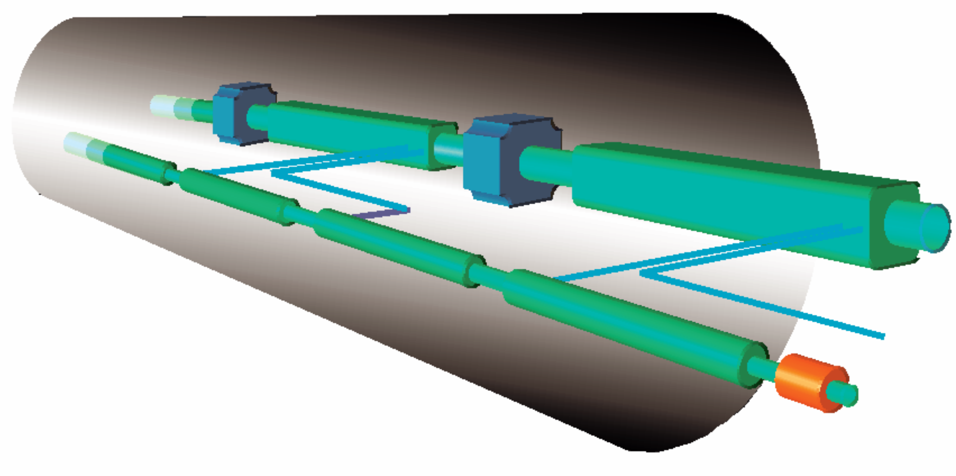
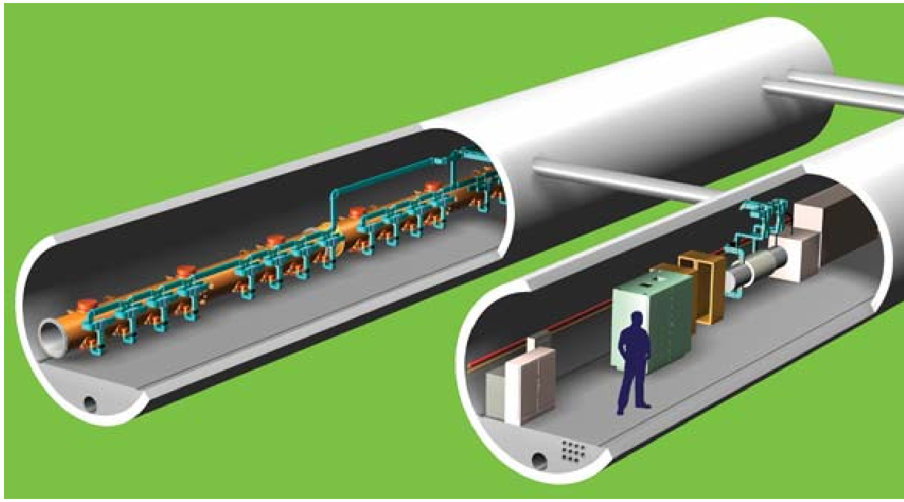
Synergies and Collaboration between CLIC and ILC on e+/e- Linear Collider studies





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

http://www.linearcollider.org/cms/

OUTLINE

- Linear Colliders in the HEP world-wide landscape
- The Compact Linear Collider (CLIC) concept
  - Design and new parameters recently adopted
  - Main challenges and key issues
  - The facilities to address the feasibility issues
  - Plans and schedule
- Synergies and Collaboration with the ILC
- Possible UK contribution
- Conclusion

World consensus about a Linear Collider as the next HEP facility after LHC

- **2001:** ICFA recommendation of a world-wide collaboration to construct a high luminosity e+/e- Linear Collider with an energy range up to at least 400 GeV/c
- **2003:** ILC-Technical Review Committee to assess the technical status of the various designs of Linear Colliders
- **2004:** International Technology Recommendation Panel selecting the Super-Conducting technology for an International Linear Collider (ILC) Linear Collider in the TeV energy range
- **2004:** CERN council support for R&D addressing the feasibility of the CLIC technology to possibly extend Linear Colliders into the Multi-TeV energy range.

CERN Council Strategy Group (Lisbon July 2006)

The European strategy *for particle physics*

Particle physics stands on the threshold of a new and exciting era of discovery. The next generation of experiments will explore new domains and probe the deep structure of space-time. They will measure the properties of the elementary constituents of matter and their interactions with unprecedented accuracy, and they will uncover new phenomena such as the Higgs boson or new forms of matter. Long-standing puzzles such as the origin of mass, the matter-antimatter asymmetry of the Universe and the mysterious dark matter and energy that permeate the cosmos will soon benefit from the insights that new measurements will bring. Together, the results will have a profound impact on the way we see our Universe; *European particle physics should thoroughly exploit its current exciting and diverse research programme. It should position itself to stand ready to address the challenges that will emerge from exploration of the new frontier, and it should participate fully in an increasingly global adventure.*

General issues

1. European particle physics is founded on strong national institutes, universities and laboratories and the CERN Organization; *Europe should maintain and strengthen its central position in particle physics.*

2. Increased globalization, concentration and scale of particle physics make a well coordinated strategy in Europe paramount; *this strategy will be defined and updated by CERN Council as outlined below.*

Scientific activities

3. The LHC will be the energy frontier machine for the foreseeable future, maintaining European leadership in the field; *the highest priority is to fully exploit the physics potential of the LHC, resources for completion of the initial programme have to be secured such that machine and experiments can operate optimally at their design performance.* A subsequent major luminosity upgrade (SLHC), motivated by physics results and operation experience, will be enabled by focussed R&D; *to this end, R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a luminosity upgrade by around 2015.*

4. In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; *a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

5. It is fundamental to complement the results of the LHC with measurements at a linear collider. In the energy range of 0.5 to 1 TeV, the ILC, based on superconducting technology, will provide a unique scientific opportunity at the precision frontier; *there should be a strong well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.*

6. Studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around 2012; *Council will play an active role in promoting a coordinated European participation in a global neutrino programme.*

7. A range of very important non-accelerator experiments take place at the overlap between particle and astroparticle physics exploring otherwise inaccessible phenomena; *Council will seek to work with ApPEC to develop a coordinated strategy in these areas of mutual interest.*

In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; *a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

It is fundamental to complement the results of the LHC with measurements at a linear collider. In the energy range of 0.5 to 1 TeV, the ILC, based on superconducting technology, will provide a unique scientific opportunity at the precision frontier; *there should be a strong well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.*

Parameters for the Linear Collider

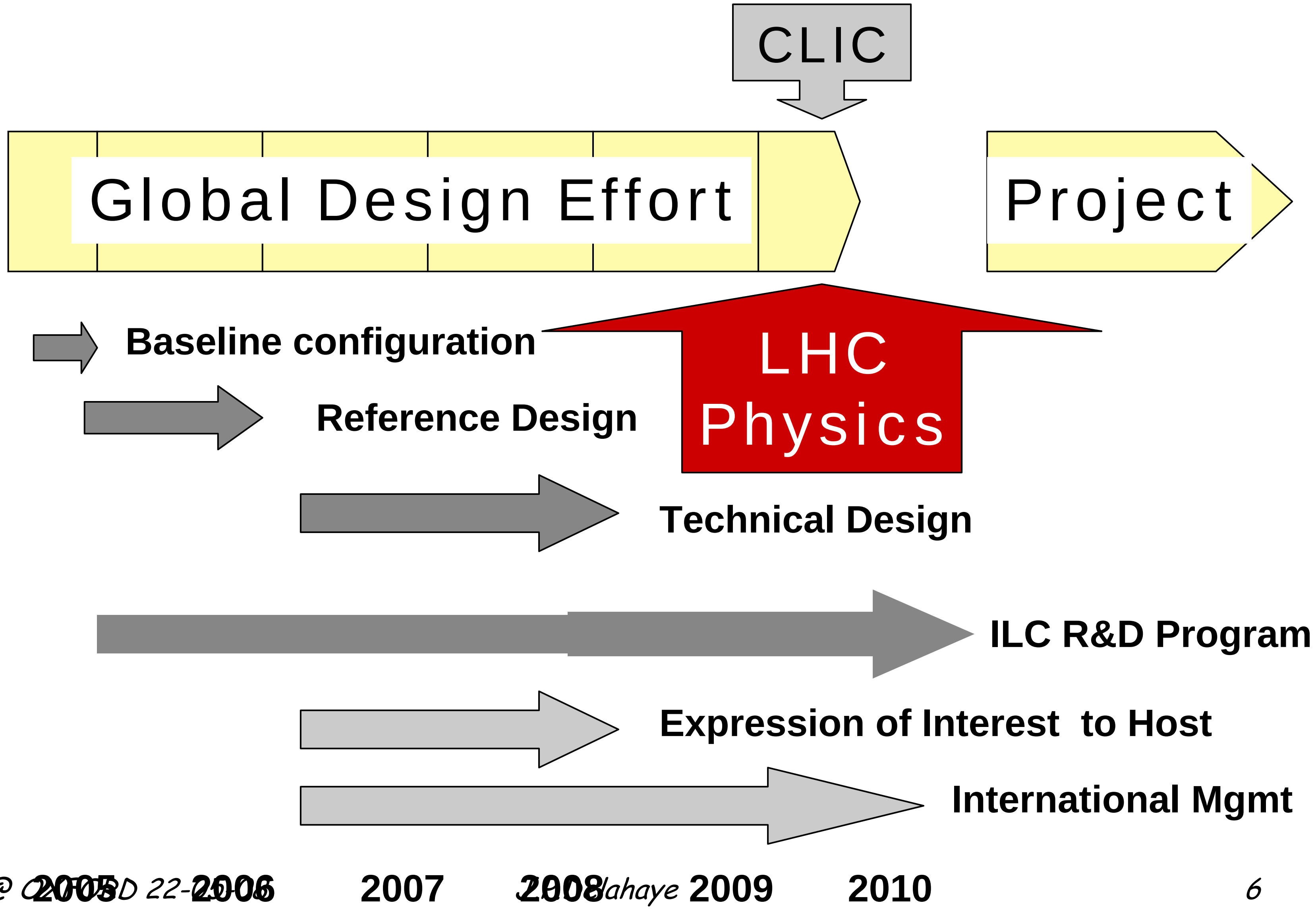
September 30, 2003

- Ecm adjustable from 200 - 500 GeV
- Luminosity → $\int L dt$ = 500 fb-1 in 4 years
- Ability to scan between 200 and 500 GeV
- Energy stability and precision below 0.1%
- Electron polarization of at least 80%

- The machine must be upgradeable to 1 TeV

The ILC Plan and Schedule

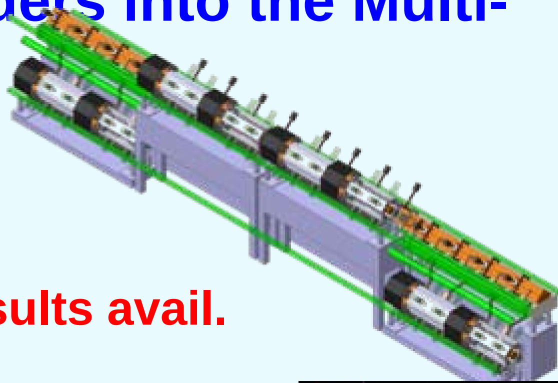
(B.Barish/CERN/SPC 050913)



THE COMPACT LINEAR COLLIDER (CLIC) STUDY

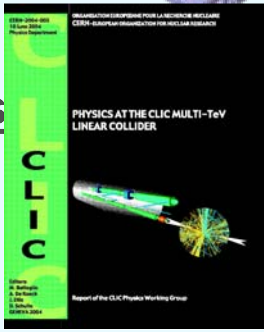
CLIC http://clic-study.web.cern.ch/CLIC-Study/

Site independent feasibility study aiming at the development of a realistic technology to extend e-/e+ linear colliders into the Multi-TeV energy range:



- ✓ E_{CM} energy range complementary to LHC
  - => E_{CM} = 0.5- 3 TeV
- ✓ L > few 10^{34} cm^{-2} with acceptable background
  - ⇒ E_{CM} and L to be reviewed when LHC physics results avail.
- ✓ Affordable cost and power consumption

Physics motivation: http://clicphysics.web.cern.ch/CLICphysics



"Physics at the CLIC Multi-TeV Linear Collider:
by the CLIC Physics Working Group:CERN 2004-5

Present goal:

Demonstrate all key feasibility issues and document in a Conceptual Design Report by 2010 and possibly Technical Design Report by 2015

CLIC Advisory CommitteE (ACE):

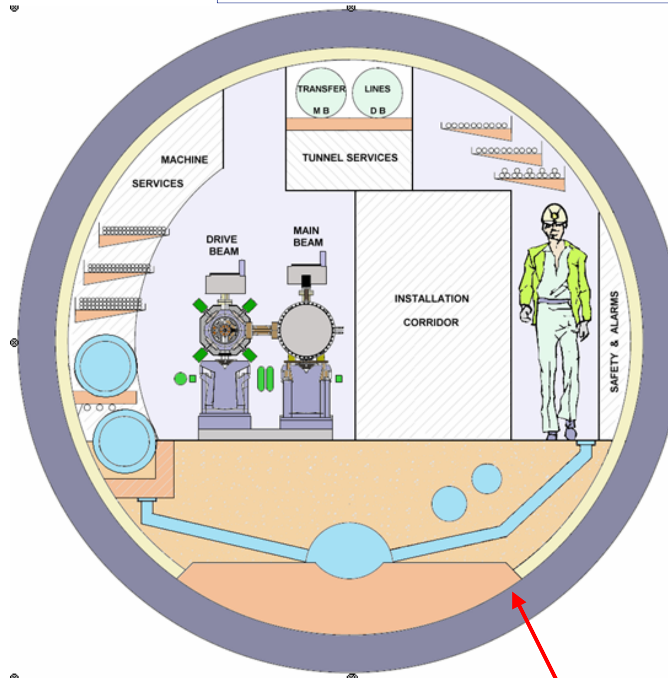
L.Evans/CERN, M.Huening/DESY, A.Mosnier/CEA, P.Raimondi/INFN, V.Shiltsev/FNAL, T.Shintake/RIKEN, T.Raubenheimer/SLAC (Chairman), N.Toge/KEK

CLIC – basic features

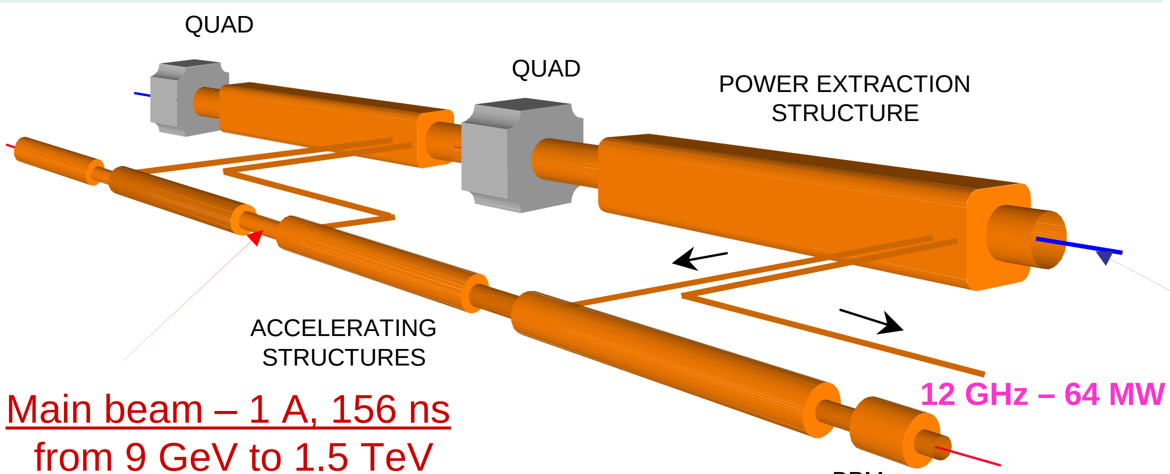
- **High acceleration gradient: > 100 MV/m**
- "Compact" collider – total length < 50 km at 3 TeV
- Normal conducting acceleration structures at high frequency

- **Novel Two-Beam Acceleration Scheme**
  - Cost effective, reliable, efficient
  - Simple tunnel, no active elements
  - Modular, easy energy upgrade in stages

CLIC TUNNEL CROSS-SECTION



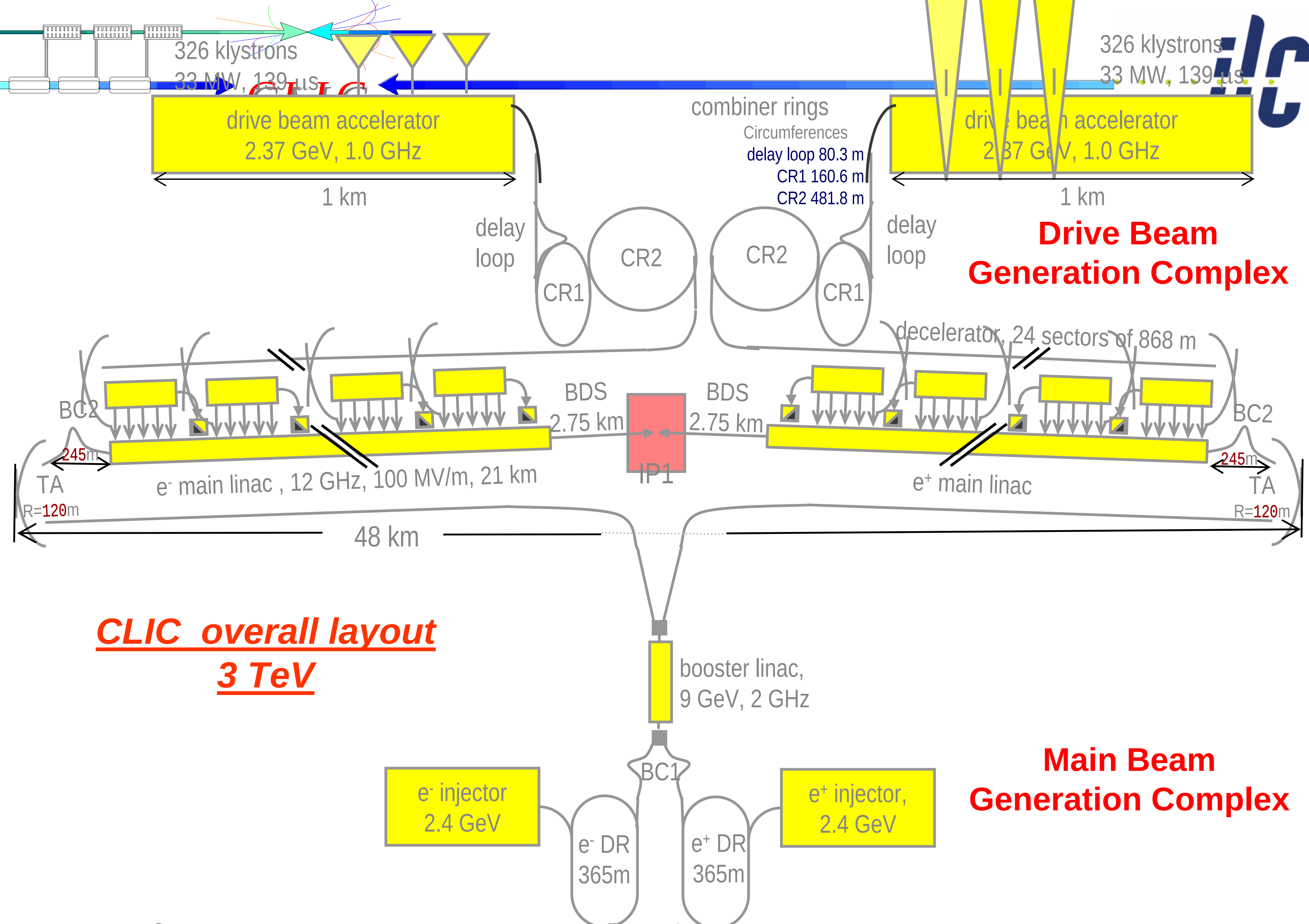
4.5 m diameter



Main beam – 1 A, 156 ns
from 9 GeV to 1.5 TeV
100 MV/m

Drive beam - 95 A, 240 ns
from 2.4 GeV to 240 MeV

CLIC overall layout 3 TeV



Strategy to address key issues

- Key issues common to all Linear Collider studies independently of the chosen technology in close collaboration with the International Linear Collider (ILC) study:
  - On Accelerator Test Facility (ATF1&ATF2@KEK)
  - With European Laboratories in the frame of the Coordinated Accelerator Research in Europe (CARE) and of a "Design Study" (EUROTeV) funded by EU Framework Programmes (FP6 presently and FP7 Integrated Activity in the future)

- Key issues specific to CLIC technology:
  - Focus of the CLIC study
  - All R1 (feasibility) and R2 (design finalisation) key issues addressed in test facilities: CTF1,2,3@CERN

Close CLIC & ILC Collaboration

- CLIC study members participating to ILC GDE
  - Major partners in specific studies and ILC Reference Design Report
  - ILC@CERN Site Specific Cost Study (CERN = European sample site)
- Key ILC experts in CLIC Advisory Committee
- Fruitful collaboration on R&D of generic Linear Colliders (CLIC&ILC) key issues
  - Participation in EUROTeV design study & CARE project
  - R&D on Beam diagnostics, Beam Delivery System (BDS), Beam dynamics
  - Tests with beam in CTF3 Test facility
  - Common participation to R&D on generation of Low Emittances generation @ ATF1/KEK and Strong Beam Focusing to nanometers sizes @ATF2/KEK
- Future common study of subjects with strong synergy between CLIC & ILC
  - FP7 EU supported in Coordinated Accelerator R&D (EUCARD) with a CLIC/ILC work package (NC Linacs)
  - Launching common CLIC/ILC studies with ILC Project Managers (Feb08 @ CERN) following constructive visit of B.Barish (Nov 07):
    - Civil engineering & conventional facilities
    - Beam delivery System and Machine –Detector Interface
    - Physics & Detectors
    - Cost & Schedule

CLIC/CTF3 Multi-Lateral Collaboration of Volunteer Institutes

Organized as a Physics Detector Collaboration

20 members representing 25 institutes involv. 17 funding agencies from 14 countries

Collab. Board: Chairperson: M.Calvetti/INFN; Spokesperson: G.Geschonke/CERN

MoU with addenda describing specific contribution (& resources)

Countries	Funding Agencies	Laboratory	Representatives & Advisory	Team Leaders	MoU _ Addenda
CERN	CERN	CERN	J-P. Delahaye, G. Geschonke	J-P. Delahaye (Deputy: G. Geschonke)	Link to pdf
FINLAND		Helsinki Inst of Phys (HIP)	D.O. Riska, K. Österberg	K. Österberg (Former: D.O. Riska)	Link to pdf
FRANCE	CEA/DSM-Saclay	IRFU (DAPNIA)	Ph. Lavocat, J. Zinn-Justin	F. Orsini (Deputy: W. Farabolini)	Link to pdf
	CNRS/IN2P3	LAL, LURE	G. Wormser	*Not yet nominated*	Link to pdf
		LAPP	Y. Kariotakis	S. Vilalte (Former: Y. Kariotakis)	
INDIA*	Indian DAE	RRCAT, Indore	V. Sahni, P. Shrivastava	V. Sahni (Deputy: P. Shrivastava)	Link to pdf Add. T1 pdf Add. M2 pdf
ITALY	INFN	LNF	M. Calvetti, A. Ghigo	A. Ghigo (Deputies: C. Biscari & F. Marcellini)	Link to pdf
NORWAY	The Research Council of Norway	University of Oslo	S. Stapnes	S. Stapnes (Deputy: E. Adli)	Link to pdf
PAKISTAN		National Centre for Physics (NCP)	H. Hoorani, S. Ahmad	H. Hoorani	Link to pdf
RUSSIA		Budker Inst (BINP)	A. Skrinski	*Not yet nominated*	Link to pdf - Draft Amendt pdf
		IAP	A.G. Litvak	*Not yet nominated*	Link to pdf
	Dubna	JINR	V. Samoilov	*Not yet nominated*	Link to pdf
SPAIN	Ministry of Education & Science (MEC)	CIEMAT, UPC, IFIC	J. Fuster, L. Garcia-Tabares	F. Toral (Deputy: L. Garcia-Tabares)	Link to pdf
SWEDEN	Swedish Research Council	Uppsala Univ and Svedberg Lab (TSL)	T. Ekelof, V. Ziemann	T. Ekelof (Deputy: V. Ziemann)	Link to pdf
	Wallenberg Foundation				Link to pdf
SWITZERLAND		Paul Scherrer Inst (PSI)	L. Rivkin, T. Garvey	L. Rivkin (Deputy: T. Garvey)	Link to pdf
TURKEY		Ankara Univ & Gazi Univ	A.K. Ciftçi	A.K. Ciftçi (Deputy: S. Sultanov)	Link to pdf
UNITED-KINGDOM	STFC	J. Adams Institute for Accelerator Science	G. Blair, K. Peach	K. Peach	Link to pdf
		Royal Holloway, Univ of London	G.Blair	G. Blair (Deputy: P. Karataev)	
USA	DOE	Northwestern Univ Illinois (NWU)	M. Velasco	*Not yet nominated*	Link to pdf
		SLAC	R. Ruth, S. Tantawi	*Not yet nominated*	Link to pdf
		Jefferson Laboratory (JLAB)	A. Hutton	*Not yet nominated*	Link to pdf

CLIC/CTF3 collaboration observers

Discussion with possible future collaboration partners:

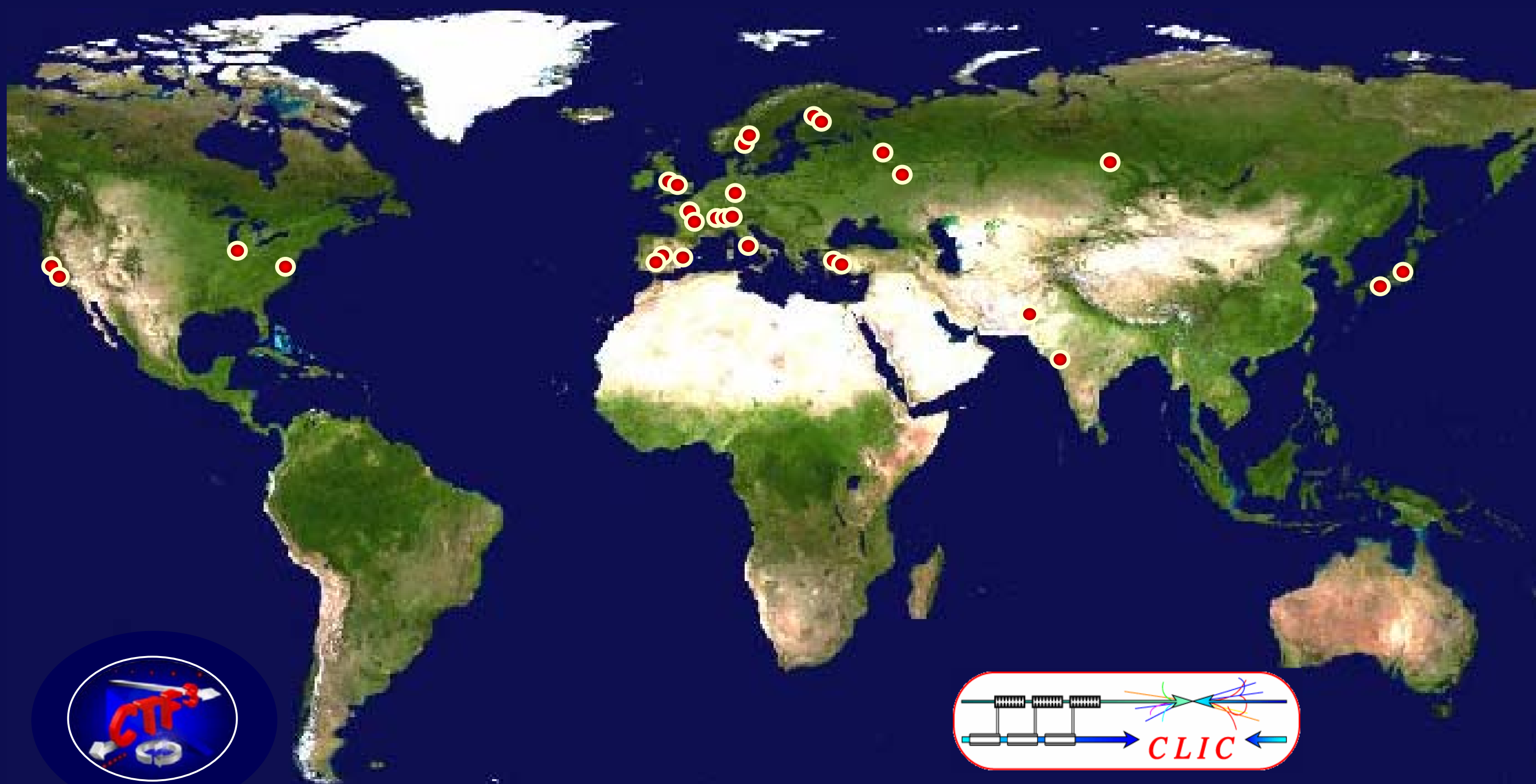
Countries	Funding Agencies	Laboratory	Representatives & Advisors	MoU _Addenda
CHINA		Tsinghua Univ	H. Chen, H. Wenhui	
IRAN		Inst for Theoretical Phys and Math (IPM)	H. Arfaei	
UNITED-KINGDOM	STFC	RAL	G. Hirst, H. Hutchinson	
		Cockcroft Institute	S. Chattopadhyay, J. Dainton	

Visiting Scientist: MoU being finalized

MoUs being finalized

Present collaboration with RAL on Laser development for PHIN in EU FP6 CARE

World-wide CLIC&CTF3 Collaboration



Ankara University (Turkey)
Berlin Tech. Univ. (Germany)
BINP (Russia)
CERN
CIEMAT (Spain)
DAPNIA/Saclay (France)
RRCAT-Indore (India)

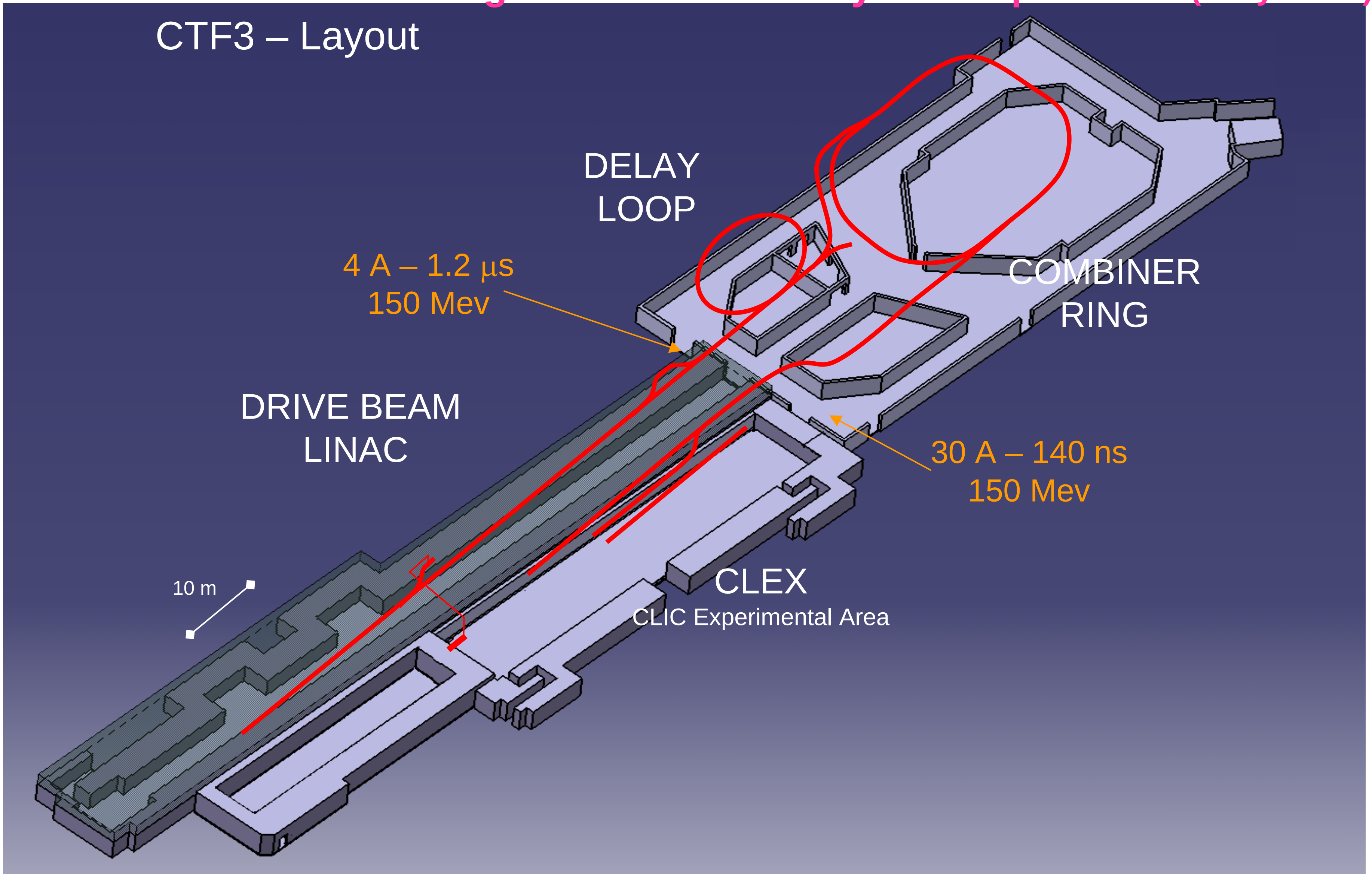
Finnish Industry (Finland)
Gazi Universities (Turkey)
Helsinki Institute of Physics (Finland)
IAP (Russia)
Instituto de Fisica Corpuscular (Spain)
INFN / LNF (Italy)
J. Addams Institute (UK)

JASRI (Japan)
Jefferson Lab (USA)
JINR (Russia)
KEK (Japan)
LAL/Orsay (France)
LAPP/ESIA (France)
LLBL/LBL (USA)
NCP (Pakistan)

Oslo University (Norway)
PSI (Switzerland)
North-West. Univ. Illinois (USA)
Polytech. University of Catalonia (Spain)
RAL (UK)
SLAC (USA)
Svedberg Laboratory (Sweden)
Uppsala University (Sweden)

Addressing all major CLIC technology key issues in CLIC Test Facility (CTF3)

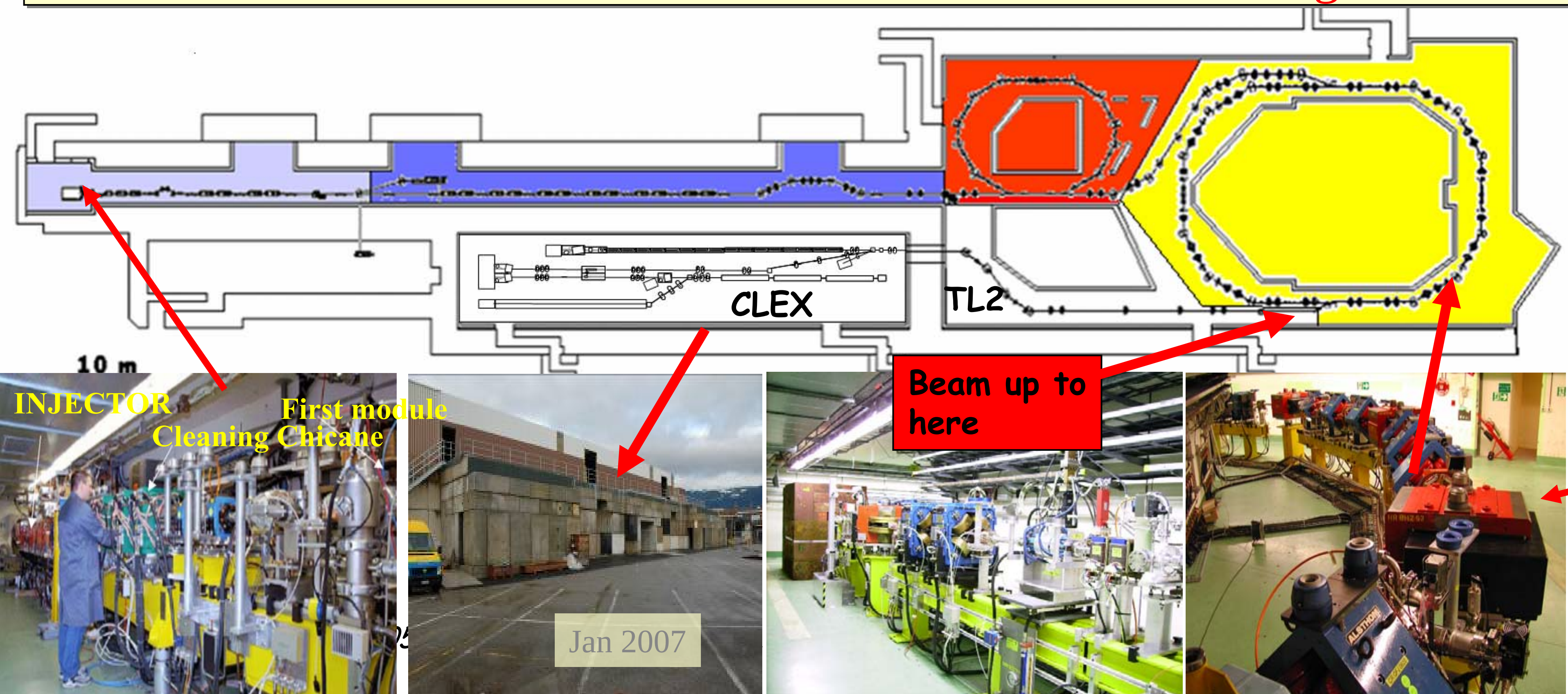
First Accelerator R&D recognized as CERN Physics Experiment (Grey Book)



CTF3 Continuous 0peration (10months/year)

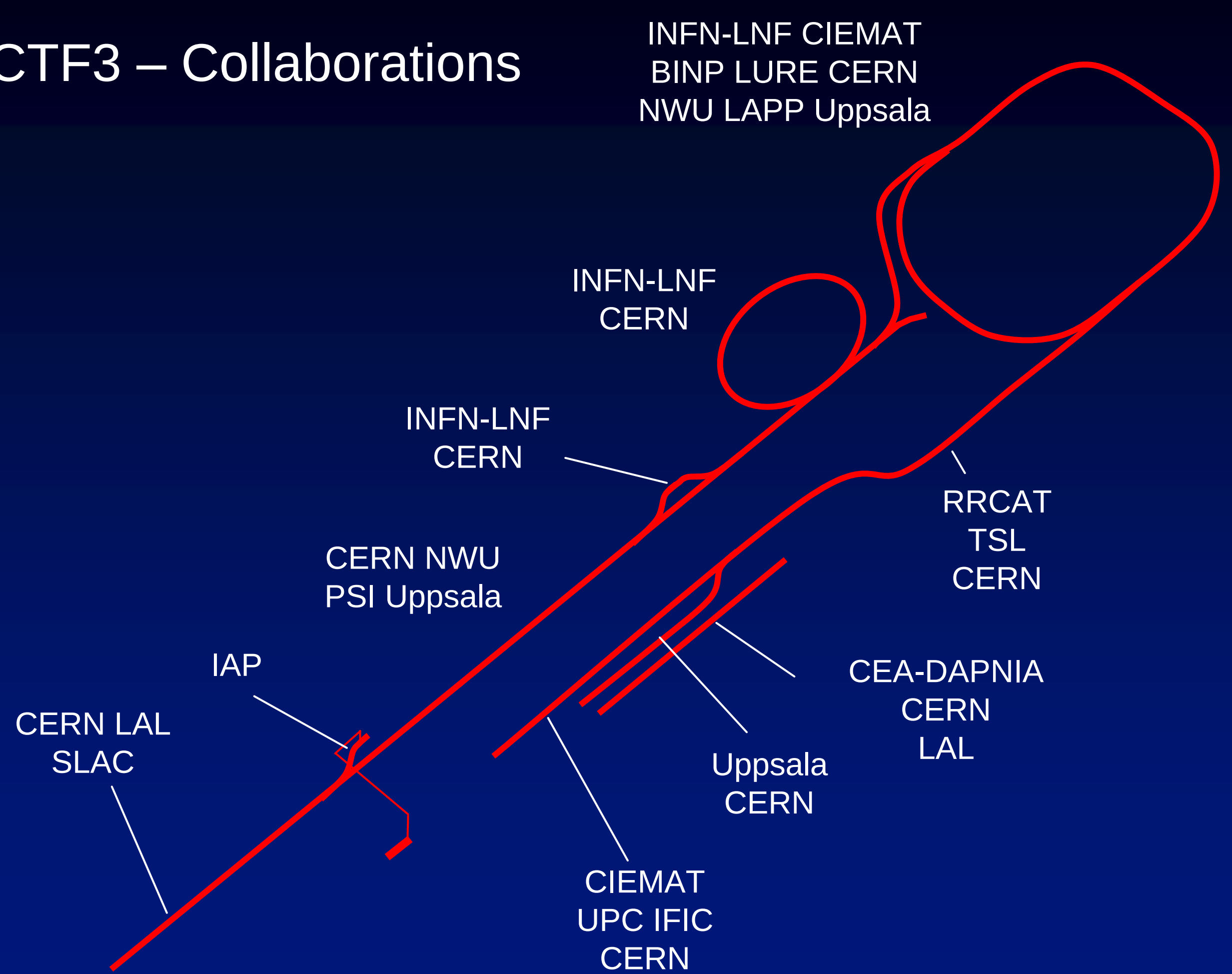
HW & Beam Commisioning and RF power production for structure tests

- Demonstrate Drive Beam generation
  (fully loaded acceleration, beam intensity and bunch frequency multiplication x8)
- Demonstrate RF Power Production and test Power Structures (PETS)
- Demonstrate Two Beam Acceleration and test Accelerating Structures

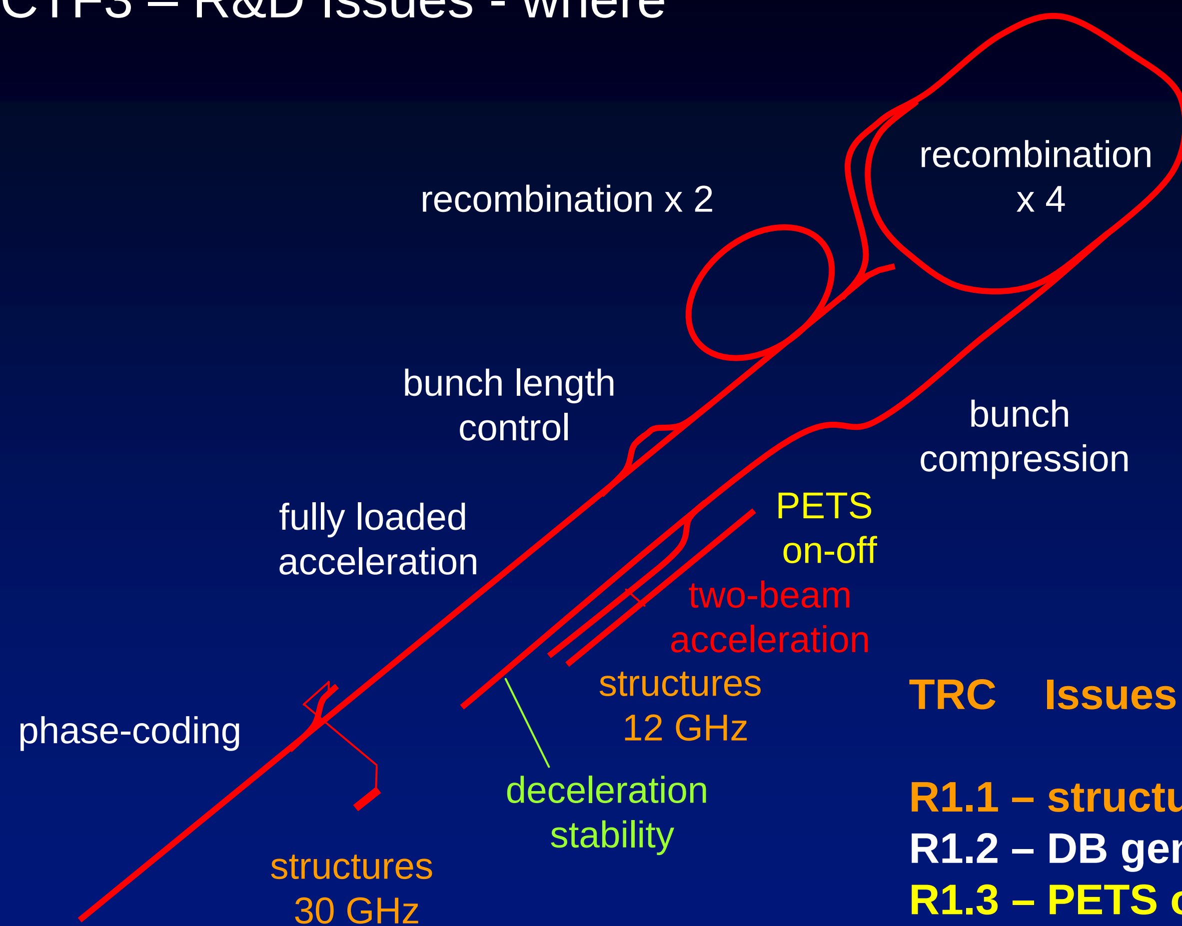


Work Package repartition

CTF3 – Collaborations



CTF3 – R&D Issues - where

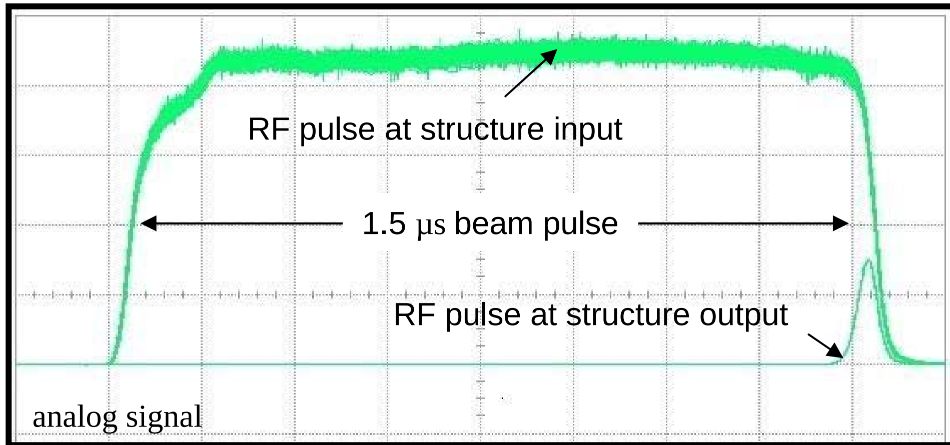


TRC	Issues addressed	When?
R1.1 –	structures	2006-10
R1.2 –	DB generation	2006-08
R1.3 –	PETS on-off	2009-10
R 2.1–	structure materials	2006-10
R 2.2 –	DB decelerator	2009-10
R 2.3 –	CLIC sub-unit	2008-10

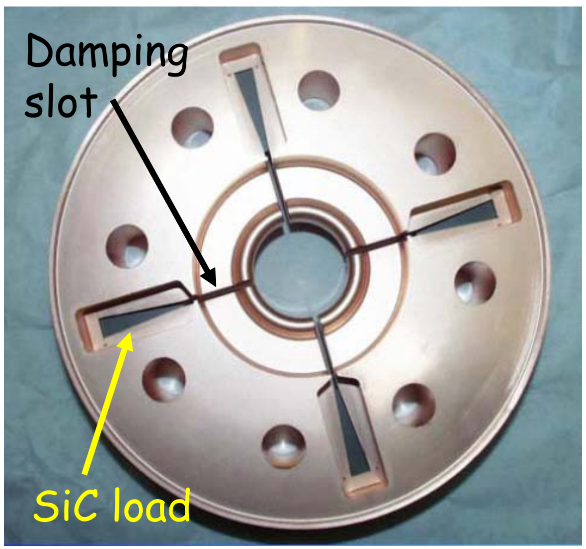
Drive beam generation with full beam-loading acceleration in CTF3 linac

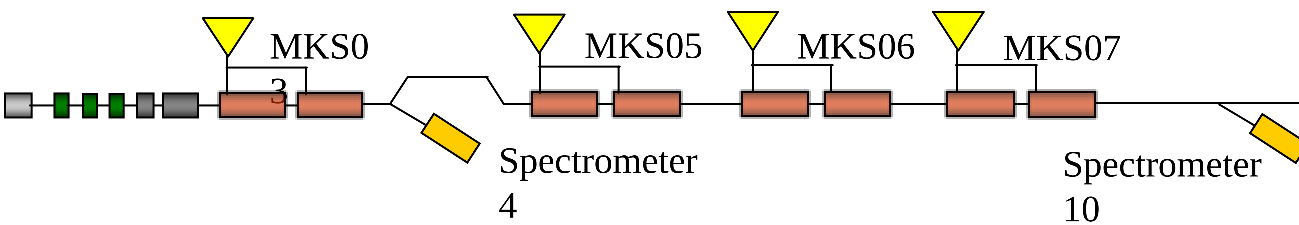
- Measured RF-to-beam efficiency 95.3%
- Theory 96%

(~ 4 % ohmic losses)

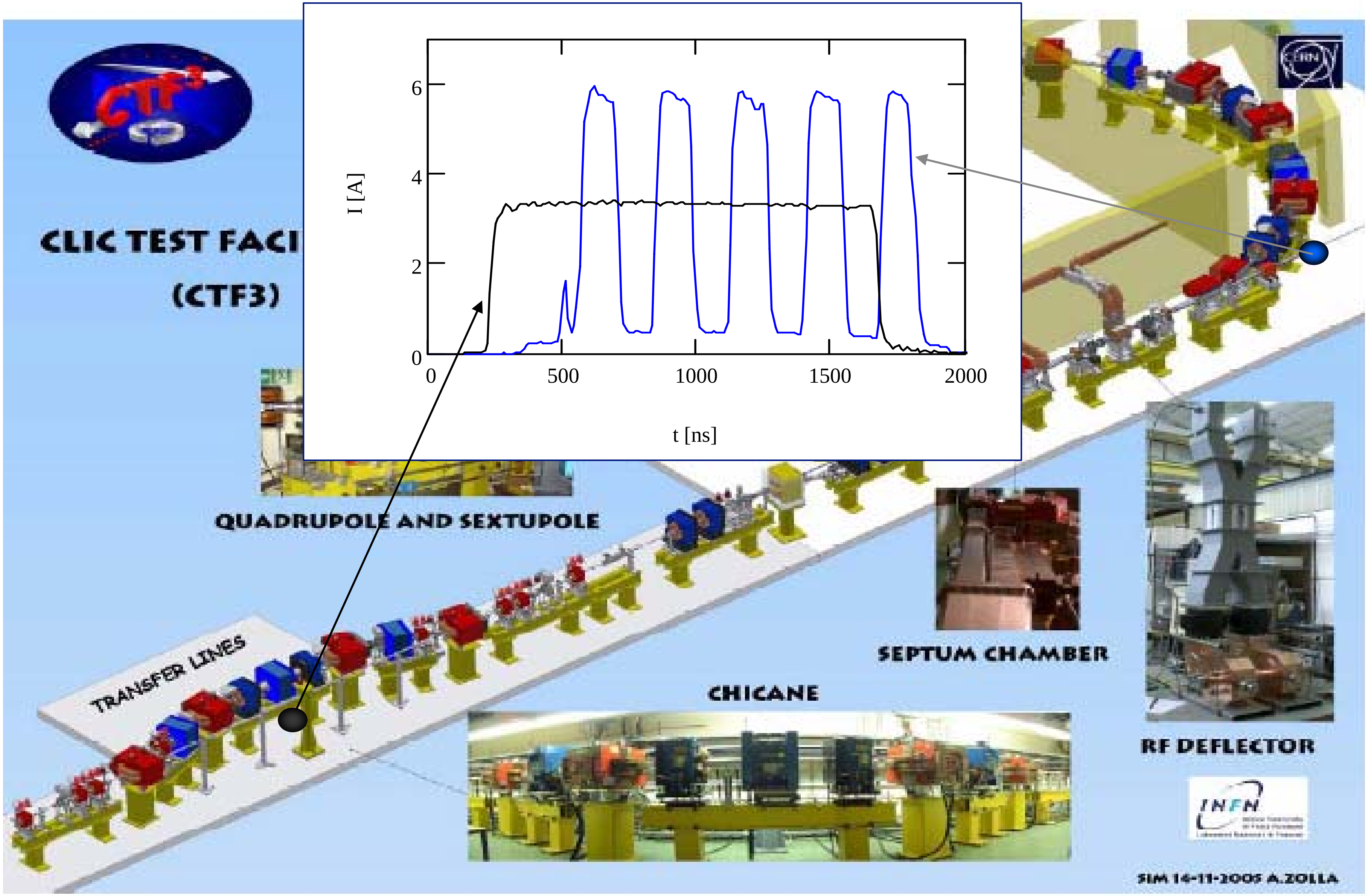


Dipole modes suppressed by slotted iris damping (first dipole's Q factor < 20) and HOM frequency detuning



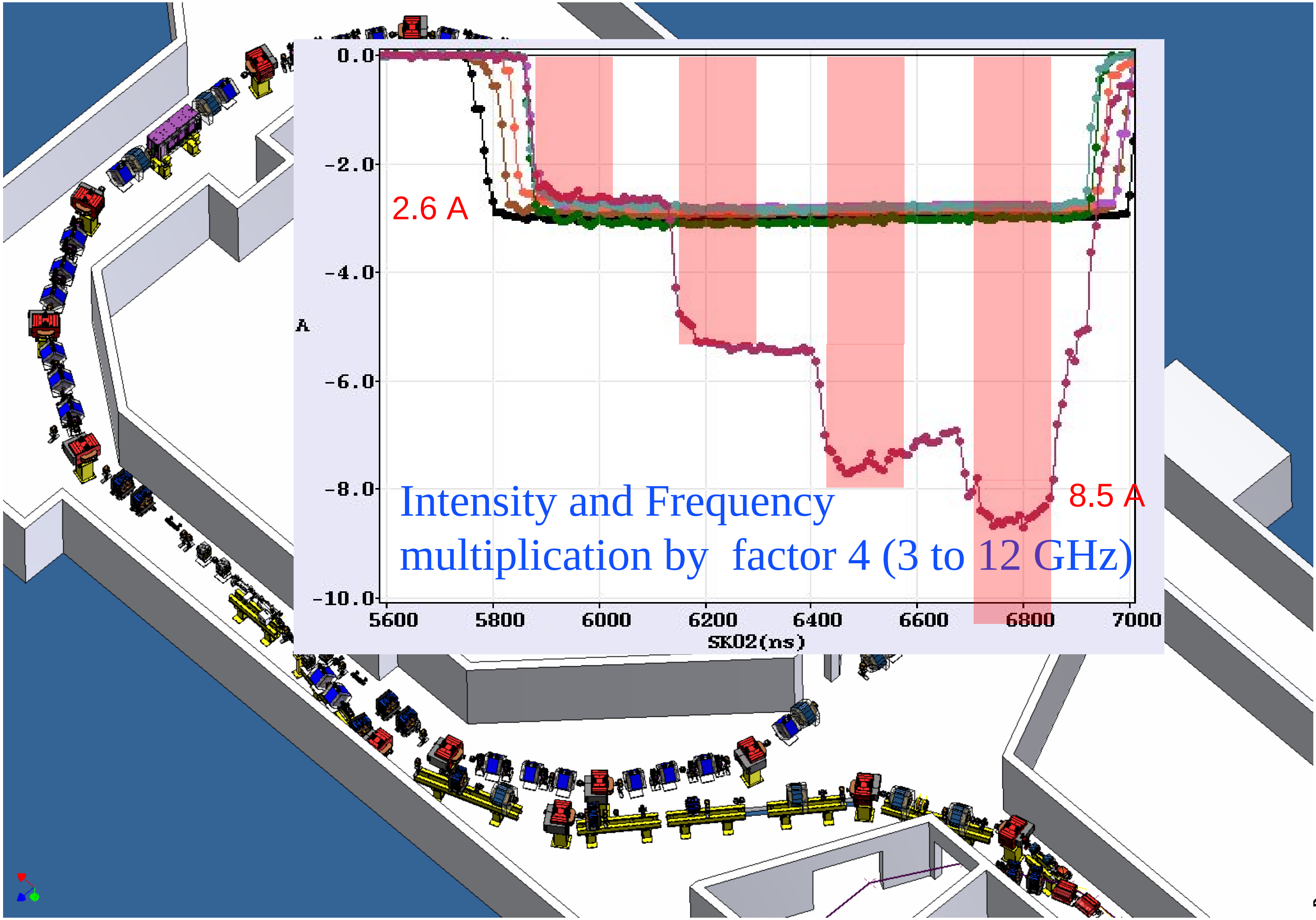


Beam intensity and RF frequency multiplication (factor 2) in CTF3 Delay Loop



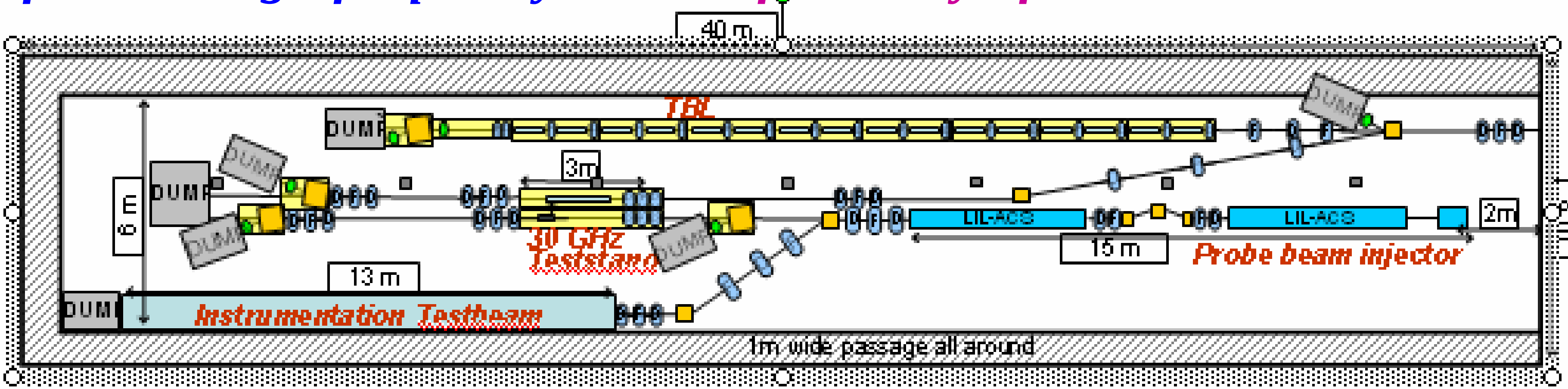
Beam commissioning of the Combiner ring

CLIC



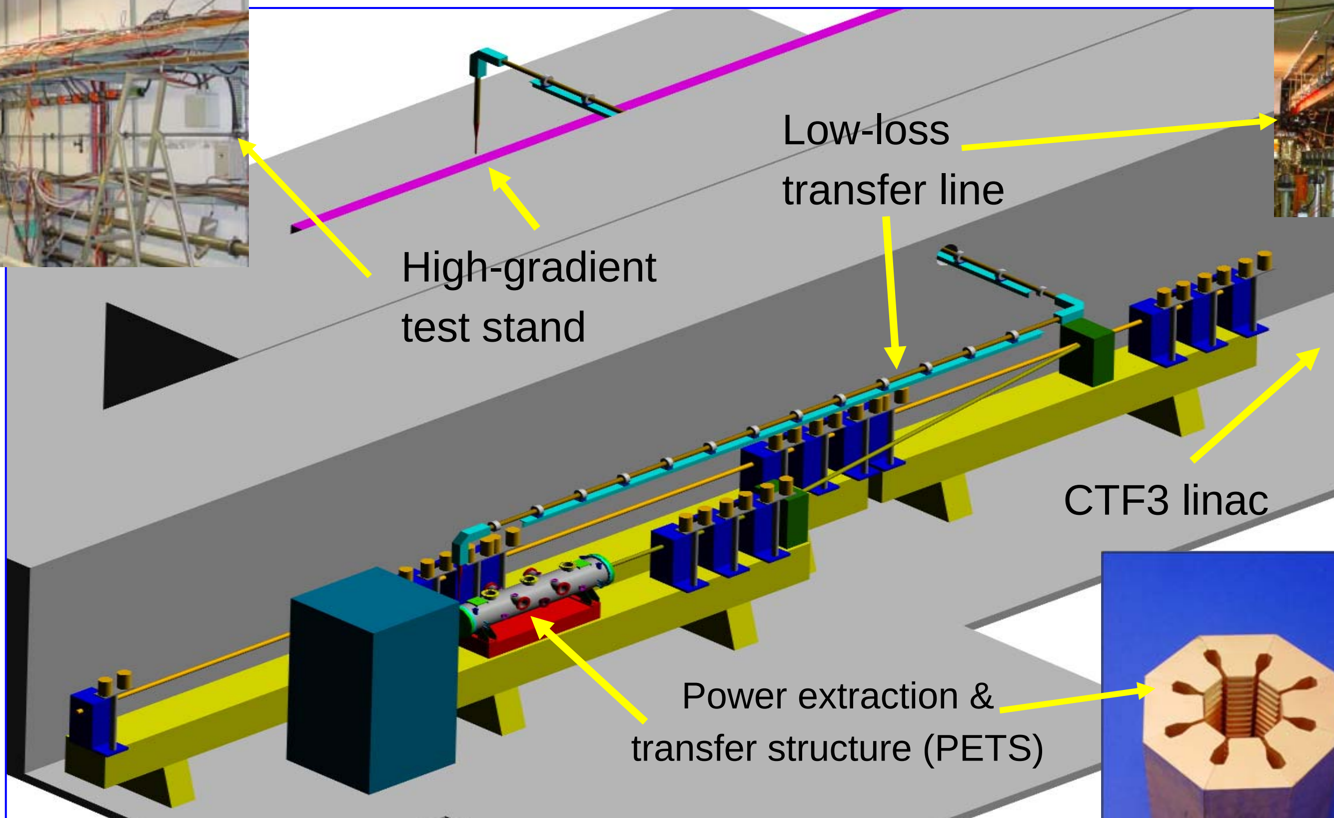
CLIC Experimental Area (CLEX)

- *Test beam line (TBL) to study RF power production (2.5 TW at 12 GHz) and drive beam decelerator dynamics, stability & losses*
- *Two Beam Test Stand to study probe beam acceleration with high fields at high frequency and the feasibility of Two Beam modules*



Construction on schedule
Equipment installation from May 2007,
Beam foreseen from March 2008

RF Power production in CTF3

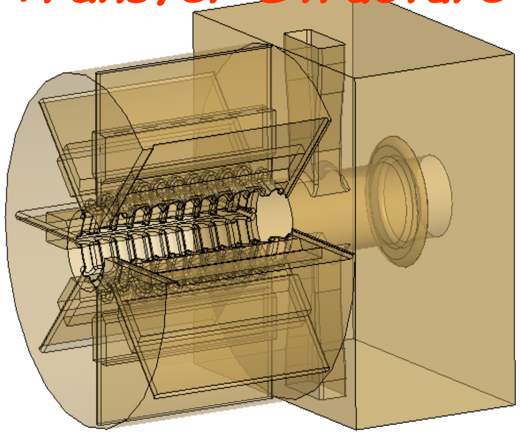


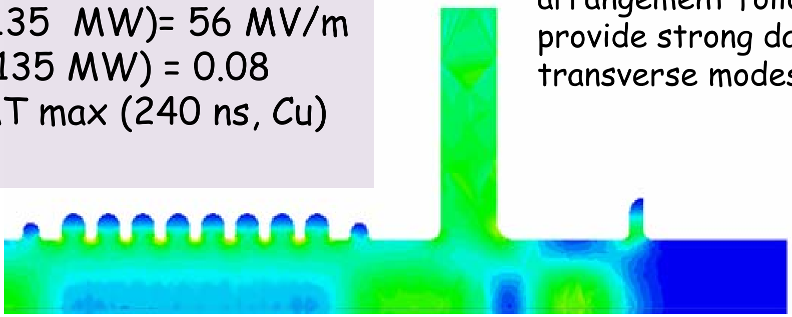
- Produced power at 30 GHz up to about 100 MW – long pulses (up to 300 ns) available for the first time
- Structure tests started in 2005 - 8 structures tested until now

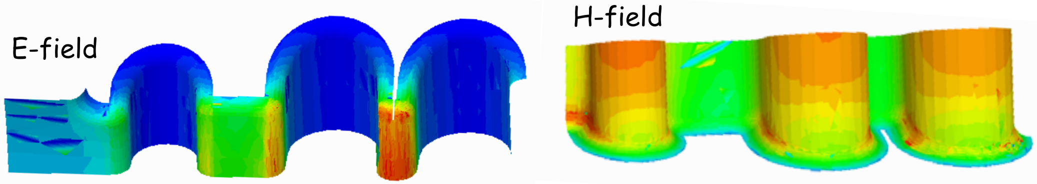
CLIC Power Extraction and Transfer Structure (PETS)

PETS parameters:
- Aperture = 23 mm
- Period = 6.253 mm (90^0/cell)
- Iris thickness = 2 mm
- R/Q = 2258 Ω
- V group= 0.453
- Q = 7200
- P/C = 13.4
- E surf. (135 MW)= 56 MV/m
- H surf. (135 MW) = 0.08 MA/m (ΔT max (240 ns, Cu) = 1.8 C^0)

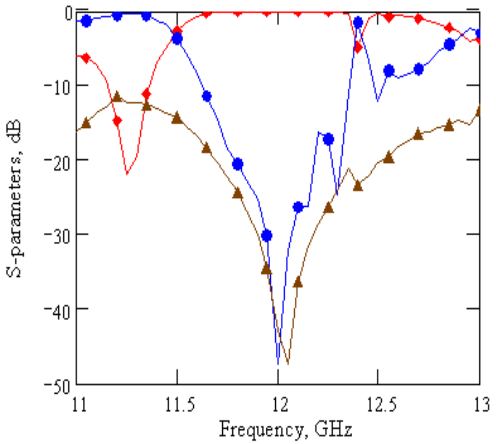
In its final configuration, PETS comprises eight octants separated by the damping slots. Each of the slots is equipped with HOM damping loads. This arrangement follows the need to provide strong damping of the transverse modes.





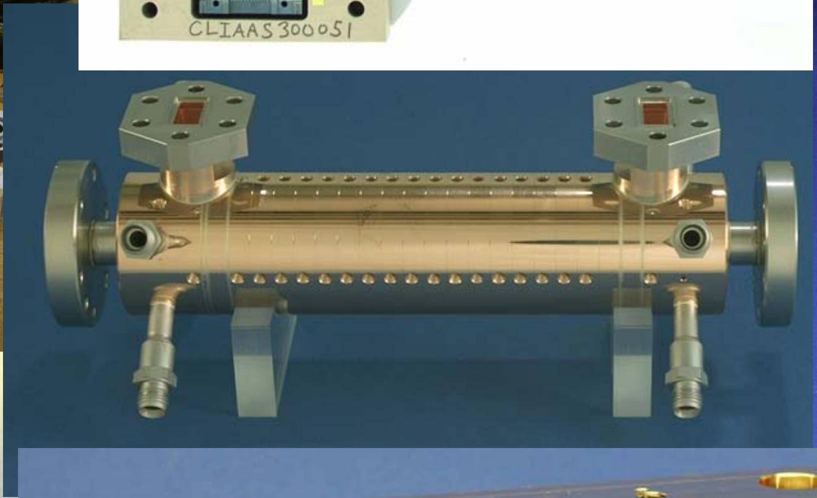
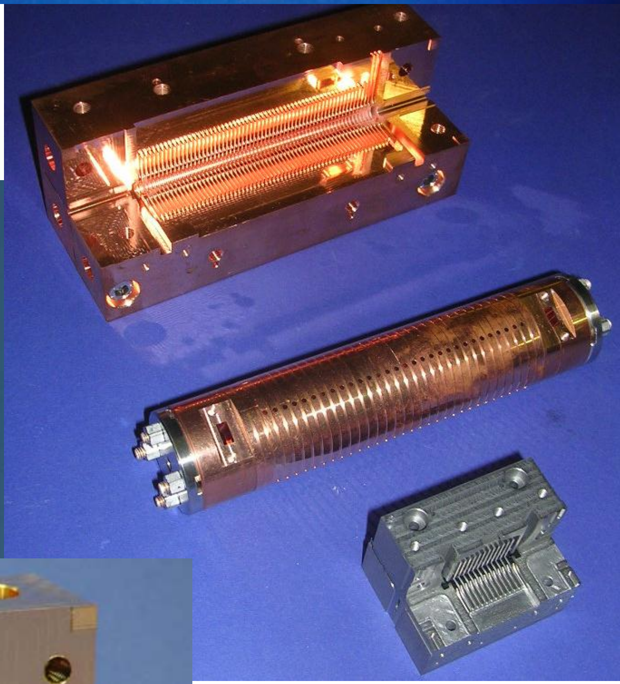


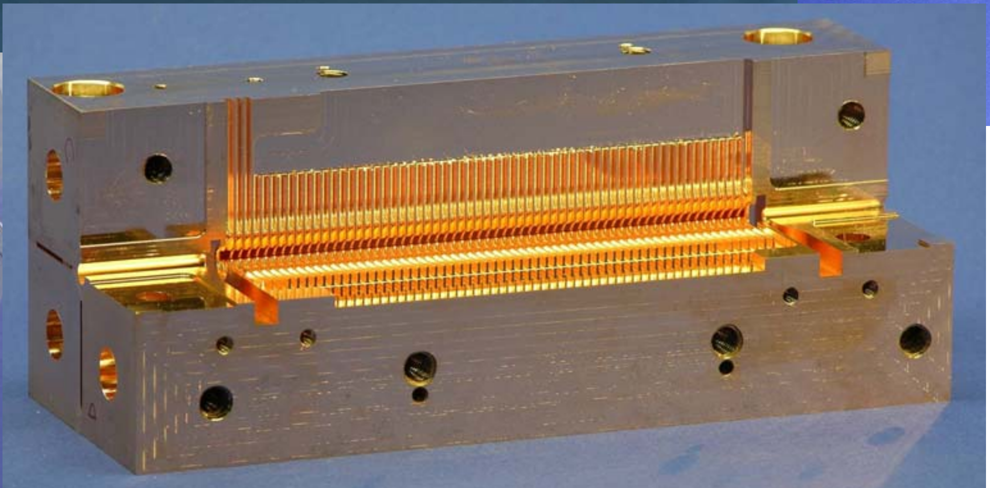
To reduce the surface field concentration in the presence of the damping slot, the special profiling of the iris was adopted.



I. Syratchev

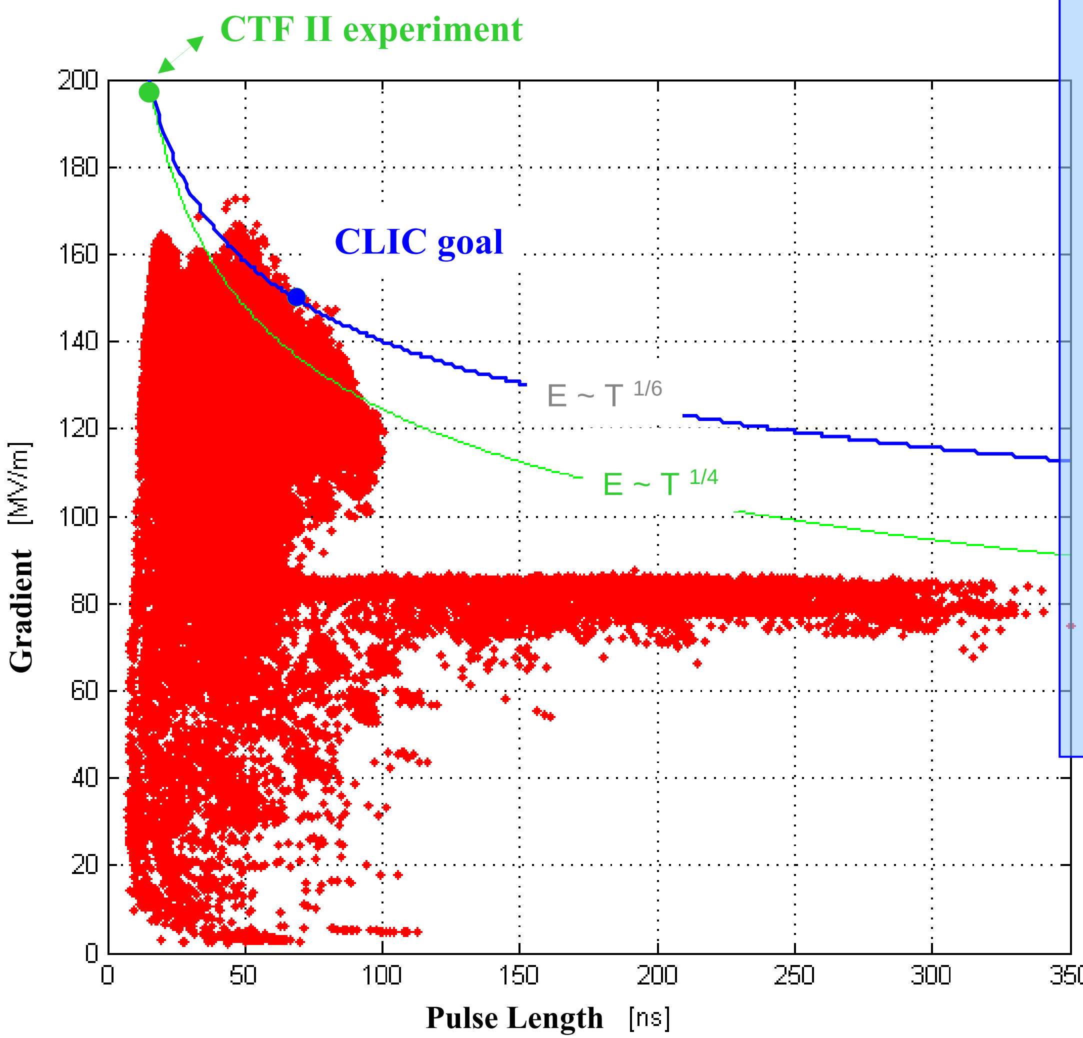




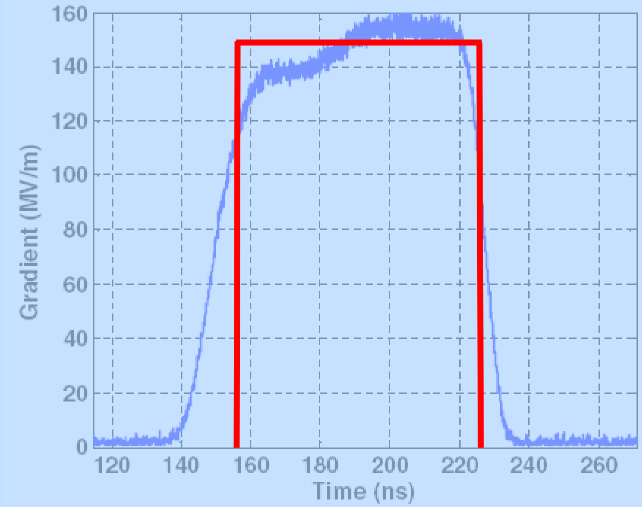
Testing Accelerating Structures

CTF3 High-Power test results @ 30 GHz



Reached nominal CLIC values :

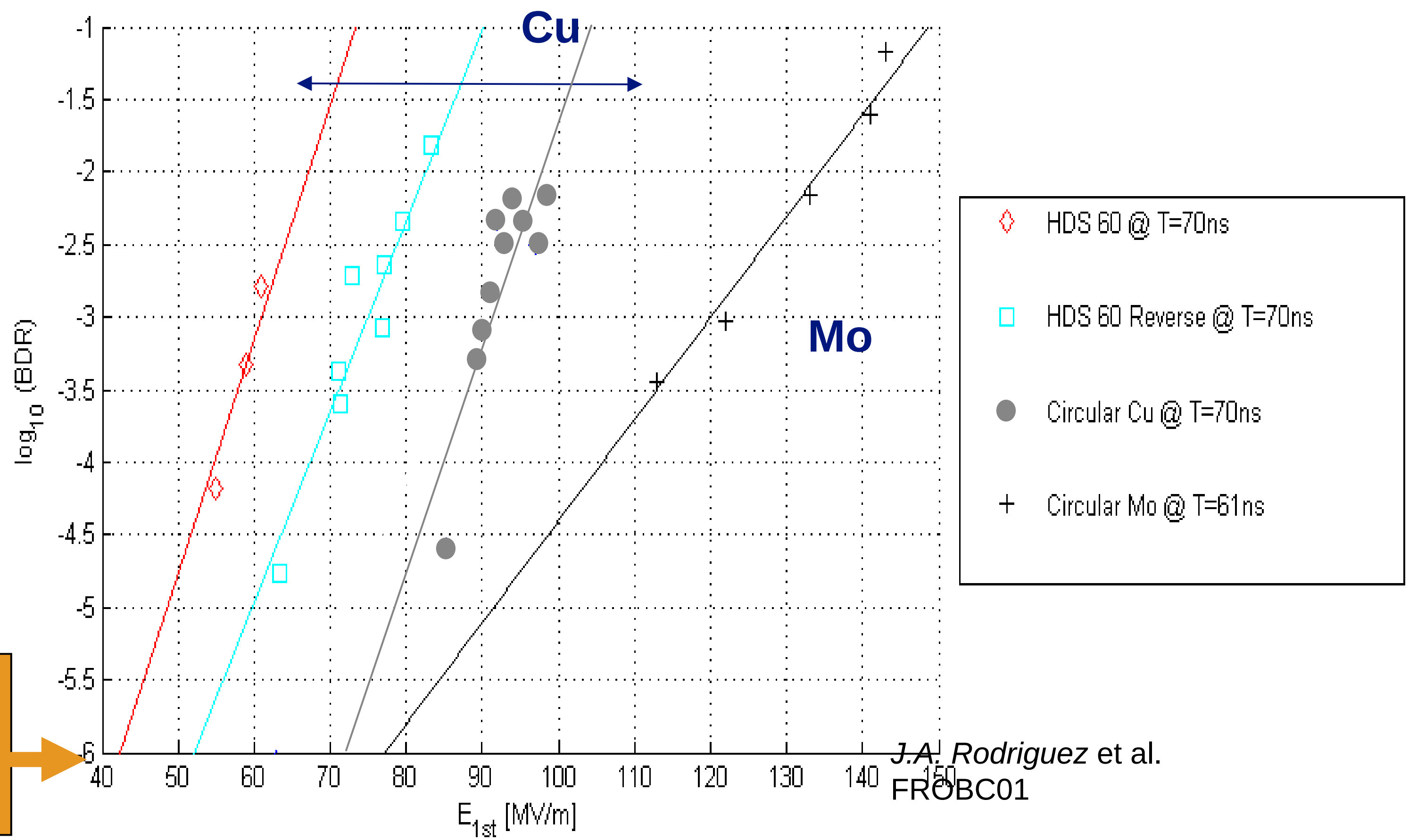
150 MV/m - 70 ns



Breakdown Rate not compatible with LC operation

CTF3 High-Power tests
various materials results @ 30 GHz

- Acceptable Breakdown Rate in linear collider operation not higher than 10-6
- Reduction of accelerating field by about 30 MV/m for low BR with Cu



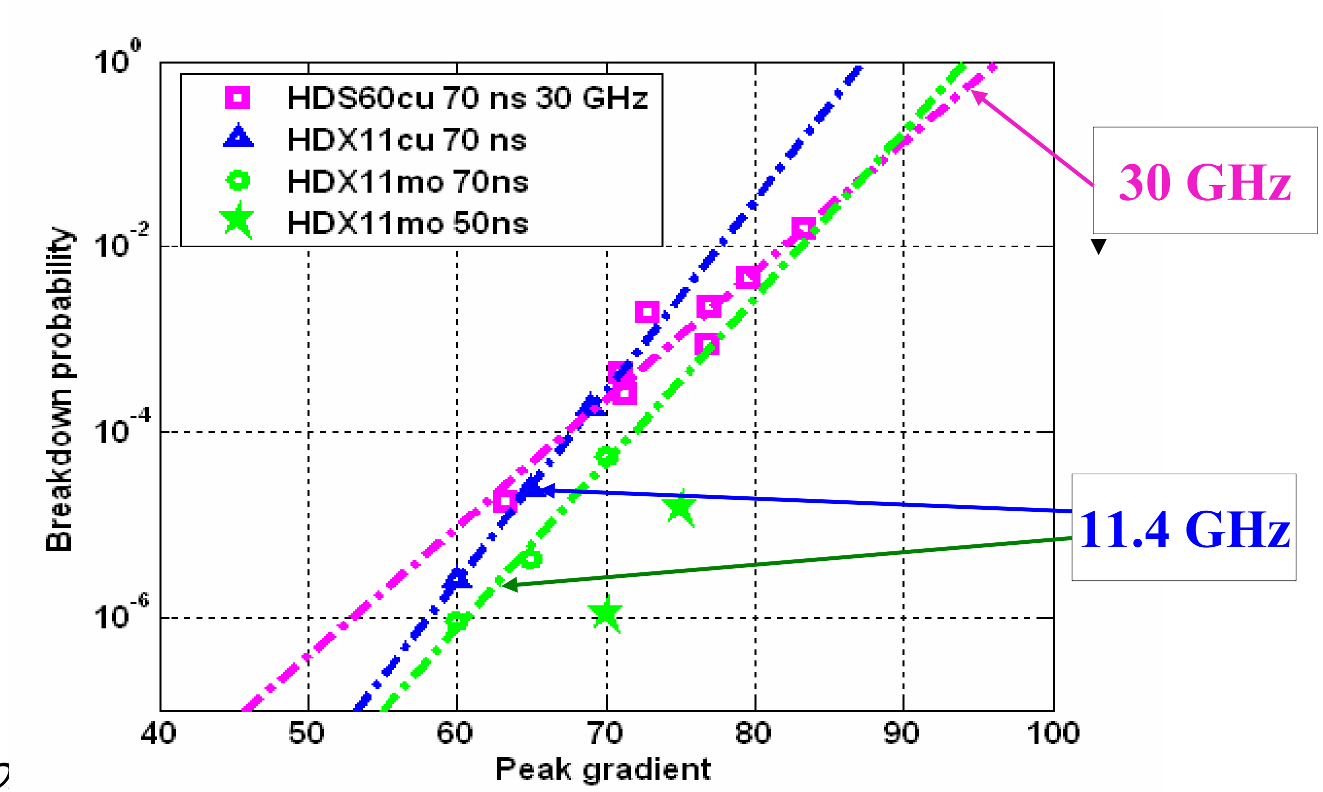
CLIC operational goal

J.A. Rodriguez et al.
FROBC01

CTF3 - SLAC High-Power test results @ 30 & 11.4 GHz

- Structures with scaled geometries at different frequencies have same performance

  Scaling introduced in a parametric model (taking into account RF structure & beam dynamics constraint), used to study optimum cost & efficiency



CLIC overall optimisation model

Accelerating structure limitations:

rf breakdown and pulsed surface heating (rf) constraints:

Beam dynamics constraints:

Beam quality preservation during acceleration in main linac with high wake fields environment: **(conditions similar to NLC)**

Beam focusing in Beam Delivery System and collison in detector in high beamstrahlung regime

Deduce CLIC parameters and performance: > 200 millions structures

Optimising

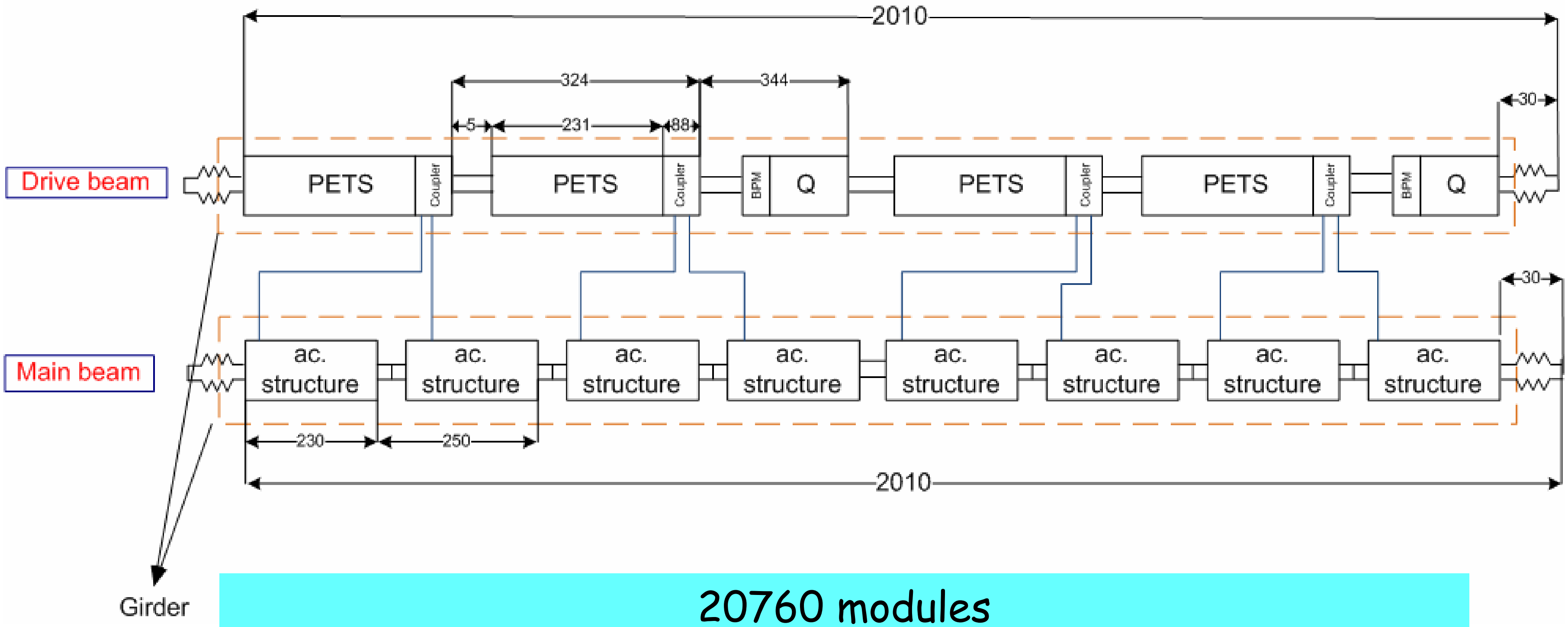
Performance or figure of merit

Luminosity per linac input power:

$$\int L dt / \int P dt \sim L_{b\times} / N \eta$$

Cost estimation of the overall complex at 3 TeV (invest. & exploit. 10 years)

Two Beam Module

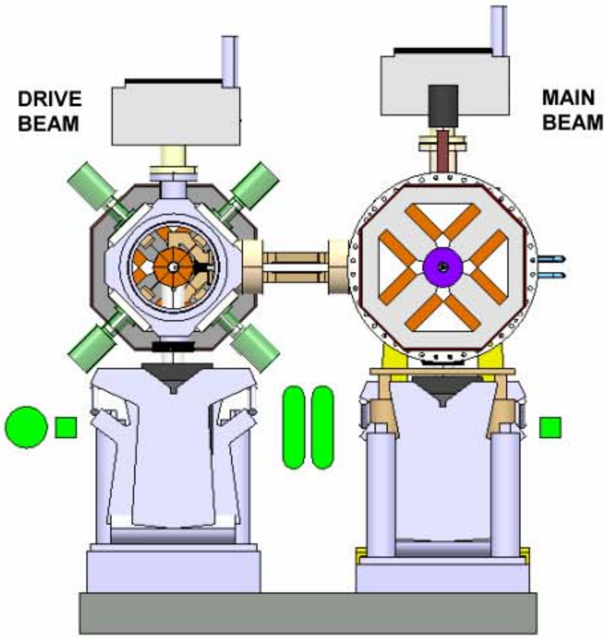


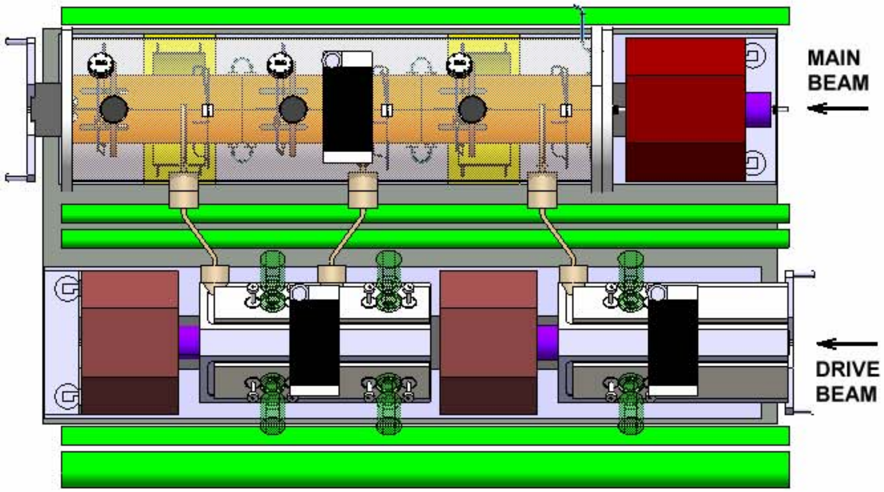
20760 modules

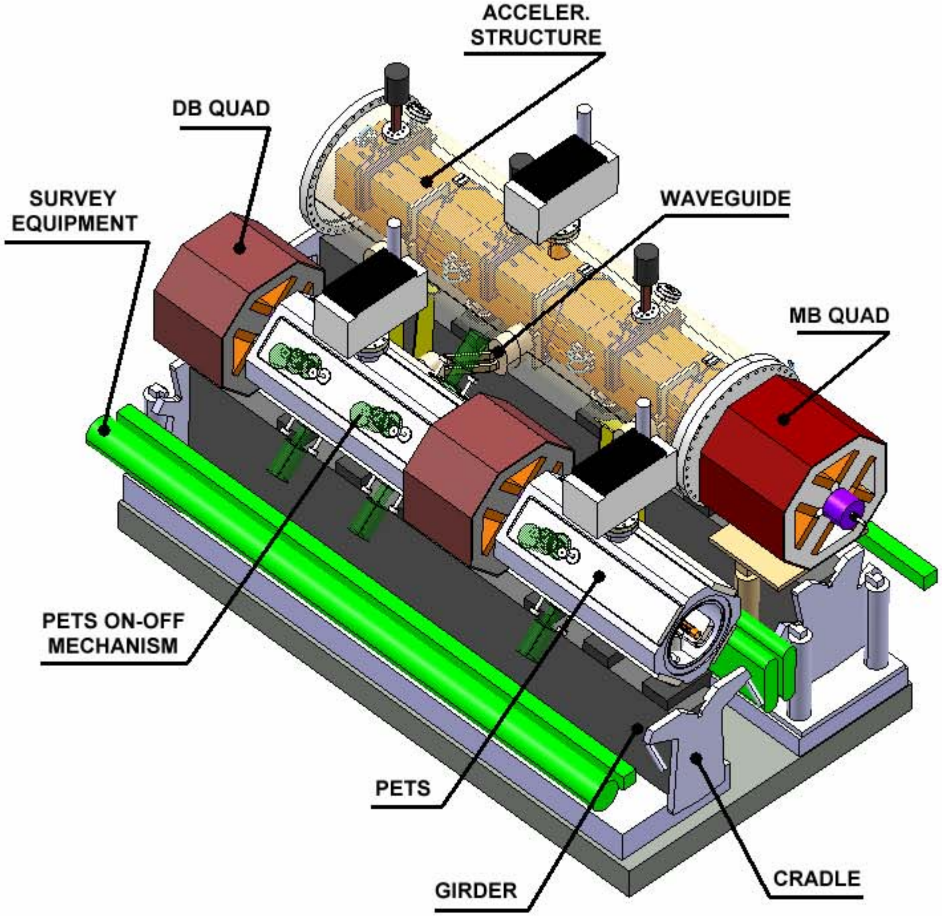
71460 power production structures PETS (drive beam)

143010 accelerating structures (main beam)

CLIC Standard Two Beam Module

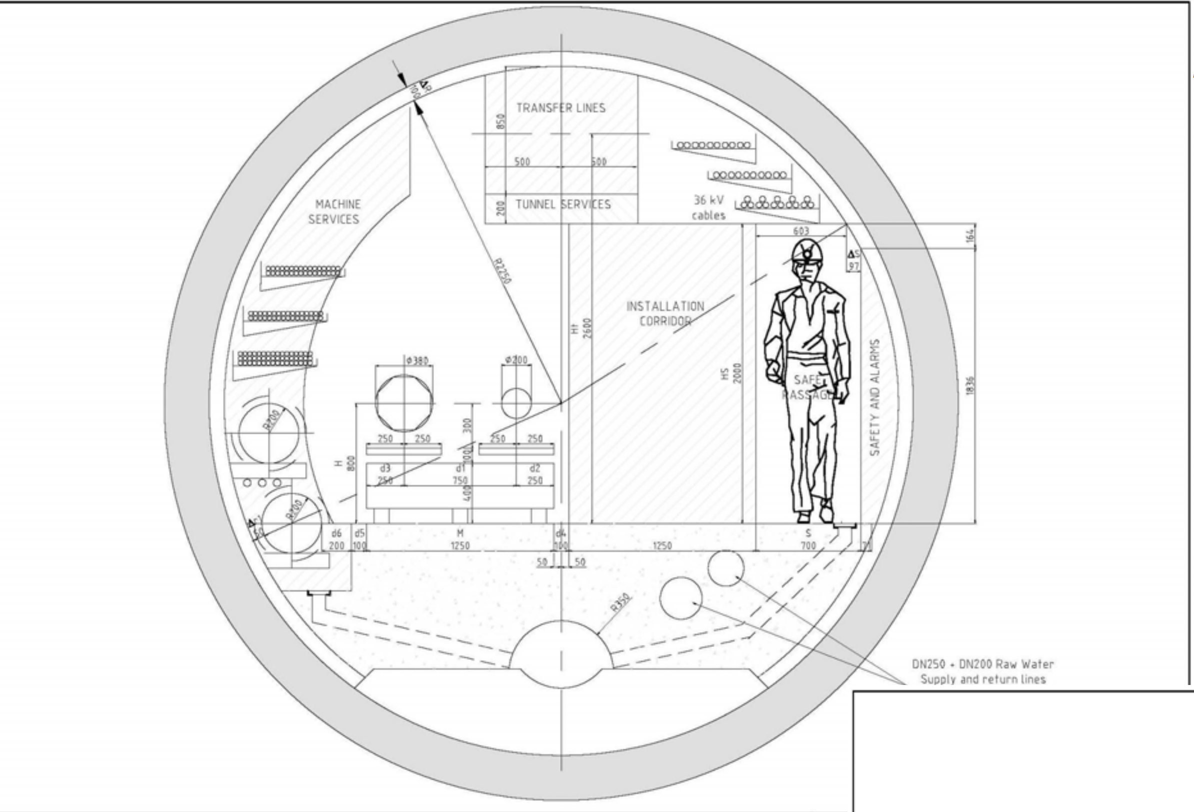


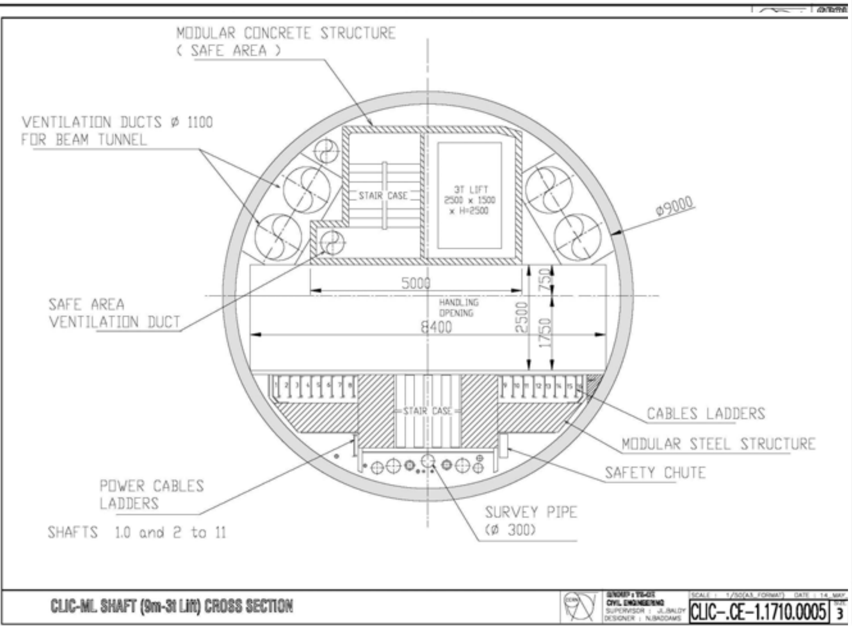


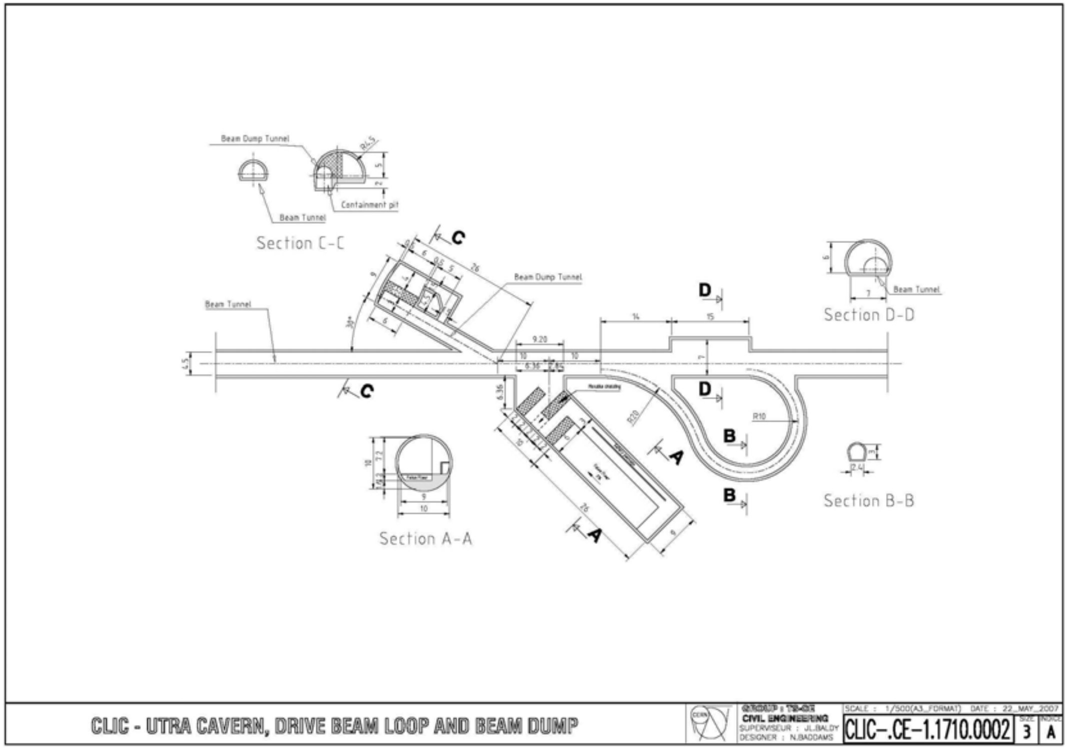


Single CLIC tunnel

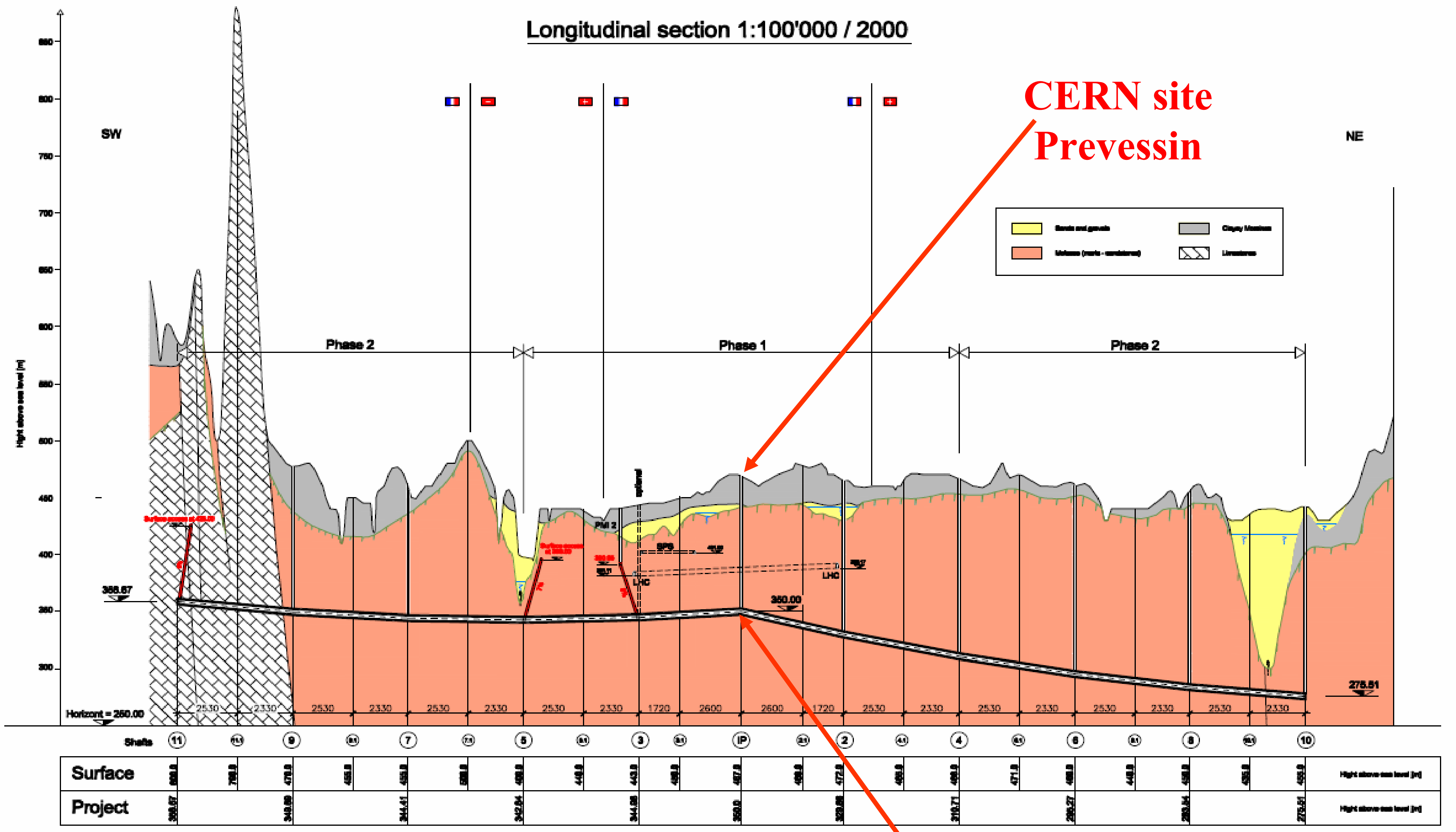
with alcoves for drive beam return loops and dumps







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



IP under CERN Prevessin site

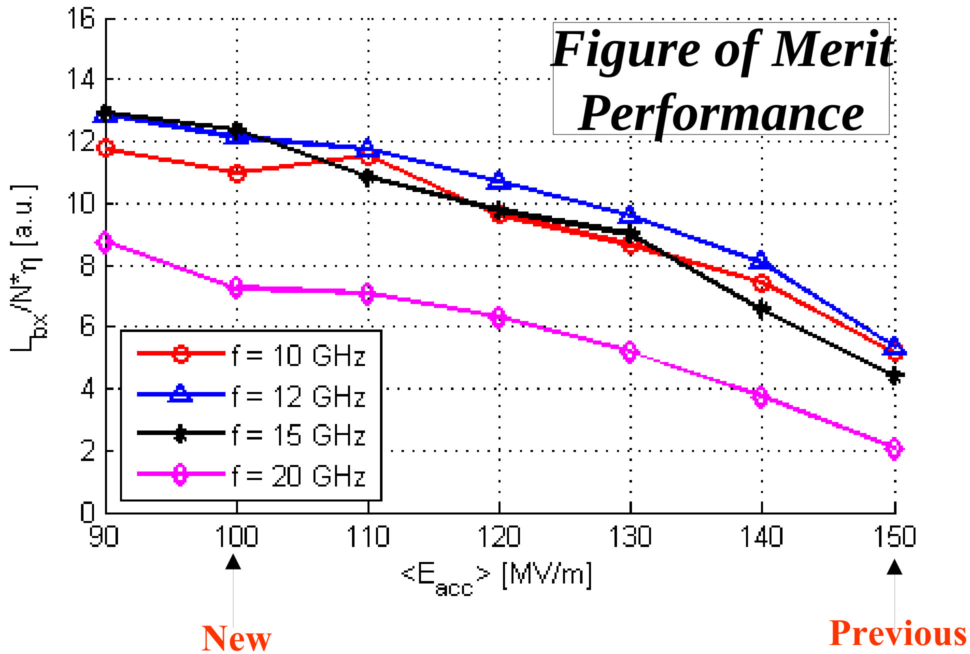
Phase 1: 1 TEV extension 19.5 km

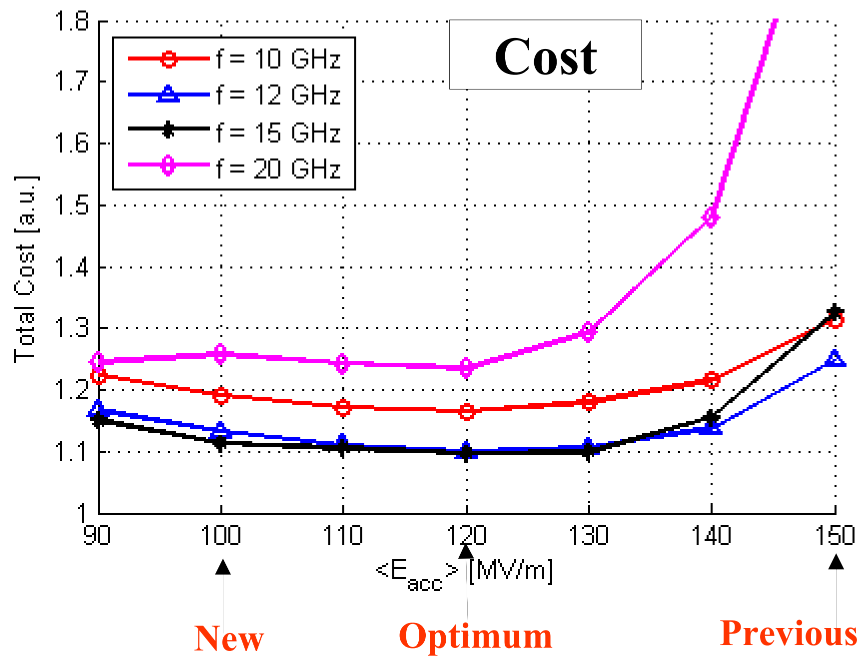
Phase 2: 3 TeV extension 48.5 km

W:\Albrdata\G017 CLIC\ACAD\Längenprofil_01.dwg

CLIC performances (FoM) and cost (relative) as a function of the accelerating gradient

E_{cms} = 3 TeV $L_{(1\%)} = 2.0\ 10^{34}\ cm^{-2}s^{-1}$

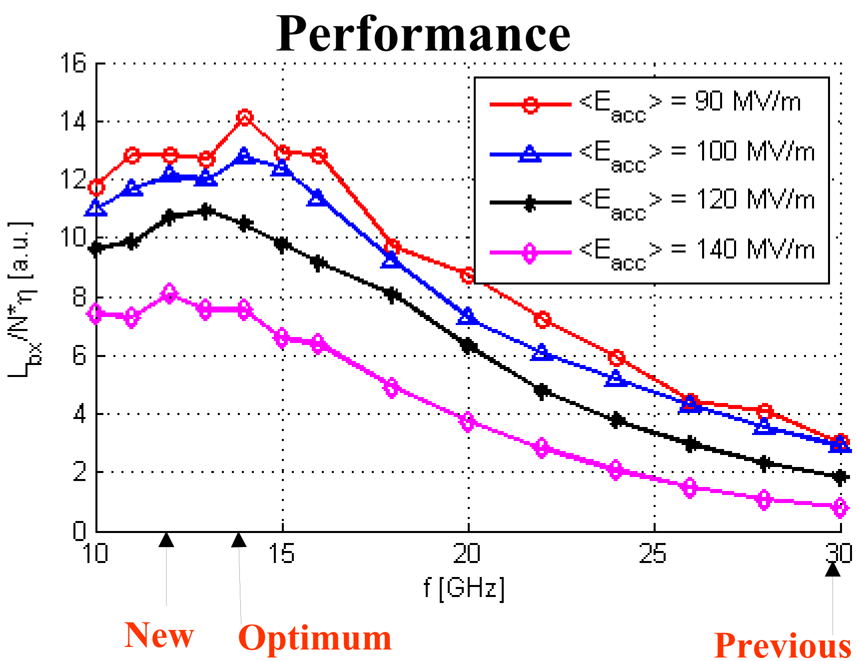


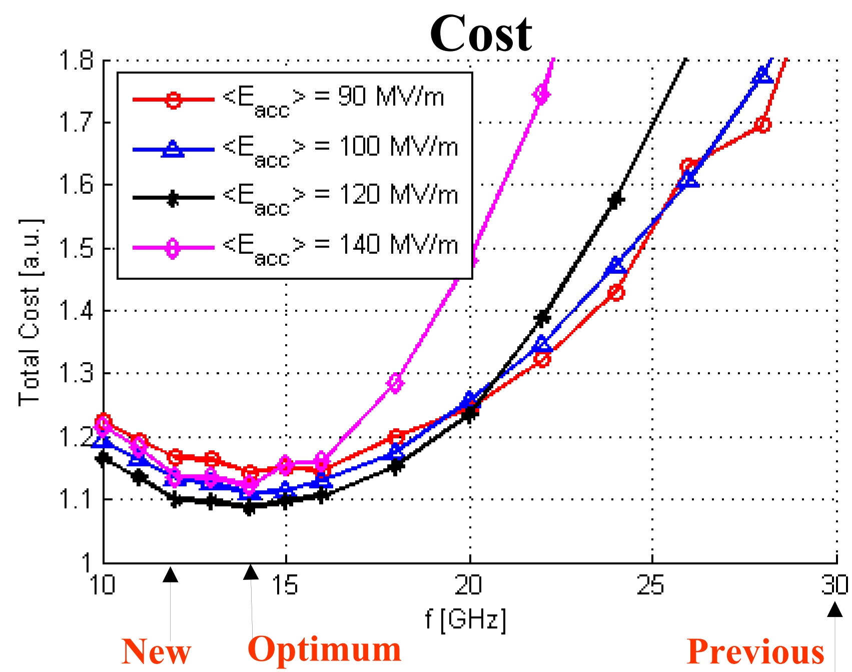


- **Performances increasing with lower accelerating gradient (mainly due to higher efficiency)**
- **Flat cost variation in 100 to 130 MV/m with a minimum around 120 MV/m**

CLIC performances (FoM) and cost optimisation as function of RF frequency

E_{cms} = 3 TeV $\quad L_{(1\%)} = 2.0\ 10^{34}\ cm^{-2}s^{-1}$





- **Maximum Performance around 14 GHz**
- **Flat cost variation in 12 to 16 GHz frequency range with a minimum around 14 GHz**

The beauty of 12 GHz

- Close to maximum Performance and minimum Cost (14 GHz)
- Very close to the NLC and JLC frequency: 11.4 GHz
  - Building up on wide expertise and long-term R&D made during many years on warm structures, RF power sources, beam dynamics at SLAC and KEK
  - Take advantage of low(er than 30 GHz) frequency for easier fabrication (tolerances, vacuum), relaxed requirements (alignment, timing, etc…),
- RF power generation and frequency multiplication in CLIC TBA RF Power Source
  - Possibly drive beam linac at 1.3 GHz (with possible synergy with ILC MBK developments) and multiplication by 8 (2*4) instead 36
  - High gradients achievable with short RF pulse provided by TBA RF power source
  - Easy adaptation of CTF3 (multiplication factor by 8 instead of 10)
- Stand alone power sources available:
  - Makes the best use of developments and equipments at SLAC and KEK

SLAC MEMORANDUM

Date: March 29, 2007

To: Jean-Pierre Delahaye (jean-pierre.delahaye@cern.ch)

CC: Sami Tantawi, Ronald Ruth, Chris Pearson, Chris Adolphsen

From: Persis S. Drell

Re: CERN and CLIC Collaboration

With the recent change of the CLIC linac frequency to 12 GHz, we anticipate a growing collaboration between our two laboratories on high gradient research. Not only do we welcome this, but believe the resulting synergy is necessary for the future developments of accelerators and related technologies.

Our work on high gradient research is done under the auspices of the US High-Gradient Research Collaboration for future colliders. This effort at SLAC is managed by Sami Tantawi, who is also the spokesman for the national collaboration. Under this umbrella we are increasing our capabilities to serve users and collaborators. Collaborators can utilize the SLAC facilities in three ways:

1. Take advantage of the world-class design capabilities and manufacturing facilities to have accelerator structures, rf components, and rf sources (klystrons) designed and built. In particular, our extensive expertise for X-band systems will help ensure a successful design and implementation.
2. SLAC can provide reusable input power couplers and compatible flanges so you need only worry about the design of the accelerator structure "proper."
3. Finally, SLAC can offer high-power rf testing at 11.424 GHz.

For collaborative efforts, including pulsed heating research, manufacturing of accelerator structures, rf components, klystrons, modifying existing 11.424 GHz components to work at 12 GHz, and acquiring reusable couplers, please contact Sami directly. He will organize the work with others including Chris Pearson, the head of the klystron department, which is the prime manufacturing facility for these components.

For the time being, the NLCTA infrastructure is the best place for testing CERN-manufactured accelerator structures at 11.424 GHz. For this, as usual, please contact Chris Adolphsen directly, who will make the appropriate arrangements. On the timescale of summer 2007 we will have dedicated test stands in the Klystron Test Lab capable of 11.424 GHz testing. We anticipate these new test stands will offer faster turn around and

Collaboration with SLAC

Collaboration with KEK

DRAFT Version 7
ICA-JP-???

Agreement on Collaborative Work

between

The European Organization for Nuclear Research
CERN CH-1211 Genève 23
Switzerland
(in the following called "CERN")

and

High Energy Accelerator Research Organization
1-1 Oho, Tsukuba-shi, Ibaraki-ken 305-0801
Japan
(in the following called "KEK")

2007

Appendix 2 to Agreement on Collaborative Work (V3)

Collaboration on
Fabrication and Tests of High-Gradient X-Band Accelerating Structures

1. Personnel of the Collaboration:

KEK: Yukihide Kamiya, Director of Accelerator Laboratory of KEK
Toshiyasu Higo, Accelerator Laboratory of KEK
Shigeki Fukuda, Accelerator Laboratory of KEK
CERN: Jean-Pierre Delahaye, Accelerators and Beams Department
Walter Wuensch, Accelerators and Beams Department

2. Time schedule:

From September, 2007 until December, 2010.

3. Scope of the Collaboration:

3.1 Test of high-field structures:
KEK utilizes the Nextef (X-band test facility) at KEK for this collaboration. CERN staff will visit KEK to help prepare the system to suit the Compact Linear Collider (CLIC) study. KEK expects to conduct a test of at least one CLIC structure in 2007. KEK will pursue the tests in a concerted manner with SLAC and CERN.

3.2 Fabrication of high-field test structures:
Test structures will be made by CERN, SLAC and KEK. The actual division of work will be decided by discussion among these three laboratories. KEK will focus in 2007 on the fabrication of "CLIC_vg1" structures composed of disks.

3.3 Fabrication of CLIC structures:
KEK starts studying the fabrication of a quadrant of a CLIC structure in 2007. If this is successful, KEK will make a high-power-ready CLIC structure in 2008.

3.4 Future studies:
Further possible structure fabrications and tests will be defined by common agreement between CERN and KEK based on the outcomes of the initial tests.

:P.

New CLIC Parameters (December 2006)

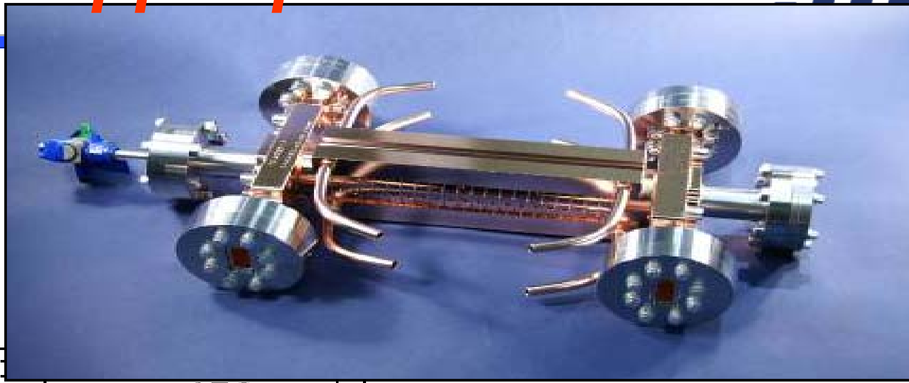
Main Linac RF frequency	**30 GHz ⇒ 12 GHz**
Accelerating field	**150 MV/m ⇒ 100 MV/m**
Overall length @ E_{CMS}= 3 TeV	**33.6 km ⇒ 48.2 km**

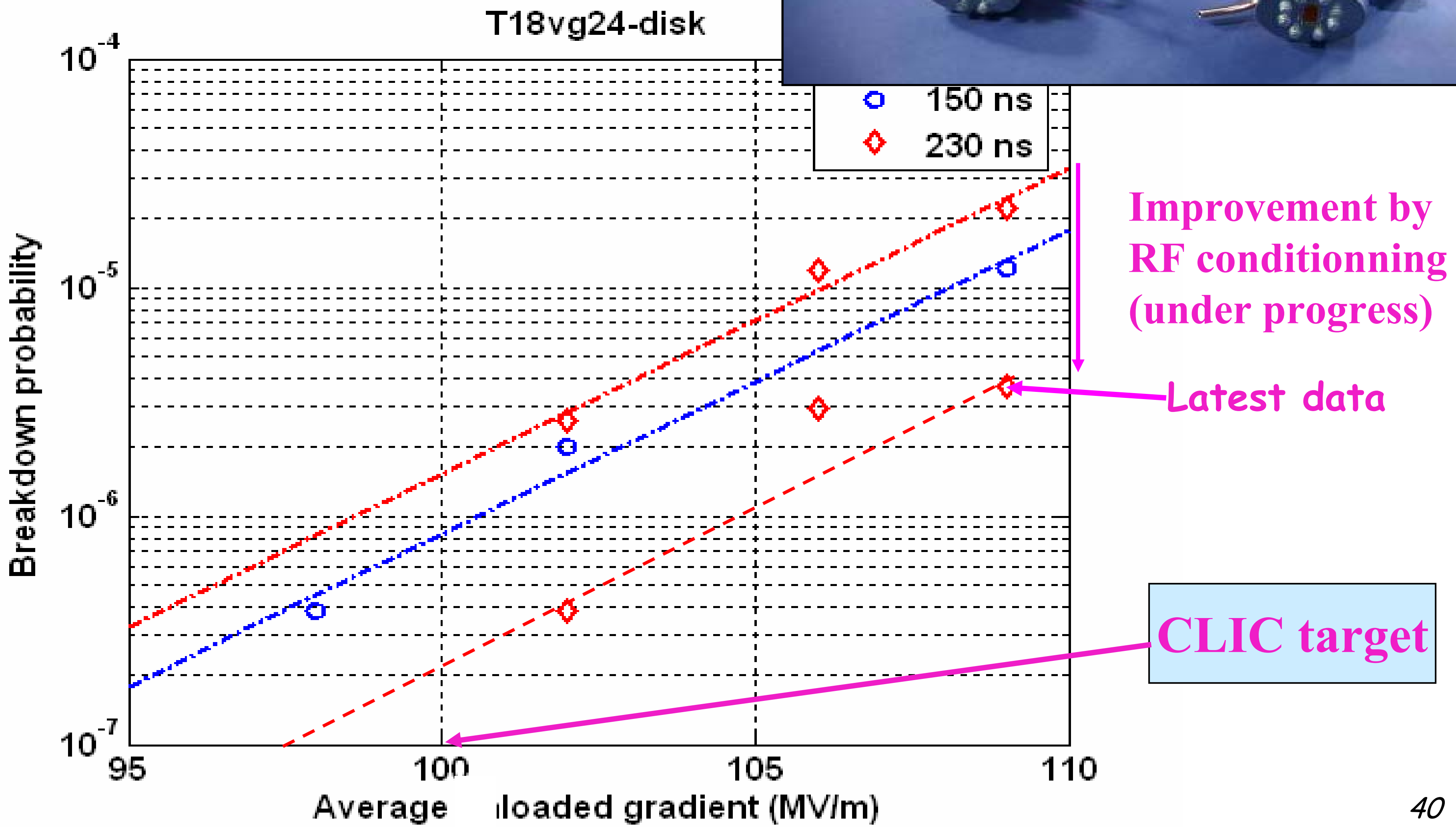
- **Substantial cost savings and performance improvements for 12 GHz / 100 MV/m indicated by parametric model (flat optimum in parameter range)**
- **Promising results already achieved with structures in test conditions close to LC requirements (low breakdown rate) but still to be demonstrated with long RF pulses and fully equipped structures with HOM damping.**
- **Realistic feasibility demonstration by 2010**

A shining example of fruitful collaboration

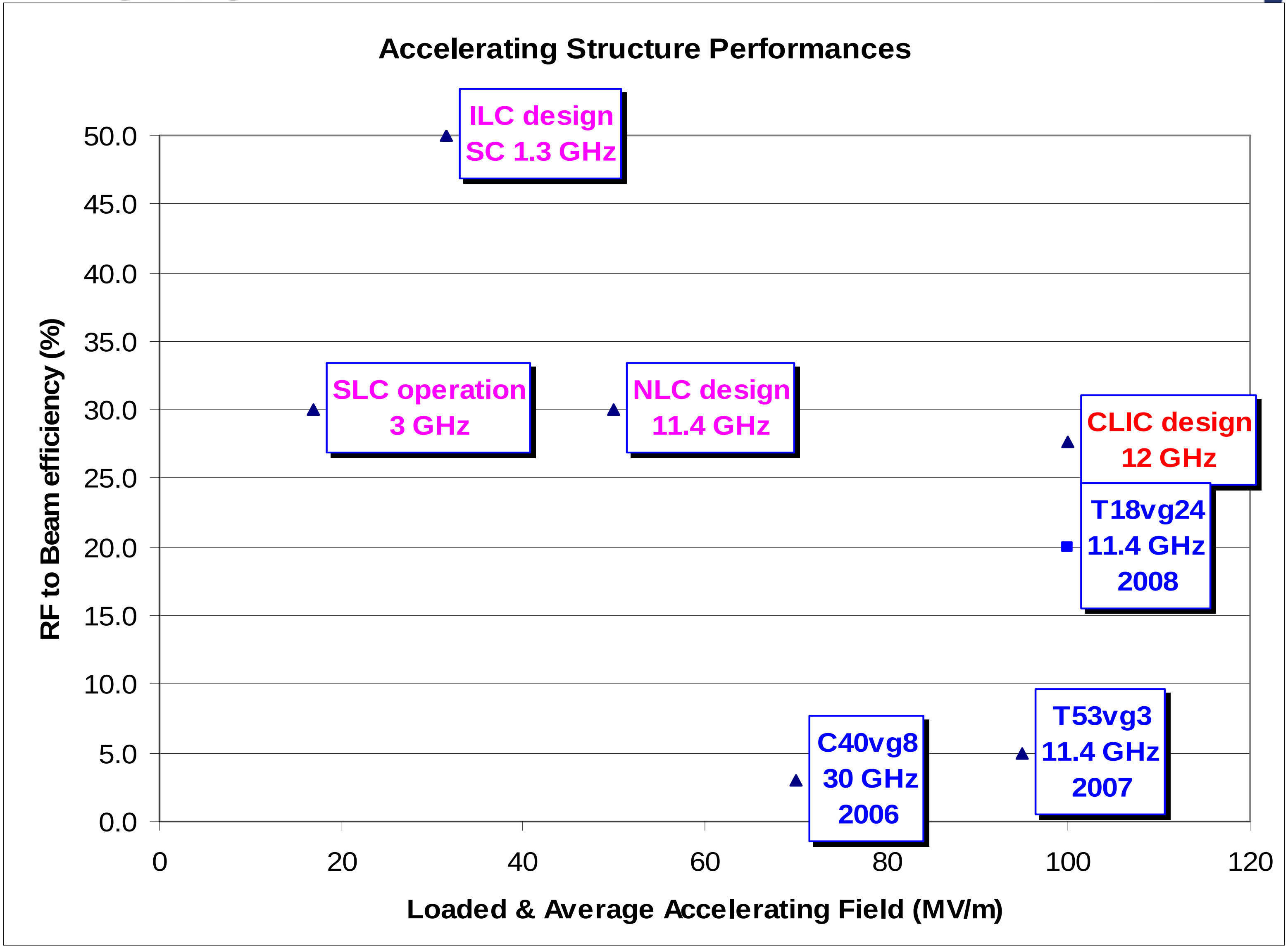
CLIC

T18_VG2.4_disk: Designed at CERN,
Built at KEK,
RF Tested at SLAC





Accelerating Structure Performances



12 GHz Structure Tests Flow Chart

CLIC

2007

TD18_vg2.4_quad

T28_vg2.9

T18_vg2.4_disk

2008

CLICvg1
geometry OK

CLICvg1
geometry not OK

Disks OK

Quads OK
+Damp

TD18_vg2.4_disk

(T18_vg2.4_quad)

TD28_vg2.9

Damping
Not OK

2009

Input from break down R&D

CLIC prototype quads damped

?

CLIC prototype disks damped

CLIC prototype TD28 like

2010

Go towards more extreme structures

Current structure testing program

2008	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
CTF3/CERN 30 GHz		HDS11_vg2	C30_vg2.6 C30_vg8.2	C30_vg2_TM02
NLCTA/SLAC Station 1 11.4 GHz	TD18_vg2.4_quad	C10vg2.9 [2x] C10vg1.5 [2x]	C10vg0.6 [2x]	C10vg2.4_thick [2x]
NLCTA/SLAC Station 2 11.4 GHz	T28_vg2.9	T18_vg2.4_disk	TD18_vg2.4	PETS 11.4 GHz
XTF/KEK 11.4 GHz	C10_vg1.5	T18_vg2.4_disk [2]	TD18_vg2.4_quad [2]	TD18_vg2.4 [2]
CLEX/CTF3 12GHz			PETS 12 GHz	T18_vg2.4_disk

New CLIC main parameters

CLIC

Center-of-mass energy	3 TeV
Peak Luminosity	$7 \cdot 10^{34}$ cm^{-2} s^{-1}
Peak luminosity (in 1% of energy)	$2 \cdot 10^{34}$ cm^{-2} s^{-1}
Repetition rate	50 Hz
Loaded accelerating gradient	100 MV/m
Main linac RF frequency	12 GHz
Overall two-linac length	41.7 km
Bunch charge	$4 \cdot 10^{9}$
Beam pulse length	200 ns
Average current in pulse	1 A
Hor./vert. normalized emittance	660 / 20 nm rad
Hor./vert. IP beam size bef. pinch	53 / ~1 nm
Total site length	48.25 km
Total power consumption	322 MW

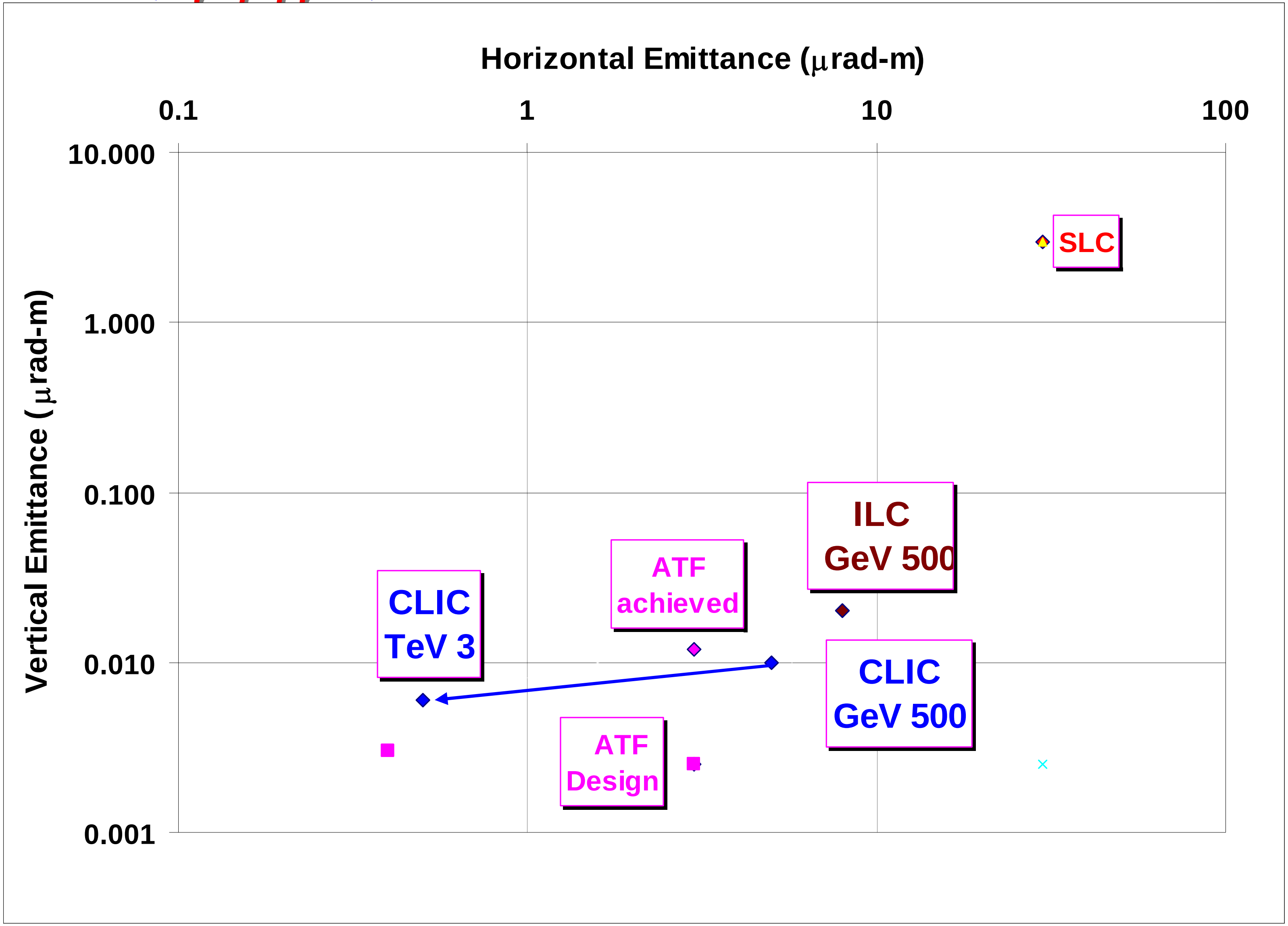
Provisional values

Main CLIC/ILC parameters @ various energies

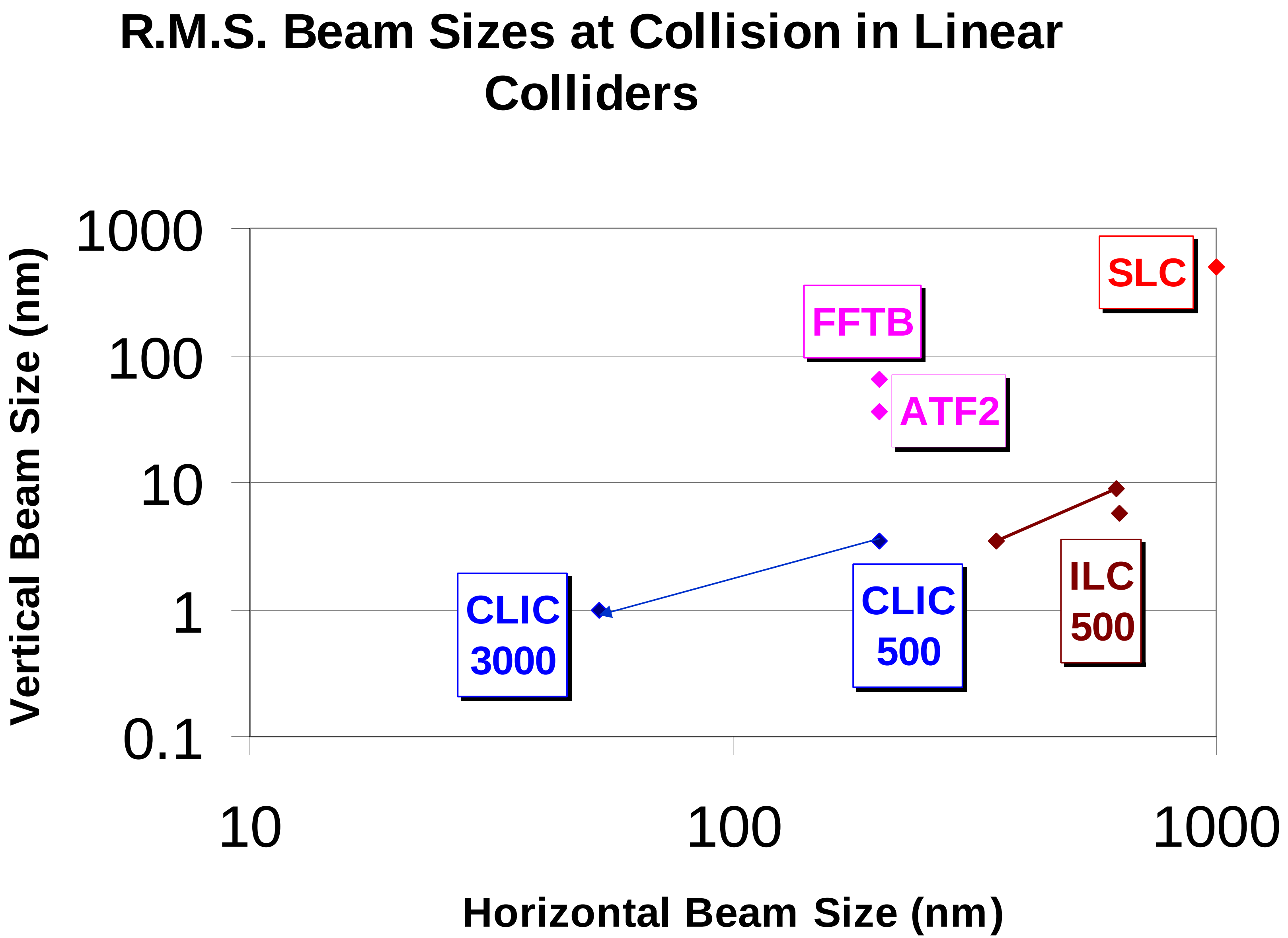
https://clic-meeting.web.cern.ch/clic-meeting/ComparisonTable_RC_12oct07.html

Parameter	Symbol	3 TeV	1 TeV	0.5 TeV	ILC	Unit
Center of mass energy	E_{cm}	3000	1000	500	500	GeV
Main Linac RF Frequency	f_{RF}	12	12	12	1.3	GHz
Luminosity	**L**	**5.9**	**2.25**	**2.24**	**2**	**$10^{34}\ cm^{-2}\ s^{-1}$**
Luminosity (in 1% of energy)	$L_{99\%}$	2	1.08	1.36		$10^{34}\ cm^{-2}\ s^{-1}$
Linac repetition rate	f_{rep}	50	50	100	5	Hz
No. of particles / bunch	N_b	3.72	3.72	3.72	20	10^9
No. of bunches / pulse	k_b	312	312	312	2670	
No. of drive beam sectors / linac	N_{unit}	24	8	4	-	-
Overall two linac length	l_{linac}	42	14	7	22	km
Proposed site length	**l_{tot}**	48	19.5	12	**31**	**km**
DB Pulse length (total train)	τ_t	139	46	23	-	µs
Beam power / beam	P_b	14	4.6	4.6	10.8	MW
Wall-plug power to beam efficiency	η_{wp-rf}	8.7	6.1	6.1	9.4	%
Total site AC power	**P_{tot}**	**322**	**~150**	**~150**	**230**	**MW**
Transverse horizontal emittance	$\gamma\varepsilon_x$	660	660	660	8000	nm rad
Transverse vertical emittance	$\gamma\varepsilon_y$	20	20	20	40	nm rad
Horizontal beam size at IP before pinch	β^*_x	40		142	640	mm
Vertical beam size at IP before pinch	β^*_y	1		2	5.7	mm

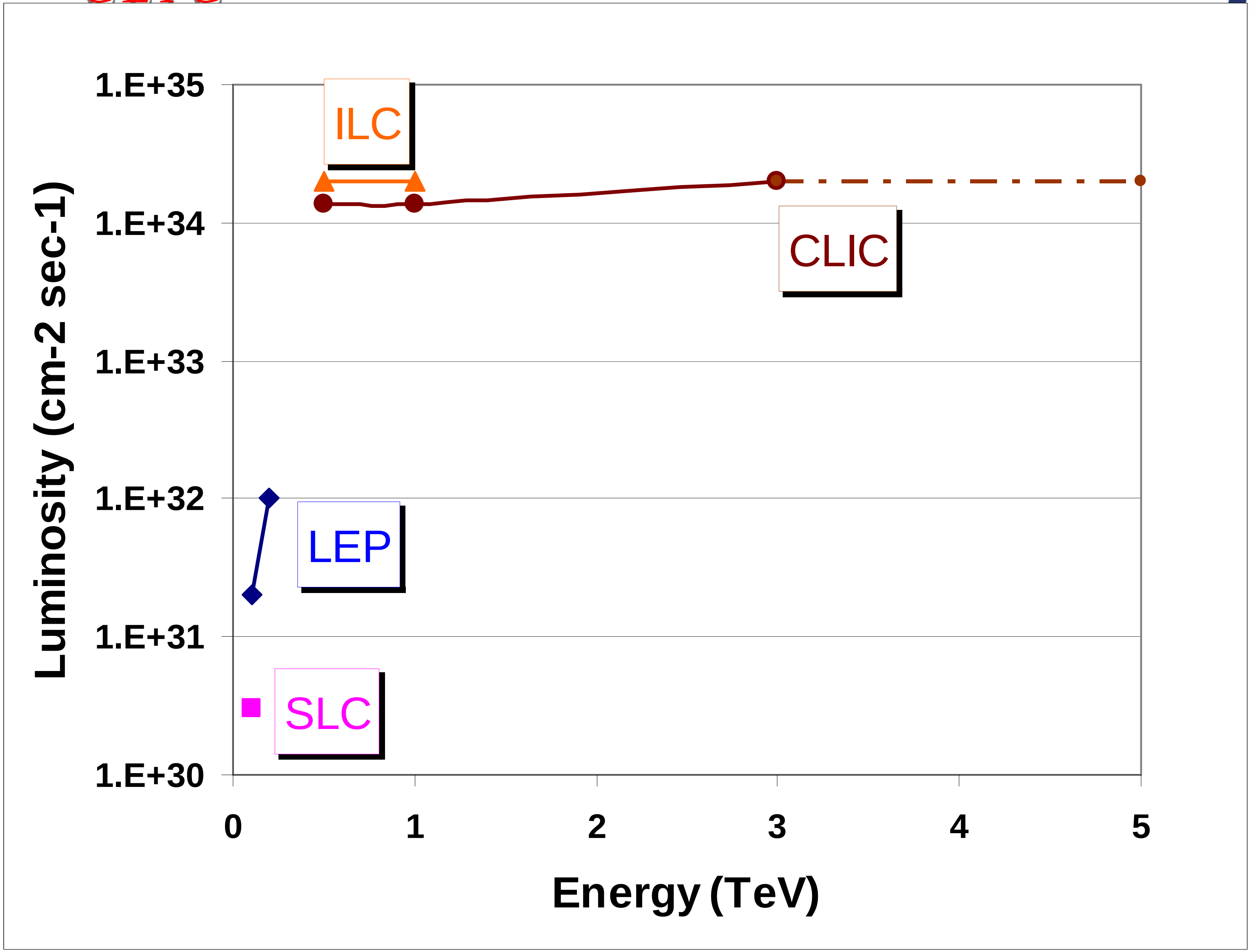
Beam emittances at Damping Rings



Beam sizes at Collisions



Performances of Lepton Colliders



CLIC Work program till 2010

- Work programme and resources (2007-2015)
  http://clic-meeting.web.cern.ch/clic-meeting/2007/CLIC_ACE/201006_CLIC_LTP_2006_15.pdf

- Demonstrate feasibility of CLIC technology in CTF3
- Design of a linear Collider based on CLIC technology
  http://clic-study.web.cern.ch/CLIC-Study/Design.htm
- Estimation of its cost in the CERN area and comparison with ILC
- CLIC Physics study and detector development:
  http://clic-meeting.web.cern.ch/clic-meeting/CLIC_Phy_Study_Website/default.html
- Preparation of a Conceptual Design Report to be published in 2010

CERN, 16-18 October 2007

CLIC'07 provides a forum to review all aspects related to the Accelerator, Detector and Particle Physics of a Multi-TeV Linear Collider based on the CLIC technology.

It is open to any interested Accelerator and Physics expert already part or not of the CLIC/CTF3 collaboration.

The workshop will address in particular:

- Present status and future plans of the CLIC study
- CLIC physics case and detector issues
- The Test Facility CTF3 used to address major CLIC technology issues
- The ongoing CLIC R&D, future plans (including FP7 proposals) and open issues
- The CLIC related collaborative efforts

Program Advisory Committee

- M. Besançon
- G. Blair
- M. Calvetti
- S. Chattopadhyay
- T. Ekelof
- A. Faus-Golfe
- L. Garcia
- T. Higo
- H. Hoorani
- Y. Karyotakis
- E. Levitchev
- K. Osterberg
- M. Poelker
- L. Rivkin
- V.C. Sahni
- G.D. Shirkov
- S. Tantawi
- M. Velasco
- G. Wormser

Local Organising Committee

- H.H. Braun (Chair)
- R. Corsini
- J-P. Delahaye
- J. Ellis
- S. Escaffre
- G. Geschonke
- A. de Roeck
- W.D. Schlatter
- D. Schulte
- W. Wuensch

CLIC Workshop 07

http://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=17870

The CLIC workshop will be held at CERN in the Main Auditorium, Main building, 1st Floor

CLIC 07 participation

200 (registered) from 49 Inst. of 19 countries

- China: Tsinghua University
- Finland: Helsinski Univ.- HIP
- France: CNRS/IN2P3/LAL-LAPP LPNHE-LPSC, THALES, CEA DAPNIA
- Germany: DESY-ANKA/FZK
- Greece: Athens NTU-IASA-PATRAS
- India: BARC-RRCAT
- Iran: IPM
- Italy: INFN/LNF-Napoly Fed.II
- Japan: KEK
- Norway: NTNU
- Pakistan: NCP
- Russia: IAP—BINP-JINR
- Spain: CIEMAT-IFIC-UPC
- Sweden: Uppsala Univ.
- Switzerland: CERN-ETHZ-IPP-PSI
- Turkey: Ankara U-Dumlupinar U TOBB Univ Eco&Tech
- UK: COCKROFT-J.ADAMS-Lancaster Univ-Oxford-RHUL
- Ukraine: IAP-NAS
- USA: LBNL-Northwestern U.-TJNAF-OHMEGA-Oklahoma Univ-SLAC

CLIC-ILC Collaboration

- Following visit of Barry @ CERN (Nov 07)

  http://www.linearcollider.org/newsline/archive/2007/20071213.html

  Independently of US/UK financial crisis,
  but even more desirable now

- CLIC-ILC Collaboration meeting #1 (Feb 08)

  http://indico.cern.ch/conferenceDisplay.py?confId=27435

- GDE/ACFA Meeting at Sendai/Japan (March 08)

  http://www.awa.tohoku.ac.jp/TILC08/

- CLIC-ILC Collaboration meeting #2 (May 08)

  http://indico.cern.ch/conferenceDisplay.py?confId=32263

CLIC-ILC Collaboration
why collaborate?
(B.Barish on May 13, 2008 @ CERN)

- The LHC is going to open a new energy frontier and we all anticipate the discoveries

- A complementary lepton collider will almost certainly be strongly motivated by those discoveries.
  - Different approaches: ILC, CLIC; Muon Collider
  - Issues include technological hurdles; parameters (e.g. energy); cost; site; timescales

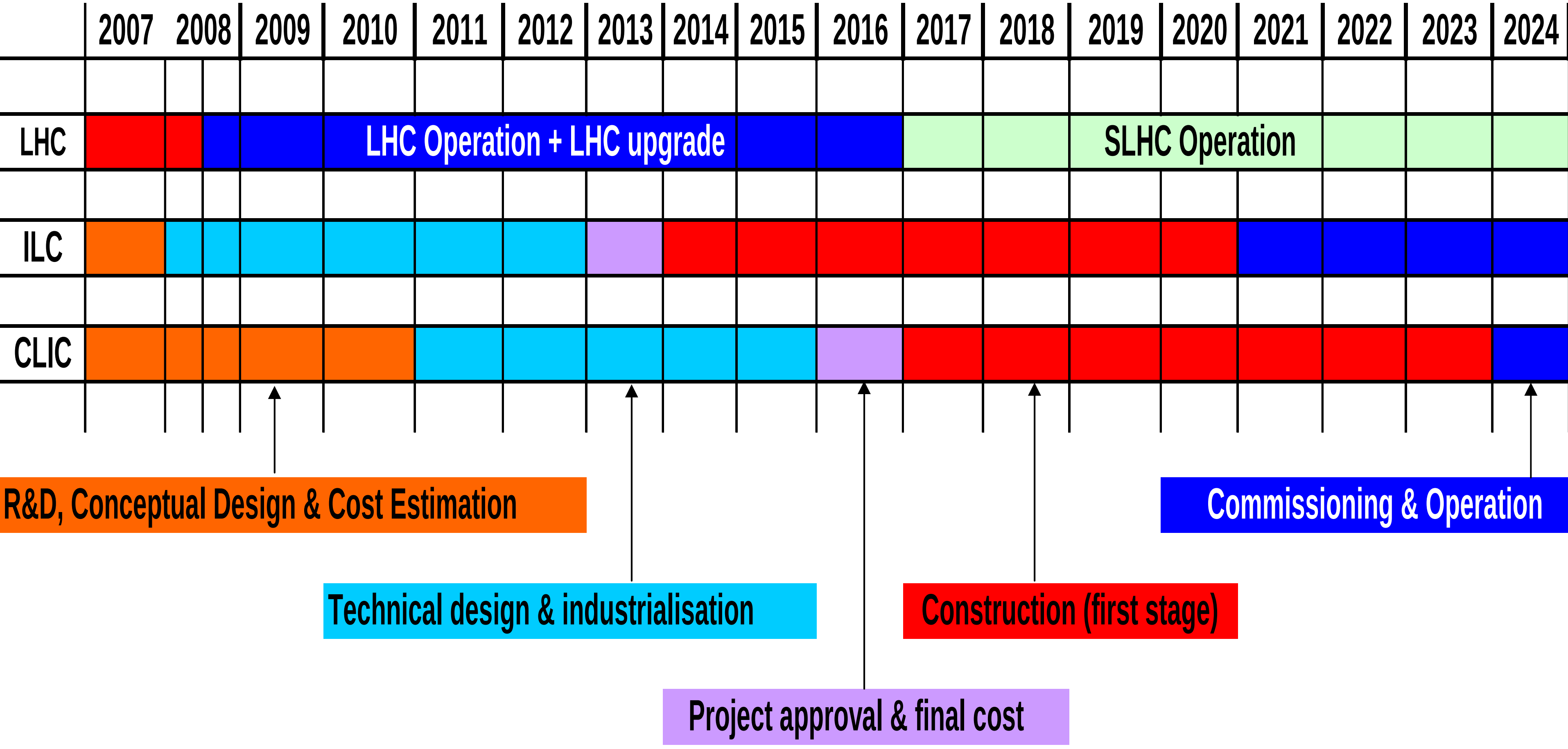
- The choice should be determined by the science!

- Common goal! We need to optimize the developments, so a lepton collider can become a reality.

(My) motivations for CLIC/ILC collaboration

- **Lack of resources: (both CLIC and ILC)**
  - Join resources where useful and avoid duplication
- **Foster ideas and favor exchanges**
  - Beneficial to both
- **Aiming (as much as possible) on common system designs**
  - similar energy; Ex: BDS, MDI, Detector, Cost….
  - Identify necessary differences due to technology and/or energy
- **Avoid negative image of conflicting teams**
  - Devastating for HEP
- **Minimize contradicting presentations in 2010-12 (?):**
  - Develop common knowledge of both designs and technologies on status, advantages, issues and prospects for the best use of future HEP
  - Common preparation of the (unavoidable) evaluation of technology
  - Avoid (another) evaluation by external (wise?) body. Better done by this community with technical expertise
- **Even if ILC technology more mature, timescale not so ≠ :**
  - Technical Design in 2010-2012 for ILC and 2014 for CLIC

LHC, ILC & CLIC Schedules



DG to CERN staff
Jan 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).

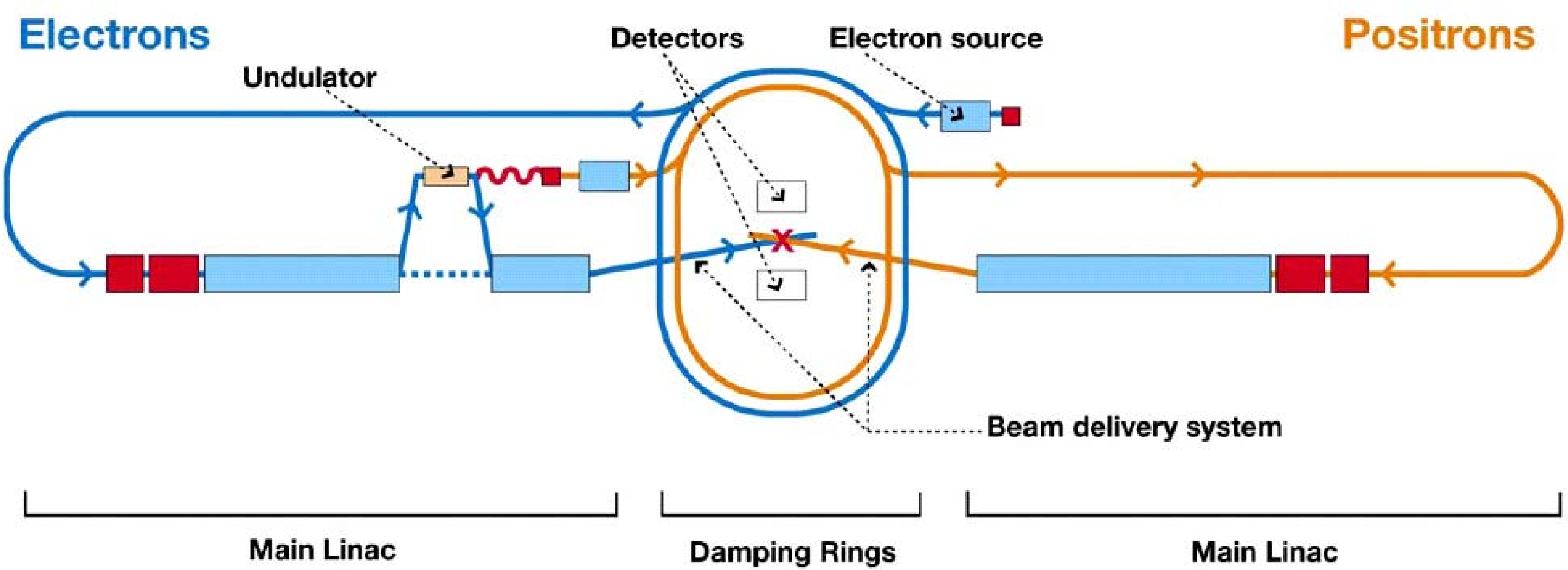
  The total cost of the investment over 6 years (2011-2016: 1000-1200 MCHF + a staff of 200-300 per year. Total budget: ~200-250 MCHF per year.

- 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.

ILC Layout


Electrons
Undulator
Detectors
Electron source
Positrons
Beam delivery system
Main Linac
Damping Rings
Main Linac

CLIC ILC working groups

- **Co-conveners of the CLIC-ILC working groups**
  - Civil Engineering and Conventional Facilities (CFS):
    Claude Hauviller/CERN, John Osborne/CERN, Vic Kuchler (FNAL)
  - Beam Delivery Systems and Machine Detector Interface:
    D.Schulte/CERN, Brett Parker (BNL), Andrei Seryi (SLAC), Emmanuel Tsesmelis/CERN
  - Detectors:
    L.Linssen/CERN, Francois Richard/LAL, Dieter.Schlatter/CERN, Sakue Yamada/KEK
  - Cost & Schedule:
    H.Braun/CERN, John Carwardine (ANL), Katy Foraz/CERN, Peter Garbincius (FNAL), Tetsuo Shidara (KEK), Sylvain Weisz/CERN
  - Beam Dynamics:
    A.Latina/FNAL), Kiyoshi Kubo (KEK), D.Schulte/CERN, Nick Walker (DESY)
- **Mandates & Plans of actions:**

http://indico.cern.ch/conferenceDisplay.py?confId=32263

Other subjects

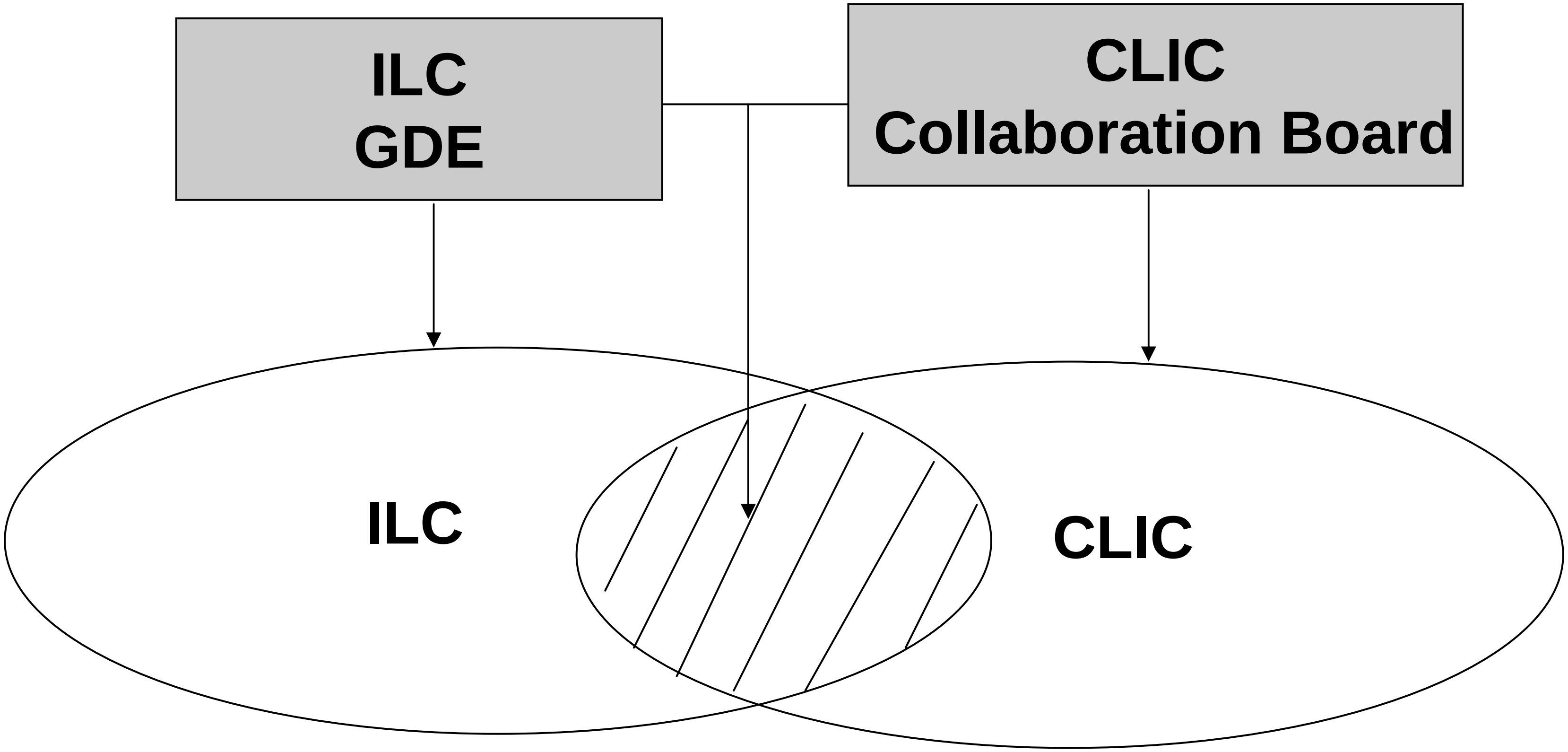
- **Possible future CLIC/ILC working groups:**
  - Polarised Positron generation (Posipol) :
    - Undulator based
    - Compton Scattering
  - Damping Rings
    - Electron clouds
    - IBS
  - Beam Instrumentation

- **Later?**
  - Klystrons (L band) & Modulators with long pulses and high efficiency
  - High power beam dumps
  - Operational & reliability issues
  - Machine Protection System
  - Others?

Method?

- Presently (for each sub-system):
  - ILC team working on ILC system with ILC beam at 500 GeV
  - CLIC team working on CLIC system with CLIC beam at 3 TeV and scaling down to 1 TeV and 500 GeV
  - Fruitful exchanges between technical experts
  - Different designs of sub-systems for (not always) good reasons
- Possible future
  - CLIC & ILC teams working together on CLIC and ILC systems at 500 GeV
  - Identify together if same design/technology can be used or not
  - understand why and what necessary differences
  - Define together necessary modifications of the sub-system for the upgrade in energy to 1 TeV for ILC and 3 TeV for CLIC

Management?



Next Steps

- No additional organisation
- No additional meetings
- Participation of CLIC members to ILC meetings
- Participation to ILC members to CLIC meetings
- Working groups reporting on progress at already scheduled meetings:
  - GDE meeting - ILC conventional facilities and siting workshop: Dubna, June 4-6, 2008
  - ECFA workshop (Physics & Detectors): Warsaw, June 6-9, 2008
  - CLIC08 workshop: CERN, Oct 14-17, 2008
  - LCWS workshop(Accelerators, Physics & Detectors): Chicago, Nov 16-20, 2008

Plea for (enlarged) UK participation

- **Existing contribution to CLIC:**
  - Collaboration with J.Adams Institute (member of CLIC collaboration)
  - Could be enlarged
- **Being defined:**
  - Collaboration with Cockroft Institute (MoU under preparation)
- **Proposal under evaluation by European Commissioning in FP7 framework program:**
  - Building-up on successful IA "CARE" in FP6 (ending end 2008)
  - Integrated Activity "European Coordinated Accelerator R&D (EUCARD)" starting early 2009 for 4 years

JAI contribution to CLIC
(Addendum to CLIC/CTF3 Collaboration MoU)

THE JOHN ADAMS INSTITUTE AT ROYAL HOLLOWAY, UNIVERSITY OF LONDON (JAI@RHUL) REPRESENTED BY GRAHAME BLAIR, in its capacity as Member of the CTF3 Collaboration, **HEREWITH AGREES** to make the following contributions:

Already provided until/inclusive 30th April 2007

- Simulation studies, including the CLIC beam delivery system.
- Plans for collaboration in the EU-FP7 scheme.

The JAI@RHUL shall assume responsibility for the provision of the following contributions for the period 2007-2010 to CTF3:

- Collaboration in the area of radiative processes from electron beams such as transition, diffraction and synchrotron radiation consisting of a PhD student, 0.5 FTE of a post doc, fractional effort from Academic Staff at the John Adams Institute at RHUL, plus hardware contributions.
- Contributions to the design and proposal to the EU of an instrumentation test beam at the CTF3/CLEX facility.
- The total financial equivalent of these contributions will be approximately 640 kCHF.

This Addendum shall form an integral part of the MoU.

Done in Geneva on 21st June 2007

For John Adams Institute at RHUL

G. A. Blair

Prof. Grahame Blair
Deputy Director of JAI

Dr. Hitesh Patel
Deputy Head (Research)
Research & Enterprise Office
Royal Holloway and Bedford New College

Envisaged Cockroft contribution to CLIC (Visit of S.Chattopadhyay on August 2007)

This letter is to assure you that the Cockcroft Institute remains committed to a growing collaboration with CERN on the CLIC program and in particular its CTF3 project, where topics below remain our foci:

- Multi-beam Klystrons (Richard Carter),
- Coherent Synchrotron Radiation from very short bunches of relativistic electrons (Robin Tucker)
- RF Crab Cavities (Amos Dexter)
- RF Cavity Design and Higher Order Mode Damping (R.Jones)

We are working hard to secure funding from multiple sources to promote activities in these areas along. Though we are proud and thankful of our 'observer status', as soon as we convince ourselves of delivering some real work on these via some symbolic funding from UK research councils, no matter how small, we will join the Collaboration proper as a full-fledged member.

FP7 IA EUCARD

CLIC

Integrated Activity (IA) on European Coordination of Accelerator R&D (EUCARD): J.P.Koutchouk/CERN: https://eucard.web.cern.ch/EuCARD/

- Joint Research Activity (JRA):
  - Normal Conducting Linac: CLIC-ILC common subjects: E.Jensen/CERN
    - 8.7: Nb3Sn short SC helical undulator (J. Clarke),
    - 10.4: BDS (Angal-Kalinin)
    - 10.6: DR Vacuum (Malyshev)
    - 11.5: Crab cavities (A.Dexter)
    - 10.2: NC High Gradient (R. Jones)
    - 10.4: BDS (Appleby)
    - 11.5: Crab cavities (McIntosh)
    - 11.7: HOM distribution (R. Jones)
- Submitted on May 1rst
- Recently evaluated: high score: 14.5/15
- Negotiation phase till end of 2008
- Starting early 2009 for 4 years

Proposal for ITB
Instrumentation Test Beamline at CTF3

Interested partners an contact persons

- Royal Holloway University of London, Grahame Blair
- LAPP Annecy, Yannis Karyotakis
- North Western University Chicago, Mayda Velasco
- University of Heidelberg, Carsten Welsch
- FZK and University of Karlsruhe, Anke-Susanne Mueller,
- University of Dortmund, Thomas Weis
- CERN, Hans Braun

Description

CTF3 is an accelerator test facility build at CERN by an international collaboration to develop CLIC linear collider technology.
The construction of the CLEX area (=CLIC EXperimental area) at CTF3 has revealed an excellent opportunity to build a flexible Instrumentation Test Beam (ITB), allowing the development and testing of a vast range of advanced beam instrumentation in a dedicated beamline. This R&D is in high demand for both CLIC and ILC instrumentation issues but also beneficial for many other accelerator applications.
The ITB is using the 180 MeV, low emittance beam from the CALIFES linac of CTF3.

The baseline concept of ITB comprises

- A bunch compressor to achieve bunch length as short as required by CLIC and ILC
- Focusing magnets to adjust beam size at test location
- Standard instrumentation to have best possible beam characterisation at the test location
- Dedicated vacuum sector to allow easy and rapid installation and pump down of experiments
- Magnet spectrometer to measure energy loss for specific experiments
- A gas target to generate beam halo in a controlled manner

A first set of experiments in ITB will address

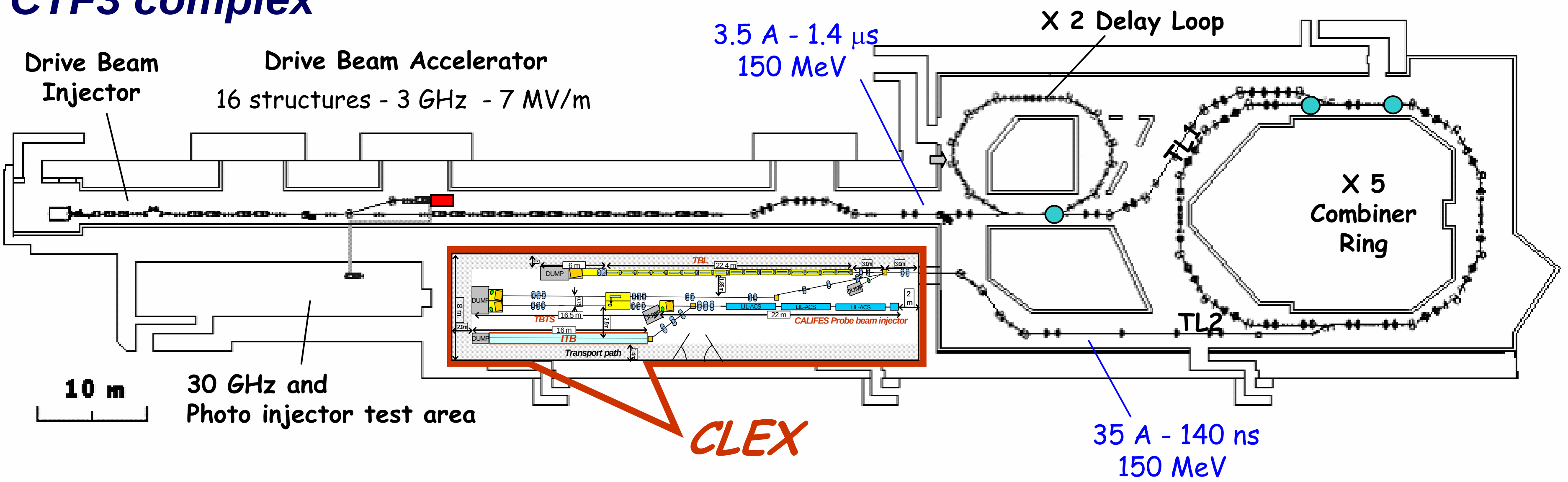
- Novel bunch length diagnostics with coherent diffraction radiation
- Novel beam halo monitoring devices
- Novel beam loss monitoring devices
- Novel methods of single shot emittance measurement with OTR
- Characterization of precision beam position monitors
- Many other ideas for experiments are evolving

Cost & schedule

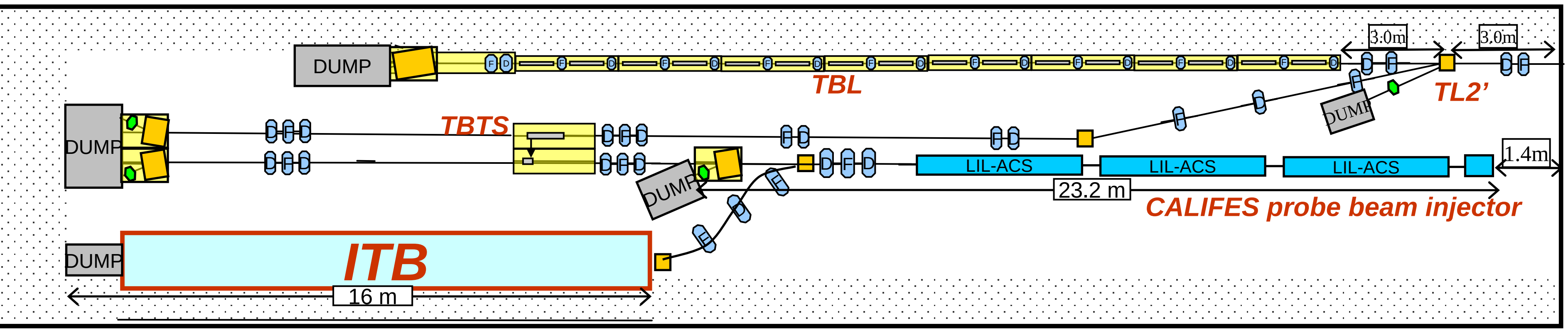
Technical infrastructure, floor space and a part of the magnets will be provided by CERN.
The missing investment costs for the baseline ITB facility is estimated at 500 k€.
Design and construction of ITB from *t0* to first experiments will take about 2 years.

ITB doesn’t start from scratch but is an add-on to existing accelerator infrastructure of CTF3 !

CTF3 complex



Layout of CLEX floor space



Conclusion

- Plea for participation of UK laboratories to future accelerator R&D:
  - CLIC R&D as active members of the CLIC/CTF3 collaboration
  - Generic Linear Collider R&D subjects
- Welcome to participate to CLIC/ILC collaboration on subjects with strong synergies between the two studies as recently launched:
  - Electron and positron sources (Compton scattering)
  - Damping ring issues (IBS)
  - Beam Delivery Systems (BDS)
  - Beam instrumentation:
    - BPM, Fast feedback, Laser wire
    - ATF2 developments towards nm beam sizes
    - CTF3 generic Instrumentation Test Line (ITB)
  - RF designs
    - Crab cavities, RF structures
  - Etc