CLIC next phase

2013 – 2019

Development Phase
Development of a project plan for a staged CLIC implementation in line with LHC results; technical developments with industry, performance studies for accelerator parts and systems, detector technology demonstrators

2020 – 2025

Preparation Phase
Finalisation of implementation parameters, preparation for industrial procurement, pre-series and system optimisation studies, technical proposal of the experiment, site authorisation

2026 – 2034

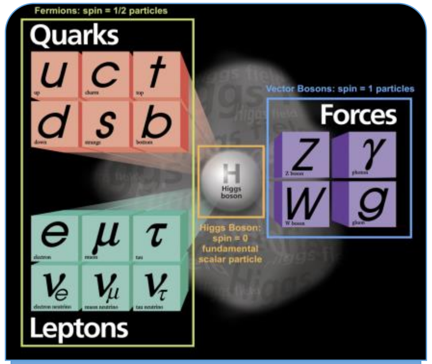
Construction Phase
Construction of the first CLIC accelerator stage compatible with implementation of further stages; construction of the experiment; hardware commissioning

2020
Update of the European Strategy for Particle Physics

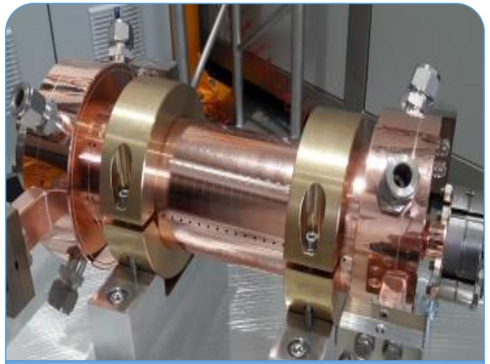
2026
Ready for construction

2035
First collisions

The CLIC project

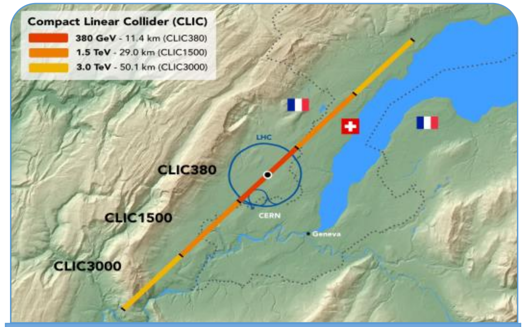


Physics case



Technical implementation and solutions

Organization and community



Industrial basis and future flexibility

For any next machine the largest challenges are the cost and timescales/size involved ….

Key activities for a CLIC TDR in the Preparation Phase will be:

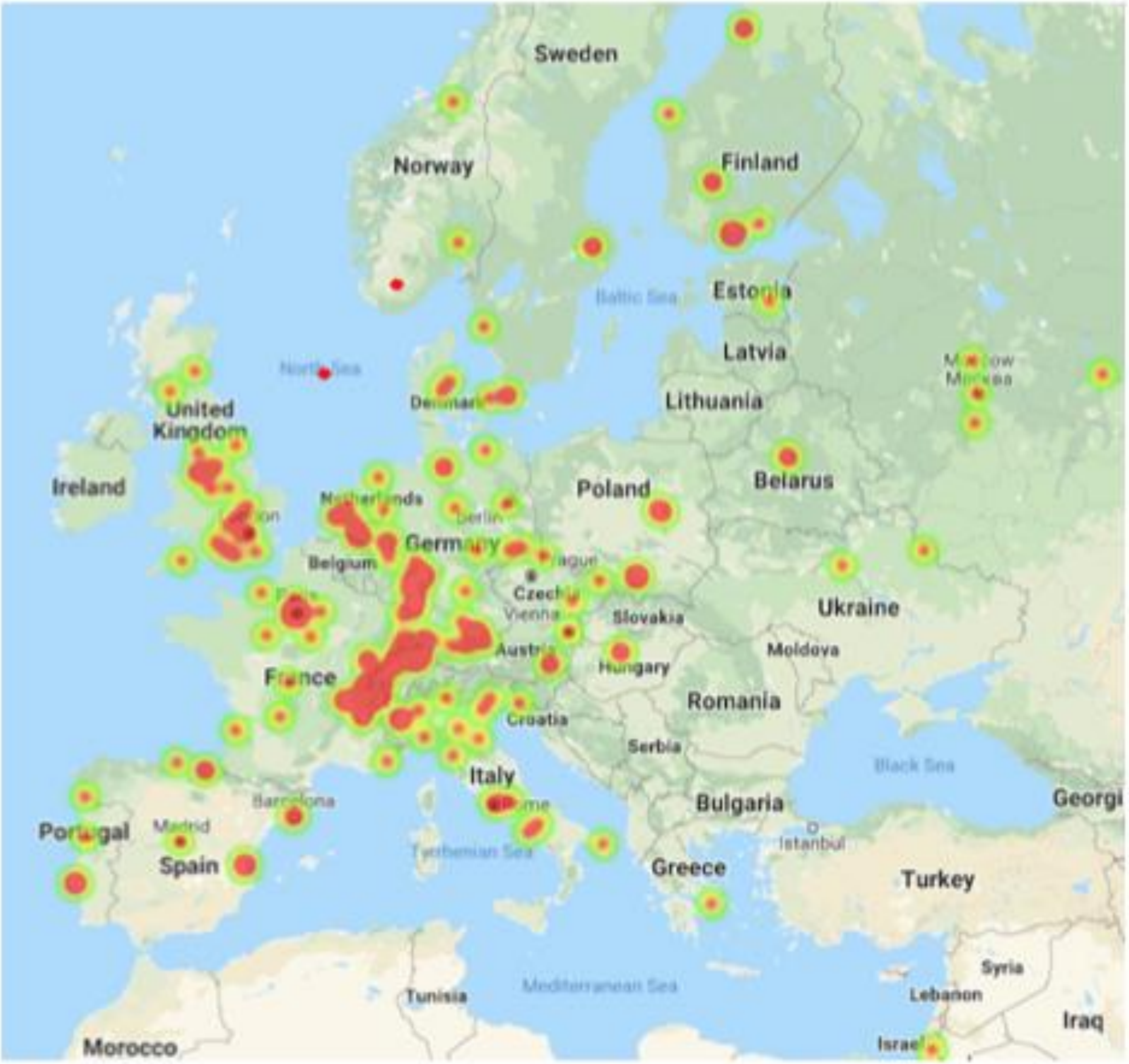
1. Prepare technically for industrial production (examples for cost and power drivers on next slide)
2. Pursue large systems tests (not necessarily at CERN)
3. Final design/parameters, cost/power, schedules, CE/site/infrastructure

From PiP
- main activities-

Activities	Purpose
Design and parameters	
Beam dynamics studies, parameter optimisation, cost, power, system verifications in linacs and low emittance rings	Luminosity performance and reduction of risk, cost and power
Main Linac modules	
Construction of 10 prototype modules in qualified industries, Two-Beam and klystron versions, optimised design of the modules with their supporting infrastructure in the Main-Linac tunnel	Final technical design, qualification of industrial partners, production models, performance verification
Accelerating structures	
Production of ~ 50 accelerating structures, including structures for the modules above	Industrialisation, manufacturing and cost optimisation, conditioning studies in test-stands
Operating X-band test-stands, high efficiency RF studies	
Operation of X-band RF test-stands at CERN and in collaborating institutes for structure and component optimisation, further development of cost-optimised high efficiency klystrons	Building experience and capacity for X-band components and structure testing, validation and optimisation of these components, cost reduction and increased industrial availability of high efficiency RF units
Other technical components	
Magnets, instrumentation, alignment, stability, vacuum	Luminosity performance, costs and power, industrialisation
Drive beam studies	
Drive beam front end optimisation and system tests to $\sim 20\,\text{MeV}$	Verification of the most critical parts of the drive beam concept, further development of industrial capabilities for L-band RF systems
Civil Engineering, siting, infrastructure	
Detailed site specific technical designs, site preparation, environmental impact study and corresponding procedures in preparation for construction	Preparation for civil engineering works, obtaining all needed permits, preparation of technical documentation, tenders and commercial documents

X-band technology base now very wide

- X-band activities and studies in institutes and industry (intensity linked to resources, publications …)
- Similar maps possible to draw for Asian and US activities (and for other technologies than X-band)
- X-band used as part of machines (linearizers, deflectors) or as main RF



High-gradient test infrastructure

CERN	XBox-1	50 MW, 12 GHz	Operational (later to CLEAR)
	Xbox-2	50 MW, 12 GHz	Operational
	XBox-3	4x6 MW, 12 GHz	Operational
KEK	NEXTEF	2x50 MW	Operational
Tsinghua	Later energy upgrade for Thompson	50 MW, 12 GHz	Operational
Trieste	CTF	45 MW, 3 GHz	Operational
Valencia		2x10 MW, 3 GHz	Commissioning
Frascati		50 MW, 12 GHz	Procurement
Shanghai		50 MW, 12 GHz	Installation
Melbourne, ALS		2x6 MW, 12 GHz	Planning
SLAC	NLCTA+XTA	2x50 MW, 11 GHz	Operational
	Klystron Test Lab	2x50 MW, 11 GHz	Operational

X-band linearizers and deflectors

Trieste	Linearizer for Fermi	50 MW	Operational
PSI	Linearizer for SwissFEL	50 MW	Operational
	Deflector for SwissFEL	50 MW	Procurement
DESY	Deflector for FLASHforward	6 MW	Procurement
	Deflector for FLASH2	6 MW	Procurement
	Deflector for Sinbad	tbd	Procurement
SINAP	Linearizer for soft X-ray FEL	6 MW	Operational
	Deflectors for soft X-ray FEL	2x50 MW	Procurement
Daresbury	Linearizer	6 MW	Procurement
Tsinghua	Linearizer for Compton source	6 MW	Planning
SLAC	LCWS linearizer	50 MW	Operational
	LCWS deflector	50 MW	Operational

X-band linacs

SLAC	NLCTA+XTA	2x50 MW, 11 GHz	Operational
Eindhoven	Compact Compton source - 25 MeV	6 MW	Procurement
CERN	CLEAR – 50 MeV (from Xbox-1)	50 MW	Preparation
Tsinghua	Thompson source upgrade – 50 MeV	50 MW	Design
Frascati	XFEL, injector to plasma - 1 GeV	8x50 MW	CDR
Collaboration	CompactLight – 6 GeV	30x50 MW	Design Study
CERN	LDMX – 3.5 GeV	24x50 MW	Letter of intent submitted
Groningen	1.4 GEV XFEL Accelerator - 1.4 GeV		NL roadmap
CERN	CLIC – 380 GeV	5800x50 MW	CDR

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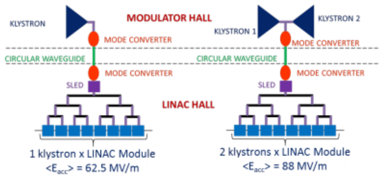
27-28 November 2018 INFN Frascati
A. Gallo: X-band RF Linac technology

X-BAND LINAC DESIGN

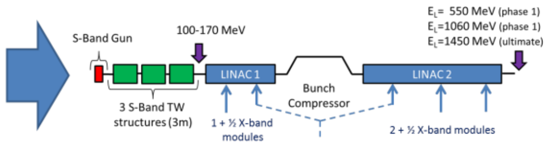
WP1: particle driven plasma acceleration
WP2: laser driven plasma acceleration
WP3: no plasma acceleration, only RF

X-Band LINAC parameters

	WP1	WP2	WP3	Ultimate
L_t [m]	16			
E_i [MeV]	100	170	170	170
E_{gain} [MeV]	450	380	890	1280
<G> [MV/m]	20(L1)-36(L2)	20(L1)-27(L2)	57	80
E_f [MeV]	550	550	1060	1450



CDR layout



Design under revision (2 RF modules in both linac #1 and #2). Work is well advanced.

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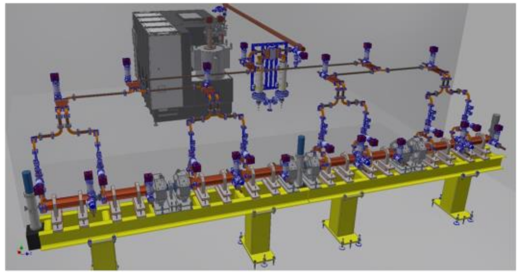
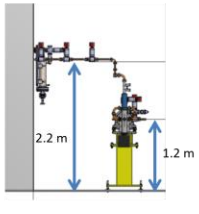
RF MODULE LAYOUT





Preliminary layout of the **RF module** (collaboration with CERN): **8 structures, 1 SLED, 1 or 2 Klystrons** per module.

WR-90 total length [mm]	3758
WC-50 circular wg length [mm]	3674
WR-90 loss [dB]	
WC-50 loss [dB]	
total loss [dB]	
total loss [%]	

Estimated **waveguide attenuation** (including circular waveguide): **10%**

Compact

EU funded design study for a compact and low-cost XFEL.

Target: SwissFEL performance at half the cost, to bring XFELs to national and regional facilities.

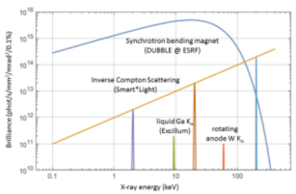
Based on advances in:

- Injectors
- X-band linac technology
- Undulators

Inverse Compton Scattering Source – Smart*Light

Compact, highly monochromatic X-ray source.
Complementary to X-ray tube and synchrotron light source.
Applications in cultural heritage, material science, medical, etc.

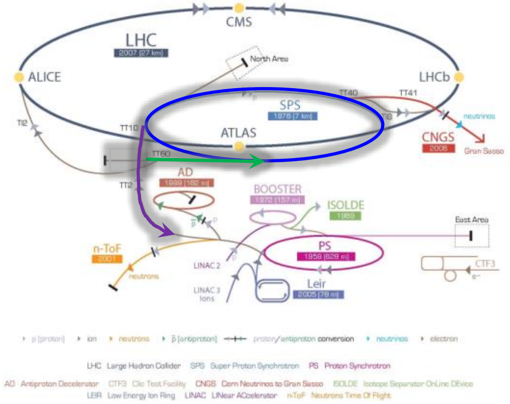
Brilliance



Electrons at CERN - overview

Accelerator implementation at CERN of LDMX type of beam

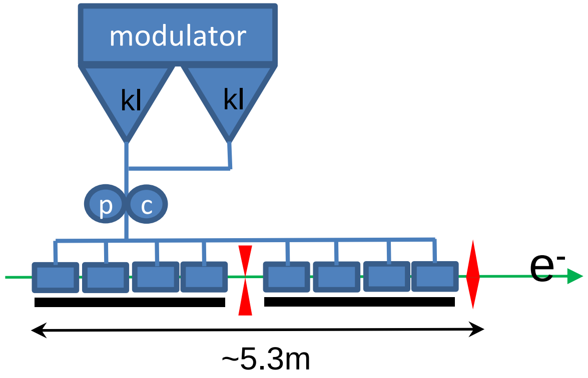
- X-band based 70m LINAC to ~3.5 GeV in TT4-5
- Fill the SPS in 1-2s (bunches 5ns apart) via TT60
- Accelerate to ~16 GeV in the SPS
- Slow extraction to experiment in 10s as part of the SPS super-cycle
- Experiment(s) considered by bringing beam back on Meyrin site using TT10



Beyond LDMX type of beam, other physics experiments considered (for example heavy photon searches)

Acc. R&D interests (see later): Overlaps with CLIC next phase (klystron based), FEL linac modules, e-beams for plasma, medical/irradiation/detector-tests/training, impedance measurements, instrumentation. positrons and damping ring R&D

Linac components



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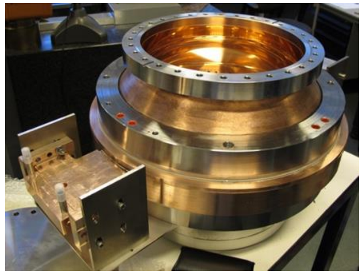
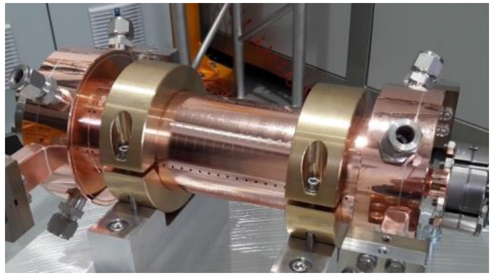
Klystron

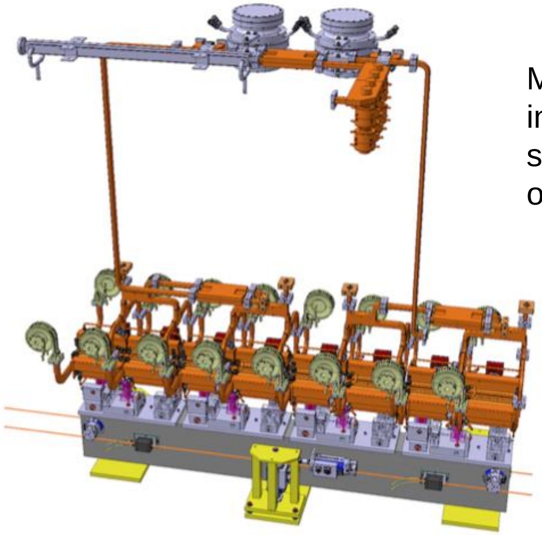
Modulator

Pulse compressor

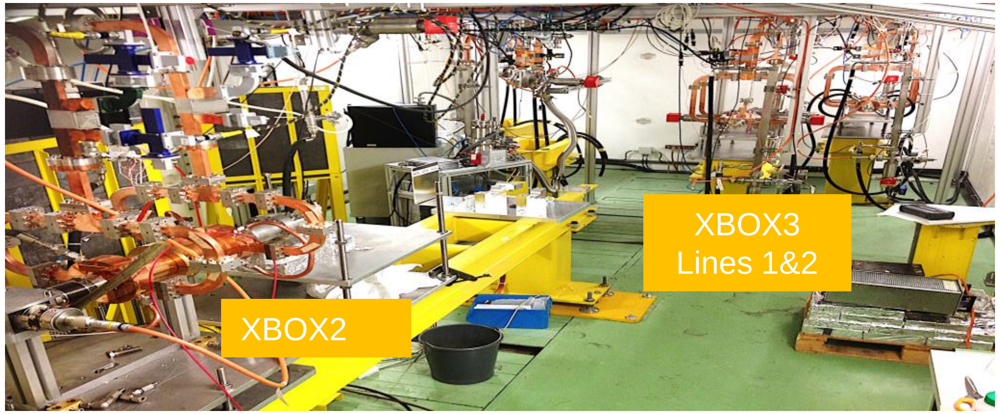


Accelerating structure





Modules, magnets, instrumentation, alignment, stability, commissioning, operation



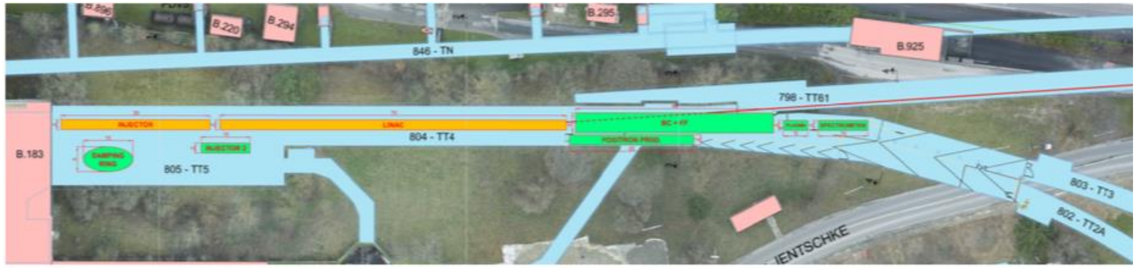
Assembled systems in continues operation at CERN, and elsewhere

Potential use of the eSPS facility

(linac more than 90% free)

Physics:

LDMX - Other hidden sector exp., incl. dump-type experiments using the available electrons - Nuclear physics



Accelerator physics opportunities:

CLIC: Linac goes a long way towards a natural next step for use of technology (collaborate with INFN and others also using technology for X-band linacs in coming years)

Relevant also for other potential future facilities using electrons (rings) considered at CERN

Plasma studies with electrons

Use electron (3.5 GeV) beam as driver and/or probe – studied by AWAKE WG

General acc. R&D as in CLEAR – existing ~200 MeV linac - today (https://clear.web.cern.ch)

Plasma-lenses, impedance, high grad studies, medical (electron irradiation), training, instrumentation, THz, ESA irradiation

Recent results: https://acceleratingnews.web.cern.ch/article/first-experimental-results-clear-facility-cern

Positron production (interesting for LC, rings and plasma) and studies with positrons for plasma and LEMMA concept for muon collider

General Linear or Ring related Collider related studies using SPS beam

Example: damped beam for final focus studies (beyond ATF2)

Estimated and existing resources

- Towards a TDR (6-7 years): ~150 MCHF material, similar for personnel (estimate made Feb 2018)
  - Roughly 30% above best years of CLIC, a factor ~two above 2017-18 budgets
  - Estimate would be slightly different today
  - Includes CLEAR and High Efficiency (HE) klystron programme (important for CLIC but not uniquely CLIC)
- Experience shows that 25-33% can come from outside CERN
- eSPS would overlap at 60-70% level with above – and provide additional system experience and R&D opportunities (see previous slide)
- MTP 2019-23 ("wait and see" budget – we hope) currently at 25% level of TDR estimate
  - Supported activities: ESU and PiP follow up, CLEAR, gun development, HE klystrons (limited), eSPS CDR, beam-dynamic and parameters and limited associated technical activities, EU projects, ATF2, X-band structures and testing (X-Boxes), module and mech./therm. engineering ML, limited DB system component development/testing
  - Fulfill existing collaborative agreement, much more limited for future ones, most activities are completely budget limited