The Linear Collider Collaboration

Lyn Evans

LCC Mandate 2013-2018

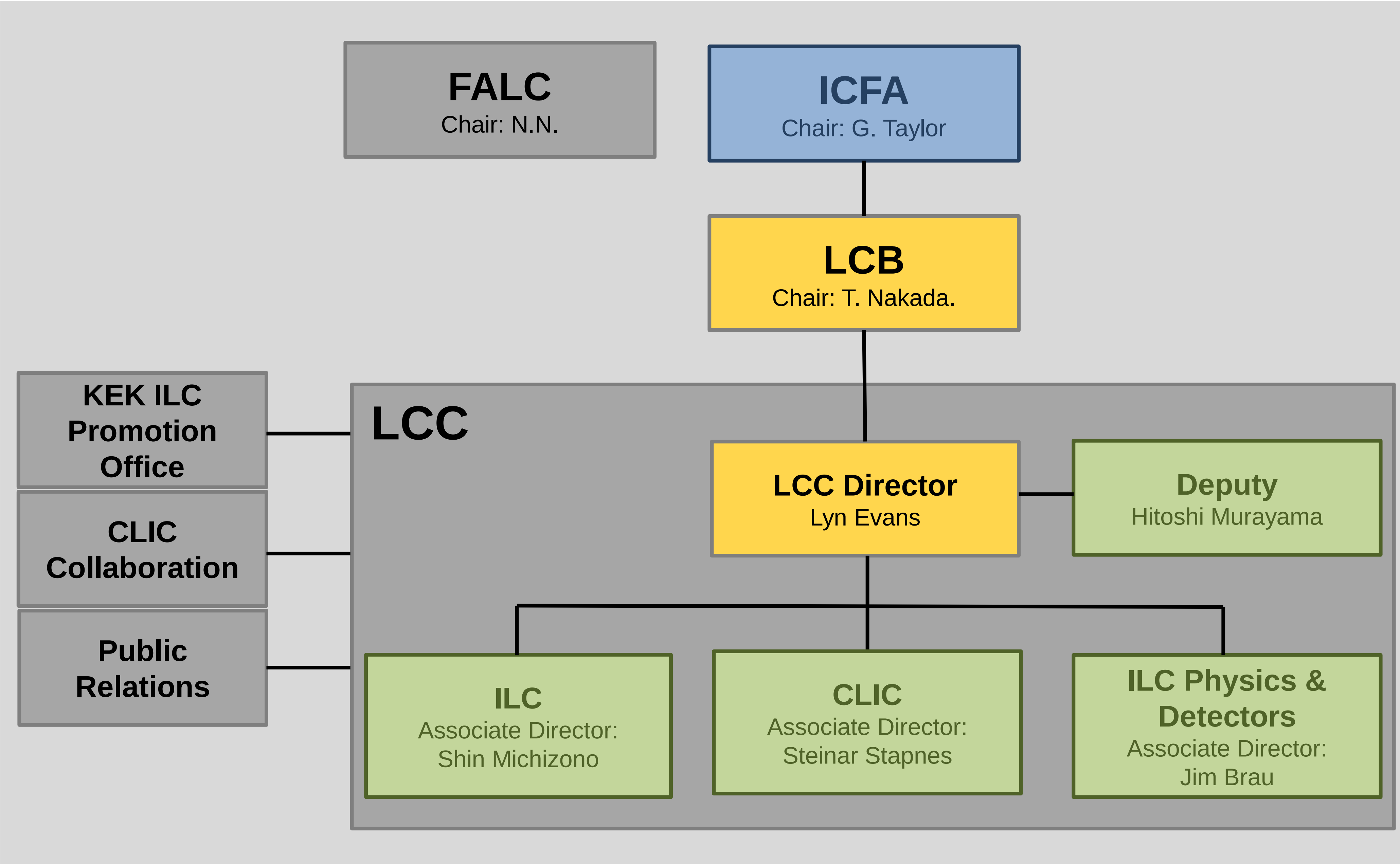
The mandate of the LCC (from ICFA) is to support the global design effort to enable the possible realization of a timely electron-positron collider and its detectors based on ILC technology, to support the CLIC technology development for a potential future higher energy machine and to coordinate both efforts in order to exploit synergies between them.

The future of LCC

Japan has made it clear that no decision on ILC will be made before end 2018.

ILL mandate has been extended by ICFA until the end of 2019.

LCB/LCC Organization 2017



ILC and CLIC Design Parameters

A. Yamamoto and K. Yokoya, Rev. of Acc. Science and Technology, (RAST) Vo. 7 (2014) 115 – 136.

Table 4. Accelerator parameters for the ILC and the CLIC in various modes [27, 28].

Parameters	ILC baseline	ILC Hi-lumi	ILC* E-upgrade	CLIC staging	CLIC baseline
Accelerating technology	SRF	SRF	SRF	NRF	NRF
Center-of-mass energy (GeV)	500	500	1,000	500	3,000
Luminosity ($cm^{-2}s^{-1}$)	1.8×10^{34}	3.6×10^{34}	4.9×10^{34}	2.3×10^{34}	5.9×10^{34}
Luminosity at top 1% CM energy	1.1×10^{34}	2.2×10^{34}	2.2×10^{34}	1.4×10^{34}	2.0×10^{34}
Accelerator length (km)	31	31	50	13.0	48.4
Acc. gradient loaded (MV/m)	31.5	31.5	31.5/45	80	100
RF (GHz)	1.3	1.3	1.3	12	12
Beam power/beam (MW)	5.2	11.0	13.6	4.7	14
No. of particles/bunch ($10^9 e^{+/-}$)	20	20	17.4	6.8	3.72
No. of bunches/pulse	1,312	2,625	2,450	354	312
Bunch separation (ns)	554	366	366	0.5	0.5
Beam pulse duration (μs)	727	900	900	177	0.156
Beam pulse current [mA]	5.8	8.8	7.6	2180	1190
Repetition rate [Hz]	5	5	4	50	50
H./V. norm. emittance ($10^{-6}/10^{-9}$)	10/35	10/35	10/30	2.4/25	0.66/20
H./V. IP beam size (nm)	474/5.9	474/5.9	335/2.7	203/2.3	40/1
Beamstrahlung photon/electron	1.72	1.72	1.97	1.3	2.1
Wall plug to beam transfer eff. (%)†	6.4	10.2	9.1	3.5	4.8
Power efficiency in the main linac‡	12	N/A	N/A	N/A	6
Total power consumption (MW)	163	204	300	271	582

*Here the parameter set *B* for 1 TeV in TDR is adopted.
†Final beam power (two beams) divided by the total site power.
‡Beam power gain in main linac divided by AC power into main linac, including cryogenics, drive linac, linac magnets, drive beam manipulation, etc.

ILC500 (TDR) →ILC250

ILC 500GeV

~31km

ILC 250GeV

→ *Cost reduction*

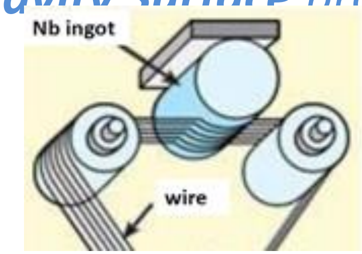
~20km

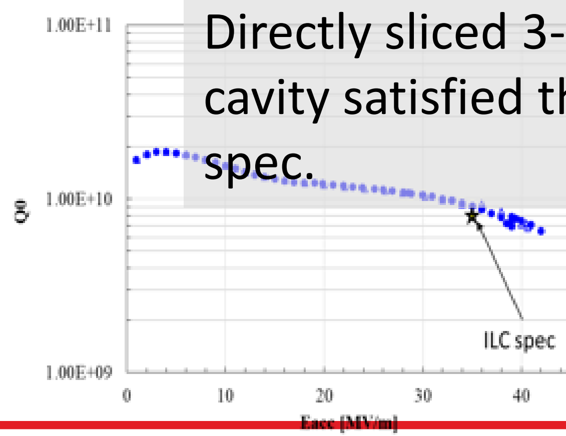
Item	Parameters
C.M. Energy	250 GeV
Length	20.5 km
Luminosity	1.35 $\times 10^{34}$ $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	7.7 nm
SRF Cavity G. Q_0	31.5~35 MV/m Q_0 = 1 ~1.6x10^{10}

SRF Cost-reduction R&D

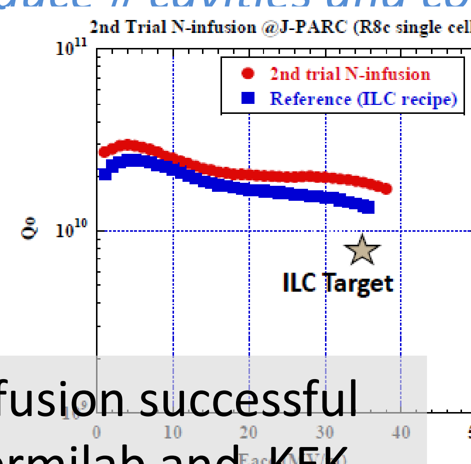
Cost reduction by techn. innovation

- ***Nb material*** *process → reduce material cost*
- ***Cavity Surface*** *process with N-infusion (High-G and –Q): reduce # cavities and cost*



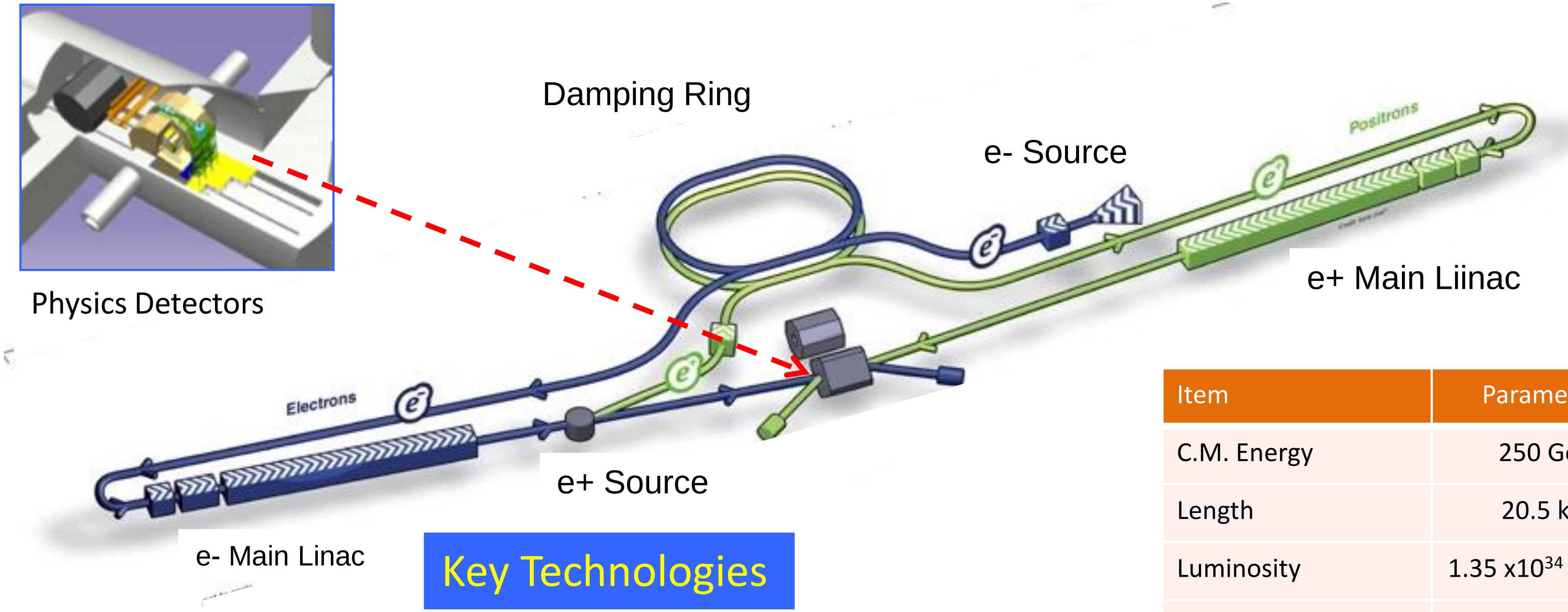


Directly sliced 3-cell cavity satisfied the ILC spec.

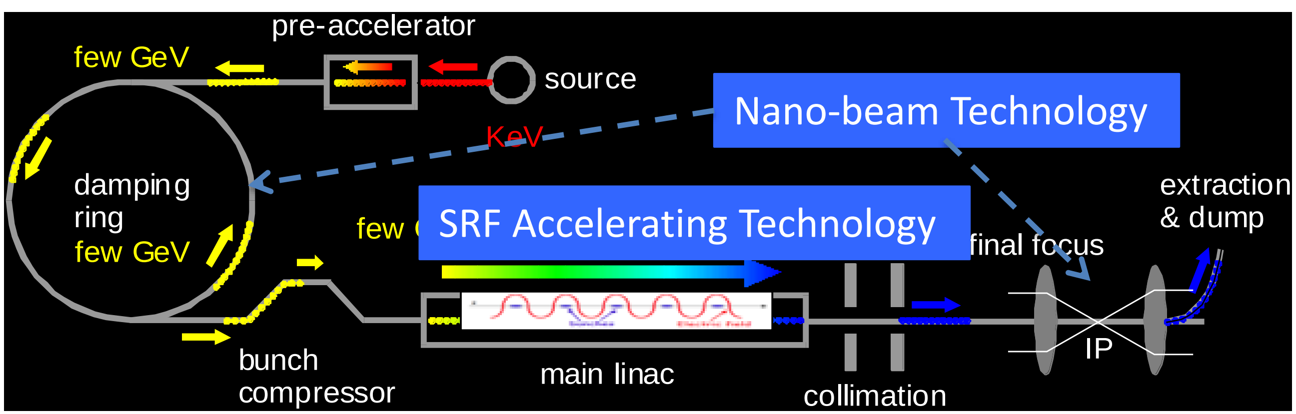


N-infusion successful at Fermilab and KEK.

ILC250 Acc. Design Overview



Key Technologies



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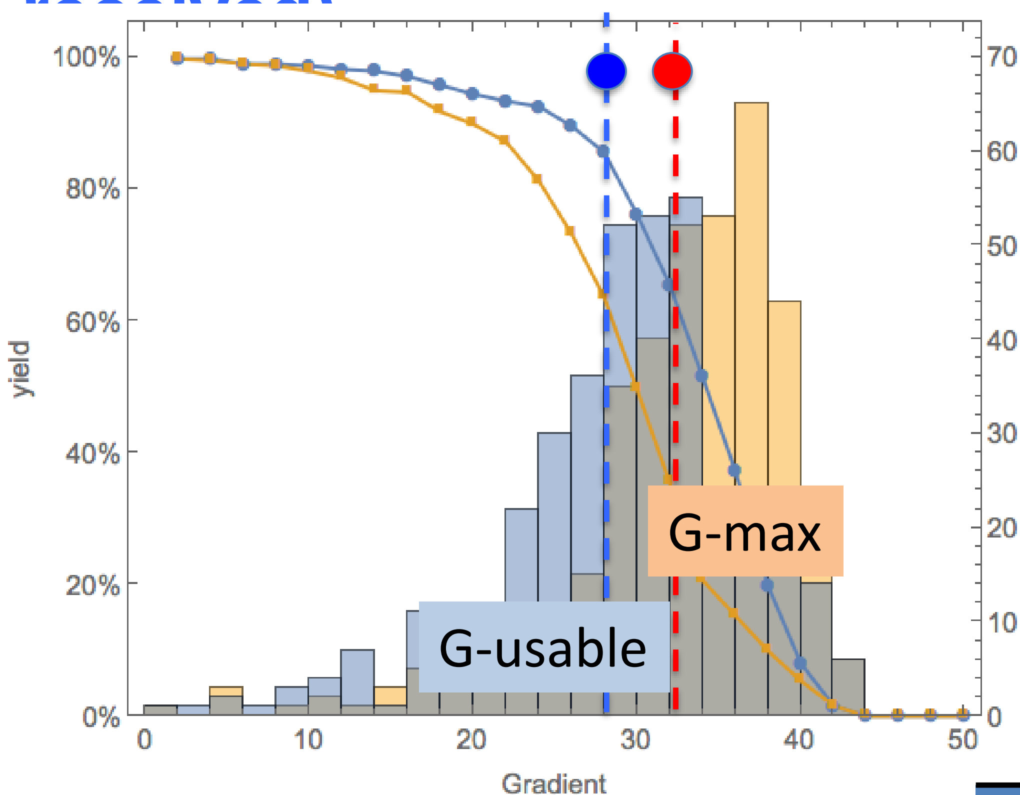
E-XFEL: SRF Cavity Performance (as received)



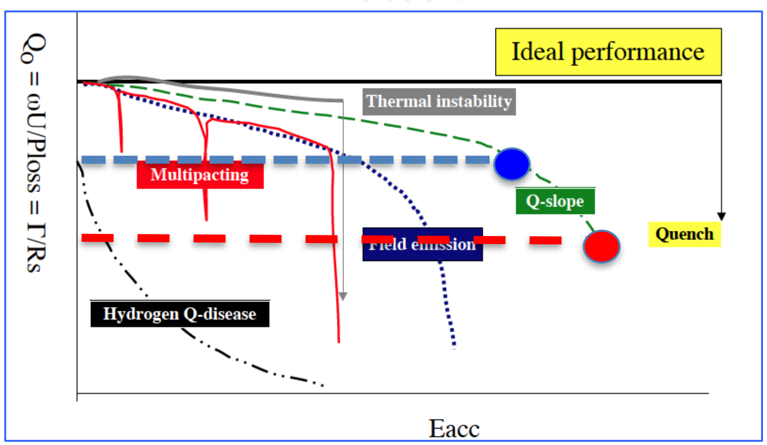
SRF cavity production/test ;

 # RI Cavities, 373 (as of Sept. 2015)

- Final process: 40 μm EP.
  - w/ same recipe to ILC-SRF's
- Tested at DESY-AMTF

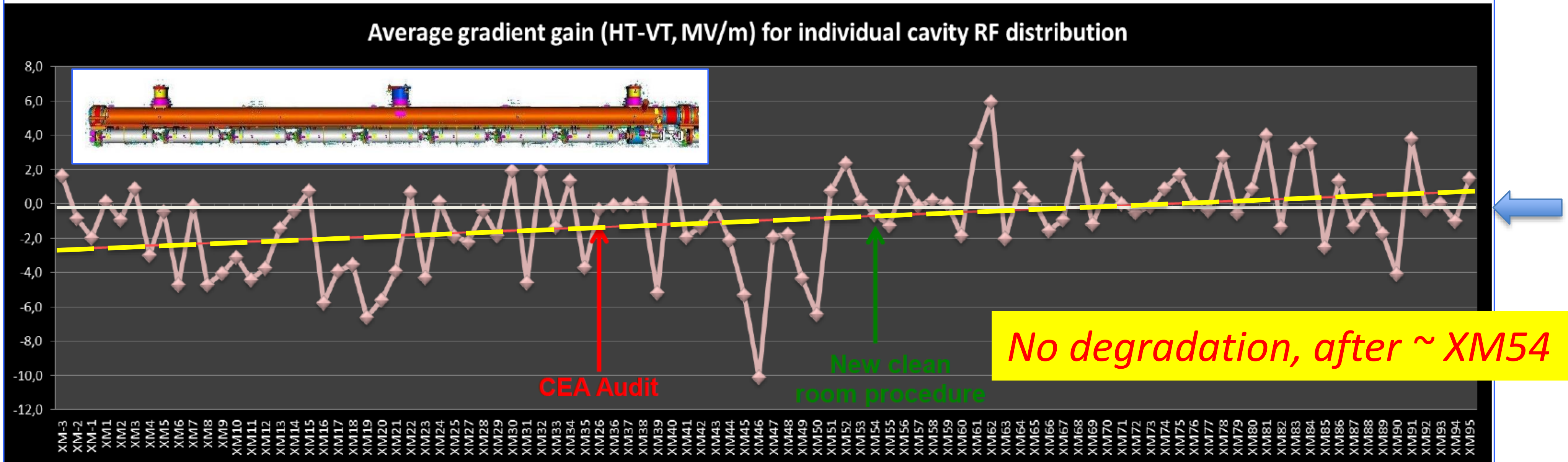
Notes::

- "Ultra-pure water rinsing as the 2nd process improving the gradient performance (> ~10%) for lower-performed cavities (not shown here).



	G-usable ($Q_0 > 10^{10}$)	G-max	(ILC)
<G> MV/m	29.4	33	(35)
Yield at 28MV/m	66%	86%	(90%)

Cryomodule Performance: VT vs. MT

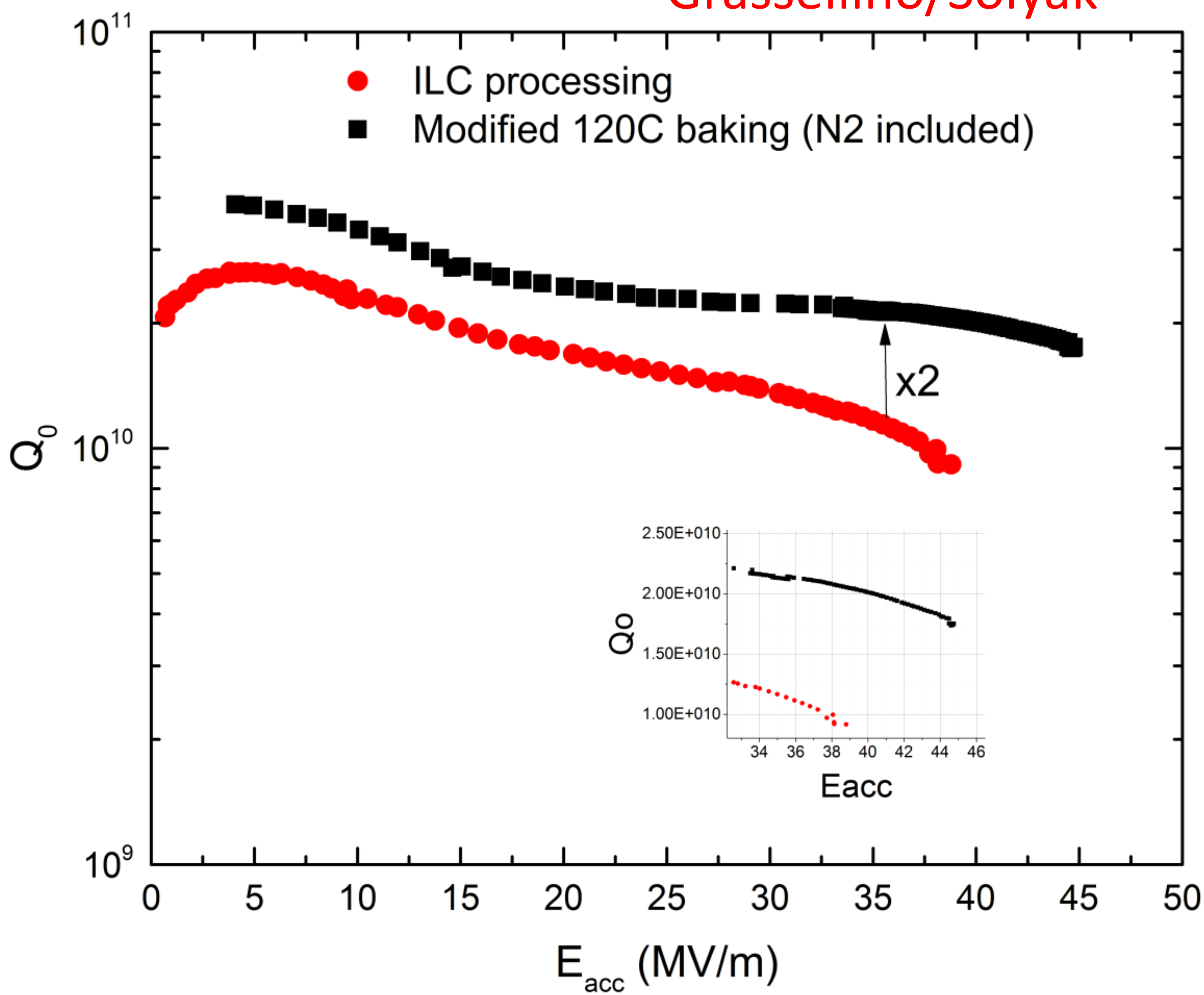


1st sample of 34 series CM	2nd sample of 19 series CM	last 42 series CM
ΔE_{op} = -2.1 MV/m	ΔE_{op} = -1.7 (-0.9) MV/m	ΔE_{op} =+0.4 MV/m

- Significant gradient degradation from XM6 to XM23, while CEA and Alsyom put all their effort in achieving production goal of 1 CM/week: an audit of string and module assembly was conducted by CEA on XM26
- A simplification of the clean room procedures was introduced at XM54: **no degradation after**

Results comparison
"standard" 120C bake vs "N infused" 120C bake

Grassellino/Solyak



- Achieved:

45.6 MV/m → 194 mT
With Q ~ 2e10!

- Q at ~ 35 MV/m ~ 2.3e10!
- ILC specs: Q=0.8e10 @ 35MV/m

Increase in Q factor of two, increase in gradient ~15%

Technical Status in 2018

Key Technologies advanced!

Nano-beam Technology:

KEK-ATF2: FF **beam size (v)**: 41 nm at 1.3 GeV (equiv. to 7 nm at ILC)

SRF Technology :

European XFEL completed: <G = ~ 30 MV/m> achieved with 800 cavities and accelerator commissioning/operation reaching > 90 % design energy.

LCLS-II: construction in progress

H-FEL (Shinghai): construction approved

US-Japan: Cost Reduction R&Ds in progress, focusing on "**N Infusion**" **process** demonstrated, at Fermilab, **for High-Q and High-G**

General design updated:

- **ILC** 250 GeV proposal has been authorized by ICFA/LCB

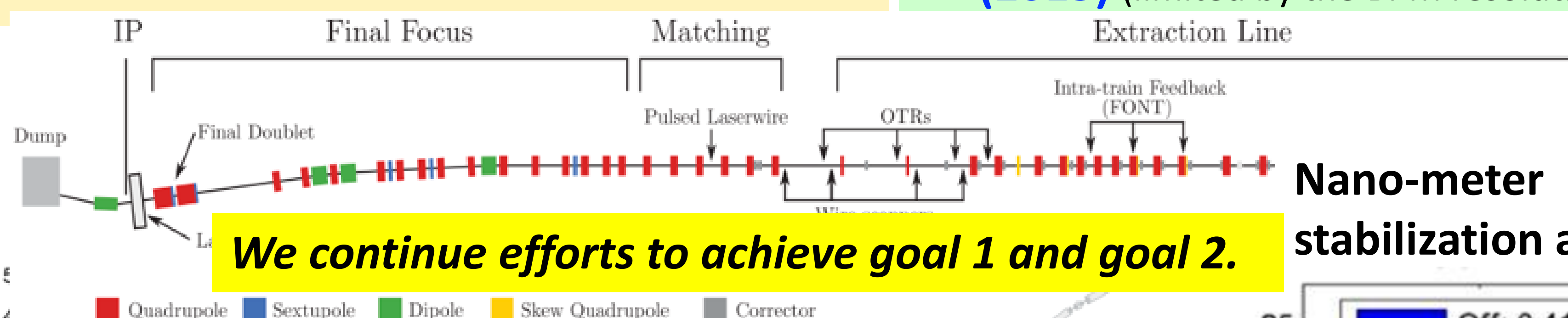
Progress in FF Beam Size and Stability at ATF2

Goal 1: Establish the ILC final focus method with same optics and comparable beamline tolerances

- ATF2 Goal : 37 nm → 6nm @ILC500GeV
  7.7nm@ILC250GeV
  - Achieved **41 nm** (2016)

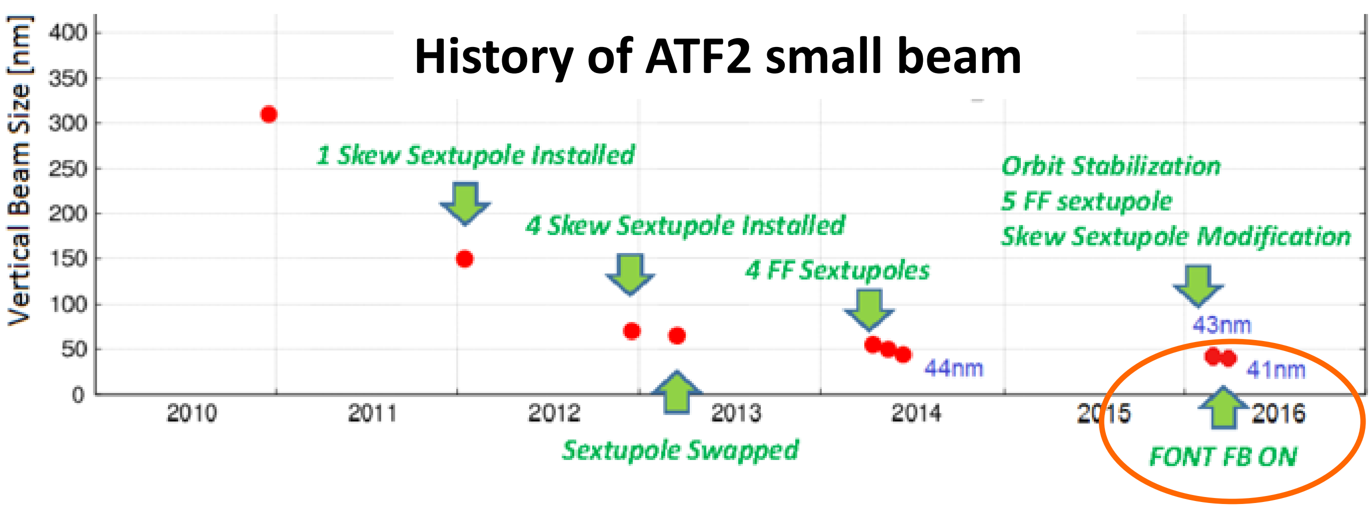
Goal 2: Develop a few nm position stabilization for the ILC collision

- **FB latency 133 nsec achieved** (target: < 300 nsec)
- **positon jitter at IP: 410 → 67 nm (2015)** (limited by the BPM resolution)

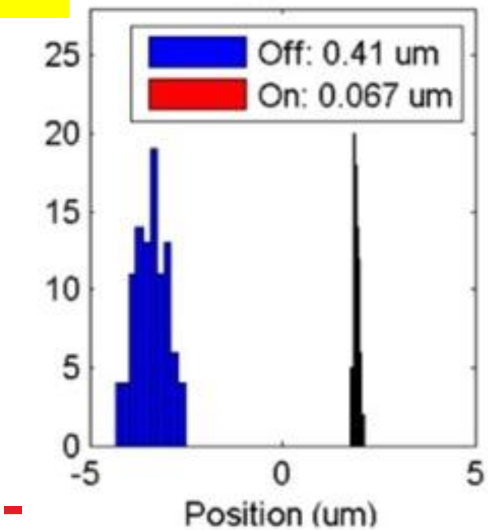


We continue efforts to achieve goal 1 and goal 2.

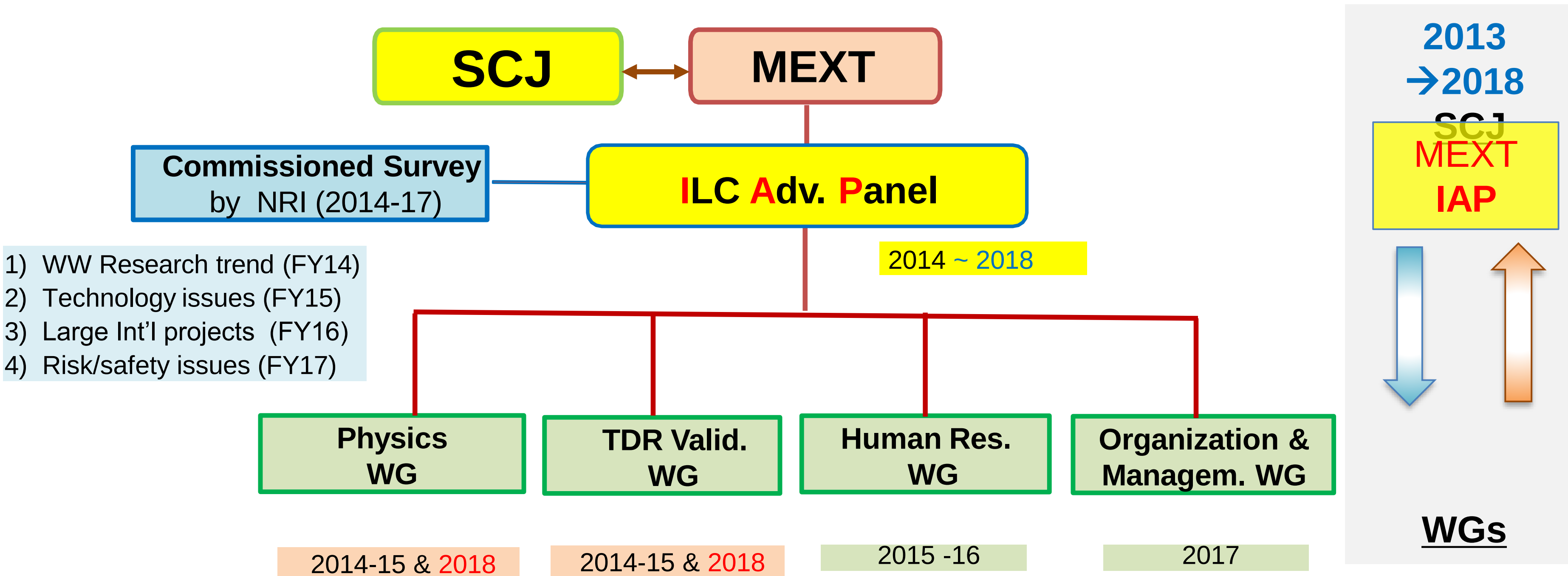
History of ATF2 small beam



Nano-meter stabilization at IP



ILC Investigation by SCJ and MEXT

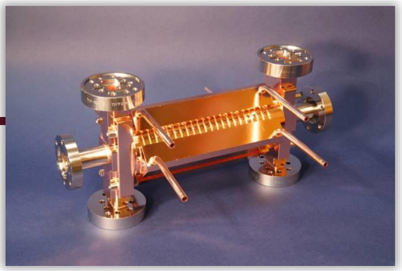


- Physics WG, and TDR Validation WG re-organized to evaluate ILC-250GeV.

Summary

- ILC collision energy first stage at 250 GeV, now accepted by the community. The accelerator construction cost is well estimated with a meaningful cost reduction,
- Key technologies of "Nano-beam" and "SRF" mature. Thanks for worldwide efforts for SRT technology, with European XFEL, LILS-II, and further.
- Polarised positron production is marginal at 250 GeV.
- The US-Japan, SRF cost-reduction R&D program in progress with encouraging results.
- Our best effort has been made to provide comprehensive information to official WGs and IAP at MEXT is reaching a very critical stage to evaluate the ILC 250 GeV proposal.

The CLIC project

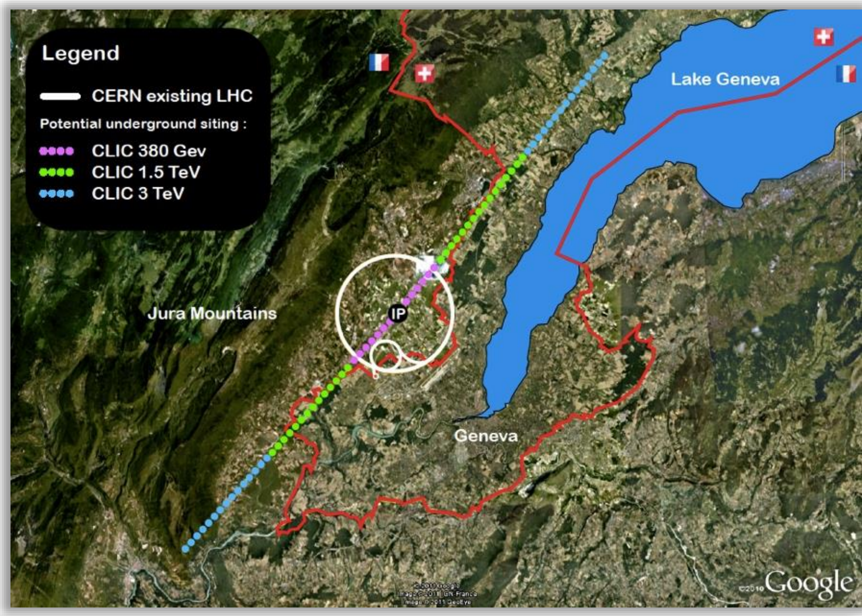


Timeline for the European Strategy ~2019, goal:

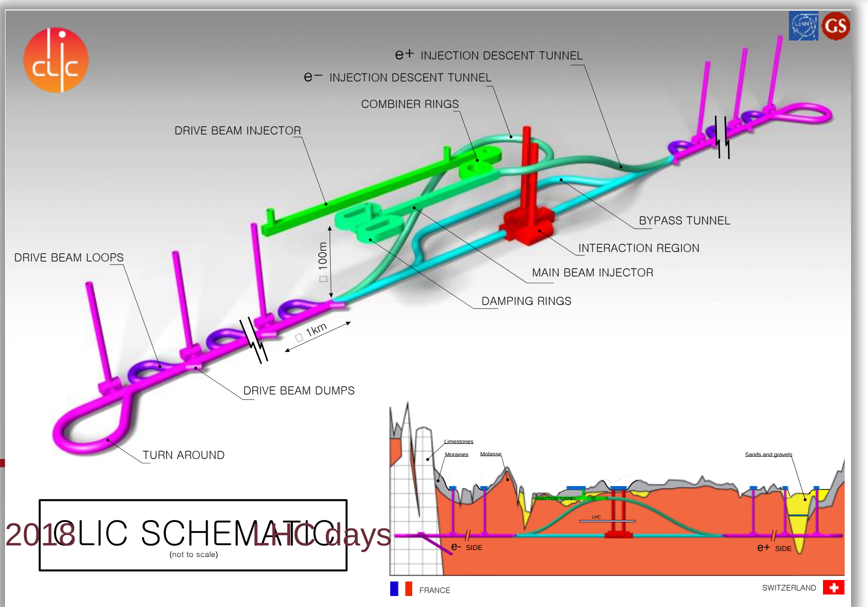
- Cost and power optimised 380 GeV machine (~11 km)(drivebeam and klystrons) upgradeable to 3 TeV

Key technical activities in the collaboration:

- Xband statistics and optimisisation for cost
- Work with FEL labs for use in smaller machines
- Permanent magnets (power)
- High Efficiency klystrons (power and cost)
- Stability and alignment (lum performance)
- Tests CTF3, CLEAR (next slide), ATF2, Low emittance rings
- Physics and detectors



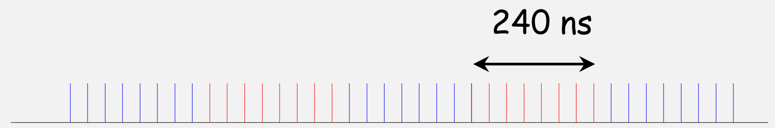
Parameter	Unit	380 GeV	3 TeV
Centre-of-mass energy	TeV	0.38	3
Total luminosity	$10^{34}cm^{-2}s^{-1}$	1.5	5.9
Luminosity above 99% of √s	$10^{34}cm^{-2}s^{-1}$	0.9	2.0
Repetition frequency	Hz	50	50
Number of bunches per train		352	312
Bunch separation	ns	0.5	0.5
Acceleration gradient	MV/m	72	100
Site length	km	11	50



CLIC Layout at 3 TeV

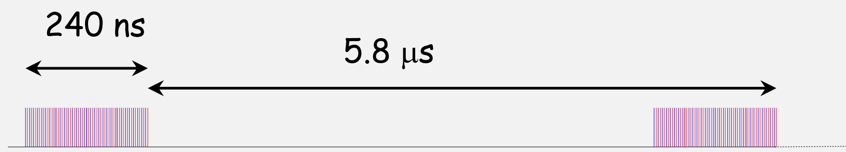
Drive Beam Generation

Drive beam time structure - initial

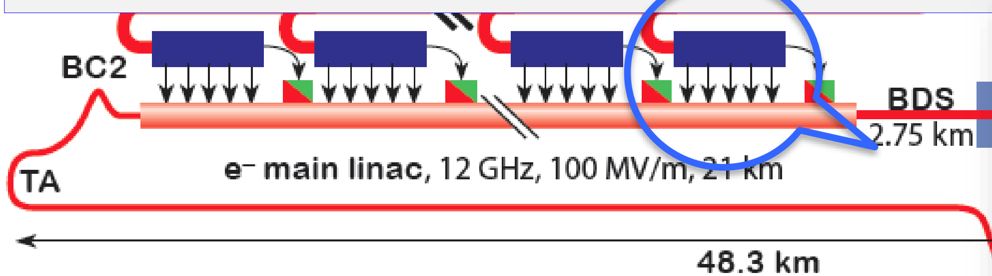


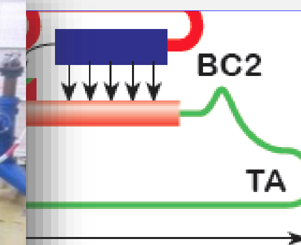
140 μs train length - 24 × 24 sub-pulses
4.2 A - 2.4 GeV – 60 cm between bunches

Drive beam time structure - final



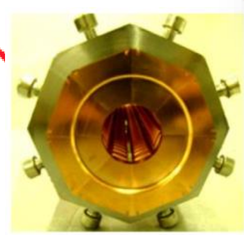
24 pulses – 101 A – 2.5 cm between bunches

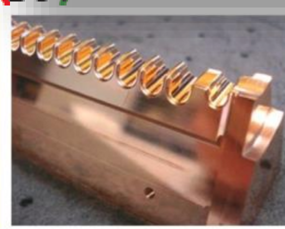


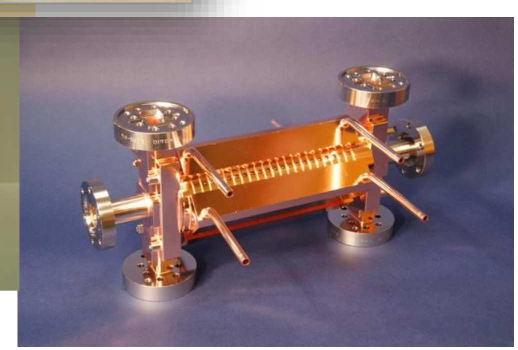


CR combiner ring
TA turnaround
DR damping ring
PDR predamping ring
BC bunch compressor
BDS beam delivery system
IP interaction point
dump

e⁻ injector, 2.86 GeV





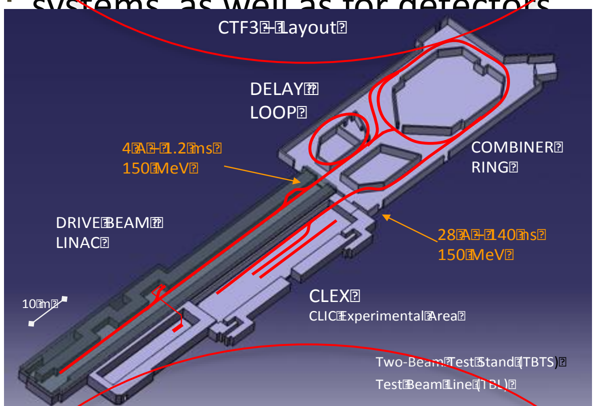


Main Beam Generation Complex

Looking forward

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

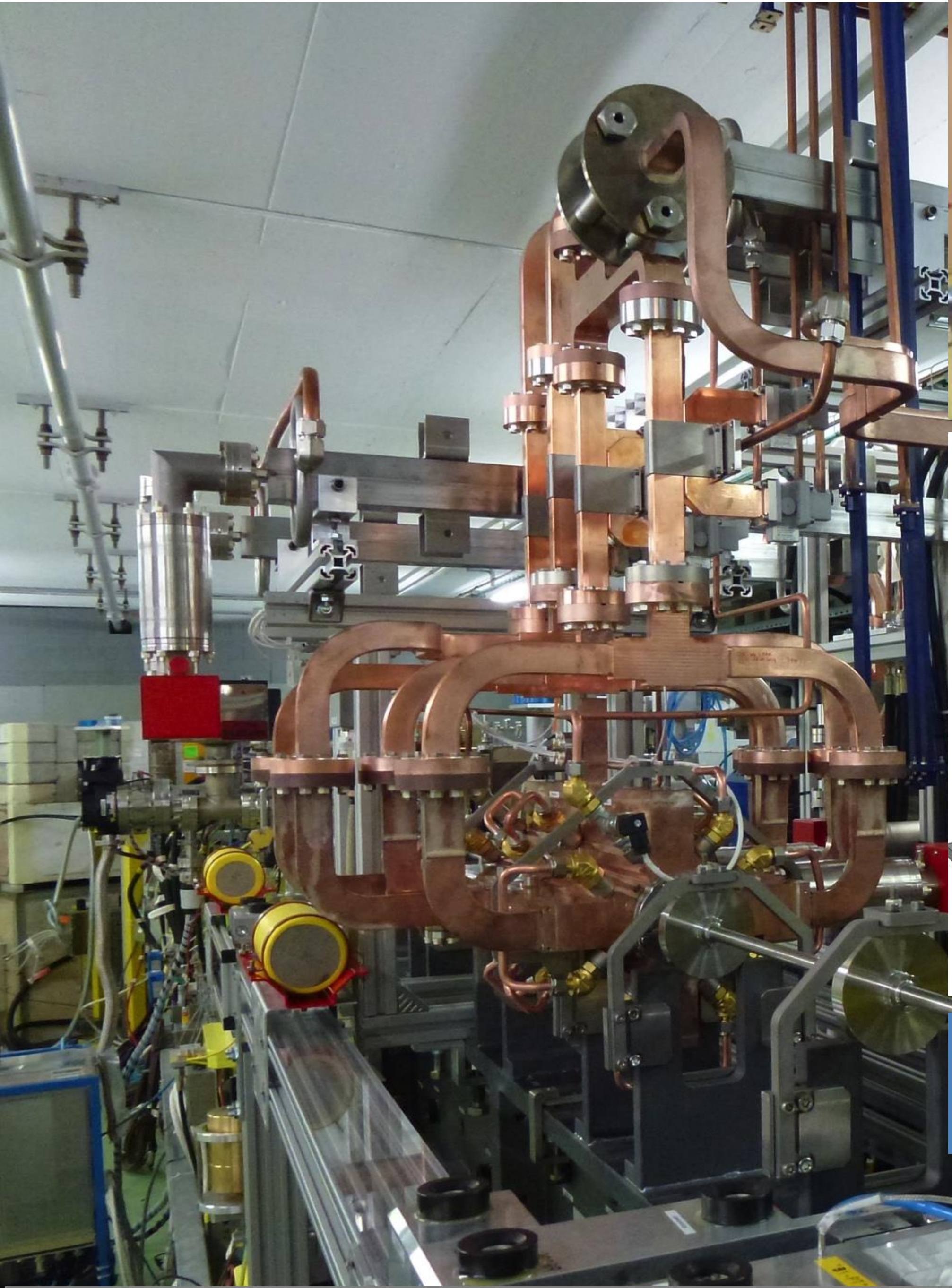


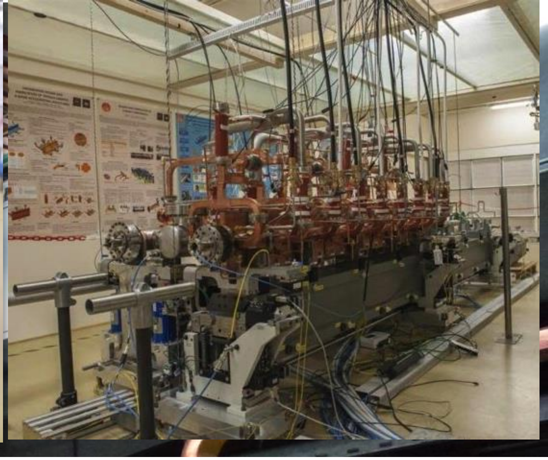
2018-19 Decisions

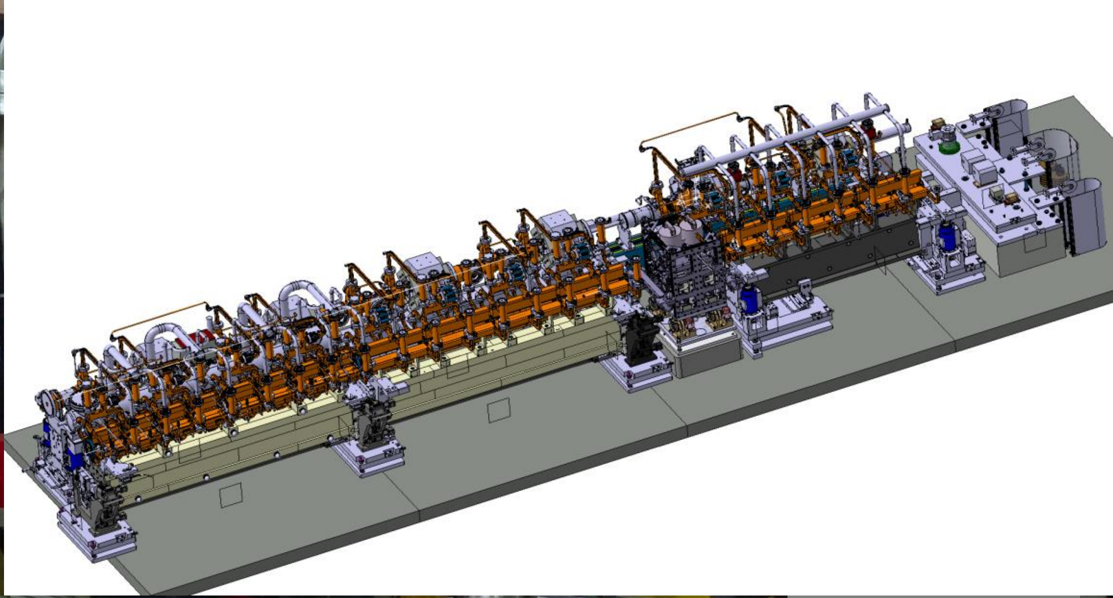
On the basis of LHC data and Project Plans (for CLIC and other potential projects as FCC), take decisions about next project(s) at the Energy Frontier.

Accelerator collaboration with ~50 institutes
Detector collaboration operative with ~25 institutes

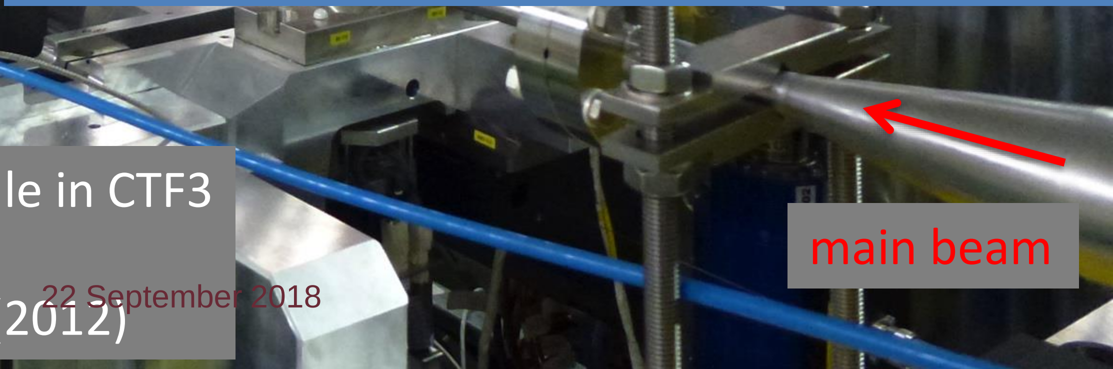
- European Strategy points addressed: High Gradient acceleration, machine studies for high energy frontier e+e- (CLIC), ILC and general accelerator and detector R&D
- Common work with ILC related to several acc. systems as part of the LC coll., also related to initial stage physics and detector developments
- Common physics benchmarking with FCC pp and common detect. challenges (ex: timing, granularity), as well as project







CLIC module review June 22:
https://indico.cern.ch/event/393250/



Recently installed 2-beam acceleration module in CTF3
(according to latest CLIC design)
First 2-beam tests stand reached 145 MV/m (2012)

Timeline

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

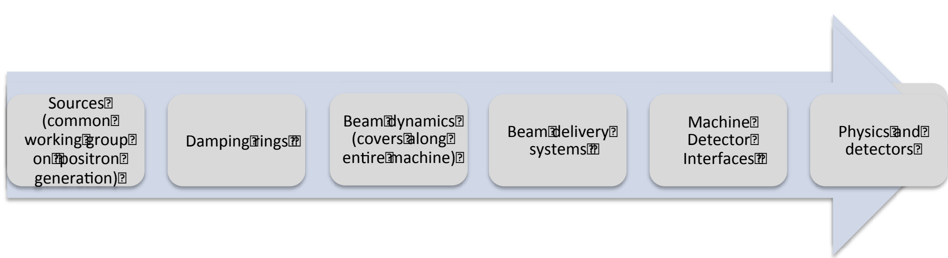
Summary (CLIC)

The goals and plans for 2015-19 are well defined for CLIC, focusing on the high energy frontier capabilities – well aligned with current strategies – also preparing to align with LHC physics as it progresses in the coming years:

- Aim provide optimized staged approach up to 3 TeV with costs and power not too excessive compared to LHC.
- Possible klystron driven start version at about 380 GeV

LC general and ILC support:

- LCC common fund and hosting, ATF as mentioned on earlier slide, participation in ILC preparation team (in the areas of BDS, RTML, Cryogenics systems, CFS and SCRF specific studies) ~10% of CERN LC effort
- Common WGs in Beam dynamics, Sources, MDI, DRs, RTML, BDS



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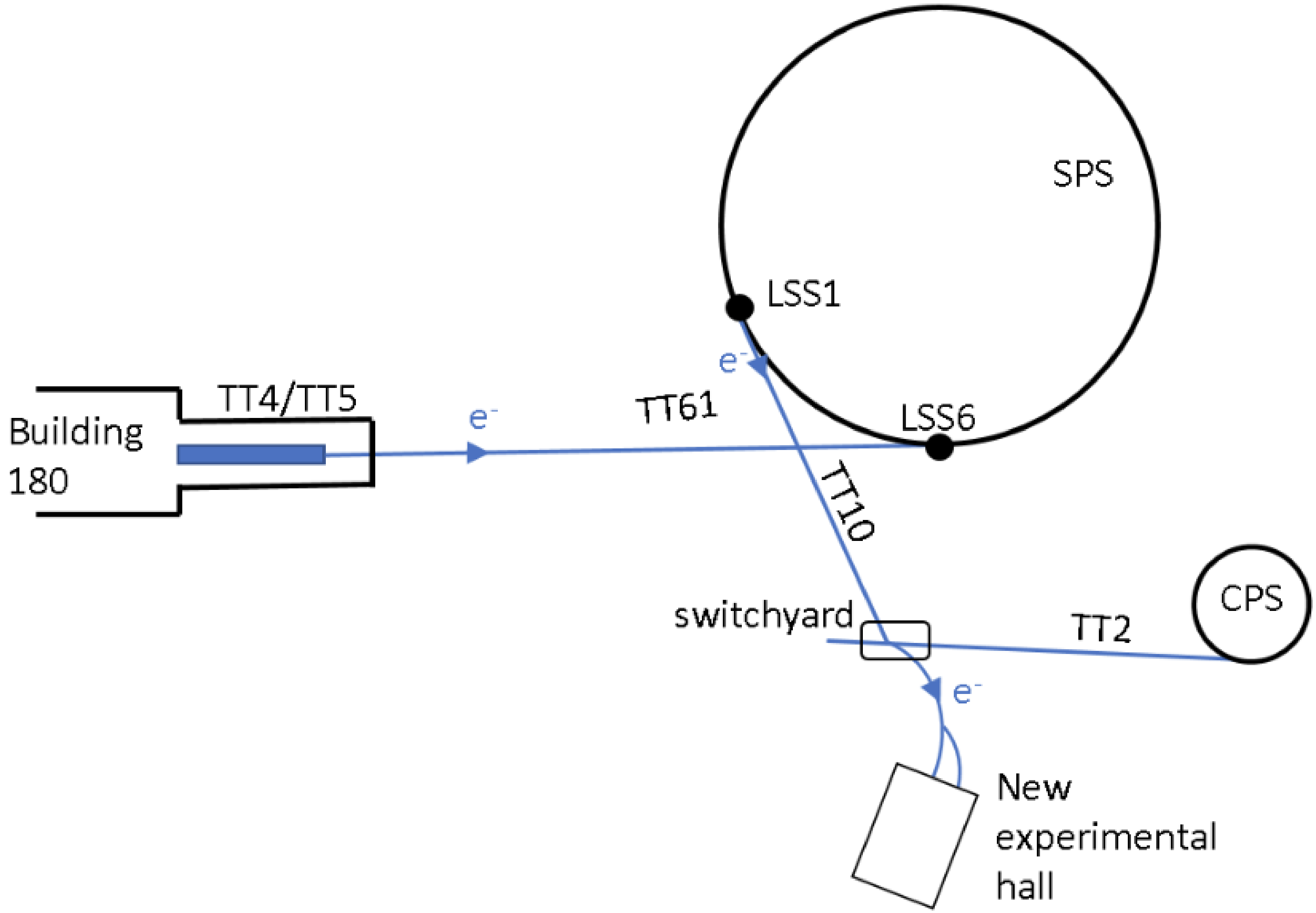
LDMX at CERN


SPS
LSS1
LSS6
e⁻
e⁻
TT4/TT5
TT61
Building
180
TT10
switchyard
TT2
CPS
e⁻
New
experimental
hall