Presentations in LTECNC parallel and common sessions of the ELAN Workshop.

R&D for CLIC technology feasibility study J.P.Delahaye

An overview is given of the necessary R&D and especially the CLIC test facility CTF3 which is presently under construction for demonstrating the key issues related to the CLIC technology and to the two-beam scheme. The results concerning the commissioning of the injector and of the first part of the linac already built and the progress made on the preparation of the various sub-systems of the next CTF3 stages are summarized. The main R&D topics to be covered with this test infrastructure are described and the planned road-map in order to reach the pre-defined goals is indicated. The potential of CTF3 for checking the bunch-train recombination, testing RF accelerating structures, investigating the use of a drive-beam for RF power production, for bench-marking simulation codes and possibly making low-energy experiments related to linear collider R&D is presented.

Multi TeV General Issues

High Accel. G; Generation/preservation of emittance
Focus to nm level; Stabilisation to better than nm
Physics experiments in high beam-strahlung regime

Strategy

Common key-issues treated in collaboration with EU LABS (EUROTEV Design Study)

Specific issues of R1/R2 ranking by ILC/TRC, dealt with in the CLIC study

R&D Work packages

1. combiner ring with transfer lines and bunch compressor
2. 30 Ghz power test stand
3. CLIC experimental area
4. 299 MeV probe beam linac
5. CLIC linac sub-unit with beam
6. 35 A Test beam line
7. 30 Ghz structure development
8. CTF3 operation
9. 30 Ghz stand alone power source

CLIC Collaboration meeting on 19/05/04 to collect proposals from potential participants.
Site with the details of the WP tasks.

Schedule

End 2007 Feasibility demonstrated
End 2009 Finalization of the design

Key results

Cavities:	Cu	120-140 MV/m with damage
	W iris	150 MV/m no damage
	Mo iris	190 MV/m no damage

With short pulses 10-30 ns, not damped structures

Stabilization test bench:	0.4 ± 0.1 nm H
	0.9 ± 0.1 nm V

CTF3: Status of INFN Collaboration
A.Ghigo

The INFN contribution to the CLIC Test Facility project is the realization of the Delay Loop, the first ring in which the bunch trains are recombined increasing the frequency, and of a Transfer Line that connects the Linac with the ring. The INFN activities on the studies, the projects, the tests and the installation are reported.

Overview about the JRA2: PHIN **A.Ghigo**

An overview of the activities related to the PHIN is presented. Eight laboratories contribute to the development of the Joint Research Activity (JRA2) "Charge production with photo-injector". Several technical meetings with the participants of the work packages (lasers, photo-cathodes, RF guns) took place and significant progress has been made. A first report about the design of the laser oscillator is foreseen in May while a report about the photo-cathodes studies is foreseen in June. A general report on the present status of the project, the achieved results and the future plans is given.

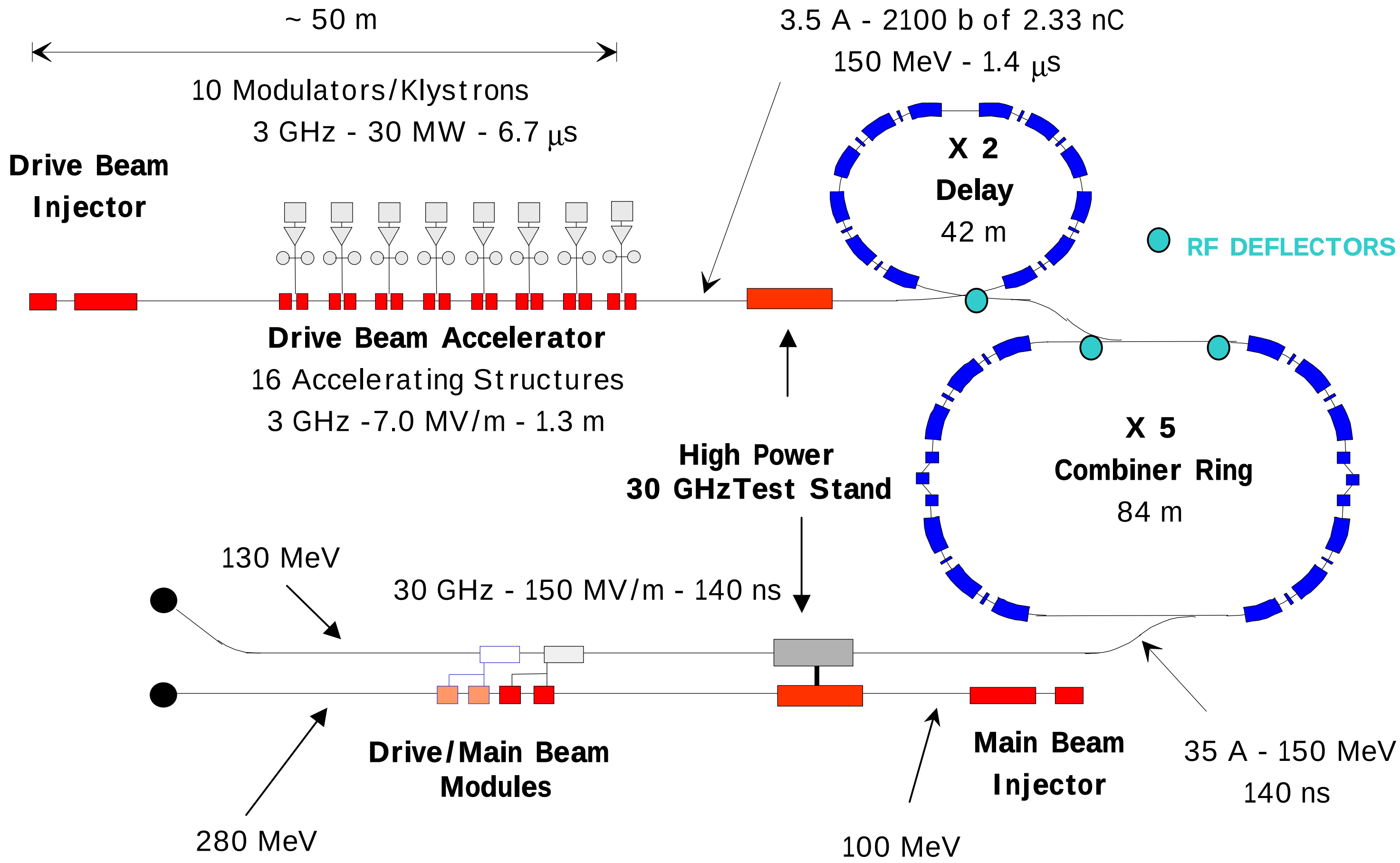
Remarks on the Eindhoven High brightness Electron source programme in relation with the injectors required for accelerators:

It applies to very short pulse 75 – 100 fs
To modest charge 10 – 100 pC
Intrinsic limitation related to short bunch-length

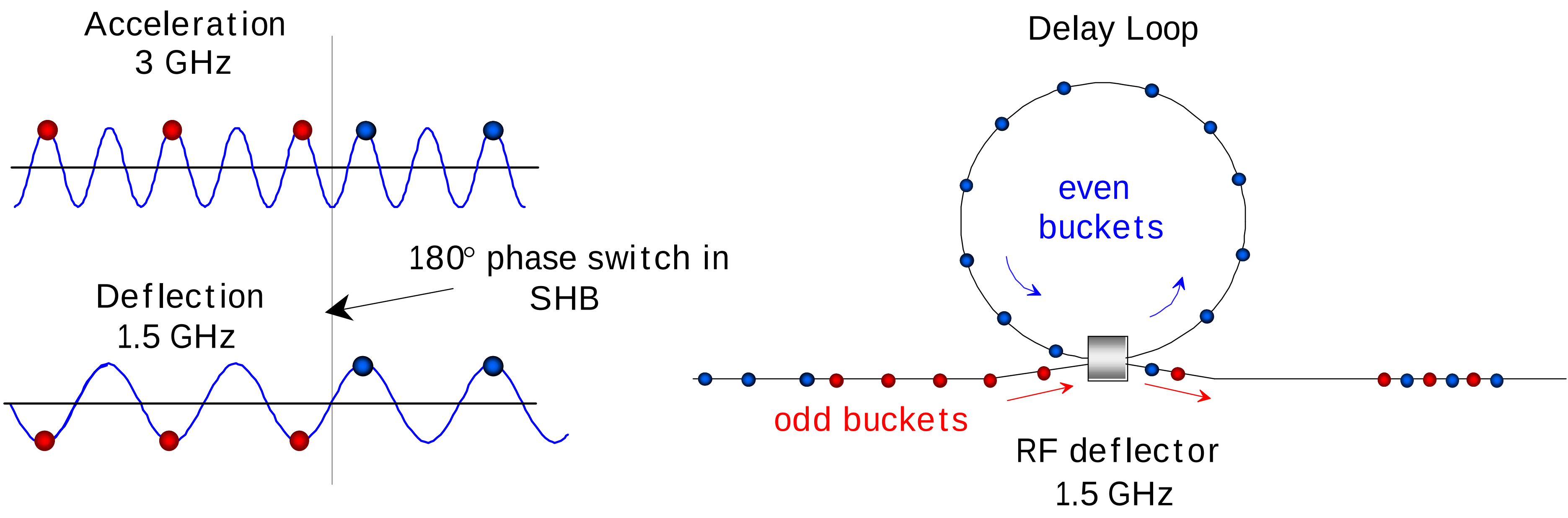
Energy of 10 MeV, emittance of 1 mrad mm DC RF photogun followed by S-band RF booster, suitable for Laser Wake-field Accel. Experiment

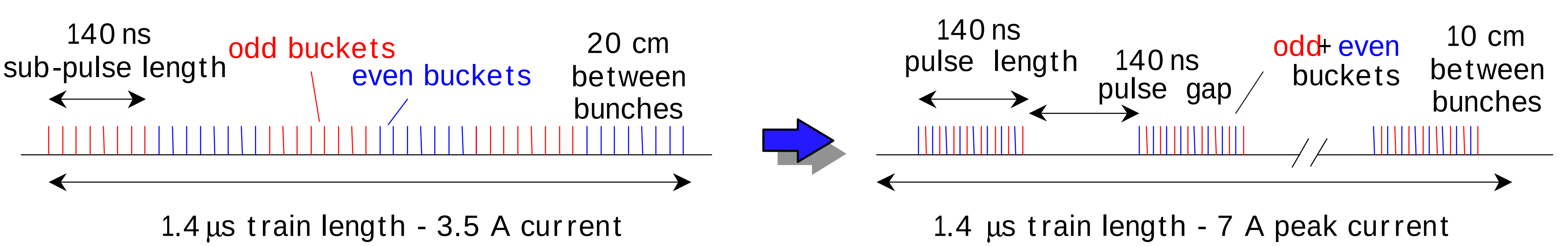
CTF3 NOMINAL PHASE

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



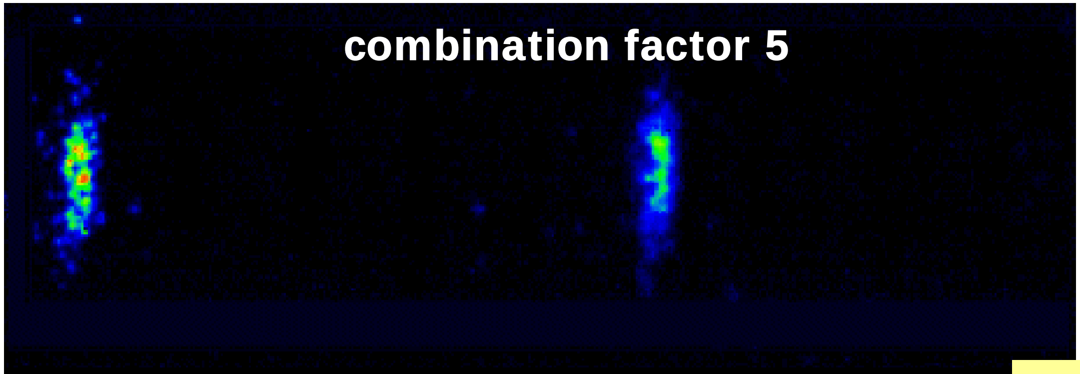
Delay Loop : X2 Multiplication scheme





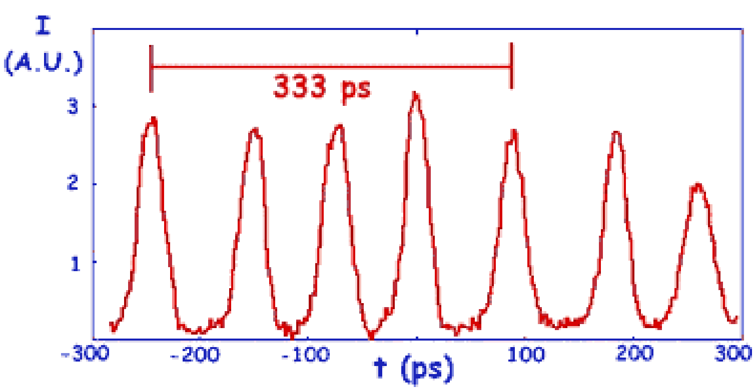
BUNCH TRAIN COMBINATION

streak camera images of beam in the ring



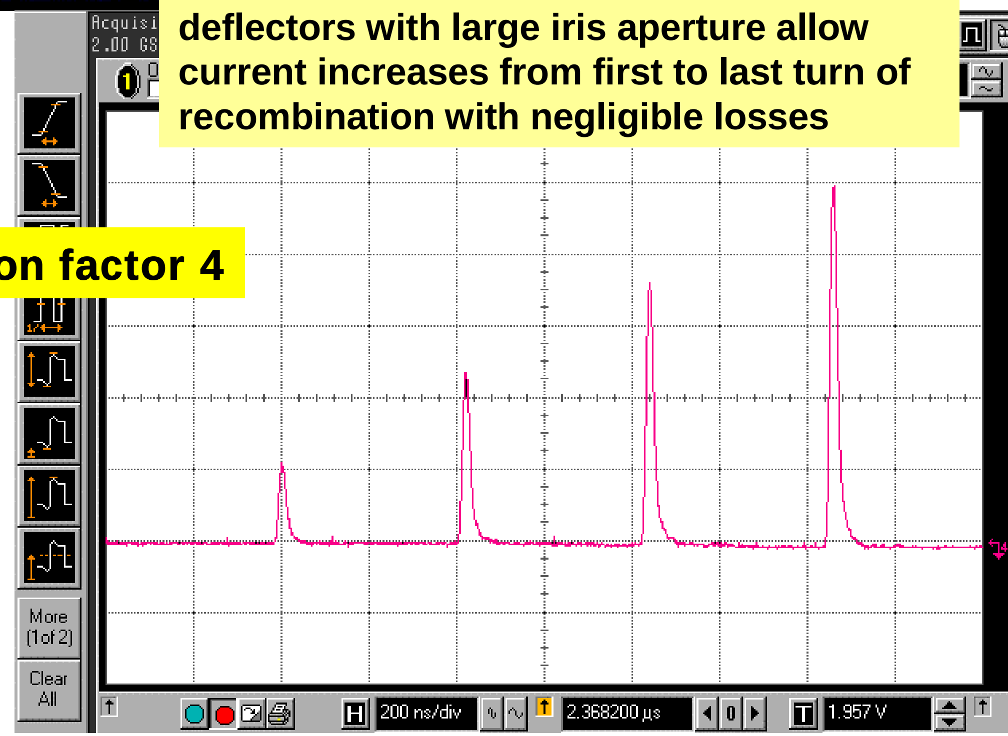
- **First demonstration in June 2002**
- **Tested combination factors 4 & 5**

Charge: $1x10^{10}$ e- / train or 0.1 nC / bunch
Beam energy: 350 MeV
Bunch length (rms) ~ 8 ps



combination factor 4

deflectors with large iris aperture allow current increases from first to last turn of recombination with negligible losses



PHIN Main Objectives

Perform Research and Development on charge-production by interaction of laser pulse with material within RF field and improve or extend the existing infrastructures in order to fulfil the objectives.

Coordinate the efforts done at various Institutes on photo-injectors.

The goal is to produce an electron source with brightness unachievable with conventional thermoionic gun.

PHIN Objectives

- **Study and model the beam dynamics in the RF gun.**
- **Develop Normal and Super Conducting RF-guns for medium-high charges.**
- **Optimize** the RF guns in order to satisfy thermal constraints and vacuum requirements of photo-cathode.
- **Optimize the combined system laser-photo-cathode for various applications, seeking for a trade-of between cathode lifetime, laser power and wavelength.**
- **Study and develop optical and laser installations for the generation of the various space and time beam-distributions related to the various PI applications.**
- **Investigate means of generating complex timing, and of shaping laser pulses.**
- **Develop necessary instrumentation.**
- **Make the necessary developments to improve existing installations in order to satisfy the objectives.**

Overview of the present status of the SRF gun design and construction. J.Teichert

A status report on the SRF photo-injector activities at FZR within the CARE/PHIN project will be given. The new SRF gun has been designed for CW operation at the ELBE linac with an average current of 1 mA, 77 pC bunch charge, and 10 MeV energy. The basic concept of the gun, operating a normal conducting, thermally insolated photo-cathode within a superconducting cavity, have been taken from the first SRF half-cell gun [1] which was successfully tested. In this report the design layout of the SRF photo-injector, the parameters of the superconducting cavity and the expected electron beam parameters are presented. The SRF gun will have a 31/2-cell niobium cavity working at 1.3 MHz and will be operated at 2 K. The cavity consists of three full cells with TESLA-like shapes and a half-cell in which the photocathode is situated.

1. D. Janssen et. al., First operation of a superconducting RF-gun, Nucl. Instr. and Meth. A507(2003)314.

ELBE SRF Photogun – Present Status

Cavity:	**Design finished**
	Fabrication of 2 (RRR 40 & 300) cavities at ACCEL GmbH and a third cavity by Peking University
Cavity tuners:	**Fabrication finished**
	tests necessary
Cathode cooling system:	
	Design finished, in fabrication
Cathode transfer system:	
	Design finished
Cathode preparation chamber:	
	Design finished, in the work-shop
Cryomodule:	Design will be finished in July

An overview of CLIC accelerating and transfer structure development. A.Grudiev

Both main-linac accelerating structure and drive-linac decelerating (transfer) structure are being developed by the CLIC study. Both types of structures have extremely demanding high-gradient, high-power and wakefield performance requirements. Extensive theoretical, computational and experimental studies have been necessary to progress towards the realization of these structures. The main challenges and progress in developing the two structures are presented.
In particular, a new accelerating structure design, HDS (Hybrid Damped Structure), with improved high-gradient performance, efficiency and simplicity of fabrication is presented. Optimization of the structure with an accelerating gradient of 150 MV/m at 30 GHz results in 29 % rf-to-beam efficiency.

PETS Low Impedance,extract power, low beam effect
Structures 30 Ghz, 16 ns, 5x10**10 cl Fatigue CuZr
Optimisation with damping, geometry, Es= 347 MV/m
DT= 122 K 125MW Wakefield at 2nd bunch 1/100
Add slots in Hybrid Damped Struct. HOM absorbtion
4 wave guides for damping Es/Eacc= 2.2 Q=3900
Dipole mode Q=12.6 at 39.66 Ghz decay in 15 cm by 100
Optimizatiom of Int(L)/Int(P) Efficiency is 29.%

Optimization constraints

Given parameters of the first and last cells and N, N_b, N_{cycles} ,
$E_{surf}^{max}, \Delta T^{max}, P_{in}, t_p$ are calculated for each structure

- rf breakdown limits for Mo

$$E_{surf}^{max} < 420 \times 0.9 = 378 \, {}^{MV}\!/\!{}_{m}$$

and

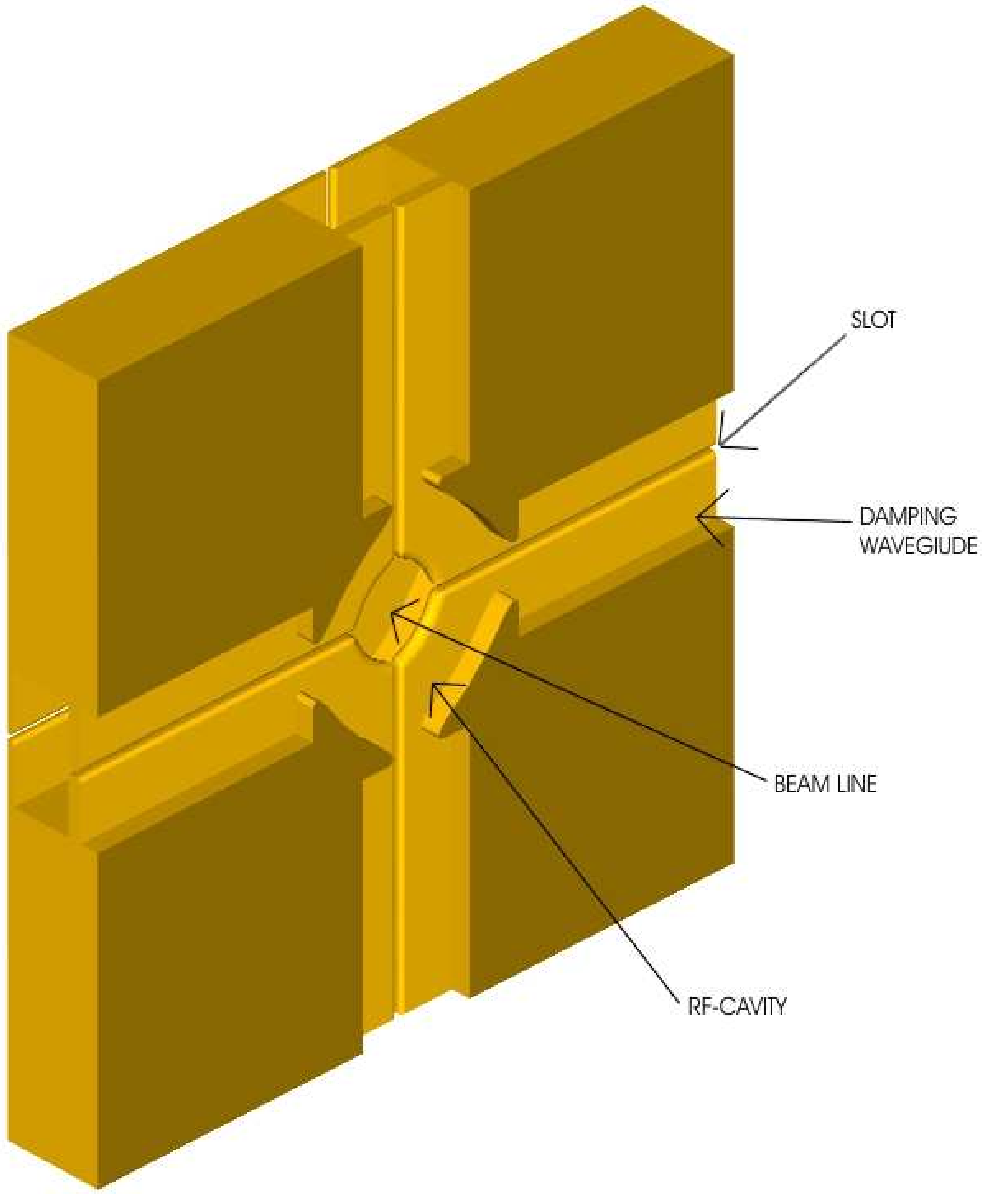
$$P_{in} < \sqrt{150ns / t_p} \cdot 100 \, MW$$

- pulsed surface heating limit for CuZr alloy

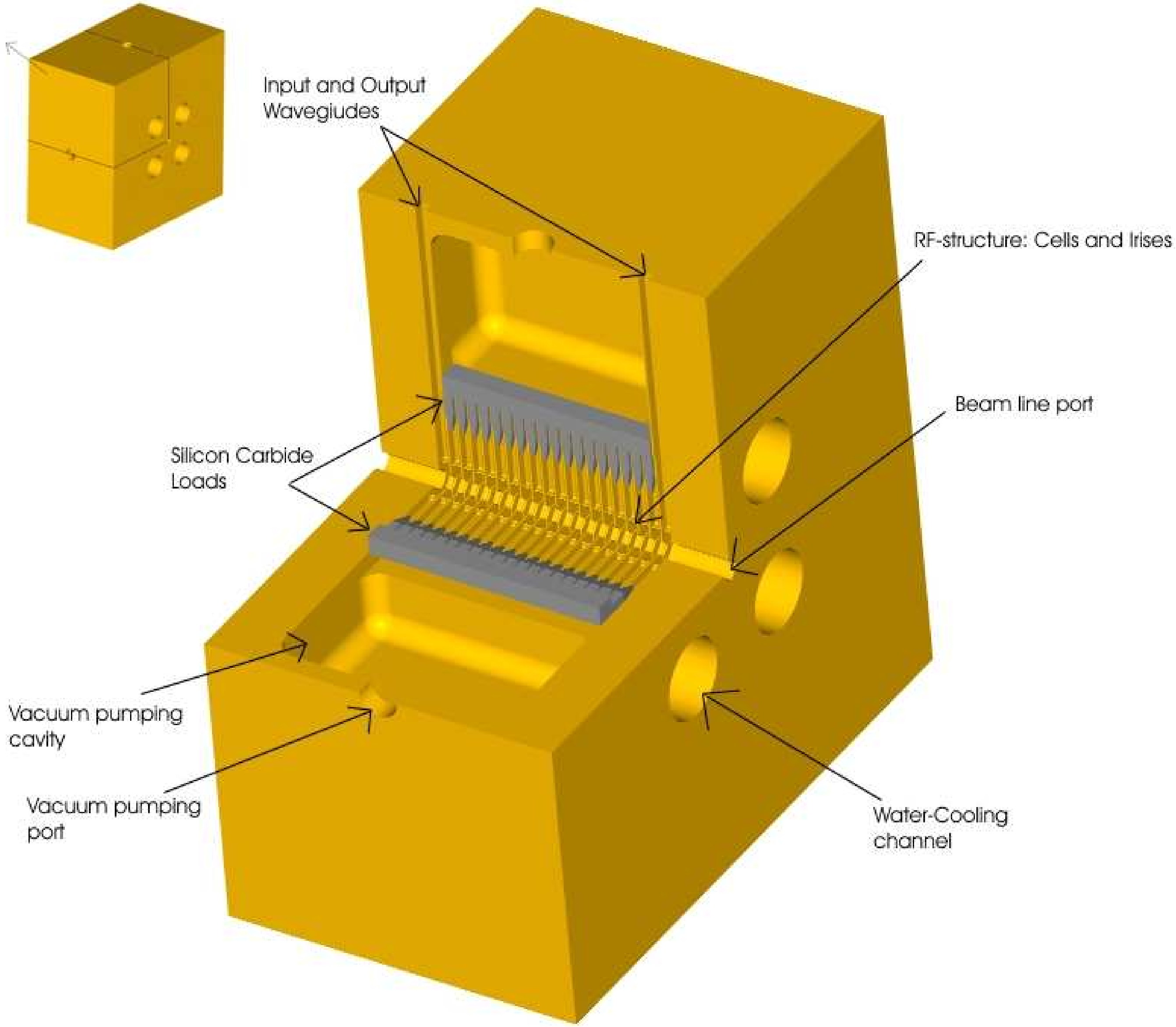
$$\Delta T^{max} < 70 \times 0.8 = 56 \, K$$

72932 (59%) structures satisfy these conditions

Geometry of HDS cell



Schematic of HDS



Development of a planar accelerating structure H. Henke

Millimeter-wave planar accelerating structures are well suited for fabrication by deep x-ray lithography. For lower frequencies high precision milling may be an attractive and low cost solution. In a first step, a 30GHz constant impedance structure was designed, built and tested under high power at CERN. Gradients of around 50MV/m were achieved at pulse lengths of 15ns. Next, a very strong suppression of transverse wakefields were attempted. It turned out that damping waveguides are needed in every cell. Two solutions for a suppression by a factor of 100 within less than 1ns (20cm) were found.

---

72 MW in 4 ns

36 MW in 16 ns, Es 300 MV/m Factor 4 Es/Eacc

Improve geometry, iris shaping,

Channels with damping material in both directions Factor 100 in 20 cm

Detuning and damping H wave guide Factor 100

Factor 4 TO 6 in Es/Eacc

Optimum geometry keeping the flat part: **factor 3**

A short pulse two-beam accelerator with energy recuperation H. Henke

In view of the high gradient limit at longer RF pulses an old idea is presented here which allows for very short pulses. It is a two-beam accelerator were the cavities for the drive and main beam are directly coupled such that a beating process takes place. At 30GHz and with an intercavity coupling of 3% an RF pulse of 1ns is possible. Although the device is essentially a single bunch machine, an energy recuperation scheme is easily incorporated which brings the overall efficiency in the range of more than 5%.

Beating between two beam cavities closely coupled:
Drive and main structures.
Close structures distant by a couple of wave lengths
Beating -> acceleration due to shift of the field envelopes

Energy recovery using SC Cavity to put E back

Works at high frequency e.g. 30 GHz

Single bunch device or several in half a period
100% gain and loss of energy in a drive bunchTwo drive bunches replaced by train of bunchlets

Status of the Linear Collider Alignment & Survey project A.Mitra

Precision survey & alignment for the linear collider will be critical to its success. The Oxford Linear Collider Alignment and Survey (LiCAS) group in collaboration with the DESY applied geodesy group is addressing this. We are developing a "Rapid Tunnel Reference Surveyor" (RTRS) to make automated surveys of a reference network and in a later stage the accelerator components.

The LiCAS group are developing two optical metrology systems for the RTRS: Frequency Scanning Interferometry (FSI) and the Laser Straightness Monitor (LSM). FSI is an "optical ruler" capable of measuring distances of several metres to a precision of approximately 1 micron. A network of FSI interferometers is used to measure the 3D position of reference markers in the tunnel wall to a precision of a few microns. The LSM measures the transverse displacement and rotations of an object with respect to an a laser beam that runs through the RTRS in an evacuated pipe. The combination of these two techniques will overcome the limitations of traditional open-air survey techniques that mainly result from refraction in the tunnel air.

The authors will describe the LiCAS project, the measurement systems and its integration into the RTRS. Results from simulations and laboratory test systems will be presented.

200 microns over 600m

Wall markers
Train moving along the markers
Measuring distance to markers; overlapping segments -> links between segments

Laser tracker Interferometer:
Measuring references and component positions
LICAS: Automated stake-out process
Resolution of 1 micron

To be tested for X-FEL then in LC

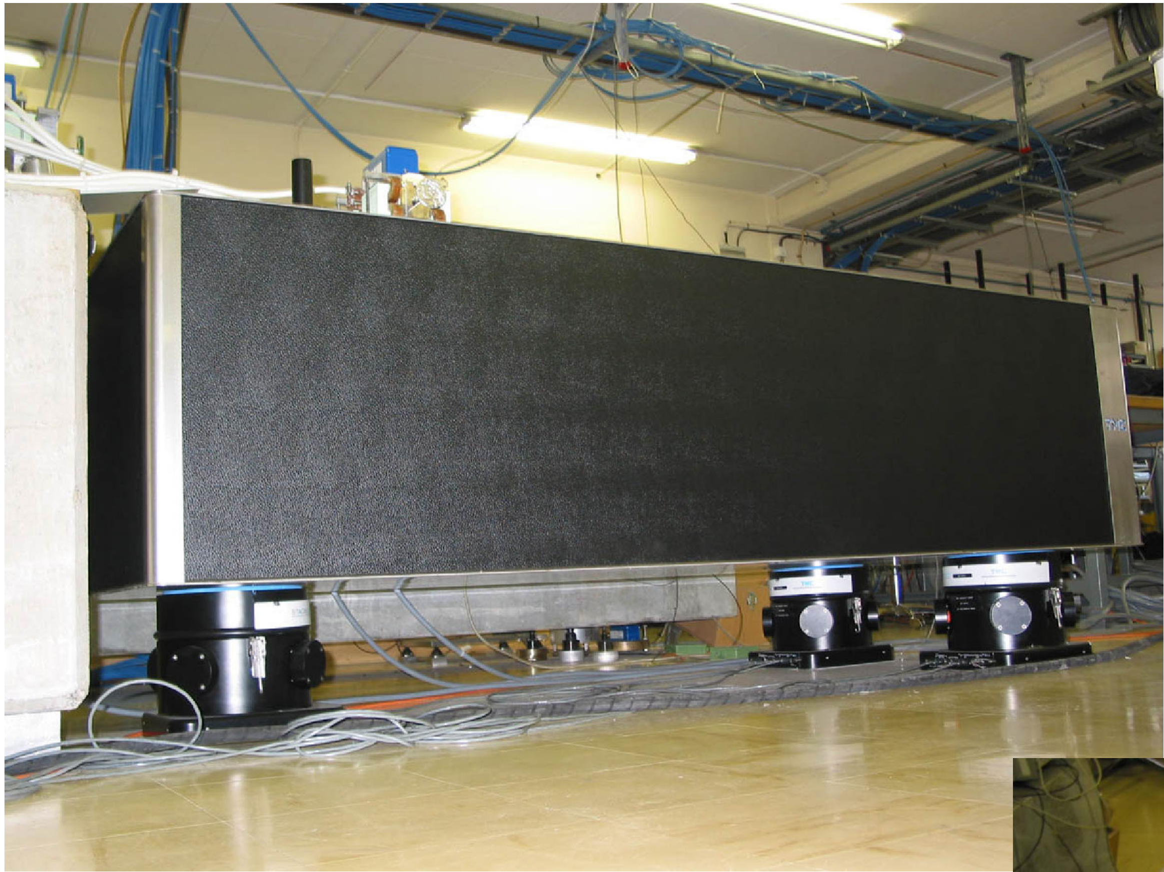
Design of a RF photo-injector in the framework of the JRA2 PHIN R. Roux

The LAL is involved in the JRA2 for the construction of a RF photo-injector for the CLIC Test Facility 3 (CTF3) in CERN. For the design of the RF gun, we take advantage of the long experience acquired by the CERN with photo-injectors. So, the initial design is largely inspired of one which was successfully operated at CERN. Basically, it has **two cells and half** and wide iris apertures. The shape of the latter have been modified using **2D and 3D HF codes and the coupling** between the input RF power and the gun is **symmetric**. The design of the RF photo-injector is now finished and will be presented during this workshop. In addition, we will briefly present the results of some beam dynamic studies we performed to check that the performances of the gun are compatible with the requirements of the CTF3 operation. Finally, we will give some insights of the ways to reach and to keep vacuum better than 2.10^{-10}.

Beam dynamics -> Beam loading -> Vacuum
mechanics -> prototype (5 MeV)
Minimize out-gassing rate; High temperature baking
RF design almost complete, beam dynamics OK, beam loading OK
Vacuum critical
Prototype order before summer: test till September
Order 2 RF guns end of year

Stabilization of Accelerator Magnets to the Sub-nm Level R. Assmann

The Compact LInear Collider (CLIC) aims at colliding electrons and positrons at 3 TeV with transverse spot sizes of 55nm (horizontal) times 0.7nm (vertical). Strict stability tolerances must be respected in order to achieve a sufficient overlap of the two colliding beams. A **stability test stand** has been set up at CERN, bringing latest stabilization technology to the accelerator field. Using this technology, a CLIC prototype magnet was stabilized in a normal CERN working environment to **less than 1-nm vertical RMS motion above 4 Hz.** The measured vibration spectra are presented. The dependence on the flow of cooling water is illustrated and results on alignment stability are shown. Detailed simulation studies have been performed in order to predict the achievable CLIC luminosity, including the measured data on magnet stability, the beam-beam interaction, and beam-based feedbacks.



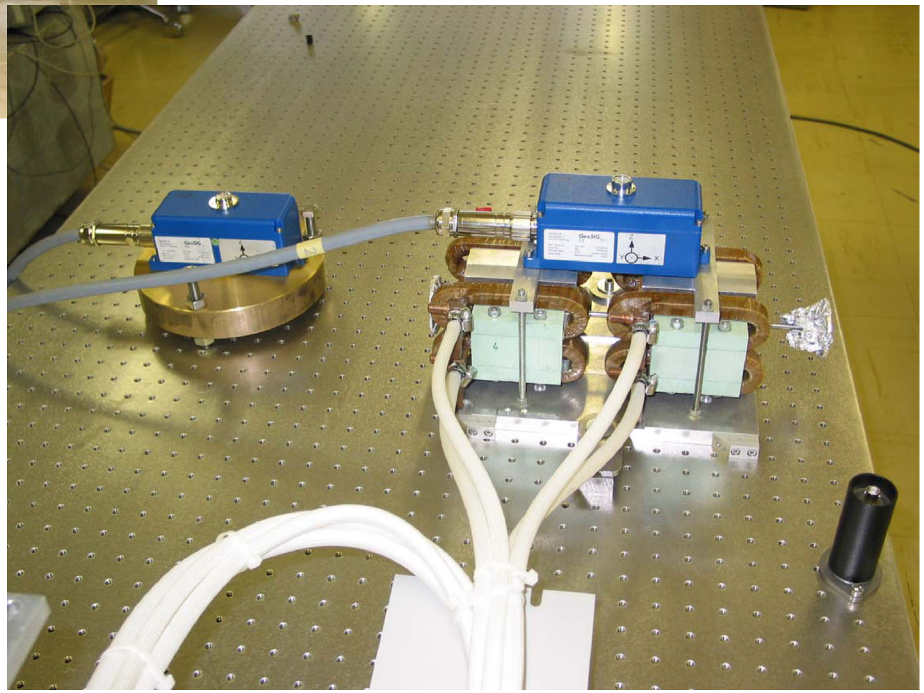
STACIS 2000 (TMC)

Rubber damping

Active feedback circuit on ground motion

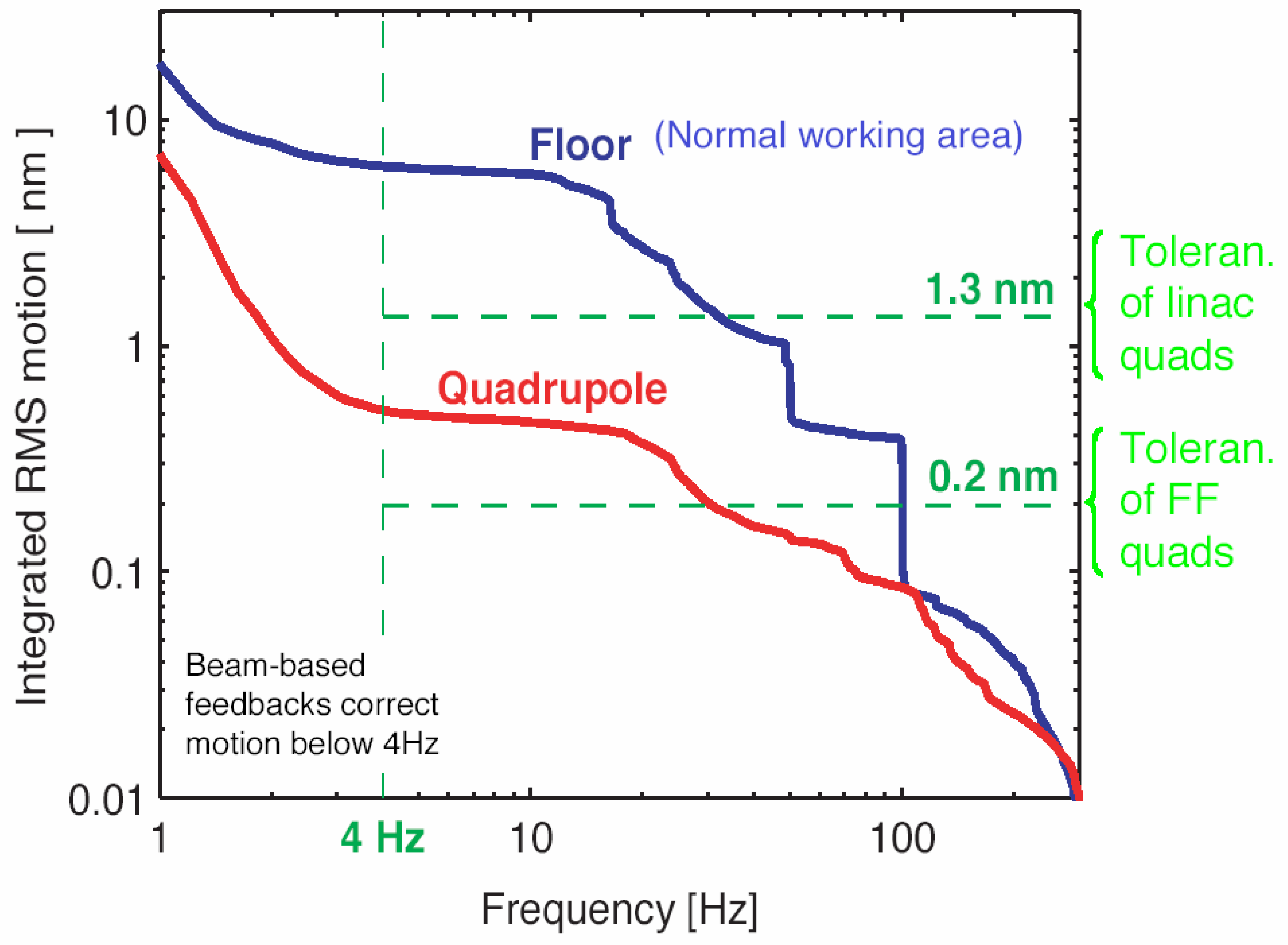
Measure ground motion

Actuators: piezos



Rigid system

Stabilization of the CLIC prototype quadrupole



553 x 5 nm TESLA ; 235 x 3 NLC ; 60 x 0,7 nm CLIC

1,3 nm uncorrelated above 4 Hz in Linac
4 nm H - 0,2 nm V above 15 Hz in FF quads

In lab 5 nm above 4 Hz, acceptable for tests
STACIS 2000 from TMC industry in US, with active piezoelectric (geophone)
Resolution above 4 Hz 0.28 nm
Accuracy 19 % for 19 nm

043 V 0.79 H 4.29 L above 4 Hz (Ground 3 to 6)
Water cooling effect

70 % of L steady with stabilization system

Design of supports to be done still.
Check in NC case if performance are maintained
In SC case piezoelectric feet work in principle

Stabilisation studies from LAPP/ESIA A.Jeremie.

The LAPP/ESIA group will present the status of the work done within the framework of the ELAN project. **Fine-element simulations of the final focus stabilization study** will be presented, as well as the latest measurements on the recently installed test bench.

Vibration measurements 0.033 Hz to 50 Hz Guralp
4 Hz to 315 Hz Normal geophone
Putting a lab together

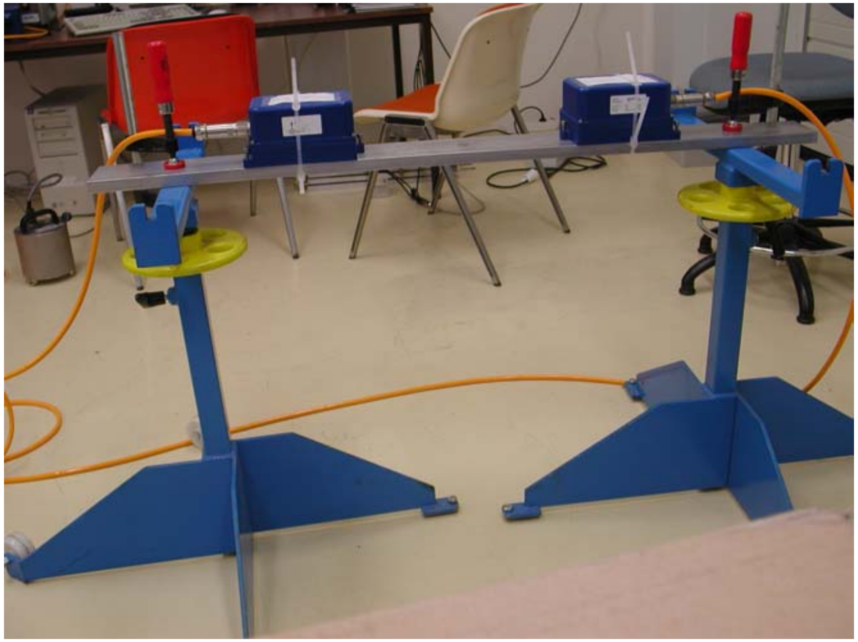
Feedback loops
Sensor with excitation loudspeaker
Matlab simulation of vibration stabilization loop

Mechanical Simulations
For the FF QUADS 3.5 m - 35 mm outside diameter
Embedded on one side -> low frequency mode

Calculate intrinsic modes
Validate the feedback loop with mock-up
Characterize ground motion in Annecy
(adapted sensors and actuators)

Vibration measurements

Test bench at LAPP



Andrea JEREMIE
Frascati, May 4-6 2004

RF Deflectors for Combiner and Damping Rings
F.Marcellini

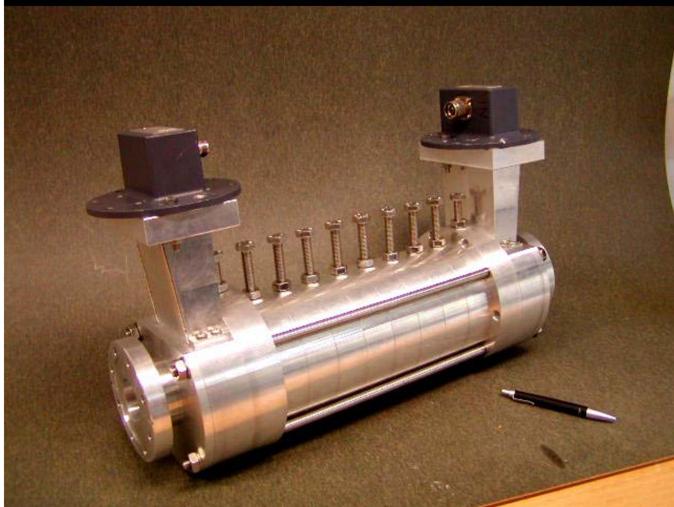
A couple of RF Deflectors has already been designed, constructed and tested in the CTF3 preliminary phase. Study and design of RF deflectors for the CTF3/CLIC Combiner Ring and Delay Loop and for the TESLA Damping Ring are presented. The electromagnetic characteristics of both **standing wave and traveling wave structures** are examined. Some issues related to the beam dynamics in the Combiner Ring and in the Delay Loop, considering the **beam loading** effect in the deflectors, are analyzed. Concerning the TESLA Damping Ring, different injection/extraction schemes with 2, 4 or 6 RF deflector groups feeded by 2 or 3 different RF frequencies, are considered.

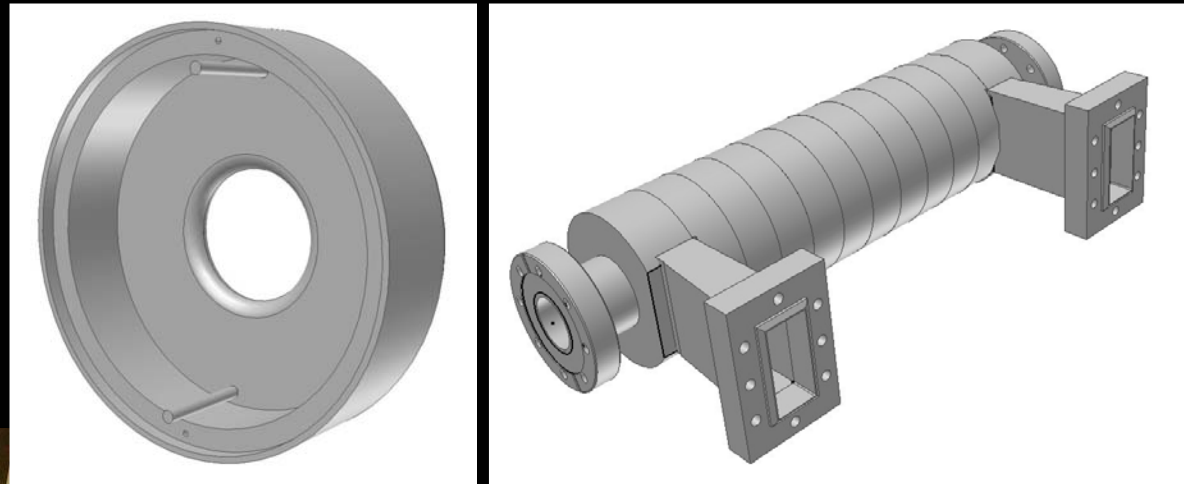
CTF3 traveling wave
Simulations w. HFSS and MAFIA -> deflecting modes
Mode Measurements of 10 cells shortened structure (couplers not taken into account)
Low charge demo in CTF3 preliminary phase

Special design for the delay loop
Suppress reflection and improve efficiency

TESLA DR similar to CTF CR in principle

ALUMINIUM PROTOTYPE





MECHANICAL DRAWING

FABRICATION STEPS