Technology Path to CLIC: CLIC status and perspectives in 2009 and beyond

CLIC in the world-wide HEP landscape

Work program 2009-10

Perspectives from 2011

Schedule

Organisation

Conclusion

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

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 of 400 GeV/c upgradeable to at least 1 TeV**
- **2003: ILC-Technical Review Committee to assess the technical status of the 15 years of R&D on various technologies and designs of Linear Colliders**
- **2004: International Technology Recommendation Panel selected the Super-Conducting RF technology developed by the TESLA Collaboration for an International Linear Collider (ILC) in the TeV energy range**
- **2004: CERN council strong 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.*

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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)

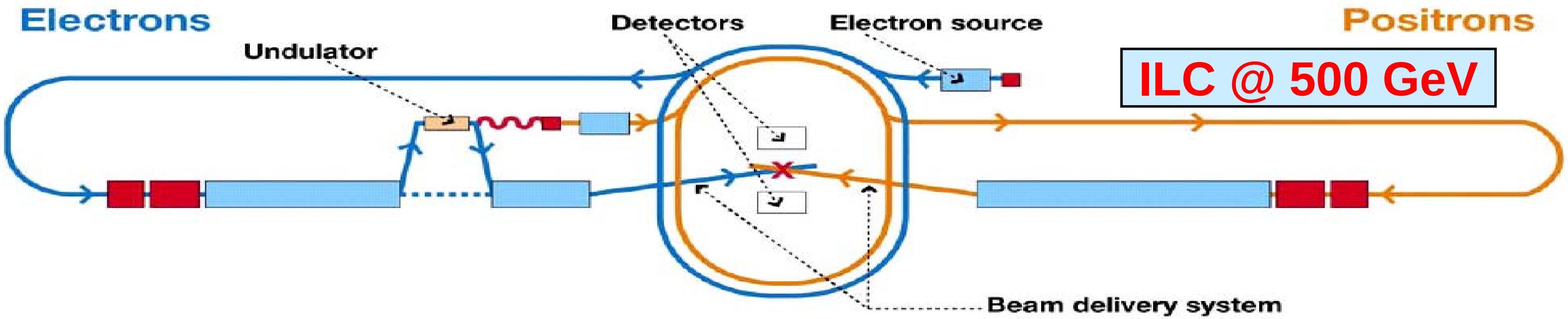
University of Oslo (Norway)
PSI (Switzerland),
Polytech. University of Catalonia (Spain)
RRCAT-Indore (India)
Royal Holloway, Univ. London, (UK)
SLAC (USA)
Uppsala University (Sweden)

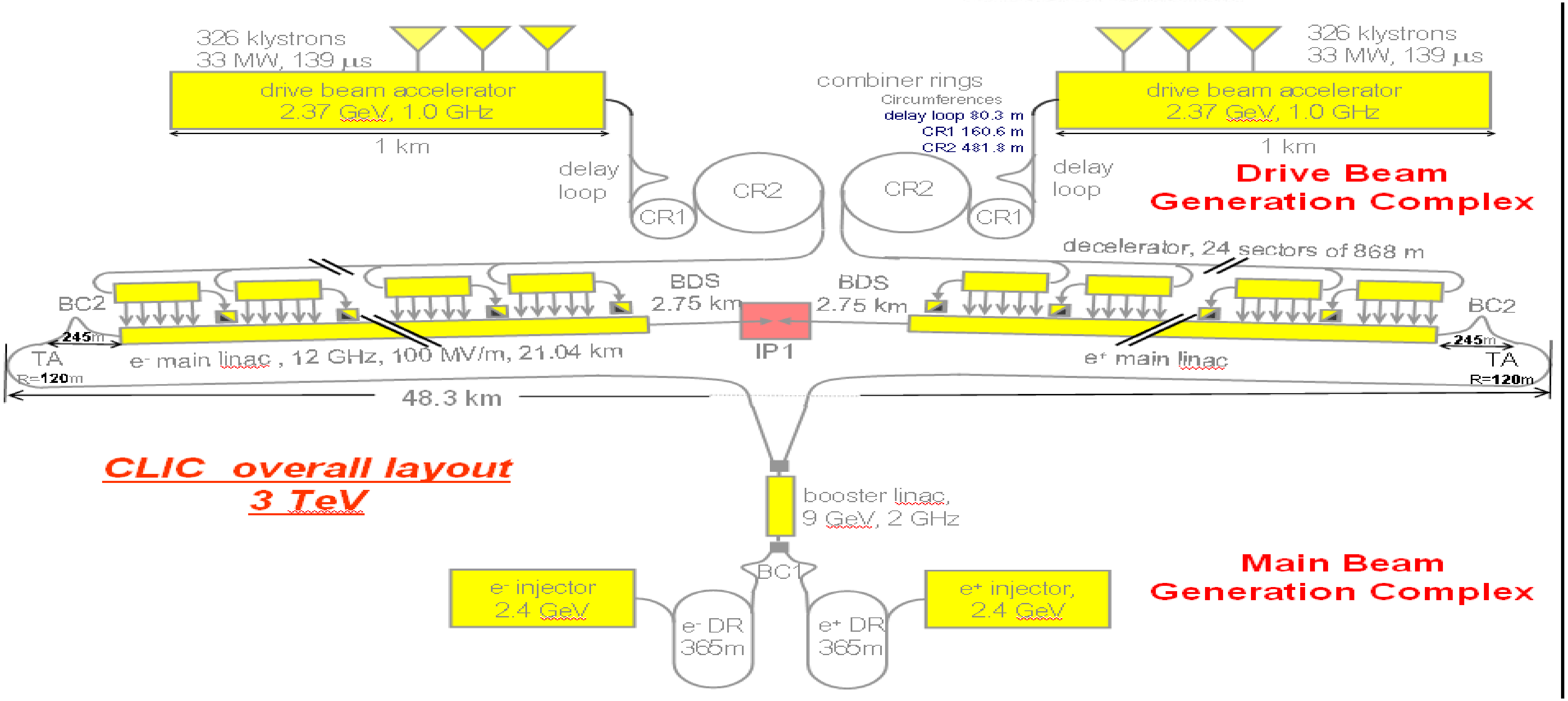
A necessary and beneficial CLIC /ILC Collaboration

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





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

Nature Editorial

- (November 27, 2008)

Friendly rivalry

The spirit of collaboration in the race to define the LHC's successor sets an example for large projects.

The future for high-energy physics is decidedly mixed. On the one hand, physicists are eagerly awaiting the insights into the Universe promised by the Large Hadron Collider (LHC) at CERN, the European particle-physics laboratory near Geneva. But as governments shift their priorities to societal problems, such as climate change, energy, health and the environment, the field as a whole must also face up to the fact that it will be increasingly difficult to secure funds for pure science.

"Given this financial uncertainty, it is important that the high-energy physics community does all it can to reduce any internal divisions and to strengthen its external coherence. That is why a new collaboration over what should come after the LHC is to be greeted with enthusiasm."

"The potential for destructive rivalry was real. Yet late last month, leaders of the two efforts formally agreed to collaborate as much as is practicable."

"The two rivals are closer than they have ever been, and yet research and development on the two underlying accelerator technologies will continue apace with a healthy spirit of competition. "

"The result is that the ILC and CLIC are setting an example that other large scientific endeavours would do well to emulate."

CLIC08 Workshop

CERN, 14-17 October 2008

CLIC09 workshop: 13-16/10/09

- Home
- Venue Details
- Accommodation
- Registration
- General Information
- Draft Program
- Working Groups
- Information for Speakers
- Program Advisory Committee
- Local Organising Committee

CLIC'08 is an Accelerator and Physics Workshop which follows the very successful 1st Workshop of this kind held at CERN in Oct 2007.

The Aims of CLIC08 are:

- Review the R&D towards CLIC Feasibility Demonstration and Conceptual Design Report in 2010. This includes Items of ILC-CLIC Common Interest as defined in the recently established ILC-CLIC Collaboration.
- Identify the R&D, Facilities and Engineering Efforts needed in the period after 2010 to progress from a Conceptual Design to a Technical Design.
- Address Particle Physics and Detector Issues of a Multi-TeV Linear Collider.

Pro memoria: CLIC07 Workshop

CLIC Study Homepage

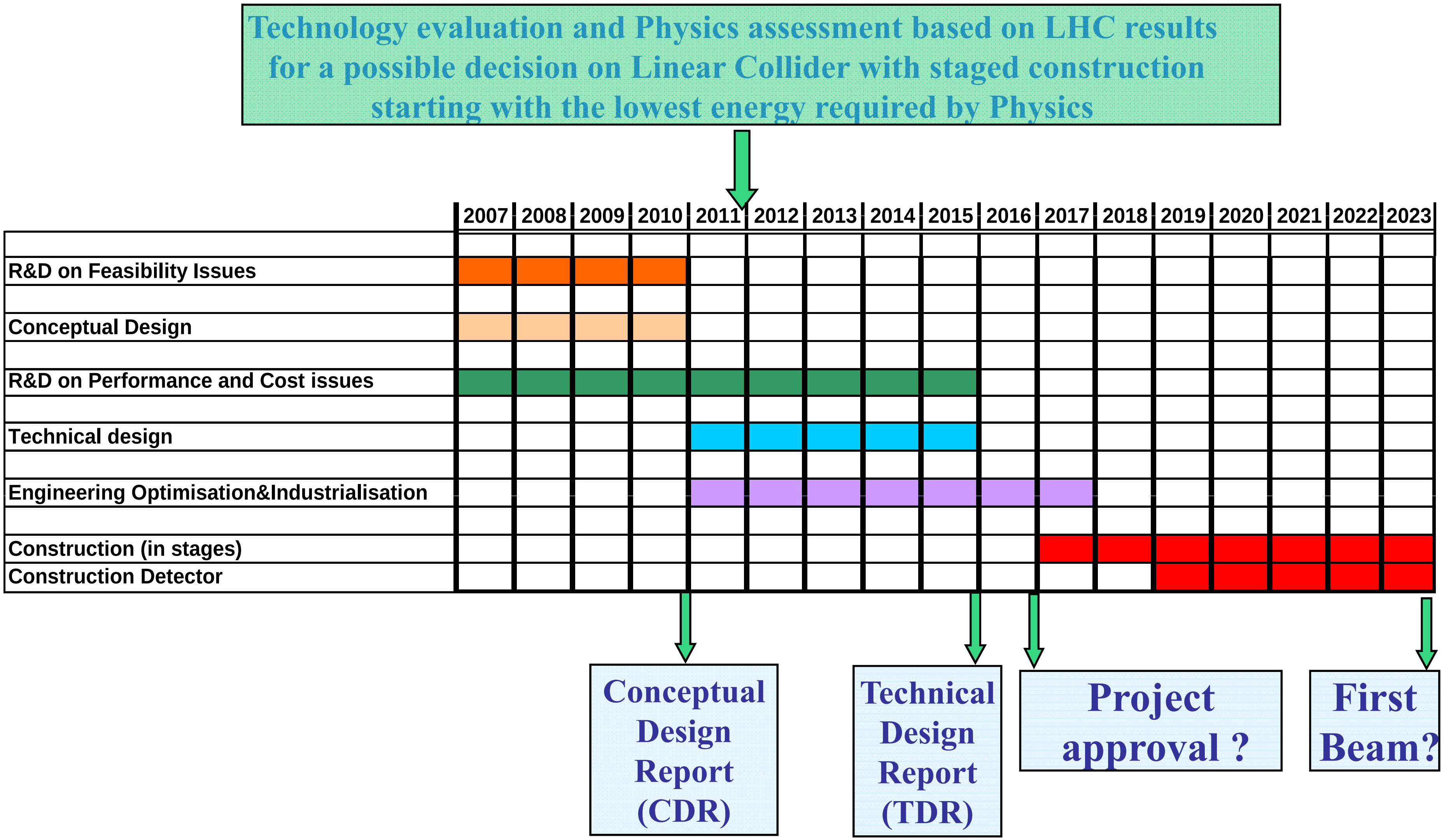
Welcome to CLIC Workshop08

Participants: 215 (registered) from 57 Inst. of 18 countries

- **China: Tsinghua University**
- **Finland: Helsinki Univ, HIP**
- **France: CEA Saclay, LAL, IPNL-IN2P3, IRFU-SPP, LAPP, LPHNE**
- **Germany: Bonn Univ., DESY, Forschungszentrum Karlsruhe, Greifswald Univ., MaxPlanck Inst.**
- **Greece: Nat Tech Univ., NTU Athens**
- **India: BARC-RRCAT, Ravishankar Shukla Univ**
- **Italy: LNF-INFN**
- **Japan: KEK**
- **Norway: Univ of Oslo**
- **Pakistan: NCP, Air Univ.**
- **Poland: Inst of Nucl Phys**
- ***Russia: BINP, JINR, SINP-MSU***
- ***Spain: CIEMAT, IFIC, Catalonia Univ., UPC Univ***
- ***Sweden: MAX-Lab, Uppsala Univ.***
- ***Switzerland: EPFL, ETH, PSI***
- ***Turkey: Ankara Univ., TAEA***
- ***United-Kingdom: ASTeC, Birmingham Univ., Cockcroft Inst., Euclid TechLab, Manchester Univ., RHUL, JAI, Oxford Univ., RAL, Lancaster Univ., STFC***
- ***United-States: ANL, Colorado Univ., Cornell Univ., LBNL, FERMILAB, SLAC, NASA Inspires***

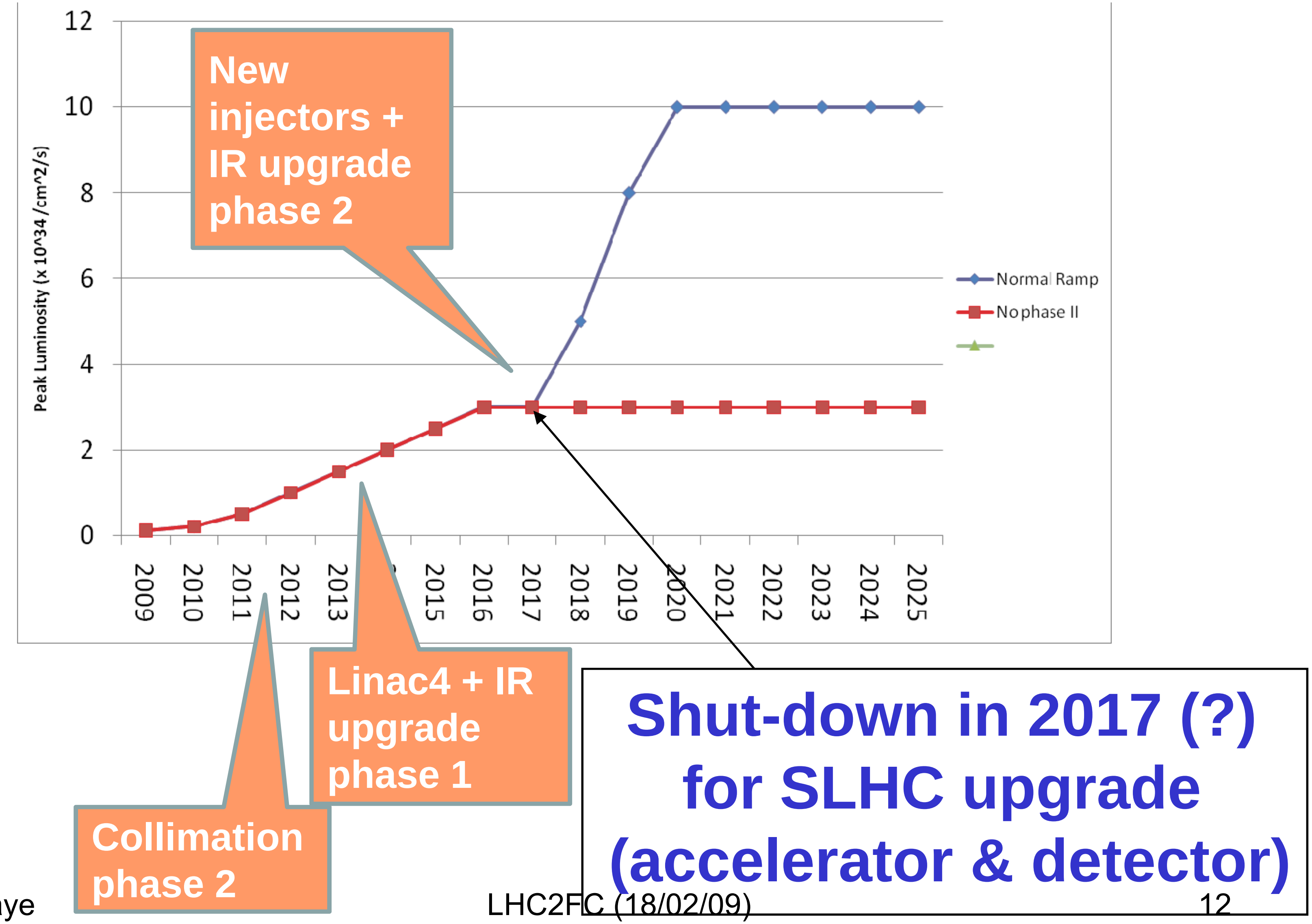
Tentative long-term CLIC scenario

Shortest, Success Oriented, Technically Limited Schedule

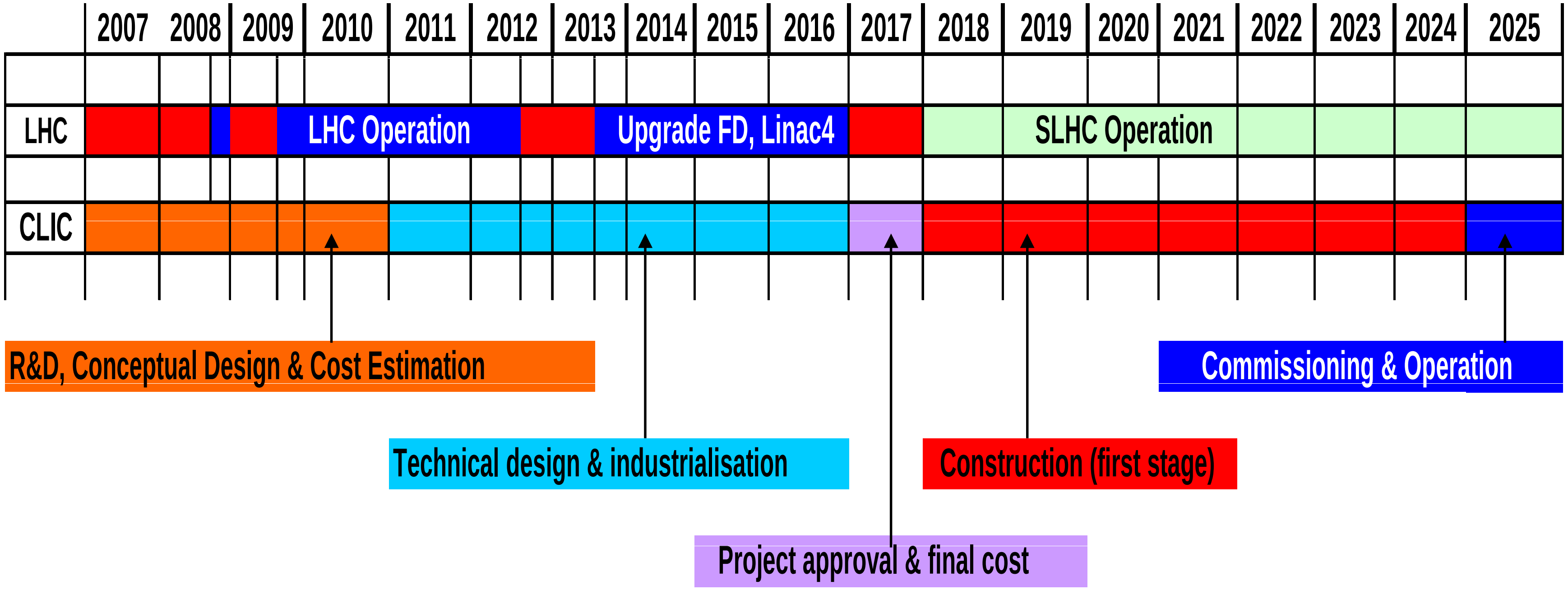


Envisaged LHC Peak Luminosity

L.Evans @ LHC2FC (10/02/09)



Tentative LHC/CLIC schedules



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).

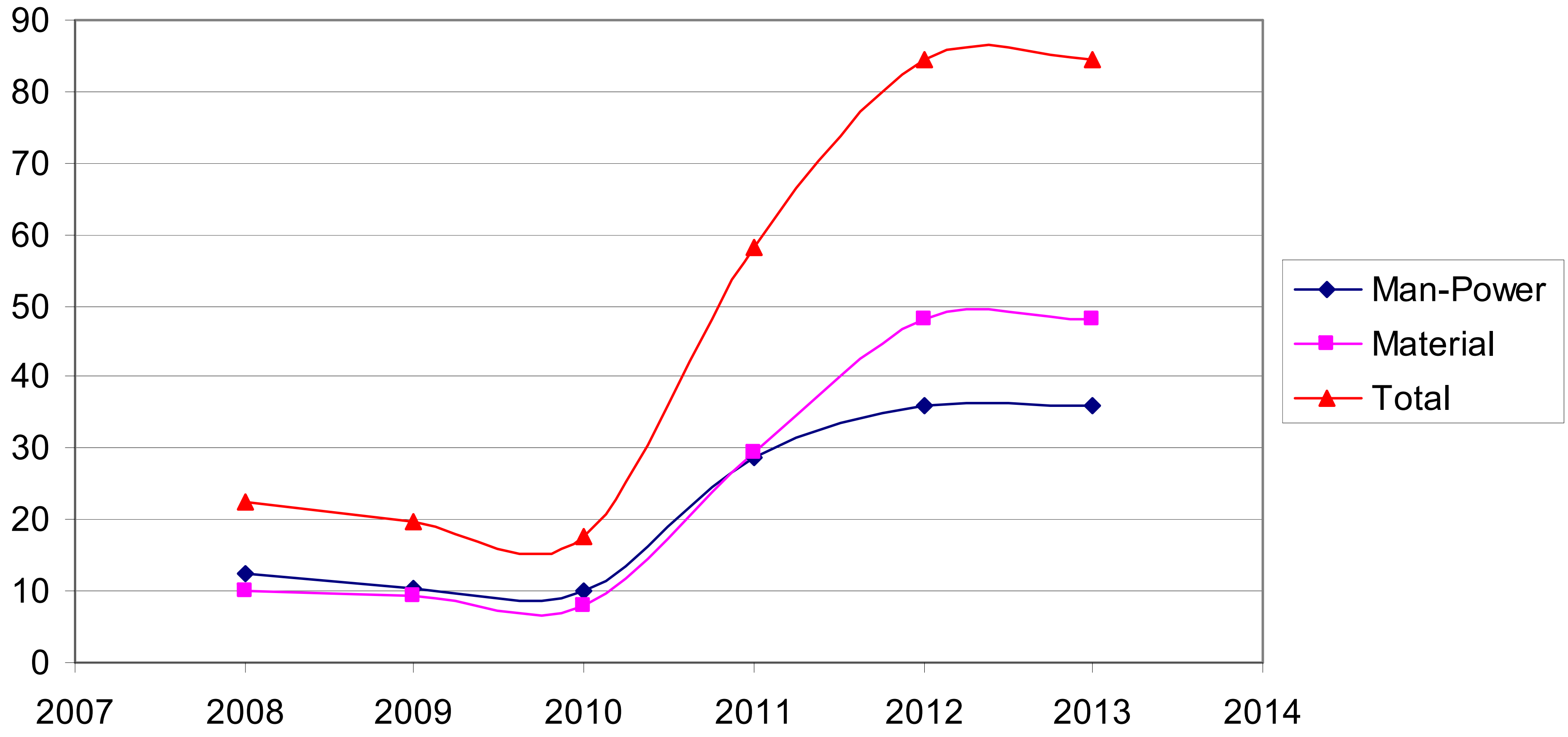
  The total cost of the investment over 6 years (2011-2016: 1000-1200 MCHF + a staff of 200-300 per year. Total budget: ~200-250 MCHF per year.

- 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.

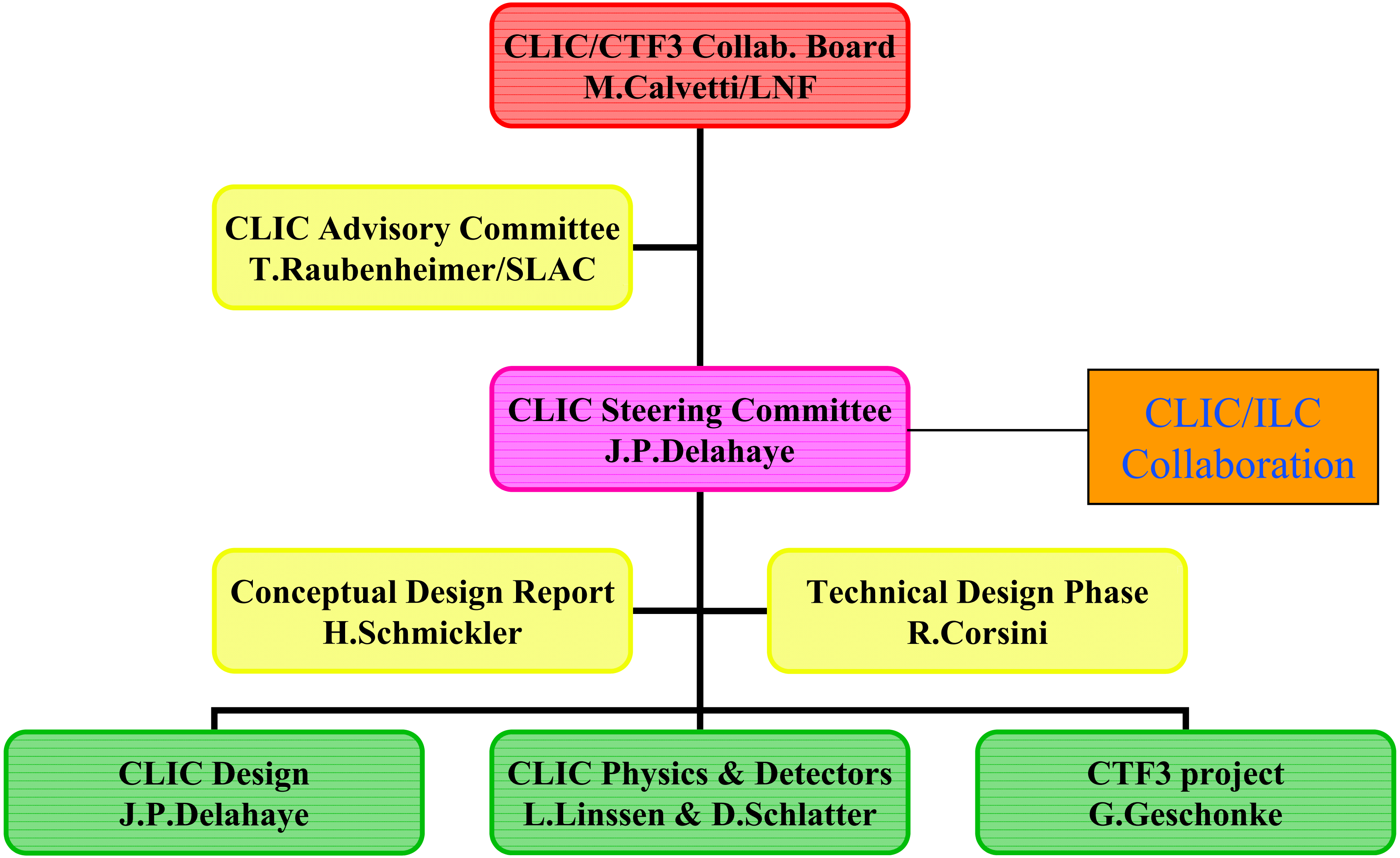
CLIC MTP resources (MCHF)
CERN/2796 (June 2008)



Resources (MCHF)

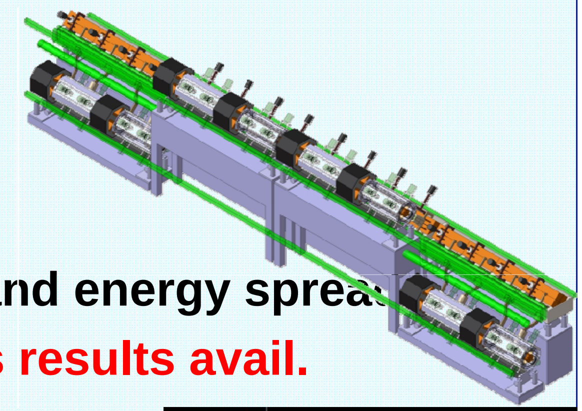
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2011-2015	2011-2016
personnel	12.3	10.4	9.9	28.8	36.1	36.1	36.1	36.1	36.1	173.2	209.3
material	10.1	9.2	7.9	29.3	48.2	48.2	48.2	48.2	48.2	222.1	270.3
Total	22.4	19.6	17.8	58.1	84.3	84.3	84.3	84.3	84.3	395.3	479.6
FTE	75.1	63.5	61.0	170.5	213.5	213.5	213.5	213.5	213.5	1024.5	1238.0
kChF/FTE	163.8	163.8	162.3	168.9	169.1	169.1	169.1	169.1	169.1	169.1	169.1

CLIC Chart 09



THE COMPACT LINEAR COLLIDER (CLIC) STUDY

Aim: develop technology to extend e-/e+ linear colliders into the Multi-TeV energy range:



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

- ✓ E_{CM} energy range from ILC to LHC maximum reach and beyond =>E_{CM} = 0.5- 3 TeV
- ✓ L > few 10^{34} cm^{-2} with acceptable background and energy spread

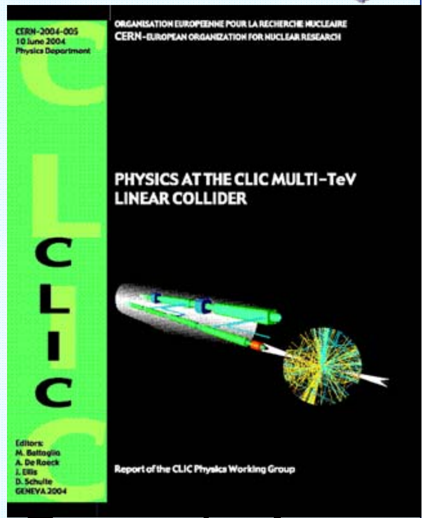
  ⇒ E_{CM} and L to be reviewed when LHC physics results avail.

- ✓ 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:

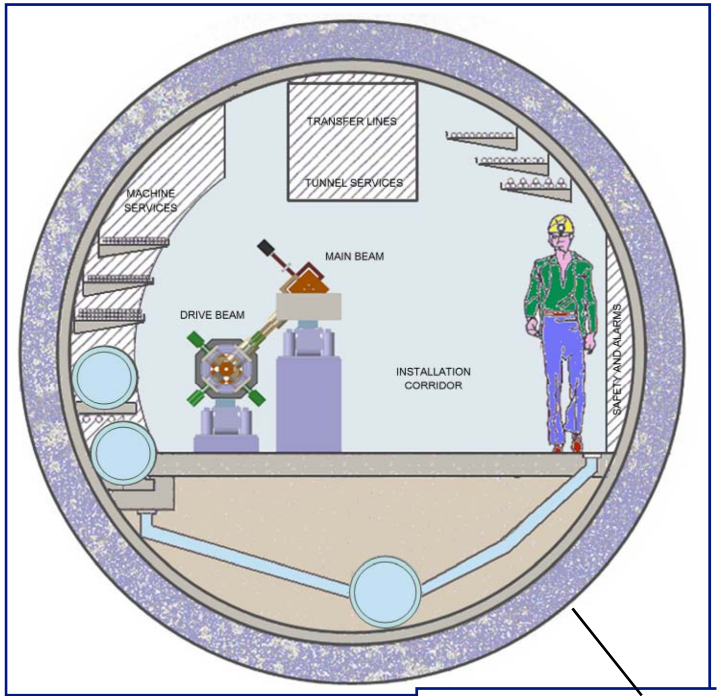
Demonstrate all key feasibility issues and document in a Conceptual Design Report by 2010 and possibly Technical Design Report by 2015

CLIC – basic features

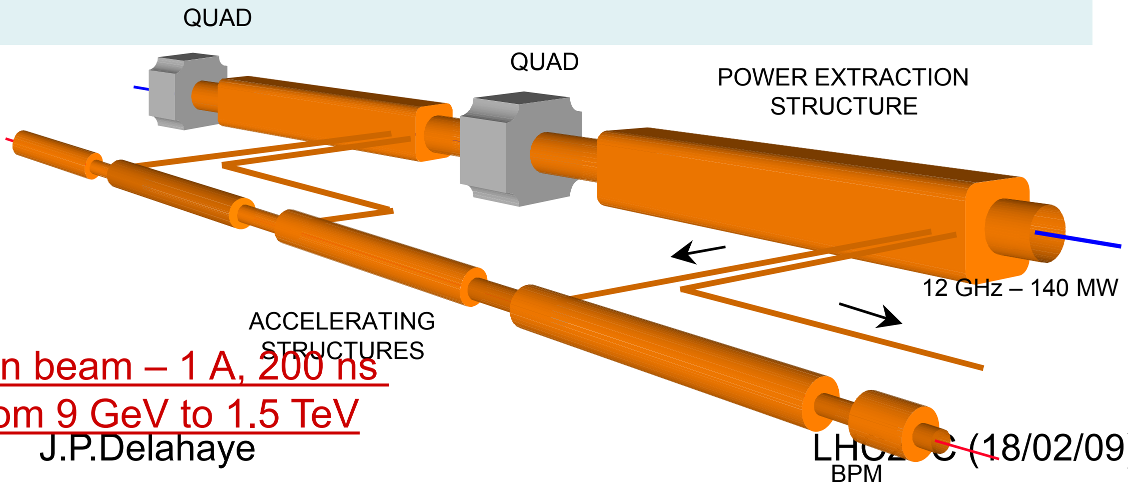
- **High acceleration gradient: > 100 MV/m**
  - **"Compact" collider – total length < 50 km at 3 TeV**
  - **Normal conducting acceleration structures at high frequency**

- **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



Drive beam - 95 A, 300 ns from 2.4 GeV to 240 MeV

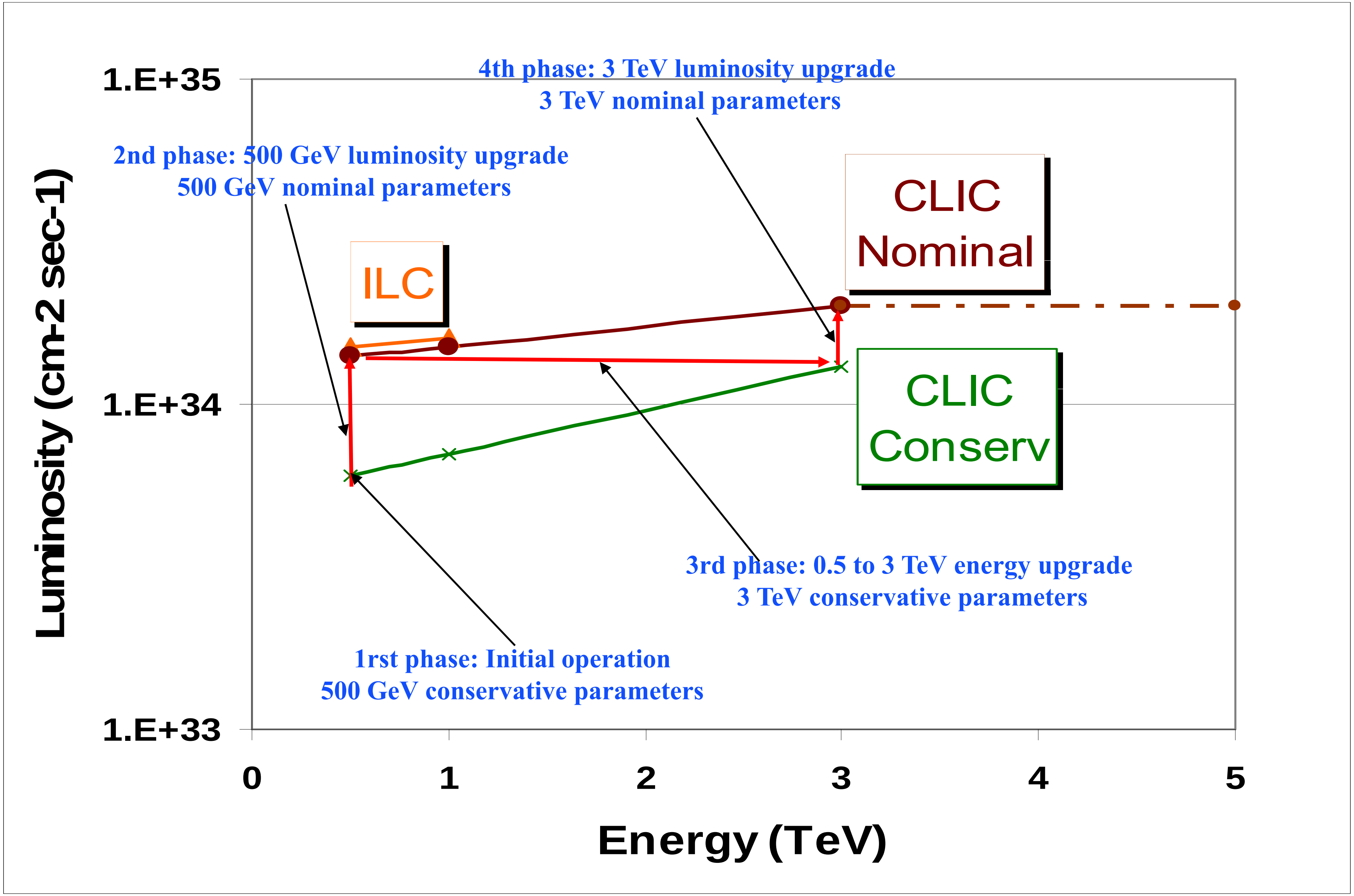
Main beam – 1 A, 200 ns from 9 GeV to 1.5 TeV

CLIC major activities and milestones up to 2010

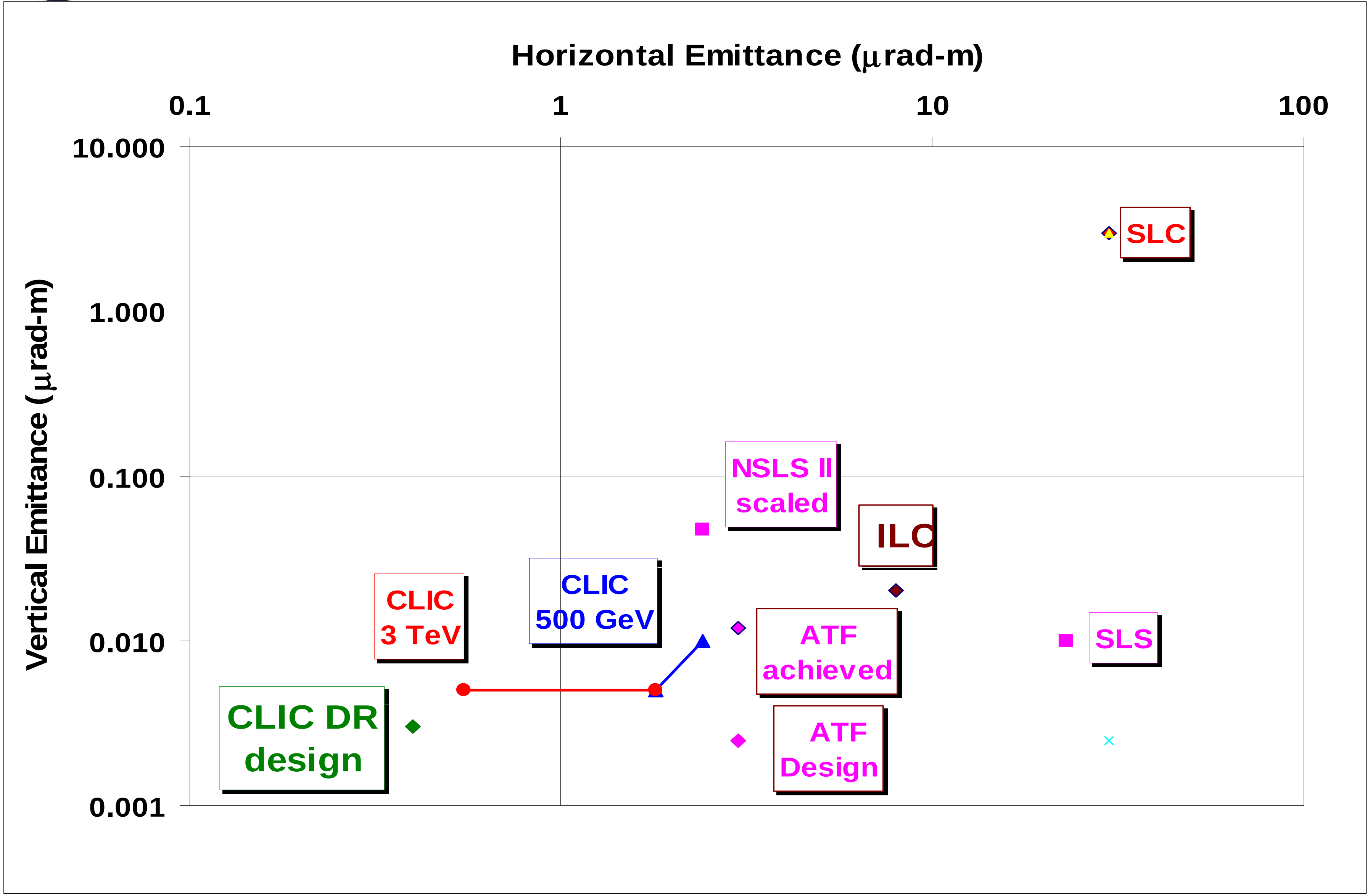
- **Demonstrate feasibility of CLIC technology**
  - **Address all feasibility issues**
- **Design of a linear Collider based on CLIC technology**
  http://clic-study.web.cern.ch/CLIC-Study/Design.htm
- **Estimation of its cost (capital investment & operation)**
- **CLIC Physics study and detector development:**
  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**

CLIC Parameters and upgrade scenario

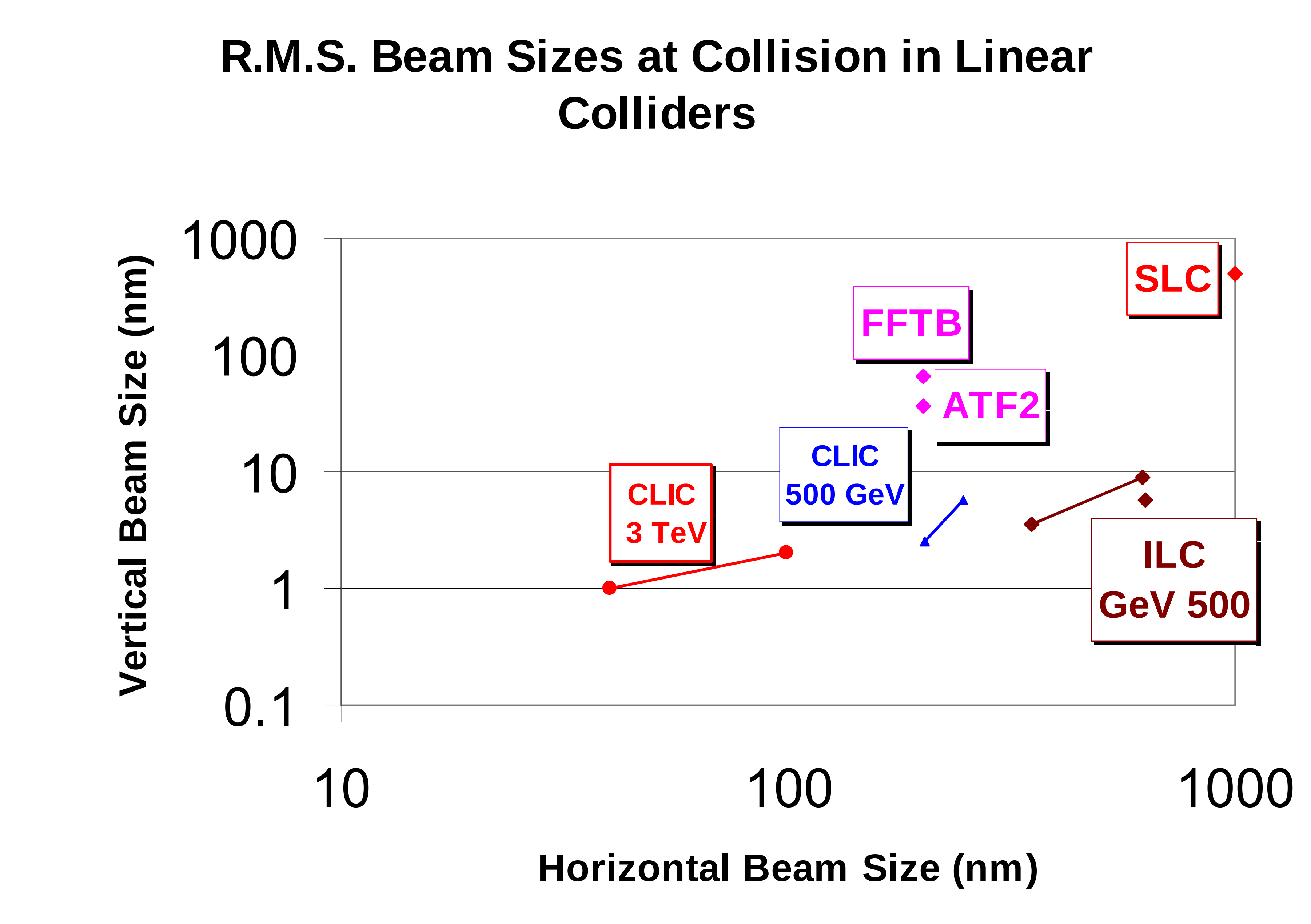
http://cdsweb.cern.ch/record/1132079/files/CERN-OPEN-2008-021.pdf



Beam emittances at Damping Rings



Beam sizes at Collisions



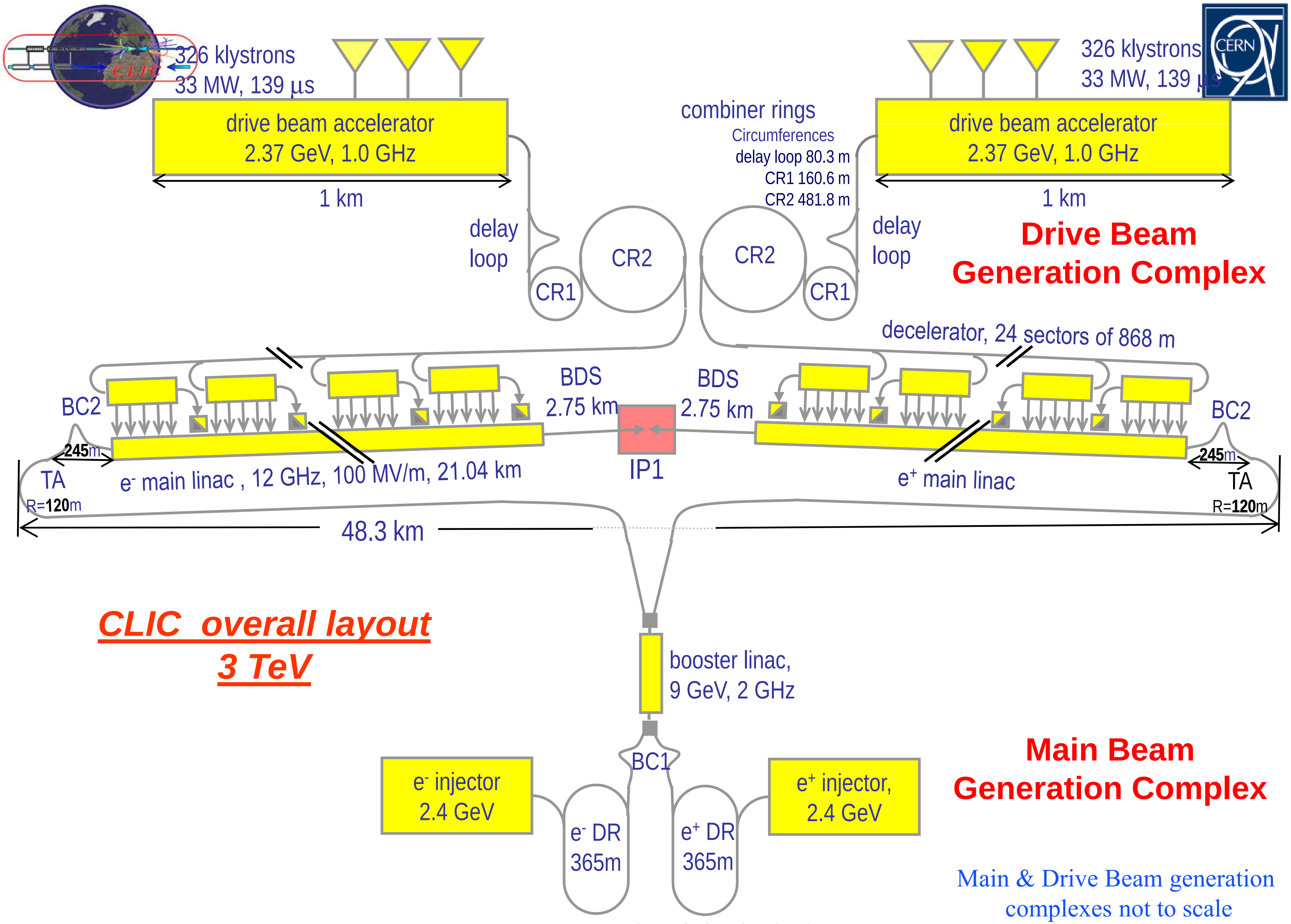
CLIC 3 TeV main parameters

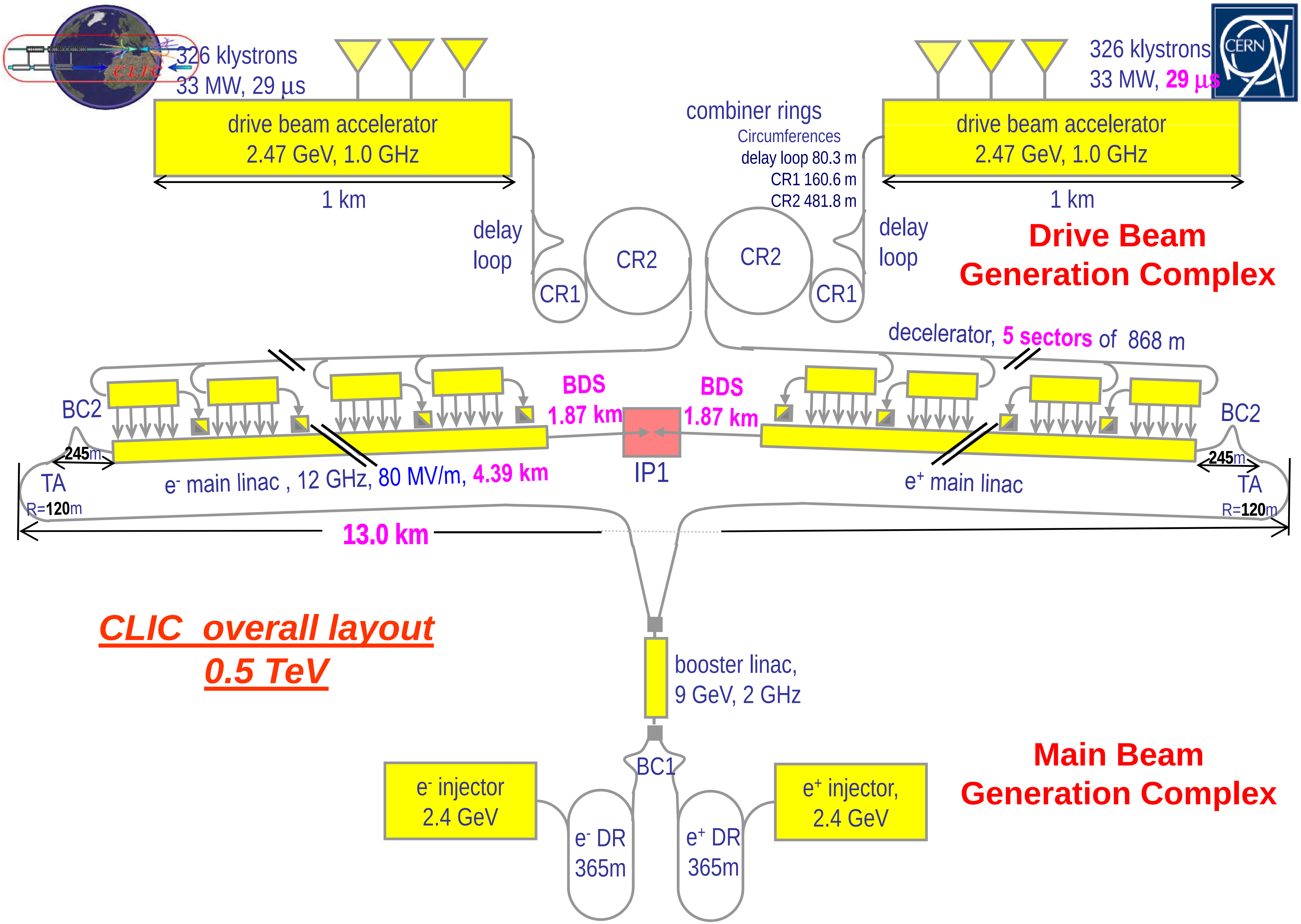
Center-of-mass energy	CLIC conserv.	CLIC Nominal
Total (Peak 1%) luminosity	$1.5(0.73)10^{34}$	$5.9(2.0)\cdot10^{34}$
Repetition rate (Hz)	50	
Loaded accel. gradient MV/m	100	
Main linac RF frequency GHz	12 (NC)	
Bunch charge10^{9}	3.72	
Bunch separation ns	0.5	
Beam pulse duration (ns)	156	
Beam power/linac (MWatts)	14	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	3 / 40	2.4 / 25
Hor/Vert FF focusing (mm)	10/0.4	8/0.1
Hor./vert. IP beam size (nm)	83 / 2.0	40 / 1.0
Soft Hadronic event at IP	0.57	2.7
Coherent pairs/crossing at IP	$5\ 10^{7}$	$3.8\ 10^{8}$
BDS length (km)	2.75	
Total site length (km)	48.3	
Wall plug to beam transfer eff.	6.8%	
Total power consumption (MW)	415	

LC 500 GeV Main parameters

Center-of-mass energy	ILC	CLIC Conserv.	CLIC Nominal
Total (Peak 1%) luminosity	$2.0(1.5)\cdot10^{34}$	$0.9(0.6)\cdot10^{34}$	$2.3(1.4)\cdot10^{34}$
Repetition rate (Hz)	5	50	
Loaded accel. gradient MV/m	33.5	80	
Main linac RF frequency GHz	1.3 (SC)	12 (NC)	
Bunch charge10^9	20	6.8	
Bunch separation ns	176	0.5	
Beam pulse duration (ns)	1000	177	
Beam power/linac (MWatts)	10.2	4.9	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	10/40	3 / 40	2.4 / 25
Hor/Vert FF focusing (mm)	20/0.4	10/0.4	8/0.1
Hor./vert. IP beam size (nm)	640/5.7	248 / 5.7	202/ 2.3
Soft Hadronic event at IP	0.12	0.07	0.19
Coherent pairs/crossing at IP	10?	10	100
BDS length (km)	2.23 (1 TeV)	1.87	
Total site length (km)	31	13.0	
Wall plug to beam transfer eff.	9.4%	7.5%	
Total power consumption MW	216	129.4	

CLIC overall layout 3 TeV



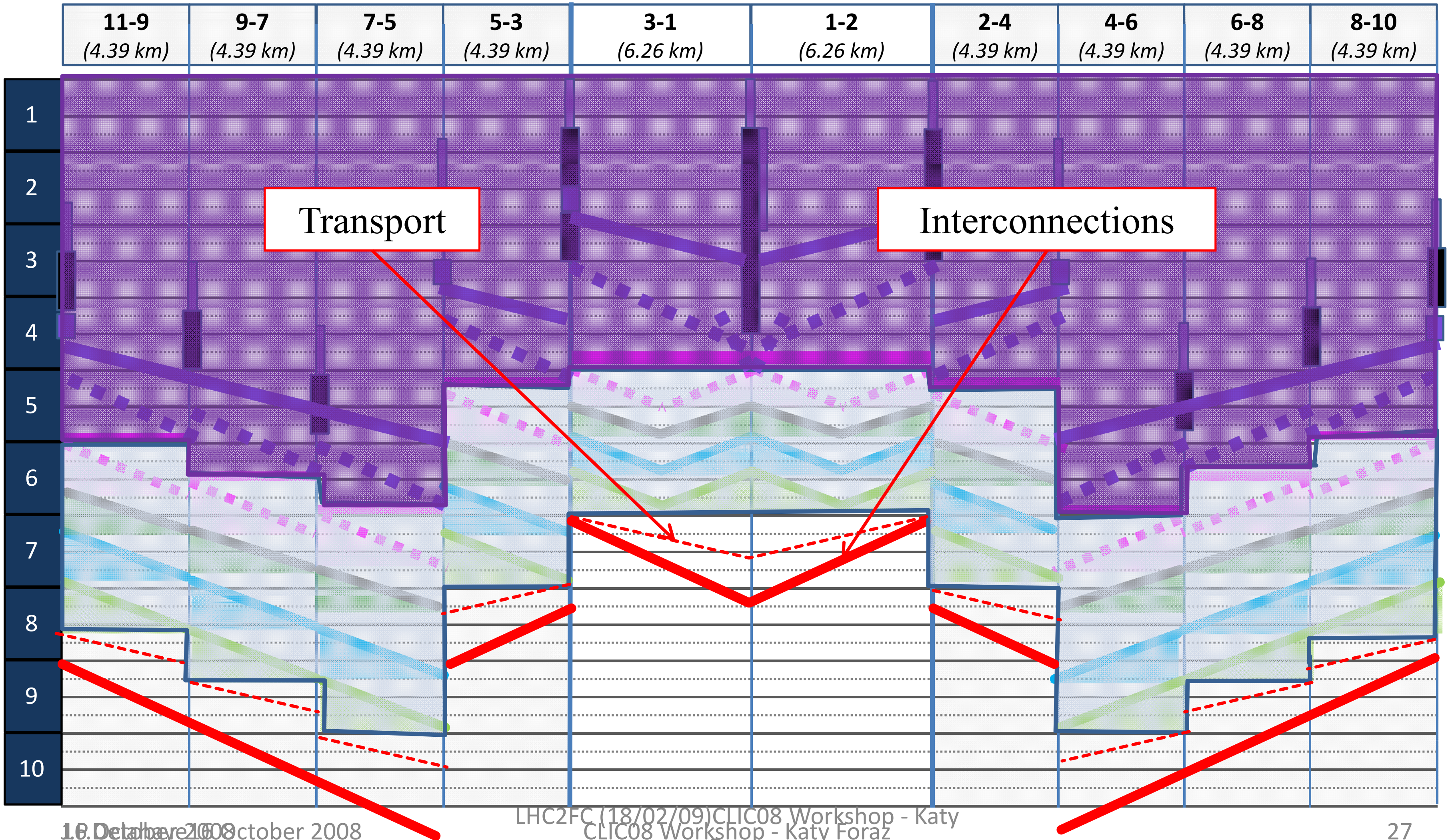


CLIC overall layout 0.5 TeV

CLIC Machine installation

3 TeV 3 additional years

500 GeV 7 years ready for HW commisioning



Strategy to address key issues

- **Key issues common to all Linear Collider studies independently of the chosen technology in close collaboration with International Linear Collider (ILC) study**
  - **The Accelerator Test Facility (ATF@KEK)**
  - **European Laboratories in the frame of:**
    - **the Coordinated Accelerator Research in Europe (CARE) and of a “Design Study” (EUROTeV) funded by EU Programme (FP6)**
    - **The European Coordination of Accerator R&D funded by EU FP7**
- **Key issues specific to CLIC technology:**
  - **Focus of the CLIC study**
  - **All R1 (feasibility) and R2 (design finalisation) key issues addressed in test facilities: CTF@CERN**

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

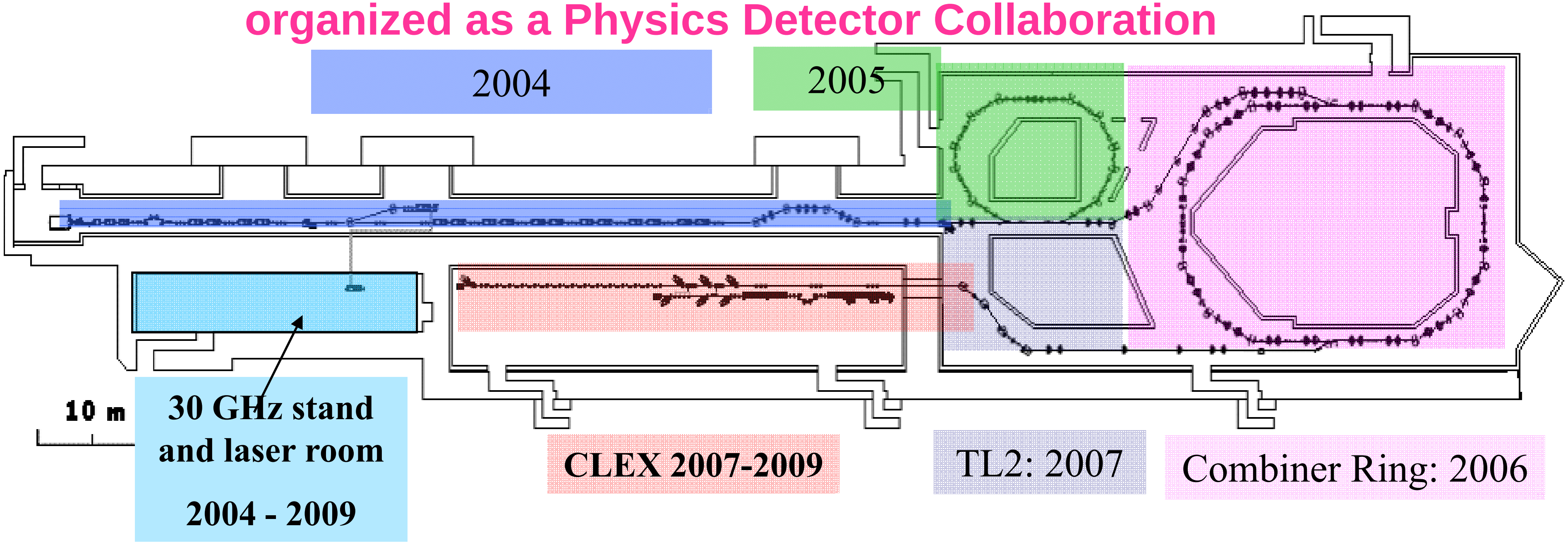
SYSTEMS (level n)		Critical parameters	Feasibility issue	Performance issue	Cost issue
Structures	**Main beam acceleration structures** Demonstrate nominal CLIC structures with damping features at the design gradient, with design pulse length and breakdown rate .	100 MV/m 240 ns 3·10-7 BR/(pulse*m)	X	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
	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
	- Preservation of low emittances (main linac + RTML)	Absolute blow-up Hor: 160nradm Vert: 15 nradm	X	X		Beam simulations LCLS SCSS
	- Beam focusing to small dimensions (BDS)	Hor: 40 nm Vert: 1 nm		X		ATF2 (2006-2012) Hor: 200 nm Vert: 36 (20) nm

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

Multi-lateral Collaboration of 27 volunteer institutes organized as a Physics Detector Collaboration



Key issues

From 2005: Accelerating structures (bi-metallic) Development& Tests (R2.1)

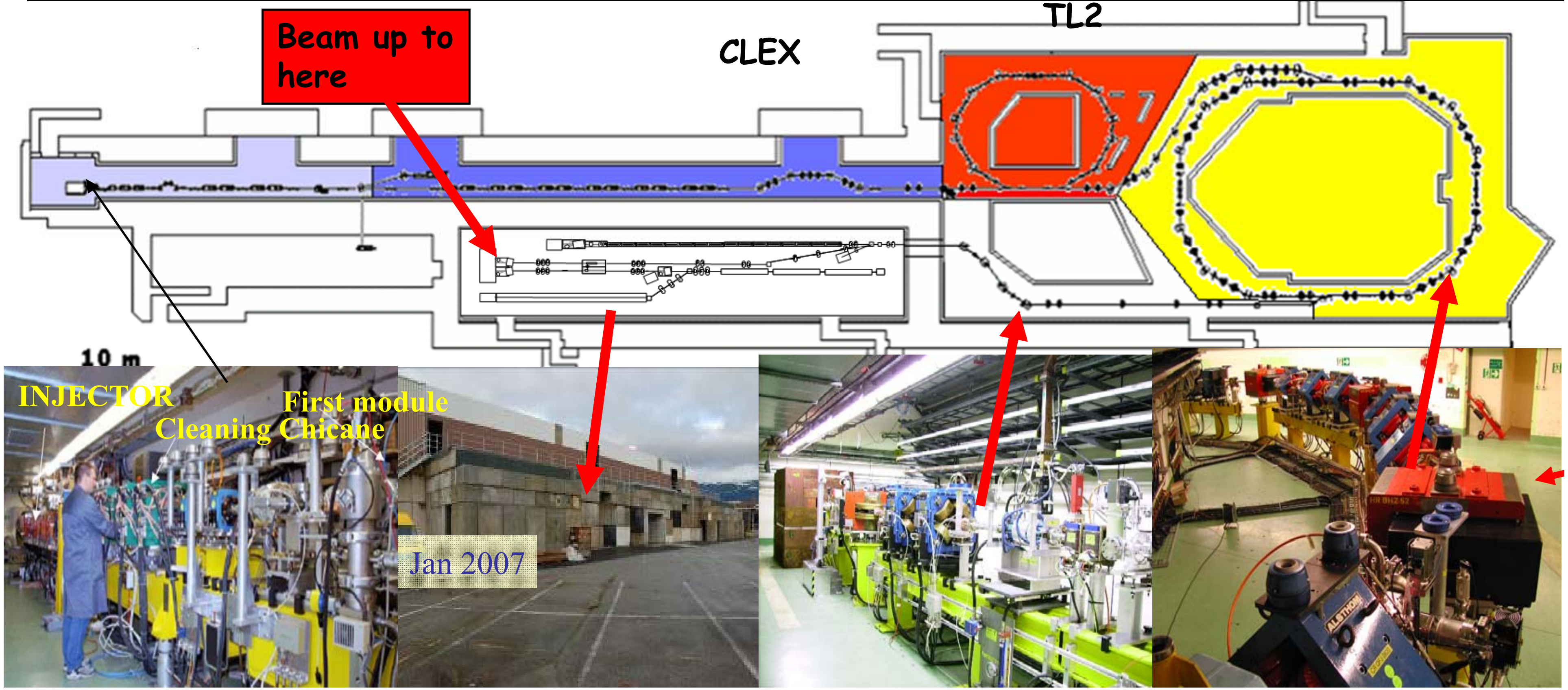
2007- 2008: Drive beam generation scheme (R1.2)

2008- 2009: Damped accelerating structure with nominal parameters (R1.1)
ON/OFF Power Extraction Structure (R1.3)
Drive beam stability bench marking (R2.2)
CLIC sub-unit (R2.3)

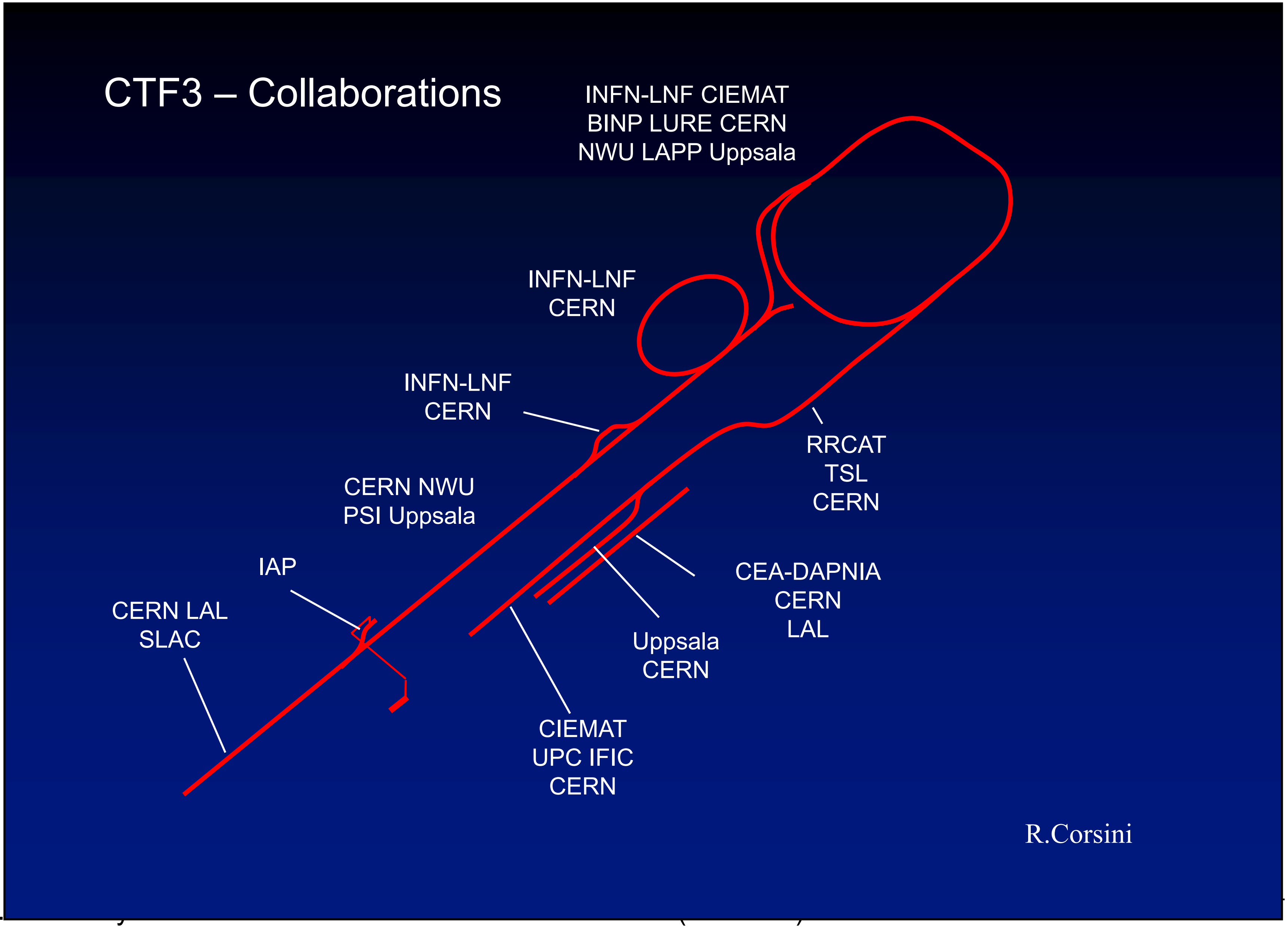
CTF3 Continuous 0peration (10months/year)

HW & Beam Commisioning and RF power production for structure tests

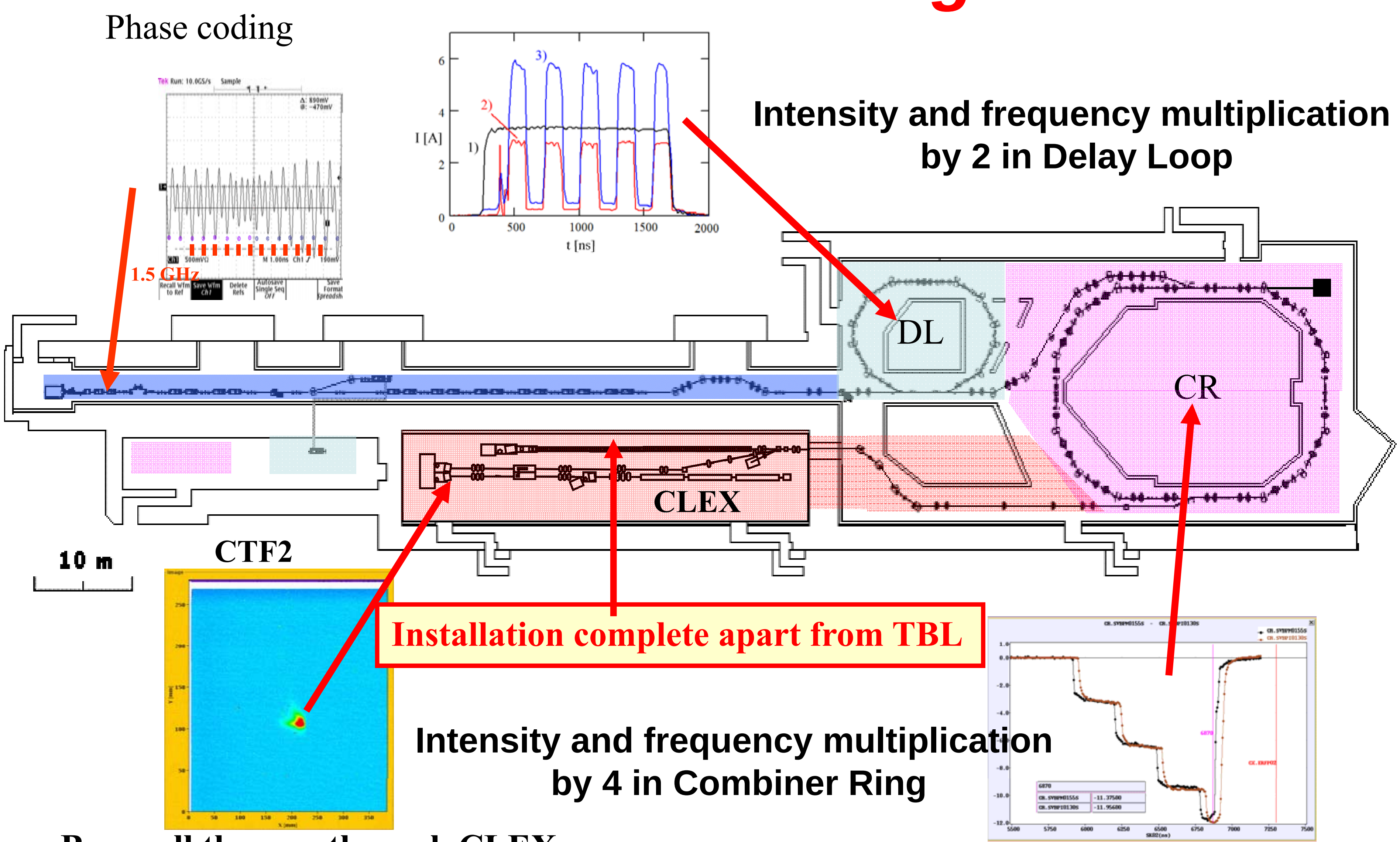
- Demonstrate Drive Beam generation
  (fully loaded acceleration, beam intensity and bunch frequency multiplication x8)
- Demonstrate RF Power Production and test Power Structures
- Demonstrate Two Beam Acceleration and test Accelerating Structures



CTF3 Collaboration



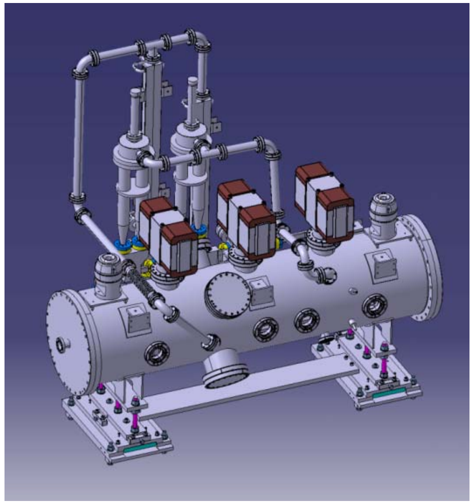
CTF3 HW & Beam Commissioning

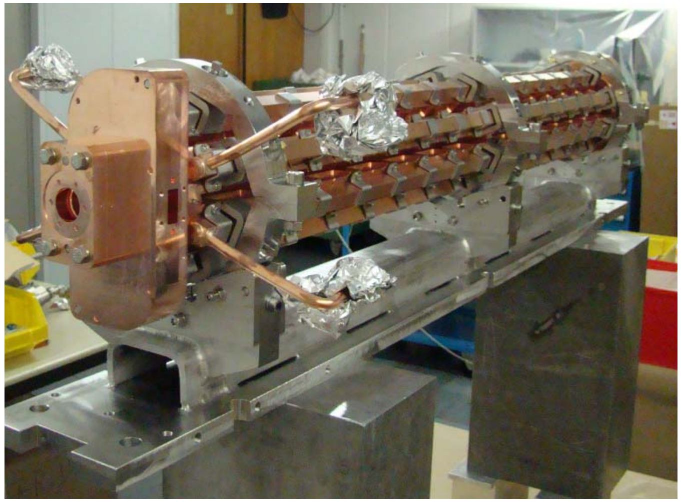


Beam all the way through CLEX


2010
CLEX
2007
June 2006
September 2006
Probe Beam linac
Two Beam Test Stand
(University Uppsala)
June 2008
Equipment installed (except TBL),
Beam from June 2008
June 2008

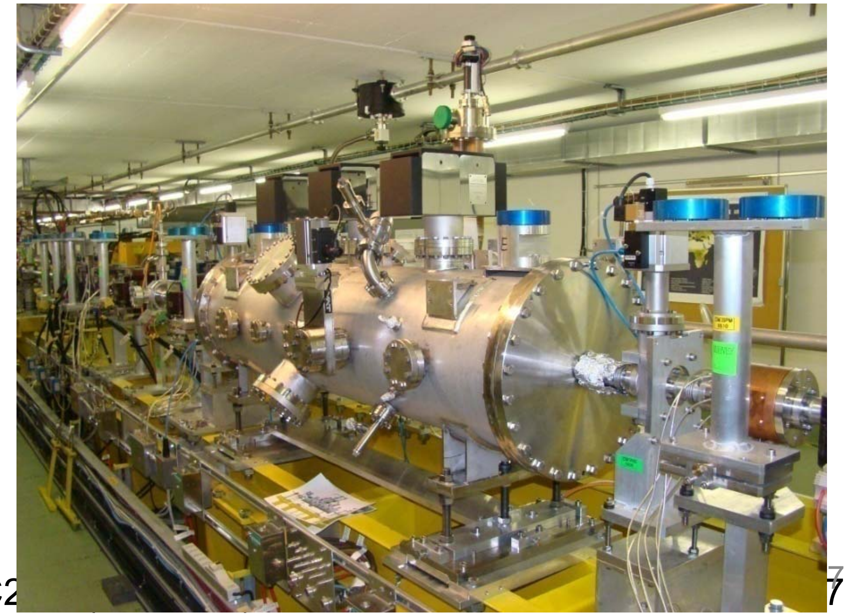
Power Extraction Structure test (PETS) in CTF3





PETS installation in tank successful
(**collaboration with Pakistan – NPC Islamabad**)

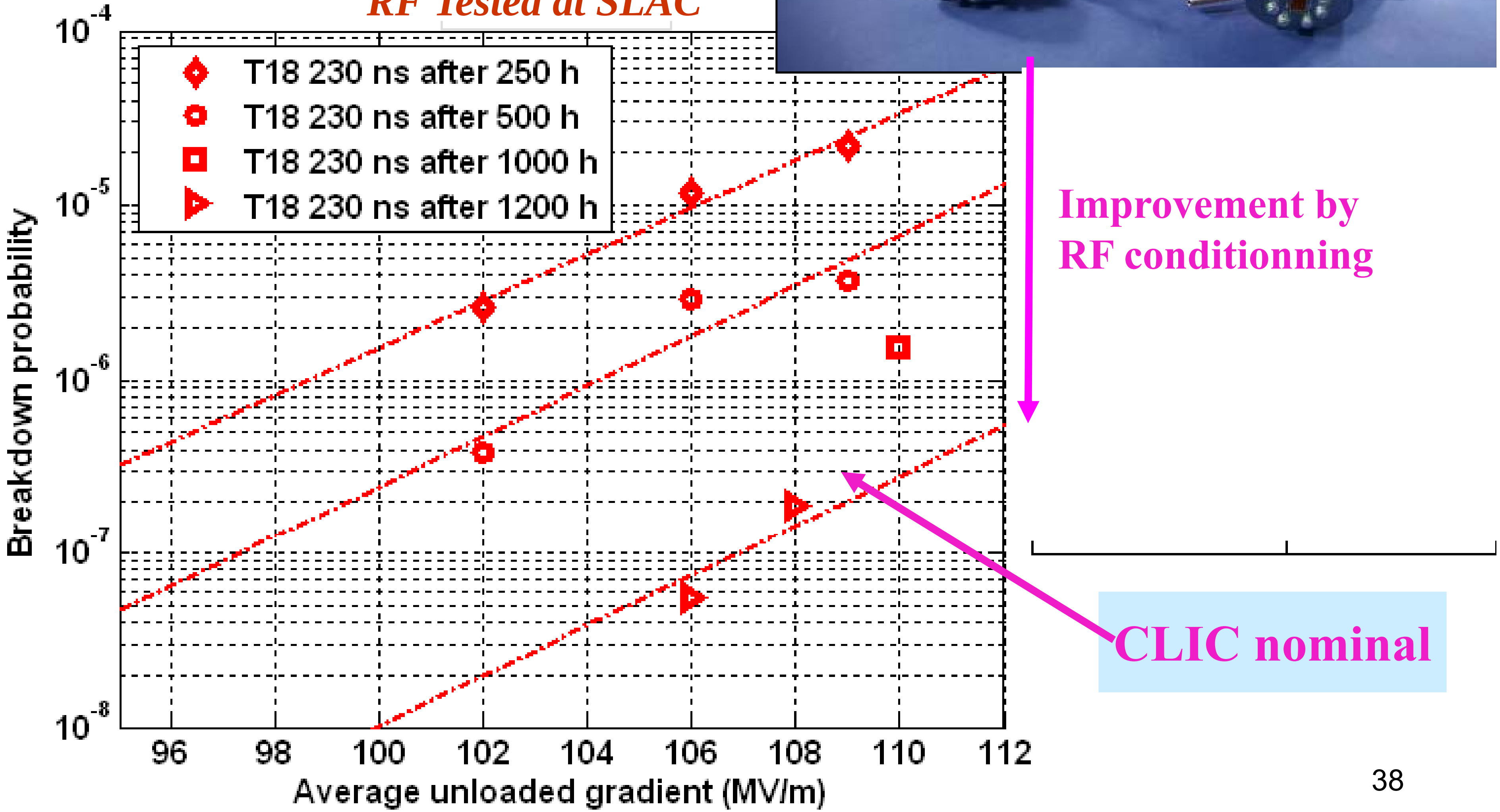
PETS installation in CLEX under way



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



The path to the CLIC full-structure feasibility demonstration

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

Supporting tests:
Quadrant fabrication
CD10
Choke mode CD10

TD18

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

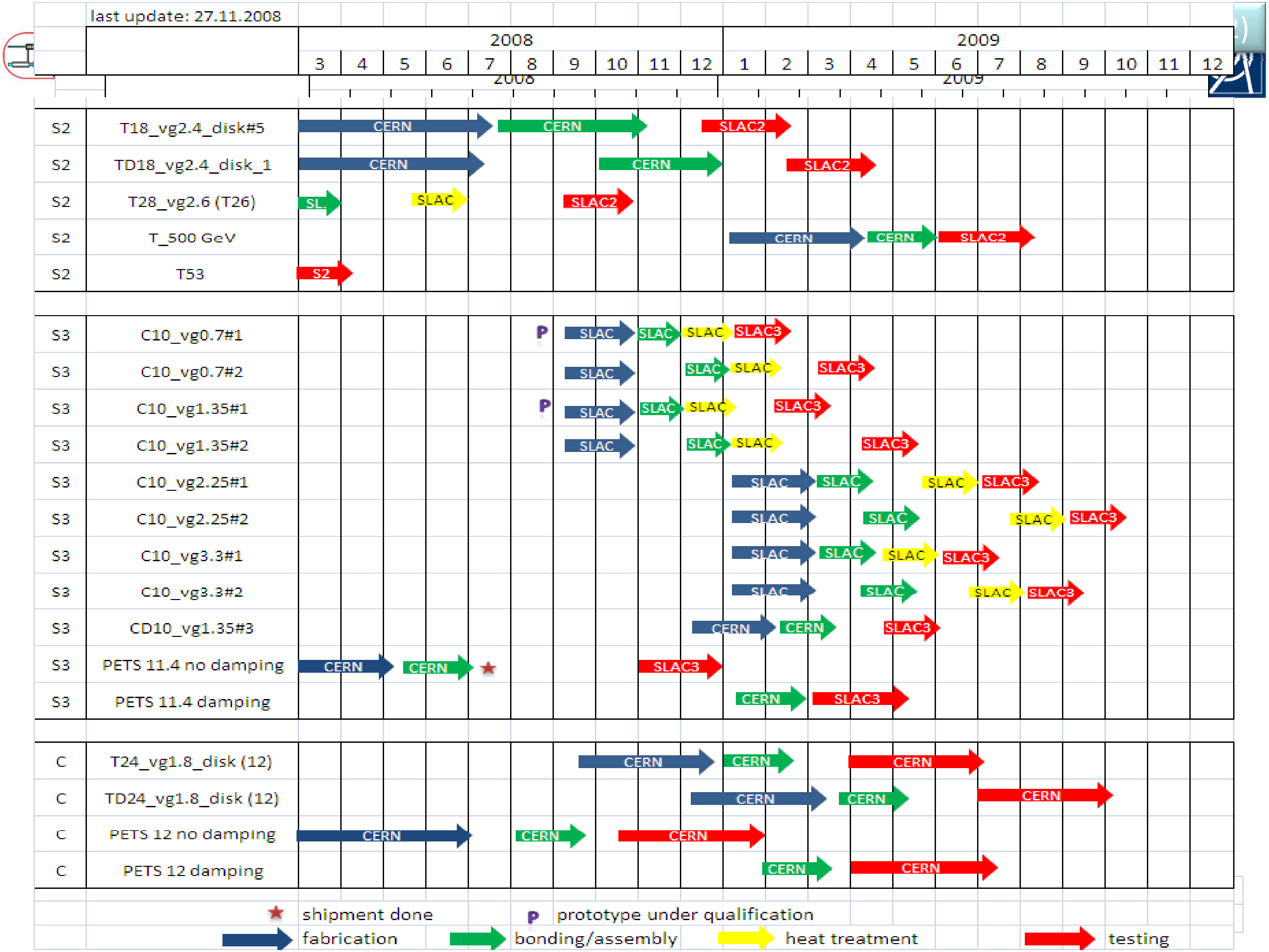
CLIC_G undamped

Supporting tests:
C10 series
T23

Today

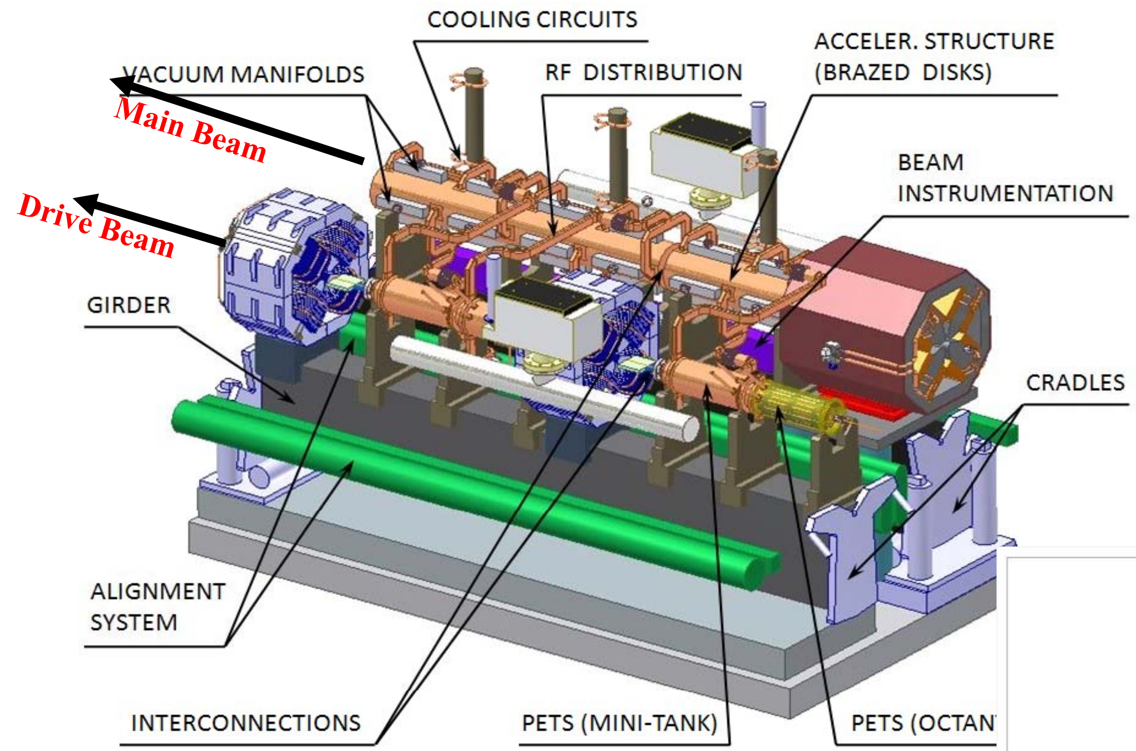
Mid 2009

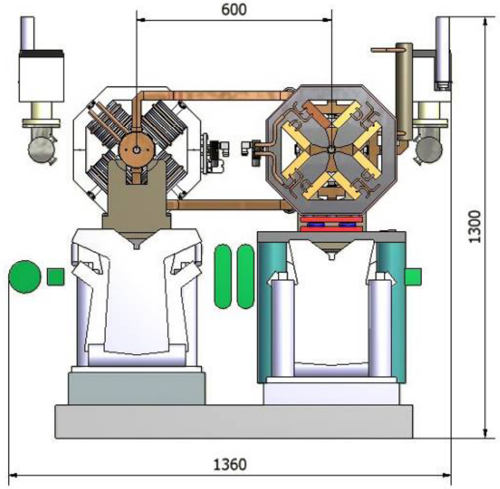
late 2009

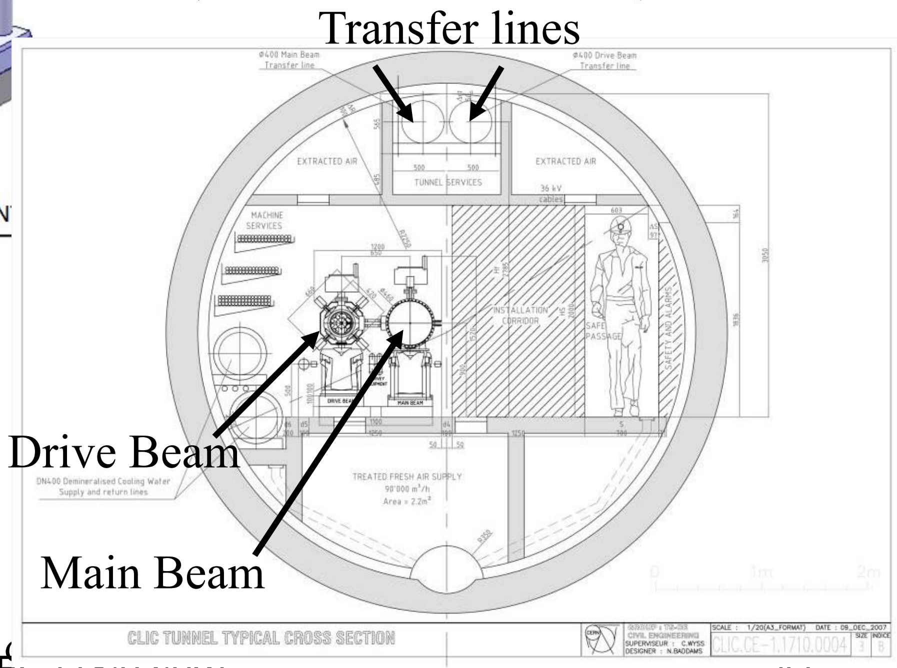


last update: 27.11.2008
2008
2009
3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
S2 T18_vg2.4_disk#5 CERN CERN SLAC2
S2 TD18_vg2.4_disk_1 CERN CERN SLAC2
S2 T28_vg2.6 (T26) SL. SLAC SLAC2
S2 T_500 GeV CERN CERN SLAC2
S2 T53 S2
S3 C10_vg0.7#1 P SLAC SLAC SLAC SLAC3
S3 C10_vg0.7#2 SLAC SLAC SLAC SLAC3
S3 C10_vg1.35#1 P SLAC SLAC SLAC SLAC3
S3 C10_vg1.35#2 SLAC SLAC SLAC SLAC3
S3 C10_vg2.25#1 SLAC SLAC SLAC SLAC3
S3 C10_vg2.25#2 SLAC SLAC SLAC SLAC3
S3 C10_vg3.3#1 SLAC SLAC SLAC SLAC3
S3 C10_vg3.3#2 SLAC SLAC SLAC SLAC3
S3 CD10_vg1.35#3 CERN CERN SLAC3
S3 PETS 11.4 no damping CERN CERN ★ SLAC3
S3 PETS 11.4 damping CERN SLAC3
C T24_vg1.8_disk (12) CERN CERN CERN
C TD24_vg1.8_disk (12) CERN CERN CERN
C PETS 12 no damping CERN CERN CERN
C PETS 12 damping CERN CERN
★ shipment done
P prototype under qualification
fabrication
bonding/assembly
heat treatment
testing

CLIC Two Beam Module





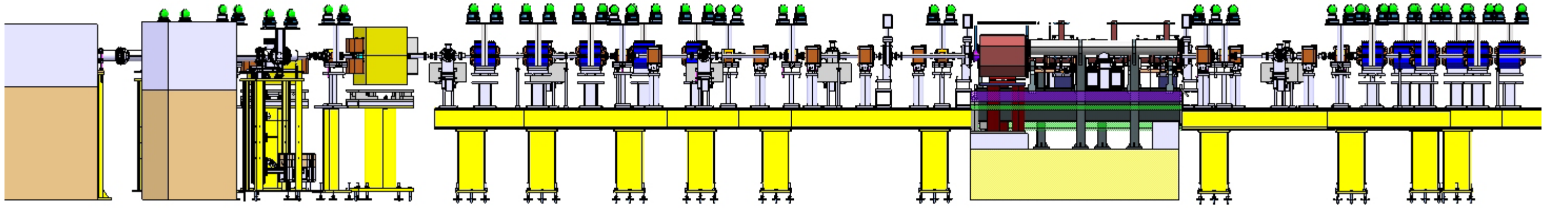


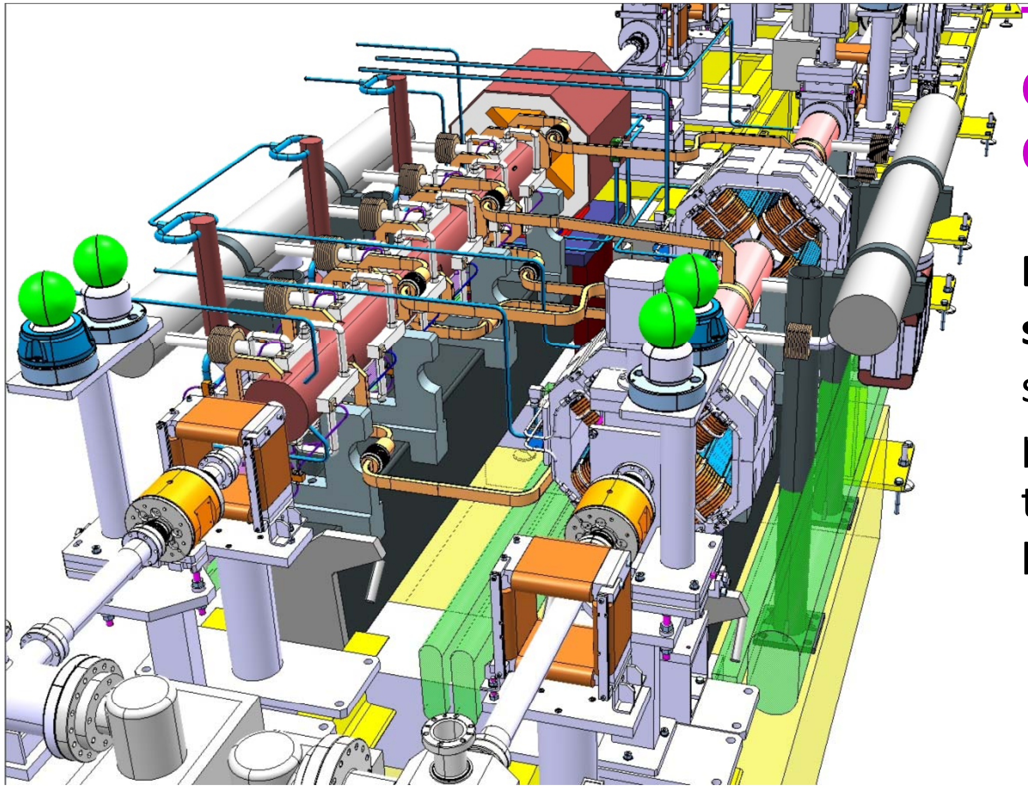
20760 modules (2 meters long)

71460 power production structures PETS (drive beam)

143010 accelerating structures (main beam)

Two Beam Module tests in CTF3/CLEX

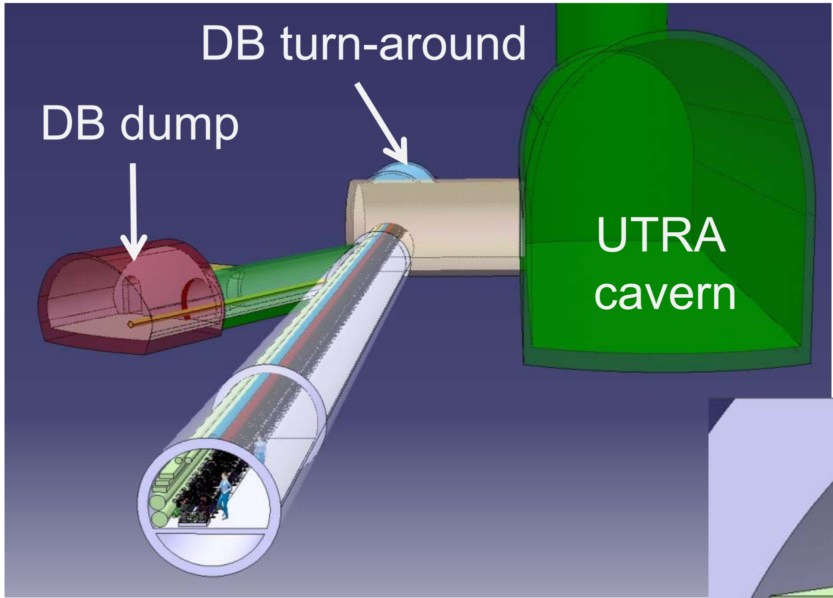


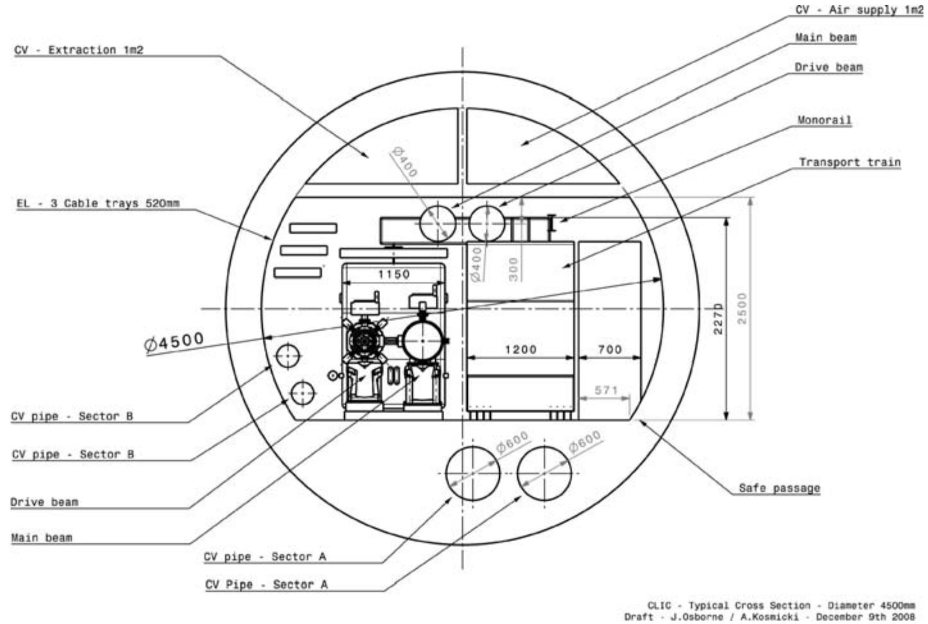


Two Beam Test Stand: Contribution of Swedish Collaboration: Uppsala Univ.

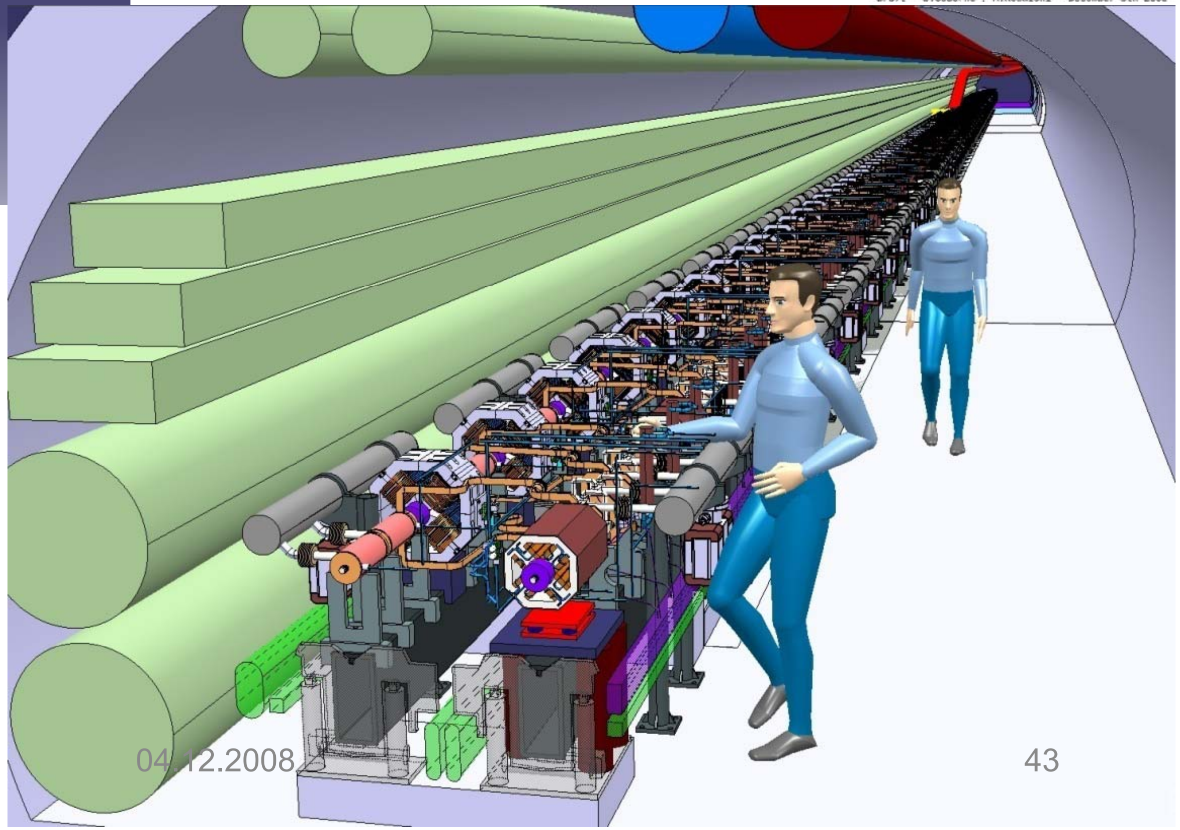
Design and integration of different sub-systems, i.e. to simultaneously satisfy requirements of highest possible gradient, power handling, tight mechanical tolerances and heavy HOM damping

Tunnel integration

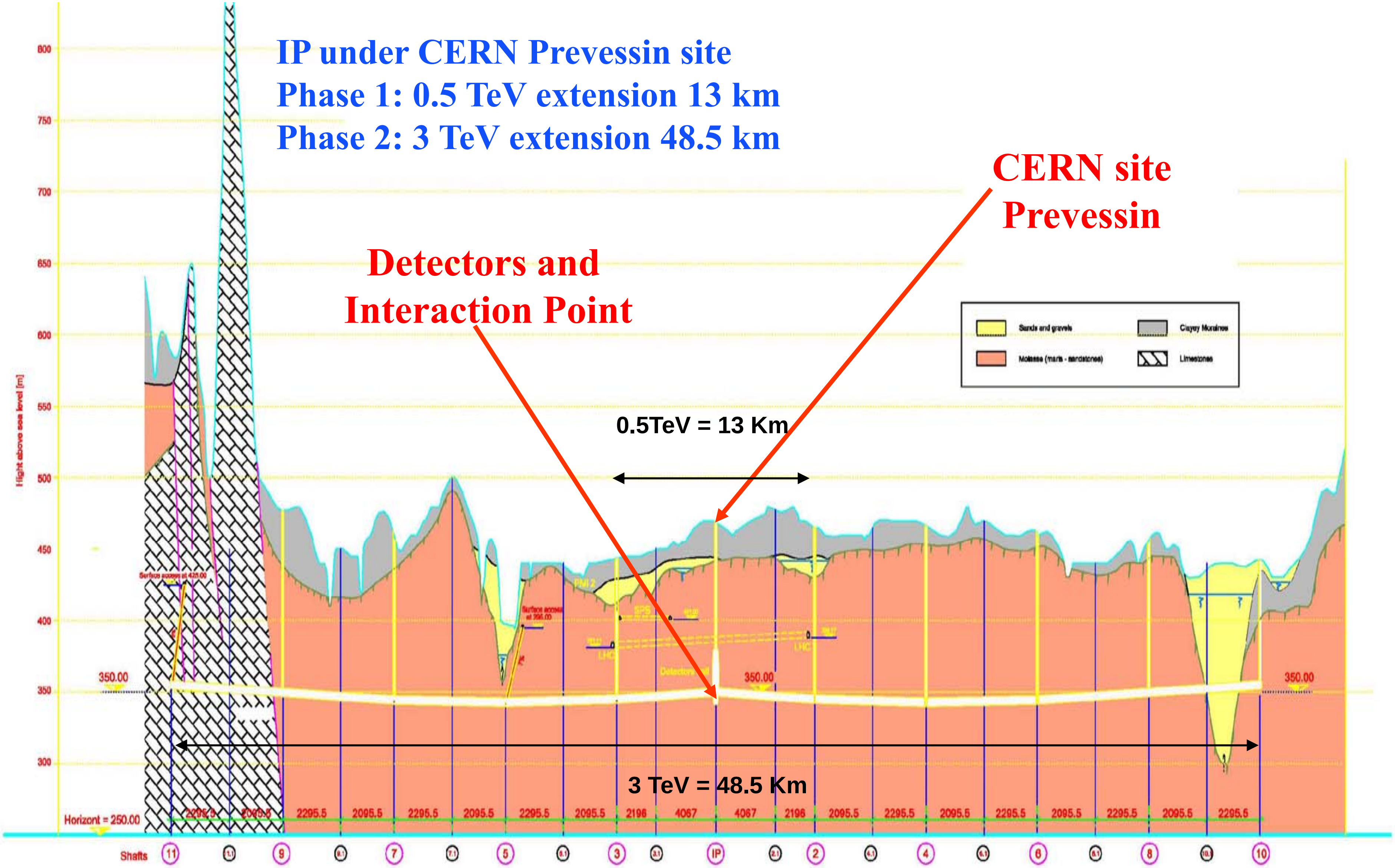




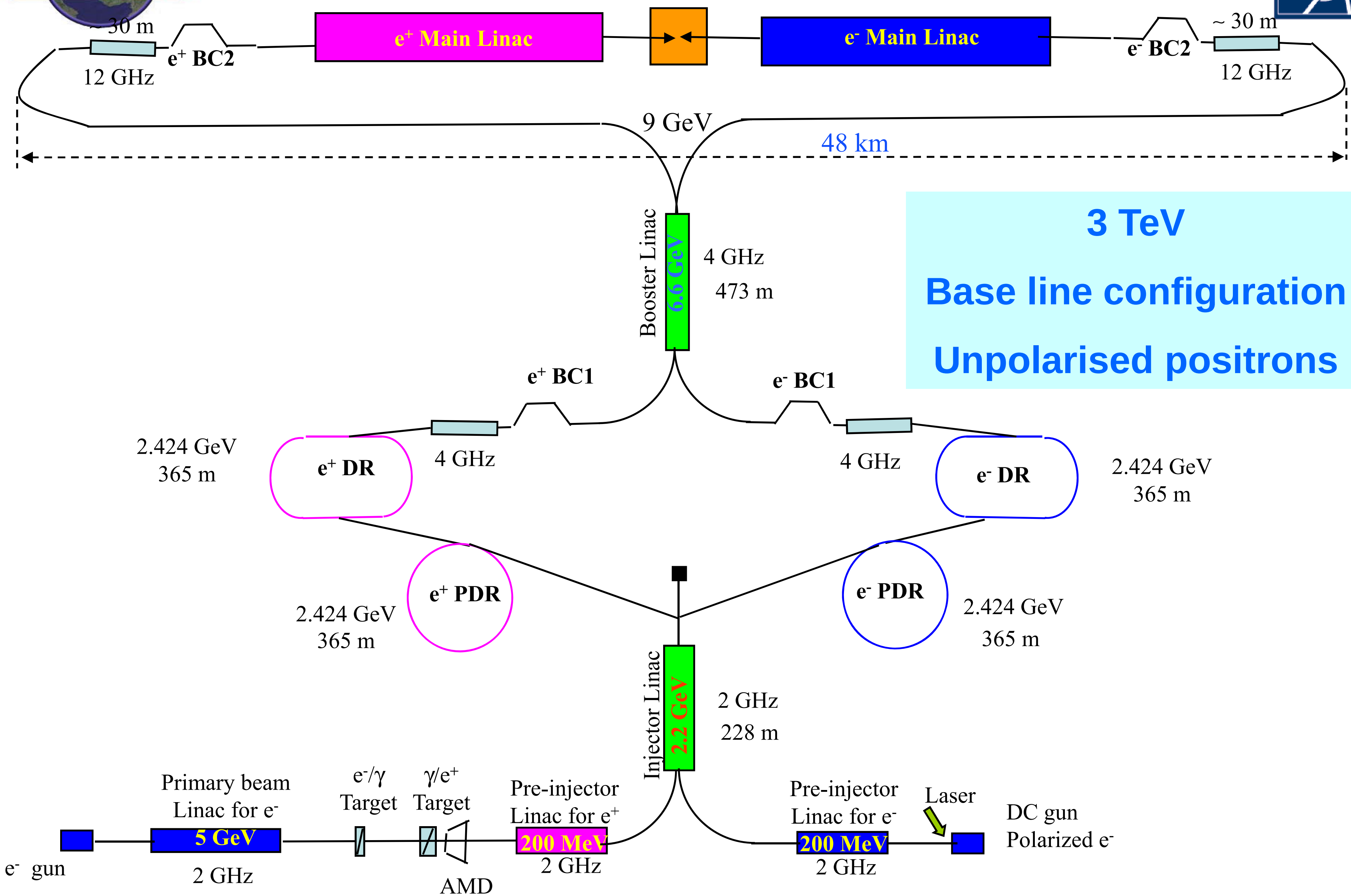
Standard tunnel with modules



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



The CLIC Injector complex in 2008

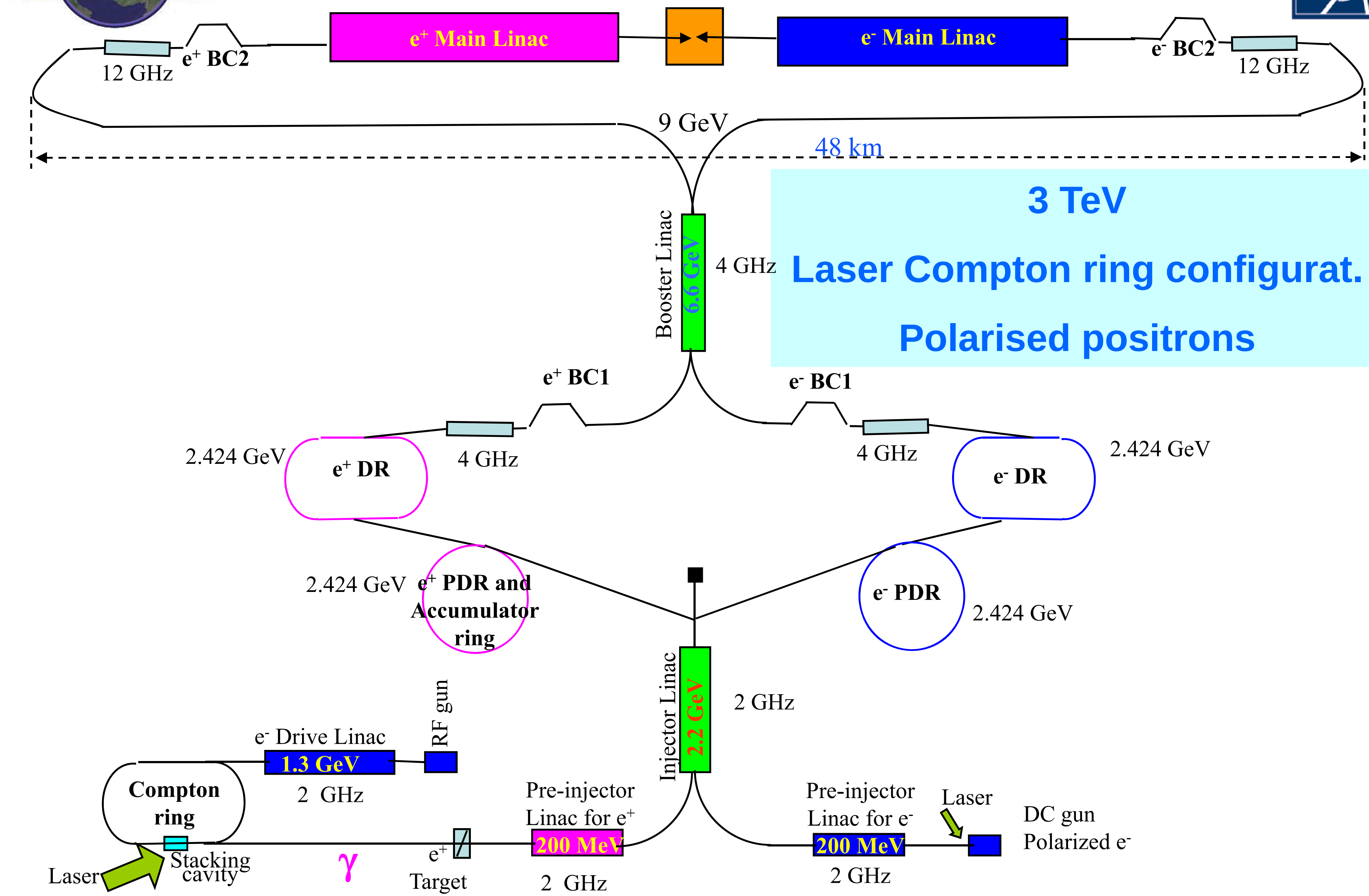


3 TeV

Base line configuration

Unpolarised positrons

The CLIC Injector complex (Compton)

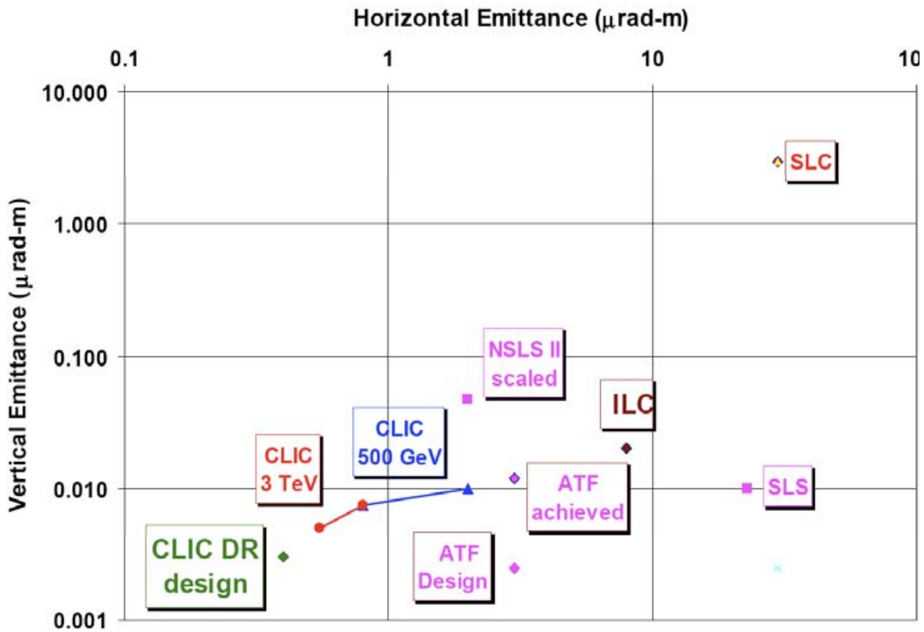


3 TeV

Laser Compton ring configurat.

Polarised positrons

Damping ring design

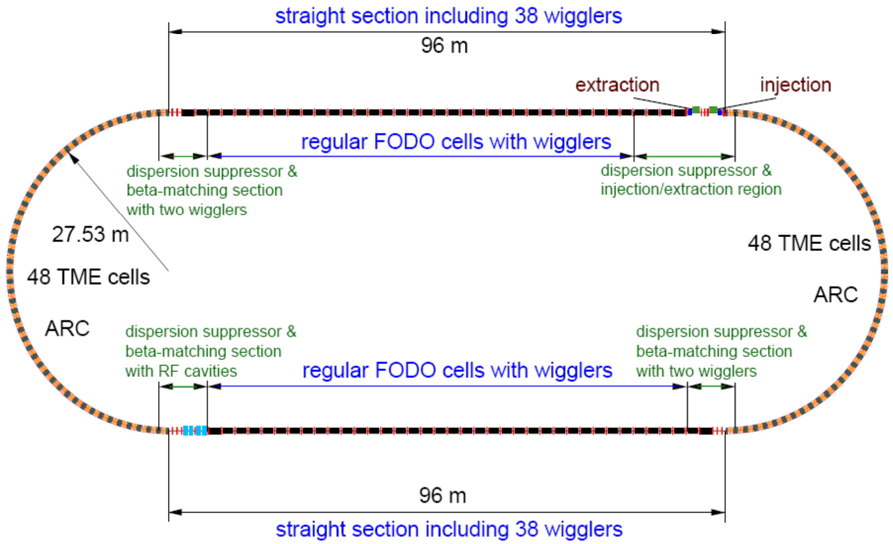


PARAMETER	NLC	CLIC (3TeV)
bunch population (10^9)	7.5	4.1
bunch spacing [ns]	1.4	0.5
number of bunches/train	192	316
number of trains	3	1
Repetition rate [Hz]	120	50
Extracted hor. normalized emittance [nm]	2370	<550
Extracted ver. normalized emittance [nm]	<30	<5
Extracted long. normalized emittance [keV.m]	10.9	<5
Injected hor. normalized emittance [µm]	150	63
Injected ver. normalized emittance [µm]	150	1.5
Injected long. normalized emittance [keV.m]	13.18	1240

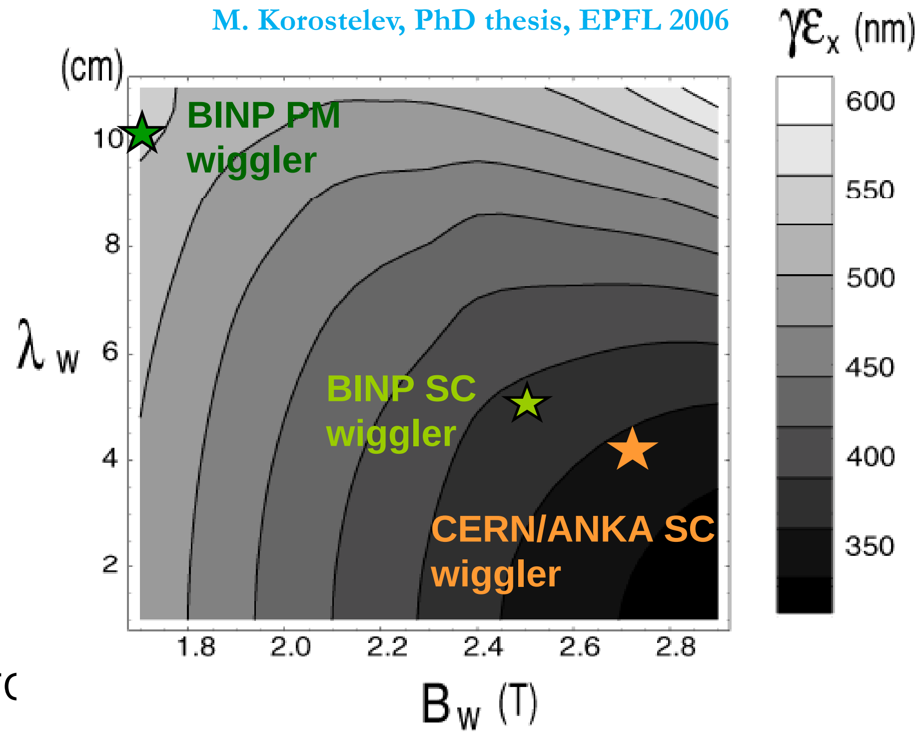
- **Present CLIC DR design for** 3TeV **achieves goals for transverse emittances with a 20%-30% margin** (380nm **horizontal and** 4.1nm **vertical)**
- **Conservative DR output emittances** (2.4µm **horizontal,** 10nm **vertical) for CLIC @** 500GeV **scaled from operational or approved light source projects (NSLSII, SLS)**
- **Route to lower emittances to be defined**

CLIC damping rings

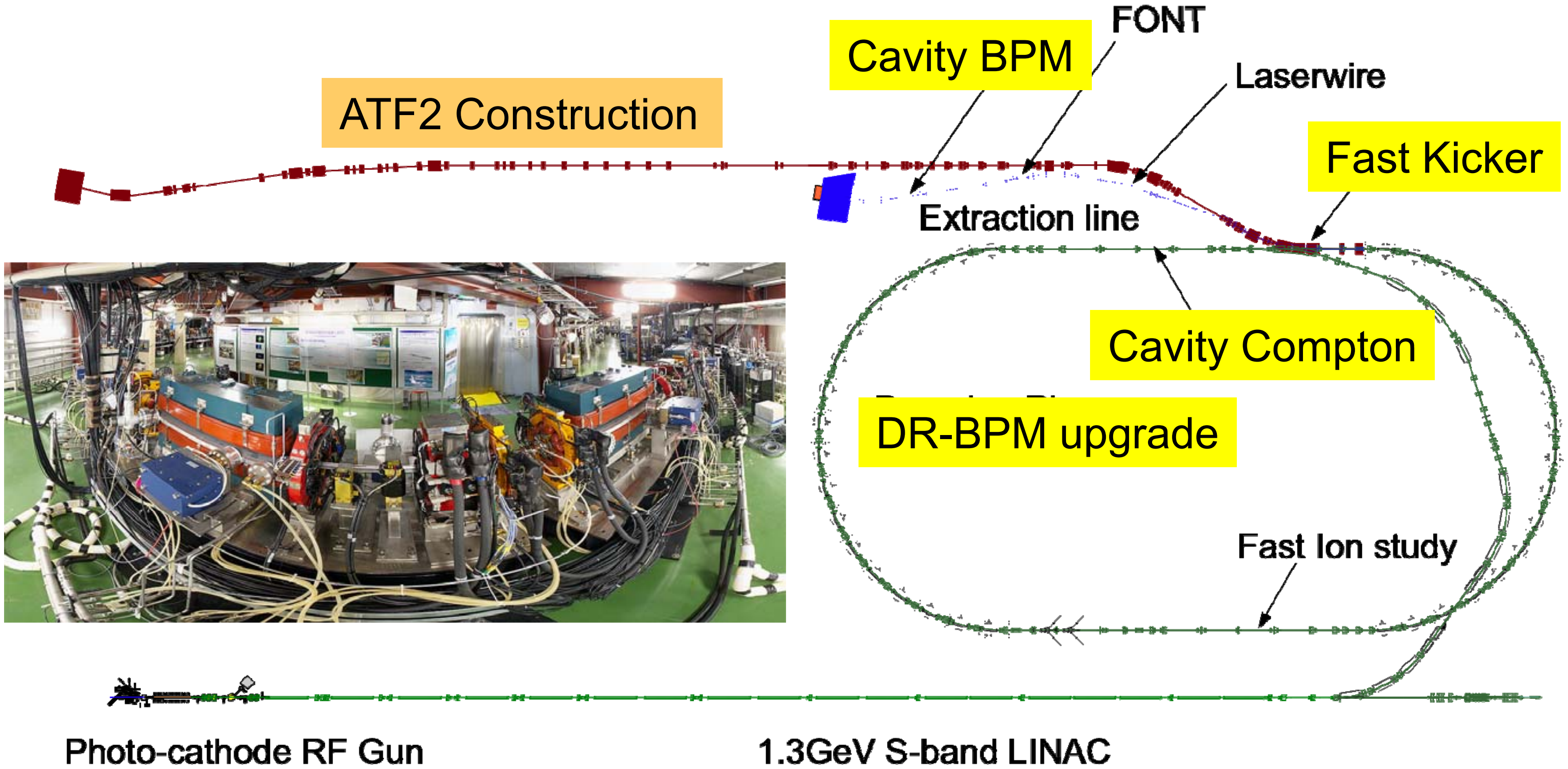
- Two **365.2m** long rings of racetrack shape @ **2.424GeV**
- Arcs filled with **TME cells** and straights with **2m-long superconducting** damping wigglers (**2.5T**, **5cm** period)
- Output emittance strongly dominated by **IBS**
- Issues to be addressed during **CLIC08**
  - Lattice optimization (magnet design, non-linear dynamics)
  - Superconducting wiggler design progress (NbTi/Nb_3Sn, radiation absorption)
  - Collective effects (e^- cloud, IBS)
  - RF system considerations
  - ILC/CLIC DR common issues
  - Pre-damping ring design (positron stacking)



M. Korostelev, PhD thesis, EPFL 2006



KEK ATF - Layout



Beam emittance preservation
Beam Dynamics, alignment and stability

Emittance blow-up from Damping Ring to BDS limited:
- **in Horizontal to 30% from 500 nrad**
- **in Vertical to 300% from 5 nrad**

Pre-alignment precision: 15 microns
Beam based alignement: 5-10 microns
Stability requirements (> 4 Hz) →

Magnet	Horiz.	Vert.
Linac (2600 quads)	14nm	1.3 nm
Final Focus (2quads)	4 nm	.15 to1 nm

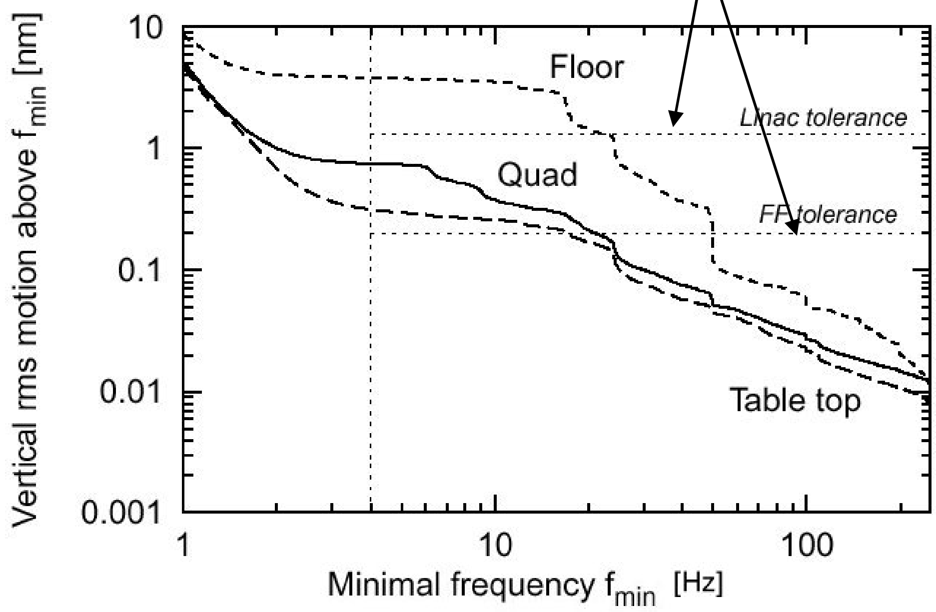
→ Need active damping of vibrations

Achieved stability

on CERN vibration test stand

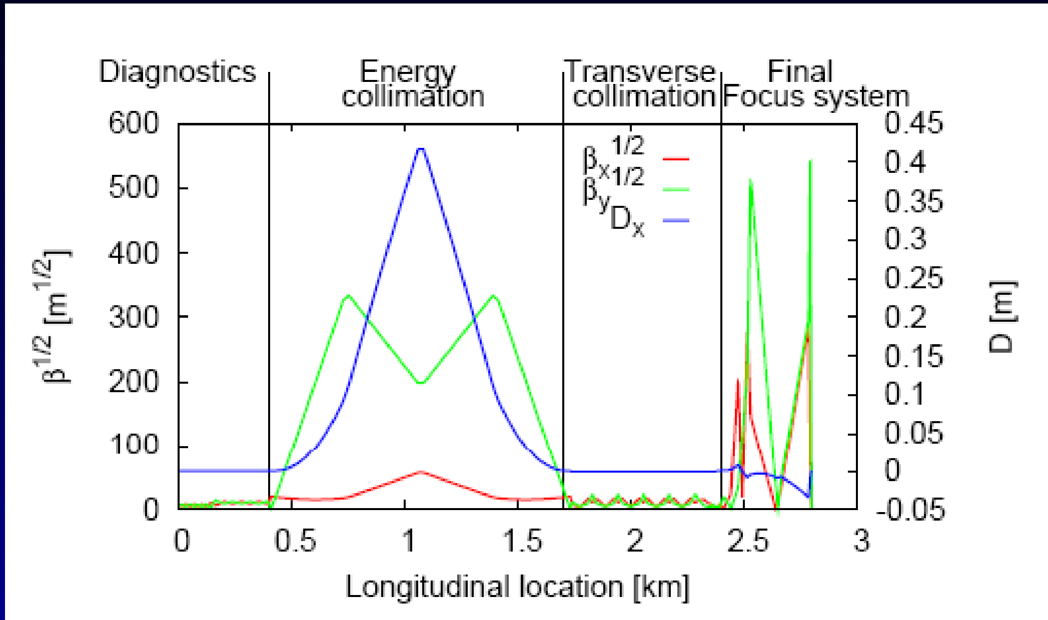
Test made in noisy environment, active damping reduced vibrations by a factor about 20, to rms residual amplitudes of:
Vert. 0.9 ± 0.1 nm
1.3 ± 0.2 nm with cooling water
Horiz. 0.4 ± 0.1 nm

CLIC tolerances

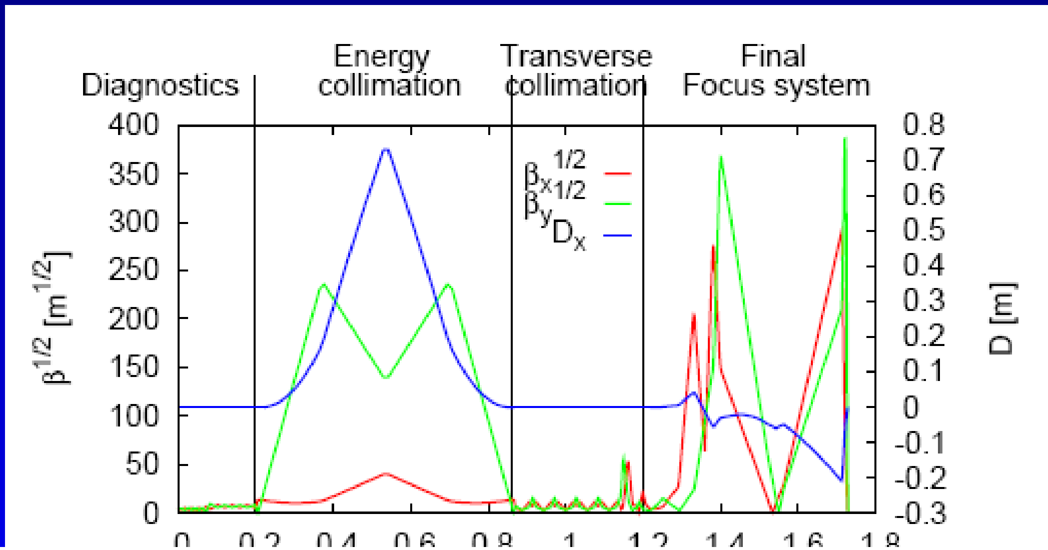


The CLIC BDS

3 TeV

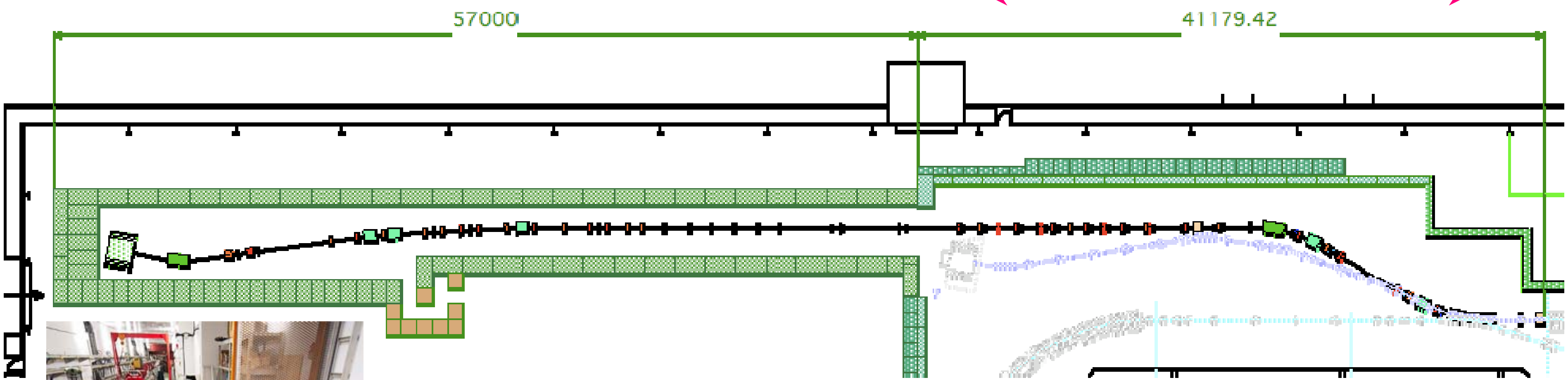


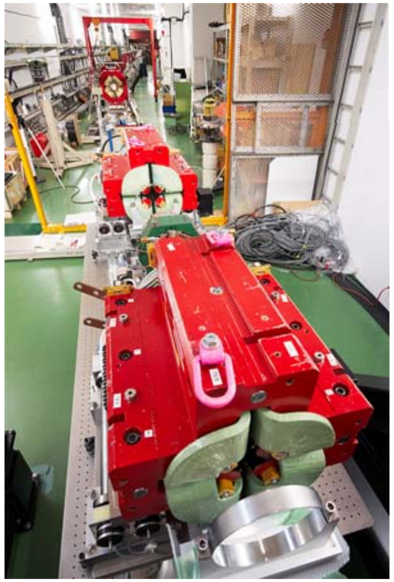
500 GeV

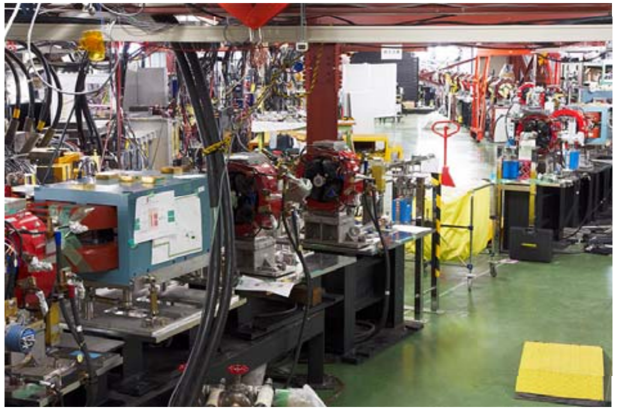


KEK ATF2 Layout

Final Focus System | β matching | Diagnostic | Extration line

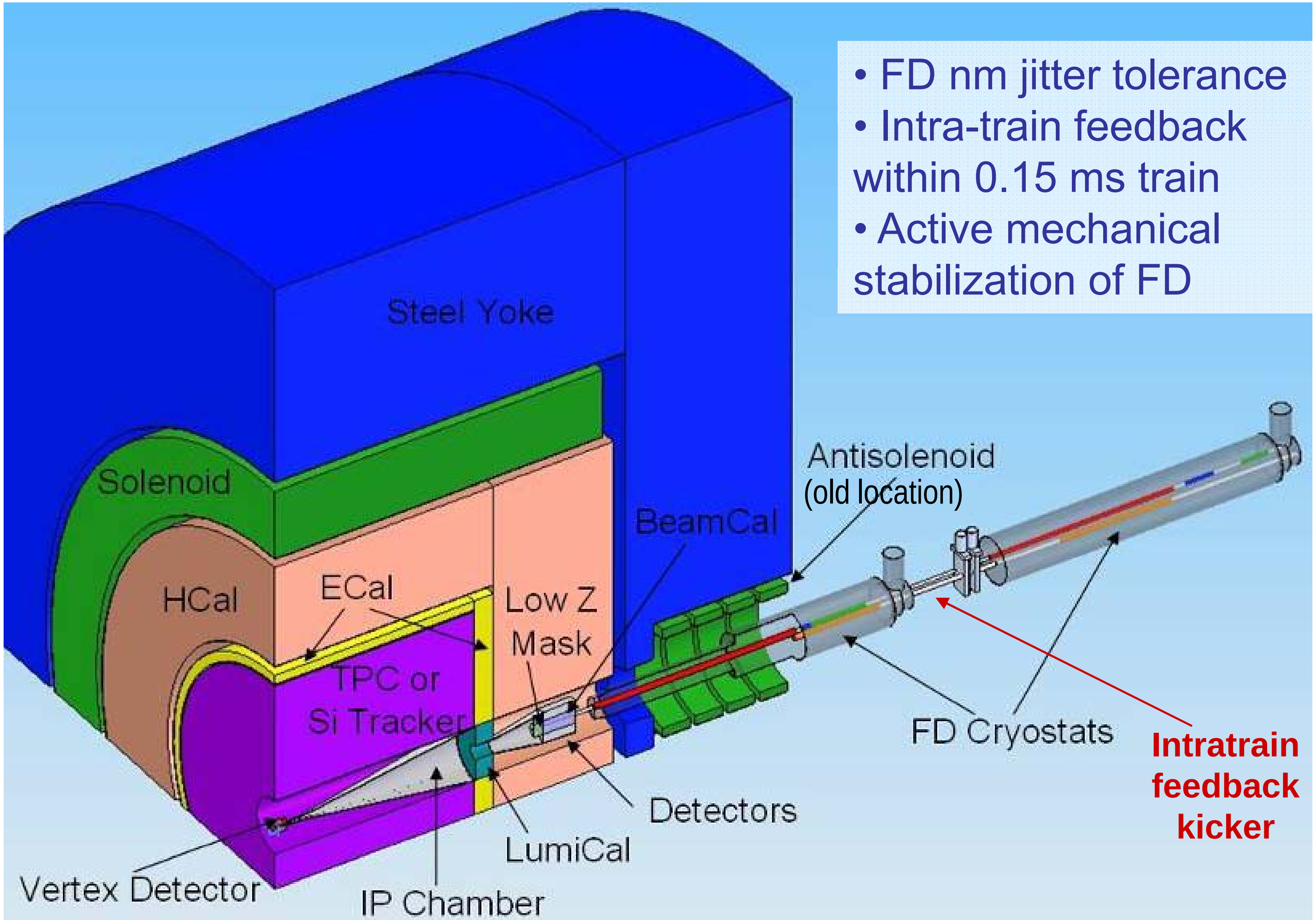




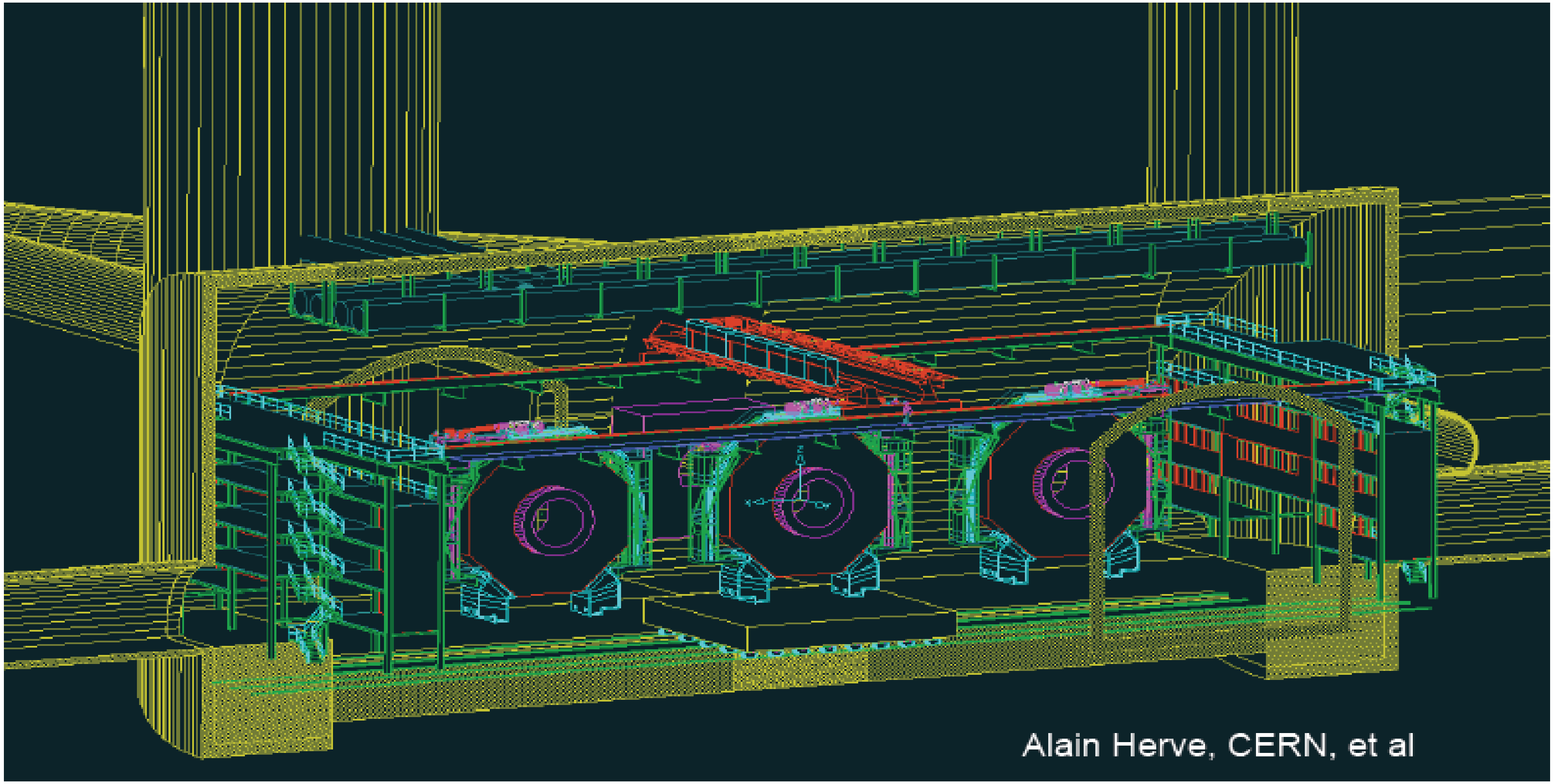


Machine Detector Interface

- FD nm jitter tolerance
- Intra-train feedback within 0.15 ms train
- Active mechanical stabilization of FD



Push-Pull studies for two detectors



30

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.

ICHEP

PARIS 2010

- Home
- Programme
- Committees
- Coordinators
- Conveners
- Submit abstract/p
- Registration
- List of participant
- Poster ICHEP2010

The French particle physics community is particularly proud to have been selected to host the 35th ICHEP conference in 2010 in Paris. This conference is the focal point of all our field since more than fifty years and is the reference

Final CLIC CDR report by end 2010

ECFA LC Workshop at CERN?

as evidence for the elusive Higgs boson, supersymmetry or new extra dimensions could therefore be announced at this conference! Spectacular discoveries in other domains such as gravitational waves, neutrino telescopes, neutrino oscillations, dark matter or in the flavour sector are also possible, just to name a few.

Secondly, 2010 will be a pivotal date to shape up the future of our field. Several major projects will present Conceptual or Engineering Design Reports during the conference. The International Linear Collider (ILC) Global Design Effort team has already decided

These reports and the LHC physics results mentioned above will

for key political decisions concerning future lepton colliders.

In summary, there can be no doubt that Paris is the place to be in summer 2010 for anyone interested in High Energy Physics and we will make every effort to make your stay as interesting and enjoyable as possible.

- Welcome
- ation
- ntact us
- ial program
- About Paris
- Transportation

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
…

Cost Reduction

Project Implementation Plan

International governance
Funding
Siting
Mass production models
…

R&D for Technical Risk Mitigation

International Project Proposal (2010)

Global Mass Production Models and Industrialisation

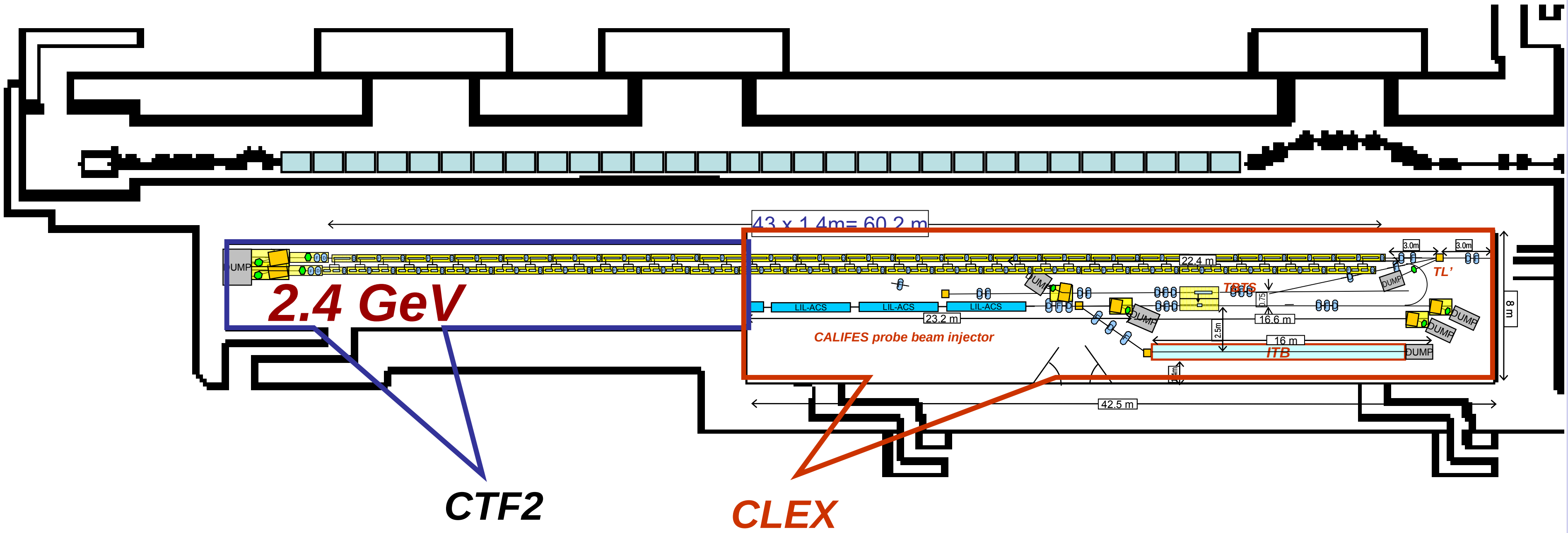
R&D based at Test Beam Facilities
- Europe (CTF3, SLS, …)
- Japan (ATF, ATF-2, Klystron lab at KEK)
- US (SLAC,CESR-TA at Cornell)

Main and Drive Linac components
-Klystrons
-…

Options for long term use of CTF3:

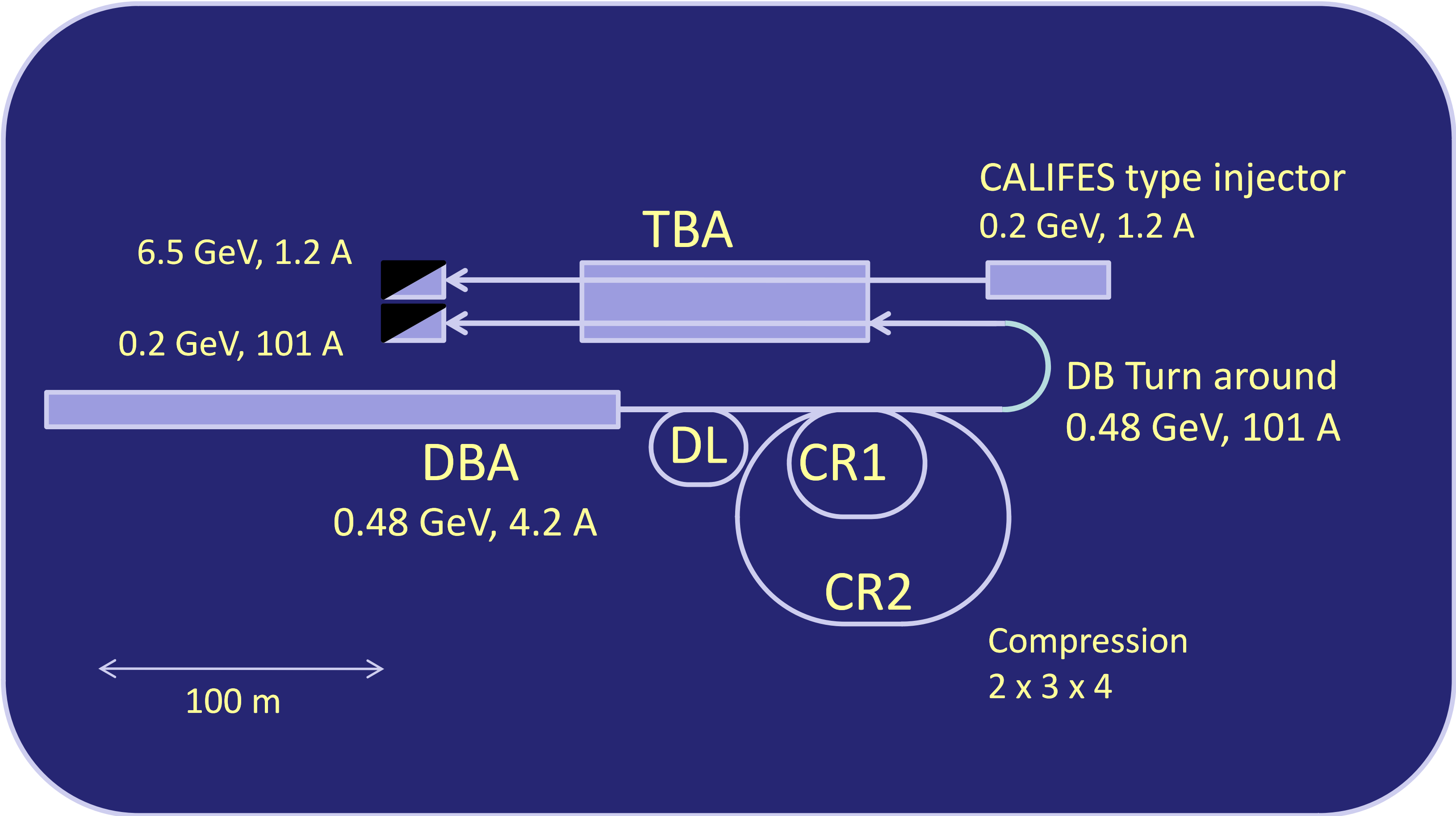
2.4 GeV Two beam X-band linac ?

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



A next facility towards CLIC: CLIC0 ?

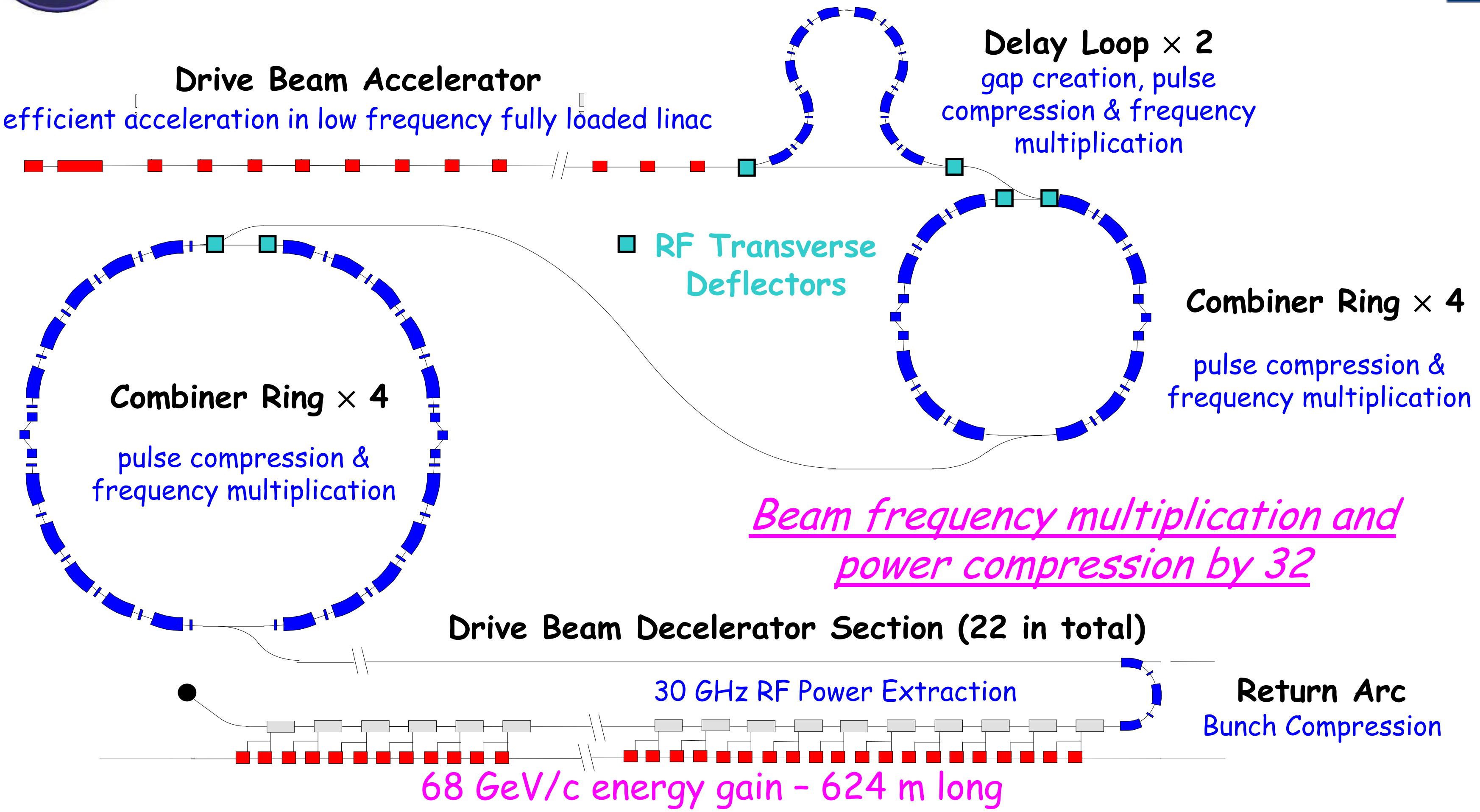
6.5 GeV Two Beam Accelerator

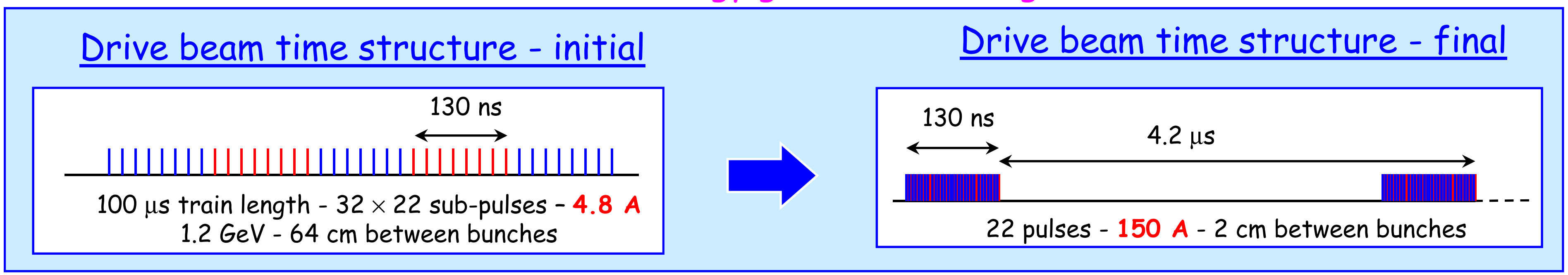


Staged approach?

Possible low energy Physics facilities which could be built with CLIC technology on the way towards a Linear Collider

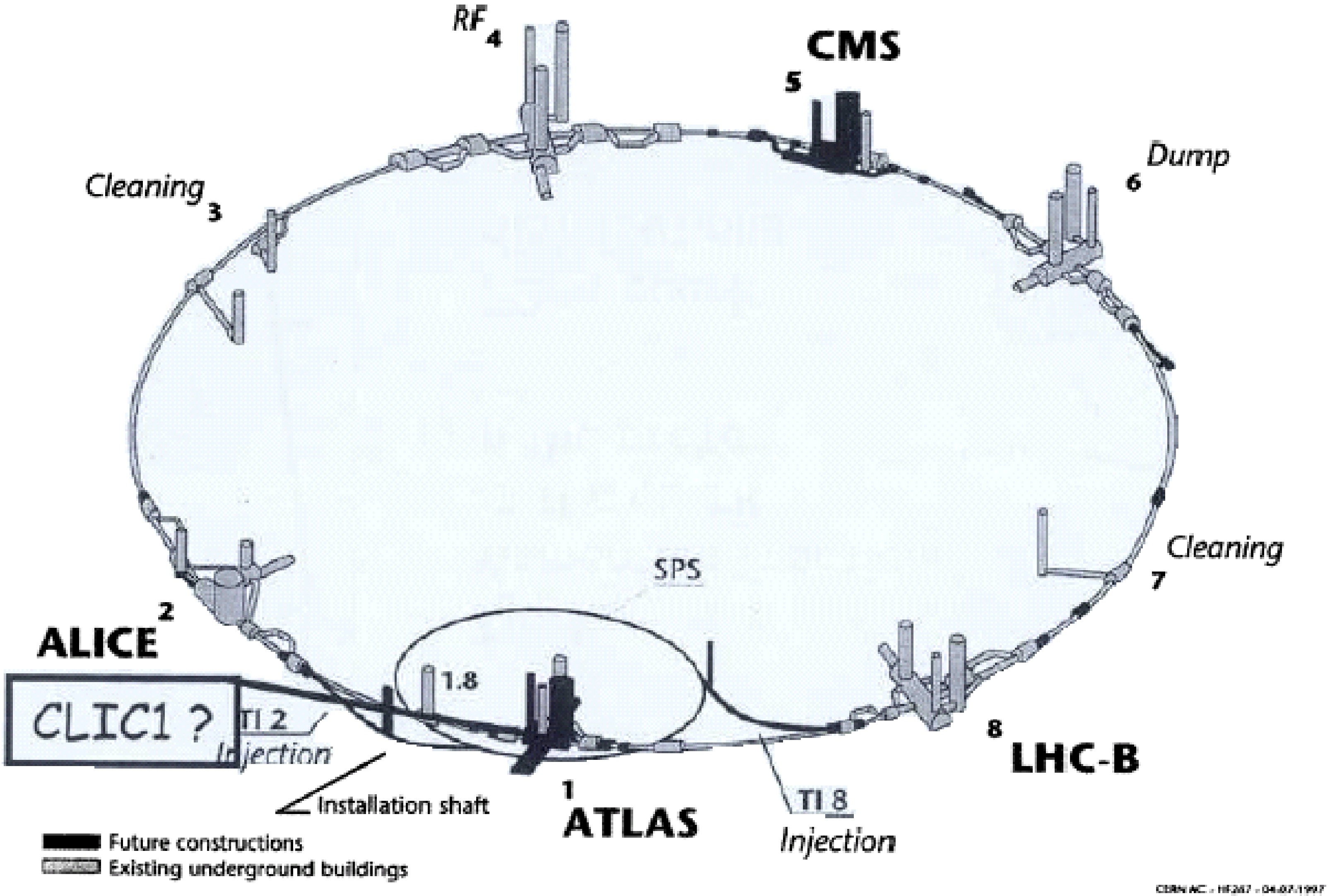
A single CLIC section: 50 to 62 GeV





LHC-CLIC1

(A de Roeck, D.Schulte, F.Zimmermann)



LHC Project Note 333

CLIC Note 589

08.01.2004

QCD Explorer Based on LHC and CLIC

D. Schulte, F. Zimmermann

Keywords: Linac-Ring Collider, Superbunches, Luminosity, Beam-Beam Interaction, Disruption

7 Summary

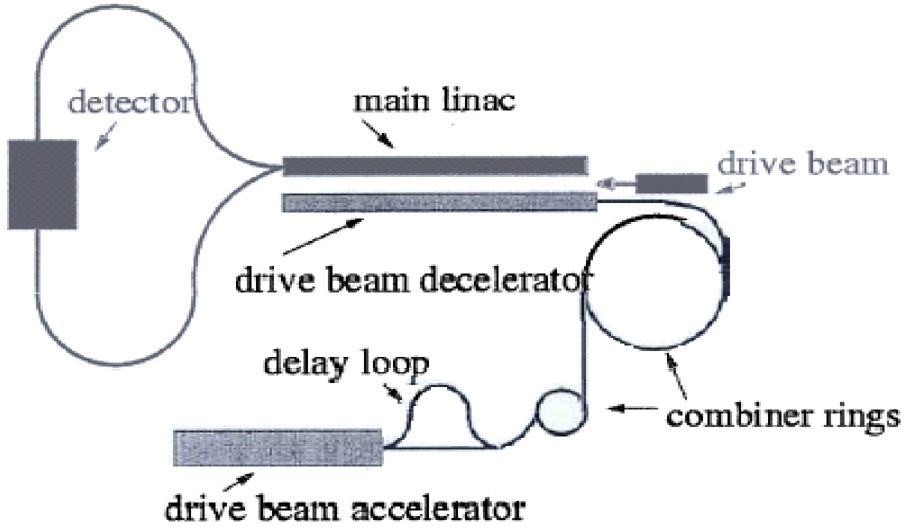
We have described a novel scheme for an ultimate QCD explorer based at CERN, where a portion of the 7-TeV LHC proton beam is repeatedly collided with 75-GeV electron bunch trains generated by a single CLIC drive-beam unit. This concept is attractive, since it exploits and fosters a large number of possible synergies between the LHC upgrade and the CLIC development in addition to its complementary physics-discovery potential. The estimated luminosity is in excess of 10^{31} cm^{-2}s^{-1}. If the nominal CLIC bunch spacing and train length were to be reduced in the future, the length and the total charge of the proton superbunch could be decreased as well for the same total luminosity.

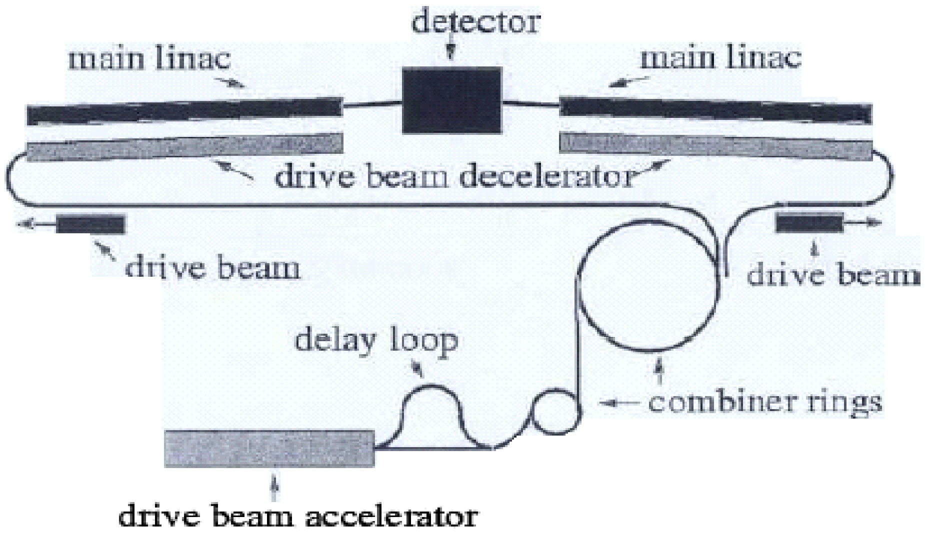
Finally, the collider concept outlined in this note strongly encourages further research in wide-band rf technologies required to create and maintain intense proton superbunches in the LHC. We note that first machine experiments with suitable novel rf units are underway at the KEK PS [7].

QCDE main parameters

	electrons	protons
energy	75 GeV	7 TeV
bunch population	$4x10^{9}$	$6.5x10^{13}$
Rms bunch length	35 μm	9 m
#bunches	154	1
effective pulse density	$2x10^{10}$ m^{-1}	$2x10^{12}$ m^{-1}
IP beta function	0.25 m	0.25 m
IP spot size	11 μm	11 μm
Interaction length	2 m	
Normalized emittance	73 μm	3.75 μm
Collision frequency	100 Hz	
luminosity	$1.1x10^{31}$ cm^{-2} s^{-1}	
beam-beam tune shift	N/A	0.004

Z factory with 1*1 CLIC section





Possible layouts

1 module + arc

2 modules

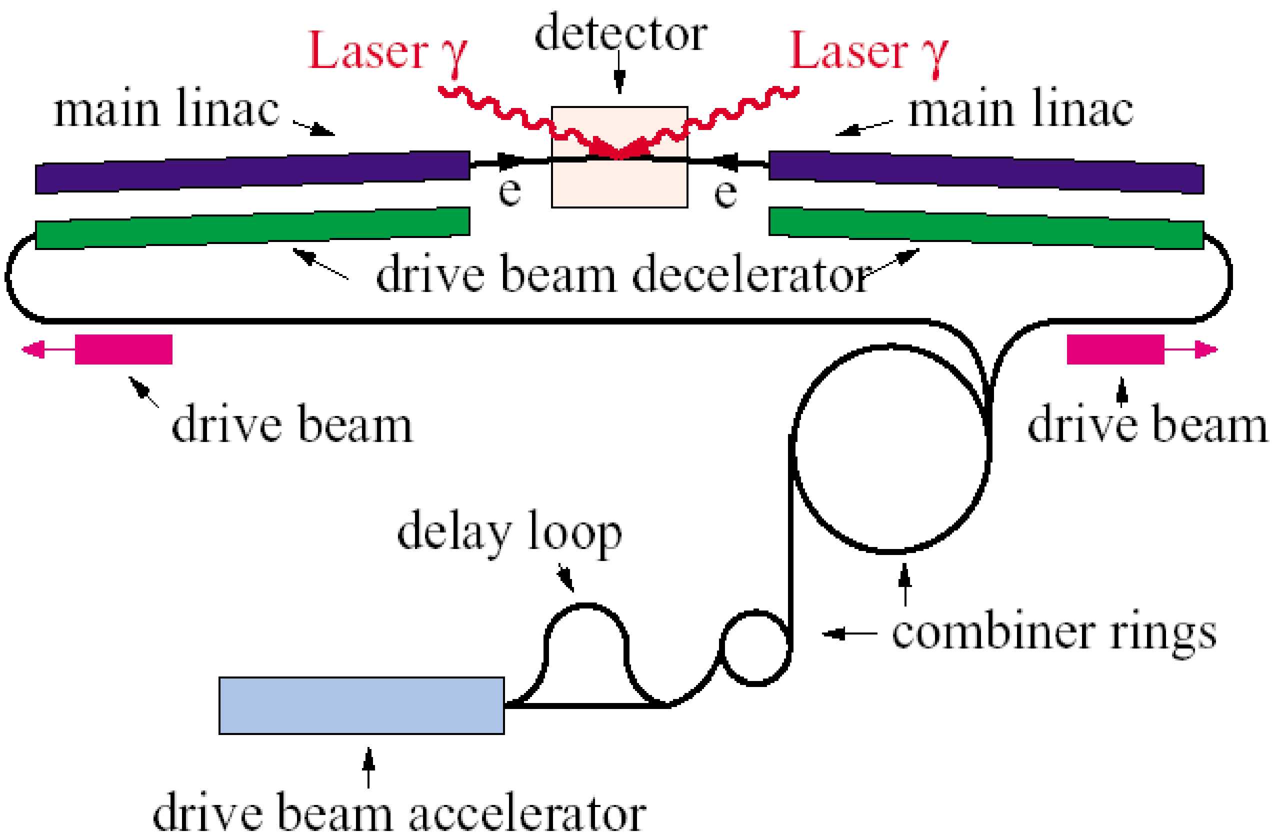
Latter is presently preferred

12

Z and W factory

- Electron to positron collisions at 90 GeV (Z) with two linacs made each by one CLIC section with an overall length of about 2.3 km
- Electron to positron collisions at 160 GeV (W) with two linacs made each by two CLIC sections with an overall length of about 4 km
- Linac at reduced gradient of 58 MV/m (nom. 80 MV/m @ 500 GeV)
- Luminosity (L1%) of 2 10^{33} cm^{-2} s^{-1} at Z and 6.5 10^{33} cm^{-2} s^{-1} at W
  - Simple energy scaling from 500 GeV design
- Luminosity improvement by linac filling with 5 consecutive pulses with power source dimensioned for 500 GeV operation
  - Possible cost savings by half of power source complex powering both linacs alternatively (To be studied)
- Luminosity (L1%) of 1.10^{34} cm^{-2} s^{-1} at Z and 2.10^{34} cm^{-2} s^{-1} at W
- Complete injector complex of electrons and positrons required with possible polarisation of electrons but not of positrons

CLIC HIGGS Experiment (CLICHÉ)



BNL-HET-01/32
CERN-PS-2001-062 (AE)
CERN-SL-2001-055 (AP)
CERN-TH-2001-235
CLIC-Note 500
HEP-PH/0111056
NUHEP-EXP/01-050
UCRL-JC-145692
Nov. 16, 2001

Higgs Physics with a $\gamma\gamma$ Collider Based on CLIC 1

D. Asner[1], H. Burkhardt[2], A. De Roeck[2], J. Ellis[2], J. Gronberg[1], S. Heinemeyer[3], M. Schmitt[4], D. Schulte[2], M. Velasco[4] and F. Zimmermann[2]

[1] Lawrence Livermore National Laboratory, Livermore, California 94550, USA
[2] CERN, CH-1211 Geneva 23, Switzerland
[3] Brookhaven National Laboratory, Upton, New York, USA
[4] Northwestern University, Evanston, Illinois 60201, USA

Abstract

We present the machine parameters and physics capabilities of the CLIC Higgs Experiment (CLICHE), a low-energy $\gamma\gamma$ collider based on CLIC 1, the demonstration project for the higher-energy two-beam accelerator CLIC. CLICHE is conceived as a factory capable of producing around 20,000 light Higgs bosons per year. We discuss the requirements for the CLIC 1 beams and a laser backscattering system capable of producing a $\gamma\gamma$ total (peak) luminosity of 2.0 (0.36) $\times 10^{34}$ cm^{-2}s^{-1} with $E_{CM}(\gamma\gamma) \sim 115$ GeV. We show how CLICHE could be used to measure accurately the mass, $\bar{b}b$, WW and $\gamma\gamma$ decays of a light Higgs boson. We illustrate how these measurements may distinguish between the Standard Model Higgs boson and those in supersymmetric and more general two-Higgs-doublet models, complementing the measurements to be made with other accelerators. We also comment on other prospects in $\gamma\gamma$ and $e^-\gamma$ physics with CLICHE.

Tentative CLICHÉ parameters

variable	symbol	value
total power consumption for RF	P	150 MW
beam energy	E	75 GeV
beam polarization	P_e	0.80
bunch population	N	4×10^9
number of bunches per train	n_b	154
number of trains per rf pulse	n_t	11
repetition rate	f_{rep}	100 Hz
rms bunch length	σ_z	30 μm
crossing angle	θ_c	$\geq$ 20 mrad
normalised horizontal emittance	ϵ_x	1.4 μm
normalised vertical emittance	ϵ_y	0.05 μm
nominal horizontal beta function at the IP	β_x^*	2 mm
nominal vertical beta function at the IP	β_y^*	20 μm
e^-e^- geometric luminosity	$\mathcal{L}$	0.9–4.8 $\times 10^{34}$ cm^{-2}s^{-1}

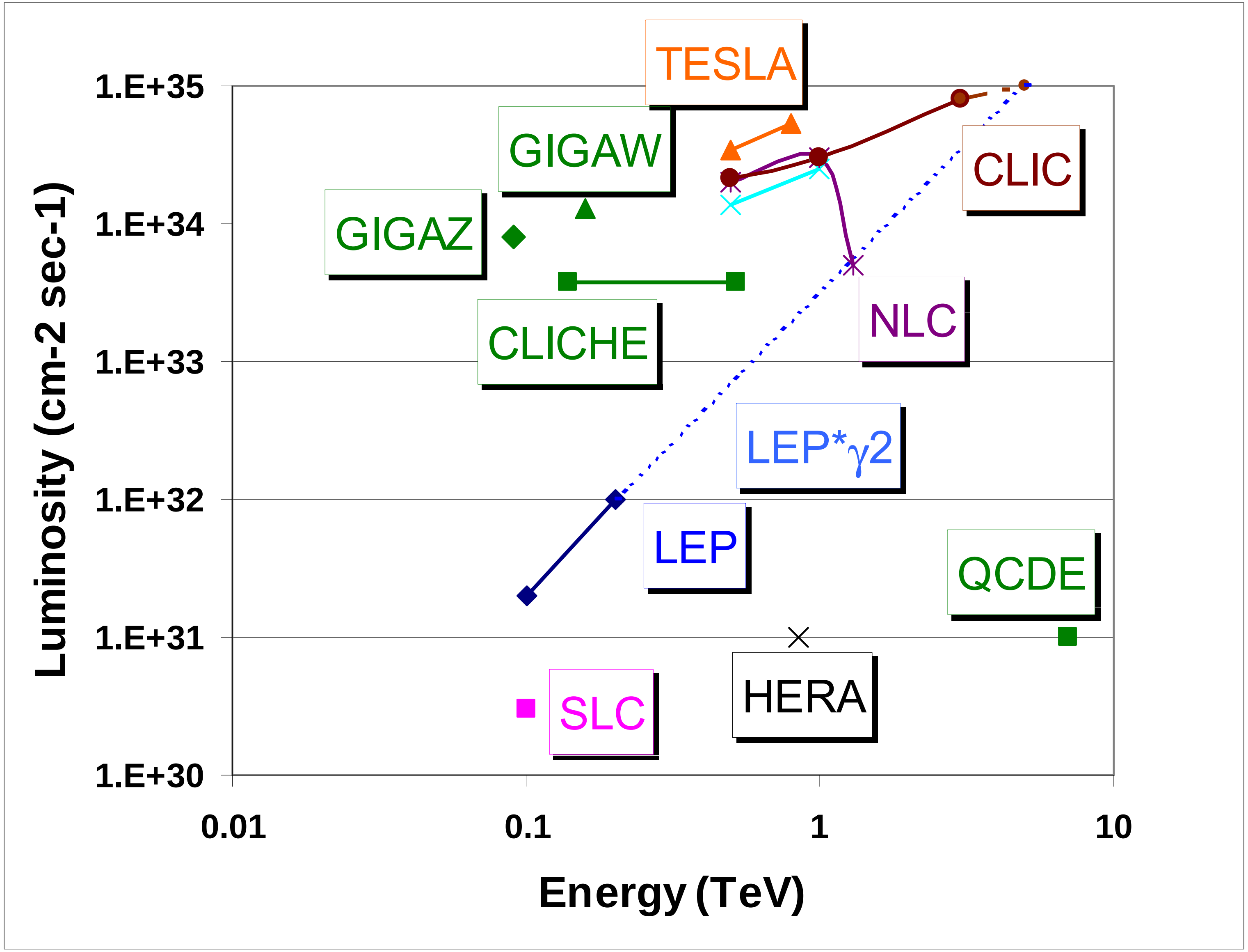
- **E-/E- geometric luminosity of 2 to 3 10^{34} cm^{-2} s^{-1} envisageable with linac filling with consecutive pulses**

Challenging Laser parameters

variable	symbol	value
Laser beam parameters		
Wavelength	λ_L	$0.351\ \mu m$
Photon energy	$\hbar\omega_L$	$3.53\ eV = 5.65\times10^{-19}\ J$
Number of laser pulses per second	N_L	$169400\,s^{-1}$
Laser peak power	W_L	$2.96\times10^{22}\ W/m^2$
Laser peak photon density		5.24×10^{40} photons/m^2/s
Photon beam		
Number of photons per electron bunch	N_γ	9.6×10^9
$\gamma\gamma$ luminosity	$\mathcal{L}_{\gamma\gamma}$	$2.0\times10^{34}\ cm^{-2}s^{-1}$
$\gamma\gamma$ luminosity for $E_{\gamma\gamma}\geq 0.6E_{CM}$	$\mathcal{L}^{peak}_{\gamma\gamma}$	$3.6\times10^{33}\ cm^{-2}s^{-1}$

- Parameters above assume unrealistic 11*100 e- beam repetition rate and 154*1100=169400 laser pulses /sec
- $\gamma\gamma$ luminosity of 3.8 10^{33} cm^{-2} s^{-1} (6.8 10^{32} cm^{-2} s^{-1} for E $\gamma\gamma$ > 0.6 Ecm) envisageable if accelerating structures shown to be able to handle 200 Hz repetition rate and laser with 30000 pulse/sec developed

Performances of CLIC based facilities



Conclusion

- CLIC work program well established and 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 and test of fully equipped structures (accelerating and PETS)
  - Technical feasibility issues: alignment, stabilisation, instrumentation, etc
- Conceptual Design Report publication by end 2010
  - First draft by the end of the year 2009
- Definition of Technical Design Phase
  - Task Force to deliver final report by mid 2009
  - Staged approach with low energy facility useful for Physics?
- CLIC Physics and Detectors R&D
- Fruitful CLIC/ILC collaboration
  - Towards a single LC community
- Excellent CLIC/CTF3 collaboration strong of 27 Institutes/15 countries
  - Additional Contributions and Newcomers Welcome

Spares

CLIC main parameters

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

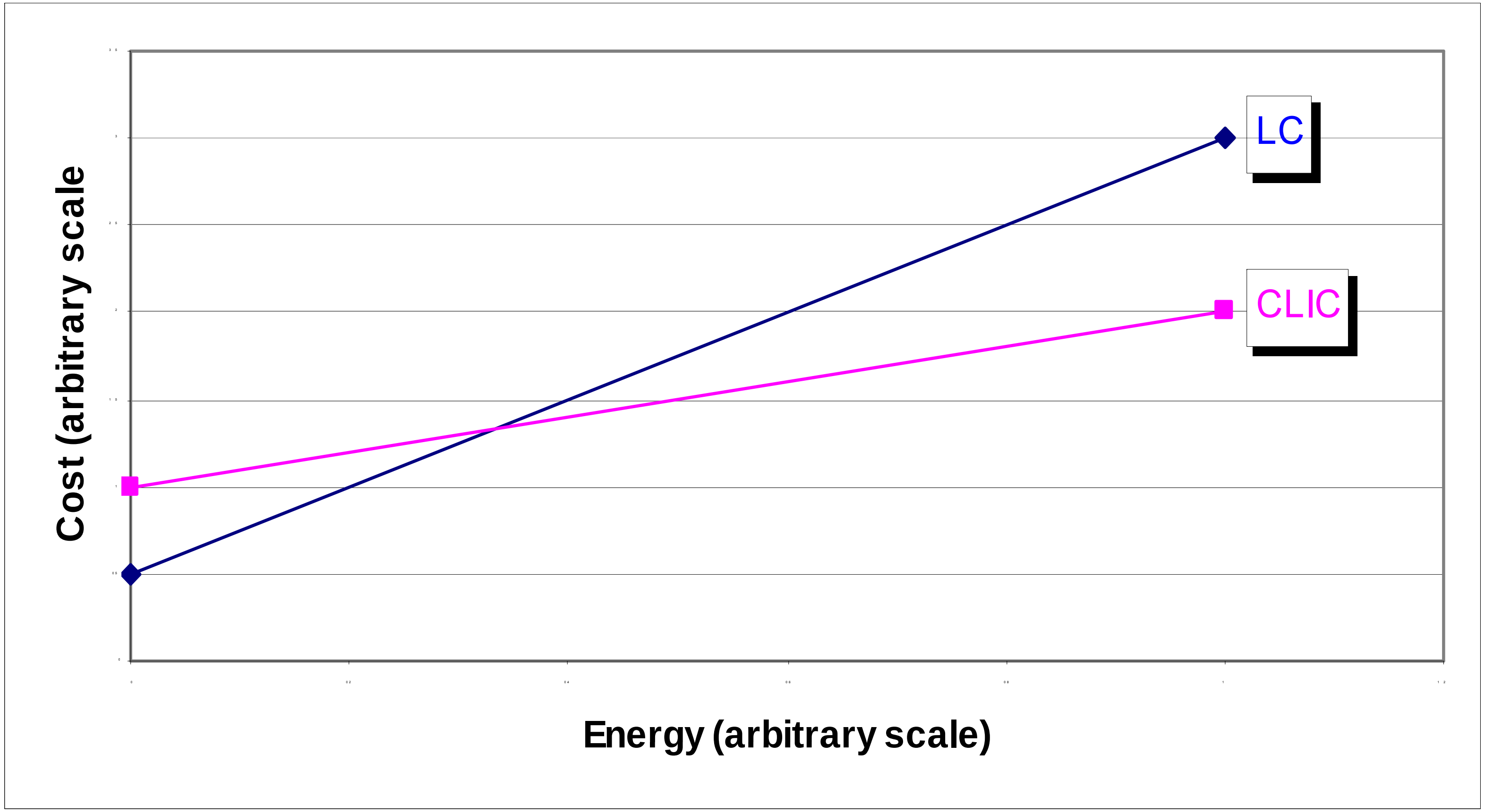
Center-of-mass energy	CLIC 500 G		CLIC 3 TeV	
Beam parameters	Conservative	Nominal	Conservative	Nominal
Accelerating structure	502		G	
Total (Peak 1%) luminosity	$0.9(0.6)\cdot10^{34}$	$2.3(1.4)10^{34}$	$1.5(0.73)10^{34}$	$5.9(2.0)\cdot10^{34}$
Repetition rate (Hz)	50			
Loaded accel. gradient MV/m	80		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	
[illegible]	[illegible]		[illegible]	

LC 500 GeV Main parameters

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

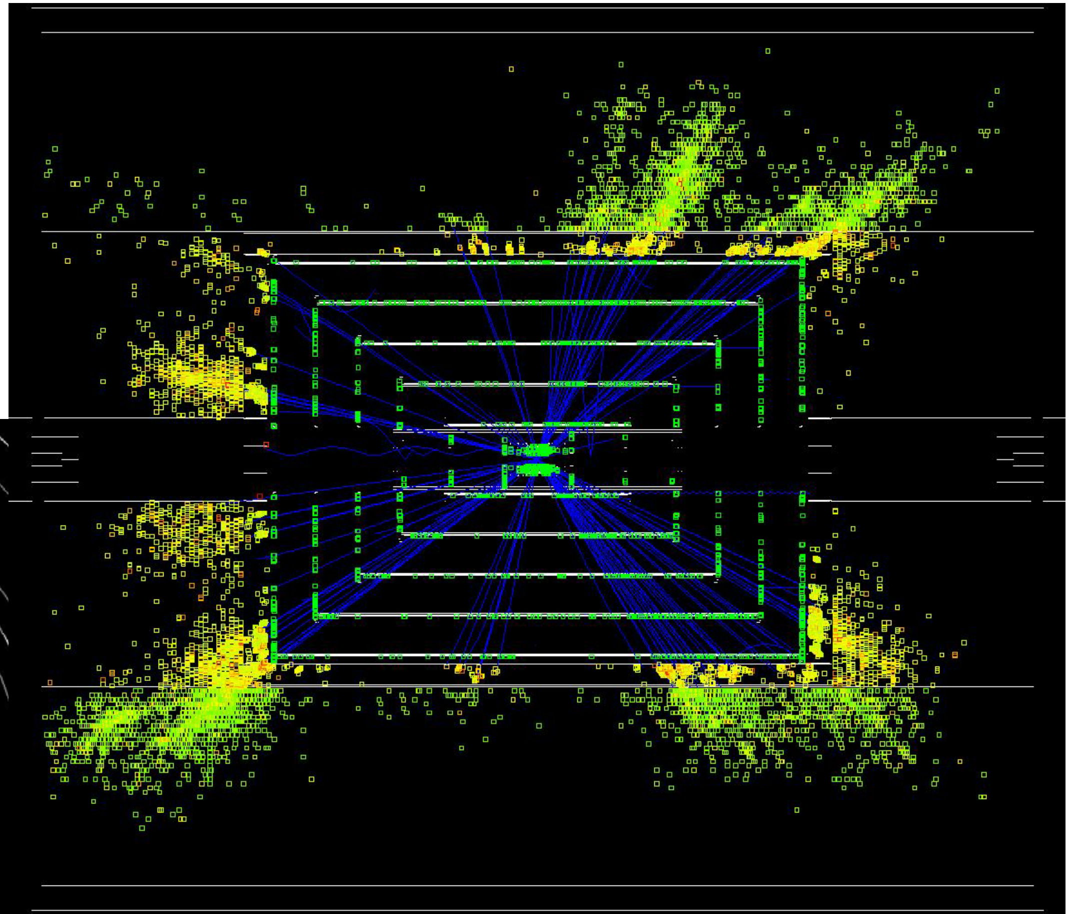
Center-of-mass energy	NLC 500 GeV	ILC 500 GeV	CLIC 500 G Conservativ	CLIC 500 G Nominal
Total (Peak 1%) luminosity	$2.0(1.3)\cdot10^{34}$	$2.0(1.5)\cdot10^{34}$	$0.9(0.6)\cdot10^{34}$	$2.3(1.4)\cdot10^{34}$
Repetition rate (Hz)	120	5	50	
Loaded accel. gradient MV/m	50	33.5	80	
Main linac RF frequency GHz	11.4	1.3 (SC)	12	
Bunch charge10^9	7.5	20	6.8	
Bunch separation ns	1.4	176	0.5	
Beam pulse duration (ns)	400	1000	177	
Beam power/linac (MWatts)	6.9	10.2	4.9	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	3.6/40	10/40	3 / 40	2.4 / 25
Hor/Vert FF focusing (mm)	8/0.11	20/0.4	10/0.4	8/0.1
Hor./vert. IP beam size (nm)	243/3	640/5.7	248 / 5.7	202/ 2.3
Soft Hadronic event at IP	0.10	0.12	0.07	0.19
Coherent pairs/crossing at IP	10?	10?	10	100
BDS length (km)	3.5 (1 TeV)	2.23 (1 TeV)	1.87	
Total site length (km)	18	31	13.0	
Wall plug to beam transfer eff.	7.1%	9.4%	7.5%	
Total power consumption MW	195	216	129.4	

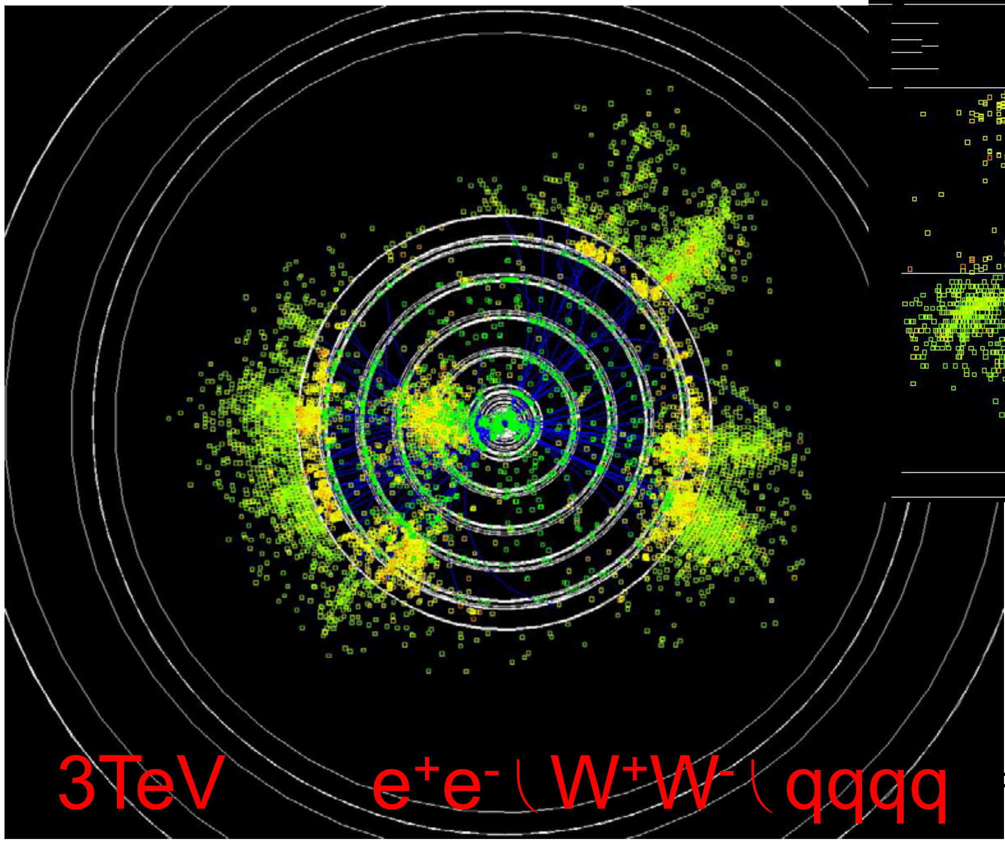
Relative cost of Linear Colliders



CLIC physics/detector studies have restarted

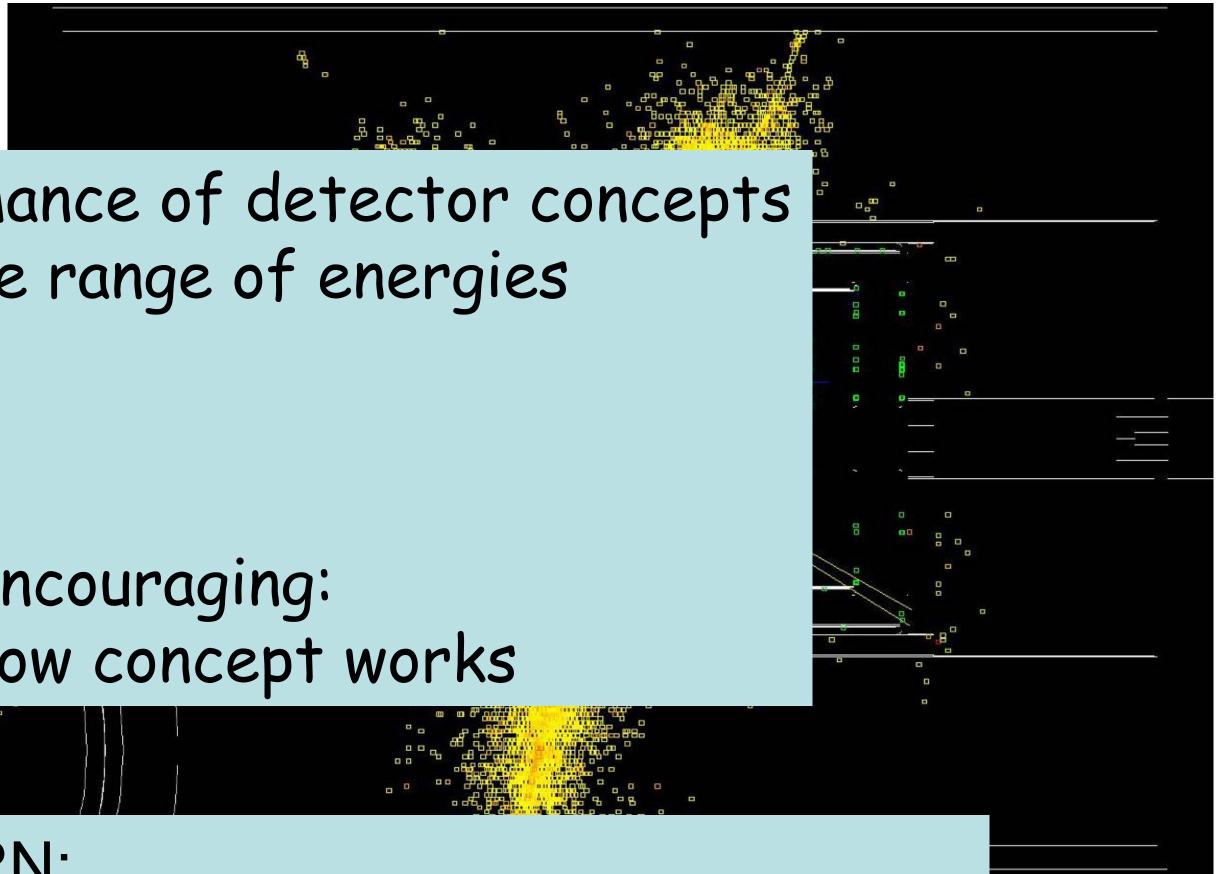
In preparation for CLIC Conceptual Design Report (CDR) by 2010
In collaboration with ILC detector community





CLIC-ILC Detector studies (R.Heuer)

W W @ 3 TeV



study performance of detector concepts over the entire range of energies

together

first results encouraging:
e.g. particle flow concept works

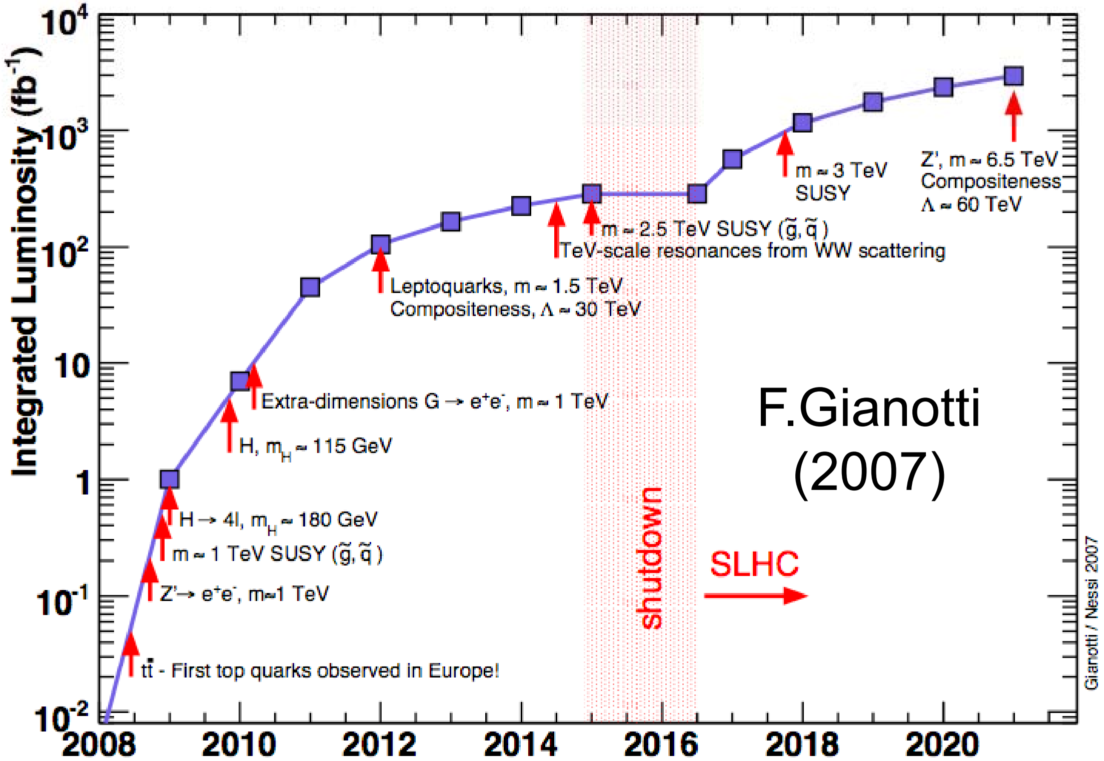
Next step at CERN:

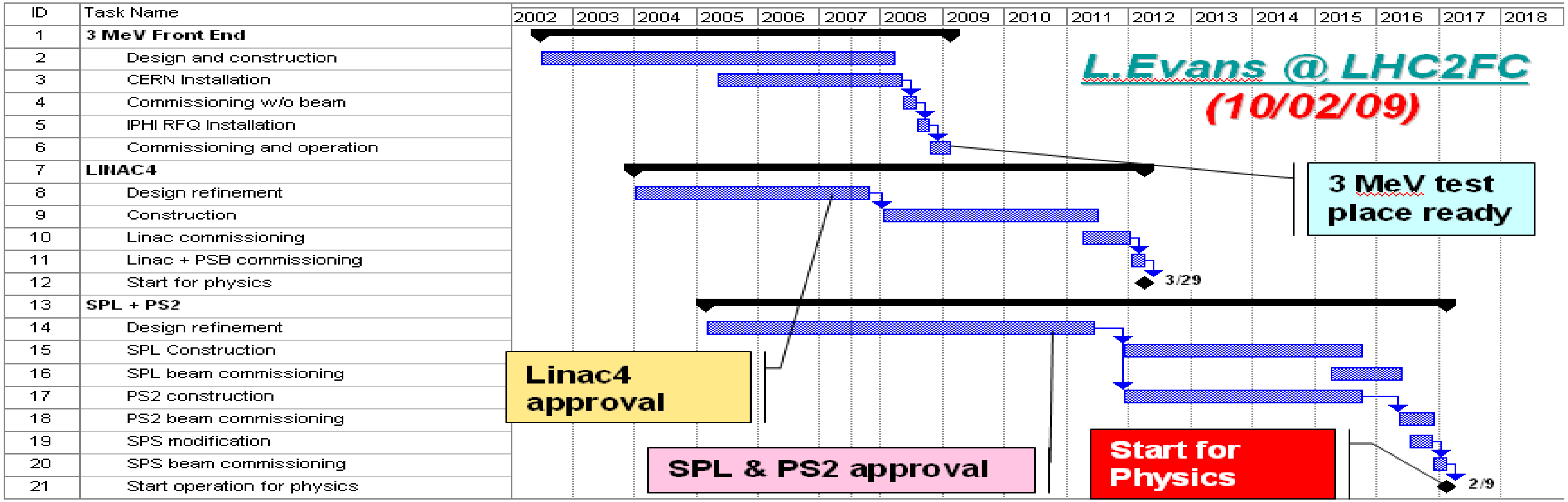
Install Project Group at CERN for LC Detector R&D starting January 2009

Detector Work plan: how to get started

- **Join present studies of ILC detectors (three concepts: SiD, ILD, 4th)**
- **Get started with SiD based simulation: (presently most well-defined)**
- **work on changes to the ILC concepts to match multi-TeV energies and CLIC conditions**
- **identification of additional cost wrt ILC concept**
- **define performance at 3 TeV**

Envisaged LHC schedule





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."

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

- **Funding Agencies for Large Projects (FALC):**
  - **09/01/09 in Madrid**

- **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.

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

- **Weekly CLIC meeting (Friday am, open):**

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

- **Annual CLIC workshop (12-16/10/09):**

http://indico.cern.ch/conferenceDisplay.py?confId=45580