A Linear Collider Vision for the Future of Particle Physics

250 GeV, 550 GeV, multi-TeV

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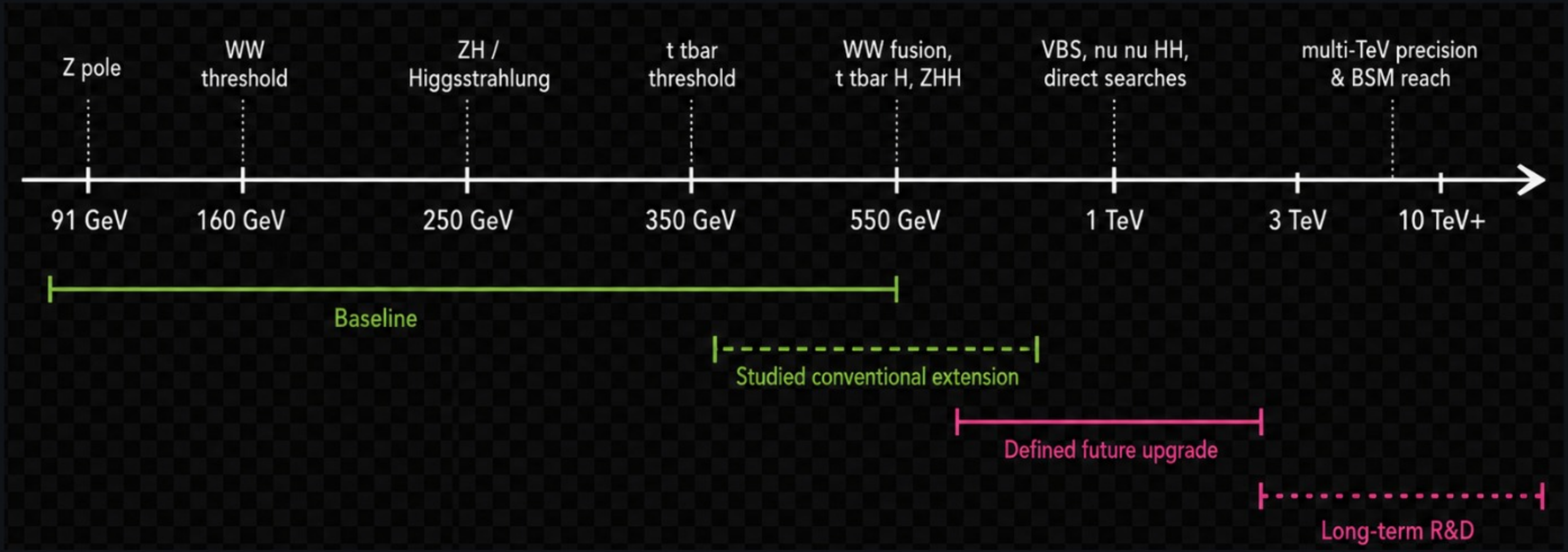
Linear Collider Vision

What programme should follow the HL-LHC?

- Precision study of the Higgs boson
- Precision electroweak and top physics
- Search for weakly interacting new particles
- Sensitivity to heavy new physics through effective interactions
- A credible route towards substantially higher collision energies

The first stage is a Higgs factory. What should come next?



A Higgs factory is necessary - but the long-term programme should not end at the Higgsstrahlung maximum

What does a linear collider add beyond HL-LHC?

Not simply smaller uncertainties - qualitatively different experimental information

Tag the Higgs inclusively

$$e^+e^- \to ZH$$

- Count ZH without observing the Higgs decay
- Anchor an absolute Higgs-coupling framework

Test the complete Higgs picture

- Direct sensitivity to invisible decays
- Constrain exotic and unobserved branching fractions

Separate chiral interactions

$$e^-_L e^+_R, \qquad e^-_R e^+_L, \qquad e^-_L e^+_L, \qquad e^-_R e^+_R$$

- SSelect electron and positron helicities
- Disentangle electroweak and EFT structures

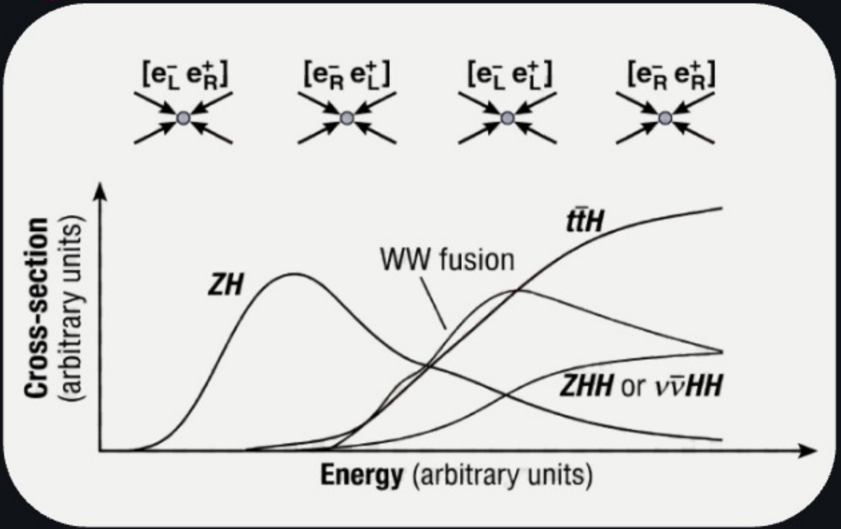
Use a known collision energy

- Scan thresholds
- Access complementary top and double-Higgs processes

Polarisation and energy change the experiment

Polarised initial states

- P(e-) = 80%, P(e+) = 30%
- Distinguish chiral interactions
- Enhance signals and suppress backgrounds
- Separate EFT contributions and provide internal cross-checks



Energy flexibility

- Run at thresholds and selected energies (extend beyond top threshold)
- Increase energy by adding or replacing accelerating systems
- Avoid the high-energy synchrotron-radiation limitation of a circular e+e- collider

A linear collider controls both the energy and the chiral structure of the initial states

From individual collider projects to a common facility strategy

1. Build with mature technology

ILC-derived SCRF

- 31.5 MV/m baseline
- Large-scale operating experience
- Established industrial production
- No new full-scale demonstrator required

2. Design a reusable facility

Infrastructure beyond one machine stage

- Tunnel and services
- Sources and damping rings
- Beam delivery and interaction regions
- Power and cryogenics
- Experimental and R&D areas

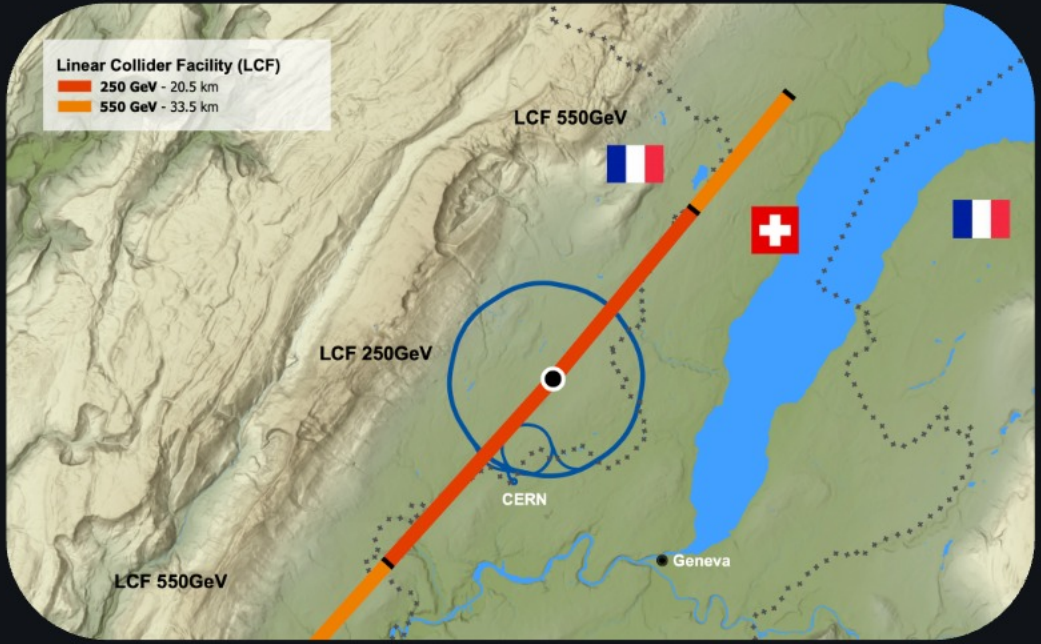
3 Upgrade when evidence is available

Future technology selected later

- Advanced SCRF
- CLIC-type RF
- Cold copper / C3
- Recovery concepts
- Wakefield acceleration

The initial and eventual accelerator technologies do not need to be the same

A concrete reference configuration for CERN



Initial facility

- Approximately 33km
- Two interaction regions
- ILC-derived SCRF
- 31.5 MV/m
- Polarised electron/positron beams
- Operation initially at 250 GeV
- Infrastructure compatible with 550 GeV conventional-SCRF operation

Updated for a CERN flagship role

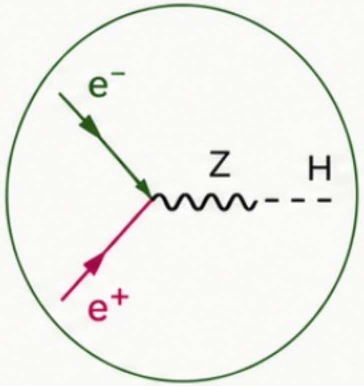
- Higher repetition rate than the original ILC baseline
- Increased luminosity options
- Improved cavity quality factor and RF efficiency assumptions

LCF is not simply the Japanese ILC relocated to CERN: it uses the mature ILC technology base in a facility rescaled for a broader CERN programme.

Physics and investment proceed in stages

STAGE 1 — 250 GeV

Baseline



- 3 ab^{-1}
- Higgsstrahlung and recoil programme
- Electroweak measurements
- Invisible and exotic Higgs decays
- Z-pole and WW-threshold operation

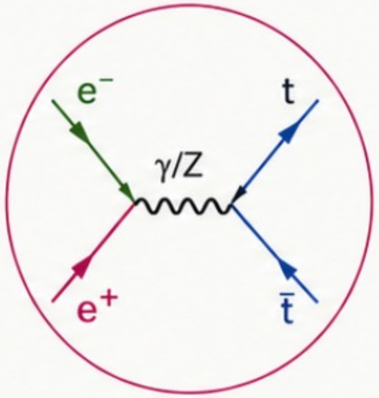
≈ 8.3 BCHF (5 Hz configuration)

≈ 9.1 BCHF (higher-luminosity configuration)

DATA TAKING AND REASSESSMENT

STAGE 2 — 550 GeV

Studied extension



- $t\bar{t}$ threshold on the way
- Target 8 ab^{-1}
- WW-fusion Higgs programme
- $t\bar{t}H$
- ZHH and $\nu\bar{\nu}HH$

≈ +5.5 BCHF

(incremental to Stage 1)

(Reference study estimates; direct comparisons require aligned scope and costing conventions.)

The first physics stage can be approved without financing the complete long-term programme from day one.

Build today
without freezing the technology of 2050

Energy upgrade

- Advanced SCRF
- CLIC-type RF
- Cold copper / C^3
- Wakefield acceleration

Luminosity upgrade

- Improved RF performance
- Energy recovery
- Particle recycling

Alternative modes

- $\gamma\gamma$
- $e\gamma$
- e^-e^-
- Specialised configurartions

These are options to preserve,
not promises that all technologies are construction-ready today.

A mature starting point and an active R&D programme

ILC (SCRF)

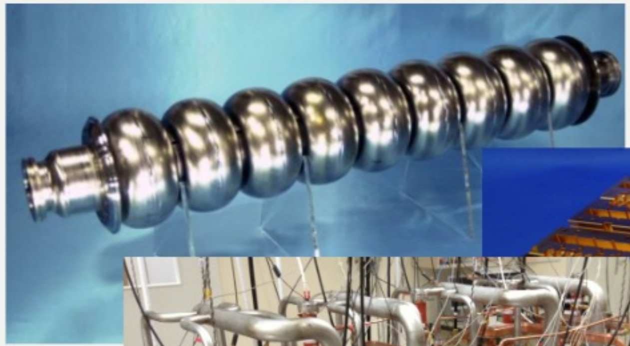
operational experience and industrial production

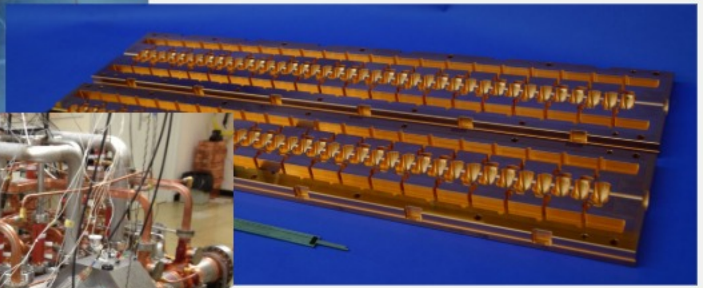
CLIC

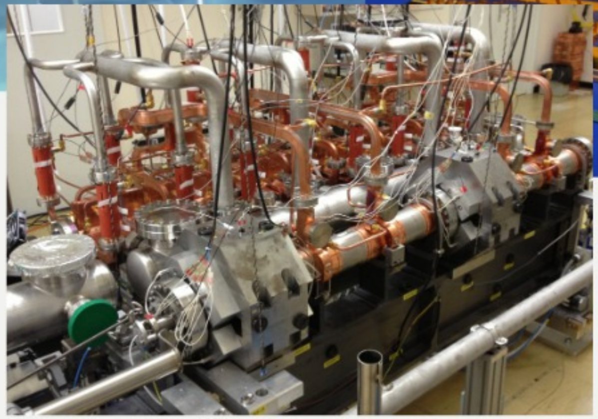
validated high-gradient RF and beam-delivery R&D

C^3 / advanced copper

active cryogenic-copper development







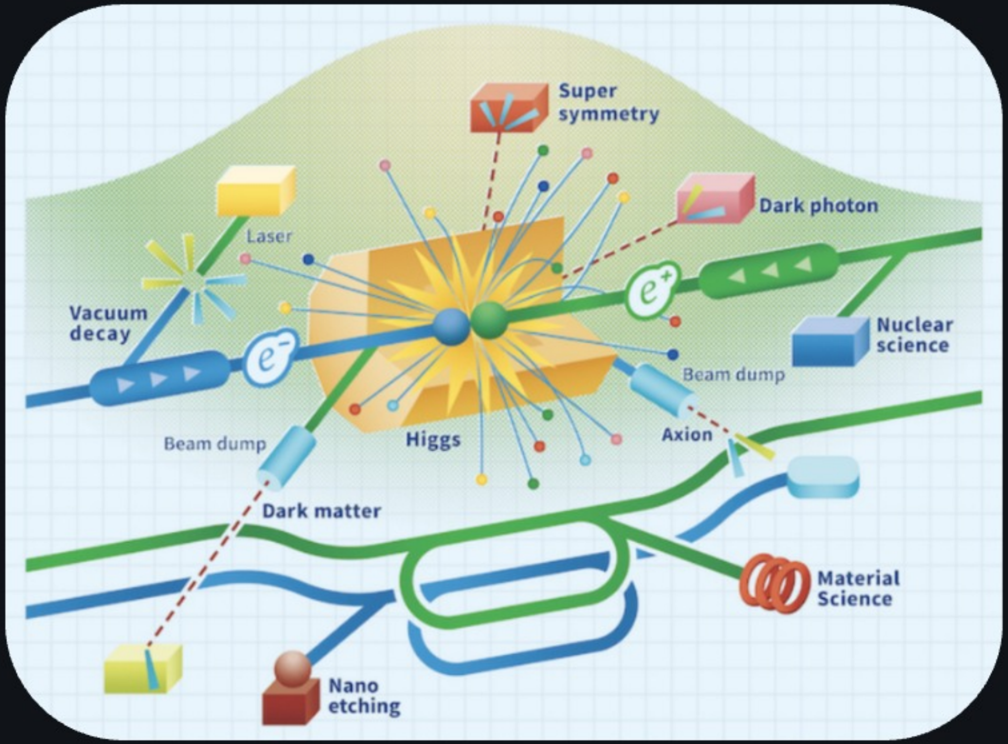
**The initial LCF does not depend on future breakthroughs;
future breakthroughs can make the same facility more powerful.**

More than one collider experiment

A linear facility naturally provides access to intense and well-defined beams before and after the interaction point.

Possible opportunities

- Beam-dump experiments
- Fixed-target experiments
- Dark sector searches
- Axion-like particle searches
- Irradiation and materials research
- Detector test beams
- Accelerator R&D
- Sources and advanced-beam studies



The facility can support a diversified scientific programme during collider operation and between energy stages.

Examples and studies:
ILCX2021 Workshop on Potential Experiments

A linear collider is a strategy of staged decisions

Mature
An initial machine based on proven superconducting RF

Precise
Polarised, clean e^+e^- collisions with controllable initial states

Extendable
A programme from the Z pole through top and double Higgs to much higher energy

Future-ready
Later technologies selected when physics and R&D justify them

Start with technology we know - preserve the freedom to use technologies we do not yet know.

250 GeV 550 GeV multi TeV