The CLIC R&D program beyond the CDR

R. Corsini for the TDR preparation task force

Talk outline

- Introduction
  - The CLIC roadmap
  - Resources
  - Requirements of TD phase
  - The CLIC Zero proposal
- Status of detailed analysis
  - Divided by areas
  - Projected status in 2010
  - Mid term goals (2011-2013)
  - Long term goals (2013-2016)
- Conclusions

The CLIC Roadmap

Work Plan until 2010:

- Demonstrate feasibility of CLIC technology (R&D on critical feasibility issues)
- Design of a linear Collider based on CLIC technology
  http://clic-study.web.cern.ch/CLIC-Study/Design.htm
- Estimation of its cost (capital investment & operation)
- CLIC Physics study and detector development
  http://clic-meeting.web.cern.ch/clic-meeting/CLIC_Phy_Study_Website/default.html

Conceptual Design Report to be published in 2010 including:

- Physics, Accelerator and Detectors
- Results of feasibility study
- Preliminary performance and cost estimation

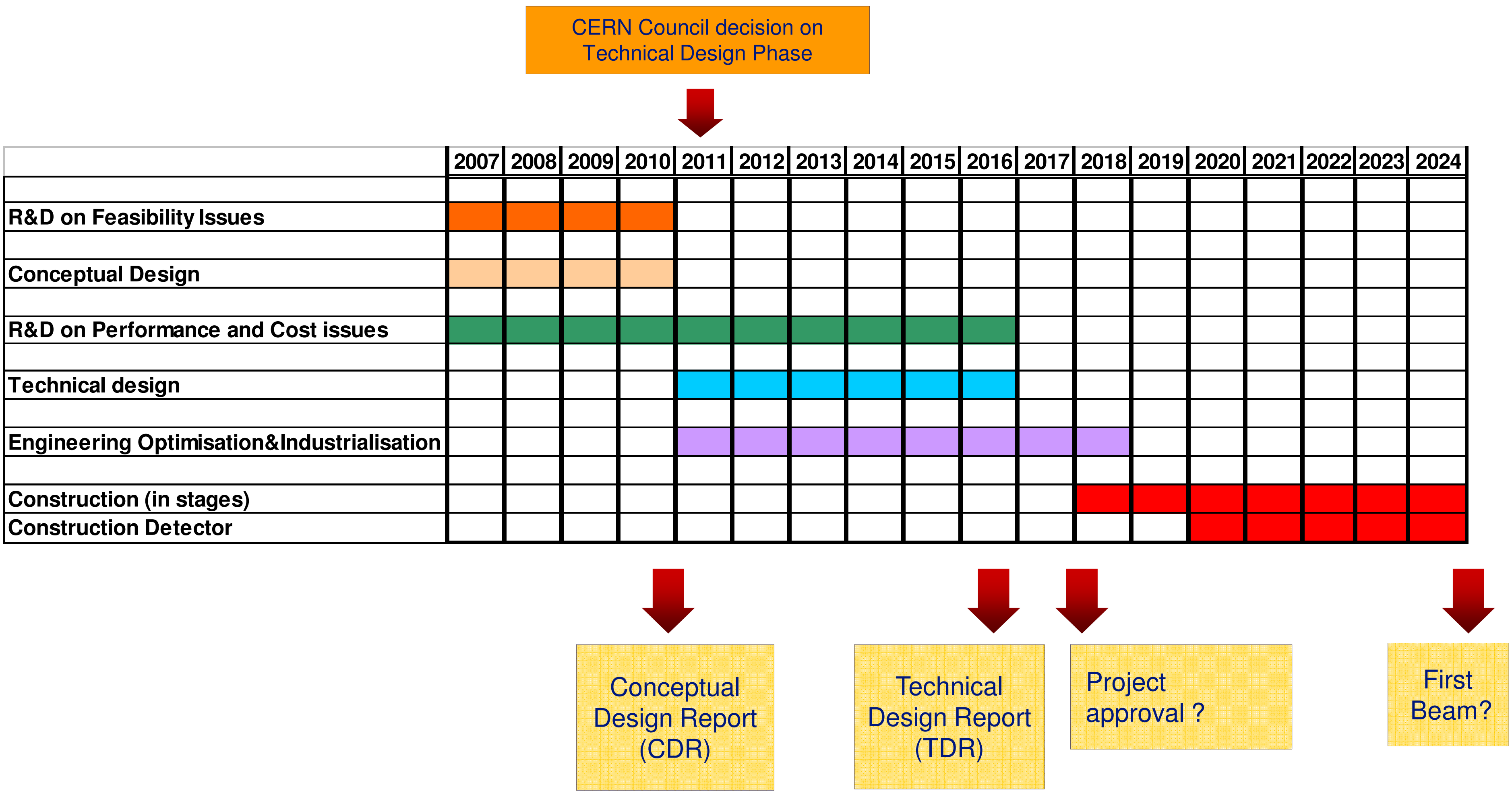
R&D Issues classified in three categories:

- critical for feasibility → fully addressed by specific R&D to be completed before 2010
  results in CDR
- critical for performance
- critical for cost

→ being addressed now by specific R&D to be completed before 2016
first assessments in CDR
results in Technical Design Report (TDR) with consolidated performance & cost

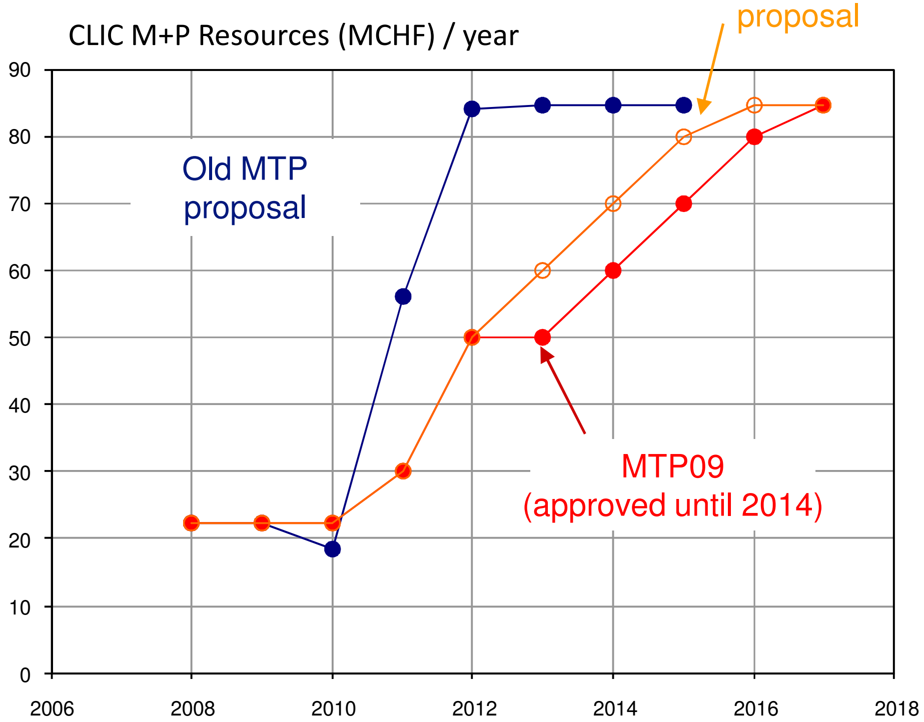
Tentative long-term CLIC scenario

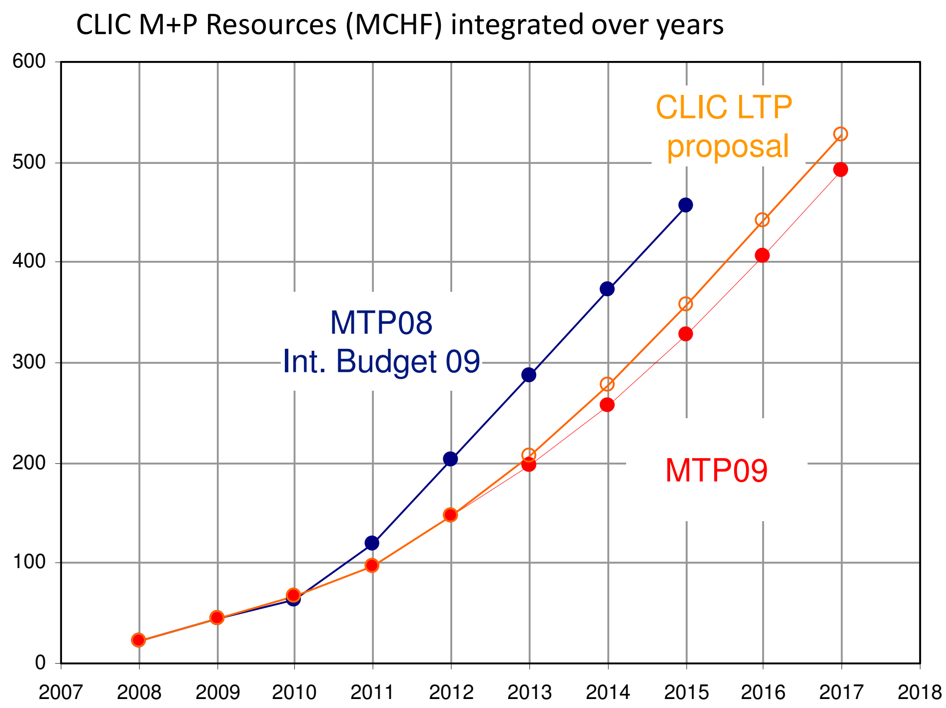
Shortest, Success Oriented, Technically Limited Schedule



Resources

CERN MTP





Expect additional resources from collaborators (from ½ to about the same level)

CERN/SPC/921
CERN/FC/5347
CERN/2847
Original: English
2 June 2009

Medium-Term Plan for the period 2010-2014 and Draft Budget of the Organization for the fifty-sixth financial year 2010

Table 5: Projects

Fact Sheet	(in MCHF, 2009 prices, rounded off)	2009 Revised budget	2010	2011	2012	2013	2014	2010-2014 Total
	Projects	**148.1**	**151.6**	**208.1**	**246.2**	**210.5**	**336.9**	**1 153.3**
16.a	**CLIC**	**22.3**	**22.2**	**30.0**	**50.0**	**50.0**	**60.0**	**212.2**
	Personnel	12.2	12.2	15.0	24.0	24.0	28.8	104.0
	Materials	10.1	10.0	15.0	26.0	26.0	31.2	108.3
16.b	**Linear collider detector**	**0.6**	**2.1**	**3.5**	**4.1**	**4.1**	**4.1**	**17.9**
	Personnel	0.3	1.5	2.6	3.0	3.0	3.0	13.0
	Materials	0.2	0.6	0.9	1.1	1.1	1.1	4.9

EuCARD - FP 7

NClinac (2009-2013) - beginning 1st April 2009

Total: 6,562,118 €, EC request: 2,001,478 €

11 Partners

Short name	Full name and hyperlink	Country
CERN	European Organization for Nuclear Research	INO
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas	Spain
CNRS/LAPP	Centre National de la Recherche Scientifique	France
INFN/LNF	Istituto Nazionale di Fisica Nucleare	Italy
PSI	Paul Scherrer Institut	Switzerland
RHUL	Royal Holloway University of London	UK
STFC/ASTeC	Science and Technology Facilities Council	UK
UH	Helsingin Yliopisto (University of Helsinki)	Finland
UNIMAN	University of Manchester - Cockcroft Institute	UK
UOXF-DL	The Chancellor, Masters and Scholars of the University of Oxford	UK
UU	Uppsala Universitet	Sweden

Task 9.2: Normal Conducting High Gradient Cavities (G. Riddone/CERN)

Task 9.3: Linac and FF Stabilisation (A. Jeremie/LAPP)

Task 9.4: Beam Delivery System (G. Blair/RHUL)

Task 9.5: Drive Beam Phase Control (F. Marcellini/LNF)

\+ EuCARD Task 10.3:Task “Crab cavities” in WP “SRF” and EuCARD Task 7.6: “Short period helical superconducting undulator” in WP “HFM”

EuCARD - FP 7, some comments

- Not really relevant financially (small final EU contribution)
- However, very important for CLIC:
    - Network with collaborating partners
    - Represents an engagement on R&D in the 2009-2013 period
- Note that the scope and size of the present program had been drastically reduced from the initial proposal
- Need to integrate FP7 in the TDR plan & use TDR resources to re-establish initial FP7 plans (when appropriate).

➡ Participation to new CNI-PP TIARA (proposal under definition)

What's required for a TDR ?

What's required for a TDR?

Should be enough to seek project approval and receive funding to build CLIC

- All major feasibility issues satisfactorily solved

- Technical design of all components which are critical for schedule
- Working prototypes for all critical technologies
- Technical feasibility of all components ensured

- Detailed site consideration and construction schedule
- Detailed material cost and manpower resource estimates and risk analysis

What hardware R&D work is needed for the TDR ?

Full technical design, *prototypes and industrialization* for all schedule critical items:

- Nominal two beam modules with all features this includes accelerating structures & PETS
- Drive beam accelerator units (modulator, klystron, RF network, accelerating structure)
- ...

Full technical design and *prototypes* (when applicable) for all critical components

Some other issues to be considered

- Low emittance generation (Damping Rings - possible tests at ATF, SR sources …)
- Low emittance transport (stability, diagnostics - Linac driven FEL's, SLC heritage …)
- CLIC final focus parameters and stability (possible tests at ATF2, …)
- Main beam injectors (polarised e^-, unpolarised and polarised e^+)
- Integration of R&D program with other relevant facilities around the world
- …

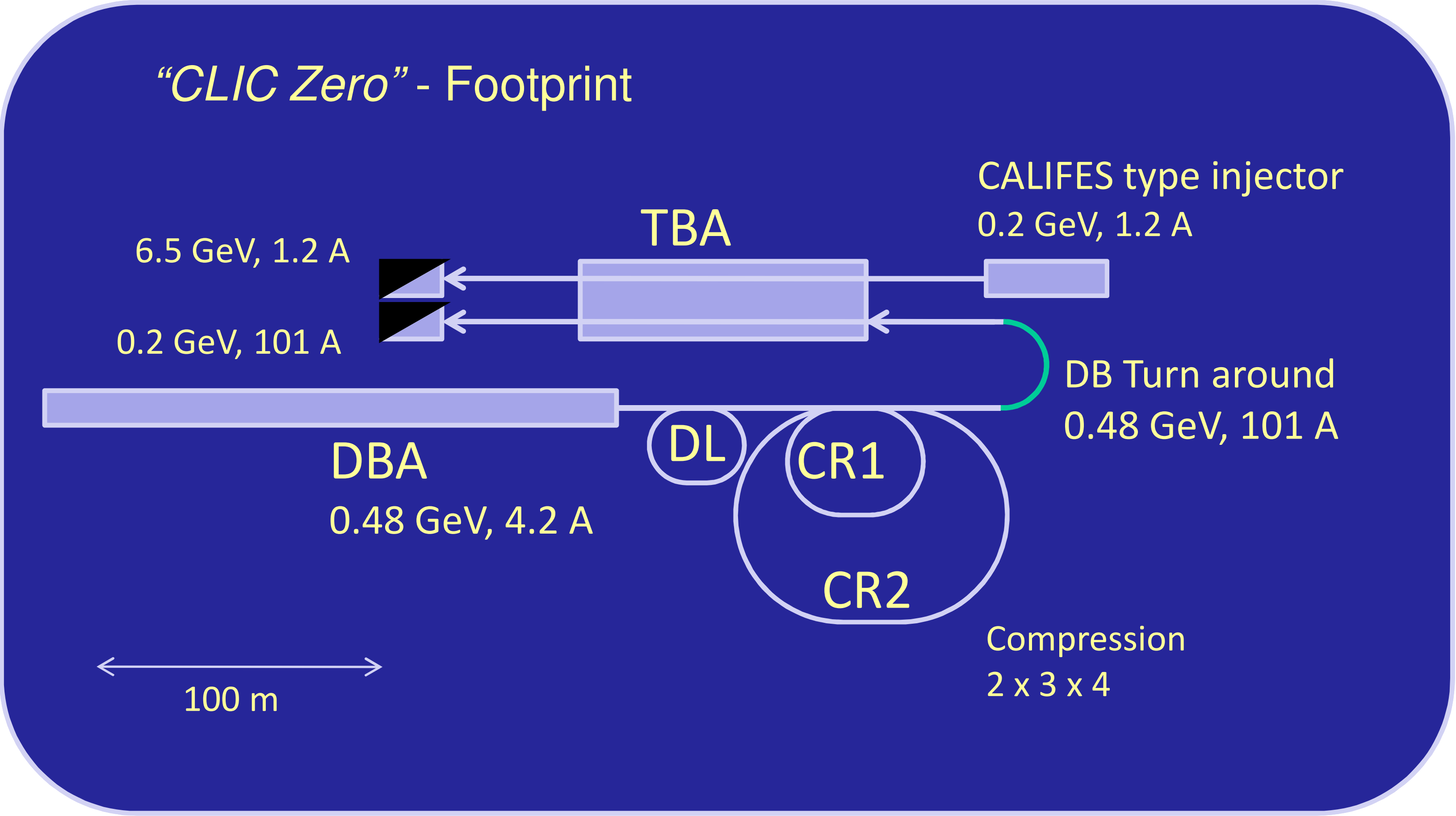
Future facilities should provide

- Engineering test-bed for critical components and industrialization of mass produced components
- Make a convincing case for project readiness
- Provide X-band RF testing capabilities

The CLIC Zero proposal

Initial proposal: A next facility towards CLIC

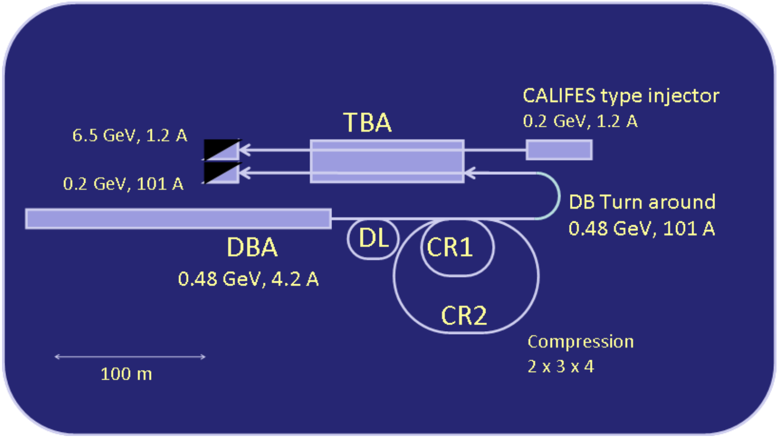
Presented & discussed at the CLIC workshop ‘08



CLIC Zero – Pros & cons

- Demonstrates nominal DBA injector with all parameters
- Creates nominal drive beam train apart from energy (0.48 GeV instead of 2.4 GeV)
- Demonstrates nominal DBA module with klystron and modulator with all parameters
- Demonstrates two beam acceleration over significant distance with fully nominal modules
- Forces pre-series production of all mass produced components → Industrialization
- Well suited to create confidence in CLIC technology
- All hardware investment is re-usable for real CLIC

- **Expensive** – will absorb a very large fraction of budget
- **Schedule too long** – results with beam not before 2015
- No obvious use of 6.5 GeV main beam but for testing
- Drive beam dynamics more difficult than in real CLIC (like in CTF3)



CLIC TDR phase preparation task force - Mandate

- Analysis of the issues still to be addressed:
  - completion of the feasibility related issues if necessary
  - performance and cost related issues
- Elaborate a *proposal of the necessary tasks to be done from mid 2010 up to 2015/16*

  That should include in particular the motivation, description and expected results of:
  - A possible upgrade of CTF3
  - A possible new facility if necessary
  - R&D on specific subjects
  - Prototyping of critical items
  - Industrialization of major components
  - Finalization of design and cost
  - Technical Design Report including consolidated performance and cost
- *Estimate the (M&P) necessary resources and timescale*
- Members of the Task Force:
  - for the Accelerator part: R.Corsini (chair), J.P.Delahaye, S.Doebert, G.Geschonke, A.Grudiev, H.Schmickler, D.Schulte, I.Syratchev, W.Wuensch
  - for the Detector part: L.Linssen, D.Schlatter

Task Force Strategy

- Don't think in term of a single facility
- Start from needs and not from (potentially) available budget / resources

- Begin with list of feasibility / critical items - determine where we will likely stand in 2010
- Define a logical extension of R&D for each activity in the short term (2010-2013) with clear goals
- Define additional R&D needed to arrive at a TDR in 2016 for each activity & identify schedule critical items

- Prioritize list and compare with potentially available resources

The Plan

Accelerating Structures

	Projected Status in 2010	Goals for 2013	Goals for 2016
Structure development, high-gradient studies	Successful test of a few structures (TD18, CLIC_G), with nominal parameters (100MV/m 240 ns 3 10^{-7} m^{-1} brkdown rate) operation for a few thousand hours Including HOM damping features (without damping material)	Test of at least five to ten structures (CLIC_G or current nominal structures) with nominal parameters for statistics. With damping material, compact coupler. Test of potential alternatives for cost & performance (10 - 20 structures)	**About 200 structures tested** Medium-series and long-term operation **Need 10-20 testing slots (12 GHz klystrons or TBL+)**
Precision manufacture	Evidence that final mechanical tolerances required by beam dynamics can be reached. Not yet fully implemented on prototypes.	Mechanical tolerances better than 5 µm	Cost optimization of procedures.
Integration, alignment	Design (or alternatives) for final solution including cooling, vacuum, alignment. Not yet implemented on prototypes.	All ancillary subsystems of prototypes (cooling, vacuum) compatible with module integration. Experimental verification in **CTF3 modules** of inner and structure-structure alignment and resolution of the wake-field monitors	Cost optimization.
Facilities, Industrialization	Precision metrology at CERN. Precision assembly (brazing) at CERN. Full qualification capability at CERN and/or within the collaboration. List of qualified outside companies.	Start **precision machining capability** at CERN or elsewhere within the collaboration	Cost optimization. **Pre-series production with industry** Input needed from costing WG and TE dept.

PETS

	Projected Status in 2010	Goals for 2013	Goals for 2016
PETS development, high-power tests	Operation (a few thousand hours) of a few PETS, in klystron-driven mode to nominal parameters (135 MW to 165 MW, 240 ns, breakdown rate a few 10^{-7} /m), eventually with damping. Beam-powered test of a single PETS with external recirculation in TBTS/CTF3, to nominal parameters (135 MW, 240 ns). Beam-powered test of 8 PETS in the TBL/CTF3, to nominal power (135 MW) and 140 ns.	Beam-powered operation of 16 PETS in the TBL/CTF3, to nominal power (135 MW) and 140 ns. Beam measurements to verify wake-field model.	**Medium series, long term operation of nominal CLIC PETS (klystron-driven)** **Possible use of TBL+ as power source**
On/Off capability	Design of PETS with internal recirculation. Components: compact damped coupler.	Test of PETS with internal recirculation prototype (TBL). Fast on/off concept.	Full implementation, cost and reliability optimization.
Further optimizations, components	Waveguide components tested to full power (e.g., choke-mode flange). First test of wake monitoring in TBTS.	Full waveguide network prototype in CLIC modules in CTF3. Wake monitoring developments?	Final design of components.
Manufacture, industrialization & integration	Specified tolerances (~10 μm) achieved by several vendors (up to now ~ 6 companies qualified). Design of module integration.	Integration of special PETS in **CLIC modules in CTF3** (no ON/OFF). Choice of damping material.	Cost optimization. **Pre-series production with industry**

Resume of RF R&D activities

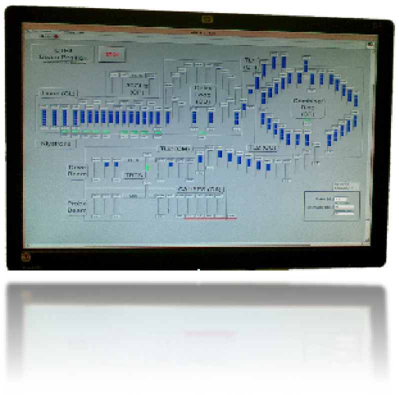
- RF design of structure, PETS and components. Basic breakdown and high-gradient studies in dedicated facilities (spark-gap, laser, stand-alone 12 GHz sources).
- Manufacturing, assembly and qualification of structures, PETS & other RF components. Preparation for industrialization.
- High-power, high-gradient testing. Long term, large statistics. Both in klystron based facilities and in CTF3.
- Two-beam tests in CTF3. Integrated RF systems, performance check.

Drive Beam

	Projected Status in 2010	Goals for 2013	Goals for 2016
Drive beam injector	Thermionic option: scheme for satellites control, stability assessment in CTF3 Photoinjector option: meas. beam quality, stability and long test running of photo-injector in CTF2	Comparison and choice between photo-injector and thermionic possible Photo-injector in CTF3 ?	**Injector prototype with CLIC nominal parameters**, possibly for both solution if choice is not made
DBA, Full Loading, efficiency	95% efficiency RF-to-beam, SICA 3 GHz, 5 A Current stability ~ 10^{-3} Energy stability ~ 10^{-3}	Current stability < 10^{-3} Energy stability < 10^{-3}	**First part of DB linac at right frequency**, 100 to 200 MeV final stability Efficiency > 90% includ. WGs
Rings, combination scheme	~ 30 A combined and transported, bunch length < 1 mm, emittance ~ 100 π mm mrad, current &energy stability a few 10^{-3} Phase stability ? CLIC DL & CR design	C & E stability below 10^{-3} Phase stability monitor (FP7), measurements	Eventually add final DL & ring(s) to injector/DBA ??
Sources (modulators & klystrons)	Parametric study of DBA power scheme, reference structure design, M&K specs	Design of M&K, start prototyping – possibly a few prototypes ready in 2012	**M&Ks with full specs, as needed for injector and DBA section.**
Drive beam phase and amplitude feedback system	timing reference system conceptual feedback system	low impedance phase monitor, test in CTF3	**DB fast phase feed-back in CTF3 – results of experimental studies** (Kickers, amplifiers, improved phase monitors) alternative timing reference (e.g. X-FEL)

Power production and Two-beam issues

	Projected Status in 2010	Goals for 2013	Goals for 2016
Power production from drive beam, Two-Beams	Beam-powered test of a single PETS with external recirculation in TBTS/CTF3, to nominal parameters (135 MW, 240 ns). Power, energy loss & gain measurements. First break-down kick measurement.	Complete break-down kick measurement. Break-down studies.	**Possible use of TBL+ as power source**
Deceleration, stability	Beam deceleration experiment in TBL 8 PETS, ~ 30 A & 30% energy extraction Lattice design including cost optimization options - study of decelerator stability, beam loss estimates, including beam based alignment	Beam deceleration experiment in TBL up to 16 PETS, ~ 30 A & 50% energy extraction	Eventually add test decelerator to final DL & ring(s) to injector/DBA ??
Beam loading compensation	Concept First experiment on beam loading control in CTF3/TBTS	Improved beam loading experiment in CTF3/TBTS – full charge	Drive beam bunch charge control Main beam current feed-forward e.g. temperature effects
Manufacture, industrialization & integration	Design of CLIC module	Integration of accelerating structures, PETS & ancillary equipment in CLIC modules in CTF3.	**Production of N modules (N>20) with combined alignment/stabilization system ?**



Drive Beam, Power production and Two-beam issues:

Next Steps in CTF3

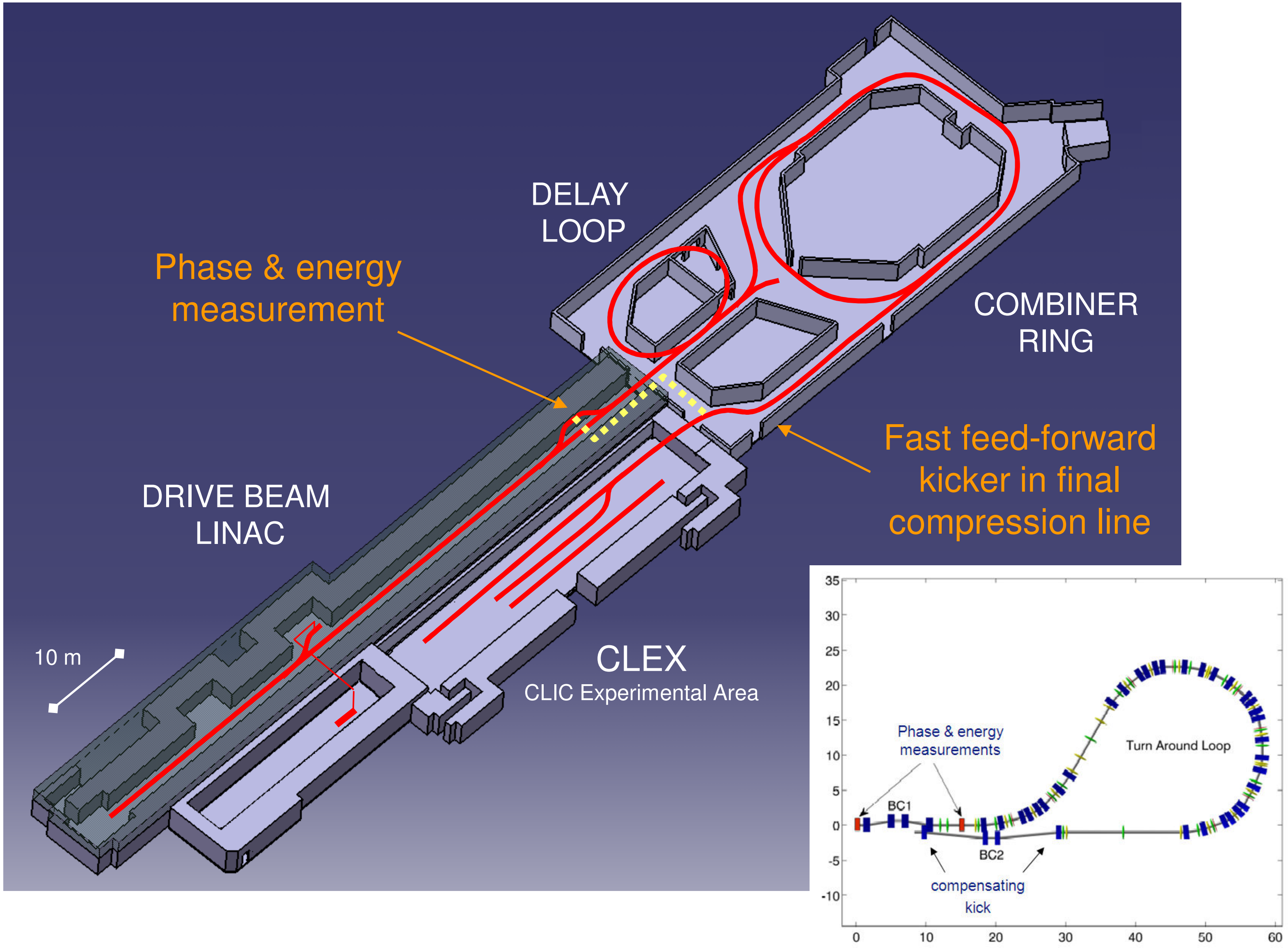
2010 +

- TBL drive beam deceleration studies (string of up to 16 PETS)
- Study of two-beam issues
  - RF breakdown kicks experiment
  - Beam loading compensation of probe beam

2013 +

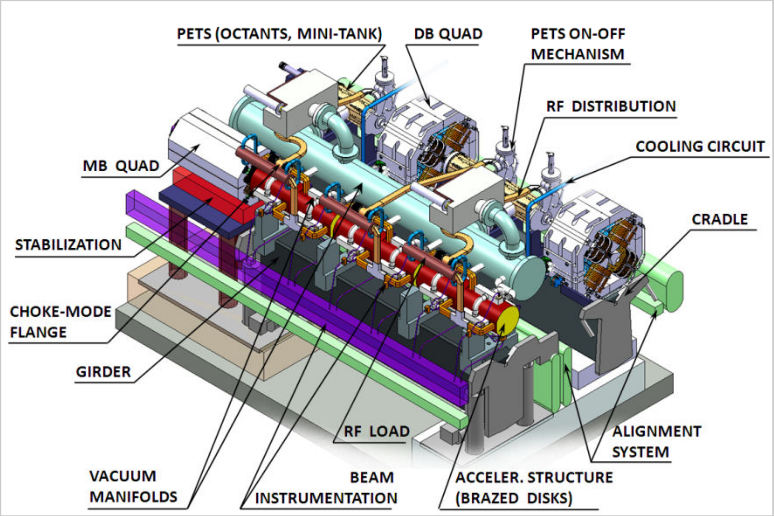
- Phase stability measurements & feed-forward tests
- Full-fledged CLIC modules beam tests in CLEX
- CTF3 upgraded to X-band power production & testing facility
- Other options under study:
  - Photo-injector option full implementation
  - Instrumentation development for LC – Instrumentation Test Beamline

Phase stability measurements & feed-forward



Two-beam modules in TBTS

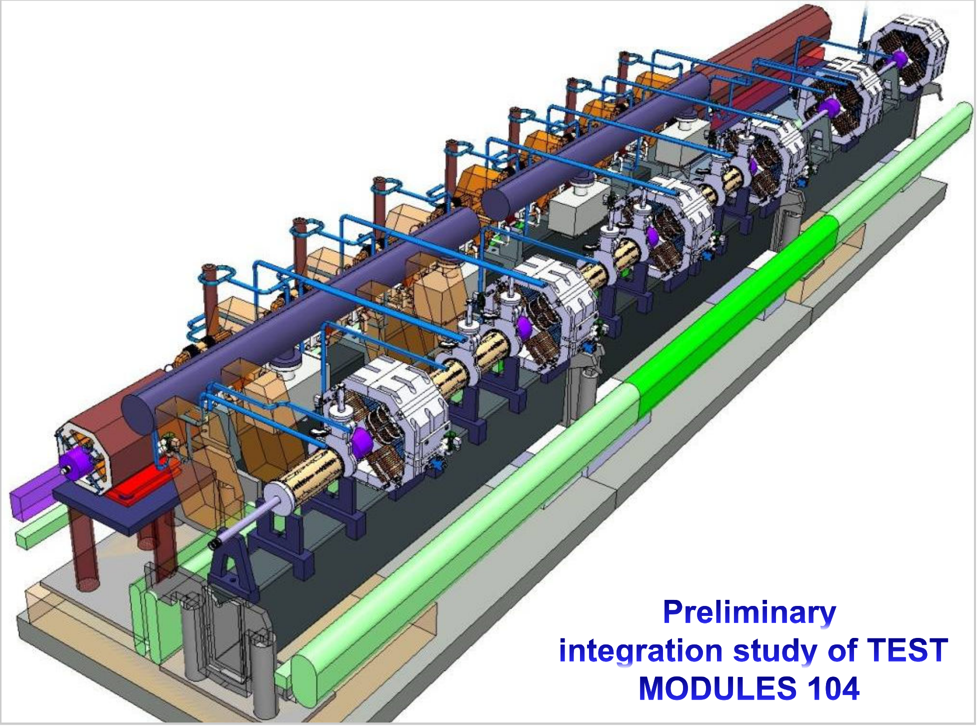
- Module design and integration have to be studied for different configurations.
- Detailed design well advanced for the main systems (vacuum, cooling, alignment, stabilization …)
- Important aspects for cost and basic parameters provided for other areas of the study.
- Goal: → test with beam of a few modules in CTF3/CLEX [includes FP7]



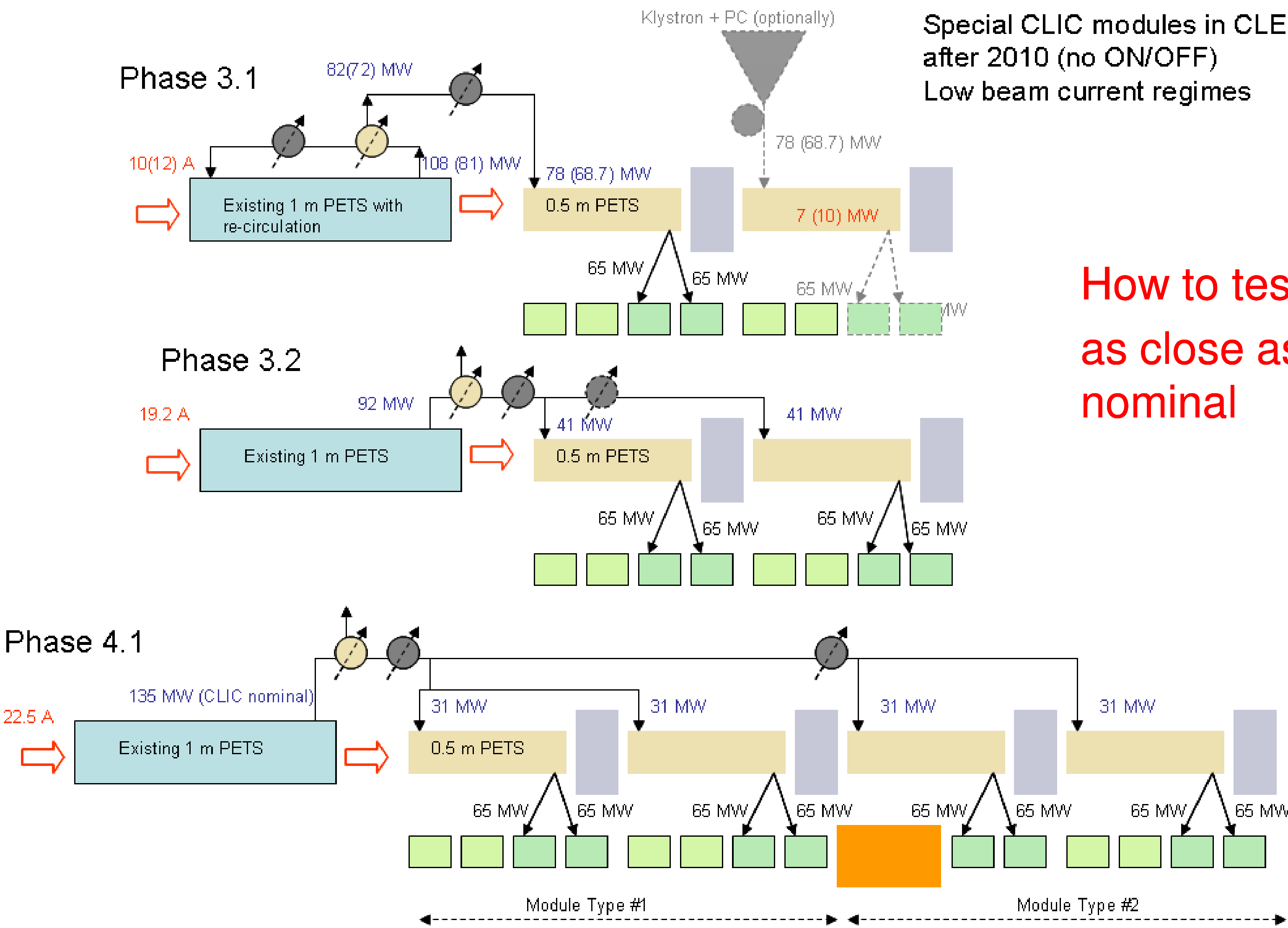
20760 modules (2 m long)

71460 power prod. structures PETS (drive beam)

143010 accelerating structures (main beam)



Special CLIC modules in CLEX after 2010 (no ON/OFF)
Low beam current regimes



How to test with beam, as close as possible to nominal

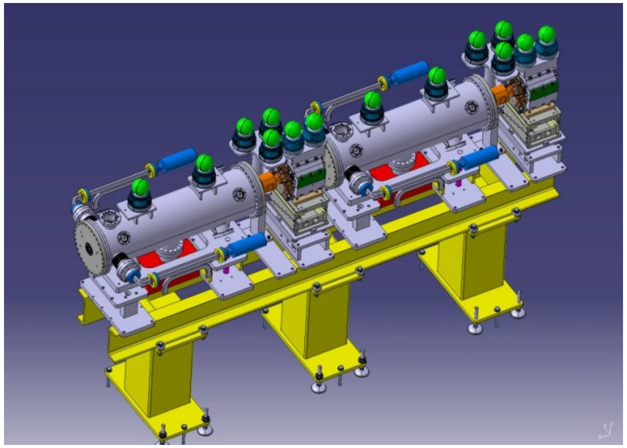
CTF3 upgraded to X-band testing plant – TBL+

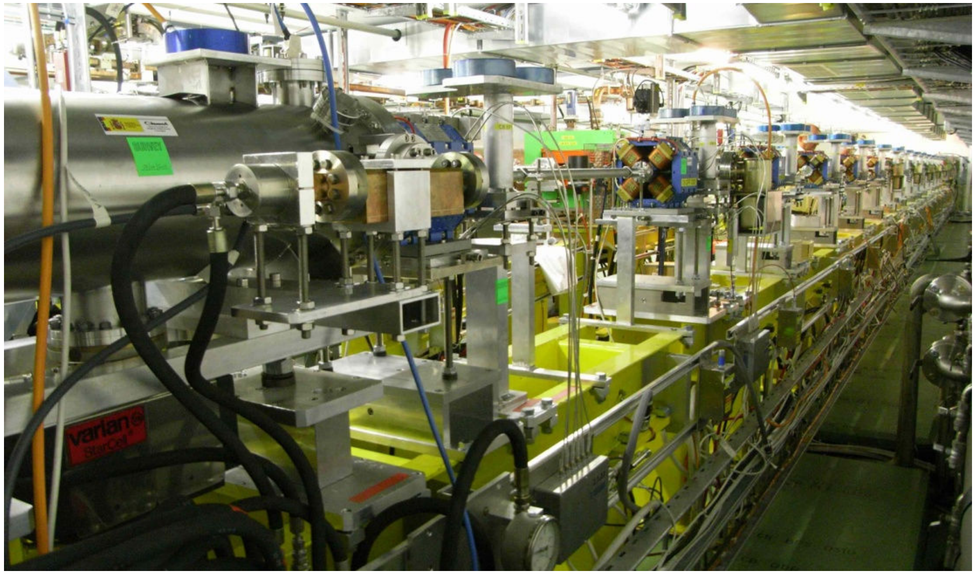
- In TBL up to 16 RF ports with nominal power & pulse length
- Cheaper than several stand-alone X-band sources
- Gives incentive to consolidate drive beam operation towards large facility standards

- Need upgrade of CTF3 beam energy – klystrons upgrade
- Need increase of present rep. rate (up to 50 Hz desirable), increase shielding
- Pulse length obtained only sacrificing power – or need priming/chaining

Remember: CLIC 3 TeV needs 143000 accelerating structures. If every structure needs two days of RF processing before installation in the tunnel and we want to build CLIC over 7 years we need more than

$$\frac{143000 \times 2}{7 \times 365} = 112 \text{ RF slots}$$





Drive Beam Injector & Linac Facility

- Demonstrates nominal DBA injector with all parameters
- Creates nominal drive beam train apart from energy (power handling, stability – phase and intensity)
- Demonstrates nominal DBA module with klystron and modulator with all parameters
- Forces pre-series production of all DBA mass produced components → Industrialization
- All hardware investment is re-usable for real CLIC

Stabilization

	Projected Status in 2010	Goals for 2013	Goals for 2016
Main linac quads	Mechanical stability assessment of Main beam Quad in CTF3. Mechanics optimized for passive damping. Design of Alignment / stabilization system, within specs for: i) automatic mechanical pre-alignment ii) beam based correction +stabilization Test mockup in laboratory with first feedback loops. Gain of external feedback below 100. Meeting specification for MB Quad of 1nm rms above 1 Hz probable.	Integration into CLIC module (in CTF3/TBTS) Validation of magnet axis stability through a beam experiment at CesrTA or elsewhere Full implementation of feedback loops	**Production of N modules (N>20) with combined alignment/stabilization system** Assessment of performance Chose technical implementation of controller; global feedback versus distributed systems.
FF quads	Measurements of ground motion and environmental vibrations. Stabilization experiments at LAPP for a simple cantilever mockup of a FF magnet. Studies on options for FF magnet technology and options for FF magnet support structures. Simulations.	Mechanical stability of a superconducting FF magnet at ATF2. Mechanics optimized for passive damping. Gain of external feedback below 100. Meeting specification of 0.18 nm is challenging, if not unlikely.	**CLIC prototype on chosen technology including alignment system and stabilization system.** Assessment of performance
General	R&D on diagnostics; laser systems, interaction of lasers or other radiation with gas filled chambers (beyond geophones, i.e. laser interferometers, other)	Apply advanced diagnostics for assessment of performance	Apply advanced diagnostics for assessment of performance

Generation & preservation of low emittances

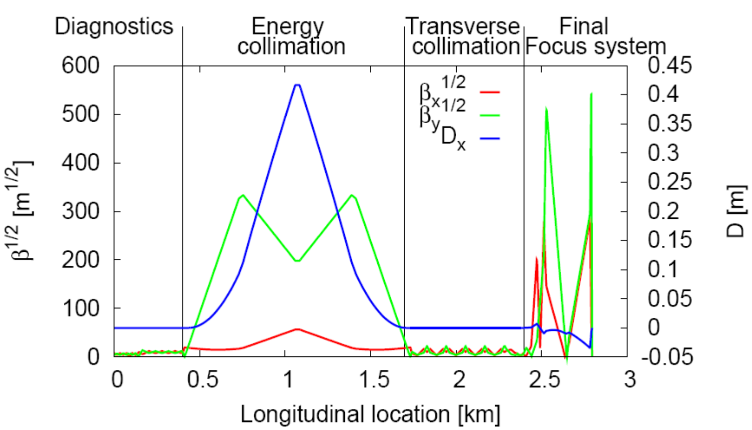
Sources, Injectors and Damping Rings

	Projected Status in 2010	Goals for 2013	Goals for 2016
Polarized electron source	Scheme & alternatives solutions for 500 GeV. Test at SLAC possible	Test at SLAC, JLAB or elsewhere.	Full design, CLIC micro + macro pulse demonstration. Possibly prototype.
Positron source	Full simulation for yield to DR R&D on polarized positrons.	R&D on polarized positrons.	Full design, Positron target demonstration (KEK/SLAC)?
Main beam injectors, RTML	Conceptual design. Simulation from DR to main linac, phase stability study, structure design.		Full design, structure prototypes, 2,4 and 12 GHz **Klystrons: 2, 4 and 12 GHz** Laser specs
Damping Rings	Updated lattice designs for DR and pre-DR rings at 3TeV and 500GeV. Simulations confirming DR performance with IBS. Simulations defining requirements to suppress e-cloud. Results of the world-wide e-cloud collaboration. SC wiggler prototype. Solution for wiggler chamber with SR absorbers. Solution for the RF system including beam loading compensation.	Low emittance tuning experiments (SLS). Experimental activities at CesrTA. SC wiggler tested with beam. Wiggler chamber prototypes. Damping ring extraction kicker prototype.	Demonstration of vertical and horizontal emittances close to minimum requirements for CLIC 500 GeV. Working prototypes of all critical components.

Generation & preservation of low emittances

Main Linac and BDS (see also Stabilization and Diagnostics)

	Projected Status in 2010	Goals for 2013	Goals for 2016
Main Linac	Concept of orbit feedback, including BPMs and correctors. Wake-field monitors design. Stray field model and mitigation concept. Main linac vacuum concept	BPMs, correctors and wake-field monitors prototypes, beam tests in CTF3 Components development and prototyping, beam tests?	BPMs, correctors and wake-fieldmonitors cost reduction Improved model/mitigation, low field vacuum pumps and shielding integrated.
BDS	Reference lattice at 3TeV and 500GeV. Concept of collimation system. Detector solenoid and shielding optimization, tuning strategy. Concept of orbit feedback.	Test of the CLIC beam-based alignment scheme at **ATF2 (ultra-low beta)**.	Updated lattices (feed-back from experiments)



Project	Status	β_y^* [mm]	L* [m]	L^*/β_y^*	ξ_y
FFTB	Measured	0.167	0.4	2400	10000
ATF2	Design	0.1	1.0	10000	19000
ATF2 ultra-low β	Proposed	0.025	1.0	40000	76000
CLIC	Design	0.08	3.5	39000	63000
Andrei's prop.	Proposed	0.1	8.0	80000	120000

Other systems

Beam Diagnostics, Machine Protection System

	Projected Status in 2010	Goals for 2013	Goals for 2016
Beam Diagnostics	Specification of all instruments, conceptual design and basic feasibility shown. small factors in resolution still to be gained for main beam BPMs and transverse/longitudinal profile monitors (resolution). Small factors in resolution and acccuracy still to be gained for and drive beam BPMs.	Beam tests of prototypes done (mainly outside CERN). R&D on cost reduction and standardization of sensors and electronics.	Final designs and prototypes available. Prototypes tested in extended CTF3 and new facility. Several vendors available. Cost reduction study results.
Machine Protection	Proposed concept, based on "2ms failsave" established as baseline. List of equipment which has to be "2ms failsave" available. SIL level for the interlock systems and for the 2ms stability of the critical machine elements documented. First specifications for beam loss monitoring.	Full design of the machine protection system is available including the designs of "2ms failsave" for the critical machine elements.	A fully functional machine protection system including its integration into the control system is implemented on CTF3 and/or on new facility.

… and more

Summarizing…

Summary (I)

A logical extension beyond 2010 of the present CLIC R&D program was identified. Such program will consolidate the feasibility demonstration and the cost estimate and provide, on the 2013 time scale, all information needed for the final cost and performance optimization of the CLIC design. In this framework:

- The operation of CTF3 should be extended to at least 2013, and should include:
  - A series of full-fledged CLIC TBA modules.
  - A fast phase feed-back system to test the phase stability requirements of the CLIC drive beam.
  - A power production facility for structure & RF component testing.
- A large number of accelerating structures (and PETS) should be tested during this phase (and even more in the following period), therefore:
  - The construction and operation of several RF test facilities, on top of CTF3, is mandatory.
  - Infrastructure needed for construction, preparation and qualification of RF structures must be strengthened as well.
- A number of experimental tests that cannot be made in CTF3 will have to be executed in other facilities around the world – many are presently pursued (ATF2, CesrTA, ANKA, …) while others are under consideration.
- Working prototypes for all critical technology items (not included in the test facilities program) should as well be developed in this period (FF stabilization, diagnostics, kickers, vacuum equipment, magnets…).

Summary (II)

On a longer time scale (2016), the R&D program is meant to achieve readiness to ask for project approval and beginning of construction. A Technical Design Report (TDR) will be delivered at the end of this second stage. In this framework:

- Beam tests outside CTF3 and hardware tests of critical technology items must be completed.

- Extensive prototyping of schedule critical items is mandatory. This implies:
  - Production,RF testing and beginning of industrialization of large numbers of structures, PETS and RF components.
  - Construction and assembly of several full-fledged two-beam modules.
  - Construction of several Drive Beam accelerator units (modulator, klystron, RF network, accelerating structure).

- Presently, we don't believe a very large facilty (like CLIC Zero) is absolutely needed to complete the TDR. However, we believe a facility including a full-scale Drive Beam injector and the first part of the DB linac has to be built and exploited in this time scale. This could be the stepping stone for a larger facility.

- The CLIC TDR shall also include:
  - A complete technical description of the CLIC complex, sufficiently detailed to ensure the technical feasibility of all components and to justify the associated cost estimate.
  - Detailed site considerations, including a realistic construction schedule.
  - A material cost and manpower resource estimate and risk analysis, consistent with the scope of the machine and the proposed construction schedule.

CONCLUSIONS

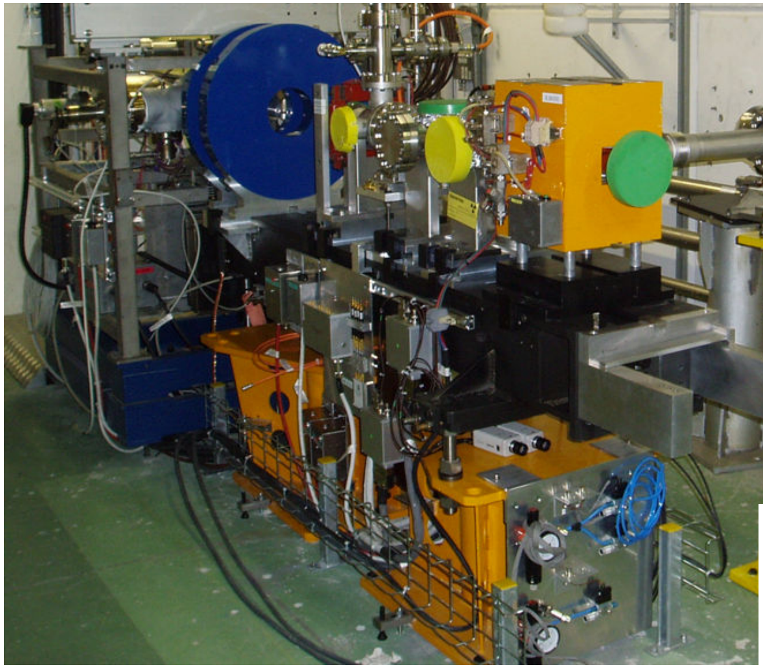
A plan for the R&D activities of the CLIC Technical Design Phase after 2010 is being finalized.

We are presently evaluating the resources needed for the planned R&D activities.

We expect your feedback during this workshop to improve and complete the present plan.

Reserve slides

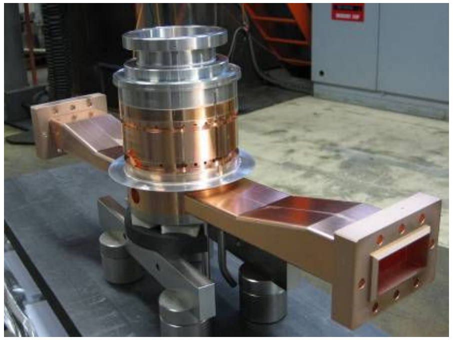
Photo-injector option full implementation

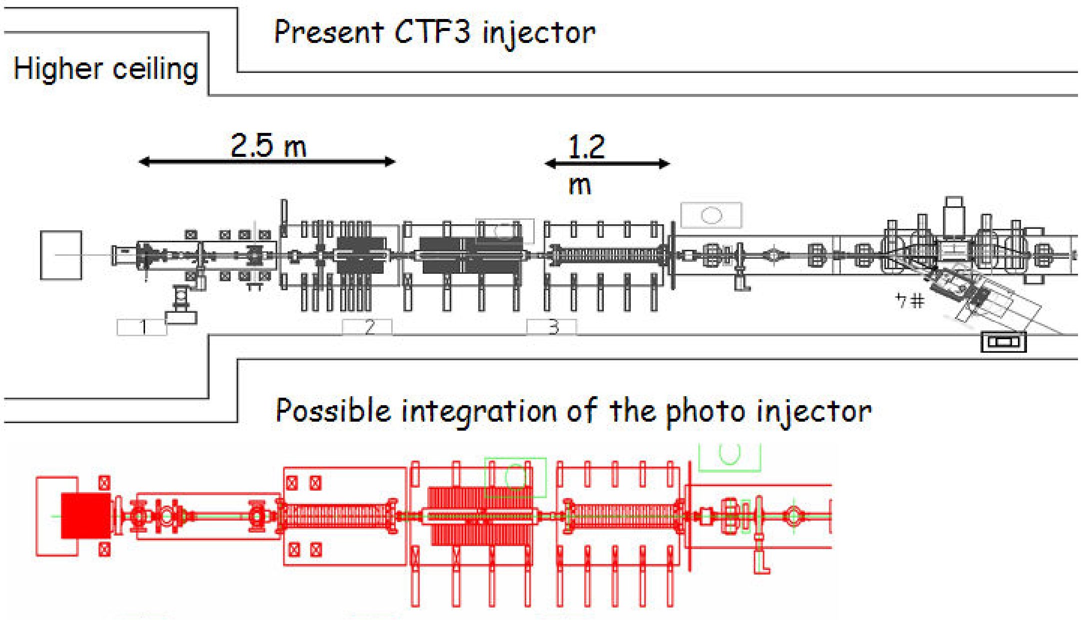


- Smaller transverse emittance
- Shorter bunches, no energy tails
- No satellites
- Lower current

Single bunch option will allow
- Check and correction of beam optics with high precision
- CSR measurements with high precision in DL, CR and TL2 bunch compressor.
- δ response of PETS and beam instrumentation
- …

Probably only dedicated tests in CTF2

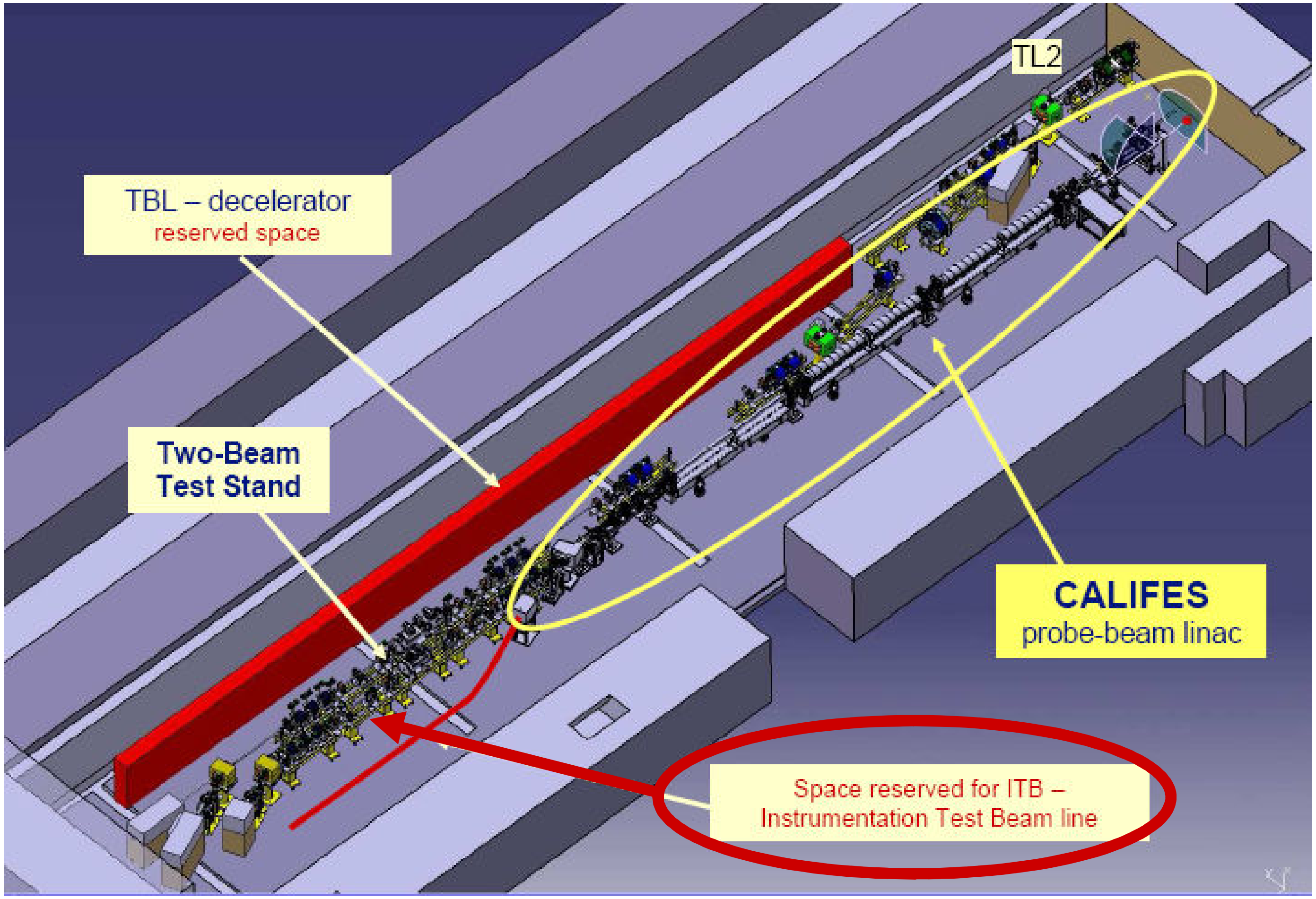


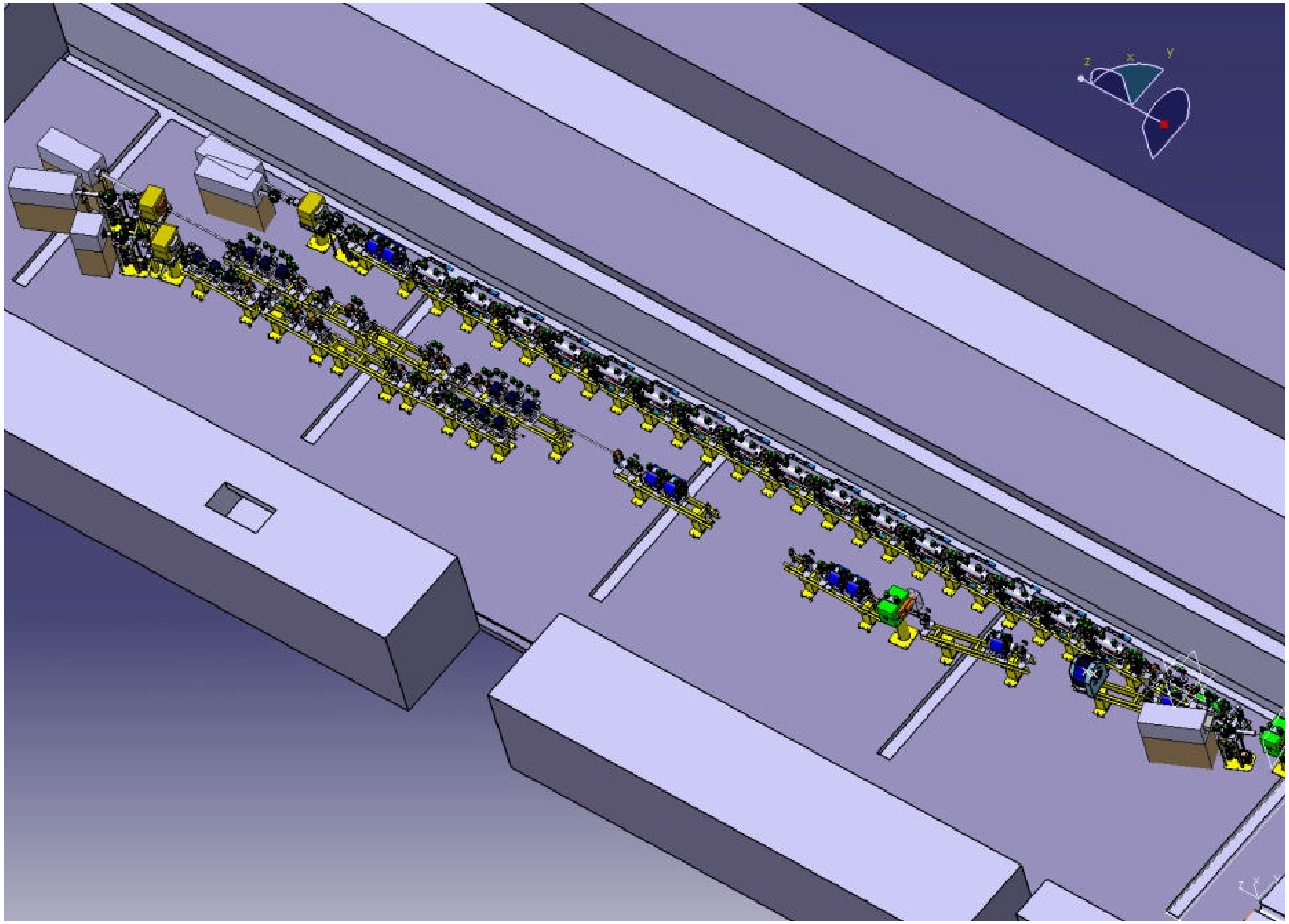


List of issues/options to be explored to get to the TDR

- Completion of feasibility demonstration (basic information on feasibility should be already available, but...)
- R&D on critical issues (performance + cost, e.g. stabilization & alignment)
- Prototyping of critical components for performance (small number items, e.g. final doublet quads, sc wigglers)
- Prototyping (and possibly pre-series) of critical components for cost (e.g. drive beam modulators/klystrons)
- Start industrialization of mass produced components (e.g. RF structures, RF components...) ?
- Integration of components in large number modular sub-systems (two-beam modules)
- Test of full (small?) sub-systems, critical for performance (e.g. D.B. Injector, positron source...)
- Tests at existing test facilities on specific issues (e.g. phase stability, electron cloud, IBS…)
- R & D on diagnostics, machine protection ?
- Need (larger) facilities for RF conditioning/testing ?

Instrumentation Test Beamline





Main Linac RF Stability

Item	By 2010	FP7/2012	Requ. for TDR
Beam loading compensation	concept some experiment in TBTS	better experiment	improved design drive beam bunch charge control main beam current feed-forward? e.g. temperature effects
Drive beam phase and amplitude feedback system	timing reference system conceptual feedback system	low impedance phase monitor	kickers, amplifiers, improved phase monitors, alternative timing reference (e.g. X-FEL)
Stable Klystrons main and drive beam (12GHz, 1GHz)	measurements of existing klystrons		development of stabilised klystron
Stable drive beam injector	measurements in CTF3 model of injector stability	satellite suppression	stable injector stable components e.g. laser
Crab cavitiy phasing		some system	stable system (impact on experiment)

Static Imperfections

Item	By 2010	FP7/2012	Requ. for TDR
Wake Monitors	design	prototypes with limited tests	improved design improved tests (FP7 can fail) cost reduction alternatives
Drive Beam BPMs	specification and number concept	prototypes	cost reduction alternatives (e.g. in PETS)
Controls	concept of low-cost read-out (wireless?)		prototypes machine protection radiation hardness number scalability improvements
Alignment system	some prototypes	motors/module	cost reduction robustness long distance
Train flattener			design
Temperature variations			evaluation for critical components component design

Main Beam Stability

Item	By 2010	FP7/2012	Requ. for TDR
Stable components and module active stabilisation see also Hermann's talk	measurement of component stability (e.g. accelerating structures)		design of critical components for low vibrations, e.g. accelerating structures, detector components vacuum pumps etc.
Orbit feedback	concept of feedback, concept of BPMs BPM prototypes concept of correctors corrector prototypes		BPM cost reduction corrector cost reduction
Breakdown detection	concept of detection		prototype system cost reduction
Main linac vacuum	concept		measurement capabilities, prototypes, improvements, dynamic vacuum w. drive beam
Stray fields	model and mitigation concept		improved model mitigation concept e.g. vacuum pumps with low field, shielding
IP feedback	concept		prototypes detector integration

RF Components

Item	By 2010	FP7/2012	Requ. for TDR
Module interconnects (impedance, mechanics)	concept	module tests	improved design alternatives robustness
Long-range wakefields PETS and accelerating structures	calculations		experiments improvements
Dark current	some indications		dedicated experiments, multiple modules
Beam halo (losses and impact on instrumentation)	some code		experiments