Sources of Quench Producing Defects Low and High Fields

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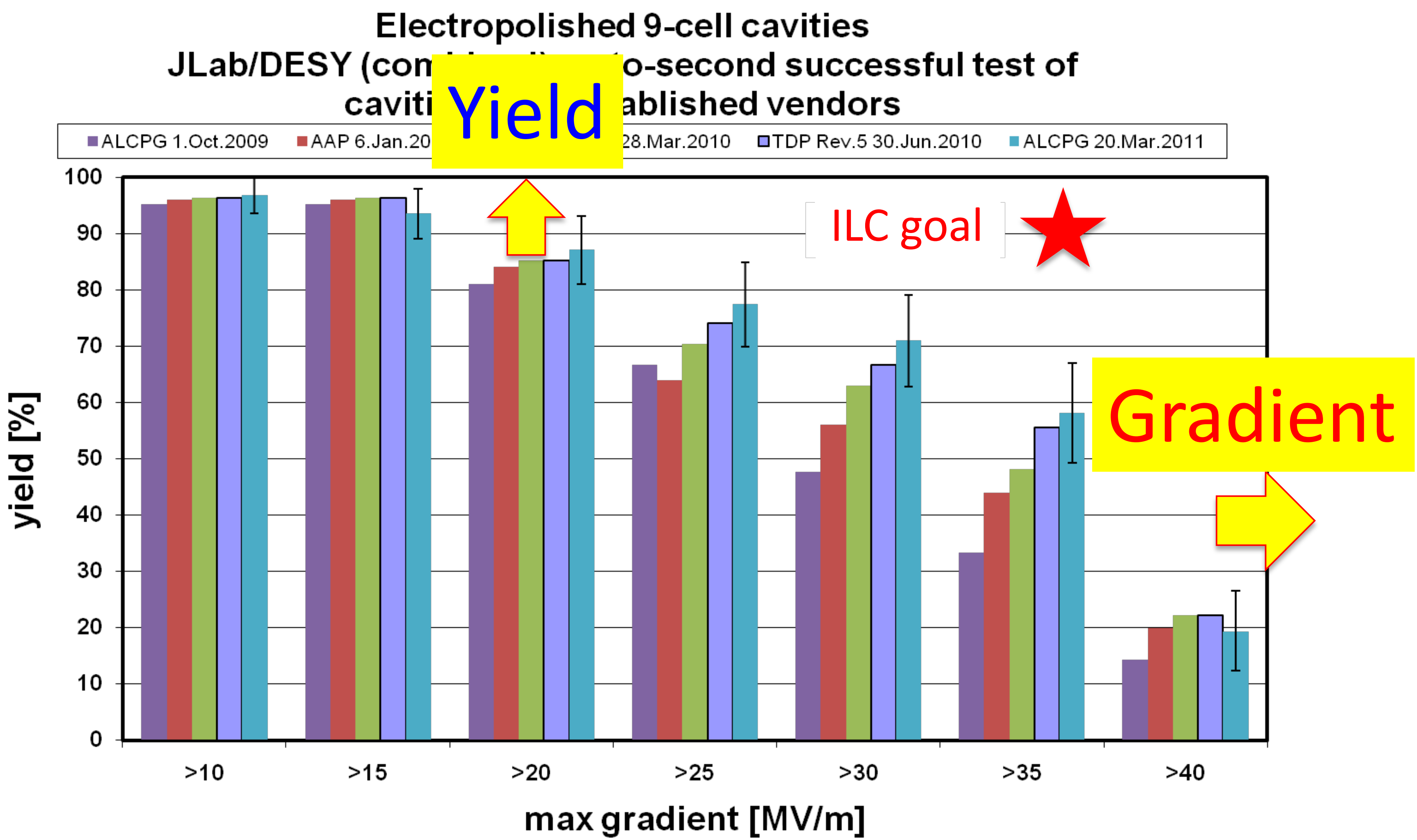
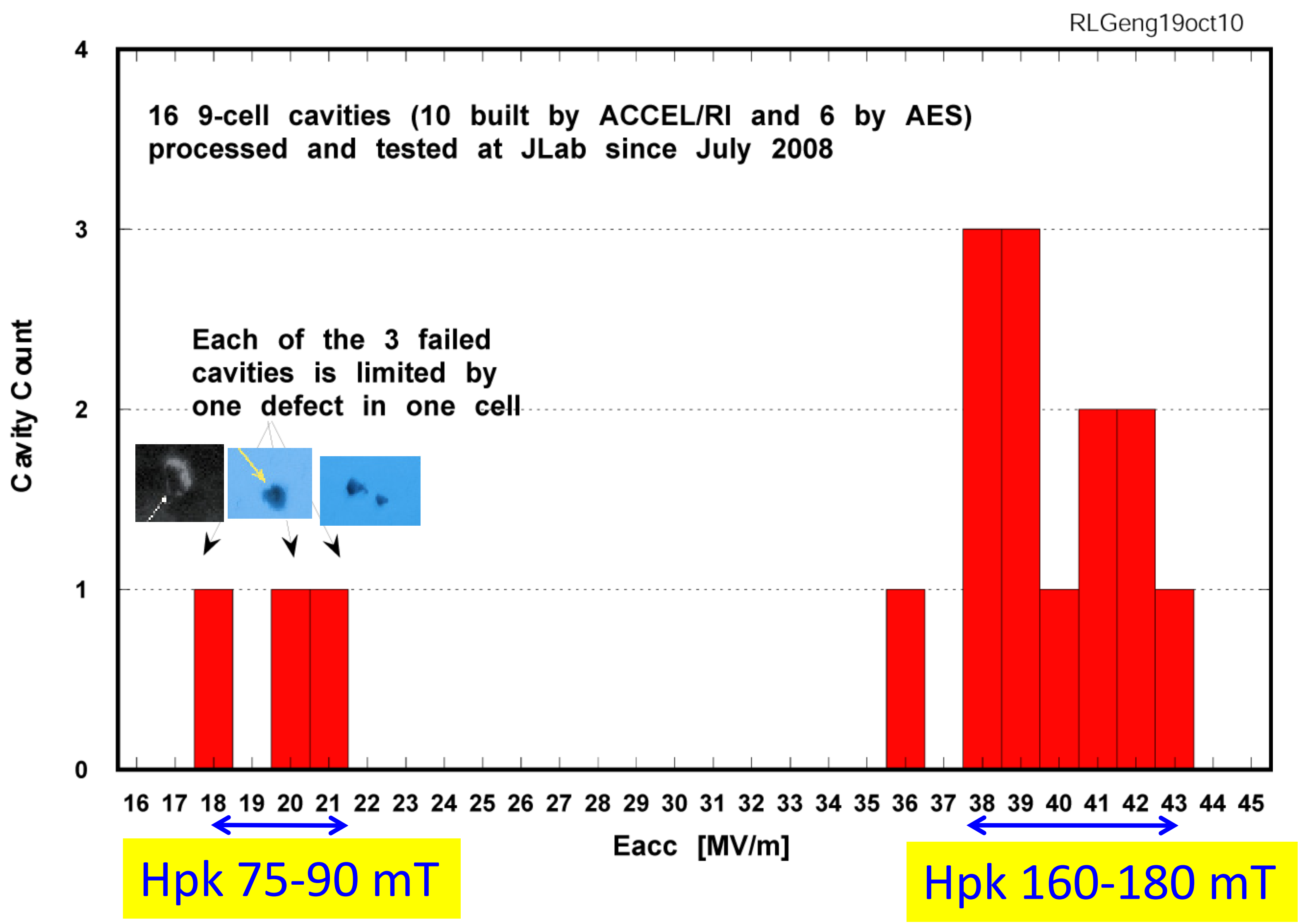
1 meter

International Linear Collider (ILC)
16000 cavities, each 1 square-meter surface area
Operation temperature 2 Kelvin



Electropolished 9-cell cavities
JLab/DESY (com
o-second successful test of
caviti
ablished vendors
ALCPG 1.Oct.2009
AAP 6.Jan.20
28.Mar.2010
TDP Rev.5 30.Jun.2010
ALCPG 20.Mar.2011
Yield
ILC goal
Gradient
yield [%]
max gradient [MV/m]
>10
>15
>20
>25
>30
>35
>40
0
10
20
30
40
50
60
70
80
90
100

Gradient Scatter (up to 2nd-pass proc.)



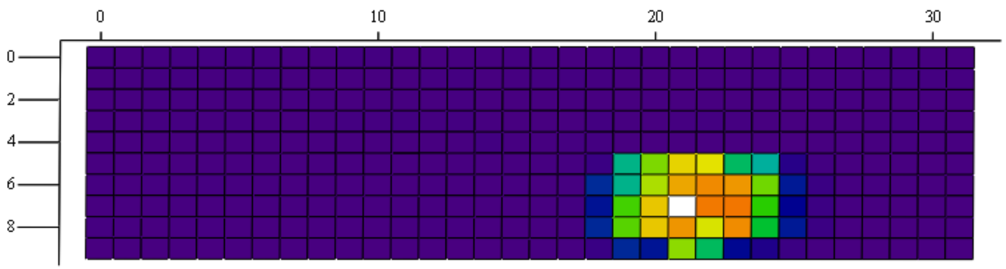
Two Types of Quench (Defect)

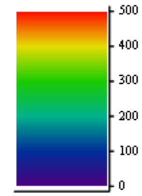
- Type-I
  - Hpk 75-90 mT
  - Defect from fabrication
    - Near or in EBW joint
    - Geometric defects
    - Sum-mm in size
      - Observable with "high-resolution" optical inspection machine
    - Little effect by repeated surface processing
    - Mechanical (local or global) polishing effective

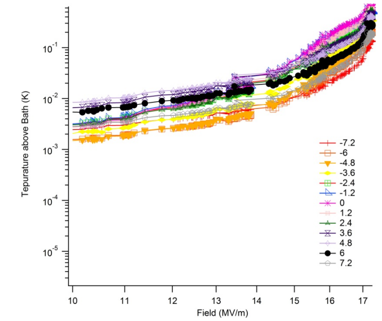
Two Types of Quench

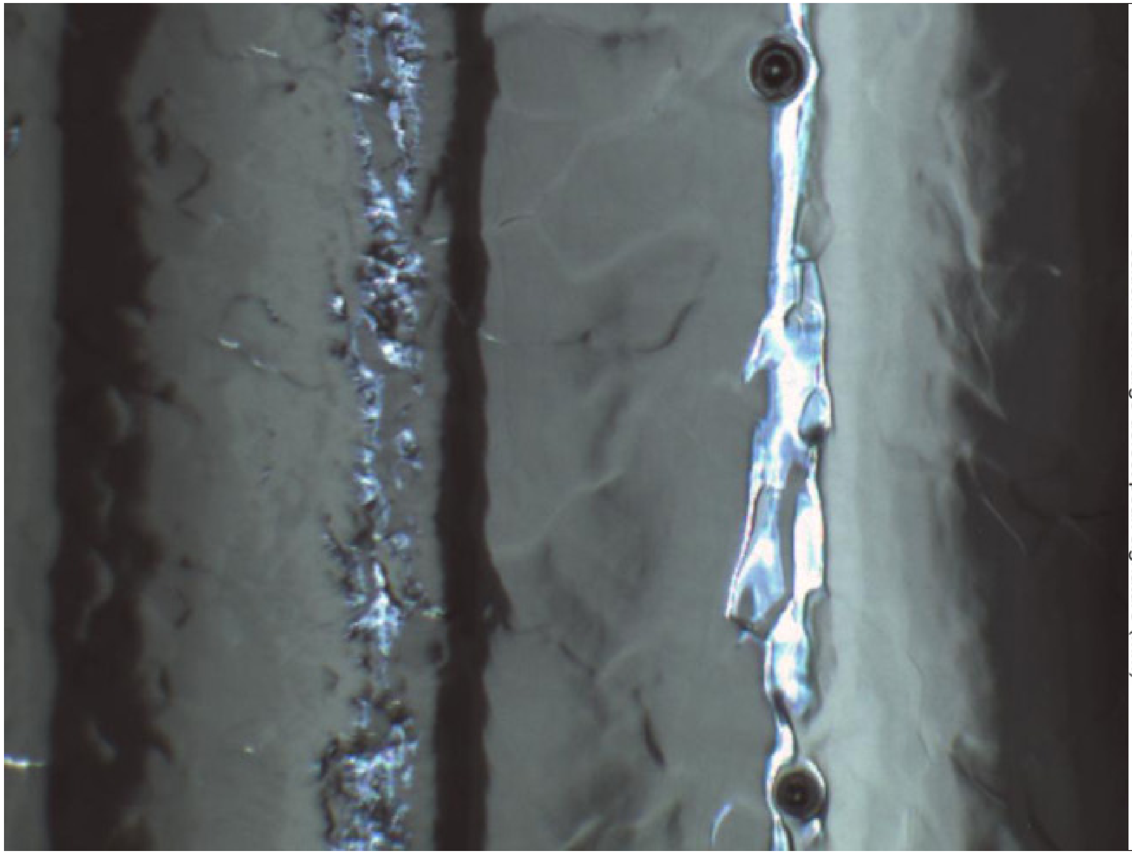
- Type-II
  - Hpk > 1100 Oe
  - Nature of defect not well understood
    - Still near EBW weld (high magnetic field region)
    - Size unknown
      - Not observable with “high-resolution” optical inspection machine
    - Re-EP is found often times effective
      - Raise limit to > Hpk 1500 Oe

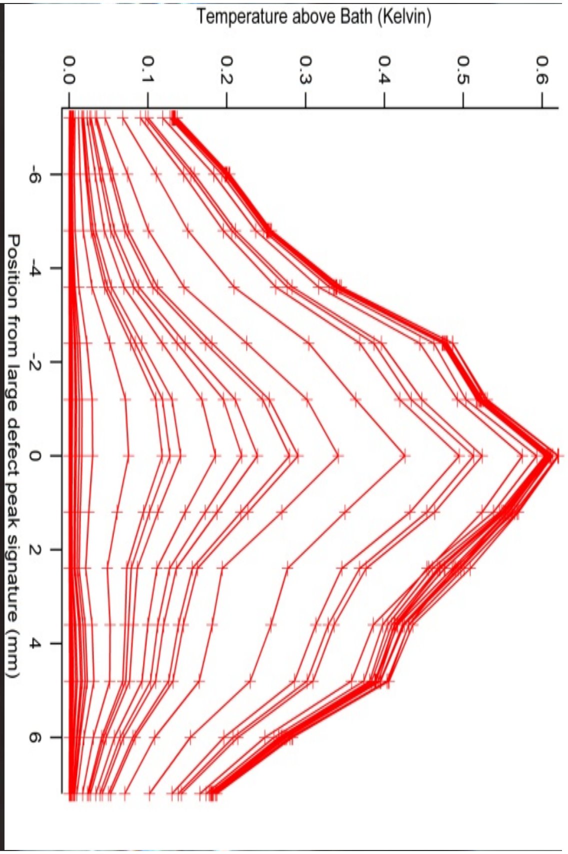
Fine grain EP
twin defects causing quench 17 MV/m. Cavity by a new vendor

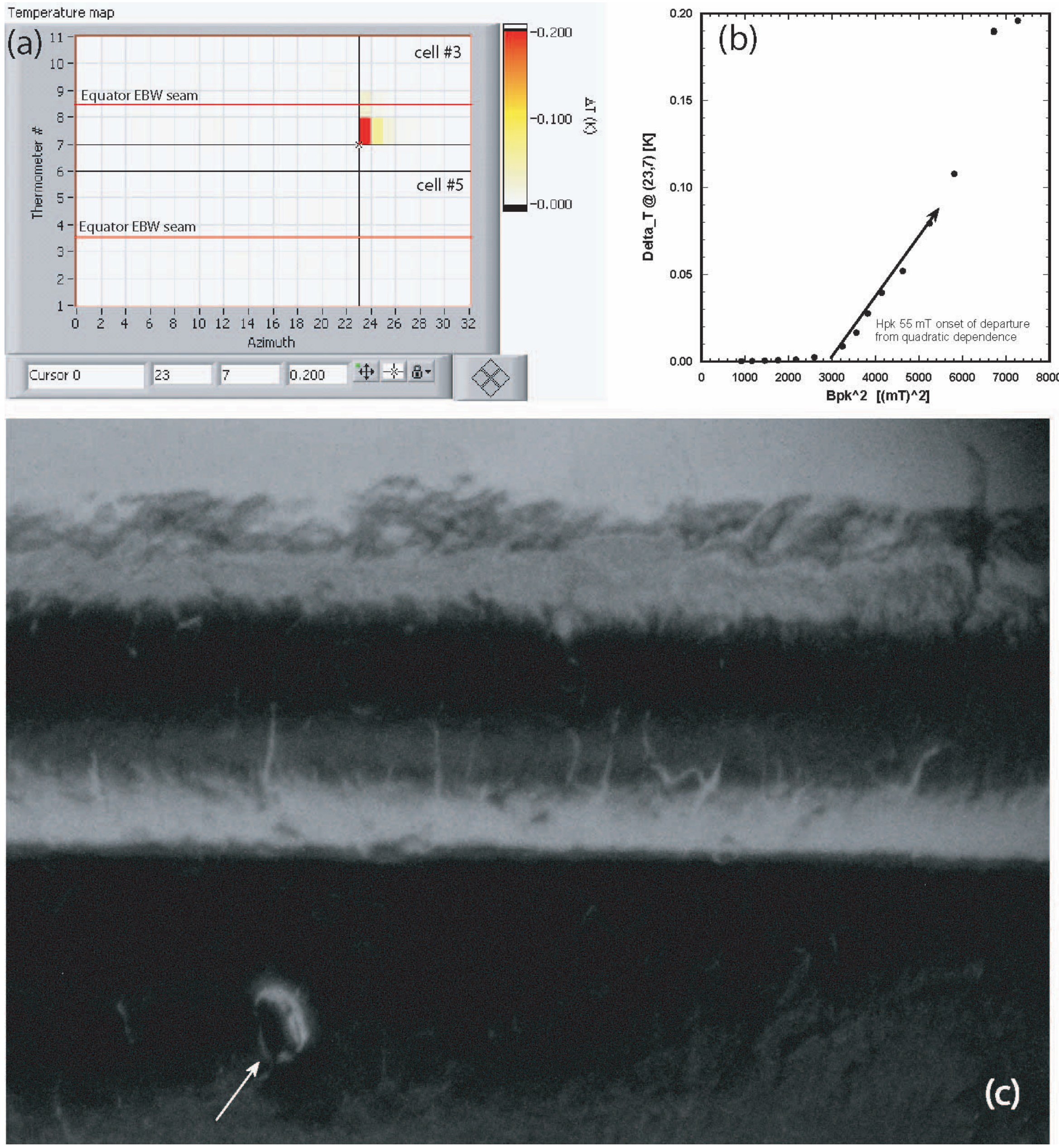






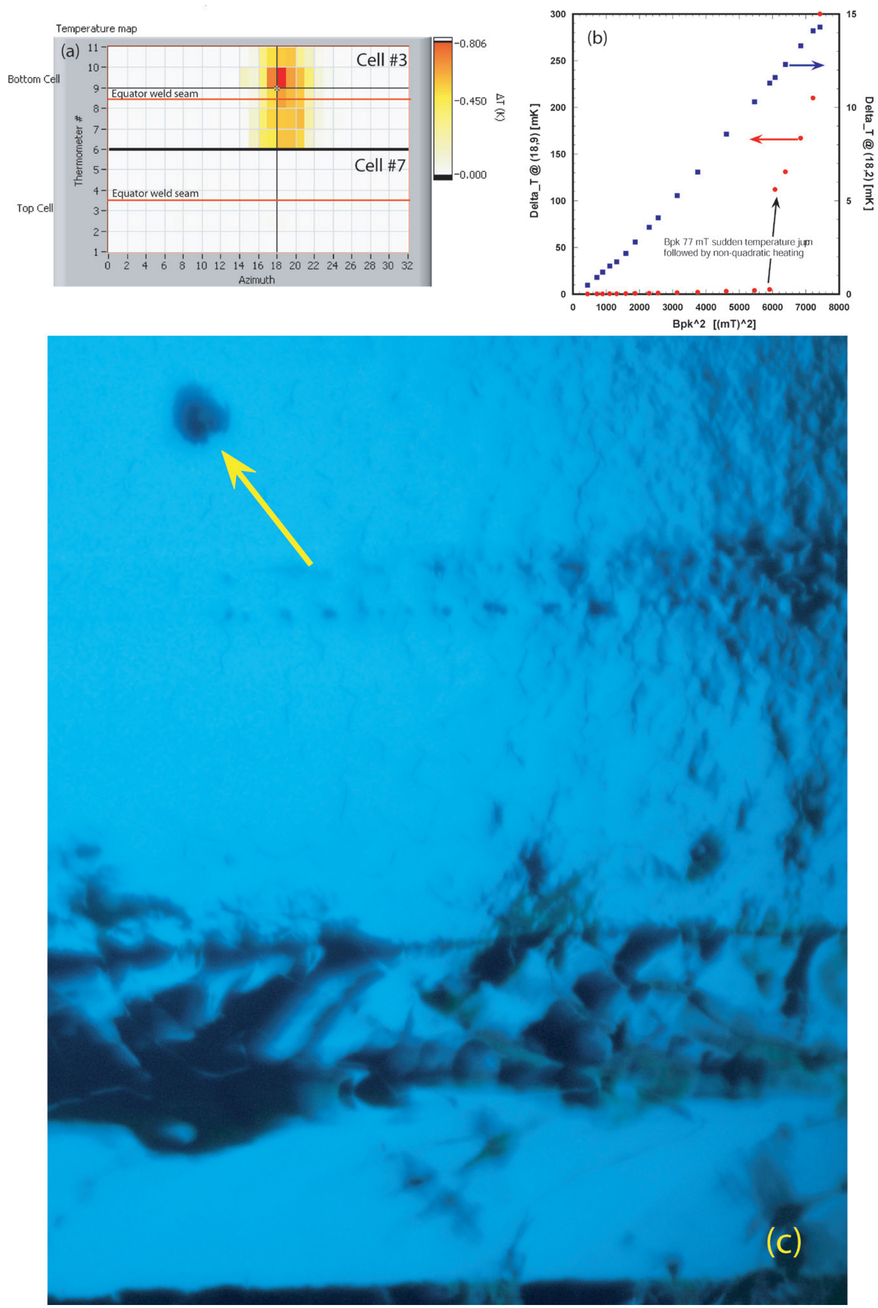






Fine grain EP defect causing quench 19 MV/m.

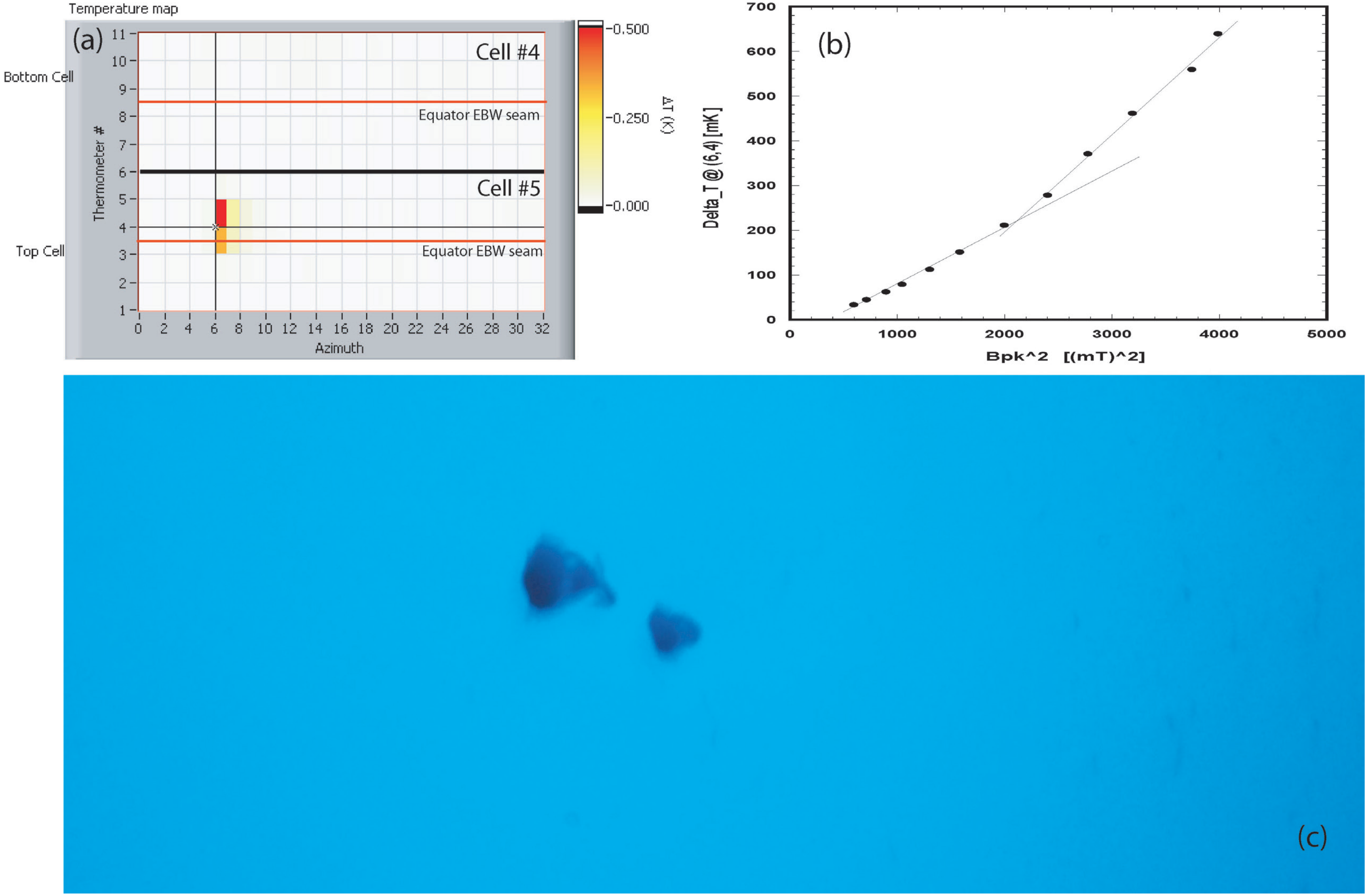
Cavity by experience vendor



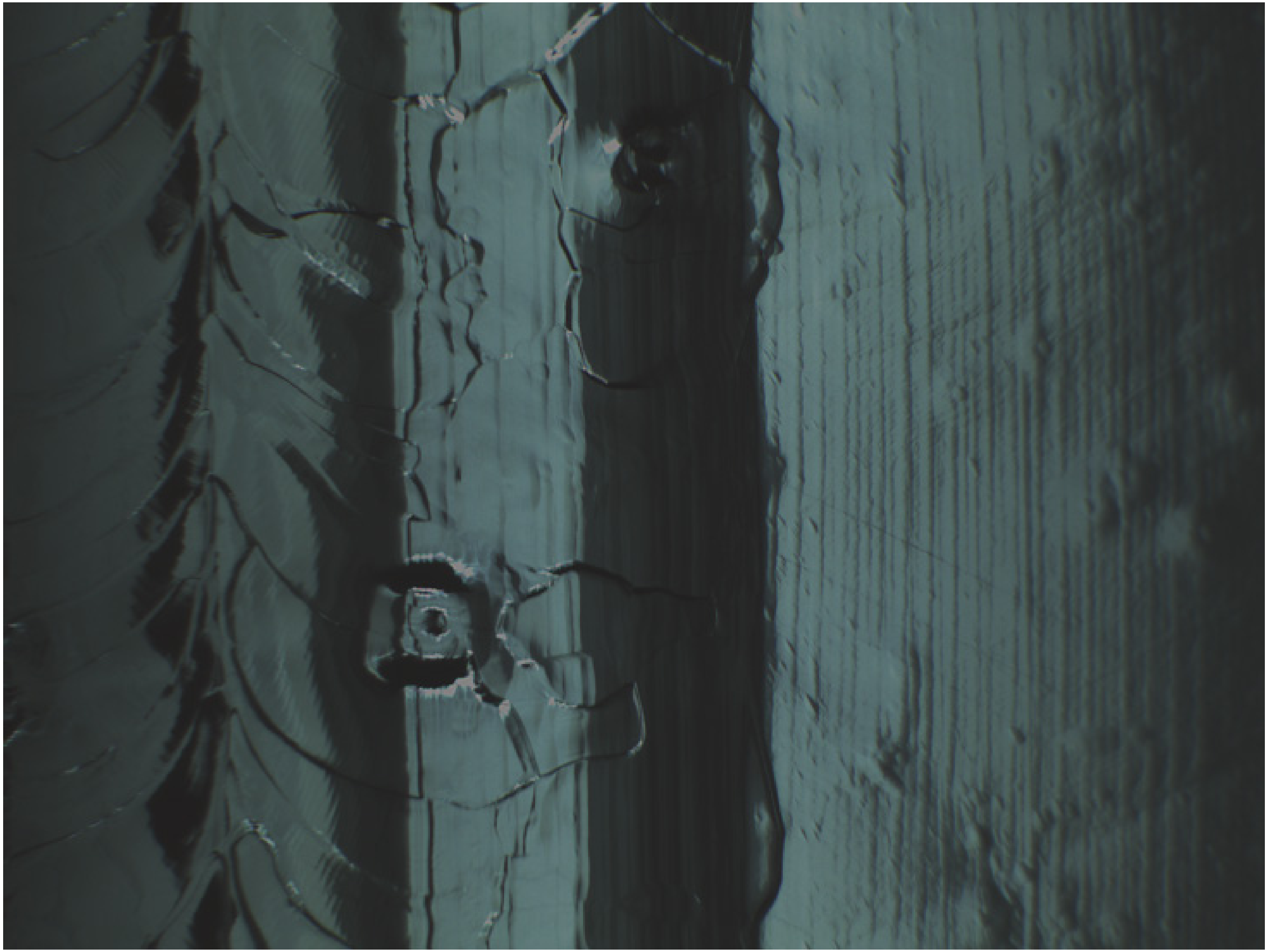
Fine grain EP
defect causing
Quench 20 MV/m.

Cavity by then
new vendor

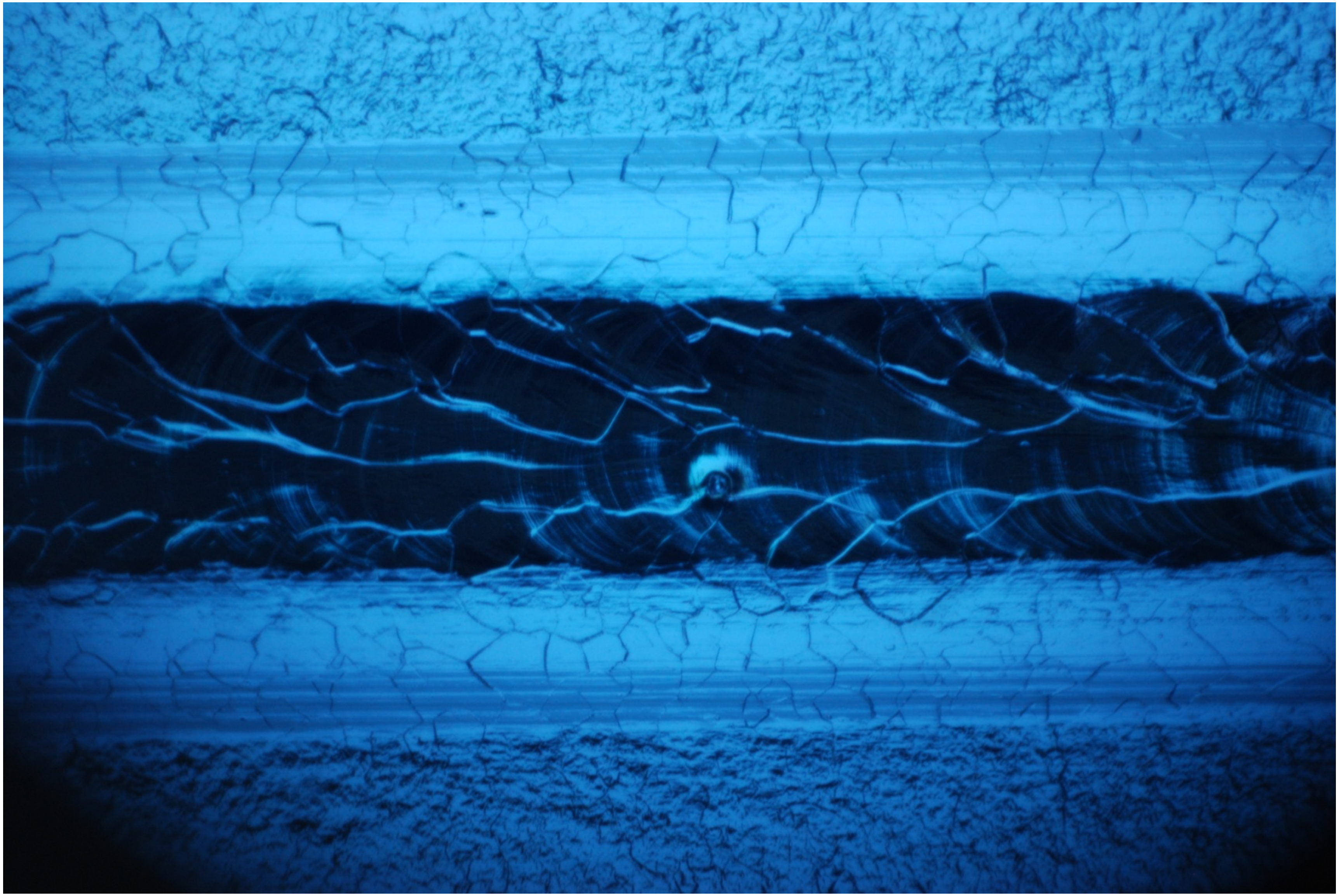
Fine grain EP defect causing Quench 15 MV/m. Cavity by then new vendor



Large grain BCP



Fine grain BCP (IA15, cavity built for CEBAF project in the 80's)



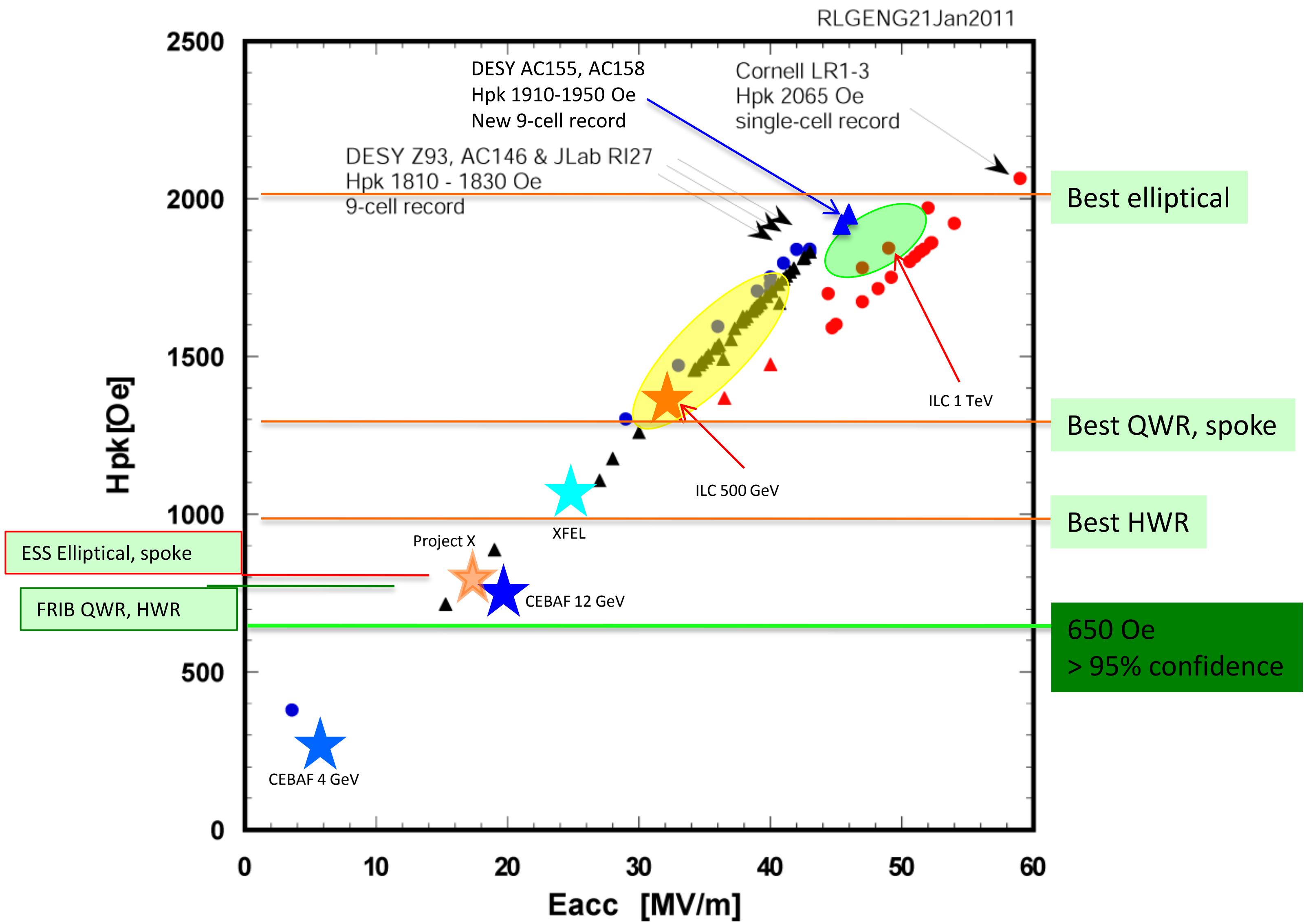
Type I Defect

- Sub-mm sized geometrical defect at or near EBW joint
  - Independent of manufacturer
    - Experienced or new
  - Independent of surface processing
    - BCP or EP
  - Independent of material
    - Fine-grain or large-grain

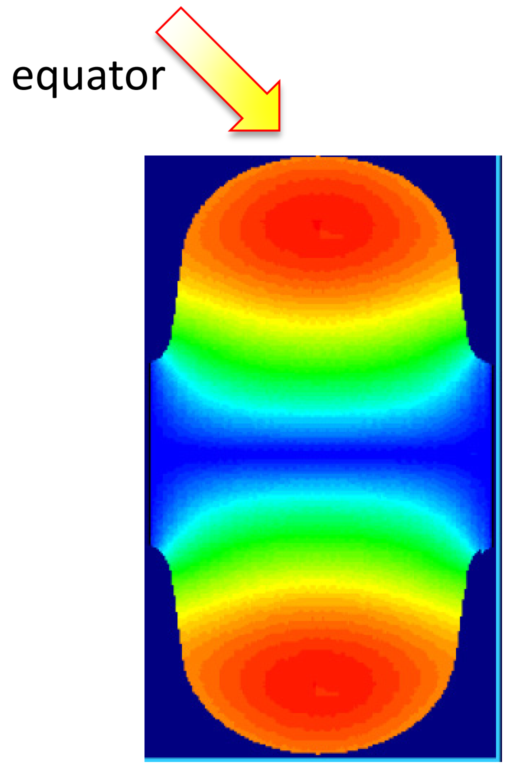
Sources of Type I Defect

- Fabrication (Electron Beam Welding)
  - Surface defects
    - Optical inspection
    - Mechanical polishing
  - Under-surface defects
    - Pocket/porosity
    - Ultrasonic/X-ray inspection
    - Re-melting
- Material?

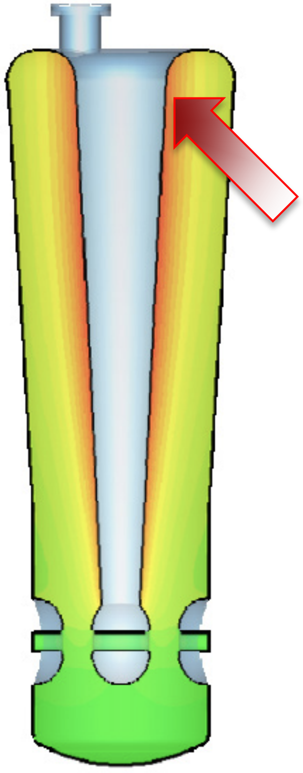
Achieved Peak Surface Magnetic Field in L-band SRF Niobium Cavities (Circle: Single-Cell Cavity; Triangle: Multi-Cell Cavity



- Quench is primarily a magnetic field effect
  - High magnetic field region (arrow) in cavity is critical

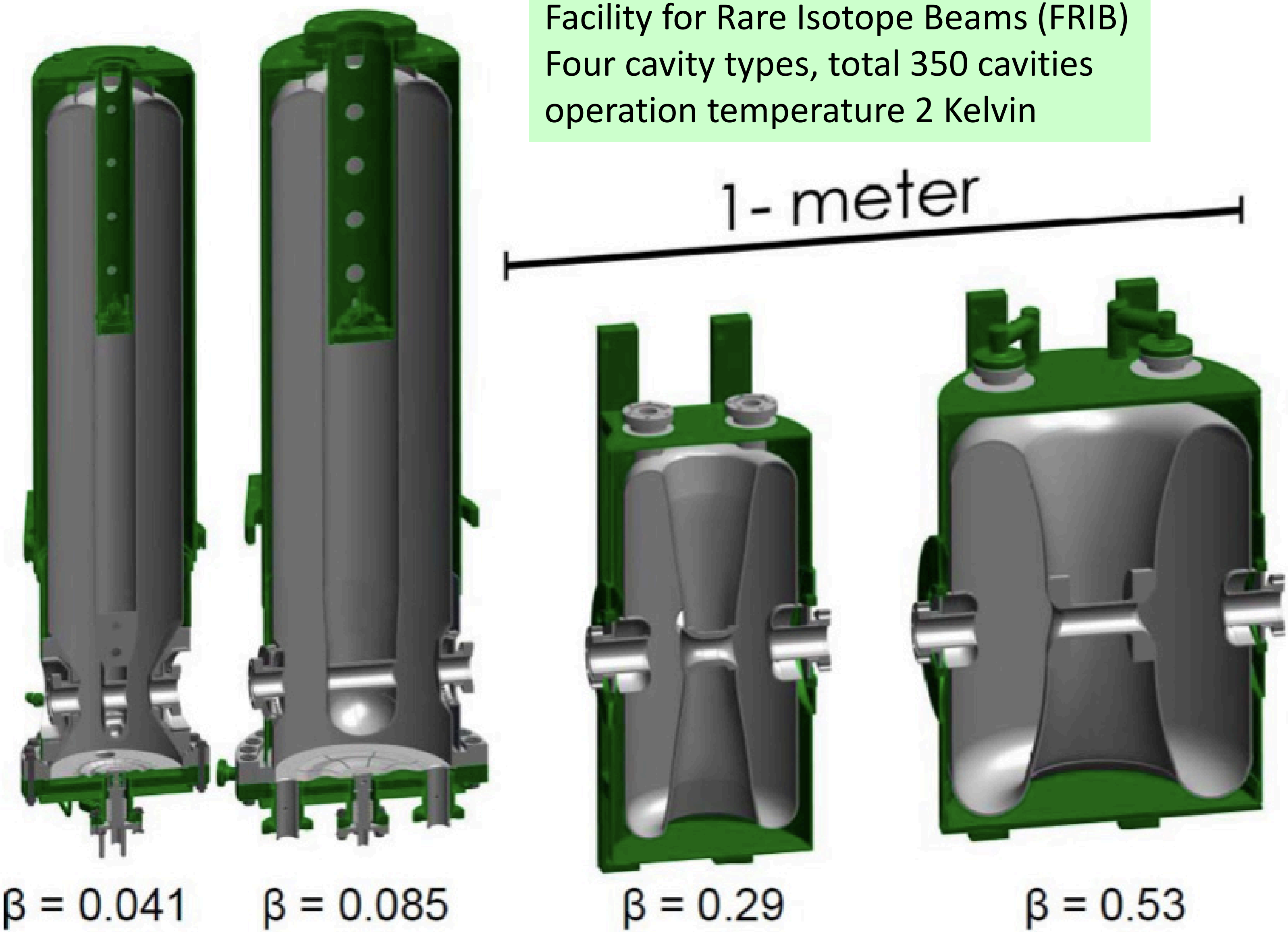


Elliptical cavity (TM-class)



Half-wave cavity (TEM-class)

Facility for Rare Isotope Beams (FRIB)
Four cavity types, total 350 cavities
operation temperature 2 Kelvin



Sources of Type II Defect

- Nature is not clear
  - Size is probably sub-micron
  - Probably has to do with surface composition irregularity
  - Probably has to do with processing
  - Probably has to do with material inhomogeneity
  - …

Observation

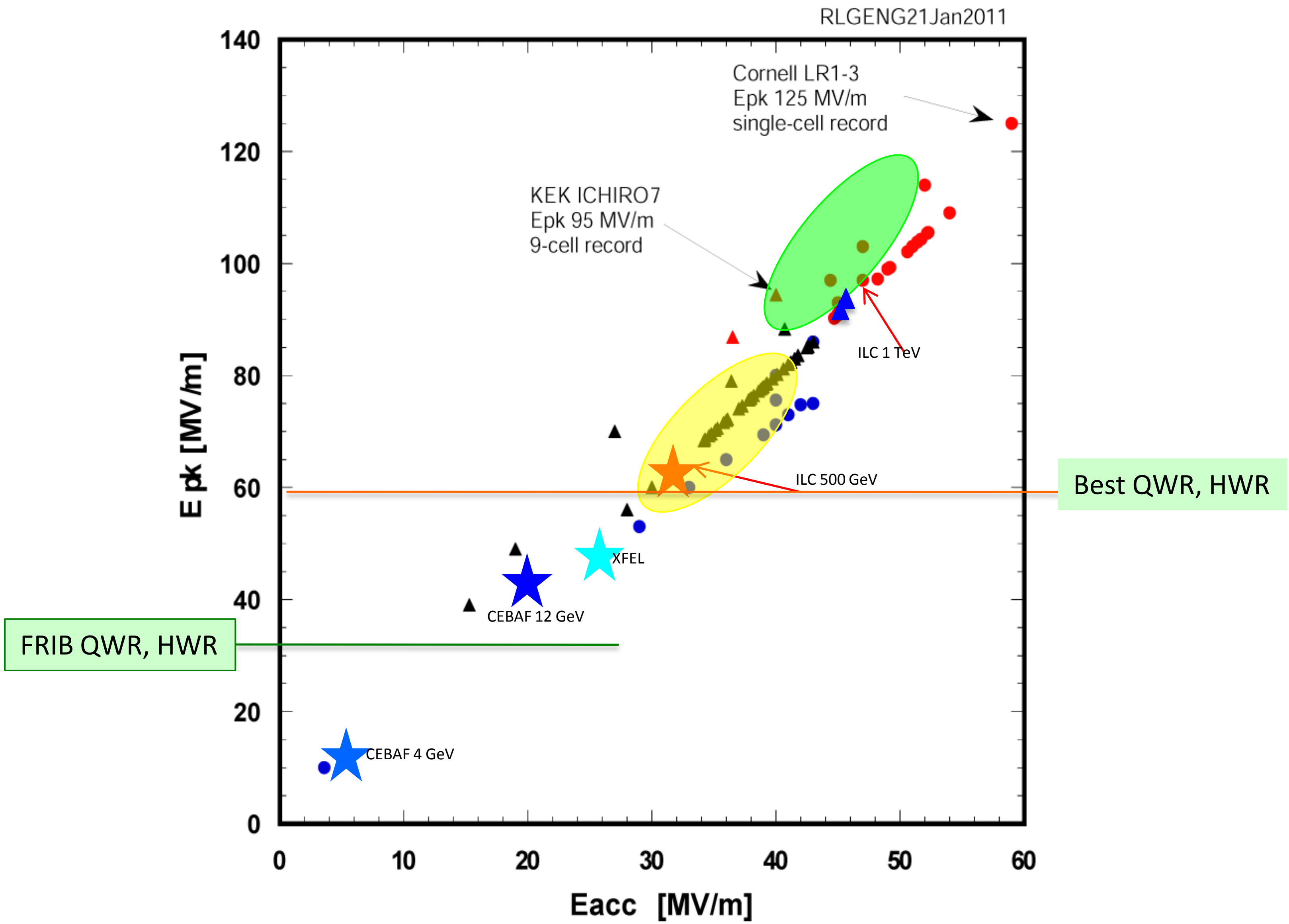
- Type I defect is an issue of common interest
  - for β=1 elliptical cavities (ILC)
  - for β<1 elliptical cavities (Px, ESS)
  - for β<1 cavities HWR, QWR cavities (FRIB)
- Quench study in elliptical cavities (for ILC) improved understanding of type I defect
- Quench study in β<1 QWR, HWR, spoke?
- Fabrication improvement is needed
  - Fabrication is and will be done in industry
  - Feedback between lab and industry

Observation (continued)

- Type II defect is a unique challenge for very high gradient application such as ILC
- Deeper understanding requires high-resolution localization of quench location and microscopic surface material studies of the quench site
- Understanding is necessary toward the ultimate gradient determined by the RF critical field

Additional Slides

Achieved Peak Surface Electric Field in L-band SRF Niobium Cavities
(Circle: Single-Cell Cavity; Triangle: Multi-Cell Cavity)



Seamless cell BCP