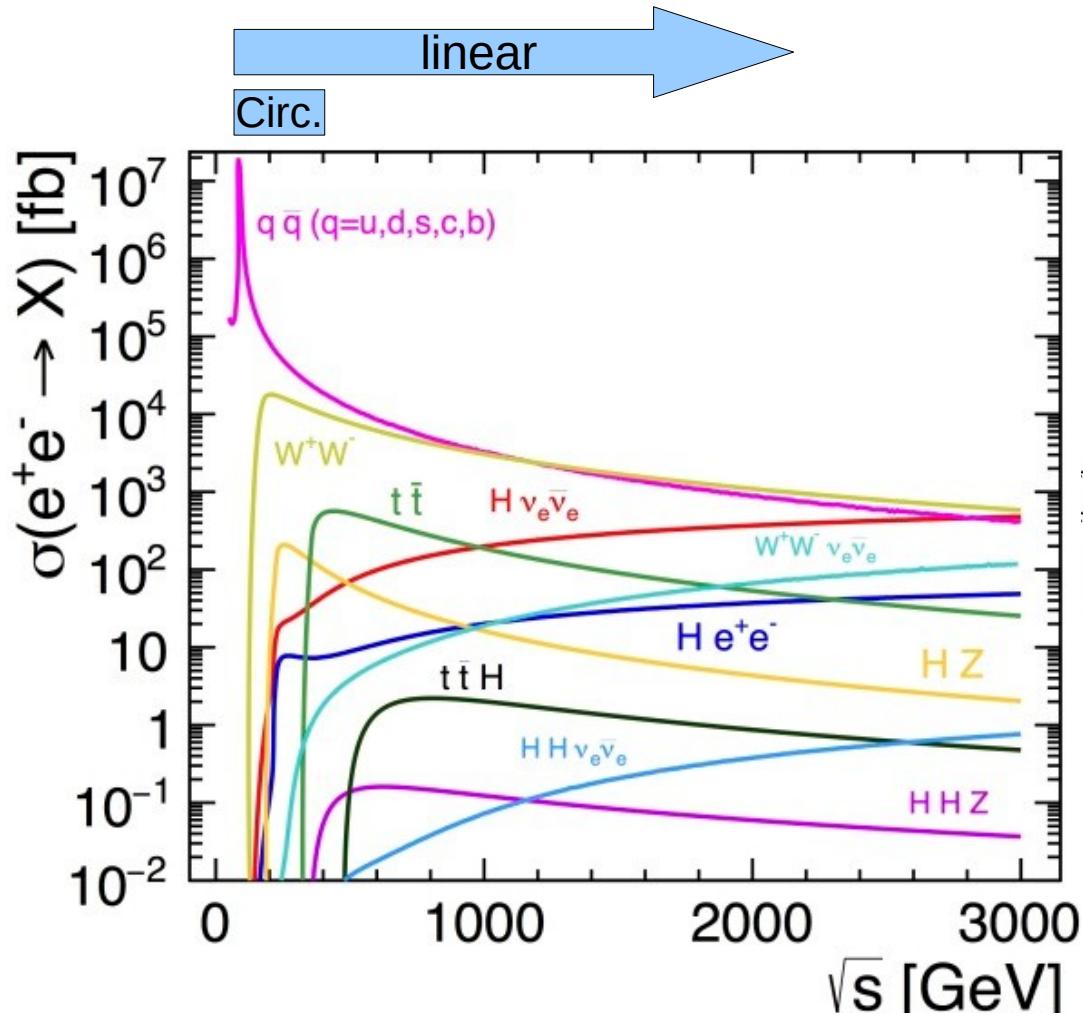
# The environment



# Higgs Factories



# Higgs Factories



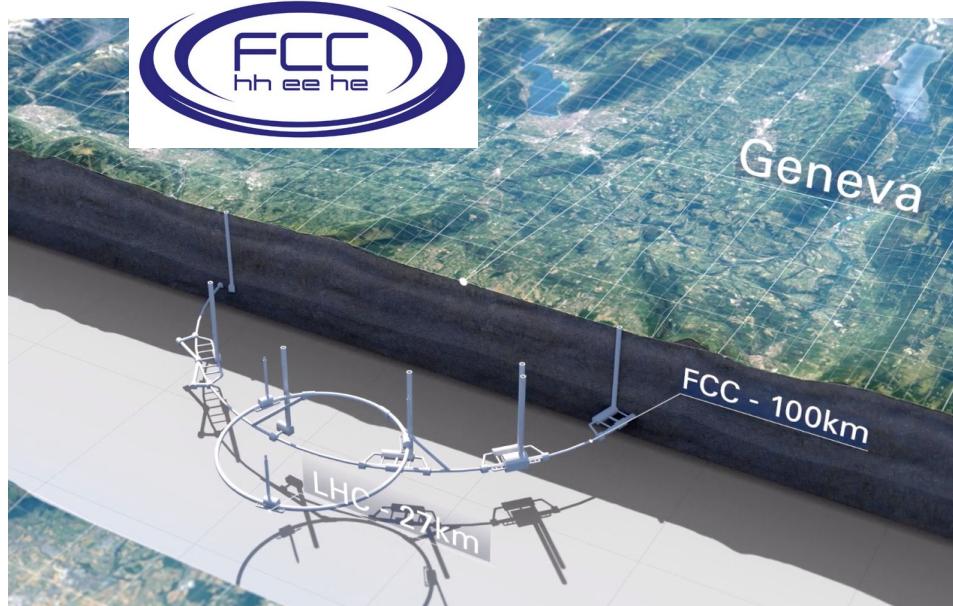
# Circular Lepton Colliders

▷ Two possibilities discussed globally - both e + e - Higgs-Top-EWK factory, followed by ~ 100 TeV hadron collider

- e+e- program: Zpole, WW, 250GeV, ttbar threshold
- High luminosity but energy reach limited by synchrotron radiation

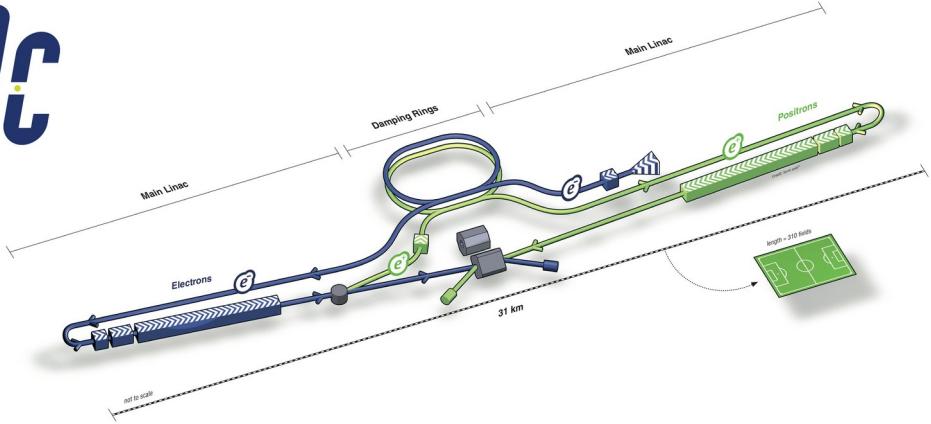
▷ CepC **accelerator TDR** [http://cepc.ihep.ac.cn/CEPC\\_tdr.pdf](http://cepc.ihep.ac.cn/CEPC_tdr.pdf)

▷ CERN FCC feasibility study ongoing

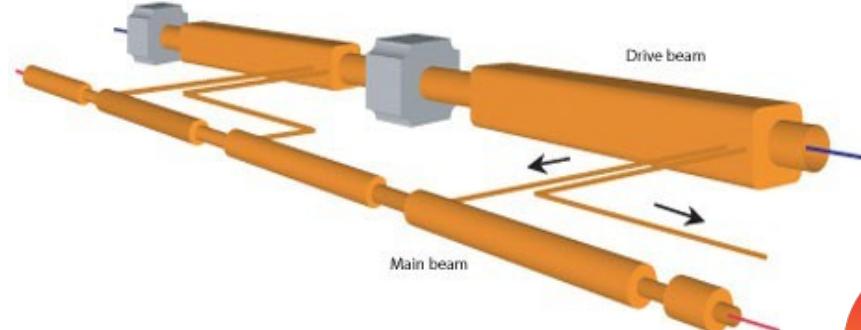


# Linear Lepton Colliders

- ▷ Energy: 0.1 - 1 TeV
- ▷ **Electron and positron polarisation**
- ▷ TDR in 2013
  - + DBD for detectors
- ▷ Footprint 31 km
- ▷ Initial Energy 250 GeV – Footprint ~20km



Under discussion in Japanese Government and international community



Possible future project of CERN



- ▷ Energy: 0.4 - 3 TeV
- ▷ CDR in 2012
  - Project Implementation Plan in 2018
- ▷ **Electron polarisation**
- ▷ Footprint 50km
- ▷ Initial Energy 380 GeV – Footprint ~11km

## The European ITN activities – 2023

European ITN studies are distributed over five main activity areas:

### A1 with three SC RF related tasks

- SRF: Cavities and Cryo Module (INFN, CEA, DESY, IJCLAB)
- Crab-cavities (UK)
- Main Linac elements: ML quads and cold BPMs (CIEMAT, IFIC)

### A2 Sources

- Pulsed magnet (Uni.H, DESY, CERN)
- Wheel/target (the same and UK groups)

### A3 Damping Ring including kickers

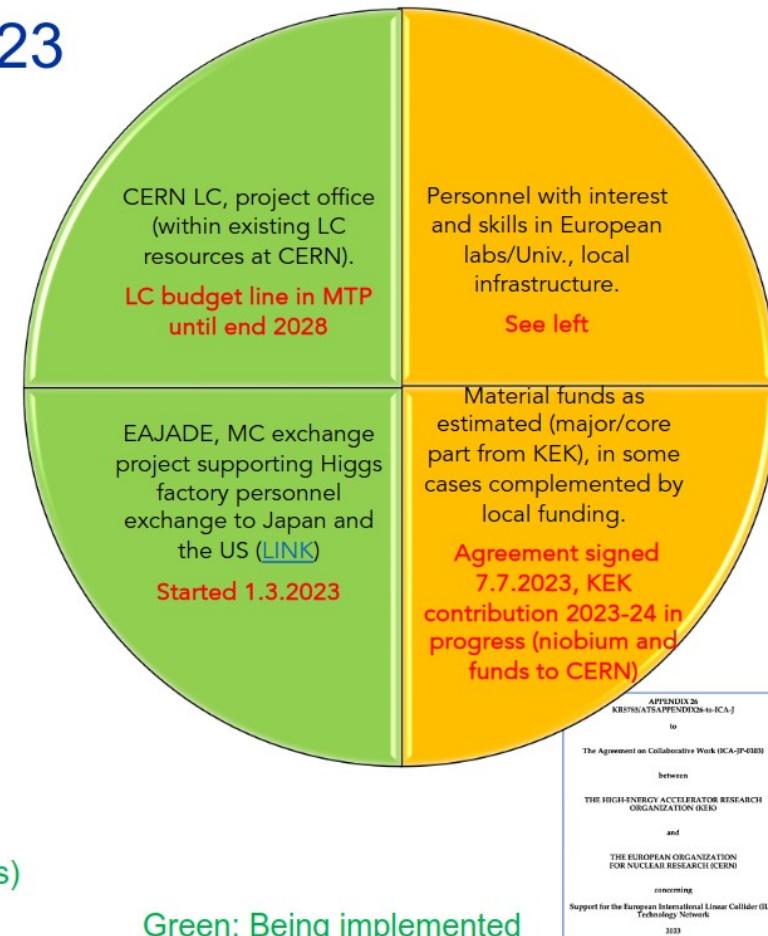
- Low Emittance Ring lab(s) (UK)

### A4 ATF activities for final focus and nanobeams

- On-going/restarted (UK, DESY, IJCLAB, CERN, IFIC)
- MDI (DESY, CEA, UK groups)

### A5 Implementation including Project Coordination

- Dump, CE, Cryo – significant earlier efforts at CERN, follow up under discussion
- Sustainability, Life Cycle Assessment (CERN, DESY, CEA, UK groups)
- EAJADE started (EU funding) (DESY, UK, CEA, CNRS, IFIC, INFN, UHH, CERN)



Green: Being implemented

Yellow: Programme being defined with partners

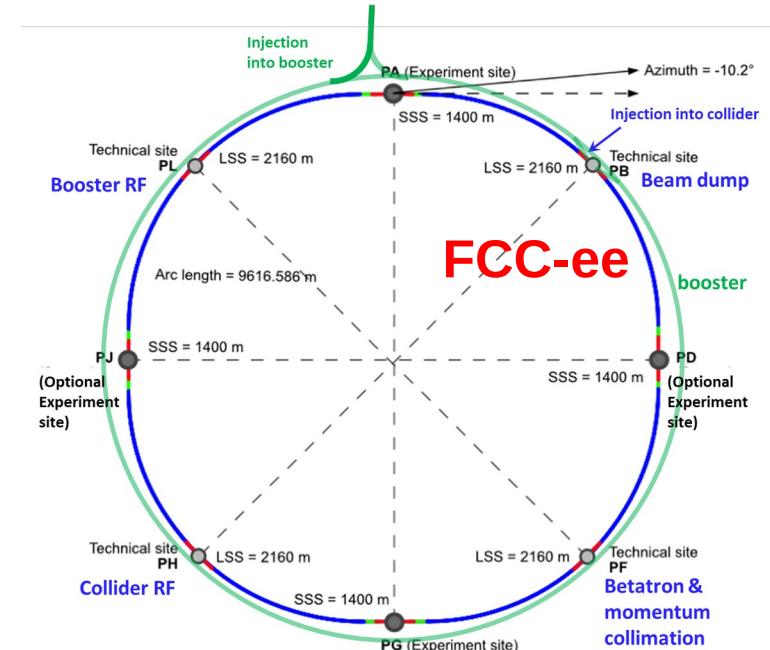
Red: Programme in Europe less well defined

# FCC – Future Circular Collider

Stage 1: FCC-ee (Z, W, H, ttbar) as Higgs factory, electroweak & top factory at highest luminosities

Stage 2: FCC-hh ( $\sim 100$  TeV) as natural continuation at energy frontier, pp & AA collisions; e-h option

- **FCC Feasibility Study:** increase collaboration on Accelerator and Physics/Experiments/Detectors (**PED**)
- 50% of FCC Feasibility Study being completed with mid-term review
  - 2 February 2024: CERN Council meeting on mid-term review
- Focus 2021-2023: identifying best placement & layout and adapting entire project to new placement
- Focus 2024-2025
  - Subsurface investigations, further optimization of implementation, surface sites, synergies, etc.
  - Full design iteration in view of technical and cost optimisation of entire project



More updates in [7th FCC Physics Workshop](#), this week!



- ▶ Series of workshops on physics studies, experiment design and detector technologies towards a future electron-positron Higgs/EW/Top factory.
- ▶ Based on the recommendations of the Update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ECFA)
  - The **aim** is to **bring together the efforts** of various e+e- projects, to share challenges and expertise, **facilitate entry for “newcomers”**, to explore synergies and to respond coherently to this high-priority strategy item.
- ▶ 3 Working groups:
  - WG1 physics performance
  - WG2 Physics Analysis Tools
  - WG3 Detector R&D

# The ECFA Higgs/Top/EW Workshop

- ▶ Kick-off meeting in June 2021: <https://indico.cern.ch/event/1033941/contributions/4342858/>
- ▶ Timeframe: May 2021 – December 2024
- ▶ Checkpoints: community-wide plenary ECFA workshops in 2022 and 2023 final “ECFA report”
  - 2022: DESY, <https://indico.desy.de/event/33640/>
  - 2023: Paestum, <https://agenda.infn.it/event/34841/>
- ▶ More info <https://gitlab.in2p3.fr/ecfa-study/ECFA-HiggsTopEW-Factories/>

# The ECFA Higgs/Top/EW Workshop

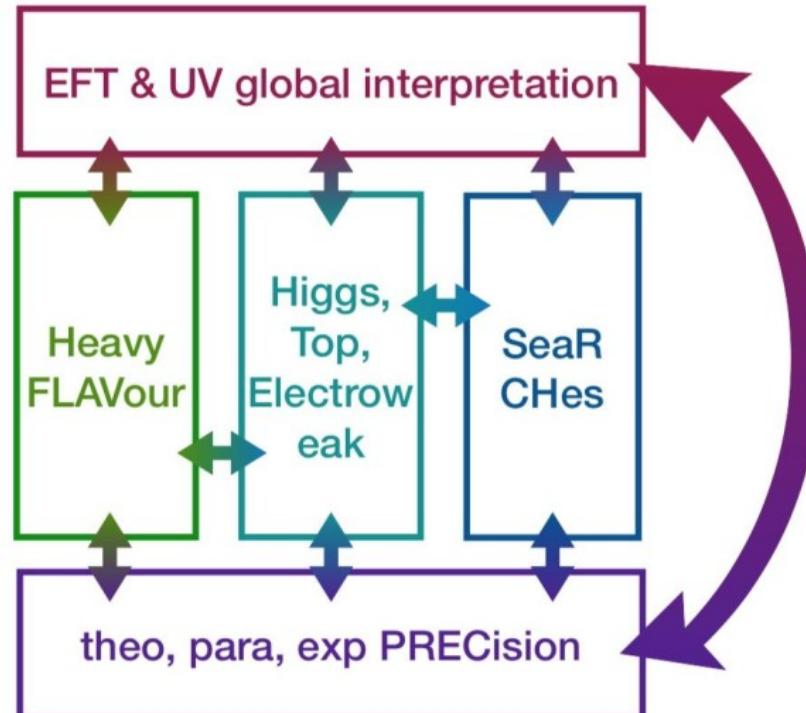
## ► WG1

- Global interpretations (WG1-GLOB) → M. Vos
- Precision (WG1-PREC) → A. I
- Higgs/Top/EW (WG1-HTE):
- Flavour (WG1-FLAV):
- Searches (WG1-SRCH):
- <https://gitlab.in2p3.fr/ecfa-study/ECFA-HiggsTopEW-Factories/-/wikis/WG1-physics-performance>

## ► Between the workshops: organize smaller events

- (i.e.) PREC seminars  
<https://indico.cern.ch/category/14871/>

## ► Focus Topic Document → next slide



## Motivation

### What can ECFA HiggsFactory Study add beyond state-of-the-art?

- Unclear which project will be built - but to get any, a strong e+e- community is required!  
=> How can HEP community engage in e+e- Higgs Factory studies after Snowmass?
- Most can only spend only a small fraction of their time on “future topics”
  - => **lower threshold to contribute as far as possible**
  - => **avoid duplication**
- ECFA Study is not tied to a specific e+e- project:
  - for people who hesitate to “sell their soul” to FCC or ILC or ... this could be the ideal place!
  - forum to present work and discuss science and detector requirements across projects
  - **trigger actual joint work => defined 14 focus topics**  
**They are NOT meant to be a comprehensive representation of the physics case, but selected examples where work is needed. The final report will contain MUCH more!**
  - support the use of common software and exchange of data-sets via Key4HEP

# Focus Topics: IFIC involvement

- ▶ <https://gitlab.in2p3.fr/ecfa-study/ECFA-HiggsTopEW-Factories/-/wikis/FocusTopics>
- ▶ <https://arxiv.org/abs/2401.07564>

Topic	Lead group	Relevant $\sqrt{s}$ [GeV]				
		91	161	240–250	350–380	$\geq 500$
1 HtoSS	HTE			✓	✓	✓
2 ZHang	HTE (GLOB)			✓	✓	✓
3 Hself	GLOB			✓	✓	✓
4 Wmass	PREC	✓	✓	✓	✓	✓
5 WWdiff	GLOB			✓	✓	✓
6 TTthres	GLOB (HTE)				✓	✓
7 LUMI	PREC	✓	✓	✓	✓	✓
8 EXscalar	SRCH			✓	✓	✓
9 LLPs	SRCH	✓	✓	✓	✓	✓
10 EXtt	SRCH				✓	✓
11 CKMWW	FLAV		✓	✓	✓	✓
12 BKtautau	FLAV	✓				
13 TwoF	HTE (PREC)	✓	✓	✓	✓	✓
14 BCfrag and Gsplit	PREC (FLAV)	✓	✓	✓	✓	✓

# Involvement on Focus topics (and beyond)

## ► TTthres topic

- Marcel Vos → coordinator of the topic (as GLOB convener) and member of expert team
- A.I, A. Saibel, D. Melini members of expert team

## ► Wmass, Lumi, BCFrag

- A.I. co-coordinator (as PREC) convener

## ► TwoF

- A.I. coordinator and member of expert team → work on AFBb, AFBC to be part of this report.  
See J.P. Márquez talk

## ► Final report by the ECFA-HF will include other studies

- Example: Hidden Valley searches (V. Mitsou as contact person). See E. Musumeci's talk

## ► LCWS

- A. I.: Plenary talk Calorimetry for Higgs Factory Detectors, Plenary Summary talk Detector Closeout
- Parallel talks by J.P.Márquez and E. Musumeci
- Participation of J. Fuster, M. Vos, J.P.Márquez and E. Musumeci and A. I.
- <https://indico.slac.stanford.edu/event/7467/>

## ► EPS-HEP

- Parallel talks by J.P.Márquez and E. Musumeci
- <https://www.eps-hep2023.eu/>

## ► 2nd ECFA Higgs/EW/Top Factories Workshop

- Participation of M. Vos, V. Mitsou, J.P.Márquez and E. Musumeci and A. I.
- <https://agenda.infn.it/event/34841/>

## ► Quantum Observables for Collider Physics

- M. Vos as co-organizer
- <https://www.ggi.infn.it/shoevent.pl?id=461>

► **Probing Gauge-Higgs Unification models at the ILC with di-quark forward-backward asymmetry at center-of-mass energies above the Z mass**

- A. Irles ( IFIC), J.P. Marquez ( IFIC), A. Saibel (IFIC) et al
- *Last stage of ILD review → to be submitted to EurPhysJ.*

► **Exploring hidden sectors with two-particle angular correlations at future  $e^+e^-$  colliders**

- E. Musumeci ( IFIC), A. Irles ( IFIC), R. Perez-Ramos (IPSA, Paris and Paris, LPTHE), I. Corredoira (Santiago de Compostela U., IGFAE), E. Sarkisyan-Grinbaum (CERN and Texas U., Arlington) et al. e-Print: 2312.06526
- Submitted to [PRD](#)

► **Probing non-perturbative QED and new physics with a LUXE-type experiment at the ILC**

- LUXE Collaboration · A. Irles ( IFIC) for the collaboration. e-Print: 2308.00117 [hep-ex]
- *Contribution to LCWS2023*

► **Two-particle angular correlations in the search for new physics at future  $e^+e^-$  colliders**

- E. Musumeci ( IFIC), R. Perez-Ramos (IPSA, Paris and Paris, LPTHE), A. Irles ( IFIC), I. Corredoira (Santiago de Compostela U. and Santiago de Compostela U., IGFAE), V.A. Mitsou ( IFIC) et al. e-Print: 2307.14734 [hep-ph]
- *Contribution to LCWS2023*

► **Experimental prospects for precision observables in  $e^-e^+ \rightarrow q\bar{q}$  with  $q=b,c$  processes at the ILC operating at 250 and 500 GeV of center of mass**

- A. Irles ( IFIC), J.P. Marquez ( IFIC) e-Print: 2307.14888 [hep-ex]
- *Contribution to LCWS2023*

► **Experimental methods and prospects on the measurement of electroweak  $b$  and  $c$ -quark observables at the ILC operating at 250 GeV**

- A. Irles ( IFIC), R. Poeschl (IJCLab, Orsay), F. Richard (IJCLab, Orsay) e-Print: 2306.11413 [hep-ex]
- *ILD-PHYS-PUB--2023-001*



## ► J. Fuster:

- Member of the **International Advisory Committee** of the ECFA -Higgs/Top/EW Workshop
- Member of the WG1 (Pre-Lab Setup) of the International Development Team (for ILC)

## ► M. Vos

- Member of the **ECFA committee** (in the spanish representatives team)
- **ILD Executive Member**
- Co-convener of WG1-GLOB working group for the ECFA -Higgs/Top/EW Workshop

## ► V. Mitsou

- FCC contact person of IFIC

## ► D. Esperante

- Member of the WG2 (accelerators) of the International Development Team (for ILC)

## ► A. Irles

- Co-convener in working groups of software (reconstruction) and physics groups (heavy quarks) for the ILD collaboration and the IDT (WG3)
- Co-convener of WG1-PREC working group for the ECFA -Higgs/Top/EW Workshop

## Some key dates / conferences

### ► LCWS2024 Tokyo (8-11 July)

- We are in the conveners team (A.I., M. Vos). Abstract call not yet open.
- <https://agenda.linearcollider.org/event/10134/>

### ► ICHEP2024 Prague (18-24 July)

- Abstracts by J.P. Márquez and E. Musumeci
- <https://ichep2024.org/>

### ► ECFA Workshop in October 2024

- We applied to be hosts... still waiting for news.

# The end





# Start of FCC-ee physics run

