Large Grain Cavities: Fabrication, RF results and Optical Inspection

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IHEP

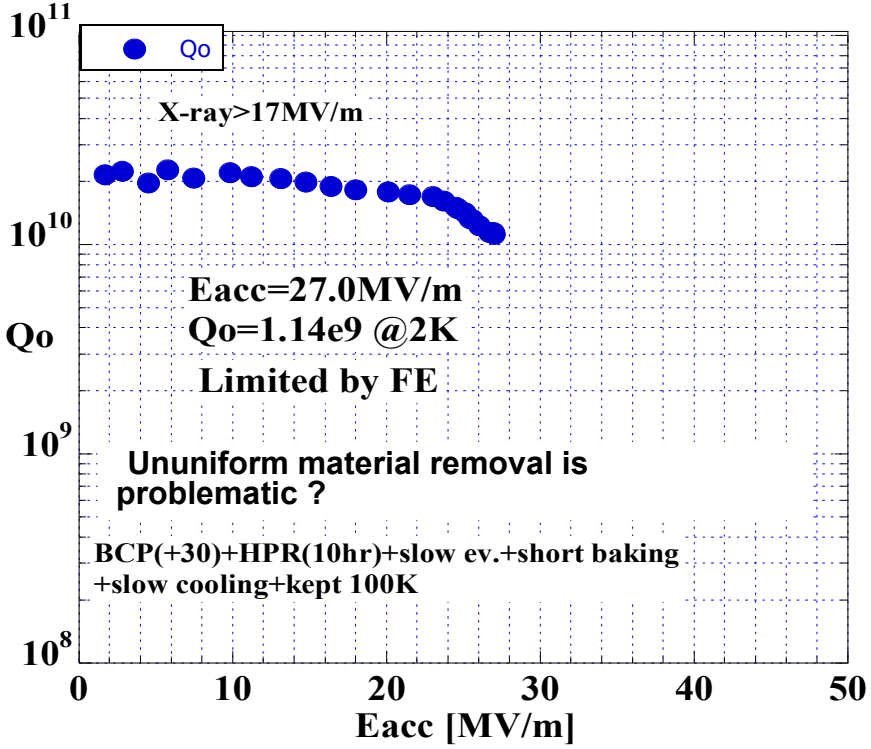
- Two large grain low-loss shape cavities IHEP1, IHEP2
- IHEP1:
  - No HOM couplers
  - Initial treatment: CBP, BCP, hydrogen outgassing, BCP
  - 1st test (KEK,July 2010): 20 MV/m limited by quench with FE
  - 2nd test at JLab
- IHEP2:
  - Built with full end-groups
  - EBW to be finished in November
  -

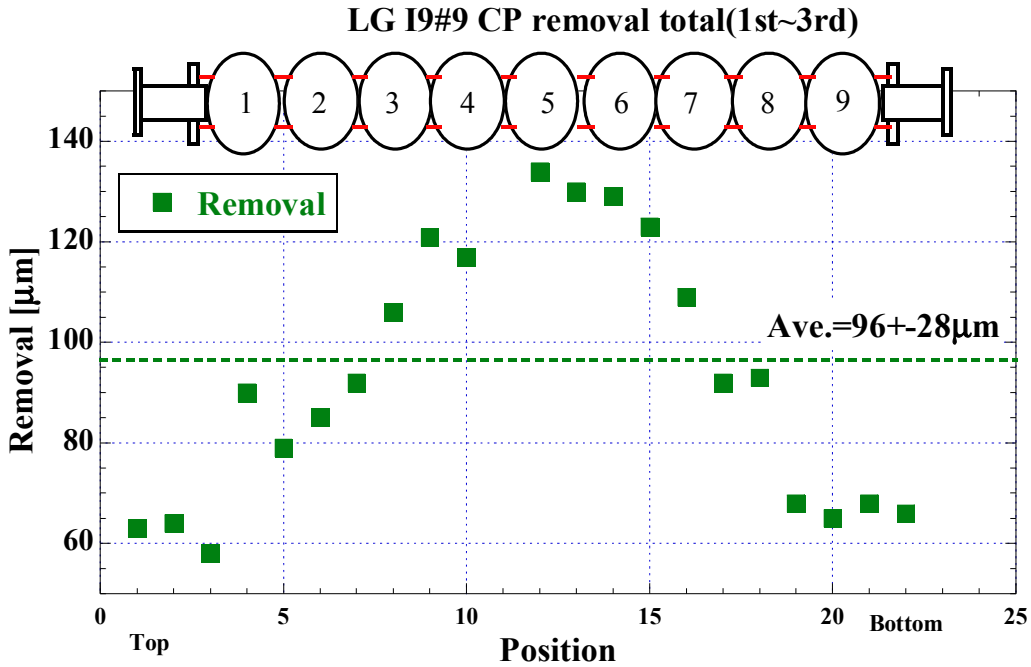
Details in talk by Jiyuan Zhai's talk

I9#9: first ICHIRO LG 9-cell at KEK

I9#9

w/o end group



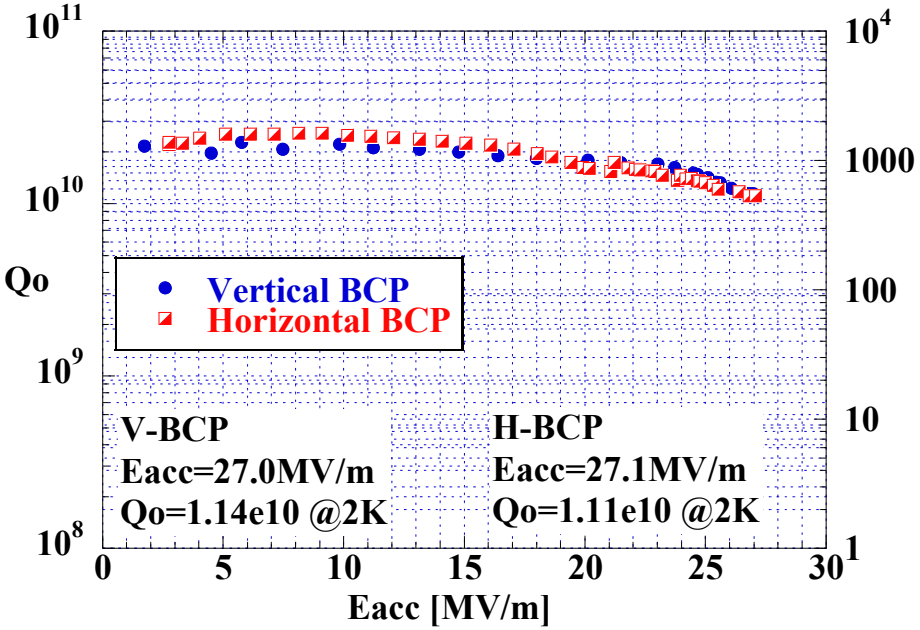


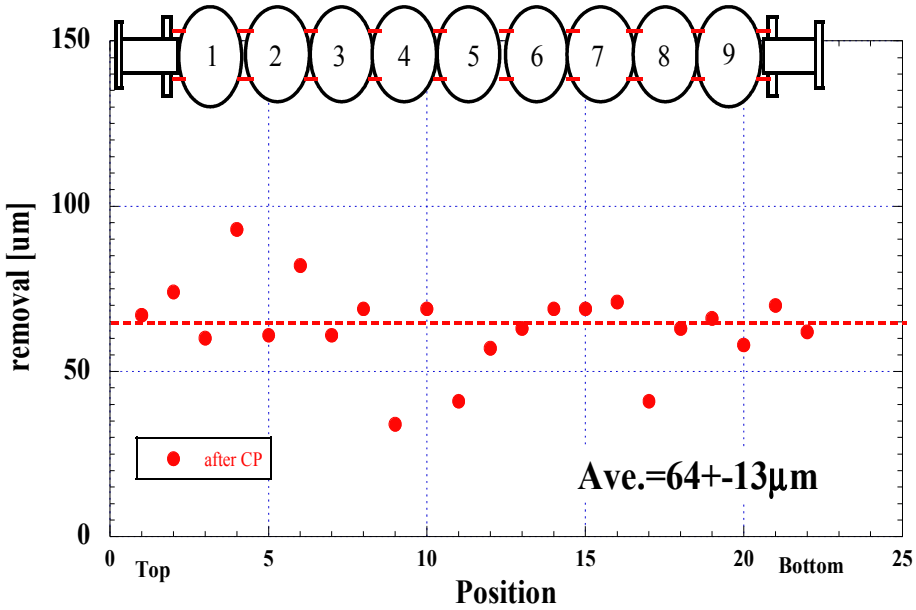
Unbalanced removal by vertical BCP

I9#9: first ICHIRO LG 9-cell at KEK

I9#9

w/o end group

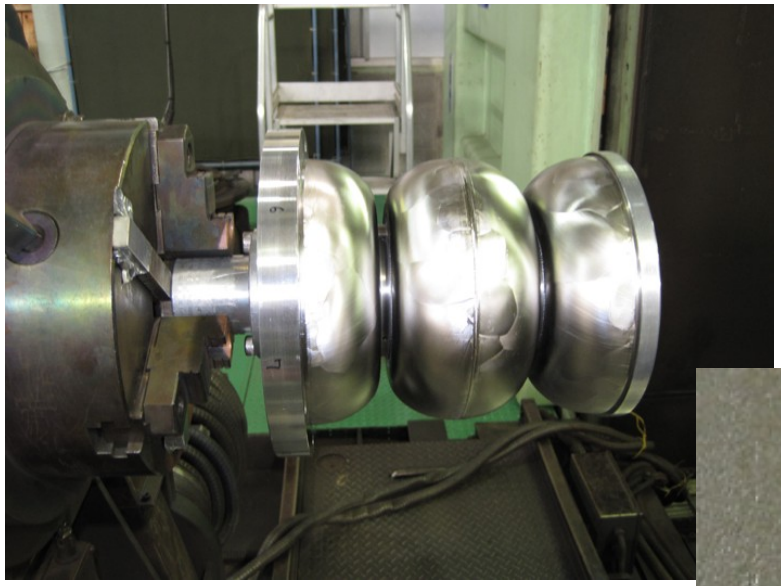


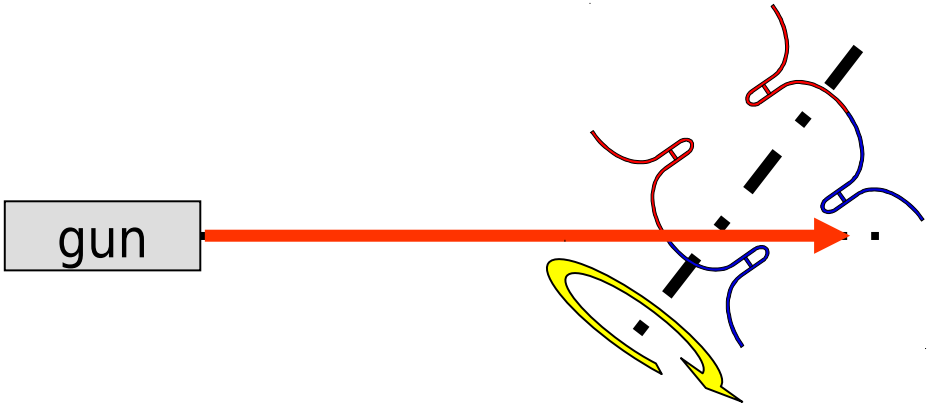


Horizontal BCP yielded more uniform removal
Gradient remained the same

KEK: EBW from cavity inside

I9#10 and I9#11 produced with inner EBW





All equator and iris parts can be welded by inner EBW.

Comparison: Outer ↔ Inner EBW

Typical equator seams

Outer EBW

Fine grain

Outer EBW

Large grain

Inner EBW

Fine grain

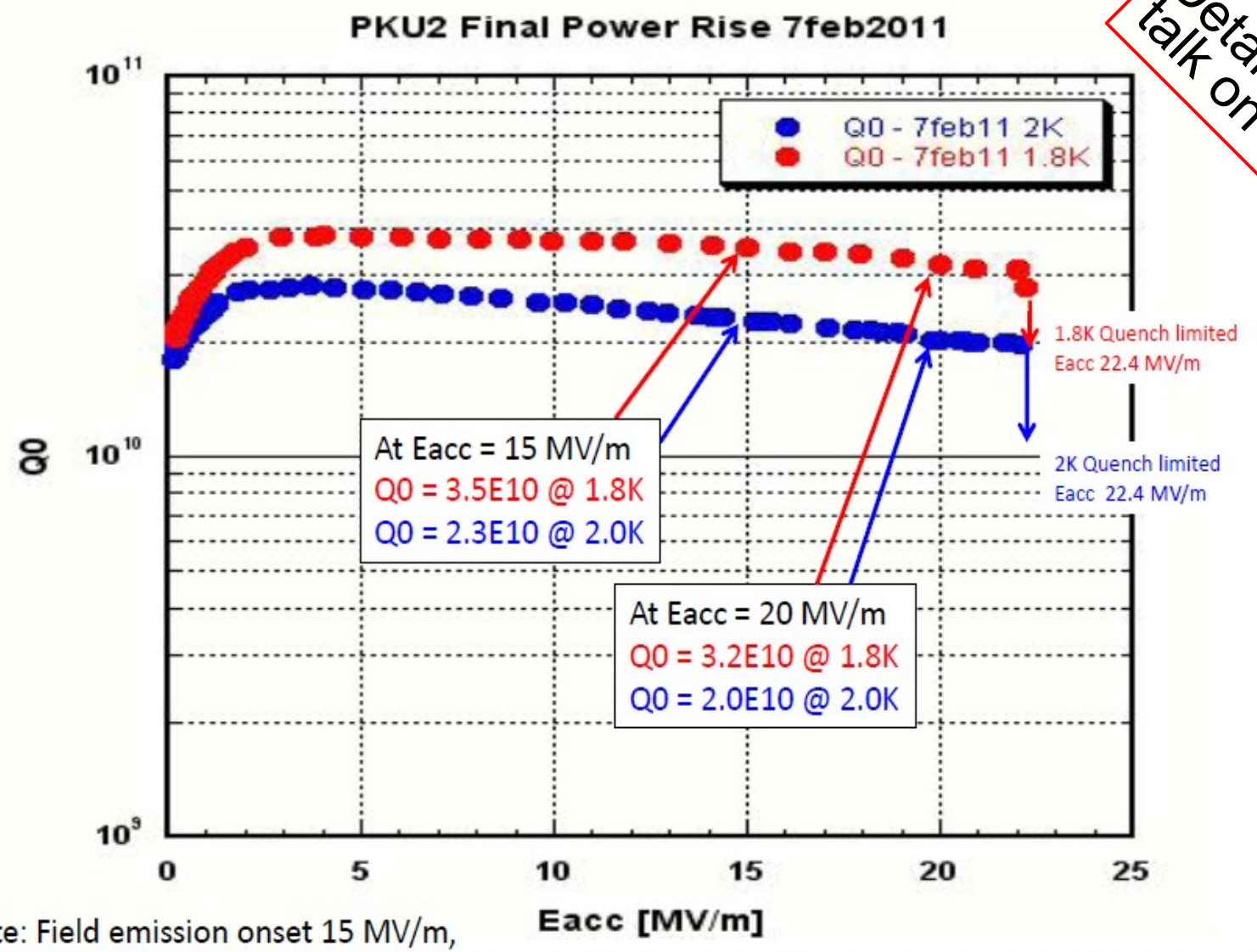
Number of „visible defects“ decreased by factor 5 from I9#9 → I9#10

Cavity PKU2

- TESLA-type, fabricated at Peking University in 2009
- Tested at Jlab in 2010/2011
- 100 µm BCP, 10 hrs at 600C, 80 µm BCP
  - RF test: limited by quench at E=19.5 MV/M with Q_0=9E9
- Optical inspection: large number of pits near EBW seam
- 2 hrs at 800C, 30 µm EP,

  48 hrs at 120C
  - RF test: limited by quench at E=22.4 MV/m with Q_0=2E10

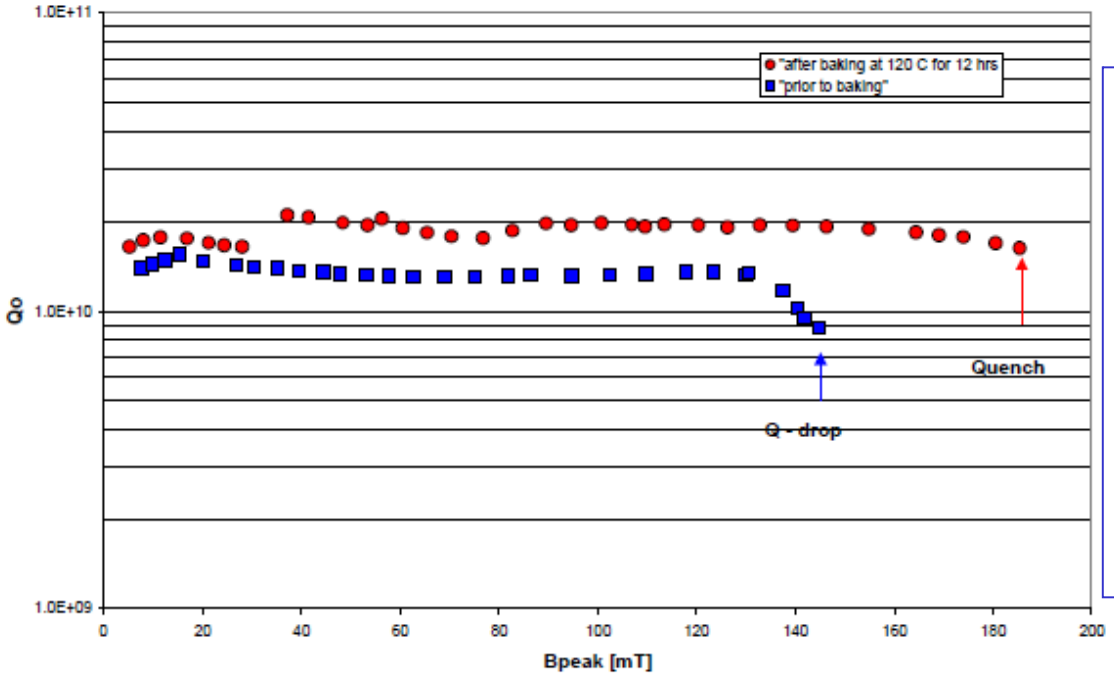
Cavity PKU2



Details: Jiankui Hao's talk on Friday

Note: Field emission onset 15 MV/m,
Maximum X-ray dose rate < 100 mR/m. No more mode mixing observed during final power rise.

Investigation of PKU-LG1 at FNAL



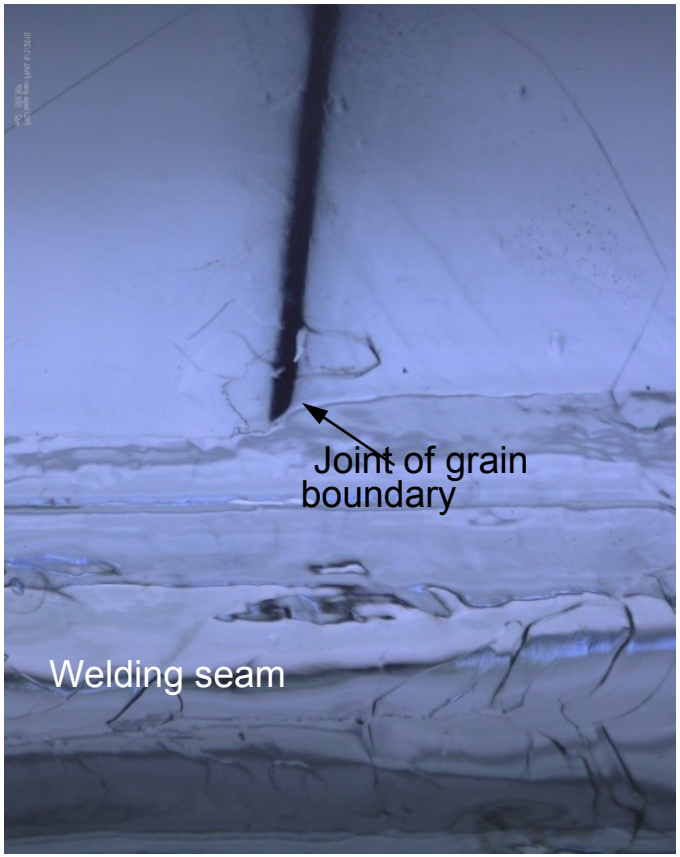
- 43 MV/m. 185 mT
- NingXia large grain RRR niobium
- Post purified
- BCP processed
- Low temperature baking

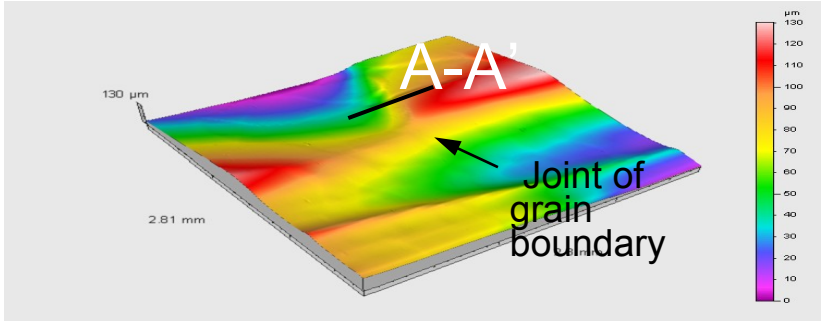
Features found at multiple locations:

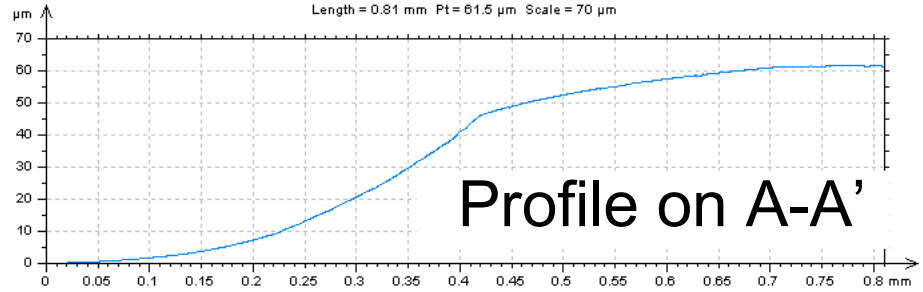
- BCP stains
- BCP etching pits
- Weld Pits
- Steep grain boundaries

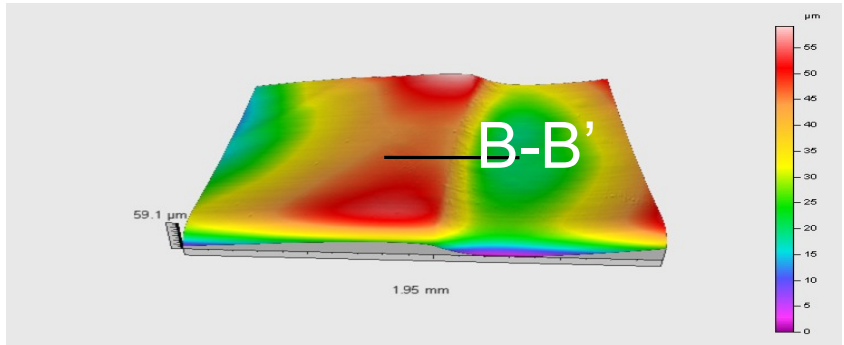
P. Kneisel, "Progress on Large Grain and Single Grain Niobium – Ingots and Sheet and Review of Progress on Large Grain and Single Grain Niobium," in *Proc. of 13th Workshop on RF Superconductivity*, Beijing, China, 2007.

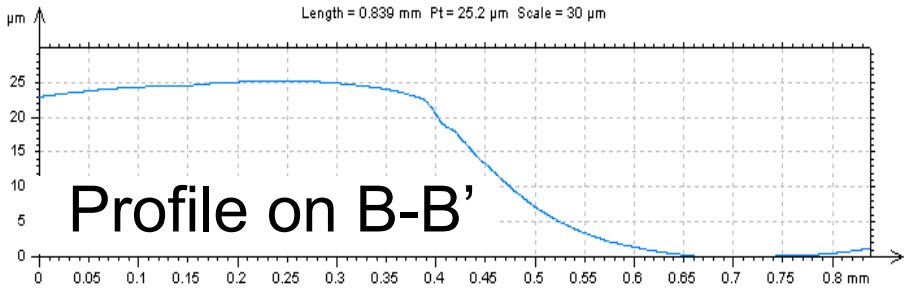
Grain boundary in PKU-LG1









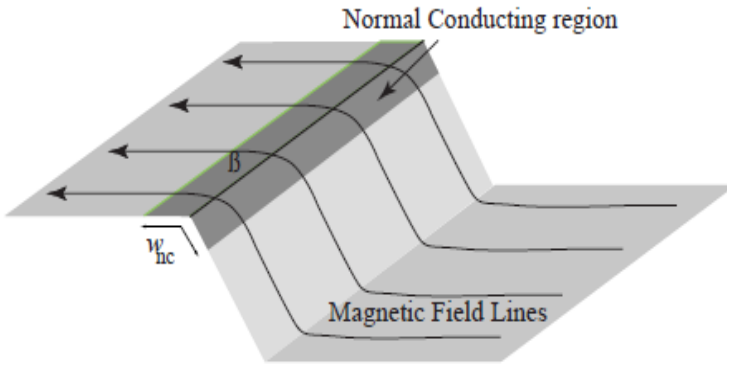


The height of step on A-A': 60µm

The height of stp on B-B': 25µm

A result from surface scanning profilometer

Field enhancement



Magnetic field enhancement model

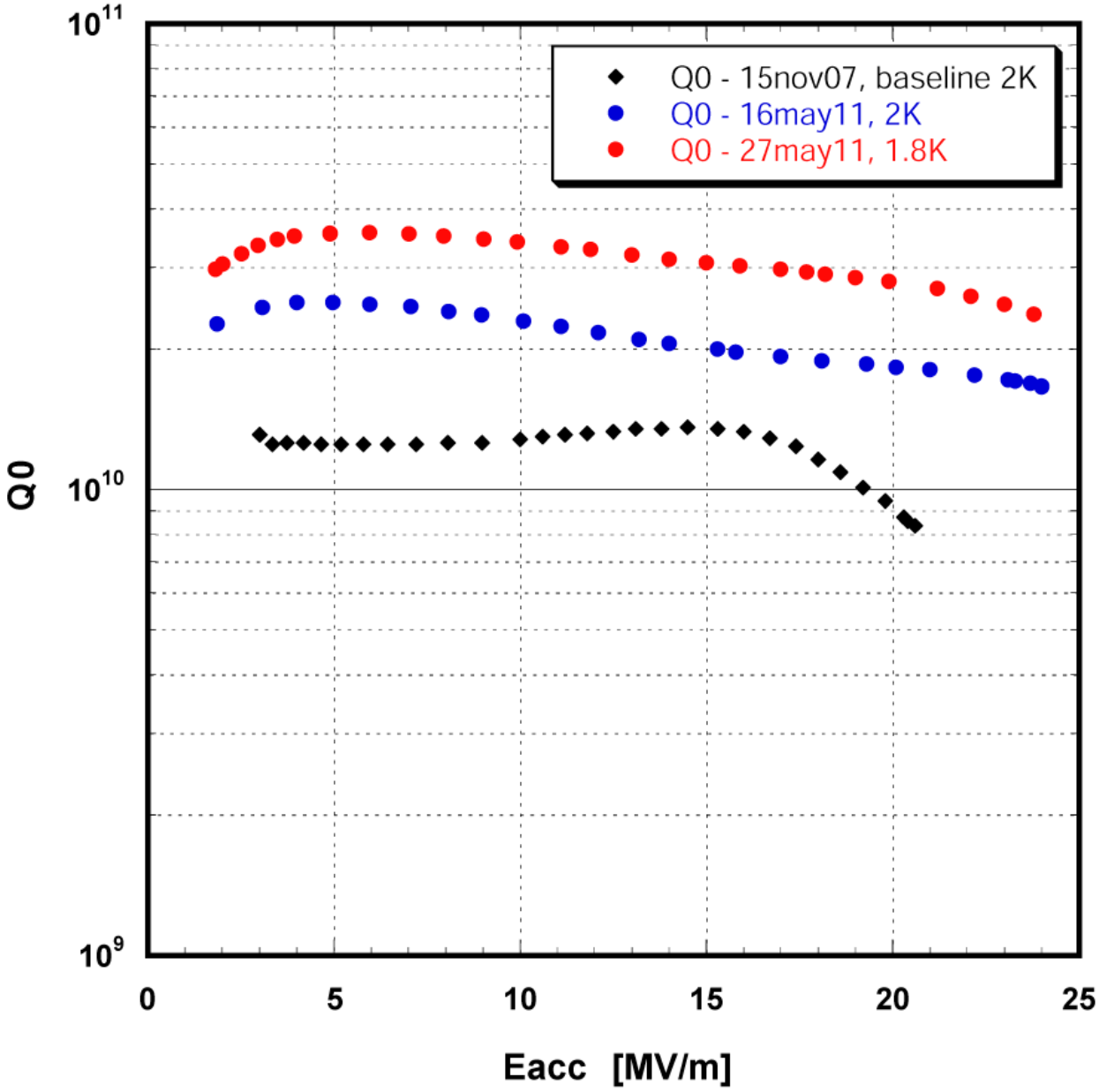
TABLE 1: Field enhancement factor of cavity defects

Cavity	Field enhancement factor	Maximum H field [mT]
TB9ACC017	2.2	54.1
AES001	1.5	96.8
TE1AES004	1.2	168.0
PKU-LG1	1.6	189.2

JLAB: Cavity JLAB-LG#1

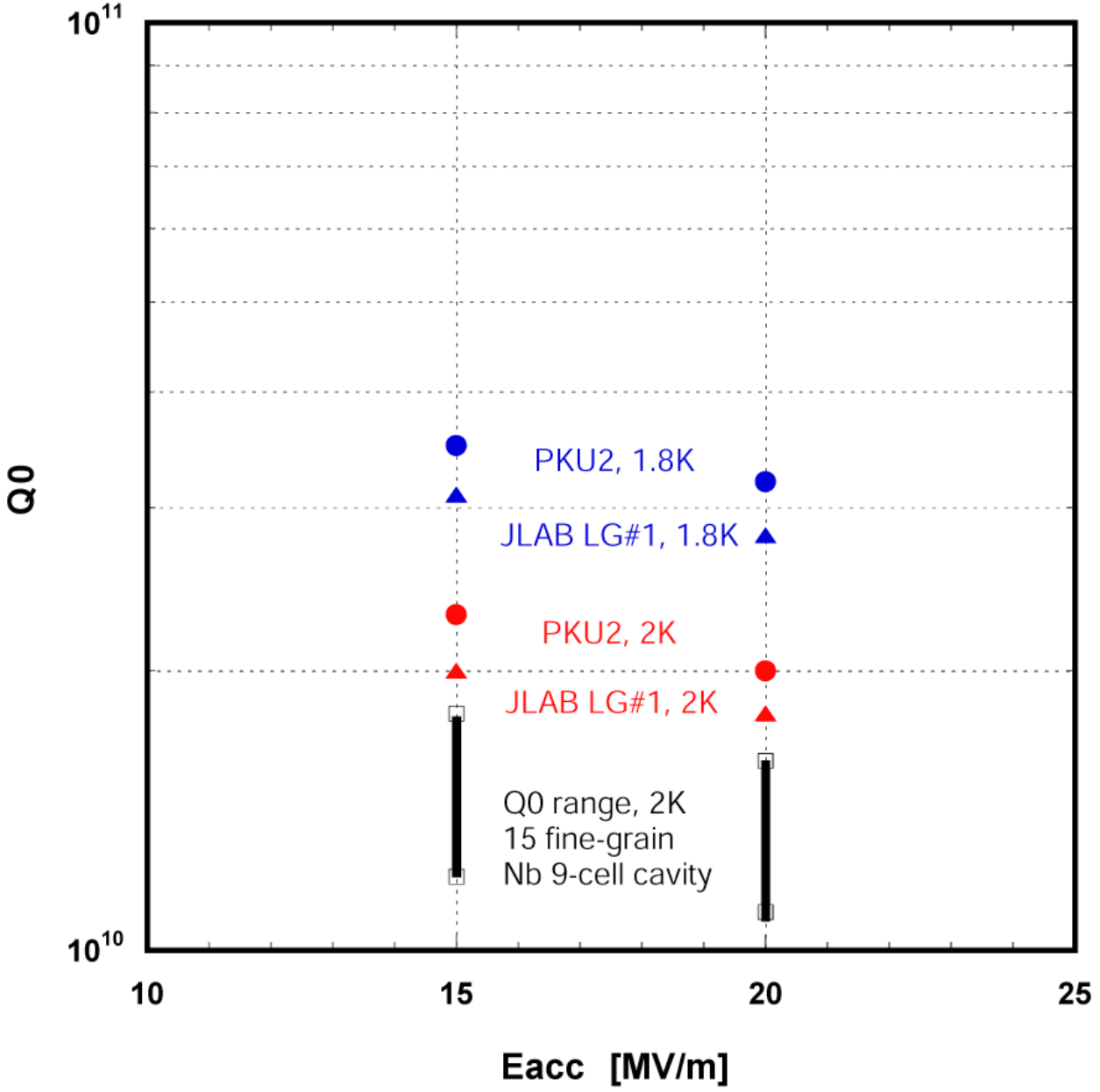
- Fabricated from CBMM material
- First test after BCP-treatment: 20 MV/m with Q0=8E9
- Improved to 30 MV/m with Q0>1E10 by 35 µm EP + 120°C bake
- Repaired part of equator weld in center cell identified as quench location by T-mapping and optical inspection
- Local grinding and 85 µm EP were done at KEK
- Vertical test at Jlab:
  - Improvement of repaired cell, overall degradation of cavity
- Final test:
  - Hydrogen outgassing, 30 µm EP, 120°C for 48 hrs
  - Limited by quench at 24 MV/m with Q0>1E10

Initial and final performance JLAB-LG#1



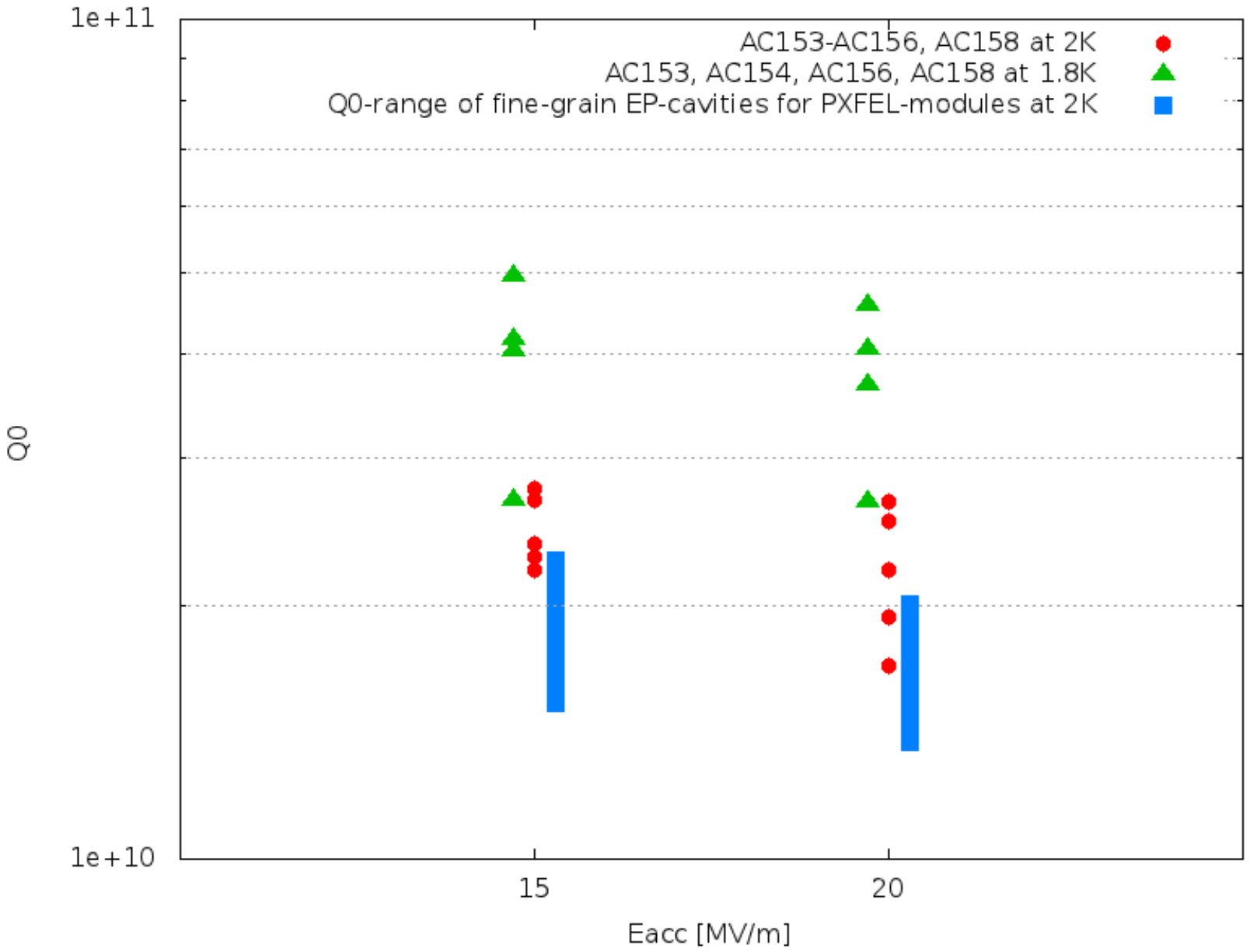
Details: R. L. Geng's poster TUPPO029

Comparison of Q0: LG ↔ FG



Details: R. L. Geng's poster TUPPO049

Comparison of Q0: LG ↔ FG

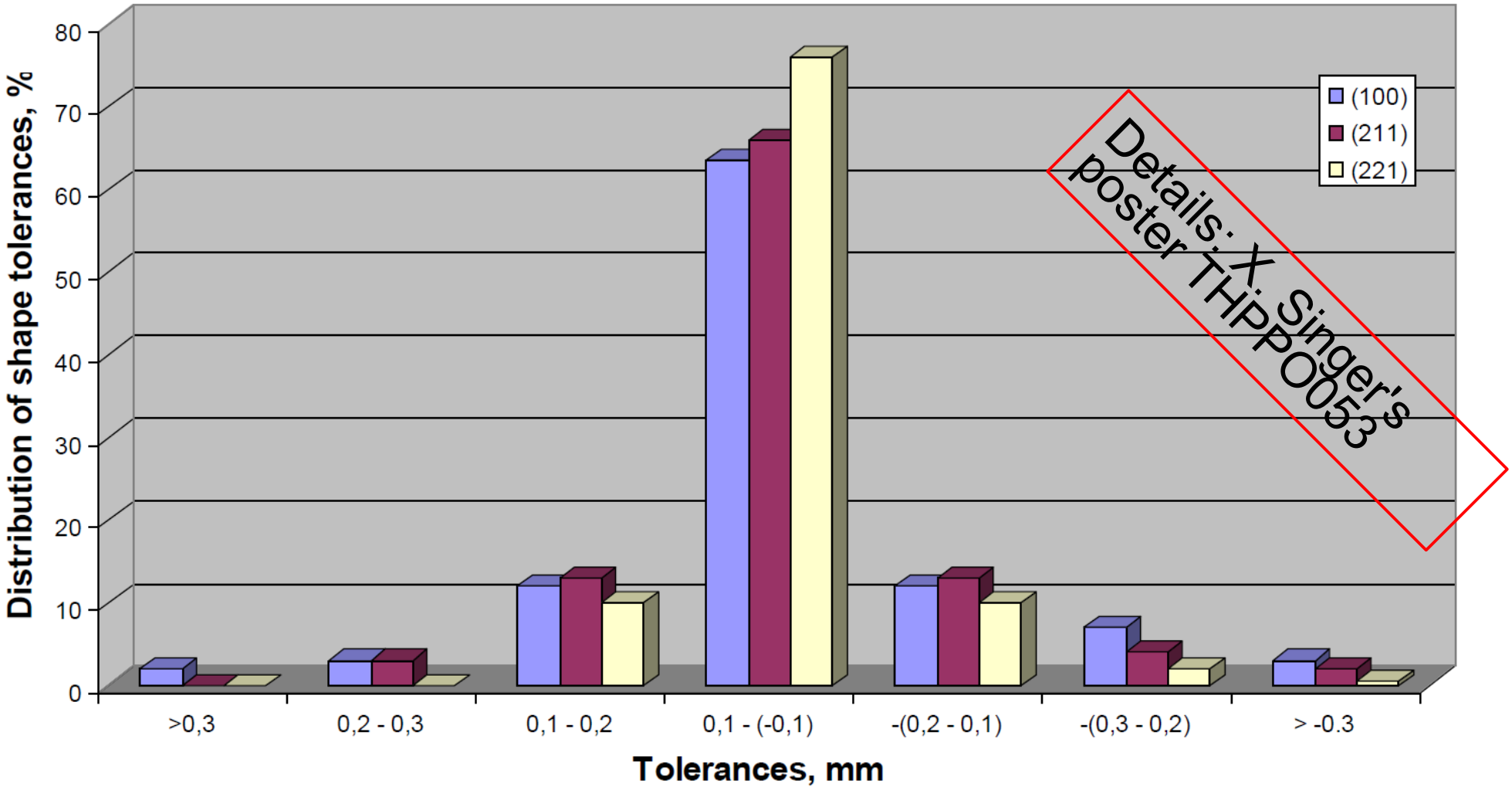


Cavities AC151-AC158

- Material production in R&D framework of DESY and W.C. Heraeus
- Wire sawing of discs from ingot
- Central crystal >150 mm
- Different orientation of central crystal
  - AC151-AC153: (100)
  - AC155-AC157: (221)
  - AC154, AC158: (211)
- AC155, AC156: grinding of grain-boundaries after deep-drawing

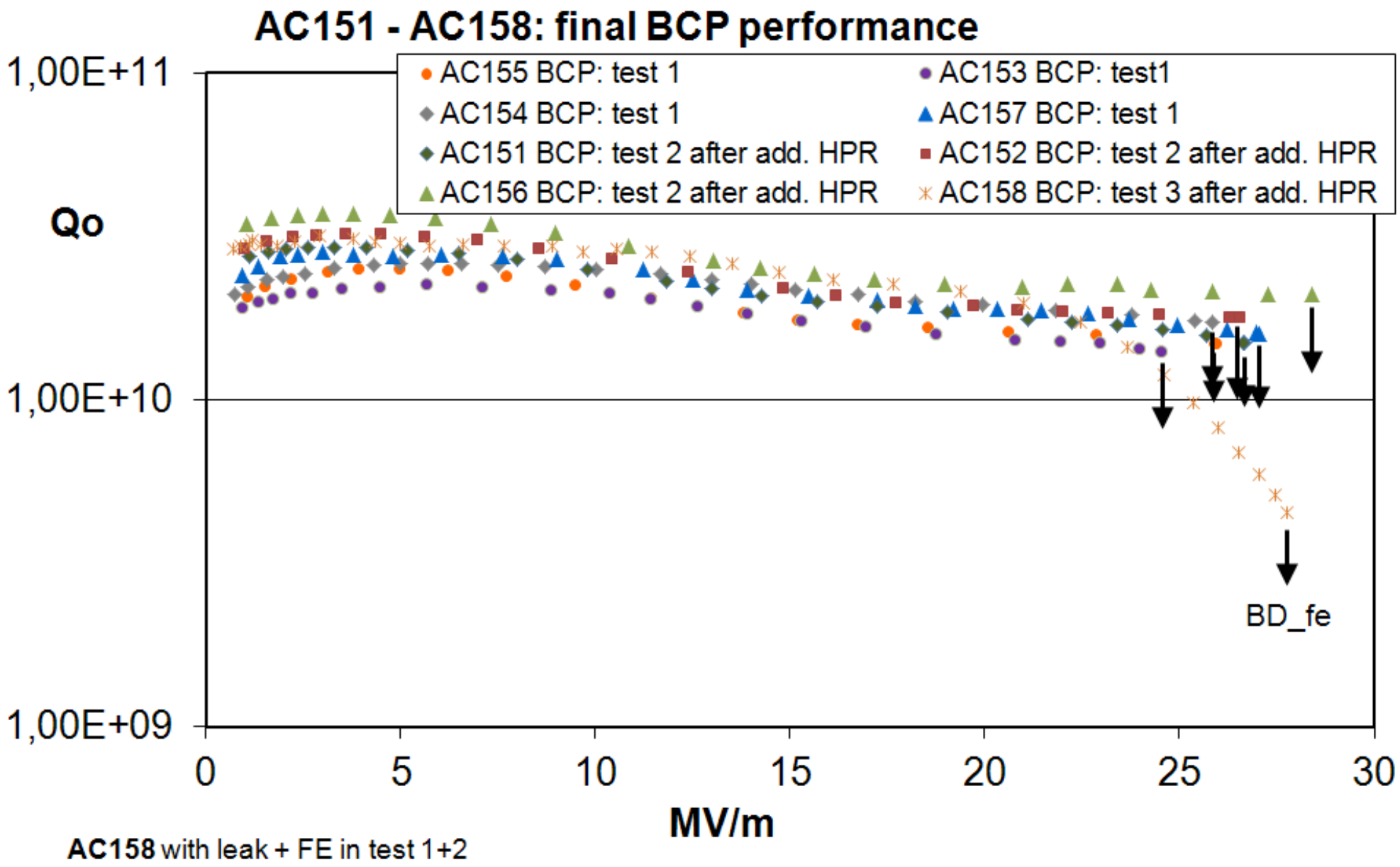
Influence of crystal orientation

Averaged deviation from „ideal half cell“ after deep-drawing

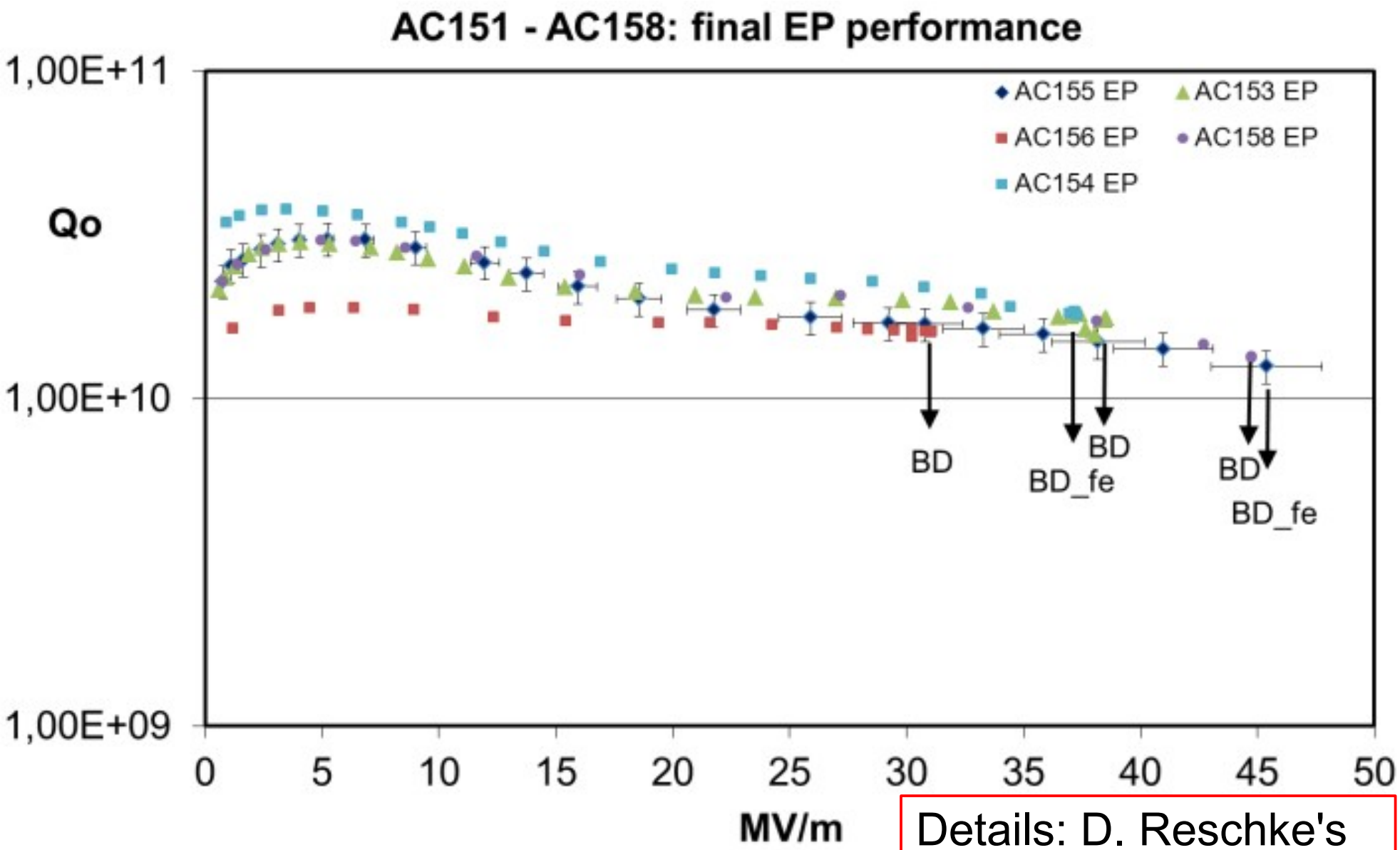


(100) [plane parallel to sheet surface] yields most deviation

AC151-AC158: BCP performance



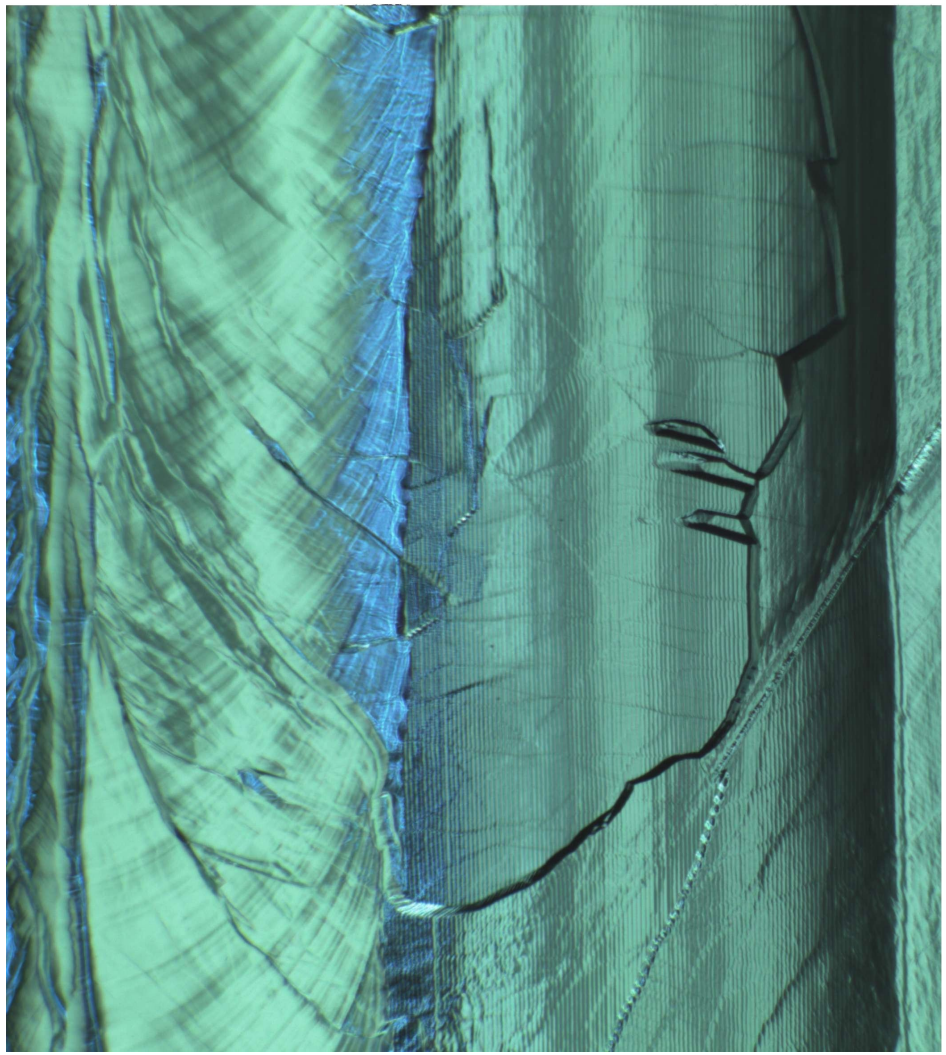
AC158 with leak + FE in test 1+2



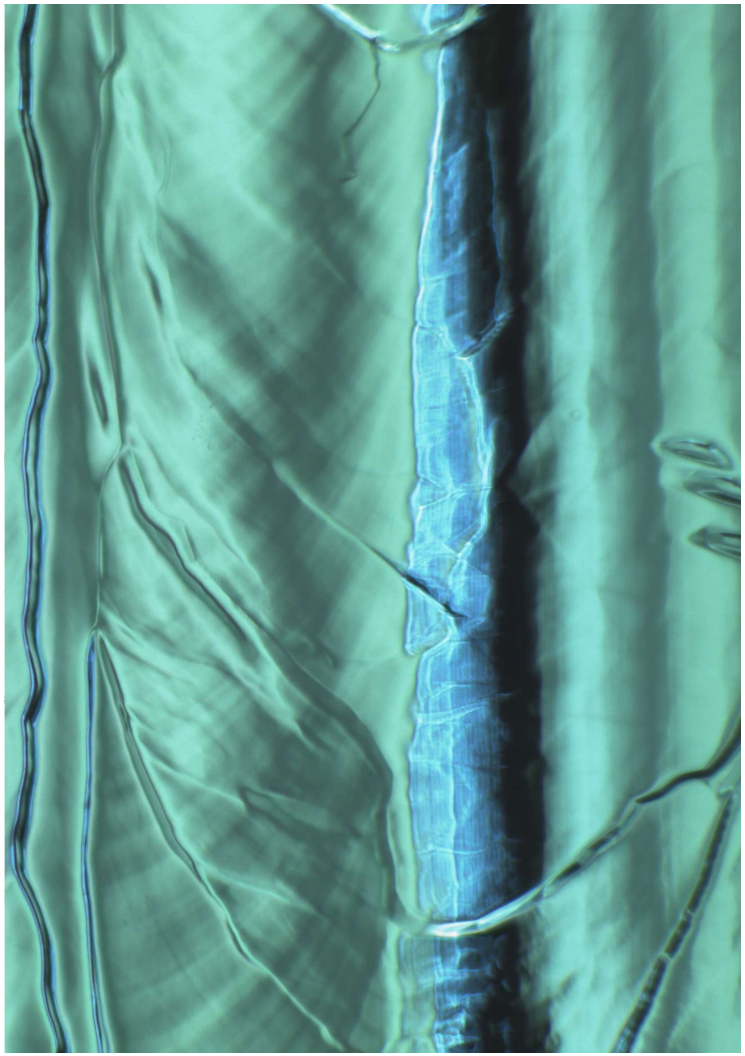
Details: D. Reschke's poster TUPO046

Example: Grain boundary in AC158

Quench-sites inspected in AC151-AC158 so far: no „obvious defects“, just etching pits (all over the cavity) and grain boundaries



After BCP: sharp edges



After EP: smoothed edges

Summary

- Increasing numbers of 9-cell large grain cavities are being built
- Large grain 9-cells give higher Q-values than comparable fine-grain cavities
- BCP-treatment yields stable gradients
  - 25-30 MV/m in the DESY-batch
- Highes gradients with EP
  - AC155 and AC158 exceed 45 MV/m
- Important role of grain-boundaries?

Many thanks to:

L. Cooley, R. L. Geng, J. Hao, D. Reschke, K. Saito, X. Singer, G. Wu and J. Zhai

for providing me with input for this talk!

And thank you for your attention!