Status of CLIC and ILC

LHCP Bologna

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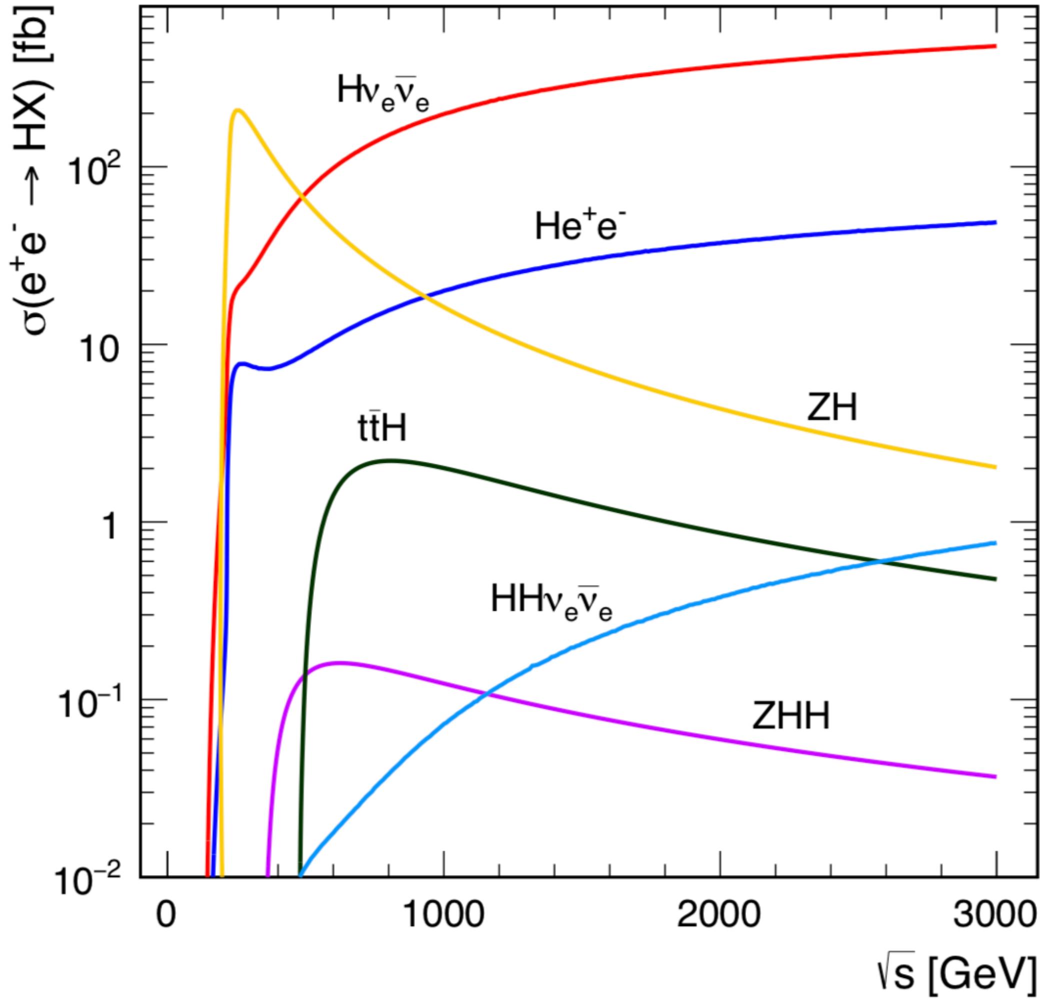
on behalf of the CLIC and ILC accelerator communities

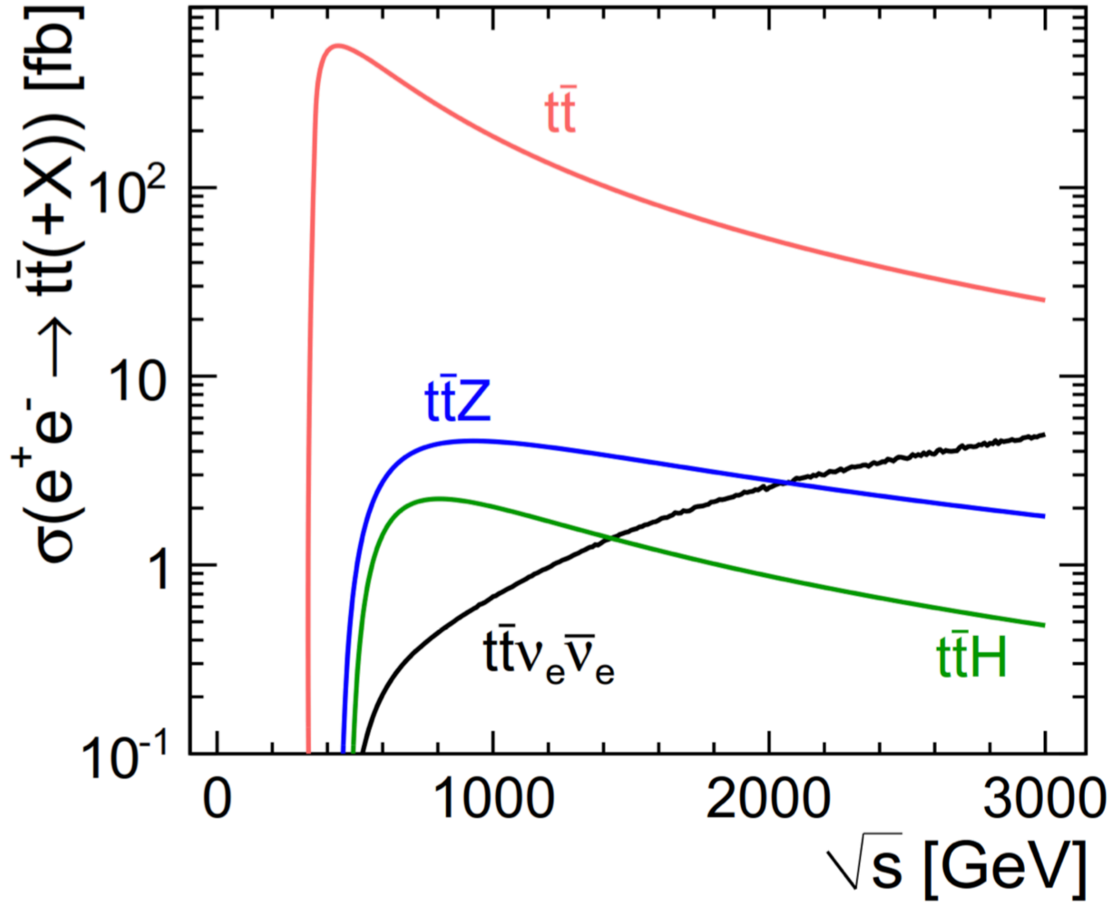
Key parameters ILC and CLIC

Parameter	Symbol [unit]	ILC	ILC	CLIC	CLIC
CMS energy	E_{cm} [GeV]	250	500	380	3000
Luminosity	L [10^{34} $cm^{-2}s^{-1}$]	1.35	1.8	1.5	6
Gradient	G [MV/m]	31.5	31.5	72	100
Repetition rate	f_r [Hz]	5	5	50	50
Bunches per train	n	1312	1312	352	312
Particles/bunch	N [10^9]	20	20	5.2	3.72
Bunch length	σ_z [μm]	300	300	70	44
Energy spread	[%]	0.1-0.2	0.1-0.2	0.35	0.35
Emittances	$\varepsilon_{x,y}$ [nm]	$5x10^3/35$	$5x10^3/35$	950/30	660/20
IP beam size	$\sigma_{x,y}$ [nm/nm]	520/8	474/6	149/3	40/1
Beta-functions	$b_{x,y}$[mm]	13/0.41	22/0.48	8/0.1	6/0.07

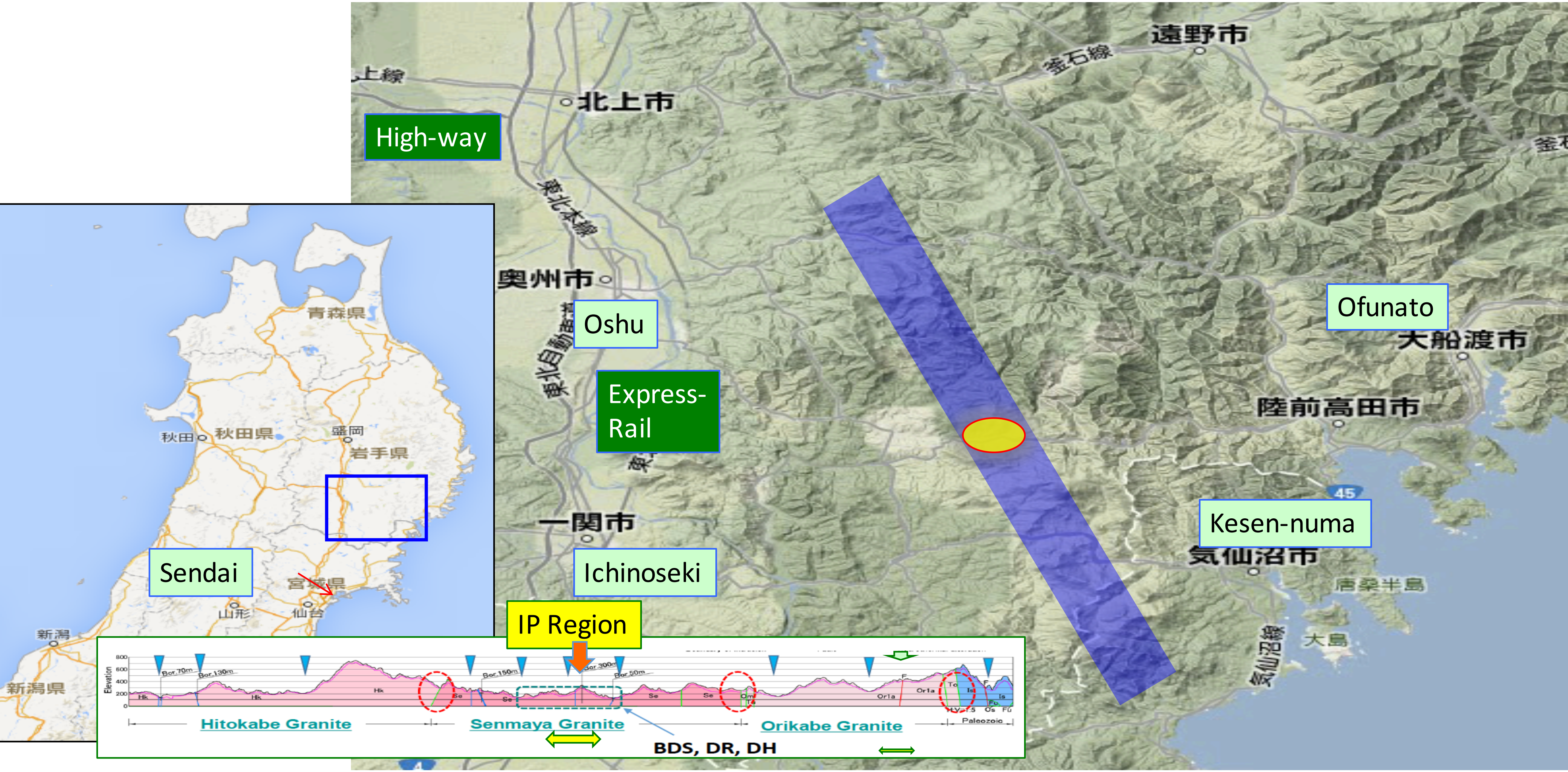
Compiled by Daniel Schulte

Energy scales

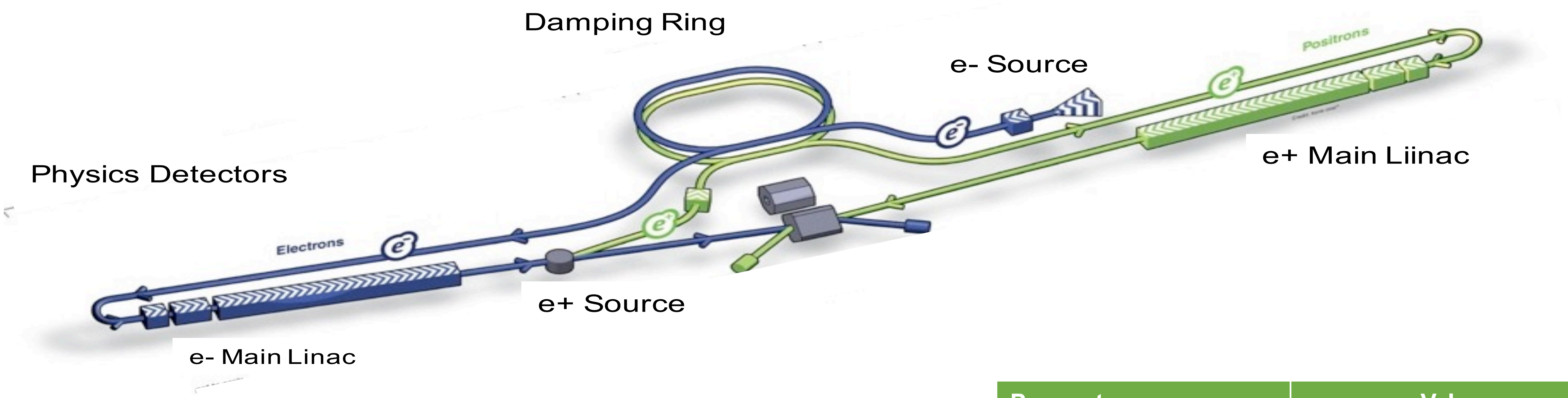


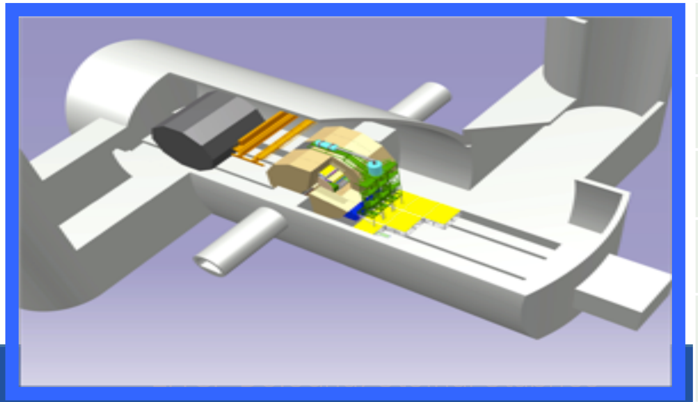


ILC Candidate Location: Kitakami, Tohoku



ILC Layout





Parameters	Value
C.M. Energy	500 GeV
Peak luminosity	1.8 x10^{34} $cm^{-2}s^{-1}$
Beam Rep. rate	5 Hz
Pulse duration	0.73 ms
Average current	5.8 mA (in pulse)
E gradient in SCRF acc. cavity	31.5 MV/m +/-20% Q_0 = 1E10

ILC: SCRF

Ultra-high Q_0 (10^{10})

Almost zero power (heat) in cavity walls (in SC RF the main efficiency issues related to fill factors and cryogenics)

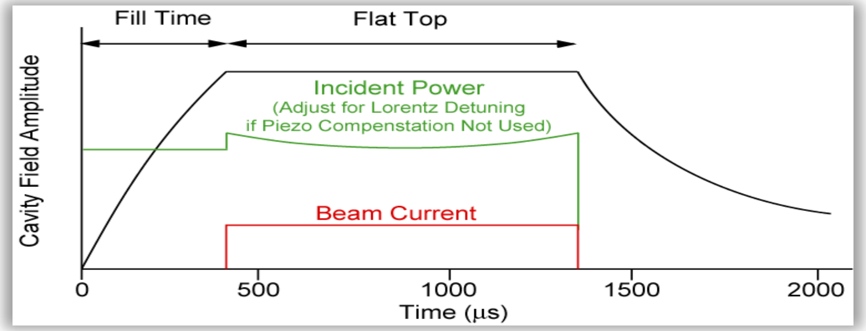
Standing wave cavities with low peak power requirements

Long beam pulse (~1 ms) - favorable for feed-backs within the pulse train

Low impedance

Beam generates low "wakefields"

Relatively large structures (1.3 GHz)



Worldwide SRF Collaboration

CERN, DESY

CEA, CNS-LAL
INFN

IHEP, PKU

KEK

IUAC, RRCAT

TRIUMF

FNAL/ANL

MSU

Cornell

JLAB

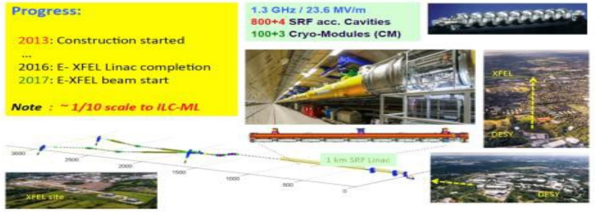
SLAC, LCLS-II

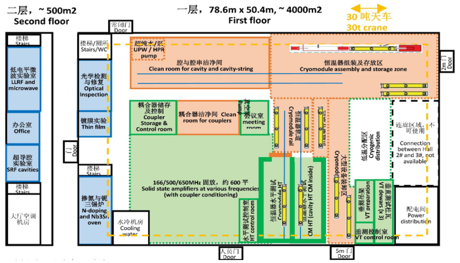
European XFEL

ILC-SRF technology

Americas, LCLS-II

Asia,
PAPS@IHEP CFF/STF@KEK





Proto-type Cryomodule (JLAB)

The European X-FEL

Progress:

2013: Construction started

...

2016: E- XFEL Linac completion

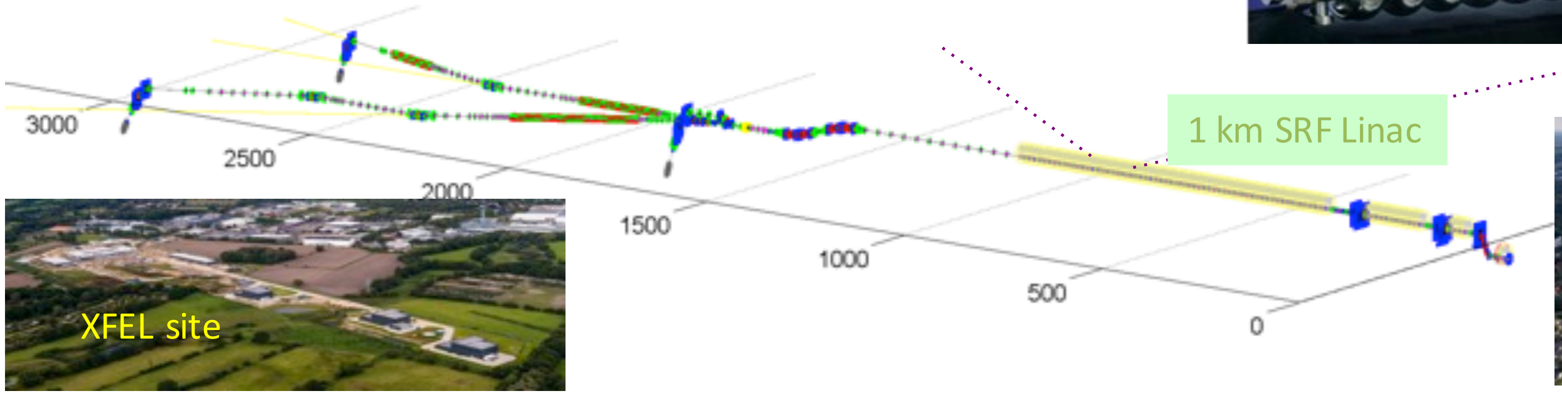
2017: E-XFEL beam start

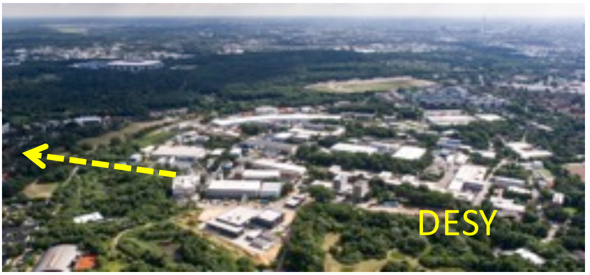
1.3 GHz / 23.6 MV/m

800+4 SRF acc. Cavities

100+3 Cryo-Modules (CM)

: ~1/10 scale to ILC-ML





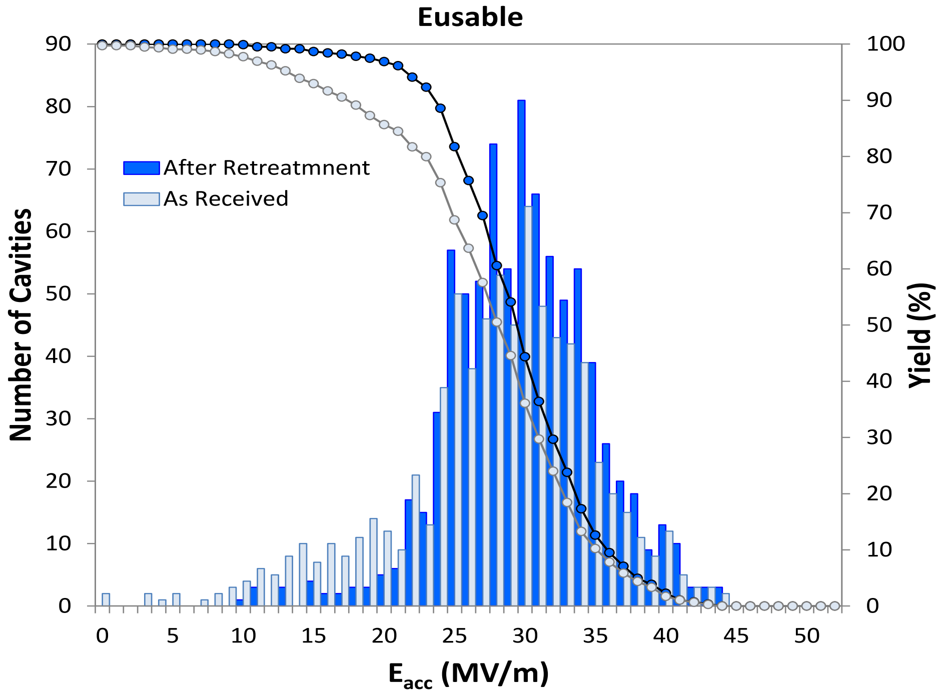
H. Weise

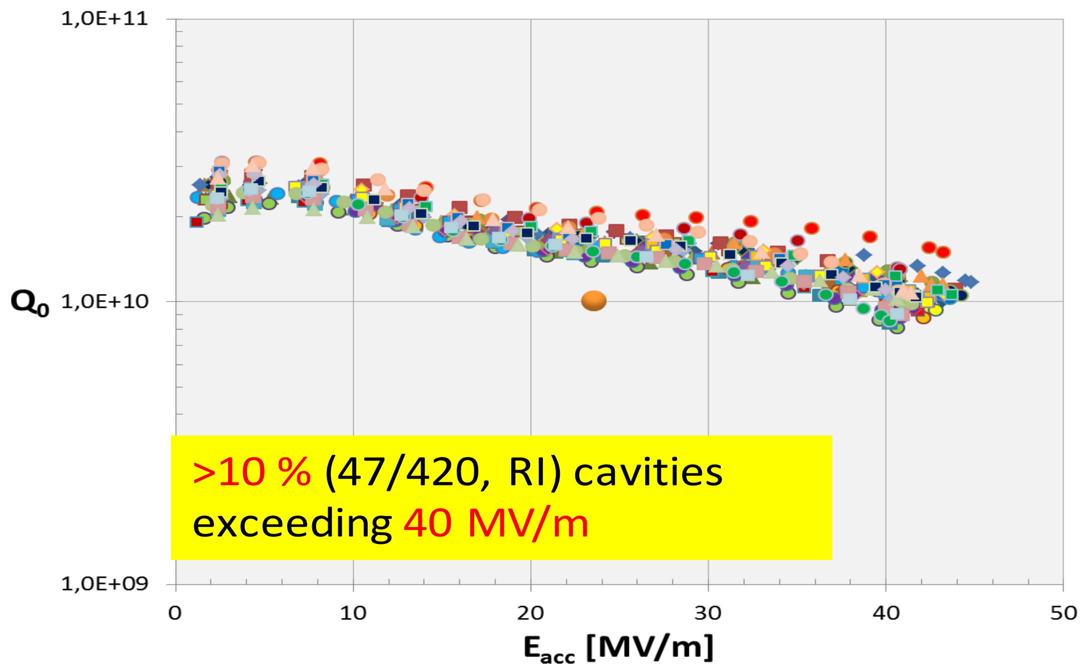
SRF Cavity Performance

ILC goal:
31.5 MV/m

FEL goal:
24 MV/m

Achieved:
29.8 MV/m



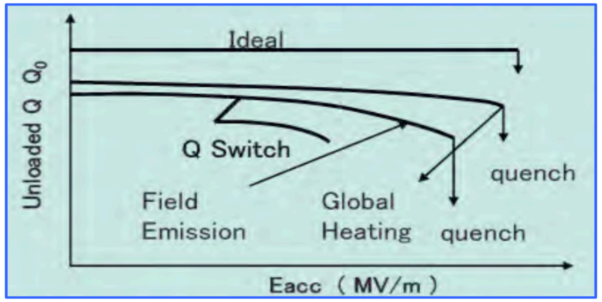


After Retreatment:

E-usable: 29.8 ± 5.1 [MV/m]

(RI): E usable 31.2 ± 5.2 [MV/m]), w/ 2nd EP

(EZ): E usable 28.6 ± 4.8 [MV/m]) , w/ BCP (instead of 2nd EP)



A. Yamamoto, 171106

14

N. Walker, D. Reschke, C. Pagani

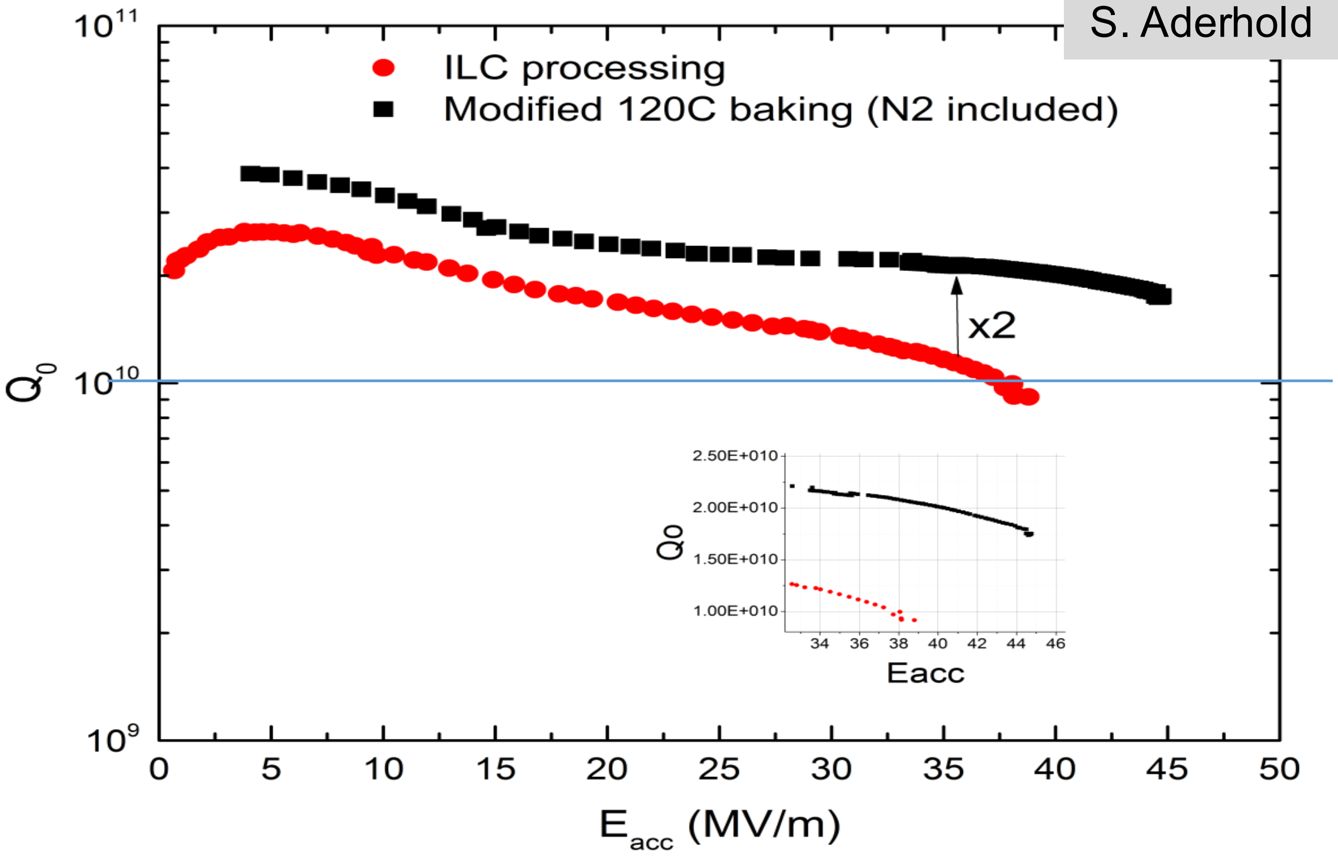
Recent ILC Development

Cost saving studies, e.g.
- Coupler design 1-2%
- Cavity material 2-3%
- No more hydrofluoric acid for chemical treatment 1-2%
- Higher gradient and more efficient cavities 4-5%
- …

L. Evans
A. Yamamoto

Nitrogen infusion appears very promising
- Increase in gradient
- Increase in Q_0

A. Grassellino,
S. Aderhold



Modified exposure to nitrogen (from FNAL)
Before: doping with few minutes at 800 °C
Now: a day or so at 120 °C

ILC since the TDR in 2012-13: Technical focus and changes

Site specific studies

Technical developments for most accelerator systems - high Q improvements for example

E-XFEL at DESY successfully constructed and put into operation – a key technology demonstration

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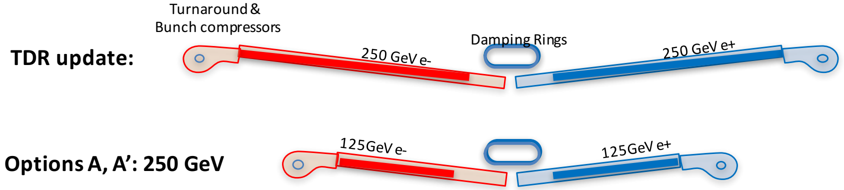
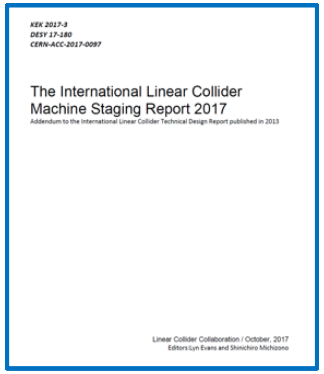


	Collision E. [GeV]	Tunnel Space [GeV]	Value Total (MILCU in 2012)	Reduction [%]
TDR	250/250	500	7,980	0
TDR update	250/250	500	7,950	-0.4
Option A	125/125	250	5,260	-34
Option A' (w/ R&D)	125/125	250	4,780 w/ R&D success	-40


KEK 2017-3
DESY 17-180
CERN-ACC-2017-0097

The International Linear Collider Machine Staging Report 2017

Addendum to the International Linear Collider Technical Design Report published in 2013

Linear Collider Collaboration / October, 2017
Editors: Lyn Evans and Shinichiro Michizono

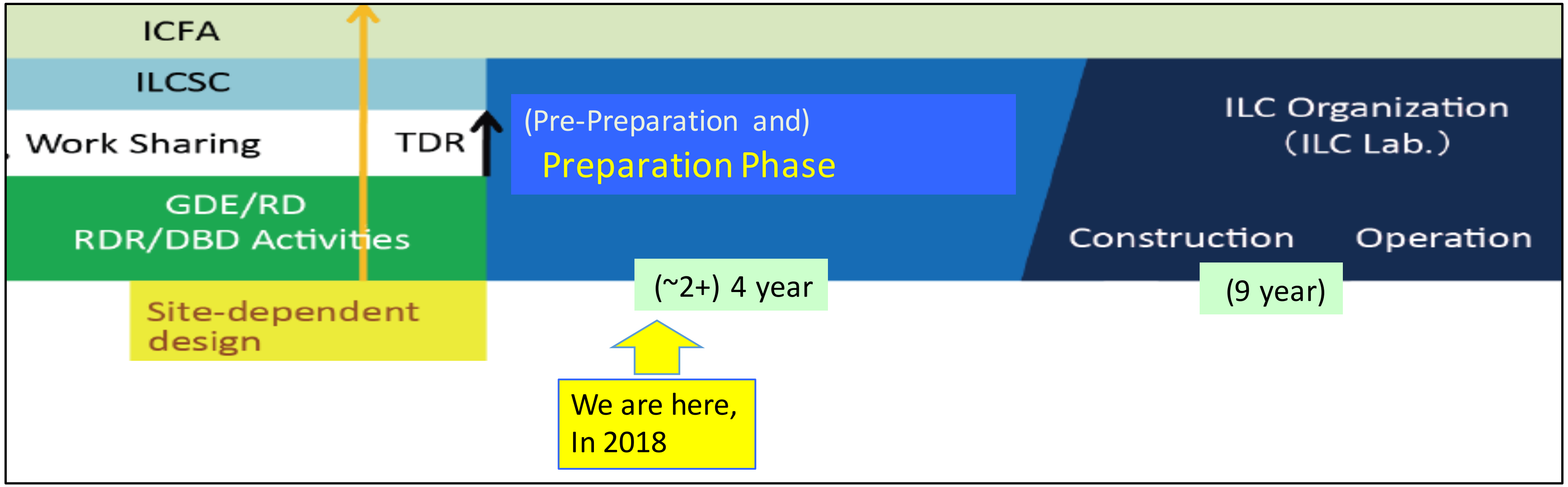
Recent proposal to start with an initial energy of 250 GeV (physics impact report) – key issues:

- Higgs precision depends significantly on HiLumi performance and theory assumptions (link)
- Below ttbar threshold
- Reduced search capabilities

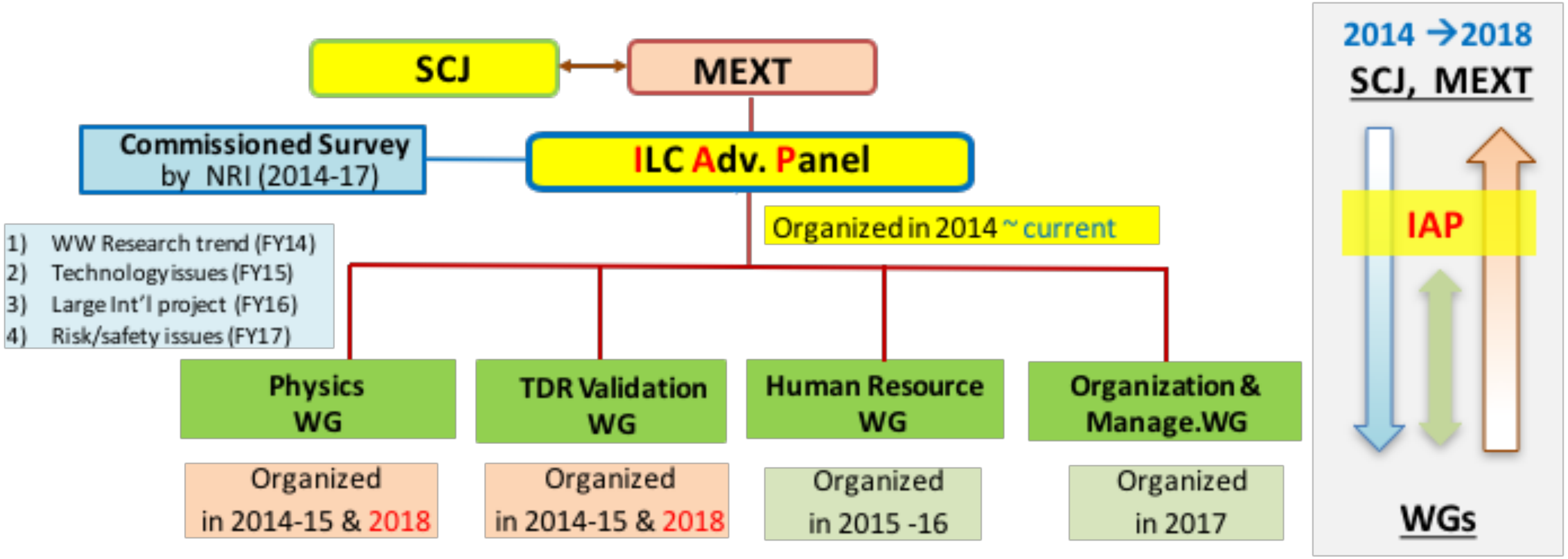
Nevertheless, provides impressive precision, and remains upgradable.

TDR costs of ~8 BILCU for 500 GeV (ILCU = 2012 US$ estimate used in the TDR) can be reduced by up to ~40%

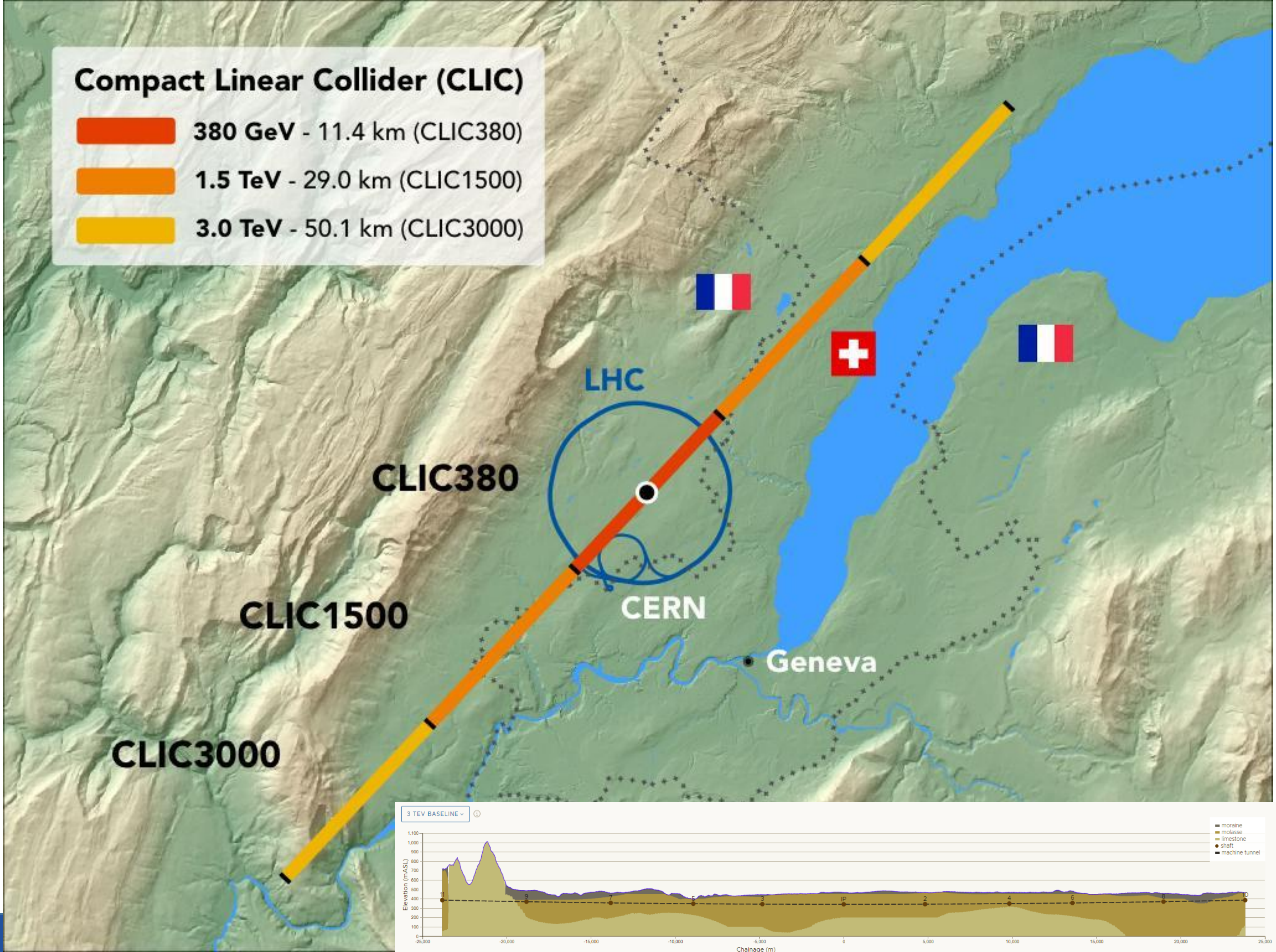
Status and Prospect for ILC



Status and Prospect for ILC



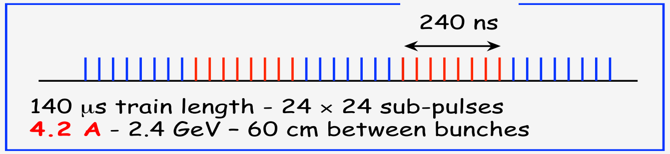
- Physics WG, and TDR Validation WG re-organized to evaluate ILC-250GeV.



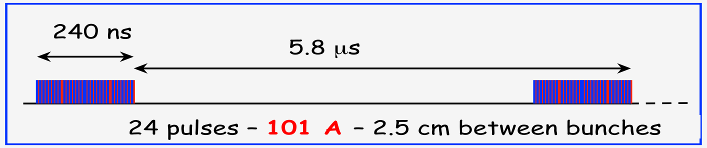
Compact Linear Collider (CLIC)
380 GeV - 11.4 km (CLIC380)
1.5 TeV - 29.0 km (CLIC1500)
3.0 TeV - 50.1 km (CLIC3000)
LHC
CLIC380
CLIC1500
CLIC3000
CERN
Geneva
3 TEV BASELINE
moraine
molasse
limestone
shaft
machine tunnel
Elevation (mASL)
Chainage (m)

CLIC layout, power generation

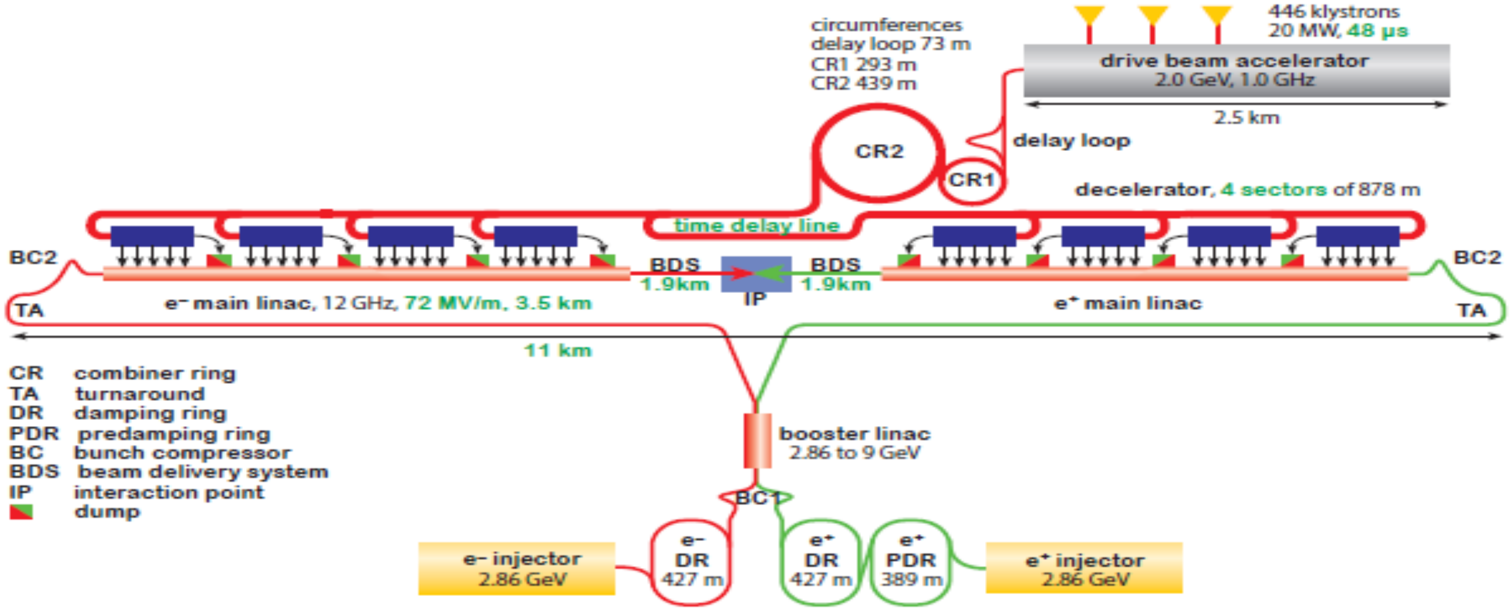
Drive beam time structure - initial

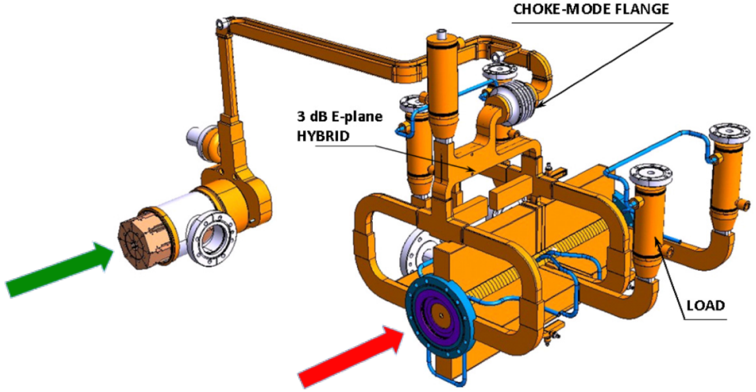


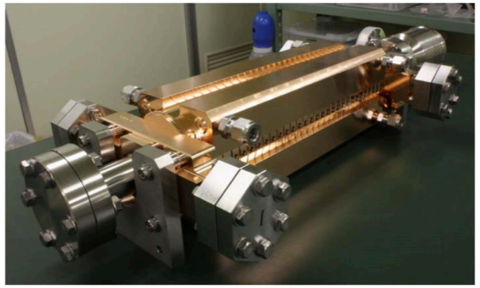
Drive beam time structure - final



Drive-beam (low energy, high intensity, long pulses) created by klystrons





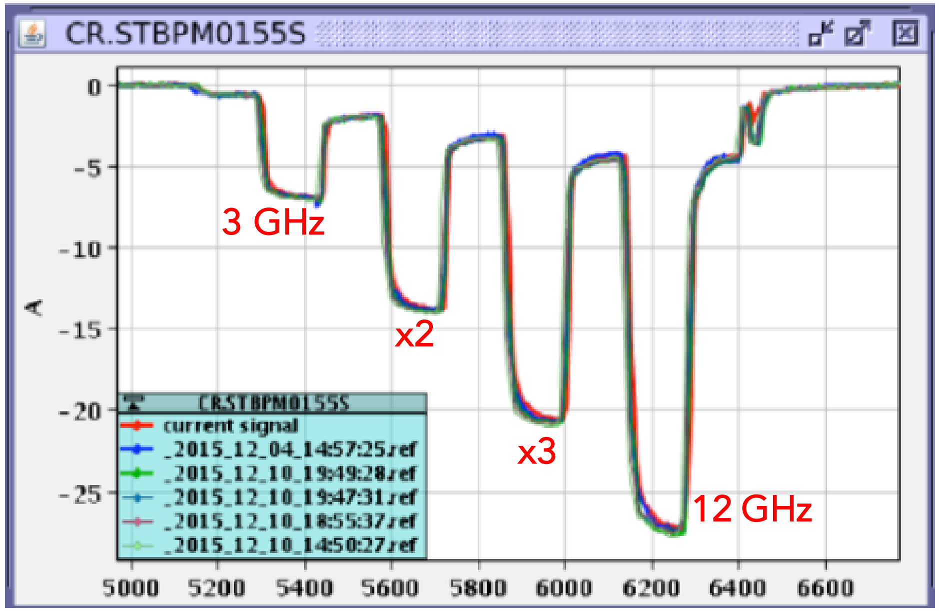


Drive beam quality

- Produced high-current drive beam bunched at 12 GHz

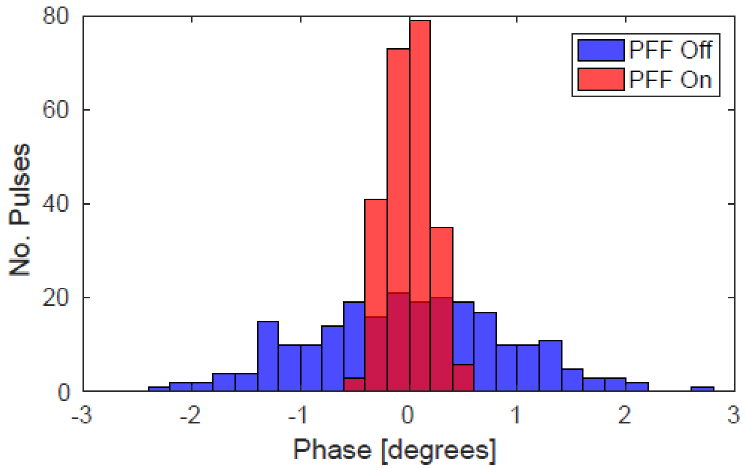
Three challenges:

- High-current drive beam bunched at 12 GHz
- Power transfer + main-beam acceleration
- ~100 MV/m gradient in main-beam cavities



28A

Arrival time stabilised to 50 fs

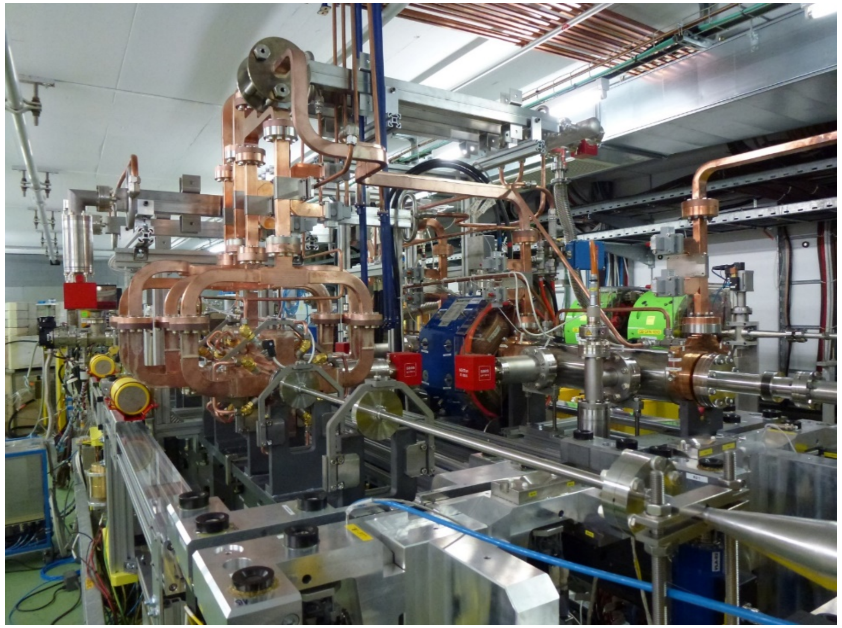


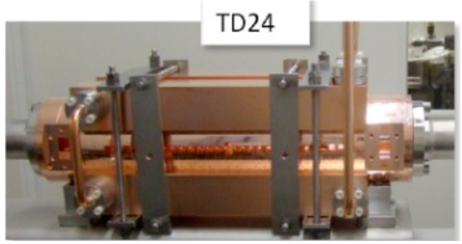
Two beam acceleration

- Demonstrated two-beam acceleration

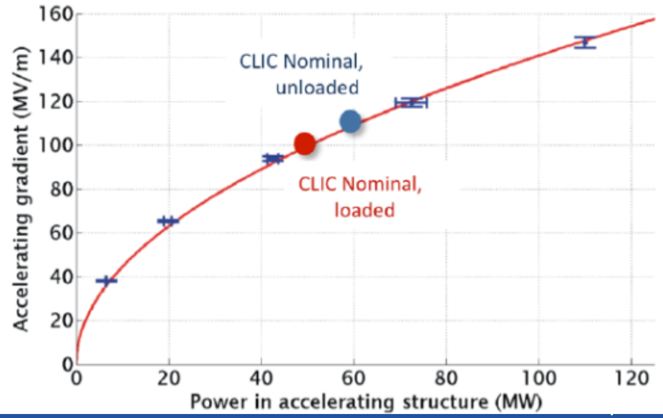
Three challenges:

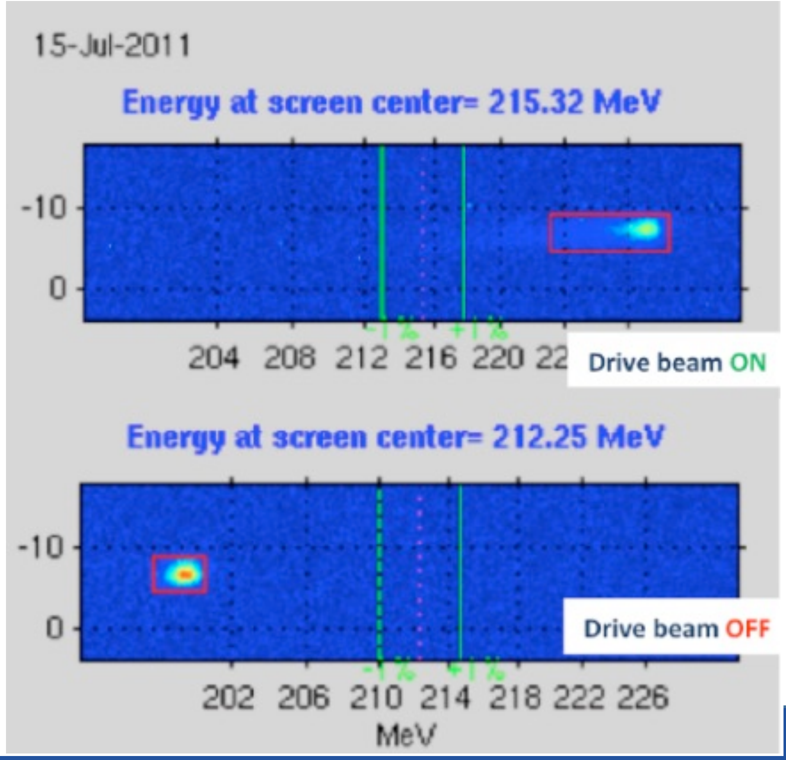
- High-current drive beam bunched at 12 GHz
- **Power transfer + main-beam acceleration**
- ~100 MV/m gradient in main-beam cavities





31 MeV = 145 MV/m



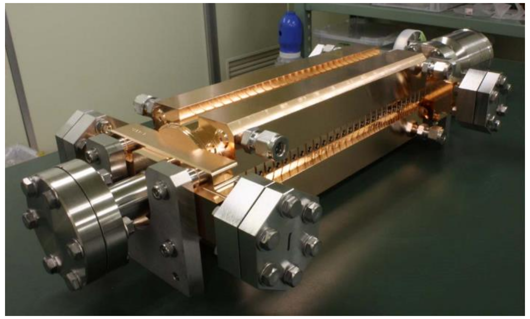


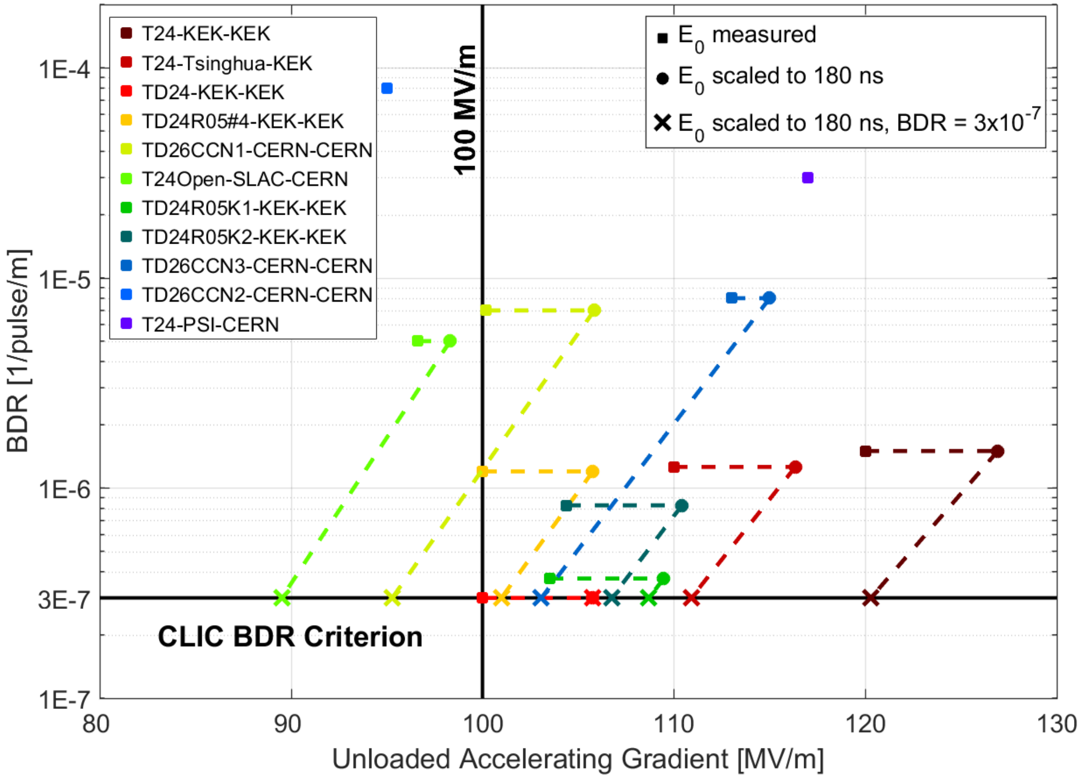
X-band performance

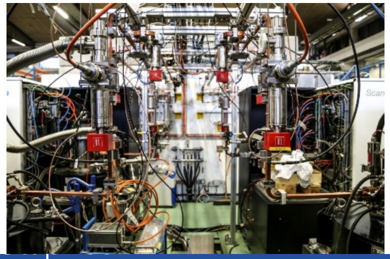
- Achieved 100 MV/m gradient in main-beam RF cavities

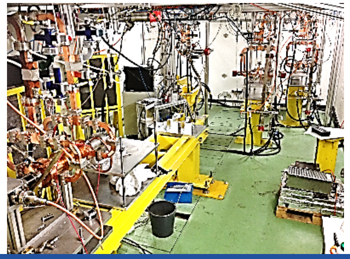
Three challenges:

- High-current drive beam bunched at 12 GHz
- Power transfer + main-beam acceleration
- **~100 MV/m gradient in main-beam cavities**





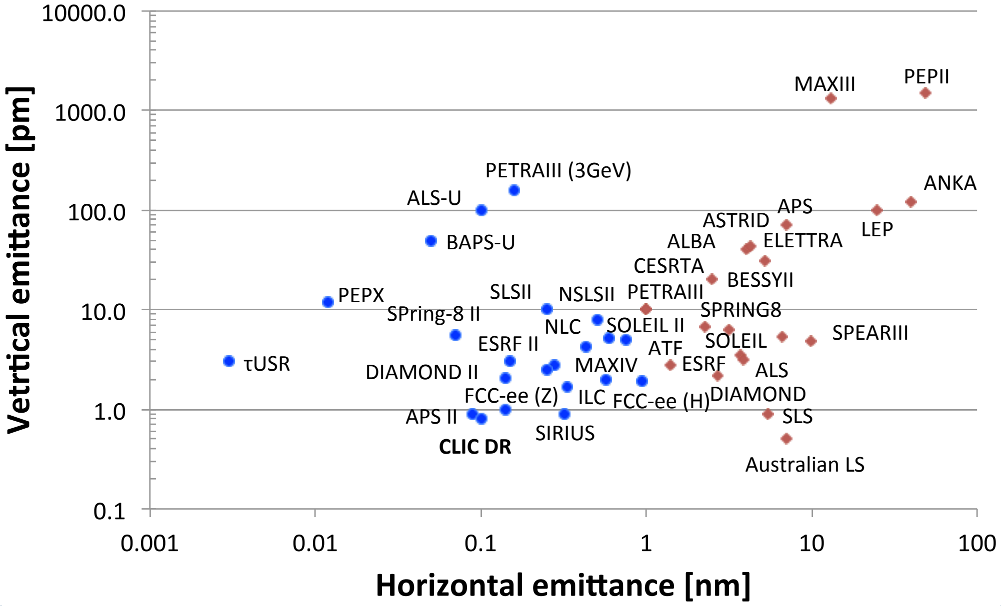


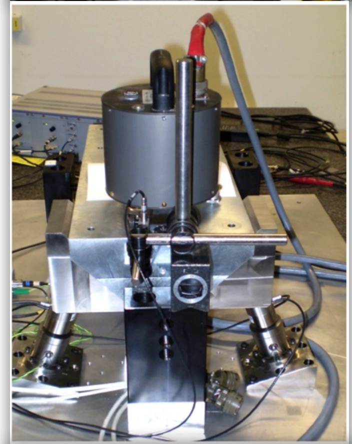


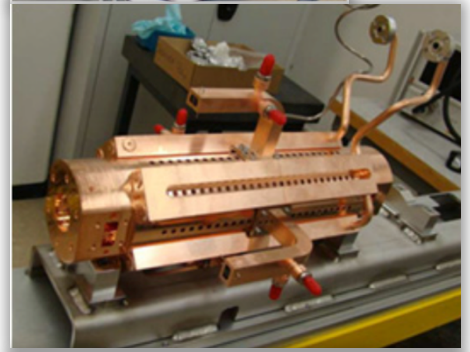
Nano-beams

The CLIC strategy:

- Align components (10μm over 200m)
- Control/damp vibrations (from ground to accelerator)
- Measure beams well – allow to steer beam and optimize positions
- Algorithms for measurements, beam and component optimization, feedbacks
- Tests in small accelerators of equipment and algorithms (FACET at Stanford, ATF2 at KEK, CTF3, Light-sources)

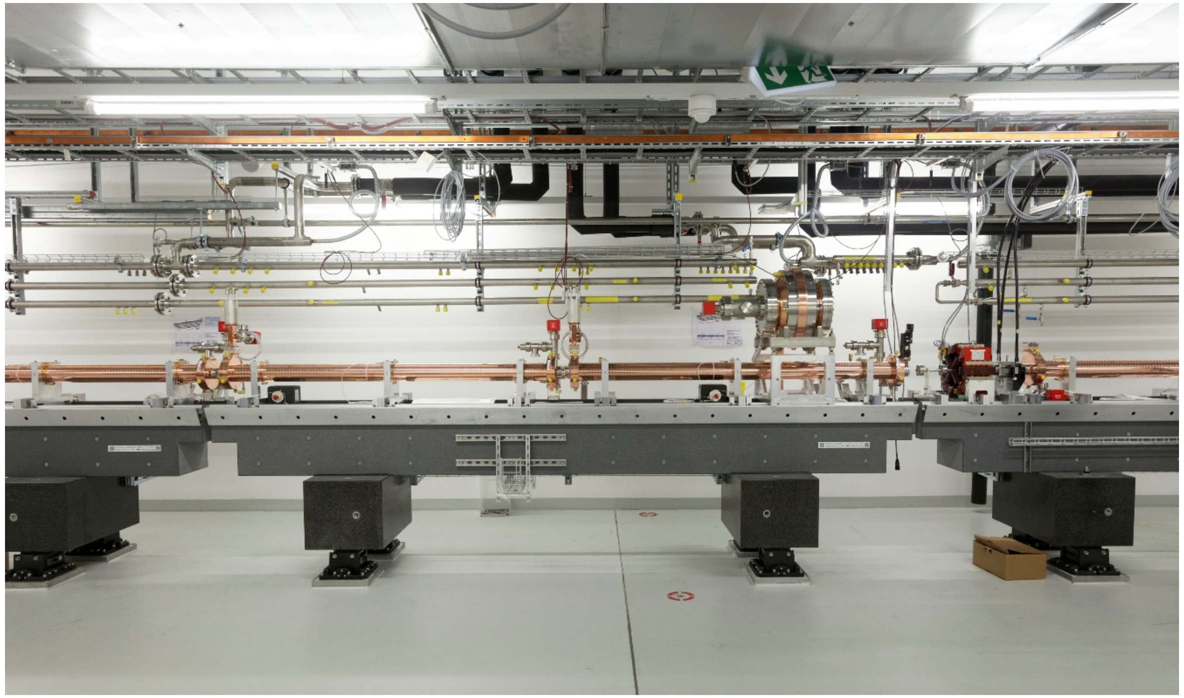






SwissFEL – C-band linac

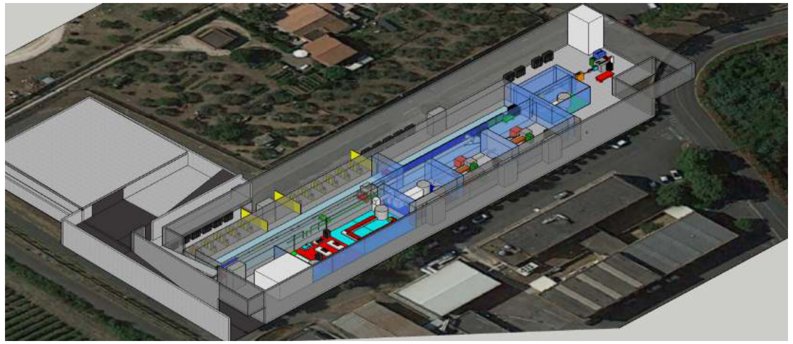
- 104 x 2m-long C-band structures
  (beam → 6 GeV @ 100 Hz)
- Similar um-level tolerances
- Length ~ 800 CLIC structures
- Being commissioned



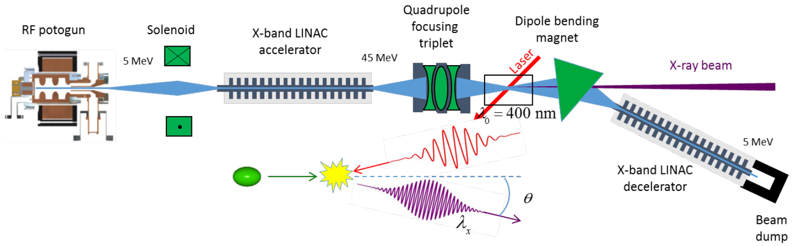
CLIC Technology and FELs

CLIC technology for different applications

- EU co-funded FEL design study
- SPARC at INFN-LNF
- … many other small systems …



INFN Frascati advanced acceleration facility
EuPARXIA@SPARC_LAB

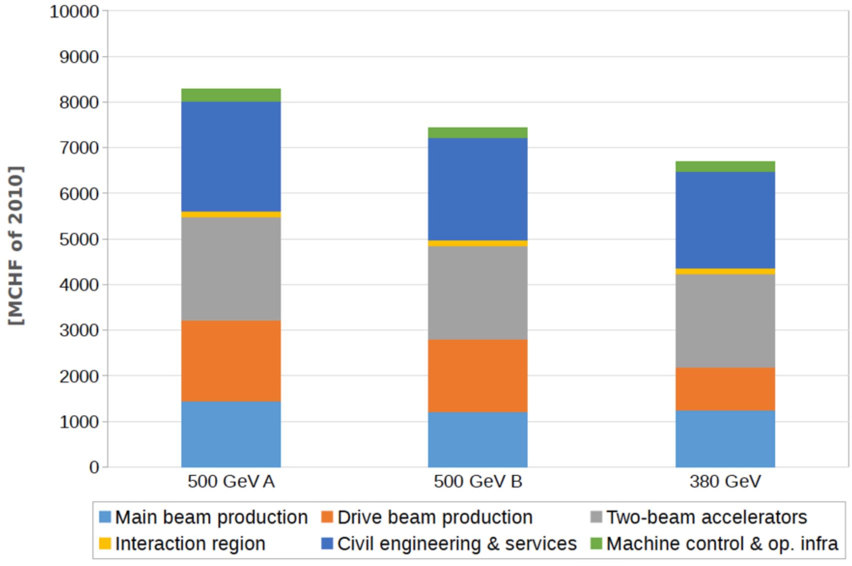


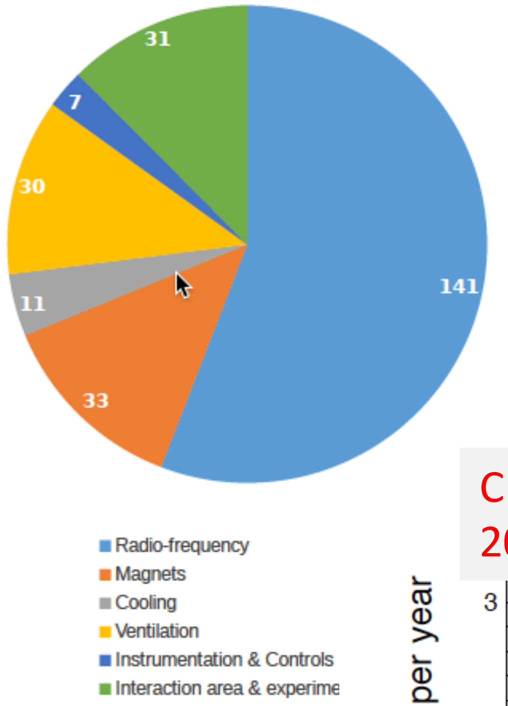
Eindhoven University led
SMART*LIGHT Compton Source

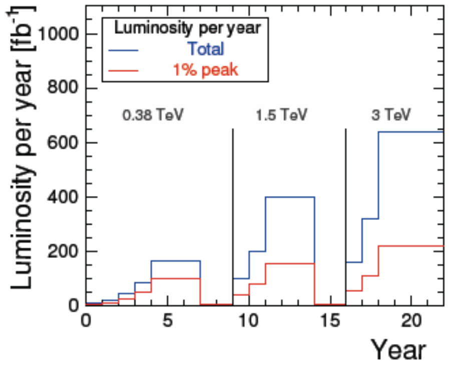
Cost and Power

Table 11: Value estimate of CLIC at 380 GeV centre-of-mass energy.

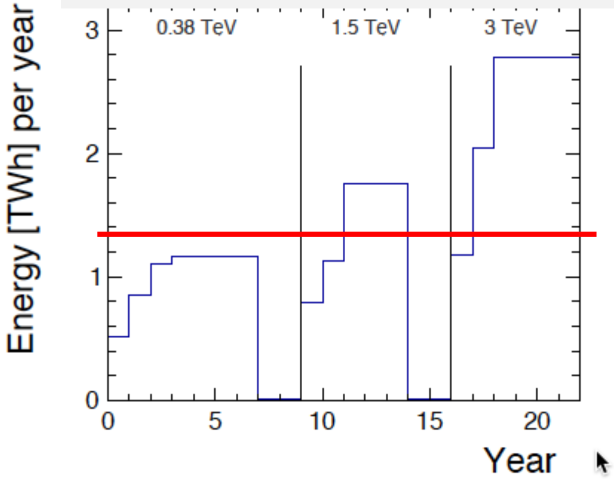
	Value [MCHF of December 2010]
Main beam production	1245
Drive beam production	974
Two-beam accelerators	2038
Interaction region	132
Civil engineering & services	2112
Accelerator control & operational infrastructure	216
Total	6690







CERN energy consumption 2012: 1.35 TWh



A cost of ~6 BCHF and power ~200 MW are considered “reasonable” values → implementable

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, Drive Beam Facility and other system verifications, 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

2019 - 2020 Decisions

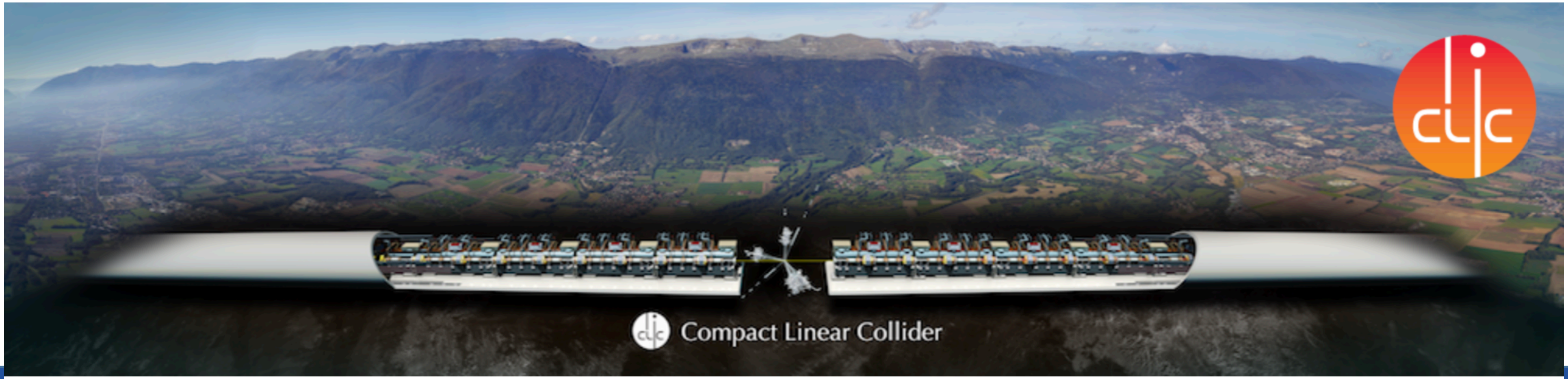
Update of the European Strategy for Particle Physics; decision towards a next CERN project at the energy frontier (e.g. CLIC, FCC)

2025 Construction Start

Ready for construction; start of excavations

2035 First Beams

Getting ready for data taking by the time the LHC programme reaches completion



Conclusions

Important progress toward the EU strategy

ILC
- 250 GeV centre-of-mass being evaluated
- SCRF: European XFEL is large-scale prototype
- Political process ongoing
- Hope for executive level statements this year

CLIC
- 380 GeV first energy stage
- Normal conducting FELs are prototypes, e.g. Swiss FEL
- Work on further stages to 3 TeV
- Project Implementation Plan by end of 2018

Many thanks to D.Schulte, L. Evans, Y.Okada, S.Michizono, A.Yamamoto, W. Wuensch, Ph. Burrows … the ILC and CLIC teams