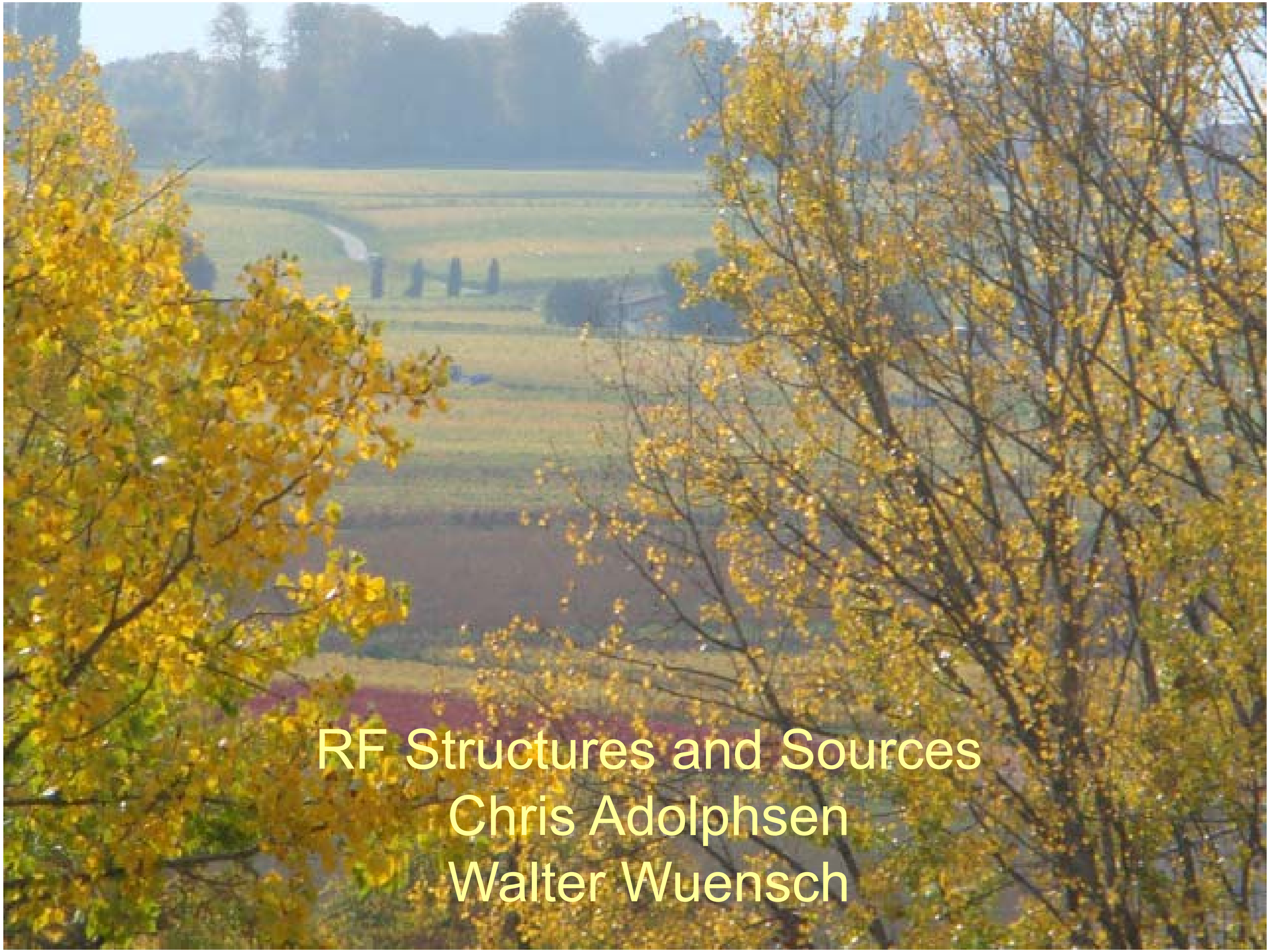
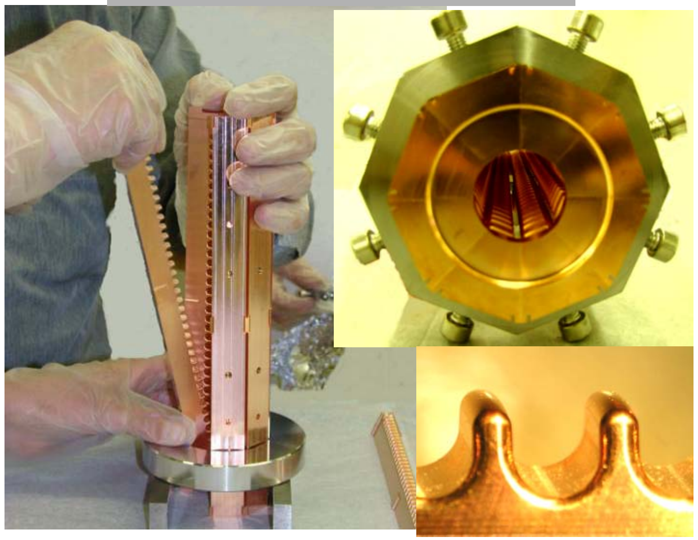

RF Structures and Sources
Chris Adolphsen
Walter Wuensch

CLIC Power Extraction and Transfer Structure (PETS) Design & Computation

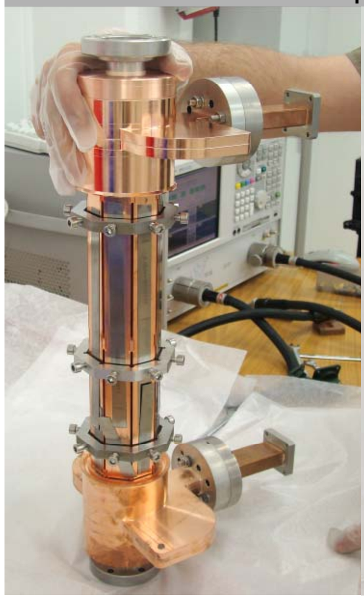
Igor Syratchev

11.424 GHz PETS

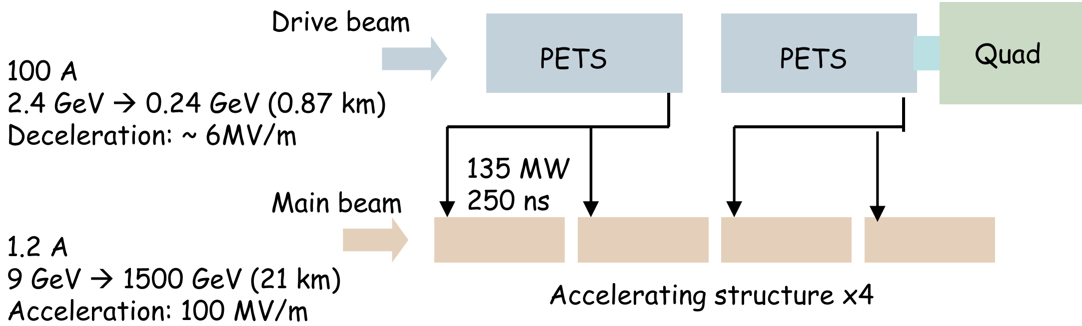
Assembly of the eight PETS bars.



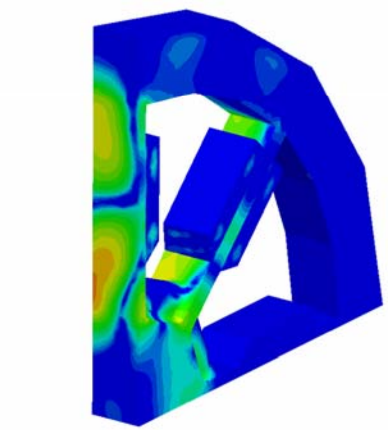
PETS during RF check



PETS before the last EB welding



HOM Damping with lossy dielectric material

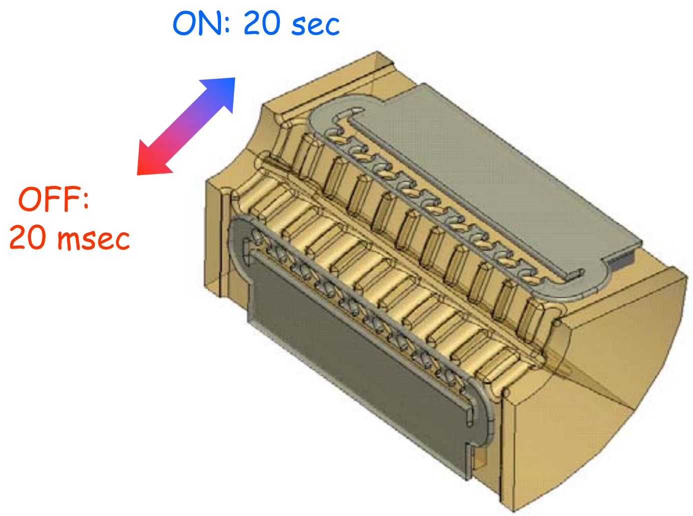


- Frequency = 11.9942 GHz
- Aperture = 23 mm
- Active length = 0.213 (34 cells)
- Period = 6.253 mm (90^0/cell)
- Iris thickness = 2 mm
- Slot width = 2.2 mm
- R/Q = 2222 Ω/m
- V group= 0.459C
- Q = 7200
- $Pt^{1/3}/C$ = 13.4
- E surf. (135 MW)= 56 MV/m
- H surf. (135 MW) = 0.08 MA/m
  (ΔT max (240 ns, Cu) = 1.8 C^0)

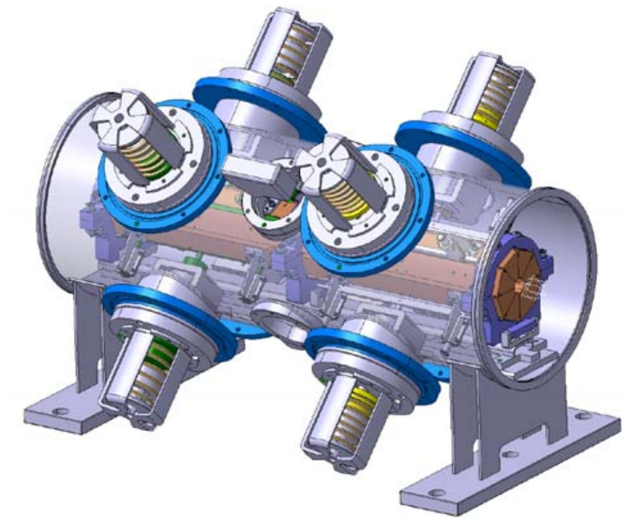
PETS machining test bar fabricated in IMP (Italy)

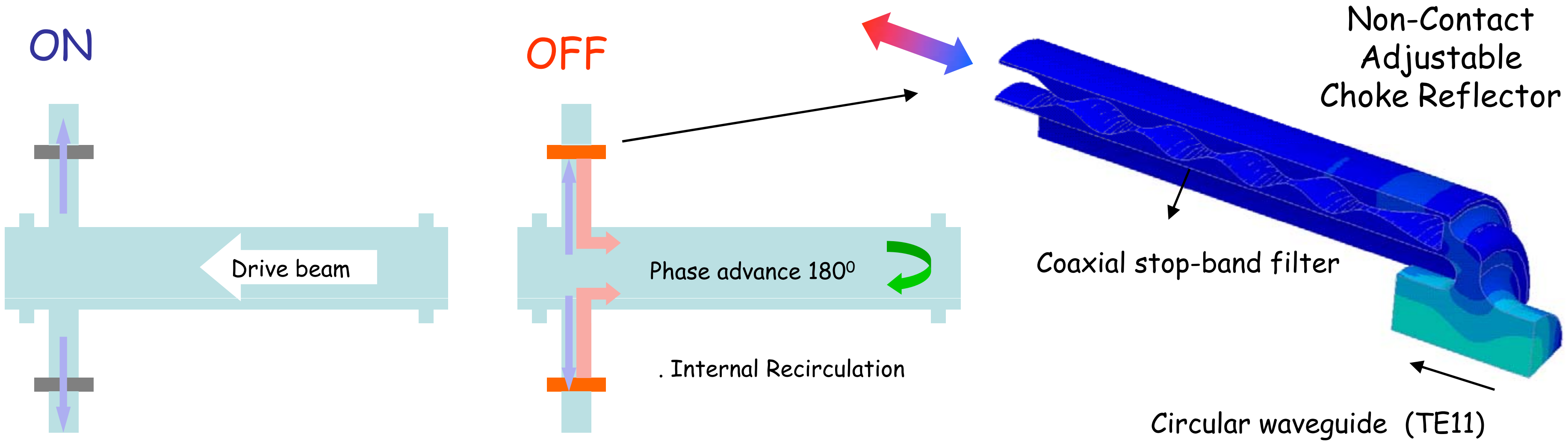
Local termination of the power production in the PETS ON/OFF options and operation

Igor Syratchev & Alessandro Cappelletti



But
Mechanically
Complicated



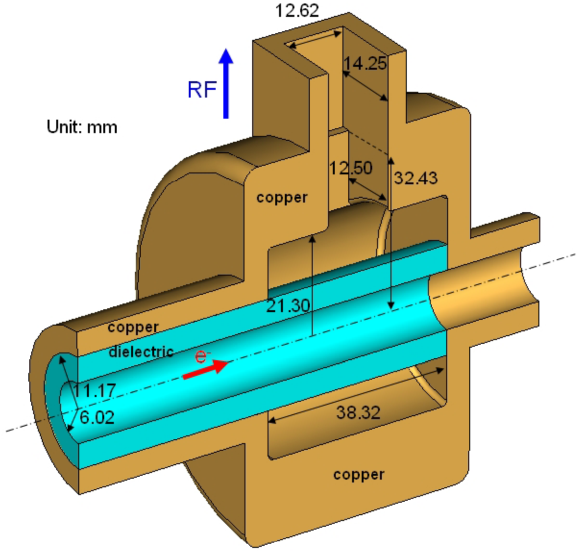


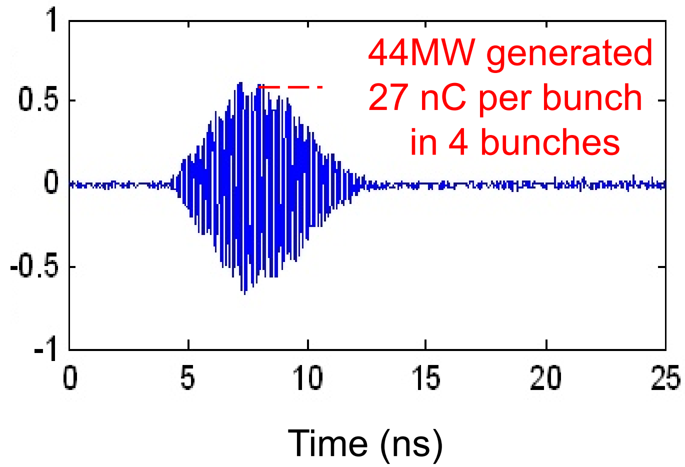
Argonne NATIONAL LABORATORY

... for a brighter future

Wei Gai

7.8 GHz Dielectric-Loaded Power Extraction



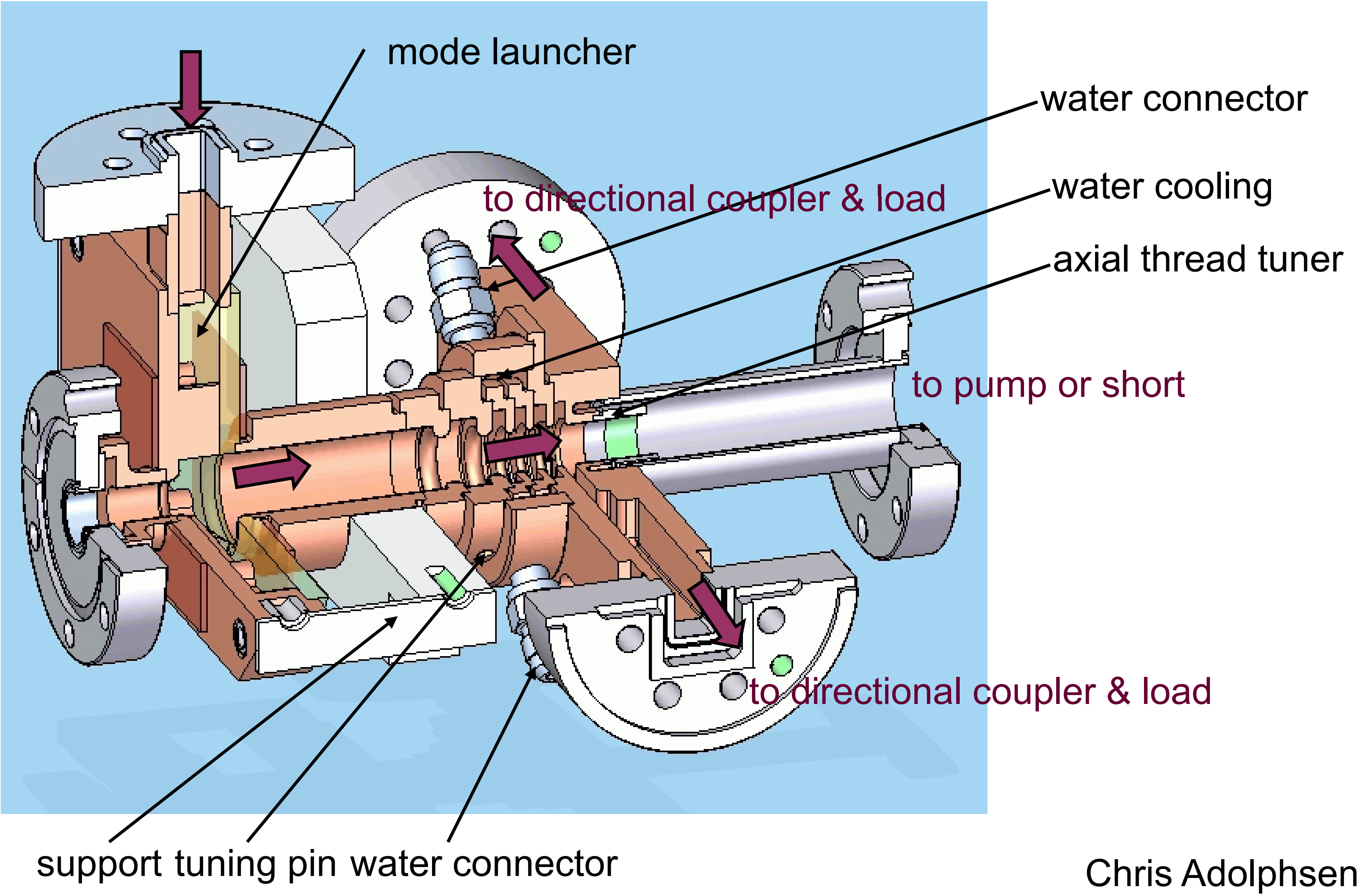


7.8 GHz dielectric-loaded power extraction has been demonstrated. 30 MW of power has been generated in single bunch tests and 44 MW in 4-bunch train tests. 10 ns and 22 ns RF pulses have been detected.

Currently, higher power generation is limited by the QE of the magnesium photocathode ($\sim 10^{-4}$). A new cesium telluride photocathode with higher QE ($\sim 10^{-2}$) has been developed - expect 280 MW of output power to be generated for 50 nC per bunch.

A 26 GHz dielectric-loaded power extractor has been designed and ready to be test.

RF-Driven Klystron Output Section to Study Pulse Tearing in SLAC XL4 Klystrons



Chris Adolphsen

CLIC08 workshop

Structure production: CERN activities and Master Schedule

G. Riddone, W. Wuensch, R. Zennaro,

Contributions from C. Achard, S. Atieh, V. Dolgashev, D. Glaude, S. Heikkinen, A. Samoshkin, I. Syratchev
+ KEK/SLAC collaborations

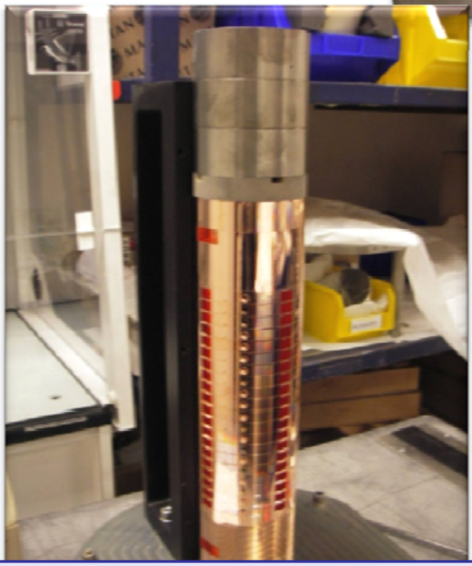
15.10.2008

11.4 GHz - CLIC vg1, T18

Damped disks

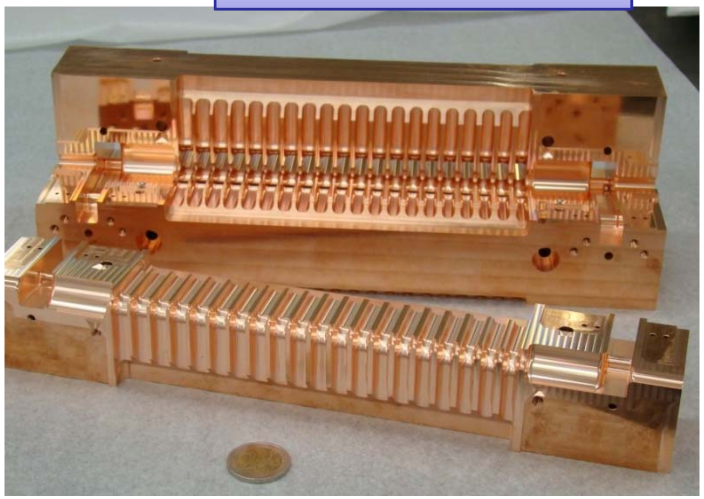
QUADRANTS
2 damped structures (1 from KEK and 1 from CERN)

DISKS
5 undamped structures (4 from KEK/SLAC and 1 from CERN)
3 damped structures (2 from KEK/SLAC and 1 from CERN)



Damped structure#1 ready for brazing (CERN)

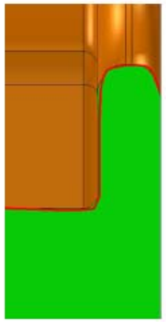
Undamped disk



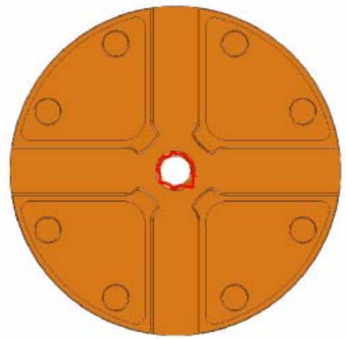
Damped quadrants

Structure Fabrication and Assembly Tolerances

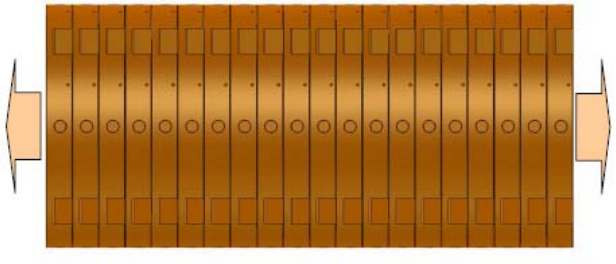
Riccardo Zennaro



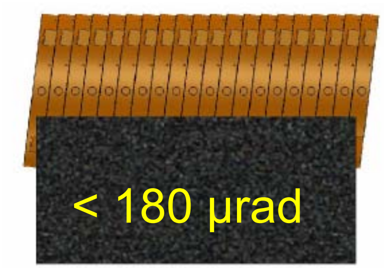
1. Iris shape



2. Shape of the matching Iris



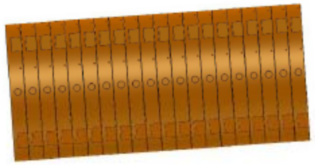
3. Expansion due to heating



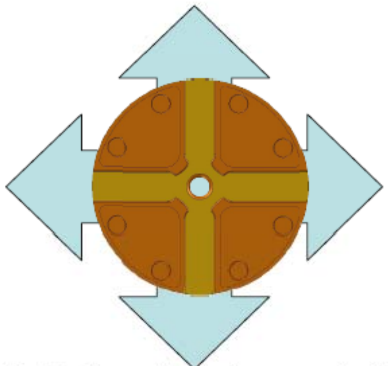
4. Tilt of the disk

5. Unsymmetrical heating

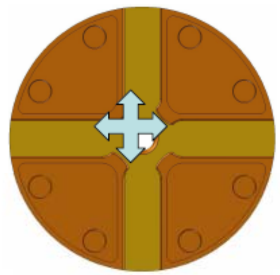
6. Relative position



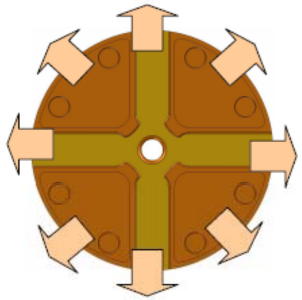
7. Tilt of the structure



8. Deformation of support



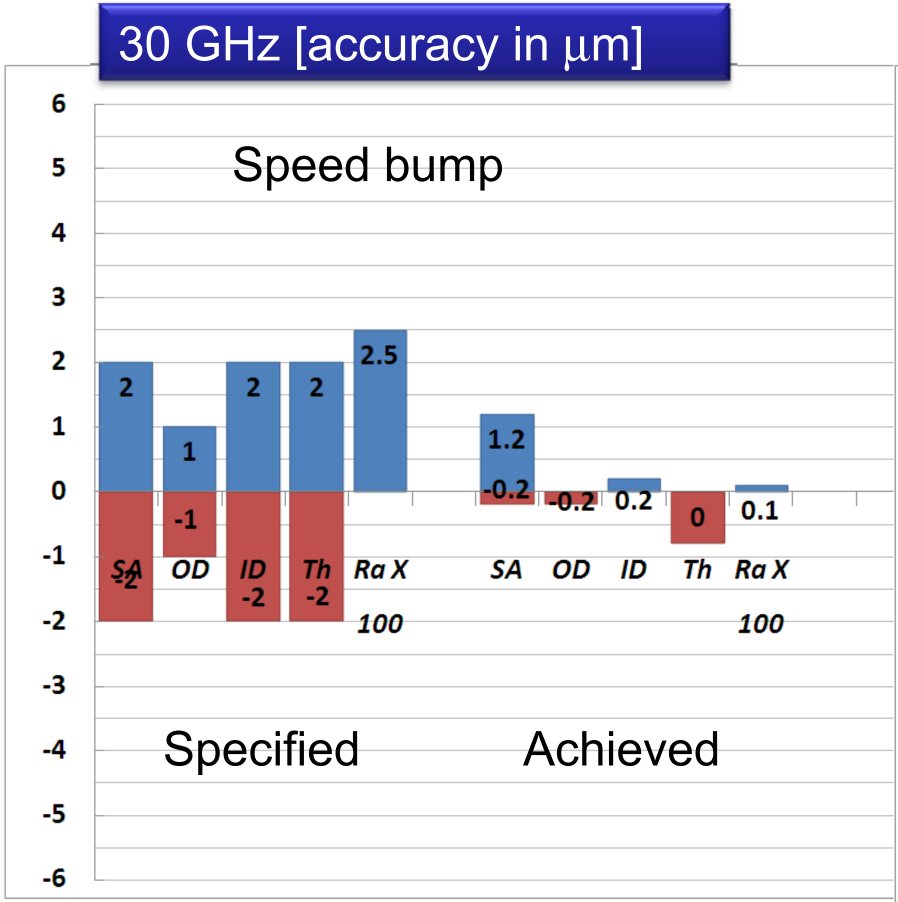
9. Support of the structure



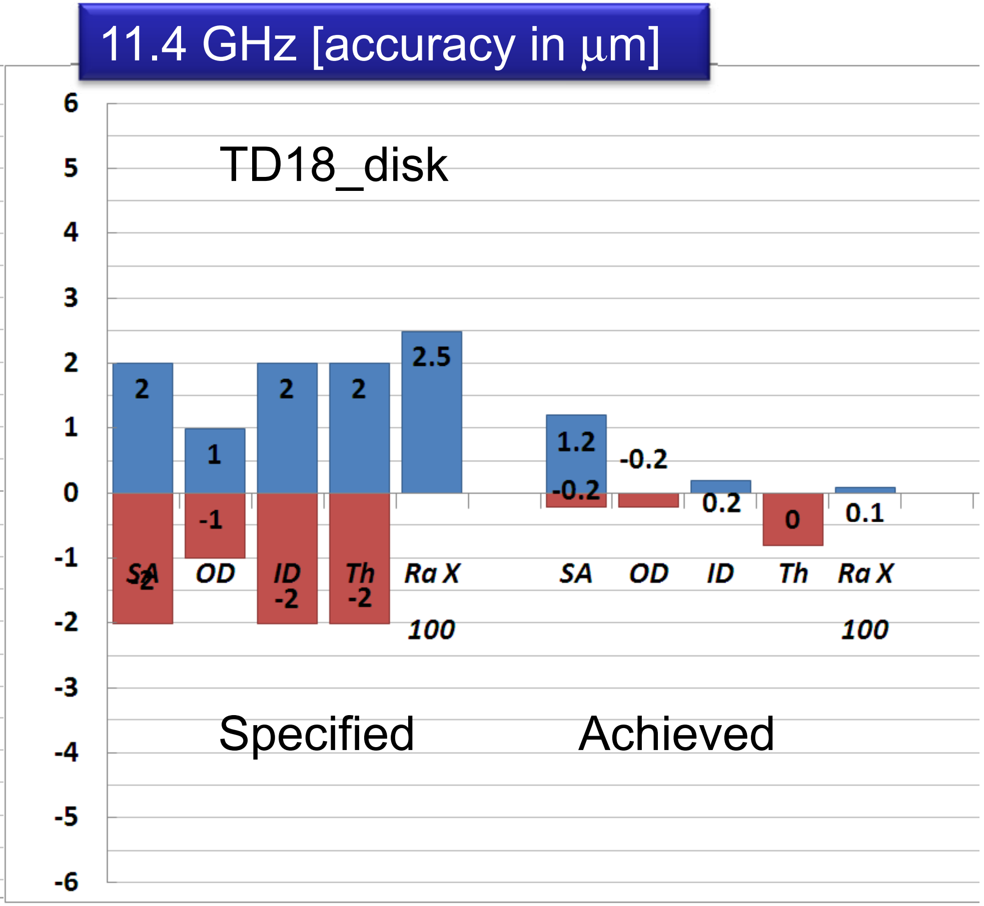
10. Isotropic heat expansion

Achieved accuracy (disk)

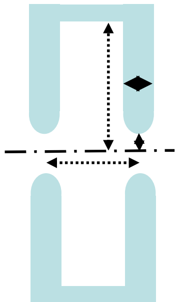
30 GHz [accuracy in μm]



11.4 GHz [accuracy in μm]



SA: iris shape accuracy
OD: outer diameter
ID: inner diameter
Th: iris thickness
Ra: roughness



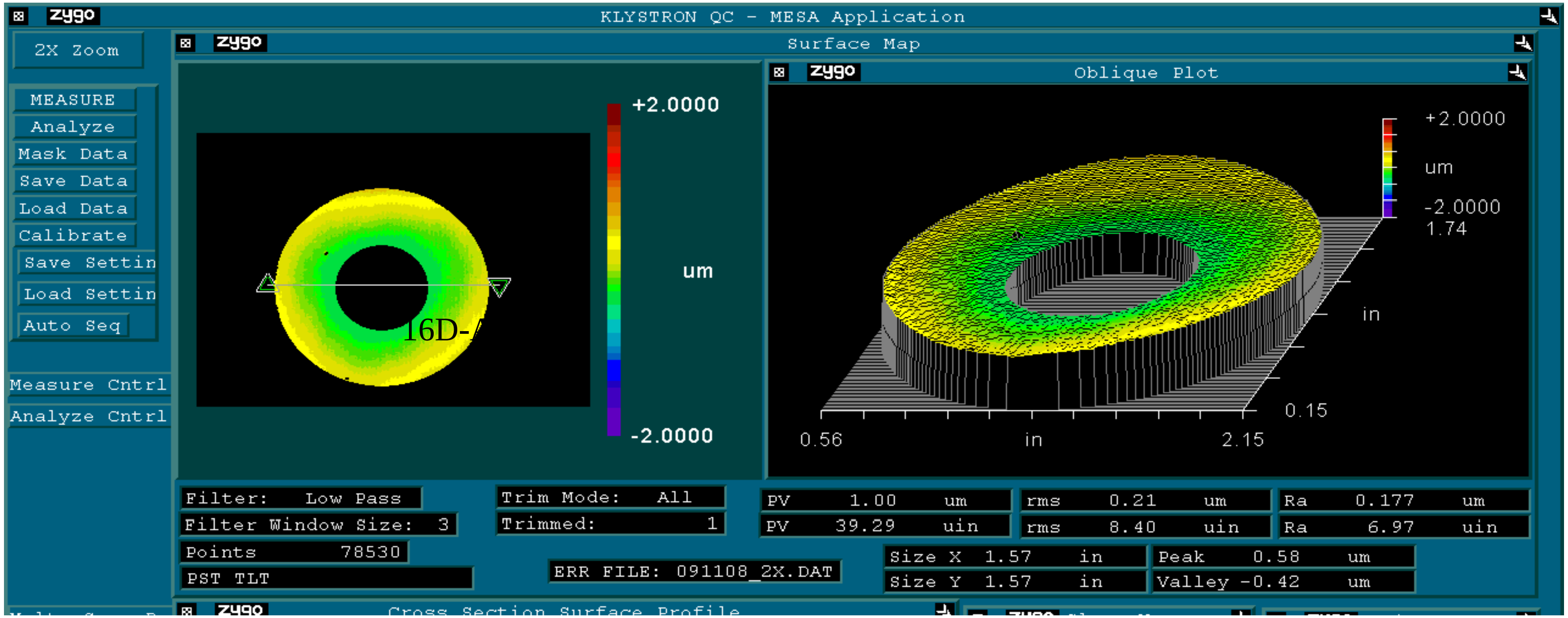
Structure Fabrication Status, SLAC

Juwen Wang

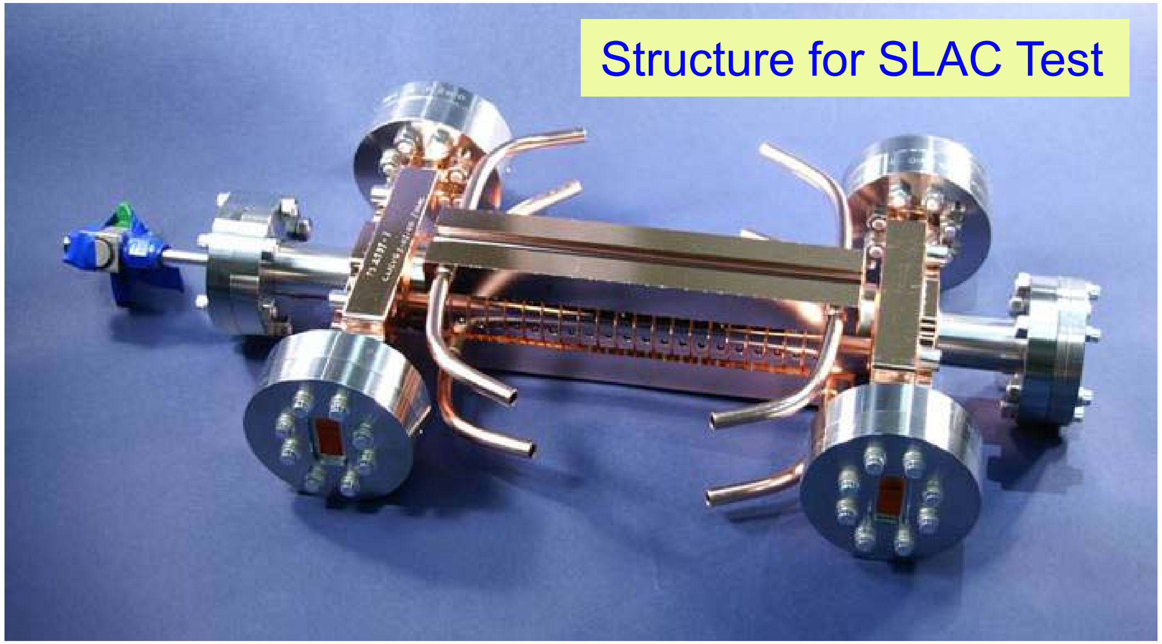
SLAC National Accelerator Laboratory

ZYGO Surface Flatness Measurement for a Typical Cell of T18_VG2.4_DISC

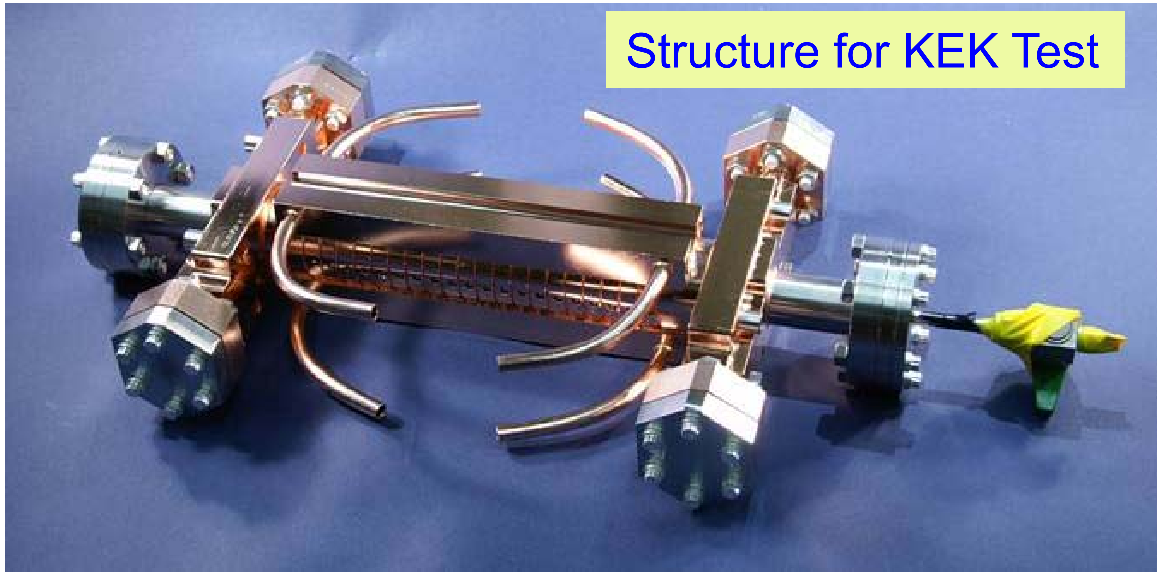
Surface < 1 micron Concaved



Two T18_VG2.4_DISC Structures

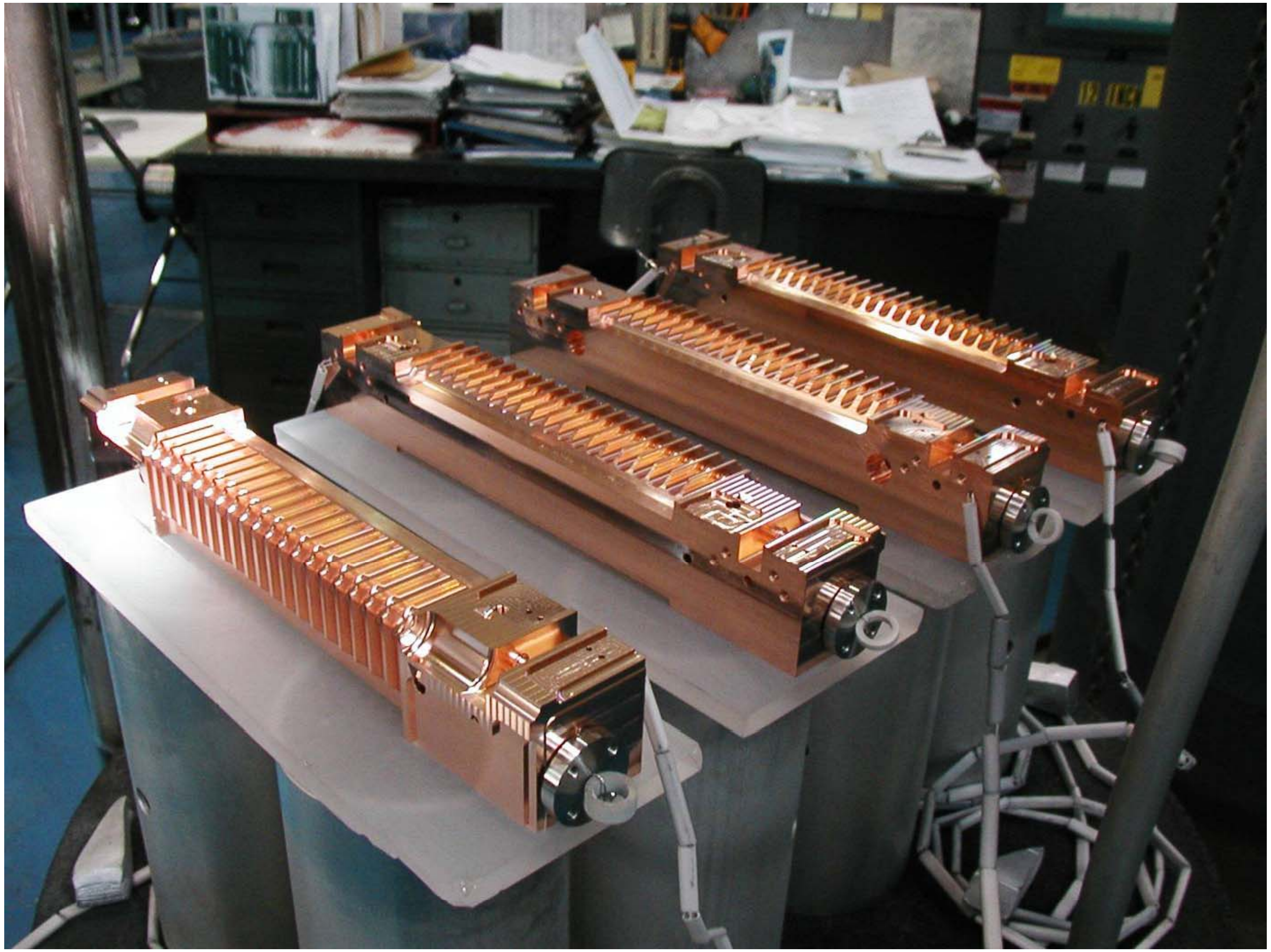


KEK Built Cells
Assembled at SLAC



Setup to Braze SLAC Built T26 Structure

Doing Final Assembly of CERN Built Quad Structure



Germana Checking Alignment of KEK Structure Prior to Brazing at SLAC

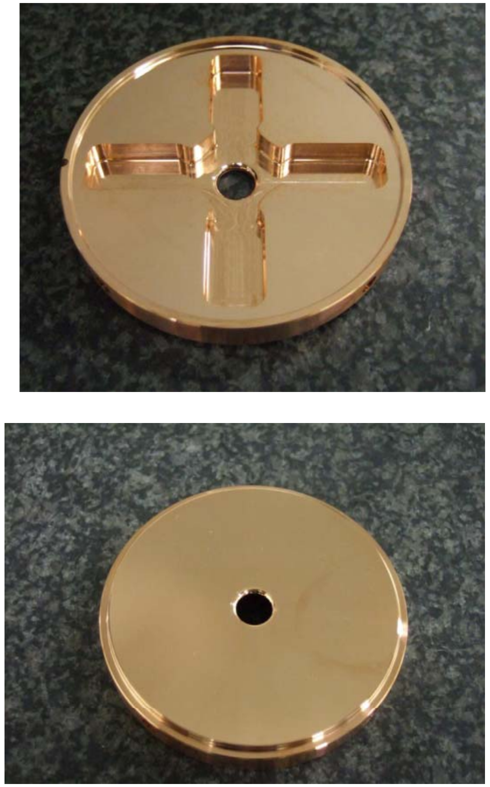
Structure Fabrication for CLIC

CLIC08,

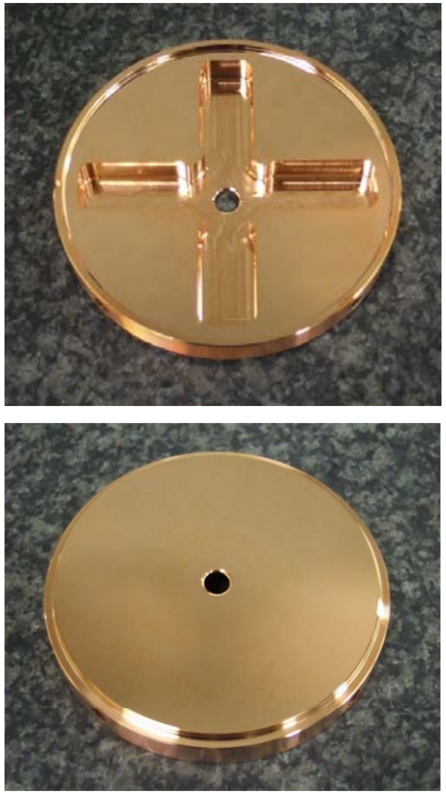
Oct. 14-17, 2008

T. Higo, KEK

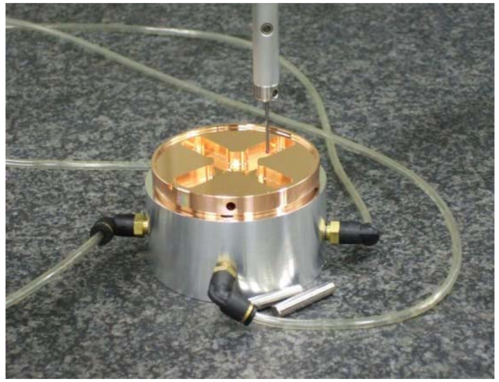
TD18_VG2.4_Disk Fabrication Test



Cell #1



Cell #19

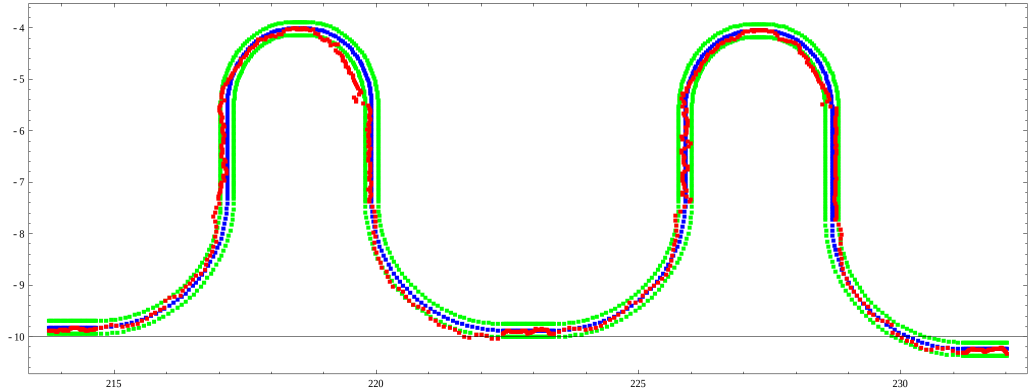


Most concerns are
- Dimension
- Flatness

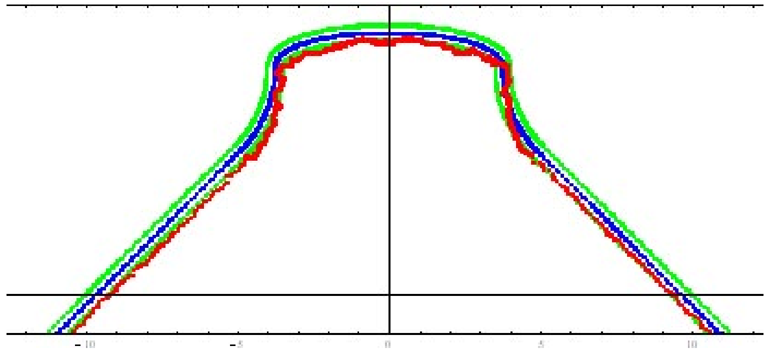
Developing Vendors in Japan to Build Quadrant Structures

Measured w.r.t. A-B-C reference planes. Green lines are ±2.5 microns.

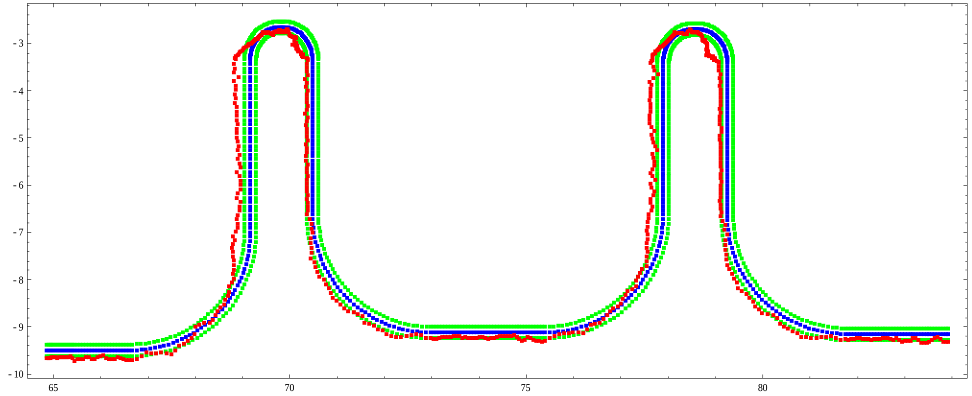
KUM data = NWDSQ7.csv



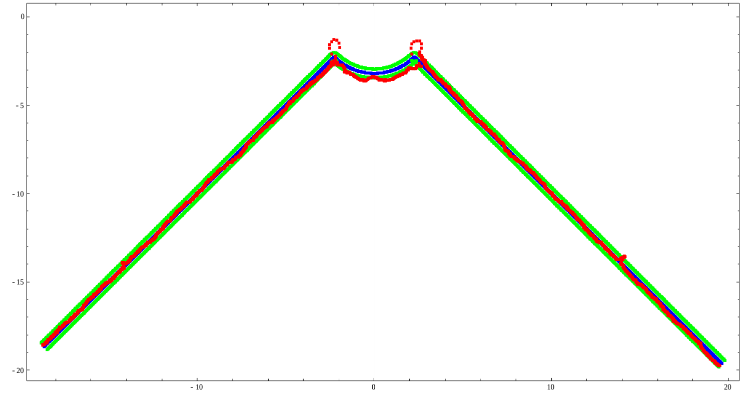
KUM data = NWDS13.csv



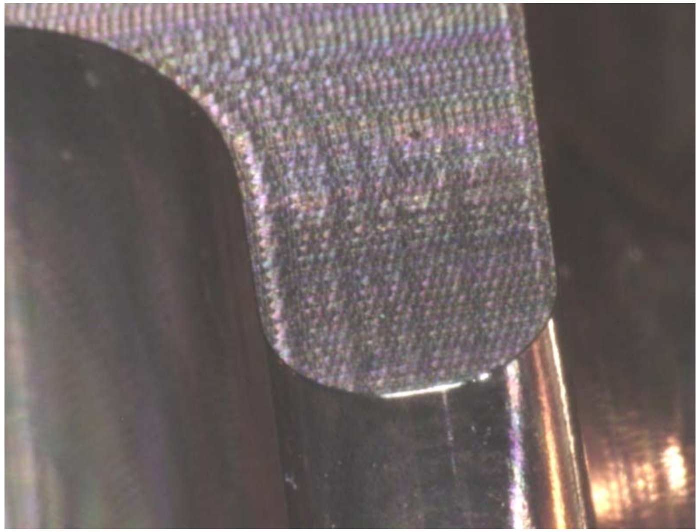
KUM data = NWDS10.csv

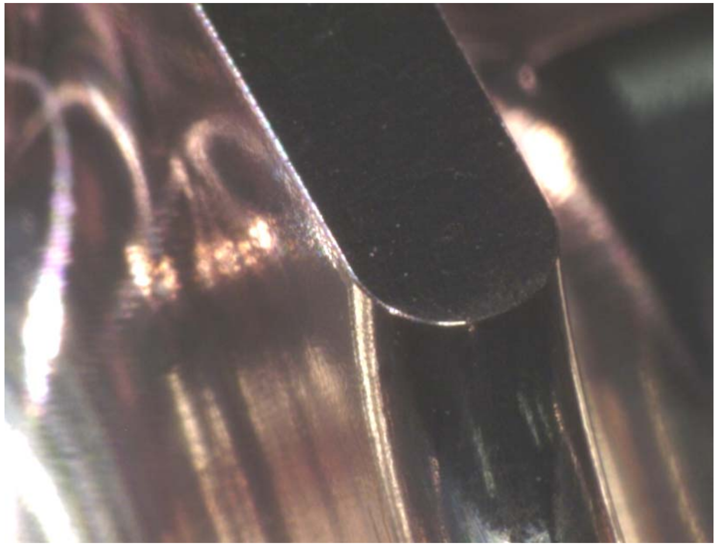


KUM data = NWDS17.csv

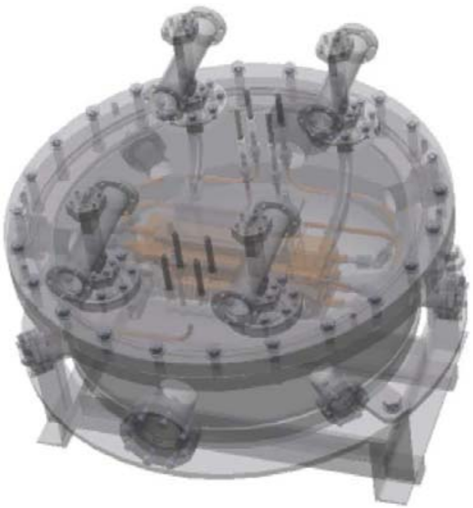


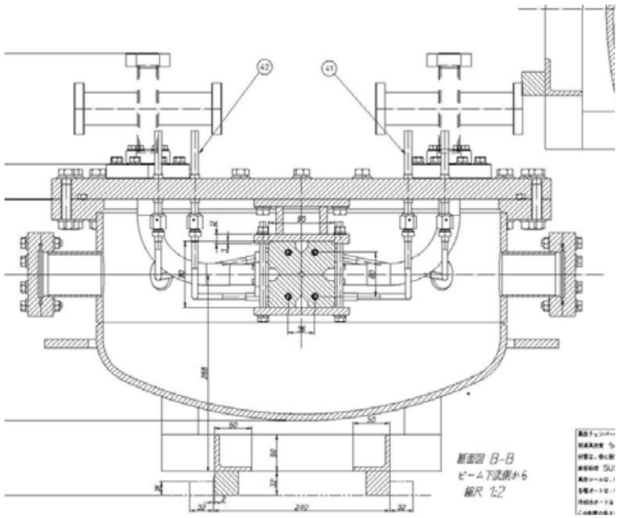
Milled Surfaces





Vacuum Can

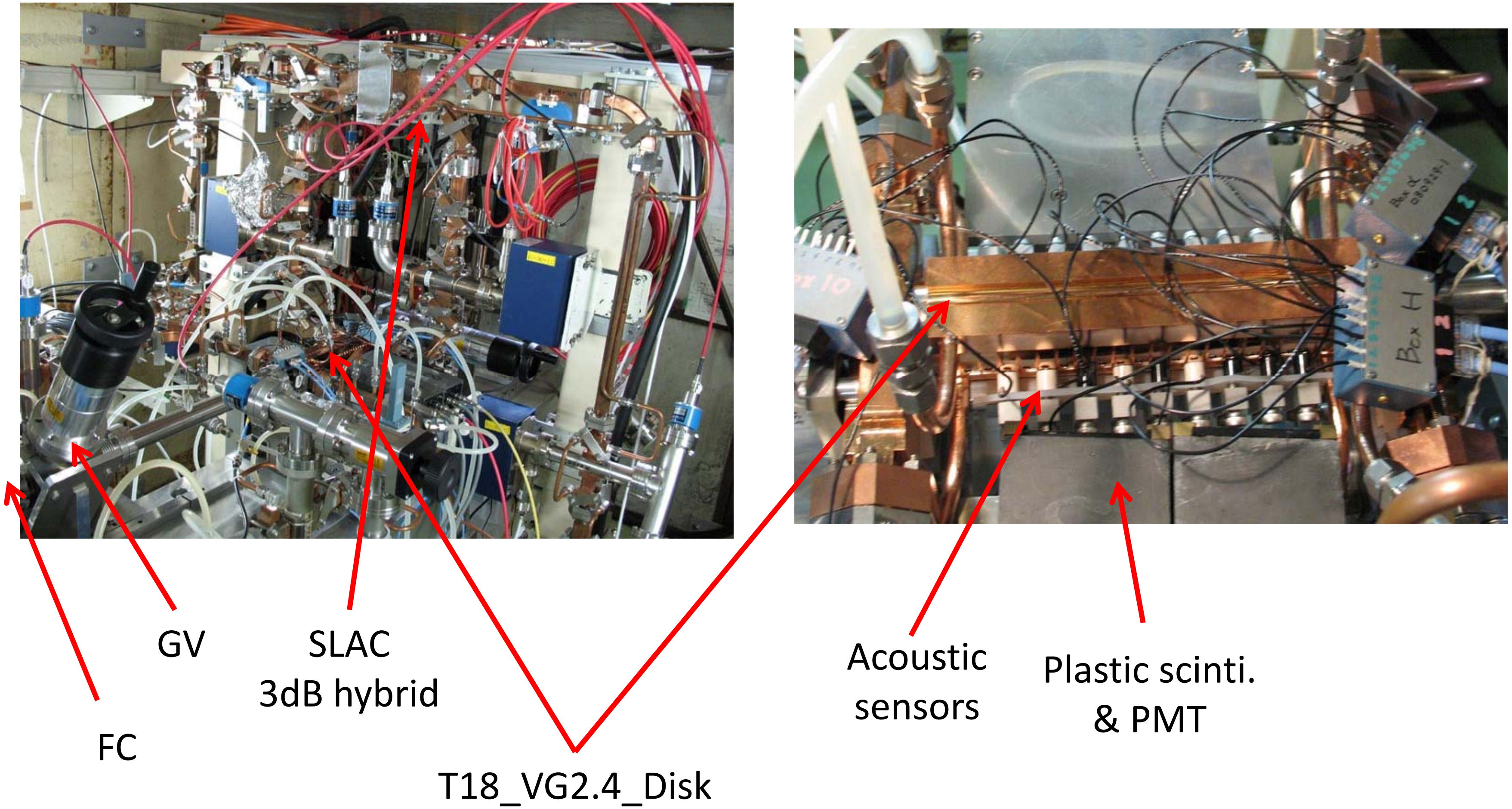




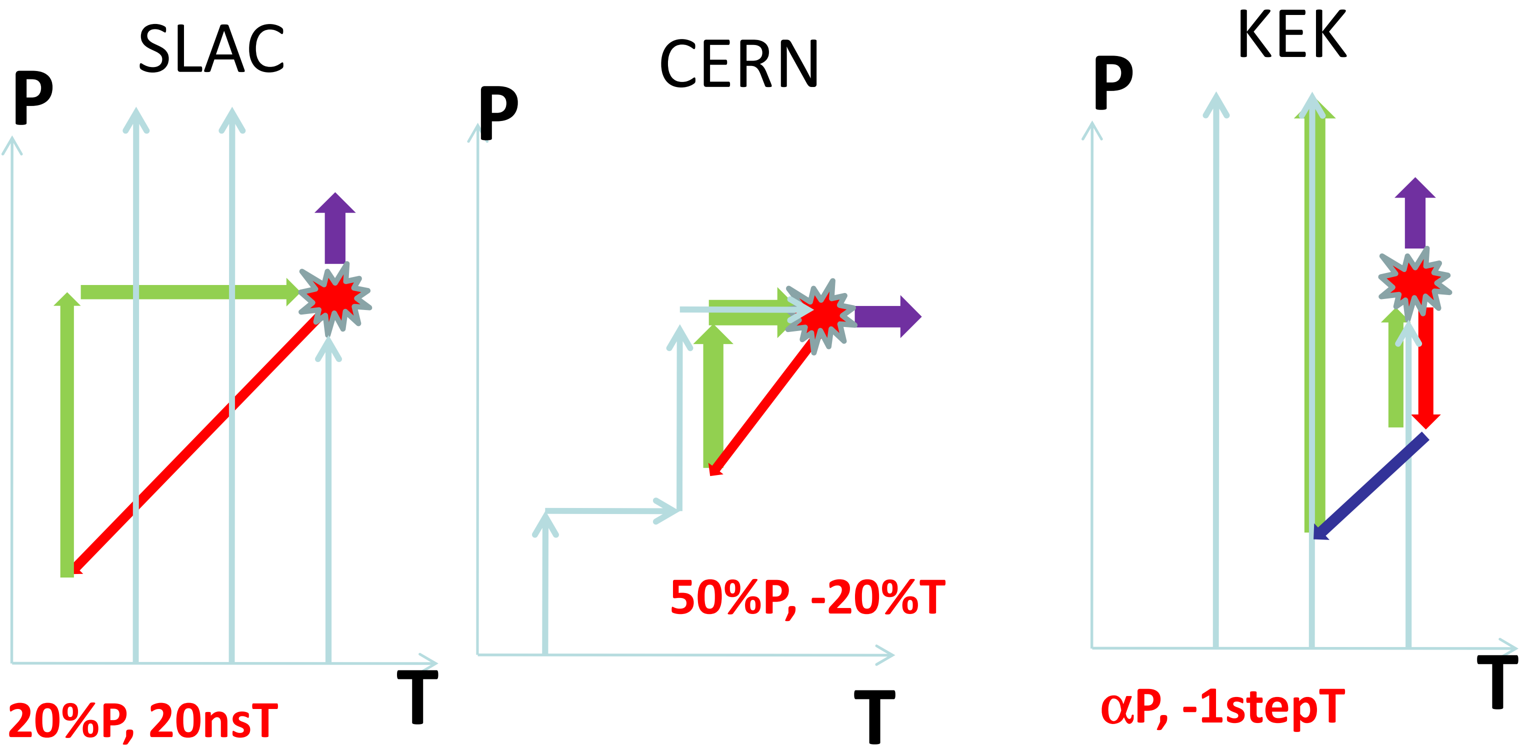
KEK Structure Test Program

Toshi Higo

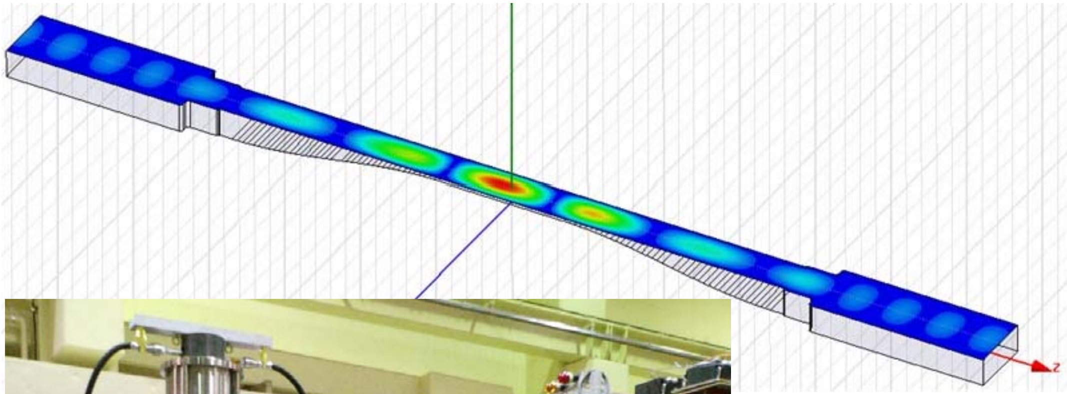
Started Processing T18_VG2.4_Disk #2 Recently
(up to 60 MV/m with 50 ns pulses)



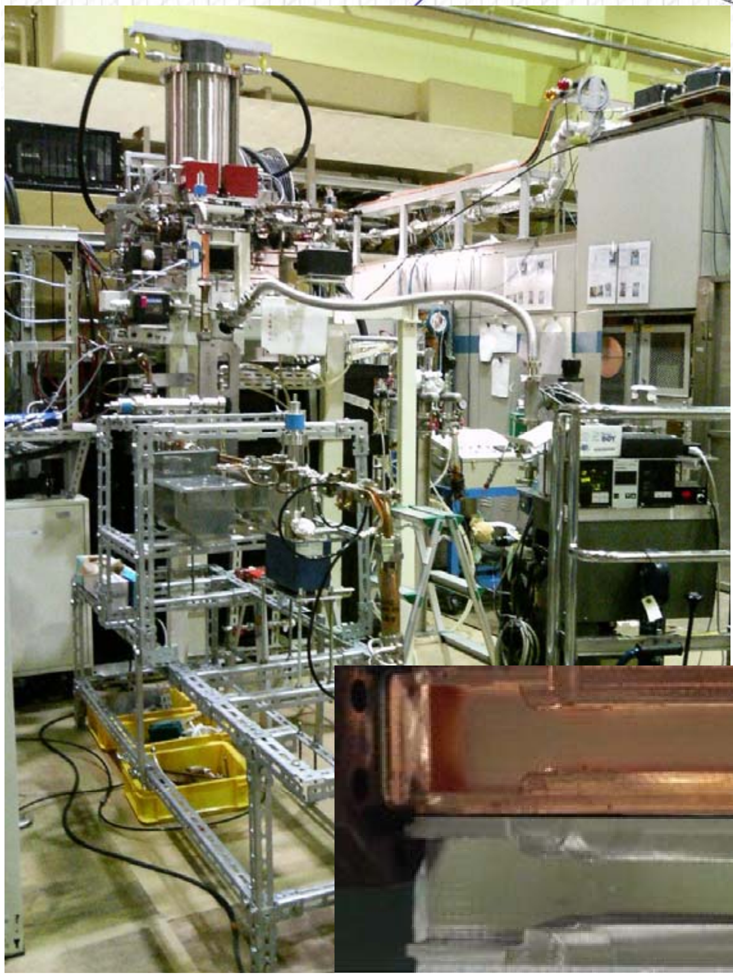
Breakdown Recovery Procedure in (T = pulse width, P = power) Space

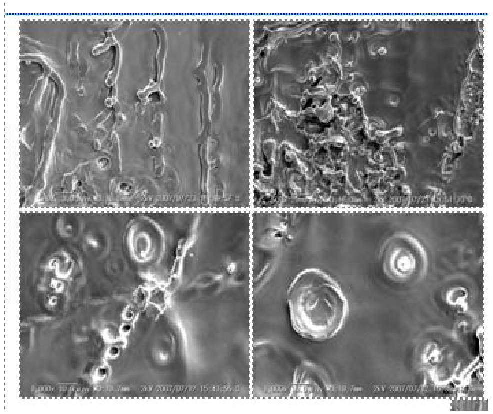


Basic High Gradient Study at KEK

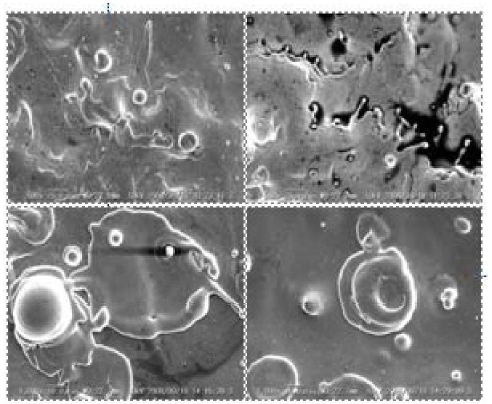


Yokoyama presentation at
LINAC08

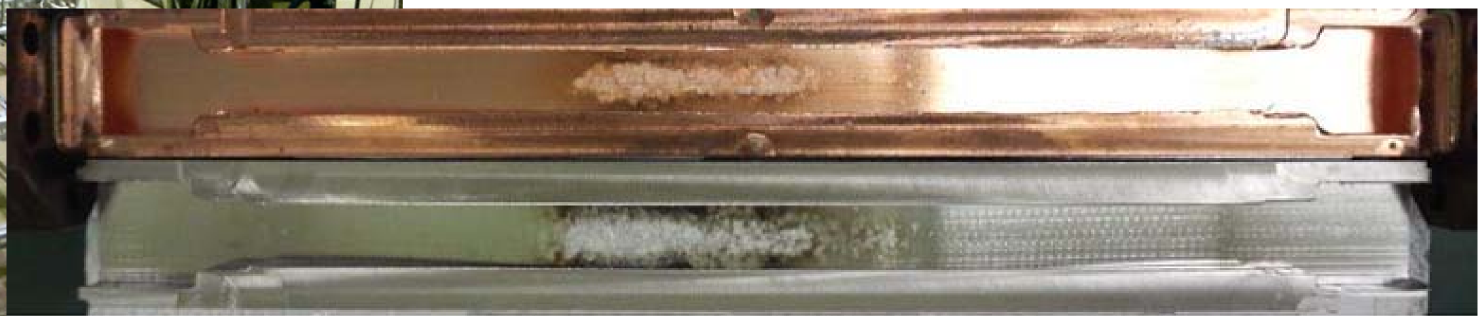




Cu: 20 MW, 400 ns

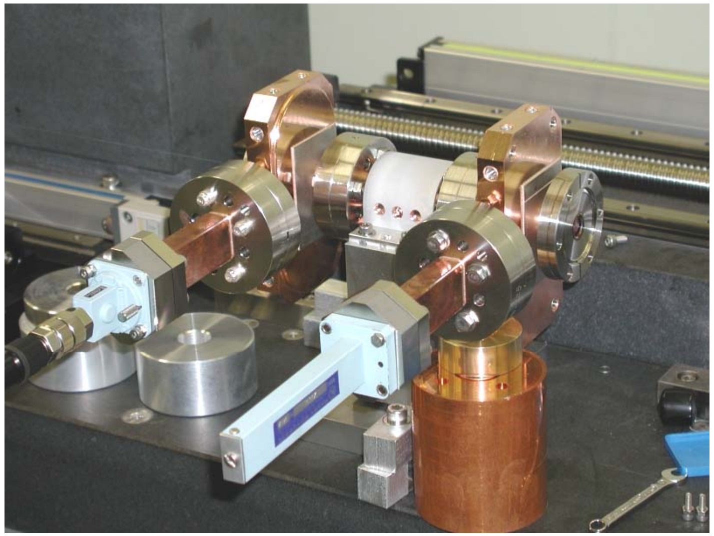


SS: 50 MW, 400 ns



SLAC High Gradient Studies
Sami Tantawi

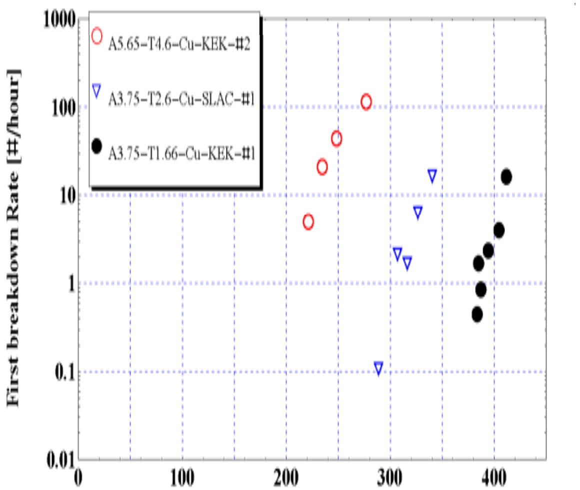
- Basic Physics Experimental Studies
  - Single and Multiple Cell Accelerator Structures (with major KEK and CERN contributions)
    - traveling- wave single cell accelerator structures – 12 tests completed
    - single-cell standing-wave accelerator structures (Performed at Klystron Test Lab)
  - Waveguide structures
  - Pulsed heating experiments (Performed at the klystron Test Lab, also with major KEK and CERN contributions)
- Full Accelerator Structure Testing (Performed at NLCTA, with CERN and KEK contributions)



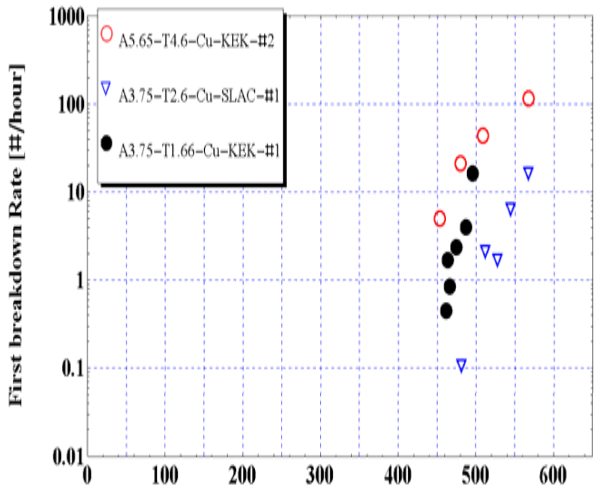
Geometrical Studies with Single Cells

3 different single cell structures: Standing wave structures with different iris diameters and shapes; a/λ=0.21, a/λ=0.14 and a/λ=0.14 and elliptical iris.

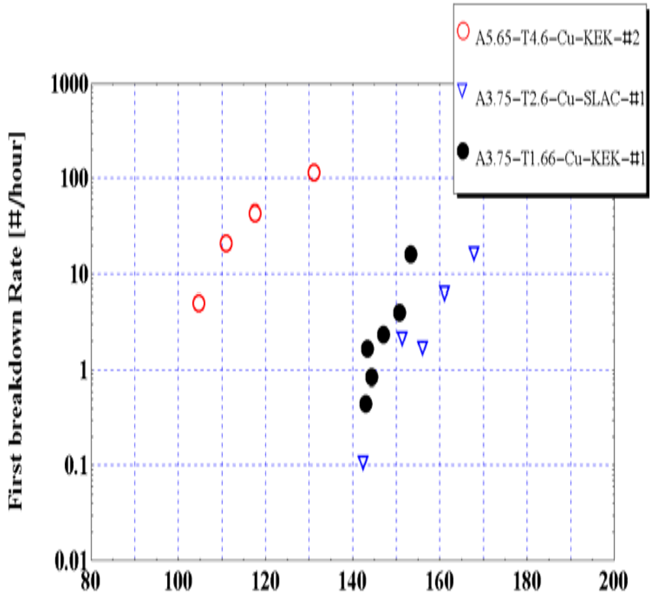
Global geometry plays a major role in determining the accelerating gradient, rather than the local electric field.



Maximum surface electric fields [MV/m]

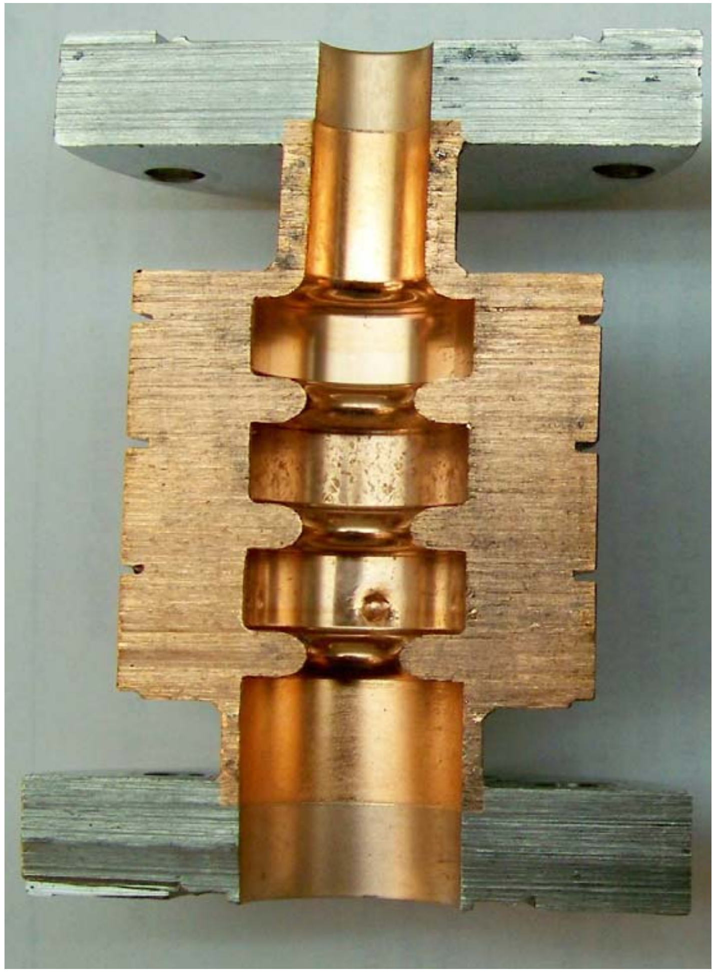


Maximum surface magnetic fields [kA/m]

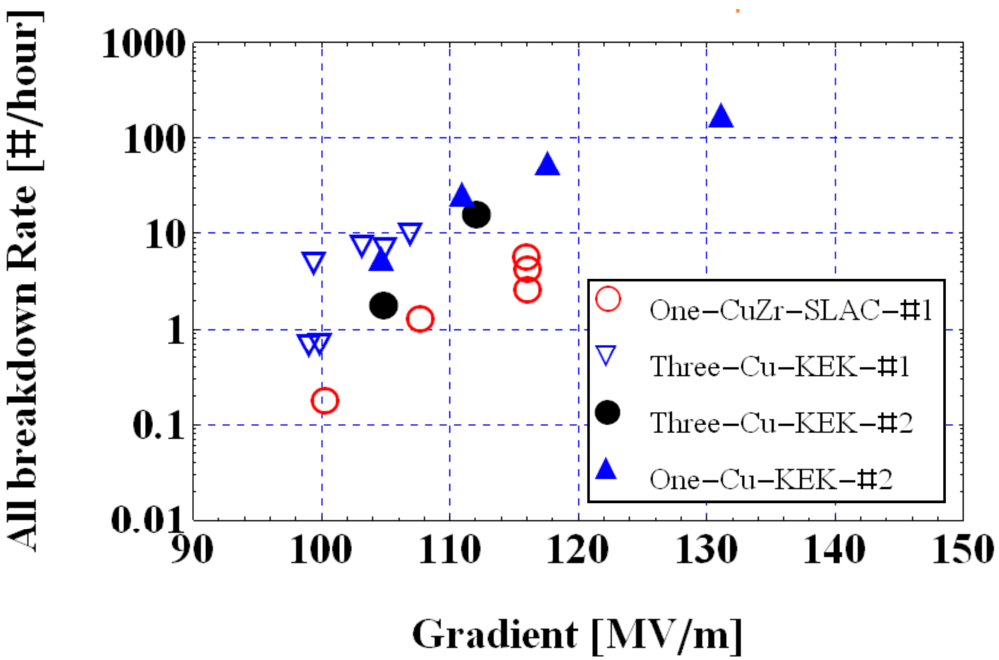


Accelerating fields [MV/m]

First Test of a CrZr ‘Single Cell’ Structure



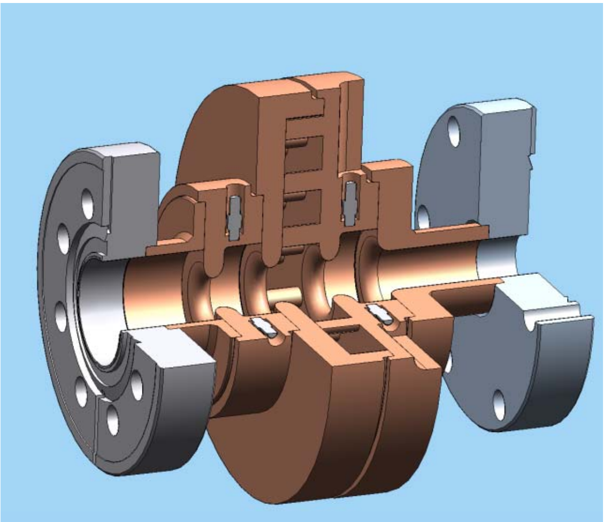
Preformed better than Copper Version



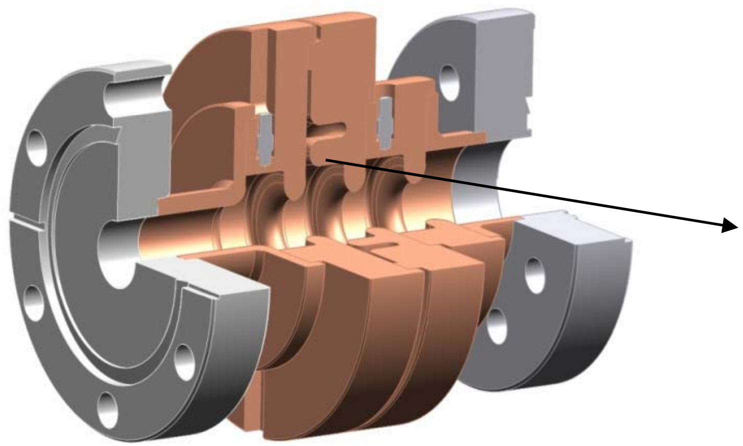
V.A. Dolgashev, 26 September 2008

Structure Modifications for Wakefield Damping

- CERN is pursuing side slotted structures (to be tested soon at NLCTA)
- MIT PBG Structure (Mechanical Design Done, submitted to shop)
- Choked structures has been manufactured and is currently under test.
- Side fed structures will pave the way to parallel fed structures with gradients above 140 MV/m (currently being manufactured)
- Other methods of damping are being studied theoretically.



PBG Structure



Choke Structure

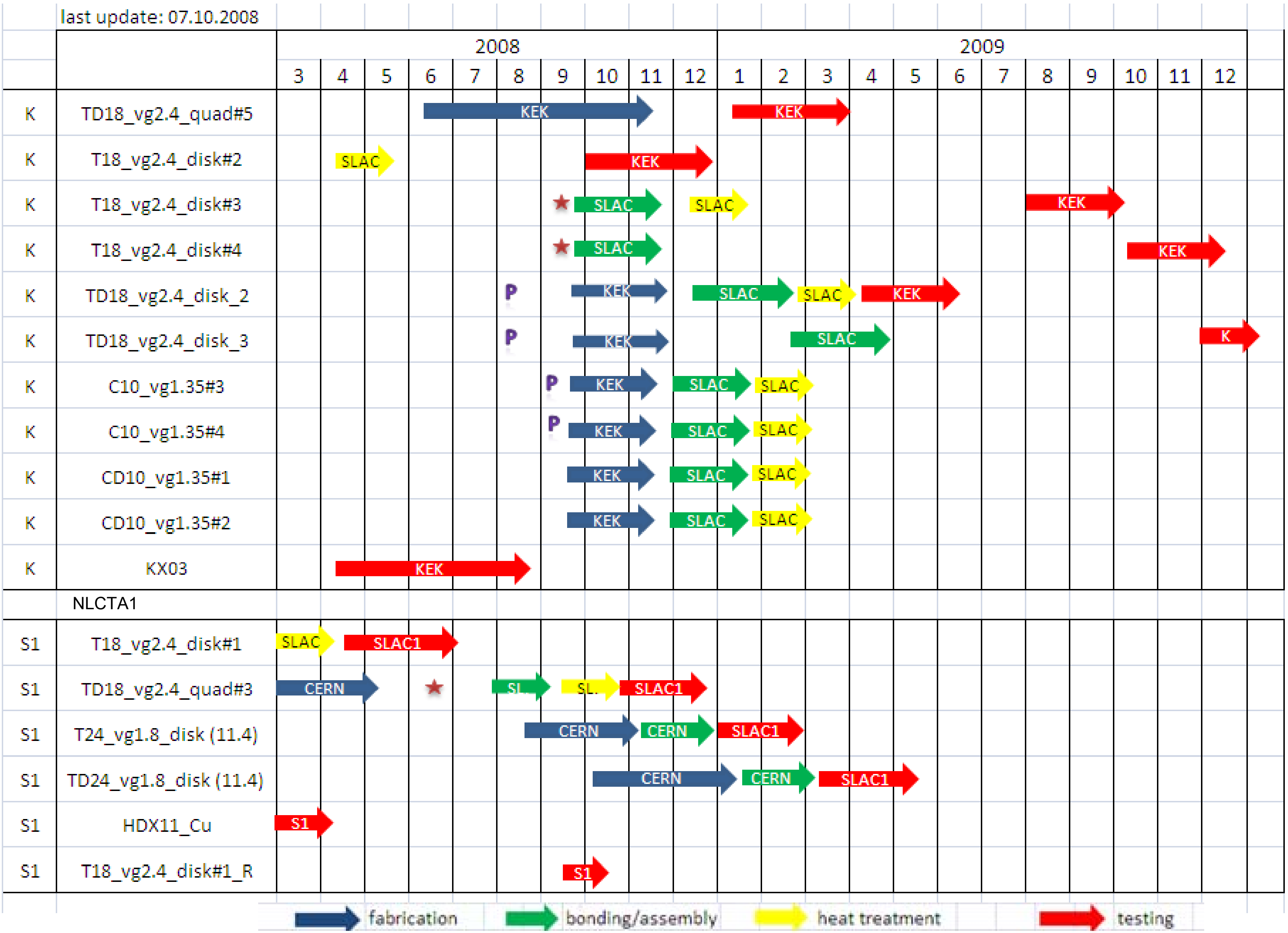
Choke Surface Damaged

CLIC X-band Structure Tests at NLCTA

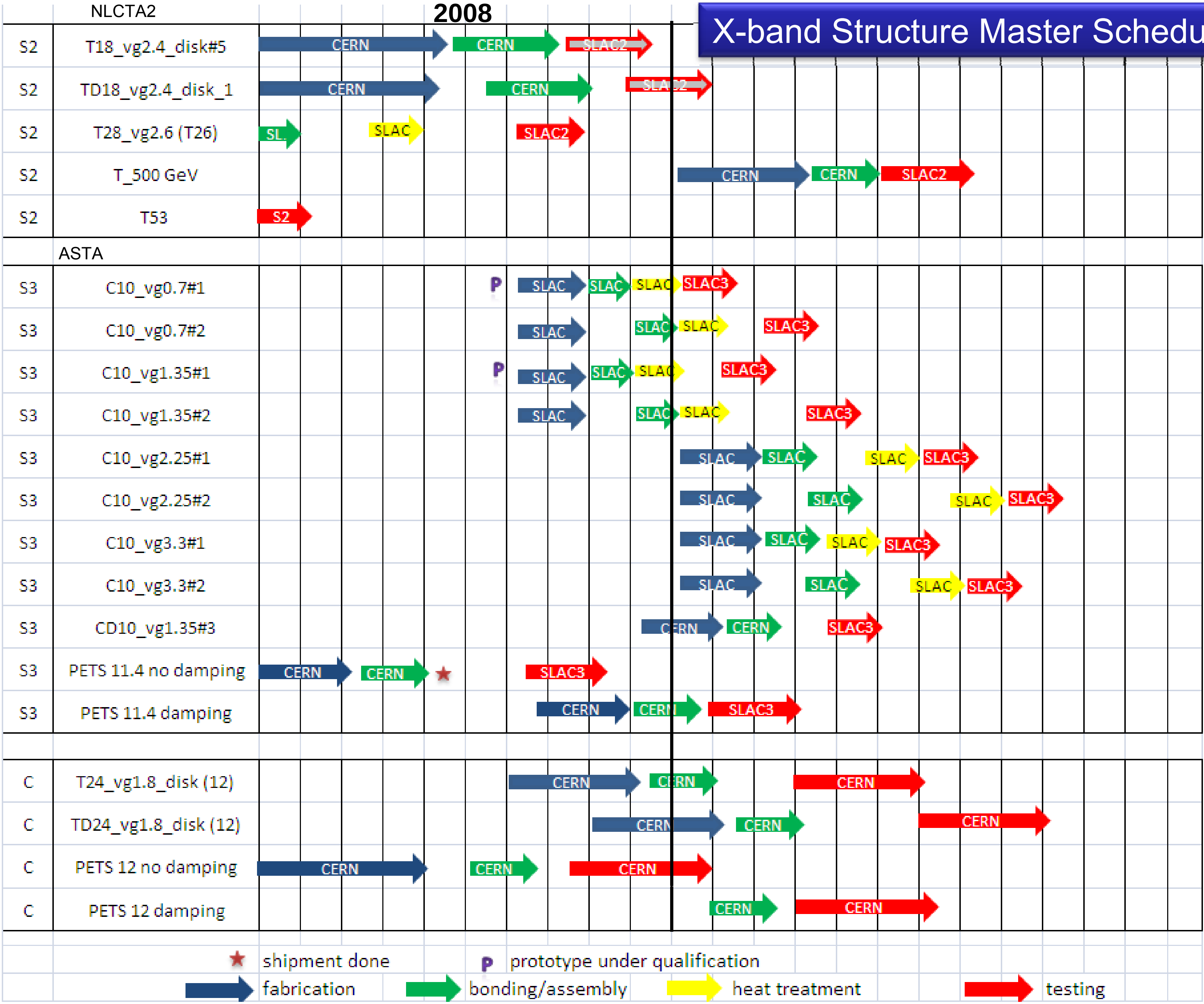
Chris Adolphsen

- T18 (a/λ = 0.13) has preformed well (bkd rate ~ 1e-6/pulse/m at 106 MV/m with 230 ns pulses after 1400 hours) but hot cell turned on after 800 hrs of processing
  - T53 (a/λ = 0.13) had a similar rate at 106 MV/m, but with 100 ns pulses
  - For CLIC, structure efficiency too low and damping needs to be added
- The bkd rate of T18 operated backward (a/λ = 0.10 for last cell) at 163 MV/m, 80 ns similar to single a/λ = 0.14 SW cell
- T26, which has every other cell as T53, performs poorly relative to T53 (~ 100 times bkd rate at 106 MV/m, 100 ns) for reasons unknown

X-band Structure Master Schedule 1

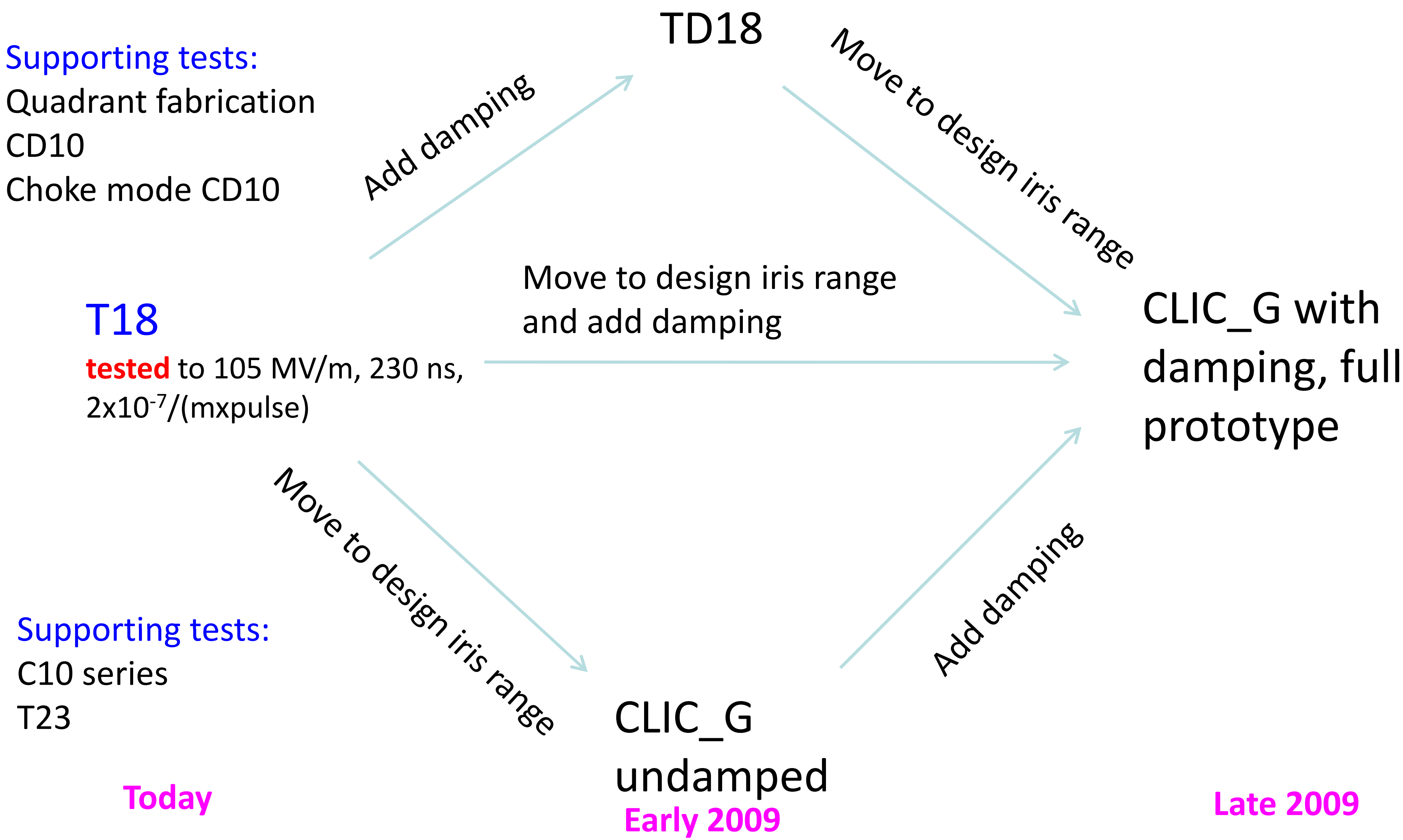


X-band Structure Master Schedule 2



The path to the CLIC full-structure feasibility demonstration

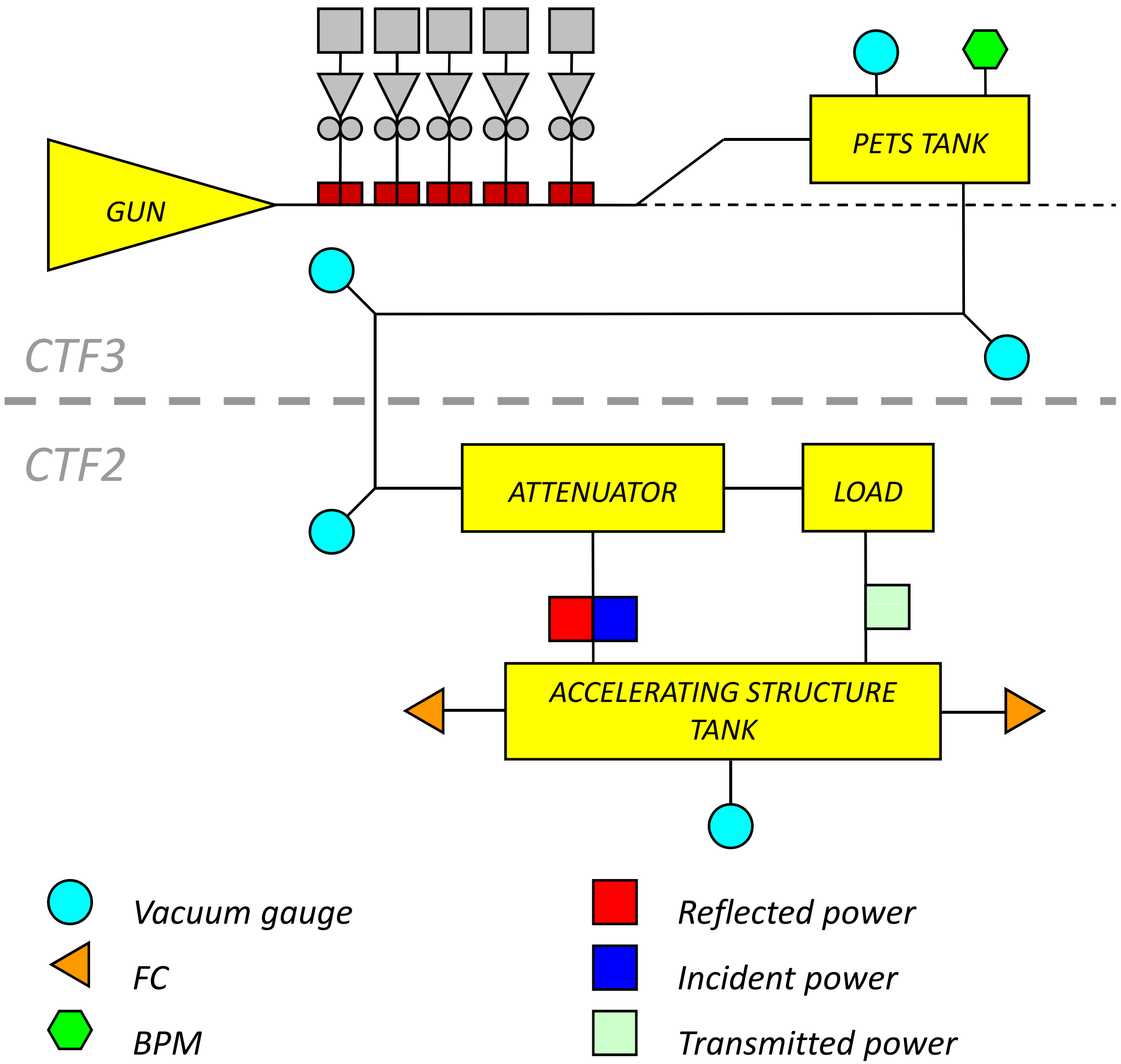
Move from achieved result with simplified structure to fully equipped, higher efficiency structure



W. Wuensch

30 GHz Structure Conditioning

Alexey Dubrovskiy



Checks:

- Gun
- Missing energy
- Reflected energy
- FC signal
- Vacuums
- Gun inhibitor
- Loss

Control:

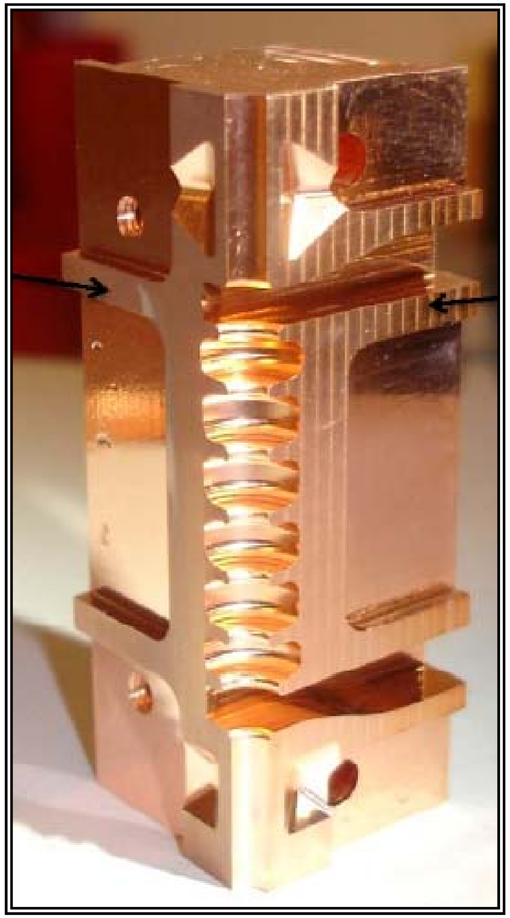
- Gun
- Attenuator
- Pulse length

Summary of 30 GHz Results

Steffen Doebert

All measured data at 70 ns pulse length and 10^{-3} breakdown rate

Structure	a/λ	P (MW)	E (MV/m)
C30vg4.7	0.175	21.0	94
HDS60vg8.0	0.190	16.1	61
HDS60vg5.1	0.160	13.3	75
C40vg7.4_pi/2	0.200	19.2	65
HDS4vg2.6_thick	0.175	7.5	67
NDS4vg2.5_thick	0.175	8.6	75
C30vg4.7_sb	0.175	20	92



Round brazed structures show better performance

Pulse Heating Experimental Testing at SLAC

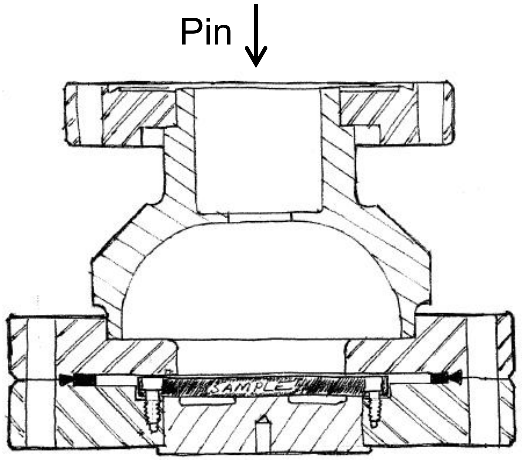
Lisa Laurent

SLAC Klystron Dept: L. Laurent, J. Eichner, E. Jongewaard, C. Pearson, C. R. Tally, B. Vanderzyl, Yoneda, J. Zelinski

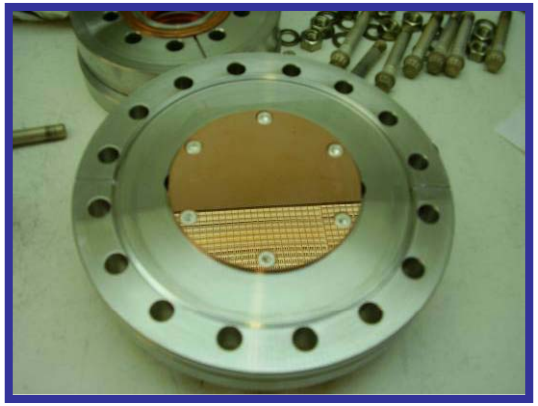
SLAC: V. Dolgashev, J. Lewandowski, S. Tantawi, D. Yremian

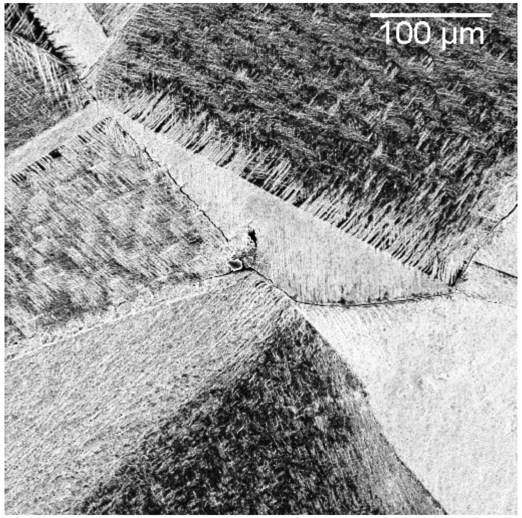
CERN: S. Heikkinen

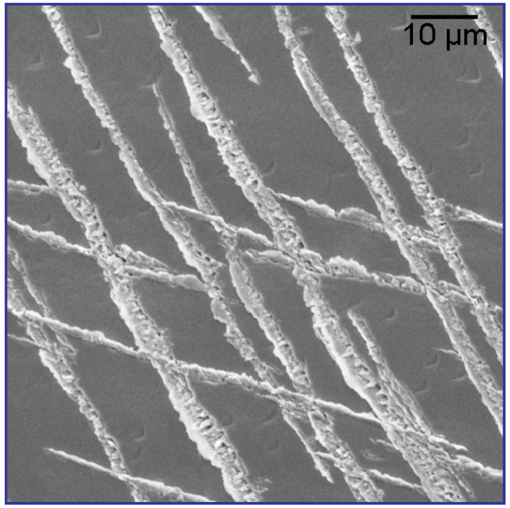
KEK: Y. Higashi



3-inch diam. pulse heating sample

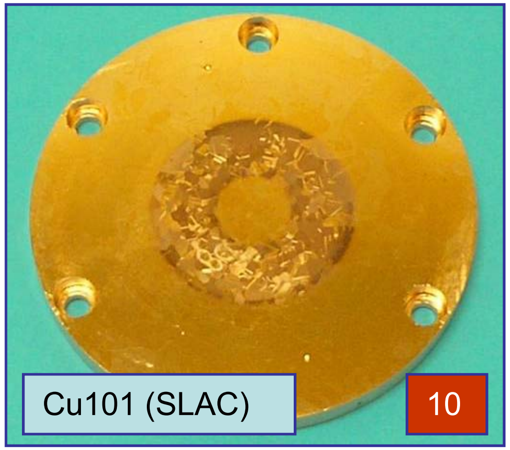


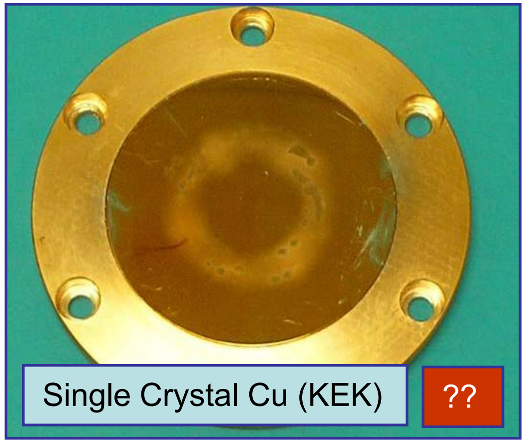


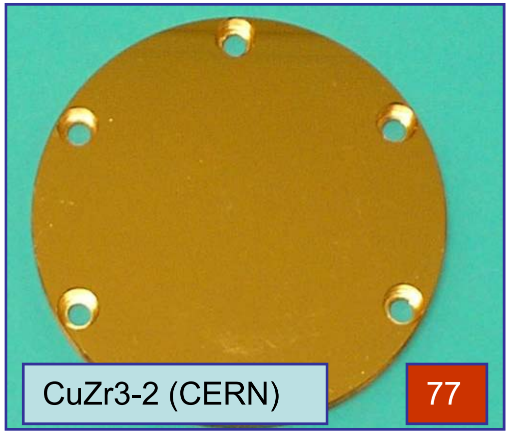


Pulse Heating Samples RF Tested

May 2008 – September 2008



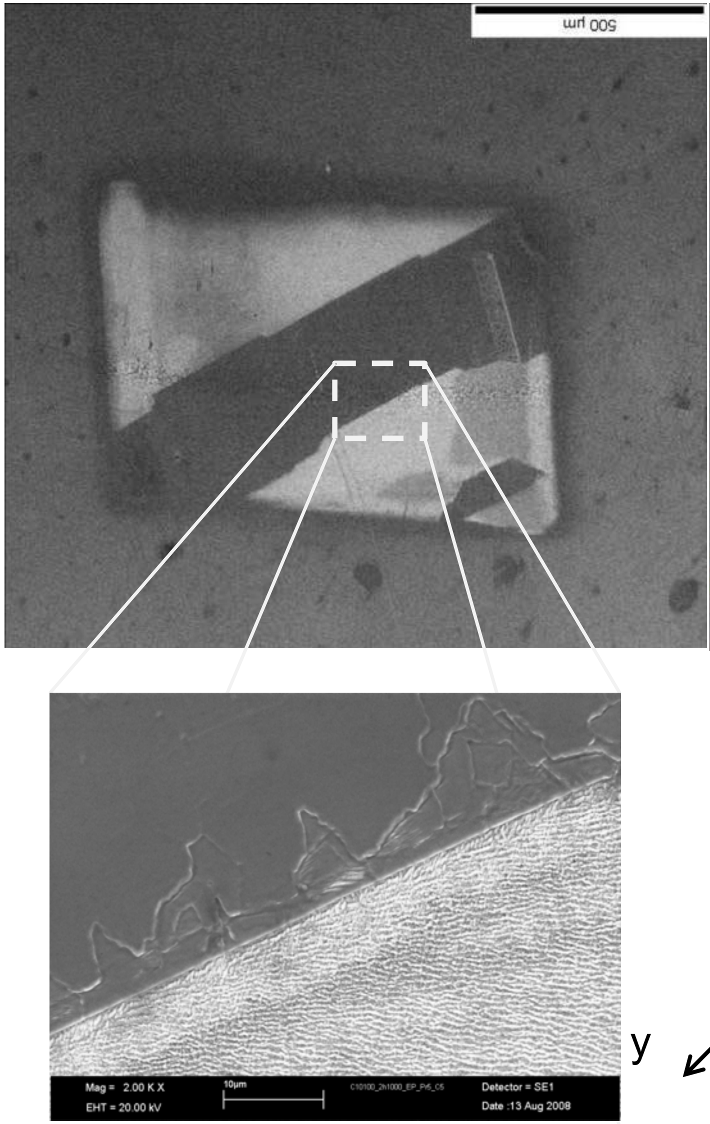


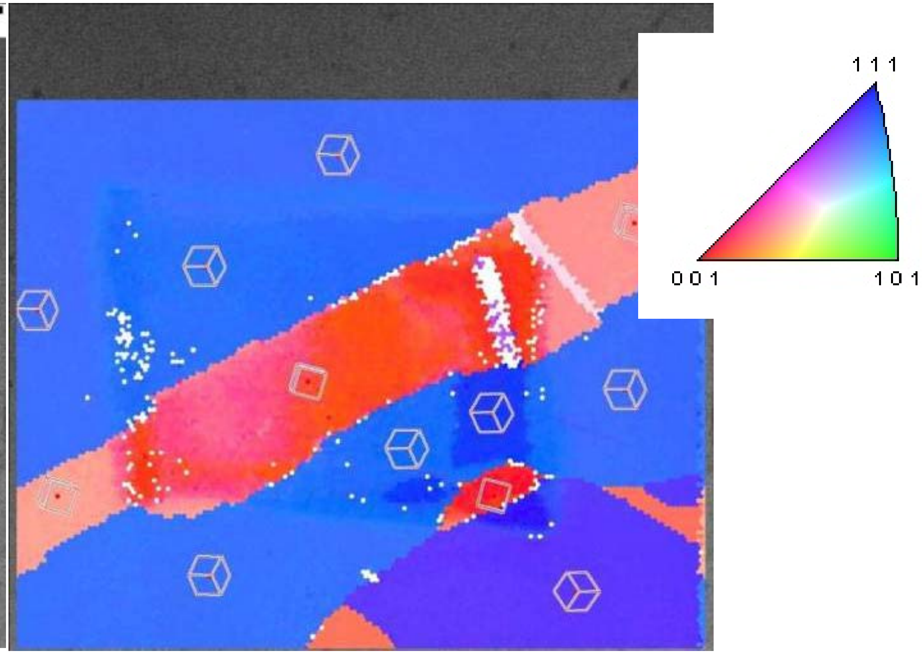


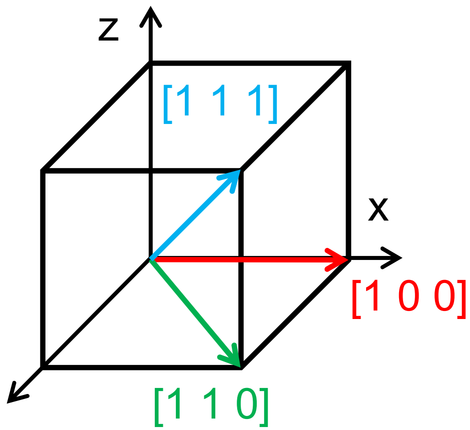
Hardness Test Value

Thermal Fatigue Behavior Versus Grain Orientation

Markus Aicheler





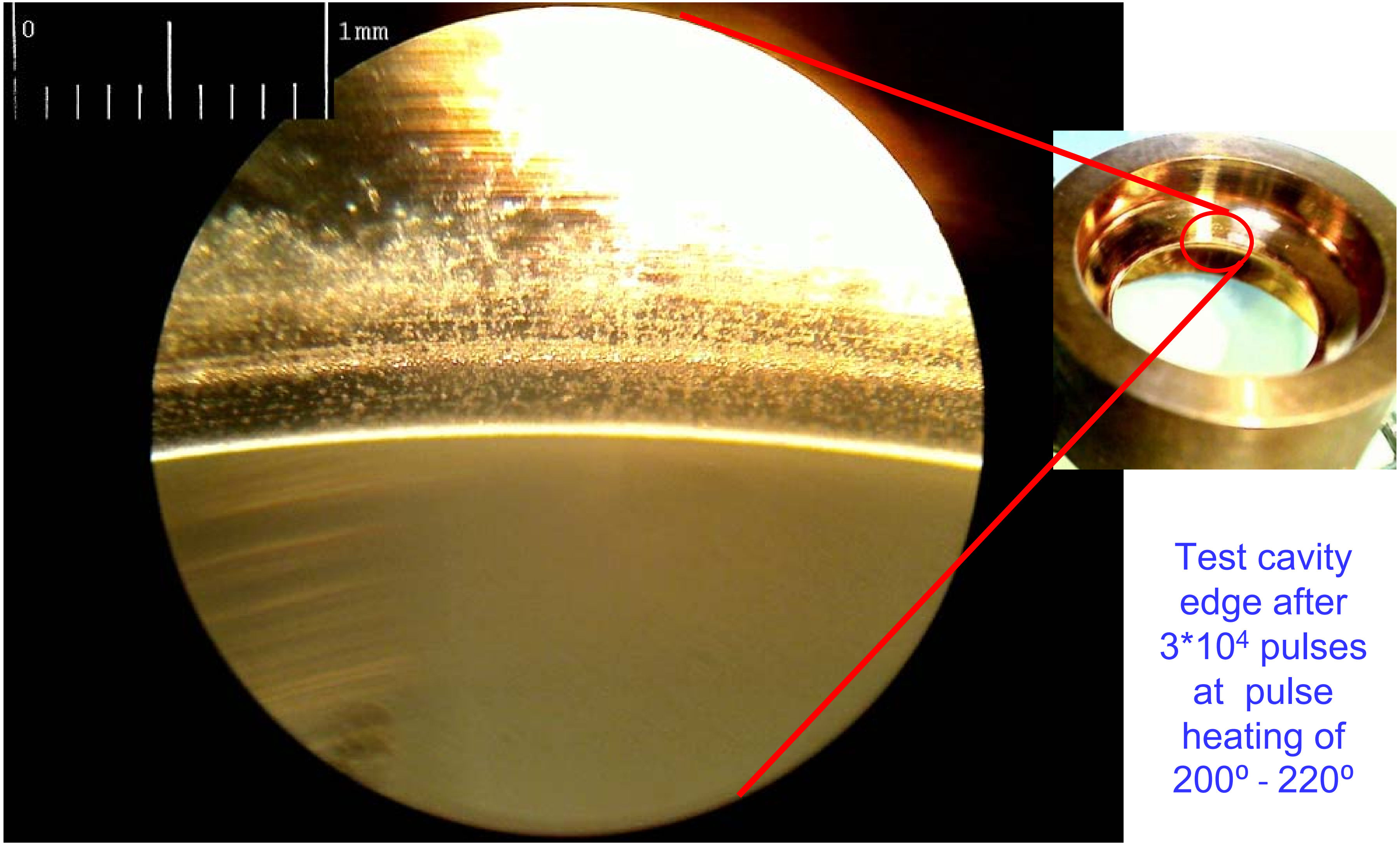


[1 1 1] (blue) direction
high developed
fatigue features

[1 0 0] (red) direction
less developed
fatigue features

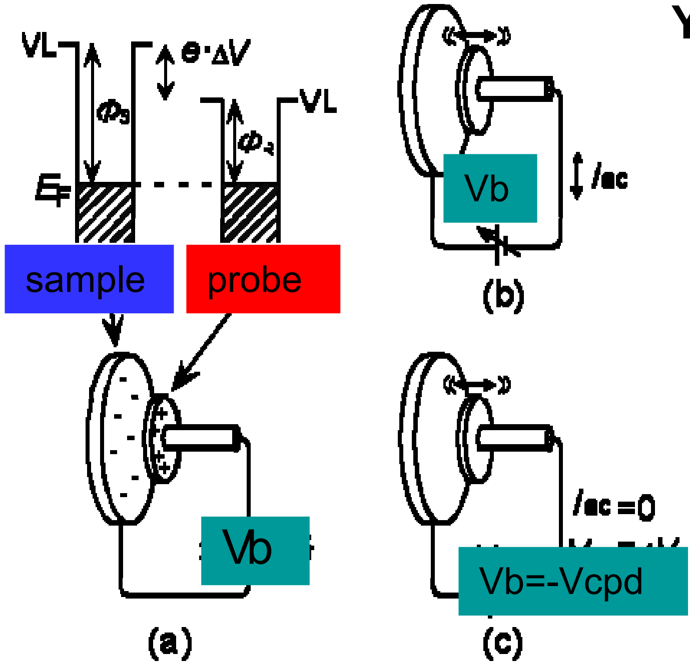
CLIC08 Workshop

Sergey Sedykh



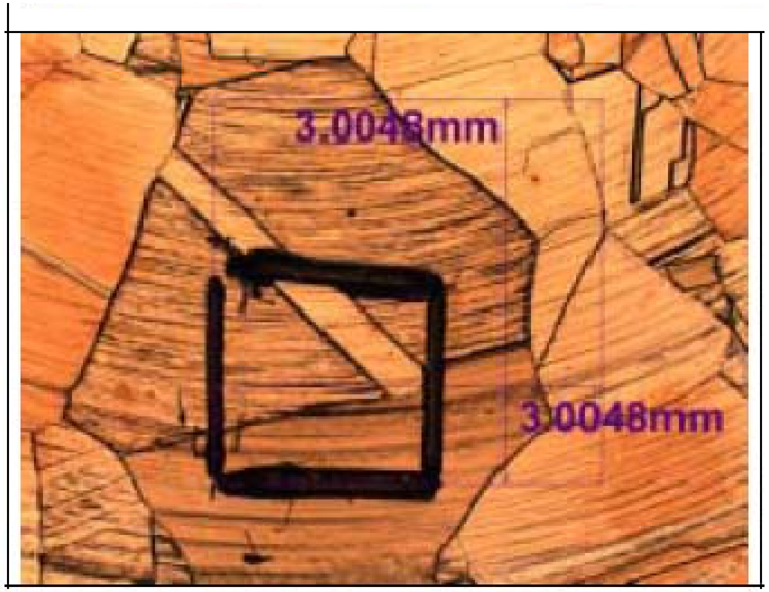
Test cavity edge after $3*10^4$ pulses at pulse heating of 200º - 220º

Work function Measurement using Kelvin Techniques

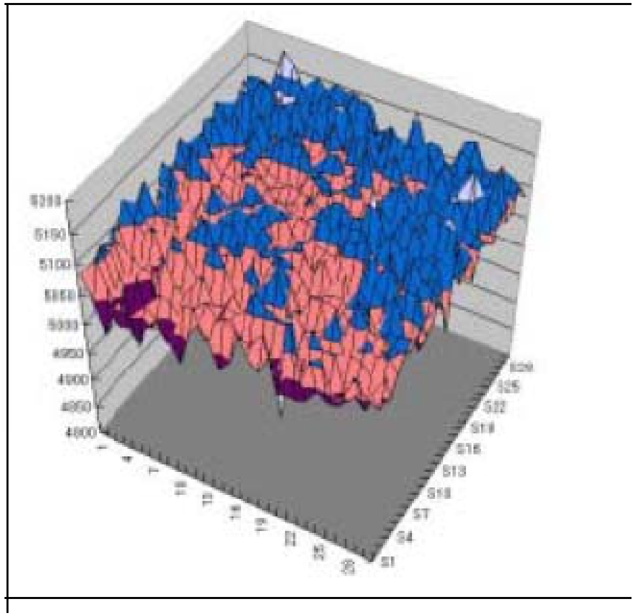


Y. Higashi

Measuring conditions	
-Probe dia.	0.3mmϕ
-Material /WF	Au /5.28eV
-Scanning	100µm pitch
-Area	3mmx3mm
Sample	including grain boundaries



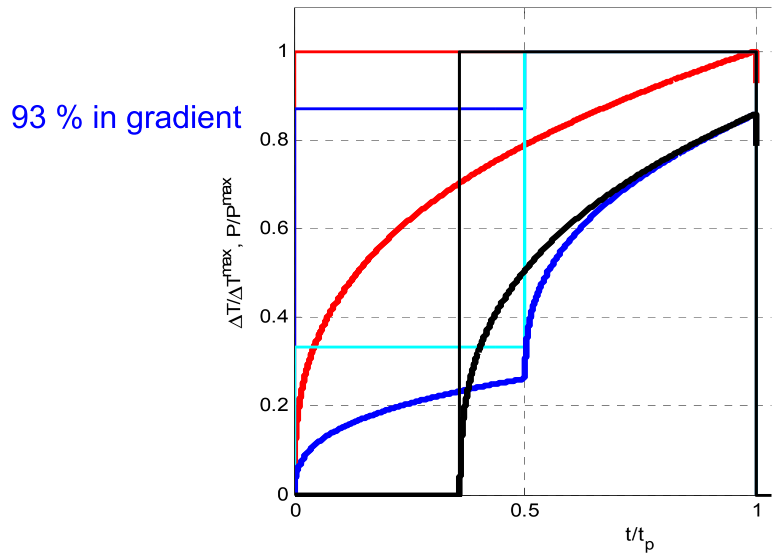
Measured Work Function

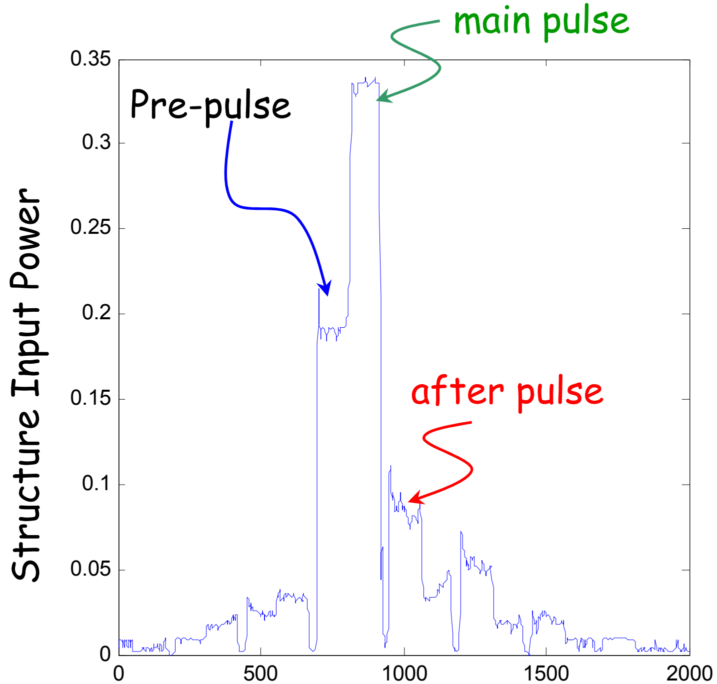


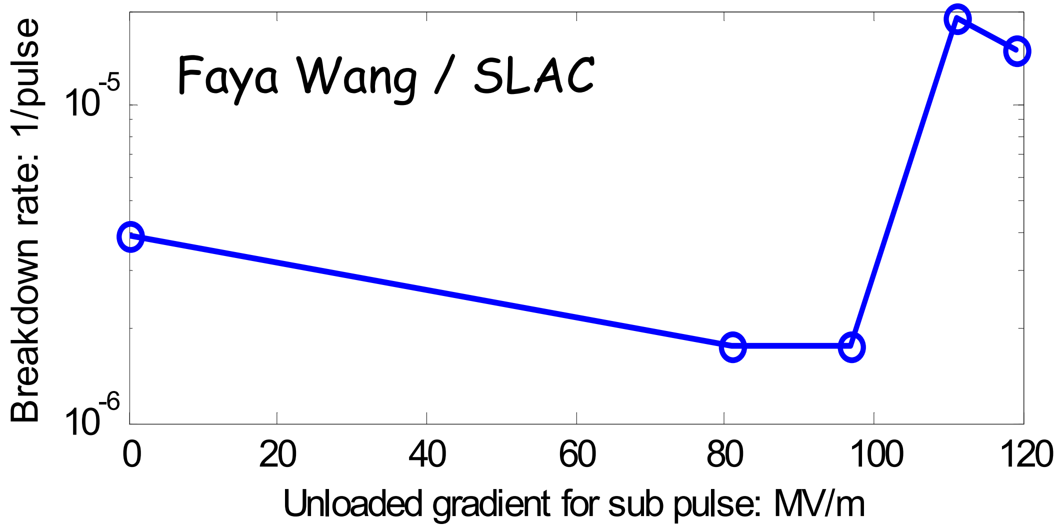
Dependence of the Breakdown Rate on Pulse Shape

Alexej Grudiev

- *No influence on BDR for gradients below 80%*
- *Strong influence on the BDR for gradients above 90%*
- *Very good agreement with SLAC data*







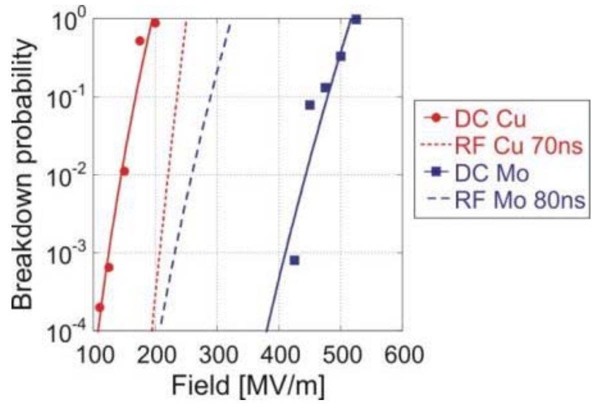
DC Spark Test Results

Antinone Descodudres

- Various metals and alloys have been tested
  - ➢ breakdown field : Cu (180 MV/m) < Mo (400 MV/m) < Stainless Steel (830 MV/m)

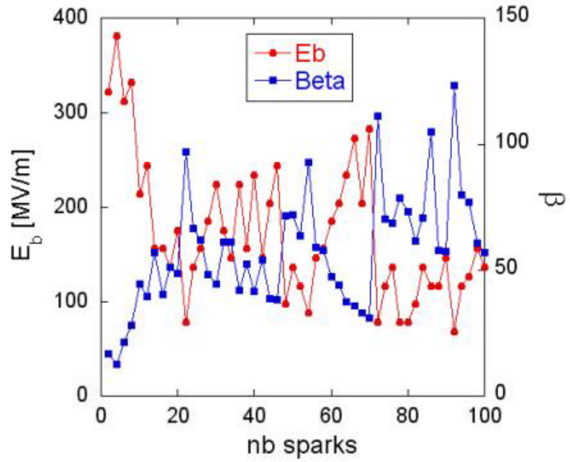
- Surface treatments of Cu affects only the very first breakdowns

- DC Breakdown Rate measurements are possible →
  - ➢ Similar behaviour as in RF

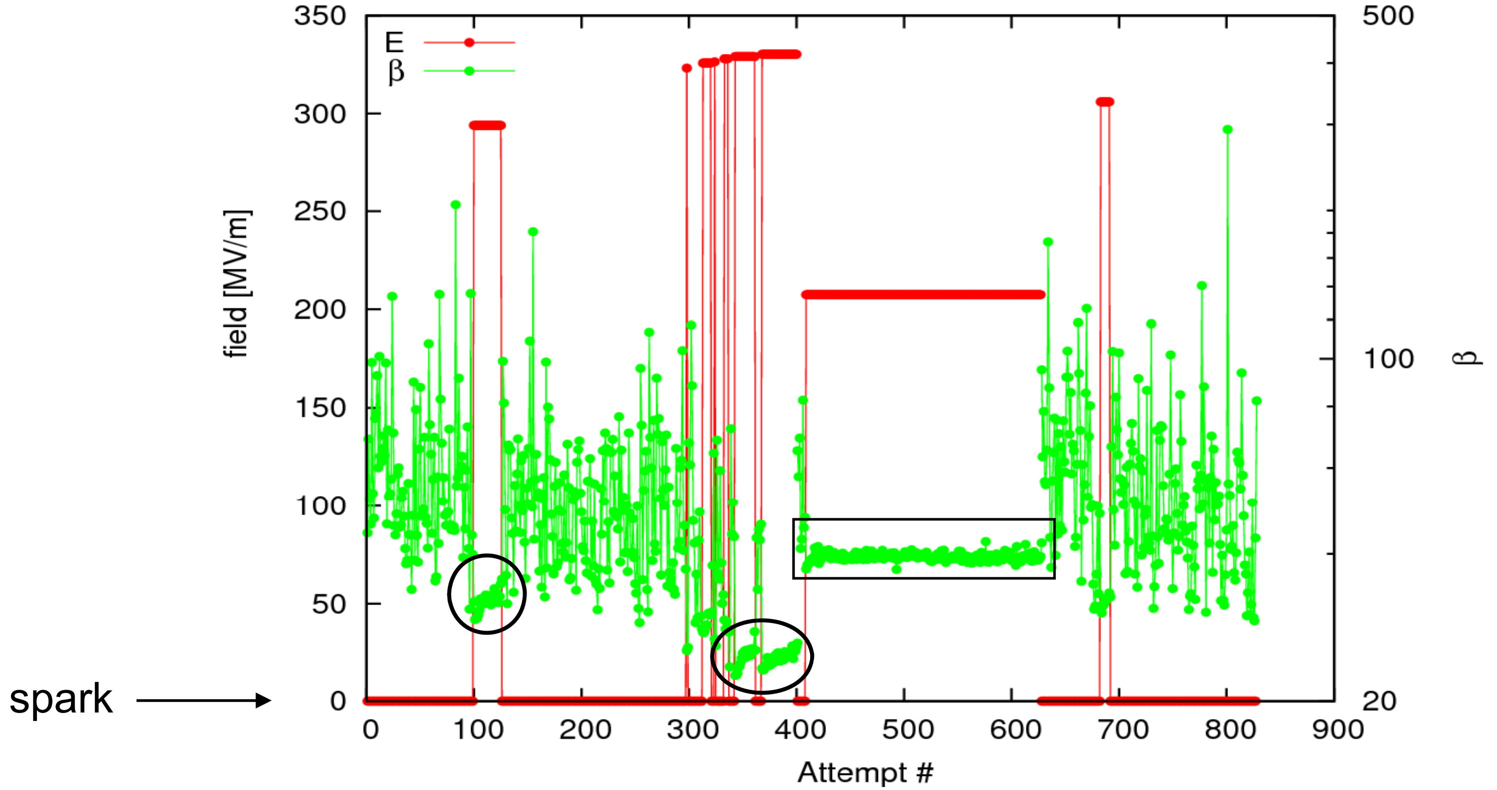


- Time delays before breakdowns
  - ➢ Two types of breakdowns observed, two different breakdown mechanisms?

- Evolution of β and breakdown field E_b →
  - ➢ Local field $\beta \cdot E_b$ is constant (10.8 GV/m for Cu)



Evolution of β during Breakdown Measurements

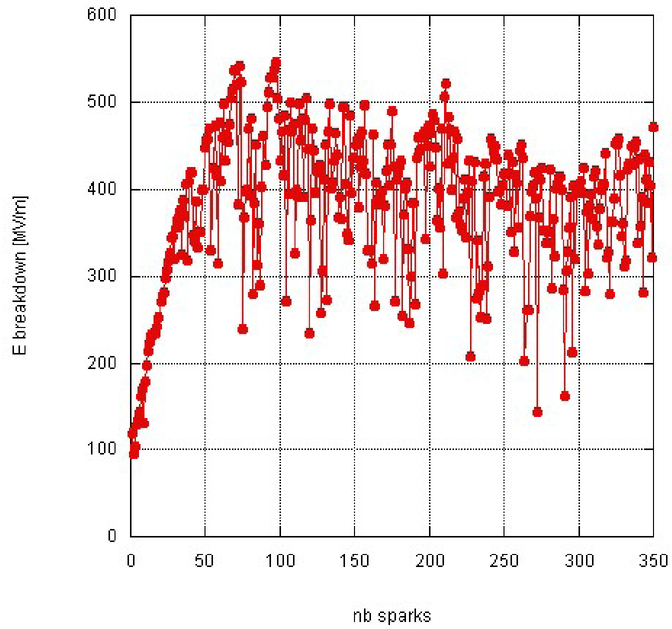


- quiet period ←→ low β
- β seems to increase (a few %) during a quiet period ***if E is sufficiently high***

➡ Are small tips pulled by the field? (we need more data)

Statistical modeling of breakdown rate and surface modification

Yngve Inntjore Levinsen



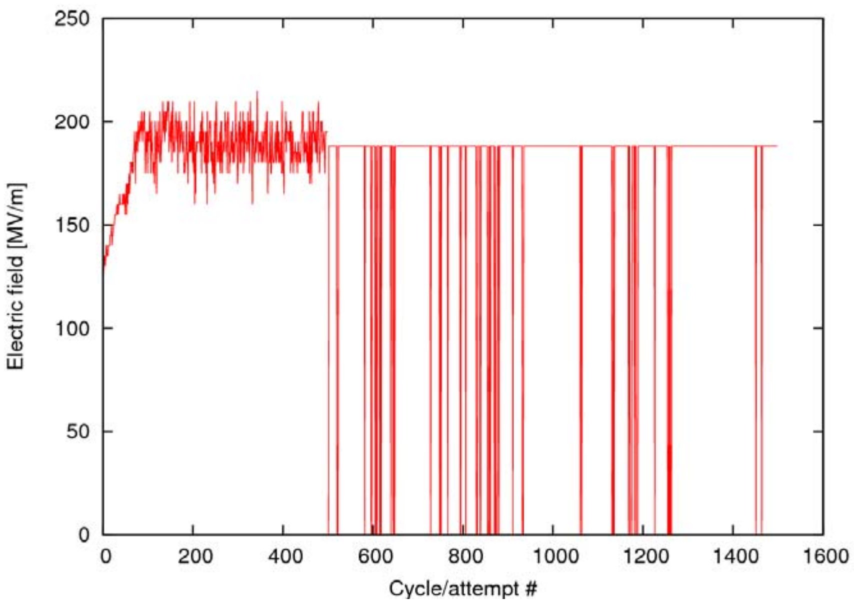
The basic model

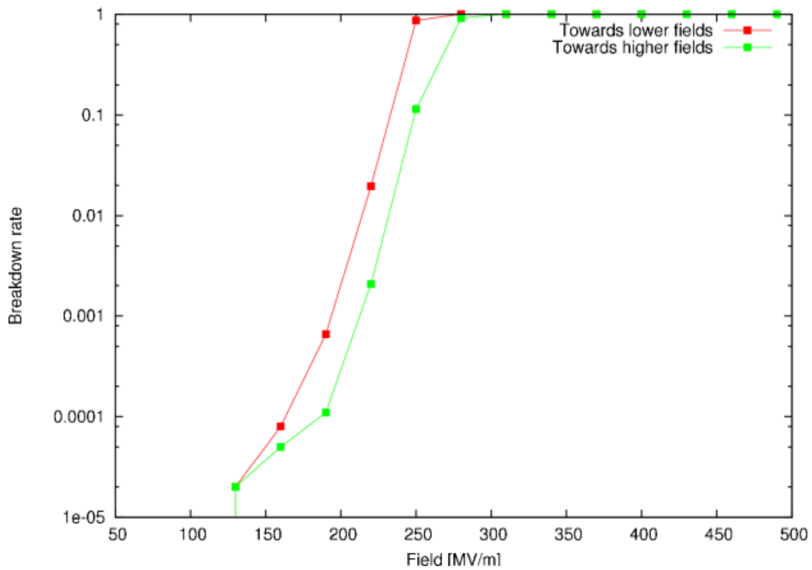
If a limit ?E is reached, a breakdown occurs

If no breakdown occurs, field emission is assumed capable of slight modification of the protrusion sites

After a breakdown, a new weakness parameter is chosen for the location, according to a given distribution (i.e. no history of breakdown energy)

Neighboring locations redistributed in same way



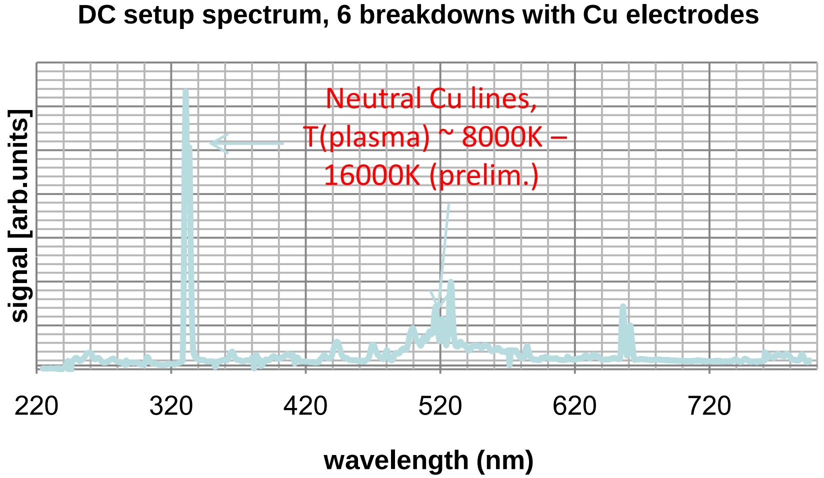


Diagnostics for Breakdown Experiments in RF & DC

Jan Kovermann

Goals:

• Better understanding of breakdown physics and its triggers
• Find similarities or differences between DC and RF experiments (saves costs and time)
• Look for possible precursors
• Unify all data from test stands like RF, optical, x-ray, electrons, ions etc.
•Feedback to structure designers, material scientists and plasma simulations



Used diagnostics:

• Spectrometer with time resolution
• RF
• Faraday cup collecting electrons and ions

Planned diagnostics:

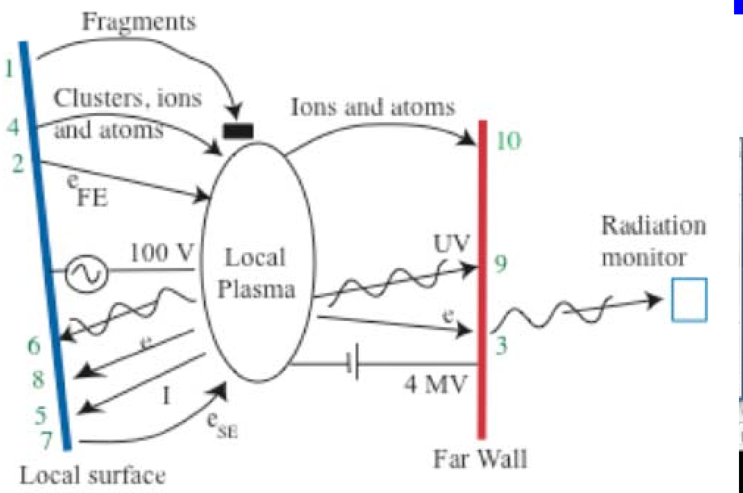
• Electron and ion spectrometer
• X-ray spectroscopy
• RF plasma density measurements

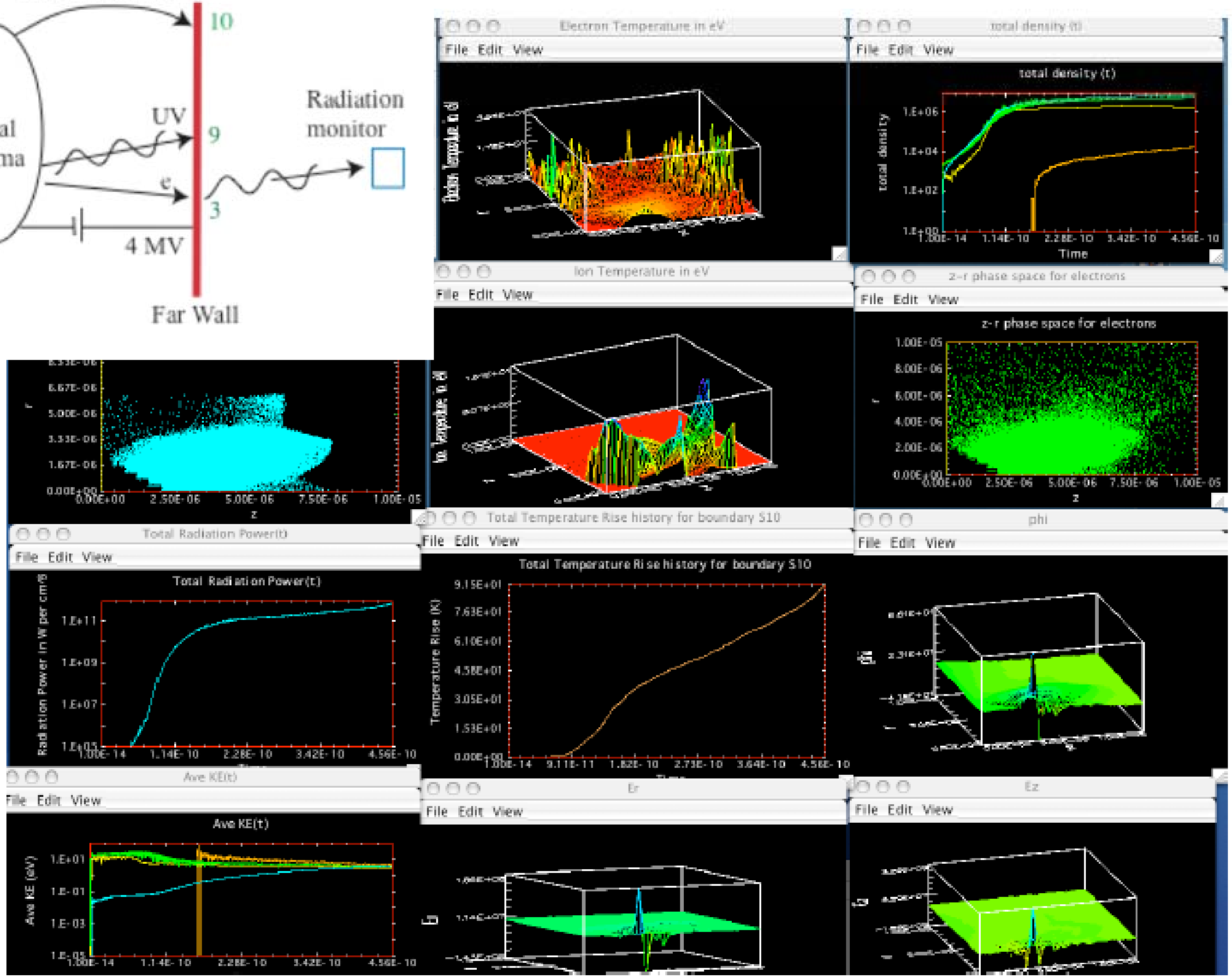
First (preliminary) results:

• DC: Electron temperature ~1eV, two-stage-light emission
• RF: Major part of missing energy goes to electron acceleration

Breakdown Modeling

Jim Norem





Results from OOPIC code from TechX

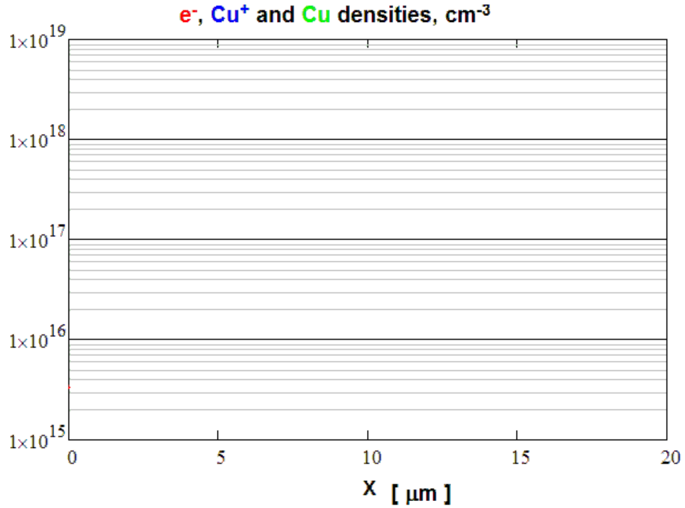
A Multiscale Model of Arc Discharge

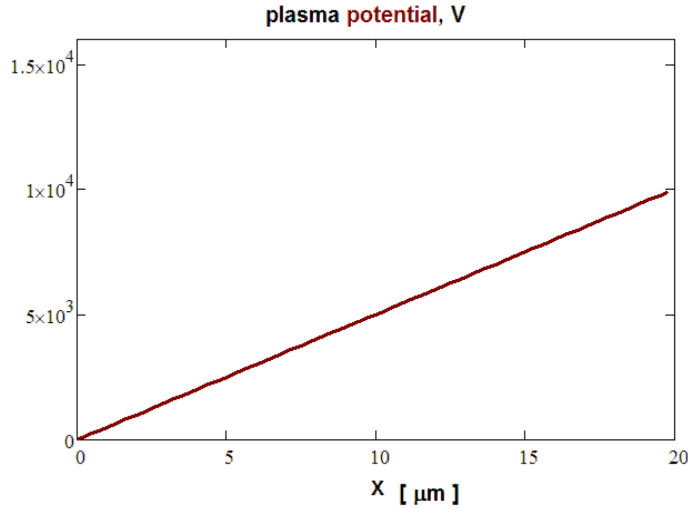
Max-Planck Institut für Plasmaphysik, Greifswald, Germany

Konstantin Matyash and Ralf Schneider

Department of Physics and Helsinki Institute of Physics – University of Helsinki, Finland

Helga Timkó, Flyura Djurabekova and Kai Nordlund





- **Simulations combining Particle-in-Cell and Molecular Dynamics**
- **Coupling: PIC gives particle fluxes and energy distributions for MD**