30 GHz CLIC structure testing in CTF3: What, why, where, how and when

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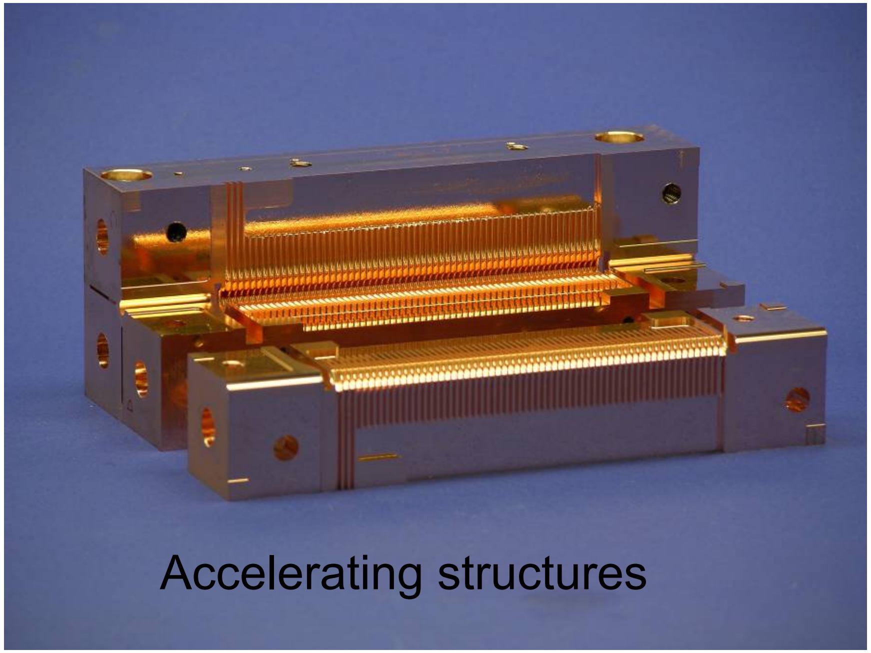
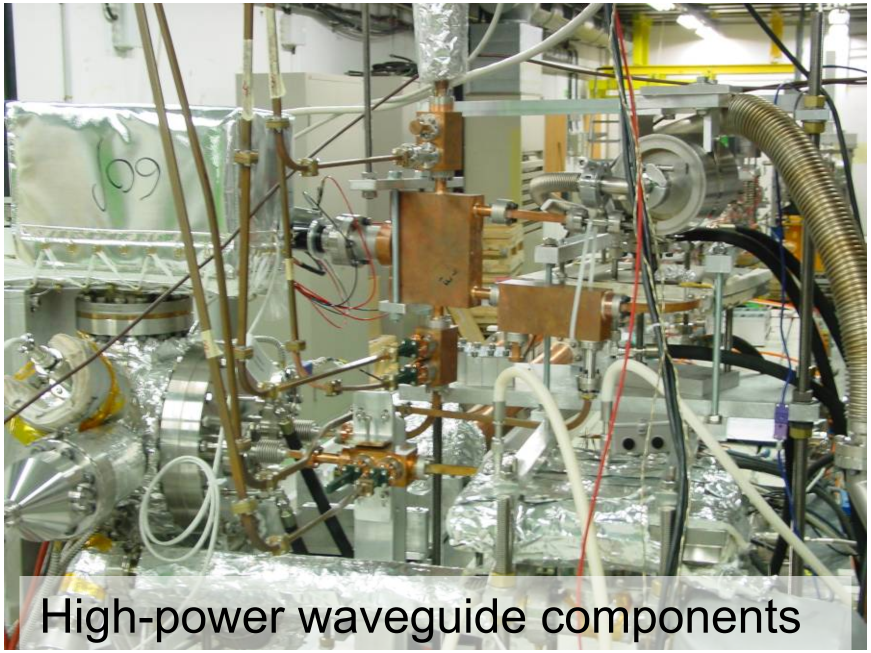
CTF3 collaboration meeting
29-11-2005

We will test in CTF3 all the 30 GHz CLIC high-power components





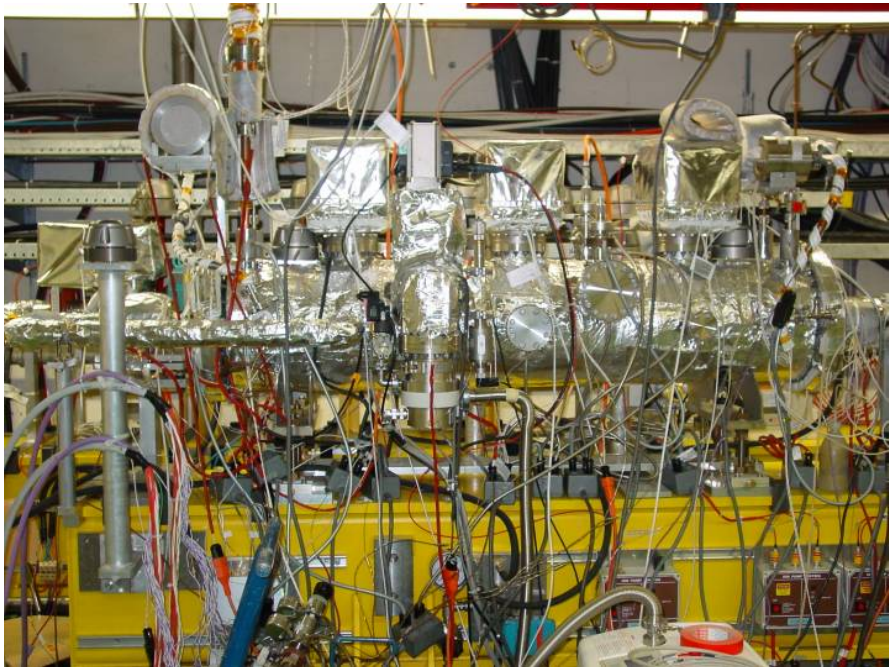
Key testing goals 1

Accelerating structures:	accelerating gradient	150+ MV/m
	pulse length	30 to 150 ns
	power level	60 to 150 MW
	low breakdown rate	
	beam aperture	3.5+ mm
	all damping features	
	pulsed surface heating*	56º C
PETS:	power	600 MW
	pulse length	30 to 150 ns
	low breakdown rate	
	extraction efficiency	98+%
	all damping features	
	on/off mechanism	
High-power waveguides:	power	100+ MW
	pulse length	30 to 150 ns
	efficiency	95+%

Key testing goals 2

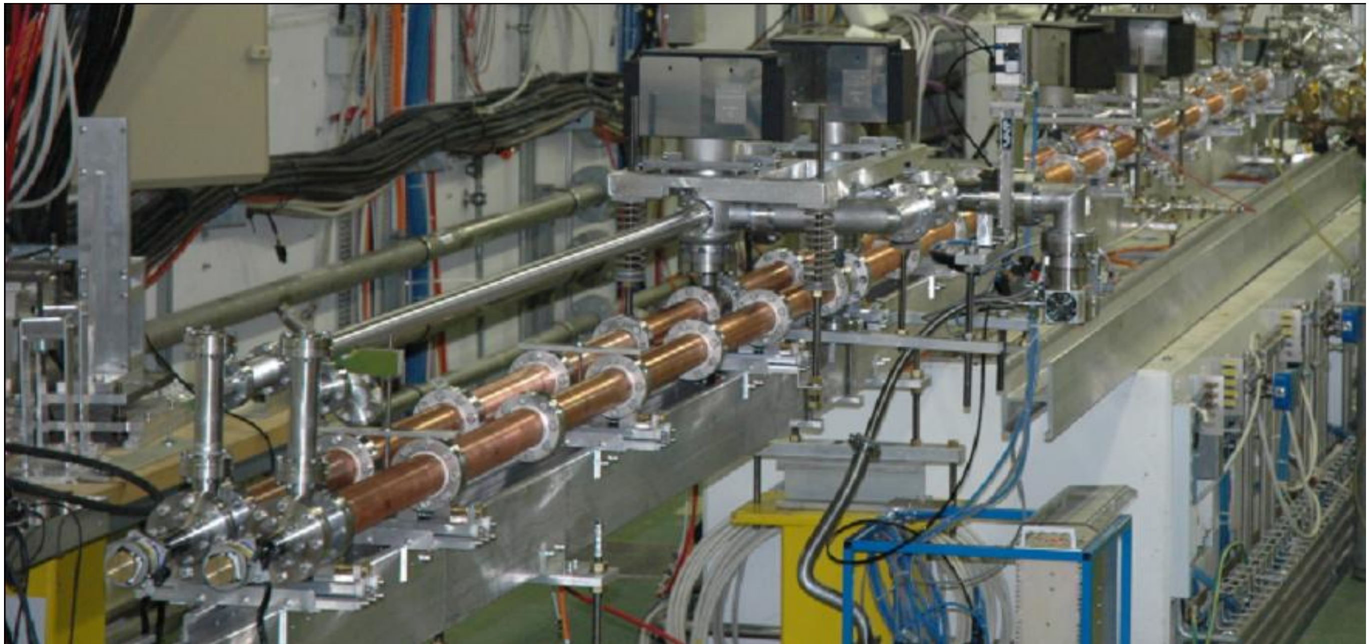
prototype performance demonstrations
quantify power/gradient limits
pulse length dependence
breakdown rate dependence
material properties
preparation techniques
conditioning strategies
physics of breakdown

30 GHz rf power facilities



Mid-linac power source

Two-beam test stand in CLEX
Volker Ziemann's talk



rf pulse compressor

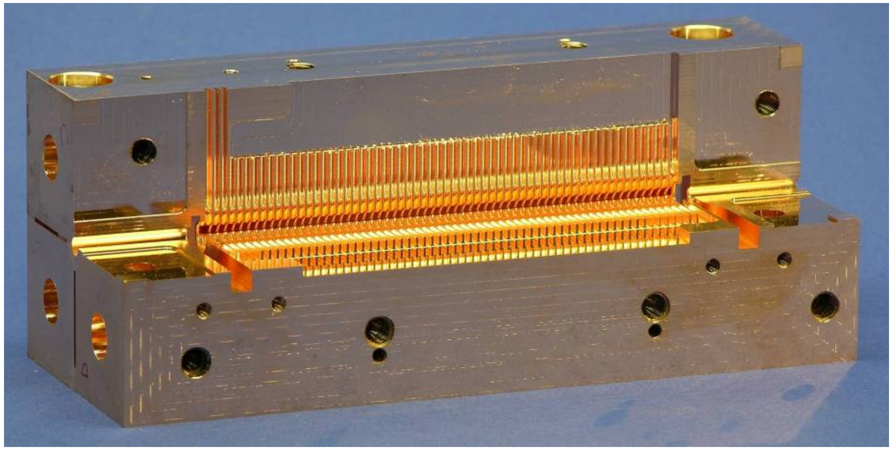
30 GHz rf power facilities

Mid-linac power source: 5 A, up to 80 MW out of special PETS. Pulse length dependent limit will be probed this run. 75% rf transmission efficiency to CTF2 giving about 60 MW (losses mostly from rectangular waveguides). Running now.

rf pulse compressor: Power gain up to 6. Up to 140 ns, currently configured for 70 ns. Requires long pulse with phase shift operation of mid-linac power source which will be tested this run. This should get us up to nominal CLIC pulses. Staged commissioning this run and next.

Two-beam test stand in CLEX: 35 A but PETS designed for 20 A to allow for routine operation. 600 MW @ 5 Hz repetition rate. CLIC PETS with special booster. Future.

Accelerating structures



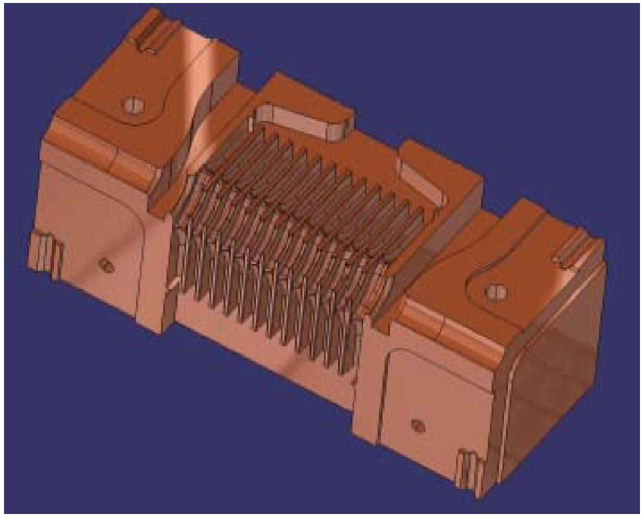
HDS60 π/3, 3.8-3.2 mm 100 MW for 150 MV/m:
Cu, structure ready, cover plate under manufacture

Circular 2π/3, 3.5 mm,
55 MW for 150MV/m:

- Mo iris - under test
- Cu - ready
- W iris – W irises at CERN, Cu cells to be ordered

Circular π/2, 4.0 mm aperture 100 MW for 150 MV/m:

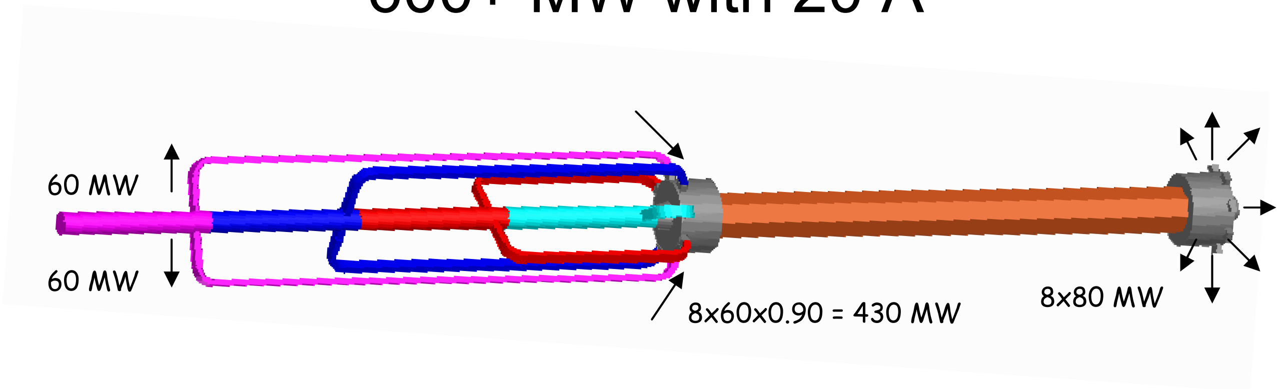
- Cu - ready

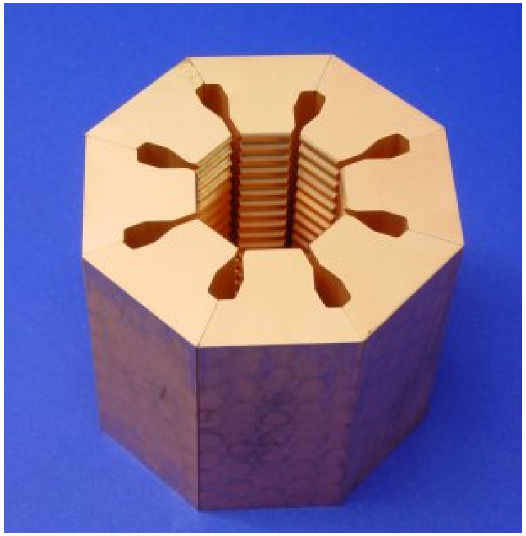


HDS11 same as first cell HDS60:
Cu, Mo, Ti, Al stainless steel, in machining cover plate to be designed

The pets with booster

600+ MW with 20 A

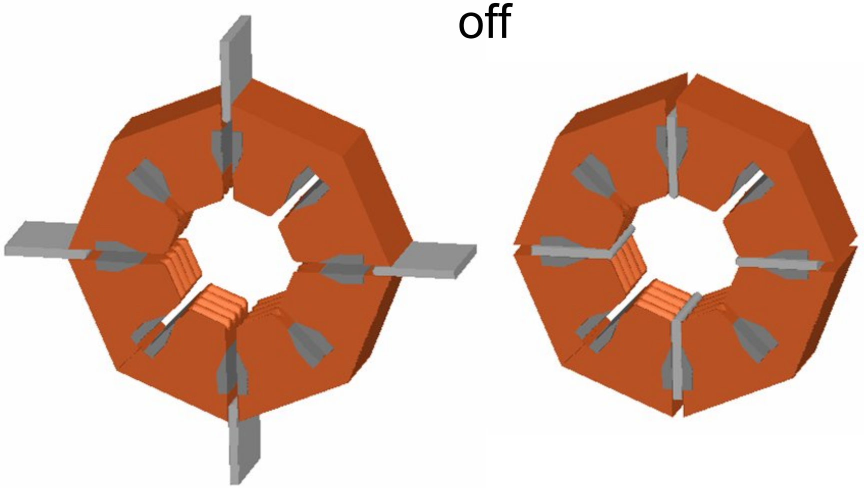




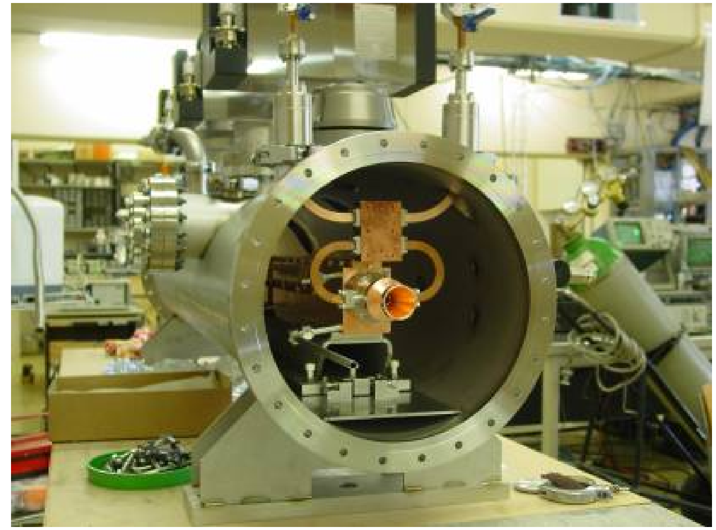
or

on

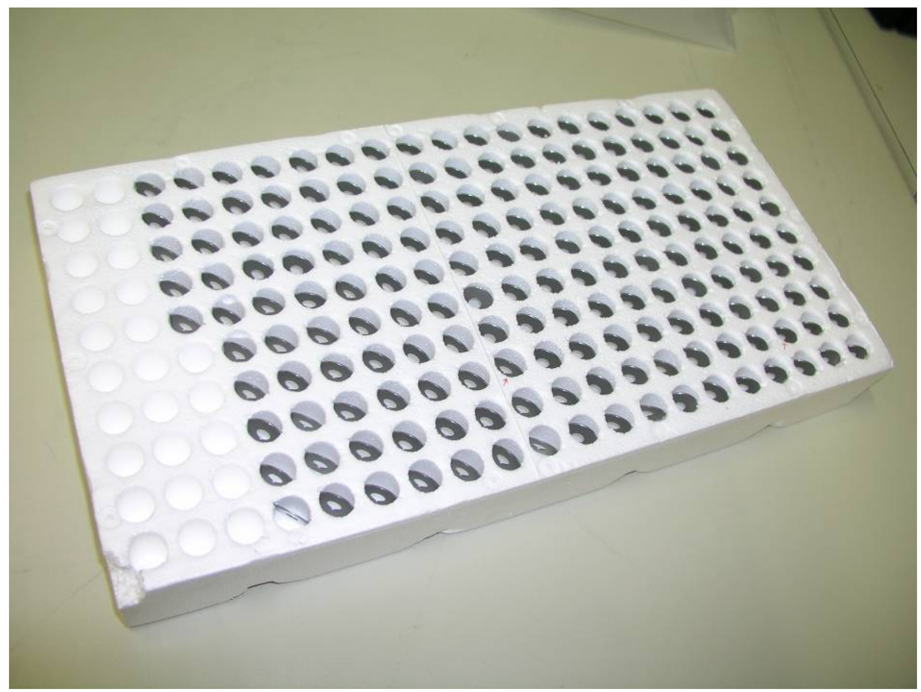
off



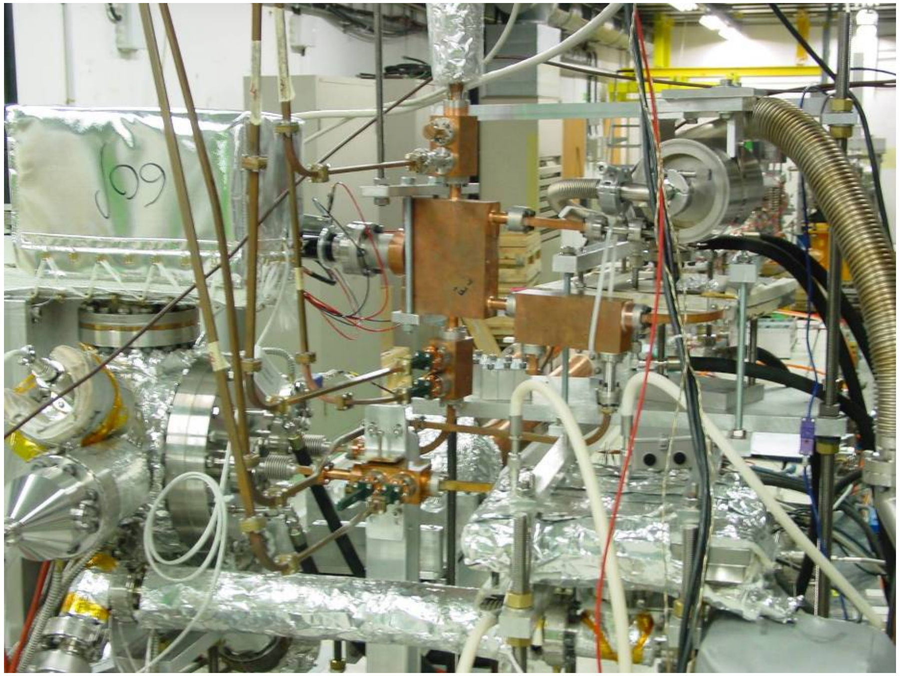
Special mid-linac PETs

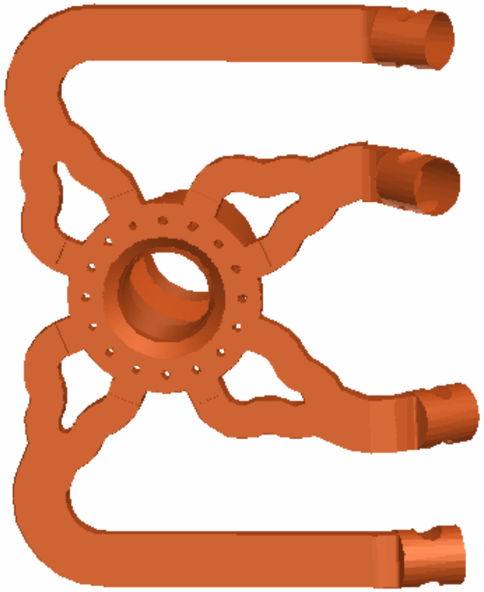


9/6.7/9 mm aperture
2π/3 phase advance
.40/.24/.40 v_g/c
1.5 m long



Waveguide components





When

Accelerating structures: Mo test underway, HDS60 next, others to follow in an order based on results. Next generation to be defined next year. We hope for an increased cadence with THE WALL.

PETS: When the two-beam test stand is ready.

Waveguide components: Essential elements will be tested automatically as we go through the testing program. A prototype system will be tested in the two-beam test stand.

Optimization

Accelerating structure parameters:

fixed: $\langle E_{acc} \rangle$= 150MV/m, f= 30GHz,

varied: $\delta\varphi$ = 50° - 130°,

a/λ= 0.1 - 0.25,

d/λ = 0.025 - 0.1,

N_b, N_{cells}, N_{cycles}

Optimization criterion

Luminosity per linac input power:

$$\int L\,\mathrm{d}t / \int P\,\mathrm{d}t \sim L_{b\times}\eta/N$$

Beam dynamics input:

$W_{t,2}$ = 20V/pC/mm/m for $N=4\times10^9$

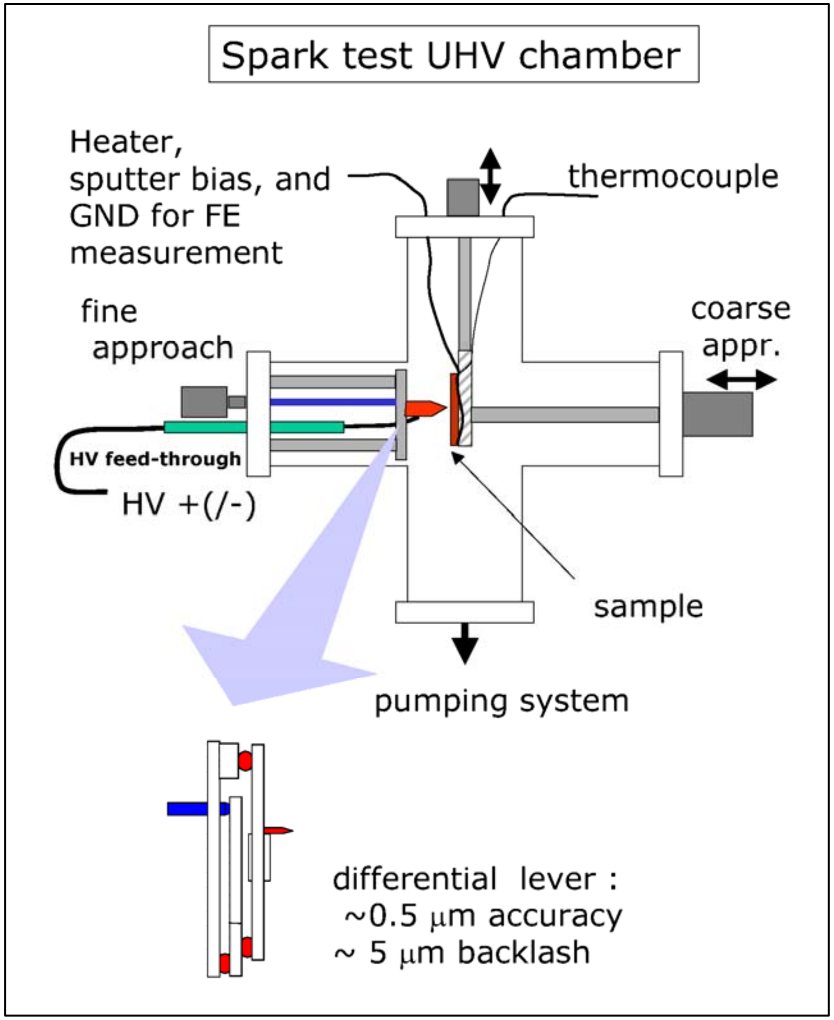
N, L_{bx} dependencies of a/λ

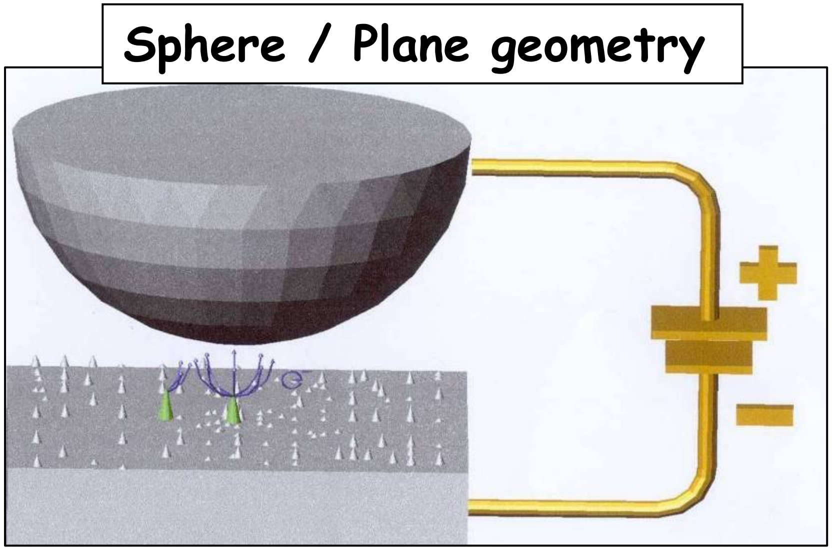
rf breakdown and pulsed surface heating (rf) constrains:

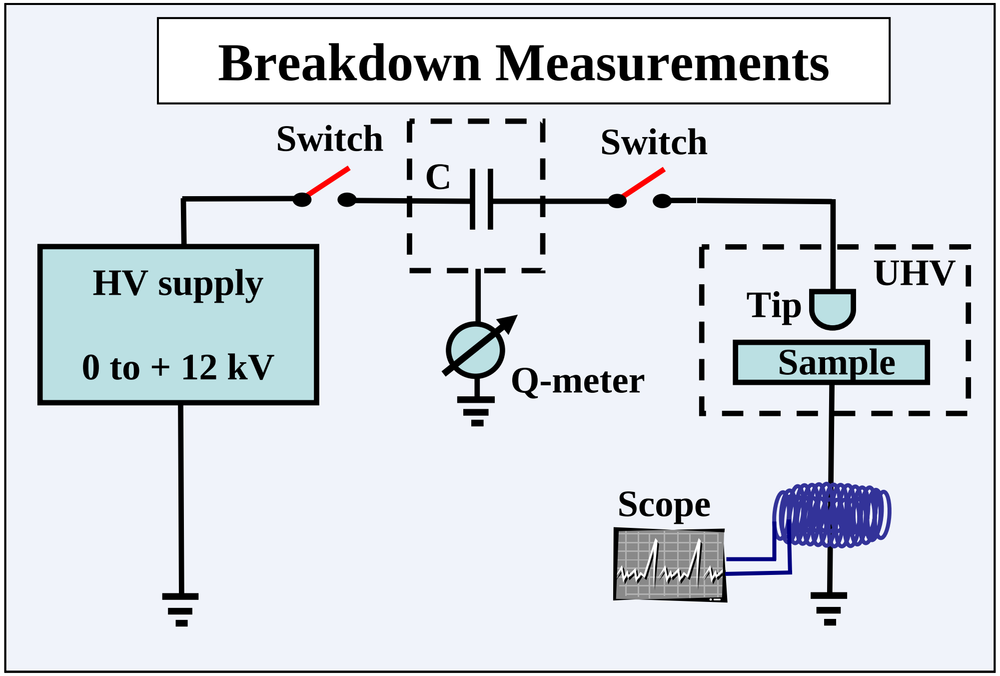
E_{surf} < 378 MV/m, ΔT < 56 K, $P_{in}t_p^{1/2}$ < 1225 MWns$^{1/2}$

Several million structures considered in the optimization

dc spark: materials, preparation techniques, breakdown physics

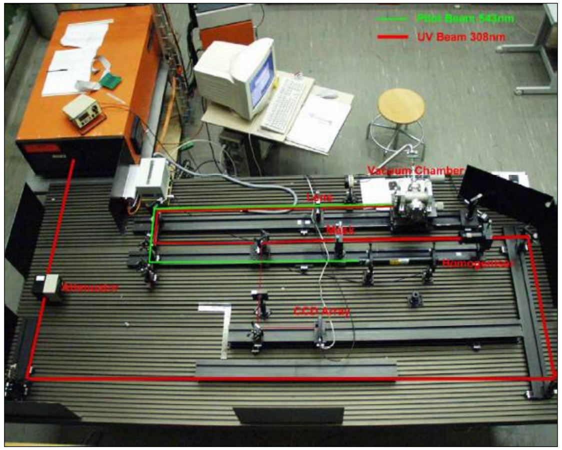




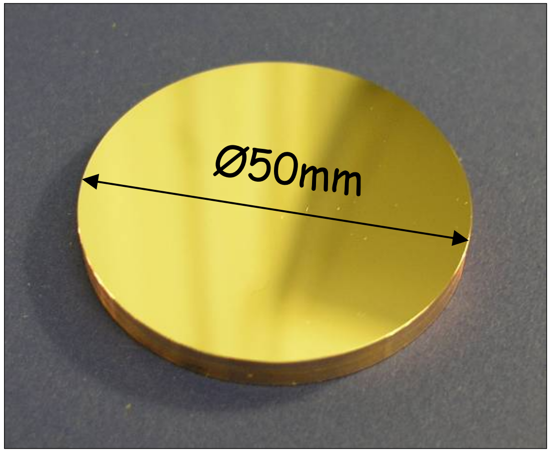


Pulsed Laser Fatigue Tests

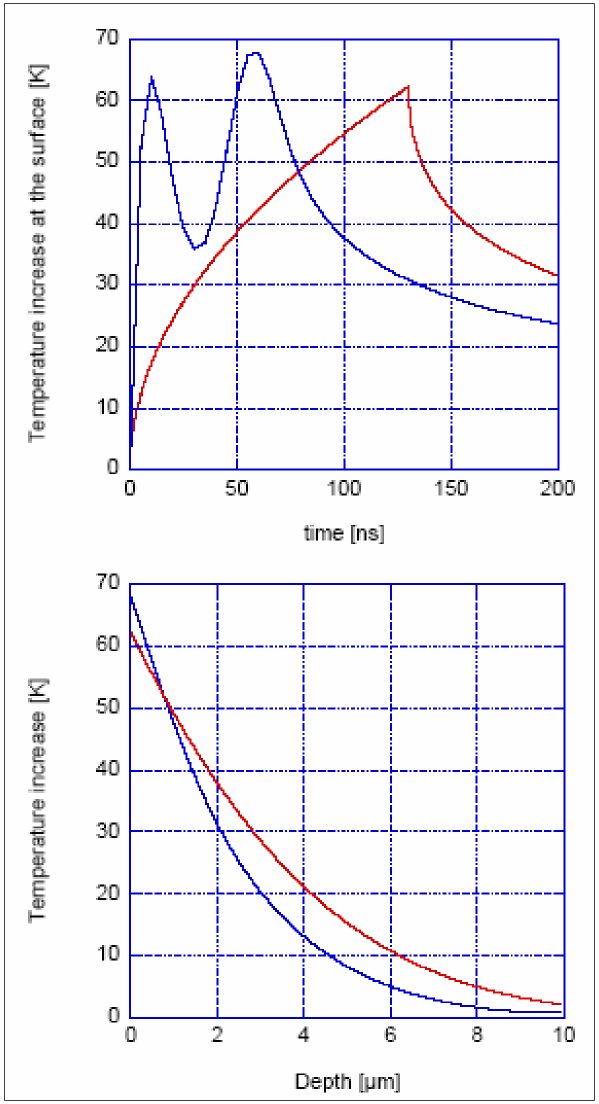
- **Surface of test sample is heated with pulsed laser. Between the pulses the heat will be conducted into the bulk.**
- **The Laser fatigue phenomenon is close to RF fatigue.**
- **The operating frequency of the pulsed laser is 20 Hz -> low cycle tests.**
- **Observation of surface damage with electron microscope and by measuring the change in surface roughness.**
- **Tests for CuZr & GlidCop in different states under way.**



Laser test setup



Diamond turned test sample, Ra 0.025μm



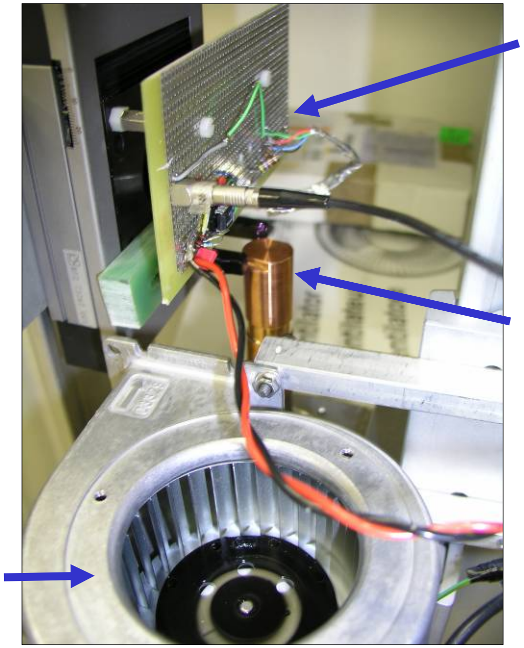
Red curve – CLIC RF pulse

Blue curve – Laser pulse

Ultrasound Fatigue Tests

- Cyclic mechanical stressing of material at frequency of 24 kHz.
- High cycle fatigue data within a reasonable testing time. 10^{10} cycles in 5 days.
- Will be used to extend the laser fatigue data up to high cycle region.
- Tests for Cu-OFE, CuZr & GlidCop under way.

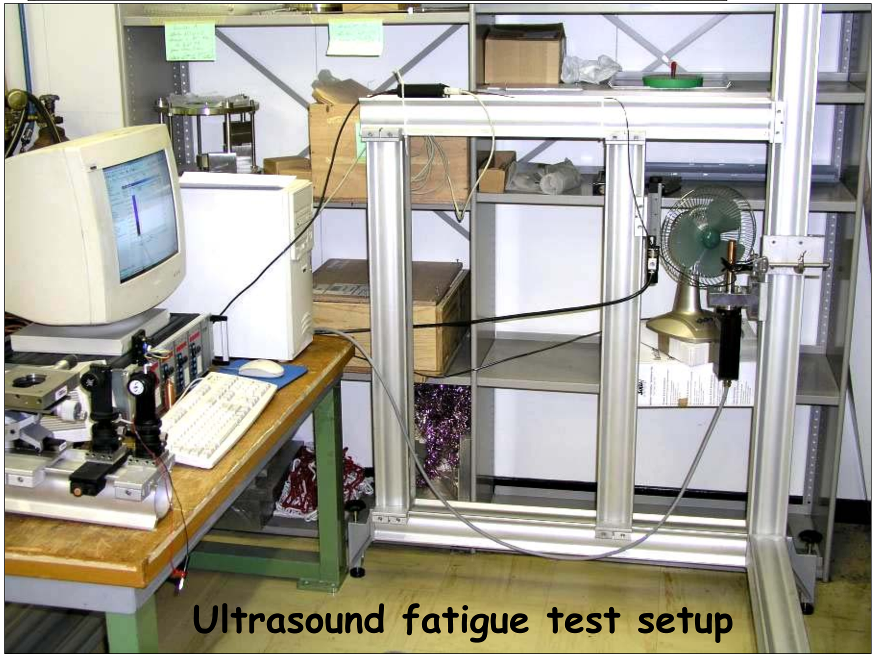
Ultrasound fatigue test samples



Calibration card measures the displacement amplitude of the specimen's tip

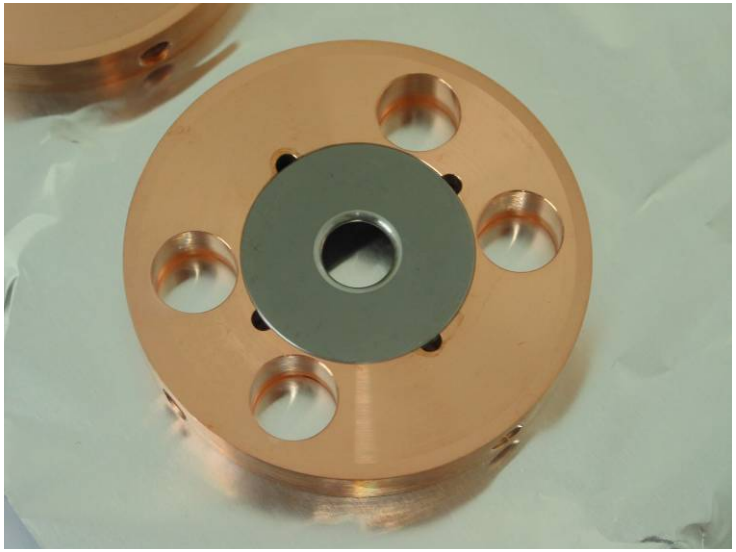
Fatigue test specimen

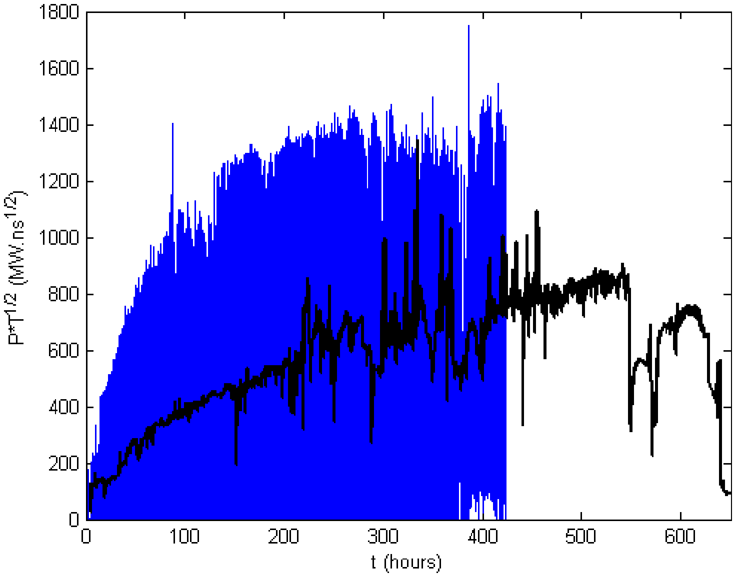
Air Cooling



Ultrasound fatigue test setup

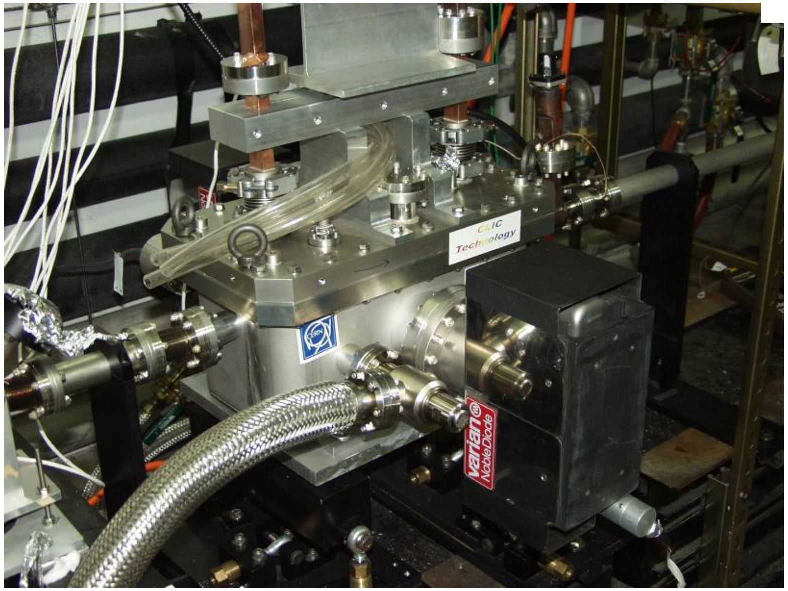
CLIC X-band testing at NLCTA



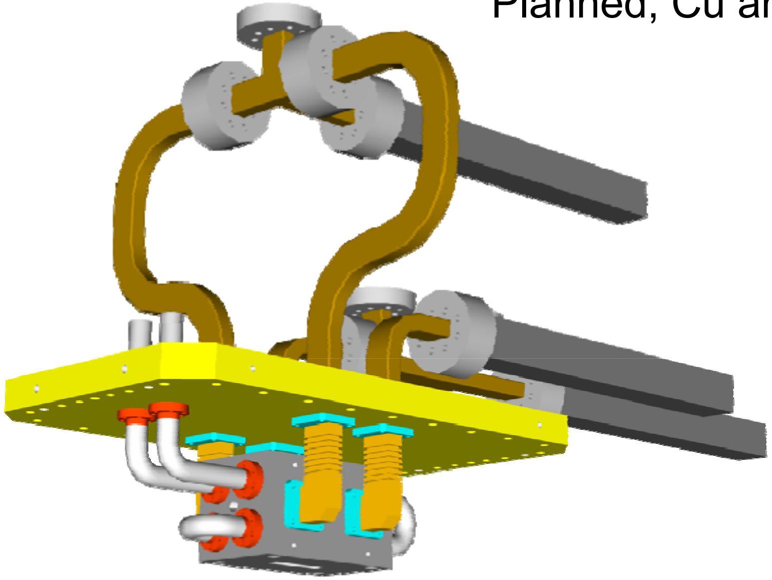


W, 93 MV/m 70 ns, ongoing

Mo, 87 MV/m, 30 ns, conditioning strategy?



Planned, Cu and Mo HDS



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