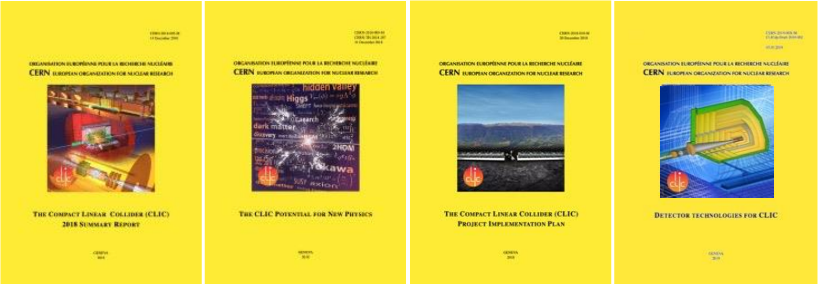
Status reports and studies

Two formal submissions to the ESPPU 2018

3-volume CDR 2012   *Updated Staging Baseline 2016*

4 CERN Yellow Reports 2018



Details about the accelerator, detector R&D, physics studies for Higgs/top and BSM

Available at:

clic.cern/european-strategy

Several LoIs have been submitted on behalf of CLIC and CLICdp to the Snowmass process:

- *The CLIC accelerator study: Link*
- *Beam-dynamics focused on very high energies: Link*
- *The physics potential: Link*
- *The detector: Link*

Snowmass white paper:

https://arxiv.org/abs/2203.09186

Broadly speaking: “Updated accelerator part of 2018 Summary Report”

The CLIC project

O. Brunner[a], P. N. Burrows[b], S. Calatroni[a], N. Catalan Lasheras[a], R. Corsini[a], G. D'Auria[c], S. Doebert[a], A. Faus-Golfe[d], A. Grudiev[a], A. Latina[a], T. Lefevre[a], G. Mcmonagle[a], J. Osborne[a], Y. Papaphilippou[a], A. Robson[e], C. Rossi[a], R. Ruber[f], D. Schulte[a], S. Stapnes[a]*, I. Syratchev[a], W. Wuensch[a]

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April 4, 2022

Abstract

The Compact Linear Collider (CLIC) is a multi-TeV high-luminosity linear e^+e^- collider under development by the CLIC accelerator collaboration, hosted by CERN. The CLIC accelerator has been optimised for three energy stages at centre-of-mass energies 380 GeV, 1.5 TeV and 3 TeV [21]. CLIC uses a novel two-beam acceleration technique, with normal-conducting accelerating structures operating in the range of 70 MV/m to 100 MV/m.

The report describes recent achievements in accelerator design, technology development, system tests and beam tests. Large-scale CLIC-specific beam tests have taken place, for example, at the CLIC Test Facility CTF3 at CERN [39], at the Accelerator Test Facility ATF2 at KEK [53, 67], at the FACET facility at SLAC [35] and at the FERMI facility in Trieste [36]. Crucial experience also emanates from the expanding field of Free Electron Laser (FEL) linacs and recent-generation light sources. Together, they demonstrate that all implications of the CLIC design parameters are well understood and reproducible in beam tests and prove that the CLIC performance goals are realistic. An alternative CLIC scenario for the first stage, where the accelerating structures are powered by X-band klystrons, is also under study. The implementation of CLIC near CERN has been investigated. Focusing on a staged approach starting at 380 GeV, this includes civil engineering aspects, electrical networks, cooling and ventilation, installation scheduling, transport, and safety aspects. All CLIC studies have put emphasis on optimising cost and energy efficiency, and the resulting power and cost estimates are reported. The report follows very closely the accelerator project description in the CLIC Summary Report for the European Particle Physics Strategy update 2018-19 [22].

Detailed studies of the physics potential and detector for CLIC, and R&D on detector technologies, have been carried out by the CLIC detector and physics (CLICdp) collaboration. CLIC provides excellent sensitivity to Beyond Standard Model physics, through direct searches and via a broad set of precision measurements of Standard Model processes, particularly in the Higgs and top-quark sectors. The physics potential at the three energy stages has been explored in detail [2, 3, 17] and presented in submissions to the European Strategy Update process.

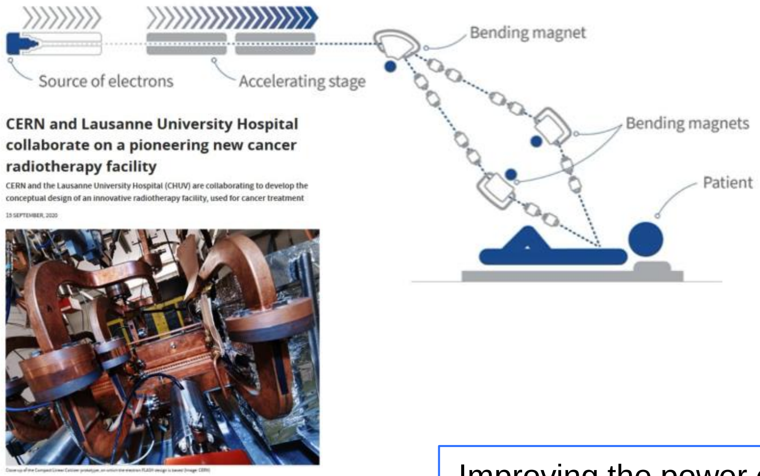
Submitted to the Proceedings of the US Community Study on the Future of Particle Physics (Snowmass 2021)

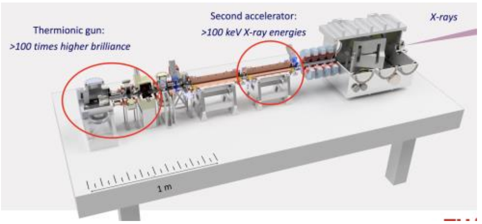
*Compiled and edited by the CLIC Accelerator Steering Group on behalf of the CLIC Accelerator Collaboration, corresponding author: steinar.stapnes@cern.ch

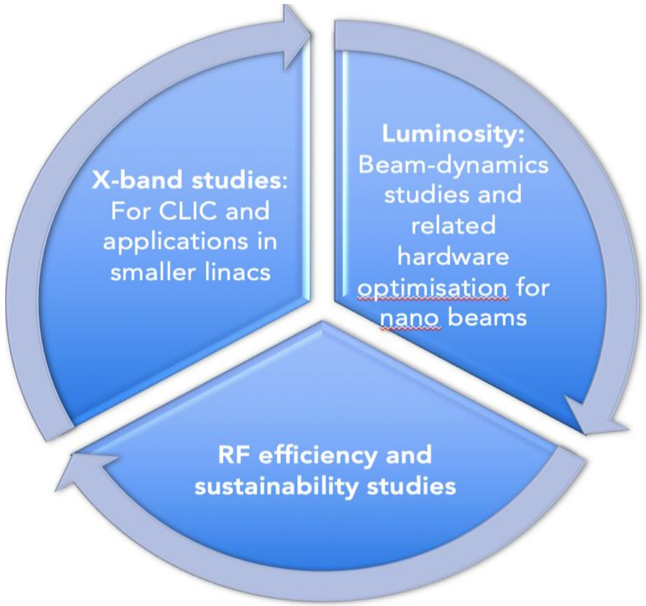
On-going CLIC studies towards next ESPP update

Project Readiness Report as a step toward a TDR
Assuming ESPP in ~ 2026, Project Approval ~ 2028, Project (tunnel) construction can start in ~ 2030.

The X-band technology readiness for the 380 GeV CLIC initial phase - more and more driven by use in small compact accelerators







Optimizing the luminosity at 380 GeV – already implemented for Snowmass paper, further work to provide margins will continue.

Luminosity margins and increases:

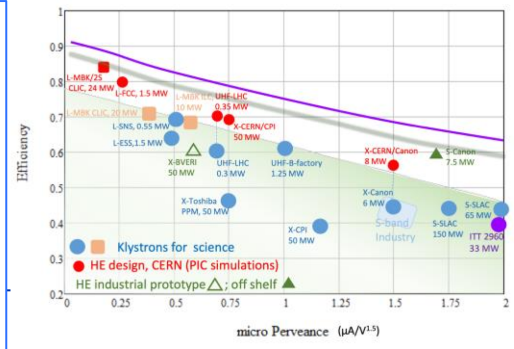
- Initial estimates of static and dynamic degradations from damping ring to IP gave: 1.5 x 10^{34} cm^{-2} s^{-1}
- Simulations taking into accord static and dynamic effects with corrective algorithms give 2.8 on average, and 90% of the machines above **2.3 x 10^{34} cm^{-2} s^{-1}** (this is the value currently used)

Improving the power efficiency for both the initial phase and at high energies, including more general sustainability studies

Power estimate bottom up (concentrating on 380 GeV systems)

- Very large reductions since the CDR, better estimates of nominal settings, much more optimised drivebeam complex and more efficient klystrons, injectors more optimized, main target damping ring RF significantly reduced, recent L-band klystron studies

Energy consumption ~0.6 TWh yearly, CERN is currently (when running) at 1.2 TWh (~90% in accelerators)



Readiness Report around ~2025-26

Update wrt Project Implementation Plan document 2018

Key updates:

- Luminosity numbers, covering beam-dynamics, nanobeam studies and hardware, and positron production - at all energies
  - Risk reduction (wrt performance), bumps, redundancies
- Energy/power/sustainability: 380 well underway, 3 TeV to be done, L-band klystrons
- Sustainability issues, more work on running/energy models, carbon (construction/operation/disassembly)
- X-band progress – for CLIC, smaller machines, industry availability, including RF network
- RF design optimization/development – including injectors, R&D for higher energies, gradient (cool/HTS/etc.), power, beam parameters - links to plasma (if it can be made)
- Cost update. Changes wrt to 2018, plus impact of going green.
- Physics “update”, use for “diversity” types of physics, LDM etc.
- Low cost/power klystron version, with fewer klystrons, 250 GeV

Work in 2024-2026 in connection to Readiness Report – resource needs

RF design and verifications - (includes DR cavity)
Xboxes and component prototyping including klystrons - including needs for DEFT (Olivier) and IFAST
Xband fundamentals including contract and including HTS and possible experimental activities
Module
Drive Beam and L-band
Positrons
Beam-dynamics and parameters including RTML and BDS
Instrumentation
ATF2 plans
Damping Rings
Costing
ICS opportunities
Power estimates
Sustainability, CE and ILC support on LC budget

I have assumed DEFT, STELLA, ICS and VULCAN are self supported and covered by a slim annual budget on our side for the unexpected, similar for CLIC specific activities in CLEAR that are in addition to possible specific proposal in the lines above.

Please consider on this single slide:

- Goals for 2024-26 - what can be achieved ("deliverables")
- Personnel (QUESTs and students and PJAS and Coll. Contract) needs and ideas
- Material funds year by year 2024-2026
- Possibilities for external funding
- Final summary publication/paper/note possible, standalone or as part of the larger one (e.g. covering cost/power and CO2, or one large covering X-band use and status in smaller setup and facilities) ?

		Background documents
Intro		
Design and Performance		Possible
	at all energies, DB and klystron	
	upgrades	

		Background documents
System overview		Possible for all systems
	from injectors to dumps	
	main beam and drivebeam	
	modules	
Technologies		Possible for technologies

	include X-band readiness	

Implementation

Update plus LCA, more about personnel for construction and operation

Possible for several topics

Further work

Towards a TDR - need to come from/be summarized from sections above

Make detailed enough to avoid background documen

Include synergies with other project (e.g other LCs)

CERN internal project documentation

Criteria/Metrics for comparison

- Performance
- Physics Reach
- Technical Readiness
- Total accelerators construction and installation costs (including injectors) - material
- Detectors: baseline assumptions and costs (material)
- Human resource requirements for accelerator construction and installation (including injectors)
- Project timeline
- Operation costs: material
- Operation costs: human resources
- Sustainability considerations and carbon footprint
- Upgrade Potential
- Experimental Community
- *Physics diversity potential including the injector chain (if available)*

Criteria/Metrics for comparison

- Main parameters and performance
  - Short description of the colliders and their main components.
  - Short description of the injectors with main parameters (identify new injectors and upgrade of existing ones –if any)
  - Flexibility and tunability considerations
  - Operation scenarios (see F. Bordry et al., CERN-ACC-2018-0037 - presented at SPC in 2018)
  - Integrated luminosity over the full programme
  - Energy consumption (including injectors) over the full programme
  - Considerations on the operational experience so far and impact on the possible luminosity ramp-up and time to achieve nominal performance