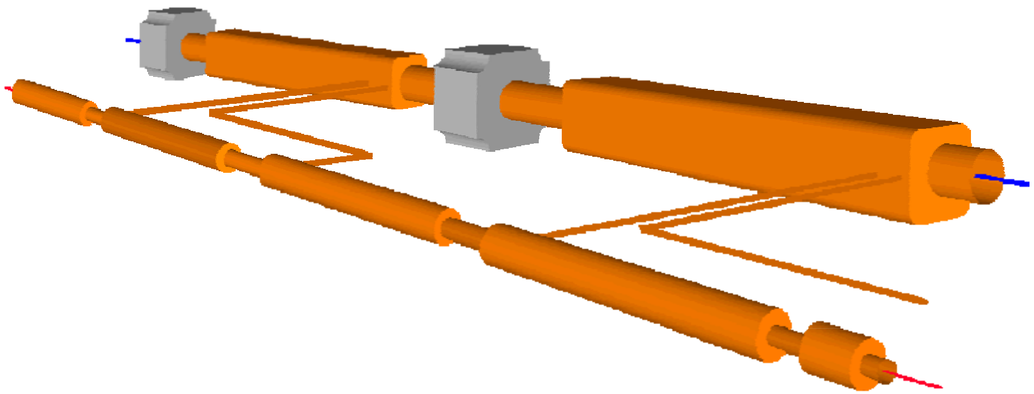
Talk outline

- Introduction – the scheme, the goals & the timescale
- The past
  - CTF II
  - CTF3 preliminary, ...
- The present
  - CTF3 - Structure R&D
  - EuroTeV
- The future
  - CTF3/CLEX potential upgrades
  - FP7
  - Other activities & further needs

INTRODUCTION



Aim of the CLIC study:

develop technology for e-/e+ linear collider with the requirements:

- ✓ E_{CM} should cover 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
- ✓ Design compatible with maximum length ~ **50 km**
- ✓ Affordable
- ✓ Total power consumption < **500 MW**

Physics motivation:

"Physics at the CLIC Multi-TeV Linear Collider: report of the CLIC Physics Working Group,“ CERN report 2004-5

Present goal:

Demonstrate all key feasibility issues and document in a CDR by 2010

What matters in a linear collider ?

Energy reach

$$E_{cm} = 2 F_{fill} L_{linac} G_{RF}$$

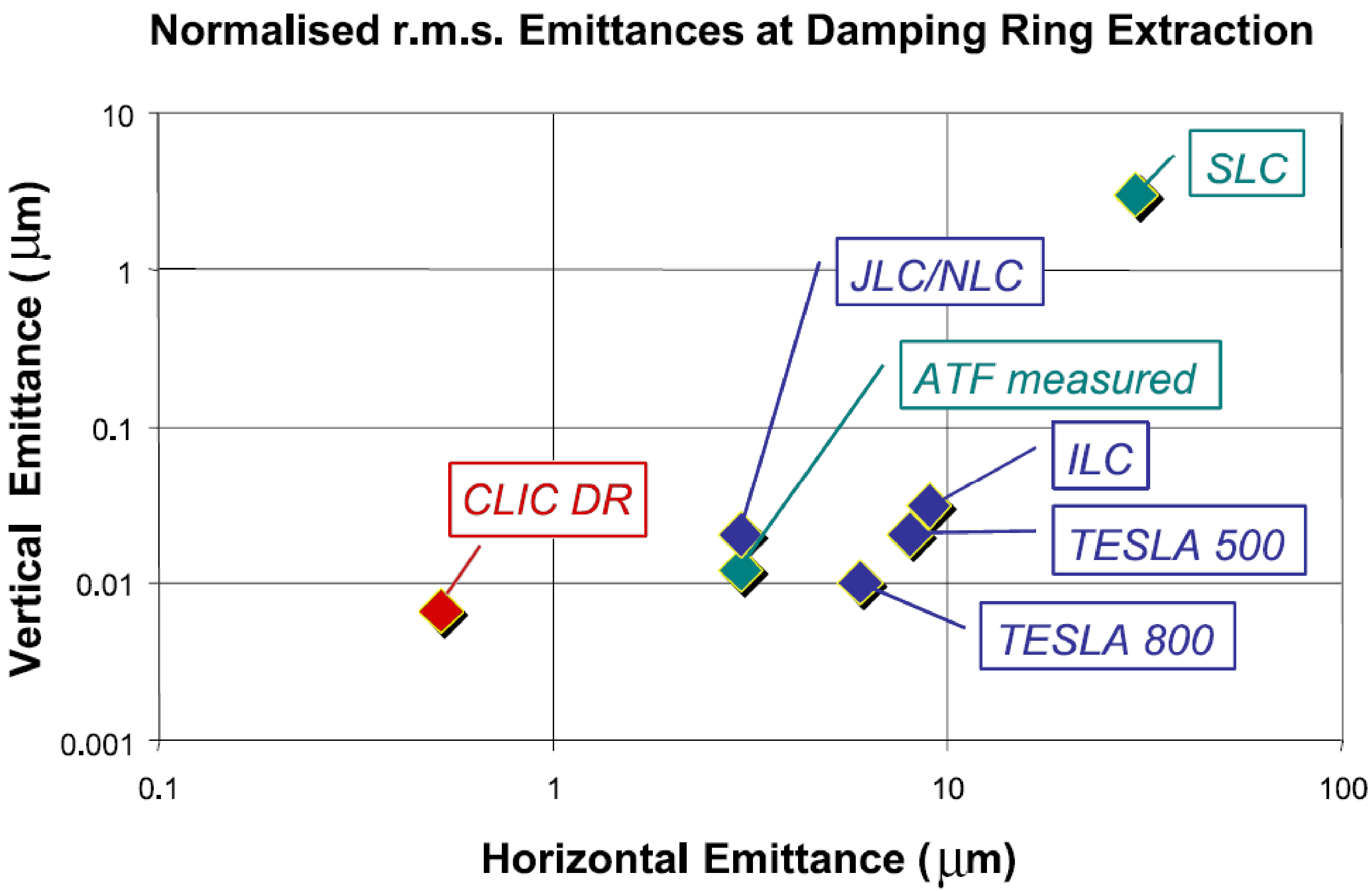
- High gradient

Luminosity

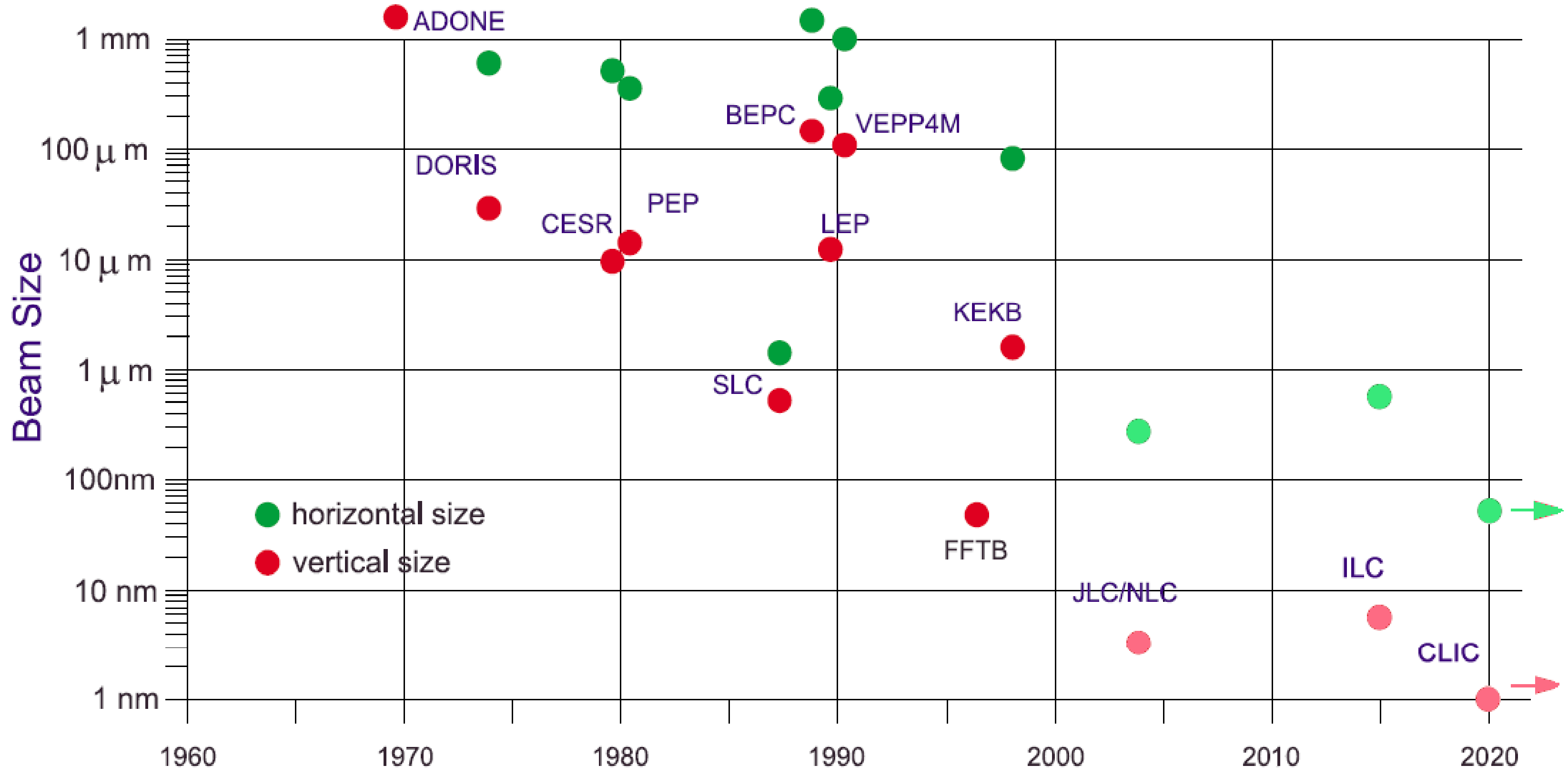
$$L = \frac{n_b N^2 f_{rep}}{4\pi\sigma_x^* \sigma_y^*} \times H_D \propto \frac{\eta_{beam}^{AC} P_{AC}}{\varepsilon_y^{1/2}} \frac{\delta_{BS}^{1/2}}{E_{cm}}$$

- Acceleration efficiency
- Generation of small emittance — damping rings
- Conservation of small emittance — wake-fields, alignment, stability
- Extremely small beam spot at Interaction Point — beam delivery system, stability

The small emittance challenge



The small beam size challenge



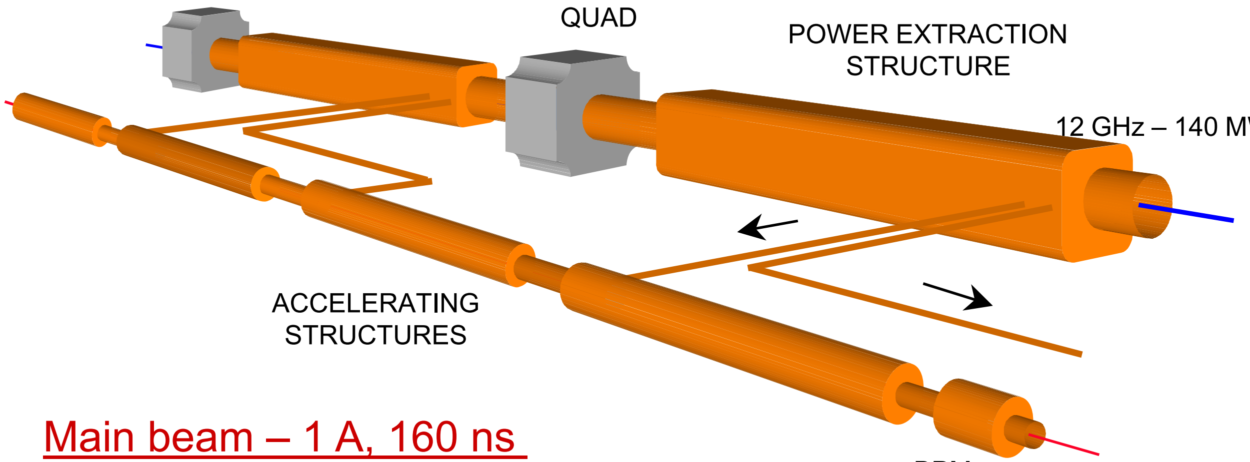
Adapded from S. Chattopadhyay, K. Yokoya, Proc. Nanobeam `02

The CLIC way to a multi-TeV linear collider - Basic features

- High acceleration gradient (100 MV/m)
  - ✓ "Compact" collider - overall length @ 3 TeV < 50 km
  - ✓ Normal conducting accelerating structures
  - ✓ High acceleration frequency (12 GHz)
- Two-Beam Acceleration Scheme
  - ✓ Cost effective, reliable, efficient
  - ✓ Simple tunnel, no active elements
  - ✓ Modular, easy energy upgrade in stages

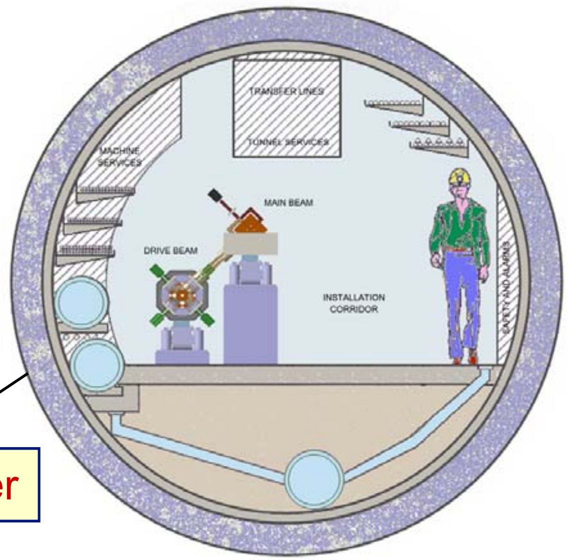
CLIC Two-Beam scheme

Drive beam - 100 A, 240 ns
from 2.4 GeV to 240 MeV



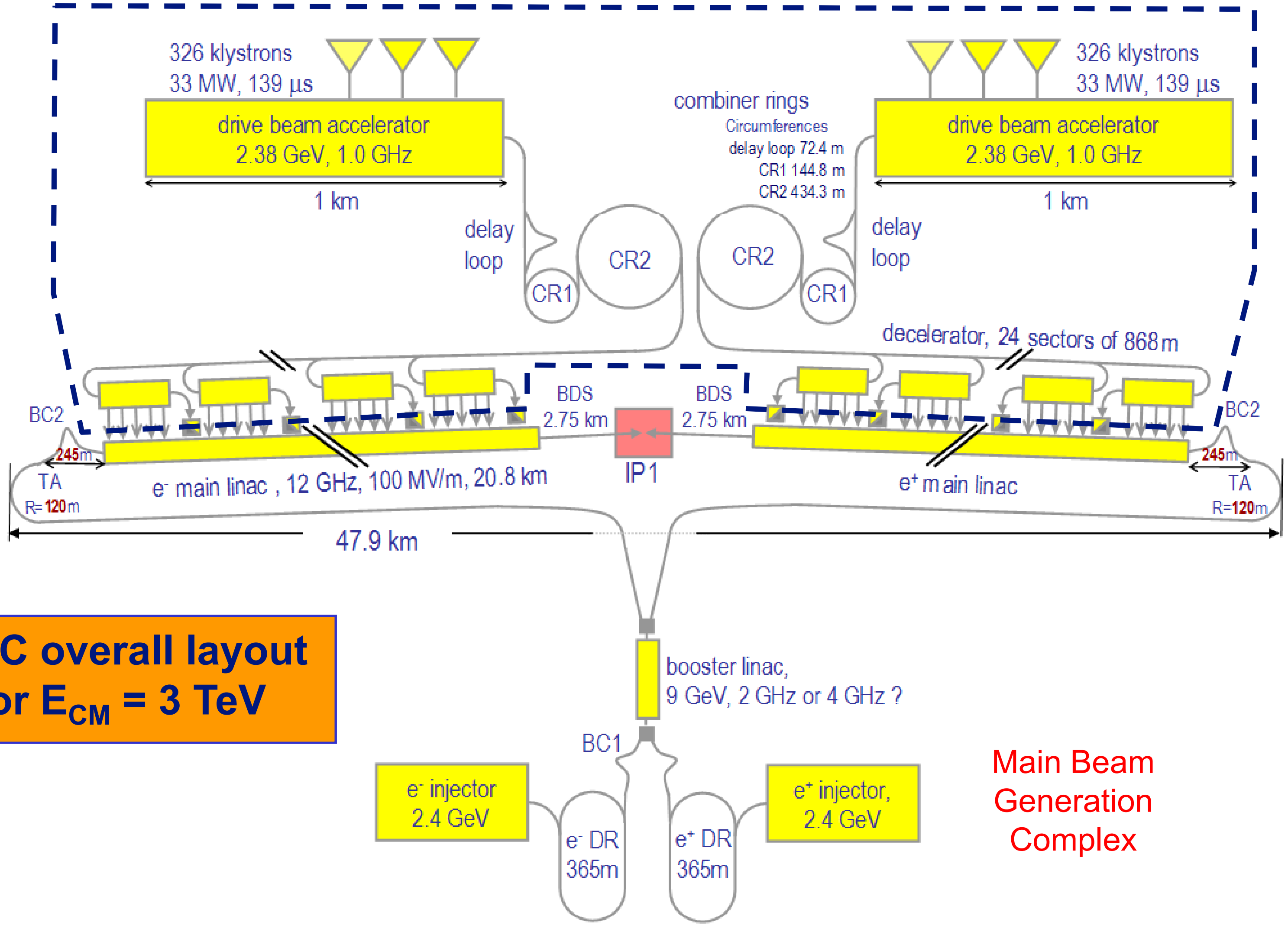
Main beam – 1 A, 160 ns
from 9 GeV to 1.5 TeV

CLIC TUNNEL
CROSS-SECTION



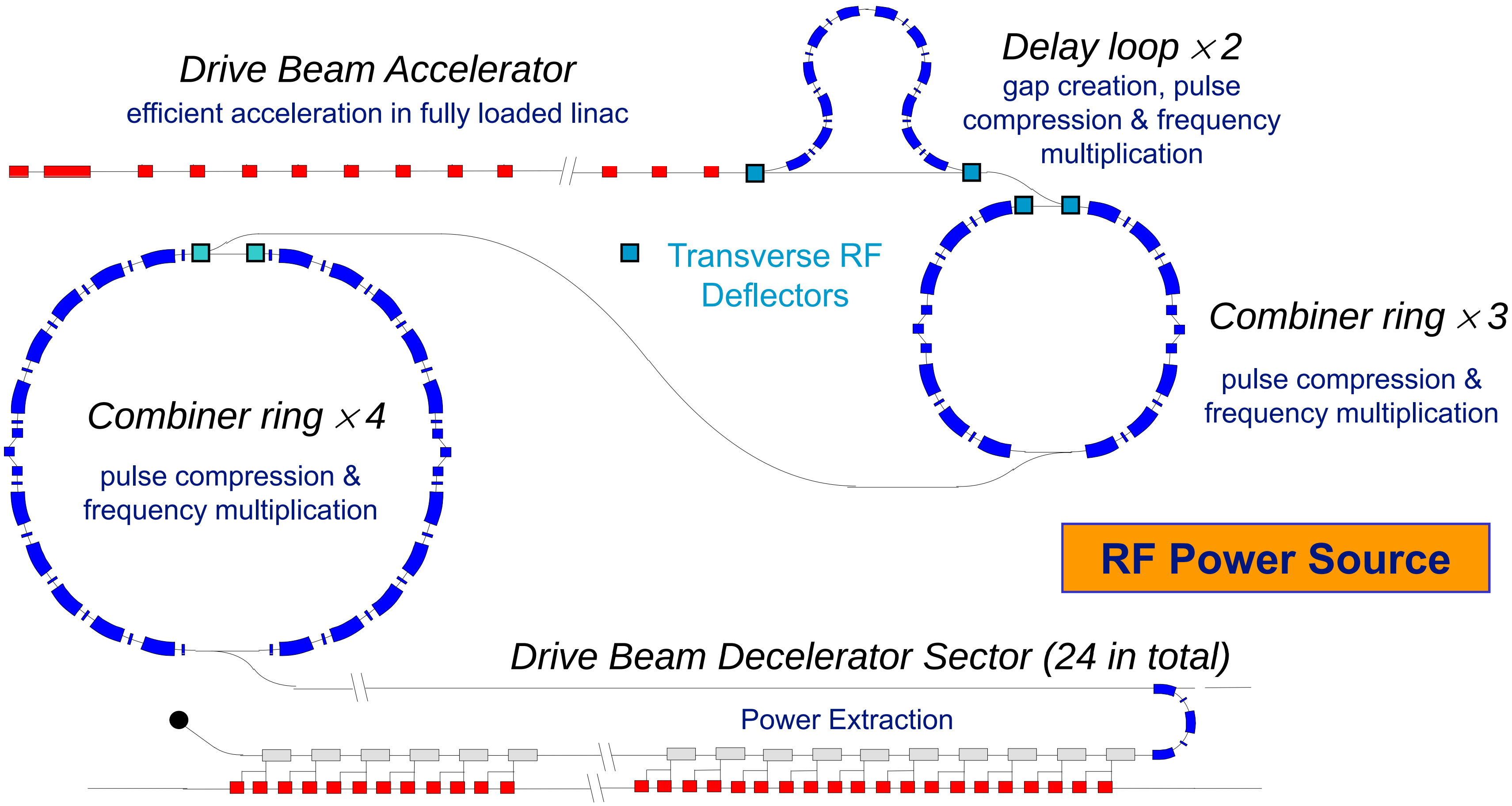
4.5 m diameter

CLIC RF power source

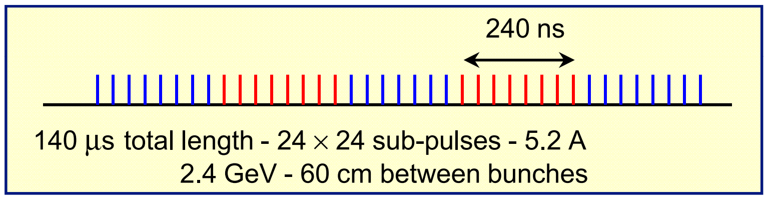


CLIC overall layout for E_{CM} = 3 TeV

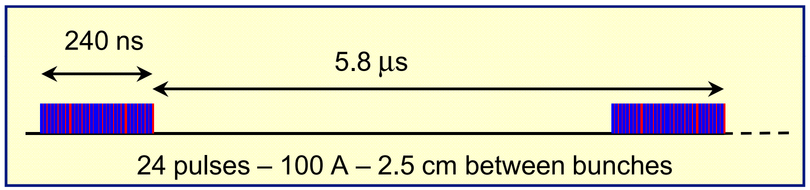
Main Beam Generation Complex



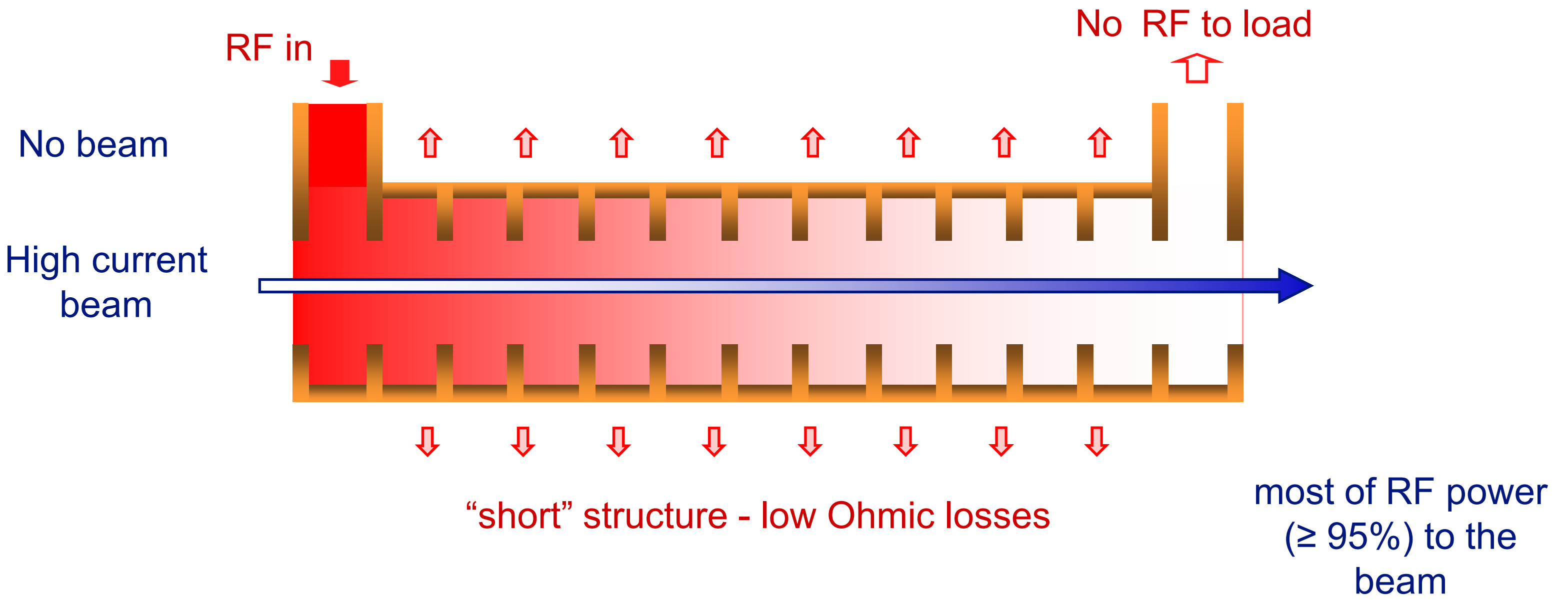
Drive beam time structure - initial



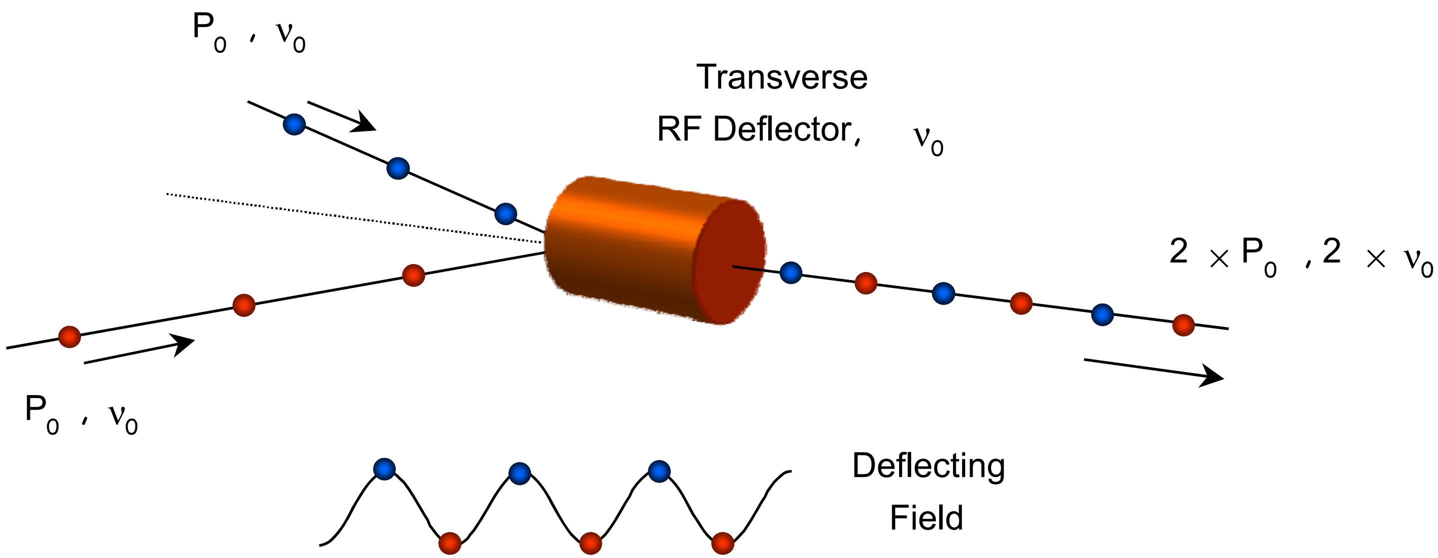
Drive beam time structure - final



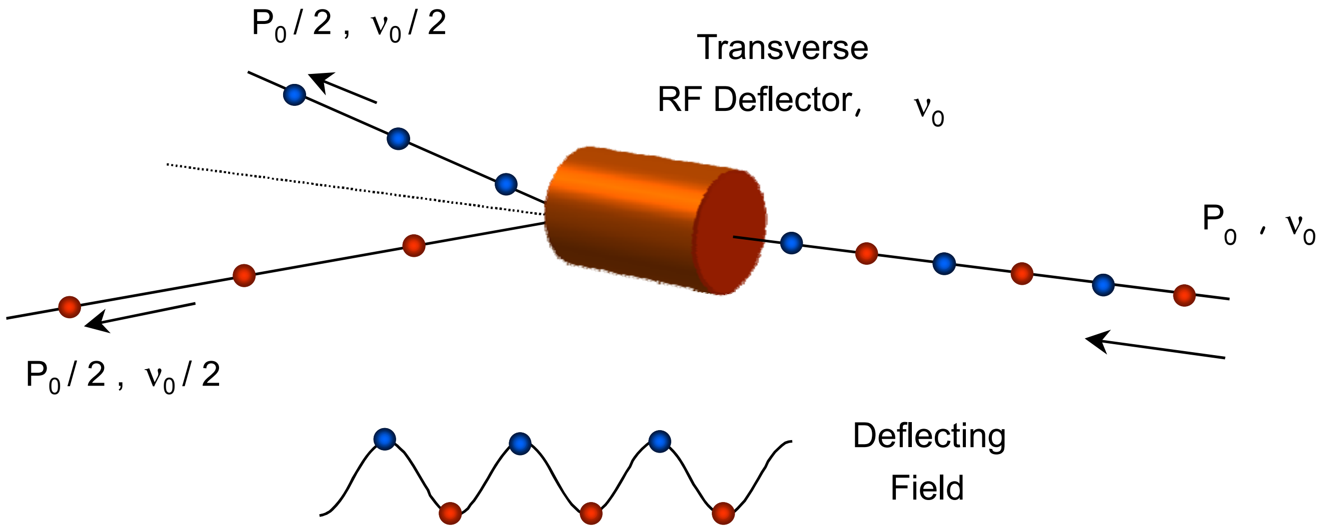
Full beam-loading acceleration in TW sections



Beam combination/separation by transverse RF deflectors



Beam combination/separation by transverse RF deflectors



The *CLIC Technology-related* key issues as pointed out by ILC-TRC 2003

Covered by CTF3

R1: Feasibility

- R1.1: Test of damped accelerating structure at design gradient and pulse length
- R1.2: Validation of drive beam generation scheme with fully loaded linac operation
- R1.3: Design and test of damped ON/OFF power extraction structure

R2: Design finalization

- R2.1: Developments of structures with hard-breaking materials (W, Mo…)
- R2.2: Validation of stability and losses of DB decelerator; Design of machine protection system
- R2.3: Test of relevant linac sub-unit with beam
- R2.4: Validation of drive beam 40 MW, 937 MHz Multi-Beam Klystron with long RF pulse *
- R2.5: Effects of coherent synchrotron radiation in bunch compressors
- R2.6: Design of an extraction line for 3 TeV c.m.

Covered by EUROTeV

* *Feasibility study done – need development by industry.*
N.B.: Drive beam acc. structure parameters can be adapted to other klystron power levels

Other R2 key issues- *common to all projects* - as pointed out by ILC-TRC 2003

Still relevant for CLIC & complete ?

What should be added / modified for the conceptual design report ?

Damping Rings

- electron cloud effects
- fast ion instability
- extraction kicker stability
- emittance correction

Low emittance transport

- static tuning studies, dynamic effects during correction
- beam instrumentation (luminosity monitor, laser-wire profile monitor)
- prototype of the main linac module (on-girder sources of vibration)

Reliability

- detailed evaluation of critical subsystem reliability
- performance of beam based tuning procedures by complete simulations

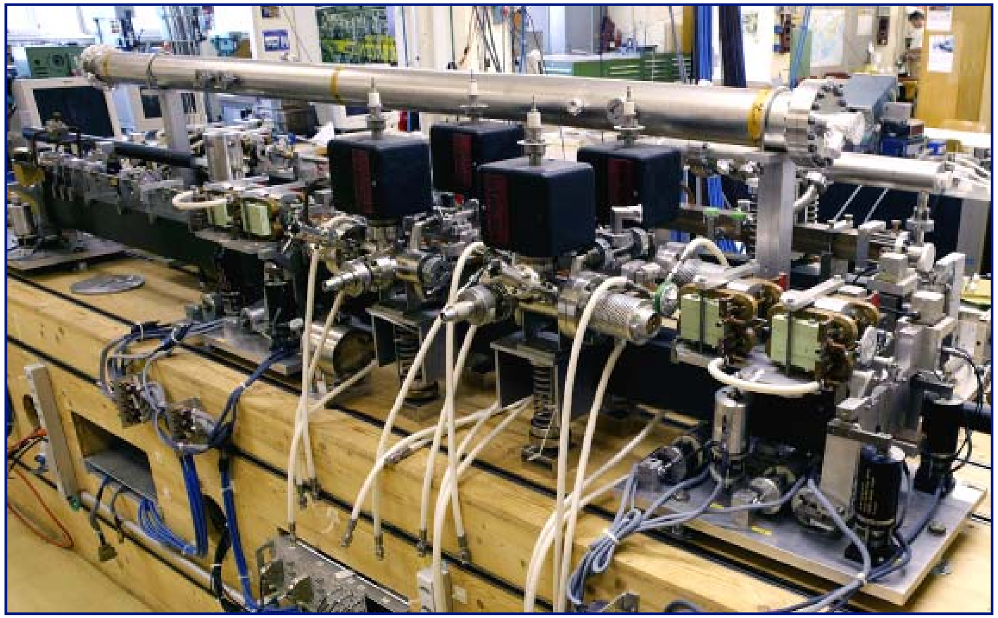
Baseline program until CDR (2010)

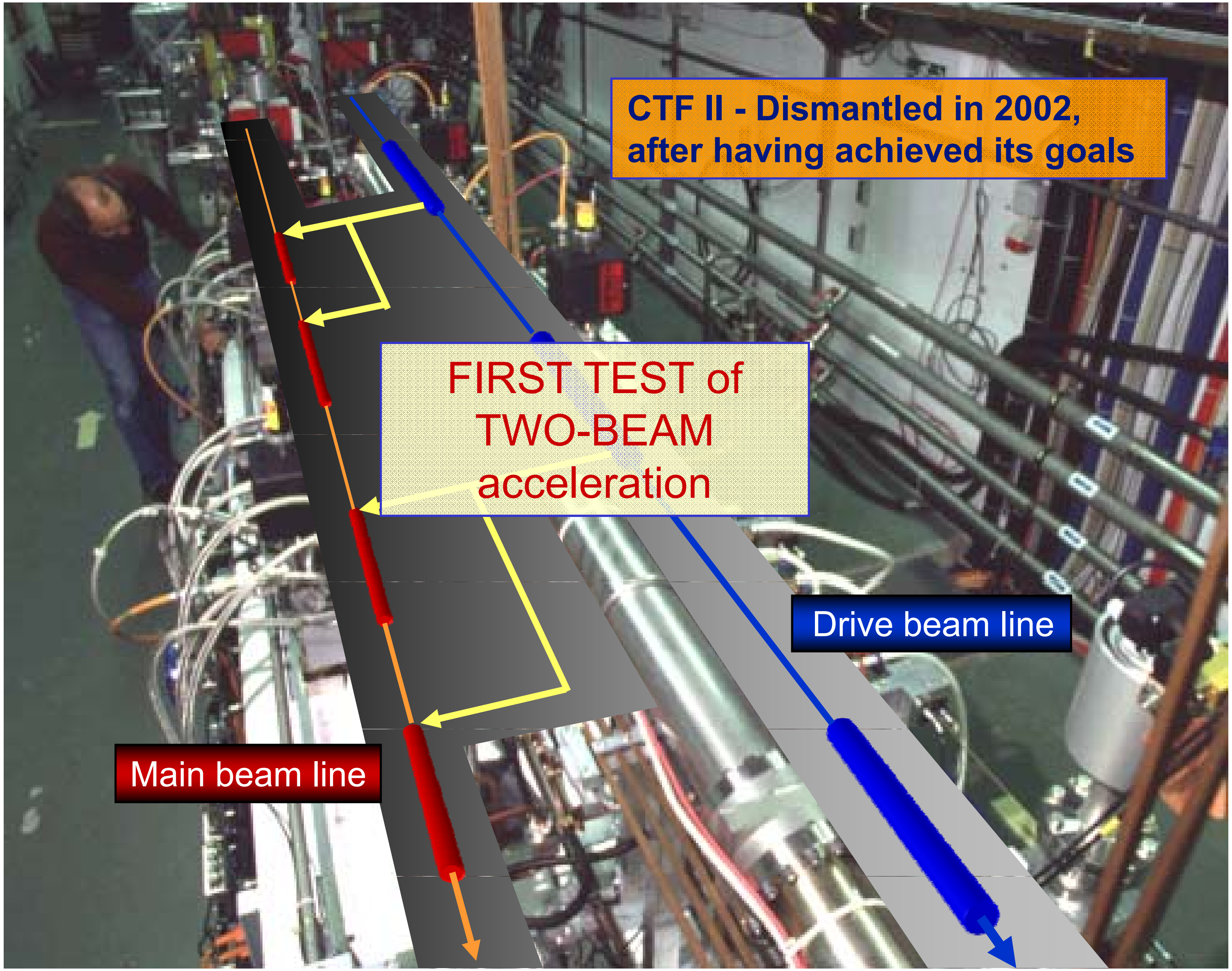
- RF Structure & PETS development
- CTF3 – Drive beam generation & use
- Civil Engineering and tech. infrastructure studies
- Cost Study
- Two Beam module design
- Active pre-alignment systems
- Beam physics
  - Dynamic effects during alignment
  - Luminosity tuning monitor
  - Ring to ML & BDS alignment
  - Integrated feedbacks
  - Fast beam ion instability (DR+LET)
  - Intra beam scattering (DR)
  - Electron cloud (DR+LET)
  - Impedances (DR+LET)
  - DR lattice optimisation, tolerances, correction algorithms
  - BDS optimisation and participation in ATF2 commissioning
  - Return line design
  - Machine Protection System concept

EU EUROTeV (Fast beam ion instability, Intra beam scattering, Electron cloud, Impedances)

To be extended …

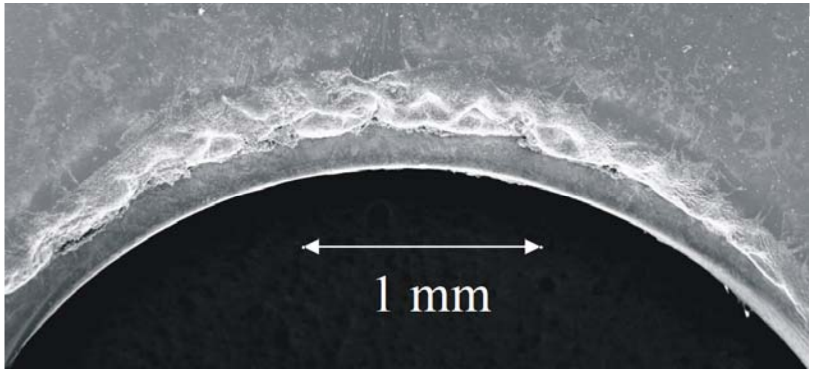
THE PAST



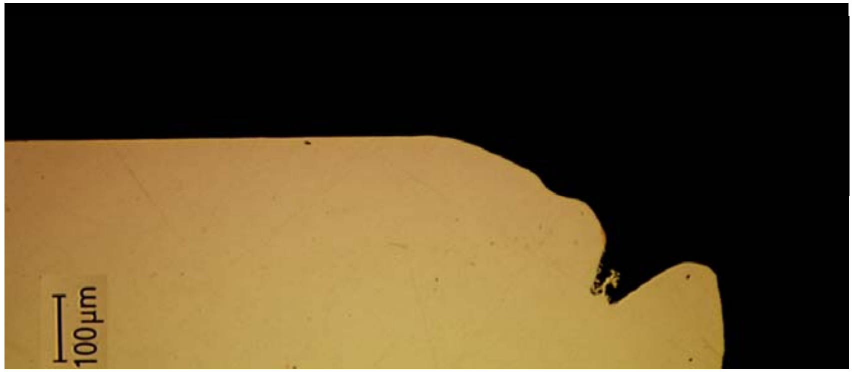

CTF II - Dismantled in 2002,
after having achieved its goals
FIRST TEST of
TWO-BEAM
acceleration
Drive beam line
Main beam line

Breakdown and damage of structures

High-power tests of copper accelerating structures in CTF II and NLCTA showed **severe damage** from breakdowns for surface fields around **300 - 400 MV/m.**



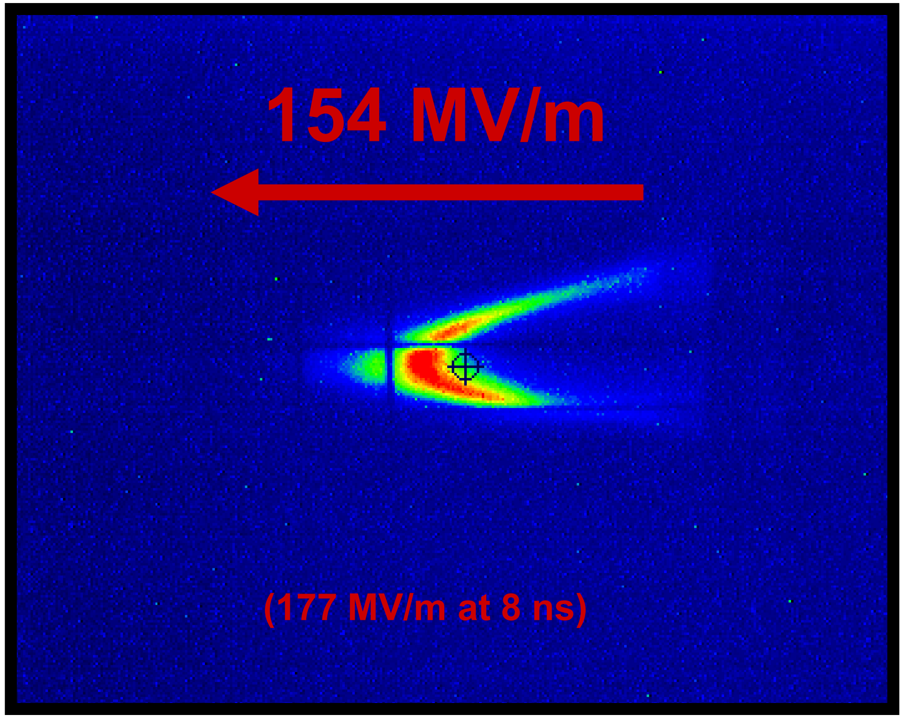
Microscopic image of damaged iris



Damaged iris – longitudinal cut

- Optimize the **RF design** for lower power and surface field **(small a/λ)**
- Investigating **new materials** that are resistant to arcing – (**tungsten, molybdenum…**)

High-gradient tests in CTF II



A 30-cell structure with Mo irises exceeded the CLIC accelerating field requirements without damage

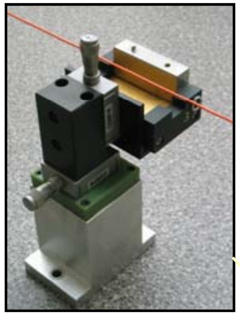
190 MV/m accelerating gradient in first cell - tested with beam ! (but only 16 ns pulse length)

Alignment studies in CTF II

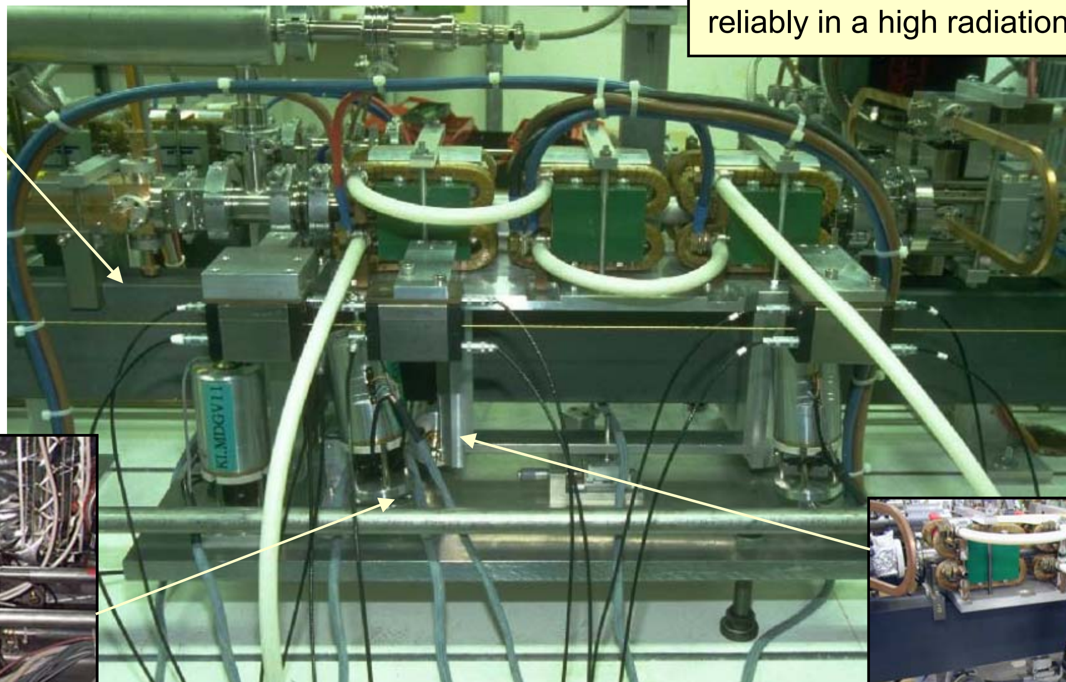
Tolerance of CLIC pre-alignment: ± 10 μm transverse position over 200 m
(enough to send a pilot beam, and start beam-based alignment)

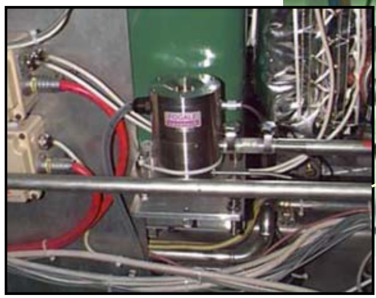
Full system Tested in CTF II:

In a closed loop, the elements were maintained w.r.t wire within a ± 5 μm window and operated reliably in a high radiation environment



WPS
Wire Positioning System

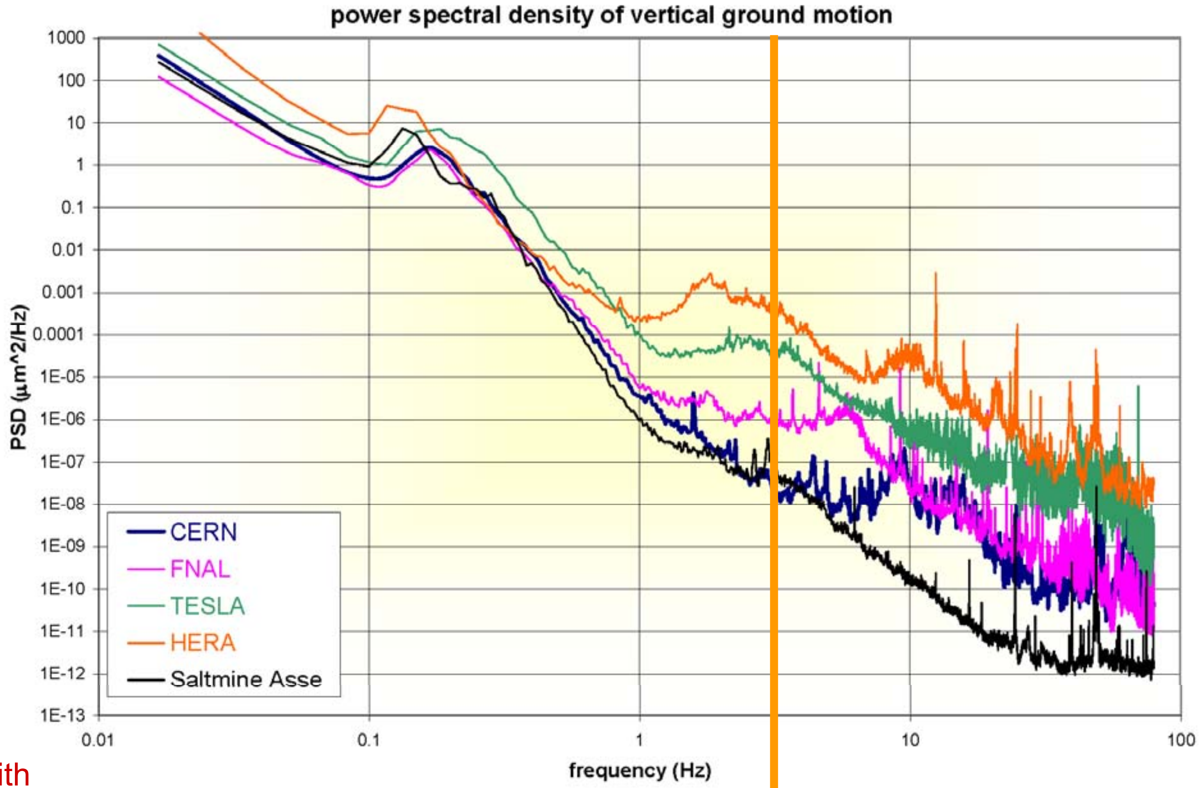




HLS
Hydrostatic Levelling System

3 D active
movers

Slow & fast motions



correction with beam-based feedbacks

Slow motion

$f_{CUT} \approx f_{REP} / 25 = 4$ Hz

Fast motion

mechanical stability of magnets

limited by f_{REP}

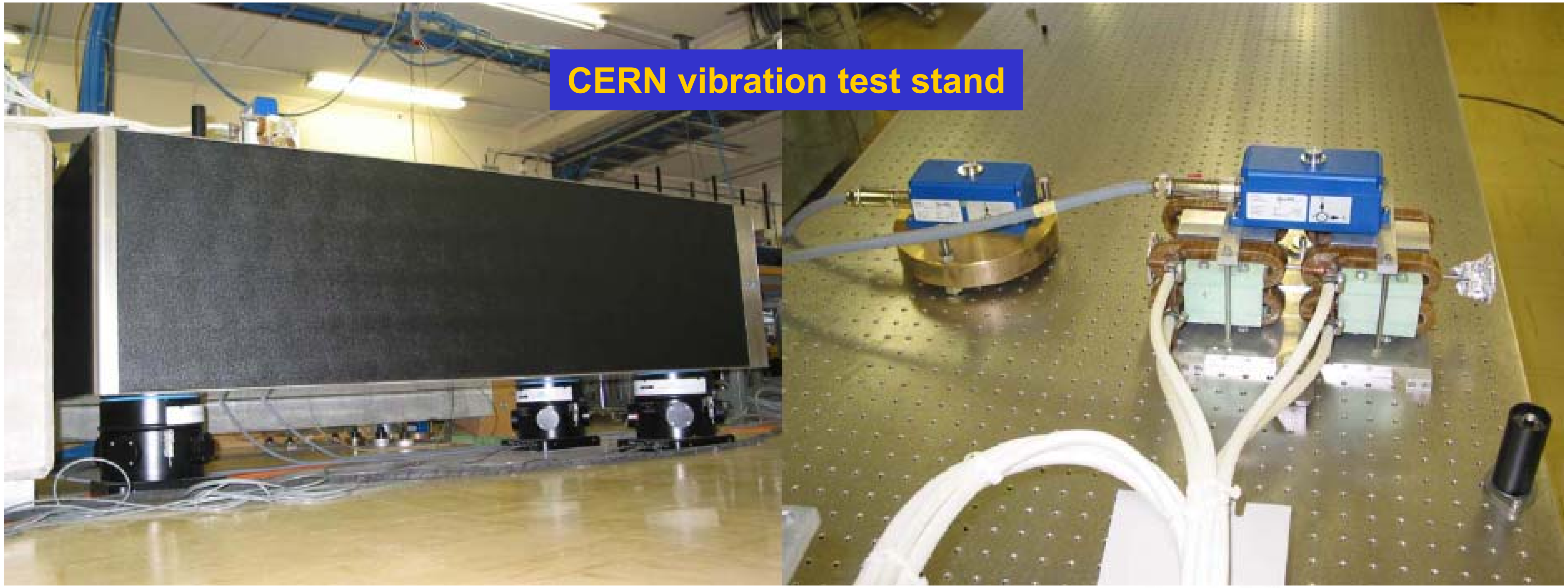
Stability

Vertical spot size at IP is ~ 1 nm *(size of water molecule)*

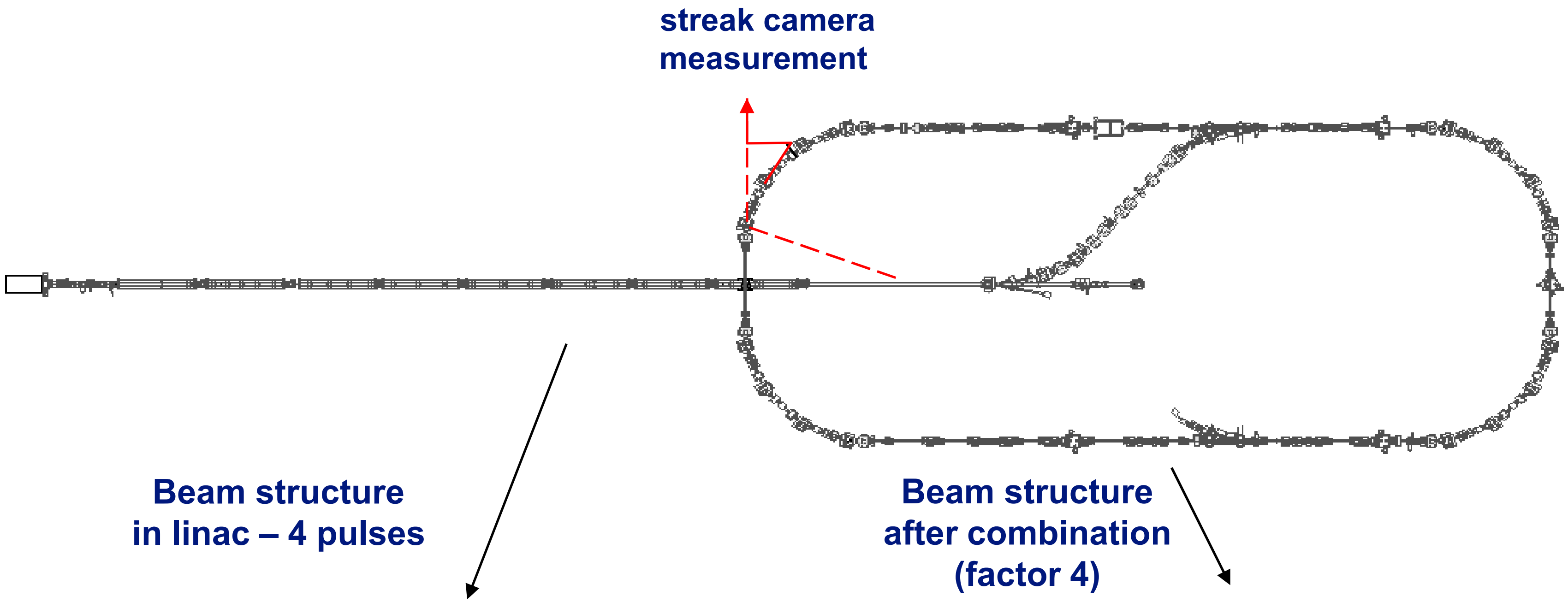
Stability requirements (> 4 Hz) for a 2% loss in luminosity

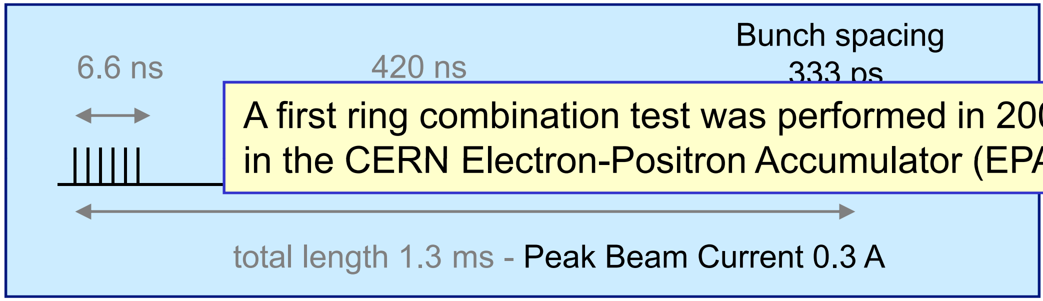
Magnet	Ix	Iy
Linac (2600 quads)	14 nm	1.3 nm
Final Focus (2 quads)	4 nm	0.2 nm

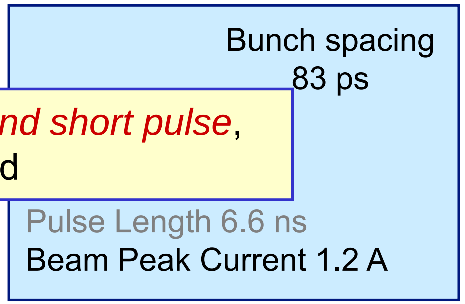
→ Need active damping of vibrations



CTF3 Preliminary Phase (2001-2002)

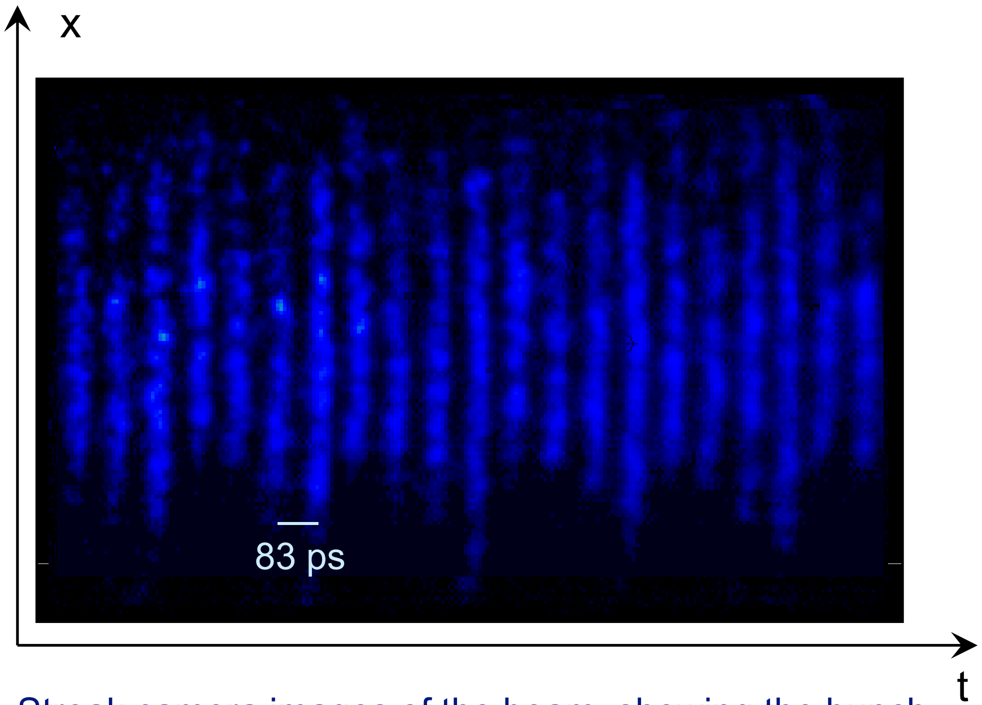






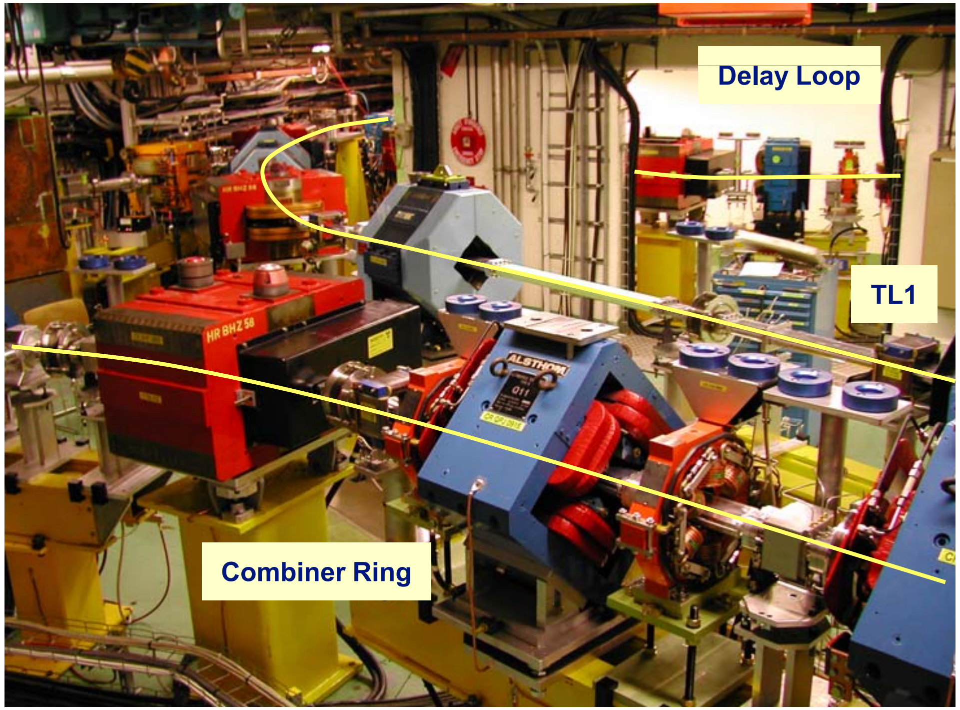
A first ring combination test was performed in 2002, *at low current and short pulse*, in the CERN Electron-Positron Accumulator (EPA), properly modified

Preliminary phase results



Streak camera images of the beam, showing the bunch combination process

THE PRESENT



Motivation and goals of CTF3 collaboration

Build a small-scale version of the CLIC RF power source, in order to demonstrate:

- ✓ **full beam-loading accelerator operation**
- ✓ **electron beam pulse compression and frequency multiplication using RF deflectors**

Provide the RF power to **test the CLIC accelerating structures and components**

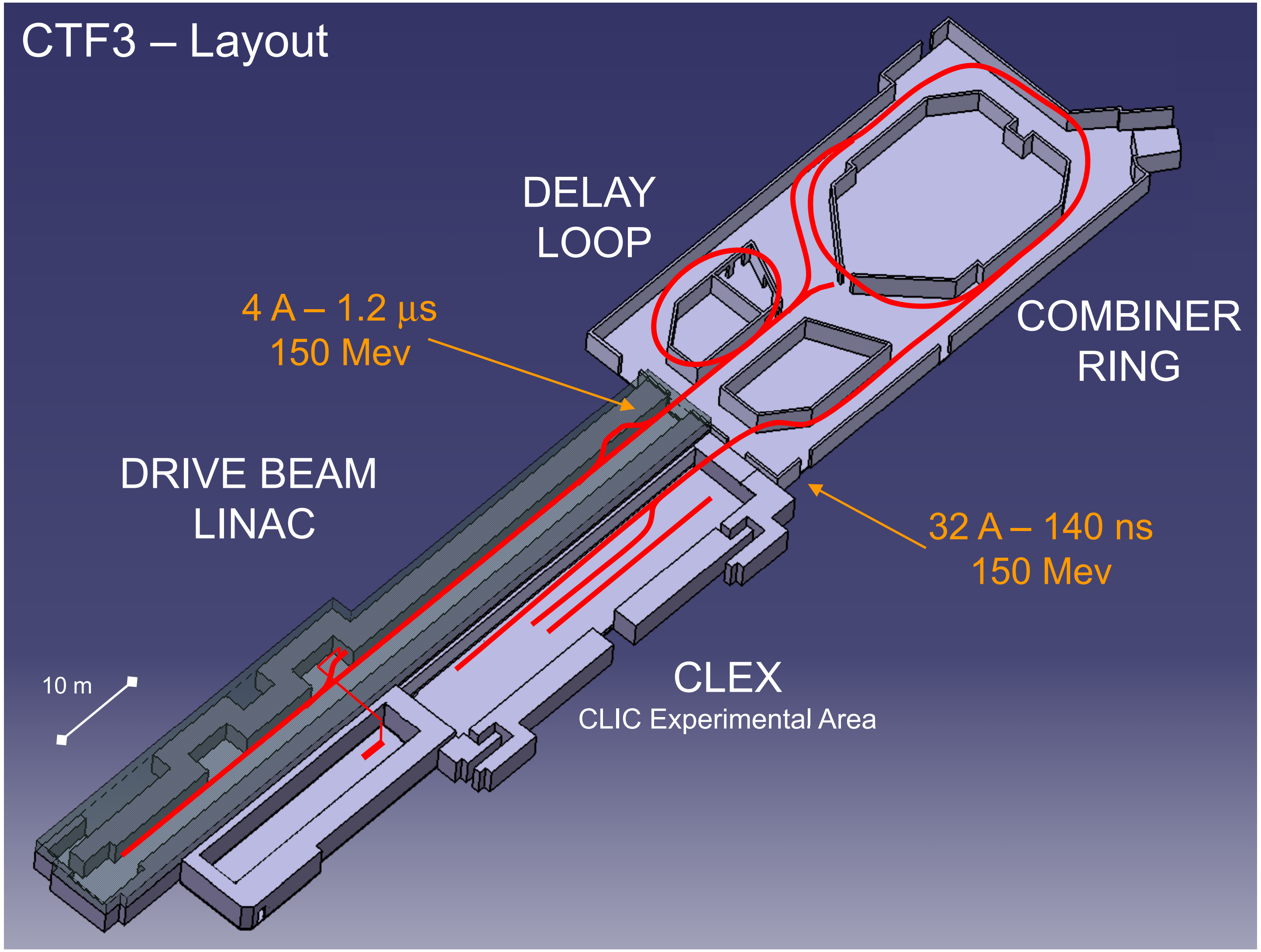
CTF3 is being built at CERN by a collaboration modeled on the large physics experiments

23 institutes from 12 countries

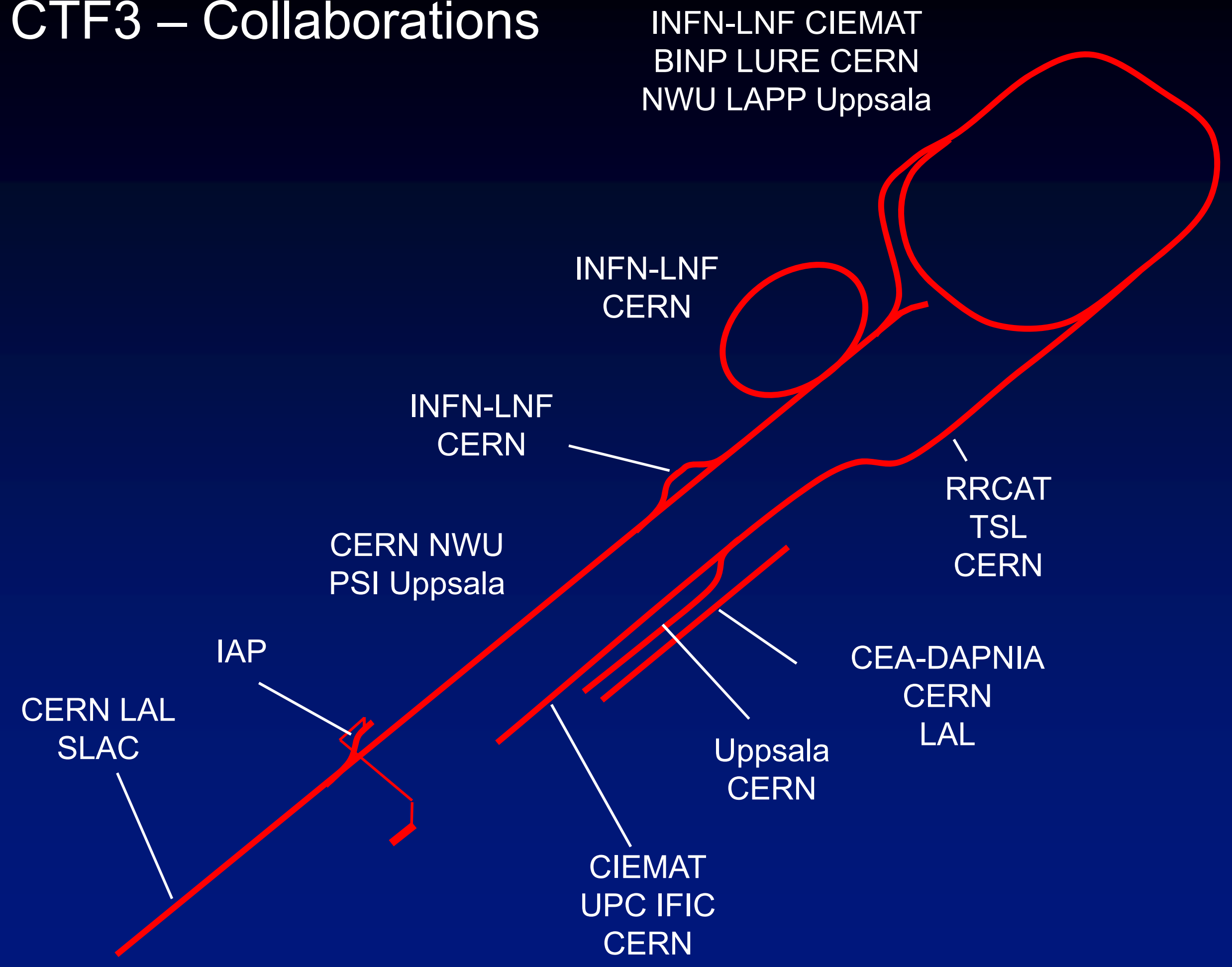
Chairman of collaboration Board:	M. Calvetti (INFN-LNF)
Spokesperson:	G. Geschonke (CERN)

➡ Will be largest LC test facility constructed

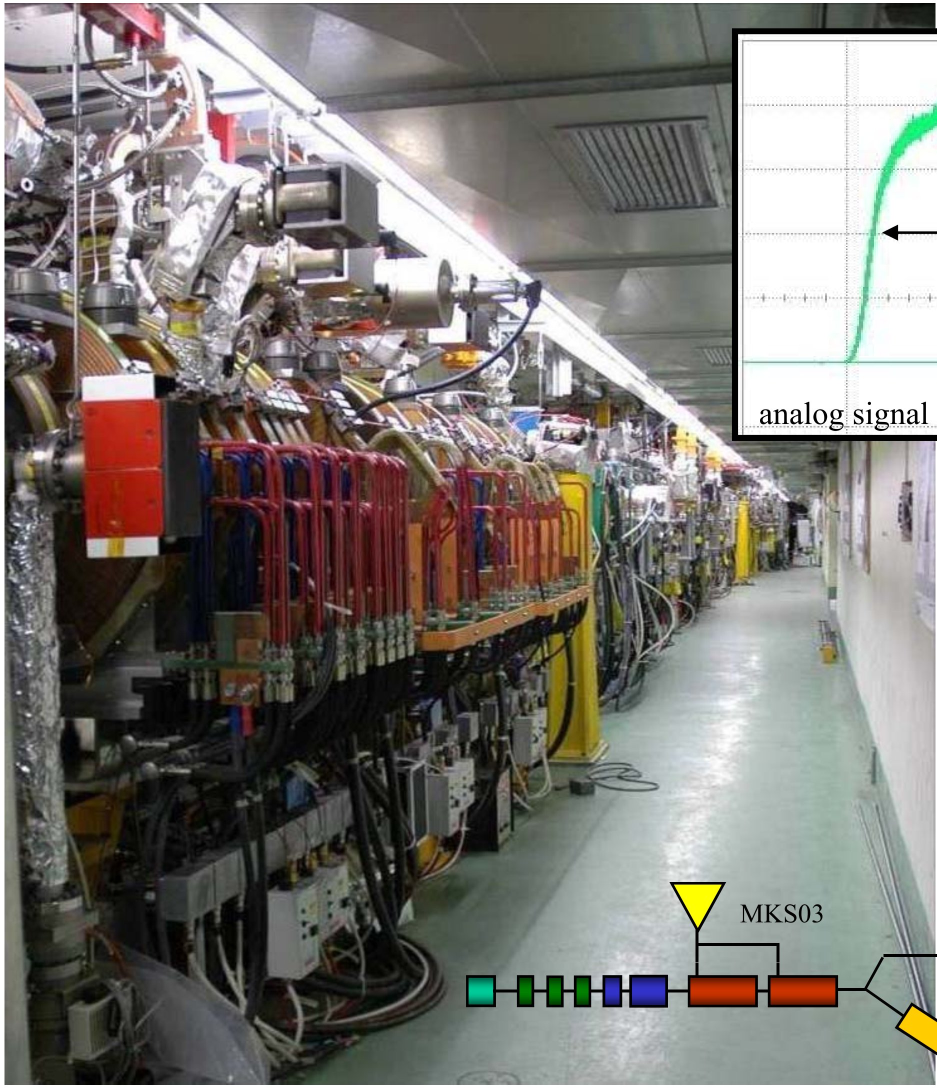
M. Huening, A. Mosnier, V. Shiltsev & T. Raubenheimer
CLIC Advisory Committee Report

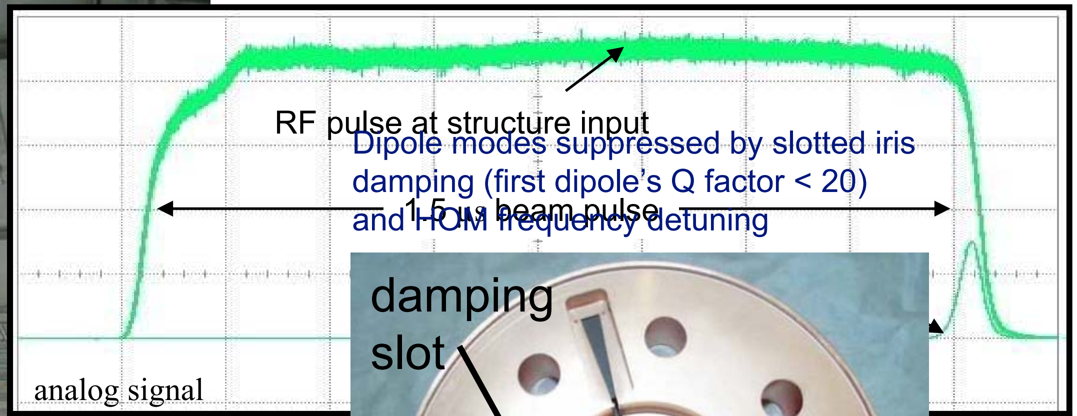

CTF3 – Layout
DELAY
LOOP
4 A – 1.2 µs
150 Mev
COMBINER
RING
DRIVE BEAM
LINAC
32 A – 140 ns
150 Mev
10 m
CLEX
CLIC Experimental Area

CTF3 – Collaborations



Full beam-loading acceleration in CTF3

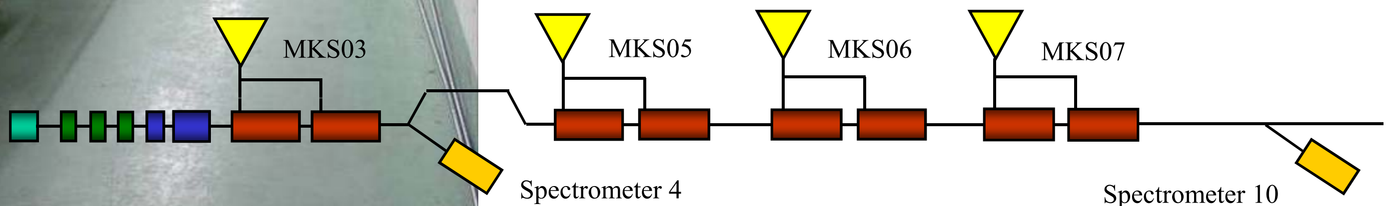


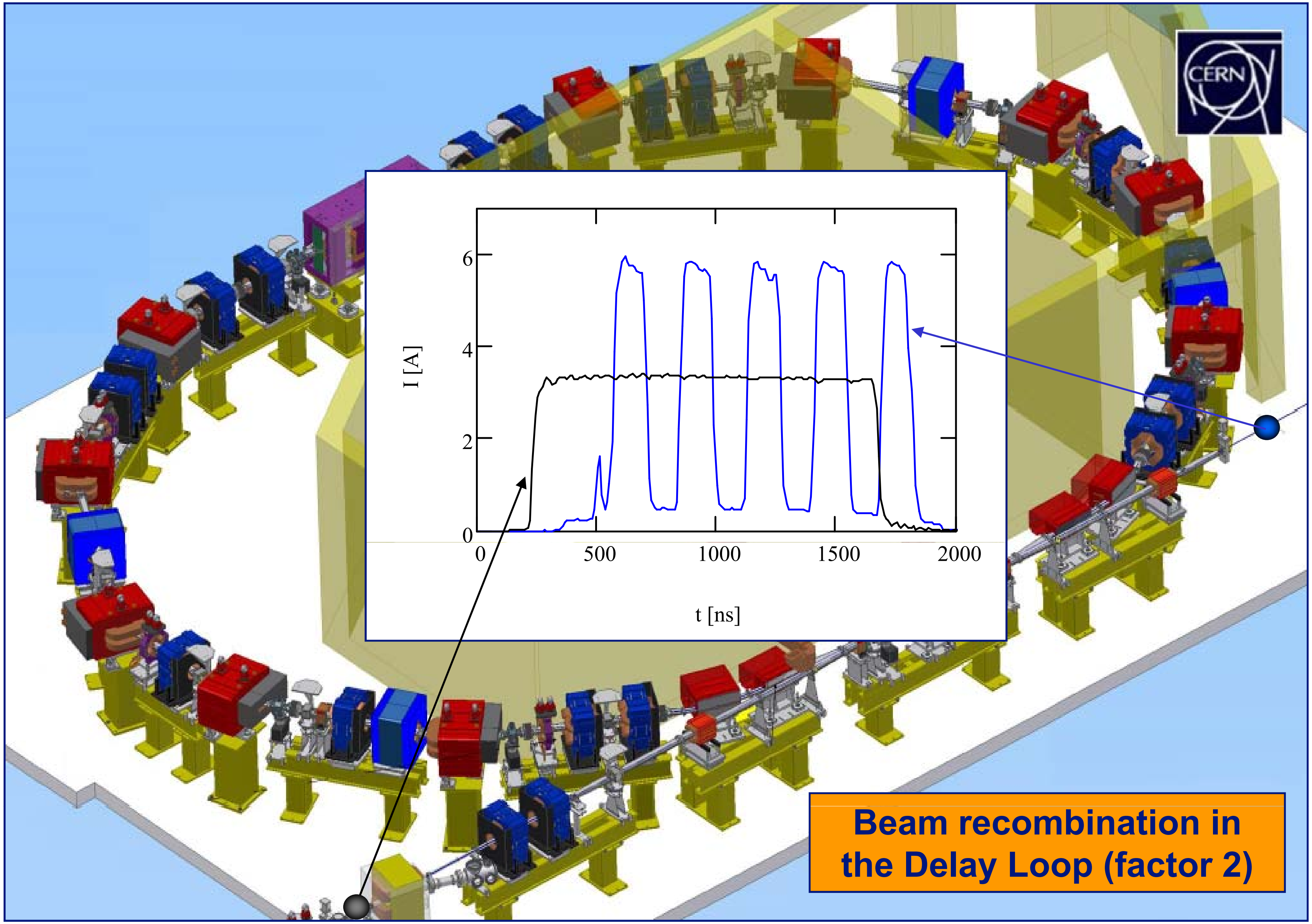


Dipole modes suppressed by slotted iris damping (first dipole's Q factor < 20) and HOM frequency detuning

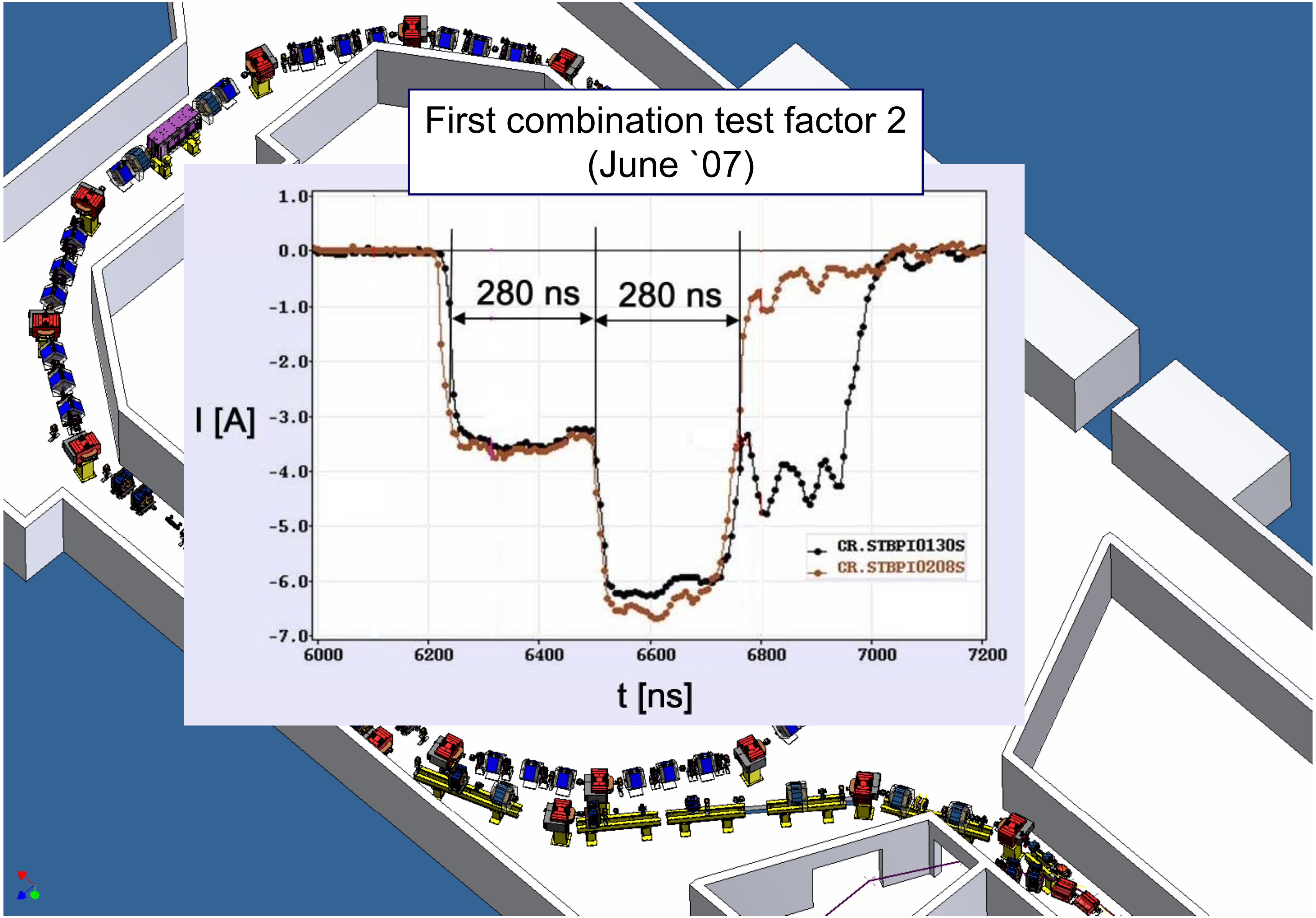
…n efficiency

…ses)

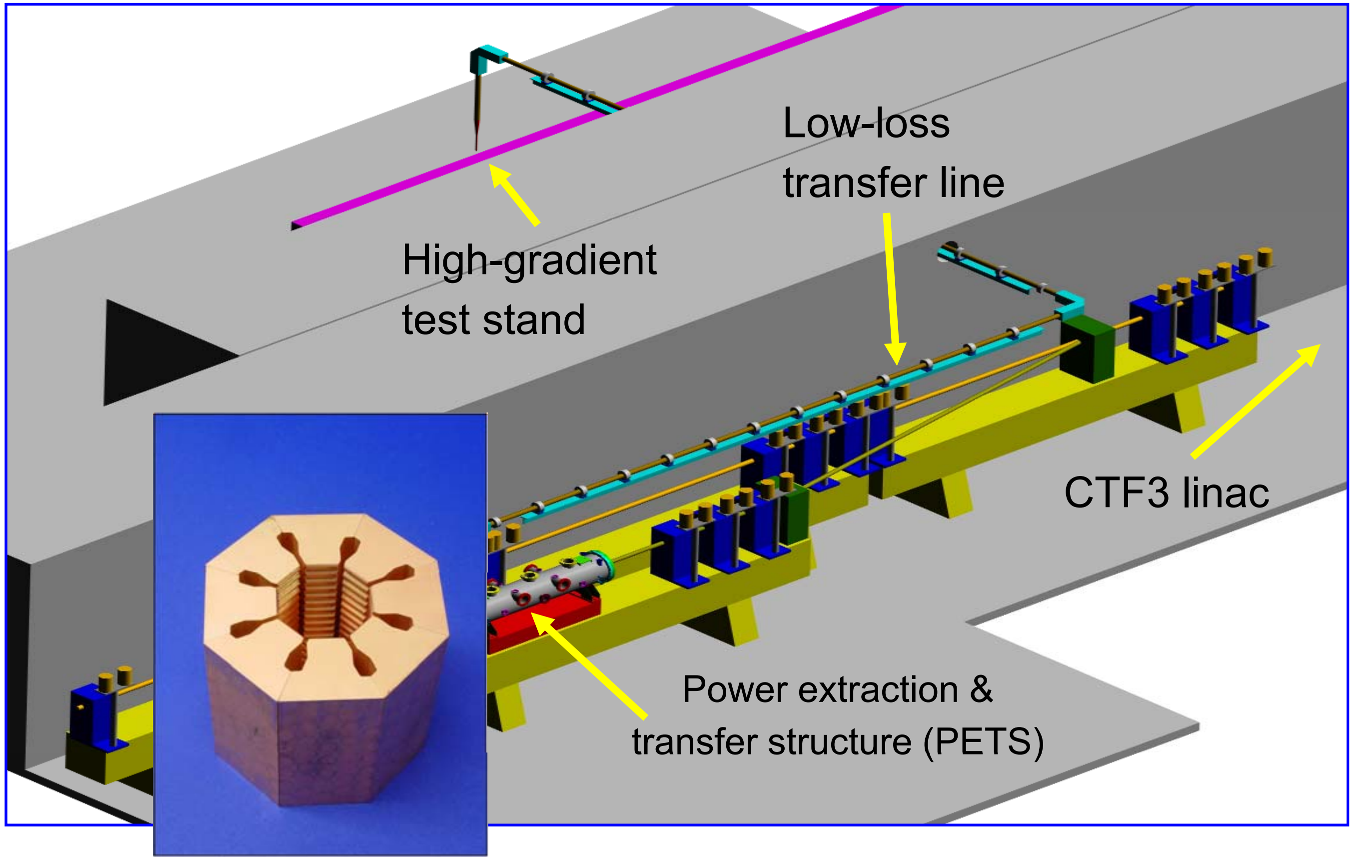




Beam recombination in the Delay Loop (factor 2)


First combination test factor 2
(June `07)
280 ns
280 ns
I [A]
t [ns]
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
6000
6200
6400
6600
6800
7000
7200
CR.STBPI0130S
CR.STBPI0208S

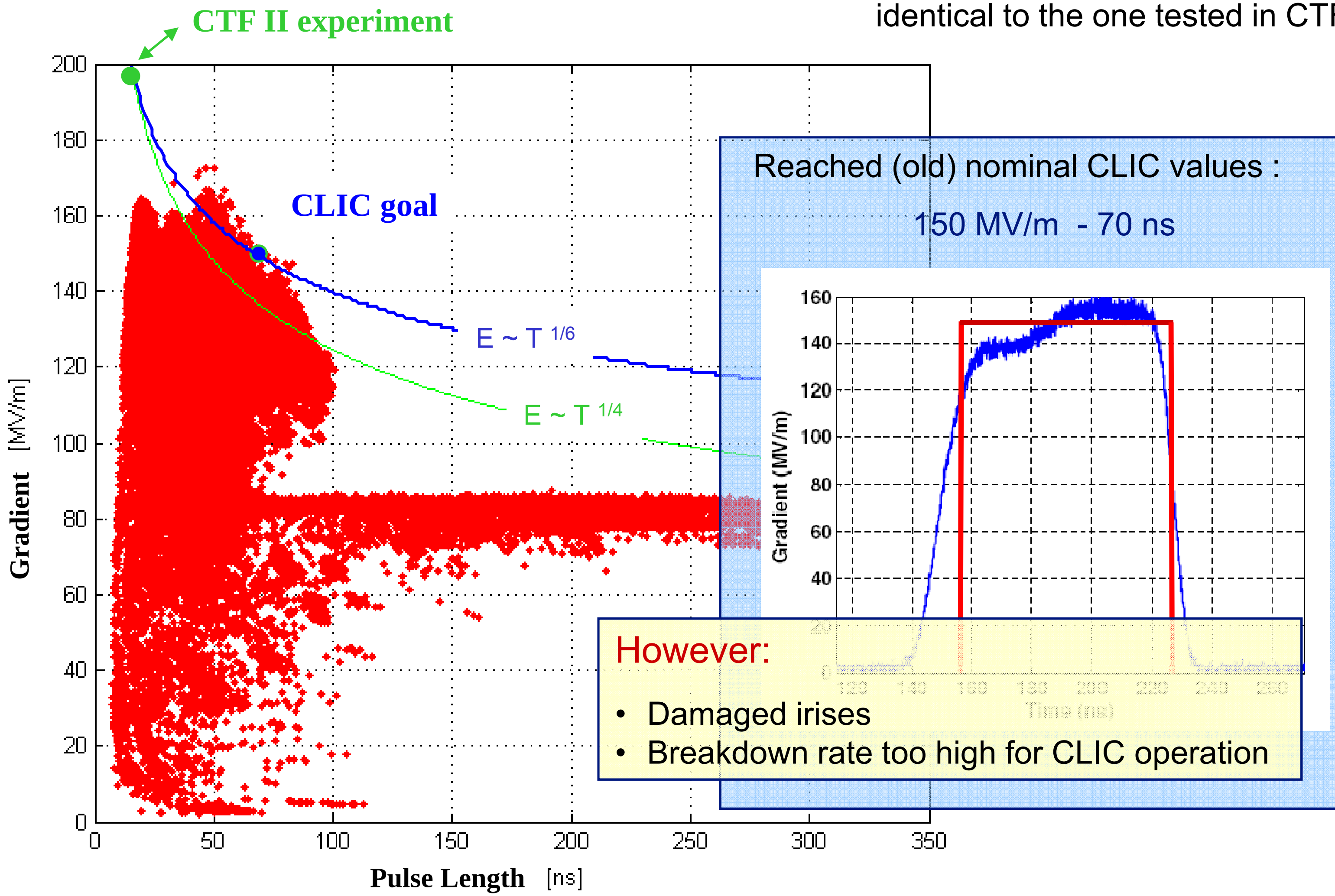
30 GHz Power production in CTF3



- Produced power up to about 100 MW – long pulses (up to 300 ns) available for the first time at 30 GHz
- Structure tests started in 2005 - 10 structures tested until now
- Routine 24h, 7 days a week operation of fully loaded linac for 30 GHz production

CTF3 High-gradient test results – 30 GHz

Mo iris – clamped structure, identical to the one tested in CTF II



Reached (old) nominal CLIC values :

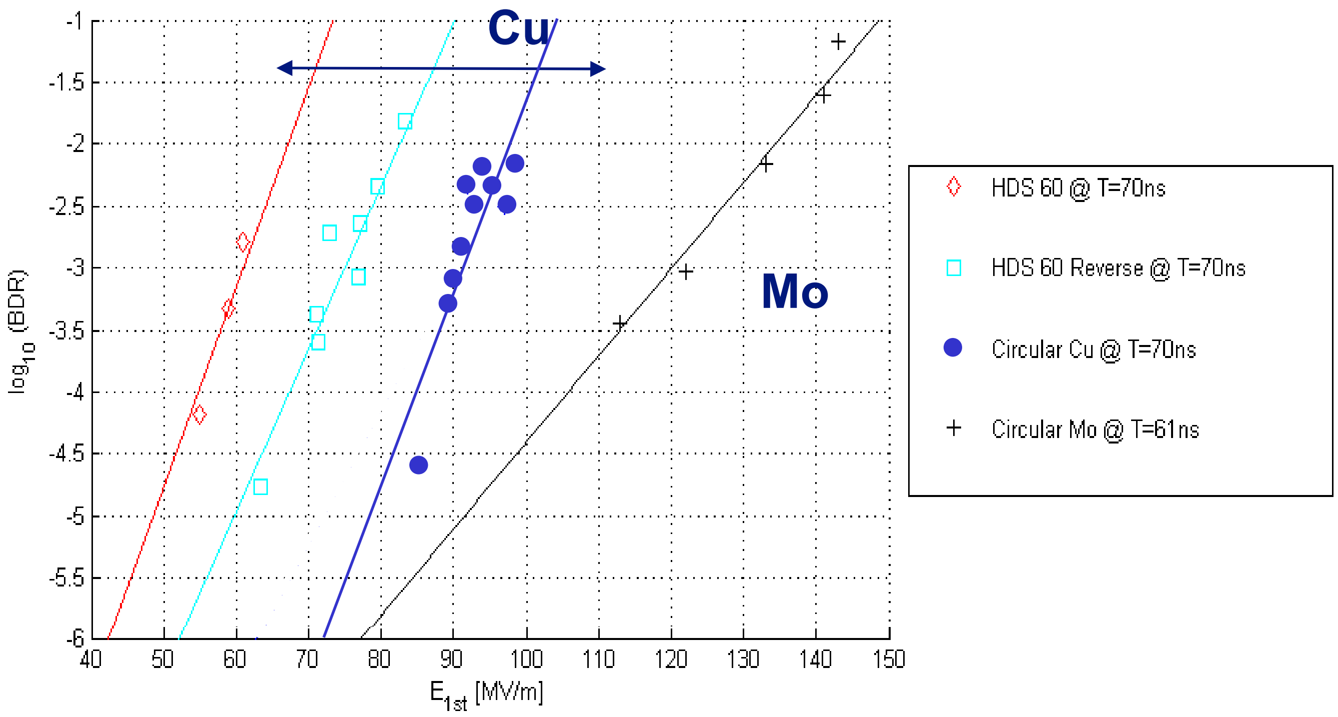
150 MV/m - 70 ns

However:

- Damaged irises
- Breakdown rate too high for CLIC operation

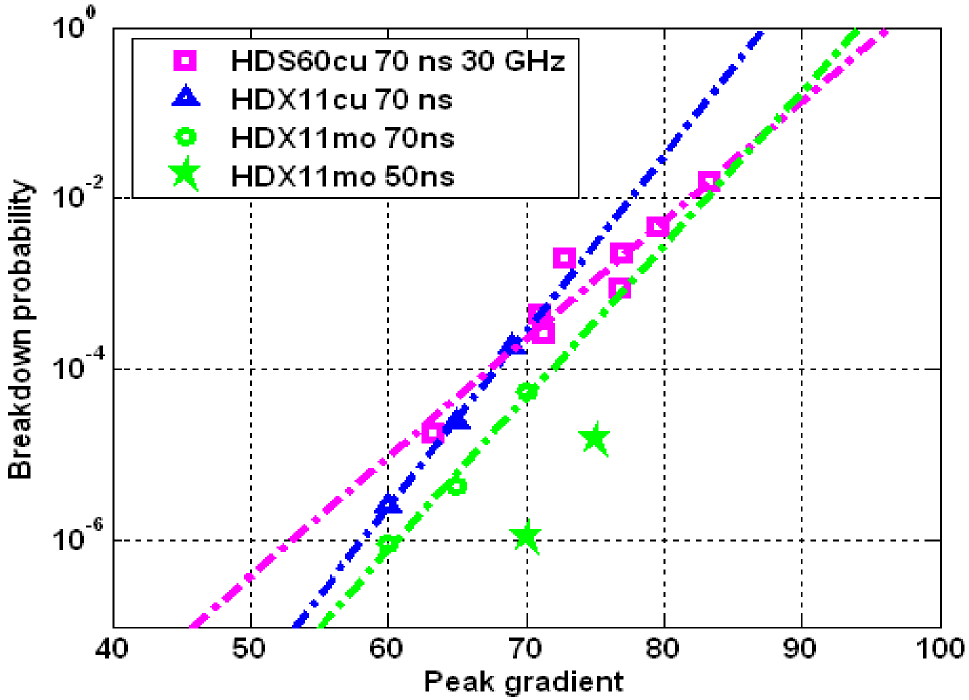
CTF3 High-gradient test results – 30 GHz

- Breakdown-rate slope for Mo (and W) in general less steep than Cu
- Mo slope & conditioning limit not consistent in different tests…

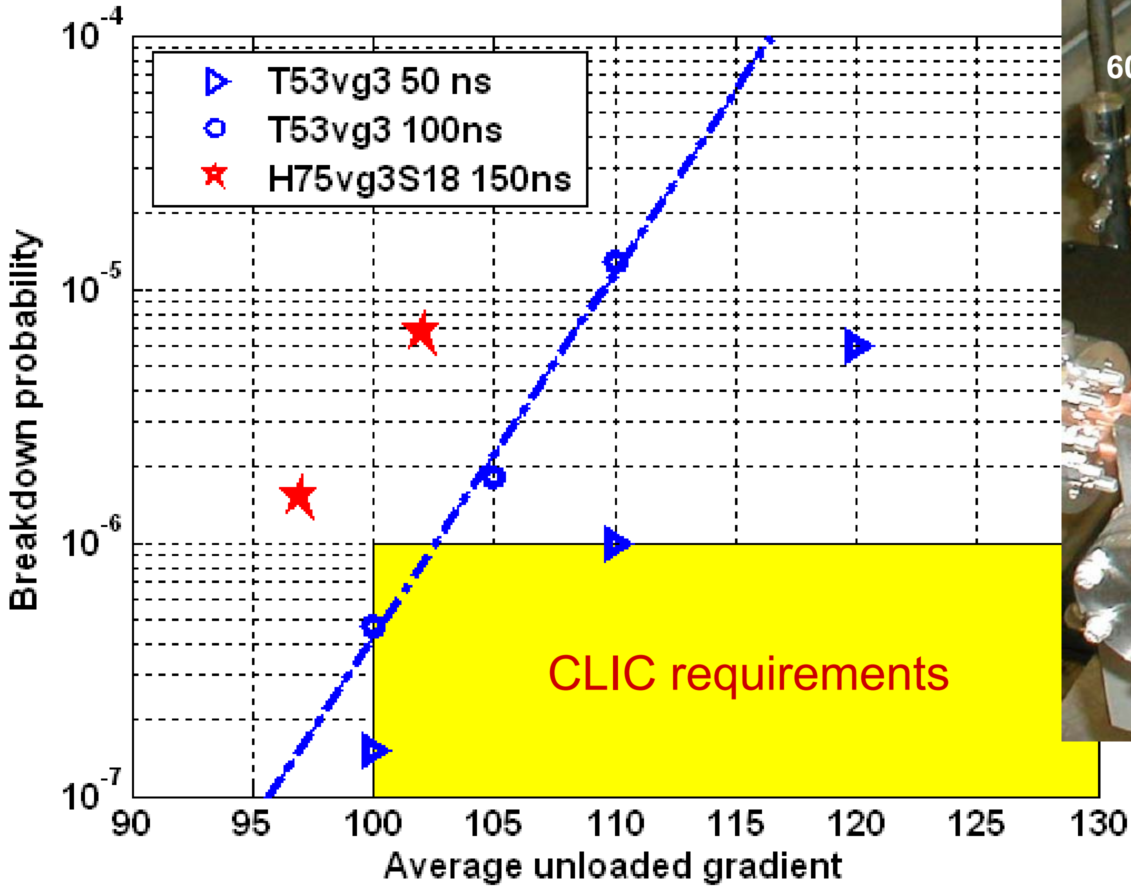


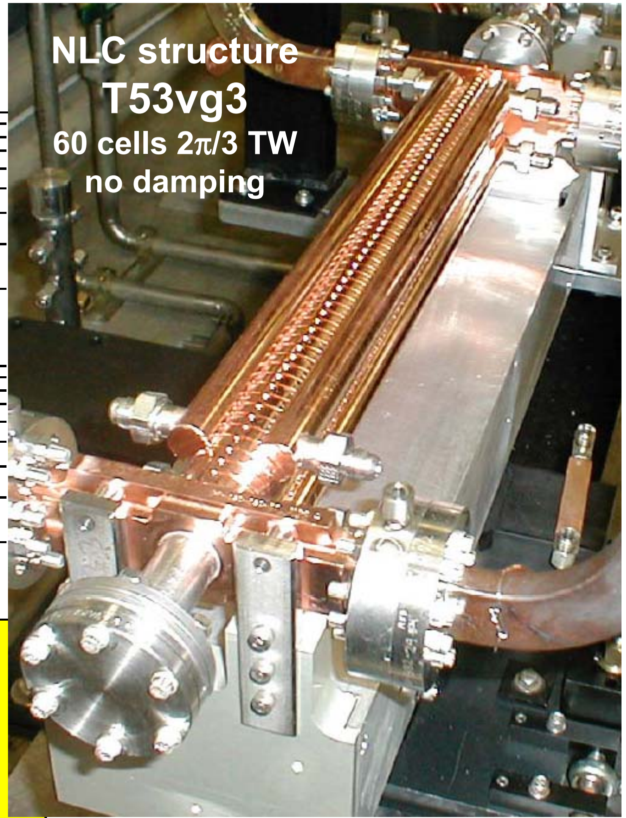
CTF3 + SLAC High-gradient test results – 30 & 11.4 GHz

- 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



Recent SLAC High-gradient test results – 11.4 GHz





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 11.4 GH		C10vg2.9 [2x]		_thick [2x]
NLCTA - S Station 11.4 GH				4 GHz
NEXTEF - I 11.4 GHz	C10_vg1.5	T18_vg2.4_disk [2]	TD18_vg2.4_quad [2]	TD18_vg2.4 [2]
CLEX – CERN 12GHz			PETS 12 GHz	T18_vg2.4_disk

Present X-band high-gradient R&D for CLIC relies heavily on collaboration with SLAC & KEK

NOT ONLY FOR TESTING !

FP6 EUROTeV funded activities (ongoing)

Diagnostic hardware

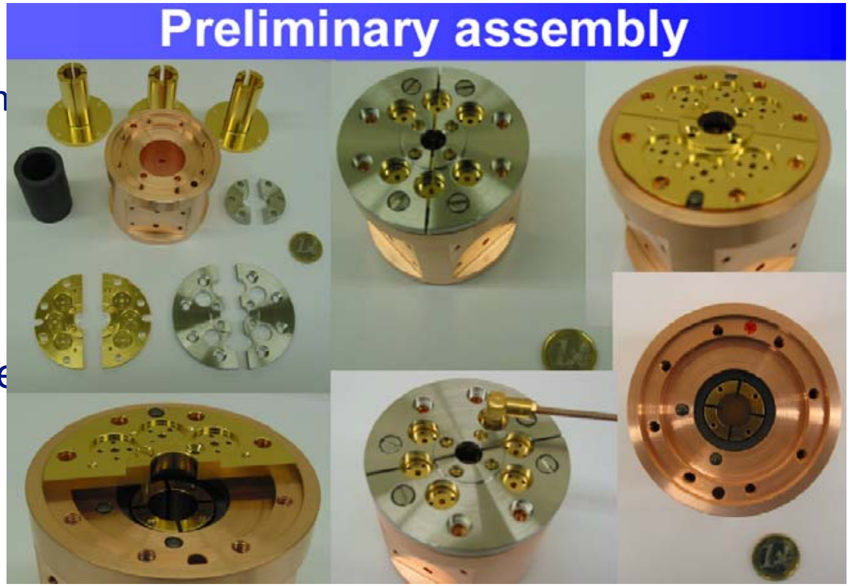
- Main linac BPM's (100nm resolution, 10μm precision)
- Wide band wall current monitors bandwidth >20 GHz for drive beam diagnostics

Precision phase measurements with better 0.1 deg.

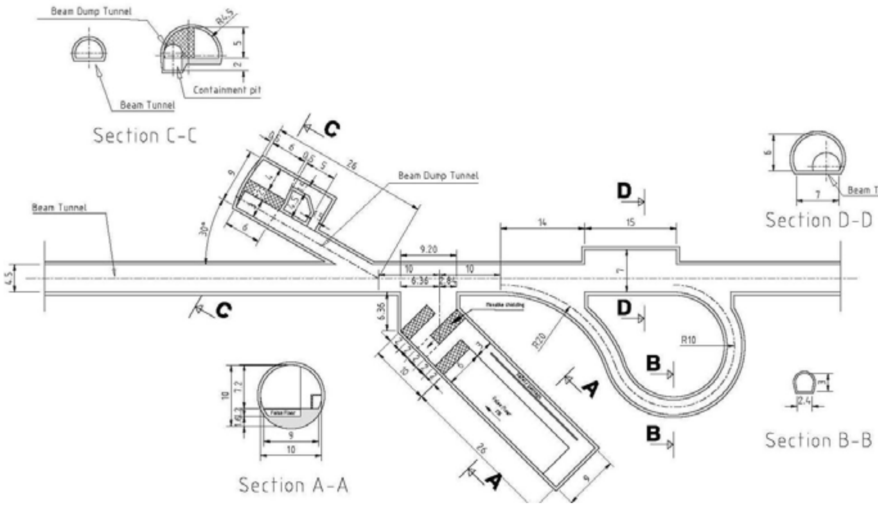
Beam dynamics activities

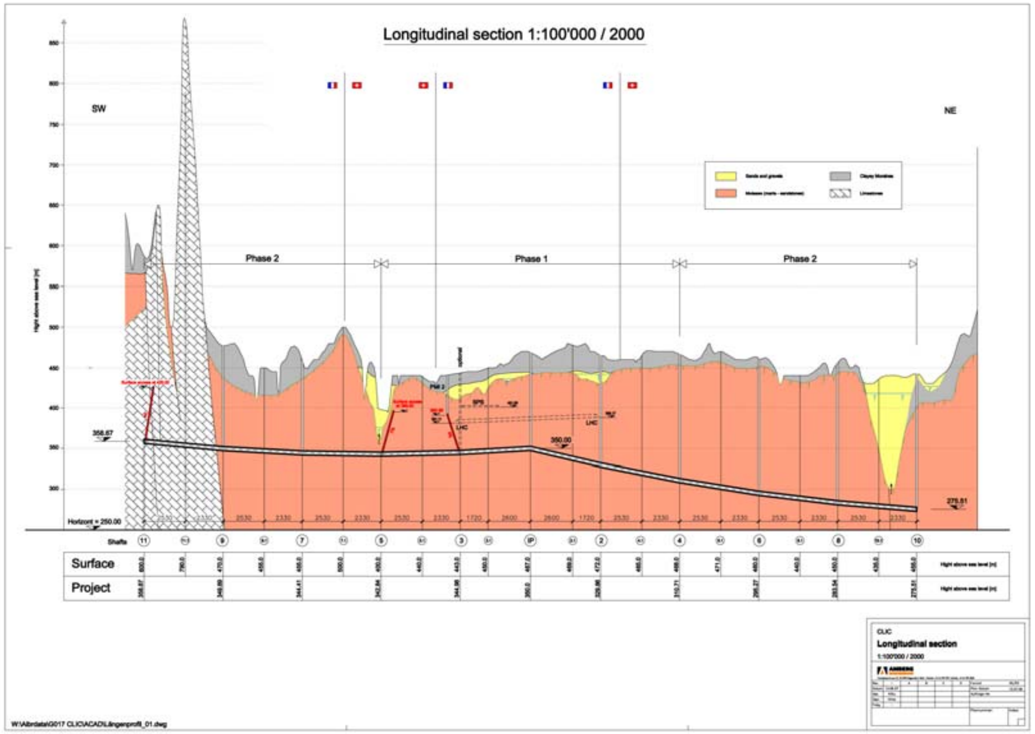
- Effects of coherent synchrotron radiation in bunch com
- Design of an extraction line for 3 TeV c.m.
- …

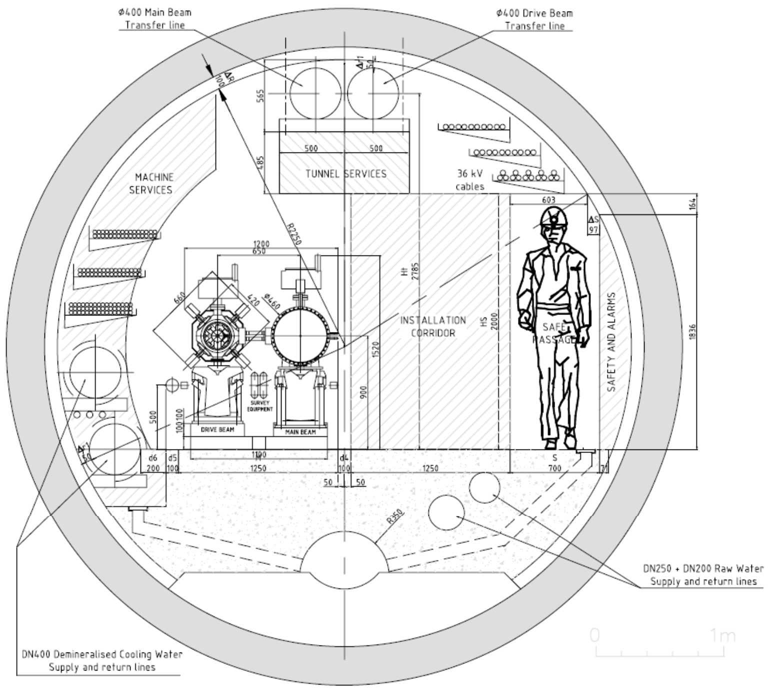
Development of 3D electron cloud code (complete



Civil Engineering Studies



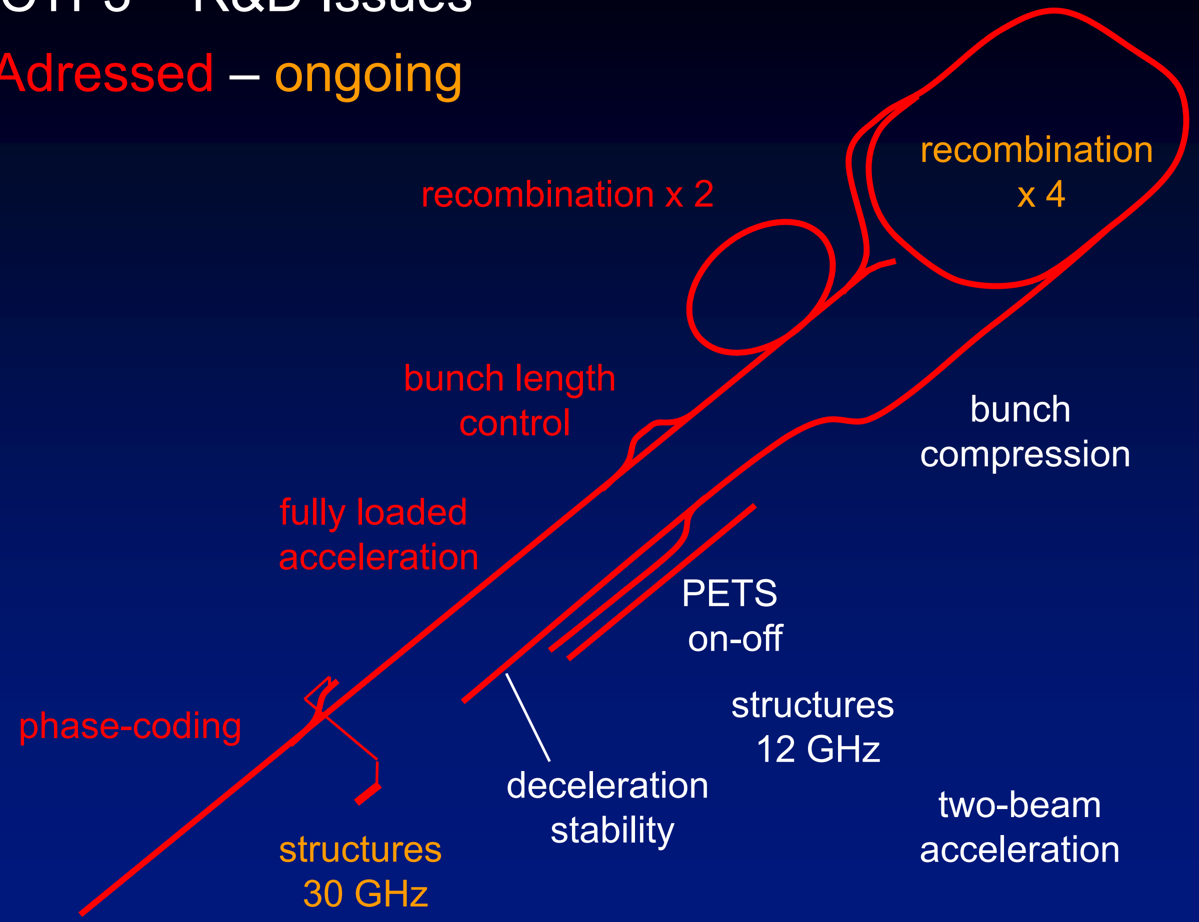


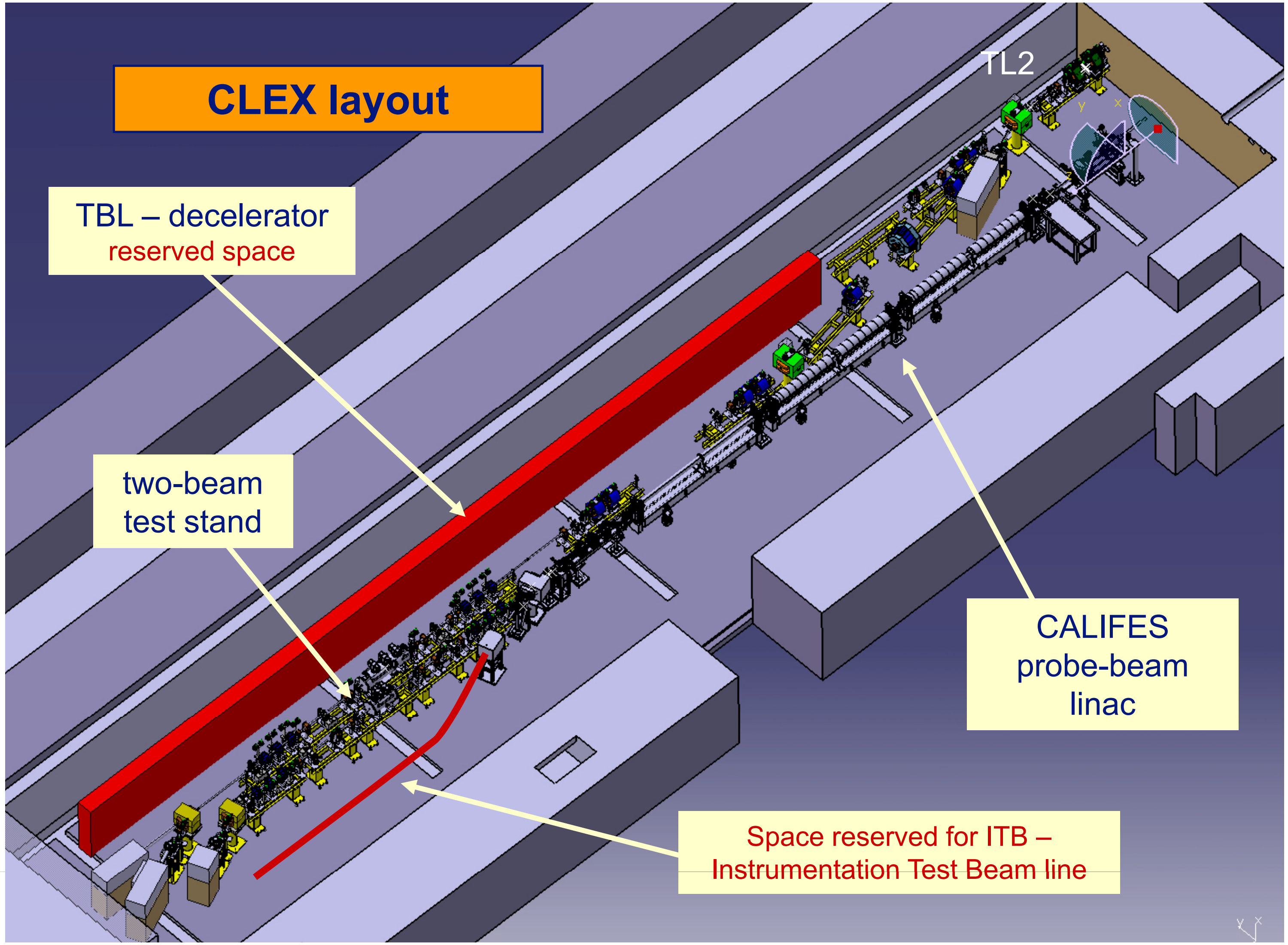


THE FUTURE

CTF3 – R&D Issues

Adressed – ongoing

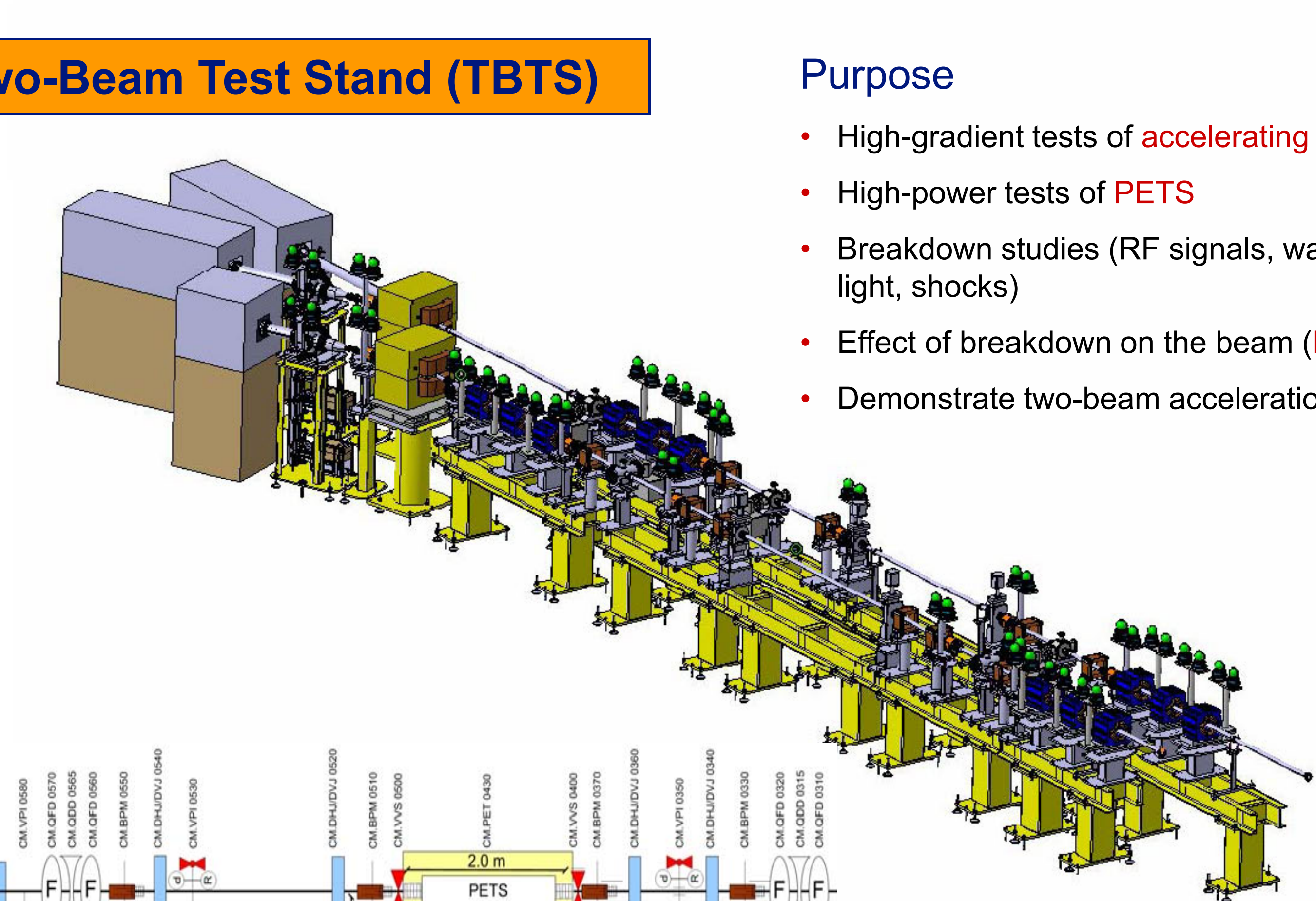


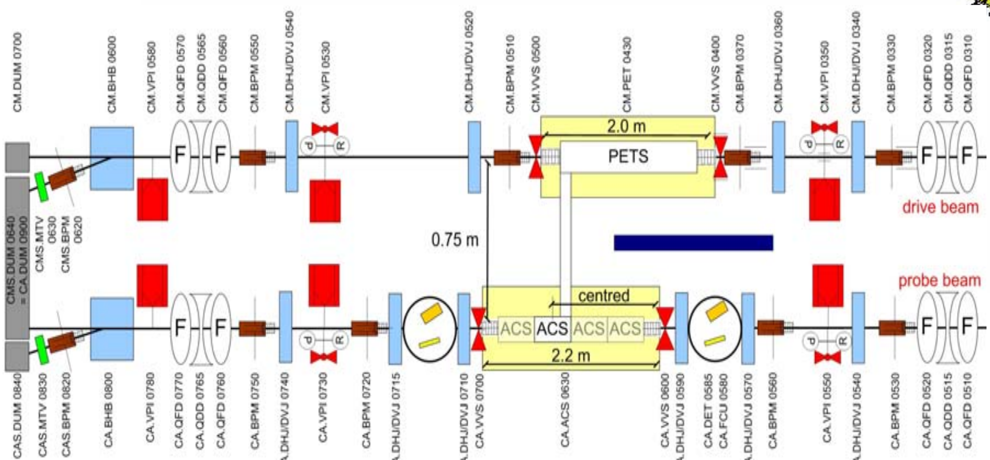

CLEX layout
TL2
TBL – decelerator
reserved space
two-beam
test stand
CALIFES
probe-beam
linac
Space reserved for ITB –
Instrumentation Test Beam line

CLEX building

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

Two-Beam Test Stand (TBTS)





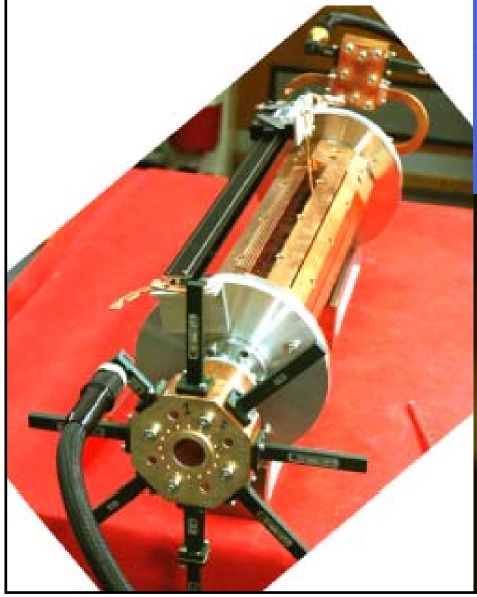
Purpose

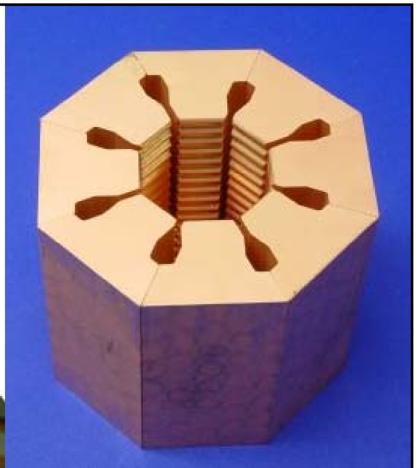
- High-gradient tests of accelerating structures
- High-power tests of PETS
- Breakdown studies (RF signals, water flow, temperature, light, shocks)
- Effect of breakdown on the beam (kicks and energy)
- Demonstrate two-beam acceleration (energy gain, spread)

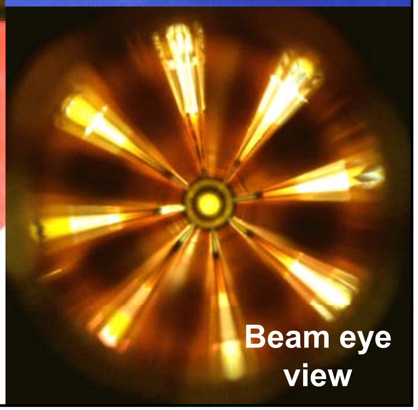
Power Extraction & Transfer Structure

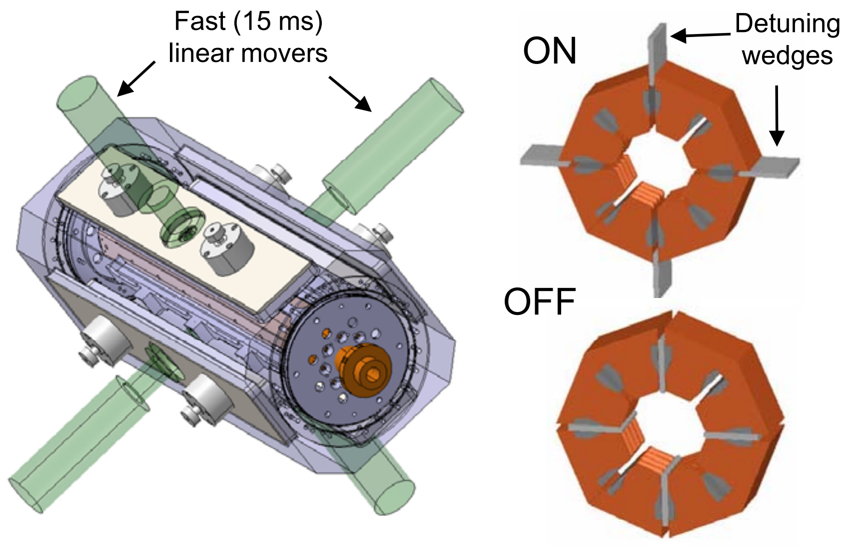
In interaction with the drive beam, the PETS must produce and efficiently extract a few hundreds MW of RF power.

Periodically corrugated structure with low impedance (big a/λ).

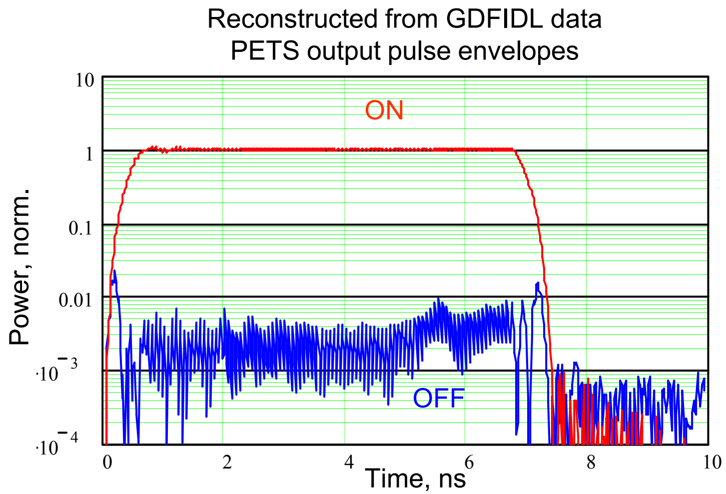






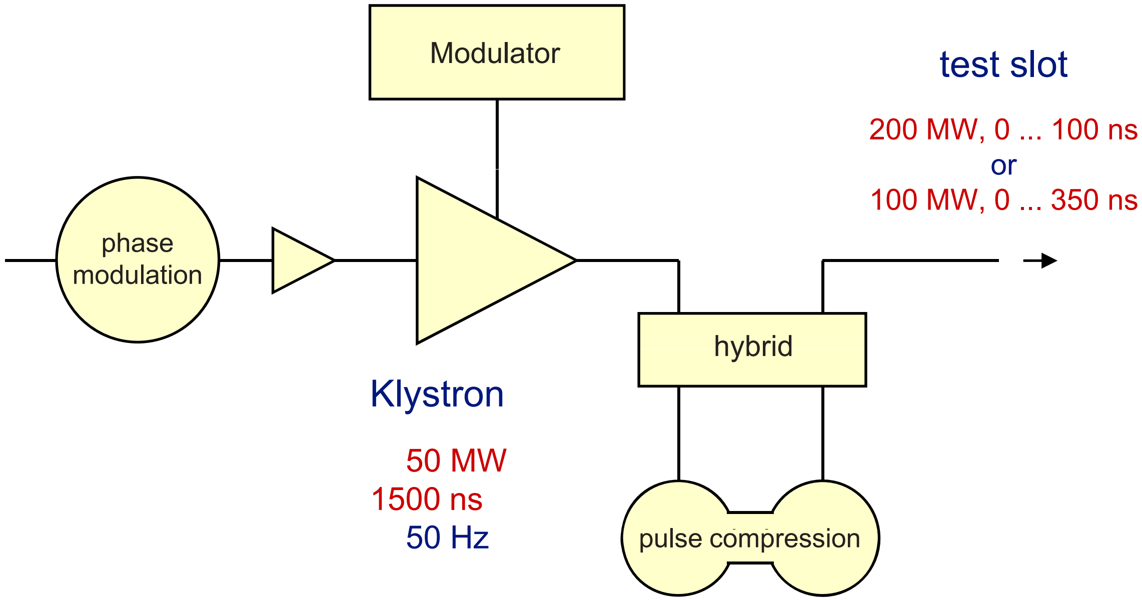


PETS ON/OFF mechanism



Stand-alone X-band RF power source

- Allows testing at CERN independend of CTF3 running from 2009 on
- Based on a scaled 11.4 GHz klystron
- Interest from other labs (PSI, INFN-Frascati, Trieste…)
- Fast turnaround increases significantly total number of tests
- Easily variable pulse length



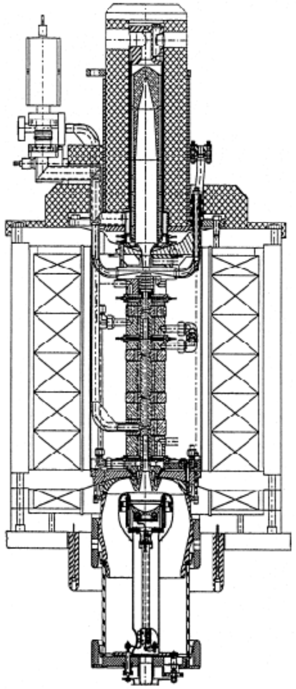
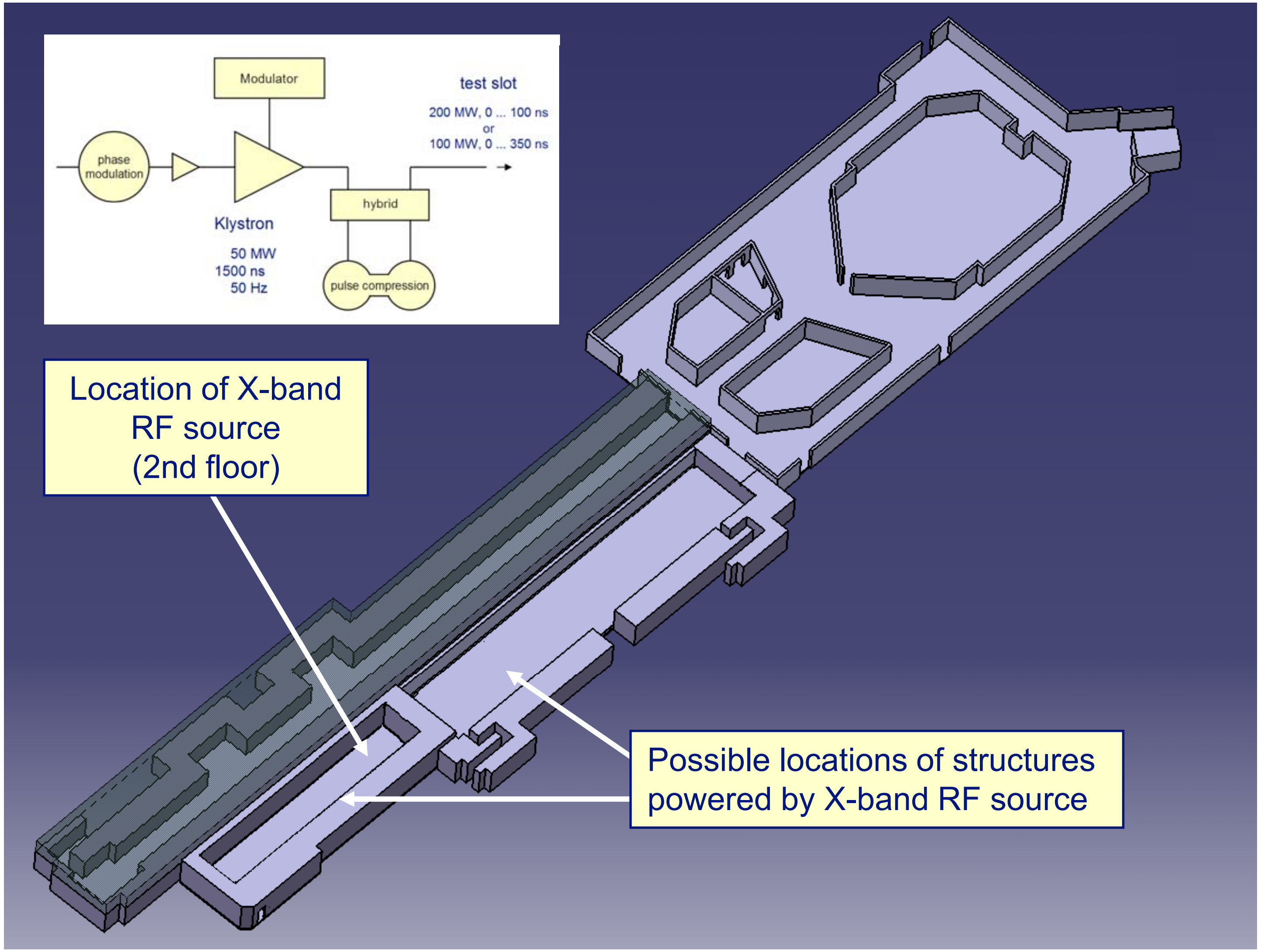


Table 1 - Klystron Parameters

PARAMETER	VALUE	UNITS
RF Frequency	11994.2	MHz
Bandwidth at -1dB	≥ 10	MHz
RF Power:		
Peak Power	≥ 50	MW
Average Power	≤ 3.75	kW
RF Pulse (at -3dB)	1.5	µs
HV pulse (at full width half height)	3.5	µs
Repetition Rate	50	Hz

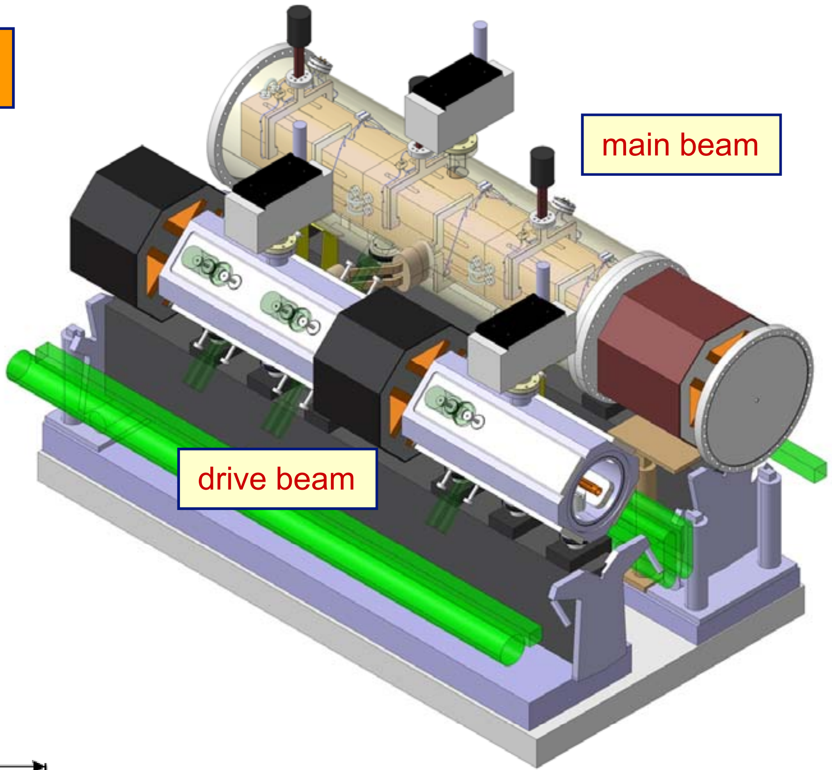
Stand-alone (?) X-band RF power source

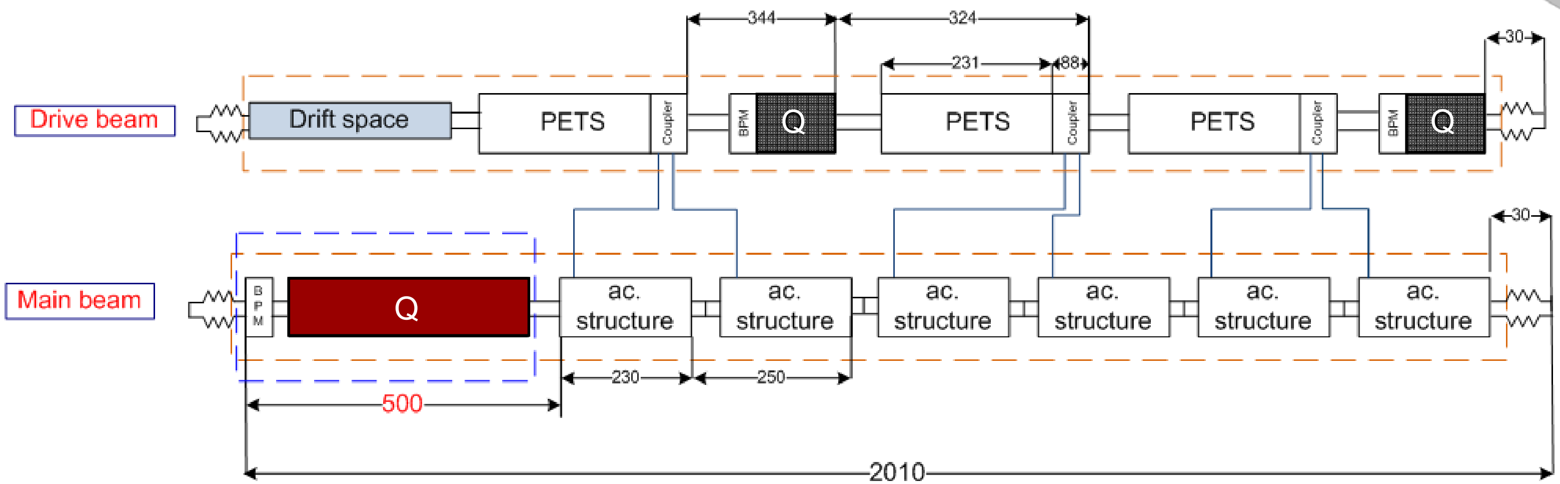


Module studies (EU-FP7 LED proposal...)

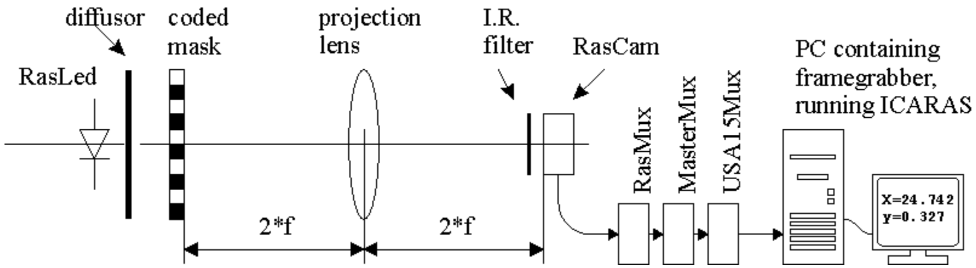
CLIC linac module with one quadrupole including

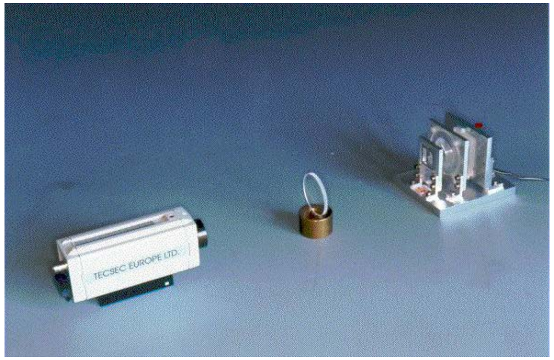
- vibration damping for quadrupole
- active pre-alignment system with sensors
- structure BPM
- test with beam in CTF3 TBTS

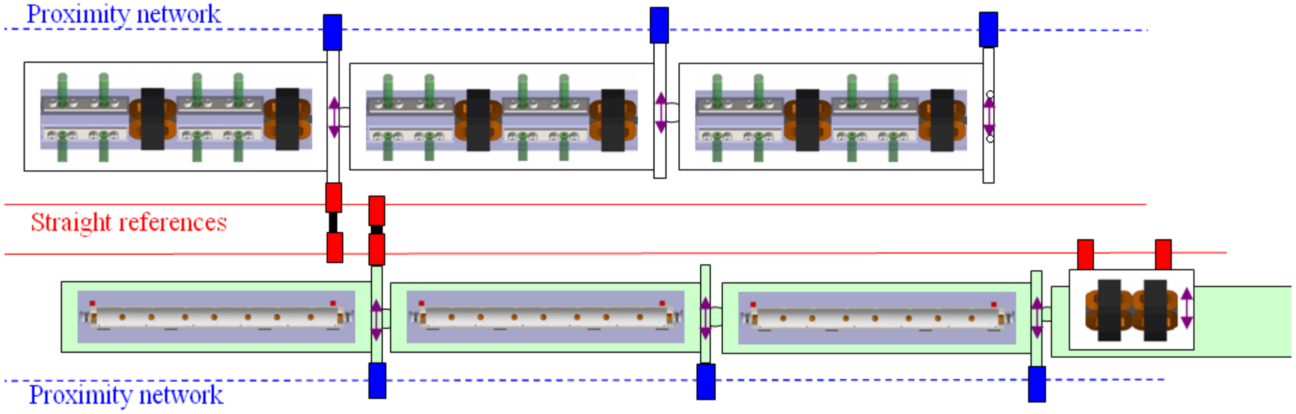




Module studies – pre-alignment

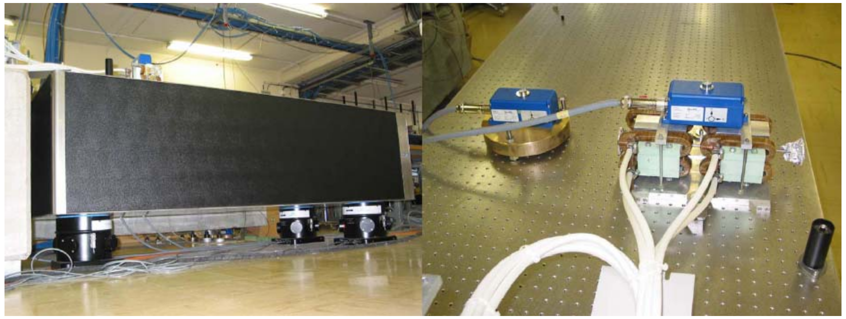






Stability

Stability of about 0.5-1nm has been demonstrated in the CERN vibration test stand



Future program:

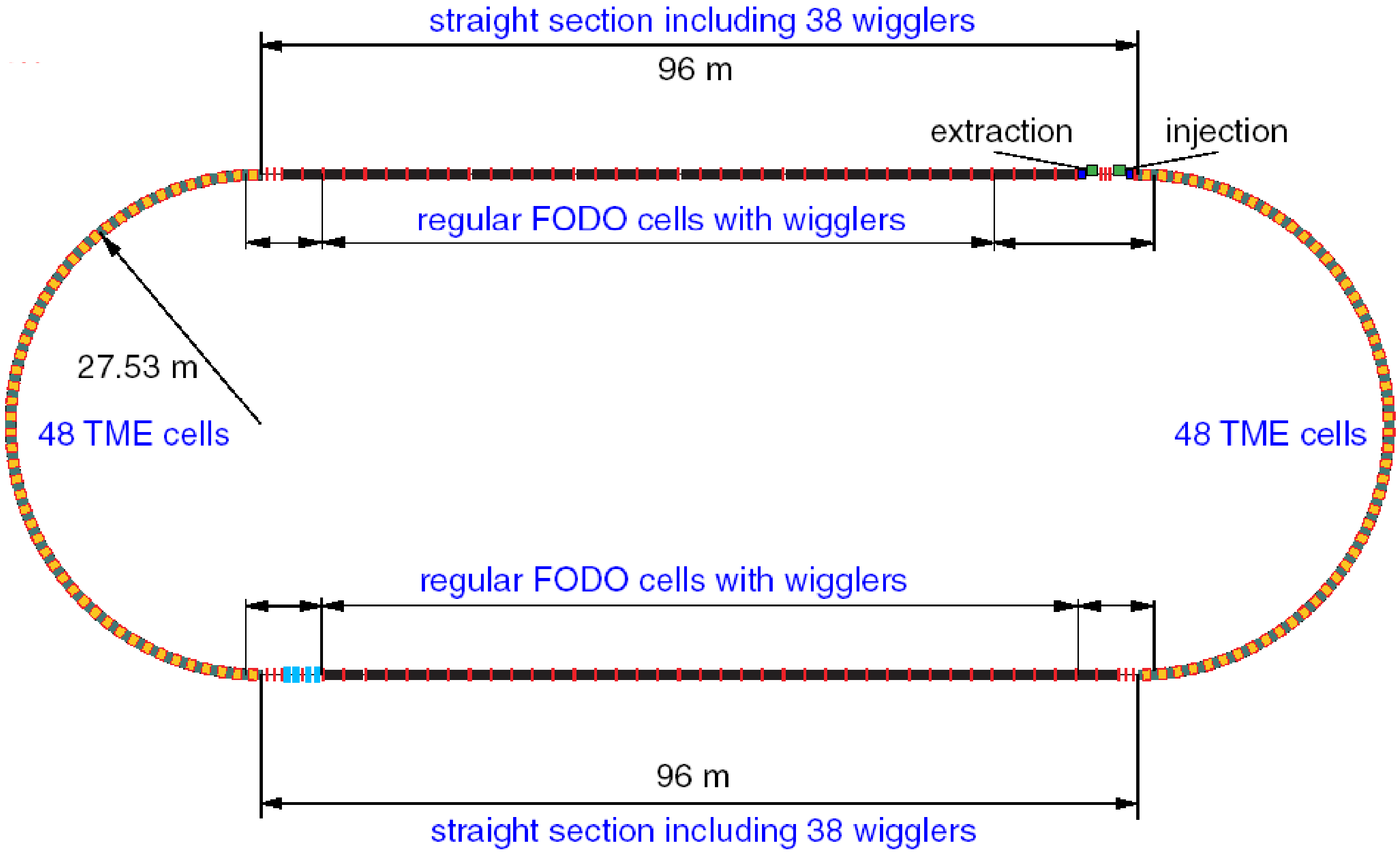
- Demonstrate 1 nm quadrupole stability above 1 Hz *(main linac, 1400 quadrupoles)*
- Demonstrate 0.1 nm stability above 5 Hz *(final focus)*
- Differences compared to previous studies:
  - 0.1 nm is beyond what we have shown
  - apply stabilization in an accelerator environment
  - achieve 1 nm with realistic equipment not simple elements on a special table
  - verify performance with two different methods
- Characterize noise sources in an accelerator

CTF3 beam tests - (EU-FP7 EURODrive)

- Start to end simulation of drive beam including trajectory and optics measurement and correction algorithm
- Integrate this program package in CTF3 controls and test with real beam
- Beam phase measurement in CTF3

R&D for CLIC damping ring hardware

wiggler dominated ring !



R&D for CLIC damping ring hardware

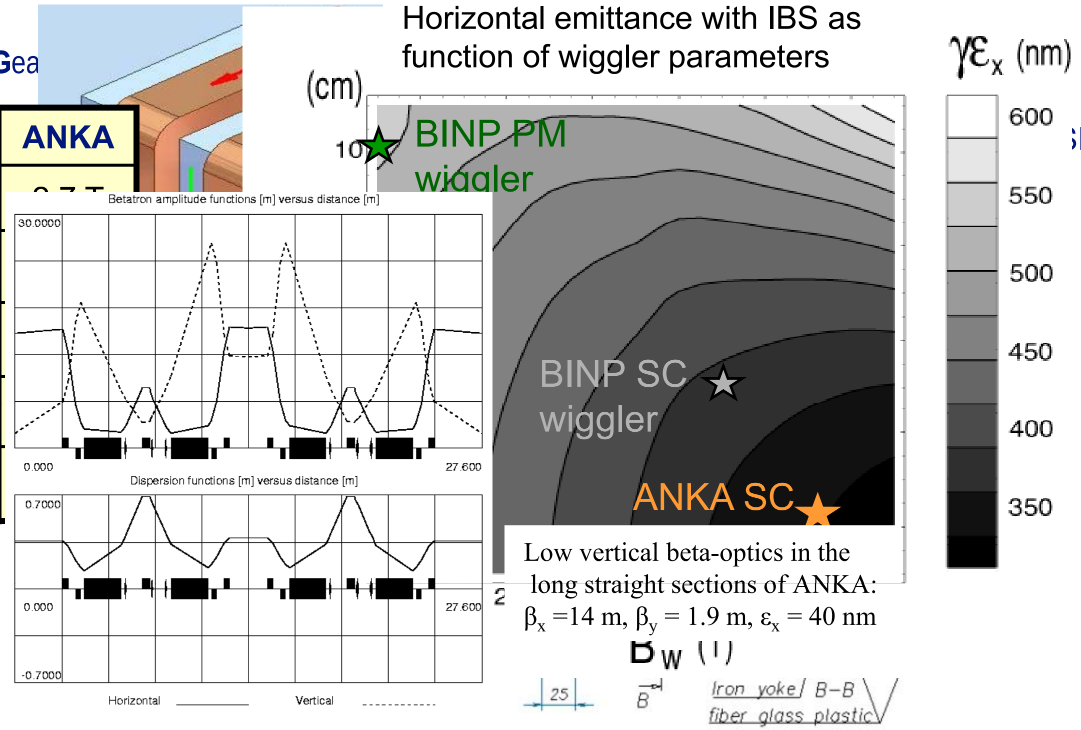
S.C. wiggler magnet development for CLIC DR

Existing CERN-BINP collaboration has produced paper design including SR absorbers.
Presently a short prototype is constructed for demonstration of magnetic feasibility and field measurement as input for beam dynamic simulations.

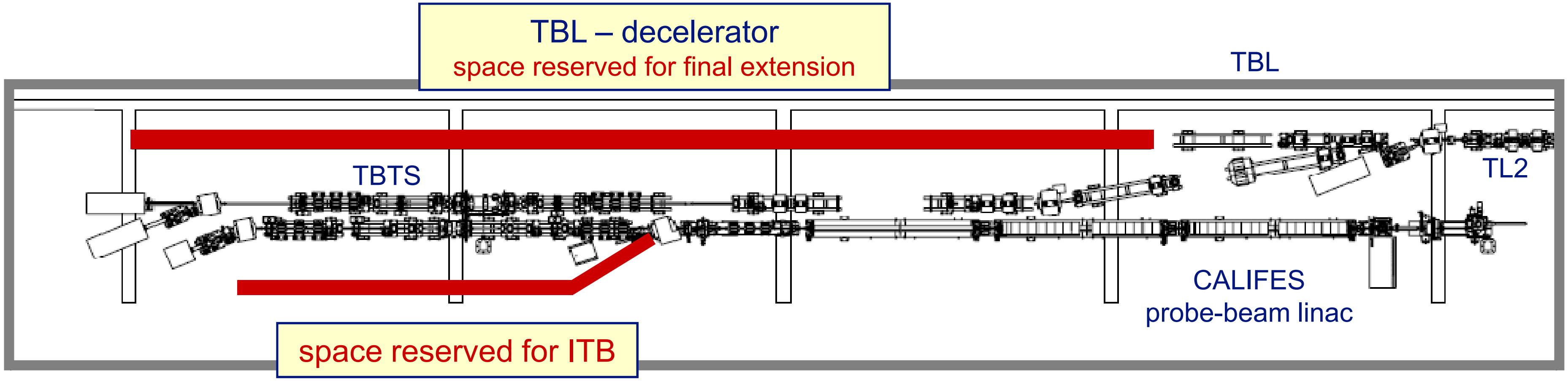
ANKA wiggler team has made a paper design for a s.c. wiggler with more aggressive parameters.

GADGET= (**G**eneration **A**nd **D**iagnostics **G**ea

	BINP	ANKA
B_{peak}	2.5 T	[illegible]
λ_W	50 mm	[illegible]
Beam aperture full height	12 mm	[illegible]
Conductor type	NbTi	[illegible]
Operating temperature	4.2 K	[illegible]



ITB – Instrumentation Test Beam line



ITB = Instrumentation Test Beam

Use of CALIFES beam for instrumentation R&D (for example cold BPM's for wiggler, bunch length measurement, …)

→ Potential to create an 800 MeV test linac using CTF3 TBL

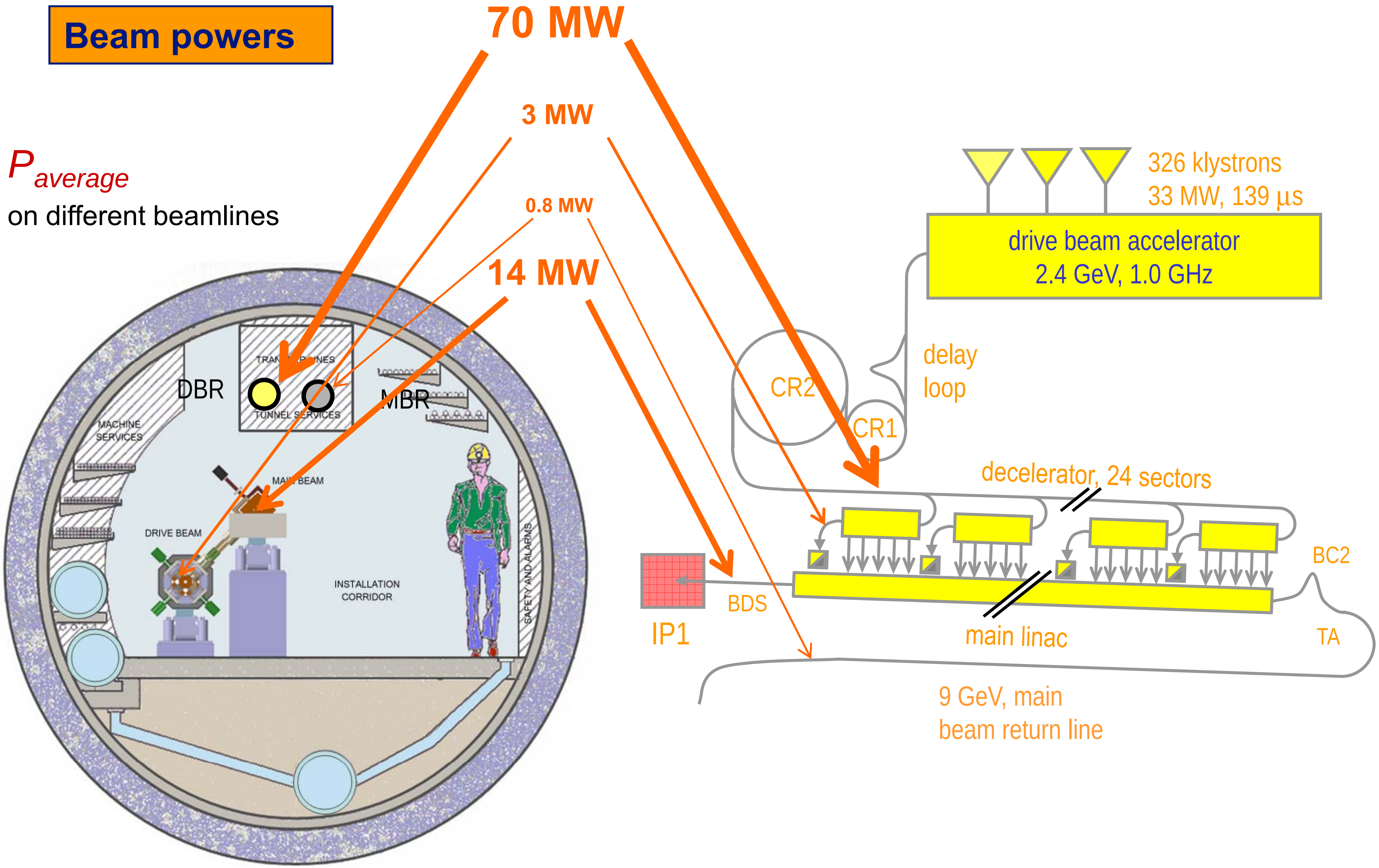
M. Huening, A. Mosnier, V. Shiltsev & T. Raubenheimer
CLIC Advisory Committee Report

Diagnostics – some issues needing more studies

- Beam profile – main beam
- Emittance – main beam (for tuning bumps)
- Beam profile – drive beam
- FFS and spent beam line instrumentation
- Luminosity monitor
- Beam loss instrumentation
- ...

Beam powers

$P_{average}$
on different beamlines



Drive-Beam Machine Protection System (MPS)

Assuming that we can accept distributed drive beam loss equivalent to 100 W/min drive beam return line (already pretty unpleasant for activation)

Length return line 21 km, P_{beam} = 70MW

⇒ total loss < 2.5%,
loss per km < 0.13%

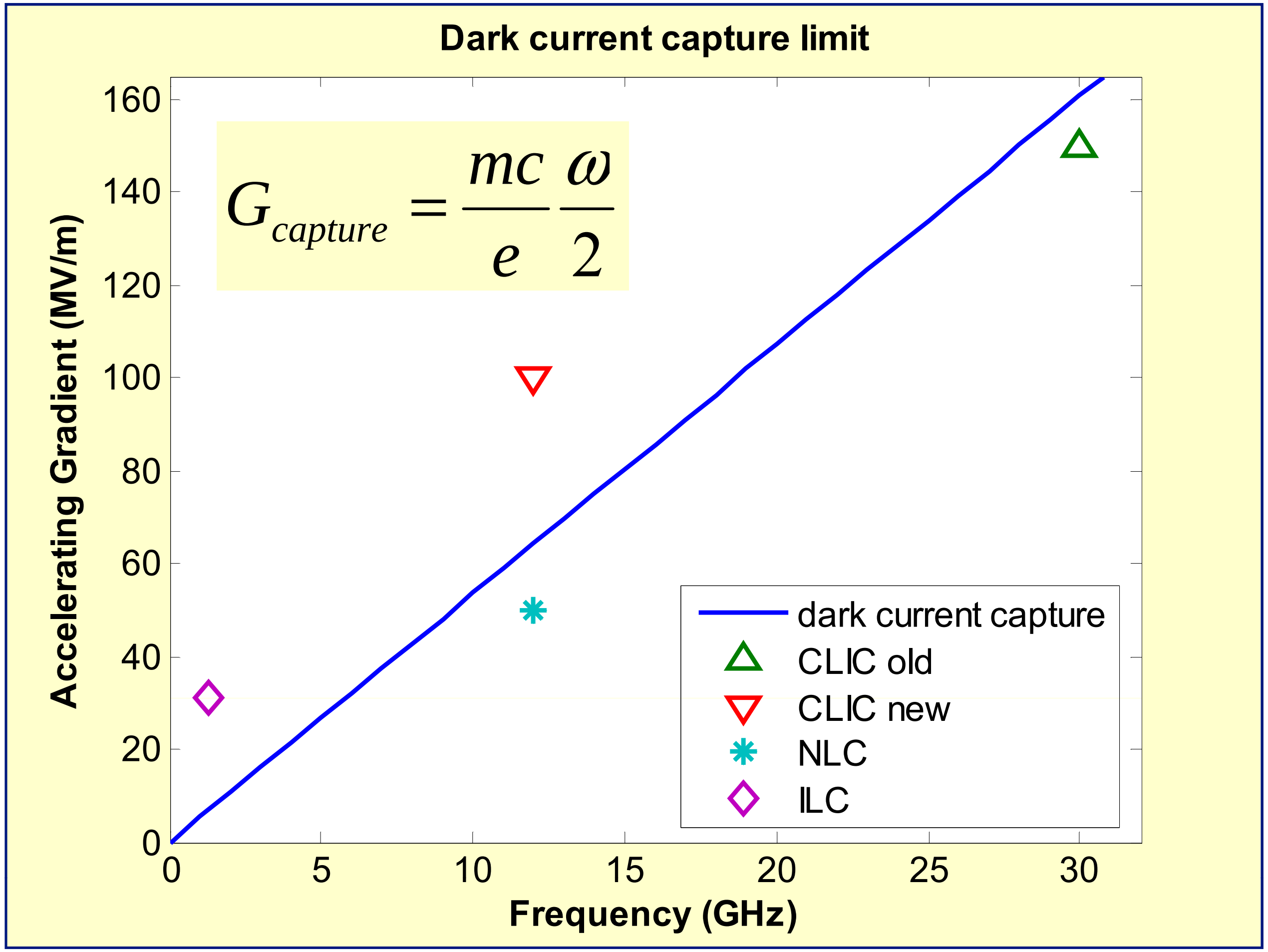
The issue of drive beam loss control is known for long time

Therefore we had foreseen in CTF3:

- *Identical wall current monitors end of injector and before each beam dump together with fast interlock for immediate gun interlock in case of differential losses*
- *A system of beam loss monitors to detect losses smaller than wall current monitor differential resolution*
- *A kicker to dump beam-loading transients in controlled manner*
- *Special OTR imaging devices to measure halo density distribution*

But all this activities are dormant, because CTF3 with 4 kW maximum beam power doesn‘t need such sophisticated MPS and it is practically impossible to motivate these activities while other key commissioning milestones have not been reached.

How important is dark current ?



Some more issues which deserve more attention

- Collimator design main beam and drive beam
- FF quadrupoles and supports
- Control system concepts capable to deal with feedback needs
- Start-up scenarios (how to switch on a 70 MW beam)
  related problem: tune-up dumps
- Impedances others than RF structures and BDS collimators (main & drive beam)
- Transient RF loading in DR
- Pre-Damping Ring
- Positron source
- ...

A concern...

For CDR we need to get credible concepts for all components.
We try to fill holes in the study and find the required resources inside and outside CERN.

But what should/could be done to get confidence:

- In DR feasibility without building a full scale prototype
- In DB decelerator feasibility without building a full sector
- In low emittance transport without building a 100 GeV linac ?

New collaborations – new model

Until now, most of the collaborations were centered on purely CTF3 activities, however, “times-are-a-changing”:

- Need still help on CTF3 (increasing activities)
- Need new collaborations on CLIC subjects (Design report and beyond)

The last MoU signed (JLab package) is a very good example:

- Help in CTF3 commissioning
- R&D on non-destructive transverse profile diagnostics
- Design & performance evaluation of isochronous beamlines from ground level to deep tunnel
- Main beam spin transport
- Design of polarized CLIC e^- source.
- Decelerator beam dump design (52 needed in total)

BACK-UP SLIDES

CLIC main parameters

NEW

Center-of-mass energy	3 TeV
Peak Luminosity	6 10^{34} cm^{-2} s^{-1}
Peak luminosity (in 1% of energy)	2 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	3.7 10^{9}
Beam pulse length	160 ns
Average current in pulse	1 A
Hor./vert. normalized emittance	660 / 20 nm rad
Hor./vert. IP beam size before pinch	40 / ~1 nm
Total site length	47.9 km
Total power consumption	320 MW

Provisional values

CLIC 07

CLIC R&D Status and Prospects

R. Corsini, 16/10/07

WORLD WIDE CLIC & CTF3 COLLABORATION

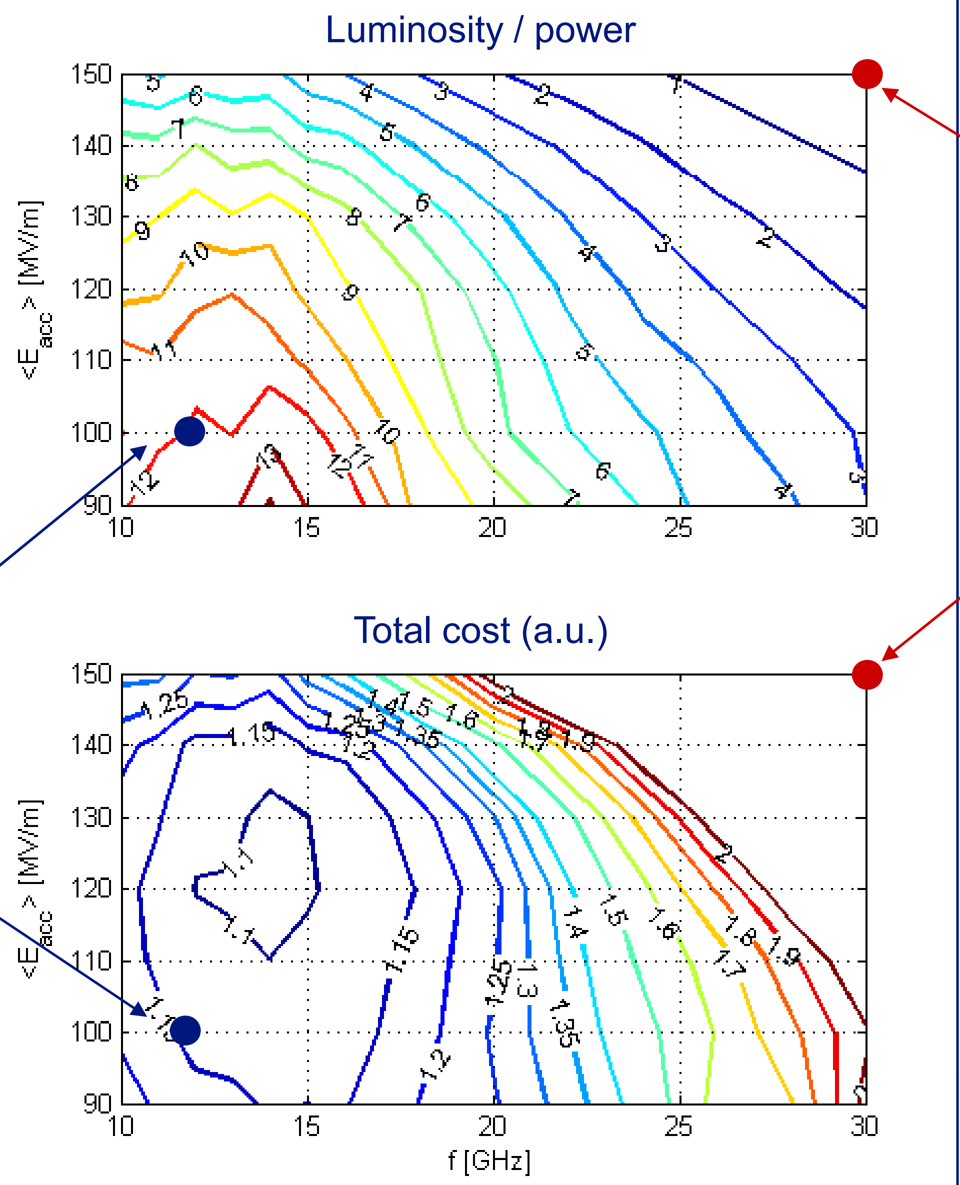
Ankara University (Turkey)
Berlin Tech. Univ. (Germany)
BINP (Russia)
CERN
CIEMAT (Spain)
DAPNIA/Saclay (France)
RRCAT-Indore (India)

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

Optimization results

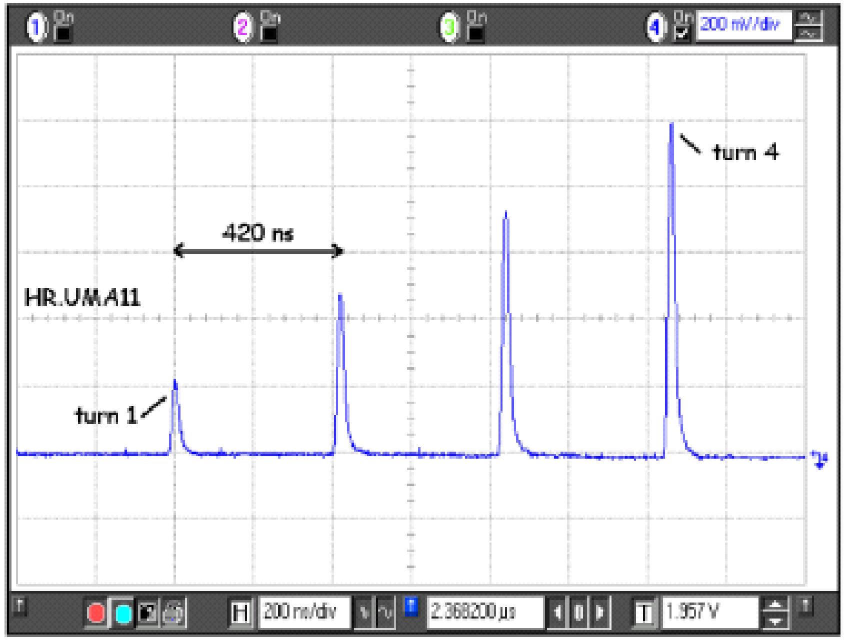


CLIC
old parameters

CLIC
new parameters

A. Grudiev et al.
EPAC '06

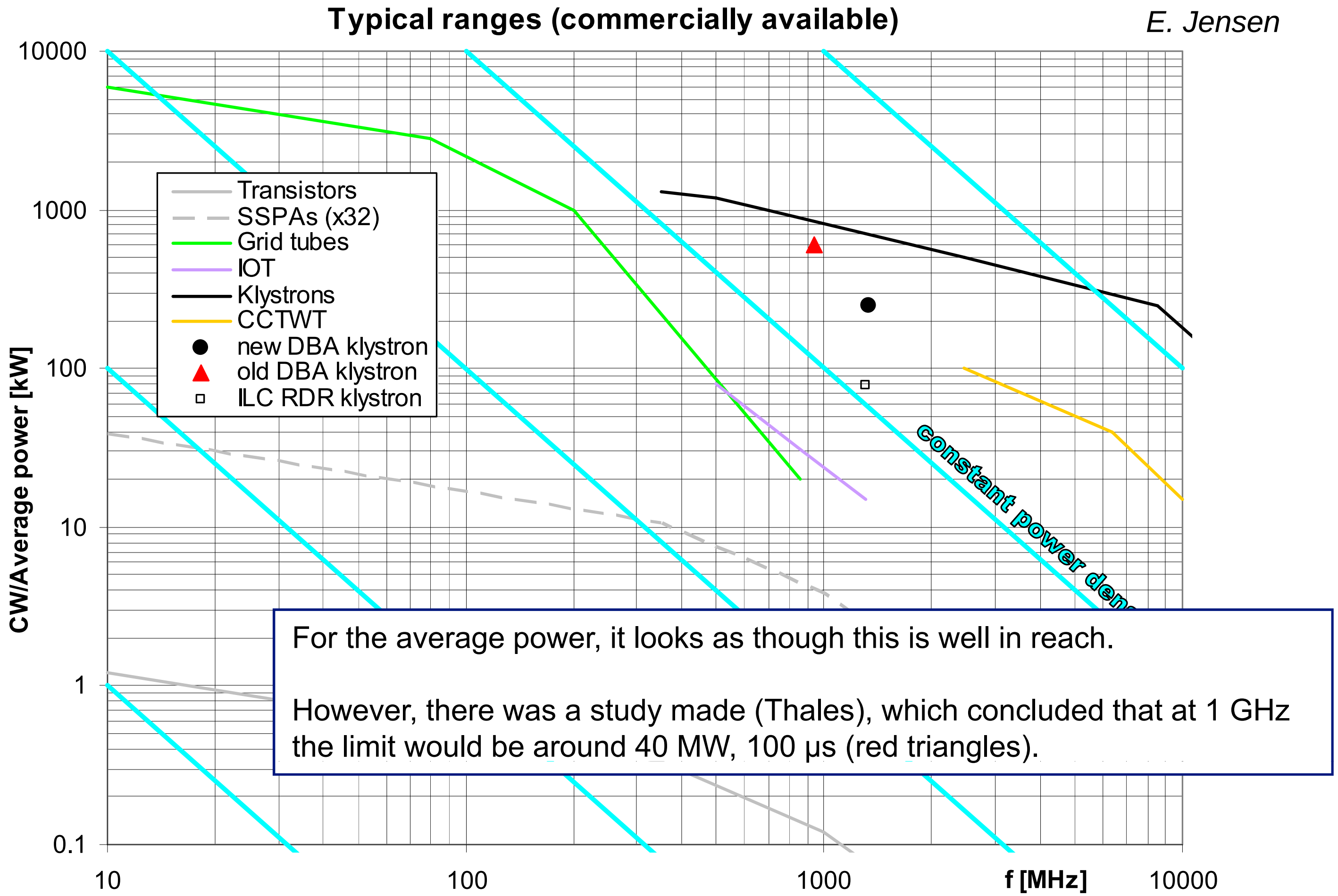
Preliminary phase results



Beam current circulating in the ring measured
during combination with a beam current monitor

R2.5: Validation of drive beam 40 MW, 937 MHz Multi-Beam Klystron with long RF pulse

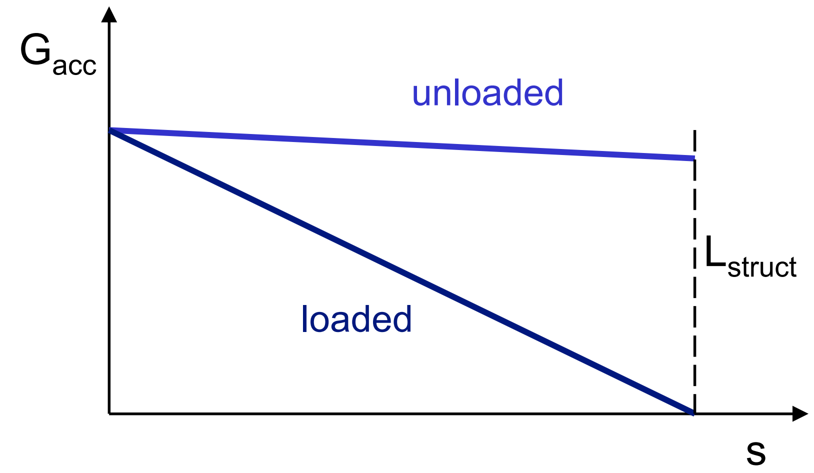
The validation of the proposed multibeam klystron performance is needed to finalize the design choices for the CLIC drive beam generation. This applies particularly to the 3 TeV energy upgrade (long pulse).

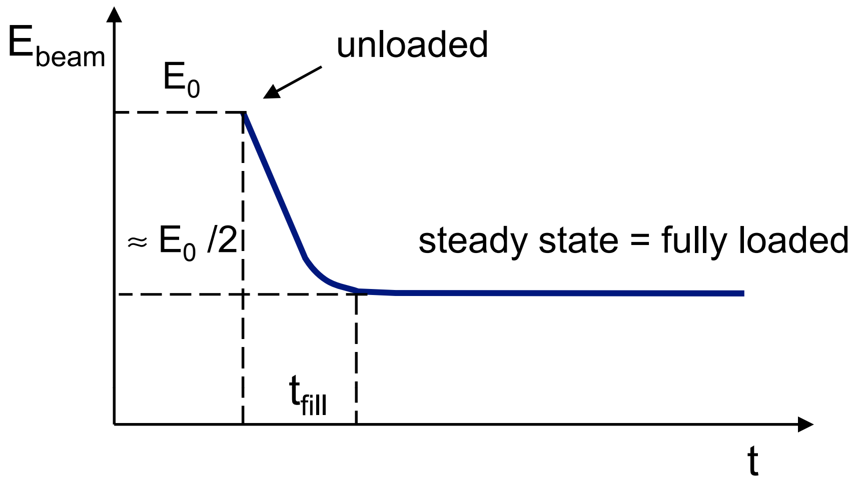


For the average power, it looks as though this is well in reach.

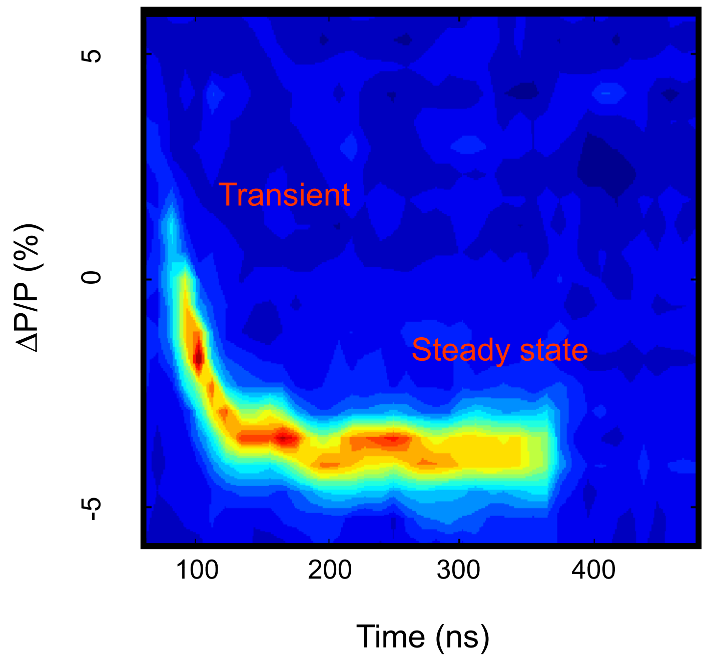
However, there was a study made (Thales), which concluded that at 1 GHz the limit would be around 40 MW, 100 μs (red triangles).

Full beam-loading acceleration





Time resolved beam energy spectrum measurement in CTF3

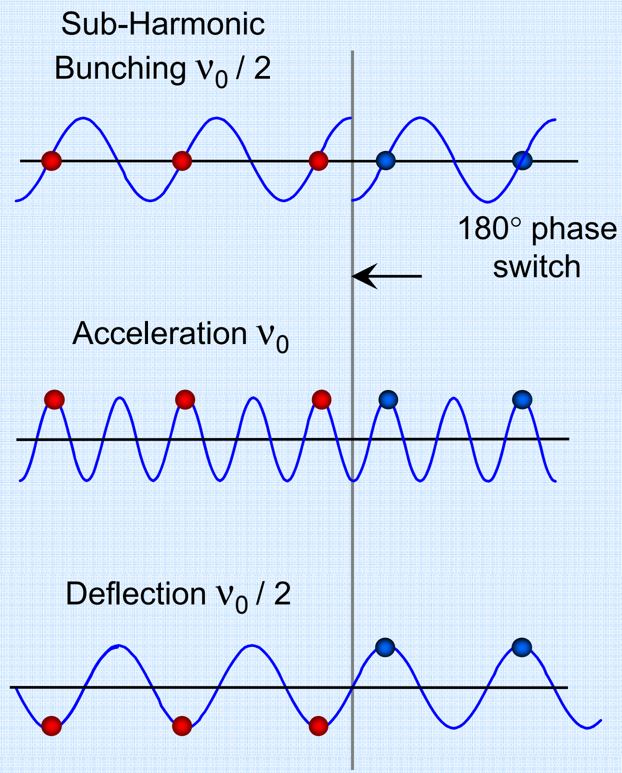


Gap creation & first multiplication × 2

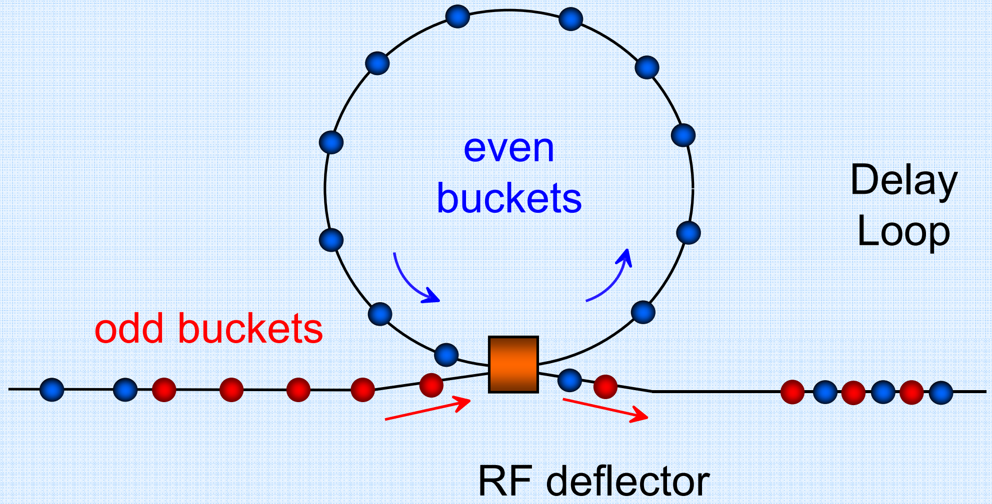
$$L_{delay} = n\,\lambda_0 = c\,T_{sub\text{-}pulse}$$

Phase coding

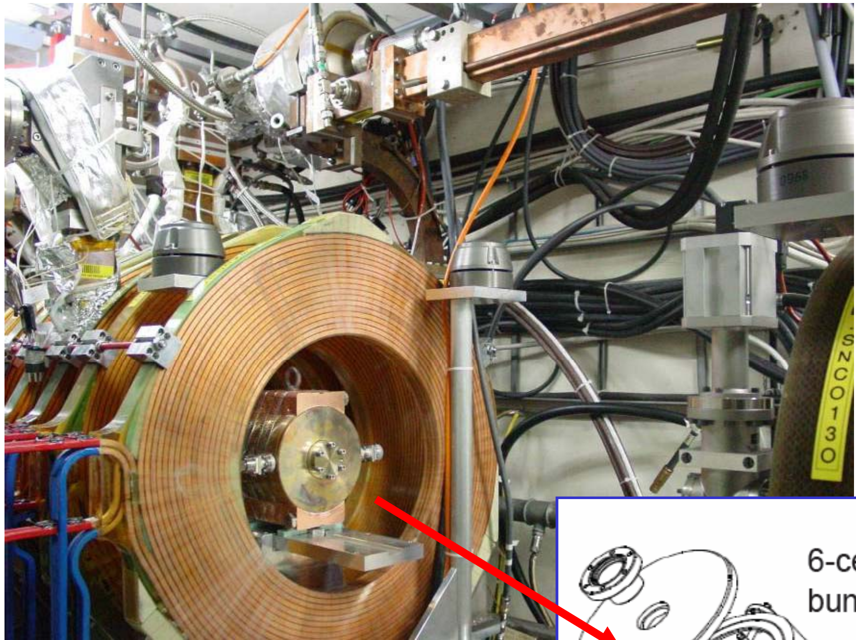
How to "code" the sub-pulses

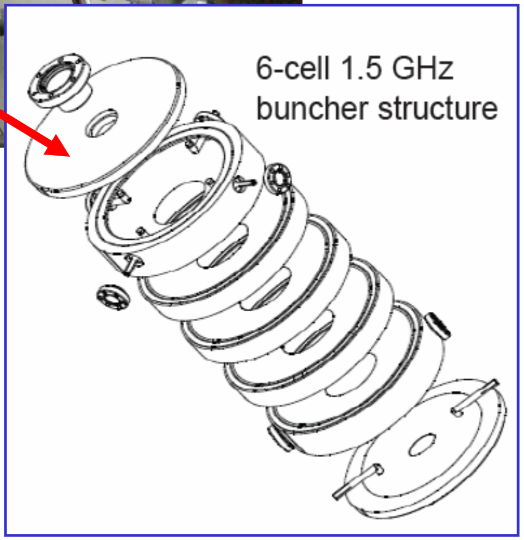


Combination scheme



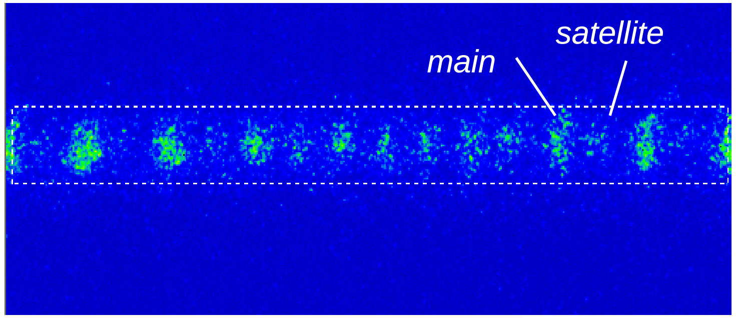
Fast phase switch from SHB system (CTF3)

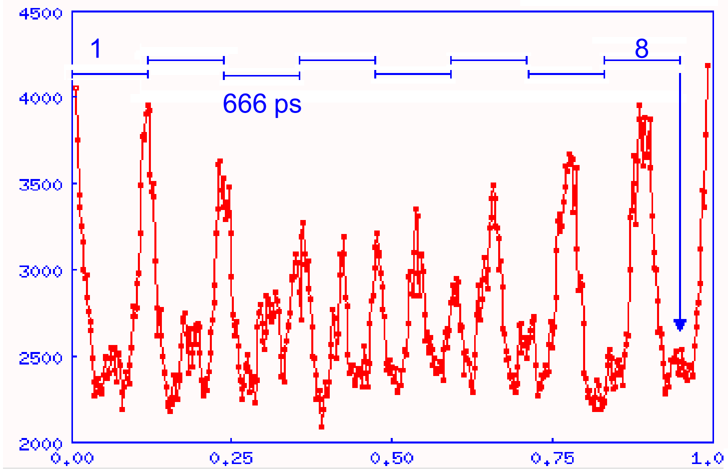




3 TW Sub-harmonic bunchers, each fed by a wide-band TWT

Streak camera image

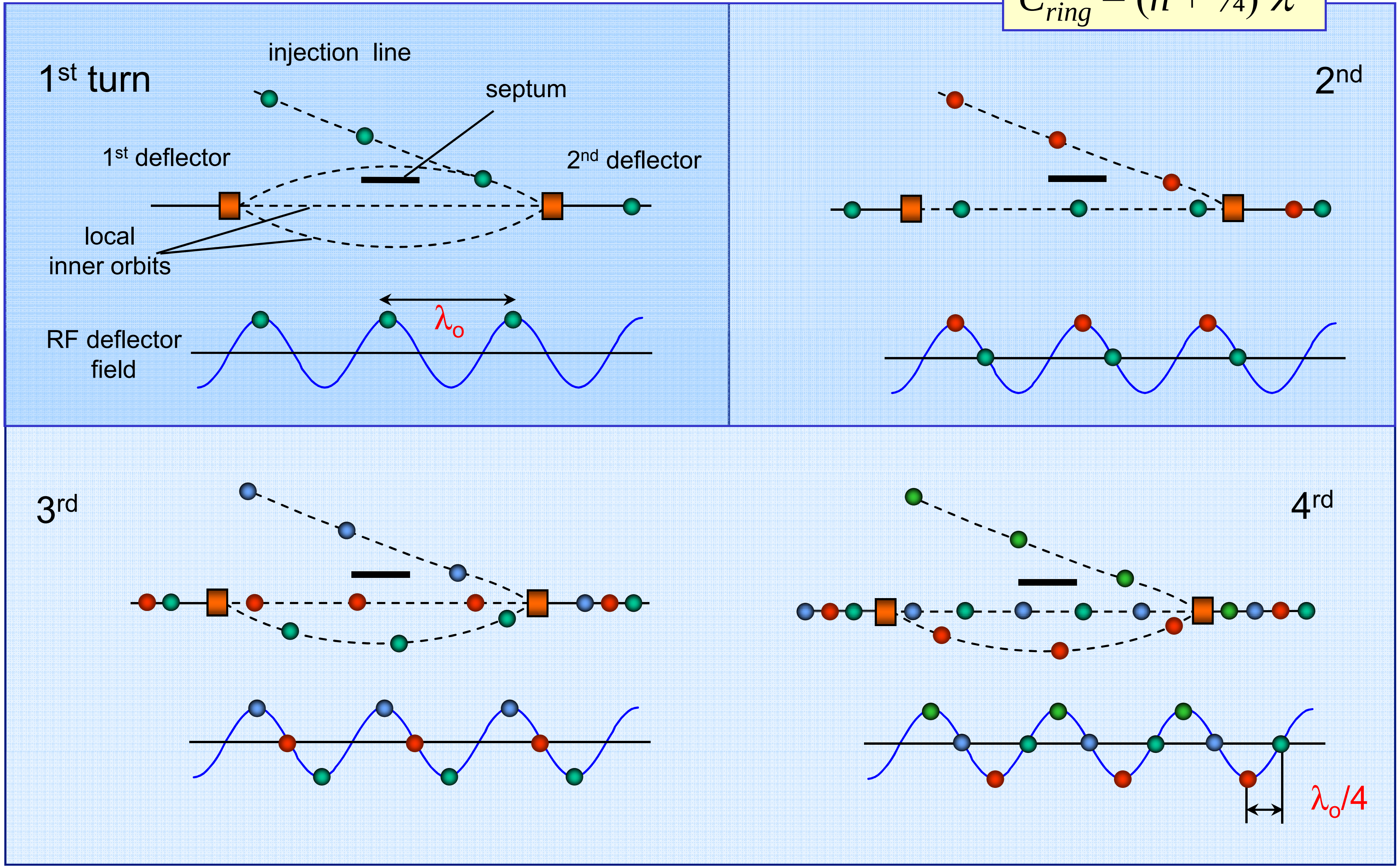


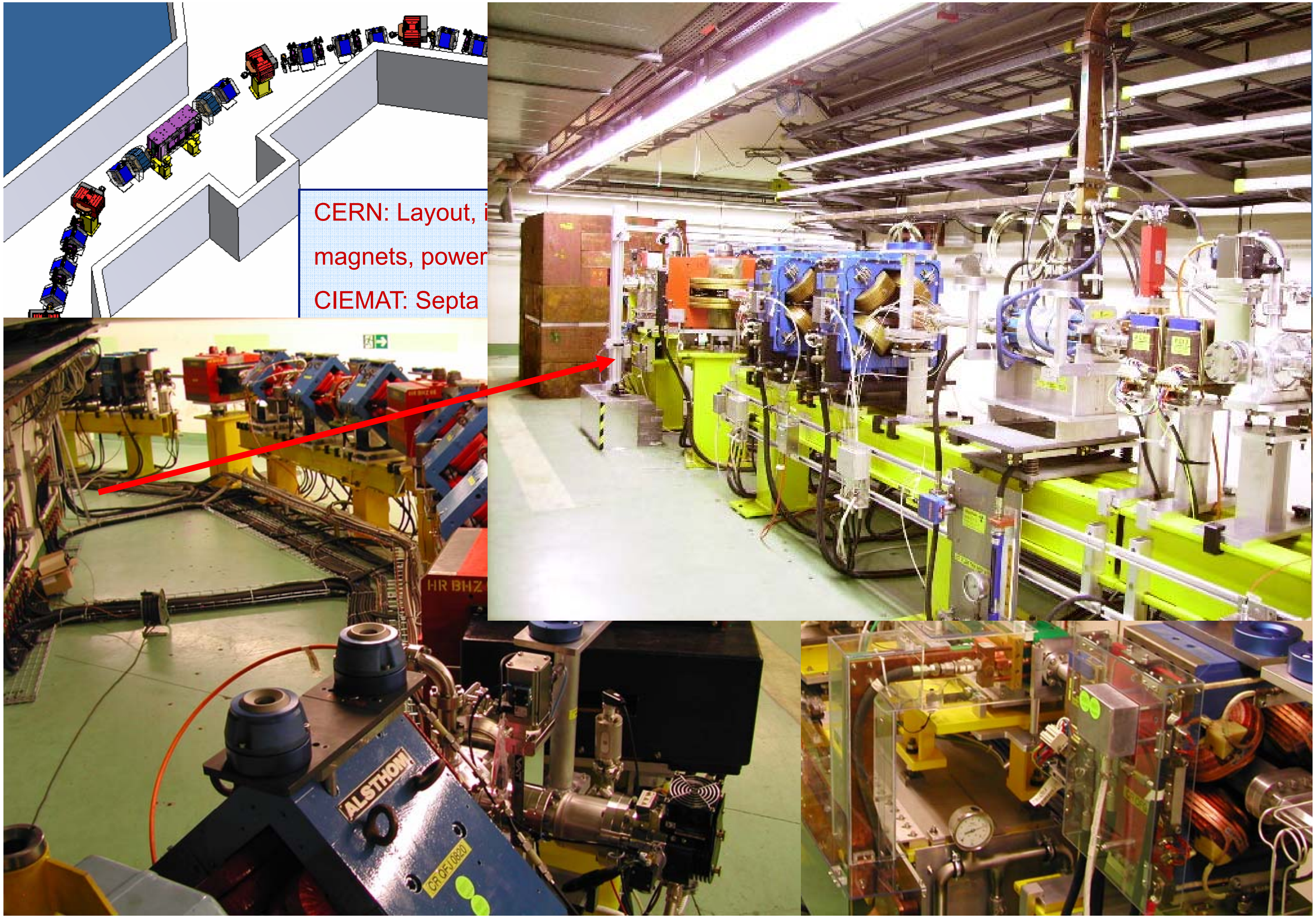


$8.5 \cdot 666$ ps = 5.7 ns

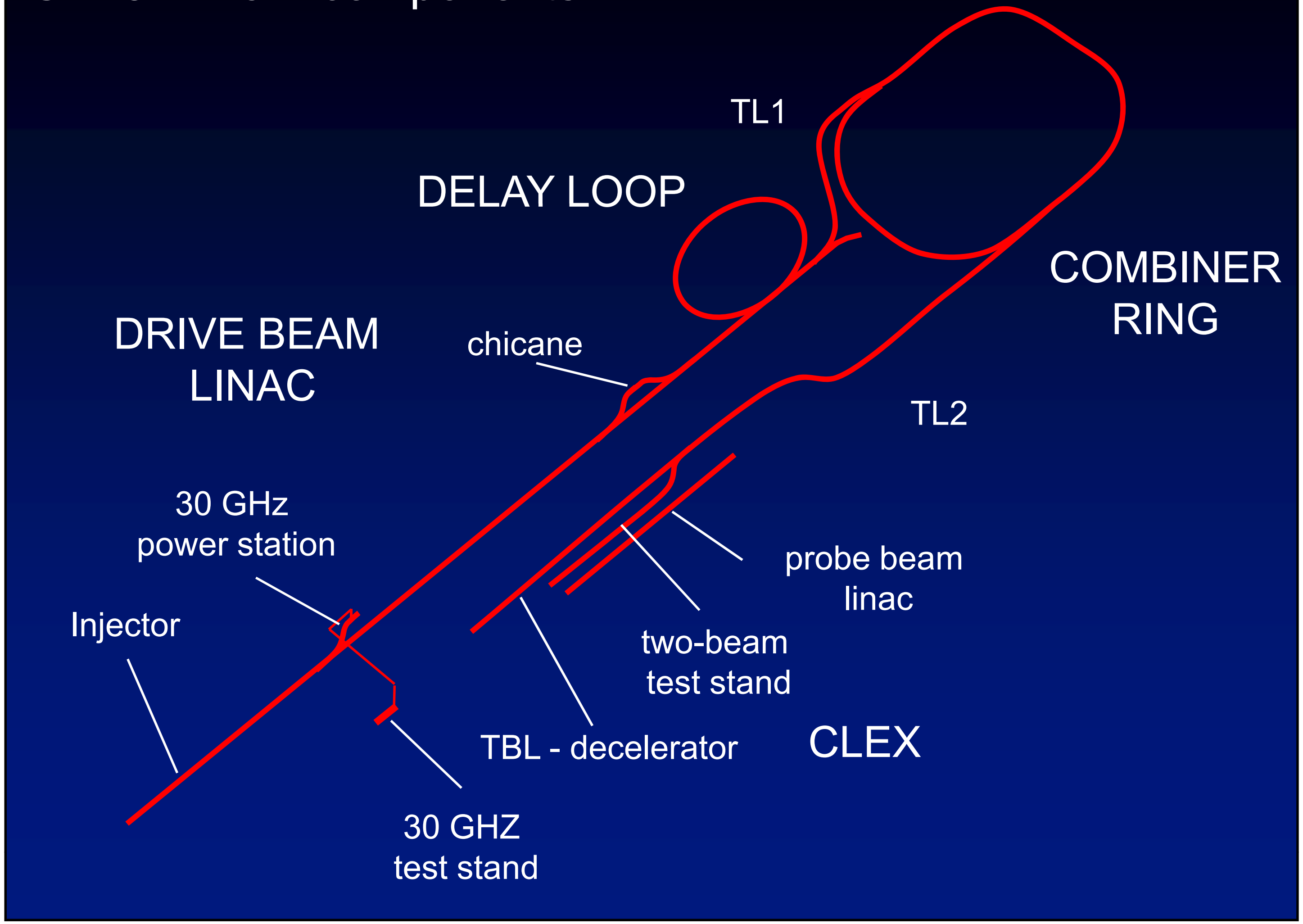
RF injection in combiner ring

$C_{ring} = (n + ¼)\ \lambda$

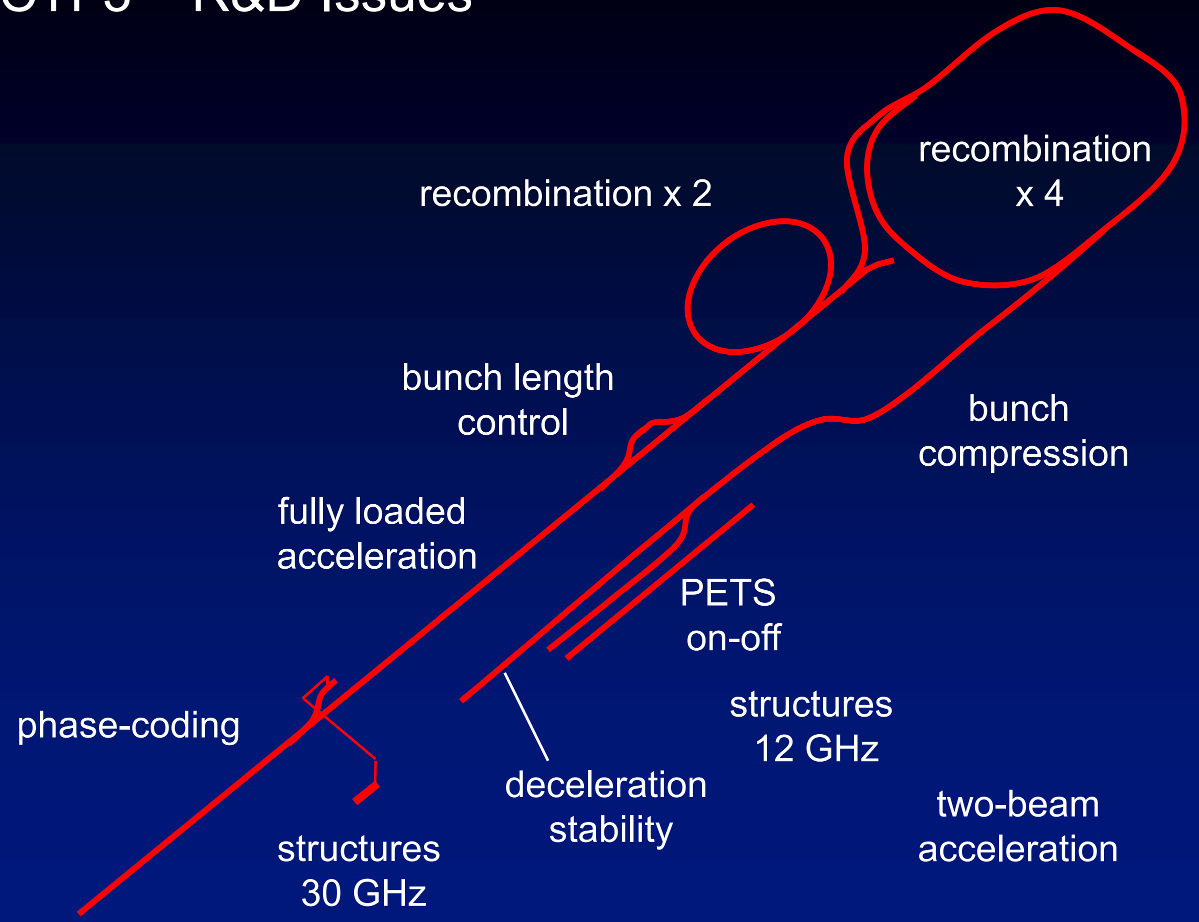



CERN: Layout, i
magnets, power
CIEMAT: Septa
ALSTHOM
HR BHZ

CTF3 – Main components



CTF3 – R&D Issues



Summary of CTF3 Achievements

- **Production and stable acceleration of 4 A beam** without significant emittance growth. Wake-fields kept under control with HOM damping+detuning. Consistent with predictions from beam dynamics simulations.
- Measured **RF power to beam energy transfer efficiency of 95%** in fully loaded operation.
- Demonstration of **bunch frequency multiplication with delay loop** using RF deflector cavities and **phase coding with fast phase switch**.
- **First circulating beam in combiner ring** and test of factor 2 combination.
- **Routine 24h, 7 days a week operation** of fully loaded linac for **30 GHz production**
$\Rightarrow$ fully loaded operation can be very reliable and stable.

Diagnostics
Beam position

Goal

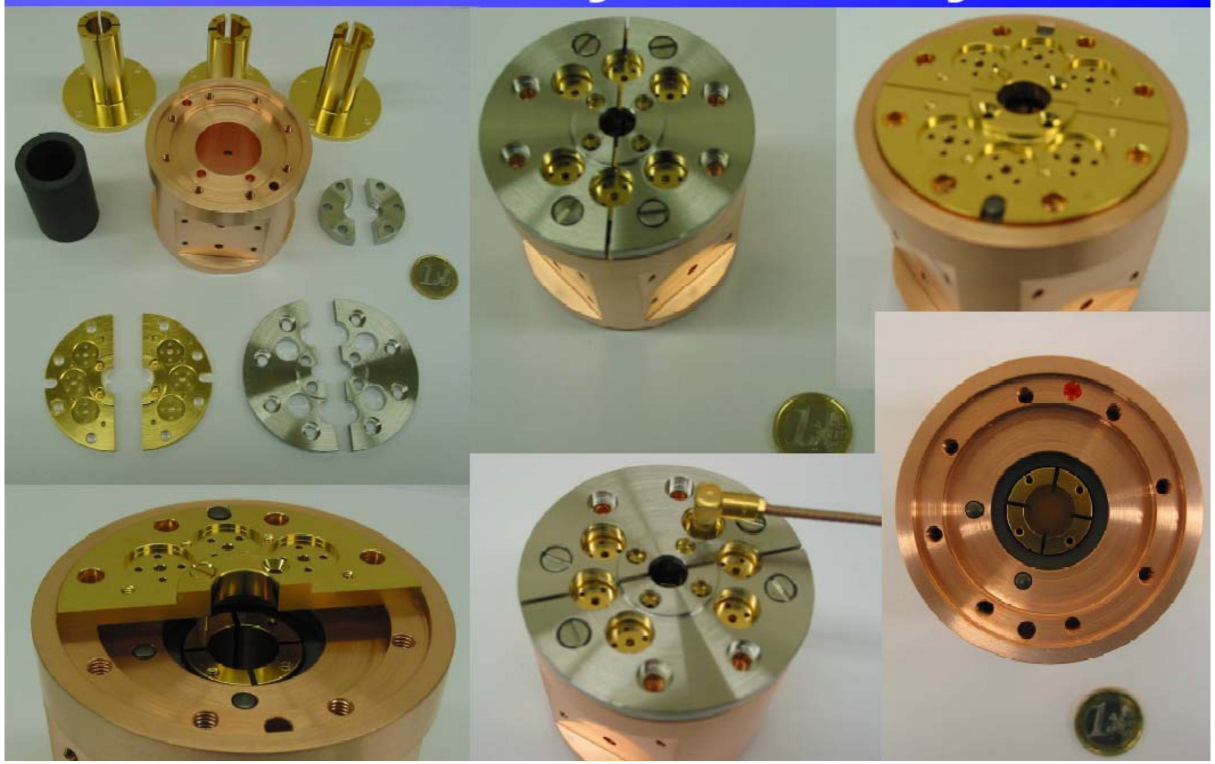
L Soby – I. Podadera

Measurement of the beam position and current in the main linac (attached to the quadrupoles) of the next generation colliders (ILC and CLIC) with the specifications:

- Resolution:100 nm.
- Aperture: 4-6 mm.
- Absolute precision: 10 μm.
- Rise time: 15 ns.

Test in CTF3 late this year

Preliminary assembly



L Soby – A. D'Elia

Diagnostics
Wall Current Monitor

The aim

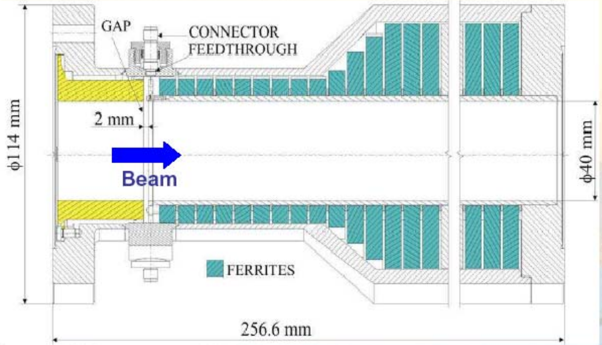
The 3rd generation of CLIC Test Facility (CTF3) foresees a beam formed by bunches separated of

Δ_b = 67 ps ⟶ WCM h. f. cut-off = 20 GHz

for a total pulse duration of

τ_r = 1.54 µs ⟶ WCM l. f. cut-off = 100 kHz

The existing design



The existing design is based on a previous design for the CTF2
(63 MHz ≤ bandwidth ≤ 10 GHz)
but

- Bigger volume of ferrite in order to lower the l. f. cut-off to 100 kHz
- The miniature feedthrough modified in order to extend their bandwidth beyond 20 GHz

Main/Drive Beam Phase stability

The Impact of Longitudinal Drive Beam Jitter on the CLIC Luminosity

CLIC Note 598

D. Schulte, E. J. N. Wilson, F. Zimmermann

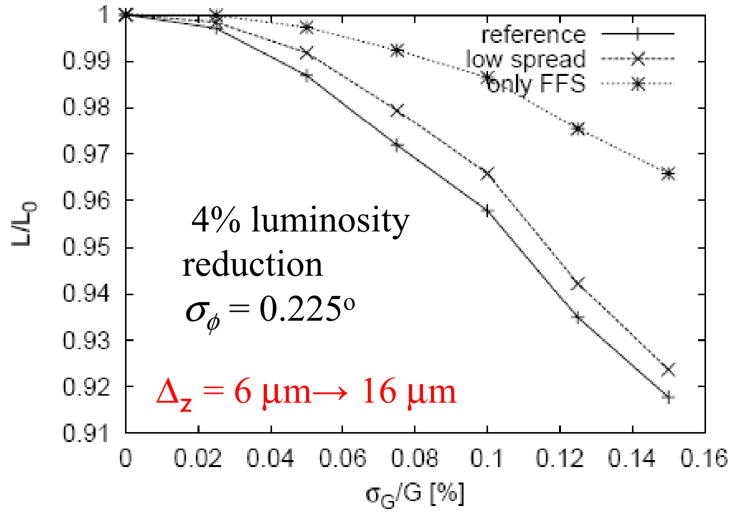
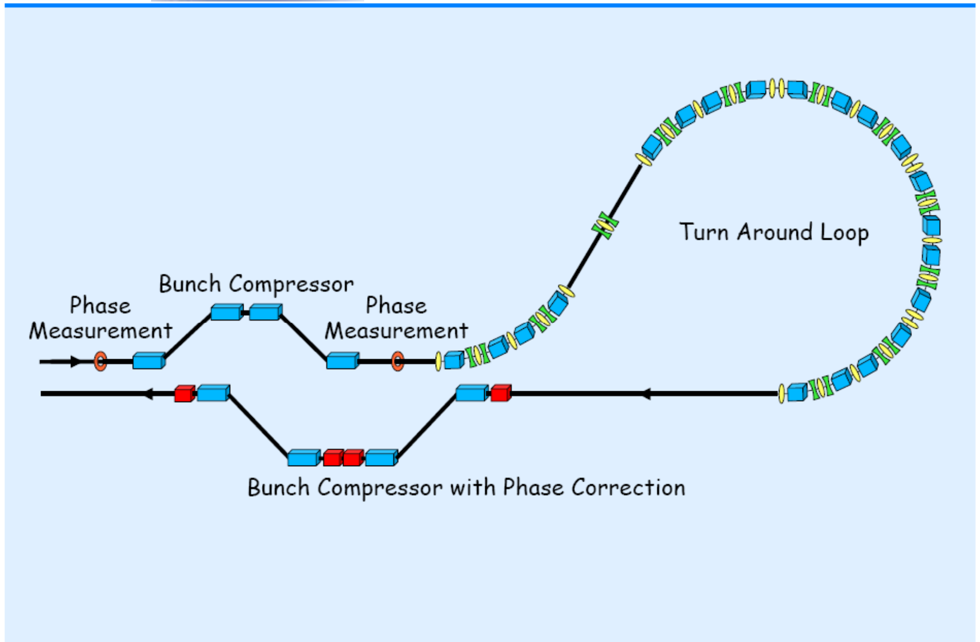
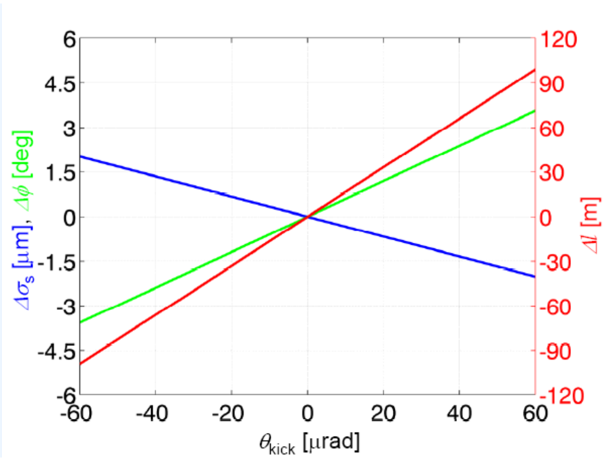


Figure 1: The relative luminosity as a function of a coherent gradient error in the main linac.

PAUL SCHERRER INSTITUT PSI EUROTeV *F. Stulle -PSI* **Beam Line Overview**



Frank Stulle, CLIC Seminar, 06.10.2006

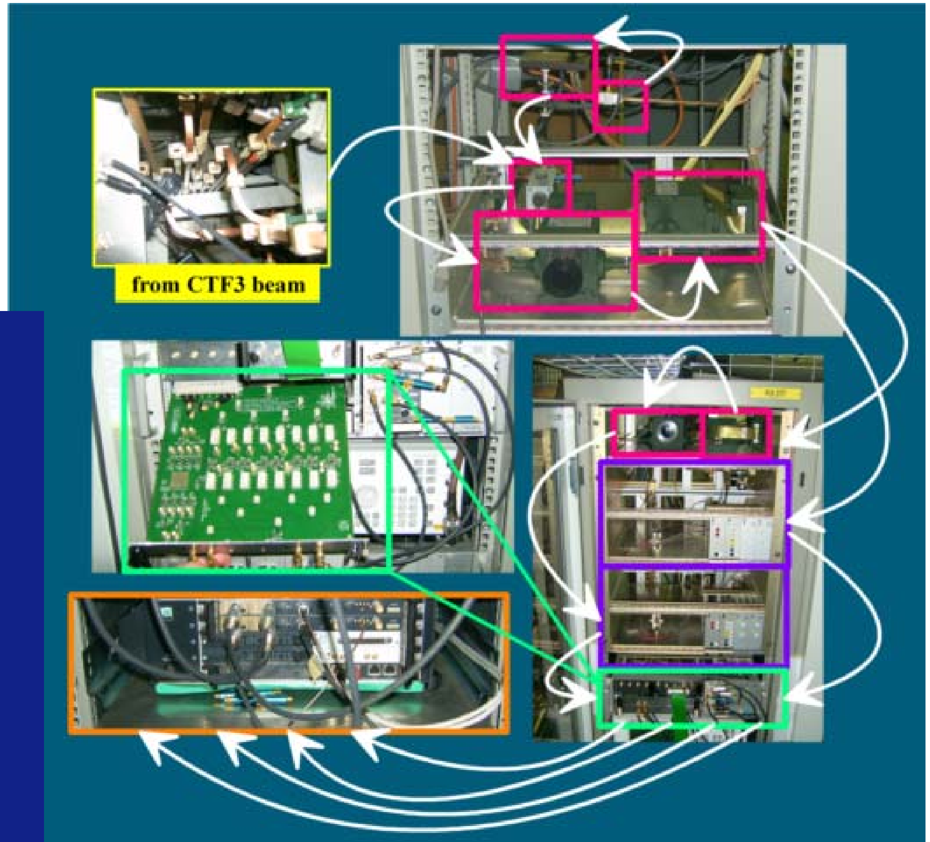


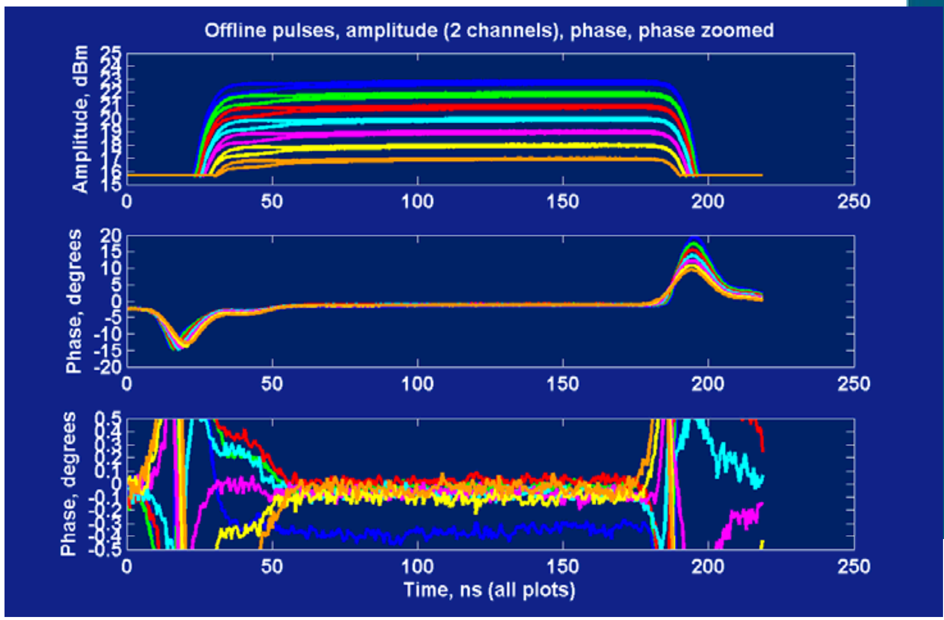
EUROTeV

J. Sladen, A. Andersson

Diagnostics
Phase measurement

- Phase accuracy: 0.1º
- Amplitude range: ~6dB
- Bandwidth: 50MHz, system investigated up to 250MHz



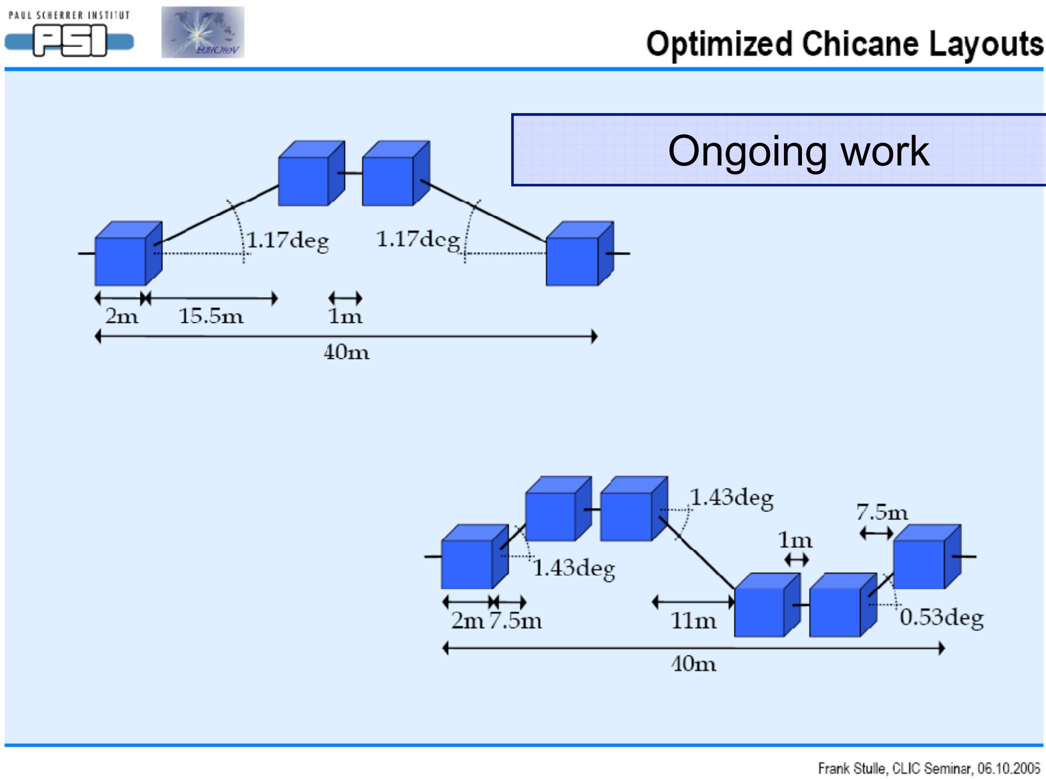


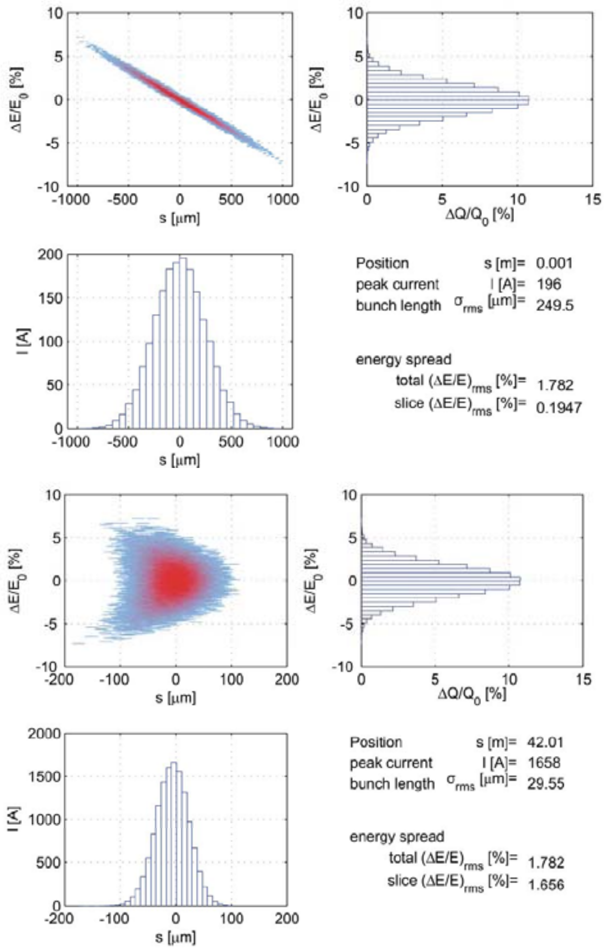
R2.5: Effects of coherent synchrotron radiation in bunch compressors

Calculations of the effects of coherent synchrotron radiation on the CLIC bunch compressors must be performed.

F. Stulle -PSI

Ongoing work





R2.6: Design of an extraction line for 3 TeV c.m.

An extraction line design for 3 TeV c.m. must be developed.

Promising first design

A. Ferrari

EUROTeV

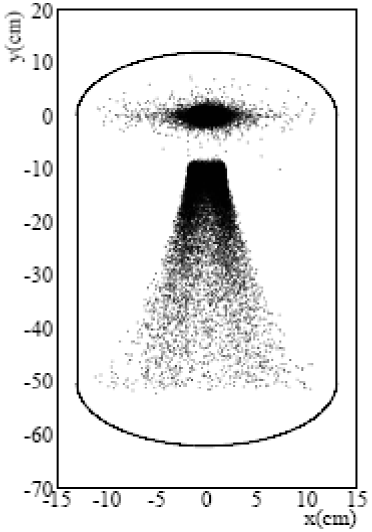


Figure 18: Transverse beam profiles obtained at the dump window, 247 m downstream of the interaction point.

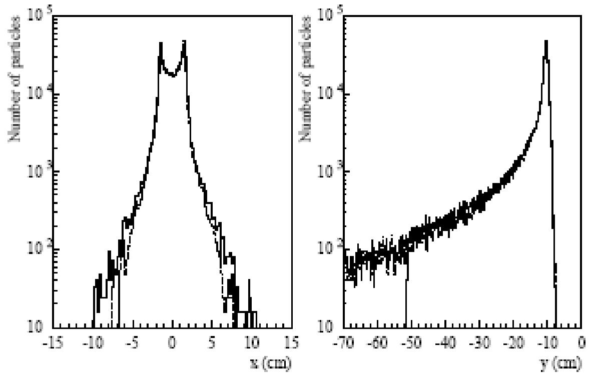


Figure 17: Horizontal and vertical profiles of the disrupted beam and the particles of the coherent pairs with the same charge, at the end of the CLIC post-collision line: the full (respectively dashed) line spectra are obtained with (respectively without) vertically focusing elements downstream of the chicane. At first order, the horizontal beam profile gives an image of the x' distribution at the interaction point, while the vertical beam profile shows the energy spectrum of the disrupted beam.

2007: Study Parameter Space at 30 GHz and testing of real structures at 11 GHz (focus on copper structures)

2008: Focus on two main geometries, develop damping, optimize structure

2009: CLIC prototype structure

2010: Longer term testing and better statistics

Number of tests (optimistic)

	2007	2008	2009	2010	sum
30 GHz	5	3	0	0	8
12 GHz	0	1	4	4	9
11.4 GHz	2	4	4	4	14
Stand alone at CERN	0	0	8	8	16
sum	7	8	16	16	47

Is it fair to compare CLIC drive beam with storage rings ?

No existing single pass accelerator has pulse energy getting anywhere close

Accelerator	Energy GeV	Revolution time or pulse duration μs	Number of Bunches	Number part. / Bunch 10^7	stored energy / beam or pulse MJ	instanteneous beam power GW
LHC	7000	88.9	2808	11500	362.1	4075
P HERA	920	21.1	180	7000	1.9	88
TEVATRON	980	20.9	36	24000	1.4	65
SR source (typical)	2.5	1.0	500	624	0.0012	1.2
CLIC drive beam DB return line	2.4	139.0	92664	4869	1.71	12
CLIC drive beam decelerator injection	2.4	0.3	3564	4869	0.07	222
CLIC main beam main linac injection	9.0	0.2	311	400	0.002	9
CLIC main beam main linac injection	1500.0	0.2	311	400	0.30	1431

MPS for drive beam needs serious studies !

How important is dark current ?

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Dark currents and their effect on the primary beam in an *X*-band linac

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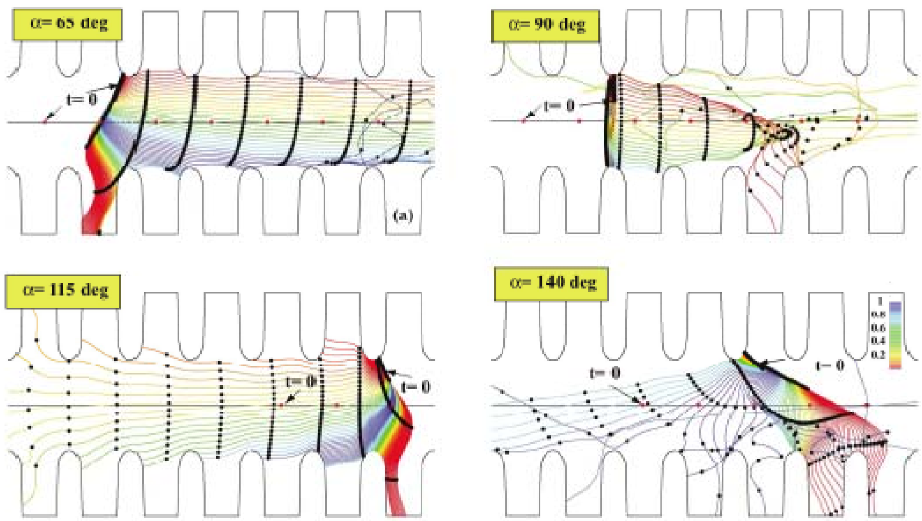
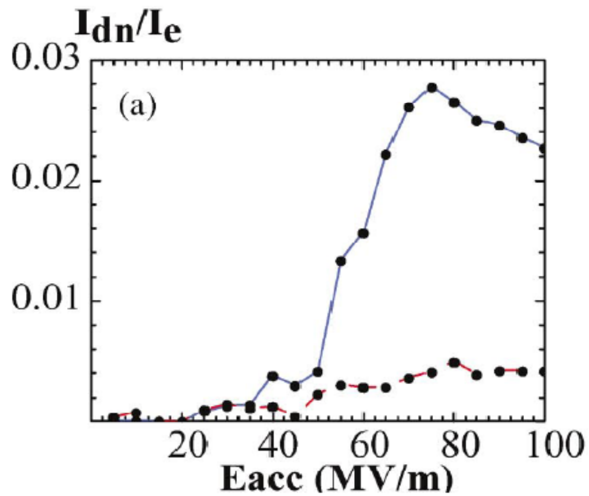


FIG. 4. (Color) Trajectories (in the x-z plane) of dark-current macroparticles emitted at rf phase interval $\Delta\phi = 1°$, for 4 selected emission angles α. Color coding indicates relative charge of the associated macroparticle. In each frame particles are emitted from an iris from above (positive x); downstream is to the right (positive z). Black dots give snapshots of the macroparticle positions, beginning with the time they have all left the iris surface ($t = 0$), and then in time steps $c\Delta t = 1$ cm. One on-axis rf crest position is also shown at snapshot times (the red dots).



According to measurement ~1 mA of current, averaged over an rf period, leaves the downstream end of the structure. Therefore, our calculations imply that ~100 mA of

Why bother about dark current, overfocusing of main beam quadrupoles will clean off d.c. electrons !

But at high energy end of linac quadrupoles are spaced by 10 modules, or 80 accelerating structures.

Assuming that all captured dark current is transported to next quadrupole

$$P_{dark} = f_{rep}\, T_{puls} \sum_{k=1}^{N} k\, V_{struct}\, I_{dark}$$

$$= f_{rep}\, T_{puls}\, V_{struct}\, I_{dark}\, N(N+1)$$

$$I_{dark} < \frac{P_{dark}}{f_{rep}\, T_{puls}\, V_{struct}\, I_{dark}\, N(N+1)}$$

$$N = 80, \quad P_{dark} < 180\,\mathrm{W} \quad (1\%\ \text{of main beam power gain})$$

$$\Rightarrow \quad I_{dark} < \quad 0.24\,\mathrm{mA}$$

According to measurement ~1 mA of current, averaged over an rf period, leaves the downstream end of the structure.'