

Optical inspection for SRF cavities



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DESY

430. Wilhelm und Else Heraeus-Seminar

Accelerators and Detectors at the Technology Frontier

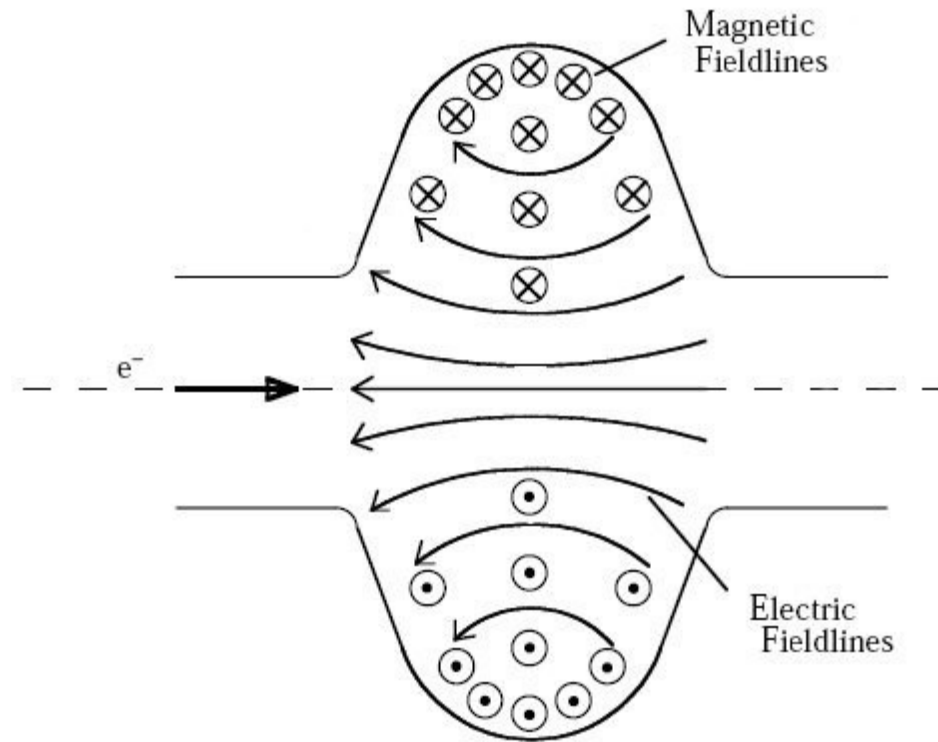
28.4.2009

Bad Honnef

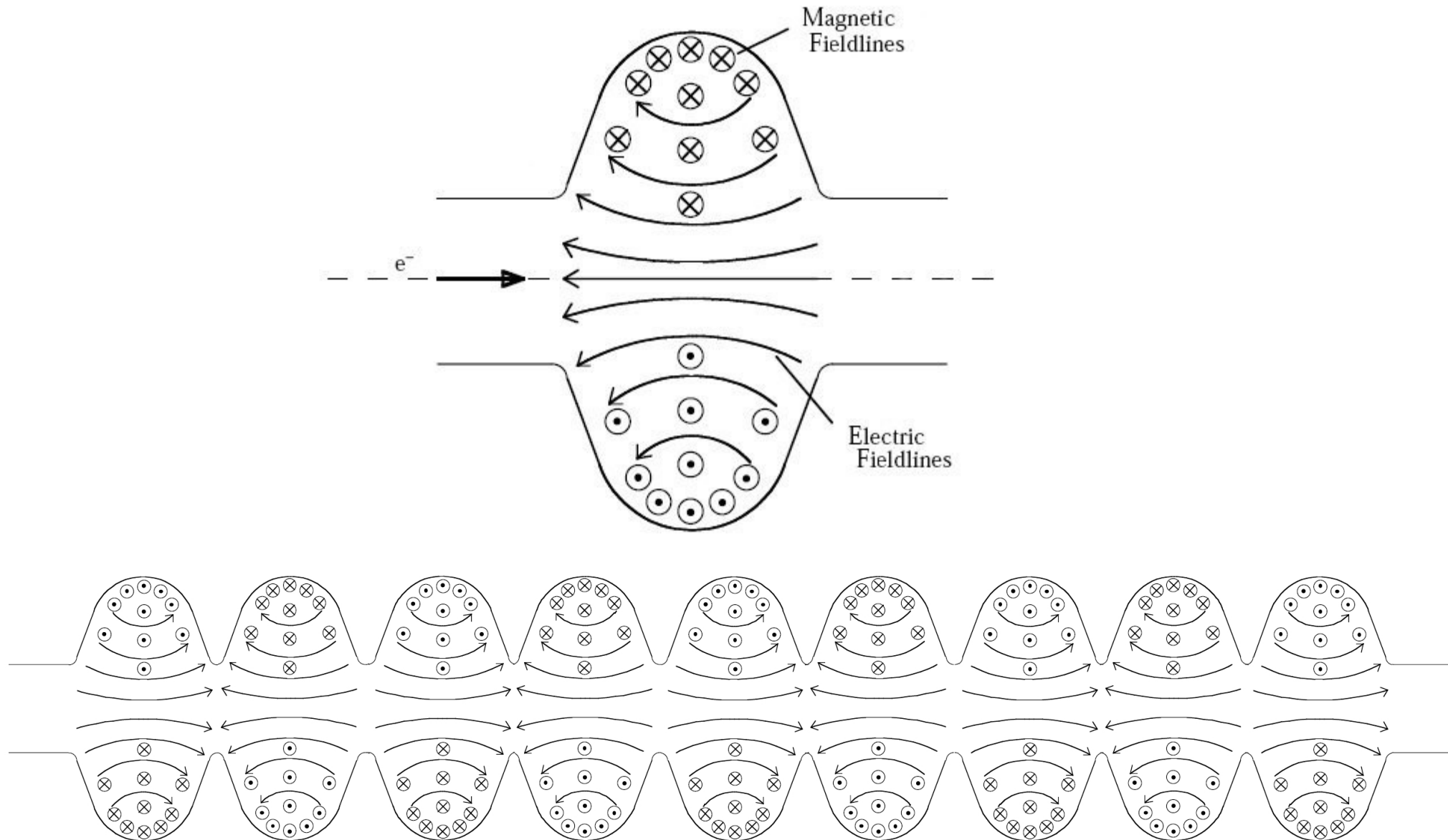
Outline

- SC Cavities for accelerators
- Limitations for SC and cavity gradients
- A new optical inspection system
- Future plans

SC cavities for accelerators



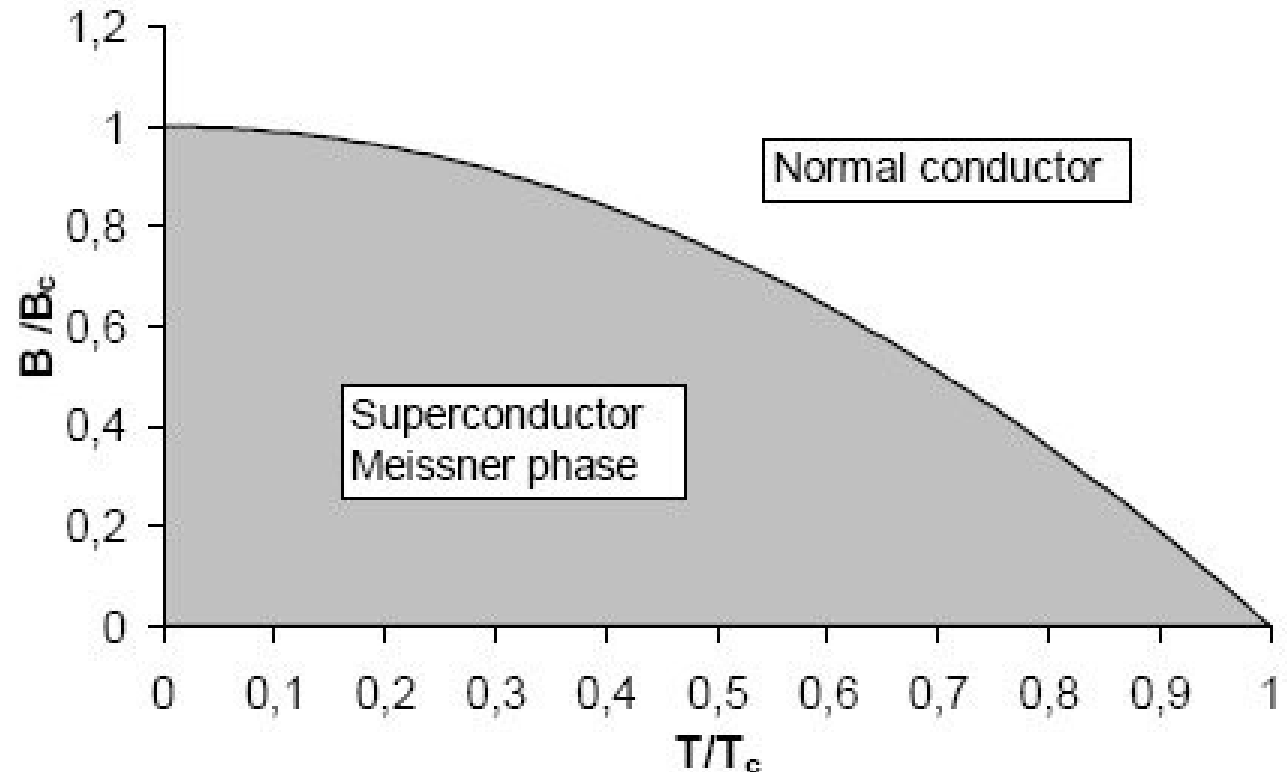
SC cavities for accelerators



Limitations on SC

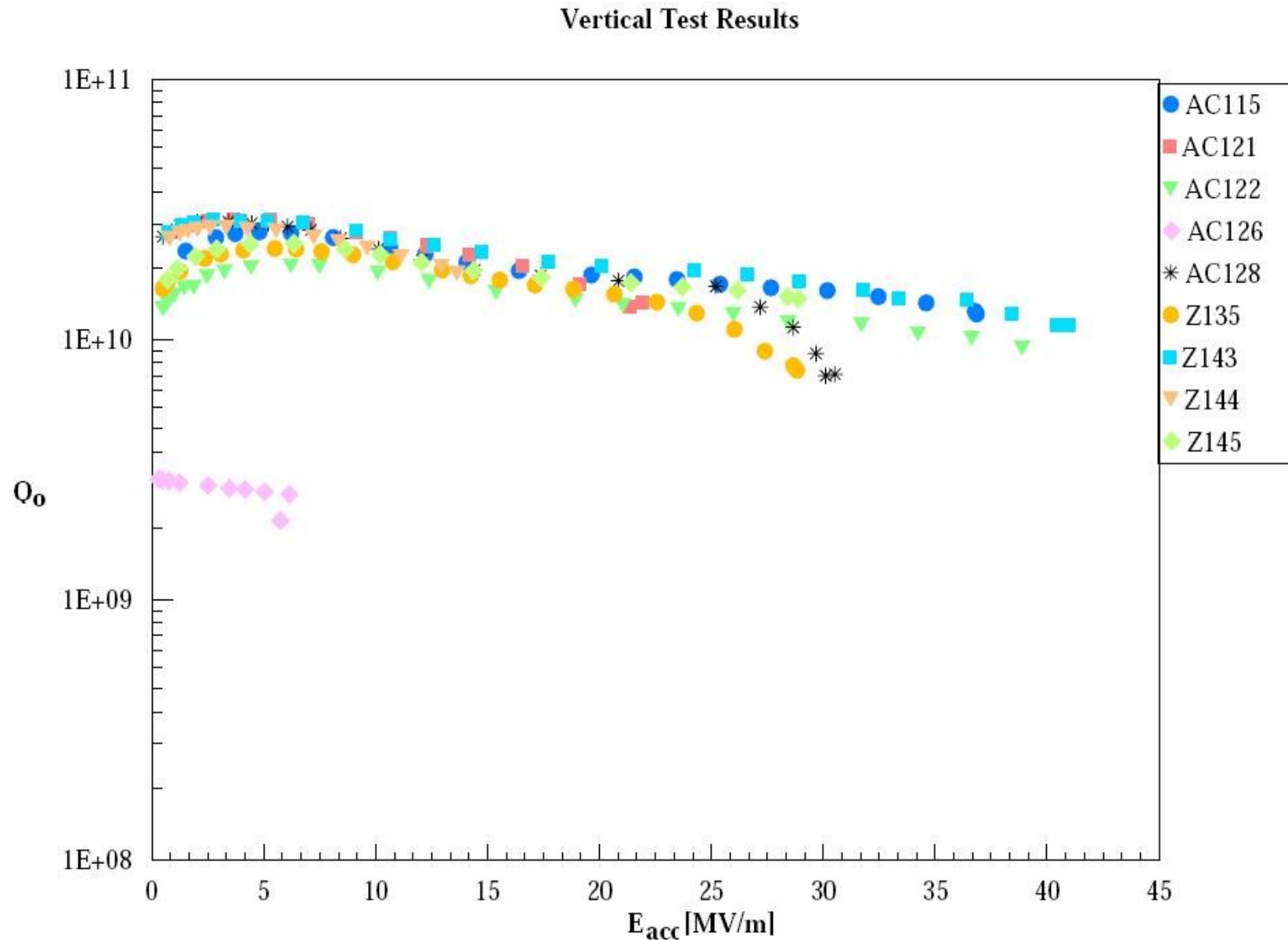
- SC state limited by two factors:

- Temperature
- Magnetic field



- Limit on peak magnetic field → fundamental limit for accelerating gradient in niobium: $E_{acc} \sim 50$ MV/m
- Design operating gradient for ILC: 31.5 MV/m

Spread in cavity performance

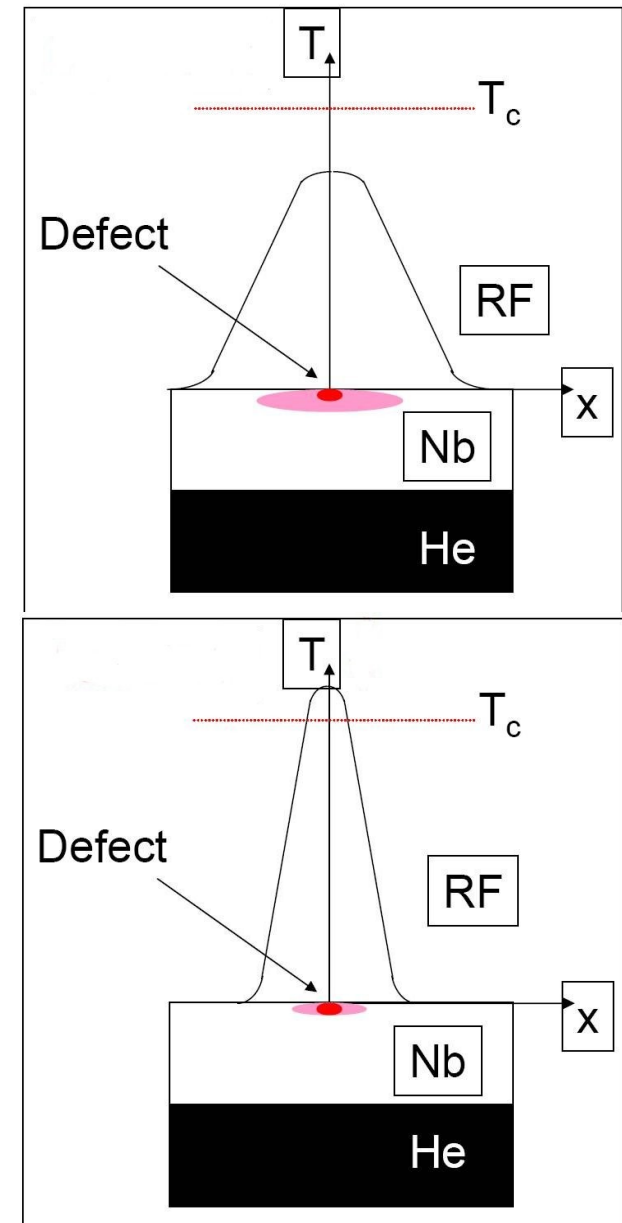


Field emission

- Lowering of potential barrier by particles on surface
→ Emission of electrons in regions with high surface electric field
- Electrons are accelerated, hit surface and cause heating
- Primary limitation over past 5-10 years
- Reduced by careful surface preparation
 - Cleanroom handling
 - Etching or electropolishing
 - High pressure water rinsing

Thermal breakdown

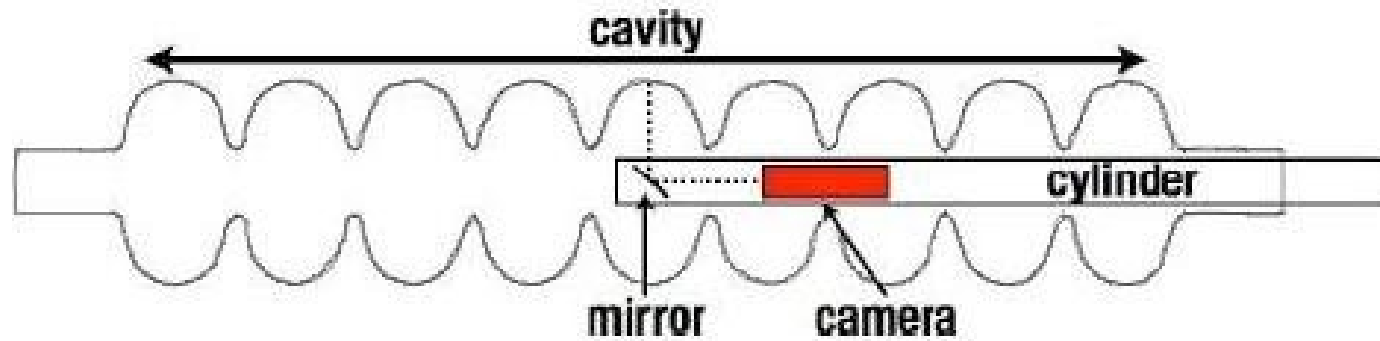
- Localized effect at „defects“ with higher R_s
 - Inclusions of foreign material
 - Bumps or pits
 - Welding defects
- Dissipation of energy → exceeding of T_c
- If heat can't be transported to He-bath by surrounding material → breakdown (quench)



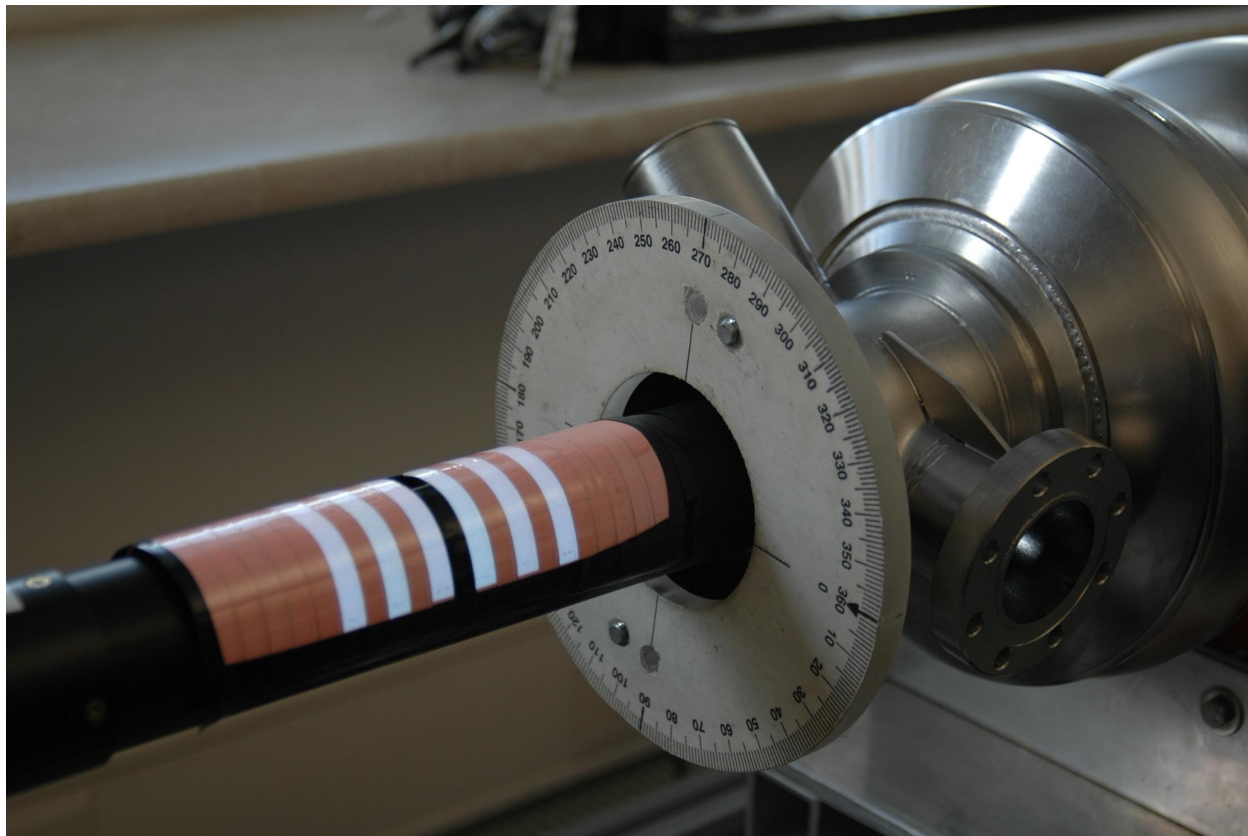
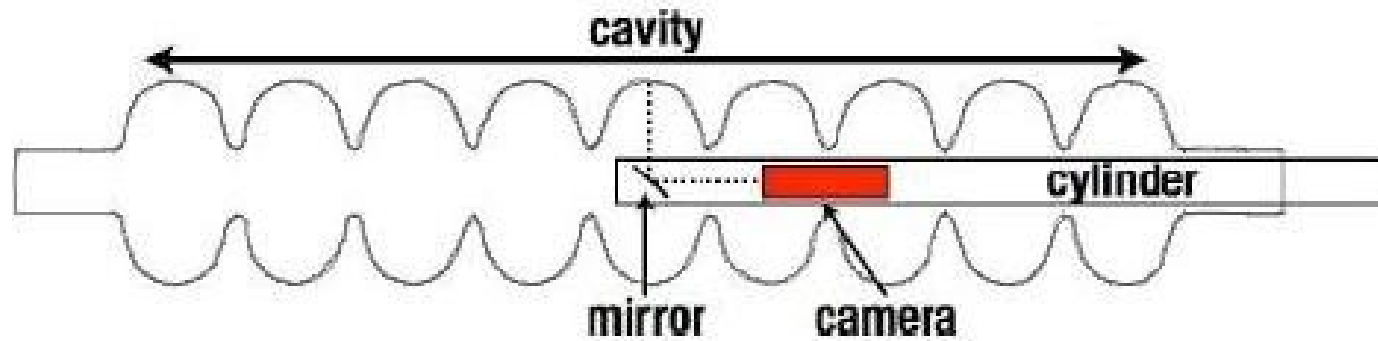
A new optical inspection system

- Developed at Kyoto University and KEK
- High resolution camera (7 μm /pixel)
- Sophisticated lighting system
 - Adapted to difficult conditions (mirror-like surface)
 - Lighting from different angles possible
- Prototype available at DESY for inspections and improvement of the system

A new optical inspection system

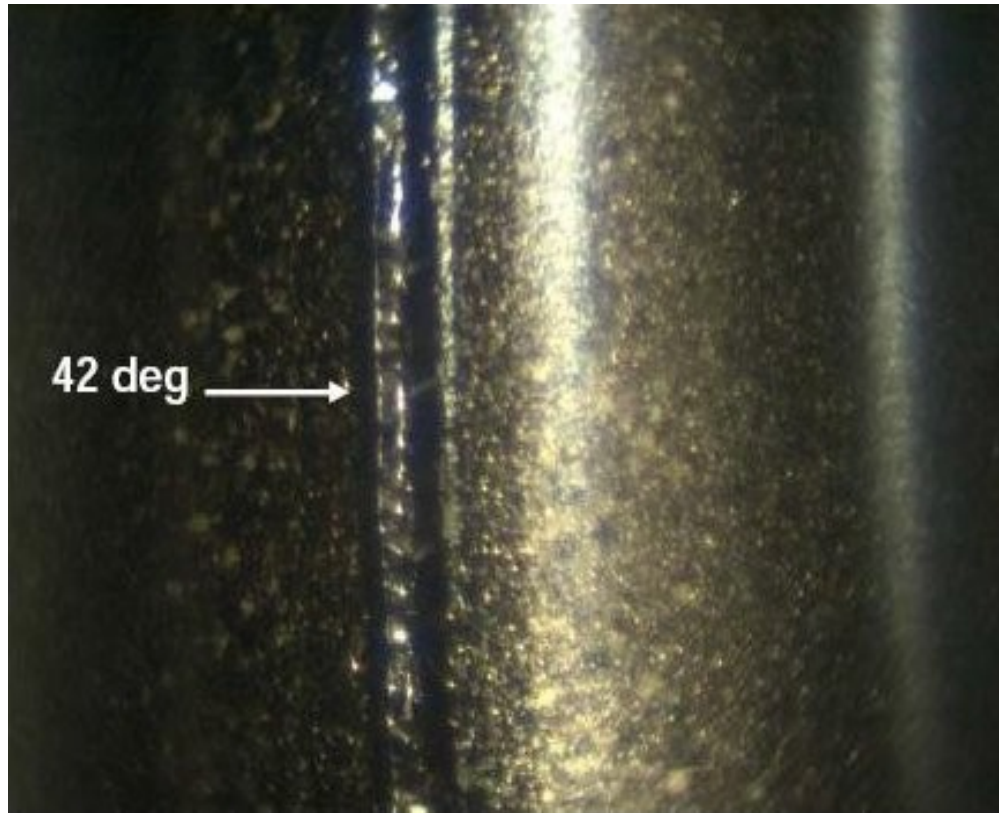


A new optical inspection system



Comparison: Old ↔ New

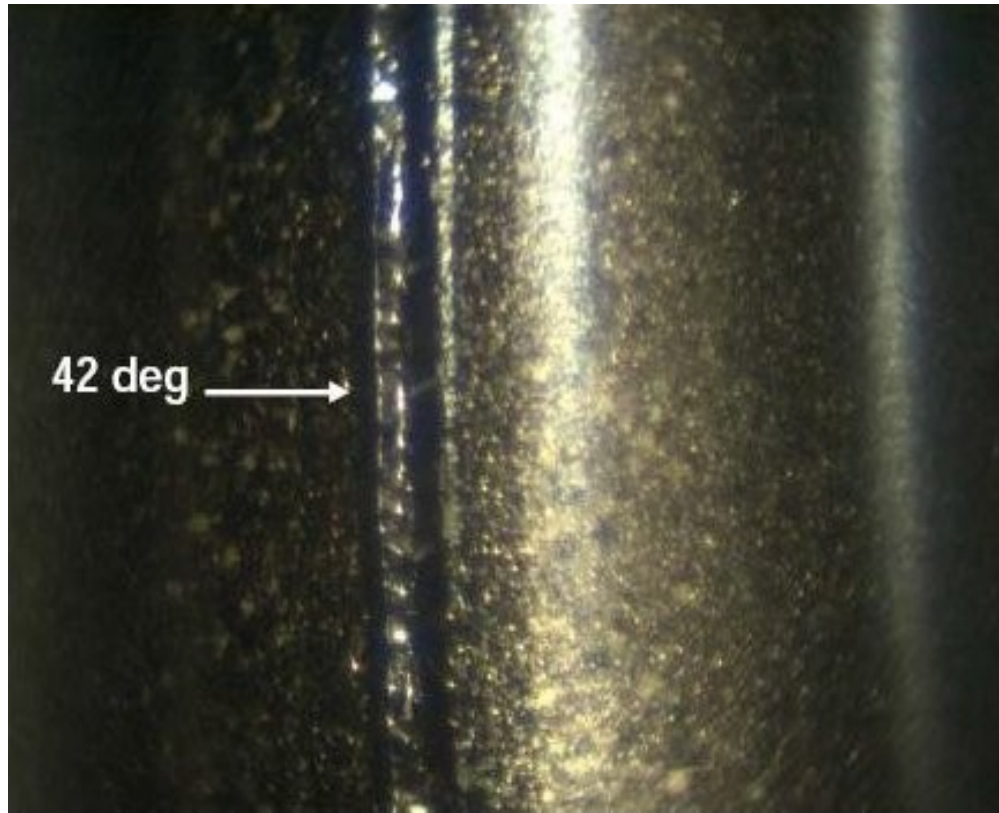
35x50 mm



DESY: Picture at 42 deg.

Comparison: Old ↔ New

35x50 mm



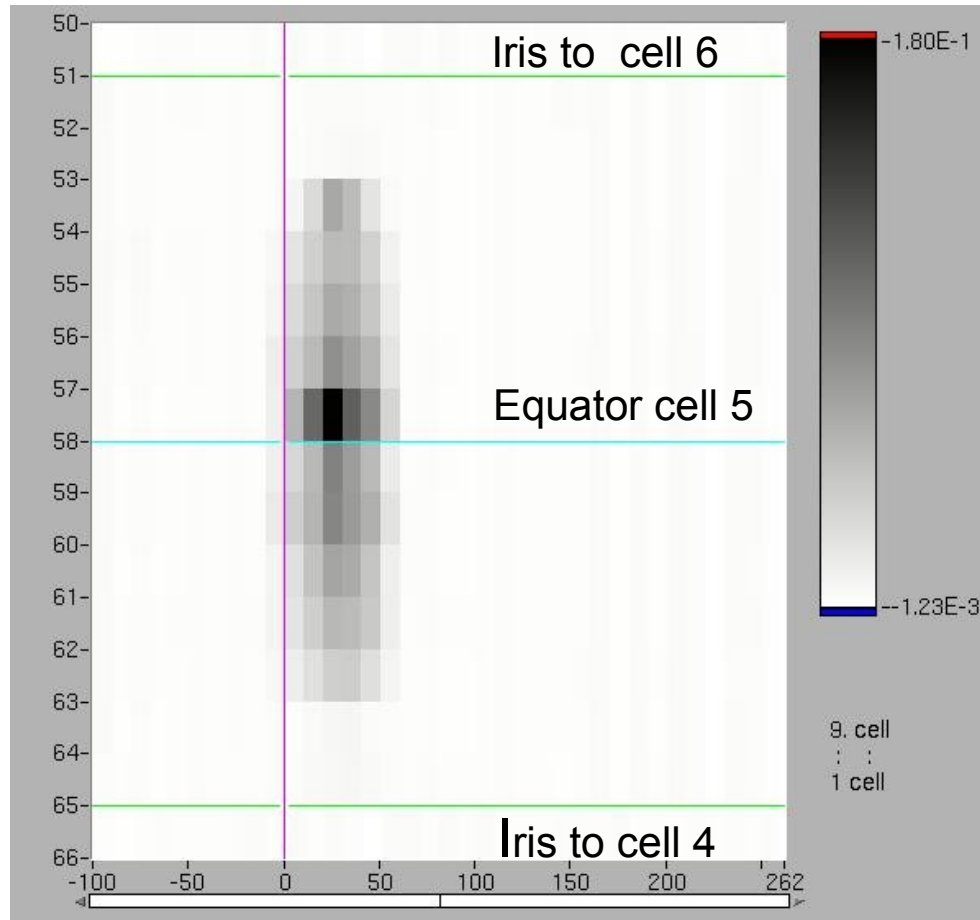
DESY: Picture at 42 deg.

9x13 mm



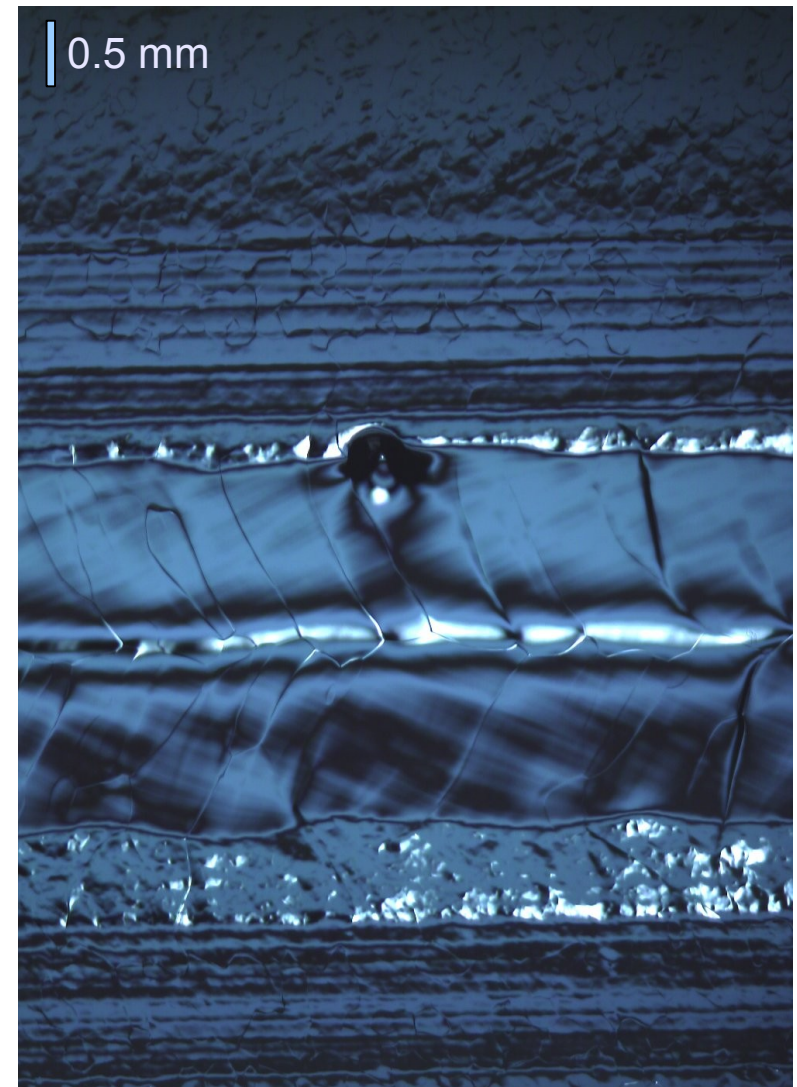
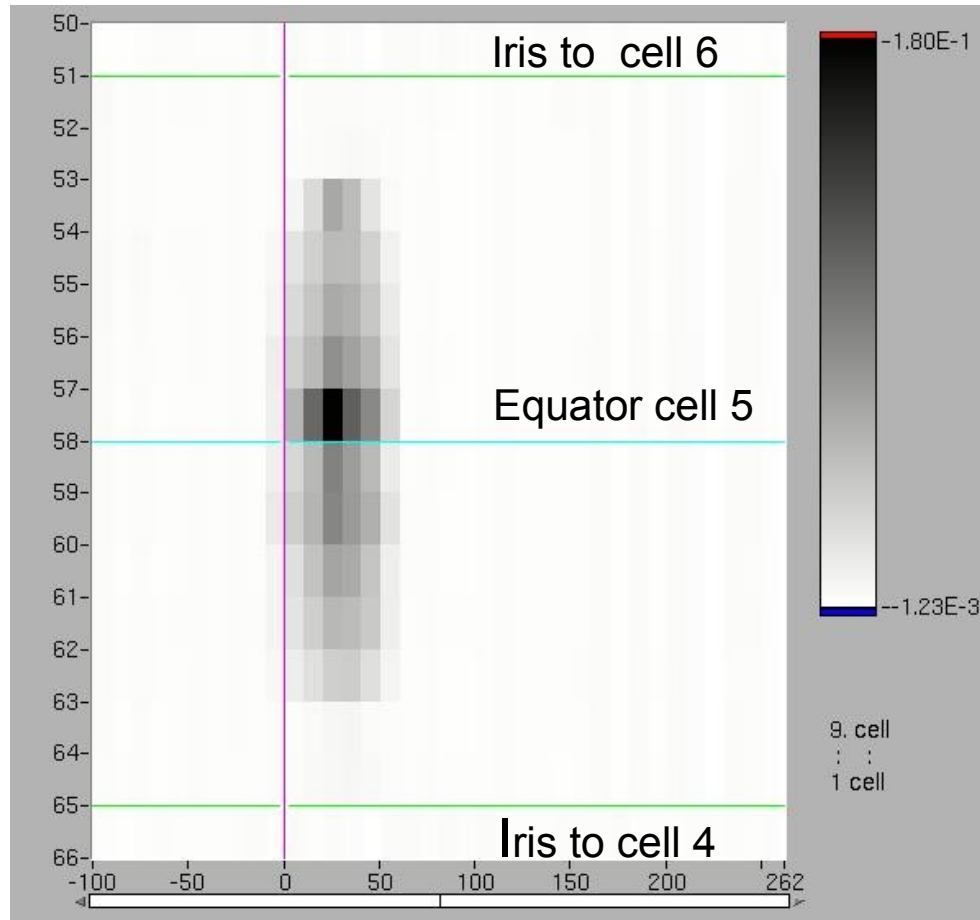
KEK: Picture at 43 deg.

Comparison: T-map \leftrightarrow Picture



Z130: Quench in $3\pi/9$ -mode at
22 MV/m

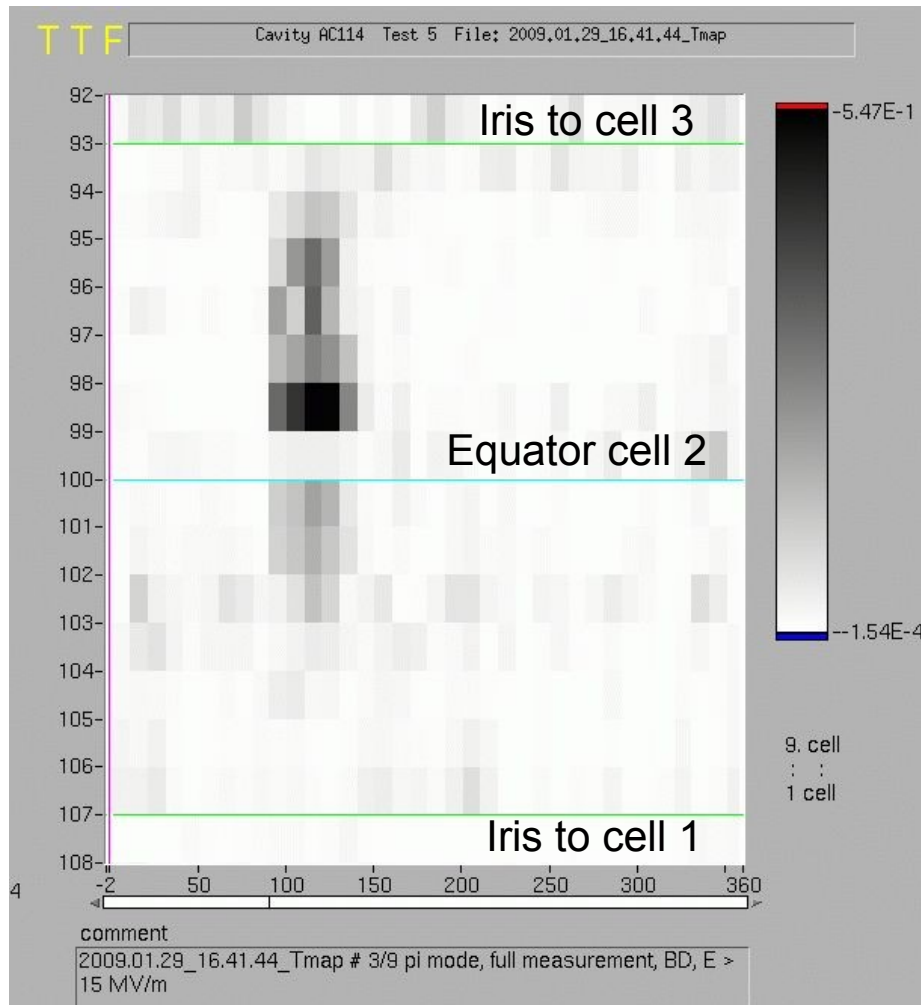
Comparison: T-map \leftrightarrow Picture



Z130: Quench in $3\pi/9$ -mode at
22 MV/m

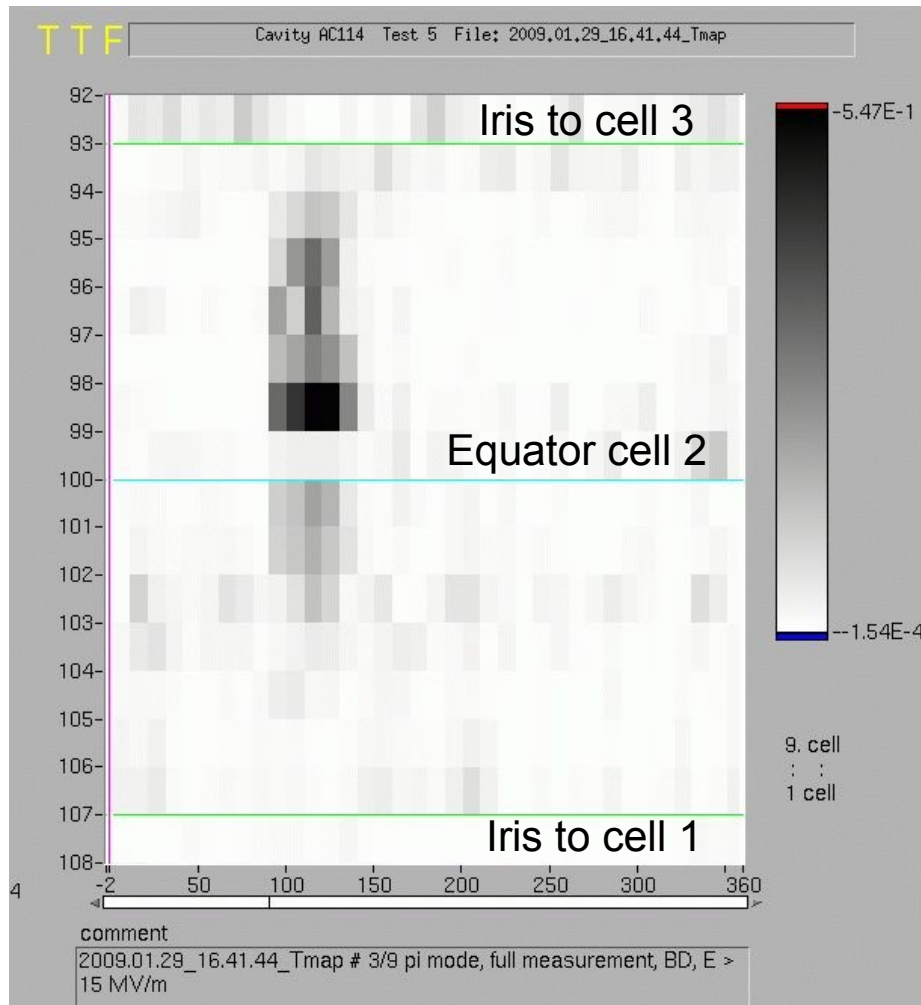
Picture at same location

Comparison: T-map \leftrightarrow Picture (2)



AC114: Quench in $3\pi/9$ -Mode

Comparison: T-map ↔ Picture (2)



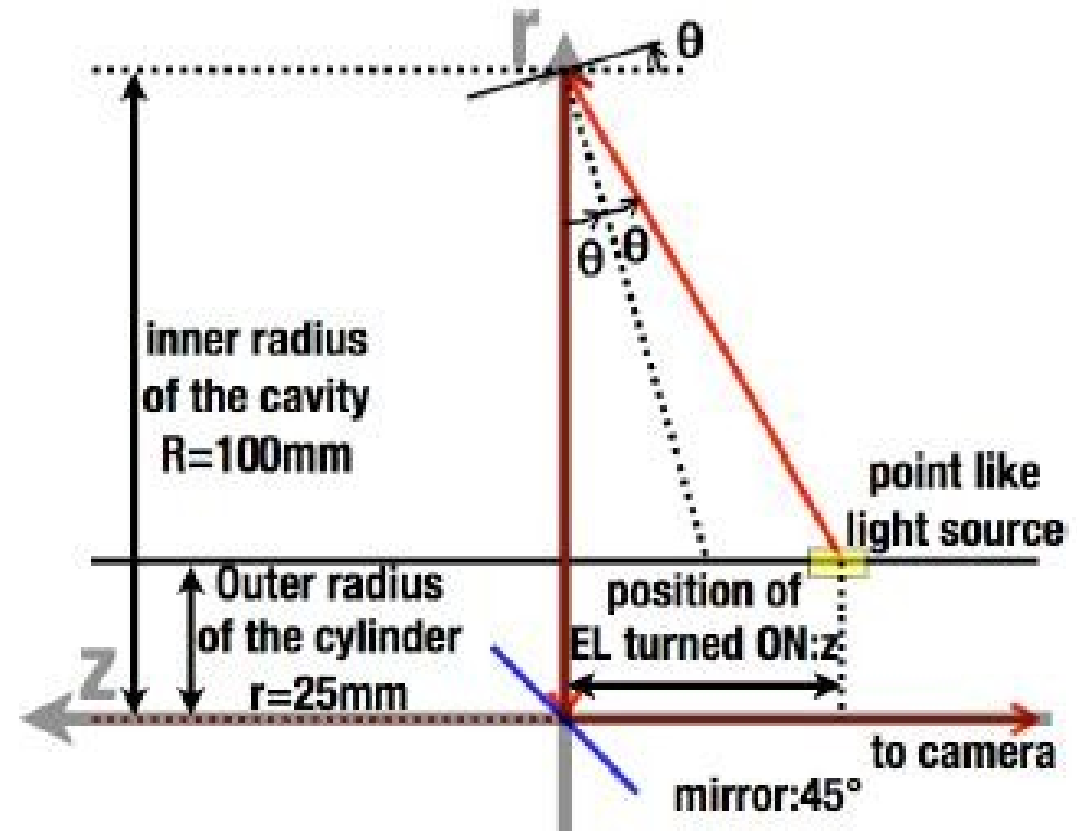
AC114: Quench in $3\pi/9$ -Mode



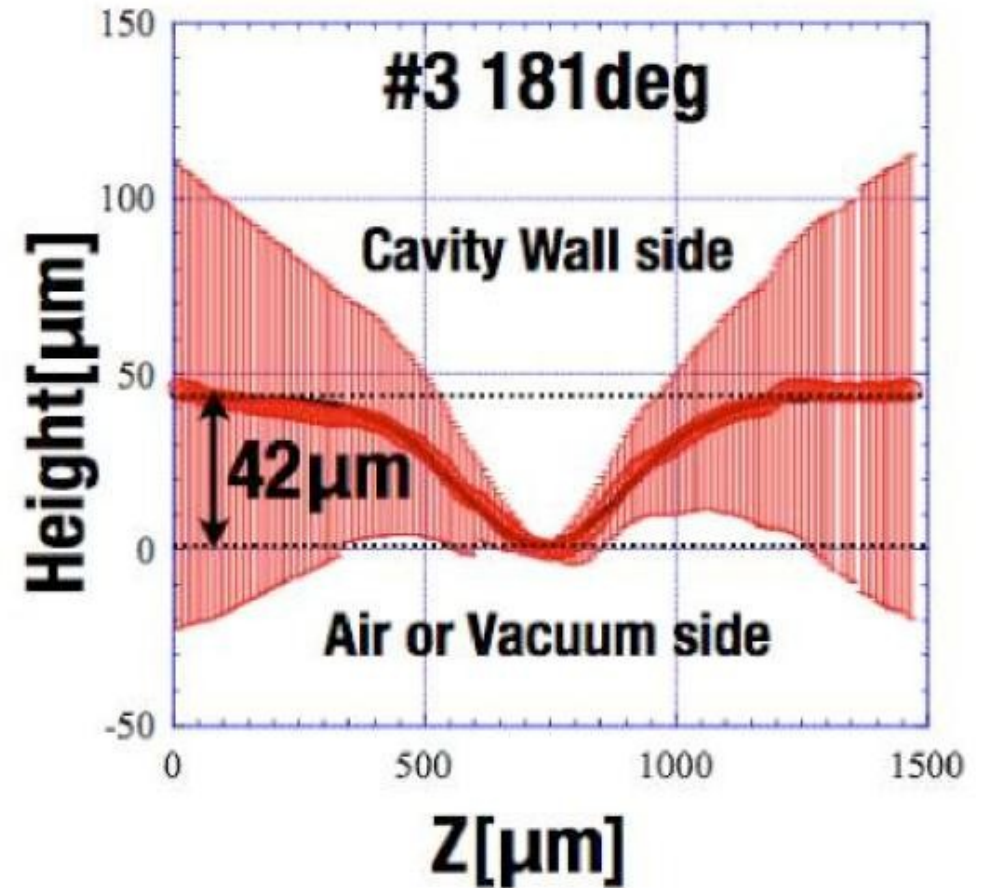
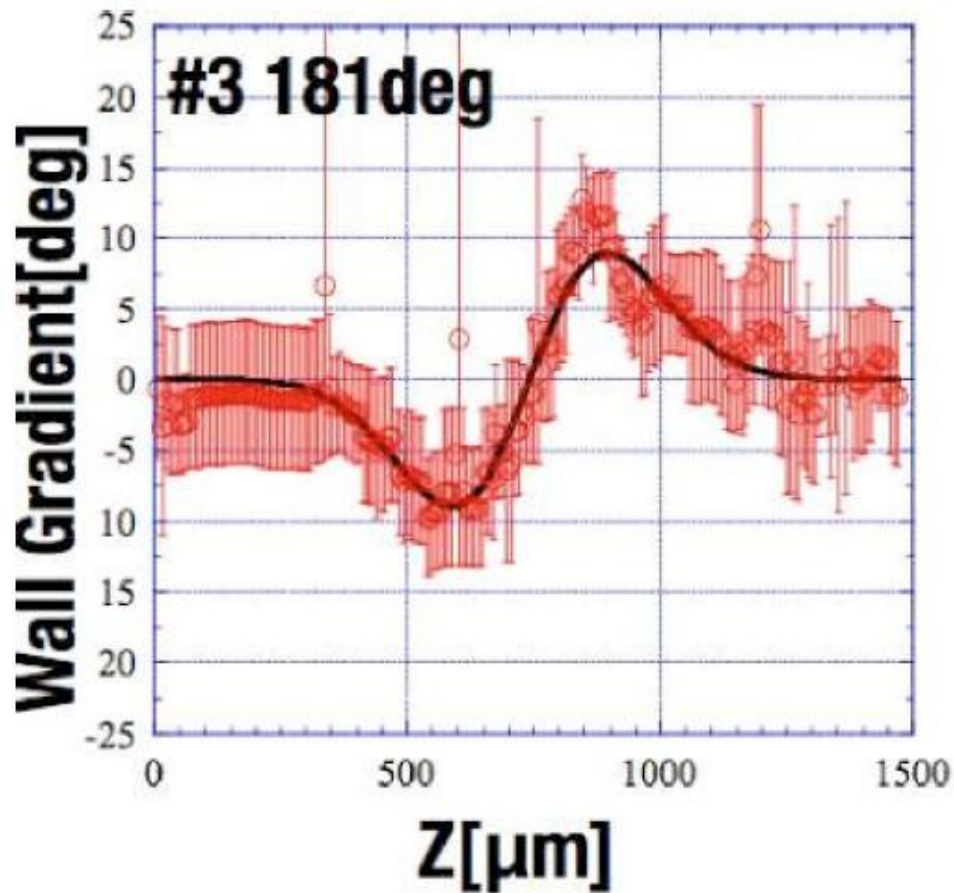
Picture at same location

Wall-gradient measurement

- Take pictures with different light sources
- Get information on wall-gradient from reflection angle
- Convert gradient into height information



Wall-gradient measurement



Measurement at KEK

Wall-gradient measurement

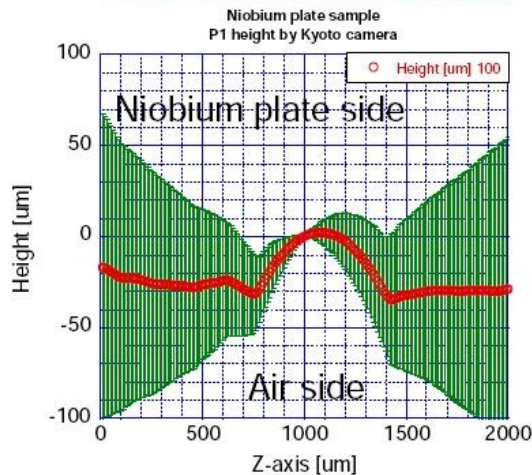
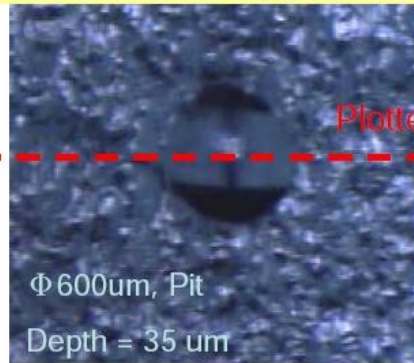


superconducting rf test facility

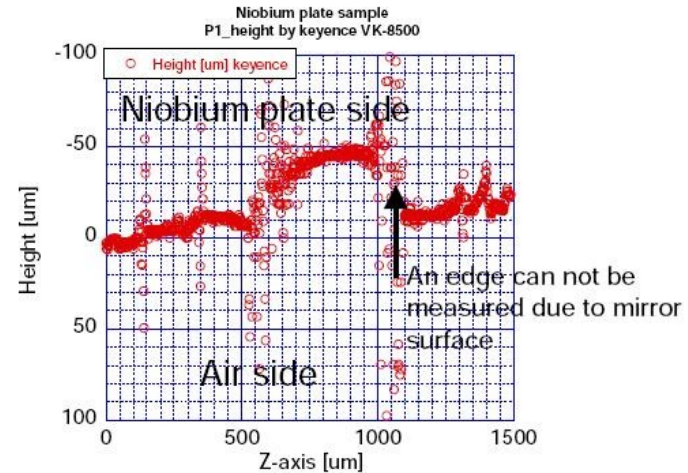
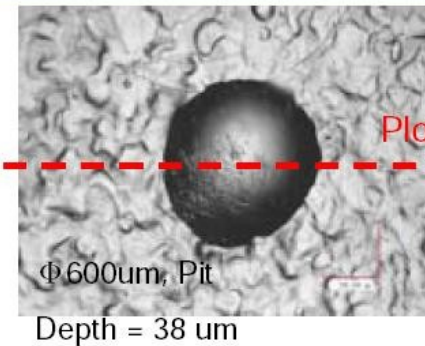


Result of Shape analysis : P1

Kyoto camera : Tajima method



Laser microscope: VK-8500



The results of depth value are almost same.

STF
K. Watanabe (KEK)

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Plans for the future

- New cavity handling system
 - Cavities without and with He-tank
 - Measurement as completely automated as possible
- Include pattern recognition software
- Correlate T-map with optical data
- Track evolution of defects during preparation steps

- Goal: Use optical data for predictions on cavity performance to maximize gradient and production yield