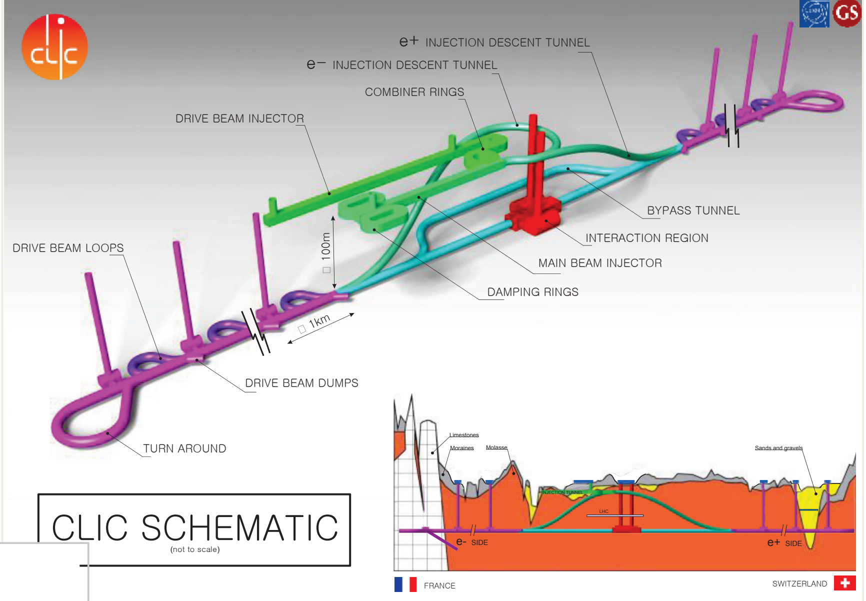
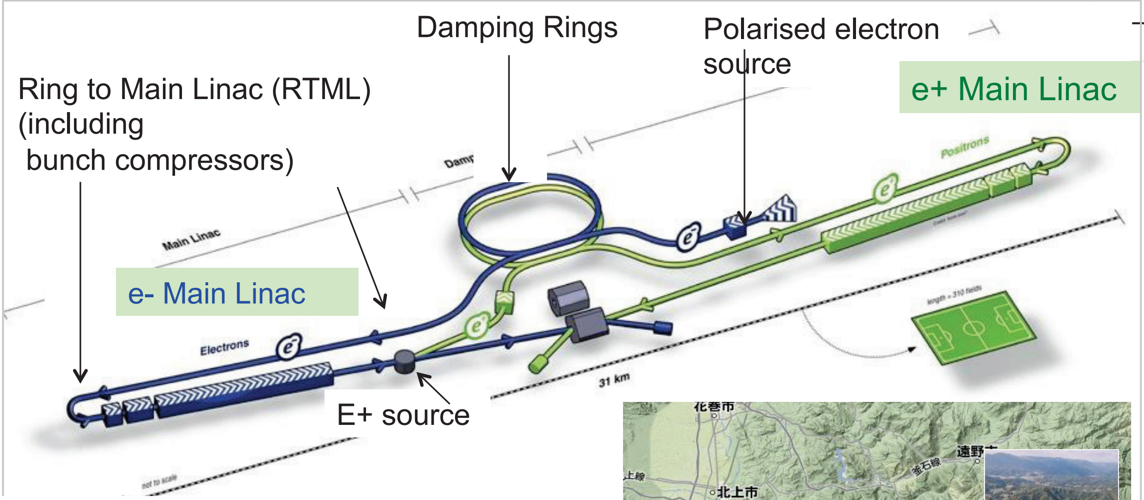
LC studies

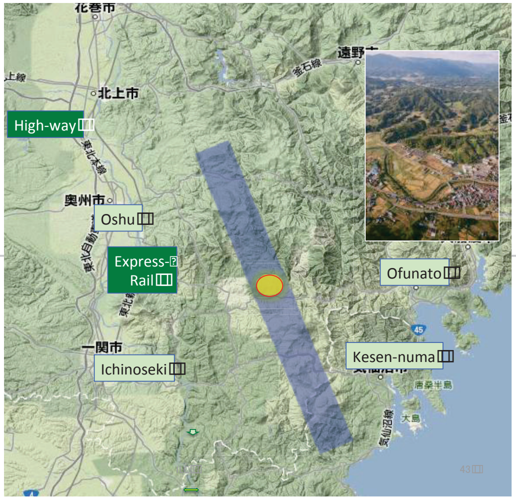
Outline:

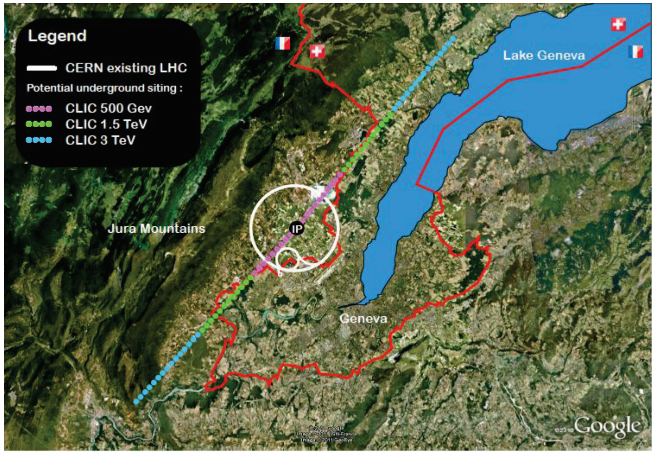
- ILC and CLIC – project overview
- Why LCs – brief physics consideration
- Recent results
- Realization of the projects
- Summary





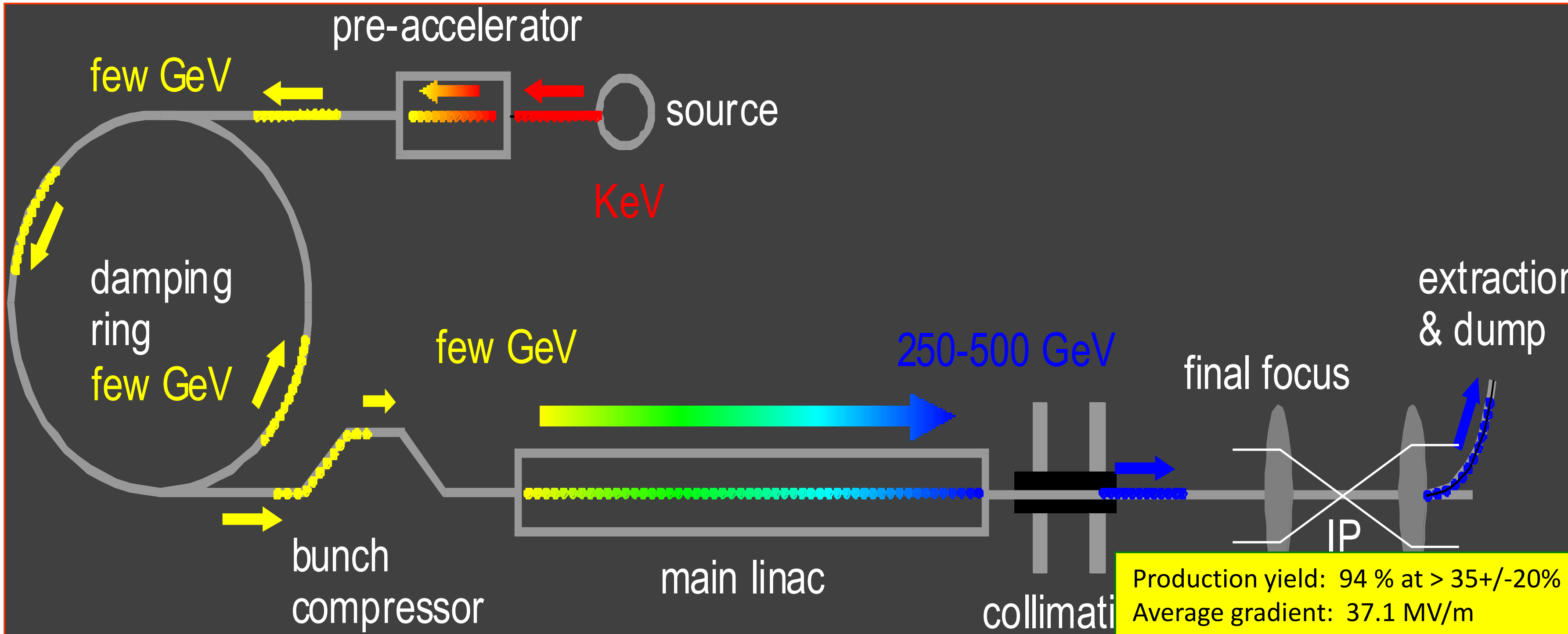
ILC SCHEMATIC





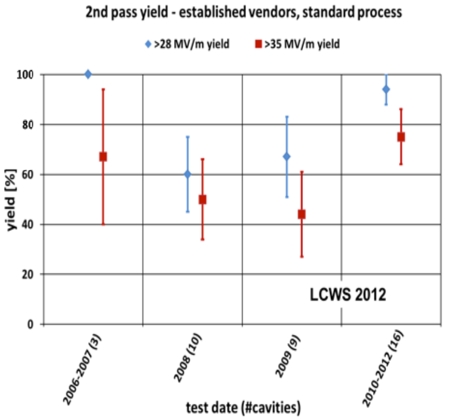
Steinar Stapnes, CERN
LCC collaboration

ILC Accelerator Concept



Production yield: 94 % at > 35+/-20%
Average gradient: 37.1 MV/m
> R&D goal of 35 MV/m reached (2012)

- Electron and Positron Sources (e-, e+) :
- Damping Ring (DR):
- Ring to ML beam transport (RTML)
- Main Linac (ML) : SCRF Technology
- Beam Delivery System (BDS)



ILC parameters

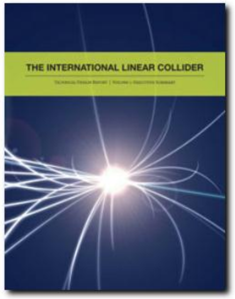
Table 2.1. Summary table of the 200–500 GeV baseline parameters for the ILC. The reported luminosity numbers are results of simulation [12]

Centre-of-mass energy	E_{CM}	GeV	200	230	250	350	500
Luminosity pulse repetition rate		Hz	5	5	5	5	5
Positron production mode			10 Hz	10 Hz	10 Hz	nom.	nom.
Estimated AC power	P_{AC}	MW	114	119	122	121	163
Bunch population	N	$\times 10^{10}$	2	2	2	2	2
Number of bunches	n_b		1312	1312	1312	1312	1312
Linac bunch interval	Δt_b	ns	554	554	554	554	554
RMS bunch length	σ_z	μm	300	300	300	300	300
Normalized horizontal emittance at IP	$\gamma\epsilon_x$	μm	10	10	10	10	10
Normalized vertical emittance at IP	$\gamma\epsilon_y$	nm	35	35	35	35	35
Horizontal beta function at IP	β_x^*	mm	16	14	13	16	11
Vertical beta function at IP	β_y^*	mm	0.34	0.38	0.41	0.34	0.48
RMS horizontal beam size at IP	σ_x^*	nm	904	789	729	684	474
RMS vertical beam size at IP	σ_y^*	nm	7.8	7.7	7.7	5.9	5.9
Vertical disruption parameter	D_y		24.3	24.5	24.5	24.3	24.6
Fractional RMS energy loss to beamstrahlung	δ_{BS}	%	0.65	0.83	0.97	1.9	4.5
Luminosity	L	$\times 10^{34}$ cm^{-2} s^{-1}	0.56	0.67	0.75	1.0	1.8
Fraction of L in top 1% E_{CM}	$L_{0.01}$	%	91	89	87	77	58
Electron polarisation	P_-	%	80	80	80	80	80
Positron polarisation	P_+	%	30	30	30	30	30
Electron relative energy spread at IP	$\Delta p/p$	%	0.20	0.19	0.19	0.16	0.13
Positron relative energy spread at IP	$\Delta p/p$	%	0.19	0.17	0.15	0.10	0.07

Upgradeable to 1 GeV – parameters sets also available

ILC TDR 2013

Volume 1 - Executive Summary



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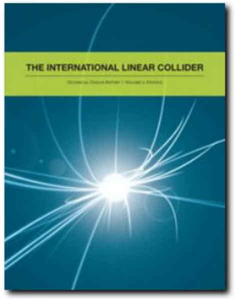
Volume 2 - Physics



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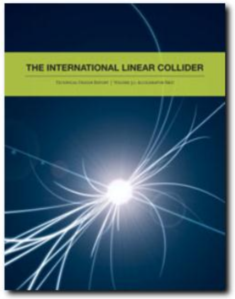
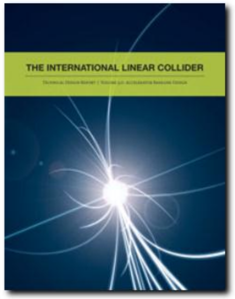
Volume 3 - Accelerator



Part I:
R&D in the Technical Design Phase

Download the pdf (91 MB)

Volume 3 - Accelerator



Part II:
Baseline Design

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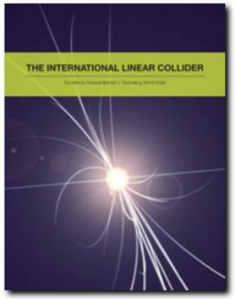
Volume 4 - Detectors



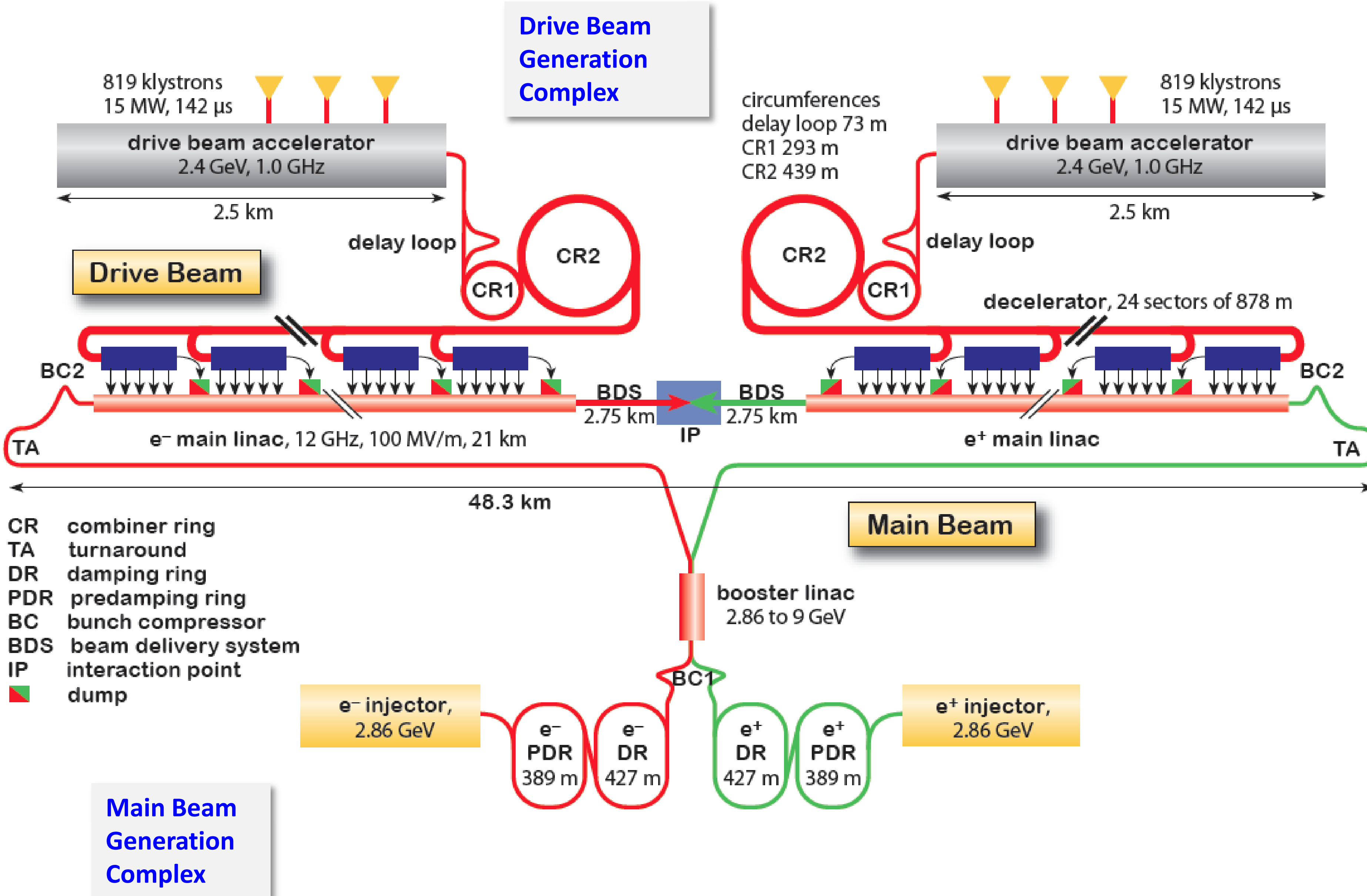
Download the pdf (66 MB)

From Design to Reality

Download the pdf (5.5 MB)
Visit the web site

http://www.linearcollider.org/ILC/Publications/Technical-Design-Report

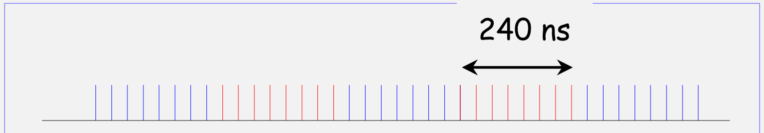
CLIC Layout at 3 TeV



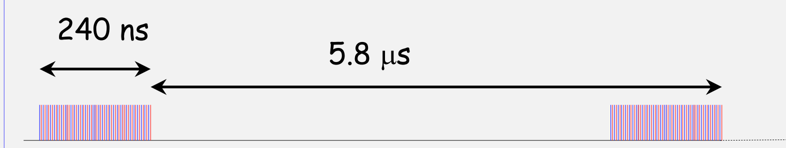
CLIC Layout at 3 TeV

Drive Beam Generation

Drive beam time structure - initial



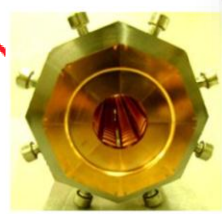
Drive beam time structure - final

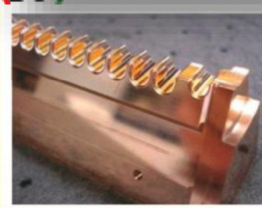


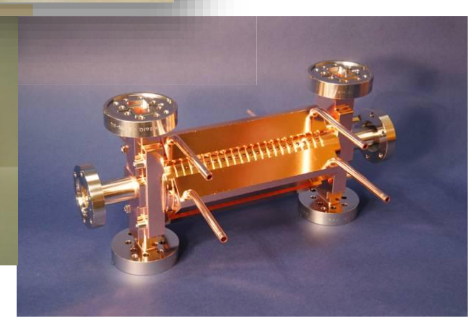
CR combiner ring
TA turnaround
DR damping ring
PDR predamping ring
BC bunch compressor
BDS beam delivery system
IP interaction point
dump

e⁻ injector, 2.86 GeV

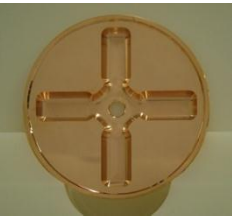
Main Beam Generation Complex

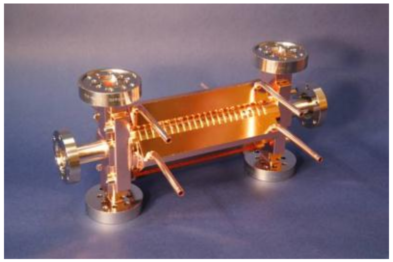






Possible CLIC stages studied in the CDR





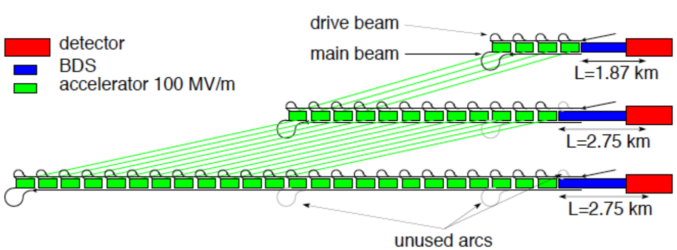


Fig. 3.6: Simplified upgrade scheme for CLIC staging scenario B.

Key features:

- High gradient (energy/length)
- Small beams (luminosity)
- Repetition rates and bunch spacing (experimental conditions)

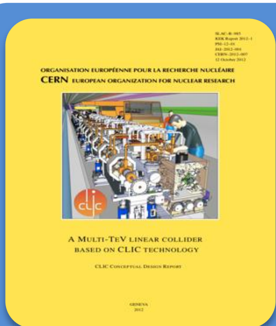
Table 1: Parameters for the CLIC energy stages of scenario A.

Parameter	Symbol	Unit	Stage 1	Stage 2	Stage 3
Centre-of-mass energy	$\sqrt{s}$	GeV	500	1400	3000
Repetition frequency	f_{rep}	Hz	50	50	50
Number of bunches per train	n_b		354	312	312
Bunch separation	Δt	ns	0.5	0.5	0.5
Accelerating gradient	G	MV/m	80	80/100	100
Total luminosity	$\mathscr{L}$	10^{34} cm^{-2}s^{-1}	2.3	3.2	5.9
Luminosity above 99% of $\sqrt{s}$	$\mathscr{L}_{0.01}$	10^{34} cm^{-2}s^{-1}	1.4	1.3	2
Main tunnel length		km	13.2	27.2	48.3
Charge per bunch	N	10^9	6.8	3.7	3.7
Bunch length	σ_z	μm	72	44	44
IP beam size	σ_x/σ_y	nm	200/2.6	~ 60/1.5	~ 40/1
Normalised emittance (end of linac)	$\varepsilon_x/\varepsilon_y$	nm	2350/20	660/20	660/20
Normalised emittance (IP)	$\varepsilon_x/\varepsilon_y$	nm	2400/25	—	—
Estimated power consumption	P_{wall}	MW	272	364	589

Table 2: Parameters for the CLIC energy stages of scenario B.

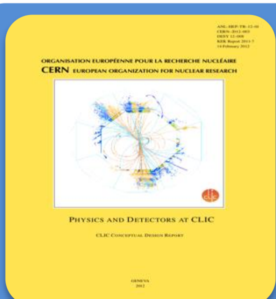
Parameter	Symbol	Unit	Stage 1	Stage 2	Stage 3
Centre-of-mass energy	$\sqrt{s}$	GeV	500	1500	3000
Repetition frequency	f_{rep}	Hz	50	50	50
Number of bunches per train	n_b		312	312	312
Bunch separation	Δt	ns	0.5	0.5	0.5
Accelerating gradient	G	MV/m	100	100	100
Total luminosity	$\mathscr{L}$	10^{34} cm^{-2}s^{-1}	1.3	3.7	5.9
Luminosity above 99% of $\sqrt{s}$	$\mathscr{L}_{0.01}$	10^{34} cm^{-2}s^{-1}	0.7	1.4	2
Main tunnel length		km	11.4	27.2	48.3
Charge per bunch	N	10^9	3.7	3.7	3.7
Bunch length	σ_z	μm	44	44	44
IP beam size	σ_x/σ_y	nm	100/2.6	~ 60/1.5	~ 40/1
Normalised emittance (end of linac)	$\varepsilon_x/\varepsilon_y$	nm	—	660/20	660/20
Normalised emittance	$\varepsilon_x/\varepsilon_y$	nm	660/25	—	—
Estimated power consumption	P_{wall}	MW	235	364	589

CDR 2013 -> input to strategy processes



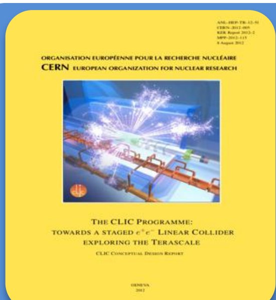
Vol 1: The CLIC accelerator and site facilities

- CLIC concept with exploration over multi-TeV energy range up to 3 TeV
- Feasibility study of CLIC parameters optimized at 3 TeV (most demanding)
- Consider also 500 GeV, and intermediate energy range
- https://edms.cern.ch/document/1234244/



Vol 2: Physics and detectors at CLIC

- Physics at a multi-TeV CLIC machine can be measured with high precision, despite challenging background conditions
- External review procedure in October 2011
- http://arxiv.org/pdf/1202.5940v1



Vol 3: “CLIC study summary”

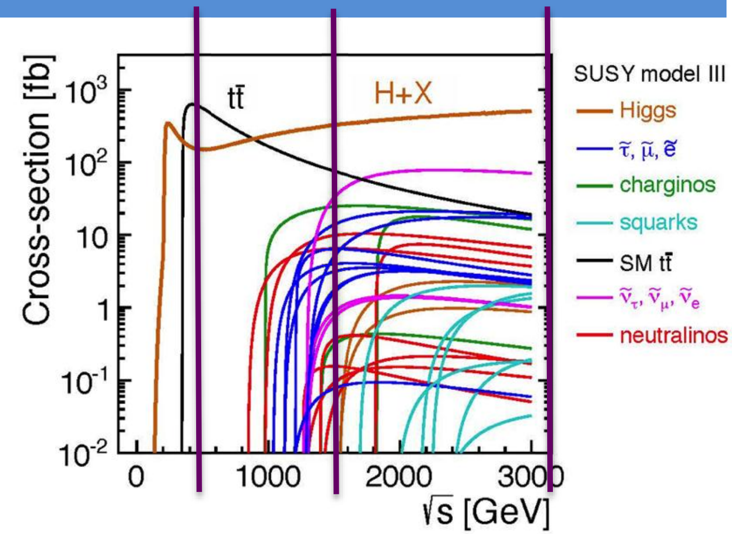
- Summary and available for the European Strategy process, including possible implementation stages for a CLIC machine as well as costing and cost-drives
- Proposing objectives and work plan of post CDR phase (2012-16)
- http://arxiv.org/pdf/1209.2543v1

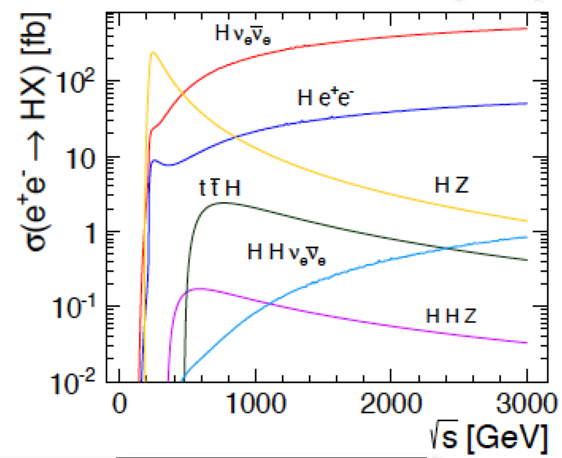
In addition a shorter overview document was submitted as input to the European Strategy update, available at: http://arxiv.org/pdf/1208.1402v1

Input documents to Snowmass 2013 has also been submitted: http://arxiv.org/abs/1305.5766 and http://arxiv.org/abs/1307.5288

Physics at LC from 250 GeV to 3000 GeV

- Physics case for the Linear Collider:
  - Higgs physics (SM and non-SM)
  - Top
  - SUSY
  - Higgs strong interactions
  - New Z' sector
  - Contact interactions
  - Extra dimensions
  - …. AOP (any other physics) …





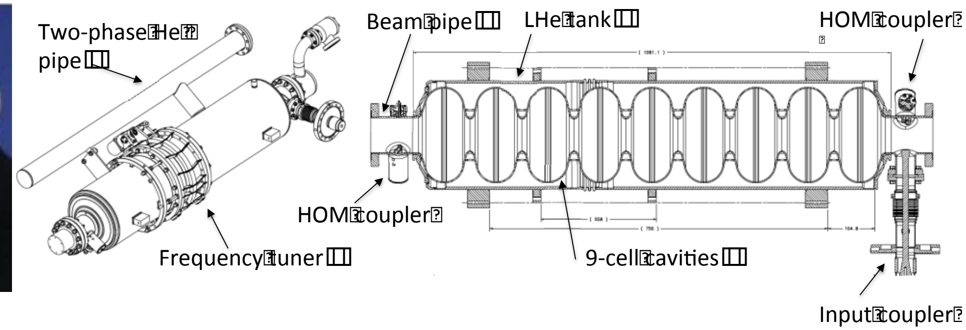
Specific challenges for CLIC studies:

- Need to address Higgs-studies, including gains for measurements at higher energies
- Reach for various "new physics" (list above) options; comparative studies with HiLumi LHC and proton-proton at higher energies (FCC).

New particle	LHC (14 TeV)	HL-LHC	CLIC3
squarks [TeV]	2.5	3	$\lesssim$1.5
sleptons [TeV]	0.3	-	$\lesssim$1.5
Z' (SM couplings) [TeV]	5	7	20
2 extra dims M_D [TeV]	9	12	20–30
TGC (95%) (λ_γ coupling)	0.001	0.0006	0.0001
μ contact scale [TeV]	15	-	60
Higgs composite scale [TeV]	5–7	9–12	70

Process	VLHC 200 TeV	CLIC 3 TeV	CLIC 5 TeV
squarks	15	1.5	2.5
sleptons		1.5	2.5
Z'	30	20	30
q^*	70	3	5
l^*		3	5
Extra two dimensions	65	20 – 33	30 – 55
$W_L W_L$	30σ	70σ	90σ
TGC (95%)	0.0003	0.00013	0.00008
Λ compos.	130	300	400

ILC: SCRF Linac Technology



1.3 GHz Nb 9-cellCavities	16,024
Cryomodules	1,855
SC quadrupole pkg	673
10 MW MB Klystrons & modulators	436 *

* site dependent

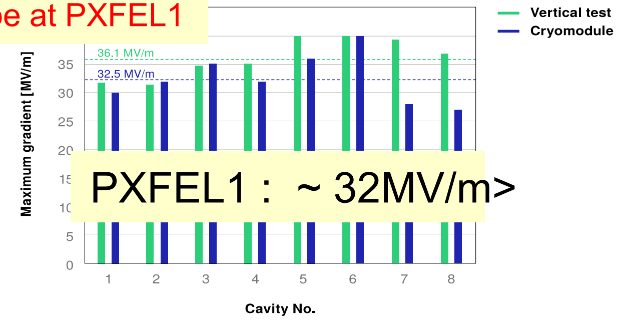
Approximately 20 years of R&D worldwide
→ Mature technology, overall design and cost

Cryomodule System Tests

DESY: FLASH

- 1.25 GeV linac (TESLA-Like tech.)
- ILC-like bunch trains:
- 600 ms, **9 mA** beam (2009); ← Demonstrated
  800 ms 4.5 mA (2012)
- RF-cryomodule string with beam → PXFEL1 operational at FLASH

XFEL Prototype at PXFEL1

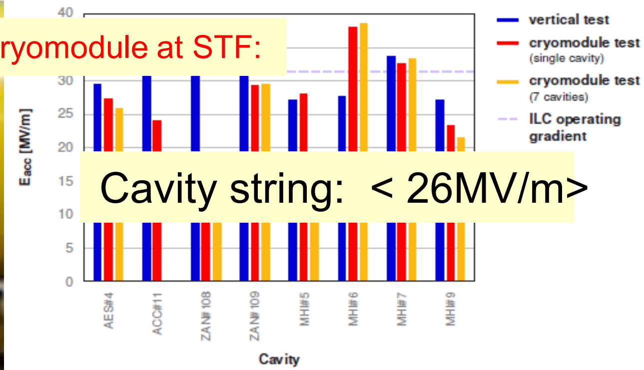


PXFEL1 : ~ 32MV/m>

KEK: STF/STF2

- S1-Global: completed (2010)
- Quantum Beam Accelerator (Inverse Llaser Compton): 6.7 mA, **1 ms** ← Demonstrated
- CM1 test with beam (2014 ~2015)
- STF-COI: Facility to demonstrate CM assembly/test in near future

S1 Global Cryomodule at STF:



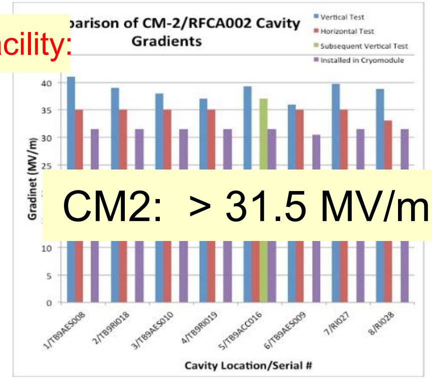
Cavity string: < 26MV/m>

FNAL: ASTA

(Advanced Superconducting Test Accelerator)

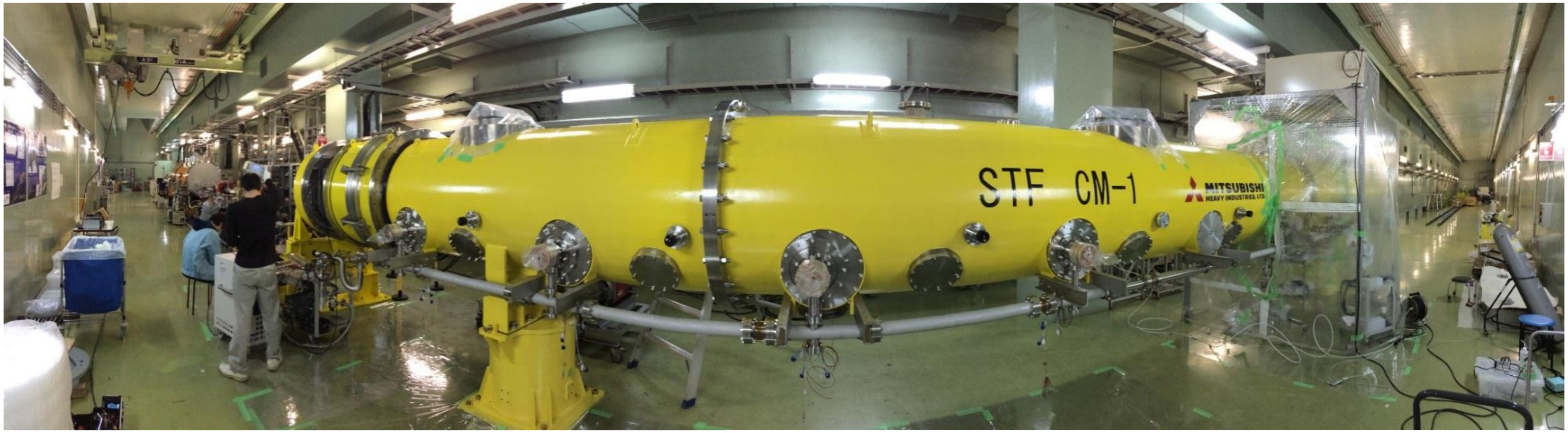
- CM1 test complete
- CM2 operation (2013)
- CM2 with beam (soon)

CM2 at NML Facility:



CM2: > 31.5 MV/m>

Technology: STF cryostring - KEK



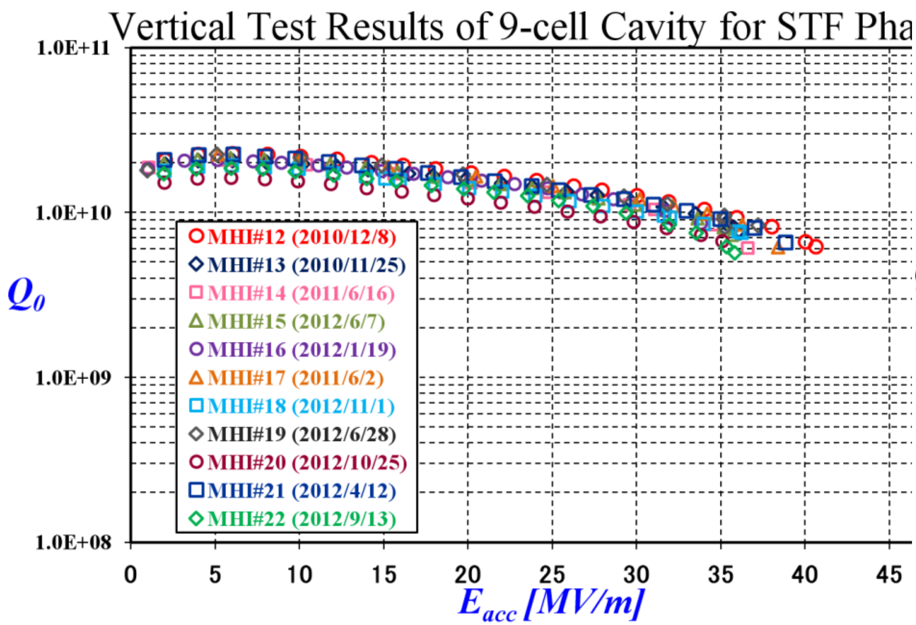
2011 disassemble S1-Global,
start construction of STF accelerator(Injector + QB)

2012 Feb: QB accelerator commissioning
Apr: beam acceleration
Jun: beam focus for Laser-Compton
Jul to Mar: experiment of Laser-Compton (QB)

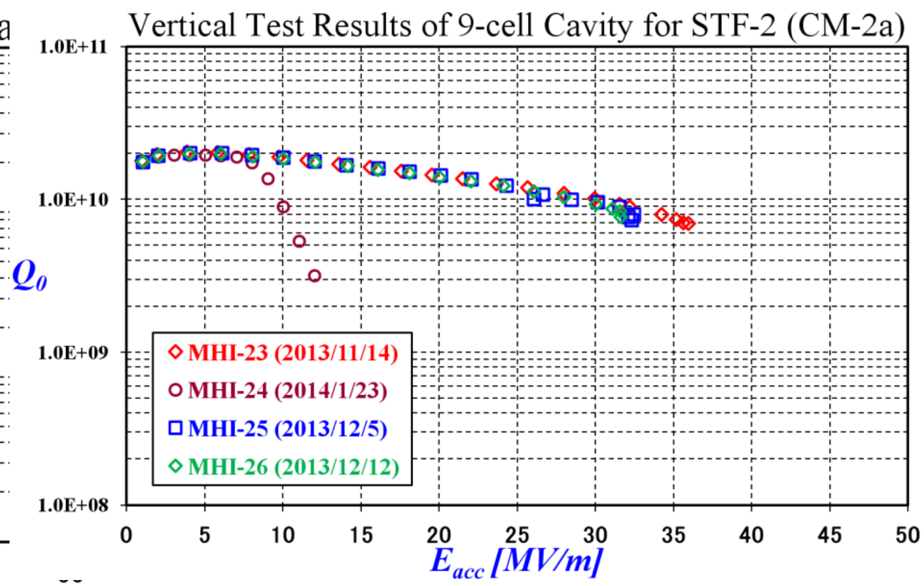
2013 Apr: disassemble Laser-Compton
start installation of CM-1
Sep: two set of 4-cavity train completed
Oct: Cryomodule assembly in STF tunnel
Dec: CM-1 completed

2014 Apr: start CM-2a assembly
Jul: CM-1 and CM-2a connection will be completed
Oct: Cool-down test

Technology: STF cryostring - KEK



CM-1



CM-2a

A High Performance cryostring

Progress in 1.3 GHz 9-cell Cavity Production

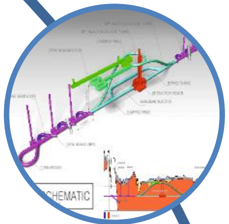
Year	Capable Lab.	Capable Industry
2006	1 DESY	2 ACCEL, ZANON
2011	4 DESY, JLAB, FNAL, KEK	4 RI, ZANON, AES, MHI,
2012	5 DESY, JLAB, FNAL, KEK, Cornell	5 RI, ZANON, AES, MHI, Hitachi

- One lab (2 vendors) in 2006
- 5 labs (5 vendors) in 2012 (maybe more)

ILC post TDR team: towards site specific design

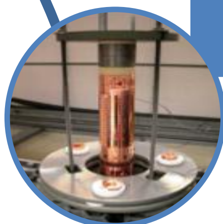
Category	Work-base	Specific subject	Global Collaboration w/
Positron Source		Positron source	PosiPol Collaboration
Nano Beam	ATF	37 nm beam 2 nm stability	ATF collaboration
SCRF Cavity Integration	STF	Power Input Coupler Tuner He-Vessel	CERN-DESY-KEK CEA-Fermi/SLAC-KEK DESY-KEK (WS at CERN? Autumn. 2014)
CM integration	STF, ILC	Conduction-cooled SC Quadrupole	Fermilab-KEK
Cryogenics	ILC	Cryog. Underground He inventry High p. Gas Safety	CERN-Fermilab-KEK (WS at CERN, 18 June)
CFS	ILC	CFS design prep.	CERN-Fermilab-KEK
Radiation Safety	ILC	ML radiation shield	SLAC-DESY-CERN-KEK

CLIC main activities (2013-19)



Parameters, Design and Implementation

- Integrated Baseline Design and Parameters
- Feedback Design, Background, Polarization
- Machine Protection & Operational Scenarios
- Electron and positron sources
- Damping Rings
- Ring-To-Main-Linac
- Main Linac - Two-Beam Acceleration
- Beam Delivery System
- Machine-Detector Interface (MDI
- Drive Beam Complex
- Cost, power, schedule, stages



X-band Technologies

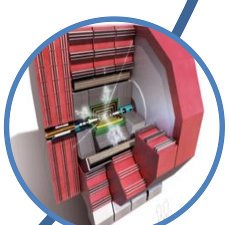
- X-band Rf structure Design
- X-band Rf structure Production
- X-band Rf structure High Power Testing
- Novel RF unit developments (high efficiency)
- Creation and Operation of x-band High power Testing Facilities
- Basic High Gradient R&D

Experimental verification

- Drive Beam phase feed-forward and feedbacks
- Two-Beam module string, test with beam
- Drive-beam front end including modulator development and injector
- Modulator development, magnet converters
- Drive Beam Photo Injector
- Low emittance ring tests
- Accelerator Beam System Tests (ATF and FACET, others)

Technical Developments

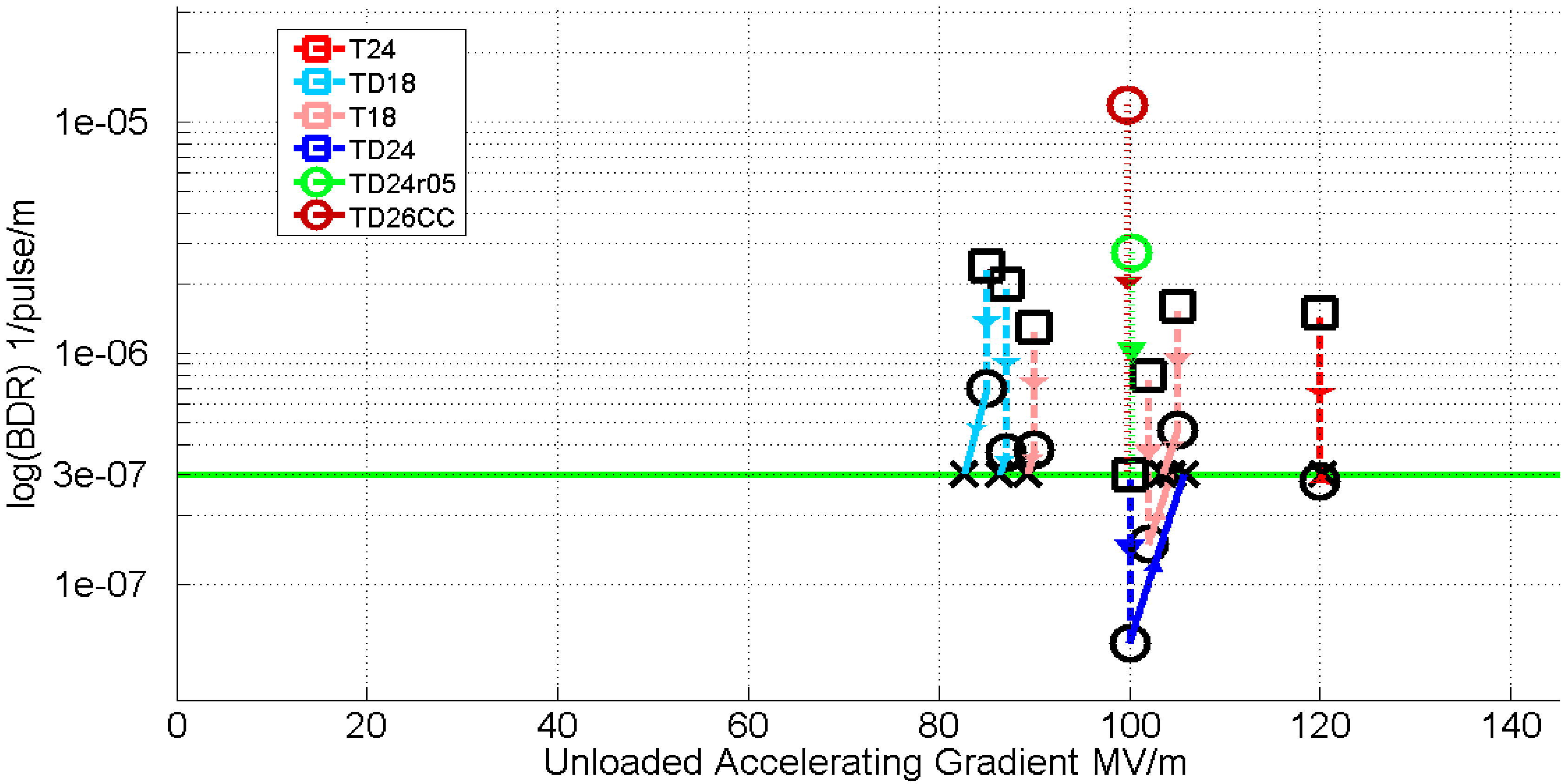
- Damping Rings Superconducting Wiggler
- Survey & Alignment
- Quadrupole Stability
- Warm Magnet Prototypes
- Beam Instrumentation and Control
- Two-Beam module development
- Beam Intercepting Devices
- Controls
- Vacuum Systems



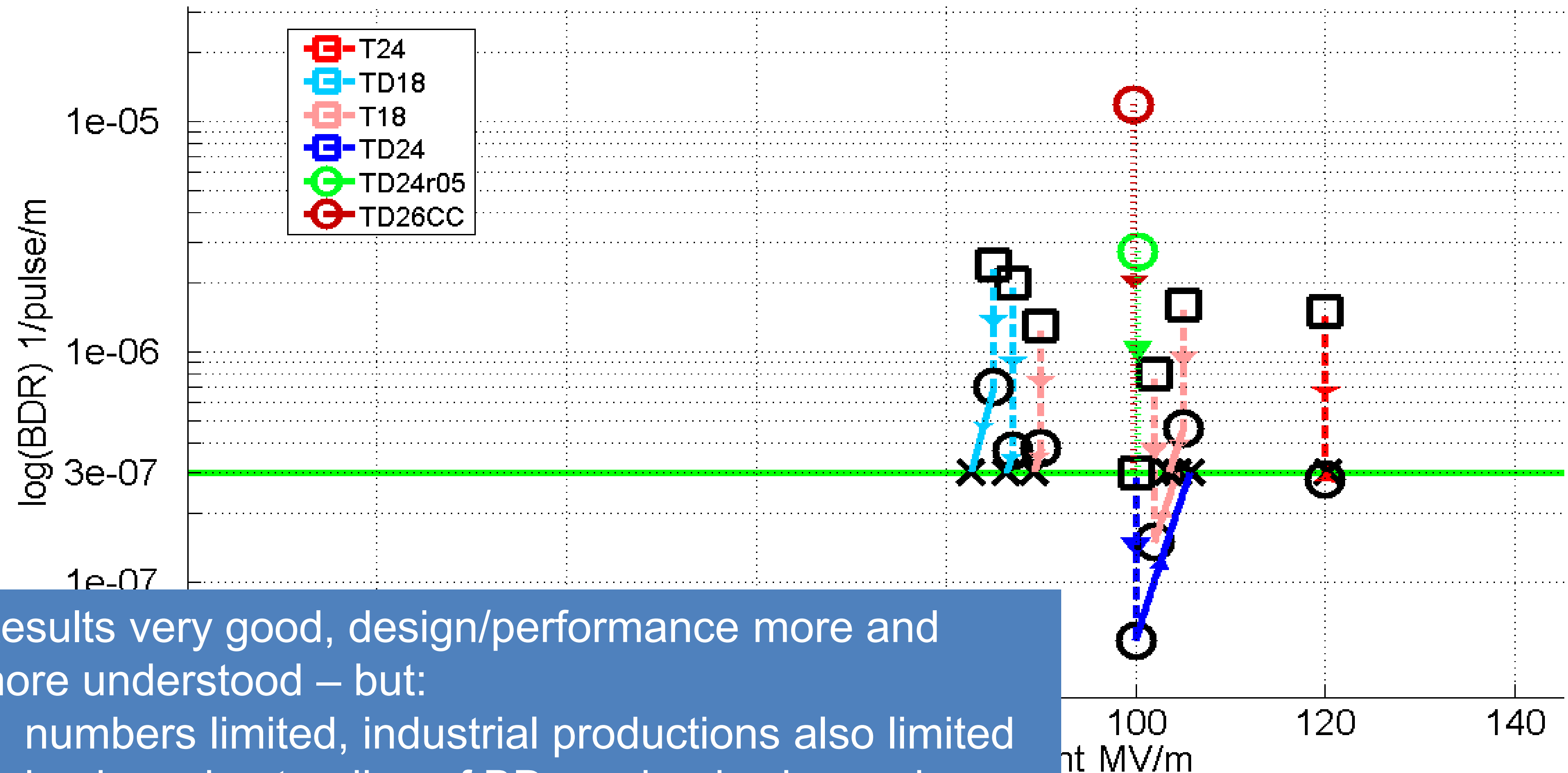
Detector and Physics

- Physics studies and benchmarking
- Detector optimisation
- Technical developments

High-gradient accel. structure test status



High-gradient accel. structure test status



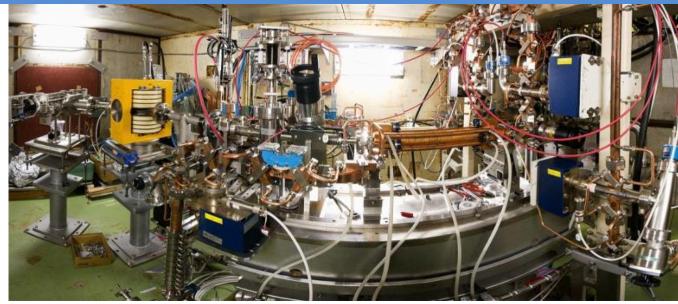
Results very good, design/performance more and more understood – but:

- numbers limited, industrial productions also limited
- basic understanding of BD mechanics improving
- condition time/acceptance tests need more work
- use for other applications (e.g. FELs) needs verification

In all cases test-capacity is crucial

X-band test-stands

Previous:
Scaled 11.4 GHz
tests at SLAC and KEK.

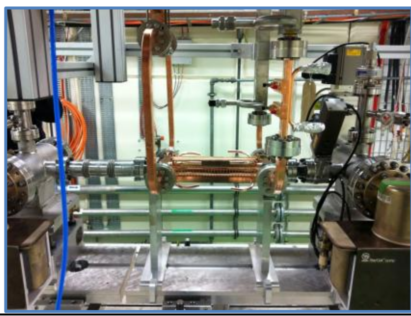


NEXTEF at KEK

ASTA at SLAC

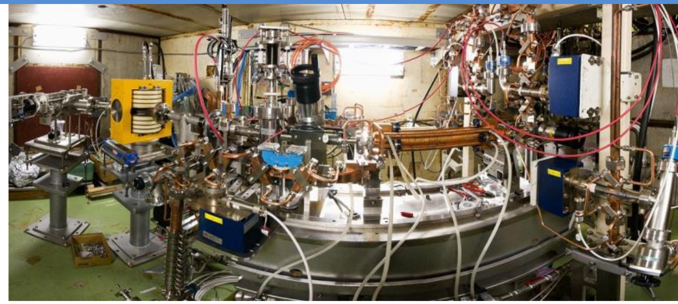
Clockwise from top-left:

- Modulator/klystron (50MW, 1.5us pulse)
- Pulse compressor (250ns, ratio 2.8)
- DUT + connections
- Acc. structure (TD26CC)



X-band test-stands

Previous:
Scaled 11.4 GHz
tests at SLAC and KEK.



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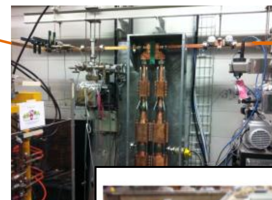

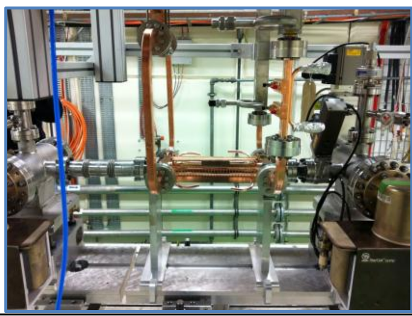

- Diode testing has started to commission modulator
- XL5 klystron installed inside the new modulator

- Waveguide network connected to klystron
  - Temporary module with pulse compressor, and load for commissioning

X-band test-stands

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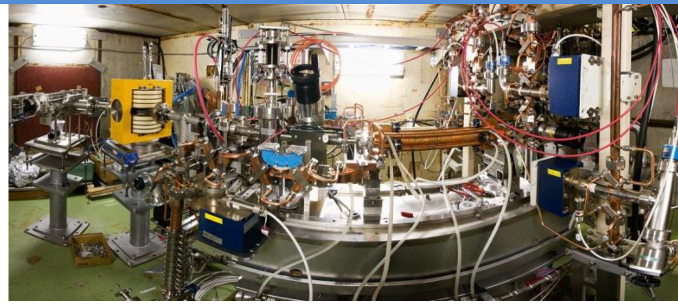

NEXTEF at KEK

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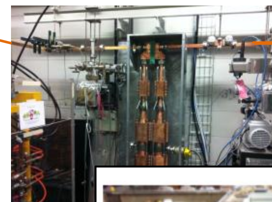

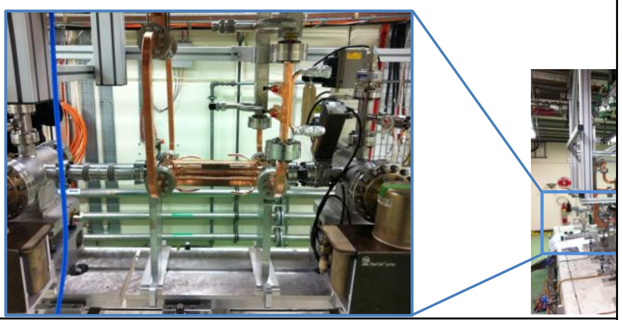

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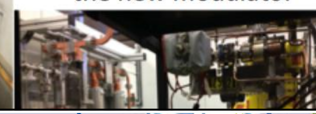

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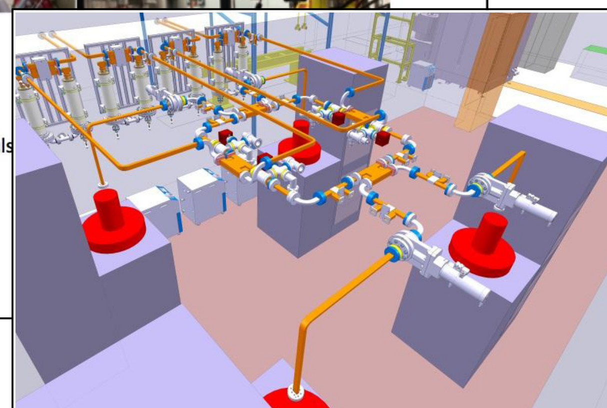
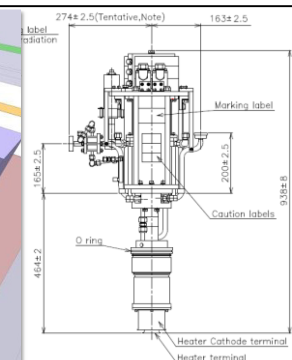




- 4 turn-key 6 MW, 11.9942 GHz, 400Hz power stations (klystron/modulator) have been ordered from industry.
- The first unit is scheduled to arrive at CERN in October 2014. The full delivery will be completed before July 2015.

Very significant increase of test-capacity
First commercial 12 GHz klystron systems becoming available
Confidence that one can design for good (and possibly better) gradient performance
As a result: now possible to use Xband technology in accelerator systems – at smaller scale

Example: 360GeV Cost vs. Bunch Charge

Automatic procedure scanning over many structures (parameter sets)

Structure design fixed by few parameters

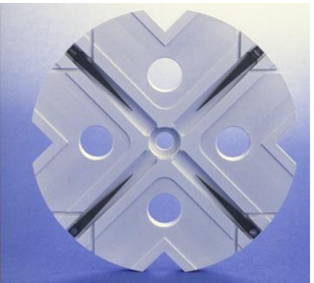
$a_1, a_2, d_1, d_2, N_c, f, G$

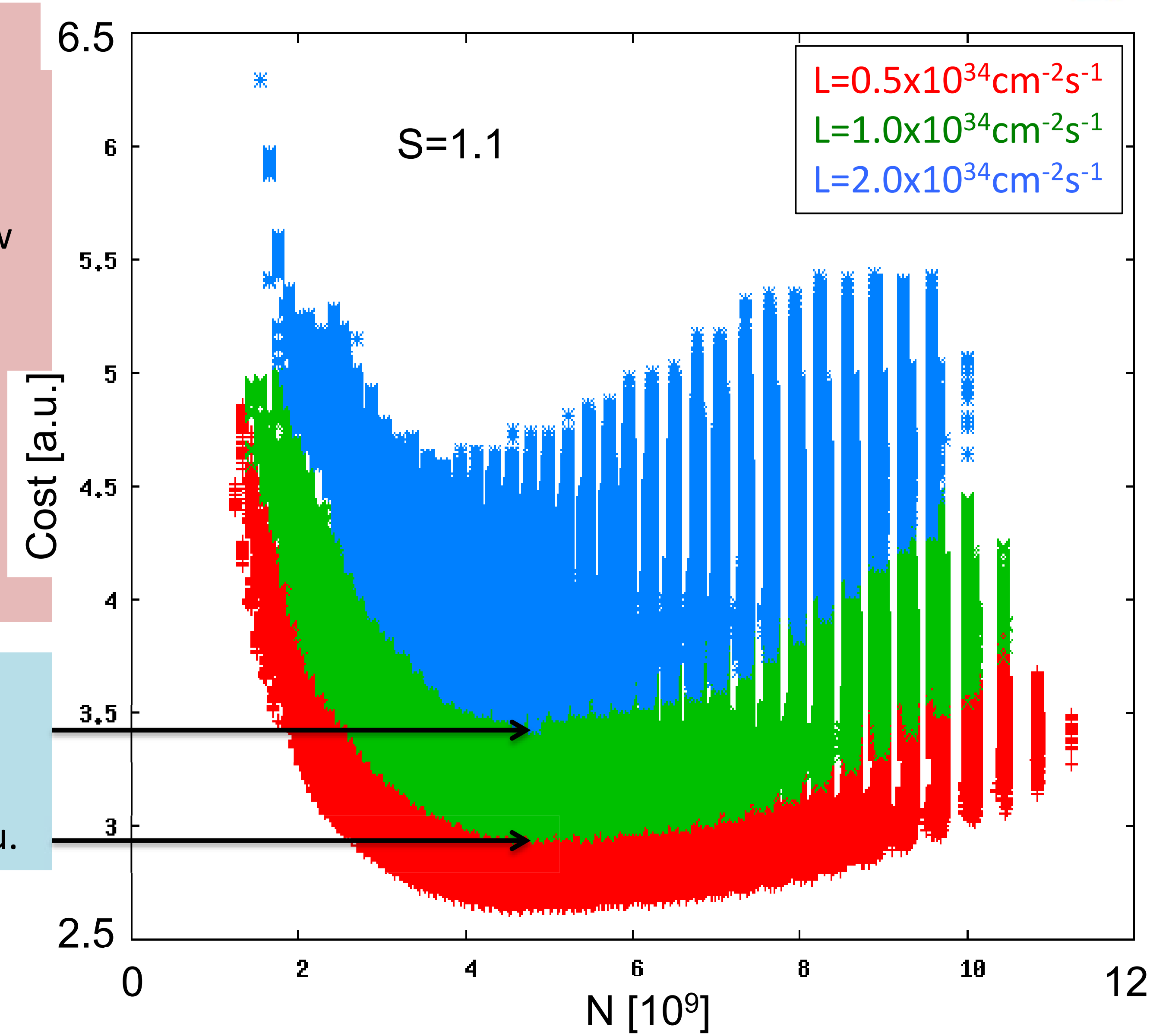
Beam parameters derived automatically

Cost calculated

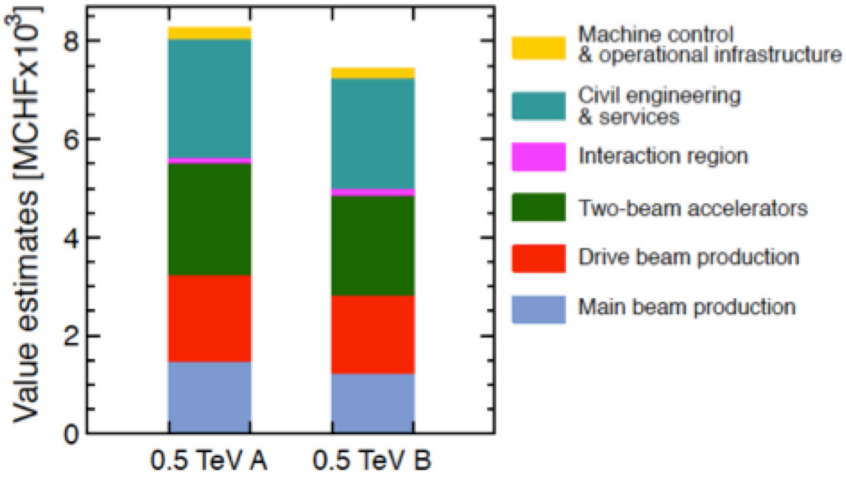
Luminosity goal significantly impact minimum cost

For $L=1 \times 10^{34} cm^{-2}s^{-1}$ to $L=2 \times 10^{34} cm^{-2}s^{-1}$ costs 0.5 a.u.





Developments for cost/power



First to second stage: 4 MCHF/GeV (i.e. initial costs are very significant)

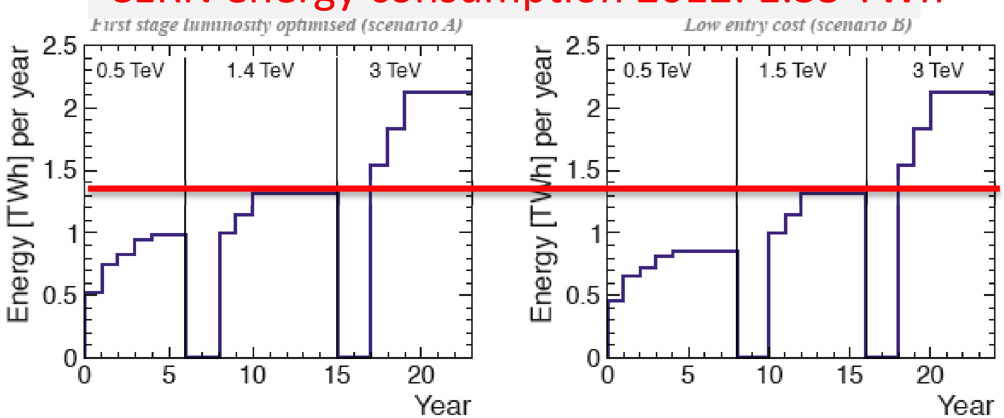
Caveats:

Uncertainties 20-25%

Possible savings around 10%

However – first stage not optimised (work for next phase), parameters largely defined for 3 TeV final stage

CERN energy consumption 2012: 1.35 TWh



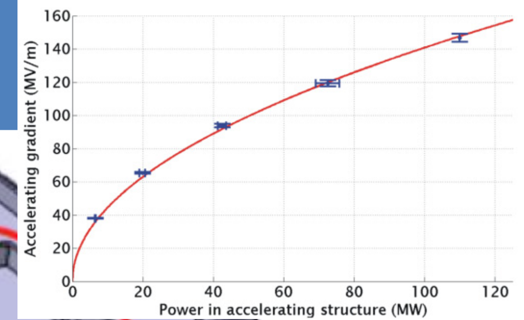
Beyond the parameter optimization there are other on-going developments (design/technical developments):

- Use of permanent or hybrid magnets for the drive beam (order of 50'000 magnets)
- Optimize drive beam accelerator klystron system
- Electron pre-damping ring can be removed with good electron injector
- Dimension drive beam accelerator building and infrastructure are for 3 TeV, dimension to 1.5 TeV results in large saving
- Systematic optimization of injector complex linacs in preparation
- Power consumption:
  - Optimize and reduce overhead estimates

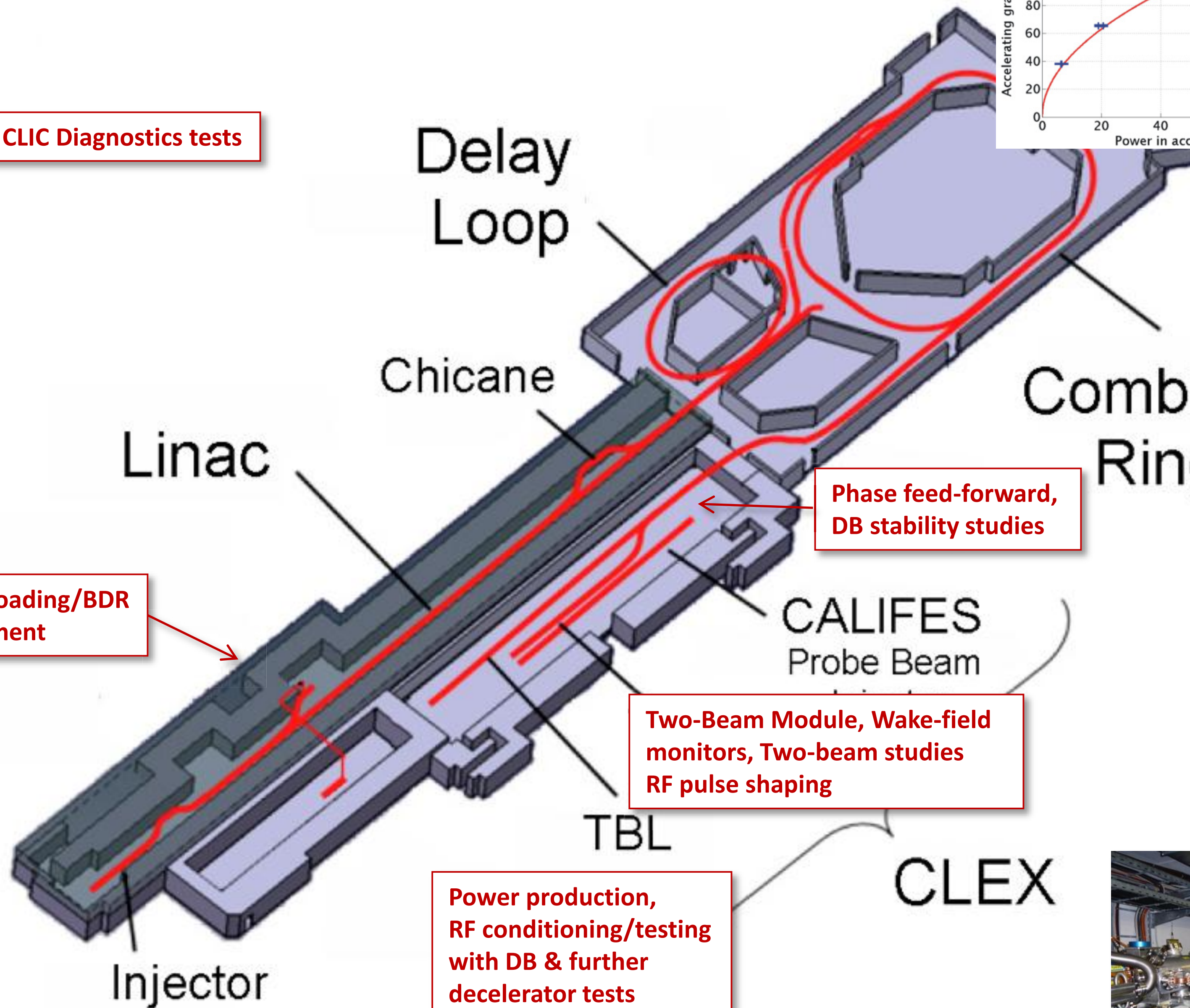
Goal:

- Rebaseline project at ~350 GeV, ~1.5 TeV, 3 Te
- Optimised cost and power for given luminosity
- End year – hopefully needed to redo with new LHC results at some point

CTF3 programme 2013-2016



CLIC Diagnostics tests



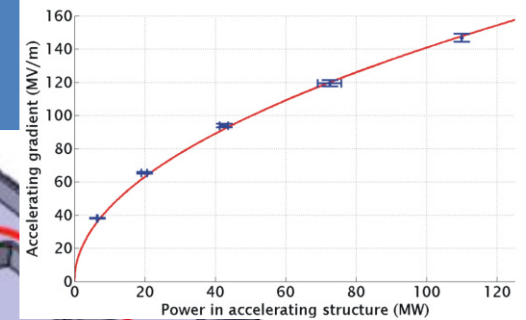
Phase feed-forward, DB stability studies

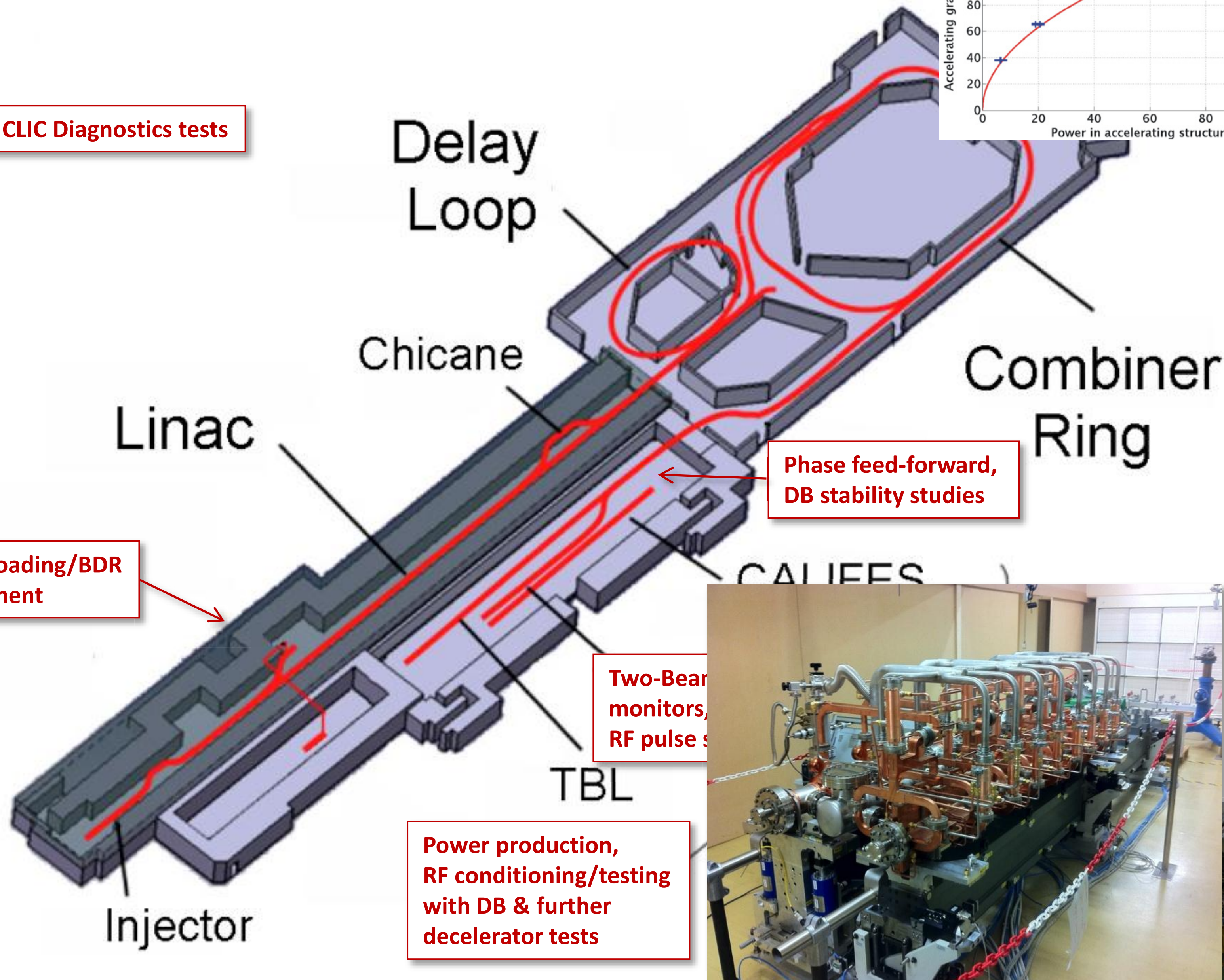
Beam loading/BDR experiment

Two-Beam Module, Wake-field monitors, Two-beam studies RF pulse shaping

Power production, RF conditioning/testing with DB & further decelerator tests

CTF3 programme 2013-2016





CLIC Diagnostics tests

Phase feed-forward, DB stability studies

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Two-Bear
monitors,
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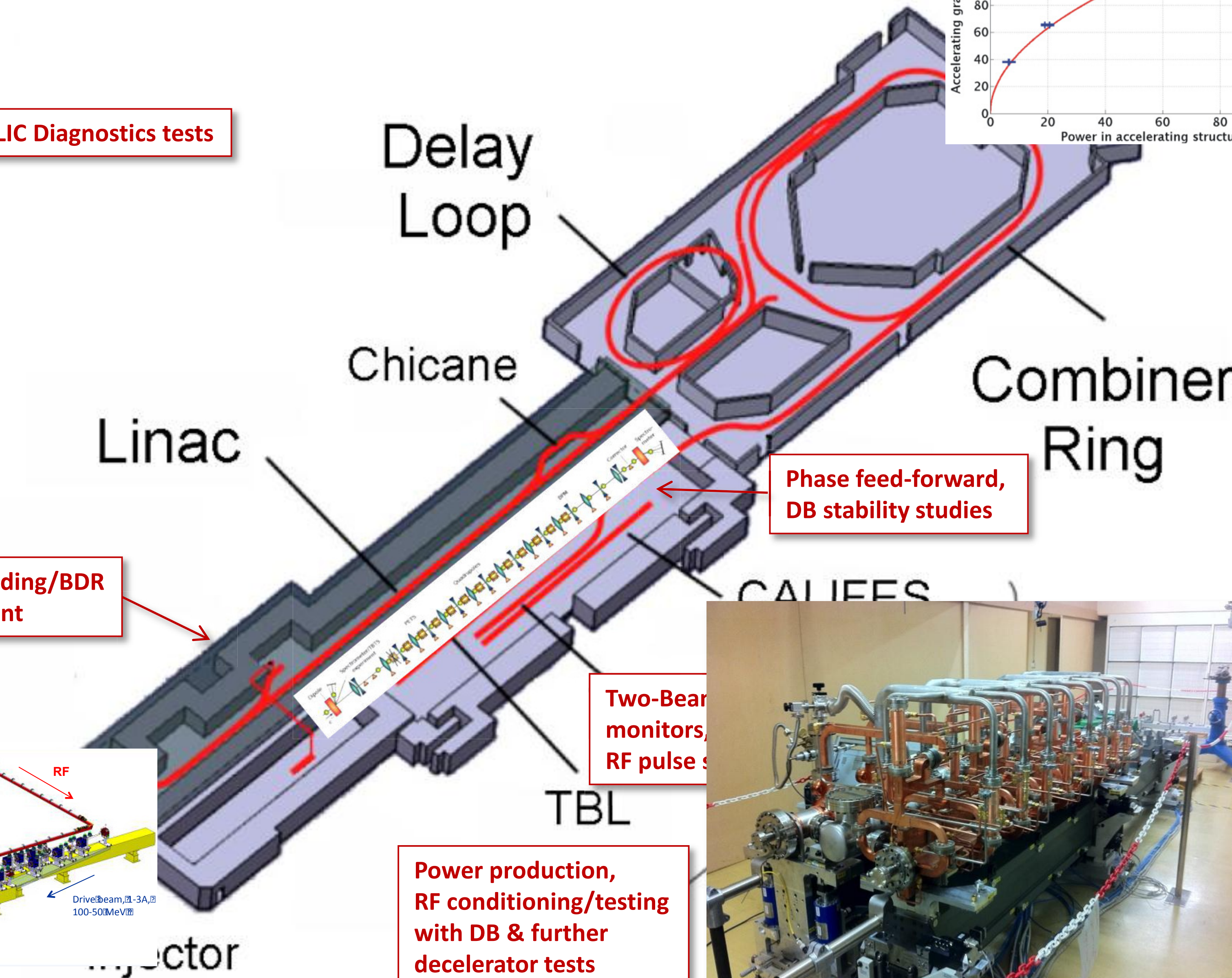
CTF3 programme 2013-2016



CLIC Diagnostics tests

Beam loading/BDR experiment

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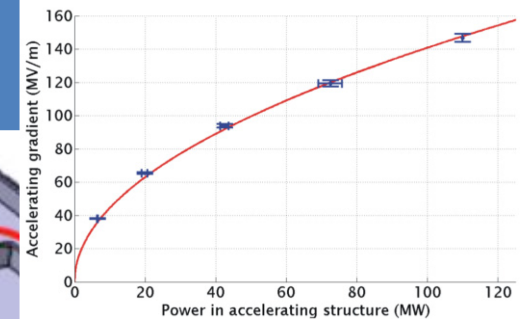
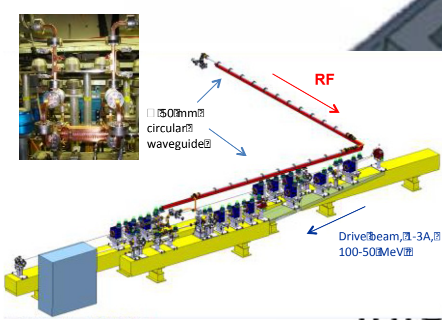
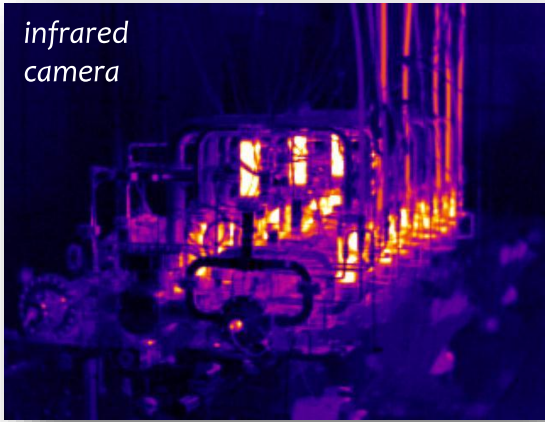


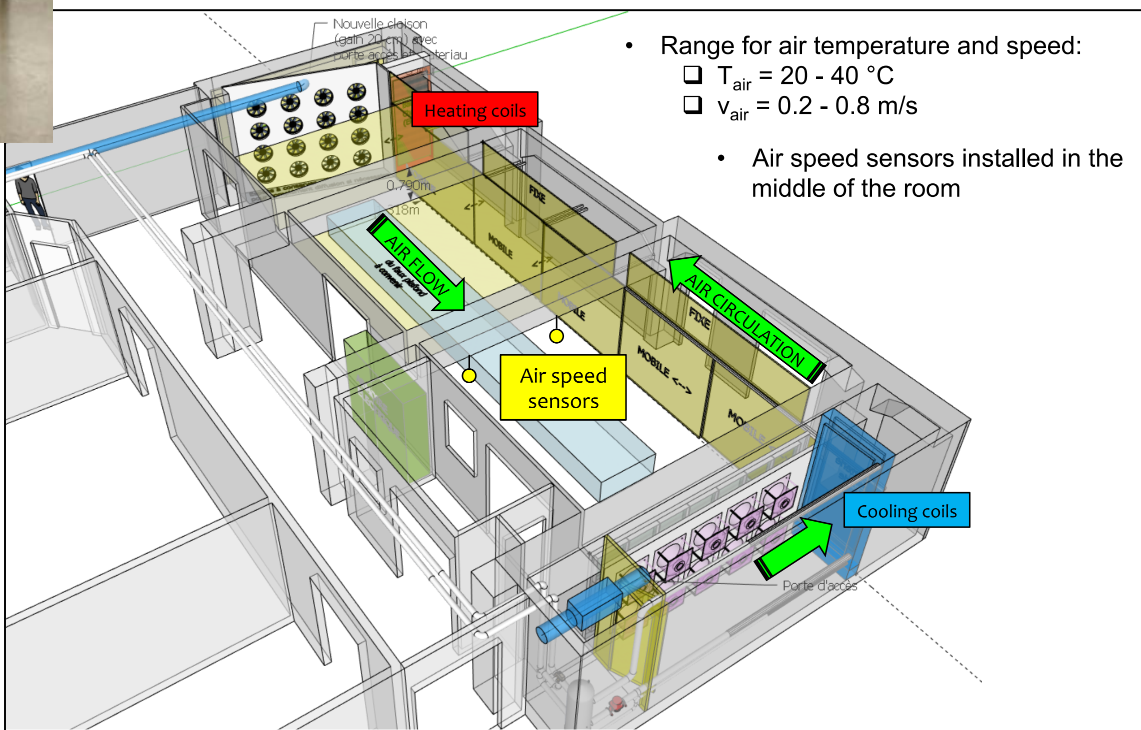


Technology example: CLIC module

- Test within laboratory (tunnel model with air flow)
- Test in CTF3 with beam (earlier slide)
- Transport test



- First module is under test, data under evaluation
- For second and third module many components have been received
- Tunnel environment modeled in experimental hall

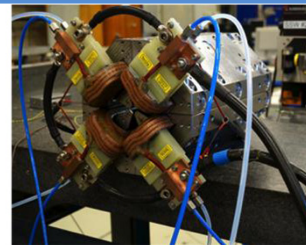


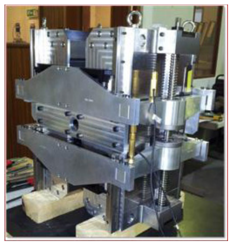
- Range for air temperature and speed:
  - ❑ T_{air} = 20 - 40 °C
  - ❑ v_{air} = 0.2 - 0.8 m/s
  - Air speed sensors installed in the middle of the room

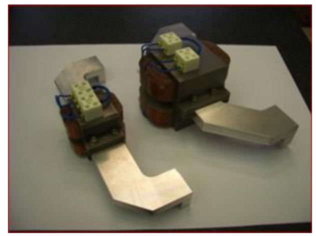
Technology examples: Magnets and Instrumentation

Magnet developments:

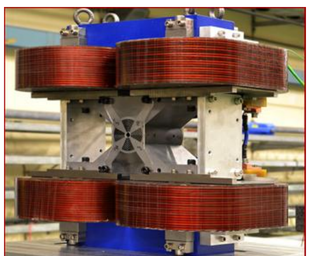
- Main Beam Quadrupole (MBQ)
- Drive Beam Quadrupoles (DBQ)
- Steering correctors

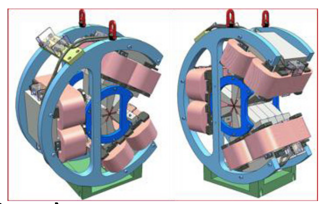




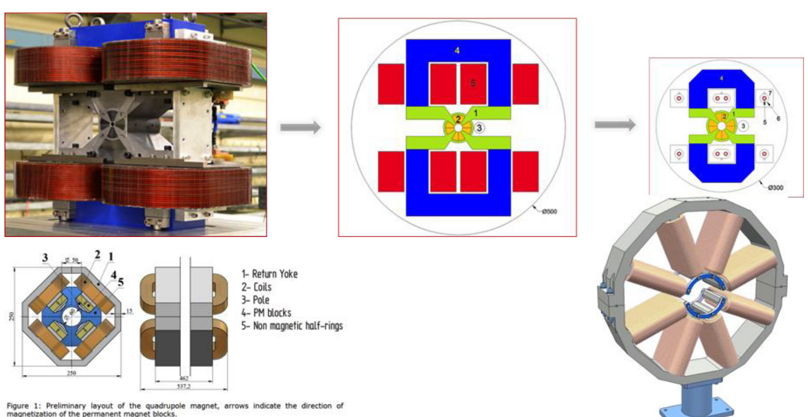


- QD0
- SD0

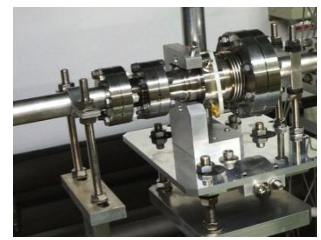




- Other studies (ILC and ATF studies)



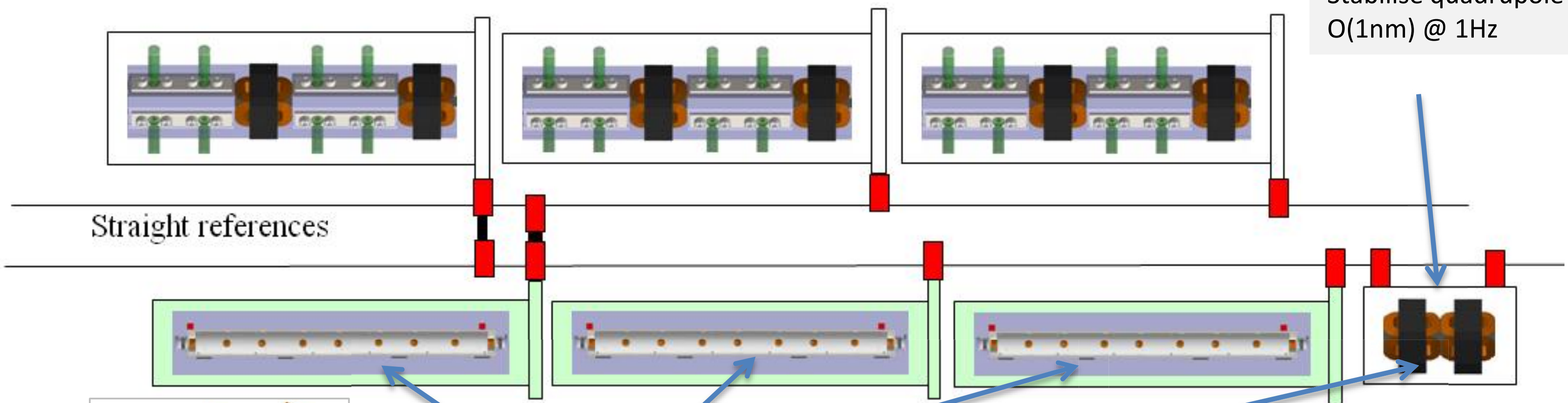
BI Type	CLIC-3-DB	CLIC-3-MB
Intensity	278	184
Position	46054	7187
Size	800	148
Energy (spread)	210 (210)	73 (23)
Bunch length	312	75
Beam loss / halo	45950	7790
Beam phase	208	96
Polarization		17
Tune		6
Luminosity		2



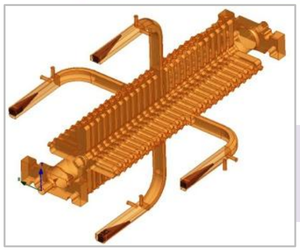
- Development of OTR/ODR simulation tools well advanced and experimental validation has already shown promising results
- Proposing future beam test at ATF2 of a combined OTR/ODR Linear collider beam size monitor
- EO SD commissioned successfully on Califes with time resolution and S/N ratio better than streak camera
- EO Transposition is currently being studied at Daresbury to provide 20fs resolution bunch length monitor
- R&D on CLIC BPMs is progressing well expecting with 2nd generation of BPM prototypes being built now
- CLIC BLM monitor are being tested intensively with the aim to select the best possible sensor with respect to sensitivity, time response and cost

Performance verifications – example CLIC

Stabilise quadrupole
O(1nm) @ 1Hz

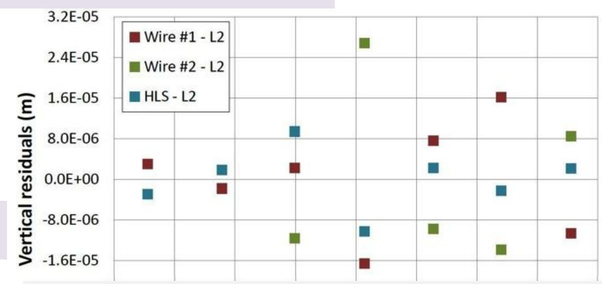


1) Pre-align BPMs+quads
accuracy O(10µm) over about 200m

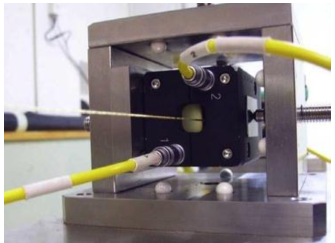


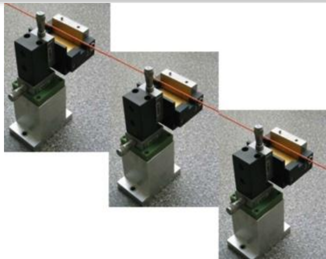
3) Use wake-field monitors accuracy
O(3.5µm) – CTF3

2) Beam-based alignment



- Test of prototype shows
  - vertical RMS error of 11µm
  - i.e. accuracy is approx. 13.5µm





Performance verifications – example CLIC

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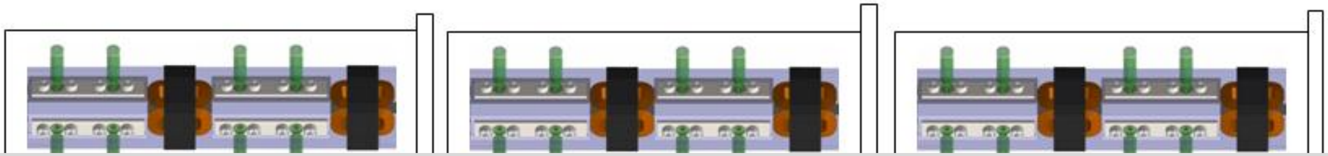
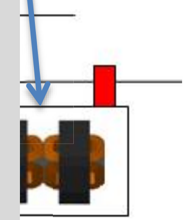
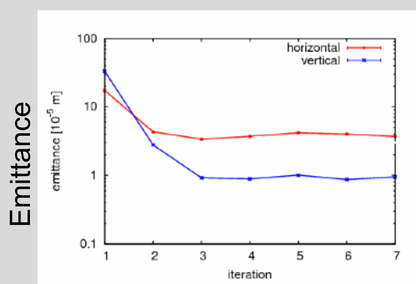
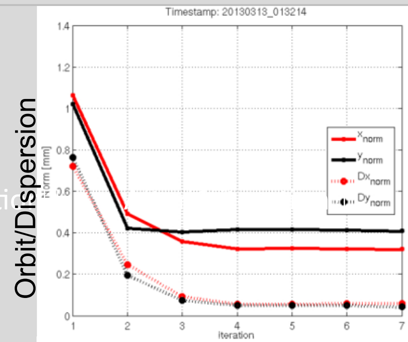
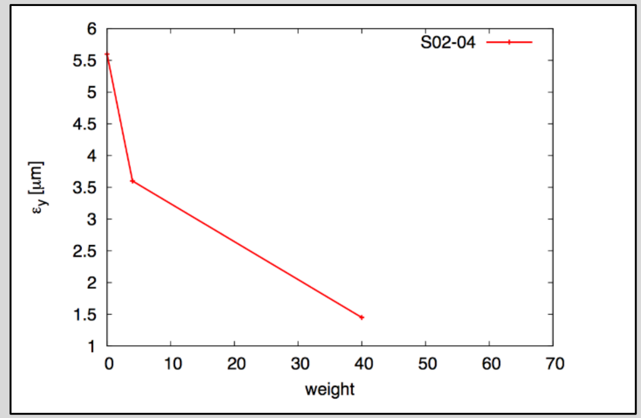




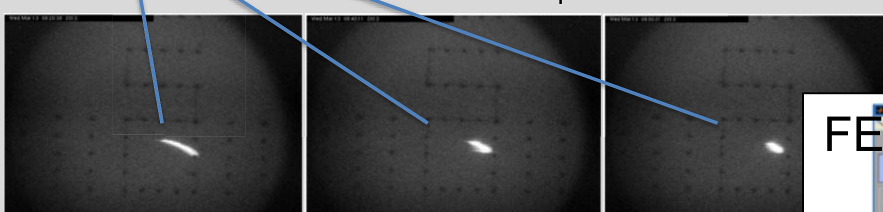
FACET (Dispersion-Free Steering and Wakefield-FS)

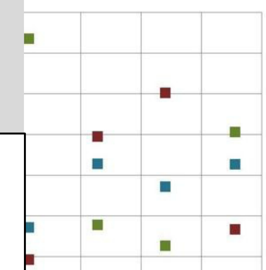






Beam profile measurement

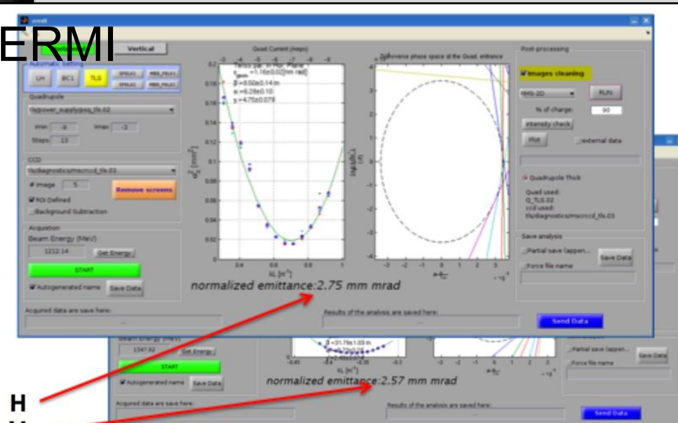


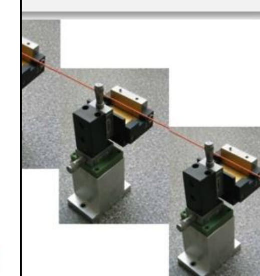


ror of 11µm
pprox. 13.5µm

More in this conference:
THPP034 – "Experimental Results of Beam-based Alignment Tests", A.Latina et al.

FERMI

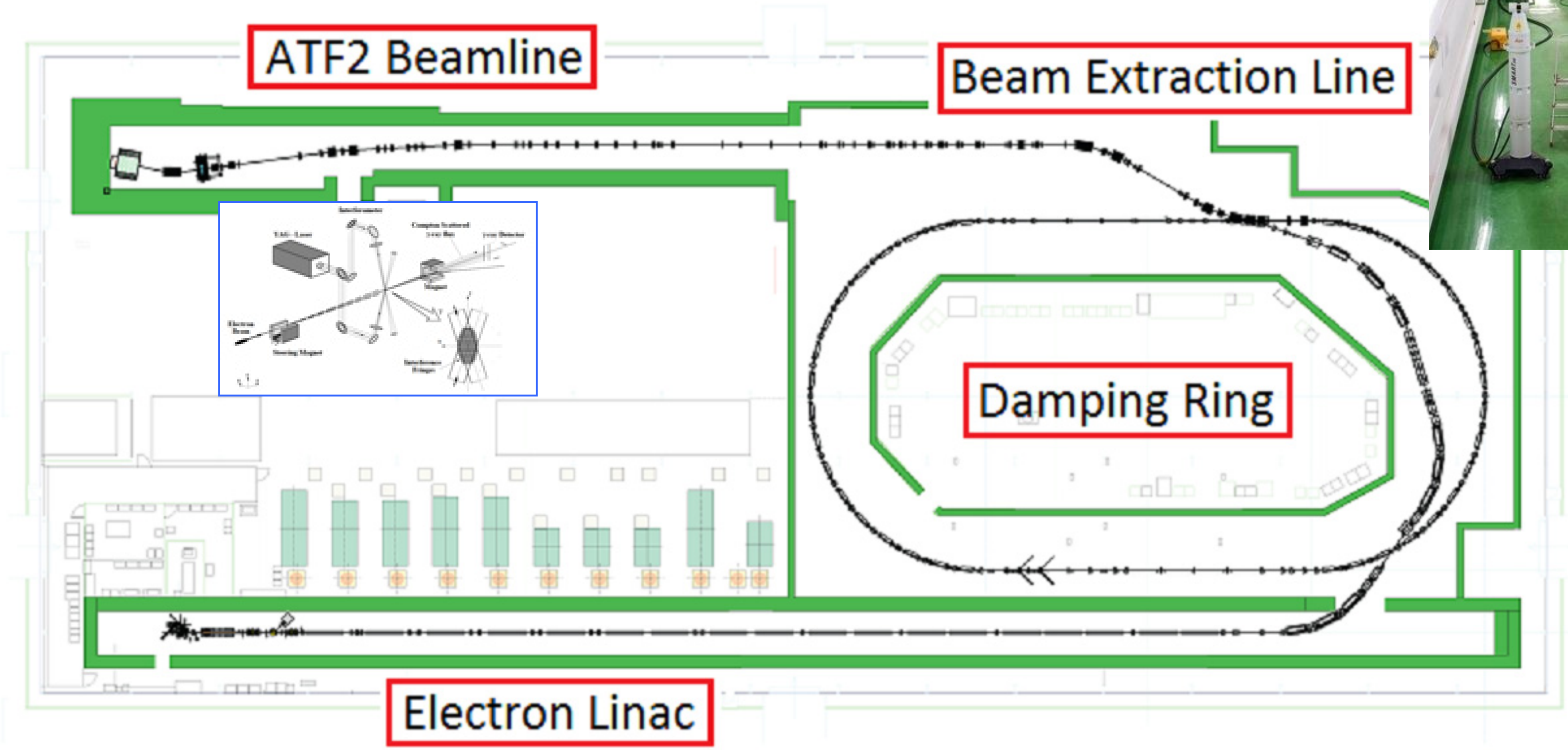


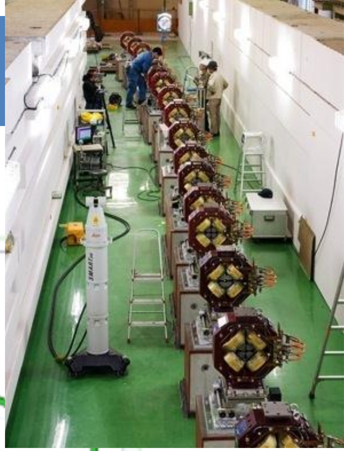


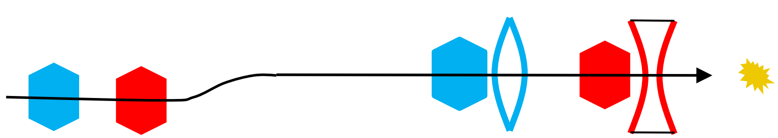
Emittance summary at Linac End: (H; V) *(measurement error: ~±0.05 mm mrad)*

Before correction:	(4.31; 3.21)	mm mrad
After DFS:	(3.30; -)	mm mrad
After DFS+WFS:	(2.75; 2.57)	mm mrad (-35% in X, -20% in Y)

Final focus: ATF 2 at KEK







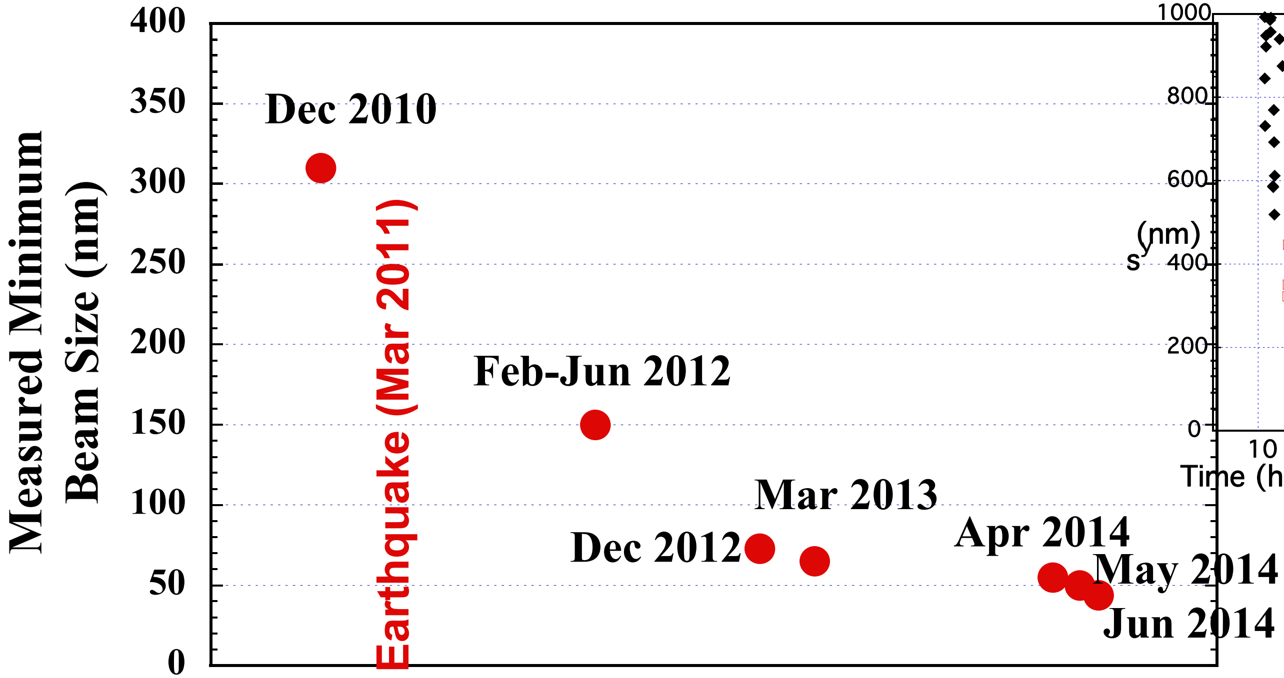
Local chromatic corrections

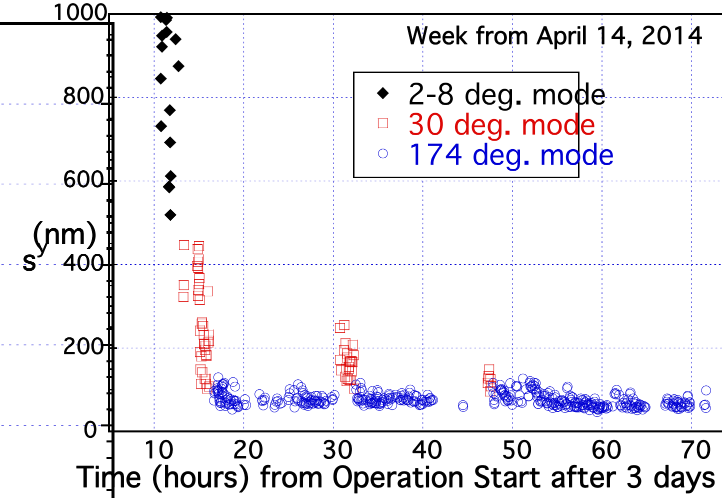
Similar optics, similar tolerances ATF and ILC

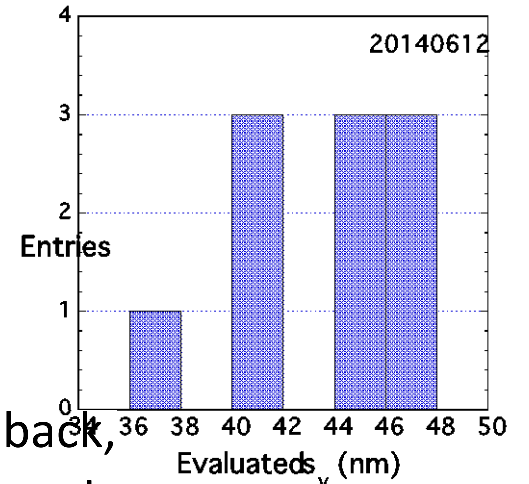
Goal 1: demonstrate optics, tunability

Goal 2: beam stabilisation through feedback

ATF-2 beam size development





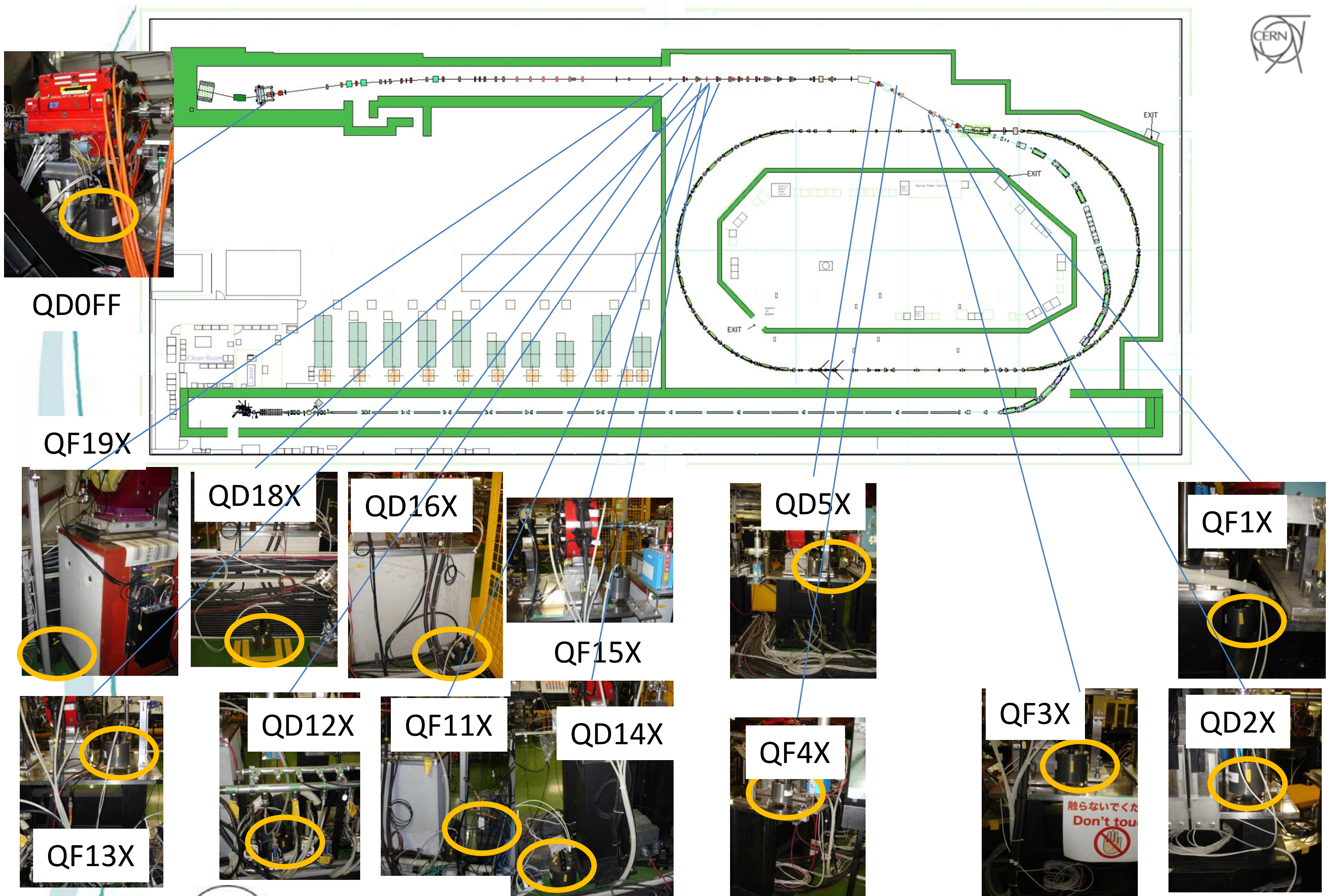


June: reaching 44 nm, very close to ILC goal
(37 nm corr. to 6nm at ILC)

Field quality improvements, orbit stabilisation through feedback, shorted turn in 6-pole magnet, beam size monitor improvements

ATF 2 Future program – next Run October

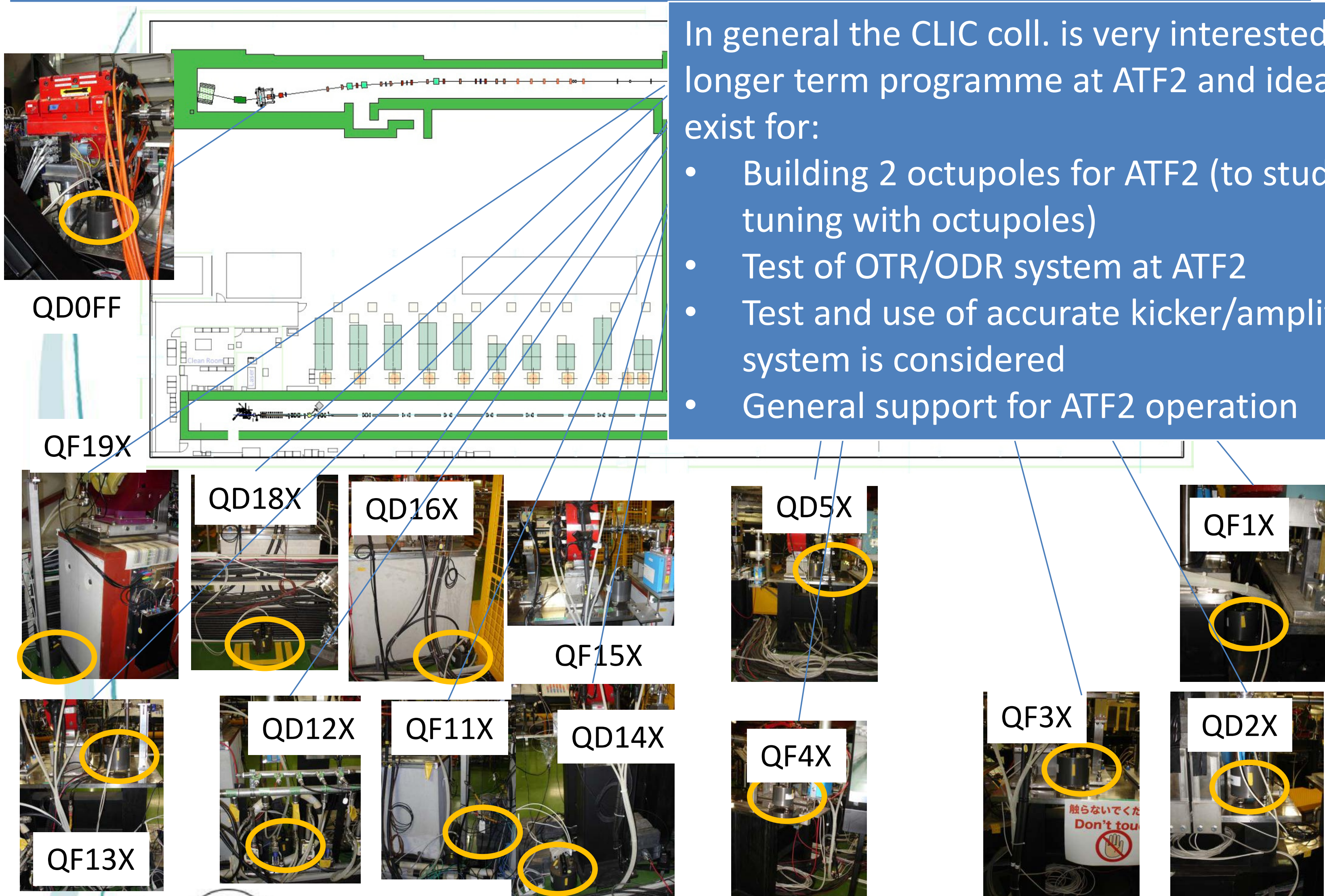
ATF2: Stabilisation Experiment



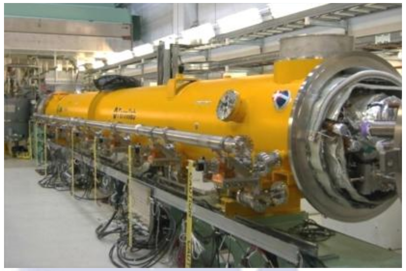
ATF2: Stabilisation Experiment

In general the CLIC coll. is very interested in a longer term programme at ATF2 and ideas exist for:

- Building 2 octupoles for ATF2 (to study FFS tuning with octupoles)
- Test of OTR/ODR system at ATF2
- Test and use of accurate kicker/amplifier system is considered
- General support for ATF2 operation



FEL linacs with SCRF modules



Largest deployment of this technology to date
- 100 cryomodules
- 800 cavities
- 17.5 GeV (pulsed)

Kitakami proposed site

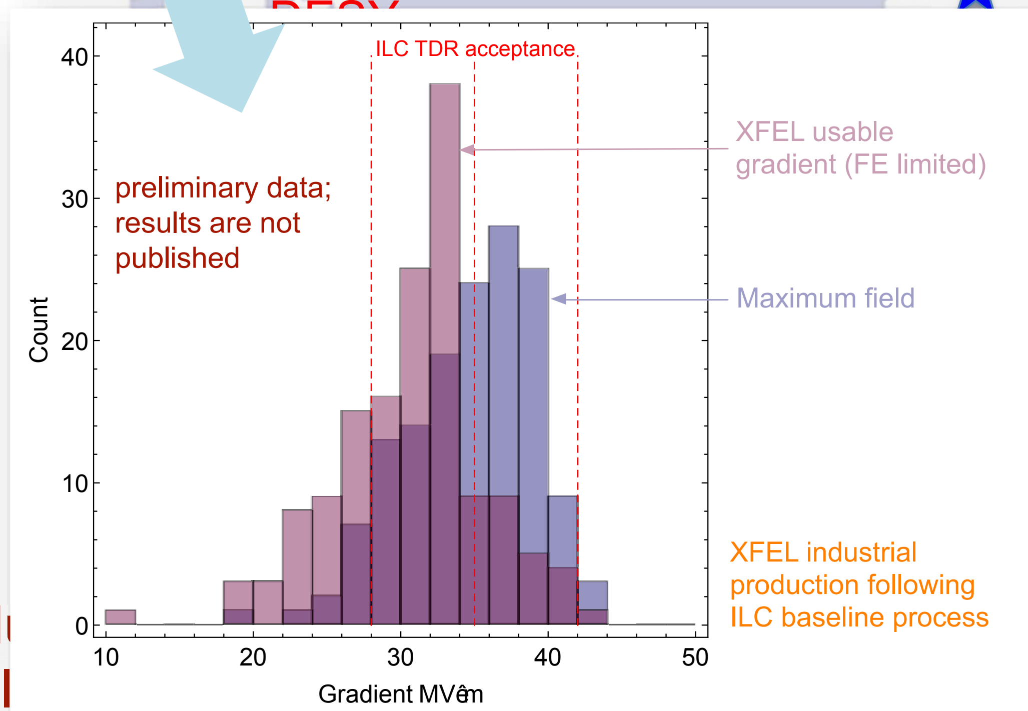
FNAL/ANL

SLAC

Cornell

JLab

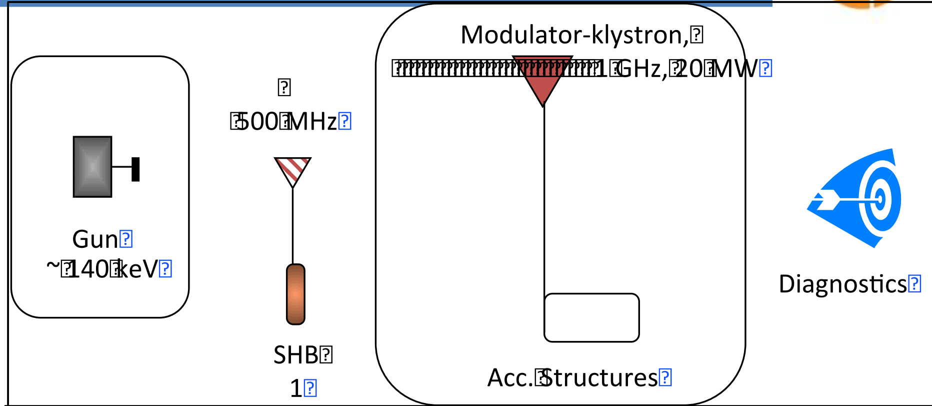
US infrastructure for
- 35 cryomodules
- 280 cavities
- 4 GeV (CW)



US and EU (industrial) produ
Perfectly placed for start of I
of this decade.

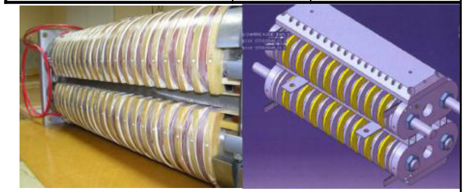
CLIC system tests beyond CTF3

- Drive beam development beyond CTF3
  - RF unit prototype with industry using CLIC frequency and parameters
  - Drive beam front-end (injector), to allow development into larger drivebeam facility beyond 2018
- Damping rings
  - Tests at existing damping rings, critical component development (e.g. wigglers) ... large common interests with light source laboratories
- Main beam (see slides later)
  - Steering tests at FACET, FERMI, ...
- Beam delivery system (see slide later)
  - ATF/ATF2



- Super-conducting wigglers
  - Demanding magnet technology combined with cryogenics and high heat load from synchrotron radiation (absorption)
- High frequency RF system
  - 1 GHz RF system respecting power and transient beam
- Coatings, chamber design and ultra-low vacuum
  - Electron cloud mitigation, low-impedance, fast-ion instability
- Kicker technology
  - Extracted beam stability
- Diagnostics for low emittance

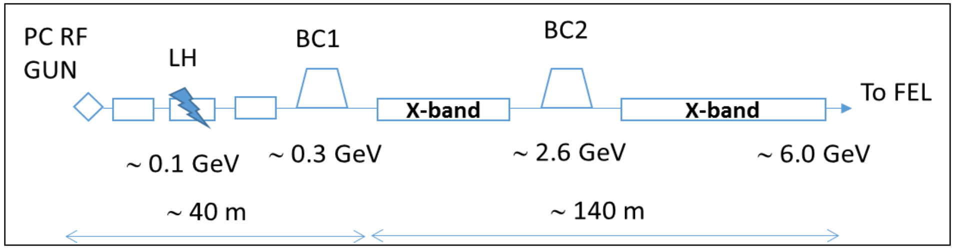
Parameters	BINP	CERN/Karlsruhe
B_{peak} [T]	2.5	2.8
λ_W [mm]	50	40
Beam aperture full gap [mm]	13	13
Conductor type	NbTi	$NbSn_3$
Operating temperature [K]	4.2	4.2

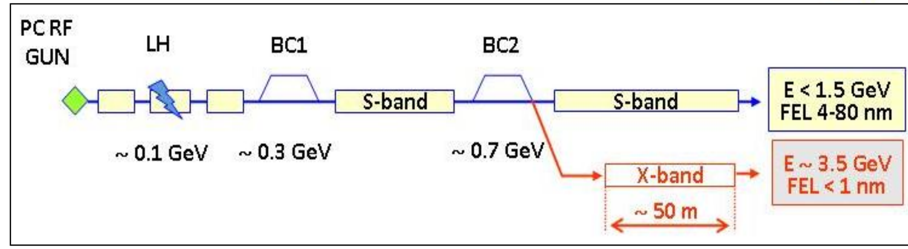


Experimental program set-up for measurements in storage rings and test facilities:

ALBA (Spain), ANKA (Germany), ATF (Japan), CESRTA (USA), ALS (Australia)...

Xband facilities - FELs

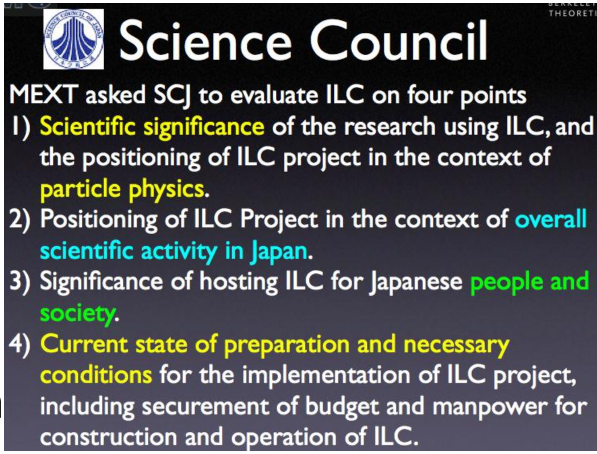




- X-band technology appears interesting for compact, relatively low cost FELs – new or extensions
  - Logical step after S-band and C-band
  - Example similar to SwissFEL: E=6 GeV, Ne=0.25 nC, σ_z=8μm
- Use of X-band in other projects will support industrialisation
  - They will be klystron-based, additional synergy with klystron-based first energy stage
- Started to collaborate on use of X-band in FELs
  - Australian Light Source, Turkish Accelerator Centre, Elettra, SINAP, Cockcroft Institute, TU Athens, U. Oslo, Uppsala University, CERN
- Share common work between partners
  - Cost model and optimisation
  - Beam dynamics, e.g. beam-based alignment
  - Accelerator systems, e.g. alignment, instrumentation…
- Define common standard solutions
  - Common RF component design, -> industry standard
  - High repetition rate klystrons (500Hz soon to be ordered for CLIC)

Great potential for collaboration (G.D'Auria et al., "X-band technology for FEL sources")

ILC Timeline



- **2013 - 2016**
  - Accelerator detailed design, R&Ds for cost-effective production, site study, CFS designs etc.
  - Negotiations among governments
  - Prepare for the international lab.
- **2016 – 2018**
  - 'Green-sign' for the ILC construction to be given (in ea 2016)
  - International agreement reached to go ahead with the ILC
  - Formation of the ILC lab.
  - Preparation for biddings etc.
- 2018
  - Construction start (9 yrs)
- 2027
  - Construction (500 GeV) complete, (and commissioning start)

  (250 GeV time-scale is slightly shorter)

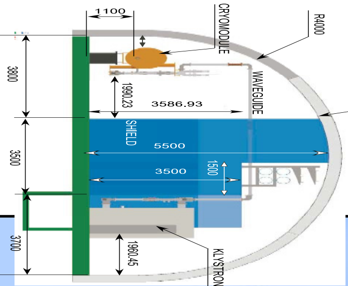
ILC Accelerator Organization

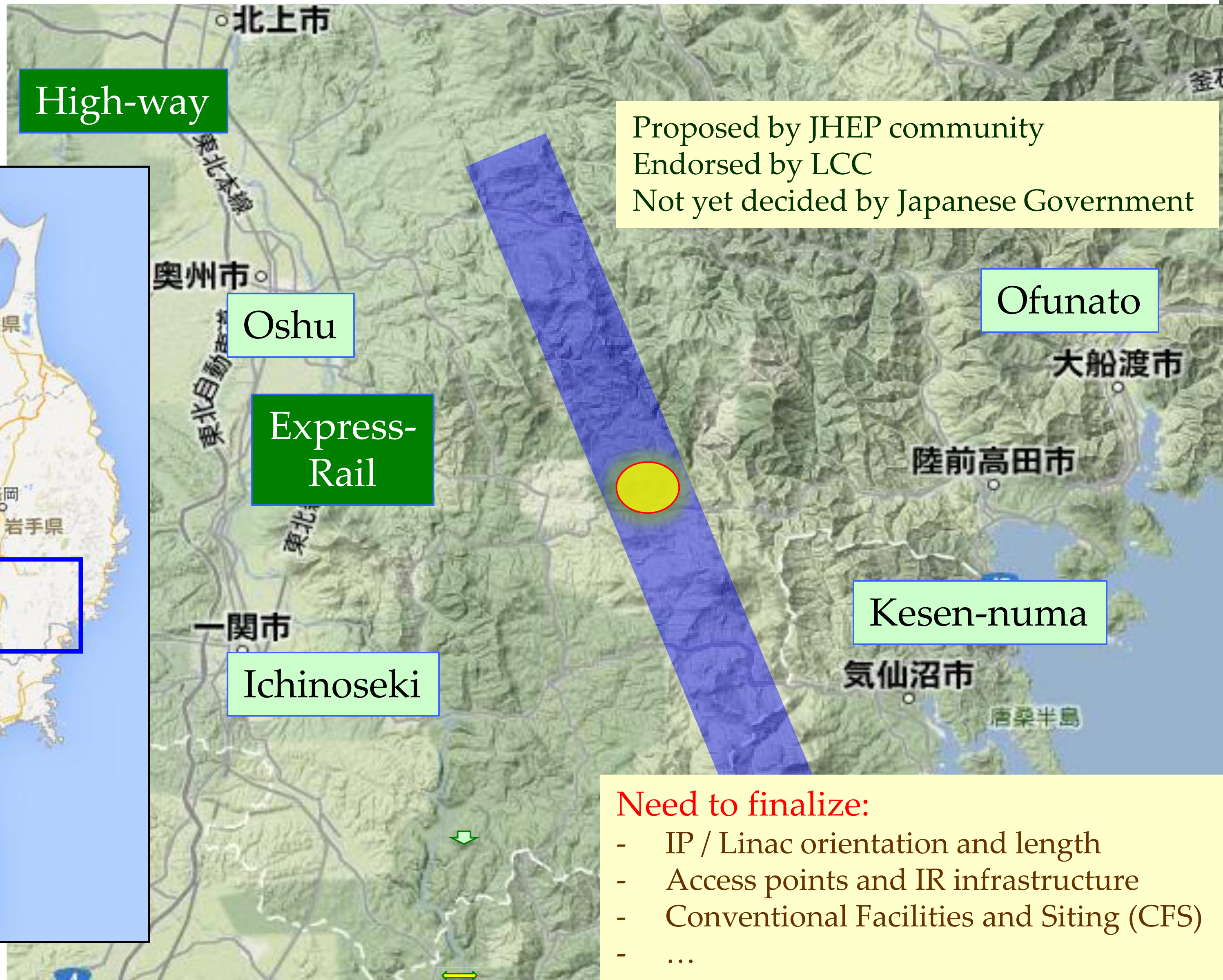
LCC-ILC Director: M. Harrison, Deputies: N. Walker and H. Hayano *KEK LC Project Office Head: A. Yamamoto

Sub-Group	Global Leader Deputy/Contact p.	KEK-Leader* Deputy	Sub-Group	Global Leader Deputy/Contact P.	KEK-Leader* Deputy
Acc. Design Integr.	**N. Walker (DESY)** K. Yokoya(KEK)	K. Yokoya	**SRF**	**H. Hayano (KEK)** C. Ginsburg (Fermi), E. Montesinos (CERN)	H. Hayano Y. Yamamoto
Sources (e-, e+)	**W. Gai (ANL)** M. Kuriki (Hiroshima U.)	J. Urakawa T. Omori	**RF Power & Cntl**	**S. Michizono (KEK)** TBD (AMs , EU)	Michizono T. Matsumoto
Damping Ring	**D. Rubin (Cornell)** N. Terunuma (KEK)	N. Terunuma	**Cryogenics** (incl. HP gas issues)	**H. Nakai: KEK** T. Peterson (Fermi), D. Delikaris (CERN)	H. Nakai Cryog. Center
RTML	**S. Kuroda (KEK)** A. Latina (CERN)	S. Kuroda	**CFS**	**A. Enomoto (KEK)** V. Kuchler (Fermi), J. Osborne (CERN),	A. Enomoto M. Miyahara
Main Linac (incl. B. Compr. & B. Dynamics)	**N. Solyak (Fermi)** K. Kubo (KEK)	K. Kubo	**Radiation Safety**	**T. Sanami (KEK)** TBD (AMs, EU)	T. Sanami T. Sanuki
BDS	**G. White (SLAC),** R. Tomas (Cern) T. Okugi (KEK)	T. Okugi	**Electrical Support** (Power Supply etc.)	TBD	TBD
MDI	**K. Buesser (DESY)** T. Tauchi (KEK)	T. Tauchi	**Mechanical S.** (Vac. & others)	TBD	TBD
			Domestic Program, Hub Lab. Facilities	TBD	H. Hayano T. Saeki

Site specific studies

Establish a site-specific Civil Engineering Design - map the (site independent) TDR baseline onto the preferred site - assuming "Kitakami" as a primary candidate



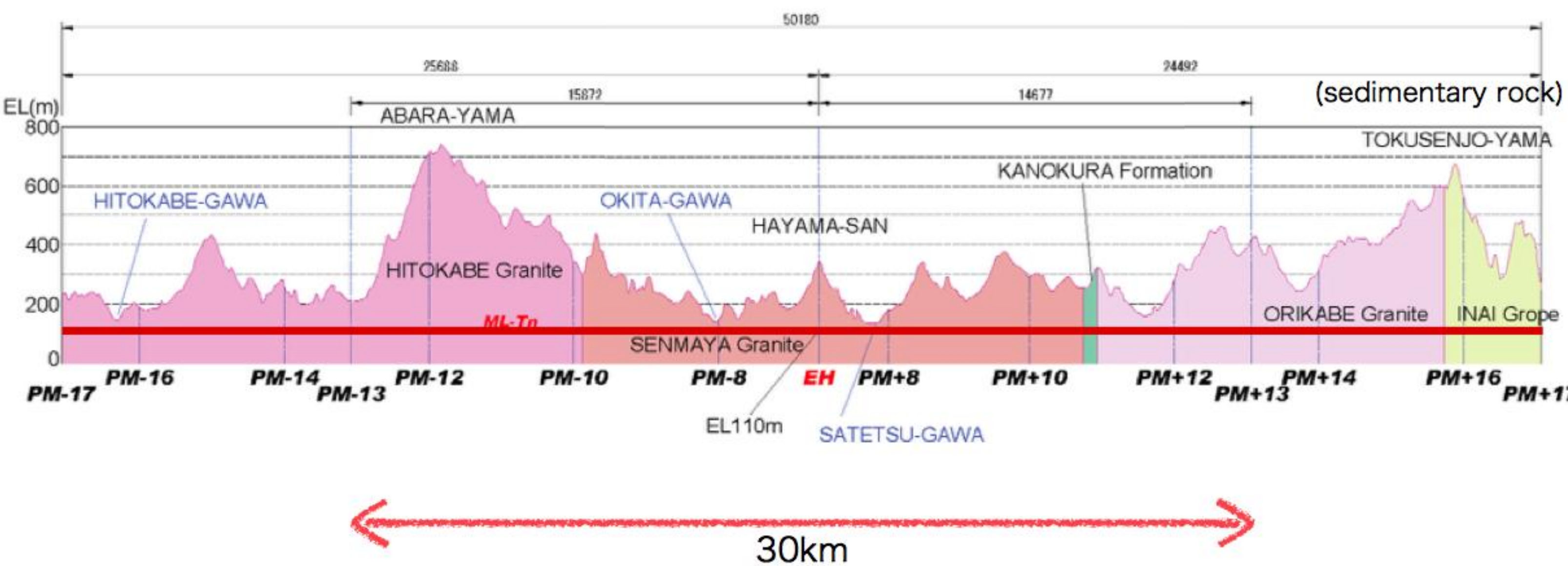


Proposed by JHEP community
Endorsed by LCC
Not yet decided by Japanese Government

Need to finalize:

- IP / Linac orientation and length
- Access points and IR infrastructure
- Conventional Facilities and Siting (CFS)
- …

ILC preferred site - Kitakami



al

ILC pre-construction work scope

Current Status: Facility Planning Progress – CFS View

	Underground Facilities					Surface Facilities		
Work	ML	AH	DR	BDS	DH	AY	CS	CC
Facility Arrangement	**B/C**	**B/C**	**C**	**C**	**B/C**	**D**	**C**	**D**
Basic Shape, Dimension	**B/C**	**B/C**	**B/C**	**C**	**B/C**	**D**	**C**	**D**
Civil/Architectural Design	**C**	**C**	**C**	**C/D**	**C**	**D**	**C**	**D**
Electronic Design	**C**	**C**	**C**	**C/D**	**C**	**D**	**C**	**D**
Mechanical Design	**C**	**C**	**C**	**C/D**	**C**	**D**	**C**	**D**

Legend: Progress degree

	Requirement	Technical Study
A	Clear	Completed
B	Clear	Under study
C	Unclear(50%)	Partially executed
D	Unclear	Not yet started

Legend: Facility

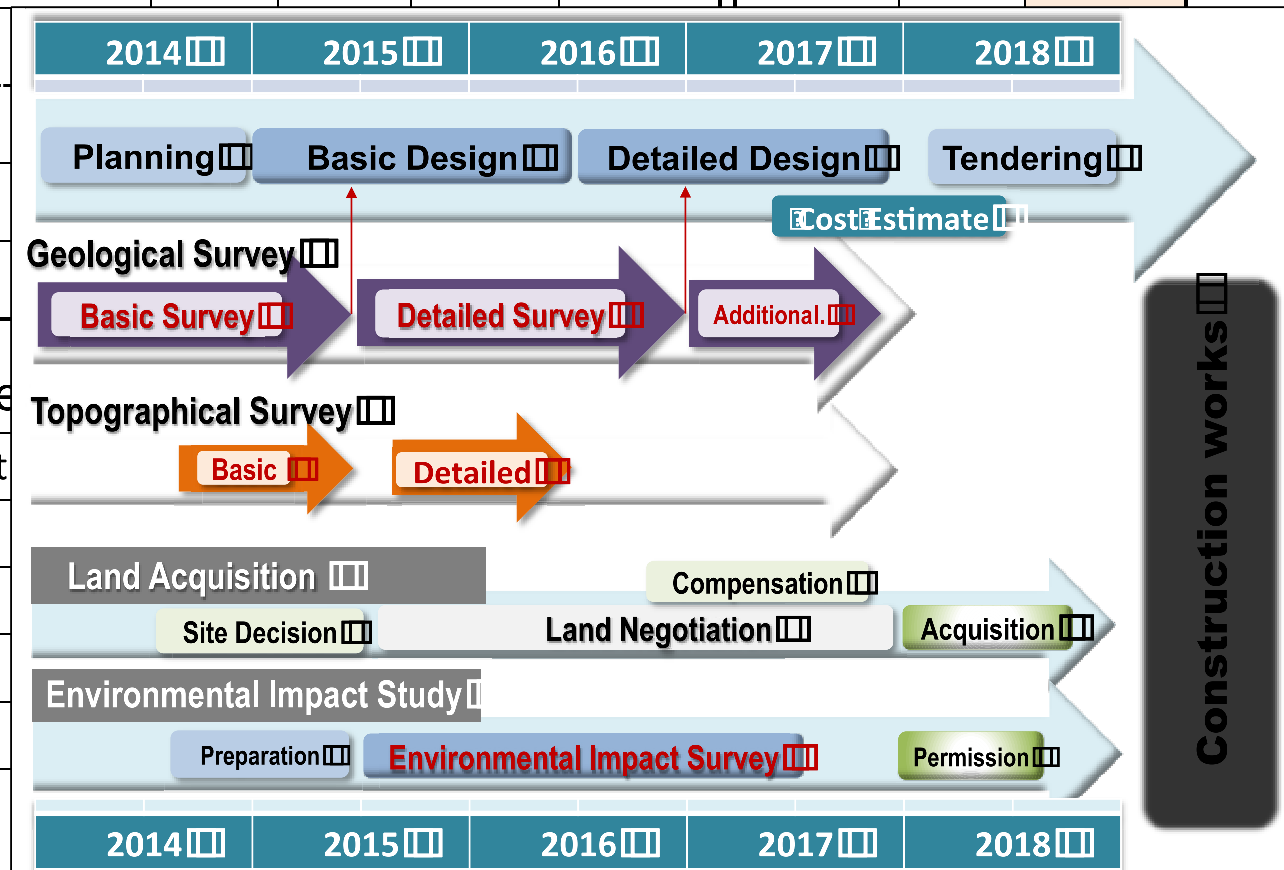
	Technical Study
AH	Access Hall
AY	Access Yard
CS	Central Substation
CC	Central Campus

From Miyahara et al

ILC pre-construction work scope

Current Status: Facility Planning Progress – CFS View

	Underground Facilities					Surface Facilities		
Work	ML	AH	DR	BDS	DH	AY	CS	CC
Facility Arrangement	B/C	B/C	C	C	B/C	D	C	D
Basic Shape, Dimension								
Civil/Architectural Design								
Electronic Design								
Mechanical Design								



Legend: Progress de

	Requirement
A	Clear
B	Clear
C	Unclear(50%)
D	Unclear

CLIC perspective

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

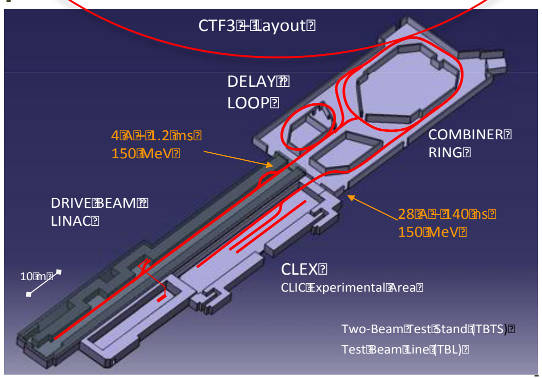
Finalise implementation parameters, Drive Beam Facility and other system verifications, site authorisation and preparation for industrial procurement.

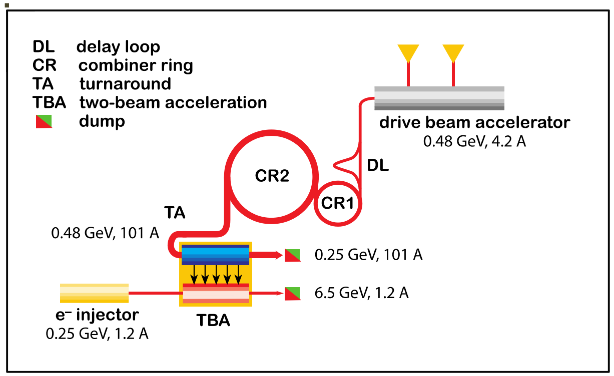
Prepare detailed Technical Proposals for the detector-systems.

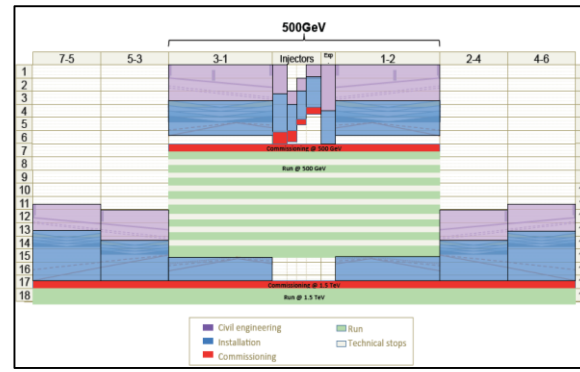
Construction Phase

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

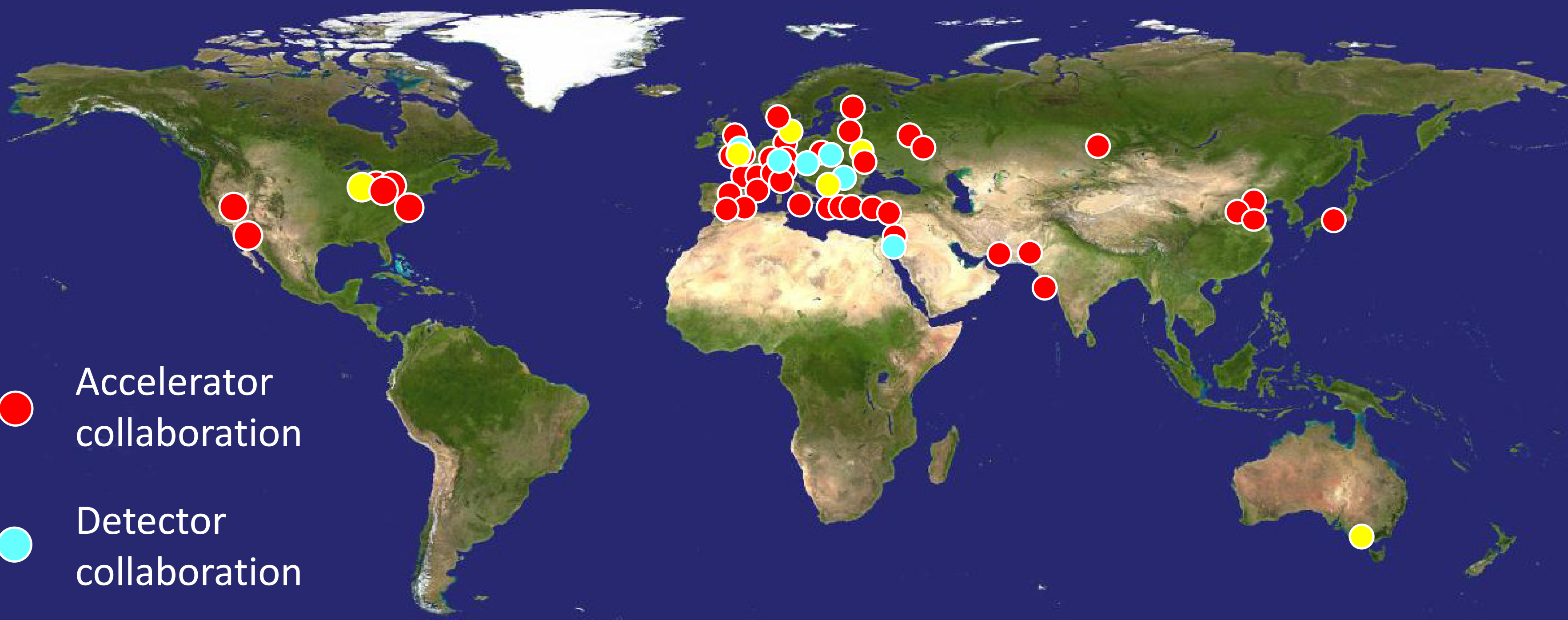
Ready for full construction and main tunnel excavation.

Commissioning

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

CLIC Collaboration

29 Countries – over 70 Institutes



Accelerator collaboration

Detector collaboration

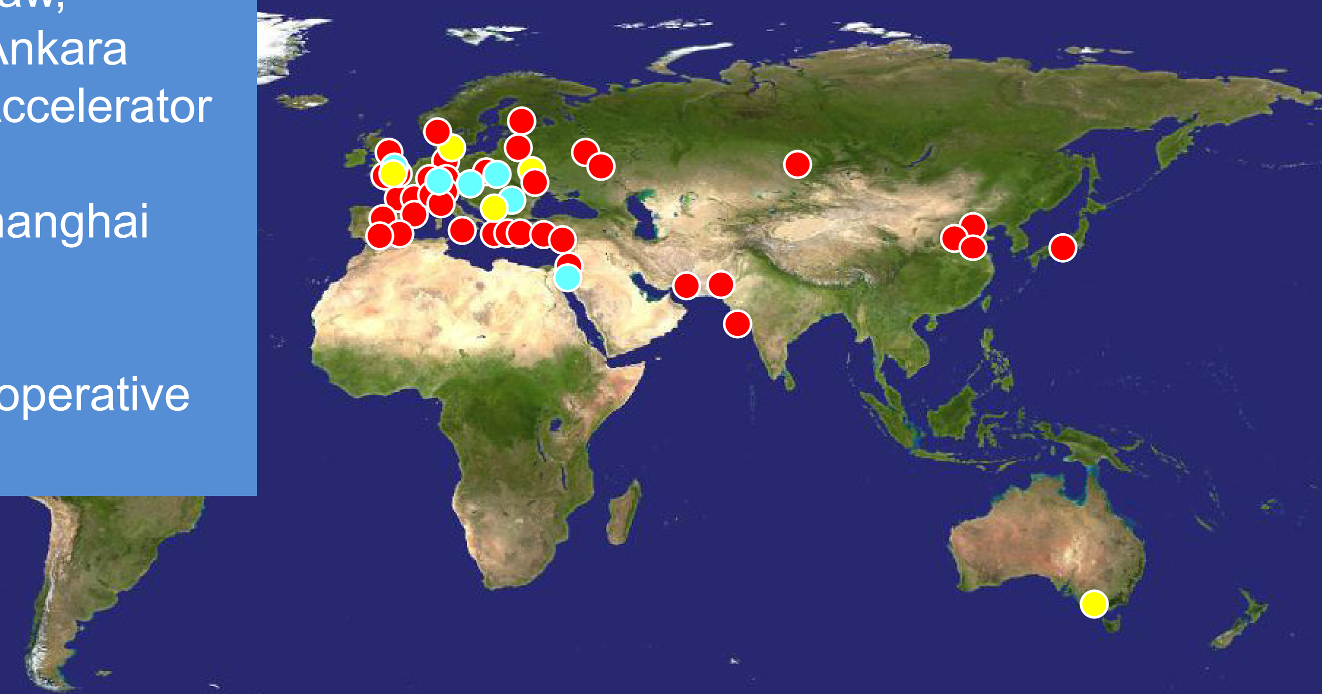
Accelerator + Detector collaboration

Collaboration

Seven new collaboration partners joined in 2013 (The Hebrew University Jerusalem, Vinca Belgrade, ALBA/CELLS, Tartu University, NCBJ Warsaw, Shandong University, Ankara University Institute of Accelerator Technologies (IAT)).
In 2014 two (SINAP Shanghai and IPM Tehran) more

Detector collaboration operative with 23 institutes

untries – over 70 Institutes



collaboration

Detector collaboration

Accelerator + Detector collaboration

Key points

The ILC and CLIC accelerator studies are organised under the heading of LCC with goals:

- Strongly support the Japanese initiative to construct a linear collider as a staged project in Japan
- Prepare CLIC machine and detectors as an option for a future high-energy linear collider at CERN
- Further improve collaboration between CLIC and ILC machine experts
- Beyond the significant progress on the basic RF studies, increased and successful effort on system-studies of various types (FACET, ATF, etc)
- Many common challenges with 3rd generation light sources and FELs, the latter providing very important industrial/lab production experiences

Thanks

- Slides/figures from LCC collaboration members and others
- Knowingly from M.Harrison, A.Yamamoto, A. Latina, K.Kubo and ATF colleagues, D.Schulte, Y.Yamamoto, W.Fang, W.Wuensch and Xband team, M. Miyahara, N.Walker, T.Lefevre, M.Modena, R.Tomas, G.D'Auria … probably several more unknowingly