

FUTURE COLLIDERS

Introduction and ECFA studies: **PK**

FCC: **Wouter Waalewijn**

P5 & muon collider: **Tristan du Pree**

Other e^+e^- colliders: **Peter Kluit**

How do we converge?: **Clara Nellist**

Discussion

02/06/2024 — Stafoverleg
[indico]

Patrick Koppenburg

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Nikhef

STRATEGIES

2020 — UPDATE OF THE EUROPEAN STRATEGY: “An **electron-positron Higgs factory** is the highest-priority.”
“For the longer term, [...] operate a **proton-proton collider** at the highest achievable energy.”

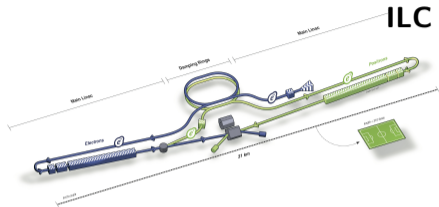
2023 — US PARTICLE PHYSICS PROJECT PRIORITIZATION PANEL: “An **off-shore Higgs factory**, realized in collaboration with international partners. FCC-ee and ILC meet our scientific requirements.”
“[...] while performing critical R&D towards a muon collider [...] on US soil. **This is our Muon Shot.**”

2025 — 15TH CHINESE FIVE-YEAR PLAN

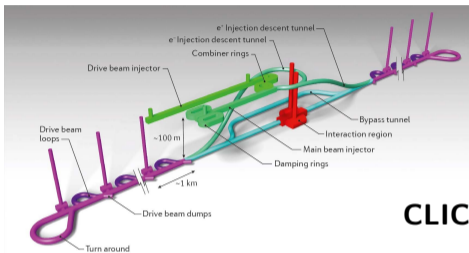
2026 (?) — UPDATE OF THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS



e^+e^- COLLIDERS

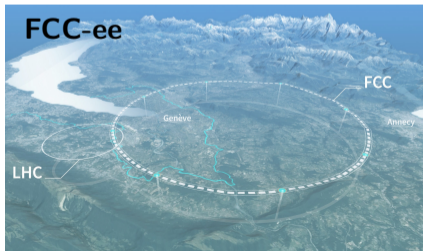
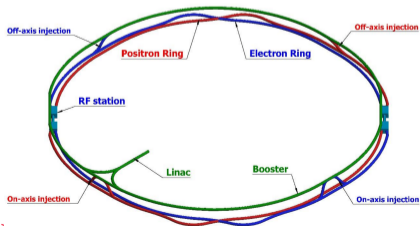


ILC



CLIC

CEPC



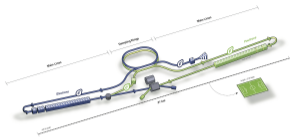
FCC-ee

FCC

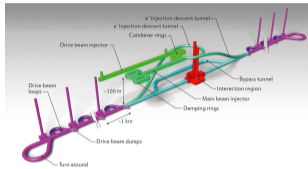
LHC

Annecy

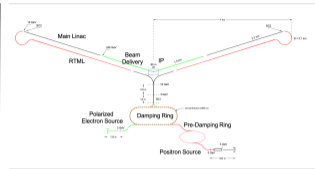
e^+e^- COLLIDERS



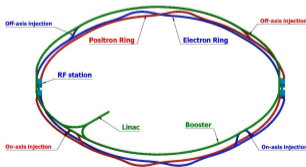
ILC



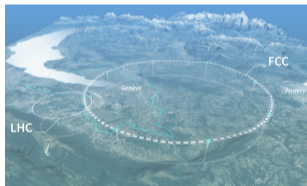
CLIC



C³

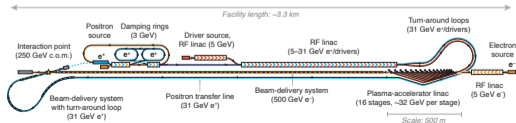


CEPC



FCC-ee

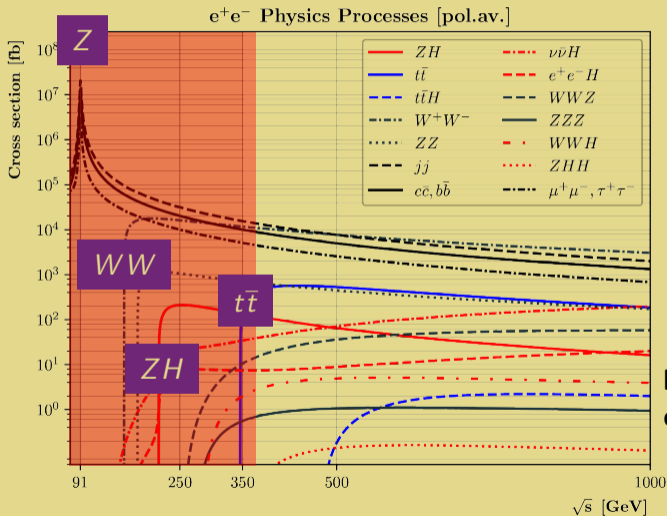
HALHF



[B]

ECFA e^+e^- HIGGS/TOP/EW FACTORY STUDY

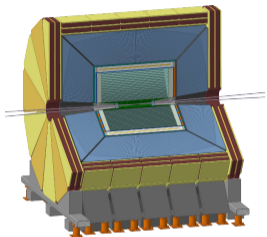
circular
colliders



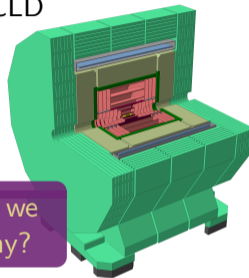
linear
colliders

FCC/ILC/CEPC/C³ DETECTORS

IDEA



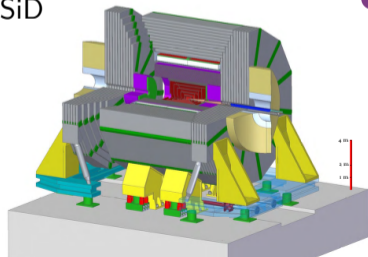
CLD



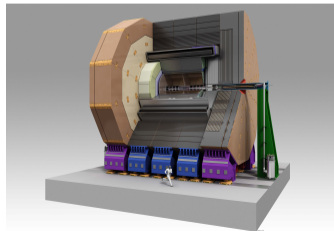
Not (yet) shown: CEPC
4th concept, ALLEGRO

Should we
join any?

SiD



ILD



[B]

PROJECTS

Project timescales

Indicative scenarios of future colliders [considered by ESG]

■ Proton collider
■ Electron collider
■ Muon collider

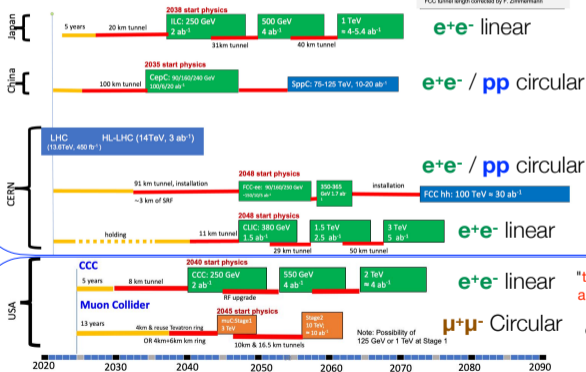
— Construction/Transformation
— Preparation / R&D

Original from ESPP by Ulmas Dasler
Updated July 25, 2022 by Meenah Nairan
FCC tunnel length corrected by F. Zimmermann

K. Jakobs

Comments:

- e^+e^- timelines are limited by approval processes
- CEPC and ILC projects need to get approval in the near future to maintain these schedules
- CERN projects are linked to completion of the HL-LHC
- hh timelines are limited by technology issues, costs, proceeding e^+e^- projects



"the timelines shown are technologically limited, and some challenges need to be sorted out, for example, successful R&D and feasibility demonstrations for C3 and Muon Collider are essential at a short timescale."

Snowmass21 Energy Frontier Report

REPORT ON THE ECFA e^+e^- WORKSHOP IN PAESTUM

- A glimpse of what you missed
- ... why you should come to the next

Dive into my
ECFA talk on
[\[indico\]](#)

02/06/2024 — Stafoverleg
[\[indico\]](#)

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Nikhef

ECFA e^+e^- WG1 FOCUS TOPICS

Topic	lead group	Title
1 HtoSS	HTE	$e^+e^- \rightarrow Zh: h \rightarrow s\bar{s}$
2 ZHang	HTE (GLOB)	ZH angular distributions and CP studies
3 Hself	GLOB	Higgs self-coupling
4 Wmass	PREC	Mass and width of the W boson
5 WWdiff	GLOB	Full studies of WW and $e\nu W$
6 TTthres	GLOB (HTE)	Top threshold
7 LUMI	PREC	Precision luminosity measurement
8 EXscalar	SRCH	New exotic scalars
9 LLPs	SRCH	Long-lived particles
10 EXtt	SRCH	Exotic top decays
11 CKMWW	FLAV	CKM matrix elements from W decays
12 BKtautau	FLAV	$B^0 \rightarrow K^{0*} \tau^+ \tau^-$
13 TwoF	HTE	EW precision: 2-fermion final states ($\sqrt{s} = M_Z$ and beyond)
14 BCfrag	FLAV (PREC)	Heavy quark fragmentation and hadronisation
15 Gsplit	PREC (FLAV)	Gluon splitting and quark-gluon separation

} merged

ECFA e^+e^- WG1 FOCUS TOPICS

Topic	lead group
1 HtoSS	HTE
2 ZHng	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
14 BCfrag	FLAV (PREC)
15 Gsplit	PREC (FLAV)

Focus topics for the ECFA study on Higgs / Top / EW factories

Juan Alcaraz Maestre¹, Juliette Alimena², John Alison³, Patrizia Azzi⁴, Paolo Azzurri⁵, Emanuele Bagnaschi^{6,7}, Timothy Barklow⁸, Matthew J. Basso⁹, Josh Bendavid¹⁰, Martin Beneke¹¹, Eli Ben-Haim¹², Mikael Berggren², Jorge de Blas¹³, Marzia Bordonone⁶, Ivanka Bozovic¹⁴, Valentina Cairo⁶, Nuno Filipe Castro¹⁵, Marina Cobal¹⁶, Paula Collins⁶, Mogens Dam¹⁷, Valerio Dao⁶, Matteo Defranichis⁶, Ansgar Denner¹⁸, Stefan Dittmaier¹⁹, Gauthier Durieux²⁰, Ulrich Einhaus², Mary-Cruz Fouz¹, Roberto Franceschini²¹, Ayres Freitas²², Frank Gaede², Gerardo Ganis⁶, Pablo Goldenzeig²³, Ricardo Gonçalo^{24,25}, Rebecca Gonzalez Suarez²⁶, Loukas Gouskos²⁷, Alexander Grohsjean²⁸, Jan Hajer²⁹, Chris Hays³⁰, Sven Heinemeyer³¹, André Hoang³², Adrián Irlés³³, Abideh Jafari², Karl Jakobs¹⁹, Daniel Jeans³⁴, Jernej F. Kamenik³⁵, Matthew Kenzie³⁶, Wolfgang Kilian³⁷, Markus Klute²³, Patrick Koppenburg³⁸, Sandra Kortner³⁹, Karsten Konecki⁴⁰, Marcin Kucharczyk⁴⁰, Christos Leonidopoulos⁴¹, Cheng Li⁴², Zoltan Ligeti⁴³, Jenny List², Fabio Maltoni²⁰, Elisa Manoni⁴⁴, Giovanni Marchioni⁴⁵, David Marzocca⁴⁶, Andreas B. Meyer², Ken Mimasu⁴⁸, Tristan Miralles⁴⁷, Victor Miralles⁴⁹, Abdollah Mohammadi⁵⁰, Stéphane Monteil⁵¹, Gudrid Mootgat-Pick²⁸, Zohreh Najafabadi⁵², María Teresa Núñez Pardo de Vera², Fabrizio Palla⁵, Michael E. Peskin⁸, Fulvio Piccinini⁵³, Laura Pintucci⁵⁴, Wiesław Placzek⁵⁵, Simon Plätzer^{56,52}, Roman Pöschl⁵⁷, Tania Robens⁵⁸, Aidan Robson⁵⁹, Philipp Roloff⁶, Nikolaos Rompotis⁶⁰, Andrej Saibel³³, André Sailer⁶, Roberto Salerno⁶¹, Matthias Schott⁶², Reinhard Schwienhorst⁶³, Felix Sefkow², Michele Selvaggi⁶, Frank Siegert⁶⁴, Frank Simon²³, Andrzej Siudmok⁶⁵, Torbjörn Sjöstrand⁶⁶, Kirill Skovpen⁶⁶, Maciej Skrzypek⁶⁰, Yotam Soreq⁶⁷, Raimund Strohmer¹⁸, Taikan Suehara⁶⁸, Junping Tian⁶⁹, Emma Torro Pastor³², Maria Ubiali³⁶, Luiz Vale Silva³³, Caterina Vernieri⁶, Alessandro Vicini⁶⁹, Marcel Vos³³, Aidan R. Wiederhold⁷⁰, Sarah Louise Williams³⁶, Graham Wilson⁷¹, Aleksander Filip Zarnacki⁷², Dirk Zerwas^{73,75}

Abstract

In order to stimulate new engagement and trigger some concrete studies in areas where further work would be beneficial towards fully understanding the physics potential of an e^+e^- Higgs / Top / Electroweak factory, we propose to define a set of focus topics. The general reasoning and the proposed topics are described in this document.

arXiv:2401.07564v3 [hep-ph] 18 Jan 2024

NEXT STEPS



NEXT STEPS (AIDAN ROBSON)

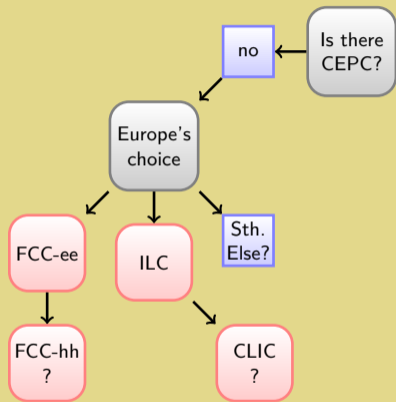
- 1 Document describing the focus topics [de Blas, Koppenburg, List, Maltoni, et al., arXiv:2401.07564]
- 2 Inputs by end 2025
 - Report structure by 2024
 - Focus input by May 2025,
 - Editing in summer
- 3 Next strategy in 2026–27

Or maybe faster?

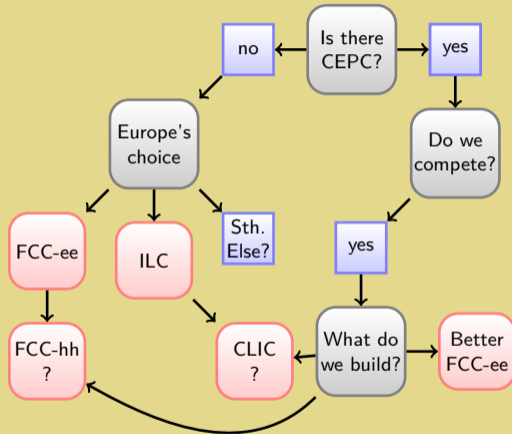
DECISION TREE (CEPC CENTRIC)

Is there
CEPC?

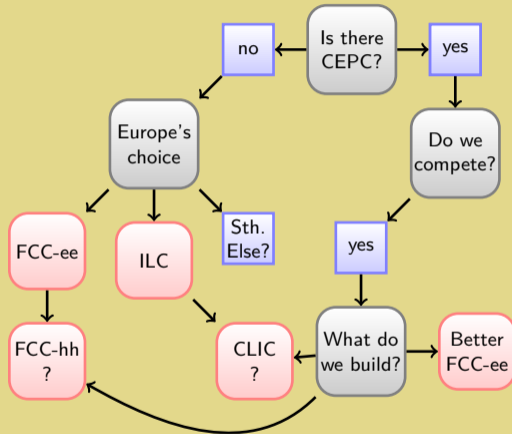
DECISION TREE (CEPC CENTRIC)



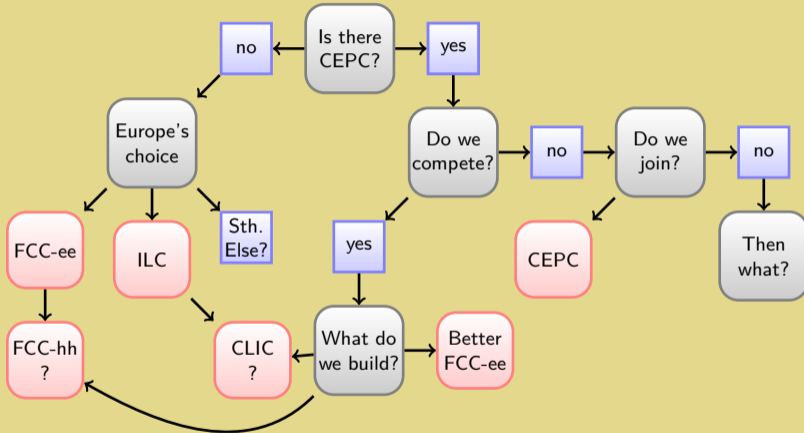
DECISION TREE (CEPC CENTRIC)



DECISION TREE (CEPC CENTRIC)

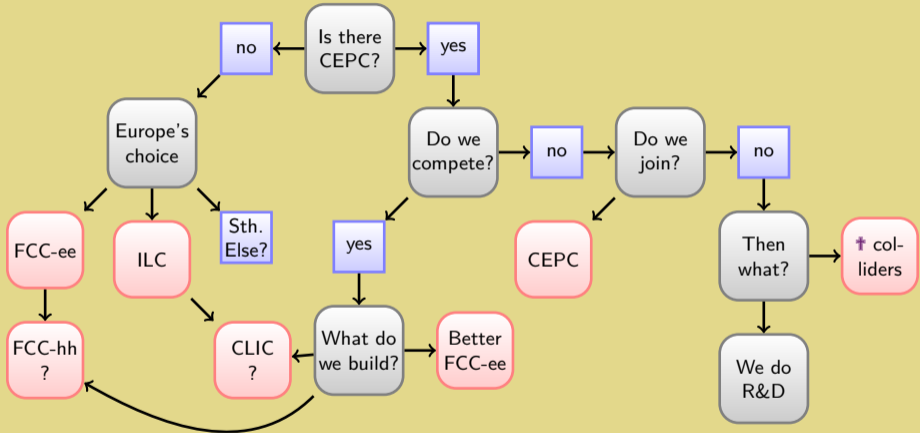


DECISION TREE (CEPC CENTRIC)

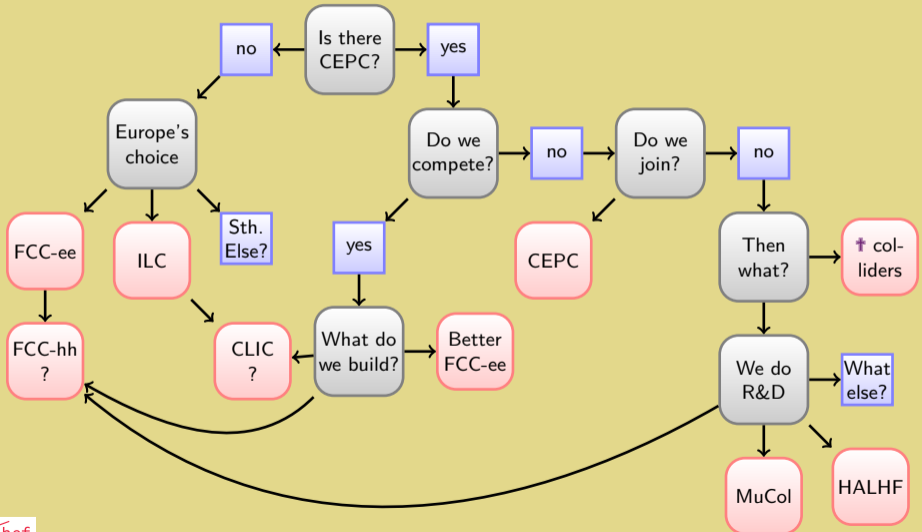


CEPC participation should be via CERN

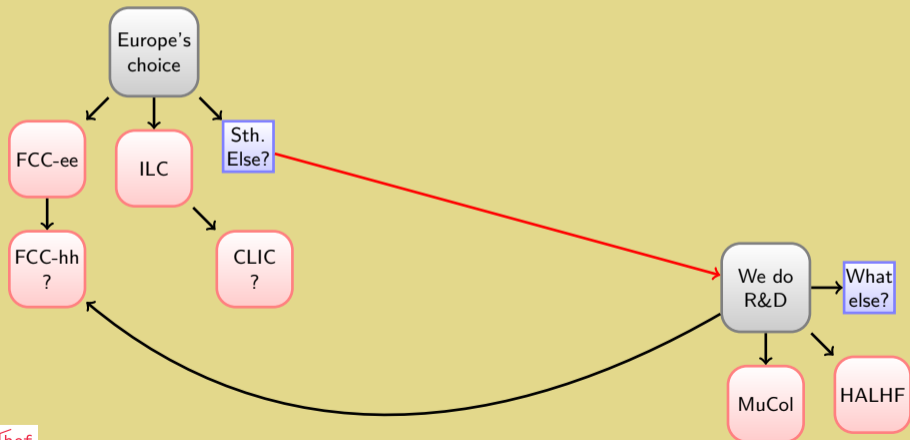
DECISION TREE (CEPC CENTRIC)

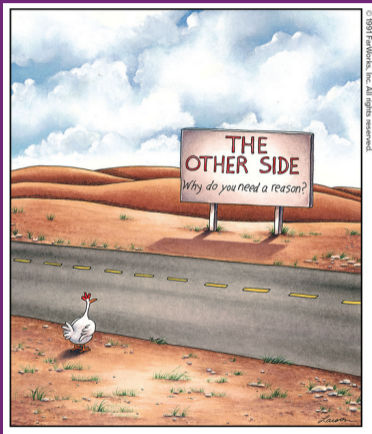


DECISION TREE (CEPC CENTRIC)



DECISION TREE (EUROPE CENTRIC)



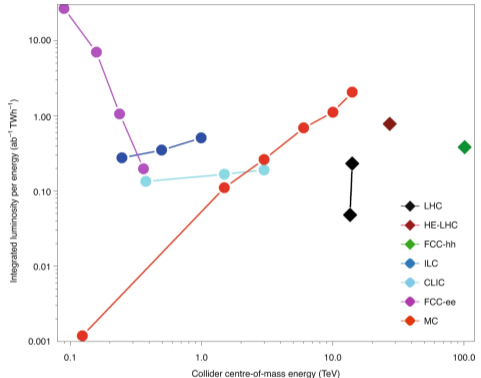


Backup

e^+e^- COLLIDERS

Linear colliders

- ILC, CLIC, C³...
- 4–20 km
- High lumi and power efficiency at high energies
- Single interaction region
- Longitudinally spin-polarised beams
- Can be upgraded by making it longer (or improving gradient)



[Long et al., Nat. Phys. 17 (2021) 289]

e^+e^- COLLIDERS

Linear colliders

- ILC, CLIC, C³...
- 4–20 km
- High lumi and power efficiency at high energies
- Single interaction region
- Longitudinally spin-polarised beams
- Can be upgraded by making it longer (or improving gradient)

Circular colliders

- FCC-ee, CEPC
- 100 km
- High lumi and power efficiency at low energies
- Multiple interaction regions
- Very clean; little beamstrahlung
- Tunnel can be re-used for hh or he collider

[B]