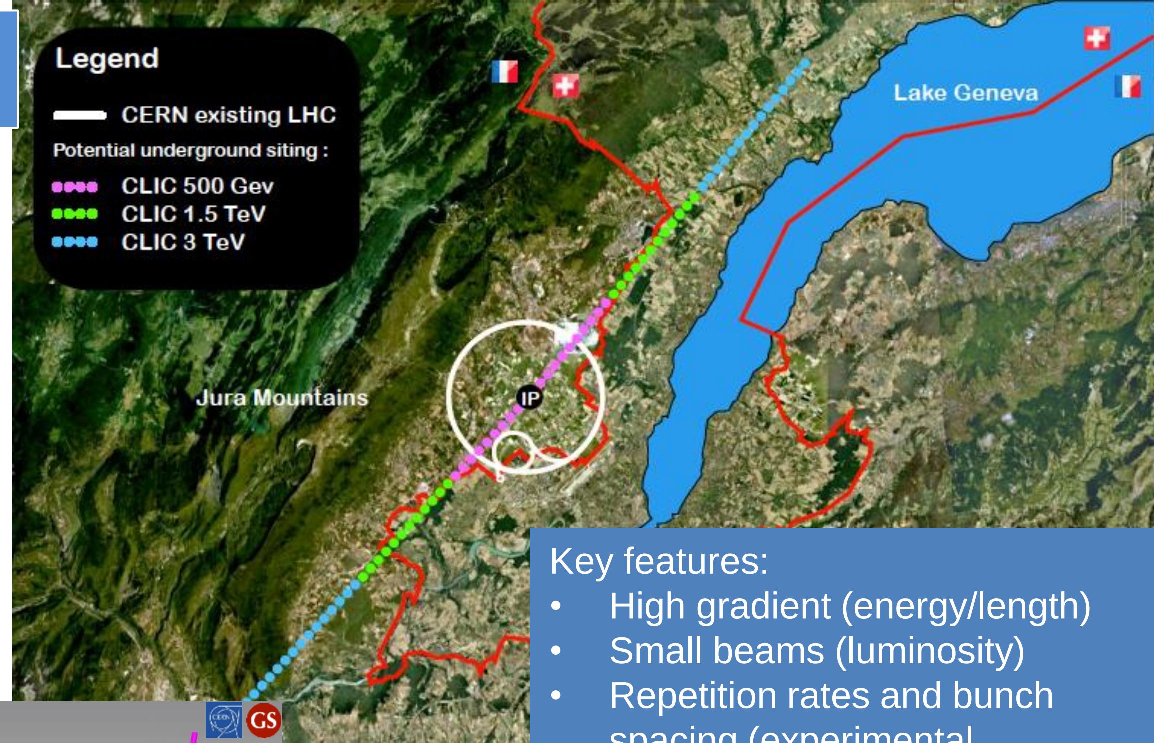
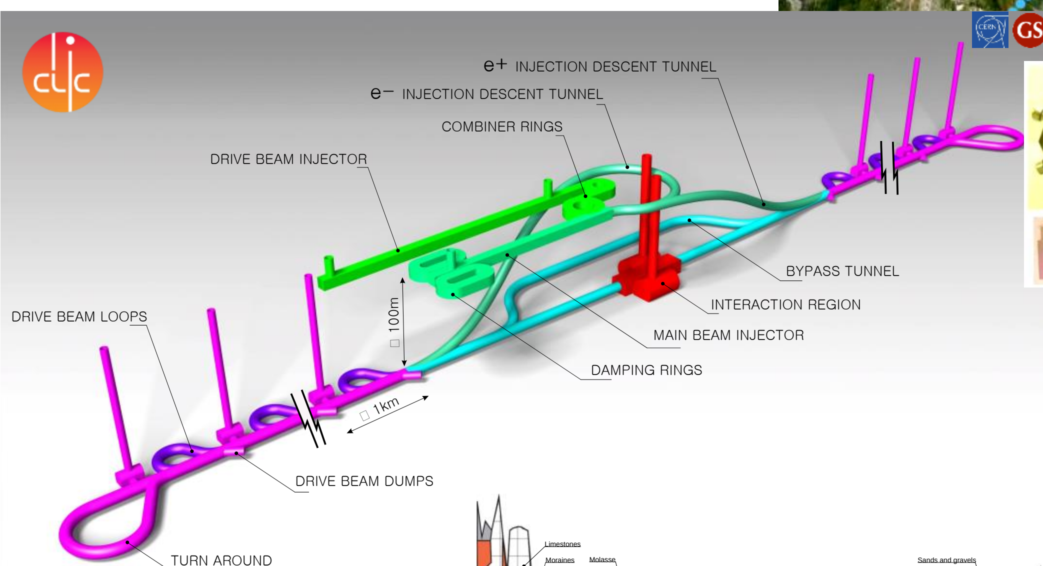
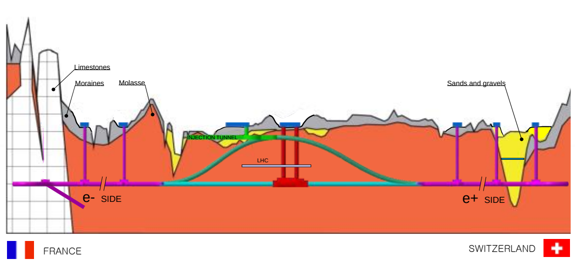
The CLIC project

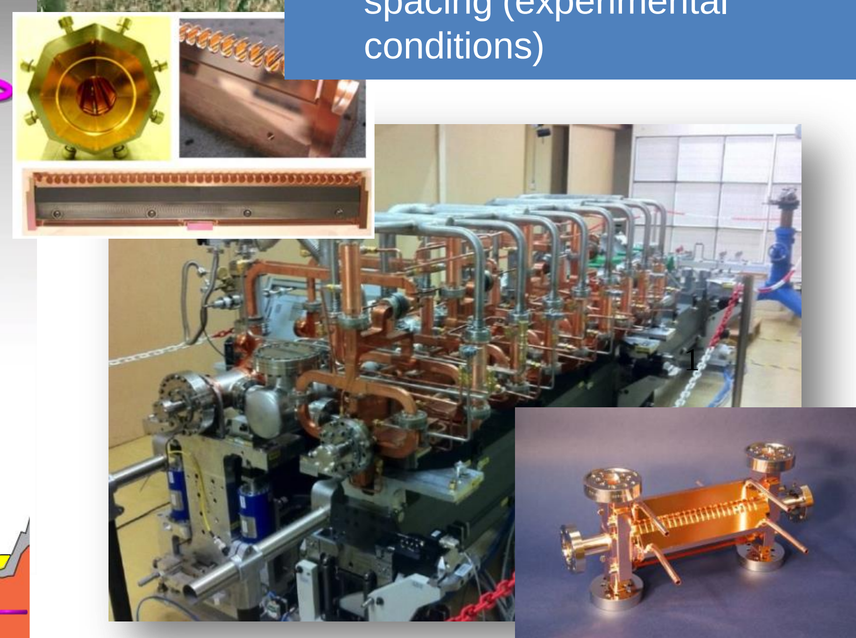
Outline:
- Brief introduction
- Recent developments/news
- Focus for this week



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

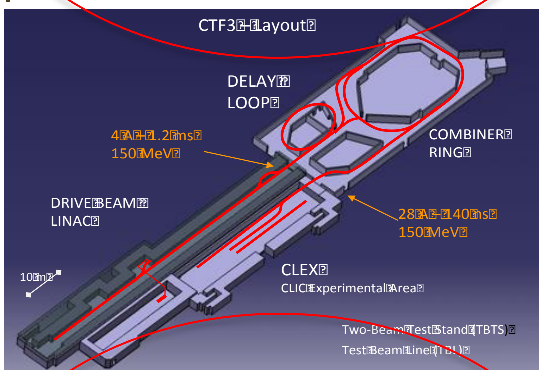






2013-18 Development Phase

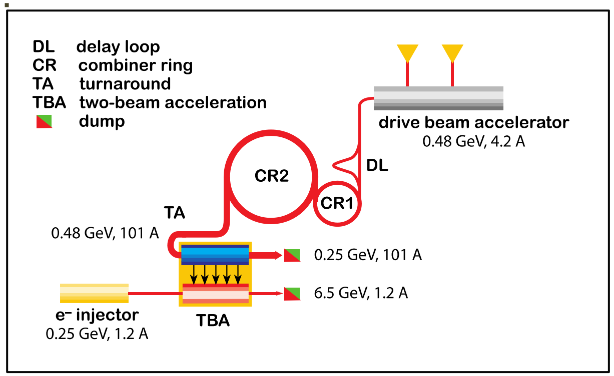
Develop a Project Plan for a staged implementation in agreement with LHC findings; further technical developments with industry, performance studies for accelerator parts and systems, as well as for detectors.



4-5 year Preparation Phase

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

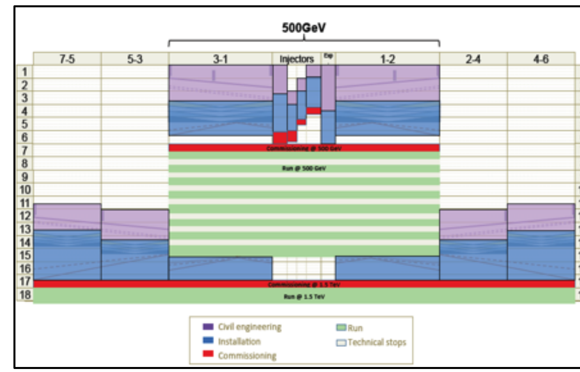
Prepare detailed Technical Proposals for the detector-systems.



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

Commissioning

Common work with ILC related to several acc. systems as part of the LC coll., also related to initial stage physics and detector developments ….. one of the focusing points for this week

Common physics benchmarking with FCC pp and common detect. challenges (ex: timing, granularity), as well as project implementation studies (costs, power, infrastructures …)

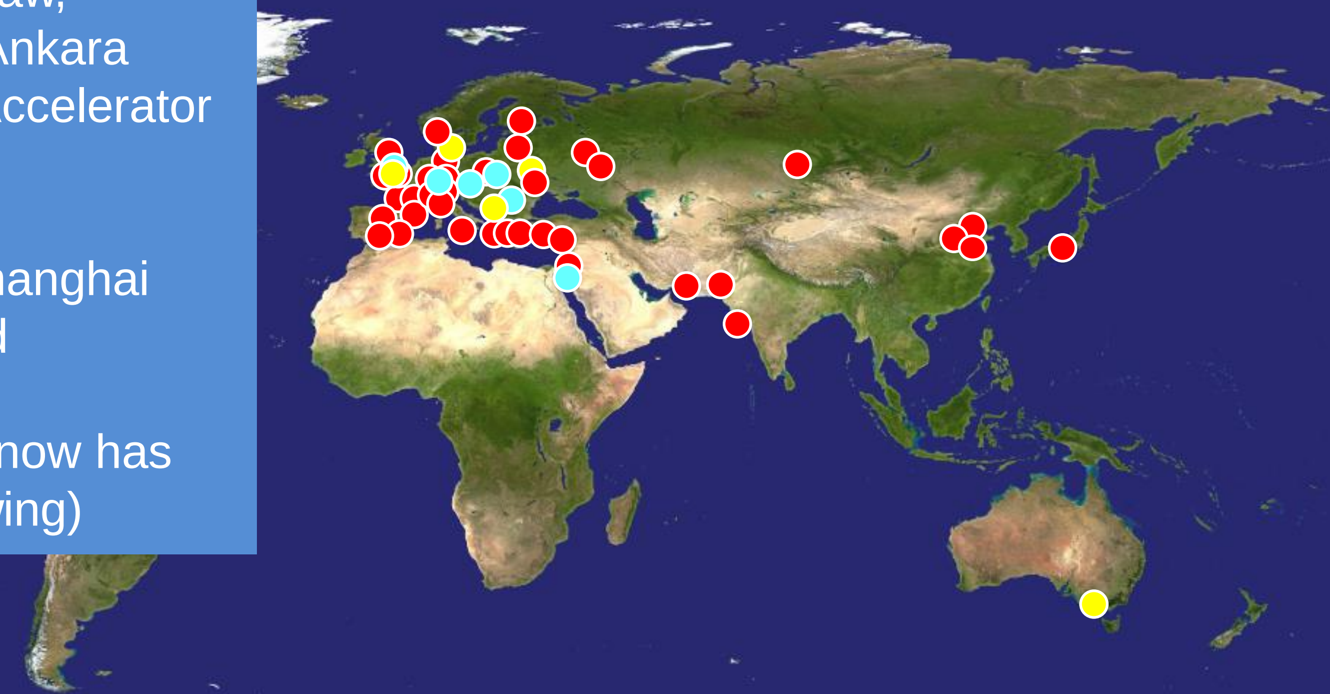
Collaboration

untries – over 70 Institutes

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) joined

Detector collaboration now has 23 institutes (also growing)

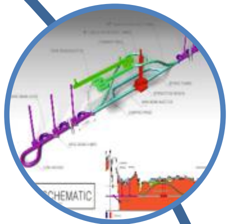


Detector collaboration

Accelerator + Detector collaboration

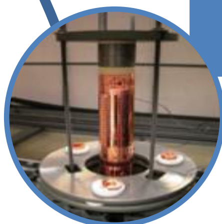
LINEAR COLLIDER COLLABORATION

Main activities



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

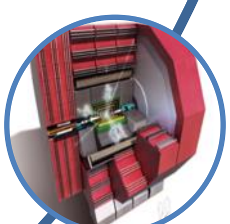
- X-band Rf structure Design
- X-band Rf structure Production
- X-band Rf structure High Power Testing
- Novel RF unit developments (high efficiency)
- Creation and Operation of x-band High power Testing Facilities
- Basic High Gradient R&D

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

Covered in talks this afternoon:
P. Roloff and S. Redford

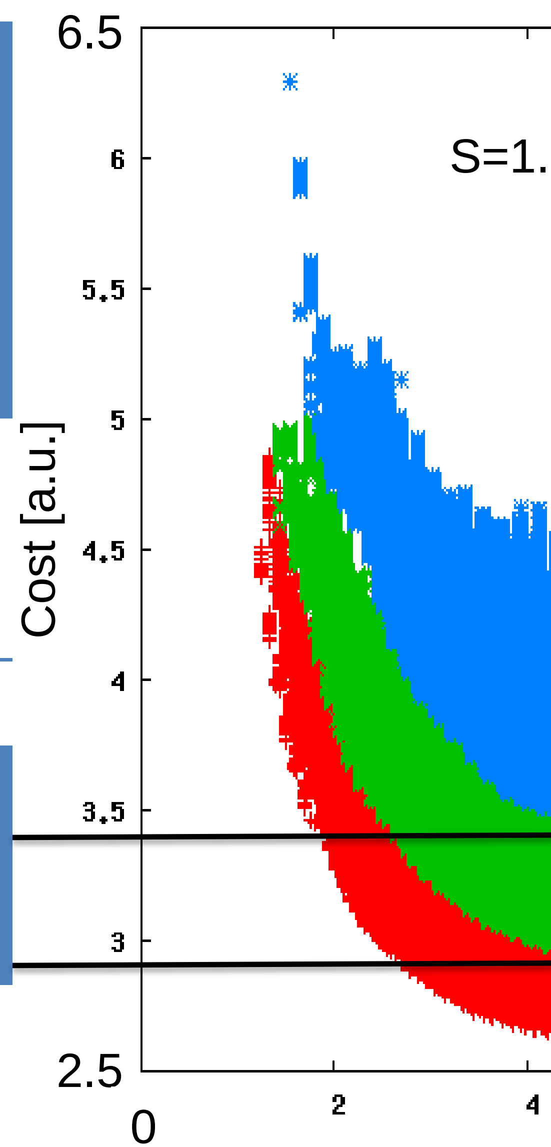
Cost/power: Design/parameters & Technical developments

Automatic procedure scanning over many structures (parameter sets)

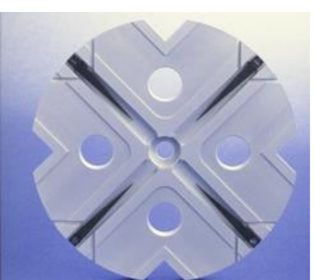
Structure design fixed by few parameters
$a_1, a_2, d_1, d_2, N_c, f, G$

Beam parameters derived automatically

Cost calculated



Luminosity goal significantly impact minimum cost
For $L=1x10^{34} cm^{-2} s^{-1}$ to $L=2x10^{34} cm^{-2} s^{-1}$ costs 0.5 a.u.



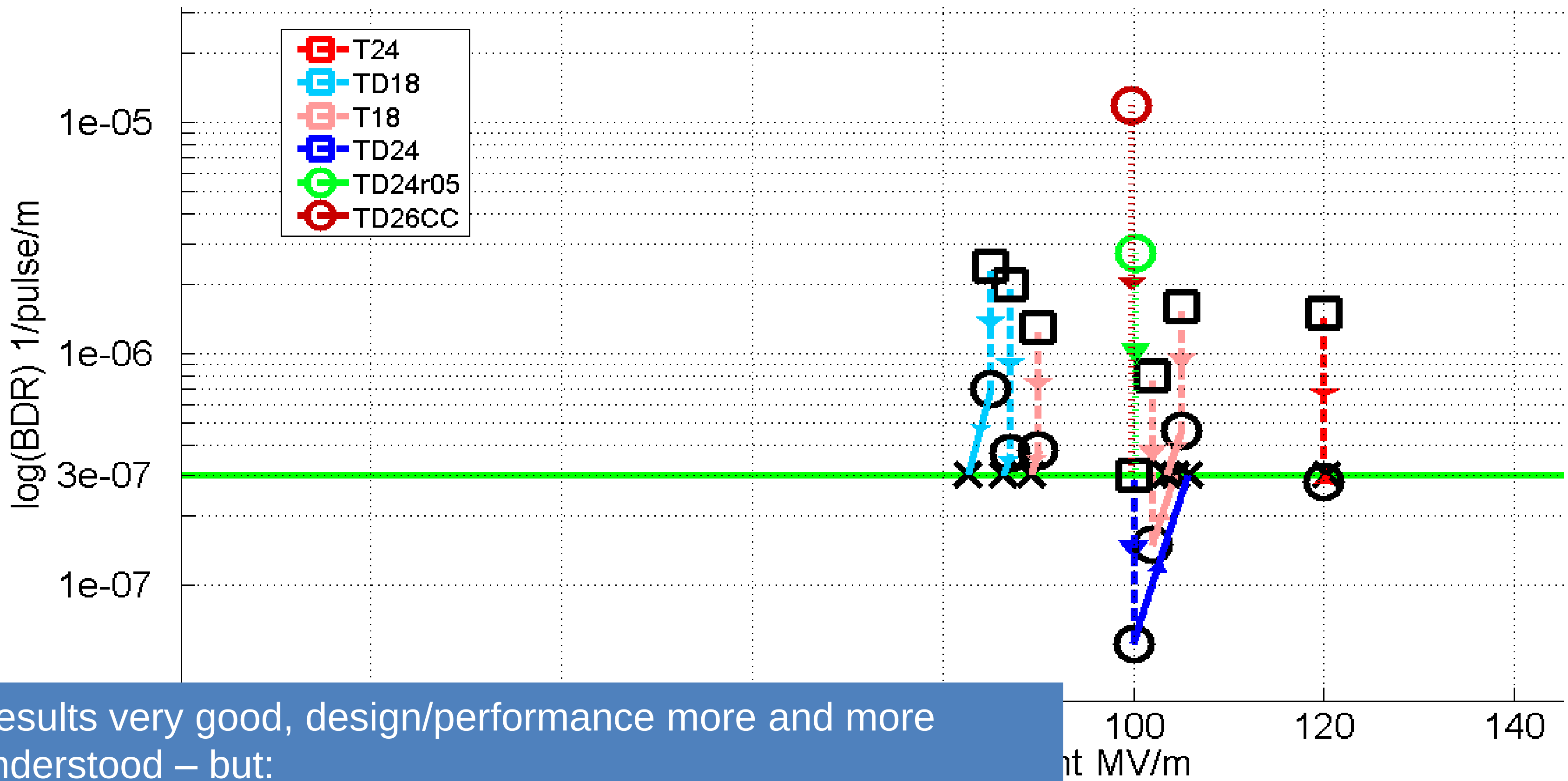
Beyond the parameter optimization there are other on-going developments (design/technical developments):

- 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 ~400 GeV, ~1.5 TeV, 3 TeV
- Optimised cost and power for given luminosity
- End year (CLIC workshop end January) – hopefully needed to redo with new LHC results at some point

High-gradient accel. structure test status



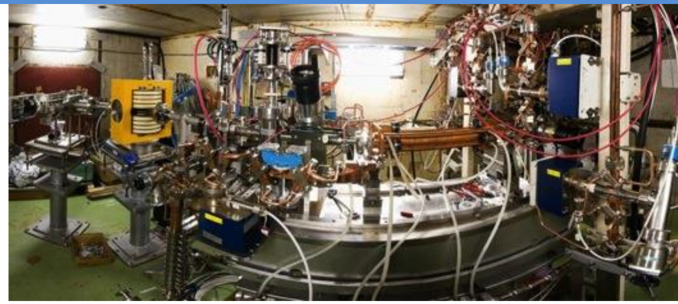
Results very good, design/performance more and more understood – but:

- 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 (session Thursday)

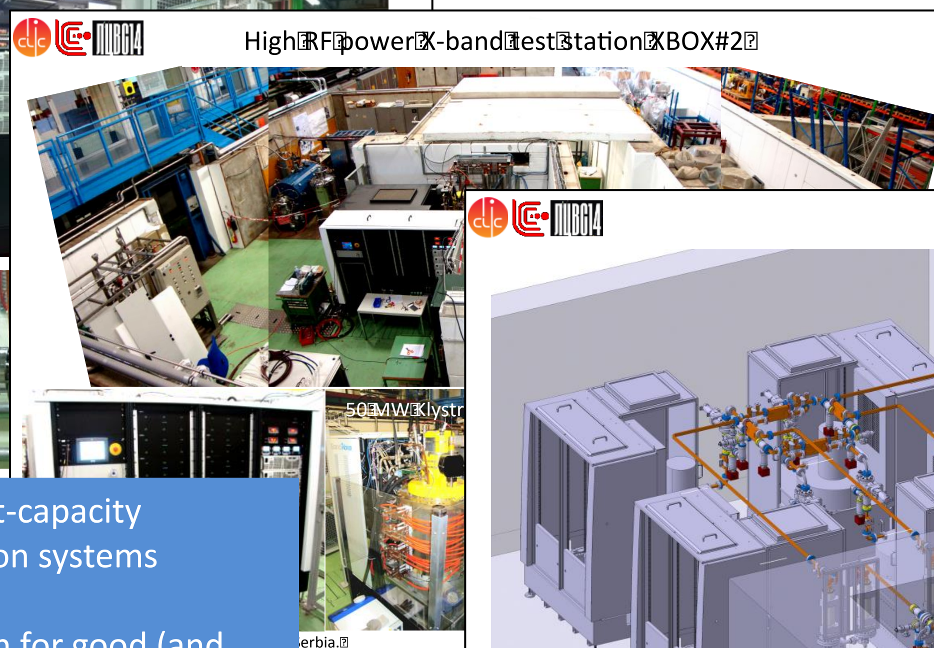
Previous:
Scaled 11.4 GHz
tests at SLAC and KEK.

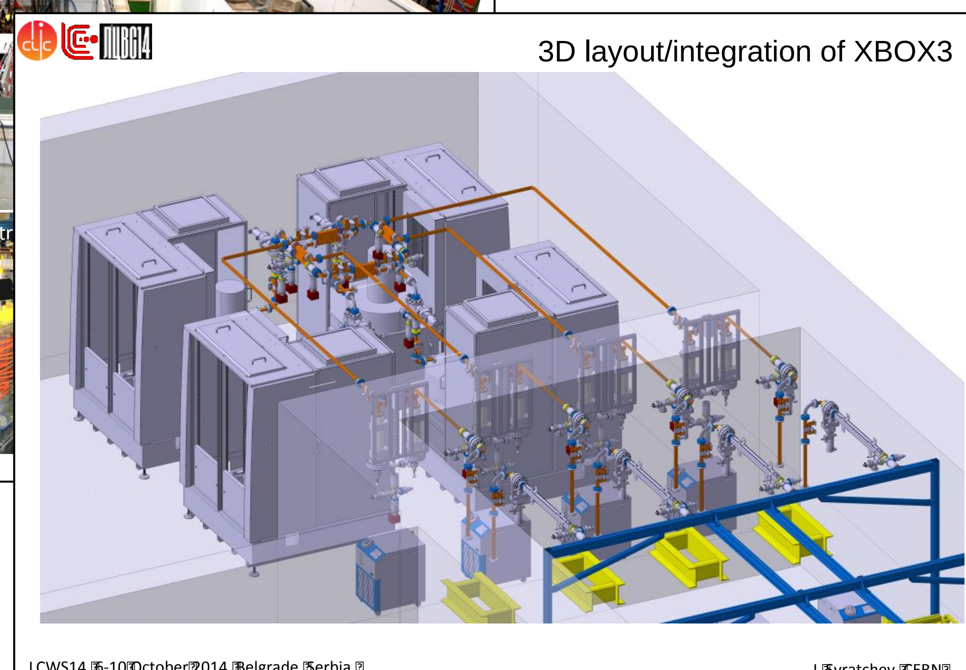


NEXTEF at KEK

ASTA at SLAC

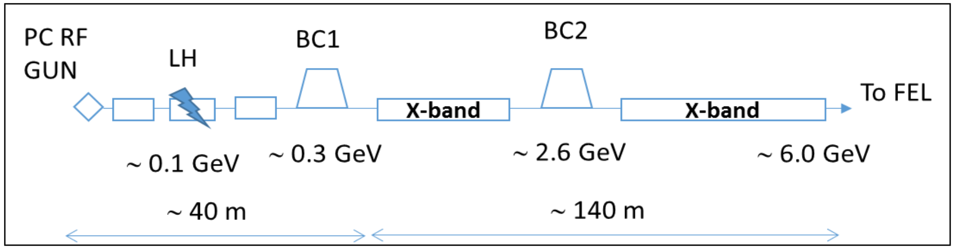
… remain important, also linked to testing of X-band structures from Tsinghua and SINAP

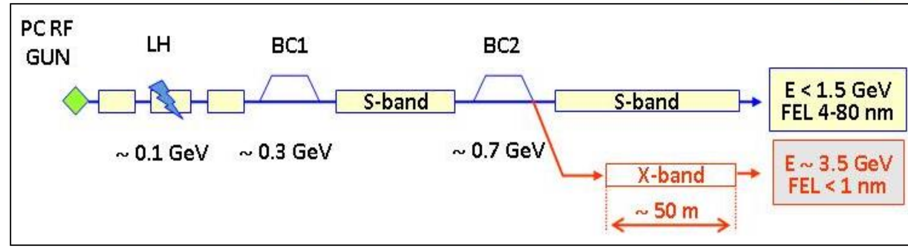




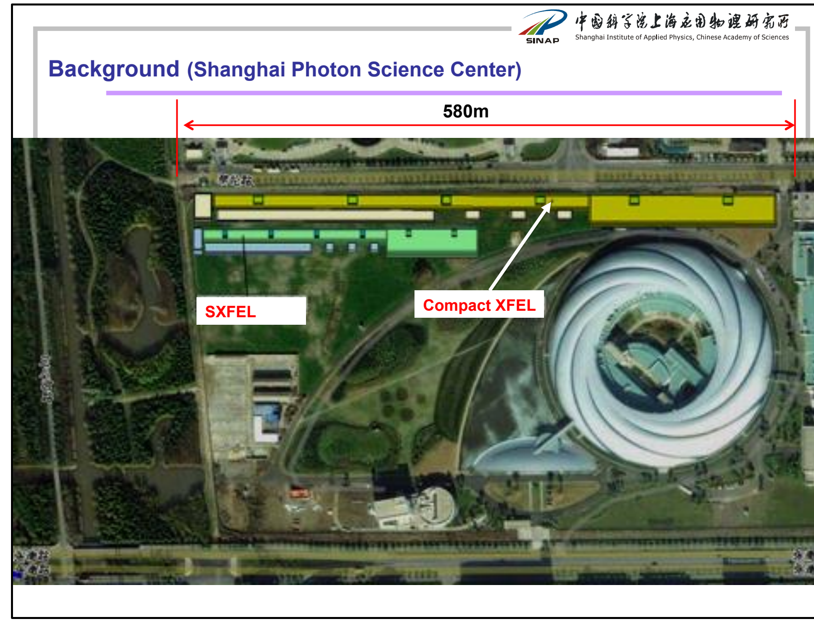
- Very significant increase of test-capacity
- First commercial 12 GHz klystron systems becoming available
- Confidence that one can design for good (and possibly better) gradient performance
- As a result: now possible to use Xband technology in accelerator systems – at smaller scale

Xband facilities - FELs



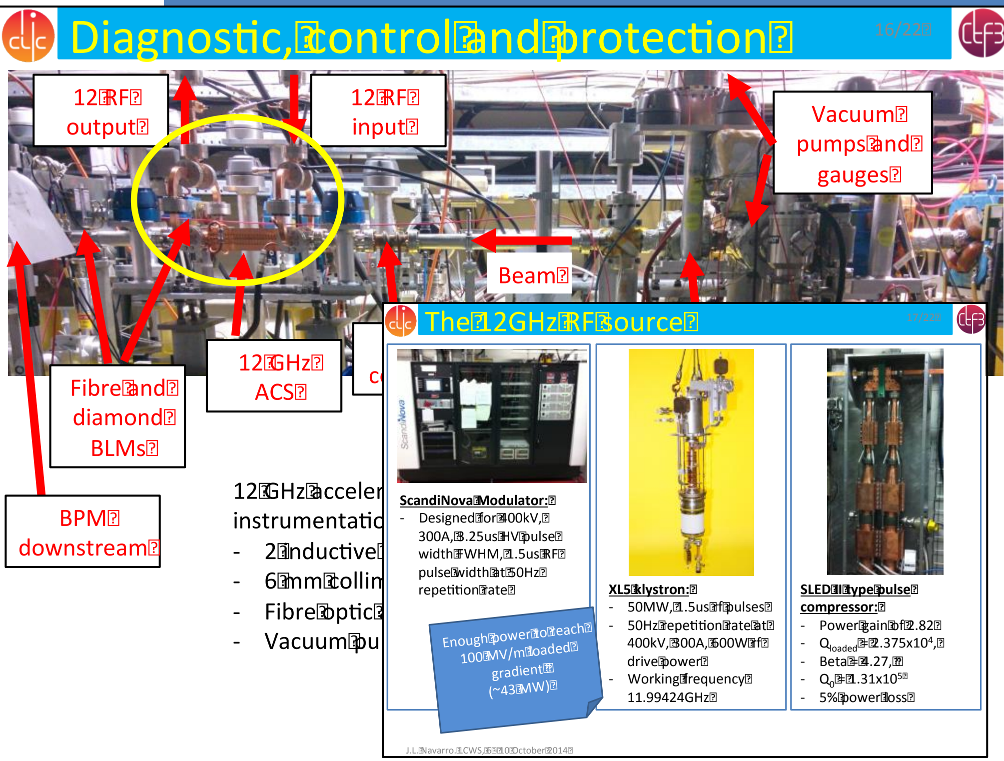


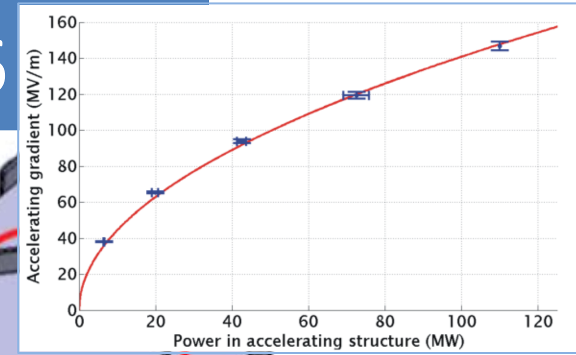
- X-band technology appears interesting for compact, relatively low cost FELs – new or extensions
  - Logical step after S-band and C-band
  - Example similar to SwissFEL: E=6 GeV, Ne=0.25 nC, $s_z=8\mu m$
- Use of X-band in other projects will support industrialisation
  - They will be klystron-based, additional synergy with klystron-based first energy stage
- Started to collaborate on use of X-band in FELs
  - Fermi-Trieste, Cockcroft Institute, Australian Light Source, Turkish Accelerator Centre, SINAP, TU Athens, U. Oslo, Uppsala University, PSI, 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 in order for CLIC)

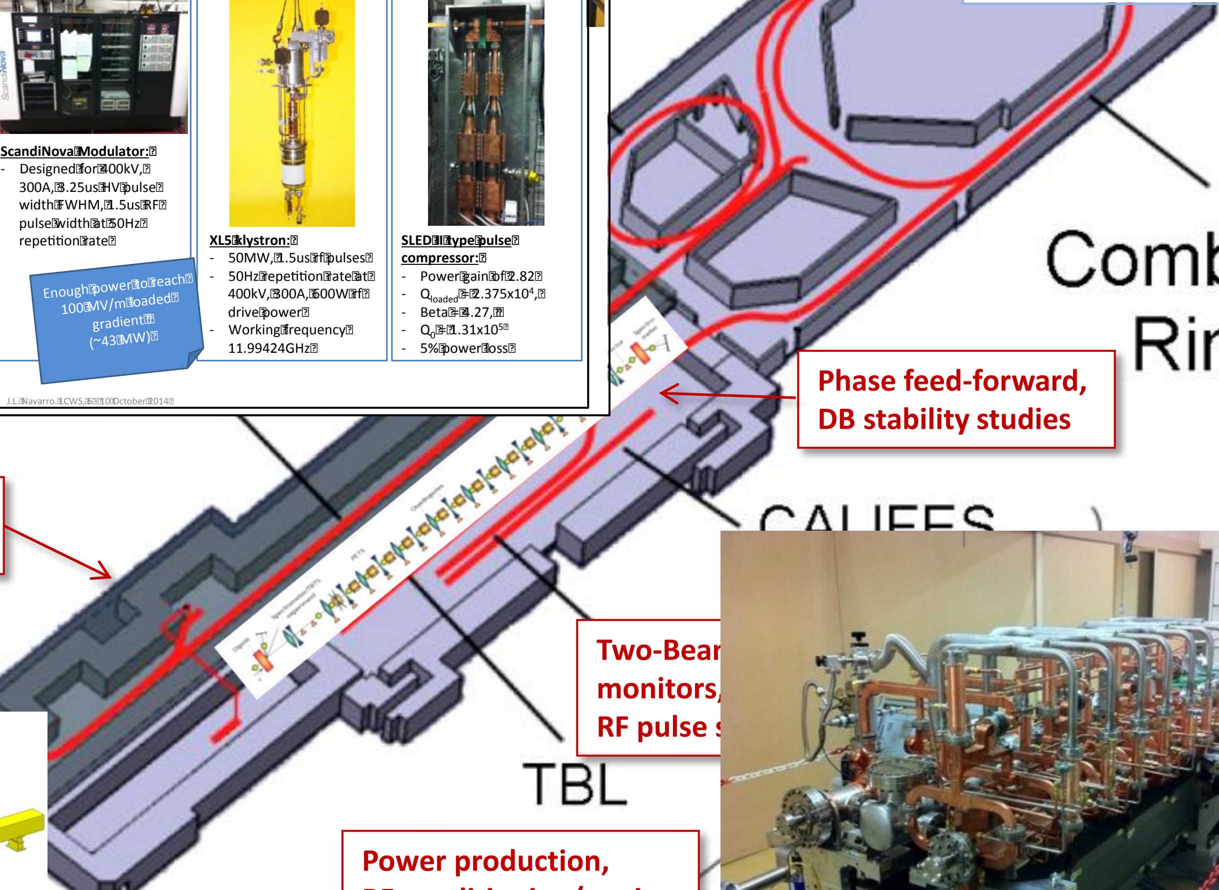


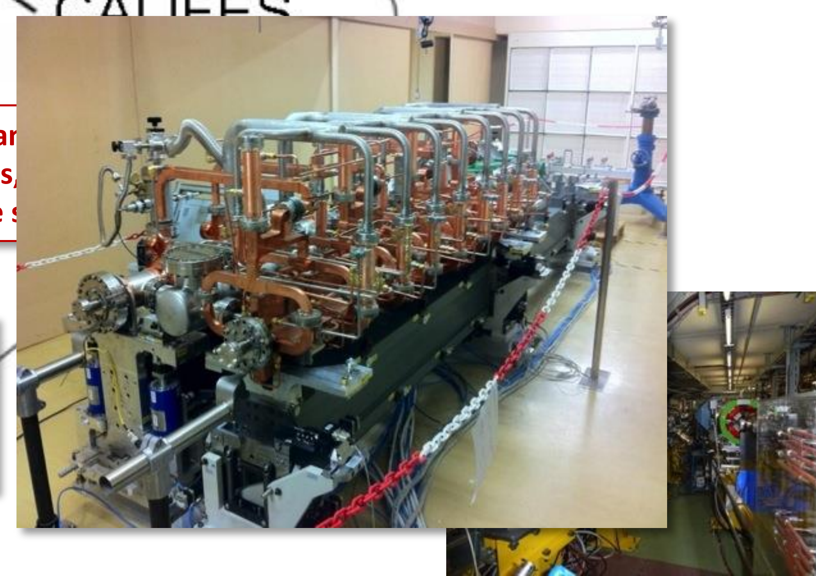
Great potential for collaboration, industrial experience, and large interest by key partners (discussed in talk by D.Schulte after coffee and in Thursday CLIC project session: G.D'Auria)

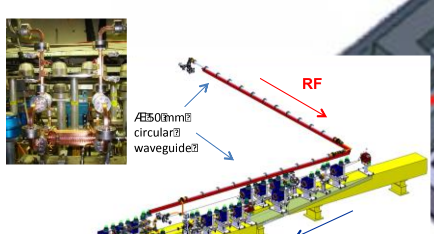
2013-2016







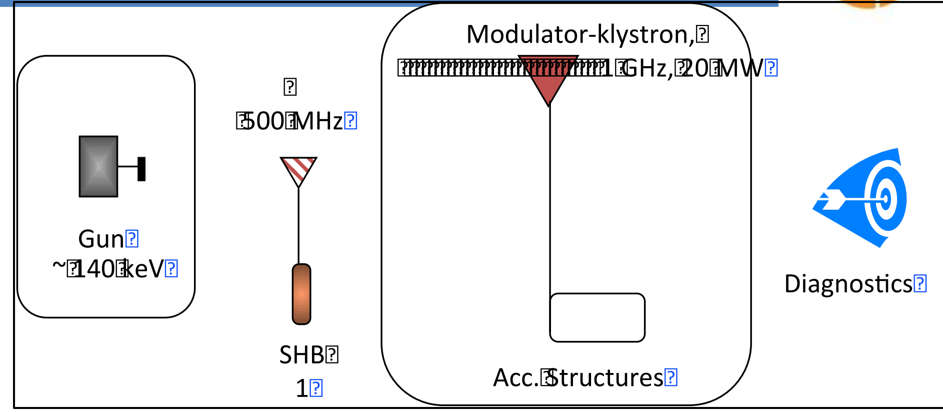




System-tests beyond CTF3 discussed Thursday, also beam-loading experiment (L.Navarro)

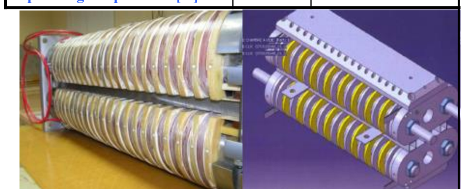
CLIC system tests beyond CTF3

- 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



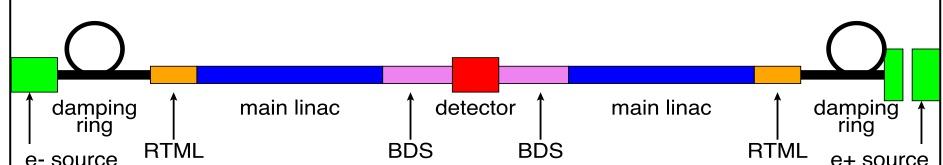
- Super-conducting wigglers
  - Demanding magnet technology combined with cryogenics and high heat load from synchrotron radiation (absorption)
- High frequency RF system
  - 1 GHz RF system respecting power and transient beam
- Coatings, chamber design and ultra-low vacuum
  - Electron cloud mitigation,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



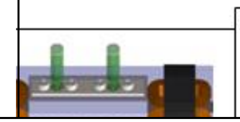
Experimental program set-up for measurements in storage rings and test facilities:

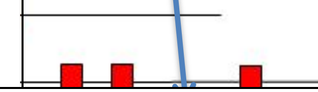
ALBA (Spain), ANKA (Germany), ATF (Japan), CESRTA (USA), ALS (Australia)…



Performance verifications – CLIC

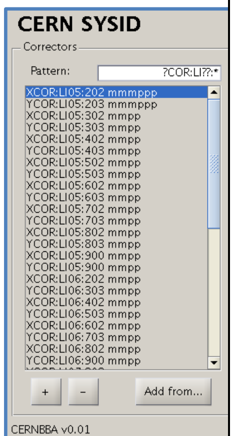
Stabilise quadrupole O(1nm) @ 1Hz





Our goal: an (almost) automatic correction

We want to make
SYSID and BBA to

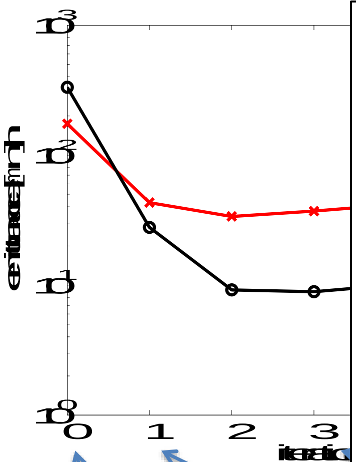


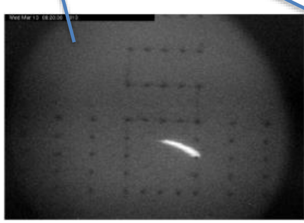
Makes BBA "easy"

Tested at SLAC and

Now being conside

DFS at the SLAC Linac





Before correction

Tests of BBA at Fermi@Elettra

To test and scan the efficiency of WFS we decided to excite an even larger emittance in the horizontal plane only, passing from 2.8um to 4.5um with a bump in the horizontal plane only, at bpm_l04.02, from 0mm to 0.9mm offset.

With S. Di Mitri, G. Gaio, E. Ferrari (Elettra)

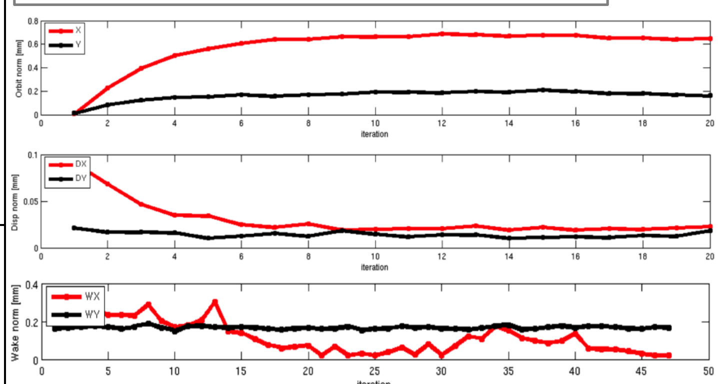
We found the following, as function of the weight on the WFS:

H-Emittance before correction = **4.5um**

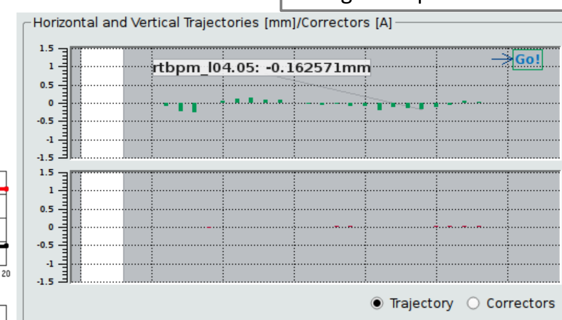
H-Emittance after correction = **2.84um**

Emittance is totally recovered in just few minutes.

Orbit, Dispersion, Wakefield convergence (bottom plot)

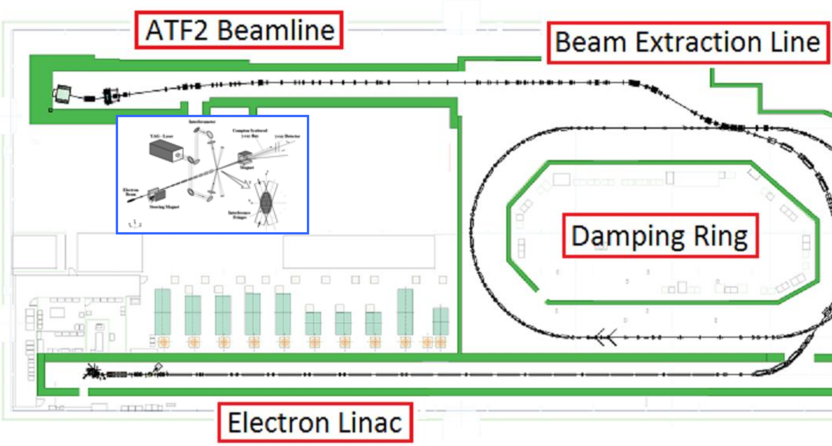


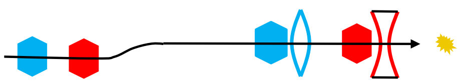
Charge-independent orbit

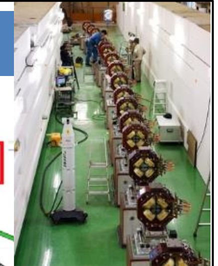


See talk by A.Latina Wednesday afternoon

Final focus: ATF 2 at KEK







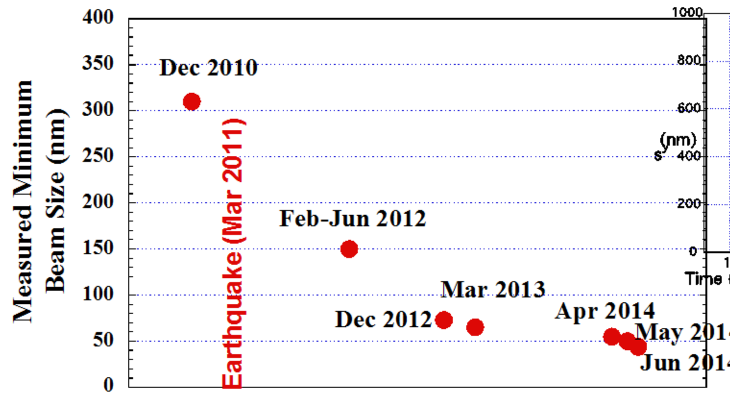
Goal 1: demonstrate optics, tunability

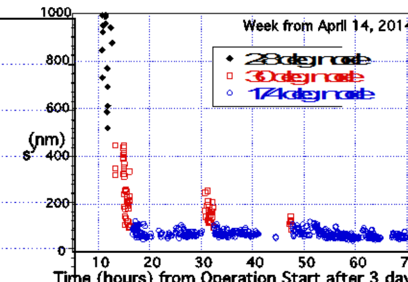
Goal 2: beam st
feedback

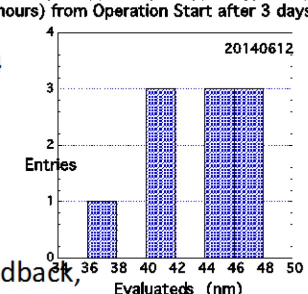
Local chromatic corrections

Similar optics, similar tolerances ATF and ILC

ATF-2 beam size development







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

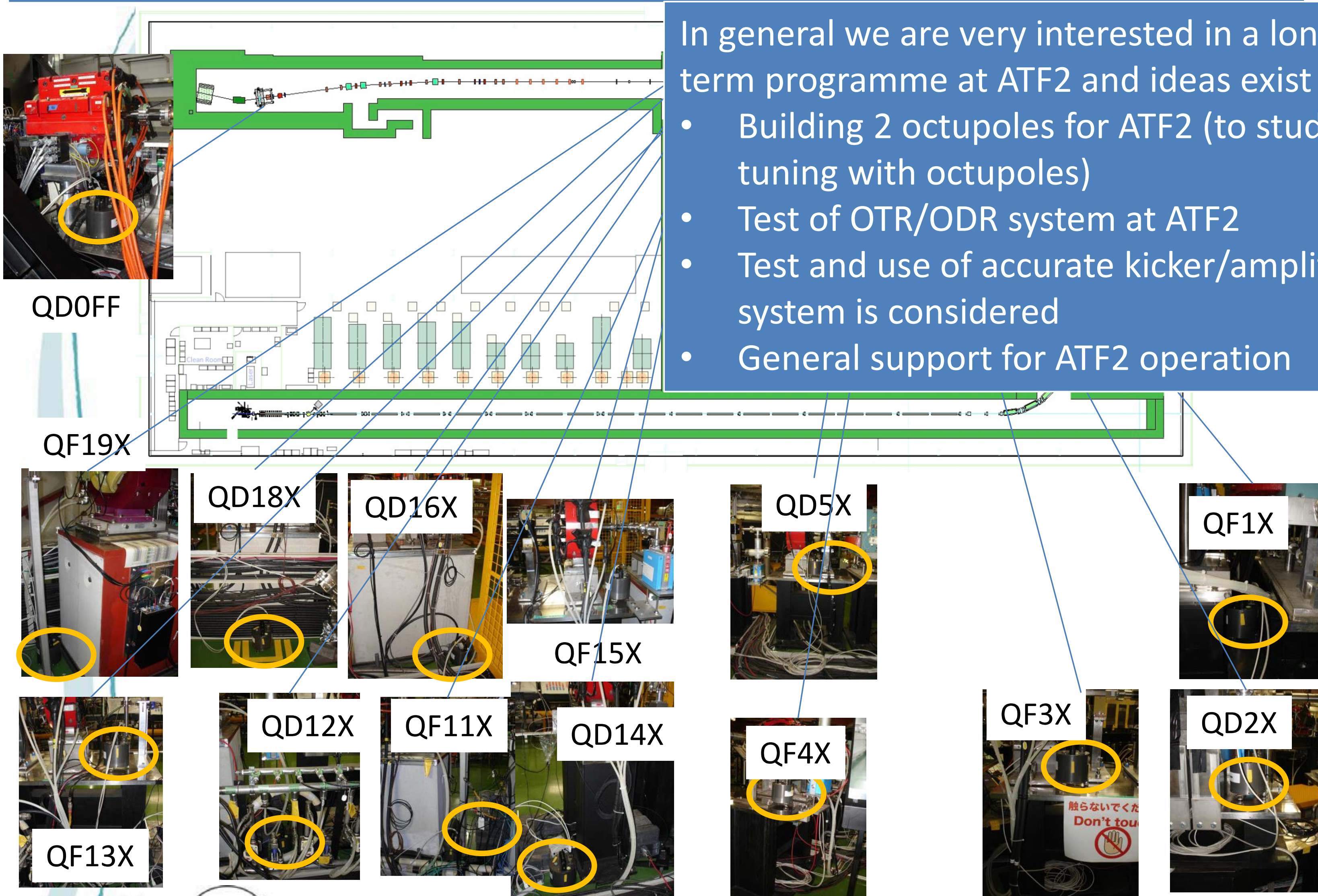
Field quality improvements, orbit stabilisation through feedback, shorted turn in 6-pole magnet, beam size monitor improvements

ATF 2 Future program – next Run October

ATF2: Stabilisation Experiment

In general we are very interested in a longer term programme at ATF2 and ideas exist for:

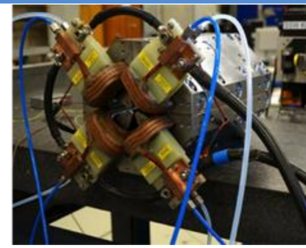
- Building 2 octupoles for ATF2 (to study FFS tuning with octupoles)
- Test of OTR/ODR system at ATF2
- Test and use of accurate kicker/amplifier system is considered
- General support for ATF2 operation

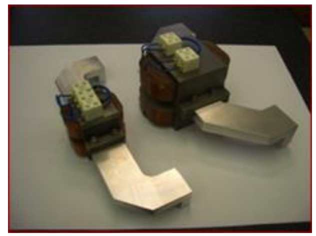


Technology examples: Magnets and Instrumentation

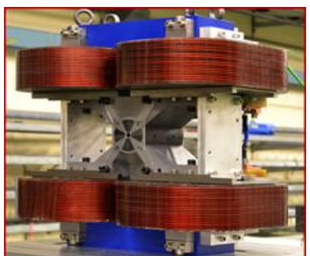
Magnet developments:

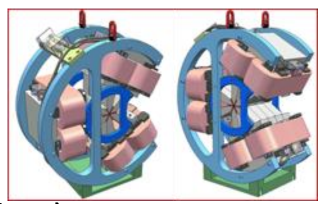
- Main Beam Quadrupole (MBQ)
- Drive Beam Quadrupoles (DBQ)
- Steering correctors



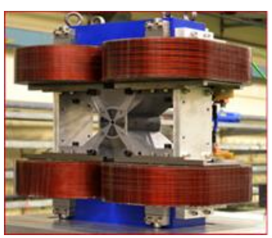


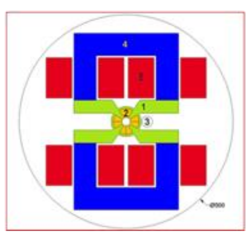
- QD0
- SD0





- Other studies (ILC and ATF studies)





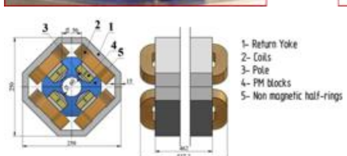
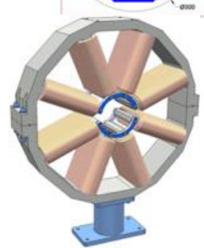


Figure 1: Preliminary layout of the quadrupole magnet, arrows indicate the direction of magnetization of the permanent magnet blocks.



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
- 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

CLIC Workshop 2015

26-30 January 2015
CERN
Europe/Zurich timezone

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Starts 26 Jan 2015 13:30
Ends 30 Jan 2015 18:30

CERN
Several rooms

In 2014: 306 registered (the key being good parallel sessions)

Main elements:
Open high energy frontier session session, including hadron options with FCC

Accelerator sessions focusing on collaboration efforts and plans 2015-2019, parallel sessions and plenary

High Gradient Applications for FELs, industry, medical

Physics and detector sessions on current and future activities

Collaboration and Institute Boards

Summary

The goals and plans for 2013-19 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 stages approach up to 3 TeV with costs and power not too excessive compared to LHC
- Very positive progress on Xband technology, due to availability of power sources and increased understanding of structure design parameters
  - This week: Review Xband progress: basic understanding, test-stands
  - Applications in smaller systems; FEL linacs key example – with considerable interesting in the CLIC collaboration
- Also recent good progress on performance verifications, drivebeam, main beam emittance conservation and final focus studies
  - This week: BBA discussions, BDS/ATF important
  - CTF3 running and plan until end 2016, strategy for systemtests beyond
- Technical developments of key parts well underway – with increasing involvement of industry – largely limited by funding
- Detector and physics programme well defined, moving ahead well – linking gradually with FCC hadron community
- Collaborations for CLIC accelerator and detector&physics studies are growing

Thanks to the CLIC collaboration for the slides and work presented (slides collected from many sources)