CLIC Project Meeting #44

Thursday 27 Apr 2023, 09:00 → 13:00 Europe/Zurich

160/1-009 (CERN)

Videoconference

CLIC Project Meeting #44 — Join — 160/1-009

09:00 → 09:25 **Introductions, readiness report and key issues, LCWS talks** — 25m

Speaker: Steinar Stapnes (CERN)

09:30 → 09:50 **Xbox and RF structure and component updates** — 20m

Speaker: Pedro Morales Sanchez (CERN)

10:00 → 10:15 **Research plans on high-gradient structures for HALF** — 15m

Speaker: Dr Yelong Wei

10:25 → 10:45 **CLEAR report, status and plans 2023** — 20m

Speaker: Roberto Corsini (CERN)

10:50 → 11:10 **Coffee Break** — 20m

11:10 → 11:30 **Metamaterials as Room Temperature Superconductors** — 20m

Speakers: Alessandro Danisi (CERN), Dr Carlo Zannini (CERN)

11:35 → 11:55 **EUPRAXIA, status and plans - potential future links to X-band and CLEAR (e.g. future EU projects)** — 20m

Speaker: Massimo Ferrario

12:00 → 12:20 **HALHF (A hybrid, asymmetric, linear Higgs factory based on plasma-wakefield and radio-frequency acceleration)** — 20m

Speaker: Richard D'Arcy (DESY)

12:25 → 12:40 **ILC and the International Technology Network activities in Europe** — 15m

Speaker: Steinar Stapnes (CERN)

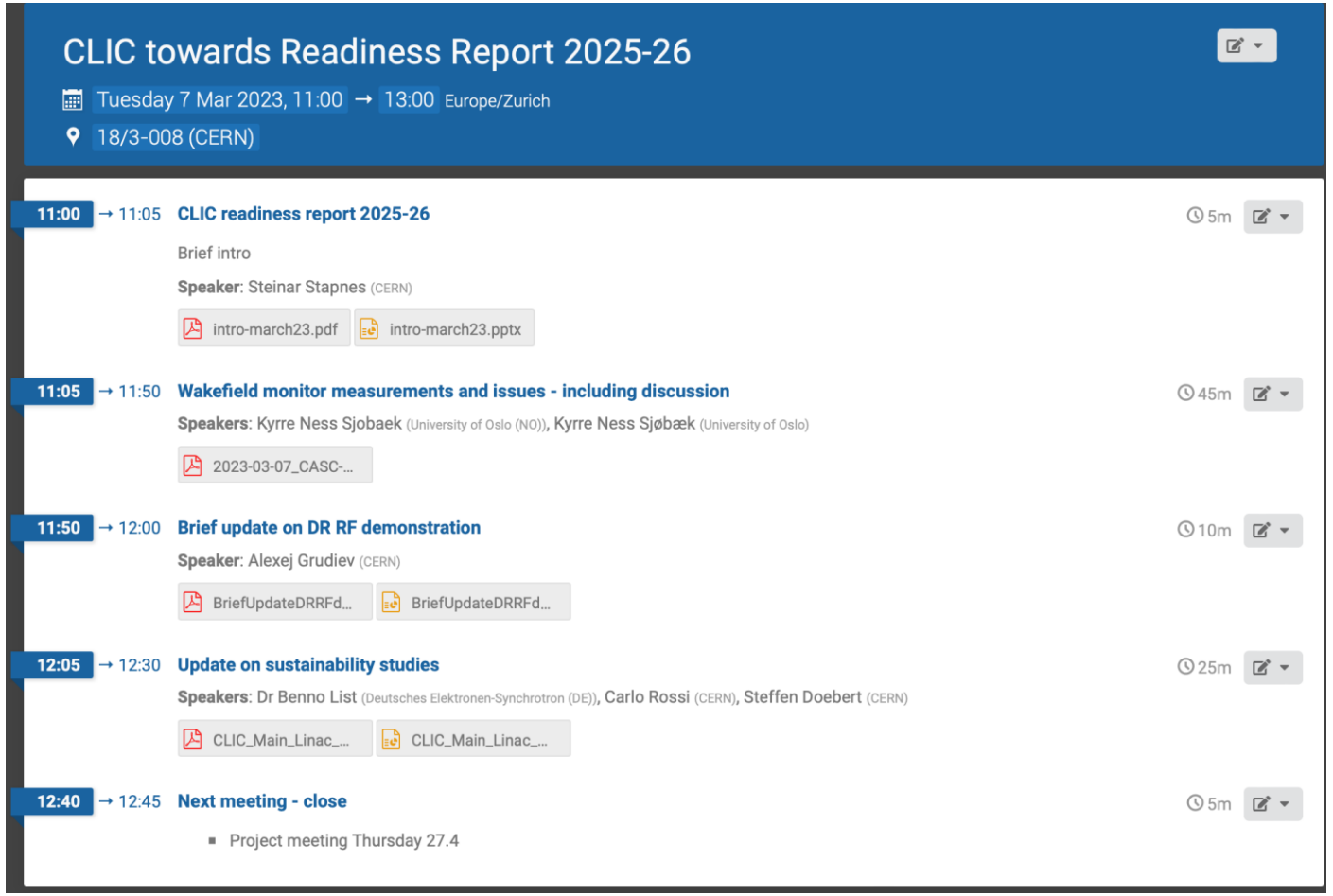
12:45 → 12:50 **AOB and close** — 5m

Towards the CLIC Readiness Report

Meeting in March

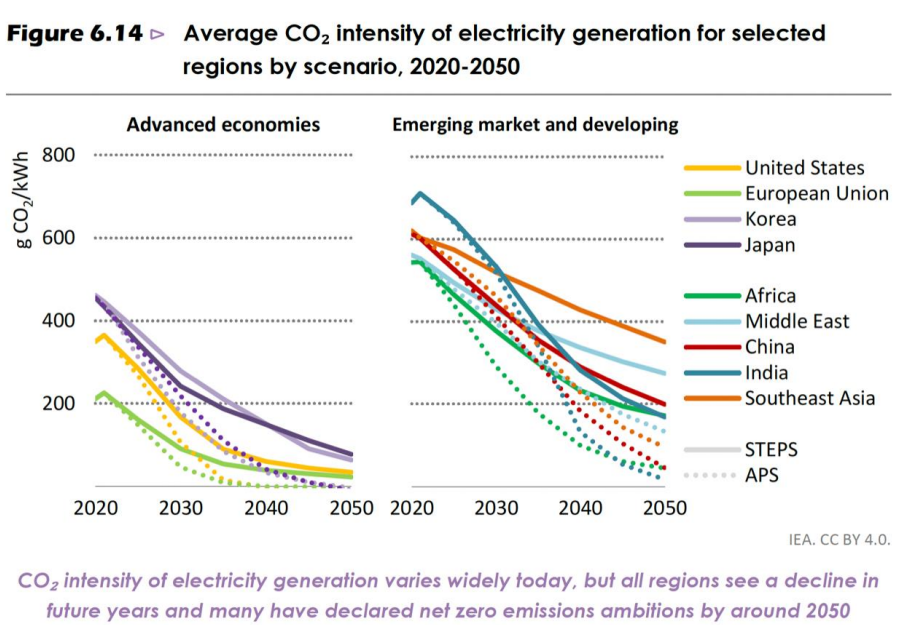
- Process to understand better specs, status and measurement results for wake-field monitors
- Prototyping DR RF cavity (essential for power reductions in this area)
- First indications of embedded carbon due to accelerator construction

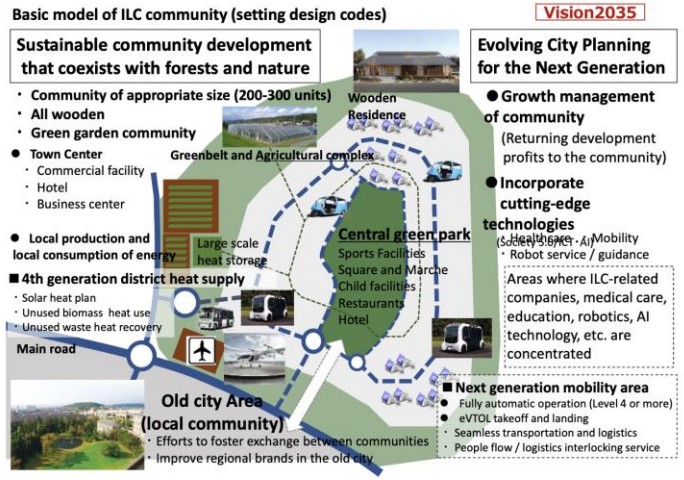
https://indico.cern.ch/event/1260607/



Sustainability during operation

- Operation costs dominated by energy (and personnel, not discussed in the following)
- Reducing power use, and costs of power, will be crucial. Other consumables (gas, liquids, travels …) during operation need to be well justified. Align to future energy markets, green and more renewables, make sure we can be flexible customer and deal with grid stability/quality.
- Carbon footprint related to energy source, relatively low already for CERN (helped by nuclear power), expected to become significantly lower towards 2050 when future accelerators are foreseen to become operational (in Europe, US and Japan). Provided we can run on green mixtures (PPA example at CERN, also built fully into the green ILC concept) we can also contractually chose green options. LCs are very suited for this (variable power load).





For ILC: renewable energy available (Tohoku Electric Power) in local grid at ~23% level, need 0.5-1 % for ILC. Additionally considers increased CO2 absorption to be fully neutral.

A rough estimate, assuming ~50% nuclear and ~50% renewables (as wind/sun/hydro):

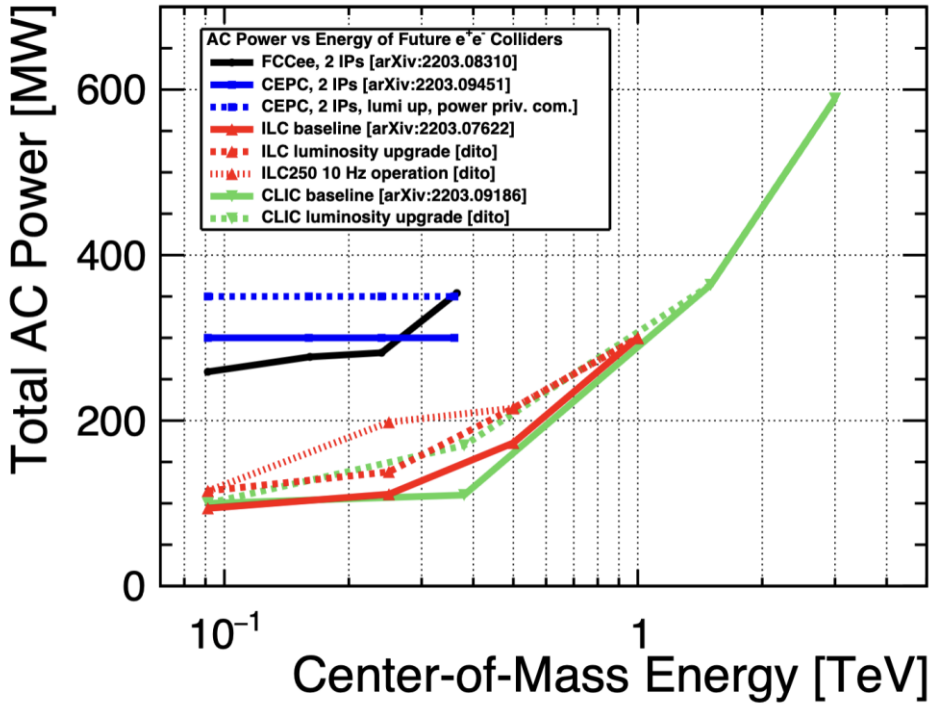
1 TWh annually equals ~12.5 ktons CO2 equiv. annually

(note: this is factor four below the current French summer month average)

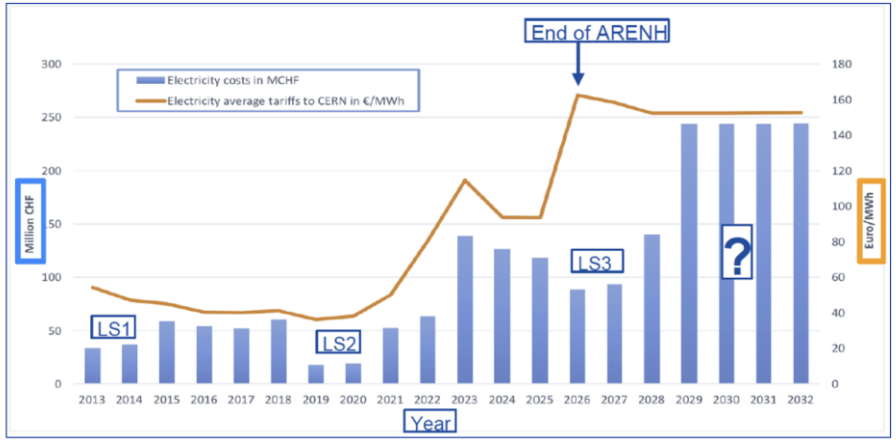
Energy costs

Typical power numbers for Higgs factories on the right – table also shown earlier

The CERN “standard” running scenario is shown below, used to convert to annual energy needs.

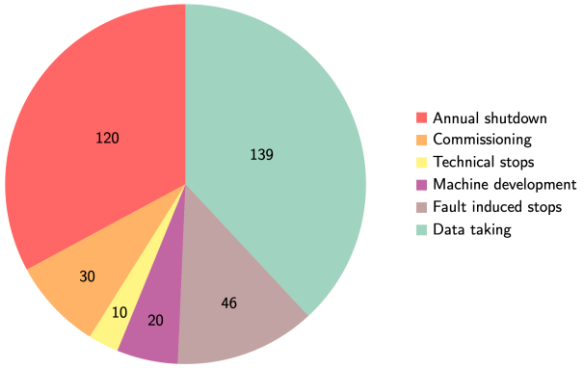


Extrapolating out to 2032 assuming: No ARENH and ”high” future electricity prices



Very uncertain but MTP assumes 140 MCHF/TWh beyond 2026.

With “standard” running scenario (on the right) every 100 MW corresponds to ~0.6 TWh annually, corresponding to ~85 MCHF annually.

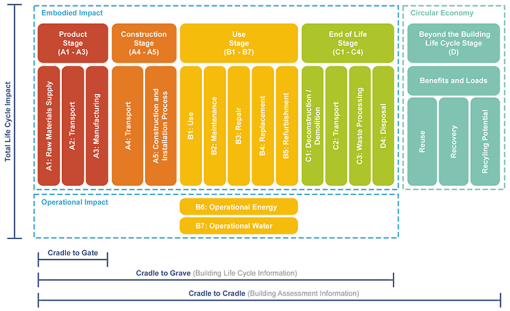


Sustainable Construction – Life Cycle Assessment

For carbon emission the construction impact will be much earlier and might be more significant (also rare earths and many other issues etc):

- Construction: CE, materials, processing and assembly – not easy to calculate
- Markets will push for reduced carbon, responsible purchasing crucial (see right) – construction costs likely to increase

Decommissioning – how do we estimate impacts ?



Assume a small tunnel (~5.6m diameter) **and** that the equipment in the tunnel has the same carbon footprint as the tunnel itself, a 20km accelerator (tunnel plus components) corresponds to 240 kton CO2 equiv.

Many caveats, this is only a very first indication of the scale:

+ many more components in tunnel (also infrastructure), injectors, shafts, detectors, construction work, spoils, etc etc
+ upgrades and decommissioning, this is not only an initial important contribution
- improvement and optimisations (e.g. less and/or better concrete mixes, support structures, less steel in tunnels, responsible purchasing, etc etc)

Responsible purchasing – and understanding the impact on our supply chain, costs and potential for changes – will be essentials for future projects (CERN implementation information from E.Cennini)

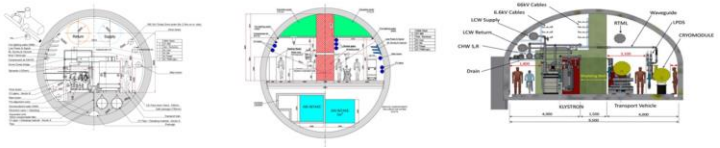
Carbon Cost/Life Cycle Assessment LCA study 2023

ARUP

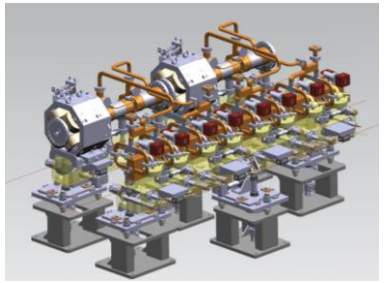
Goal and Scope

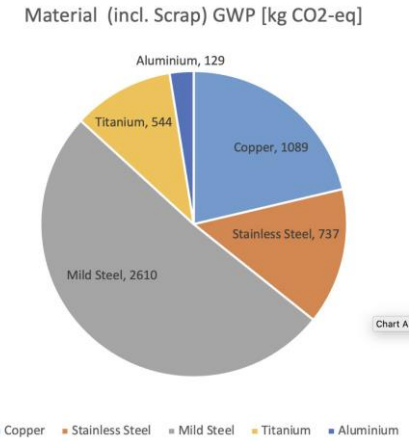
- Goal: Reduce embodied and construction environmental impacts
- LCA for 3 tunnel options (tunnels, caverns & access shafts)
- System boundaries: Embodied and construction.
  Excluding operation, use and end of life.

1. CLIC Drive Beam tunnel, 5.6m internal diameter
2. CLIC Klystron tunnel, 10m internal diameter
3. ILC Japan tunnel, arched 9.5m span



Quantity	DB	Klys.
Inner Diameter [m]	5.6	10
Tunnel Cross Section [m²]	25	79
Lining / Grouting [cm]	30 / 10	45 / 15
Concrete Area [m²]	12.4	44.8
Lining & Floor Area [m²]	8.2	19.7
Concrete per m [t/m]	31	129
Steel per m [t/m]	0.95	2.3
Concrete GWP [t CO2-eq/m]	3.1	12.9
Steel GWP [t CO2-eq/m]	1.6	3.8
Material GWP [t CO2-eq/m]	**5**	**17**
Total GWP (25% overhead)	**6**	**21**





Talk by B.List (link)

Readiness Report ~2025

Update wrt PiP 2018, format to be determined

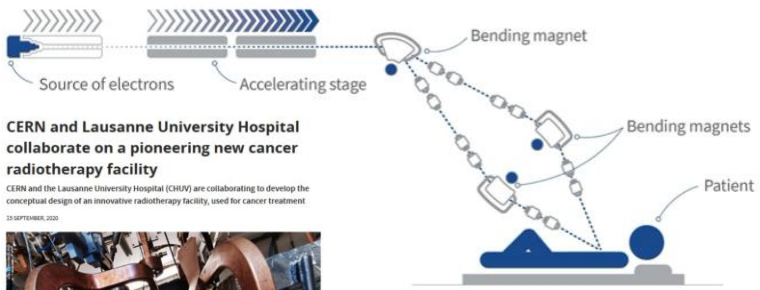
Key updates:

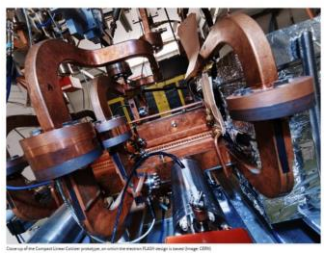
- Luminosity numbers, covering beam-dynamics, nanobeam studies and hardware, and positron production - at all energies
    - Risk reduction (wrt performance), bumps, redundancies
- Energy/power/sustainability: 380 well underway, 3 TeV to be done, L-band klystrons
- Sustainability issues, more work on 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. CHANGED
- Physics “update”, use for “diversity” types of physics, LDM etc. CHANGED
- Low cost/power klystron version, with fewer klystrons, 250 GeV

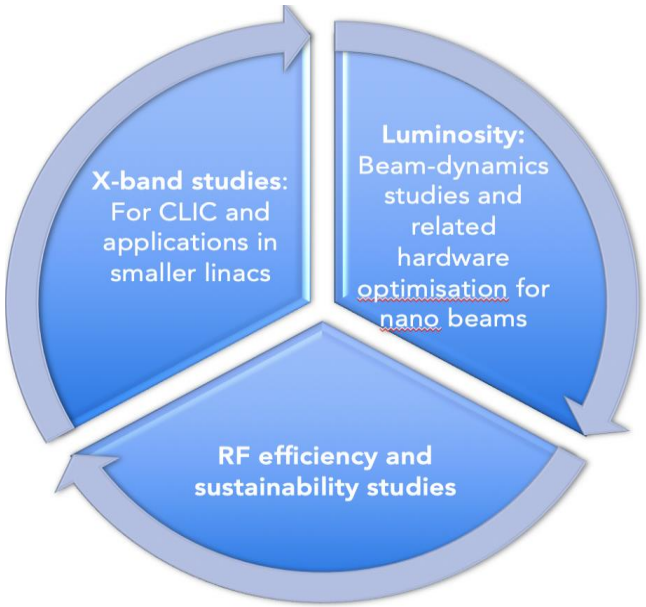
On-going CLIC studies towards next ESPP update

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



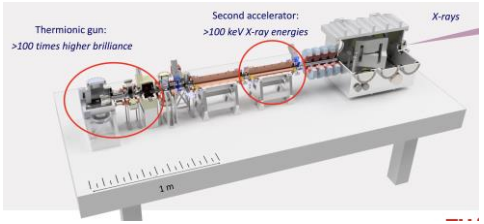




Optimizing the luminosity at 380 GeV – already implemented for Snowmass paper, further work to provide margins will continue.

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)

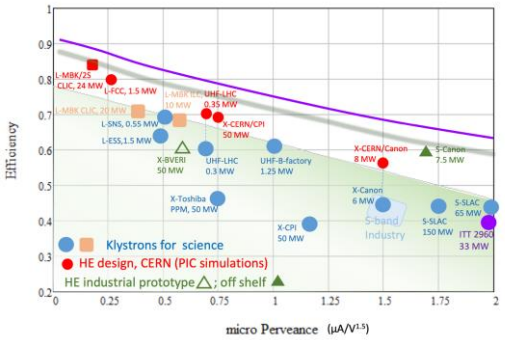


Improving the power efficiency for both the initial phase and at high energies, including more general sustainability studies

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



Various other updates:

Budget planning CERN, no significant changes wrt to last year for the LC studies.

ATF3 kick off 8-9.3: https://indico.cern.ch/event/1259176/

EAJADE kick off 29-30.3: https://indico.desy.de/event/36774/

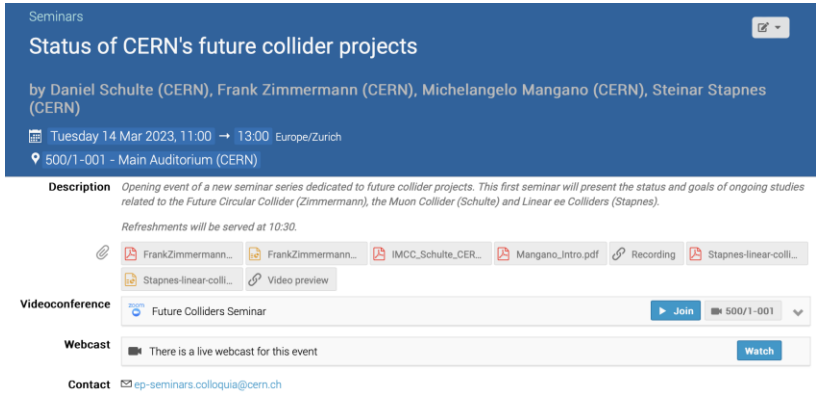
CompactLight follow up Eindhoven 3-4.4: https://indico.cern.ch/event/1250754/
(SmartLight on the table top right)

Snowmass and P5: Snowmass input completed, P5 session at SLAC next week with talk given by E.Nanni and about C3 and CLIC (dominated by C3 resources "bid")

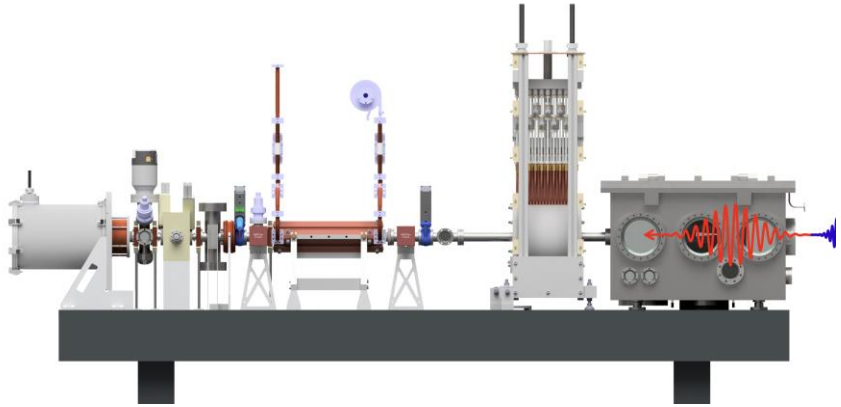
LCWS 15-19.5: https://indico.slac.stanford.edu/event/7467/overview

- Plenary talks about CLIC and CLIC inspired Applications
- High Eff. Klystrons, Sustainability and ATF with common LC approach
- Parallel talks (several) not yet posted

2-3 day meeting in Oct-Nov, including nano beam WS ? Also CB



https://indico.cern.ch/event/1260648/



https://agenda.infn.it/event/34253/

CLIC in accelerating news

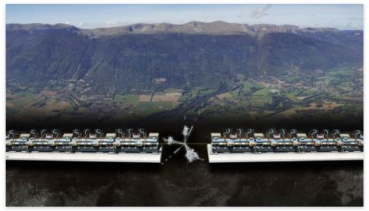
https://acceleratingnews.eu/topic/compact-linear-collider-clic

The Compact Linear Collider (CLIC) is a proposed accelerator, designed as an addition to CERN's accelerator complex. Its objective is to collide electrons and positrons (antielectrons) head-on at energies of up to several teraelectronvolts (TeV). For an optimal exploitation of its physics potential, CLIC is intended to be built and operated in three stages, at collision energies of 380 GeV, 1.5 TeV and 3 TeV respectively, for a site length ranging from 11 to 50 km. The design and technology development for CLIC being is pursued by an international collaboration of more than 70 institutes in more than 30 countries.

Japan's Accelerator Test Facility 2 opens again for overseas collaborators experiments

Located in KEK Japan, this experimental facility will pursue the necessary R&D to maximize the luminosity potential of linear colliders.

Issue 43 | Compact Linear Collider (CLIC) | 15 March, 2023



CLIC looks towards 2025

The CLIC collaboration is moving towards its technical design report.

Issue 42 | Compact Linear Collider (CLIC) | 15 December, 2022

Optimising CLIC for reducing the electricity consumption at machine and laboratory level

Optimised system designs for power efficiency, high efficiency klystrons, permanent magnets, renewable power… The linear collider projects are working to address power efficiency and reduce the environmental impact of the facilities.

Issue 41 | Compact Linear Collider (CLIC) | 19 September, 2022

Permanent magnets, a new design paradigm for ultra-low emittance rings

In order to reduce the beam emittance by a large factor, the CLIC Collaboration has developed an innovative dipole magnet prototype and built a permanent magnet demonstrator

Issue 40 | Compact Linear Collider (CLIC) | 23 June, 2022

CompactLight completes the Conceptual Design Report for an advanced and compact hard X-ray facility

The EU-funded project held the promise of designing more compact and cost-effective linac-based photon sources.

Issue 39 | Compact Linear Collider (CLIC) | 04 March, 2022