CLIC plans for the next European strategy update, and beyond

Roberto Corsini

for the CLIC Accelerator Collaboration

CLIC position in the HEP (and CERN) landscape

Scientific strategy: 3 main directions

F. Gianotti,
A great year ahead of us

Full exploitation of the LHC:
- ❑ successful Run 2 (~100 fb^{-1} of good data) and LS2
- ❑ construction of LIU/HL-LHC on track and financially secured (accelerator and experiments)

Complementary diverse programme serving a broad community, e.g.:
- ❑ ongoing experiments and projects at Booster, PS, SPS and their upgrades (ELENA, HIE-ISOLDE 2)
- ❑ participation in (global) neutrino projects outside Europe (presently mainly LBNF in the US) through CERN Neutrino Platform

Preparation for the future of CERN (and of the discipline):
- ❑ vibrant accelerator R&D programme exploiting CERN's strengths and uniqueness (→ enhance worldwide coordination)
- ❑ design studies for future accelerators: CLIC, FCC (including HE-LHC*)
- ❑ develop a compelling diverse scientific programme complementary to high-E colliders → "Physics with injectors" WG (involving accelerator experts, experimentalists, the
pre
co

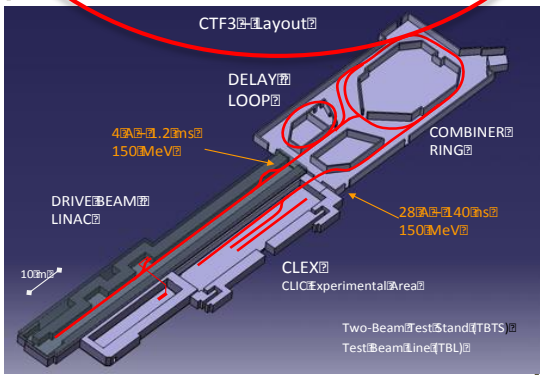
European Strategy 2013: "To stay at the forefront of particle physics, Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update … emphasis on pp and e^+e^- high-energy frontier machines"

We know where we stand … should keep the momentum

CLIC Timeline

2013-18 Development Phase

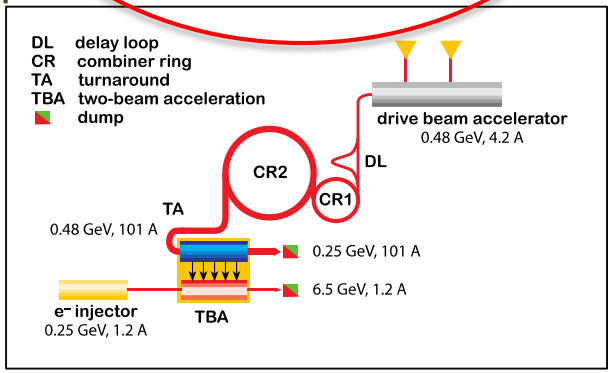
Develop a Project Plan for a staged implementation in agreement with LHC findings; further technical developments with industry, performance studies for accelerator parts and systems, as well as for detectors.



4-5 year Preparation Phase

Finalise implementation parameters, Drive Beam Facility and other system verifications, site authorisation and preparation for industrial procurement.

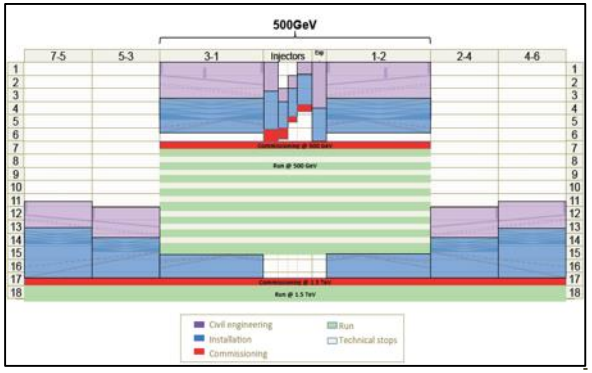
Prepare detailed Technical Proposals for the detector-systems.



Construction Phase

Stage 1 construction of CLIC, in parallel with detector construction.

Preparation for implementation of further stages.



2018-19 Decisions

On the basis of LHC data and Project Plans (for CLIC and other potential projects as FCC), take decisions about next project(s) at the Energy Frontier.

2024-25 Construction Start

Ready for full construction and main tunnel excavation.

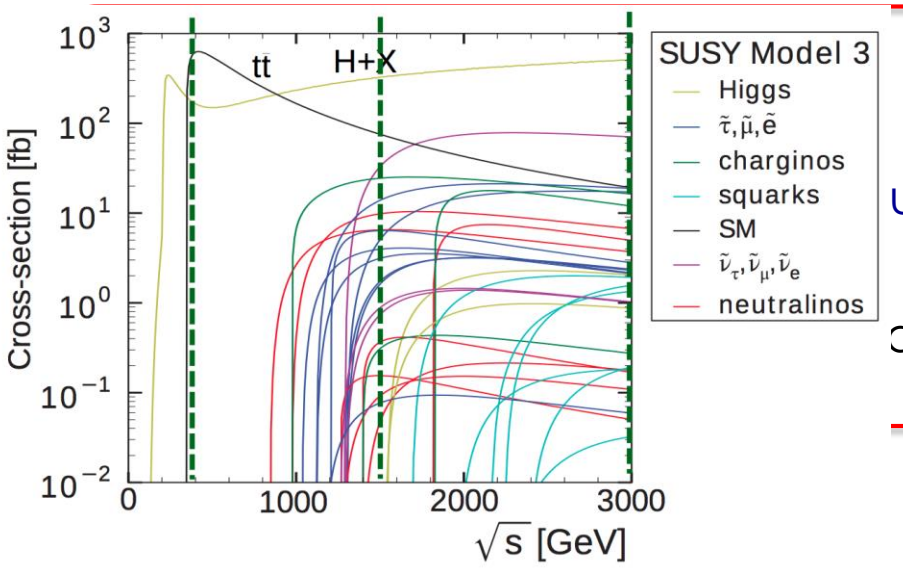
Commissioning

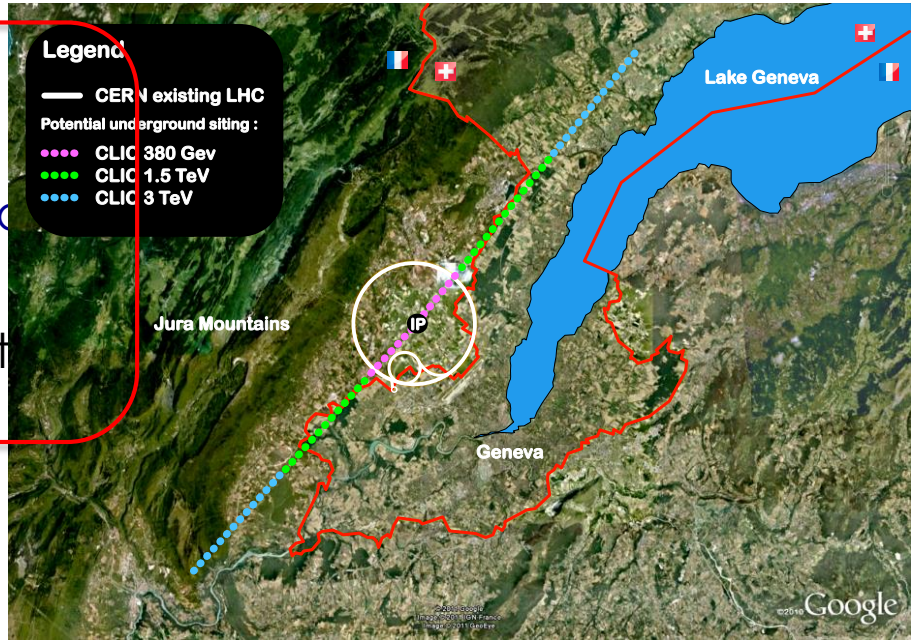
Becoming ready for data-taking as the LHC programme reaches completion.

Development phase

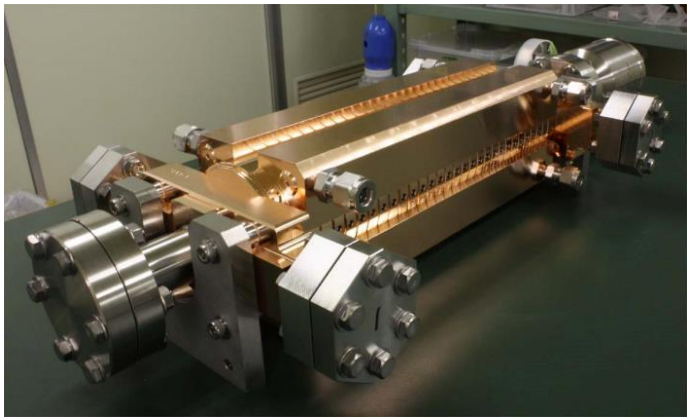
Develop a Project Plan for a staged implementation of CLIC, consistent with LHC findings, as an option for CERN in post-LHC era, for consideration in next European Strategy update 2019/20

- Update physics studies in light of LHC results
- Rebaseline, cost/staging strategy with a 20-30 year perspective

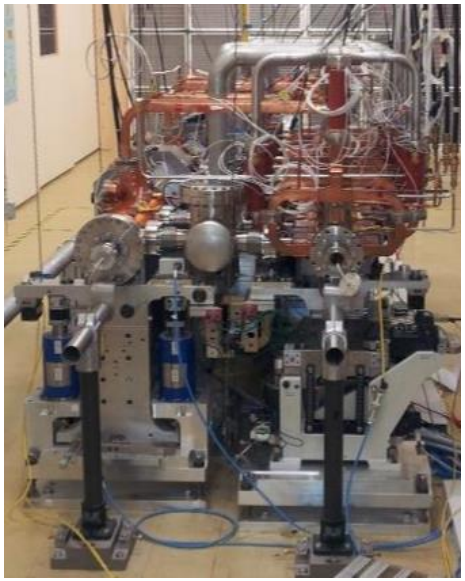




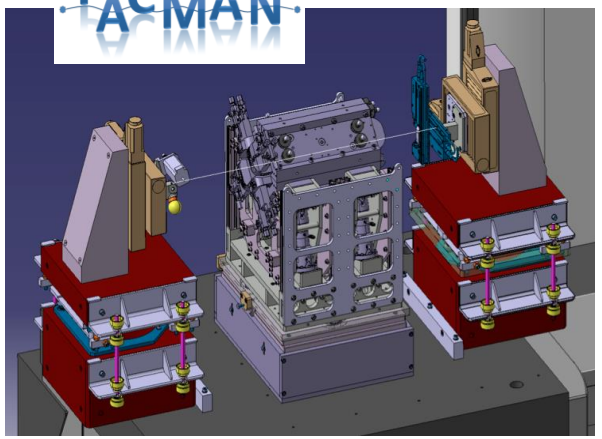
Key technical R&D

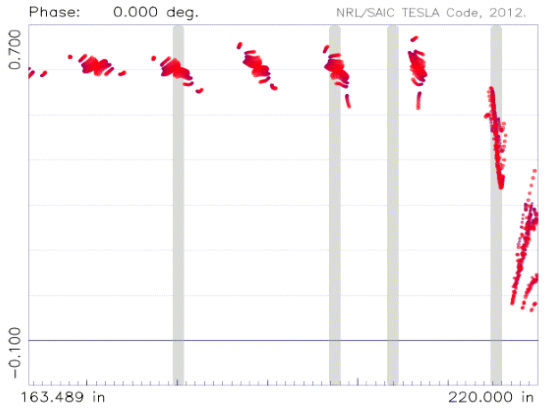


X-band accelerating structures

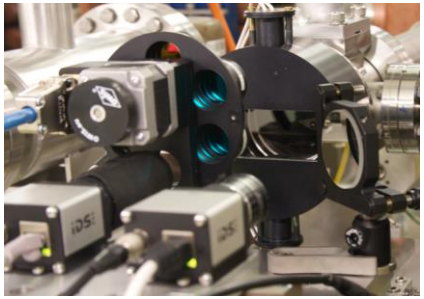


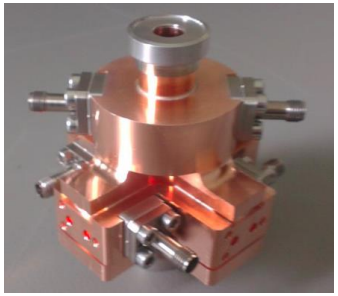
Module – alignment – assembly





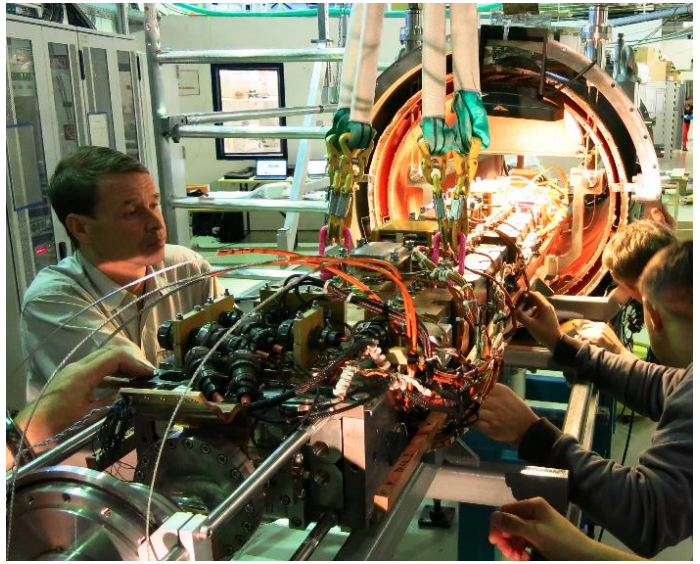
High Efficiency klystrons





Key diagnostics equipment

Other critical components *(NbTi Wiggler test at ANKA)*



High-power X-band testing at CERN

Xbox-1

OPERATIONAL

CPI 50MW 1.5us klystron
Scandinova Modulator
Rep Rate 50Hz

Current test:
Dogleg beam-loading experiment, TD26CC#1 (in CTF3 LINAC)

Previous tests:
TD24R05 (CTF2, 2013)
TD26CC#1 (CTF2, 2013)
T24 (Dogleg, 2014-15)

Xbox-2

OPERATIONAL

CPI 50MW 1.5us klystron
Scandinova Modulator
Rep Rate 50Hz

Current test:
T24_OPEN (in halves)

Previous test:
CLIC Crab cavity (2014-15)

Xbox-3

Xbox-3A: OPERATIONAL

Xbox-3B/C/D: COMMISSIONING

4x Toshiba 6MW 5us klystron
4x Scandinova Modulators
Rep Rate 400Hz

LLRF, pulse compressors and waveguide network to be completed at the end 2015

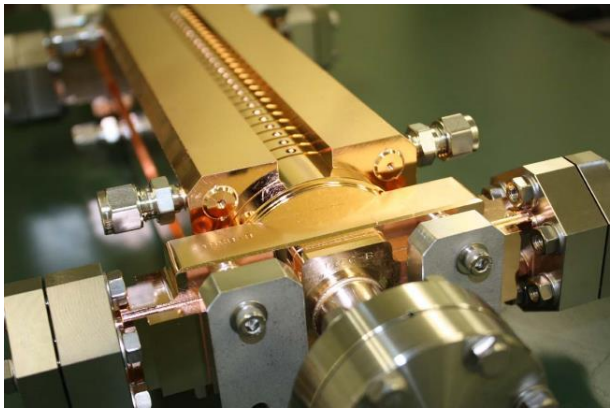
Medium power test:
3D printed Ti waveguide (Xbox-3A)

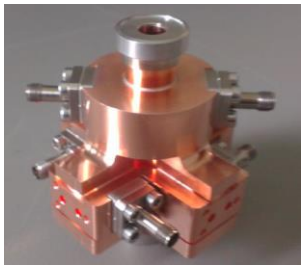
Industrialization

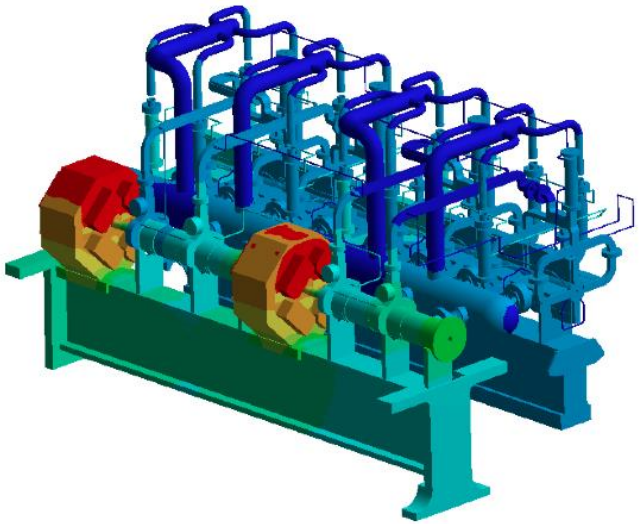
- Prepare for industrialization of individual main components
- Study mass production/qualification process/assembly/installation procedures adapted to CLIC requirements

L-band klystrons/modulators

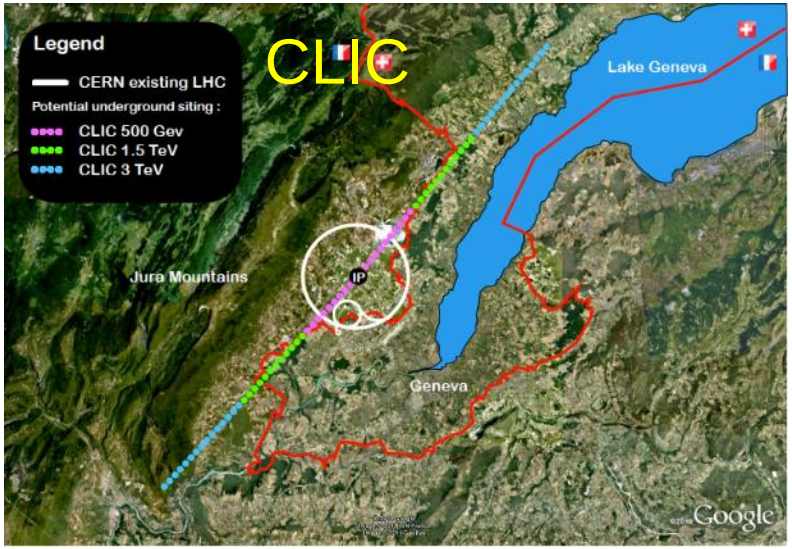
Accelerating structures and other main components of the Two-Beam Module





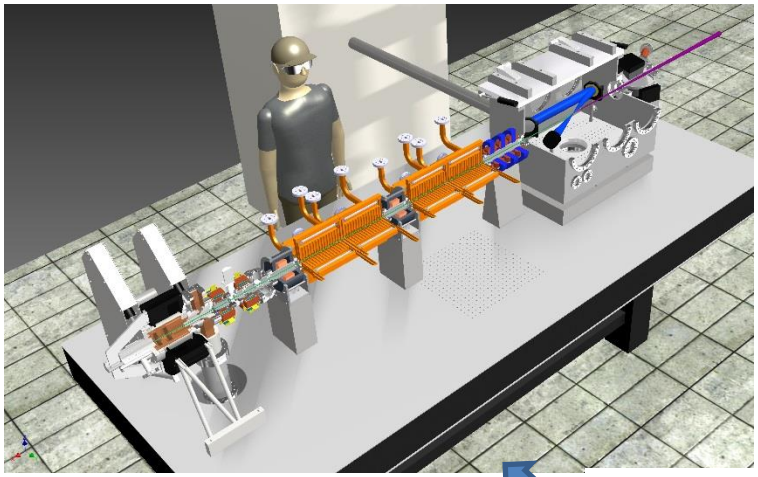


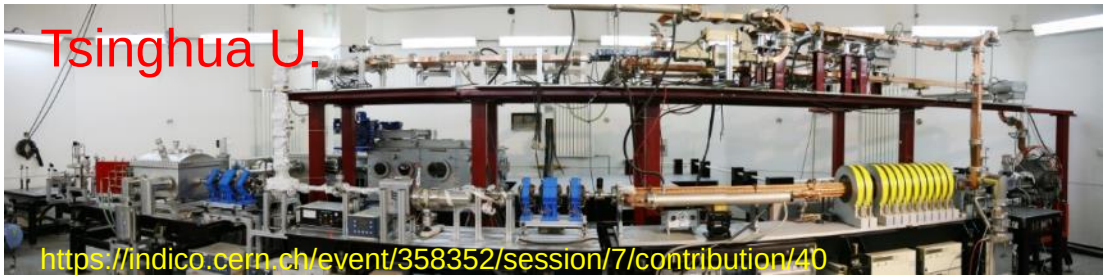
X-band technology



Linear collider - TeV

XFEL – 1 to 10 GeV

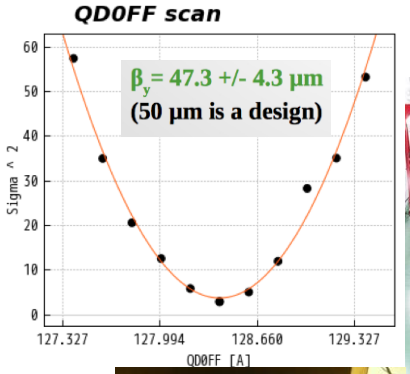




Thompson/Compton source – few 100s MeV

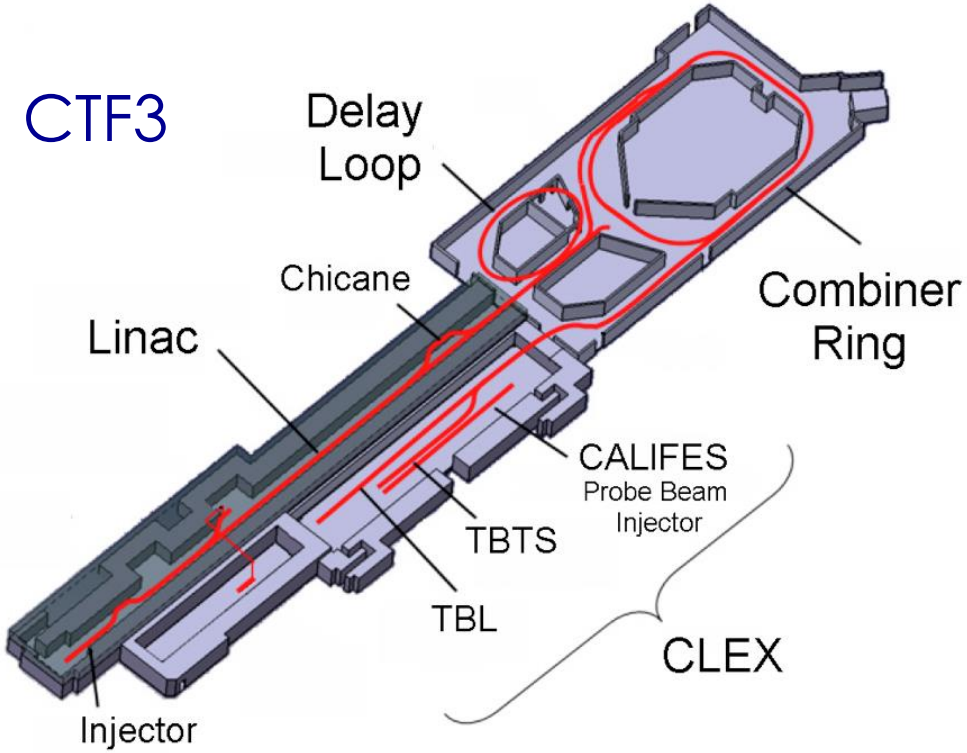
Compact Compton source few 10s MeV

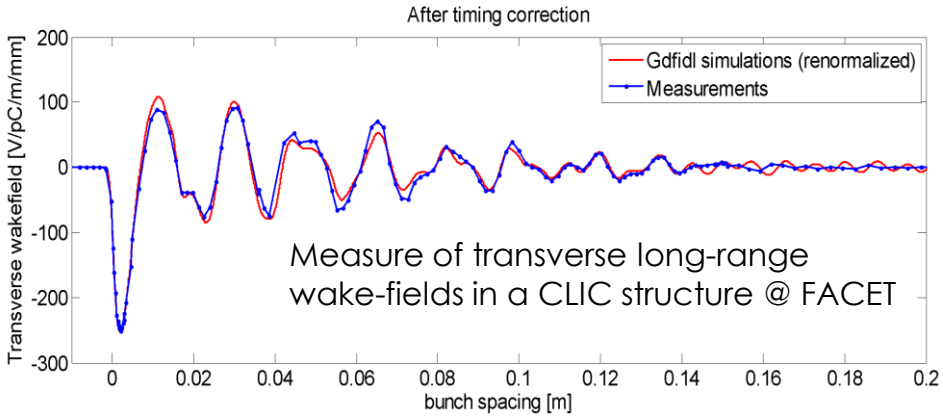
System Tests



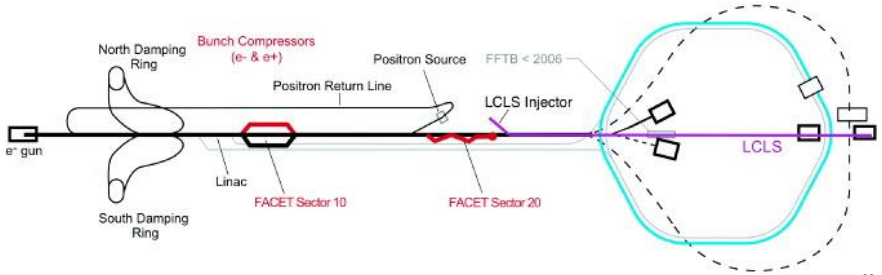
ATF2

CTF3

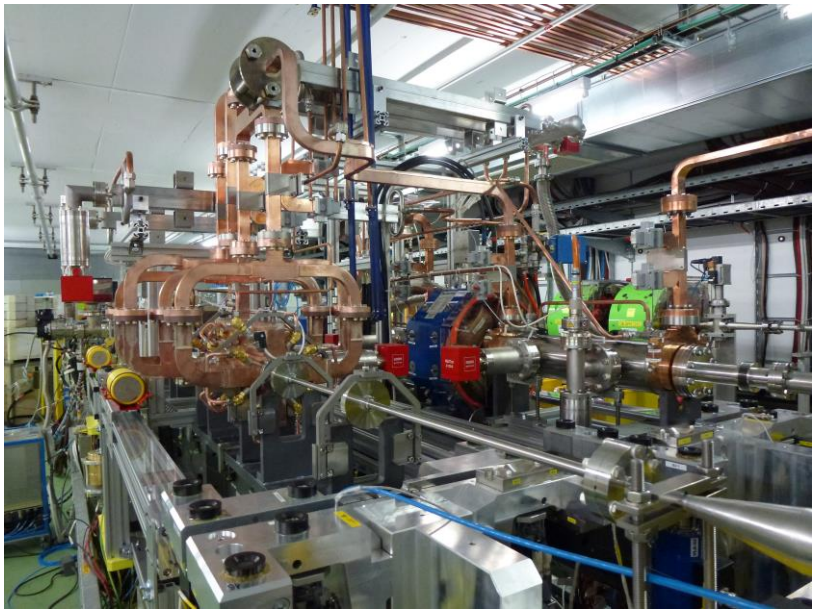




FACET

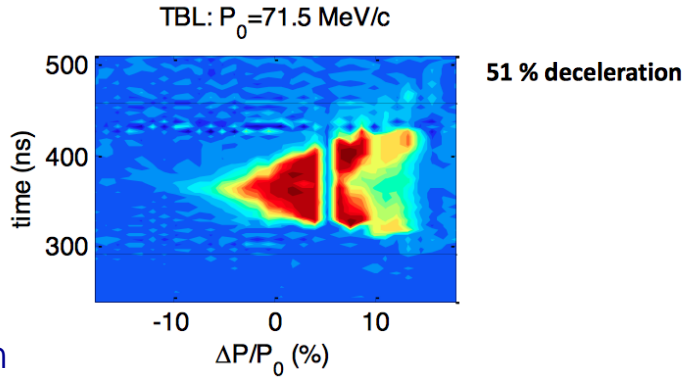


CTF3 Experimental Program 2016



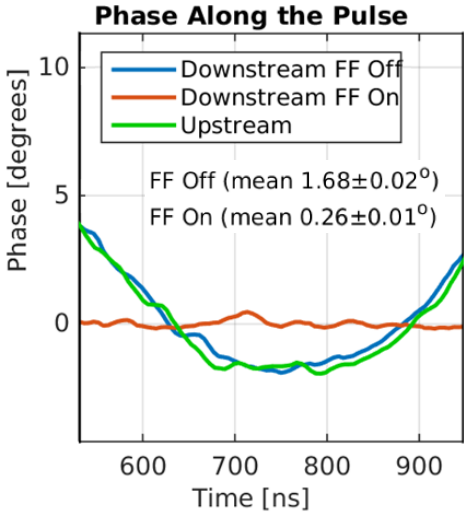
CLIC two-beam module tests

- Power production, stability + control of RF profile (beam loading compensation)
- RF phase/amplitude drifts along TBL, PETS switching at full power
- Alignment tests



Drive Beam

- Dispersion free-steering, dispersion matching, orbit control, chromatic corrections, emittance, stability
- Beam deceleration + optics check in TBL

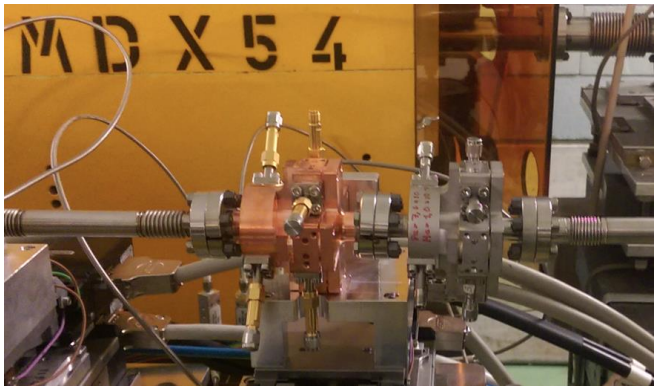


Drive-beam phase feed-forward tests

- Increase reproducibility
- Demonstrate factor 10 jitter reduction

Ongoing instrumentation tests

- Wake-Field Monitors
- Main and Drive beam BPMs …



Discussions on a CALIFES - based facility

- Keep testing CLIC components (X-band structures, diags…) with beam
- Advance high-gradient e- accelerator R&D
- Support strategic partnerships with relevant communities: XFEL, medical, industrial, space
- Enable instrumentation/equipment tests for consolidating CERN accelerator complex (LHC and injectors)
- Provide unique + complementary test facility for CERN's European (and worldwide) users
- Maintain accelerator training facility for next generation of accelerator scientists + engineers

Re-use 1/3 CTF3 area; 80% equipment available

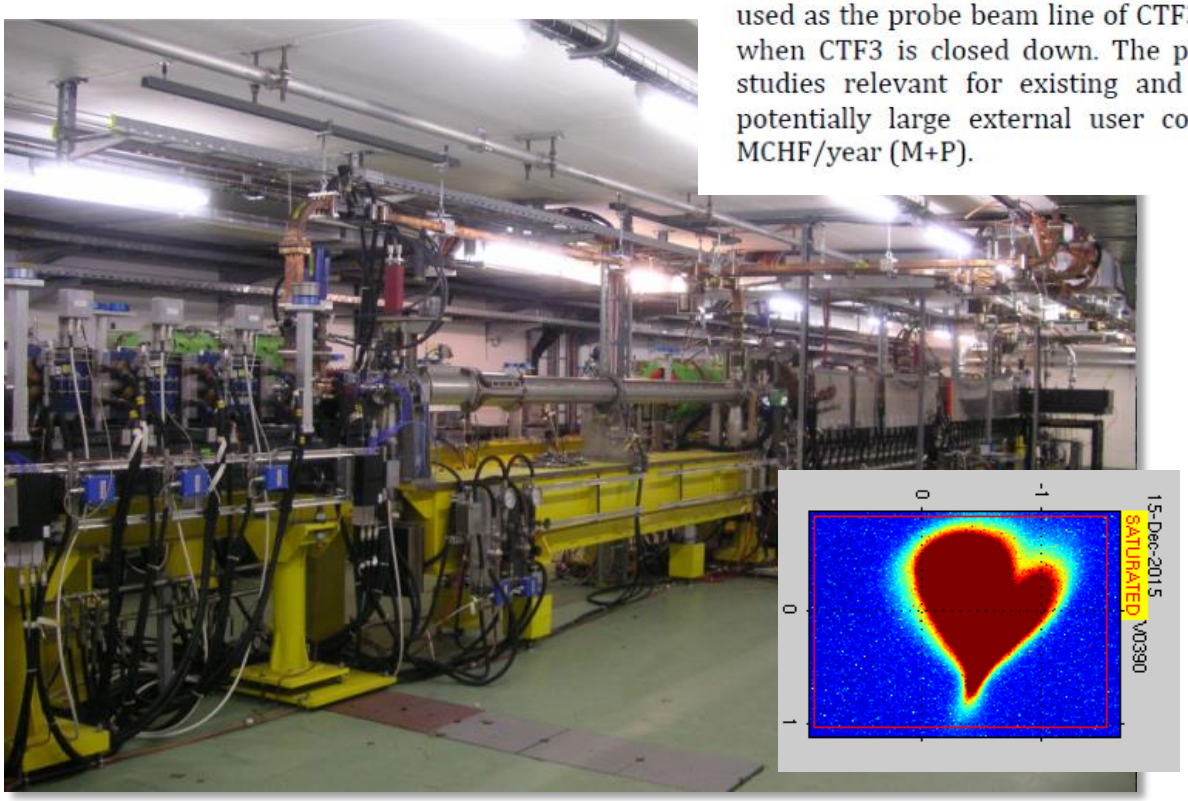
Proposal of a CALIFES-based Accelerator Test Stand

Expression of Interest for the future operation of the CALIFES linac

Prepared by: E.Adli (Univ. of Oslo), P.Burrows (Univ. of Oxford), R.Corsini (CERN), S. Stapnes (CERN)

Abstract

In this document we propose to operate the CALIFES electron linac at CERN, presently used as the probe beam line of CTF3, as a stand-alone user facility from 2017 onwards when CTF3 is closed down. The possible uses include general accelerator R&D and studies relevant for existing and possible future machines at CERN, involving a potentially large external user community. The resources required are around 2 MCHF/year (M+P).



CATS

Development phase - Main goals/deliverables

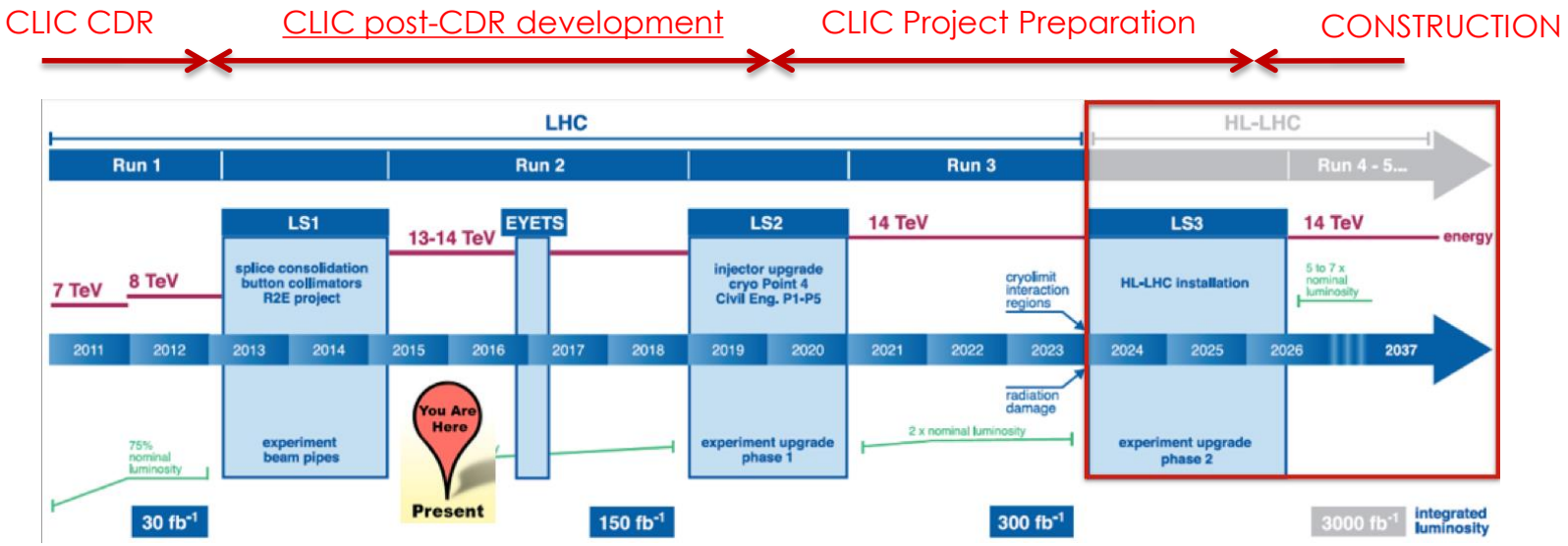
- Concise project plan document: physics, machine parameters, cost, power, site, staging, construction schedule, main technical issues, preparation phase (2019- 2025) summary, detector studies.
- Comprehensive physics and detector documentation: summary papers planned 2015-2018 covering physics topics, detector studies and R&D.
- Detailed, consistent technical documentation across project: EDMS/WBS based.
- Technology transfer/spin-off document, including training (PhDs, postdocs, fellows).
- Preparation phase plan document: critical parameters, status and next steps 2019-2025 - what is needed before project construction start up, strategy, risks and how to address them, inside and outside CERN, and involving industry.

The Preparation phase - "Technical" considerations

- What we will have in 2019:
  - A basic design for the first low energy stage
  - A reasonable & flexible upgrade scenario
  - A credible cost and power consumption update
  - Prototypes of several key components (NOT in final state)
  - *A work plan for the next phase (project preparation, 2020-2025)*
- What will be missing, but will be needed before construction could start:
  - A Technical Design
  - Site detailed studies and authorizations
  - Finalized prototypes of all main components
  - Fully developed industrial basis for main components
  - Facilities for testing and qualification of components

"Other considerations"

- Timeline & resources availability at CERN



- What kind of decision may we expect in 2019?
  What will be the approval procedure of the project after that?
  What resources may we expect in the period 2020-2025?

- Should we propose a technically limited plan, or anticipate at least to some extent resources and time constraints?

Finalized prototypes of all main components I

- Modules – status before 2020
  - Two-Beam Modules – LAB, design more or less consistent with CDR parameters, but not fully representative (use of components mock-ups, …)
  - TBM – CLEX, fully operational components, but design adapted to CTF3
  - PACMAN – Fundamental input to new design
  - Klystron-based Modules – Only sketches so far
  - *Should have full design of both two-beam and klystron based versions before 2020*

- Drive Beam accelerator units
  - Klystrons (1st generation) under procurement in Industry.
  - Modulators under development
  - Structure design exist
  - R&D on higher efficiency klystrons ongoing
  - *Should have full unit (1st generation) by 2020, RF tested*

Finalized prototypes of all main components II

- Main linac modules should be the first priority, will need time to build – and test – prototypes (even more if we should iterate the process).
- Drive beam linac modules should be in a more advanced state by 2020. However, in case we will aim at a CLIC Zero like facility for the preparation phase, they may also be very much on the critical path.

- Of course full prototypes of main linac modules and DB accelerator units prototypes are mandatory before construction start.

However:

- We should review what other components will need prototyping (mainly items critical for performance, e.g., extraction kickers, SC wigglers, phase feed-forward components, specific diagnostics components…).

- Even more than that, we have to define and include in the plan a meaningful testing program for all prototypes.

Fully developed industrial basis for main components

- Modules – still a long way to full industrialization for all components ➔ full industrialization must be addressed after new generation design.

  Further considerations:

  - Industrialization of accelerating structures including assembly should be done as soon as possible
  - X-FEL projects based on X-band are an invaluable opportunity to develop industrial basis
  - However, they are not fully applicable to CLIC modules (even for klystron-based)

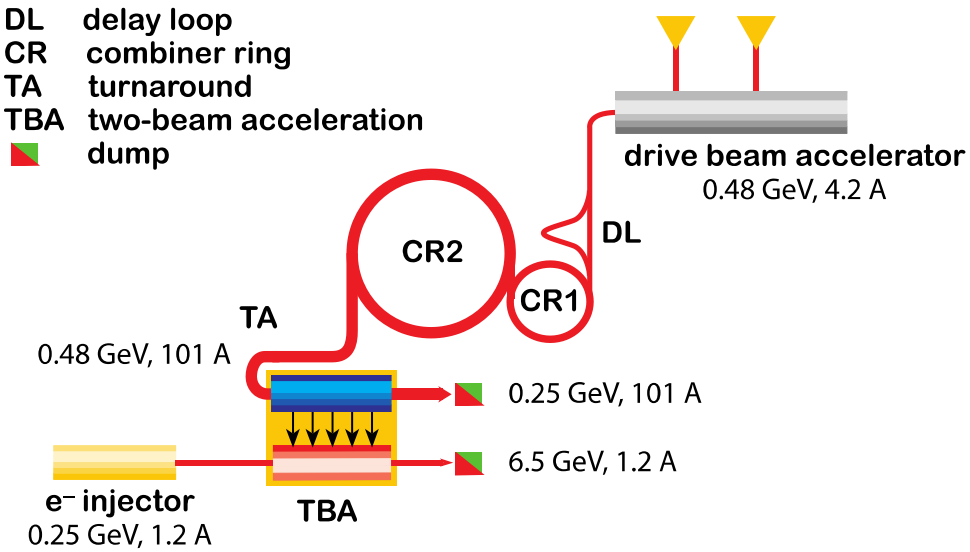
- Drive Beam Accelerator components – R&D on CLIC front-end components have put us on the right track

  However:

  - Modulators will not be fully industrialized in 2020
  - Same for accelerator structures (but they are relatively standard components…)
  - Klystrons may need a second iteration if R&D on high efficiency tubes successful
  - Need to keep momentum and critical mass…

Facilities for testing and qualification of components

- Such facilities will be needed at the latest in the early stage of construction
- May have a very long lead time, so their construction should be part of the project preparation
- CLIC Zero may be one of these, its main use should indeed be the qualification of two-beam modules. It is therefore critical to understand early what will be the needs for qualification and the corresponding procedures



RF conditioning, structure qualification, operational issues

- Possibly the main critical issue linked to that is RF conditioning of accelerating structure and subsequent breakdown behavior
- It is paramount to collect a good statistics in the high-gradient tests in order to understand the process and develop a realistic strategy for conditioning.

Important questions:

- How many structures will have to be rejected? How to detect the faulty ones early on during conditioning?
- How many structures will have to be (pre-)conditioned in parallel?
- Would it be acceptable to condition the structures in situ?
- How much of the conditioning should be done before?
- Will we need special procedures to preserve performance during transport?
- Will we need to reprocess installed structures occasionally? Do we need a very fast PETS on-off mechanism?
- …

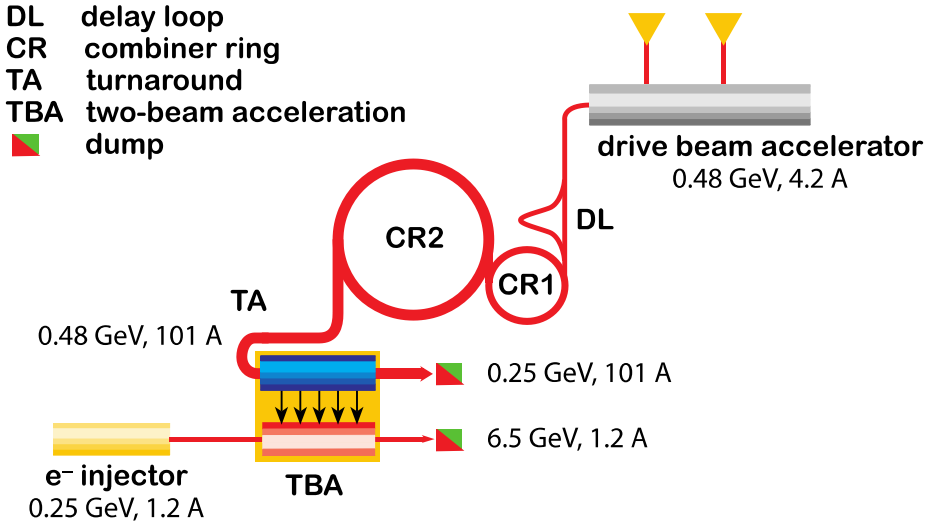
The CLIC Zero issue

- CLIC Zero was proposed in the past as part of the post-CDR phase. Motivations:
  - Focus to develop main components to large scale
  - Needed for modules qualification tests
  - Gain experience/time in operation of full scale drive beam complex
  - Full-scale system test for Two-Beam

- Main issue: cost (~300 MCHF, to be reviewed) and time (a few years)

- Will need a serious commitment towards CLIC

- May CLIC Zero be integrated in early construction stage?
- Were will we test modules?
- What kind of facility will we need if we choose the klystron option?



Two-beam and/or klystron based 1st stage

- Prototypes, testing procedures and testing facilities may be very different for the two cases
- The two options should be pursued in parallel in the present stage
- However, we should soon define a decision point, in order to not duplicate efforts in a period were investment will have to go up
- Will we have a decision already before 2020?
- Should we present two alternative plans for the next phase?

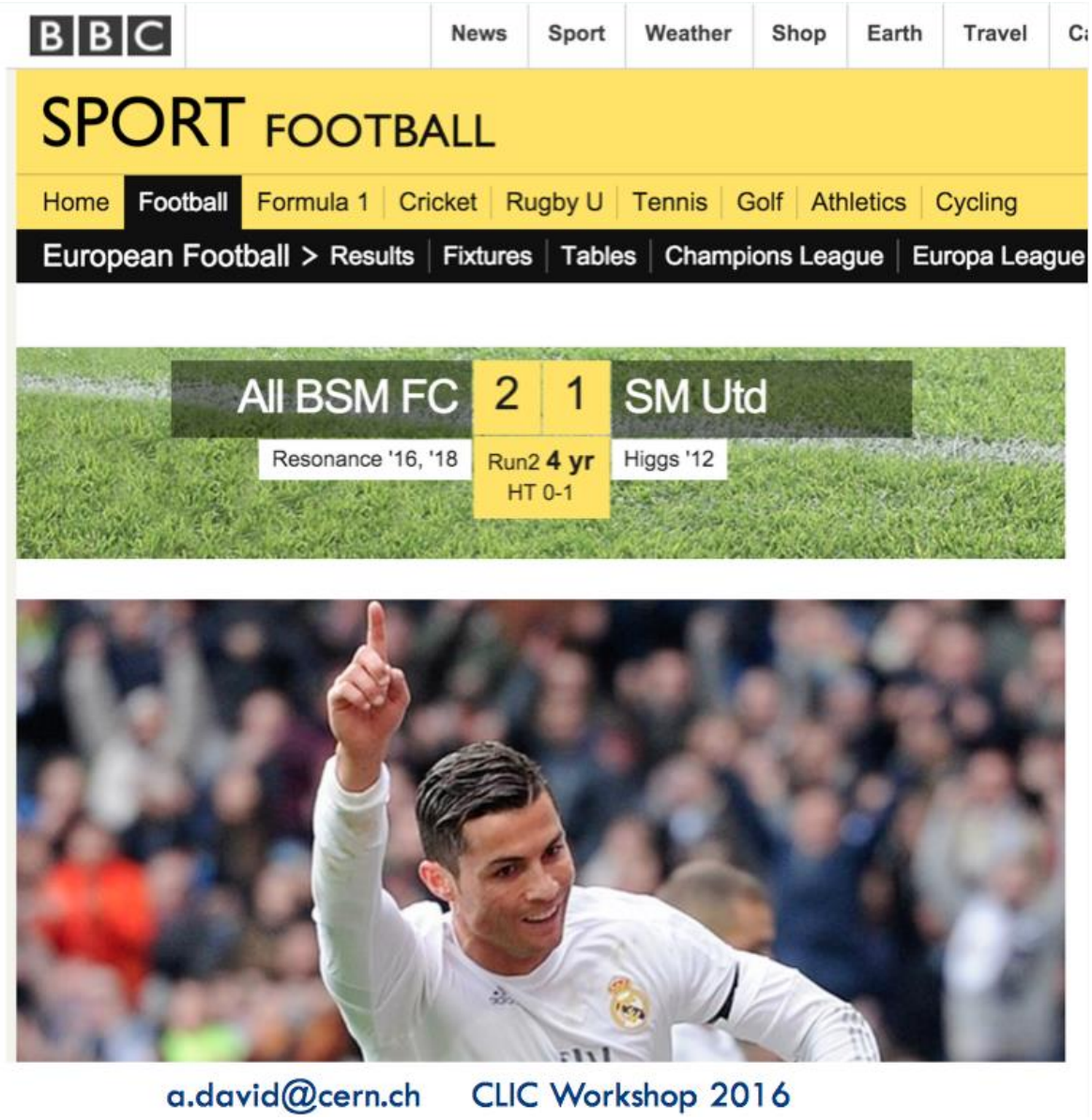
Conclusion and Outlook

- CLIC is one of the main options for the future of CERN and of high energy physics in general after LHC.

- We have a well defined mandate to complete and document the CLIC study in preparation for the next European Strategy exercise (2018/2019), when an informed decision should be taken (hopefully with good indications from physics results from LHC run2) and we have a clear plan to fulfill such a mandate.

- One of the deliverables of the present phase is a detailed plan for the CLIC Preparation Phase (2020-2025), to bring the project at the start of construction in case of a positive decision.

- It is now time to start developing in detail such a plan. Most of the needed information exists, and we should be able to get what is still missing in the next couple of years, in the framework of the present program.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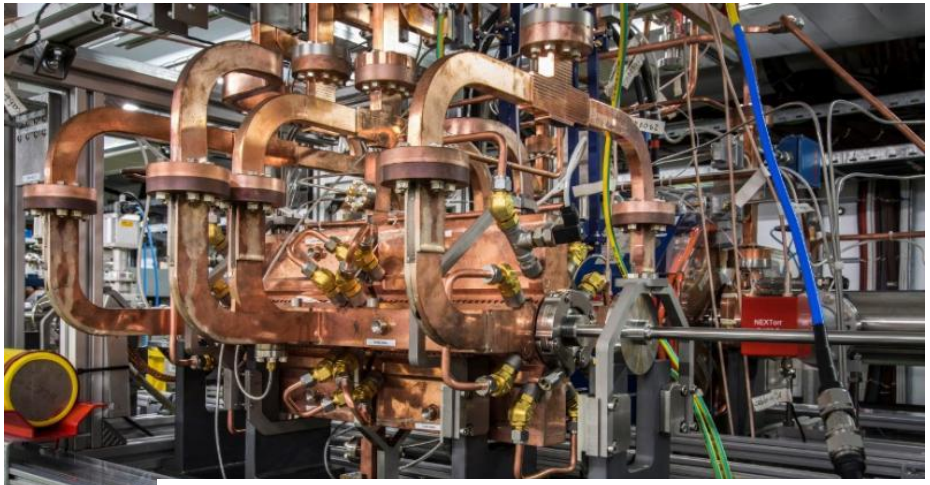
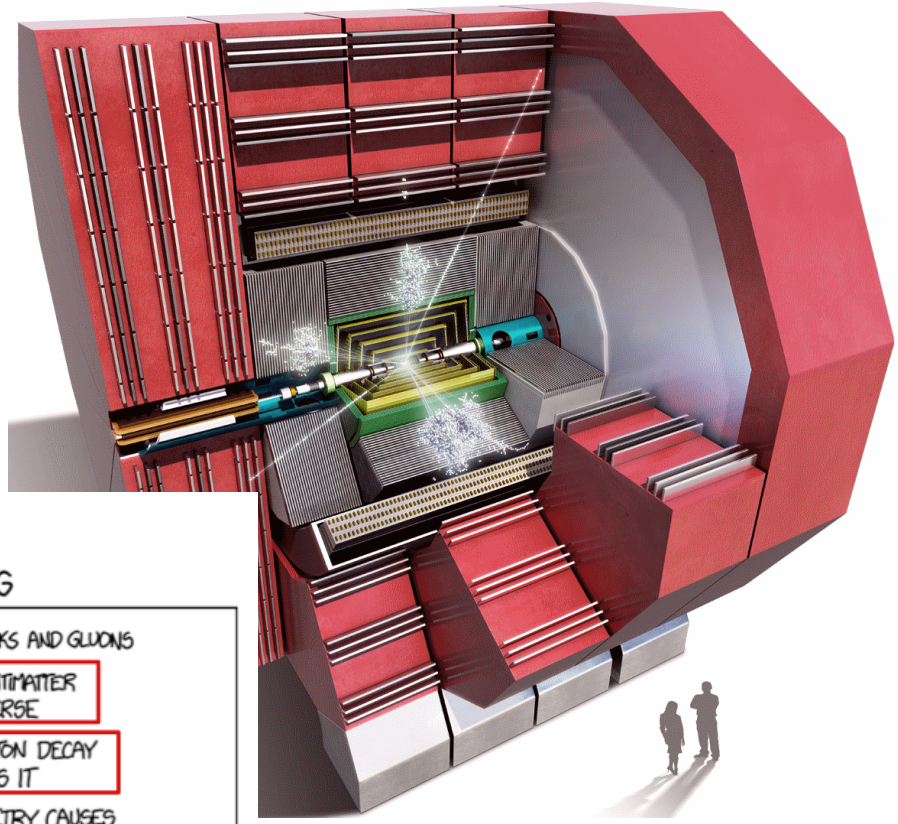
CLIC Workshop 2016






THE FIXION
A NEW PARTICLE THAT EXPLAINS EVERYTHING
MAIN COMPONENT OF DARK MATTER
NEUTRALIZES MONOPOLES
SPONTANEOUSLY EMITS DARK ENERGY
INTRODUCES DISPERSION INTO PERYTONS FROM KITCHEN MICROWAVES, EXPLAINING FAST RADIO BURSTS
CAUSES ALPHA EFFECT
INTERCEPTS CERTAIN GRAVITATIONAL WAVES BEFORE THEY'RE OBSERVED
HIGGS-ISH
ACCELERATES CERTAIN SPACECRAFT DURING FLYBYS
MELTS ICE IN "SNOWBALL EARTH" SCENARIO
SUPPRESSES SIGMA IN EXPERIMENTS
CONFINES QUARKS AND GLUONS
SUPPRESSES ANTIMATTER IN EARLY UNIVERSE
MEDIATES PROTON DECAY BUT THEN HIDES IT
BROKEN SYMMETRY CAUSES θ=0, EXPLAINING UNOBSERVED NEUTRON DIPOLE MOMENT
COVERS NAKED SINGULARITIES
CAUSES CORONAL HEATING
SUPERLUMINALLY SMOOTHS ANISOTROPIES IN EARLY UNIVERSE (BUT ADDS FAINT POLARIZATION FOR BICEP3 TO FIND)
TRIGGERS SIBERIAN SINKHOLES
TRANSPORTS NEUTRINOS FASTER THAN LIGHT, BUT ONLY ON CERTAIN DAYS THROUGH ONE AREA OF FRANCE.
Italy