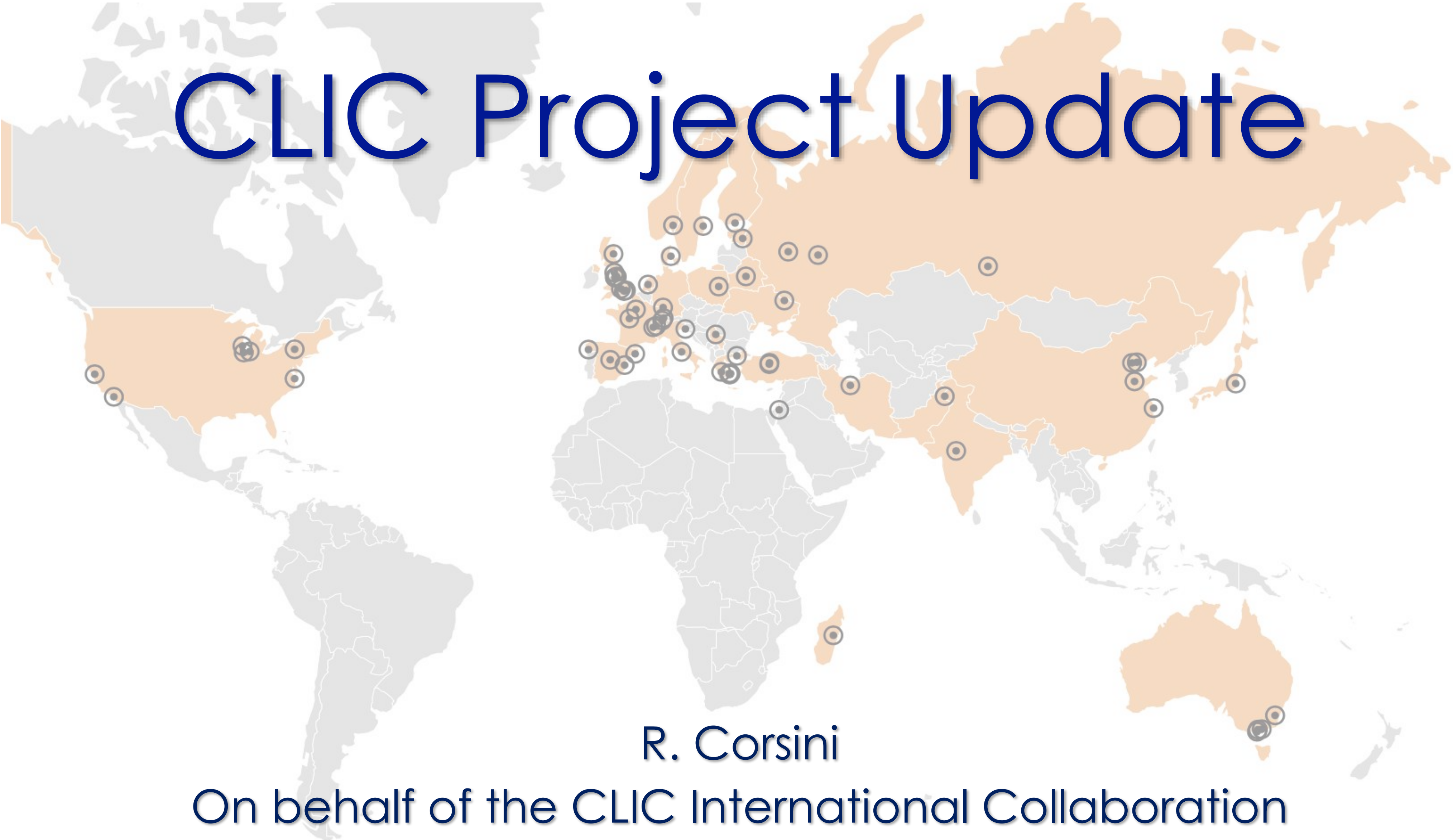
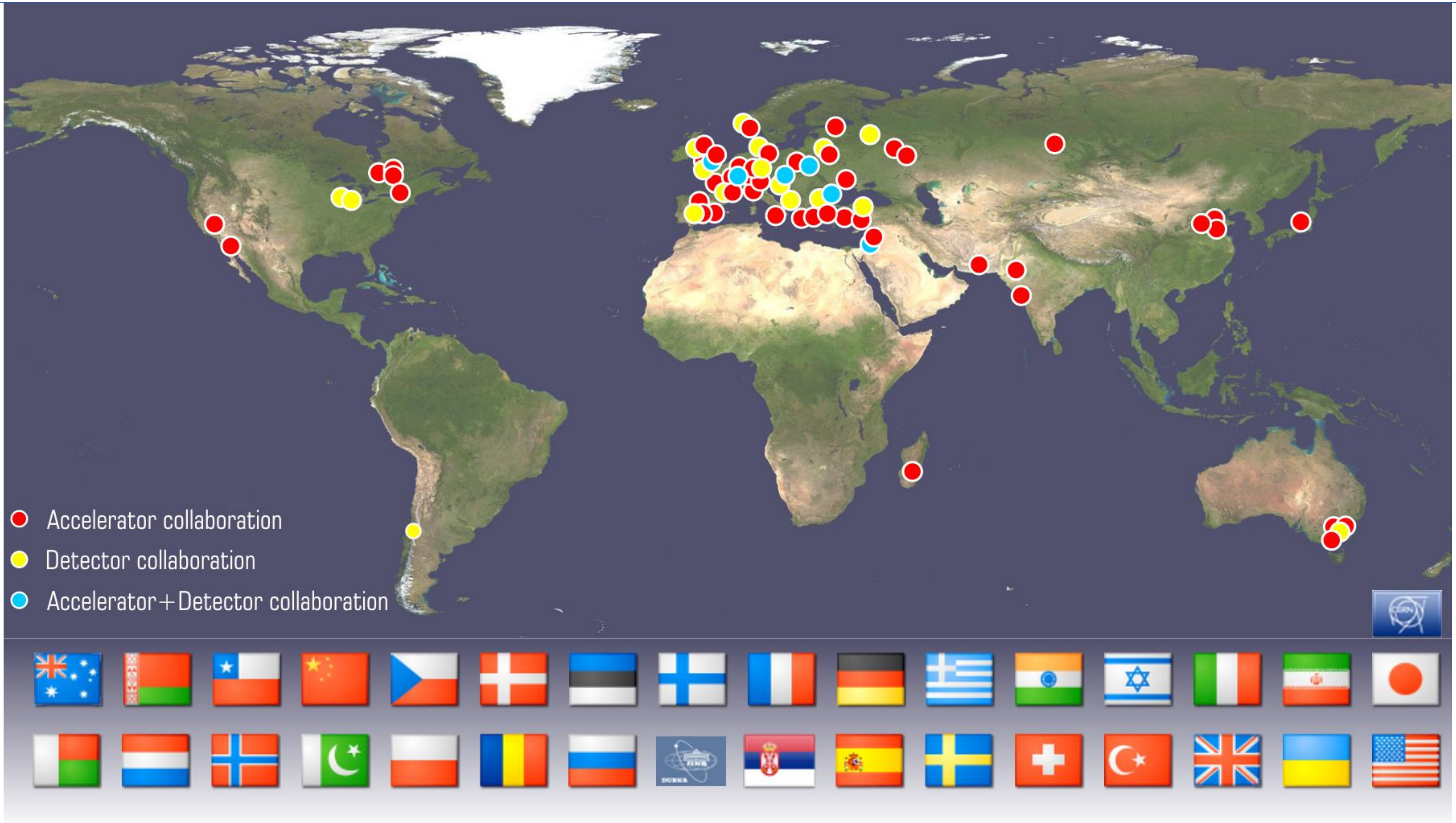


# CLIC Project Update

R. Corsini
On behalf of the CLIC International Collaboration

# The CLIC International Collaboration

R. Corsini

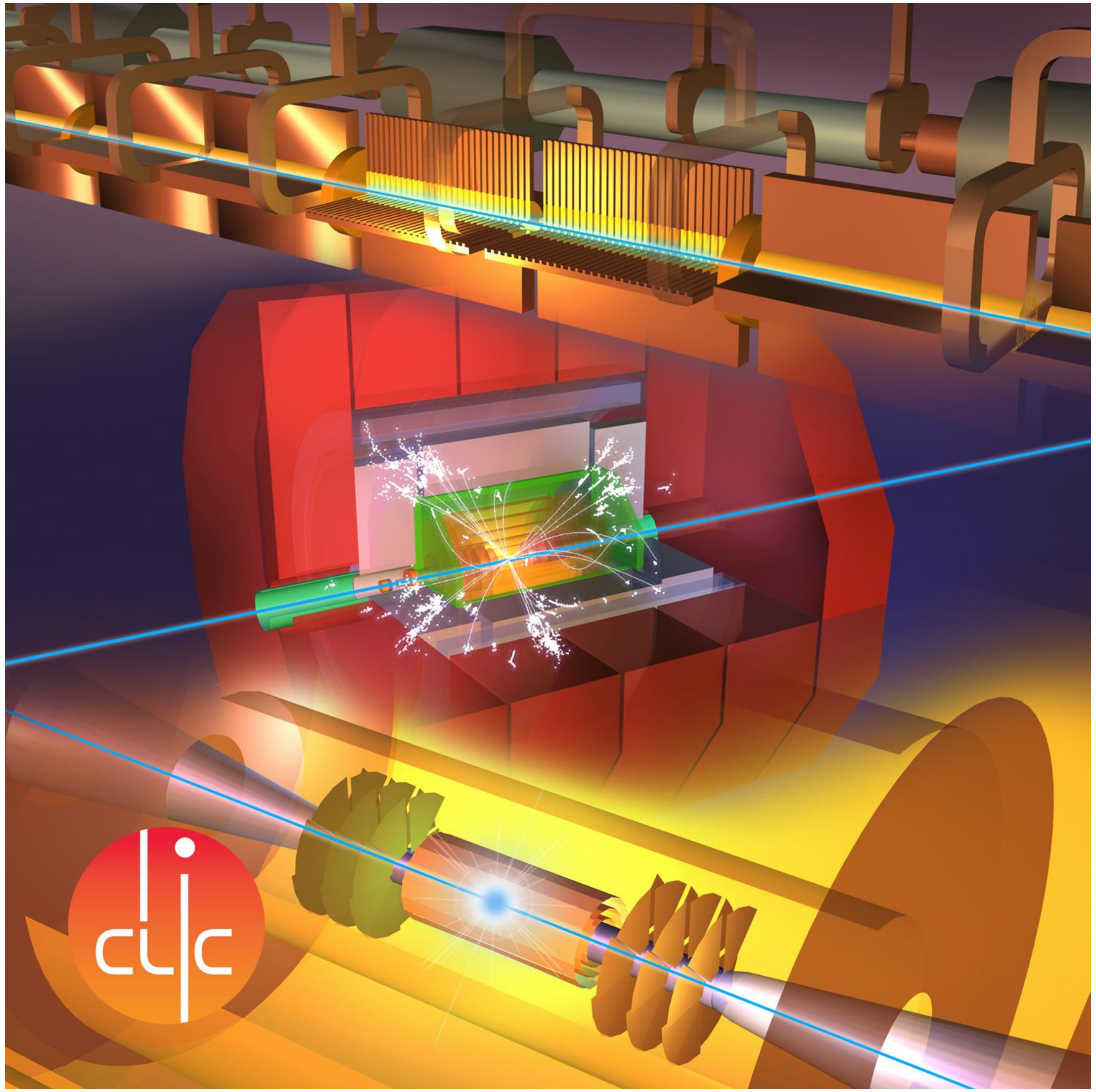



- Australia
- Belarus
- China
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- India
- Israel
- Iran
- Italy
- Japan
- Madagascar
- Netherlands
- Norway
- Pakistan
- Poland
- Russian Federation
- Serbia
- Spain
- Sweden
- Switzerland
- Turkey
- Ukraine
- United Kingdom
- United States

CLIC is a global, multi-lateral collaboration of more than 70 institutes from more than 30 countries

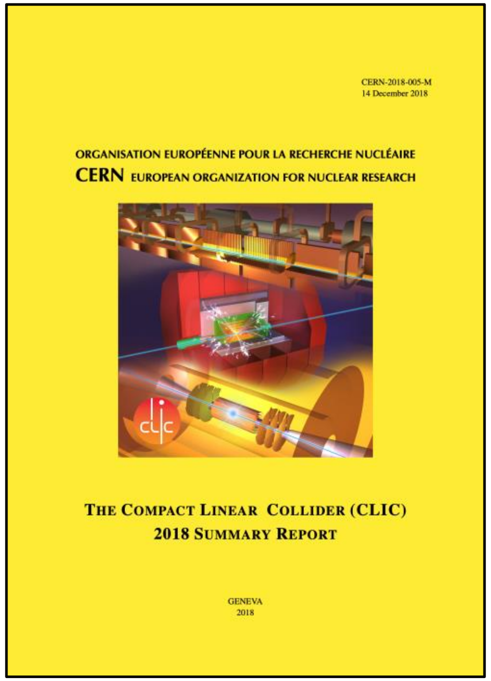
Talk outline:

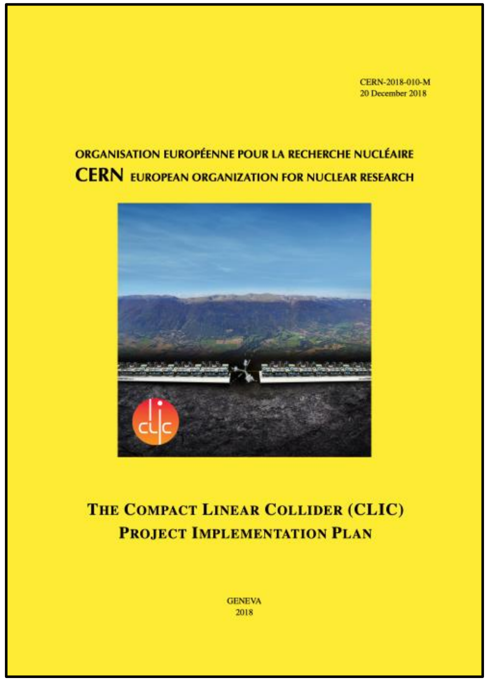
- Introduction
- The CLIC Project implementation plan
  - Parameters & layout
  - Staging
  - Cost
  - Power
  - Schedule & Implementation
- Review of Key technical challenges
  - Past achievements
  - Recent progress & ongoing activities
- Conclusion & Outlook



# European Strategy Input

R. Corsini







## 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** (CERN-2018-010-M, arXiv:1903.08655)
- **The CLIC potential for new physics** (CERN-2018-009-M, arXiv:1812.02093)
- **Detector technologies for CLIC** (CERN-2019-001, arXiv:1905.02520)

*Journal publications*

- **Top-quark physics at the CLIC electron-positron linear collider** [In journal review] (arXiv:1807.02441)
- **Higgs physics at the CLIC electron-positron linear collider** (Journal, arXiv:1608.07538)
  - Projections based on the analyses from this paper scaled to the latest assumptions on integrated luminosities can be found here: CDS, arXiv.

*CLICdp notes*

- **Updated CLIC luminosity staging baseline and Higgs coupling prospects** (CERN Document Server, arXiv:1812.01644)
- **CLICdet: The post-CDR CLIC detector model** (CERN Document Server)
- **A detector for CLIC: main parameters and performance** (CERN Document Server, arXiv:1812.07337)

European Strategy Update

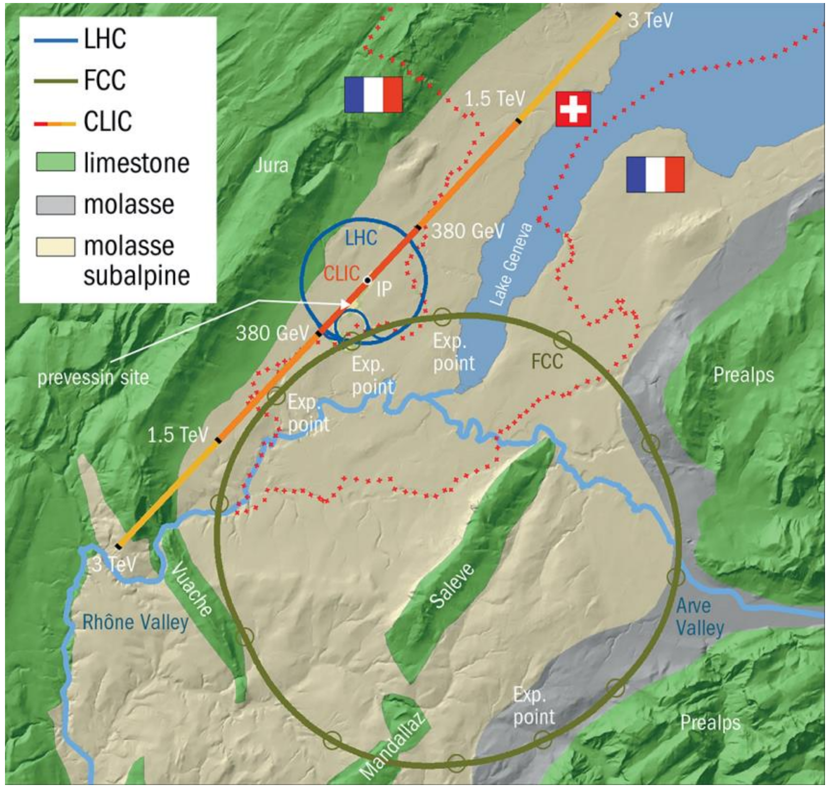
Link: http://clic.cern/european-strategy

# Future CERN Collider?

R. Corsini

European Strategy Update

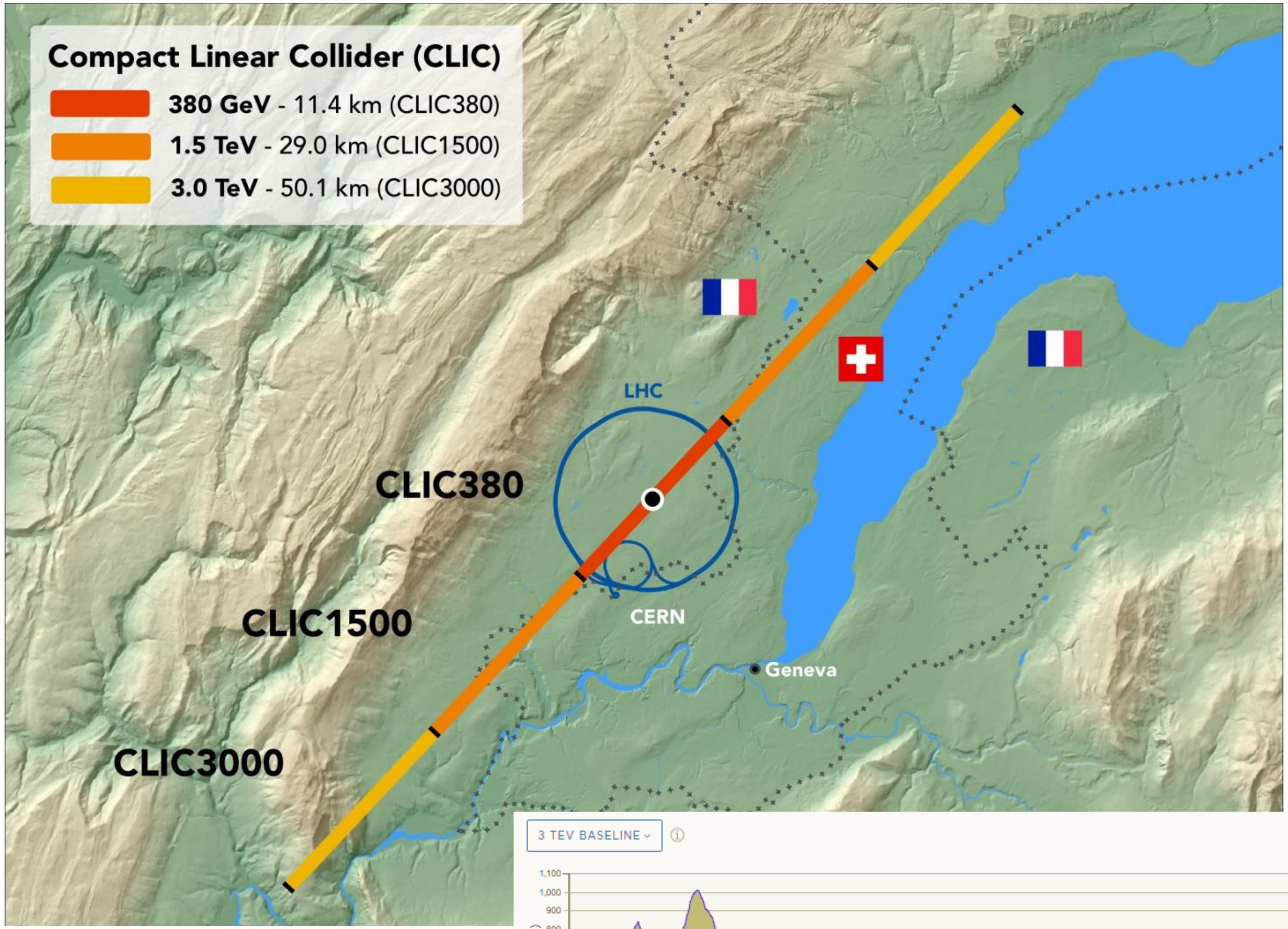
| | 2020-2040 | 2040-2060<br>1st gen technology | 2060-2080<br>2nd gen technology |
|---|---|---|---|
| **CLIC-all** | HL-LHC | **CLIC380-1500** | CLIC3000 / other tech |
| **CLIC-FCC** | HL-LHC | **CLIC380** | FCC-h/e/A (Adv HF magnets) / other tech |
| **FCC-all** | HL-LHC | **FCC-ee (90-365)** | FCC-h/e/A (Adv HF magnets) / other tech |
| **LE-to-HE-FCC-h/e/A** | HL-LHC | **LE-FCC-h/e/A (low-field magnets)** | FCC-h/e/A (Adv HF magnets) / other tech |
| **LHeC-FCC-h/e/A** | HL-LHC **+ LHeC** | **LHeC** | FCC-h/e/A (Adv HF magnets) / other tech |

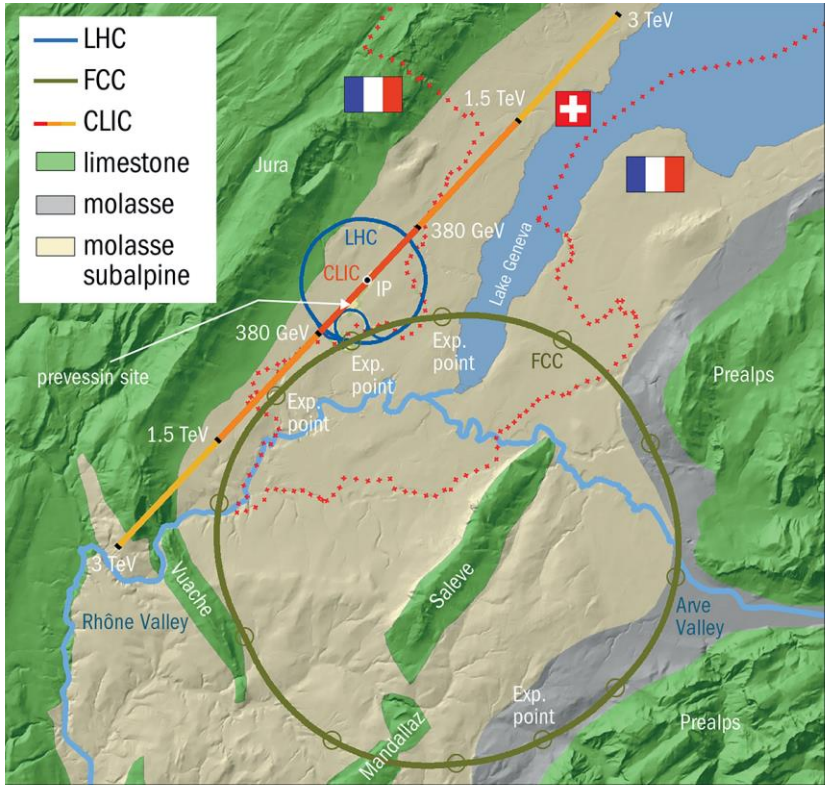


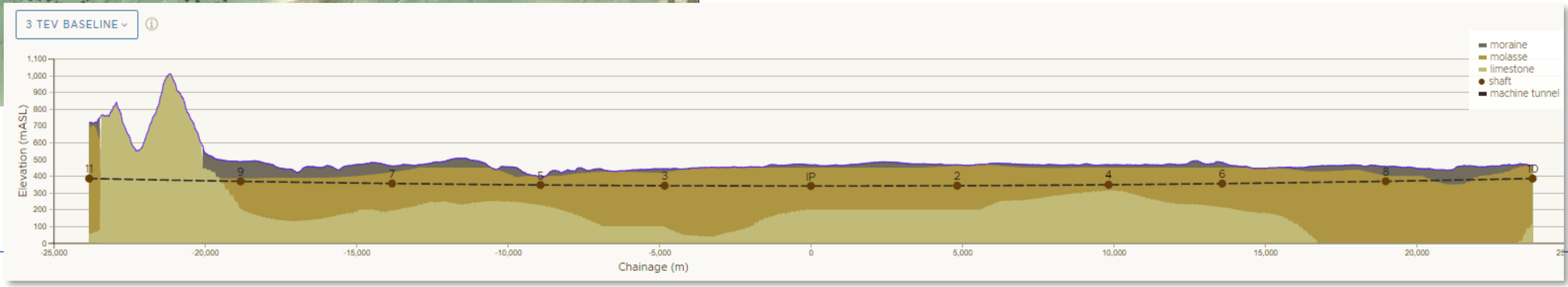

CLIC is one of the main alternatives for the next major collider facility in Europe in the scenarios presently considered by the European Strategy Group (ESG).

# Future CERN Collider?

R. Corsini

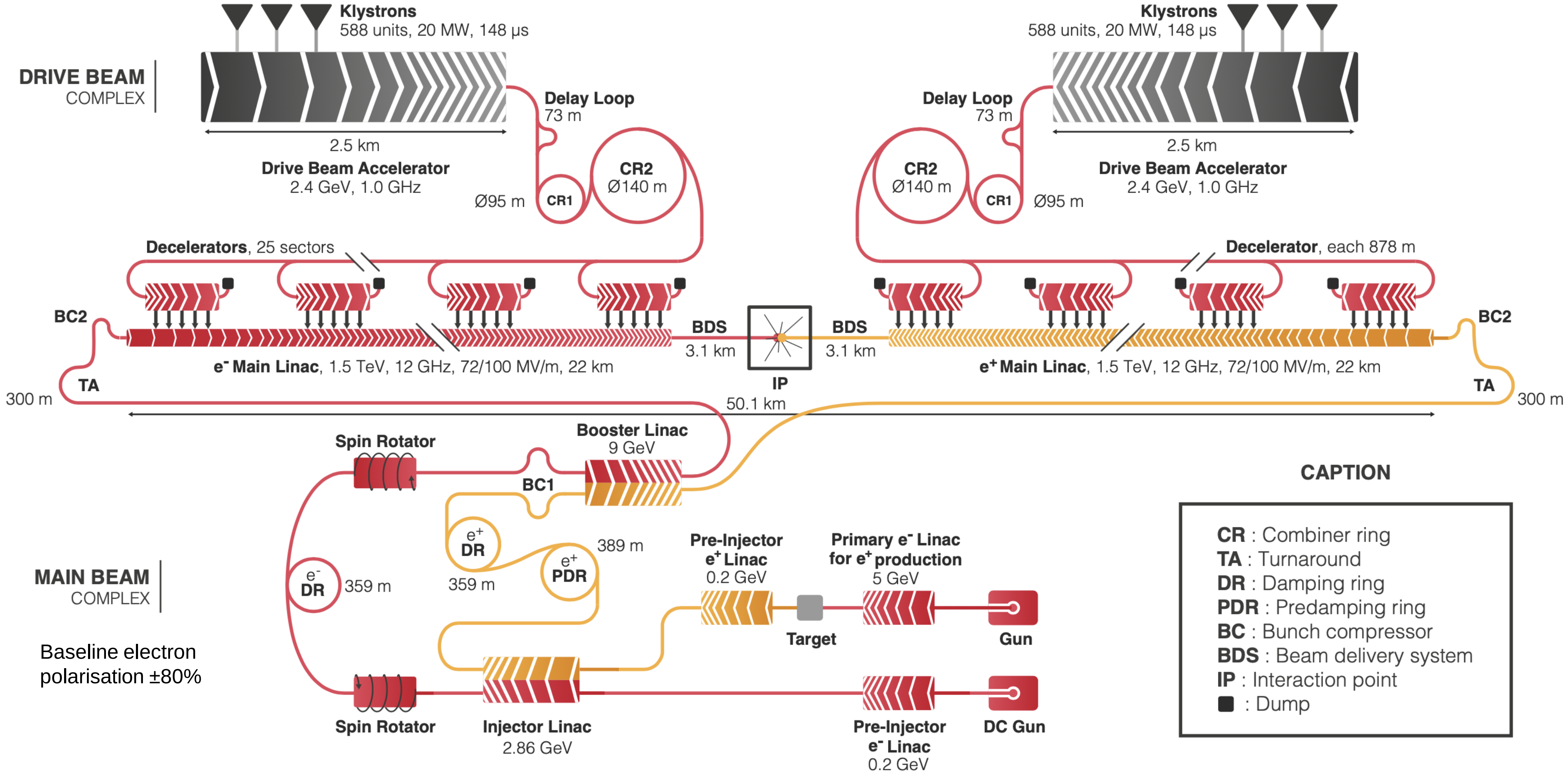


# CLIC layout – 3TeV

R. Corsini




Baseline electron polarisation ±80%

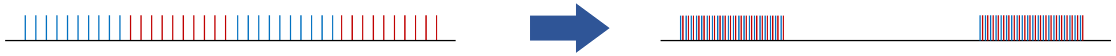
# CLIC 380 GeV layout and power generation

R. Corsini

## Single drive beam complex (up to ~ 1.5 TeV c.m.)

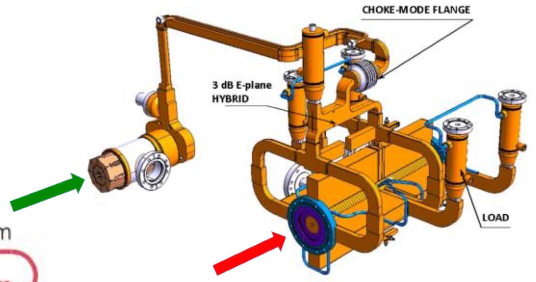
Drive beam time structure - initial

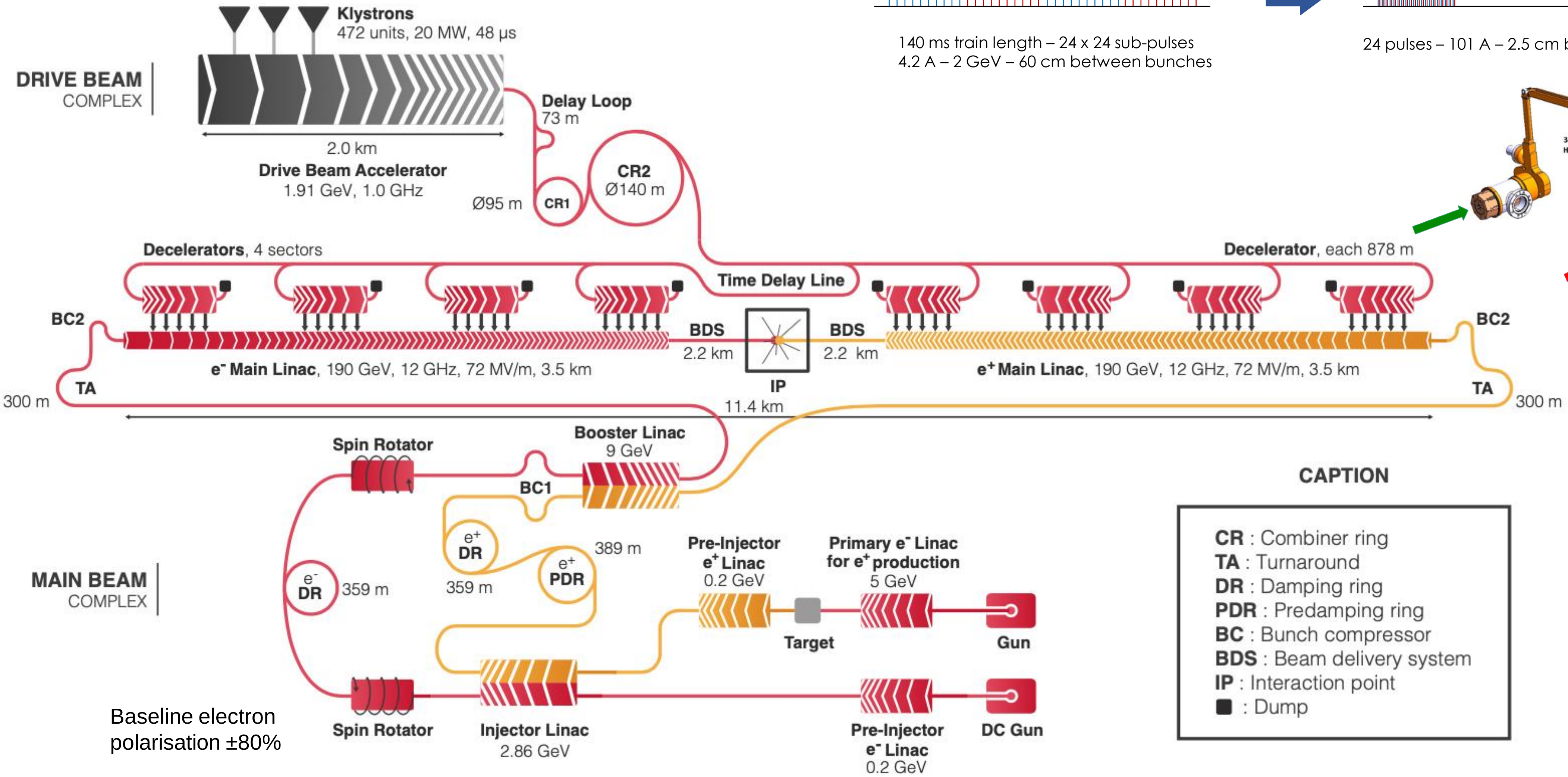
Drive beam time structure - initial



140 ms train length – 24 x 24 sub-pulses
4.2 A – 2 GeV – 60 cm between bunches

24 pulses – 101 A – 2.5 cm between bunches

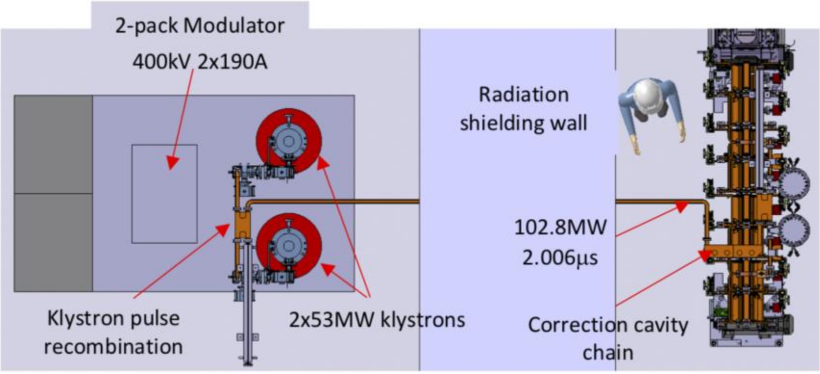


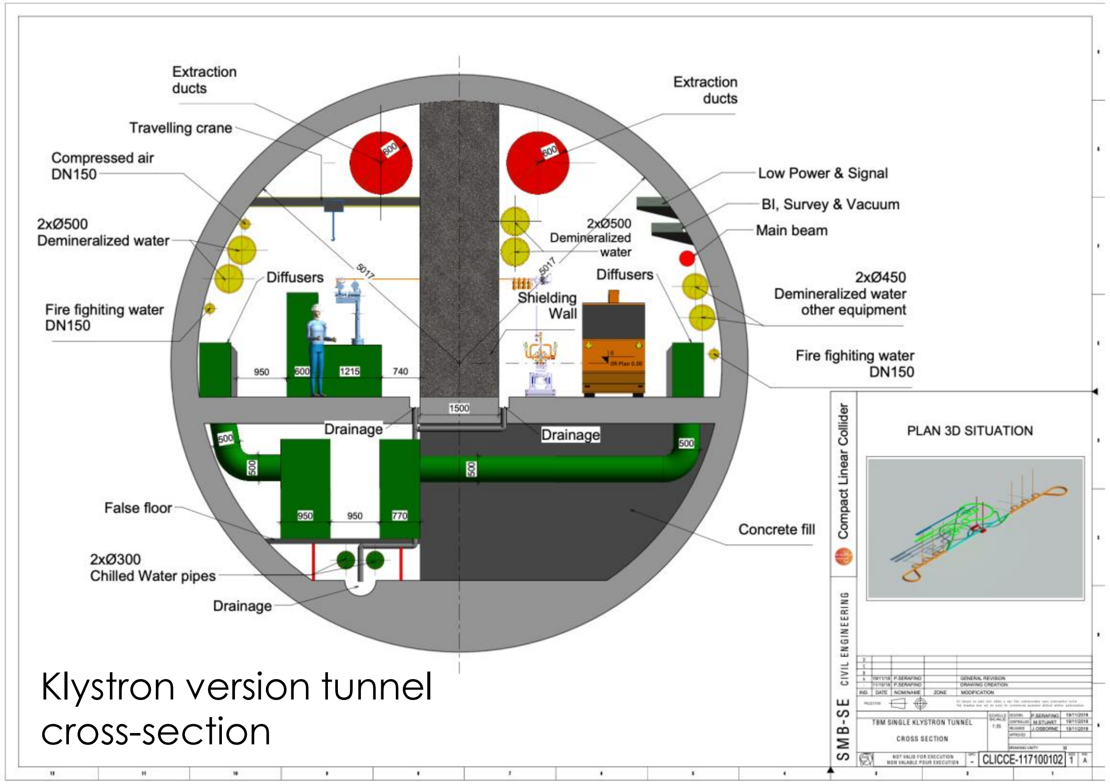

Baseline electron polarisation ±80%

# Klystron-based alternative

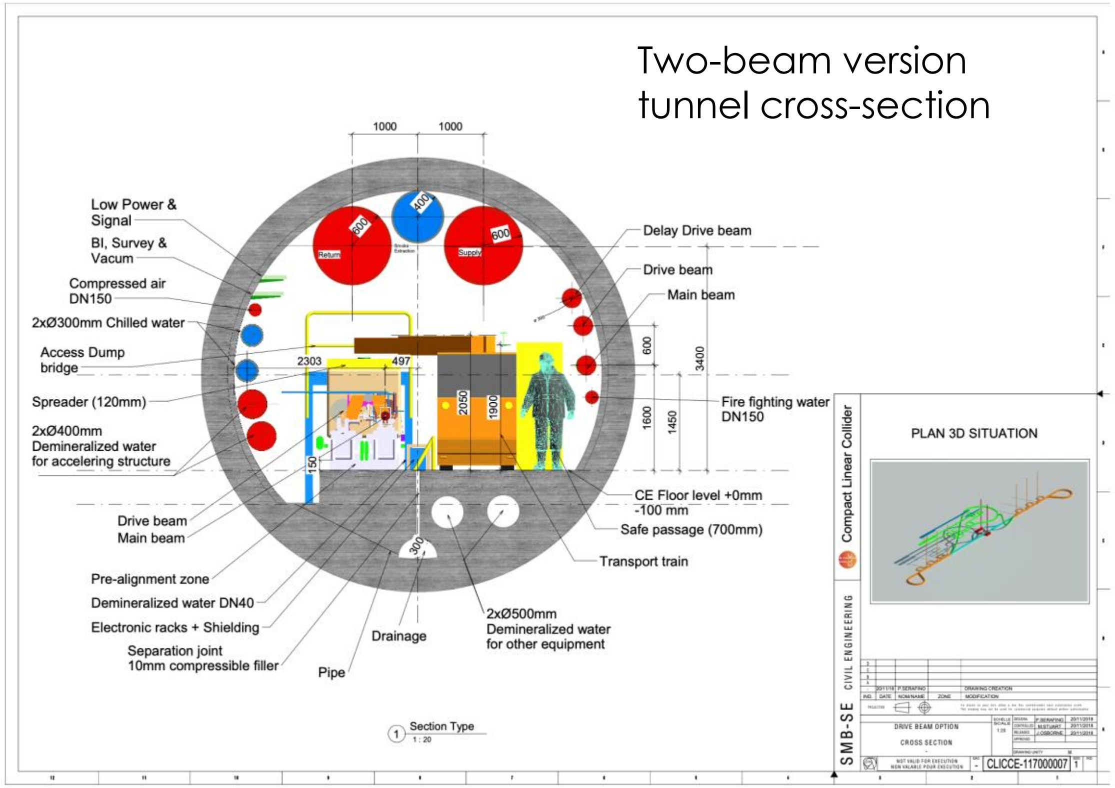
R. Corsini




- Klystron-powered version studied and costed for 1st stage (380 GeV c.m.)
- Upgrade to 1 TeV and beyond based in any case on Two-beam scheme (klystron-based sectors re-usable with modifications)




Klystron version tunnel cross-section




Two-beam version tunnel cross-section

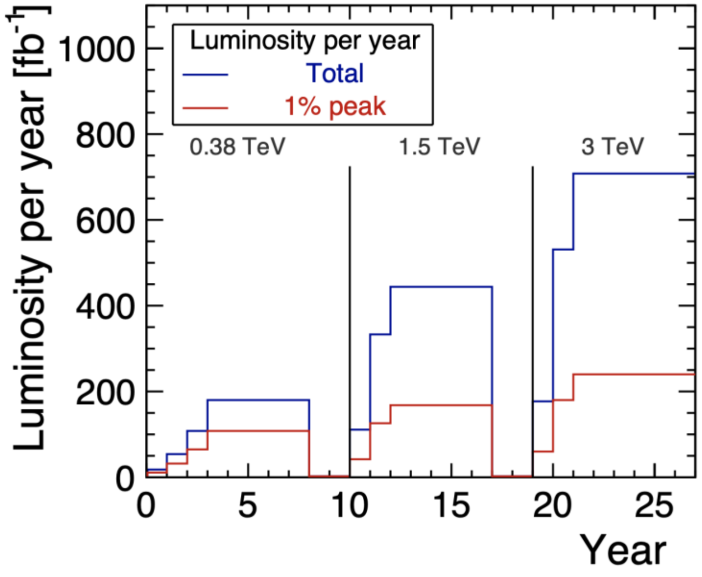
# CLIC parameters

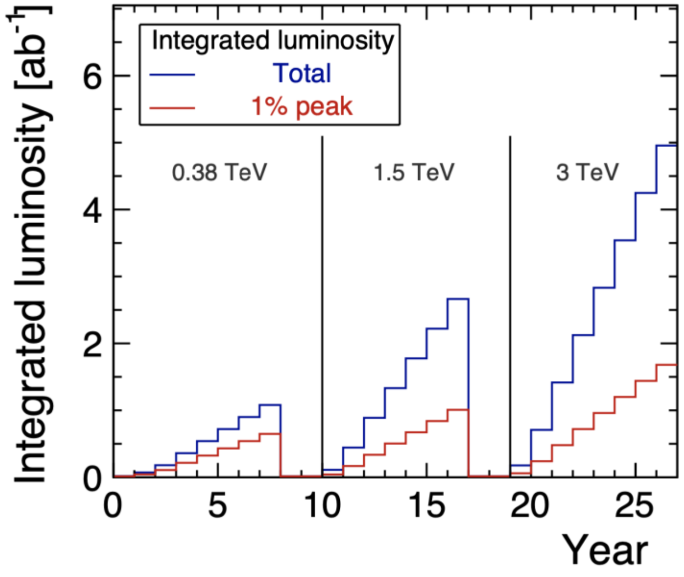
R. Corsini

| Parameter | Symbol | Unit | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|---|---|
| Centre-of-mass energy | $\sqrt{s}$ | GeV | 380 | 1500 | 3000 |
| Repetition frequency | $f_{\text{rep}}$ | Hz | 50 | 50 | 50 |
| Number of bunches per train | $n_b$ | | 352 | 312 | 312 |
| Bunch separation | $\Delta t$ | ns | 0.5 | 0.5 | 0.5 |
| Pulse length | $\tau_{\text{RF}}$ | ns | 244 | 244 | 244 |
| Accelerating gradient | $G$ | MV/m | 72 | 72/100 | 72/100 |
| Total luminosity | $\mathcal{L}$ | $10^{34}$ cm$^{-2}$s$^{-1}$ | 1.5 | 3.7 | 5.9 |
| Luminosity above 99% of $\sqrt{s}$ | $\mathcal{L}_{0.01}$ | $10^{34}$ cm$^{-2}$s$^{-1}$ | 0.9 | 1.4 | 2 |
| Main tunnel length | | km | 11.4 | 29.0 | 50.1 |
| Number of particles per bunch | $N$ | $10^9$ | 5.2 | 3.7 | 3.7 |
| Bunch length | $\sigma_z$ | $\mu$m | 70 | 44 | 44 |
| IP beam size | $\sigma_x/\sigma_y$ | nm | 149/2.9 | $\sim$ 60/1.5 | $\sim$ 40/1 |
| Normalised emittance (end of linac) | $\epsilon_x/\epsilon_y$ | nm | 900/20 | 660/20 | 660/20 |

# Luminosity staging baseline






Staging and live-time assumptions following guidelines consistent with other future projects: Machine Parameters and Projected Luminosity Performance of Proposed Future Colliders at CERN

arXiv:1810.13022, Bordry et al.

Sensitivities updated for new luminosity staging baseline

| Stage | $\sqrt{s}$ [TeV] | $\mathscr{L}_{int}$ [ab$^{-1}$] |
|---|---|---|
| 1 | 0.38 (and 0.35) | 1.0 |
| 2 | 1.5 | 2.5 |
| 3 | 3.0 | 5.0 |

Increased from

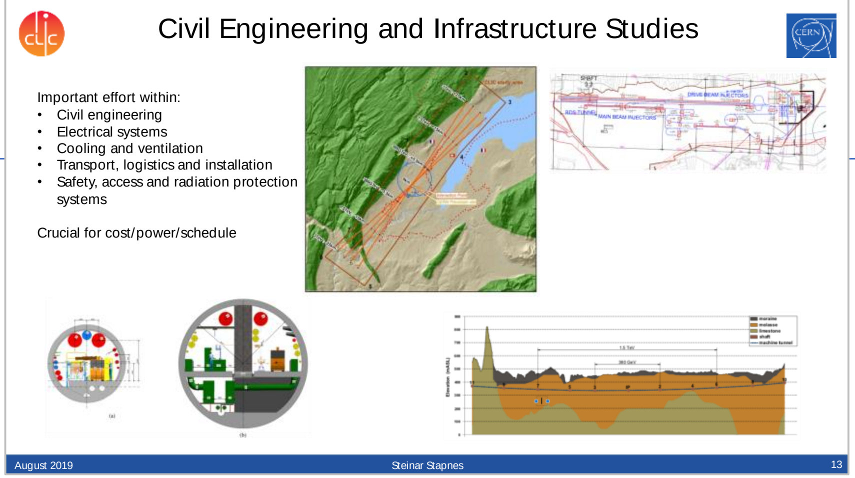
0.5+0.1ab$^{-1}$

1.5ab$^{-1}$

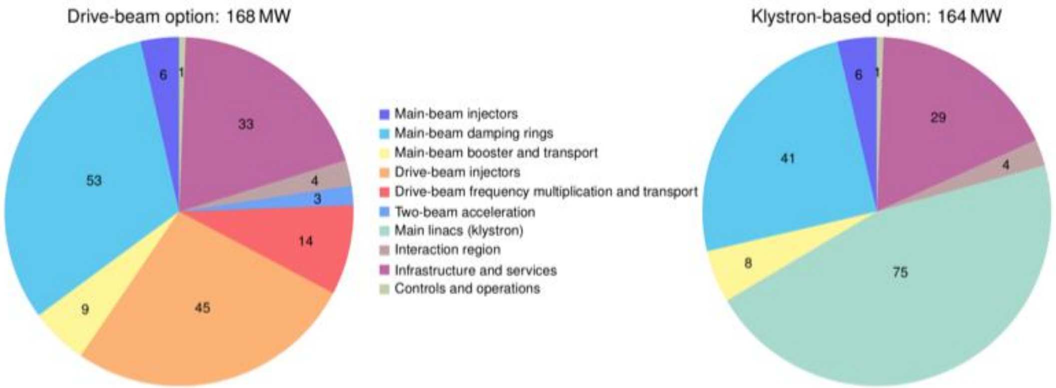
3ab$^{-1}$

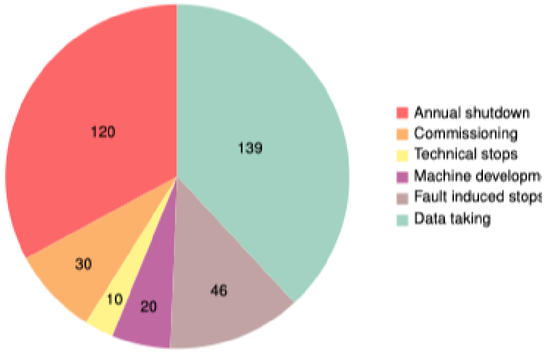
Baseline polarisation scenario adopted:
electron beam (–80%, +80%) polarised in ratio (50:50) at √s=380GeV ; (80:20) at √s=1.5 and 3TeV

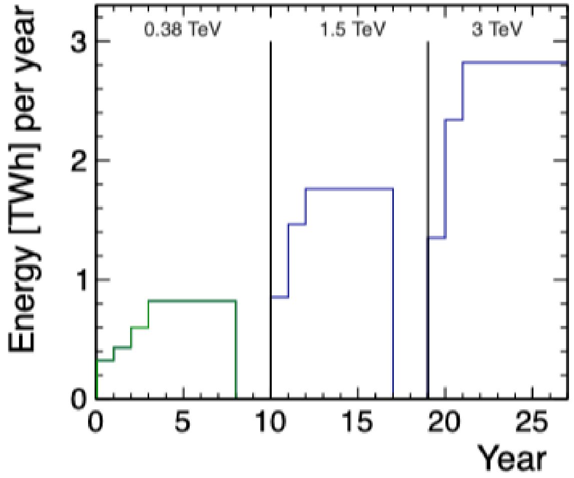
# Implementing CLIC




| Collision Energy [GeV] | Running [MW] | Standby [MW] | Off [MW] |
|---|---|---|---|
| 380 | 168 | 25 | 9 |
| 1500 | 364 | 38 | 13 |
| 3000 | 589 | 46 | 17 |




Power estimate bottom up (concentrating on 380 GeV systems)

- Very large reductions since CDR, better estimates of nominal settings, much more optimised drive beam complex and more efficient klystrons, injectors more optimisation, etc

Further savings possible, main target damping ring RF
Will look also more closely at 1.5 and 3 TeV numbers next

From running model and power estimates at various states – the energy consumption can be estimated

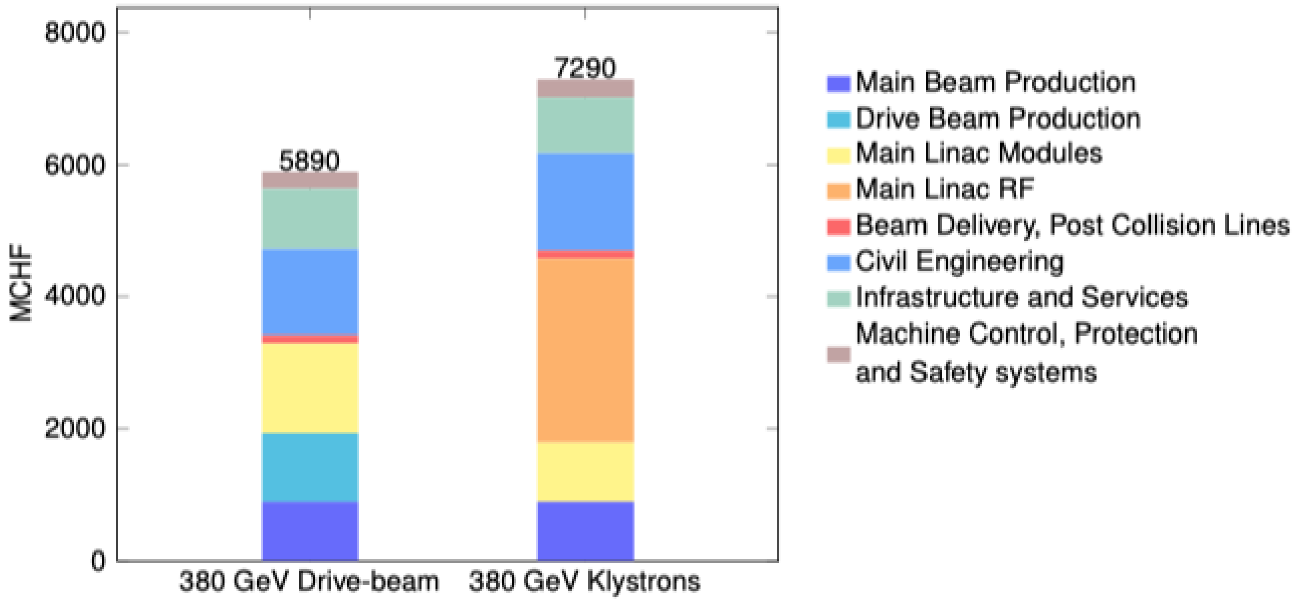
CERN is currently consuming ~1.2 TWh yearly (~90% in accelerators)

# Cost – First Stage

R. Corsini

Machine has been re-costed bottom-up in 2017-18

- Methods and costings validated at review (7 November 2018) – similar to LHC, ILC, CLIC CDR
- Technical uncertainty and commercial uncertainty estimated




| Domain | Sub-Domain | Cost [MCHF] Drive-Beam | Cost [MCHF] Klystron |
|---|---|---|---|
| Main Beam Production | Injectors | 175 | 175 |
| | Damping Rings | 309 | 309 |
| | Beam Transport | 409 | 409 |
| Drive Beam Production | Injectors | 584 | — |
| | Frequency Multiplication | 379 | — |
| | Beam Transport | 76 | — |
| Main Linac Modules | Main Linac Modules | 1329 | 895 |
| | Post decelerators | 37 | — |
| Main Linac RF | Main Linac Xband RF | — | 2788 |
| Beam Delivery and Post Collision Lines | Beam Delivery Systems | 52 | 52 |
| | Final focus, Exp. Area | 22 | 22 |
| | Post-collision lines/dumps | 47 | 47 |
| Civil Engineering | Civil Engineering | 1300 | 1479 |
| Infrastructure and Services | Electrical distribution | 243 | 243 |
| | Survey and Alignment | 194 | 147 |
| | Cooling and ventilation | 443 | 410 |
| | Transport / installation | 38 | 36 |
| Machine Control, Protection and Safety systems | Safety system | 72 | 114 |
| | Machine Control Infrastructure | 146 | 131 |
| | Machine Protection | 14 | 8 |
| | Access Safety & Control System | 23 | 23 |
| **Total (rounded)** | | **5890** | **7290** |

CLIC 380 GeV Drive-Beam based: $5890^{+1470}_{-1270}$ MCHF;

CLIC 380 GeV Klystron based: $7290^{+1800}_{-1540}$ MCHF.

# Cost – Operation & Further Stages



Other cost estimates:

Construction:

- From 380 GeV to 1.5 TeV, add 5.1 BCHF (drive-beam RF upgrade and lengthening of ML)
- From 1.5 TeV to 3 TeV, add 7.3 BCHF (second drive-beam complex and lengthening of ML)
- Labour estimate: ~11500 FTE for the 380 GeV construction

Operation:

- 116 MCHF (see assumptions in box below)
- Energy costs

– 1% for accelerator hardware parts (e.g. modules).
– 3% for the RF systems, taking the limited lifetime of these parts into account.
– 5% for cooling, ventilation and electrical infrastructures etc. (includes contract labour and consumables)

These replacement/operation costs represent 116 MCHF per year.

# CLIC Accelerator key technical challenges

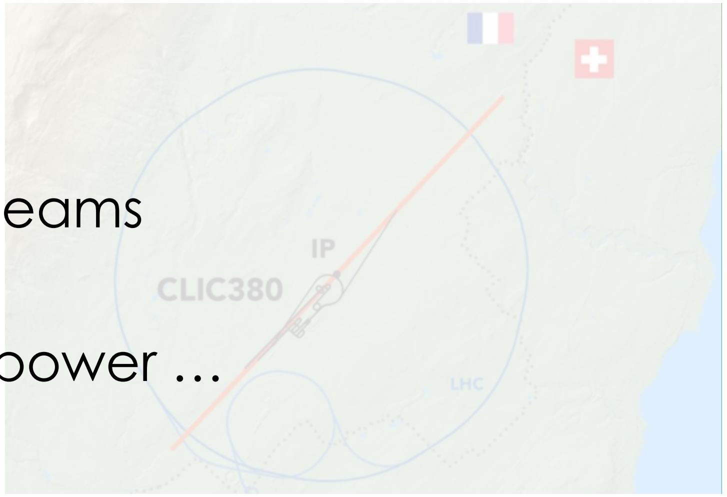
R. Corsini

- Main technologies have been demonstrated
- CLIC is now a mature project, ready for construction

## Key Challenges:

- High-current drive beam, bunched at 12 GHz
- Power transfer and two-beam acceleration
- 100 MV/m acceleration gradient
- Produce, transport, and collide low-emittance beams
- System integration, engineering, reliability, cost, power …





# The CLIC Test Facility CTF3 (2003-2016)

R. Corsini

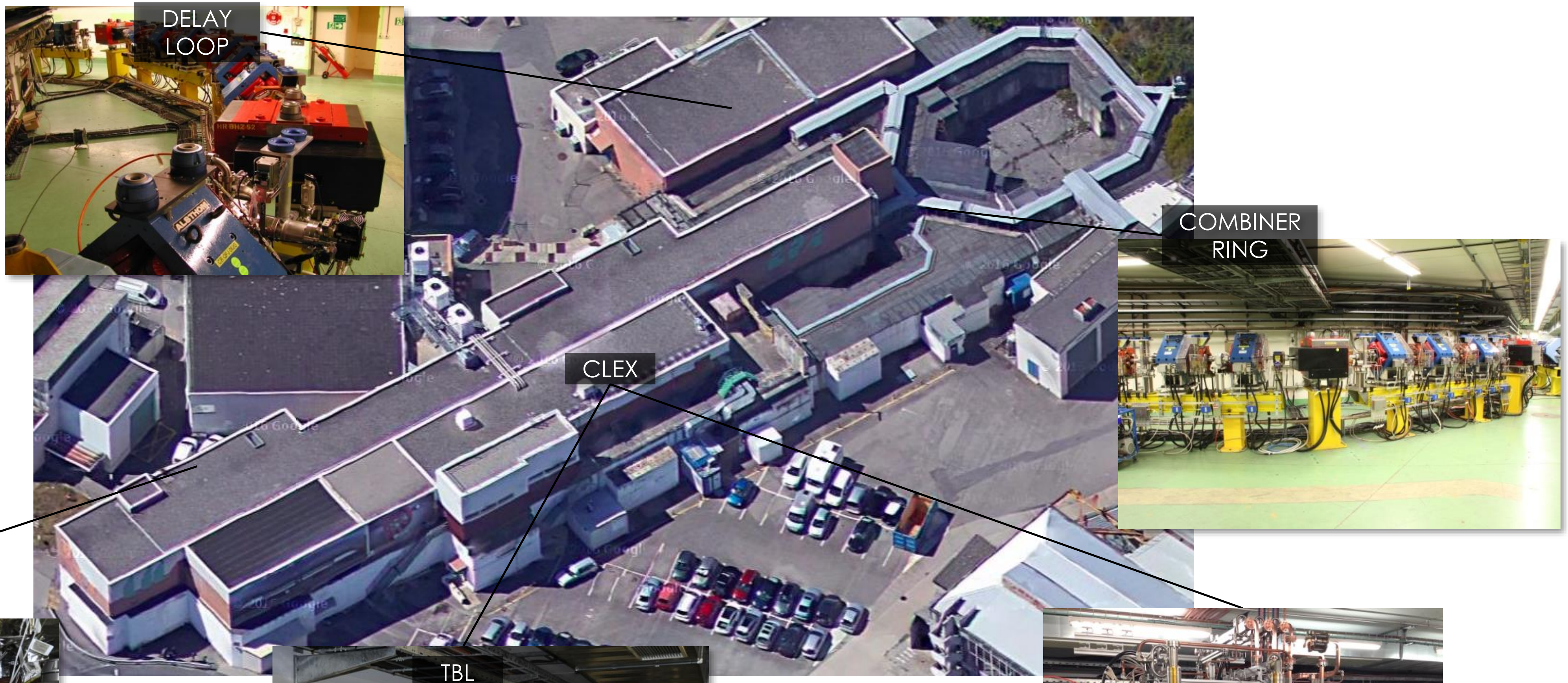
Key challenges:

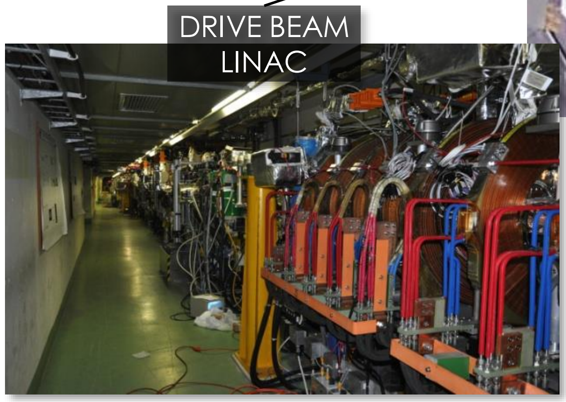
High-current drive beam, bunched at 12 GHz

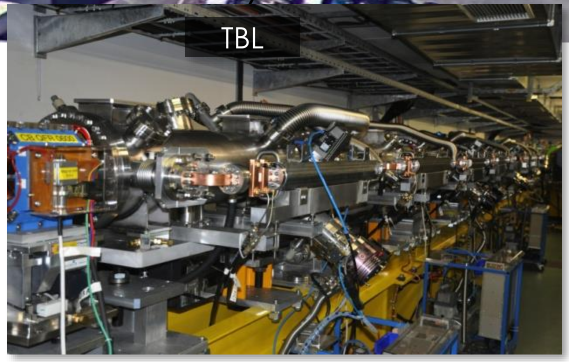
Power transfer & two-beam acceleration

100 MV/m accelerating gradient

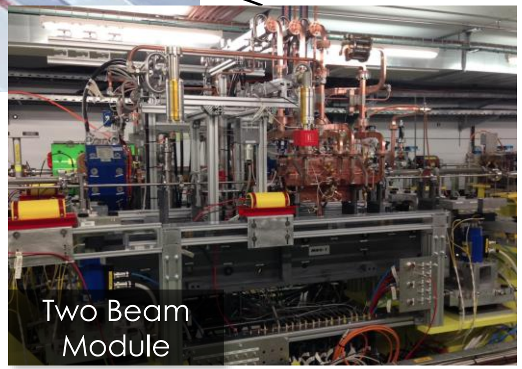
Low emittance generation, preservation, collision




CTF3/CLEX is now the 'CERN Linear Electron Accelerator for Research' facility, CLEAR



# CTF3 – Drive Beam Generation

R. Corsini

## Key challenges:

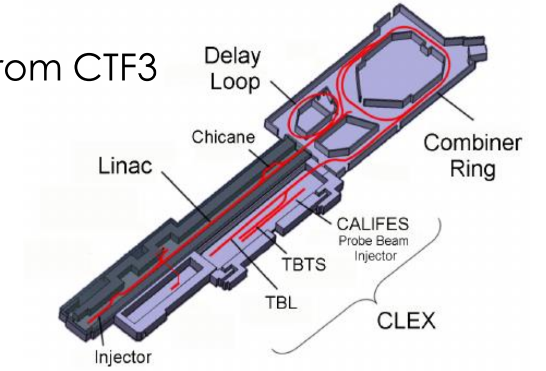
High-current drive beam, bunched at 12 GHz

Power transfer & two-beam acceleration

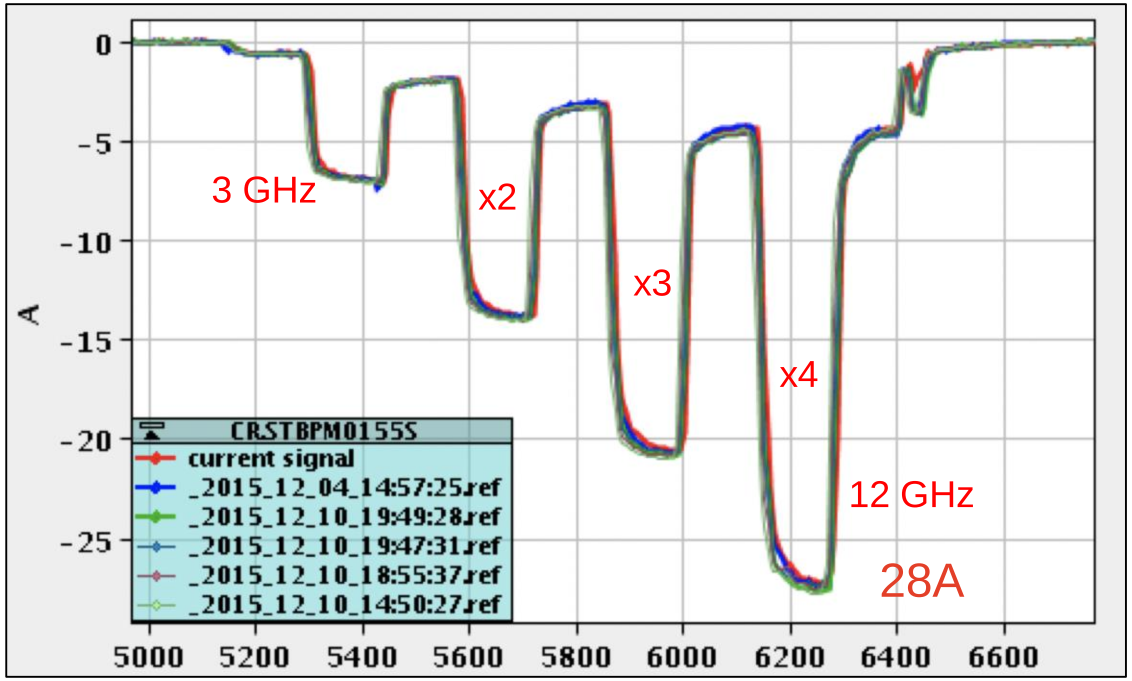
100 MV/m accelerating gradient

Low emittance generation, preservation, collision

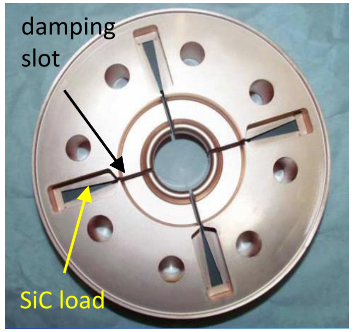
Examples of measurements from CTF3

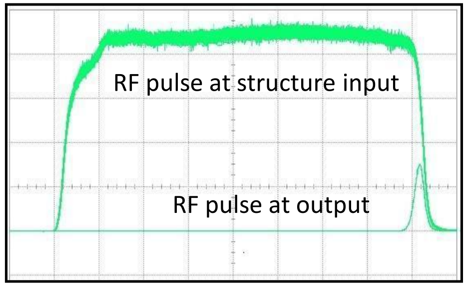



Combination of high-current drive beam, bunching at 12 GHz



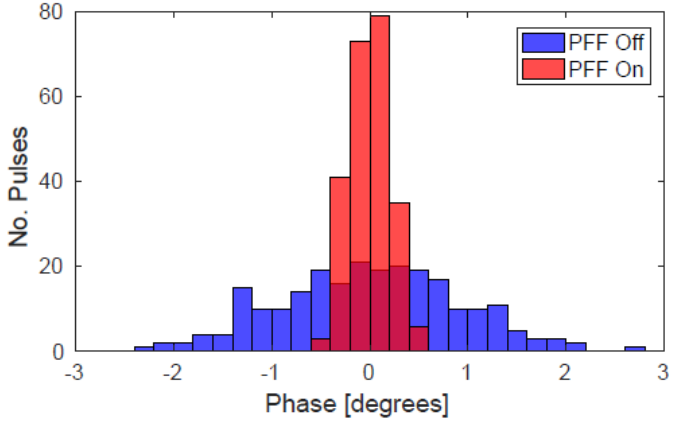

Current in combiner ring




High-current full beam loading acceleration

Drive beam arrival time stabilised to CLIC specification of 50 fs:



# CTF3 – Two-Beam Acceleration

R. Corsini

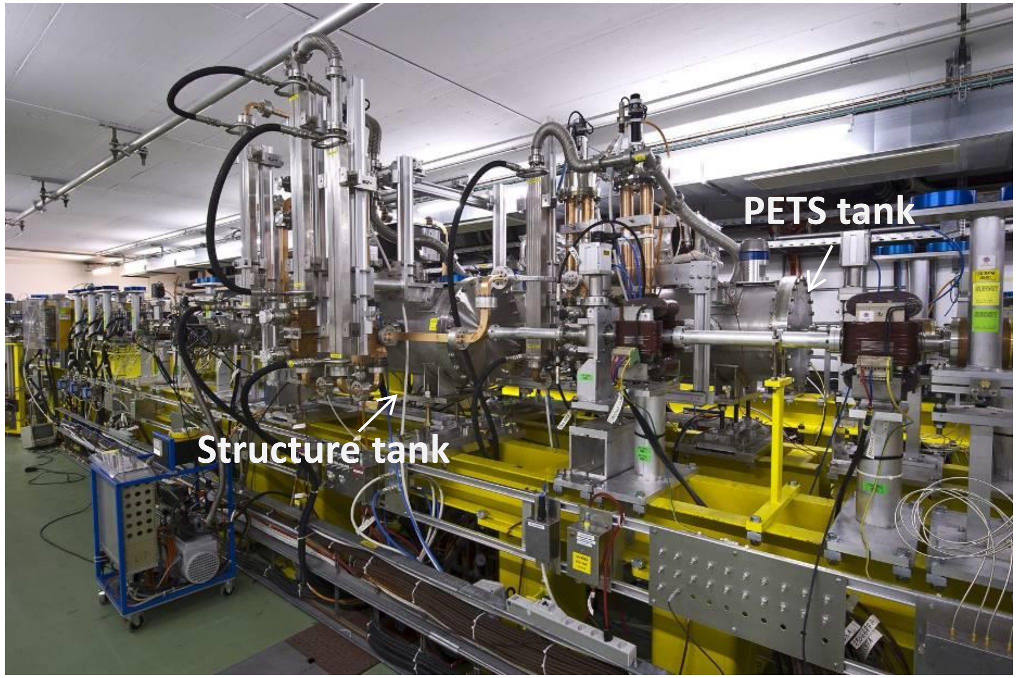
Key challenges:

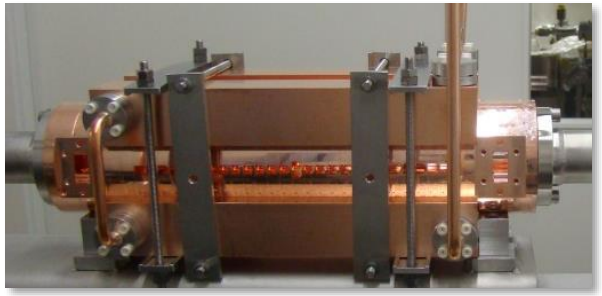
High-current drive beam, bunched at 12 GHz

Power transfer & two-beam acceleration

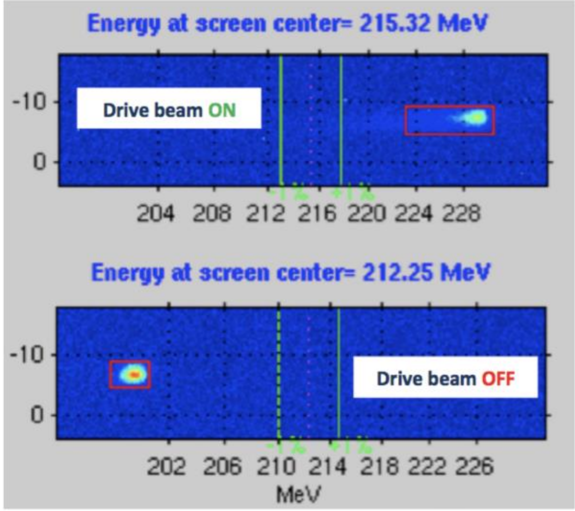
100 MV/m accelerating gradient

Low emittance generation, preservation, collision

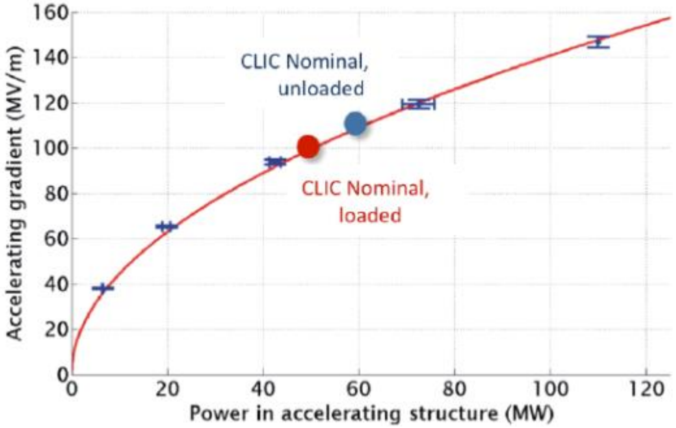


31MeV = 145MV/m




First demonstration of Two-beam acceleration (2011)



# CTF3 – Two-Beam Acceleration

R. Corsini

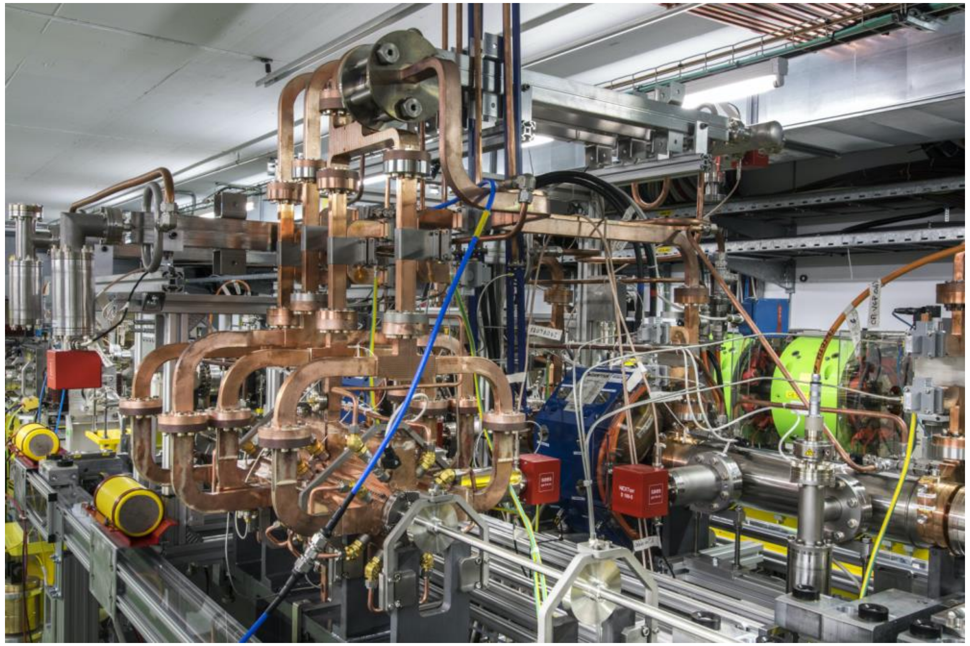
Key challenges:

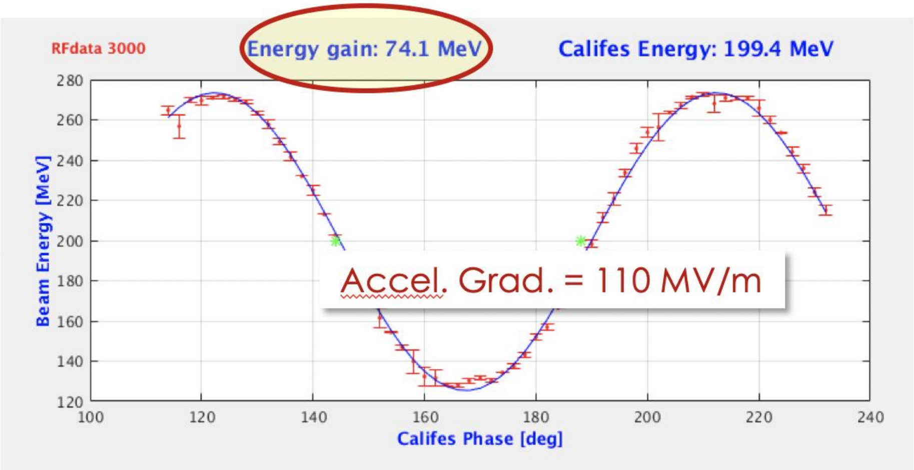
High-current drive beam, bunched at 12 GHz

Power transfer & two-beam acceleration

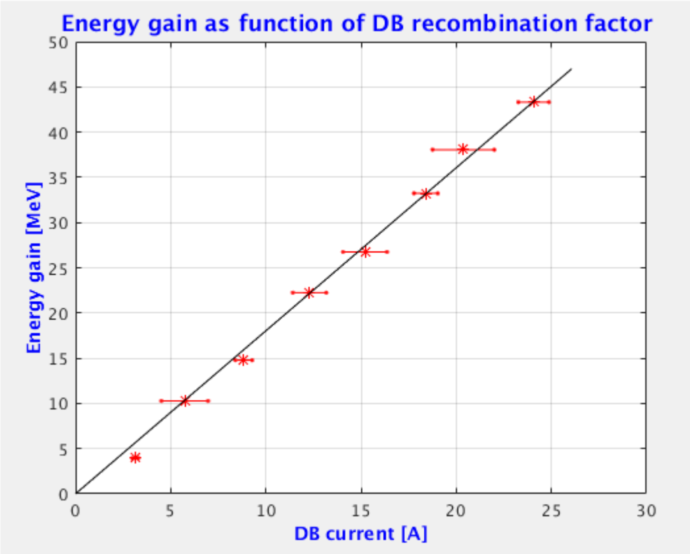
100 MV/m accelerating gradient

Low emittance generation, preservation, collision






Full Two-Beam module studies (2015-2016)



# High-Gradient X-band Technology

R. Corsini

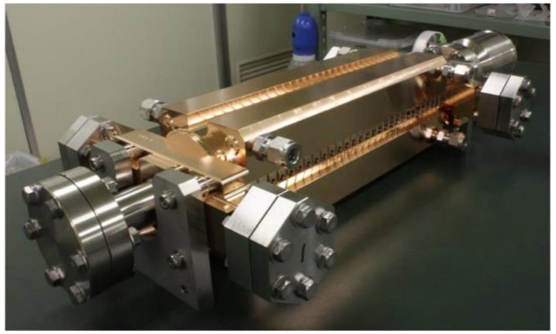
## Key challenges:

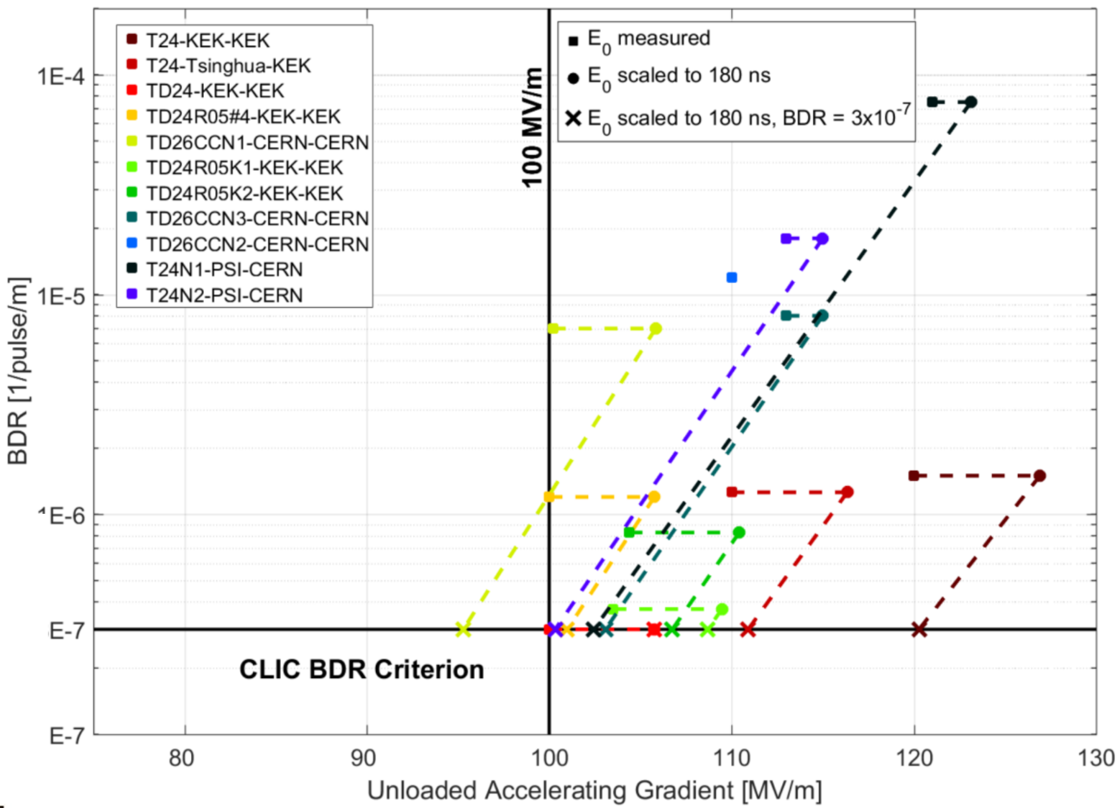
High-current drive beam, bunched at 12 GHz

Power transfer & two-beam acceleration

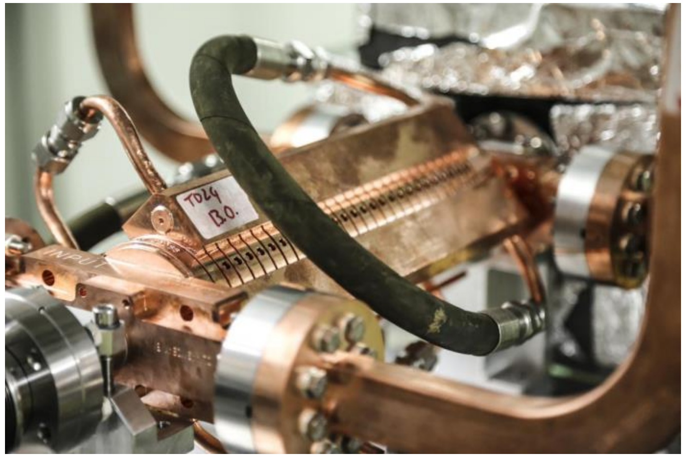
100 MV/m accelerating gradient

Low emittance generation, preservation, collision






X-band performance:
achieved 100MV/m gradient
with CLIC breakdown rate



# Generation of Extremely Low Emittance Beams

## Key challenges:

High-current drive beam, bunched at 12 GHz

Power transfer & two-beam acceleration

100 MV/m accelerating gradient

Low emittance generation, preservation, collision

CLIC damping ring layout

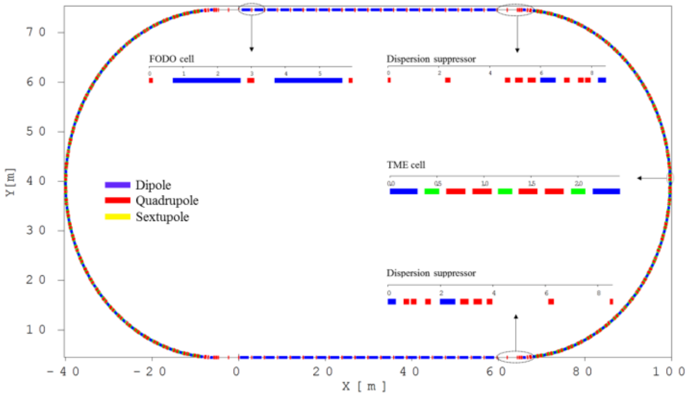
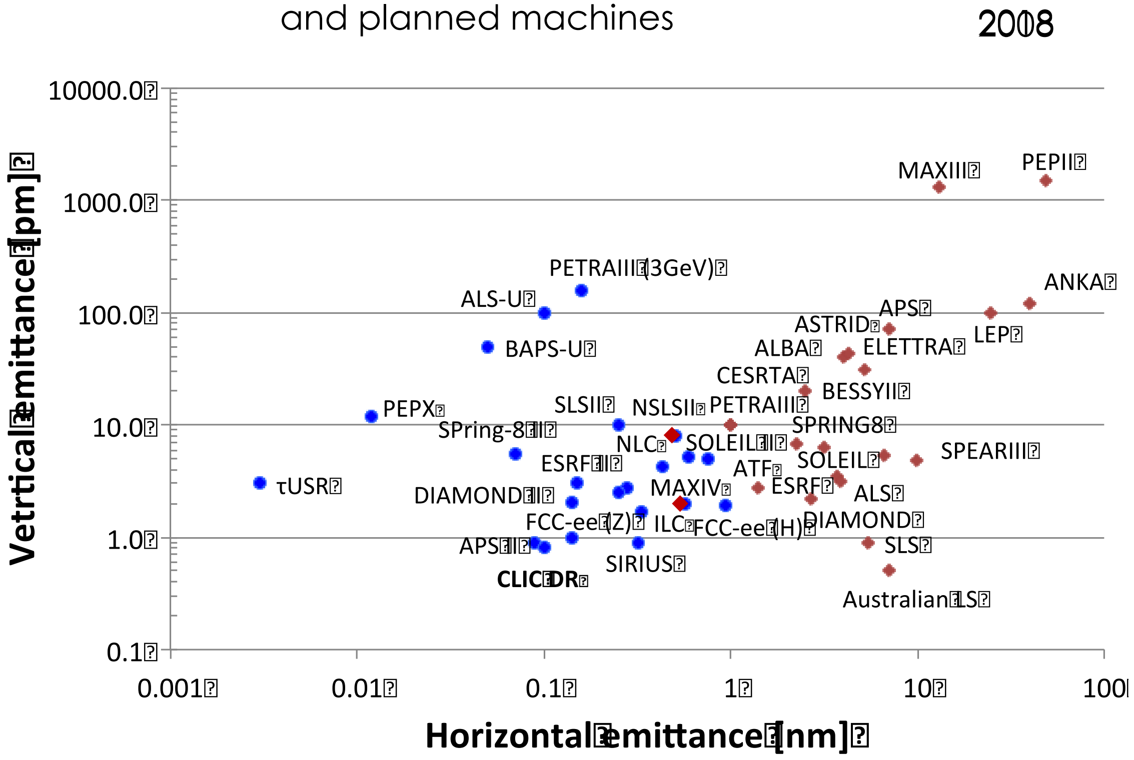



**Table 2.3:** Design parameters for the improved design of the CLIC DRs, for the case of $f_{RF} = 2$ GHz and $N_b = 5.7 \times 10^9$. The magnetic field is varying along the dipoles.

| Parameters, Symbol [Unit] | Variable dipole |
|---|---|
| Energy, $E$ [GeV] | 2.86 |
| Bunch population, $N_b$ [$10^9$] | 5.7 |
| Circumference, $C$ [m] | 359.4 |
| Number of arc cells/wigglers, $N_d/N_w$ | 90/40 |
| RF Voltage, $V_{RF}$ [MV] | 6.50 |
| RF Stationary phase [$^o$] | 63.0 |
| Harmonic number, $h$ | 2398 |
| Momentum compaction, $\alpha_c$ [$10^{-4}$] | 1.2 |
| Damping times, $(\tau_x, \tau_y, \tau_l)$ [ms] | (1.15, 1.18, 0.60) |
| Energy loss/turn, $U$ [MeV] | 5.8 |
| Horizontal and vertical tune, $(Q_x, Q_y)$ | (45.61, 13.55) |
| Horizontal and vertical chromaticity, $(\xi_x, \xi_y)$ | (-169, -51) |
| Wiggler peak field, $B_w$ [T] | 3.5 |
| Wiggler length, $L_w$ [m] | 2 |
| Wiggler period, $\lambda_w$ [cm] | 4.9 |
| Normalized horiz. emittance with IBS, $\gamma\epsilon_x$ [nm-rad] | 535.9 |
| Normalized horiz. emittance with IBS, $\gamma\epsilon_x$ [nm-rad] | 6.5 |
| Longitudinal emittance with IBS, $\epsilon_l$ [keVm] | 4.8 |
| IBS factors hor./ver./long. | 1.22/1.96/1.05 |

Target and achieved emittance in existing and planned machines



# Acceleration and emittance preservation

R. Corsini

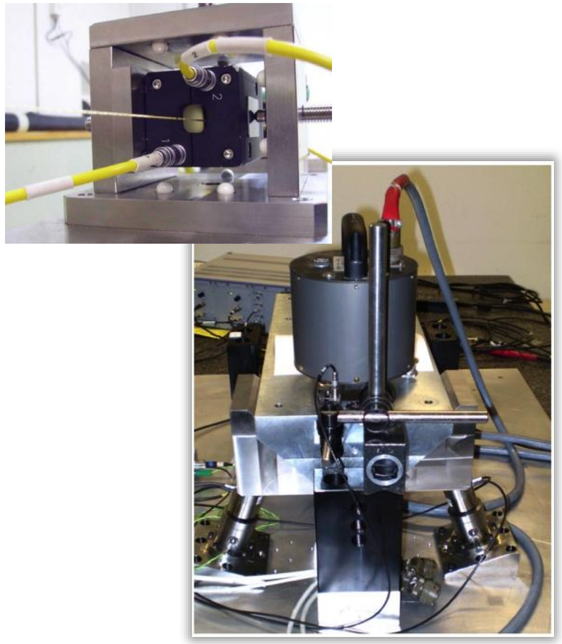
## Key challenges:

High-current drive beam, bunched at 12 GHz

Power transfer & two-beam acceleration

100 MV/m accelerating gradient

Low emittance generation, preservation, collision



## The CLIC strategy:

- Align components (10 µm over 200 m)
- Control/damp vibrations (from ground to accelerator)
- Beam based measurements
  – allow to steer beam and optimize positions
- Algorithms for measurements, beam and component optimization, feedbacks

- Experimental tests in existing accelerators of equipment and algorithms
  (FACET at Stanford,  ATF2 at KEK, CTF3, Light-sources)

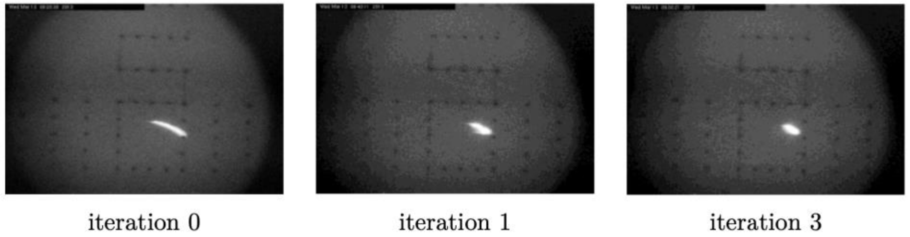
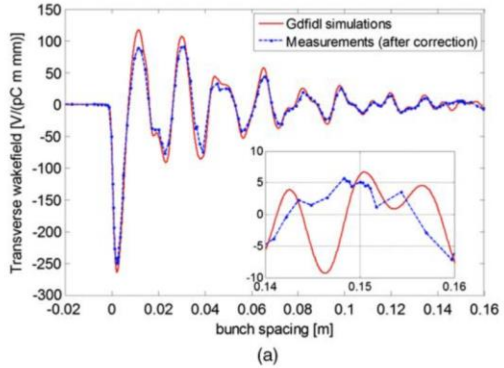
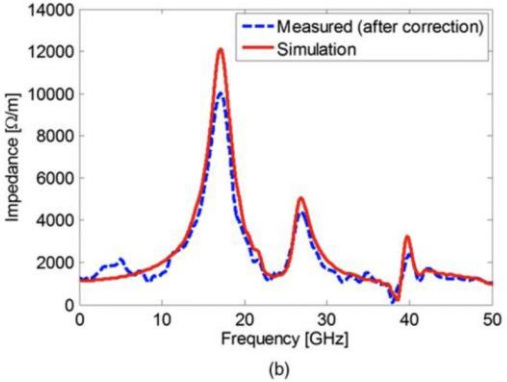



**Figure 8.10:** Phosphorous beam profile monitor measurements at the end of the FACET linac, before the dispersion correction, after one iteration step, and after three iteration steps. Iteration zero is before the correction.



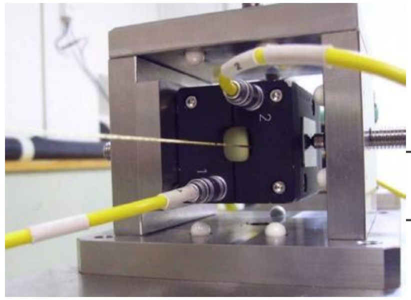



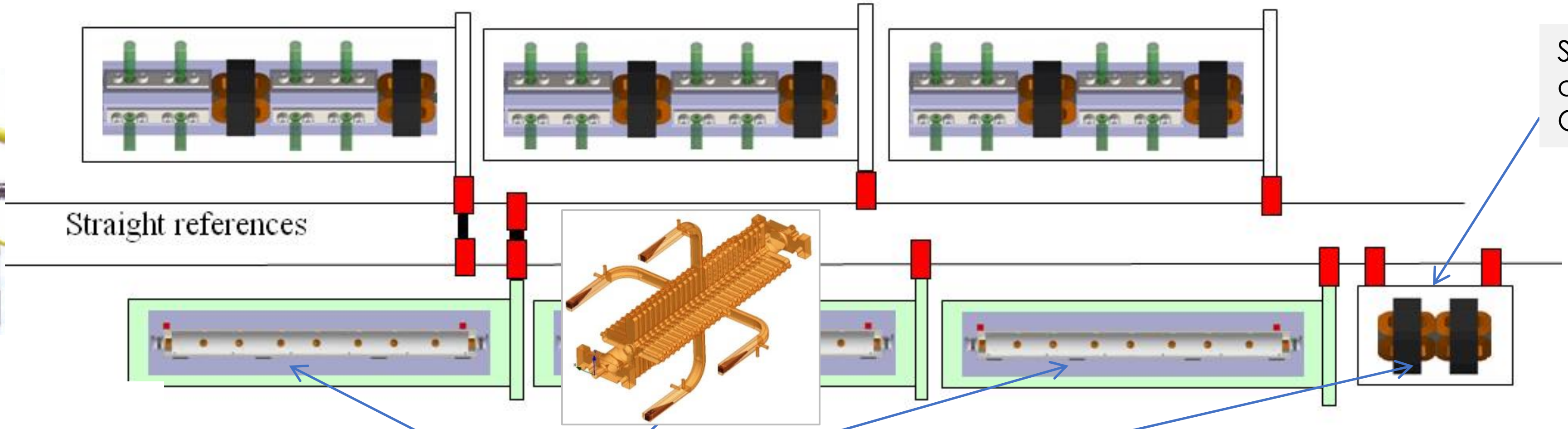

Wake-field measurements in FACET

(a) Wakefield plots compared with numerical simulations.
(b) Spectrum of measured data versus numerical simulation.

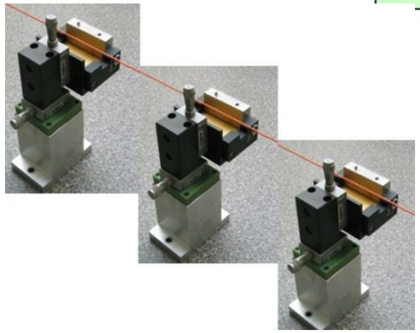
# Main Linac Alignment

R. Corsini





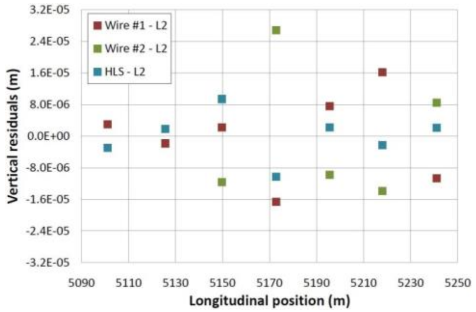

Stabilise quadrupole O(1nm) @ 1Hz



3) Use wake-field monitors accuracy O(3.5μm)

1) Pre-align BPMs+quads accuracy O(10μm) over about 200 m

2) Beam-based alignment

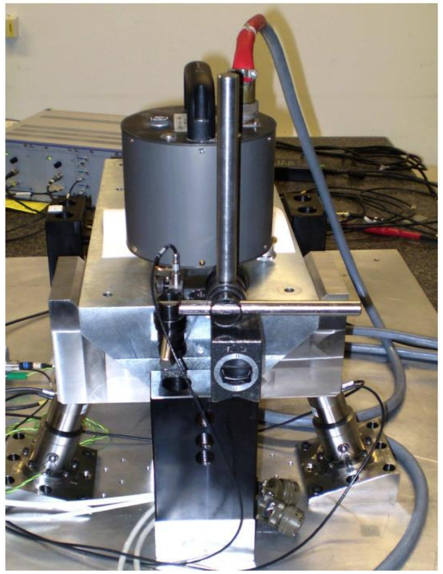


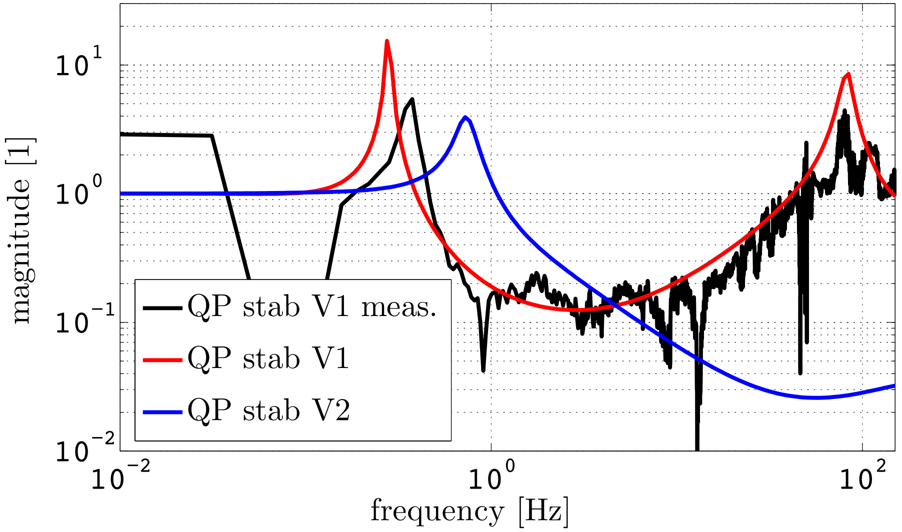

Test of prototype shows vertical RMS error of 11 μm

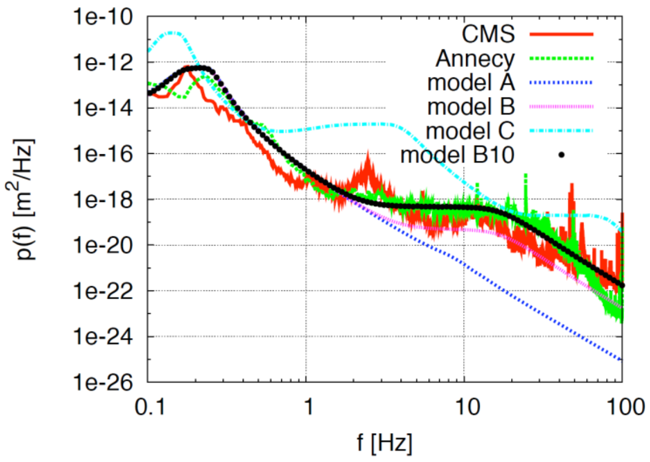
**Table 2.8:** Key alignment specifications for the ML components and the resulting emittance growth. The values after simple steering (1-2-1), Dispersion Free Steering (DFS) and realignment of the accelerating structures using the wakefield monitors (RF) are shown.

| Imperfection | With respect to | Value | $\Delta\epsilon_y$ [nm] 1-2-1 | DFS | RF |
|---|---|---|---|---|---|
| Girder end point | Wire reference | 12 $\mu m$ | 12.91 | 12.81 | 0.07 |
| Girder end point | Articulation point | 5 $\mu m$ | 1.31 | 1.30 | 0.02 |
| Quadrupole roll | Longitudinal axis | 100 $\mu rad$ | 0.05 | 0.05 | 0.05 |
| BPM offset | Wire reference | 14 $\mu m$ | 188.99 | 7.12 | 0.06 |
| Cavity offset | Girder axis | 14 $\mu m$ | 5.39 | 5.35 | 0.03 |
| Cavity tilt | Girder axis | 141 $\mu rad$ | 0.12 | 0.40 | 0.27 |
| BPM resolution | | 0.1 $\mu m$ | 0.01 | 0.76 | 0.03 |
| Wake monitor | Structure centre | 3.5 $\mu m$ | 0.01 | 0.01 | 0.35 |
| All | | | 204.53 | 25.88 | 0.83 |

# Active Stabilization Results






Code

Machine model
Beam-based feedback

| Luminosity achieved/lost | |
|---|---|
| No stab. | 53%/68% |
| Current stab. | 114%/7% |
| Improve stab. | 118%/3% |
| Close to/better than target | |

# Final Focusing – nano beams

R. Corsini

## Key challenges:

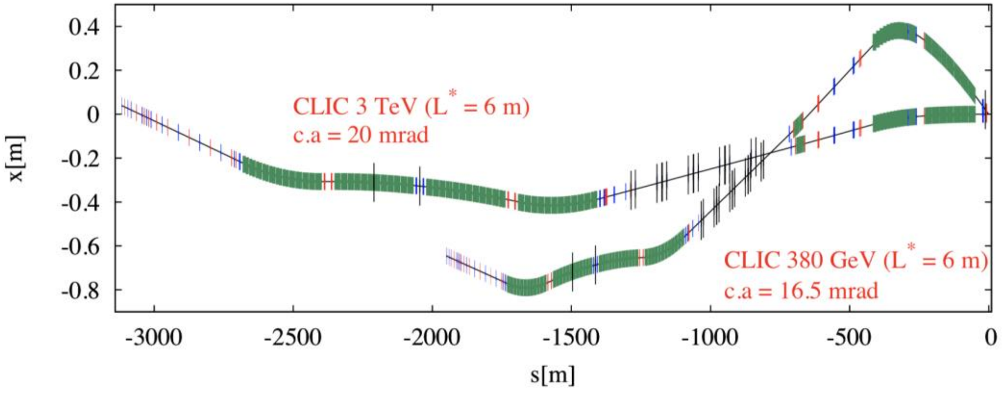
High-current drive beam, bunched at 12 GHz

Power transfer & two-beam acceleration

100 MV/m accelerating gradient

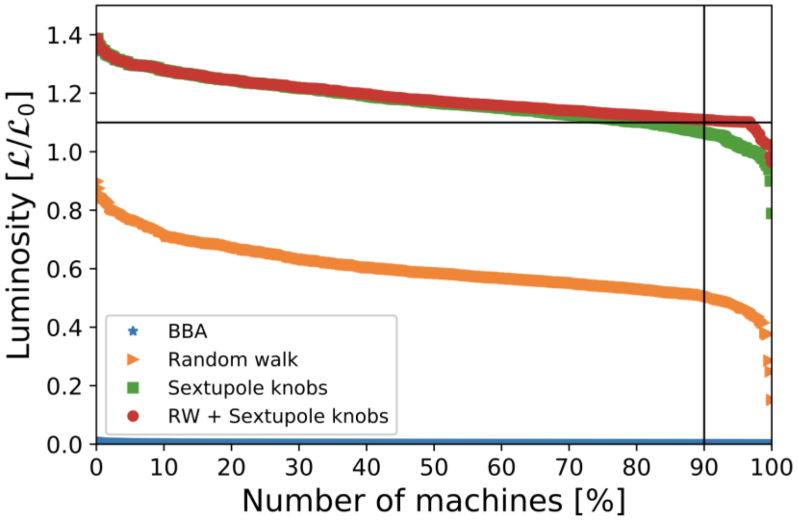
Low emittance generation, preservation, collision

## CLIC BDS Design



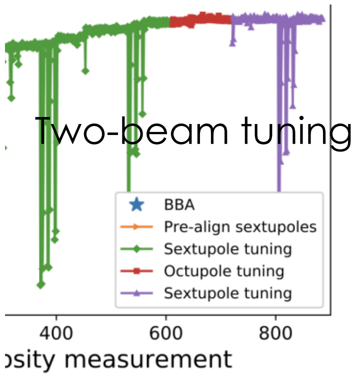


## CLIC BDS tuning



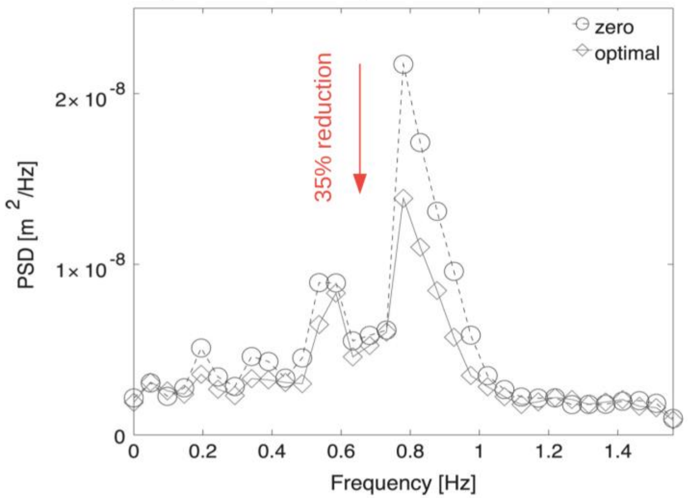

**Final results:** 484 machines successfully tuned

484/500 = **96.8% success rate**




*See J. Ogren presentation tomorrow*

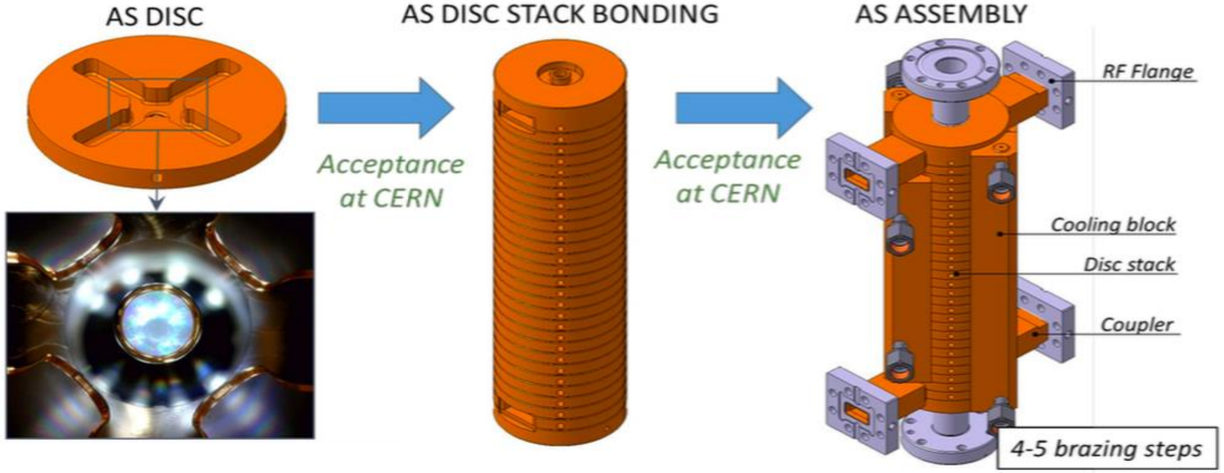
e.g., Vibration/jitter control in ATF2




*See D. Arominski, S. Pastushenko, P. Korysko tomorrow*

# Industrialization

R. Corsini



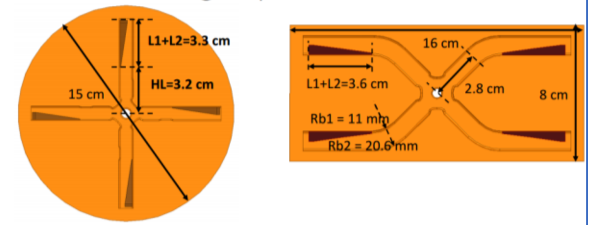

Investigating paths to industrialization:

Suppliers qualification, processes

Baseline manufacturing technique:
bonding and brazing

Alternatives:

- brazing as for SwissFEL
- machining halves

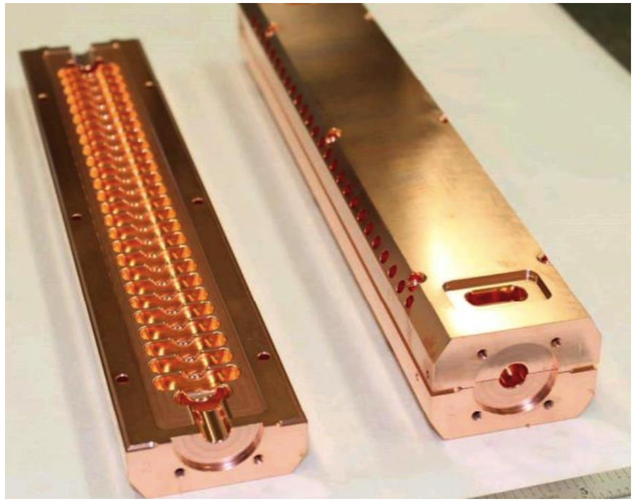



| | | | |
|---|---|---|---|
| HL | 32 mm | D2 | 5 mm |
| L1 | 31 mm | T2 | 5 mm |
| L2 | 2 mm | Mx | 0.75 mm |
| D1 | 0.8 mm | Mz | 1 mm |
| T1 | 0.6 mm | Tx | 0 mm |
| | | Tz | 0.7 mm |

| | | | |
|---|---|---|---|
| | | D2 | 5.2 mm |
| L1 | 34 mm | T2 | 4.8 mm |
| L2 | 2 mm | Mx | 0.2 mm |
| D1 | 1 mm | Mz | 1 mm |
| T1 | 1 mm | Tx | 0 mm |
| | | Tz | 0 mm |

Target:

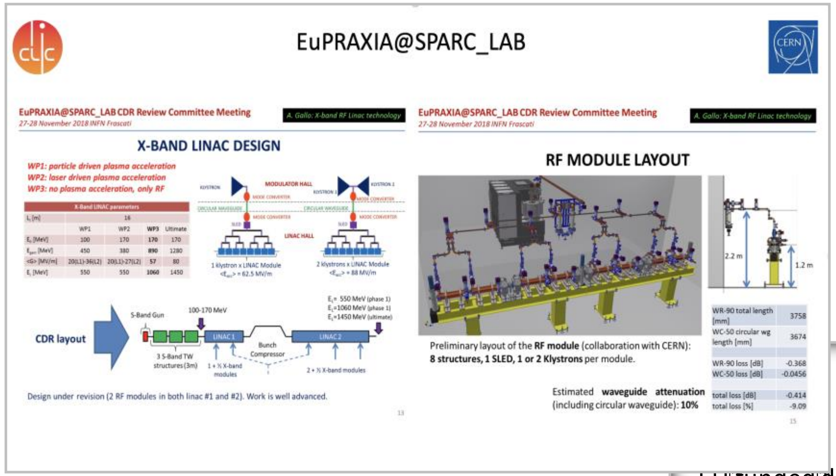
improved structures that are both
low-cost & easy-to-manufacture



*See W. Wuensch presentation tomorrow*

# X-Band High-Gradient Technology

R. Corsini




*See W. Wuensch presentation tomorrow*

## 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.

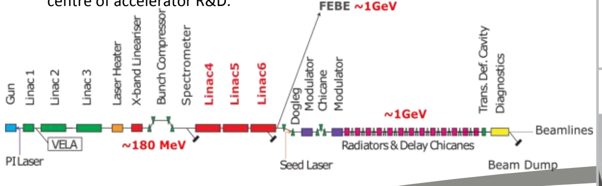
Based on advances in:

- Injectors
- X-band linac technology
- Undulators


W. Wuensch, CERN

## Upgrade proposal: XARA

- X-band Accelerator for Research and Applications
- The 4th CLARA linac is replaced by an X-band accelerating section to reach 1 GeV
- Novel FEL technology
- An EUV/soft x-ray FEL facility for ultra fast chemistry and biology, and a centre of accelerator R&D.




Science & Technology Facilities Council | UK Research and Innovation

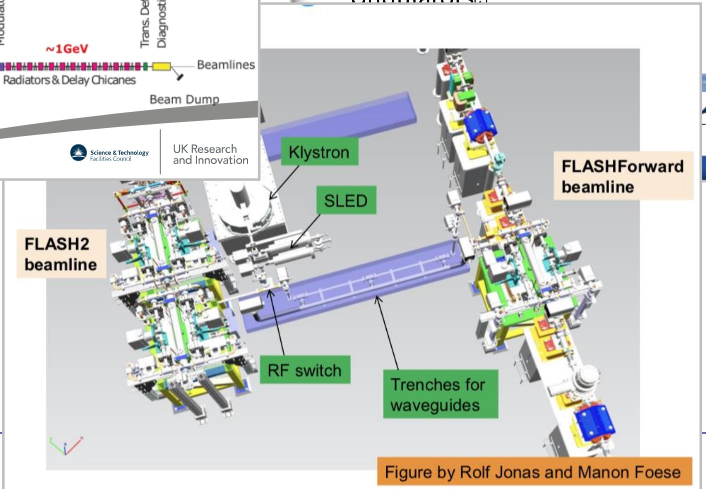
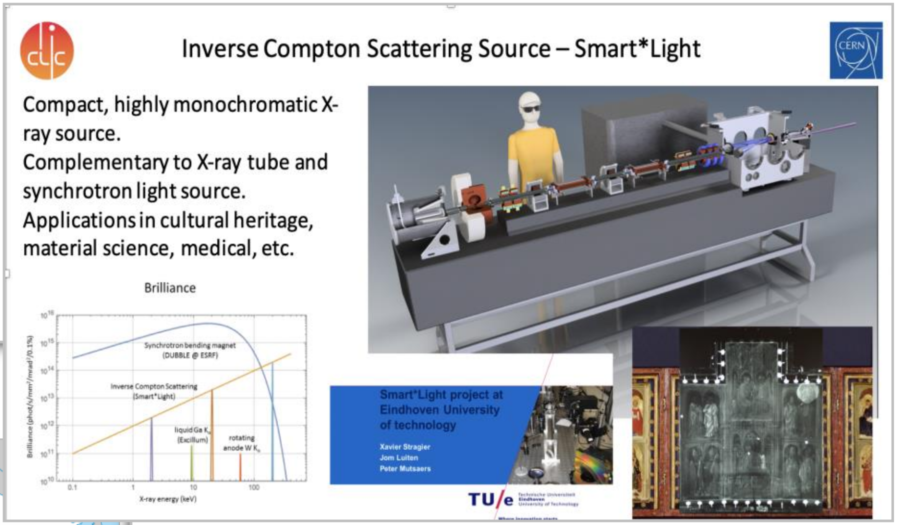



Figure by Rolf Jonas and Manon Foese



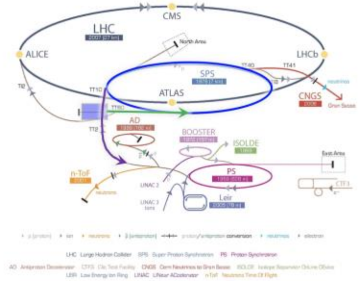

Compact, highly monochromatic X-ray source.
Complementary to X-ray tube and synchrotron light source.
Applications in cultural heritage, material science, medical, etc.

Elements in existing linacs (DESY, PSI)

## 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



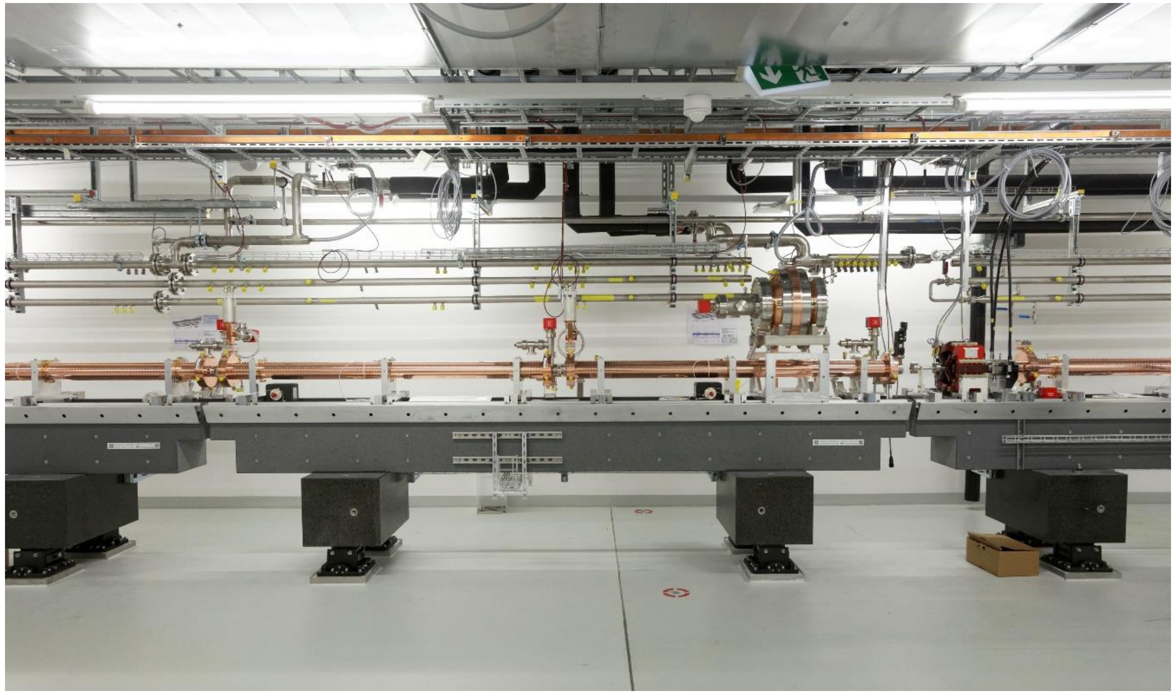

Beyond LDMX type of beam, other physics experiments considered (for example heavy photon searches)

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

# SwissFEL – C-band linac

R. Corsini

- 104 x 2m-long C-band structures
  (beam → 6 GeV @ 100 Hz)
- Similar μm-level tolerances
- Length ~ 800 CLIC structures
- Being commissioned



# Higher Luminosities

R. Corsini

$$\mathcal{L} \propto H_D \frac{N}{\sigma_x} \frac{1}{\sqrt{\beta_y \epsilon_y}} N n_b f_r$$

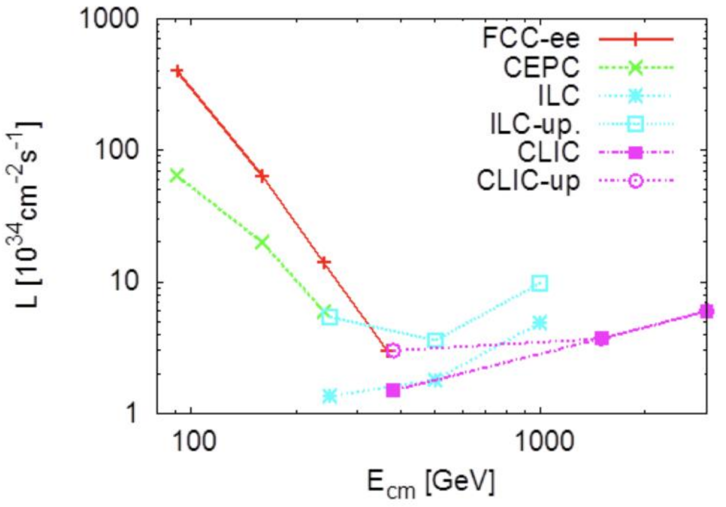



Fig. 10.2: Luminosity versus c.m. energy for $e^+e^-$ Higgs Factories. Two IPs are assumed for the circular colliders FCC-ee and CEPC.

European Strategy Update

- The CLIC design has a large margin for luminosity
  (e.g., normalized vertical emittance used for lumi evaluation is 30 nm, while 5 nm are expected from the damping ring – see also previously discussed margin for BDS tuning and vibration control)

  N.B.: → a "perfect" machine will give : 4.3 x $10^{34}$ $cm^{-2}$ $s^{-1}$

- A (further) potential luminosity upgrade based on doubling the repetition rate (50 Hz → 100 Hz) was recently studied
  - The luminosity increases by a factor 2
  - The power required by the RF systems increases also by a factor 2, however the total power consumption only increases from 170 MW to 220 MW, i.e. less than 30%
  - The corresponding capital cost increase is expected to be in the 5% range

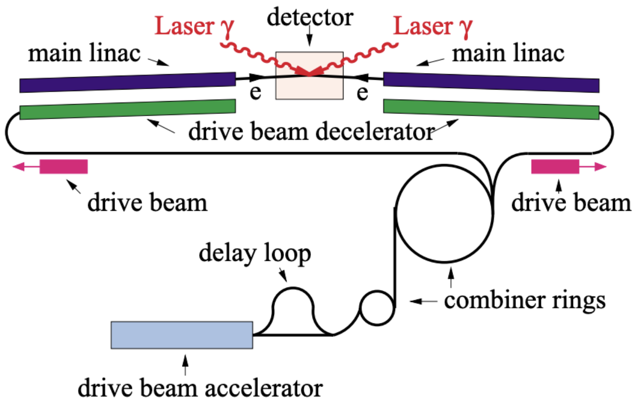
- Open up the opportunity to have two detectors (push-pull, or double BDS - the latter will have an increased cost ~15% and is feasible for 380 GeV

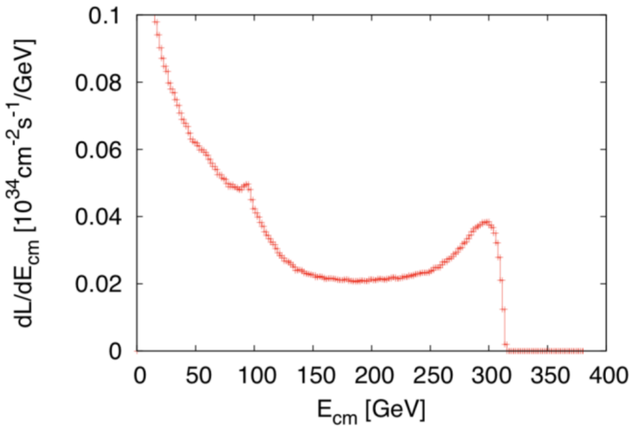
CERN-ACC-2019-0051 ; CLIC-Note-1143
http://cds.cern.ch/record/2687090
*See A. Latina presentation tomorrow*

# Z-pole and Gamma-Gamma options

R. Corsini

- Operating the fully installed 380 GeV CLIC accelerator complex but at the Z-pole results in a luminosity of about $L = 2.3 \times 10^{32}\ cm^{-2}s^{-1}$
- On the other hand, an initial installation of just the linac needed for Z-pole energy factory, and an appropriately adapted beam delivery system, would result in a luminosity of L = 0.36 × 1034 cm−2s−1 for 50 Hz operation.
- In gamma-gamma mode, the electrons in both beams are focused at the IP and an intense laser pulse can be used to back-scatter photons from each beam and make them interact. The electron polarisation is important for this process and 80% can be expected. Although detailed studies of the interaction region configuration have not yet been performed, a first order an idea the performance can be obtained, including the luminosity spectrum.




CERN-ACC-2019-0051 ; CLIC-Note-1143
http://cds.cern.ch/record/2687090
*See A. Latina presentation tomorrow*

# Conclusions



- CLIC is now a mature project, ready to move towards the next phase
- There is an  consistent way forward with an initial stage at 380 GeV, keeping the options open for future upgrades and/or other options
- The cost and implementation time for CLIC 380 are similar to LHC
- Key technical challenges have been solved, now further optimizing cost, power and performance

# Outlook



**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**

# THANKS FOR YOUR ATTENTION