High-power 30 GHz testing with CTF3

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CTF3 collaboration meeting
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CLIC accelerating and power generating parameters:

30 GHz,
150 MV/m accelerating gradient,
150 ns pulse length,
130 MW input power,
20 J total pulse energy

Major constrains are:

- Drive beam loss
- Rf breakdown
- Pulsed surface heating

In the coming years almost the entire CLIC 30 GHz high gradient/power development program will take place in CTF3,

- first opportunity to test 30 GHz structures at the full CLIC pulse length
- refinement (correction?) of our understanding of the physics of rf breakdown and of the limits to accelerating gradient
- test of prototype accelerating structures at specification
- test of scaled power generating structures at subsets of specification
- test of high power waveguide components

The program will take place in a (series of) test stand(s) that consists of:

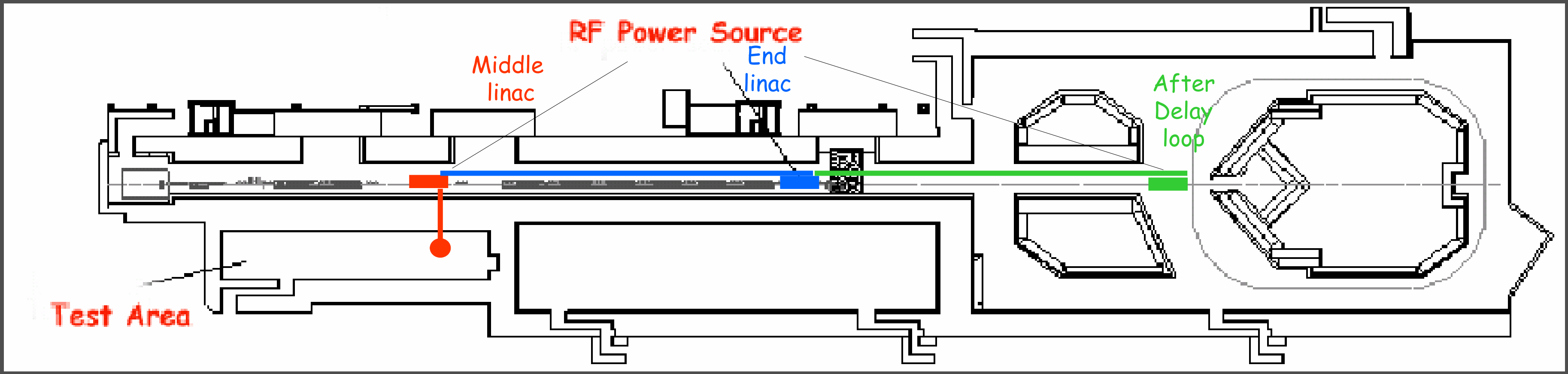
1. A structure that generates 30 GHz rf power by decelerating the CTF3 beam and that feeds
2. An accelerating structure
3. Many rf pulses

…a unit of CLIC, but with the notable difference that 3.5/5/7/35 A maximum will be available rather than 200 A

We hope to learn about 1,2 and 3.

The CTF3 rf test program will be the successor to the CTFII program which ended in 2002.

30 GHz testing in CTF3, possible locations



Decision: RED

The high gradient/power program will begin in parallel with CTF3 construction, commissioning and experimentation.

- Designed to profit from beam developments and improvements, but constrained by very limited resources.
- Designed so that the beam and rf production programs can coexist.

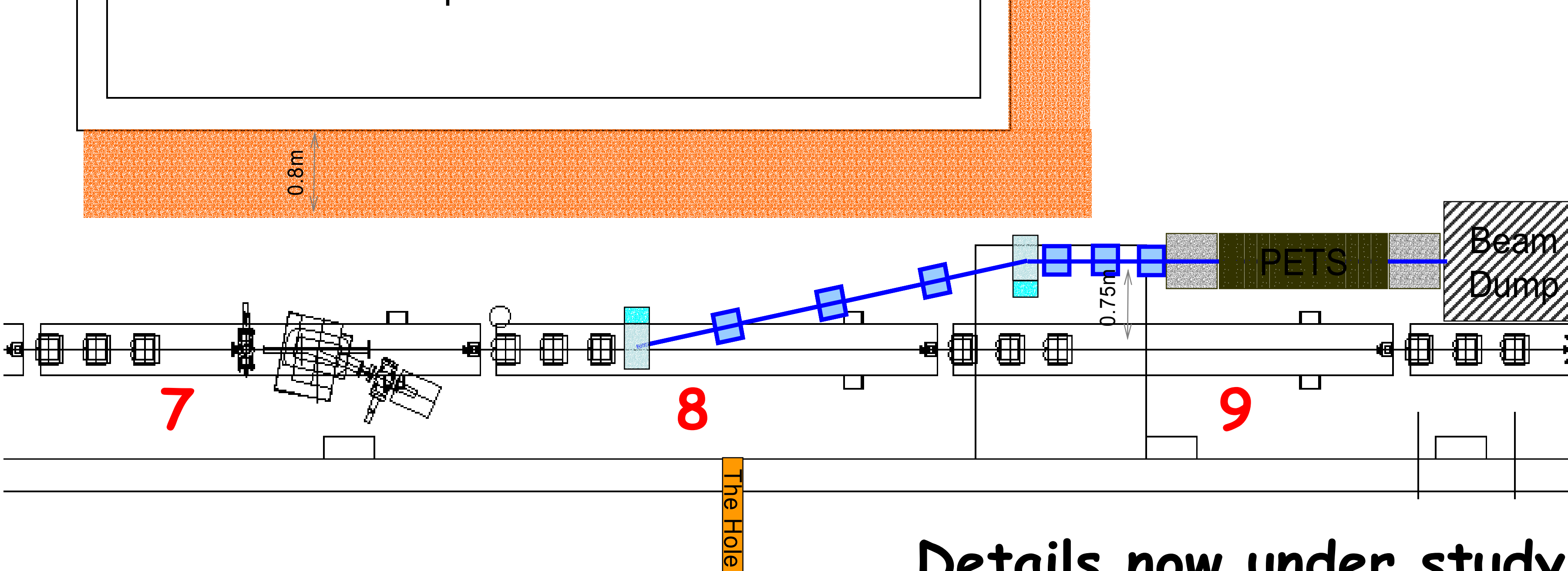
Power source arrangement C

in case beam-power turns out to be insufficient spectrometer
and MTV can be moved from module 7 to module 9 and
two SICA’s can be placed in module 7

The beam line

place available at short distance of PETS output

distance PETS output/Hole ≈ 7 m



Details now under study

CTF2 area

H. Braun

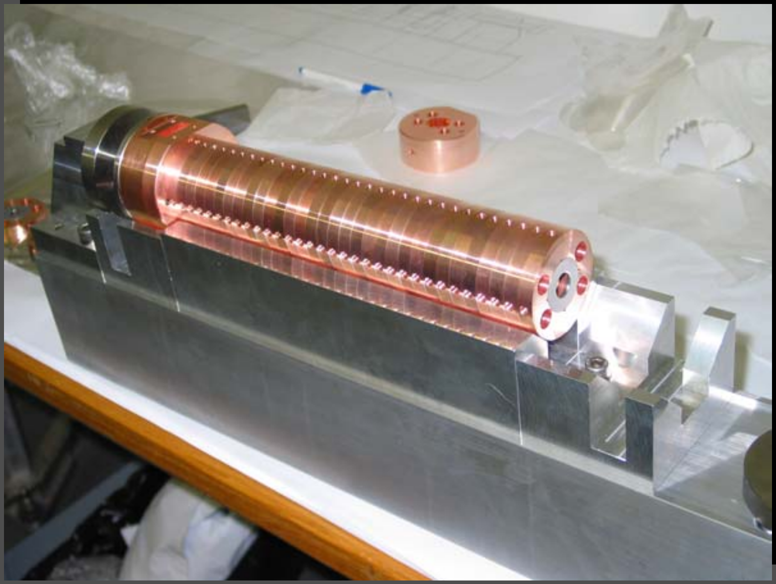
Middle of linac power source, challenges

- Enough energy in beam but low current – 5 A (CTFII 25 A, CTF3 loop+ring 35 A and CLIC 200 A). High impedance structure required.

- Beam dynamics – tough combination of high impedance power extraction, small aperture with limited beam energy. Few % beam losses mean a hot structure, a few more destruction.

These issues are addressed in Igor's talk

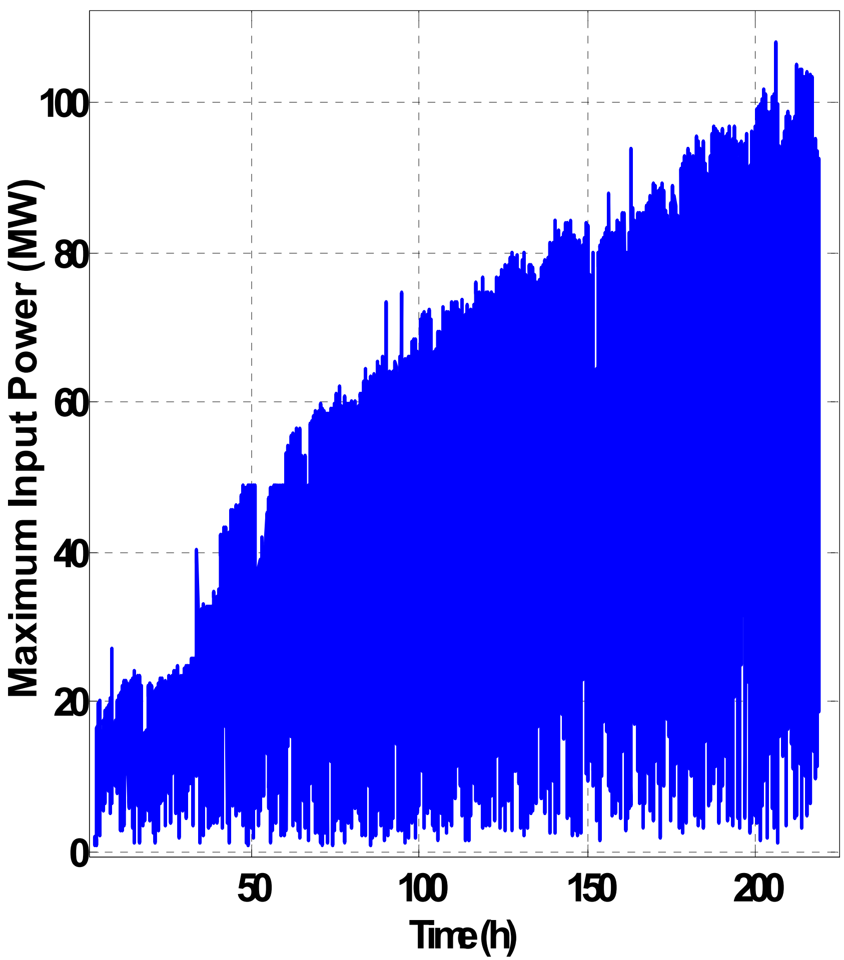
What long pulse testing may be like,

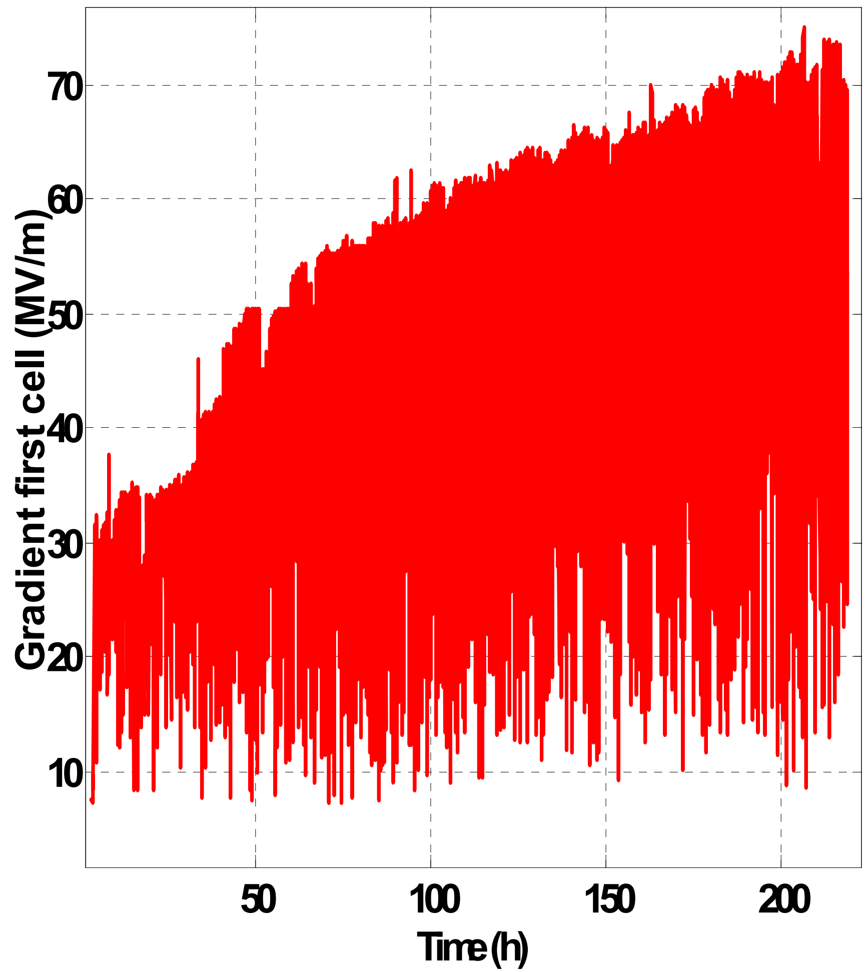


11 GHz Mo and W iris structures for test in NLCTA (Mo shown)

C30vg4-Mo processing history at 50 ns pulse length, 60 Hz repetition rate, automated conditioning

Experiment still underway.



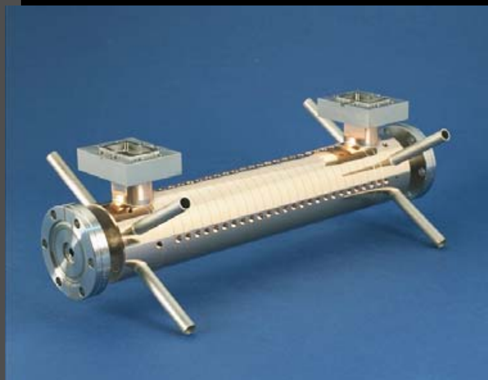


S. Doebert

Lessons from NLCTA set-up

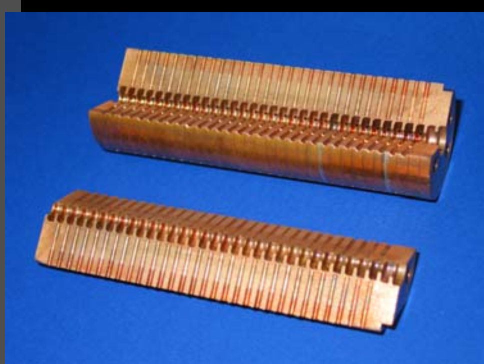
- Instrumentation – A lot. Shot by shot acquisition of rf pulses (missing energy, breakdown location), wall current monitors, vacuum. Data logging.
- Control – Automated and programmable conditioning scheme. Certainly for the accelerating structure and probably for the PETS. With vacuum, rf, etc. inputs/interlocks. Interrupted pulsing, adjustable rf pulse length and power.
- Time – A lot, 'round the clock operation, high repetition rate.

Permutations

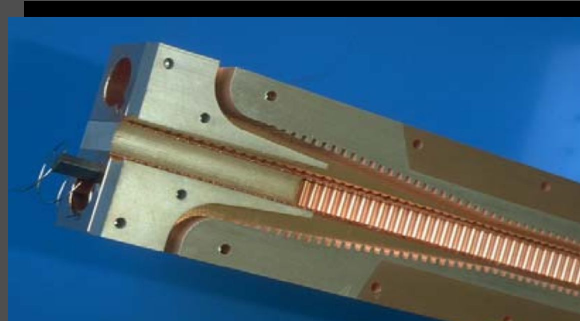


11 GHz, Cu, 1.1%v_g/c
150 ns,
E_{acc} 153 MV/m,
E_{surf} 285 MV/m
P_{in} 69 MW
U_{total} 10 J

30 GHz, Cu, 8 %v_g/c
15 ns,
E_{acc} 66 MV/m,
E_{surf} 240 MV/m
P_{in} 36 MW
U_{total} .5 J



30 GHz, Cu, 4.6%v_g/c
30 ns,
E_{acc} 110 MV/m,
E_{surf} 260 MV/m
P_{in} 35 MW
U_{total} 1 J

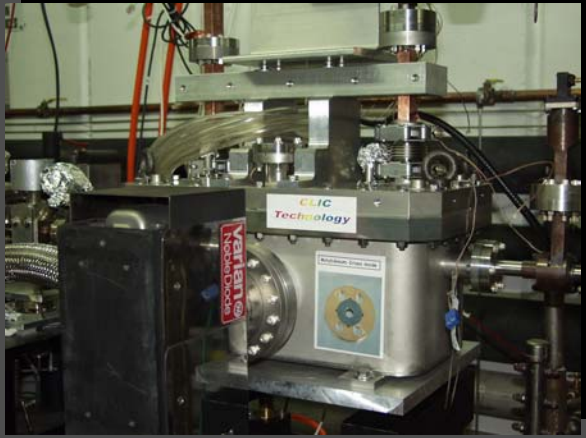


30 GHz, Cu, 55 % v_g/c
15 ns,
E_{acc} 24 MV/m,
E_{surf} 268 MV/m
P_{out} 240 MW, 60 MW/channel
U_{total} 3.6 J, .9 J/channel

More permutations

30 GHz, Mo, 4.6%v_g/c
15 ns,
E_{acc} 193 MV/m,
E_{surf} 426 MV/m
P_{in} 93 MW
U_{total} 1.5 J

30 GHz, W, 4.6%v_g/c
15 ns,
E_{acc} 154 MV/m,
E_{surf} 340 MV/m
P_{in} 59 MW
U_{total} 1 J



11 GHz, Mo, 4.6%v_g/c
Under test with long pulses
11 GHz, W, 4.6%v_g/c
Under preparation

High-power testing program – 'near' term

Cu PETs

Complete Cu, Mo and W standardized tests:

CTFII - 30 GHz short pulse
NLCTA - 11 GHz medium to long pulse
CTF3 - 30 GHz medium to long pulses

Complete material, pulse length and frequency dependency data.
Basic data for structure design – field and power limits.
Hopefully first demonstration of full gradient, pulse length at 30 GHz.

Plenty more to follow.

Our understanding of rf breakdown stands on the shoulders of experimental results.

Each time more rf energy/power has become available, something has been learned (euphemism) and solutions eventually found.

Look forward to CTF3.