CLIC'09 Workshop

STATUS OF CLIC ACTIVITY AT IAP

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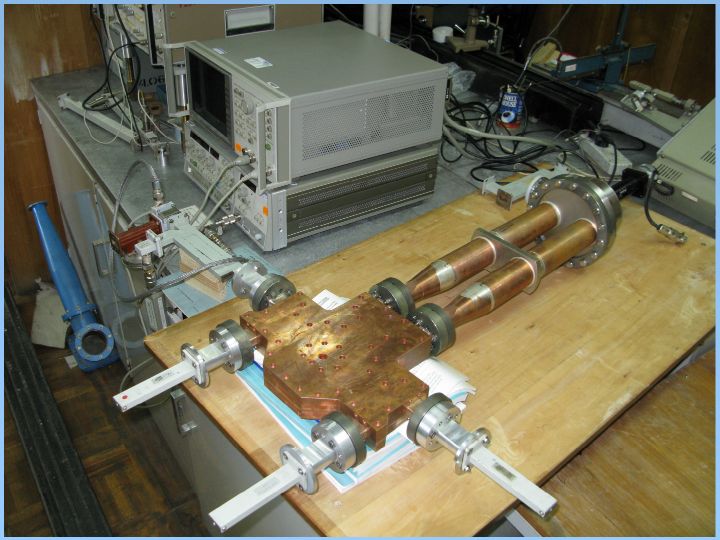
Outline

1. Scope of activities
2. 12 GHz BMC
3. IAP – JINR pulse heating experiments at 30 GHz
4. 30 GHz multi-megawatt gyrotron and gyroklystron
5. Studies of multipactor discharges
   1. Methods to suppress multipactor on dielectric surface (windows and dielectric based accelerating structures)
   1. Multipactor on metallic surface (RF switches)
6. Future plans and prospects

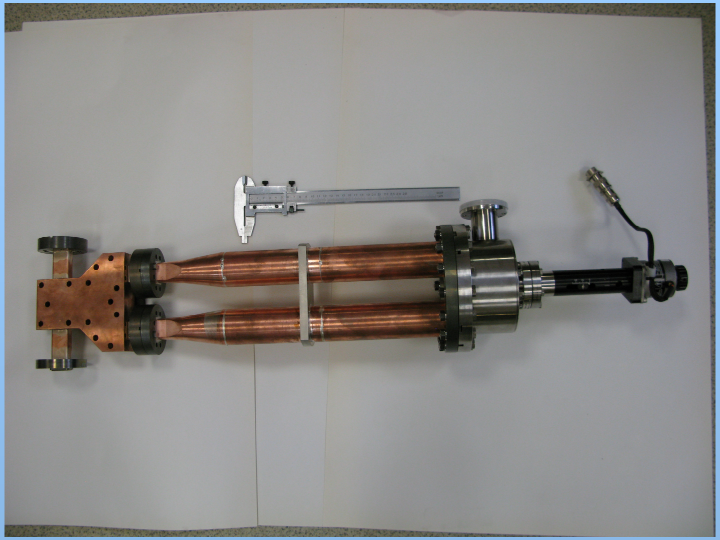
Contracts with Gycom Ltd.:

1. 30 GHz transmission line and RF components
2. 30 GHz SLED II PC
3. Length compensators for transmission lines
4. Pumping ports at big waveguide diameter
5. Vacuum valve
6. Attenuators and phase shifters at 30 GHz and 12 GHz
7. 12 GHz BMC

Total: 10 contracts for last 3 years

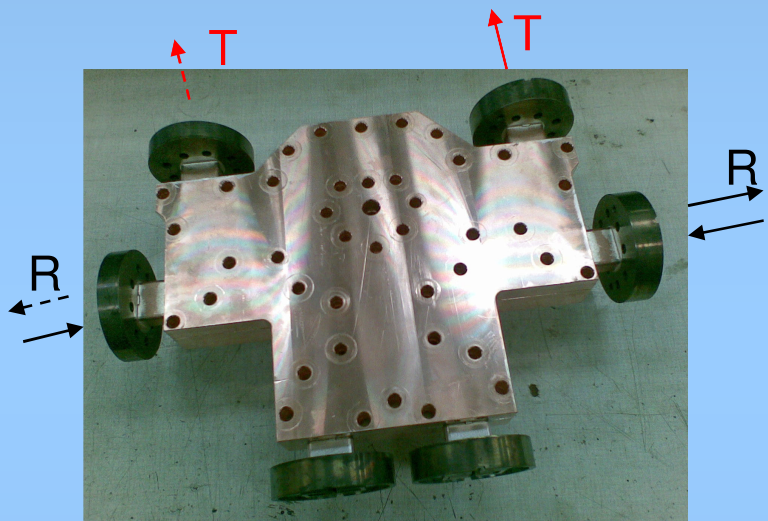


12 GHz attenuator

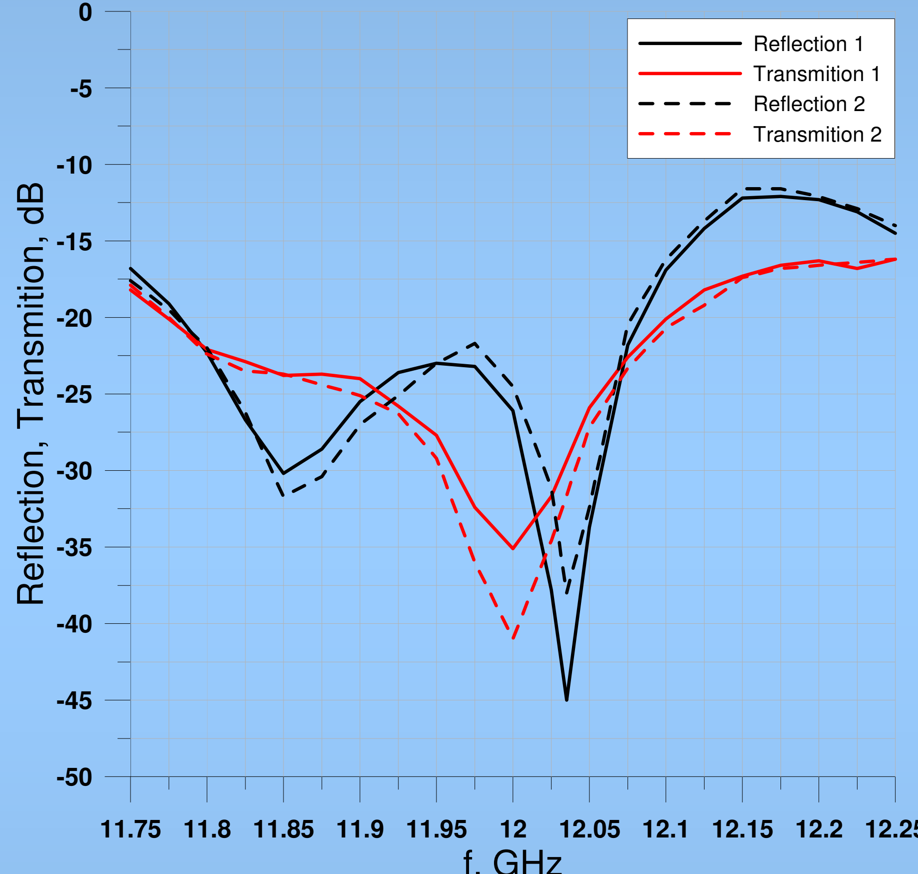


12 GHz phase shifter

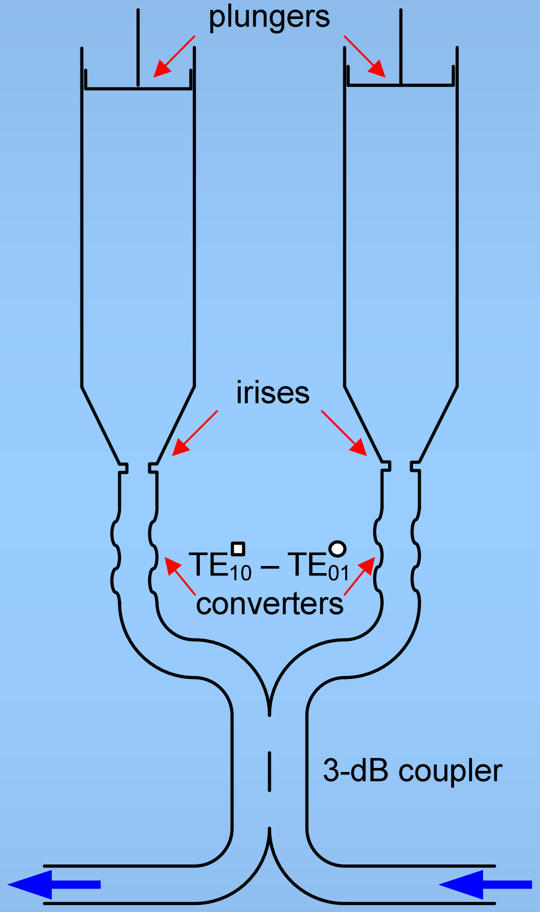
The last contract component

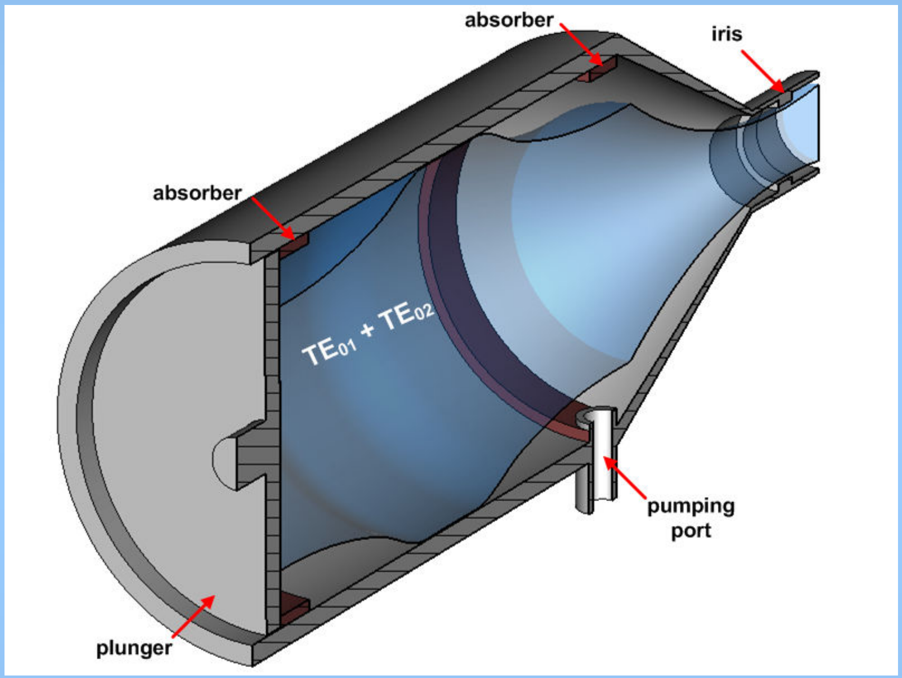


12 GHz attenuator body

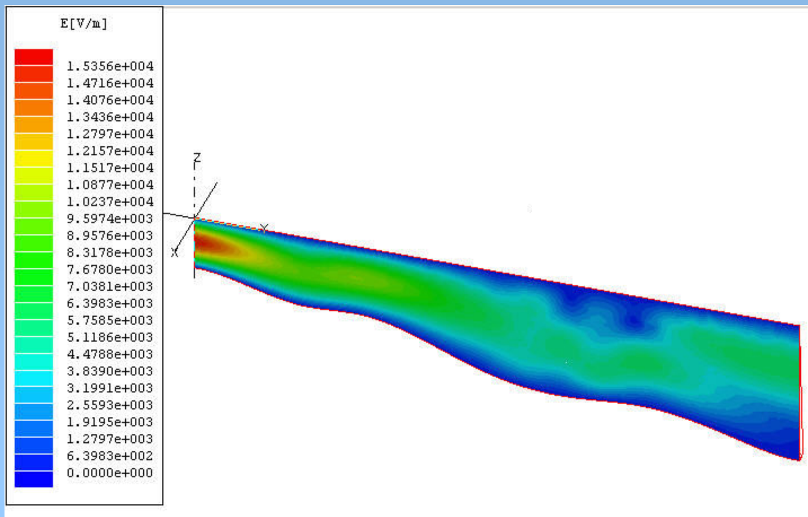


12 GHz BMC (under construction)

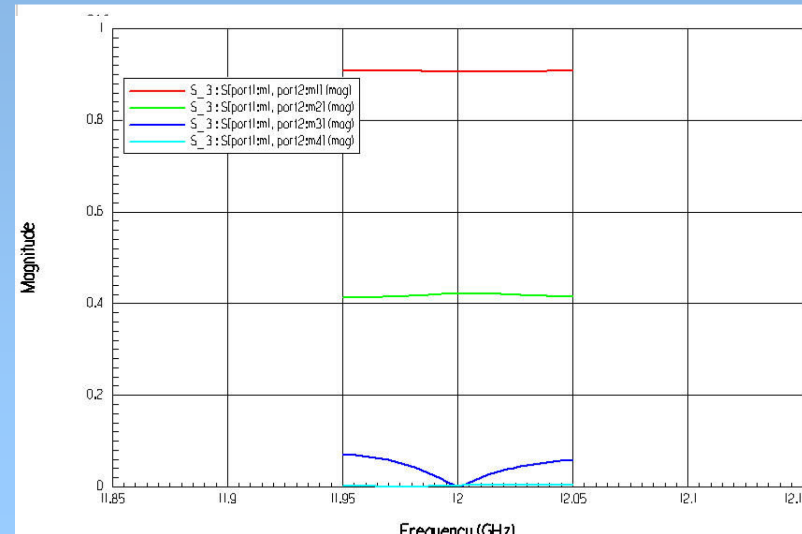




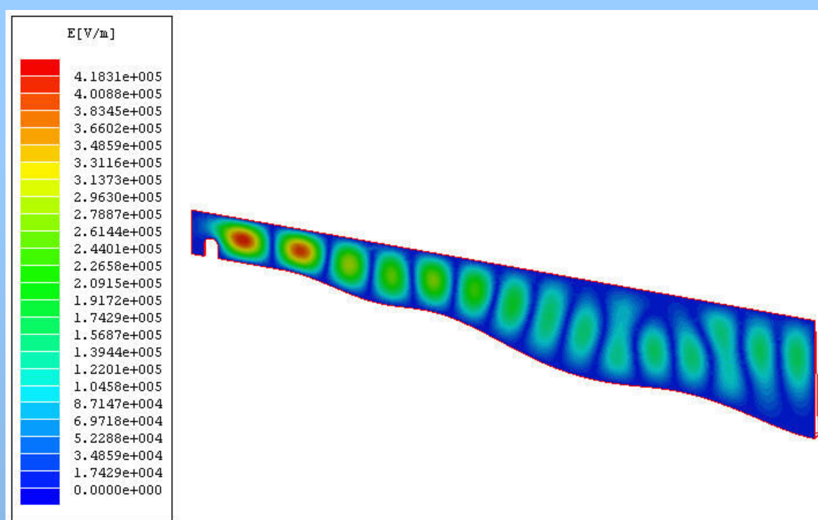
Scheme of BMC (beet mode pulse compressor).



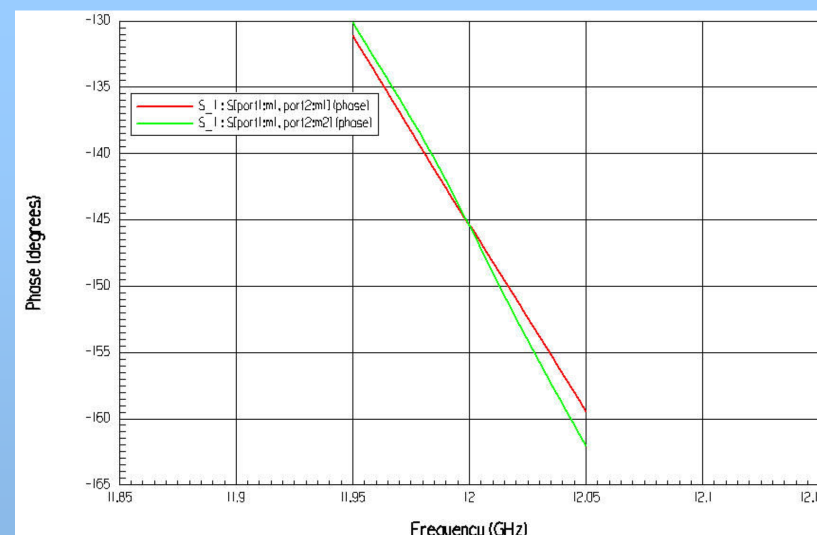
TE_{01} – TE_{01}+TE_{02} beeting mode converter



Reflected and transmitted modes



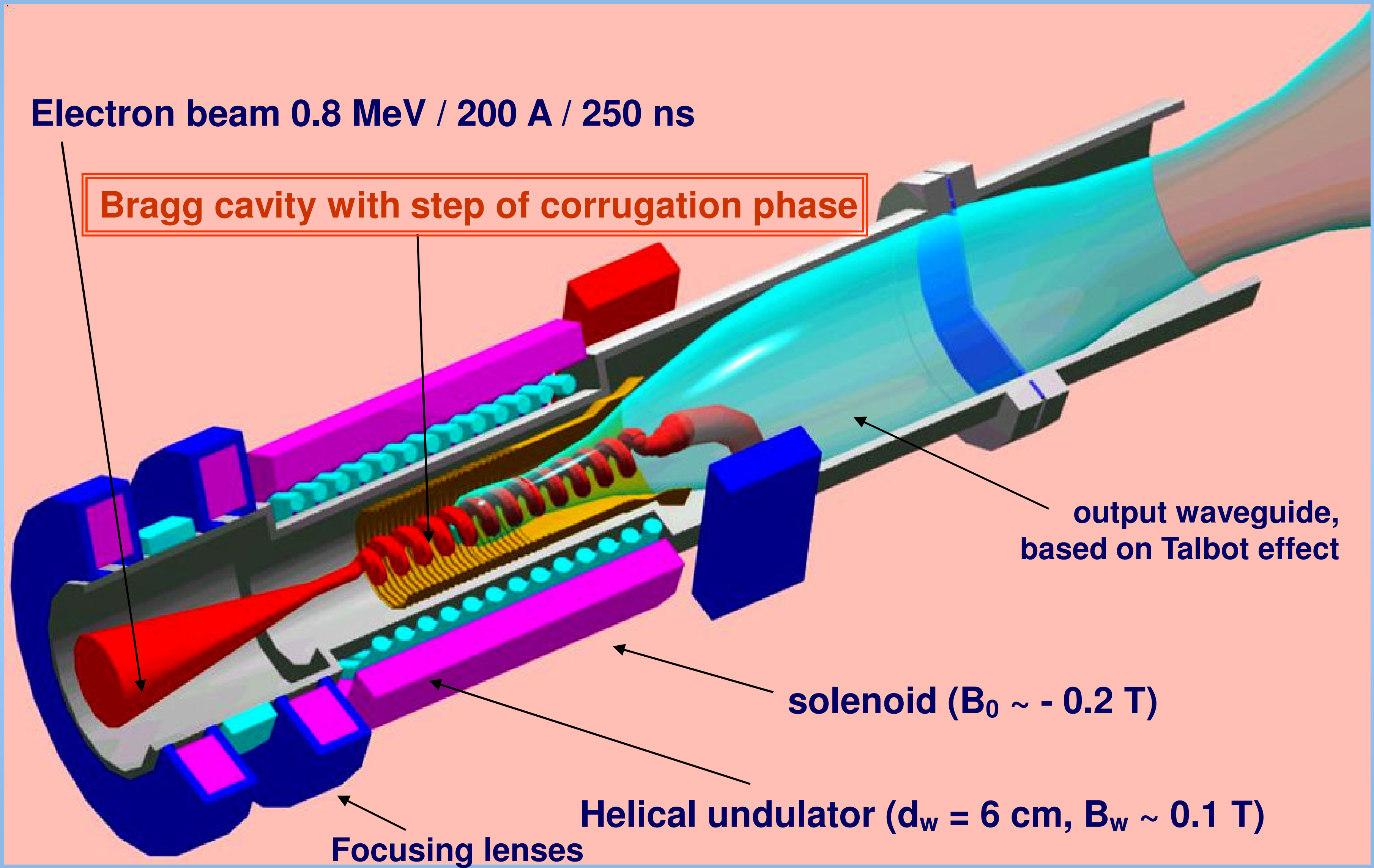
Simulation of the BMC with coupling iris



TE_{01} and TE_{02} phases

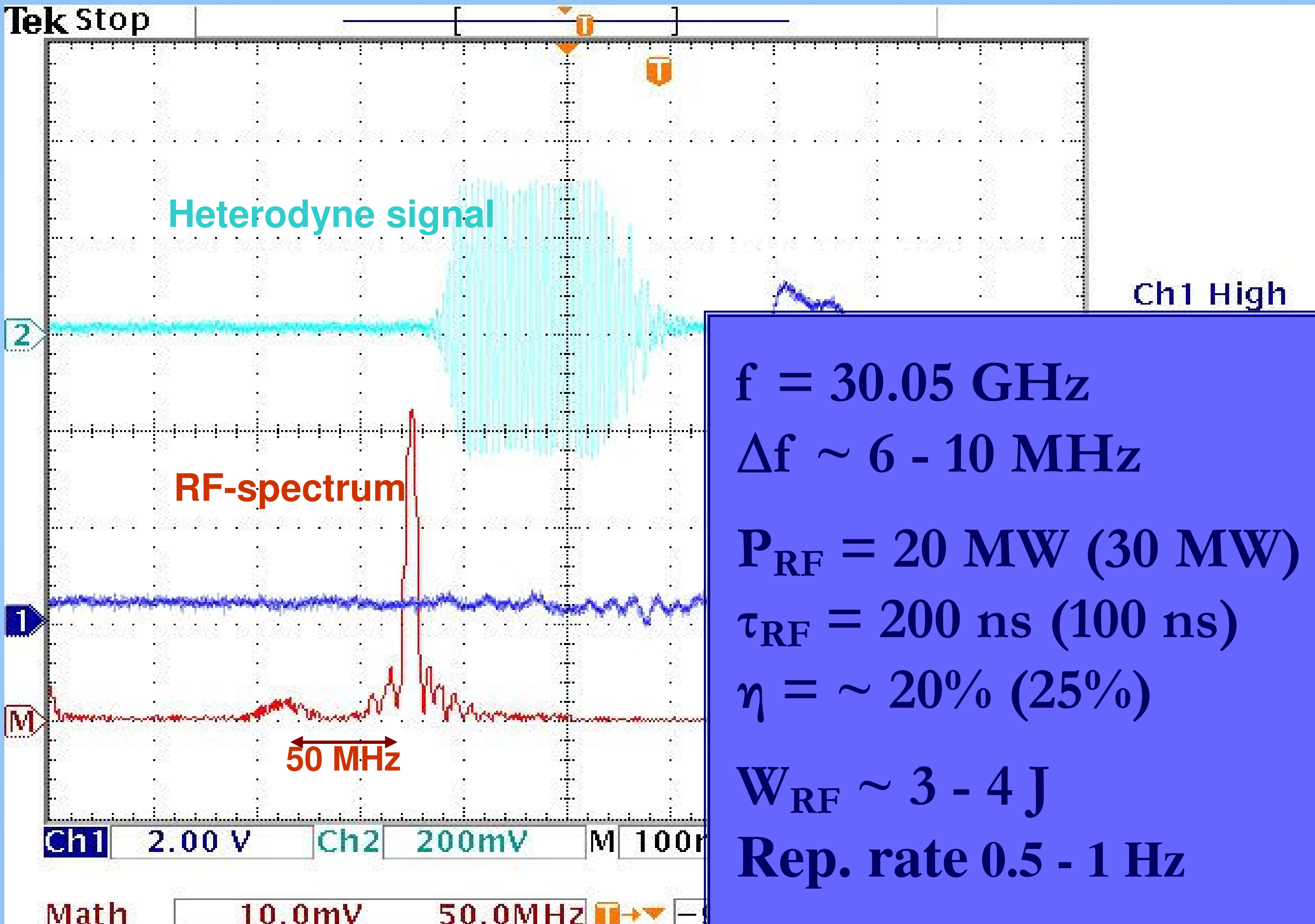
All necessary parts have been produced. We wait for the second stepping motor.
Low power tests are scheduled on October - November 2009.

Pulse heating experiments



Scheme of the 30 GHz FEM based on accelerator LIU-3000

Experimental results



$f = 30.05$ GHz

$\Delta f \sim 6 - 10$ MHz

$P_{RF} = 20$ MW (30 MW)

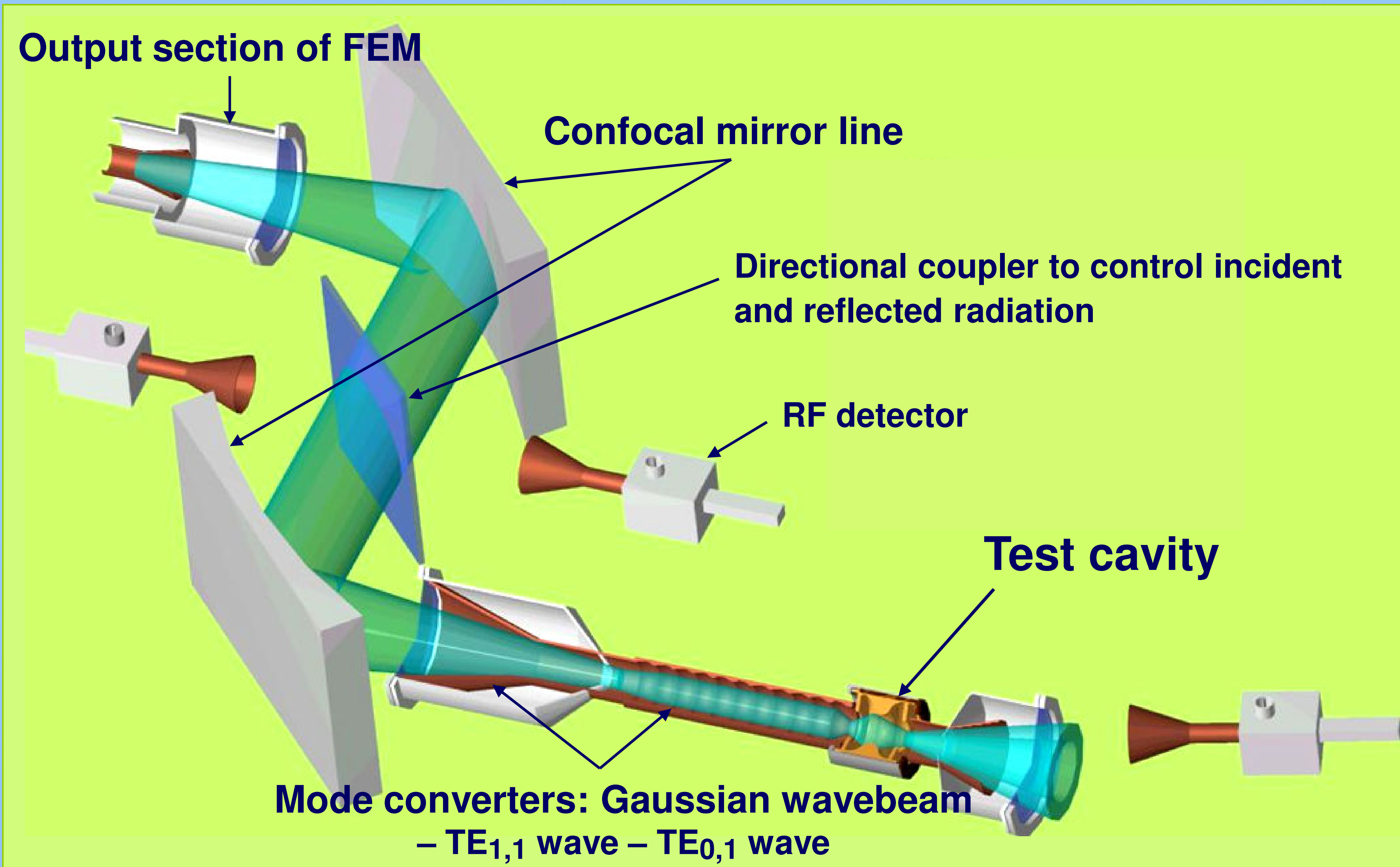
$\tau_{RF} = 200$ ns (100 ns)

$\eta = \sim 20\%$ (25%)

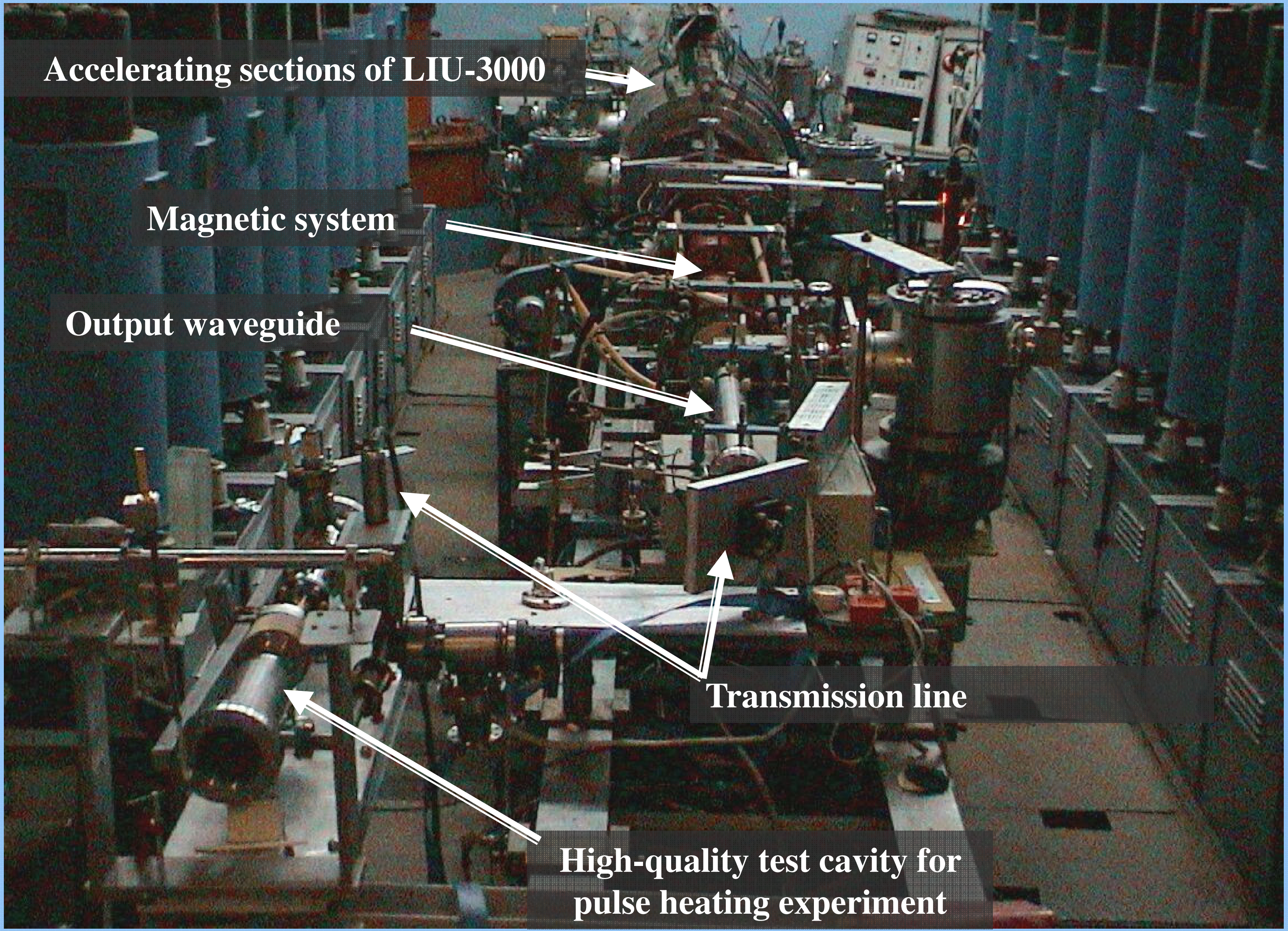
$W_{RF} \sim 3 - 4$ J

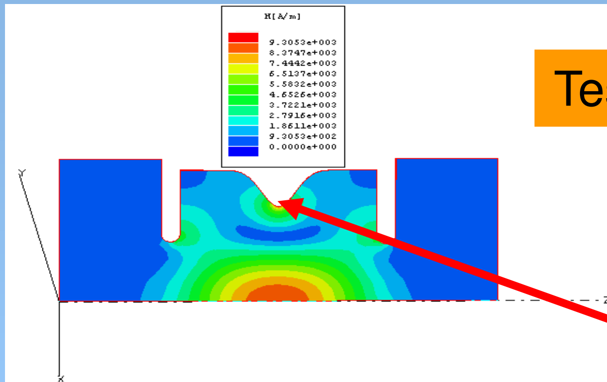
Rep. rate 0.5 - 1 Hz

Experimental investigations of copper degradation effects caused by RF pulsed heating by means of 30 GHz FEM



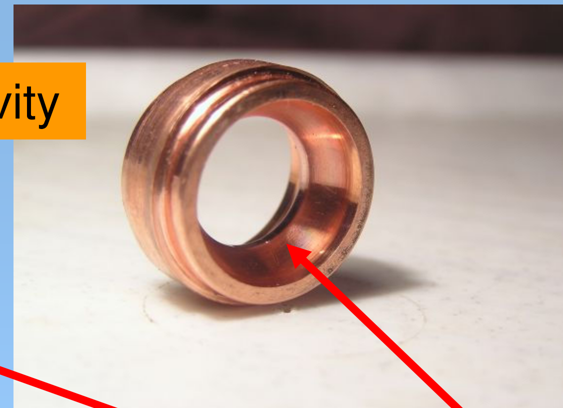
FEM on a base of LIU-3000

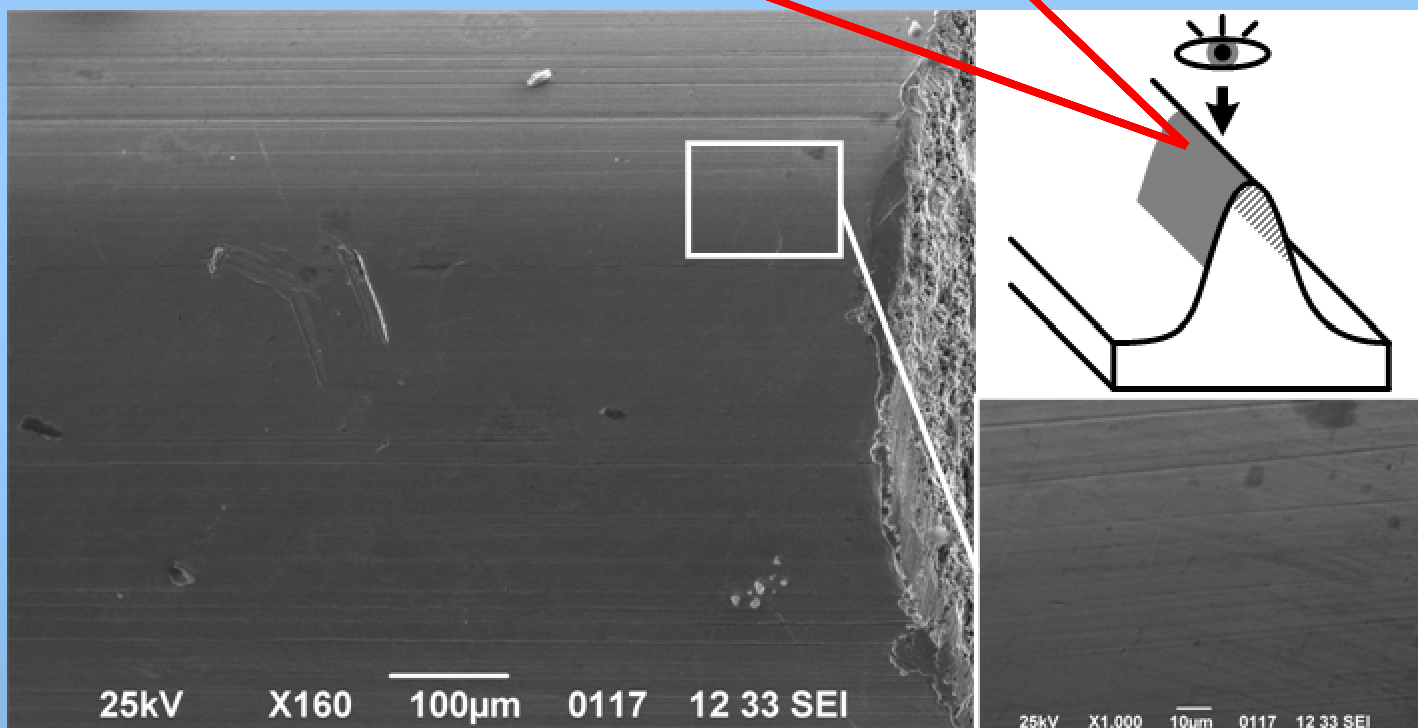




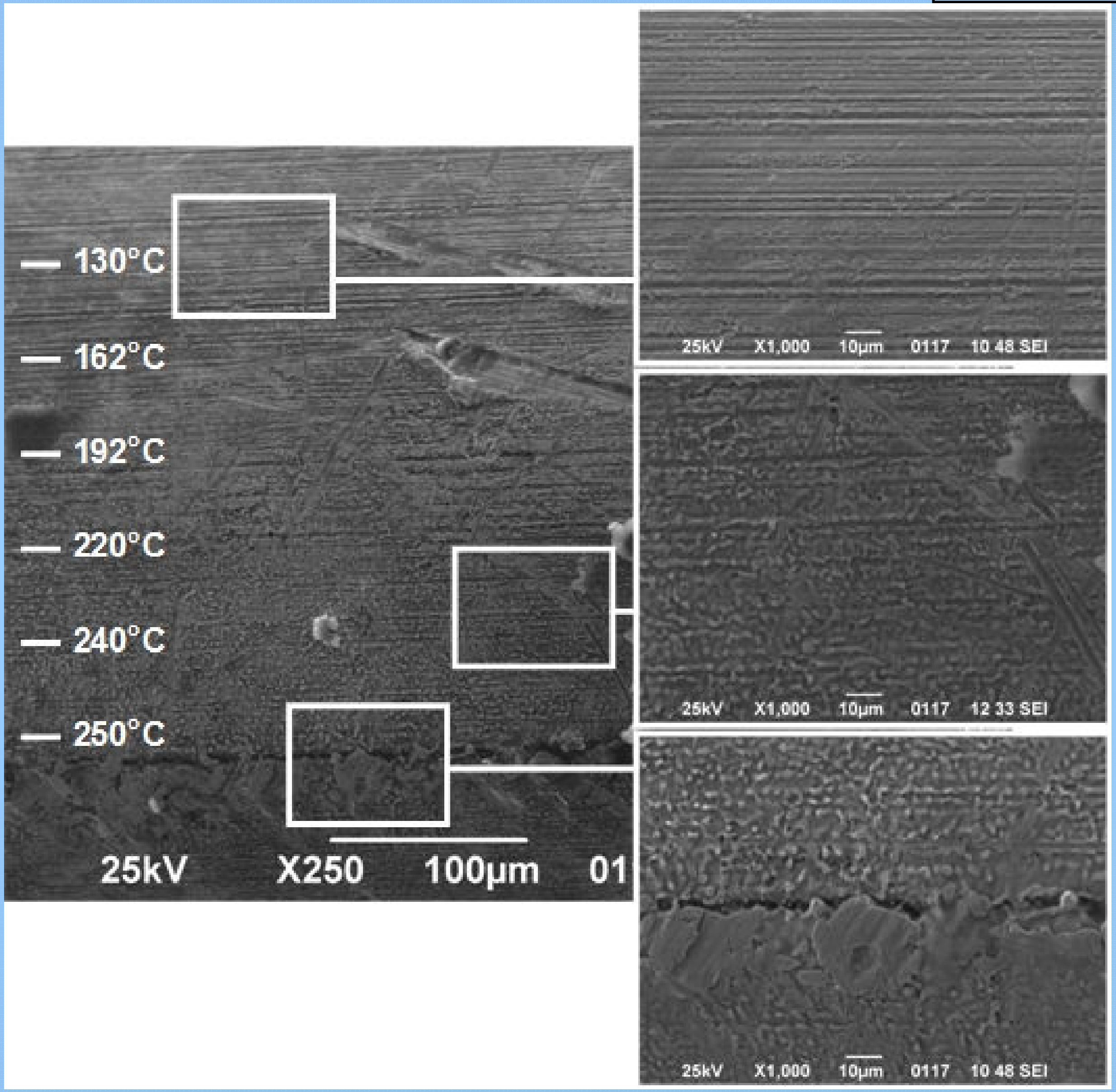
Magnetic field

Test cavity

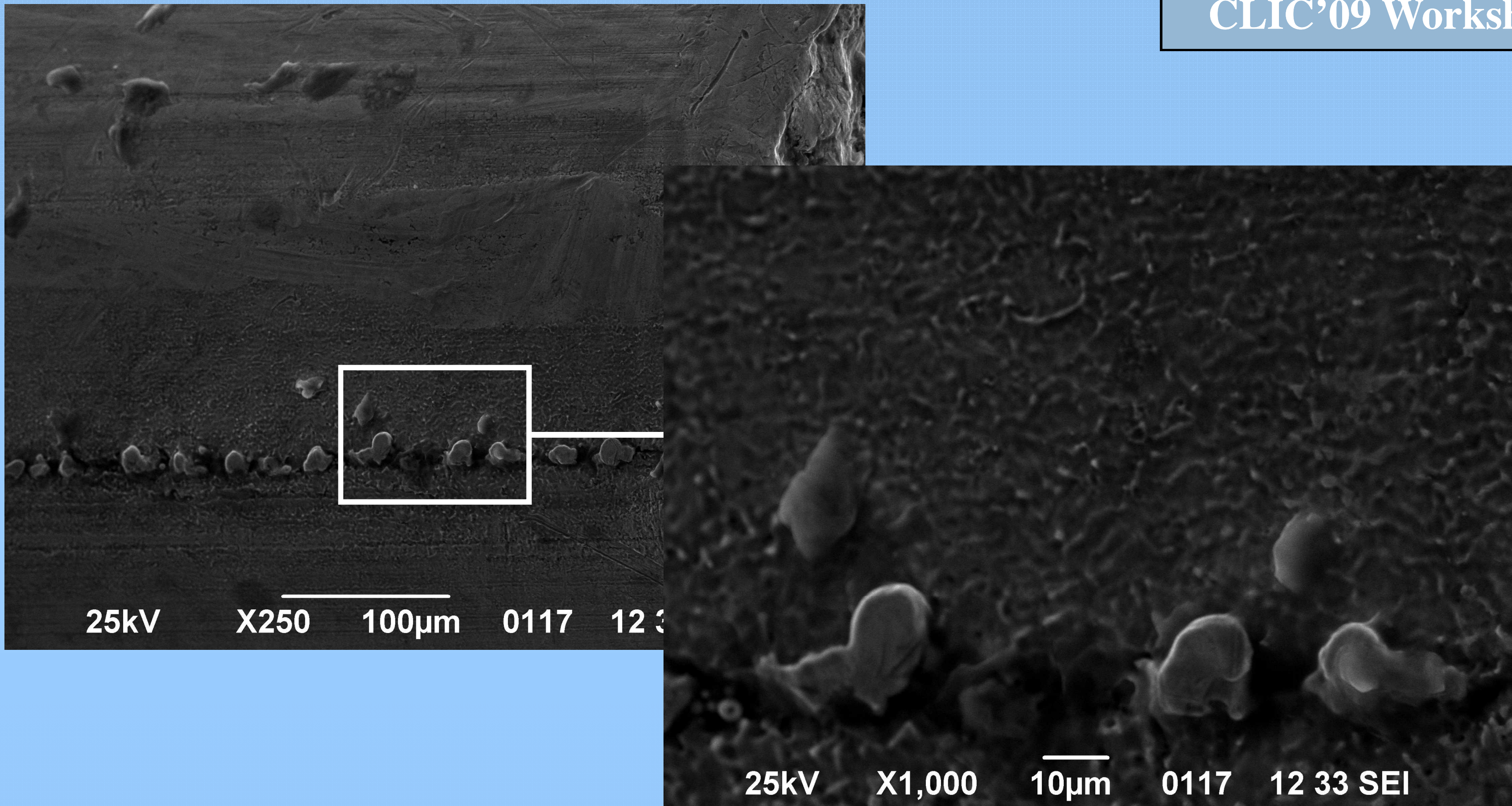




Photograph of the unexposed surface



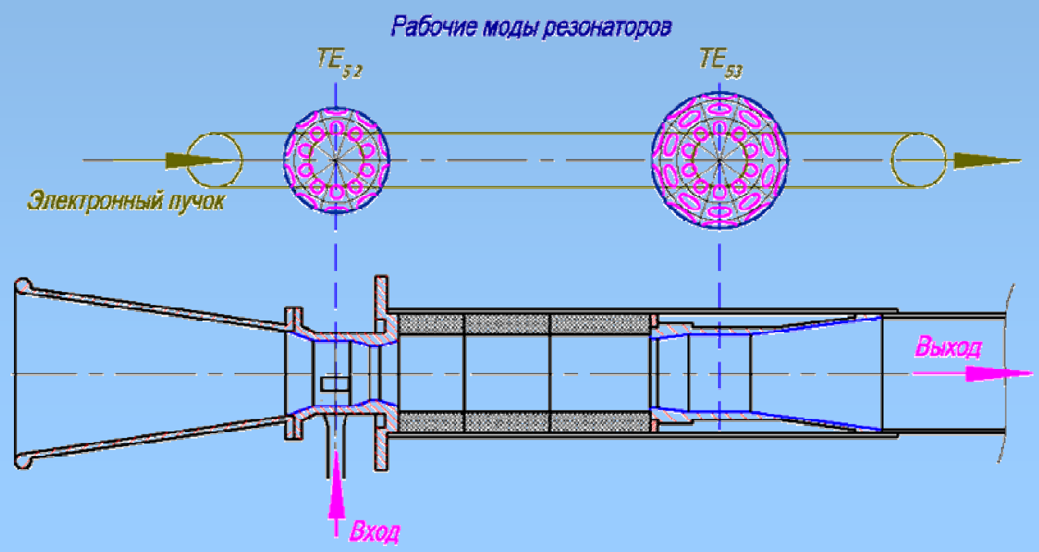
Photographs of the exposed surface (250° C, 6×10^4 RF pulses)



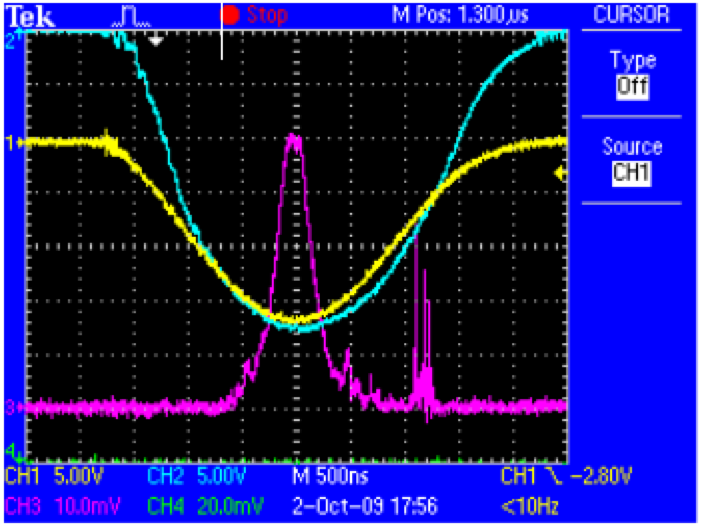
Breakdown marks

The carried out experiments on pulse heating at 30 GHz show that temperature rise ~50° C per pulse does not spoil cavity surface ($N<10^5$).
Temperature rise 200-250° C leads to dramatic degradation of the tested copper surface and causes very frequent breakdown (BDR=0.3-0.5) if total number of RF pulses reaches $6\cdot10^4$.

30 GHz gyrotron/gyroklystron



U=300-450 кV,
I=180 A,
τ=0.5-1.5 μs,
f_{rep}=1-10 Hz,
F=30 GHz
RF power = 10-15 MW.



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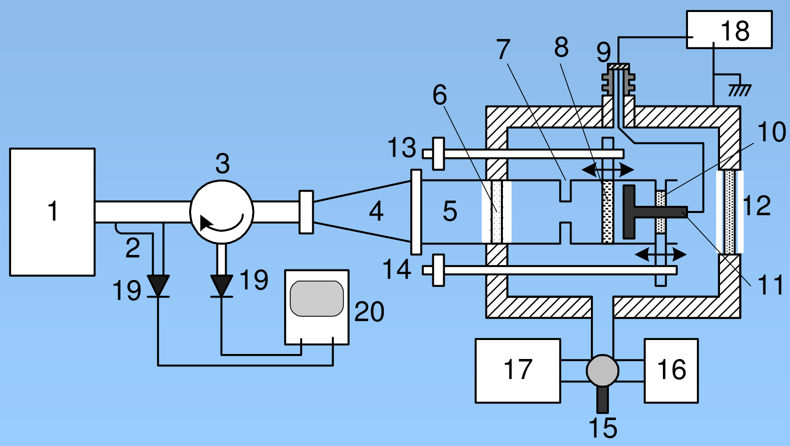
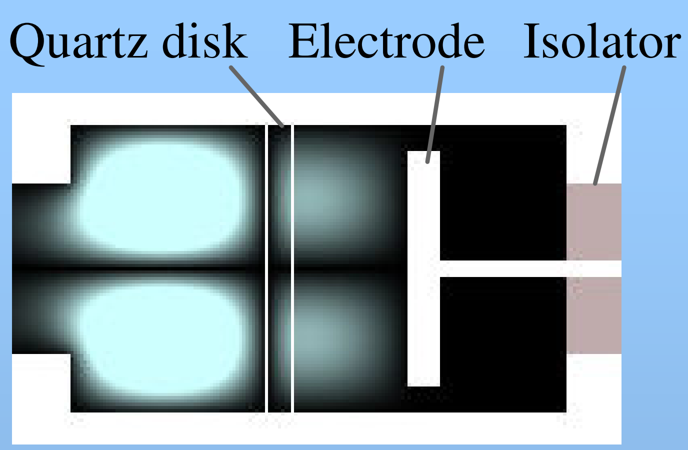
IAP experiments with multipactor discharge in X – band

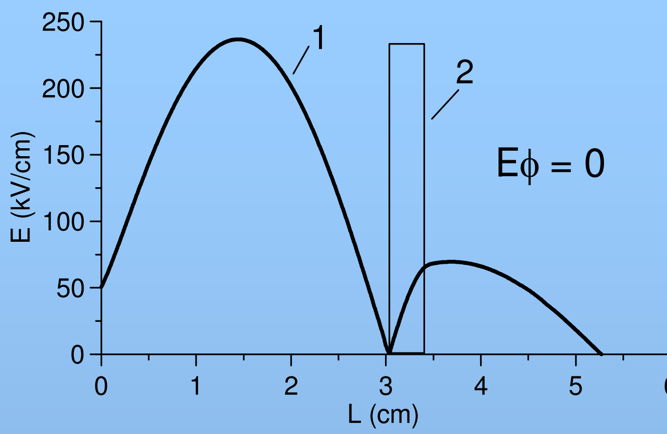


Experimental setup

1 - magnetron, 2 - directional coupler, 3 - circulator, 4 - mode converter, 5 - circular waveguide, 6 - microwave window, 7 - diaphragm, 8 - studied dielectric disk, 9 - high voltage input, 10 - insulator, 11 - electrode (back wall of the resonator), 12 - observation window, 13 and 14 - disk and electrode transfer mechanisms, respectively, 15 - pressure gauge, 16 - mechanical pump, 17 - ion pump, 18 - high-voltage source, 19 - microwave detector, 20 - oscilloscope

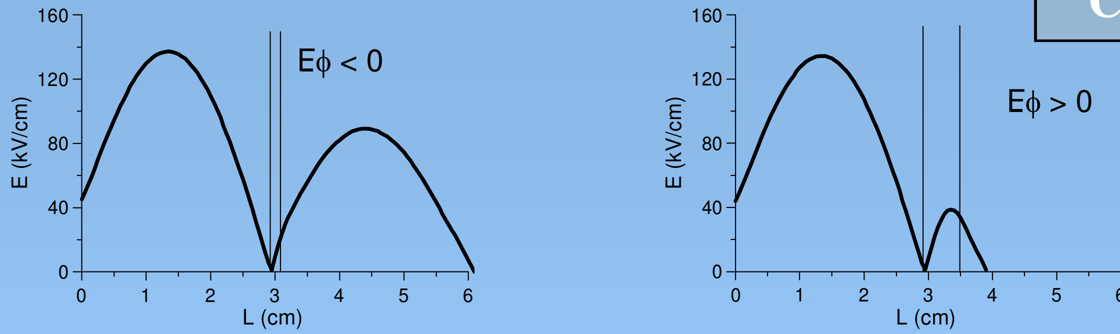


TE_{012}

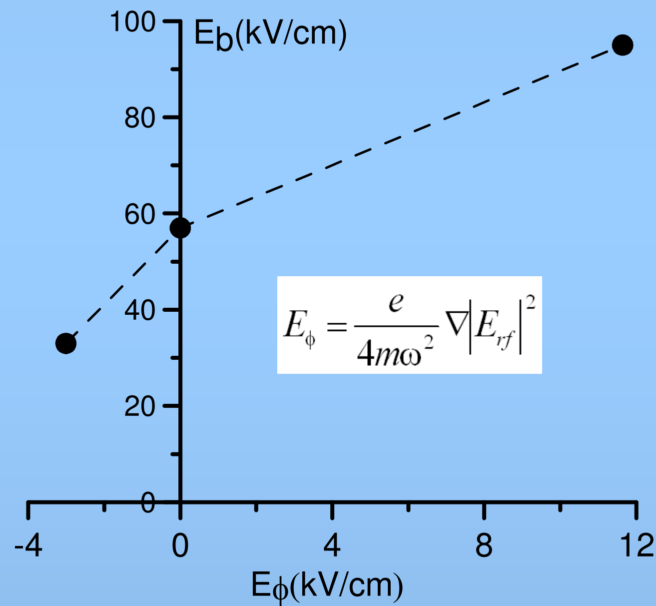


1 – amplitude of the RF field for an incident power 100 kW
2 – quartz disk

Distribution of the microwave electric field in the resonator



Distribution of the microwave electric field



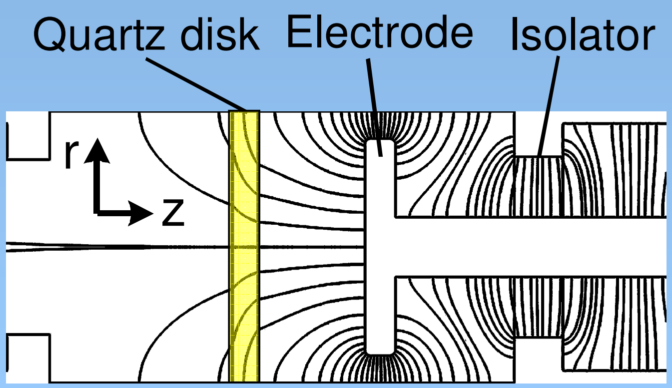
$$E_{\phi} = \frac{e}{4m\omega^2}\nabla\left|E_{rf}\right|^2$$

Dependence threshold value of pondermotive force

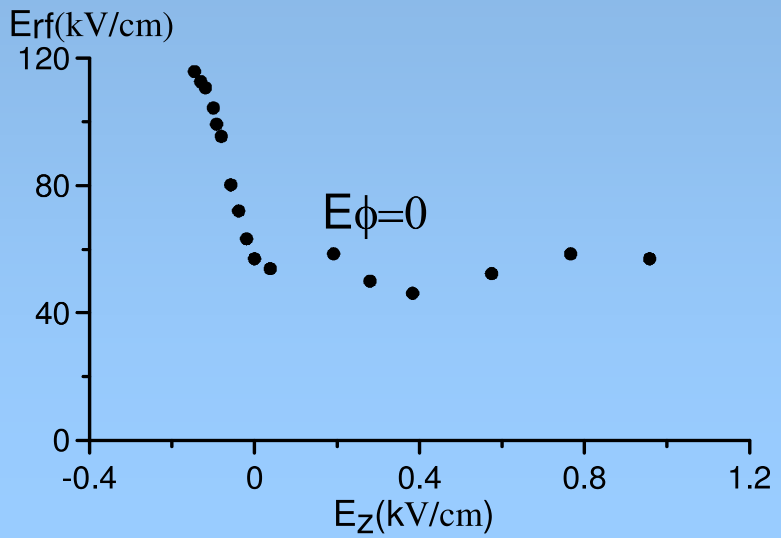
[1] - M.A. Lobaev, O.A. Ivanov, V.A. Isaev, A.L. Vikharev, Tech. Phys. Lett. v. 35, N 12.

[2] - O.A. Ivanov, M.A. Lobaev, V.A. Isaev, A.L. Vikharev, Physical Revue ST AB (in press)

Influence of external DC bias



Distribution of the electrostatic field

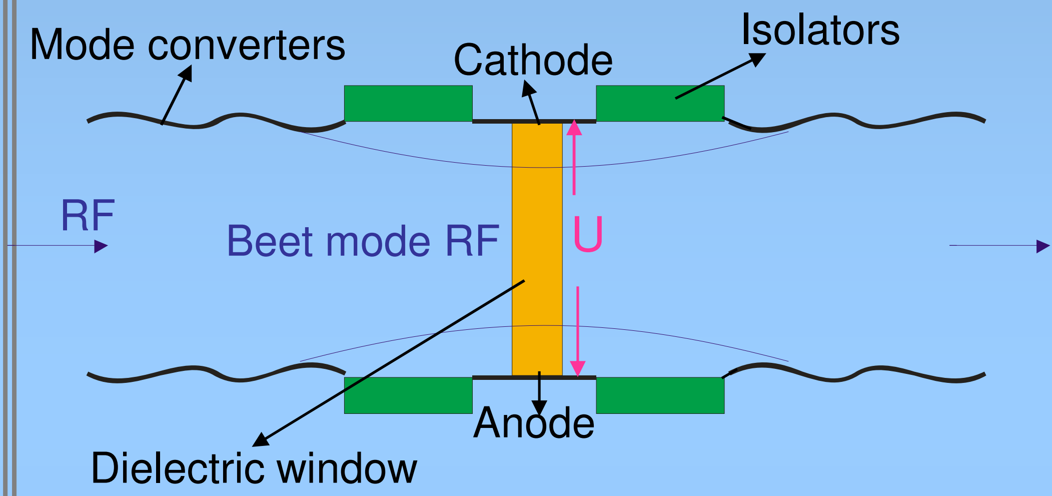


Dependence of the multipactor threshold on the amplitude of the electrostatic field

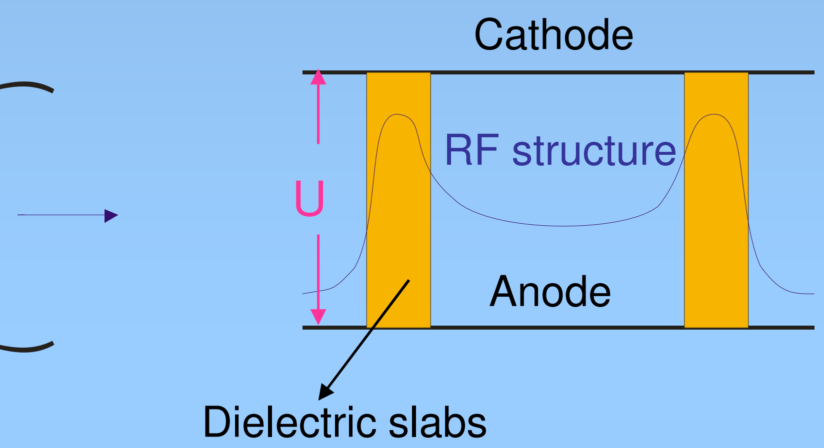
1. **The experiments performed showed that one can effectively suppress the multipactor dicharge on a dielectric.**

2. **The effects make it possible to use such an undesirable phenomenon as a multipactor for practical purposes, e.g., in high-power microwave switches intended to modulate the Q-factor in active compressors of microwave pulses.**

Raise of multipactor threshold by means of external DC bias

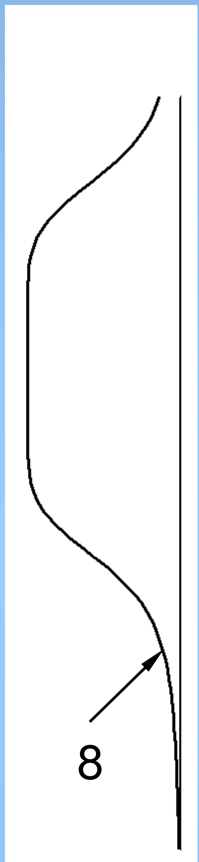


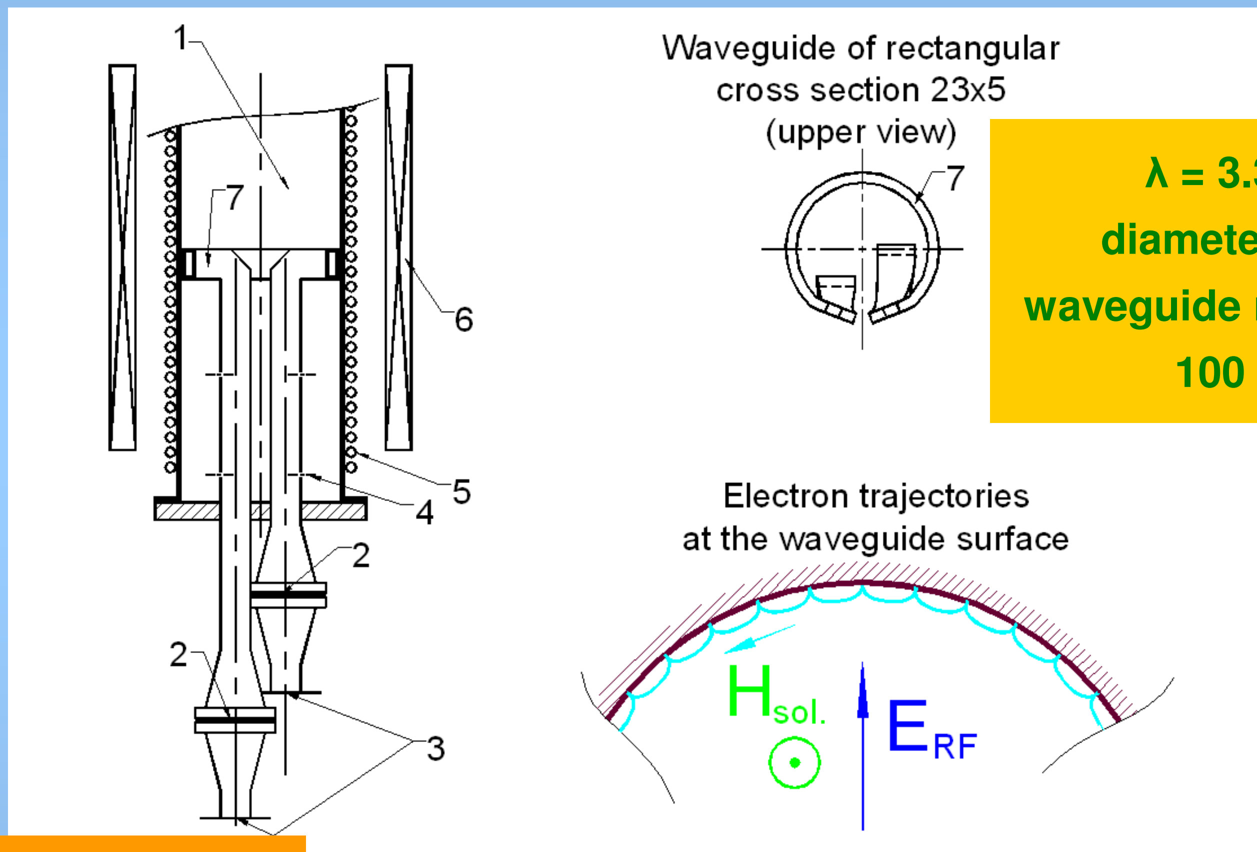
High-power window



Dielectric accelerating structure

Multipactor at metallic surface with external static magnetic field





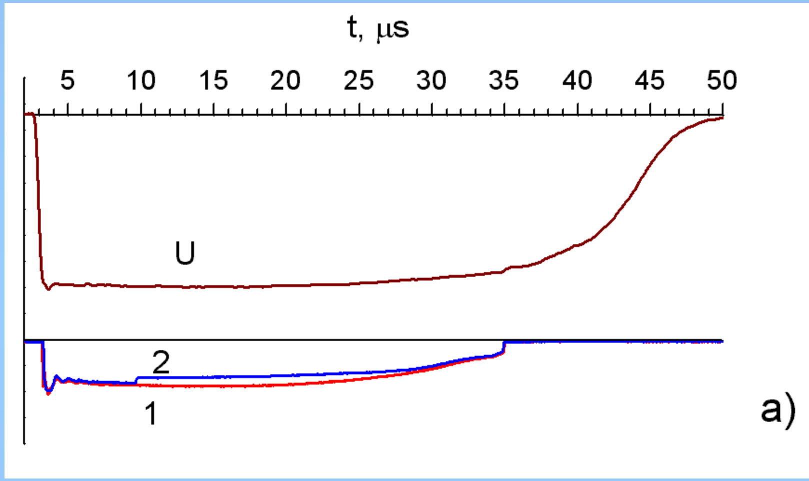
λ = 3.3 cm, diameter of the waveguide ring is near 100 mm

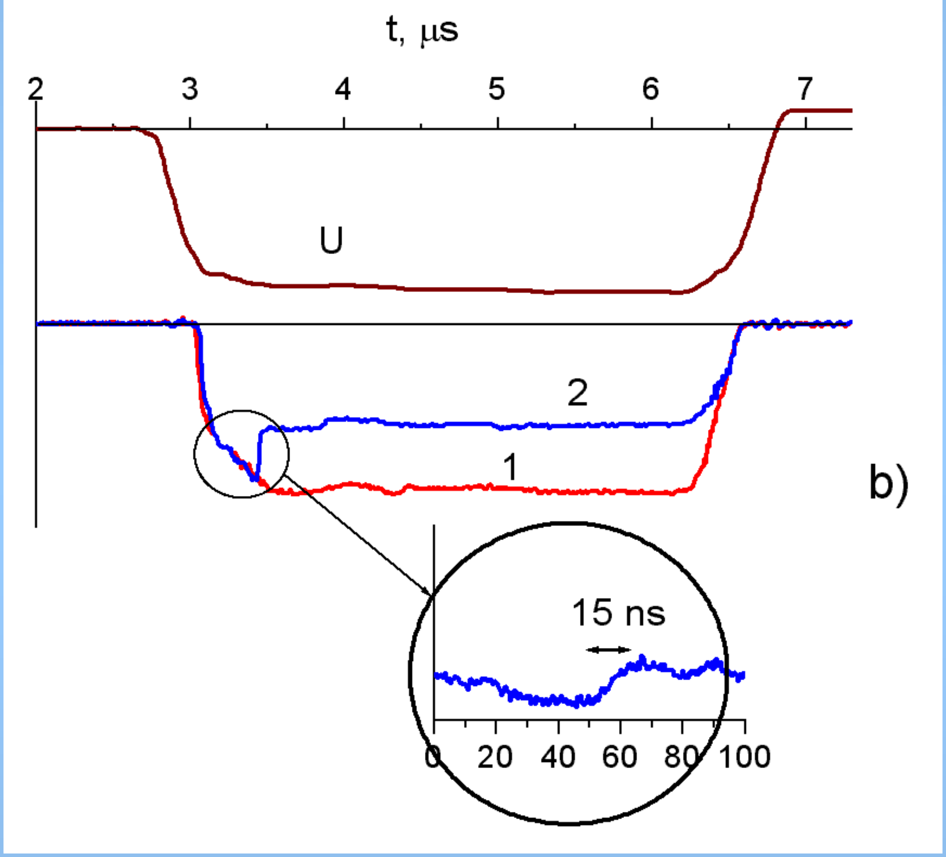
10 GHz 200 kW magnetron

1 – vacuum casing; 2 - RF window; 3 – input and output waveguide flange; 4 – openings for waveguide evacuation; 5 – heater; 6 – pulse solenoid; 7 – waveguide bended into a ring; 8 – magnetic field profile

Tested waveguide

Transmitted RF power at the absence and presence of multipactor discharge

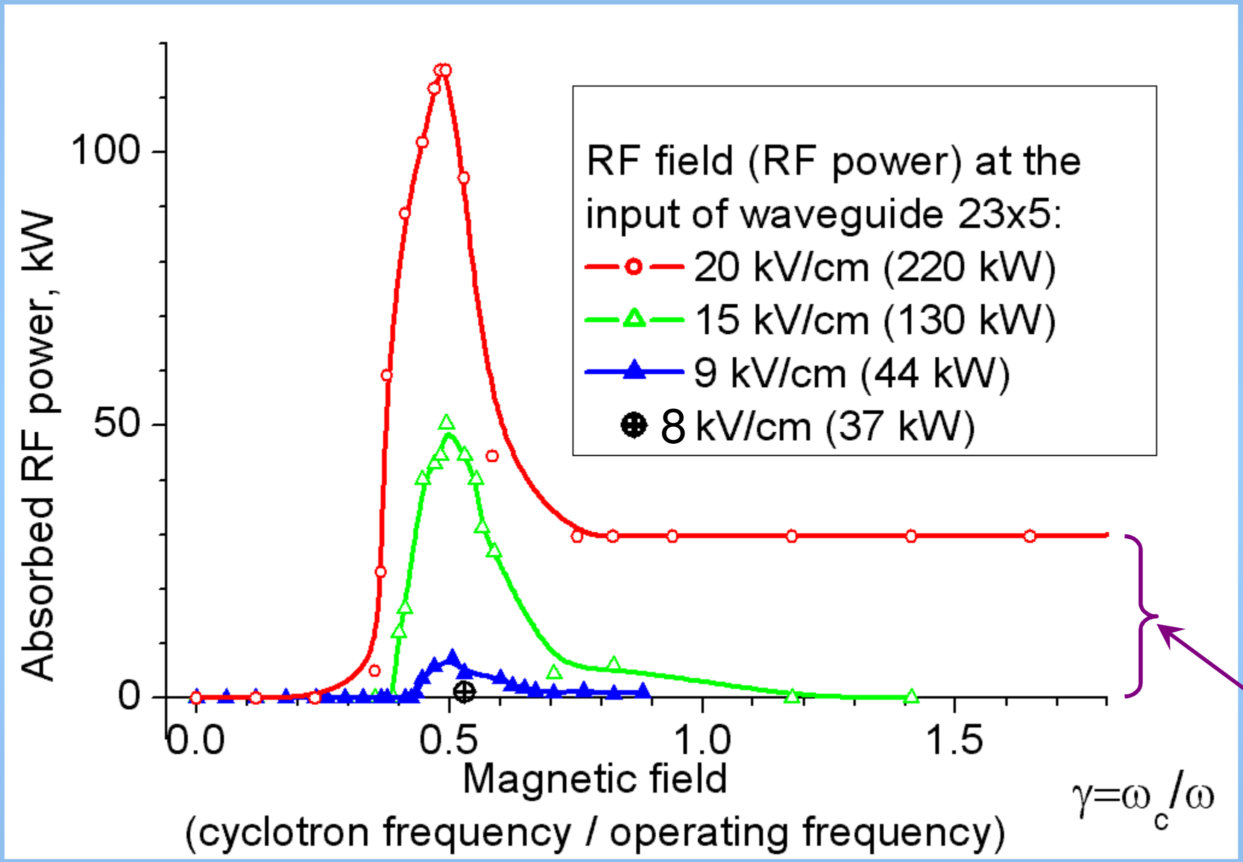




Traces of output power at the absence (1) and the presence (2) of multipactor discharge. The input power is 44 kW (a) and 220 kW (b)

U – voltage pulse

Dependence of the absorbed RF power on the static magnetic field

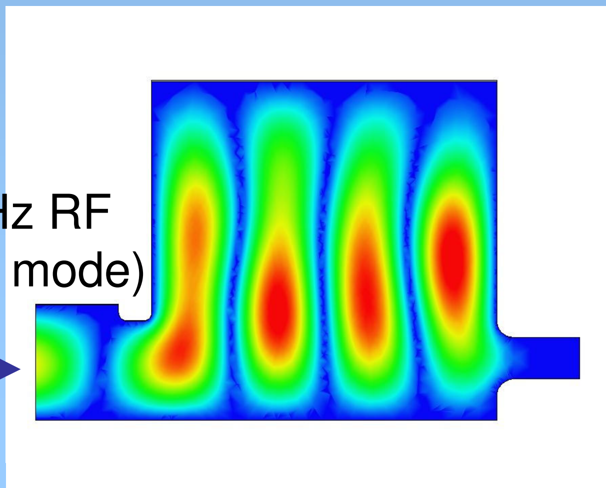


Multipactor absorption in the input and output waveguides near the brink of solenoid

Magnetic field can be used for slow (~1 μs) RF switching

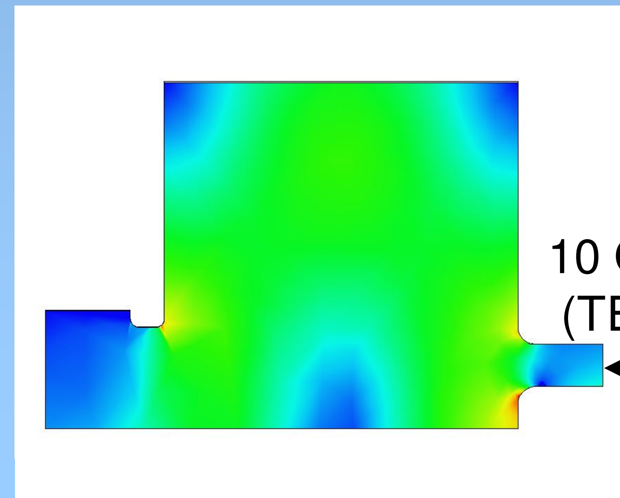
Fast active RF switch (phase shifter) based on induced multipactor

30 GHz RF
(TE_{01} mode)



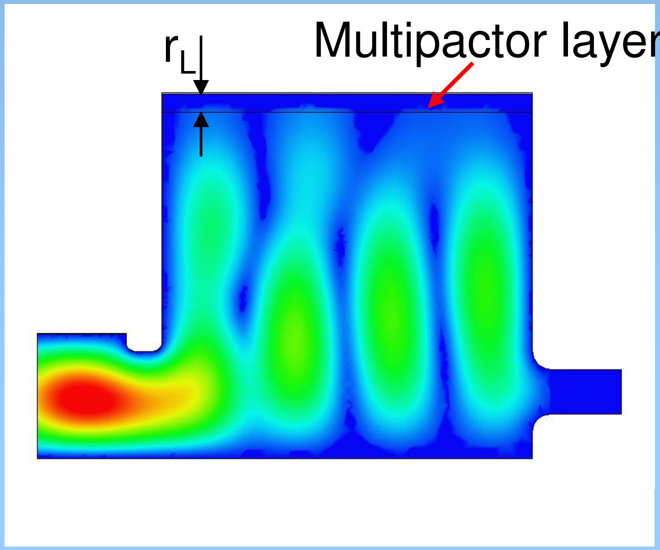
High-Q 30 GHz cavity (operating RF)

10 GHz RF
(TEM mode)



The same cavity at 10 GHz, low-Q (switching RF)

10 GHz radiation of kW power level initiates multipactor,
30 GHz operating radiation of multi-megawatt power level is scattered and absorbed by the prepared multipactor.
Swiching time is 10-20 ns.

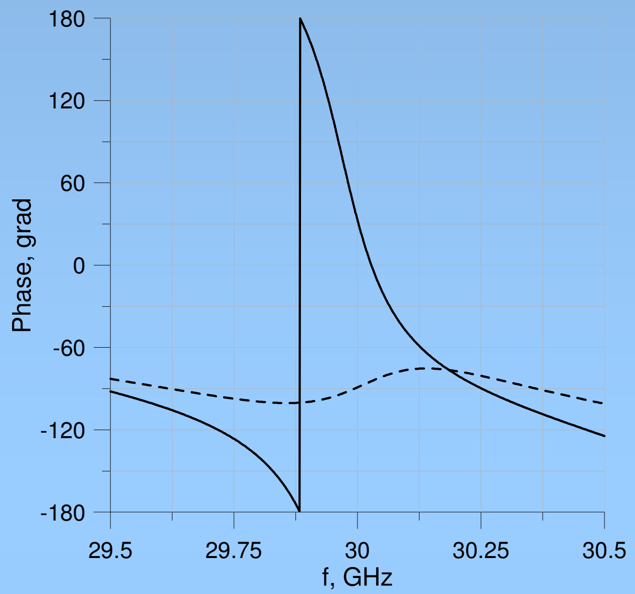


Simulation of multipactor influence

$$\varepsilon = 1 - \frac{\omega_{pe}^2}{(\omega + i\omega_c)^2},$$

$$\omega_{pe} = \left(\frac{4\pi \cdot N_e e^2}{m}\right)^{1/2}, \ \omega_c = \frac{eH}{mc}.$$

r_L – is Larmour radius.



Phase switching by multipactor
Solid curve is the phase before multipactor,
Dashed curve is the phase under multipactor.

Conclusion

We will do the best in order to complete all day-to-day contracts, to solve all technical problems, and hope to continue collaboration with CLIC.