CLIC status and perspectives in 2009 and beyond

Welcome to 2009 CTF3 Technical Meeting

CLIC highlights 2008

Work program 2009-10: Feasibility and CDR preparation

Definition TDR phase (2011-15)

Schedule

Organisation

Conclusion

World-wide CLIC / CTF3 collaboration

http://clic-meeting.web.cern.ch/clic-meeting/CTF3_Coordination_Mtg/Table_MoU.htm

24 members representing 27 institutes involving 17 funding agencies of 15 countries

Ankara University (Turkey)
BINP (Russia)
CERN
CIEMAT (Spain)
Cockcroft Institute (UK)
Gazi Universities (Turkey)
IRFU/Saclay (France)

Helsinki Institute of Physics (Finland)
IAP (Russia)
IAP NASU (Ukraine)
Instituto de Fisica Corpuscular (Spain)
INFN / LNF (Italy)
J.Adams Institute, (UK)

JINR (Russia)
JLAB (USA)
KEK (Japan)
LAL/Orsay (France)
LAPP/ESIA (France)
NCP (Pakistan)
North-West. Univ. Illinois (USA)

University of Oslo (Norway)
PSI (Switzerland),
Polytech. University of Catalonia (Spain)
RRCAT-Indore (India)
Royal Holloway, Univ. London, (UK)
SLAC (USA)
Uppsala University (Sweden)

CLIC/CTF3 Collaboration 2008 new members

- **Cockcroft Institute/UK**
  - **Accelerating Structures + Crab cavities**
  - **CTF3 operation**
  - **Damping Ring design**
  - **Positron sources**
  - **Beam diagnostics**
- **University of Oslo/Norway**
  - **Beam dynamics and PETS tests in TBL**
- **KEK/Japan**
  - **Fabrication and Tests of Accelerating Structures**
- **IAP/Ukraine**
  - **RF breakdown (simulations and theoretical studies)**

MoU under preparation:

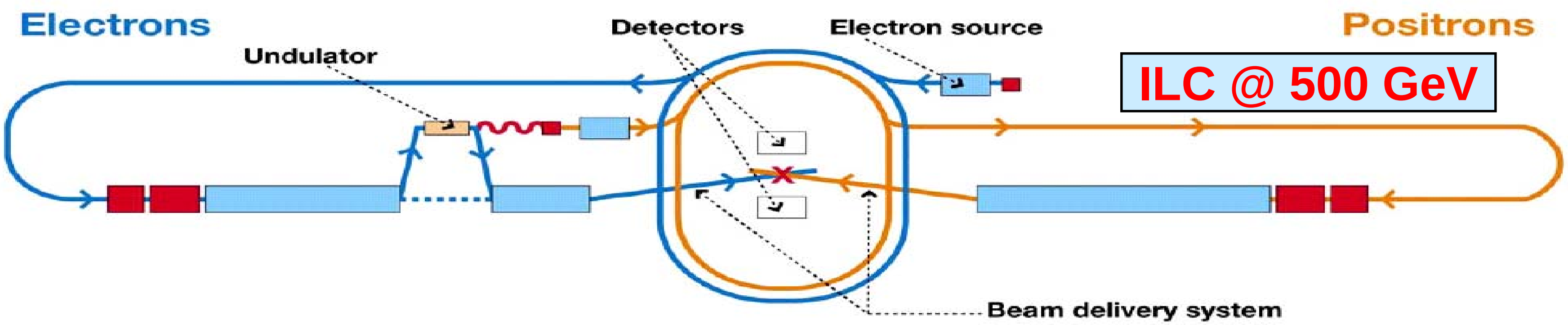
China (IHEP, Tsinghua Univ.), FNAL (USA), Greece (NTU-Athens, UoPatras), Iran (IPM), Karlsruhe (Germany)

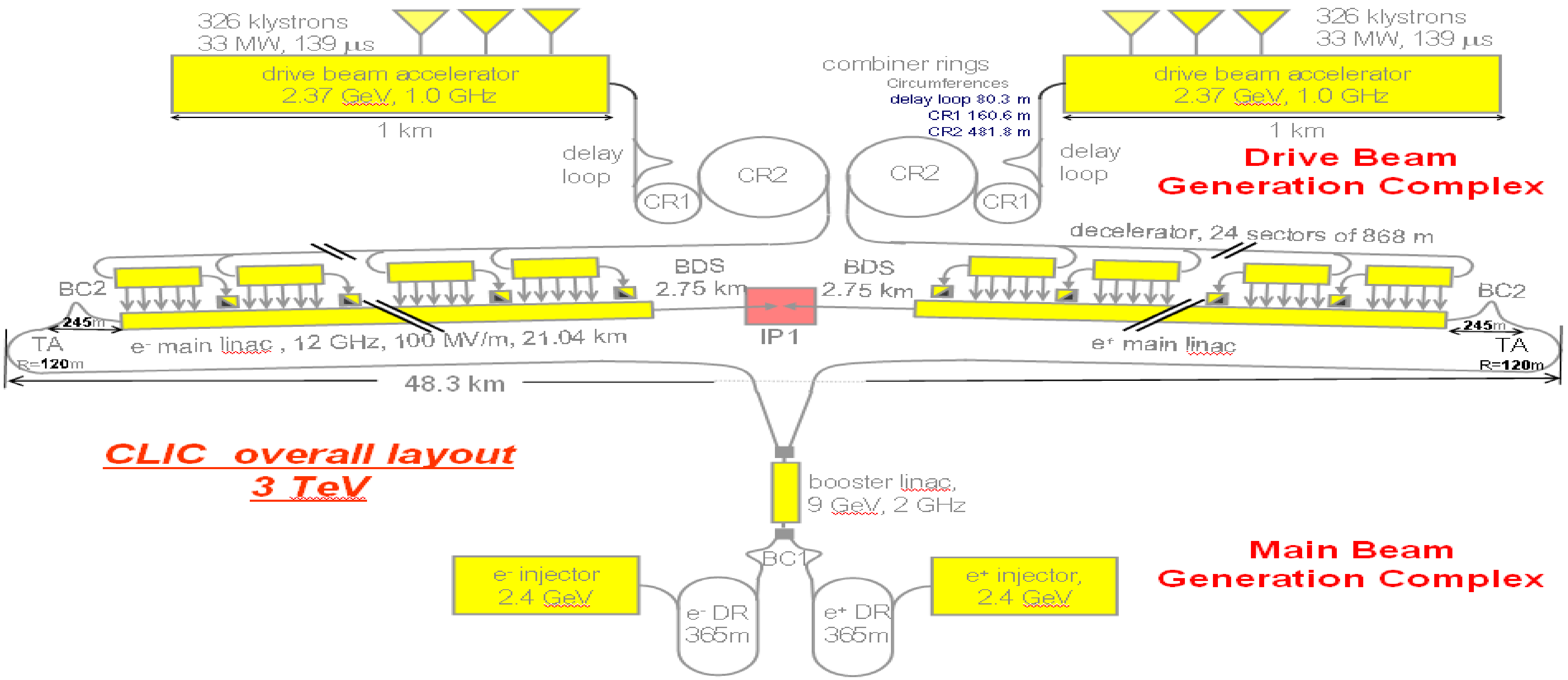
A necessary and beneficial CLIC /ILC Collaboration

http://clic-study.web.cern.ch/CLIC-Study/CLIC_ILC_Collab_Mtg/Index.htm

- **Focusing on subjects with strong synergy between CLIC & ILC**
- **making the best use of the available resources**
- **adopting systems as similar as possible**
- **identifying and understanding the differences due to technology and energy (technical, cost….)**
- **developing common knowledge of both designs and technologies on status, advantages, issues and prospects for the best use of future HEP**
- **preparing together by the Linear Collider Community made up of CLIC & ILC experts:**
  - **the future evaluation of the two technologies**
  - **proposal(s) best adapted to the (future) HEP requirements**

CLIC and ILC layouts





CLIC overall layout
3 TeV

Subjects with strong synergy Working Groups & Conveners

	CLIC	ILC
Physics & Detectors	L.Linssen, D.Schlatter	F.Richard, S.Yamada
Beam Delivery System (BDS) & Machine Detector Interface (MDI)	D.Schulte, R.Tomas Garcia E.Tsesmelis	B.Parker, A.Seriy
Civil Engineering & Conventional Facilities	C.Hauviller, J.Osborne.	J.Osborne, V.Kuchler
Positron Generation (new)	L.Rinolfi	J.Clarke
Damping Rings (new)	Y.Papaphilipou	M.Palmer
Beam Dynamics	D.Schulte	A.Latina, K.Kubo, N.Walker
Cost & Schedule	H.Braun (P.Lebrun), K.Foraz, G.Riddone	J.Carwardine, P.Garbincius, T.Shidara

CLIC ILC collaboration extremely well appreciated by HEP community and beyond

- **ILC 'Physics Advisory Committee' review (Oct. 2008):**

"The PAC views very positively the recent start of common activities between the ILC and CLIC on many items such as conventional facilities, beam delivery system, detectors, physics, cost estimation, etc. This avoids unnecessary duplication of effort, and keeps the particle physics community focused on the goal of a linear collider as the next major new facility for the field."

- **NATURE, Vol 456, 27 November 2008, page 422**

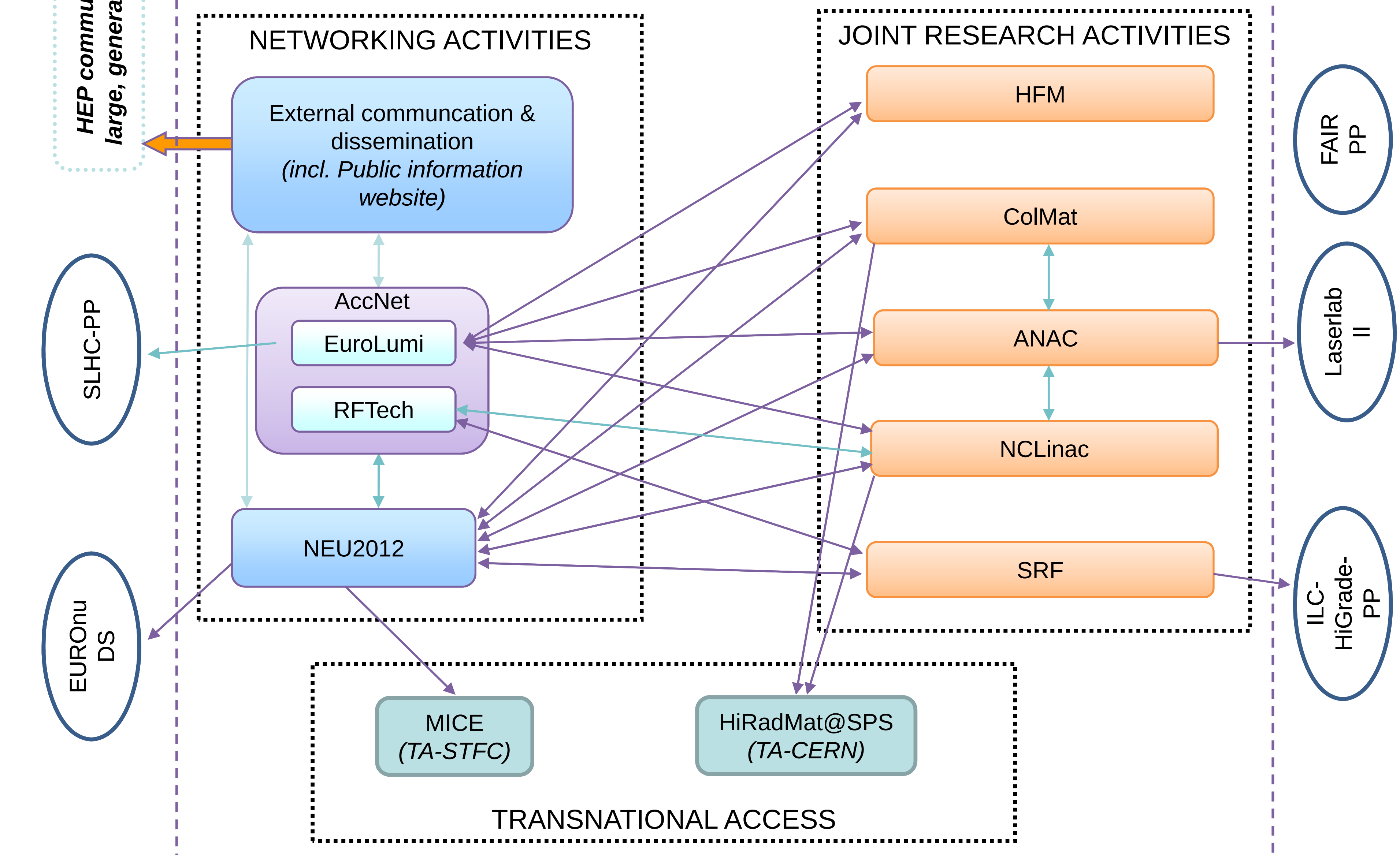
  "Friendly rivalry: The spirit of collaboration between CLIC and ILC in the race to define the LHC's successor sets an example for large projects that other scientific endeavours would do well to emulate.

- **CERN DG:**
  - **Conclusion of LCWS08 workshop in Chicago (Nov 08)**
  - **Presentation to CERN staff January 09**

FP7 - EuCARD

- ***Eu**ropean **C**oordination of **A**ccelerator **R**esearch and **D**evelopment*
- **EuCARD is an "Integrating Activity" (IA) supported by the European Commission (EC) coordinated by CERN**
- **37 "beneficiaries" (participating labs, universities and companies) from 12 European countries.**
- **Duration: April 2009 – March 2013**
- **Overall budget: 33 M€, EC contribution: 10 M€**
- **Details at: https://eucard.web.cern.ch/EuCARD/index.html**
- **Present status: finalizing *Grant Agreement* with EC and *Consortium Agreement* with the partners**

Project management and internal communication



EuCARD WP9 “NCLinac”

- Full name: ***“Technology for normal conducting higher energy linear colliders”***
- 5 tasks:
  - NCLinac Coordination and Communication
  - Normal conducting High Gradient Cavities

    PETS, alignment & HOM’s, breakdown simulation, BD diagnostics, precise assembly
  - Linac and Final Focus Stabilisation

    Quadrupole mock-up, FF test-stand
  - Beam Delivery System

    tuning procedures at ATF2, high-precision BPM’s, Laser-wire
  - Drive Beam Phase control

    20 fs RF monitor, electro-optical monitor
- Partners: CERN, CIEMAT, CNRS, INFN, PSI, RHUL, STFC, UNIMAN, UOXF-DL, UU
- **Resources: 6.5 MEuros, 540 persons-years**

CLIC major activities and milestones up to 2010

- **Demonstrate feasibility of CLIC technology**
  - **Address all 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:**

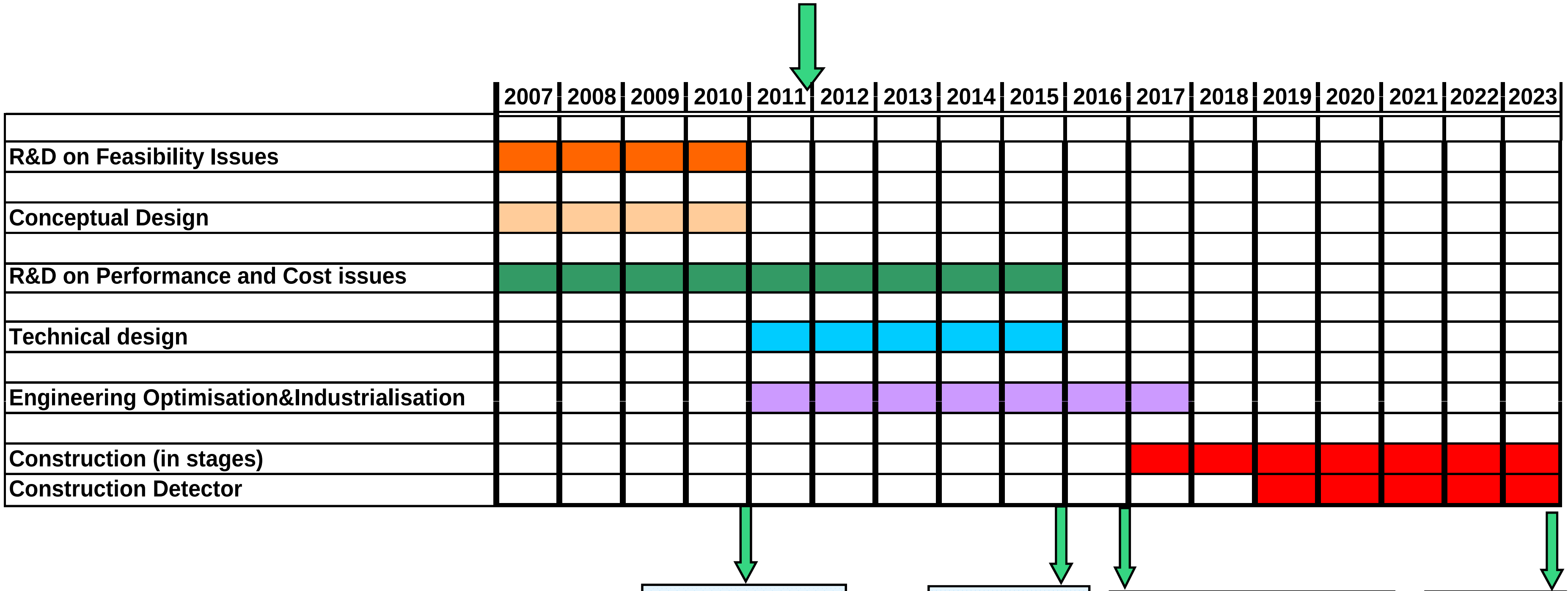
http://clic-meeting.web.cern.ch/clic-meeting/CLIC_Phy_Study_Website/default.html

- **Conceptual Design Report to be published in 2010 including**
  - **Physics, Accelerator and Detectors**
  - **R&D on critical issues and results of feasibility study,**
  - **Preliminary performance and cost estimation**

Tentative long-term CLIC scenario

Shortest, Success Oriented, Technically Limited Schedule

Technology evaluation and Physics assessment based on LHC results
for a possible decision on Linear Collider with staged construction
starting with the lowest energy required by Physics



Conceptual Design Report (CDR)

Technical Design Report (TDR)

Project approval ?

First Beam?

Basics of CDR

- 3 TeV option for CLIC as baseline for the optimization of the parameters.
- Construction staging starting from the lowest demanded energy (let us say 500 GeV) as indicated by LHC results up to the full 3 TeV machine.
- Parameter changes and optimization for the “500 GeV” machine plus additional consequences for later energy upgrades in a separate chapter
- Description of the physics and beam dynamics of all machine components following the order in the newly elaborated CLIC PBS.
- Technology chapters grouped together by disciplines.

Like ILC report

Layout of CDR

Vol1: Executive Summary: target 20 pages

Vol2: Physics at CLIC

progress will depend on LHC results; presently we use the report from 2004; no action before mid 2009

Vol3: The CLIC accelerator and site facilities

Vol4: The CLIC physics detectors

just received first breakdown from co-coordinating authors

Detailed value Estimate

will be treated in volumes 2-4; summary in volume 1.

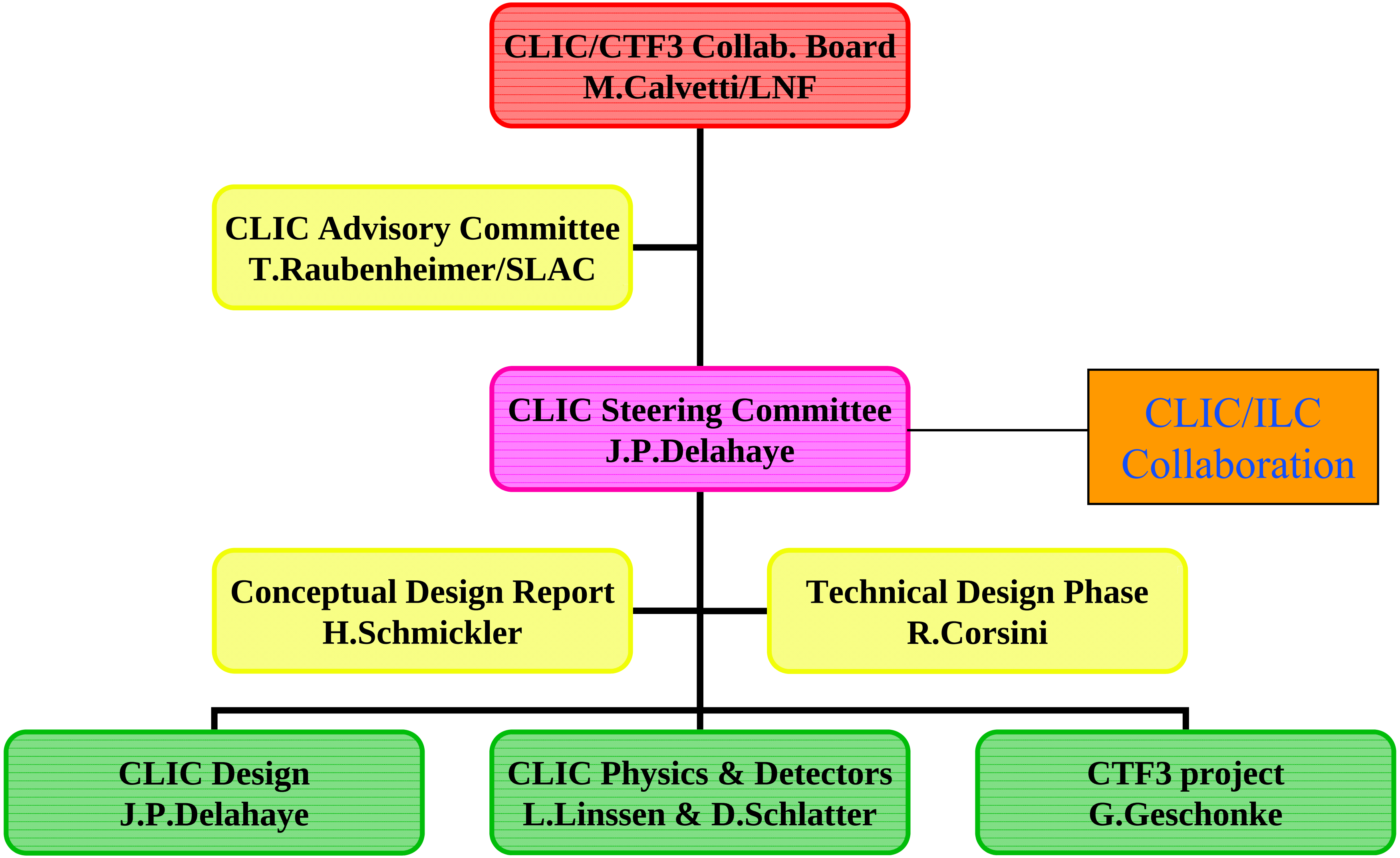
Possible Time Scale

- We have defined 5 sample authors (all CERN), who will deliver before the CLIC october workshop different chapters of the CDR. Those will be made available to all collaboration members and those templates should be used as style templates. (until october 2008)
- Some PR work will be made during the workshop in order to motivate authors; in particular non CERN authors
   definition of authors (for volume 3) by the end of 2008
- Summer 2009 we schedule a "90% draft" of volume 3
- Summer 2010 we schedule a full draft of the whole CDR.

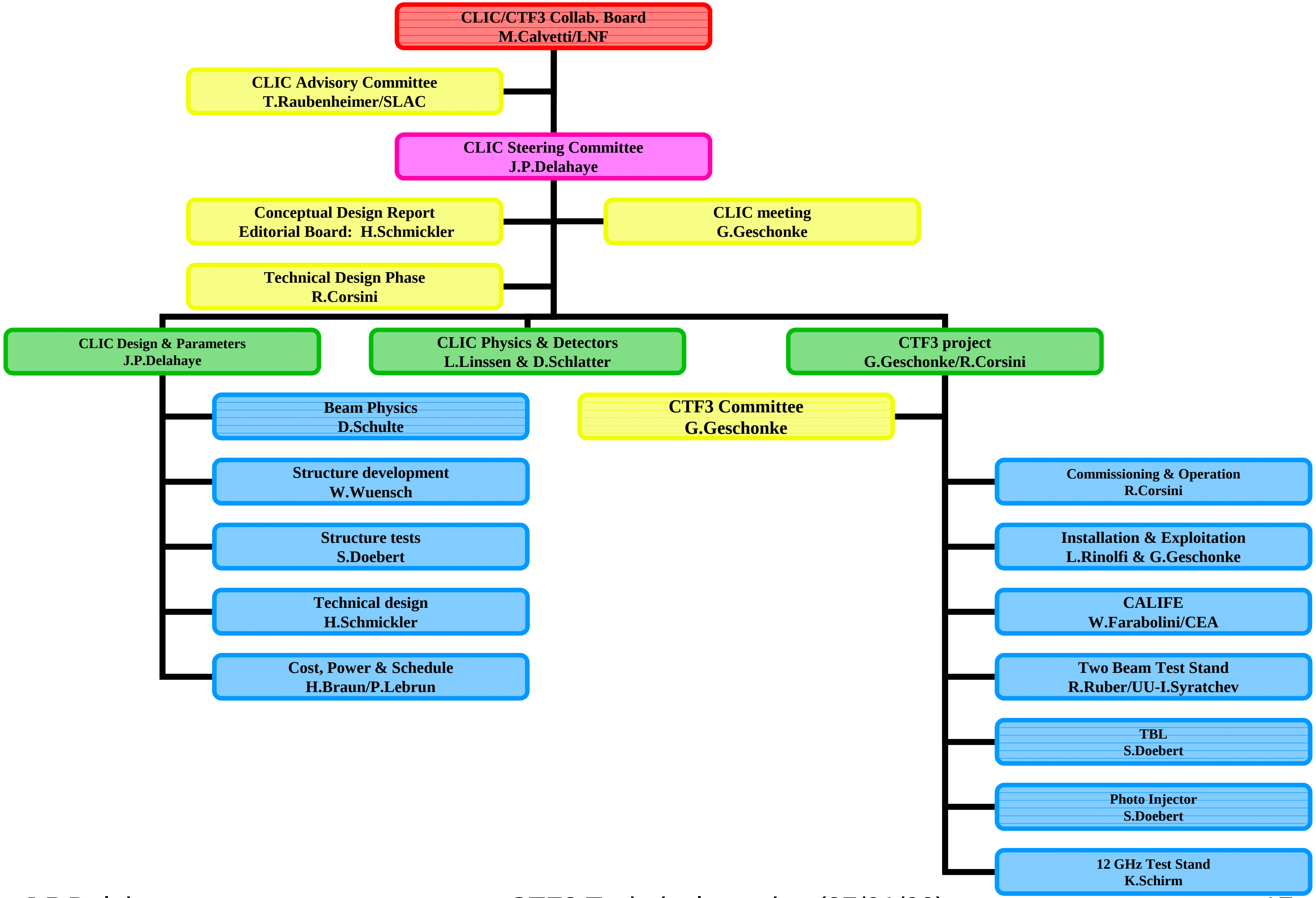
These deadlines can only be met if the progress in the still necessary R&D has been successfully achieved.

- Contribution and participation of external collabrators to CDR preparation and publication mandatory

CLIC Chart 09



CLIC Chart 09



CLIC Web Site and Doc

- **Web site reflecting the CLIC organisation**

http://clic-study.web.cern.ch/CLIC-Study/Mtgs_Wkg_Grp.htm

- **Technical documentation on EDMS:**

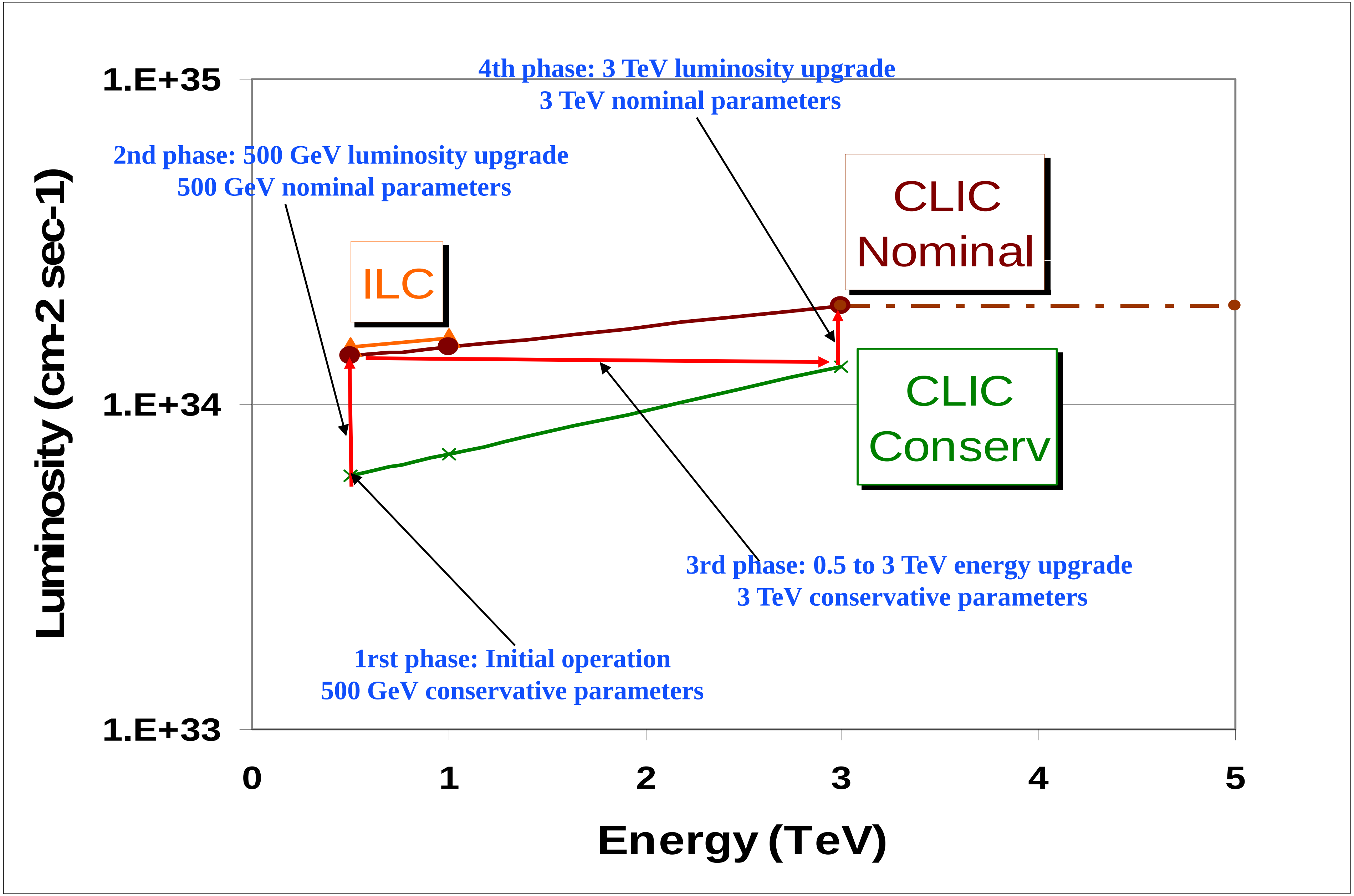
https://edms.cern.ch/nav/CERN-0000060014

- **General CLIC meeting (open):**
  - **Weekly basis (Friday am), chair: G.Geschonke**
  - **Information + exchanges**
  - **Review of progress of CLIC Design, Working Groups and tests**
  - **Project oriented with minutes and recommendations**
  - **Participation of collaborations welcome**

http://clic-meeting.web.cern.ch/clic-meeting/

CLIC Parameters and upgrade scenario

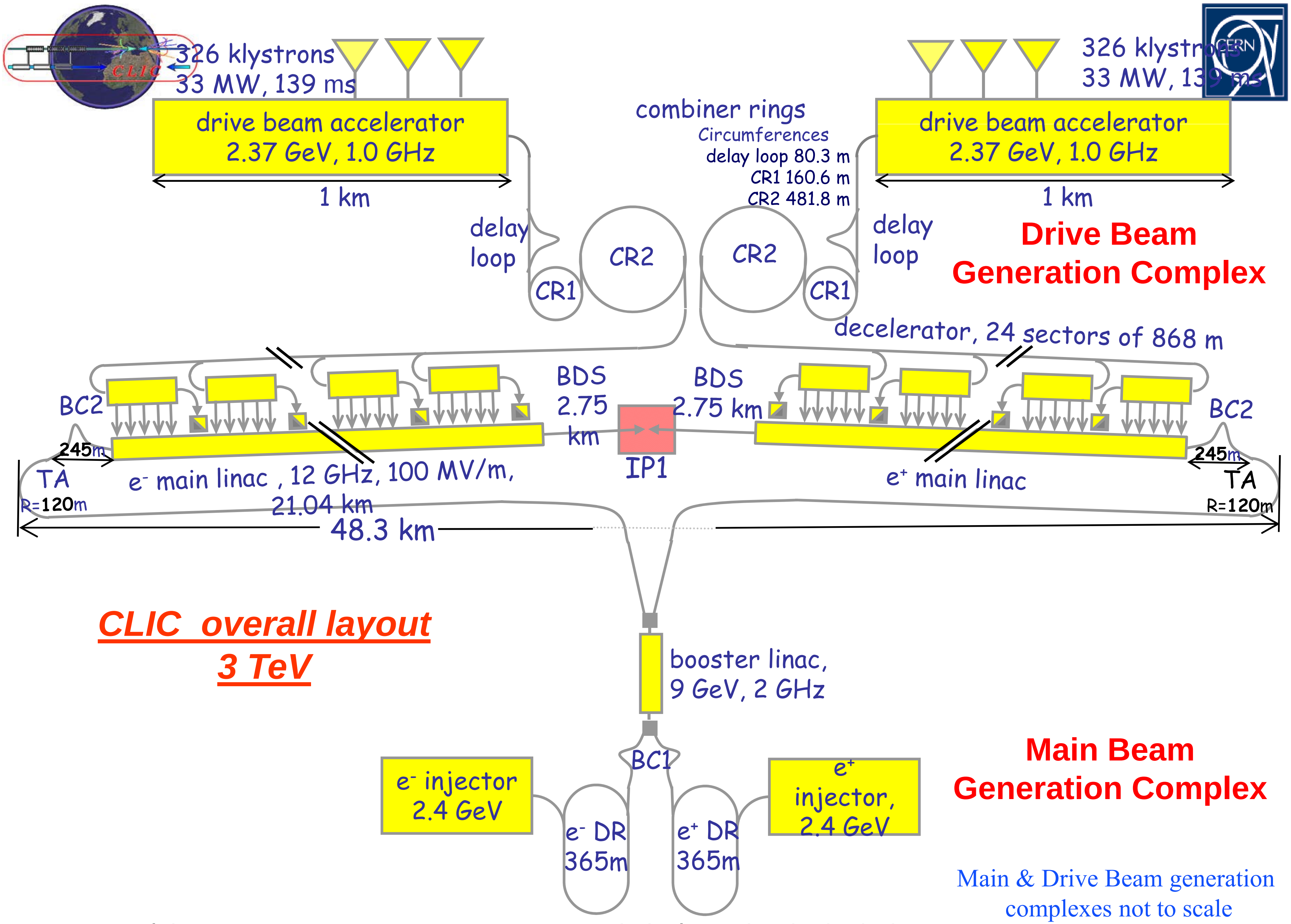
http://cdsweb.cern.ch/record/1132079/files/CERN-OPEN-2008-021.pdf



CLIC main parameters

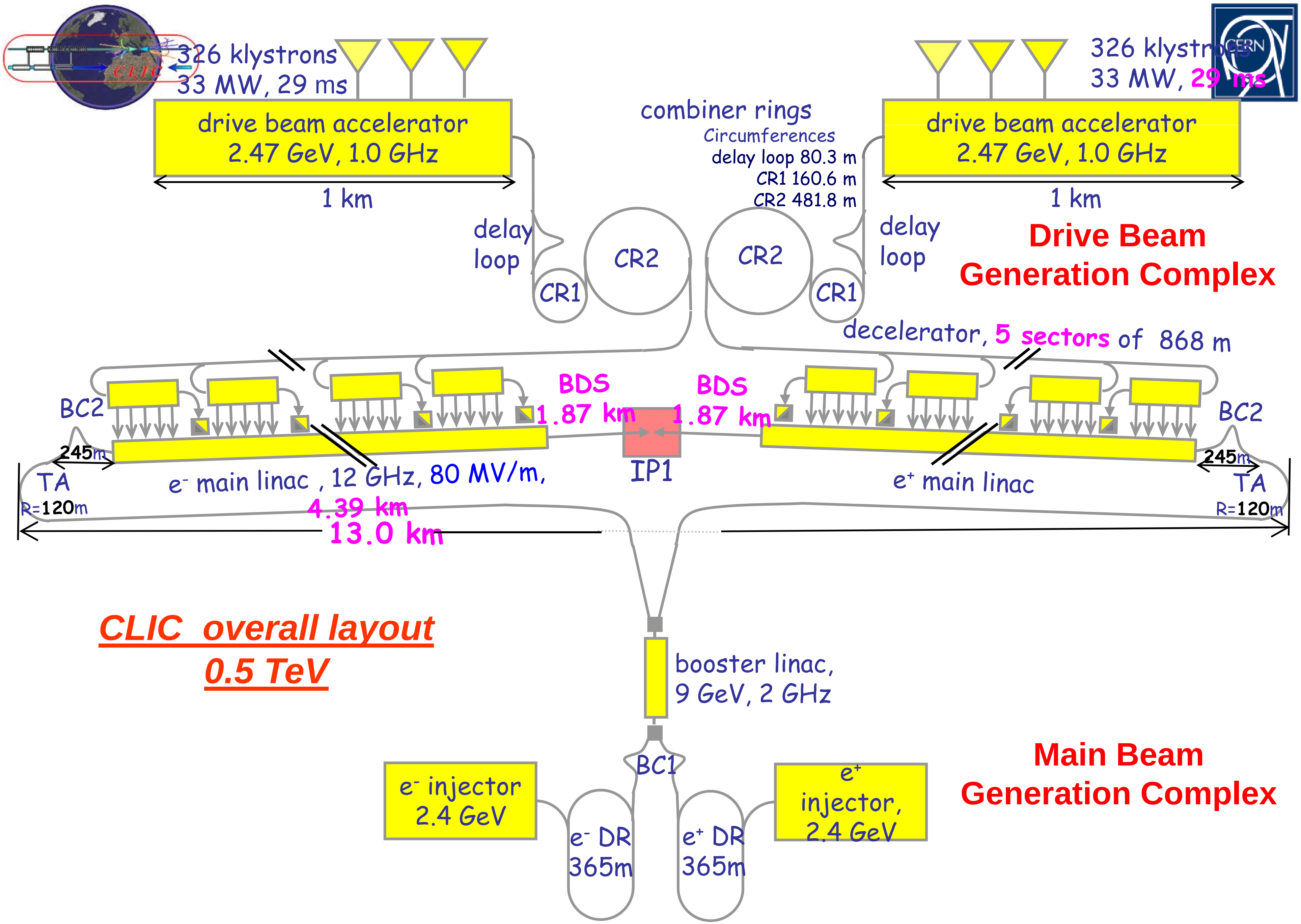
http://cdsweb.cern.ch/record/1132079?ln=fr http://clic-meeting.web.cern.ch/clic-meeting/clictable2007.html

Center-of-mass energy	CLIC 500 G		CLIC 3 TeV	
Beam parameters	Conservative	Nominal	Conservative	Nominal
Accelerating structure	502		G	
Total (Peak 1%) luminosity	$0.9(0.6)\cdot10^{34}$	$2.3(1.4)\cdot10^{34}$	$1.5(0.73)\cdot10^{34}$	$5.9(2.0)\cdot10^{34}$
Repetition rate (Hz)	50			
Loaded accel. gradient MV/m	80		100	
Main linac RF frequency GHz	12			
Bunch charge10^9	6.8		3.72	
Bunch separation (ns)	0.5			
Beam pulse duration (ns)	177		156	
Beam power/beam (MWatts)	4.9		14	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	3/40	2.4/25	2.4/20	0.66/20
Hor/Vert FF focusing (mm)	10/0.4	8 / 0.1	8 / 0.3	4 / 0.07
Hor./vert. IP beam size (nm)	248 / 5.7	202 / 2.3	83 / 2.0	40 / 1.0
Hadronic events/crossing at IP	0.07	0.19	0.57	2.7
Coherent pairs at IP	10	100	$5\ 10^7$	$3.8\ 10^8$
BDS length (km)	1.87		2.75	
Total site length km	13.0		48.3	
Wall plug to beam transfert eff	7.5%		6.8%	
Total power consumption MW	129.4		415	



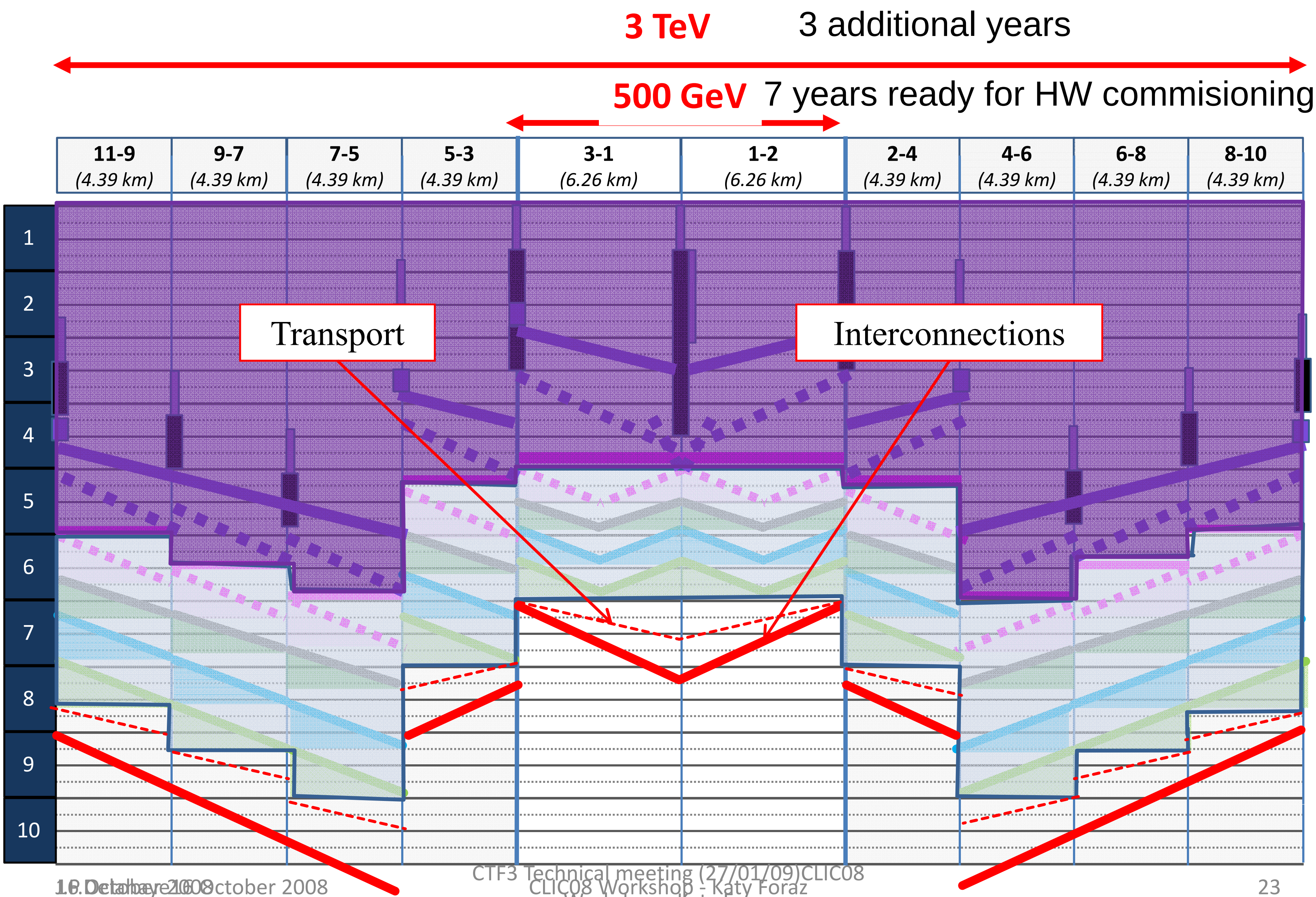
CLIC overall layout 3 TeV

Main & Drive Beam generation complexes not to scale



CLIC overall layout 0.5 TeV

CLIC Machine installation



CLIC critical issues R&D strategy and schedule

Updated from the Technical Review Committee (TRC) (2003)

Overall list available under: https://edms.cern.ch/document/918791

Issues classified in three categories:

- **critical for CLIC design and technology feasibility**

  Fully addressed by 2010 by specific R&D with results in Conceptual Design Report (CDR) with Preliminary Performance & Cost

- **critical for performance**
- **critical for cost**

  Both being addressed now by specific R&D to be completed before 2015 with results in Technical Design Report (TDR) with Consolidated Performance & Cost

CLIC feasibility issues

	SYSTEMS (level n)	Critical parameters	Feasibility issue	Performance issue	Cost issue
Structures	**Main beam acceleration structures** Demonstrate nominal CLIC structures with damping features at the design gradient, with design pulse length and breakdown rate .	100 MV/m 240 ns 3·10-7 BR/(pulse*m)	X	X	X
Structures	**Decelerator structures** Demonstrate nominal PETS with damping features at design power, with design pulse length, breakdown rate on/off capability	136 MW 240 ns	X		X
Drive Beam	**Validation of drive Beam** - production - phase stability , potential feedbacks - MPS appropriate for beam power	0.2 degrees phase stability at 12 GHz	X	X	
Two Beam	Test of a relevant linac sub-unit with both beams	NA	X		
Beam Physics	- Preservation of low emittances (main linac + RTML)	Absolute blow-up Hor: 160nradm Vert: 15 nradm	X	X	
Stabilization	Main Linac and BDS Stabilization	Main Linac : 1 nm vert (>1 Hz) BDS: 0.15...1 nm vert (>4 Hz) depending on implementation of final doublet girder	X	X	X
Operation and reliability	Commissioning strategy Staging of commissioning and construction MTBF, MTTR Machine protection	Handling of drive beam power of 72 MW	X	X	X

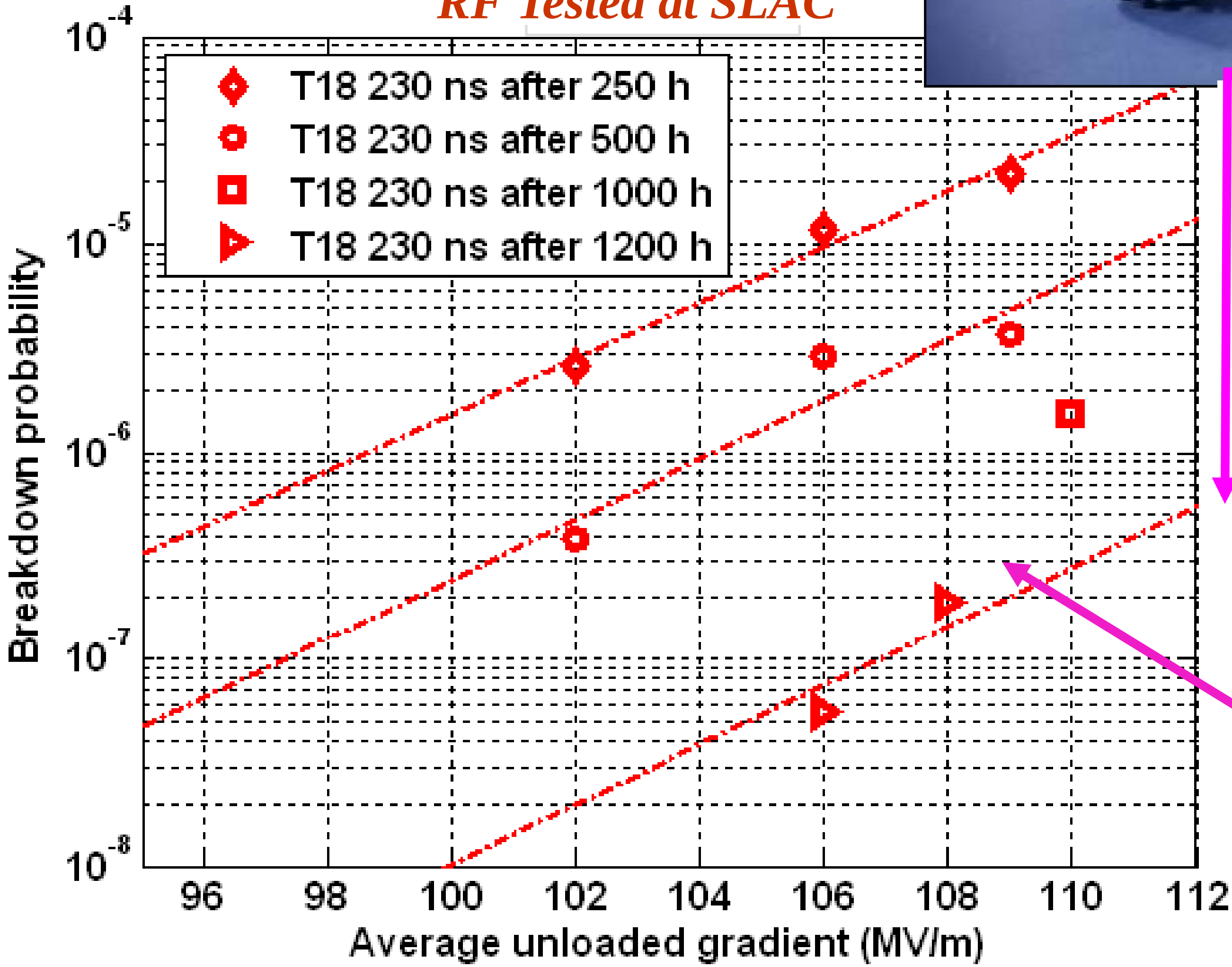
CLIC & ILC common Test Facilities (identified in red)

CLIC critical issues SYSTEMS (level n)		Critical parameters	Crucial design choice or fesibility	Performance issue	Cost issue	Relevant Facilities (also valid for ILC)
Structures	Main beam acceleration structures Demonstrate nominal CLIC structures with damping features at the design gradient, with design pulse length and breakdown rate .	100 MV/m 240 ns 3·10-7 BR/(pulse*m)	X	X	X	CTF2&3 (2005-2010) Test Stand (2009-2010) SLAC/NLCTA SLAC/ASTA KEK/NEXTEF
Structures	Decelerator structures Demonstrate nominal PETS with damping features at design power, with design pulse length, breakdown rate on/off capability	136 MW 240 ns	X		X	CTF3 (2005-2010) CTF3/TBTS (2008-2010) CTF3/TBL (2009-2010) SLAC ASTA
Drive Beam	Validation of drive Beam - production - phase stability , potential feedbacks - MPS appropriate for beam power	0.2 degrees phase stability at 12 GHz	X	X		CTF3 (2005-2010) CTF3/TBL (2009-2010) X-FEL LCLS
Two Beam	Test of a relevant linac sub-unit with both beams	NA	X			CTF3/TBTS (2008-2010)
Beam physics	Ultra-low emittances - Generation of low-emittances (damping rings)	Hor:500 nradm Vert: 5 nradm		X		ATF (2008-10): 3000/12 CESRTA:Electron Cloud NSLSII: Hor 2000nradm SLS: Vert 10nm
Beam physics	- Preservation of low emittances (main linac + RTML)	Absolute blow-up Hor: 160nradm Vert: 15 nradm	X	X		Beam simulations LCLS SCSS
Beam physics	- Beam focusing to small dimensions (BDS)	Hor: 40 nm Vert: 1 nm		X		ATF2 (2006-2012) Hor: 200 nm Vert: 36 (20) nm

Nominal CLIC Structure Performance demonstrated

A shining example of fruitful collaboration:

T18_VG2.4_disk: *Designed at CERN,*
(without damping) *Built at KEK,*
RF Tested at SLAC



Improvement by RF conditionning

CLIC nominal

The path to the CLIC full-structure feasibility demonstration

Move from achieved result with simplified structure to fully equipped, higher efficiency structure

TD18

Supporting tests:
Quadrant fabrication
CD10
Choke mode CD10

Add damping

Move to design iris range

T18
tested to 105 MV/m, 230 ns, $2x10^{-7}$/(mxpulse)

Move to design iris range
and add damping

CLIC_G with damping, full prototype

Move to design iris range

Add damping

Supporting tests:
C10 series
T23

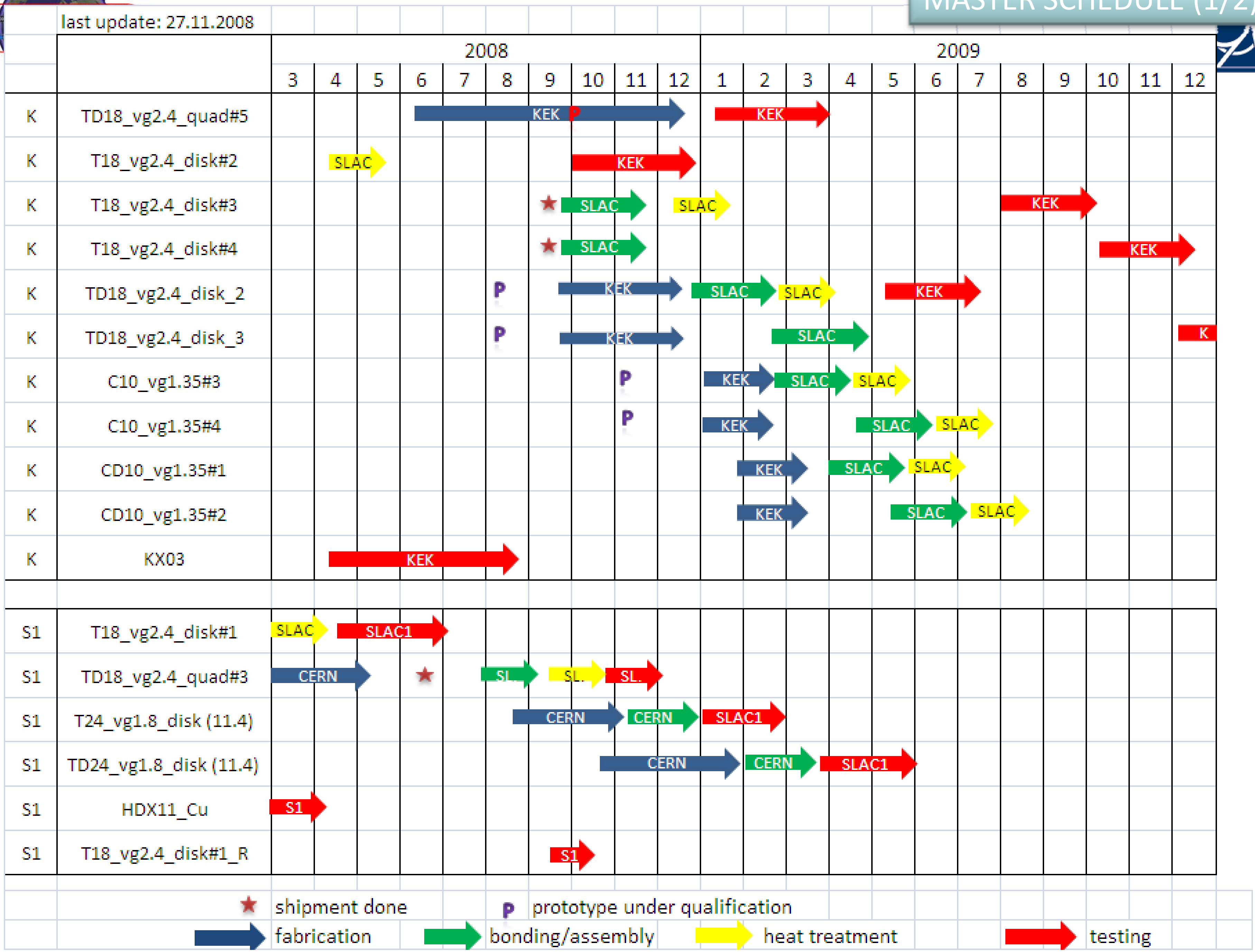
CLIC_G undamped

Today

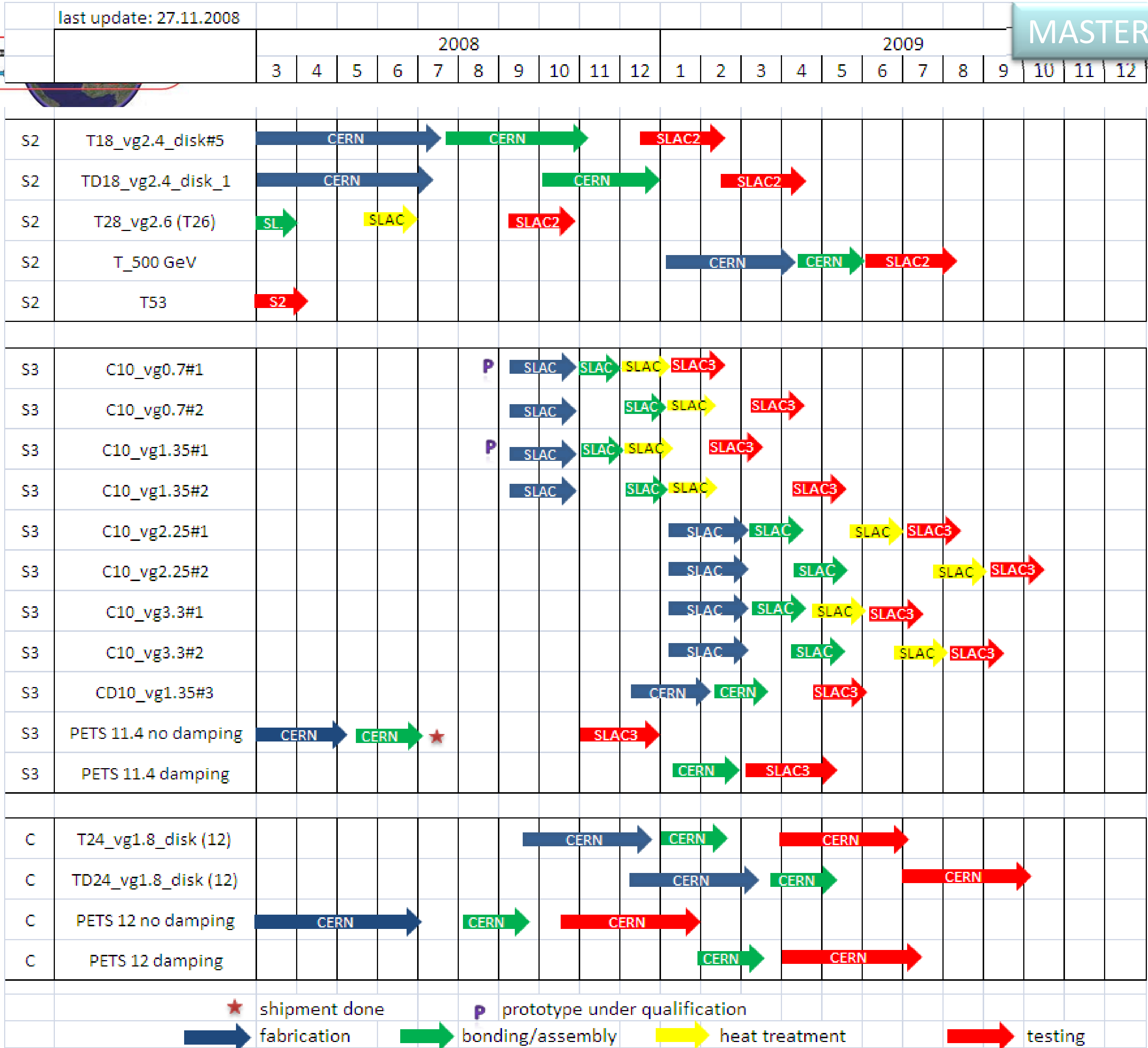
early 2009

late 2009

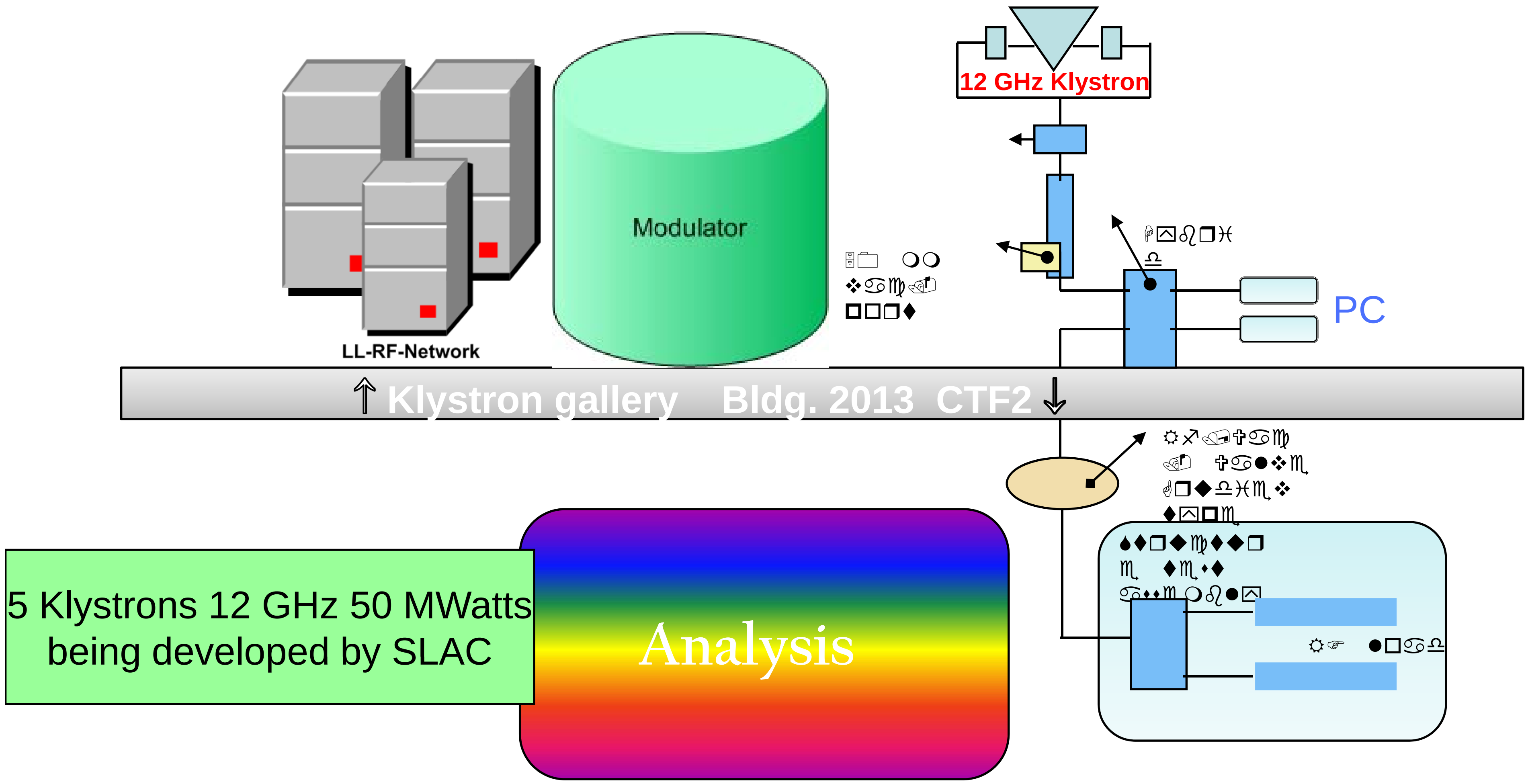
MASTER SCHEDULE (1/2)



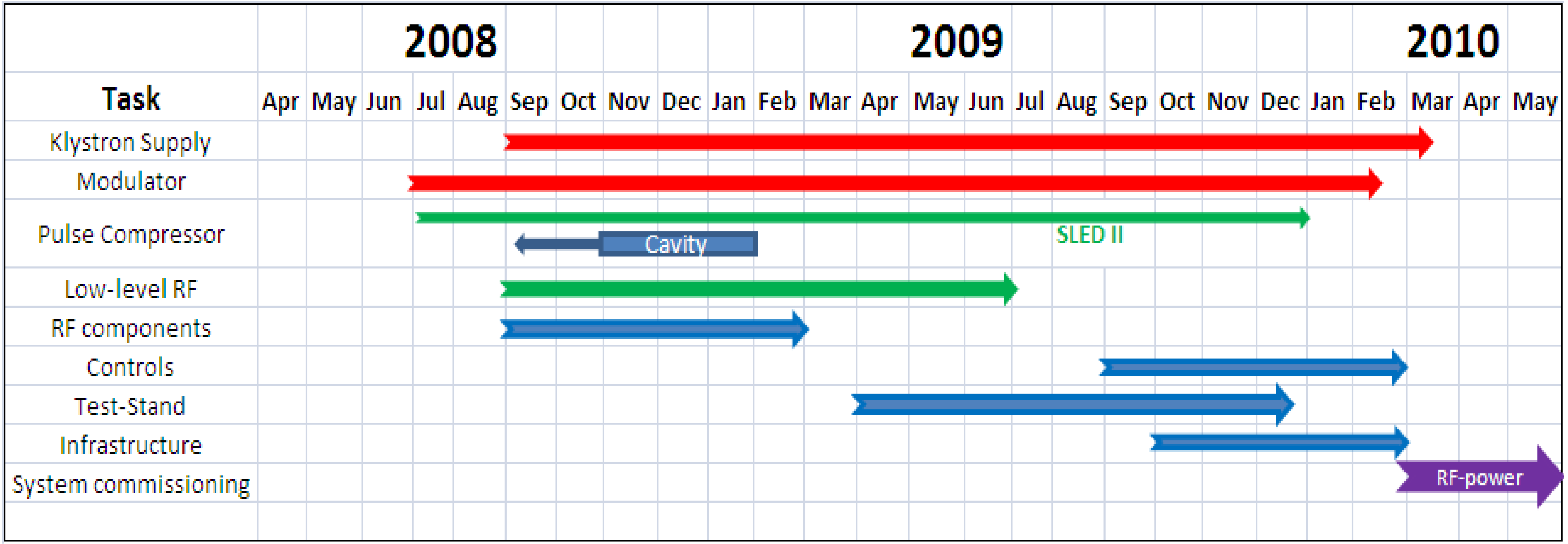
MASTER SCHEDULE (2/2)



12 GHz Klystron based RF power source
X-b Structure Test-Stand at CERN (and later CEA)
X-b Structure Operation at PSI and Trieste



12 GHz Test-Stand Schedule
(In-kind contribution of CEA/France)



X-Band structures for PSI/X-FEL and ELETTRA Linac based X-FEL

FEL-DM84-002-1

Date15.08.2008

Collaboration framework for a common CLIC/PSI-XFEL X Band structure.

M.Dehler, J.-Y. Raguin, A. Citterio, A. Falone (PSI)

W. Wuensch, G. Riddone, A. Grudiev, R. Zennaro (CERN)

Motivation

To compensate nonlinearities in the longitudinal phase space at the injector prototype of the PSI-XFEL, PSI requires a high frequency RF structure in the X band. At the same time CLIC is pursuing a program for producing and testing high gradient RF structures in the X band, exploring the effect of different geometries and materials on break down limits and rates.

Given that the PSI-XFEL has somewhat lower requirements in terms of gradient and efficiency, it may be interesting to share work and expense in designing and producing a common CLIC/XFEL structure. It would provide new data for the CLIC structure tests and be simultaneously a safe and low risk solution for the more relaxed operating gradient used at the PSI-XFEL. At the same time the prolonged operation of such a structure in the PSI FEL injector, albeit not at CLIC parameters, would constitute a good quality test for the procedure employed.

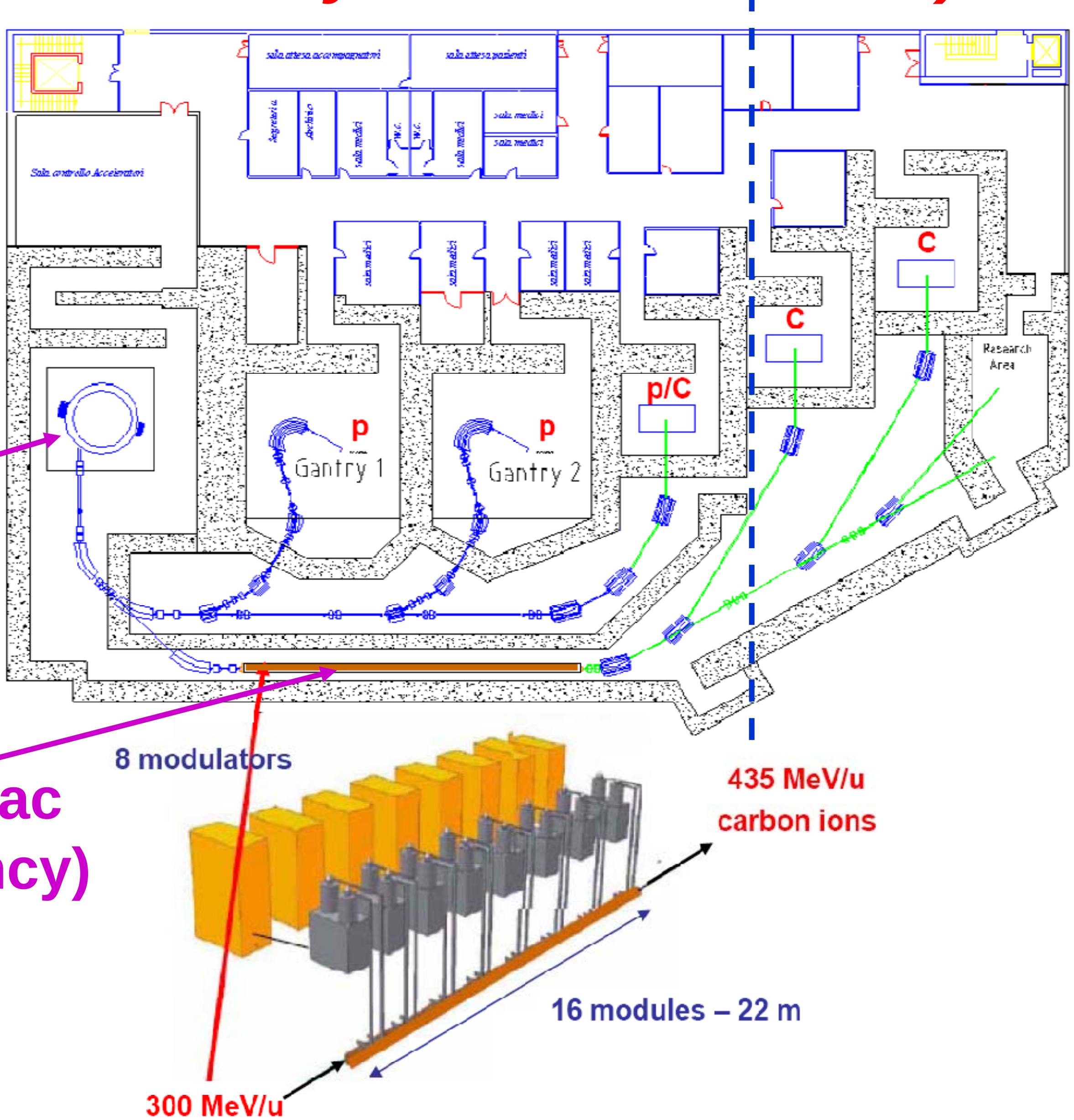
The collaboration covers the design, fabrication, tuning and low level testing of the X band structures. Two structures will produced, of which the first will go directly to PSI to be integrated into the 250 MeV injector. The second will undergo high power tests at the two beam test stand in CTF3. As soon as these are finished and the necessary data has been taken, this structure will serve as a spare at PSI.

CArbon BOoster Therapy in Oncology (CABOTO by TERA foundation)

TERA

SC cyclotron

12 GHz NC Linac (power efficiency)



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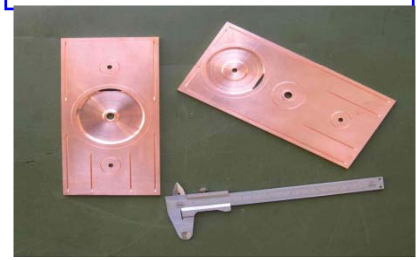
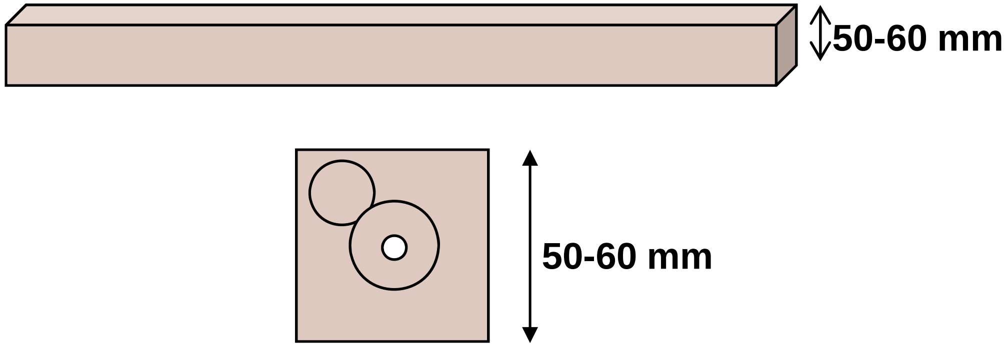
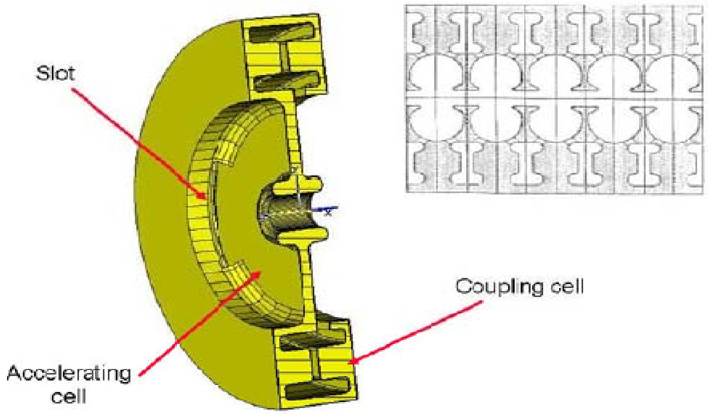
Design and construction/tests of 12 GHz accelerating structures Collaboration CLIC TERA

A. SCL very similar to LIGHT for IDRA





B. ACS studied by TERA



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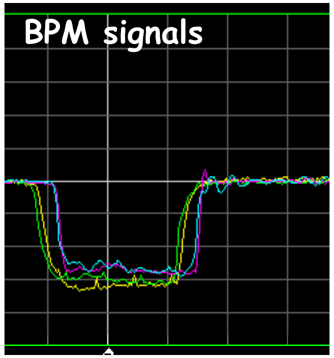
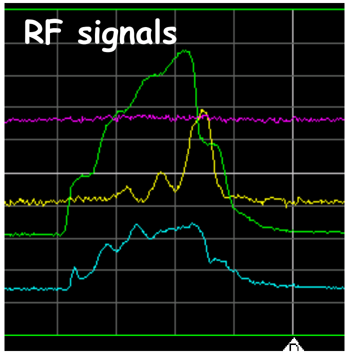
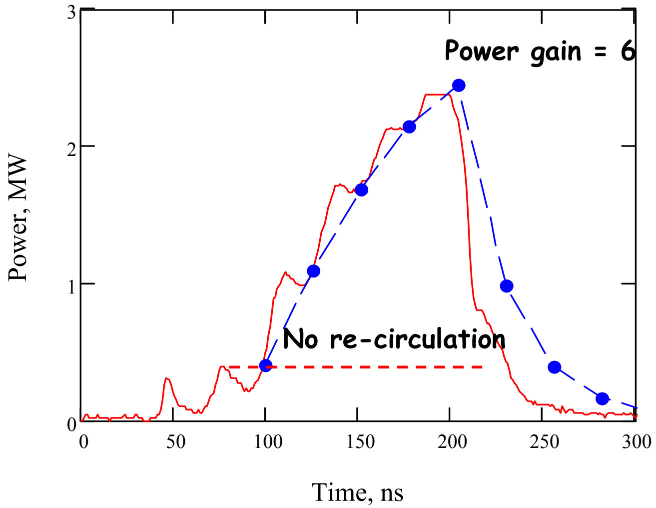
PETS high power tests at CERN (TBTS)

The first RF 12 GHz power generation from the PETS in re-circulation regime 15.11.008







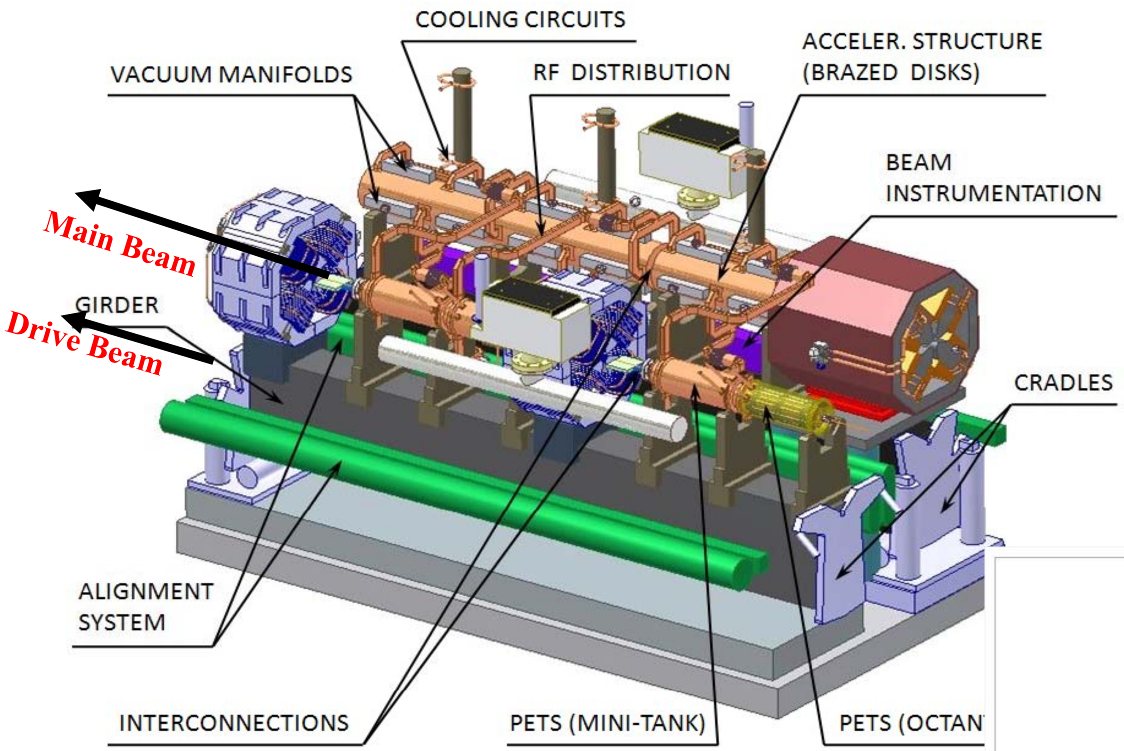
Input for calculations:

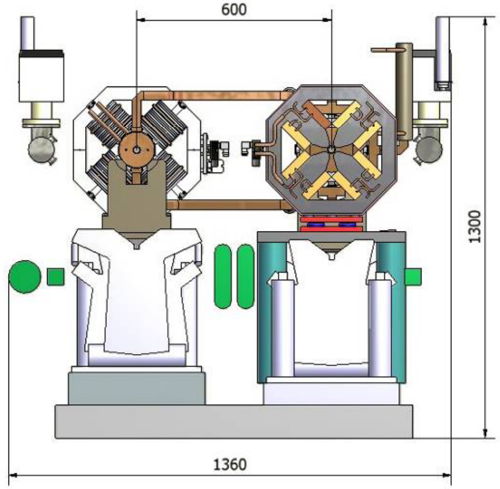
~Measured: **I = 1.18 A**

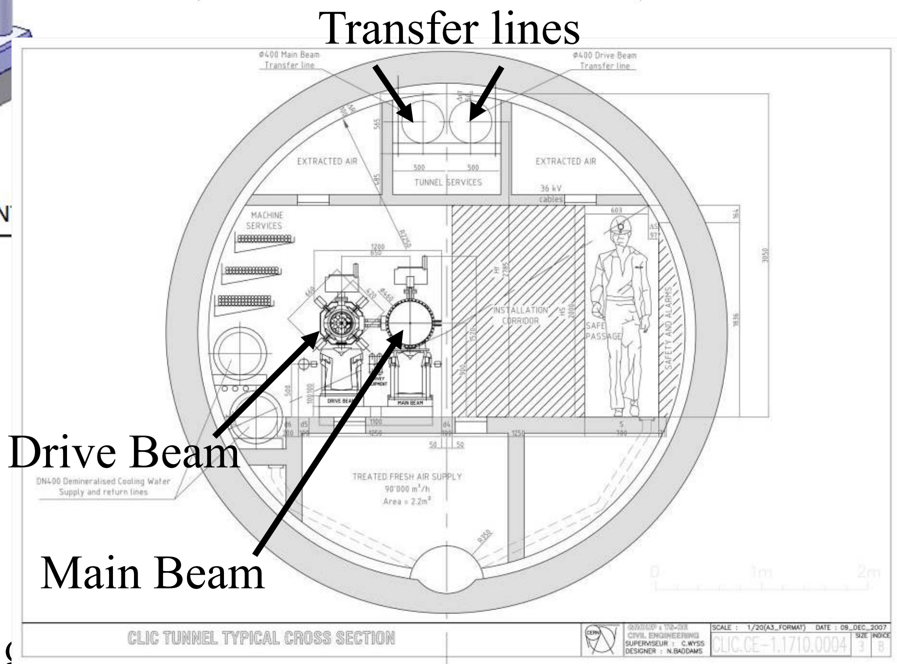
Coupling = 0.82

Similar to SLAC, the conditioning of the system is accomplished with heavy out gassing

CLIC Two Beam Module





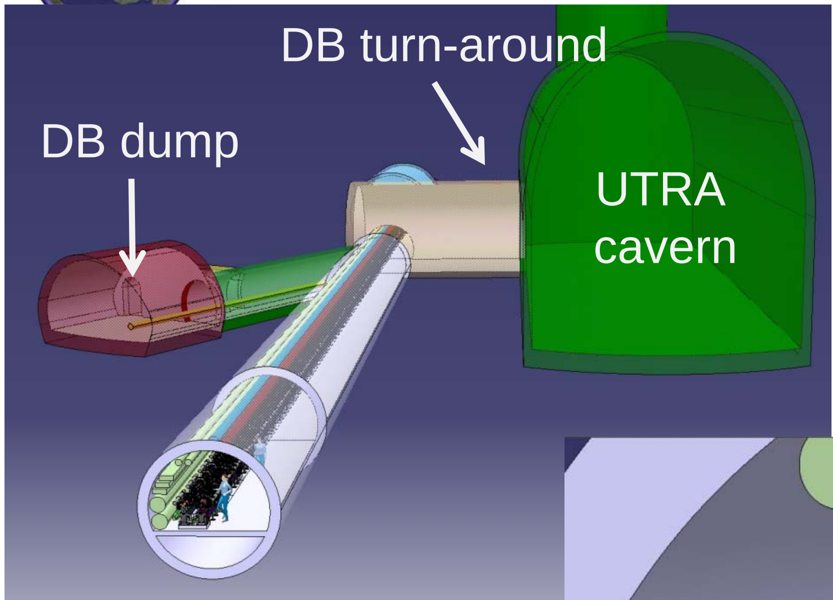


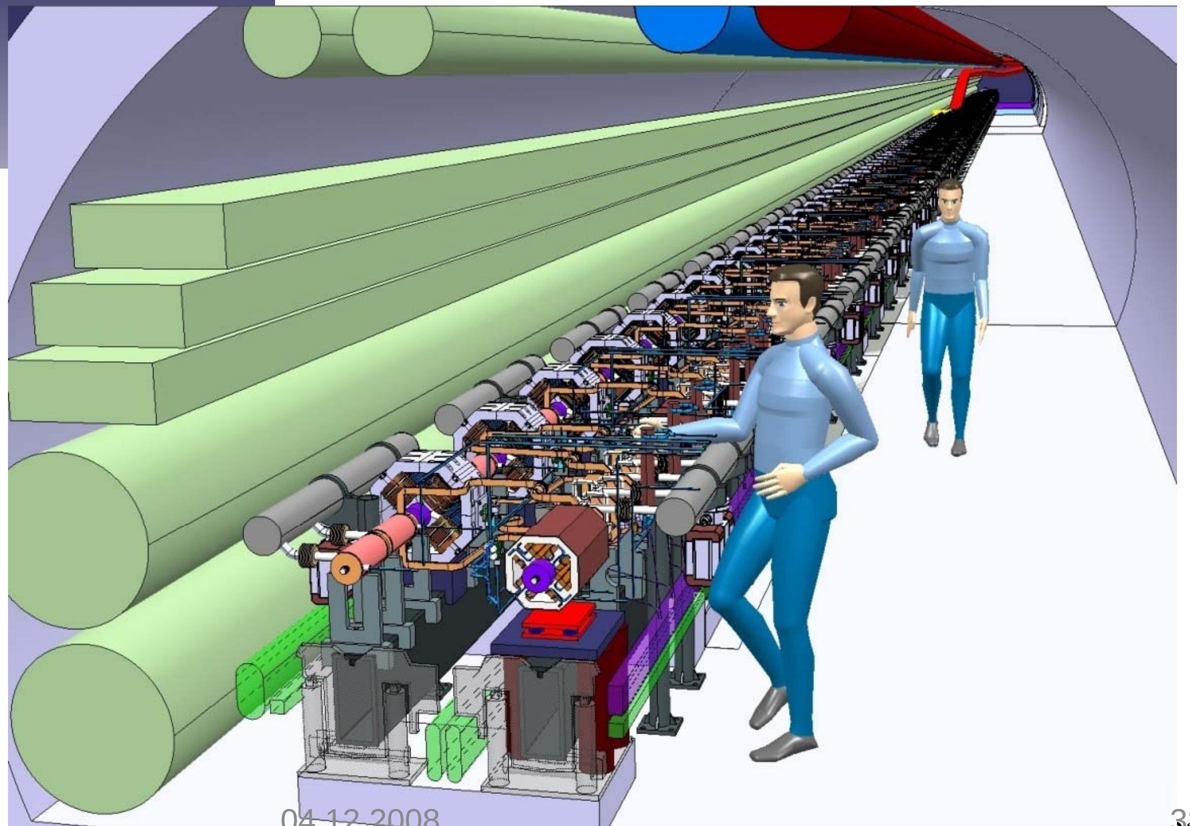
20760 modules (2 meters long)

71460 power production structures PETS (drive beam)

143010 accelerating structures (main beam)

Tunnel integration





Standard tunnel with modules

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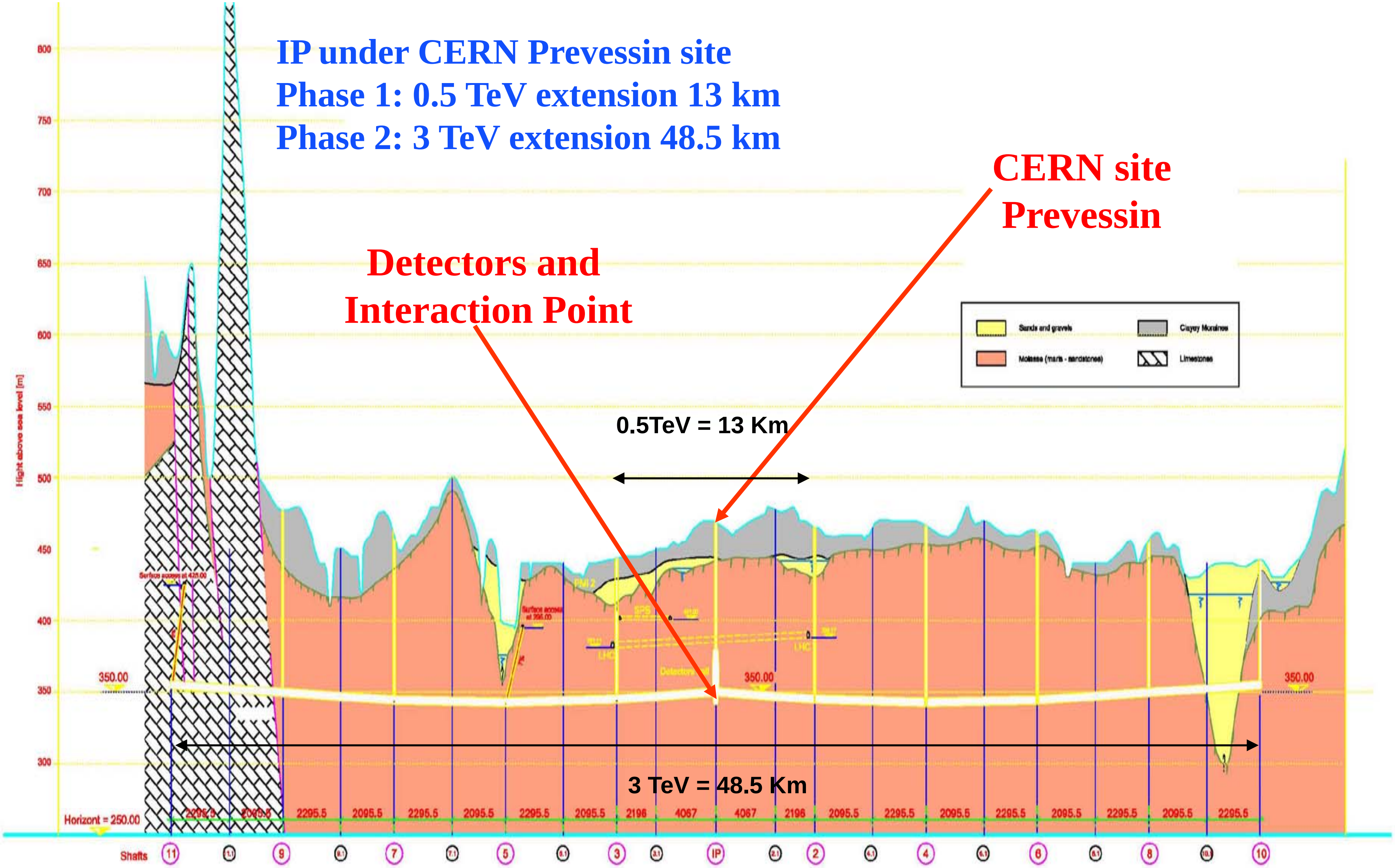
Longitudinal section of a laser straight Linear Collider on CERN site–



CERN DG's talk to Staff
3 October '08

Prospects for Scientific Activities over the Period 2012 - 2016

To be decided in 2010-2011 in light of first physics results from LHC, and designed and R&D results from the previous years. This programme could most probably comprise:

- An LHC luminosity increase requiring a new injector (SPL and PS).

  The total cost of the investment over 6 years (2011-2016: 1000-1200 MCHF + a staff of 200-300 per year. Total budget: ~200-250 MCHF per year.

- Preparation of a Technical Design for the CLIC programme, for a possible construction decision in 2016 after the LHC upgrade (depending on the ILC future).
  Total CERN M + P contribution + ~250 MCHF + 1000-1200 FTE *over 6 years*.

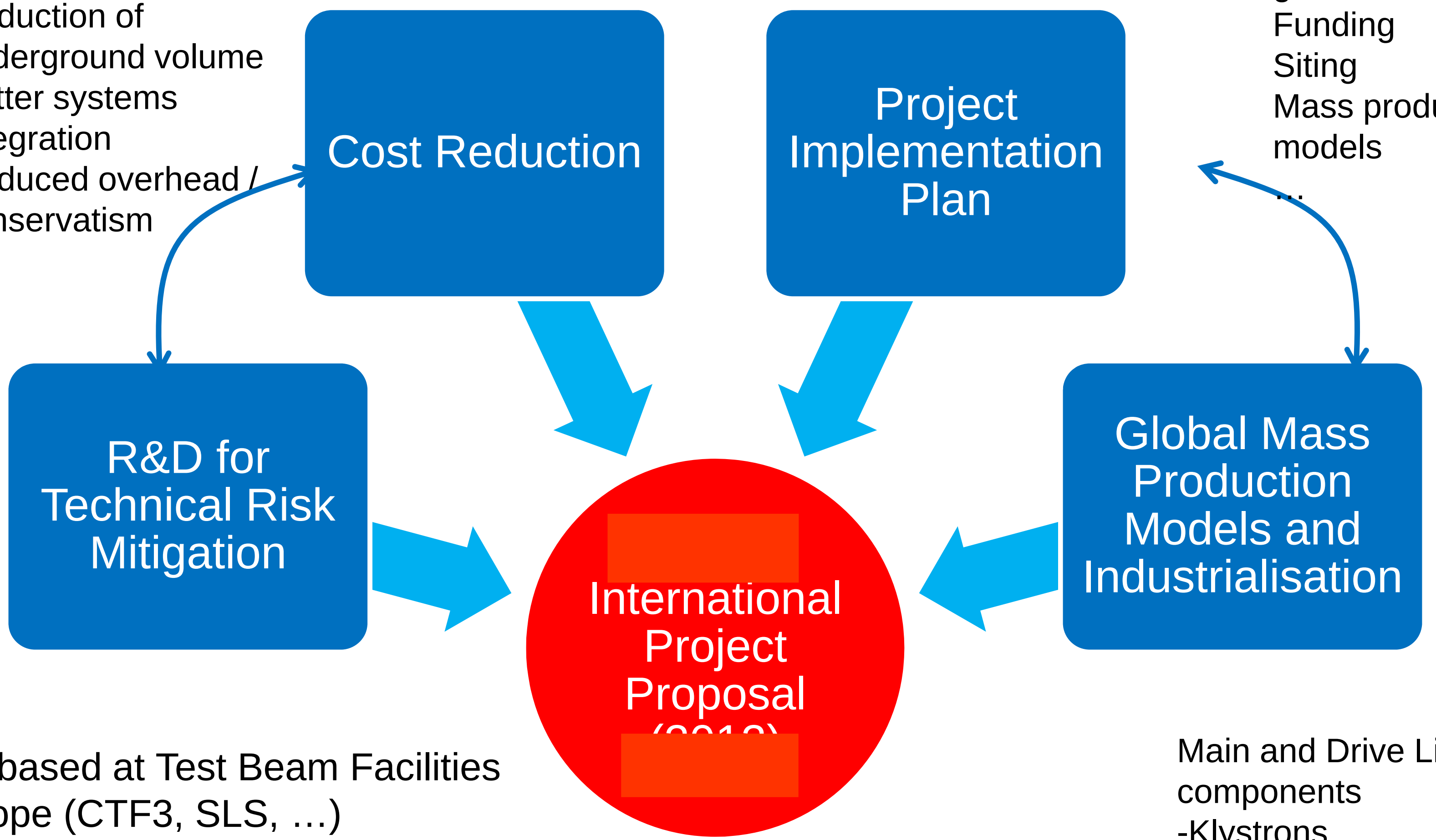
- Enhanced infrastructure consolidation: 30 MCHF + 40 FTEs from 2011.

  NB: Over the period 2012-2016. Effective participation of CERN in another large programme (ILC or a neutrino factory) will not be possible within the expected resources if positive decisions taken on LHC upgrade and CLIC Technical Design. This situation could totally change *if none of the above programmes is approved* or if a new, more ambitious level of activities and support is envisaged in the European framework.

CLIC Technical Design (2011-2015)
(inspired from ILC priorities courtesy of N.Walker)

Structure R&D
Reduction of underground volume
Better systems integration
Reduced overhead / conservatism
…

International governance
Funding
Siting
Mass production models
…



R&D based at Test Beam Facilities
- Europe (CTF3, SLS, …)
- Japan (ATF, ATF-2, Klystron lab at KEK)
- US (SLAC,CESR-TA at Cornell)

Main and Drive Linac components
-Klystrons
-…

Reflections on future Test facilities

- **2008 CTF3 technical meeting: 23/01/08**

http://indico.cern.ch/getFile.py/access?contribId=40&sessionId=13&resId=1&materialId=slides&confId=23022

- **CLIC08 Workshop: 16/10/08**

http://indico.cern.ch/getFile.py/access?contribId=40&sessionId=13&resId=1&materialId=slides&confId=23022

- **US High Gradient Collaboration**

  (coordinated by S.Tantawi/SLAC)

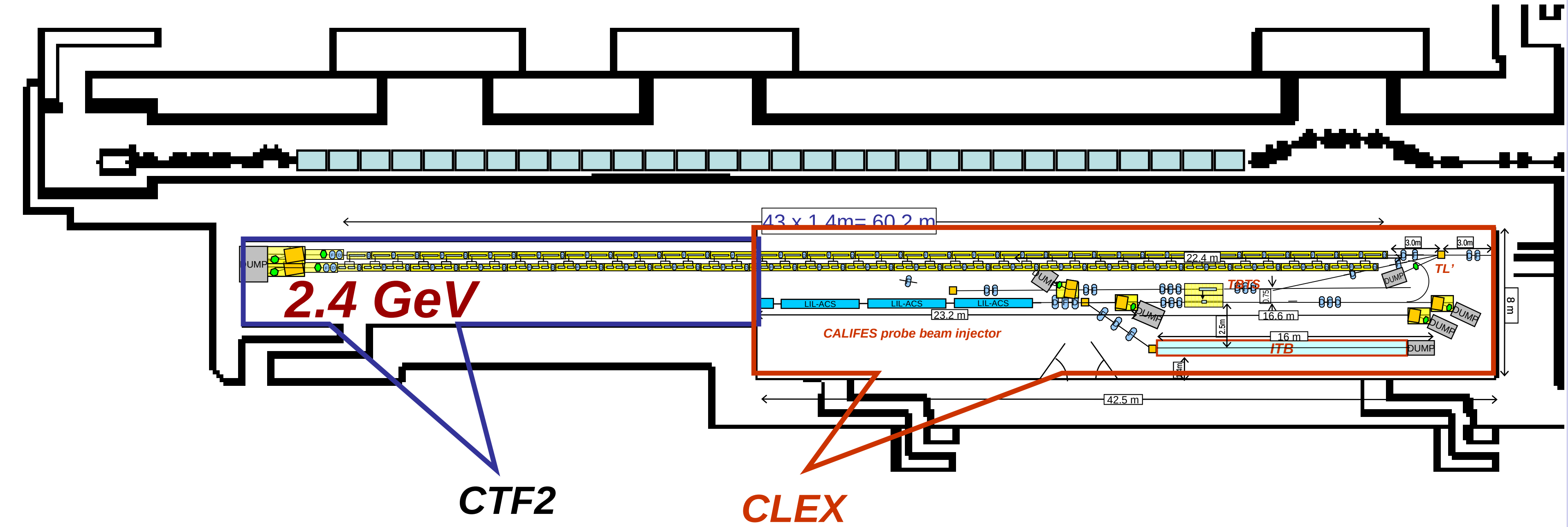
- **2009 CTF3 Technical meeting : 29/01/09**
  - **Presentation R.Corsini**

- **CLIC09 workshop:**
  - **Chairman: D.Schulte**

Options for long term use of CTF3:

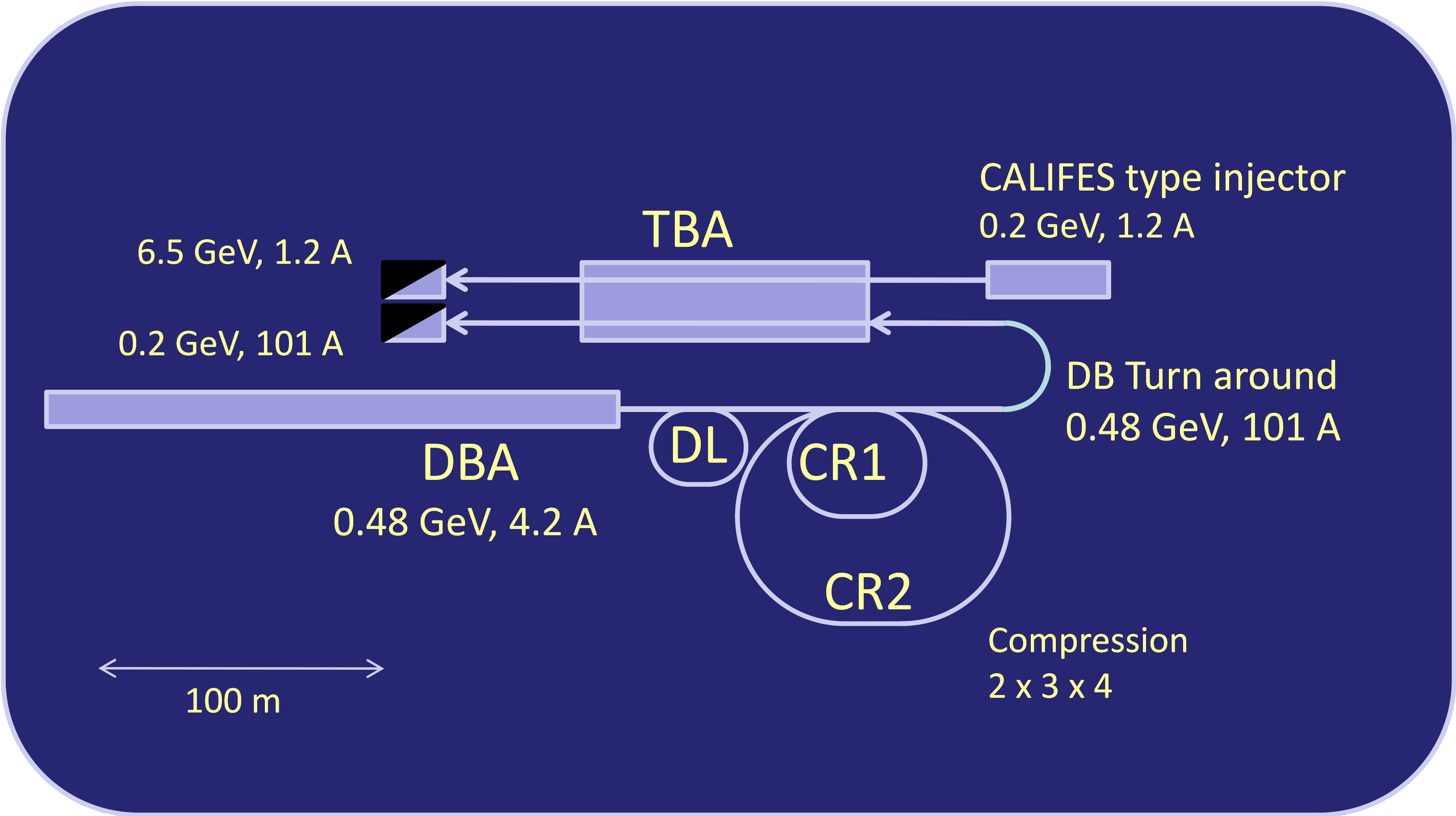
2.4 GeV Two beam X-band linac ?

The ultimate, only building limited two beam accelerator in CTF3 !



A next facility towards CLIC: CLIC0 ?

6.5 GeV Two Beam Accelerator



Future X-band Test Facilities (>2012) (T.Raubenheimer/SLAC)

- **After initial R&D, need a new test facility if either X-band klystron-based or TBA-based collider are to be pursued**
- **3 GeV X-band Test Facility**
  - **10 rf units with 100 MV/m X-band linac**
  - **Demonstrate emittance preservation, rf stability, and reliability**
  - **Completed facility could deliver beams for AARD or BES programs**
- **Two-Beam Demonstration (CTF4 ??)**
  - Next step beyond CTF3 at CERN
  - Use ~150 SLAC linac klystrons to generate 10 Amp 1 GeV few us drive beam (share rf with FACET and LCLS-II)
  - 8x combiner using SLC damping ring complex → 80 Amps
  - Drive beam would power 40 GeV of TBA linac

CLIC Technical Design (TDR) Phase

- **Scenario**

Assume a successful demonstration of the CLIC technology feasibility and a publication by end 2010 of a Conceptual Design Report including a Multi-TeV Linear Collider based on CLIC technology and the estimation of its cost,

Technical Design will have to be prepared for possible project approval by 2016

Available resources in period 2011-2015:

From CERN as allocated in MTP 08: 250 MCH + 1000 FTE

Identical resources provided by external collaborations

- **Task Force mandate:**

Analysis of the issues still to be addressed including in particular:

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**
- **Industrialisation of major components**
- **Finalisation of design and cost**
- **Technical Design Report including consolidated performance and cost**

Estimate the (M&P) necessary resources and timescale

Two studies made in parallel for the Accelerator and the Detector

Describe the proposal (concerning both accelerator and detector) in a document to be available by mid 2009 at the latest with a preliminary report with main strategy by March 2009 in preparation of the MTP

The Task Force reports to the CSC

- **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

Conclusion

- CLIC work program well established and (still) on schedule to address CLIC feasibility demonstration with preliminary performance and cost by 2010, but still a lot of work
  - CTF3 completion (TBL..) and commissioning (consolidation)
  - RF structure: fabrication & test of fully equipped structures (accel&PETS)
  - Technical feasibility issues: alignment, stabilisation, instrumentation, etc.
  - Essential and appreciated contributions of CLIC/CTF3 collaboration
- Conceptual Design Report publication by end 2010
  - Fist draft by the end of the year 2009; Participation of CLIC/CTF3 collab.
- Definition of Technical Design Phase
  - Task Force to deliver final report by mid 2009 with preliminary strategy by March 2009 and proposal to ACE in May
- Challenging work and tight schedule: Can we do it?
  - With apologies to Obama …

YES, WE CAN!

Thanks to outstanding contributions of CLIC/CTF3 collabor. in the past and welcome participation in the future