Summary of activities of CLIC Study Team for 2004

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Purpose of presentation – to give you brief overview (just a flavour) of all different subjects studied in 2004 by the CLIC team without giving too much detail

This summary will be published as CLIC Note 625 in a more detailed form – N.B. numbers quoted are 2004 numbers

In particular I will :

- Review progress made CLIC Machine Studies (CMS)
- Give results obtained with test facilities – mostly CTF3
- Outline initiatives taken to expand CLIC collaboration to obtain additional resources
- Mention CARE and EUROTeV activities within EU FP6

Given large amount of work accomplished by CLIC Team during this 12-month period – faced with 2 options for this presentation

- Either to choose some particular high-lights and give detailed results with plots and photos
- Or to provide an overall picture by trying to cover all activities with only a very brief statement of what we have achieved
- Chosen latter because I believe once a year - important to review and make public - full extent and quality of our achievements

Comment

- If you see errors please let me know after meeting so I can correct CLIC Note before it goes out

Damping ring

- Present DR design based on compact TME (Theoretical Minimum Emittance) arc cells with short-period wigglers in two long straight FODO sections - energy 2.42 GeV - ring circum 360 m. - rf 2.6 MV.

- Optimisation of ring params. takes into account effects of SR and IBS
  Present design does not, however, quite meet design goals :
  Achieved at least on paper $\gamma\varepsilon x$ = 570 nm and $\gamma\varepsilon y$ = 6.2 nm
  To be compared to nominal values $\gamma\varepsilon x$ = 450nm and $\gamma\varepsilon y$ = 3 nm
  Long. emit. of 5100 eVm is close to design value of 4800 eVm.

- Studies of alignment tolerances and beam-based tuning have started.

- Shown - present design can accommodate anticipated changes in particles/bunch from 4 to 3 $\times 10^9$, and bunch spacing from 0.66 to 0.33 ns.

- BUT still does not quite meet design goals - concerns that design based on TME cells and wigglers with state-of-the-art magnets will never produce desired emittances - either target emittances have to be revised or an alternative (more exotic) approach has to be found.

Main linac beam dynamics

- Integrated simulations of main linac and BDS used to study lum. loss from particles with energy errors falling outside bandwidth of BDS.

- Energy errors result from phase and amplitude errors in main linac, and these come directly from phase and intensity errors of drive beam.

- Found - phase and amplitude tolerances in main linac are determined by limited bandwidth of collimation system of BDS - it's 70% larger for FF alone. Implied tolerance on drive-beam phase jitter is about 0.15 degrees at 30 GHz – this needs longitudinal feedback system.
  Developed first concept using "short-cut path" in drive-beam turn-around loops to correct measured incoming phase jitter on same pulse.

- Re-optimization of collimation system would very likely loosen this very tight tolerance but would almost certainly involve an increase in length.

- A study of possible sources of phase and intensity errors is on-going.

Accelerating structure design

- New HDS design has new geometry which includes fully-profiled rf surfaces optimized to minimize surface fields, and hybrid damping using both iris slots and radial waveguides.
- Slotted irises allow a simple structure fabrication in quadrants with no rf currents across joints.
- New structure constructed from two different metals, molybdenum used for tips of irises and copper zirconium used for cavity walls.
- New structure-optimization procedure used to simultaneously balance surface fields, power flow, short and long-range transverse wakefields, rf-to-beam efficiency and ratio of luminosity to input power.
- This procedure is based on interpolation of structure parameters and allows millions of structures to be analyzed taking into account full and complex interplay between rf and beam dynamics parameters.

Accelerating structure design - continued

- For 30 GHz structure with loaded accelerating gradient of 150 MV/m this procedure led (in 2004) to bunch spacing of eight rf cycles, rf-to-beam efficiency of 31 %, total rf pulse length of 42 ns for 125 bunches, and a bunch population of 3.1×10^9. The optimized structure at that time had a length of 263 mm (158 cells) and phase advance per cell of 60 degrees.

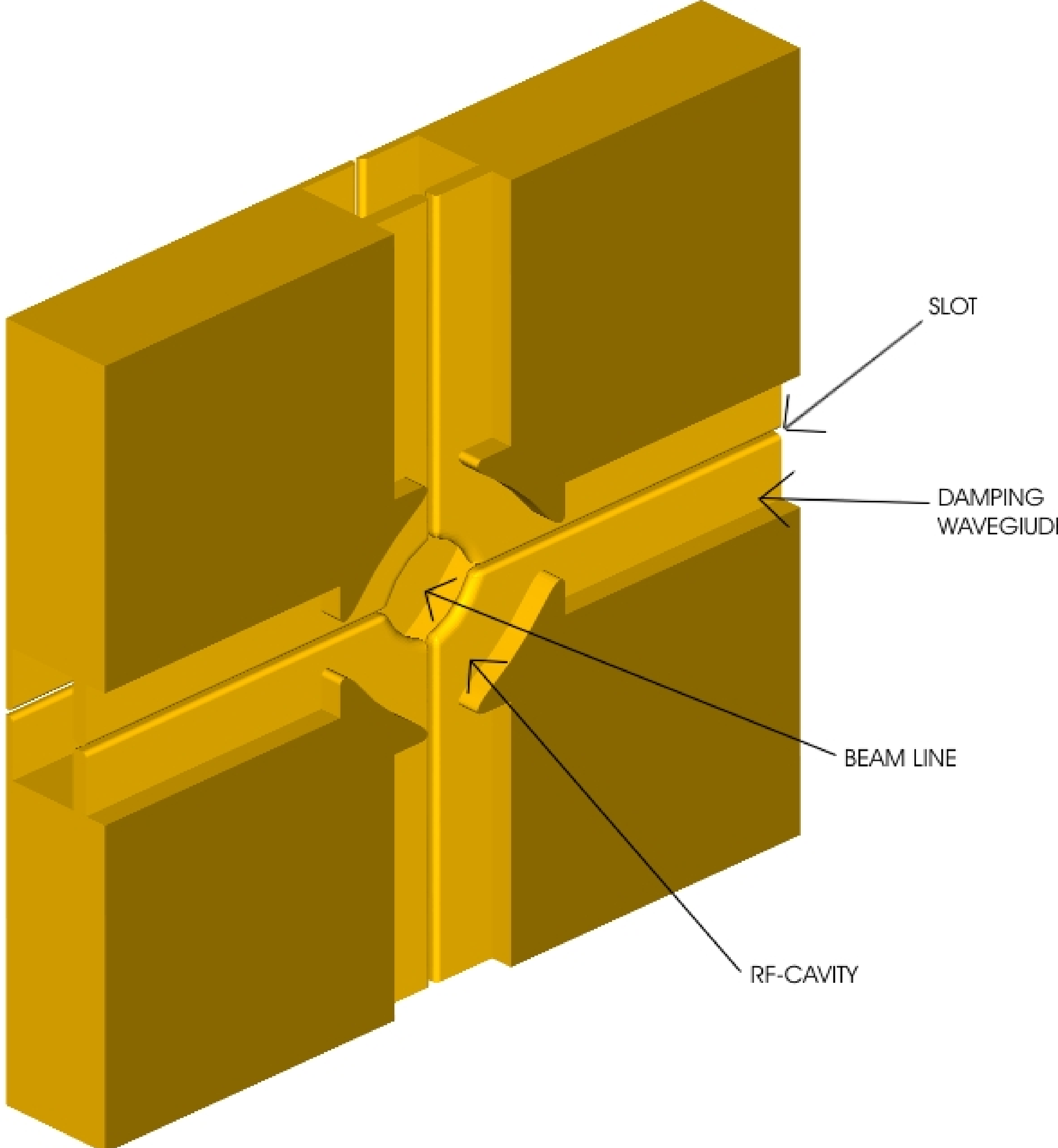
- This novel accelerating structure design and assembly gives a number of advantages compared to traditional structures in which individual cells are brazed together - these include (i) reduction of the number of pieces per structure to four and a significant decrease in surface area to be machined (ii) free choice of joining technique because there are no rf currents between quadrants (iii) no water/vacuum joints nor brazed-on cooling channels (iv) excellent vacuum pumping and (v) the slots can be as narrow as needed and can be profiled.

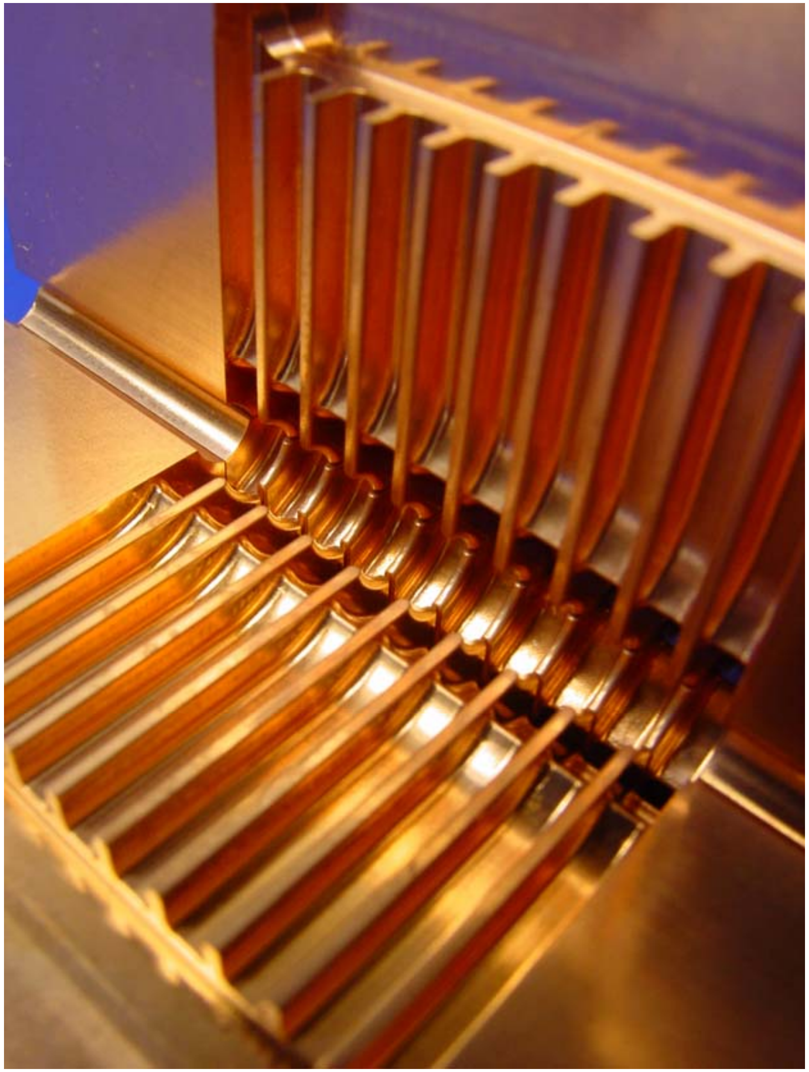
Accelerating structure design - continued

- These structure developments have in part made possible by purchase and installation at CERN of GdfidL.
- Code runs on cluster of 20 parallel processors with 40 GB RAM, can run very large jobs (300-500 million mesh points).
- Now primary tool for wakefield calculations and, along with HFSS, is main code used in structure design.

- Largest job to date 980 Million mesh points !!!

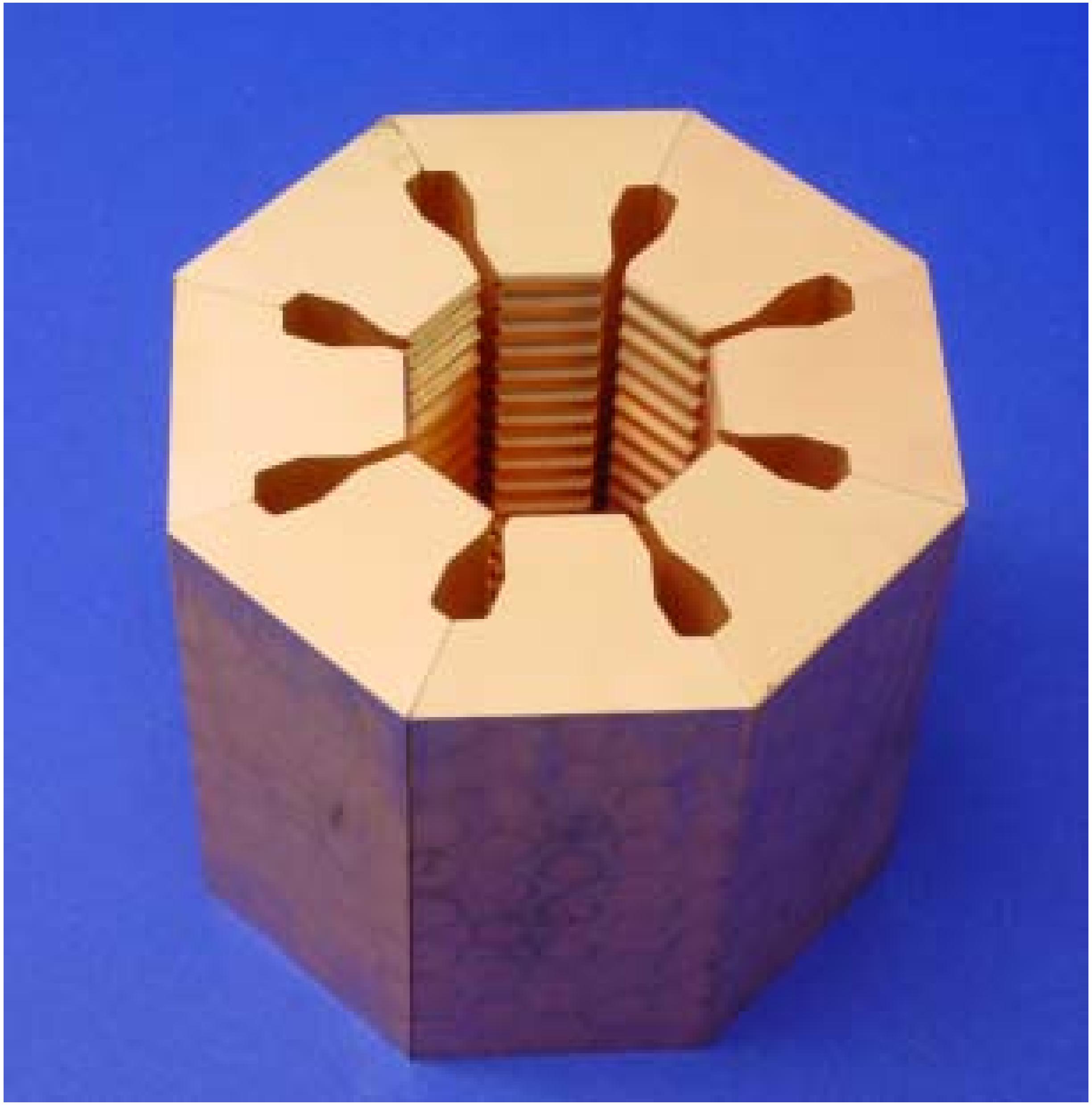
(something we did for LHC)


SLOT
DAMPING
WAVEGIUDE
BEAM LINE
RF-CAVITY

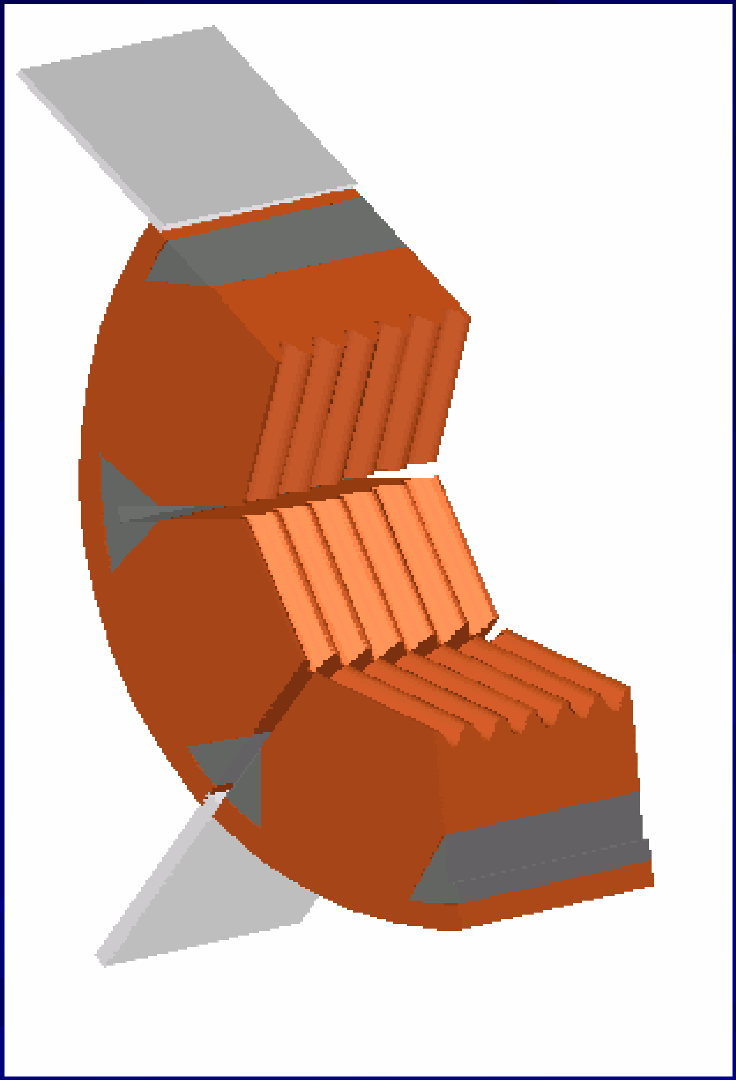


CLIC Power Extraction and Transfer Structures (PETS)

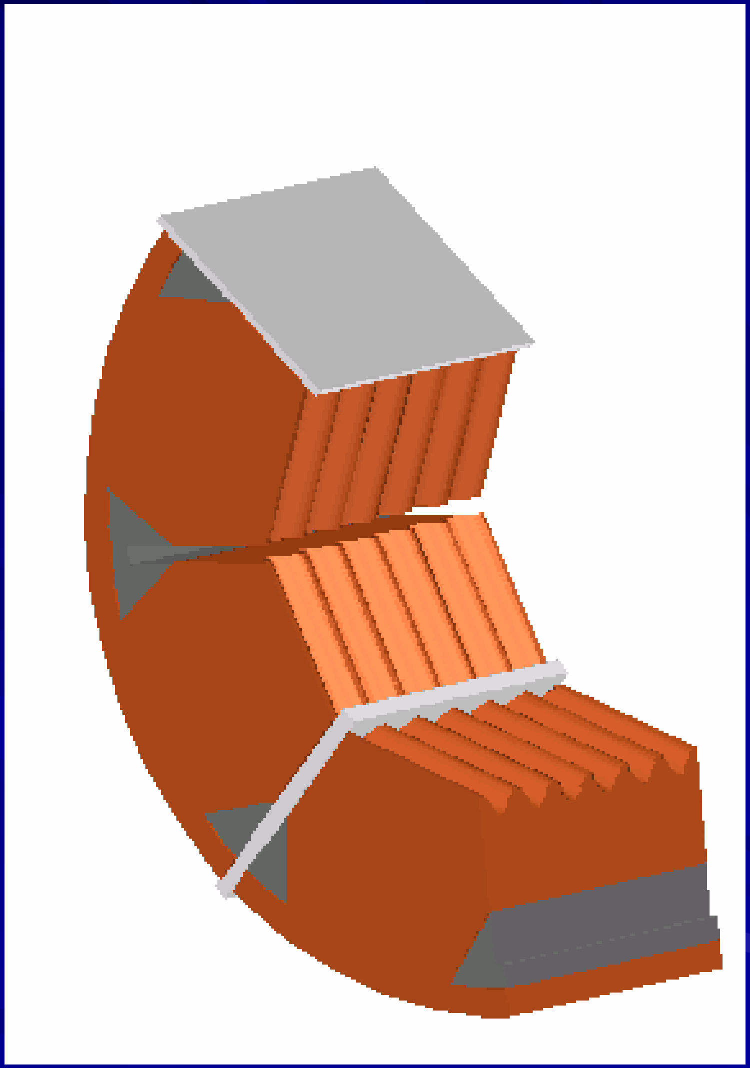
- Good progress made with design of CLIC PETS - designed to produce 800 MW from 164 A drive beam.
- Eight radial 1.3 mm wide slots cutting PETS all the way along its length, channel out disruptive HOM energy to SiC loads.
- Main body has octagonal x-section (~22.5 mm diameter) composed of 8 identical racks with shallow (~1.3 mm deep) sinus-type corrugations with 140 degrees phase advance per period (3.889 mm).
- Eight HOM damping slots placed symmetrically around circumference.
- Power can be turned OFF or just attenuated by inserting thin (~1.6mm) corrugated metal wedges into PETS through four of eight damping slots. These wedges detune synchronous mode frequency and prevent coherent build up of excited field.



Power 'on'

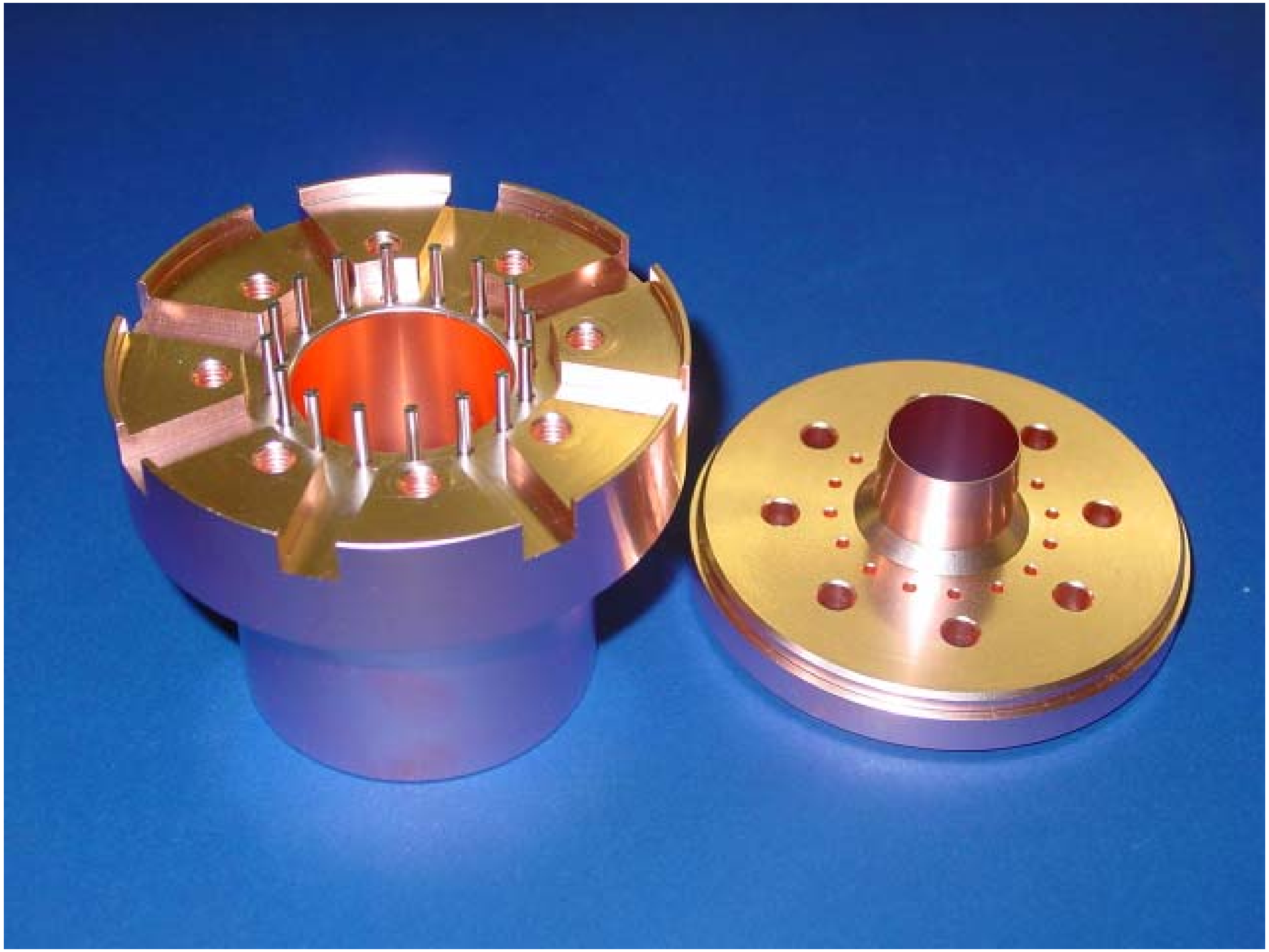


Power 'off'



CLIC Power Extraction and Transfer Structures (PETS) - continued

- A new broad-band 8-channel quasi-optical extraction coupler based on multi-mode mixing approach designed to couple out power from CLIC PETS with efficiency of 98%.
- Coupler consists of three parts, a mode launcher, a diffractor section, and a combiner/extraction section; these units provide an efficient step-by-step conversion of energy from E01 mode of over-moded circular waveguide to fundamental H10 mode of standard rectangular waveguides.
- A low power prototype been built and rf tested and shown to be in good agreement with HFSS simulations.



Material test facilities

- The two new experimental facilities, "dc-spark test stand" and "laser pulsed-surface-heating test stand" - developed for CLIC by TS became fully operational in 2004. These facilities will speed-up technical development in areas such as materials studies and preparation techniques.

- "dc-spark test stand" used to investigate electrical breakdown behavior of Mo, W and Cu in ultra-high vacuum. Found that maximum stable field increased as function of number of breakdown events for W and Mo. In contrast, no systematic increase observed for Cu.

- The highest values obtained were typically 500 MV/m for W, 350 MV/m for Mo and only 180 MV/m for Cu. These results are qualitatively in agreement with RF breakdown experiments performed on prototype 30 GHz accelerating structures.

Material test facilities - continued

- For CLIC main linac - amplitude of thermal cycling due to rf surface heating of ~ fifty degrees, and expected lifetime of linac is estimated at ~ 10^{11} pulses. The laser test stand simulates this thermo-mechanical fatigue behaviour. Tests made on Cu and CuZr alloy in vacuum on an area of 0.5 mm2 at repetition rate of 25 Hz.
- Purpose of experiment - to produce high-stress/low-cycle data which can be extrapolated to very large number of cycles required for CLIC. The surface of samples irradiated with 40 ns pulses of UV light (308 nm) using an excimer laser. Number of laser shots needed to create a break-up of surface measured as a function of peak surface ΔT. Surface break-up was characterized by average surface roughness.
- Energy densities applied - corresponded to surface temperature increases of 90 and 240 K respectively. Observations by Scanning Electron Microscope showed that the surface damage obtained was similar to that produced in RF tests.
- Confirmed that CuZr withstands much larger number of cycles than Cu for same peak surface ΔT.

Material test facilities – JINR / Dubna

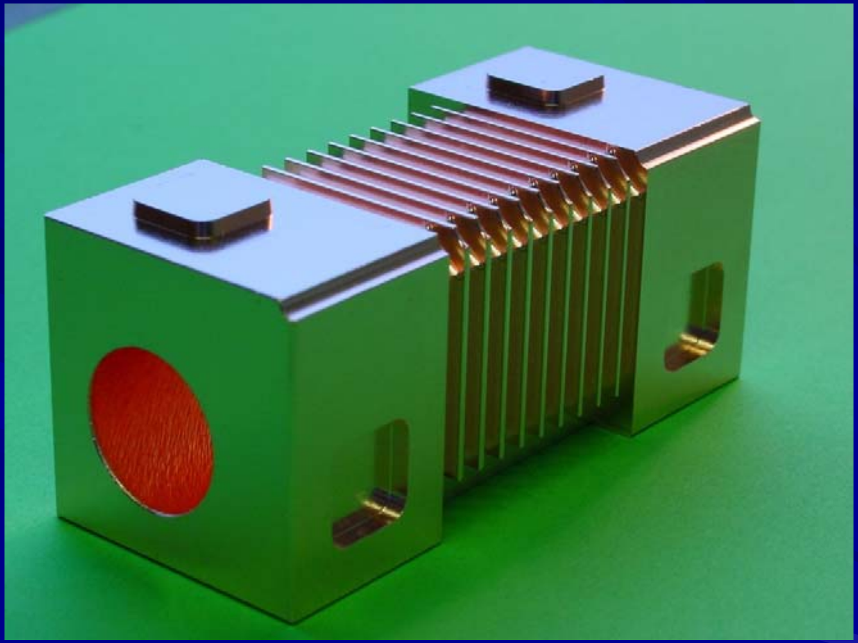
- Collaboration between CERN, JINR (Dubna) and IAP (Nizhny Novgorod) to provide pulsed-surface-heating fatigue data again delayed this year by need to replace and improve many parts of JINR FEM. This experiment now running more than three years late but latest results are encouraging and new schedule foresees results by mid-2005.

Cracks in high H-field region

Material, machining and metrology studies

- TS investigating fabrication and machining of bimetallic HDS structures. Two bars of CuZr with a Mo core ordered from Finnish firm METSO - bars made by HIP (Hot Isostatic Pressing).

- Two machining techniques being studied, high-speed 3D milling and 3D EDM. Short prototype piece of Cu HDS successfully milled to accuracy of +/-5 μm by Finnish firm IMTEC and longer piece ordered from German firm Dahmen.

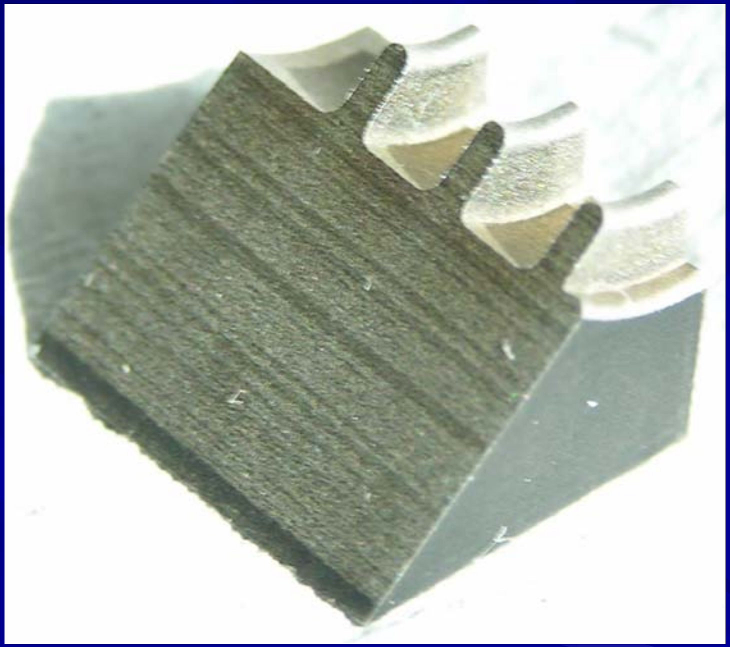


Material, machining and metrology studies - contd

- TS are collaborating with "Ecole d'Ingénieurs de Geneve" to study problems of EDM machining of Mo.

- A short low-accuracy piece of HDS made entirely from Mo produced to demonstrate capability of technique and to see what surface quality could be obtained.

- Piece revealed presence of micro-cracks - believed these can be eliminated by more suitable choice of machining parameters.



Beam parameters

- Recent structure developments opened up possibility of modification of CLIC main parameters - no firm decisions were taken in 2004 but new design of HDS structure would make it possible to reduce bunch spacing in main linac from 20 to 8 rf cycles and to reduce overall rf pulse length by about half to ~ 70 ns.
- Implications of these eventual parameter changes are still being studied – will almost certainly lead to a new set of CLIC parameters being issued sometime ~ mid-2005.

Luminosity at IP

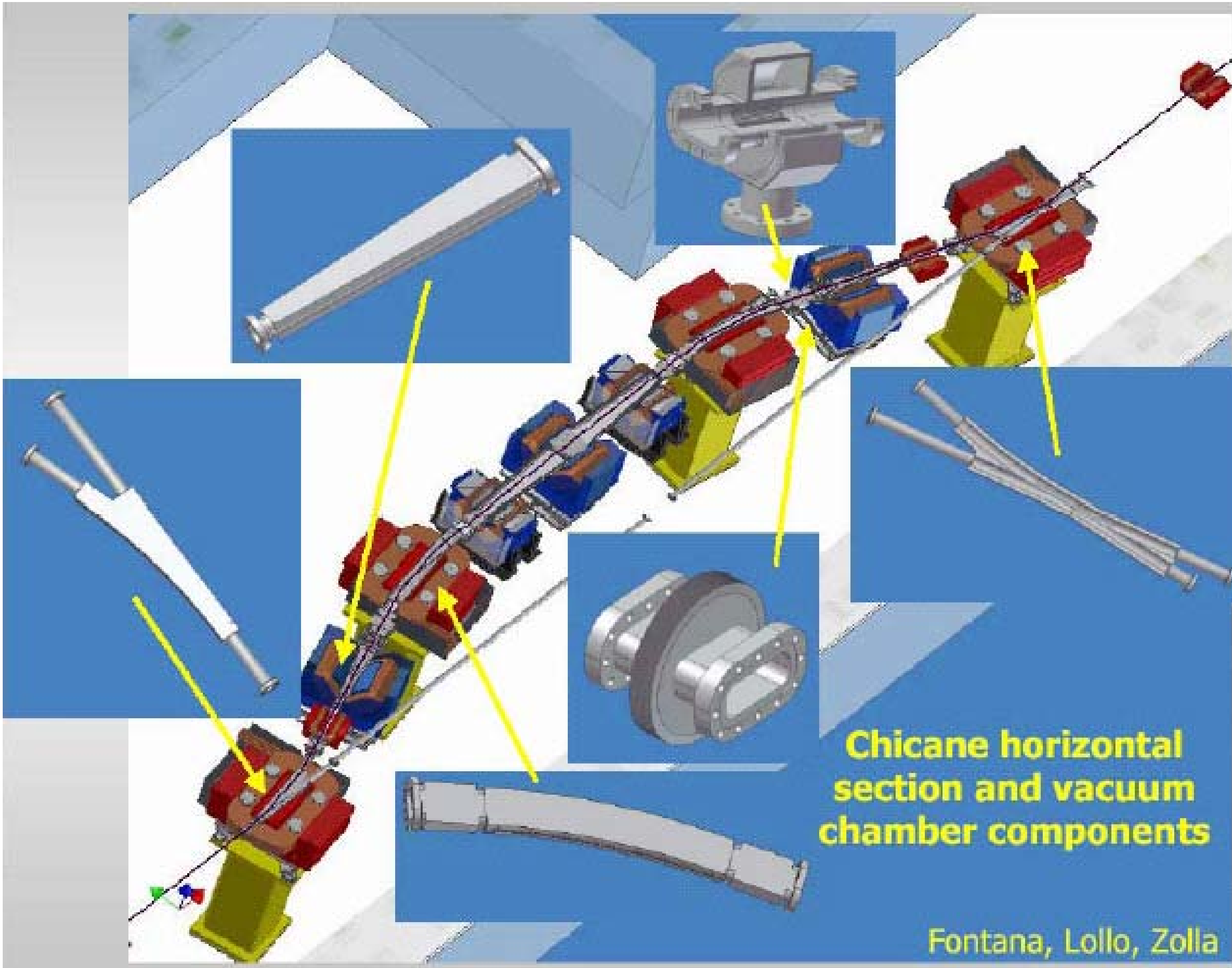
- CLIC collision parameters, such as collision offset, collision angle and longitudinal position of beam waists, need to be carefully tuned in order to maximize luminosity - needs a fast luminosity signal.
- Since strong CLIC beam-beam interaction gives rise to emission of few MWs of beamstrahlung and creates very large numbers of coherent pairs (~10^9 per bunch crossing at 3 TeV) - good candidates.
- Simulations were done to see how effective these signals were.
- To get realistic bunch shapes at IP - beam transport through main linac and BDS was simulated with PLACET - beams then collided pair-wise using GUINEA-PIG.
- Found that by performing an offset scan in order to minimize total beamstrahlung or coherent pair power about 99.6% of basic luminosity obtained for both vertical offsets and crossing angles.
- For optimization of long. position of beam waist value was 98.8%.

CLIC Test Facility (CTF3) Studies

- Large fraction of CLIC resources devoted again in 2004 to CTF3.
- Appropriate at this moment to mention - this facility is being built in collaboration with Ankara University, BINP, CEA (Dapnia), CIEMAT (Spain), INFN (Frascati), IN2P3 (LAL), RAL, SLAC, the University of Uppsala, the North-Western University of Illinois and Finnish Industry.
- Following chapters summarize various CTF3 activities in 2004.

CTF3 linac

- During winter shut-down all support girders and four more SICA (Slotted Iris Constant Aperture) structures installed in linac. This brought total number of SICA structures to 10.
- In addition new so-called PETS line installed parallel to main linac. (more detail given later in section on 30 GHz power generation).
- In second half of year, Frascati team installed variable R56 bunch stretcher/compressor magnetic chicane (4 dipoles and 7 quadrupoles) together with its vacuum chamber and BD equipment at end of linac.
- This bunch stretcher/compressor will lengthen short linac bunches to ~2 mm to avoid CSR in delay loop, but will enable very short bunches to be produced when required for CSR studies.
- To commission this line, vacuum tube along whole linac installed and beam line terminated with spectrometer. A particularly interesting part of BD equipment was 3 GHz transversely deflecting rf cavity and its associated BPM which were used for bunch length measurement.


Chicane horizontal section and vacuum chamber components
Fontana, Lollo, Zolla

CTF3 beam diagnostic equipment

- A comprehensive beam diagnostic system has either been developed, or adapted, to special beam requirements of CTF3.
- Use of SEM-grids in the spectrometer lines to get time-resolved measurements of position/energy variations within bunch train at high charge did not work and further attempts to use SEM-grids will probably be abandoned.
- More success was obtained with two water-cooled segmented dumps consisting of 24 (2mm thick) tungsten plates spaced by ~ 1mm which were installed in the spectrometer lines on girders 4 and 7. Useful energy spread distributions were obtained with an energy spread resolution of ~ 1%
- Encouraging results also obtained using a beam splitter and 32-channel segmented photomultiplier in optical line of CT spectrometer to view OTR light produced by an aluminium screen with a gated CCD camera. With 0.8mm segments, and a distance between segments of 1mm, the system has resolution of 2.8mm (~ 1ns).

Beam loss monitors – NW University of Illinois

- North-Western University of Illinois hoping to get resources to build radiation-hard beam-loss monitoring system for future CLEX TBL. As part of their development programme have installed time-resolved beam-loss monitoring system on CTF3 linac and around CTF3 PETS.
- Idea <u>was</u> to measure beam loss with small ionization chambers 'SIC chambers' with 10mm diameter collectors - monitors however did not work at all as expected - both 'applied voltage' and 'gas content' (argon, helium and vacuum) had little or no effect.
- Chambers found to be sensitive to both charged particles and low energy X-rays (<100keV) - turned out X-ray signal (via photo-electric effect directly on electrodes) was dominant signal.
- Since this signal depends on beam loss characteristics (position, intensity and energy) - very difficult to get an absolute calibration of device. -level of beam loss therefore estimated by normalizing SIC signals to signals from Faraday cups installed nearby - not however entirely satisfactory since FC's only measure charged particles.

Beam loss monitors - continued

- These "secondary emission" monitors installed at different positions along linac (four per girder) to obtain longitudinal beam-loss mapping along machine.
- System able to measure beam loss current of 1mA corresponding to ~0.03% of nominal beam current (3.5A) with time resolution of 2ms.
- During normal beam operation, this system measured an overall beam loss of 2-5% of total beam current - number confirmed by beam current measurements on linac.
- Further along linac, as beam energy increases, level of losses found to decrease - on girders 12 and 13 for example, no beam loss was measured by this SIC system.
- For extremely small losses North-Western built much more sensitive device - this new monitor measures Cherenkov light produced by charged particles in air with a photomultiplier - can detect ~ 100μA (~10^{-5} of total beam current).

CTF3 operation

- There were two runs in 2004 - first from 7 June–18 July, and second from 13 Sept–15 Nov. with total of 14 weeks of beam operation.
- First run was used to commission additional linac modules (four accelerating structures), and to test 30 GHz power production with short PETS structure.
- Second run used to commission (i) rest of linac, (ii) chicane and final instrumentation section, and (iii) to produce 30 GHz power with full-length PETS and high power transfer line to CTF2.
- During operation main problems came from gun current instabilities, inadequate cooling water temperature regulation, beam diagnostic screens, charging power supply faults in new type of modulator, and broken diodes.

CTF3 operation - continued

- Operation greatly facilitated by implementation of time-adjusted generic sampler data-acquisition software for BPMs, WCMs, the RF phase and amplitude signals, BLMs and segmented dumps.
- Also MAD model found to be rather accurate in predicting optical behaviour of line which speeded-up general progress.
- An automatic trajectory correction scheme was tested and found to work very well but was not used regularly because measurement very long.
- A new program to optimize flatness of compressed rf pulses in linac by iteration proved to be very useful and was put to good use.
- For CERN 50th anniversary Open Day more than thousand visitors visited CTF3 - some queuing for more than an hour – lot's of interest.

Preparation for the next CTF3 stages

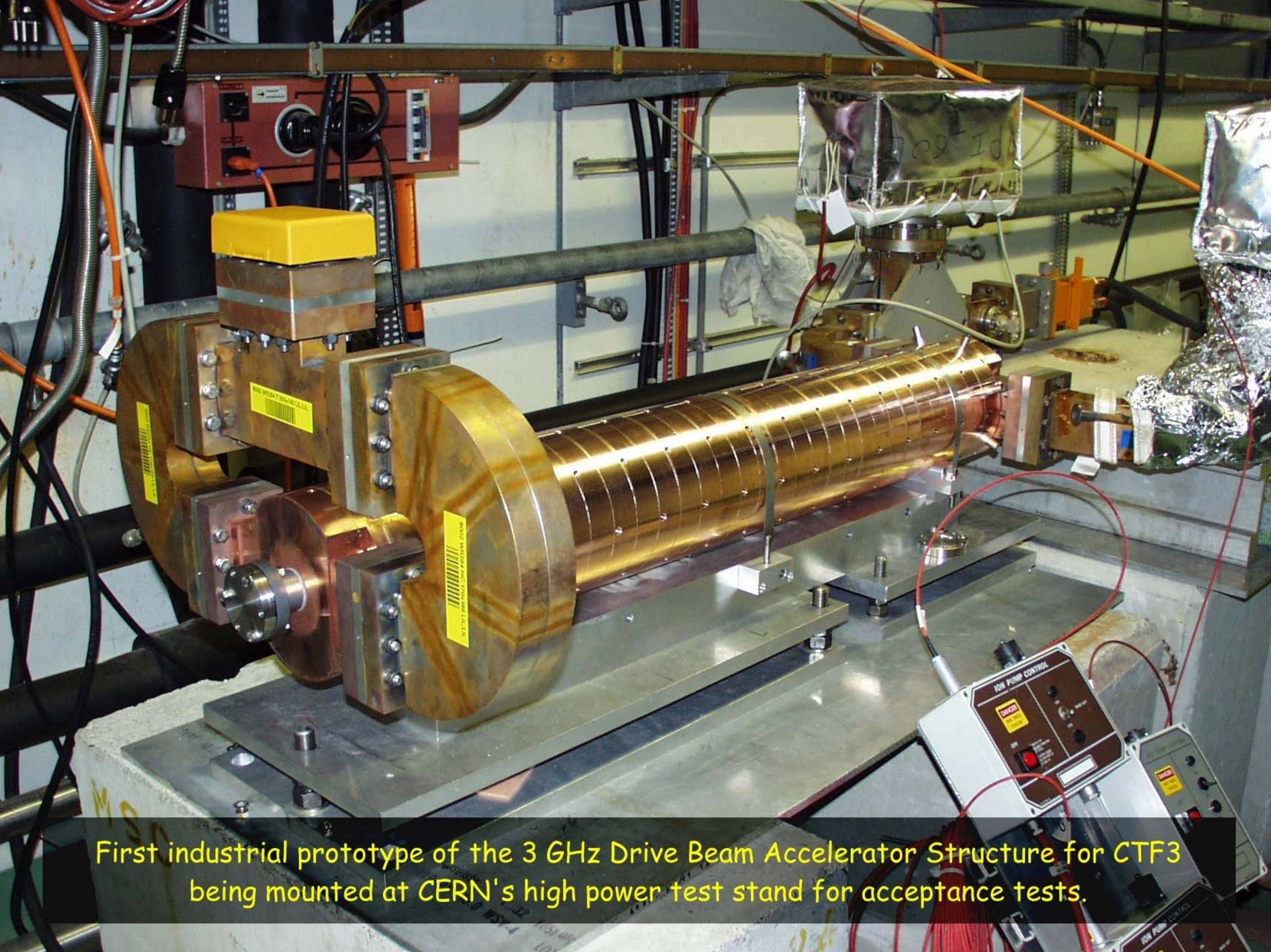
- Good progress was made in parallel with the 2004 installation and test programme, to design, build and order equipment in preparation for next installation phases.
- Following transparencies summarize this preparatory work.

Preparation – linac structures, waveguides and loads

- All SICA structures for drive beam linac now delivered to CERN.
- All WG's and pumping ports for rf power distribution system ordered.

- Following delays in development of SiC loads, order placed for 25 high-power (50 MW peak) rf water loads, for operation with 4.5 microsec pulses at repetition frequency of 100 Hz.

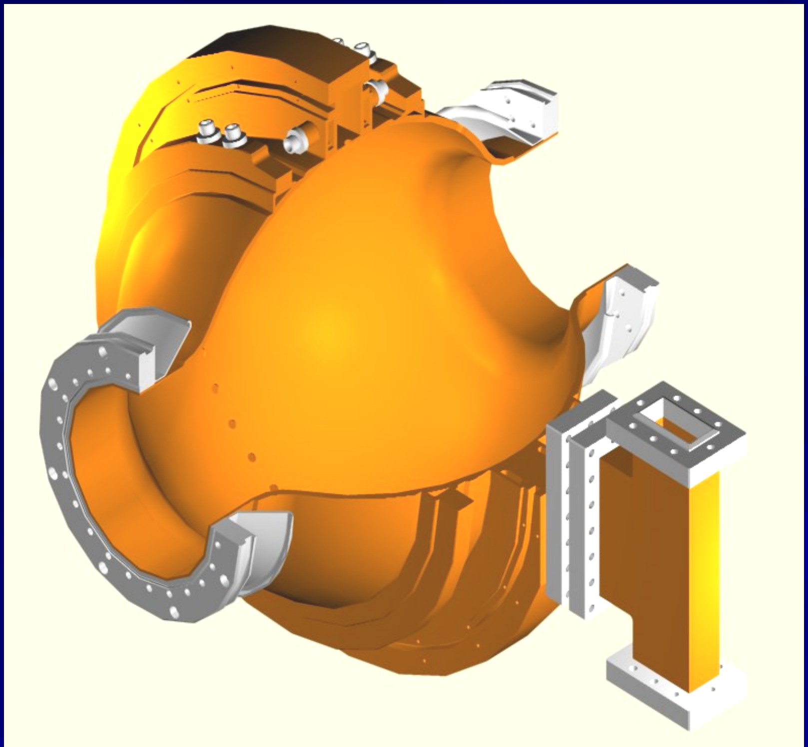
- Development work on SiC loads will however continue.
- First prototype load consisting of two SiC absorber plates electrolytically-bonded to copper waveguide tested up to 35 MW and 2 μs - very promising first result (nominal requirement - 60 MW and 1.5μs) - more work required.
- A second water-cooled prototype consisting of two 20 cm long profiled SiC slabs attached to the copper waveguide by a low-temperature vacuum soldering process at ~230C is currently under test



First industrial prototype of the 3 GHz Drive Beam Accelerator Structure for CTF3
being mounted at CERN's high power test stand for acceptance tests.

Preparation – rf power system

- Six new Barrel Open Cavity (BOC) pulse compression systems been manufactured to complement and partly replace existing LIPS systems.
- These BOC compressors have unloaded Q's of ~ 187000 and operate in TM 10, 1, 1 whispering gallery mode - equipped with a mechanical detuning system to enable operation without compression if required, and a SiC absorber to remove unwanted resonances.
- Of six BOC systems built - one installed and successfully operated in CTF3 in 2004 -three are foreseen for CTF3 linac, two for CLEX probe beam - leaving one spare.



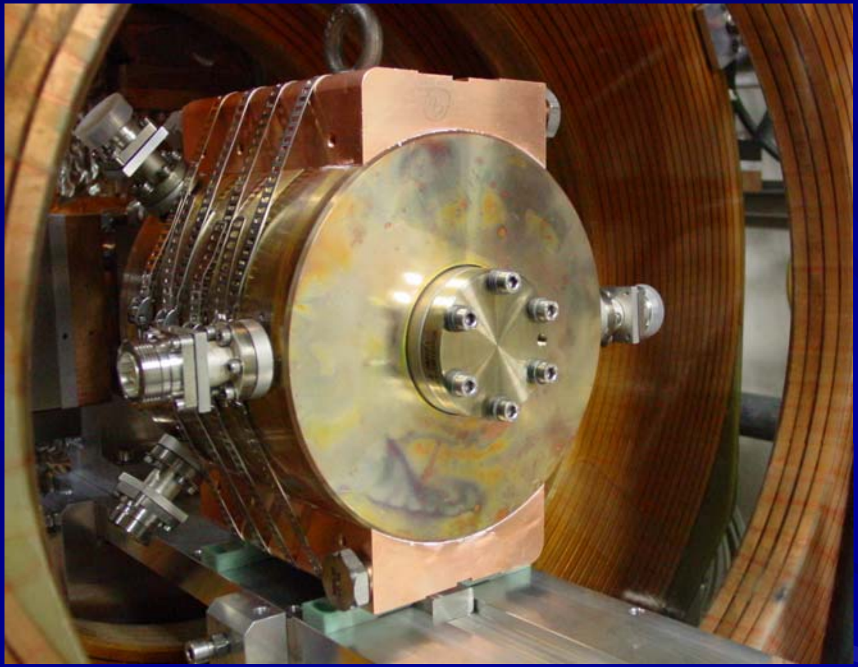

BOC # 01

Preparation – sub harmonic bunching system

- All elements of 1.5 GHz sub-harmonic bunching system either constructed or ordered in 2004. This wide-band (10%) bunching system foreseen to be installed in Spring 2005.

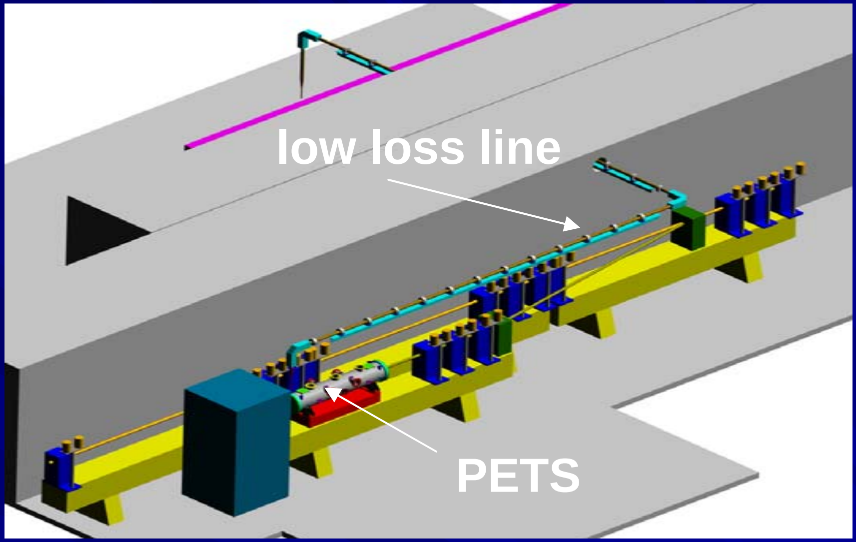
- Will allow phase of bunching voltage to be changed very quickly (typically 10-20 ns) so that bunches of 140 ns-long bunch trains can be placed alternatively in even and odd RF buckets.

- The three 6-cell large-aperture TW structures been fabricated, and the three 40 kW TWT's and power supplies been ordered.

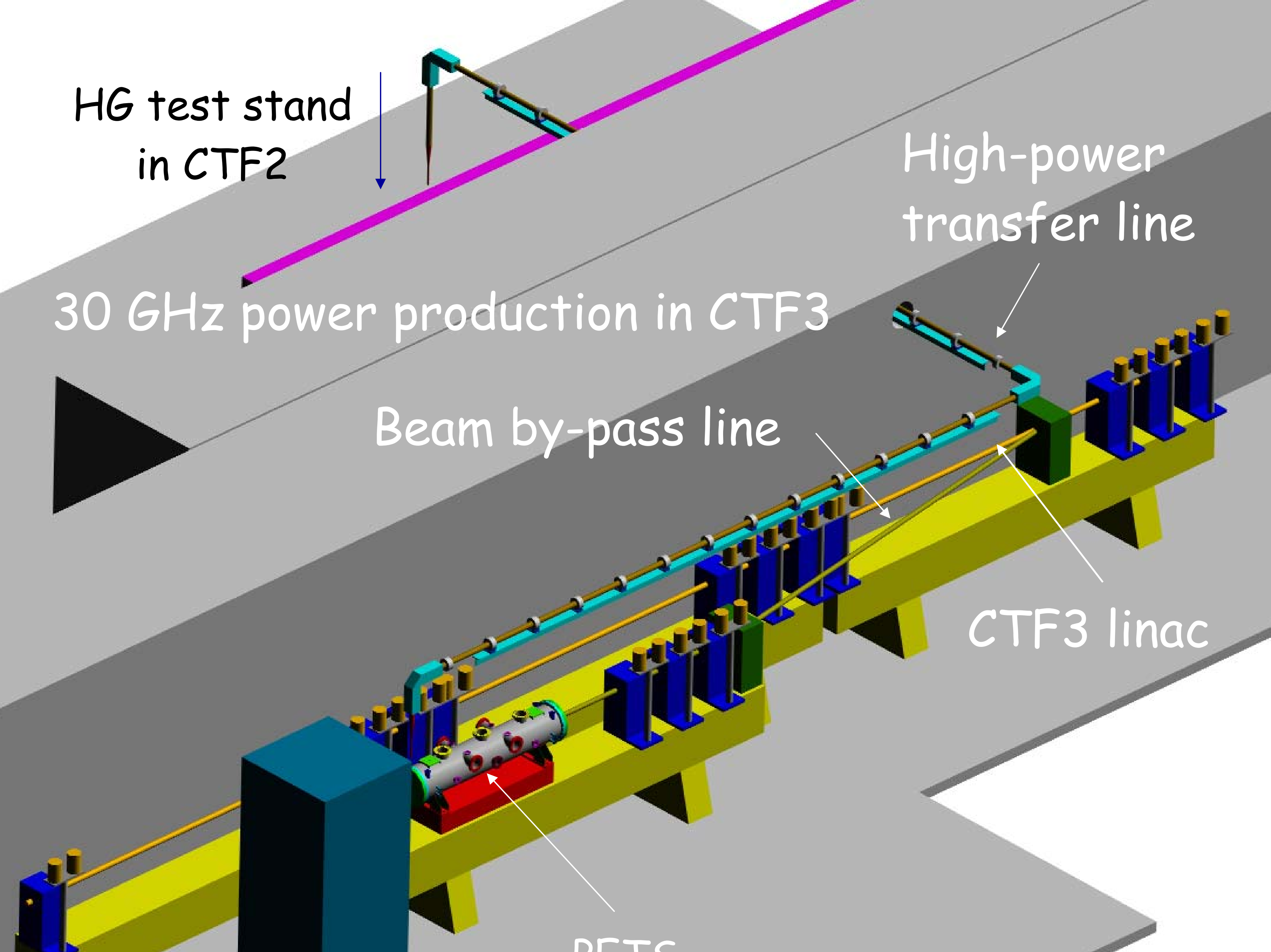


Preparation – 30 GHz power source

- Special PETS line built alongside CTF3 linac in by-pass configuration to use 5A beam at ~60 MeV for 30 GHz power production.
- The 400-cell copper PETS structure made from three segments with 9, 6.7 and 9 mm diameter apertures to follow waist of drive beam.



- 30 GHz power generated transferred to CTF2 via low-loss line.
- This line built by Russian firm GYCOM - basically circular waveguide operating in TE01 mode - consists of mode-converters, pumping ports and mitred-bends and its mode of operation is quasi-optical.
- For 2004 run power sent to load - will eventually be used for HG testing.


HG test stand
in CTF2
High-power
transfer line
30 GHz power production in CTF3
Beam by-pass line
CTF3 linac

30 GHz power source - continued

- By end of run, peak power of 53 MW for 73 ns produced in CTF2 - enough power to generate a gradient of 150 MV/m for nominal new CLIC pulse length of ~70 ns in Mo-iris structure foreseen to be tested in first run of 2005
- Short period of CTF3 operation dedicated to making phase jump of 18 degrees in 3 GHz bunch train to obtain 180 degree phase jump in 30 GHz power pulse opening way to eventual use of SLED-like rf pulse compressor
- Peak power generated in this mode of operation limited by conditioning time of PETS to about 16 MW – hope to do better in 2005.

Construction of CTF3 photo-injector

- Laser and photocathode activities in 2004 focused on construction of CTF3 drive-beam PI - work being carried out within FP6 Program of EU as part of CARE PHIN JRA.
- Laser being developed and built by RAL, RF gun by LAL, and PC's, installation and commissioning by CERN.
- JRA also aims to improve performance of present cesium telluride photocathodes and to develop new photocathode materials.
- Specification for 3 GHz RF gun is for electron beam of 2300 pulses of 2.3 nC with emittance of 20π.mm.mrad and vacuum at PC of 10^{-10} mbar. Construction of cold model of this gun in progress.
- Design of main parts of laser been completed - oscillator and preampli which are capable of delivering CW train of 10 W at 1.5 GHz being built by Austrian firm - optical pumping of amplifiers will be made with laser diodes with Quasi CW total power greater than 35 kW.

CLIC accelerated R&D programme

- Reminder - CLIC study team showed - with extension to foreseen facilities, all CLIC-technology-related feasibility issues could be demonstrated in CTF3 BUT with resources foreseen - could not be completed before 2014 - this time frame considered unacceptable by management and asked to study accelerated programme to demonstrate key issues before 2010.
- This was completed and preliminary proposal made by DG designate to council in Dec 2003 and accelerated CLIC R&D programme approved by Council in March 2004.
- Following this decision, DG organized special collaboration meeting on 19th May 2004 to which he invited all directors of main laboratories around world, delegates of member states and representatives of main funding agencies asking them to make specific proposals in form of voluntary contributions “a la carte”, in cash, in kind or man-power to support programme.

CLIC accelerated R&D programme - continued

- At this meeting following delegations expressed interest in making specific contributions : DAPNIA, LAL and LAPP (France), Uppsala University and Manne Siegbahn National Accelerator Laboratory (Sweden), Finland, Netherlands, Ciemat (Spain), INFN (Italy), and University of Royal Holloway (England). All of these proposals however subject to approval by respective funding agencies.

  Final decisions to be announced at follow-up meeting on 28th Jan '05.

- In particular INFN Frascati waiting for approval of proposal to continue its contribution beyond delay loop to include (i) optics design for CR and Transfer Lines (TL1 and TL2) (ii) vacuum chambers and beam diagnostic equipment (without electronics) for CR and TLs (iii) path length wigglers for CR.

CLIC accelerated R&D programme - continued

- Sweden is waiting for approval of proposal for (i) optics design, dipole magnets and power converters, and beam diagnostic equipment for TL2 and bunch compressor (ii) two-beam test stand including optics, magnets, vacuum, beam diagnostic equipment and RF diagnostics and data handling.
- Spain is building (i) corrector magnets and waiting for approval of proposal for (ii) two double septum magnets and an ejection kicker (iii) quadrupole magnets with precision movers for TBL (iv) RF structure work with aim of building one PETS for TBL.
- Finland is waiting for approval of proposal for (i) power converters for CR and special technology for fabrication of CLIC accel structures.

CLIC accelerated R&D programme - continued

- France waiting for approval of proposal for (i) construction of probe-beam linac (DAPNIA and LAL) and (ii) 32 quads from LURE for CR.
- North-Western University of Illinois would like to build BD equipment for TBL but this depends on decision concerning US commitment.
- Turkey intends to send 4 young physicists for periods of 3 months to participate in CTF3 operation.
- Order placed with BINP (Novosibirsk) for 11 slim-quads and 26 sextupoles for CR.

CTF3 collaboration meeting

- The ninth CTF3 collaboration meeting held at CERN from 23rd to 25th November 2004.
- All collaborating institutes participated: Ankara and Gazi Universities (Turkey), CEA (Saclay), CIEMAT (Spain), LAL (Orsay), LNF (Frascati), RAL (Oxford), SLAC (Stanford), North Western University (Illinois) and Uppsala University.
- The CTF3 status, results obtained in 2004 and plans for coming year 2005 were presented.
- For details see: http://ctf3.home.cern.ch/ctf3/New_collab_meet.htm

EUROTeV activities

- In March 2004, consortium of 27 institutes (including CERN) submitted new bid to EC for programme of DS under name EUROTeV for LC in TeV energy range - approved 9 million Euros.

- EUROTeV will concentrate on issues common to all LC's - in particular will address some of high ranking issues identified by TRC with aim of making significant input to ILC CDR and TDR - also investigate upgrade paths into multi-TeV energy regime (CLIC).

- Design study structured around 7 WPs, covering DR, BDS, instrumentation, luminosity performance simulations, potential to stabilize machine against ground motion, potential to produce polarized positrons and possibility to use computer networks for machine operation.

- As well as contributing to preparation of bid CERN is contributing to management of study by participating in overall scientific coordination and by coordinating WP on integrated luminosity performance studies.

CARE activities

- Remind you that some members of CLIC study team already have commitments to another EU FP6 activity called CARE (Coordination of Accelerator Research in Europe).
- In particular, for CLIC, means participation in European-wide network on linear accelerators (ELAN), and JRA to construct CTF3 PI.
- As part of ELAN activity, workshops held at INFN in Frascati and at DESY and resulted in several initiatives - first to setup common repository for different codes available together with working examples to facilitate their use.
- Other workshops are planned including one in Frascati dedicated to wigglers. ELAN also associated itself with November CTF3 collaboration meeting and mini workshop on CTF3 operation when automatic steering was tested.

QCD explorer based on LHC and CLIC

- Argued that "linac-ring" type e-p collider could provide important discoveries for QCD physics - study therefore made to find possible parameter set for such "QCD-Explorer" by colliding 7 TeV LHC super-bunches with 75 GeV CLIC bunch trains (this could be done with just one drive-beam unit).

- 2808 LHC bunches spaced at 25 ns and spread out over ~ 100 μs
  154 CLIC bunches spaced at 0.66 ns - extend over ~ 100 ns.
  Colliding these beams would produce very little luminosity as only few bunches of either beam would participate in collisions.

- However one option for future LHC luminosity upgrade is to combine 2808 small bunches into few super-bunches extending over ~ 300 m. This LHC proton super-bunch with length of ~ 30 m would be ideal counterpart of CLIC bunch train - would ensure that all CLIC bunches and significant part of LHC beam (10%) would contribute to e-p luminosity.

- Estimated achievable luminosity ~ 10^{31} $cm^{-2}s^{-1}$

Other CLIC-based future collider options

- On this same theme, but this time on initiative of Turkish CLIC collaborators (Universities of Ankara and Gaza, & Institute of Physics, Baku), had one-day workshop at CERN to discuss all the different possibilities for colliding CLIC beam with not only the proton beam of LHC but also the ion beam, and to review physics potential.

- Options included e-p, e-A, γ-p, and γ-A collisions to study Quantum Chromo-Dynamics (QCD) in a wide kinematical region and FEL based γ-A collisions for Nuclear Resonant Fluorescence.

Interfacing with CLIC Physics Study Group

- Several members of CLIC study team contributed to work of CLIC physics study group which published its report on physics potential of CLIC in June 2004.
- Report also discusses experimental issues, including backgrounds and gives the assumed conceptual detector design used in physics analyses that are presented.

Technical publications of the CLIC Study Group

- More than 30 CLIC Notes written
  http://clic-study.web.cern.ch/CLIC-Study/Publications/2004.html
- 6 CTF3 Technical Notes
  http://clic-study.web.cern.ch/CLIC-Study/CTF3/Lists/2000.html

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