LLNL-CONF-654629

Serendipitous Holography of Shocked Surfaces using Ultrashort Pulse-Pair 2d-Velocimetry

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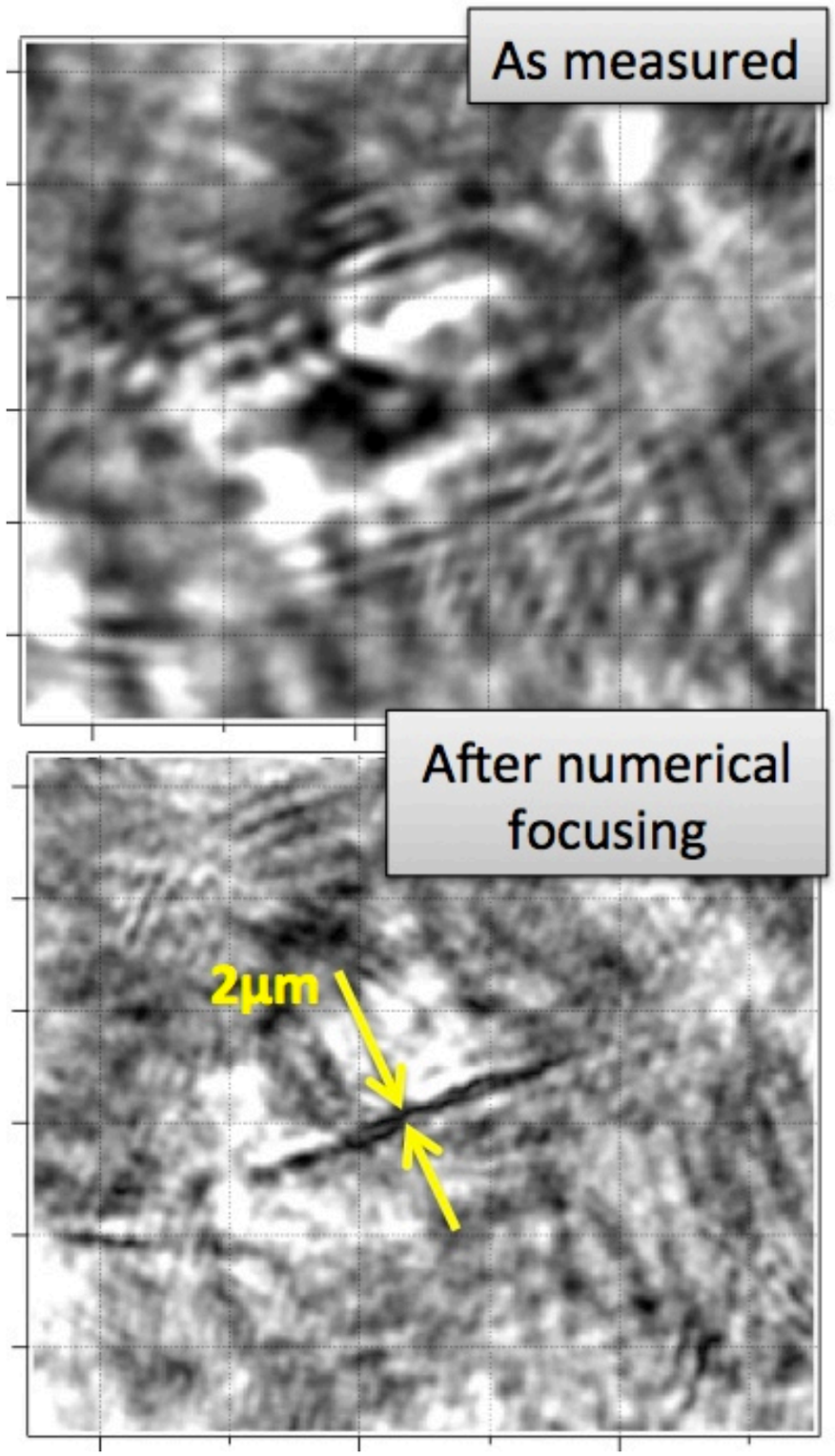
CASIS Talk

LLNL, May 21, 2014



Colleagues

Ray Smith

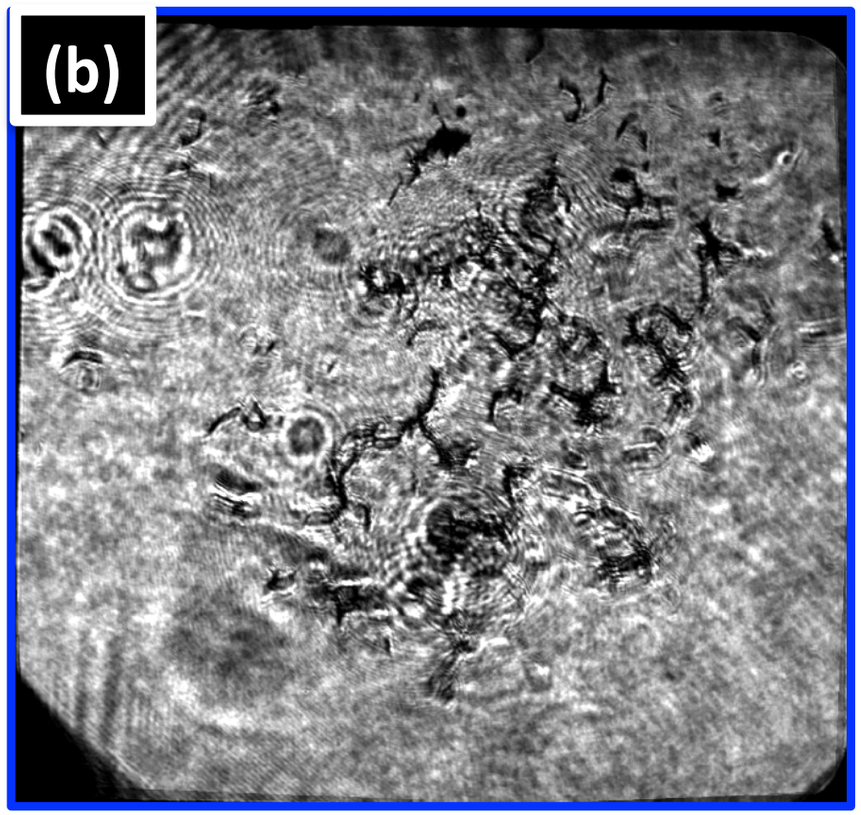
Cynthia Bolme (LANL)

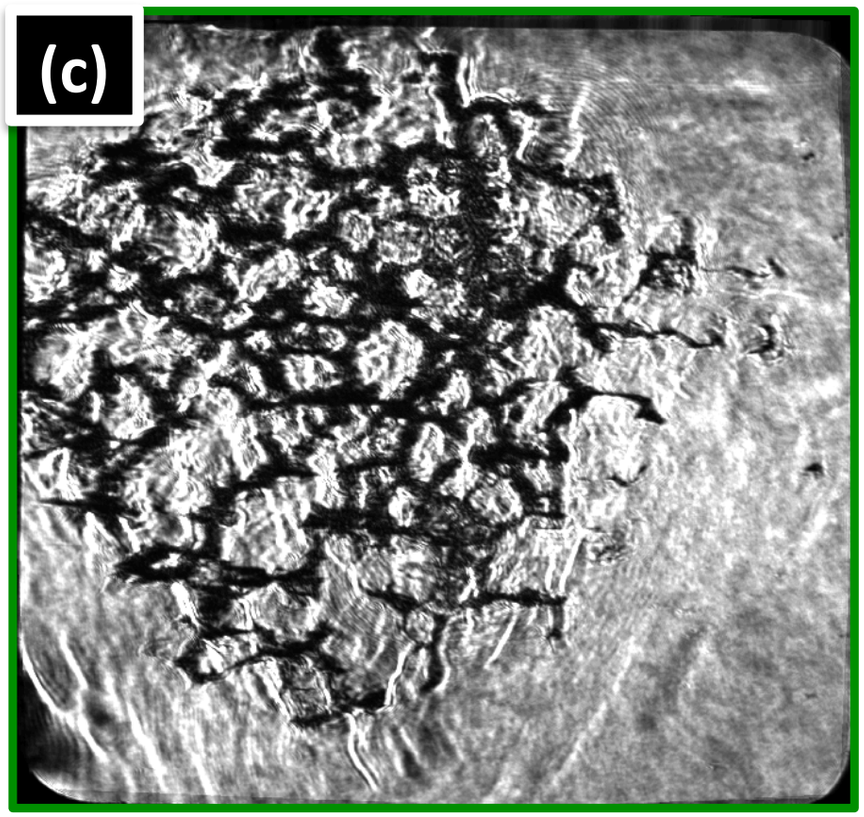
Suzanne Ali (UCB)

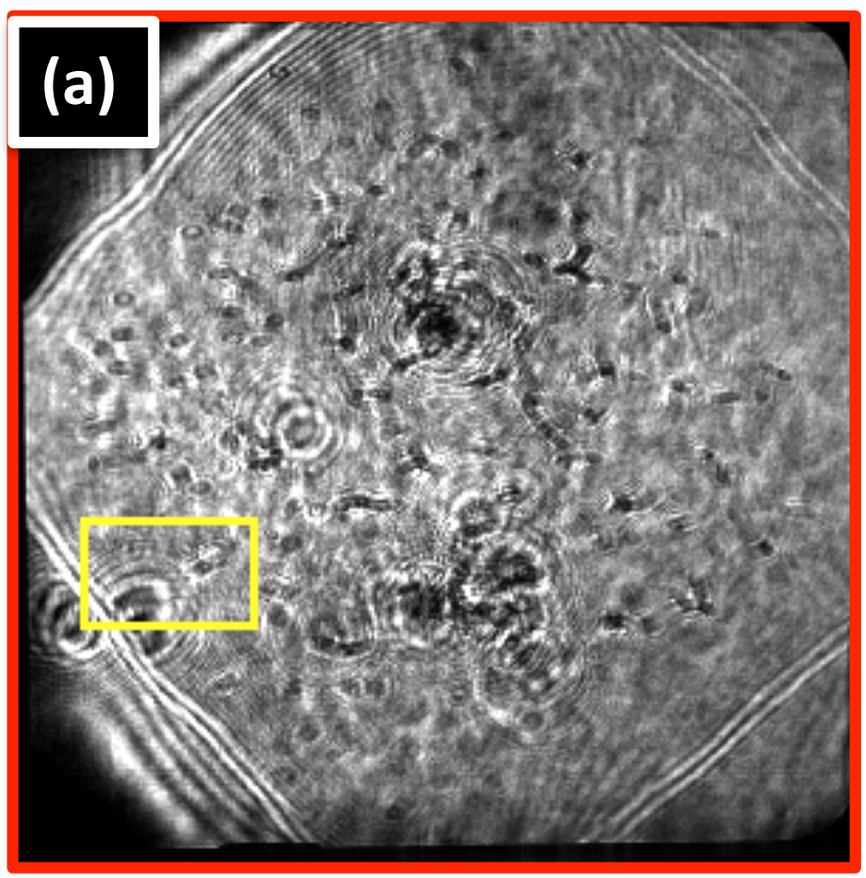
Peter Celliers

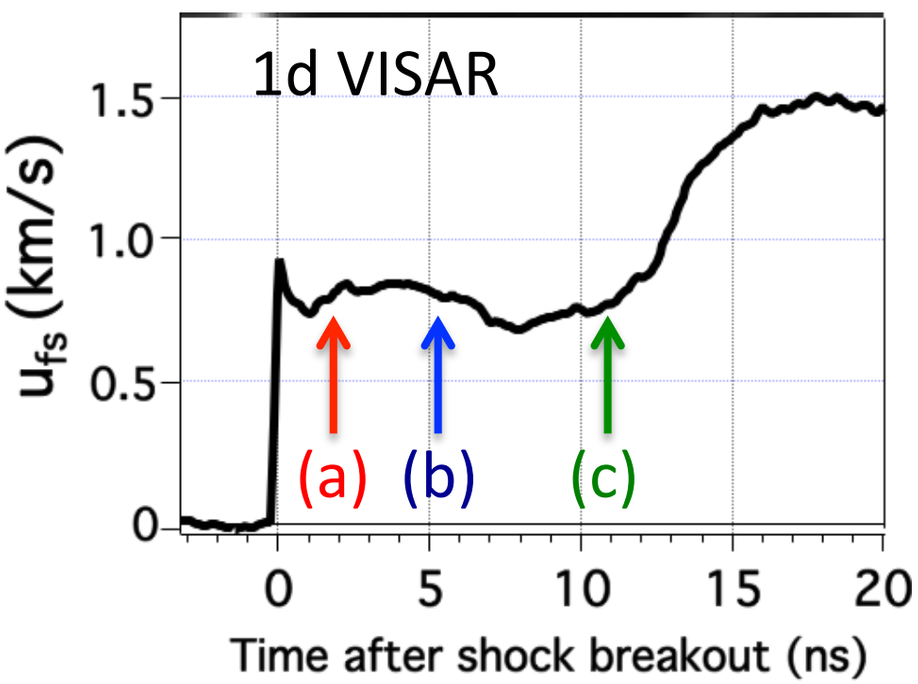
Gilbert Collins

Untamped Si target strobed at 3 ps

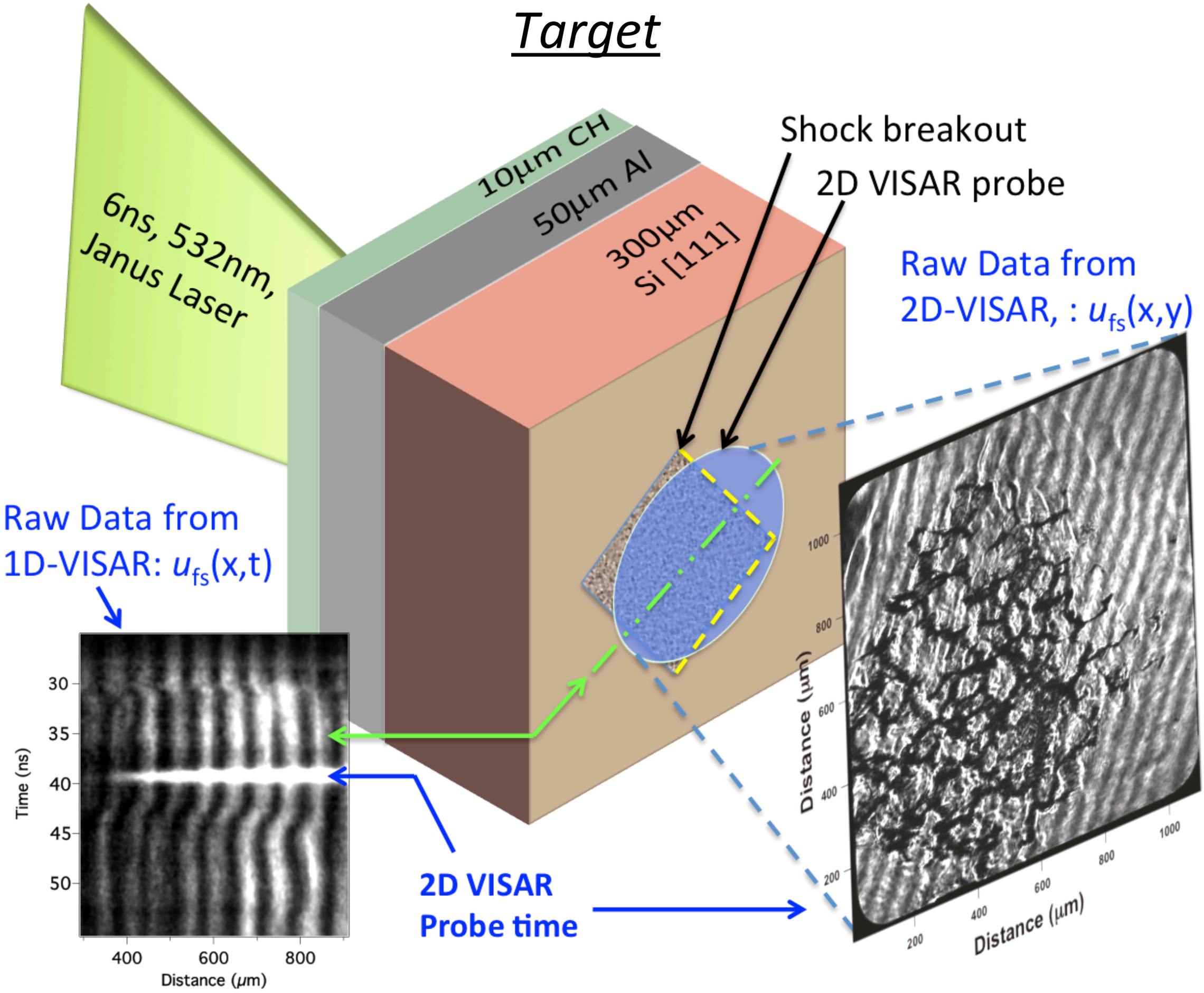




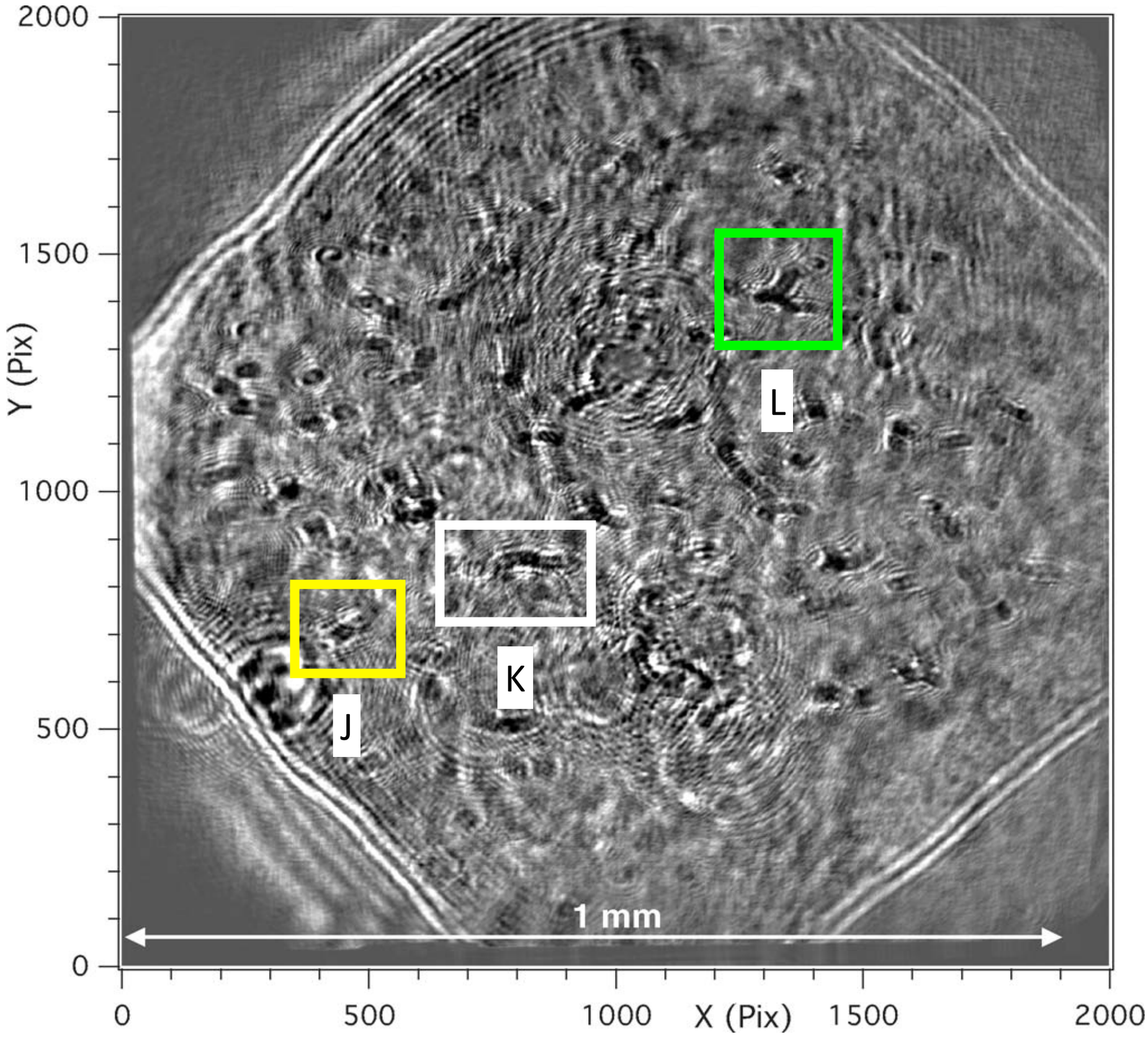




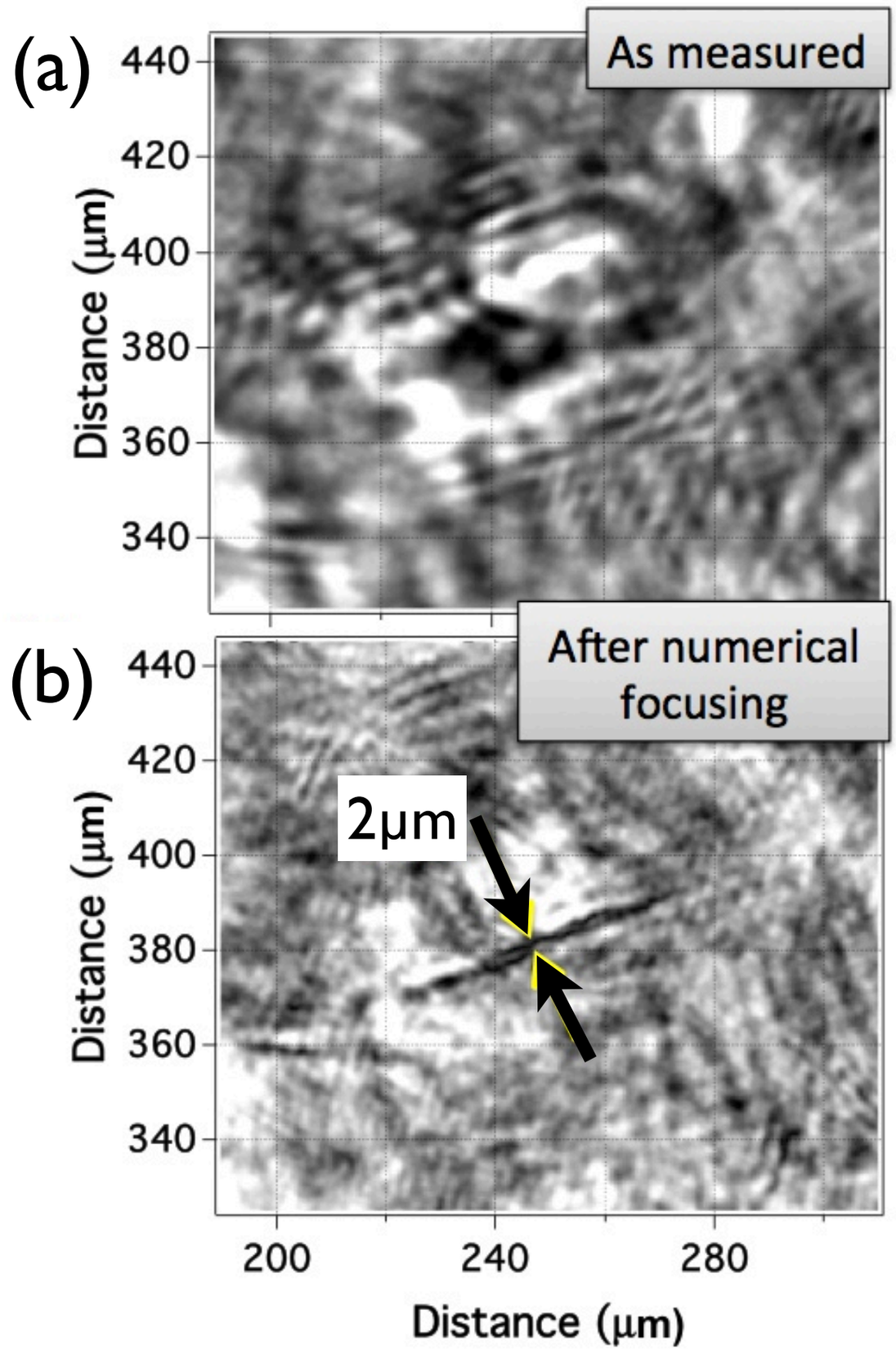
Target

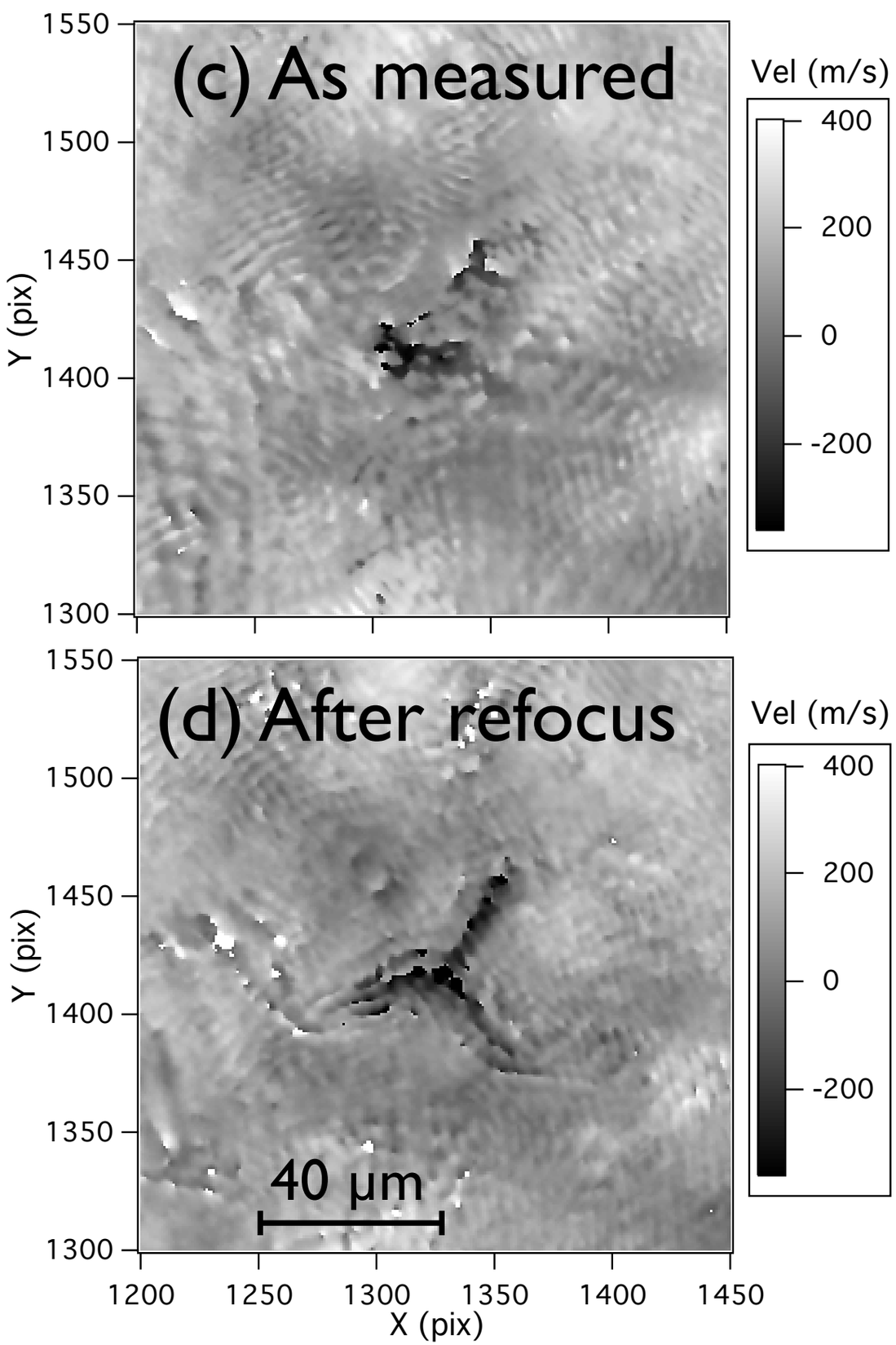

6ns, 532nm,
Janus Laser
10μm CH
50μm Al
300μm
Si [111]
Shock breakout
2D VISAR probe
Raw Data from
2D-VISAR, : $u_{fs}(x,y)$
Raw Data from
1D-VISAR: $u_{fs}(x,t)$
Time (ns)
30
35
40
45
50
400
600
800
Distance (μm)
2D VISAR
Probe time
Distance (μm)
200
400
600
800
1000
Distance (μm)
200
400
600
800
1000

As-taken, accidentally out of focus

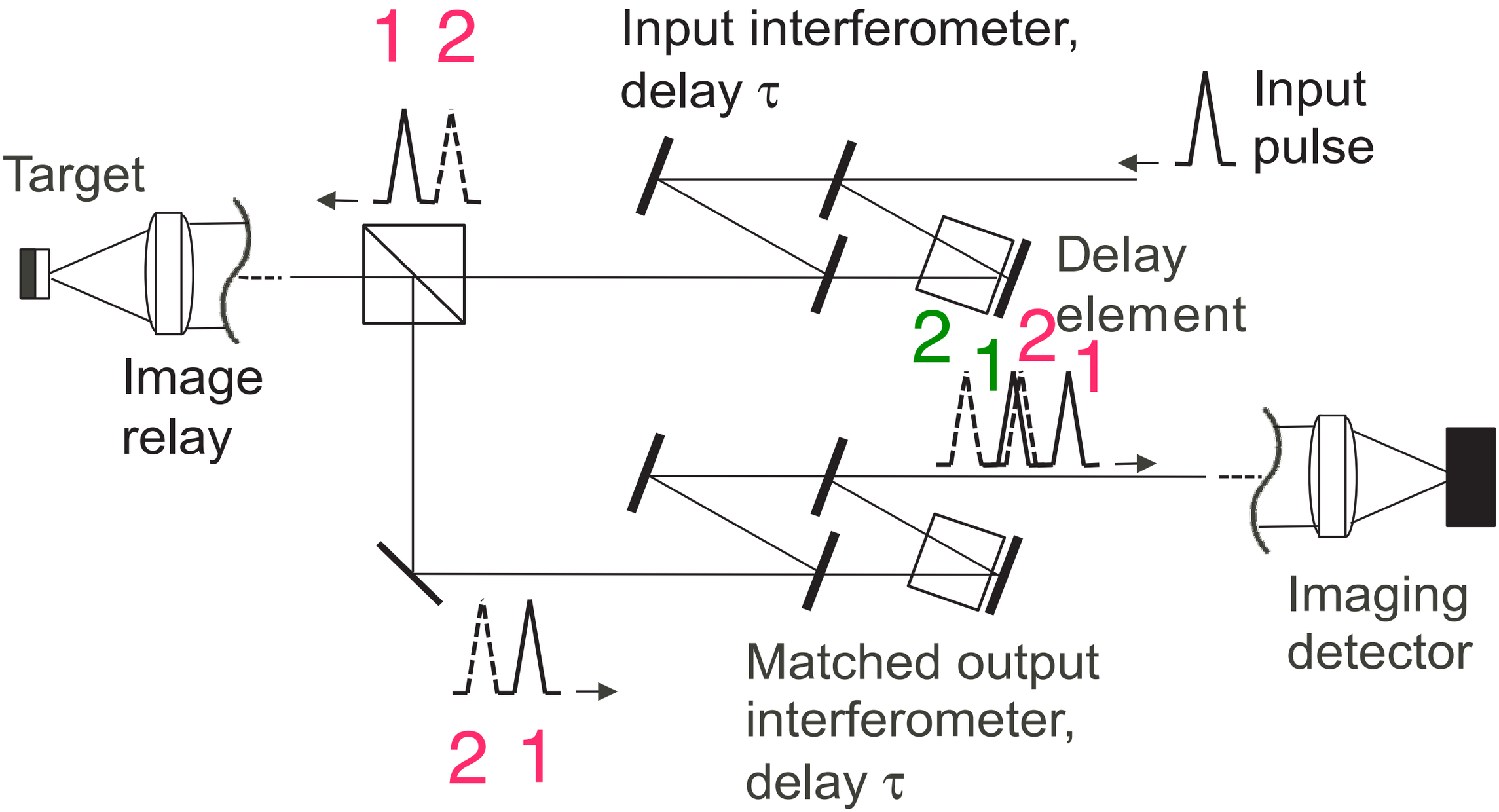


Refocusing done numerically post-shot





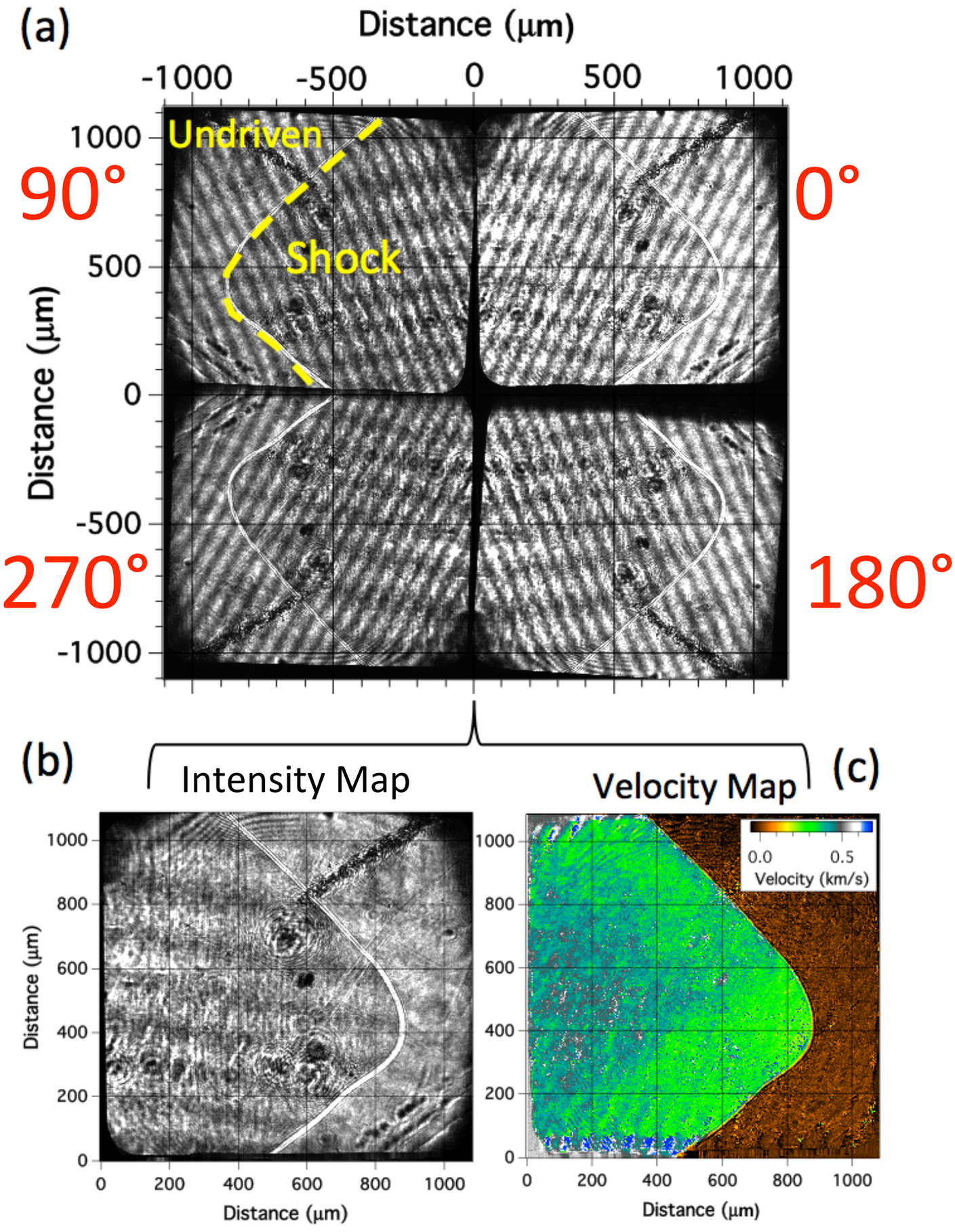
Need to use a pair of pulses, for velocimetry (detect position twice, over an interval)

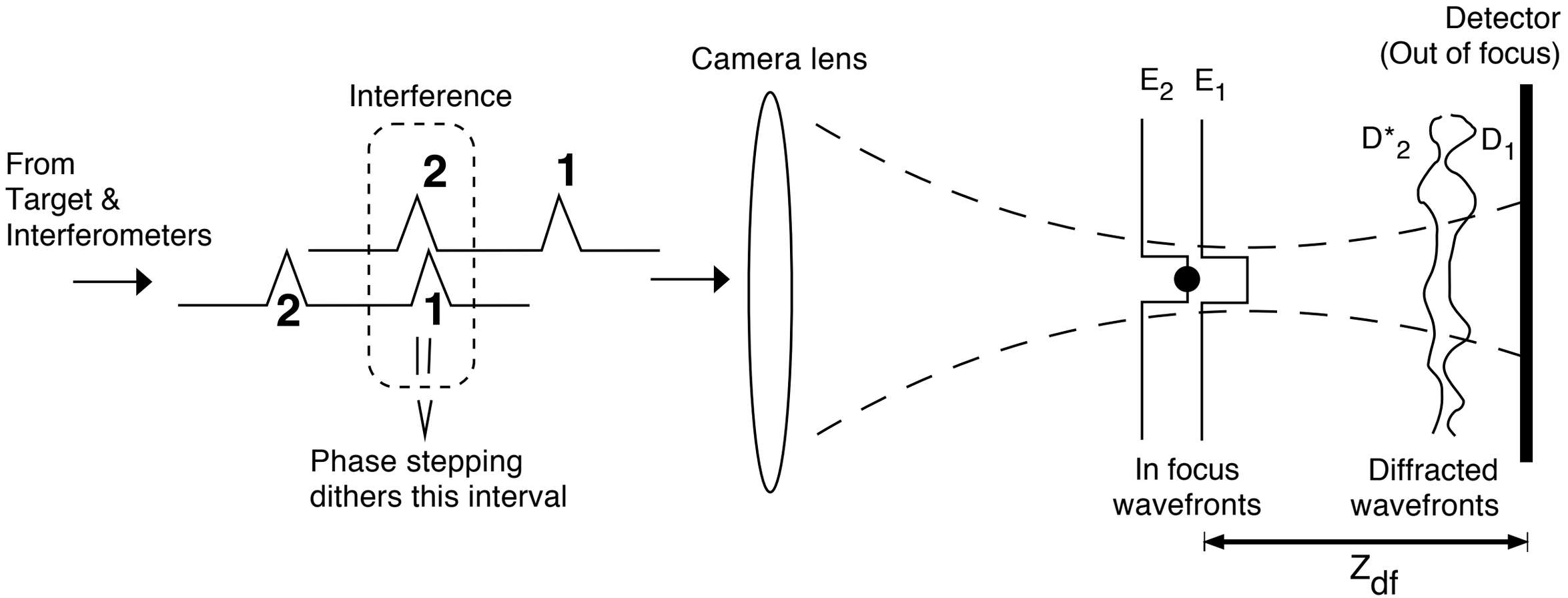


Phase-stepped recording

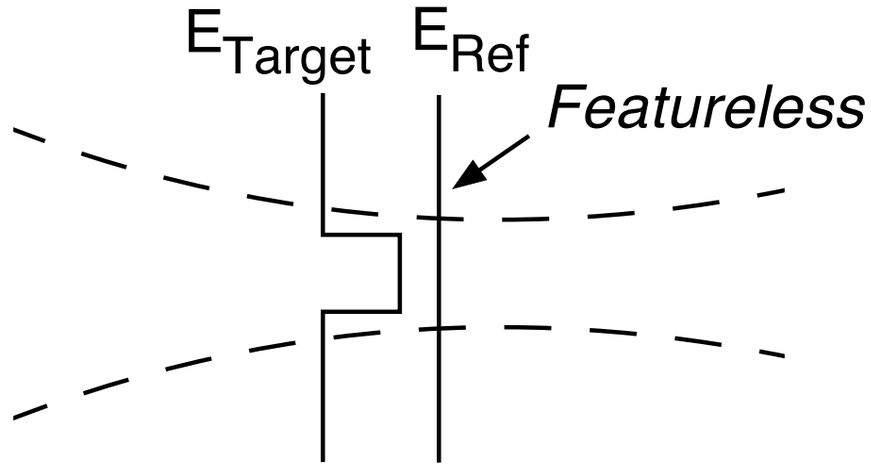
Phase & Magnitude recovered

Fringing & nonFringing separable

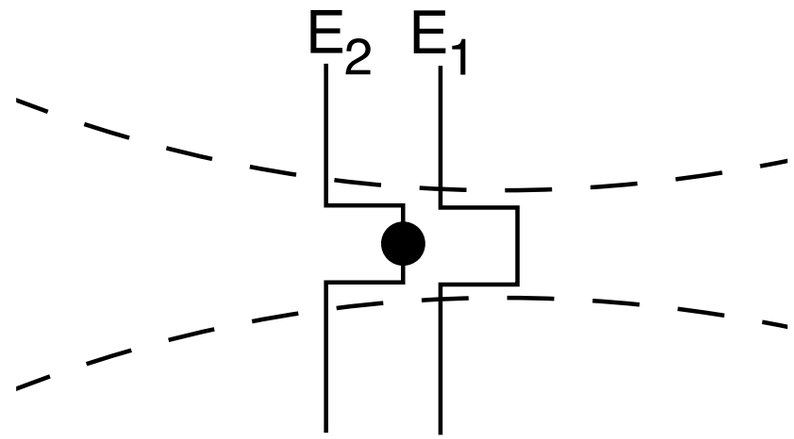



From
Target &
Interferometers
Interference
2
1
2
1
Phase stepping
dithers this interval
Camera lens
E2 E1
Detector
(Out of focus)
D*2
D1
In focus
wavefronts
Diffracted
wavefronts
Zdf

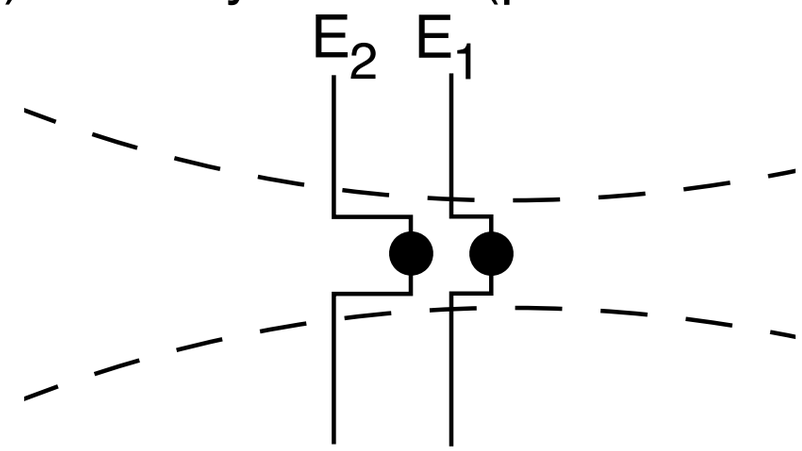
(a) Classic Holography



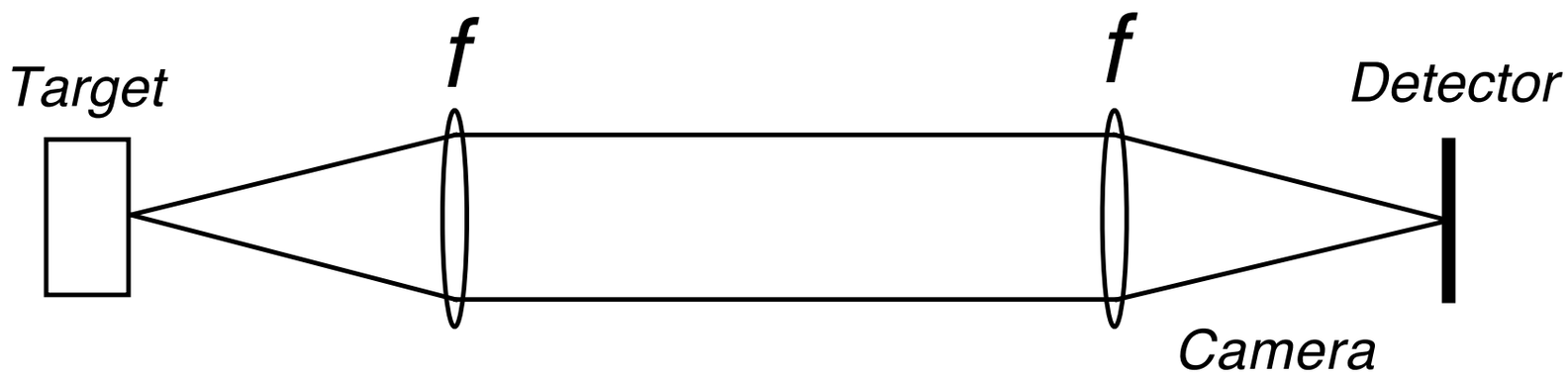
(b) Reflectivity feature (crack develops)

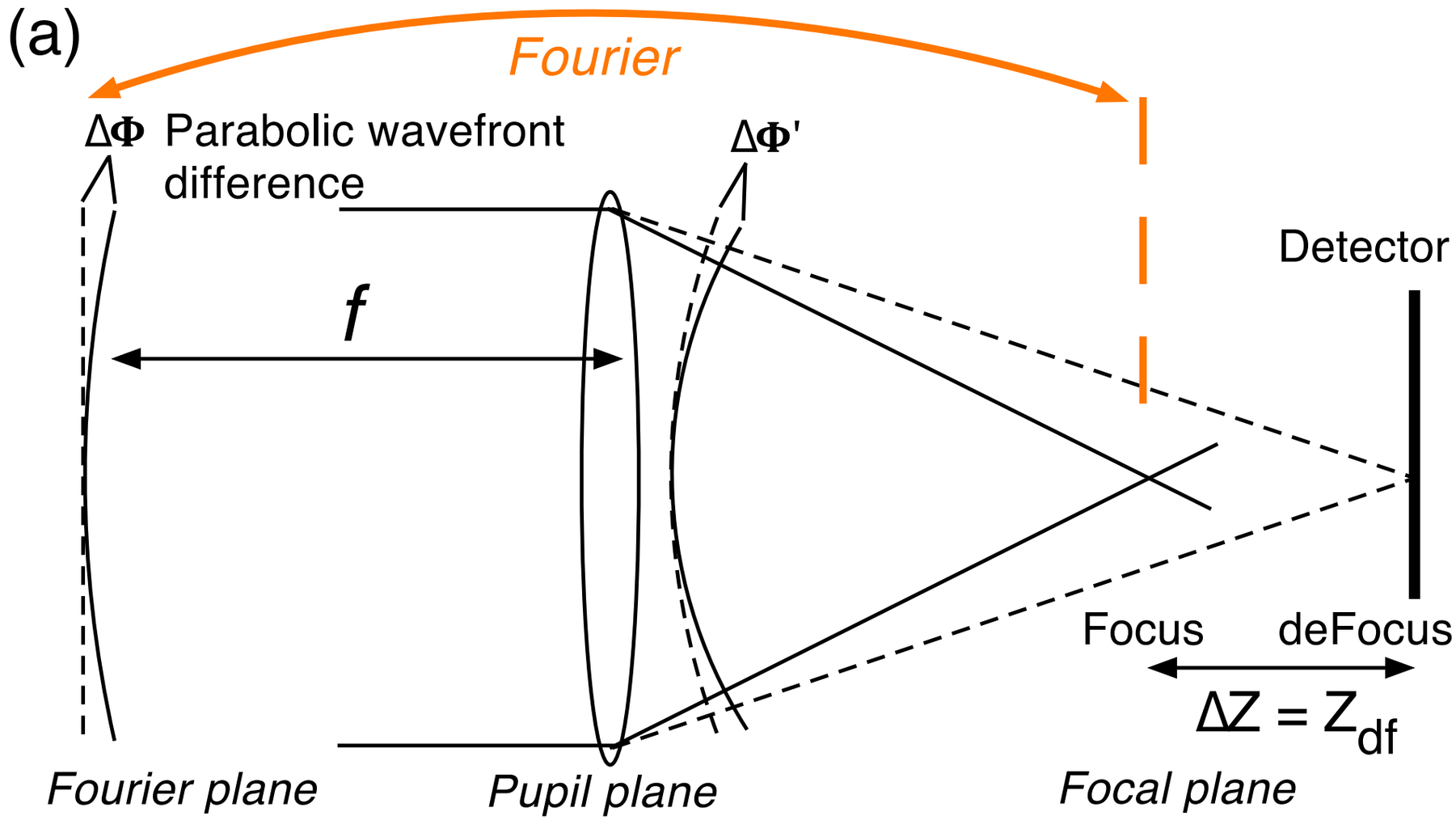


(c) Velocity feature (phase develops)

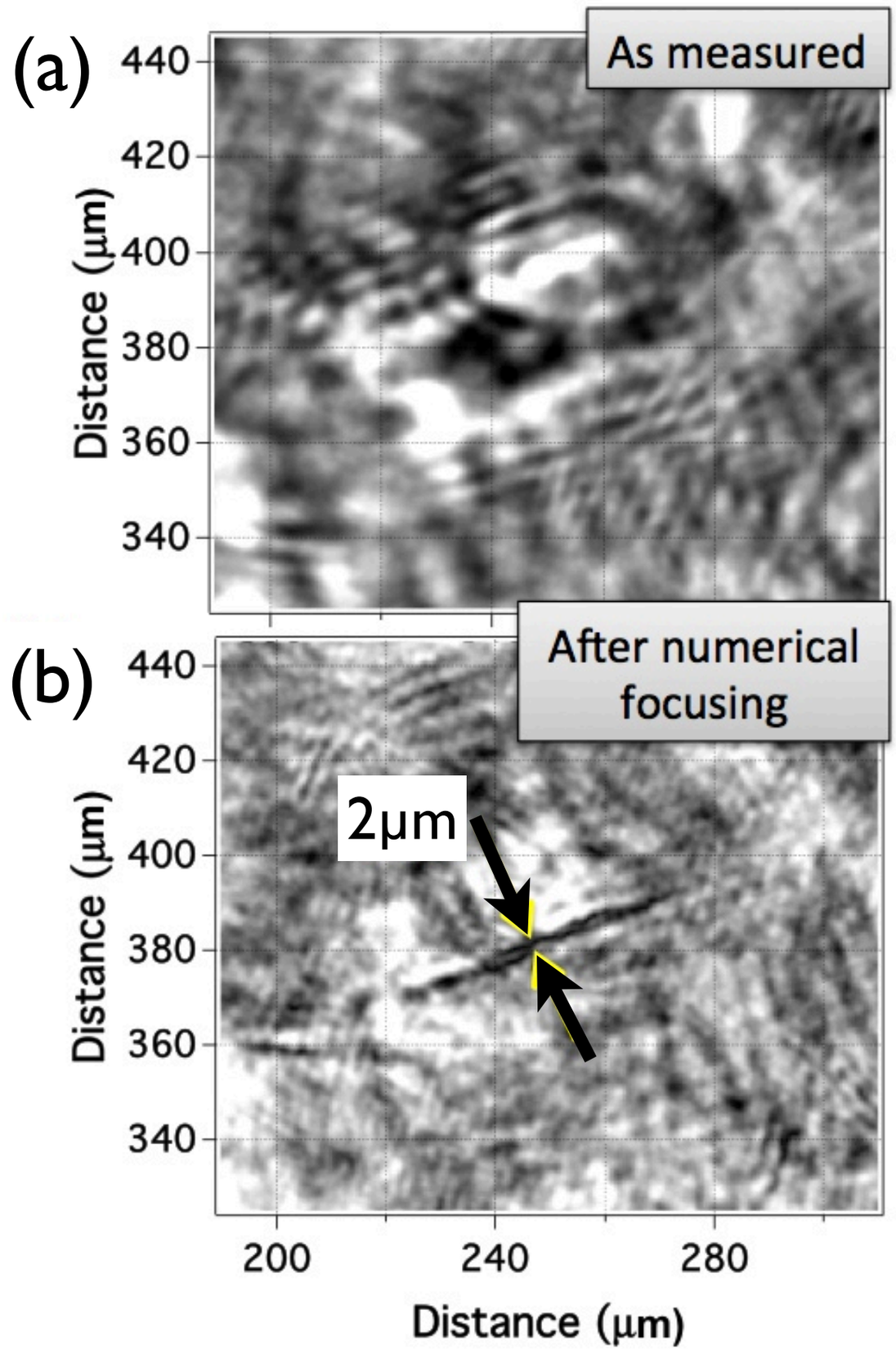


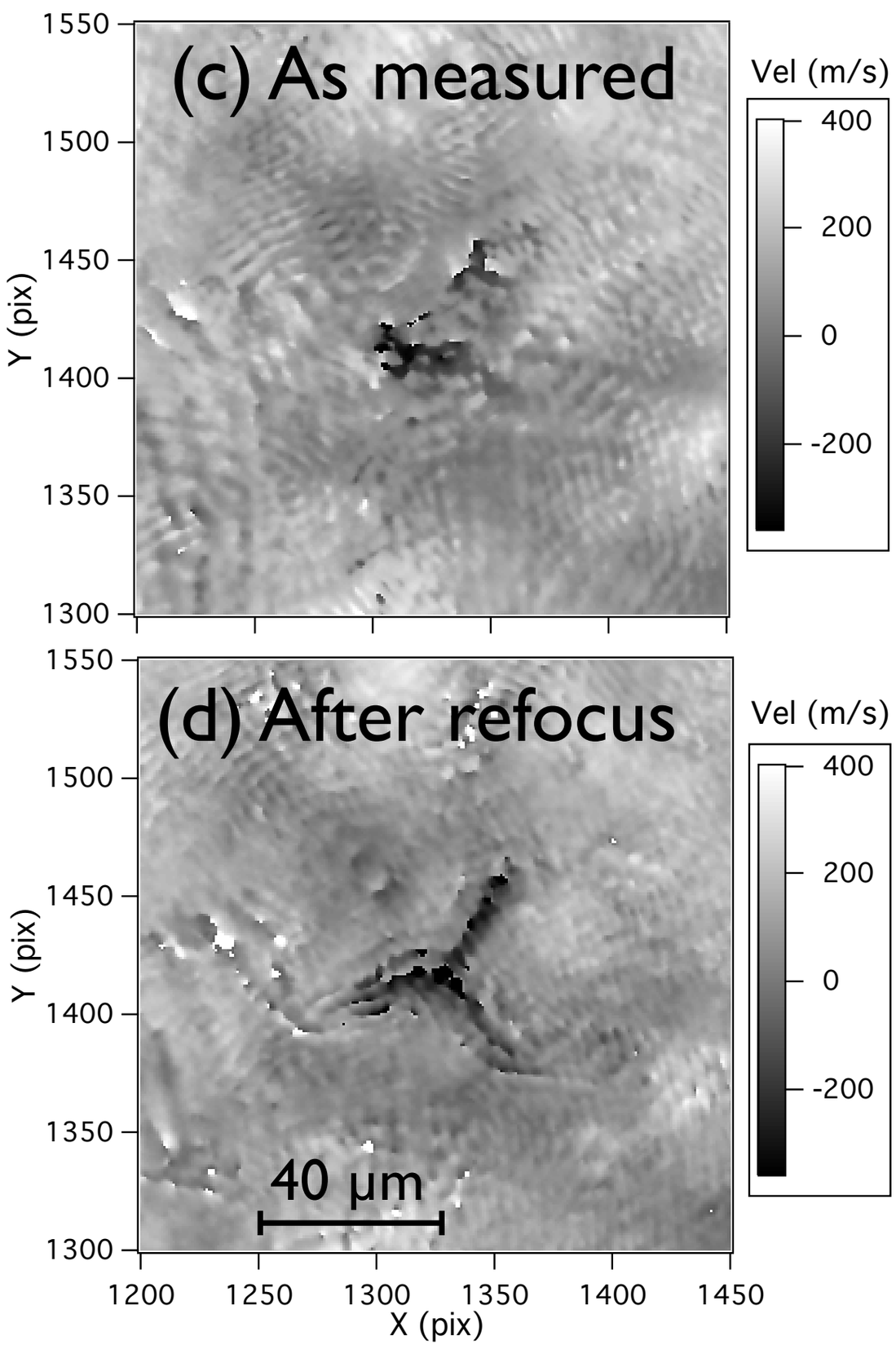
(b)

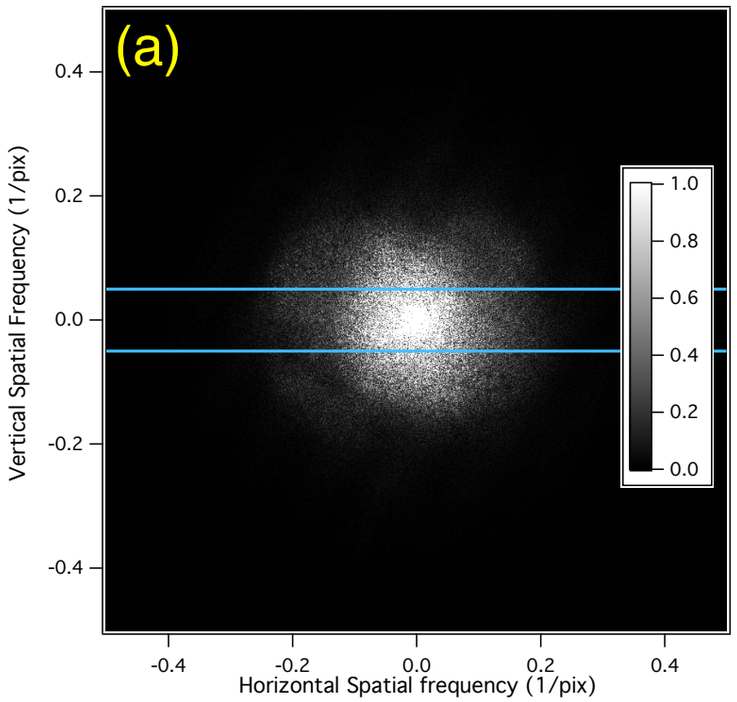


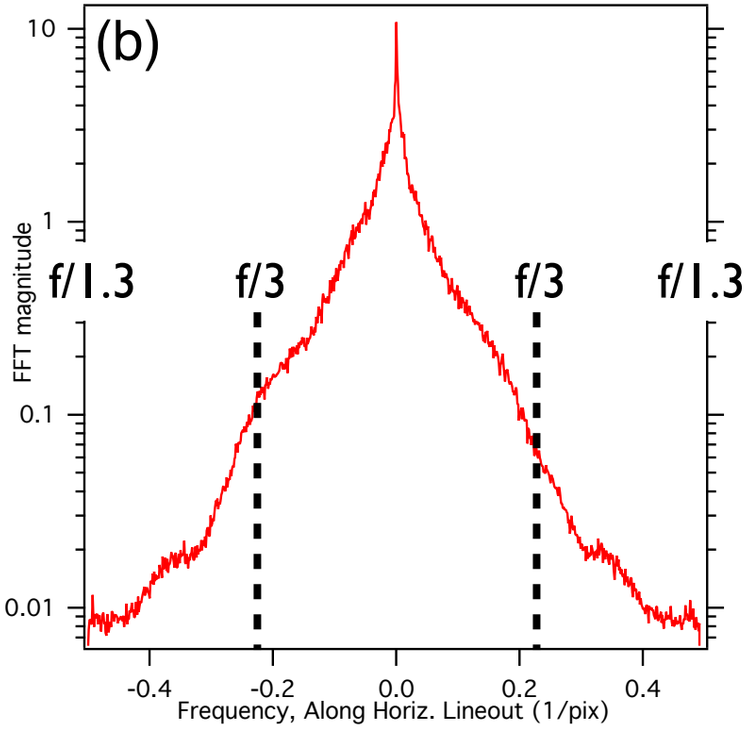

(a)
Fourier
ΔΦ
Parabolic wavefront
difference
ΔΦ'
Detector
f
Focus
deFocus
ΔZ = Z_df
Fourier plane
Pupil plane
Focal plane

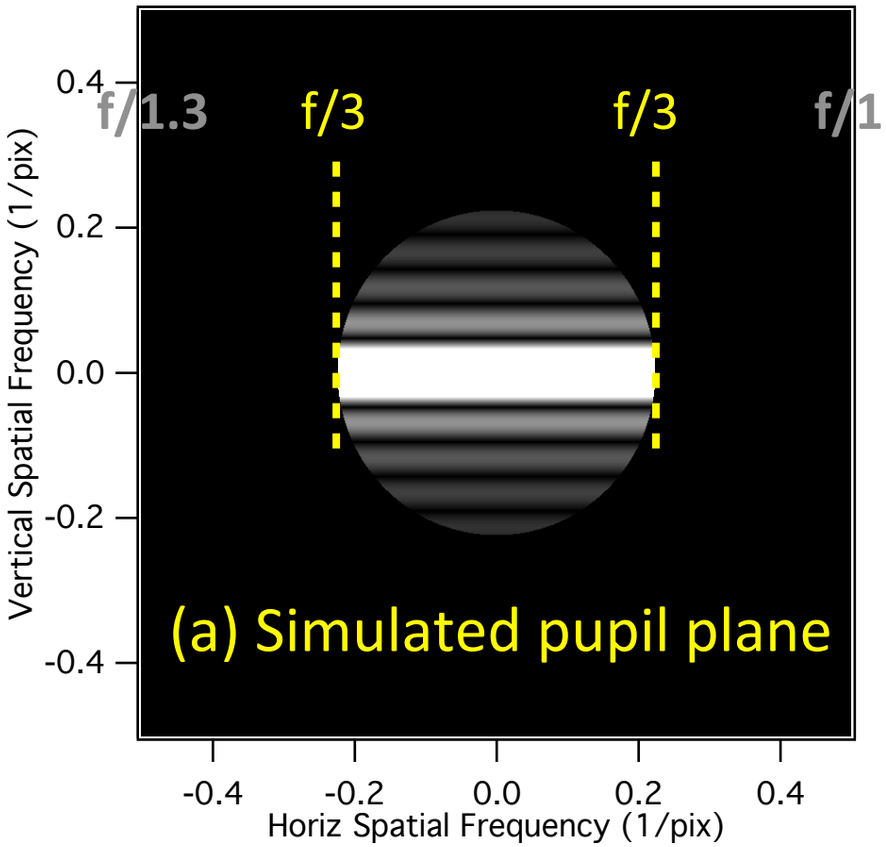
Refocusing done numerically post-shot

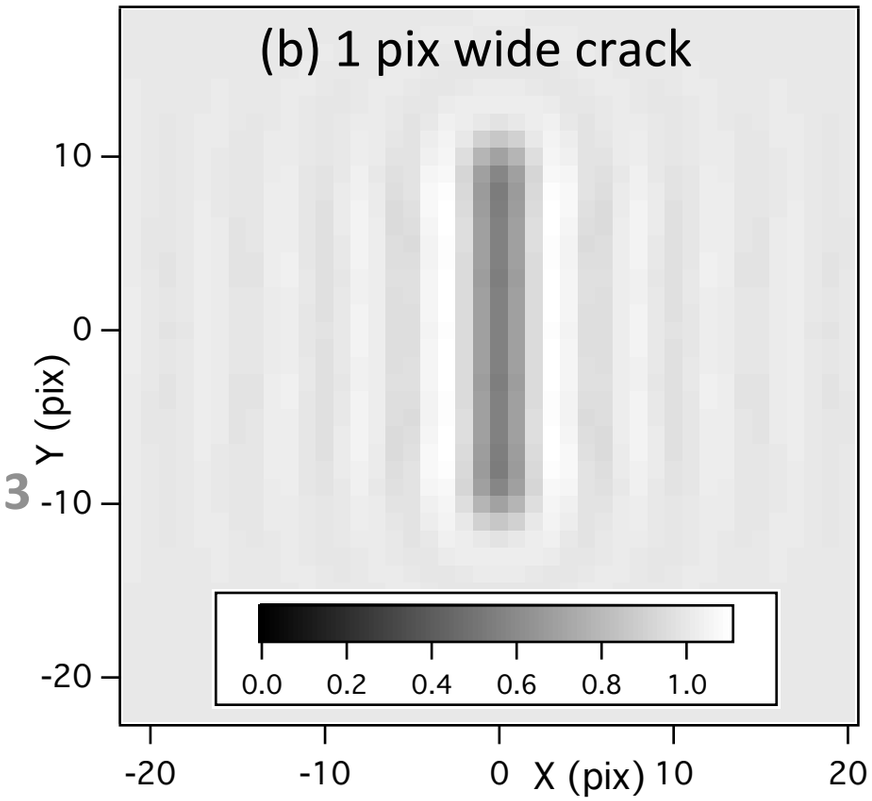


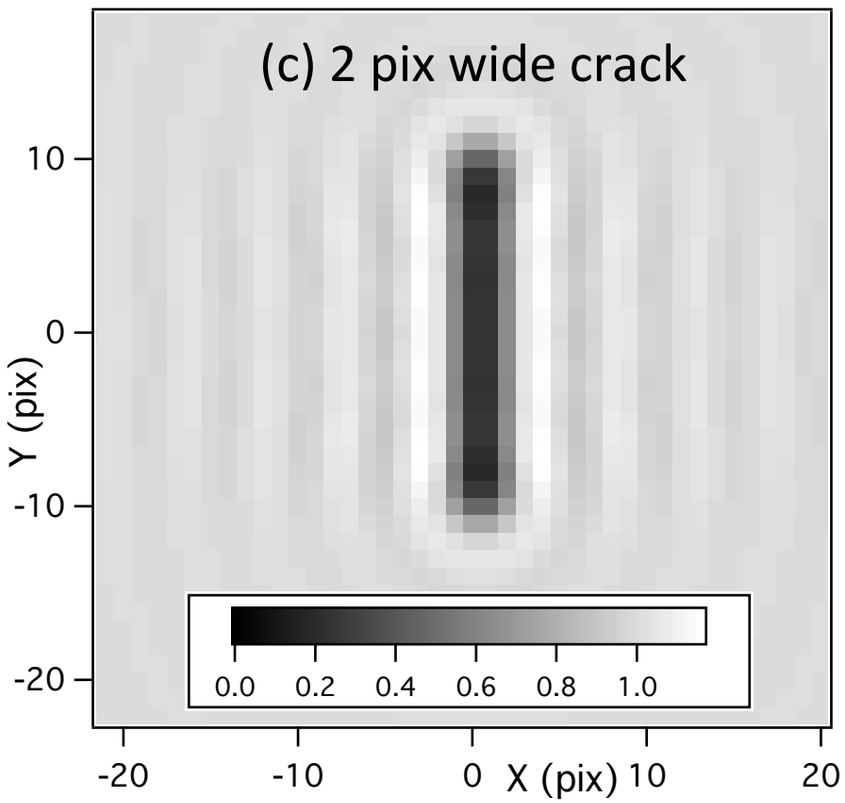



(a)
0.4
0.2
0.0
-0.2
-0.4
Vertical Spatial Frequency (1/pix)
1.0
0.8
0.6
0.4
0.2
0.0
-0.4
-0.2
0.0
0.2
0.4
Horizontal Spatial frequency (1/pix)


(b)
10
1
0.1
0.01
FFT magnitude
f/1.3
f/3
f/3
f/1.3
-0.4
-0.2
0.0
0.2
0.4
Frequency, Along Horiz. Lineout (1/pix)


f/1.3
f/3
f/3
f/1.3
(a) Simulated pupil plane
Vertical Spatial Frequency (1/pix)
Horiz Spatial Frequency (1/pix)
0.4
0.2
0.0
-0.2
-0.4

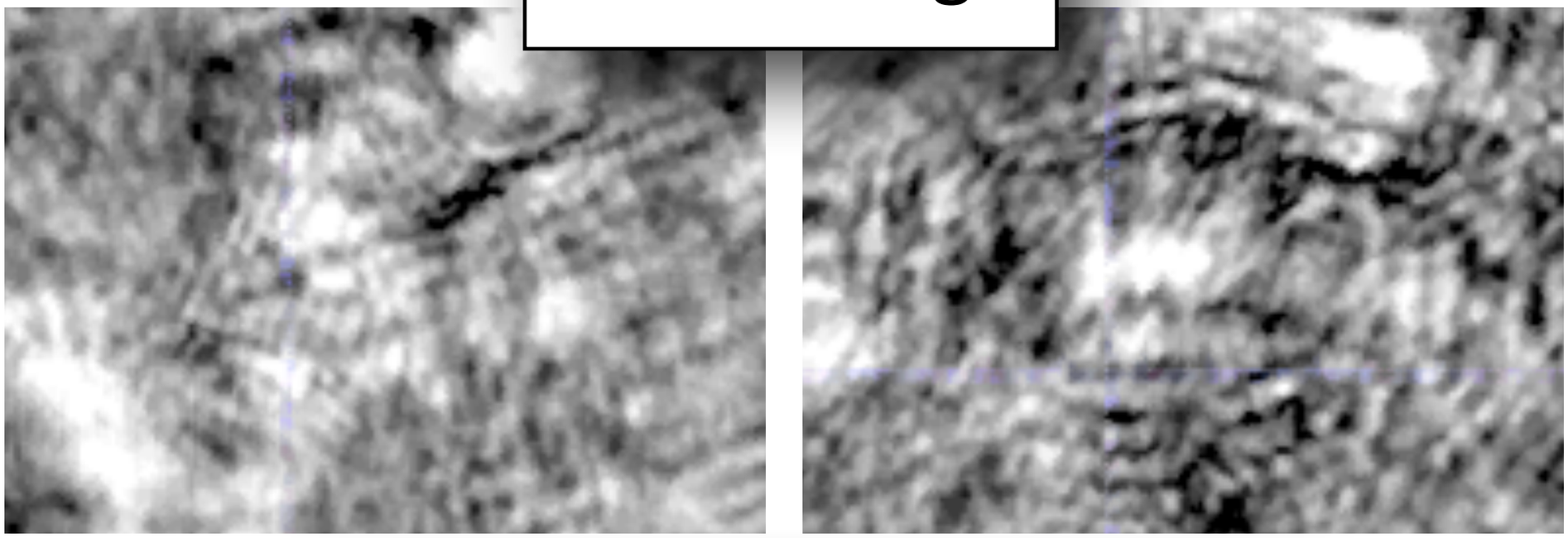

(b) 1 pix wide crack
Y (pix)
X (pix)
10
0
-10
-20
0.0
0.2
0.4
0.6
0.8
1.0


(c) 2 pix wide crack
Y (pix)
X (pix)
10
0
-10
-20
0.0
0.2
0.4
0.6
0.8
1.0

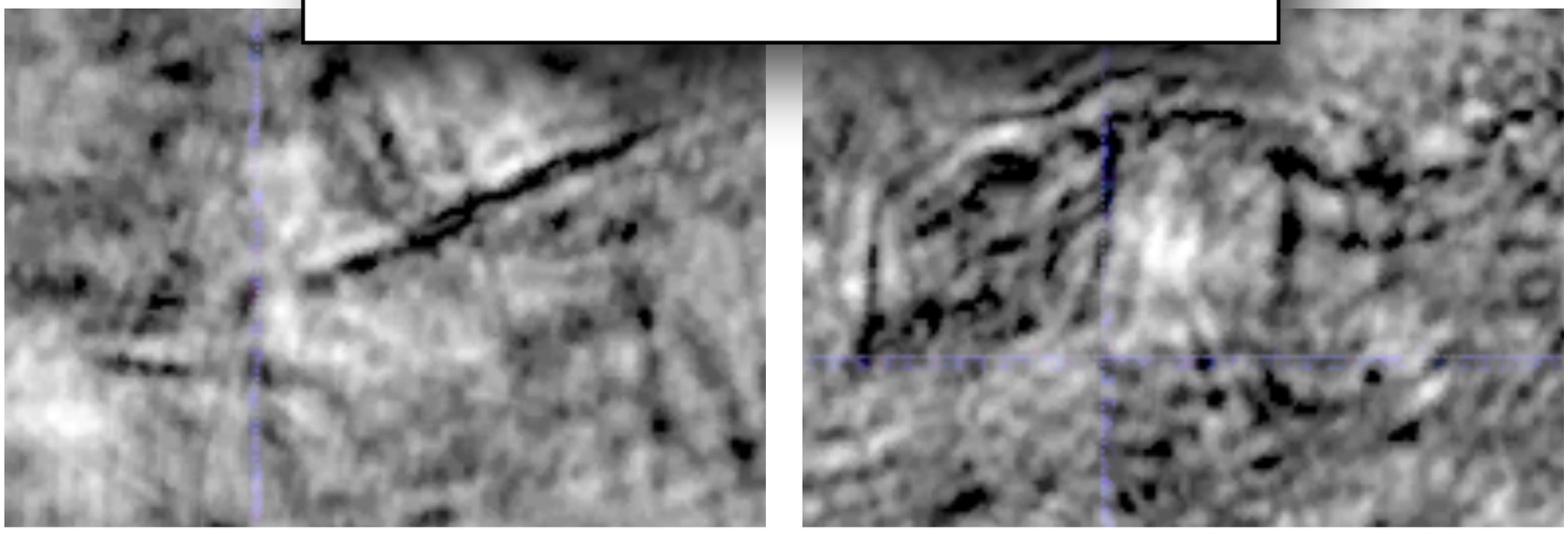
Place J

Ghost image

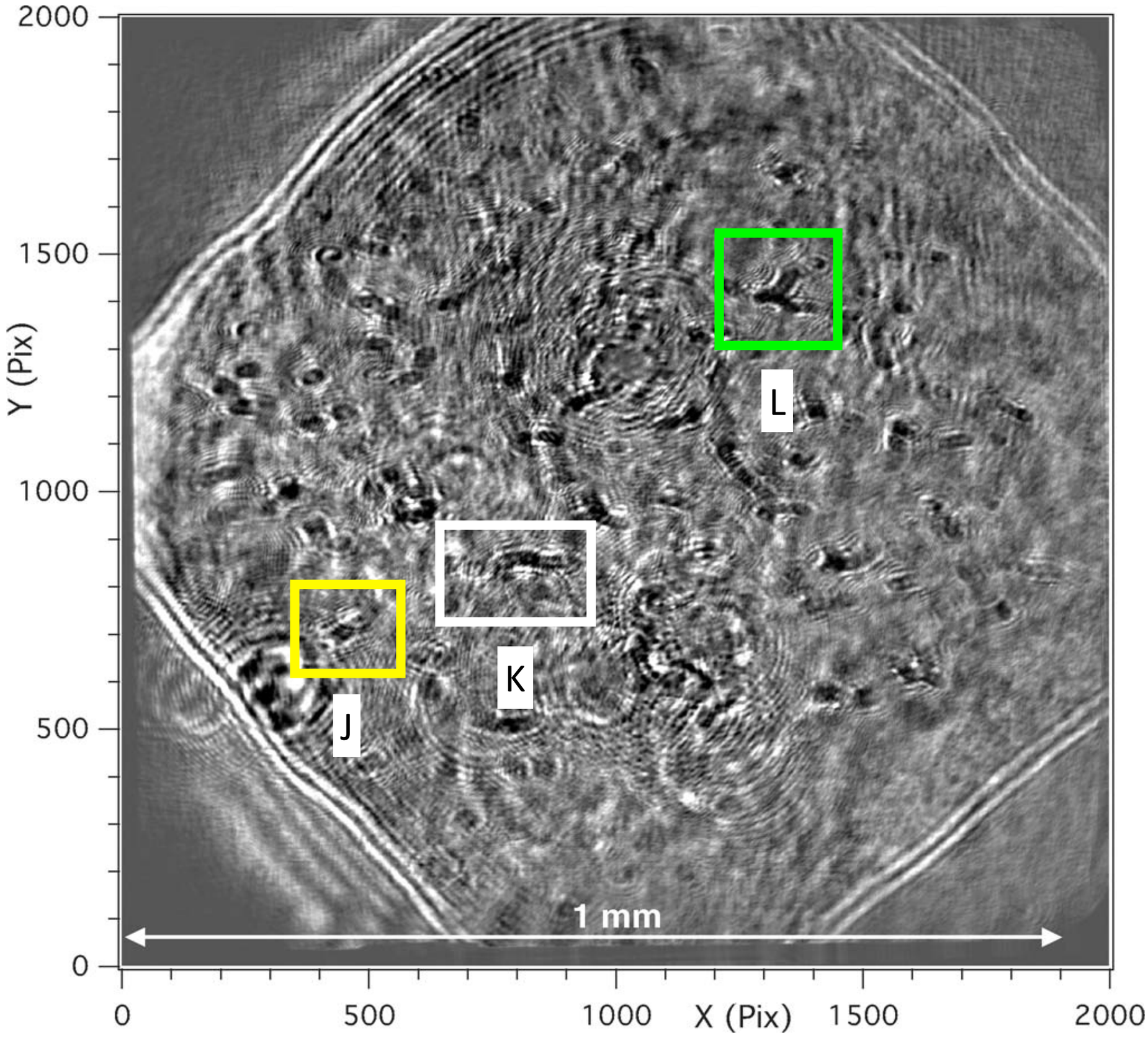
Place K



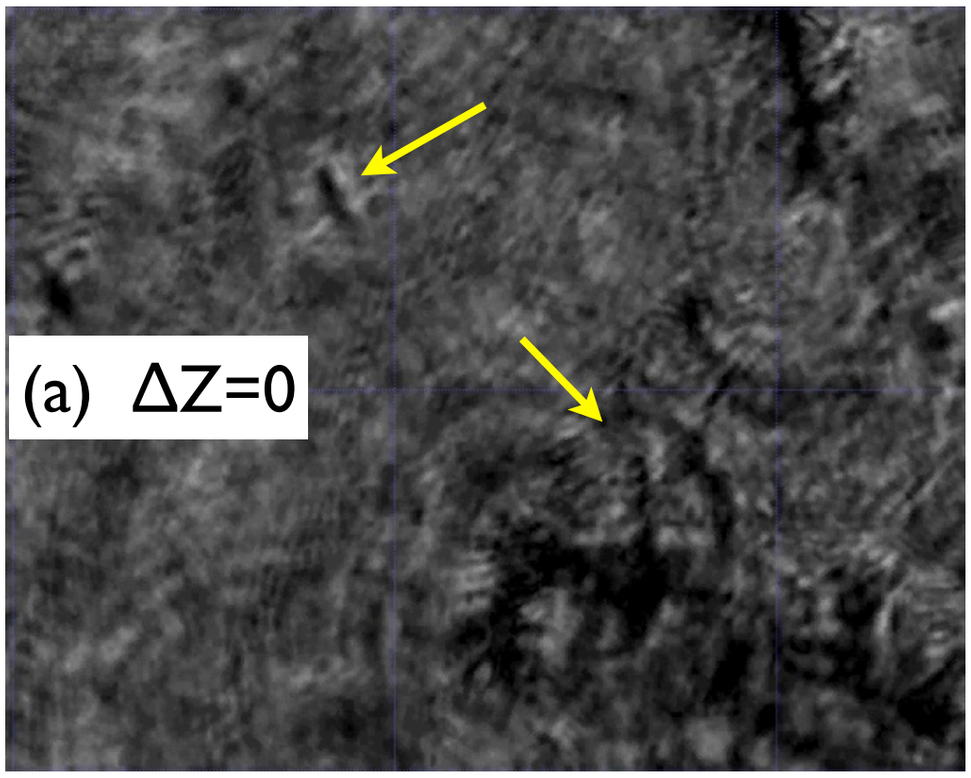
Main image, 268 ps later

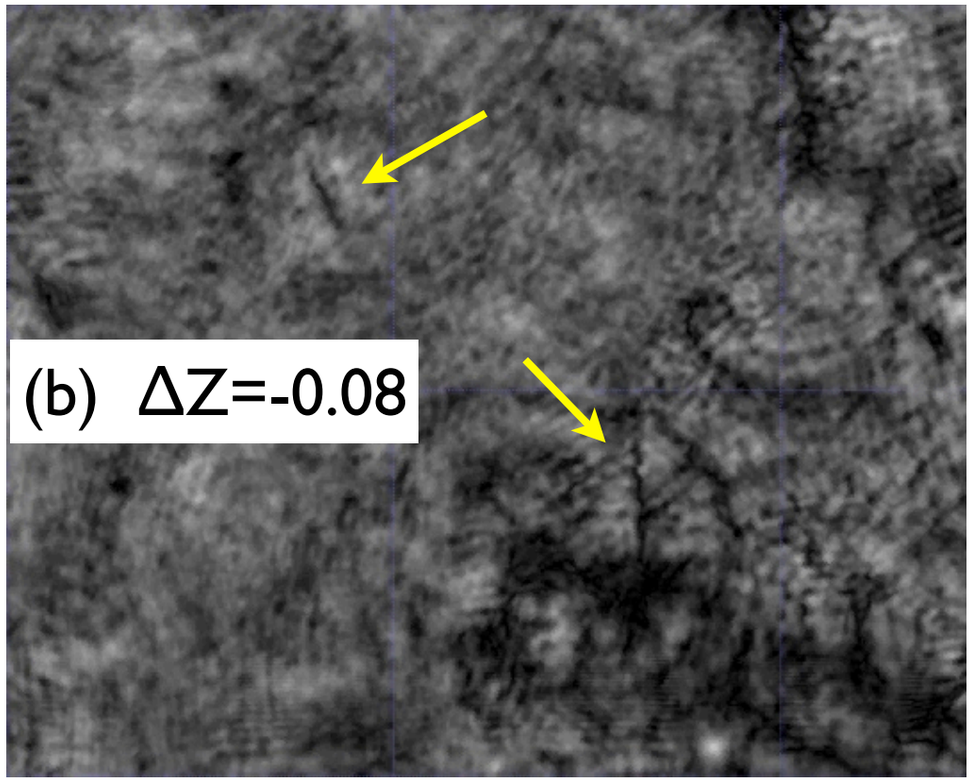


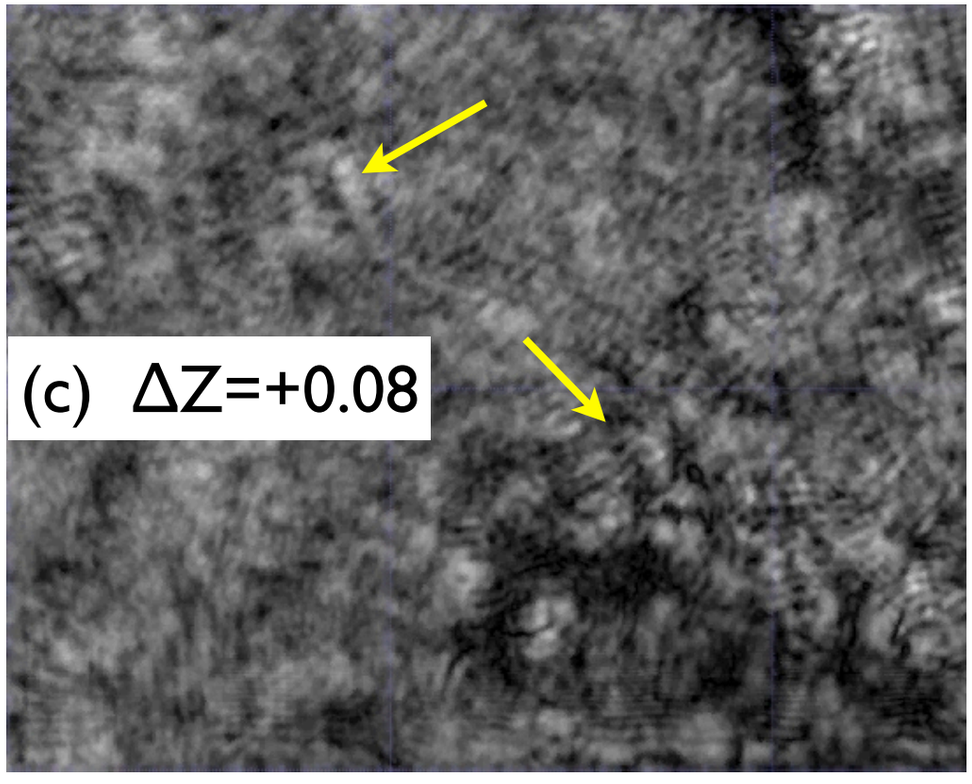
As-taken, accidentally out of focus



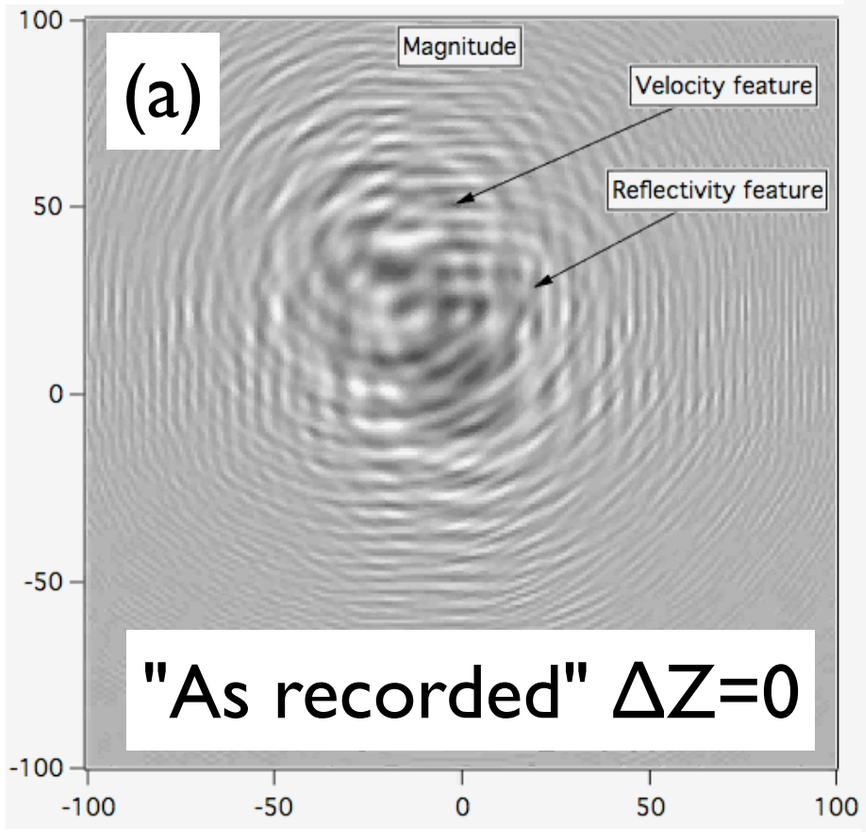
Also seen on another shot, so its not a fluke

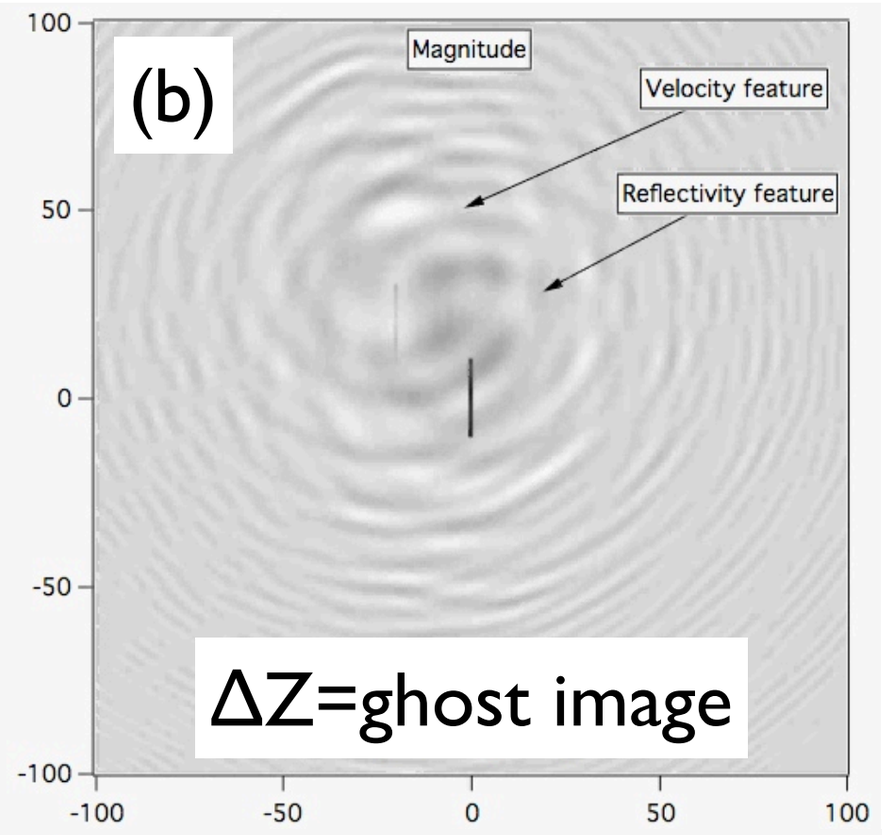


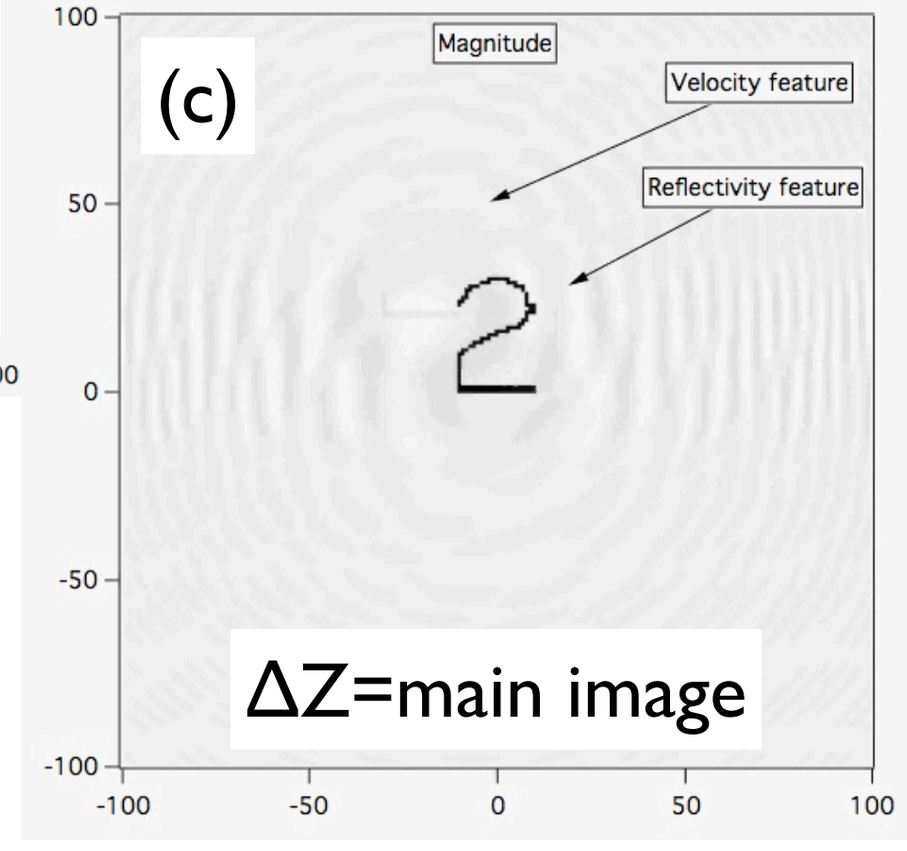




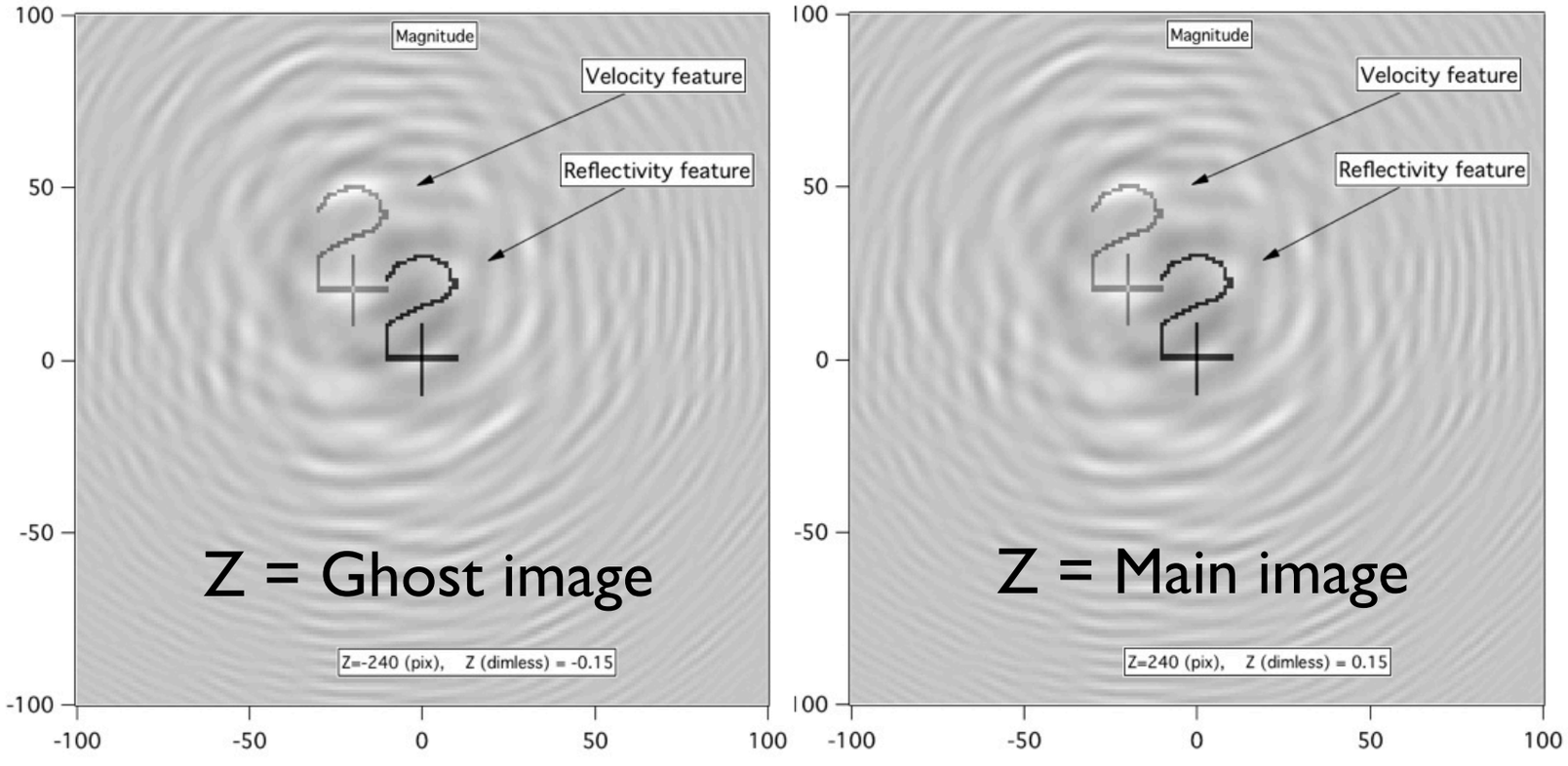
Simulations predict two-frame movie ability



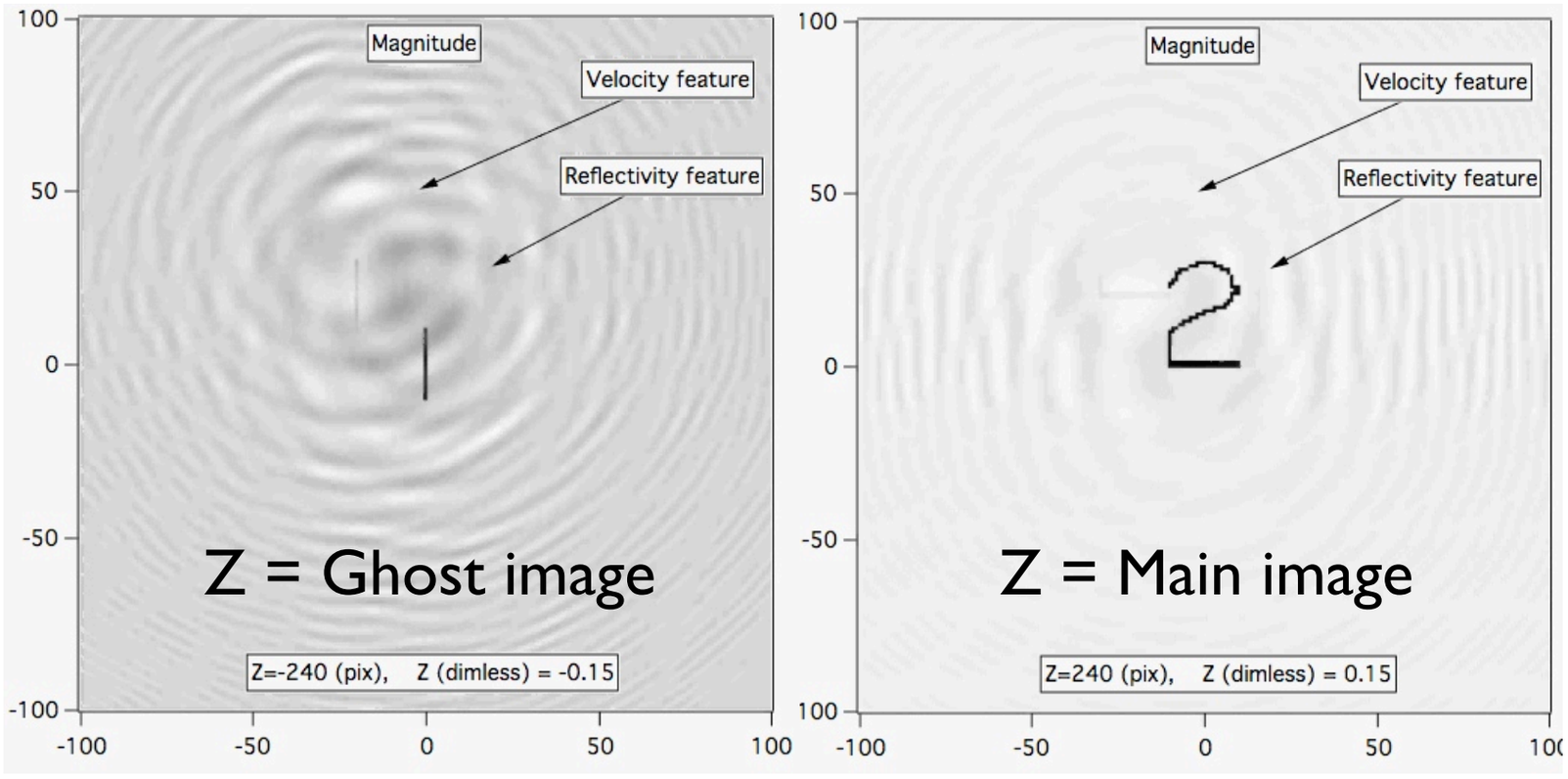




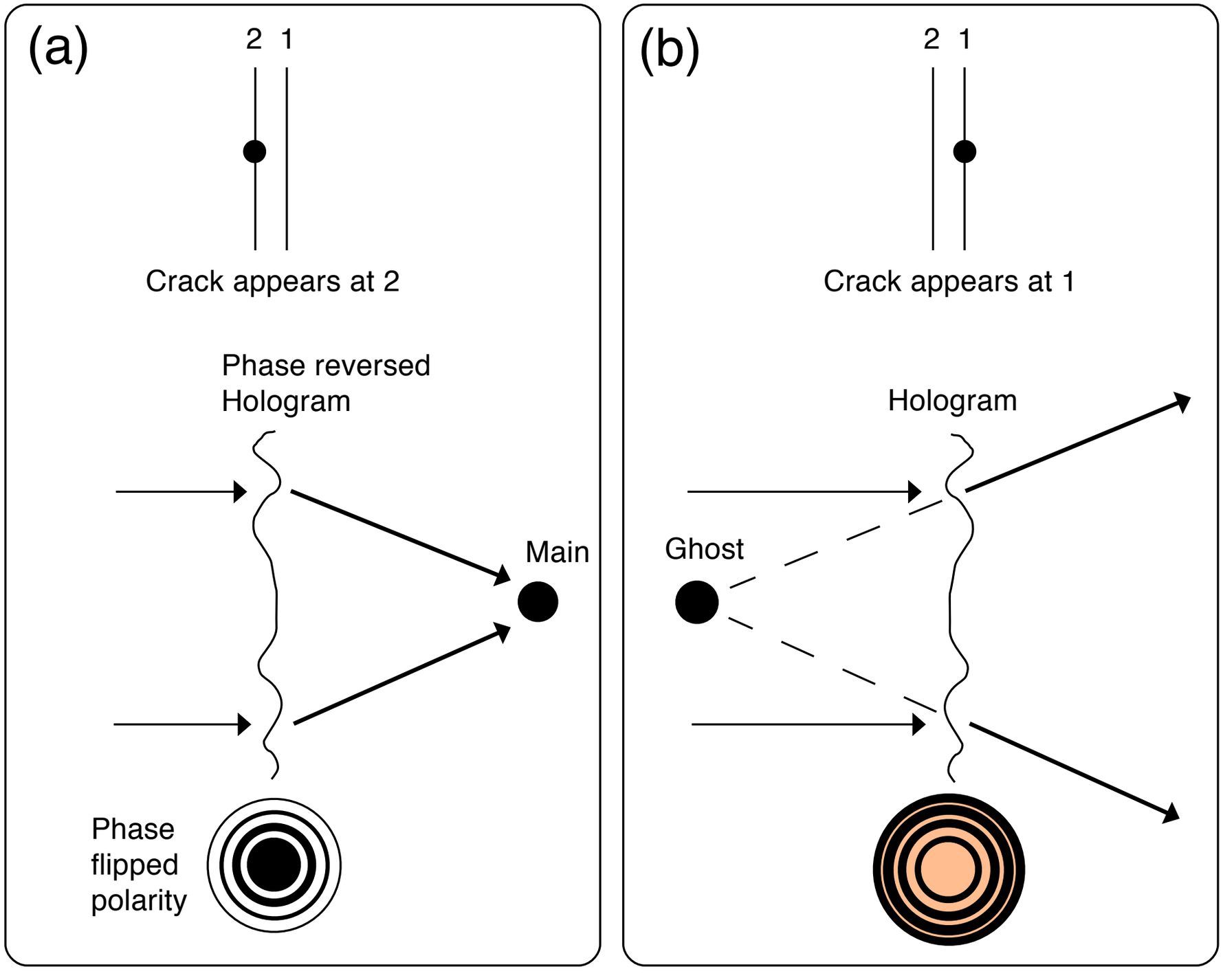
(A) No phase stepping

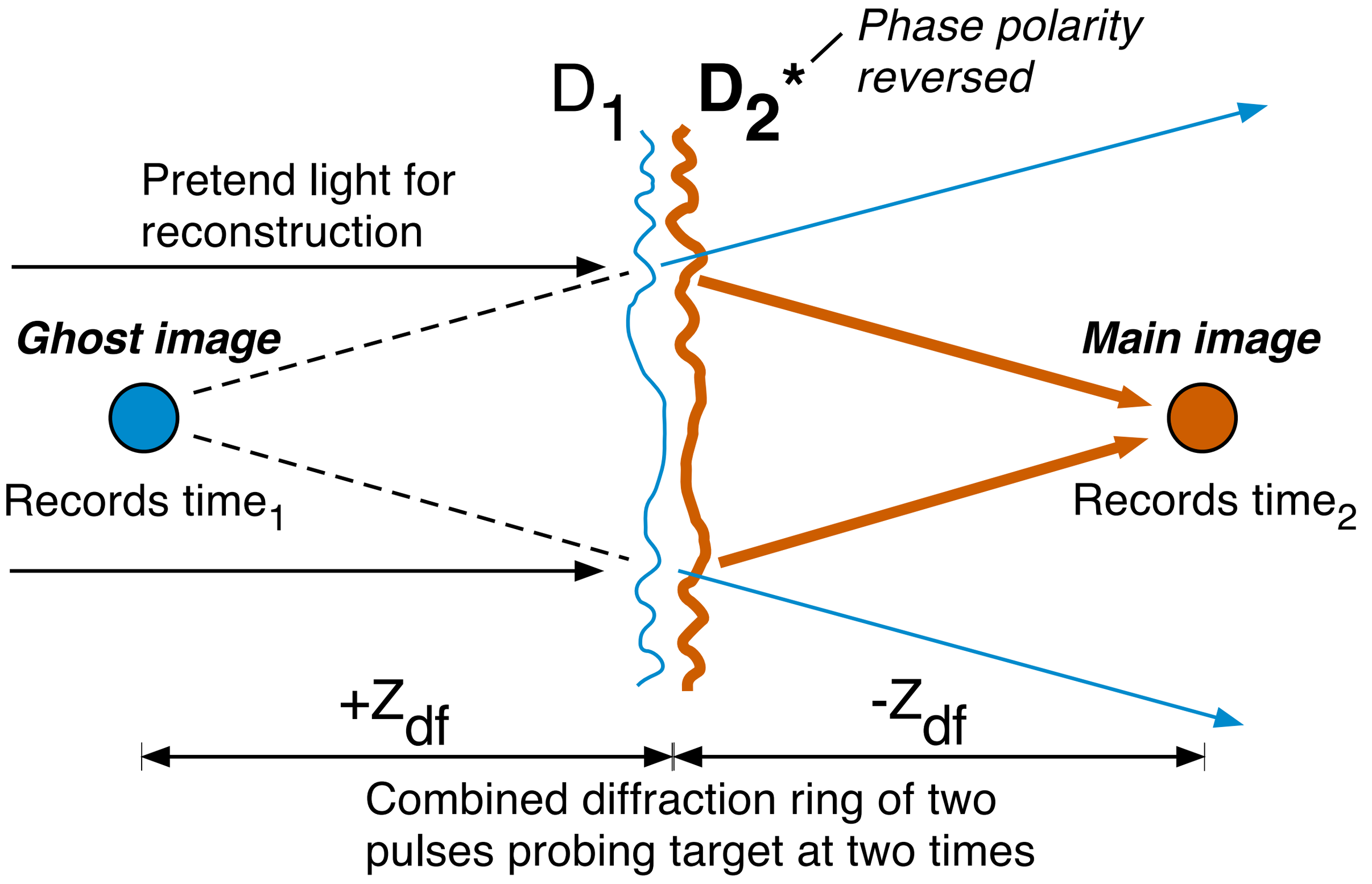


(B) Yes phase stepping



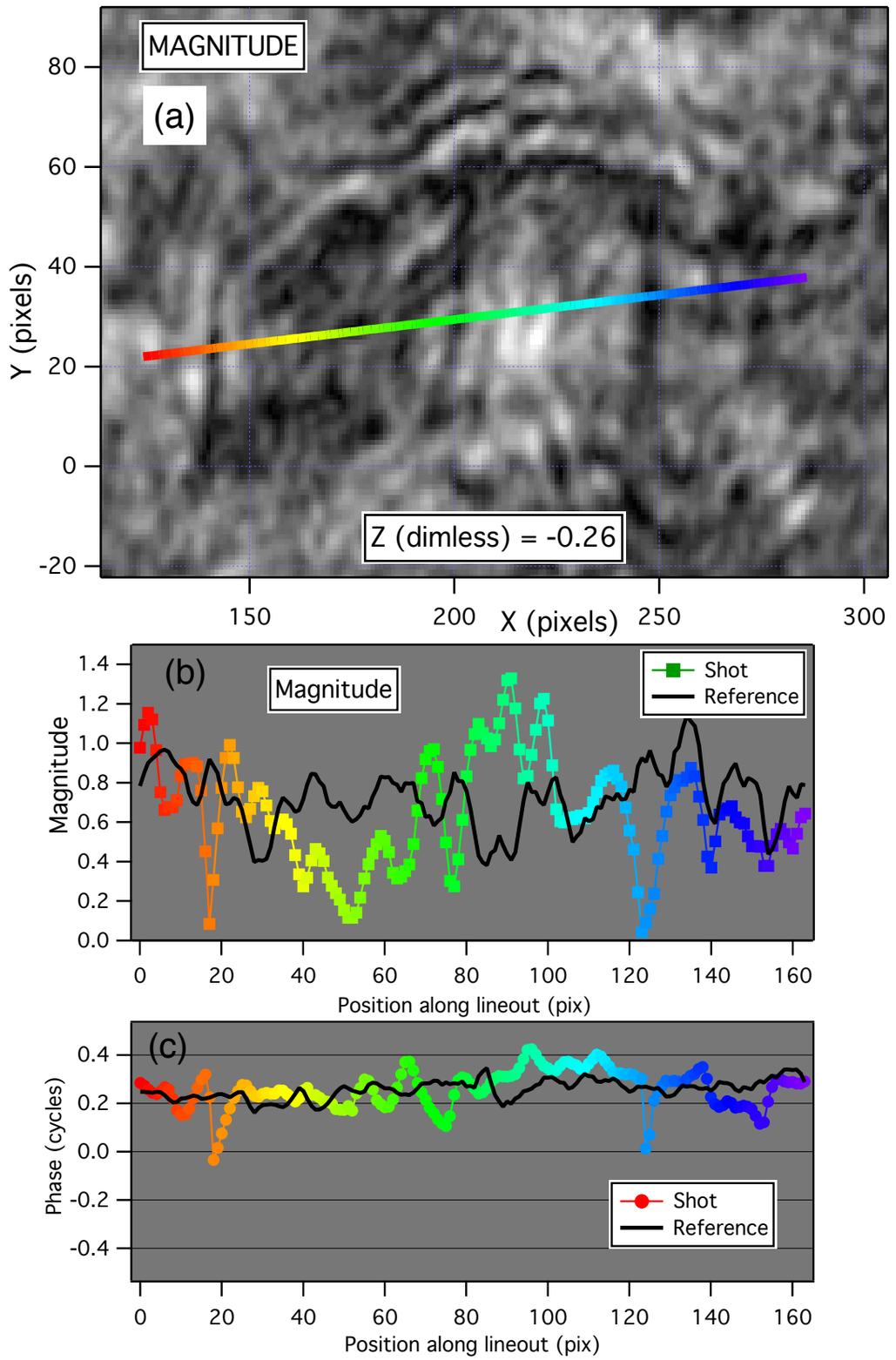
Arrow of time sets polarity of phase in rings

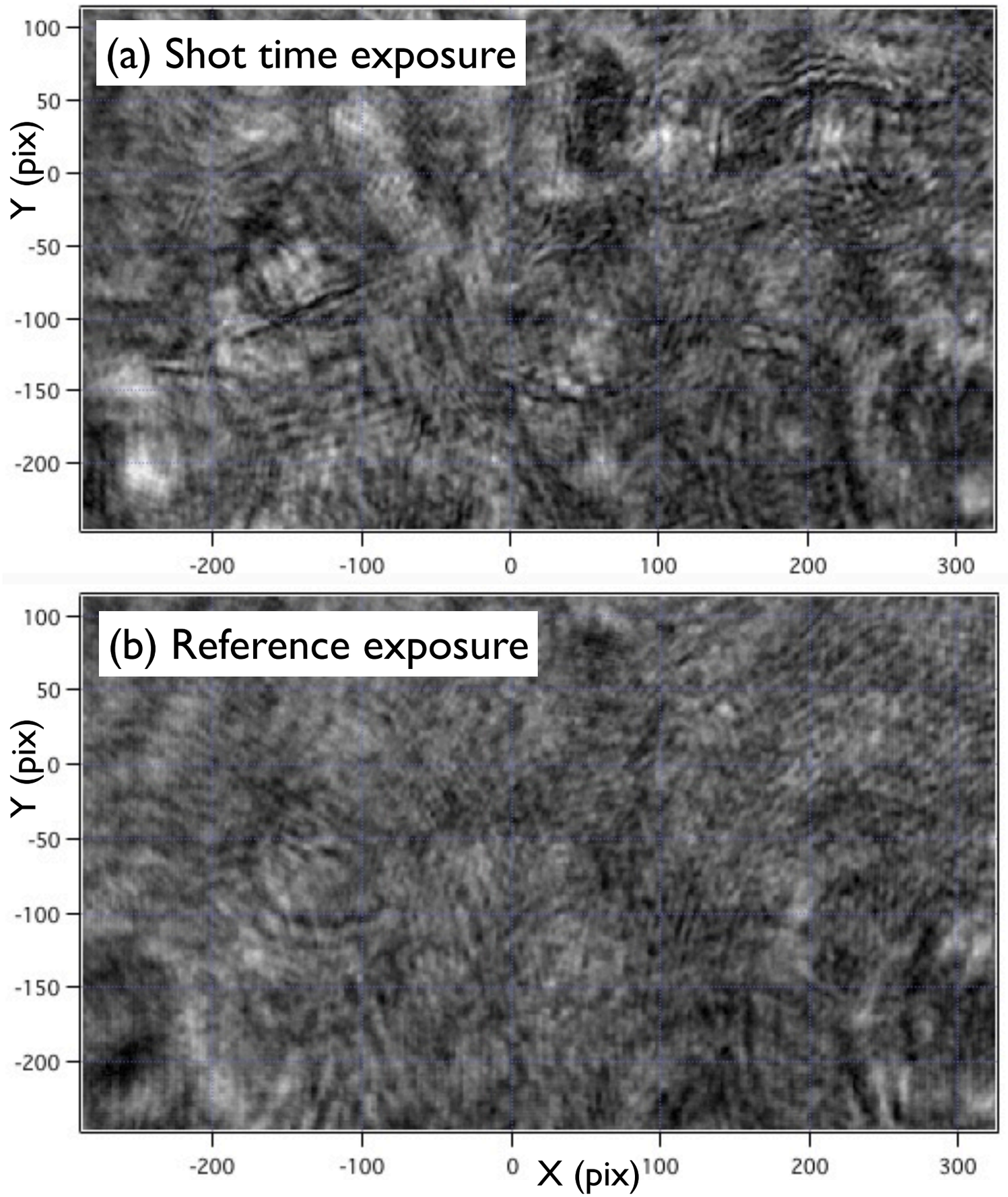



Phase polarity reversed
D1
D2*
Pretend light for reconstruction
Ghost image
Main image
Records time1
Records time2
+Zdf
-Zdf
Combined diffraction ring of two pulses probing target at two times

The End

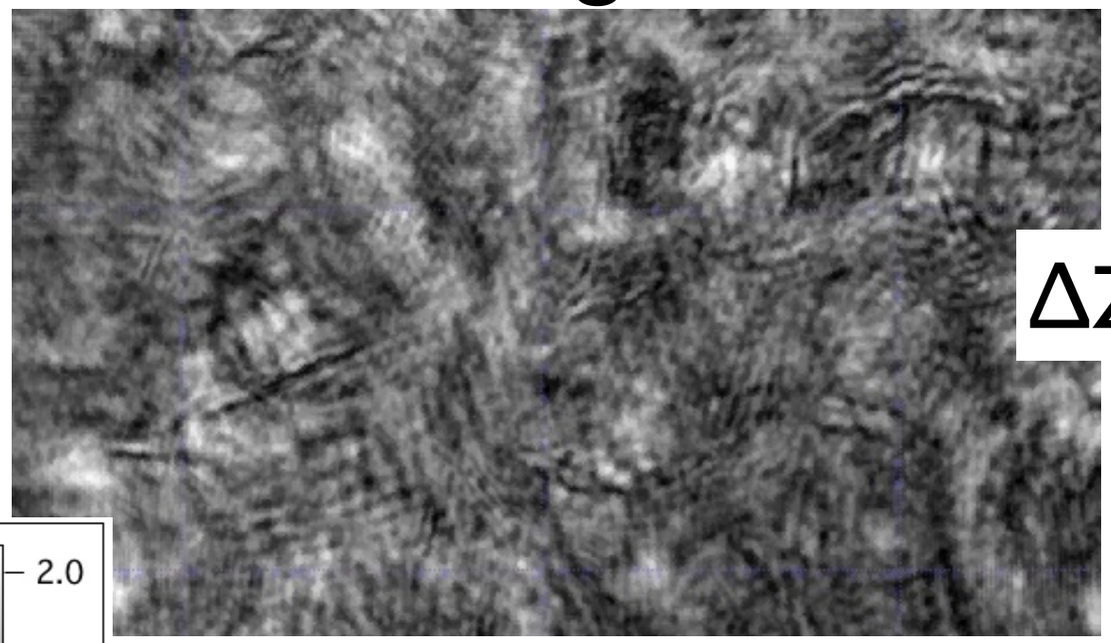
Garage of possible slides could use


MAGNITUDE
(a)
Z (dimless) = -0.26
Y (pixels)
80
60
40
20
0
-20
150
200
250
300
X (pixels)
(b)
Magnitude
Shot
Reference
Magnitude
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
140
160
Position along lineout (pix)
(c)
Phase (cycles)
0.4
0.2
0.0
-0.2
-0.4
Shot
Reference
Position along lineout (pix)

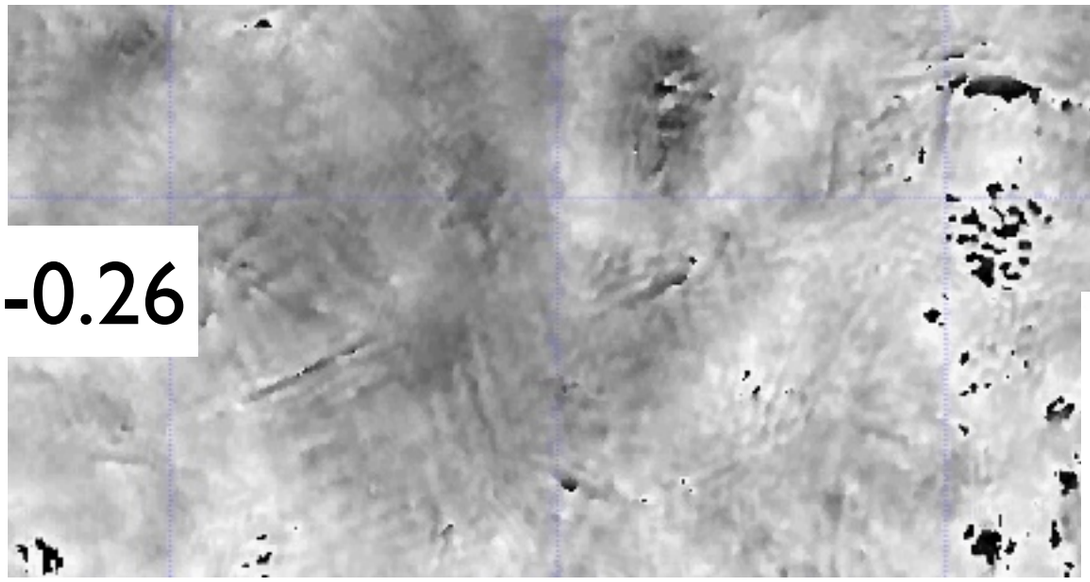

(a) Shot time exposure
(b) Reference exposure
Y (pix)
X (pix)
100
50
0
-50
-100
-150
-200
-200
-100
0
100
200
300

Mag

Phase



ΔZ=-0.26



cycles

0.4

0.2

0.0

-0.2

-0.4

2.0

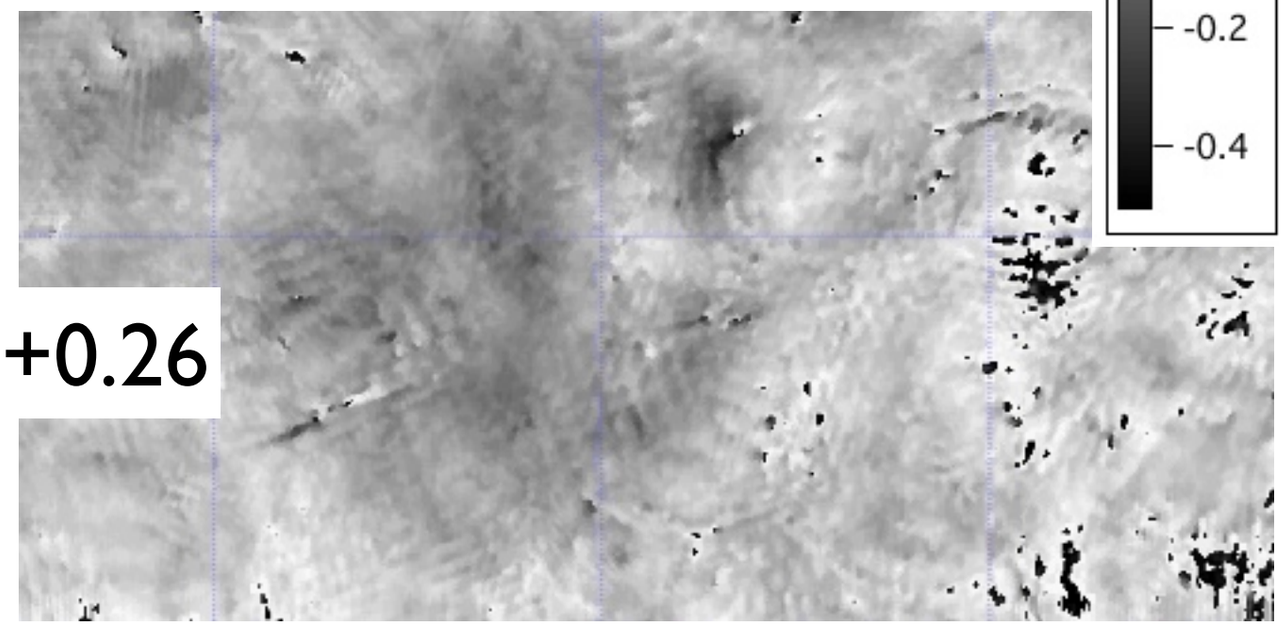
1.5

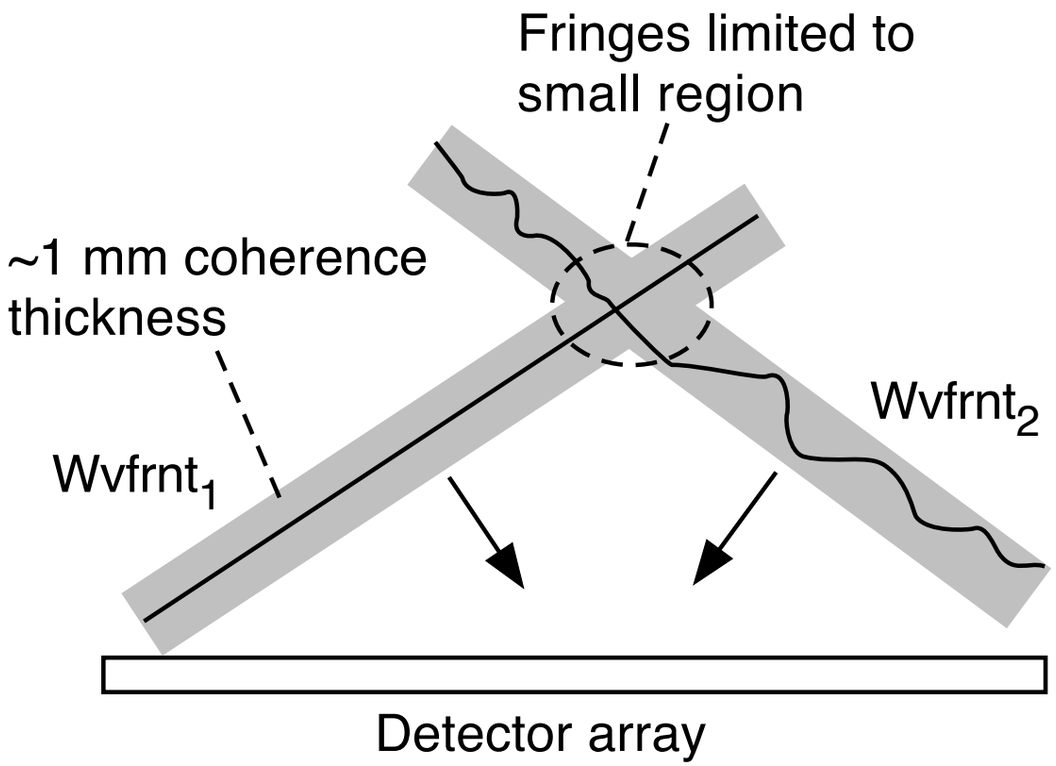
1.0

0.5

0.0

ΔZ=+0.26




Fringes limited to
small region
~1 mm coherence
thickness
Wvfrnt1
Wvfrnt2
Detector array

Two wavefronts,
overlapped spatially, but
separated temporally

Fringes result

Time-dependence of target sensed

Velocity

Reflectivity changes