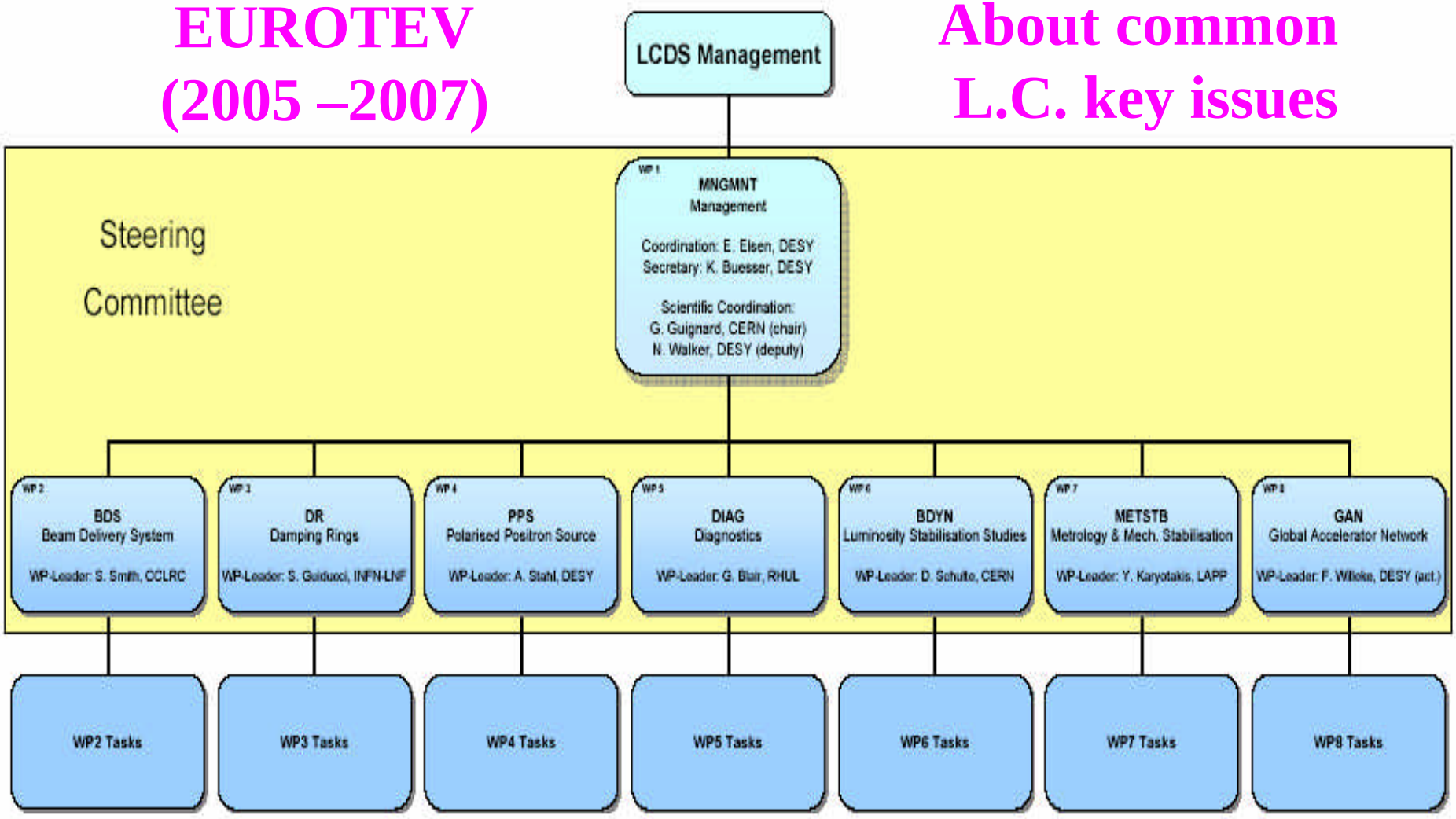
CERN contribution to ILC

- **R&D on generic key issues independent of technology: (common to former LC studies TESLA, NLC, JLC, CLIC)**
  - **EUROTeV design study**
  - **CARE; ELAN network & JRA on Photo Injector PHIN**
  - **Participation to R&D on low emittance generation @ ATF/KEK**
- **Tests with beam in CTF3 Test facility:**
  - **Beam instrumentation and beam simulations benchmarking**
  - **Beam combination as possible DR injection/extraction with RF transverse cavities**
- **Additional key issue common to ILC and CLIC:**
  - **Multi-Beam Klystrons with long RF pulse and high efficiency**
- **Expertise on Super-Conducting technology**
  - **Nb coated Copper SC cavities (LEP2 352 MHz and 1.5 GHz high gradient R&D)**
  - **Expertise on large scale cryogenics systems (18kW @ 4.5K and 2.4kW @ 1.8K in LHC)**

EU supported Linear Colliders Design Study

EUROTEV (2005 –2007)

About common L.C. key issues



Participation to EUROTeV

e 4.1 Work Package participation (C: coordinating institute)

Institute	WP1: MNGMNT	WP2: BDS	WP3: DR	WP4: PPS	WP5: DIAG	WP6: ILPS	WP7: METSTB	WP8: GANMVL
CCLRC	X	C	X	X			X	
CEA		X						
CERN	C	X	X		X	C		
DESY	C		X	C	X	X	X	C
ELETTRA								X
FHG								X
GSI								X
INFN-LNF	X		C					X
INFN-Mi								X
INFN-Ro2								X
IPPP				X				
LAL					X	X		
LAPP	X						C	
PSI						X		
QMUL		X				X		
RHUL	X				C	X		
TEMF,TUD		X						
UBER				X				
UCAM					X			
UCL					X			
ULANC		X						
ULIV				X				
UMA		X				X		
UMH								X
UNIUD								X
UOXF,DL					X		X	
UU					X	X		

CERN resources to EUROTeV

Work-package	Task ID	Task	Description	EU additional resources	CERN committed resources
WP2 (BDS)	BDSLD	BDS Lattice Design	Exploration of non-linear collimation schemes	1.0 p·y	0.27 staff·y 0.666 fell.y
	SWMD	Spoiler Wakefields & Mech. Design	Trapped-mode Calculation	0.5 p·y	0.13 p·y 0.33 py
WP3 (DR)	ECLOUD	Studies of Electron Cloud and other Instabilities	Development of simulation codes Benchmark and tuning of simulations against experimental data in SPS and co. Application of codes to DR lattices Fast ion instability studies		1.5p·y **2.0 py**
WP5 (DIAG)	PBPM	Precision Cavity BPM	BPM with <100 nm resolution, <10 µm precision, < 15 ns rise-time design and fabrication of prototype Beam tests in CTF3	2.5 p·y 84kEuro	1.5 p·y 84kEuro
	TPMON	Timing & Phase Monitoring	design&construction of phase reference system with stability better 15 fs rms over long distances (km) Beam tests in CTF3	2.5 p·y 120kEuro	2.0 p·y 120kEuro
	WBCM	Wide-Band Current Monitor	development of a 20 GHz bandwidth bunch charge monitor resolving single bunches in a bunch train design&construction of prototype Beam tests in CTF3	84kEuro	1.0 p·y 84kEuro
	CFBPM, PBPM, TPMON, WBPM	Confocal Resonator BPM + preceding ones	Tests with beam in CTF3		0.3 p.y

CERN contribution to EUROTeV

WP6 (BDYN)	FMSIM	Failure Mode & Effect Simulations	Key failure modes (FM) determination Simulation of FMs and impact on accelerator performance / design	0.5 p·y	0.1 p·y
	COLSIM	Collimation Simulations	Simulation of post-linac beam halo Collimation impact on design&perform.	0.5 p·y	0.1 p·y
	LAST	Luminosity and alignment system tuning	Alignment and feedback strategy for luminosity performance optimization Develop tools to evaluate luminosity	2.5 p·y	0.5 p·y 2.25py
	HTGEN	Halo and Tail Generation	Study of potential sources of halo and tail generation in the LET Development of halo models Explore possibilities for benchmarking	2.5 p·y	1.5 p·y
	BBSIM	Beam-Beam Simulation Code Development	Support of development and benchmarking of simulation code GUINEA-PIG		0.1 p·y

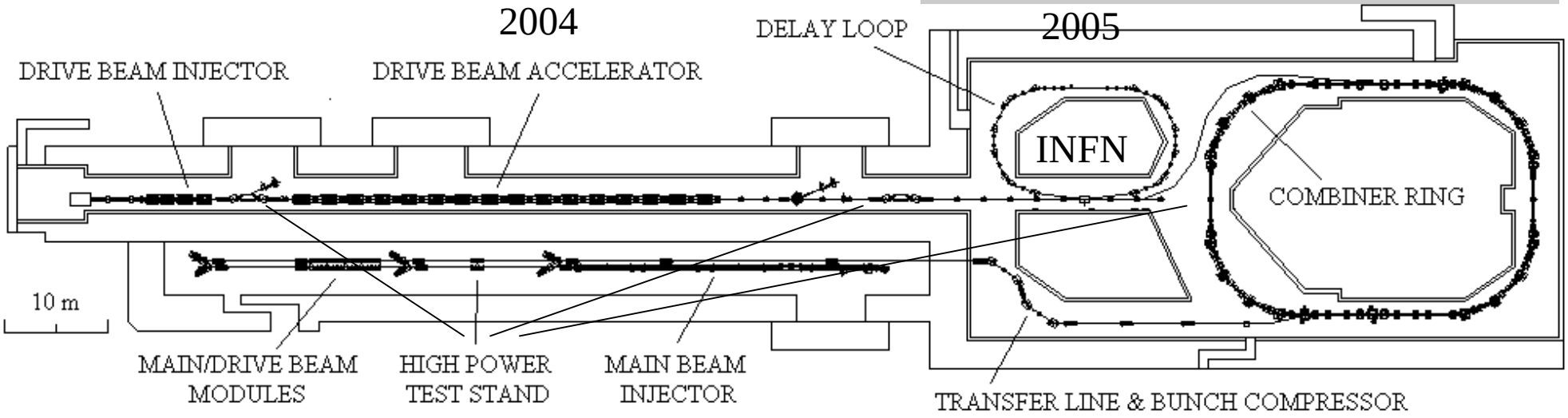
Use of CLIC Test Facility (CTF3)

Test with beam of beam diagnostics and RF transverse cavities

Damped accelerating structure (R1.1)

2004

2005



CLEX

2006

Drive beam generation scheme (R1.2)
ON/OFF PETS (R1.3)

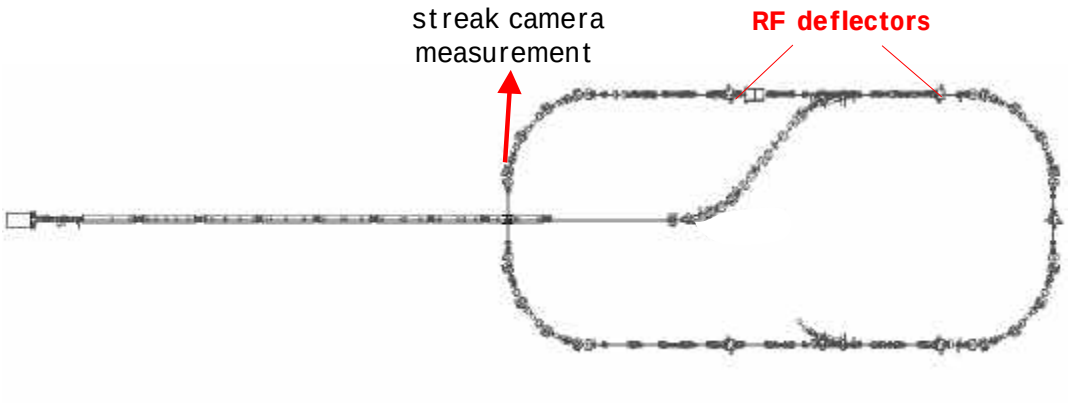
2007

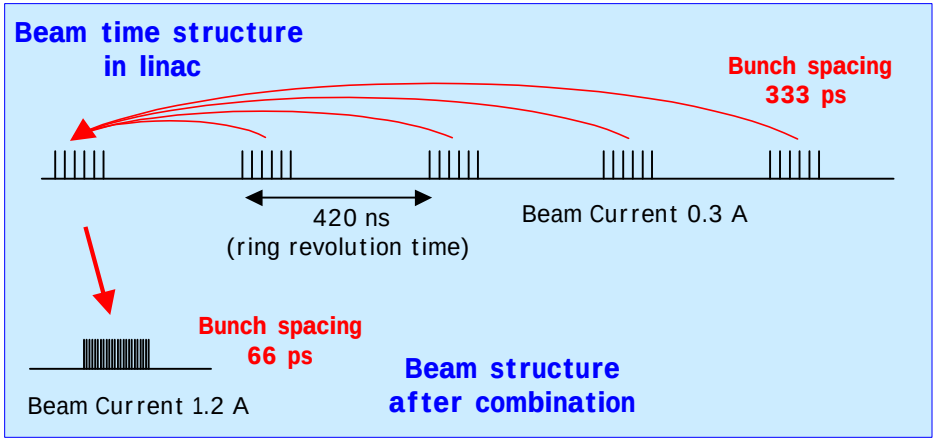
Stability bench marking (R2.1)
CLIC sub-unit (R2.3)

Test of possible DR injection/extraction scheme with RF transverse deflectors in CTF3

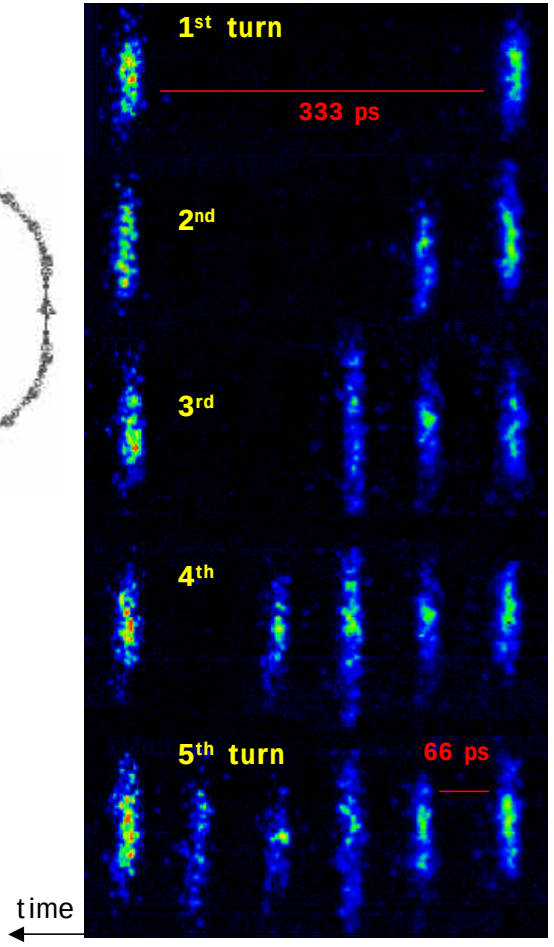
CTF3 - PRELIMINARY PHASE

low-charge demonstration of electron pulse combination and bunch frequency multiplication by up to factor 5





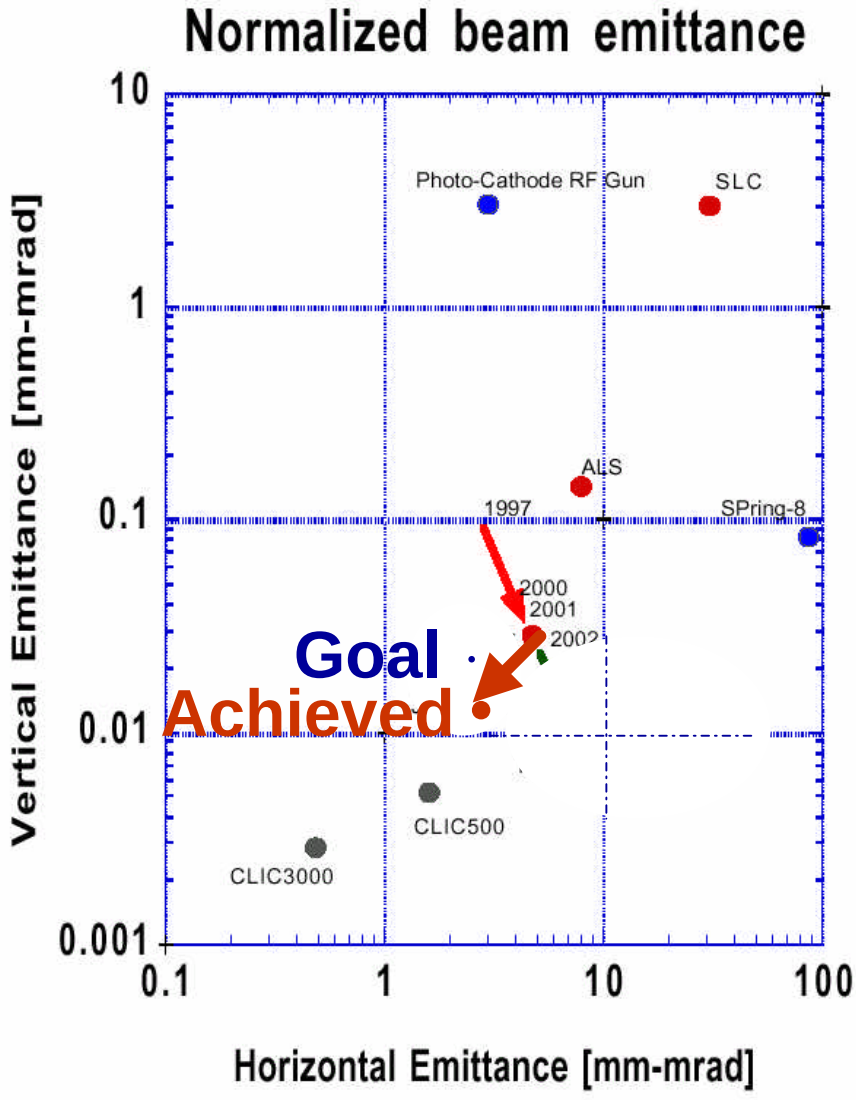
Streak camera image of
beam time structure evolution



R& D about Ultra low beam emittances at ATF Damping Ring (KEK)

SLAC and KEK physicists survey ring

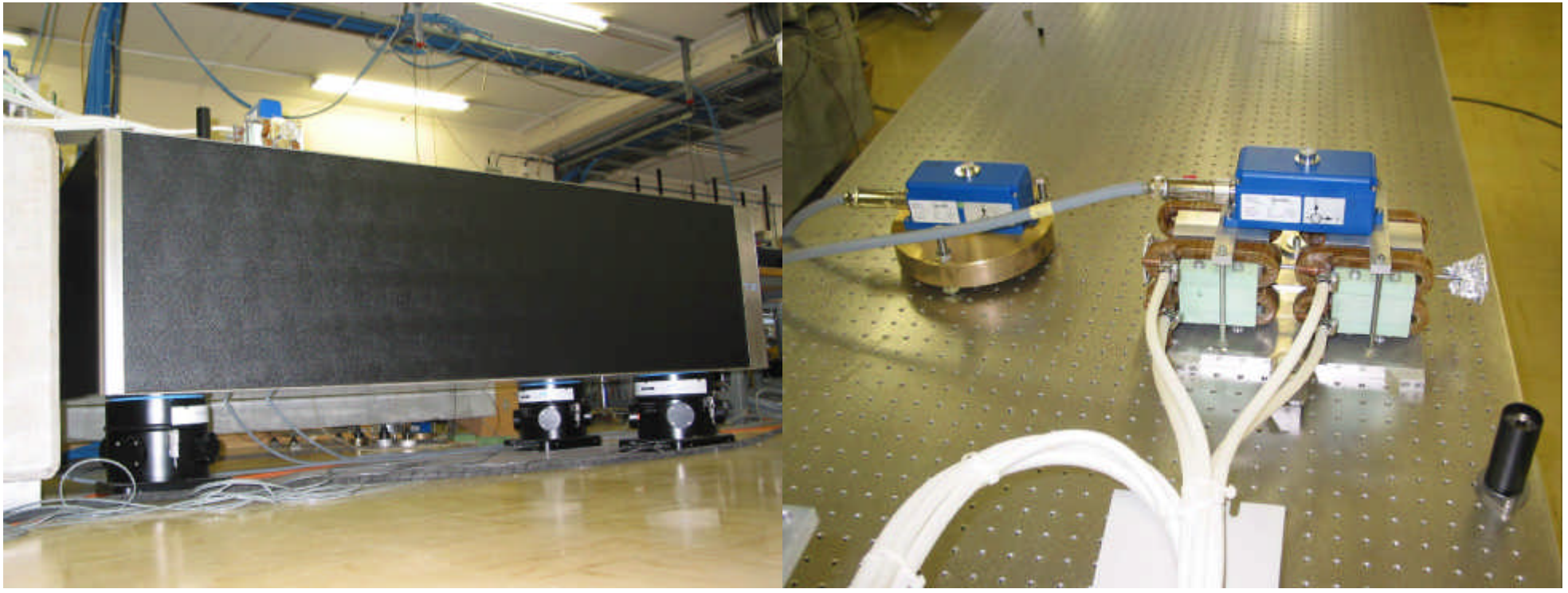
"Laser Wire"



Collaboration on Nanometer Stabilisation

Latest stabilization technology applied to the accelerator field

Transfer to LAPP of Test Bench developed @ CERN ?



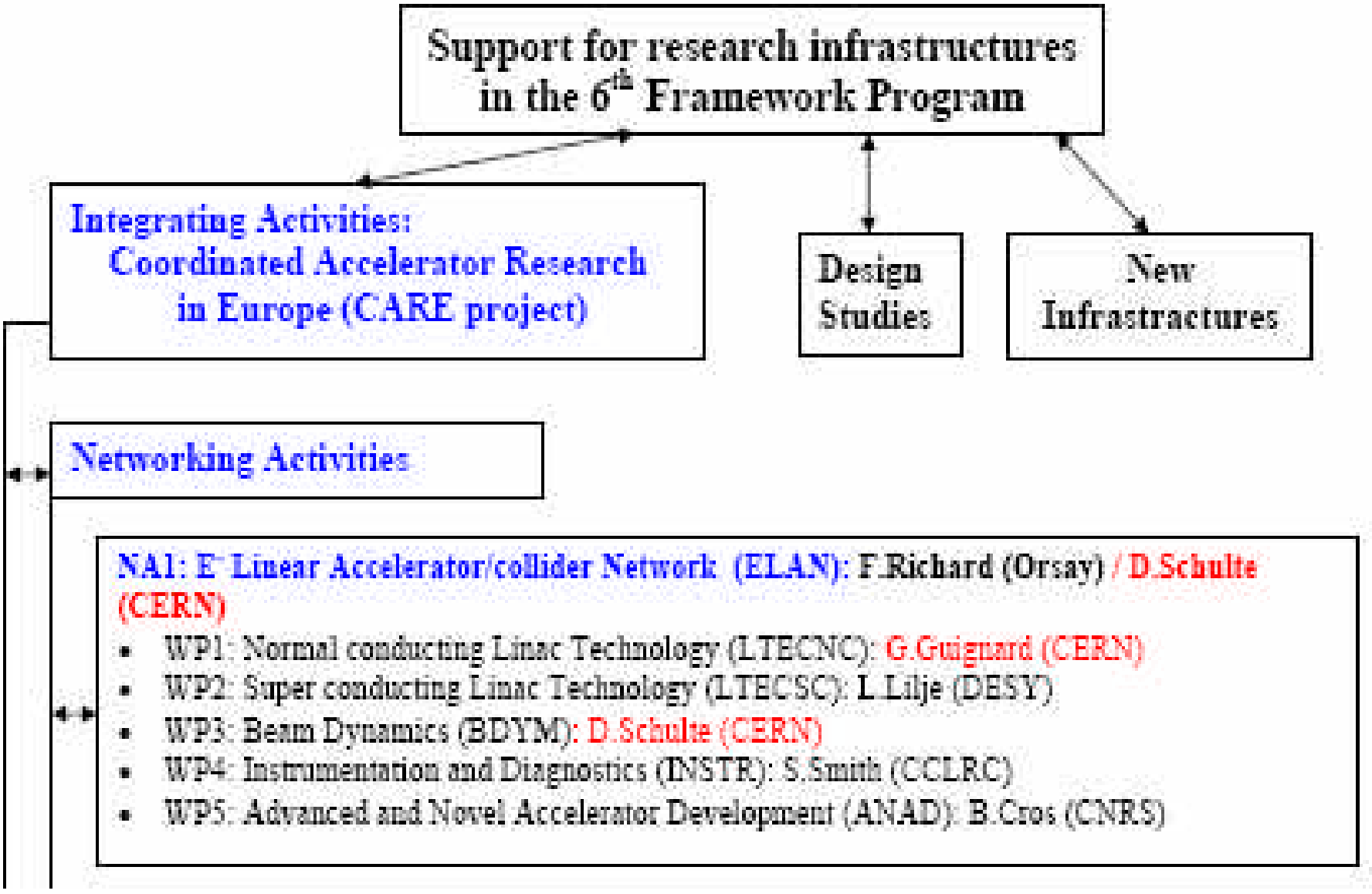
Stabilizing quadrupoles to the **0.5 nm** level!

(up to 10 times better than supporting ground, above 4 Hz)

CERN contribution to CARE ELAN&PHIN

Work-package	Task ID	Task	Description	EU additional resources Personal 1.5 (p.y) Material 1.26 M€	CERN committed resources Personal 11s+2.5f (p.y) Material 0.40 M€
ELAN	LTECNC BDYN		Contribution to the exchange between experts and reflection on the definition of R&D on Sources, Beam dynamics simulation codes, alignment & vibration, RF transverse deflectors	0.08 M€	3 p.y (staff) 0.18 M€
PHIN WP1	M&C	Management & Communication	Oversee and coordinate the work of the entire JRA. Creation of tools, databases and web site.	0 0.02 M€	0.5 p.y (Staff) 0 M€
PHIN WP2	CP	Charge Production	Study of fabrication technology and new materials. Tests at different labs.	0. p·y 0.045 M€	4.5 Staff 1 Fellow 0.1 M€
PHIN WP3	LAS	Lasers systems	Design and develop laser system Amplifier design Stability issues and feedbacks	0. p.y 0.948 M€	(2.5 Staff) (1.5 Fellow) 0.1 M€
PHIN WP4	GUN	RF guns and beam dynamics	Design for high charge, high average current, and long pulse trains Study and construction of a RF gun Tests in CTF3.	1.5. p·y (Fellow) 0.165 M€	0.5. p·y (Staff) 0.02 M€

Participation to ELAN



JRA PHIN: Photo-Injector R&D

JRA2: Charge Production with Photo-Injector (PHIN): A.Ghigo (INFN) / L.Rinolfi (R.Losito from Nov 04) (CERN)

- WP1: Management and Communication (M&C): A.Ghigo (INFN)
- WP2: Charge Production (CP): J.Teichert FRZ-ELBE)
- WP3: Lasers (LAS): G.Hirst (CCRLC-RAL)
- WP4: RF Guns and Beam Dynamics (GUN) G.Bienvenu (CNRS-Orsay)

JRA PHIN: Photo-Injector R&D

CERN

Photocathodes

+

Timing

RF power

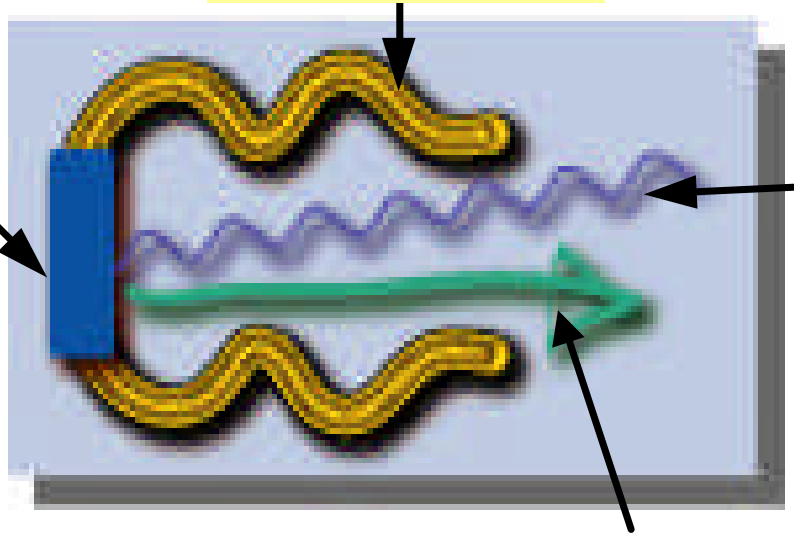
Laser beam transport

Installation

Monitoring …

LAL (F)

3 GHz RF gun



RAL (GB)

High power

Laser

2332 e^- pulses distant of 667 ps ; σ = 4 ps ; Q_{pulse} = 2.33 nC

2004 - 2006 : construction and installation of the photo-injector included in the European program CARE (FP6)

E.U. funding: 90 % of the request » 2 MCHF

CERN resources towards ILC

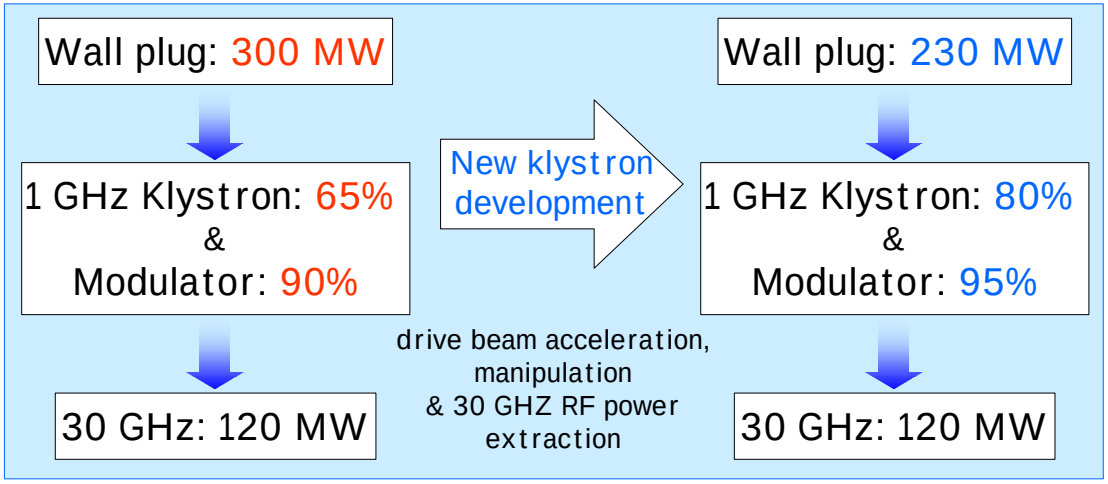
	EU			CERN			Total		
	Material	Staff	Fellows	Material	Staff	Fellows	Material	Staff	Fellows
	MEuros	P-y	P-y	MEuros	P-y	P-y	MEuros	P-y	P-y
EUROTeV	0.35	0	12.5	0.4	11.7	4	0.75	11.7	16.5
ELAN	0.08	0	0	0.18	3	0	0.26	3	0
PHIN	1.10	0	1.5	0.20	8	2.5	1.30	8	4
CARE mngt	0	0	0	0	2	0	0	2	0
Total	1.53	0	14	0.78	24.7	6.5	2.31	24.7	20.5

Multi Beam Klystrons
Common key issue to ILC & CLIC

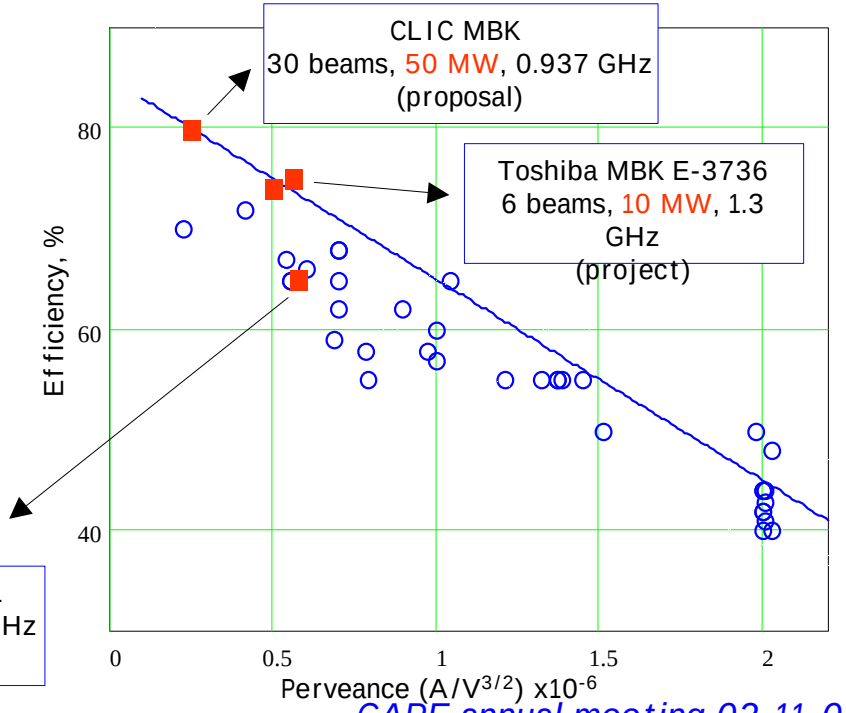
Parameters	Units	CLIC	ILC
RF frequency	GHz	0.937	1.3
RF Power	MWatts	50	10
RF pulse duration	microsec	92	1300
Repetition frequency	Hz	100	5
Energy per pulse	kJoules	4.6	13
Average power	kWatts	460	65
RF power generation efficiency	%	>65	>65

MBK development towards improved efficiency

Wall Plug & 30 GHz RF power in CLIC



Thales MBK TH1801
6 beams, 10 MW, 1.3 GHz
(measured)



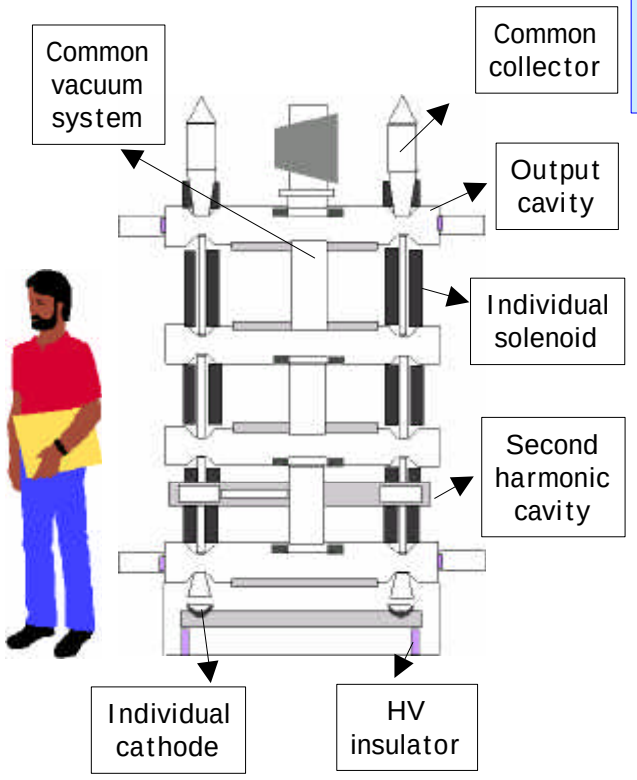
State-of-the-art klystron efficiencies vs. perveance for
single beam ○
multi-beam ■

Why Multi Beam?

- Low perveance ($A/V^{3/2}$) favor klystron efficiency.
- Multi Beam devices keep single beam perveance small to provide high efficiencies for high RF power output (tens of MW).

A novel idea of super-efficient Multi-Beam Klystron (80%)

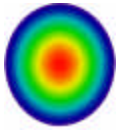
General layout of CLIC MBK 0.937 GHz, 50 MW



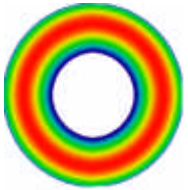
In order to host a large number of beams in a MB Klystron, it is necessary to use RF cavities operating at a mode with higher 1) radial or 2) azimuthal order.

The second case was chosen for the CLIC MBK, which allows higher impedance seen by single beam.

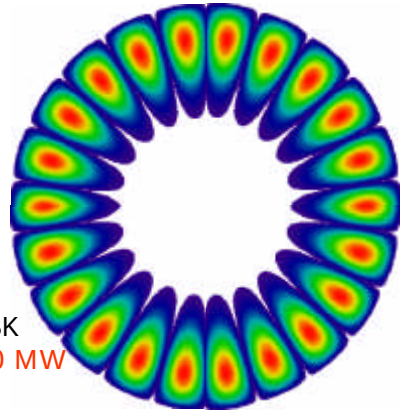
Electric field plots for different MBK's RF cavities. The beams are located in the maximum field area (red color)



Thales MBK TH1801
6 beams, 10 MW

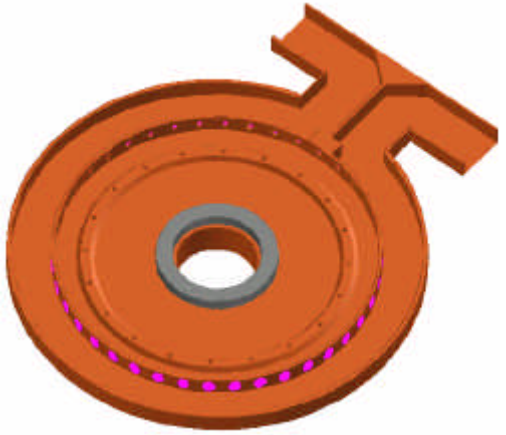


Toshiba MBK E-3736
6 beams, 10 MW

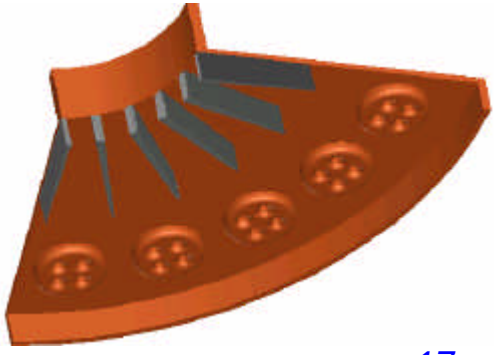


CLIC MBK
30 beams, 50 MW

General view of the output cavity and waveguide feeder

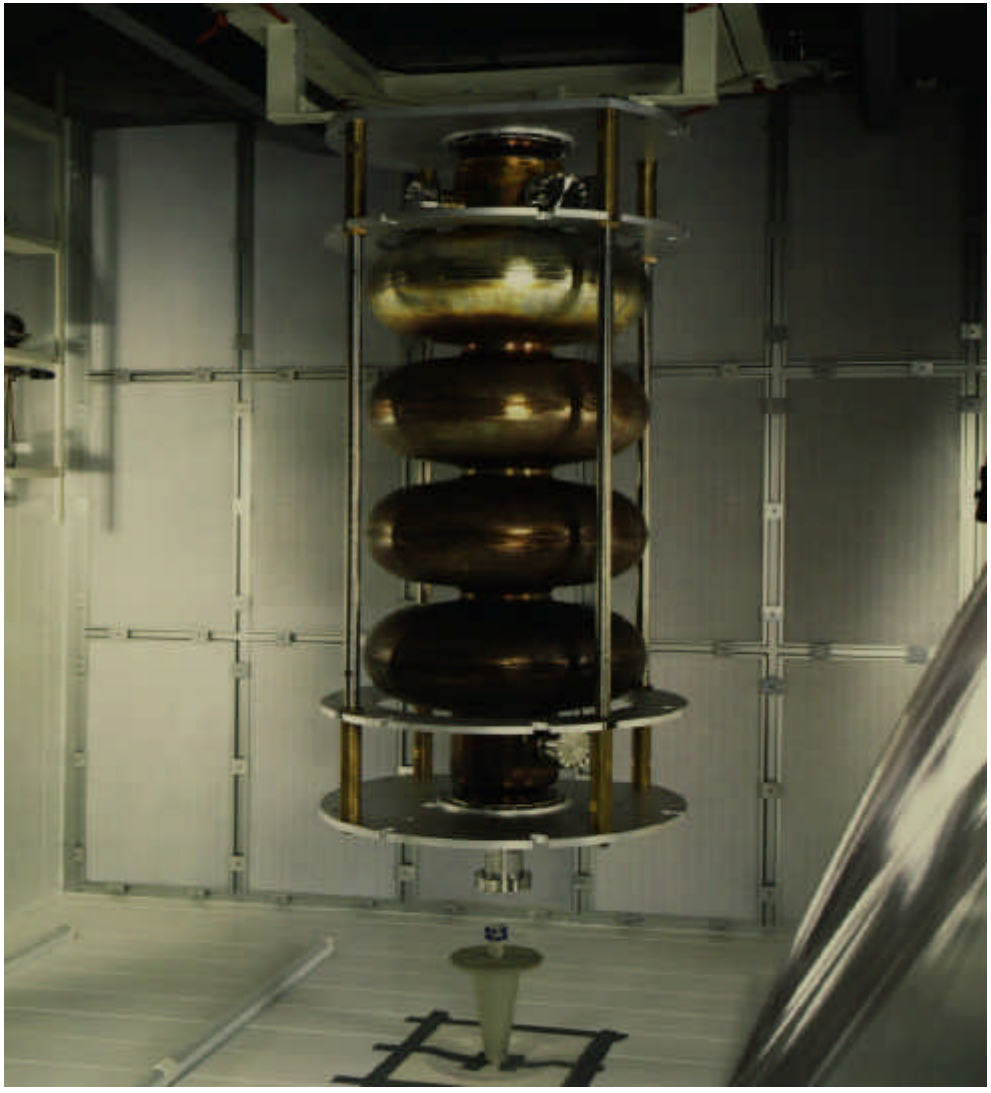


Damping of the HOM with array of many thin SiC wedges



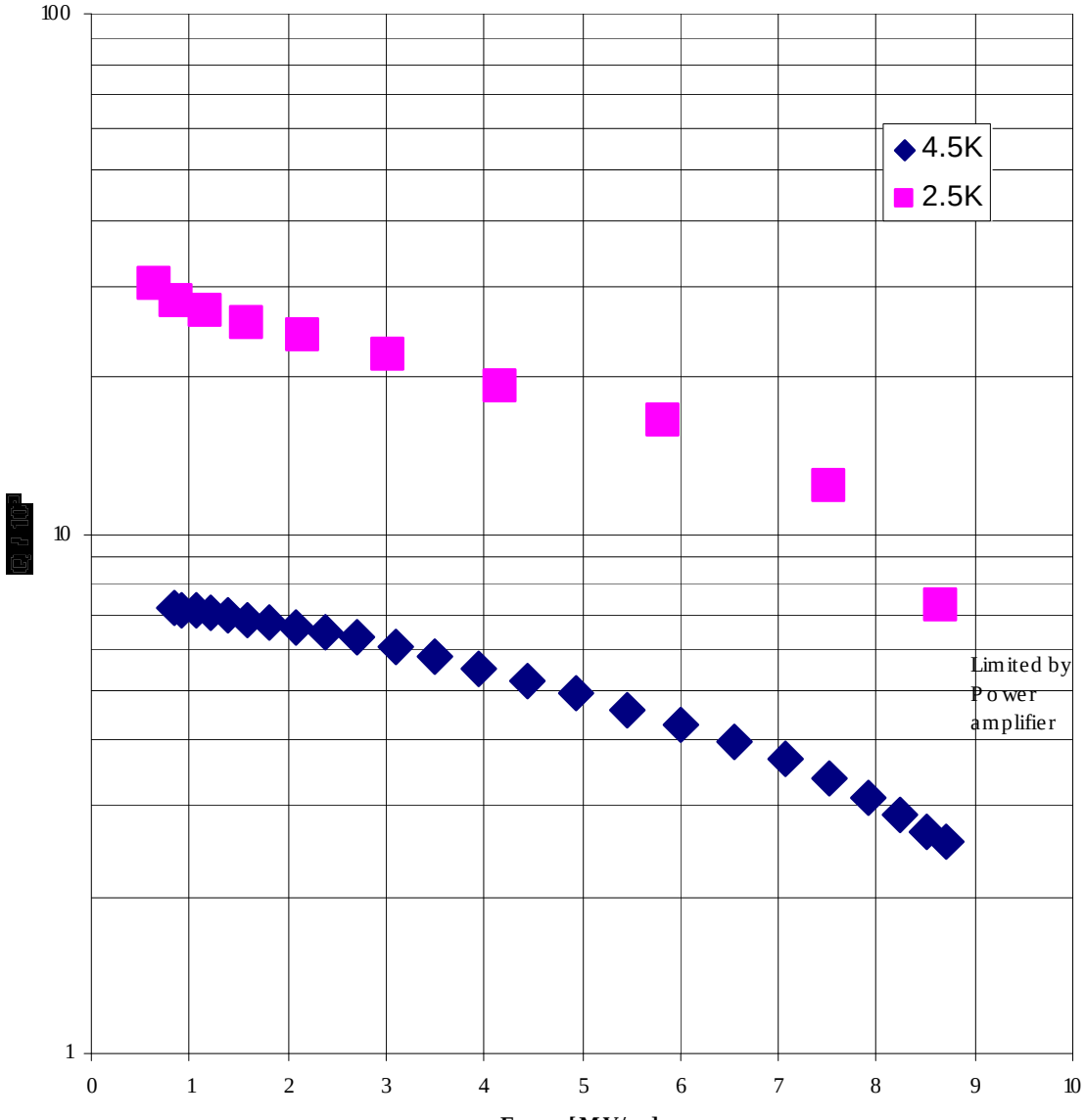
The CLIC MBK uses a series of mini-windows instead of a single ceramic window, thus reducing local RF power flow and ensuring reliability.

Expertise on Nb coated copper cavities
LEP2 (352 MHz)

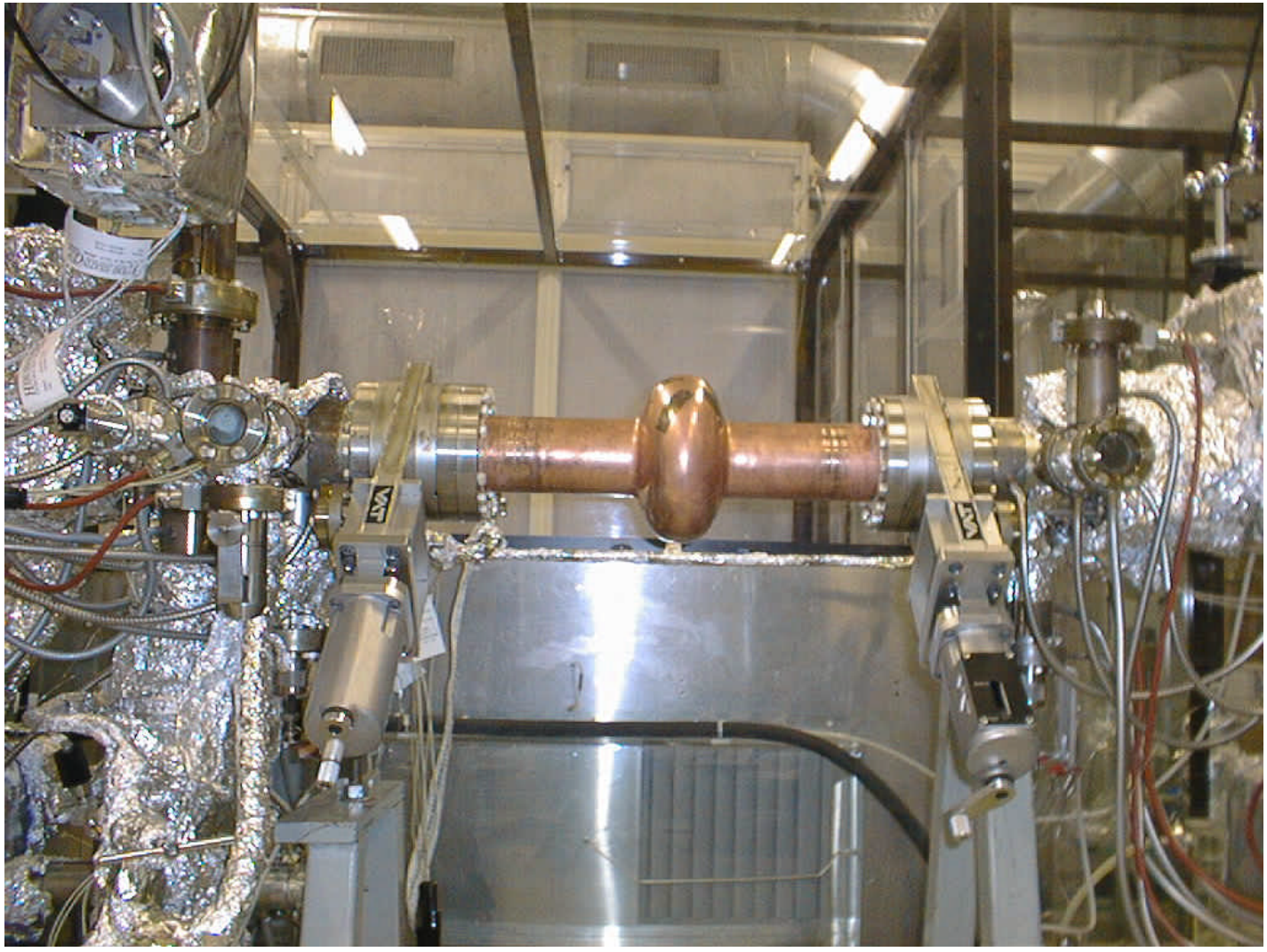


"High gradient" in LEP SC cavities (352 MHz)

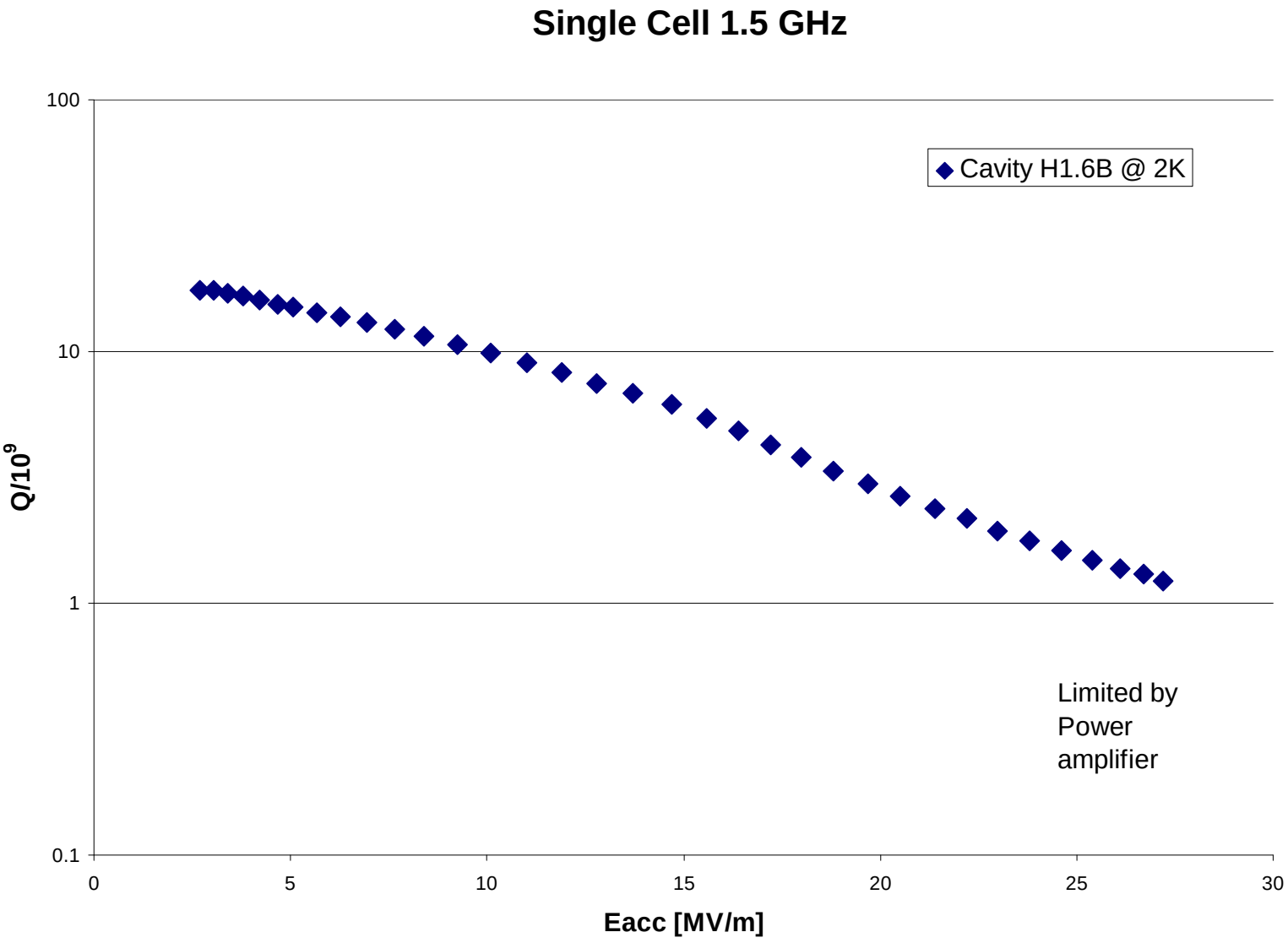
LEP cavity: typical performance in vertical cryostat



High gradient R&D on 1.5 GHz Nb coated copper cavity



R&D on 1.5 GHz SC single cell



Conclusion

- **CERN focused on LHC, resources committed up to 2010**
- **CERN committed to demonstrate feasibility of CLIC technology towards colliding beam energies in multi-TeV range complementary to ILC, within the frame of a multi-lateral network of collaborating institutes**
- **Limited but substantial participation to ILC within the frame of the EU supported EUROTeV design study and CARE project (ELAN, PHIN) on generic key issues independent of technology with resources (2005-07):**

  2.3 MEur., 25 staff-years, 20 fellow-years
- **Additional common interest on R&D about low frequency Klystrons with high efficiency (MBK and/or novel scheme based RF cavity with high order modes)**
- **Available expertise on SC technology: Nb coated copper cavities and large cryogenics systems**