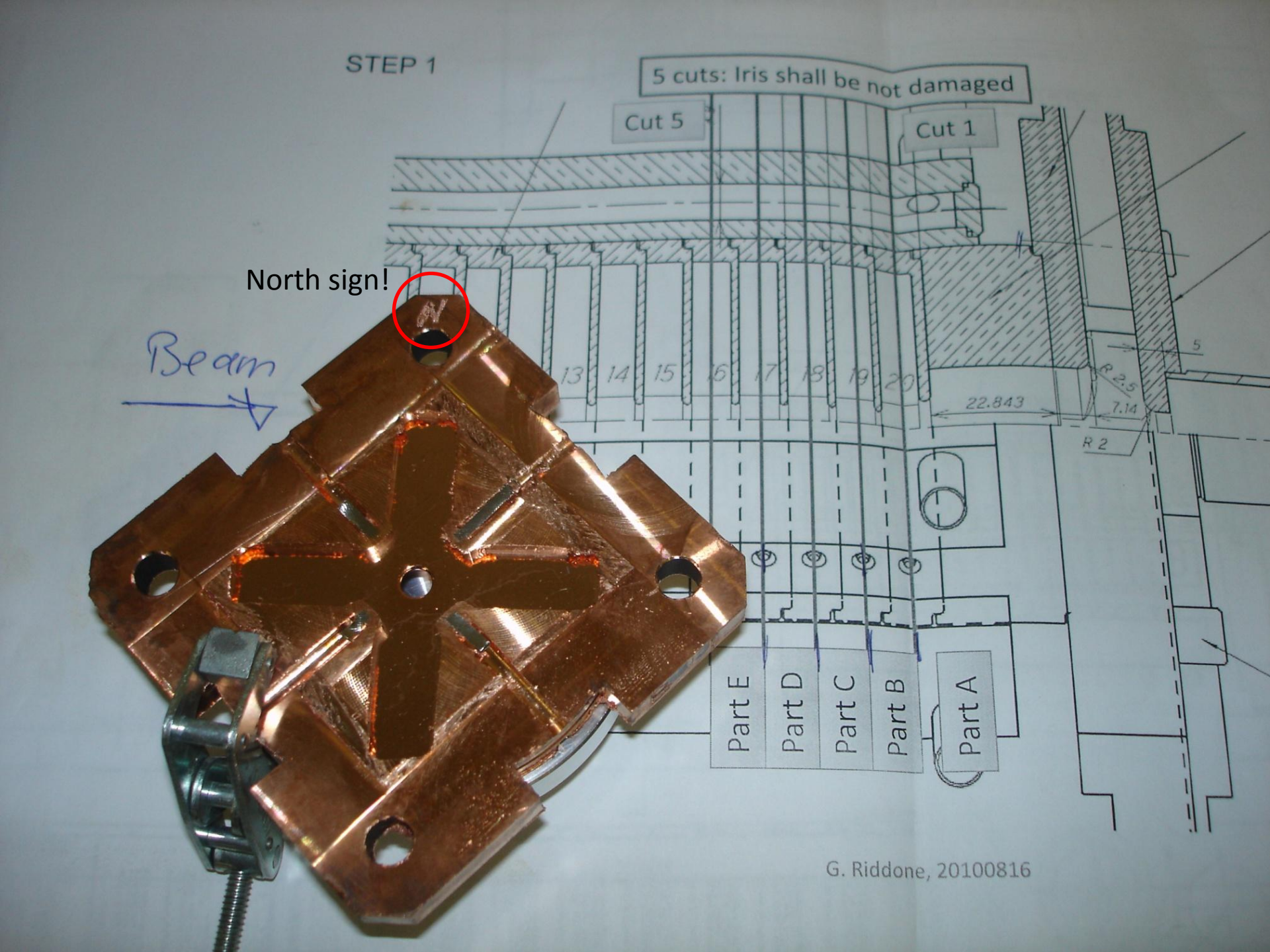
TD18 post-mortem SEM observation: Findings, Questions and Answers

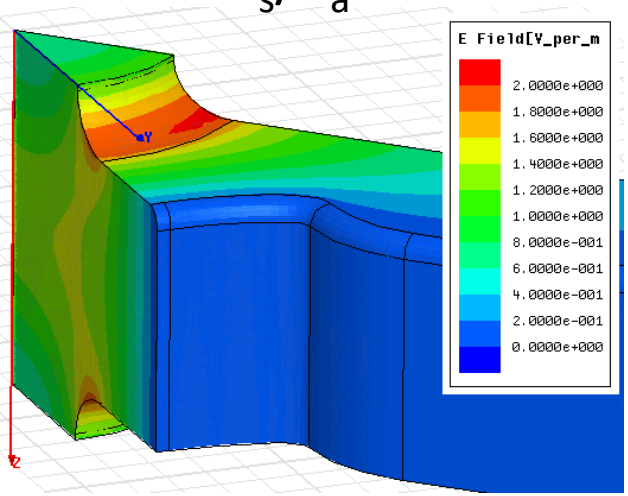
Markus Aicheler

13. Oct. 2010

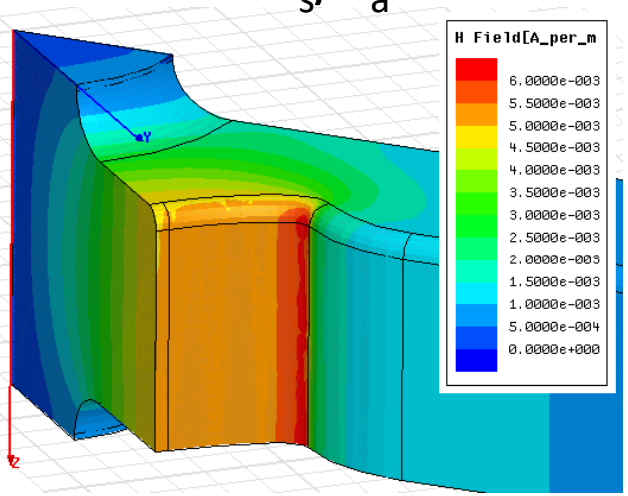

STEP 1
5 cuts: Iris shall be not damaged
Cut 5
Cut 1
North sign!
Beam
13
14
15
16
17
18
19
20
22.843
7.14
R 2.5
R 2
5
Part E
Part D
Part C
Part B
Part A
G. Riddone, 20100816

First cell

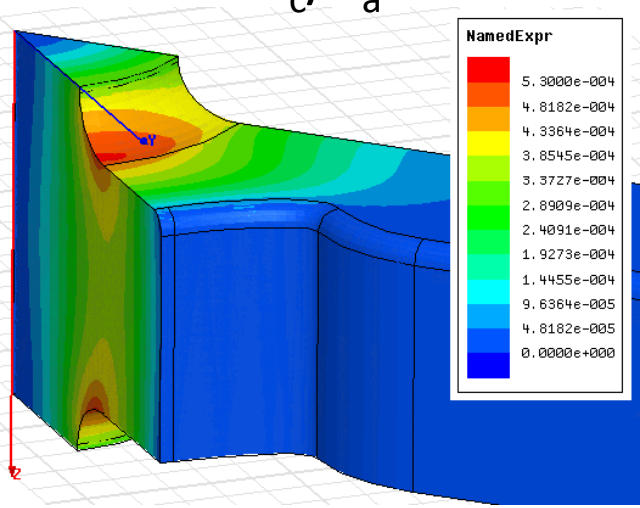
E_s/E_a



H_s/E_a



S_c/E_a^2



a [mm]	4.06
d [mm]	2.794
e	1.21
f [GHz]	11.424
Q(Cu)	5100
vg/c [%]	2.23
r'/Q [LinacΩ/m]	10200
Es/Ea	2.0
Hs/Ea [mA/V]	6.0
Sc/Ea^2 [mA/V]	0.53

Courtesy of Alexej Grudiev

Strategy of the presentation:

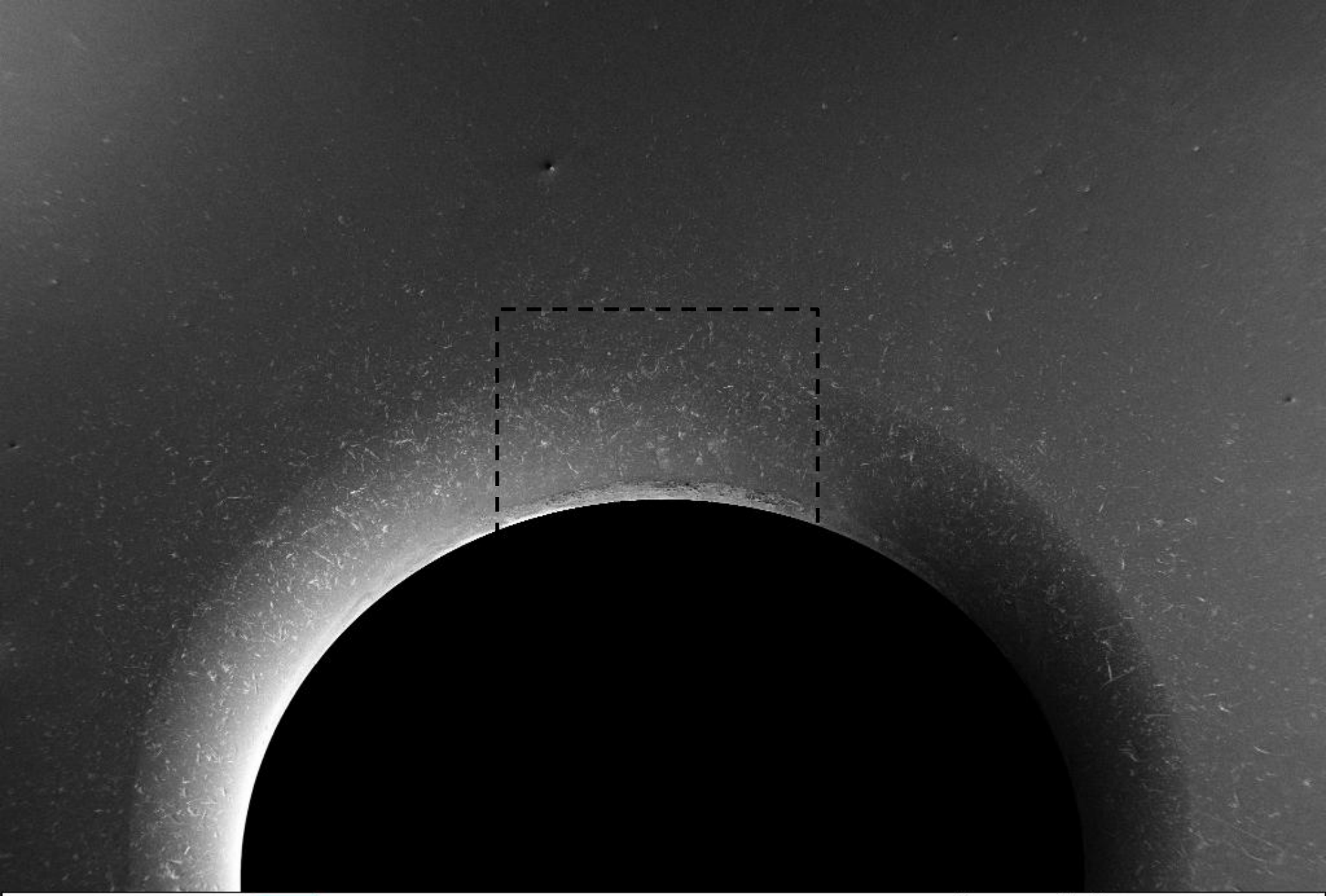
Part 1: Introduction and a little microscopic walk through “part B”

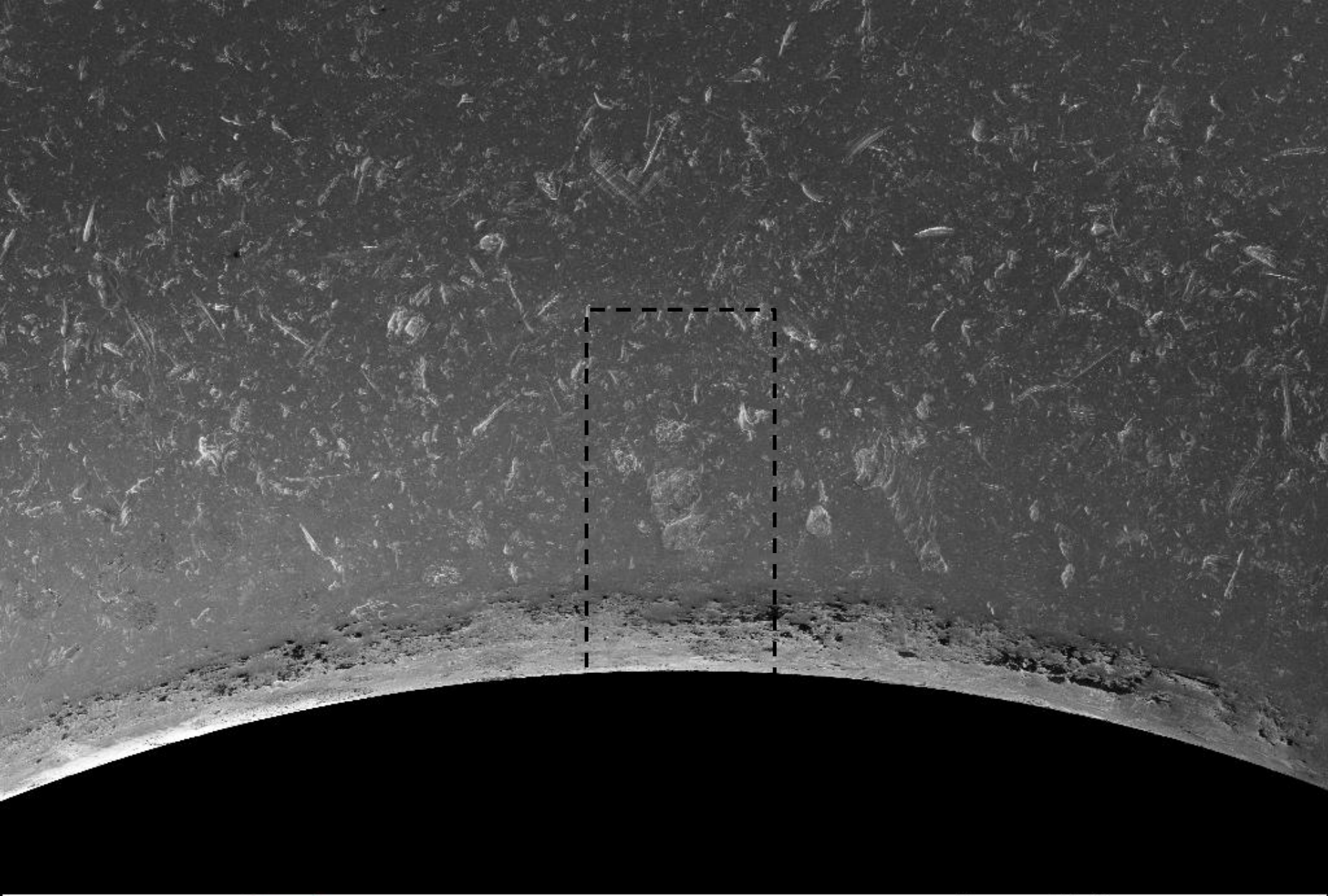
Part 2: An unexpected finding...

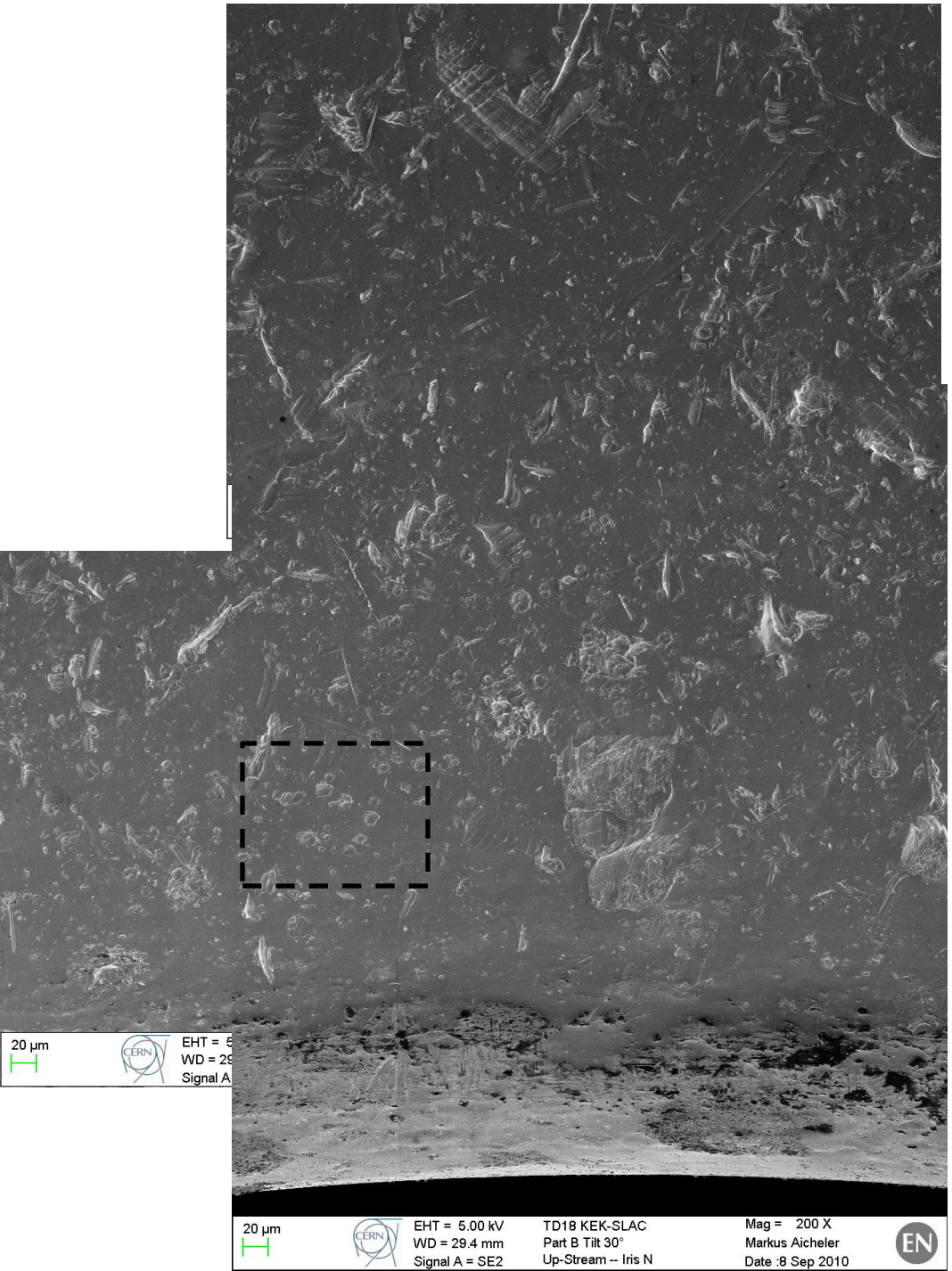
Part 3: Current observation method and next steps

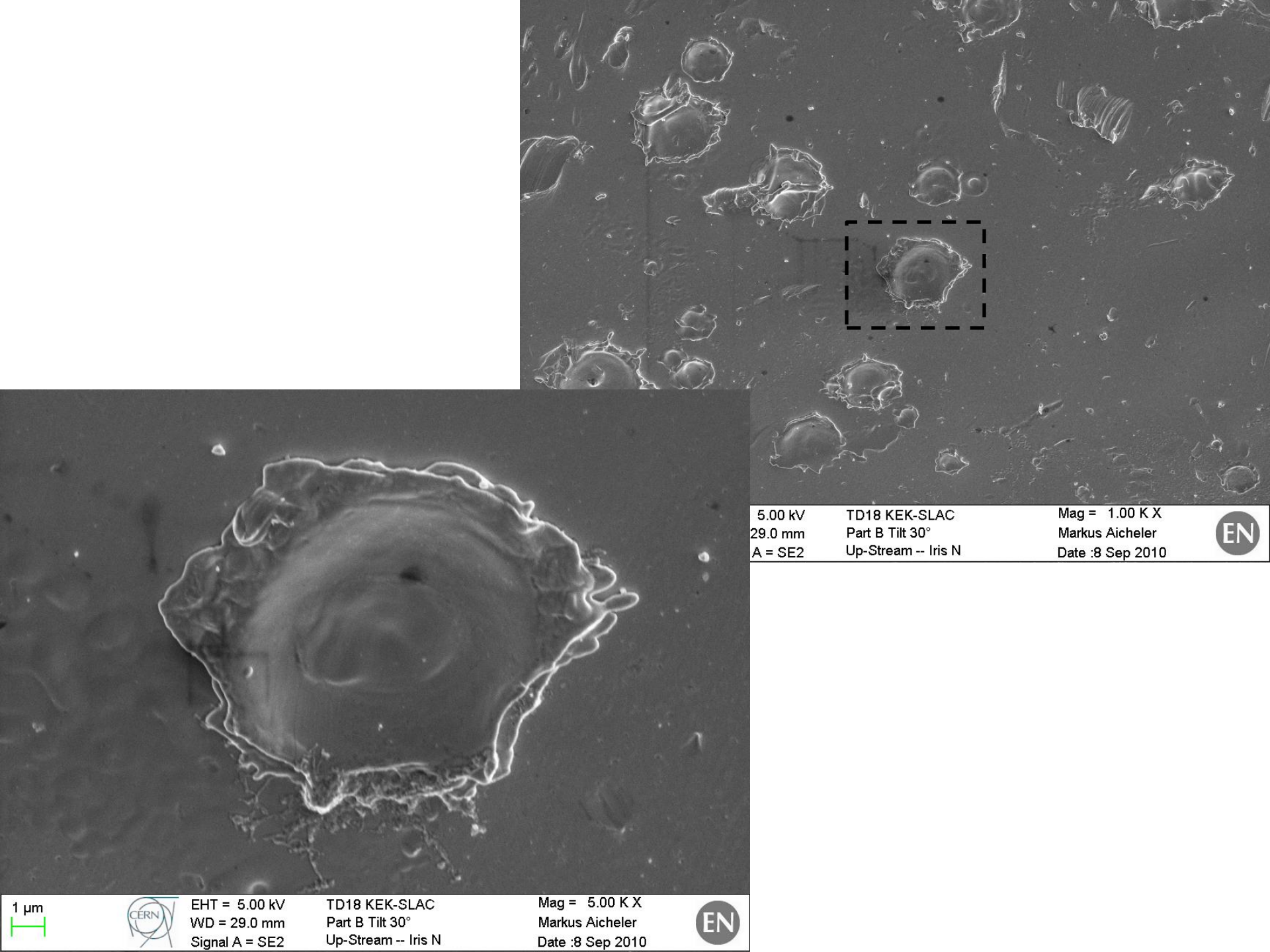
Part B

Up-stream side - Iris north!


1 mm
CERN
EHT = 5.00 kV
WD = 29.4 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Up-Stream -- Iris N
Mag = 13 X
Markus Aicheler
Date :8 Sep 2010
EN

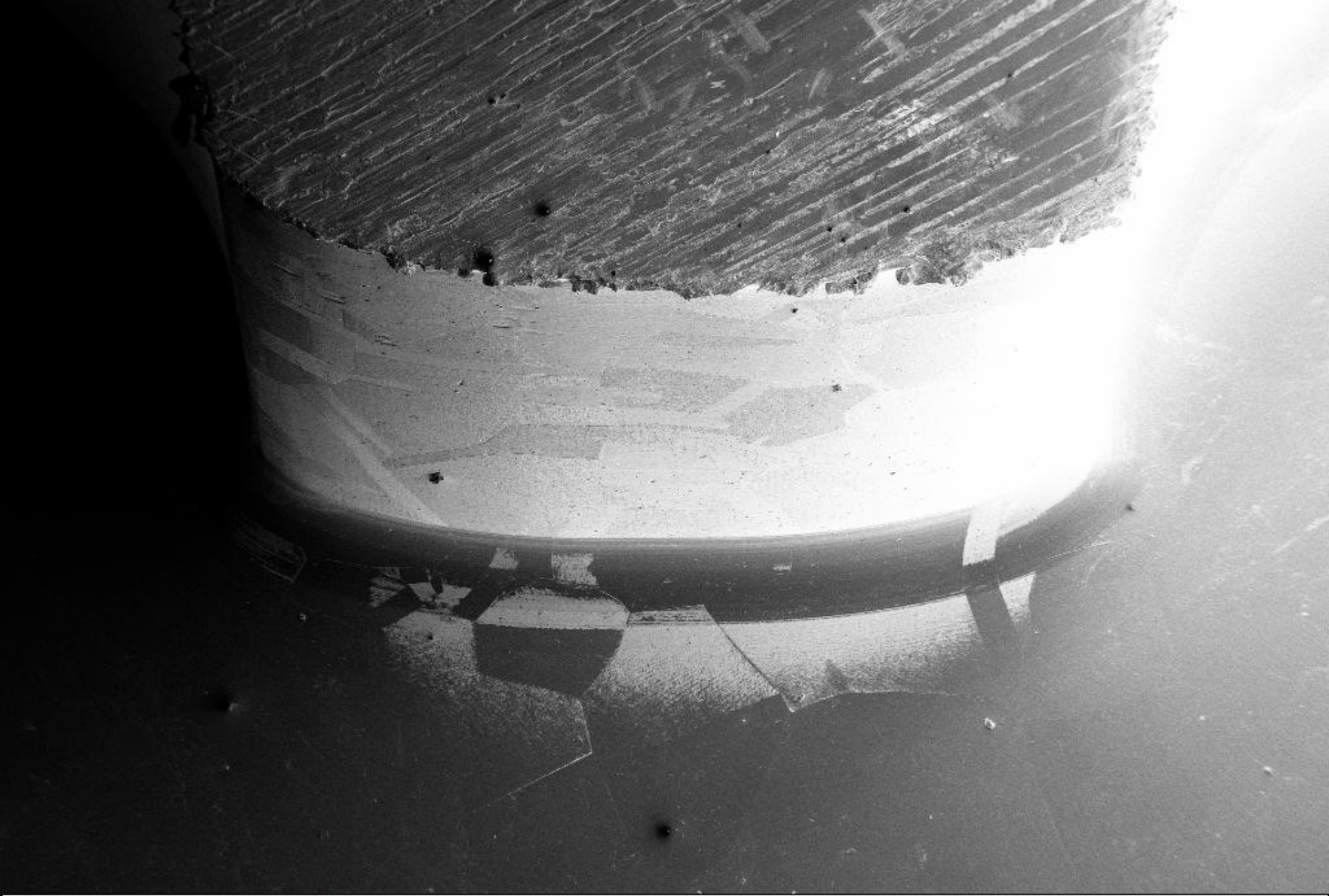

100 µm
CERN
EHT = 5.00 kV
WD = 29.4 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Up-Stream -- Iris N
Mag = 50 X
Markus Aicheler
Date :8 Sep 2010
EN

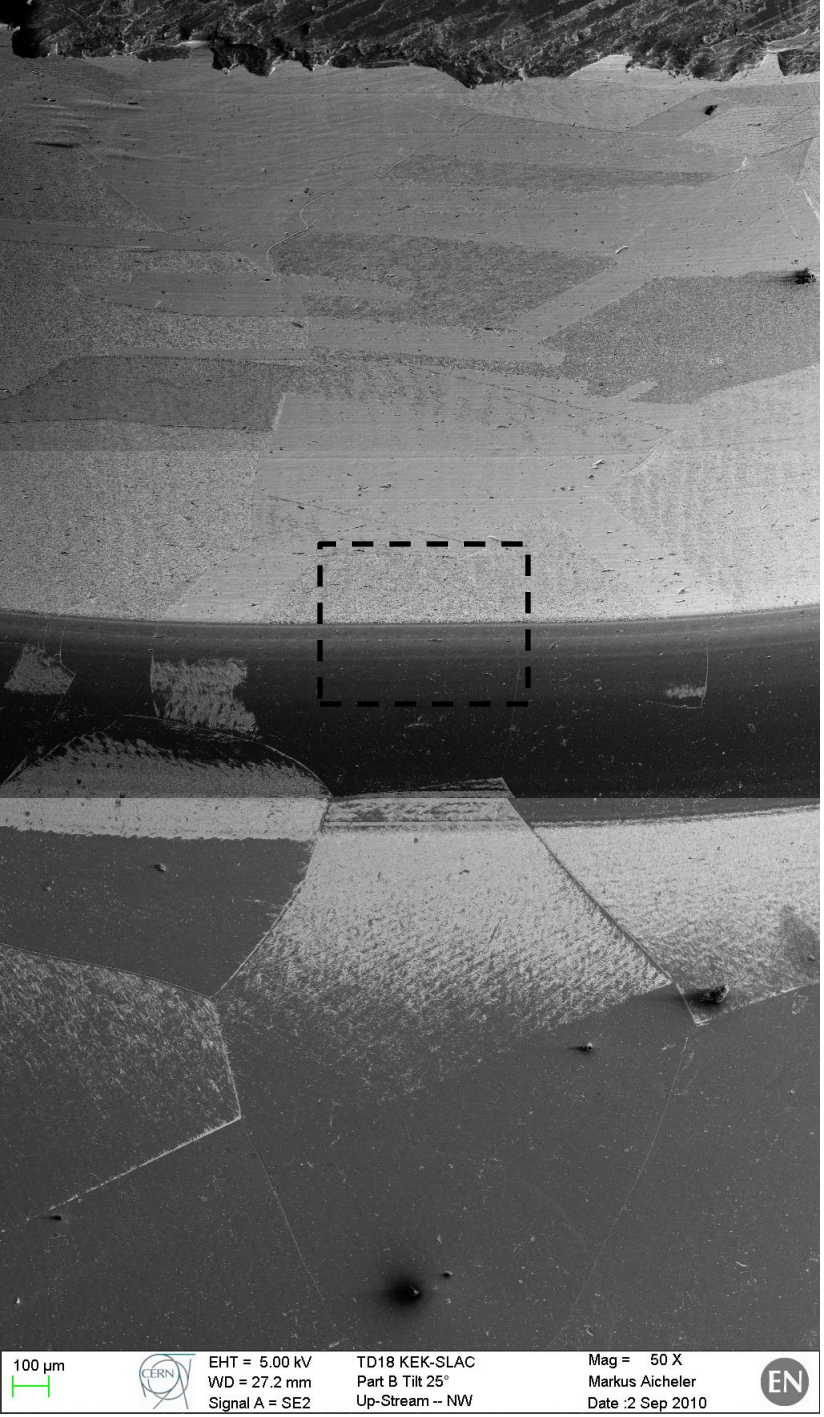

20 µm
EHT = 5
WD = 29
Signal A
20 µm
EHT = 5.00 kV
WD = 29.4 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Up-Stream -- Iris N
Mag = 200 X
Markus Aicheler
Date :8 Sep 2010
EN

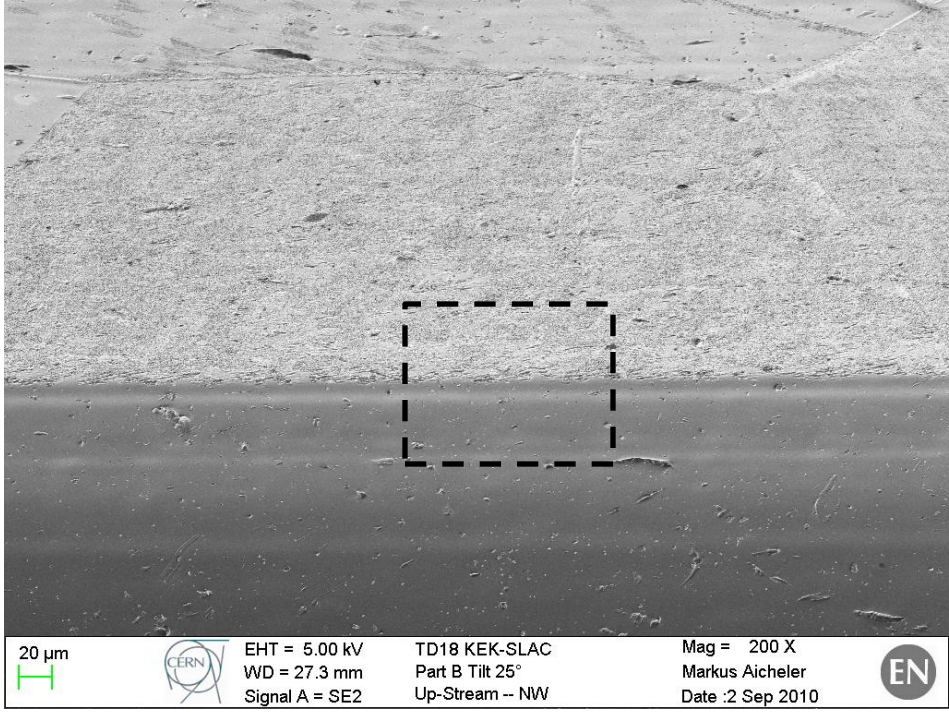

5.00 kV
29.0 mm
A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Up-Stream -- Iris N
Mag = 1.00 K X
Markus Aicheler
Date :8 Sep 2010
EN
1 µm
EHT = 5.00 kV
WD = 29.0 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Up-Stream -- Iris N
Mag = 5.00 K X
Markus Aicheler
Date :8 Sep 2010
EN

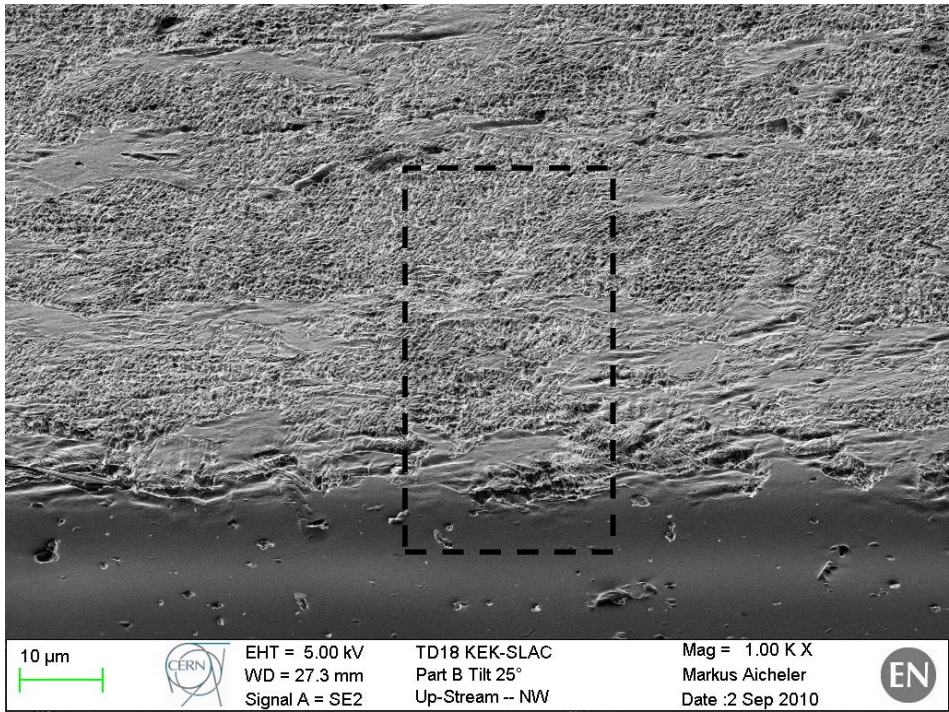
Part B

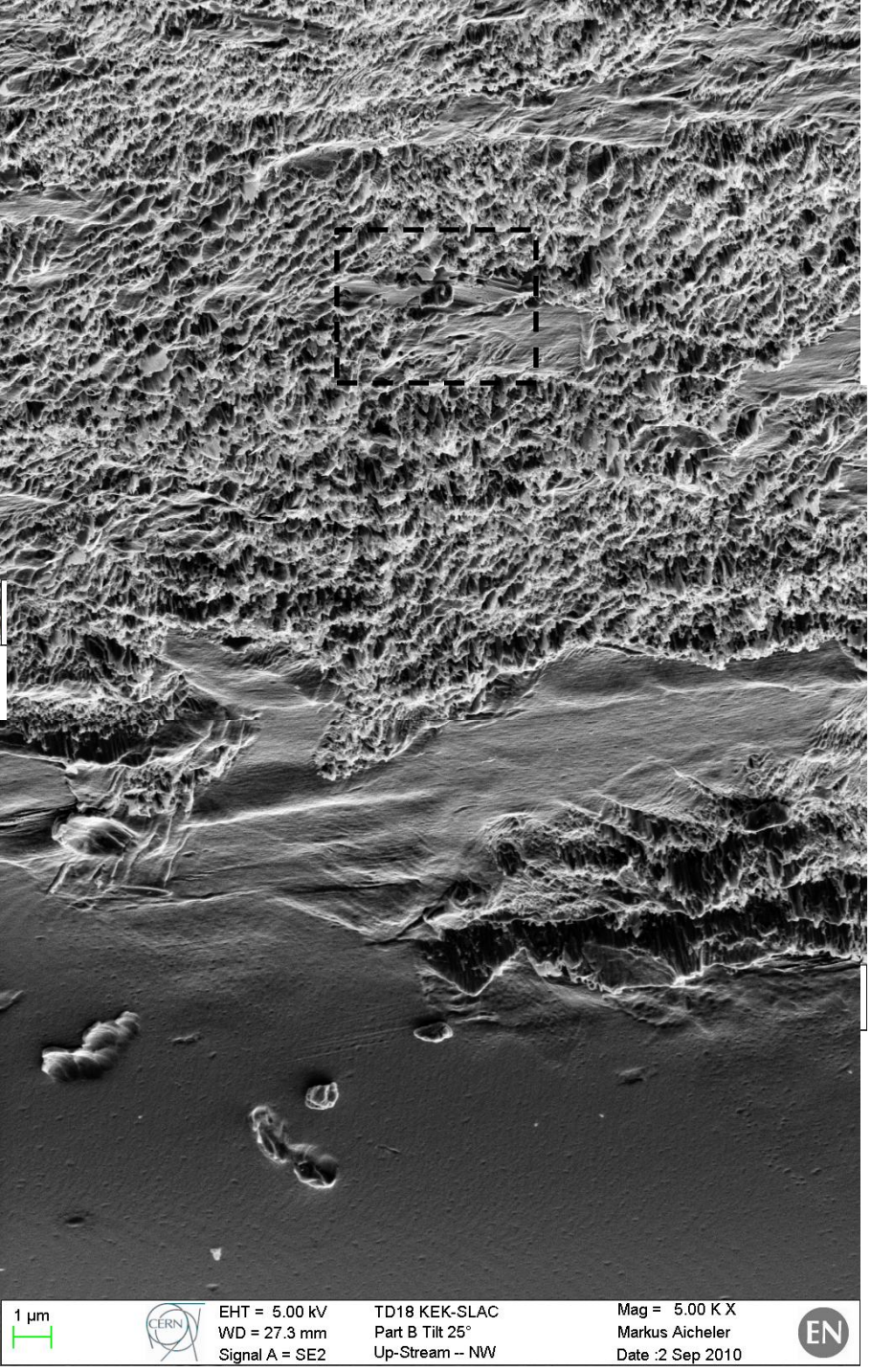
Up-stream side - Cell Wall north-west!

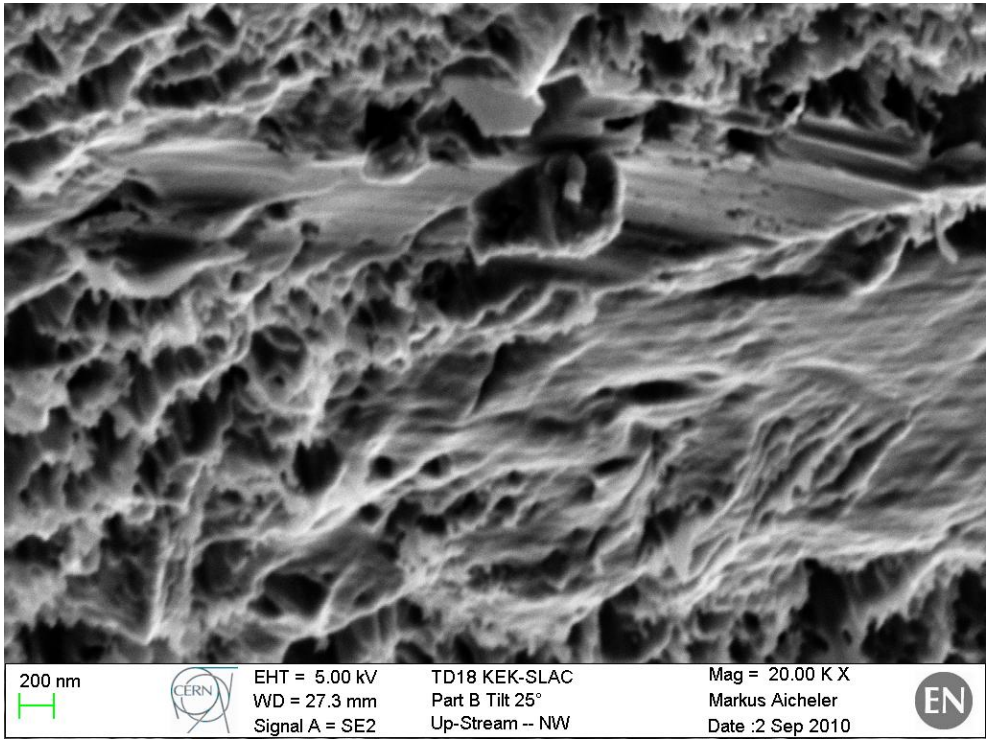

1 mm
CERN
EHT = 5.00 kV
WD = 25.9 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 14 X
Markus Aicheler
Date :2 Sep 2010
EN

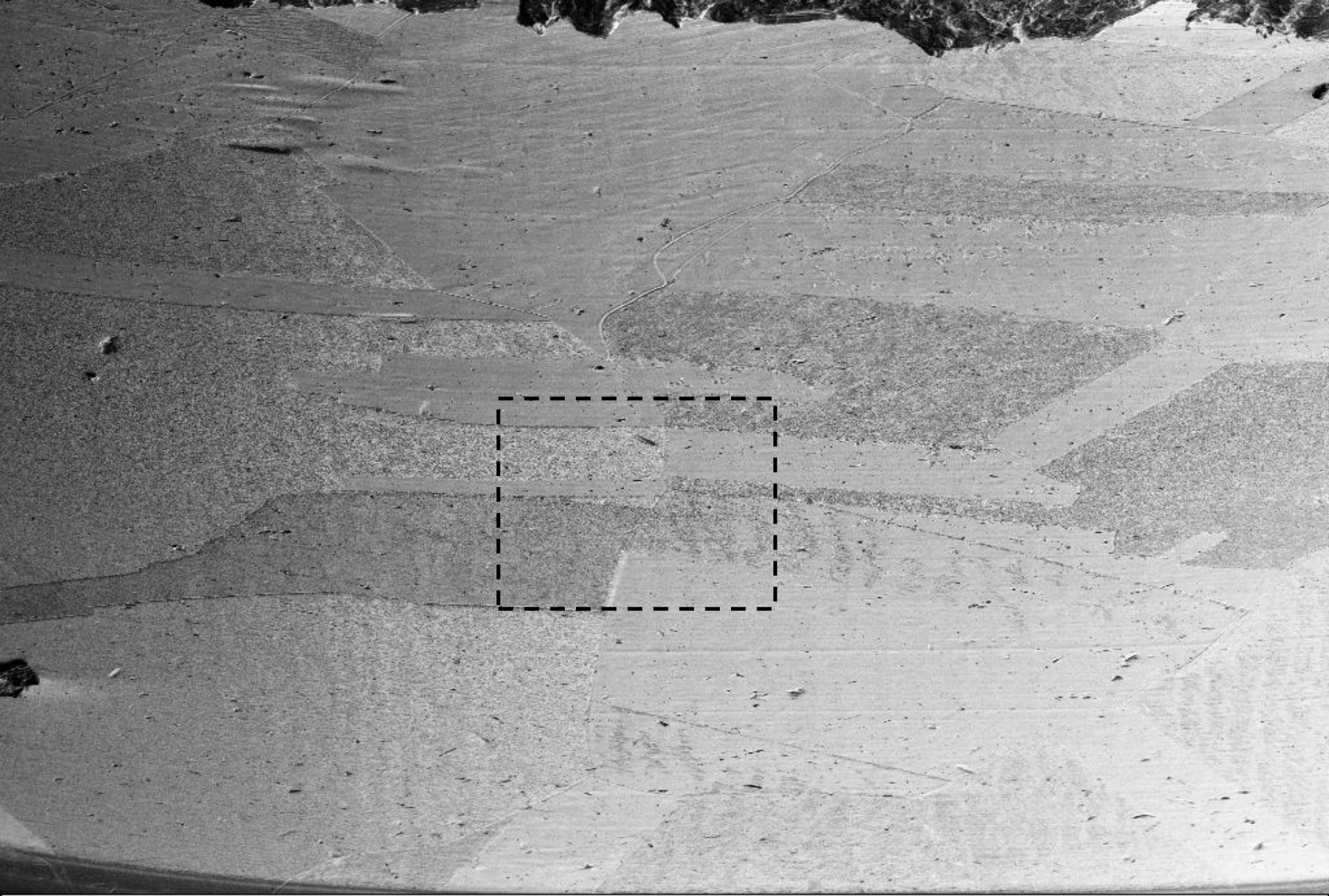

100 µm
EHT = 5.00 kV
WD = 27.2 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 50 X
Markus Aicheler
Date :2 Sep 2010
EN

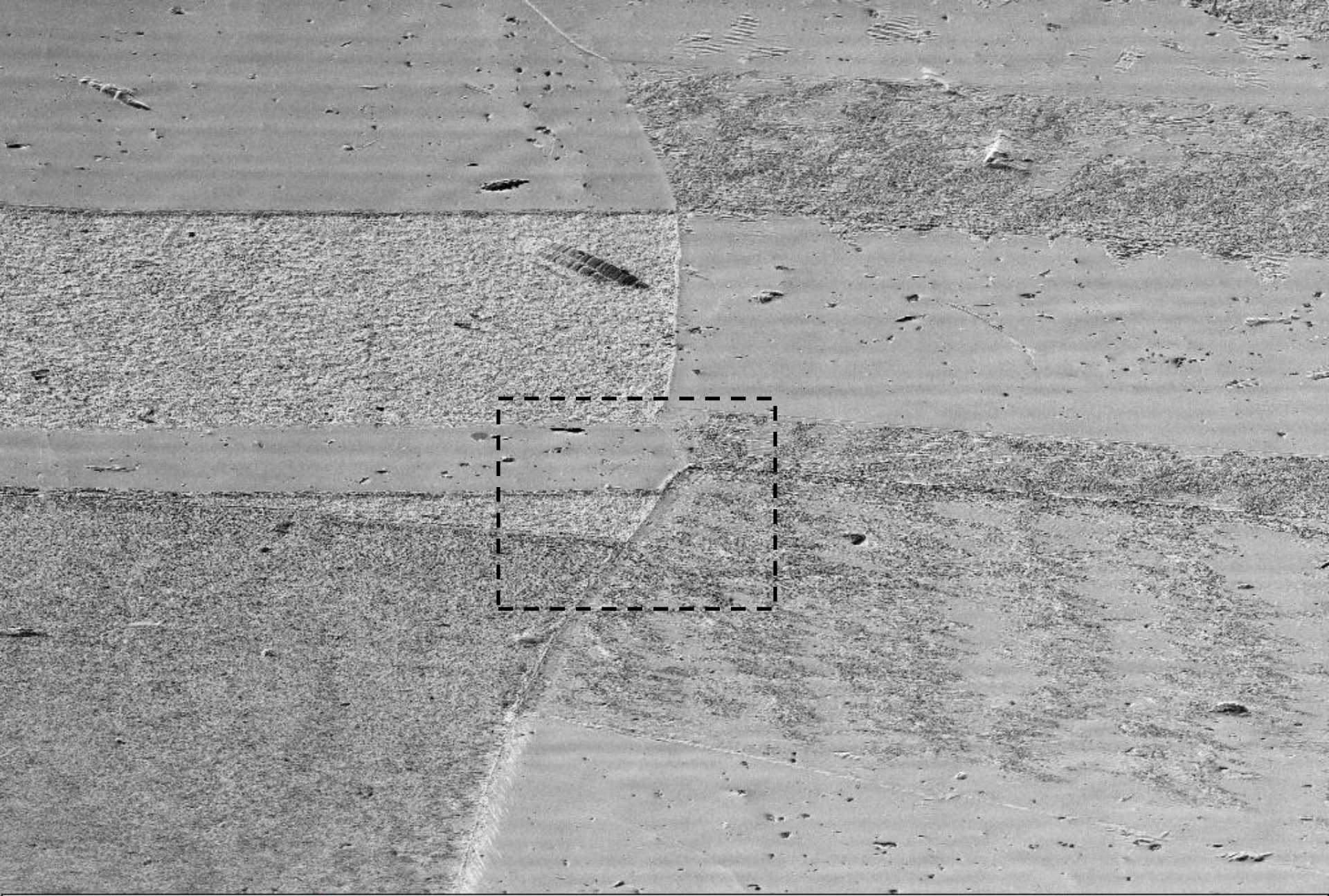

20 µm
EHT = 5.00 kV
WD = 27.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 200 X
Markus Aicheler
Date :2 Sep 2010
EN

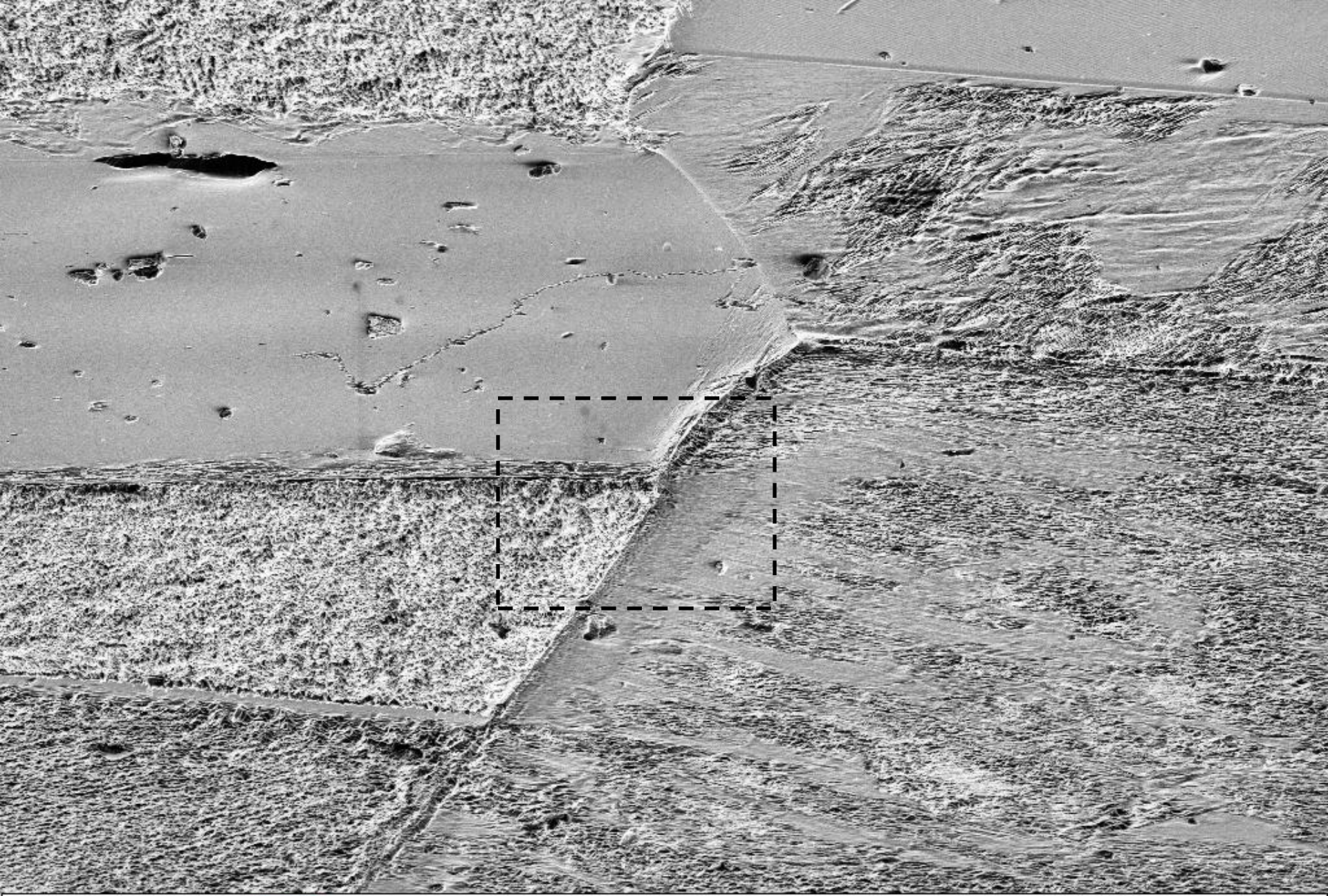

10 µm
EHT = 5.00 kV
WD = 27.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 1.00 K X
Markus Aicheler
Date :2 Sep 2010
EN

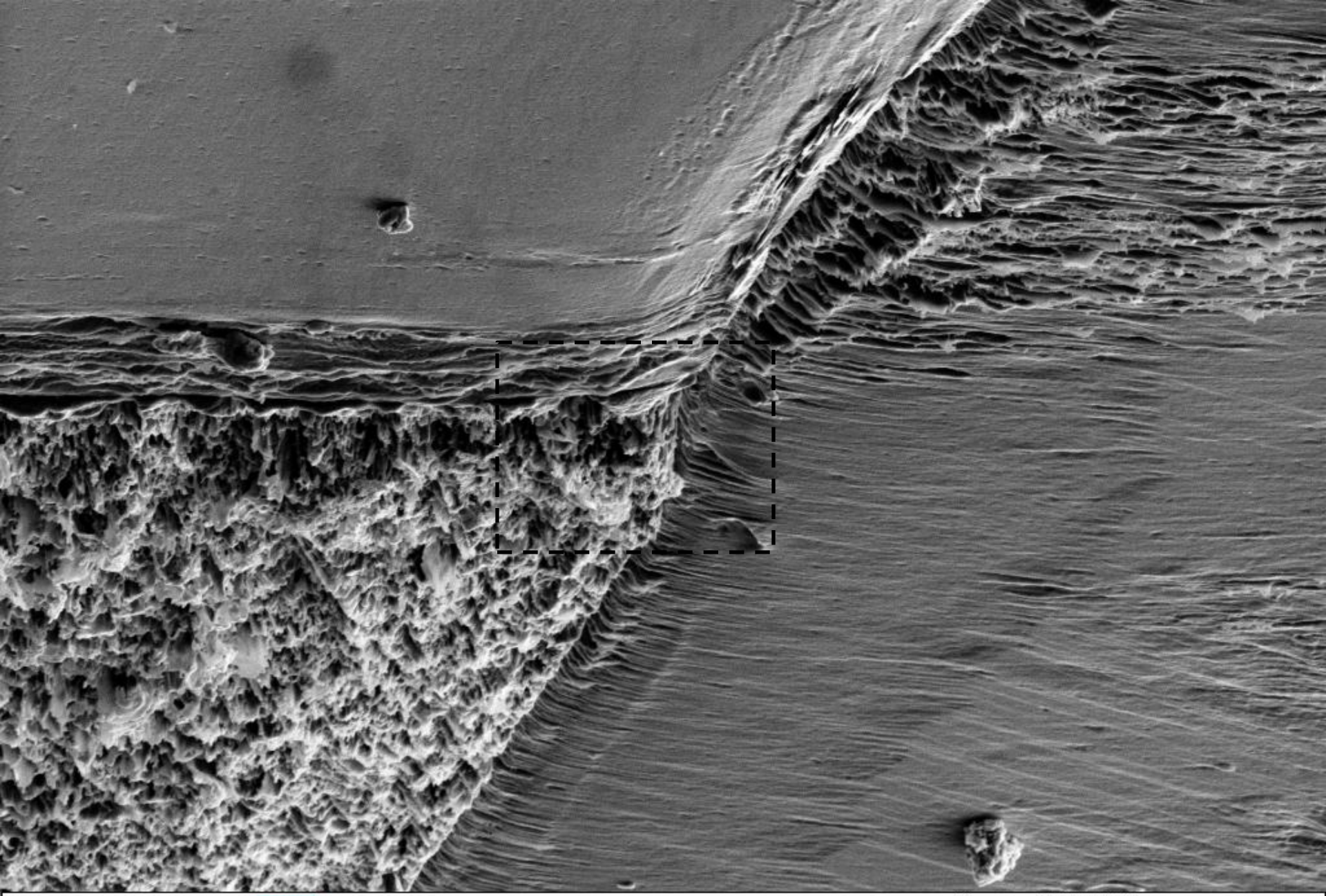

1 µm
EHT = 5.00 kV
WD = 27.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 5.00 K X
Markus Aicheler
Date :2 Sep 2010
EN

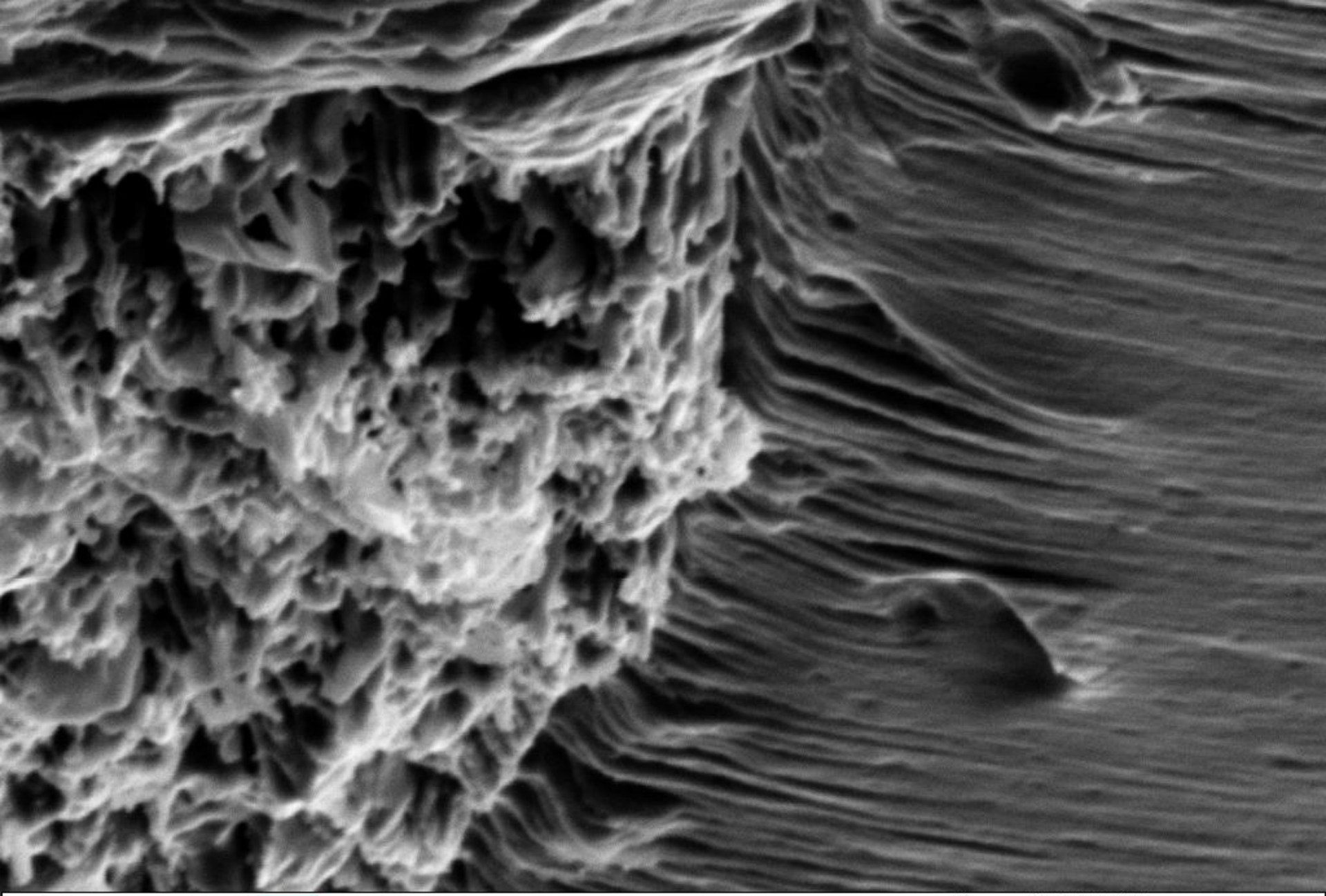

200 nm
EHT = 5.00 kV
WD = 27.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 20.00 K X
Markus Aicheler
Date :2 Sep 2010
EN


100 µm
CERN
EHT = 5.00 kV
WD = 25.6 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 50 X
Markus Aicheler
Date :2 Sep 2010
EN


20 µm
CERN
EHT = 5.00 kV
WD = 25.6 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 200 X
Markus Aicheler
Date :2 Sep 2010
EN

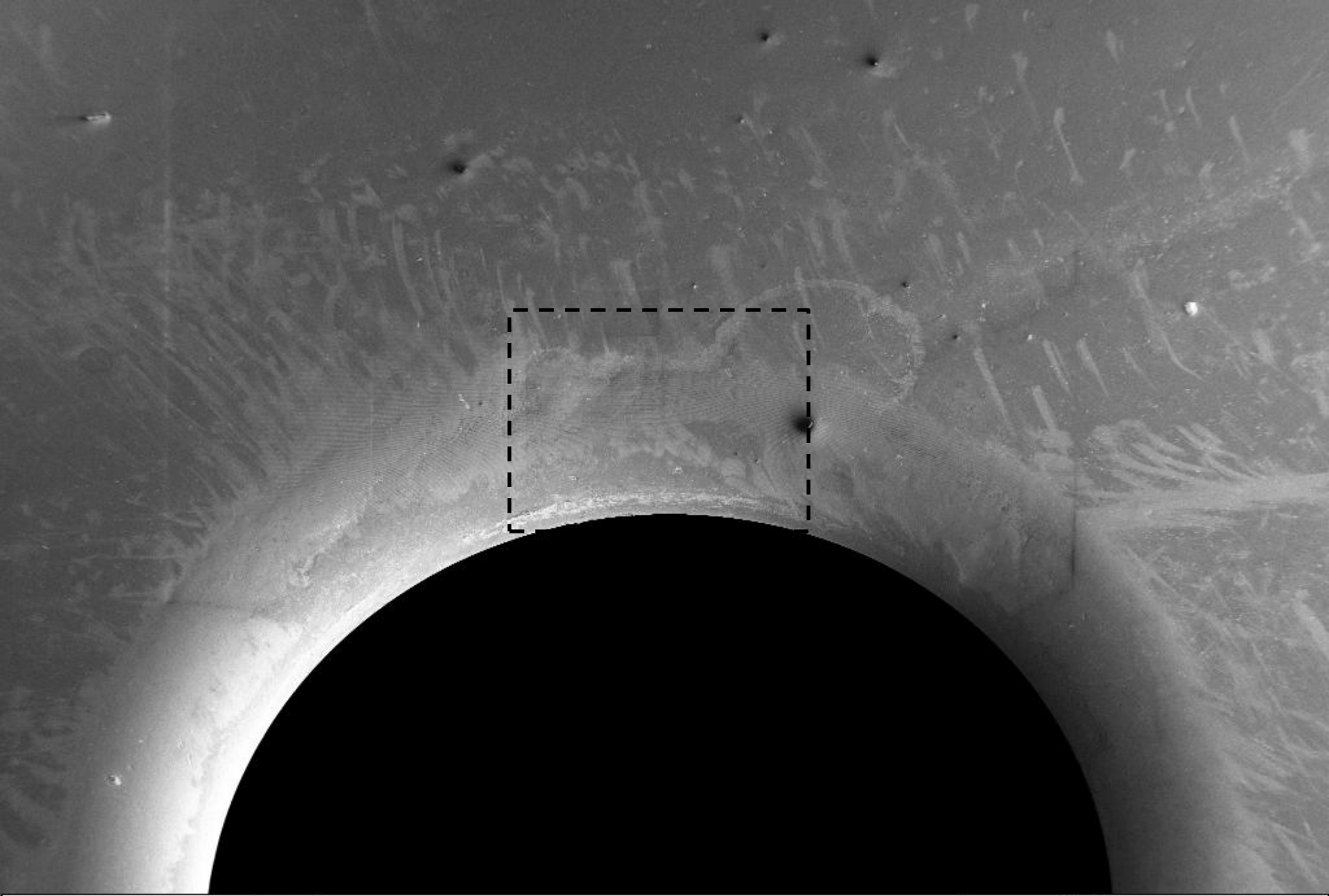

10 µm
CERN
EHT = 5.00 kV
WD = 25.6 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 1.00 K X
Markus Aicheler
Date :2 Sep 2010
EN

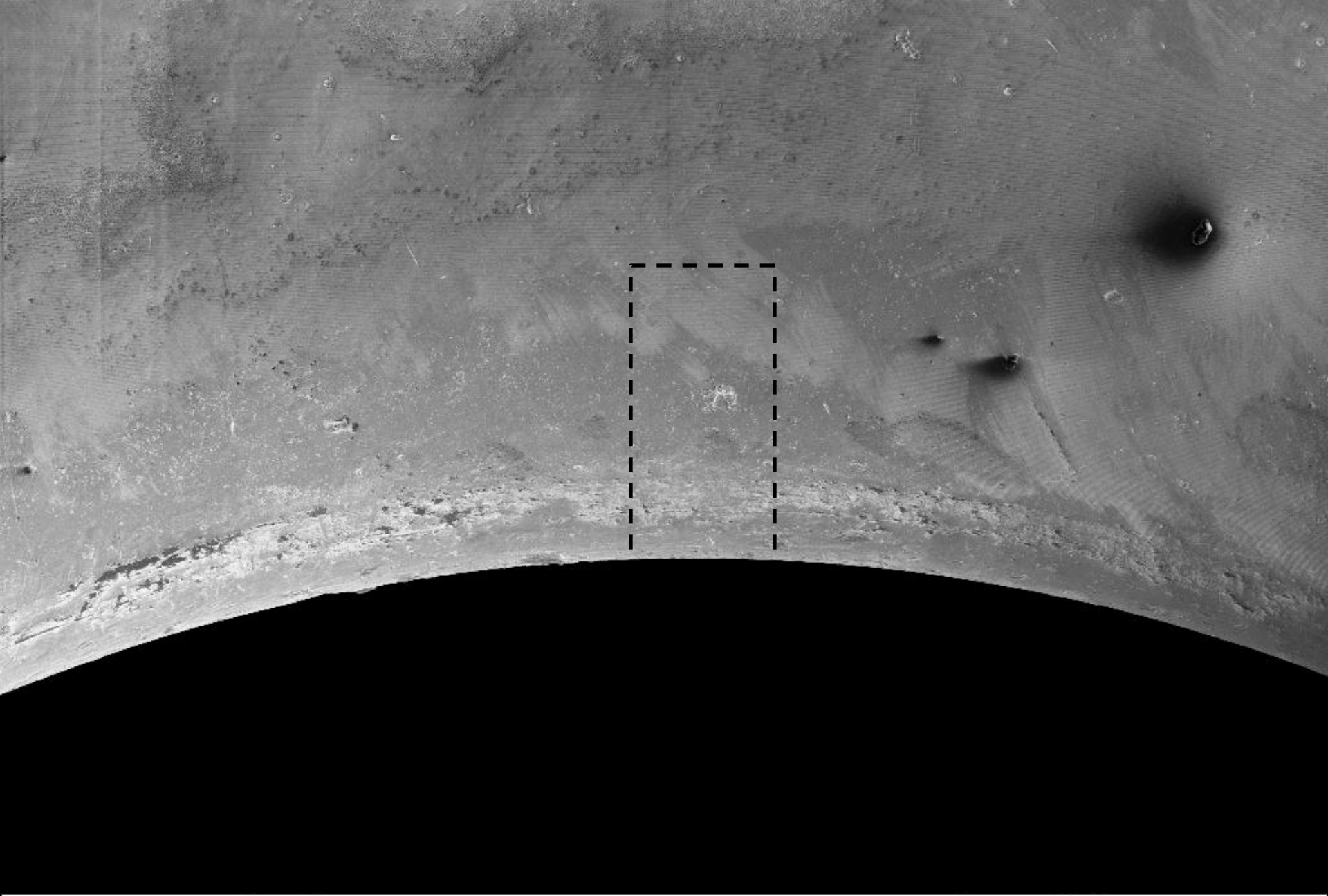

1 µm
CERN
EHT = 5.00 kV
WD = 25.6 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 5.00 K X
Markus Aicheler
Date :2 Sep 2010
EN

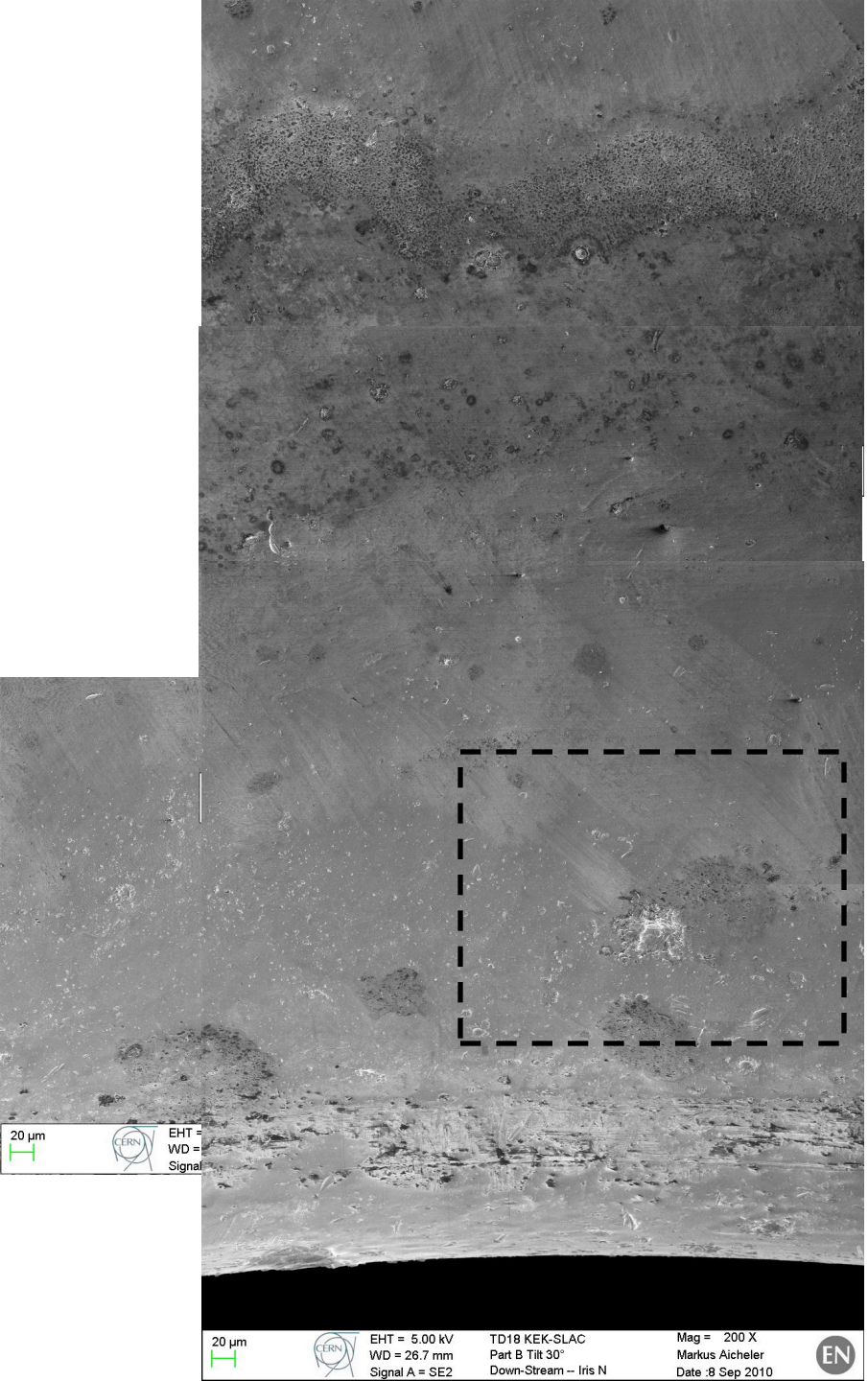

200 nm
CERN
EHT = 5.00 kV
WD = 25.6 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 25°
Up-Stream -- NW
Mag = 20.00 K X
Markus Aicheler
Date :2 Sep 2010
EN

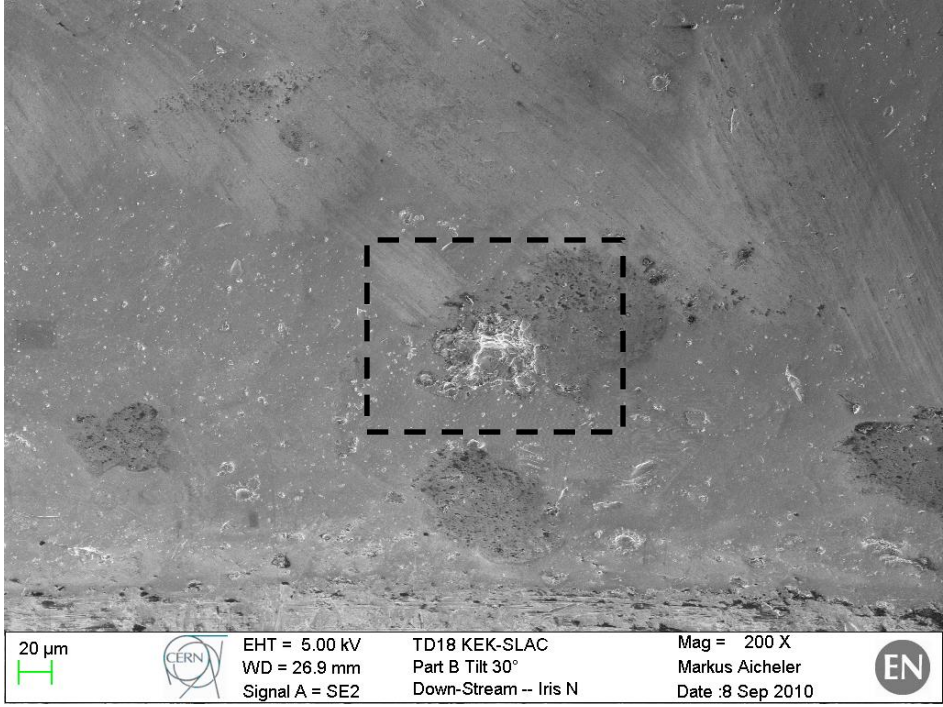
Part B

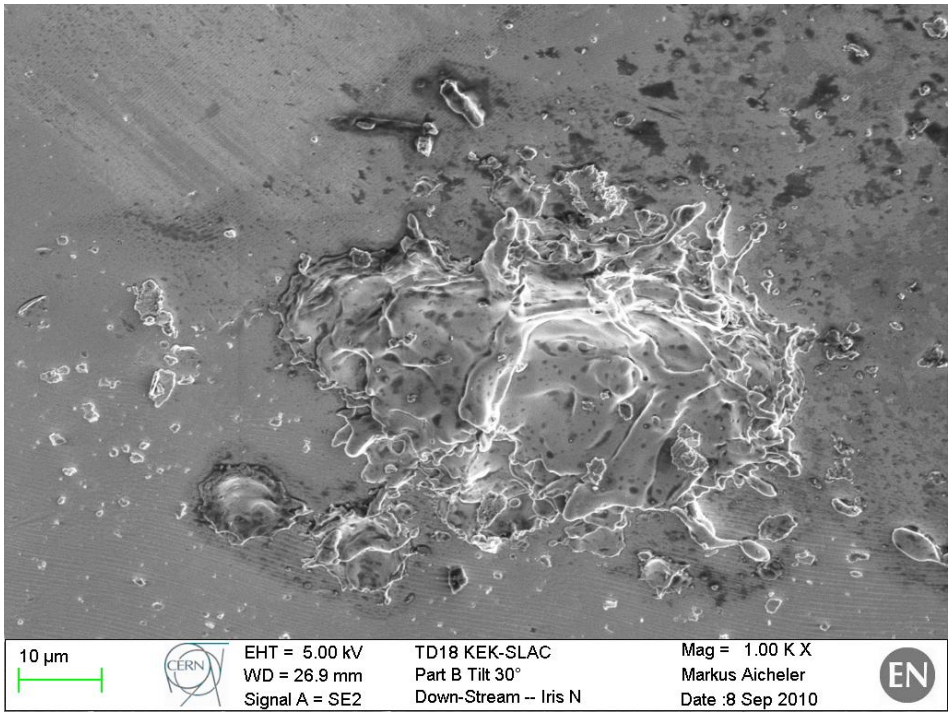
Down-stream side - Iris north!


1 mm
CERN
EHT = 5.00 kV
WD = 26.7 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 14 X
Markus Aicheler
Date :8 Sep 2010
EN


100 µm
CERN
EHT = 5.00 kV
WD = 26.7 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 50 X
Markus Aicheler
Date :8 Sep 2010
EN

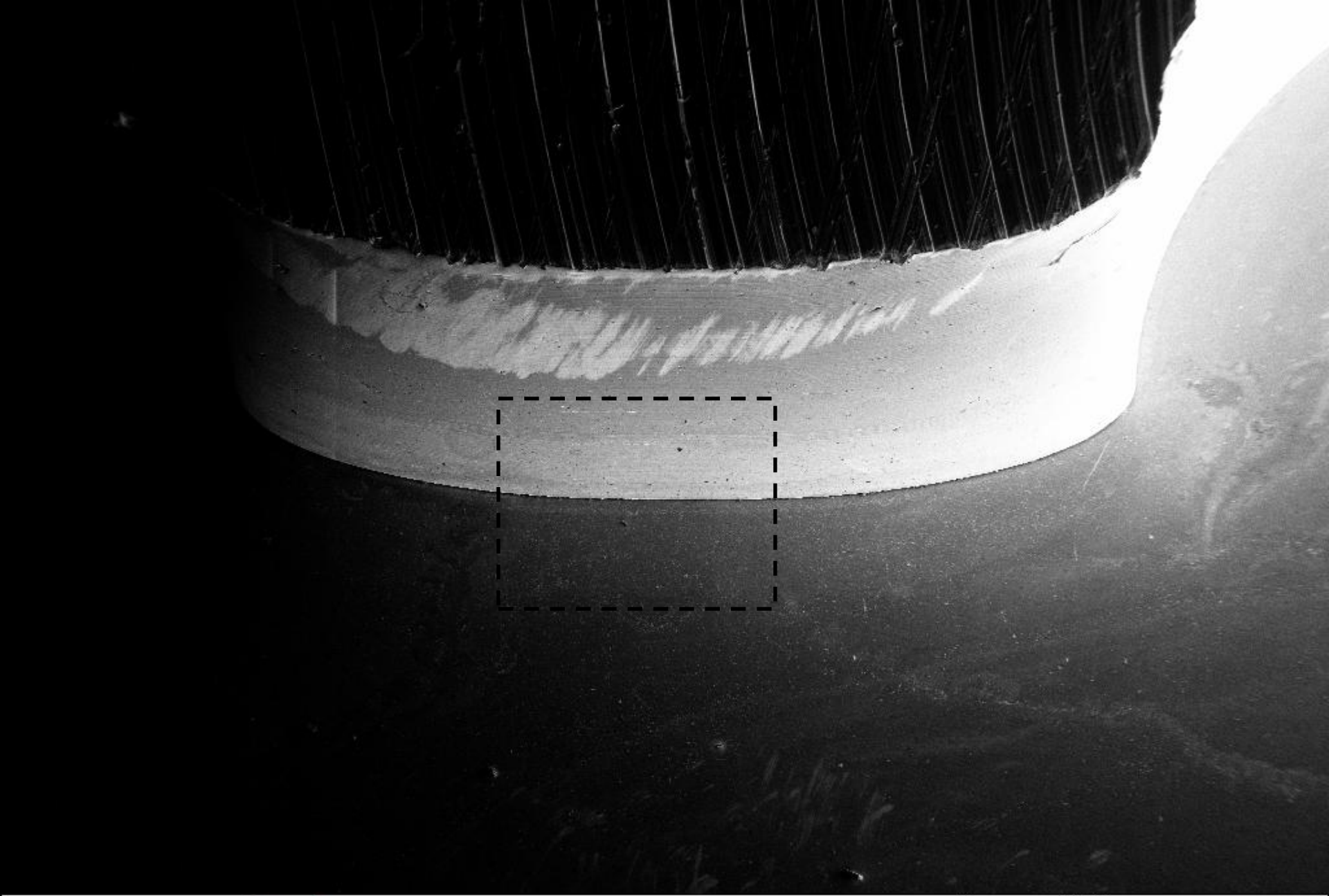

20 µm
EHT =
WD =
Signal
20 µm
EHT = 5.00 kV
WD = 26.7 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 200 X
Markus Aicheler
Date :8 Sep 2010
EN

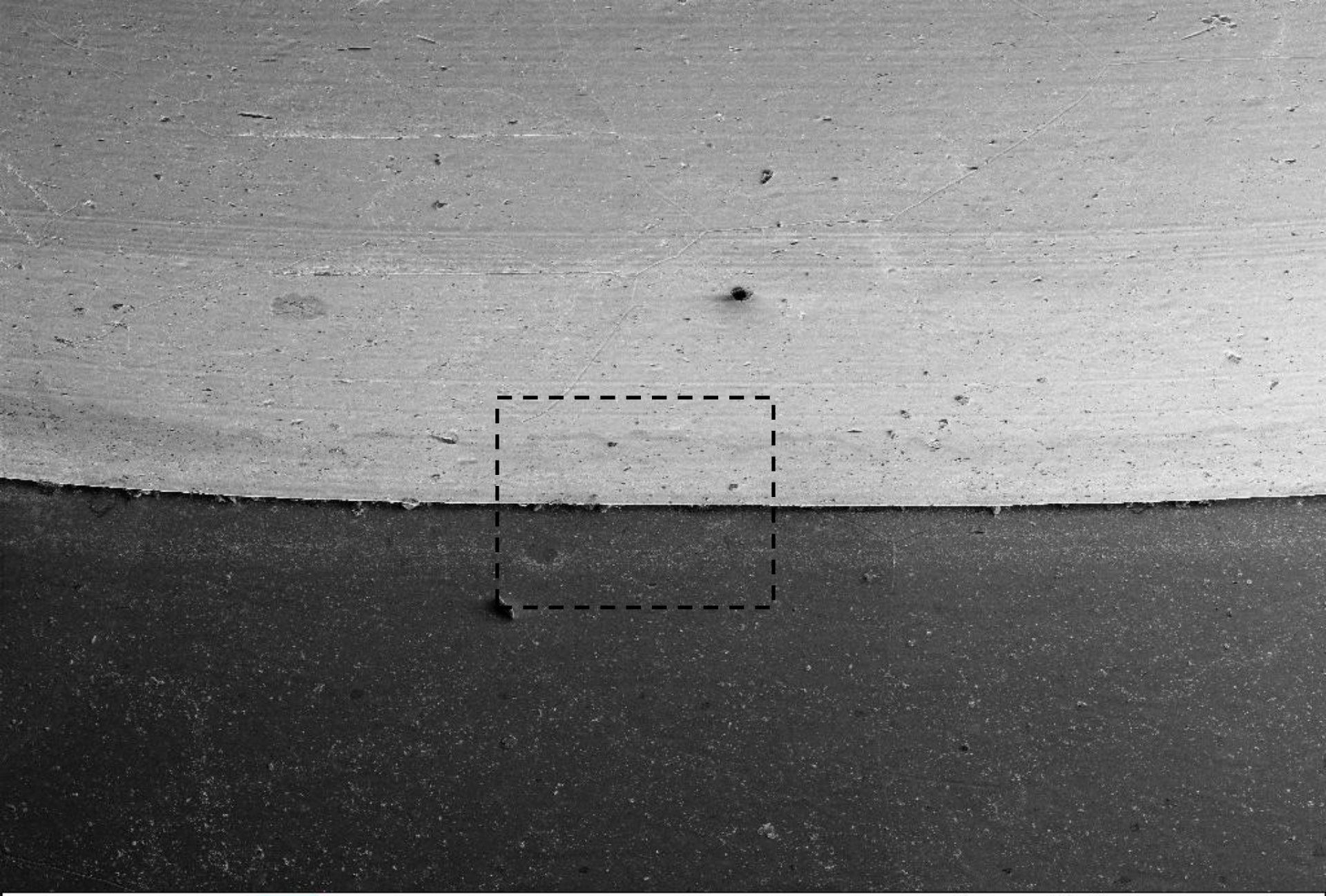

20 µm
EHT = 5.00 kV
WD = 26.9 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 200 X
Markus Aicheler
Date :8 Sep 2010
EN

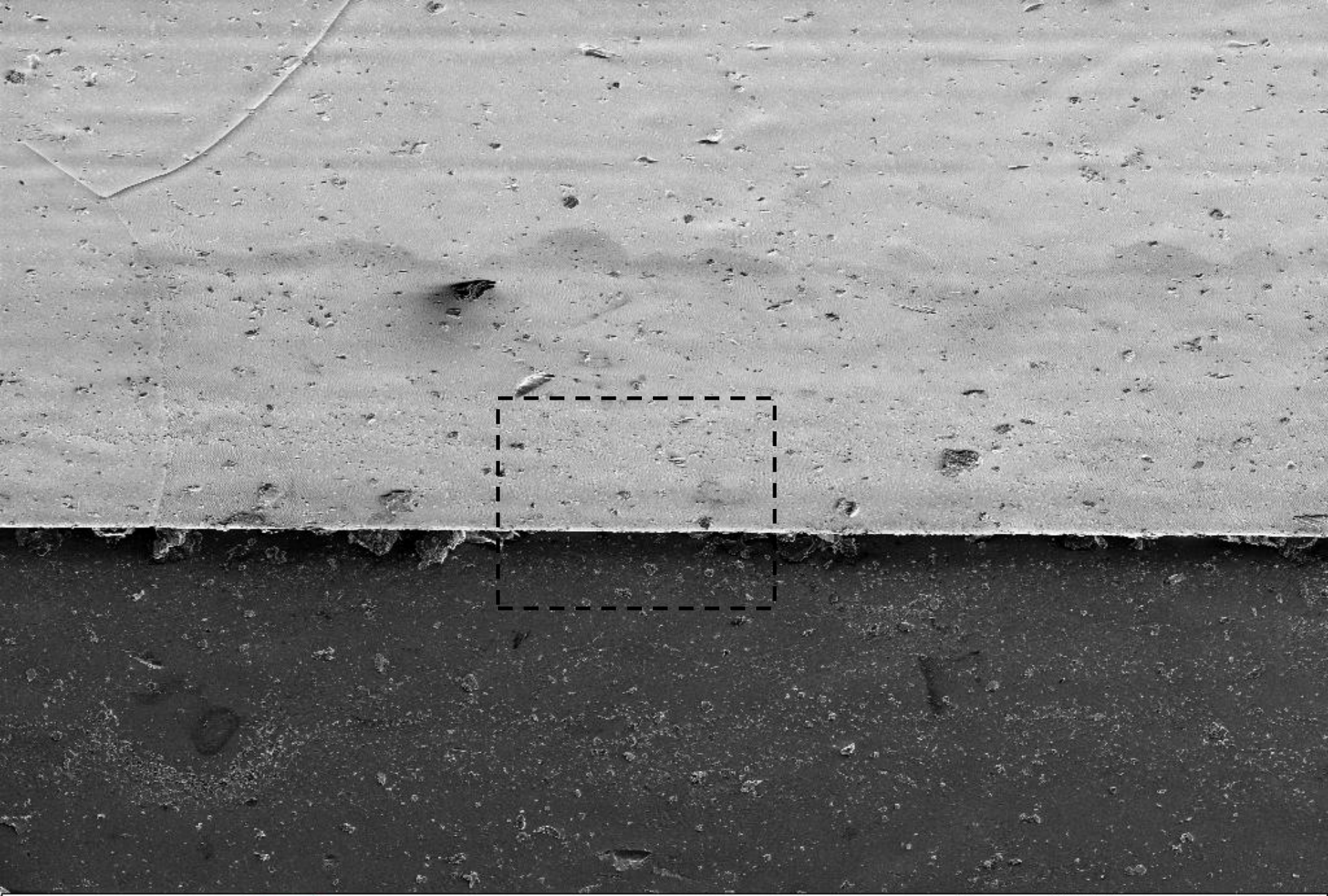

10 µm
EHT = 5.00 kV
WD = 26.9 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 1.00 K X
Markus Aicheler
Date :8 Sep 2010
EN

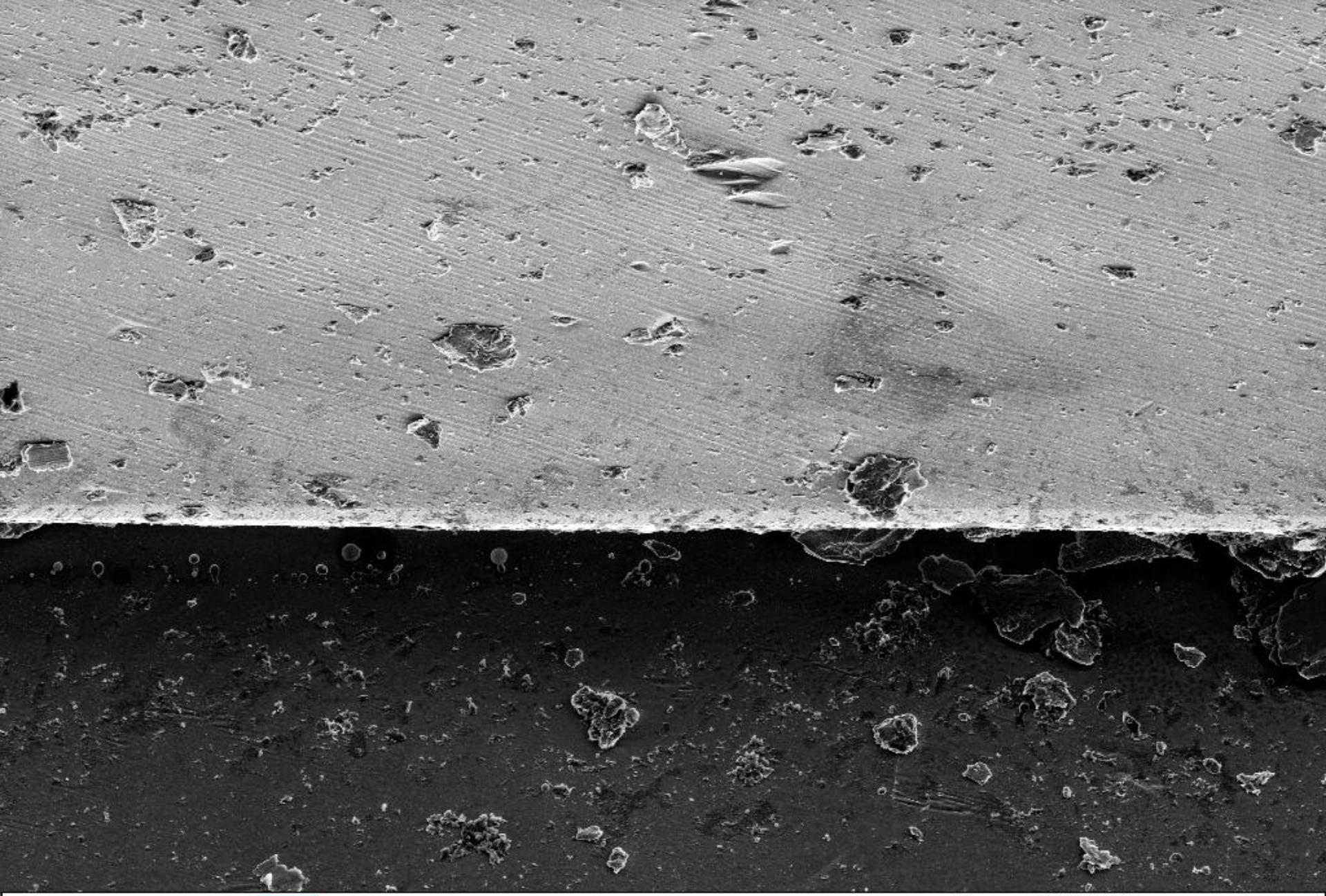
Part B

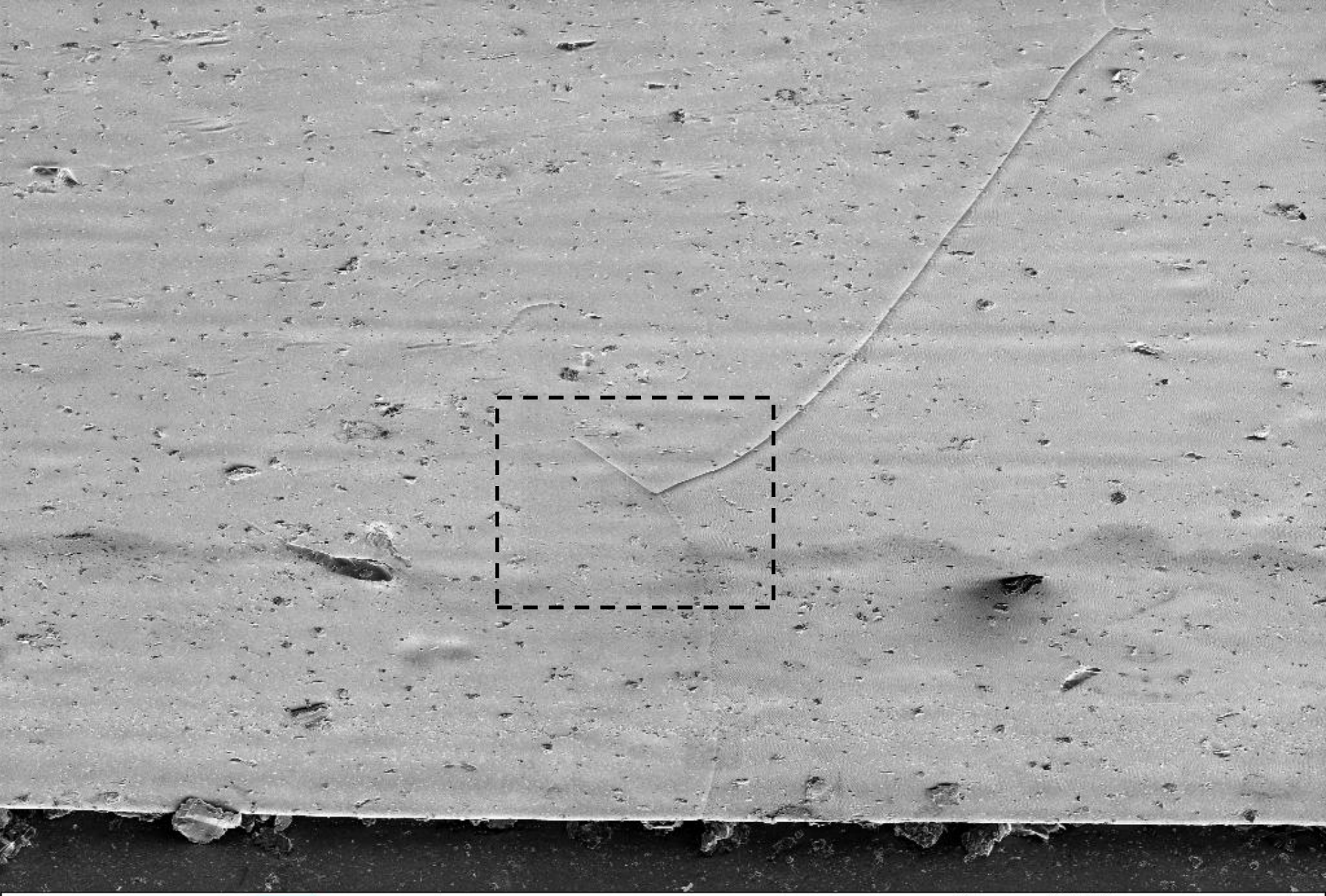
Down-stream side – Cell Wall north-west!

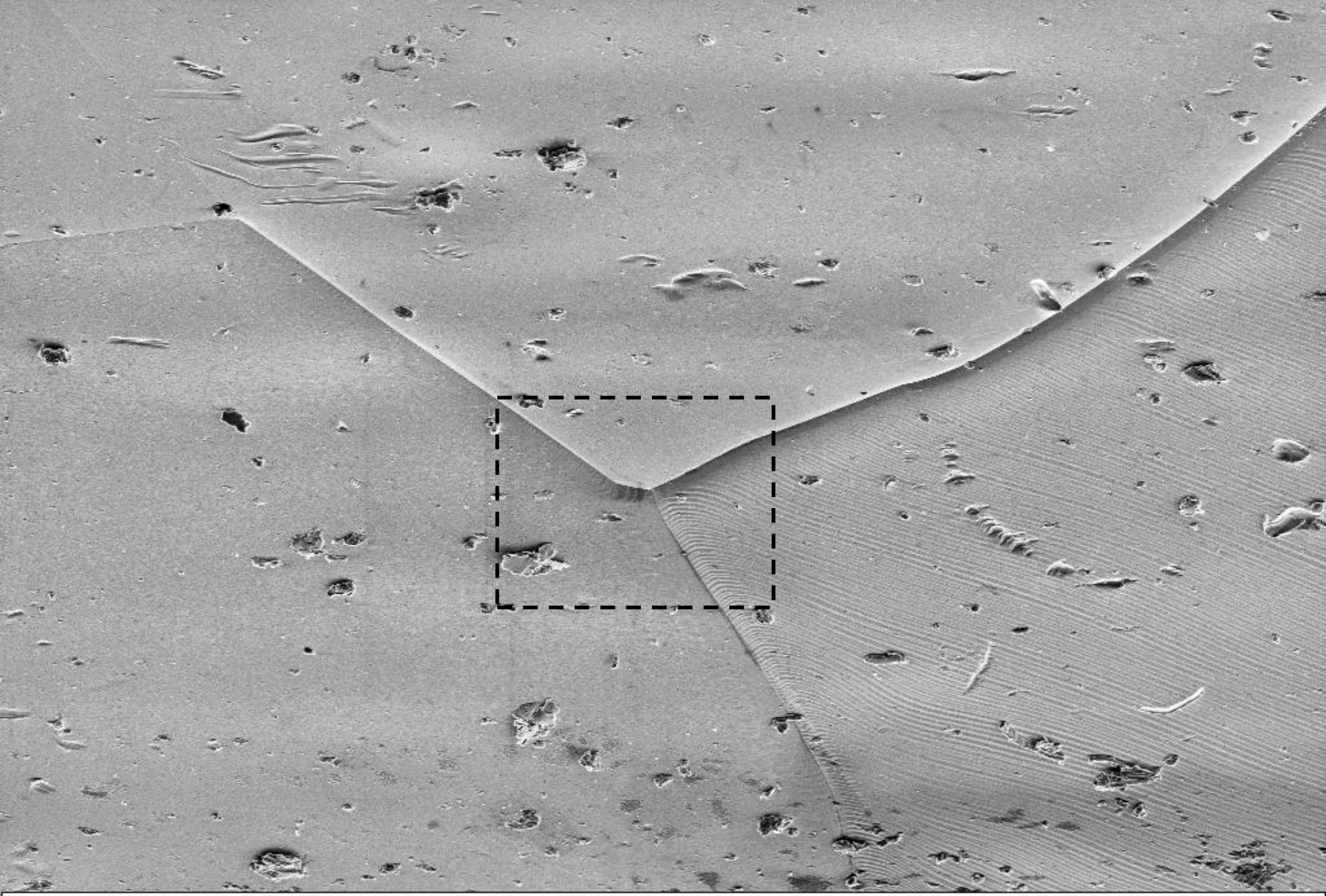

1 mm
CERN
EHT = 5.00 kV
WD = 30.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Wall NW
Mag = 12 X
Markus Aicheler
Date :8 Sep 2010
EN

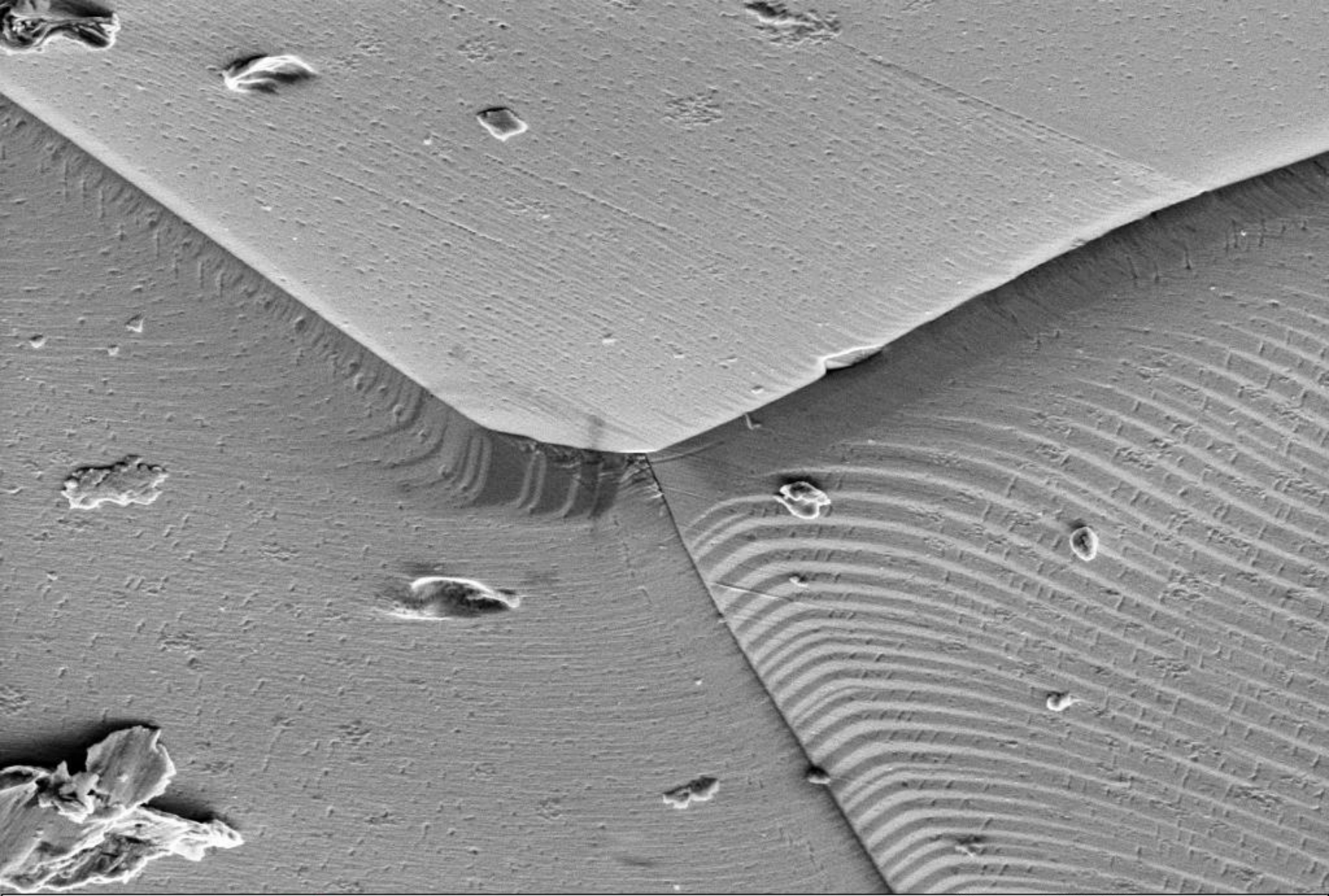

100 µm
CERN
EHT = 5.00 kV
WD = 30.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Wall NW
Mag = 50 X
Markus Aicheler
Date :8 Sep 2010
EN


20 µm
CERN
EHT = 5.00 kV
WD = 30.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Wall NW
Mag = 200 X
Markus Aicheler
Date :8 Sep 2010
EN


10 µm
CERN
EHT = 5.00 kV
WD = 30.3 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Wall NW
Mag = 1.00 K X
Markus Aicheler
Date :8 Sep 2010
EN


20 µm
CERN
EHT = 5.00 kV
WD = 30.1 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Wall NW
Mag = 200 X
Markus Aicheler
Date :8 Sep 2010
EN


10 µm
CERN
EHT = 5.00 kV
WD = 30.1 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Wall NW
Mag = 1.00 K X
Markus Aicheler
Date :8 Sep 2010
EN


1 µm
CERN
EHT = 5.00 kV
WD = 30.1 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Wall NW
Mag = 5.00 K X
Markus Aicheler
Date :8 Sep 2010
EN

Strategy of the presentation:

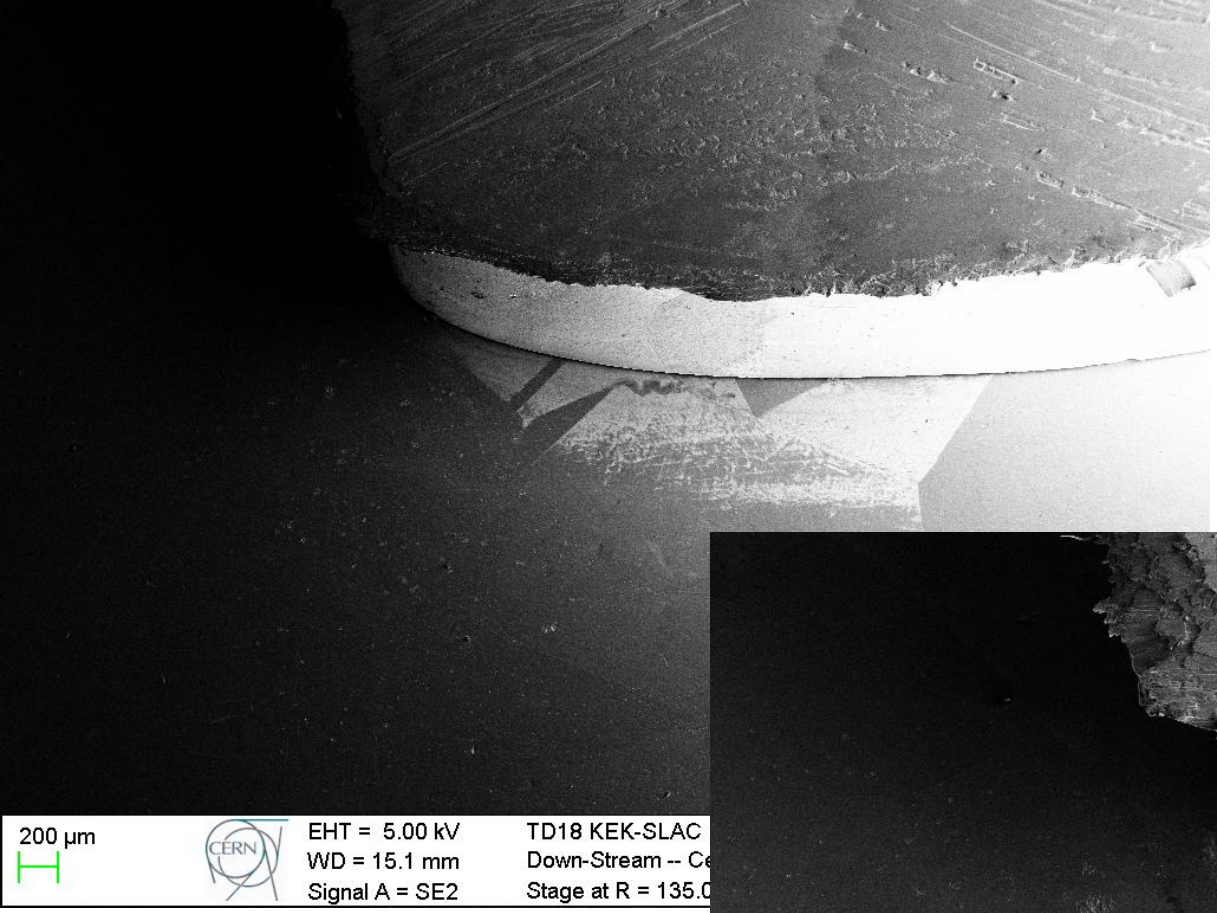
Part 1: Introduction and a little microscopic walk through “part B”

Part 2: An unexpected finding

Part 3: Current observation method and next steps

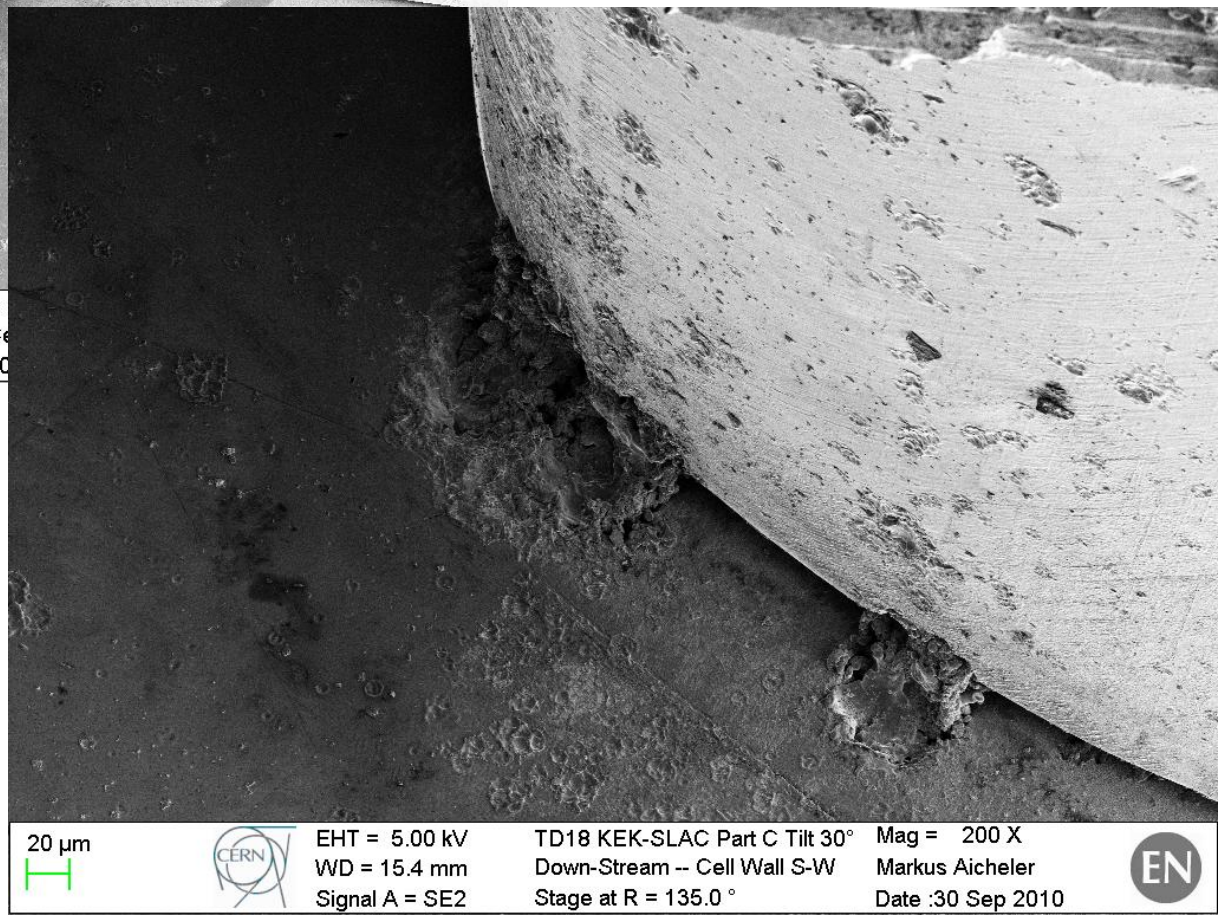
The unexpected finding:

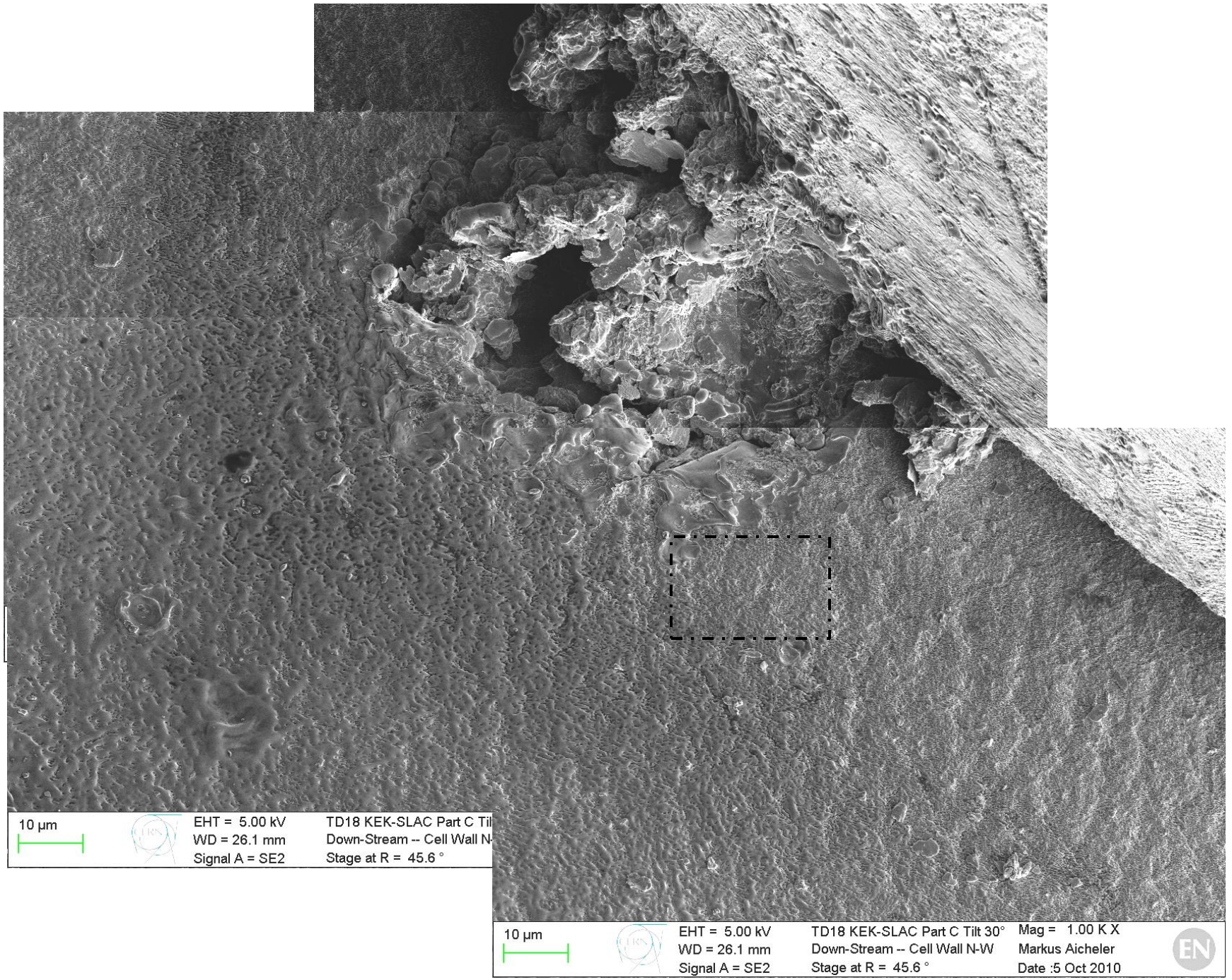
What is that? And why are there breakdowns?

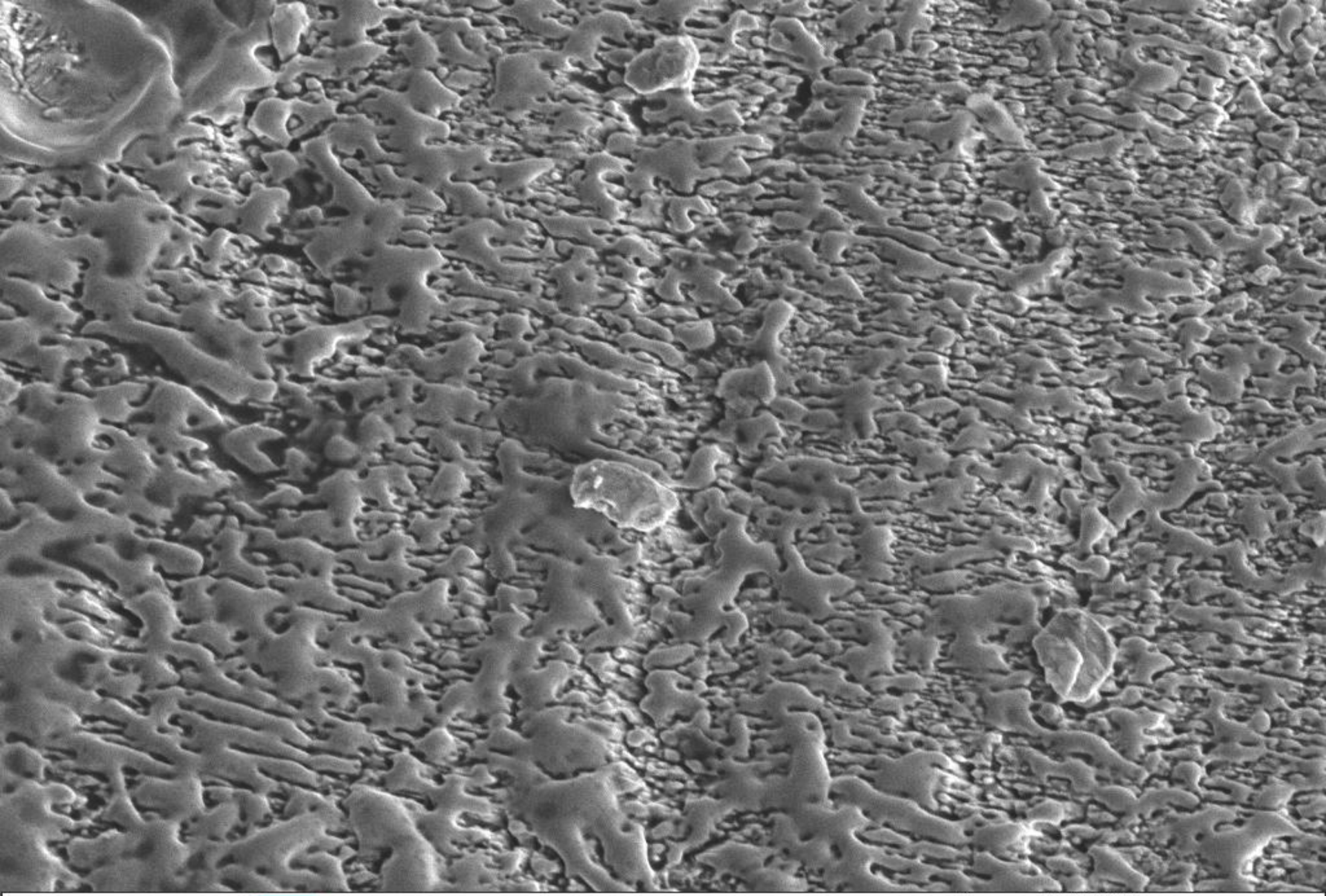


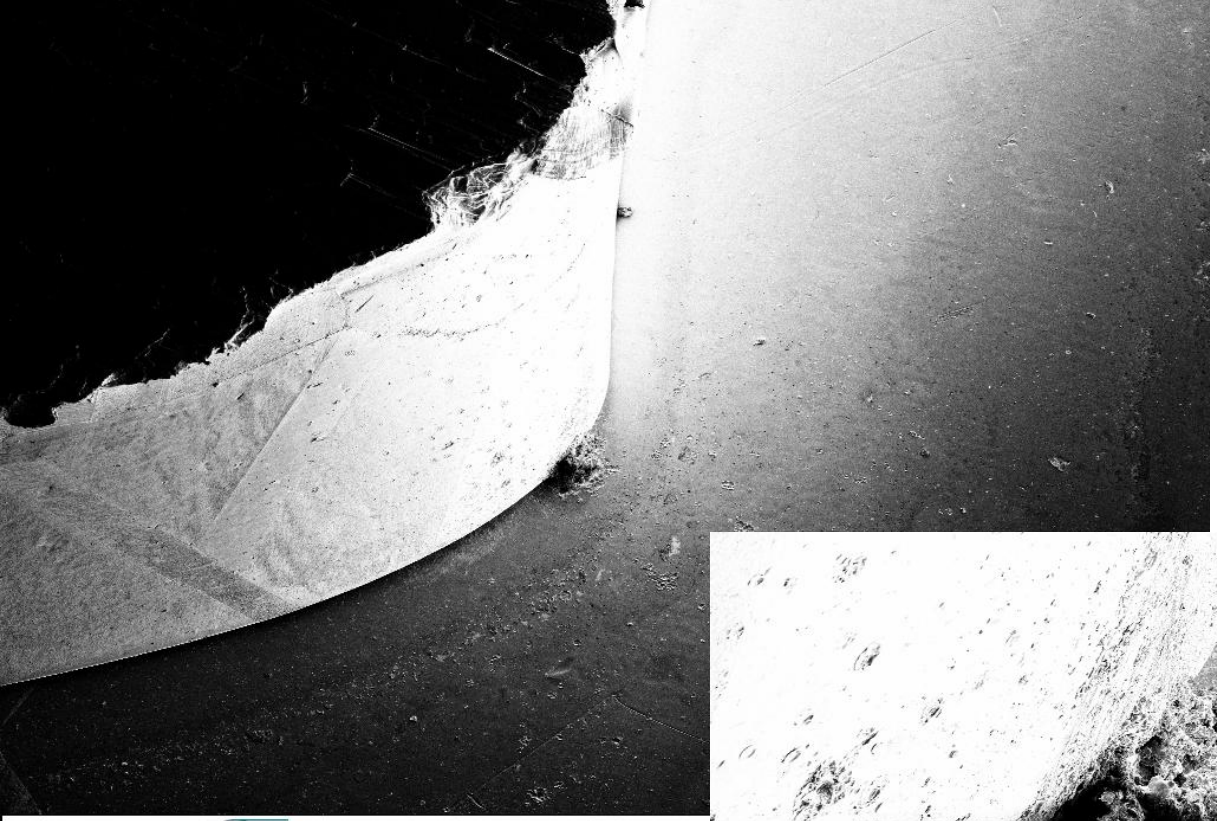
Part C
Down-stream side – Cell Wall S-W!
Tilt 30°


100 µm
EHT = 5.00 kV
WD = 15.4 mm
Signal A = SE2
TD18 KEK-SLAC
Down-Stream -- Ce
Stage at R = 135.0


20 µm
EHT = 5.00 kV
WD = 15.4 mm
Signal A = SE2
TD18 KEK-SLAC Part C Tilt 30°
Down-Stream -- Cell Wall S-W
Stage at R = 135.0 °
Mag = 200 X
Markus Aicheler
Date :30 Sep 2010
EN


10 µm
EHT = 5.00 kV
WD = 26.1 mm
Signal A = SE2
TD18 KEK-SLAC Part C Til
Down-Stream -- Cell Wall N-
Stage at R = 45.6 °
10 µm
EHT = 5.00 kV
WD = 26.1 mm
Signal A = SE2
TD18 KEK-SLAC Part C Tilt 30°
Down-Stream -- Cell Wall N-W
Stage at R = 45.6 °
Mag = 1.00 K X
Markus Aicheler
Date :5 Oct 2010
EN

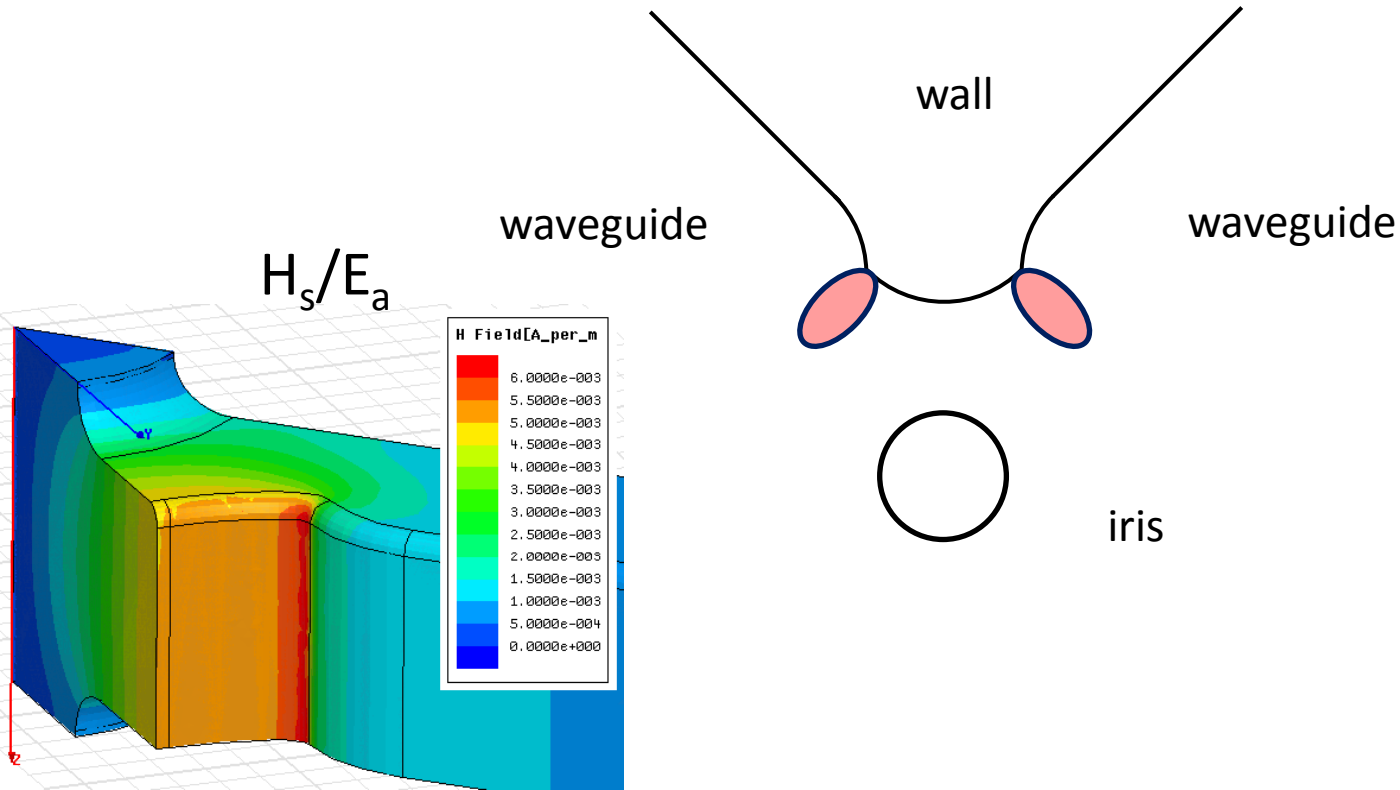

1 µm
EHT = 5.00 kV
WD = 26.0 mm
Signal A = SE2
TD18 KEK-SLAC Part C Tilt 30°
Down-Stream -- Cell Wall N-W
Stage at R = 45.6 °
Mag = 5.00 K X
Markus Aicheler
Date :5 Oct 2010
EN


100 µm
EHT = 5.00 kV
WD = 15.4 mm
Signal A = SE2
TD18 KEK-SLAC
Down-Stream -- Ce
Stage at R = 135.0

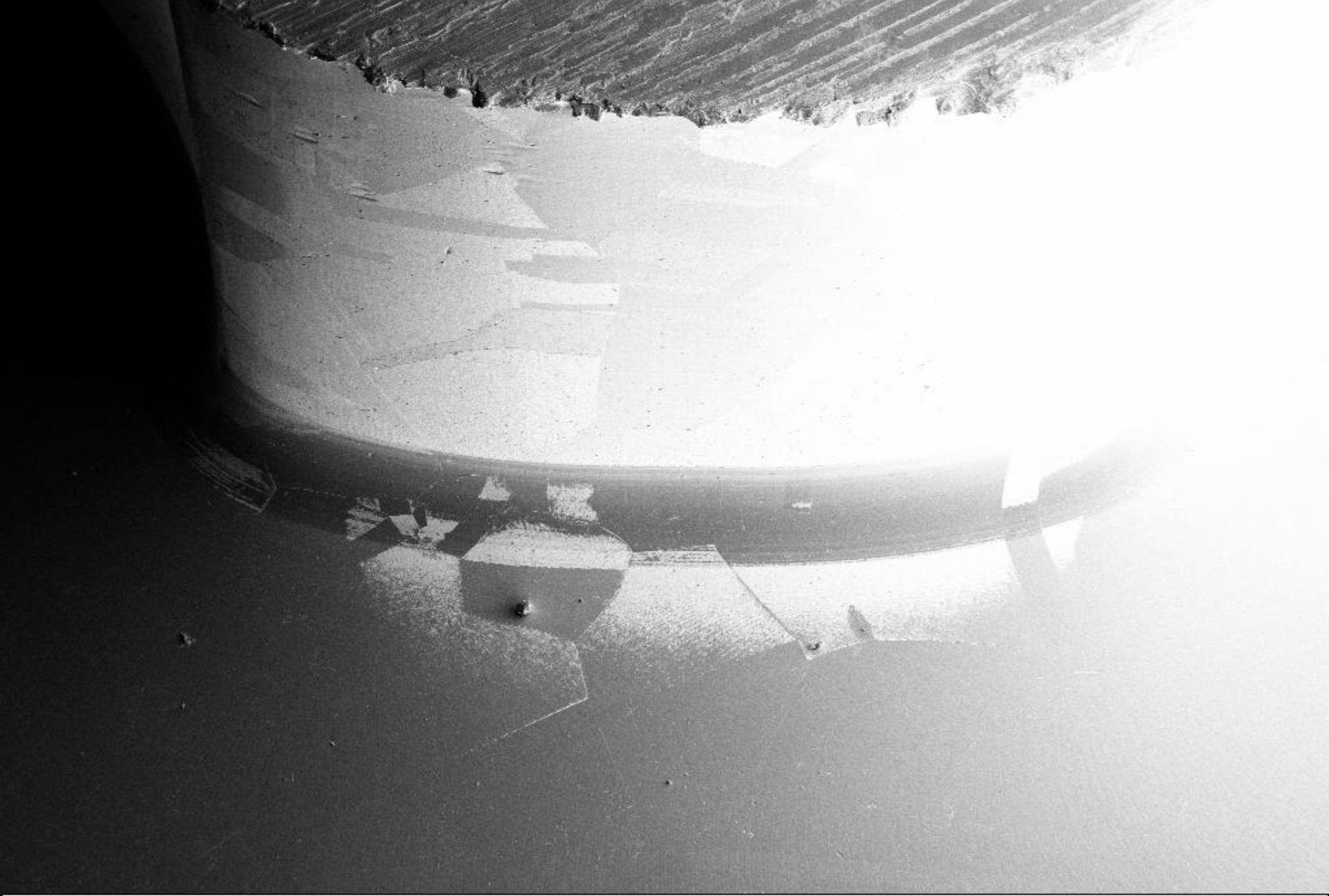

20 µm
EHT = 5.00 kV
WD = 15.4 mm
Signal A = SE2
TD18 KEK-SLAC Part C Tilt 30°
Down-Stream -- Cell Wall S-W
Stage at R = 135.0 °
Mag = 200 X
Markus Aicheler
Date :30 Sep 2010

Facts for part C down-stream side:

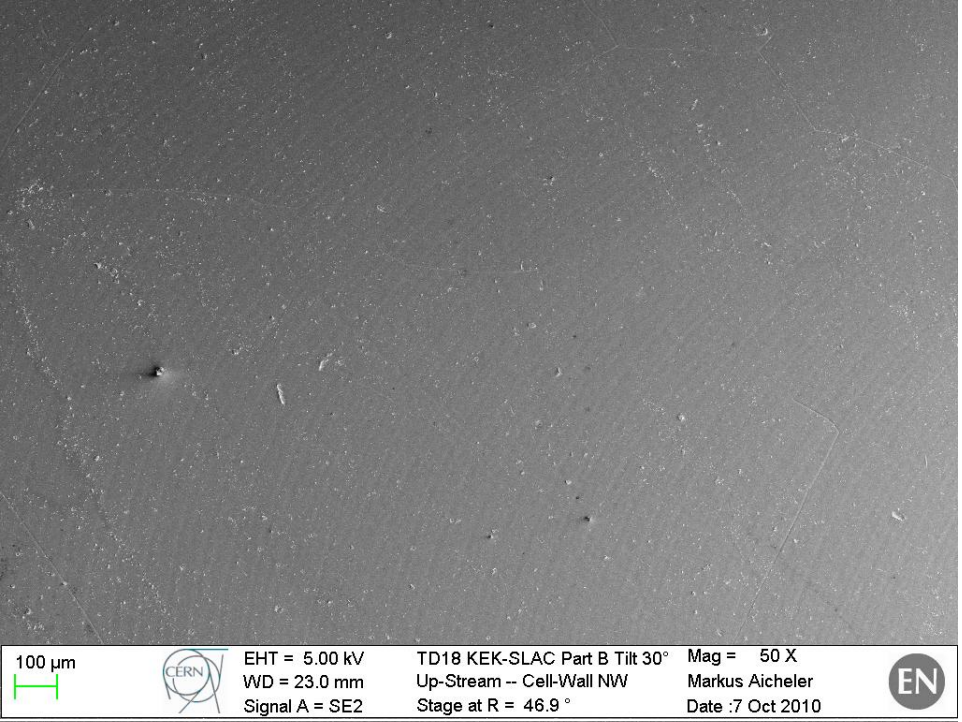
- 6 of 8 highest magnetic field regions exhibit this “B-Field arc”
- numerous breakdown sites are located around this feature expanding in direction to the waveguide entry

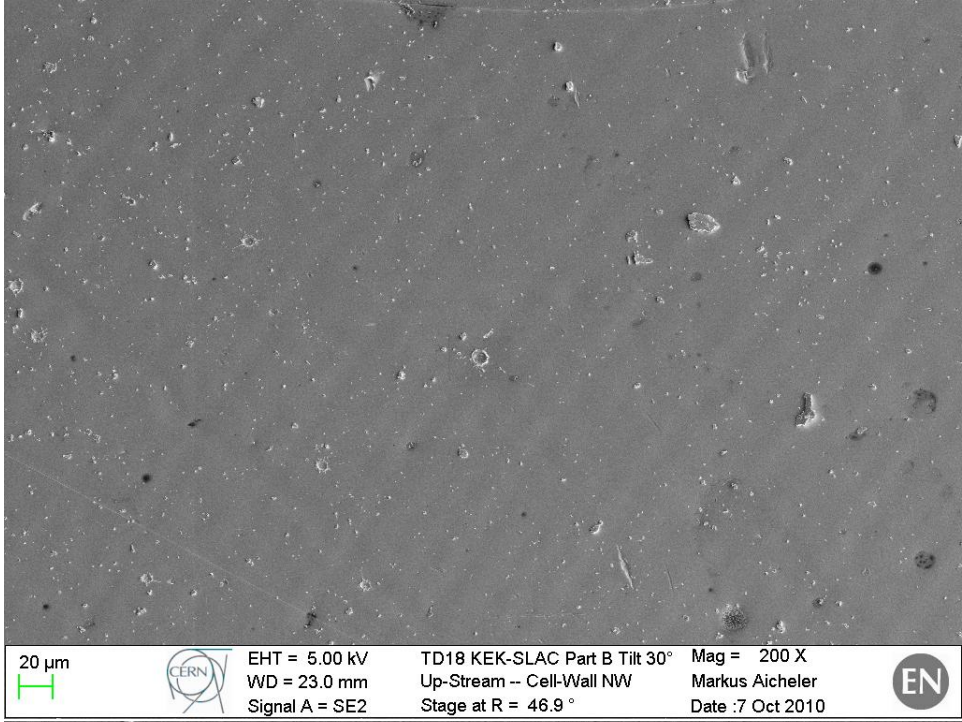


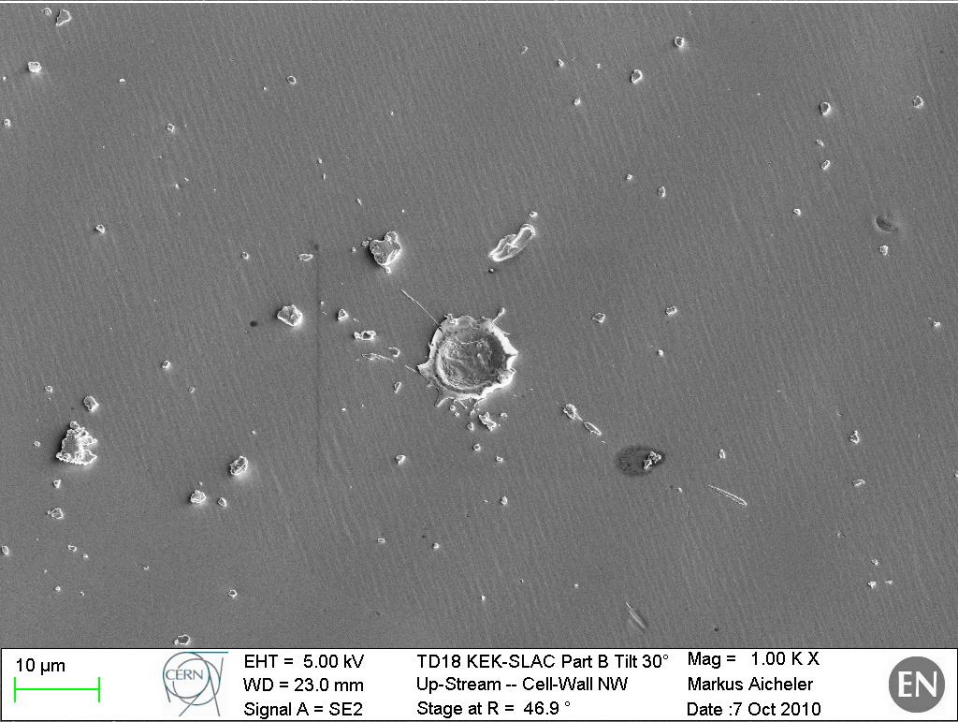
Part B
Up-stream side – Cell Wall N-W!
Tilt 30°

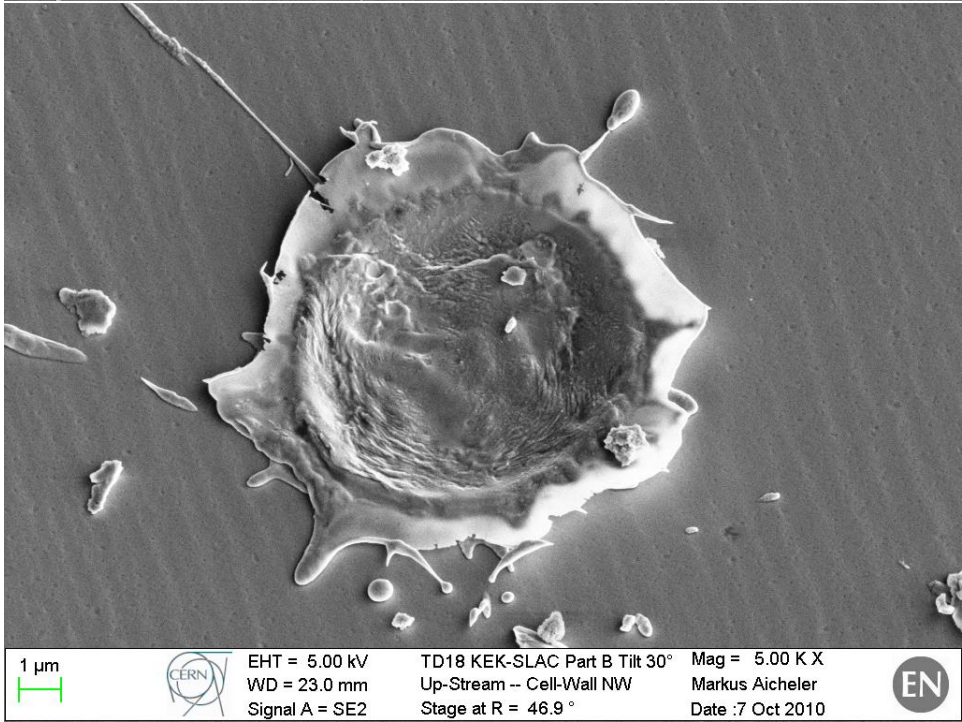

1 mm
CERN
EHT = 5.00 kV
WD = 23.4 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 15 X
Markus Aicheler
Date :7 Oct 2010
EN

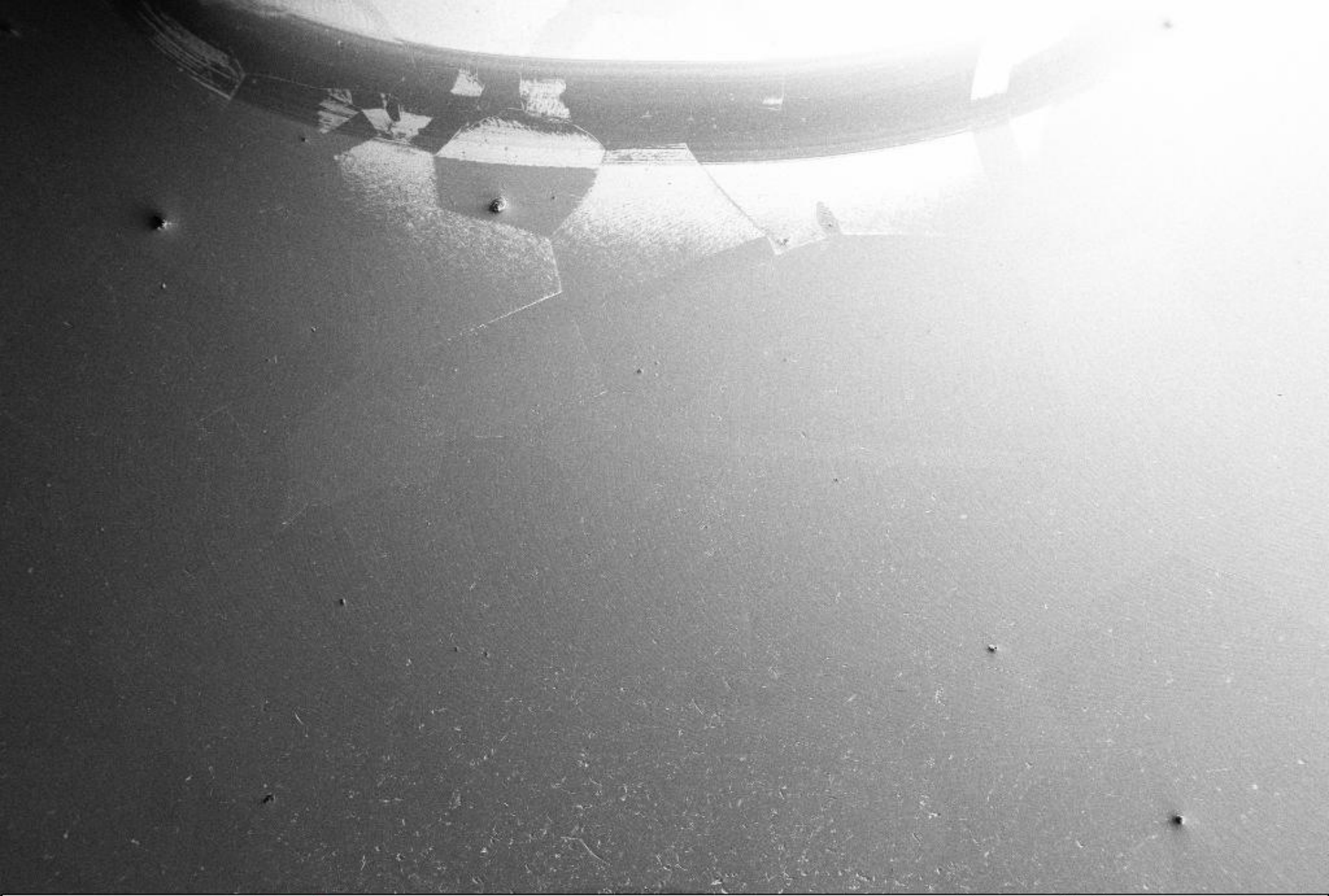

1 mm
CERN
EHT = 5.00 kV
WD = 23.0 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 15 X
Markus Aicheler
Date :7 Oct 2010
EN

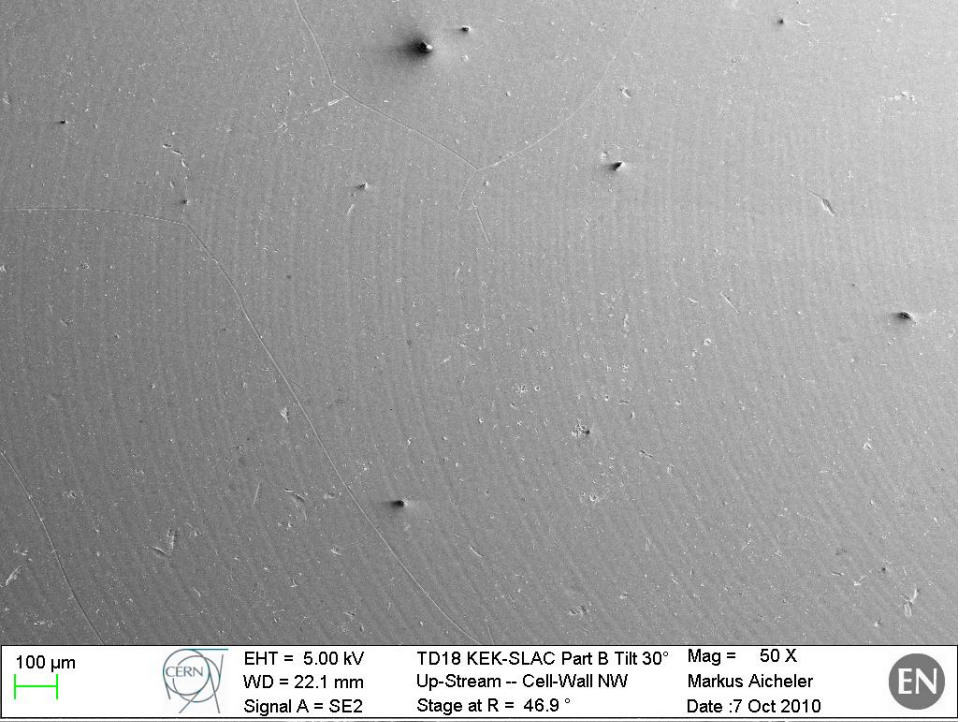

100 µm
EHT = 5.00 kV
WD = 23.0 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 50 X
Markus Aicheler
Date :7 Oct 2010

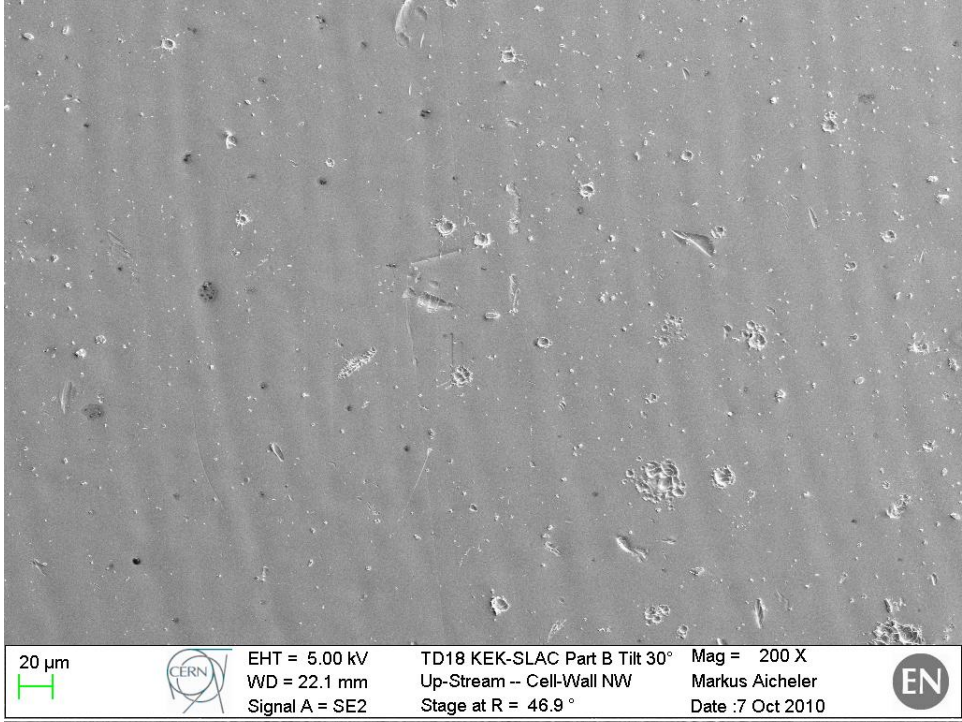

20 µm
EHT = 5.00 kV
WD = 23.0 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 200 X
Markus Aicheler
Date :7 Oct 2010

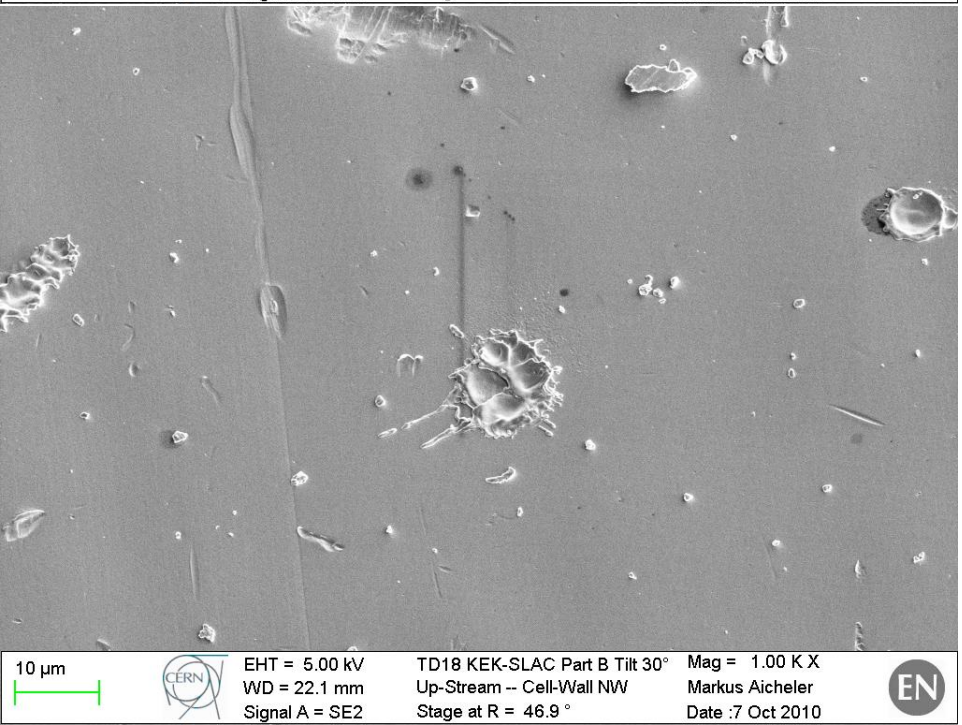

10 µm
EHT = 5.00 kV
WD = 23.0 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 1.00 K X
Markus Aicheler
Date :7 Oct 2010

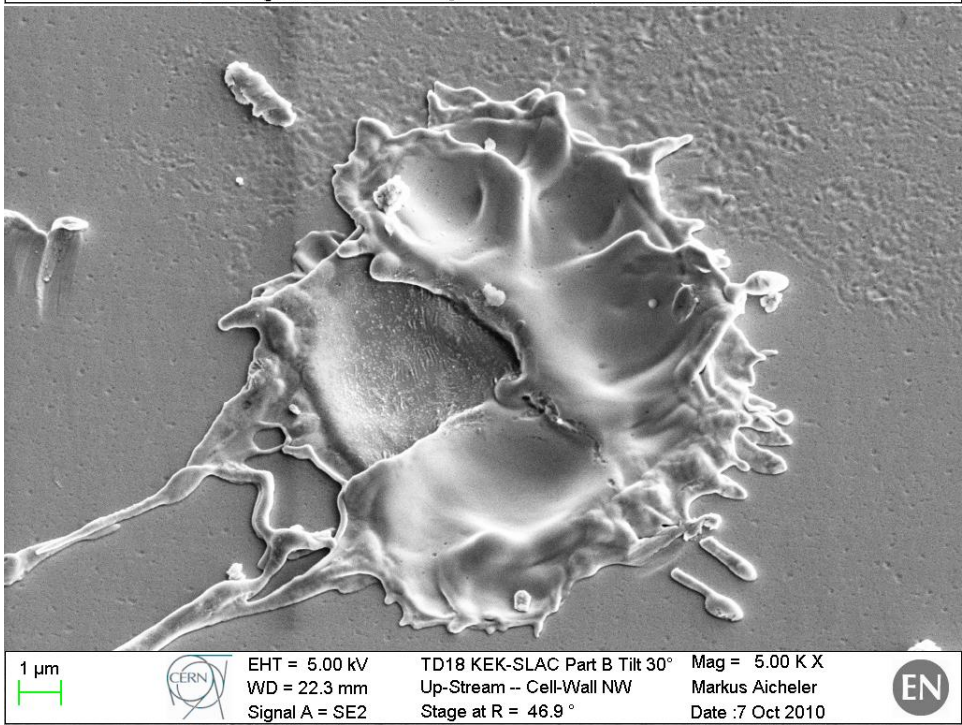

1 µm
EHT = 5.00 kV
WD = 23.0 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 5.00 K X
Markus Aicheler
Date :7 Oct 2010


1 mm
CERN
EHT = 5.00 kV
WD = 22.1 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 15 X
Markus Aicheler
Date :7 Oct 2010
EN


100 µm
EHT = 5.00 kV
WD = 22.1 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 50 X
Markus Aicheler
Date :7 Oct 2010
EN

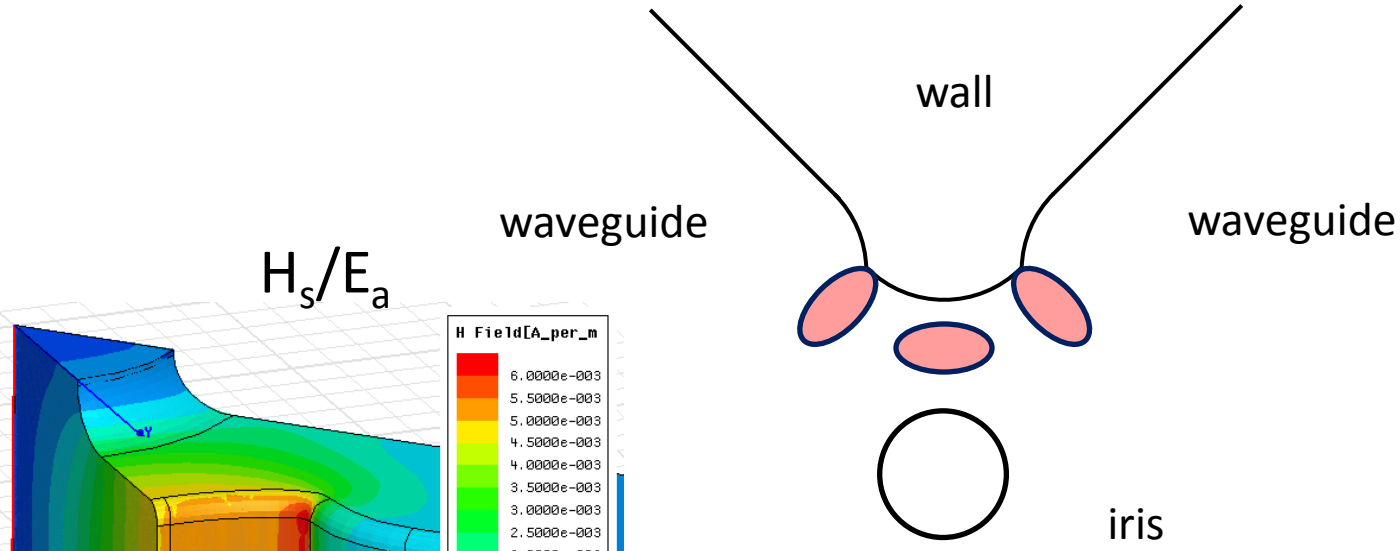

20 µm
EHT = 5.00 kV
WD = 22.1 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 200 X
Markus Aicheler
Date :7 Oct 2010
EN


10 µm
EHT = 5.00 kV
WD = 22.1 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 1.00 K X
Markus Aicheler
Date :7 Oct 2010
EN


1 µm
EHT = 5.00 kV
WD = 22.3 mm
Signal A = SE2
TD18 KEK-SLAC Part B Tilt 30°
Up-Stream -- Cell-Wall NW
Stage at R = 46.9 °
Mag = 5.00 K X
Markus Aicheler
Date :7 Oct 2010
EN

Facts for part B up-stream side:

- no “B-Field arc”
- numerous breakdown sites are located at similar locations as on the other side of the cell
- additionally breakdowns found between the cell wall and the iris



H_s/E_a

Strategy of the presentation:

Part 1: Introduction and a little microscopic walk through “part B”

Part 2: From obvious to less obvious findings
⇒Formulation of question and explanation attempt.

Part 3: Current observation method and next steps

Current observation method on one slice side:

- Sample tilting 30° (more is not practical for SEM and less no access to outer cell wall and inner part of iris).
- Documentation of iris at 50x and 100x magnification.
- Documentation of 4x outer cell wall with each part both noses.
- Searching for eventual break down sites at 100x magnification

Next steps:

- Completing the observation set for the remaining 2 relevant slices (D+E).
- Image-Analysis of assembled Iris micrographs for circumferential (and maybe radial) crater distribution on iris.
- Proposal for observation and cutting strategy for remaining structure part

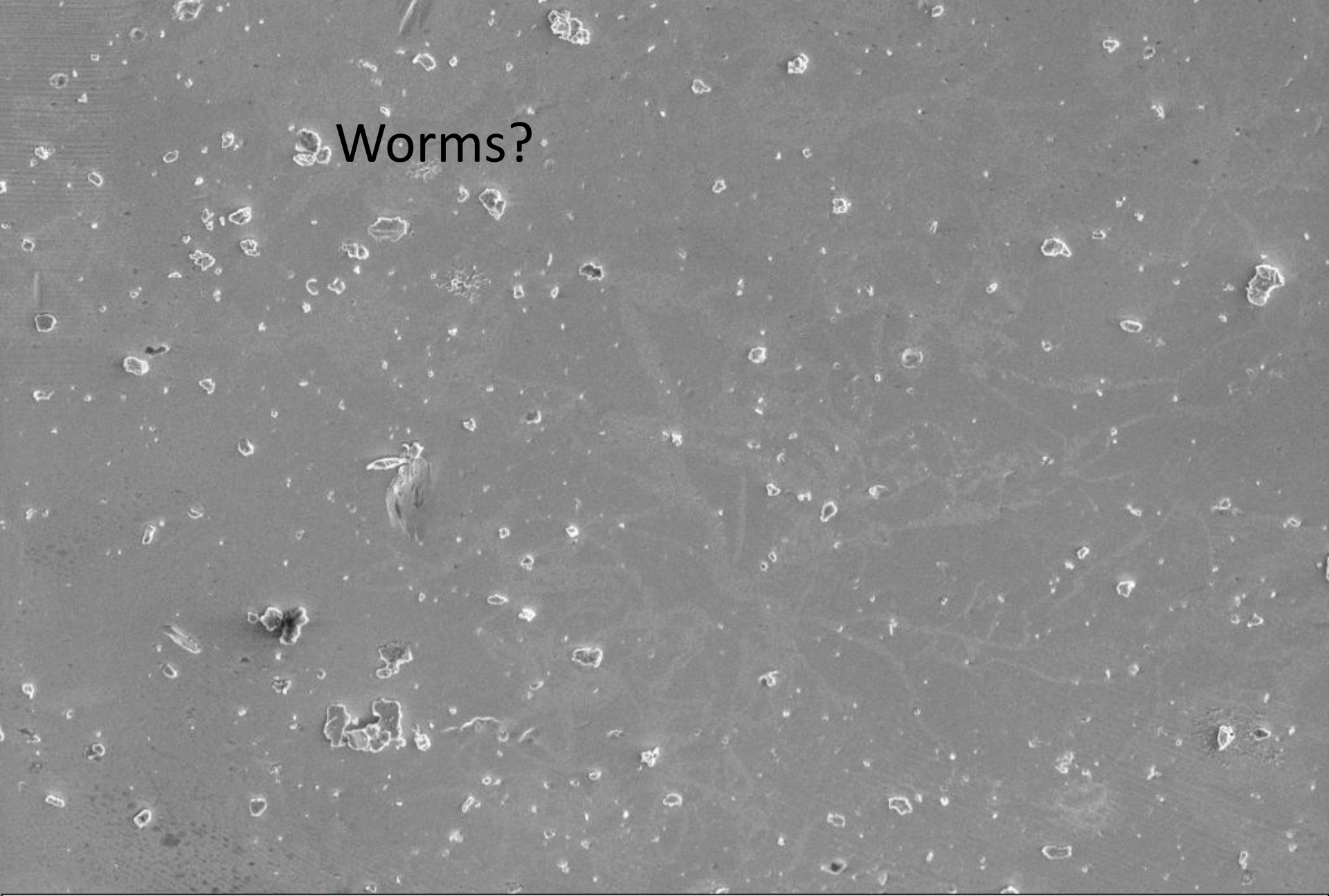
Thanks! ☺

…any requests for observations?

Part B
Down-stream side - Iris north!

My favorites!

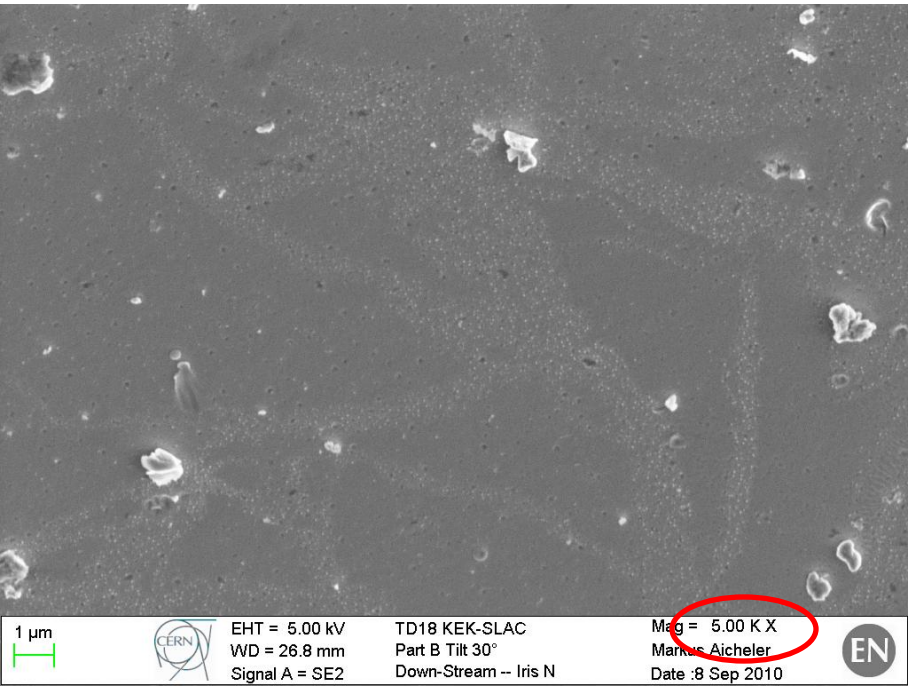
Worms?


10 µm
CERN
EHT = 5.00 kV
WD = 26.7 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 1.00 K X
Markus Aicheler
Date :8 Sep 2010
EN

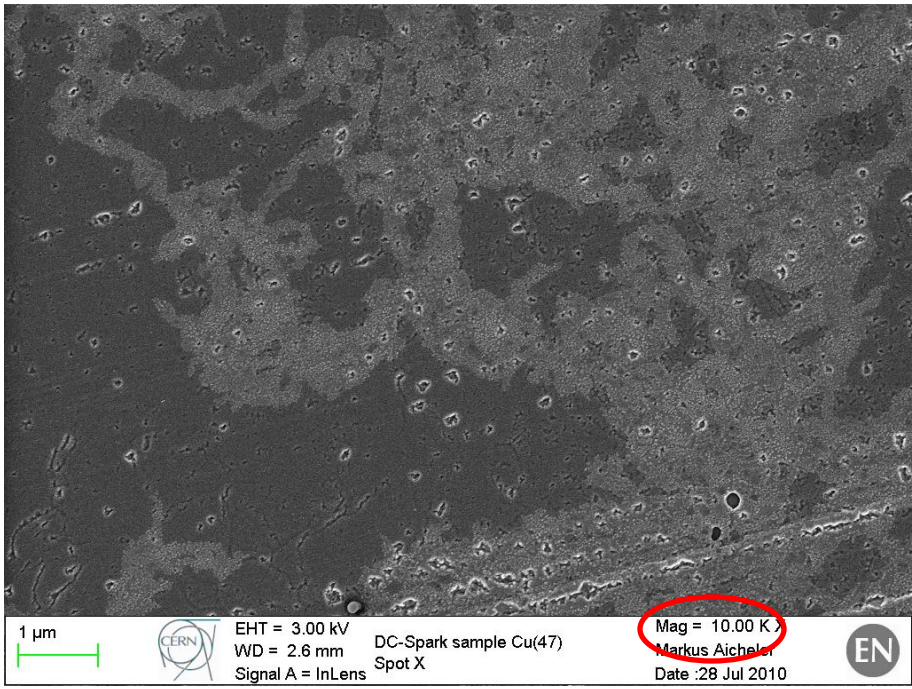

Yes, Worms!
1 µm
CERN
EHT = 5.00 kV
WD = 26.8 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 5.00 K X
Markus Aicheler
Date :8 Sep 2010
EN

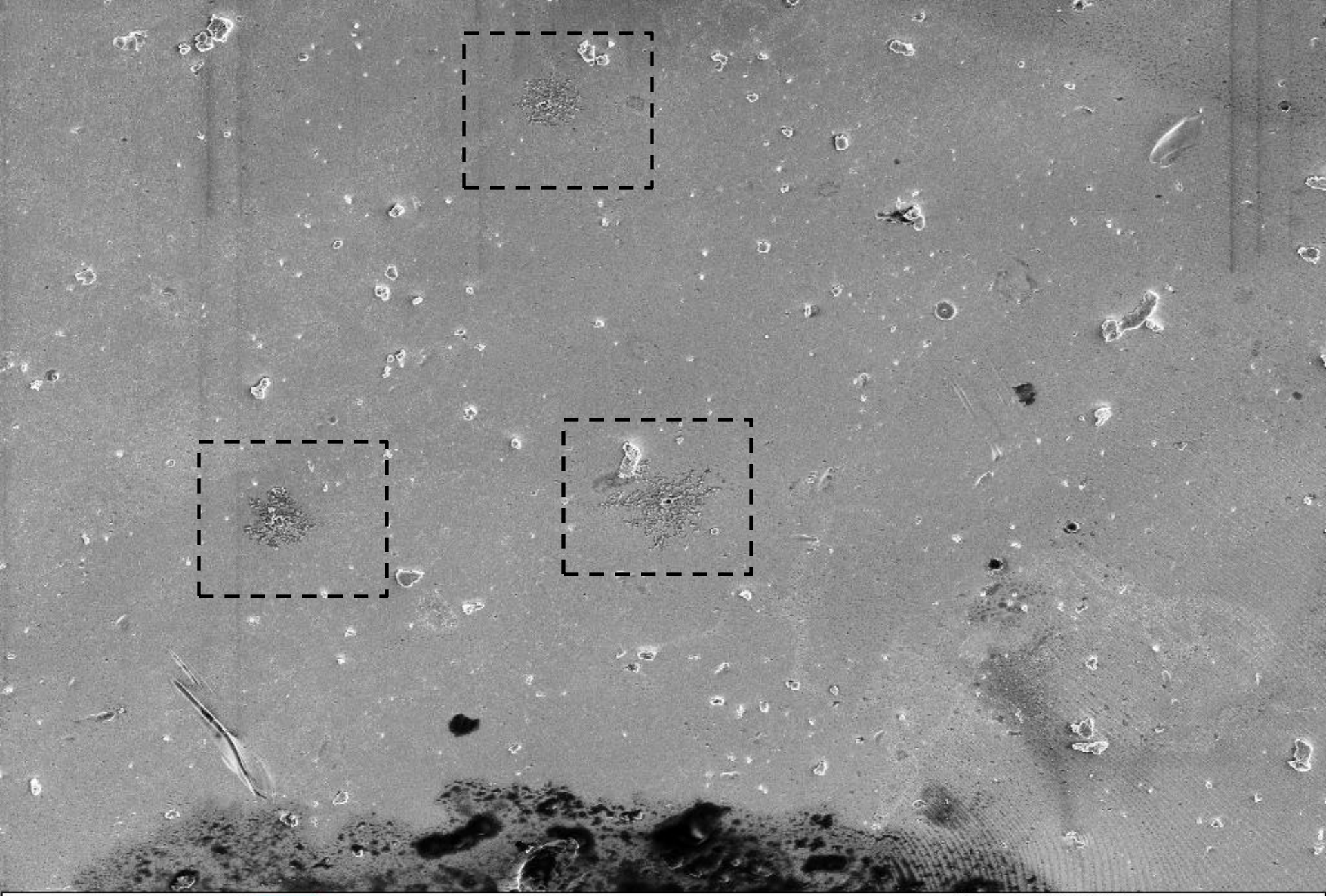
Yes, Worms!

TD18 SE2

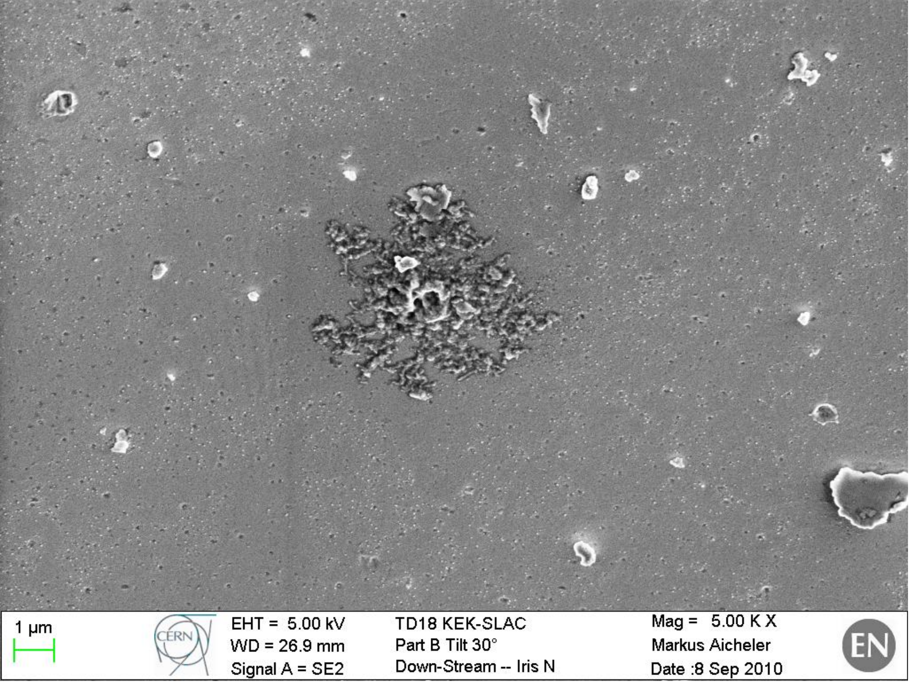


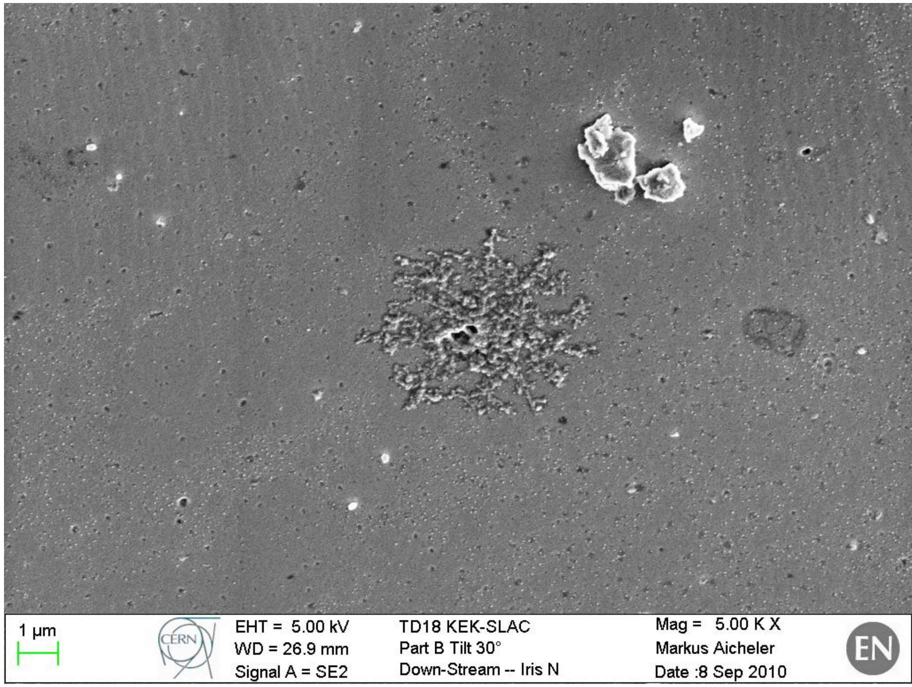
DC-Spark InLens

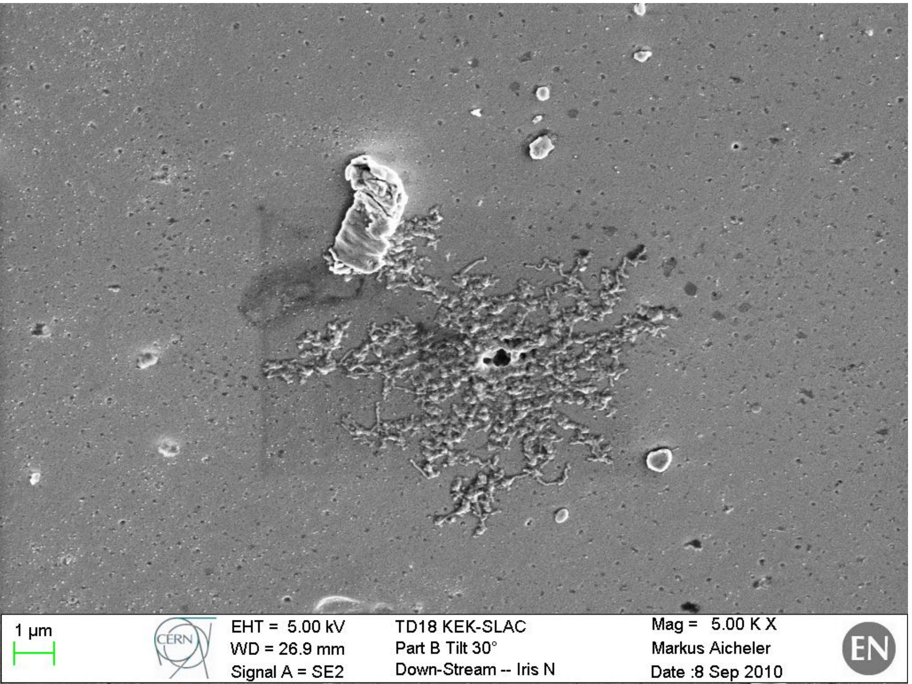



10 µm
CERN
EHT = 5.00 kV
WD = 26.9 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 1.00 K X
Markus Aicheler
Date :8 Sep 2010
EN

Molehills!


1 µm
EHT = 5.00 kV
WD = 26.9 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 5.00 K X
Markus Aicheler
Date :8 Sep 2010
EN


1 µm
EHT = 5.00 kV
WD = 26.9 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 5.00 K X
Markus Aicheler
Date :8 Sep 2010
EN


1 µm
EHT = 5.00 kV
WD = 26.9 mm
Signal A = SE2
TD18 KEK-SLAC
Part B Tilt 30°
Down-Stream -- Iris N
Mag = 5.00 K X
Markus Aicheler
Date :8 Sep 2010
EN