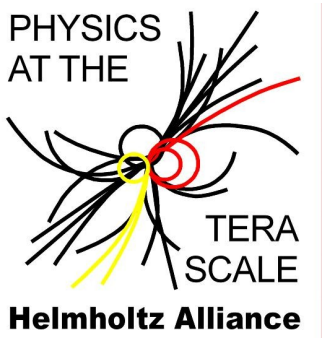
Optical inspection for high gradient SRF cavities



Sebastian Aderhold
DESY

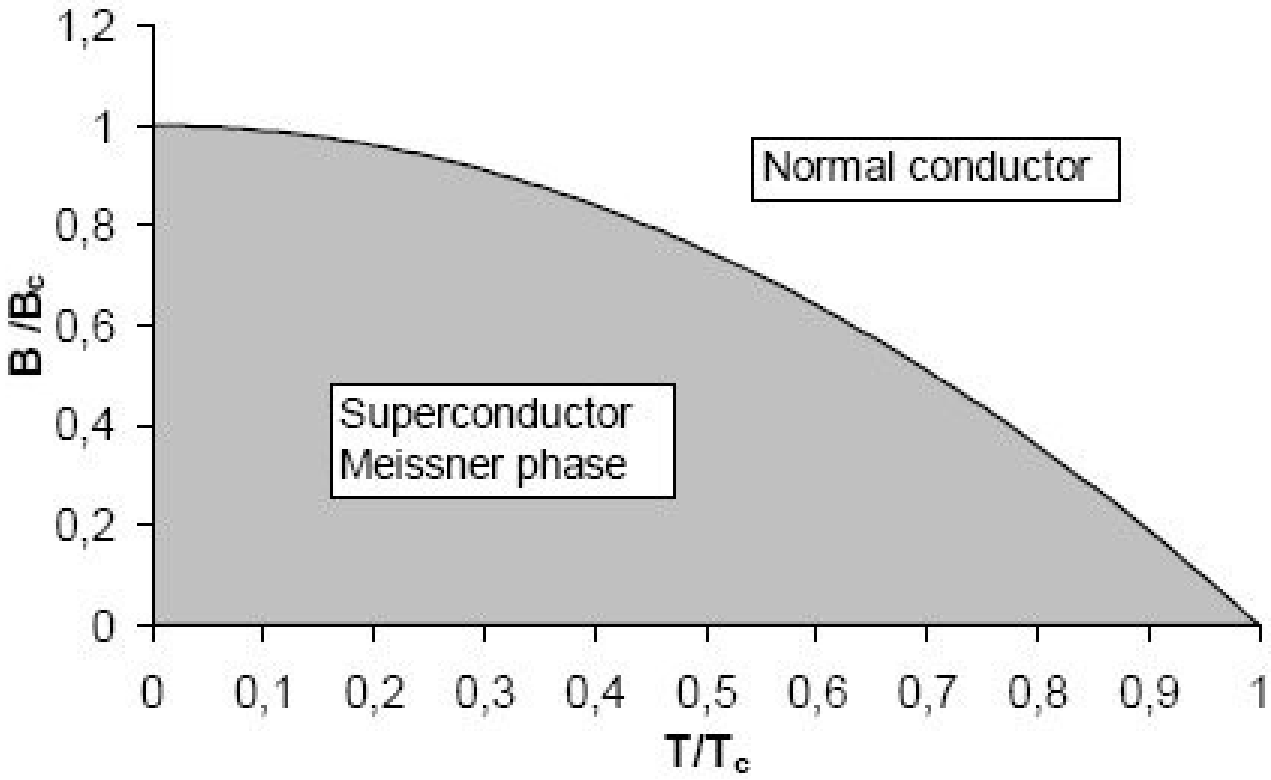
2nd Annual Workshop 'Physics at the Terascale'
Aachen 27.11.2008

Outline

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

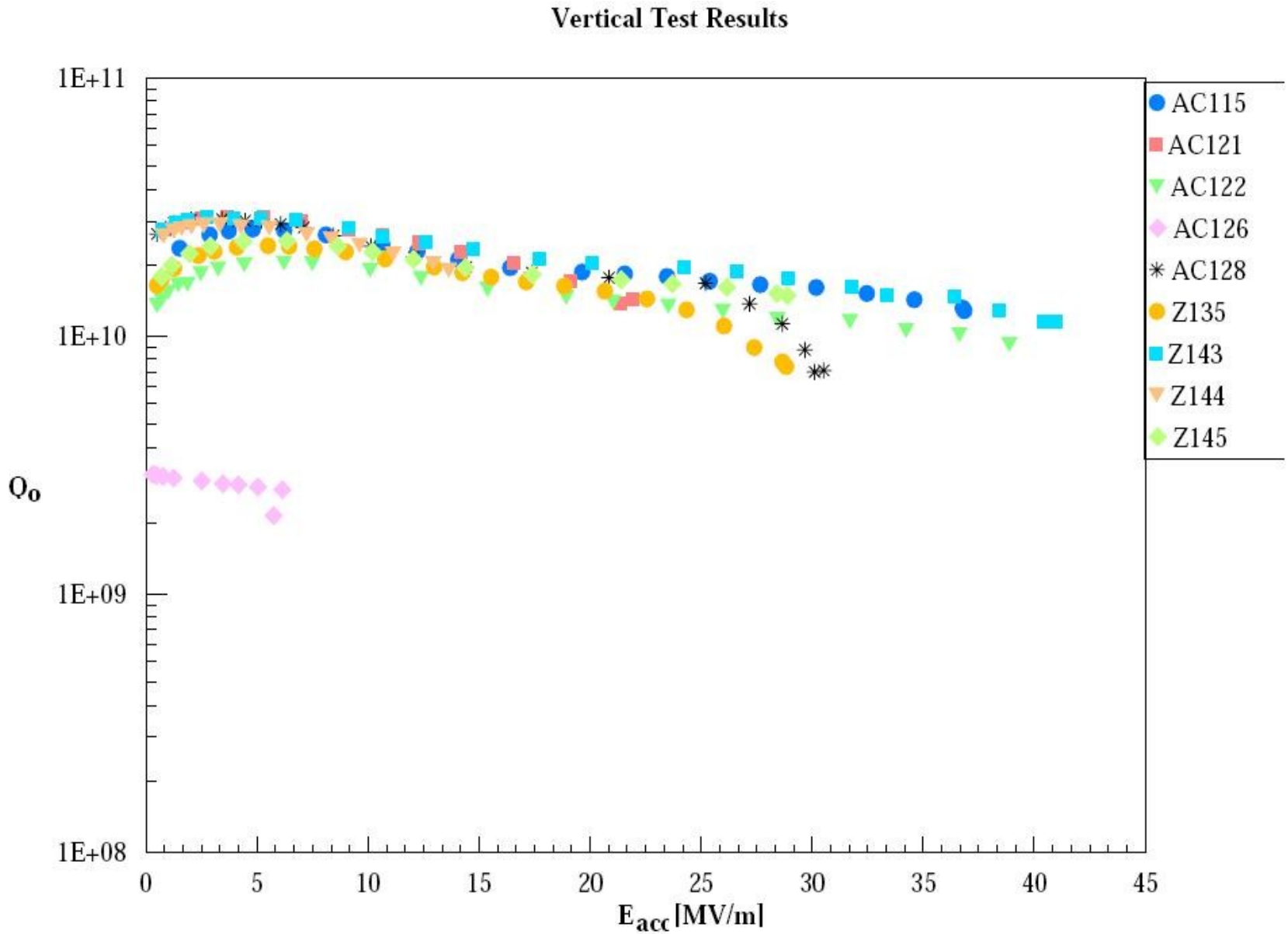
Limitations on SC

- SC state limited by two factors:
  - temperature
  - magnetic field



- Peak magnetic field: fundamental limit in niobium
  E_{acc} ~ 57 MV/m

Spread in cavity performance

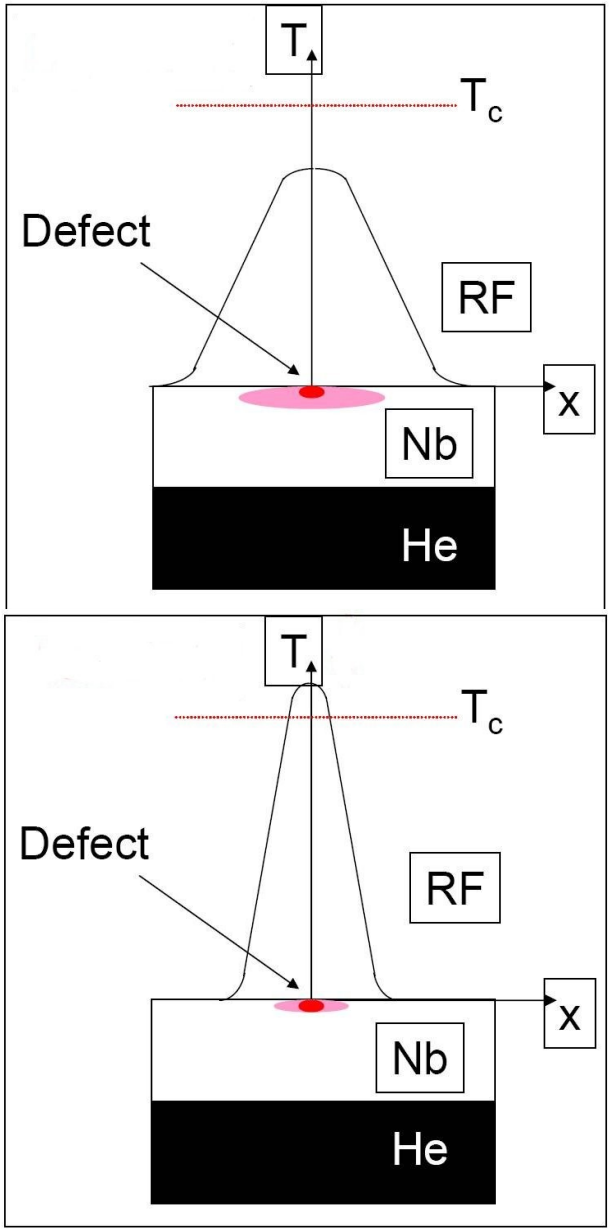


Field emission

- 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
- Nearly eliminated by careful surface preparation
  - Cleanroom handling
  - Etching or electropolishing
  - High pressure water rinsing

Thermal breakdown

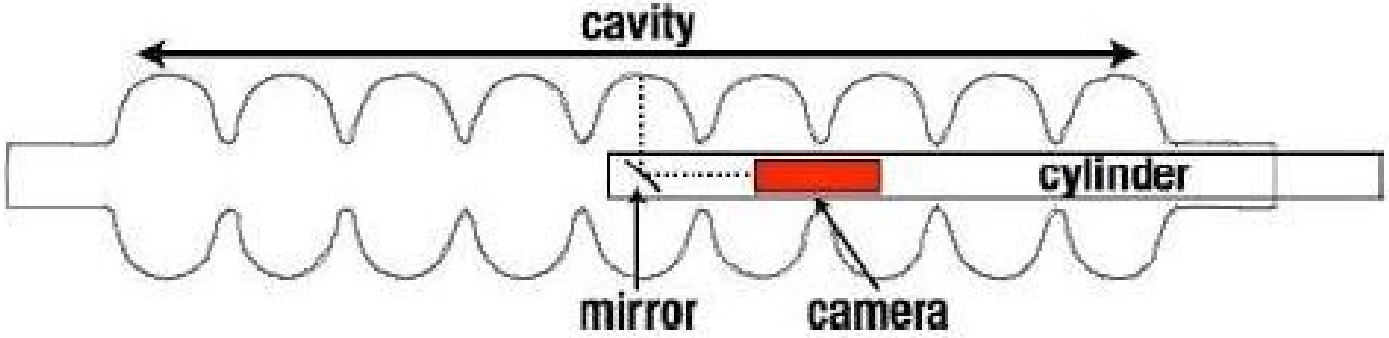
- Localized effect at „defects“ with higher R_S
  - Inclusions of foreign material
  - Bumps or pits
  - Welding defects
- Dissipation of energy
  $\longrightarrow$ exceeding of T_C
- If heat can't be transported to He-bath by surrounding material $\longrightarrow$ breakdown (quench)



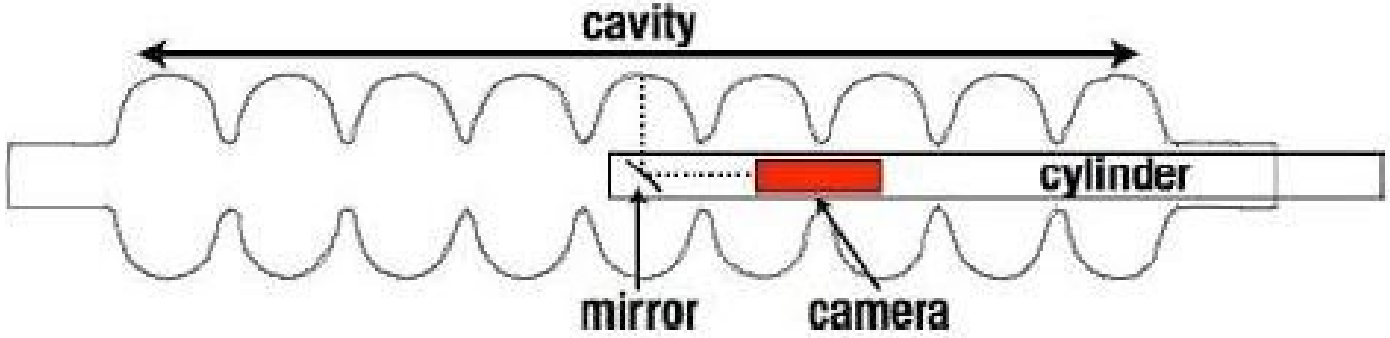
A new optical inspection system

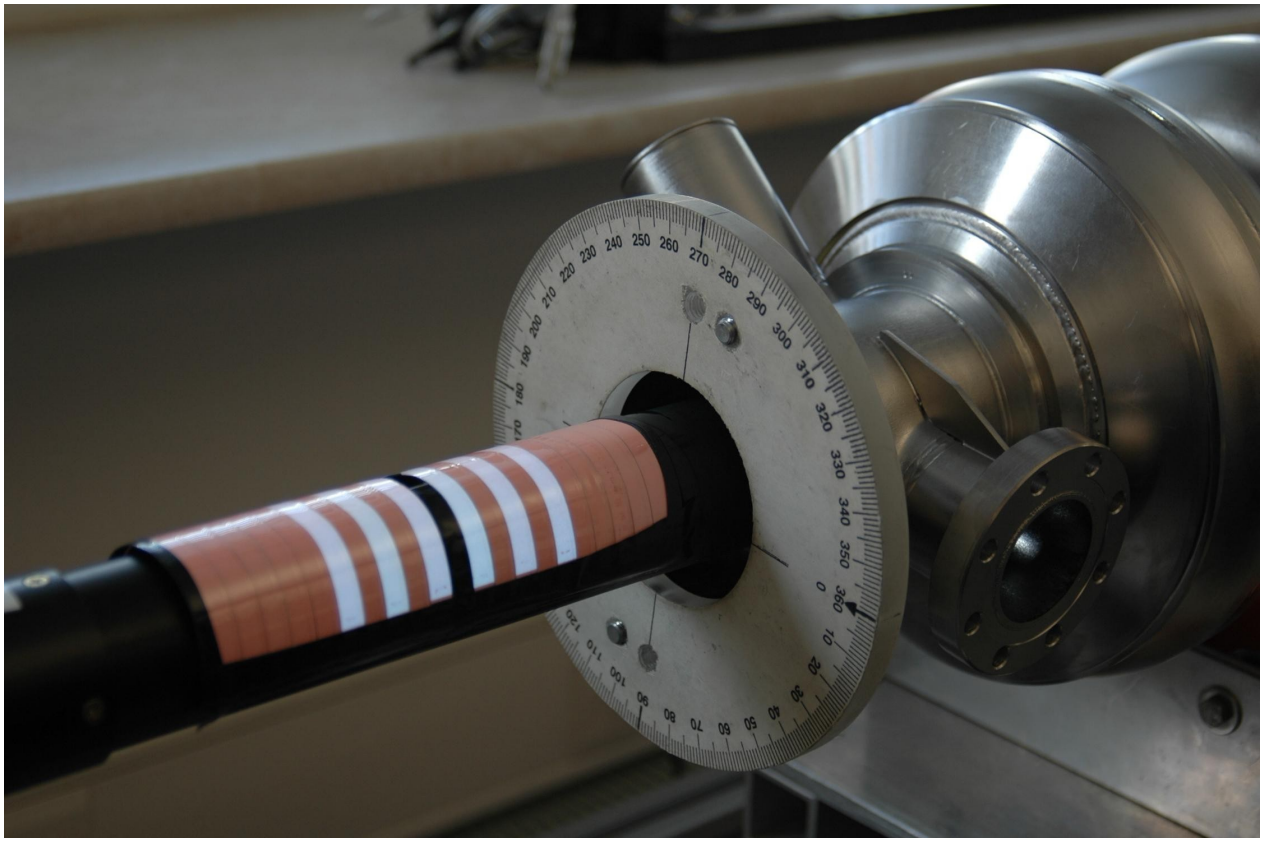
- Developed at Kyoto University and KEK
- High resolution camera (7 μm/pixel)
- Sophisticated lighting system
  - Adapted to difficult conditions (mirror-like surface)
  - Lighting from different angles possible
- Prototype reached DESY end of August
- Several cavities inspected with temporary setup

A new optical inspection system



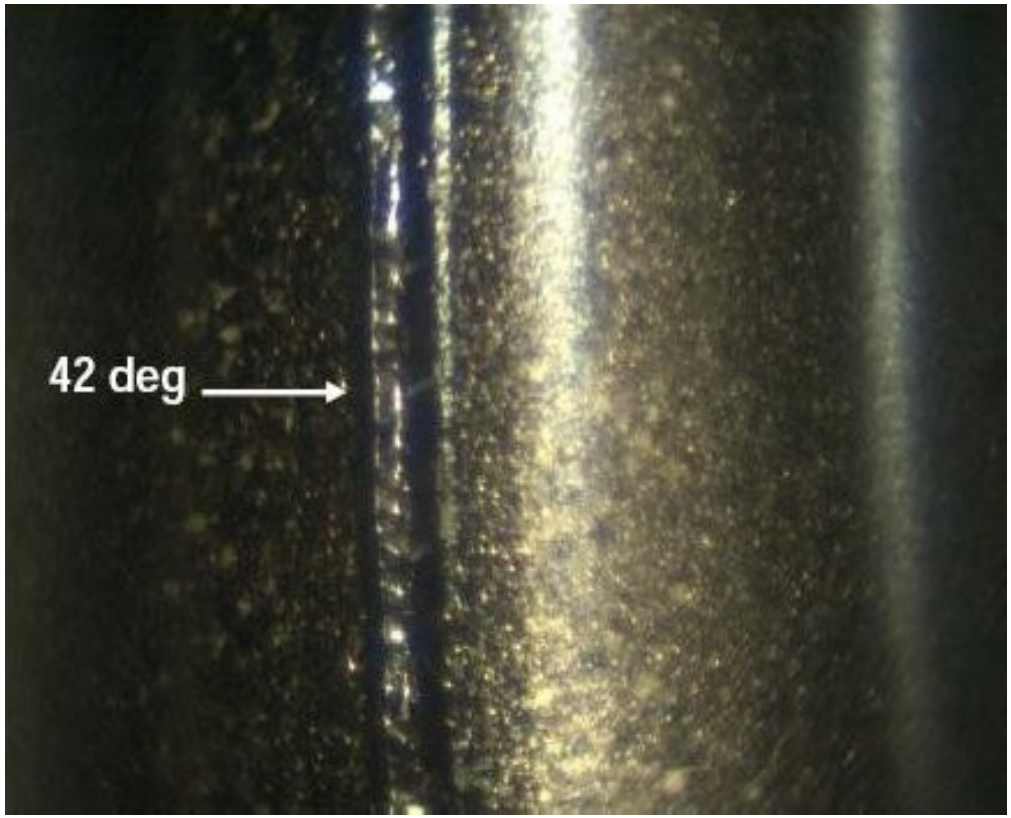
A new optical inspection system





Comparison: Old ↔ New

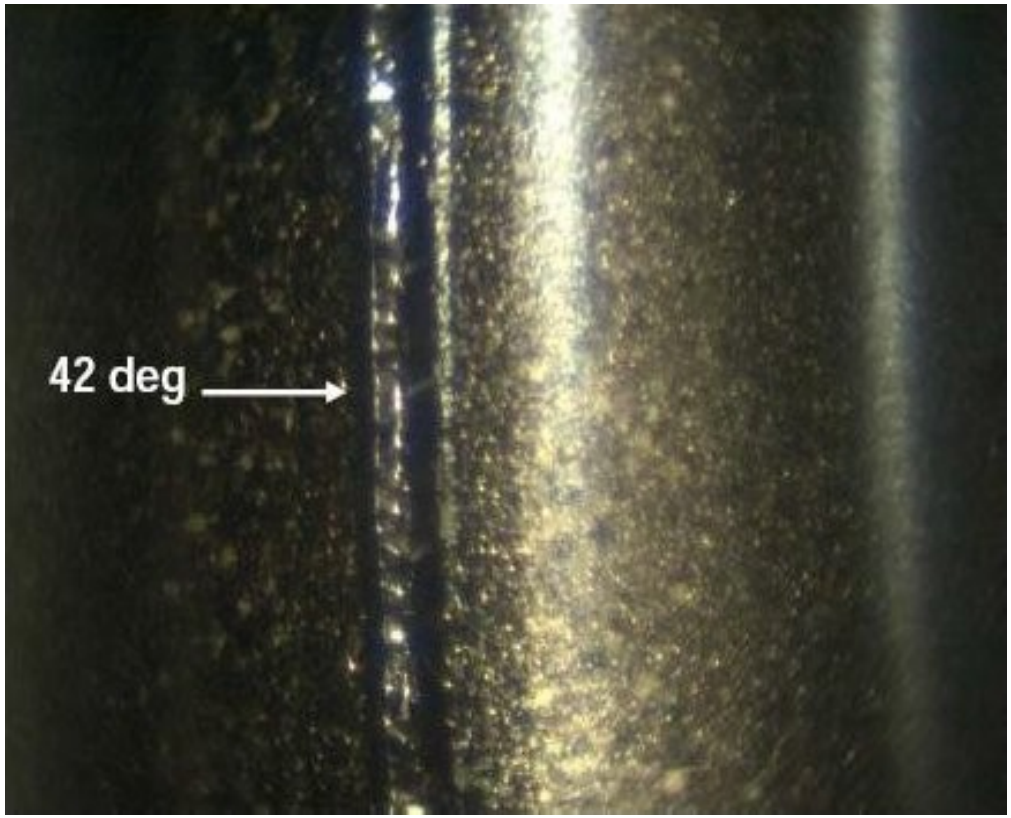
35x50 mm



DESY: Picture at 42 deg.

Comparison: Old ↔ New

35x50 mm

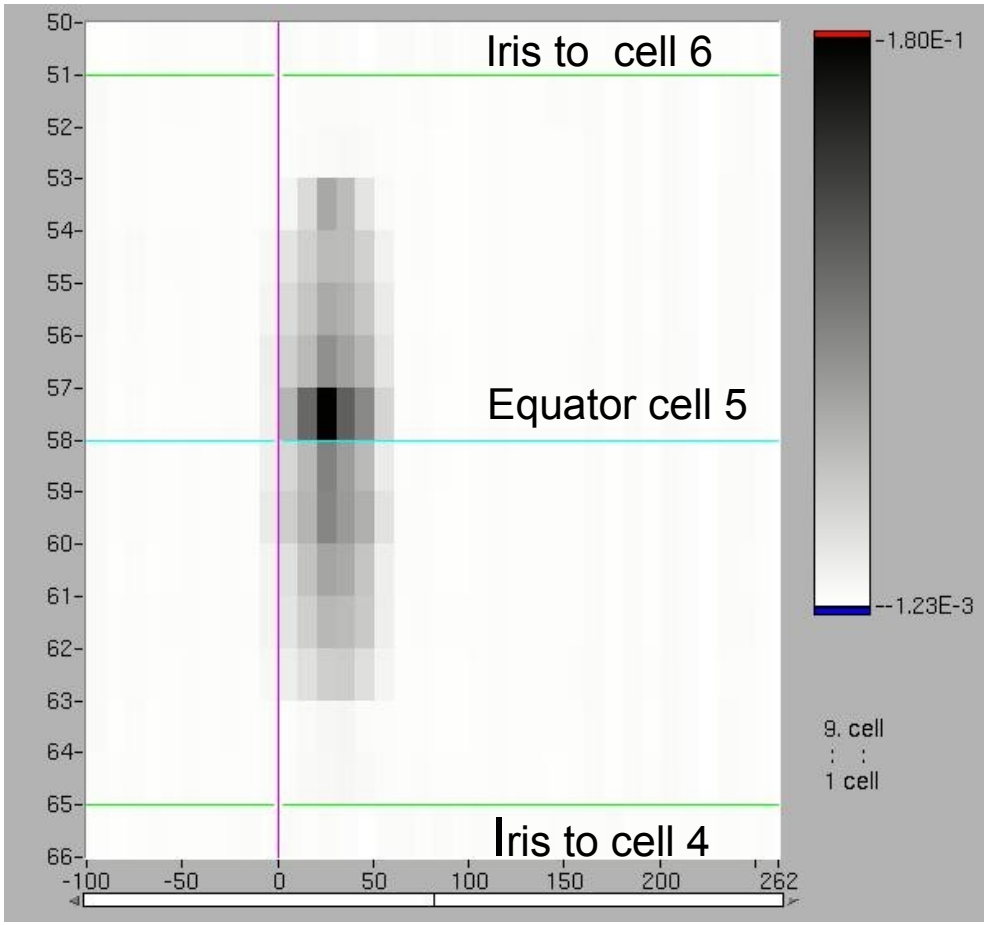


DESY: Picture at 42 deg.

9x13 mm

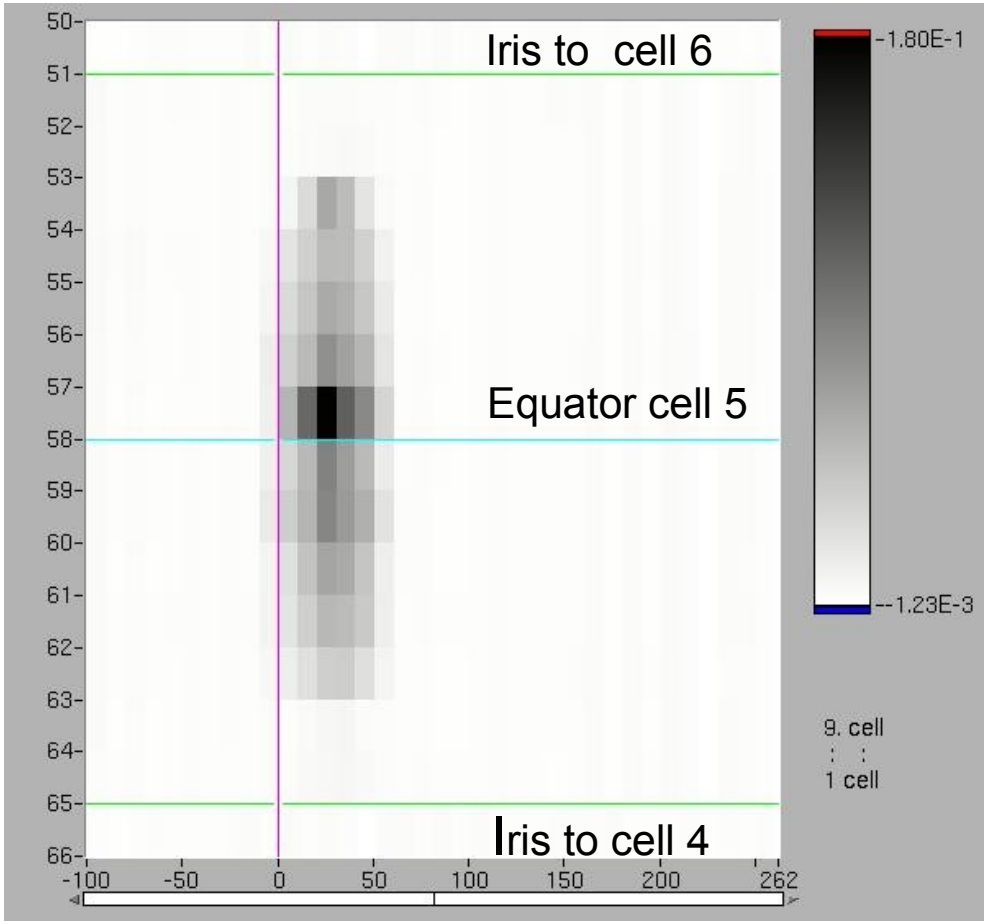
KEK: Picture at 43 deg.

Comparison: T-map ↔ Picture

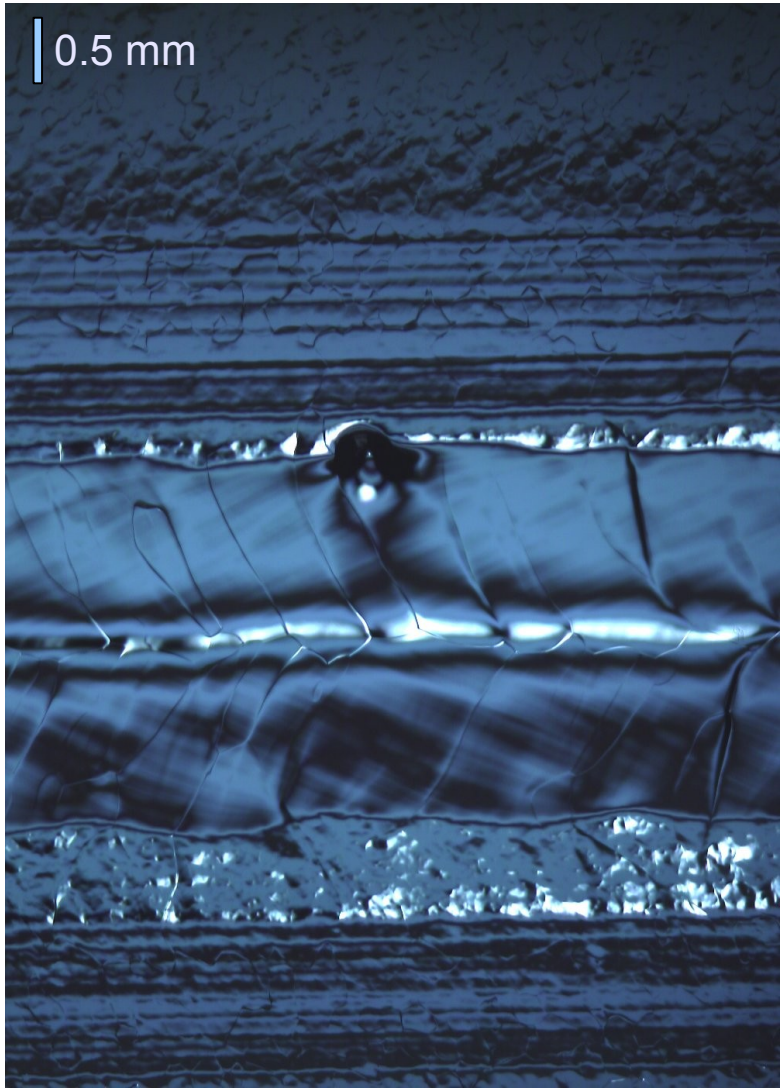


Z130: Quench in 3π/9-mode at 22 MV/m

Comparison: T-map ↔ Picture



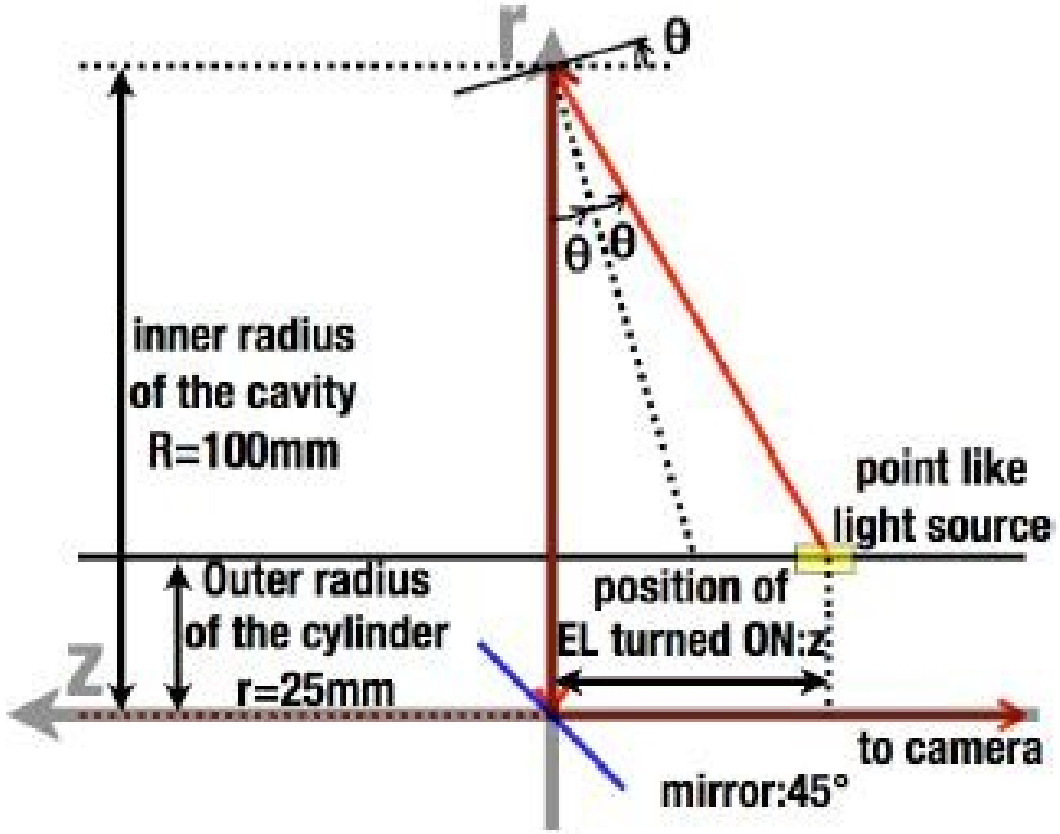
Z130: Quench in 3π/9-mode at 22 MV/m



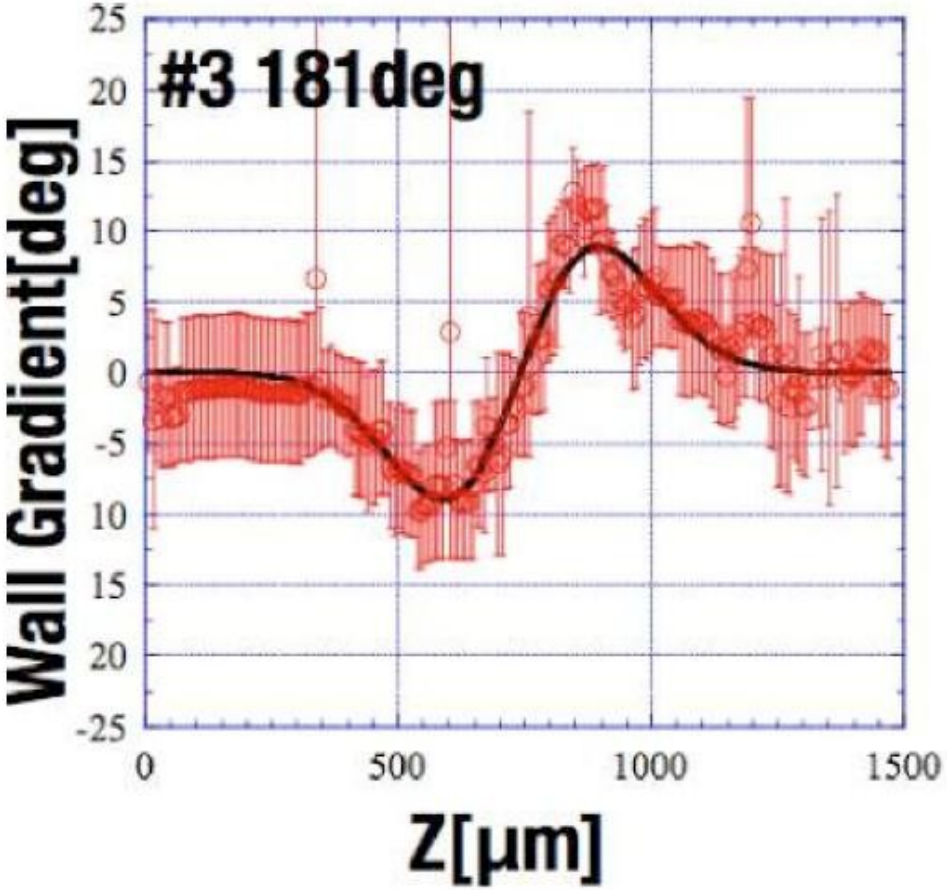
Picture at same location

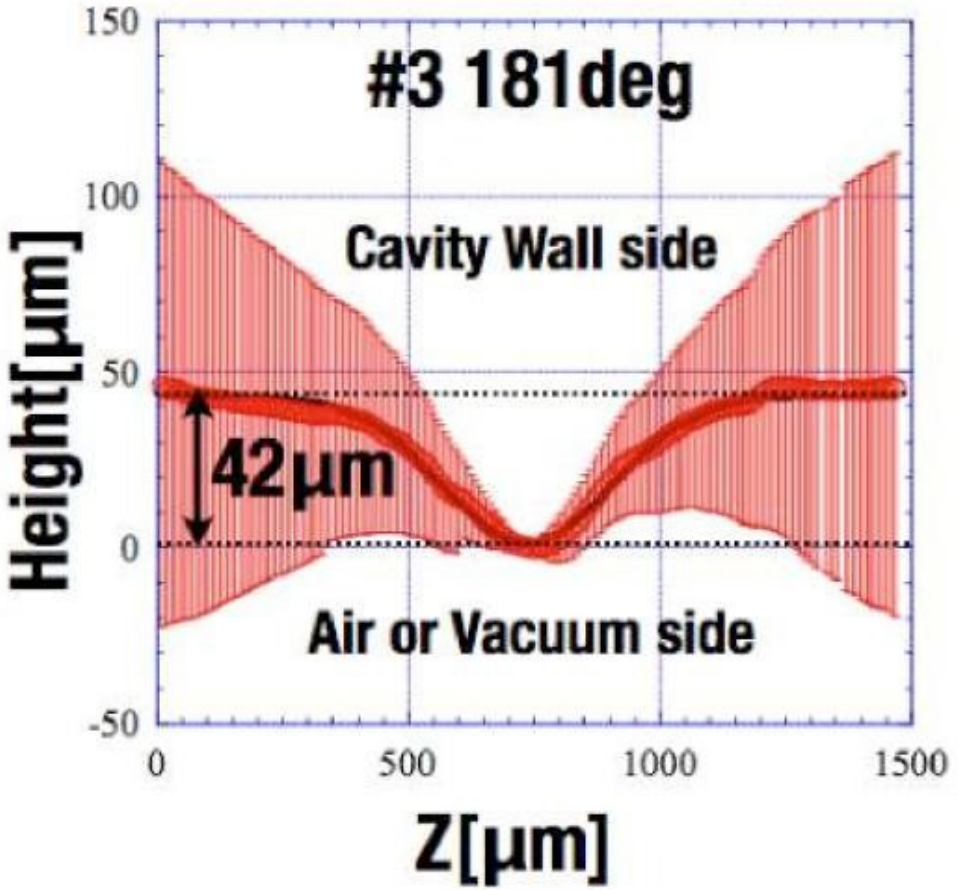
Wall-gradient measurement

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



Wall-gradient measurement





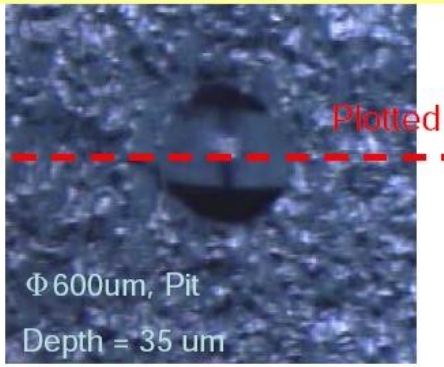
Measurement at KEK

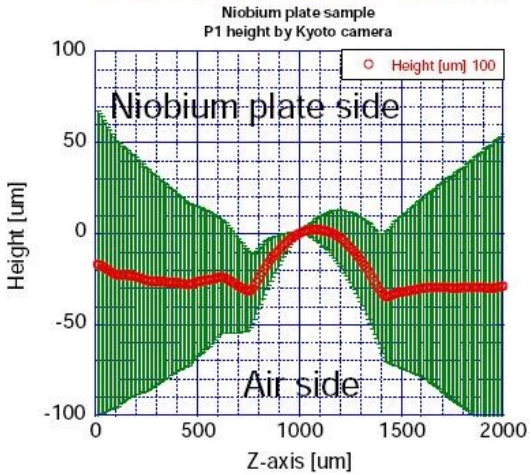
Wall-gradient measurement

Result of Shape analysis : P1

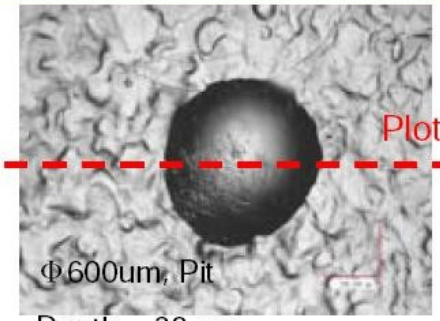
superconducting rf test facility

Kyoto camera : Tajima method

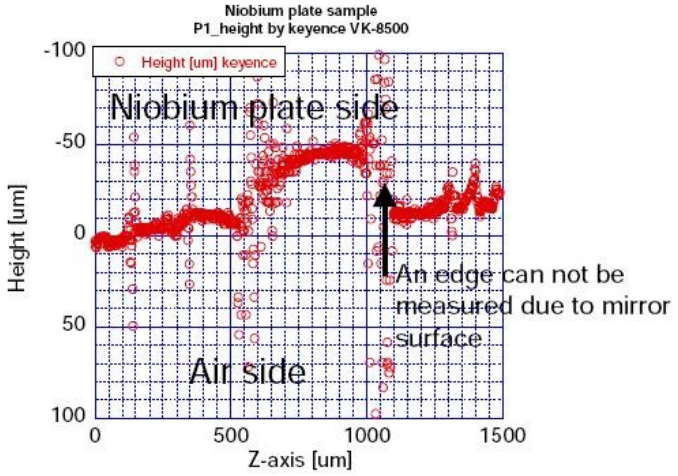




Laser microscope: VK-8500



Depth = 38 um



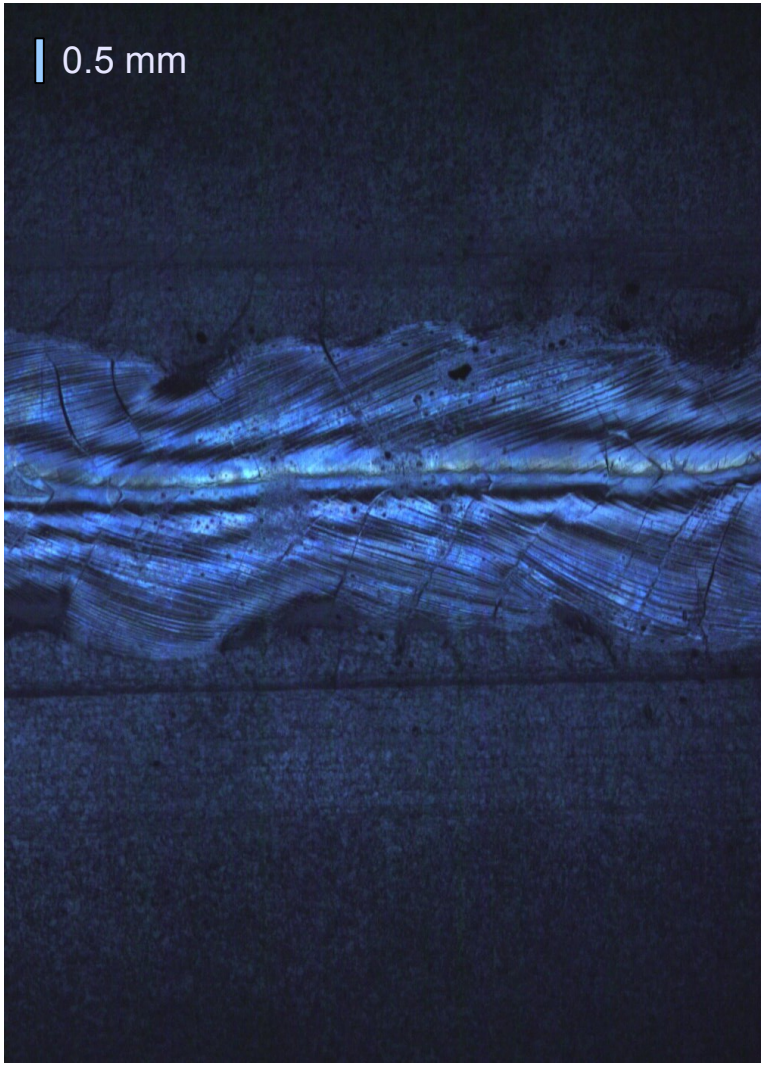
The results of depth value are almost same.

STF

6

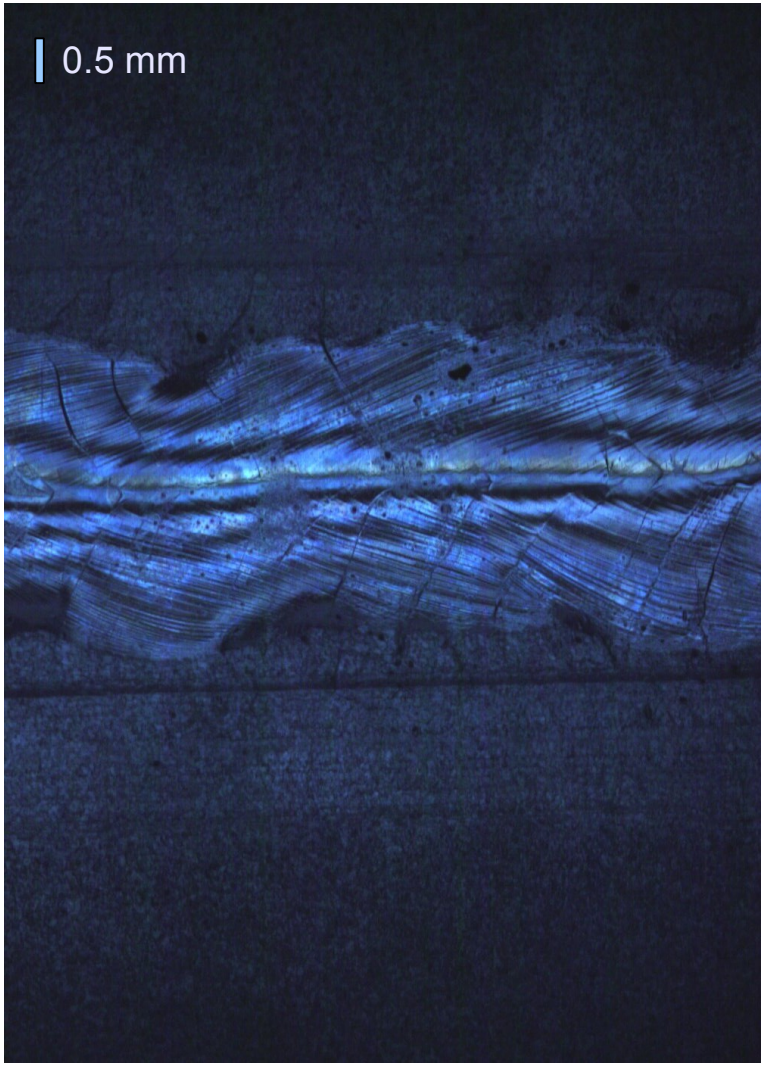
K. Watanabe (KEK)

Evolution of defects



Z142: no chemical treatment yet

Evolution of defects



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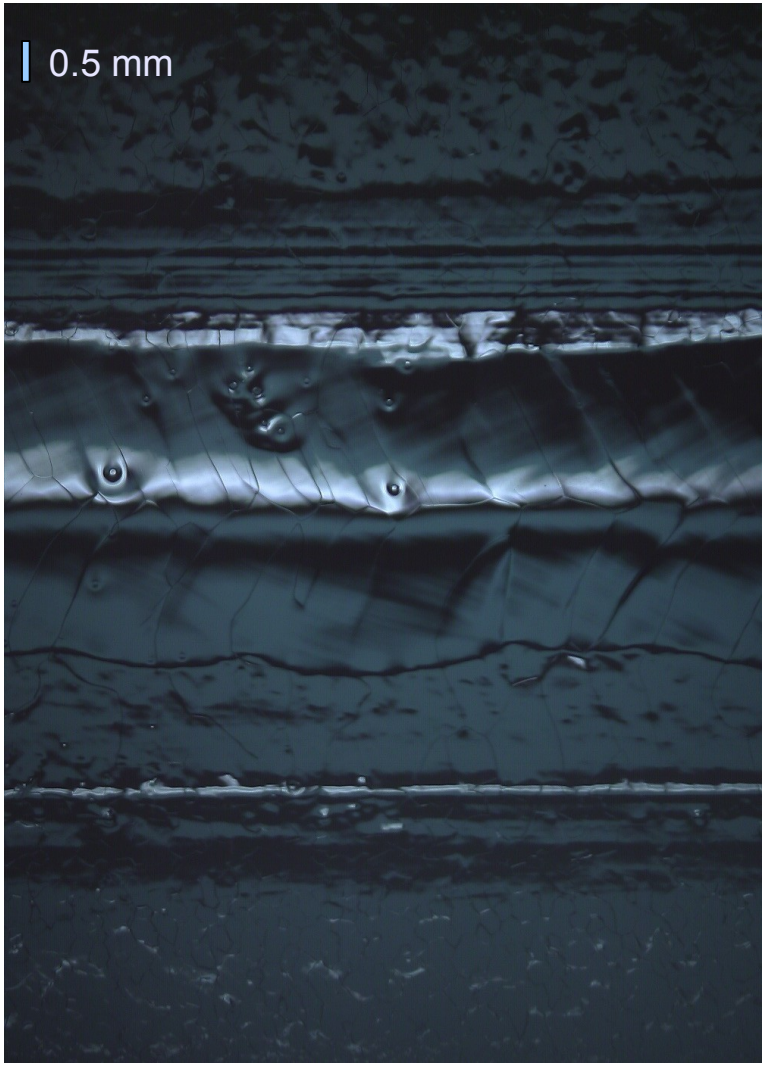

Z142: no chemical treatment yet

Z111: treated by EP and BCP

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
- Cut inspected cavity for surface analysis (ongoing)

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