European Strategy Input

Updated Baseline for a Staged Compact Linear Collider
arXiv: 1608.07537, CERN-2016-004 ✓

Higgs Physics at the CLIC Electron-Positron Linear Collider
arXiv: 1608.07538, Eur. Phys. J. C77 (2017) 475 ✓

The optimised CLIC detector model CLICdet
CLICdp-Note-2017-001 ✓ and CLICdet detector validation note ✓

Top-quark physics at the CLIC electron-positron linear collider
arXiv: 1807.02441, in journal review ✓

- CLIC Project Implementation Plan — 2018
- The CLIC Potential for New Physics — 2018
- Detector Technologies for CLIC — early 2019

Four new CERN Yellow Reports

CLIC 2018 Summary Report — 2018

Official short ESU submissions (~10 pages):
1) CLIC project (accelerator + detector)
2) CLIC physics

All documentation available:
https://clic.cern/european-strategy

CLIC Accelerator — Organisation Publications
CLIC Detector & Physics — Organisation Publications

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European Strategy for Particle Physics

The **Compact Linear Collider** (CLIC) is a **TeV-scale high-luminosity linear electron-positron collider** under development by international collaborations hosted by CERN.

The CLIC accelerator collaboration and CLIC Detector and Physics collaboration together comprise around **400 participants from approximately 75 institutes** worldwide. Additional contributions are made from beyond the collaborations.

A number of **documents** report on the **CLIC accelerator and detector and physics status** in advance of the **European Strategy update 2018-2020**, including the design, technology, and implementation aspects of the CLIC accelerator and the detector, and summaries of the physics potential of CLIC.

CLIC input to the European Strategy for Particle Physics Update 2018-2020

Formal European Strategy submissions

- **The Compact Linear e+e- Collider (CLIC): Accelerator and Detector** (arXiv:1812.07987)
- **The Compact Linear e+e- Collider (CLIC): Physics Potential** (arXiv:1812.07986)

Yellow Reports

- **CLIC 2018 Summary Report** (CERN-2018-005-M, arXiv:1812.06018)
- **CLIC Project Implementation Plan** [Draft]
- **The CLIC potential for new physics** (CERN-2018-009-M)
- **Detector technologies for CLIC** [In collaboration review]

–> please publicise widely

The CLIC Potential for New Physics

CERN-2018-XXX
04.12.2018

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

THE CLIC POTENTIAL FOR NEW PHYSICS

GENEVA
2018

Submitted 4/12/18

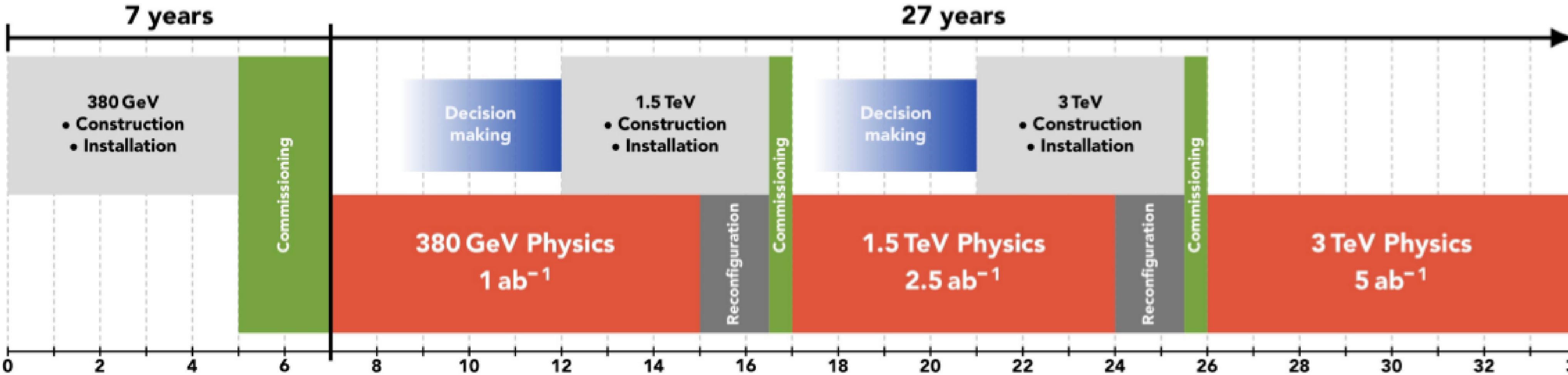
Congratulations & thanks to all involved!

Contents

CERN-2018-009-M
http://dx.doi.org/10.23731/CYRM-2018-003

Costs and schedules

CLIC TDR 2025, start construction 2026



Cost of stage 1: CHF 5.9B
stage 2: + CHF 5.1B
stage 3: + CHF 7.3B

FCC (from DG's new year message)

Purely technical schedule, assuming green light to preparation work in 2020.
A 70 years programme

8 years preparation	10 years tunnel and FCC-ee construction	**15 years FCC-ee operation**	11 years FCC-hh preparation and installation	**25 years FCC-hh operation pp/PbPb/eh**
2020-2028		**2038-2053**		**2064-2090**

FCC-ee

Estimated cost: ~ **11.6** BCHF: 5.4 B (tunnel), 5.1 B (injectors + collider up to √s=240 GeV), 1.1 B (additional RF for operation at √s ~365 GeV)

FCC-hh

Estimated cost: ~ **17** BCHF (13.6 B collider [magnets!] + injectors) if built after FCC-ee (tunnel and part of infrastructure exists); 24 BCHF if standalone.

Time to make CLIC's message very clear

Unprecedented, excellent, diverse physics reach

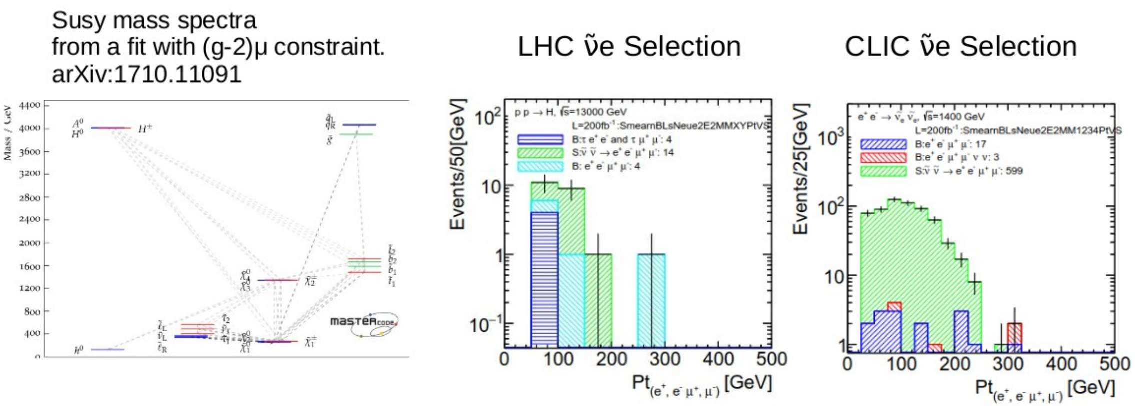
Feasible timescale

Cost of CLIC 380GeV + 1.5TeV < cost of FCC-ee

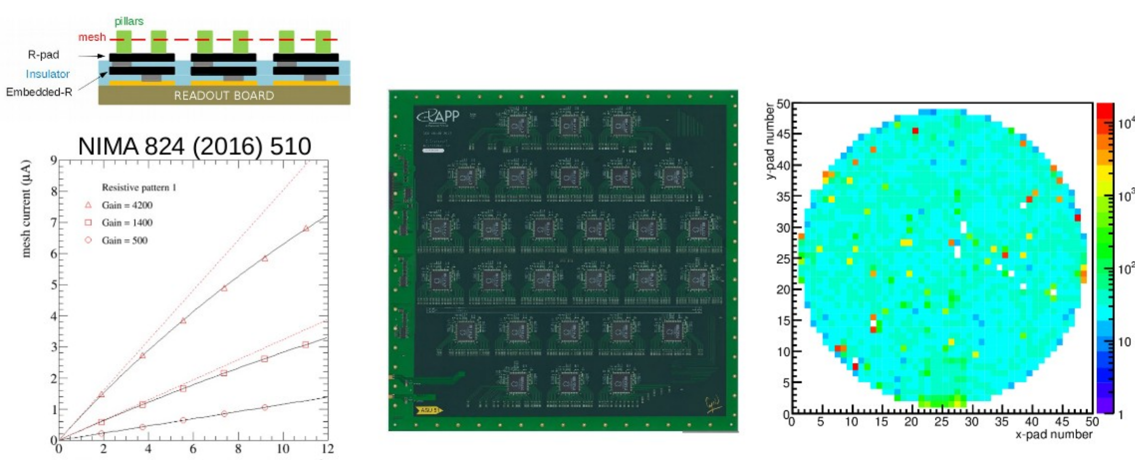
CLIC staging brings cost staging, and accompanying implications on affordability

Linear tunnel provides natural infrastructure for future beyond CLIC

- **Comparison of LHC-CLIC discovery potential for SUSY particles.**
  - **Start from 2 best fit points of current measurements to pMSSM11 (m ~ 400 GeV)**
  - **Study sensitivity with CLIC 1.4 TeV and 13 TeV LHC for decays to 4 leptons (200 fb-1)**
  - **CLICdp input to european strategy update**



- **2016: optimisation des anodes résistives sur de petits prototypes (10x10 cm²).**
- **2017: obtention d'un support financier (RD51 "common project") pour la fabrication d'un prototype de calorimètre utilisant des détecteurs à micro-structures comme milieu sensible.**
- **2018: fabrication et opération des premiers plans Micromegas résistifs de 50x50 cm² et collaboration avec le Weizmann Institute of Science pour la partie GEM. (+ participation financière du LAPP)**



Expertise LAPP

R&D Micromegas
(M Chefdeville)

Etude de physique
(J-J Blaising)

+ Stabilisation
(LaVista, Brunetti)

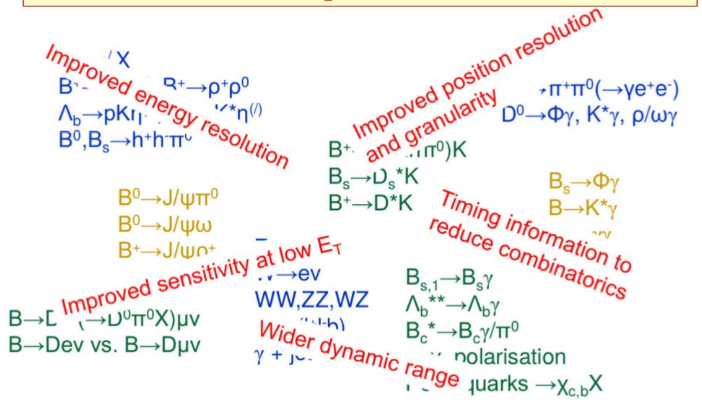
+ Instrumentation faisceau
(CTF3, Vilalte, Nappa)

- CLIC
  - Peu de fond, pas de trigger, état initial connu (modulo beamstrahlung), repousse les frontières de précision ET d'énergie
  - Physique, machine & détecteurs documentés, calendrier solide
  - Au-delà de 3 TeV (100 MV/m), gradients de 145 MV/m atteints avec le prototype CTF3 ($\rightarrow$ 5 TeV)

- FCCee VS CLIC
  - Lumi x 1000 @ Zpole (égales @ tt)... 100 kHz de Z vraiment nécessaires?
  - Plus loin dans le temps (5-10 ans), plus cher (conjoncture économique)
  - Favori du CERN, passerelle vers FCCpp

- Mesures de précision
  - = programme des saveurs de LHCb (& Belle 2), Upgrade Run3 (L. x 6)
et LOI pour Run5 (L. x 60) avec un projet de nouveau calorimètre (FCPPL)
  - Confirmation des anomalies de saveur avec les données du Run2? Recherche de leptoquarks.

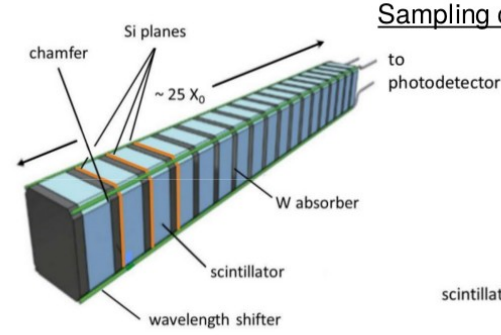
Physics analysis with particular sensitivity to ECAL performance

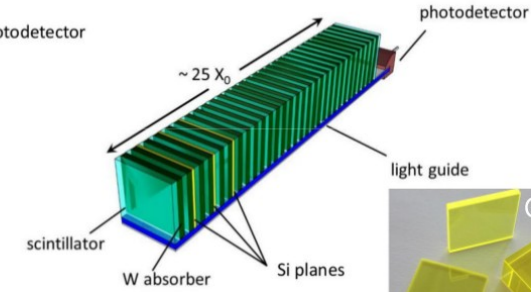


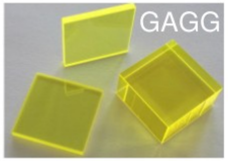
➢ Simulation studies needed to define the design parameters

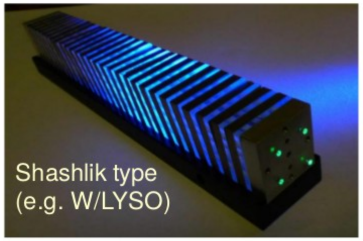
Ideas "on the market" for LHCb ECAL upgrade

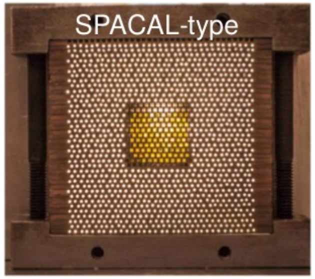
Sampling calorimeters of various type



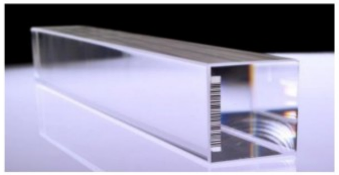






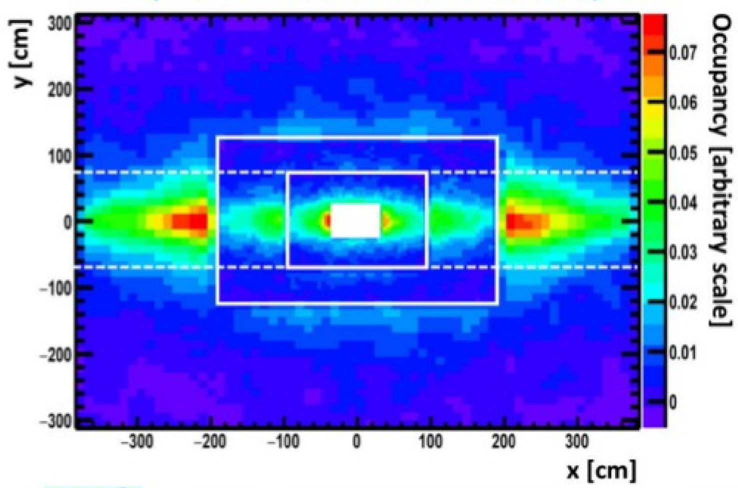


Homogeneous Crystals

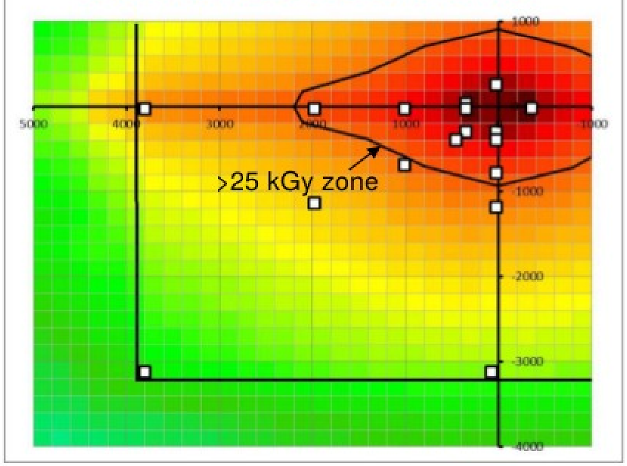


[a lot of expertise in CMS and RD18]

Occupancies in different ECAL regions

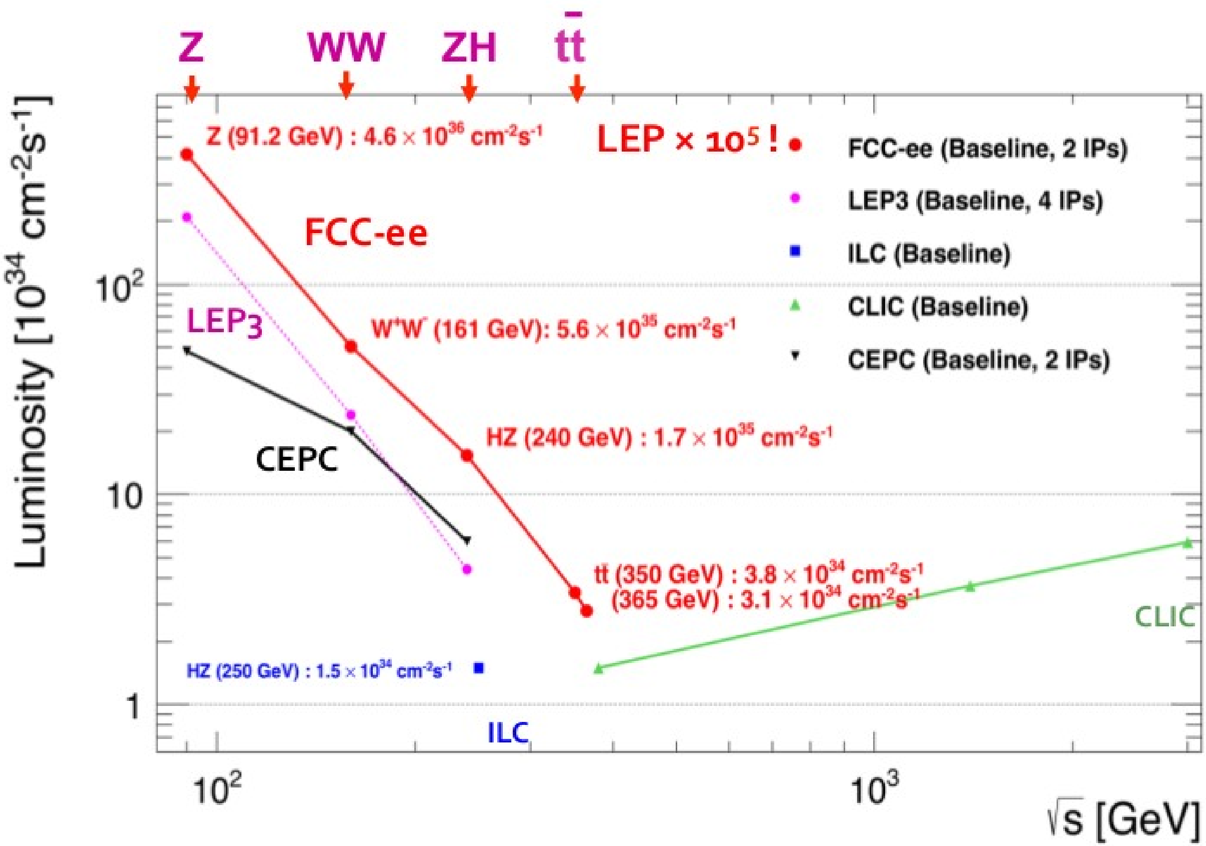


Radiation dose on ECAL front



EW factories : Energies and luminosities

- The FCC-ee offers the largest luminosities in the 88 → 365 GeV √s range



- Ultimate precision:
  - 100 000 Z / second (!)
    - 1 Z / second at LEP
  - 10 000 W / hour
    - 20 000 W at LEP
  - 1 500 Higgs bosons / day
    - 10 times ILC
  - 1 500 top quarks / day

    in each detector

… in a clean environment:

- No pileup
- Beam backgrounds under control
- E,p constraints

PRECISION and SENSITIVITY to rare or elusive phenomena

- The FCC-ee discovery potential at the precision frontier is multiplied by the presence of the four heaviest SM particles (Z, W, H, and top) in its energy range

The FCC-ee discovery potential (excerpt)

- **EXPLORE the 10-100 TeV energy scale**
  - With precision measurements of the properties of the Z, W, Higgs, and top particles
    - Up to 20-50-fold improved precision on ALL electroweak observables (EWPO)
      - ➨ m_Z, m_W, m_{top}, Γ_Z, $\sin^2\theta_W^{eff}$, R_b, $\alpha_{QED}(m_Z)$, $\alpha_s(m_Z\ m_W\ m_\tau)$, top EW couplings …
    - Up to 10-fold more precise and model-independent Higgs couplings measurements

arXiv:1512.05544
arXiv:1603.06501
arXiv:1503.01325

- **DISCOVER that the Standard Model does not fit**
  - NEW PHYSICS ! Pattern of deviations may point to the source.
- **DISCOVER a violation of flavour conservation / universality**
  - Examples: $Z \to \tau\mu$ in 5×10^{12} Z decays; or $\tau \to \mu\nu$ / $\tau \to e\nu$ in 2×10^{11} τ decays; …
  - Also $B^0 \to K^{*0}\tau^+\tau^-$ or $B_S \to \tau^+\tau^-$ in 10^{12} bb events
- **DISCOVER dark matter as invisible decays of Higgs or Z**
- **DIRECT DISCOVERY of very-weakly-coupled particles**
  - in the 5-100 GeV mass range, such as right-handed neutrinos, dark photons, ALPs, …
    - Motivated by all measurements / searches at colliders (SM and "nothing else")

FCC-ee is not only a Higgs factory. Z, WW, and $t\bar{t}$ factories are important for discovery potential

First look at the physics case of TLEP https://arxiv.org/abs/1308.6176 (Aug. 2013)