



# Optical Inspection Update and Material Studies at JLab

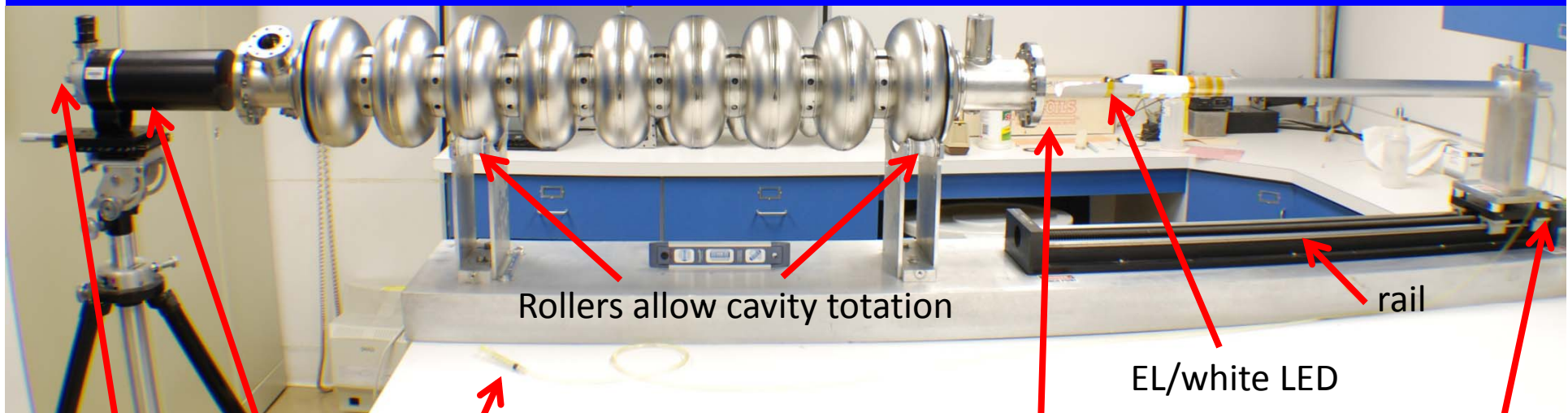
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Jefferson Lab

ILC08, November 16-20, 2008, UIC



# JLab High Resolution Cavity Inspection Apparatus



Rollers allow cavity totation

rail

EL/white LED

Mirror tilter

Mirror

Step motor

Questar QM1

- Working Range: 22 – 66 inches
- Resolution: better than 3 microns at 22 inches

Nikon digital camera  
Pixelink CCD camera

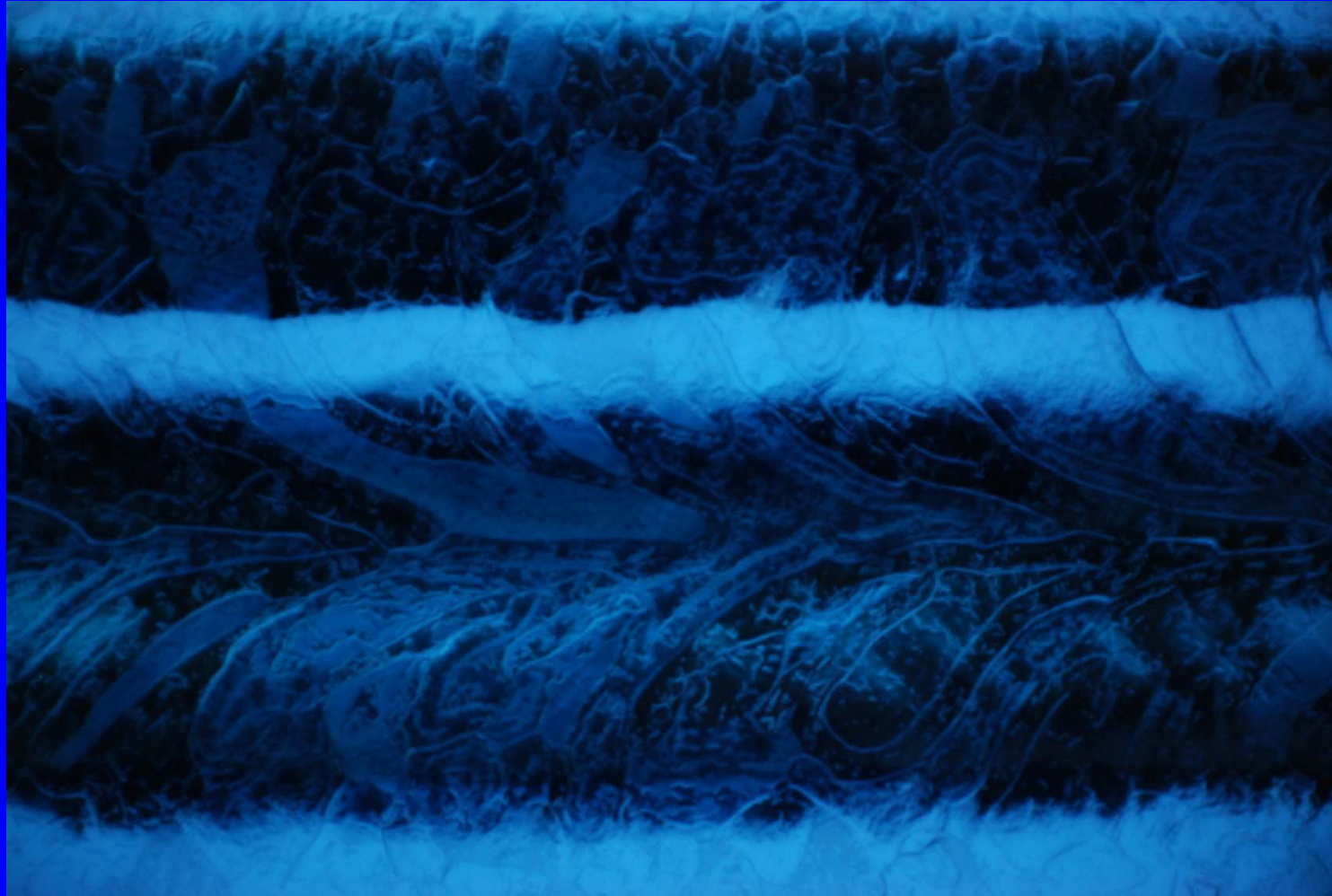
# An Incomplete List of Cavities Optical Inspected

Recent TTC@India talk by Rimmer has lots of information; this talk focuses on new results

ICHIRO5	ILC 9-cell ACD shape	Fine grain	CBP+EP
AES4	ILC 9-cell BCD shape	Fine grain	EP
A8	ILC 9-cell BCD shape	Fine grain	EP
A15	ILC 9-cell BCD shape	Fine grain	EP
A12	ILC 9-cell BCD shape	Fine grain	EP
A13	ILC 9-cell BCD shape	Fine grain	EP
A14	ILC 9-cell BCD shape	Fine grain	No EP yet
J2	ILC 9-cell BCD shape	Fine grain	EP
J1	ILC 9-cell BCD shape	Fine grain	No EP yet
JL001	ILC 9-cell BCD shape	Fine grain	BCP
LG1	ILC 9-cell BCD shape	Large grain	BCP
PKU9-1	ILC 9-cell BCD shape	Fine grain	BCP+EP
HG006	CEBAF 7-cell prototype HG	Fine grain	BCP
IA15	CEBAF 5-cell Cornell shape	Fine grain	BCP

# A13 Bulk EP + 600CX10hr Full Inspection

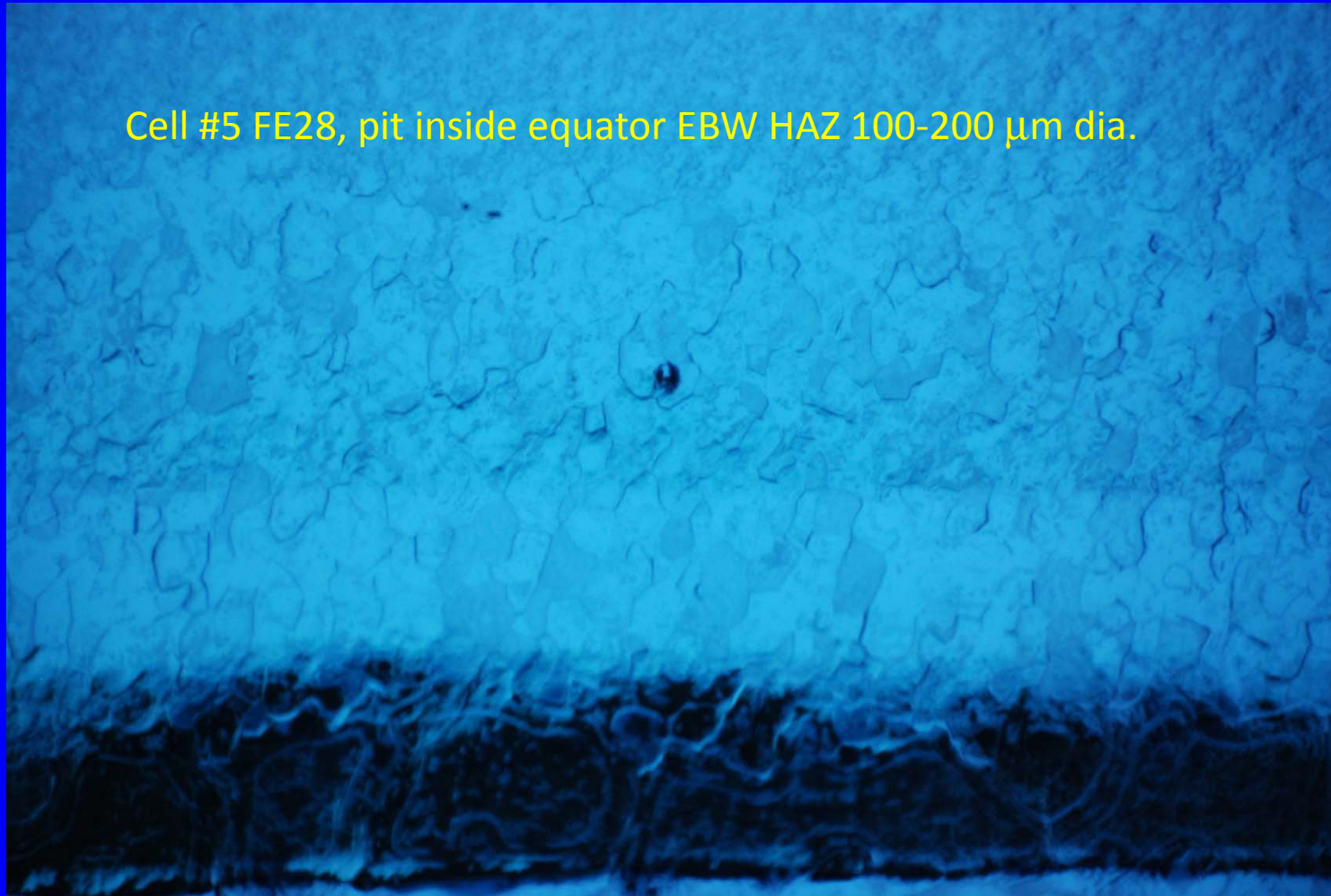
## Equator EBW typical





# A13 Bulk EP + 600CX10hr Full Inspection

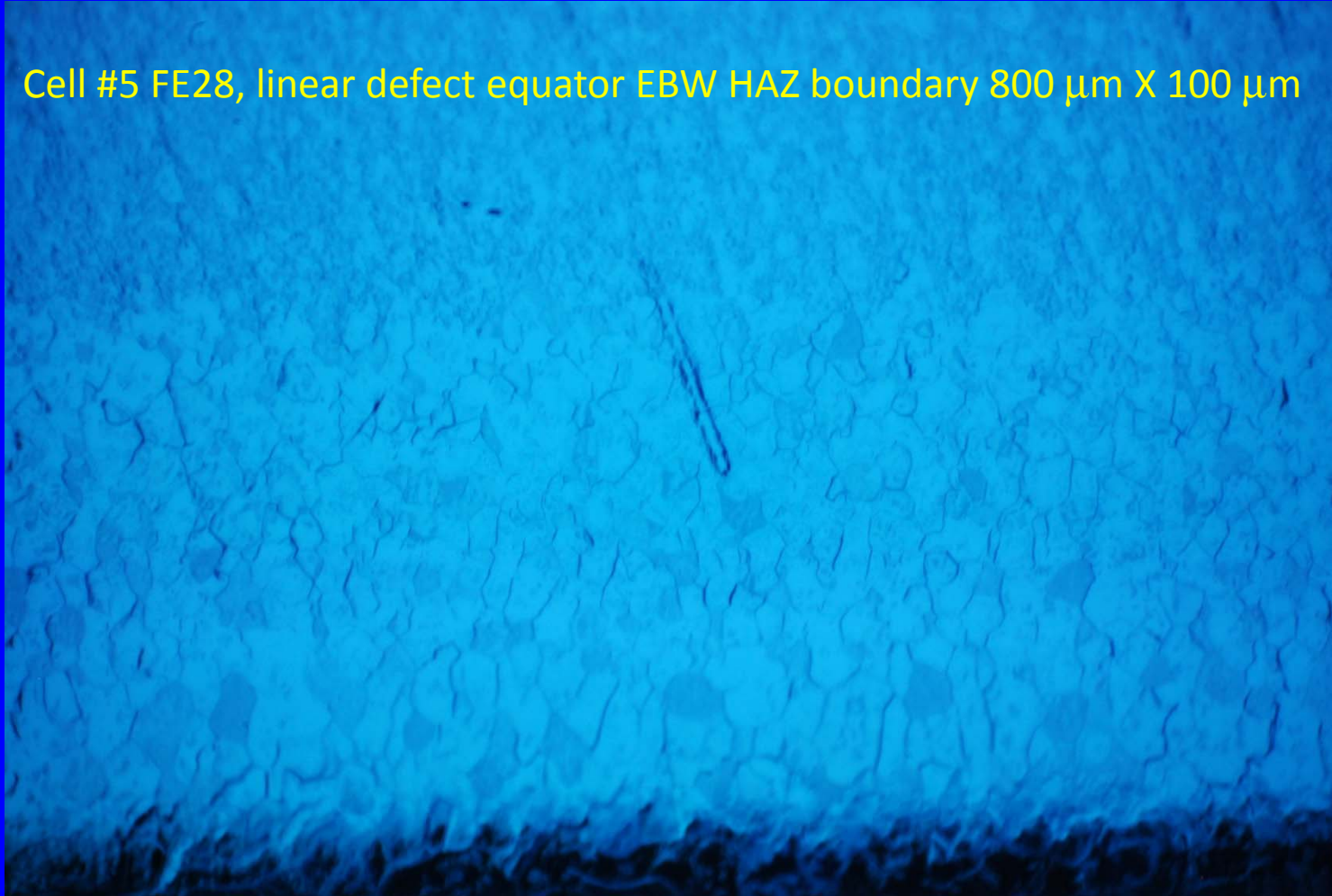
many pits of various sizes (50-200  $\mu\text{m}$  dia.) **inside & outside** equator EBW HAZ



# A13 Bulk EP + 600CX10hr Full Inspection

First observation of linear defect (most likely dislocation etching pit)

Cell #5 FE28, linear defect equator EBW HAZ boundary 800  $\mu\text{m}$  X 100  $\mu\text{m}$



# A13 Bulk EP + 600CX10hr Full Inspection

Linear defect in textured area (likely associated with severe plastic deformation)





# A13 Next Steps

- Defect tracking

- Pits and linear defects already observed in Cell#5 before bulk EP.
- Data being analyzed for correlation.
- Re-inspection after first light EP and first RF test.

- A13 first RF test

- First light EP 25  $\mu\text{m}$  done.
- Plan to mount thermometry boards on Cell#5 & 6 for first RF test.
- Goal is to verify prediction based on optical inspection data.

- Cell#5 & 6 history

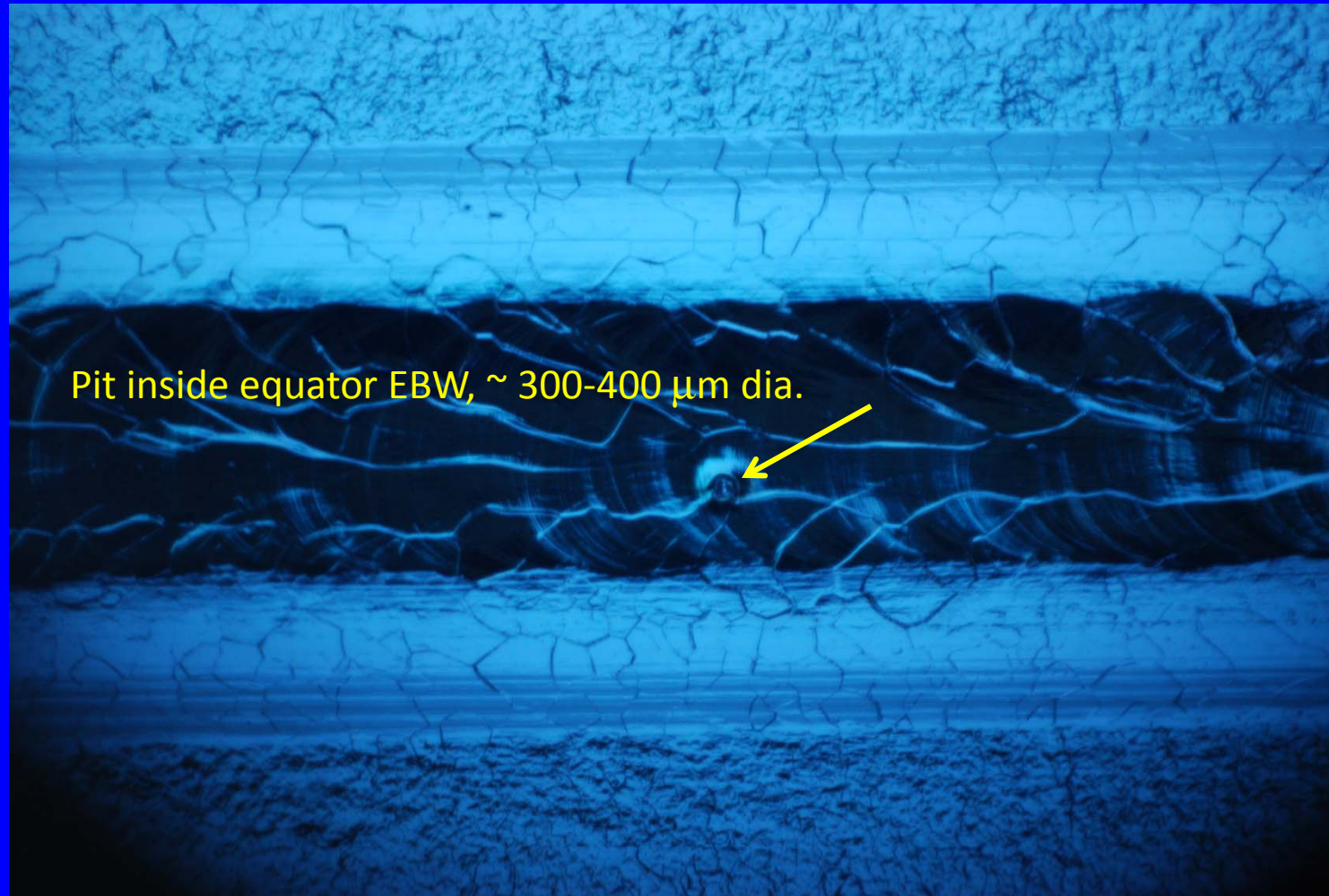
- Half-cell FE28 & FE40 handling and processing.
- Direct communication with cavity builder highly valuable.



# IA15 – Reference Inspection

- 5-cell original CEBAF cavity. Built about 20 years ago.
- BCP etched only.
- Recently re-etched and tested.
- Quench limited at 10 MV/m.
- Goal of inspection: establish reference defects naturally existing in real cavities.

# IA15 – Reference Inspection

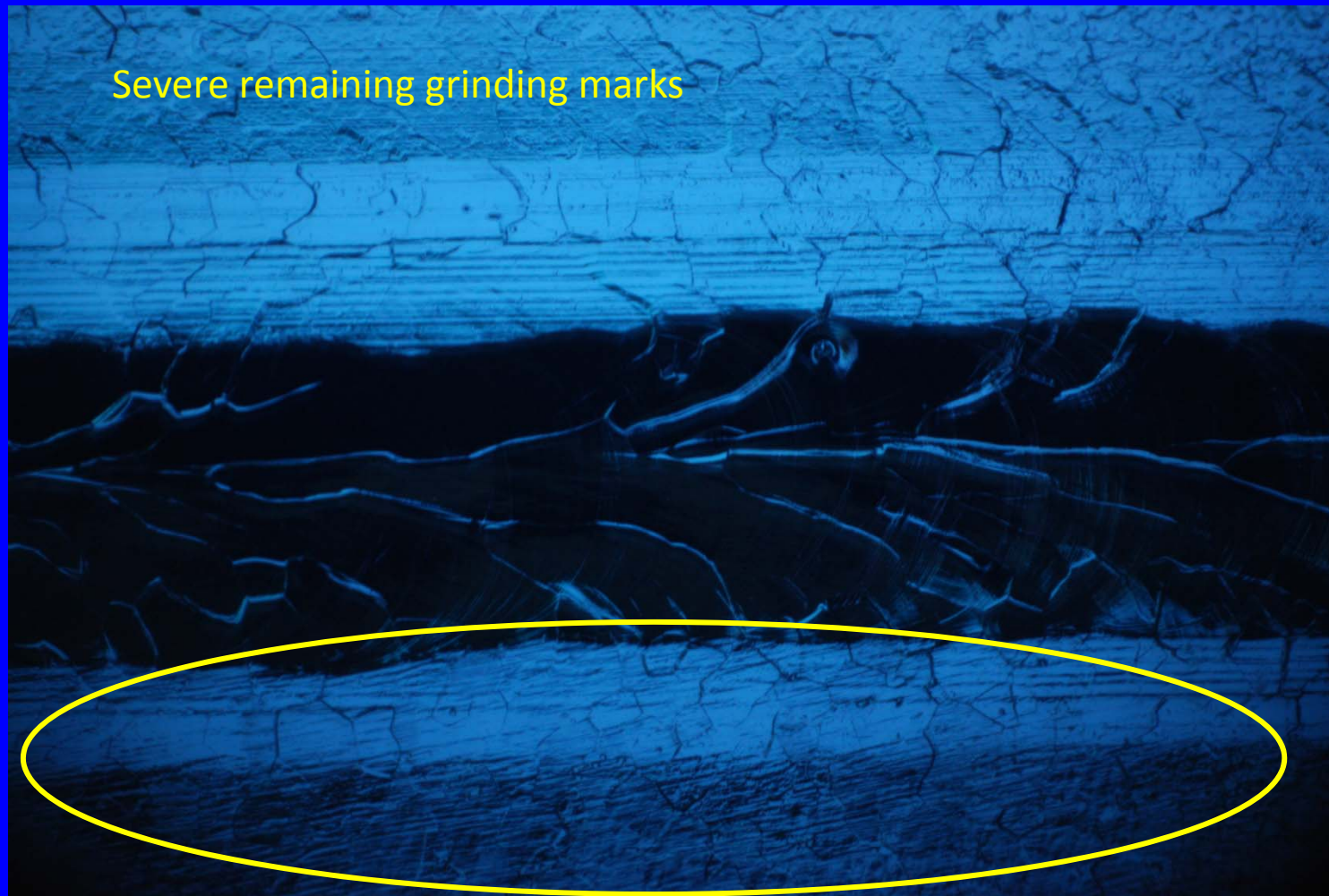


# IA15 – Reference Inspection



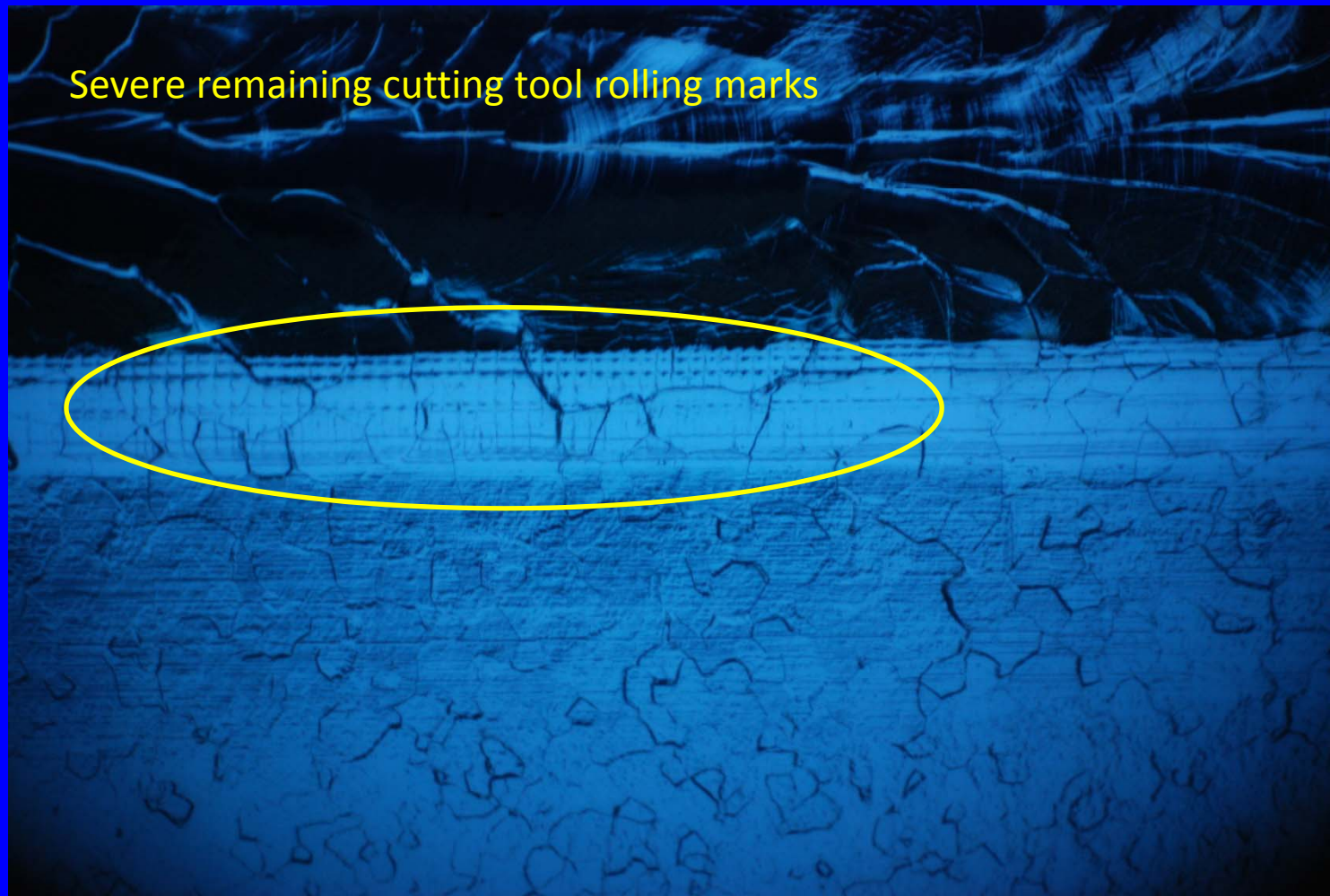


# IA15 – Reference Inspection

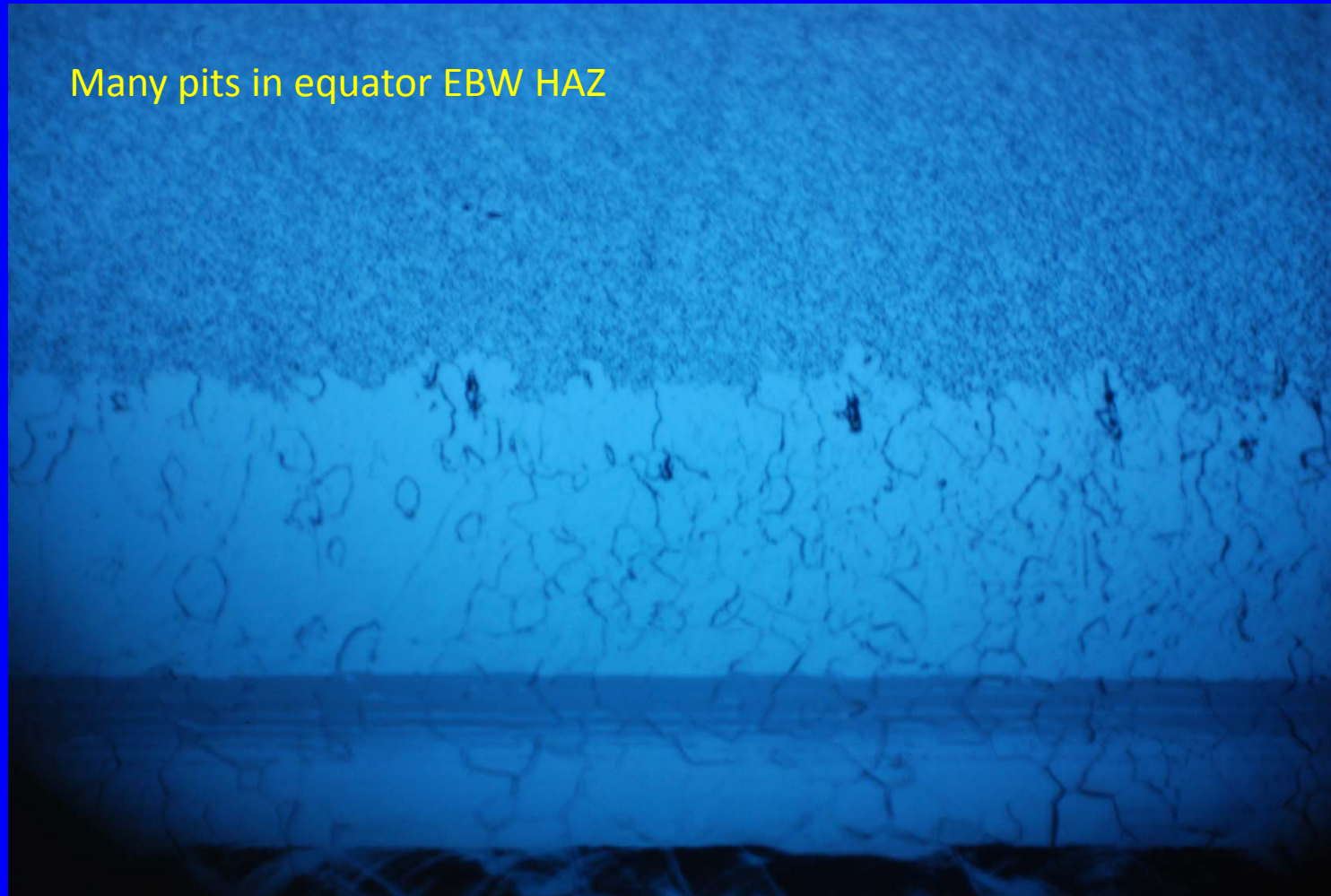




# IA15 – Reference Inspection



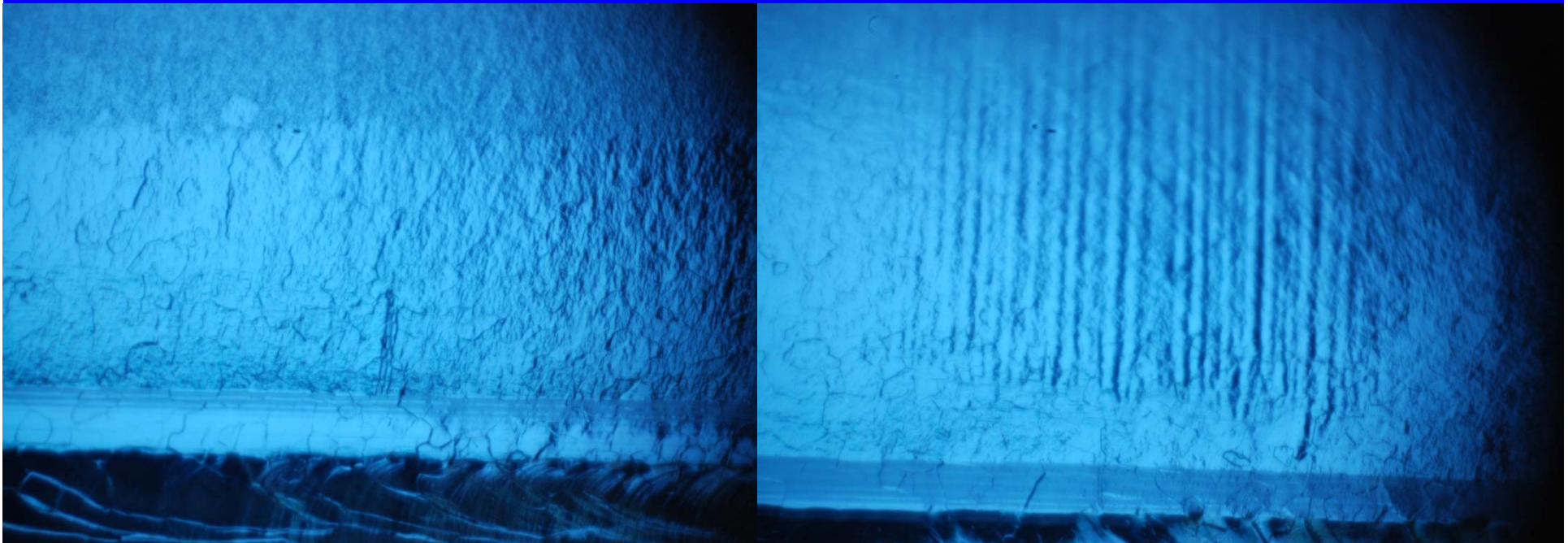
# IA15 – Reference Inspection





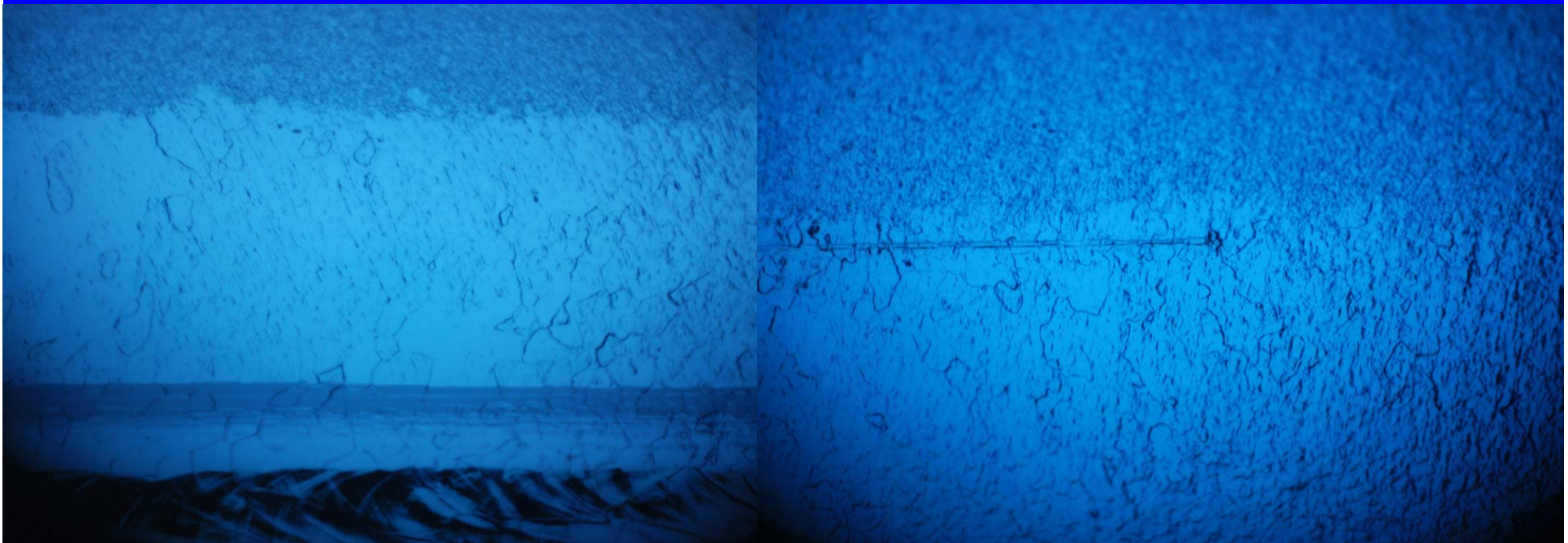
# IA15 – Reference Inspection

Linear defects (most likely slip lines and slip bands associated with plastic deformation)



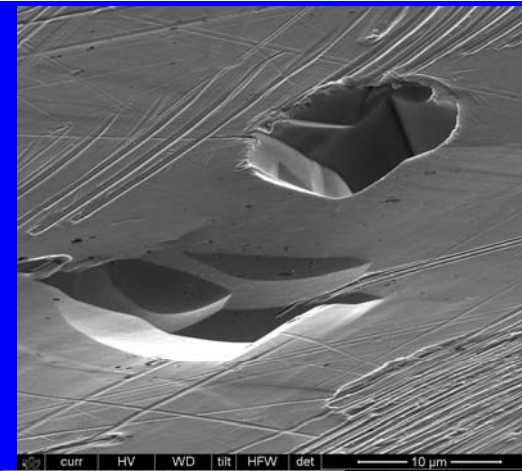
# IA15 – Reference Inspection

Textured surface in equator EBW HAZ  
(most likely dislocation etching pits)

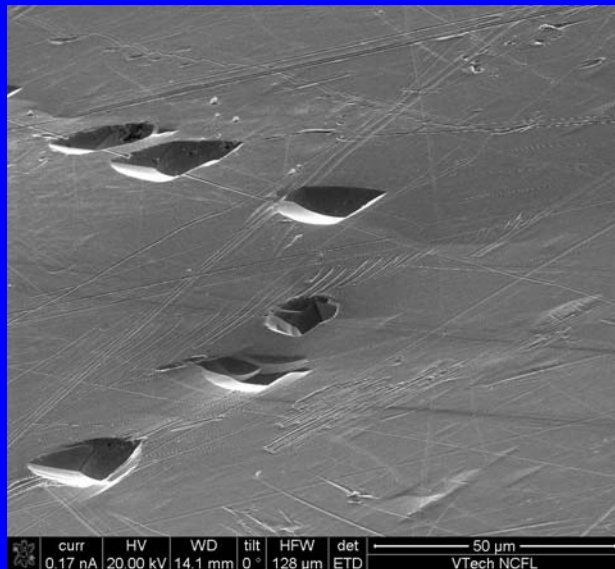
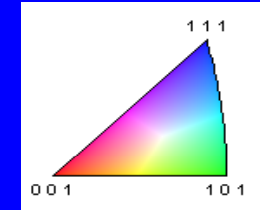




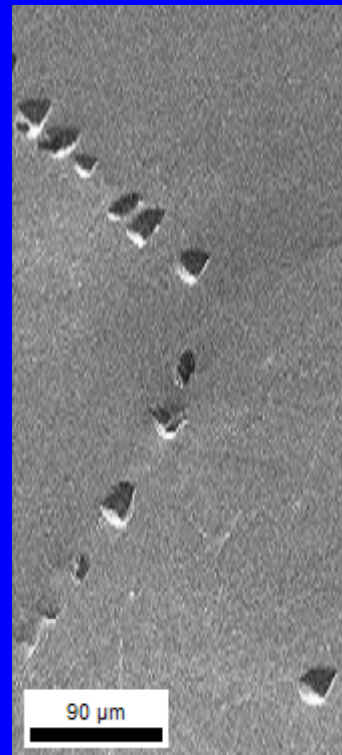
A recent JLab result by Xin Zhao et al  
dislocation etching pit  
large-grain BCP  
presented at MSU material workshop



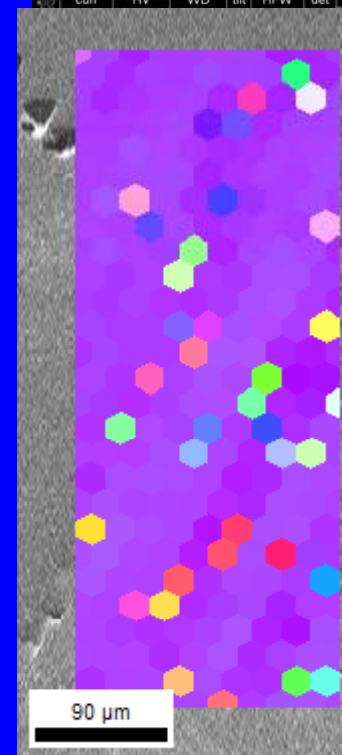
Nb [001] Inverse  
Pole Figure (IPF)  
Triangle Color  
Legend



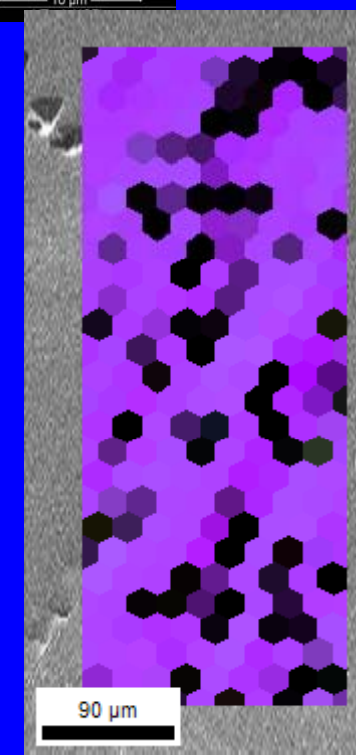
EBSD+IPF+IC figure  
shows all the etching  
pits are in a single  
crystal grain



SEM

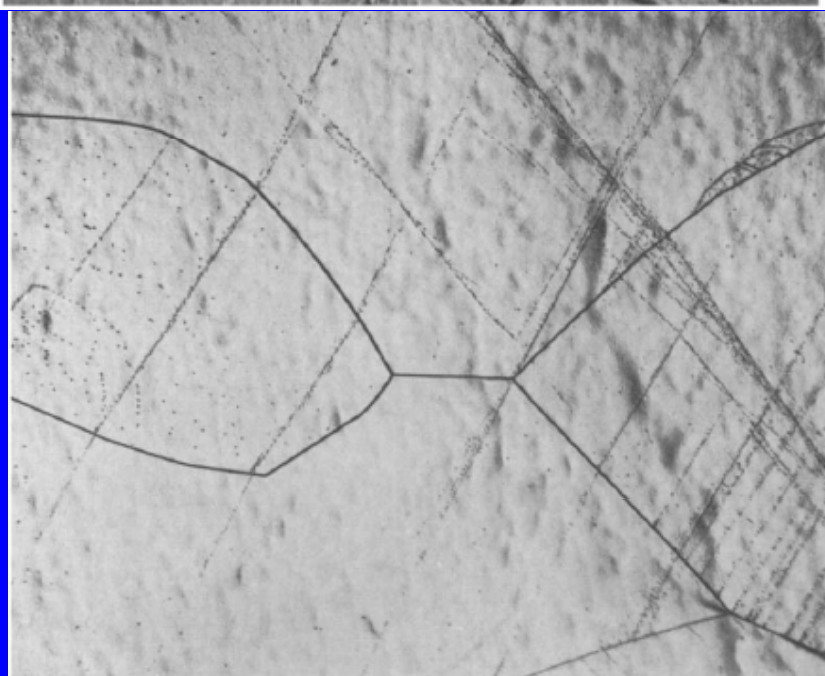
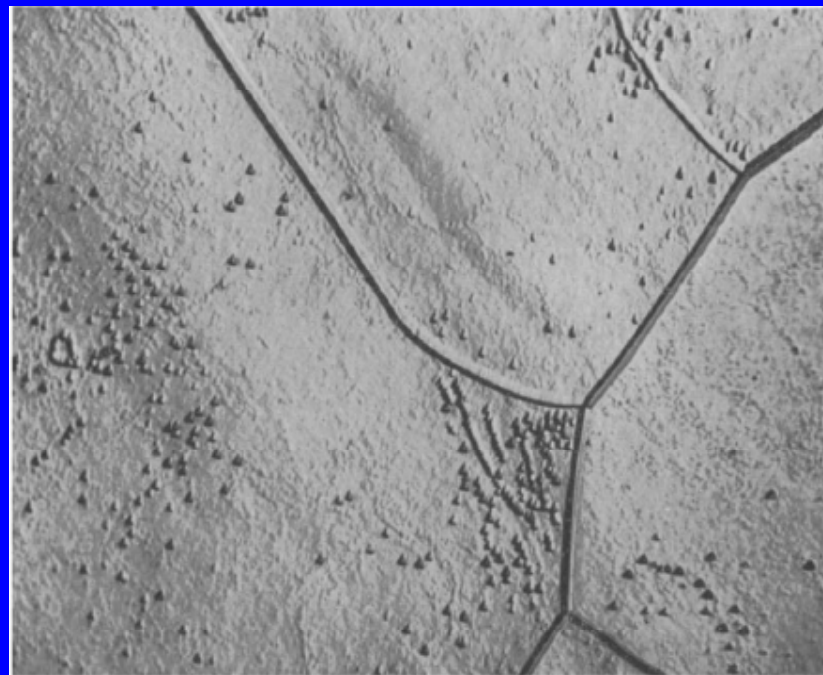
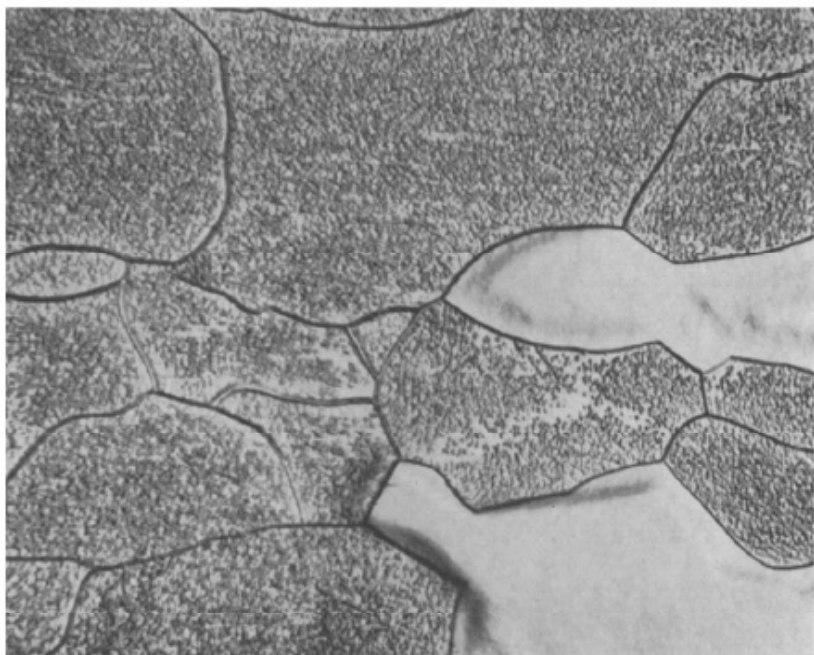


SEM+I.P.F



SEM+I.P.F+C.I.

EBSD Scanning Step 20 um  
Average CI 0.64



# Future Plans and Challenges

- Routine ILC S0 9-cell cavities inspection and tracking, correlate defect with quench by T-mapping.
  - First examples: A13 and J2.
  - Two more new cavities at JLab (A14 and J1)
  - FY09 more new cavities expected.
- Expand inspection to include other interesting cavities
  - Document species of natural defects in real cavities.
  - Taking advantage of large number of cavities processed & tested at JLab.
- Intensify material studies and RF characterization of controlled defect for basic understanding.
  - Brilliant young material scientists on board in PMA group.
  - PMA group pushes for collaborative studies w/ South-Eastern univ. groups.