Status and Future Prospects for CLIC

- Introduction
- CLIC design
- CLIC Test Facility (CTF 3) results
- Outlook and Conclusions

Steffen Döbert, LINAC 08, 29.9-3.10, 2008, Victoria, Canada

Introduction

CLIC = Compact Linear Collider (length ~ 50 km)

Goal: Design for a 3 TeV e^+e^- linear collider

ICFA: 'LC is necessary to complement LHC physics'

→ ILC (0.5 TeV) or CLIC (3TeV) depending on LHC results

European strategy for particle physics

'to be well positioned to push the energy frontier,
R&D on CLIC should be intensified
as well as on high performance magnets and on high intensity neutrino facility'

Present:
Mandate at CERN for a feasibility study with a CDR in 2010

What is so special about CLIC

High-Frequency and High-Gradient normal conducting rf:

Accelerating gradient: 100 MV/m

RF frequency: 12 GHz

Two beam scheme:

Low-energy high-current drive beam

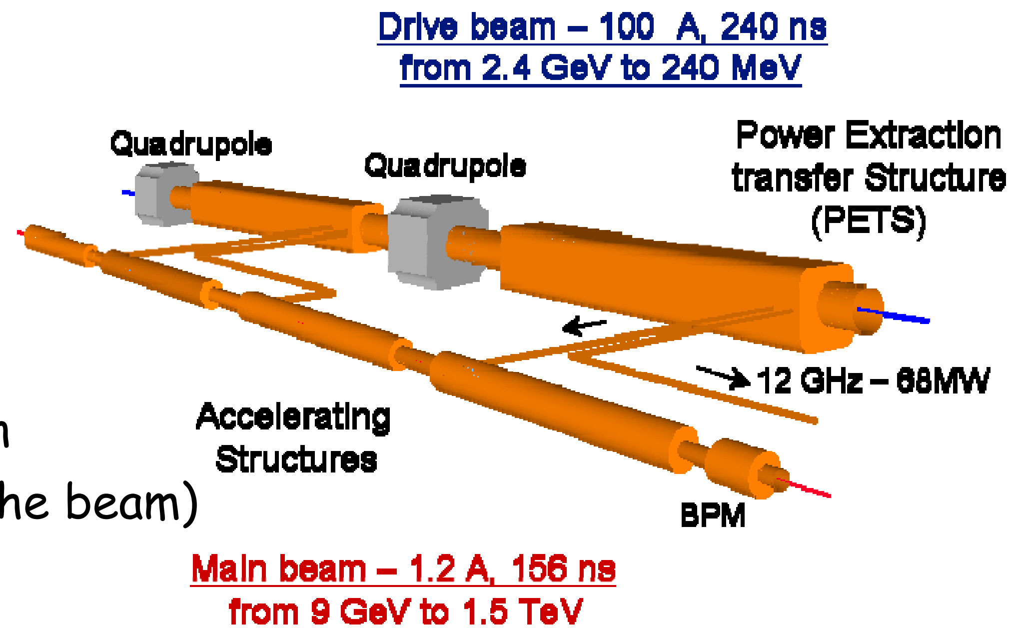
High-energy low-current main beam

Sophisticated drive beam generation

(high Q rf pulse compression using the beam)

Power extraction structure:

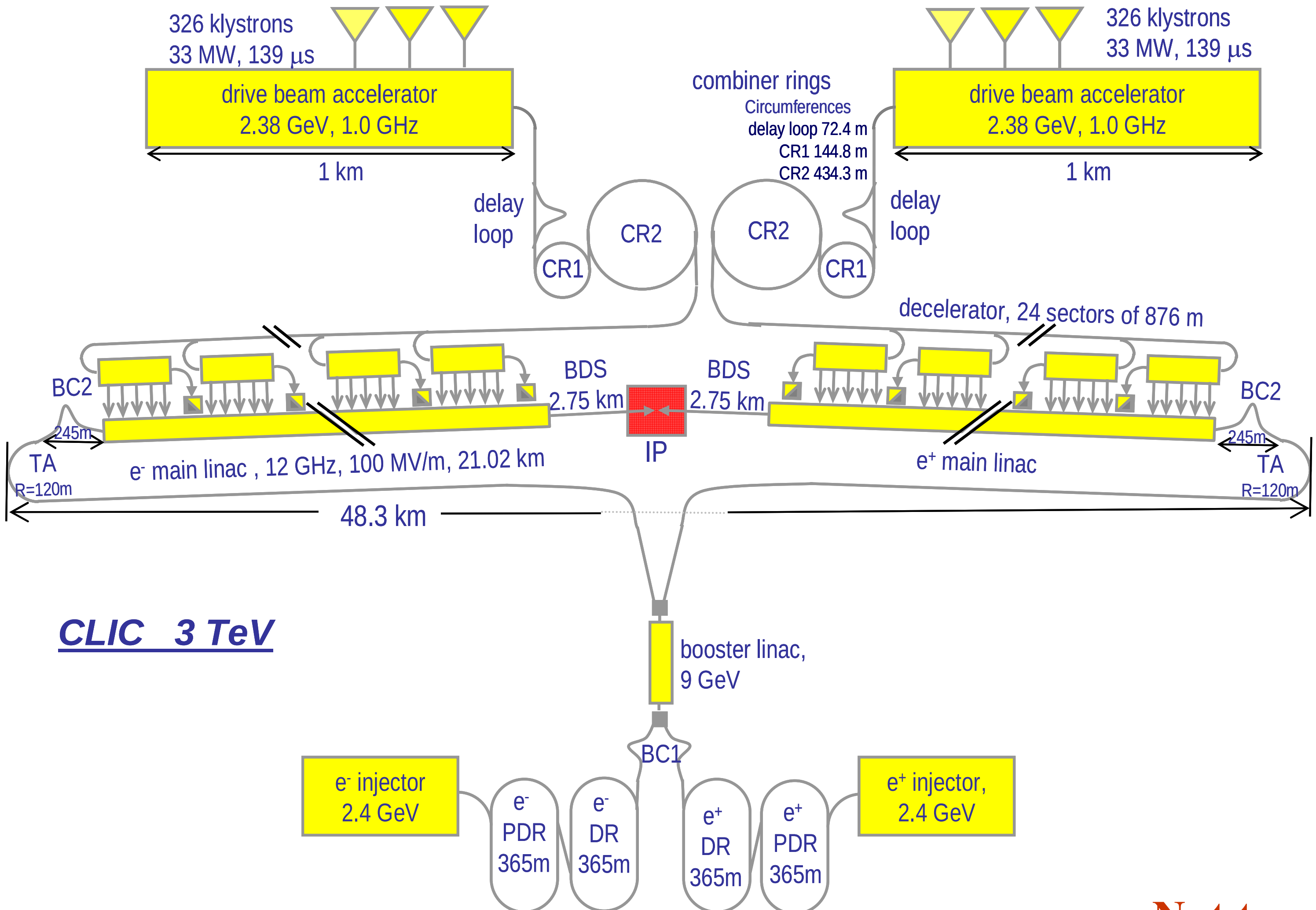
136 MW, 0.21 m long



Main accelerator structure:

64 MW input power, 0.23 m long

CLIC schematic layout



CLIC 3 TeV

Not to scale!

CLIC 3 TeV parameters

Center-of-mass energy	3 TeV
Peak Luminosity	$5.9 \cdot 10^{34}$ 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	$3.72 \cdot 10^{9}$
Bunch separation	0.5 ns
Beam pulse duration	156 ns
Beam power/beam	14 MW
Hor./vert. normalized emittance	660 / 20 nm rad
Hor./vert. IP beam size bef. pinch	40 / 1 nm
Total site length	48 km
Total power consumption	389 MW

New Main Beam accelerating structure

Structure optimization taking into account:

Rf constraints, Beam dynamics, collider performance and cost

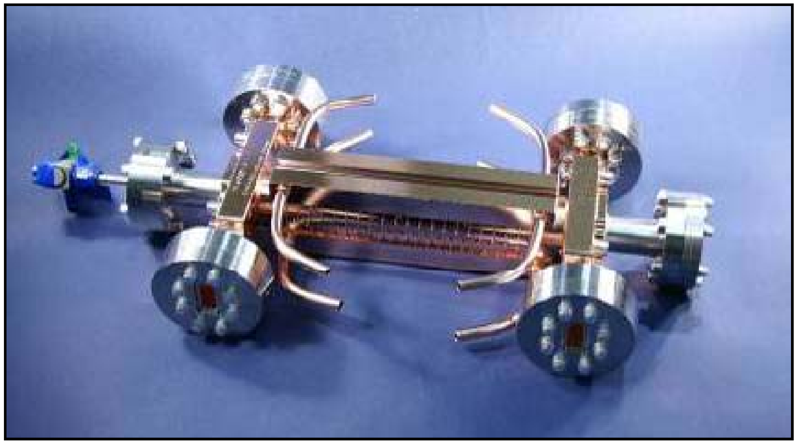
Structure	TD24vg1.7
Frequency: f [GHz]	12
Average iris radius/wavelength: $\langle a \rangle/\lambda$	0.11
Input/Output iris radii: $a_{1,2}$ [mm]	3.15, 2.35
N. of reg. cells, str. length: N_c, l [mm]	24, 229
Bunch separation: N_s [rf cycles]	6
Filling time, rise time: τ_f, τ_r [ns]	62.9, 22.4
Pulse length: τ_p [ns]	240.8
Input power: P_{in} [MW]	63.8
Max. surface field: E_{surf}^{max} [MV/m]	245
Max. temperature rise: ΔT^{max} [K]	53
Efficiency: η [%]	27.7

See Poster, THP062, A. Grudiev

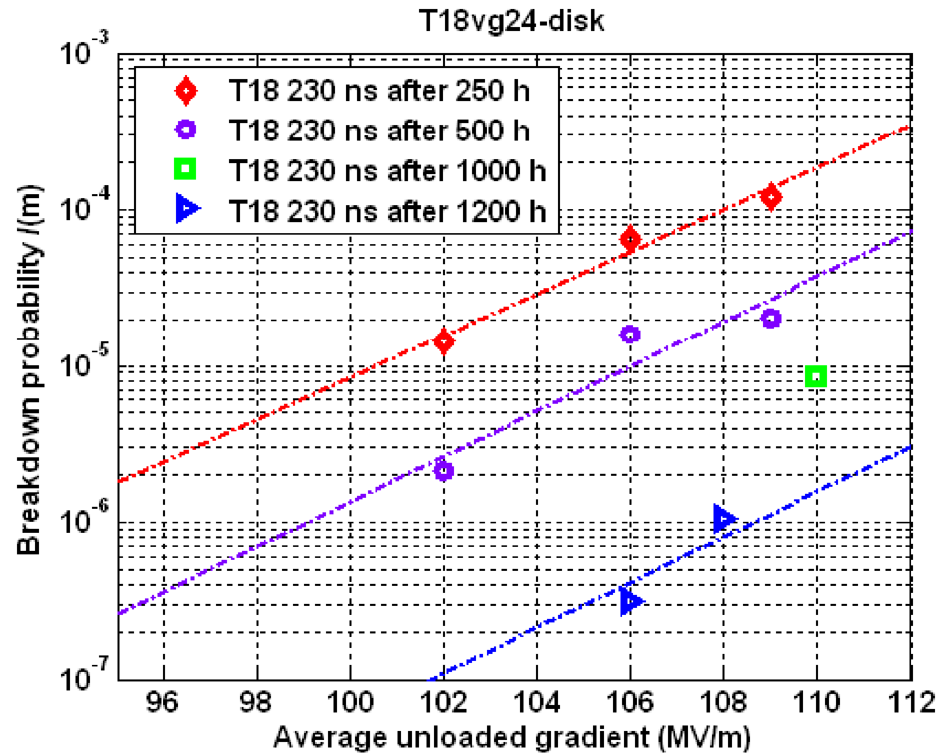
Prototype accelerating structure

Collaboration between KEK, SLAC and CERN

High Power test of T18_VG2.4_disk [1]



Frequency:	11.424 GHz
Cells:	18+2 matching cells
Filling Time:	36 ns
Length: active acceleration	18 cm
Iris Dia. a/λ	0.155~0.10
Group Velocity: vg/c	2.6-1.0 %
Phase Advace Per Cell	2π/3
Power for <Ea>=100MV/m	55.5 MW
Unloaded Ea(out)/Ea(in)	1.55
Es/Ea	2



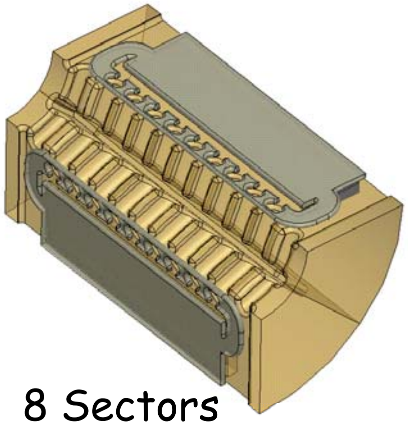
CLIC goal: trip rate < 3 10^{-7}/m

→ Proof of principle !
No HOM damping yet

See Poster, THP061, TUP057

Deceleration structure

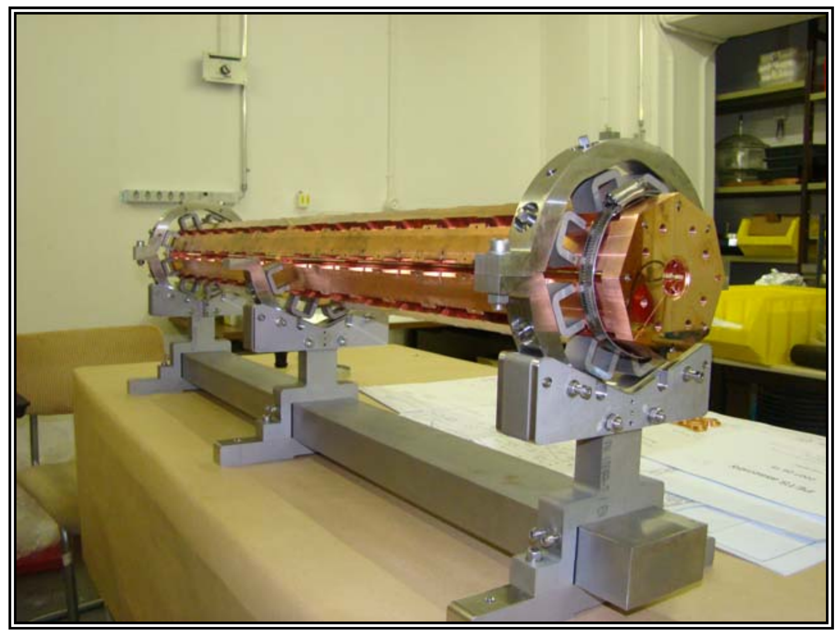
Power Extraction and Transfer Structure (PETS)



8 Sectors
damped
on-off possibility

Special development for CLIC

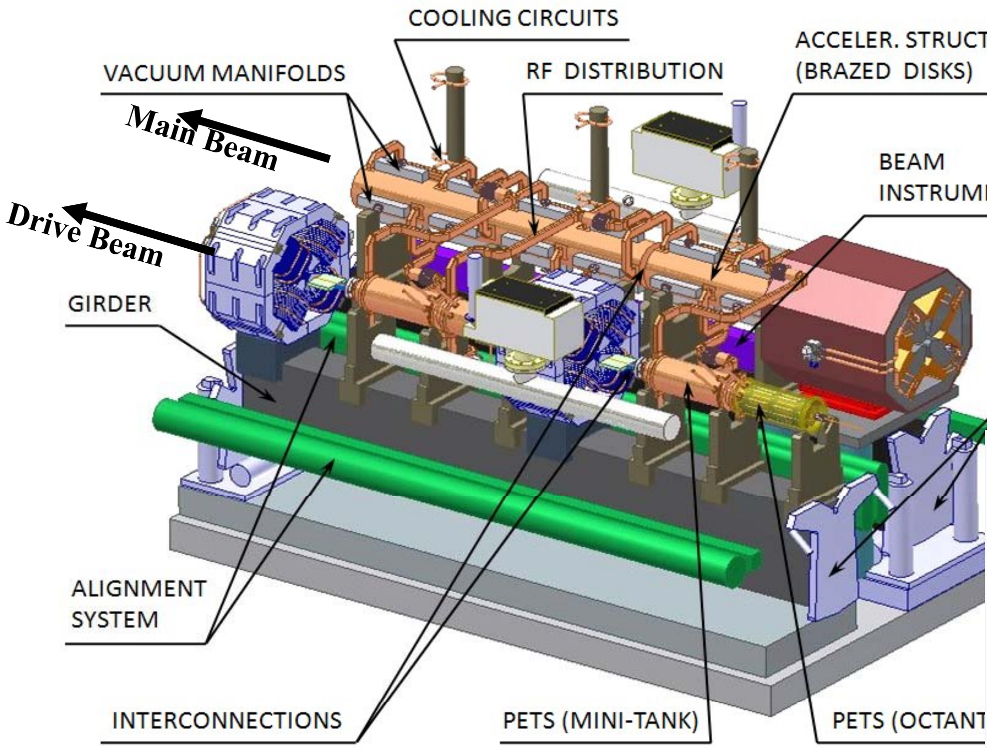
- Travelling wave structures (136 MW for 240 ns per structure)
- Small R/Q : 2.2 kΩ/m (accelerator: 15-18 kΩ/m)
- High group velocity vg/c = 48 %
- 0.21 m active length (~ 36000 needed per linac)
- 100 A beam current



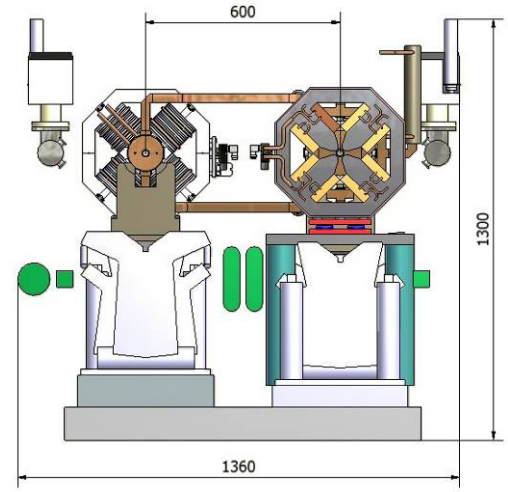
Status:
RF power testing at SLAC and
with beam in CTF3 at the end of 2008

ref: Igor Syratchev

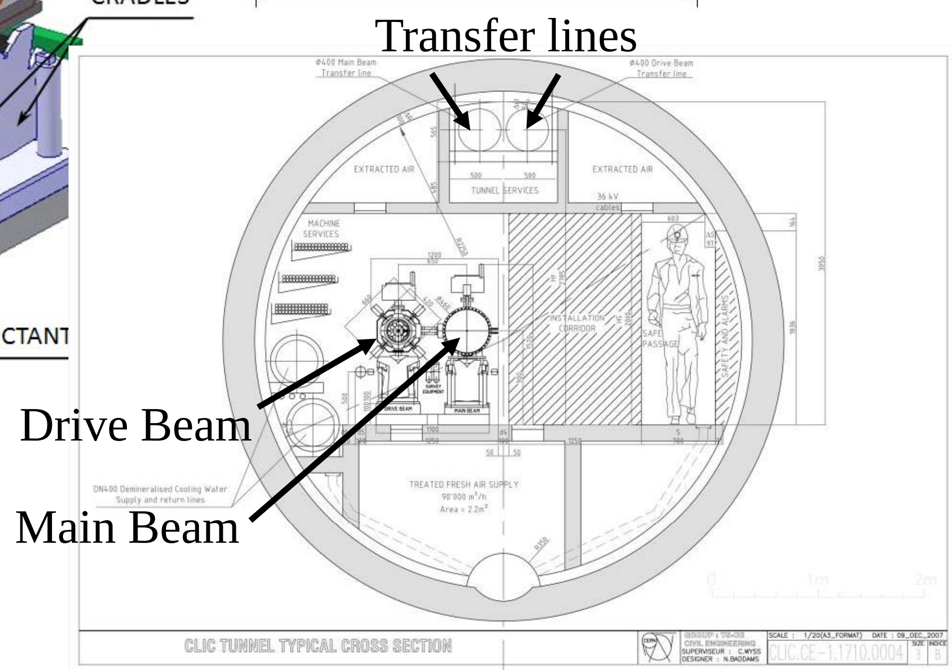
CLIC module



COOLING CIRCUITS
VACUUM MANIFOLDS
RF DISTRIBUTION
ACCELER. STRUCTURE (BRAZED DISKS)
Main Beam
Drive Beam
BEAM INSTRUMENTATION
GIRDER
CRADLES
ALIGNMENT SYSTEM
INTERCONNECTIONS
PETS (MINI-TANK)
PETS (OCTANT



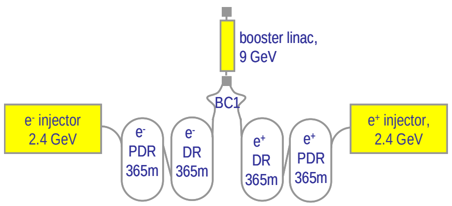
600
1300
1360



Transfer lines
Drive Beam
Main Beam
EXTRACTED AIR
TUNNEL SERVICES
MACHINE SERVICES
TREATED FRESH AIR SUPPLY
CLIC TUNNEL TYPICAL CROSS SECTION

Beam quality and preservation

Generating ultra low emittance beams:



CLIC has two damping rings each for e^+ and e^-

output DR: $\gamma\varepsilon_x$=381 / $\gamma\varepsilon_y$= 4.1 nm rad

for $4.1 \cdot 10^9$ particles at 2.4 GeV

Key issues: high field wiggler, e^--cloud

Preserving ultra low emittance beams:

Beam size at Interaction Point (rms) : σ_x = 40 nm, σ_y = 1 nm

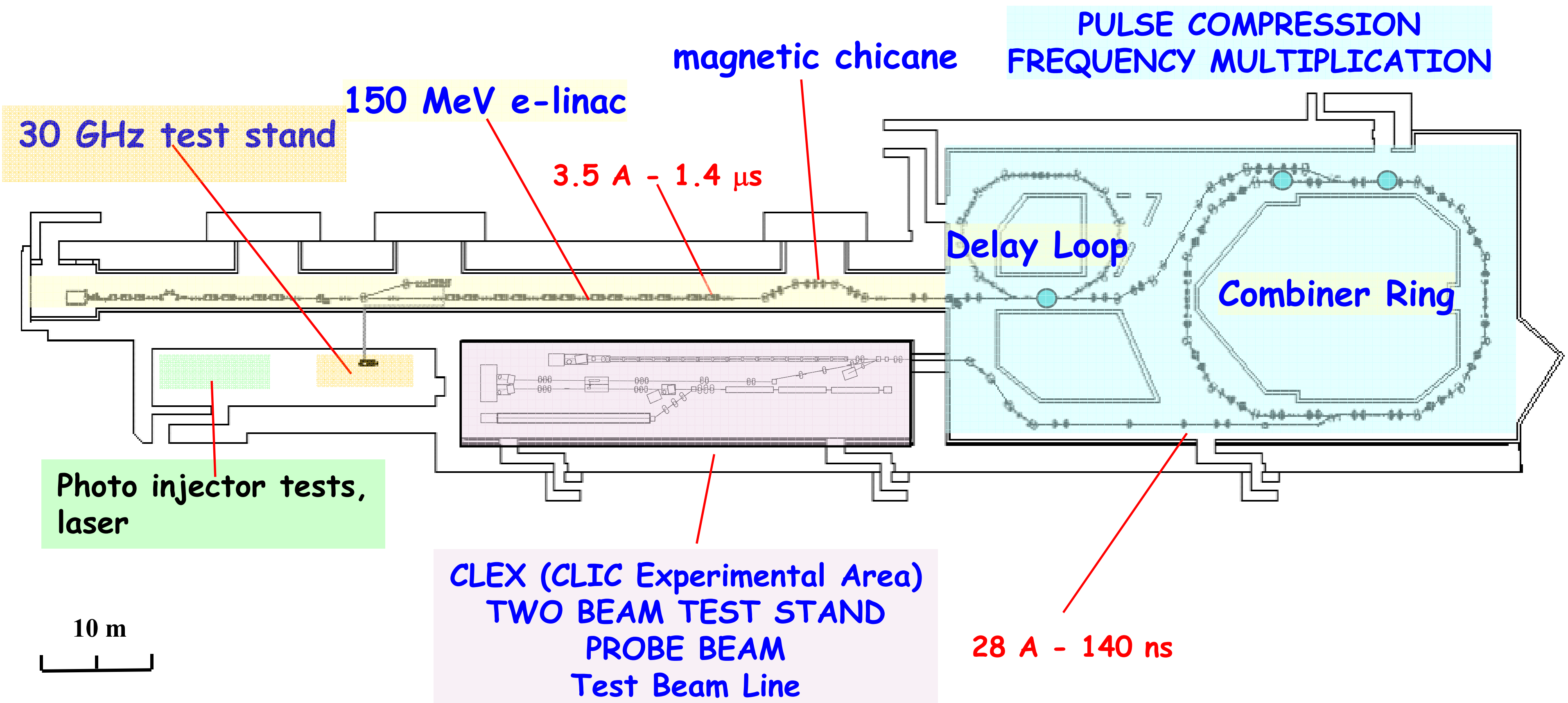
Jitter tolerances

	Final Focus quadrupoles	Main beam quadrupoles
Vertical	~0.2 nm > 4 Hz	~1 nm > 1 Hz
Horizontal	2 nm > 4 Hz	5 nm > 1 Hz

Proof-of-principle:
quadrupole stabilized
to < 0.5 nm
in vertical plane

CLIC Test Facility: CTF3

Facility to demonstrate critical issues for CLIC



total length about 140 m

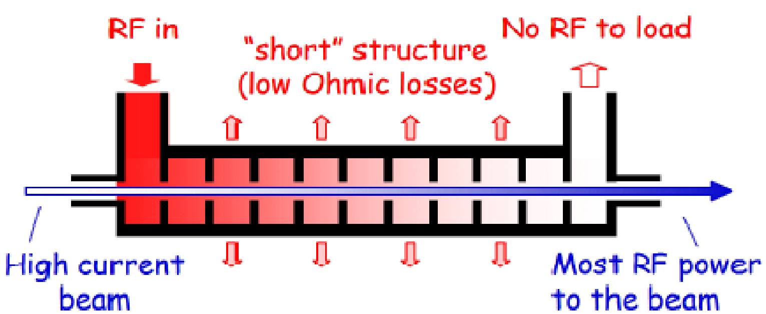
CTF3 vs CLIC

CTF3 is scaled down from CLIC and uses existing infrastructure:
<u>Main goals:</u>
→ Demonstrate CLIC drive beam generation
→ Demonstrate 12 GHz rf structure with two beam acceleration
→ Demonstrate stable and efficient deceleration with test beam line

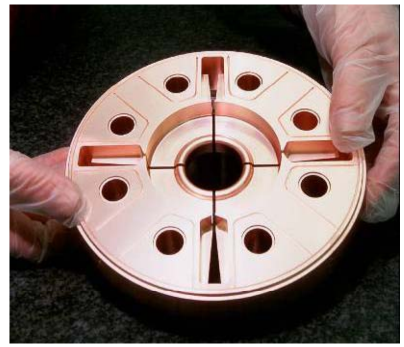
	CLIC	CTF3
Drive Beam energy	2.4 GeV	150 MeV
compression / frequency multiplication	24 (Delay Loop + 2 Combiner Rings)	8 (Delay Loop + 1 Combiner Ring)
Drive Beam current	4.2 A*24 → 101 A	3.5 A*8 → 28 A
RF Frequency	1 GHz	3 GHz
train length in linac	139 µs	1.5 µs
energy extraction	90 %	~ 50 %

Fully loaded drive beam linac

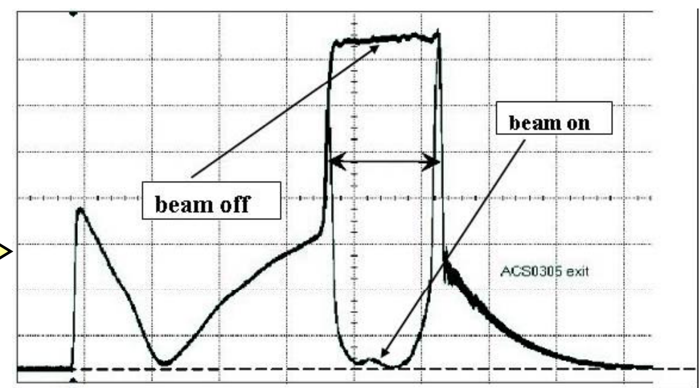
Proof of one of the major CLIC features:
Full Beam Loading



Drive Beam accelerating structure:



RF to beam transfer:
95.3 % measured

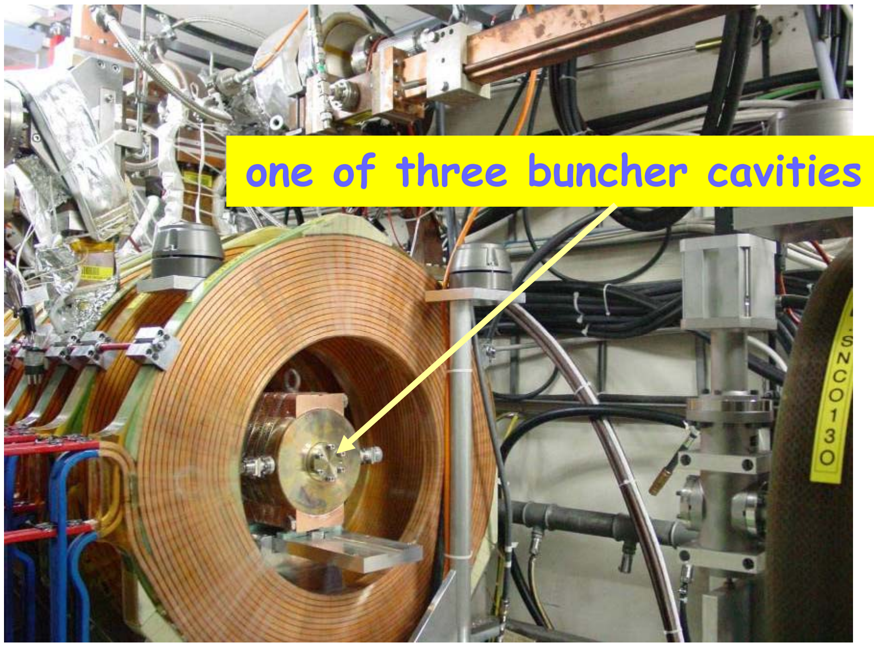


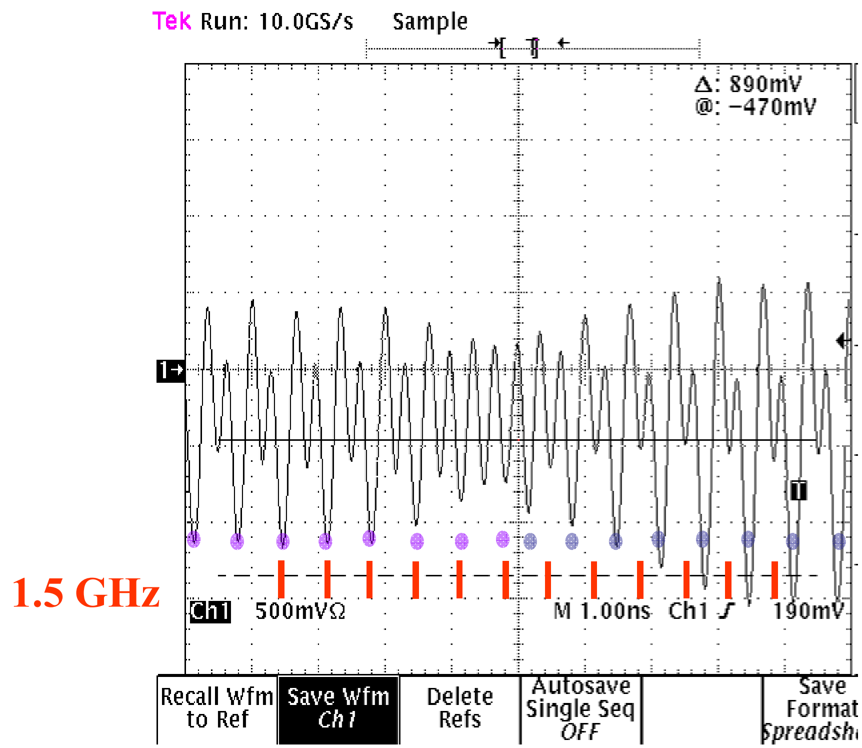
RF power at output of accelerating structure

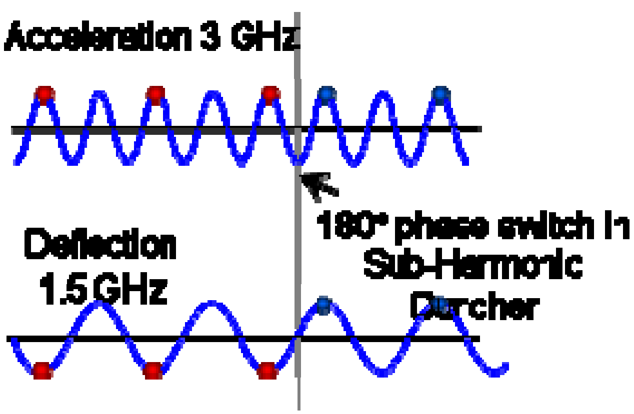
Linac routinely operated with full beam loading

See Poster, TUP081, A. Dabrowski

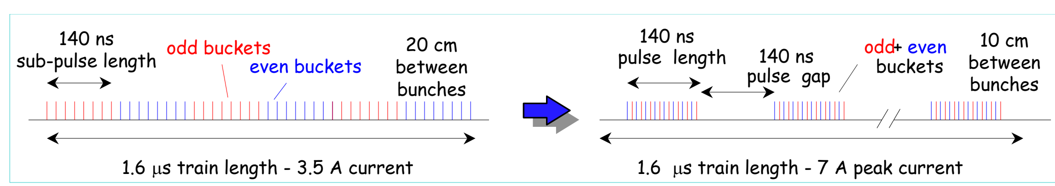
Phase coding with sub-harmonic buncher's





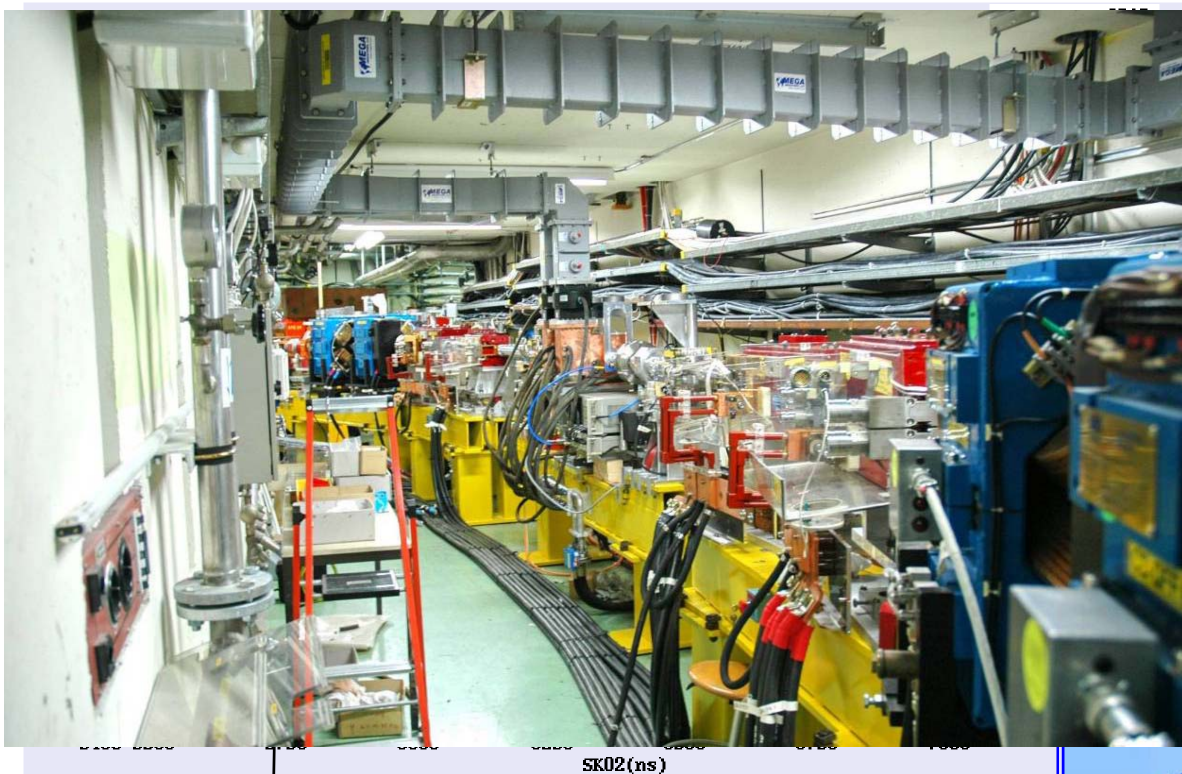


Switching transient about 7 bunches



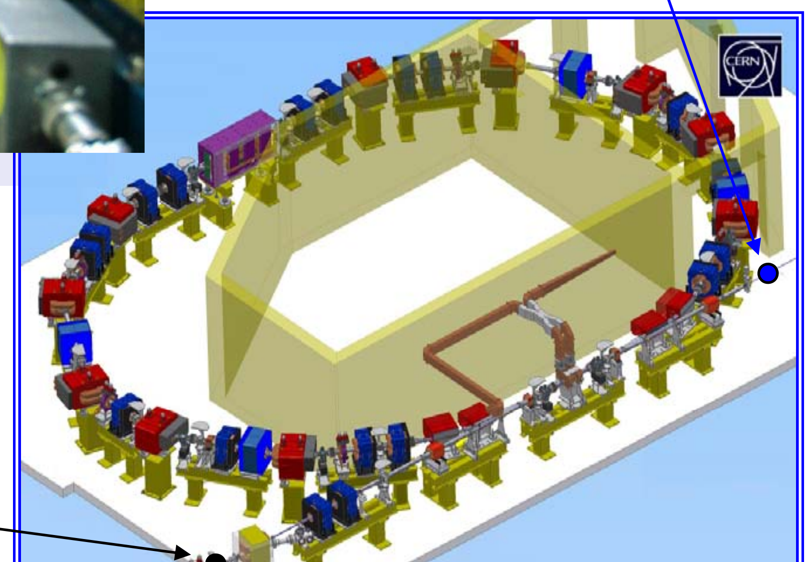
Delay Loop, First Results

circumference 42 m (140 ns)
isochronous optics
wiggler to tune path length
(9 mm range)



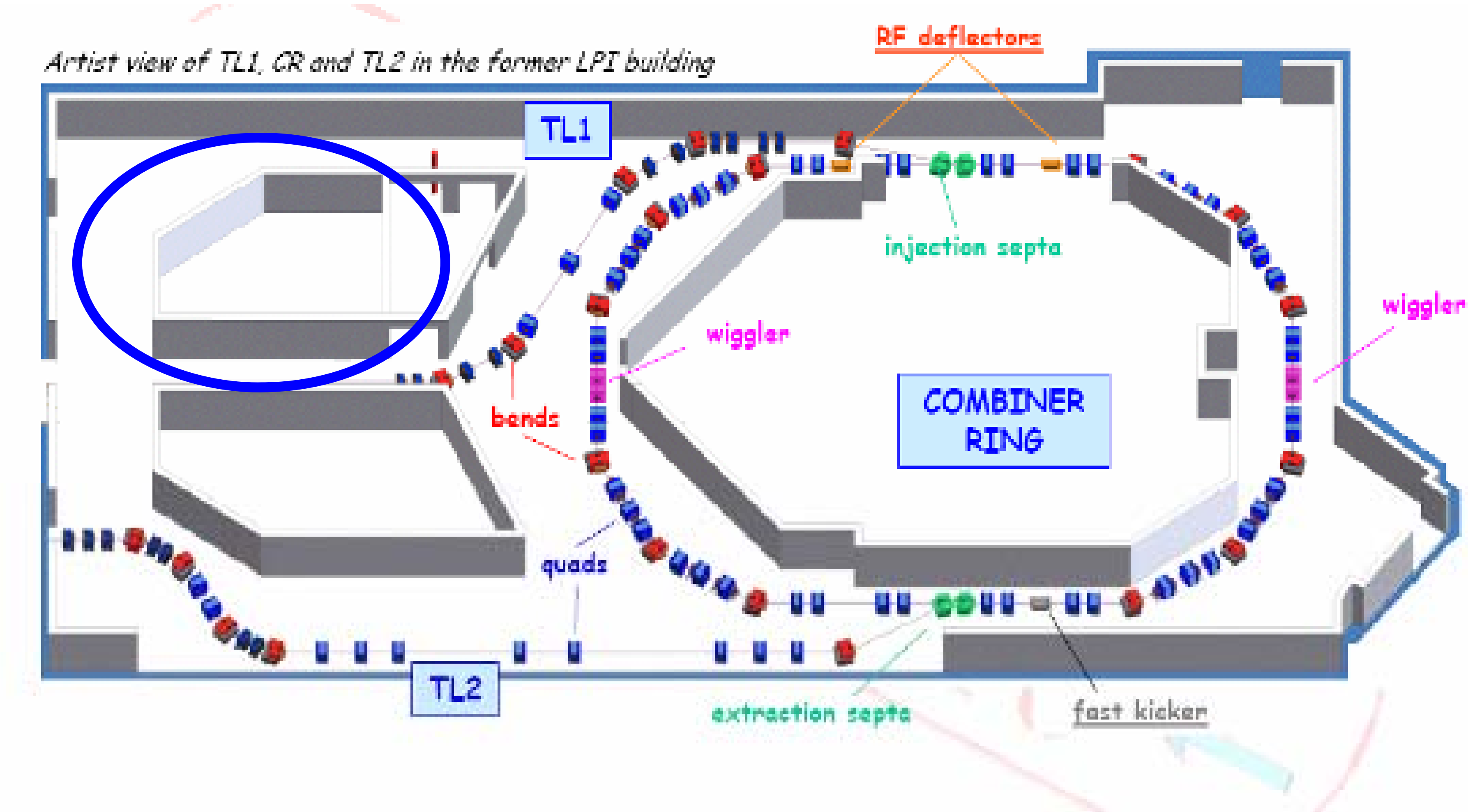
CT.BPM 515
5.8 A + 0.5 A

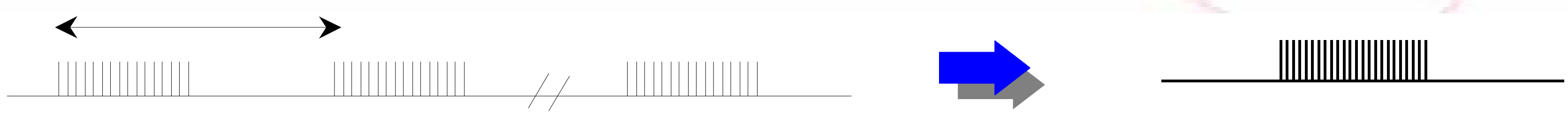
CT.BPM 430
3.3 A



Designed and built by INFN Frascati

Combiner Ring





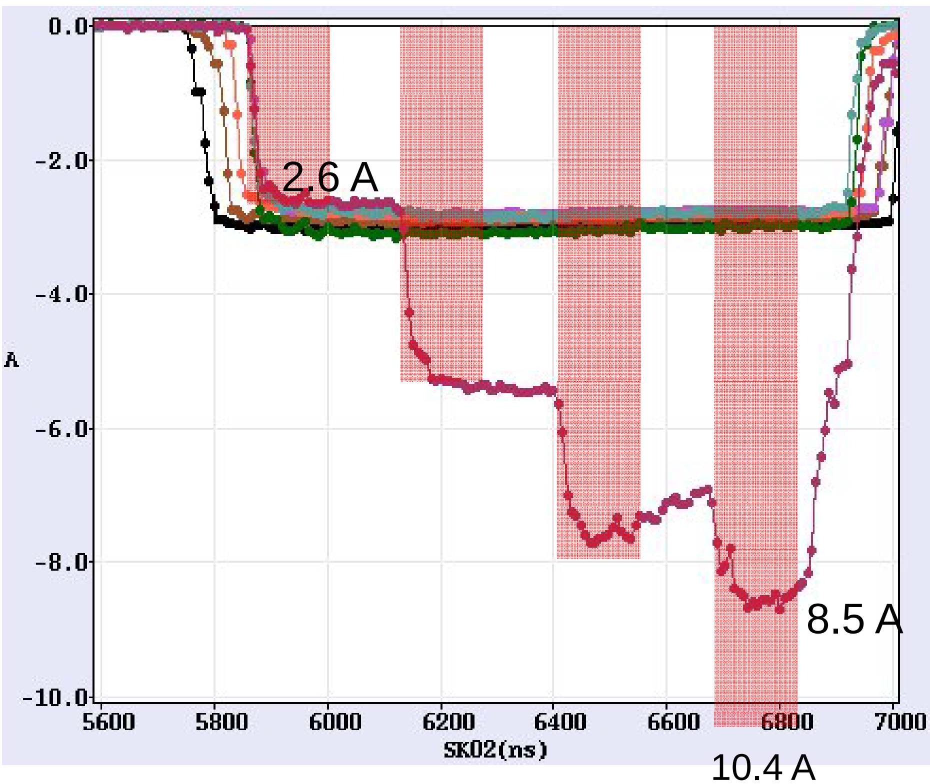
4 trains - I_o peak current

1 train - 4 $\times$ I_o peak current

Combiner Ring, first results

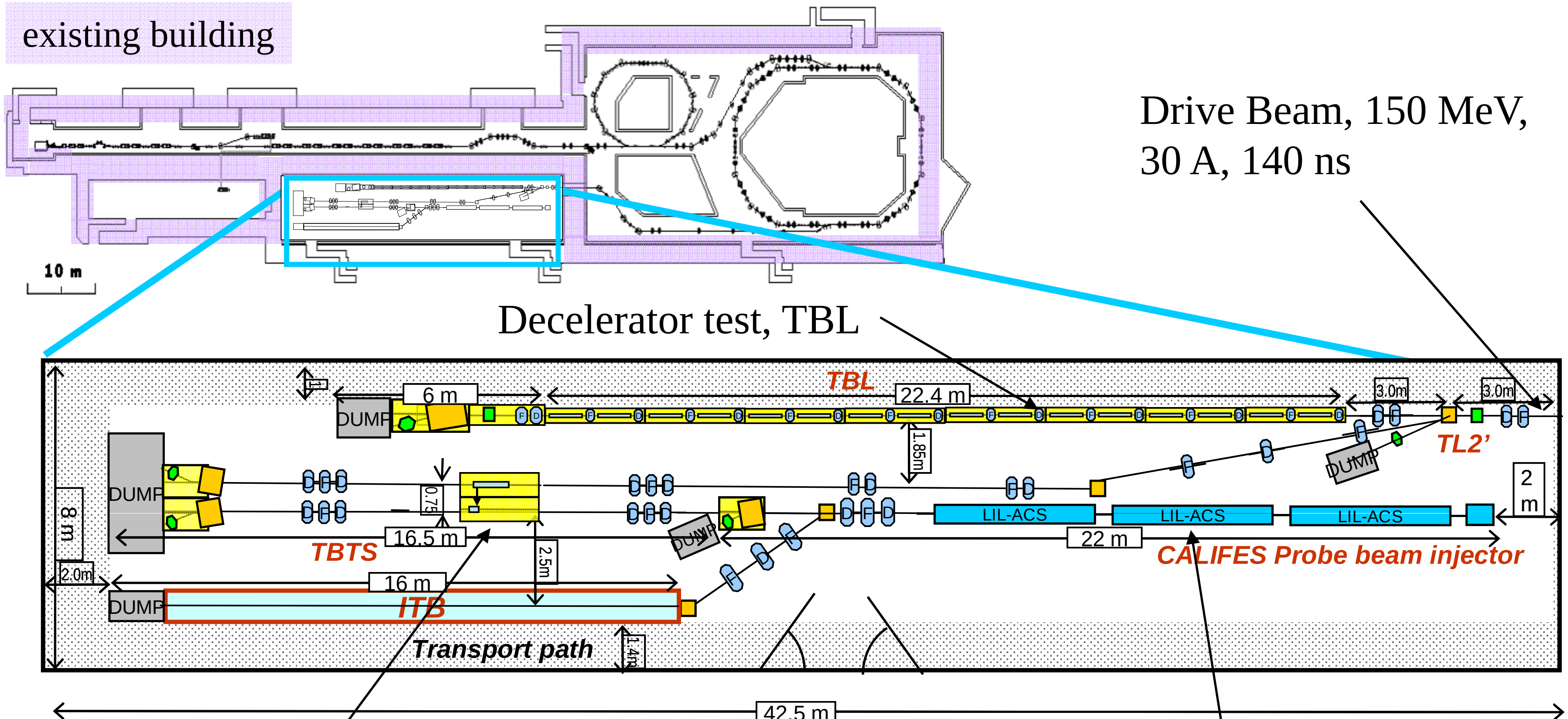
Optics studied and first recombination trials:

- Linac current lower than nominal
- DL bypassed (no holes, missing factor 2)
- Losses during recombination (**instability**…)



See Poster, TUP056, P. Skowronski

CLIC experimental area (CLEX)



Two beam acceleration, Two Beam Test Stand
(Upsalla University)

Probe Beam, 180 MeV
(CEA-Daphnia)

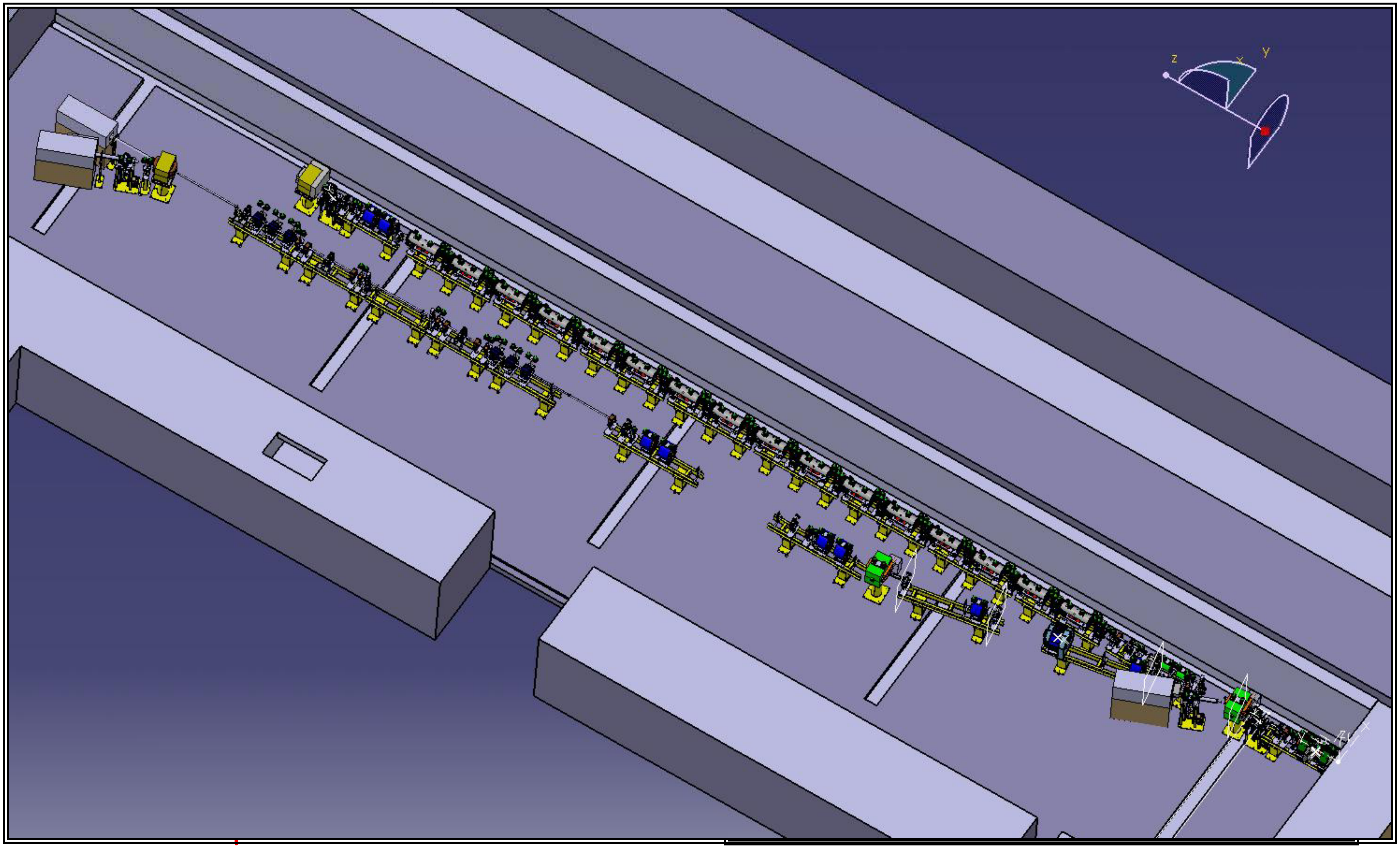
Installation of equipment from 2007 - 2009

Beam in CLEX since August

See Poster, TUP004,F. Peauger

Test beam Line (TBL)

Decelerator experiment

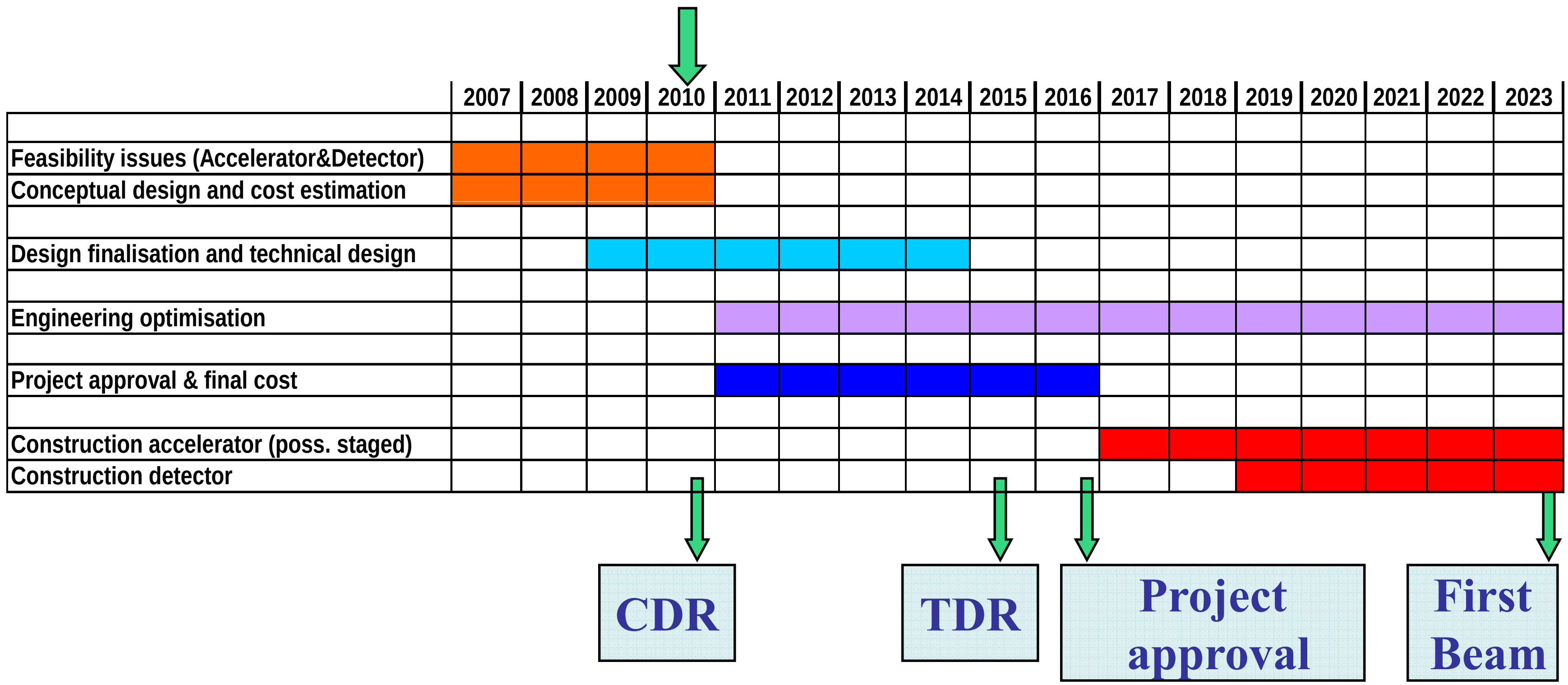


BPM: IFIC Valencia and UPC Barcelona

CLIC long term scenario

Shortest, Success Oriented, Technically Limited Schedule
(Jean-Pierre Delahaye)

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



Tentative CLIC 500 GeV conservative parameters

Center-of-mass energy	500 GeV
Peak luminosity (in 1% of energy)	$1 \cdot 10^{34}$ cm^{-2} s^{-1}
Repetition rate	50 Hz
Loaded accelerating gradient	80 MV/m
Main linac RF frequency	12 GHz
Overall two-linac length	8.8 km
Bunch charge	$6.8 \cdot 10^9$
Bunch separation	0.5 ns
Beam pulse duration	177 ns
Beam power/beam	4.9 MW
Hor./vert. normalized emittance	3000 / 40 nm rad
Hor./vert. IP beam size bef. pinch	221 / 2.8 nm
Total site length	12.8 km
Total power consumption	126 MW

Conclusions

- Consistent and realistic parameter set for CLIC
- Conservative 500 GeV parameters and staged construction to 3 TeV under development
- Feasibility demonstration well advanced
- Drive beam partly demonstrated

  full beam loading, bunch phase coding, delay loop operation, first results on combiner ring
- Proof of principle for the accelerating structure
- Feasibility demonstration and CDR by 2010
- Very strong and growing collaboration for CTF3 and CLIC

CLIC / CTF3 collaboration

24 collaborating institutes

Ankara University (Turkey)
Berlin Tech. Univ. (Germany)
BINP (Russia)
CERN
CIEMAT (Spain)
Finnish Industry (Finland)
Gazi Universities (Turkey)

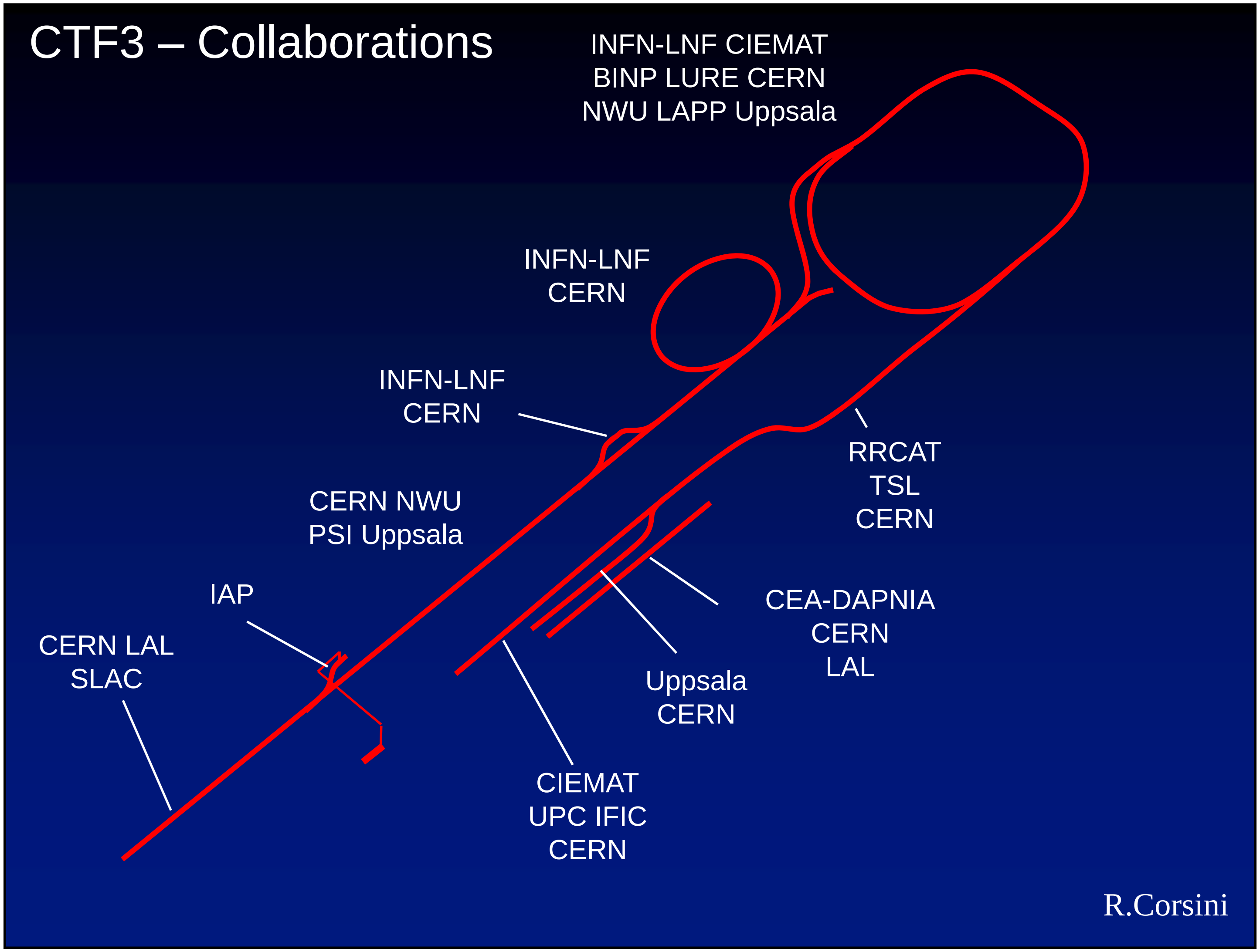
IRFU/Saclay (France)
Helsinki Institute of Physics (Finland)
IAP (Russia)
IAP NASU (Ukraine)
Instituto de Fisica Corpuscular (Spain)
INFN / LNF (Italy)
J.Adams Institute, (UK)

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

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

Reserve slides

CTF3 collaboration



New Main Beam accelerating structure

Structure optimization taking into account:

Rf constraints, Beam dynamics,

collider performance, cost

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