

# Welcome Address to the ICFA Nanobeam 2002 Workshop

*Prof. Luciano Maiani*  
*Director General CERN*

26th Advanced ICFA Beam Dynamics Workshop on  
Nanometre-Size Colliding Beams

Lausanne, 2-6 September 2002

**ICFA**, the International Committee for Future Accelerators, was created to facilitate international collaboration in the construction and use of accelerators for high energy physics.

It was created in 1976 by the International Union of Pure and Applied Physics. Its purposes, as stated in 1985, are as follows:

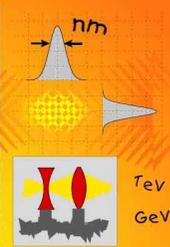
- To promote international collaboration in all phases of the construction and exploitation of very high energy accelerators.
- To organize regularly world-inclusive meetings for the exchange of information on future plans for regional facilities and for the formulation of advice on joint studies and uses.
- To **organize workshops** for the study of problems related to super high-energy accelerator complexes and their international exploitation and to foster research and development of necessary technology.

Sixteen members, selected primarily from the regions most deeply involved in high energy physics.

# NANOBEAM 2002

26<sup>th</sup> Advanced ICFA Beam Dynamics Workshop on Nanometre Size Colliding Beams

September 2-6, 2002, Lausanne, Switzerland



#### International Advisory Committee:

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J.P. Delahaye	CERN	D. Trines	DESY
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S.I. Kurokawa	KEK		ICFA Beam Dynamics Panel

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M. Mayout	CERN	N. Toge	KEK
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O. Nagoly	CEA/Saclay	K. Yokoya	KEK
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T. Raubenheimer	SLAC	F. Zimmermann	CERN

#### Local Organizing Committee:

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E. Luthi, J. Thomashausen	(Secretarial)
A. Bay	Lausanne U.
T. d'Amico	CERN
S. Redelli	CERN, Lausanne U.

E-mail: [nanobeam@cern.ch](mailto:nanobeam@cern.ch)



ICFA - International Committee for Future Accelerators



UNIL - UNIVERSITE DE LAUSANNE



EPFL - ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE

<http://www.cern.ch/nanobeam>

Accelerators have produced high-energy particle beams with sizes as small as 70 nm and with 500 nm beams in stable collision. These "nanobeams" impose stringent tolerances on the magnetic focusing and the stability of the accelerator. Future linear colliders foresee colliding high-energy particle beams with vertical spot sizes down to the 1 nm level. For the production and control of these beams many new challenges must be met. **The ICFA Workshop on Nanometre-Size Beams will look at:**

Technical issues in producing and controlling particle beams with nm-size, including the Final Focus, collimation, beam instrumentation, and beam-based feedback systems.

Disturbing effects from ground motion, magnet vibration, optics errors, etc.

Achievable limits with present accelerator and stabilization technology.

Possible applications of nanobeams in and beyond particle physics.

**The workshop is addressed to:**

The linear collider accelerator community, that relies on nm-size beams to push the frontier of particle physics.

The synchrotron radiation accelerator community, which has extensive experience with accelerator stabilization and the control of small beams.

The general accelerator physics community with interest in optics design, higher-order chromatic corrections, and advanced beam collimation.

Scientists working with sub-nm stabilization, like for gravitational wave detectors, chip production, and Transmission Electron Microscopy (using low energy nanobeams).

Scientists with interests to use high-energy nanobeams for new applications.

Industrial companies specializing in the development of advanced active and passive stabilization equipment.

The workshop should inspire a lively exchange of advanced ideas and concepts between the scientists involved in the different areas of research. **The following goals should guide the workshop:**

Describe a path towards proving feasibility of colliding and non-colliding nanometre-size beams, document existing solutions, and identify open questions.

Develop a coherent program for future research and development.

Strengthen and expand international and inter-disciplinary collaborations.

**Mini-workshop on measurement of beam energy in linear colliders:**

A parallel session will be devoted to the precise measurement of the beam energy in linear colliders, based on the experience in existing and past accelerators.

Details will be announced on the Nanobeam02 web site.

About 90 participants from more than 30 institutes in Europe, Asia, the US.

About 90 scheduled presentations.

Workshop topics:

1. Production and control of nanometre-size beams,
2. Component stabilization against disturbing effects such as ground motion,
3. An understanding of the achievable limits,
4. Calibration of the beam energy for precision measurements
5. Laser wires as a novel beam diagnostic.

## **Particle accelerators:**

**among the most powerful scientific instruments mankind has built**

**essential for advancing our knowledge about the structure of matter**

## **Particle colliders:**

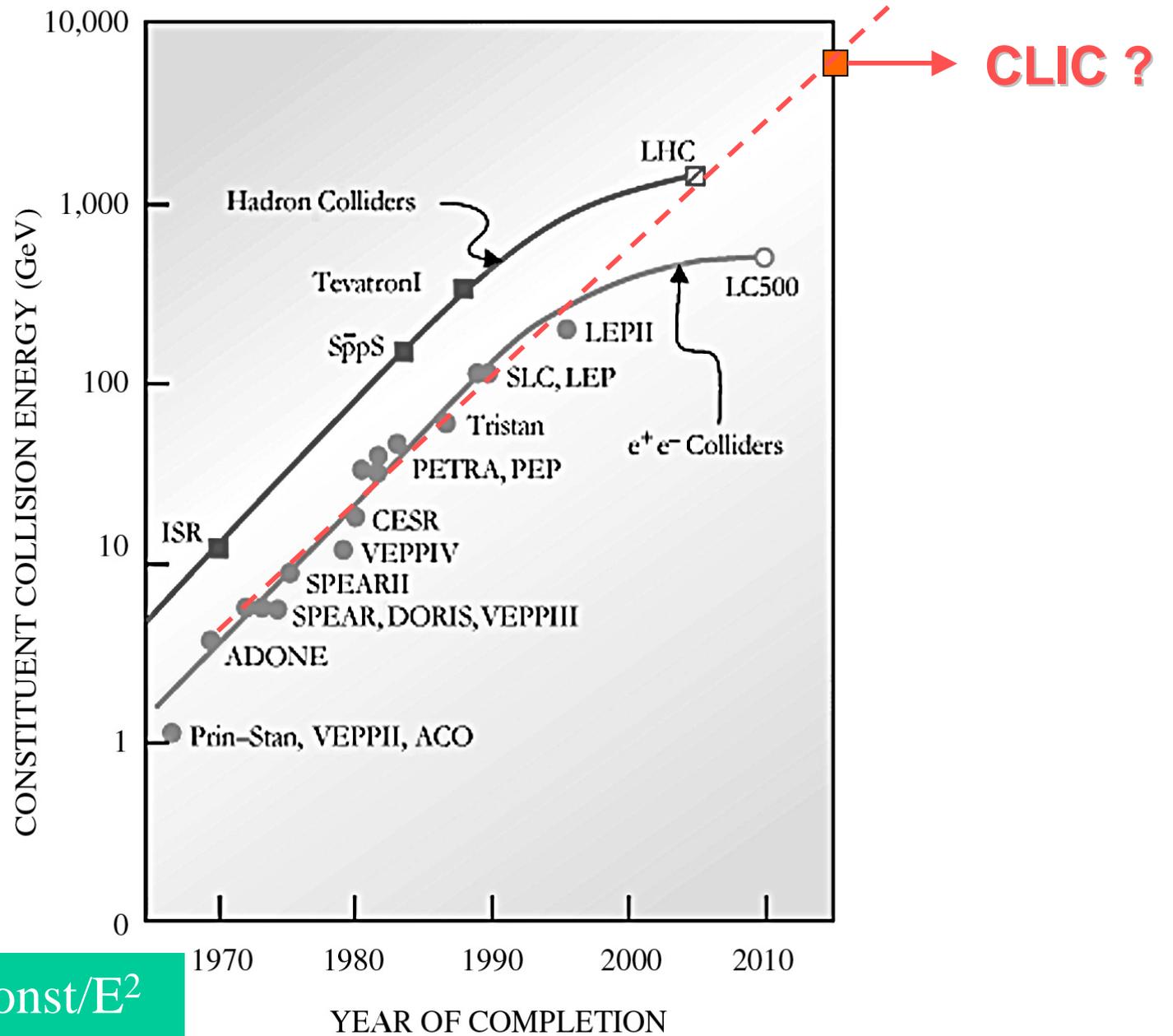
particle physics (energy + luminosity)

## **Synchrotron radiation facilities:**

biology, material science (brilliance)

**Both require smaller and smaller transverse  
beam cross sections!**

# Livingston plot:



Cross sections  $\sim \text{const}/E^2$   
 Higher energy needs  
 smaller and smaller beams

(M. Tigner)

## The quest for new science is also the quest for small beams:

Typical collision-point beam size for particle physics

circular colliders	linear colliders
1970s: $\sim 50 \mu\text{m}$	
1990s: $\sim 2.5 \mu\text{m}$ (LEP, B factories)	$\sim 0.5 \mu\text{m}$ (SLC)

**Sub-micron beams (nanobeams) have been achieved for particle physics at the SLC!**

**At the same time tremendous progress at the synchrotron light sources; submicron orbit stability established!**

# The road to high-energy nanobeams has been opened

30  $\mu\text{m}$  = width of the human hair  
1 nm = size of a water molecule

All future linear colliders aim at spot sizes **< 5 nanometres**

**This opens new challenges for accelerator physics (how to generate these beams) and technology (sub-nanometre vibration tolerances).**

Accelerators can benefit from and further drive strong scientific and industrial advances in technology:

- gravitational wave detectors (talk F. Raffaele),
- transmission electron microscopy,
- production of microchips,
- nanotechnology,...

**Sub-angstrom electron beam**  
(120 keV) in Scanning Transmission  
Electron Microscope  
P.E. Batson et al, Nature 418 (2002)

## Accelerator R&D at CERN

CERN remains committed to future accelerator R&D even in difficult times.

Particle-physics requirements beyond LHC guide CERN's interest towards a 3-TeV linear collider.

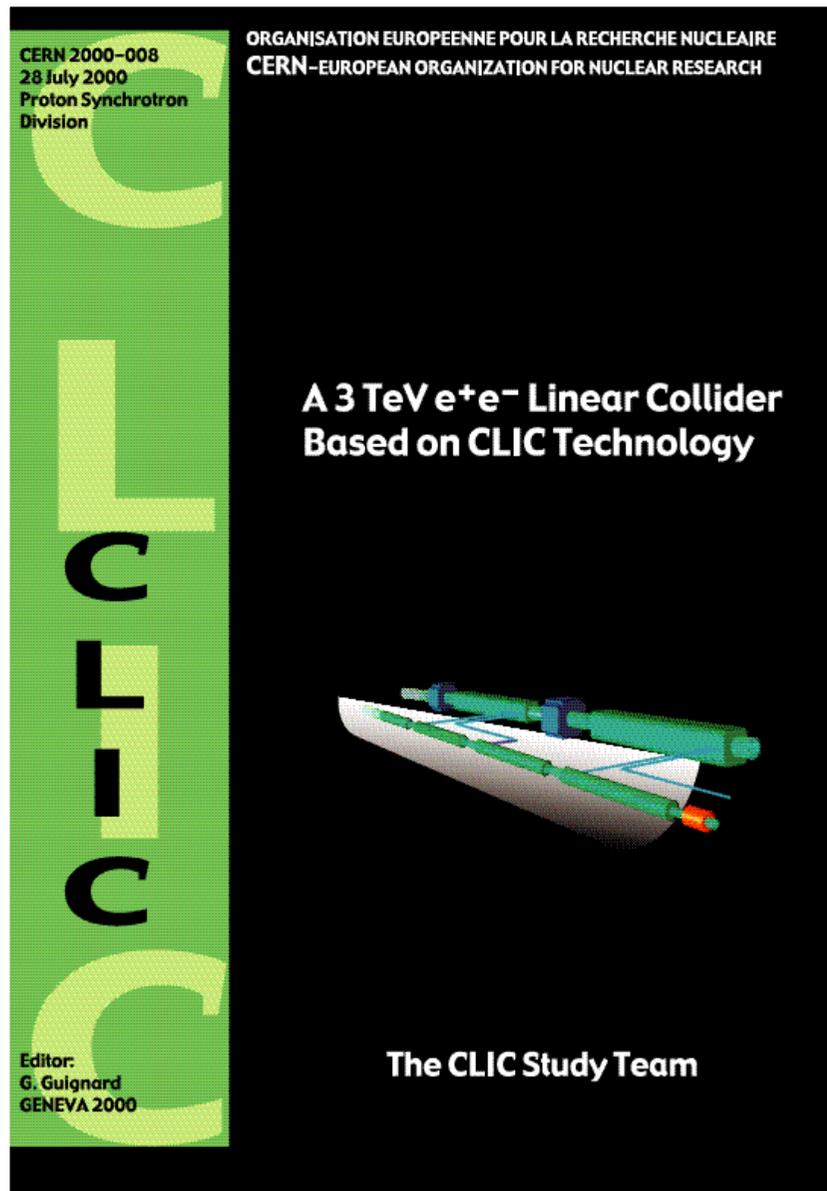
*(see talk by John Ellis)*

## CLIC activity at CERN

Collaboration and support from other labs and universities  
Excellent progress despite of limited resources

- 150 MV/m accelerating gradient demonstrated,
- Drive-beam combination shown (preliminary CTF3),
- Magnet stabilization to sub-nanometre level *(talks at this workshop)*

# The CLIC study at CERN: Compact Linear Collider



## International collaboration:

[Berlin TU](#) (Germany) , [Daresbury](#) (UK),  
[DESY](#) (Germany), [INFN/LNF](#) (Italy),  
[FNAL](#) (USA), [TJNAF](#) (USA),  
[JINR & IAP](#) (Russia), [LAL](#) (France),  
[KEK](#) (Japan), [LBL](#) (USA) , [RAL](#) (UK),  
[Royal Institute of Stockholm](#) (Sweden),  
[SLAC](#) (USA) , [Uppsala](#) (Sweden)

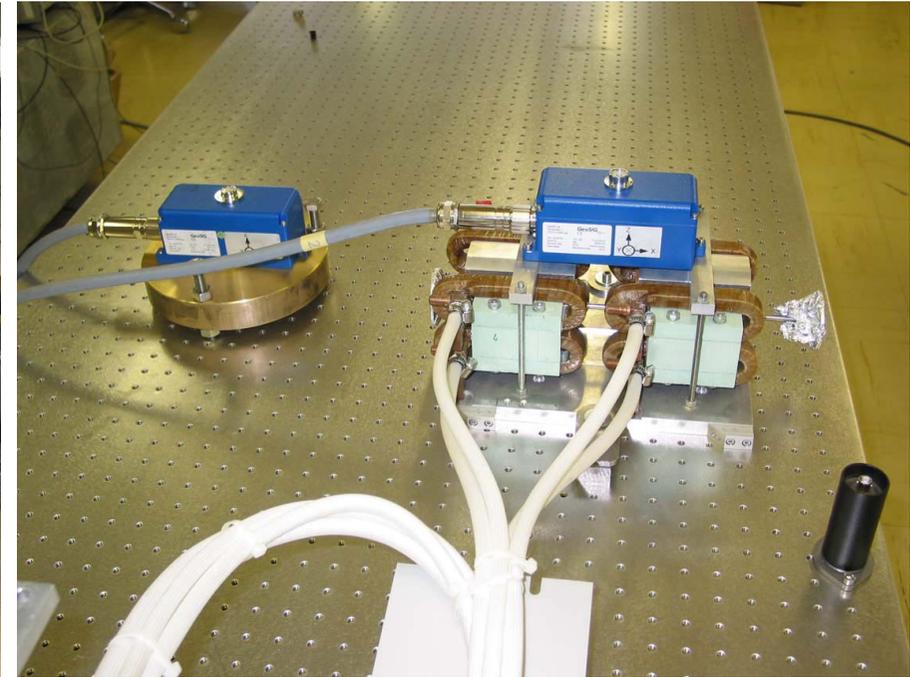
## The CLIC team:

R. Assmann, F. Becker, R. Bossart, H. Burkhardt, H. Braun, G. Carron,  
W. Coosemans, R. Corsini, E.T. D'Amico, J.-P. Delahaye, S. Doebert,  
S. Fartoukh, A. Ferrari, G. Geschonke, J.-C. Godot, L. Groening,  
G. Guignard, S. Hutchins, J.-B. Jeanneret, E. Jensen, J. Jowett,  
T. Kamitani, A. Millich, O. Napoly (Saclay, France), P. Pearce,  
F. Perriollat, R. Pittin, J.-P. Potier, S. Redaelli, A. Riche, L. Rinolfi,  
T. Risselada, P. Royer, T. Raubenheimer (SLAC, Stanford, USA),  
F. Ruggiero, R. Ruth (SLAC, Stanford, USA), D. Schulte, G. Suberlucq,  
I. Syrathev, L. Thorndahl, H. Trautner, A. Verdier, I. Wilson,  
W. Wuensch, F. Zhou, F. Zimmermann

# CLIC STABILITY STUDY

R. Assmann, W. Coosemans, G. Guignard, N. Leros, S. Redaelli, W. Schnell, D. Schulte, I. Wilson, F. Zimmermann

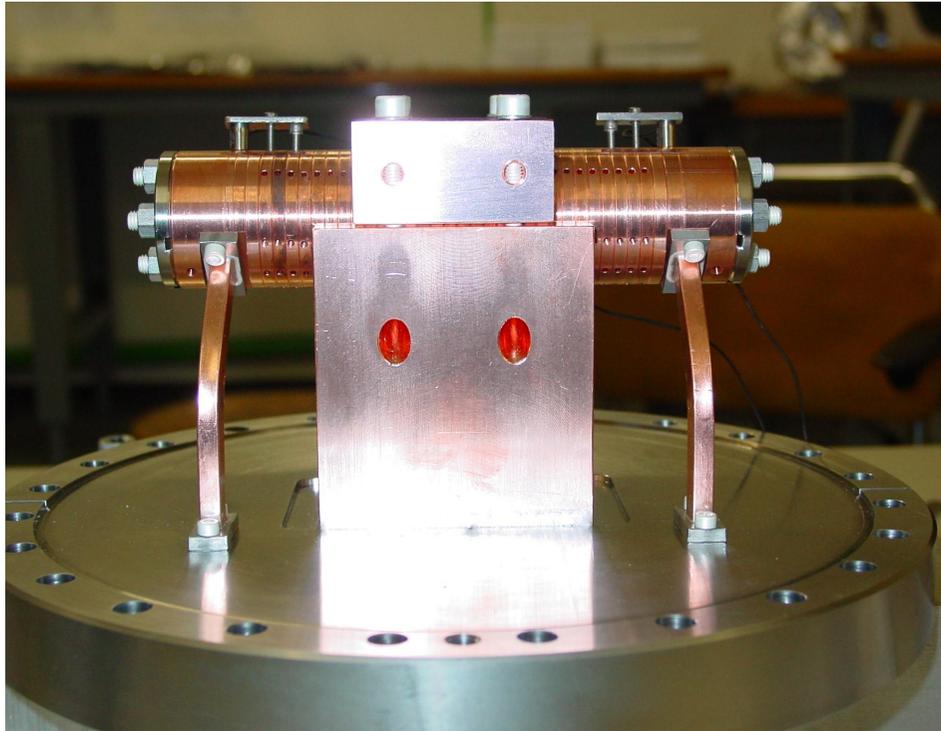
Latest stabilization technology applied to the accelerator field



Stabilizing quadrupoles to the **0.5 nm** level!  
(*up to 10 times better than supporting ground, above 4 Hz*)  
CERN has now one of the **most stable places on earth's surface!**

# CLIC tungsten-iris structure:

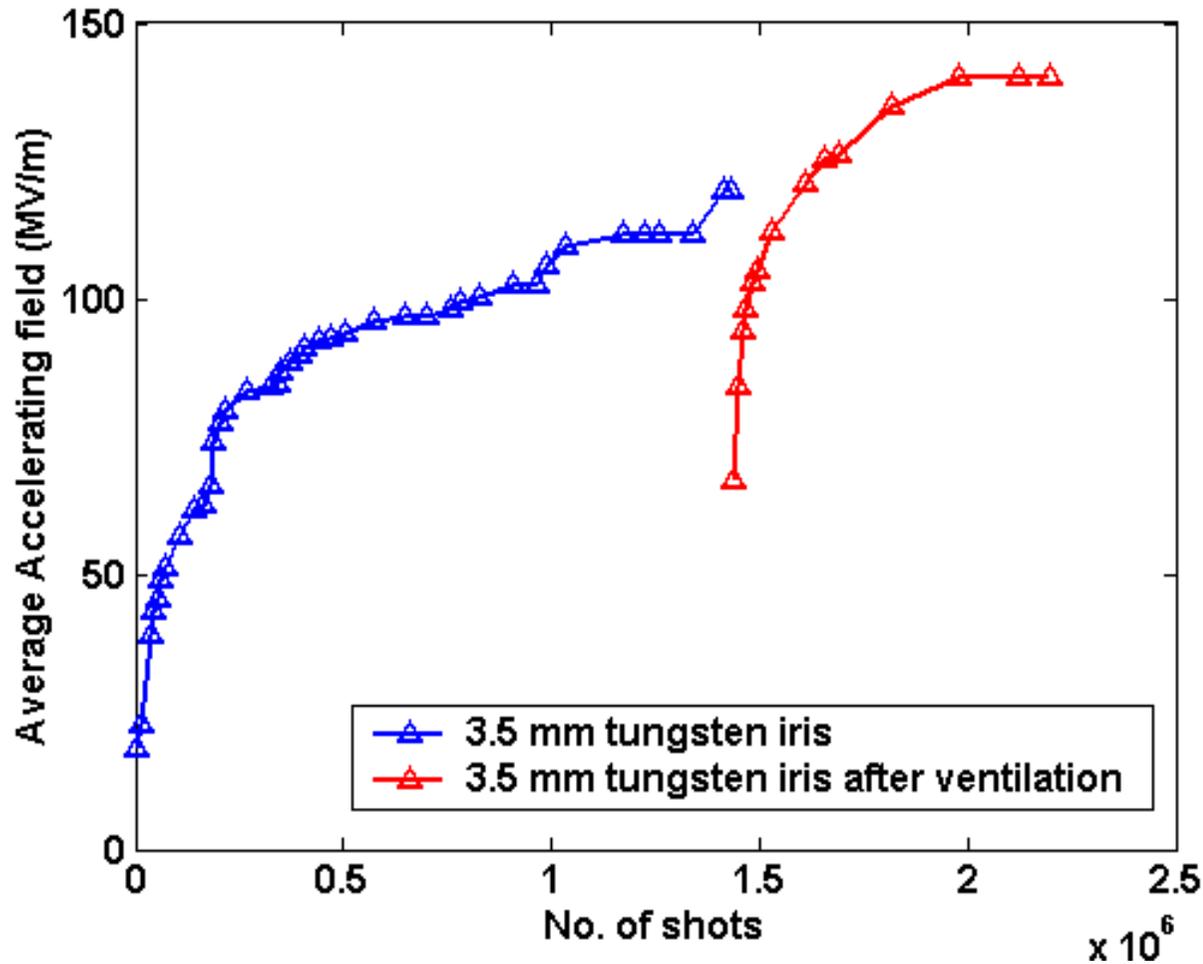
**150 MV/m**



*W. Wuensch*

# 30 cell tungsten-iris structure

Conditioning history (last update:17/06/02).



170 MV/m peak  
Accelerating  
380 MV/m peak  
Surface

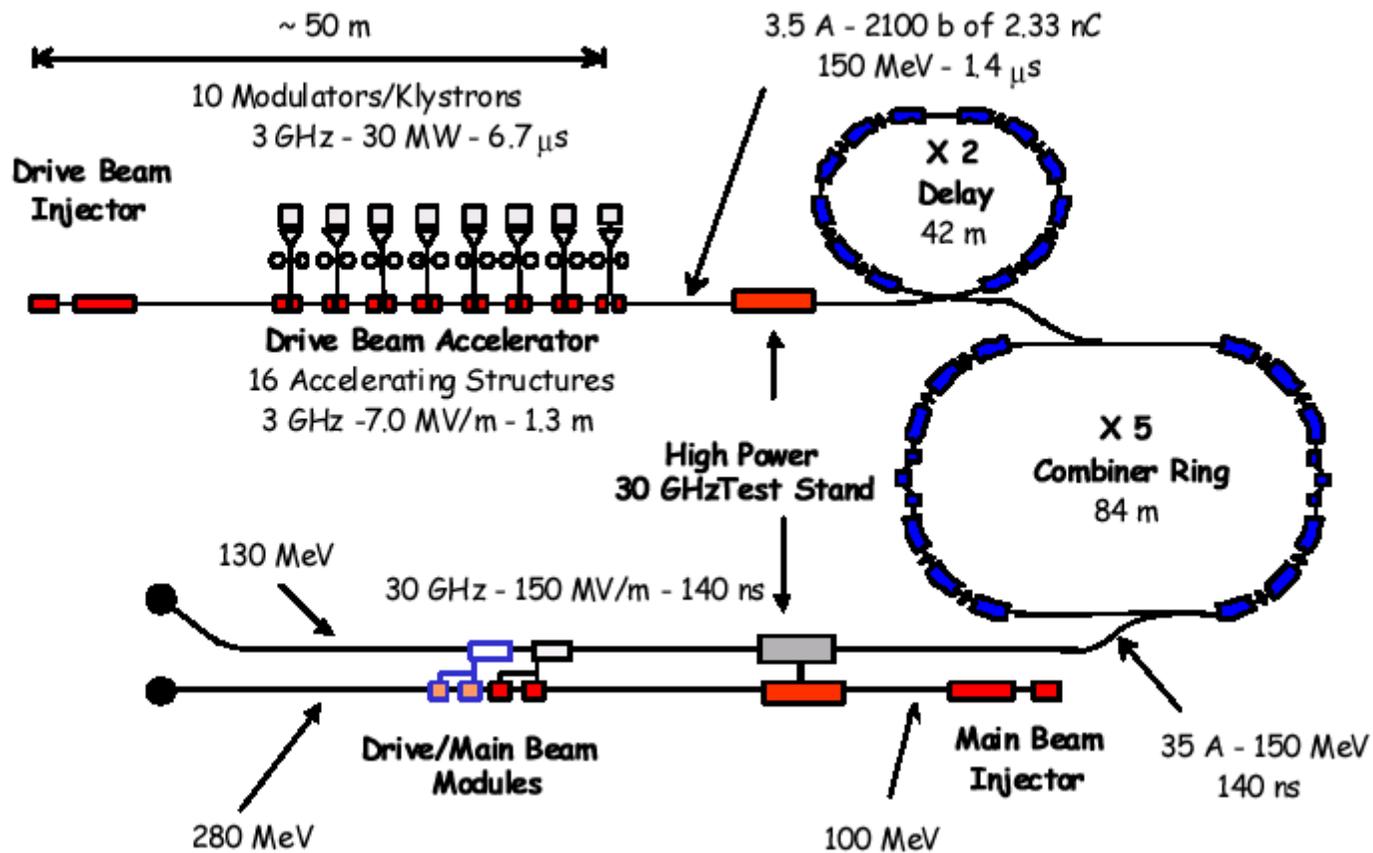
30 GHz  
16 ns pulse



# CLIC Test Facility CTF3

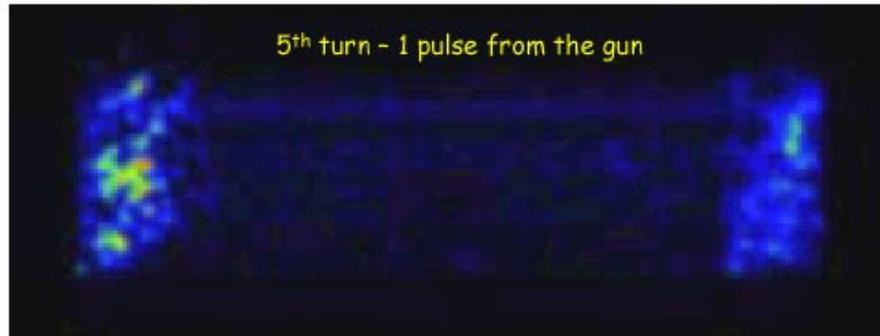
Demonstrate that CLIC power generation works as required

CTF3 - Test of Drive Beam Generation, Acceleration & RF Multiplication by a factor 10

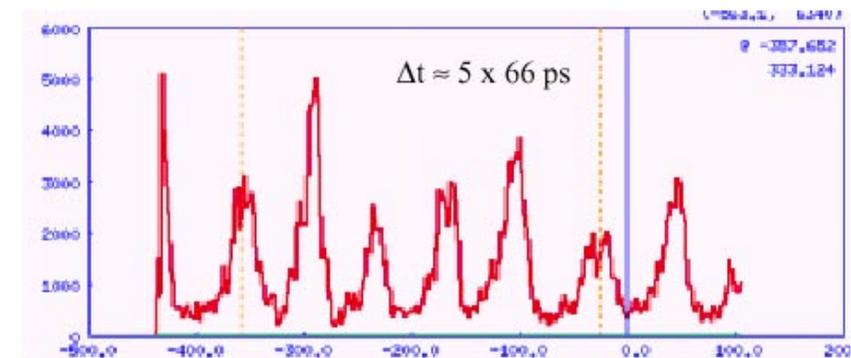
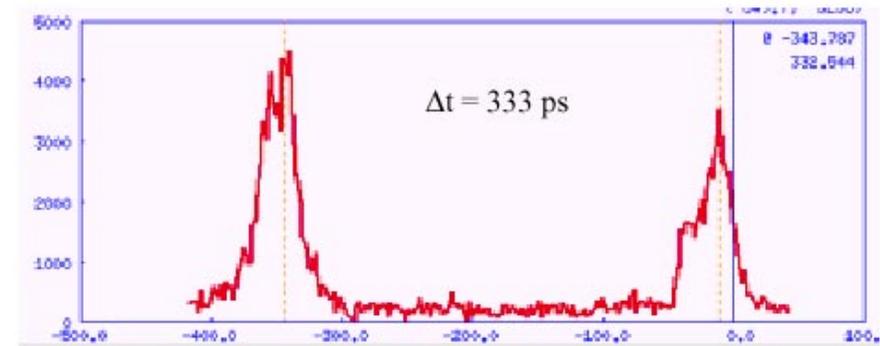
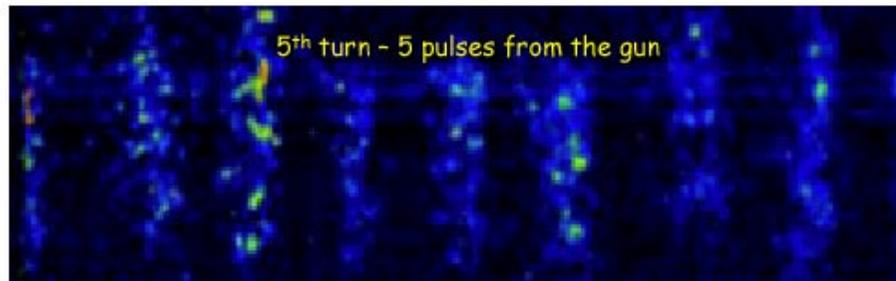


*ongoing for next 3-4 years*

# First experimental demonstration of bunch frequency multiplication



↓ x 5



21<sup>st</sup> June 2002

R. Corsini, L. Rinolfi, P. Royer, F. Tecker

ICFA recommendation: **Next machine should be a linear collider at 500 GeV.**

CLIC is an option for the CERN future, reaching beyond LHC/LC500 and opening the multi-TeV e+e- frontier.

Progress at future X-ray FELs, synchrotron-light sources, ...

This workshop shows the need for exchanging new ideas and results between the different projects and communities.

Collaboration with universities and industry allows maintaining critical momentum for future accelerator R&D.

**Technology is advancing fast. We can both profit and further push its frontier.**

## Workshop goals:

1. Describe a path towards proving **feasibility of colliding and non-colliding nanometer-size beams**, document existing solutions, and identify open questions.
2. Develop a **coherent program for future research and development**.
3. Strengthen and expand **international and inter-disciplinary collaborations**.

Nanobeams are one possible way into the future.

ICFA needs your help in exploring this path!